ERL PHASE
Power Technologies Ltd

TESLA

Disturbance Recorder

Model 2000, 2000/P

User Manual

Version 4.0 Rev 2

Table of Contents

Preface i
Contact Information i
Version Descriptions iii
Using This Guide ix

1 Overview 1-1

TESLA Recorder Features 1-1
TESLA Control Panel Features 1-2
Overview of TESLA Control Panel 1-3
Front View (model 2000) 1-4
Rear View (model 2000) 1-4
Front View (model 2000/P) 1-5
Physical Mounting 1-6
Power Supply 1-6

2 TESLA Control Panel Setup 2-1

PC System Requirements 2-1
Installing TESLA Control Panel 2-1
Configuring Windows 2-2
Installing TESLA Control Panel Software from CD-ROM 2-4
Installing Null Modem Driver Software 2-5
Dial-up Network Connections (DUN) 2-13
Windows 95/98 2-13
Windows NT 2-17
Windows 2000 2-20
Windows XP 2-26
First Time Start-Up 2-31

3 Connecting to the Recorder 3-1

Communication Ports for Recorder 3-1
Communication Ports for Portable Recorder 3-2
Accessing the User Interface 3-3
Accessing SCADA Services 3-10
Setting Windows Serial Port Parameters 3-12
Communication Port Details 3-15

4 Working with TESLA Control Panel 4-1

Recorder Workspace 4-1
Adding/Editing a Recorder Workspace Definition 4-2
Online and Offline Operation 4-4
Navigating in TESLA Control Panel 4-5

5 Recorder Setup Utilities 5-1

Unit Identification 5-2
Communication Port Settings 5-3
Recording Settings 5-5
Time Display and Settings 5-9
Analog Input Calibration 5-10
Notify 5-10
Password Protection 5-13

6 Managing Configuration Files 6-1

Managing Configuration Files 6-1
Available Channel Types and Triggers 6-3
Planning Your Configuration 6-6

7 The Configuration Editor 7-1

Navigation through Configuration Settings 7-2
Main Branches 7-3
Settings Version 7-4
Element and Channel Tree Views 7-5
Channel Overview Screens 7-6
Individual Channel Configuration Screens 7-7
Chatter Limits 7-8
Storage Alarms 7-9
Analog Input Channels 7-9
External Input Channels 7-13
Summation Channel 7-14
Sequence Component Channels 7-17
Impedance Channels 7-19
Watts and Vars Channels 7-21
Frequency Channels 7-23
Logic Channels 7-24
Fault Locator Channels 7-26
Power Factor Channels 7-27
Triggers 7-28
Actions 7-29
Priority 7-30
Meter Groups 7-30
Trends 7-31
Printing a Configuration 7-33
Printing a Modbus Address List 7-33
Printing a DNP Address List 7-34

8 External Connections and Metering 8-1

Analog Input Channels 8-1
Analog Input Isolation Modules 8-1
External Input Channels 8-3

Alarm Contacts 8-3
IRIG-B Time Signal 8-4
Communication Ports 8-4
Power Supply 8-4
Analog Input Calibration 8-5
Metering 8-7

9 Record Management and Display 9-1

Record Listing, Transfer and Management 9-1
Trend Listing, Transfer and Management 9-3

10 Graphing Records 10-1

Getting Started 10-1
RecordGraph Menu Items 10-6
Views 10-32
Graphs 10-34
Templates 10-56
View and Graph Titles 10-62
Readouts and Measurements 10-64
Calculated Channels 10-71
Exporting Views 10-72
Exporting Channel Data 10-73
Record Summary 10-75
Digital Channel Status Indicator 10-75
IRIG-B Input Status Display 10-76
Derived Digital Swing Channels for TESLA Swing Recordings 10-76
Derived Channels for L-PRO, F-PRO High Speed Recordings 10-76
COMTRADE Import 10-77
Print Options 10-79

11 Record Export Utility 11-1

12 The Event Log 12-1

Event Log 12-1

13 Error Handling and Maintenance 13-1

Status Indicators 13-1
TESLA States 13-2
Startup Sequence 13-2
Error Handling 13-3
Failure Modes 13-4
Maintenance Menu 13-4

Appendix A Specifications A-1
Appendix B TESLA Hardware Description B-1
Appendix C Glossary C-1
Appendix D Modbus Functions D-1

Appendix E DNP3 Reference E-1
Appendix F TESLA Mechanical Drawing F-1
Appendix G Rear Panel G-1
Appendix H AC Analog Connections H-1
Appendix I AC Voltage Input Module I-1
Appendix J AC Current Input Module J-1
Appendix K AC Current Input Options K-1
Split Core CT (optional) K-1
Appendix L DC Input Module L-1
DC Analog Module Connection Schematic L-2
DC Analog Module Physical Dimensions L-3
Input and Range Configuration L-4
Standard Series of Values in a Decade L-8
Appendix M AC Low Voltage Input Module M-1
Appendix N TESLA Portable Wiring Connections N-1
Index I
Software Installation Instructions V

Preface

Information in this document is subject to change without notice.

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

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Version Descriptions

TESLA Version Compatibility			
Release Date	**TESLA Firmware**	**Setting Version**	**Control Panel**
2004 Oct 22	v4.0	7	v4.0
2004 Feb 17	v3.6d	7	v3.6
2004 Jan 28	v3.6c	7	v3.6
2003 Oct 10	v3.6b	7	v3.6
2003 Sep 09	v3.6b	7	v3.6
2003 June 23	v3.6a	7	v3.6
2003 April 17	v3.6	7	v3.6
2003 Feb 14	v3.5	6	v3.5
2002 Oct 11	v3.4	5	v3.4
2002 Apr 12	v3.3	5	v3.3
2001 Sep 10	v3.2	5	v3.2
2001May 04	v3.1	5	v3.1
2001 Feb 02	v3.0	4	v3.0
2000 Nov 06	v2.2	3	v2.3 or greater
2000 Jul 13	v2.1	3	v2.2 or greater
2000 May 30	v2.1	3	v2.1 or greater
2000 Feb 23	v2.0	2	v2.0 or greater
1999 Dec 16	v1.9	1	v1.3 or greater
1999 Nov 02	v1.8	1	v1.3 or greater
1999 Oct 18	v1.7	1	v1.3 or greater
1999 Jun 28	v1.6B	1	v1.3 or greater
Note: Newer versions of Control Panel are compatible with all older versions of TESLA firmware.			

TESLA Firmware Revision History		
Release Date	Version	Change Summary

TESLA Firmware Revision History		
2004 Oct 15	v4.0	Fixed issue with missing events in records when communicating with RecordBase Server over a LAN. Trend and recording alarm contacts now restore their previous state after unit reboot. Performance improvement in SCADA communication.
2004 Feb 17	v3.6d	Fixed issue with DNP Class 0 polls.
2004 Jan 28	v3.6c	Improvements to IP address handling. Fixed issue with IRIG-B where the ’sync’ flag would not be properly set in records under certain conditions.
2003 Sep 09	v3.6b	Fixed incorrect handling of user specified IP addresses with leading zeros. Improved recovery from a possible test mode deadlock state. Internal file system performance improvements.
2003 June 23	v3.6a	Corrected erratic behaviour on some units at startup.
2003 April 17	v3.6	Support for not connected modem/LAN notify communication modes. Support for cross-triggering and new record notification via LAN. SCADA interface to fault location information.
2003 Feb 14	v3.5	Support for stop/recycle recording modes. Support for recording alarm and record storage summary information. SCADA interface to record storage summary information. SCADA interface to trend summary information.
2002 Oct 11	v3.4	Support for separate primary and secondary units. Improved frequency resolution and frequency change handling. Improved phasor calculations. Improved THD calculations for small signal levels.
2002 Apr 12	v3.3	Watts/vars values calculated from sequence functions use all three sequence components of the defined inputs, rather than just the positive sequence components.
2001 Sep 10	v3.2	Trigger duration recording control mode
2001 May 04	v3.1	Power factor function Support for DC input channels Support for 1A nominal input channels Selection of input channel to use as the angle measurement reference
2001 Feb 02	v3.0	Trend logging Sag and swell detection Phase angle offsets in summation channels Increased circular event log size to 250 events Increased maximum number of user-defined meter groups to 10
2000 Nov 06	v2.2d	Corrects failure to capture longer swing records which can occur under some conditions

TESLA Firmware Revision History		
2000 Sep 26	v2.2c	Increased dial-out time-out to overcome difficulty calling into RecordBase
2000 Sep 22	v2.2b	DNP 3 SCADA protocol Enhancement to the Modbus SCADA protocol Improved THD and fault location accuracy (note: v2.2 and v2.2a were not released)
2000 Jun 09	v2.1a	Improved record extension algorithms Fixed problem with modem auto-answer handling
2000 May 30	v2.1	Support for RecordBase (dial-out, remote cross-trigger, automated record collection) Support for Ethernet option Changed *Diagnostic* login to *Maintenance* login Implemented new unit option identification system Fixed problem with invalid repeated external input detector triggers Improved THD calculation some (inter-channel variations)
2000 Feb 23	v2.0	Fault location Logic channels and triggers Events via Modbus Primary quantities over Modbus (metering)
1999 Dec 16	v1.9	Fixed problem of repeated triggering of low level analog detector
1999 Nov 02	v1.8	Fixed crash associated with connecting IRIG B signal
1999 Oct 15	v1.7	User access levels & passwords Fixes to impedance triggers and frequency trigger hysteresis Minor clean-up issues

TESLA Control Panel Revision History

Release Date	Control Panel Version	Change History
2004 Oct 22	v4.0	Fixed incorrect start time when exporting combined TESLA records in COMTRADE format. RecordGraph: corrected absolute time readout for combined TESLA records. RecordGraph: Impedance View now works with COMTRADE files. RecordGraph: correct trigger time now works with COMTRADE files. RecordGraph: Trigger Marker now follows Time Alignment settings.

TESLA Control Panel Revision History		
2003 Oct 10	v3.6a	Prevent Utilities views from closing while saving changes. Status of High/Low speed recorders now shows “stopped” when Accumulation Mode is set to ‘stop’ and the recorder is full. Corrected erroneous status bar text in the Configuration view. RecordGraph: fixed scaling prefix on derived channels. RecordGraph: differential view for T-PRO v3.3 firmware now displays the differential slope settings. RecordGraph: fixed incorrect display of DC channel units.
2003 April 17	v3.6	Notify operation through LAN connection is now configurable. Printed SCADA points lists include fault location.
2003 Feb 14	v3.5	Displays the number of remote recordings and percent disk space used. Option to have circular record storage or to stop when full, including a near-full alarm. Fault Locator can be configured with summation current inputs.
2002 Oct 11	v3.4	Support for new low voltage ac module. Support for separate primary and secondary units (Control Panel and RecordGraph). RecordGraph – B-PRO settings characteristics display in differential view.
2002 Apr 12	v3.3	DNP over Ethernet Additional Fault Locator functions (now 5 per channel group) Data storage controls - individual directory locations for records and configuration files from each recorder to allow shared access to data and better data backup planning. Support for 50 Hz systems
2001 Nov 26	v3.2a	Enhanced record graphics
2001 Sep 10	v3.2	Enhanced record graphics Trigger duration based recording mode. Automatic on-site record printing capability
2001 May 04	v3.1	Power factor function Support for DC input channels Support for 1A nominal input channels Selection of input channel to use as the angle measurement reference
2001 Feb 02	v3.0	Trend logging Sag and swell detection Phase angle offsets in summation channels Increased circular event log size to 250 events Increased maximum number of user-defined meter groups to 10
2000 Sep 19	v2.3a	Include updated setting example files

TESLA Control Panel Revision History		
2000 Sep 14	v2.3	Support for TESLA's new DNP implementation Various fixes and minor improvements
2000 Jul 17	v2.2a	Fixed problem with output contact assignment for 18 channel recorders
2000 Jul 13	v2.2	Users RecordGraph v1.2 module (with harmonics display) Supports 480V modules Various fixes and minor improvements
2000 May 31	v2.1	Can configure TESLA for use with RecordBase Online user manual help Uses RecordGraph v1.1 module Modbus settings report Event list printout
2000 Feb 23	v2.0	Fault location Logic channels and triggers Backward compatibility support
2000 Jan 10	v1.5	Enhanced record export utility (COM-based) - transient and swing Enhanced graphics - primary/secondary, symmetrical component view, vertical scale handling Password handling improvements Improved communications (connection cancel, progress window, shorter timeout, etc.) Meter cacheing Configuration - numerous minor improvements Other minor improvements.
1999 Dec 05	v1.44	Corrected problem with metering calculated impedance Corrected problem with printing a configuration Corrected problem with graphing summations with fewer than 3 inputs
1999 Nov 24	v1.43	Corrected problem with configuration of summation channels
1999 Oct 20	v1.41	Corrected problem access remote records
1999 Oct 18	v1.4	User access levels & passwords Improved disconnect / re-connect handling Improved configuration screen layouts including primary/secondary scaling.
1999 Jul 28	v1.3	

TESLA User Manual Revision History		
Release Date	**Manual Version**	**Change Summary**
2008 Feb 08	v4.0 Rev 2	Branding to ERLPhase.

TESLA User Manual Revision History		
2004 Oct 22	v4.0 Rev 1	Update to firmware v4.0 and Control Panel v4.0.
2003 Oct 10	v3.6 Rev 3	Update to Control Panel v3.6a. Minor improvements to Chapter 2.
2003 June 23	v3.6 Rev 2	Change the TESLA Firmware Revision History table to reflect update to v3.6a.
2003 April 17	v3.6	Update to Control Panel v3.6.
2003 Feb 14	v3.5	Update to Control Panel v3.5. Support for TESLA Portable (model 2000/P).
2002 Oct 11	v3.4	Update to Control Panel v3.4.
2002 Apr 12	v3.3	Update to Control Panel v3.3.
2001 Nov 26	v3.2 Rev 2	Update to include enhanced graphics.
2001 Sep 10	v3.2	Update to Control Panel v3.2.
2001 May 04	v3.1	Update to Control Panel v3.1.
2001 Feb 02	v3.0	Update to Control Panel v3.0.
2000 Sep 21	v2.3	Add DNP3 Reference Update Modbus Functions
2000 Jul 10	v2.2	Update with new RecordGraph module instructions.
2000 May 10	v2.1	Support for RecordBase
2000 Feb 24	v2.0	Updated to match Control Panel v2.0/TESLA Firmware v2.0 Formatting and text changes
2000 Jan 06	v1.5	Updated to match Control Panel v1.5/ TESLA Firmware Add more instructions to Record Graphing section Added Equipment List Added and changed some diagrams Formatting and text changes
1999 Oct 14	v1.4	Updated to match Firmware Release v1.7/Control Panel v1.4 Added Appendix E: Windows Setup Minor additions and corrections
1999 Jun 25	v1.3	Updated to match Firmware Release v1.6/Control Panel v1.3

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**
Start>Settings>Control Panel	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
Recordings	Menu items and tabs are shown in italics.
service	User input or keystrokes are shown in bold.
Text boxes similar to this one	Relate important notes and information.
..	Indicates more screens.
▶	Indicates further drop-down menu, click to display list.
	Indicates a warning.

1 Overview

The TESLA Disturbance Recorder (model 2000, 2000/P) is a multi-time frame recording system for monitoring electrical power systems.

The recorder operates simultaneously in three time domains: high speed transient fault (seconds), low speed dynamic swing (minutes) and trending (continuous).

TESLA recorder provides an extensive set of triggers including rates and levels, THD, sequence components, summations, watts, vars, power factor, impedance and frequency.

The TESLA recorder consists of:

1 A recorder unit which is either a 19 inch 3U rack mount chassis or a portable housing
2 Analog input isolation modules connected to station CT, PT and other signals
3 Control Panel software installed either on a laptop or desktop PC

TESLA Recorder Features

- Simultaneous operation in transient fault and dynamic swing time frames
- 5760 samples/second (96 samples/cycle) transient fault recordings produce records from 0.2–5.0 seconds with automatic record extension up to 10.0 seconds for multiple trigger conditions
- 60 samples/second (1 sample/cycle) dynamic swing recordings produce records from 10–120 seconds with automatic record extension up to 180 seconds for multiple trigger conditions
- Continuous trending process preserves operational data and detects events
- User-defined, calculated channels for summations, watts, vars, power factor, positive, negative and zero sequence components, impedance, THD, frequency, harmonics and fault locator
- 36 analog inputs (or 18 analog inputs—configuration-dependent)
- 64 external inputs (or 32 event inputs—configuration-dependent)
- 10 fault locators (or 5 fault locators – configuration dependent)
- User-configured logic function specifies logic operations on external and internal states
- 5 user-configurable output contacts (or 2 user-configurable output contacts—configuration dependant)
- Rates and level triggering on input and calculated channels with extensive individual controls including delay, logging, record initiation and alarm contact activation
- Element configuration format simplifies complex setups by modelling the power system within the recorder
- User-assigned trigger priorities used to help identify critical events and records

- Complete recorder configuration information and relevant event information is embedded in each record
- Each analog input configured to monitor a voltage can be used to detect sags and swells
- Record compression reducing record size, maximizing storage capacity and minimizing transmission time
- Standard TCP/IP communication protocol used to communicate with Control Panel and RecordBase software
- Analog input isolation modules are external and are mounted on DIN rails up to one hundred feet from the main unit for flexible installation
- Events track all external and internal triggers
- Each recorder can have one or two channel groups (configuration dependent) Each channel group has 18 analog and 32 external channels using a floating point Digital Signal Processor (DSP). A separate 486 processor is used for data storage and all communication control.
- Self-monitoring supervisory software with hardware self-checking circuit ensures reliable operation
- IRIG-B input with flexible configuration supports both Universal Time Code (UTC) and local time
- SCADA (Supervisory Control and Data Acquisition Systems) protocols—Modbus, DNP3. DNP3 over Ethernet is supported
- IEEE standards for surge withstand and RFI

TESLA Control Panel Features

- Windows-based software with intuitive user interface
- Provides separate storage space for each recorder’s records and configuration files
- Offline mode allows records to be viewed and configurations created without connecting to the recorder
- Record summary shows sequence of events
- Record management facilities include multiple record selection for transfer and deletion and record renaming
- Record graphics provide a flexible multi-page interactive display and measurement of all channels including calculated ones
- COMTRADE recording export facility
- Configuration facility maintains multiple configurations
- Real-time metering display shows all input and calculated quantities in user-customizable layouts
- Point and click interface shows record summary and event list for records so that a preliminary evaluation can be made before the record is transferred

Figure 1.1: Front View

Overview of TESLA Control Panel

TESLA Control Panel is a Windows-based software program that runs on a desktop or laptop PC. It communicates with and manages information from your TESLA recorders.

Offline/Online Use

TESLA Control Panel can be used with or without a connection to a recorder. When connected to a recorder, all TESLA Control Panel functions are available. When a recorder is not available, you can create/modify configuration files and view uploaded records.

TCP/IP Protocol

TESLA Control Panel communicates with a recorder using the TCP/IP protocol standard. A communications link can be established through a direct serial cable connection, a modem or 10BaseT Ethernet.

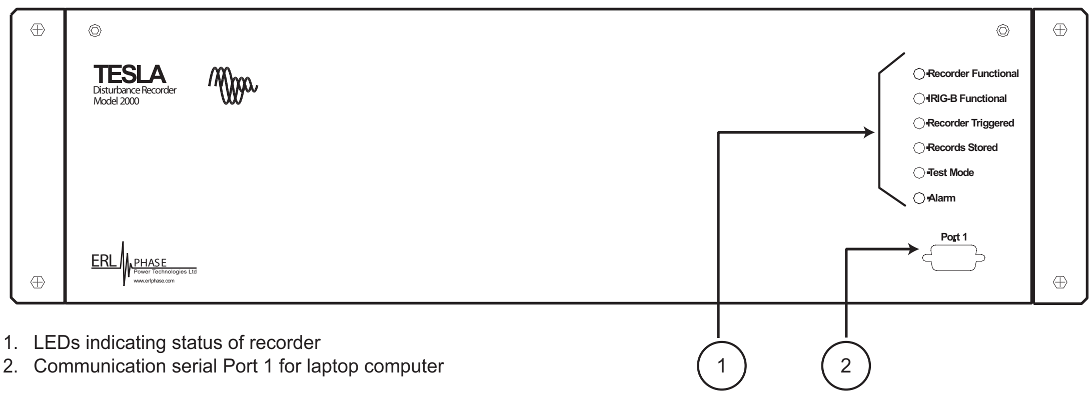
Dial-Up Networking

The Windows operating system has built-in support for TCP/IP—you may have to activate it. To use TCP/IP over a serial link, Windows uses its Remote Access Service (RAS) and Dial-Up Networking making the serial link appear similar to other network connections to Windows.

Null Modem

Windows Dial-Up Network supports modem communication. When a special modem driver called the Null Modem is installed, you can use it for direct serial connection to a TESLA recorder. The Null Modem driver is provided as part of the TESLA Control Panel software.

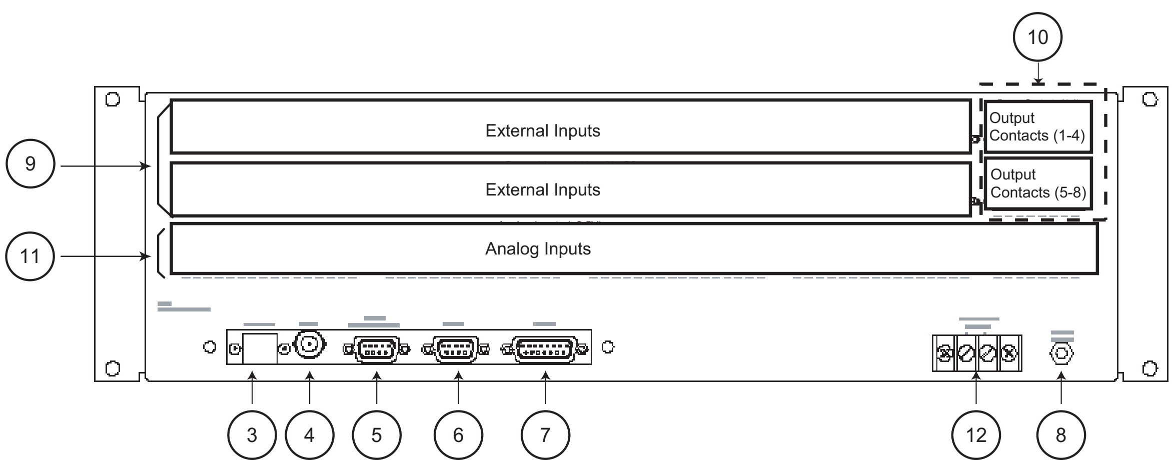
Front View (model 2000)



1. LEDs indicating status of recorder
2. Communication serial Port 1 for laptop computer

Figure 1.1: Front View

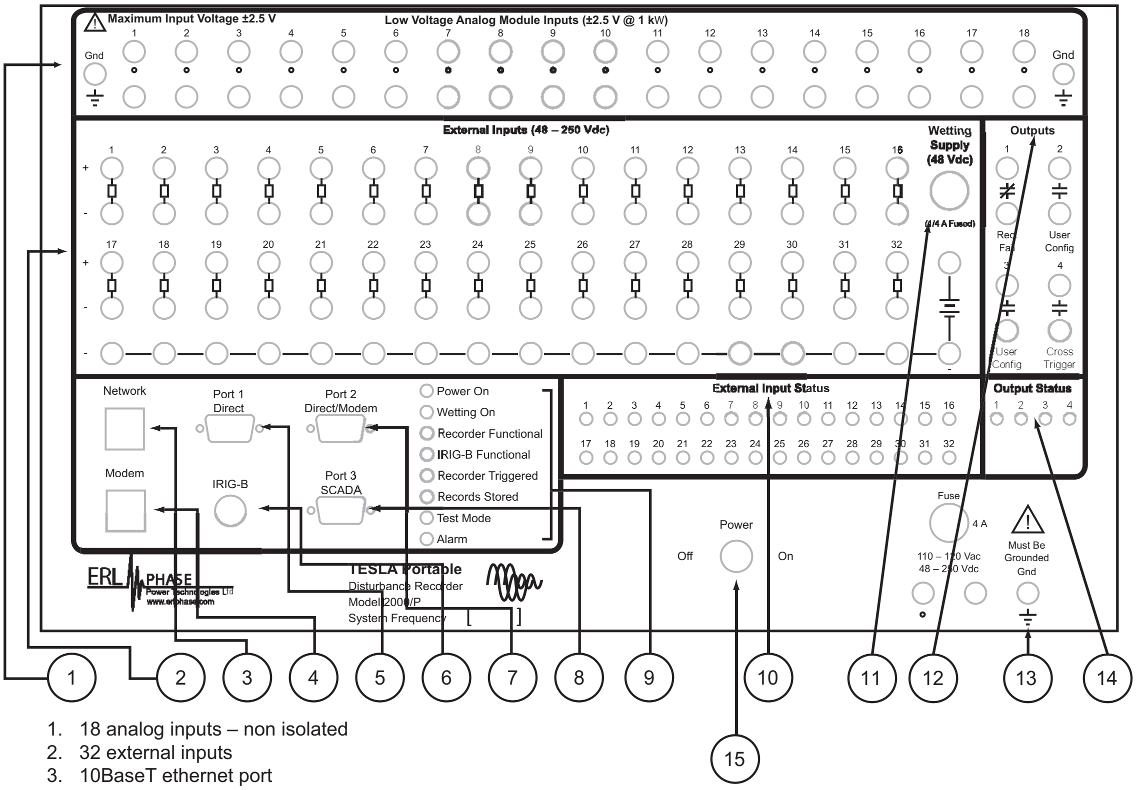
Rear View (model 2000)



3. Port 5 for optional internal modem (RJ-11) or Ethernet connection (RJ-45)
4. External clock, IRIG-B modulated or not modulated
5. Communication port 2 for direct connect to PC or external modem
6. EIA 232 SCADA communication port 3
7. Port 4 (unused)
8. Case external ground
9. 32/64 external inputs(32 inputs per channel group)
10. 4/8 output contacts (4 per channel group)
11. 18/36 analog inputs (18 per channel group) - non isolated
12. Power supply 48/125/250 Vdc, 120 Vac nominal

Figure 1.2: Rear View

Front View (model 2000/P)



1. 18 analog inputs – non isolated
2. 32 external inputs
3. 10BaseT ethernet port
4. 33.6 Kbps modem port
5. EIA 232 communication port for direct connect to PC
6. External clock, IRIG-B modulated or not modulated
7. EIA 232 communication port for direct connect to PC or external modem
8. EIA 232 SCADA communication to port
9. LEDs indicating status of recorder
10. LEDs indicating status of external inputs
11. 48 Vdc isolated wetting supply
12. 4 output contacts
13. Case external ground
14. LEDs indicating status of output contacts
15. Power supply 48/125/250 Vdc, 120 V ac nominal

Figure 1.3: Portable Front View

Physical Mounting

The recorder is 3 rack units or 5.25 inches high and approximately 12 inches deep. The standard recorder is designed for a 19-inch rack. For a complete mechanical drawing see “TESLA Mechanical Drawing” in Appendix F.

To install the recorder you need the following:

- 19 inch rack
- 4 - #10 screws

Power Supply

ERLPhase recorders come with a wide range power supply. The nominal operating range is 48–250 Vdc, 120 Vac, 50/60 Hz. To protect against possible short circuit in the supply use an inline fuse or circuit breaker with a 5 A rating. Make the chassis ground connection to ensure proper operation and safety.

There are no power switches on the TESLA rack mount. When power is applied, the recorder starts its initialization process and takes about 40 seconds to complete showing the green Recorder Functional LED.

A power switch on the TESLA portable is used to select a dc or ac power supply source and turn off the power supply.

Case Grounding

WARNING!

To ensure safety and proper operation you must connect the recorder to the station ground using the rear grounding terminal on the recorder.

Ground the recorder even when testing.

Do not rely on the rack mounting screws to provide case grounding.

You must ground the recorder to station ground using the case-grounding terminal at the back of the recorder (see Figure 1.2: Rear View).

48 Vdc Wetting Supply

TESLA Portable (model 2000/P) has a dc wetting supply capable of turning on one or all 32 external inputs. The power switch controls the wetting supply and must be turned on before the wetting supply becomes operational. To protect against possible short circuits the output is fused with a user-serviceable 1/4 A, 125 Vdc fuse located on the front panel.

2 TESLA Control Panel Setup

PC System Requirements

Install TESLA Control Panel software on a standard desktop or laptop PC running Windows 95, 98, ME, NT 4.0, 2000 and XP.

Hardware

The minimum hardware requirements are:

- Any 486 or greater processor
- 64 MB of available RAM
- 50–75 MB of available hard-disk space (60 MB recommended)
- VGA monitor
- CD-ROM drive
- A modem and/or serial communication port and/or LAN card

Operating System

The following software must be installed and functional prior to installing TESLA Control Panel:

- Microsoft Windows 95, 98, ME, NT 4.0, 2000 or XP.
- Windows Dial-up Networking
- Windows TCP/IP protocol

Installing TESLA Control Panel

Basic Steps

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

The basic steps are:

1 Set up Windows' Dial-Up Networking and TCP/IP, if not previously enabled.

2 Install TESLA Control Panel.

3 Install the Null Modem driver.

4 Create Windows Dial-Up Network definitions for modem and direct serial connections.

Configuring Windows

Setting Up Windows' Dial-Up Networking and TCP/IP

TESLA Control Panel software uses the Windows' Dial-Up Networking and the TCP/IP communication protocol. These functions must be enabled on your PC to run TESLA Control Panel. This section helps you check and enable these functions if required. Separate instructions are provided for Windows 95/98, 2000, NT and XP.

Windows 95/98 Setup

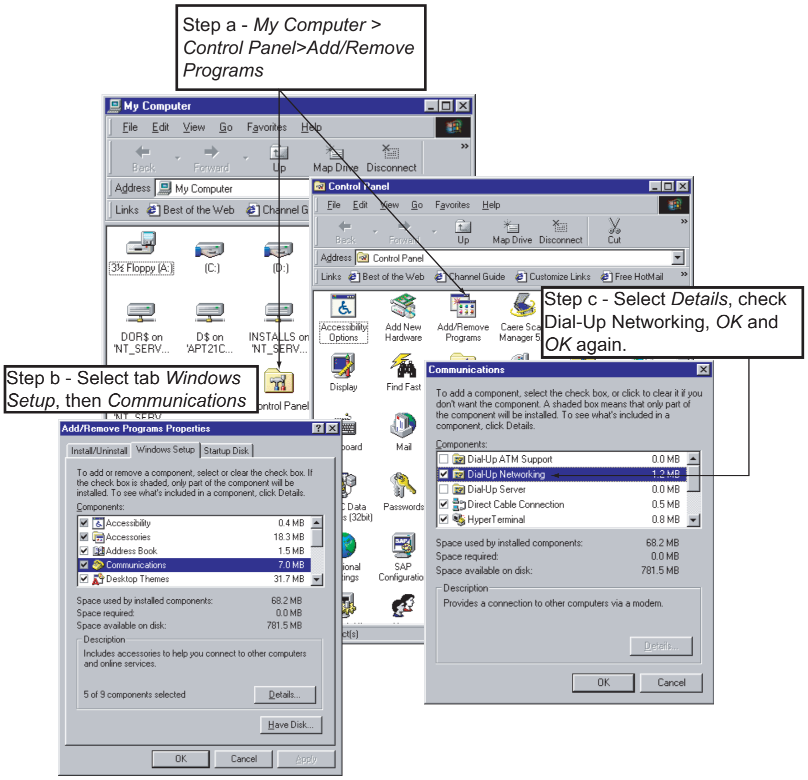


Figure 2.1: Windows 95/98 Setup

1 Determine if your computer has Dial-Up Networking installed by double-clicking the My Computer icon and looking for a folder called Dial-Up Networking. If it is not there, complete the following steps to install it:

  a Double-click *My Computer>Control Panel>Add/Remove Programs*.

  b Select the *Windows Setup* tab: highlight *Communications*.

  c Select *Details* and check mark *Dial-Up Networking*.

  d Select *OK*, then *OK* again (insert your Win 95/98 CD-ROM if prompted).

  e Select *Yes* when prompted to restart.

2 Double-click the *My Computer>Control Panel>Network* icon.

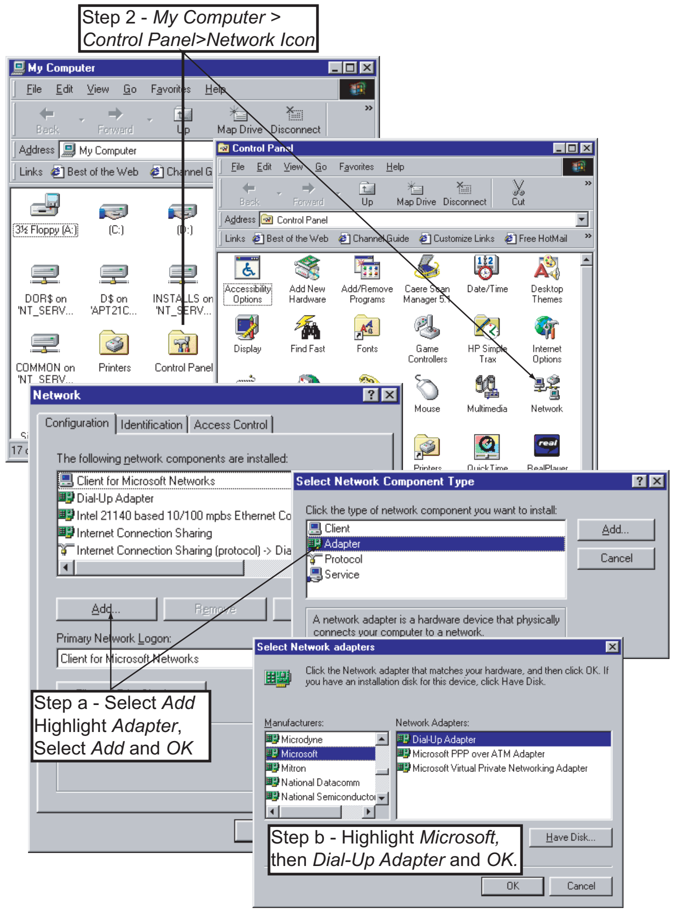


Figure 2.2: Verify Dial-Up Adapter

3 Verify that Dial-Up Adapter is in the list of installed components. If not:

a Select *Add*, highlight *Adapter* and select *Add* again.

b Highlight *Microsoft*, then highlight *Dial-Up Adapter* and select *OK*.

4 In the Network Control Panel screen, verify that TCP/IP is installed (TCP/IP>Dial-Up Adapter is in the list of installed components).

If not:

a Select *Add*, highlight *Protocol* and select on *Add* again.

b Highlight *Microsoft*, then highlight *TCP/IP* and select *OK*.

c Select *OK* (insert your Win 95/98 CD-ROM if prompted).

d Select *Yes* when prompted to restart.

Windows NT 4.0 Setup

1 Determine if your computer has Dial-Up Networking installed by double-clicking the My Computer icon and looking for a folder called Dial-Up Networking. If it is not there, complete the following steps to install it:

a Select *Start>Programs>Accessories>Dial-Up Networking*.

b Select *Install*.

c When prompted, type the location of the Windows NT 4.0 installation files. If you are directing the install process to an NT Workstation, select the installation Windows NT CD-ROM and browse to the “I386” directory.

d After the installation select *Continue*, and restart when prompted.

NB. If you were not prompted to install, Dial-Up Networking has already been installed.

2 Double-click the *My Computer>Control Panel>Network* icon.

3 Select the *Protocol* tab. If TCP/IP does not appear in the Network Protocols list then:

a Select *Add*.

b Double-click the *TCP/IP* protocol.

c Enter the path to the Windows NT CD-ROM, then select *OK*.

Windows 2000/XP Setup

Dial-up networking is always installed in Windows 2000/XP.

Installing 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 (usually D drive).

3 To install TESLA Control Panel software on your computer, select the *TESLA Disturbance Recorder* icon, then the *Install TESLA Control Panel*.

4 The Control Panel installation program starts automatically, but may take a few minutes.

5 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, install TESLA Control Panel again.

6 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, the icon can be deleted and you can start Control Panel through Windows Start menu (*Start>Programs>NxtPhase/TESLA Control Panel*).

Installing Null Modem Driver Software

A virtual software modem called a “Null Modem” must be set up for direct serial cable communication with the 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.

Null Modem Driver Installation (Windows XP)

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.

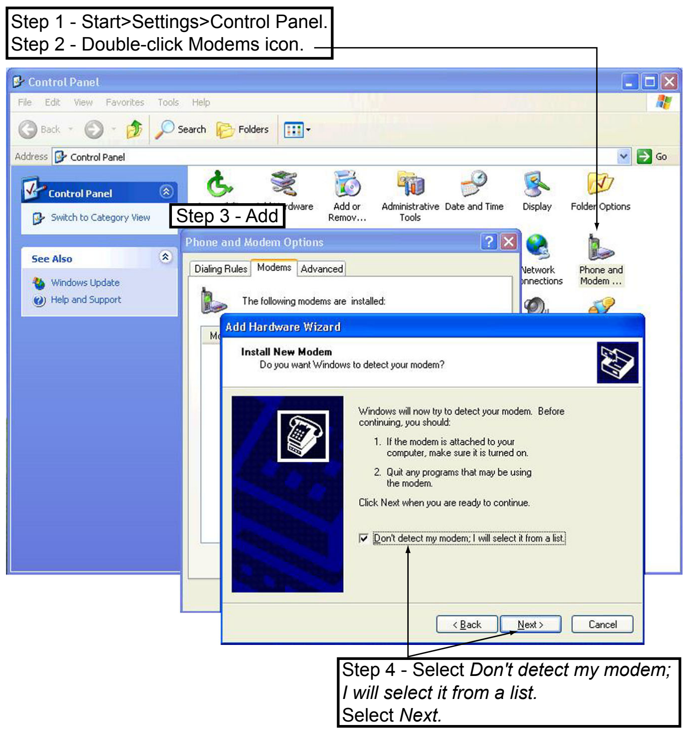


Figure 2.3: Null Modem Driver Installation

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.

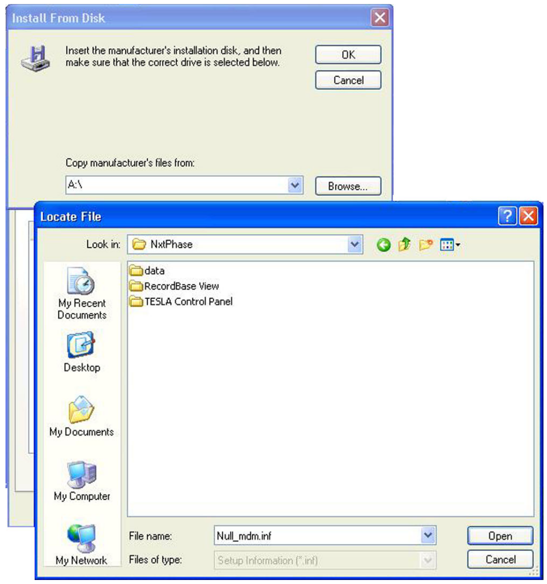


Figure 2.4: Browse for Null_mdm.inf

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*.

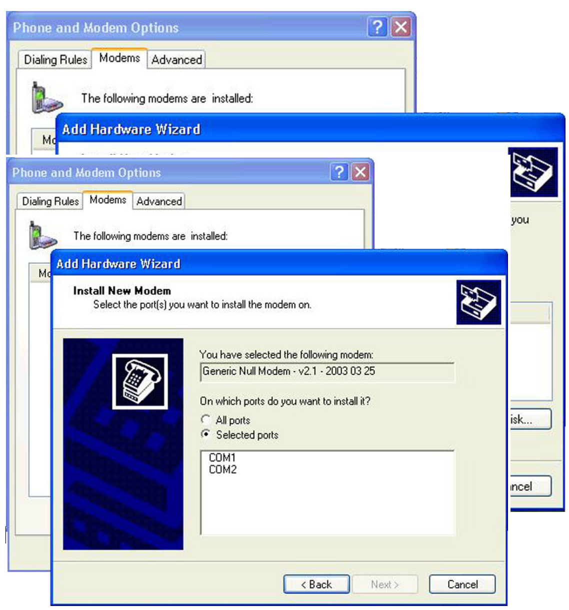


Figure 2.6: Select Serial Port

You will get a message stating “Digital Signature Not Found” and asking “Do you want to continue the installation?” Select *Continue Anyway* to continue.

You will get a message saying, “Your modem has been set up successfully”.

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

Null Modem Driver Installation (Windows 2000)

1 Start Windows Control Panel by going to the *Start>Settings>Control Panel.*

2 Double-click the *Phone and Modem Options* icon.

3 Select the *Modems* tab. Select *Add* to open the Add/Remove Hardware Wizard.

4 Select *Don't detect my modem; I will select it from a list,* then select the *Next* button.

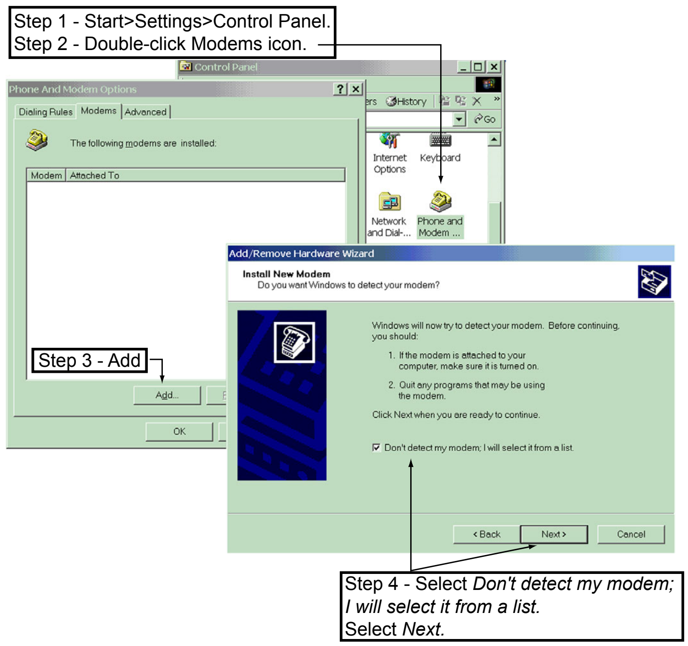


Figure 2.7: Null Modem Driver Installation

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.

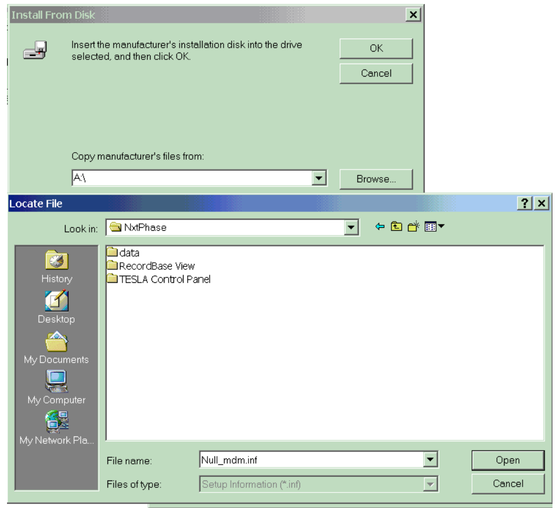


Figure 2.8: Browse for Null_mdm.inf

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*.

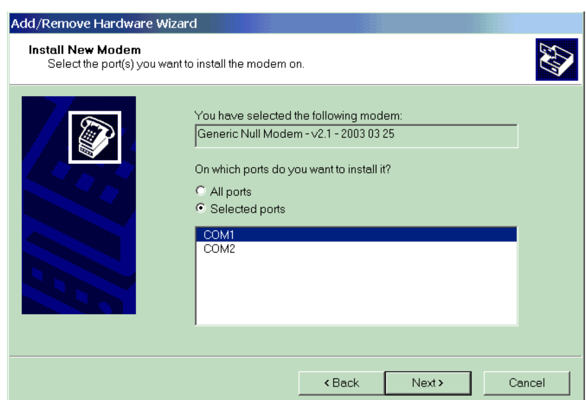


Figure 2.9: Select Serial Port

You may get a message stating “Digital Signature Not Found” and asking “Do you want to continue the installation?” Select Continue Anyway to continue.

You will get a message saying, “Your modem has been set up successfully”.

8 Select *Finish* to close the Add/Remove Hardware Wizard and close the Phone and Modem Options and Control Panel dialog boxes.

Null Modem Driver Installation (Windows NT)

1 Start Windows Control Panel by going to the *Start>Settings>Control Panel.*

2 Double-click the *Modems* icon.

3 Select *Add* to open the *Install New Modem* dialog box.

4 Select *Don't detect my modem; I will select it from a list,* then select the *Next* button.

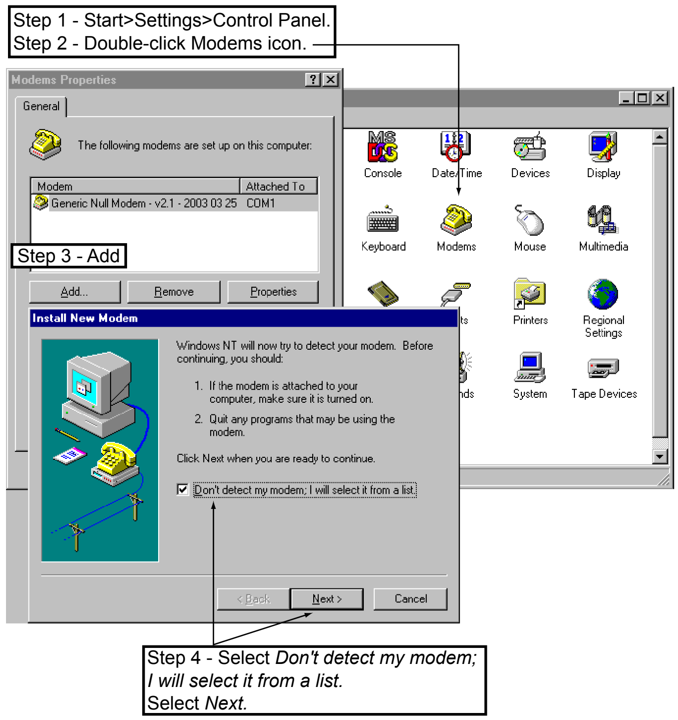


Figure 2.10: Null Modem Driver Installation

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.

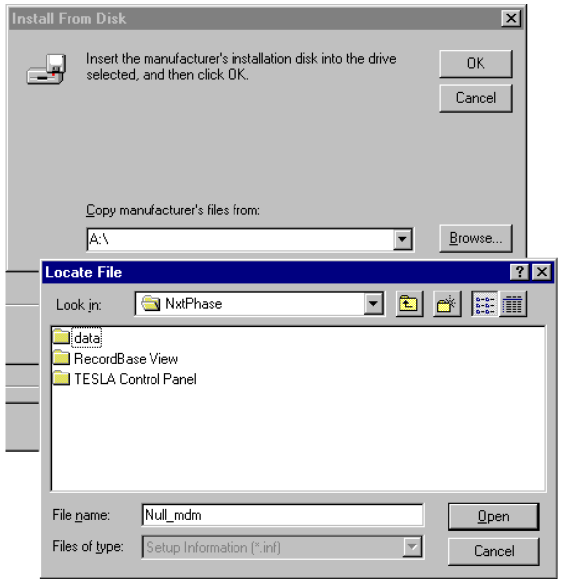


Figure 2.11: Browse for Null_mdm.inf

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. You will get a message saying, “Your modem has been set up successfully”.

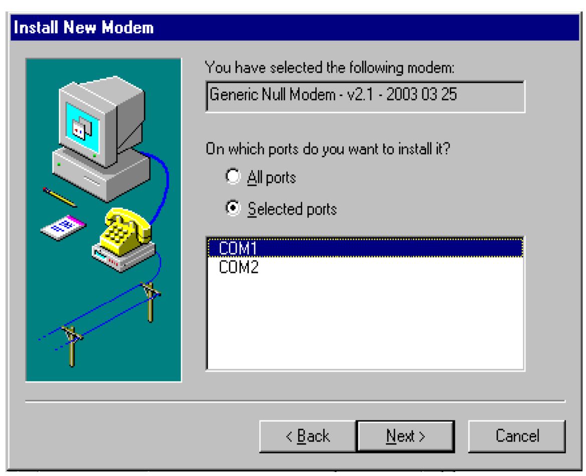


Figure 2.12: Select Serial Port

8 Select *Finish* to close the Install New Modem dialog box and close the Modems and Control Panel dialog boxes.

Null Modem Driver Installation (Windows 95/98)

1 Start Windows Control Panel by going to the *Start>Settings>Control Panel.*

2 Double-click the *Modems* icon.

3 Select *Add to open the Install New Modem* dialog box.

4 Select *Don't detect my modem; I will select it from a list,* then select the *Next* button.

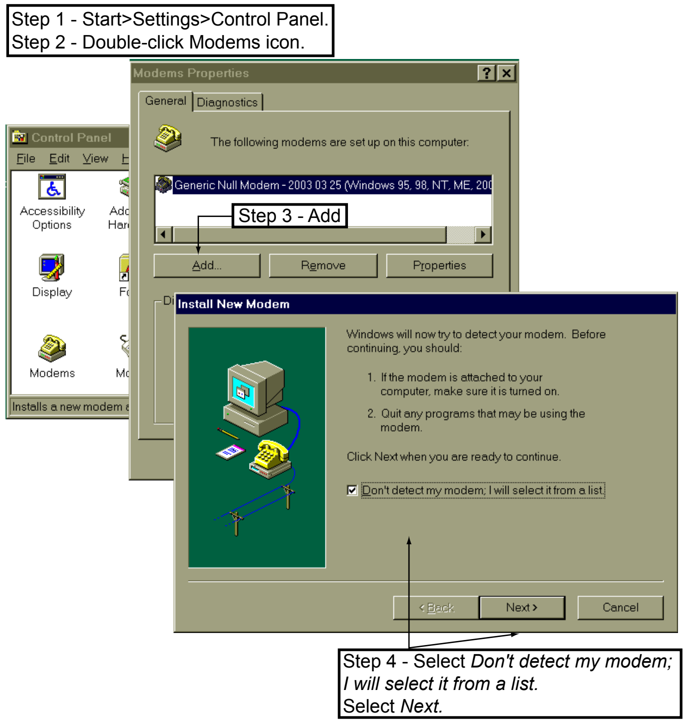


Figure 2.13: Null Modem Driver Installation

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.

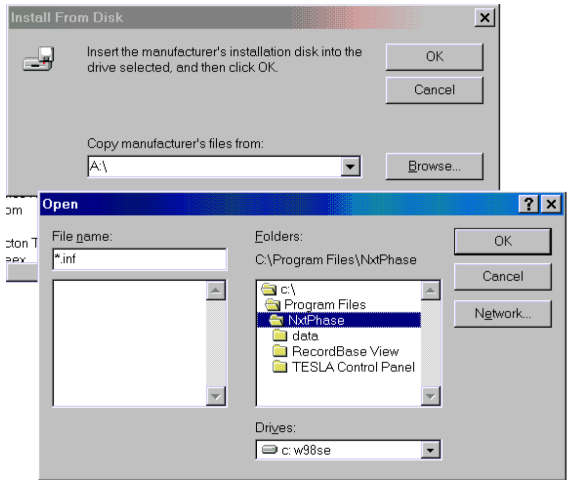


Figure 2.14: Browse for Null_mdm.inf

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.

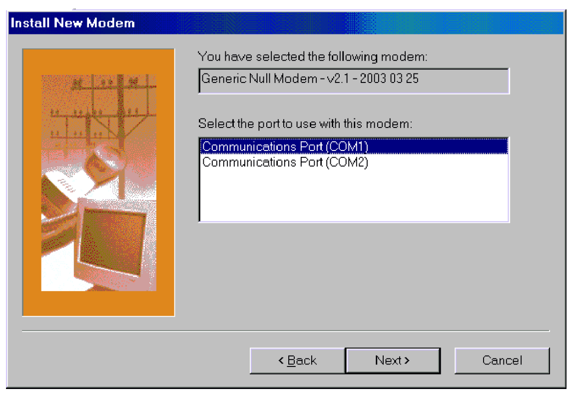


Figure 2.15: Select Serial Port

In Windows 98 you may get a message saying “The file Null_mdm.cat cannot be found”. Select the Skip File button. You will get a message saying, “Your modem has been set up successfully”.

8 Select *Finish* to close the Install New Modem dialog box and close the Modems and Control Panel dialog boxes.

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.

Windows 95/98

Windows 95/98 APT_SERIAL Dial-Up Network

To set up APT_SERIAL Dial-Up Networking:

1 Double-click the *My Compute*r icon on your desktop, then double-click the *Dial-Up Networking* icon.

2 Double-click the *Make New Connection* icon.

3 Change the name "My Connection" to **APT_SERIAL**. The name must be exactly APT_SERIAL.

4 Choose *Generic NULL Modem* under Select a device and select *Next*.

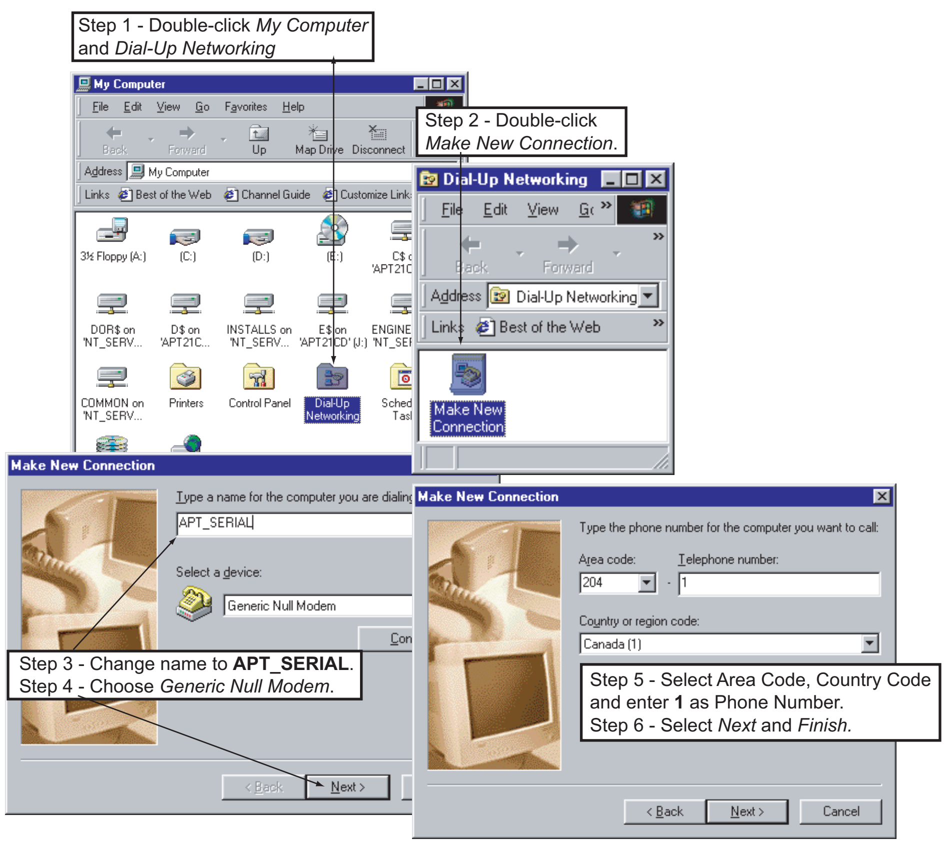


Figure 2.16: Windows 95/98 APT_SERIAL Dial-Up Network Connection

5 Select the proper Area Code and Country Code from the list, and enter **1** as the Phone Number.

6 Select *Next*, then *Finish*.

You should see the APT_SERIAL icon or text in Dial-Up Networking dialog box.

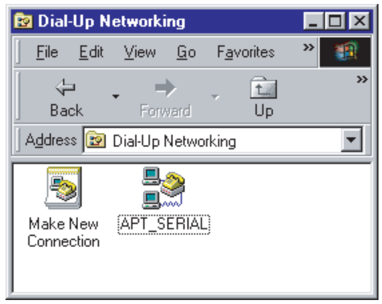


Figure 2.17: Windows 95/98 Dial-Up Networking showing the new APT_SERIAL connection

7 Select *APT_SERIAL* icon, right-click to select *Properties*.

8 Select on the *Server Types* tab and set the Server Type settings. For *Type of Dial-Up Server* select *PPP, Internet, Windows NT Server, Windows 98*. If necessary, click the downward arrow to select Type of Dial-Up Server.

Older versions of Windows have a Server Type button rather than a tab.

Not all versions will have the Multilink tab; it is not necessary. Use the Advanced option settings and Allowed network protocols as shown in Figure 2.18: Windows 95/98 Server Type Settings.

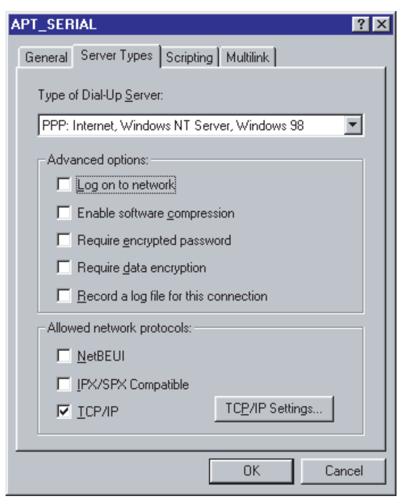


Figure 2.18: Windows 95/98 Server Type Settings

9 The default TCP/IP Settings should be used. “Server assigned IP address,” “Server assigned name server address,” “Use IP header compression,” and “Use default gateway on remote network” should be selected. Select *OK*.

10 Select on the *Scripting* tab and set the Scripting settings. Use the *Browse* button to find the file tesla.scp in c:\Program Files\Accessories. Select *OK*.

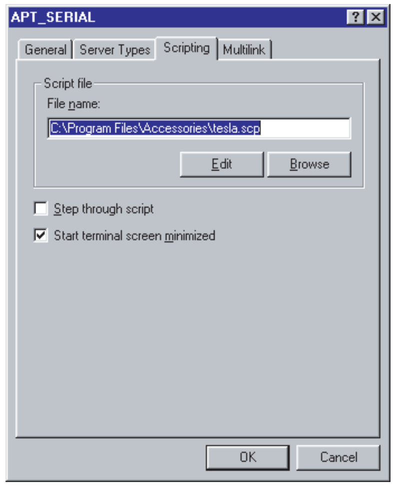


Figure 2.19: Windows 95/98 Scripting Type Settings

11 On some versions of Windows, this dialog box looks for script files in other directories. To handle this, copy the tesla.scp file from c:\Program Files\Accessories to the required location.

12 Select *OK* to complete the installation of the APT_SERIAL Dial-Up Networking connection.

13 In the Windows Control Panel (*Start>Settings>Control Panel*), double-click to choose *Modems*.

14 With *Generic Null Modem* highlighted, select *Properties* to view the Generic Null Modem Properties dialog box and set the baud rate to 38,400. Select *OK*.

15 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 5-3).

16 Select *Close* to close the Modems Properties dialog box.

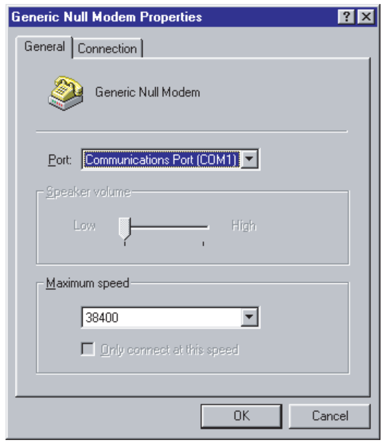


Figure 2.20: Windows 95/98 Generic Null Modem Properties

Windows 95/98 APT_MODEM Dial-Up Network

Repeat the previous steps 1 to 14 to set up APT_MODEM Dial-up Networking (see “Windows 95/98 APT_SERIAL Dial-Up Network” on page 2-13) except do the following:

- Use the name APT_MODEM instead of APT_SERIAL
- You may wish to set a higher baud rate in Step 14. When a modem is used, this setting only determines the speed of communication between your PC and the modem.
- Select the particular modem installed on your PC when setting up APT_MODEM.

Windows NT

Windows NT APT_SERIAL Dial-Up Network

To set up APT_SERIAL Dial-Up Networking:

1 Double-click the *My Compute*r icon on your desktop, double-click the *Control Panel* icon, then double-click the *Dial-up Networking* connections icon.

2 When the *Dial-up Networking* dialog box appears, click *New*.

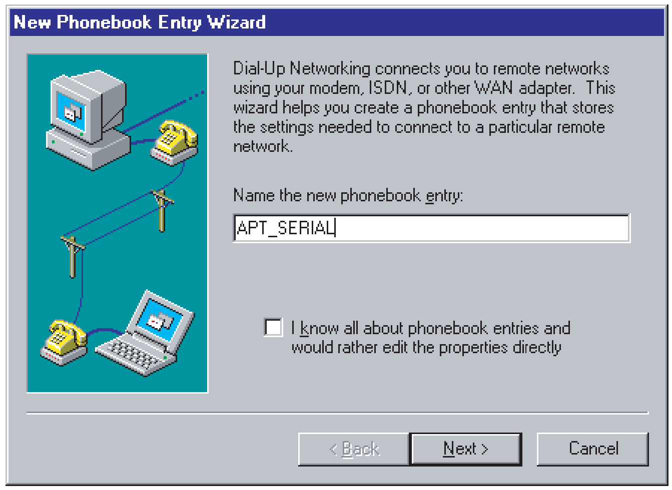


Figure 2.21: Windows NT New Phonebook Entry

3 Edit the Name the Phonebook Entry to **APT_SERIAL**. The name must be exactly APT_SERIAL. Click *Next*.

4 Select "I am calling the Internet" as the server. Click *Next*.

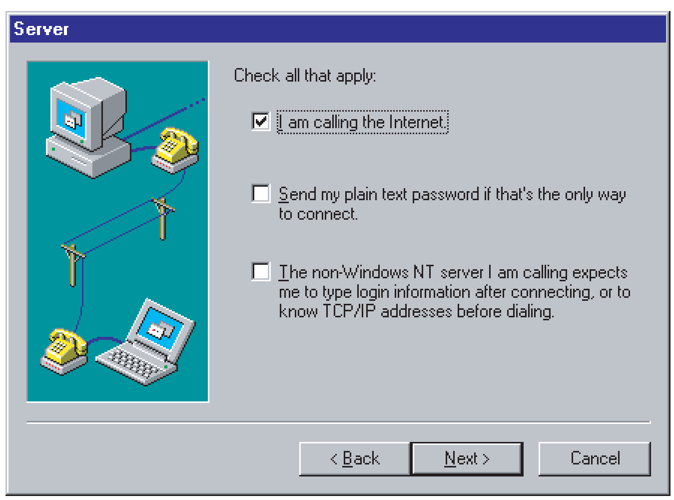


Figure 2.22: Windows NT Server

5 Enter **1** as the phone number and click *Next*.

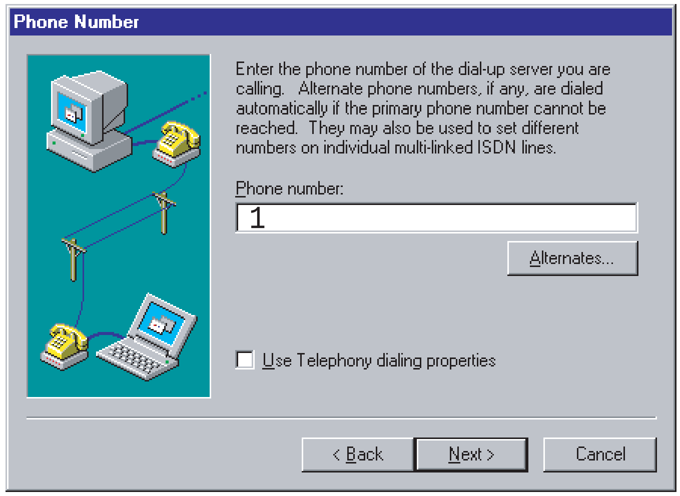


Figure 2.23: Windows NT Phone Number

6 Select *Finish* when complete.

7 In the Dial-up Networking dialog box, select *APT_SERIAL* Phonebook entry and select *More> Edit Entry and Modem properties.*

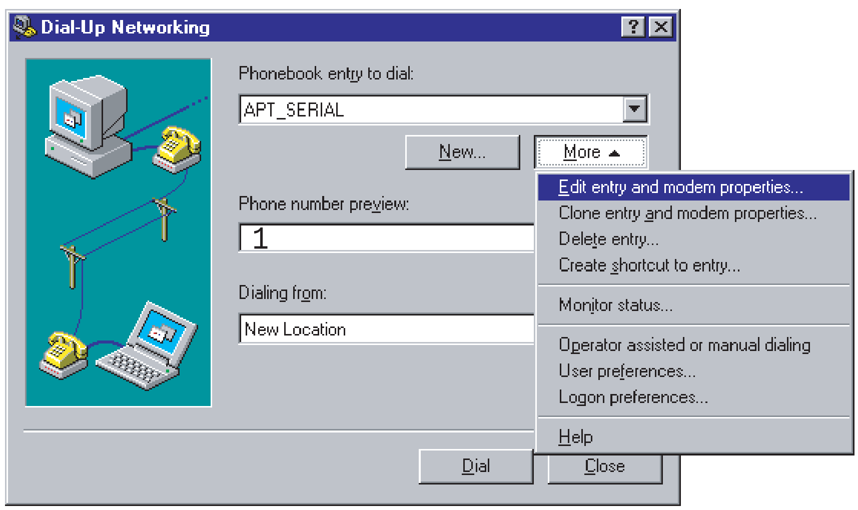


Figure 2.24: Windows NT Dial-up Networking - Edit entry and modem properties

8 In the Edit Phonebook entry window select the *Com Port* to connect the recorder. Select *Configure* and set the initial speed to 38,400 bps. 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 5-3).

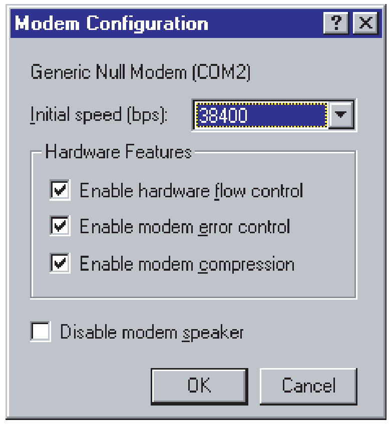


Figure 2.25: Windows NT Modem Configuration

9 Select the *Script tab*, select *Run this script* and select tesla.scp and *OK*.

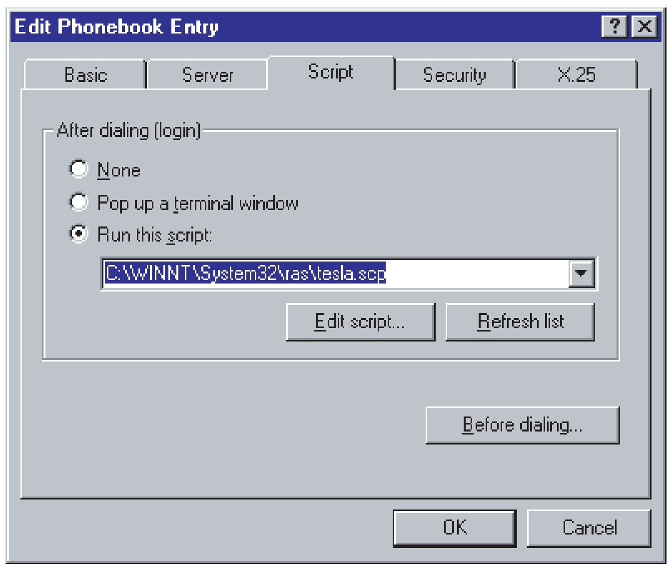


Figure 2.26: Windows NT Edit Phonebook Entry

10 Select *Close* to finish setting up APT_SERIAL.

Windows NT APT_MODEM Dial-Up Network

Repeat the previous steps 1 to 10 to set up APT_MODEM Dial-up Networking (see “Windows NT APT_SERIAL Dial-Up Network” on page 2-17) except:

- Use the name APT_MODEM instead of APT_SERIAL
- You may wish to set a higher baud rate in Step 8. When a modem is used, this setting only determines the speed of communication between your PC and the modem.

Windows 2000

Windows 2000 APT_SERIAL Dial-Up Network

To set up APT_SERIAL Dial-Up Networking:

1 Double-click the *My Compute*r icon on your desktop, double-click the *Control Panel* icon, then double-click the *Network and Dial-up* connections icon.

2 When the Network Connection Wizard dialog box appears, click *Next*. (The Network Connection Wizard dialog box is available only if no previous dial-up connection exists.) Otherwise double-click the *Make New Connection* icon to bring up the Network Connection Wizard dialog box, click *Next*.

3 Select *Dial-up to private network* and click *Next*.

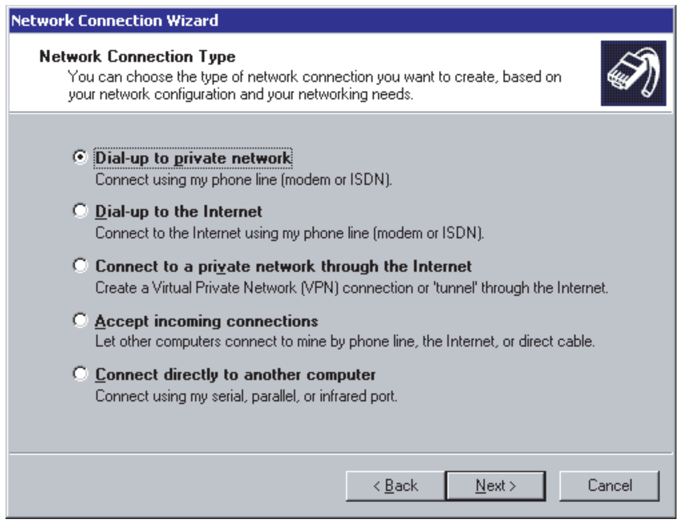


Figure 2.27: Windows 2000 Network Connection Type

4 Select the *Modem-Generic Null Modem* for the comm port that you wish to use for direct serial connection to the TESLA Recorder; uncheck all other check boxes; and click *Next*.

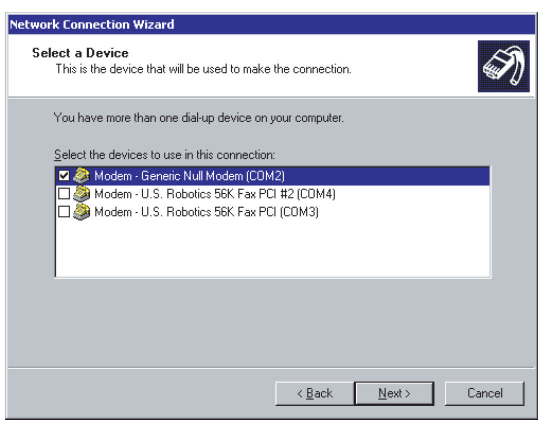


Figure 2.28: Windows 2000 Select a Device

5 When prompted for a phone number, enter **1** and click *Next*.

6 For Connection Availability select *For all users* and click *Next*.

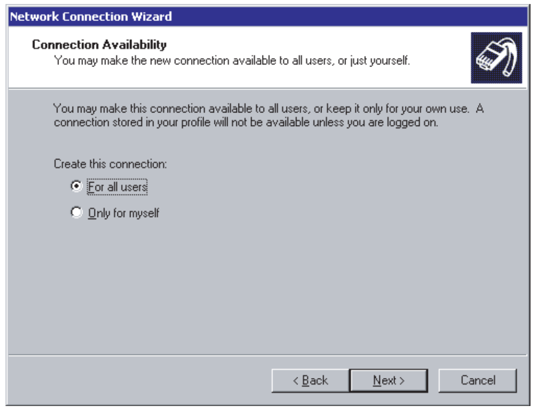


Figure 2.29: Windows 2000 Connection Availability

7 When the Completing the Network Connection Wizard dialog box appears, replace the name "Dial-up Connection" with **APT_SERIAL**. The name must be exactly APT_SERIAL. Click *Finish*.

Figure 2.30: Windows 2000 Completing the Network Connection Availability

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

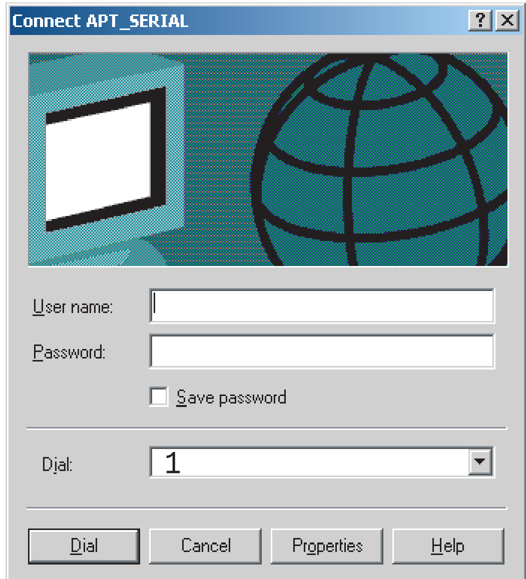


Figure 2.31: Windows 2000 Connect APT_SERIAL

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

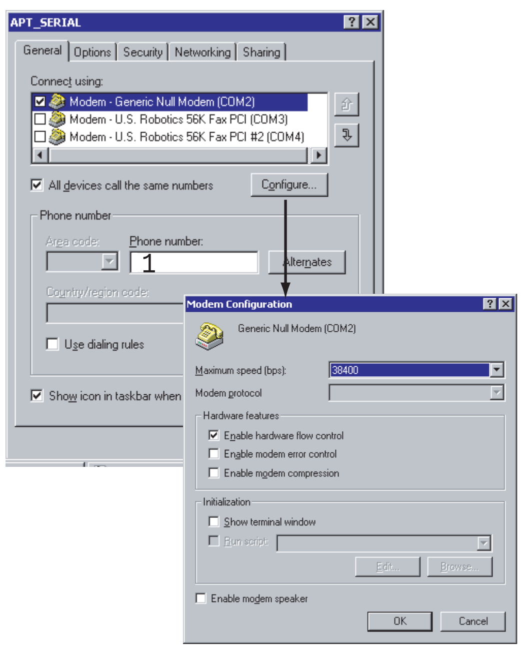


Figure 2.32: Windows 2000 Select Modem

10 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 5-3).

11 Select the *Options* tab of Figure 2.32: Windows 2000 Select Modem.

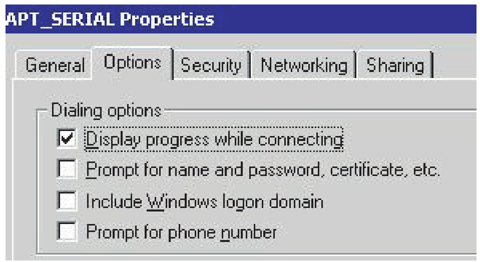


Figure 2.33: Windows 2000 Options

12 Select the *Security* tab, check the *Run Script* box; in the Run Script list select the file t*esla.scp*.

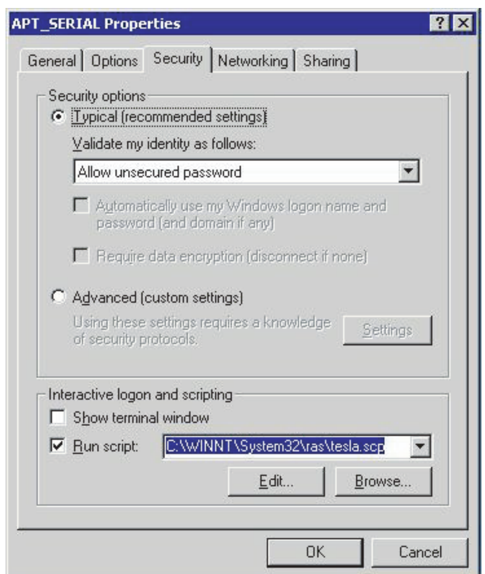


Figure 2.34: Windows 2000 Security

13 Select the *Networking* tab.

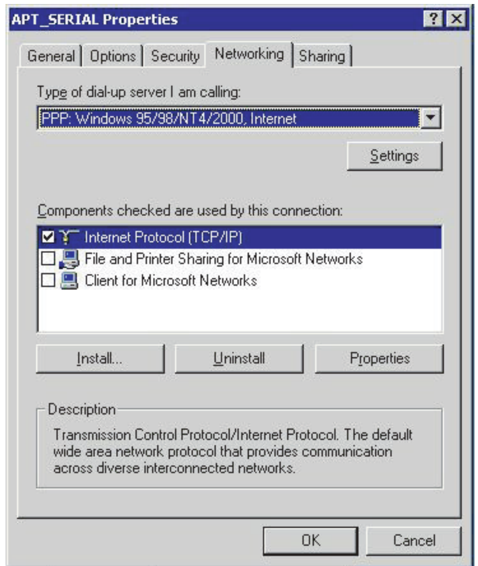


Figure 2.35: Windows 2000 Networking

14 Select the *Sharing* tab.

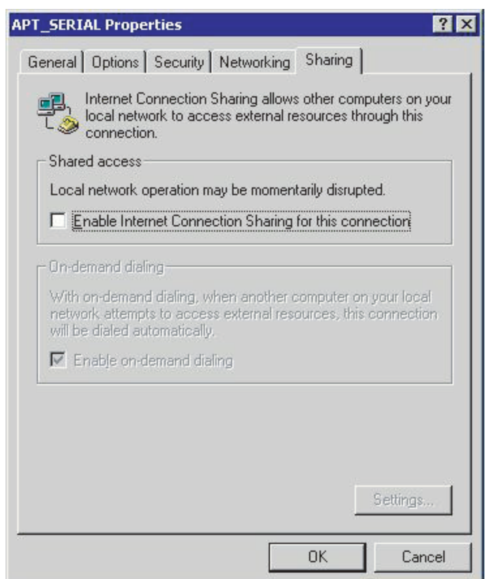


Figure 2.36: Windows 2000 Sharing

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

Windows 2000 APT_MODEM Dial-Up Network

You must have a modem installed before you start this section.

Repeat the previous steps 1 to 15 to set up APT_MODEM Dial-up Networking (see “Windows 2000 APT_SERIAL Dial-Up Network” on page 2-20) except do the following:

- Use the name APT_MODEM instead of APT_SERIAL
- Select the particular modem installed on your PC, shown in Figure 2.28: Windows 2000 Select a Device.
- You may wish to set a higher baud rate, shown in Step 10. When a modem is used, this setting determines the speed of communication between your PC and the modem.

Windows XP

Windows XP APT_SERIAL Dial-Up Network

To set up APT_SERIAL Dial-Up Networking:

1 Double-click the *My Compute*r 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*.

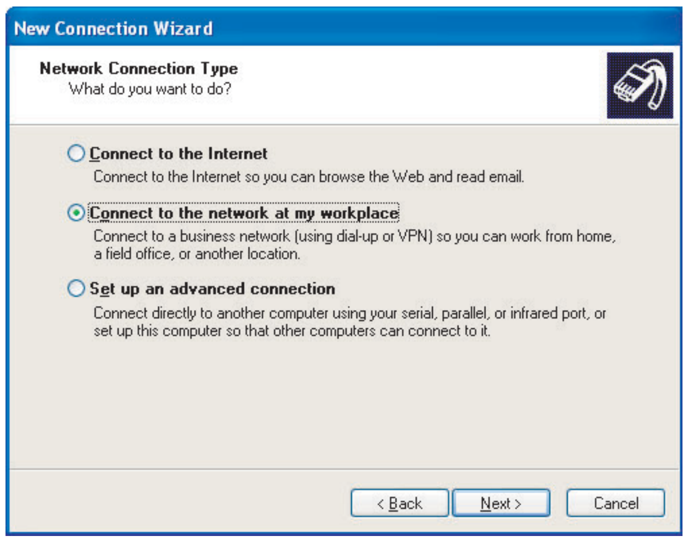


Figure 2.37: Windows XP Network Connection Type

6 When prompted for a phone number, enter **1** and click *Next*.

7 For Connection Availability select *Anyone's use* and click *Next*.

Figure 2.38: Windows XP Connection Availability

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

Figure 2.39: Windows XP Completing the New Connection Wizard

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

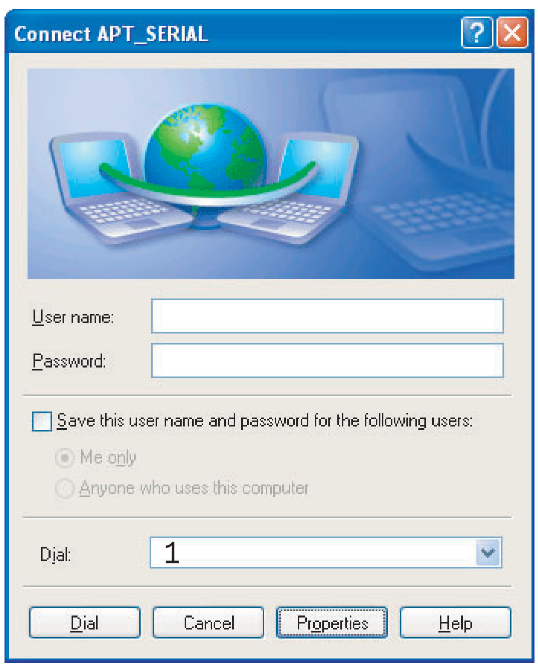


Figure 2.40: Windows XP Connect APT_SERIAL

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

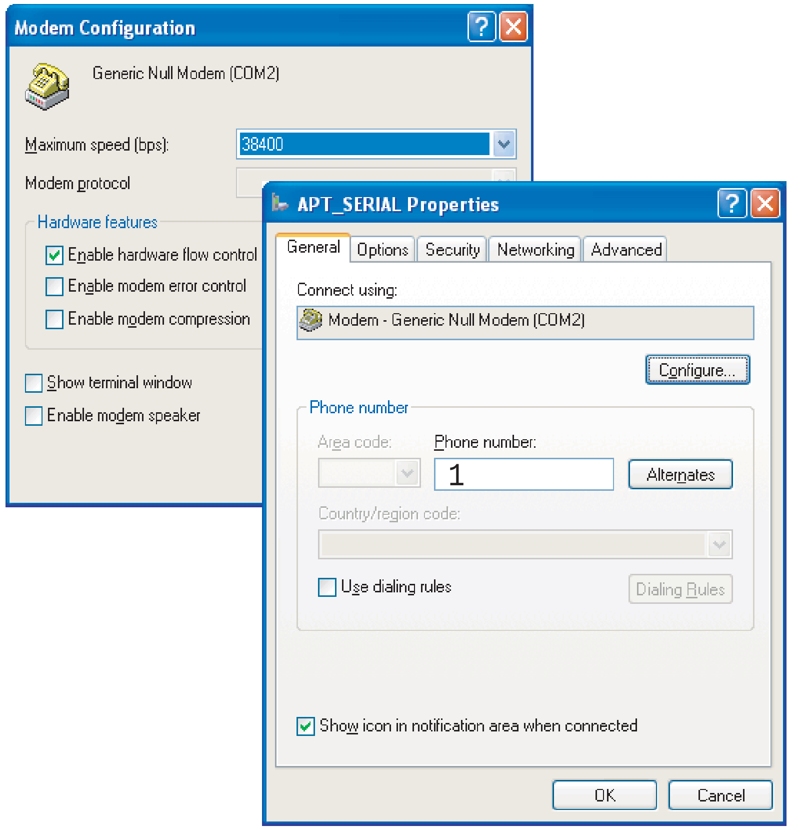


Figure 2.41: Windows XP Select Modem

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 5-3).

12 Select the *Options* tab of Figure 2.41: Windows XP Select Modem on page 2-28.

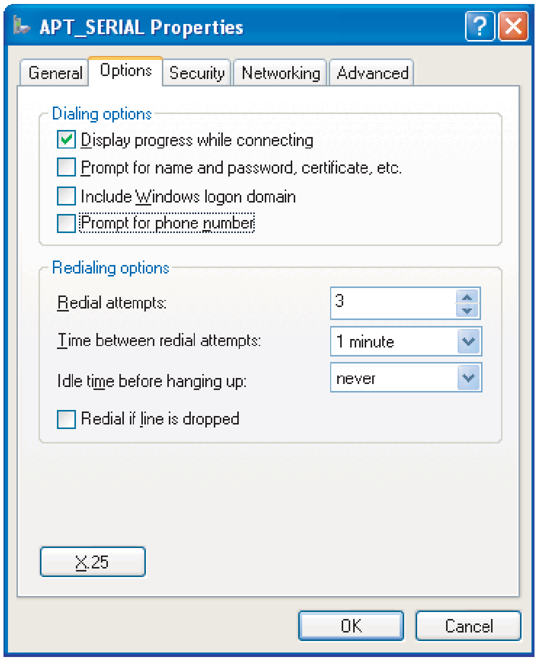


Figure 2.42: Windows XP Options

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

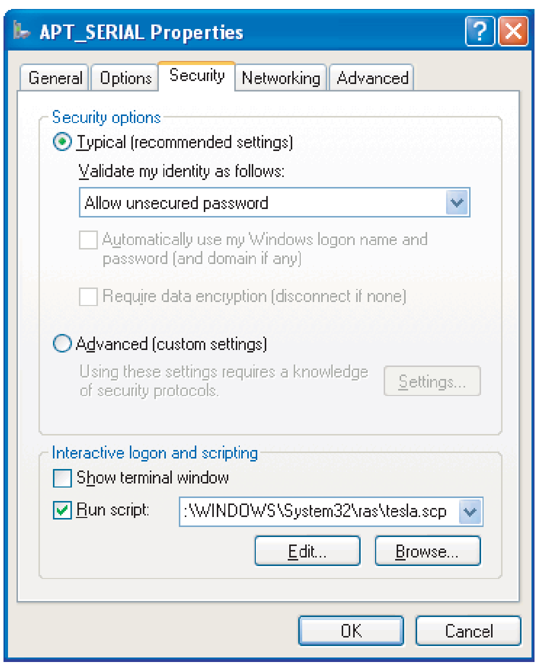


Figure 2.43: Windows XP Security

14 Select the *Networking* tab.

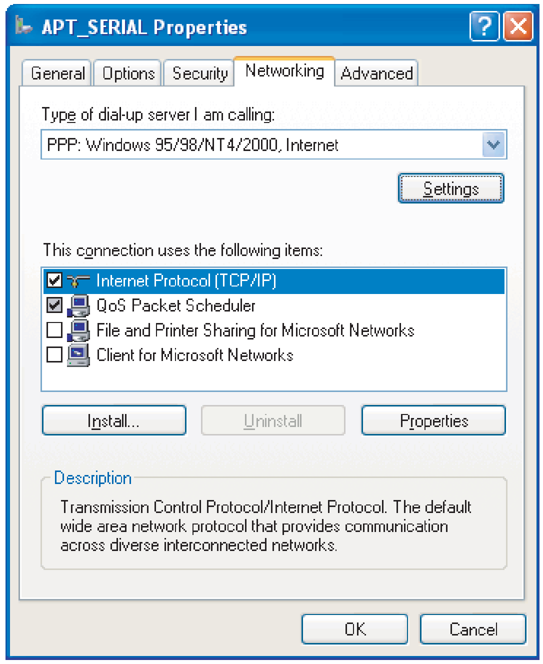


Figure 2.44: Windows XP Networking

15 Select the *Advanced* tab.

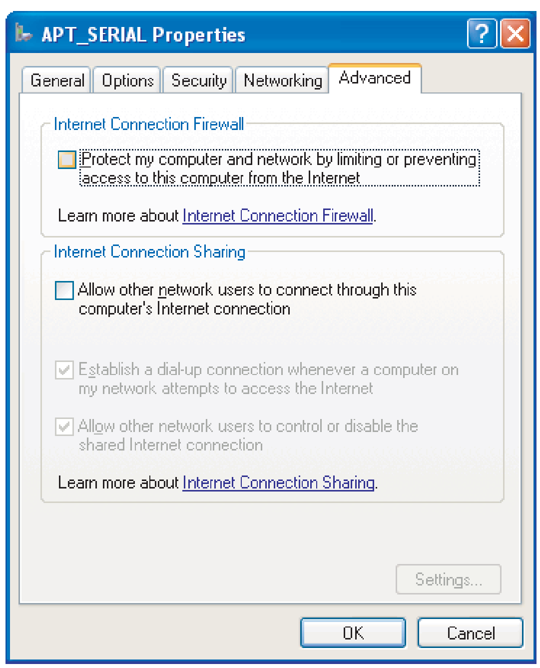


Figure 2.45: Windows XP Advanced

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

Windows XP APT_MODEM Dial-Up Network

You must have a modem installed before you start this section.

Repeat the previous steps 1 to 16 to set up APT_MODEM Dial-up Networking (see “Windows XP APT_SERIAL Dial-Up Network” on page 2-26) except do the following:

- Use the name APT_MODEM instead of APT_SERIAL
- Select the particular modem installed on your PC, shown in Figure 2.41: Windows XP Select Modem on page 2-28.
- You may wish to set a higher baud rate, shown in Step 11. When a modem is used, this setting determines the speed of communication between your PC and the modem.

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.

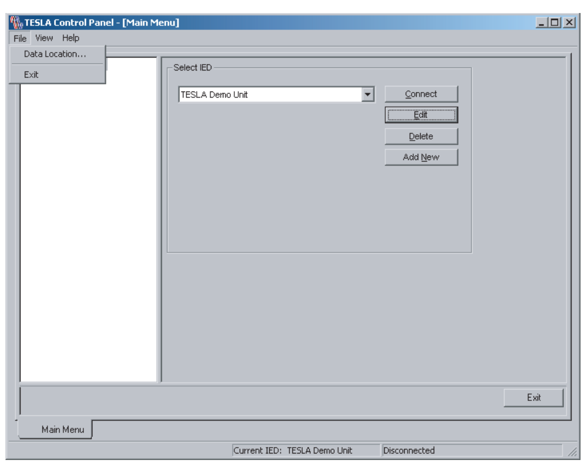


Figure 2.46: Data Location

3 Connecting to the Recorder

Communication Ports for Recorder

The TESLA recorder has multiple communication ports for local and remote access to the user interface and SCADA services. For port pin-out and cabling information see “Communication Port Details” on page 3-15.

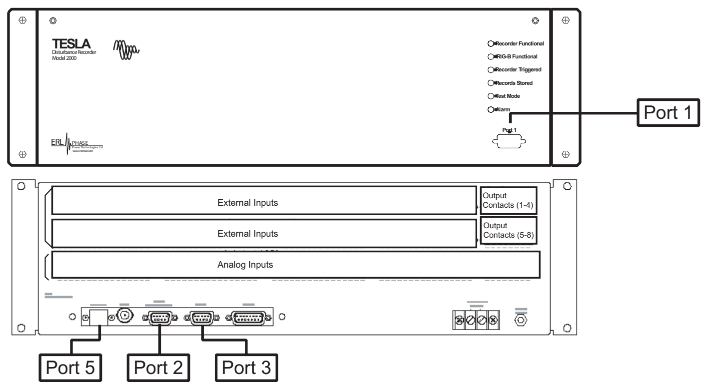


Figure 3.1: Communication Port Summary

Port	Description
Port 1	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	RS-232 DCE female DB9. Used for: 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: 9,600 baud, 8 data bits, no parity, 1 stop bit. N.B. Port 2 is disabled if the recorder is equipped with an internal modem (see Port 5).
Port 3	RS-232 DCE female DB9. Used for SCADA communication. Default Setting: 9,600 baud, 8 data bits, no parity, 1 stop bit.
Port 5	RJ-11/RJ-45 receptacle. When equipped with optional internal modem: Used for user interface access via modem. When equipped with optional internal Ethernet card: User interface access. DNP SCADA access. Default Ethernet IP address: 192.168.1.100.

Communication Ports for Portable Recorder

The TESLA Portable Recorder has multiple communication ports for local and remote access to the user interface and SCADA services. For port pin-out and cabling information see “Communication Port Details” on page 3-15.

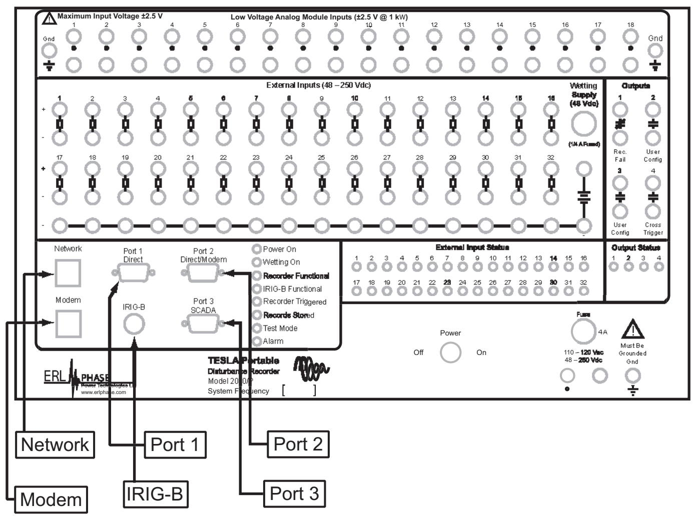


Figure 3.2: Communication Port Summary

Port	Description
Port 1	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	RS-232 DCE female DB9. Used for: 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: 9,600 baud, 8 data bits, no parity, 1 stop bit. N.B. Port 2 is always disabled unless the modem is disabled via the maintenance menu, for details see “Maintenance Menu” on page 13-4.
Port 3	RS-232 DCE female DB9. Used for SCADA communication. Default Setting: 9,600 baud, 8 data bits, no parity, 1 stop bit.
Network	RJ-45 receptacle. Used for user interface access via direct connection. Used for DNP SCADA access via TCP or UDP. Default Ethernet IP address: 192.168.1.100.
Modem	RJ-11 receptacle. Used for user access via modem.

Accessing the User Interface

The recorder's user interface can be accessed through TESLA Control Panel software via a direct serial connection, a modem or an Ethernet LAN. You can run Control Panel on any standard PC with a Windows operating system (Win95 or later).

> Your Windows system must be appropriately configured to run TESLA Control Panel (see "TESLA Control Panel Setup" on page 2-1).

Direct Serial Link

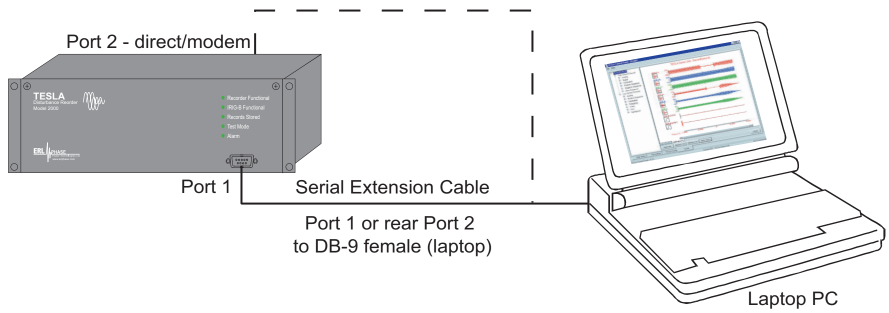


Figure 3.3: Direct Serial Link

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 3-15.
   - 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 "Maintenance Menu" on page 13-4.

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.
   - The default baud rate of Port 1 is 38,400. The default baud rate of Port 2 is 9,600.
   - 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 3-12).

3 Choose the target recorder from the *Select IED* list in TESLA Control Panel's Main Menu.

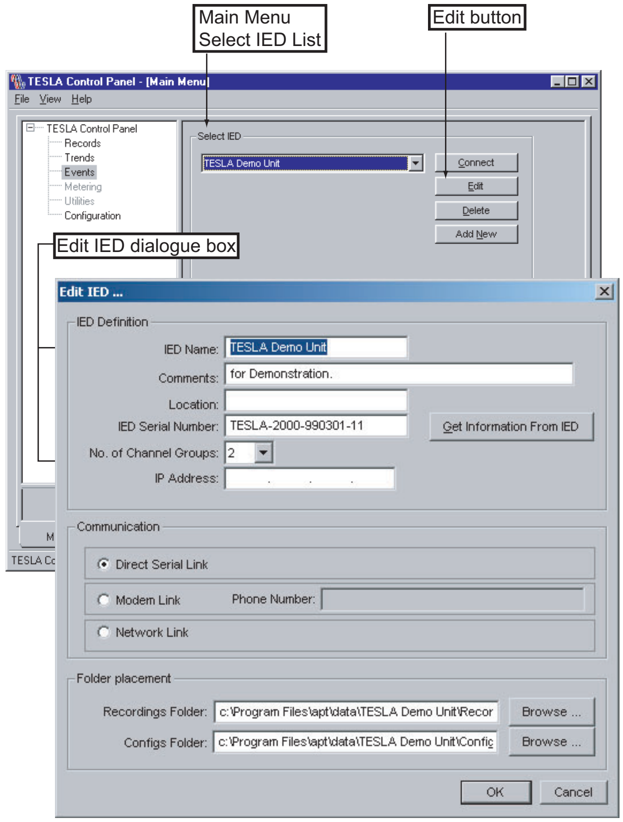


Figure 3.4: Edit IED

- 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 *Direct Serial Link* option is selected.
- For details on IED definitions see "Working with TESLA Control Panel" on page 4-1.
- For a quick, first time direct serial connection to a recorder you can use the TESLA Demo Unit IED.

4 Initiate the connection by selecting the *Connect* button.

- A dialog box will appear to show connection progress.

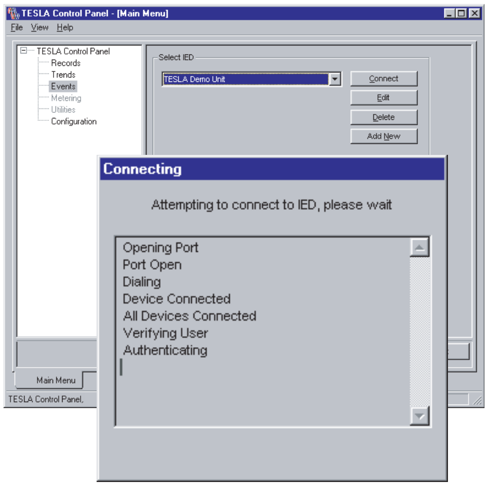


Figure 3.5: Connect Button Dialog Box

- The connection state and the current IED you are connected to is shown on the Windows status bar at the bottom of the screen.

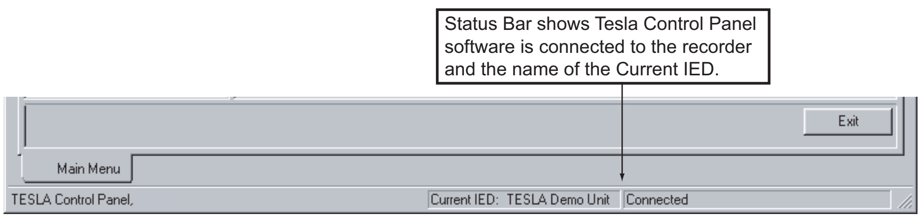


Figure 3.6: Status Bar

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 Setup” on page 2-1).
- The communication parameters are the same on both ends (see Step 2 above).
- The correct serial port has been selected on your computer.

Modem Link - External

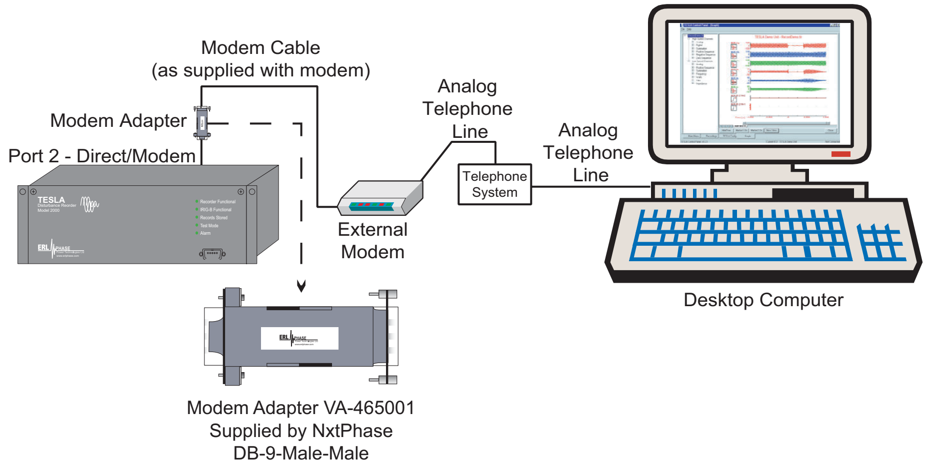


Figure 3.7: Modem Link - External

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 # VA-465001) 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 3-15.
- 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 direct serial connection between your computer and Port 1 on the recorder, run TESLA Control Panel software and initiate a connection to the unit. For details, see Direct Serial Link above.

  b When connected, select *Utilities* in the Main Menu list, and go to the *Communication* tab to access the Port 2's settings.

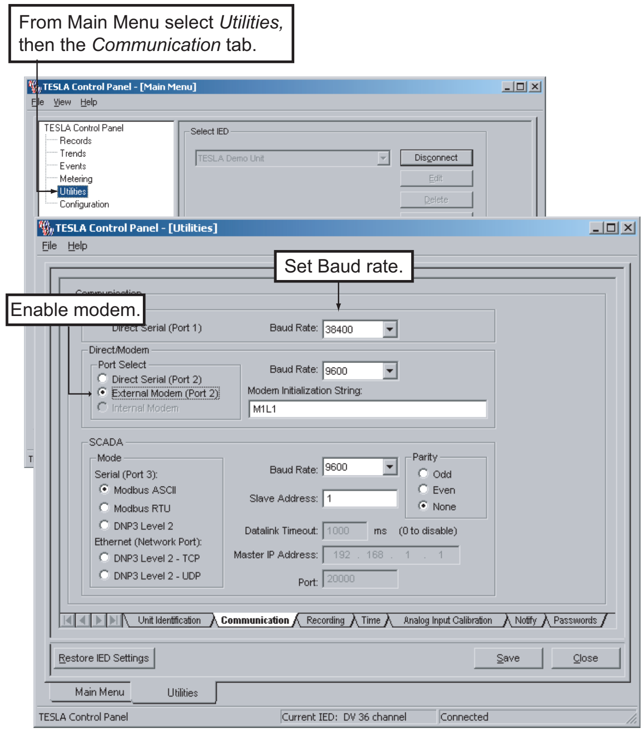


Figure 3.8: Communications Setup Utility

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 Enable the Modem box by checking the modem box.

e The Modem Initialization String lets you set any special command codes required by your modem. The factory default for this field is "M0" for external modems. These default values are all that are required for most modems.

f Save your changes 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 Setup" on page 2-1).

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 4-1.

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.

Modem Link - Internal

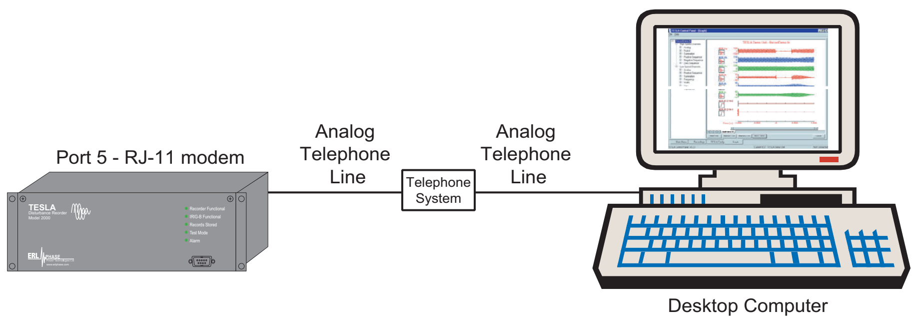


Figure 3.9: Modem Link - Internal

An optional internal modem is available for the TESLA recorder. Port 5 on the recorder's rear panel will be labelled "INTERNAL MODEM" if the modem is installed. The TESLA Portable includes an internal modem; the modem port is labelled "Modem" on the recorder front panel.

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 with a standard RJ-11 connector on Port 5 or Modem Port.
- Internal modem configuration is done in the same way as for an external modem. Modem Initialization String which is "M0" for internal modems (see Figure 3.8: 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, the recorder's Port 2 is not available for use by an external modem or a direct serial connection.

Ethernet LAN Link

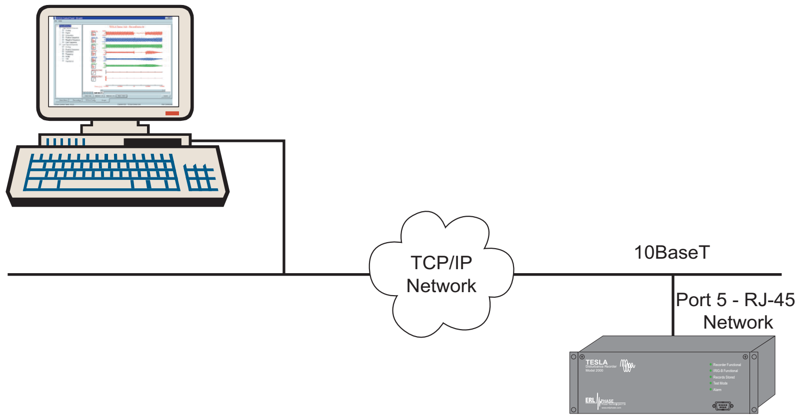


Figure 3.10: Ethernet LAN Link

You can access the recorder's user interface through an optional Ethernet TCP/IP LAN. Port 5 on the recorder's rear panel will be labelled "NETWORK" if the Ethernet port is installed. The TESLA Portable includes an internal ethernet port and is labelled "Network" on the recorder's front panel.

Recorder Setup

1 Connect recorder's ethernet port to the ethernet LAN hub using an appropriate 10BaseT cable with an RJ-45 connector on Port 5 or Network Port.

- The recorder supports 10BaseT, although a dual speed 10/100 Ethernet hub or switch can be used.

2 Modify the IP address.

- The default IP address is 192.168.1.100.
- To modify or view the IP address, use the recorder's Maintenance menu (see "Maintenance Menu" on page 13-4).
- 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.

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 and has its TCP/IP protocol enabled.

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.
- 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 *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 4-1.

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.

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 the DNP3 and Modbus protocols are available on the recorder’s serial Port 3, a standard 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 Ports for Recorder” on page 3-1.

Ethernet Connection

If the recorder is equipped with an Ethernet card, the DNP protocol can made available over Ethernet using TCP or UPP. A standard 10BaseT Ethernet cable with an RJ-45 jack is required.

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

For details on setting the IP address of the Ethernet card see “Ethernet LAN Link” on page 3-9.

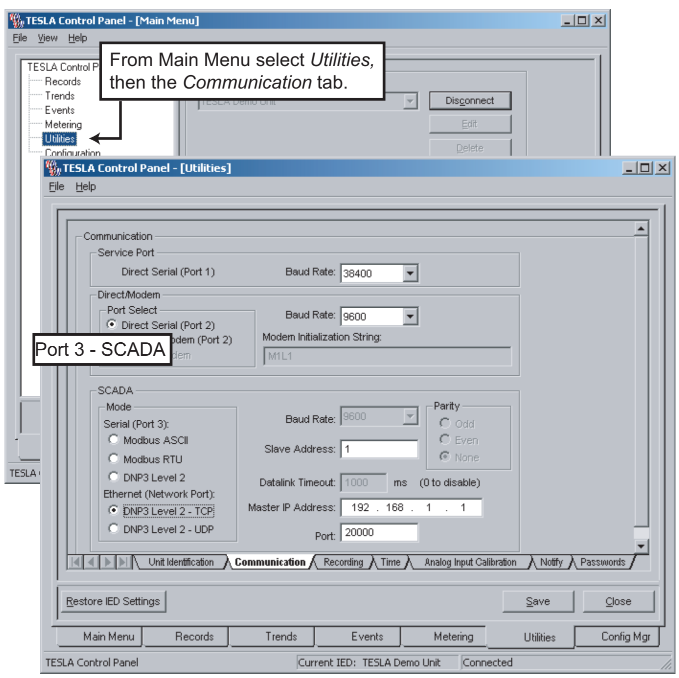


Figure 3.11: SCADA Protocol

Protocol Settings

Configuration of the SCADA protocol and communication parameters is made through the recorder user interface. Use Control Panel to connect to the recorder, then go to the SCADA section of the *Utilities>Communication* tab (see “Accessing the User Interface” on page 3-3).

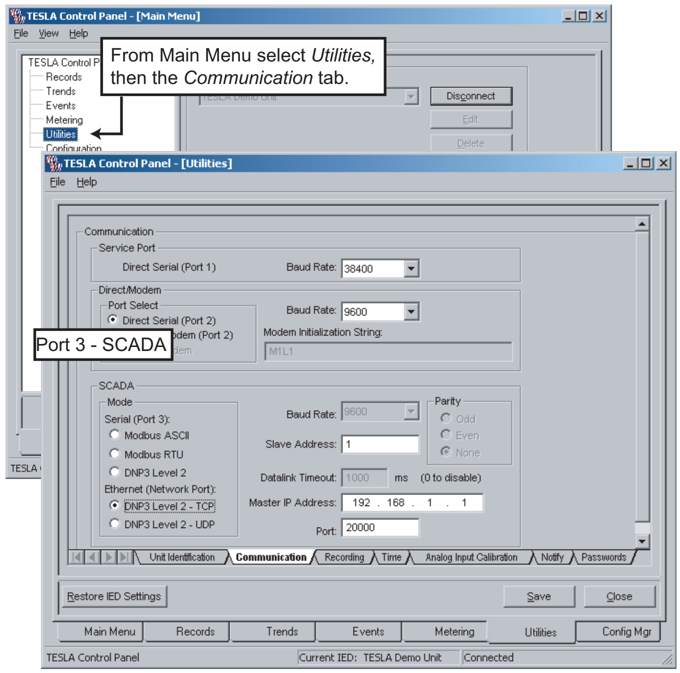


Figure 3.12: SCADA Protocol Settings

SCADA Configuration	
Mode	Select one of the available SCADA modes.
Baud Rate	Port 3 serial baud rate. Default is 9600.
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.

SCADA Configuration	
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.
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 (see “Maintenance Menu” on page 13-4).

Setting Windows Serial Port Parameters

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

Direct Serial Link

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.

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 is 38,400, Port 2’s default baud rate is 9,600. The baud rate for these ports is configured through the recorder’s user interface via TESLA Control Panel software (see “Accessing the User Interface” on page 3-3).

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 95/98

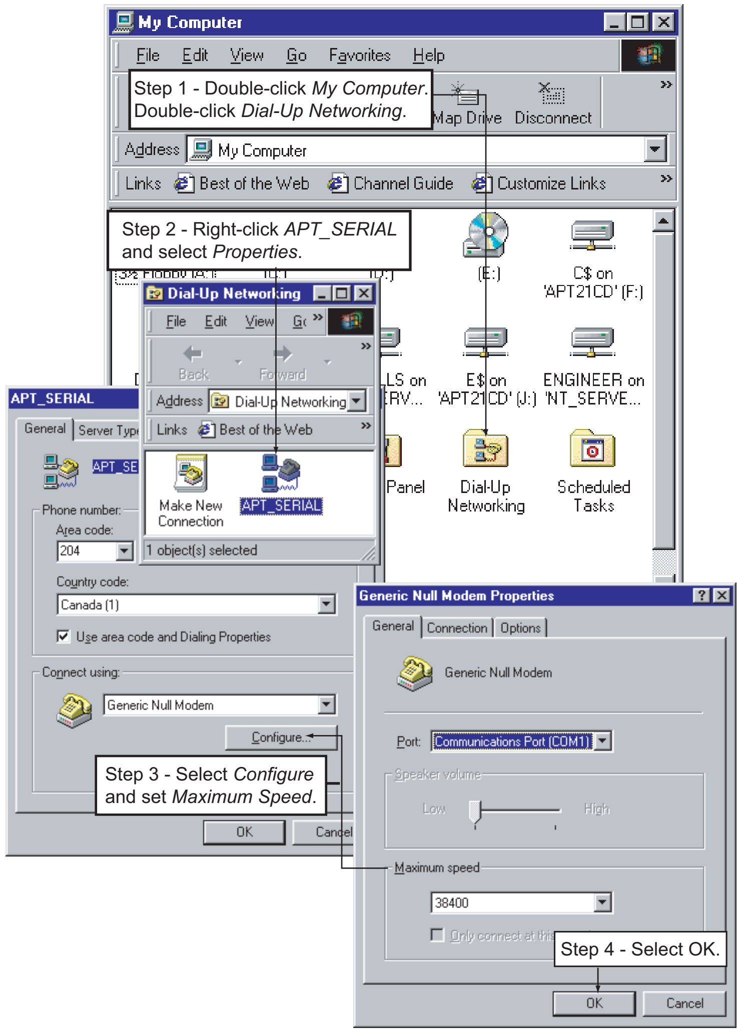


Figure 3.13: Windows 95/98

1 Access the APT_SERIAL Dial-Up Network icon by double-clicking *My Computer* on the Windows desktop and then double-clicking on *Dial-Up Networking*.

2 Bring up the APT_SERIAL properties control by right-clicking on the *APT_SERIAL icon* and selecting *Properties*.

3 Select the *Configure* button and set the desired baud rate in the *Maximum Speed* field. To set other communication parameters, use the *Connections* tab.

4 Select *OK* to save changes

Windows NT

1 Access the APT_SERIAL Dial-Up Network icon by double-clicking *My Computer* on the Windows desktop and then double-clicking on *Dial-Up Networking*.
2 Select *APT_SERIAL* from the pick list
3 Select the *More* button and pick *Edit Entry* and *Modem Properties* from the list.
4 Select the *Configure* button and set the desired baud rate in the *Speed* field.
5 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 *Modems* function found in Windows Control Panel.

Windows 2000

1 Access the Network and Dial Up Connections function through Windows Control Panel.
2 Bring up the APT_SERIAL properties control by right-clicking on the *APT_SERIAL icon* and selecting *Properties*
3 Select *Modem - Generic Null Modem* from the *Connect using* modem list and select the *Configure* button.
4 Set the desired baud rate in the *Maximum Speed* field.
5 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 # VA-465001) 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.

TESLA Recorder

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 9,600 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 9,600 baud.

TESLA Portable

Port	Location (Portable Recorder)	Function
1	Front Panel	Serial port for direct connection to a computer. Default baud rate set at 38,400 baud.
2	Front Panel	Serial port for connection to an external modem or for direct connection to a computer (configurable). Default baud rate set at 9,600 baud. This port is unused unless the internal modem is disabled via the Maintenance Menu.
3	Front Panel	Connection to SCADA (DNP3 or Modbus) interface. Default baud rate set at 9,600 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
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

Signal Name	Direction Modem <-> IED	Pin # on the Modem Adapter
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.

4 Working with TESLA Control Panel

Recorder Workspace

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

Create a separate recorder workspace for each individual recorder.

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

Selecting A Recorder Workspace

To work with a particular recorder first select its corresponding recorder workspace in TESLA Control Panel from the *Select IED* box on the *Main Menu* tab. Use the pull-down list to display and select the desired recorder.

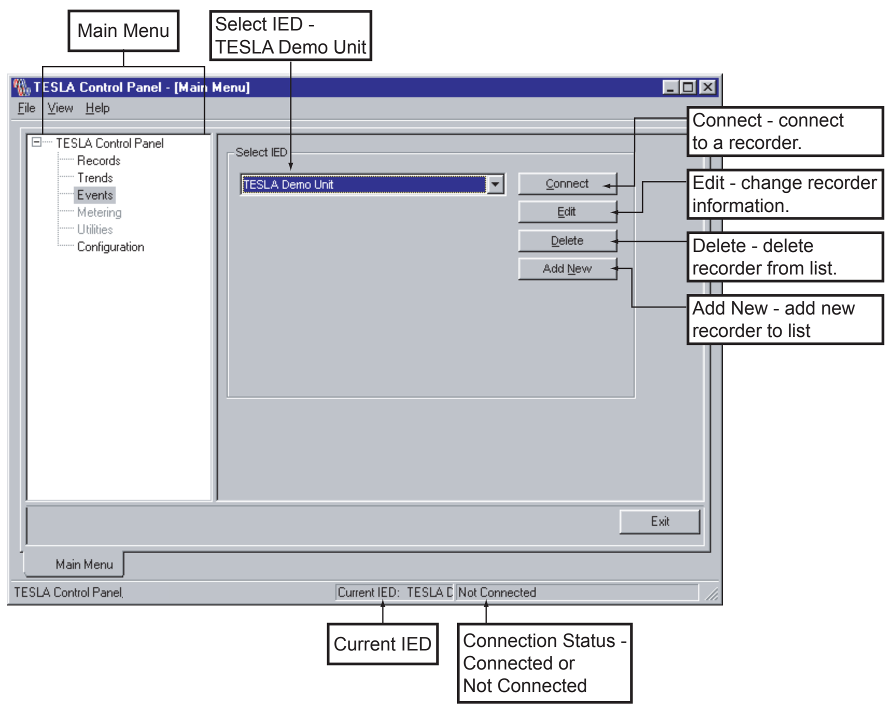


Figure 4.1: Selecting a Recorder Workspace

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 tell TESLA Control Panel to initiate a connection, 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 4.1: Selecting a Recorder Workspace).

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 (e.g. via a direct serial cable), causes the records and configuration files of that recorder to be mixed with those of the Current IED.

Adding/Editing a Recorder Workspace Definition

Recorder work spaces are added, modified or deleted from the TESLA Control Panel Main Menu using controls in the *Select IED* dialog box. The *Edit* button displays the selected recorder's definition screen. The *Add New* button is used to create a new recorder definition (see Figure 4.1: Selecting a Recorder Workspace).

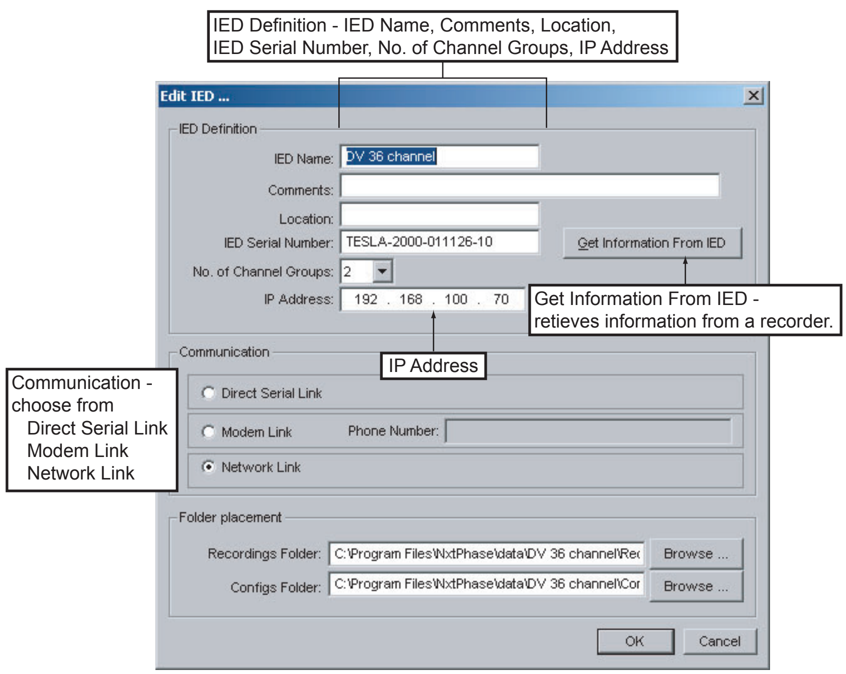


Figure 4.2: Adding/Editing a Recorder Workspace Definition

Add New IED...	
IED Definition	
IED Name	The IED Name is the name you assign to this recorder's workspace. It appears in the IED selection and the Current IED display at the bottom of the TESLA Control Panel window. We recommend that you use the same name for this workspace as the Unit Name given to the recorder (see "Unit Identification" on page 52).
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.
No. of Channel Groups	Refers to the hardware configuration of the recorder. A Channel Group consists of 18 analog and 32 digital inputs. TESLA recorders come with either 1 or 2 Channel Groups.
IP Address	If the Network Link is used, the IP address of the recorder must be specified.
Get Information from IED	Connecting to the recorder this function automatically retrieves information such as the IED name and location. The automatic retrieval function happens only after the communication parameters have been set.
Communication	Determines the way Control Panel communicates with the recorder.
Direct Serial Link	Connection to a recorder through a serial cable.
Modem Link	Connection to the recorder via telephone link.
Network Link	Connection to the recorder via TCP/IP network connection.
Phone Number	If modem link is used, insert telephone number in the Phone Number field. It can contain numbers plus standard modem dial characters (e.g. comma represents a pause).
Folder Placement	
Recordings Folder	The path where the IED records are stored.
Configs Folder	The path where the IED configs are stored.

For further information on the Communication link setup see "Connecting to the Recorder" on page 3-1 and for the IP address setup see "Maintenance Menu" on page 13-4.

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 recorder workspace you have selected as the Current IED.

Offline

Manage and display a recorder's local (previously uploaded) records and its configuration files without having a communications link with the unit.

Online

Obtain full access to all functions:

- Records—records (both local and on the recorder)
- Trends
- Events
- Metering—a live metering display
- Utilities and record configuration screens
- Channel and trigger configurations (the one presently active in the recorder and any saved ones you may have created)
- Record graphics display

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/tree 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 on the appropriate item on the Navigation Tree.

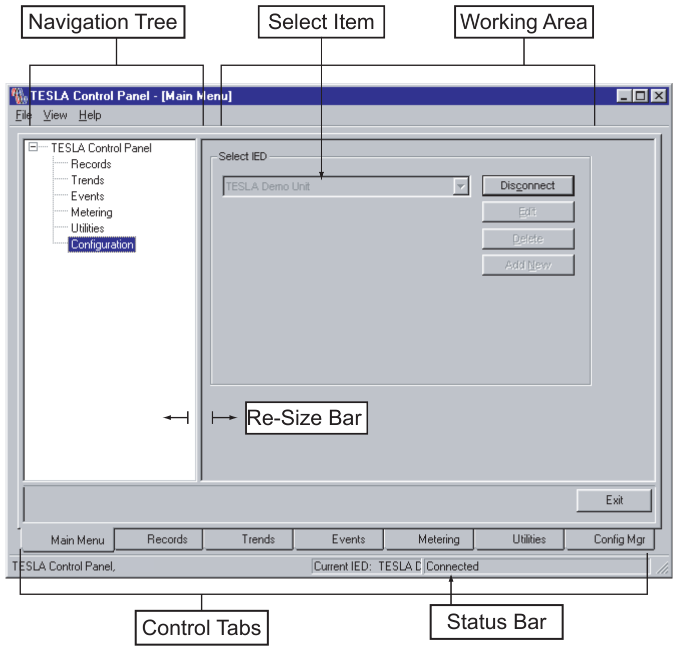


Figure 4.3: TESLA Control Panel Display Sections Navigation Tree

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).

For example, in the *Main Menu* choose the 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 section of the TESLA Control Panel software creates a corresponding tab.

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.

5 Recorder Setup Utilities

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

- Unit identification
- Communication ports
- Recording settings
- Time display and settings
- Analog Input Calibration
- Notify (RecordBase Server users only)
- Password protection

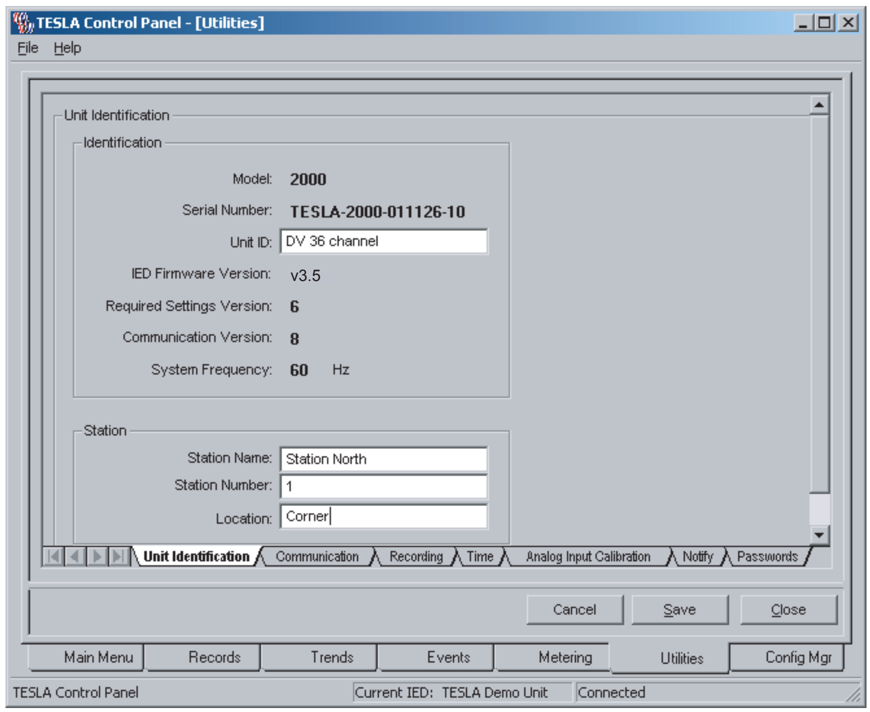


Figure 5.1: Recorder Setup Utilities

> The Setup parameters are accessed with the Utilities function of the TESLA Control Panel, if Control Panel is communicating with the recorder.
>
> For details on connecting to the recorder using TESLA Control Panel software see “Connecting to the Recorder” on page 3-1.

Unit Identification

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

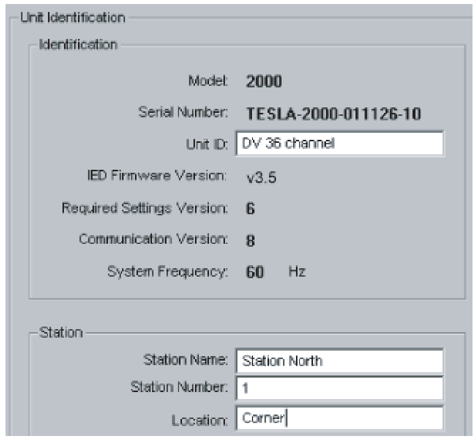


Figure 5.2: Recorder Setup Utilities - Unit Identification

Unit Identification	
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 and identifies their origin. By convention, this name should be the same as the one used to name the recorder and recorder's workspace on the Main Menu. The names 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 63).
Communication Version	Read-only field that displays the firmware version of the currently connected TESLA unit.
System Frequency	Read-only field that displays the system frequency.
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. When equipped with an internal network card, the IP address of the TESLA is changed using the maintenance login (see "Maintenance Menu" on page 13-4).

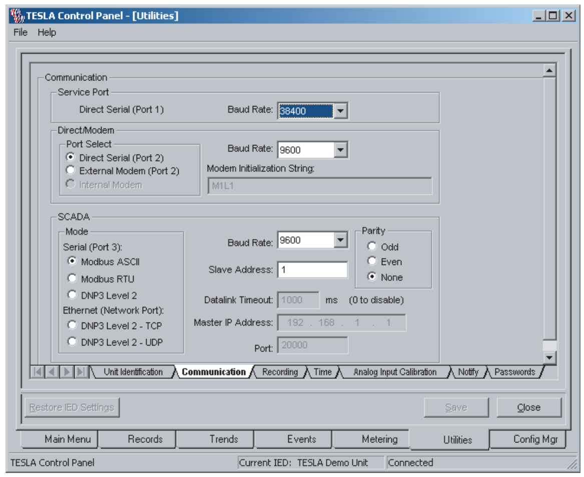


Figure 5.3: Recorder Setup Utilities - Communication Ports

Communication	
Service Port	
The service port is a DB-9 serial port (Port 1) and is used for direct connection to a computer running TESLA Control Panel user interface software.	
Baud Rate	Sets the baud rate of the port. Default baud rate set at 38,400 baud. The baud rate must be the same as that used by 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 3-12.
Direct/Modem Port	
The direct/modem port can either be the DB-9 serial port (Port 2) or the RJ11 (Port 5) depending on whether or not an internal modem is installed and enabled. When an internal modem is not installed or disabled (see "Maintenance Menu" on page 13-4 to enable/disable the internal modem) Port 2 is active and may be used for direct connection like Port 1, or can be configured to connect to an external modem. When an internal modem is installed and enabled, Port 2 is inactive and a telephone connection to the RJ11 Port can be made.	
Port Select	Selects the port and function of the rear user port. If an internal modem is not installed or not enabled, Port 2 can be used for direct serial connection or for connection to an external modem. If an internal modem is installed and enabled, the internal modem must be selected.

Baud Rate	Sets the baud rate of the port. If configured for direct connection, the baud rate must be the same as that used by the serial port of the computer connected to Port 2, for details about changing the baud rate see “Setting Windows Serial Port Parameters” on page 3-12. Default baud rate is set at 9,600 baud. When configured as a modem port, the baud rate specifies the rate at which the recorder communicates with the modem. The actual communication rate between the two modems is less than or equal to this setting, depending on what the modems can negotiate over the phone line. The slower default baud rate provides a means of establishing an initial direct serial connection to the recorder in cases where the computer running TESLA Control Panel is unable to communicate at high rates. You can increase the rate if a modem is used or if your computer is able to handle higher direct serial baud rates.
Modem Initialization String	When using a modem, an optional modem initialization string can be entered containing modem control codes. Refer to your modem manual for details.
SCADA	
The SCADA protocols can be accessed via either the DB-9 serial port (Port 3) or the RJ-45 (Port 5). If no Ethernet card is installed or if Modbus ASCII, Modbus RTU or DNP3 Level 2 is selected, Port 3 is used. If an Ethernet card is installed and either DNP3 Level 2 - TCP or DNP3 Level 2 - UDP are selected, SCADA can be accessed via ethernet. The factory configuration for SCADA is 9,600 baud, no parity, Modbus ASCII mode, Slave Address 1.	
Mode	This selects the SCADA protocol. DNP3 Level 2 - TCP and UDP are only available if an Ethernet card is installed
Baud Rate and Parity	Must be set the same as the master device on the SCADA network. 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.
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 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.
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 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

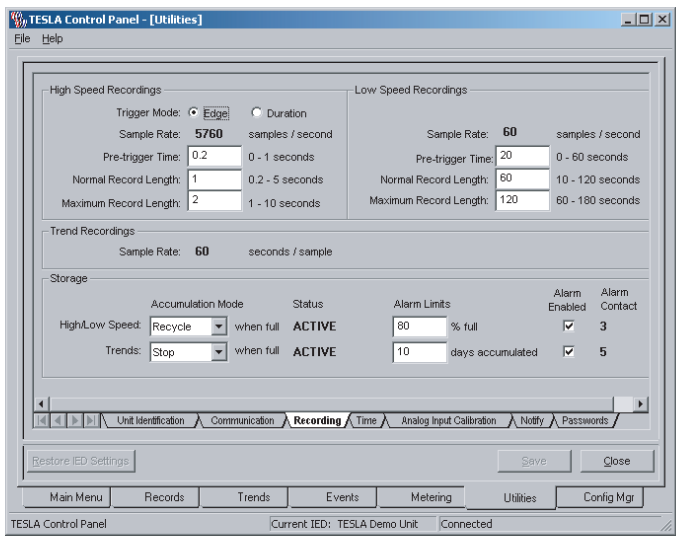


Figure 5.4: Recorder Setup Utilities - Edge Recording

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.

Duration Mode

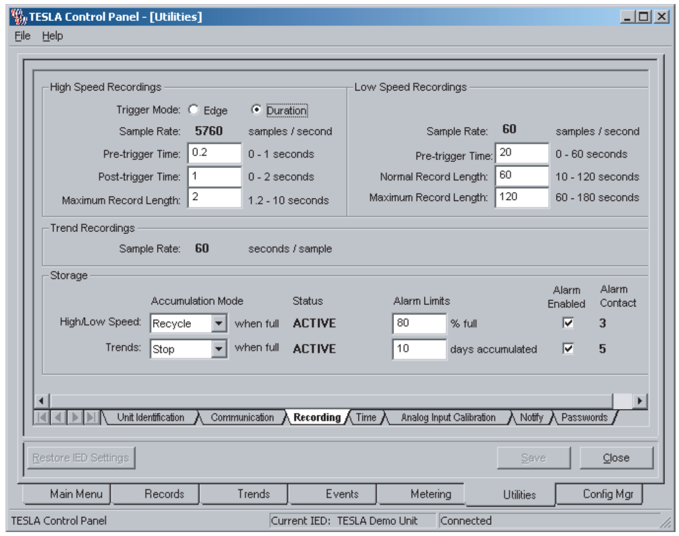


Figure 5.5: Recorder Setup Utilities - Duration Recording

In Duration Recording, the duration of the trigger is used to create a record that has a set amount of pre-trigger data, continues to record while the trigger is active and then records a set amount of post-trigger data. If a trigger remains active, the TESLA stops recording once the Maximum Record Length limit is reached. When a subsequent trigger is processed while the 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		
Accumulation Mode	Selects whether to overwrite (“recycle”) the oldest transient or swing data when the disk space is full. If stop is selected, the recording stops when the disk space is full.	
Alarm when recording space is	When enabled, you can enter a limit giving the percentage of recording space that causes an alarm condition. Enter a number between 60 and 90.	
High Speed Recording		
Trigger Mode	**Edge Recording**	**Duration Recording**
Sample Rate	Samples at 5760 samples/second (96 samples/cycle) producing record lengths of a few seconds to capture transient fault conditions	
Pre-trigger Time	The length of data that is recorded prior to the trigger time	The length of data that is recorded prior to the trigger time
Normal Record Length	The length of the record including pre-trigger data, without any record extensions	N/A
Post-trigger Time	N/A	The length of data that is captured after the falling edge of trigger event
Maximum Record Length	The maximum length of the record including pre-trigger, post-trigger and extensions	The maximum length of the record including pre-trigger, trigger and post-trigger
Low Speed Recording		
Trigger Mode	**Edge Recording**	
Sample Rate	Samples at 60 samples/second (1 sample/cycle) producing record lengths of a few minutes to capture slower system dynamic swings	
Normal Record Length	Determines the total duration of each recording under single trigger conditions and includes the pre-trigger time	
Pre-trigger Time	The length of data that is recorded prior to the trigger time	
Max. Extended Record Length	The maximum length of the record including pre-trigger, post-trigger and extensions	
Trends	Records at intervals of 10 seconds to 1 hour are configured for any analog input channel, harmonic, THD, summation, sequence component, MW, Mvar, frequency or Z Controls the trending operation by showing the status of the trending function and the configured recording rate Allows you to select trend alarm option strategy to follow when the trending area is full and operation of the trend almost full alarm	

Recording	
Status	Current state of the trending function. The trending function has four states Active Stopped—trending has stopped because the trend data accumulation area is full and Stop when full option is selected Unconfigured—trending has not been specified in the current operating configuration; specified in the setting file (see “Trends” on page 7-31). Unavailable—the firmware on the TESLA recorder requires an update in order to support the trending process
Sample Rate	Indicates the trending interval in seconds; specified in the setting file (see “Trends” on page 7-31).
Accumulation Mode	Selects whether to overwrite (“recycle”) the oldest trending data when the amount of accumulated trend data exceeds the maximum. If Stop is selected, trending stops when the accumulated data area is full
Alarm after data collected for	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.

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.

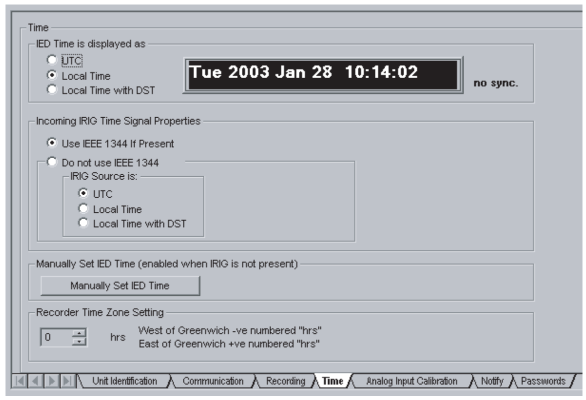


Figure 5.6: Recorder Setup Utilities - Time Control

Time	
IED Time is displayed as	
UTC	Universal Coordinated Time (UTC) is consistent worldwide. Changes the time offset used by the recorder; does not change the recorder’s time.
Local Time	Local Time has the appropriate time zone time offset applied (e.g. 6 hours for Central Standard Time), but no DST. Changes the time offset used by the recorder; does not change the recorder’s time.
Local Time with DST	Local Time with Daylight Savings Time (DST) is local time with one hour of DST compensation added from 2 AM on the first Sunday in April until 2 AM on the last Sunday in October. Changes the time offset used by the recorder; does not change the recorder’s time.
Present Time	When connected to a recorder, the recorder’s present time is shown and continually updated.
Sync/No Sync	Indicates whether the recorder is presently 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, if it is present.
Use IEEE 1344 If Present	If Use IEEE 1344 if Present is checked, the recorder obtains its offset to UTC from the IEEE 1344 code on the IRIG-B time signal, if it is available. If IEEE 1344 is not present on the IRIG-B time signal, the recorder will use the manually entered offset to UTC.
Do not use IEEE 1344	If Do Not Use IEEE 1344 is selected, the mode of the IRIG-B signal must be specified as either UTC, Local Time or Local Time with DST.

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. This value is used for local time display when Local Time is selected for display.

Analog Input Calibration

The Analog Input Calibration utility provides a means of calibrating the TESLA recorder's analog input channels (see "Analog Input Calibration" on page 8-5).

Notify

The TESLA recorder has the capability of calling 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 through the RecordBase central station.

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.

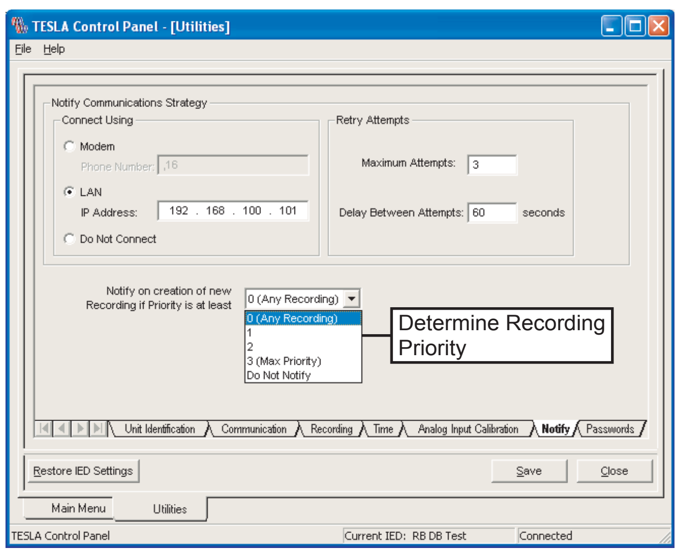


Figure 5.7: Notify Communication Strategy

Notify Communication Strategy	
Connect Using	The TESLA recorder can be set to notify RecordBase via modem, LAN, or to not notify at all. These 3 options are mutually exclusive. Note that the availability of these controls is dependent on the specific hardware and firmware configuration of your particular TESLA recorder.
Modem	If *Modem* 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 *LAN* is selected, enter the IP address of the computer running RecordBase Server.
Do Not Connect	If *Do Not Connect* is selected, the TESLA recorder will not notify RecordBase server 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 Server (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 Server, this is the maximum number of attempts it will make before giving up.
Delay Between Attempts	This is 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	Brings up a drop-down menu that determines when the recorder should call its RecordBase central station to report a new record. The setting specifies the minimum record priority that will cause the recorder to send a New Record notification message to RecordBase. When a record is created with a priority equal to, or greater than value specified in the drop-down box, the recorder will send a New Record Created notification message to RecordBase. For reference, the priority of a record is calculated by taking the maximum priority of the events contained in the record.

Control of cross trigger notification calls is handled through the configuration of individual trigger detectors (see “Triggers” on page 7-28).

Setting Trigger Priorities

Event	Outcome
Triggers (Channel Configuration) Assign priority 0 to 3, highest is 3.	The priority is assigned to the record.
Record (Utilities) Each trigger has a different priority. Record priority is the priority of the triggers in the record with the highest priority.	When the record is created, TESLA notifies RecordBase that the record has been made.

Notify Notify on creation of new record in record priority selection of Utility/Notify Screen. Select notify priority if record priority is a least (3 or less) for notification to RecordBase of new record.	When notified RecordBase establishes a connection to the TESLA and takes appropriate action (such as down loading the record).

Control of trigger priorities is handled throughout the configuration of individual trigger detectors (see “Triggers” on page 7-28).

Password Protection

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

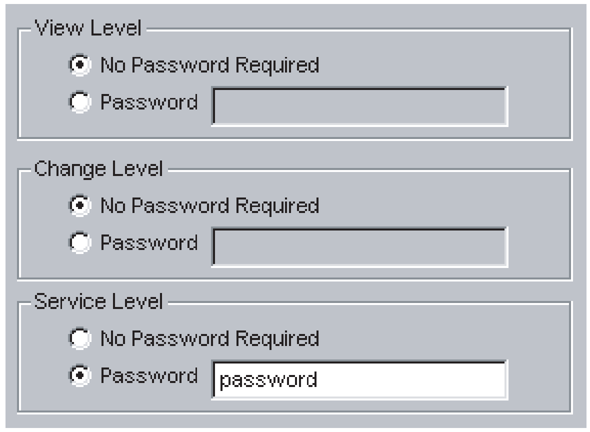


Figure 5.8: Passwords

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

6 Managing Configuration Files

Managing Configuration Files

The recorder's configuration is controlled by a configuration file stored in the recorder's non-volatile memory. TESLA Control Panel is used to create and manage configuration files and handle transfers to and from the recorder.

Recorder configurations are managed through the Config Edit screen which can be started by double-clicking the *Configuration* line in the left pane of the Main Menu screen.

The configurations shown in the Config Edit screen are those that apply to your selected Current IED. To work with configurations from another recorder, you must first select that unit as the Current IED (from the Main Menu).

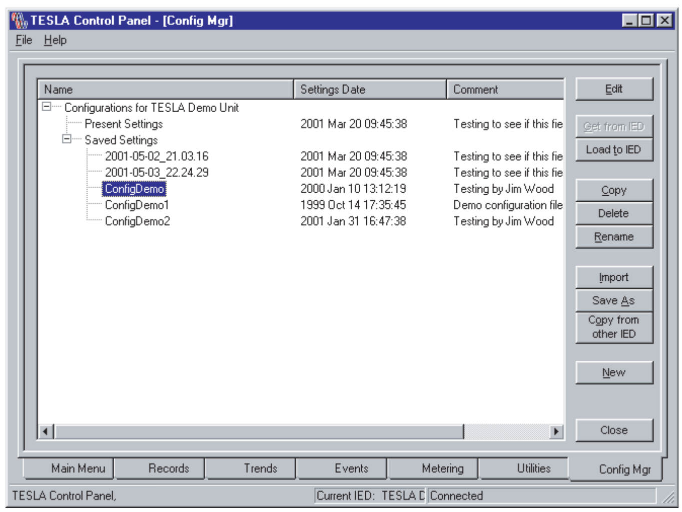


Figure 6.1: IED Configuration Manager

Recorders with older firmware may require older versions of configuration files. The Configuration Editor creates configuration files with older setting versions and converts existing configuration files between versions (see “Settings Version” on page 7-4).

If you attempt to load an incompatible configuration version to a recorder, Control Panel will give you the option of converting the file unless the version of Control Panel does not support the required setting version. In that case you must update the version of Control Panel installed on your computer.

The settings version required by a recorder is shown in the *Utilities/ Unit Identification* screen. (This applies only to firmware v2.0 and Control Panel v2.0 or greater; earlier releases all require Settings Version 1). If the settings version is not shown, you should update your own version of Control Panel.

Working Directly with the IED's Present Configuration

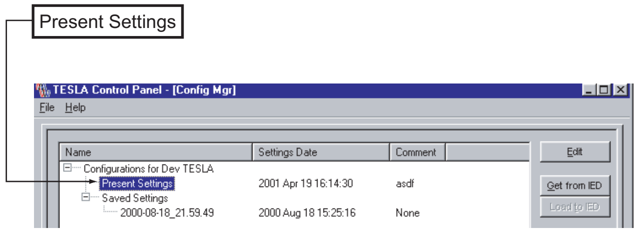


Figure 6.2: Present Configuration

If a communication link to the Current IED is available, you can work directly with the recorder's configuration in three ways.

1 Double-click on the *Present Settings* item in the list

2 Select *Present Settings* and use the *Edit* button to automatically transfer the configuration and bring it up in the Configuration Editor. When you close the Configuration Editor, the configuration can be automatically loaded back to the recorder. This gives you a quick way to make changes on the fly.

3 Choose to transfer the recorder's configuration to a saved file using the *Get from IED* button. When transferred, the configuration appears in the *Saved Settings* list. This feature maintains a copy of the configuration and makes changes that you might not want to immediately load to the recorder.

Working with Saved Configurations

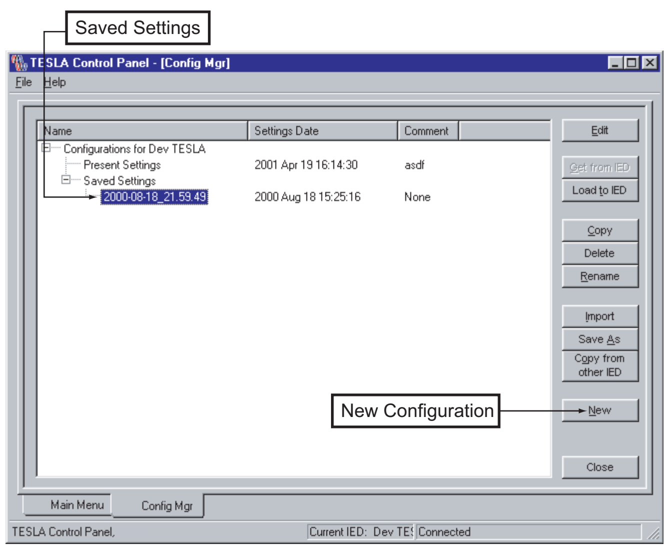


Figure 6.3: Saved Configurations

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. Select the desired configuration from the Saved Settings list by selecting on it, then select the appropriate button on the right of the screen. Double-clicking on a configuration is equivalent to hitting the *Edit* button.

Creating a New Configuration

Use the *New* button to create a new configuration file.

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 IED based on an existing one from another recorder.

Available Channel Types and Triggers

Analog Input Channels (18 per Channel Group)

The TESLA's analog input channels are sampled at 96 samples per cycle and converted into phasor quantities. The individual sample points are recorded for transient fault conditions and phasors are recorded for dynamic swing conditions. The Analog Input channel processing can also produce THD calculations and selected single harmonic magnitude for triggering purposes.

Triggers are available for:

High magnitude
Low magnitude
Negative rate of change
Positive rate of change
Single harmonic magnitude
THD magnitude
Sag
Swell

External Input Channels (32 per Channel Group)

The external inputs are sampled at the same rate as the analog channels (96 samples per cycle). The individual sample points are recorded for transient fault conditions.

Triggers are available for:

Positive edge transition
Negative edge transition

Summation Channels (15 per Channel Group)

TESLA continuously evaluates the analog input phasor quantities. Summation combines individual analog inputs to create a summed phasor quantity. Each input can be scaled and rotated to create the appropriate summation channel, in addition the previously combined summation channels can be used as an input to a new summation channel. You can easily create station totalized current channels that are the sum total of the individual phases. With an 18 channel TESLA you can monitor three bus voltages and the phase currents of five lines. Summating the individual phase currents and combining them with the bus voltage allows you to create a station totalized watt/vars signal of the combined phase currents for each of the lines.

Triggers available for:

High magnitude
Low magnitude
Negative rate of change
Positive rate of change

Sequence Channels (6 per Channel Group)

TESLA provides the specialized processing associated with sequence components as a function which you may specify. A sequence function 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.

Triggers are available for:

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

Watts/Vars Channels (9 per Channel Group)

A watts/vars function in TESLA calculates apparent power (volt-amps), real power (watts) and reactive power (vars) for one voltage input and one current input. If you specify analog inputs as inputs to the watts/vars function you may calculate watts and vars on a single-phase basis. If you specify a positive sequence voltage and a positive sequence current as the function inputs, you may calculate three-phase volt-amps, watts and vars.

Triggers are available for:

Watts: high level Detector 1/Detector 2
Watts: low level Detector 1/Detector 2
Watts: positive rate of change Detector 1/Detector 2
Watts: negative rate of change Detector 1/Detector 2
Vars: high level
Vars: Low level
Vars: positive rate of change
Vars: negative rate of change

Impedance Channels (9 per Channel Group)

An impedance function may be applied in a similar manner to a watts/vars function. The resulting impedance value is not intended for impedance recording, but the trajectory of the calculated value may indicate a swing condition of interest.

Triggering is based on the rate of impedance within a defined impedance circle centered around the origin.

Frequency Channels (1 per Channel Group)

A frequency function measures the frequency of the analog input of your choice.

Triggers are available for:

High magnitude
Low magnitude
Negative rate of change
Positive rate of change

Logic Channels (15/ channel group)

A logic function performs a chain of logical operations (AND, OR, etc.) on individual external (external inputs) and internal (detectors, other logics) TRUE/ FALSE values within the recorder.

Triggers are available for:

Transition to asserted (ON) state
Transition to unasserted (OFF) state

Fault Locators Channels (5/channel group)

A fault locator monitors 3 voltage phases and 3 current phases continuously. 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. In addition, the information is made available on the SCADA channel.

Power Factor Channels (9/channel group)

A power factor channel monitors the power and reactive power values calculated by a watts/vars channel and triggers depending on total power level. Inductive power factor is defined as a situation where the calculated reactive power and real power are of the same sign. Capacitive power factor is defined as a situation where the reactive power and real power are of opposite signs.

Separate triggers are available for:

Inductive power factor – Low magnitude
Capacitive power factor– Low magnitude

Phase Angle Metering Reference

The TESLA recorder can have two channel groups (configuration dependent) installed on one recorder. Each channel has 18 analog and 32 external input channels. A recorder with two channel groups thus has a total capacity of 36 analog channels and 64 external input channels.

The angle of each of the calculated phasors in a channel group is referenced to a single analog channel, designated as the angle reference channel. Earlier TESLA recoders use the first analog channel in each channel group as the angle reference channel. Beginning with firmware version 3.1, the angle reference channel used for each channel group is configurable, and may be selected from any ac channel (for best results use a voltage channel).

Circular Storage

The event log stores up to 250 events with automatic overwrite the oldest event. The trending module, accessed through the “logging tab”, preserves the daily events, up to 1000 events can be saved in the daily trend log.

Planning Your Configuration

With the amount of real input and calculated channels available to the user, it is useful to plan the channel setups and naming convention used in your configuration. The following section describes the configuration approach used in setting up a TESLA recorder.

Channel Groups

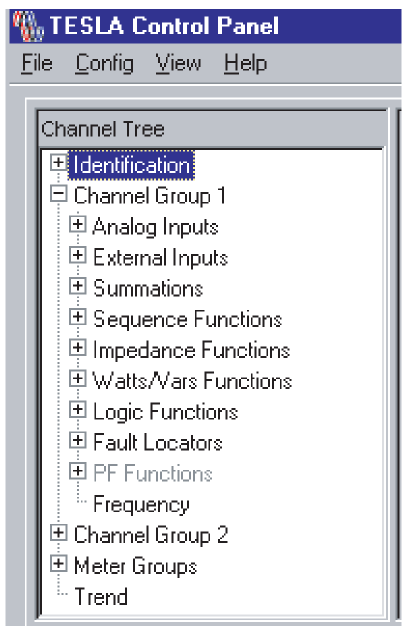


Figure 6.4: Channel Group 1

The TESLA recorder can have two channel groups (configuration dependent) installed on one recorder. Each channel has 18 analog and 32 external input channels. A recorder with two channel groups thus has a total capacity of 36 analog channels and 64 external input channels.

Channel Group	Analog Channels	External Inputs
1	1-18	1-32
2	19-36	33-64

> A channel group is associated with a DSP processor in the recorder. Each DSP processor works independently and has access only to its own channels. For this reason, you must ensure that your channels are organized so that calculated channels (e.g. summations) and their corresponding input channels are contained within the same channel group.

It is important that the number of channel groups specified in the Control Panel's IED Definition matches the capabilities of the actual recorder. The number of channel groups is defined as part of the IED's workspace.

Grouping by Power System Element

An effective way to organize the many channels available on the recorder is to group them by the power system element they are monitoring.

The Configuration Editor allows you to identify each element by name and use this element name to group and identify the analog, digital and calculated channels associated with it.

For example, if you have a transmission line named A6B, you can define the element as "Line A6B." The channels associated with that element might then be:

Line A6B:Va
Line A6B:Vb
Line A6B:Vc
Line A6B:Ia
Line A6B:Ib
Line A6B:Ic

External inputs (digital) can also be reasonably associated with the A6B line:

Line A6B:EI:BRK12_a
Line A6B:EI:21N_Trip

Calculated channels fit the model as well:

Line A6B:W/V:Watts (watts)
Line A6B:W/V:Vars (vars)
Line A6B:Iseq: (sequence components)

Channel Types and Naming

An understanding of how the TESLA creates and uses channel names is helpful to producing an optimal configuration.

The TESLA structures channel names into three parts:

Element Name (10 chars)	Free-form text describing the power system element associated with this channel (e.g. Line A6B). 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.	
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 A6B:Va). In other cases, the Description is required to clarify the channel name. (e.g. You might name an external input channel as “Line A6B:EI:BRK 23 Open.”). Free-form text available for additional descriptive information on a channel. The Element, Channel Type and Description fields are combined to produce the full channel name: Element:Type:Description. This is the name that will appear beside a channel when it is graphed. The recorder’s Event Log uses this format when generating log messages. For example: 2000 Jan 12 20:44:33.672 LineA6B.EI.BRK23 open.	

7 The Configuration Editor

If you have not already done so, read “Planning Your Configuration” on page 6-6 to gain an understanding of how the TESLA names and organizes channels.

The Configuration Editor provides the means to create, display and modify configurations for the recorder. The Configuration Editor is part of Control Panel.

The screen pictures shown in this section are from the sample configuration file ConfigDemo provided as part of Control Panel installation. We recommend that you run this configuration as you read this section.

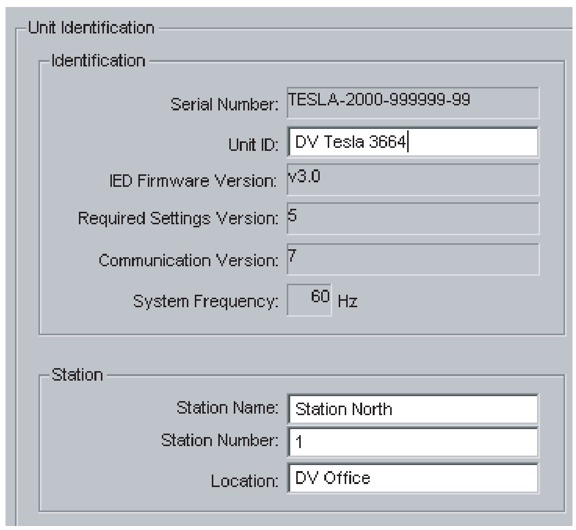


Figure 7.1: Unit Identification

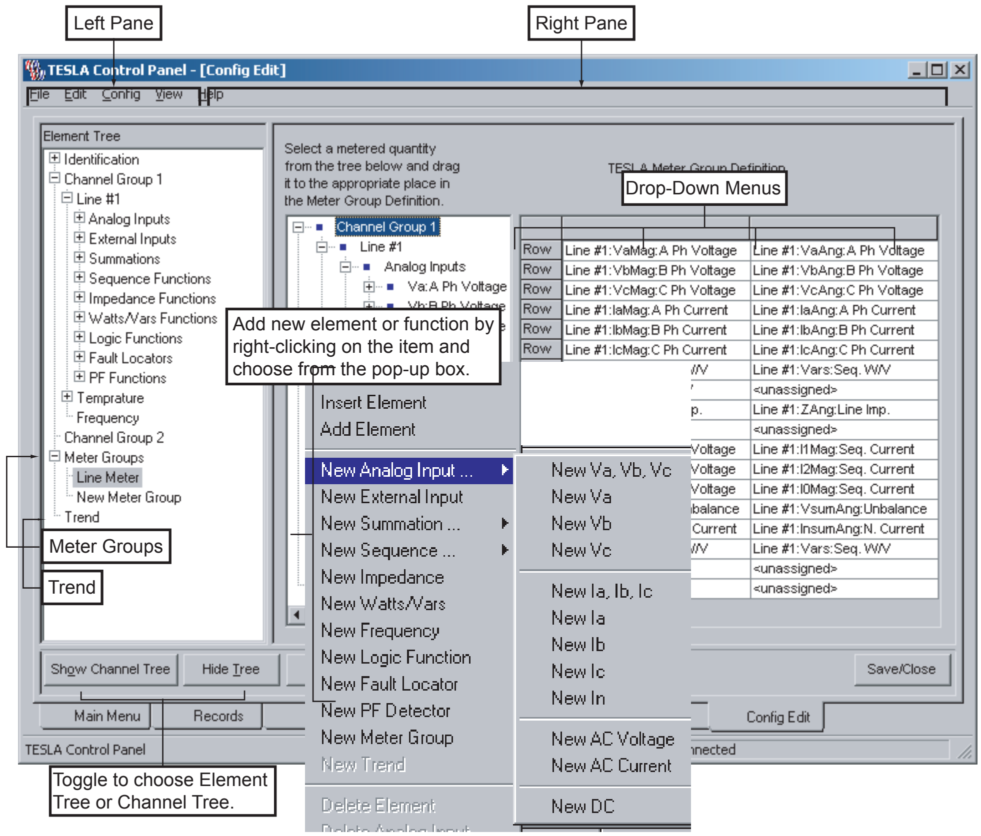


Figure 7.2: TESLA Configuration Editor

Navigation through Configuration Settings

The list tree in the left pane is used to navigate through the configuration. Selecting an item in the tree shifts the large right pane view to the appropriate topic.

The tree can be viewed in two ways, the Element Tree or the Channel Tree. The title at the top of the tree designates which tree is visible. To change to the alternate view select the bottom tab *Show Channel/Element Tree*.

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.

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.

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.

Main Branches

Identification Screen

The Identification view provides information about the selected IED and the particular configuration file being edited. Most of the information is drawn from the IED Definition and is provided to identify the target recorder (see “Adding/Editing a Recorder Workspace Definition” on page 4-2).

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.

Channel Group 1
Channel Group 2

Depending on the number of channels in the recorder, the tree presents one or two channel groups. Expand a channel group branch to access individual element and channel definitions.

Meter Groups

The main editor tree also has a branch for meter groups (see “Meter Groups” on page 7-30).

Trend

The main editor shows a branch for trends if your settings version is 4 and above (see “Trends” on page 7-31).

Settings Version

Recorders with older firmware may require older versions of configuration files. The Configuration Editor creates older configuration file versions and automatically converts between different versions.

The version of a configuration file is controlled through the Settings Version field in the main identification screen (see Figure 7.2: TESLA Configuration Editor). Changing the Setting Version 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 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 an recorder with older firmware, set the Setting Version appropriately after opening the new file.

To Determine the Required Settings Version

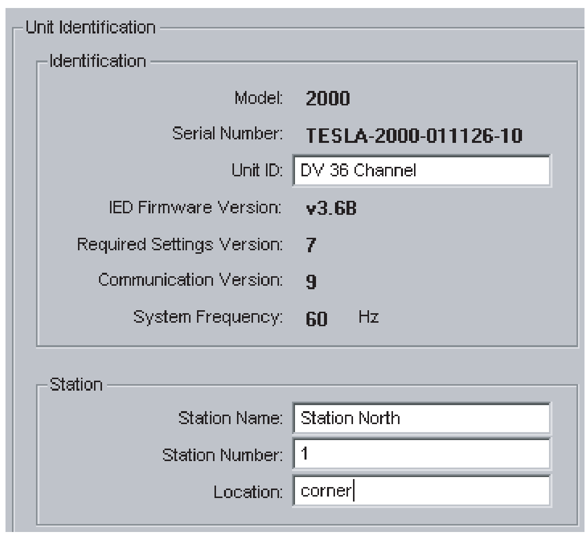


Figure 7.3: Determine Settings Version

The settings version required by a TESLA recorder is shown in the Unit Identification screen of the Utilities menu. You must be connected to the recorder to view this information.

If the settings version is not shown in this screen, you should update your own version of Control Panel. Earlier versions of TESLA and Control Panel do not report the required settings version. TESLA firmware earlier than v2.0 always requires settings Version 1. TESLA Control Panel software earlier than v2.0 always creates settings Version 1.

Auto-Check and Convert When Loading

When you load a configuration file to a recorder, Control Panel first checks that the Settings Version is compatible. If it is not, you are given the option of converting the file on the spot. If your version of Control Panel is older than the recorder's firmware and does not support its required Settings Version, you need to update your copy of Control Panel.

Element and Channel Tree Views

The Config Editor presents the recorder channels in two distinct views. 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 View

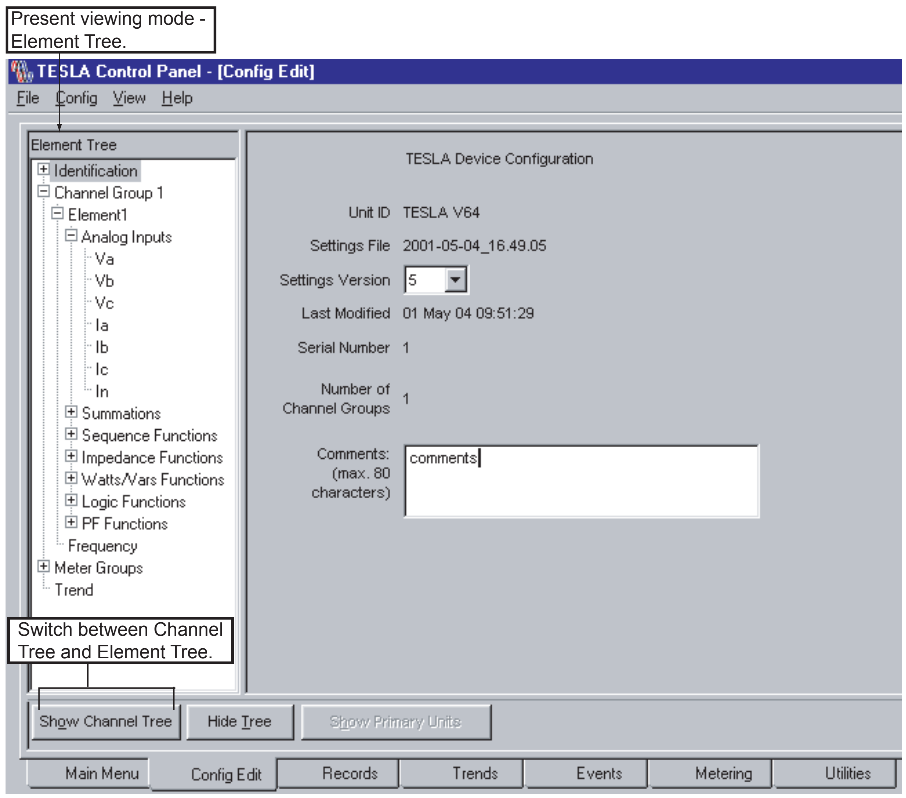


Figure 7.4: Element Tree View

The Element Tree View organizes channels by the element names you create. Element 1 has been further expanded to show some of the channels associated with it, such as Va.

Channel Tree View

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

Channel Overview Screens

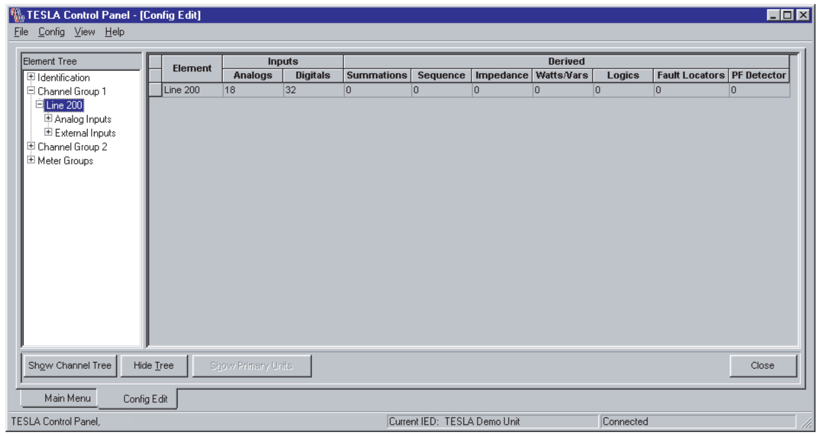


Figure 7.5: Channel Group Overview Screen

An overview of elements and channel settings is available by selecting a channel group, element or channel type from the tree. You can edit individual parameters in the overview display.

Use the Channel Group Overview screen to choose the Angle Reference Channel for each Channel Group (see “Phase Angle Metering Reference” on page 6-6). Choose any analog channel configured as an ac channel, for best results choose a voltage.

The Channel Group Overview screen shows a listing by element of the allocated functions. The last line shows functions available to be allocated.

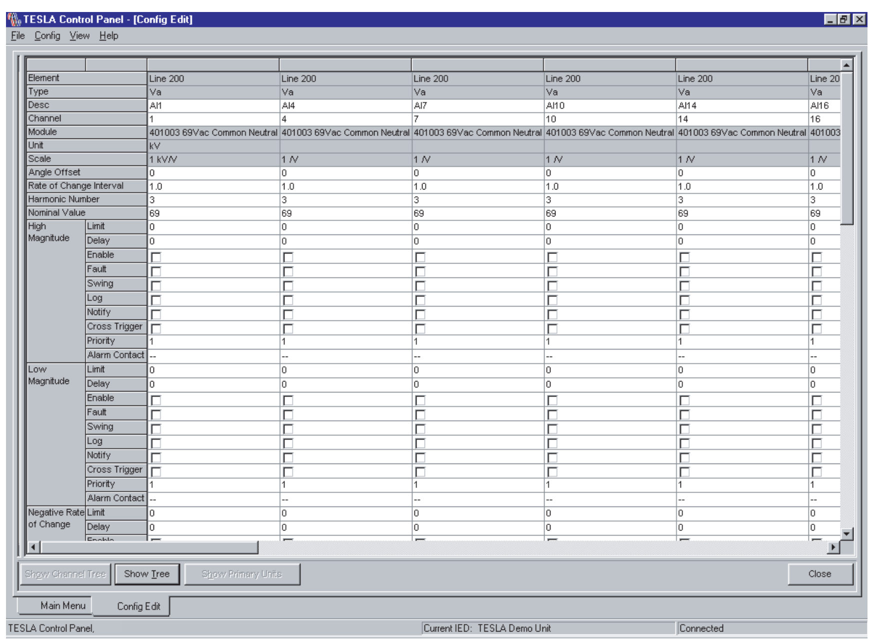


Figure 7.6: Analog Input Channel Configuration Screen

Individual Channel Configuration Screens

The settings for each channel can be displayed in individual screens by selecting the specific channel in the tree. Each channel type has its own configuration screen with parameters appropriate for its type.

Adding an Element

To add an element in the Element Tree view:

1 Select the desired channel group in the tree.

2 Right-click and select *Add Element* from the shortcut menu.

3 Type the element name and *Enter*. The typed text replaces the *New Element* text.

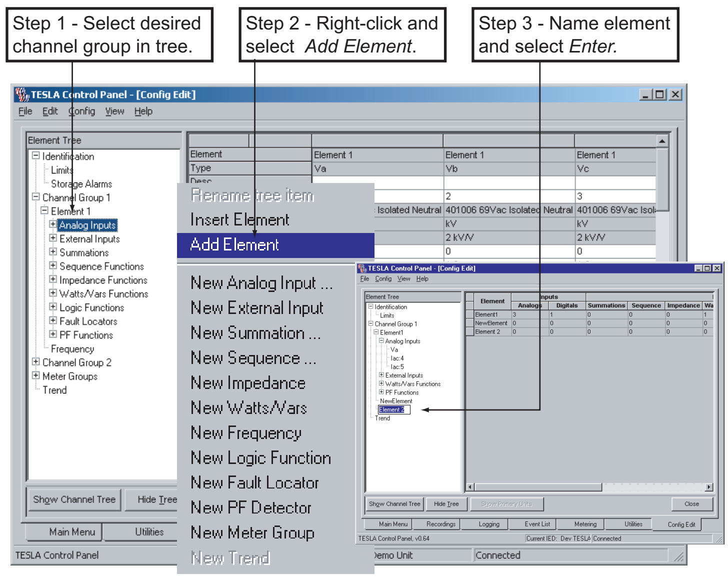


Figure 7.7: Add an Element

For information on settings for triggers and actions see “Triggers” on page 7-28. For additional information on channel types see “Channel Types and Naming” on page 6-8.

Adding a Channel

To add a channel in the Channel Tree view:

1. Select the desired channel group 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*.

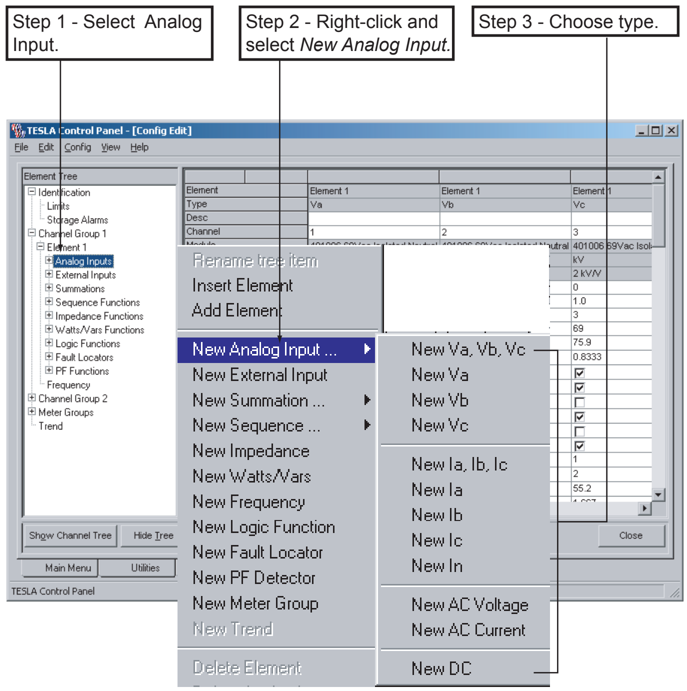


Figure 7.8: Adding Analog Input Channels

Chatter Limits

There are chatter limit functions built into the TESLA trigger definition. Chatter limits are applied to all triggers, although separate settings are available for External Input channels. The chatter limit function counts the number of changes of state that occur within a given period. Any trigger that generates more than four changes of state in a user-specified period Chatter Detection Window is immediately disabled, and fixed in the inactive state. The chatter limit function continues to monitor the number of changes of state, however, and while the count of changes of state (in further periods) continues to exceed four, the disabled status of the input or trigger continues. The input or trigger is re-enabled when the change count is less than four for a user-specified number of periods Recovery Time.

To access the chatter limits settings, select the *Identification>Limits* entry in the configuration's main tree view.

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

Storage Alarms

There are record and trend storage alarm conditions that can be configured to close an alarm contact. The record and trend storage alarm condition can be accessed via the SCADA protocols. You can enable the recorder nearly full and trend nearly full alarm conditions in the *Recording* tab of the *Utilities* screen.

To access the storage alarm configuration, select *Identification>Storage Alarms* in the configuration editor's main tree view.

Analog Input Channels

The menu entry New Analog Input is used to add an Analog Inputs Channel.

1 Select *Analog Inputs* in the tree. If the Channel Tree is showing, expand Analog Inputs under the appropriate Channel Group and choose an unallocated channel.

2 Right-click and select *New Analog Input*.

3 Select the desired channel type from the list. 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. To monitor a dc quantity, select *New DC*.

4 When you chose a channel type, the right pane displays a channel configuration screen.

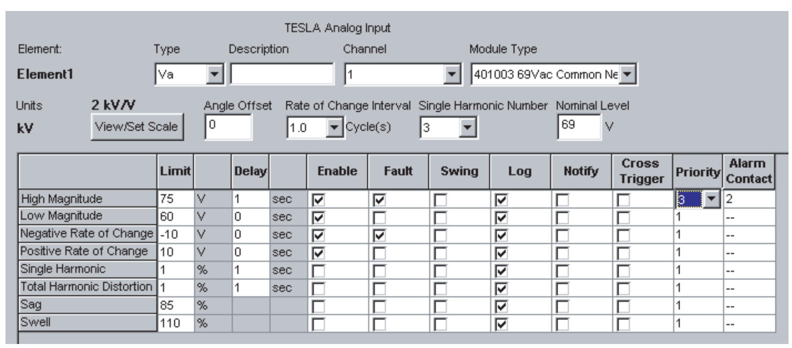


Figure 7.9: Analog Input Screen

For more information about Settings for triggers and actions see "Triggers" on page 7-28 and "Actions" on page 7-29.

TESLA Analog Input	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.

TESLA Analog Input	
Type	Based on the channel type you selected. If desired, use the Type field to modify the phase reference of an existing channel. It cannot be used to define a new analog channel or change a voltage channel into a current channel and vice versa.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Channel	Identifies the hardware input associated with the channel group. 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	The Module Type indicates type of external input isolation module being used with this channel (see “AC Voltage Input Module” in Appendix I, and “DC Input Module” in Appendix L). This provides scaling information to the system. A dc isolation module channel can be used for either an ac or a dc input to the TESLA recorder. DC signals brought to the TESLA through dc isolation modules is bipolar, that is, if the full-scale value is 5 volts the module will also read voltages down to -5 volts.
Units	AC current select mA, A or kA. AC voltage select mV, V or kV. DC module select mA, A, mV or V.
Angle Offset	Provides a phase angle offset for the Analog Input channels. It affects: • The phasor (phase angle) value for the analog channel to which it is applied. • The analog channel metering screen’s phase angle values. • The calculated channels which use the analog channel’s phasors (phase angle) as part of the calculation (watts, vars, Impedance, Summations, Sequence components, etc.). Anything to do with the calculated channels will be affected, such as metering screens and triggers. • The graphs for the calculated channels will be affected because the data points for the graph are calculated. The data points for the analog channel graphs are not affected because they are measured value data points. When the Angle Offset is used on a reference channel, it affects all other channels and appears on the metering screens.
Rate of Change Interval	Period of time over which both positive and negative rate of change is measured. 0.5 to 8.0 cycles.
Single Harmonic Number	2 to 25 multiple of fundamental frequency
Nominal Level	Provides a nominal level for sag and swell detector.
Limit	Specifies magnitude, rate of change, single harmonic, THD, sag and swell trigger levels.
Delay	Requires an element to be energized before an active state is determined. Magnitudes with rate of change are settable from 0 to 1,200 seconds in half-cycle increments. Single harmonic and THD are settable from 1 to 10,000 seconds in 1 second increments.
Enable	Enable/disable
Fault	Enable/disable

TESLA Analog Input	
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

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. The scaling factor is the equivalent to the turns ratio of the primary transducer (CT or PT). The nominal secondary value is the default calibration 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 “DC Input Module” in Appendix L.

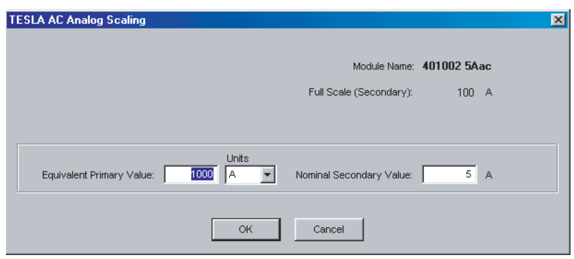


Figure 7.10: AC Scaling

DC Scaling

When you select the *View/Set Scale* button on the Analog Input form for a dc channel, Control Panel displays the Scaling dialog box, Figure 7.11: DC Scaling. 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 L. Enter the associated Full Scale value from “DC Input Module” in Appendix L 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.

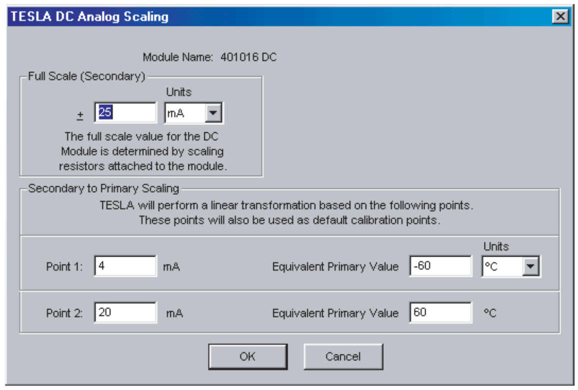


Figure 7.11: DC Scaling

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

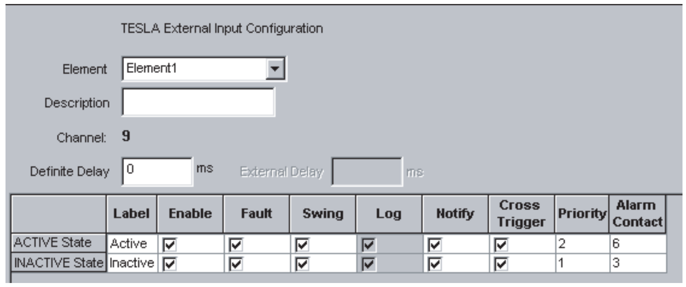


Figure 7.12: External Input Configuration Screen

The menu entry New External Input is used to add an External Input Channel.

5 Select *External Inputs* in the tree.

6 Right-click and select *New External Input* and give it an unique name.

7 When you chose a channel type, the right pane displays a channel configuration screen.

For more information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA External Input Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Fixed as EI (external input) and is not shown. It will automatically be used as part of the channel’s name.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Channel	Identifies the actual External Input number connected to the input. This number is identified on the rear of the TESLA chassis. The list only shows inputs which have not been assigned to other channels.
Definite Delay	Requires the element to be energized before an active state is determined. Settable from 0 to 5,000 ms in eighth cycle increments.
Label	On/Off
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3

TESLA External Input Configuration	
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Summation Channel

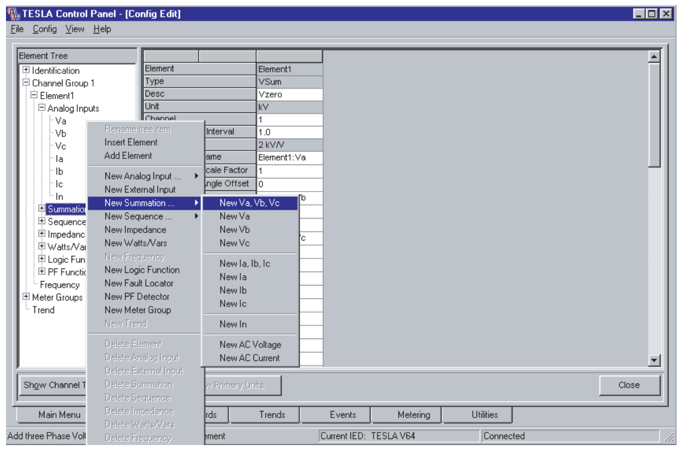


Figure 7.13: Adding Summation Channels

The menu entry New Summation is used to add a Summation Channel.

8 Select *Summations* in the tree. If the Channel Tree is showing, expand Summations under the appropriate Channel Group and choose an unallocated channel.

9 Right-click and select *New Summations*.

10 Select the desired channel type from the list. 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.

11 When you chose a channel type, the right pane displays a channel configuration screen.

For information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

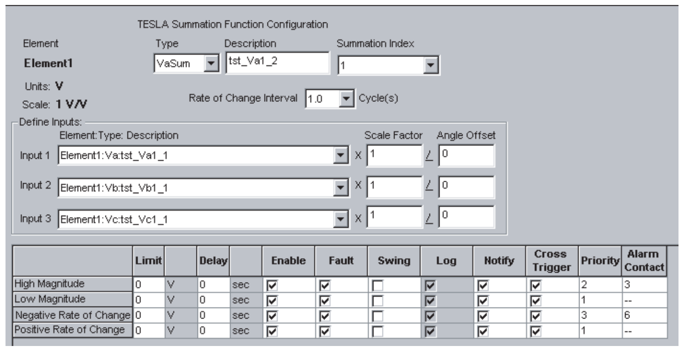


Figure 7.14: Summation Function Configuration Screen

TESLA Summation Function Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Selected for you based on the channel type you just selected. If desired, the Type field can be used to modify the phase reference of an existing channel; it cannot be used to define a new summation channel, it cannot change a Voltage channel into a Current channel, nor vice versa.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Summation Index	Identifies the internal 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. Each channel group has 15 available summation channels. Select any available channel. If the only option is “undefined”, you have already used all available channels.
Rate of Change Interval	Period of time over which both positive and negative rate of change is measured. 0.5 to 8.0 cycles.
Element Type Description	Identifies the channels to be used in the summation. The list includes all previously defined analog channels and any summation channel with a lower summation index field. It grows automatically as you define new channels.

TESLA Summation Function Configuration	
Scale Factor	Specify a Scale Factor and a Rotation for each of the inputs. TESLA applies the scale factor to measurements in the Secondary domain. When converting to the Primary domain, TESLA applies the scale factor of the first defined input. Click *Show Primary Units* to see how this affects the summation calculation. While Control Panel is in Primary Units mode, you may view and/or modify the scale factor as it would apply in the Primary domain. When you click *Show Secondary Units*, TESLA Control Panel shows you the equivalent scale factor in the Secondary domain.
Angle Offset	With Settings Version 4 and above specify an angle offset.
Limit	Specifies the magnitude and rate of change trigger levels.
Delay	Requires the element to be energized before and active state is determined. Settable from 0 to 1,200 seconds in half-cycle increments.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Sequence Component Channels

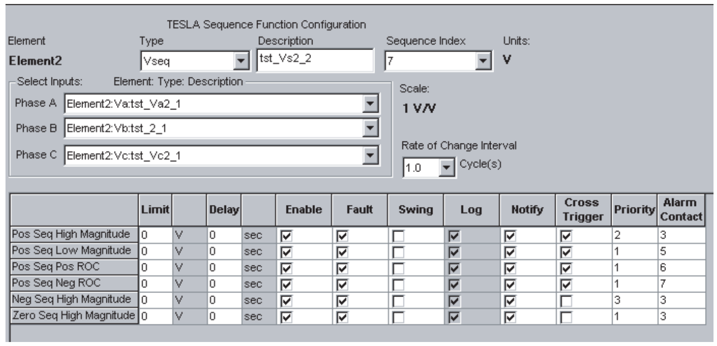


Figure 7.15: Sequence Function Configuration

The menu entry New Sequence Functions is used to add a Sequence Function Channel.

12 Select *Sequence Functions* in the tree. If the Channel Tree is showing, expand Sequence Functions under the appropriate Channel Group and choose an unallocated channel. Use new sequence to add a sequence set—positive, negative and zero.

13 Right-click and select *New Sequence Function*—select a choice of voltage or current sequence set. Only one voltage sequence or one current sequence per element is supported.

14 When you chose a channel type, the right pane displays a channel configuration screen.

For information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA Sequence Function Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Selected for you based on the channel type you just selected.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Sequence Index	Identifies the internal sequence channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual sequence channels will be used. Each channel group has 6 available sequence channels. Select any available channel. If the only option is “undefined”, you have already used all available sequence channels.
Element Type Description	Identifies the channels used to create the sequence set. The list includes all analog input or summation channels which have already been defined. It grows automatically as you define new channels.
Scale Factor	A Scale Factor and a rotation for each of the inputs can be specified.

TESLA Sequence Function Configuration	
Rate of Change Interval	Period of time over which both positive and negative rate of change is measured. 0.5 to 8.0 cycles.
Limit	Specifies the magnitude and rate of change trigger levels.
Delay	Requires the element to be energized before an active state is determined. Settable from 0 to 1,200 seconds in half-cycle increments.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Impedance Channels

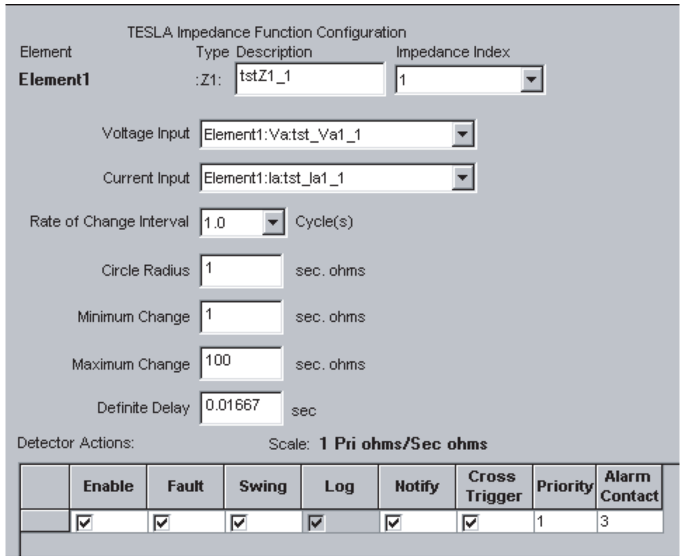


Figure 7.16: Impedance Configuration Screen

The menu entry New Impedance is used to add an Impedance Channel.

1 Select *Impedance Functions* in the tree. If the Channel Tree is showing, expand Impedance Functions under the appropriate Channel Group and choose an unallocated channel.

2 Right-click and select *New impedance*.

3 The Impedance function continuously recalculates the apparent impedance from the configured 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.

4 When you chose a channel type, the right pane displays a channel configuration screen.

For information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA Impedance Function Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Fixed as Z1, automatically used as part of the channel’s name.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).

TESLA Impedance Function Configuration	
Impedance Index	Identifies the internal 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. Each channel group has 9 available impedance channels. Select any available channel. If the only option is “undefined,” you have already used all available channels.
Voltage 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.
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.
Rate of Change Interval	Period of time over which both positive and negative rate of change is measured. 0.5 to 8.0 cycles.
Circle Radius	Specifies impedance circle to be modified.
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.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Watts and Vars Channels

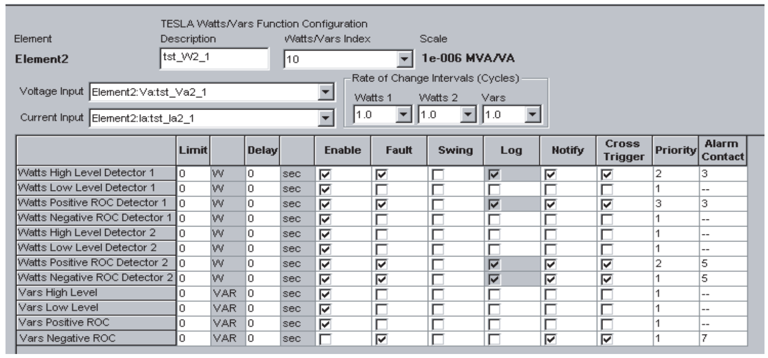


Figure 7.17: Watts/Vars Configuration

The menu entry New Watts/Vars Function is used to add Watts/Vars Function Channel.

1 Select *Watts/Vars Functions* in the tree. If the Channel Tree is showing, expand Watts/Vars Functions under the appropriate Channel Group and choose an unallocated channel.

2 Right-click and select *New Watts/Vars Function* from the shortcut menu.

3 When you chose a channel type, the right pane displays a channel configuration screen.

For information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA Watts/Vars Function Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Fixed as W/V, automatically used as part of the channel’s name.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Watts/Vars Index	Identifies the internal watts/vars set channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual channels will be used. Each channel group has 9 available watts/vars channels. Select any available channel. If the only option is “undefined”, you have already used all available channels.
Scale Factor	A Scale Factor and a rotation for each of the inputs can be specified.
Voltage Input	Identifies the 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.

TESLA Watts/Vars Function Configuration	
Current Input	Identifies the 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.

Rate of Change Interval	
Watts 1	Period of time over which both positive and negative rate of change for Watt Detector 1 is measured. 0.5 to 8.0 cycles.
Watts 2	Period of time over which both positive and negative rate of change for Watt Detector 2 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 magnitude and rate of change trigger levels.
Delay	Requires the element to be energized before an active state is determined. Settable from 0 to 1,200 seconds in half-cycle increments.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Frequency Channels

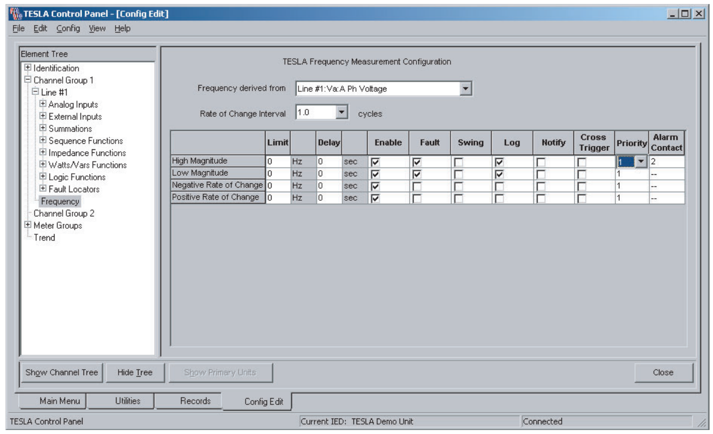


Figure 7.18: Frequency Channels

The menu entry New Frequency is used to add a Frequency Channel.

1 Select *Frequency* in the tree.

2 Right-click and select *New Frequency*. Unlike the other calculated channels, there is only one frequency channel per Channel Group.

3 When you chose a channel type, the right pane displays a channel configuration screen.

For more information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

For information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA Frequency Measurement Configuration	
Frequency derived from	Identifies the analog input channel on which to measure frequency.
Rate of Change Interval	Period of time over which both positive and negative rate of change is measured. 0.5 to 8.0 cycles
Limit	Specifies the magnitude and rate of change trigger levels. High magnitude limit is 7/6 x nominal frequency, low magnitude limit is 5/6 x nominal frequency.
Delay	Requires the element to be energized before an active state is determined. Settable from 0 to 1,200 seconds in half-cycle increments.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable

TESLA Frequency Measurement Configuration	
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Logic Channels

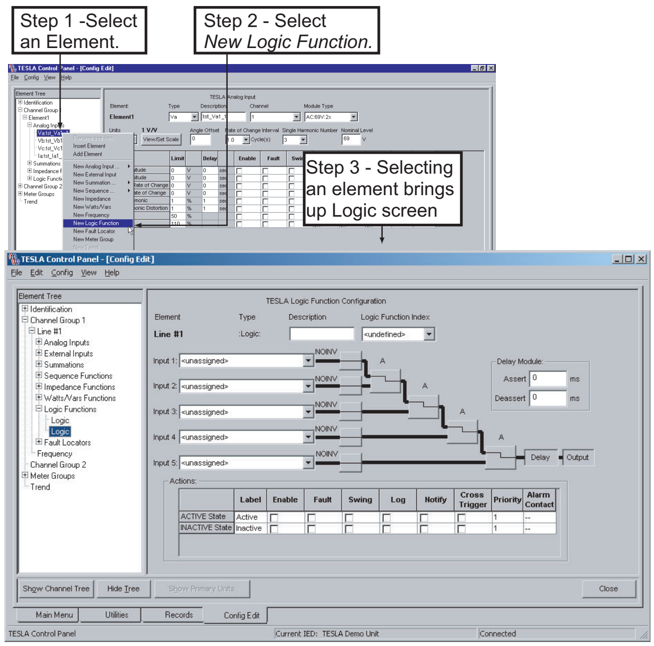


Figure 7.19: Logic Channel

The menu entry New Logic Function is used to add a Logic Function Channel.

1 Select *Logic Function* in the tree.

2 Right-click and select *New Logic Function*. The menu entry New Logic adds a logic channel. You can choose up to 5 state values from all the defined detectors in the channel group. Each of these may be inverted, and a chain of logic operations are performed on the 5 state values. Transitions in the resultant state may be delayed as required by the application.

3 When you chose a channel type, the right pane displays a channel configuration screen.

For more information about Settings for triggers and actions see “Triggers” on page 7-28 and “Actions” on page 7-29.

TESLA Logic Function Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	The type is fixed as “Logic.”
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
Logic Function Index	Each channel group has 15 available logic channels. Select any available channel. If the only option is “undefined,” you have already used all available channels.
Inputs 1–5	Select from previously defined detectors.
Delay Module	Assert—selectable from 0 to 20,000 ms in half-cycle increments. Deassert
Gates	NOT, AND, NAND, OR, NOR, Exclusive OR, and Exclusive NOR.
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Fault Locator Channels

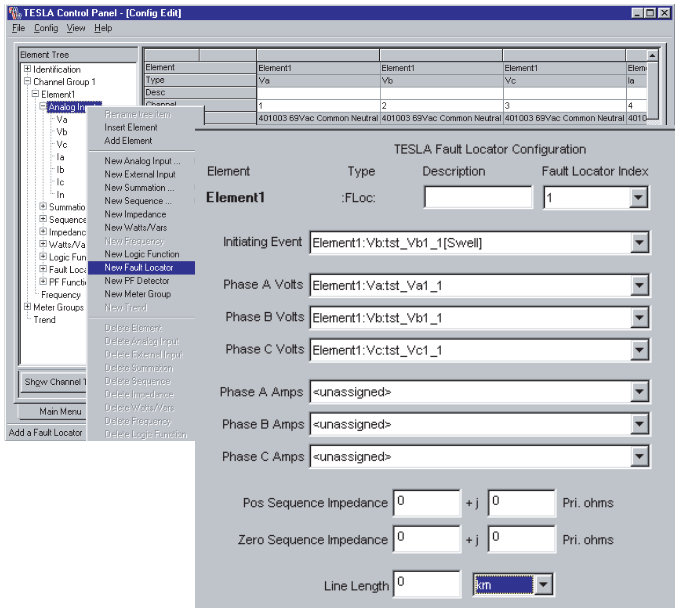


Figure 7.20: Fault Locators

The menu entry New Fault Locator is used to add a Fault Locator Channel.

1 Select *Fault Locator* in the tree.

2 Right-click and select *New Fault Locator*. The menu entry New Logic adds a logic channel.The fault locator channel monitors 3 line voltage inputs and 3 line current inputs. When an "assert" transition occurs, the phase information collected is used to determine the location of the fault from the line conditions monitored prior to the transition. The line parameters refer to the total line length. The distance may be indicated in miles or kilometers.

3 When you chose a channel type, the right pane displays a channel configuration screen.

TESLA Fault Locator Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Fixed as "FLoc."
Description	Extends the channel name if it requires further description to make it unique (see "Planning Your Configuration" on page 6-6).
Fault Locator Index	Each channel group has 5 available fault locator channels. Select any available channel. If the only option is "undefined," you have already used all available channels.
Initiating Event	Select from previously defined detectors.

Power Factor Channels

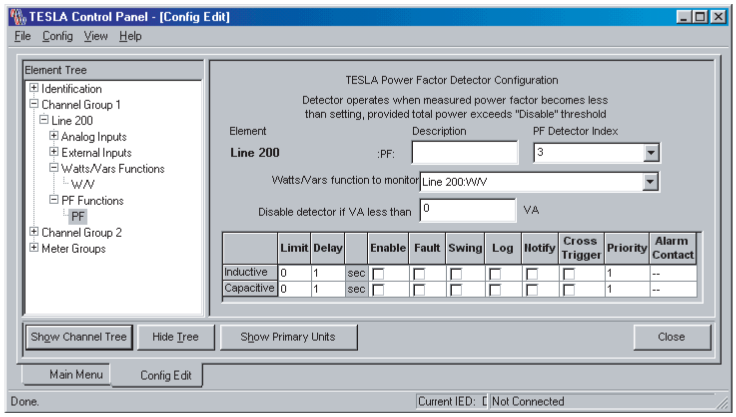


Figure 7.21: Power Factor Channels

The menu entry New Power Factor is used to add a Power Factor Channel.

1 Select *Power Factor* in the tree.

2 Right-click and select *New PF Detector.* The Power Factor Detector monitors the watts, vars, and volt-amps values computed by a watts/vars function 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.

3 When you chose a channel type, the right pane displays a channel configuration screen.

TESLA Power factor Detector Configuration	
Element	Selected from the Channel Tree the element is variable. Selected from the Element tree the element is fixed.
Type	Fixed as PF.
Description	Extends the channel name if it requires further description to make it unique (see “Planning Your Configuration” on page 6-6).
PF Detector Index	Each channel group has 9 available PF channels. Select any available channel. If the only option is “undefined,” you have already used all available channels.
Watts/Vars function to monitor	Select from previously defined detectors.
Disable detector if VA less than	Can be set using 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.

TESLA Power factor Detector Configuration	
Enable	Enable/disable
Fault	Enable/disable
Swing	Enable/disable
Log	Enable/disable
Notify	Enable/disable
Cross Trigger	Enable/disable
Priority	1, 2, 3
Alarm Contact	2, 3, 5, 6, 7 – 36 channel TESLA 2, 3 – 18 channel TESLA

Triggers

You can apply trigger conditions to each input or calculated channel. The trigger parameters for each channel are included in that channel's configuration screen, as detailed above.

High and Low Magnitude Triggers

The magnitude triggers are used to detect conditions where the channel's signal is outside of the defined threshold. For analog input channels, the magnitude of the fundamental is used. The Limit parameter defines the trigger threshold in units defined in the Units field above. The Delay parameter specifies the minimum duration of the condition required to initiate a trigger.

To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers. Frequency magnitude triggers have a fixed 0.02 Hz hysteresis. Power factor triggers have a fixed hysteresis of 0.05.

Positive and Negative Rate of Change Triggers

Rate of change detectors are used to detect conditions where the channel's signal is changing at a rate outside the defined boundary. The Rate of Change Interval determines the period over which the signal change is evaluated. Longer intervals can be used to reduce nuisance triggers due to short-term signal; shorter intervals improve pick-up time. The other part of the rate of change setting is the Limit, which sets the amount of change which can occur over the specified interval. The Delay parameter specifies the minimum duration of the condition required to initiate a trigger.

Some channel types (e.g. Watts/Vars) have a number of Rate of Change Interval settings to provide greater flexibility.

THD Triggers

THD magnitude triggering is available on all analog input channels. The Limit parameter specifies the percentage of THD. The Delay parameter specifies the minimum duration of the condition required to initiate a trigger.

Single Harmonic Triggers

A trigger on the magnitude of a selected individual harmonic is available on all analog input channels. The Single Harmonic Number parameter sets the target harmonic. The Limit parameter specifies the percentage of fundamental of the harmonic. The Delay parameter specifies the minimum duration of the condition required to initiate a trigger.

External Input and Logic Triggers

External Input and Logic triggers are available for either or both state edges. The Definite Delay parameter specifies the minimum duration of the condition required to initiate a trigger for an external input. Individual delay settings are available for each transition of logic channels. Logic triggers are generated when the state of the logic output changes.

Sag and Swell

Sag and Swell triggers are available for ac voltage channels. The magnitude thresholds used by Sag and Swell detectors for a channel are defined in terms of a Nominal Value, which must be defined for that channel.

> With a Definite Delay of 0, the recorder still requires that a state change be present for a minimum of four consecutive samples to be considered valid.

Impedance Triggers

Impedance triggers are available on calculated Impedance channels. The rate of change of impedance is calculated as the movement of the calculated impedance in the complex plane over the Rate of Change Interval. If that movement is between the Minimum Change and Maximum Change values, the detector becomes active. If the calculated value of impedance is outside a “circle of interest,” the trigger is automatically disabled. The centre of the “circle of interest” lies at the origin, and its radius is user-specified.

Actions

When a trigger occurs, a number of independent actions can be initiated.

Record Fault

The recorder makes/continues a high speed transient fault recording.

Record Swing

The recorder makes/continues a low speed dynamic swing recording.

Log

The recorder enters a message into the Event Log.

Cross-Trigger

The recorder activates the Cross-Trigger contact output, enabling other recorders to activate on the same event.

Alarm Contact

One of the alarm contacts (2, 3, 5, 6, or 7) that may be activated as a result of the trigger.

Notify

The recorder attempts to place a call through the attached modem to the RecordBase Central Station.

Priority

Each individual trigger detector can be assigned a priority level from 0 to 3, with 3 being the highest priority. Notify contains settings to control the dial-out process and the initiation of record transfers, see “Notify” on page 5-10.

The priority number is used to assign a priority to each record. The record’s priority is based on the highest priority event contained in the record. The record priority is shown as part of the record summary.

Meter Groups

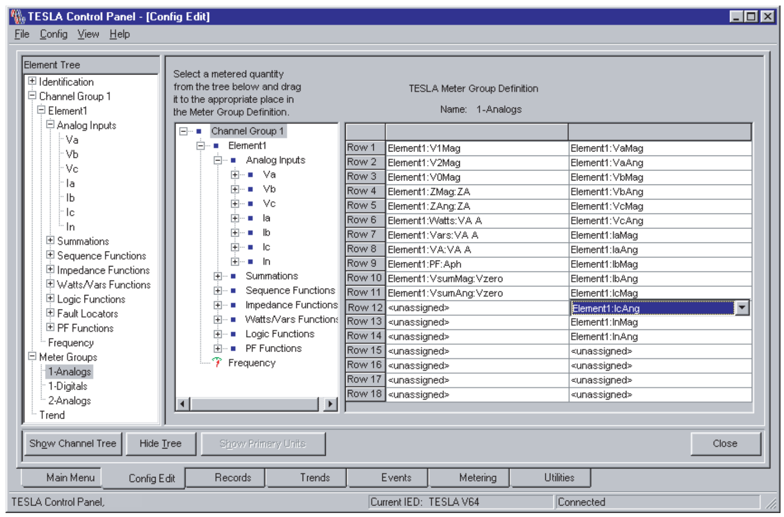


Figure 7.22: Add Meter Group Screen

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 for a total of ten metering groups in all.

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 utilize the first channel of each Channel Group as a reference channel for the angle measurement “Phase Angle Metering Reference” on page 6-6.

Trends

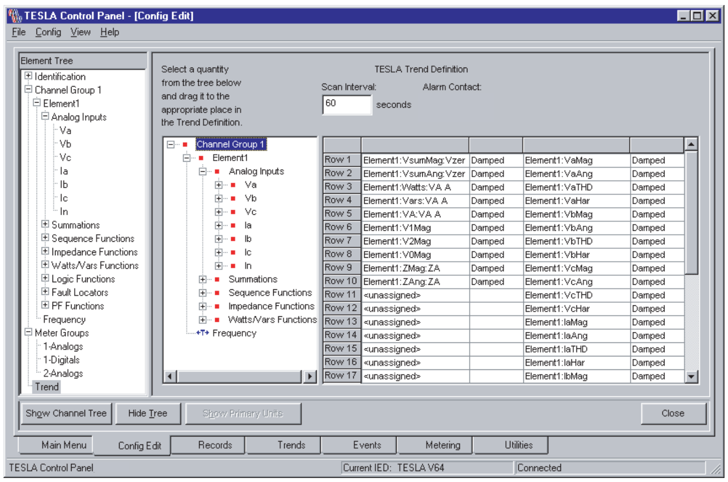


Figure 7.23: Configuration showing Trends

To define a trend 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. When you define a trend, specify up to 60 trended channels selected from the measured and derived channels defined in your recorder. The trending process supports long term event logging.

At regular intervals (the Scan Interval), TESLA records a value for each of the trended channels. You can set the interval from 10 seconds up to 3,600 seconds.

TESLA accumulates up to 3 months of trend data and activates an alarm when the amount of accumulated data exceeds a specified number of days. Choose which contact is used in the Trend Definition display. This contact may not be used for any other purpose. Specify the number of days threshold and the enabled state of the alarm in the Utilities screen, for details see “Recording” on page 5-7.

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.

Choose a *Process Option* for each trended channel.

The Process Option is defined as follows:	
Damped (default)	TESLA records a value representative of the measurements during the interval.
Undamped	TESLA records the last value measured during the interval.
Avg	TESLA records the average measured value over the interval.
Min	TESLA records the minimum measured value over the interval.
Max	TESLA records 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 a Configuration

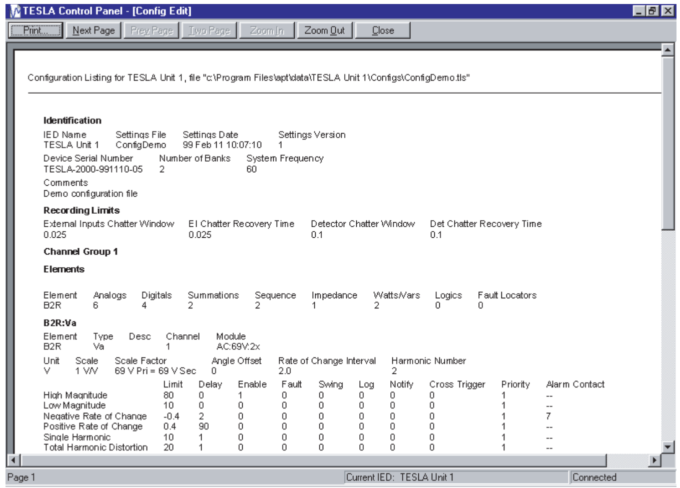


Figure 7.24: Print a Configuration

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 Modbus Address List

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.

Printing a DNP Address List

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.

8 External Connections and Metering

Reference connection Appendix drawing, “AC Analog Connections” in Appendix H and “Specifications” in Appendix A for ratings.

Analog Input Channels

The recorder’s 18 or 36 analog inputs are generic, low level (5 V peak) non-isolated signal inputs that take their input from external isolation modules.

Any analog input can be connected to any isolation module. The configuration of a channel as a voltage or current and channel scaling is handled by channel definitions in the downloadable configuration.

When an input module is changed or moved to a different channel, a calibration should be performed (see “Analog Input Calibration” on page 8-5).

Analog Input Isolation Modules

The recorder requires the use of ERLPhase external isolation input modules for voltage and current inputs. The isolation modules provide scaling, isolation and surge protection. Module outputs are low level voltage signals which feed directly into the recorder’s analog inputs. The modules are mounted on DIN rails to make wiring easier and minimize rack space requirements.

The isolation modules can be located up to 100 feet away from the recorder. Shielded wire (e.g. Belden 9730 - three pair or 9728 - four pair) is recommended with the ground attached only at the recorder end.

> All analog input modules must be grounded via the ground stud on the module.
>
> Each output channel of an isolation module should be connected to no more than one TESLA input channel.

The isolation module outputs use matched source and load impedance to minimize noise susceptibility.

AC Voltage Input Module

This ac 3 channel isolated voltage input module provides isolation and scaling for three ac voltage channels. Nominal voltage is 69 V RMS with a 2x over-range capability (see “AC Voltage Input Module” in Appendix I).

There are two models of ac voltage modules:

1 Common Neutral: (Model 401003) Four input terminals for VA, VB, VC, N. Use Model 401003; 69 Vac Common Neutral as the module type for analog inputs using these modules.

2 Independent Neutral: (Model 401006) Six input terminals for VA, Neutral, VB, Neutral, VC, Neutral. Use Model 401006; 69 Vac Isolated Neutral as the module type for analog inputs using these modules.

Both voltage models have two output terminals for each of the three phases. The positive reference polarity is marked by a dot.

AC Current Input Module

This ac 4 channel isolated input current module provides isolation and scaling for four independent ac current channels. Nominal current is 5 A RMS with a 20x over-range capability for 1 second.

There are three models of ac current modules:

1. Model 401002: use Model 401002; 5 A ac as the module type for analog inputs using these modules.
2. Model 401014: Model 401014 is the same as Model 401002, but has improved phase angle accuracy at lower current values. Use Model 401014 5 A ac as the module type for analog inputs using these modules.
3. Model 401020: use Model 401020; 1 A ac as the module type for analog inputs using these modules.

The module has input and output terminal pairs for I1 through I4. The polarity is marked by a dot on both the input and output terminals.

Split-Core CT (5A, 20x)

This Split Core Current Transformer (Model 401013) is an optional input device used where it is difficult to get an outage to install in circuit ERLPhase current modules (Model 401002, Model 401014; 4 CT Modules). These CTs are designed to clamp around the secondary circuit wires from the primary current transformers. The split core CT option installs quickly and easily. The outputs from the CTs are impedance matched to connect directly to the TESLA's analog input connectors.

There are two models of ac split core CTs:

1. Use Model 401013; 5 A split-core as the module type for analog inputs using these modules.
2. Use Model 401017; 1 A split-core as the module type for analog inputs using these modules

Clamp-on CT

This Clamp-on CT (Model 401012) is an optional input device used where it is difficult to get an outage to install in circuit ERLPhase current modules (Model 401002, Model 401014; 4 CT Modules). These CTs are designed to clamp around the secondary circuit wires from the primary current transformers. The Clamp-on CT option installs quickly and easily. Use Clamp-on for quicker, more portable installation. The outputs from the CTs are impedance matched to connect directly to the TESLA's analog input connectors. Use Model 401012; 5 A clamp-on as the module type for analog inputs using these modules.

DC Module

This module is an optional input device to provide dc-coupled isolation and scaling for four independent dc or ac voltage or current channels. These channels have a dc to 2 kHz bandwidth but are limited to 1.5 kHz by antialiasing filters inside the recorder. Externally mounted resistors set the input type and full scale range (see "DC Input Module" in Appendix L). Use Model 401016 DC as the module type for analog inputs using this module.

AC Low Voltage Input Module

This 4 channel isolated ac voltage input module provides isolation and scaling for four low voltage channels. Nominal input voltage is 4 Vrms with a 7 Vrms overvoltage capability. Maximum input level is 12 Vrms continuous, 15 Vrms for 10 seconds. Use 401022; Low V as the module type for analog inputs using these modules (see “AC Low Voltage Input Module” in Appendix M).

External Input Channels

The recorder’s external inputs are dry inputs intended for use with signals from a 48 Vdc or 125 Vdc station battery. The external inputs are isolated and protected against transient surges. The external inputs activate at approximately 18 Vdc. Other station battery voltage ranges are available.

For recorders with serial number TESLA-2000-021010-01 or later the external input boards have an operational voltage range from 48 Vdc to 250 Vdc. The external inputs 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 (Check Note following for details.)
2. User-configurable
3. User-configurable
4. Cross-trigger, Channel Group 1

Additional, for 36/64 channel units:

1. User-configurable
2. User-configurable
3. User-configurable
4. Cross-trigger, Channel Group 2

The Cross-trigger contact is used to initiate recording on another recorder when this unit triggers. On 36/64 channel units, contacts 4 and 8 should be connected in parallel.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.

> For recorders with s/n 981103-xx or 990318-xx: Contact 1: Recorder fail. Open on failure.
>
> For recorders with s/n 991110-xx or later: Contact 1: Recorder fail. Closed on failure.

The user-configurable alarm contacts can be defined for use as part of the recorder’s overall configuration (see “Actions” on page 7-29).

IRIG-B Time Signal

The BNC connector on the rear of the unit accepts either modulated or unmoduled IRIG-B time signals.

Communication Ports

To access user interface and SCADA services see “Communication Ports for Recorder” on page 3-1 and “Communication Ports for Portable Recorder” on page 3-2.

Power Supply

Model 2000

TESLA comes with a wide range power supply. The nominal operating range is 48 to 250 Vdc, 120 Vac, 50/60 Hz. We recommend that you use an inline fuse or circuit breaker with a 5 A rating to protect against possible short circuit in the supply. Make the chassis ground connection to ensure proper operation and safety. There are no power switches on the recorder. When the power supply is connected, the recorder starts its initialization process.

Model 2000/P

TESLA Portable comes with a wide range power supply. The nominal operating range is 48 to 250 Vdc, 120 Vac, 50/60 Hz. Make the chassis ground connection to ensure proper operation and safety. An ac power cord is used to connect to the ac power source. Binding posts are used to connect to a dc power source. A three position power switch is used to turn the LED On or Off. You can select AC, Off or DC positions.

Case Grounding

WARNING!

To ensure safety and proper operation you must connect the recorder to the station ground using the rear grounding terminal on the recorder.

Ground the recorder even when testing.

Do not rely on the rack mounting screws to provide case grounding.

You must ground TESLA to station ground using the case-grounding terminal at the back of the recorder or green binding post on the front of the portable recorder.

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.

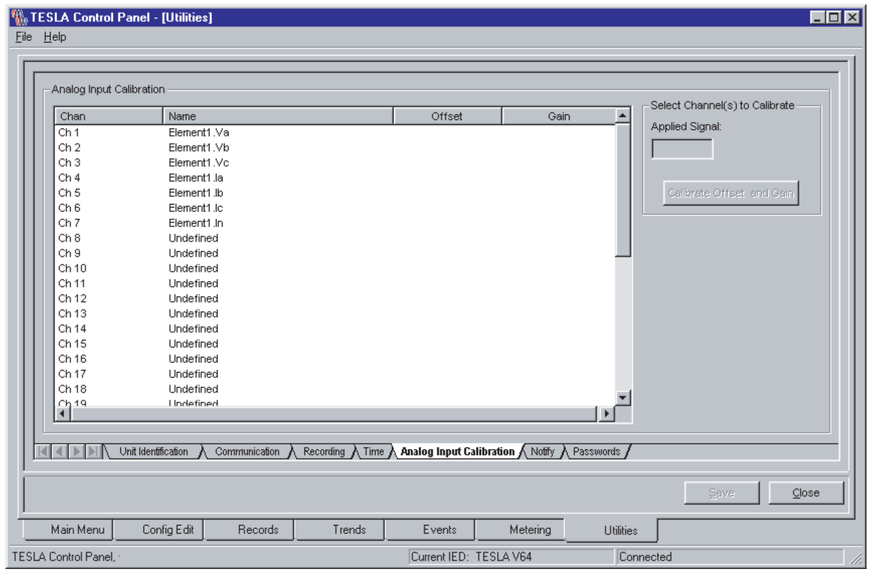


Figure 8.1: Analog Input Calibration

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 8-5).

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.

Metering

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

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

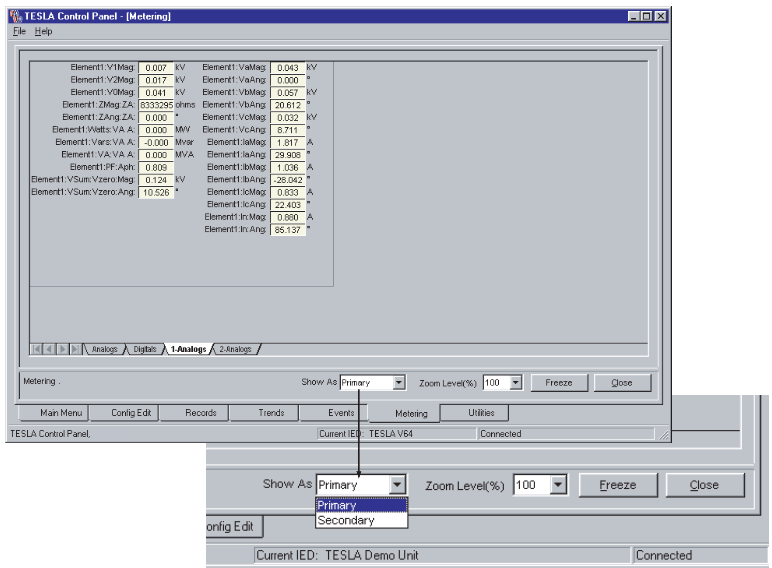


Figure 8.2: Metering Display

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 7-30).

Display Zoom

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

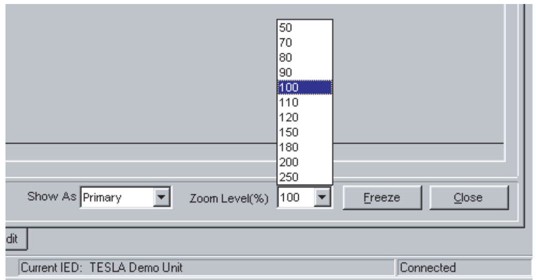


Figure 8.3: Zoom Level

Freeze

The Freeze button provides a means of temporarily stopping 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 utilize the first channel of each Channel Group as a reference channel for the angle measurement (see “Phase Angle Metering Reference” on page 6-6).

9 Record Management and Display

Record Listing, Transfer and Management

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

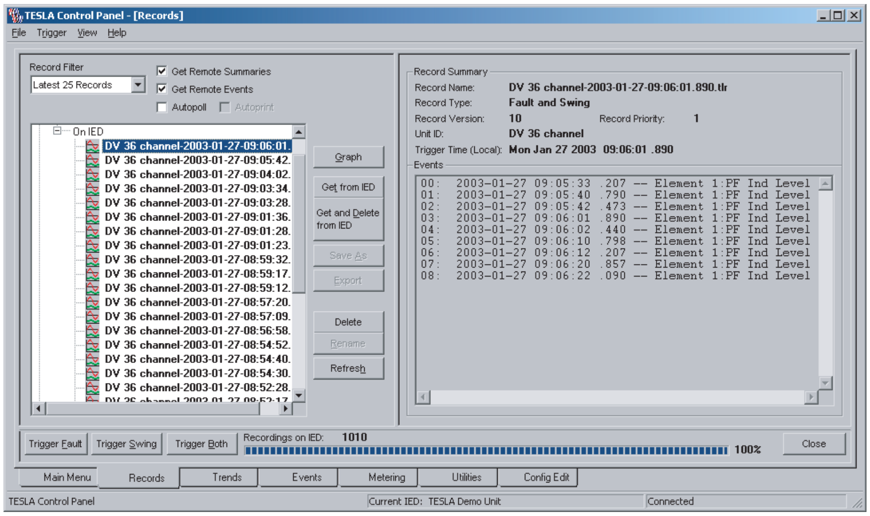


Figure 9.1: Record Listing

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 the TESLA Control Panel are shown on the *Local* heading. The corresponding records under the *On IED* heading are shown in regular font. 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 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.

Fetch Remote Summaries/Fetch Remote Events

When both *Fetch Remote Summaries* and *Fetch Remote Event* 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. Alternatively you can launch RecordBase by double-clicking the desired record (see "Graphing Records" on page 10-1).

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 remove the record from the IED.

Get from IED and Delete

Selecting a record file under *On IED* and operating the *Get from IED and Delete* button causes a record file on the IED to be transferred from the recorder to your local computer and then deleted from the IED. More than one file can be transferred at a time using Windows file selection function (*Control/Shift* + *left-click*).

Save As

Selecting a local record and selecting the *Save As* button copies a record to a diskette or a network drive. 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 (see "Record Export Utility" on page 11-1).

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. A file on IED cannot be renamed (button greyed out).

Refresh

Selecting *Refresh* updates the *Recordings* screen. It checks the Local computer and the remote IED (if connected) for new and stored files. Then it updates Control Panel's records database and refreshes the screen.

Trigger Fault

Operating this button causes the recorder to operate and generate a Transient or High Speed Record.

Trigger Swing

Select *Swing Trigger* to operate and generate a Swing or Low Speed Record. Swing records take about a minute due to long post trigger.

Trigger Both

Select *Trigger Both* to operate and generate a combine fault and swing record.

Trigger Time (Local)

Trigger time (local) depends on the time zone setting on your computer.

Recordings Stored

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

File/Select Remote

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

Trend Listing, Transfer and Management

The trend manager services are available from the *Logging* tab, accessible from the *Main Menu*.

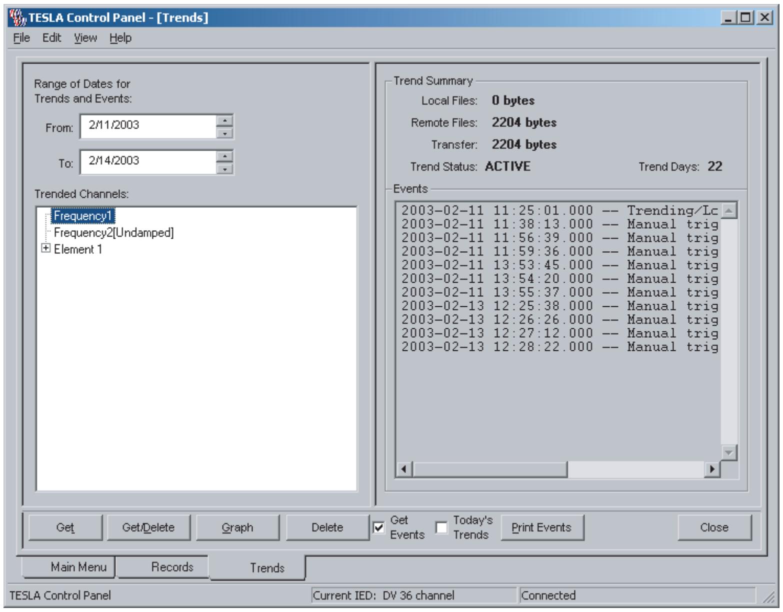


Figure 9.2: Trend Listing

Range of Dates

Set the time range using the two date control boxes, *Set Range 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.

Channel List

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

Transfer, Transfer/ Delete

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

Graph

The trend data selected via the *Set Range* and the *Channel List* is viewed with RecordGraph, ERLPhase's interactive graphing software (see "Graphing Records" on page 10-1). Any files that are not already in your computer are transferred now.

Export

The trend data selected via the *Set Range* and the *Channel List* is passed to the Export utility (see "Record Export Utility" on page 11-1). Any files that are not already in your computer will be transferred now.

Delete

The Trend data selected is removed from your computer. If you are currently connected, you have the option of removing the remote files as well.

Fetch Events

Each time you change the Range of Dates, Control Panel's Trend Manager software attempts to display any events that occurred between those dates. If you are not interested in this action, click the checkbox so that the chicanery disappears.

Today's Trends

If the currently selected Range of Dates includes data that is currently being recorded, some of the data may not be in a form that is suitable to be transferred to Control Panel. If this checkbox is selected, Control Panel will send a request to the TESLA 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 deselected by clicking the checkbox until the check mark disappears.

Print Events

A listing of events that you see in the *Events* portion of your screen is printed.

10 Graphing Records

Getting Started

RecordGraph is a tool that is 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 can be launched from RecordBase View software.

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.

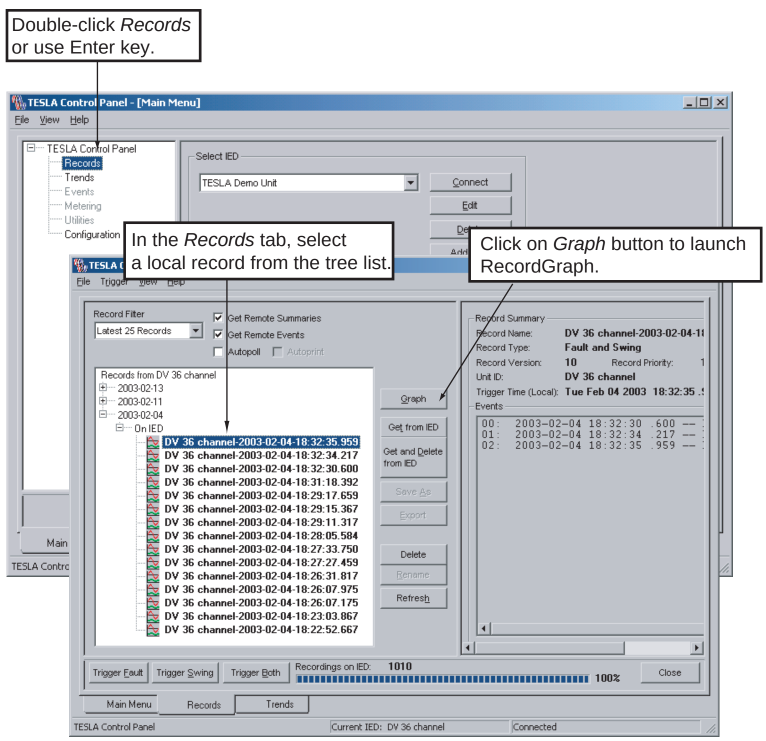


Figure 10.1: Launching RecordGraph from TESLA Control Panel

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.

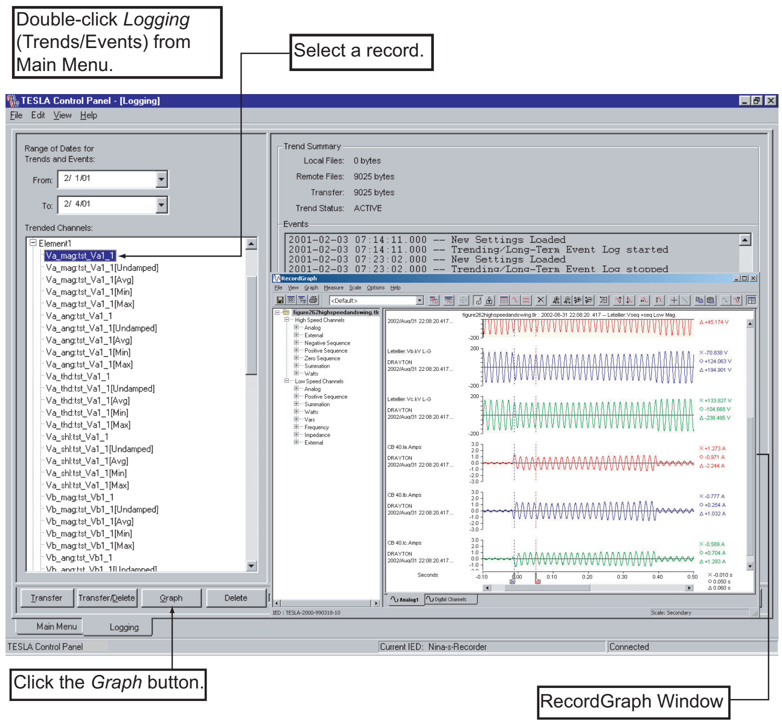


Figure 10.2: Launch from Logging (Trends/Events)

Launch RecordGraph from Windows Explorer

1 Open Windows Explorer.

2 Select a record. (It should have valid extensions, *.lpr, *.lpl, *.tpr, *.tpt, *.tlr, *.bpr,*.fpr.)

3 Right-click the selected record.

4 Choose, the *RecordBaseView>Launch Graph* option.

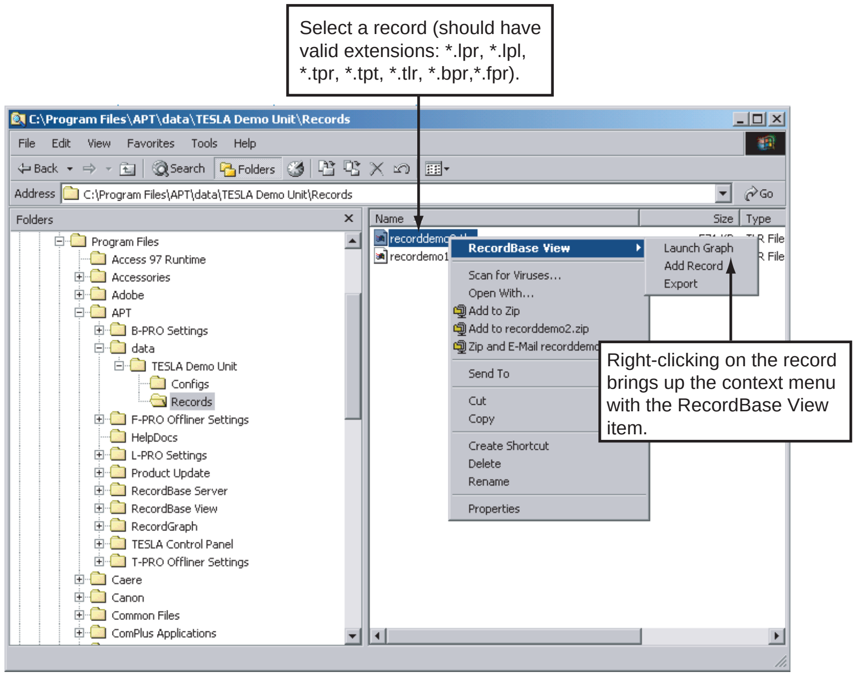


Figure 10.3: Launching RecordGraph from Windows Explorer

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*.

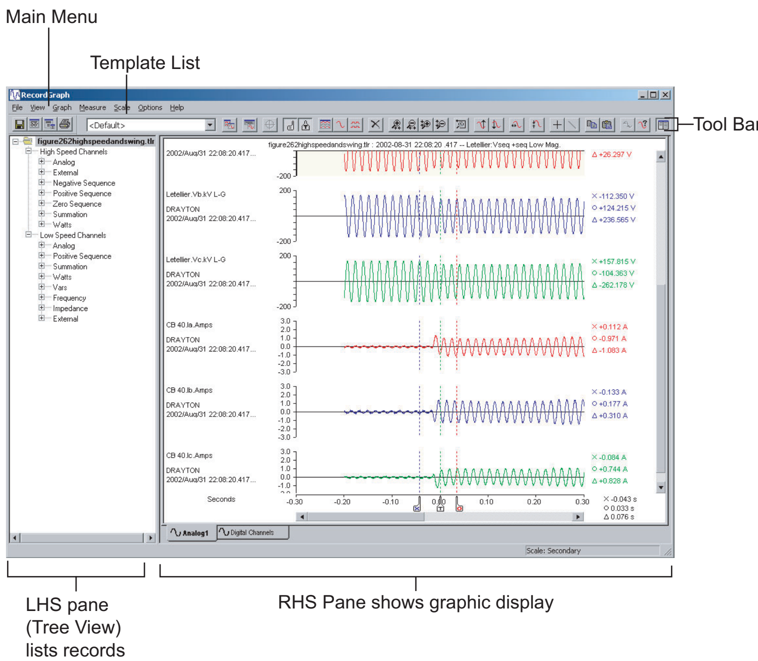


Figure 10.4: Components of RecordGraph Window

Menus

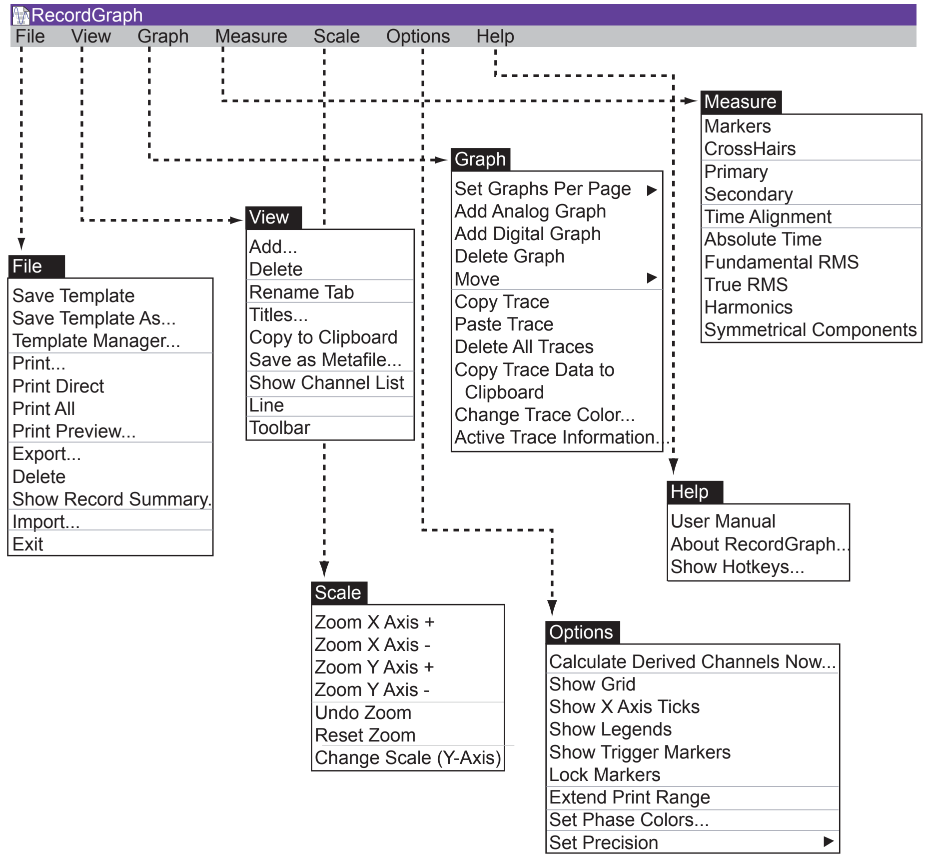


Figure 10.5: Menus

RecordGraph Menu Items

File Menus

File>Save Template

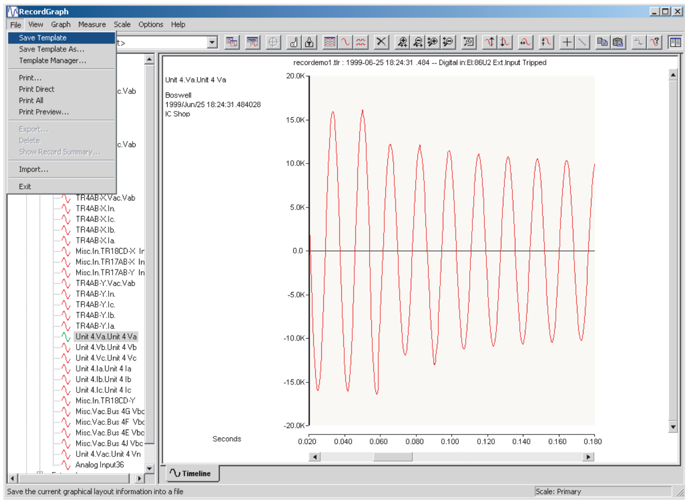


Figure 10.6: Save Template

Use this option to save the current graphical layout information to a file (see “Templates” on page 10-56 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…

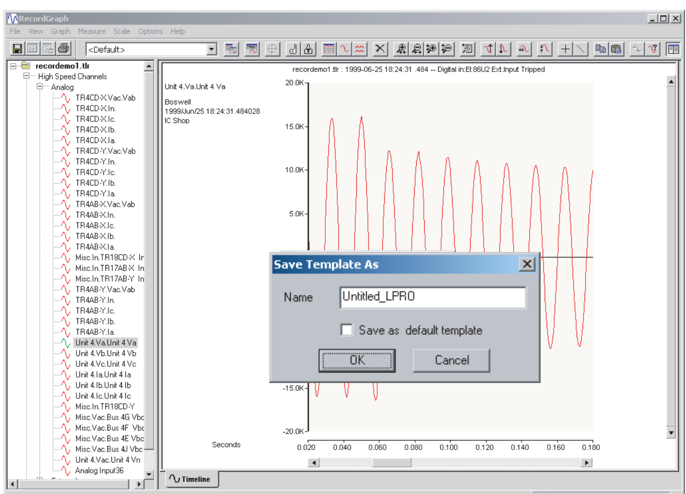


Figure 10.7: Save Template As

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 10-56).

File>Template Manager

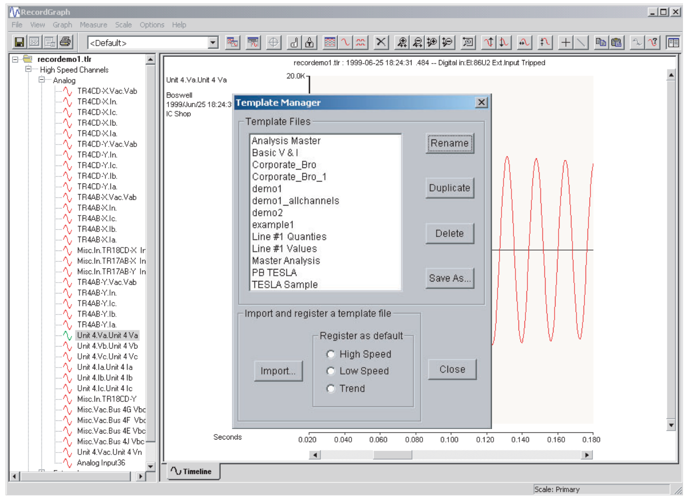


Figure 10.8: Template Manager

Rename, duplicate, save as, import or delete template files. A dialog box is displayed to manage the template files (see “Templates” on page 10-56).

File>Print

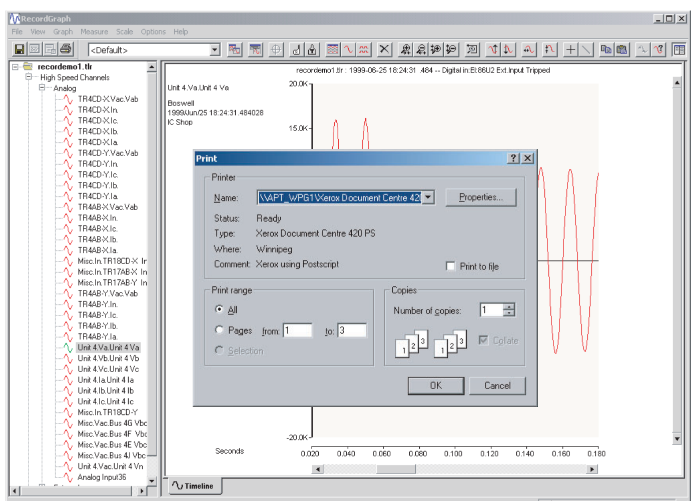


Figure 10.9: Print

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

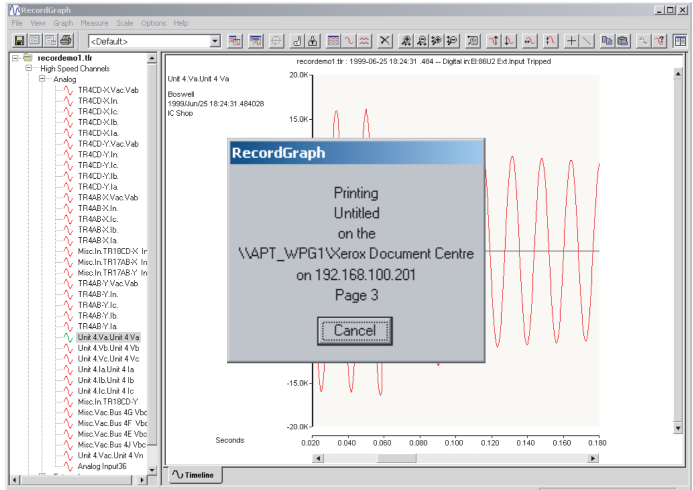


Figure 10.10: Print Direct

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

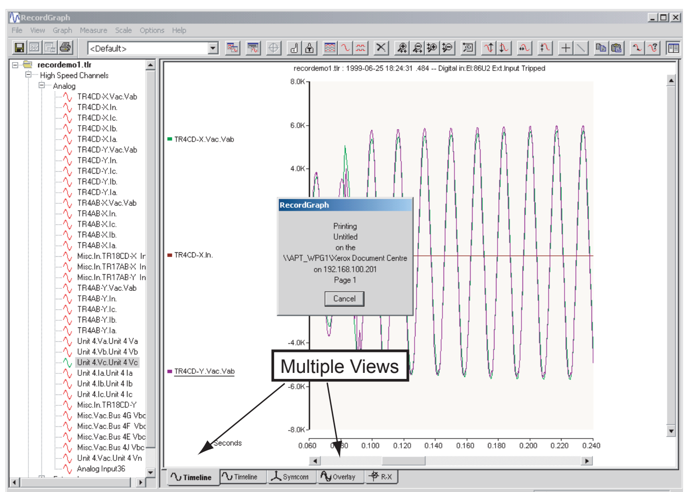


Figure 10.11: Print All

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

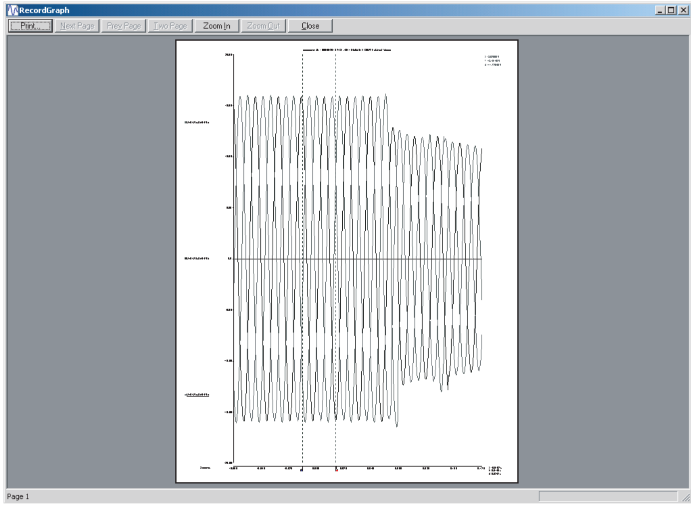


Figure 10.12: Print Preview

Display the print preview window of the active view page.

File>Export

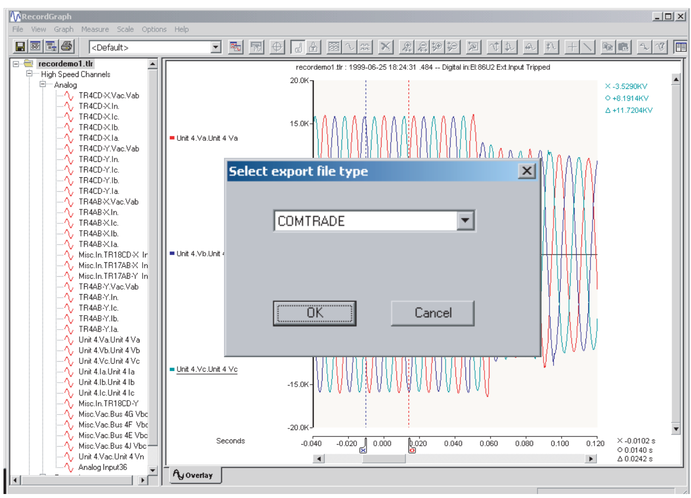


Figure 10.13: Export

Export the selected record to a user-defined format (see “Record Export Utility” on page 11-1).

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

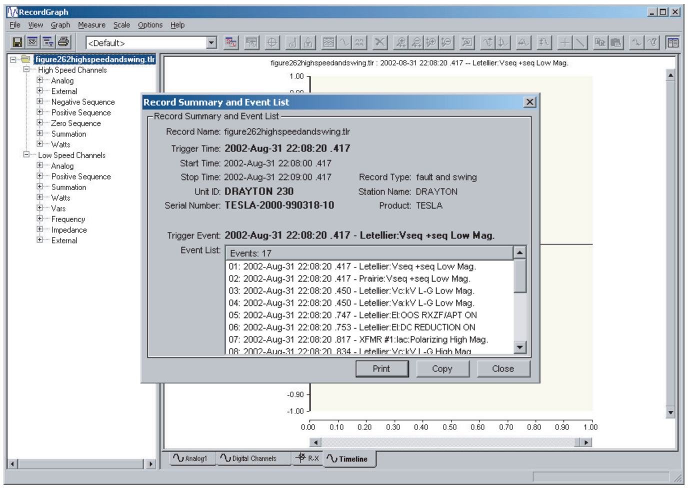


Figure 10.14: Show Record Summary

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

File>Import

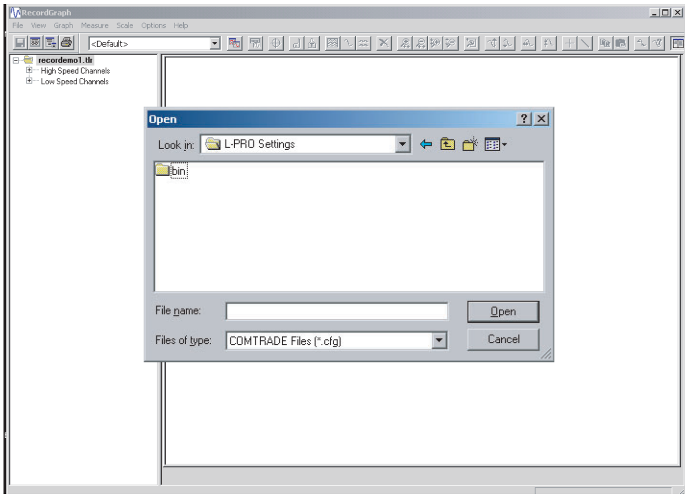


Figure 10.15: Import

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 10-32).

View>Delete

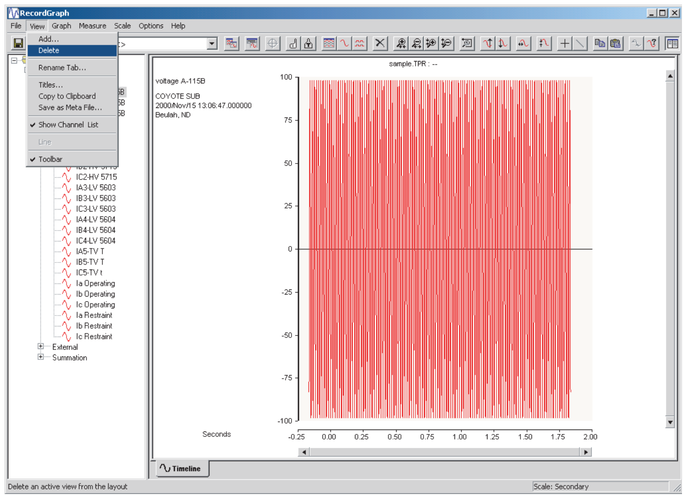


Figure 10.16: Delete

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

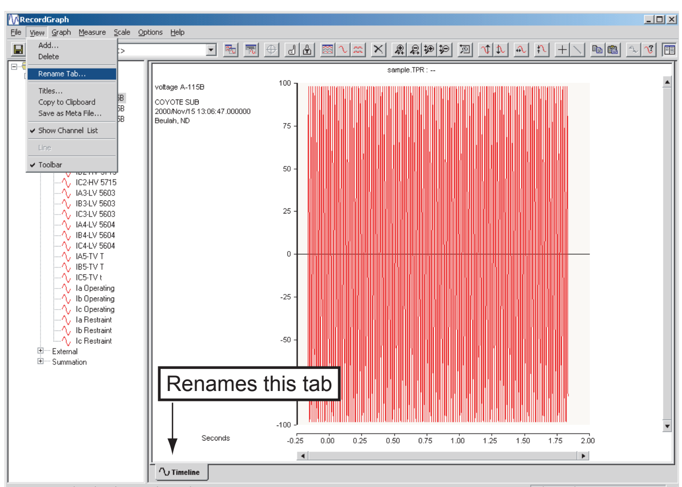


Figure 10.17: Rename Tab

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

View>Titles

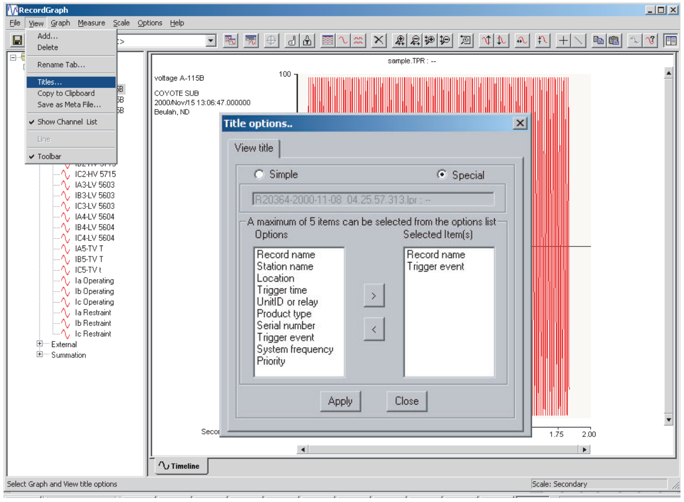


Figure 10.18: Titles

Select graph and view titles options to compile titles and various options (see "View and Graph Titles" on page 10-62).

View>Copy to Clipboard

Copy an active view to the clipboard for import to another program such as MS Word or Excel (see "Record Export Utility" on page 11-1).

View>Save As Metafile

Save an active view page as a Windows metafile (see "Record Export Utility" on page 11-1).

View>Show Channel List

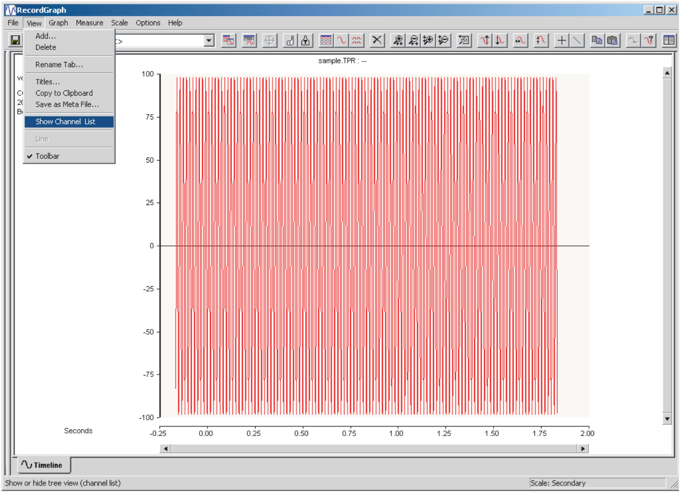


Figure 10.19: Show Channel List

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

View>Line

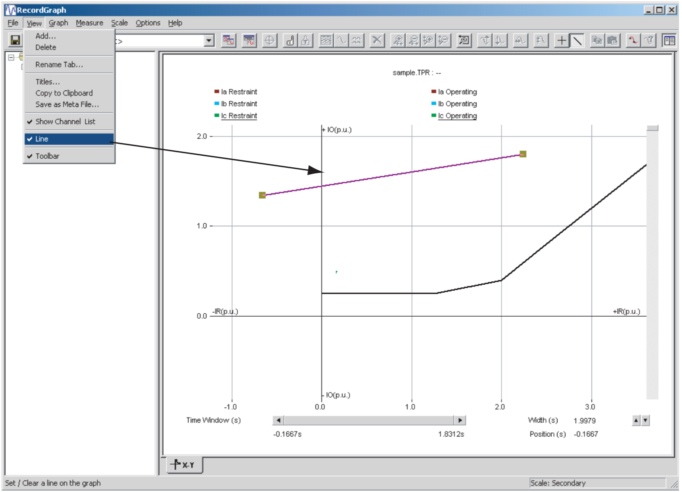


Figure 10.20: Line

Place a reference line on the graph (for Impedance and Differential views only). Use Line in conjunction with the CrossHair measurement for quick readouts. 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

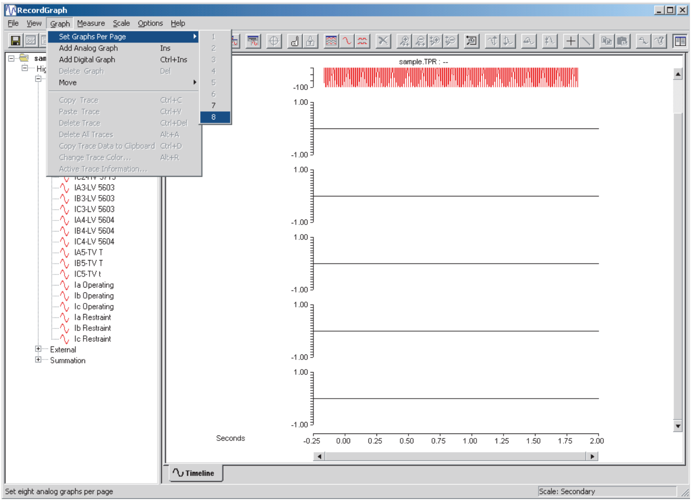


Figure 10.21: Set Graphs Per Page

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

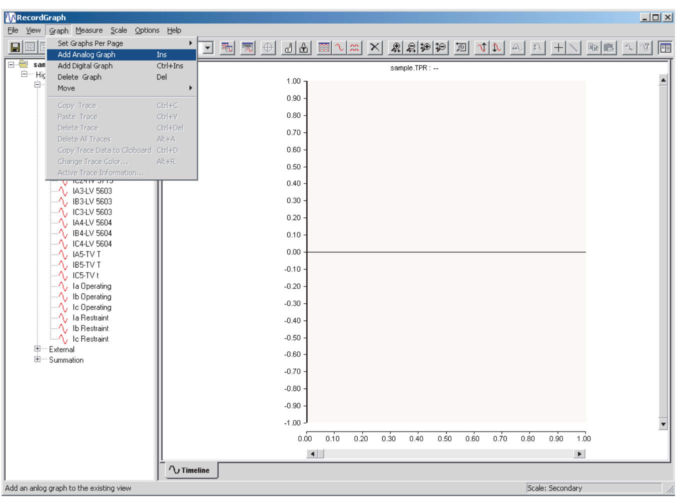


Figure 10.22: Add Analog Graph

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

Graph>Add Digital Graph

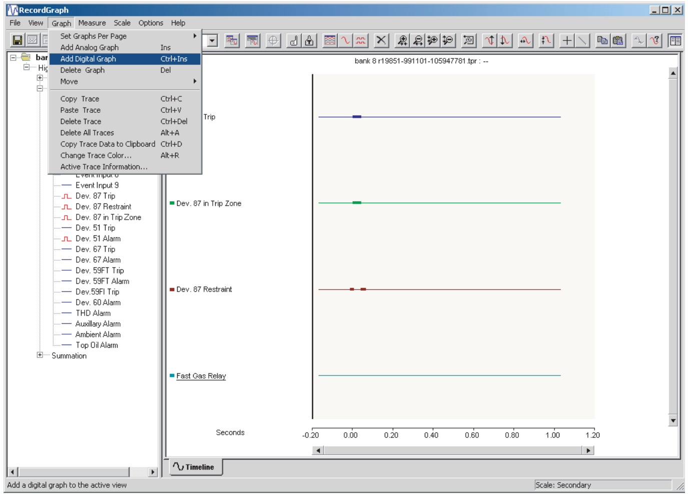


Figure 10.23: Add Digital Graph

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

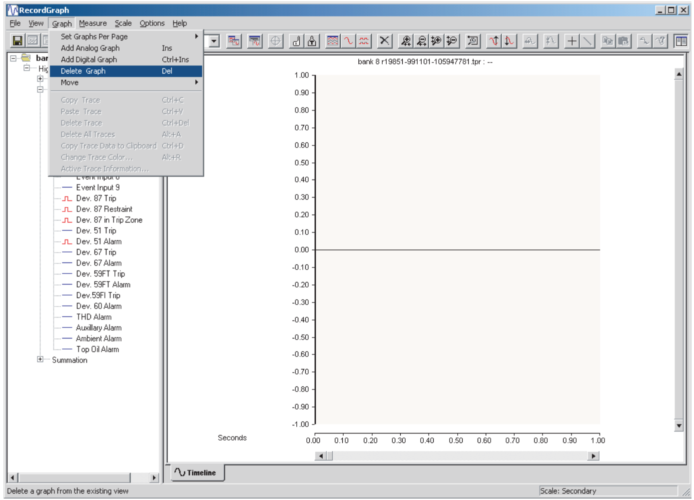


Figure 10.24: Delete Graph

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

Graph>Move

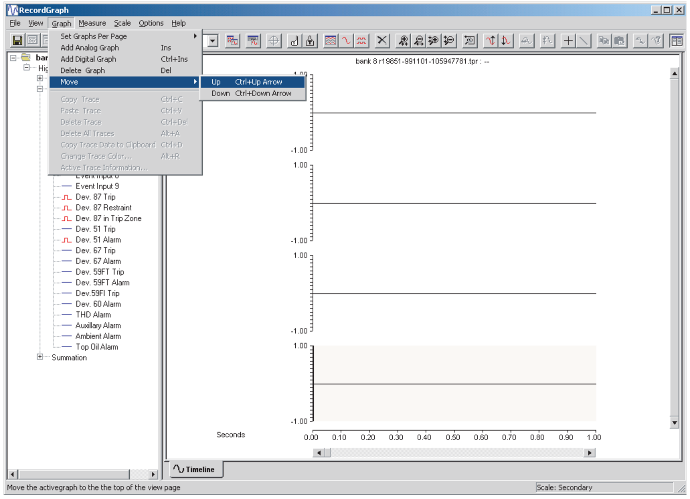


Figure 10.25: Move

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

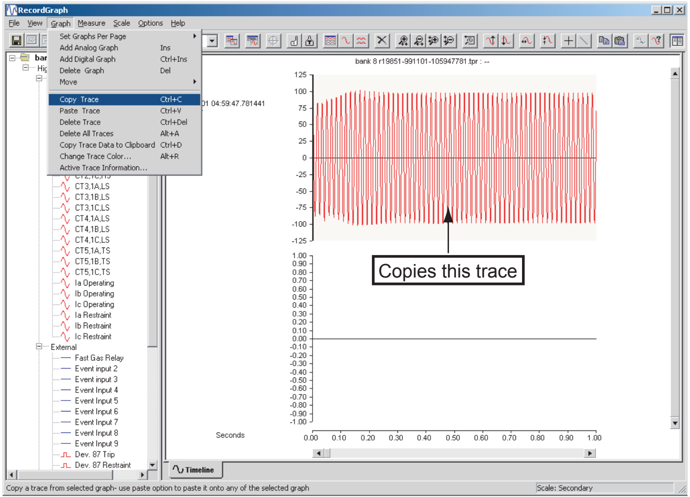


Figure 10.26: Copy Trace

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

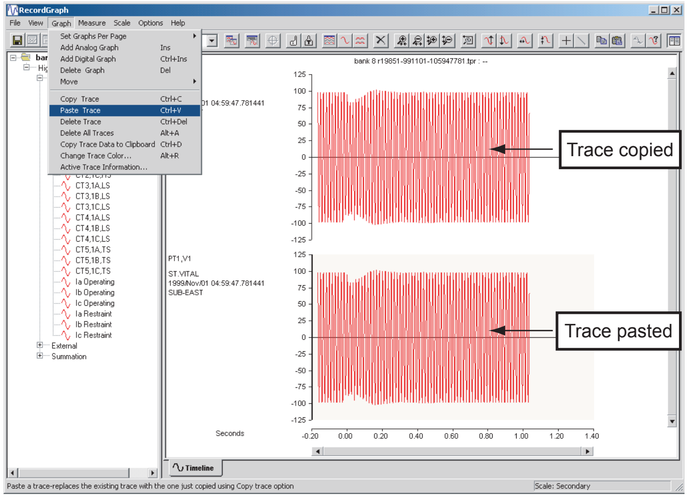


Figure 10.27: Paste Trace

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

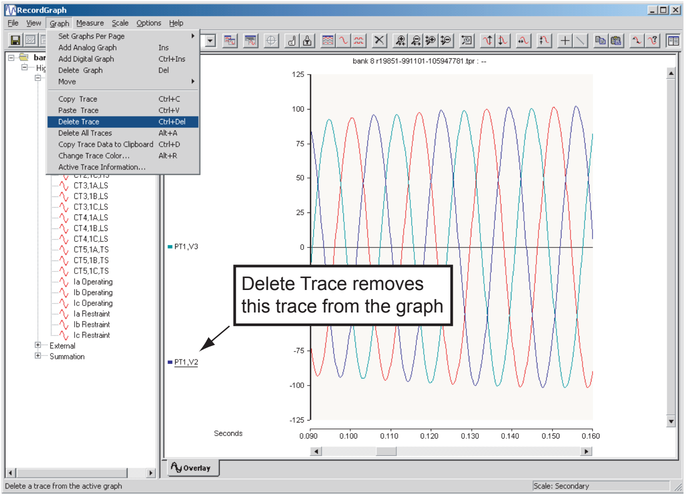


Figure 10.28: Delete Trace

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

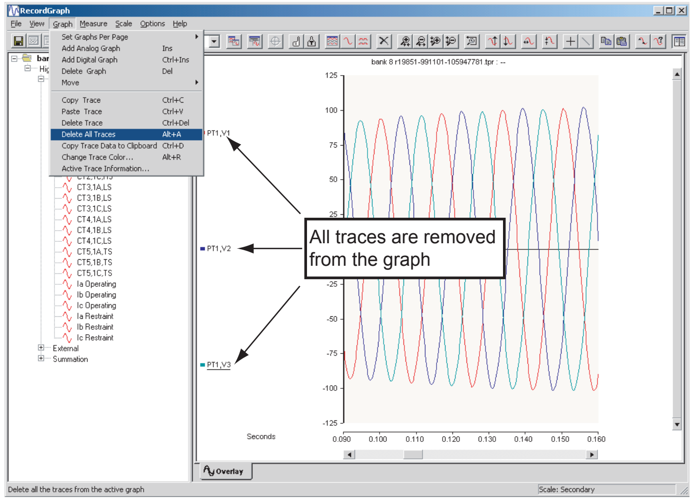


Figure 10.29: Delete All Traces

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 10-73).

Graph>Change Trace Color

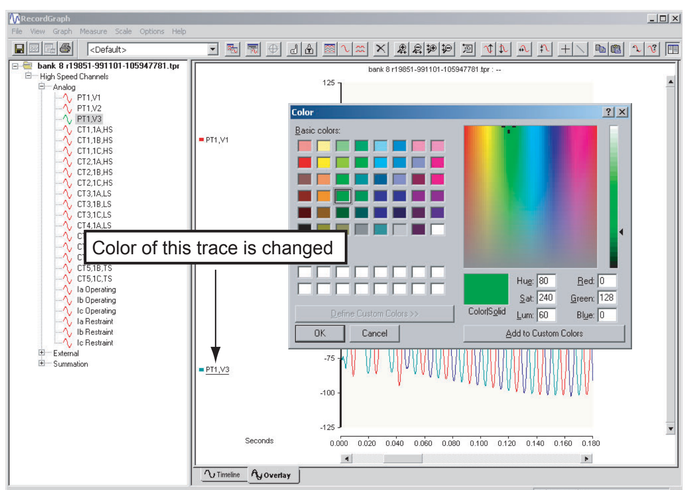


Figure 10.30: Change Trace Color

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

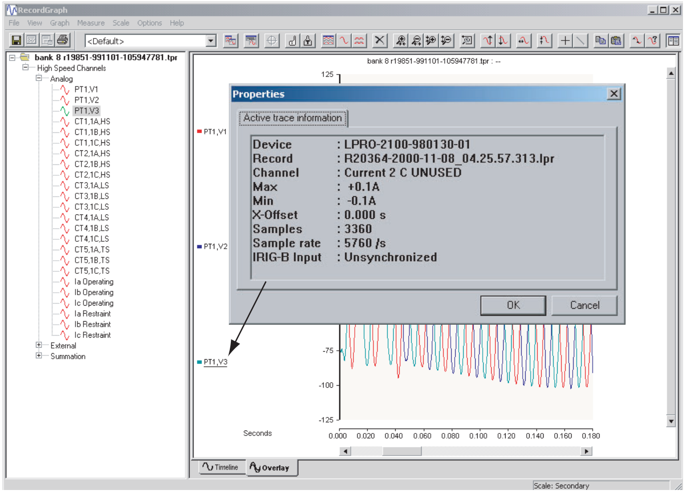


Figure 10.31: Active Trace Information

Display the trace information of the active graph.

Measure Menus

Measure>Markers

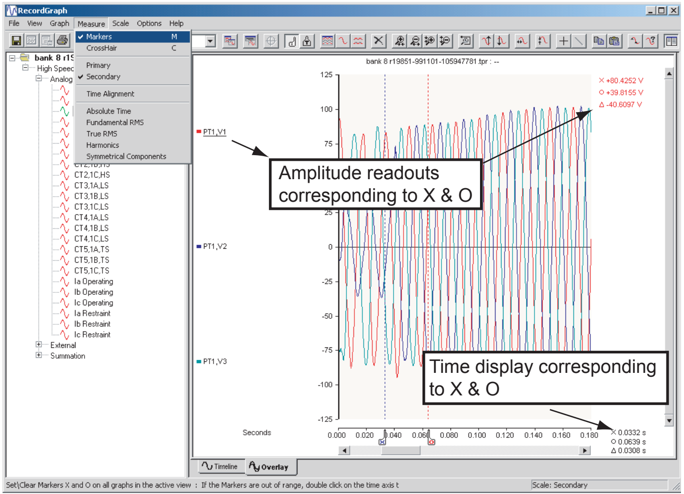


Figure 10.32: Markers

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

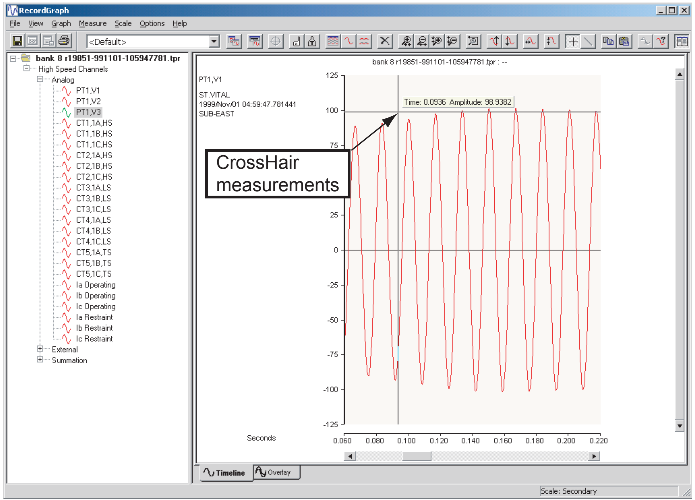


Figure 10.33: CrossHair

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

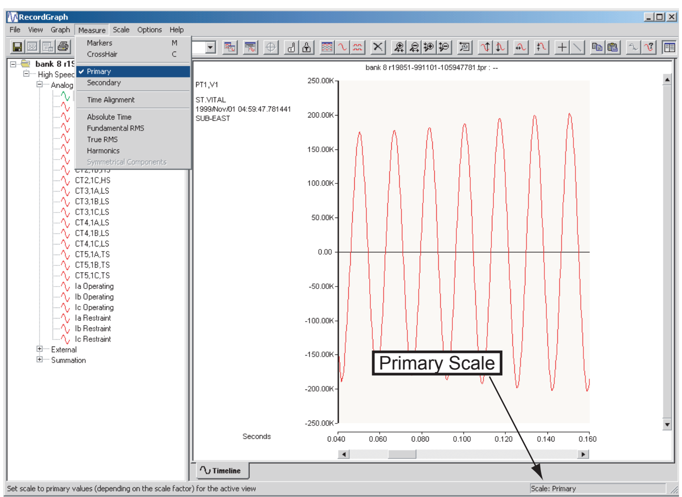


Figure 10.34: Primary

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

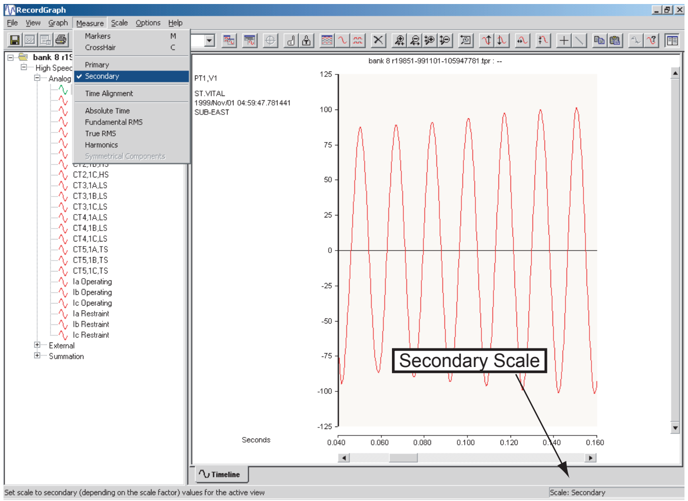


Figure 10.35: Secondary

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 10-64).

Measure>Absolute Time

Display absolute time (actual recorded time) measurements for the active trace of the graph (see “Readouts and Measurements” on page 10-64).

Measure>Fundamental RMS

Display fundamental RMS measurement for the active trace of the graph (see “Readouts and Measurements” on page 10-64).

Measure>True RMS

Display true RMS measurement for the active trace of the graph (see “Readouts and Measurements” on page 10-64).

Measure>Harmonics

Display harmonics measurement – up to 5th order and THD expressed in percent with reference to the fundamental (up to 25 harmonics depending on the sample rate) for the active trace of the graph (see “Readouts and Measurements” on page 10-64).

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 10-64).

Scale Menus

Scale>Zoom X Axis +

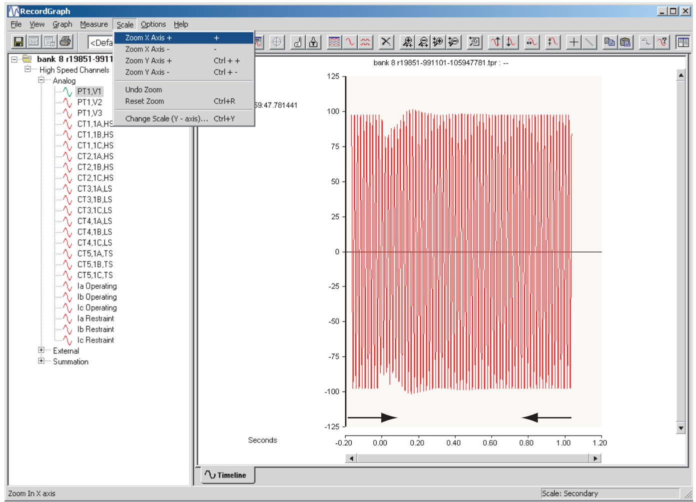


Figure 10.36: Zoom X Axis +

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

Scale>Zoom X Axis -

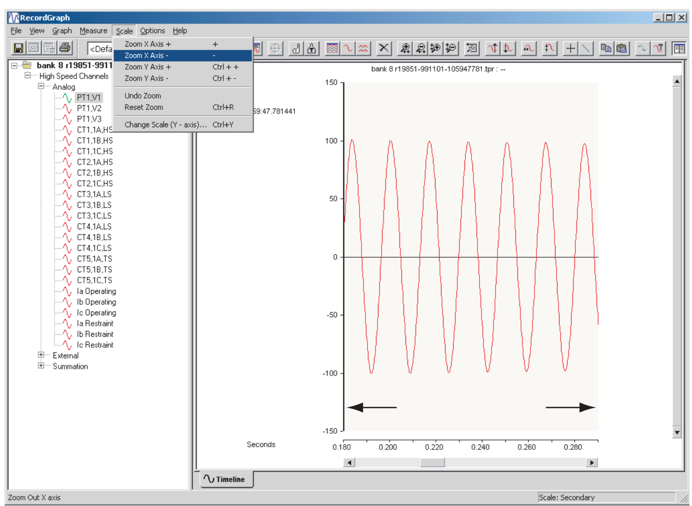


Figure 10.37: Zoom X Axis -

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

Scale>Zoom Y Axis +

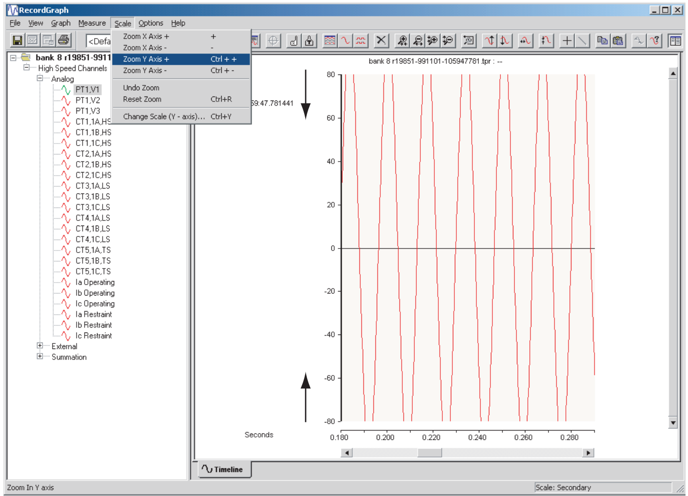


Figure 10.38: Zoom Y Axis +

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

Scale>Zoom Y Axis -

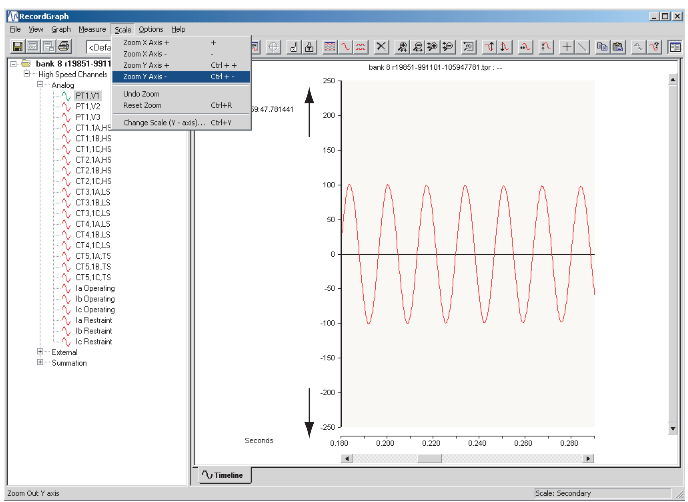


Figure 10.39: Zoom Y Axis -

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

Scale>Undo Zoom

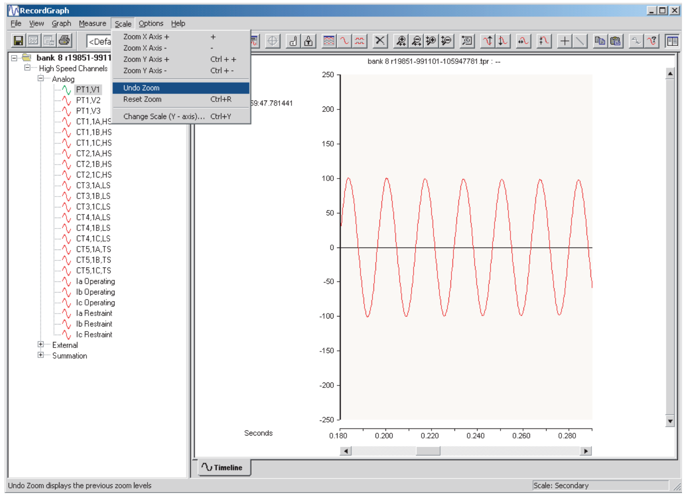


Figure 10.40: Undo Zoom

Display the previous zoom level.

Scale>Reset Zoom

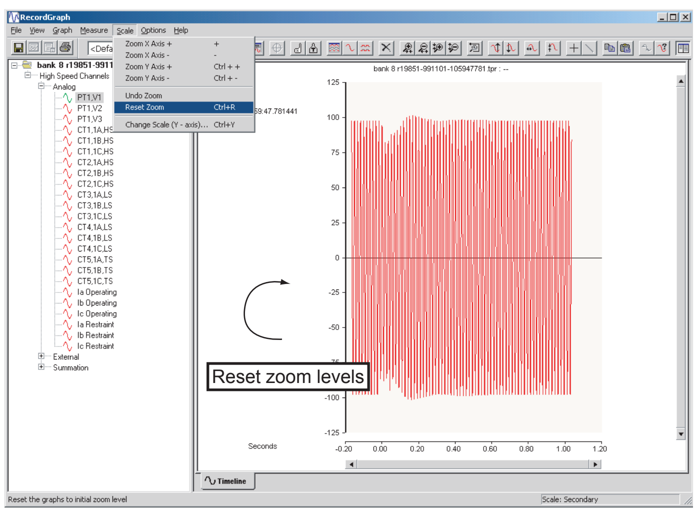


Figure 10.41: Reset Zoom

Reset the graphs to the initial zoom level.

Scale>Change Scale (Y axis)

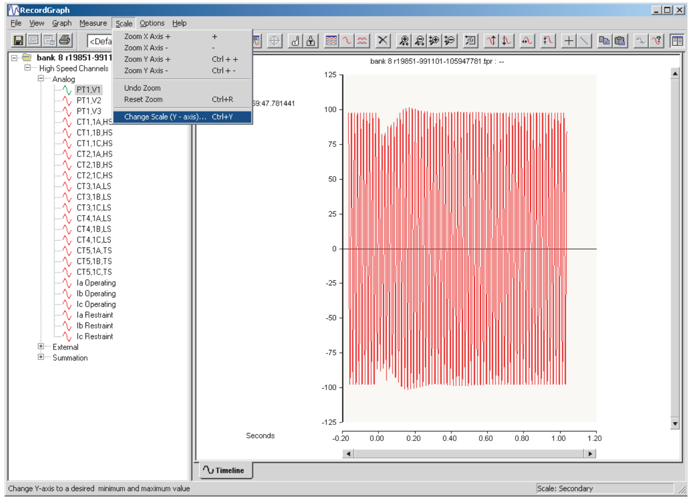


Figure 10.42: Change Scale (Y axis)

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 10-56).

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 10-71).

Options>Show Grid

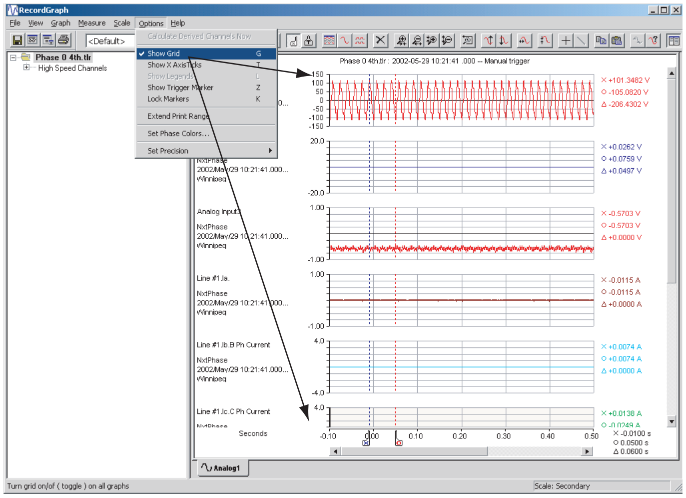


Figure 10.43: Show Grid

Turn grid on or off on all graphs.

Options>Show X Axis Ticks

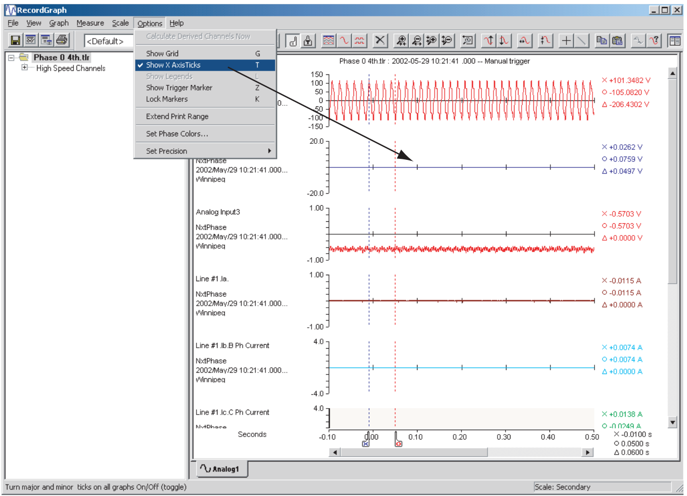


Figure 10.44: Show X Axis Ticks

Show X axis ticks on all graphs.

Options>Show Legends

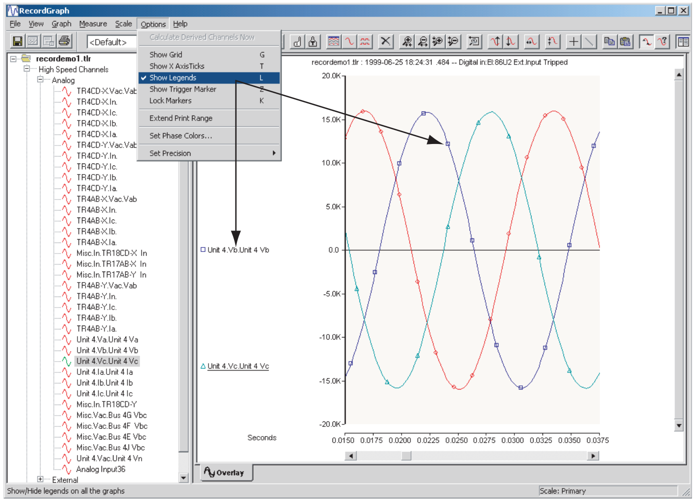


Figure 10.45: Show Legends

Show or hide legends on all the graphs.

Options>Show Trigger Marker

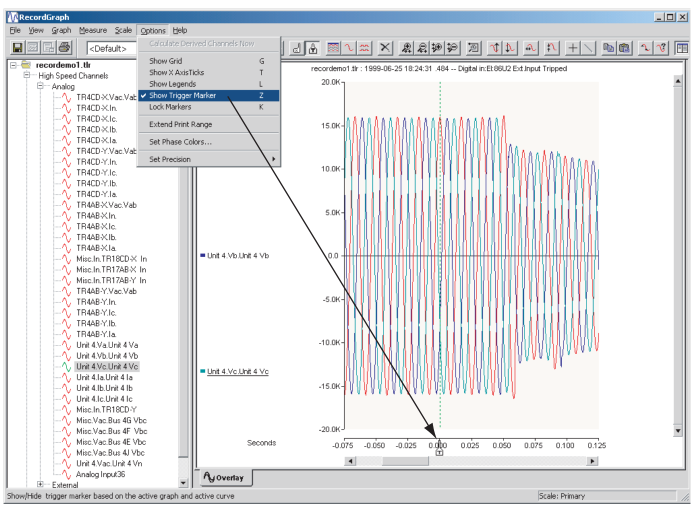


Figure 10.46: Show Trigger Marker

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

Options>Lock Markers

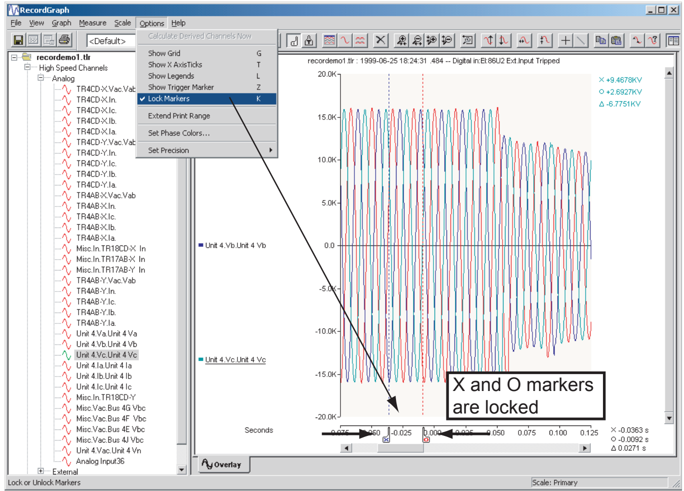


Figure 10.47: Lock Markers

Lock or unlock X and O markers.

Options>Extend Print Range

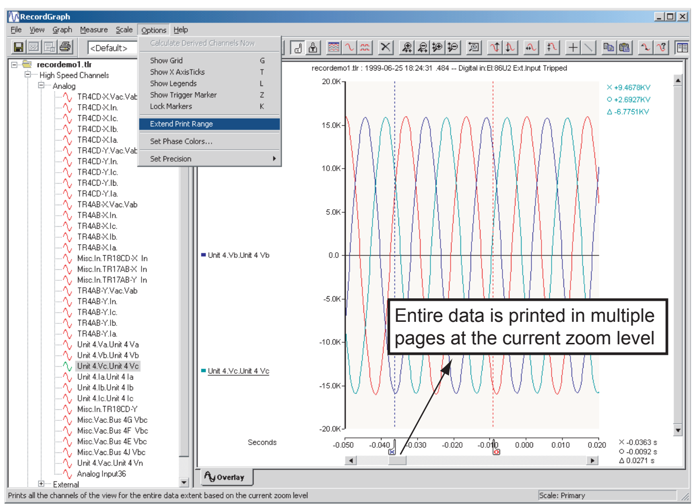


Figure 10.48: Extend Print Range

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

Options>Set Phase Colors

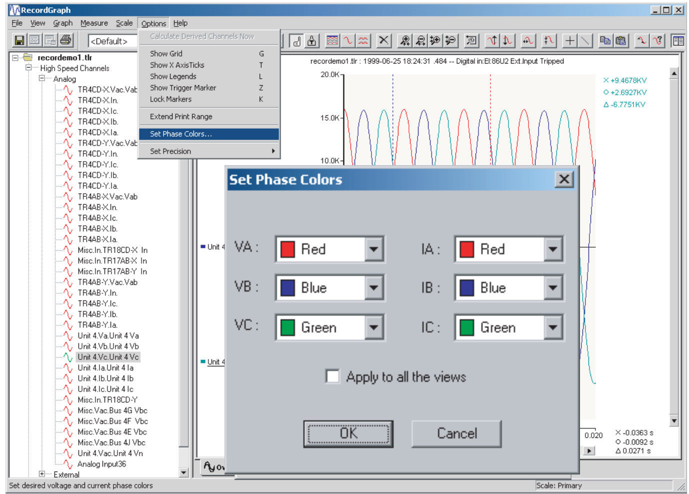


Figure 10.49: Set Phase Colors

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

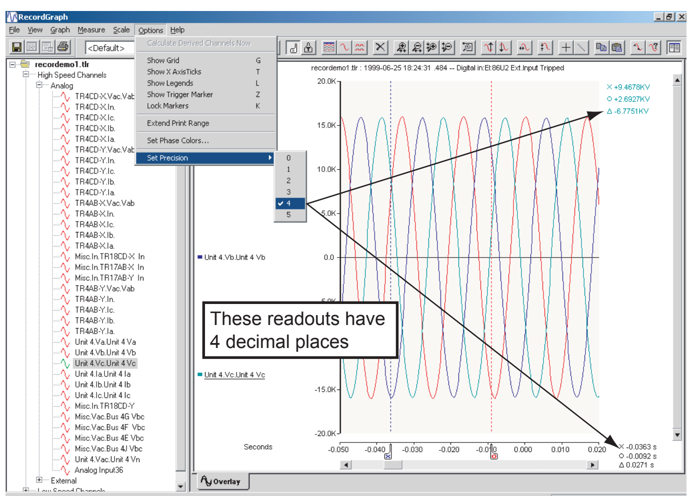


Figure 10.50: Set Precision

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

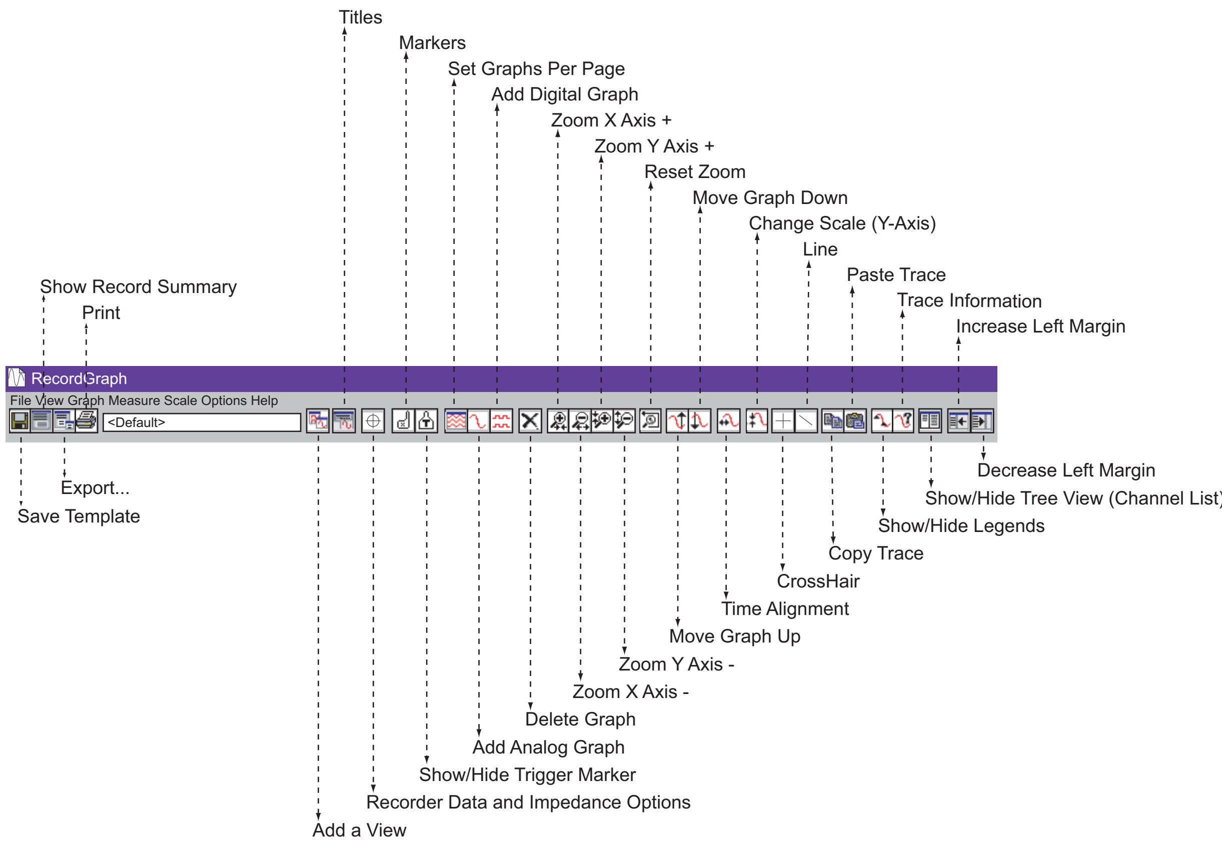


Figure 10.51: Tool Bar Buttons

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 “View Title Options” on page 10-63).
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 15 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*.

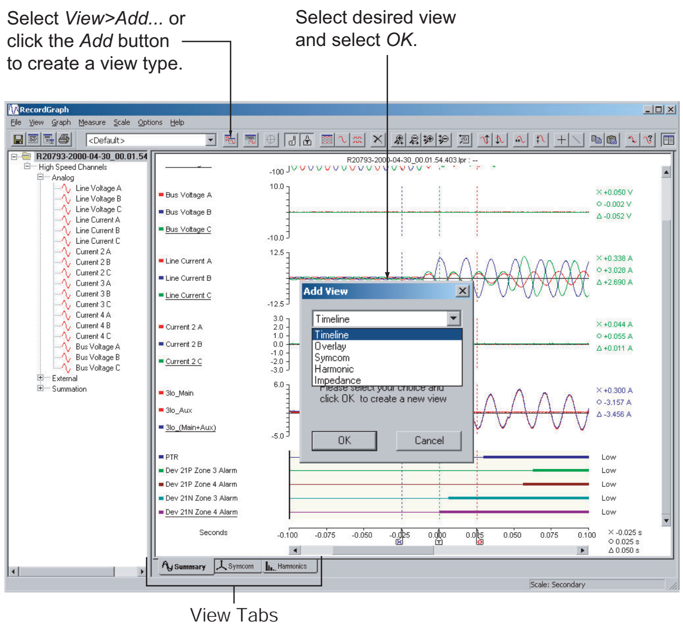


Figure 10.52: Add a View

> 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 10.53: 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 an digital graph to the Timeline View.

A maximum of 36 graphs (analog and digital) can be created for each Timeline View, Overlay View and Trend 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
- 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

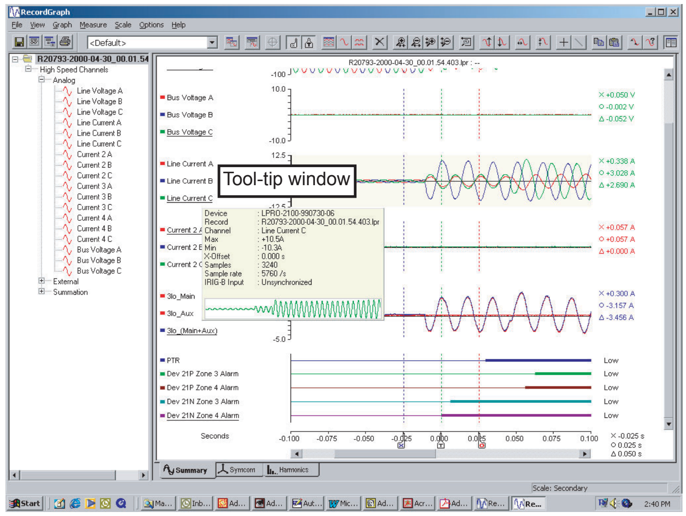


Figure 10.54: Tool-tip

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.

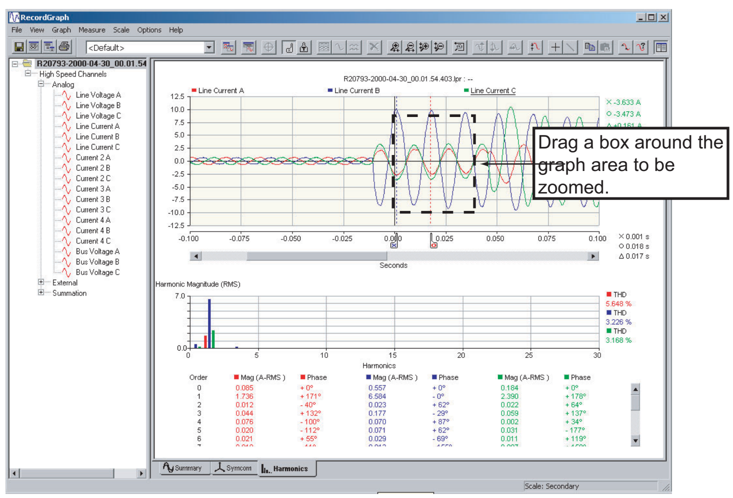


Figure 10.55: Select a Section of the Graph to Zoom

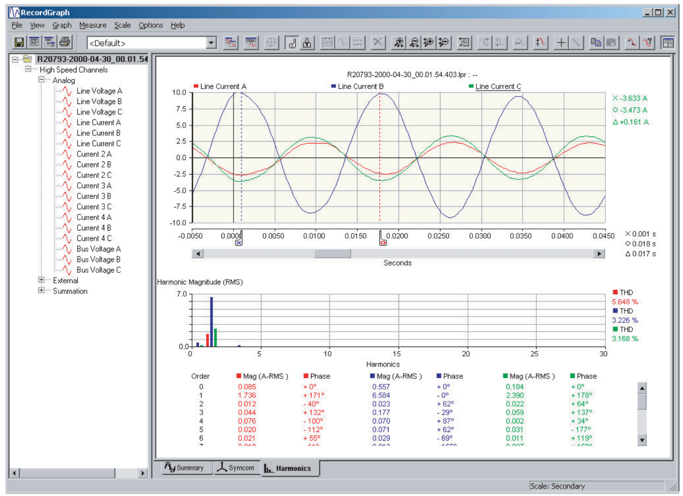


Figure 10.56: Portion of Zoomed Graph

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.

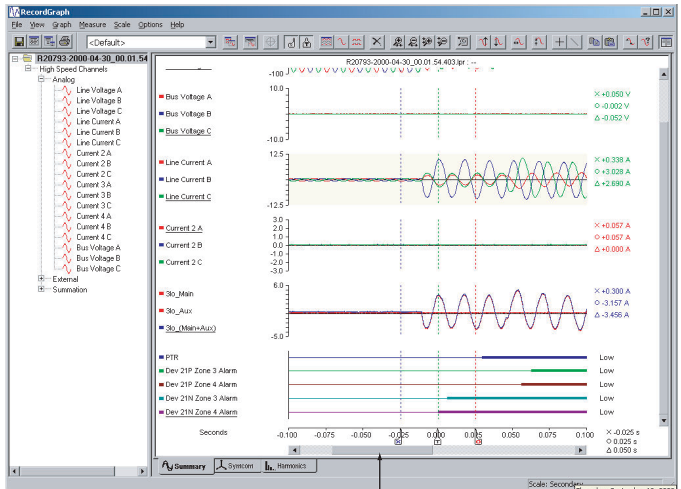
3 Graphs are redrawn to the previous zoom level.

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 Ctrl and click on the right arrow scroll button.

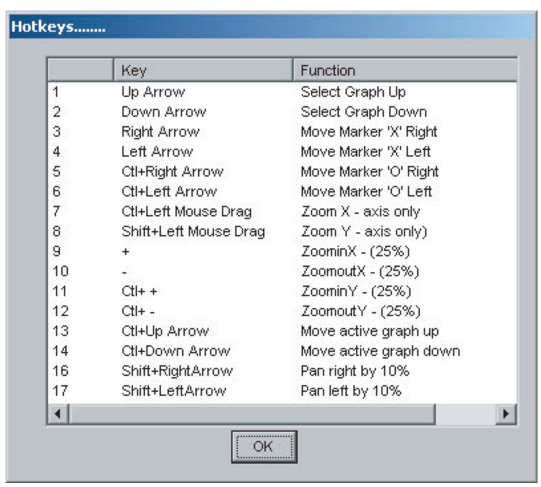


Thumb Track - move right/left to pan graph

Figure 10.57: 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 H*ot keys* 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%

OK

Figure 10.58: Hot Keys

Right-click Context Menu

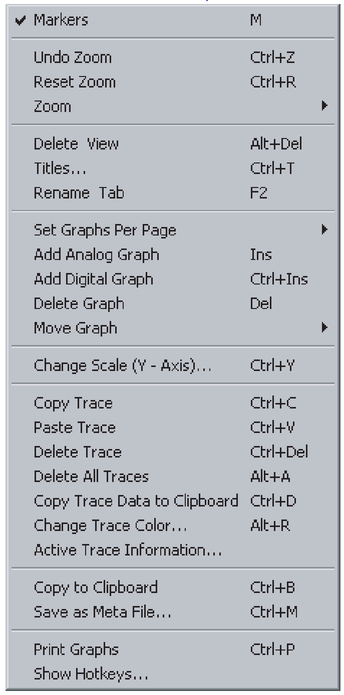


Figure 10.59: Right-click Context Menu

Timeline View

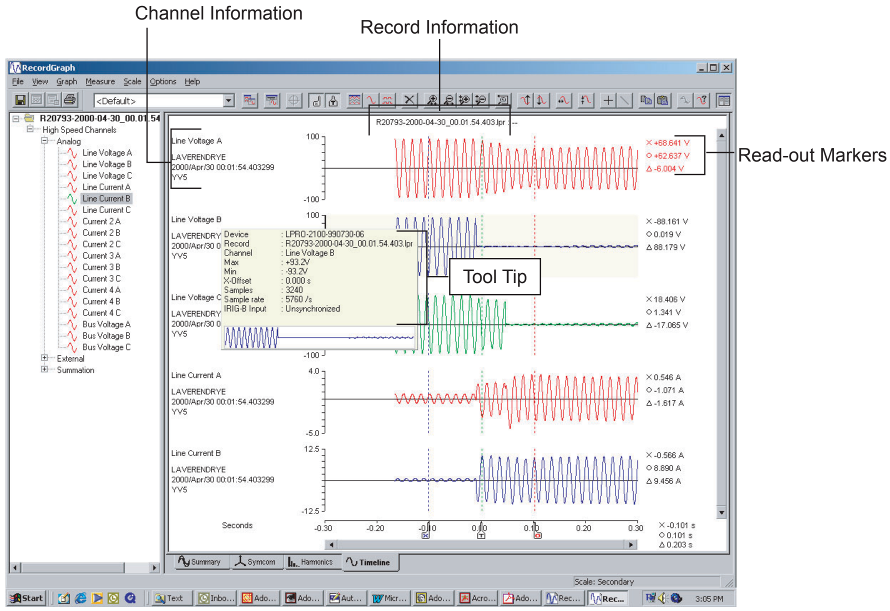


Figure 10.60: Timeline View

- 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

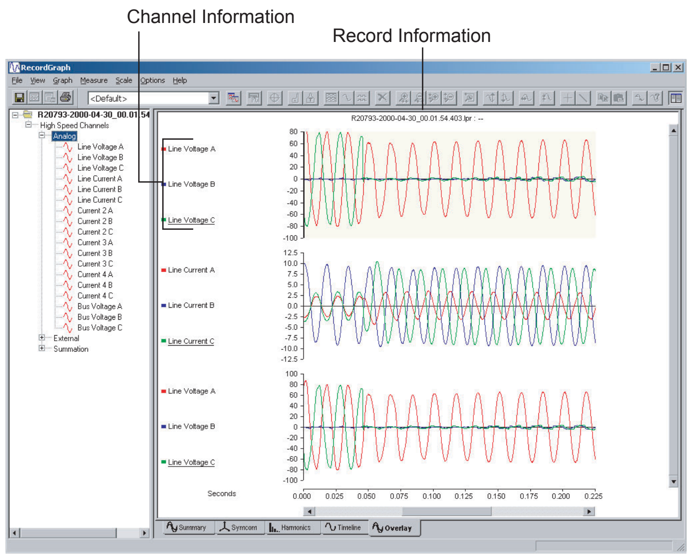


Figure 10.61: Overlay View

- 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 6 traces.
- 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

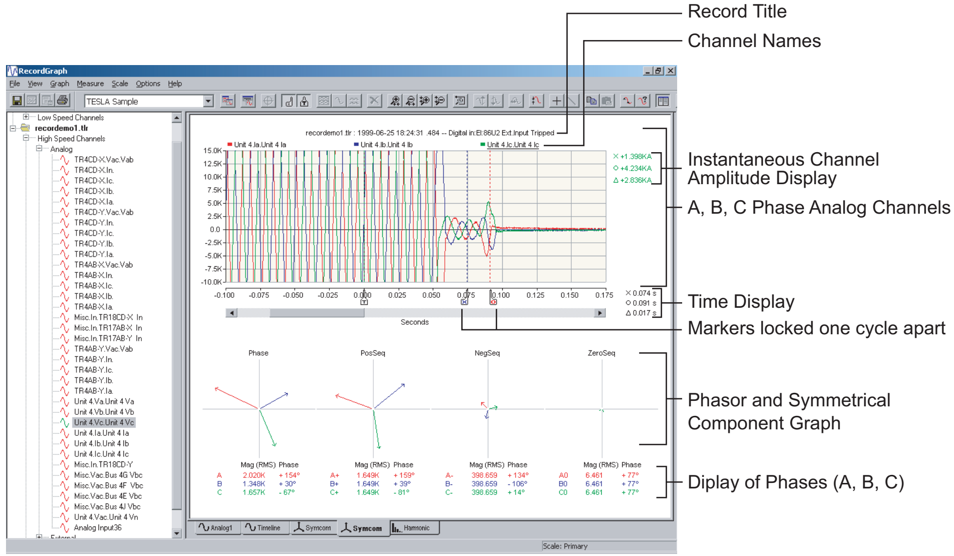


Figure 10.62: Symcom View

- 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

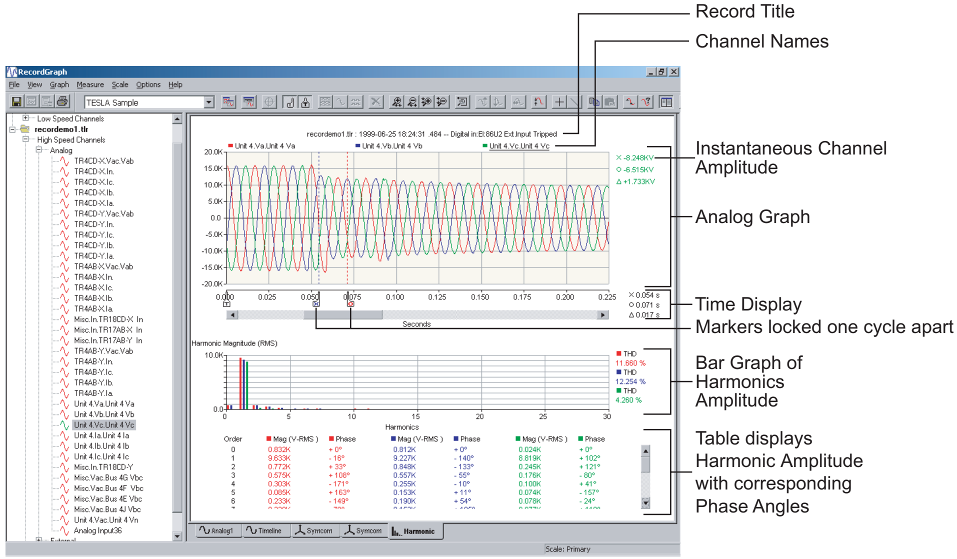


Figure 10.63: Harmonic View

- Harmonic View is designed to analyse harmonics associated with analog channels.
- 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.
- A maximum of 25 harmonics (order) can be displayed.
- 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 compensated and referenced with respect to A-phase voltage in relays and a configured channel in TESLA recorder. For COMTRADE records phase voltage is the analog channel 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 superimposition 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 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.

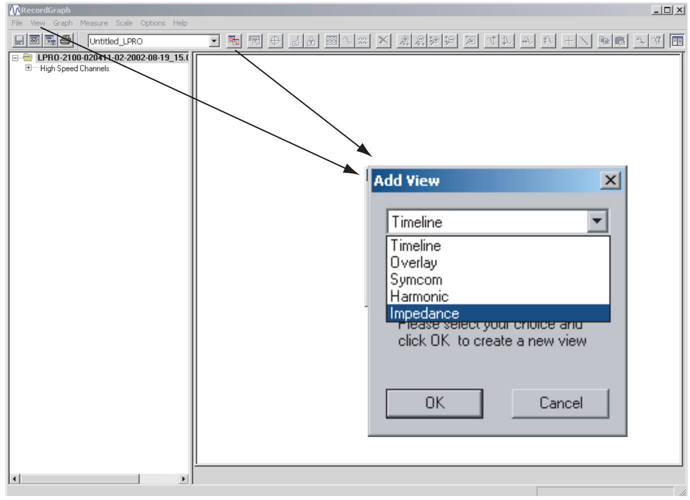


Figure 10.64: View>Add> Impedance

> 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, following initial screen is displayed.

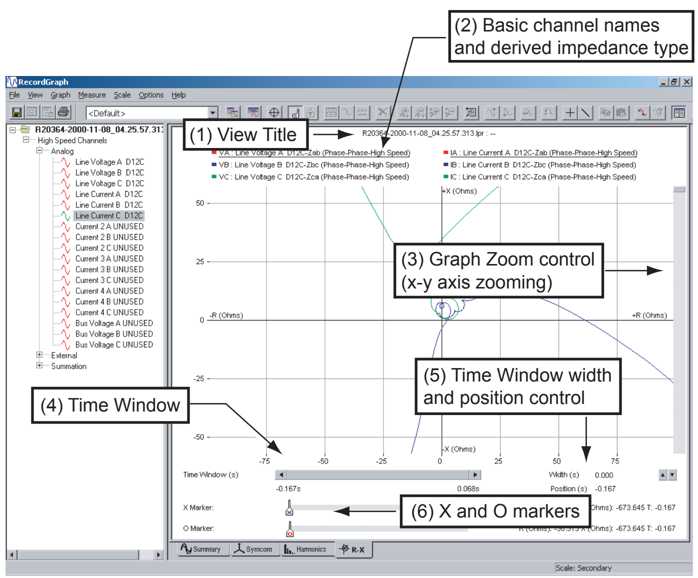


Figure 10.65: Opening Impedance Screen

Components and Controls

(1) A text component displays the title at the top of the Impedance View shown in Figure 10.65: 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, refer to table "Channel Types" on page 10-43.

(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.

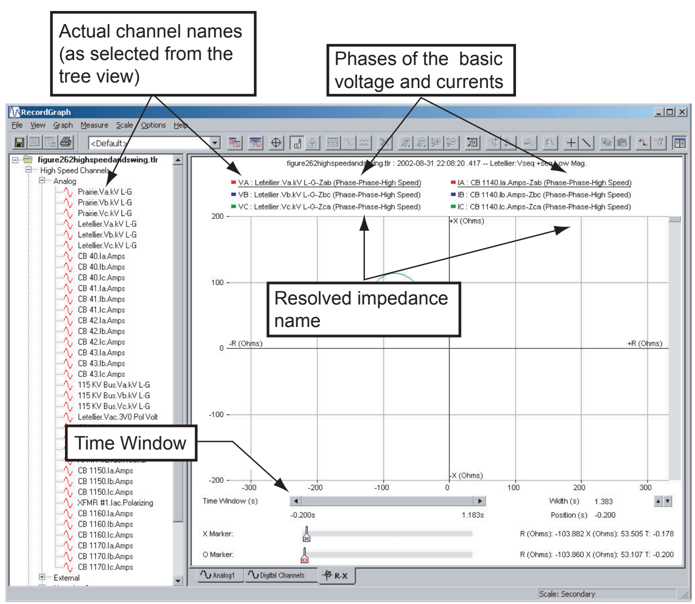


Figure 10.66: Create Impedance View with an TESLA Record

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.

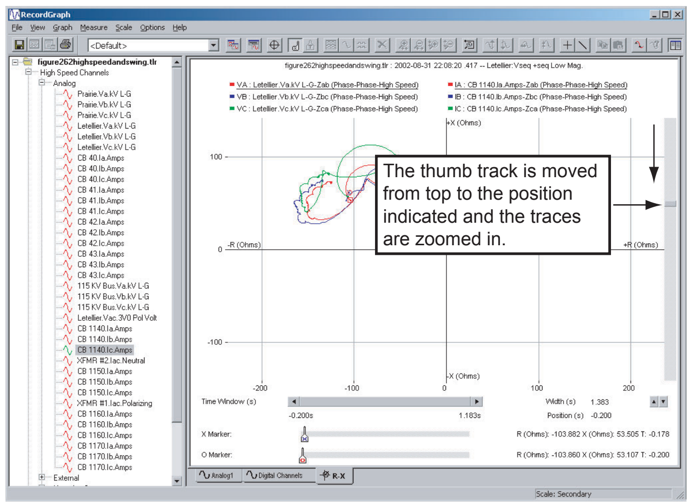


Figure 10.67: Example of graph zoom control

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.

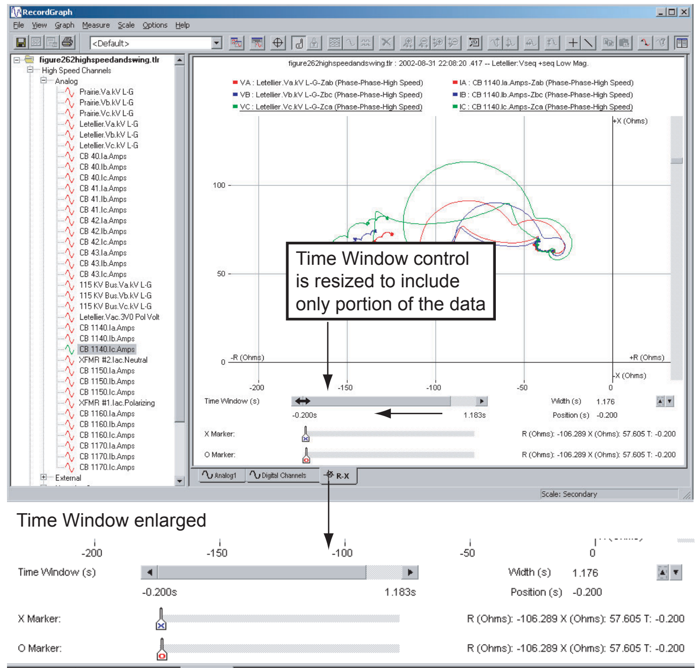


Figure 10.68: Example of using Time Window control

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

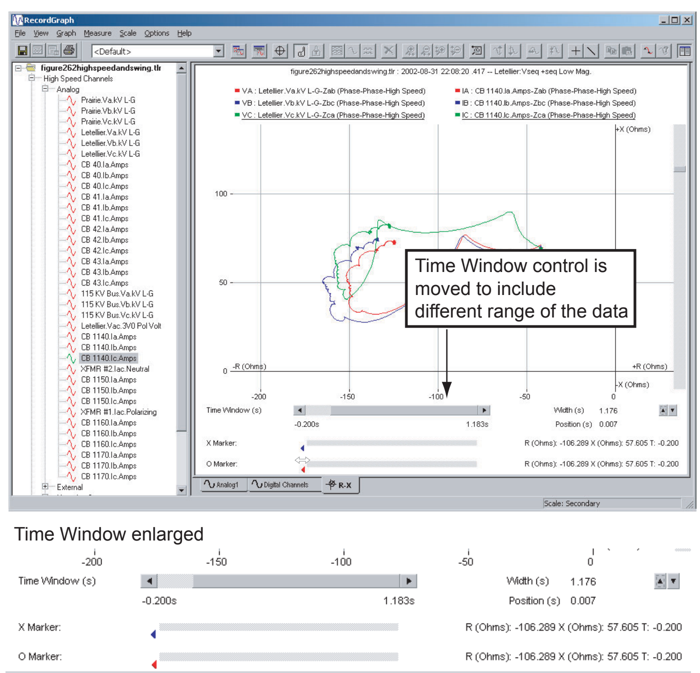


Figure 10.69: Time Window control moved to new location

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.

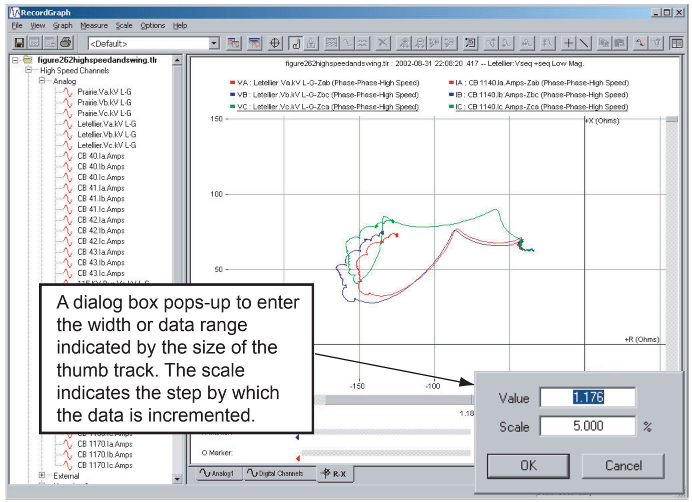


Figure 10.70: Indicate data range

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 detrimental by 5%.

Example to Superimpose the L-PRO Relay Characteristics

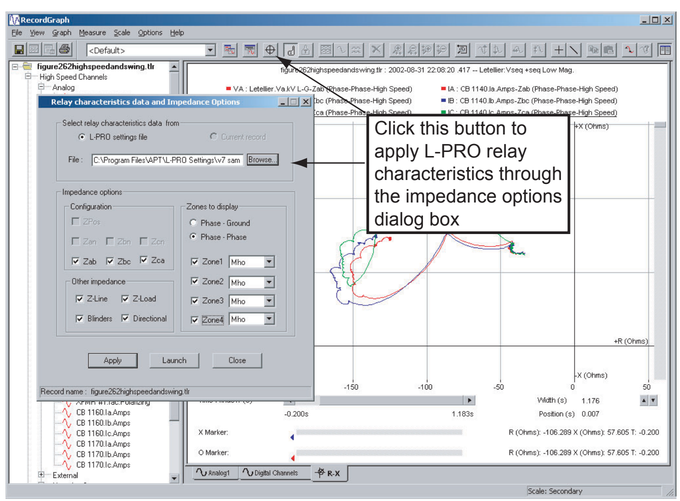


Figure 10.71: Superimpose the L-PRO Relay Characteristics

When you select the *Relay data & impedance options* button, a dialog box appears. The parameter required, such as k0 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	
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 *Offliner* settings program. Note that the L-PRO *Offliner* 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).

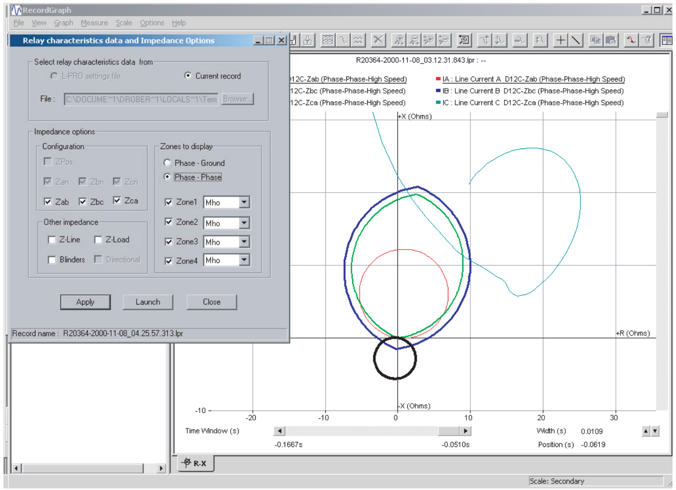


Figure 10.72: Example superimposing the zone characteristics

In the above example phase-phase impedances Zab, Zbc and Zca are selected, indicated by a check mark, but only Zca is in the zoom range.

All the four zones mho characteristics are superimposed. You can see that the Zca 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.

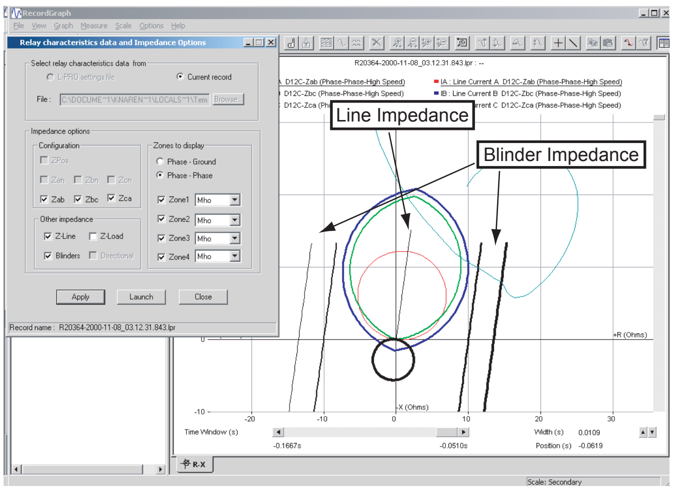


Figure 10.73: Example showing the Line and Blinder impedances

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

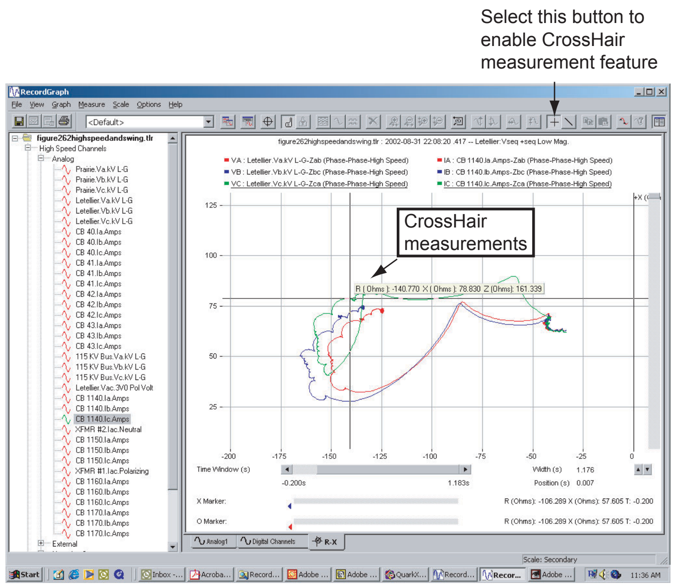


Figure 10.74: Example illustrating the use of the CrossHair measurement

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.

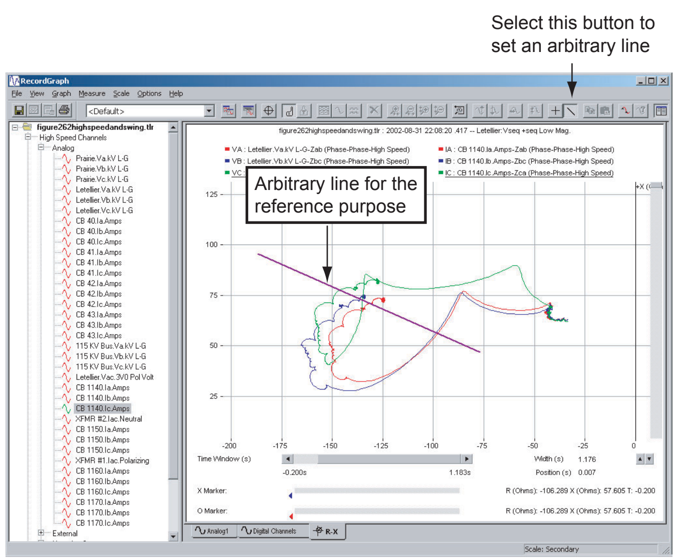


Figure 10.75: Example of the Line feature

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 enable the CrossHair option to measure the values.

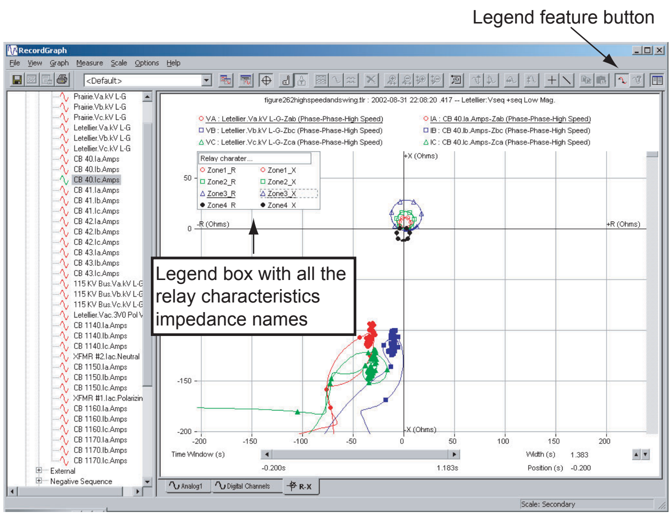


Figure 10.76: Example of the Legends feature

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.

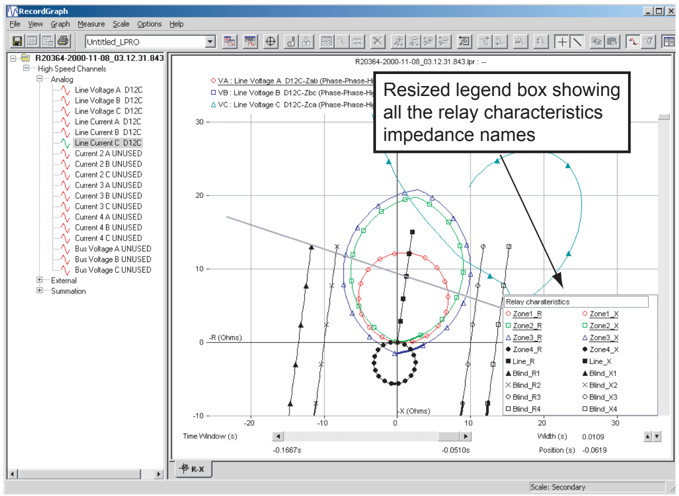


Figure 10.77: Legends features moved and enlarged

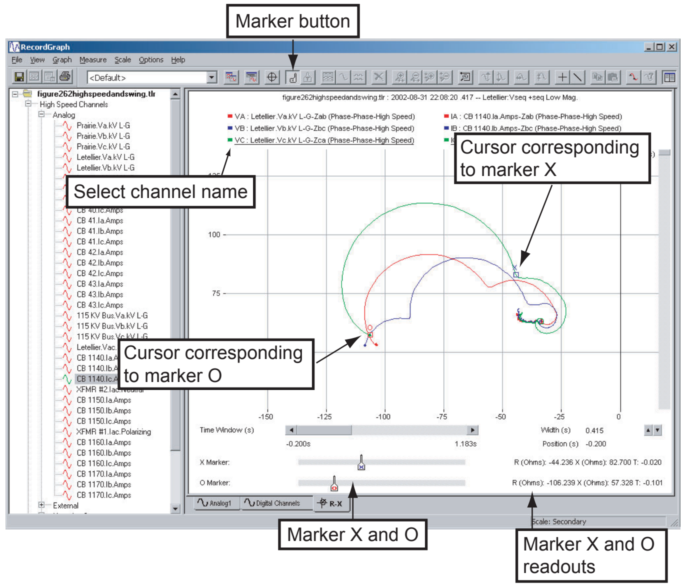


Figure 10.78: Example illustrating the use of data markers

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.

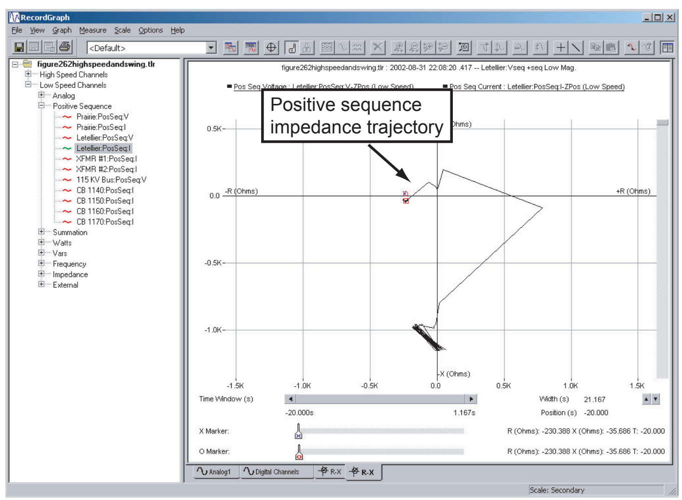


Figure 10.79: Example of TESLA swing record choosing positive sequence voltage and current

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.

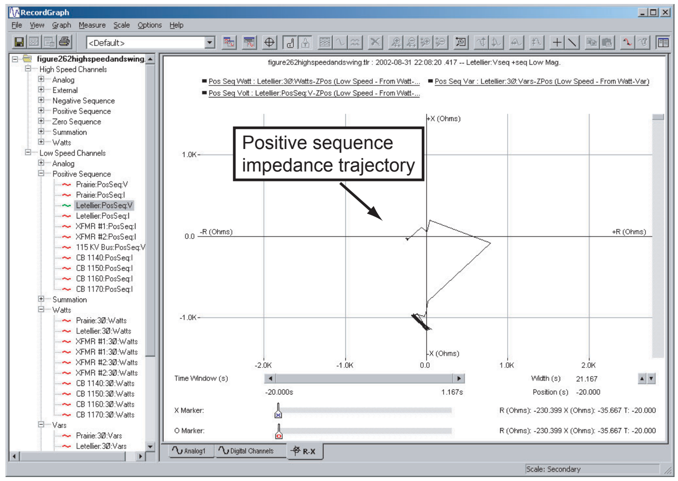


Figure 10.80: Example of TESLA swing record choosing watt, var and positive sequence voltage channels

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.

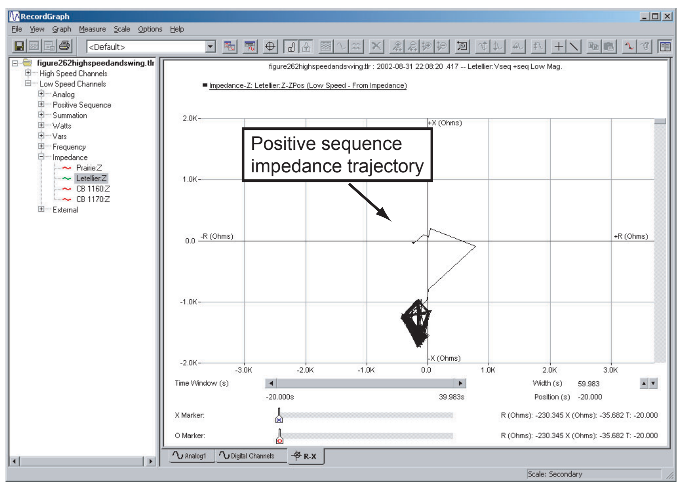


Figure 10.81: Example of TESLA swing record choosing impedance channel

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

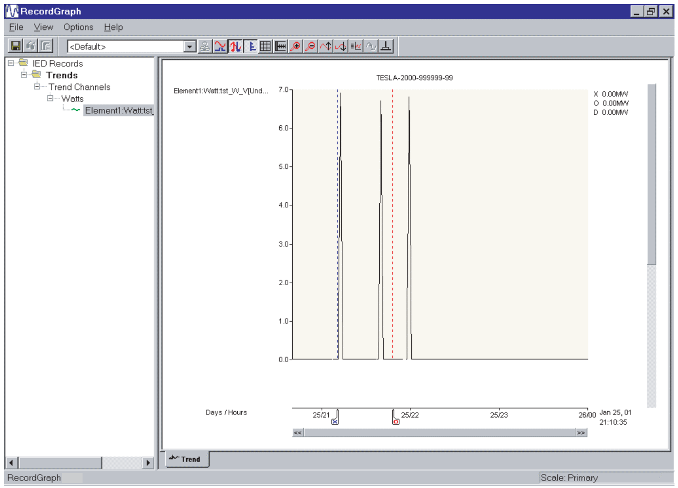
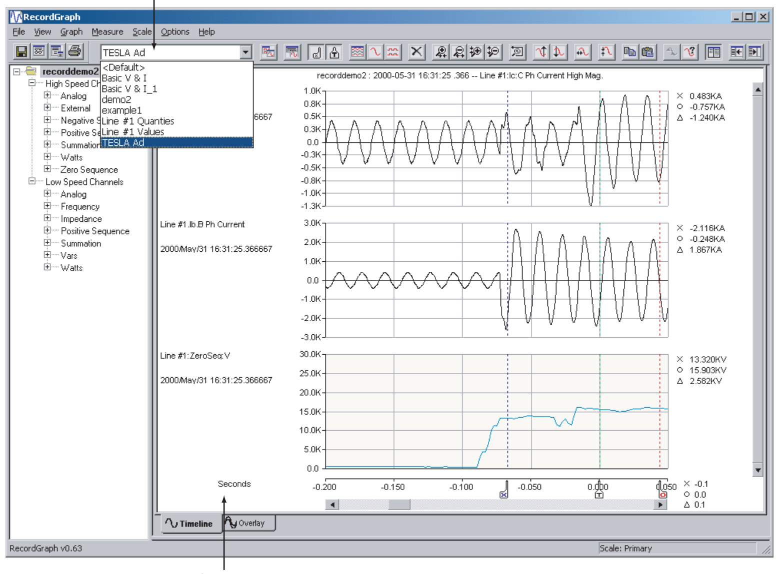


Figure 10.82: Trend View

- 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.



Left Margin

Figure 10.83: 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...

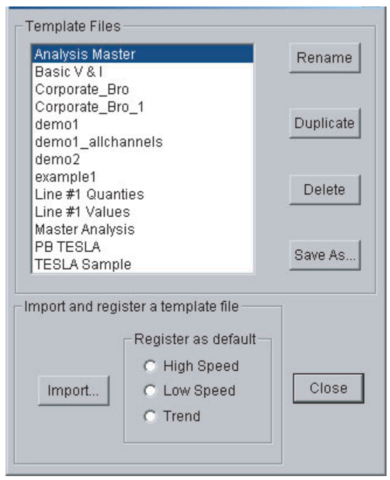


Figure 10.84: Template Manager

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

Rename

Renames the currently selected template.

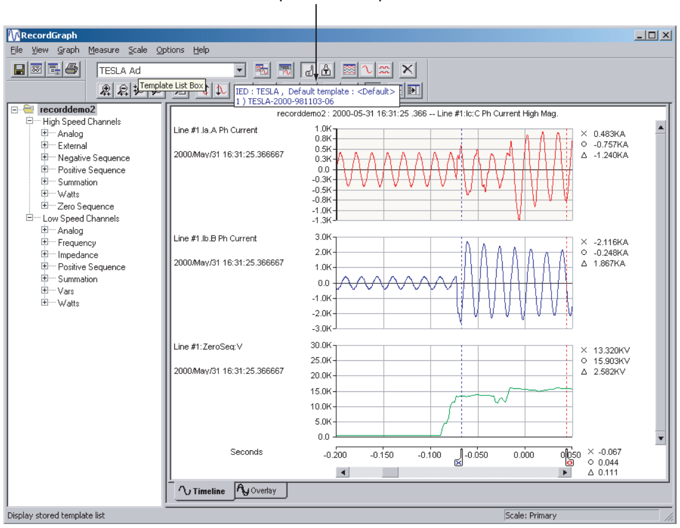
Duplicate

Copies the contents of the selected template into another file.

Delete

Deletes currently selected template.

Template - Tool Tip



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.

Template - Multiple IED

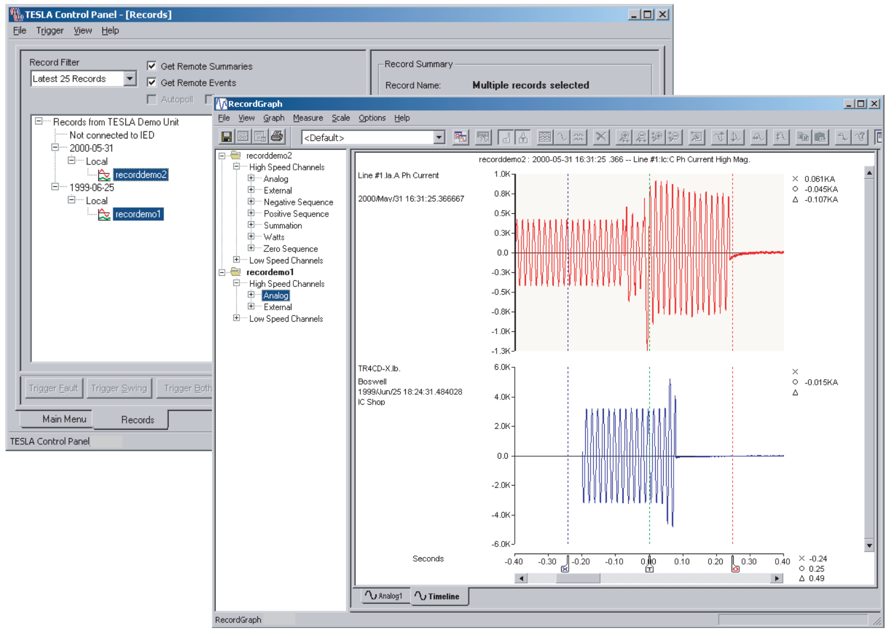


Figure 10.85: Multiple IEDs

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 reapplys 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.

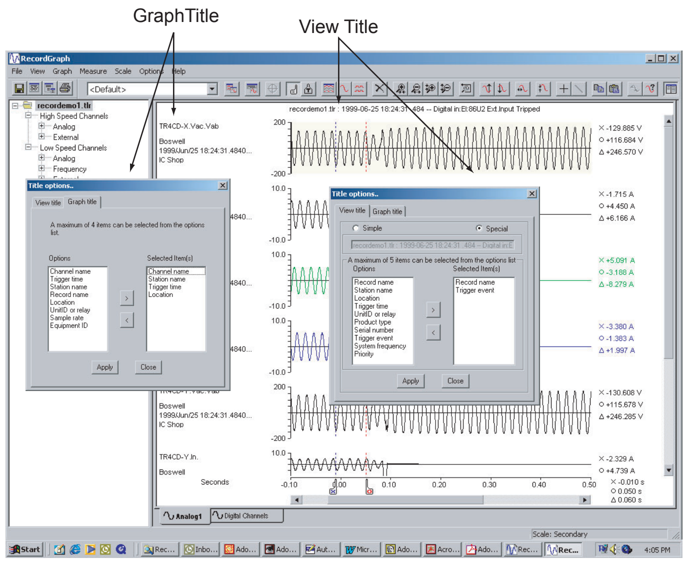


Figure 10.86: View and Graph Titles

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

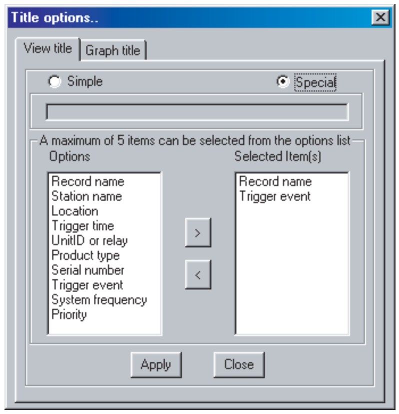


Figure 10.87: View Title Options

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

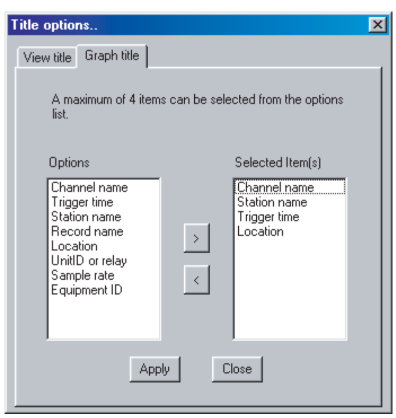


Figure 10.88: Graph Title Options

Readouts and Measurements

The Measure menu consists of the following:

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

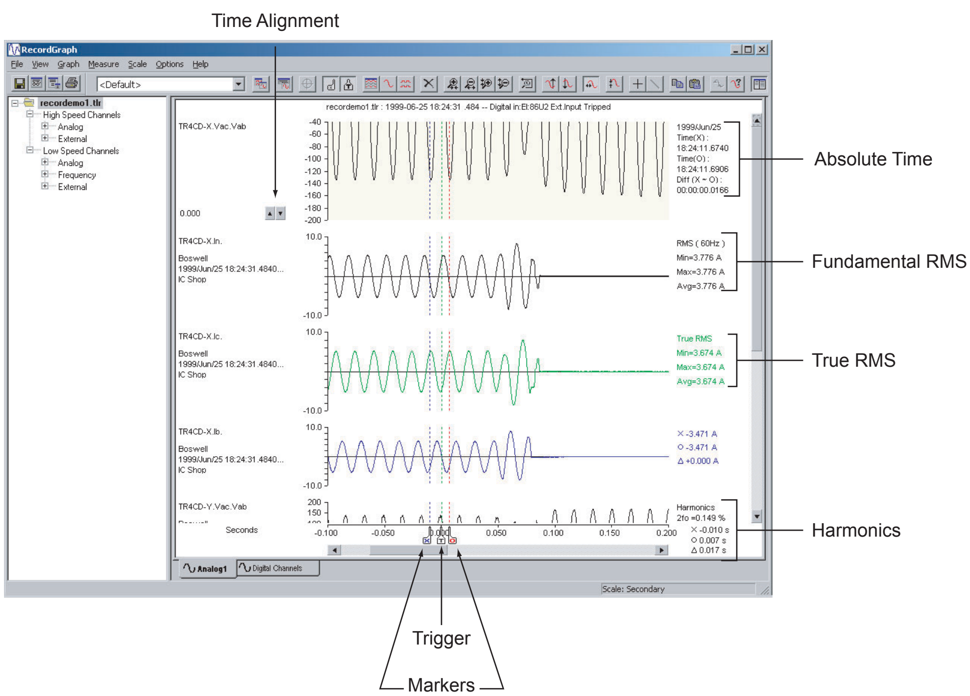


Figure 10.89: Readouts and Measurements

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 *Graph>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.

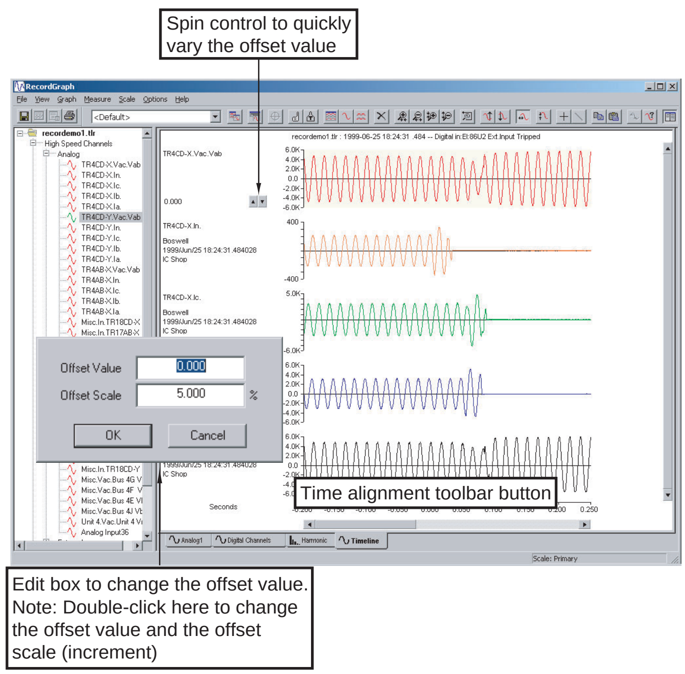


Figure 10.90: Time Alignment

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

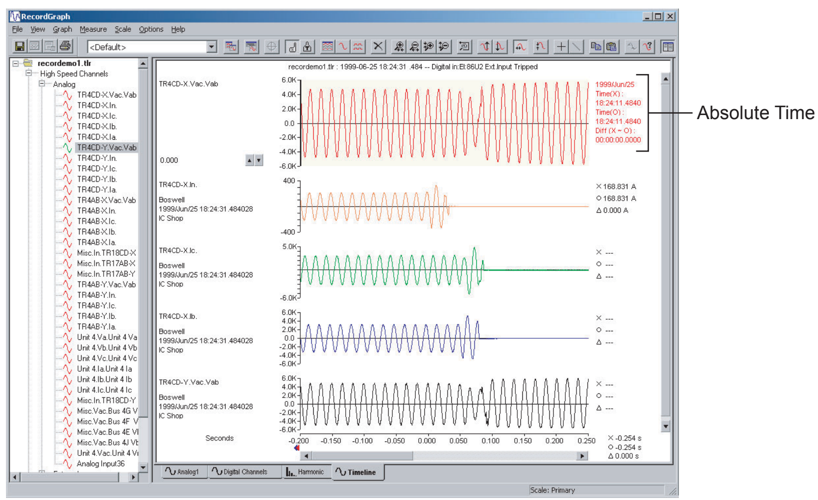


Figure 10.91: Absolute Time

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

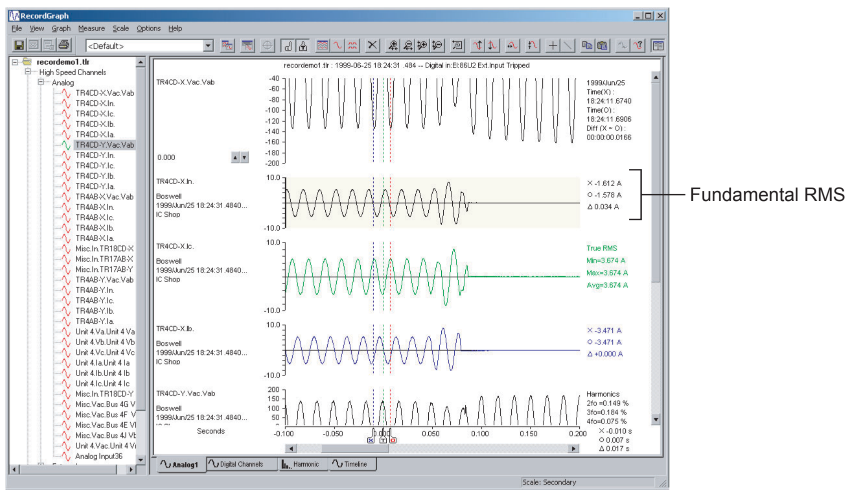


Figure 10.92: Fundamental RMS

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

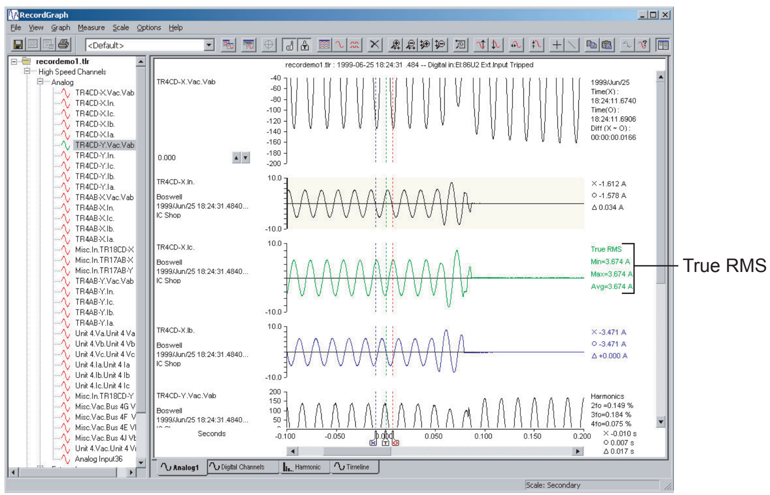


Figure 10.93: True RMS

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 (up to 25 harmonics) depending on the sample rate.

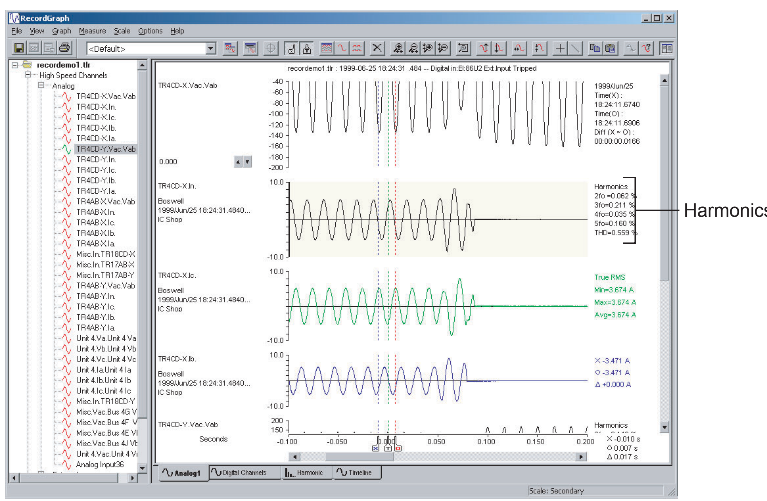


Figure 10.94: Harmonics

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>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.

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

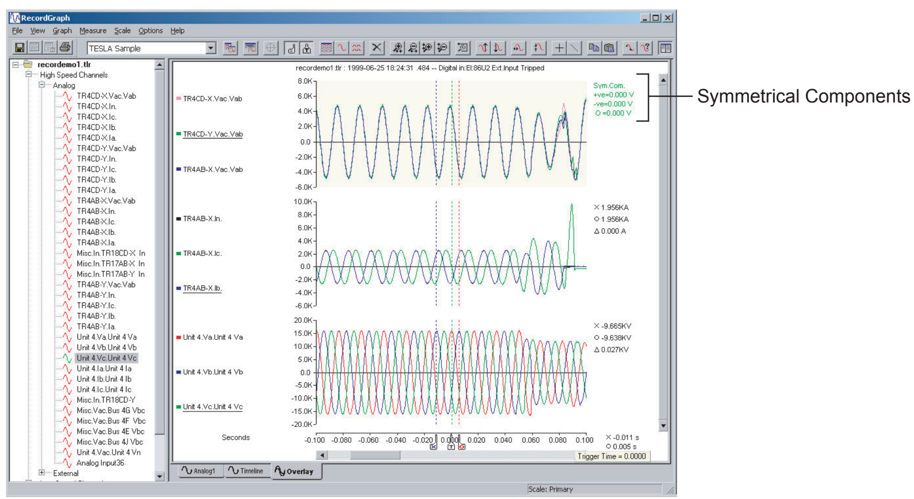


Figure 10.95: Symmetrical Components

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 for the 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.

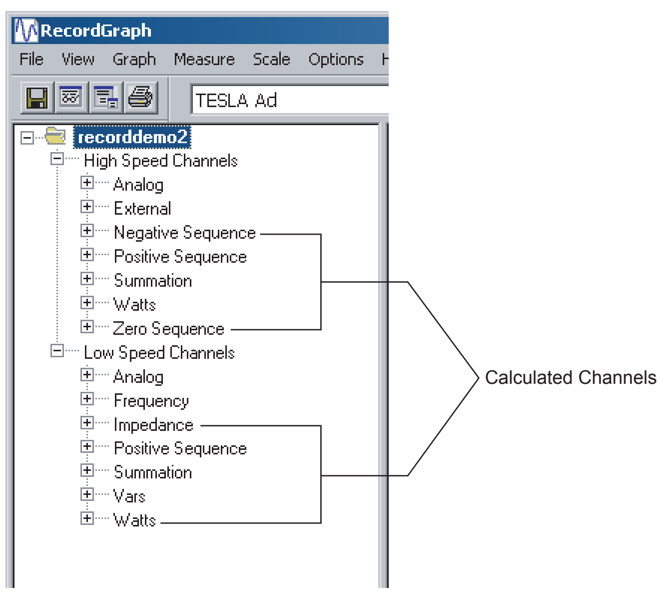


Figure 10.96: Calculated Channels

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

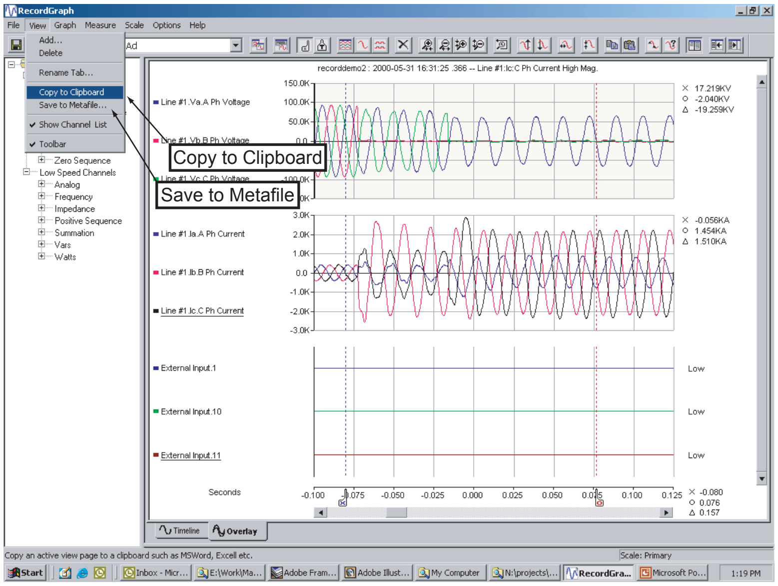


Figure 10.97: Export Views

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.

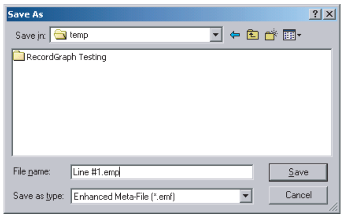


Figure 10.98: Save to Metafile

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.

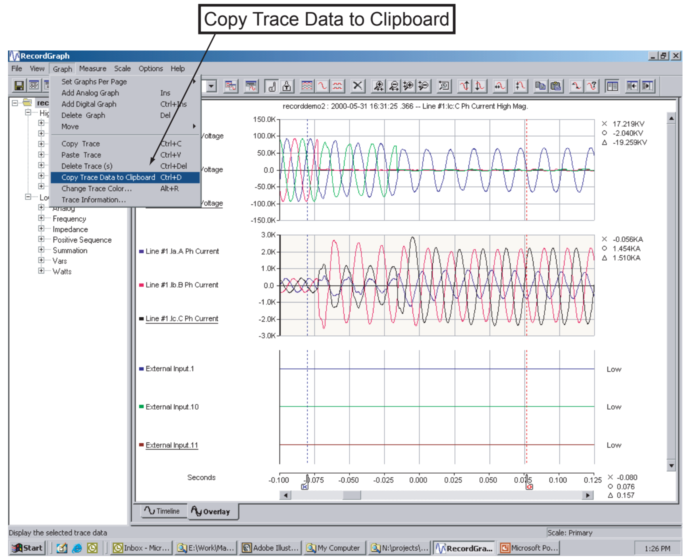


Figure 10.99: Copy Trace to Clipboard

Pasting exported data using Microsoft Excel

1 Open Microsoft Excel.

2 Choose *Edit>Paste Special.*

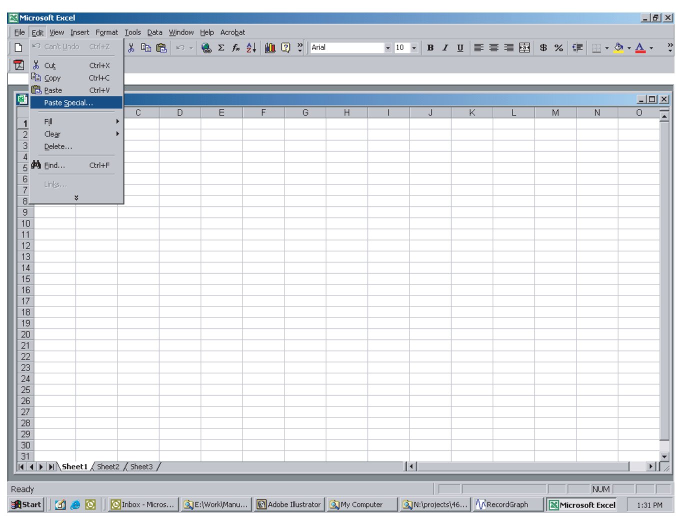


Figure 10.100: Paste Special using Excel

Pasting exported data using Microsoft Excel

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

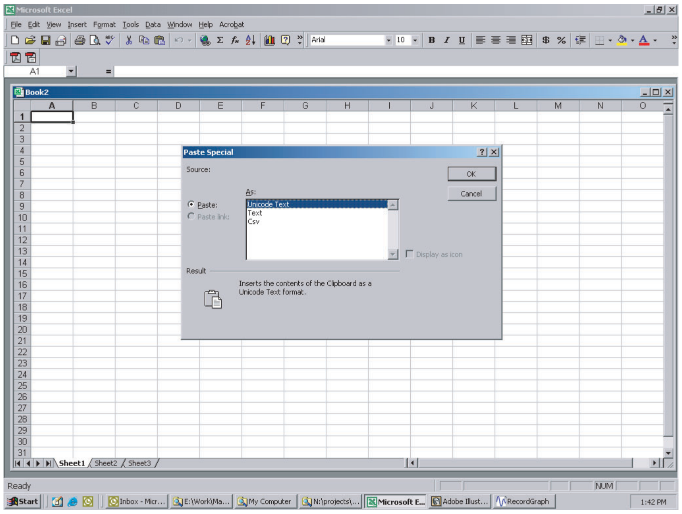


Figure 10.101: Choose csv

Pasting exported data using Microsoft Excel

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

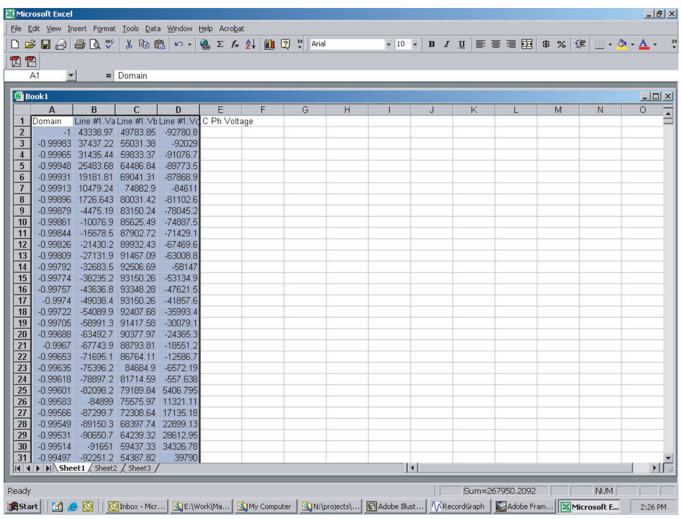


Figure 10.102: Past to Excel

Record Summary

1 Click the record name to enable this feature.

2 Choose *File>Show Record Summary…* to display the record summary.

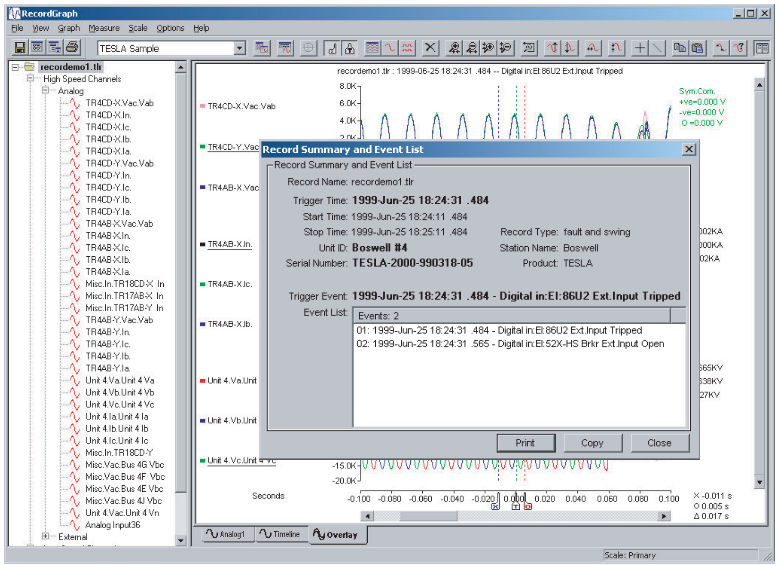


Figure 10.103: Show Record Summary

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.

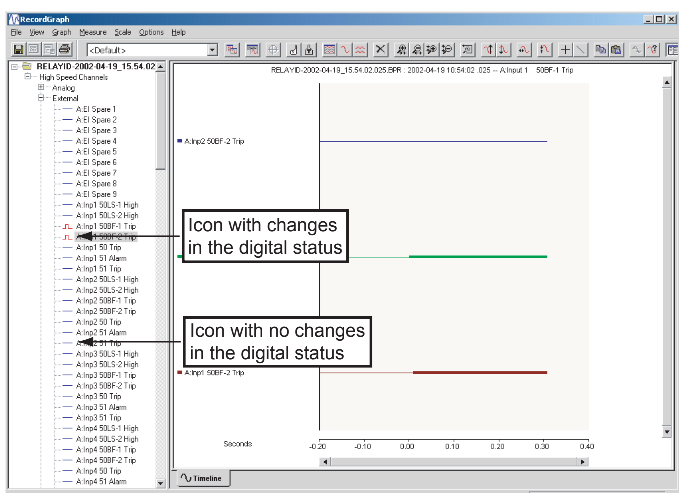


Figure 10.104: Digital Channel Status Indicator

IRIG-B Input Status Display

IRIG-B input status (synchronized, unsynchronized or unknown) is displayed in the tool tip window when you place the mouse on the channel name or use Active Trace Information.

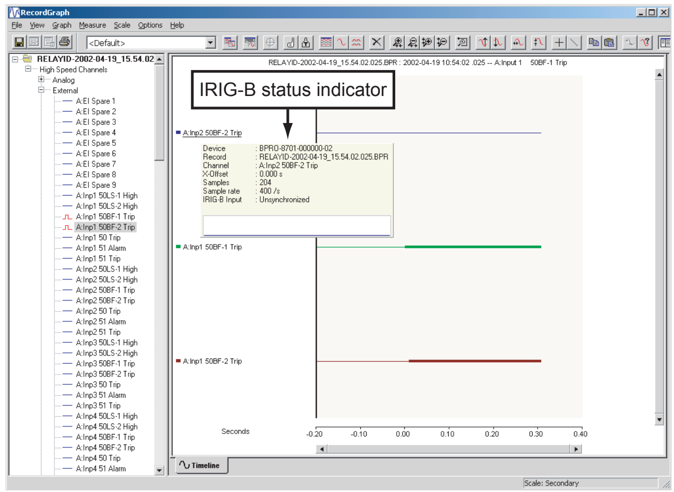


Figure 10.105: IRIG-B Input Status Indicator

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 and 1999). 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.

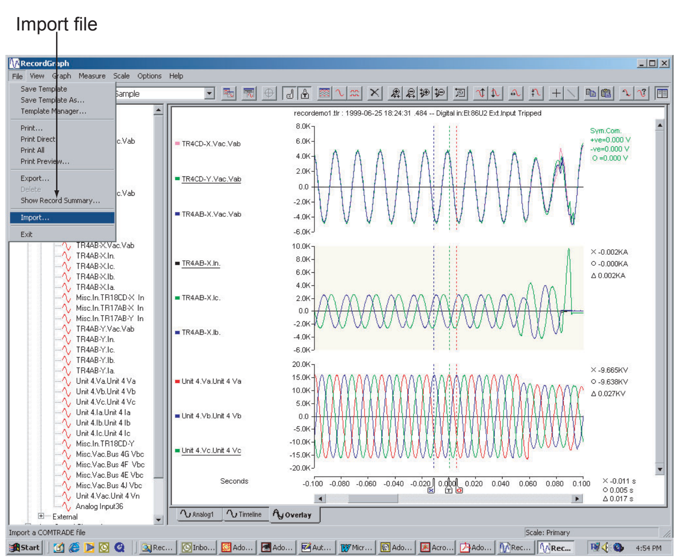


Figure 10.106: Import COMTRADE File

Choose COMTRADE File

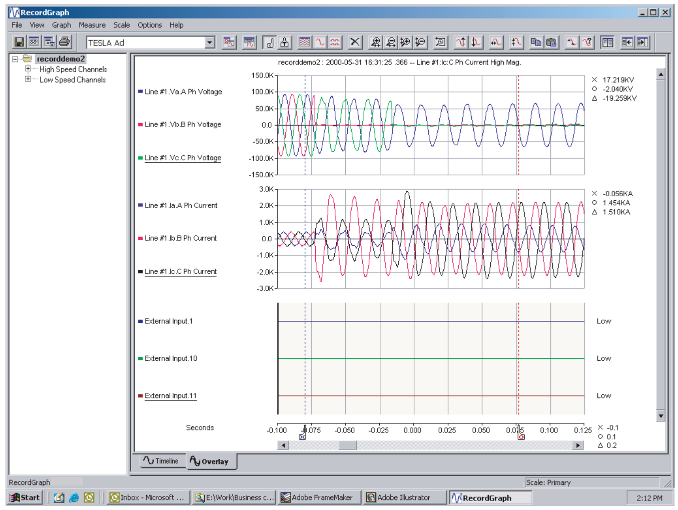


Figure 10.107: Select COMTRADE File

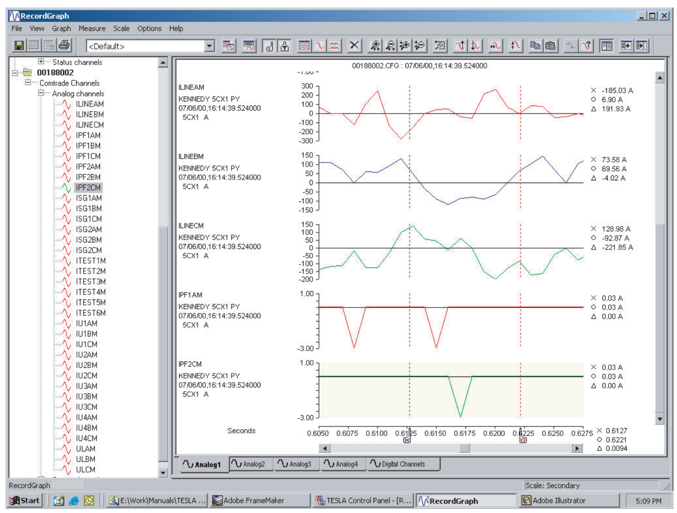


Figure 10.108: Apply <Default> Template

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.

11 Record Export Utility

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

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 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 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*.

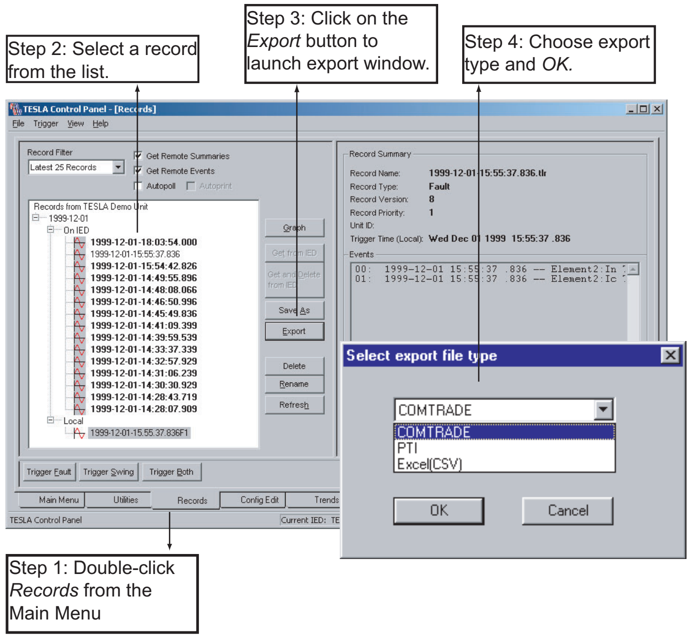


Figure 11.1: Select Export File Type

COMTRADE Format

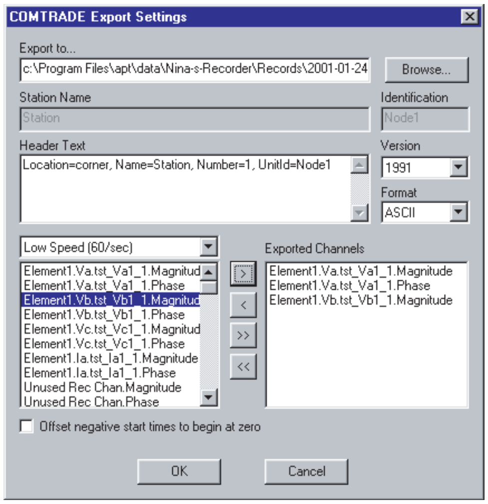


Figure 11.2: COMTRADE Settings

The COMTRADE format (IEEE C37.111) defines a common format for storing digital data records of transient and dynamic swing events.

COMTRADE export 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). COM-TRADE export produces the configuration, header and data files.

With reference to Figure 11.2: COMTRADE 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 the unit’s Station which 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.
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.

Name	Function
Format	The Format field specifies that the data in the COMTRADE file (ASCII or BINARY format). ASCII data has the advantage of being usable by simple text editor and spreadsheet programs, but results in a significantly larger record relative to binary format. BINARY format is therefore recommended if the software package you will be using the data in supports binary format COMTRADE.
Selecting Channels (Exported Channels)	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed (5760/sec): 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

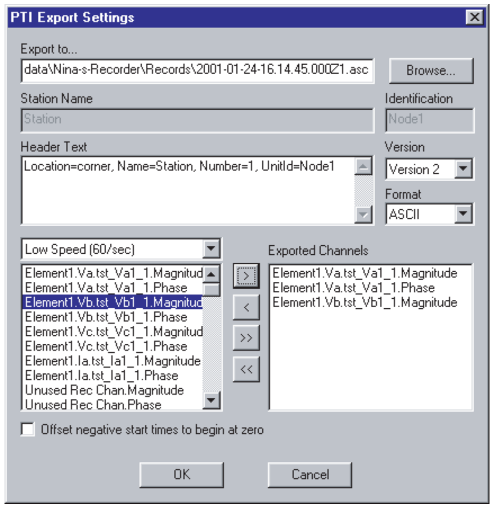


Figure 11.3: PTI Settings

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.

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.

Name	Title
Channel Selection	Use Channel Selection to select channels to export. You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed (5760/sec): 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.

Excel (CSV) Format

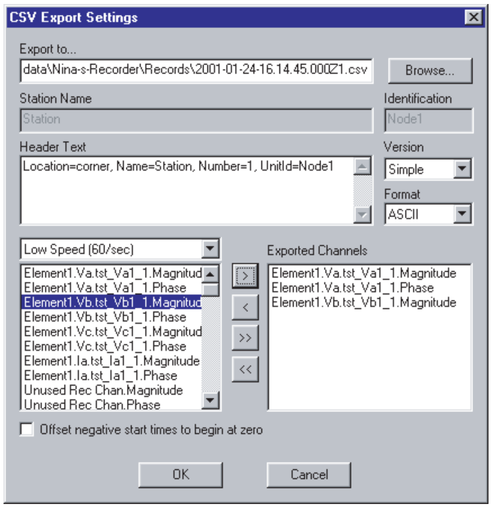


Figure 11.4: Excel (CSV) Settings

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.

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.

Name	**Function**
Channel Selection	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed (5760/sec): 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.

12 The Event Log

Event Log

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

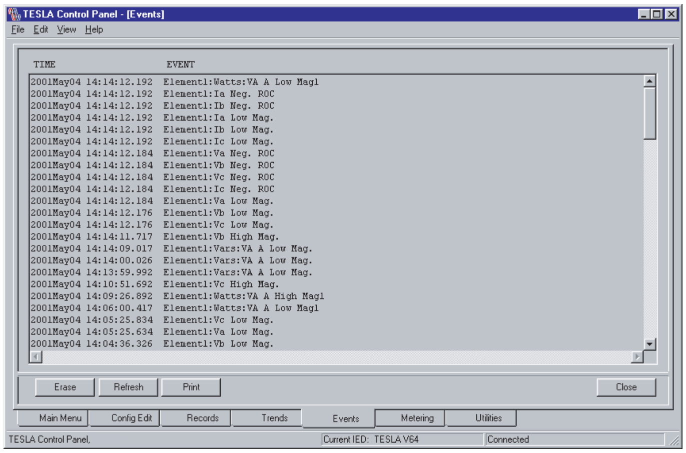


Figure 12.1: Event Log Display

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.

> A copy of all Event messages that correspond to the time frame of a given record is also stored in each record and displayed as part of the record summary

Circular Storage

The Event Log stores up to 250 events with automatic overwrite of the oldest event. The trending module, accessed through the "logging" tab, preserves events, up to 1000 events can be saved in the daily event log.

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 input
- *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

e.g. 2000 Jan 19 00:57:16.000 Line245.EI.BkrA detector pickup

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

e.g. 2000 Jan 19 00:57:16.000 Line245.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 logged on to remote IED (recorder).

Controls

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

13 Error Handling and Maintenance

The recorder has hardware and software self-check and error detection capabilities that work to keep it running and to provide a clear indication if a failure occurs.

Status Indicators

Recorder Functional LED

Normally active green LED on the front panel is turned on by the self-checking hardware with approximately 35 seconds after power up. If a firm failure has been detected, it turns off. The LED state corresponds directly with the rear-panel failure contact (see below).

Test Mode LED

Normally inactive red LED on the front panel turns on immediately on power up and remains on until the self-test has been completed (approximately 45 to 60 seconds). It may blink briefly during the self-test process.

Alarm LED

Activation of this red LED 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, described below.

Failure Contact

Output Contact #1 on the rear panel. Driven by the sanity hardware, this contact provides a hardware-based failure indication that corresponds with the Recorder Functional LED.

For units with serial numbers before 990318-xx, failure is indicated by an open contact.

For units with serial numbers after 991110-xx, failure is indicated by a closed contact.

Trend Alarm Contact

If configured, one of contacts 2, 3, 5, 6, or 7. The contact closes when the number of days of accumulated trend data exceeds a user-selectable threshold (see “Recording Settings” on page 5-5). When sufficient data is deleted so that the number of days of accumulated trend data is below the threshold, the contact opens.

Recording Alarm Contact

If configured, one of contacts 2, 3, 5, 6, or 7. The contact closes when the number of recordings exceeds a user-selectable percentage of the total allowable (see “Recording Settings” on page 5-5). When sufficient records are deleted so that this value is below the threshold, the contact opens.

TESLA States

State	Description	Front Panel LEDs		Failure Contact
Startup	Initial power-up. Low-level self-test and program load	Recorder Functional Test Mode Alarm	Off On Off	Active
Verification	System self-test	Recorder Functional Test Mode Alarm	On On Off	Active
Normal	Normal operation	Recorder Functional Test Mode Alarm	On Off Off	Inactive
Reset	Hardware reset (induced by watchdog hardware or supervisor software)	Recorder Functional Test Mode Alarm	On On Off	Inactive (unless error occurred on unit startup)
Detected Error	Hard fault detected by software.	Recorder Functional Test Mode Alarm	Off Off On	Active
Watchdog	Hard fault detected by watchdog (supervisor software not running)	Recorder Functional Test Mode Alarm	Off On Off	Active

Startup Sequence

On power up, the unit goes through the following startup sequence:

1 Startup State The Test Mode LED turns on immediately. The microprocessors perform initial self-check and program loading.

2 Verification State Approximately 35 seconds after power-up, the supervisory software is in control of the system. It activates the front panel LEDs and conducts further self-checks.

- The Recorder Functional LED turns on.
- The Recorder Fail contact opens (Output Contact #1 on the rear panel).
- The Test Mode LED may blink once.
- If the unit has any records on its hard disk, the Records Stored LED turns on.

3 Normal State Approximately 10 seconds later, if the supervisory software determines that the system is functioning correctly, it turns off the Test Mode LED.

Error 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 of the external indicators.

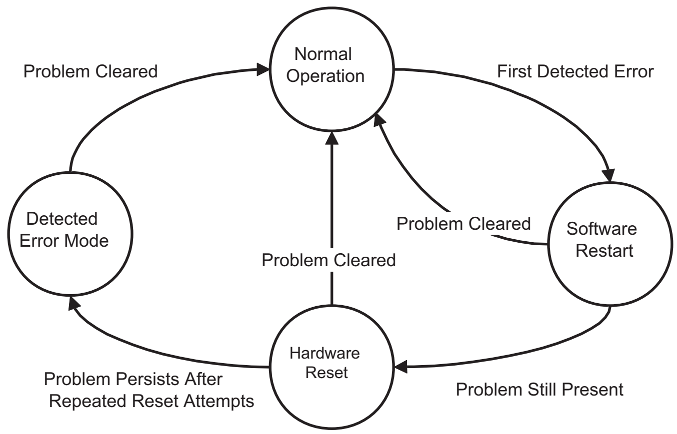


Figure 13.1: Error Handling

If the failure persists, an attempt is made to correct the problem through a full hardware reset. External indicators are those described above for the Reset state. If the problem is not cleared by repeated resets, the unit enters the Detected Error state as described above.

If a fundamental hardware failure occurs that prevents the unit supervisory software itself from running, the self-checking hardware will initiate a reset. After four consecutive resets, the sanity hardware will assert the Recorder Failure contact and enter the Watchdog state as described above.

Failure Modes

Failure Indication	Action
No active front panel LEDS on power up	Check power external connection. For dc supply sources, check polarity. Is the voltage level correct? Open front panel. Check for loose cables
Test Mode LED stays on for more than 5 minutes on startup	Open front panel. Check that sanity disable jumpers have not been inadvertently left on the MPB. Remove if present and allow unit to cycle through reset. (Temporary installation of these jumpers is done as part of the firmware update process). Attempt to log in to the diagnostics menu (see below). If login is possible, the System Diagnostics log could be viewed (or sent to ERLPhase Customer Support) to help pinpoint the problem.
Alarm LED active	Wait 2 minutes. If the system fault can be cleared without intervention, the system will automatically revert to the Normal state. If the condition persists, the System Diagnostics log could be viewed (or sent to ERLPhase Customer Support) to help pinpoint the problem. See Diagnostic Tools, below.

Maintenance Menu

The TESLA has a set of utilities that provide diagnostic, recovery and TCP/IP services. These utilities are available through a 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 the front panel serial port.

Any terminal program that fully supports VT-100 emulation and provides z-modem file transfer services can be used. HyperTerminal, which is included with Microsoft Windows, 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
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.

The Maintenance Menu appears as below.

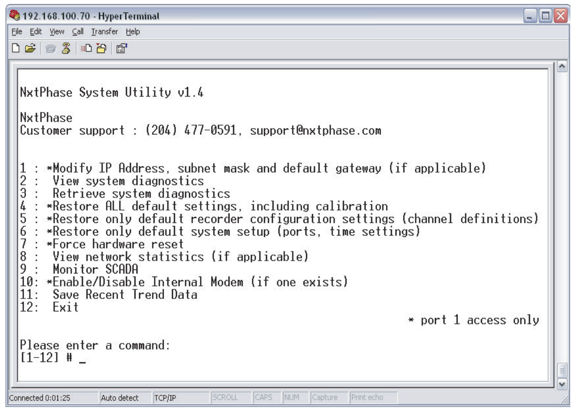


Figure 13.2: Maintenance Menu

Modify IP Address, subnet mask and default gateway	When equipped with an optional Internal 10Base-T Ethernet card, this utility can modify the LAN IP address, default subnet mask and default gateway.
View system diagnostic	Displays the TESLA's internal status log.
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 ERLPhase customer support to help diagnose a problem.
Restore settings	If you suspect a problem due to the unit's settings, calibration and/or setup parameters, you can use the menu to force the system back to default values.
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.
View network statistics	View IP, TCP and UDP statistics when equipped with internal 10BaseT Ethernet card.
Monitor SCADA	Shows real time display of SCADA data.
Enable/Disable internal modem	Enables or disables the optional internal modem.
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.
Exit	

Appendix A Specifications

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
General:		
Nominal Frequency	50 or 60 Hz	
Power Supply	Nominal Range: 48–250 Vdc, 120 Vac Full Operating Range: 40–300 Vdc	Other ranges available
Input Types	The unit accepts ac or dc low voltage analog signals on its rear terminals. These inputs are non-isolated and require external isolation in the form of CTs, PTs or dc isolation circuits. The following DIN rail mounted modules are available to provide connection input signals: • PT module: AC voltage input, 69 V or 115 V nominal, linear to 138 V. • CT module: AC current input, 1 A or 5 A nominal, linear to 20 x nominal. No damage to 20 A continuous, 100 A for 1 second/hour • DC Module: DC or AC voltage or current input, 100 mV to 1 kV full scale or 1 mA to 100 mA full scale nominal. Range is set by resistors mounted on outside of module.	
Measurement Accuracy	Sampling Resolution: 12 bits plus sign Amplitude Measurement Accuracy: ± 0.1% of full scale Phase Measurement Accuracy: ± 1 degree Frequency Measurement Accuracy: ± 0.01 Hz @ 60 Hz	
Response	Transient Response: Rise time <400 second (10 to 90%) with <5% overshoot AC Amplitude Response: ± 2 dB from 10 to 1550 Hz AC Phase Response: ± 1 degree from 10 to 2880 Hz DC Amplitude Response: ± 2 dB from 0 to 1000 Hz	
Noise	Signal to Noise ratio: 66 dB at full scale Common mode rejection: 66 dB at full scale Crosstalk: -66 dB	
Burden	AC Input Module - Voltage: < 0.15 VA @ 69 V AC Input Module - Current: < 0.25 VA @ 5 A DC Input Module: Dependent on configuration (see “DC Input Module” in Appendix L)	
Analog Input Sampling	Fixed at 96 samples/cycle Global to all analog input channels All input channels sampled within 45 microseconds of each other (within 1 degree @ 60 Hz)	
Recording:		
Recording Rate:		

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
Transient Fault	96 samples/cycle	Up to 10 seconds per record
Dynamic Swing	1 sample/cycle	Up to 3 minutes per record
Analog Input Accuracy	+/- 0.1% of FS amplitude +/- 1.0 degree phase	
Record Storage	Up to 1000 fault, swing or combined records	2 Gigabyte hard disk standard Larger capacity or flash disk options
A/D Resolution	13 bits, 8192 counts full scale	
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. Assigned a priority.
Summations	High/low threshold, +/- rate of change	2 or 3 input channel
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	
Logic	Rising edge, falling edge or both	
Fault Locator	Triggered by internal or external events	
Chatter Detection	The chatter detection applicable to other detectors applies also to sags and swells. Chatter detection reduces the number of event messages in a situation where there is substantial possibility of rapid re-triggering.	
Sags and Swells	Sag and swell detection can be enabled on any analog input channel configured as a voltage.	
Thresholds	The minimum sag level is configurable from 90% to 50% of nominal. The maximum sag level is fixed at 10% of nominal. To be reported, the measured voltage must start and end above the minimum sag level. As well, all measurements in between must be above the maximum threshold (10%).	
	The minimum swell level is configurable from 110% to 150% of nominal. The maximum swell level is fixed at 180% of nominal. To be reported, the measured voltage must start and end below the swell minimum level. As well, all measurements in between must be below the maximum threshold (180%).	

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
Duration	Sags or swells with duration—0.5 cycle and 1 minute are reported. This range is not configurable.	
Message Data	The minimum voltage (in the case of sags) or the maximum voltage (swells) during the episode is be reported.	
Input & Output:		
Analog Input Channels	36 or 18	Rating: In = 5 A or 1 A, Vn = 69 V Continuous: 3x In, 2x Vn One Second: 20x In without distortion
External Inputs (digital)	64 or 32	40 - 150 Vdc, externally wetted
Alarm Output Relays (contacts)	8 or 4	Make: 8 A Carry: 8 A Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc
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 115 K baud	Port 2 can support an external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional on TESLA 2000
Network	10BaseT Ethernet port	Optional on TESLA 2000
SCADA Interface	DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Configurable Alarms	5 contacts	Normally open
Cross-trigger	2 contacts	Normally open
Self Checking/Recorder Inoperative	1 contact	Normally closed
Time Sync	IRIG-B, BNC connector	Modulated or unmodulated
Environmental:		
Ambient Temperature Range	0°C–55°C	IEC 60068-2-1/IEC 60068-2-2
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs (through external isolation modules), external inputs, output contacts -1.5 kV, 50/60 Hz, 1 minute.	IEC 60255-5
Electrical Fast Transient		ANSI/IEEE C37.90.1-1989
Oscillatory Transient		ANSI/IEEE C37.90.1-1989
RFI Withstand		ANSI/IEEE C37.90.2, IEC 255-22-3
Shock and Bump		IEC 60255-21-2 Class 1

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
Physical:		
Weight	12 kg	26.5 lbs
Dimension	3U high (5.25"), 19" wide, 12" deep	Rack mount
Input Modules	4 input current or 3 input voltage modules available	DIN rail mount, up to 100' away from recorder chassis. Clamp-on CT available. Contact ERLPhase for details.
Modularity	Two standard channel set options are available: • 18 analog inputs, 32 digital inputs and 4 output contacts • 36 analog inputs, 64 digital inputs and 8 output contacts	Analog inputs utilize external isolation and signal translation circuits as required (e.g. DIN rail mounted CT or PT).
Terminal	Direct-wire terminal strips with tightening screws on the input module. External CT and PT transformers have screw-down terminal that accept ring or fork crimps.	
Front Panel Indicators	6 LEDs: Recorder Functional, IRIG-B Functional, Recorder Triggered, Records Stored, Test Mode, Alarm	
Communications Hardware	Port 1, RS-232 serial port to 115 K baud (front panel) Port 2, RS-232 serial port to 115 K baud (rear of unit) - unavailable with optional internal modem Port 3, RS-232 serial port for SCADA (rear of unit) - 33.6 kbd	
Optional	Internal modem 33.6 Kbps, V.32 bis 10BaseT Ethernet port	
External Inputs		
Number	32 or 64 channels	
External Input Thresholds	Standard (covers 48 and 125 V systems): Will turn on: >=38.4 V Will not turn on: <=17.0 V Maximum input: <160 V High range (covers 125 and 250 V systems) Will turn on: >=110.0 V Will not turn on: +30.0 V Maximum input: <295 V	
	Will turn on: >=38 V Will not turn on: <=25 V Maximum input: <300 V	For recorders with serial number TESLA-2000-021010-01 or later the external input boards have an operational voltage range from 48 Vdc to 250 Vdc. The external inputs activate at approximately 32 Vdc.
Burden	Burden Resistance: >10 kilo-ohm	
Sample Rate	Same as selected for the analog input channels (synchronized)	
Terminals	Direct-wire terminal strips with tightening screw	
Output Contacts		

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
Number	4 or 8	
Function	1: Recorder Failure - normally closed 2: User-definable - Pick-up <1.0 s, latch 1.0 s 3: User-definable - Pick-up <1.0 s, latch 1.0 s 4: Channel Group 1 cross trigger output - Pick-up <10 ms, latch 100 ms The following additional contacts are available on the 36 channel version only: 5: User definable - Pick-up <1.0 s, latch 1.0 s 6: User definable - Pick-up <1.0 s, latch 1.0 s 7: User definable - Pick-up <1.0 s, latch 1.0 s 8: Channel Group 2 cross trigger output - Pick-up <10 ms, latch 100 ms	
Dry Contact Rating	5 A @ 150 Vdc make and continuous 300 mA @ 150 Vdc break	Carry: 8 A Make: 8 A Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc
Terminals	Direct-wire terminal strips with tightening screws	
Record Length		
Transient Record Length	normal 0.2 to 5 seconds auto extend to 10 seconds	
Swing Record Length	normal 10 to 120 seconds auto extend 180 seconds	
Total Records Stored	1000 records	
Event Log Record	250 events	
Time Synchronization and Accuracy		
External Time Source	The recorder can be synchronized using modulated or unmodulated IRIG-B. IEEE 1344 is supported.	
Free Running Accuracy	In the absence of an external time source, the recorder maintains time with a maximum 1 part per million drift. The recorder can detect loss or re-establishment of external time source and switch between internal and external time.	
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external) All time stamping accurate to 45 microseconds (equivalent to 1 degree @ 60 Hz)	
Trends		
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.	

TESLA Recorder (model 2000)		
Item	**Quantity/Specs**	**Note**
Accumulation mode	Each channel can be configured to accumulate data in one or more of the following modes.	
	Accumulation Mode	Description
	Minimum	Smallest reading seen over the interval
	Maximum	Largest reading seen over the interval
	Average	Average of all readings seen over the interval
	Damped	Single zero low pass filter, with a time constant preset to one-half the user-selected Sample Interval.
	Undamped	Last reading in the interval
	Data is accumulated at a rate of 100 (50 Hz systems) or 120 (60 Hz systems) samples/second and is produced and stored at the selected trend sample interval.	
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 on the recorder	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.	
Accumulation mode	Accumulation of trend data can be configured to either stop or recycle when the trend log is full. In recycle mode, the oldest data is overwritten.	
Trend “full” indicator	An alarm contact can be activated when the oldest data in the trend log reaches a specified age. The alarm level is configurable from 10 to 90 days in daily steps. Once activated, the alarm will remain on until the user removes the data (via TESLA Control Panel) or the configured alarm level is increased.	
Scaling	Data is always stored in primary quantities	
Change of configuration	The configuration of the recorder can be changed without loss of previously accumulated trend data. If the new configuration stops the trending of a channel, previously accumulated data for that channel remains available until it reaches the 90- day storage limit or until it is removed by the user.	
Event Storage	The storage capacity for Trend events is set at a maximum of 1000 events/day and is retained for the same period as Trend data.	

TESLA Portable Recorder (model 2000/P)

Item	Quantity/Specs	Note
General:		
Nominal Frequency	50 or 60 Hz	
Power Supply	Nominal Range: 48–250 Vdc, 120 Vac Full Operating Range: 40–300 Vdc	Other ranges available
Input Types	The unit accepts ac or dc low voltage analog signals on its terminals. These inputs are non-isolated and require external isolation in the form of CTs, PTs or dc isolation circuits. The following DIN rail mounted modules are available to provide connection input signals: • PT module: AC voltage input, 69 V or 115 V nominal, linear to 138 V. • CT module: AC current input, 1 A or 5 A nominal, linear to 20 x nominal. No damage to 20 A continuous, 100 A for 1 second/hour • DC Module: DC or AC voltage or current input, 100 mV to 1 kV full scale or 1 mA to 100 mA full scale nominal. Range is set by resistors mounted on outside of module.	
Measurement Accuracy	Sampling Resolution: 12 bits plus sign Amplitude Measurement Accuracy: ± 0.1% of full scale Phase Measurement Accuracy: ± 1 degree Frequency Measurement Accuracy: ± 0.01 Hz @ 60 Hz	
Response	Transient Response: Rise time <400 second (10 to 90%) with <5% overshoot AC Amplitude Response: ± 2 dB from 10 to 1550 Hz AC Phase Response: ± 1 degree from 10 to 2880 Hz DC Amplitude Response: ± 2 dB from 0 to 1000 Hz	
Noise	Signal to Noise ratio: 66 dB at full scale Common mode rejection: 66 dB at full scale Crosstalk: -66 dB	
Burden	AC Input Module - Voltage: < 0.15 VA @ 69 V AC Input Module - Current: < 0.25 VA @ 5 A DC Input Module: Dependent on configuration (see “DC Input Module” in Appendix L).	
Analog Input Sampling	Fixed at 96 samples/cycle Global to all analog input channels. All input channels sampled within 45 microseconds of each other (within 1 degree @ 60 Hz)	
Recording:		
Recording Rate:		
Transient Fault	96 samples/cycle	Up to 10 seconds per record

TESLA Portable Recorder (model 2000/P)		
Item	**Quantity/Specs**	**Note**
Dynamic Swing	1 sample/cycle	Up to 3 minutes per record
Analog Input Accuracy	+/- 0.1% of FS amplitude +/- 1.0 degree phase	
Record Storage	Up to 1000 fault, swing or combined records	1 gigabyte flash disk standard
A/D Resolution	13 bits, 8192 counts full scale	
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. Assigned a priority.
Summations	High/low threshold, +/- rate of change	2 or 3 input channel
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	
Logic	Rising edge, falling edge or both	
Fault Locator	Triggered by internal or external events	
Chatter Detection	The chatter detection applicable to other detectors applies also to sags and swells. Chatter detection reduces the number of event messages in a situation where there is substantial possibility of rapid re-triggering.	
Sags and Swells	Sag and swell detection can be enabled on any analog input channel configured as a voltage.	
Thresholds	The minimum sag level is configurable from 90% to 50% of nominal. The maximum sag level is fixed at 10% of nominal. To be reported, the measured voltage must start and end above the minimum sag level. As well, all measurements in between must be above the maximum threshold (10%).	
	The minimum swell level is configurable from 110% to 150% of nominal. The maximum swell level is fixed at 180% of nominal. To be reported, the measured voltage must start and end below the swell minimum level. As well, all measurements in between must be below the maximum threshold (180%).	
Duration	Sags or swells with duration—0.5 cycle and 1 minute are reported. This range is not configurable.	

TESLA Portable Recorder (model 2000/P)		
Item	**Quantity/Specs**	**Note**
Message Data	The minimum voltage (in the case of sags) or the maximum voltage (swells) during the episode is be reported.	
Input & Output:		
Analog Input Channels	18	Rating: In = 5 A or 1 A, Vn = 69 V Continuous: 3x In, 2x Vn One Second: 20x In without distortion
External Inputs (digital)	32	40 - 150 Vdc, externally wetted
Alarm Output Relays (contacts)	4	Make: 8 A Carry: 8 A Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc
Interface & Communication:		
Front Panel Indicators	8 Status LEDs, 32 external inputs and 4 outputs	Power On, Wetting On, Recorder Functional, IRIG-B Functional, Recorder Triggered, Records Stored, Test Mode, Alarm
Serial User Interface	RS-232 ports up to 115 K baud	Port 2 can support an external modem
Internal Modem	33.6 Kbps, V.32 bis	
Network	10BaseT Ethernet port	
SCADA Interface	DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Port 3
Configurable Alarms	2 contacts	Normally open
Cross-trigger	1 contact	Normally open
Self Checking/Recorder Inoperative	1 contact	Normally closed
Time Sync	IRIG-B, BNC connector	Modulated or unmodulated
Environmental:		
Ambient Temperature Range	-10°C–55°C	IEC 60068-2-1/IEC 60068-2-2
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs (through external isolation modules), external inputs, output contacts -1.5 kV, 50/60 Hz, 1 minute.	IEC 60255-5
Electrical Fast Transient		ANSI/IEEE C37.90.1-1989
Oscillatory Transient		ANSI/IEEE C37.90.1-1989
Physical:		
Weight	14.97 kg	33 lbs
Dimension	29.21 cm high, 44.45 cm wide, 46.99 cm deep	11.5" high, 17.5" wide, 18.5" deep

TESLA Portable Recorder (model 2000/P)		
Item	**Quantity/Specs**	**Note**
Input Modules	4 input current or 3 input voltage modules available 3 input voltage and 12 split core	
Modularity	Two standard channel set options are available: • 18 analog inputs, 32 digital inputs and 4 output contacts	Analog inputs utilize external isolation and signal translation circuits as required (e.g. DIN rail mounted CT or PT)
Terminal	External CT and PT transformers have screw-down terminal that accept ring or fork crimps	
Front Panel Indicators	6 LEDs: Recorder Functional, IRIG-B Functional, Recorder Triggered, Records Stored, Test Mode, Alarm	
Communications Hardware	Port 1, RS-232 serial port to 115 K baud Port 2, RS-232 serial port to 115 K baud Port 3, RS-232 serial port for SCADA - 33.6 kbd	Port 2 is only available if the internal modem is disabled
	Internal modem 33.6 Kbps, V.32 bis 10BaseT Ethernet port	
External Inputs		
Number	32 channels	
External Input Thresholds	Will turn on: >=38 V Will not turn on: <=25 V Maximum input: <300 V	
Burden	Burden Resistance: >10 kilo-ohm	
Sample Rate	Same as selected for the analog input channels (synchronized)	
Terminals	Binding posts	
Wetting Supply	48 Vdc fused 1/4 A	Capable of driving all 32 external inputs
Output Contacts		
Number	4 or 8	
Function	1: Recorder Failure - normally closed 2: User-definable - Pick-up <1.0 s, latch 1.0 s 3: User-definable - Pick-up <1.0 s, latch 1.0 s 4: Channel Group 1 cross trigger output - Pick-up <10 ms, latch 100 ms	
Dry Contact Rating	5 A @ 150 Vdc make and continuous 300 mA @ 150 Vdc break.	Carry: 8 A Make: 8 A Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc
Terminals	Binding posts	
Record Length		
Transient Record Length	normal 0.2 to 5 seconds auto extend to 10 seconds	

TESLA Portable Recorder (model 2000/P)		
Item	**Quantity/Specs**	**Note**
Swing Record Length	normal 10 to 120 seconds auto extend 180 seconds	
Total Records Stored	1000 records	
Event Log Record	250 events	
Time Synchronization and Accuracy		
External Time Source	The recorder can be synchronized using modulated or unmodulated IRIG-B. IEEE 1344 is supported.	
Free Running Accuracy	In the absence of an external time source, the recorder maintains time with a maximum 1 part per million drift. The recorder can detect loss or re-establishment of external time source and switch between internal and external time.	
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external) All time stamping accurate to 45 microseconds (equivalent to 1 degree @ 60 Hz)	
Trends		
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	Each channel can be configured to accumulate data in one or more of the following modes.	
	Accumulation Mode	Description
	Minimum	Smallest reading seen over the interval
	Maximum	Largest reading seen over the interval
	Average	Average of all readings seen over the interval
	Damped	Single zero low pass filter, with a time constant preset to one-half the user-selected Sample Interval.
	Undamped	Last reading in the interval
	Data is accumulated at a rate of 100 (50 Hz systems) or 120 (60 Hz systems) samples/second and is produced and stored at the selected trend sample interval.	
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.	

TESLA Portable Recorder (model 2000/P)		
Item	**Quantity/Specs**	**Note**
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 on the recorder	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.	
Accumulation mode	Accumulation of trend data can be configured to either stop or recycle when the trend log is full. In recycle mode, the oldest data is overwritten.	
Trend “full” indicator	An alarm contact can be activated when the oldest data in the trend log reaches a specified age. The alarm level is configurable from 10 to 90 days in daily steps. Once activated, the alarm will remain on until the user removes the data (via TESLA Control Panel) or the configured alarm level is increased.	
Scaling	Data is always stored in primary quantities	
Change of configuration	The configuration of the recorder can be changed without loss of previously accumulated trend data. If the new configuration stops the trending of a channel, previously accumulated data for that channel remains available until it reaches the 90- day storage limit or until it is removed by the user.	
Event Storage	The storage capacity for Trend events is set at a maximum of 1000 events/day and is retained for the same period as Trend data.	

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.

External Input Boards #1 and #2

The 18 channel TESLA and the Portable TESLA has 32 external inputs and 4 contact outputs, provided by External Input Board #1. Inputs are optically isolated and factory preset to the customer's requested voltage level.

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.

Connection to the board is provided by removable screw terminal strips. Posts are mounted on the Portable TESLA and the rack binding. Terminal strips on the rack mounted units 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 and Portable TESLA has only half of the board populated.

Connection to the board is provided by removable screw terminal strips on the rack-mounted TESLA and binding posts on the Portable TESLA. Terminal strips 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, and network or telephone is a female RJ-45 modular jack.

Power Supply

The Power Supply conditions and converts the input power for use by the internal electronics. A wide input power supply provides the TESLA with the ability to operate from 40 to 300 Vdc or 120 Vac ± 20% 50/60 Hz.

PC-104 CPU Board

A 100 MHz 486-class CPU with 36 MB of RAM provides data storage, information management, housekeeping, and communications for the TESLA. The 486 runs QNX®, a POSIX-compliant real-time operating system optimized for high speed, high precision computing. The 486 provides sophisticated facilities for communications and field software updates. Local and wide area networking is supported by QNX, providing the TESLA with a path to future networking capability.

Main Processor Boards #1 and #2

The 18 channel TESLA and the Portable TESLA has one Main Processor Board (MPB) to service its 18 analog and 32 external inputs. The 36 channel TESLA uses a second MPB for another 18 analog and 32 external inputs.

Each MPB has analog data acquisition, high-speed digital signal processing for triggering and data conversion, communications and interface logic to perform the core functions of the TESLA recorder.

The Main Processor Board has:

- 24 channels of high-speed 12 bit-plus-sign analog-to-digital conversion
- 512 KB of high speed cache memory for the DSP
- Re-programmable flash memory for the DSP allows field software upgrades

- 50 MHz TMS320C32 32-bit floating point Digital Signal Processor (DSP) for fast capture and manipulation of data
- 3 FIFO-enabled 16550 serial RS-232 communications ports
- High speed 512 word FIFO in both directions between DSP and 486 processors
- Time synchronism processor with automatic detection of modulated and unmodulated IRIG-B
- Sophisticated fault detection and recovery “watchdog” hardware

Hard Disk

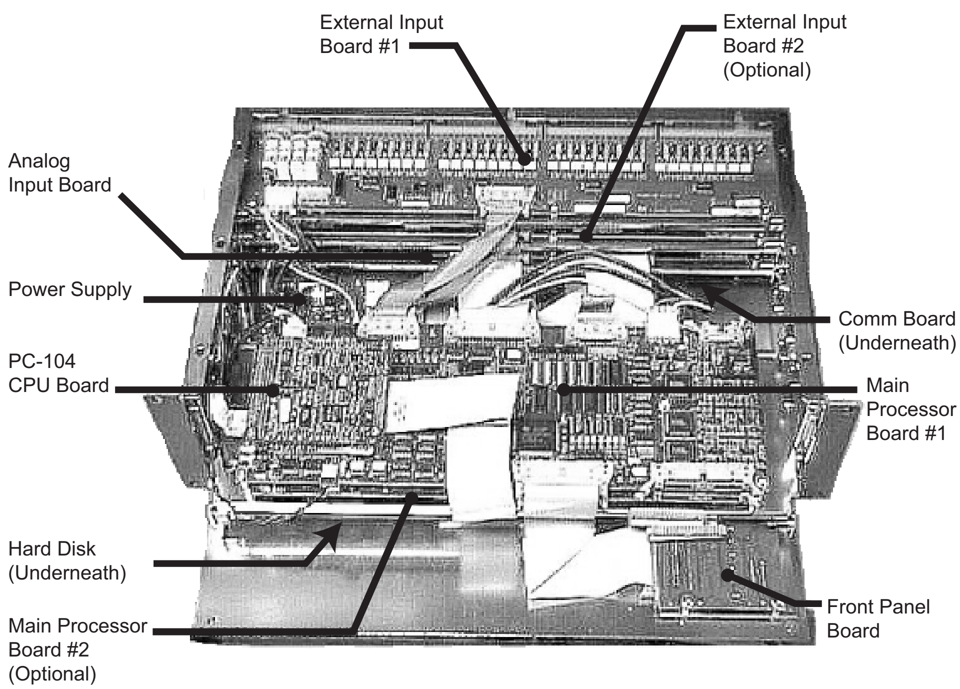
Data storage for the TESLA recorder is a high capacity hard disk drive. The Portable TESLA uses a 1 GB solid state flash IDE drive.

Front Panel Board

The Front Panel Board provides visual indication of the status of the TESLA recorder and a front-panel RS-232 port. The RS-232 port is female DB-9S connector.

Wetting Supply

The Wetting Supply is available only on the Portable TESLA. It supplies enough power to wet all 32 external input contacts.



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.
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 from 2 AM on the first Sunday in April, until 3 AM / 2 AM on the last Sunday in October.
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).

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 Modbus Address List” on page 7-33.

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
AI23Angle	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 1Magnitude	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” in Appendix D)	42052 – 42144		
Length (in 16 bit registers) of the current 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" in Appendix D)	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 2000.
- Version and issue will each be positive integers, say X and Y.
- The TESLA is defined as "Model 2000, 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’

Register	Value	Meaning	
42063	0x2E	0x39	‘.’, ‘9’
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: NxtPhase Corporation	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 Fragme 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		
60	3	Class 2 Data	1(read)	0x06, 0x07,0x08		
80	1	Internal Indications	2 (write)	0x00, index=7		

Object			Request		Response	
Grp	Var	Description	Function Codes	Qualifier Codes	Function Codes	Qualifier Codes
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. Please refer to “Printing a DNP Address List” on page 7-34.

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
External Input 14	13	1
External Input 15	14	1
External Input 16	15	1
External Input 17	16	1

Name	Point Index	Change Event Class
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
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

Name	Point Index	Change Event Class
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
Logic1 4	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
Output Contact 8	36	N/A

Name	Point Index	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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

Name	Point Index	Units	Scale	Change Event Class
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
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				

Name	Point Index	Units	Scale	Change Event Class
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 Distanc	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
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				

Name	Point Index	Units	Scale	Change Event Class
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
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 TESLA Mechanical Drawing

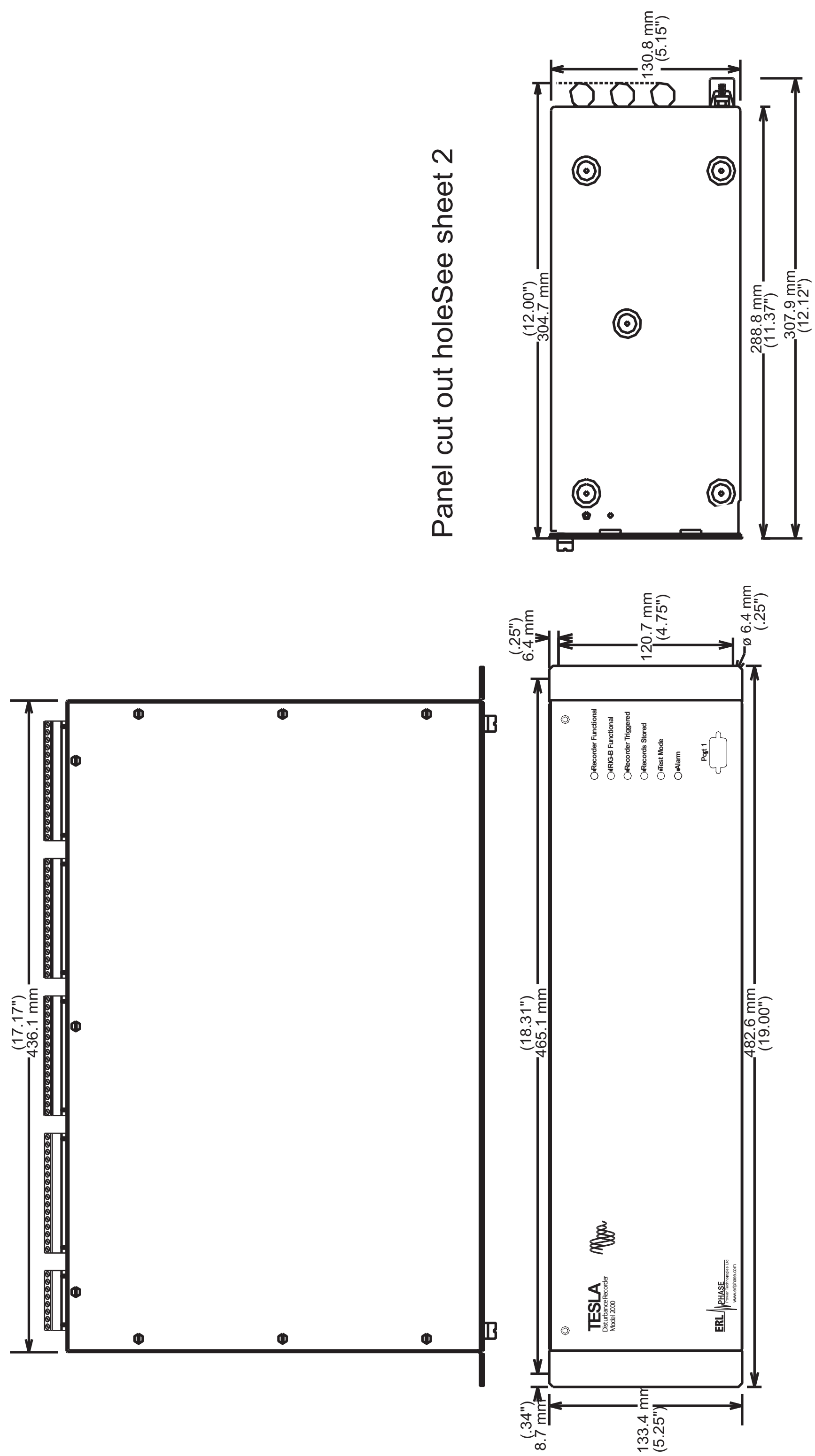


Figure F.1: Mechanical Drawing (rack-mounted TESLA model 2000)

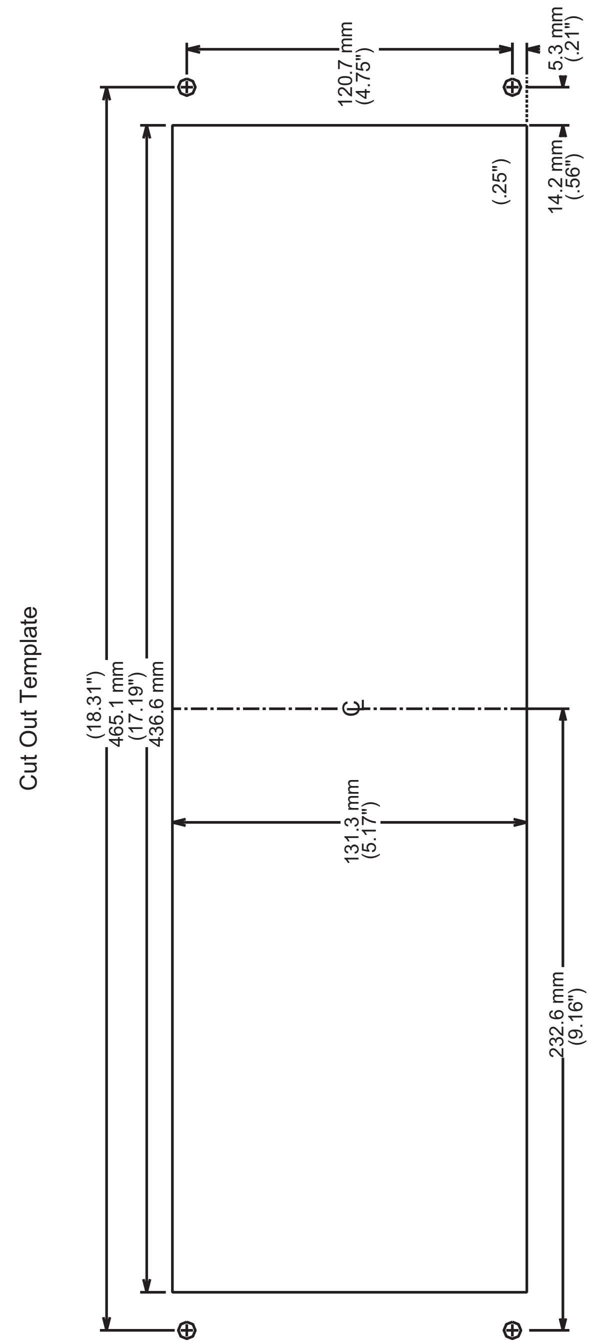


Figure F.2: Cut-out Template(rack-mounted TESLA model 2000)

Appendix G Rear Panel

For larger view, see folded diagram at back.

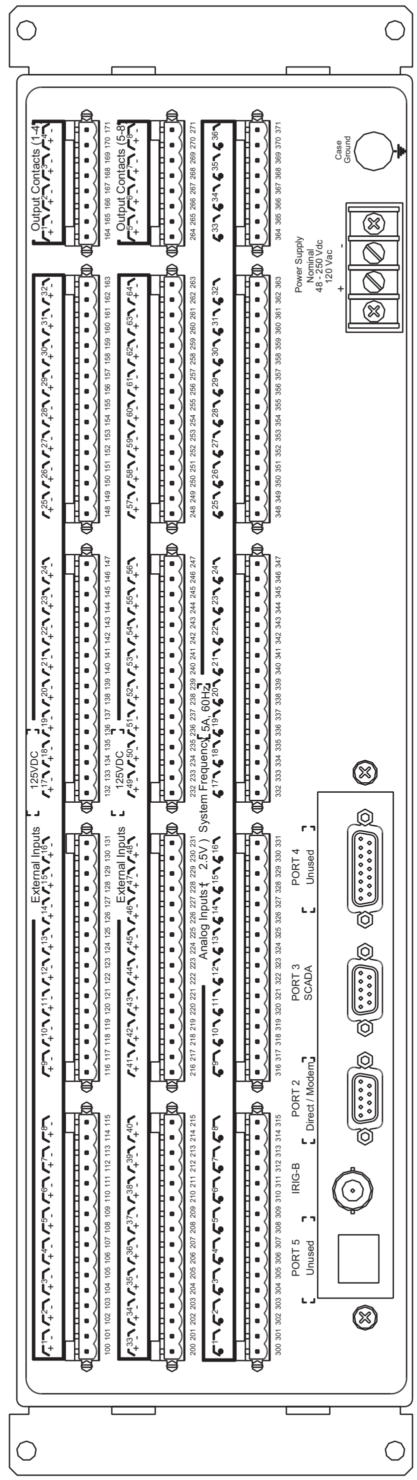


Figure G.1: Rear Panel

Appendix H   AC Analog Connections

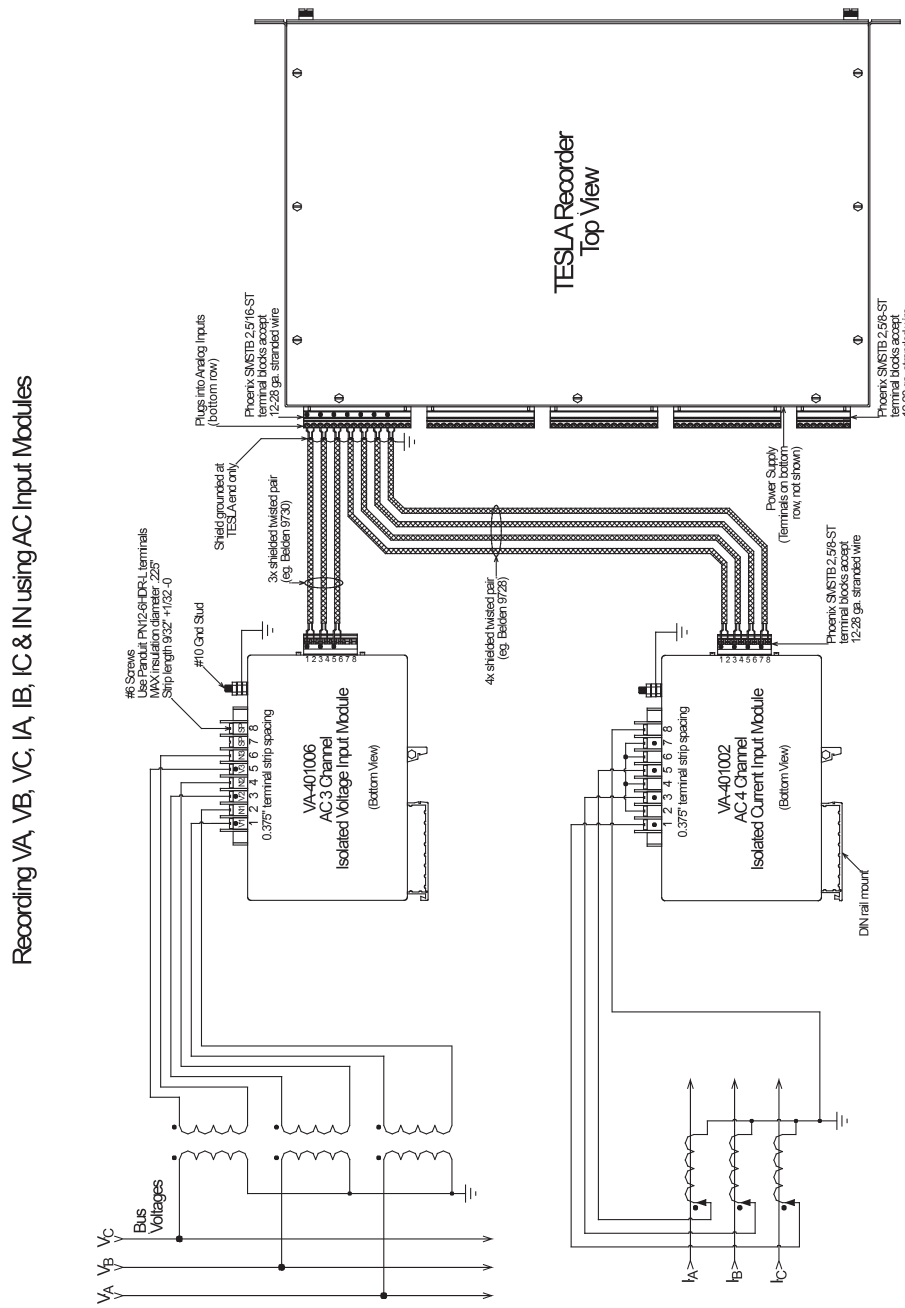


Figure H.1: AC Analog Connections

Appendix I AC Voltage Input Module

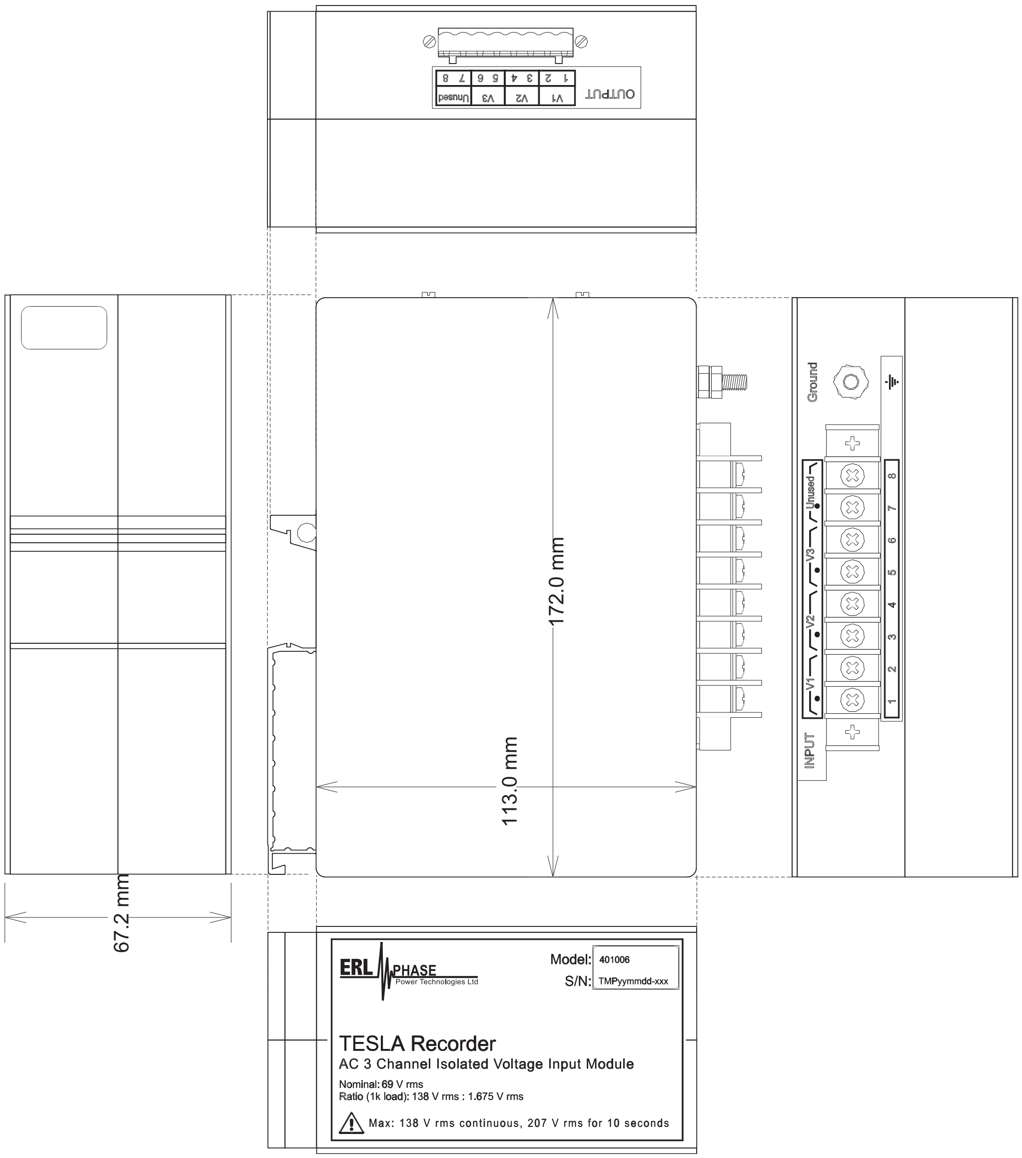


Figure I.1: 401006 AC Voltage Input Module

Figure I.2: 401006.02 AC Voltage Input Module

This module has been superceded by the 401006 shown on the previous page.

Appendix J AC Current Input Module

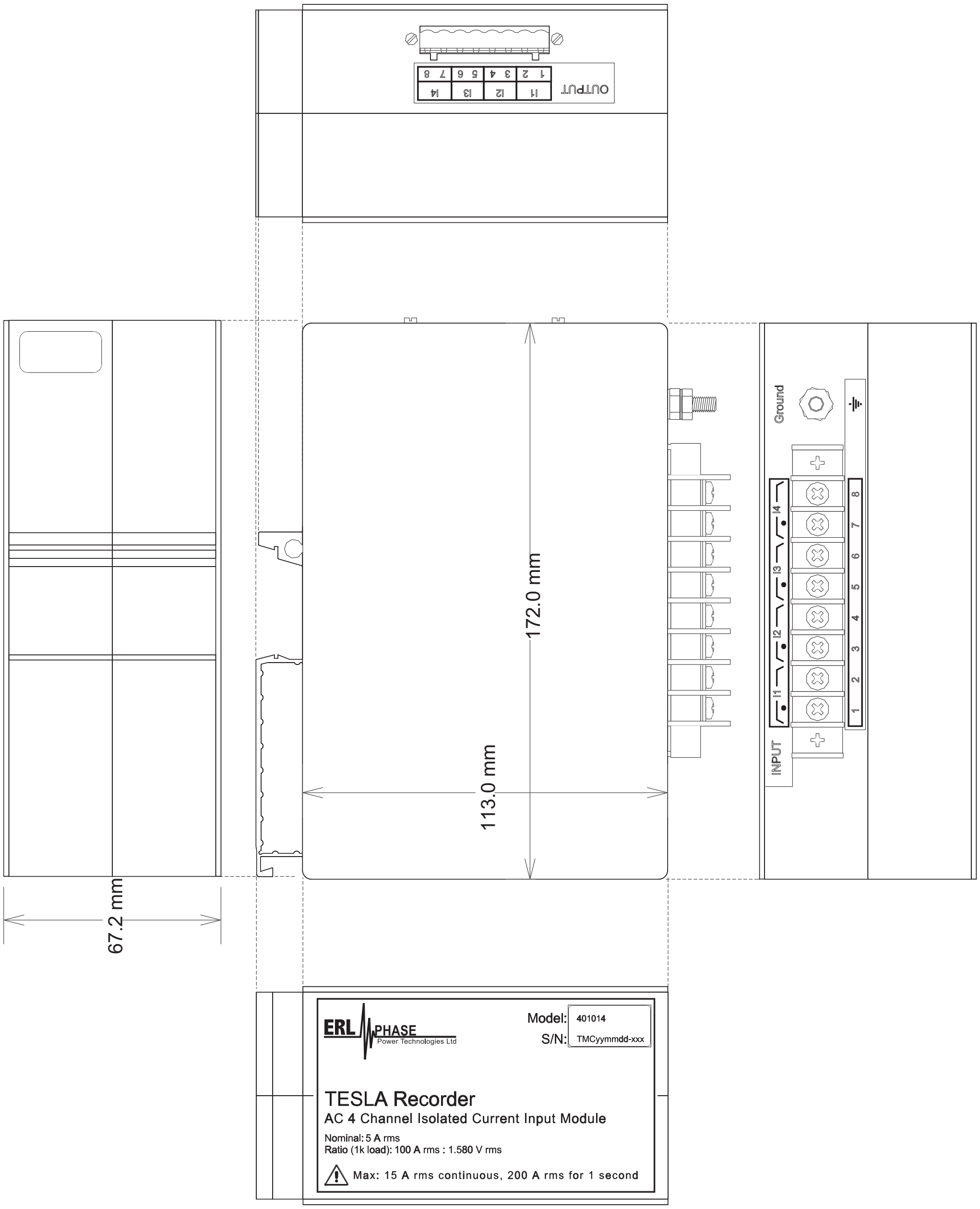


Figure J.1: 401014 AC Current Input Module

Figure J.2: 401002.02 AC Current Input Module

This module has been superceded by the 401014 module shown on the previous page.

Appendix K AC Current Input Options

Split Core CT (optional)

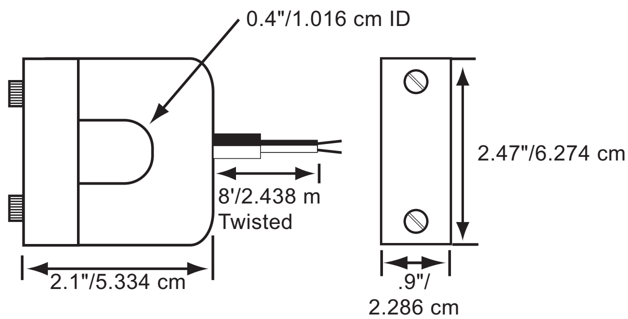
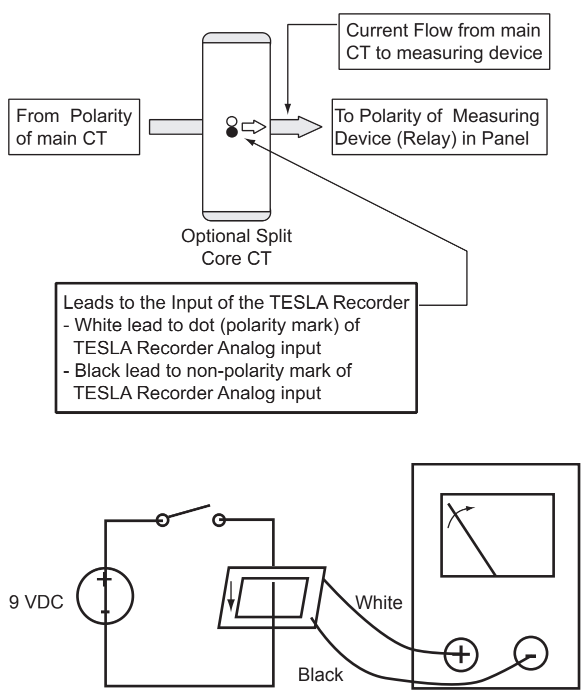


Figure K.1: Split Core CT (optional)



1. Connect 9 VDC battery or supply with positive polarity in the direction of arrow on the CT as shown.
2. Connect DC meter (d'Arsonal movement) with positive polarity connected to the white lead on the CT as shown.
3. Momentarily close and open the switch and watch for movement of DC voltmeter. The meter will move in the direction shown for a white lead as polarity.

Figure K.2: Connection of Optional Split Core CT

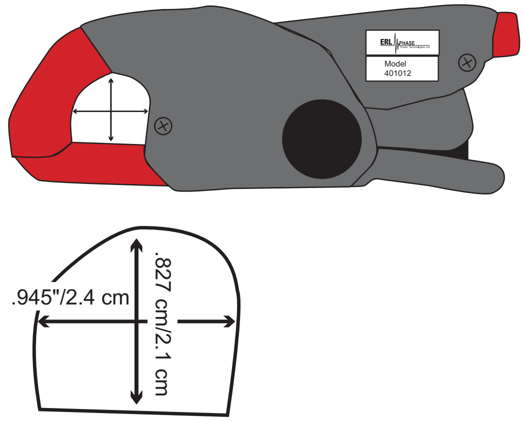


Figure K.3: Clamp-on CT (optional)

Appendix L DC Input Module

The DC Analog Module is an optional input device to provide DC-coupled isolation and scaling for four independent dc or ac voltage or current channels.

DC Analog Module Connection Schematic

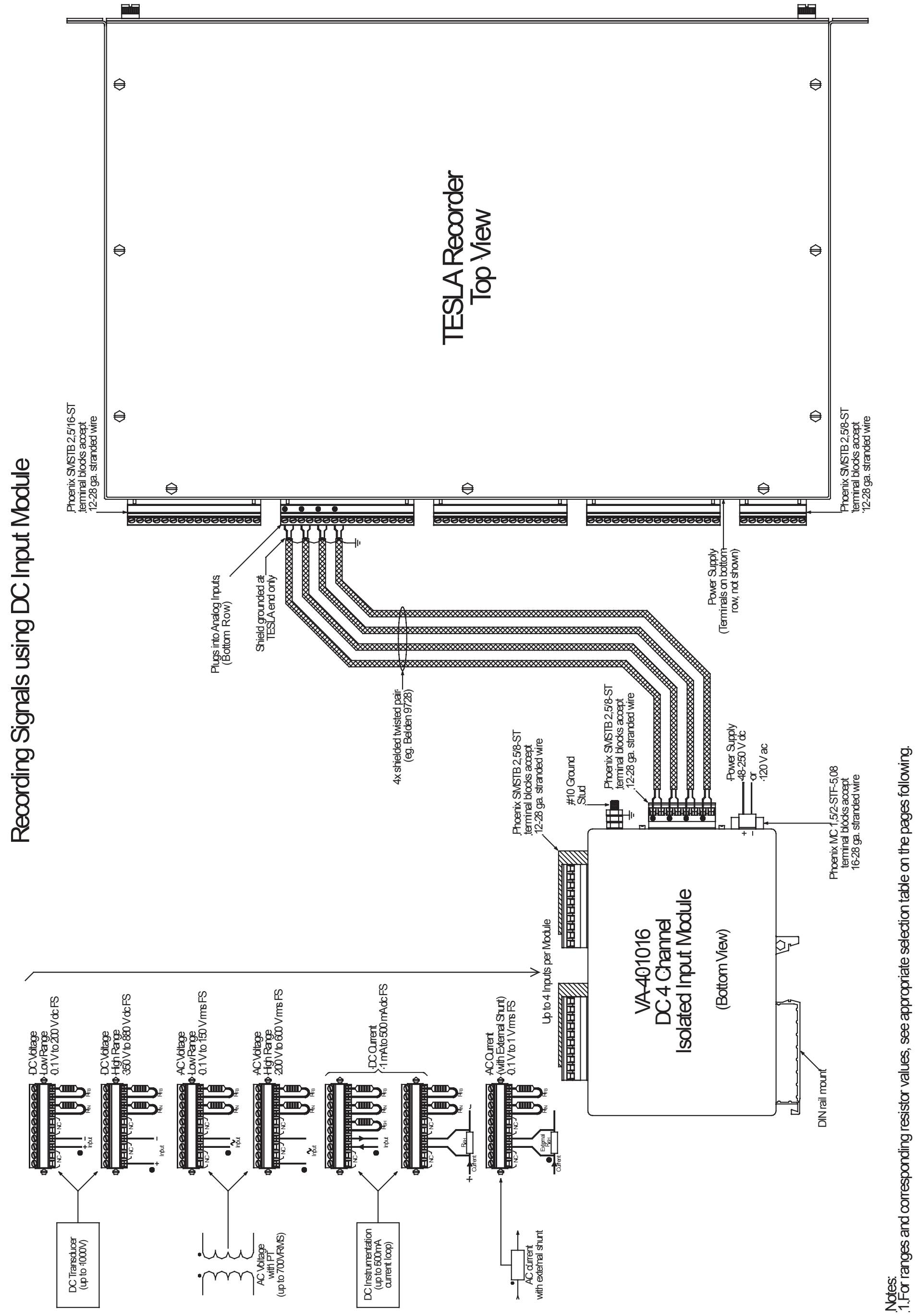


Figure L.1: DC Analog Module Connection Schematic

DC Analog Module Physical Dimensions

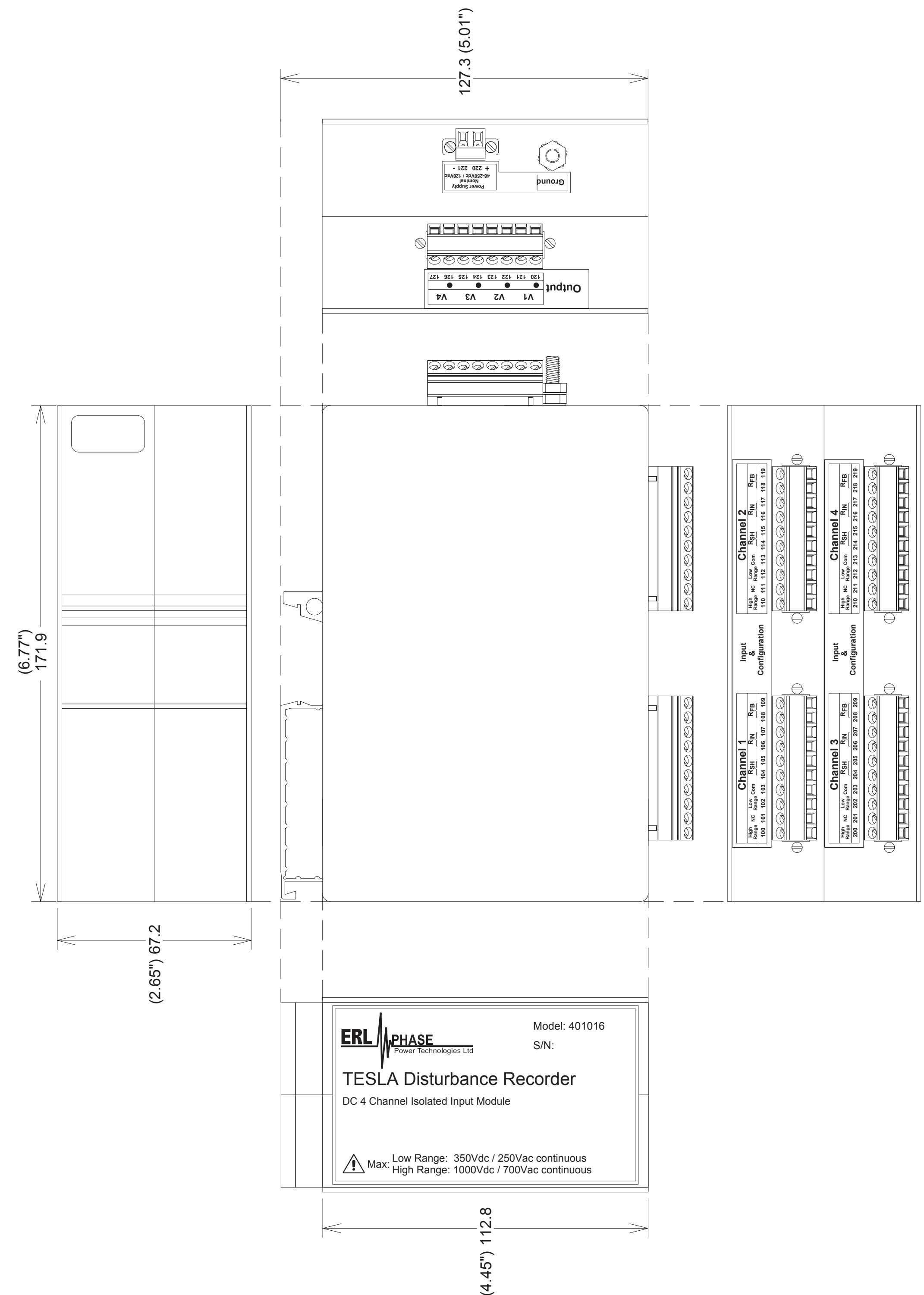


Figure L.2: 401016 DC Input Module Model

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.

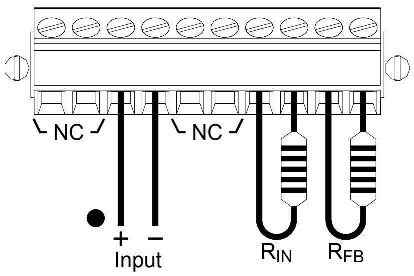
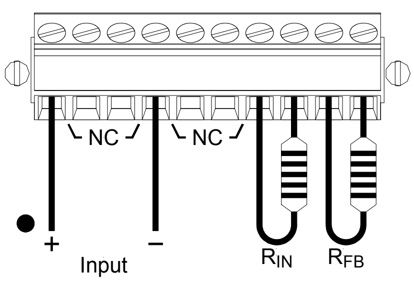
The input signal is applied to low or high range terminals, as appropriate for the selected input range.

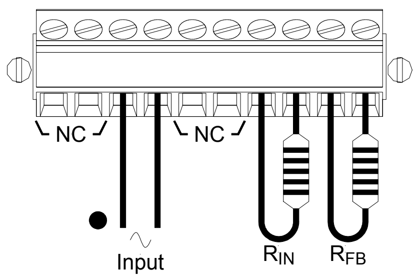
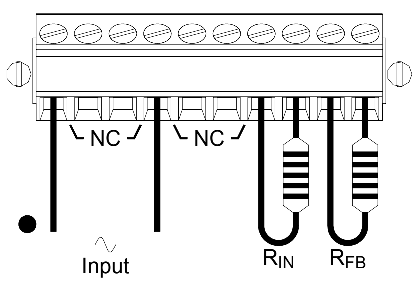
The following tables give resistor values and wiring examples for different applications. For applications that are not in these tables, contact ERLPhase.

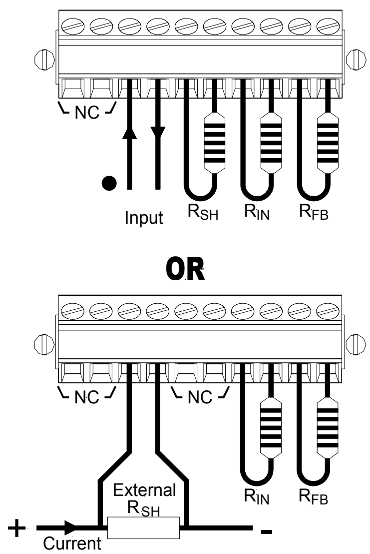
All resistors must be rated for ¼ watt or more, unless otherwise specified. Unless otherwise noted, the R_{IN} resistor must be rated to handle the full input voltage, which may require a physically larger resistor be used. This is generally true of any application that has an input in excess of 50 V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

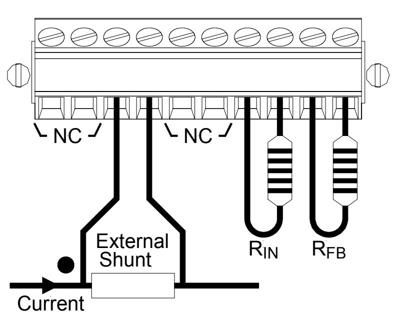
The resistor values specified are precision values as per the E48 standard series of resistance values in a decade. See the section L.3 Input and Range Configuration for the full table of standard values. It is possible to use other available values, although range and resolution may be compromised. 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 ±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 Ω to 1 MΩ 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 kΩ
	± 0.2		0 Ω	422 kΩ	10 kΩ
	± 0.5		0 Ω	100 kΩ	10 kΩ
	± 1		0 Ω	40.2 kΩ	10 kΩ
	± 2		0 Ω	13.3 kΩ	10 kΩ
	± 5		1.40 kΩ	0 Ω	11 kΩ
	± 10		13.3 kΩ	0 Ω	22 kΩ
	± 20		38.3 kΩ	0 Ω	47 kΩ
	± 25		51.1 kΩ	0 Ω	60 kΩ
	± 50		121 kΩ	0 Ω	120 kΩ
	± 100		287 kΩ 1/2 W	0 Ω	240 kΩ
	± 150		511 kΩ 1 W	0 Ω	350 kΩ
	± 200		825 kΩ 1 W	0 Ω	450 kΩ
High Range **350 V to 880 V dc FS** 	± 350		0 Ω	10.0 kΩ	1.5 MΩ
	± 500		0 Ω	3.48 kΩ	1.5 MΩ
	± 880		1 MΩ 2W	0 Ω	2 MΩ

AC Voltage Input					
	Full Scale (V rms)	**Shunt Resistance R_{SH} (Ω)**	**Input Resistance R_{IN} (Ω)**	**Feedback Resistance R_{FB} (Ω)**	**Input Impedance (Ω ±10%)**
Low Range **0.1 V to 150 V rms FS**  	0.1		0 Ω	1.00 MΩ	10 k Ω
	0.2		0 Ω	237 kΩ	10 k Ω
	0.5		0 Ω	64.9 kΩ	10 k Ω
	1		0 Ω	23.7 kΩ	10 k Ω
	2		0 Ω	6.19 kΩ	10 k Ω
	5		6.19 kΩ	0 Ω	16 k Ω
	10		23.7 kΩ	0 Ω	33 k Ω
	20		59.0 kΩ	0 Ω	66 k Ω
	50		178 kΩ 1/2 W	0 Ω	160 k Ω
	100		464 kΩ 1 W	0 Ω	320 k Ω
	150 (for 69 V)		909 kΩ 2 W	0 Ω	490 k Ω
High Range **200 V to 600 V rms FS**  	200		0 Ω	15.4 kΩ	1.5 M Ω
	250 (for 120 V)		0 Ω	9.53 kΩ	1.5 M Ω
	500 (for 240 V)		121 kΩ	0 Ω	1.6 M Ω
	600		750 kΩ 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 kΩ	0.2
	5	100 Ω	0 Ω	100 kΩ	0.5
	10	100 Ω	0 Ω	40.2 kΩ	1.0
	20	100 Ω	0 Ω	13.3 kΩ	2.0
	25 (for 4-20 mA)	100 Ω	0 Ω	8.25 kΩ	2.5
	50	10 Ω	0 Ω	100 kΩ	0.5
	100	1 Ω	332 Ω	Open	0.1
	200	1 Ω	0 Ω	422 kΩ	0.2
	500	1 Ω 1/2 W	0 Ω	100 kΩ	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 (Ω ±10%)**
0.1 V to 1 V rms FS 	0.1		0 Ω	1.00 MΩ	10 kΩ
	0.2		0 Ω	237 kΩ	10 kΩ
	0.5		0 Ω	64.9 kΩ	10 kΩ
	1.0		0 Ω	23.7 kΩ	10 kΩ

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 ±2% and ±5% resistors in the E24 series, 1% resistors in the E96 series, and ±0.1%, ±0.2% and ±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 ±2% and ±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 ±1% resistors, E192 generally used for ±0.1%, ±0.2% and ±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 M AC Low Voltage Input Module

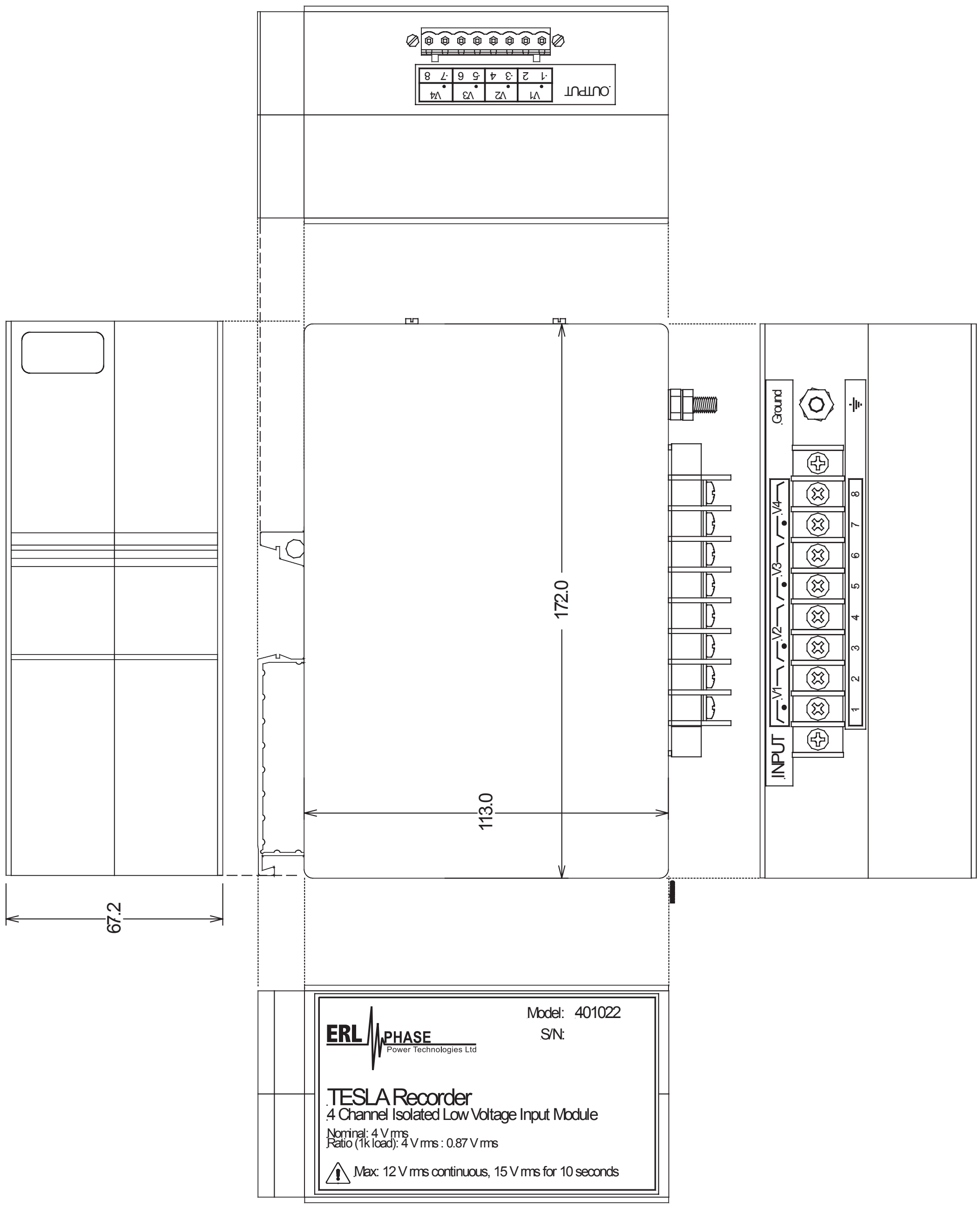


Figure M.1: 401022 AC Low Voltage Input Module

Appendix N TESLA Portable Wiring Connections

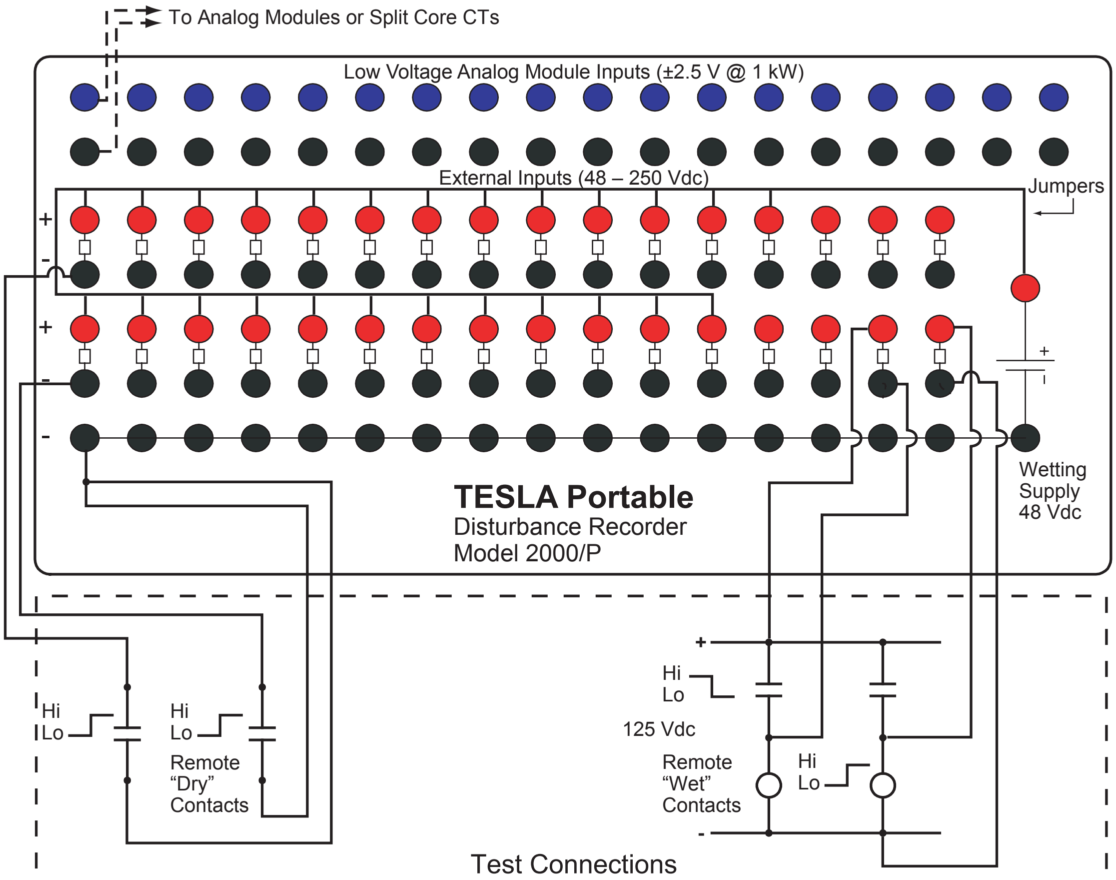


Figure N.1: TESLA Portable 2000/P Simplified Wiring Connections

Figure N.1: TESLA Portable 2000/P Simplified Wiring Connections on page 1 shows how to connect the analog input devices, as well as Dry and Wet contacts. Note how the “Wetted” contact signal on one part of the signal (+/-125 Vdc) shows the Hi or Lo signal. On the “Dry” contact note how the voltage signal appears on the digital inputs. The recorder is protected from “mixing up” the 48 Vdc Wetting 48 Supply to the external voltage supply (48 to 250 volts).

Index

A

absolute time 21
AC 3 Channel isolated voltage input module 1
AC 4 Channel isolated current input module 2
AC current input module 2
AC Scaling 11
Actions 29
active trace information 19
add 11
add analog graph 14
add digital graph 15
Alarm contacts 3
Analog input 3, 8
  calibration 10
  channels 1
Analog input isolation modules 1, 2, 1, 2, 1

C

calculate derived channels now 26
calculated channels 71
Calibration
  analog input 10
change scale (Y axis) 25
change trace color 18
Channel groups 6
Channel naming 8
channel tool-tip 34
Channel types and triggers 3
  external inputs 3
  fault locators 5
  frequency 5
  impedance 5
  logics 5
  power factor 5
  sequence 4
  summation 4
  Watts/Vars 4
Channel view 5, 7
Chatter limits 33
Clamp-on CT 2
Communication ports 4
  settings 3
COMTRADE import 77
Configuation
  planning 6
Configuration files
  channel view 5
  element view 5
  main branches 3
  managing 1
  navigating 2
  older firmware versions 1
  saved configurations 2
  working with IED’s present configuration 1
Configuring
  Windows 95/98 setup 2
  Windows NT 4.0 setup 4
Control panel
  control tabs 5
  features 2
  navigating 5
  status bar 5
  working area 5
copy to clipboard 12
copy trace 16
copy trace data to clipboard 18
cross hair 20

D

DC module 2
DC Scaling 11
delete 9, 11
delete all traces 18
delete graph 15
delete trace 17
Dial-up Network Connections (DUN)
  APT_MODEM Dial-Up 16, 19
  APT_SERIAL Dial-Up 13
DNP 15, 34, 1
Duration recording 6

E

Edge recording 5
Element view 5
  adding an element 7, 8
  external input channels 11
  fault locator channels 26
  frequency channels 23
  impedance channels 19
  logic channels 24
  power factor channels 27
  sequence component channels 17
  summation channel 14
  Watts/Vars channels 21
Error handling 1, 3
Event log 14, 1
Event messages 1
Event priority 30
exit 10
Export

COMTRADE 1, 3
Excel (CSV) 1, 7
launch 2
PTI 1, 5
export 9
exporting channel data 73
exporting views 72
extend print range 28
External input 3, 11, 13, 3

F

Failure modes 4
Fault locator 5, 26
file menus 6
Frequency 5
front view 4
fundamental RMS 21

G

Glossary 1
Graph 2
graph 34
adding 34
adding channels 34
copy to clipboard 72
keyboard functions 37
panning 37
save as meta file 72
time alignment 65
zooming 35
graph menus 14
Grounding 6, 4

H

Hardware description 1
harmonics 21
help menus 30

I

Identification 2
Impedance 5, 19
import 10
Installation
null modem 5
software 3
TESLA Control Panel 1
IRIG-B time signal 4

L

Launch RecordGraph
from TESLA Control Panel 1
from Windows Explorer 3
line 13
lock markers 28
Logic channels 5, 24

M

Maintenance menu 4
markers 19, 20, 21, 64
measure
absolute time 66
fundamental RMS 67
harmonics 69
markers 64
primary 64
secondary 64
symmetrical components 70
true RMS 68
measure menus 19
measurements 64
Mechanical drawing 1
menus 5
Meter groups 30
Metering 14, 7
Modbus 15, 33, 2, 1
move 16

N

Navigating in TESLA Control Panel 5
Notify 10
Null modem 3

O

Offline 3
Operation
offline 4
online 4
options menus 26

P

Password
protection 13
setting 13
paste ttrace 17
Phase angle metering 6
Physical mounting 1
Power supply 6, 1
primary 20, 64
print 7
print all 8
print direct 8
print options 79
print preview 9
Printing 34
configuration 33
MODBUS address list 33
Priority 30

R

readouts 64
rear view 4
Record lists 1
Record priority 30
record summary 75
Recorder features 1

Recorder workspace 1
- adding/editing 2
- current IED 2
- selecting 1

RecordGraph
- components 4
- graphs 34
- menus 5
- tool bar buttons 30

Recording
- duration 5, 6, 7
- edge 5, 7
- high speed 7
- low speed 7
- settings 5
- trends 7

Records 14
rename tab 11
reset zoom 24

S

Sag/Swell 3, 11, 12, 29
save as metafile 12
save template 6, 7, 8, 9
save template as 6
scale menus 22
secondary 21, 64
Selecting workspace 1
Sequence 4, 17
set graphs per page 14
set phase colors 29
set precision 29
Settings version 4
Setup utilities 1
show channel list 13
show grid 26
show legends 27
show record summary 10
show trigger marker 27
show X axis ticks 26
Split-Core CT 2
Starting TESLA Control Panel 31
Startup sequence 2
Summation 4, 14
System requirements
- hardware 1
- operating system 1

T

template manager 7
templates 56
- create new 58
- default 57
- manager 59
- managing 58
- menus 59
- multiple IED 61
- single IED 60
- tool tip 60

Time
- manual set 10

time alignment 21, 65
titles 12
- graph 63
- view 62

tool bar 13
tool bar buttons 30
Trend listing, transfer and management 3
Trends
- configuration 31
- display 3
- settings 7, 14

Triggers 27, 28
- external input 29
- high and low magnitude 28
- impedance 29
- positive and negative rate of change 28
- single harmonic 28
- THD triggers 28

true RMS 21

U

undo zoom 24
Utilities 14
- communication port settings 3
- password protection 11
- recording settings 5
- unit identification 2

V

view 32
- adding 32
- deleting 32
- exporting 72
- harmonic 42
- impedance 43
- overlay 40
- renaming 33
- symcom 41
- timeline 39
- trend 55

view menus 11

W

Watts/Vars 4, 21

Z

zoom 35, 36
zoom X axis - 22
zoom X axis + 22
zoom Y axis - 23
zoom Y axis + 23

Software Installation Instructions

The CD-ROM contains software and the User Manual for TESLA Disturbance Fault Recorder.

Software is installed directly from the CD-ROM to a Windows PC.

The CD-ROM contains the following:

- TESLA Control Panel: interface software
- TESLA Firmware: Firmware and installation instructions
- TESLA User Manual: TESLA manual in PDF format

Access the CD-ROM

Insert the CD-ROM in your drive; the CD-ROM should open automatically. If the it does not, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the TESLA.exe file to launch the CD-ROM.

> Installation of TESLA Control Panel software requires that your Windows system be properly configured. For details see “TESLA Control Panel Setup” on page 2-1.

To view the TESLA User Manual you must have Adobe Acrobat on your computer. If you need a copy, download a copy by clicking on Download Adobe Acrobat.