F6000 Family of Power System Simulators User Guide

F6Meter Control Panel

Doble Engineering Company
85 Walnut Street
Watertown, Massachusetts 02472-4037
(USA)

PN 500-0348

72A-1998-01 Rev. A 1/03

Warranty

Equipment Limited Warranty

Doble Engineering Company (DOBLE) warrants the products that it manufactures to be free from defects in material and workmanship for a period of one year from the date shipped from the factory.

During the one year warranty period, DOBLE will repair or replace, at its option, any defective products or components thereof at no additional charge, provided that the product or component is returned, shipping prepaid, to DOBLE. The Purchaser is responsible for insuring any product or component so returned and assumes the risk of loss during shipment. All replaced products and components become the property of DOBLE.

THIS LIMITED WARRANTY DOES NOT EXTEND TO ANY PRODUCTS WHICH HAVE BEEN DAMAGED AS A RESULT OF ACCIDENT, MISUSE, ABUSE, OR AS A RESULT OF MODIFICATION BY ANYONE OTHER THAN DOBLE OR AN AUTHORIZED DOBLE REPRESENTATIVE.

EXCEPT AS EXPRESSLY SET FORTH ABOVE, NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, ARE MADE WITH RESPECT TO THE PRODUCT INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. DOBLE EXPRESSLY DISCLAIMS ALL WARRANTIES NOT STATED HEREIN. IN THE EVENT THE PRODUCT IS NOT FREE FROM DEFECTS AS WARRANTED ABOVE, THE PURCHASER'S SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS PROVIDED ABOVE. UNDER NO CIRCUMSTANCES WILL DOBLE BE LIABLE TO THE PURCHASER OR ANY USER FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION, PERSONAL INJURY OR PROPERTY DAMAGE CAUSED BY THE PRODUCT, ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOST PROFITS, LOST SAVINGS, OR OTHER DAMAGES ARISING OUT OF THE USE OF OR INABILITY TO USE THIS PRODUCT.

Software Limited Warranty

Doble warrants that: (i) for a period of one hundred twenty (120) days from the date of shipment from Doble, the media on which the Software is furnished will be free of defects in materials and workmanship under normal use; and (ii) for a period of one year from the date of shipment from Doble, the Software will perform in substantial conformance to its published specifications. This limited warranty extends only to Customer as the original licensee. Customer's exclusive remedy and Doble's entire liability under this limited warranty will be, at Doble's option, to repair or replace the Software, or to refund a pro rata portion of the purchase price. Doble makes no warranty or representation that its software products will meet Customer's requirements, that the operation of the software products will be uninterrupted or error free, or that all defects in the software products will be corrected.

This warranty does not apply if the software (a) has been altered, except by Doble, (b) has not been installed, operated, repaired, or maintained in accordance with instructions supplied by Doble, (c) has been subjected to abnormal physical or electrical stress, misuse, negligence, or accident, or (d) is used in ultrahazardous activities.

Disclaimer

THE FOREGOING WARRANTIES AND REMEDIES ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER WARRANTIES, TERMS, OR CONDITIONS, EXPRESS OR IMPLIED, WHETHER ALLEGED TO ARISE BY LAW, BY REASON OF CUSTOM OR USAGE IN THE TRADE, OR BY COURSE OF DEALING, INCLUDING WARRANTIES, TERMS, OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, SATISFACTORY QUALITY, CORRESPONDENCE WITH DESCRIPTION, AND NONINFRINGEMENT, ALL OF WHICH ARE EXPRESSLY DISCLAIMED.

IN NO EVENT WILL DOBLE BE LIABLE FOR ANY LOST REVENUE, PROFIT, OR DATA, OR FOR SPECIAL, INDIRECT, CONSEQUENTIAL, INCIDENTAL, OR PUNITIVE DAMAGES HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY ARISING OUT OF THE USE OF OR INABILITY TO USE THE SOFTWARE EVEN IF DOBLE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. In no event shall Doble's liability to Customer, whether in contract, tort (including negligence), or otherwise, exceed the price paid by Customer. The foregoing limitations shall apply even if the above-stated warranty fails of its essential purpose. SOME STATES DO NOT ALLOW LIMITATION OR EXCLUSION OF LIABILITY OR CONSEQUENTIAL OR INCIDENTAL DAMAGES.

Limitations of Remedies

DOBLE's entire liability and Purchaser's exclusive remedy shall be:

1. The replacement of any disks not meeting DOBLE'S "limited warranty" which are returned to DOBLE.
2. If DOBLE is unable to deliver replacement disks which are free from defects in materials and workmanship, Purchaser may terminate this agreement. By returning the software product and all copies thereof in any form and affirming compliance with this requirement in writing, DOBLE will refund the purchase price.

IN NO EVENT WILL DOBLE BE LIABLE TO PURCHASER FOR ANY DAMAGES, INCLUDING ANY LOST PROFITS, LOST SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE SUCH SOFTWARE PRODUCT, EVEN IF DOBLE OR AN AUTHORIZED DEALER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY CLAIM BY ANY OTHER PARTY.

Some states do not allow the limitation or exclusion of liability for incidental or consequential damages, so the above limitation or exclusion may not apply.

For Equipment Maintenance, contact:

Customer Service Manager (Extension 2921)
Doble Engineering Company
85 Walnut Street
Watertown, MA 02472-4037 (USA)

Telephone: 617-926-4900
FAX: 617-926-0528
Email: customerservice@doble.com

Contents

Figures

Tables

Preface

The F6000 family of power system simulators consists of an integrated group of precision test instruments, related options, and associated control software. The *F6000 Family of Power System Simulators User Guide* contains detailed information regarding the setup, operation and maintenance of the F6000. The sections below explain how the book is organized and the conventions it uses.

Structure of This Manual

This user guide consists of eight chapters and seven appendices:

Chapter 1 ”Introducing the F6150”

Chapter 1 gives an overview of the F6000 Instrument. Included is a description of the instrument’s hardware architecture, the F6Meter Control Panel, and the options available for the F6000.

Chapter 2 ”Instrument Front Panel”

Chapter 2 explains the features and functions on the front panel of the F6000 Instrument.

Chapter 3 ”Setup and Configuration”

Chapter 3 shows how to get started with the F6000. It explains how to configure the software and set up the instrument.

Chapter 4 ”F6Meter Control Panel Operations”

Chapter 4 describes the settings and controls on the F6Meter Control Panel and associated displays.

Chapter 5 ”Basic Test Procedures”

Chapter 5 explains how to use the F6000 Instrument to conduct simple tests, and how to make use of the various features on the Control Panel.

Chapter 6 ”Troubleshooting Guide”

Chapter 6 provides a diagnostic flow chart for identifying problems, defines LED status indicators and lists hardware and software error messages.

Chapter 7 ”Field Replacement Procedures”

Chapter 7 gives detailed instructions about how to remove the various circuit boards in the instrument, and how to replace them with new boards.

Chapter 8 ”Safety and Maintenance”

Chapter 8 lists rules for safe use of the F6000 Instrument, discusses routine maintenance of the equipment, and explains how to obtain service for the instrument from Doble Engineering.

Appendix A ”Software Maintenance”

Appendix A explains how to use the Flash Loader to update the F6000 firmware, and how to enable pre-installed options.

Appendix B ”Ethernet Communications”

Appendix B explains how to assign the control PC an IP address for the purpose of communicating on a private internet, and how to change the IP address of the F6000 Instrument.

Appendix C ”Source Configurations”

Appendix C discusses the different kinds of sources available on the instrument front panel, gives rules for source selection, and illustrates the pre-set source configurations available.

Appendix D ”Global Positioning System”

Appendix D explains how to conduct an end-to-end test with two F6000 Instruments synchronized using the Global Positioning System.

Appendix E ”Timing Between State Changes”

Appendix E contains technical information on the operating characteristics of the F6000 Instrument.

Appendix F ”Field Calibration Verification”

Appendix F lists testing specifications and procedures for performing amplitude and distortion tests and phase shift tests on configured current and voltage sources.

Appendix G ”F6150 Specifications”

Appendix G contains detailed electrical specifications for the F6000 Instrument, including the operating characteristics of the sources in various modes.

Document Conventions

The following font conventions serve to distinguish various references in the text:

- Button labels, menu selections, and items on pick lists (items in a display that the user can click) are shown in **bold type**.
- The names of displays are shown in **bold type**.
- Section names on the Control Panel, labels on the instrument front panel, and other labels are shown in *italics*.

The following definitions distinguish the software controls in the F6Meter Control Panel from the hardware on the instrument:

- *Control Panel* refers to the main software display used to operate the F6000 Instrument.
- *Instrument front panel* refers to the front panel of the instrument itself.
- *Instrument Display* refers to the display on the front panel used to show equipment status information.

Notes, Cautions, and Warnings

Note, Caution, and Warning icons denote information of special interest. The icons appear in the column to the left of the text and are reproduced below, along with explanations of their meanings. Failure to observe a Warning or a High Voltage warning could cause a dangerous condition.

COMPLIANCE — The **CE** icon signifies that the equipment complies with CE requirements.

WARNING — The **WARNING** icon signifies information that denotes a potentially hazardous situation, which, if not avoided, may result in death or serious injury.

GROUND — Protective Earth Ground symbol.

NOTE — The **Note** icon signifies a cautionary statement, an operating tip or maintenance suggestion. Instrument damage may occur if not followed.

VOLTAGE — Hazardous voltage: risk of shock or injury.

ESD — The **ESD Susceptibility** icon signifies that the equipment is sensitive to electrostatic discharges. Instrument damage may occur if proper handling methods are not followed.

Safety

WARNING

Before turning on or using any F6150, verify that the instrument is safely grounded to eliminate the potential of a dangerous electric shock. Always turn the source output off and disable the unit before connecting, removing, or touching any output terminal or cable.

VOLTAGE

Dangerous and potentially fatal voltages can be developed across the output terminals of any Power System Simulator. USE EXTREME CAUTION when turning on or using the F6150. Always turn the source output off and disable the unit before connecting, removing, or touching any output terminal or cable. Never ground any F6150 output source connection.

The high intensity yellow LED flashes to indicate that dangerous and potentially fatal voltages may be present. Flashing occurs when the battery simulator is on, or when other sources are enabled or on.

1. Introducing the F6150

The F6150 power system simulator (Figure 1.1) is designed to test protective relays and transducers. The F6150 has three voltage sources and three current sources. Each source is rated at 150 VA of continuous power. Each of these sources can be configured as two 75 VA sources to provide a maximum of:

- 6 voltage sources, *or*
- 6 current sources, *or*
- 6 voltage sources and 6 current sources

For more information on source configurations, see Chapter 2 "Instrument Front Panel" and Appendix C "Source Configurations".

Figure 1.1 F6000 Power System Simulator

Configuration of the sources is internal and independently controlled by a computer to meet diverse requirements for various transducer tests. By configuring the current sources in series or in parallel, the F6150 yields more power for testing high burden relays or protection schemes.

Eight logic input and output channels provide the means to evaluate protection scheme performance. An independent DC battery simulator is also furnished for powering digital and static relays.

Hardware Architecture

The components of the F6000 Instrument are:

- Front Panel
- Logic I/O Board
- CPU Board
- Analog I/O Board
- Three Current Amplifiers
- Three Voltage/Current (VI) Amplifiers
- Power Supply
- Battery Simulator
- Four Cooling Fans

Figure 1.2 shows the location of these components in the instrument.

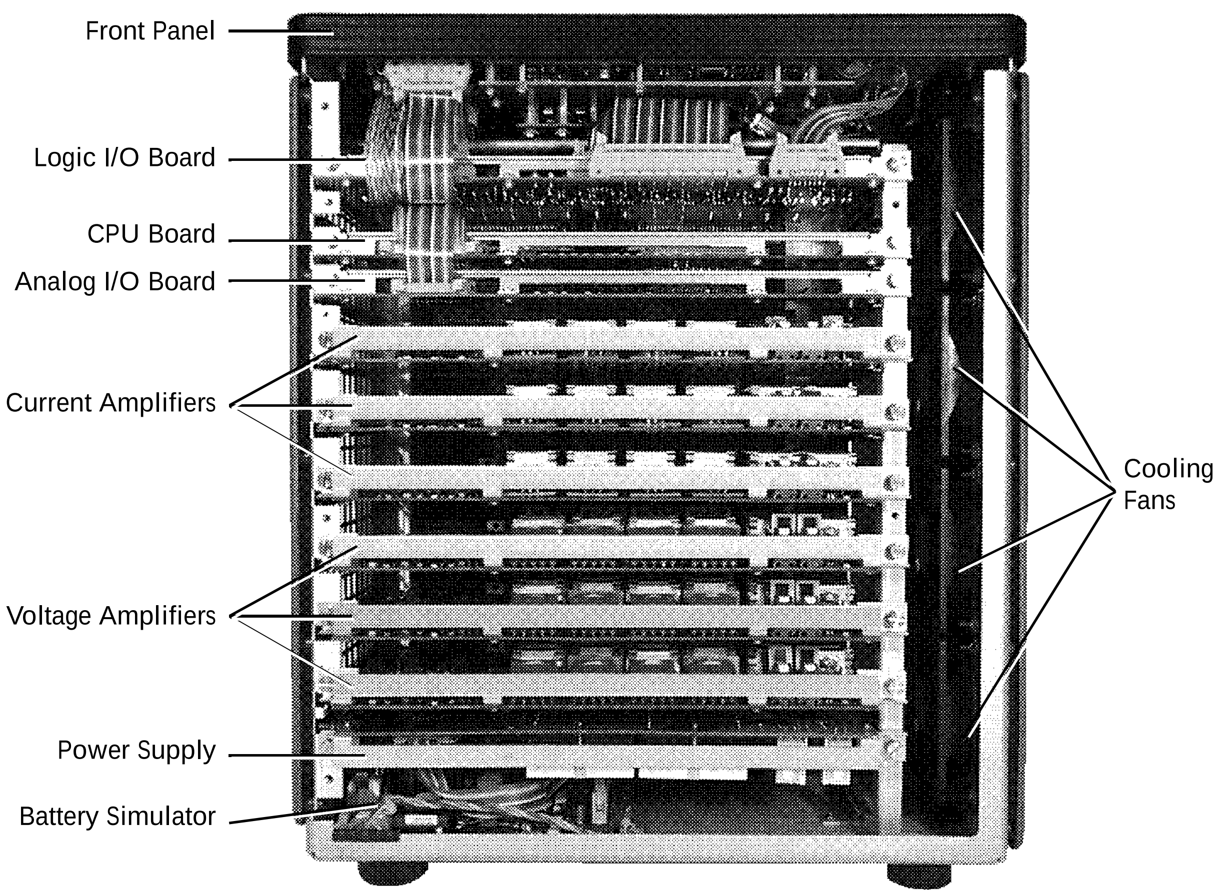


Figure 1.2 Instrument Architecture

Integrated System

Figure 1.3 illustrates how the F6000 Instrument interacts with other components of the system.

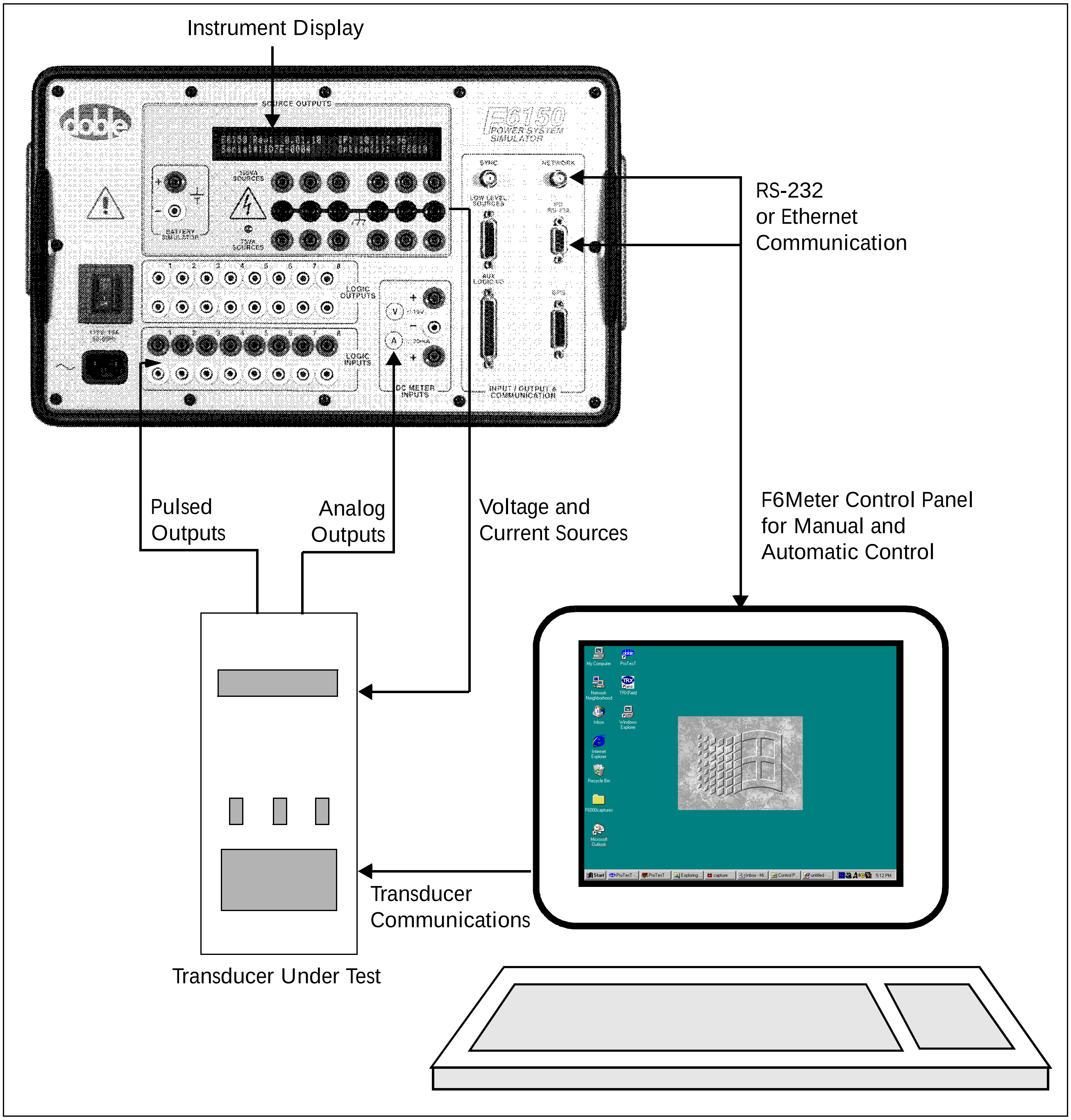


Figure 1.3 Test Setup with Workstation F6000 Instrument, and Transducer Under Test

Control Panel

The F6Meter Control Panel (Figure 1.4) controls the power system simulator from a computer connected to the instrument front panel. It configures and controls the instrument's voltage sources, current sources, logic inputs, and logic outputs. The F6Meter Control Panel emulates front panel controls. It also employs flexible data entry procedures to accommodate the wide range of test configurations possible. The Control Panel's intuitive controls can be used to check a transducer without an elaborate test plan.

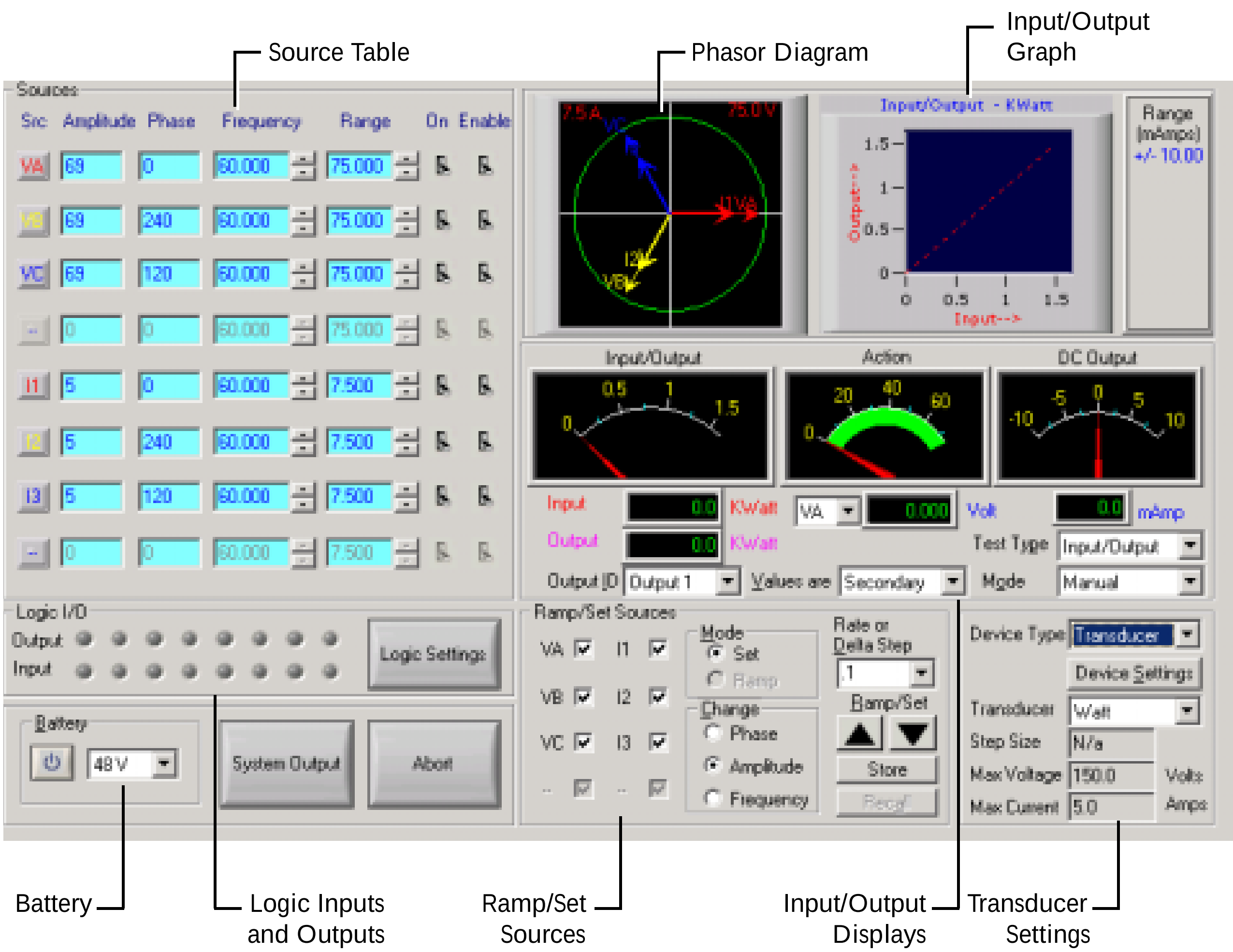


Figure 1.4 F6Meter Control Panel

When the program opens, the dialog box shown in Figure 1.5 appears. Select the desired language from the pull down list and click **OK**.

Figure 1.5 Language Options

Options

Several options for the F6000 Instrument are available:

Option F6810 — *High power convertible voltage/current sources.* Provides three low current/high compliance voltage sources for testing high burden electromechanical relays.

Option F6909 — *Control Panel Enable.* Permits the F6Meter Control Panel to communicate with the F6000 Instrument.

Option F6910 — *Simulator control and automation module.* Use with the F6Meter Control Panel or third party software.

Option F6885 — *Global Positioning System (GPS) satellite receiver interface.* GPS antenna (Option F6895) must be ordered separately.

The Global Positioning System allows users to synchronize multiple F6000 simulators at remote locations. The power sources in each simulator use the one-pulse-per-second signal of the GPS satellite to synchronize their outputs. GPS synchronization eliminates hardware and software timing errors in end-to-end testing.

Option F6895 — *GPS antenna.* Requires Option F6885, GPS satellite receiver interface.

Option F6800 — The *Transducer Interface* enables the F6150 to test energy meters and transducers with the highest accuracy. This option includes meter measurement studio software.

2. Instrument Front Panel

The instrument front panel in Figure 2.1 contains:

- Outputs for three 150 VA voltage/low current convertible sources
- Outputs for three 150 VA current sources
- Outputs for 75 VA sources when the 150 VA sources are split
- Battery simulator
- Connections for eight logic outputs
- Connections for eight logic inputs
- Ports for system communications
- On/Off switch and AC power connection

Control of all test functions is accomplished from a computer.

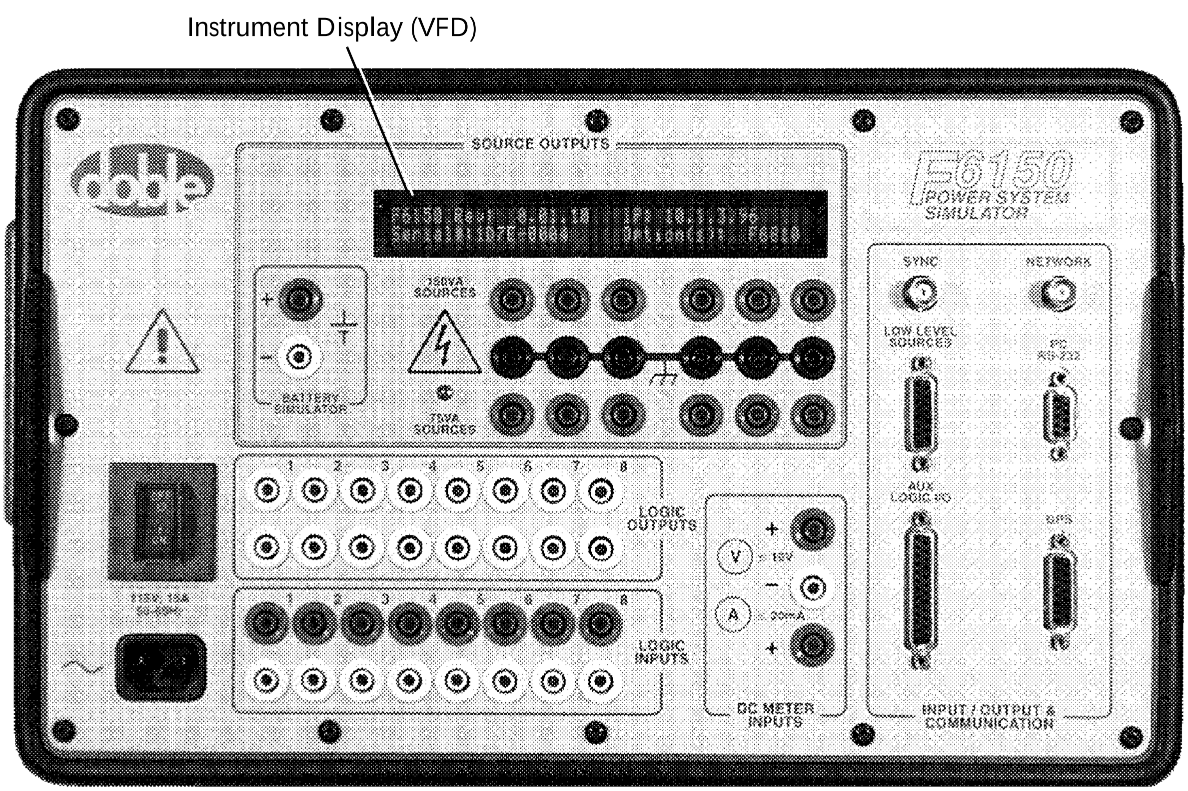


Figure 2.1 F6000 Instrument Front Panel

Source Outputs

The *Source Outputs* section of the F6150 Instrument front panel contains outputs for AC/DC voltage and current sources, and a battery simulator that supplies DC power. It also contains an Instrument Display that shows key information about the operation of the instrument (Figure 2.1 on page 2-1).

Instrument Display

On bootup, the messages in the Instrument Display cycle in a predictable and recognizable pattern. This pattern is disrupted if the F6000 Instrument fails its internal diagnostic test. The F6000 performs a set of internal diagnostics to check the integrity of the system's memory, data, and communication paths. It also checks the integrity of all the system modules. After a successful bootup, the F6000 Instrument Display shows the following information:

- CPU serial number
- Firmware revision currently installed
- Options enabled
- Instrument's IP address for purposes of network communications
- Status of the GPS receiver (if Option 6885 is installed and Receiver Option 6895 is powered up and connected to the F6150)

During normal operation, the Instrument Display shows source names and the layout of the sources. When any source is on or enabled, it shows the amplitude and phase angle of the source for up to six sources.

NOTE

When a source is enabled, the source label uses a lower case identifier (for example, va, vb, vc, i1, i2, and i3). When a source is on, the source label uses an upper case identifier (for example, VA, VB, VC, I1, I2, and I3).

Voltage and Current Sources

Figure 2.2 shows the voltage and current sources on the instrument front panel. The F6150 provides three 150 VA voltage sources, which can be optionally converted into current sources to provide low range current testing. It also provides three 150 VA current sources, which can be combined to achieve more power. Two 150 VA current sources can be combined to form a 300 VA source. Three 150 VA current sources can be combined to form a 450 VA source.

For source selection rules and examples of different test setups, see Appendix C ”Source Configurations”.

NOTE

Low current convertible sources and current sources must not be paralleled. See ”Rules for Source Selection” on page C-2.

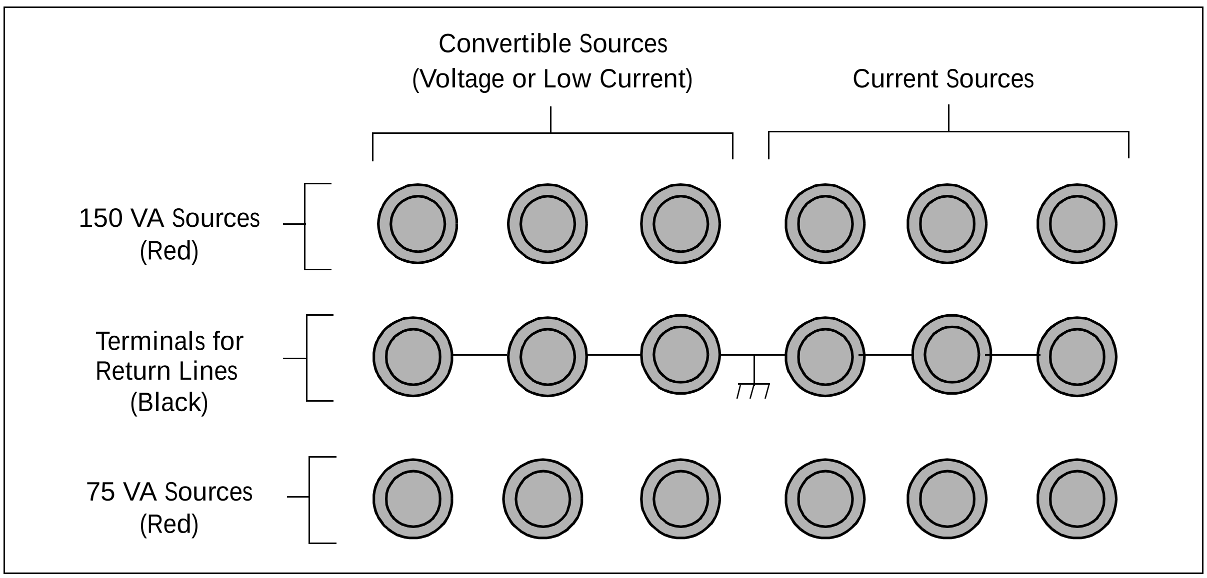


Figure 2.2 F6000 Instrument Front Panel Source Outputs

The F6150 voltage sources are optionally convertible and may be configured as either voltage or current sources. A convertible source, when used in current mode, provides a low range current at a high compliance voltage. The current ranges for 150 VA sources are 0.5 A, 1.0 A and 2.0 A, at a compliance voltage of 300 V, 150 V, and 75 V AC, respectively (Table 2.1).

Table 2.1 150 VA Convertible Sources Configured to Supply Low Current at a High Compliance Voltage

Current	Compliance Voltage
0.5 A	300 V
1.0 A	150 V
2.0 A	75 V

WARNING

The high intensity yellow LED flashes when the battery simulator or any output source is on or enabled to indicate the potential for dangerous or fatal voltages.

The F6150 supplies three convertible voltage/current and three current sources. Each source is rated at 150 VA of continuous power (Figure 2.3).

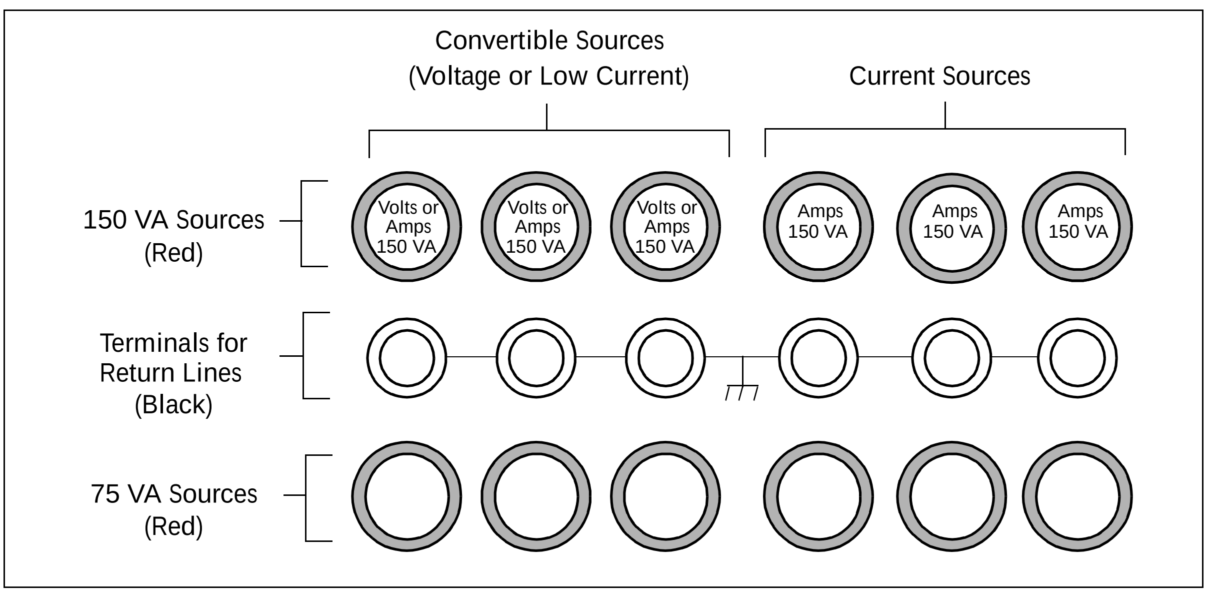


Figure 2.3 Six 150 VA Sources

These six sources can be switched to eight sources by splitting two of the 150 VA sources into four 75 VA sources (Figure 2.4).

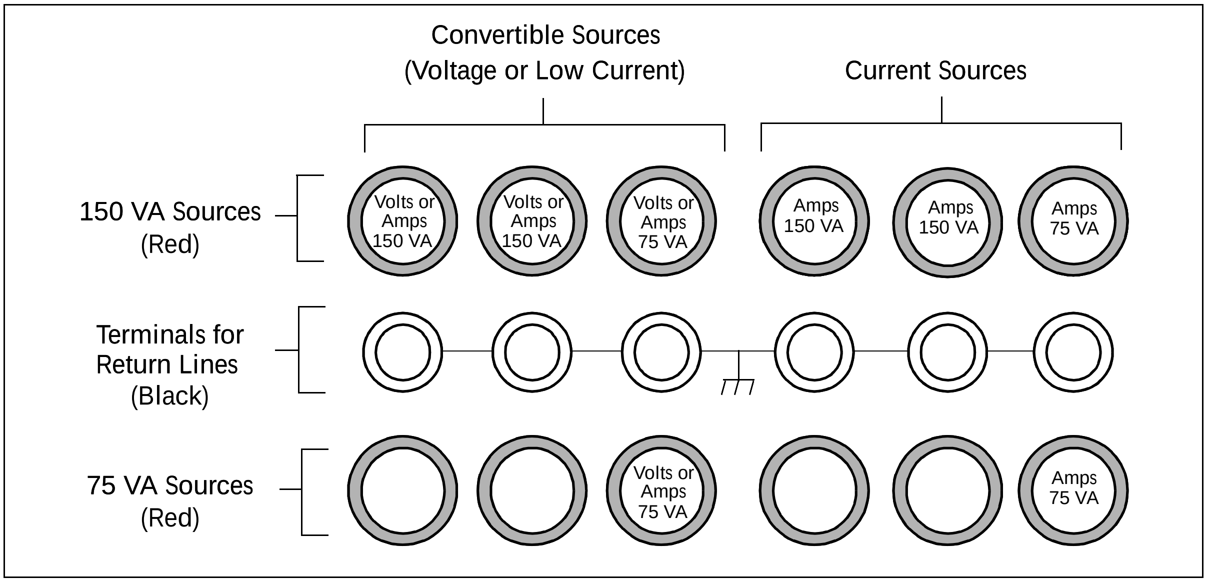


Figure 2.4 Four 150 VA Sources and Four 75 VA Sources

The source outputs on the F6150 Instrument front panel include terminals for 150 VA and 75 VA sources as well as terminals for return lines:

- The six red terminals in the first row of outputs supply 150 VA of power.

  The first set of three 150 VA outputs are convertible sources. Use these as voltage sources or optionally as low current sources. The fourth, fifth, and sixth outputs are 150 VA current sources.

- The six black terminals in the second row are for return lines.

  When a 150 VA source is split into two 75 VA sources, the return line for both sources uses the common terminal in the middle row.

- The six red terminals in the third row of outputs supply 75 VA of power when a 150 VA source is split.

Figure 2.5 illustrates the front panel source configuration when three 150 VA voltage sources are split into six 75 VA sources.

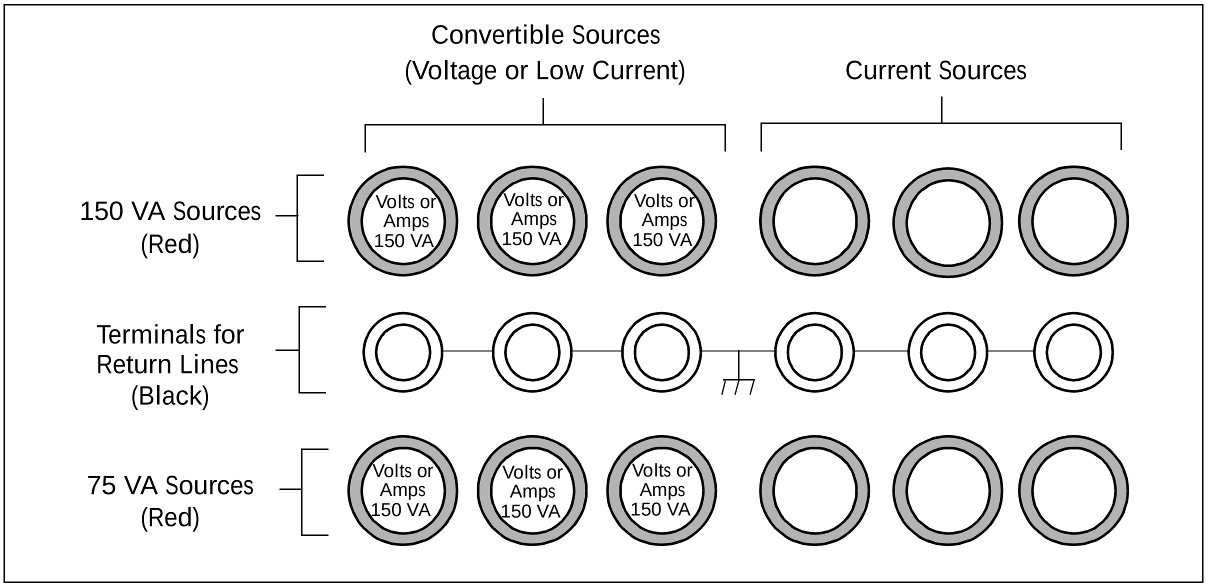


Figure 2.5 Six 75 VA Sources

Battery Simulator

The battery simulator can be used to power transducers and may be set to provide 48, 125, or 250 V of DC output at 60 W.

Auxiliary Functions

Other functions on the F6150 front panel include:

- Communications
- Logic Inputs
- Logic Outputs
- DC Meter Inputs
- Power Connection and Switch

Communications

The computer is connected to the instrument via an RS-232 serial port or an Ethernet communications link.

WARNING

Use the Ethernet communications link only with a discrete PC on a private network. Connecting the F6000 to a local-area or a wide-area network permits unauthorized control of the test instrument.

To configure the F6Meter Control Panel to communicate using either the serial port or an Ethernet connection, see "Setup Display" on page 3-4. Table 2.2 summarizes the requirements for both serial and Ethernet connections.

Table 2.2 Requirements for Serial and Ethernet Connections

	Serial Connection	Ethernet Connection
F6000 Instrument	9 pin female connector (labeled PC RS-232)	BNC connector (labeled NETWORK)
Computer	Serial port	Network card with BNC adapter
Cable	RS-232 cable 9-pin straight through cable	Coaxial Ethernet cable with BNC connectors and 50 Ohm end terminators
Communication Setup	COM*X* (COM1 by default)	IP address (10.1.3.1 by default)
Baud Rate	57600 bps	N/A

The *Input/Output & Communication* section of the F6150 front panel also contains a GPS port for use with a Global Positioning System (see "Options" on page 1-5). The other ports in this section (*SYNC*, *Low Level Sources*, and *Auxiliary Logic I/O)* are for future applications.

Logic Outputs

Logic outputs send logic signals from the F6150 Instrument to external devices. They act as logical relays located in the test equipment. The F6150 front panel includes eight discrete logic outputs. Each output can be configured as normally open or normally closed. Use the F6Meter Control Panel software to configure and control the logic outputs.

Logic Inputs

Logic inputs receive signals from a test circuit. The F6150 front panel includes eight discrete logic inputs. Inputs can be programmed for either voltage sense or contact sense. Use the F6Meter Control Panel software to configure and control the logic inputs.

DC Meter Inputs

The front panel contains three DC meter input terminals. These DC inputs, used to test the analog transducer outputs, include a:

- Voltage input on the top.
- Common negative input in the middle.
- Current input on the bottom.

Power

The connection for the electrical power cord is in the lower left corner of the front panel. The *On/Off* switch for the unit is directly above the power connection. The F6000 is factory configured to use either 115 V or 230 V 50/60 Hz power as specified by the user when ordering. The instrument front panel is labeled at the power entry receptacle with the selected power option.

3. Setup and Configuration

This chapter explains how to set up the F6000 Instrument and how to establish communications between the instrument and the software used to control it. It also explains briefly how to configure the voltage and current sources on the front panel of the instrument.

Getting Started

To set up the F6000 power system simulator:

1. Unpack the instrument and inspect it for completeness and transportation damage. Verify that all system components are present:
   - F6150 Instrument
   - Cable bag, containing the following:
     - 1 F6000 User Guide
     - 1 F6150 Marketing Release Notice
     - 1 Power Cord
     - 1 RS-232 Cable
     - 3 I Output Cables
     - 1 V Output Cable
     - 9 Logic I/O Cables
     - 2 #4 R Lug 3 x 4 mm F Adapter Cables
     - Coaxial Ethernet Cable
     - 2 Ring Lug to 3 x 4 mm Adapters
     - 15 Spade Lug 4 mm Red Adapters
     - 9 Spade Lug 4 mm White Adapters
     - 2 In-line 50 Ohm BNC Terminators
2. Connect the power cord to the power connection socket in the lower left corner of the instrument front panel and plug it into a standard wall outlet.
3. Turn the instrument on with the On/Off switch located above the power connection socket.

4. On bootup, the messages in the Instrument Display cycle in a predictable and recognizable pattern. This pattern is disrupted if the F6000 Instrument fails its internal diagnostic test. The F6000 performs a set of internal diagnostics to check the integrity of the system's memory, data, and communication paths. It also checks the integrity of all the system modules.

WARNING

When the instrument is on, the possibility of hazardous voltages or currents at the sources exists. Proceed with caution.

A series of messages appears in the display on the instrument front panel as the F6000 firmware boots up (Figure 2.1 on page 2-1). These messages track the sequence of steps in a successful bootup:

Starting Power On Test

Run the Doble Bootloader (Version Number)

Loading Compressed Image . . . Done

At the end of this series of messages, the following information appears in the display (Figure 3.1):

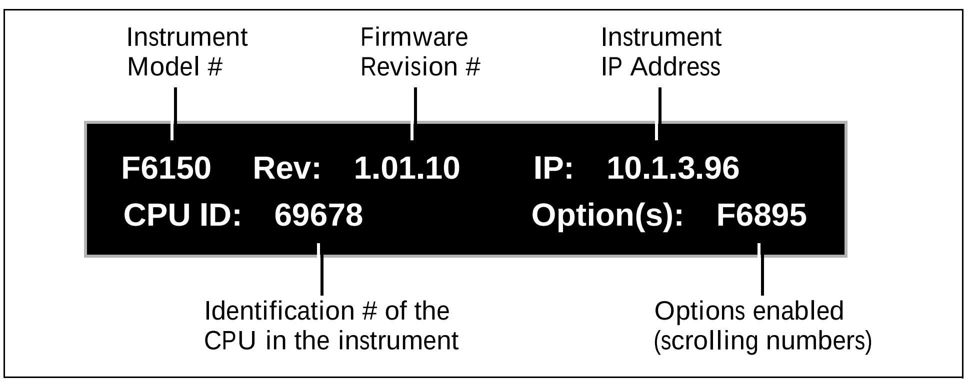


Figure 3.1 Instrument Display After Successful Bootup

NOTE

If an error message appears in the VFD at the end of the bootup sequence, refer to "Hardware Errors" on page 6-12.

The F6000 Instrument is controlled via the F6Meter Control Panel. The Control Panel requires the following hardware and software:

- Personal computer with a Pentium class processor
- Windows 95/98/2000/NT 4.0 operating systems
- F6Meter Control Panel installed on the hard drive of the computer.
- RS-232 serial cable or Ethernet BNC cable with a 10 MB network card
- At least 64 MB RAM (Random Access Memory)
- A color monitor with 640x480 VGA resolution minimum (800x600 VGA 256 color is recommended)

To complete the initial setup process (with power OFF to the control PC and to the F6150):

5. Connect one end of the RS-232 cable to the serial port on the computer, or connect the Ethernet BNC cable to the network card on the computer.

6. Connect the other end of the RS-232 cable to the serial port on the instrument front panel. Alternately, connect the Ethernet BNC cable to the network connection on the instrument front panel. Both connections are on the right side of the front panel.

7. Turn the computer on.

8. Click **Start | Program | Meter Control Panel** to launch the Control Panel.

Setup Display

Use the **Setup** display (Figure 3.2) to configure the Control Panel to communicate with the F6000 instrument. To open the **Setup** display, close the Control Panel, then click **Tools | Setup** in the top menu bar of the Control Panel. Locate the section labeled *F6 Instrument*. It contains several settings related to system communications. It also contains a checkbox to specify simulation mode for the F6Meter Control Panel if no F6000 Instrument is connected.

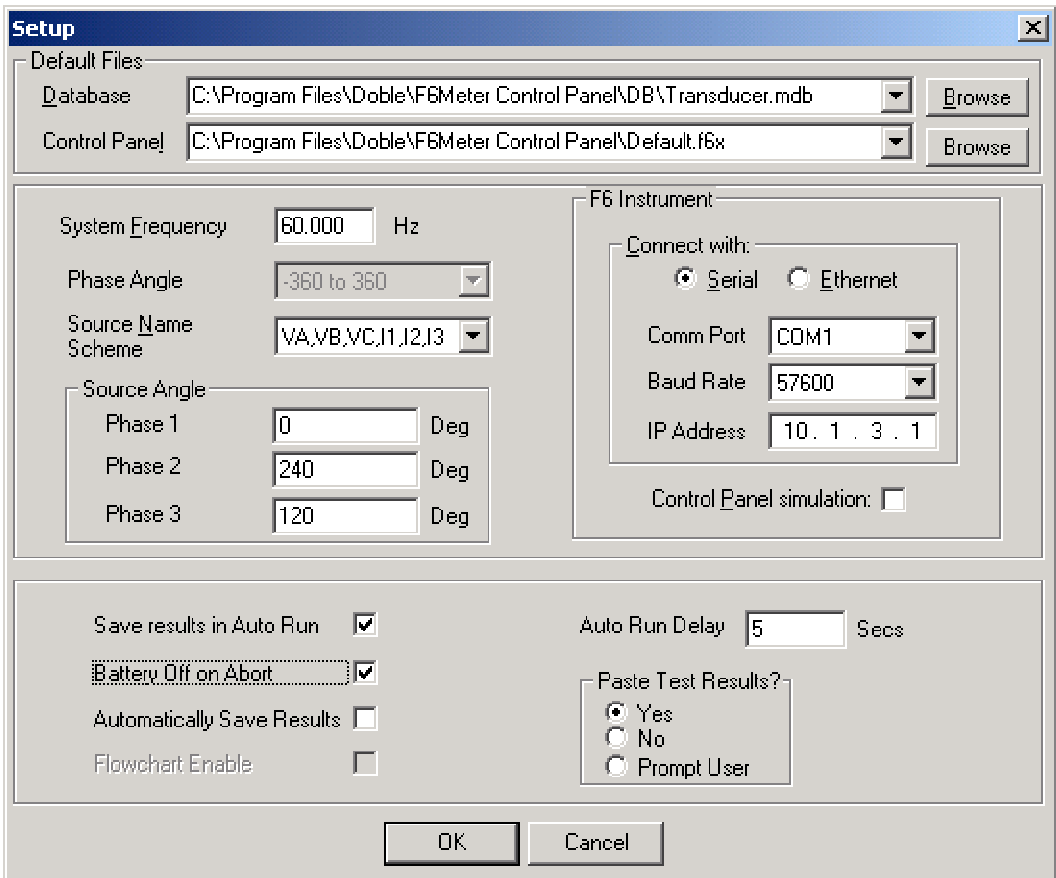


Figure 3.2 Setup Display

Default Files

Database - For future use.

Control Panel - Sets the default startup control panel. To designate a new file as the default control, click the **Browse** button or type in the file name using the full path.

System Frequency

Sets the base frequency of the instrument. For example, to change the base frequency of the instrument from 60 Hz to 50Hz, enter 50 in the *System Frequency* field.

Phase Angle

Sets the way phase angles are displayed. The current release displays both positive and negative phase angles.

Source Name Scheme

Sets the default source name scheme for the Control Panel and for Auto Test configurations.

Source Angle

Sets both the default voltage and current source phase angles for the Control Panel and for the Auto Test configurations.

For example, to achieve ACB counter-clockwise rotation and 120° separation between phases, enter 0 for Phase 1, 120 for Phase 2, and 240 for Phase 3.

F6000 Instrument Communications

Comm Port — The computer communicates with the F6000 Instrument through either the RS-232 serial port or the Ethernet port. If communication is through the serial port, set the *Comm Port* and the *Baud Rate* in the **Setup** display. The default communications port for the serial connection is *Comm Port 1*. If the computer does not communicate with the F6000 Instrument on COM1, make sure the communications port in the Setup display matches the port assigned in Windows 95/98/2000/NT.

Baud Rate — The baud rate for serial port communications is 57,600 baud per second.

IP Address — If the computer communicates with the F6000 through the Ethernet port, enter the IP address of the instrument in the *IP Address* field of the **Setup** display (Figure 3.2 on page 3-4).
The IP address appears in the Instrument Display on the front panel when the instrument is turned on and the F6000 firmware boots up.

Connect with — Radio buttons to select serial or Ethernet communication.

Control panel simulation

If the computer is not connected to an instrument, or if the instrument is switched off, operate the Control Panel in simulation mode. Simulation mode is useful for training and for configuring tests that will be conducted at a later time. To choose this mode, check the box for *Control panel simulation*.

NOTE **If the computer is not connected to an instrument or if the instrument is switched off when the F6Meter Control Panel is opened, an error message appears. Acknowledge the error message, then specify *Control panel simulation* in the Setup display or switch the instrument on.**

After all the settings in the **Setup** display are changed or confirmed, click **OK** to accept the modifications and close the display, or **Cancel** to close without change.

F6000 Configuration

The F6000 sources can be placed in a number of configurations to suit test requirements. Configure these sources via the **F6000 Configuration** display:

1. Click **Tools | F6000 Configuration** in the top menu bar to open the **F6000 Configuration** display (Figure 3.3).

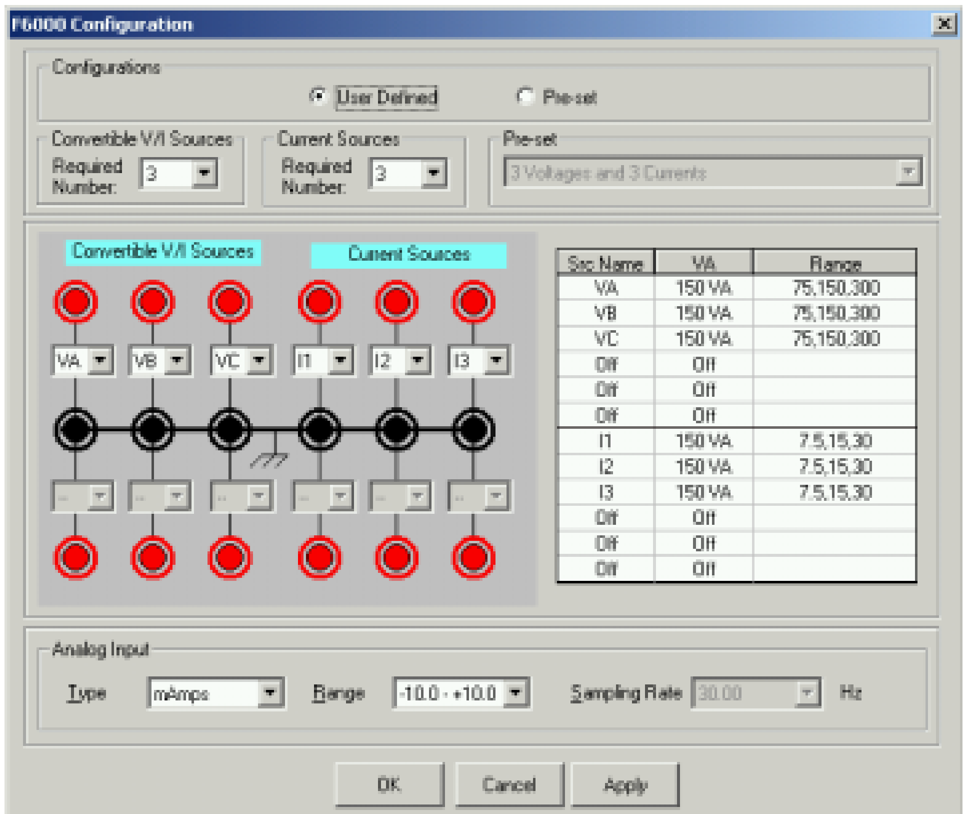


Figure 3.3 Configuration Display

The table in Figure 3.3 shows the VA rating and the range settings for each configured source.

To configure the sources manually, select the **User defined** radio button. Then select the number of convertible sources and the number of current sources in the two pick lists at the top of the display. These lists correspond to the two types of sources available.

NOTE

If the F6150 Instrument does not have the F6810 convertible source option installed, the sources on the left side of the Configuration display can output voltages only.

Convertible V/I Sources

If Option 6810 is installed, the sources on the left side of the display can be used as voltage sources or as low range current sources. The number of convertible sources available in the **F6000 Configuration** display depends on the number selected in the *Convertible V/I Sources* pick list. Refer to Figure 3.3 on page 3-7.

Current Sources

The sources in the right half of the display are configurable only as current sources. The number of current sources available depends on the number selected in the *Current Sources* pick list.

The **F6000 Configuration** dialog box has a graphic display which represents the voltage and current source output terminals on the F6150 front panel. When a preset configuration is selected, the source names and layout are displayed in this graphic. For user defined configurations, the required number of convertible V/I sources and current sources can be selected. Moreover, the source names can be chosen from the available options for each source shown in the graphic.

Once the number of convertible and current sources is specified, assign a name to each one. Name the sources by choosing from active pick lists in the middle of the display.

- Voltage sources start with the letter *V.*
- Current sources start with the letter *I.*
- Transient current sources start with the letter *T.*

Pre-set Configurations

To use a pre-set configuration, select one of the options from the pick list at the bottom of the display:

- 3 Voltages and 3 Currents
- 3 Voltages and 3 Transient Currents
- 4 Voltages and 4 Currents
- 6 Currents (right bank)
- 1 Voltage and 2 Low Range Currents
- 1 Voltage 150 VA and 1 Current 450 VA
- 4 Voltages and 4 Transient Currents
- 6 Voltages
- 6 Low Range Currents
- 6 Low Range Transients
- 6 Transient Currents
- 1 Voltage and 2 Low Range Transients
- 3 Voltages and 1 Current 450 VA

To finish configuring the sources, click one of the three buttons at the bottom of the display (Figure 3.3 on page 3-7):

- Click **OK** to configure the sources on the F6000 Instrument and close the **F6000 Configuration** display.
- Click **Cancel** to ignore changes to the source configuration and close the **F6000 Configuration** display.
- Click **Apply** to configure the sources on the F6000 Instrument without closing the **F6000 Configuration** display.

F6Meter Control Panel

The F6Meter Control Panel (Figure 3.4) contains all the functions and controls needed to conduct tests with the F6000 Instrument. To open the F6Meter Control Panel, click **Tools | F6Meter Control Panel** in the top menu bar. Chapter 4 ”F6Meter Control Panel Operations” describes the F6Meter Control Panel settings in detail.

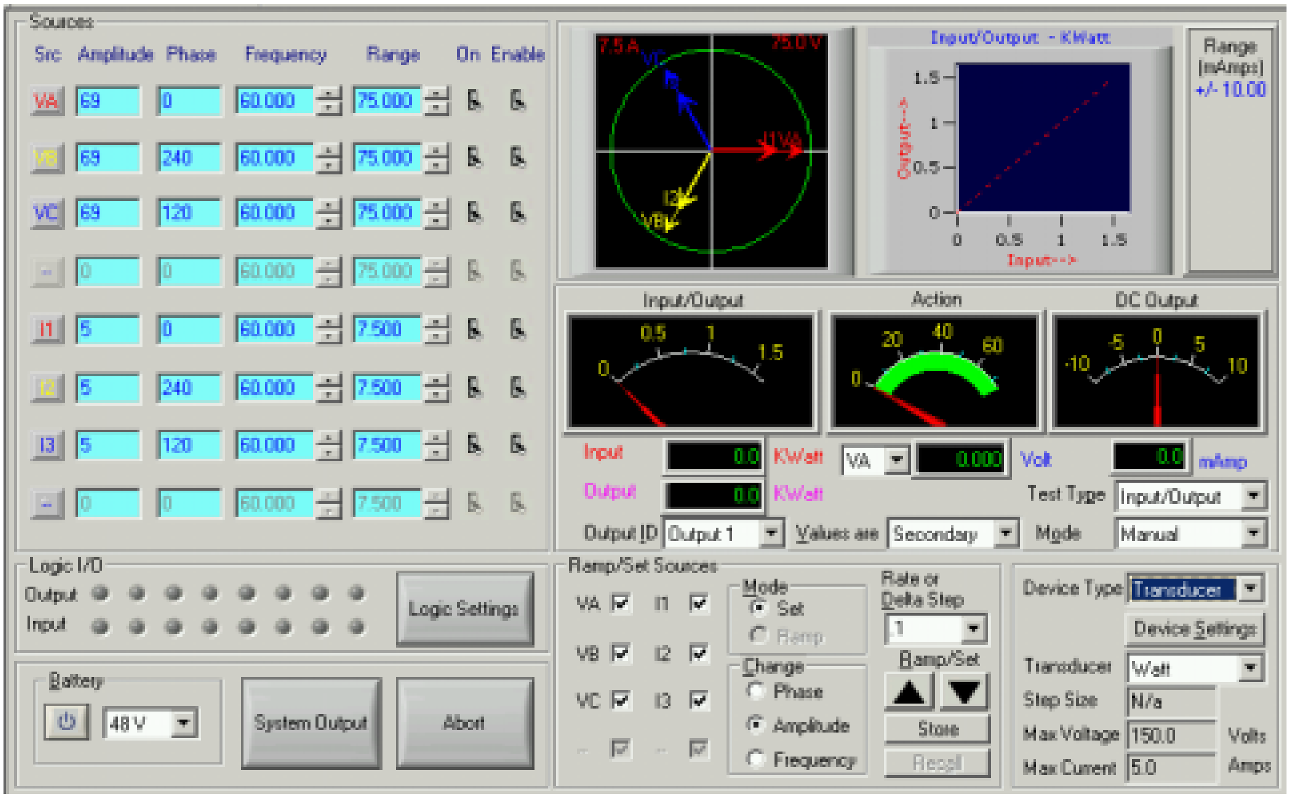


Figure 3.4 F6Meter Control Panel

4. F6Meter Control Panel Operations

This chapter describes the settings and controls in the F6Meter Control Panel. The F6Meter Control Panel is a virtual front panel used for manual and automatic control of F6000 sources. To open the Control Panel, click **Tools | F6Meter Control Panel** in the top menu bar. Figure 4.1 illustrates the main panel.

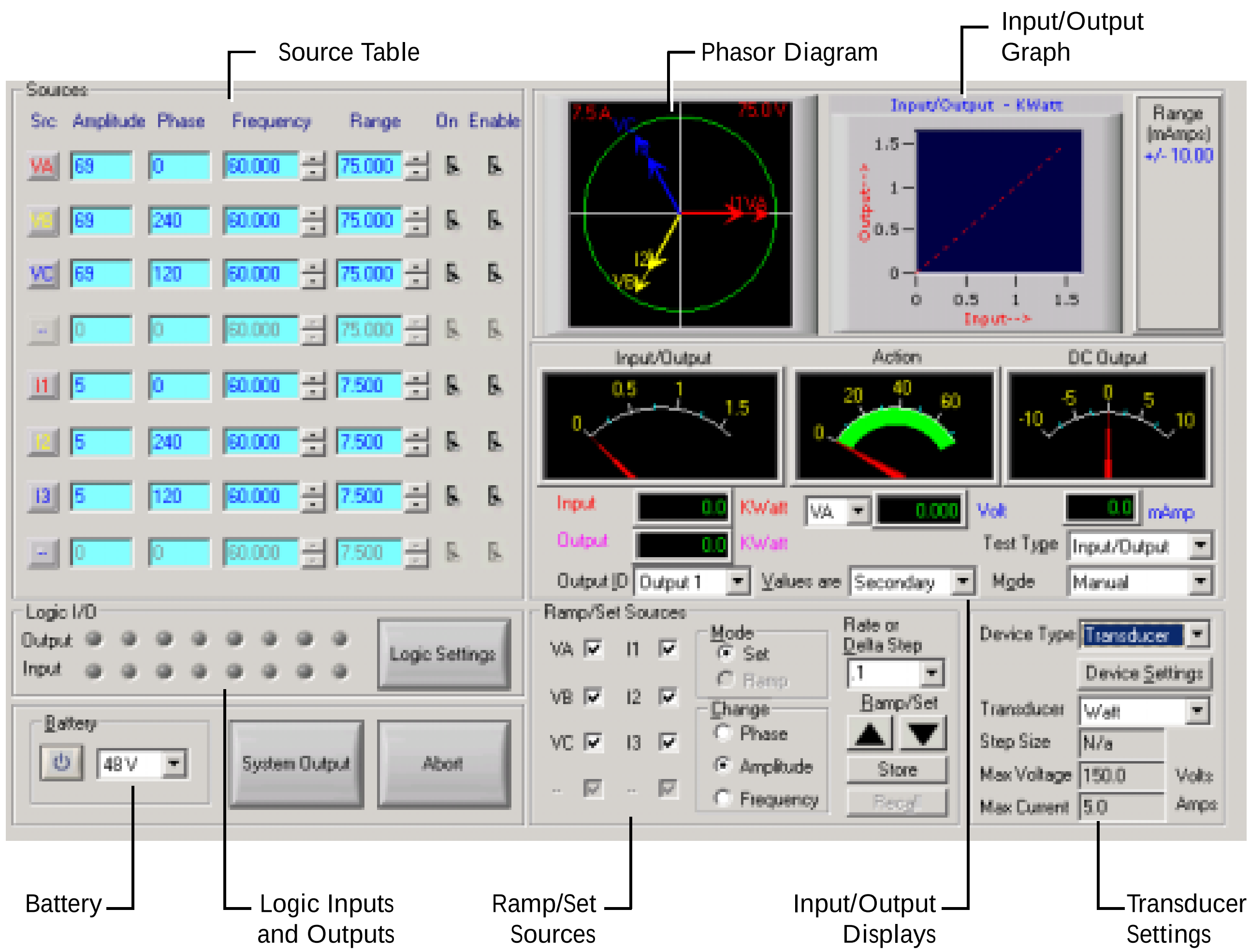


Figure 4.1 F6Meter Control Panel

The Control Panel contains several sections. The functions in these sections control the instrument's voltage and current sources. The major sections and controls in the Control Panel are:

- *Source Table*
- *Ramp/Set Sources*
- *Input/Output Graph*
- *Logic Settings (Inputs and Outputs)*
- *Phasor Diagram*
- *Transducers: Analog Output Transducers and Pulsed Output Transducers*
- *Battery Setting*

Source Table

The source table (Figure 4.2) in the upper left portion of the Control Panel contains seven columns. The column headings are:

- *Src (Source)*
- *Amplitude*
- *Phase*
- *Frequency*
- *Range*
- *On*
- *Enable*

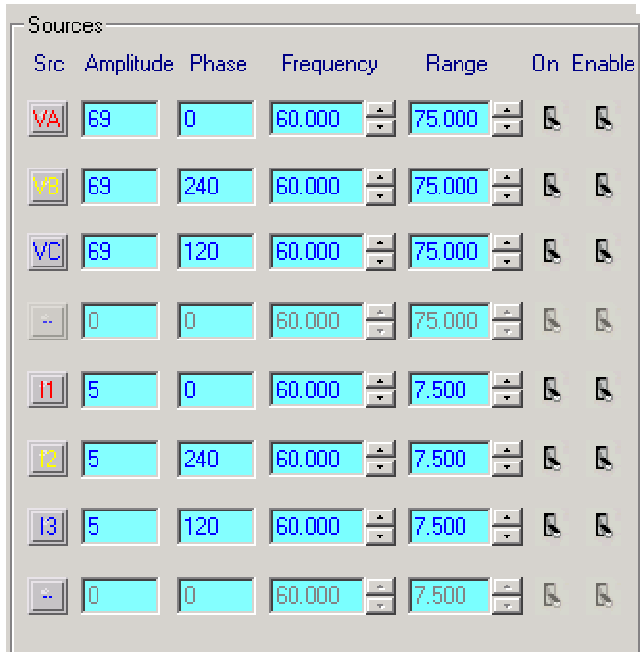


Figure 4.2 Source Table

The first five columns contain the settings for each source:

Src (Source)	The *Src* column in Figure 4.2 shows that six out of eight sources are active: three voltage sources *VA*, *VB* and *VC* and three current sources *I1*, *I2* and *I3*.
Amplitude	Amplitude indicates the voltage or current value of a source. The amplitude is determined by the range settings. If the entered amplitude exceeds the maximum range value, an error message appears. To correct the error, reduce the amplitude or increase the range.
Phase	Phase indicates the phase angle of each source in degrees.

Frequency	The default system frequency is 60 Hz. Use the Setup display (Figure 3.2 on page 3-4) to change the default frequency. Use the spinner arrows in the *Frequency* column to select the AC harmonic (1-20), or to select a DC or a –DC range.
Range	The range setting determines the maximum value for the amplitude of a particular source. For the maximum VA at any given test value, use the lowest range that can produce the desired test value. See Appendix G ”F6150 Specifications” for more details about range settings.

NOTE

If a source error occurs, the alarm is visible in the source table: the name of the source affected changes to ER and blinks, the Amplitude and Phase fields for that source blink, and an audible alarm sounds from the speakers of the control PC. See ”Source Errors” on page 6-15.

The last two columns in the source table contain On and Enable buttons for each source.

On	Click the **On** button to turn a source on. The button turns red, and the System Output button blinks red. Click the **On** button again to turn a source off, the button turns gray. The System Output button stops blinking when all the sources have been turned off.
Enable	Click the **Enable** button to place selected sources in standby status. The Enable button for each source to be activated turns green. When **System Output** is selected, all the enabled sources turn on. The System Output button turns red, but the On buttons for the individual sources stay gray. Clicking **System Output** again turns the enabled sources off.

The default color for System Output, On, and Enable buttons is gray. Table 4.1 summarizes the panel indications associated with all three indicators.

WARNING

The high intensity yellow LED flashes when the battery simulator or any output source is Enabled or On to indicate that dangerous or fatal voltages may be present on the front panel.

Table 4.1 Indications for Activated Sources

	Method of Source Activation	
	Click *On*	**Click *Enable*, then click *System Output***
On Button Color	Red	Gray
Enable Button Color	Gray	Green
System Output Color	Blinking Red	Steady Red
Abort Button Color	Red	Red

NOTE

To turn off all active sources during a test, click Abort. Clicking Abort in the Control Panel turns off the battery simulator if *Battery Off on Abort* is checked on the Setup window.

Ramp/Set Sources

The *Ramp/Set sources* section (Figure 4.3) contains these tools for changing the values in the source table:

- Mode setting: Ramp or Set (default mode)
- Rate or Delta Step pick list (or user entered value field)
- Variable to change: Phase, Amplitude (default variable), and Frequency
- Checkboxes to designate sources to change
- Up and down control arrows
- Store and Recall buttons

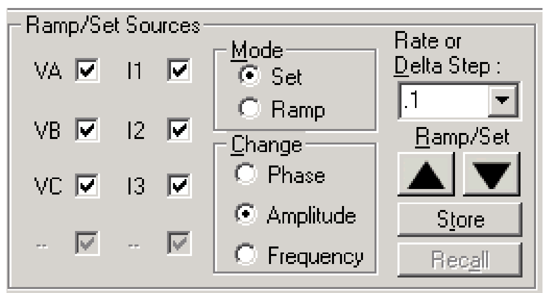


Figure 4.3 Ramp/Set Sources Section

NOTE

Use the source table and the *Ramp/Set* section to control the amplitude, phase angle, and frequency of each source.

Sources to Change

The *Ramp/Set* section has eight checkboxes, one for each source. To change the selected variable (amplitude, phase angle, or frequency) for a given source, click the checkbox for that source. Alternately, a right-click menu exists that enables the user to select or deselect: all current sources, all voltage sources or all sources.

NOTE

To avoid altering the values for a source during a test, make sure the checkbox for that source is not selected.

Variable to Change

Under *Change*, select a variable to increase or decrease:

- Click the radio button for *Phase* to vary the phase angle of the selected sources by clicking either the up or down control arrow.
- Click the radio button for *Amplitude* to vary the voltage or the current of the selected sources by clicking either the up or down control arrow.
- Click the radio button for *Frequency* to vary the frequency of the selected sources by clicking either the up or down control arrow.

NOTE

The frequency of the first source in the source table varies independently of the other seven sources. The frequencies of sources 2 through 8 vary together.
For example, if VA is the only source checked in the *Ramp/Set sources* section, the frequency for VA is the only variable that changes when the up or down arrow is pressed. When VB is the only source checked, however, the frequencies for VB, VC, VN, I1, I2, I3 and IN all change at the same time.

Control Arrows

The up and down arrows to the right of *Ramp/Set* on the Control Panel permit the change of selected source variables. The up arrow increments and the down arrow decrements the selected source variables. The type of change depends on the mode selected (see ''Mode and Ramp/Delta Step'' on page 4-8).

All six activated sources in Figure 4.3 are checked. When the up arrow is pressed, the sources step up by the amount in the *Delta step* box, or increase at the rate specified in the *Rate/second* box. The setting cannot increase beyond the limit set in the *Range* column of the source table. The setting stops at the last valid value and remains there.

When *Change* is set to *Phase*, click and hold the up arrow to rotate the selected sources counter-clockwise and the down arrow to rotate the selected sources clockwise.

Mode and Ramp/Delta Step

The settings in the source table can be varied continuously when in *Ramp* mode or in discrete steps when in *Set* mode.

Ramp Mode — Select a value from the pick list or enter the Rate=value/second manually. The selected source variables increment or decrement at this rate when the up or down arrows are clicked and held.

Set Mode — Select a value from the pick list or enter the Delta step manually. The selected source variables increment or decrement by this amount when the up or down arrows are respectively clicked.

For both the *Ramp* and *Set* modes, the values in the *Ramp or Delta step* pick list are 0.1, 1, 10, and 100.

NOTE

In *Ramp* mode, the Rate=value/second is a continuous change at 10 kHz, *not* one value change per second.

Store and Recall

To save the values displayed in the source table, click **Store** at any time. The source table values can then be altered via user entry or step/ramp tests. To reinstate the stored values, click **Recall**. Recall is inactive until Store is clicked.

Input and Output Indicators

The F6000 Instrument has eight logic inputs and eight logic outputs. The Control Panel contains a status indicator for each one (Figure 4.4). The status indicators are numbered 1 through 8 from left to right.

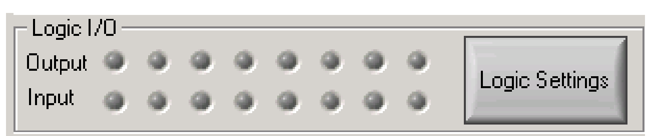


Figure 4.4 Input and Output Status Indicators

Each voltage and current source maps to a logic output. The mapping of sources to outputs depends on the source configuration in effect. The mapping rule assigns outputs to voltage and current sources in ascending order, first from left to right, then from top to bottom. Figure 4.5, Figure 4.6, and Figure 4.7 illustrate how the rule works for three common source configurations.

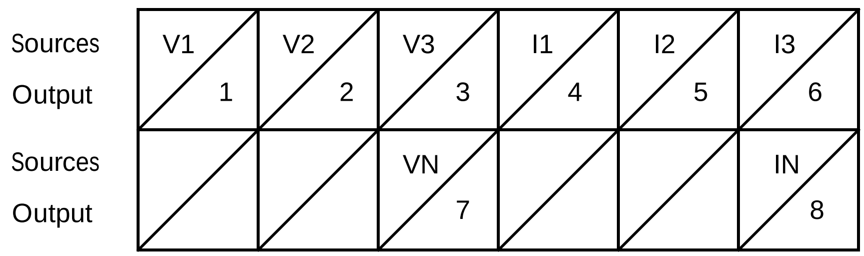


Figure 4.5 Four Voltage and Four Current Sources Mapped to Eight Output Indicators

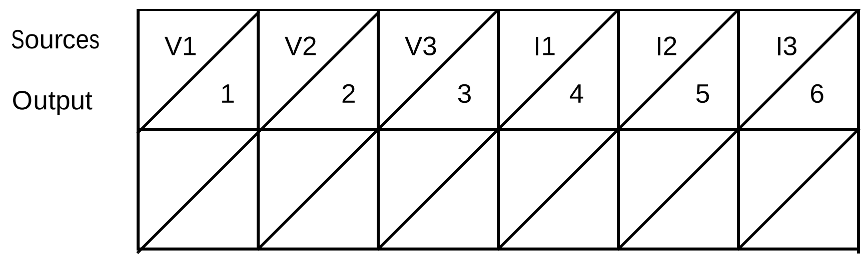


Figure 4.6 Three Voltage and Three Current Sources Mapped to Six Output Indicators

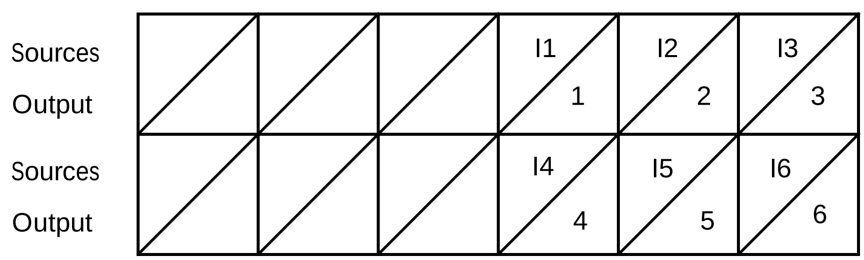


Figure 4.7 Six Current Sources Mapped to Six Output Indicators

A logic output gives the F6000 the ability to send out its own signal. As a logical relay, it opens or closes its contacts when its associated source goes on. The output is in its normal state when the source is off. A normally open output contact closes when the source is turned on and its corresponding status indicator illuminates. The Logic Output indicators are gray when Open and green when Closed.

A logic input is a signal that originates with the device under test and is sent to the instrument. The logic Input indicators are gray for a false state and red for a true state.

Logic Settings

Click **Logic Settings** to bring up the **Settings** display (Figure 4.8). The **Settings** display has three tabs:

- *Inputs*
- *Outputs*
- *Notes*

Inputs Tab

The *Inputs* tab (Figure 4.8) contains the settings for eight logic inputs, one for each input terminal on the instrument front panel. The *Inputs* tab also contains controls for the Threshold option.

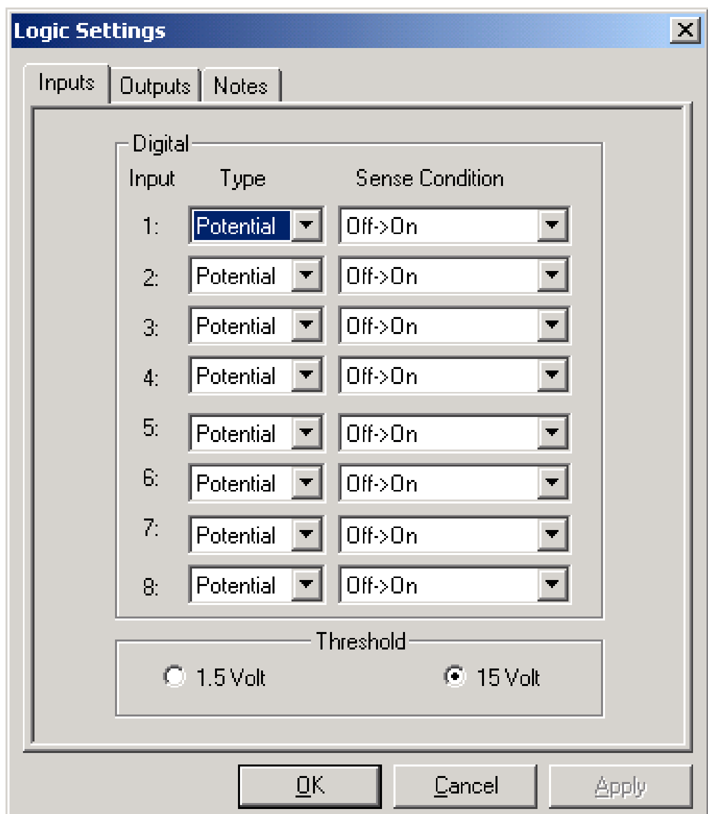


Figure 4.8 Inputs Tab

For each input, choose the *Type* of input and the *Sense Condition*:

Type	Select **Potential** or **Contact** from the pick list.
Sense Condition	Select the transition that must occur for the input to be true.

Each input type, Potential or Contact, has two selectable sense conditions. The sense condition is false when no potential exists across the inputs (Table 4.1). The sense condition is true when potential does exist across the inputs. Whether the type of input is Potential or Contact, the first sense condition is always false and the second sense condition is always true.

Table 4.2 Sense Conditions for Input Types

Type of Input	Sense Conditions	Description
Potential	Off → On	False → True
	On → Off	False → True
Contact	Open → Close	False → True
	Close → Open	False → True

The *Threshold* section applies to tests where a potential is present on contacts. The threshold setting of 15 V is provided to reduce sensitivity to circuit noise. Use the 1.5 V setting when no noise is present or when greater sensitivity to circuit noise is required.

Outputs Tab

The *Outputs* tab (Figure 4.9) sets the default contact status for each of the eight logic outputs on the instrument front panel. *Normally open* is the default contact status for all eight logic outputs in the *Outputs* tab. Click the desired radio button for each output.

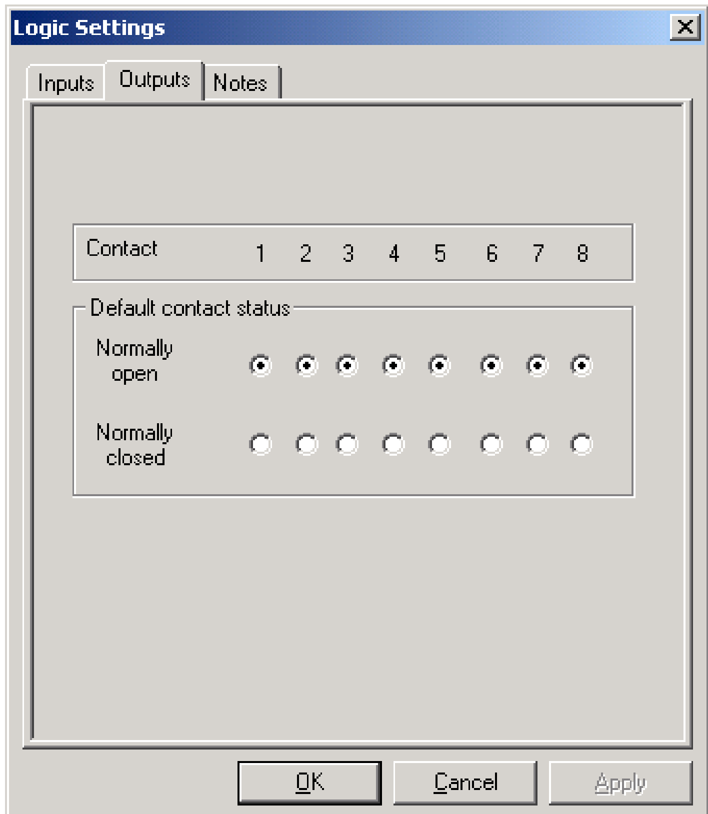


Figure 4.9 Outputs Tab

NOTE

The logic outputs change state with the status of their mapped output sources. See ''Input and Output Indicators'' on page 4-8.

Notes Tab

Use the *Notes* tab (Figure 4.10) to document any part of a test setup or test procedure by entering text such as a test sequence or the reasons for key settings. When in simulation mode, the settings for a test can be entered, saved, and sent to a technician in the field. The field technician can then use the information in the *Notes* tab to set up and conduct the test.

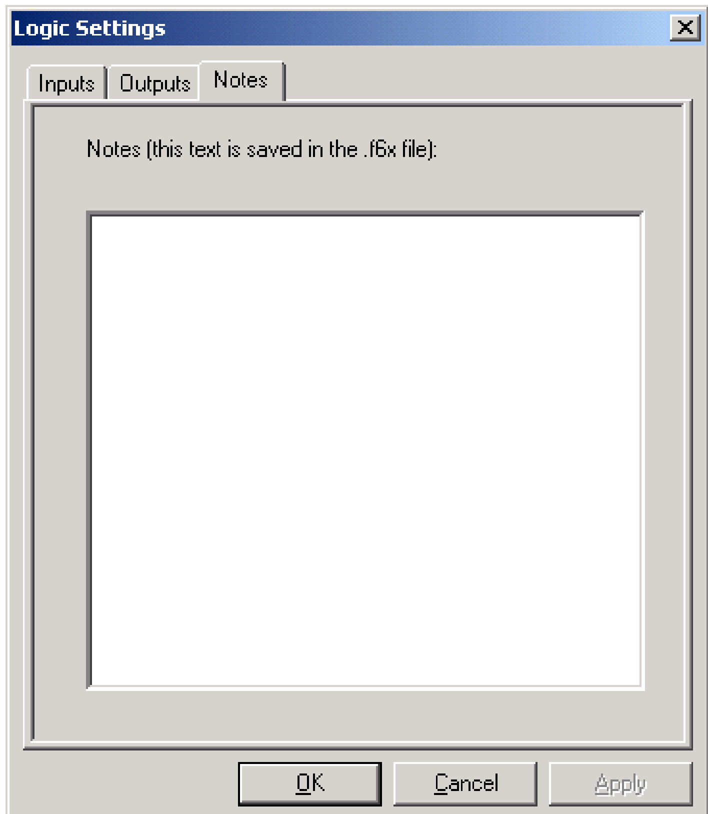


Figure 4.10 Notes Tab

To save the text in the *Notes* tab along with other Control Panel settings, see ''Save a Control Panel Configuration'' on page 4-74.

Phasor Diagram

The phasor diagram (Figure 4.11) in the upper right portion of the Control Panel is based on polar coordinates. Each phasor represents the amplitude and phase angle of a source. The distance from the origin to the endpoint of the phasor represents the amplitude of a source. The angle formed by the phasor and the positive half of the horizontal axis represents the phase angle of a source.

The phasor diagram gives a visual representation of the amplitude and phase values in the source table. The source table and phasor diagram interact with each other. Source table values are continuously updated as phasors are dragged to new locations in the diagram using the mouse, but the change is not sent to the F6000 Instrument until the phasor is dropped.

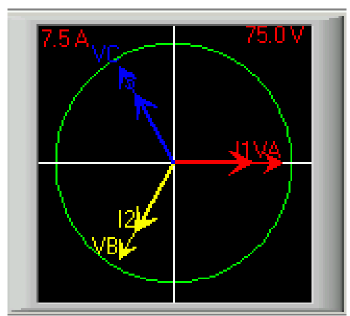


Figure 4.11 Phasor Diagram

Range Settings

The upper left corner of the phasor diagram contains the highest current setting from the *Range* column of the source table. The upper right corner of the phasor diagram contains the highest voltage setting from the *Range* column of the source table.

These settings determine the scale of the phasor diagram. For example, if the amplitude for current source I1 is 15 A and the highest range setting for the current sources is 15 A, the I1 phasor reaches to the perimeter of the circle in the phasor diagram. Similarly, if the potential for voltage source VA is 50 V and the highest range setting for the voltage sources is 75 V, the length of the VA phasor is two-thirds the radius of the circle in the phasor diagram.

Multi Rotation

Right-click in the phasor diagram and select **Multi Rotation** in the pop-up menu (Figure 4.12). The phasors for a set of voltage or current sources can then be moved by dragging and dropping any one of them. Each phasor maintains its position relative to the other two. When phasors are being moved, the source table is continuously updated, but the new phase angle values are not sent to the F6000 Instrument until the selected phasor is dropped. Only the Phase Angle can be changed in Multi Rotation mode.

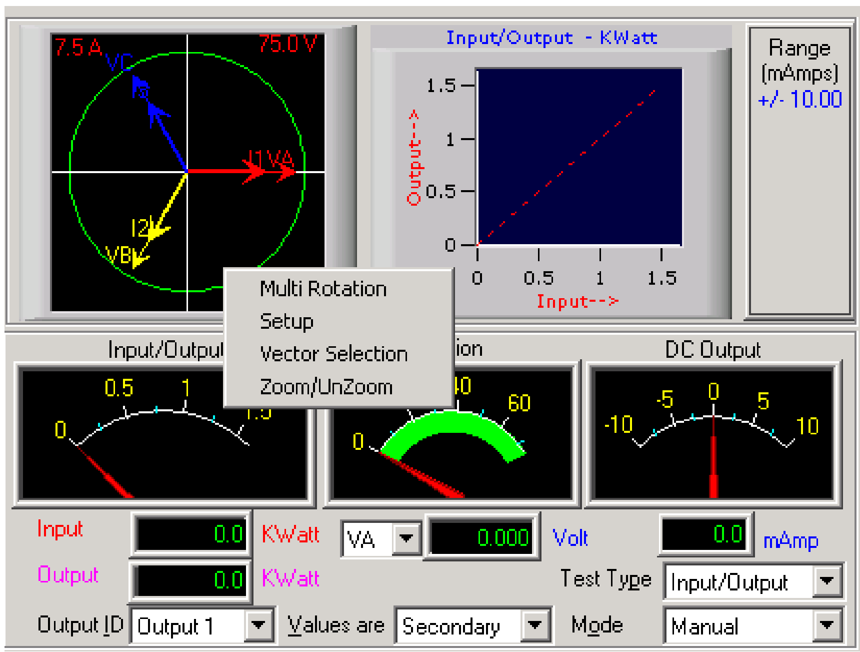


Figure 4.12 Phasor Diagram Right-Click Menu

Setup

To configure each phasor, right-click in the phasor diagram and select **Setup** in the pop-up menu. The Phasor dialog box appears (Figure 4.13). Use the dialog box to select the color, thickness, and line type for each phasor and circle. In addition, use the Phasor dialog box to set color for the axes and background. By default, the current phasors are thicker than the voltage phasors.

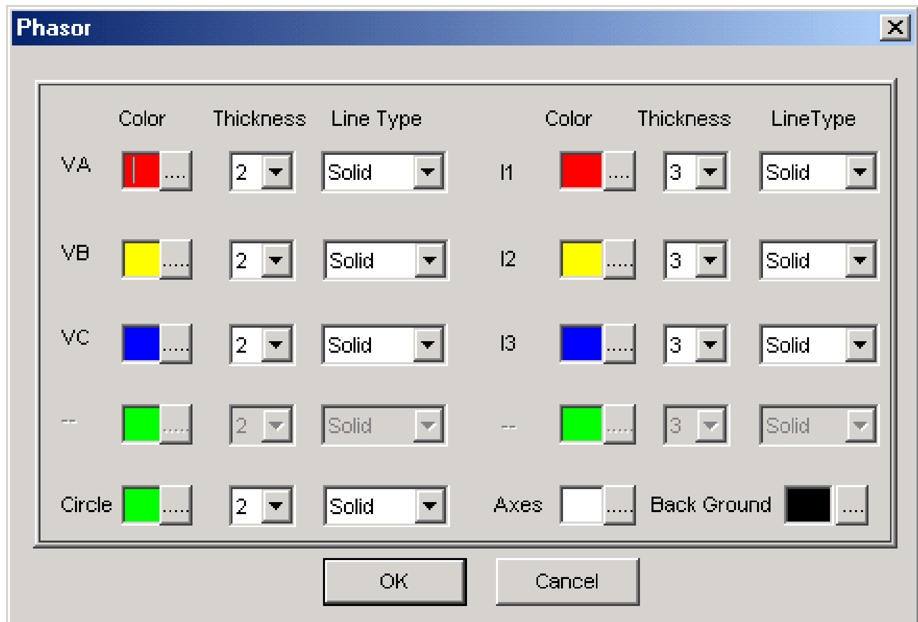


Figure 4.13 Phasor Dialog Box

Vector Selection

To select the phasor for display, right-click in the phasor diagram and select **Vector Selection** in the pop-up menu. The Vectors dialog box appears (Figure 4.14). Check or uncheck the box for each active source as desired. To select all the phasors, click **Select All**. Click **Apply** to change the vectors selected in the phasor diagram without closing the dialog box. Click **OK** to close the dialog box with the new vector selection settings in effect.

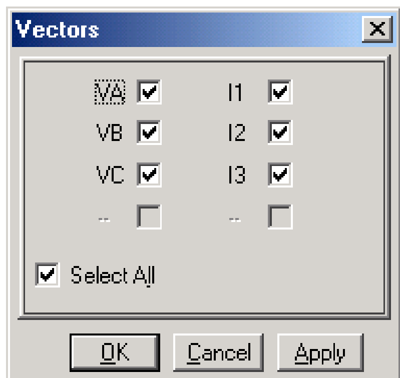


Figure 4.14 Vectors Dialog Box

Zoom/Unzoom

The Zoom/Unzoom feature enlarges an area of the phasor diagram. To use the feature, right-click and select **Zoom/Unzoom** in the pop-up menu. The pop-up menu closes with the Zoom feature in effect.

To select an area, click the left mouse button in the diagram and drag the cursor down and to the right. A dashed rectangle appears around the selected area. When the mouse button is released, the selected area is enlarged.

To deselect the Zoom feature, right-click in the phasor diagram and select **Zoom/Unzoom** in the pop-up menu. When the pop-up menu closes, the phasor diagram returns to its normal state.

Analog Output Transducers

Figure 4.15 highlights the portion of the Control Panel used to test analog output transducers.

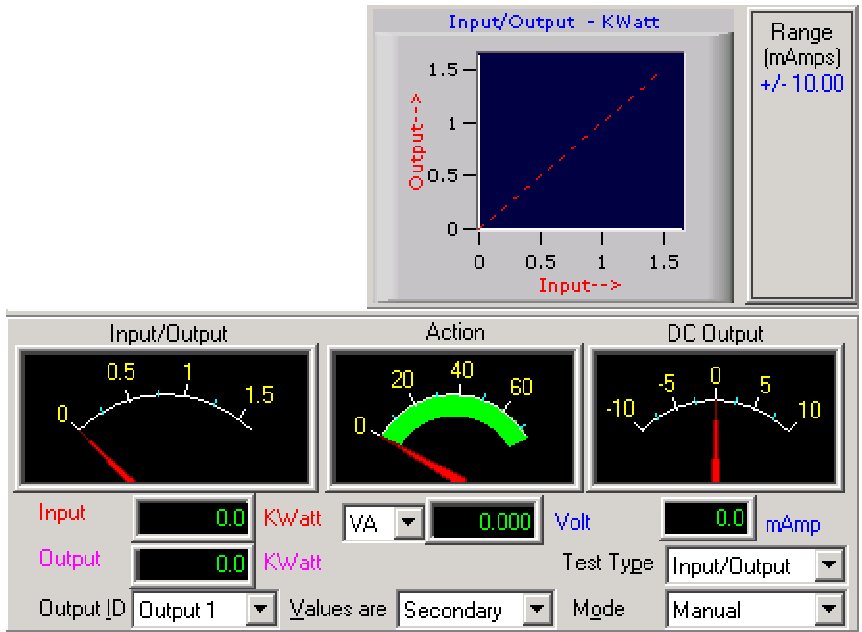


Figure 4.15 Settings and Displays for Analog Output Transducers

The analog output portion of the Control Panel contains these parts:

- Input/Output graph and the F6000 input range to the right of the graph
- Input/Output meter
- Action meter
- DC Output meter
- Selection lists for the transducer output, value type, test type, and test mode

Use the Device Settings window to set up a transducer test. Click **Device Settings** in the lower right portion of the Control Panel to open the window (Figure 4.16). The settings in this window affect the conduct of the transducer test in the Control Panel. For a summary of the settings in the Device Settings window, see ''Settings for Analog Output Transducers'' on page 4-33.

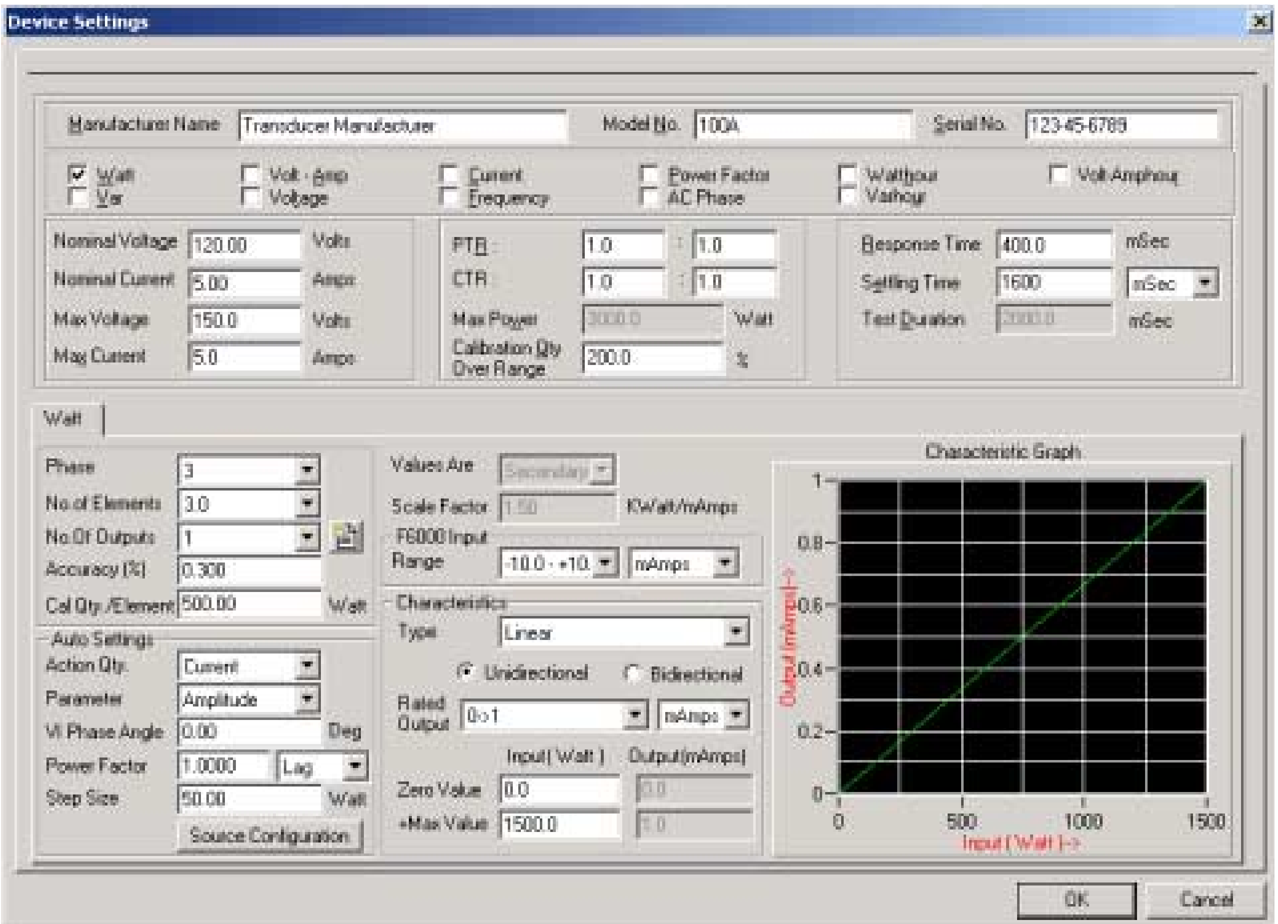


Figure 4.16 Device Settings Window with an Analog Output Transducer Selected

To configure the Control Panel for testing a particular type of transducer:

1. Click **Device Settings** in the Control Panel.

   The Device Settings window opens (Figure 4.16).

2. Click the function of each transducer type to be tested.

   A check mark appears next to the selected transducer function, and a tab for each transducer selected appears in the lower portion of the Device Settings window.

3. Click **OK** to close the Device Settings window and return to the Control Panel.

4. In the *Transducer* drop-down list, select the type of transducer to be tested.

   The entries in the *Transducer* drop-down list correspond to the transducer type selected in the Device Settings window.

Test Type

The F6Meter Control Panel can perform two types of tests on transducers. Step Response and Input/Output. A Step Response test sets the DC meter input sampling rate to 204.6 Hz. Clicking the up or down control arrow causes the recording of the transducer's output. The recording start when the arrow is clicked and stops once the sum of the Response Time and the settling time elapses.

The Input/Output test sets the DC meter input sampling rate to 10 Hz. A timer starts each time an up or down control arrow is clicked. After the sum of the Response Time and the settling time elapse, the transducer's output is recorded.

To conduct a Step Response transducer test, select **Step Response** in the *Test Type* pick list. The graph above the Input/Output meters plots the transducer output quantity against time (Figure 4.17).

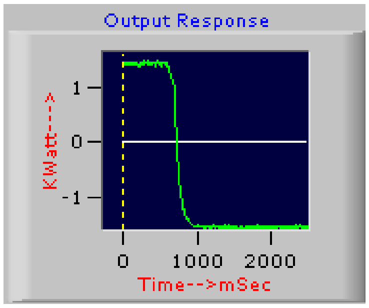


Figure 4.17 Output Response Graph

To conduct an Input/Output test, select **Input/Output** from the *Test Type* pick list. The graph above the Input/Output meters plots the transducer output quantity against the transducer input quantity (Figure 4.18).

Input/Output Graph

The Input/Output graph plots the data points created during a transducer Input/Output test (Figure 4.18). The data points are those that appear in the Input and Output fields below the Input/Output meter. The red dashed line in the graph shows the location of expected values for the device under test. Test data appears in the graph as green points. In a successful test, the data points lie along the dashed line.

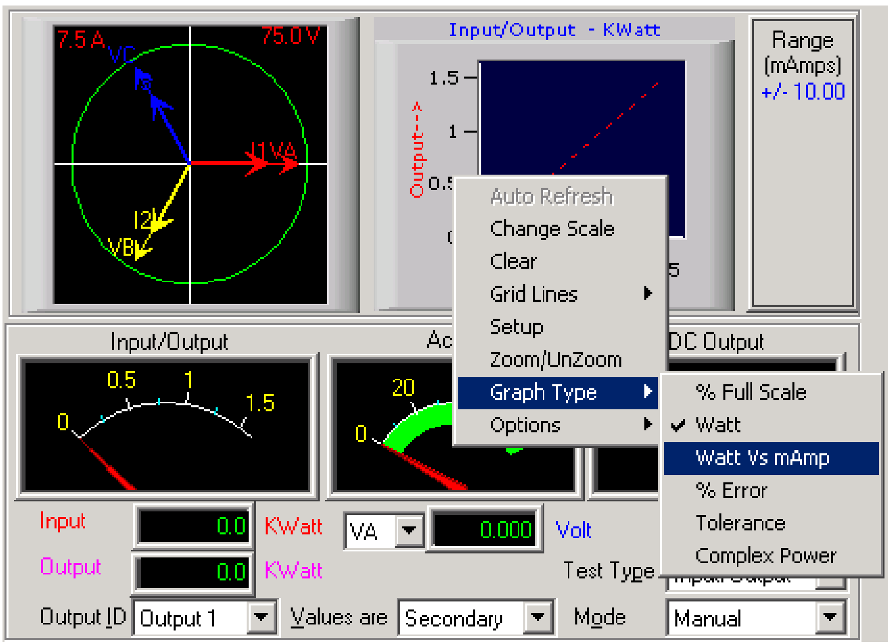


Figure 4.18 Input/Output Graph Right-Click Menu

Table 4.3 explains the options available via the Input/Output graph right-click menu.

Table 4.3 Input/Output Graph Right-Click Menu Items

Main Menu Items	Sub-Menu Items	Effect
Auto Refresh	None	To be implemented in future releases.
Change Scale	None	Opens the Scale Setting dialog box. See Figure 4.19 on page 4-24.
Clear	None	Clears all data points from the graph.
Grid Lines	X Axis, Y Axis, or both	Shows horizontal grid lines parallel to the X axis, vertical grid lines parallel to the Y axis, or both.
SetUp	None	Opens the Graph dialog box. See Figure 4.20 on page 4-25.
Zoom/Unzoom	None	Enables or disables the zoom feature. Refer to ''Zoom/Unzoom'' on page 4-25.
Graph Type	% Full Scale, Selected test quantity (i.e.: Watt), Input test quantity Vs Selected input type (mA or V), % Error, Tolerance, or Complex Power	Select one of the six options: • **% Full Scale** to plot output as a percent of the rated transducer limit vs. input test quantity. • Selected test quantity (i.e.: **Watt**) to plot output in kilowatts vs. input in kilowatts. • Input test quantity vs. selected input type (**mA** or **V**) to plot output in mAmps vs. input in kilowatts. • **% Error** to plot percent error vs. input in selected test quantity. The default tolerance is plus or minus 0.3%. • **Tolerance** to enable or disable green tolerance lines in the above three plots. Tolerance lines are present by default in the % Error plot. • **Complex Power** to plot P, Q, and S vectors for complex power.
Options	Maximize or Minimize	Click either: • **Maximize** to enlarge the Input/Output graph to occupy the entire window. • **Minimize** to close the graph and return to the Control Panel.

Scale Setting

Right-click in the Input/Output graph and select **Change Scale** from the pop-up menu to open the Scale Setting dialog box (Figure 4.19). The scale style for both the Input and the Output is Auto by default. To set the minimum and maximum values for each axis manually, click **Manual** in both the Input section and Output section, enter the desired values in the *Min.* and *Max.* fields, and click **OK** to close the dialog box and to implement the new settings.

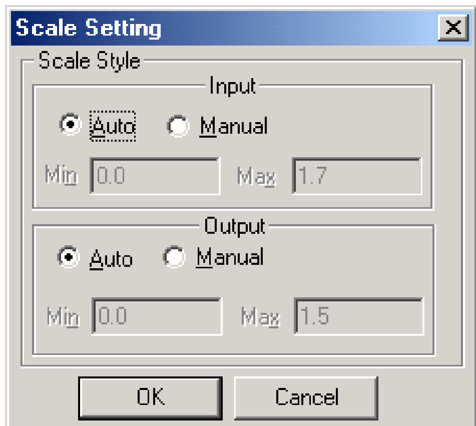


Figure 4.19 Scale Setting Dialog Box

Graph

Right-click in the Input/Output graph and select **Setup** to open the Graph dialog box (Figure 4.20). Use the dialog box to set the color of the actual data points, the expected values, the two axes, the grid lines, and the background. Then set the width and the line type for the actual and expected values. Click **OK** to close the dialog box and to implement the new settings.

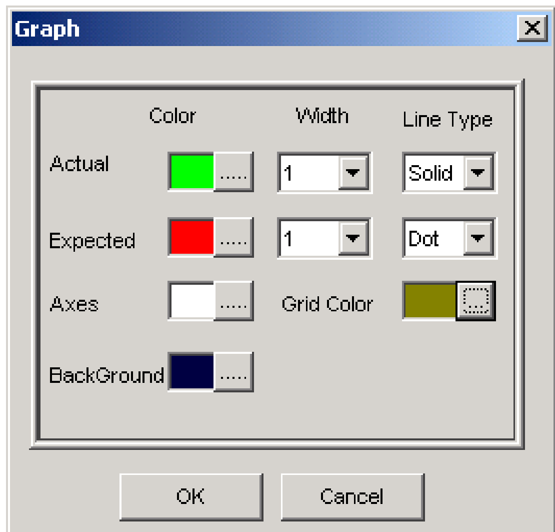


Figure 4.20 Graph Dialog Box

Zoom/Unzoom

The Zoom/Unzoom feature enlarges an area of the Input/Output graph. To use the feature, right-click and select **Zoom/Unzoom** in the pop-up menu. The pop-up menu closes with the Zoom feature in effect.

To select an area, click the left mouse button in the diagram and drag the cursor down and to the right. A dashed rectangle appears around the selected area. When the mouse button is released, the selected area is enlarged.

To deselect the Zoom feature, right-click in the Input/Output graph and select **Zoom/Unzoom** in the pop-up menu. When the pop-up menu closes, the Input/Output graph returns to its normal state.

Input/Output Meter

The Input/Output meter uses a red needle to indicate the transducer input and a purple needle to indicate the transducer output (Figure 4.21). The indications in the meter correspond to the values in the Input and Output fields below the meter. The red Input field labels correspond to the red meter needle. The purple Output field labels correspond to the purple meter needle.

From the *Output ID* pick list, select the output indicated in the meter. From the *Values are* pick list, and select whether the values indicated are shown in secondary or primary quantities.

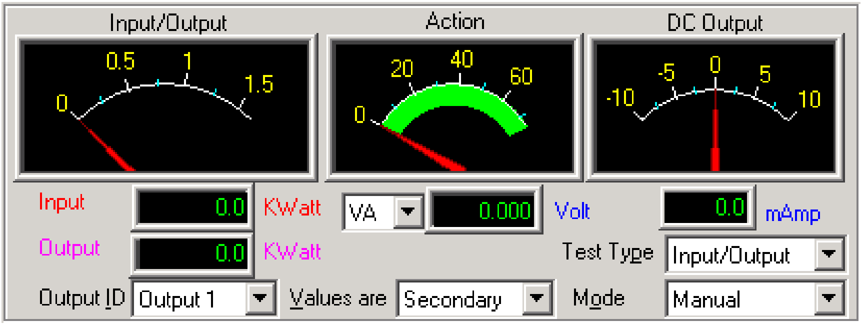


Figure 4.21 Input/Output Meter

Right-click in the Input/Output meter to open the menu of options available for that meter (Figure 4.22).

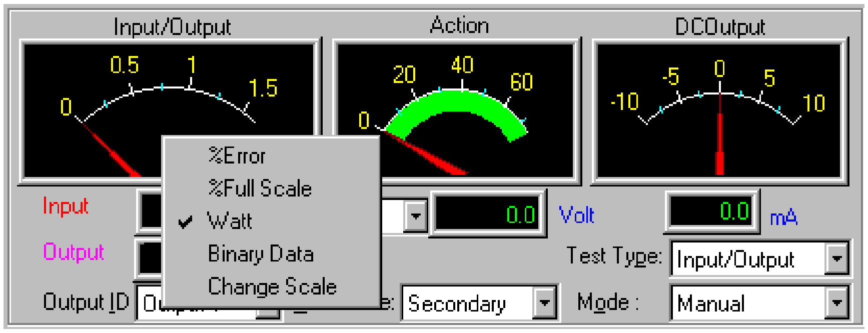


Figure 4.22 Input/Output Meter Right-Click Menu

Table 4.4 lists the menu selections available in the right-click pop-up menu for the Input/Output meter shown in Figure 4.22.

Table 4.4 Right-Click Menu for the Input/Output Meter

Menu Item	Effect
% Error	The meter displays the percent error between the transducer input quantity and transducer output quantity. The meter scale is set to +/- the percent accuracy of the transducer as entered in the Device Settings window.
% Full Scale	The meter displays the transducer's output quantity as a percentage of the full scale of the transducer. The meter scale is set from 0% to 100%.
Test Quantity	The meter displays the transducer test input quantity on the horizontal axis and transducer test output quantity on the vertical axis. The meter scale is set to the + Max Value and – Max Value of the transducer as entered in the Device Setting dialog box. A list of Test Quantities includes: Watt, Var, VA, Volts, Amps, Deg and Hz.
Binary Data	The meter displays the transducer's output quantity as raw binary input data from the F6150's DC Meter Input reads. The meter scale is set to binary input data range: 0 to 32,500.
Change Scale	Select **Change Scale** to increase or decrease the meter resolution. Selecting this menu option opens a Scale Setting dialog box (Figure 4.23).

Figure 4.23 shows the Scale Setting dialog box for the Input/Output meter. Select **Manual**, enter the minimum and maximum values for the meter, and click **OK**. The new settings appear in the Input/Output meter.

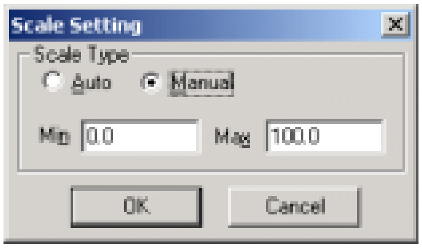


Figure 4.23 Scale Setting Dialog Box for the Input/Output Meter

Action Meter

The Action meter (Figure 4.24) indicates the action output of the active source. Use the pick list directly below the Action meter to select the active source. The sources in the list correspond to the sources checked in the Ramp/Set sources section. If a voltage source is selected, the meter readout is in Volts for Amplitude mode, Degrees for Phase mode, and Hertz for Frequency. If a current source is selected, the meter readout is in Amps for Amplitude mode, Degrees for Phase mode and Hertz for Frequency.

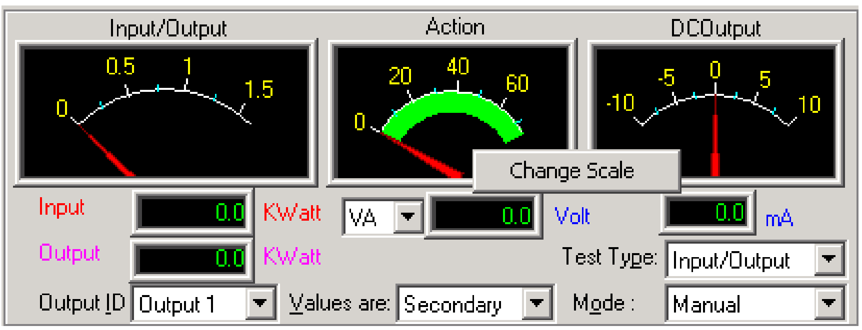


Figure 4.24 Action Meter Right-Click Menu

When displaying Volt or Amps, values above the green bar are at or less than the Nominal value entered in Device Settings. Values above the yellow bar are greater than the Nominal value but less than the Maximum value. Values above a bar are greater than the Maximum value. The user is warned on entering the red zone.

To change the scale of the Action meter, right-click in the meter and click **Change Scale**. The scale setting dialog box for the Action meter opens (Figure 4.25). Enter the desired minimum and maximum values for the meter scale, and click **OK** to implement the new settings.

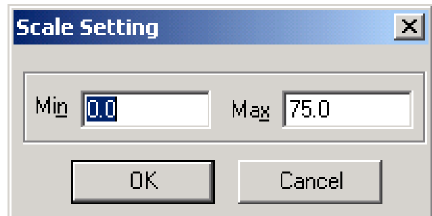


Figure 4.25 Scale Setting Dialog Box for the Action Meter

DC Output Meter

The DC Output meter, which measures the output of the transducer is shown in Figure 4.26. The label for the digital readout below the meter indicates the meter units.

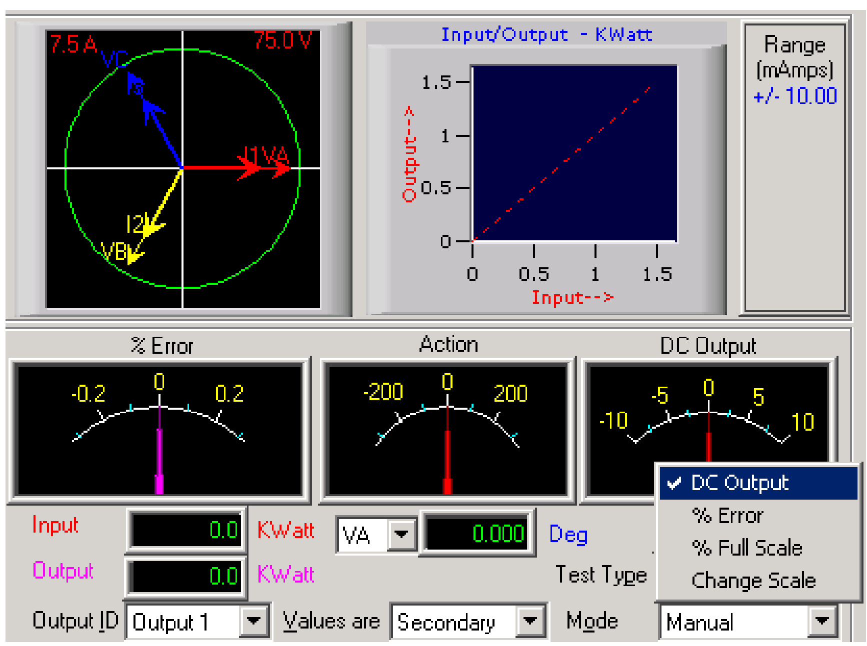


Figure 4.26 DC Output Meter Right-Click Menu

Right-click in the DC Output meter to open the menu of options available for the meter. Table 4.5 lists the selections in the right-click menu.

Table 4.5 Right-Click Menu for the DC Output Meter

Menu Item	Effect
DC Output	The meter displays the transducer DC output quantity: mAmps, or Volts. The meter scale is set to the Rated Output (RO) of the transducer as entered in the Device Setting window.
% Error	The meter displays the percent error between the transducer input quantity and transducer output quantity. The meter scale is set to +/- the percent accuracy of the transducer as entered in the Device Setting window.
% Full Scale	The meter displays the transducer's output quantity as a percentage of the full scale of the transducer. The meter scale is set from 0% to 100%.
Change Scale	Select **Change Scale** to increase or decrease the meter resolution. Selecting this menu option opens a Scale Setting dialog box (Figure 4.27).

Figure 4.27 shows the Scale Setting dialog box for the DC Output Meter.

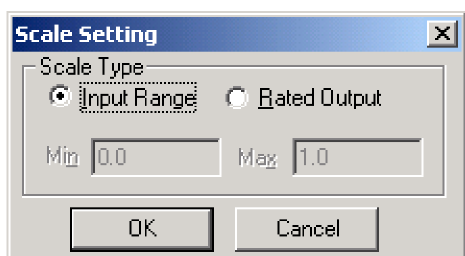


Figure 4.27 Scale Setting Dialog Box for the DC Output Meter

Mode

To conduct a transducer test in Auto mode, select **Auto** in the *Mode* pick list. The confirmation box in Figure 4.28 appears in the Control Panel. Click **OK** to close the warning box and reconfigure the Control Panel for Auto mode. Chapter 5, Sample Test Procedures, discusses how to conduct transducer tests in Auto mode.

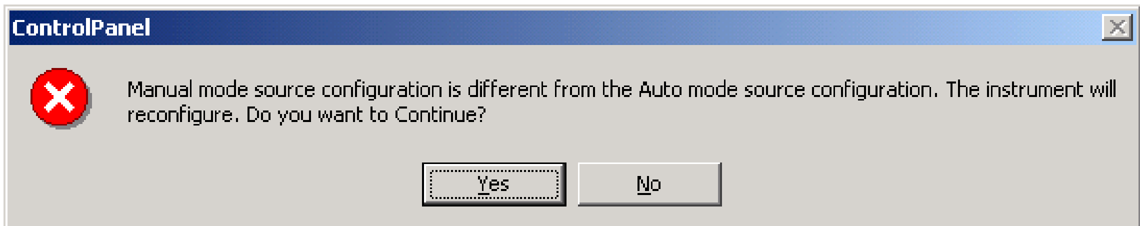


Figure 4.28 Auto Mode Confirmation Box

The Mode selection defines how the set step size functions and has two choices:

Manual Mode	In Manual Mode the step size entered by the user has an amplitude, phase or frequency quantity. The step size is entered using the *Rate or Delta Step* field on the Control Panel. Clicking the up and down spinner buttons causes the source's amplitude, phase or frequency quantity to increase or decrease based upon the *Ramp Set Sources* check box selection(s). The transducer function Input quantity is then calculated based on the state of the instrument's source.
Auto Mode	In Auto Mode the step size is automatically calculated based on the transducer function *Auto Settings* in *Device Settings*. The step size is entered using the *Step Size* field. Clicking the up and down spinner buttons causes the source's amplitude, phase or frequency quantity to increase or decrease based on the *Auto Settings* in *Device Settings,* producing a step equal to the *Step Size* value. In Auto mode, the auto step size appears in the *Step Size* field on the Control Panel. In Manual mode the auto step size display is not applicable and *N/A* appears.

The Source table and most *Ramp Set Source* fields are disabled. The selections that appear in the Source table and most *Ramp Set Source* fields reflect the selections in the transducer function's *Auto Settings* in the *Device Settings*.

Settings for Analog Output Transducers

Click **Device Settings** in the Control Panel to open the Device Settings window. Figure 4.29 shows the composition of the Device Settings window when the Control Panel is configured to test a watt transducer.

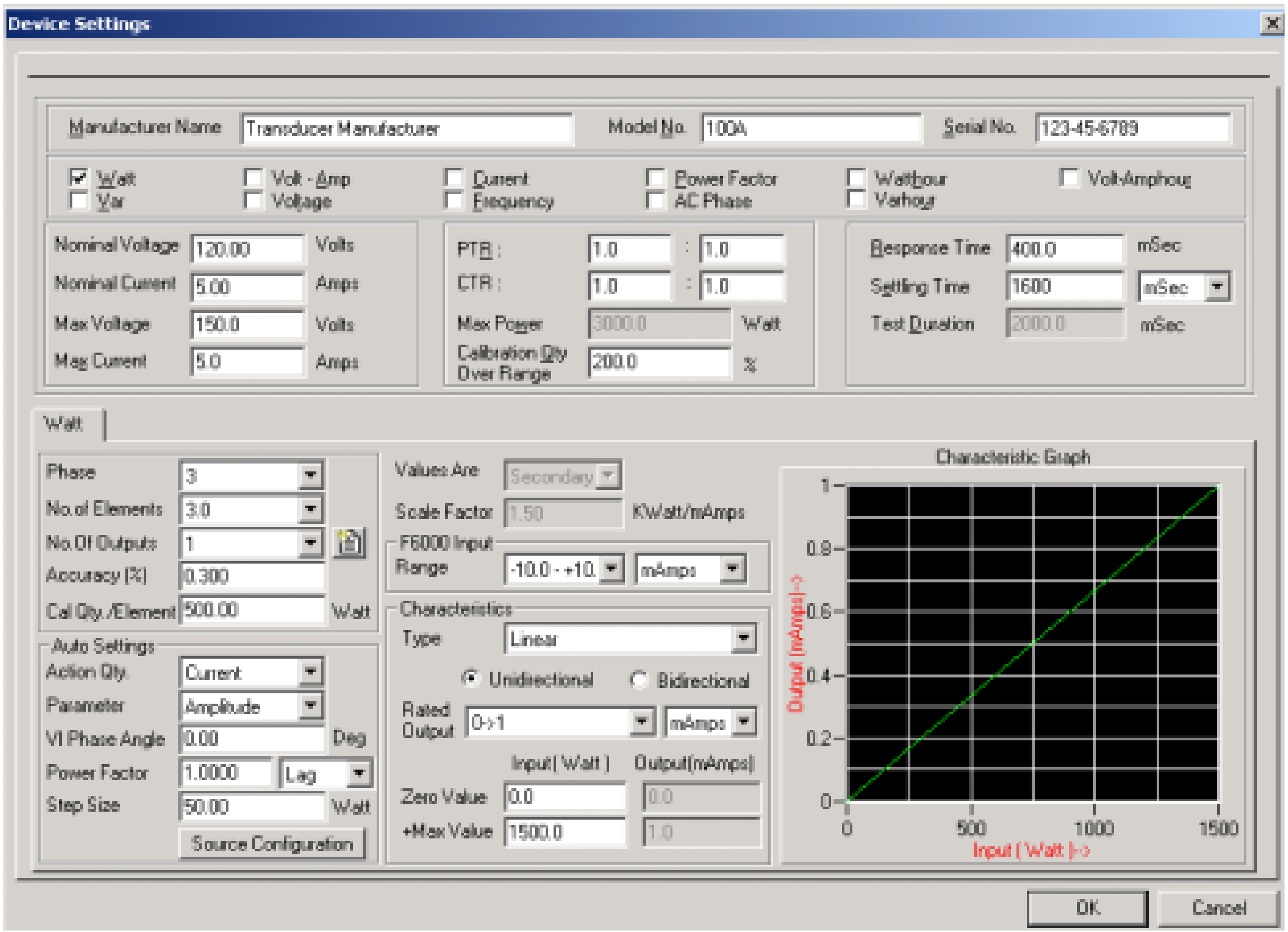


Figure 4.29 Device Settings Window with an Analog Output Transducer Selected

Nameplate Data

Use the manufacturer's transducer documentation to enter the name of the manufacturer, the model number, and the serial number of the transducer (Figure 4.30). These entries help to identify the summary reports that document the test results.

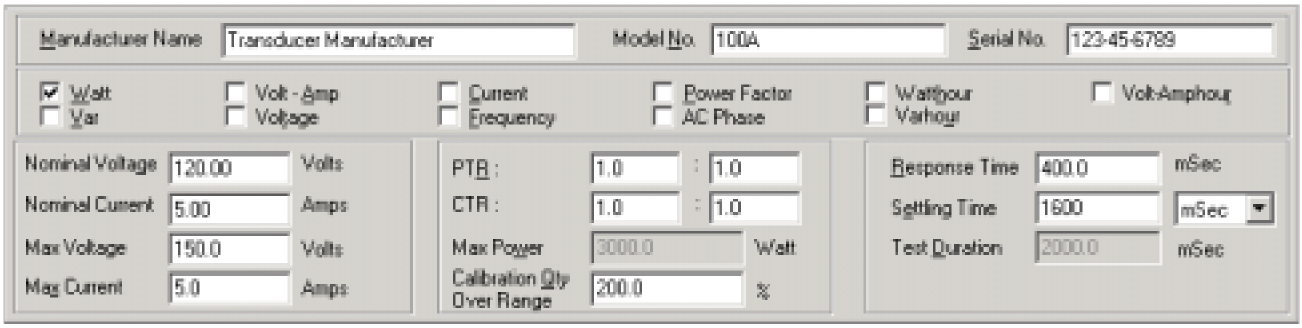


Figure 4.30 Analog Output Transducers Nameplate Data

The first eight checkboxes, left to right, under the manufacturer name designate analog output transducers:

- Watt
- Var
- Volt-Amp
- Voltage
- Current
- Frequency
- Power Factor
- AC Phase

Select the box or boxes that correspond to the device under test. One tab opens in the lower portion of the Device Settings window for each box checked.

Underneath the checkboxes, enter general test data. The first section on the left has four fields:

- Nominal Voltage – the rated line to neutral voltage in volts.
- Nominal Current – the rated current in amps.
- Maximum Voltage – the maximum specified continuous voltage.
- Maximum Current – the maximum specified continuous current.

The remaining entries in the nameplate section are:

- Potential transformer ratio (PTR) – enter the ratio of primary (left) to secondary (right) voltages.
- Current transformer ratio (CTR) – enter the ratio of primary (left) to secondary (right) currents.
- Maximum Power – This field is automatically calculated for Watt, VAR, and VA transducers. All others are equal to zero.
- Calibration Quantity Over Range.
- Response Time, in mSec – enter the time required to respond to a change of input from the manufacturer's specifications.
- Settling Time, in mSec, Sec, or Cycles – enter the time required to stabilize the new output signal.
- Test Duration, in mSec – equals the sum of Response Time and Settling Time (automatically calculated).

Analog Output Transducer Tabs

The eight tabs for analog output transducers are similar, but they differ in the measurement units and default settings they use.

Summary of Device Settings

For purposes of this summary, the device settings tab for analog output transducers is divided into these sections:

- *Basic settings*
- *Auto settings*
- *F6000 Input*
- *Characteristics*

The *Watt* tab is used as a model.

Basic Settings

Table 4.6 lists the fields and possible values for the first group of settings in the *Watt* tab.

Table 4.6 Basic Transducer Settings

Field	Value
Phase	Select **1** for a single phase transducer and **3** for a three phase transducer.
Number of Elements	Select the number of elements in the transducer. This field is only relevant to power and energy transducers. For a single phase transducer, 1 is the only option. For a three phase transducer, the options are 2, 2.5 and 3.
No. of Outputs	Select the number of outputs on the transducer (**1**, **2** or **3**) for this function. F6Meter Control Panel supports up to three outputs.
Accuracy (%)	Enter the transducer's percent accuracy for this function.
Calibration Quantity per Element	For power and energy transducers enter the Calibration Quantity per Element. For all other transducers enter the Calibration Quantity.
Values Are	Select whether all entered values are entered as Secondary or Primary quantities. **Note: Primary is inactive for this release of F6Meter Control Panel.**
Scale Factor	The transducer input quantity (Watt, Var, Volt, etc.) per transducer output quantity (Volt dc or mAmp dc).

Scale Factor Calculation

For power and energy transducers:

$$\text{Scale Factor} = \frac{\text{(Calibration Quantity/Element) x [(No. of Elements)]}}{\text{(Maximum Rated Output - Minimum Rated Output)}}$$

NOTE

For the Scale Factor calculation, round half elements up to their next whole element. If No. of Elements = 2.5, use 3.0 in the calculating the Scale Factor.

For all other transducers:

$$\text{Scale Factor} = \frac{\text{(Calibration Quantity)}}{\text{(Maximum Rated Output – Minimum Rated Output)}}$$

In the Device Settings window, click the document icon next to the *No. of Outputs* field to open the Output Name dialog box (Figure 4.31). Enter a new designation for each output in the *Name* column as desired. Click **OK** to close the dialog box. The new output name appears in the Control Panel in the *Output ID* field under the Input/Output meter and in all Test Summary reports.

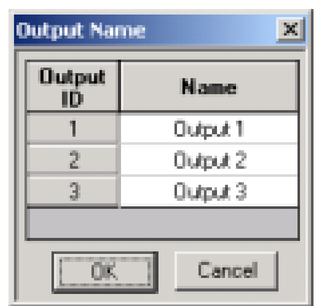


Figure 4.31 Output Name Dialog Box

Auto Settings

Table 4.7 lists the fields and possible settings for a transducer being tested in Automatic mode.

Table 4.7 Auto Settings

Field	Explanation
Action Quantity	Select the source type: **Voltage** or **Current**, to be varied by the Auto Test for the selected transducer function. For transducer functions with both Current and Voltage selections, the amplitude of the unselected or unchecked source is fixed during Auto testing to the nominal source rating. The choices vary based upon the transducer function. For example, a watt transducer has a Voltage and a Current selection; a voltage transducer only has a Voltage selection.
Parameter	Select the source parameter: **Amplitude**, **Phase** or **Frequency**, to be varied by the Auto Test for the selected transducer function. The choices vary based upon the transducer function. For example, a watt transducer has an Amplitude and Phase parameter selection; a frequency transducer only has a frequency selection.
VI Phase Angle	Enter the current phase angle to voltage phase angle relationship for the Auto Test. The values are entered as the voltage angle less the current angle. Therefore, entering 45 makes the current lag the voltage by 45°. For example, enter 45° for the *VI Phase Angl*e and an *A phase voltage angle* of 0°. The calculation is then 0° – (45°) = – 45°. Entering a VI Phase Angle value causes the Power Factor field to automatically update reflecting the new VI Phase Angle. VI Phase Angle is available for Phase, Power and Energy transducers.

Table 4.7 Auto Settings (Continued)

Field	**Explanation**
Power Factor	Enter the power factor for the current phase angle to voltage phase angle relationship for the Auto Test. Enter a numeric value between zero and one. Then specify Lag or Lead. Entering a Power Factor value causes the VI Phase Angle to automatically update reflecting the new Power Factor. Power Factor is available for Phase, Power and Energy transducers.
Step Size	Enter the test quantity Auto Test step size. This is the incremental increase or decrease from the F6000 sources during Auto test. The step quantity changes based upon the transducer function. For a Watt transducer, the step quantity is Watts. For a voltage transducer, the step quantity is volts.

In the Device Settings window, click **Source Configuration** in the Auto Settings section to open the Source Configuration window (Figure 4.32).

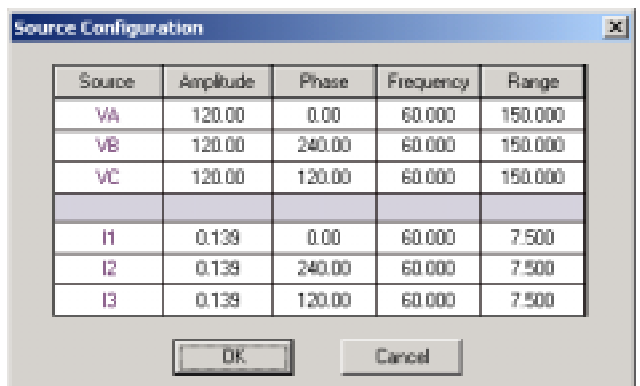


Figure 4.32 Automatic Settings Source Configuration

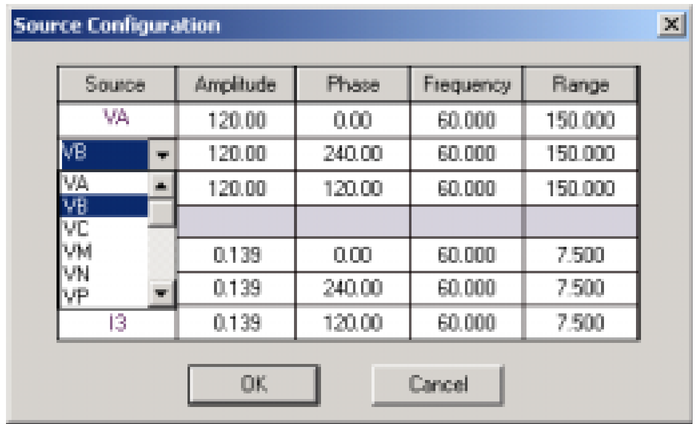


Figure 4.33 Source Configuration Dialog Box – Rename Source

The entries in the other four columns show how the source table in the Control Panel are configured when Auto mode is selected. The entries in these columns depend on all five settings in the Auto Settings section:

Source — The *Source* column shows the Auto mode F6000 source names. The default source names are defined in the Source Name Scheme in Setup. To change the name of a source, click the source name twice and select the new name from the drop-down list that appears (Figure 4.33).

The number of sources that appear is based on the *Phase* and the *No. Of Elements* selections.

Amplitude — Non-editable. The *Amplitude* column shows the Auto mode F6000 source amplitudes.

Amplitude values:

- The source's amplitude is set to the Nominal value if the source is not an Action Qty.
- The source's amplitude is set to the Nominal value if the source is an Action Qty, but Amplitude is not the Action Parameter.
- The source's amplitude is set to the step value if the source is an Action Qty and Amplitude is the Action Parameter.

Phase	Non-editable. The *Phase* column shows the Auto mode F6000 source phase values. The default phase values are defined in the Source Angle of Setup. Phase values: • The source's phase is set to the default value if the source is not an Action Qty. • The source's phase is set to the default value if the source is an Action Qty, but Phase is not the Action Parameter. • The source's phase is set to the step value if the source is an Action Qty and Phase is the Action Parameter.
Frequency	Non-editable. The *Frequency* column shows the Auto mode F6000 source frequency values. The default frequency values are defined in the System Frequency of Setup. Frequency values • The source's frequency is set to the default value if the source is not an Action Qty. • The source's frequency is set to the default value if the source is an Action Qty, but Frequency is not the Action Parameter. • The source's frequency is set to the step value if the source is an Action Qty and Frequency is the Action Parameter.
Range	Non-editable. The Range column shows the calculated Auto mode F6000 source range. The range is calculated based upon the +/- Max Values and the Calibration Qty Over Range.

F6000 Input

The F6000 Input section contains fields for selecting the active DC Meter Input, mAmps or Volts, and setting the input range. Table 4.8 lists the available settings for the DC meter input voltage and current ranges.

Table 4.8 F6000 DC Meter Input Ranges

Units	Ranges
mAmps	– 25 to + 25 – 10 to + 10 – 1 to + 1
Volts	– 12.5 to + 12.5 – 5.0 to + 5.0 – 0.5 to + 0.5

Setting the Active DC Meter Input

Setting the units selection to *Volts* causes the F6150 to read the DC Meter Voltage input. Setting the units selection to *mAmp* causes the F6150 to read the DC Meter mAmp input.

Setting the DC Meter Input Range

The input default range is automatically calculated from the transducer's Rated Output (RO) and the Calibration Qty Over Range value. With an RO of 1 mAmp and a 200% Calibration Qty Over Range, the calculated default range is in the –10 to +10 range. The –10 to +10 mAmp range is selected because the maximum transducer output at 200% Calibration Qty Over Range is 2 mAmps. The –1 to +1 range is saturated at 2 mAmps. Changing the transducer's RO and the Calibration Qty Over Range value causes the default Input Range to be recalculated.

To change the input range, select a new range from the drop-down box. The new range is sent to the F6150 as soon as the selection is made.

Characteristics

The Characteristics section contains fields for defining the transducer's DC output characteristic for the selected function. Table 4.9 lists the fields and possible values for the transducer's output characteristic settings.

Table 4.9 Transducer Characteristic

Field	**Value**
Type	Select the transducer's output characteristic type from the Type drop-down box. This release of F6Meter Control Panel supports linear characteristics. Other characteristic types will be added to future releases.
Polarity	Select whether the transducer function's output is directional or not. Select **Unidirectional** for non-directionally sensitive outputs and **Directional** for directionally sensitive outputs.
Rated Output	Enter the Rated Output for the transducer function. The Rated Output is entered by first selecting the output units (mAmps or Volts). Then select the output range. Changing the units changes the F6000 Input units and range to match the selection. Table 4.10 on page 4-44 provides details on selecting the Rated Output range.
Zero Value (Input)*	This field is active for Unidirectional Polarity selection. The units are transducer function dependent. Enter the input value that corresponds to the zero transducer output.
Zero Value (Output)*	This field is not user editable. It is active for Unidirectional Polarity selection. The units are dependent on the transducer's output units. Changing Rated Output units changes the Zero Value Output units. This value corresponds to the zero value of the Rated Output selection.
– Max Value (Input)*	This field is active for Directional Polarity selection. The units are transducer function dependent. Enter the input value that corresponds to the maximum negative transducer output.

Table 4.9 Transducer Characteristic (Continued)

Field	Value
– Max Value (Output)*	This field is not user editable. It is active only for Directional Polarity selection. The units are dependent on the transducer's output units. Changing Rated Output units changes the – Max Value Output units. This value corresponds to the maximum negative value of the Rated Output selection.
+ Max Value (Input)*	This field is active for both Unidirectional and Directional Polarity selections. The units are transducer function dependent. Enter the input value that corresponds to the maximum positive transducer output.
+ Max Value (Output)*	This field is not user editable. It is active for both Unidirectional and Directional Polarity selections. The units are dependent on the transducer's output units. Changing Rated Output units changes the + Max Value Output units. This value corresponds to the maximum positive value of the Rated Output selection.

* Changing the Phase or No. of Elements may cause these fields to be recalculated.

Table 4.10 Rated Output Range Selection

Unidirectional Units	Unidirectional Output Range*
Amps	0 -> 1 1 -> 5 4 -> 20 Custom (Select **Custom** to enter a custom range)
Volts	0 -> 1 1 -> 10 Custom (Select **Custom** to enter a custom range)

Table 4.10 Rated Output Range Selection

Unidirectional Units	**Unidirectional Output Range***
Directional Units	Directional Output Range**
Amps	0 -> 1 1 -> 5 4 -> 20 Custom (Select **Custom** to enter a custom range)
Volts	–1 ->0 -> 1 1 -> 3 -> 5 4 -> 12 -> 20 Custom (Select **Custom** to enter a custom range)

* Unidirectional Output Range Key: Y -> Z

Y	The transducer output value that equals the zero or minimum input quantity.
Z	The transducer output value that equals the maximum positive input quantity.

** Directional Output Range Key: X -> Y -> Z

X	The transducer output value that equals the maximum negative input quantity.
Y	The transducer output value that equals the zero input quantity.
Z	The transducer output value that equals the maximum positive input quantity.

Characteristic Graph

Configuration of the Characteristic graph on the right side of the tab reflects the input/output settings to the left of the graph. The scale of the vertical axis depends on the Rated Output selected.

Table 4.11 lists the items in the right-click menu for the Characteristic graph.

Table 4.11 Right-Click Menu Items for the Characteristic Graph

Main Menu Items	Description
Grid	Displays grid lines parallel to the X-Axis, Y-Axis, or both.
Properties	Opens the Properties dialog box to select colors (Figure 4.34 on page 4-46).
Zoom/Unzoom	Enables or disables the Zoom feature (''Zoom/ Unzoom'' on page 4-18 explains how to use this feature in the Control Panel).

Click **Properties** in the right-click menu of the Characteristic graph to open the Properties dialog box (Figure 4.34). Use the box to select colors for both axes, the background, the minor and major grids, and the data plots. Click **OK** to close the dialog box.

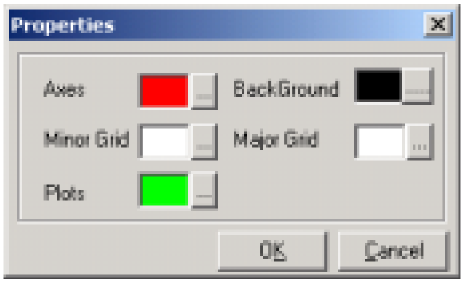


Figure 4.34 Properties Dialog Box for the Characteristic Graph

Watt

The *Watt* tab contains the settings used to test a watt transducer (Figure 4.35). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

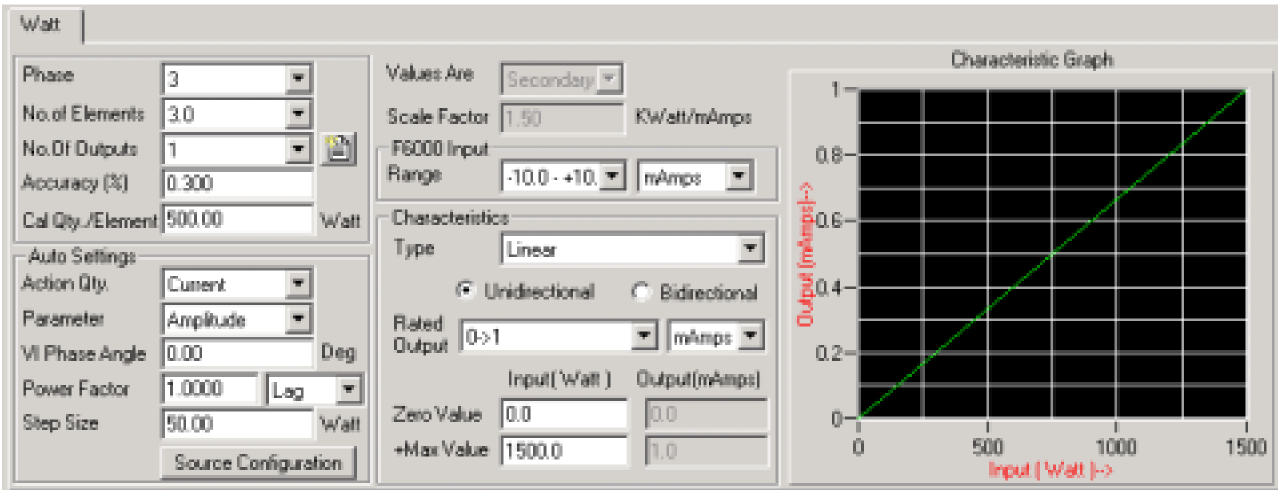


Figure 4.35 Watt Tab

Table 4.12 lists the values for the Auto settings in the *Watt* tab.

Table 4.12 Auto Settings for the Watt Tab

Setting	Values
Action Quantity	• Current • Voltage
Parameter	• Amplitude, Phase – Deactivates the VI Phase Angle and Power Factor
VI Phase Angle	• 0.00° to ±359.9°
Power Factor	• 0.000 (Lag) to ±1.000
Step Size	• Watts

Var

The *Var* tab contains the settings used to test a var transducer (Figure 4.36). To modify the default settings, refer to the test protocol and to the manufacturer’s transducer documentation.

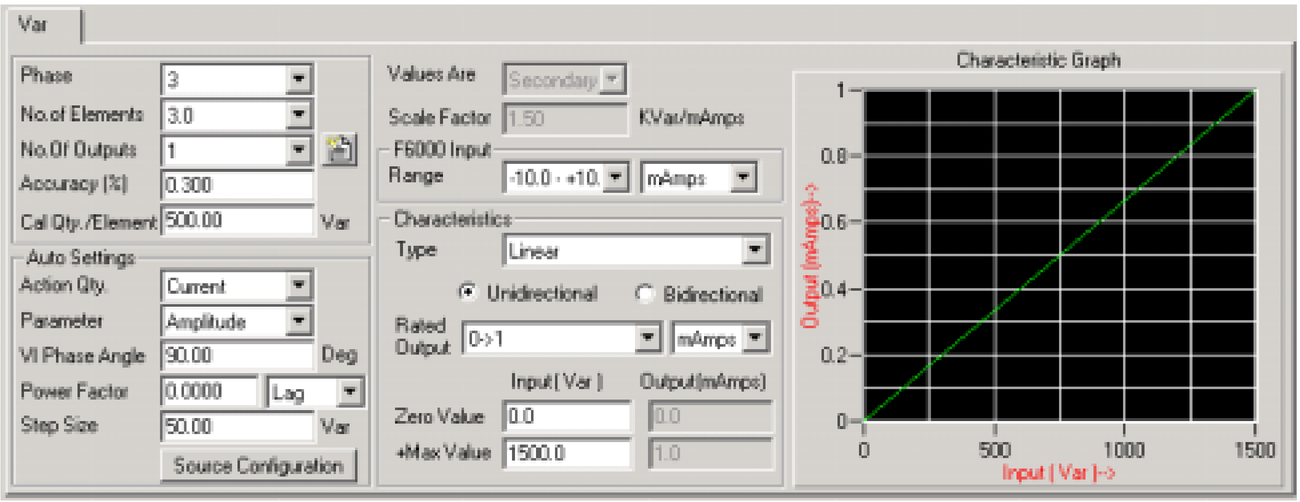


Figure 4.36 Var Tab

Table 4.13 lists the values for the Auto settings in the *Var* tab.

Table 4.13 Auto Settings for the Var Tab

Setting	Value
Action Quantity	• Current • Voltage
Parameter	• Amplitude, phase – deactivates the VI phase angle and power factor
VI Phase Angle	• 0.00° to ±359.9°; default is 90°
Power Factor	• 0.000 to ±1.000
Step Size	• Var

Volt-Amp

The *Volt-Amp* tab contains the settings used to test a volt-amp transducer (Figure 4.37). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

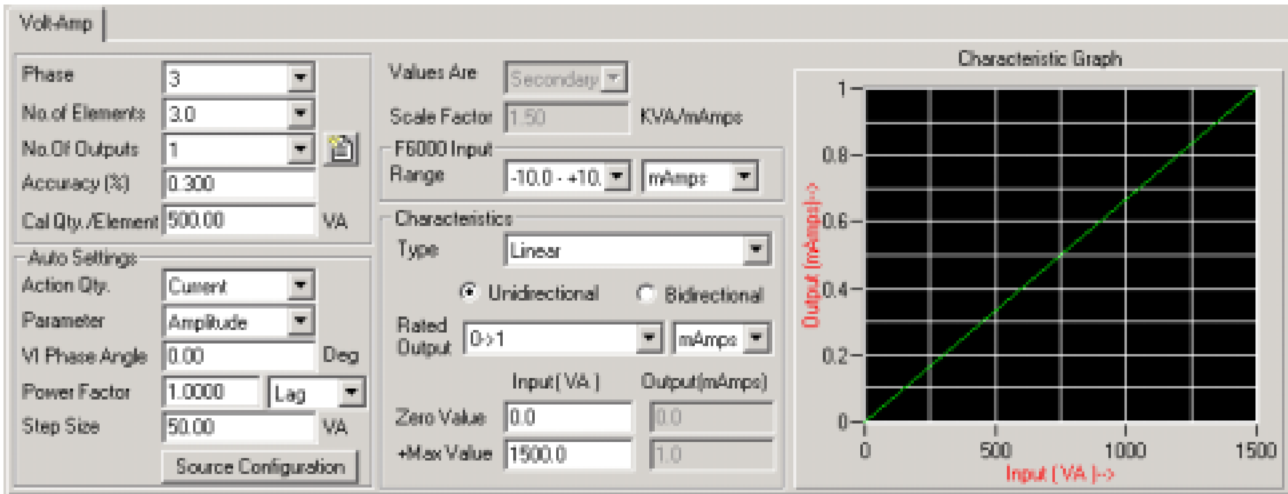


Figure 4.37 Volt-Amp Tab

Table 4.14 lists the values for the Auto settings in the *Volt-Amp* tab.

Table 4.14 Auto Settings for the Volt-Amp Tab

Setting	Value
Action Quantity	• Current • Voltage
Parameter	Amplitude, Phase – Deactivates the VI Phase Angle and Power Factor
VI Phase Angle	0.00 to ±359.9°; default = 0°
Power Factor	0.000 to + or –1.000
Step Size	VA (Volt-Amps)

Voltage

The *Voltage* tab contains the settings used to test a voltage transducer (Figure 4.38). To modify the default settings, refer to the test protocol and to the manufacturer’s transducer documentation.

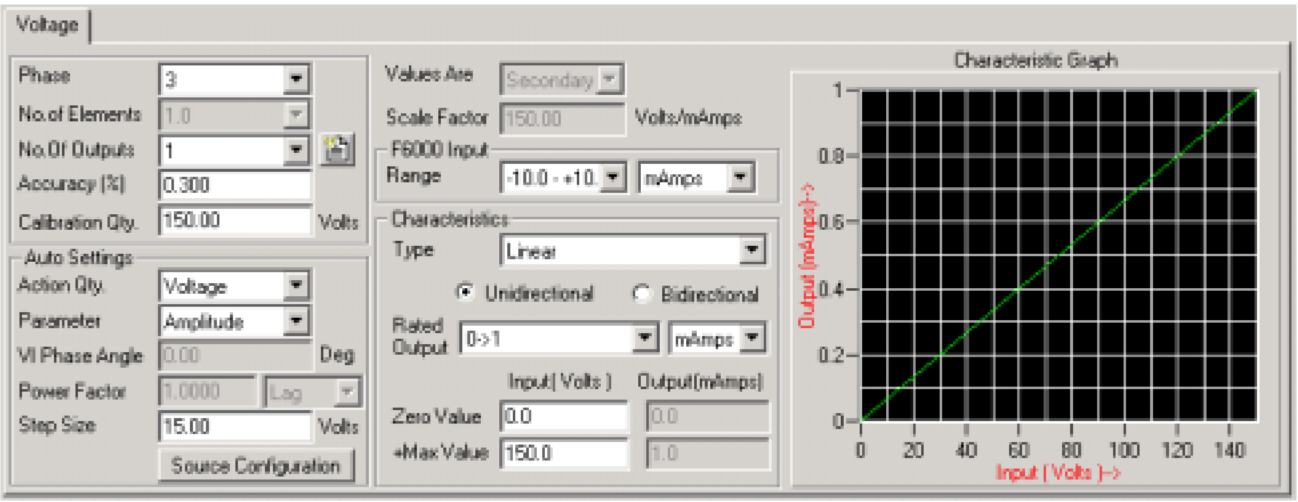


Figure 4.38 Voltage Tab

Table 4.15 lists the values for the Auto settings in the *Voltage* tab.

Table 4.15 Auto Settings for the Voltage Tab

Setting	Value
Action Quantity	Voltage
Parameter	Amplitude
VI Phase Angle	Disabled
Power Factor	Disabled
Step Size	Volts

Current

The *Current* tab contains the settings used to test a current transducer (Figure 4.39). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

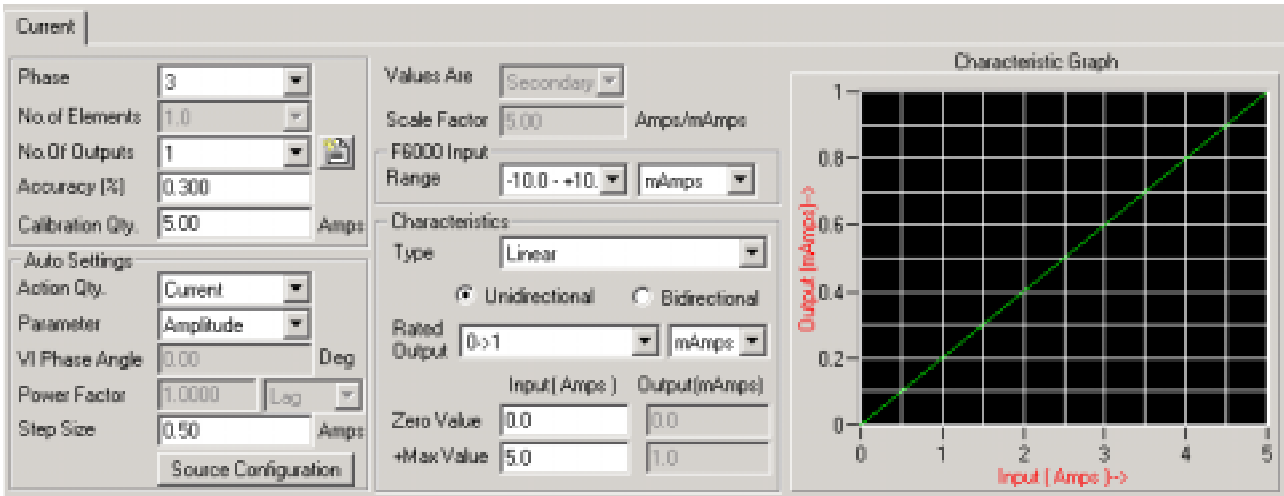


Figure 4.39 Current Tab

Table 4.16 lists the values for the Auto settings in the *Current* tab.

Table 4.16 Auto Settings for the Current Tab

Setting	Value
Action Quantity	Current
Parameter	Amplitude
VI Phase Angle	Disabled
Power Factor	Disabled
Step Size	Amps

Frequency

The *Frequency* tab contains the settings used to test a frequency transducer (Figure 4.40). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

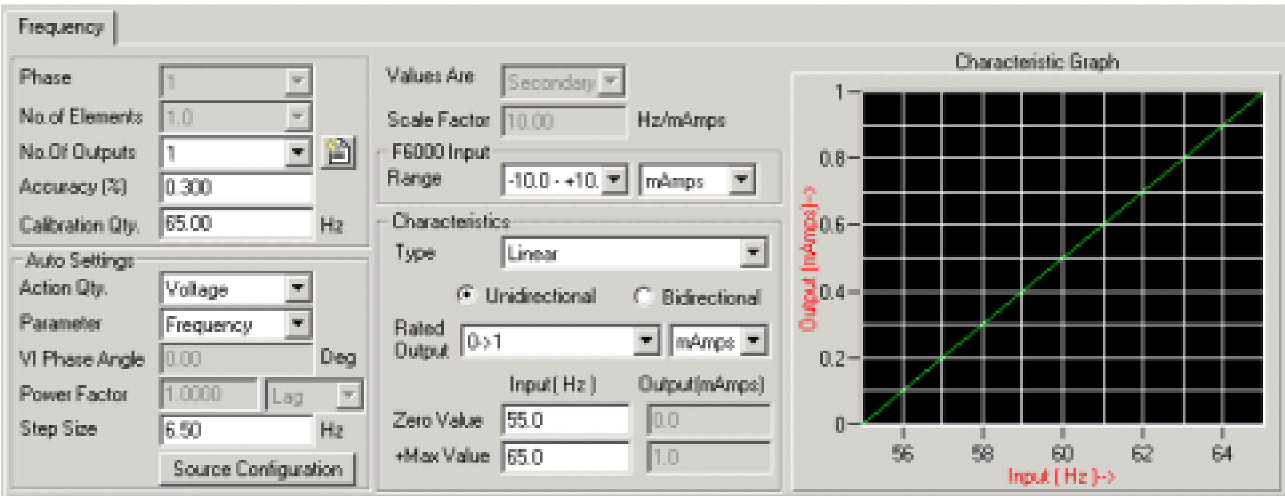


Figure 4.40 Frequency Tab

Table 4.17 lists the values for the Auto settings in the *Frequency* tab.

Table 4.17 Auto Settings for the Frequency Tab

Setting	Value
Action Quantity	• Voltage • Current
Parameter	Frequency
VI Phase Angle	Disabled
Power Factor	Disabled
Step Size	Hz

Power Factor

The *Power Factor* tab contains the settings used to test a power factor transducer (Figure 4.41). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

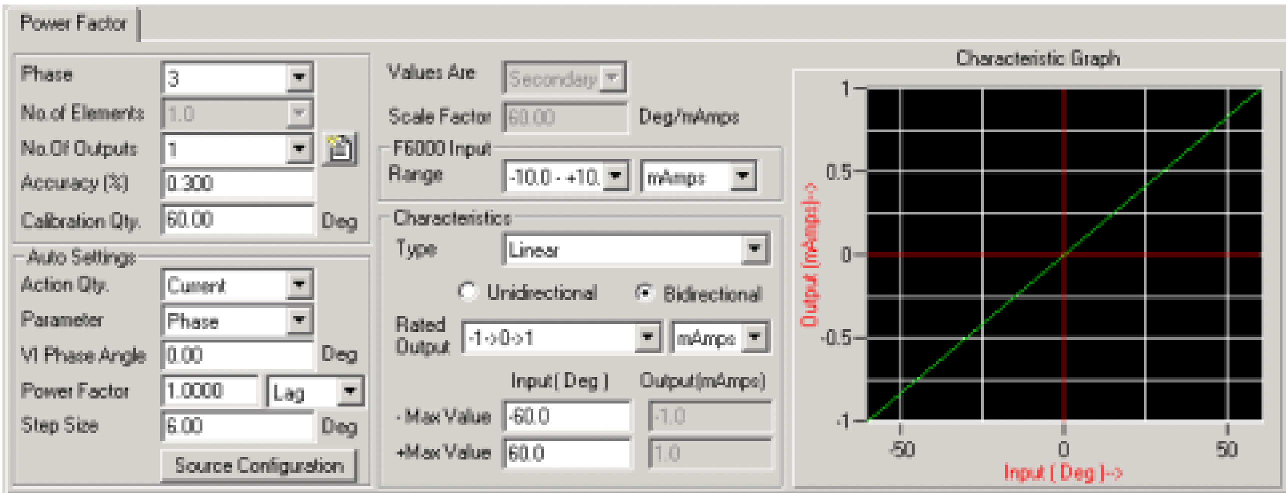


Figure 4.41 Power Factor Tab

Table 4.18 lists the values for Auto settings in the *Power Factor* tab.

Table 4.18 Auto Settings for the Power Factor Tab

Setting	Value
Action Quantity	• Current • Voltage
Parameter	Phase
VI Phase Angle	0.00° to ±359.99°; default = 0°
Power Factor	0.000 to ±1.000
Step Size	Degrees

AC Phase

The *AC Phase* tab contains the settings used to test an AC phase transducer (Figure 4.42). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

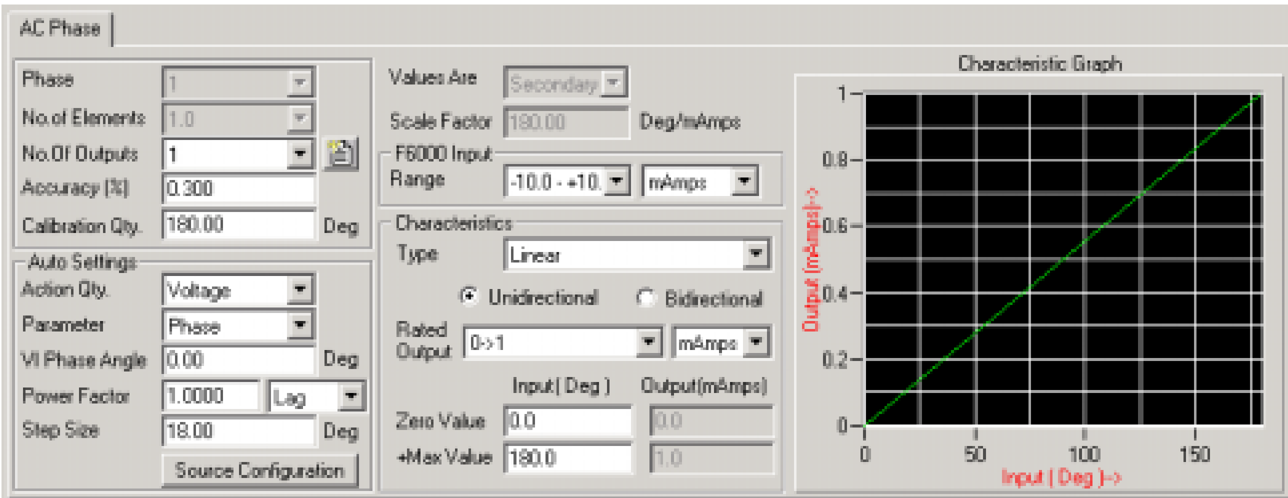


Figure 4.42 AC Phase Tab

Table 4.19 lists the values for the Auto settings in the *AC Phase* tab.

Table 4.19 Auto Settings for the AC Phase Tab

Setting	Value
Action Quantity	Voltage
Parameter	Phase
VI Phase Angle	0.00° to ±359.99°
Power Factor	0.000 to ±1.000
Step Size	Degrees

Pulsed Output Transducers (Energy Transducers)

Figure 4.43 highlights the portion of the Control Panel used to test pulsed output transducers.

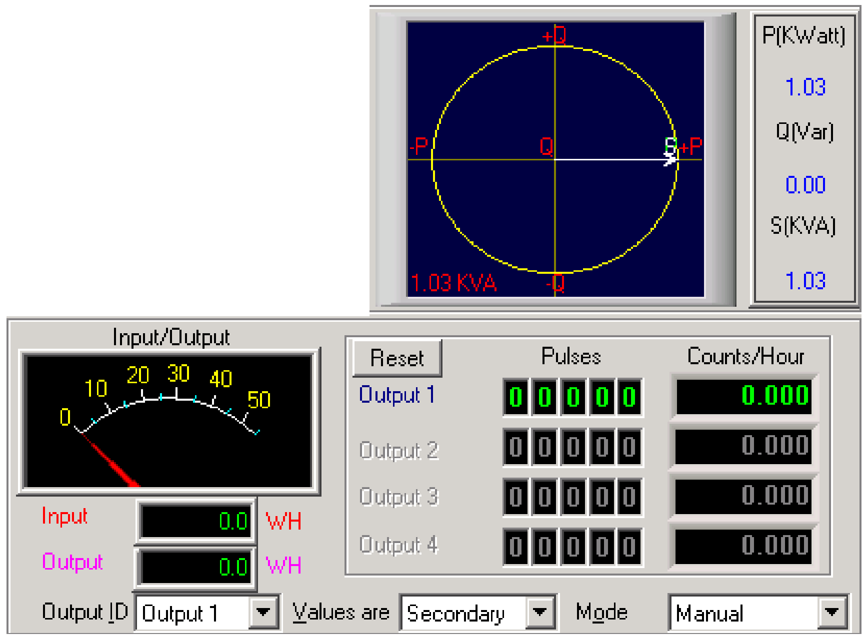


Figure 4.43 Settings and Displays for Pulsed Output Transducers

The pulsed output portion of the Control Panel contains these parts:

- Complex energy graph, with information on:
  - P active power
  - Q reactive power
  - S complex power (vector sum of P and Q)
- Input/Output meter
- Pulse recorder, with readouts for pulses counted and counts per hour or energy/pulse or pulse/energy
- Selection lists for the transducer output, the value type, and the test mode

Use the Device Settings window to set up a transducer test. Click **Device Settings** in the lower right portion of the Control Panel to open the window (Figure 4.44). The settings in this window affect the conduct of the transducer test in the Control Panel. For a summary of the settings in the Device Settings window, see ''Device Settings for Pulsed Output Transducers'' on page 4-62.

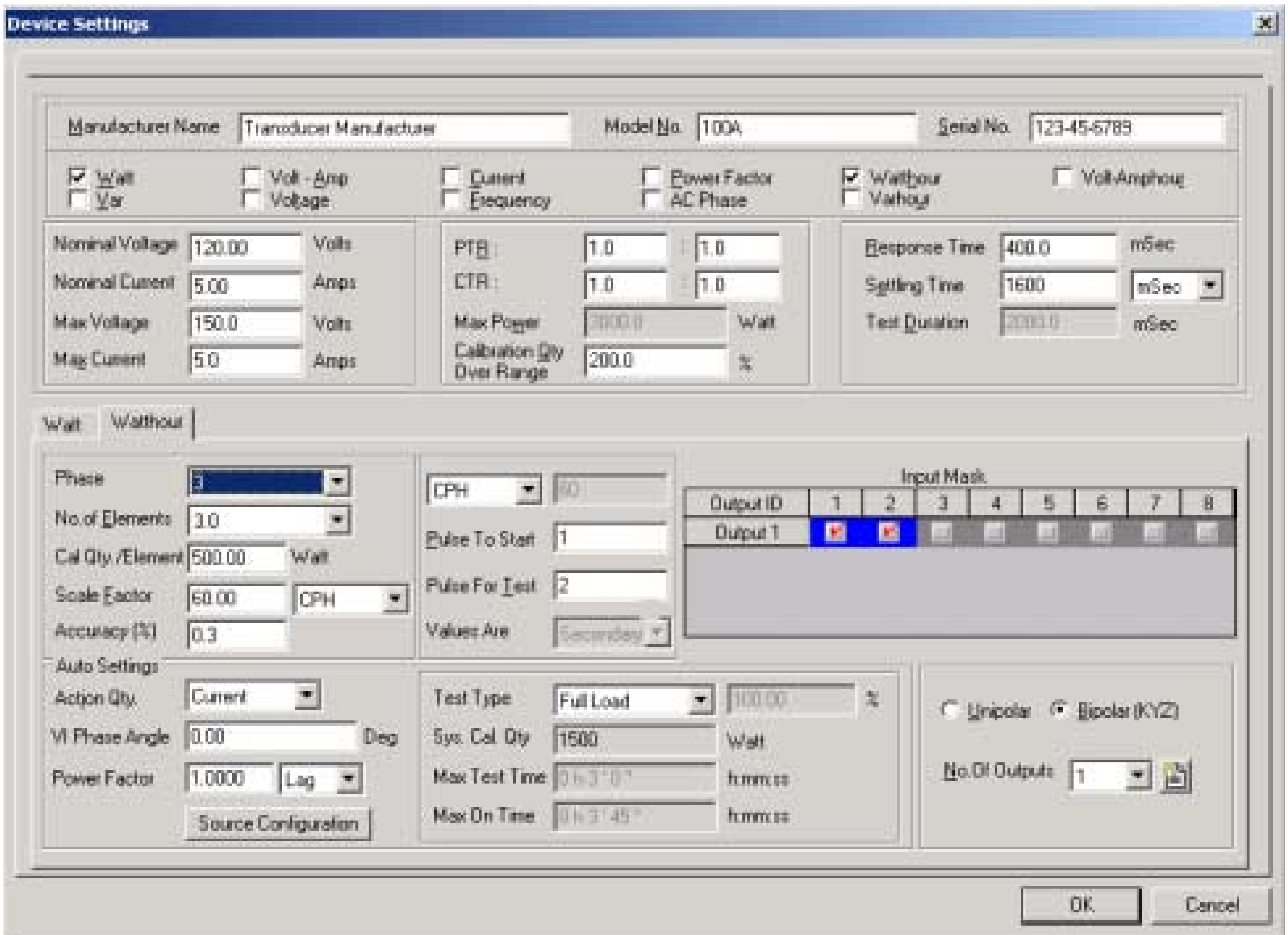


Figure 4.44 Device Settings Window with a Pulsed Output Transducer Selected

To configure the Control Panel for testing a particular type of transducer, select the transducer from the pick list located under the Device Settings button. The transducer types listed here correspond to the tabs open in the Device Settings window.

Complex Power Graph

Figure 4.45 shows the selections available in the complex power graph right-click menu.

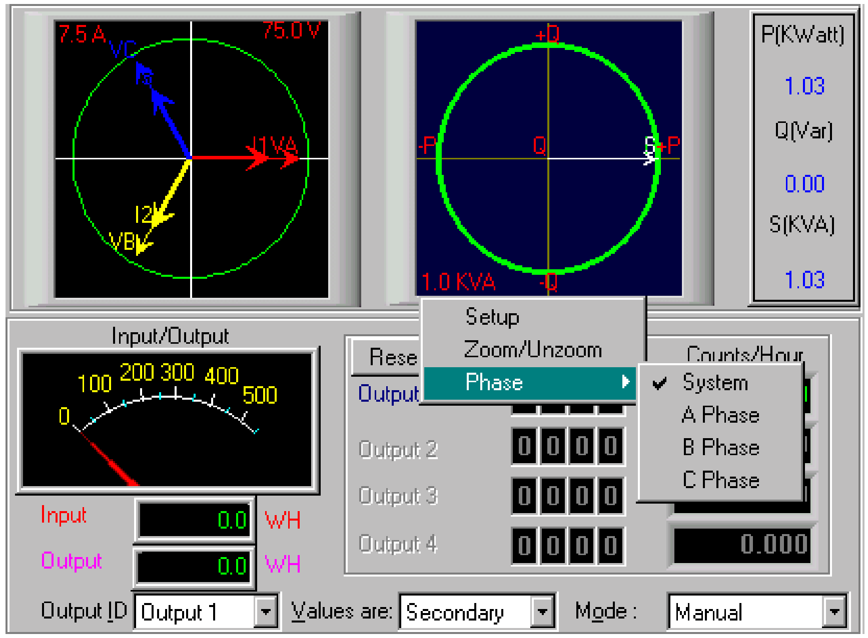


Figure 4.45 Complex Power Graph Right-Click Menu

The symbols to the right of the Complex Power graph are:

- P active power
- Q reactive power
- S complex power (vector sum of P and Q)

Table 4.20 lists the right-click menu items for the complex power graph.

Table 4.20 Right-Click Menu Items for the Complex Energy Graph

Main Menu Items	Description
Setup	Opens the Digital Graph SetUp dialog box. See Figure 4.46 on page 4-58.
Zoom/Unzoom	Enables or disables the Zoom feature.
Phase	Opens a submenu for a selection containing these options: System, A Phase, B Phase, or C Phase.

Setup

Click **Setup** in the right-click pop-up menu to open the Digital Graph SetUp dialog box (Figure 4.46). Use the box to select colors for all three vectors in the complex energy graph, as well as the axes, the circle, and the background. Also use the dialog box to set the line width and line types for all elements of the graph. Click **OK** to close the dialog box.

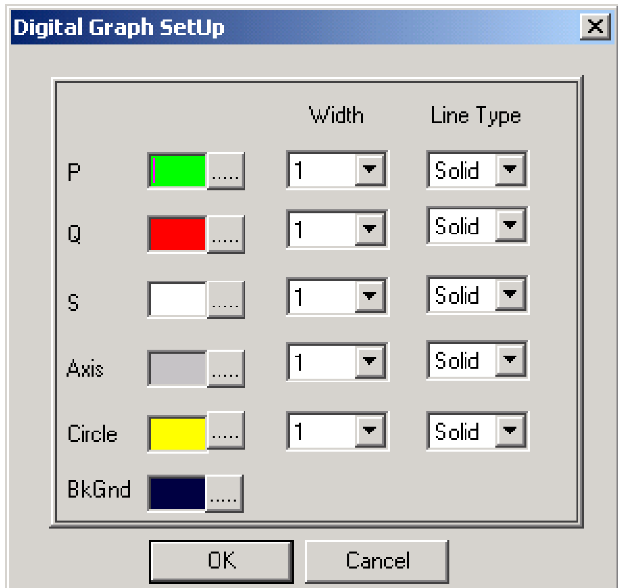


Figure 4.46 Digital Graph SetUp Dialog Box

Zoom/Unzoom

The Zoom/Unzoom feature enlarges an area of the complex power graph. To use the feature, right-click and select **Zoom/Unzoom** in the pop-up menu. The pop-up menu closes with the Zoom feature in effect.

To select an area, click the left mouse button in the diagram and drag the cursor down and to the right. A dashed rectangle appears around the selected area. When the mouse button is released, the selected area is enlarged.

To deselect the Zoom feature, right-click in the complex power graph and select **Zoom/Unzoom** in the pop-up menu. When the pop-up menu closes, the complex power graph returns to its normal state.

Input/Output Meter

The Input/Output meter in Figure 4.47 indicates the transducer input with a red needle and the transducer output with a purple needle.

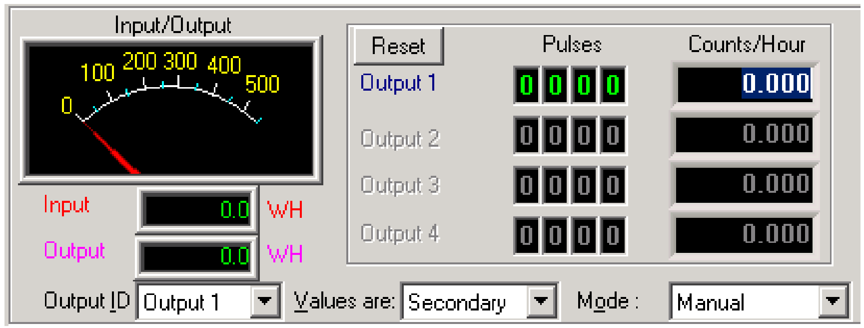


Figure 4.47 Input/Output Meter for Pulsed Output Transducers

Right-click in the Input/Output meter and click **Change Scale** to open the Scale Setting dialog box (Figure 4.48). Select **Manual** and enter the minimum and maximum values for the meter scale. Click **OK** to close the dialog box.

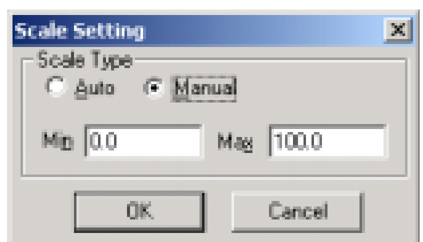


Figure 4.48 Scale Setting Dialog Box

Pulse Recorder

The F6Meter Control Panel can test up to four pulsed transducer outputs simultaneously. The pulse recorder in Figure 4.49 displays, in real time, the number of pulses received during a test and the calculated energy between the displayed pulse and the previous pulse for each output. The energy can be displayed in Counts Per Hour (CPH), energy per pulse, and pulses per energy unit.

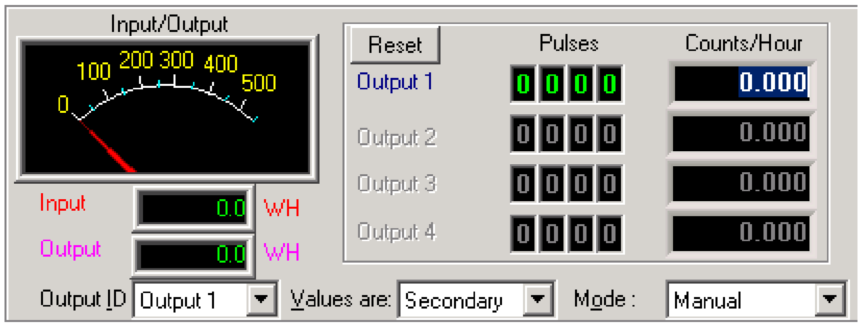


Figure 4.49 Pulse Recorder for Pulsed Output Transducers

Output ID	Selects which calculated energy for the transducer outputs (up to four) is displayed in the Input/Output meter's output quantity and the Output field. The number of outputs, and the names of the outputs in the selection list, are set in the Device Settings window.
Values Are	Selects whether the Input/Output meter and the Output field quantities appear in secondary or primary units. The quantities are converted to the primary unit using the Potential Transformer Ratio (PTR) and Current Transformer Ratio (CTR) in the Device Settings window.

Mode

To conduct a transducer test in Auto mode, select **Auto** in the *Mode* pick list. The confirmation box in Figure 4.50 appears in the Control Panel. Click **OK** to close the warning box and reconfigure the Control Panel for Auto mode. Chapter 5 ”Basic Test Procedures”, discusses how to conduct transducer tests in Auto mode.

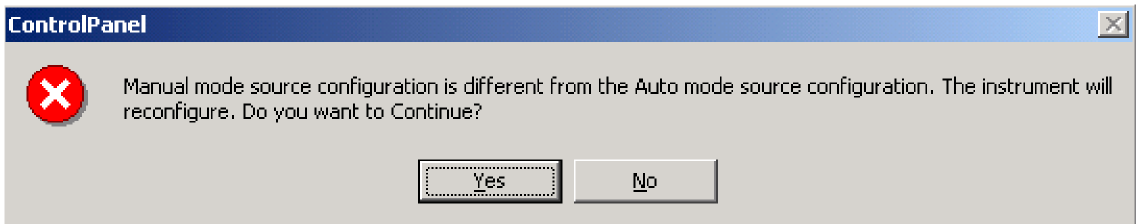


Figure 4.50 Auto Mode Confirmation Box

Refer to ’’Mode’’ on page 4-31 for a description of Auto and Manual modes.

Device Settings for Pulsed Output Transducers

Click **Device Settings** in the Control Panel to open the Device Settings window. The fields in the upper portion of the window are the same for both analog and pulsed output transducers. See ''Settings for Analog Output Transducers'' on page 4-33. Figure 4.51 shows the composition of the Device Settings window when the Control Panel is configured to test a watthour transducer.

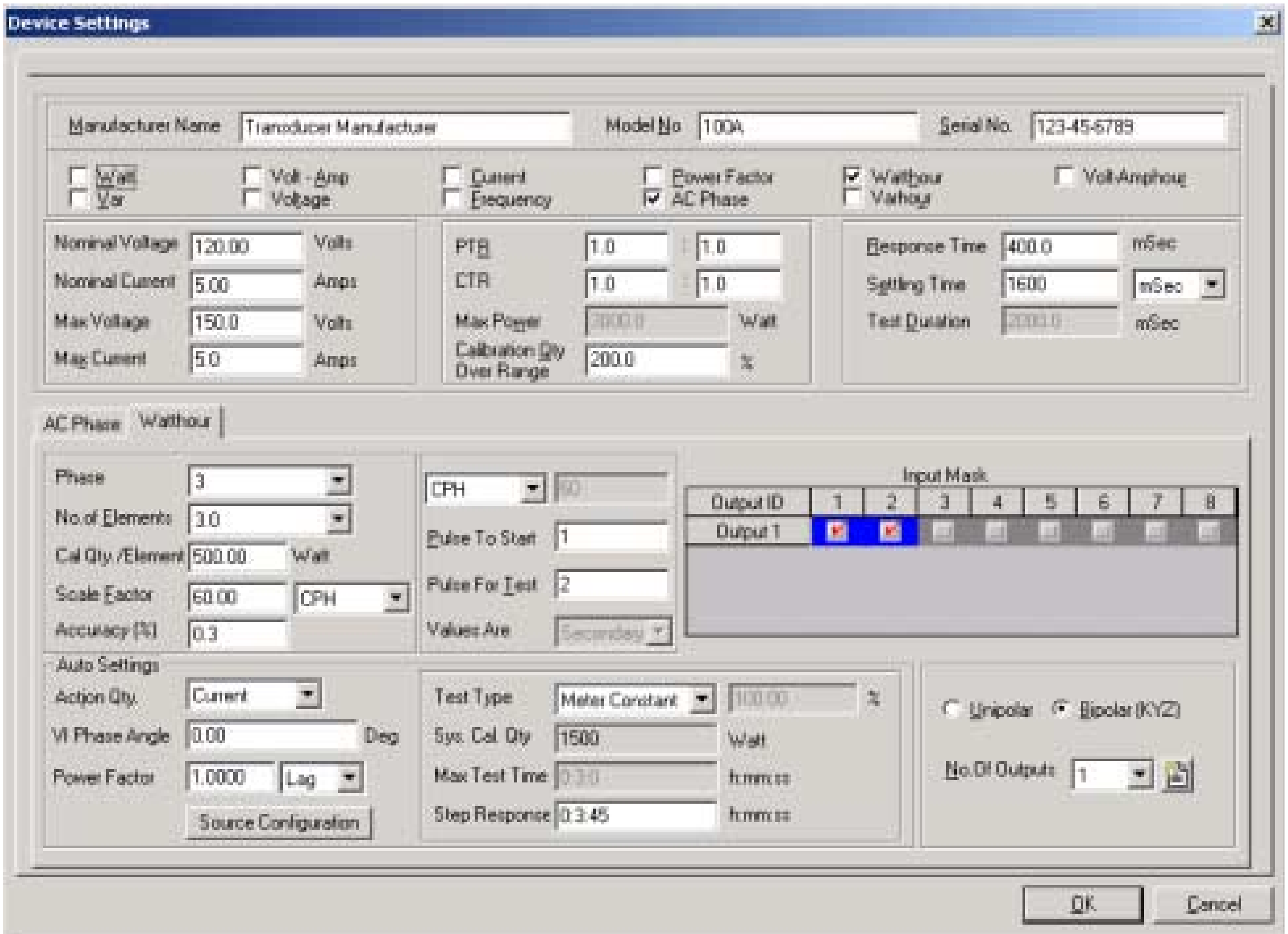


Figure 4.51 Device Settings Window with a Pulsed Output Transducer Selected

Nameplate Data

Use the manufacturer's transducer documentation to enter the name of the manufacturer, as well as the model number and serial number of the transducer (Figure 4.52). These entries identify the summary reports that document the test results.

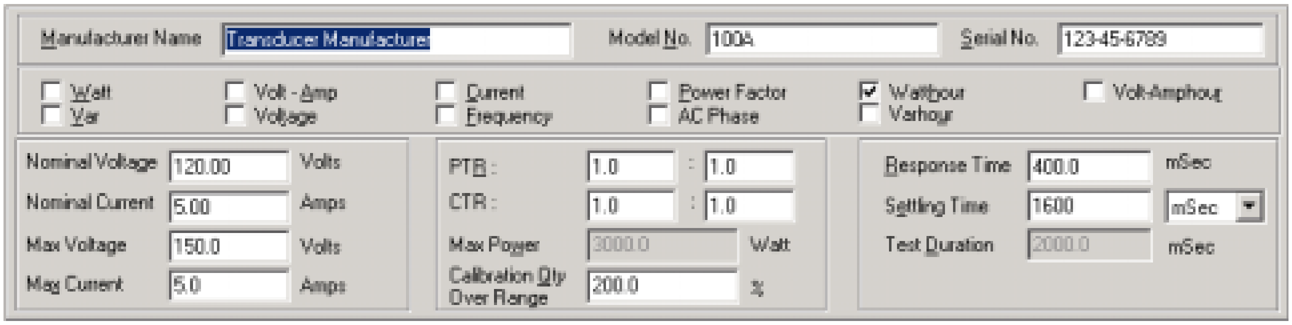


Figure 4.52 Device Nameplate Data

The last three checkboxes under the model and serial numbers designate pulsed output transducers:

- Watthour
- Varhour
- Volt-Amphour

Select a box for each transducer type to be tested. A tab opens in the lower portion of the Device Settings window for each box checked.

Below the checkboxes, enter general test data. The fields in this portion of the Device Settings window are the same as those defined in ''Nameplate Data'' on page 4-34.

Pulsed Output Transducer Tabs

The three tabs for pulsed output transducers are similar, but they differ in the measurement units and default settings they use.

Summary of Device Settings

For purposes of this summary, the device settings tab for pulsed output transducers is divided into these sections:

- *Basic Settings*
- *Pulse Recorder Settings*
- *Auto Settings*
- *Input Mask*

Basic Settings

Table 4.21 lists the and possible values for the first group of settings in the *Watt* tab.

Table 4.21 Basic Transducer Settings

Field	Value
Phase	Select **1** for a single phase transducer and **3** for a three phase transducer.
Number of Elements	Select the number of elements in the transducer. This field is only relevant to power and energy transducers. For a single phase transducer, 1 is the only option. For a three phase transducer, the options are 2, 2.5 and 3.
Calculated Quantity per Element	Enter the Calibration Qty. (Quantity) per Element.
Scale Factor	Enter the transducer's Scale Factor or Meter Constant. Then select the type of scale factor: **Counts Per Hour** (CPH), **energy per pulse**, or **pulses per energy**.
Accuracy	Enter the transducer's percent accuracy for this function. This value is used to evaluate Pass/Fail in the Summary Reports.

Calculate the scale factor for the device under test as follows:

$$\text{Scale Factor in WH/Pulse} = \frac{[(\text{No. of Elements}) \times (\text{Calibration Quantity/Element})]}{\text{Counts Per Hour}}$$

In the *watthour* tab, if the Calibration Quantity/Element is 500 Watts and the number of elements is 3, the scale factor is (500 x 3 = 1500) divided by 60 counts per hour (1500 divided by 60 = 25 Watthours per pulse). Thus, this transducer measures 25 Watthours for each pulse recorded, 0.04 pulses/Watthour.

Pulse Recorder Settings

Table 4.22 explains the second group of settings in the *Watt* tab.

Table 4.22 Pulse Recorder Settings

Field	Value
Test Units	Select the test units for the Pulse Recorder and the Summary report. The choices are: CPH (Counts Per Hour), energy per pulse and pulses per energy unit.
Pulse To Start	Enter the number of pulses that must occur before the test starts. The minimum number for Pulse To Start is one. This value applies to ALL outputs in the test.
Pulse for Test	Enter the number of pulses that must occur before the test ends. The minimum number for *Pulse For Test* is one. This value applies to ALL outputs in the test.

Auto Settings

Table 4.23 lists the Automatic mode settings.

Table 4.23 Auto Settings

Field	Value
Action Quantity	Select the source type, **Voltage** or **Current**, to be varied by the Auto Test for selected transducer function.
VI Phase Angle	Enter the current phase angle to voltage phase angle relationship for the Auto Test. The values are entered as the voltage angle less the current angle. Therefore, entering 45 makes the current lag the voltage by 45°. For example, enter 45° for the *VI Phase Angl*e and an *A phase voltage angle* of 0°. The calculation is then 0° – (45°) = – 45°. Entering a VI Phase Angle value causes the Power Factor field to automatically update reflecting the new VI Phase Angle. VI Phase Angle is available for Phase, Power and Energy transducers.
Power Factor	Enter the power factor for the current phase angle to voltage phase angle relationship for the Auto Test. Enter a numeric value between zero and one. Then specify Lag or Lead. Entering a Power Factor value causes the VI Phase Angle to automatically update reflecting the new Power Factor.
Test Type	Select the Auto Test type: **Meter Constant** (Full Load), **No Load**, **Creep** or **User Defined**.
Test Type %	Enter the percentage of the *Action Qty.* for the Auto Test. For a Meter Constant (Full Load) test the Test Type % is fixed to 100%. For a No Load test the Test Type % is fixed to 0%.

Table 4.23 Auto Settings (Continued)

Field	Value
Sys. Cal. Qty.	The System Calibration Quantity equals the *Calibration Quantity/Element* multiplied by *No. of Elements* multiplied by *Test Type %*. In doing this calculation, round half elements up to the next whole element. For example, if No. of Elements = 2.5, use 3.0 in calculating the Scale Factor. The Sys. Cal. Qty. are transducer function dependent.
Max Test Time	Represents the calculated time for the sum for the *Pulse to Start* and *Pulse For Test* to occur when the *Sys. Cal. Qty*. is applied to the transducer.
Max On Time	This value is equal to 125% of the *Max. test Time*. An Auto test turns off the *Enabled* sources when all counters have counted the correct number of pulses or when the maximum on time is reached. Max. On Time is not editable for No Load Test Type.

Click **Source Configuration** in the Auto Settings section to open the Source Configuration window (Figure 4.53).

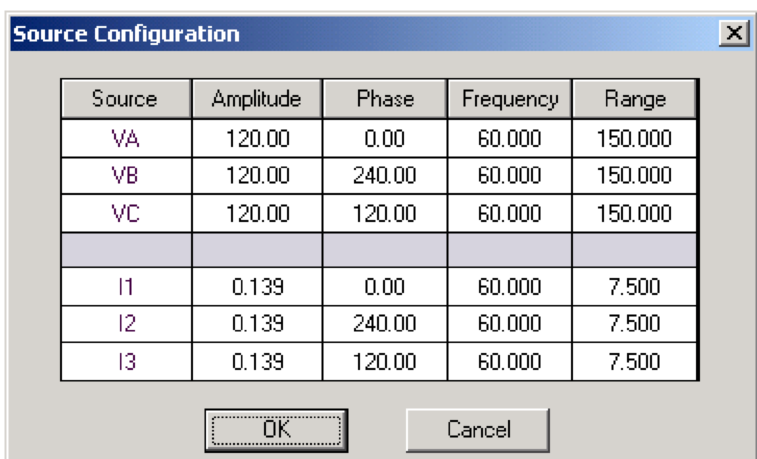


Figure 4.53 Automatic Settings Source Configuration Window

The entries in the other four columns show how the source table in the Control Panel are configured when Auto mode is selected. The entries in these columns depend on all five settings in the Auto Settings section. For a description of these settings, refer to ''Auto Settings'' on page 4-38.

Input Mask

The rows of the Input Mask correspond to a transducer output. The number of rows equals the *No. Of Outputs* selection. Therefore, there will be one row for each output. The columns are numbered 1 through 8 and correspond to inputs 1 through 8 on the F6000. Placing a check mark in a column in a row assigns the input with the column's number to that transducer's output associated with that row.

- If the outputs are defined as unipolar, check one input in each row.
- If the outputs are bipolar, check two inputs on each row. When assigning the inputs to a bipolar output, the inputs need not be adjacent to one another.

A cyan background indicates that a box can be checked. When the required number of inputs for an output have been checked, the background of the rest of the inputs in that row turns dark gray. Also, any given input can only be assigned to one output. In other words, only one box in each column can be checked.

Figure 4.54 shows a typical setup for three bipolar outputs.

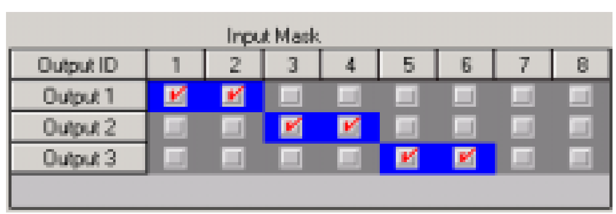


Figure 4.54 Input Mask

Unipolar or Bipolar (KYZ)

If the transducer outputs are a single Normally Open or a single Normally Closed contact, select **Unipolar**. If the transducer's outputs are a form *C* or KYZ output contact, select **Unipolar**. Figure 4.55 shows Unipolar and Bipolar switch configurations.

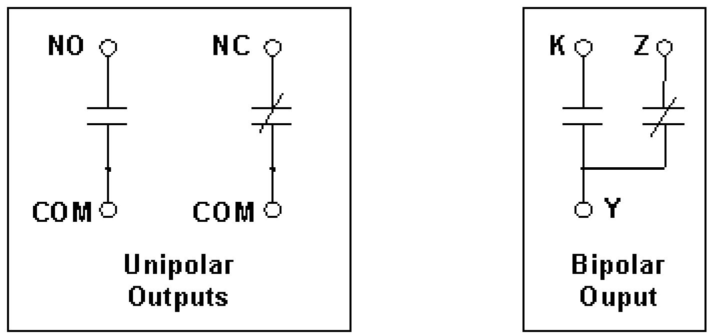


Figure 4.55 Unipolar and Bipolar Output Configurations

No. Of Outputs

No. Of Outputs defines the number outputs tested for the transducer function. Select a number from 1 to 4 from the drop-down box. The default names that appear in the Control Panel *Output ID* selection list and the Test Summary reports are Output 1 to Output 4. Click on the document icon next to the *No. Of Outputs* field to change the default names. Figure 4.56 shows the *Output Name* dialog box. Enter a new name for each output in the Name column as desired. Click **OK** to close the dialog box and apply the new names.

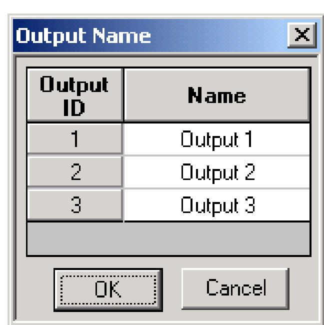


Figure 4.56 Output Name Dialog Box

Watthour

The *Watthour* tab contains the settings used to test a watthour transducer (Figure 4.57). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

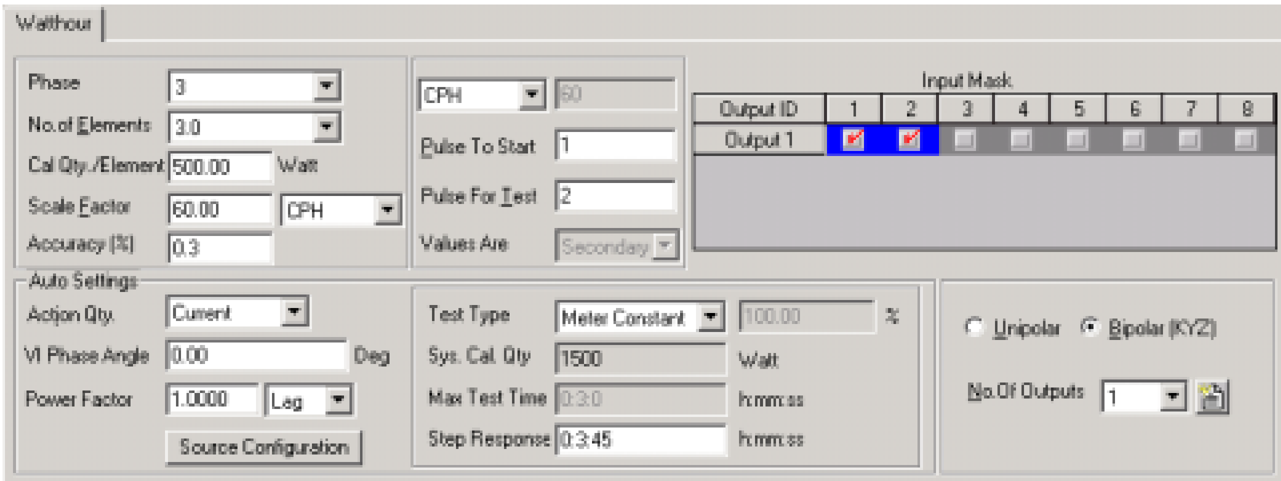


Figure 4.57 Device Settings Watthour Tab

Table 4.24 lists the values for the Auto settings in the *Watthour* tab.

Table 4.24 Auto Settings for the Watthour Tab

Setting	Value
Sys. Cal. Qty	Watts

Varhour

The *Varhour* tab contains the settings used to test a varhour transducer (Figure 4.58). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

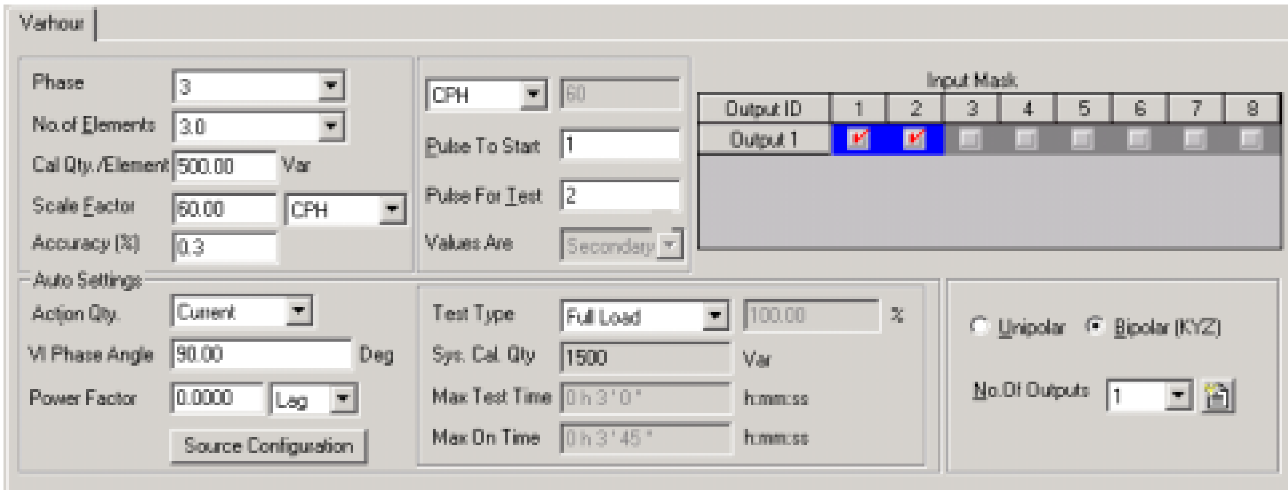


Figure 4.58 Varhour Tab

Table 4.25 lists the values for the Auto settings in the *Varhour* tab.

Table 4.25 Auto Settings for the Varhour Tab

Setting	Value
Sys. Cal. Qty	Vars

Volt-Amphour

The *Volt-Amphour* tab contains the settings used to test a volt-amphour transducer (Figure 4.59). To modify the default settings, refer to the test protocol and to the manufacturer's transducer documentation.

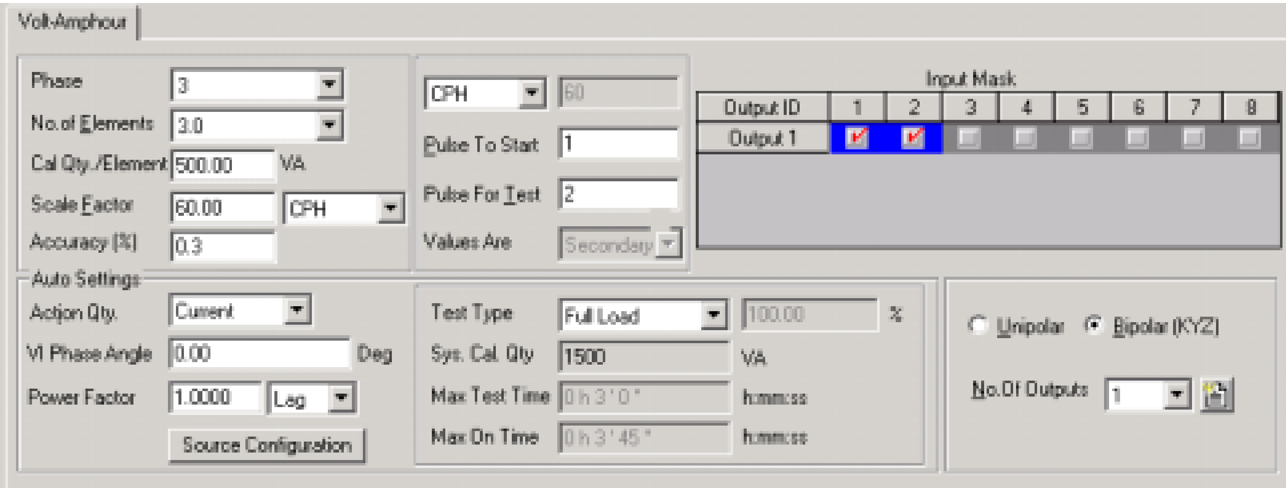


Figure 4.59 Volt-Amphour Tab

Table 4.26 lists the values for the Auto settings in the *Volt-Amphour* tab.

Table 4.26 Auto Settings for the Volt-Amphour Tab

Setting	Value
Sys. Cal. Qty	VA

Battery

Locate the Battery section (Figure 4.60) in the lower left corner of the Control Panel. If the test protocol requires a DC voltage supply, turn the battery on before conducting the test. Typically, the device under test requires a DC voltage from the battery to send output signals to the instrument. Use the pick list next to the On/Off button to set the battery voltage. The options in the list are 48 V, 125 V, and 250 V DC.

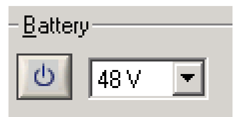


Figure 4.60 Battery Controls

Click the button to the left of the pick list to toggle the battery simulator on and off. The battery simulator has the following operating characteristics:

- When the battery simulator is on, it provides continuous output while the user conducts tests or changes the logic settings.
- The battery simulator provides continuous output when either the Control Panel or the Configuration display is open, or when a third party application is running.
- When the battery simulator is on, a red BT icon appears in the lower right corner of the Control Panel.
- The battery simulator switches off if the Control Panel is closed or if communication with the F6000 Instrument is lost.

WARNING

Care should be taken when using the battery simulator as it is capable of up to 250 V DC at 60 Watts.

Save a Control Panel Configuration

To save a setup on the Control Panel, click **File|Save** in the top menu bar. To save a setup under a new name, click **File|Save As**. The application saves the new Control Panel information in an *.f6x* file. The default settings for the Control panel are saved in a file named *Default.f6x*. The Control Panel uses the settings in this file when it first opens.

To designate a new file as the file used at startup, click **Tools|Setup** and click the Control Panel Browse button. Use the Select Control Panel file dialog box to designate a new file and click **Open**.

Summary Reports

To create a summary of the current test results:

1. Click **Summary|Report Configuration** in the top menu bar to configure the summary report.
2. Click **Summary|Test Results** in the top menu bar to view the data selected in the Report Configuration window.
3. Save or print the summary report.

To retrieve a previously saved report, click **Summary|Open Results** in the top menu bar.

The next sections explain how to create and save summary reports.

Report Configuration

Click **Summary | Report Configuration** in the top menu bar to open the Report Configuration window (Figure 4.61). The window opens with all the options selected.

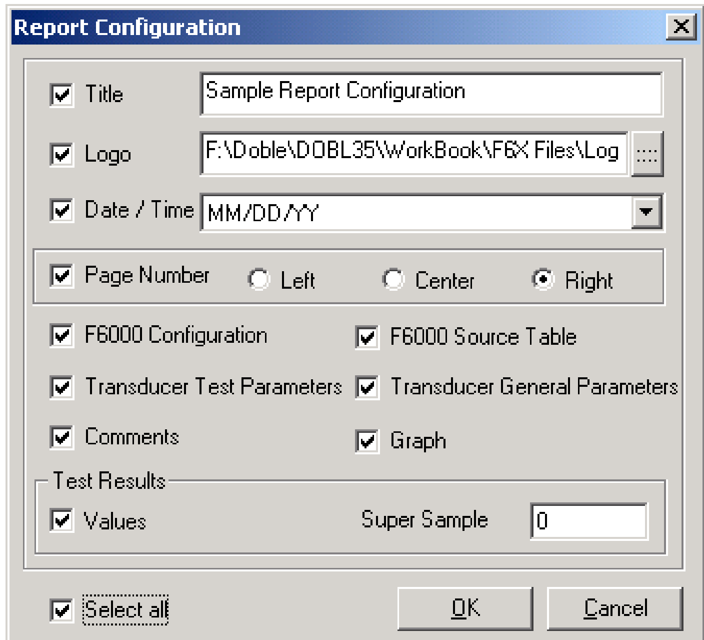


Figure 4.61 Report Configuration

To configure a test report in the Report Configuration window:

1. Enter a descriptive title for the report.
2. Include a company logo in the report, or deselect for no logo.
3. Select a format from the *Date/Time* drop-down list.
4. Select the position of the page number at the bottom of the page in the printed version of the report.
5. For each of the checkboxes in the lower portion of the Report Configuration window:
   - Leave the box checked to include the corresponding data in the summary report.
   - Uncheck the box to remove the corresponding data from the summary report.
6. Click **OK** to close the Report Configuration window and return to the Control Panel.

Test Results

Click **Summary | Test Results** in the top menu bar to open the Test Summary window. Figure 4.62 shows the Test Summary window with all the options in the Report Configuration window selected.

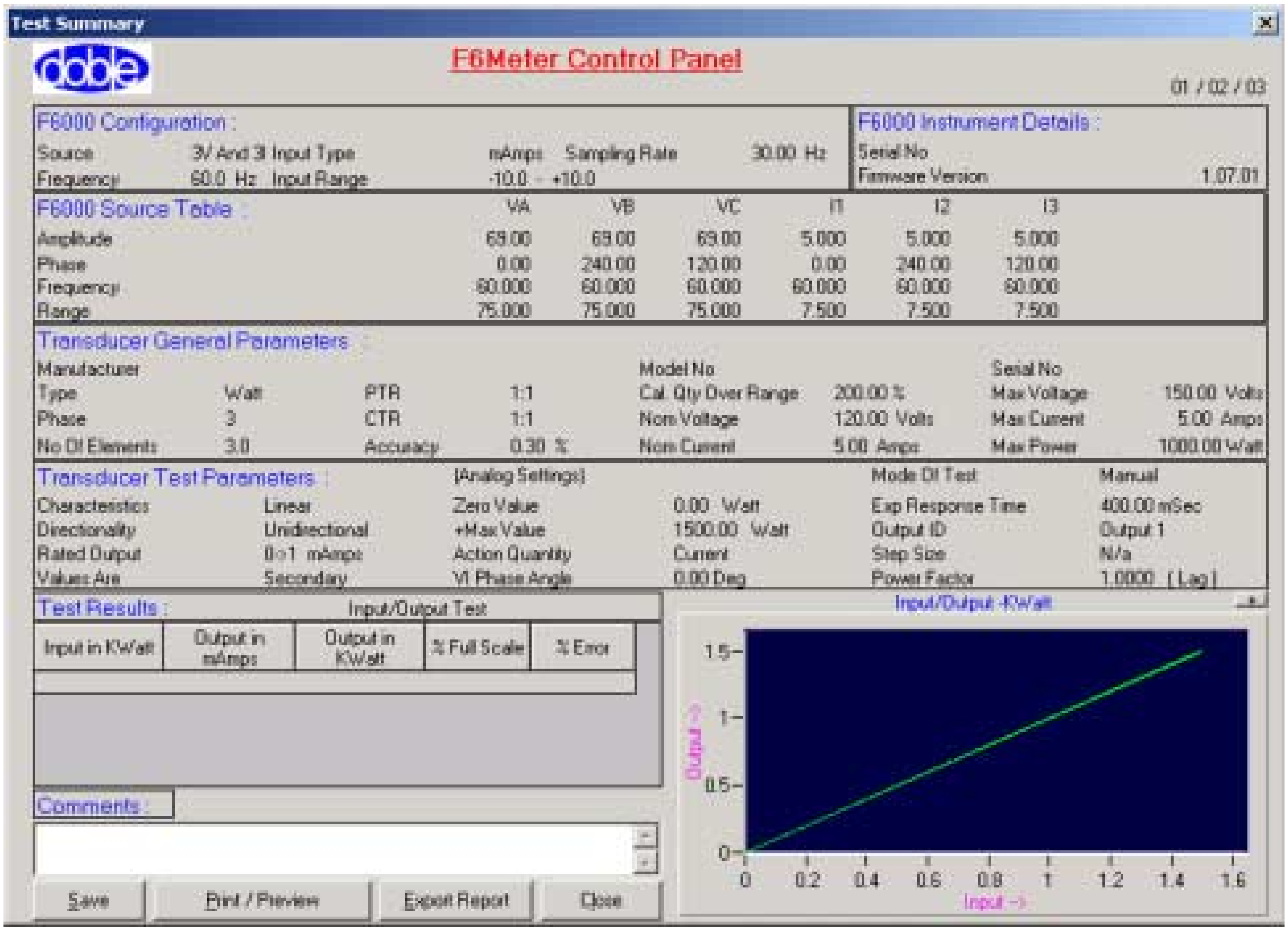


Figure 4.62 Test Summary

To create the report shown in Figure 4.63, open the Report Configuration window and uncheck *F6000 Configuration*, *F6000 Source Table*, and *Transducer Test Parameters*. Then close the Report Configuration window and click **Summary | Test Results** in the top menu bar.

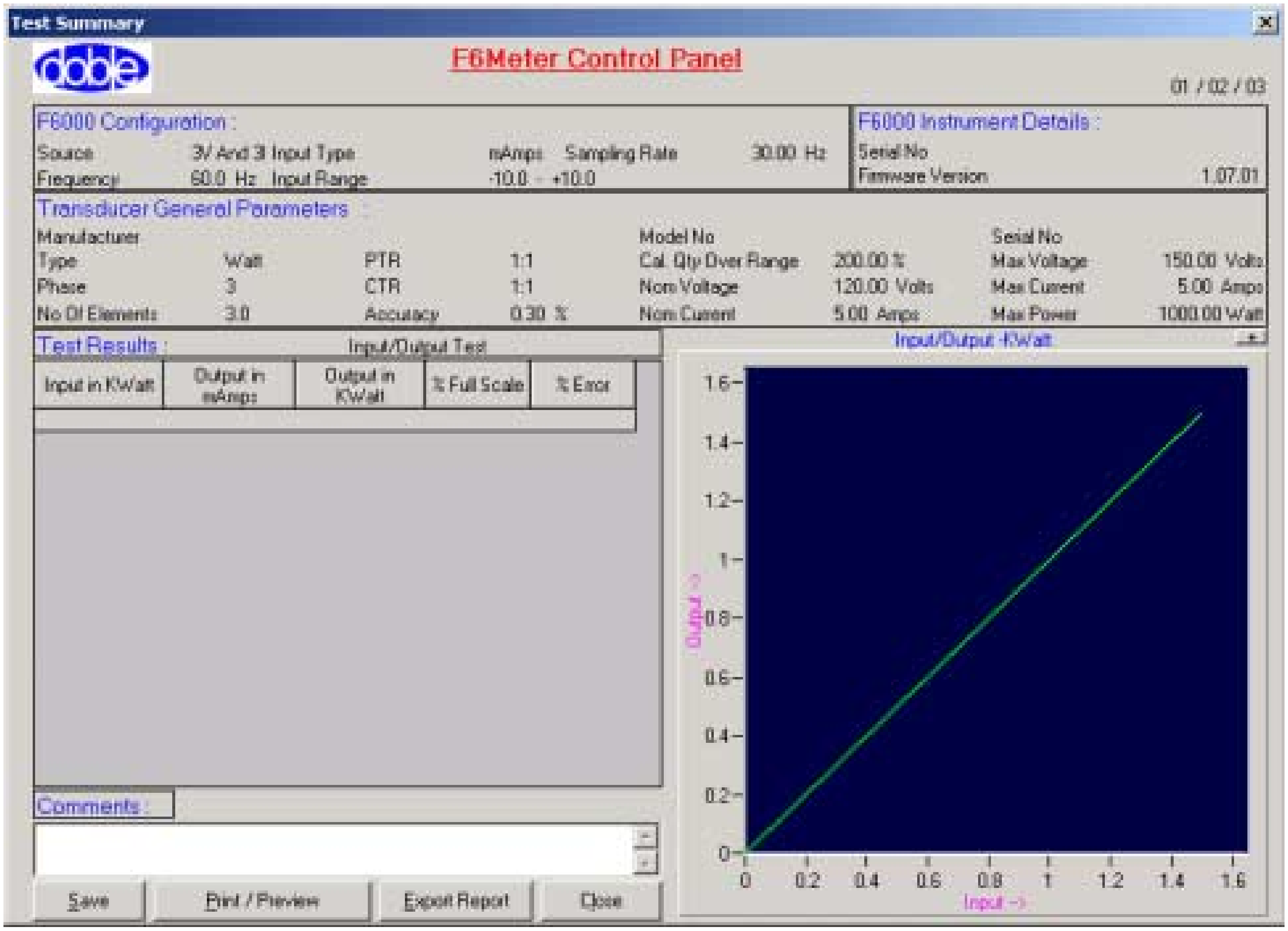


Figure 4.63 Reconfigured Test Summary

The report in Figure 4.63 contains these sections:

- The report title and date of creation in the header.
- General parameters for the device under test.
- A table of the current test results.
- A field for comments entered by the user.
- A graph of the test results.

To save a report as an Excel worksheet, click **Save** at the bottom of the Test Summary window. Enter a file name in the Save As dialog box and click **Save**. This report appears when **Summary | Open Results** is selected from the top menu bar of the Control Panel.

To export a report, click **Export Report** at the bottom of the Test Summary window. Enter a file name in the Save As dialog box, select a file type (**.rtf**, **.xls, .doc**) and click **Save**. Reports are opened separately from the F6Meter Control Panel.

To print a report, click **Print | Preview** at the bottom of the Test Summary window. Then click the printer icon in the top toolbar of the preview window.

Open Results

To open previously saved test results:

1. Click **Summary | Open Results** in the top menu bar of the Control Panel.

The Open dialog box appears (Figure 4.64).

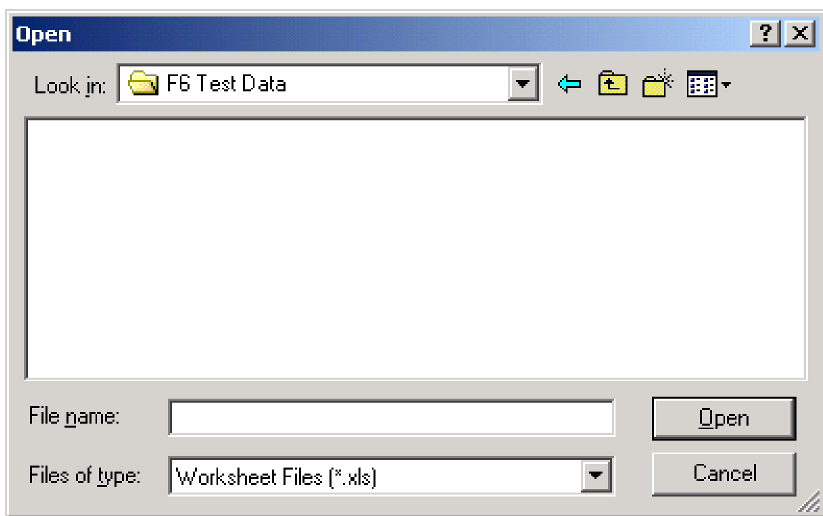


Figure 4.64 Open Test Results

2. Select the folder and file name of the previously saved report.

3. Click **Open** and the results appear in the Test Summary window.

NOTE

Only Test Summary reports saved in Excel format (.xls), can be opened by the Control Panel.

5. Basic Test Procedures

The test procedures in this chapter introduce the various controls on the F6Meter Control Panel. Complete the basic setup procedure in "Setup and Configuration" on page 3-1 before conducting these tests.

Prepare for a Transducer Test

To prepare a Transducer Test:

1. Connect the transducer to the F6000 Instrument front panel.

The sample procedures in this chapter assume the transducer is properly connected to each of these sections of the instrument front panel:

- Voltage and current sources
- Logic inputs
- DC meter inputs
- Battery simulator

Use the manufacturer's transducer documentation to make the connections correctly.

2. Turn the F6000 Instrument on and make sure it boots up properly.

WARNING

Proceed with caution. The high intensity yellow LED flashes on the instrument front panel when the battery simulator or any output source is on or enabled to indicate the potential for dangerous or fatal voltages.

3. Launch the F6Meter Control Panel (Figure 5.1 on page 5-2).

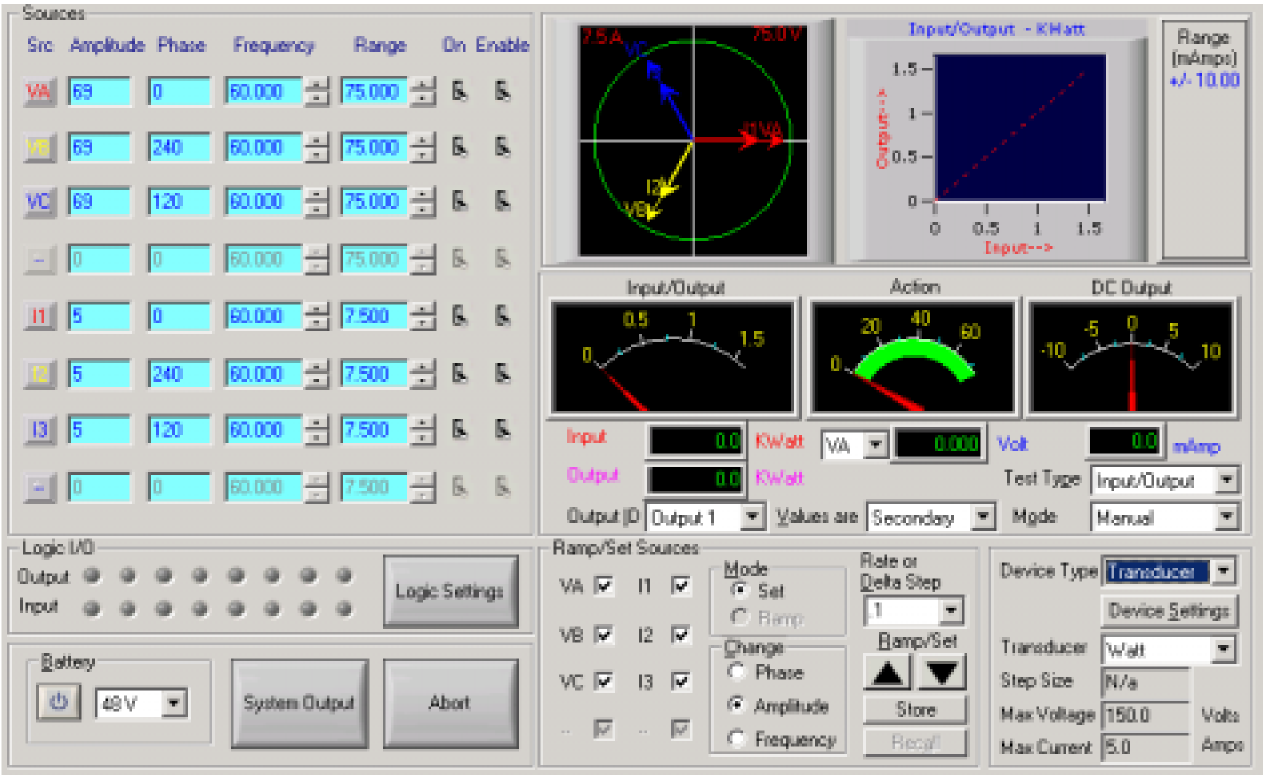


Figure 5.1 F6Meter Control Panel

4. Check the source configuration in the instrument display to verify that the computer is in communication with the F6000 Instrument.

How to Test a Watt Transducer

Use the F6Meter Control Panel to test a Watt transducer:

- Set up the source table
- Enter the device settings
- Configure *Ramp/Set Sources*
- Conduct the test

These procedures use a Watt transducer to test an analog output device.

Set Up the Source Table

Set up the source table as shown in Figure 5.2. This test uses one phase and two sources – VA at 100 V and I1 at 5 A.

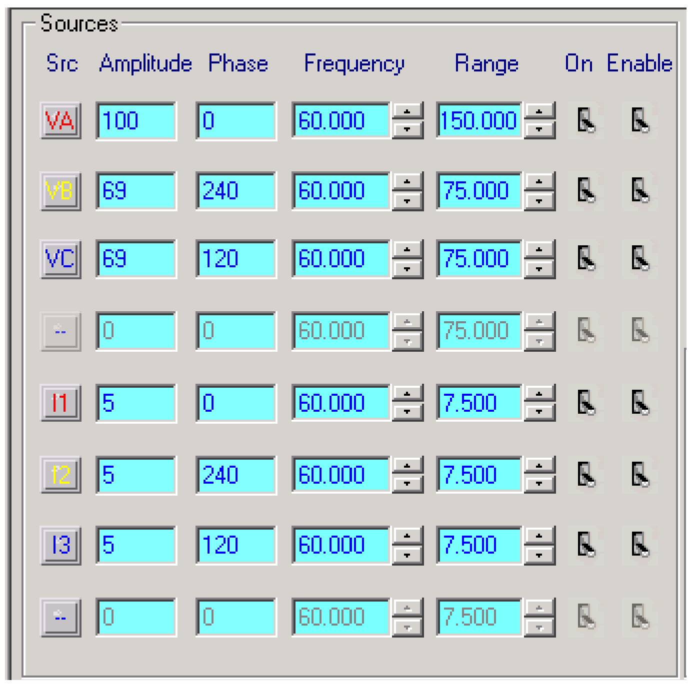


Figure 5.2 Source Table Settings for the Watt Transducer Test

Enter the Device Settings

1. Click **Device Settings** in the lower right section of the Control Panel.

   The Device Settings window opens (Figure 5.3).

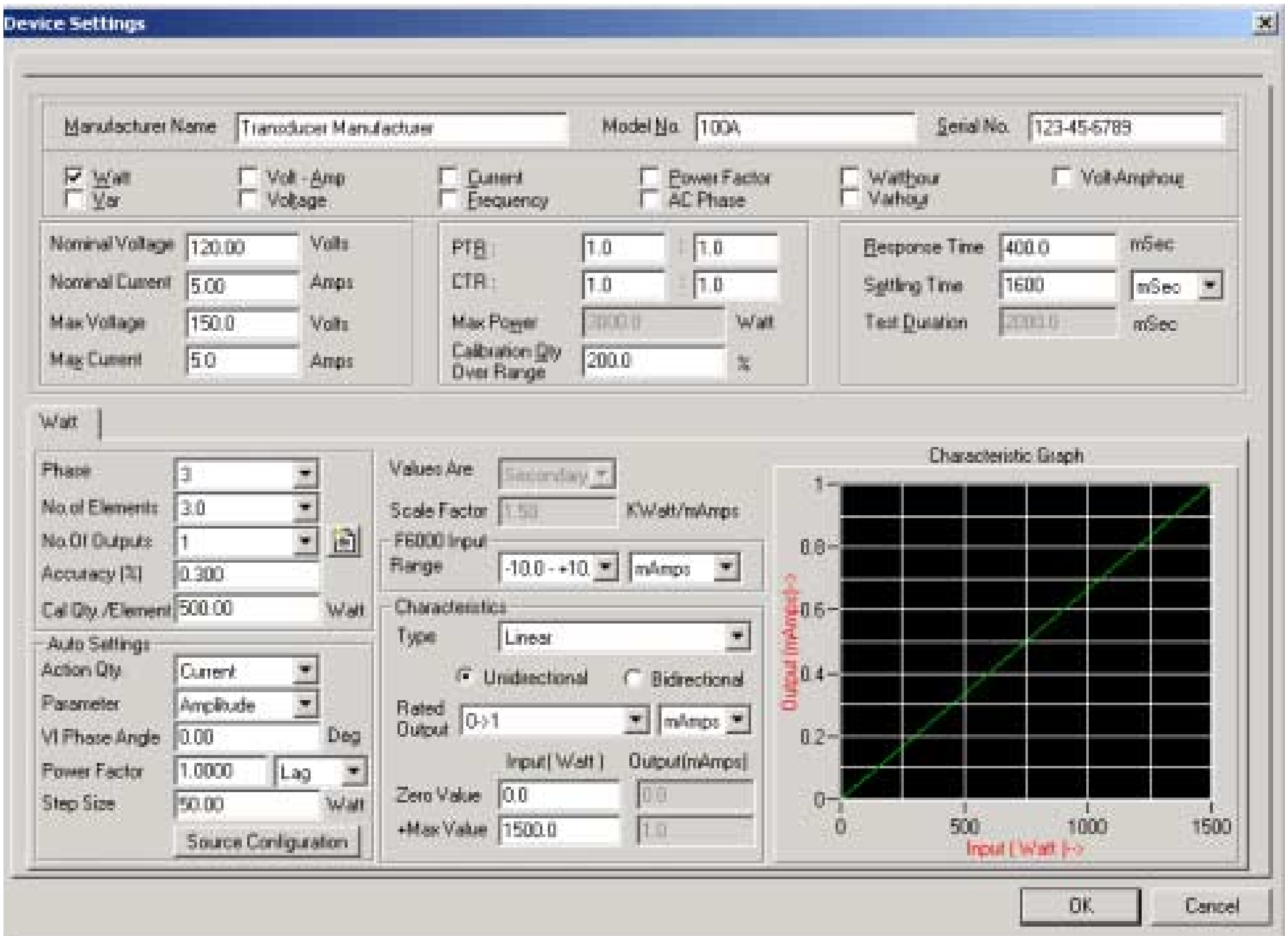


Figure 5.3 Device Settings Window – Watt Transducer

2. Select **1** in the *Phase* drop-down list in the Watt tab. Otherwise, use the default settings shown in Figure 5.4.

The number of elements changes from 3.0 to 1.0. The Scale Factor is 500 Watts/mAmp, and the Rated Output is 0 –> 1 mAmps. The Max Value on the input side is 500 Watts.

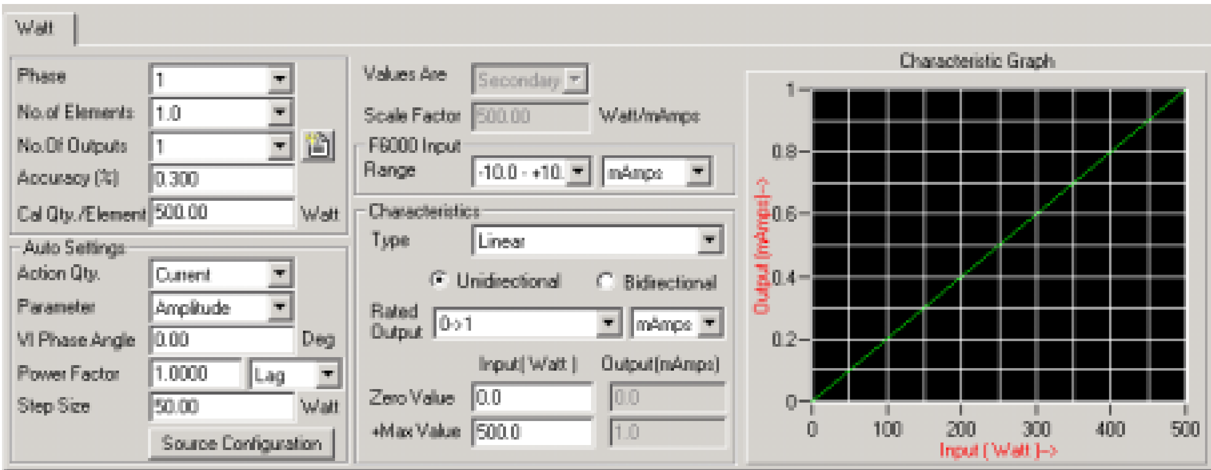


Figure 5.4 Watt Tab Device Settings

3. Click **OK** to close the Device Settings window and return to the Control Panel.

Configure Ramp/Set Sources

Configure *Ramp/Set Sources* as shown in Figure 5.5:

1. Check VA only (clear VB, VC, I1, I2, and I3).

2. In the *Rate or Delta Step* drop-down list, select **10**.

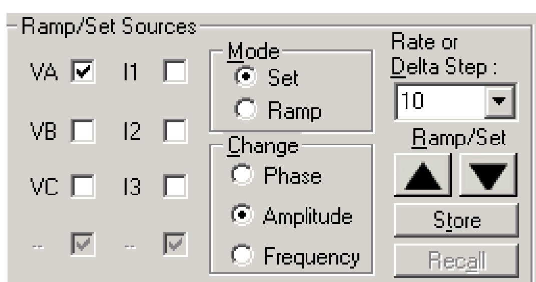


Figure 5.5 Settings in the Ramp/Set Sources Section

Conduct the Test

Check that all Control Panel settings are correct. Use the default settings on the right hand side of the Control Panel:

- Source selected under the Action meter: VA
- Test Type: Input/Output
- Transducer: Watt

To test the accuracy of the Watt transducer:

1. Use the drop-down list in the lower left corner of the Control Panel to select **125 V** for the Battery.
2. Click the button to the left of the drop-down list to turn on the Battery.
3. Enable VA and I1. In the *Enable* column of the source table, click the Enable switch for VA and the Enable switch for I1. The box around each switch turns green.

NOTE **To enable all the sources in the source table at once, right-click in the *Enable* column. Then select *Enable All* in the pop-up menu that appears.**

4. Click **System Output** below the source table.

   VA and I1 supply input power to the transducer.

   Before changing the voltage, check the following items (Figure 5.6):

   - The Input/Output meter indicates 500 Watts. The values for Input and Output below the meter are nearly equal.
   - The Action meter indicates 100 V.
   - The DC Output meter indicates 1 mAmp.
   - The first data point in the Input/Output graph lies along the red dashed line.

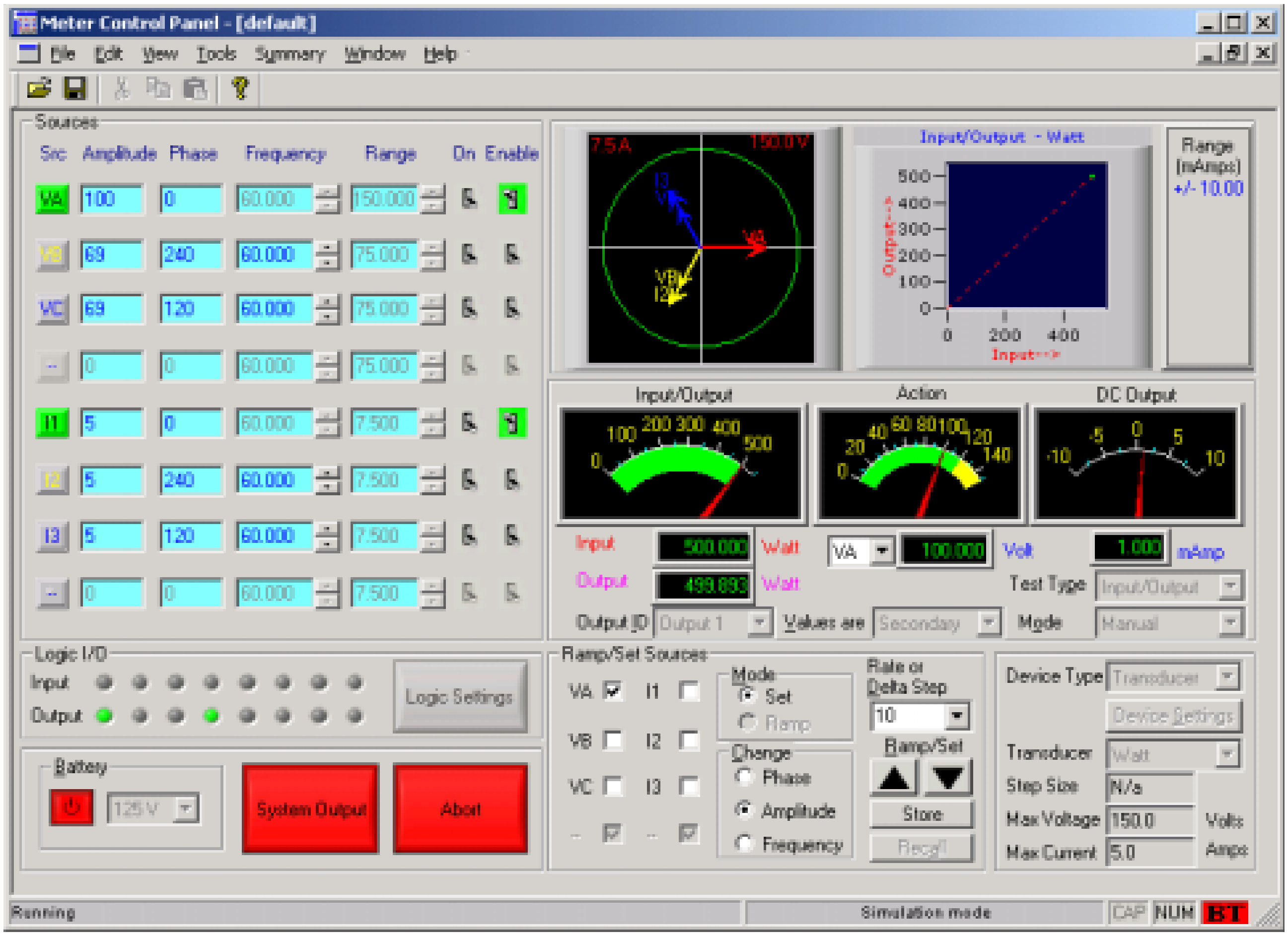


Figure 5.6 Indicators and Displays for the Watt Transducer Test

5. Click the *Ramp/Set* down arrow to change the input voltage from 100 Watts to 90 Watts.

Observe that the Action meter reads 90 V and the DC Output meter reads 0.9 mAmps. The Input/Output meter reads 450 Watts and the second data point appears below and to the left of the first in the Input/Output graph.

6. Continue to step down the input voltage in 10 Volt increments.

   a. Click the *Ramp/Set* down arrow for each step down.

   b. Click the *Ramp/Set* up arrow to increase the input voltage in 10 Volt increments.

To conduct the test by varying the current:

   a. Clear VA and check I1 in the *Ramp/Set Sources* section.

   b. Select **1** in the *Ramp or Delta Step* drop-down list.

   Use the up and down arrows in the *Ramp/Set Sources* section to vary the current.

   In a successful test, all the data points lie along the red dashed line in the Input/Output graph. The actual transducer output indicated by the data point then equals the expected transducer output, indicated by the red dashed line.

   c. To end the test, click **System Output** and then disable the enabled sources.

   The sources VA and I1 turn off and the three meters under the Input/Output graph indicate 0.

7. To view the test results, click **Summary|Test Results** in the top menu bar.

The current test results appear in the Test Summary window (Figure 5.7).

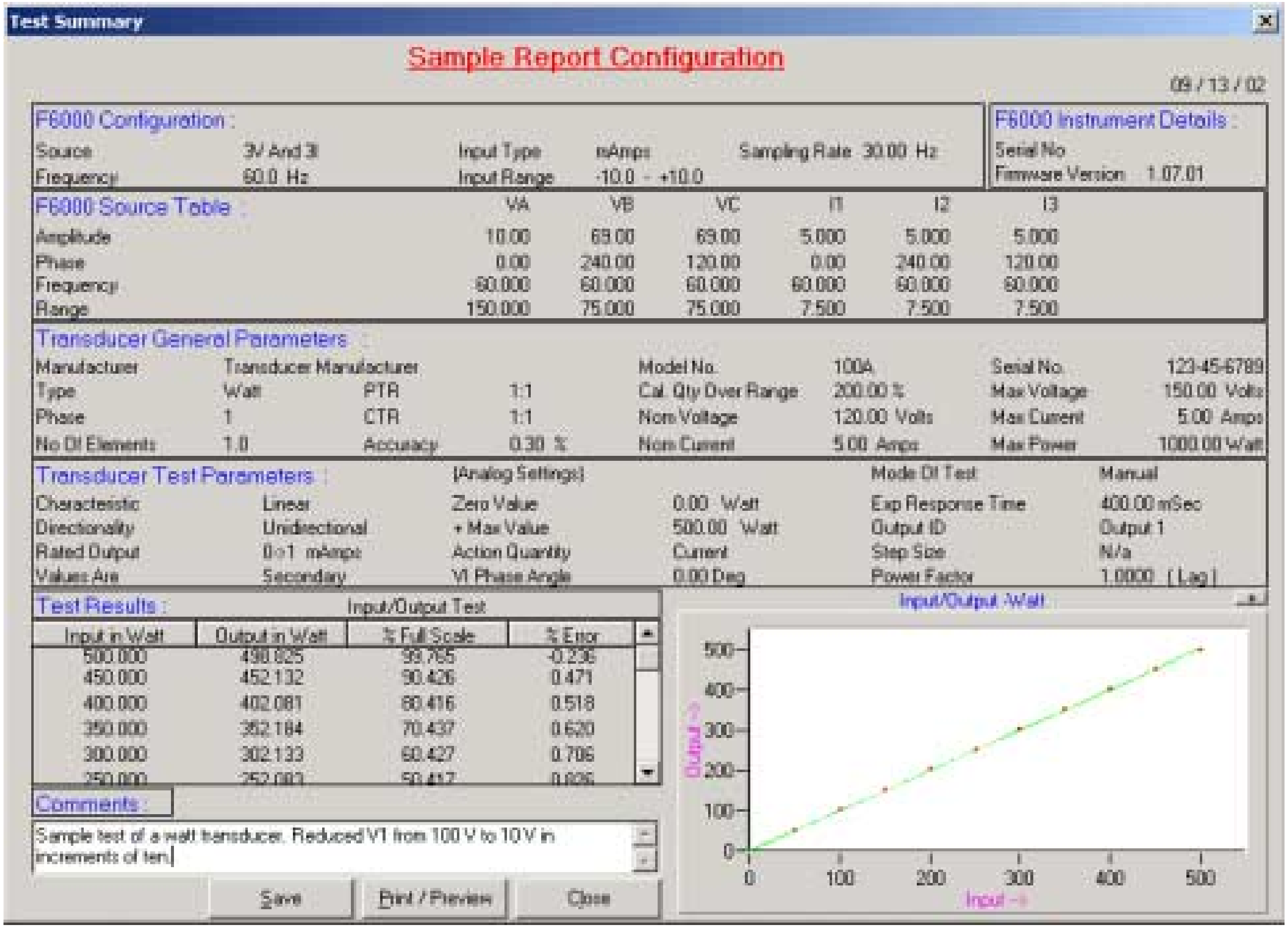


Figure 5.7 Sample Test Summary for a Watt Transducer

8. Click **Close** to close the Test Summary window and return to the Control Panel.

Test a Watt Transducer in Auto Mode

Auto mode uses pre-set parameters to simplify the test setup. This part of the sample test procedure explains how to test a Watt transducer in Auto mode.

Configure the Auto Settings

To test the transducer in Auto mode:

1. Select **Auto** in the *Mode* drop-down list on the right side of the Control Panel.

A confirmation dialog box appears (Figure 5.8).

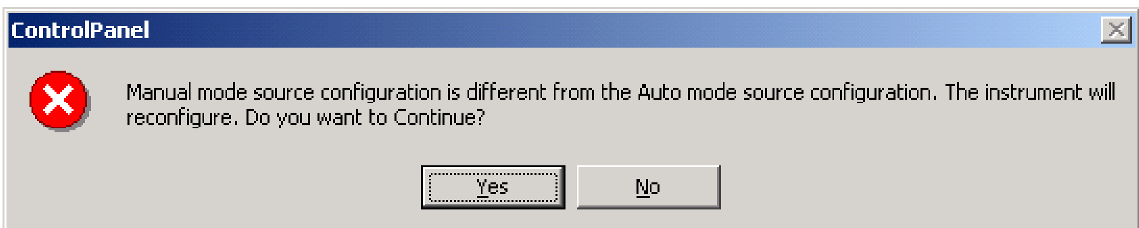


Figure 5.8 Auto Mode Confirmation Dialog Box

2. Click **Yes** in the dialog box to confirm the new Auto settings.

The entire Control Panel reconfigures to reflect the current Auto mode settings (Figure 5.9):

- The Amplitude and Phase settings for VA and I1 change only if the Auto settings in the Device Settings window change.
- The range setting for VA and I1 is adjustable.
- The settings in the *Ramp/Set Sources* section are pre-set and not adjustable.

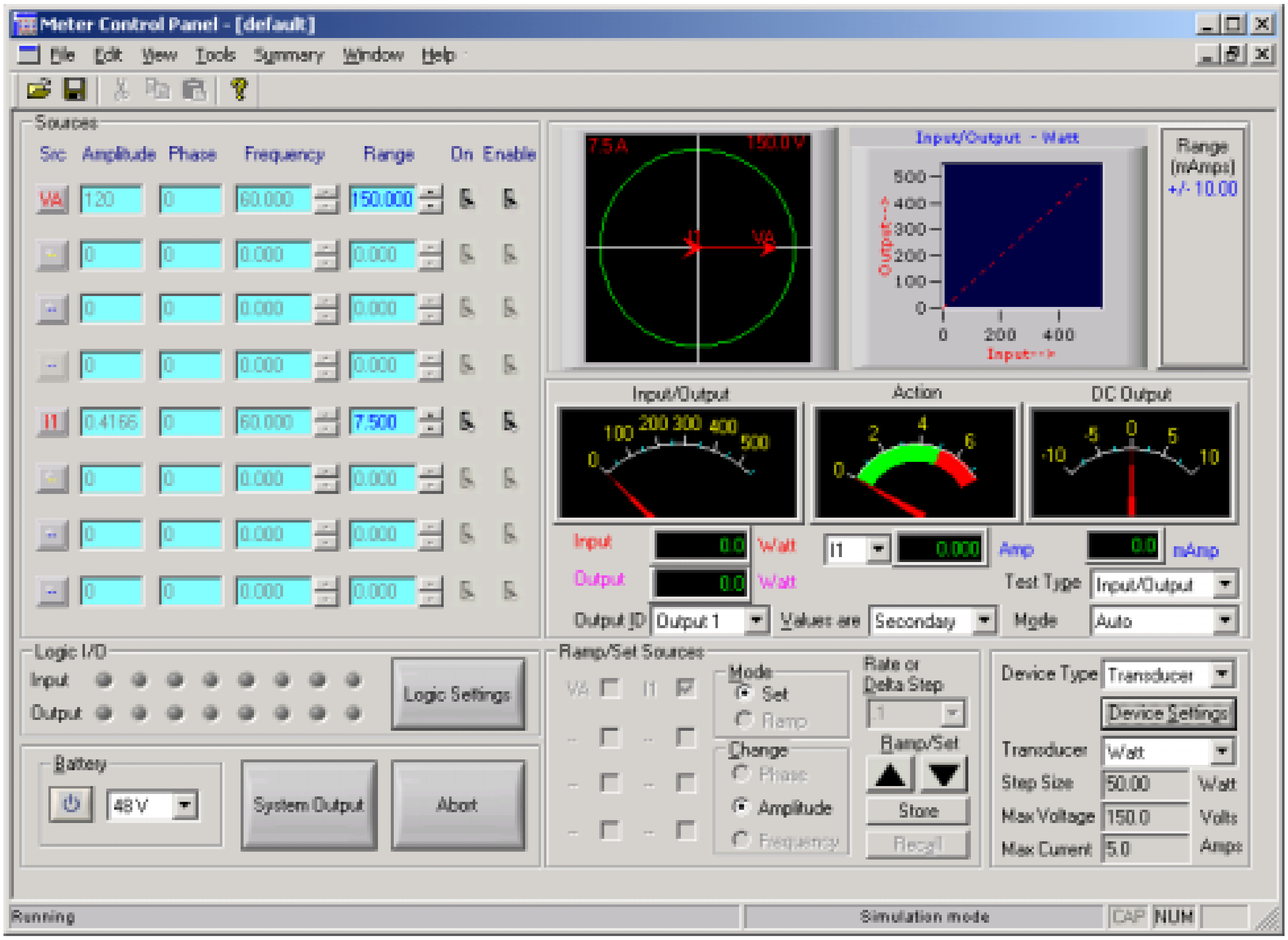


Figure 5.9 Control Panel Configuration for the Watt Transducer Auto Test

3. To change the settings for Auto mode, click **Device Settings** in the Control Panel.

The Device Settings window opens. The Auto Settings section of the Watt tab shows the current settings for Auto mode (Figure 5.10).

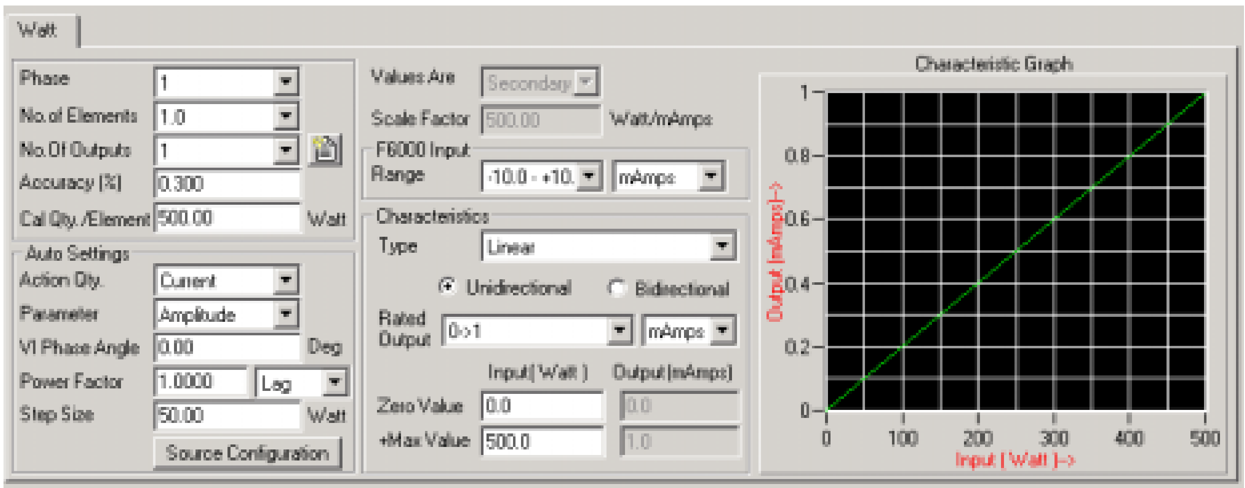


Figure 5.10 Watt Tab Auto Settings

4. In the *Action Quantity* drop-down list, select **Voltage**.

VA changes from 120 V to 10 V, and I1 changes from 0.4166 A to 5 A.

5. To check the new source table settings, click **Source Configuration** at the bottom of the *Auto Settings* section of the Device Settings window.

   The Source Configuration dialog box opens. The dialog box shows the source table settings for each active source (Figure 5.11). VA is 10 V and I1 is 5 A.

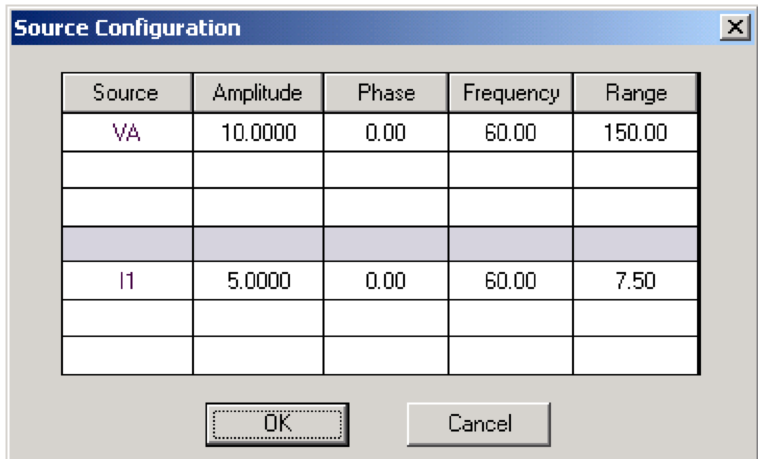


Figure 5.11 Source Configuration Dialog Box – Watt Transducer

6. Click **OK** to confirm the settings in the Source Configuration dialog box.
7. To change the default value for other Auto settings in the Watt tab, delete the existing value from the field and enter a new one.
8. When the Auto settings are correct for the device under test, click **OK** to close the Device Settings window and return to the Control Panel.

Conduct the Test

To conduct the Watt transducer test from the Control Panel:

1. Turn on the Battery.
2. Right-click in the *Enable* column and select **Enable All** to enable VA and I1.
3. Click **System Output** to turn VA and I1 on.

   The Input/Output, Action, and DC Output meters all register initial values that correspond to the Auto settings in effect. The Input/Output graph shows 50 Watts input to the transducer and 50 Watts output from the transducer.

NOTE **When in Auto mode, the settings in the *Ramp/Set Sources* section are not available. They do show the settings that Auto mode uses to vary the action source or sources.**

4. Click the *Ramp/Set* up arrow in the *Ramp/Set Sources* section.

   The action source, VA, steps up 10 Volts and the Input/Output meter indicates 100 Watts.
5. Click the *Ramp/Set* up arrow until VA equals 100 Watts and the Input/Output meter reads 500 Watts.
6. Click **System Output** and then disable the enabled sources to turn off the sources and end the test.
7. To view the test results, click **Summary|Test Results** in the top menu bar.

   The current test results appear in the Test Summary window (Figure 5.12).

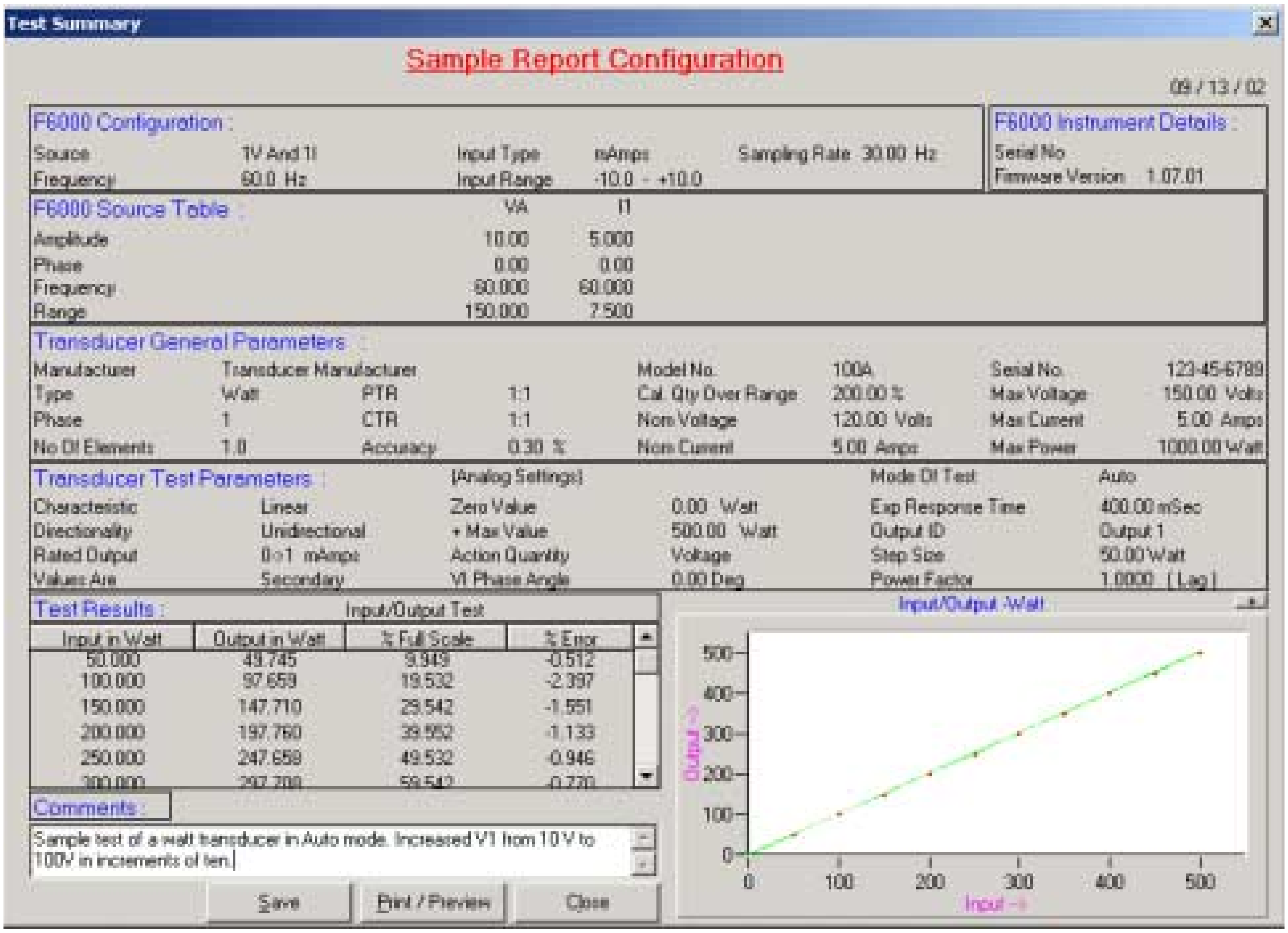


Figure 5.12 Sample Test Summary for a Watt Transducer – Auto Mode

8. Click **Close** to close the Test Summary window and return to the Control Panel.
9. To clear the data points from the Input/Output graph, right-click in the graph and select **Clear**.
10. To restore the source table to its original settings, select **Manual** in the *Mode* drop-down list. Then click **Yes** in the confirmation dialog box.

    The source table and the rest of the Control Panel reconfigure.

How to Test a Watthour Transducer

Use the F6Meter Control Panel to test a Watthour transducer:

- Set up the source table
- Enter the device settings
- Conduct the test

These procedures use a Watthour transducer to test a pulsed output device.

Set Up the Source Table

Set up the source table as shown in Figure 5.13. Use six sources for this test – VA, VB, and VC at 100 V each, and I1, I2, and I3 at 5 A each.

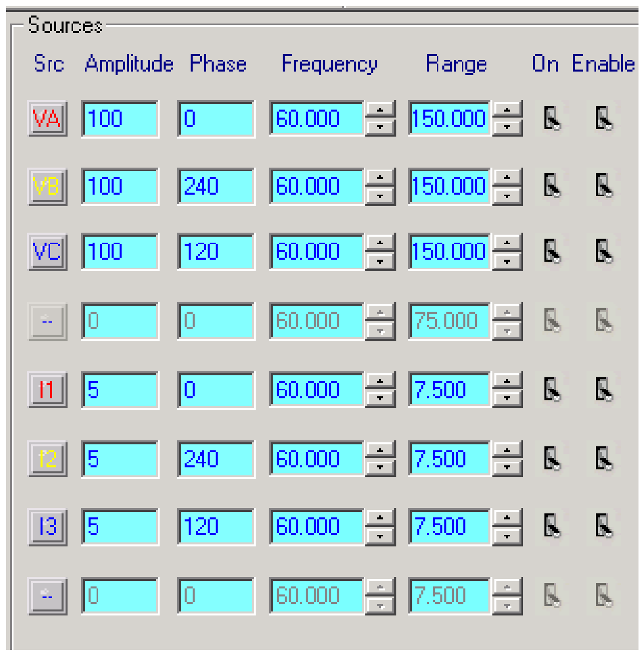


Figure 5.13 Source Table Settings for the Watthour Transducer Test

Enter the Device Settings

To enter the device settings:

1. Click **Device Settings** in the lower right portion of the Control Panel.

   The Device Settings window opens (Figure 5.14).

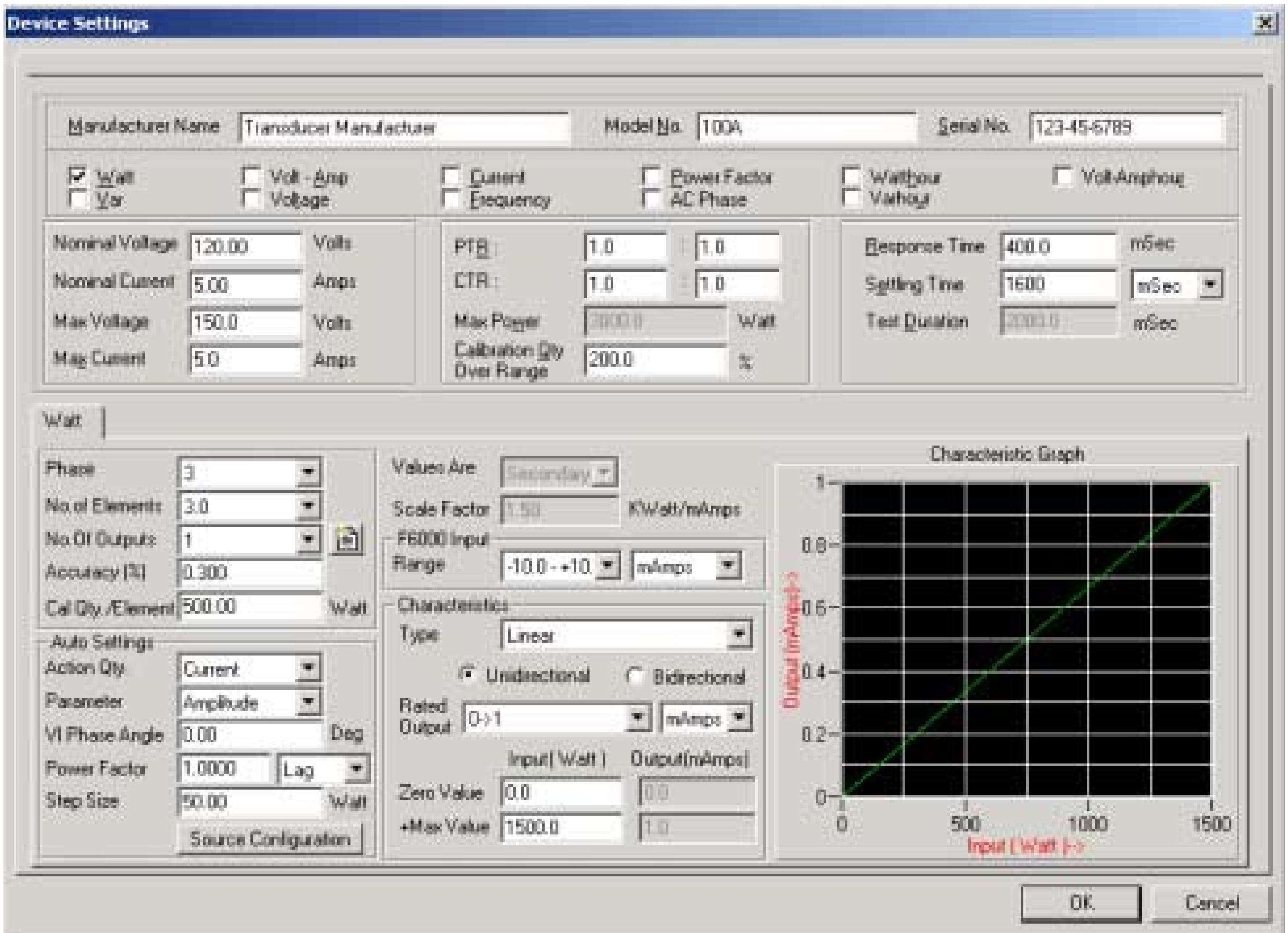


Figure 5.14 Device Settings Window

2. Click the checkbox for Watthour near the top of the window.

The Watthour tab opens in the lower portion of the Device Settings window (Figure 5.15).

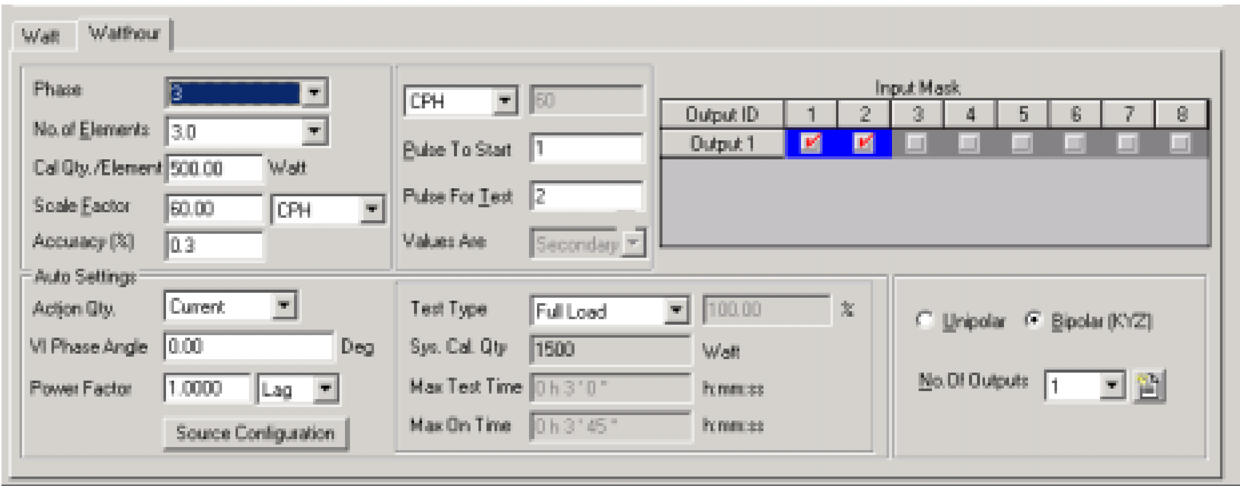


Figure 5.15 Watthour Tab Device Settings

3. Check the manufacturer’s transducer documentation to determine the counts per hour setting for the transducer. Enter the setting in the *Counts Per Hour* field of the Watthour tab.

For example, if the device under test is a Watthour transducer set for 3,600 counts per hour, enter 3,600 in the *Counts Per Hour* field.

4. Verify that the Unipolar/Bipolar (KYZ) selection is correct. Check the manufacturer’s transducer documentation to determine the correct setting.

5. Select the required number of outputs in the *No. Of Outputs* drop-down list. Configure the input mask according to the number of outputs selected.

6. Increase the figure in *Pulse to Start* from 1 to 3.

The test begins after the third pulse.

7. Increase the figure in *Pulse for Test* from 2 to 20.

The test runs for 20 pulses.

8. After verifying that the settings in the Watthour tab are accurate, click **OK** to close the Device Settings window and return to the Control Panel.

Conduct the Test

To test the accuracy of the Watthour transducer:

1. Turn on the Battery.
2. Right-click in the *Enable* column of the source table and select **Enable All** to enable all six sources.
3. Click **System Output** below the source table.

   The test proceeds without further intervention. Monitor the Input/Output meter and the pulse recorder while the test is under way. The default Scale Factor in the Device Settings window is 25 Watts per pulse. The Input/Output meter increments by 25 Watts for each count registered in the pulse recorder.

   During the test, the pulse recorder shows the number of pulses registered as well as the counts per hour. The pulse recorder counts to the value entered in the *Pulse for Test* field of the Device Settings window.
4. To view the test results, click **Summary | Test Results** in the top menu bar.

   The current test results appear in the Test Summary window (Figure 5.16 on page 5-20).

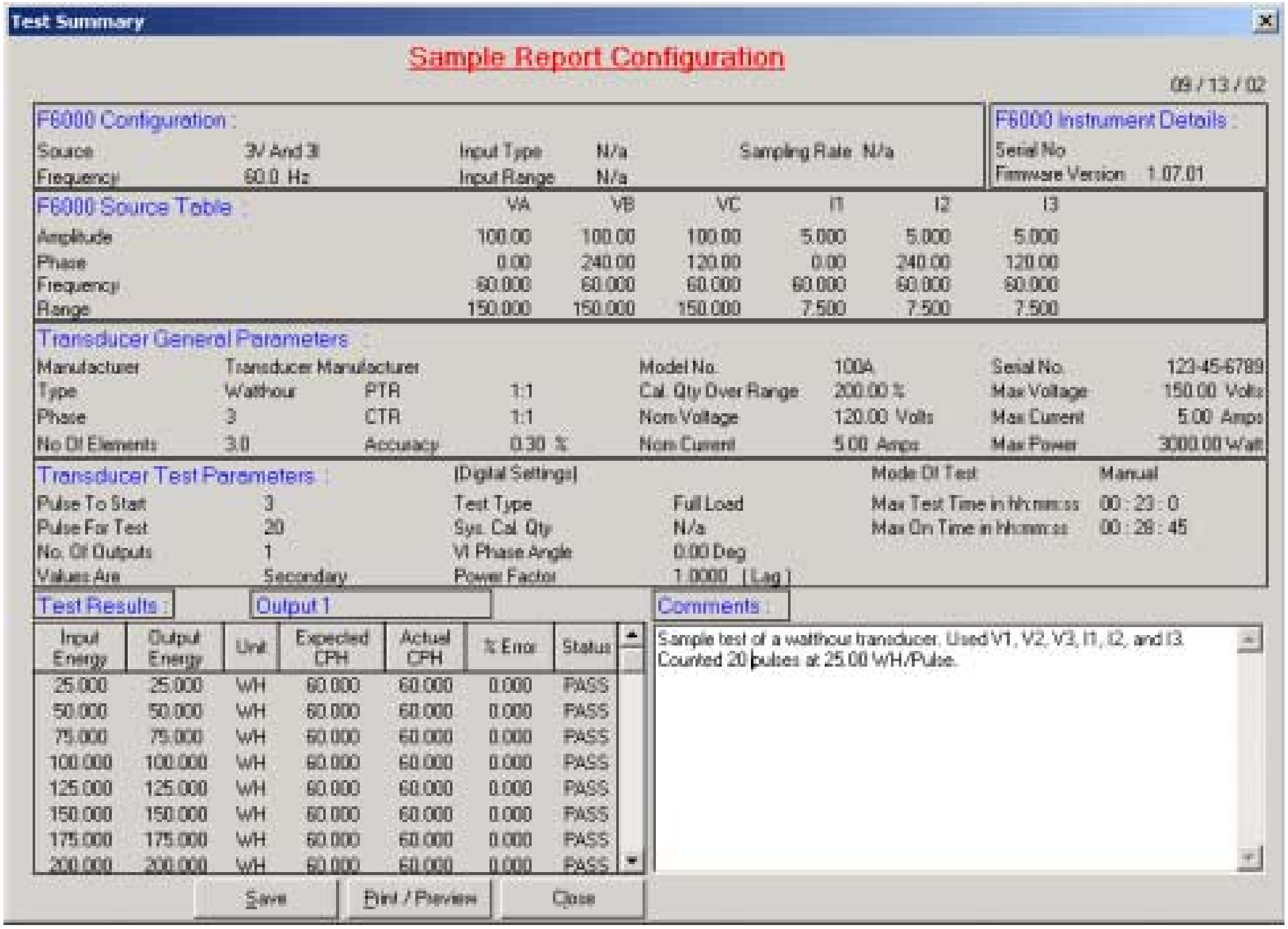


Figure 5.16 Sample Test Summary for a Watthour Transducer

5. Click **Close** to close the Test Summary window and return to the Control Panel.
6. When prompted with *Do you want to save the Report?*, Click **No** to return directly to the Control Panel.
7. To conduct another test, click **Reset** in the pulse recorder. Then click **System Output** again.
8. To end the test, click **Abort**.

Test a Watthour Transducer in Auto Mode

Auto mode uses pre-set parameters to simplify the test setup. This part of the sample test procedure explains how to test a Watthour transducer in Auto mode.

Configure the Auto Settings

To test the transducer in Auto mode:

1. Select **Auto** in the *Mode* drop-down list on the right side of the Control Panel.

   A confirmation dialog box appears (Figure 5.17).

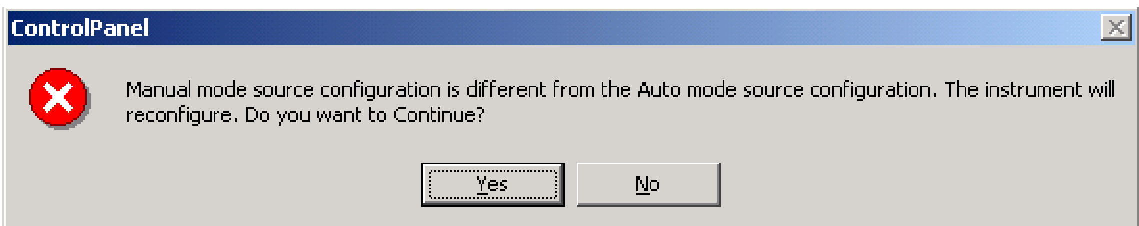


Figure 5.17 Auto Mode Confirmation Dialog Box

2. Click **Yes** in the dialog box to confirm the new Auto settings.

The entire Control Panel reconfigures to reflect the current Auto mode settings (Figure 5.18):

- The Amplitude, Phase, and Frequency settings for the active voltage and current sources in the source table are pre-set and not adjustable.
- The range settings in the source table are adjustable.
- The *Ramp/Set Sources* section has no action sources checked.

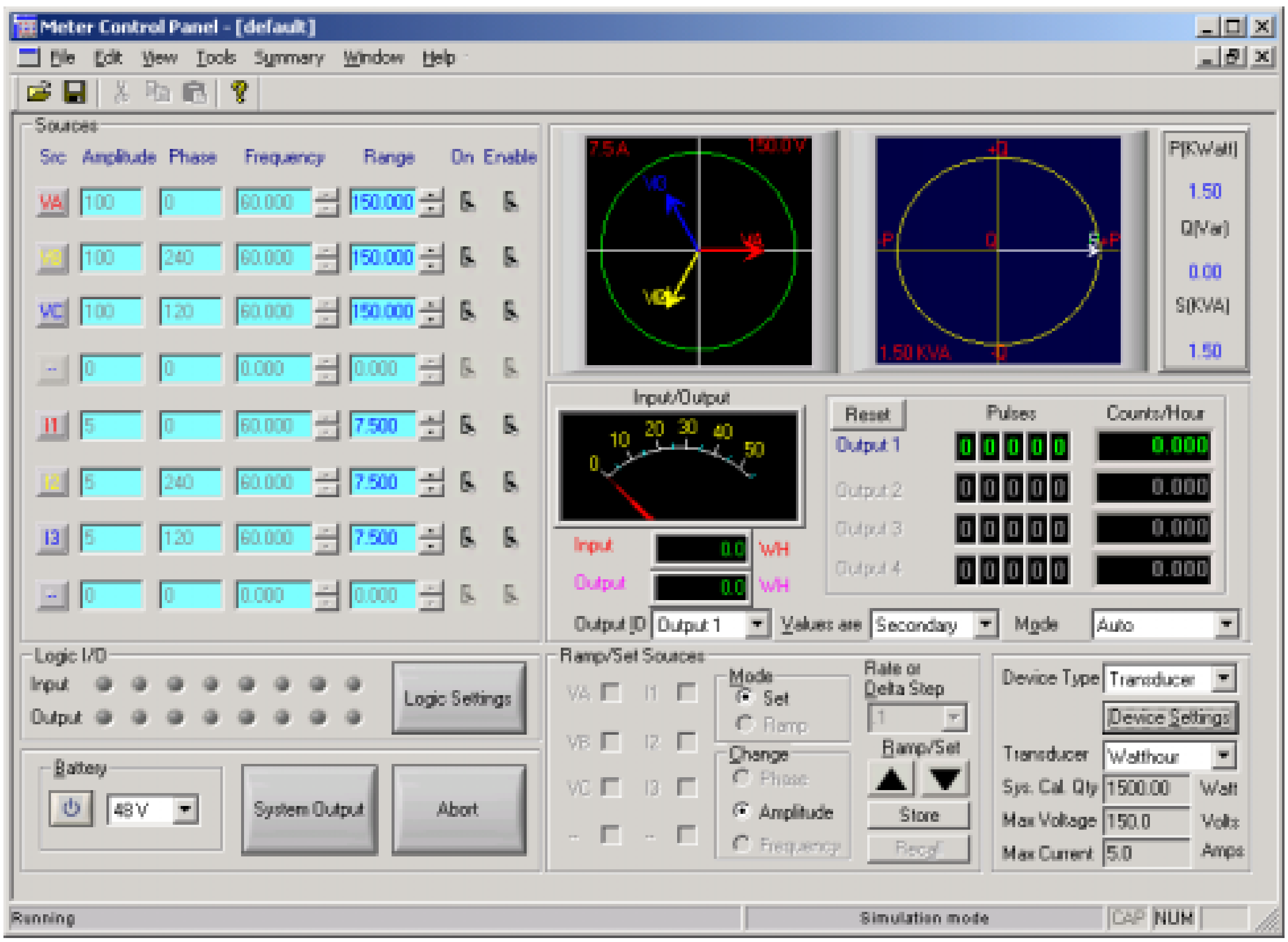


Figure 5.18 Control Panel Configuration for the Watthour Transducer Auto Test

3. To change the settings for Auto mode, click **Device Settings** in the Control Panel.

The Device Settings window opens. The Auto Settings section of the Watt tab shows the current settings for Auto mode (Figure 5.19).

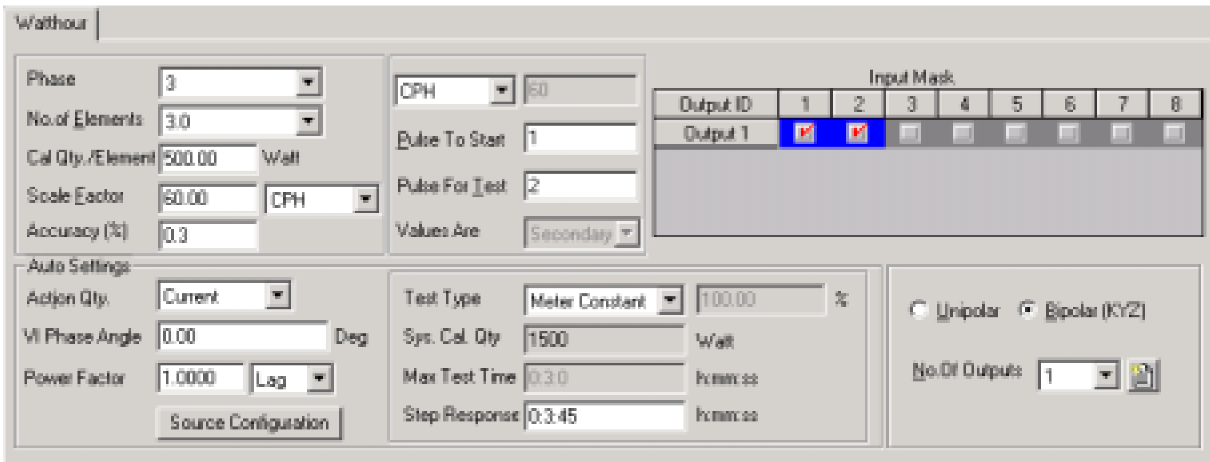
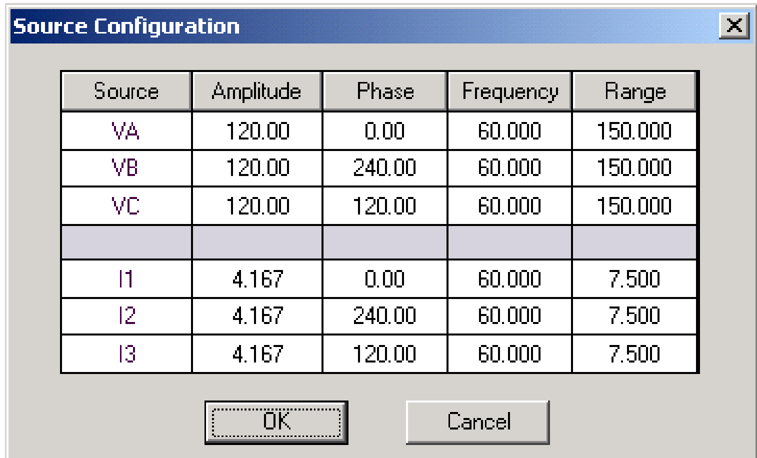


Figure 5.19 Watthour Tab Auto Settings

4. Change these settings in the Watthour tab:

- *Counts Per Hour:* Delete 60.0 and enter 3600.
- *Pulse to Start:* Delete 1 and enter 3.
- *Pulse for Test:* Delete 2 and enter 20.

5. Click **Source Configuration** at the bottom of the *Auto Settings* section to open the Source Configuration dialog box. The dialog box shows the source table settings for each active source (Figure 5.20).



Source	Amplitude	Phase	Frequency	Range
VA	120.00	0.00	60.000	150.000
VB	120.00	240.00	60.000	150.000
VC	120.00	120.00	60.000	150.000
I1	4.167	0.00	60.000	7.500
I2	4.167	240.00	60.000	7.500
I3	4.167	120.00	60.000	7.500

Figure 5.20 Source Configuration Dialog Box – Watthour Transducer

6. Click **OK** to confirm these settings and close the Source Configuration dialog box.
7. When the Auto settings are correct for the device under test, click **OK** to close the Device Settings window and return to the Control Panel.

Conduct the Test

To conduct the Watthour transducer test from the Control Panel:

1. Turn on the Battery.
2. Right-click in the *Enable* column of the source table and select **Enable All** to enable all six sources.
3. Click **System Output** to turn the voltage and current sources on.

   Monitor the Input/Output meter and the pulse recorder during the test. The pulse recorder counts to the value entered in the *Pulse for Test* field of the Device Settings window.

4. To view the test results, click **Summary | Test Results** in the top menu bar.

The current test results appear in the Test Summary window (Figure 5.21).

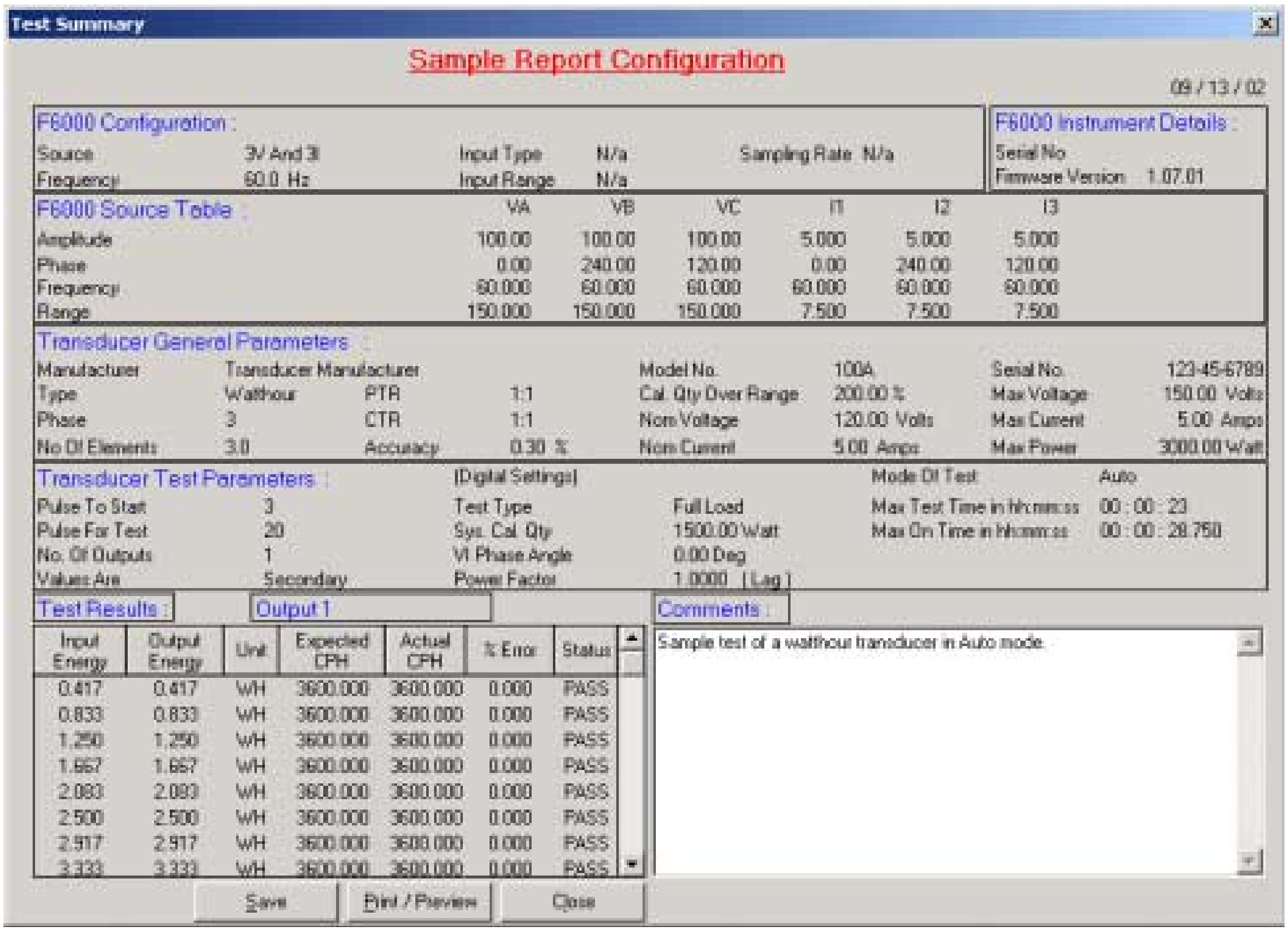


Figure 5.21 Sample Test Summary for a Watthour Transducer – Auto Mode

5. Click **Close** to close the Test Summary window and return to the Control Panel.

6. Click **System Output** and then disable the enabled sources to end the test.

6. Troubleshooting Guide

This chapter contains diagnostic information and troubleshooting tools for the F6000 Instrument that are designed to pinpoint problems based on symptoms. Topics include:

- Troubleshooting flowcharts
- General troubleshooting techniques
- Status indicators
- Component checkout procedures
- Error types
- Resolving communication errors

If the solutions discussed in this guide do not resolve the problem, obtain further assistance by contacting Doble customer service:

Web site: www.doble.com/support/support.htm

Email: customerservice@doble.com

Telephone: 617-926-4900, Extension 321/232/406

Troubleshooting Flow Charts

Diagnostic flow charts are shown in Figure 6.1 on page 6-2 and Figure 6.2 on page 6-3. Use the flow charts to identify and isolate problems in F6150 operations.

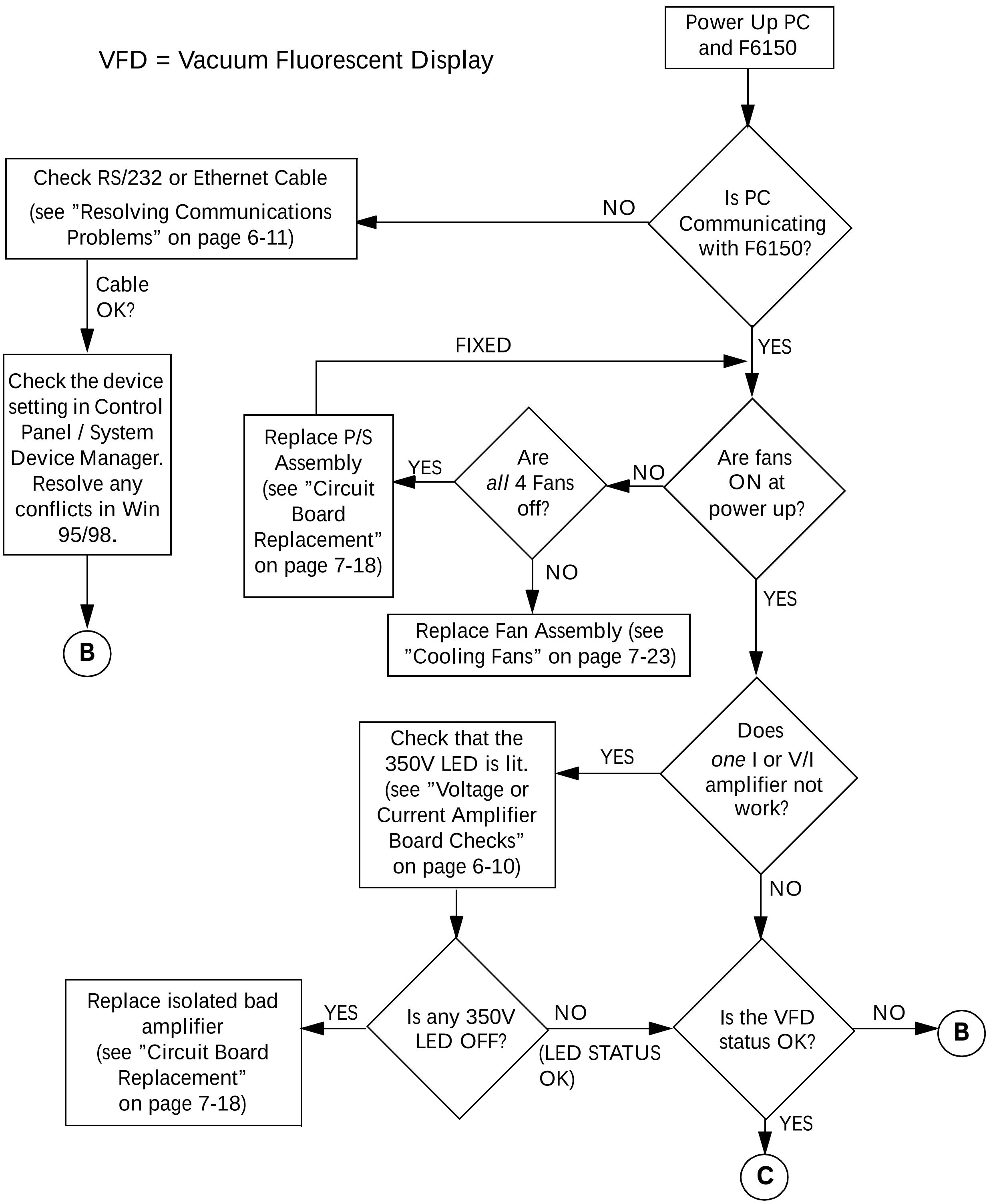


Figure 6.1 Troubleshooting Flow Chart — Part 1

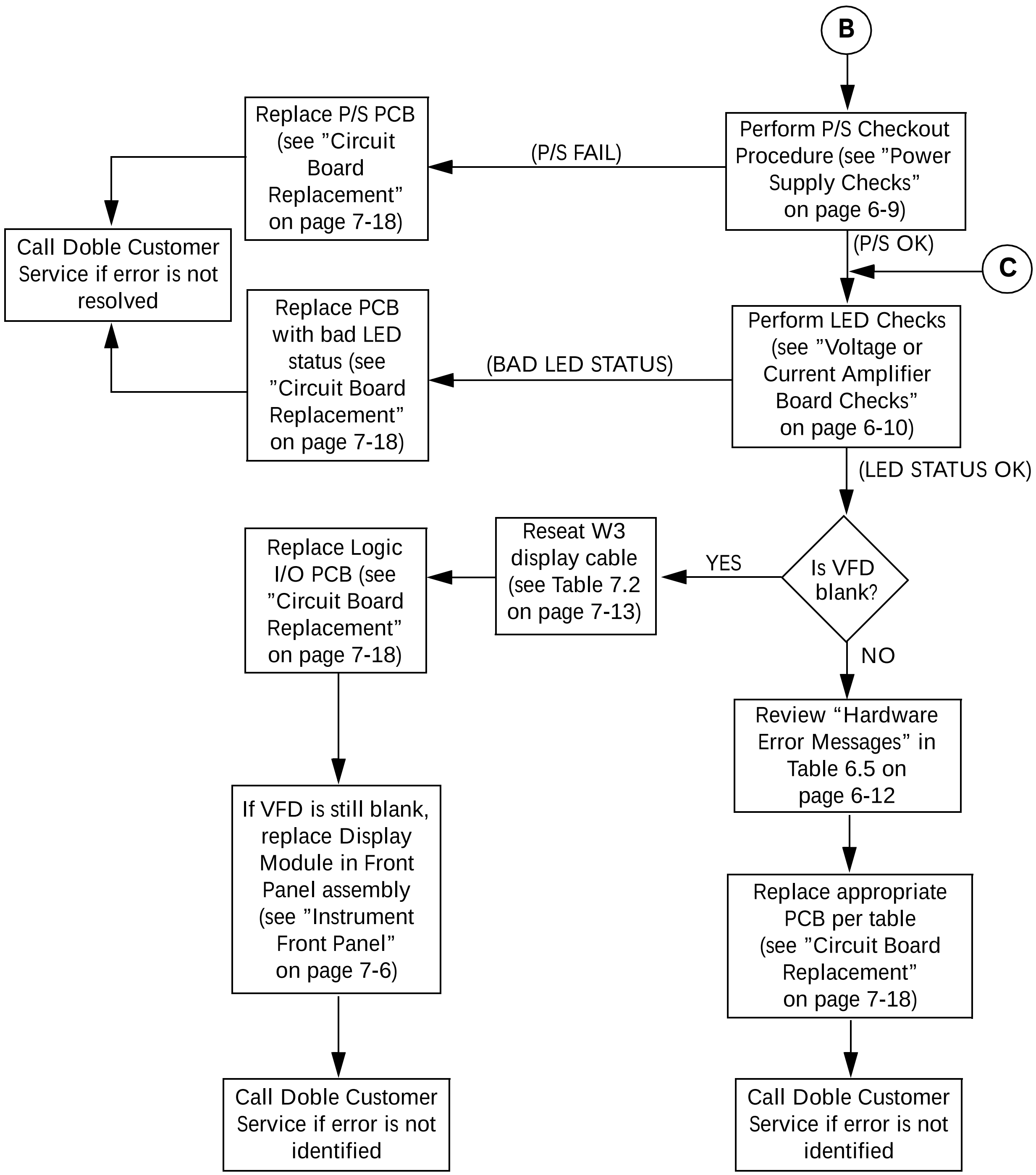


Figure 6.2 Troubleshooting Flow Chart — Part 2

General Troubleshooting Techniques

If the F6000 experiences difficulties, perform the following external checks to isolate the problem before removing the cover.

NOTE

Many of the major problems encountered in the F6000 are corrected by replacing a board in the unit. Chapter 7 "Field Replacement Procedures" explains how to remove a defective board and replace it.

- Check for boot-up errors.

  Power up the F6000 and watch the boot sequence displayed in the VFD (Vacuum Fluorescent Display).

- Check for source errors in the Source Table of the Control Panel.
- Verify the configuration of voltage and current sources.

  Click **Tools | F6000 Configuration** in the top menu bar.

- Check the battery simulator.

  Turn the battery simulator on from the Control Panel and measure its output with a voltmeter.

- Check for short circuits (voltage sources).

  Remove all connections to the F6000 and check the source outputs with a voltmeter. If no voltmeter is available, turn the source on and check for error messages.

- Check for open circuits (current sources).

  Remove all connections and check the source outputs with an ammeter, or short the output terminals.

- If the F6000 is connected via Ethernet, verify that the Ethernet connection is functioning properly.

  Ping the F6000 from a DOS window (see Appendix B "Ethernet Communications").

If the preliminary external checks do not identify the problem, remove the cover (refer to page 7-3) and check the LED status of internal components for proper operation (refer to "LED Status Indicators" on page 6-5).

LED Status Indicators

The following circuit boards have status LEDs:

- Voltage and current amplifier circuit boards
- CPU circuit board
- Analog I/O board
- Power supply circuit board

VOLTAGE

Lethal voltages are exposed with the cover removed. Follow safe procedures designed to protect against electrical shock. Always turn the unit off before making contact with any of the internal components.

Amplifier Circuit Boards

Three current amplifier boards are installed in slots 5-7. Three voltage amplifier boards are installed in slots 8-10.

Each current and voltage amplifier circuit board has two LEDs that are visible when looking at the front of the board.

Table 6.1 defines the function of the LEDs.

Table 6.1 Voltage/Current Amplifier Board LED Indicators

Amplifier Board LED	Indication
350V	Illuminates steady green after the Power up diagnostics pass, indicating a healthy status. This LED is located on the left side of the board, close to the top edge, as viewed with the front panel oriented towards the front.
SRC ON (right side *)	Illuminates steady green when the amplifier is enabled or turned on at the Control Panel, indicating an active source. This LED is located on the right side of the board, close to the top edge, as viewed with the front panel oriented towards the front.

NOTE

If the 350V LED is not illuminating green, replace the amplifier circuit board. Refer to "Circuit Board Replacement" on page 7-18.

CPU Circuit Board

The CPU circuit board is installed in slot 3. It has twelve LEDs located at the top of the CPU board (Figure 6.3), and one push button.

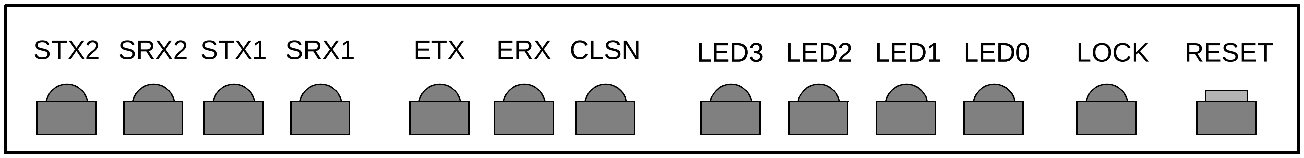


Figure 6.3 CPU Board Status Indicator LEDs and Push Button

- The LEDs indicate communication status (either RS-232 or Ethernet) and are described in Table 6.2.
- The **RESET** push button activates a new power diagnostic cycle when pressed.

Table 6.2 CPU Board LED Indicators

CPU Board LED	Indication
STX2 [D13]	RS-422 GPS transmit active. Illuminates green during power up only, otherwise it is OFF.
SRX2	RS-422 GPS receive active.
STX1 [D1]	RS-232 serial port transmit active. Blinks red during RS-232 communication with the controlling computer.
SRX1 [D2]	RS-232 serial port receive active. Blinks red during RS-232 communication with the controlling computer.
ETX [D3]	Ethernet transmit active. Blinks during Ethernet communication. This LED is always OFF if no Ethernet cable is attached.
ERX [D4]	Ethernet receive active. Blinks during Ethernet communication. This LED is always OFF if no Ethernet cable is attached.
CLSN [D5]	Ethernet collision. Blinks red during power up, and when no Ethernet cable is attached.

Table 6.2 CPU Board LED Indicators (Continued)

CPU Board LED	Indication
LED3	General purpose lights used for CPU/RAM status and power-on self-test.
LED2	
LED1	
LED0	
LOCK	1PPS lock for GPS communications (not supported in software).

Analog I/O Circuit Board

The analog I/O circuit board is installed in slot 4 and has four LEDs. When the F6000 is powered up, but idle, all LEDs should be OFF. Analog I/O board LEDs are defined in Table 6.3.

Table 6.3 Analog I/O Board LED Indicators

Analog I/O Board LED	Indication
A/D Test [D1]	Illuminates red during power up only, then OFF. This LED is for Doble use only. • If the LED illuminates a steady red, the PCB may be installed in an incorrect slot.
CPU ENAB [D2]	Illuminates green during power up only, then OFF.
SAFESTAT [D3]	Should never illuminate green during power up.
SAFECTRL [D4]	Illuminates green when any source is turned ON. • Does not illuminate during power up or when idle.

Power Supply Circuit Board

The power supply board is installed in slot 11. The board has three LEDs designated D1, D2 and D3 that are visible from the rear of the chassis. Refer to Table 6.4.

Table 6.4 Power Supply Board LED Indicators

Power Supply Board LED	Indication
PSERR [D1]	Illuminates green for the first 30 seconds after power up, then is OFF after completing the Power Supply power up sequence. • The power supply has its own power up sequence. The PSERR LED performs this sequence even if the CPU board is not installed.
LOFLOW [D2]	This LED is normally OFF. If illuminating green, check the following: • Check the power supply voltages on the CPU PCB. • Check for proper fan operation.
BATTON [D3]	Illuminates green when the Battery Simulator is instructed to turn ON, otherwise it is OFF. • Illuminating green indicates *only* that the Battery Simulator is instructed to turn ON, and is not an indication of proper operation.

Fuses

In addition to the LEDs, two fuses are located on the power supply board for the AC input (F3 and F4 designation).

- For a 115 V power supply, the fuse value is 20 A.
- For a 230 V power supply, the fuse value is 10 A.

Component Checkout Procedures

This section lists procedures for troubleshooting the following components:

- Power Supply Board
- Logic I/O Board
- Current and Voltage Amplifier Boards
- Battery Simulator
- Cooling Fans

Power Supply Checks

To verify proper operation of the power supply, perform the following procedure:

1. Connect a multimeter to a ground point on the chassis, for example Test Point 8.
2. Measure each of the following test points on the F6000 CPU circuit board, located in slot 3 of the backplane:

Test Point #8:	Ground (any point on the Instrument chassis can be used as a reference).
Test Point #5:	+5 V DC ±0.25 V
Test Point #7:	+12 V DC ±0.25 V
Test Point #10:	–12 V DC ±0.25 V

NOTE

These test points are not on the edge of the printed circuit board. They are located near the middle of the circuit board.

3. Replace the Power Supply Assembly circuit board (04S-0670-01) in slot 11 if any of the test point voltages are not present. Refer to ”Circuit Board Replacement” on page 7-18.

Logic I/O Printed Circuit Board Checks

If the VFD displays a **Logic Input** or **Logic Output** error, perform the following steps:

1. Verify proper operation of the power supply (refer above to ”Power Supply Checks”).
2. If the power supply is operating correctly, replace the Logic I/O circuit board (04S-0672-01) in slot 1. Refer to ”Circuit Board Replacement” on page 7-18.

Voltage or Current Amplifier Board Checks

To verify proper operation of the amplifier circuit boards:

1. From the F6Meter Control Panel, select three Is and three Vs.
2. Verify that the **350V** and **SRC ON** LEDs illuminate when enabled.
3. If any LED fails to illuminate when enabled, replace the circuit board for that amplifier. Refer to ”Circuit Board Replacement” on page 7-18.

Battery Simulator Checks

The Battery Simulator is mounted on the chassis rear. It is equipped with one non-standard fuse soldered on the circuit board. There are no LED indicators.

To check the Battery Simulator:

1. Remove the cover (refer to page 7-3) and inspect the Battery Simulator’s fuse.

   The fuse is designated F1 and is located near J4.
2. If shorted, the fuse is ok. If open, the fuse is blown; proceed to step 3.
3. Replace the battery simulator circuit board (04D-0598-01). Refer to ”Battery Simulator” on page 7-20.

Cooling Fan Checks

To verify cooling fan operation, power up the F6150 and listen for the audible sound of the fans spinning. This sound is the only indication that the fans are functioning. No LEDs or error messages will appear to indicate a problem until an over-temperature condition occurs.

CAUTION

It is very important to verify fan operation at power up. Equipment damage can result during operation with one or more broken fans.

If one or more of the cooling fans is not operating, perform these steps:

1. Immediately power down the F6150.
2. Remove the cover. Refer to page 7-3.
3. Check that the large inductor (L1) located in the middle of the power supply circuit board has not broken loose.
   - If the L1 inductor has broken loose, replace the power supply board (04S-0676-01 or 04S-0676-02).
   - If the L1 inductor has not broken loose, replace the fan. Refer to "Cooling Fans" on page 7-23.

Resolving Communications Problems

If communication fails or cannot be established between the F6150 and the F6Meter Control Panel, check the following:

1. Check the RS-232 cable or Ethernet cable.
2. Verify that the CPU circuit board LEDs (D1 & D2) are blinking.
3. Check for conflicts in the COMM PORT of the Computer or laptop running the F6Meter Control Panel.

   To do this:

   a. Click **Control Panel | System Device Manager**.
   b. Verify that no other device, such as a Palm Pilot, or software is using the same COMM PORT as the F6Meter Control Panel.
   c. Check the Control Panel and Hardware Devices in Windows 95, Windows 98, Windows 2000 for serial device conflicts. If a device conflict is found, contact your System Administrator.
4. If the communication cable is functioning and no conflicts are found, replace either the CPU circuit board (page 7-18), Analog I/O circuit board (page 7-18) or the Communications circuit board (page 7-14).

Error Types

Three types of errors can occur while using the F6000 Instrument:

- Hardware Errors
- Source Errors
- System errors

Hardware Errors

Hardware error messages display on the VFD on the Instrument front panel. They are often the first sign that something is not functioning properly in the Instrument.

NOTE

Hardware errors must be resolved before further testing can proceed.

Table 6.5 describes hardware errors and possible solutions.

Table 6.5 Hardware Errors

Error Message	Description	Action
Cal A/D Hardware failure	The calibration analog to digital conversion hardware failed.	Replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
DAC Calibration hardware failure	The digital to analog converter calibration hardware failed.	Replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
DAC Calibration out of limits	The digital to analog converter calibration is out of limits.	Replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Analog GND sense failed	The analog GND sense failed.	Check the power supply with a voltmeter (see page 6-9). • If the voltages are not correct replace the power supply board. • If the voltages are ok replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.

Table 6.5 Hardware Errors (Continued)

Error Message	Description	Action
Analog I/O –5V out of range	The instrument reads out of range.	Check the power supply with a voltmeter (see page 6-9). • If the voltages are not correct replace the power supply board. • If the voltages are ok replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Analog I/O +5V out of range	The instrument reads out of range.	Check the power supply with a voltmeter (see page 6-9). • If the voltages are not correct replace the power supply board. • If the voltages are ok replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Positive DAC readback failure	Positive digital to analog converter readback failure.	Replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Negative DAC readback failure	Negative digital to analog converter readback failure.	Replace the analog I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Missing/bad Logic I/O board	The logic I/O circuit board is either missing or bad.	Replace the logic I/O board. Refer to ”Circuit Board Replacement” on page 7-18.
Missing/bad Analog I/O board	The analog I/O circuit board is either missing or bad.	Replace the analog I/O circuit board. Refer to ”Circuit Board Replacement” on page 7-18.
Missing/bad (I AMP#0) SLOT 5	The current amplifier in slot 5 is either missing or bad.	Replace the current amplifier board in slot 5. Refer to ”Circuit Board Replacement” on page 7-18.

Table 6.5 Hardware Errors (Continued)

Error Message	Description	Action
Missing/bad (I AMP#1) SLOT 6	The current amplifier in slot 6 is either missing or bad.	Replace the current amplifier board in slot 6. Refer to "Circuit Board Replacement" on page 7-18.
Missing/bad (I AMP#2) SLOT 7	The current amplifier in slot 7 is either missing or bad.	Replace the current amplifier board in slot 7. Refer to "Circuit Board Replacement" on page 7-18.
Missing/bad (V AMP#0) SLOT 8	The voltage amplifier in slot 8 is either missing or bad.	Replace the voltage amplifier board in slot 8. Refer to "Circuit Board Replacement" on page 7-18.
Missing/bad (V AMP#1) SLOT 9	The voltage amplifier in slot 9 is either missing or bad.	Replace the voltage amplifier board in slot 9. Refer to "Circuit Board Replacement" on page 7-18.
Missing/bad (V AMP#2) SLOT 10	The voltage amplifier in slot 10 is either missing or bad.	Replace the voltage amplifier board in slot 10. Refer to "Circuit Board Replacement" on page 7-18.
Missing/bad HVPS	The high-voltage power supply is either missing or bad.	Check the power supply with a voltmeter (see page 6-9). Replace the board if necessary. Refer to "Circuit Board Replacement" on page 7-18.
Bad/Blank CPU EEPROM	The CPU board is either bad or the EEPROM has no data.	Replace the CPU board. Refer to "Circuit Board Replacement" on page 7-18.

Source Errors

Source errors display in the Source Table of the F6Meter Control Panel (see page 4-2). A source error is typically due to problems with the load. For example:

- Current is driven into an open circuit or high impedance.
- Voltage is applied across a short circuit or low impedance.
- Power requirements of the transducer under test exceed the capacity of the source.

If a source error occurs:

- The name of the affected source displays as **ER** and blinks in the Source Table.
- The Amplitude and Phase fields for the affected source blink in the Source Table.
- An audible alarm sounds from the speakers of the control PC.

Common source errors are defined in Table 6.6.

Table 6.6 Common Source Errors

Error	Explanation	Action
Transient over 1.5 seconds	Hardware disables the source.	Reboot the system.
Peak current	Hardware disables the source. Normally, this error does not occur for a current source. It typically means a voltage source is overloaded (as, for example, when a short circuit occurs at high amplitude).	Reduce the voltage.
Clip Fast	A current source cannot drive a load.	
Clip Slow	A current source cannot drive a load.	

Table 6.6 Common Source Errors (Continued)

Error	Explanation	Action
Distortion	Software processing of error feedback ADCs. A current source cannot drive a load.	
Battery Power Limit	Battery simulator load has exceeded maximum power output of 60 W.	Reduce the battery simulator load.
Battery Current Limit	Battery simulator load has exceeded maximum current limit of 1.25 A at 48 volts.	Reduce the battery simulator load.

System Errors

System errors are indicated on the Source Table of the F6Meter Control Panel. A System error occurs when an Instrument component controlled by the Control Panel is functioning improperly. For example, a current amplifier overheats and shows a system error message.

System errors appear in the Control Panel dialog box. Figure 6.4 shows the first message that appears.

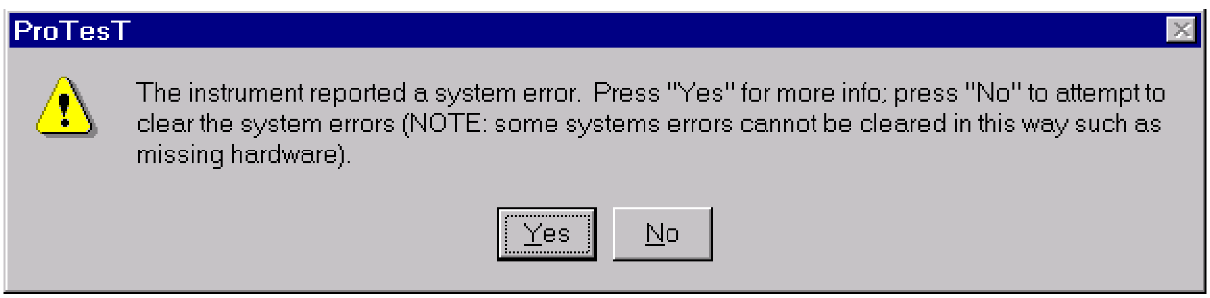


Figure 6.4 System Error Message

Click **Yes** for more information about the system error. Figure 6.5 illustrates the kind of error that can occur.

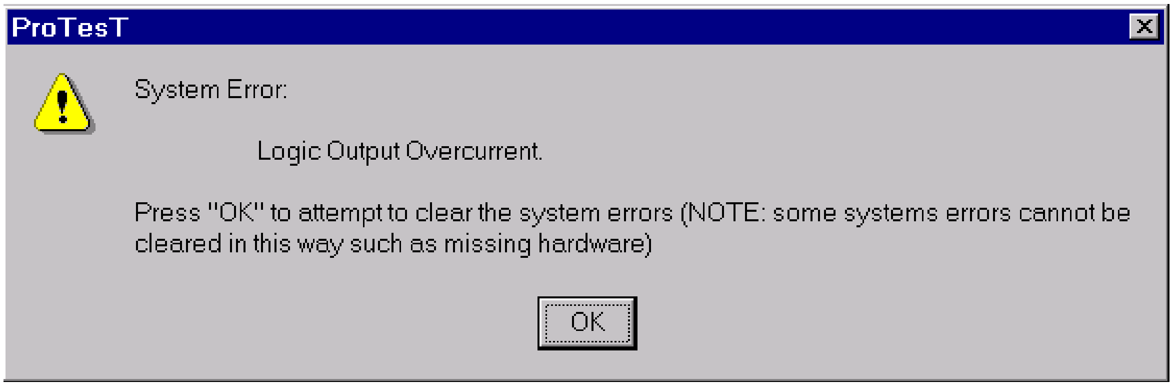


Figure 6.5 System Error Diagnostic Information

Click **OK** to close the dialog box and clear the system error. As the note in the dialog box indicates, the system error does not clear if the problem is related to missing hardware.

Use Table 6.7 on page 6-17 to diagnose and correct system errors.

Table 6.7 System Errors

Error	**Explanation**	**Action**
Current monitor (Power supply high amps)	Input line current is too large. Hardware detects that the Instrument is drawing too much current from the wall. The total of all amplifier outputs exceeds system specifications.	Reduce the source amplitude or reduce the load.
Voltage monitor (Power supply high volts)	Either the AC input line voltage is too high, or power is being fed back into the F6000 through the amplifier outputs.	Reduce the input line voltage.
Open ground detector (Power supply)	Hardware detects an open ground detector.	This hardware problem must be addressed before it is safe to operate the F6000. When the F6000 clears the error, it occurs again if the hardware problem has not been fixed.

Table 6.7 System Errors (Continued)

Error	Explanation	Action
Logic Output (Logic I/O)	Hardware detects an overcurrent condition on a logic output. The F6000 software shuts down all amplifiers. The F6000 hardware latches all logic outputs open.	Reboot the system. If the error persists, replace the Logic I/O circuit board (see ”Circuit Board Replacement” on page 7-18).
+12 Volt fail monitor (DC power supply)	Hardware disables amplifiers to prevent damage to relays on the amplifier assemblies if System +12 V falls below a threshold of approximately +5 volts.	Check the DC power supply.
High voltage heart beat	Five-second software timeout on lack of communication while hazardous voltages may be present on the front panel terminals. The F6000 software shuts down the amplifiers. This fault can occur if a communication cable is removed. The PC gets a communication timeout and displays it in the F6Meter Control Panel. The system error is only displayed when communication is re-established.	Replace the communication cable.
Fan flow monitor error	Fans are blocked or inoperative.	Verify fan operation (see ”Cooling Fan Checks” on page 6-11). Replace the fan assembly if required (page 7-23). If the fans are functioning, replace the power supply circuit board (page 7-18).
Lost pulse per second	Software shuts down the amplifiers because it detects lost external synchronization. This only occurs in an external synchronization mode.	Verify that the Global Positioning System (GPS) components are correctly connected, and that the Instrument is synchronized to the GPS clock. Refer to Appendix D ”Global Positioning System”.

Table 6.7 System Errors (Continued)

Error	Explanation	Action
Waveform Under-run	System error in waveform generation and I/O.	Verify operation of the Logic I/O board. (”Logic I/O Printed Circuit Board Checks” on page 6-10). Replace the board if necessary (”Circuit Board Replacement” on page 7-18).
Source Disabled	One or more sources were disabled by the hardware.	Verify the status of the amplifier circuit boards (refer to ”Voltage or Current Amplifier Board Checks” on page 6-10). Replace the board if necessary (”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (I AMP#0) SLOT 5	Current amplifier in slot 5 is overheated or has a blown fuse.	Replace the current amplifier board in slot 5 (refer to ”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (I AMP#1) SLOT 6	Current amplifier in slot 6 is overheated or has a blown fuse.	Replace the current amplifier board in slot 6 (refer to ”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (I AMP#2) SLOT 7	Current amplifier in slot 7 is overheated or has a blown fuse.	Replace the current amplifier board in slot 7 (refer to ”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (V AMP#0) SLOT 8	Voltage amplifier in slot 8 is overheated or has a blown fuse.	Replace the voltage amplifier board in slot 8 (refer to ”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (V AMP#1) SLOT 9	Voltage amplifier in slot 9 is overheated or has a blown fuse.	Replace the voltage amplifier board in slot 9 (refer to ”Circuit Board Replacement” on page 7-18).
Over Temperature or fuse blown (V AMP#2) SLOT 10	Voltage amplifier in slot 10 is overheated or has a blown fuse.	Replace the voltage amplifier board in slot 10 (refer to ”Circuit Board Replacement” on page 7-18).

Table 6.7 System Errors (Continued)

Error	Explanation	Action
Missing analog I/O board	Hardware is missing or not communicating properly with the CPU.	Check the communication cable. If OK, replace the analog I/O board in slot 4 (refer to ”Circuit Board Replacement” on page 7-18).
Missing digital I/O board	Hardware is missing or not communicating properly with the CPU.	Check the communication cable. If OK, replace the battery simulator board (04D-0598-01). (Refer to ”Battery Simulator” on page 7-20).
Control Panel Mode	Option F6909 required.	Call Doble Customer Service.
Macro Mode	Option F6910 required.	Call Doble Customer Service.
No convertible sources	Option F6810 required.	Call Doble Customer Service.

NOTE

Some system errors cannot be cleared. For example, if the Instrument has no analog I/O board, the error condition remains until the board is supplied.

7. Field Replacement Procedures

Chapter 7 explains how to replace a major component in the field. The procedures apply to the replacement of a failed component or to the installation of a new upgrade. To replace a component in the field, follow these basic steps:

1. Turn the instrument off.

2. Remove the instrument cover (page 7-3).

3. Turn the instrument on and perform a visual check to identify the faulty component (page 7-6).

4. Turn the instrument off and remove the power cord.

5. Replace the component.

6. Replace the cover, plug in the power cord and turn the instrument on.

7. Verify that the replacement solves the problem (page 7-27).

The replaceable components in the F6150 are:

- Instrument front panel (page 7-6)
- Communications board (page 7-14)
- Circuit boards in slots 1 through 11 (page 7-18)
- Battery simulator (page 7-20)
- Cooling fans (page 7-23)

Preparatory Steps

The replacement of any component in the F6150 requires removal of the cover first. If the cause of a problem is undetermined at the time the cover is removed, turn the instrument on and check the components visually. When the faulty component is identified, follow the replacement procedures in this chapter.

VOLTAGE

When replacing internal components, follow safe procedures designed to protect against electrical shock. Always turn the unit off before making contact with any of the internal components.

ESD

The F6000 contains electrostatic-sensitive components. Practice safe handling methods to protect components against electrostatic discharge.

Remove the Instrument Cover

Remove the cover to access the replaceable components in the Instrument. Figure 7.1 illustrates the location of these components.

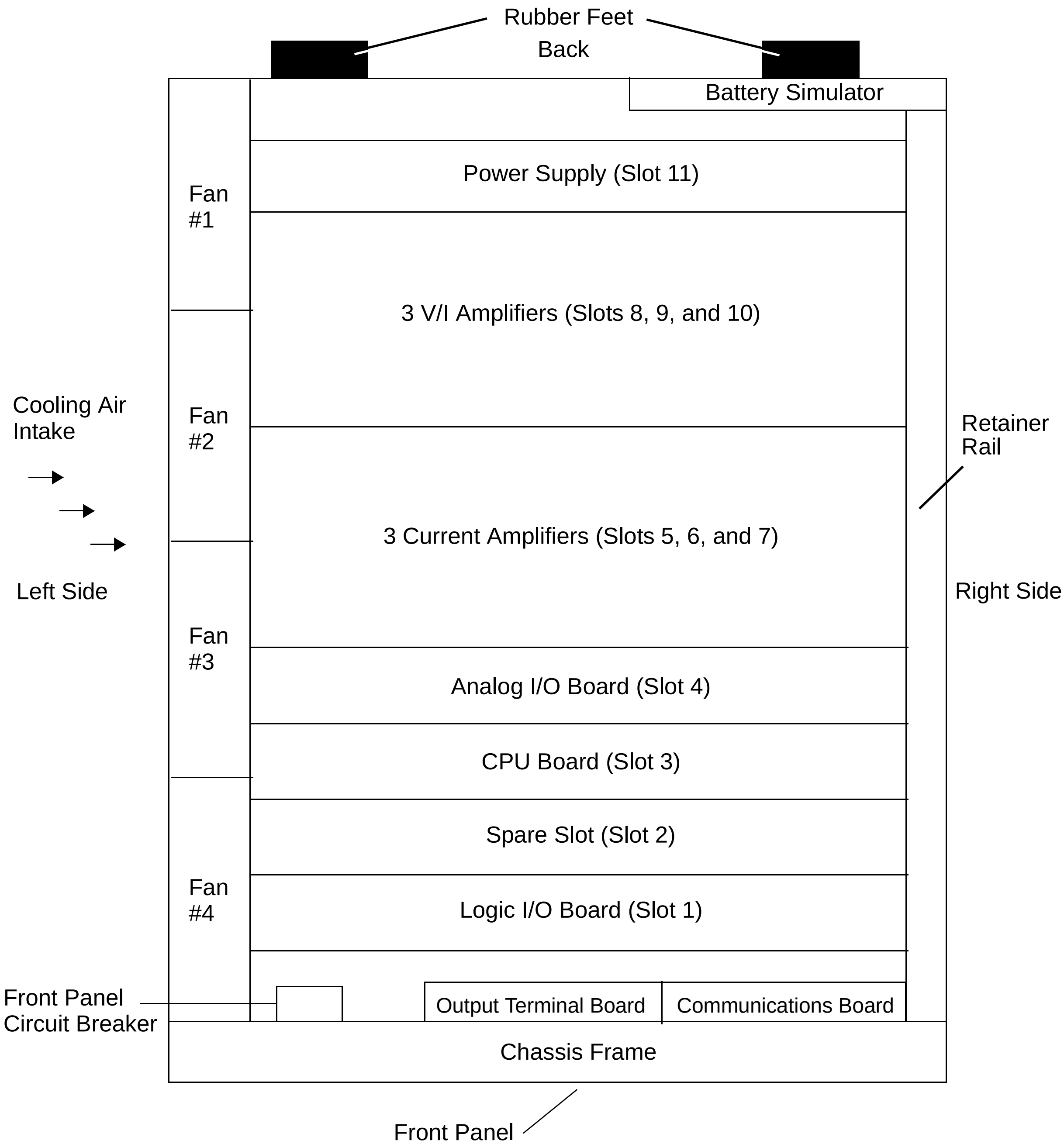


Figure 7.1 Top View of the F6150 Instrument

To remove the instrument cover:

1. Turn the instrument off.
2. Remove the power cord.
3. Use a flat head screwdriver to remove the top two rubber feet from the back of the instrument (Figure 7.2).

Figure 7.2 Rubber Feet at the Back of the Instrument

4. Remove the cover to expose the circuit boards and other components inside the instrument (Figure 7.3).

Figure 7.3 Instrument Rear with Cover Removed

5. Use a Phillips head screwdriver to remove the screws on the side of the capture rail.

6. Use a flat head screwdriver to remove the four screws on top of the capture rail.

7. Remove the capture rail.

8. Re-seat the circuit boards and ribbon cables to make sure all the connections are firm.

Power Up and Perform a Visual Check

1. Attach the power cord to the instrument and turn it on.
2. Observe the LED lights on the left side of each amplifier board.

   A green light indicates a good board. No light indicates a bad board. When the sources are active, the green LED on the right side of an amplifier board illuminates when that particular amplifier is supplying power.
3. Verify, through the audible sound, that the four cooling fans are operating.

Table 7.1 summarizes the information conveyed by the status indicator lights on the voltage and current amplifier boards.

Table 7.1 Status Indicator Lights on the Amplifier Boards

Indication	350V (Left Side)	SRC ON (Right Side)
Green	Instrument is turned on and the amplifier is healthy.	The amplifier is supplying power to an output terminal at the front panel.
Not Lit	The amplifier is faulty.	The amplifier is not supplying power.

Instrument Front Panel

To remove the front panel of the instrument, follow these steps:

1. Remove the 12 hex-head screws from the front panel.
2. Disconnect W2, W3, W4, W5, W6, and W7 from the Logic I/O board, CPU board, and Analog I/O board.
3. With fingers resting on the inside surface of the front panel, grasp the top of the black instrument frame.

4. Press the front panel out from the frame.

The front panel tilts forward and stops at about a 30° angle (Figure 7.4).

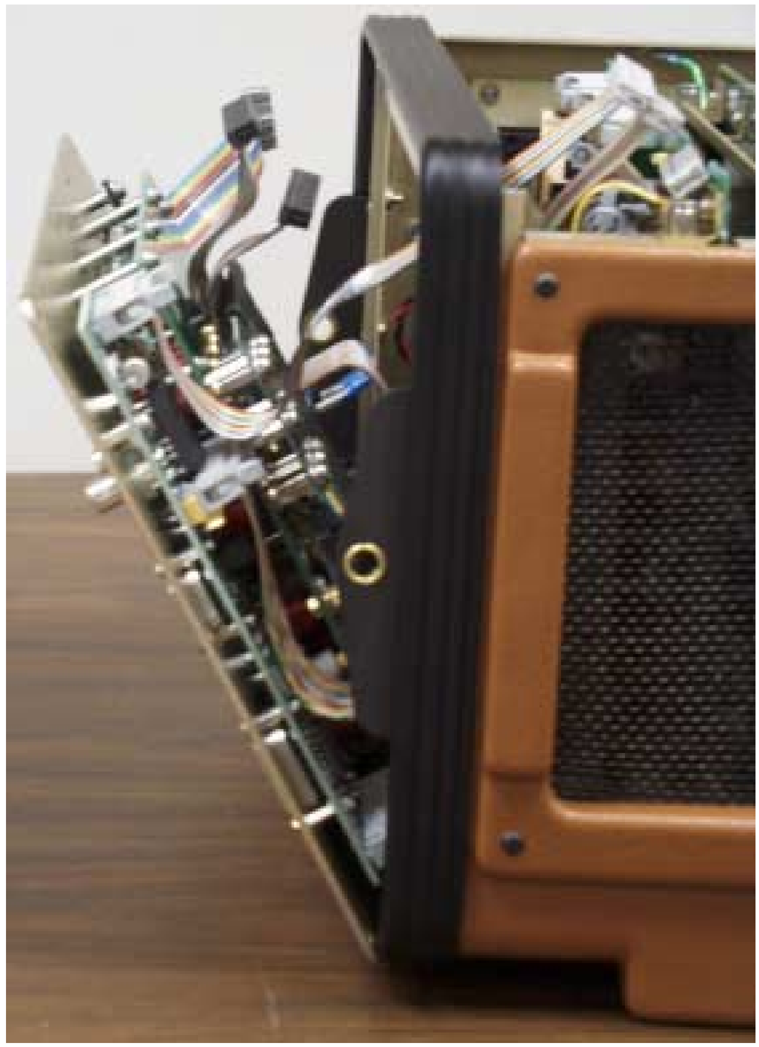


Figure 7.4 Instrument Front Panel Tilted Forward 30°

NOTE

A High Current Interface connects the lower part of the Output Terminal board to the motherboard (Figure 7.5). Carefully work this connection loose as the front panel tilts away from the chassis frame.

5. Gently lift the front panel up and away from the bottom of the instrument.
6. Lay the front panel face down on the table in front of the instrument (Figure 7.5).

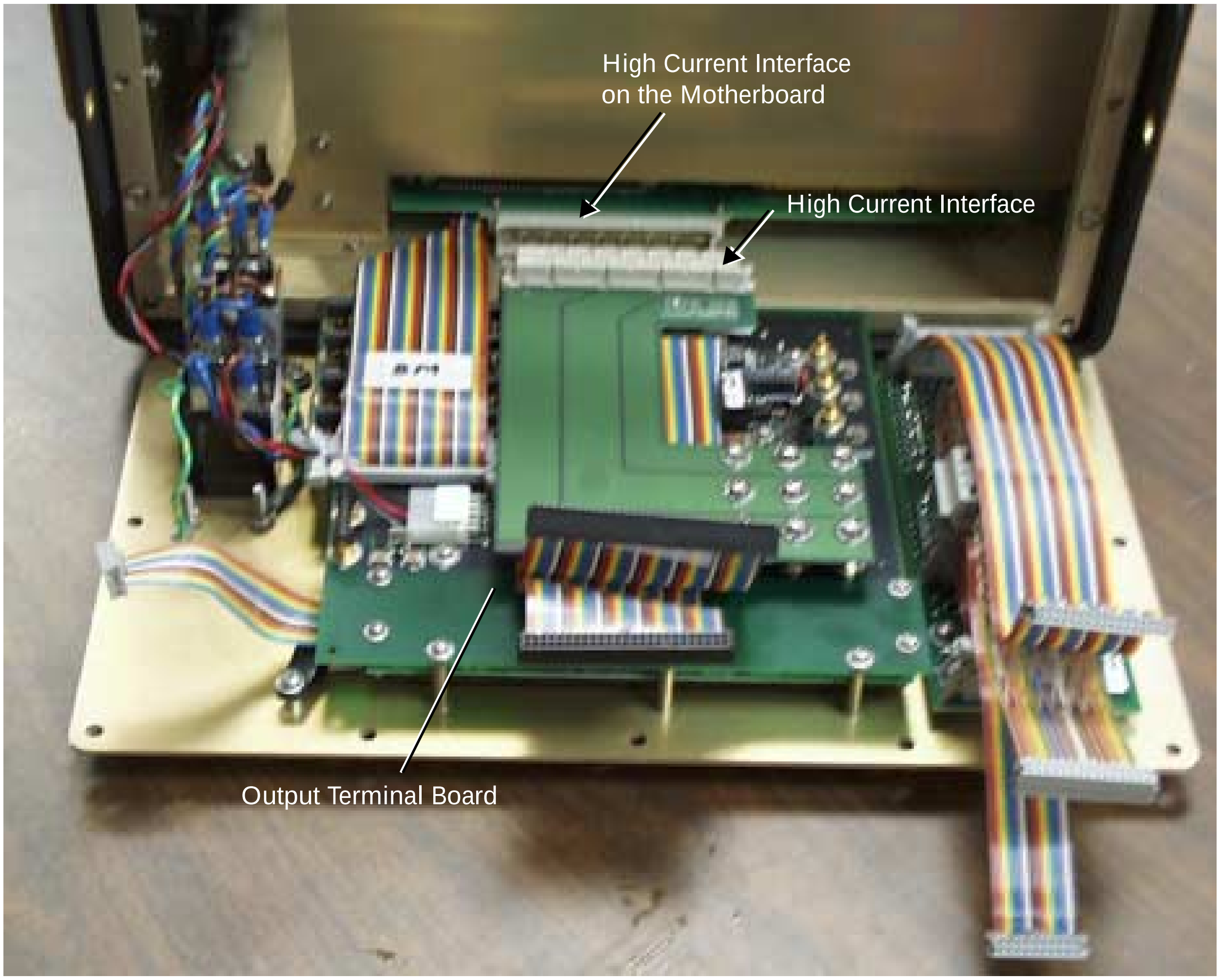


Figure 7.5 Front Panel Lying Face Down in Front of the Instrument

7. Disconnect wires W8 and W18 from the Output Terminal board.

8. Disconnect wires W2, W6, and W7 from the communications board and set them aside for use with the new front panel (Figure 7.6).

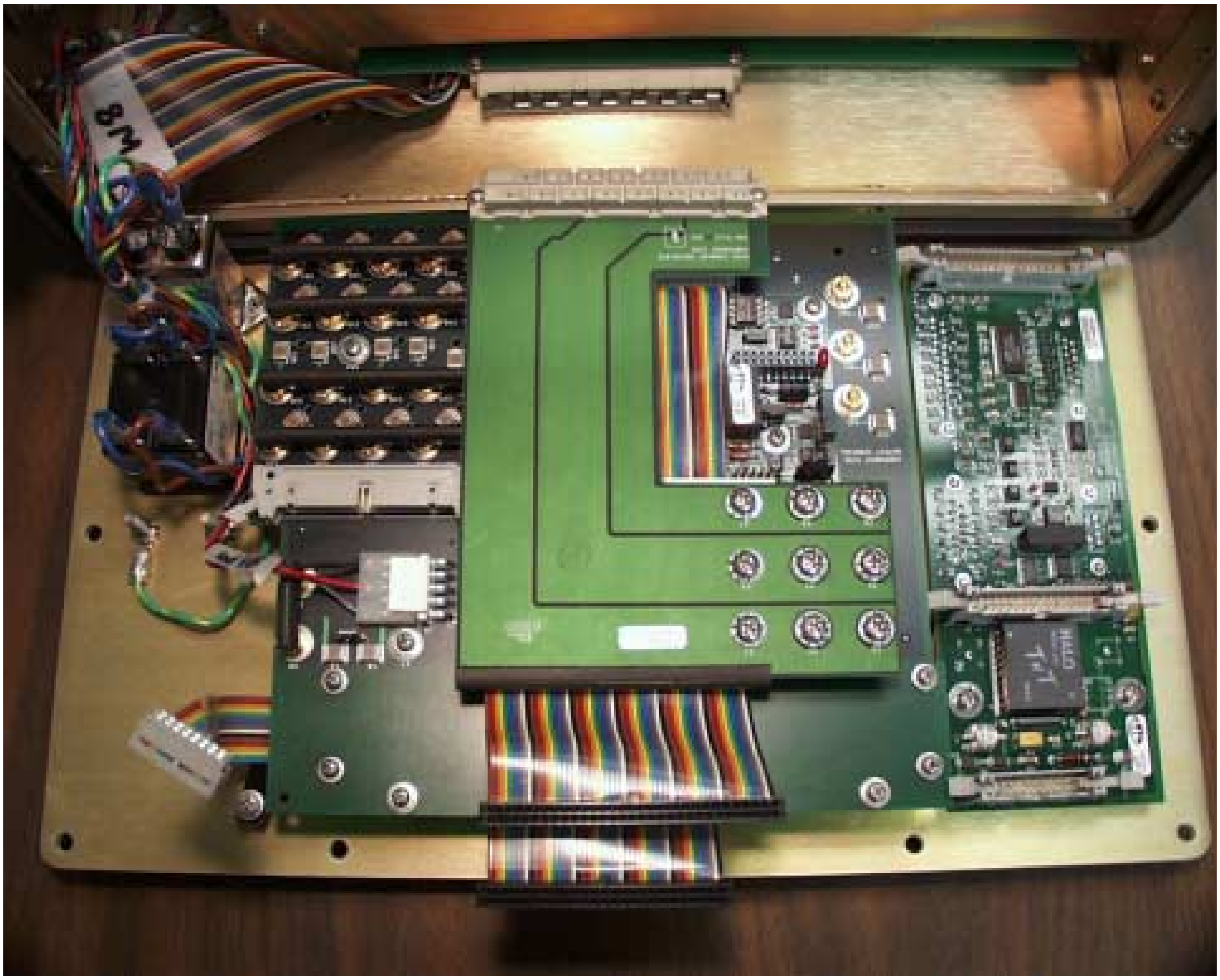


Figure 7.6 Instrument Front Panel with Wires Disconnected

9. Disconnect the blue and brown AC wires that lead from the circuit breaker back to the instrument.
    - Grasp the blue insulation.
    - Pull hard and work the connectors loose.
10. Use an open-ended wrench to remove the hex nut that secures the chassis ground wire to the circuit breaker.
11. Disconnect the ground wire.

Figure 7.7 shows the location of the AC leads and the ground wire.

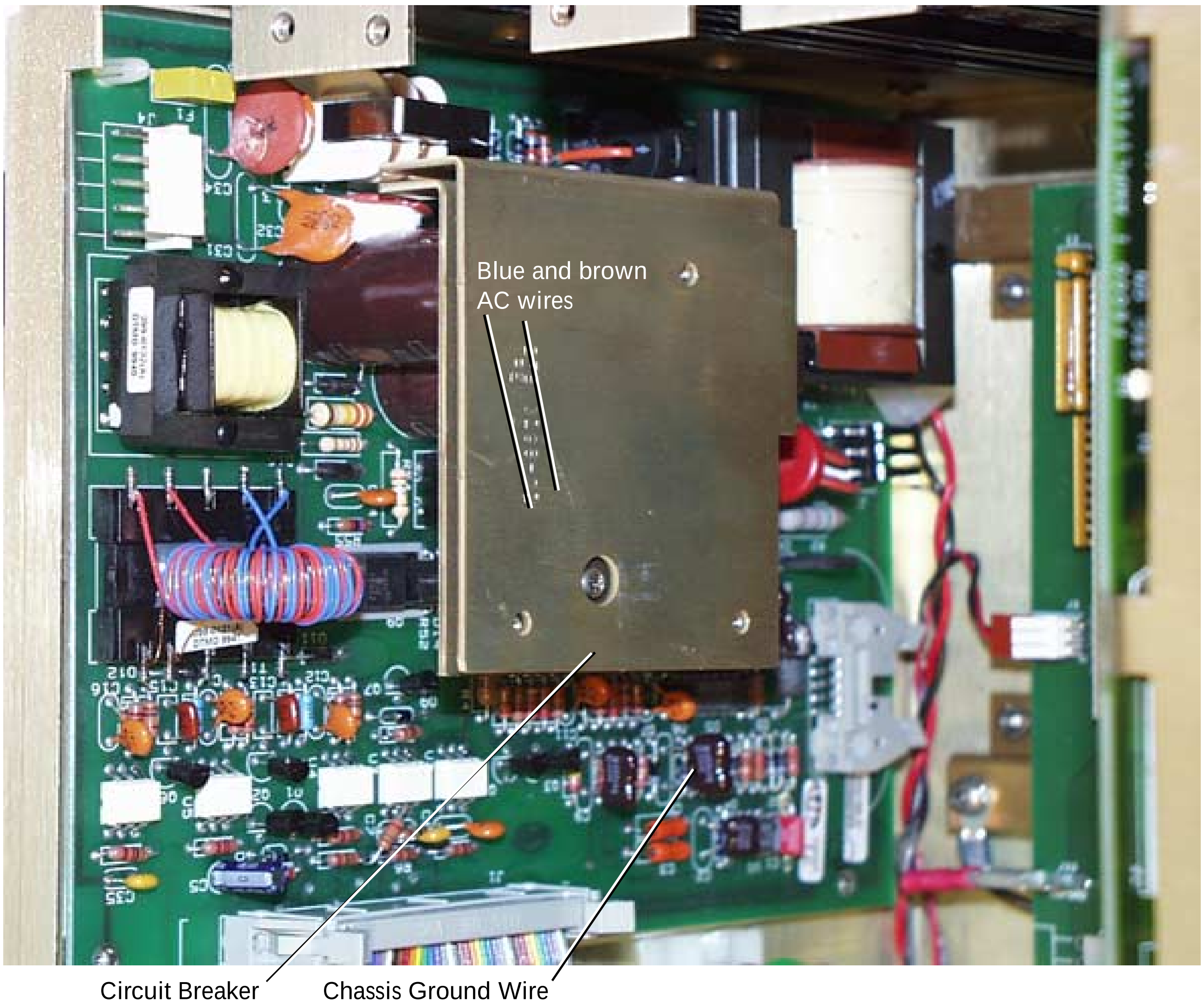


Figure 7.7 Wire Connections at the Front Panel Circuit Breaker

Figure 7.8 shows the circuit breaker after the blue AC lead, the brown AC lead, and the chassis ground wire have been disconnected.

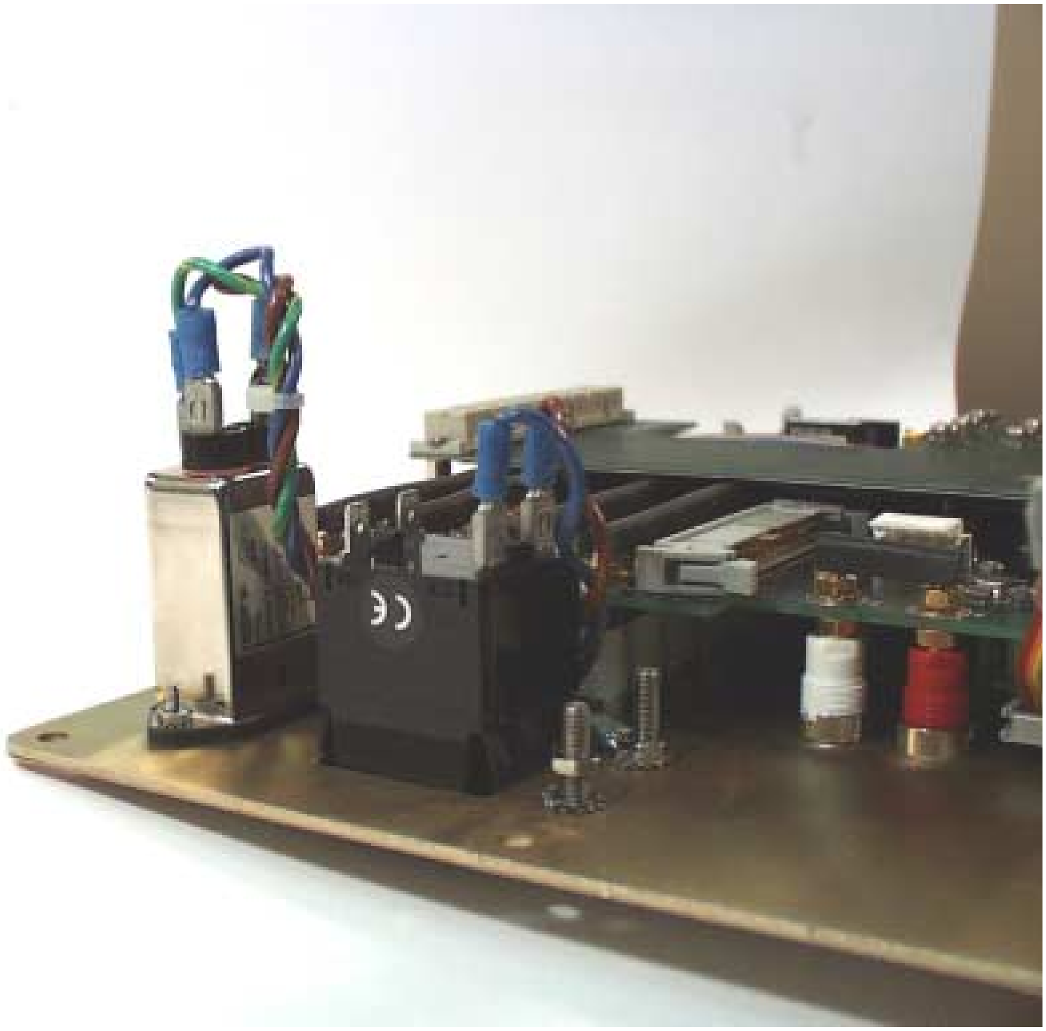


Figure 7.8 Circuit Breaker with Wires Disconnected

The front panel is now completely disconnected from the instrument.

To install a new front panel, reverse the above steps as follows:

1. Lay the new front panel face down in front of the instrument, with the communications board on the right.
2. Reconnect the ground wire in front of the circuit breaker.
3. Reconnect the blue and brown AC leads to the circuit breaker.
   - Connect the blue lead opposite the blue wire at the front of the circuit breaker.
   - Connect the brown lead opposite the brown wire at the front of the circuit breaker.
4. Reconnect wire W8 to the Output Terminal board.
5. Tilt the front panel up and rest the bottom of the front panel inside the bottom of the black instrument frame.
6. Line up the connector at the bottom of the High Current Interface board with its mate on the motherboard.
7. Tilt the front panel into a vertical position and press the bottom of the panel until the High Current Interface connector mates.
8. Secure the front panel with 12 hex-head screws.
9. Reconnect W2, W3, W4, W5, W6, and W7 (see Table 7.2).
10. Replace the instrument cover.

Except for W16, all the wires in the F6150 connect to the communications board or the output terminal board on the instrument front panel. Table 7.2 lists these wires and their connections.

Table 7.2 Wire Connections

Wire Number	Connects From	Connects To
W2	Communications board	Logic I/O board
W3	Output Terminal board	Logic I/O board
W4	Output Terminal board	Logic I/O board
W5	Output Terminal board	Logic I/O board
W6	Communications board	CPU board
W7	Communications board	Analog I/O board
W8	Output Terminal board	Motherboard
W16	Power supply	Battery simulator
W18	Power Supply	Output Terminal board

Communications Board

The communications board supports the input and output terminals on the right side of the front panel. To replace the communications board, first remove the instrument front panel, but *do not disconnect the leads from the circuit breaker* on the left side of the panel.

To remove the instrument front panel:

1. Remove the 12 hex-head screws from the front panel.

2. Disconnect W2, W3, W4, W5, W6, and W7 from the Logic I/O board, CPU board, and Analog I/O board.

3. With fingers resting on the inside surface of the front panel, grasp the top of the black instrument frame.

4. Press the front panel out from the frame.

The front panel tilts forward and stops at about a 30° angle (Figure 7.4 on page 7-7).

NOTE

A High Current Interface connects the lower part of the Output Terminal board to the motherboard. Carefully work this connection loose as the front panel tilts away from the chassis frame.

5. Gently lift the front panel up and away from the bottom of the instrument.

6. Lay the front panel face down on the table in front of the instrument (Figure 7.5 on page 7-8).

7. Disconnect wires W8 and W18 from the Output Terminal board.

8. Disconnect wires W2, W6, and W7 from the communications board and set them aside for use with the new front panel (Figure 7.6 on page 7-9).

The communications board is ready to be removed (Figure 7.9).

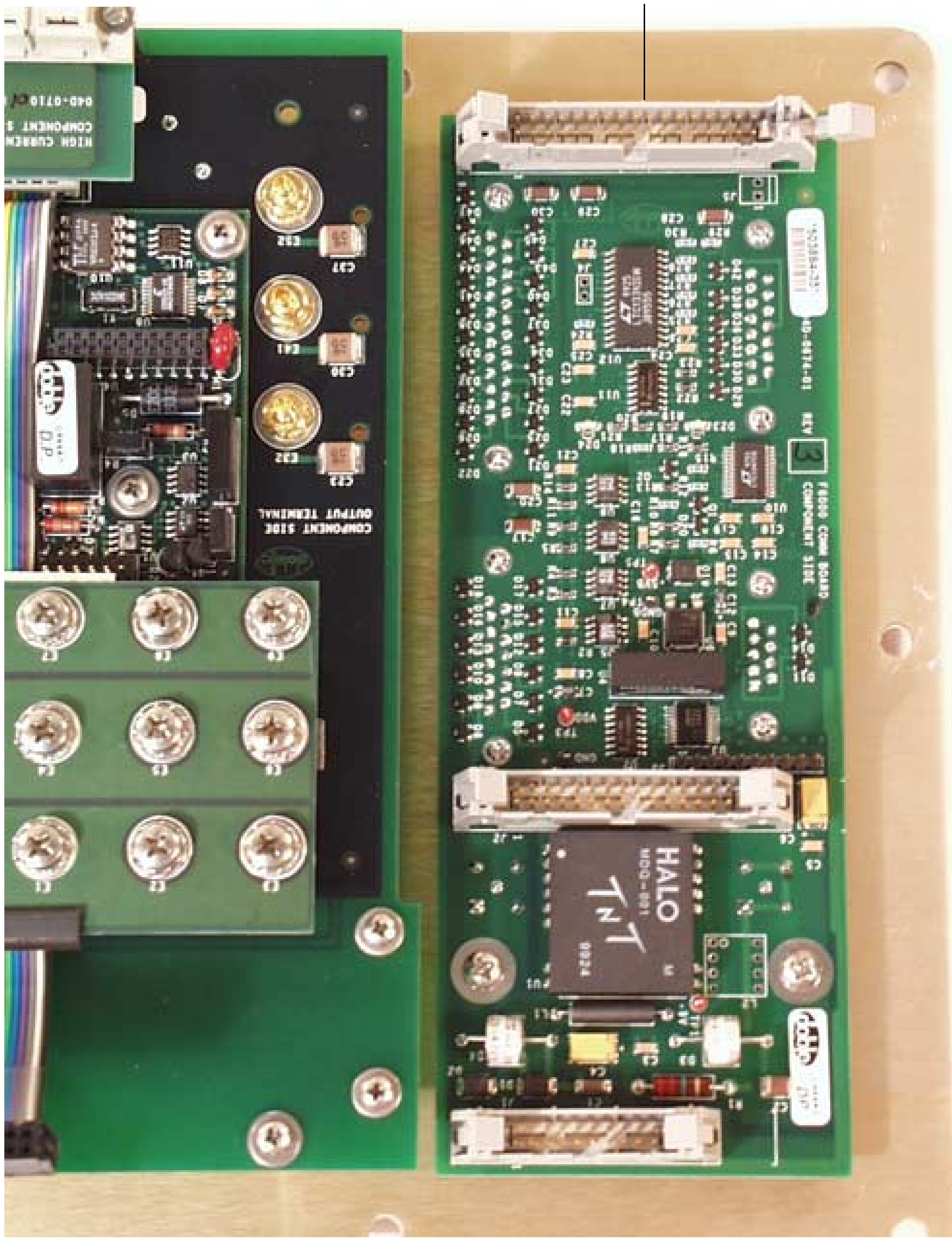


Figure 7.9 Communications Board Ready for Removal

To remove the communications board from the instrument front panel:

1. Remove the two Phillips head screws that secure the communications board to the front panel.
2. Tilt the front panel up until it leans against the instrument.
3. Use an open-ended wrench or pliers to remove the 8 nuts on the right side of the front panel (two for each of the four connectors). See Figure 7.10.

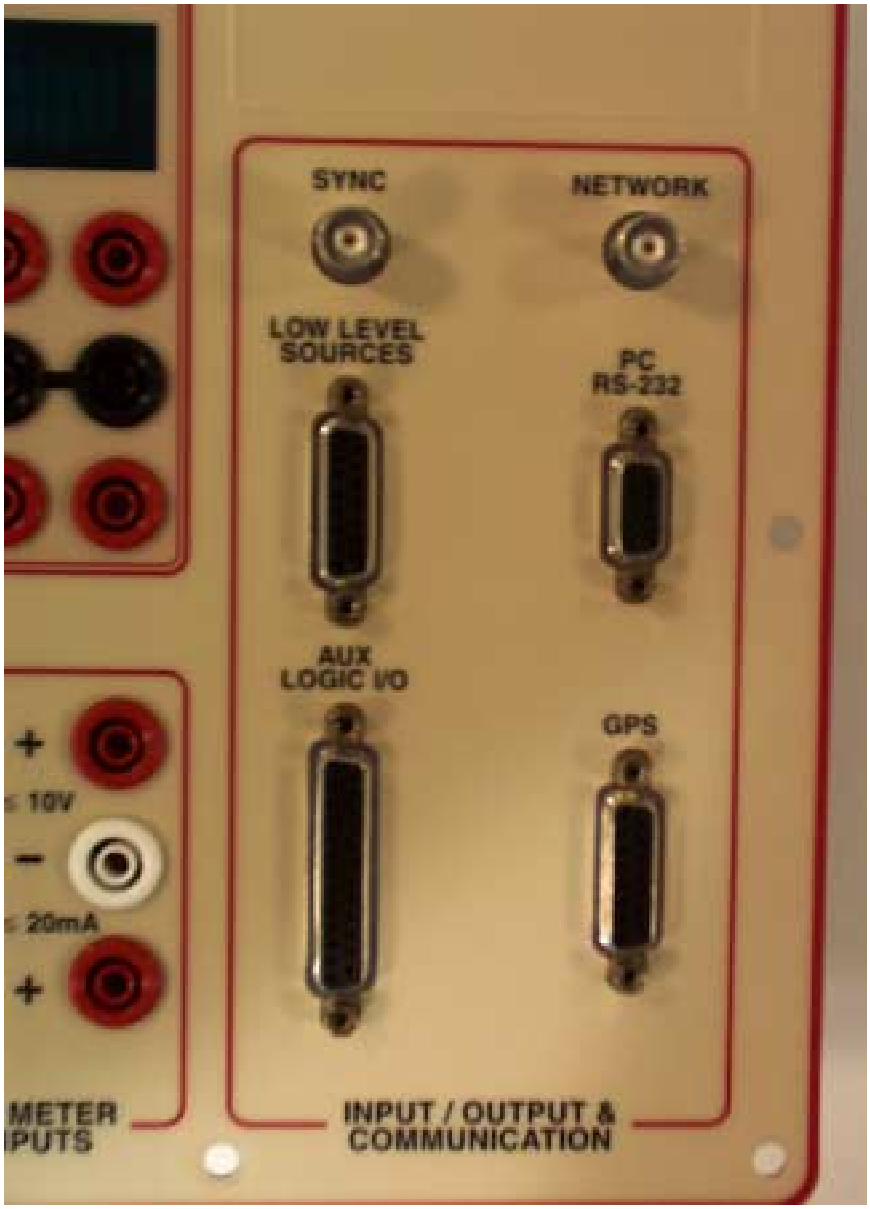


Figure 7.10 Right Side of the Instrument Front Panel

4. Tilt the front panel back down until it lies face down on the table.
5. Lift the communications board off the front panel.
6. Place the new communications board in its position on the right side of the front panel.
7. Secure the communications board to the front panel with the two Phillips head screws.
8. Use an open-ended wrench or pliers to turn the 8 nuts on the front of the front panel.
9. Tilt the front panel back into place.

   Be sure the High Current Interface at the bottom of the front panel mates properly with the connector on the motherboard.
10. Secure the front panel to the instrument chassis with the 12 hex-head screws.
11. Reconnect wires W2, W3, W4, W5, W6, and W7 (Table 7.2 on page 7-13).
12. Replace the instrument cover.

Circuit Board Replacement

Doble Customer Service may recommend that a circuit board be replaced to remedy an operating problem. None of the solid-state circuit boards requires user calibration or adjustment. Table 7.3 contains a list of slot numbers and circuit boards in the F6150.

Table 7.3 Circuit Boards in the F6150

Slot Number	Circuit Board
Slot 1	Logic I/O board
Slot 2	Spare slot
Slot 3	CPU board
Slot 4	Analog I/O board
Slot 5	Current amplifier #1
Slot 6	Current amplifier #2
Slot 7	Current amplifier #3
Slot 8	Voltage amplifier #1
Slot 9	Voltage amplifier #2
Slot 10	Voltage amplifier #3
Slot 11	Power supply

NOTE

Remove or insert printed circuit assemblies carefully to avoid damage to their mating connectors. To ensure that new boards go into their correct locations, replace them individually.

Contact Doble for a replacement circuit board, or obtain one from your company inventory of replacement parts, if available.

To replace a circuit board:

1. Turn the instrument off.
2. Remove the power cord.
3. Disconnect all external cables from the instrument.
4. Remove the instrument cover.
5. Remove the capture rail.
6. Disconnect any circuit board ribbon cables required to perform the replacement.
7. Unscrew the captive fasteners on the circuit board.
8. Firmly grasp the defective board and pull it straight up.
9. Place the new board firmly in the slot and make sure it is squarely seated.
10. Re-attach ribbon cables if necessary.

    See Table 7.2 on page 7-13 to verify the placement of all cables.
11. Replace the capture rail.
12. Attach the power cord and turn the instrument on.

    If the new board is a current or a voltage amplifier, verify that the healthy status indicator light on the left side of the board is on.

Battery Simulator

The battery simulator is at the back of the F6150 (Figure 7.11).

Figure 7.11 Battery Simulator Mounted at the Back of the Instrument

To remove the battery simulator, perform the following procedure:

1. Turn the instrument off.
2. Remove the power cord.
3. Remove the instrument cover.
4. Remove the capture rail.
5. Remove the power supply circuit board from slot 11.
6. Disconnect wire W16 from the power supply.

7. Remove the voltage amplifiers from slots 8, 9, and 10 (Figure 7.12).

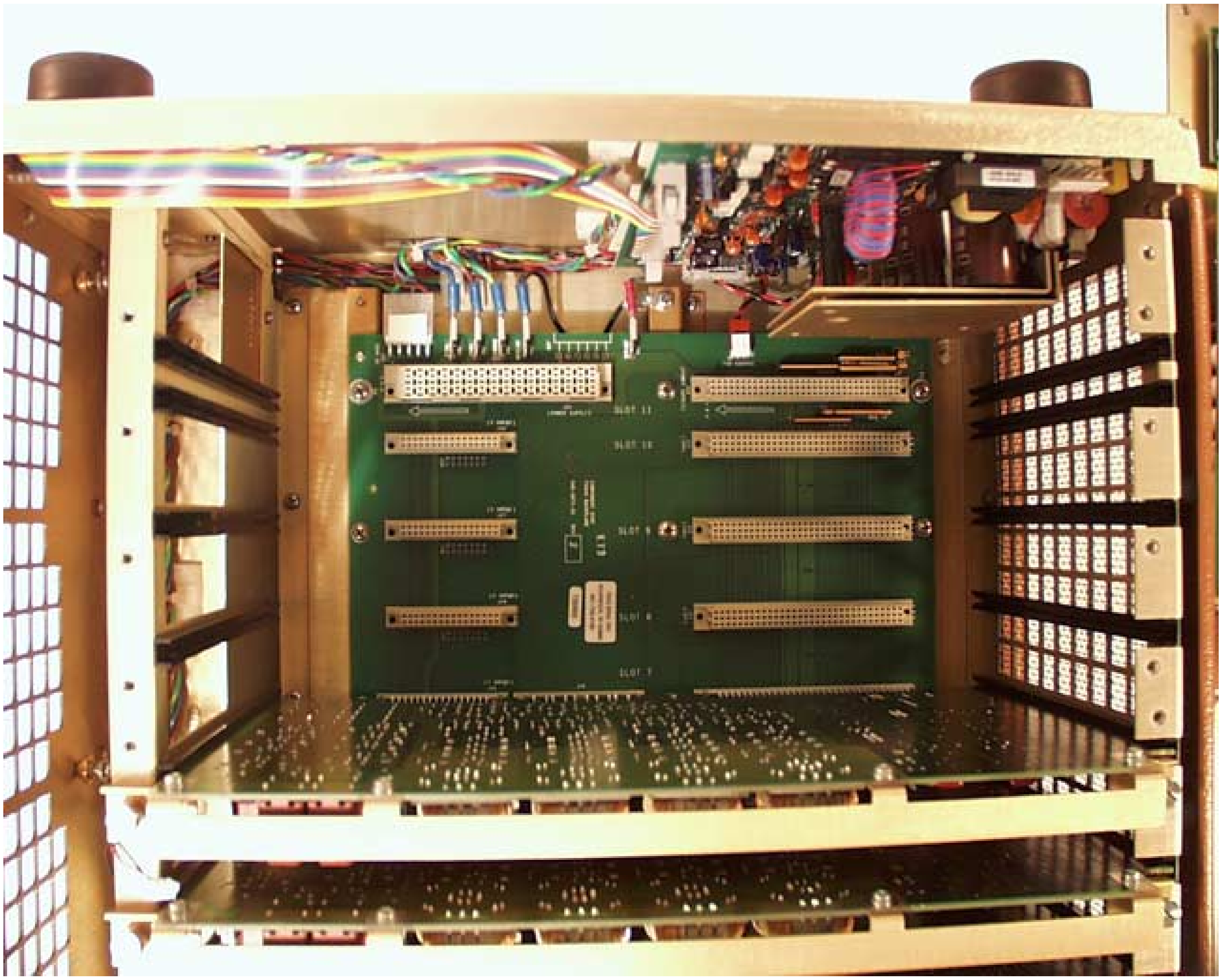


Figure 7.12 Removal of the Power Supply and Voltage Amplifiers for Access to the Battery Simulator

NOTE

The power supply is easily identifiable, but each voltage amplifier looks the same. Label each voltage amplifier with its slot number when it is removed from the instrument, and return it to its own slot when the instrument is reassembled. The instrument will not be properly calibrated if an amplifier is not returned to its original slot.

8. Use a Phillips head screwdriver to remove the screws in the upper left corner and the lower left corner of the board.

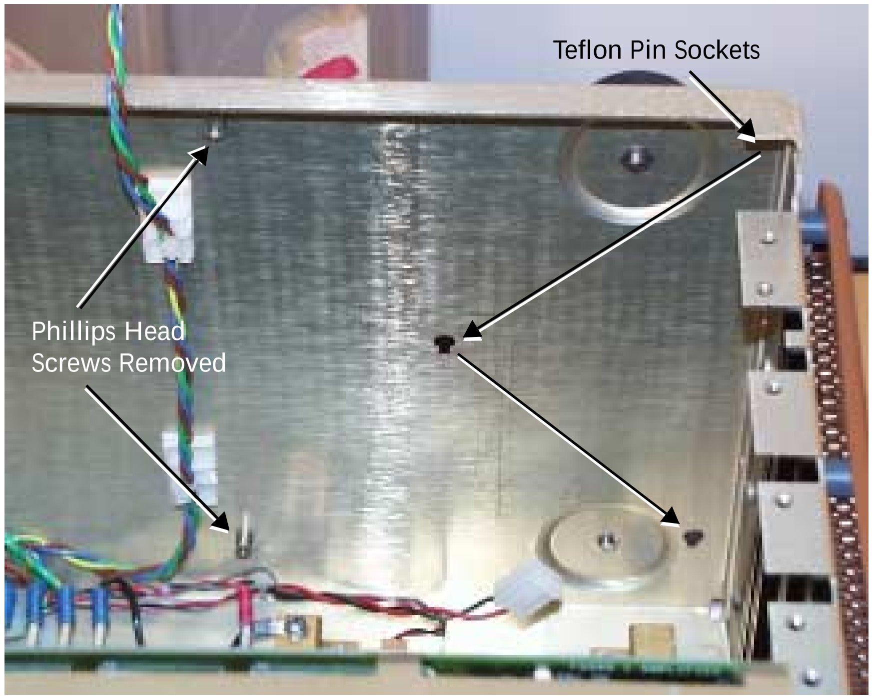


Figure 7.13 Back Panel After Removal of Battery Simulator

9. Disconnect the wire from connector J4 in the upper right corner of the board.

10. Lift the circuit board up, then pull it out from the back panel.

Three teflon pins hold the battery simulator to the rear panel of the instrument. These pins are located in the upper right corner, the center, and the lower right corner of the circuit board. Work all three pins loose from their sockets in the rear panel. Figure 7.13 shows the location of the pin sockets on the instrument chassis.

11. Disconnect the wire from connector J3 at the bottom of the board.

12. Lift the board out of the instrument.

13. To replace the battery simulator, reverse steps 1-11.

NOTE

When replacing the Battery Simulator, reconnect wire W16 to the power supply before seating the power supply in its slot, as it is difficult to reach the wire connector after the power supply board is seated.

Cooling Fans

The cooling fans are located on the left side of the instrument.

Perform the following procedure to replace a cooling fan:

1. Turn the instrument off.
2. Remove the power cord.
3. Remove the instrument cover.
4. Remove the eleven hex-head screws from the left side of the instrument.
5. Remove the side frame and protective screen from the side of the instrument.
6. Remove the three Phillips head screws above the fans from the instrument chassis (Figure 7.14).

Figure 7.14 Side View of the Instrument Before Removal of Cooling Fans

7. Remove the two Phillips head screws that hold the top retaining bracket in place.

NOTE

The two screws that secure the retaining bracket are of different length (Figure 7.15). When the bracket is replaced during reassembly, put each screw in its original position.

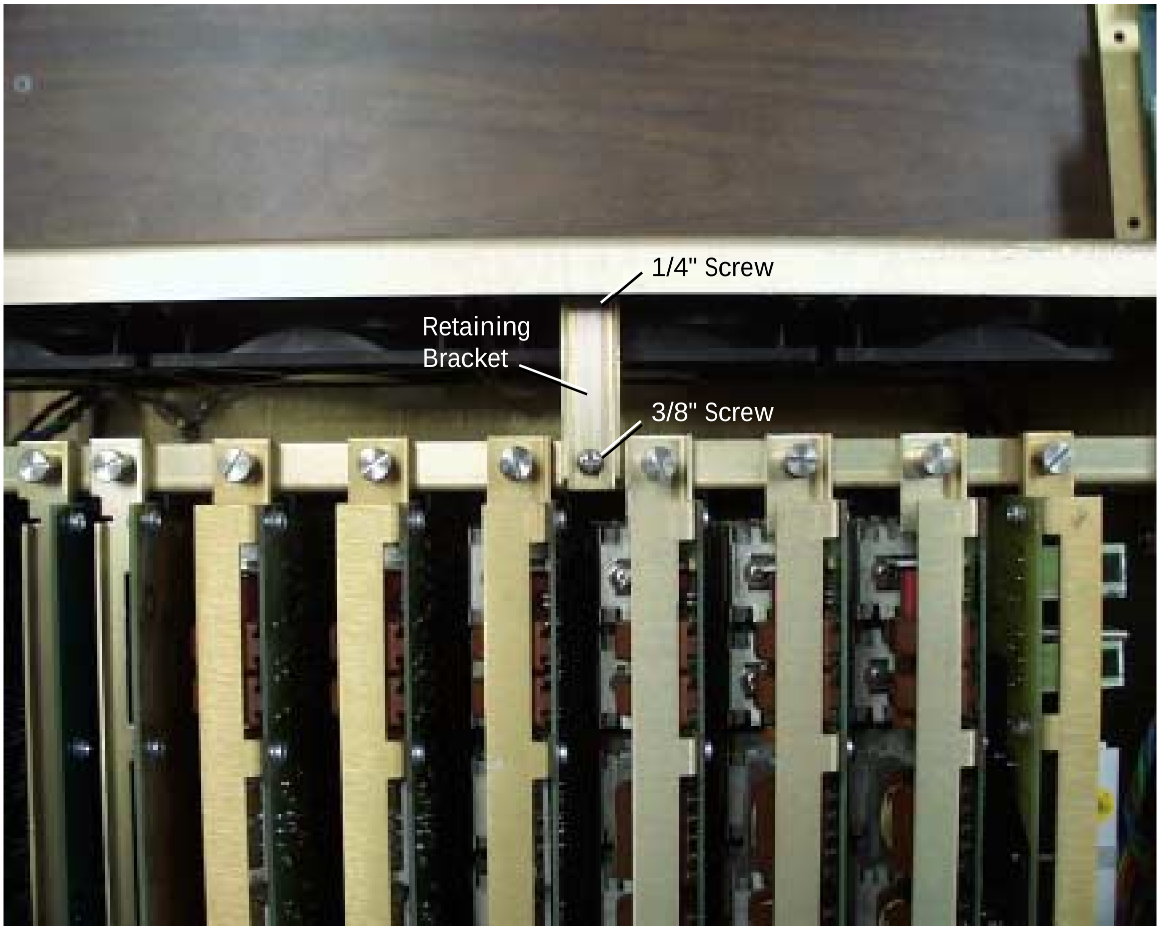


Figure 7.15 Retaining Bracket for Cooling Fans

8. Pull the fan assembly up out of the instrument until all four wire connectors are exposed (Figure 7.16).

Figure 7.16 Cooling Fans with Wires Connected

9. Disconnect the wire from each of the four fans.

10. Pull the fan assembly the rest of the way out of the instrument.

11. Use an open-ended wrench to remove the four hex nuts that secure the fan to be replaced (Figure 7.17).

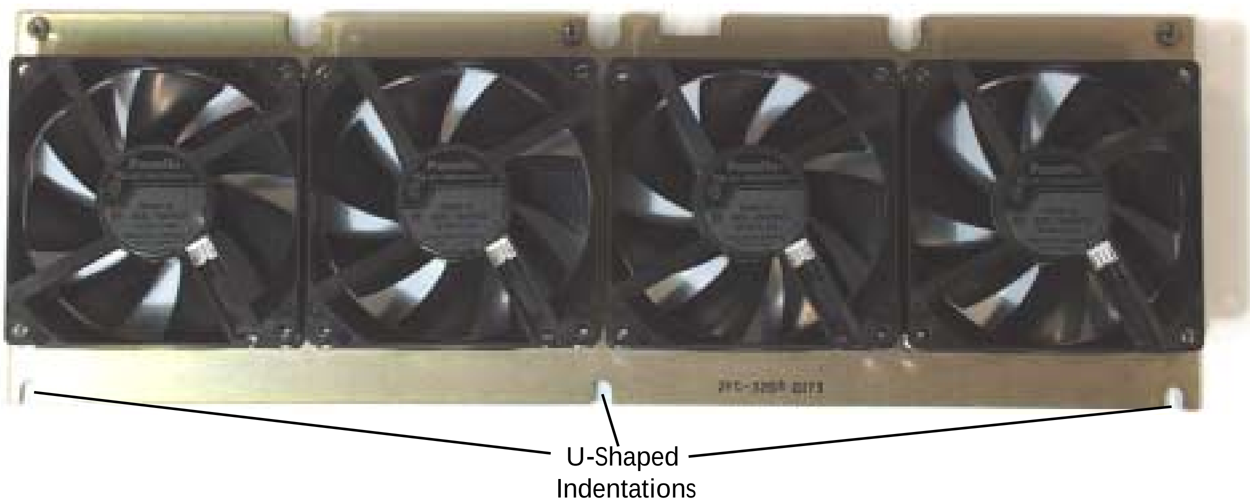


Figure 7.17 Cooling Fan Assembly

12. Pull the defective fan off of its supporting plate.
13. Install the replacement fan.
14. Secure the fan with the four hex nuts.
15. Reconnect the four wires, one to each fan.
16. Lower the fan assembly into the instrument until the bottom of the assembly rests on the three spring-loaded supports attached to the chassis.

    Verify that the U-shaped indentations in the fan plate (Figure 7.17) line up with the spring-loaded supports.
17. Push the fan assembly down onto the spring-loaded supports.
18. Replace the retaining bracket above the fan assembly.
19. Put the two Phillips head screws used to secure the bracket in their original positions.
20. Replace the three Phillips head screws that fasten the top of the fan assembly to the chassis.
21. Replace the side frame and protective screen with the eleven hex-head screws.

Verify the Replacement

To determine whether the replacement procedure is successful:

1. Turn the instrument on.
2. Monitor the messages on the front panel as the instrument goes through its startup sequence.
3. Check the status indicator light on the left side of each amplifier board.

   If the replacement is successful, the status indicator lights are green and the error message on the front panel is cleared.
4. Repeat the test sequence that led to the error.
5. Check the instrument front panel for error messages.
6. Check the F6Meter Control Panel for source errors.

Replaceable Components and Cables

Table 7.4 lists the part numbers of field replaceable items.

Table 7.4 Field Replaceable Parts

Field Replaceable Part	Part Number
Battery Simulator Board	04D-0598-01
CPU-F6 Board	04S-0670-01
Logic I/O Board	04S-0672-01
Analog I/O Board	04S-0673-01
F6 Communications Board	04S-0674-01
Output Terminal Board	04S-0675-01
115 V DC Power Supply Board	04S-0676-01
230 V DC Power Supply Board	04S-0676-02
I Amplifier Board	04S-0678-01
V/I Amplifier Board	04S-0679-01
DC Meter Board	04S-0680-01
Front Panel Assembly	03D-1356-01

Table 7.5 lists all the cables used with the F6150. If a system failure is traced to a particular cable, ensure that the cable is properly seated and connected before replacing it. Contact Doble Customer Service to order replacement cables.

Table 7.5 Cable and Adapter Replacement List

Part Number	Description
05B-0616-01	Assy, Cable, I Output
05B-0617-01	Assy, Cable, V Output
05B-0618-01	Assy, Cable, Logic I/O
05B-0619-01	Cable, Adapt #4 R LUG-3x4 mm, F
181-0088	Cord, Power, 14AWGX3, USA Plug
181-0118	Cable, RG58C/U, 500 HM 20 A M/M
212-0527	Adapter, SM, Spade LUG-4 mm, Black
212-0528	Adapter, SM, Spade LUG-4 mm, Red
212-0529	Adapter, SM, Spade LUG-4 mm, White
401-0167	Cable, RS-232, INSTR-PC 10 Ft/3.05 Meter
401-0157	Terminator, In-line 50 Ohm BNC

8. Safety and Maintenance

Chapter 8 discusses rules for the safe operation of the F6150, and several topics related to maintenance of the unit.

F6150 Rules for Safe Operation

Safe operation of the system requires adherence to the following guidelines:

- *Do not* use the F6150 unless a safety ground is connected.
- *Do not*, for any reason, cut or remove the grounding prong from the power cord.
- *Do not* defeat the AC power input source ground connection, and verify that the power connections have proper hot and neutral polarity.
- Use the correct electrical line voltage to avoid an electrical short circuit, overheating and shocks. If in doubt, check the electrical rating label attached to each unit.
- Always turn the power OFF and disconnect the F6000 from line power before reaching into the instrument.

NOTE

The F6000 contains capacitors capable of storing hazardous voltages even after the instrument is turned off and the power cord is removed. Always proceed with caution when reaching into the instrument.

- Never insert metal objects, such as screwdrivers or paper clips, inside the instrument while power is ON.
- Unplug the instrument if it is not to be used for an extended period of time, or before cleaning.
- If the instrument is dropped, have it checked by a qualified service technician before placing it back in service. Dropping the instrument can disturb the insulation system.
- Do not place the instrument in excessively warm or humid locations.
- If the instrument is dropped or physically damaged, or if spilled liquid penetrates the instrument case, return the instrument to Doble for repair.

The F6150 output and measurement terminals are intended for Installation Category I usage. The F6150 power input is intended for connection to an Installation Category II (overvoltage category) AC main supply. The F6150 is intended for indoor use only.

Cleaning the F6150

To clean the instrument, sponge the instrument covers and panels with a mild soap solution. Observe the following precautions whenever the instrument is cleaned:

- Disconnect the instrument's power cord and all other external cables before cleaning or removing the instrument cover.
- Do not use household cleaners containing chlorinated or abrasive compounds.
- Do not spray liquids directly onto the instrument.
- Do not use flammable liquids, such as gasoline or lighter fluid, for cleaning electrodes, electrical components or moving parts.

Customer Service

To request assistance with any question or problem, call Doble Engineering Customer Service at 617-926-4900 or send e-mail to customerservice@doble.com. Before contacting Customer Service for help, please take the following preliminary steps:

- Review the pertinent portions of this user guide.
- Check all cable connections.
- Work through the diagnostic flow charts shown in Figure 6.1 (page 6-2) and Figure 6.2 (page 6-3) to identify and isolate problems in F6150 operations.
- Perform the "Component Checkout Procedures" on page 6-9 to verify component operations.
- If the instrument fails during a transducer test and another instrument is available, try the test using the second instrument.
- If the instrument fails during a transducer test, compare the requirements in the test plan to your test setup and source configuration.

If possible, have the instrument set up near a telephone to facilitate telephone assistance. Please have the following available when calling Customer Service:

- Date of purchase.
- The instrument serial number, which is found on the bottom outer case of the F6150.
- The hardware configuration and software revision, which are displayed on the instrument front panel during the bootup sequence.
- A precise description of the problem. Include any error messages that have appeared, and the sequence of events leading to the messages.
- The solutions that have been tried.
- Electronics tool kit and digital multimeter, in case Customer Service suggests that a board or subassembly be removed.

Write down the name of the Customer Service representative, and ask to speak to the same person during subsequent calls. Write down any instructions the representative gives during a service call.

Safe Packing of the F6150

If troubleshooting checks and the replacement of defective parts in the field fails to correct a problem with the instrument, the F6150 may need to be returned to Doble for servicing. Contact Doble Engineering Customer Service at 617-926-4900 before shipping the instrument.

To prepare the F6150 for shipping, disconnect all external cables and attach the cover that protects the front panel of the instrument. Use the original packing materials if they are available. If the original packing materials are not available, pack the instrument for shipment as for any fragile electronic equipment.

Triple-wall shipping containers can be ordered from Customer Service for a nominal charge (Doble Part # 903-0045). Alternately, the instrument may be packed using either of the following methods:

- Double-wall cardboard box with a minimum of 2-inch thick poly foam padding all around.
- Wooden crate with a minimum of 2-inch thick poly foam padding all around.

NOTE

Doble Engineering is not responsible for shipping damage. Carefully protect each instrument from shipping and handling hazards. Ensure that protective covers are securely in place.

Send the instrument to Doble Engineering, freight pre-paid, unless other arrangements have been authorized in advance by Doble Customer Service. The shipping address is:

Customer Service Manager
Doble Engineering Company
85 Walnut Street
Watertown, MA 02472-4037

Before returning the instrument to Doble Engineering, contact Customer Service to obtain a *Repair Work Order* (RWO) number. The RWO number must be attached to the instrument, as it is used to track the instrument through the repair cycle.

Do not return instruction manuals and cables with the instrument, unless Doble Customer Service requests these items.

Appendix A. Software Maintenance

Use the utilities available in the F6Meter Control Panel to accomplish routine maintenance of the software:

- The *F6000 Flash Loader* installs revised firmware.
- *F6000 Key Code Update* installs F6000 options.

Open both utilities from the **Tools** pull-down menu in the top menu bar.

NOTE

When the F6000 Instrument boots up, the current firmware revision number and the options installed appear in the display on the instrument front panel.

Flash Loader

The Flash Loader installs revised firmware in the F6000 Instrument. Click **Tools|F6000 Flash Loader** in the top menu bar to open the program. The **Flash Loader** display appears (Figure A.1).

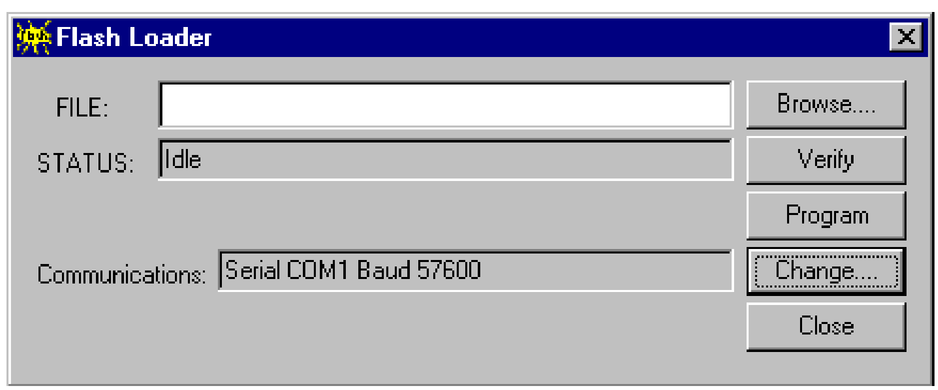


Figure A.1 Flash Loader

The fields and buttons in the Flash Loader display perform these functions:

File	Displays the name of the package file to load.
Status	Shows the progress of the last action.
Communication	Displays the current settings for communication between the computer and the F6000 Instrument.
Browse	Browses for the location of the package file to load.
Verify	Verifies that the current firmware version is compatible with the selected package file.
Program	Downloads the selected package file to the F6000 Instrument.
Change	Changes the communication settings.
Close	Closes the Flash Loader and aborts any actions in progress.

Loading New Firmware

Firmware is supplied on a 3.5" disk and is loaded from a computer via an RS-232 serial connection. Update the F6000 firmware as follows:

1. Click **Tools|F6000 Flash Loader**.
2. Click **Browse** and locate the package file to be loaded.

   The release notice contains the name and location of the package file. The name of the package file appears in the *File* field.
3. Click **Verify** to confirm that the current firmware version is compatible with the selected package file (refer to the Note below).

   The *Status* field of the **Flash Loader** displays the progress of the verification in percent complete format. When complete, the *Status* field displays *Idle*.
4. Click **Program** to update the firmware with the selected package file.

If necessary, click **Change** to modify the settings for communication between the computer and the F6000 Instrument.

NOTE

Check the Marketing Release Notice to ensure that the firmware enables all required options and enhancements, and is compatible with the installed version of the F6Meter Control Panel.

Use **Verify** to determine whether a package file is already in the FLASH. The same determination can be made by comparing the software revision of the F6150 with the one in the package file. The software revision of the F6150 displays at power on. A package file consists of ASCII data followed by a Control-z (DOS end of file character) followed by binary data. The software revision is in the second line of the package file as an ASCII string. The package file can be viewed in a text editor such as Windows Notepad, or by using the **type** command in a DOS window.

Communications Parameters

If the revised firmware does not load successfully, check the setup for communication between the computer and the F6000 Instrument. To verify or change the communications settings:

1. Click **Change** in the **Flash Loader** display.

   The **Set Communications Parameters** display appears (Figure 8.1).

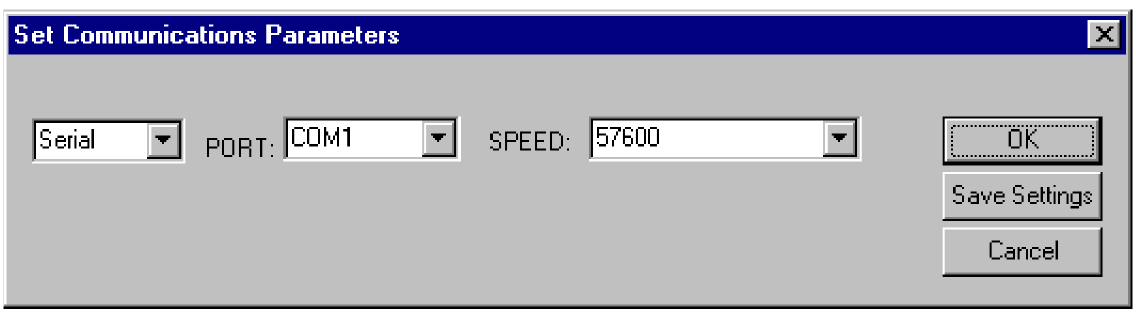


Figure 8.1 Set Communications Parameters

2. Select the correct setting from each of the three pick lists in the display:
   - Connection type: Serial or Ethernet
   - Port: COM1 through COM4
   - Speed: The connection speed must be 57,600 baud per second
3. Click **OK** to save the settings and close the display.

   To abort the action, click **Cancel**.

To make the settings in the **Set Communications Parameters** display the default settings for future firmware updates, save them in the INI file.

To do so:

1. Click **Save Settings**.

   The **FlashLoader** dialog box appears (Figure A.2).

2. Click **Yes** to save the settings in the INI file.

   The **FlashLoader** dialog box closes.

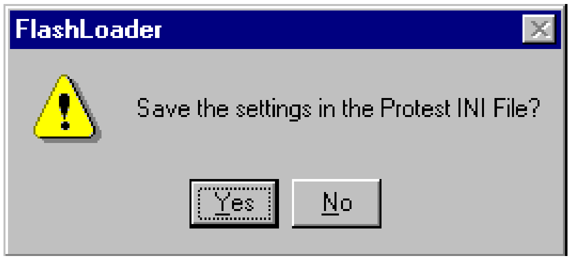


Figure A.2 Save Communications Settings

The Flash Loader normally updates the FLASH by communicating with the application that is already in the FLASH. The link is made using either serial or Ethernet communication. If there is no valid application in the FLASH, the loader updates the FLASH by communicating with the boot loader that is already in the FLASH. In this case, the update can only be done using serial communication.

Key Code Update

The Key Code Update utility installs options available for the F6000 Instrument (see ”Options” on page 1-5). These options require a Doble Engineering software key for access. Obtain the software key from the Doble Engineering Company when the option is purchased. The F6000 options available to the operator are identified by numbers that scroll in the Instrument Display after bootup.

NOTE

The Key Code Utility is only required when options are to be installed in the field, as all ordered options are installed before delivery.

To update the F6000 options:

1. Click **Tools|F6000 Key Code** from the top menu bar.

   The **Key Code Update** display appears (Figure A.3).

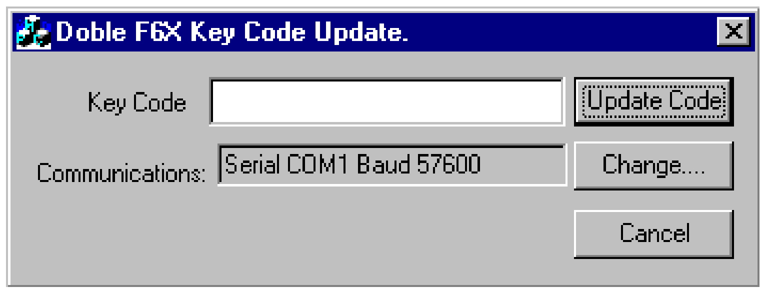


Figure A.3 Key Code Update

2. Type the software key in the Key Code field.
3. Click **Update Code**.

   An error message appears if an incorrect code is entered.
4. If necessary, click **Change** to enter new communications parameters. Refer to ”Communications Parameters” on page A-3.

Appendix B. Ethernet Communications

If the control PC is configured for Ethernet communications, it can communicate with the F6150 on a private network using the UDP/IP protocol. When it initiates two-way communication, the PC sends its IP address to the instrument. Both the F6150 and the PC must have an IP address assigned.

NOTE

One PC can control multiple F6000 Instruments via an Ethernet connection, in order to execute end-to-end protection scheme tests under laboratory conditions. Controlling multiple F6000s using one PC eliminates the need for GPS synchronization.

Connect the Control PC to the F6150

To connect the Ethernet card in the control PC to the F6150, use two 50 ohm terminators and a 50 Ohm coax 10Base2 network cable. The terminators and the cable are supplied with the instrument.

1. Connect one of the 50 Ohm terminators to the network port on the right side of the instrument front panel.
2. Connect the second 50 Ohm terminator to the connector on the Ethernet card in the control PC.
3. Connect the supplied RG-58 coax cable to both the F6150 and the control PC.

   Figure B.1 illustrates two ways to make these connections.

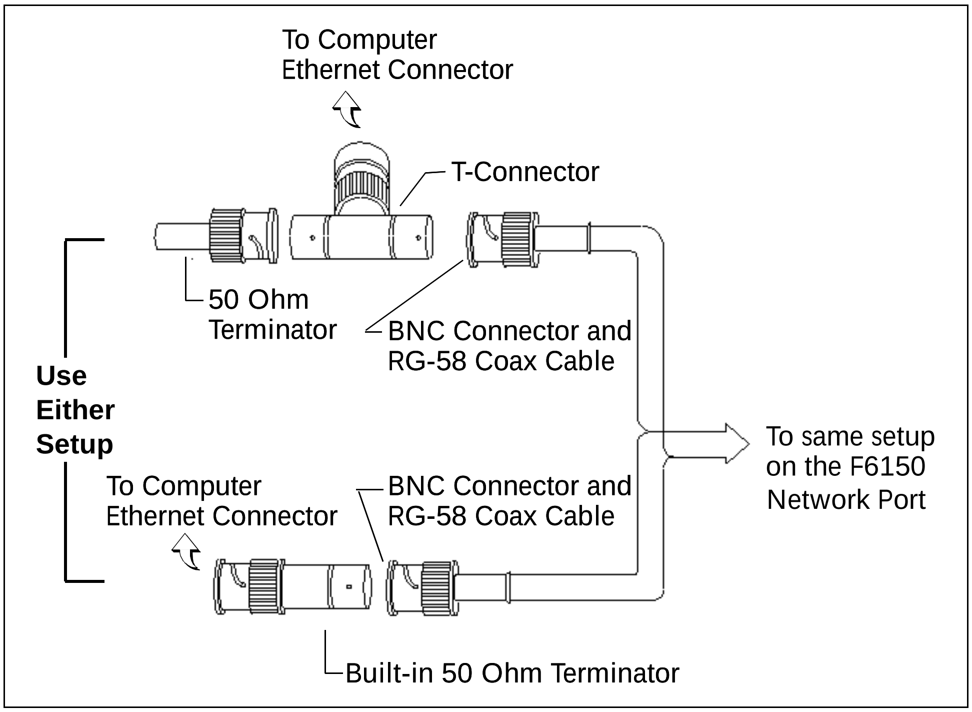


Figure B.1 Alternate 50 Ohm Terminator Connections for the Coax Cable

Configure the Control PC

To configure Windows 95/98/2000/NT for communication with the F6150 on a private network:

1. Right-click the **Network** icon on the desktop and select **Properties**.

   The **Network** display appears (Figure B.2).

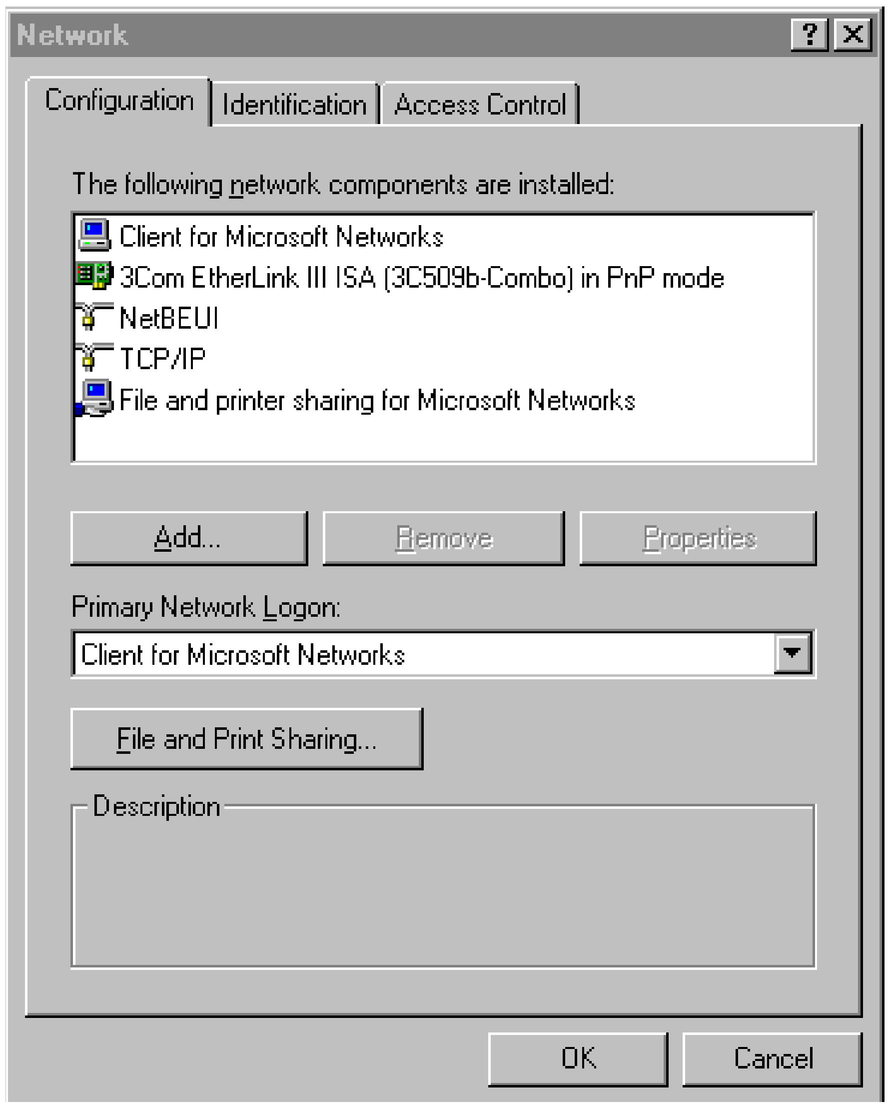


Figure B.2 Network Display: Scroll to the TCP/IP Network Component

2. In the Configuration tab, scroll down the list of network components and select the component that corresponds to the Ethernet card in the control PC.

3. Click **Properties** underneath the list of network components.

   The TCP/IP dialog box opens (Figure B.3).

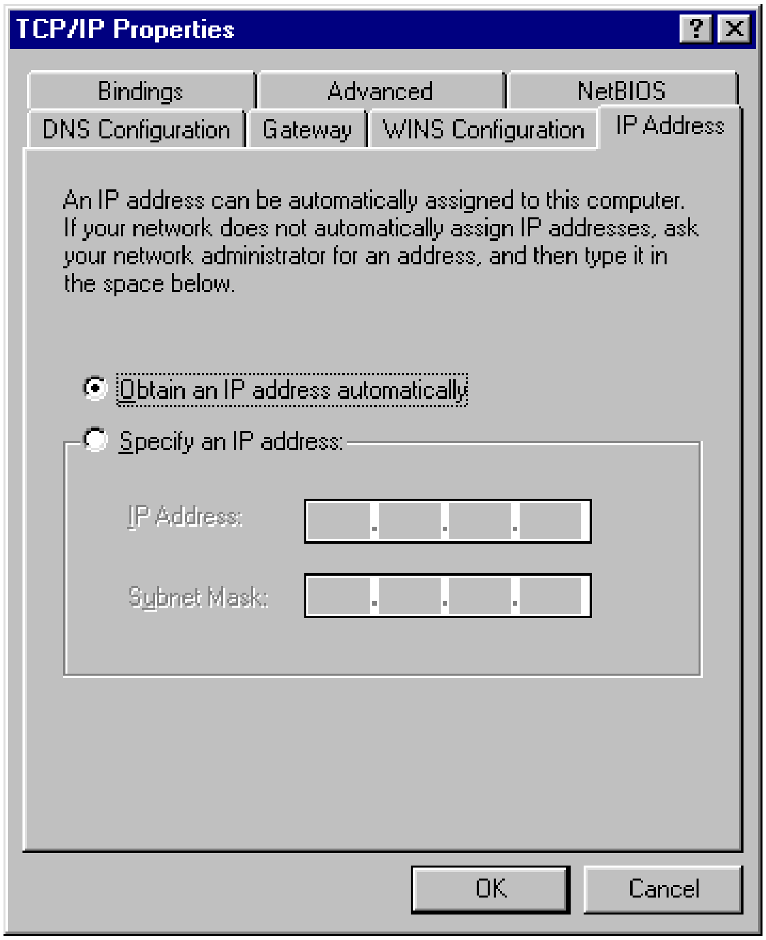


Figure B.3 TCP/IP Properties

4. Click the **IP Address** tab in the **TCP/IP Properties** dialog box.
5. Select the radio button for *Specify an IP address*.

   The *IP Address* and *Subnet Mask* fields become available.
6. In the *IP Address* field, enter an IP address close to, but different from the IP address that is displayed on the F6150 after it is turned on.

7. Enter the subnet mask in the *Subnet Mask* field (Figure B.4).

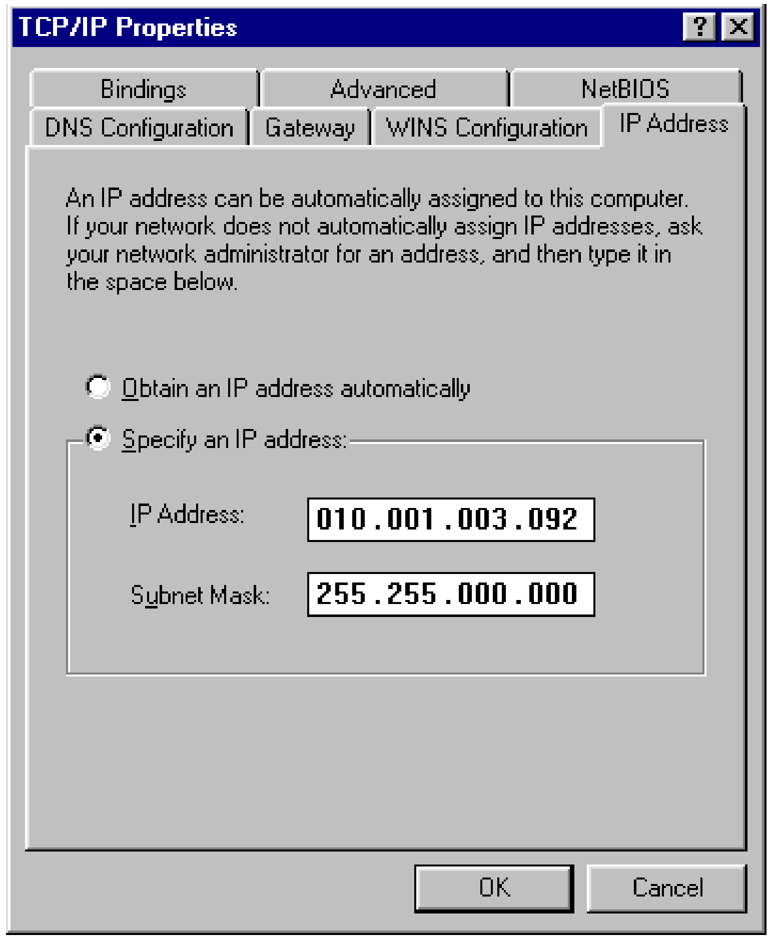


Figure B.4 IP Address Tab in TCP/IP Properties

8. Reboot the computer to effect these changes.

9. When the computer has rebooted, double-click the MS-DOS icon on the desktop to open an MS-DOS window.

10. Type **ping** after the prompt, followed by a space and the IP address of the F6150.

- If the Ethernet connection is working, four replies from the F6150 appear (Figure B.5).

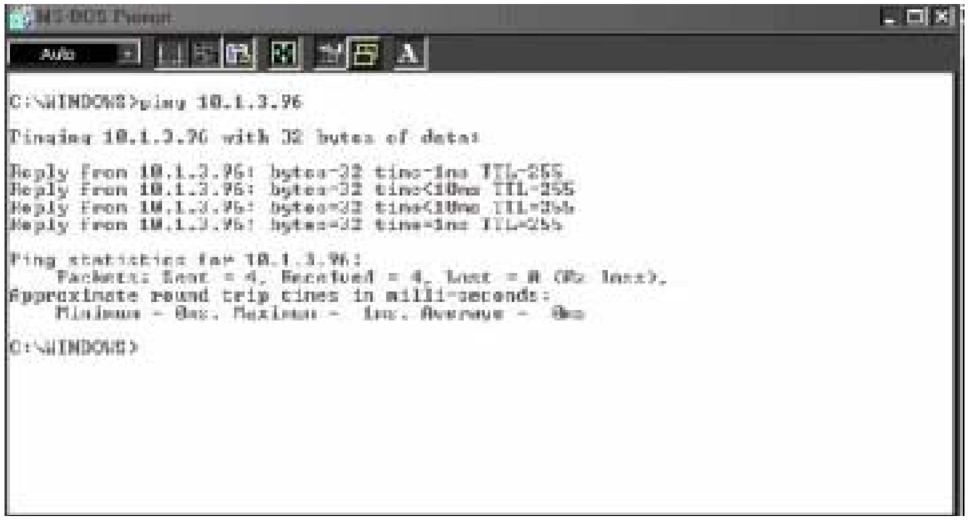


Figure B.5 Successful Ping

- If the connection is not good, four time outs appear (Figure B.6).

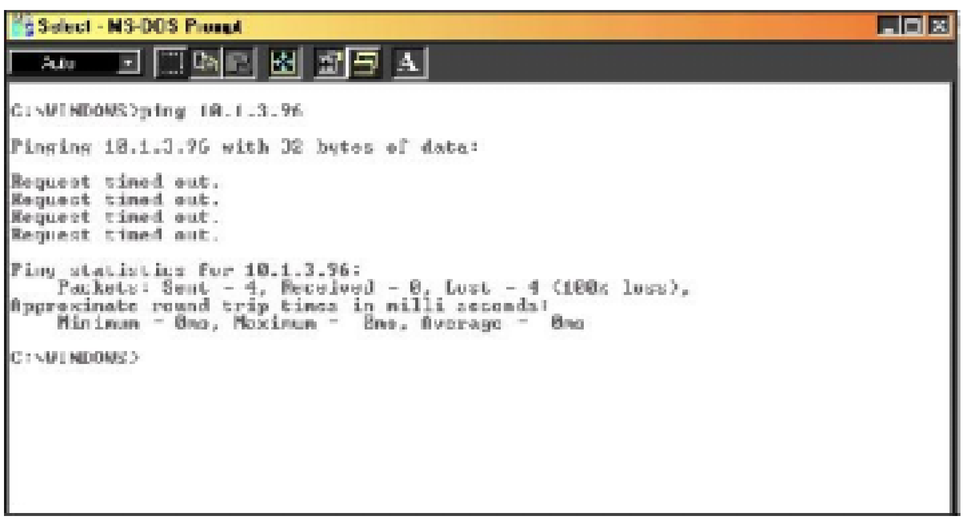


Figure B.6 Unsuccessful Ping

- If the ping is unsuccessful, check the network connections, terminators, connecting cable, and network properties. Then try again.

11. Open the F6Meter Control Panel and click **Setup** on the Tools menu.

The Setup dialog box appears (Figure B.7).

12. In the *F6 Instrument Connect with* box, enter the IP Address of the instrument in the *IP Address* field and select *Ethernet*.

The instrument IP address appears in the Vacuum Fluorescent Display (VFD) of the instrument front panel after boot-up.

Figure B.7 shows the Setup dialog box with these changes entered.

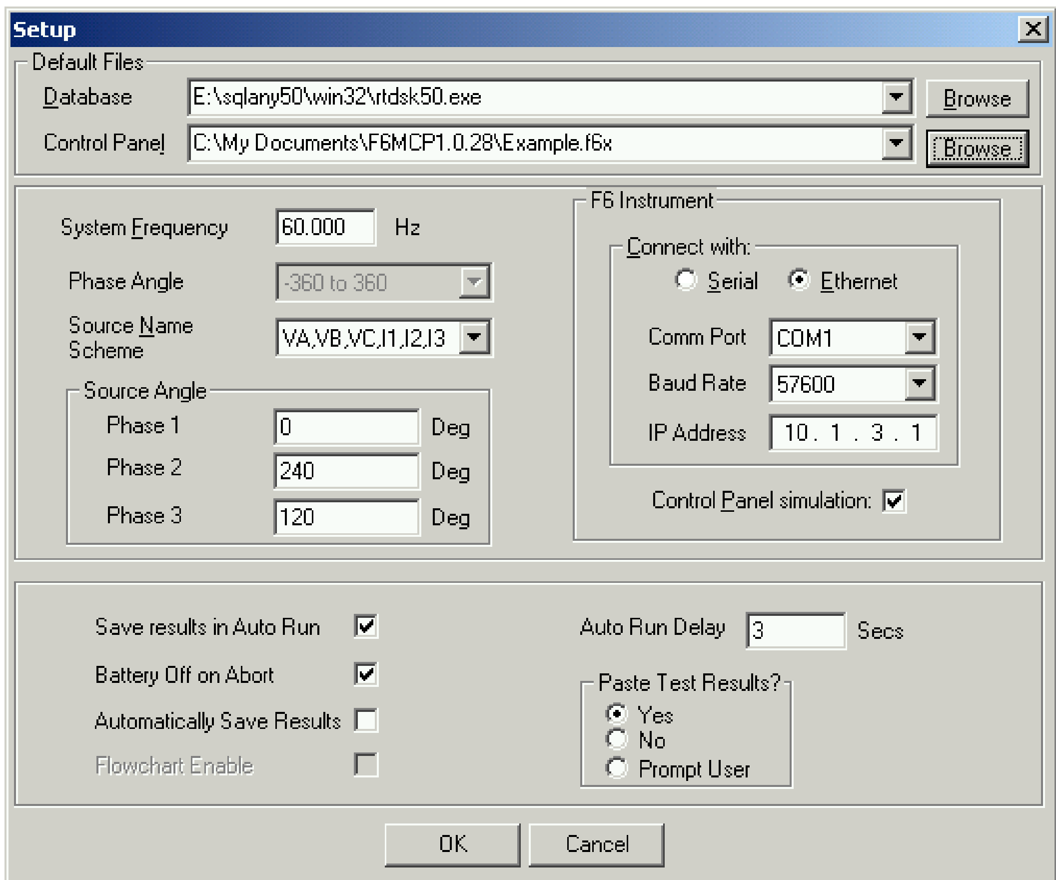


Figure B.7 Setup Display Configured for Ethernet Communications

13. Click **OK** to apply the new settings.

14. Click **Tools | F6Meter Control Panel** in the top menu bar.

The Control Panel opens and provides manual control of the instrument.

NOTE **If the control PC is subsequently connected to any kind of local-area or wide-area network, return to the Network TCP/IP Properties display and select *Obtain IP address automatically*.**

Set the F6000 IP Address

The Set IP Address utility sets or changes the IP address that the instrument uses for Ethernet communications. The current IP address of the instrument, if assigned, appears in the display on the instrument front panel after a successful boot-up.

To set the instrument IP address:

1. Click **Tools|F6000 IP Set** in the top menu bar.

The Set F6000 IP Address dialog box appears (Figure B.8).

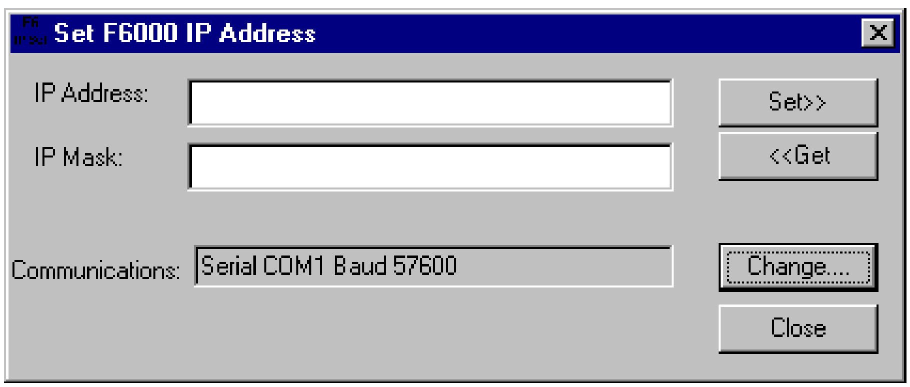


Figure B.8 Set F6000 IP Address

2. Enter the IP Address in the *IP Address* field.

3. Click **Set**.

4. Click **Get** to obtain the IP Mask that corresponds to the IP Address entered in step 3.

The mask name appears in the *IP Mask* field.

If necessary, click **Change** to enter new communications parameters. Refer to "Communications Parameters" on page A-3.

Appendix C. Source Configurations

This appendix explains the configuration of power sources for the F6000 Instrument. Source configuration is set from the F6Meter Control Panel to meet transducer test requirements.

Convertible Voltage/Current Sources

The F6150 has three convertible V/I sources, each rated at 150 VA. These sources are referred to as convertible V/I sources because the 6810 option allows them to be used as low range current sources. Each convertible V/I source can be split into two 75 VA sources to yield as many as six 75 VA sources.

- When in voltage mode, the ranges for the 150 VA sources are 75, 150, and 300 V. The voltage ranges for the 75 VA sources are 75 and 150 V.
- When in current mode, the ranges for the 150 VA sources are 0.5, 1.0, and 2.0 A. The current ranges for the 75 VA sources are 0.5 and 1.0 A.

The convertible sources can be placed in transient current mode to increase the output power by 30% and the current range by 50% for 1.5 seconds. When in transient current mode, the 150 VA sources supply 195 VA for 1.5 seconds. The 75 VA sources supply 97.5 VA. The current ranges for the 195 VA sources are 0.75, 1.5, and 3.0 A. The current ranges for the 97.5 VA sources are 0.75 and 1.5 A.

Current Sources

The F6000 has three current sources, each rated at 150 VA. Each 150 VA current source can be split in two to yield six 75 VA sources. The current ranges for the 150 VA sources are 7.5, 15, and 30 A. The current ranges for the 75 VA sources are 7.5 and 15 A.

The current sources can be placed in transient current mode to increase the output power by 50% and the current range by 100% for 1.5 seconds. When in transient current mode, the 150 VA sources supply 225 VA for 1.5 seconds; the 75 VA sources supply 112.5 VA. The current ranges for the 225 VA sources are 15, 30, and 60 A. The current ranges for the 112.5 VA sources are 15 and 30 A.

Rules for Source Selection

The F6000 software supports a maximum of eight sources at a time. Apply the following rules for source selection and paralleling:

- A source is not usable if no source name is assigned.
- Voltage sources cannot be paralleled, therefore no duplication of voltage source names is allowed. The maximum power for voltage sources is 150 VA.
- The number of usable voltage sources is zero if no source name is assigned.
- To parallel 150 VA convertible sources when in current mode, assign the same source name to the sources to be paralleled.

  For example, if all three convertible sources in low current mode are named IA, the three sources in parallel yield 450 VA of power. If the current range for the paralleled low current source is 3.0 A, the compliance voltage is 150 V. See Table C.1.
- To parallel 150 VA current sources, assign the same source name to the sources to be paralleled.

  For example, if all three current sources are named I1, the three sources together yield a single current source rated at 450 VA.
- Only adjacent 150 VA sources can be paralleled. A maximum of three current sources can be paralleled to create one 450 VA source.

NOTE

Low current convertible sources and current sources must not be paralleled.

- When one 300 VA source and one 150 VA source are needed, the first two adjacent 150 VA sources supply 300 VA and the third source supplies 150 VA.
- Each 150 VA source is made up of a pair of 75 VA sources, and these pairs must remain intact. Therefore a 150 VA source cannot be paralleled with a 75 VA source from another pair.
- A 150 VA source can be split into two 75 VA sources only if it is not paralleled with any other source.
- Convertible sources and current sources cannot use the same source designations.

NOTE

When using paralleled current sources, it is recommended to parallel the wiring in order to reduce cable heating and voltage drop.

Compliance Voltage and Current Range

The compliance voltage of a current source is the highest voltage into which the current source can inject current. The formula for calculating the compliance voltage of a current source is:

$$V = P \div I$$

where *P* is the VA rating of the current source and *I* is the current range. For example, if a source is rated at 150 VA and the current range is set at 7.5 A, the compliance voltage for the source is 20 V.

NOTE

For maximum compliance voltage, use the lowest current range that can produce the desired test current. For example, if the test requires 5 A, set the range at 7.5 A, not 15 A.

Table C.1 through Table C.4 show range settings and compliance voltages for all common source configurations. See Appendix G ”F6150 Specifications”, for more information on range settings.

Table C.1 Maximum Compliance Voltage for Low Current Source Combinations

	Maximum Compliance Voltage			
Current Range	**75 VA Source**	**150 VA Source**	**300 VA Source**	**450 VA Source**
0.5 A	150 V	300 V	—	—
1.0 A	75 V	150 V	300 V	—
1.5 A	—	—	—	300 V
2.0 A	—	75 V	150 V	—
3.0 A	—	—	—	150 V
4.0 A	—	—	75 V	—
6.0 A	—	—	—	75 V

Table C.2 Maximum Compliance Voltage for Low Transient Current Source Combinations

Current Range	Maximum Compliance Voltage			
	97.5 VA Source	**195 VA Source**	**390 VA Source**	**585 VA Source**
0.75 A	130 V	260 V	—	—
1.5 A	65 V	130 V	260 V	—
2.25 A	—	—	—	260 V
3.0 A	—	65 V	130 V	—
4.5 A	—	—	—	130 V
6.0 A	—	—	65 V	—
9.0 A	—	—	—	65 V

Table C.3 Maximum Compliance Voltage for Current Source Combinations

Current Range	Maximum Compliance Voltage			
	75 VA Source	**150 VA Source**	**300 VA Source**	**450 VA Source**
7.5 A	10 V	20 V	40 V	60 V
15 A	5 V	10 V	20 V	30 V
22.5 A	—	—	—	20 V
30 A	—	5 V	10 V	—
45 A	—	—	—	10 V
60 A	—	—	5 V	—
90 A	—	—	—	5 V

Table C.4 Maximum Compliance Voltage for Transient Current Source Combinations

Current Range	Maximum Compliance Voltage			
	112.5 VA Source	**225 VA Source**	**450 VA Source**	**675 VA Source**
15 A	7.5 V	15 V	30 V	45 V
30 A	3.75 V	7.5 V	15 V	22.5 V
45 A	—	—	—	15 V
60 A	—	3.75 V	7.5 V	—
90 A	—	—	—	7.5 V
120 A	—	—	3.75 V	—
180 A	—	—	—	3.75 V

Pre-set Configurations

To configure the sources on the instrument front panel independently of the preset options, select **User defined** from the *Pre-set Configurations* pick list in the **F6000 Configuration** display (Figure 3.3 on page 3-7). The list of preset configurations contains thirteen options:

- User Defined
- 3 Voltages and 3 Currents
- 3 Voltages and 3 Transient Currents
- 4 Voltages and 4 Currents
- 6 Currents (right bank)
- 1 Voltage and 2 Low Range Currents
- 1 Voltage 150 VA and 1 Current 450 VA
- 4 Voltages and 4 Transient Currents
- 6 Voltages
- 6 Low Range Currents
- 6 Low Range Transients
- 6 Transient Currents
- 1 Voltage and 2 Low Range Transients

Figure C.1 through Figure C.12 illustrate the twelve pre-set configurations in the list.

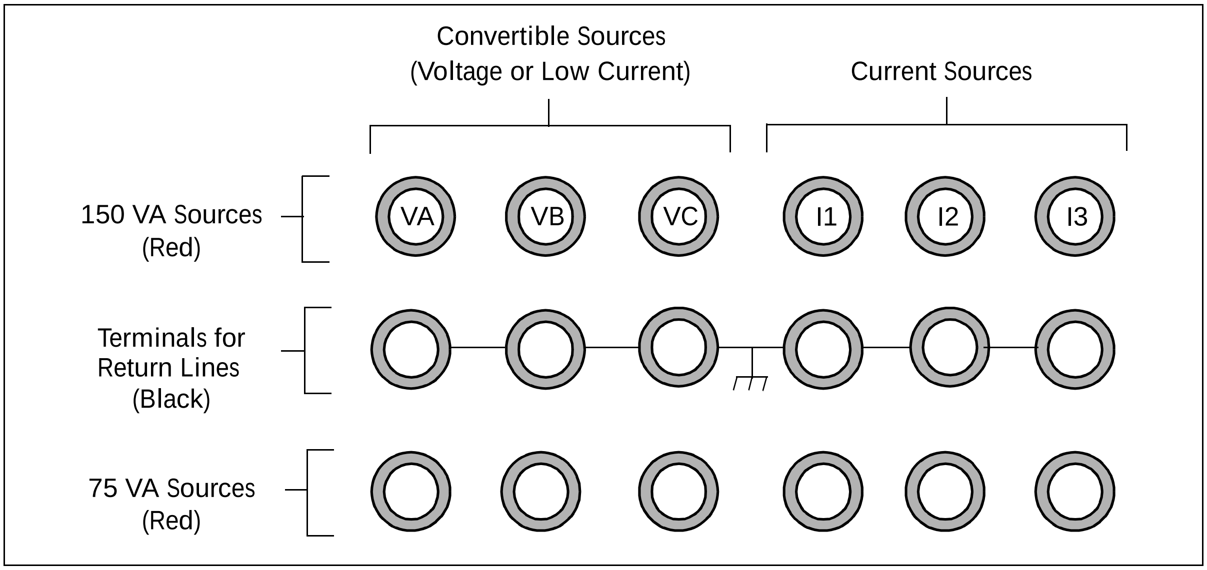


Figure C.1 3 Voltages and 3 Currents

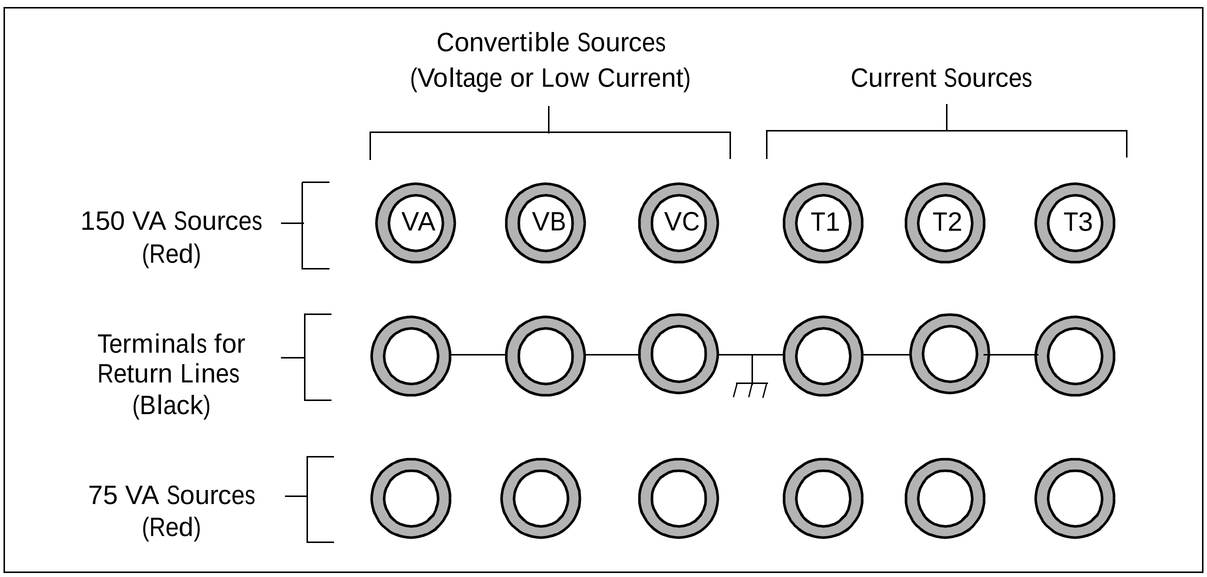


Figure C.2 3 Voltages and 3 Transient Currents

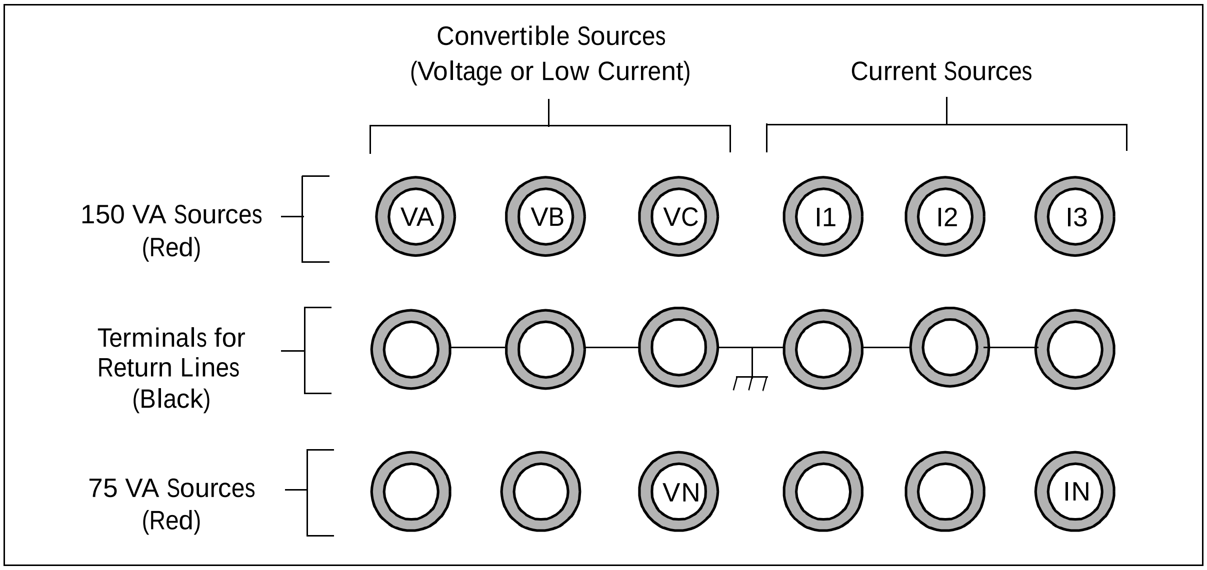


Figure C.3 4 Voltages and 4 Currents

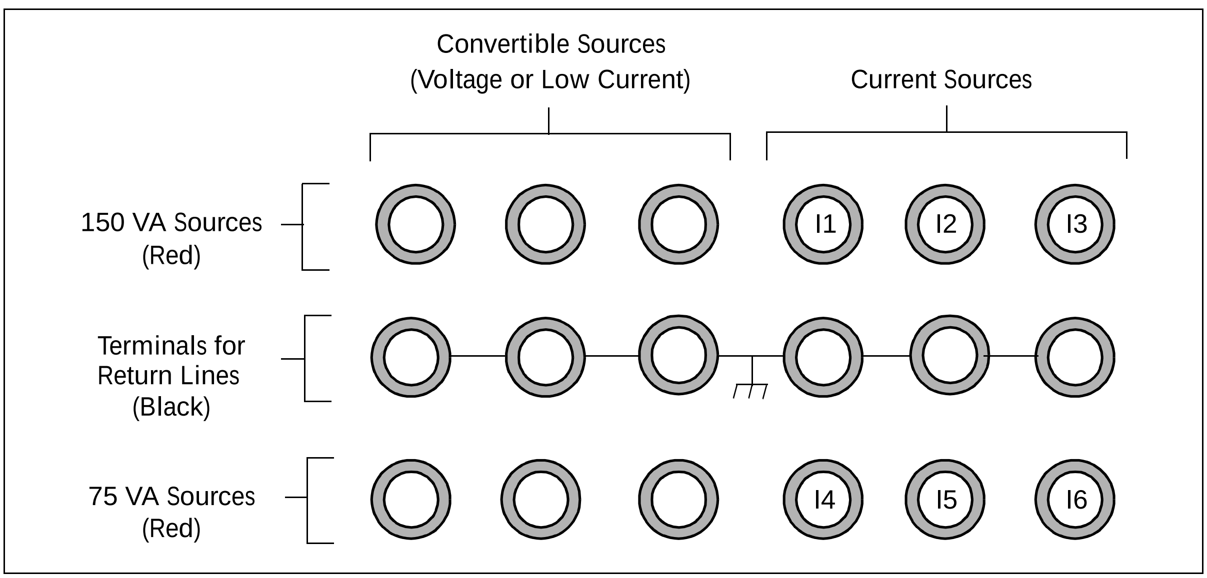


Figure C.4 6 Currents (right bank)

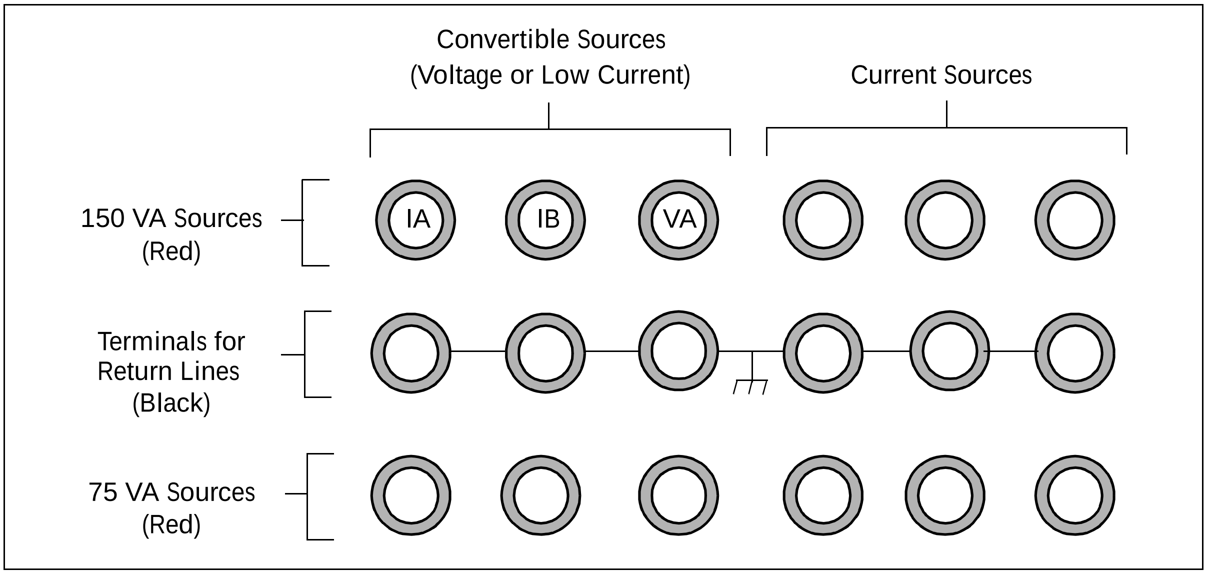


Figure C.5 1 Voltage and 2 Low Range Currents

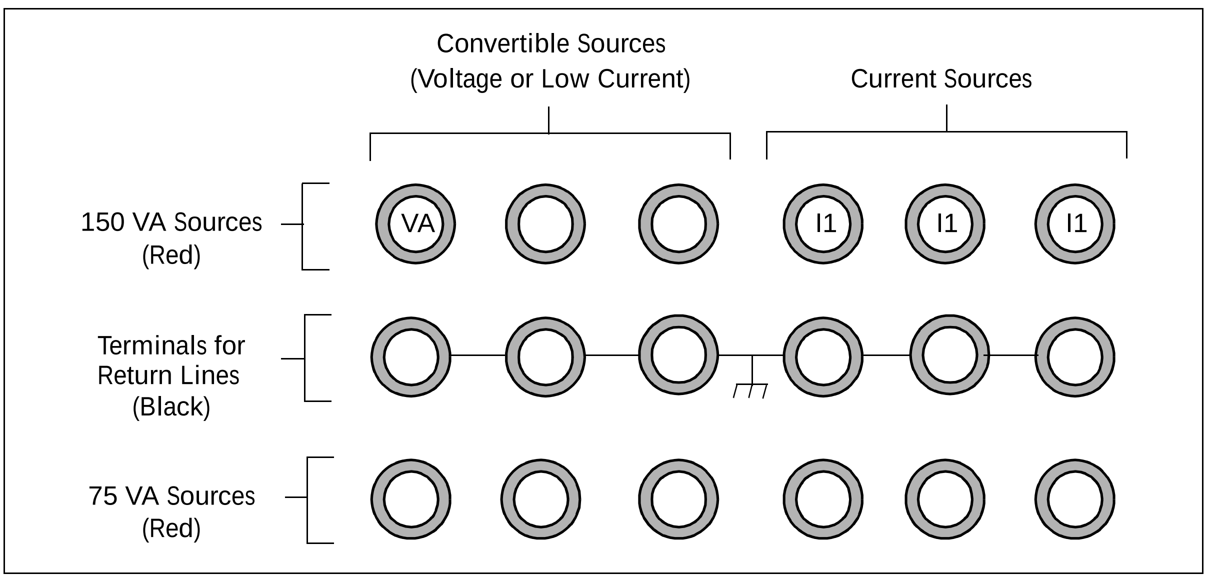


Figure C.6 1 Voltage 150 VA and 1 Current 450 VA

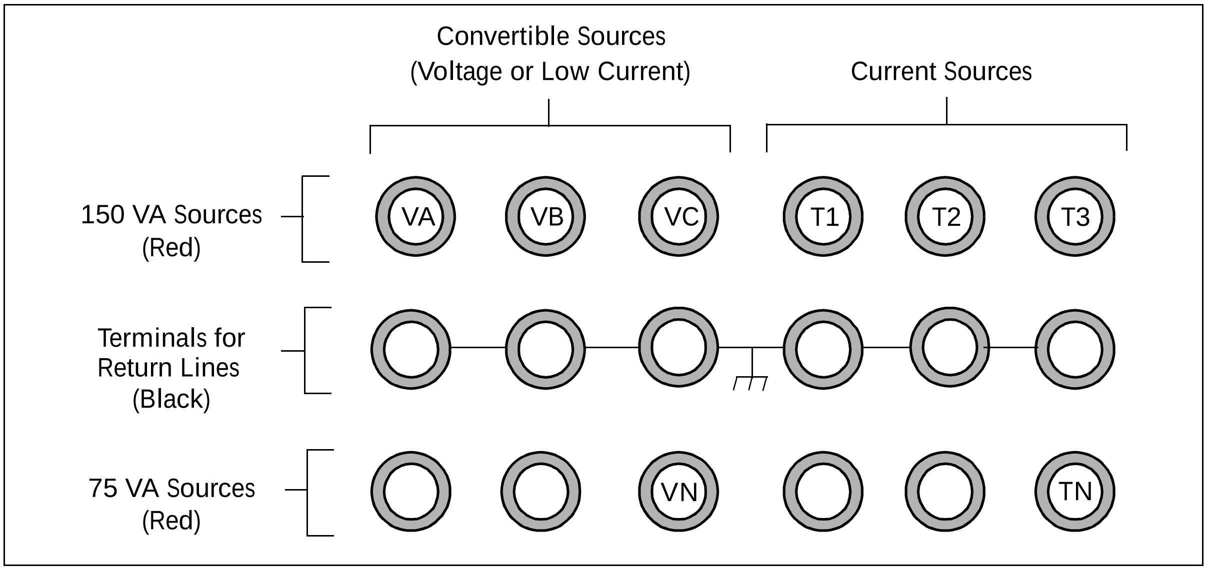


Figure C.7 4 Voltages and 4 Transient Currents

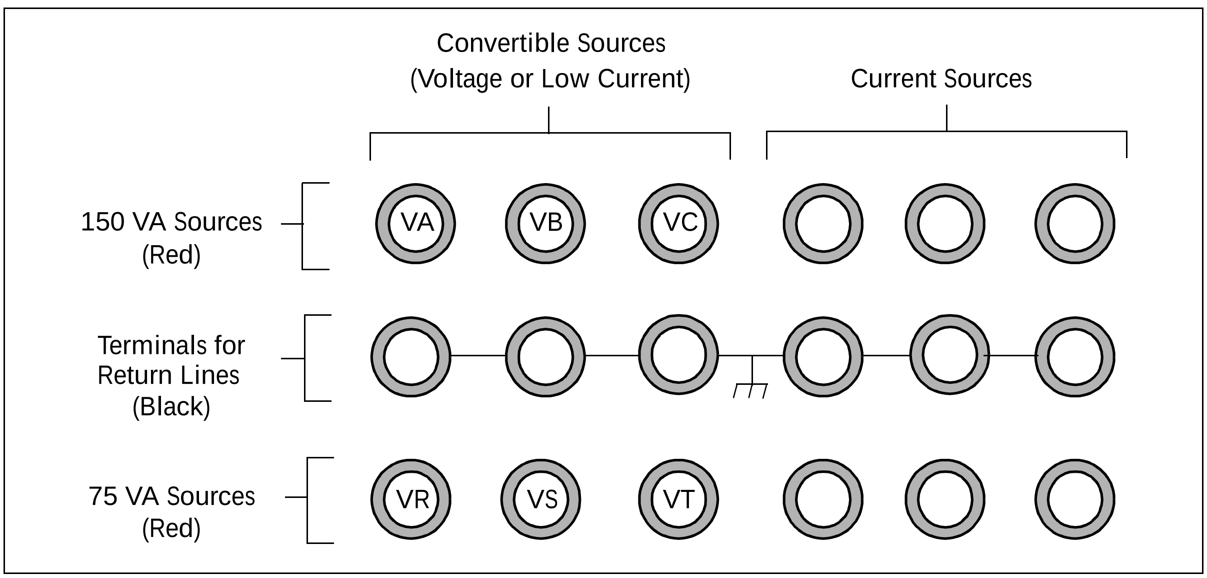


Figure C.8 6 Voltages

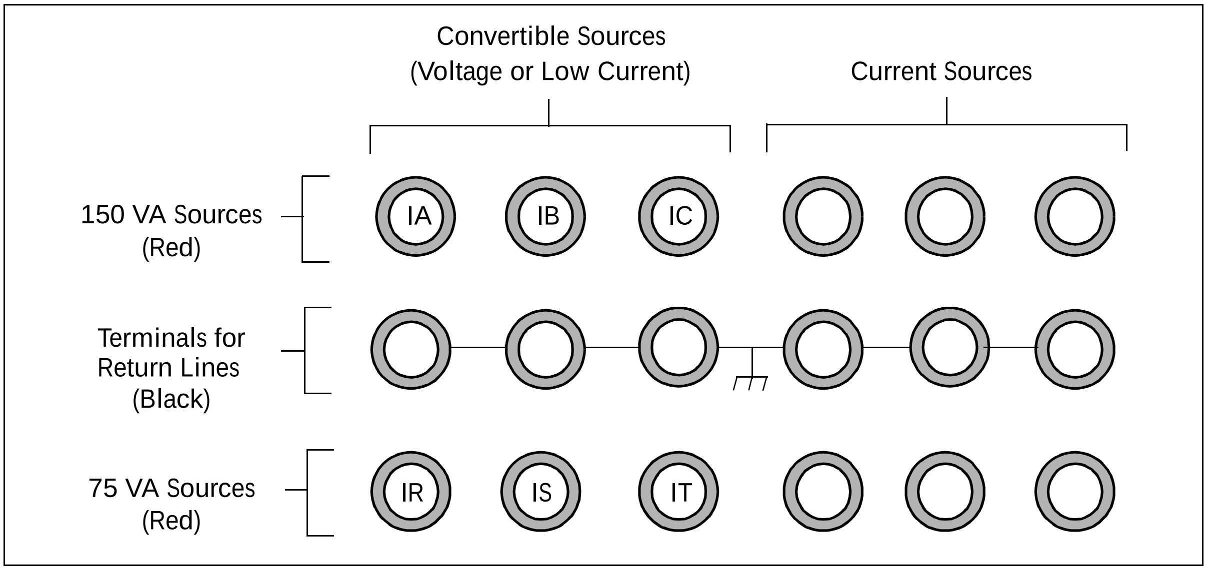


Figure C.9 6 Low Range Currents

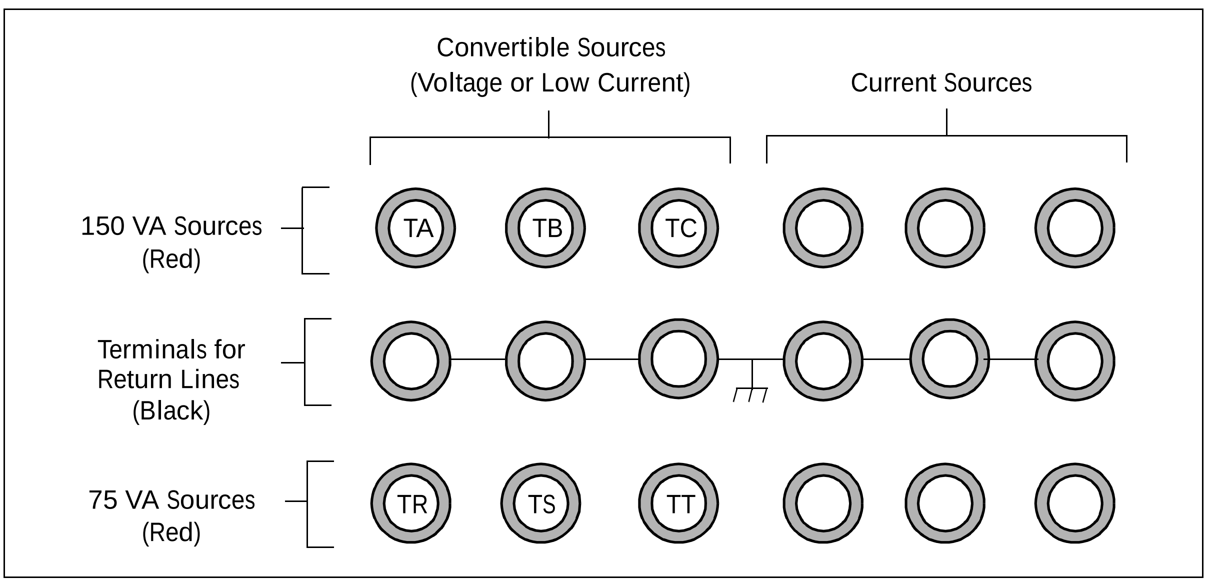


Figure C.10 6 Low Range Transients

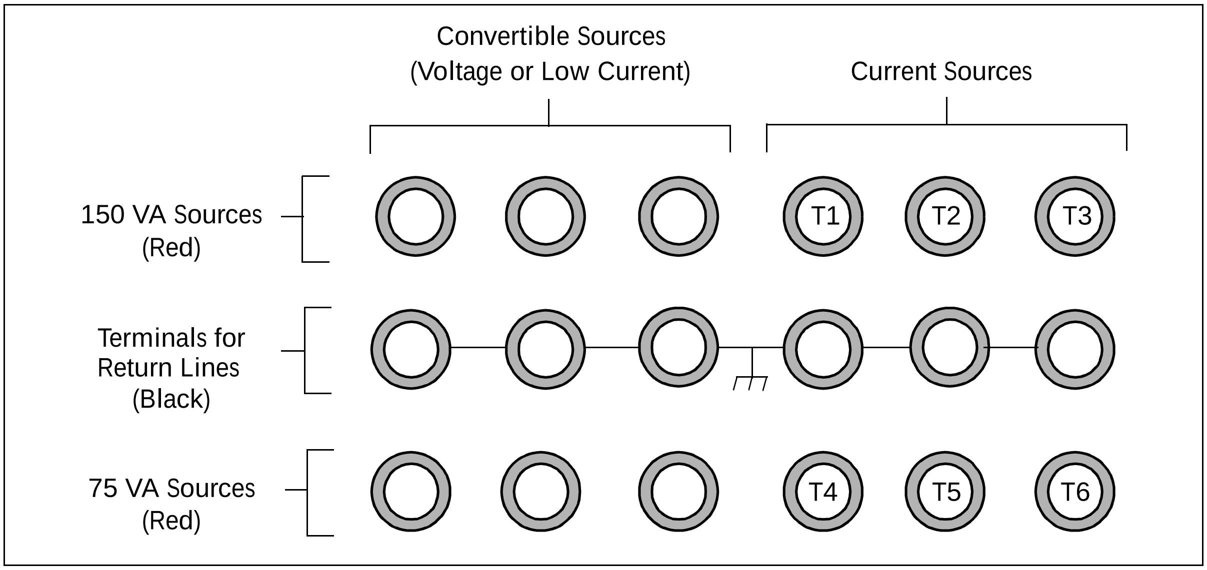


Figure C.11 6 Transient Currents

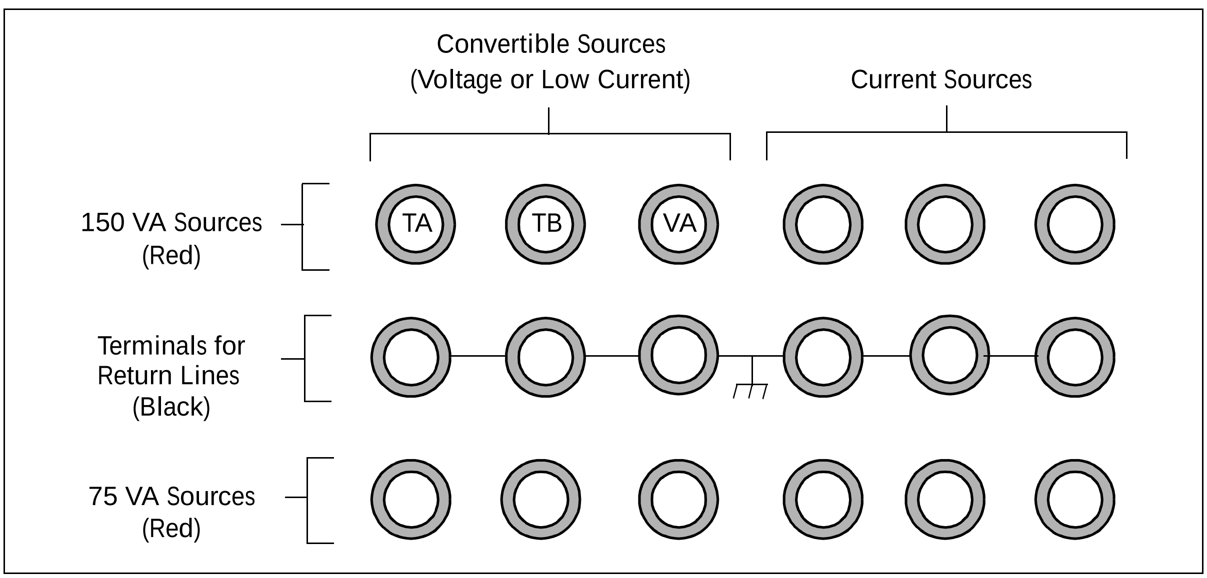


Figure C.12 1 Voltage and 2 Low Range Transients

Appendix D. Global Positioning System

The receiver and antenna available for the F6150 are useful for end-to-end testing, where two instruments must be precisely synchronized in order to simulate a power system fault accurately. Each F6150 synchronizes its internal clock with the one pulse per second signal transmitted by satellites in the Global Positioning System (GPS). This setup allows multiple F6150s to synchronize to a common reference signal without the need for networking.

GPS Synchronization

End-to-end testing of a protection scheme requires that two F6000 Instruments not connected to the same network be precisely synchronized. Two F6000 Instruments inject the same fault at each end of the line at the same moment. When an actual fault occurs, the relay at the near end and the relay at the far end of the line both detect the fault simultaneously. In this situation, the only way to simulate what each relay sees is to apply the fault to each relay at exactly the same time.

End-to-end testing using GPS synchronization permits evaluation of a complete protection scheme. The test evaluates the performance of the system's protective relays and its communication equipment. Figure D.1 on page D-2 gives an overview of all the components required to conduct an end-to-end test using GPS synchronization.

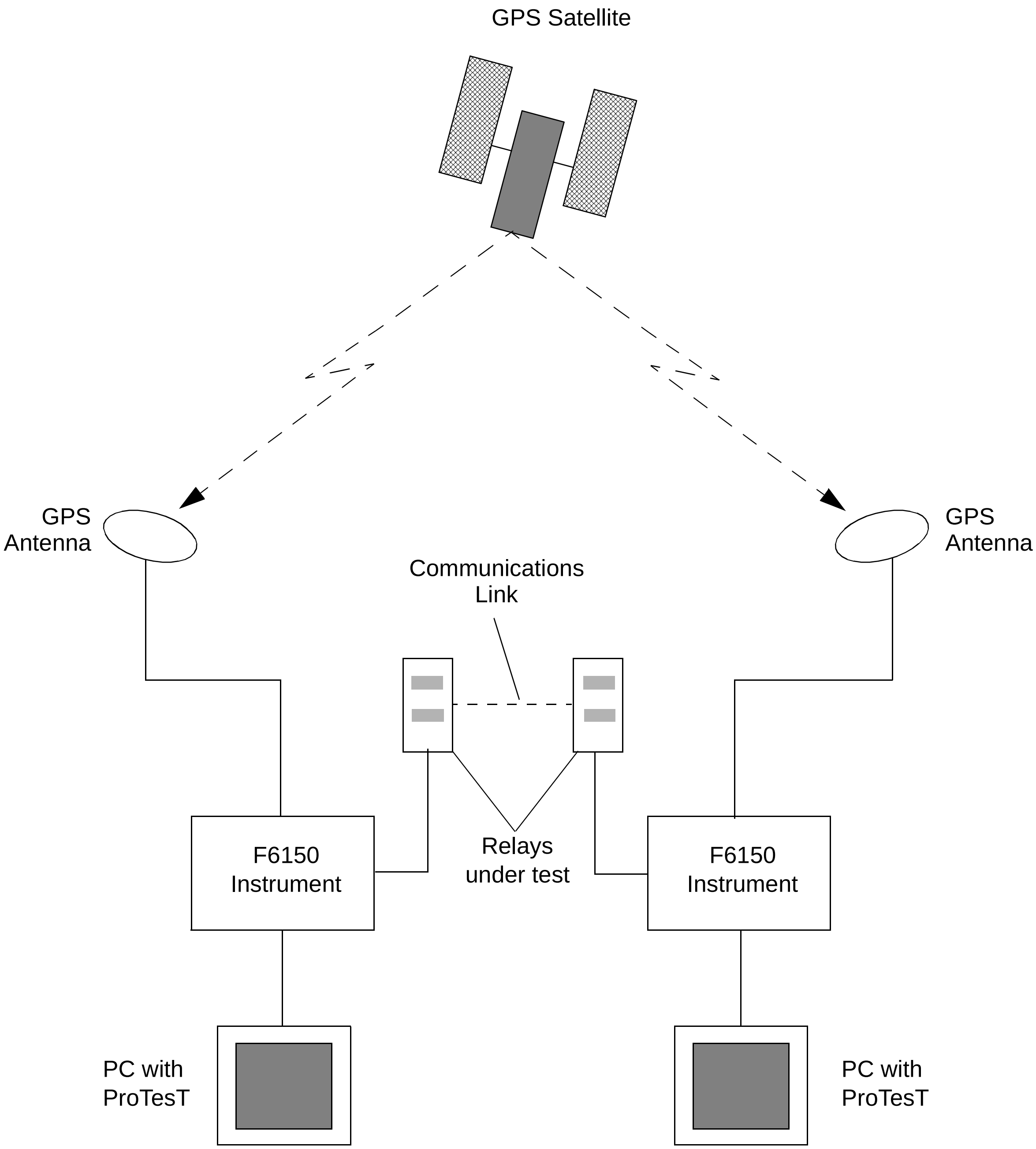


Figure D.1 End-to-End Testing with GPS Synchronization

Equipment Setup

GPS synchronization requires a GPS satellite receiver (Option F6885) and a GPS antenna (Option F6895). When the antenna is connected to the GPS port on the instrument front panel, it sends the satellite's timing signal to the F6000 Instrument.

The GPS antenna comes with the following equipment:

- 100-foot cable
- Connector for the F6000 Instrument (15-pin)
- Connector for the F2000 Instrument (9-pin)
- 12 V DC power supply, with power cord and connecting line

To use the GPS:

1. Connect the 15-pin adapter cable for the F6000 Instrument to the GPS port on the instrument front panel.
2. Connect the 100-foot cable to the adapter cable.
3. Place the 8-inch diameter GPS antenna outside in an open area.

   The antenna should be two to three meters away from walls or other obstructions to get 360° coverage.
4. Connect the 100-foot cable to the antenna.
5. Connect the 12 V DC power supply to the adapter cable.
6. Plug the power supply into a 115 V or 230 V AC outlet.
7. Turn the F6000 Instrument on.

When the power supply is plugged in and the GPS antenna is properly positioned, the antenna receives signals from the satellite. The antenna transmits a pulse per second signal to the instrument, along with a serial communication stream to identify the time of day. The equipment setup in Figure D.2 shows all the equipment required for the test.

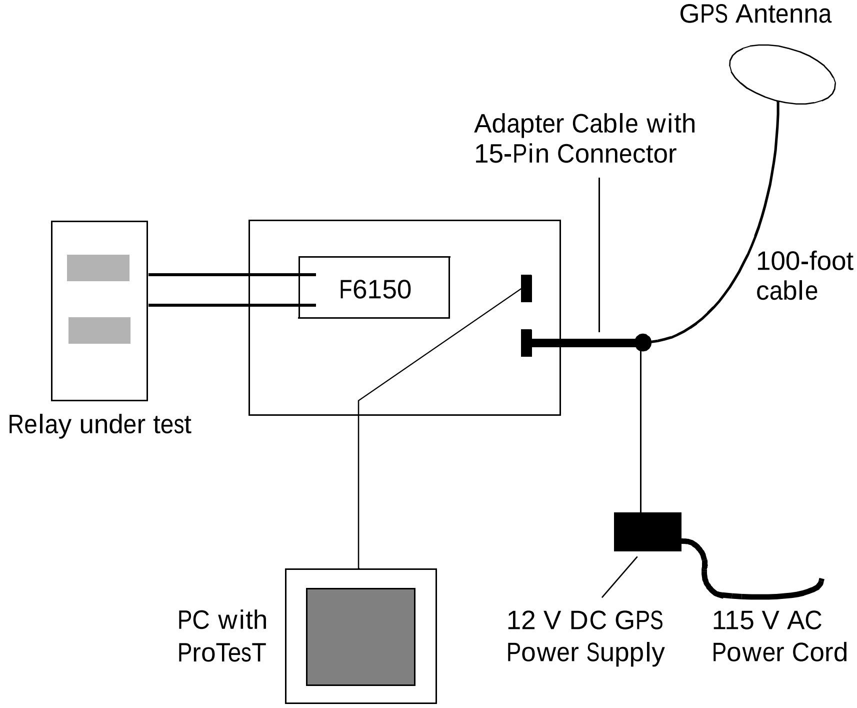


Figure D.2 Equipment Setup for GPS Synchronization

When the GPS antenna is connected and powered as shown in Figure D.2, turn the F6000 Instrument on. The normal sequence of messages in the VFD confirms a successful boot-up. At the end of the sequence, the message *GPS 0 Sats* indicates the GPS receiver is initializing. Allow several minutes for the initialization process. When the system is ready, *GPS 6 Sats* appears, followed by the time in Universal Time Coordinates: *GPS 17:04:26 UTC*. This message indicates that the components are connected correctly and the instrument is synchronized to the GPS clock.

Conduct the Test

The ProTesT Starter Kit includes the control software needed for end-to-end testing with GPS synchronization.

Use the State Simulation (SSIMUL) or TRANS macro in ProTesT to conduct an end-to-end test. Use the Power System Model in ProTesT to specify the values needed for the test table in the State Simulation macro.

1. With the technician at the other end of the transmission line, define the exact time to conduct the test.

2. Enter the agreed time in the Go At field of the ProTesT display.

Once each second, the F6000 receives the exact time from the GPS receiver. When the reference time is the same as the common Go At time specified for each test instrument, the two instruments apply the specified fault to each relay.

For example, the technicians agree by phone to conduct the test at 17:00:00 UTC. They program each instrument to deliver the same fault to each relay at the same time. Since both instruments key on the same satellite, their internal clocks are synchronized and they both inject the fault at precisely 17:00:00 UTC.

Appendix E. Timing Between State Changes

The F6150 builds waveforms based on a 10 kHz sample rate. Its waveforms are assembled with data every 100 microseconds or 0.1 milliseconds. When the instrument generates a waveform, it rounds the total time for the required number of cycles to the nearest 0.1 millisecond.

In a 60 Hz waveform, for example, one cycle is completed over 16.66666... milliseconds. Under the rounding function, the cycle actually completes at 16.7 milliseconds. For two cycles at 60 Hz, the time is 33.33333... milliseconds, rounded to 33.3 milliseconds.

The rounding function may cause a discrepancy between expected and actual times for state simulations where a timer is started in one state and stopped after one or several states with a long duration time. A workaround for this discrepancy is to have state durations in factors of time that negate the rounding factor.

For example, 60 Hz durations in factors of three cycles per state (3, 6, 9..., 63...) equate to an even 50 milliseconds per three-cycle duration. In this case, no discrepancy appears because no rounding is used to generate the waveform.

NOTE

50 Hz systems do not use the rounding function at all, as their base time unit per cycle is 20 milliseconds.

Appendix F. Field Calibration Verification

This appendix defines testing specifications and procedures for performing Amplitude and Distortion tests, and Phase Shift tests on configured current and voltage sources.

Testing Specifications

Ambient Accuracy

F6000 Test Instruments are normally used in areas where the temperature is between 68 and 86 °F (20-30 °C) and the AC power is within ±10% of 115 (or 230) V. Under these conditions, and when connected to a load that does not exceed the source's range limits, F6000 AC test signals are warranted to meet the following accuracy specifications:

Amplitude	±0.03% of range from 0 to 10% of range, and within ±0.3% of setting from 10 to 100% of range for High Current and Convertible Voltage Sources.
Amplitude	±0.06% of range from 0 to 10% of range, and within ±0.6% of setting from 10 to 100% of range for Convertible Current Sources.
Phase Angle	±0.25° at 50 or 60 Hz.
Distortion	2% maximum at 50 or 60 Hz., 0.1% typical

Test Setup

All ambient accuracy tests are measured with open circuit Voltage Sources. All Current Sources are measured with either a shunt or ammeter connected across the output.

Test Equipment

All test equipment must be more accurate than the signal being measured, and have a valid calibration sticker tracing the calibration to the Nation Bureau of Standard references. As a reference, the instruments used by Doble Engineering for factory calibration of the F6000 are listed in Table F.1.

Table F.1 Test Equipment

Equipment	Manufacturer	Model Number
Voltmeter	Hewlett Packard	Model 3458A
Phase Meter	Arbiter	Model 931A
Current Meter	Arbiter	Model 931A
Distortion Analyzer	Krohn-Hite	Model 6880A
100 A Shunt	Julie	CS-1R-100-2-05A
20 A Shunt	Julie	CS-1R-20-1-01A

NOTE

The Arbiter Current Meter is used for Convertible Source Current measurements only. All other current measurements are made with the Julie shunts. A differential amplifier with a gain of 10 is used to boost the shunt output for distortion measurements.

Amplitude and Distortion Checks

The amplitude and distortion check consists of measuring the amplitude and total harmonic distortion (THD) from configured current and voltage sources, and comparing the measurements to specified values. This test is conducted on the following source types:

- High Current Sources
- Convertible Low Current Sources
- Convertible Voltage Sources

75 VA High Current Source

To perform the Amplitude and Distortion check on a 75 VA High Current source:

1. Configure the F6000 for six currents (right bank) using the Pre-set Configurations on the F6000 Configuration display.

   Refer to "F6000 Configuration" on page 3-7 for more information.
2. Set the range to 7.5 A and amplitude to 7.5 A. Connect an ammeter or appropriate shunt across the Source I1 output terminals, and turn the source ON.

   Verify that the amplitude is within limits and the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.2 on page F-4.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 15 A range.
5. Repeat steps 2, 3, and 4 for Source I2, I3, IR, IS, and IT.

NOTE

The load, including wire and connections, must not exceed the Max. Load specified in Table F.2.

Table F.2 lists the specifications for the 75 VA High Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.2 75 VA High Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
7.5 A	1.333 Ohm	7.5 A	7.48 A	7.523 A	2%
		0.75 A	0.748 A	0.7523 A	2%
15 A	0.333 Ohm	15.0 A	14.96 A	15.05 A	2%
		1.5 A	1.496 A	1.505 A	2%

Figure F.1 shows a typical setup for 75 VA (right bank) Current and Distortion measurement.

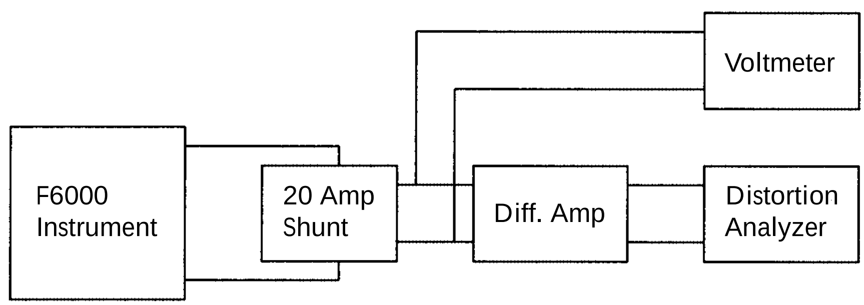


Figure F.1 75 VA High Current Source Measurement

150 VA High Current Source

To perform the Amplitude and Distortion check on a 150 VA High Current source:

1. Configure the F6000 for three 150 VA Currents by clicking **User Defined** on the F6000 Configuration display.
    - Set the number of Current Sources to 3.
    - Set the number of Convertible V/I Sources to 0.
2. Set the range to 7.5 A and amplitude to 7.5 A. Connect an ammeter or appropriate shunt across the Source I1 output terminals, and turn the source ON.

    Verify that the amplitude is within limits and the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.3 and verify that the amplitude and distortion are within the limits
4. Repeat step 3 for the 15 and 30 A range.
5. Repeat steps 2, 3, and 4 for Source I2 and I3.

NOTE

The load including wire and connections must not exceed the Max. Load in Table F.3.

Table F.3 lists the specifications for the 150 VA High Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.3 150 VA High Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
7.5 A	2.67 Ohm	7.5 A	7.48 A	7.523 A	2%
		0.75 A	0.748 A	0.7523 A	2%
15 A	0.67 Ohm	15.0 A	14.96 A	15.05 A	2%
		1.5 A	1.496 A	1.505 A	2%
30 A	0.167 Ohm	30.0 A	29.91 A	30.09 A	2%
		3.0 A	2.991 A	3.009 A	2%

Figure F.2 shows a typical setup for 150 VA (right bank) High Current and Distortion measurements.

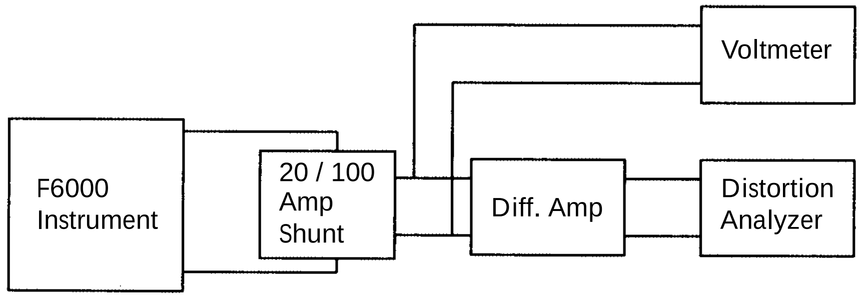


Figure F.2 150 VA High Current Source Measurement

300 VA High Current Source

To perform the Amplitude and Distortion check on a 300 VA High Current source:

1. Configure the F6000 for one 300 VA Current source by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Current Sources to 2.
   - Set the number of Convertible V/I Sources to 0.
   - Set the **Current Sources Reference Designations** so that both sources are named I1.
2. Set the range to 7.5 A and amplitude to 7.5 A. Connect an ammeter or appropriate shunt across the Source I1 output terminals (*both I1 terminals must be connected to the ammeter or shunt*), and turn the source ON.

   Verify that the amplitude is within limits and the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.4 and verify that the amplitude and distortion are within the specified limits.
4. Repeat step 3 for the 60 A range.

NOTE

The load including wire and connections must not exceed the Max. Load specified in Table F.4.

Table F.4 lists the specifications for the 300 VA High Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.4 300 VA High Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
7.5 A	5.33 Ohm	7.5 A	7.48 A	7.523 A	2%
		0.75 A	0.748 A	0.7523 A	2%
60 A	0.0833 Ohm	60.0 A	59.82 A	60.18 A	2%
		6.0 A	5.982 A	6.018 A	2%

Figure F.3 shows a typical setup for 300 VA High Current and Distortion measurements.

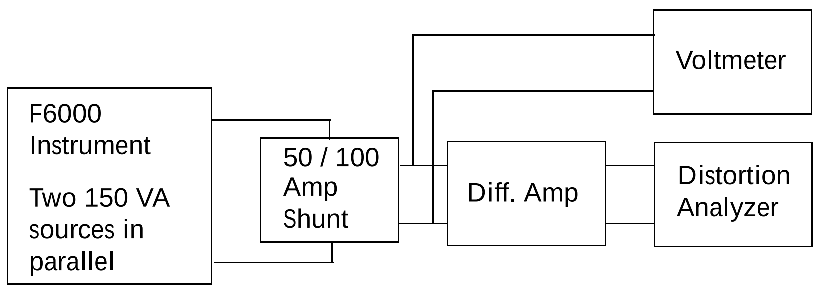


Figure F.3 300 VA High Current Source Measurement

450 VA High Current Source

To perform the Amplitude and Distortion check on a 450 VA High Current source:

1. Configure the F6000 for one 450 VA Current Source by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Current Sources to 3.
   - Set the number of Convertible V/I Sources to 0.
   - Set the **Current Sources Reference Designations** so that all three sources are named I1.
2. Set the range to 7.5 A and amplitude to 7.5 A, connect an ammeter or appropriate shunt across the Source I1 output terminals, (*all three I1 terminals must be connected to the ammeter or shunt)* and turn the source ON.

   Verify that the amplitude is within limits and that the total harmonic distortion (THD) is <2%.

3. Change the amplitude as shown in Table F.5 on page F-8.

   Verify that the amplitude and distortion are within the limits.

4. Repeat step 3 for the 90 A range.

NOTE **The load including wire and connections must not exceed the Max. Load in Table F.5.**

Table F.5 lists the specifications for the 450 VA High Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.5 450 VA High Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
7.5 A	8 Ohm	7.5 A	7.48 A	7.523 A	2%
		0.75 A	0.748 A	0.7523 A	2%
90 A	0.0555 Ohm	90.0 A	59.82 A	60.18 A	2%
		9.0 A	5.982 A	6.018 A	2%

Figure F.4 shows a typical setup for 450 VA (right bank) High Current and Distortion measurements.

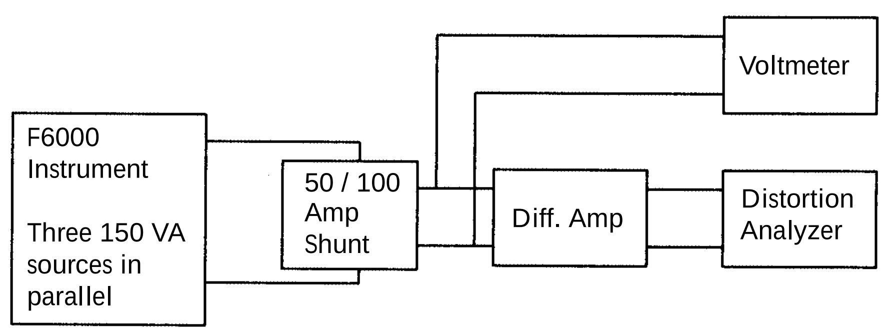


Figure F.4 450 VA High Current Source Measurement

75 VA Convertible Low Current Source

To perform the Amplitude and Distortion check on a 75 VA Convertible Low Current source:

1. Configure the F6000 for six Low Current sources using the Pre-set Configurations on the F6000 Configuration display.
2. Set the range to 0.5 A and amplitude to 0.5 A, connect an ammeter or appropriate shunt across the Source I1 output terminals, and turn the source ON.

   Verify that the amplitude is within the limits and that the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.6.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 1 A range.
5. Repeat steps 2, 3, and 4 for Source I2, I3, IR, IS, and IT.

Table F.6 lists the specifications for the 75 VA Convertible Low Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.6 75 VA Convertible Low Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
0.5 A	Ammeter / Shunt	0.5 A	0.497 A	0.503 A	2%
		0.05 A	0.0497 A	0.0503 A	2%
1 A		1.0 A	0.994 A	1.006 A	2%
		0.1 A	0.0994 A	0.1006 A	2%

Figure F.5 shows a typical setup for 75 VA Convertible Low Current Source and Distortion measurements.

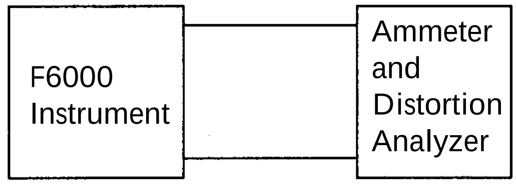


Figure F.5 75 VA Convertible Low Current Source

NOTE **The ammeter and THD Analyzer are functions of the Arbiter 931A.**

150 VA Convertible Low Current Source

To perform the Amplitude and Distortion check on a 150 VA Convertible Low Current source:

1. Configure the F6000 for three Low Current 150 VA sources by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Current Sources to 0.
   - Set the number of Convertible V/I Sources to 3.
   - Set the Convertible V/I Source designations to I1, I2, and I3.
2. Set the range to 0.5 A and amplitude to 0.5 A, connect an ammeter or appropriate shunt across the Source I1 output terminals, and turn the source ON.

   Verify that the amplitude is within limits and the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.7.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 1 and 2 A range.
5. Repeat steps 2, 3, and 4 for Source I2 and I3.

Table F.7 lists the specifications for the 150 VA Convertible Low Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.7 150 VA Convertible Low Current Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
0.5 A	Ammeter / Shunt	0.5 A	0.497 A	0.503 A	2%
		0.05 A	0.0497 A	0.0503 A	2%
1 A		1.0 A	0.994 A	1.006 A	2%
		0.1 A	0.0994 A	0.1006 A	2%
2 A		2.0 A	1.988 A	2.012 A	2%
		0.2 A	0.1988 A	0.2012 A	2%

Figure F.6 shows a typical setup for 150 VA Convertible Low Current Source and Distortion measurements.

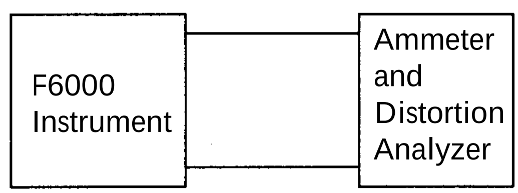


Figure F.6 150 VA Convertible Low Current Source Measurement

NOTE **The ammeter and THD Analyzer are functions of the Arbiter 931A.**

300 VA Convertible Low Current Source

To perform the Amplitude and Distortion check on a 300 VA Convertible Low Current source:

1. Configure the F6000 for one Low Current 300 VA source by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Current Sources to 0.
   - Set the number of Convertible V/I Sources to 2.
   - Set the Convertible V/I Source designations to I1 and I1 (two sources with the same name).
2. Set the range to 1 A and amplitude to 1 A, connect an ammeter or appropriate shunt across the Source I1 output terminals, (*both I1 terminals must be connected to the ammeter or shunt)* and turn the source ON.

   Verify that the amplitude is within limits and that the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.8.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 2 and 4 A range.

Table F.8 lists the specifications for the 300 VA Convertible Low Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.8 300 VA Convertible Low Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
1 A	Ammeter / Shunt	1.0 A	0.994 A	1.006 A	2%
		0.1 A	0.0994 A	0.1006 A	2%
2 A		2.0 A	1.988 A	2.012 A	2%
		0.2 A	0.1988 A	0.2012 A	2%
4 A		4.0 A	3.976 A	4.024 A	2%
		0.4 A	0.3976 A	0.4024 A	2%

Figure F.7 shows a typical setup for 300 VA Convertible Low Current and Distortion measurements.

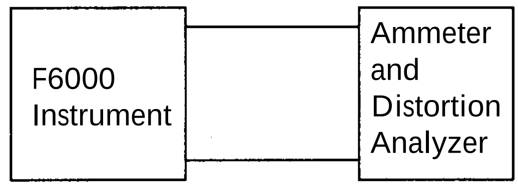


Figure F.7 300 VA Convertible Low Current Source Measurement

NOTE **The ammeter and THD Analyzer are functions of the Arbiter 931 A.**

450 VA Convertible Low Current Source

To perform the Amplitude and Distortion check on a 450 VA Convertible Low Current source:

1. Configure the F6000 for one Low Current 450 VA source by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Current Sources to 0.
   - Set the number of Convertible V/I Sources to 3.
   - Set the Convertible V/I Source designations to I1, I1, and I1 (three sources with the same name).
2. Set the range to 1.5 A and amplitude to 1.5 A, connect an ammeter or appropriate shunt across the Source I1 output terminals, (*all three I1 terminals must be connected to the ammeter or shunt)* and turn the source ON.

   Verify that the amplitude is within limits and that the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.9 on page F-14 and verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 3 and 6 A range.

Table F.9 lists the specifications for the 450 VA Convertible Low Current Source measurements. Minimum and maximum amplitudes are given in amperes. When using a 4-terminal shunt, convert the values to the appropriate voltages.

Table F.9 450 VA Convertible Low Current Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
1.5 A	Ammeter / Shunt	1.5 A	1.491 A	1.509 A	2%
		0.15 A	0.1491 A	0.1509 A	2%
3 A		3.0 A	2.982 A	3.018 A	2%
		0.3 A	0.2982 A	0.3018 A	2%
6 A		6.0 A	5.964 A	6.036 A	2%
		0.6 A	0.5964 A	0.6036 A	2%

Figure F.8 shows a typical setup for 450 VA (right bank) Convertible Low Current Source measurement.

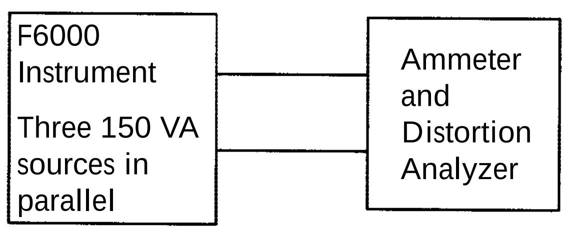


Figure F.8 450 VA Convertible Low Current Source Measurement

NOTE **The ammeter and THD Analyzer are functions of the Arbiter 931A.**

75 VA Convertible Voltage Source

To perform the Amplitude and Distortion check on a 75 VA Convertible Voltage source:

1. Configure the F6000 for six voltages using the Pre-set Configurations on the F6000 Configuration display.
2. Set the range to 75 V and amplitude to 75 V, connect the test instruments as shown across Source VA and turn the source ON.

   Verify that the amplitude is within limits and that the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.10.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 150 V range.
5. Repeat steps 2, 3, and 4 for Source VB, VC, VR, VS, and VT.

Table F.10 lists the specifications for the 75 VA Convertible Voltage Source measurements.

Table F.10 75 VA Convertible Voltage Source Specifications

Range	Max. Load	Value	Minimum	Maximum	Max. THD
75 V	Open	75 V	74.8 V	75.2 V	2%
		7.5 V	7.48 V	7.52 V	2%
150 V		150 V	149.6 V	150.5 V	2%
		15 V	14.96 V	15.05 V	2%

Figure F.9 shows a typical setup for the 75 VA Convertible Voltage Source measurements.

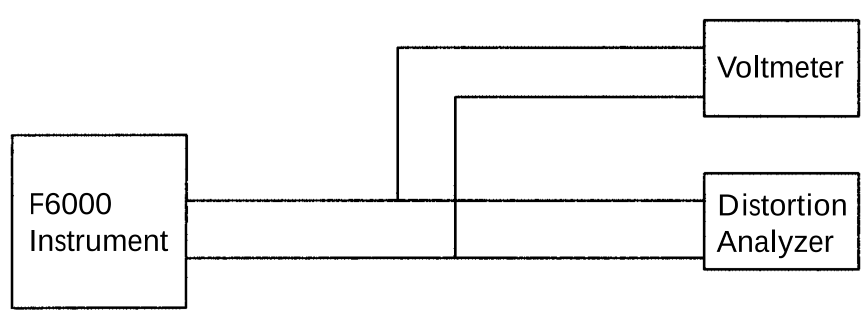


Figure F.9 75 VA Convertible Voltage Source Measurement

150 VA Convertible Voltage Source

To perform the Amplitude and Distortion check on a 150 VA Convertible Voltage source:

1. Configure the F6000 for three 150 VA voltages by clicking **User Defined** on the F6000 Configuration display.
   - Set the number of Voltage Sources to 3.
   - Set the number of Current Sources to 0.
2. Set the range to 75 V and amplitude to 75 V, connect the test instruments as shown across Source VA and turn the source ON.

   Verify that the amplitude is within limits and that the total harmonic distortion (THD) is <2%.
3. Change the amplitude as shown in Table F.11.

   Verify that the amplitude and distortion are within the limits.
4. Repeat step 3 for the 150 and 300 V range.
5. Repeat steps 2, 3, and 4 for Source VB and VC.

Table F.11 lists the specifications for the 150 VA Convertible Voltage Source measurements.

Table F.11 150 VA Convertible Voltage Source Specification

Range	Max. Load	Value	Minimum	Maximum	Max. THD
75 V	Open	75 V	74.8 V	75.2 V	2%
		7.5 V	7.48 V	7.52 V	2%
150 V		150 V	149.6 V	150.5 V	2%
		15 V	14.96 V	15.05 V	2%
300 V		300 V	299.1 V	300.9 V	2%
		30 V	29.91 V	30.09 V	2%

Figure F.10 shows a typical setup for the 150 VA Convertible Voltage Source measurements.

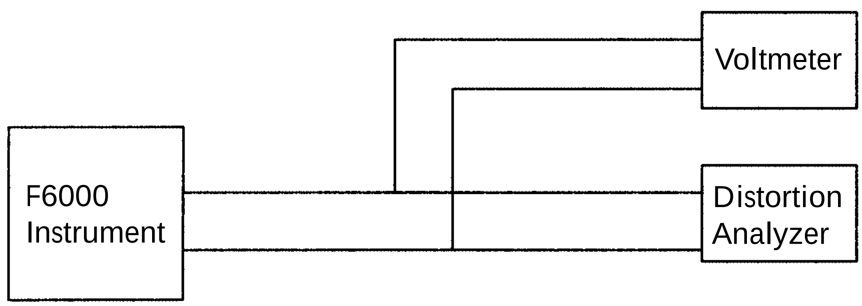


Figure F.10 150 VA Convertible Voltage Source Measurement

Phase Shift Testing

75 VA (Right Bank) High Current Sources at 50 or 60 Hz

To perform the Phase Shift test on a 75 VA High Current source at 50 or 60 Hz:

1. Configure the F6000 for six currents (right bank) using the Pre-set Configurations on the F6000 Configuration display.
2. Set all six ranges to 7.5 A and all amplitudes to 5 A.
3. Set all six phase angles to 0°.
4. Connect source I1 to the reference input of the phase meter.
5. Connect source I2 to the signal input of the phase meter.
6. Turn both sources ON.
7. Verify that the phase angle is within ± 0.25°.
8. Turn OFF the signal source.
9. Repeat steps 5 through 8 for sources I3, IR, IS, and IT as signal sources.

Figure F.11 shows a typical setup for phase testing six Current Sources. The phase meter shown is an Arbiter model 931 A.

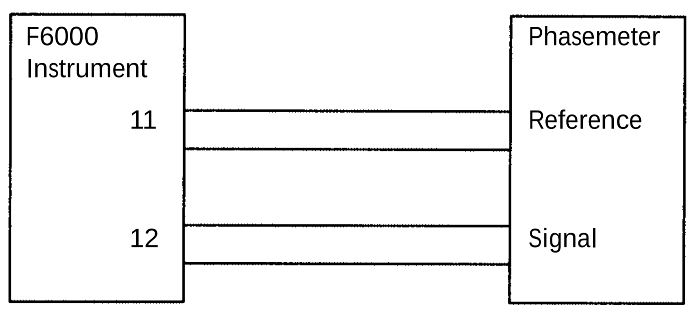


Figure F.11 Test Setup for Phase Testing Six Current Sources

75 VA Convertible Voltage Sources at 50 or 60 Hz

To perform the Phase Shift test on a 75 VA Convertible Voltage source at 50 or 60 Hz:

1. Configure the F6000 for six voltages using the Pre-set Configurations on the F6000 Configuration display.
2. Set all six ranges to 75 V and all amplitudes to 75 V.
3. Set all six phase angles to 0°.
4. Connect source VA to the reference input of the phase meter.
5. Connect source VB to the signal input of the phase meter.
6. Turn both sources ON.
7. Verify that the phase angle is within ±0.25°.
8. Turn OFF the signal source.
9. Repeat.

Figure F.12 shows a typical setup for phase testing six voltage sources. The phase meter shown is an Arbiter model 931 A.

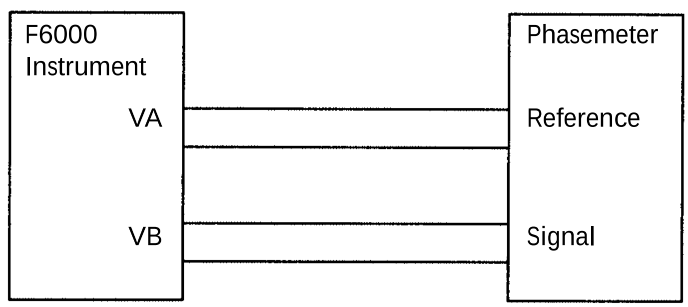


Figure F.12 Test Setup for Phase Testing Six Voltage Sources

Appendix G. F6150 Specifications

Convertible Voltage/Current Sources

Each 150 VA Convertible V/I Source can be used as a voltage source or optionally as a low range, high-power current source.

Source Configurations

Output Power Continuous	Output Power Transient for 1.5 Sec.	Number of Sources
75 VA	97.5 VA	6
150 VA	195 VA	3
450 VA	585 VA	1
300 VA	390 VA	1 + (150 VA)

Each 150 VA convertible V/I source can be split into two 75 VA sources. Two 150 VA convertible low current sources can be combined in parallel into one 300 VA current source. Three 150 VA convertible low current sources can be combined in parallel into one 450 VA current source.

Ranges and Resolution

75 VA Source

	Ranges (Resolution)
AC Voltage	75, 150, V rms (0.01 V)
DC Voltage	106, 212 VDC (0.01 V)
AC Current 1.5 Seconds Transient Continuous Power	 0.75, 1.5, A rms (0.0001 A) 0.5, 1.0, A rms (0.0001 A)
DC Current 1.5 Seconds Transient Continuous Power	 0.53, 1.06 ADC (0.0001 A) 0.354, 0.707 ADC (0.0001 A)

150 VA Source

	Ranges (Resolution)
AC Voltage	75, 150, 300 V rms (0.01V)
DC Voltage	106, 212 V (0.01 V), 300 VDC (0.1 V)
AC Current 1.5 Seconds Transient Continuous Power	 0.75, 1.5, 3.0 A rms (0.0001 A) 0.5, 1.0, 2.0 A rms (0.0001 A)
DC Current 1.5 Seconds Transient Continuous Power	 0.53, 1.06 A (0.0001 A), 2.12 ADC (0.001 A) 0.354, 0.707 A (0.0001 A), 1.41 ADC (0.001 A)

300 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 1.5, 3.0 A, 6.0 A rms (0.0001 A) 1.0, 2.0 A, 4.0 A rms (0.0001 A)
DC Current 1.5 Seconds Transient Continuous Power	 1.06 A (0.0001A), 2.12, 4.24 ADC (0.001 A) 0.707 A (0.0001A), 1.41 A, 2.83 A (0.001 A)

450 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 2.25, 4.5 A, 9.0 A rms A (0.001 A) 1.5, 3.0 A, 6.0 A rms A (0.001 A)
DC Current 1.5 Seconds Transient Continuous Power	 1.59 A (0.0001 A), 3.18, 6.36 ADC (0.001 A) 1.06 A, 2.12 A, 4.24 ADC (0.001 A)

Current Sources

Source Configurations

Output Power Continuous	Output Power Transient for 1.5 Sec.	
75 VA	112.5 VA	6
150 VA	225 VA	3
450 VA	675 VA	1
300 VA	450 VA	1 + (150 VA)

Each 150 VA current source can be split into two 75 VA sources. Two 150 VA current sources can be combined in parallel into one 300 VA current source. Three 150 VA current sources can be combined in parallel into one 450 VA current source.

Ranges and Resolution

75 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 15, 30 A rms (0.001 A) 7.5,15 A rms (0.001 A)
DC Current 1.5 Seconds Transient Continuous Power	 10, 20 ADC (0.01 A) 5 A (0.001A), 10 ADC (0.01 A)

150 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 15, 30 A (0.001 A), 60 A rms (0.01 A) 7.5,15 A (0.001A), 30 A rms (0.01A)
DC Current 1.5 Seconds Transient Continuous Power	 10, 20, 40 ADC (0.01 A) 5 A (0.001A), 10, 20 ADC (0.01 A)

300 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 15, 30 A (0.001 A), 60, 120 A rms (0.01 A) 7.5, 15 A (0.001 A), 30, 60 A rms (0.01 A)
DC Current 1.5 Seconds Transient Continuous Power	 10 A (0.001 A), 20, 40, 80 ADC (0.01 A) 5 A (0.001 A), 10, 20, 40 ADC (0.01 A)

450 VA Source

	Ranges (Resolution)
AC Current 1.5 Seconds Transient Continuous Power	 15, 30 A (0.001 A), 45, 90, 180 A rms (0.01 A) 7.5, 15, 22.5 (0.001 A), 45 A, 90 A rms (0.01 A)
DC Current 1.5 Seconds Transient Continuous Power	 10 A (0.001 A), 20, 30, 60, 120 ADC (0.01 A) 5 A (0.001 A), 10, 15, 30, 60 ADC (0.01 A)

Technical Specifications

Battery Simulator

Range: 48, 125, 250 VDC

Power: 60 Watts, 1.5 A maximum

50/60 Hz Ripple: <0.2% of range

AC Amplitude Accuracy at 50/60 Hz

From 20° to 30° C: < 0.02% typical 0.09% guaranteed

From 0° to 50° C: < 0.04% typical 0.09% guaranteed

Typically <0.02% of reading

Convertible Source in Current Mode

From 20° to 30° C: < 0.02% up to 20% rated load
<0.03% guaranteed

From 0° to 50° C: < 0.04% up to 20% rated load
<0.03% guaranteed

Distortion

Low distortion sine waves; total harmonic distortion <0,02% typical; 0.07% maximum at 50/60 Hz

Noise (10-30 kHz)

Voltage Source: 0.02% of range or 50 mV

Current Source: 0.02% of range or 1 mA

Phase Angle

Range: 0^o to $+359.9^o$ (Lead)/0 to $–359.9^o$ (Lag)

Accuracy: $\pm 0.25^o$ at 50/60 Hz

Accuracy: $\pm 0.5^o$ at 50/60 Hz for convertible sources in current mode (F6810 Option)

Resolution: $\pm 0.1^o$ at 50/60 Hz

Frequency

Bandwidth: DC to 3 kHz at full power for transient playback

Range: DC, AC from 0.1 Hz to 2 kHz at full power, continuous load

Resolution: 0.001 Hz

Accuracy:

0.5 PPM:	Typical
1.5 PPM:	20° to 30° C
10 PPM:	0° to 50° C

Ramp/Set

Ramp: increments/decrements voltage, current, phase angle, and frequency at user defined ramp rates. Ensures smooth, linear changes in value.

Metering Functions

DC Meter Inputs	Input Range: 0 to ± 10 VDC or 0 to ± 20 mA DC Accuracy: <0.003% typical <+0.05% guaranteed
AC Sources	Accuracy: <0.02% for typical meter loads
Logic Inputs as Counters	Frequency: 10 kHz Pulsewidth: >175 microseconds

Logic Outputs

Eight galvanically isolated Logic Outputs configured as Normally Open (NO) or Normally Closed (NC) switches.

Applied Voltage: 250 V DC or AC

Switching Current: 0.5 A make or break, maximum

Response Time: 0.1 millisecond maximum pick up and drop out

Isolation: ±500 V Peak

Logic Inputs

Eight galvanically isolated Logic Inputs, configurable as Voltage Sense or Contact Sense.

Voltage Sense: Up to 250 VAC or DC

Open Circuit Test Voltage: 12 VDC nominal

Short Circuit Test Current: 20 mA VDC nominal

Response Time: 0.1 millisecond maximum pick up and drop out

Isolation: ±500 V Peak

Triggers

Number: 8

Boolean combination of logic inputs can be used to define triggers. Triggers are used to set timer start and stop conditions.

Timers

Number: 8

Max Recording Time: 24 hours

Accuracy: ±0.0005% of reading, ±50 microseconds

Resolution: 100 microseconds

Time can be displayed in milliseconds, seconds and cycles

General Specifications

Source Operation

Worst-case accuracy specifications *simultaneously* include all errors contributed by variations in power line voltage, load regulation, stability, and temperature, up to full output power. Includes stable source operation in four quadrants while delivering power — load power factor from nearly 1 to 0, leading or lagging. Each F6000 Instrument is supplied with a Certificate of Calibration traceable to the National Institute of Standards and Technology.

Electrostatic Discharge Immunity

IEC 801-2 I.E.C. performance level 1 @ 10 kV: normal performance within specifications. IEC performance level 2 @ 20 kV: no permanent damage.

Surge Withstand Capability

ANSI/IEEE C37.90. The F6000 Instrument functions as a source during surge withstand capability tests, when the ANSI/IEEE-specified isolating circuit is interposed between the instrument and the relay under test.

Line Power Supply

105 V to 132 V (50 Hz)

210 to 264 (60 Hz)

Temperature

Operating temperature: 0° to 50° C

Storage temperature: –25° to +75° C

Humidity

Up to 95% relative humidity, non-condensing

Weight

44 lbs/20 kgs

Interfaces

RS-232 or Ethernet remote control to computer

Safety

European Standard:

EN61010-1:1993/A1+A2

EN61010-2-031:1994

Electromagnetic Compatibility (EMC)

European Standard:

EN61326:1997/A1:1998

US Standard:

FCC 47CFR Part 15 Class A

Enclosure

High impact, molded, flame retardant ABS. Meets National Safe Transit Association testing specification No. 1A for immunity to severe shock and vibration.

Measurements

Dimensions: 15 x 9.5 x 18 in or 38 x 24 x 45.7 cm

Weight: 44 lbs/20 kgs

NOTE

All specifications are subject to change without notice.

Index

D

E

F

G

H

I

K

L

M

N

O

P

R

S

-

T

U

V

W

Z