F6000 Family of Power System Simulators User Guide

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

PN 500-0206

72A-1589 Rev. C 02/01

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 321)
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, ProTesT software, 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 ″Control Panel Operations″

Chapter 4 describes the settings and controls on the F6000 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 ProTesT from the hardware on the instrument:

- *Control Panel* refers to the main display in ProTesT 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.

CE 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 systems. 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*
- 4 voltage sources and 4 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 relay 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 Amplifiers
- Power Supply
- Battery Simulator
- Four Cooling Fans

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

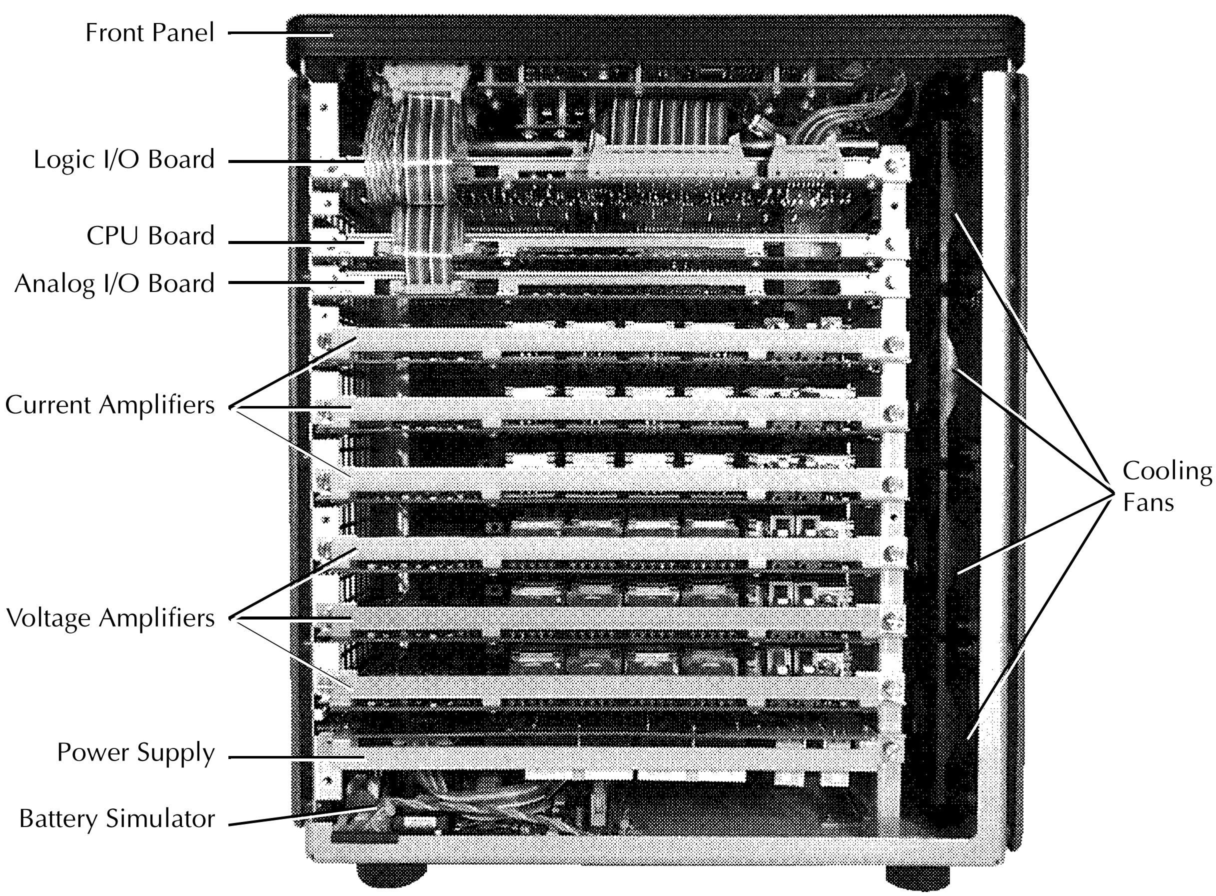

Figure 1.2 Instrument Architecture

ProTesT

ProTesT is a software system for protective relay testing and equipment maintenance. It includes the F6000 Control Panel for manual control of the instrument. It also combines automatic control of the F6000 Instrument with the functions of a client server database.

ProTesT uses test templates called macros to automate tests on protection scheme relays. The ProTesT database also documents relay settings, test conditions, and test history. Figure 1.3 on page 1-4 illustrates how the ProTesT software interacts with the F6000 and with the relay under test.

ProTesT allows the use of three testing methods:

- Steady state relay calibration
- Dynamic state testing
- Transient testing

Steady state relay calibration uses macros to automate tests on protection relays and schemes. These macros test individual relay functions, such as reach, instantaneous overcurrent, reverse current response, pick up and dropout, and operation and reset timing.

Dynamic state testing uses a special state simulation macro. The state simulation macro simultaneously applies fundamental frequency components of voltage and current that represent power system states. Typically these states are pre-fault, fault, and post-fault.

Transient testing uses the optional ProTesT TPlan. Transient simulation tests simultaneously apply fundamental and non-fundamental frequency components of voltage and current that represent power system conditions obtained from Disturbance Fault Recorders (DFR) or system modeling tools such as EMTP or ATP. The DFR and system modeling tool data are typically stored in a COMTRADE file. ProTesT TPlan can work with COMTRADE files.

To enhance the capabilities of the F6000 Instrument, ProTesT:

- Automates protective relay tests to reduce testing time and increase accuracy
- Tests complete protection schemes under realistic power system conditions
- Creates standardized test plans with repeatable results
- Stores test plans and test results for later retrieval and analysis

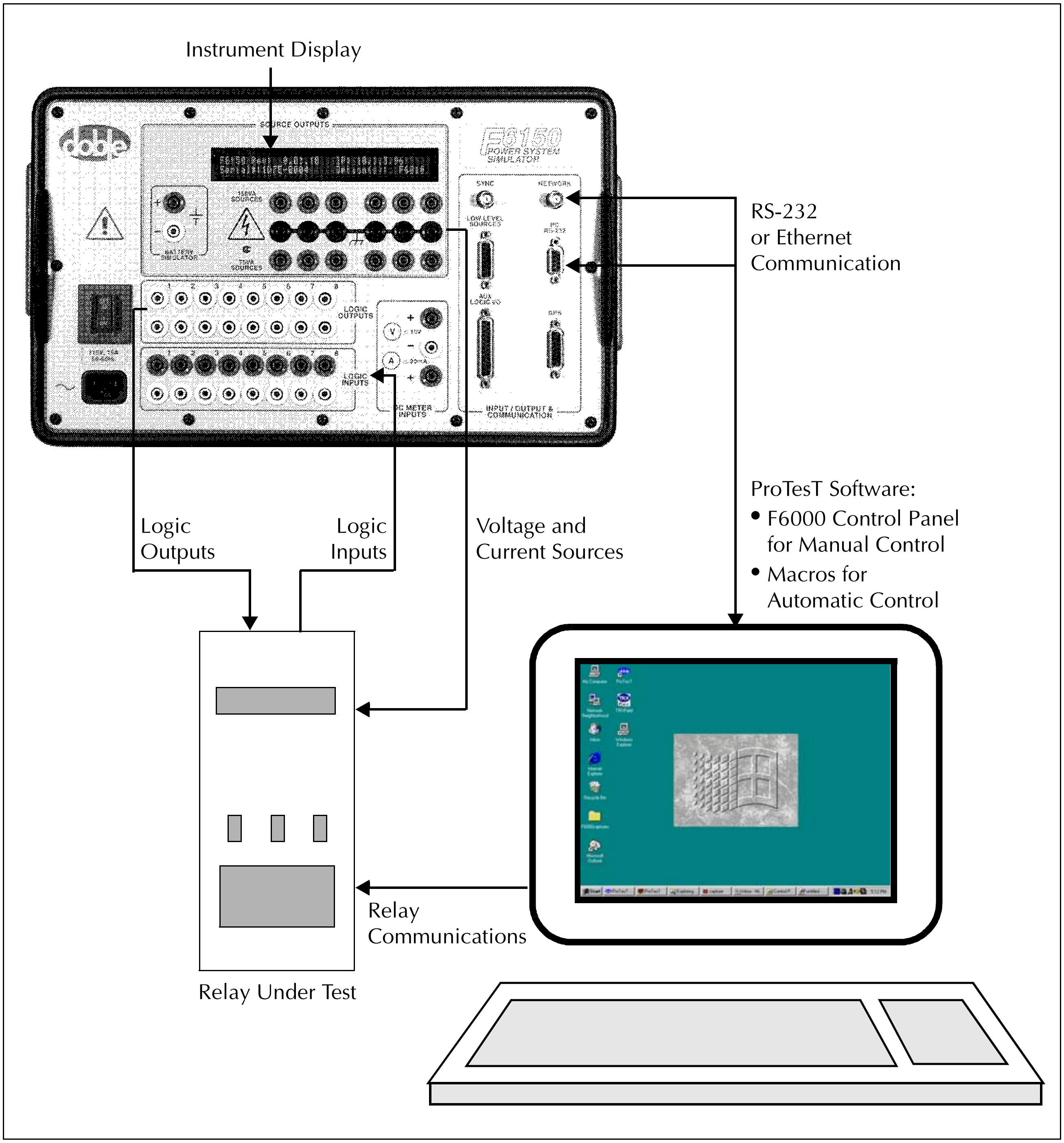

Figure 1.3 Test Setup with ProTesT, F6000 Instrument, and Relay Under Test

Control Panel

The F6000 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, logic outputs, and timers. The F6000 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 relay without an elaborate test plan.

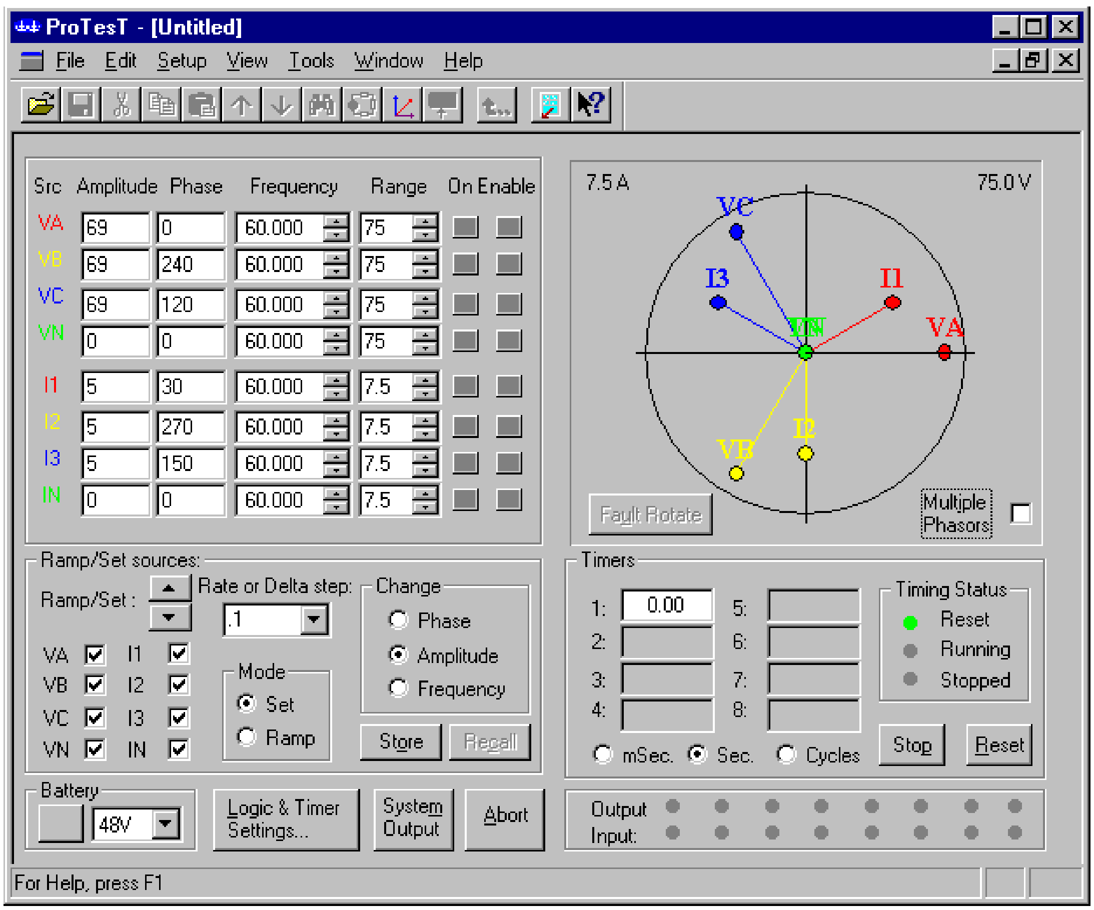

Figure 1.4 F6000 Control Panel

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 ProTesT F6000 Control Panel to communicate with the F6000 Instrument.
Option F6910	*Simulator control and automation module.* Use with ProTesT software or third party software.
Option F6885	*Global Positioning System (GPS) satellite receiver interface.* GPS antenna (Option F6895) must be ordered separately.
Option F6895	*GPS antenna.* Requires Option F6885, GPS satellite receiver interface.

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.

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.

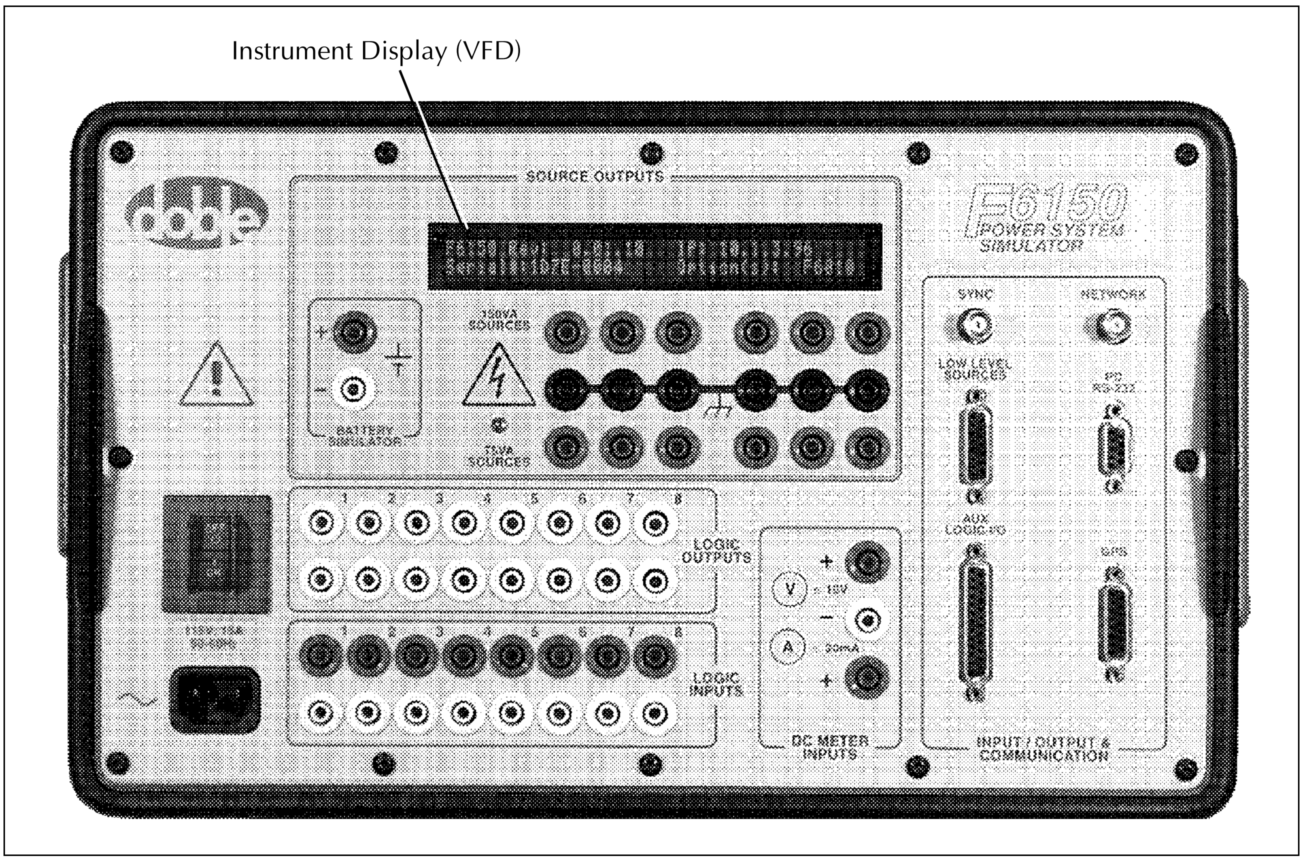

Figure 2.1 F6000 Instrument Front Panel

Source Outputs

The *Source Outputs* section of the relay F6150 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.

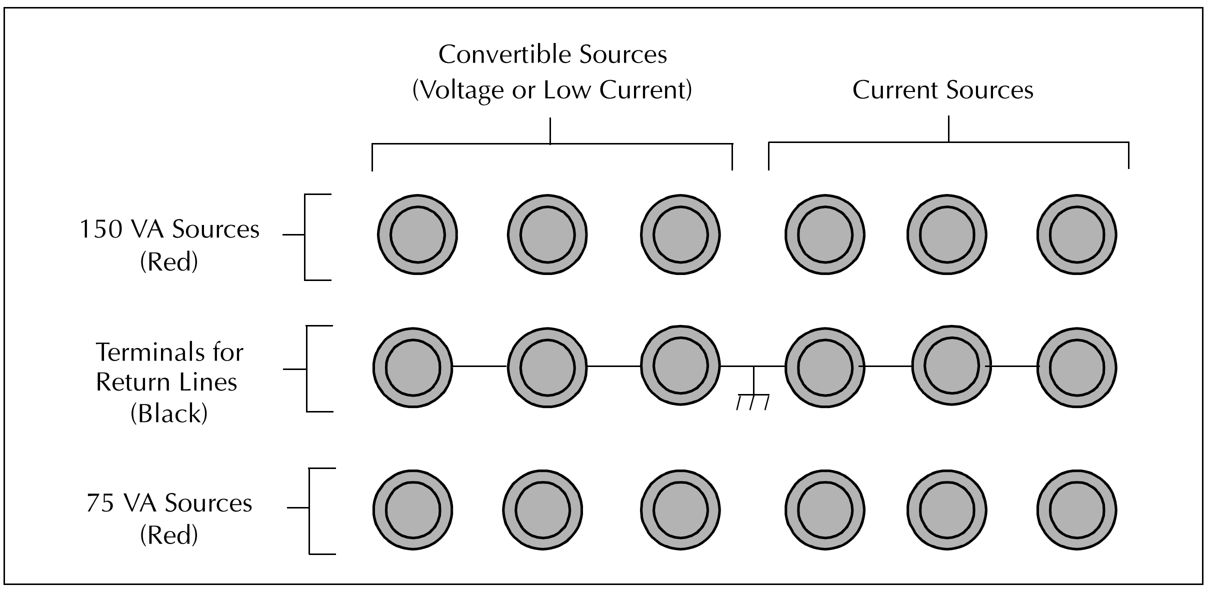

Figure 2.2 F6000 Instrument Front Panel Source Outputs

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).

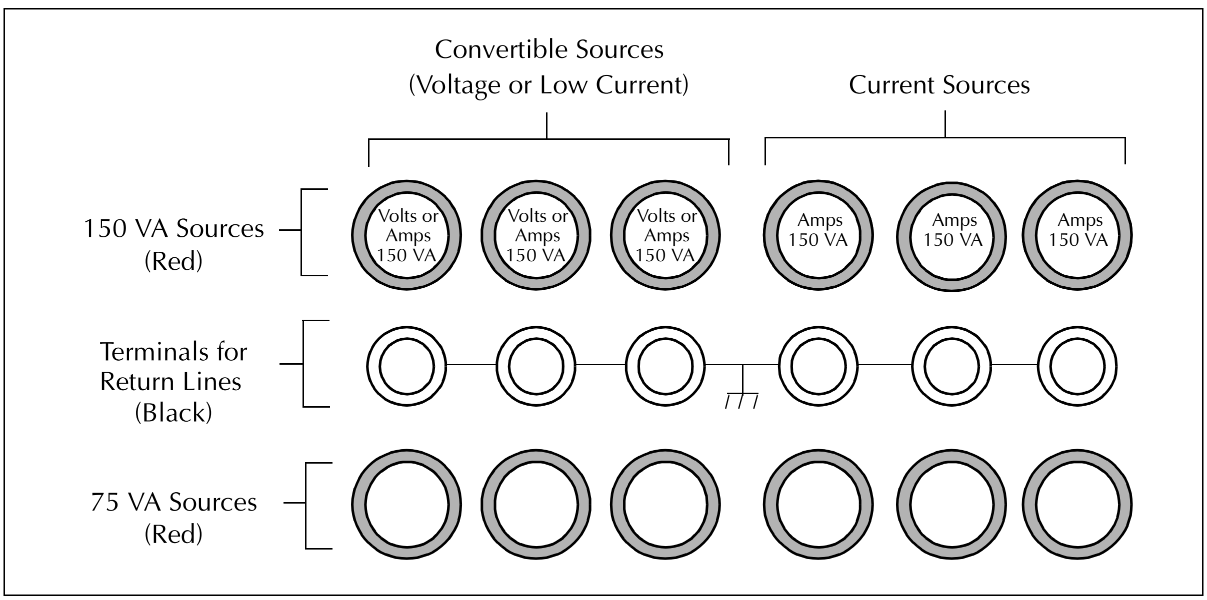

Figure 2.3 Six 150 VA Sources

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).

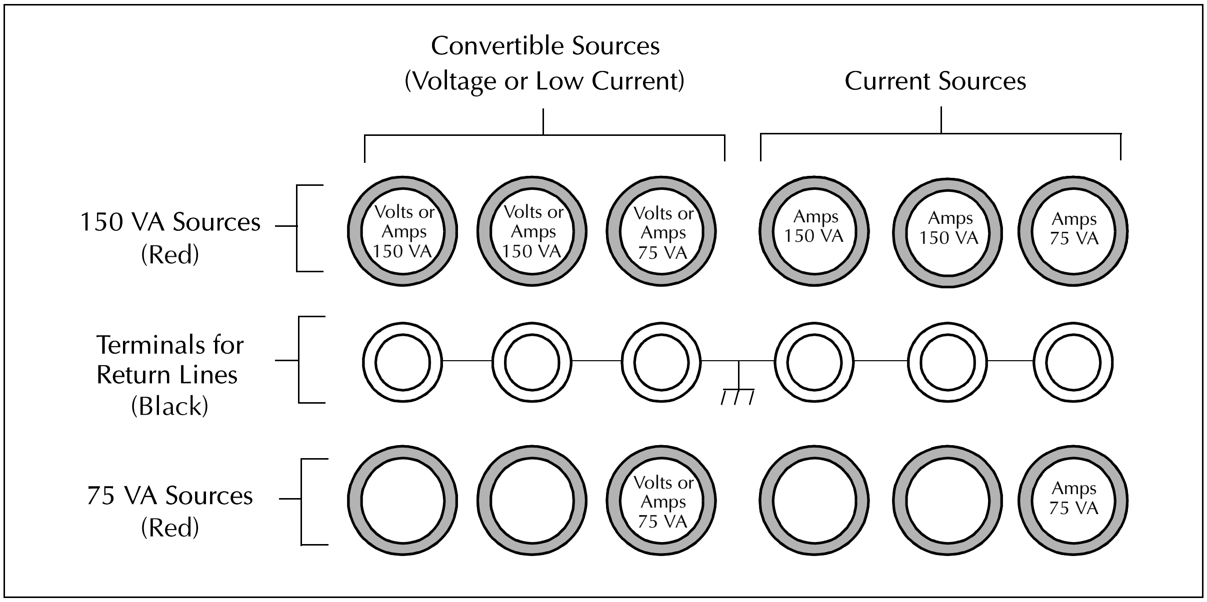

Figure 2.4 Four 150 VA Sources and Four 75 VA Sources

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.

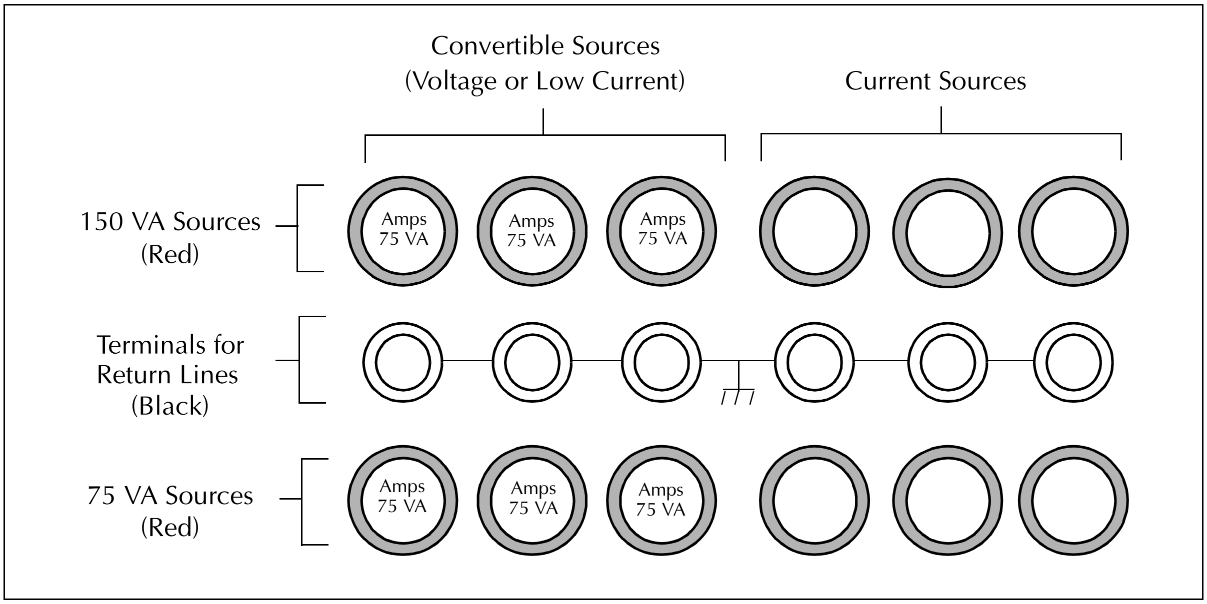

Figure 2.5 Six 75 VA Sources

Battery Simulator

The battery simulator can be used to power digital relays 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 ProTesT to communicate using either the serial port or an Ethernet connection, see "Setup Display" on page 3-5. 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	Coaxial Ethernet cable with BNC connectors and 50 Ohm end terminators
Communication Setup (in ProTesT)	COM*X* (COM1 by default)	IP address (10.1.3.1 by default)
Baud Rate (in ProTesT)	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 1-6). 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 F6000 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 F6000 Control Panel software to configure and control the logic inputs.

DC Meter Inputs

The front panel contains three DC meter input terminals. These are for future use.

Power

The connection for the electrical power cord is in the lower left-hand 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
   - Brown 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-hand 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):

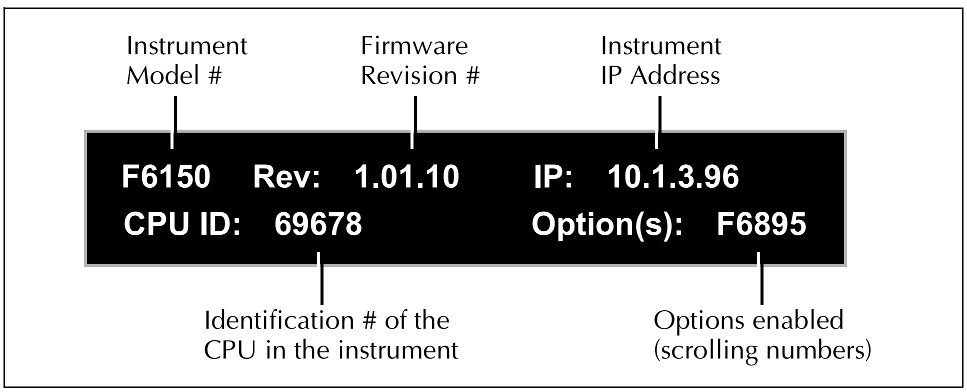

Figure 3.1 Instrument Display After Successful Bootup

NOTE

If an error message appears in the VFD at the end of the bootup sequence, refer to "Hardware Errors" on page 6-11.

The F6000 Instrument is controlled via the F6000 Control Panel installed with ProTesT 1.70 software. ProTesT 1.70 or later requires the following hardware and software:

- Personal computer with a Pentium class processor
- Windows 95/98/NT 4.0 operating systems
- ProTesT 1.70 or later installed on the hard drive of the computer (for installation instructions, see the *ProTesT User Guide*)
- RS-232 serial cable or Ethernet BNC cable with a 10 MB network card
- At least 32 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-hand side of the front panel.

7. Turn the computer on.

8. Click **Start | Programs | ProTesT** to launch ProTesT.
   The **Login** display appears (Figure 3.2)

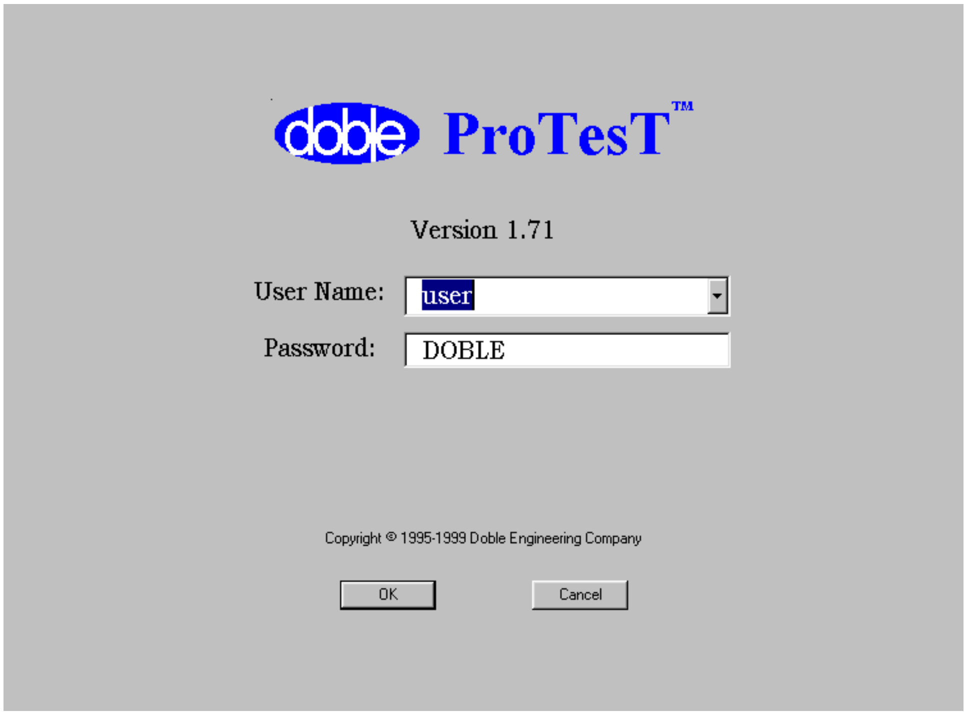

Figure 3.2 Login Display

9. Click **OK** in the **Login** display to open ProTesT.

Setup Display

Use the **Setup** display (Figure 3.3) to configure the ProTesT software to communicate with the F6000 instrument. To open the **Setup** display, click **Setup** in the ProTesT menu bar. Select *F6* as the default instrument. Locate the section labeled *F6 Instrument*. It contains several settings related to system communications. It also contains a check box to specify simulation mode for the F6000 Control Panel if there is no F6000 Instrument connected.

Figure 3.3 Setup Display

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/NT.
Baud Rate	The baud rate for serial port communications must be 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 ProTesT **Setup** display (Figure 3.3 on page 3-5). 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 simulator mode. Simulator 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 F6000 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 ProTesT menu bar to open the **F6000 Configuration** display (Figure 3.4).

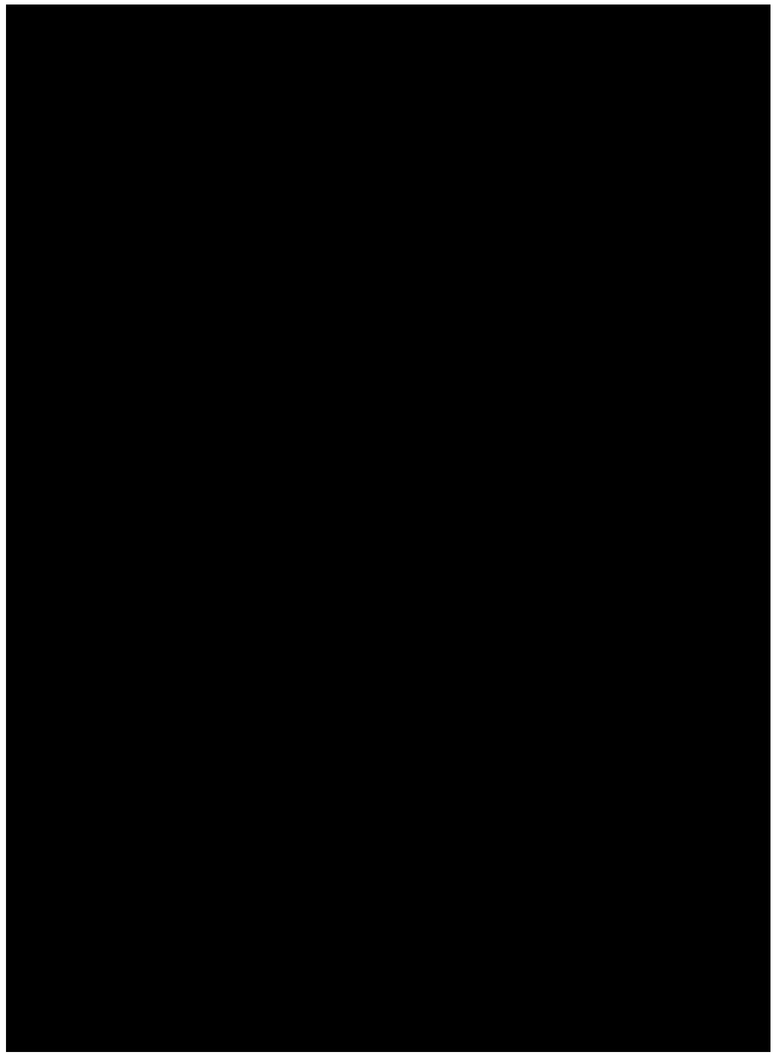

Figure 3.4 Configuration Display

2. Click **Show Source Summary** to show the VA rating and the range settings for each configured source (Figure 3.5).

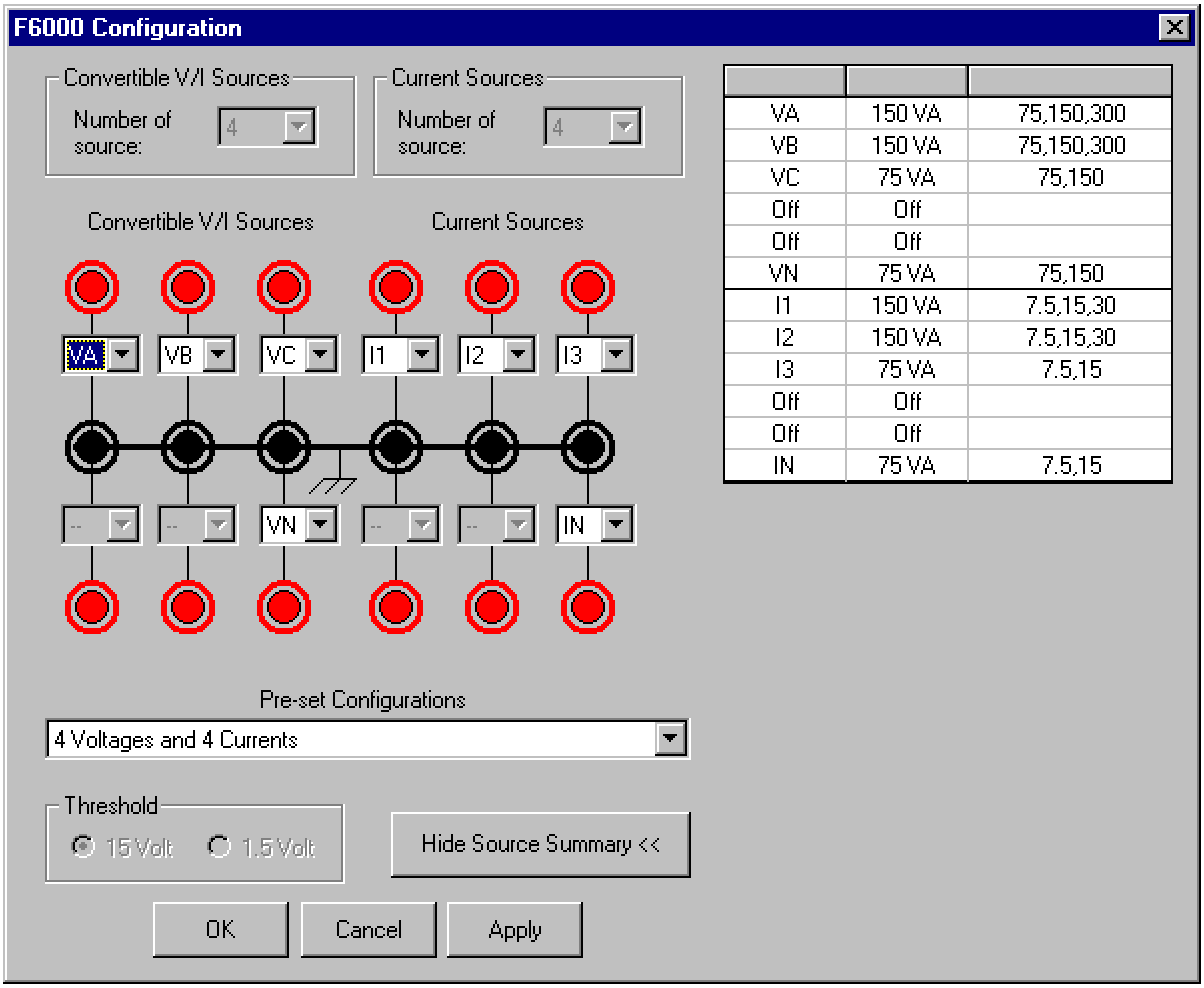

Figure 3.5 Configuration Display with Source Summary

To configure the sources manually, select **User defined** in the *Pre-set Configurations* pick list. 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, then 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 3.5 on page 3-8.

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 are typically designated *VA, VB,* and *VC.*
- Current sources are typically designated *I1, I2,* and *I3.*
- *VN* is a general label for a fourth voltage source.
- *IN* is a general label for a fourth current source.

Pre-set Configurations

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

- 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

To finish configuring the sources, click one of the three buttons at the bottom of the display (Figure 3.5 on page 3-8):

- 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.

F6000 Control Panel

The F6000 Control Panel (Figure 3.6) contains all of the functions and controls needed to conduct tests with the F6000 Instrument. To open the F6000 Control Panel, click **Tools | F6000 Control Panel** in the ProTesT menu bar. Chapter 4 describes the F6000 Control Panel settings in detail.

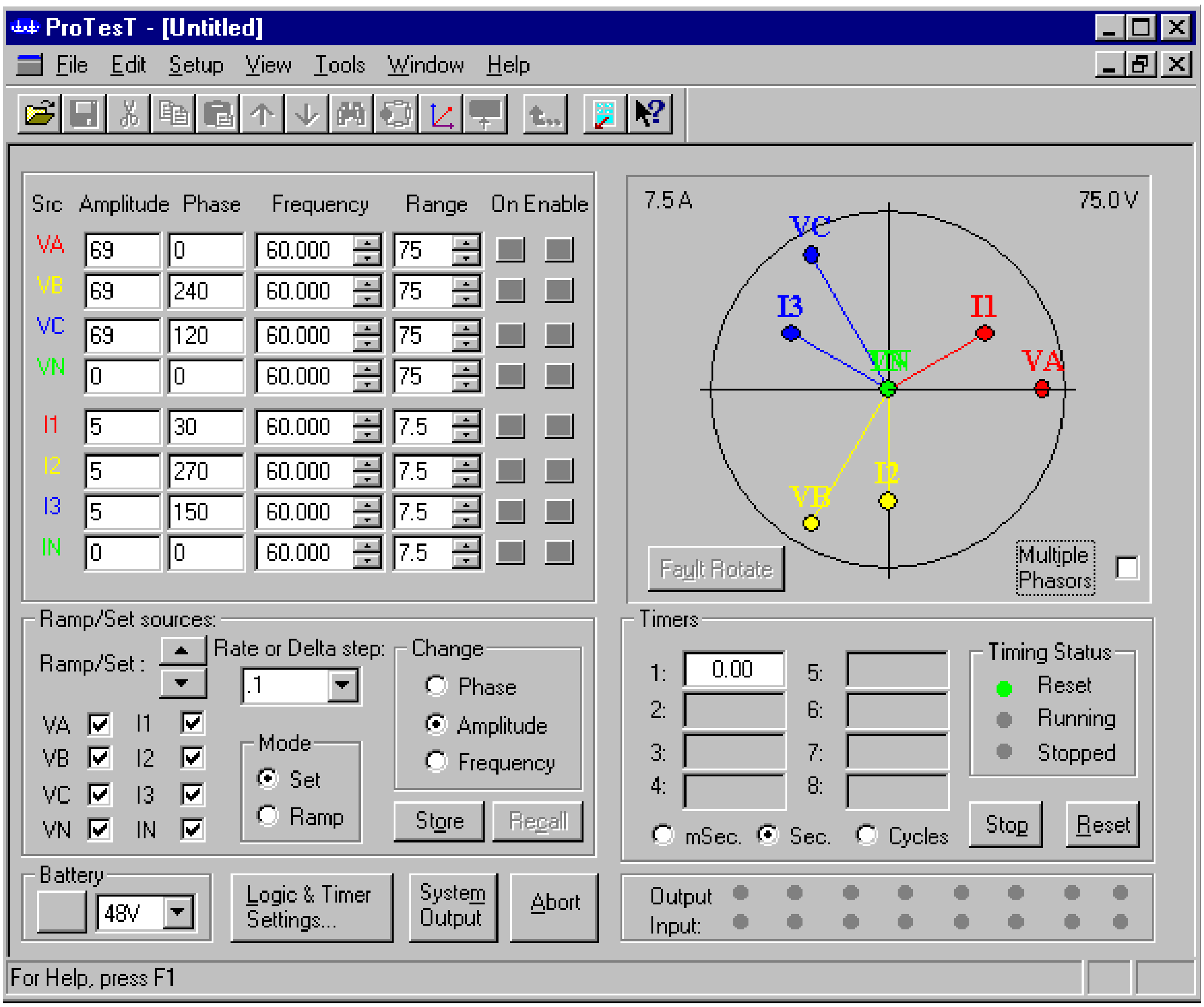

Figure 3.6 F6000 Control Panel

4. Control Panel Operations

This chapter describes the settings and controls in the F6000 Control Panel. The F6000 Control Panel is a virtual front panel used for manual control of F6000 sources. To open the Control Panel, click **Tools | F6000 Control Panel** in the ProTesT menu bar. The Control Panel opens in ProTesT (Figure 4.1).

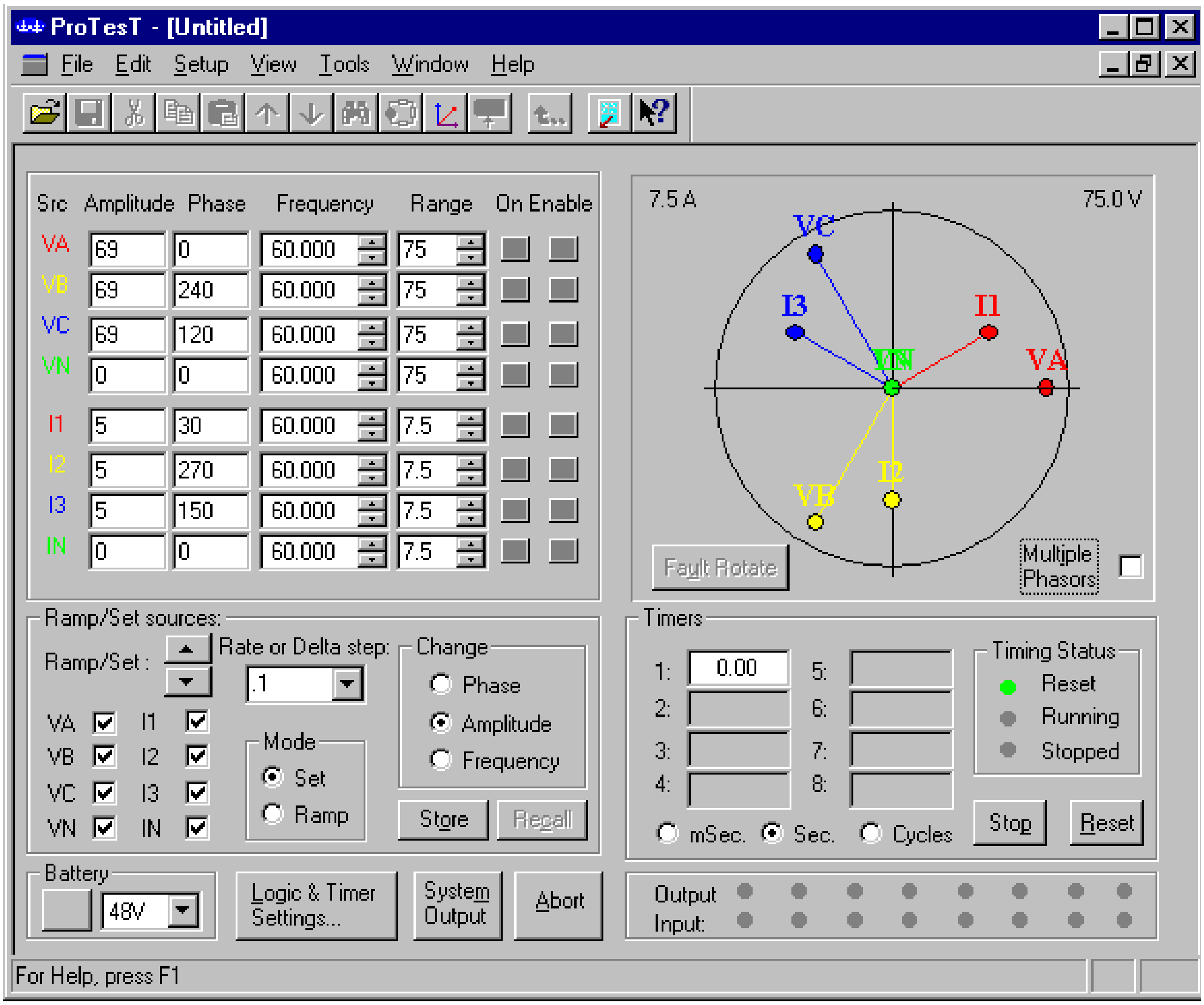

Figure 4.1 F6000 Control Panel

The Control Panel contains eight sections. The functions in these sections control the instrument's source outputs, logic inputs, logic outputs, and timers. Starting in the upper left-hand corner, these are:

- Source table
- Ramp/Set sources
- Battery simulator
- Logic and timer settings button
- Phasor diagram
- Timers
- Logic output and logic input indicators
- System Output
- Abort

Source Table

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

- Source
- Amplitude
- Phase
- Frequency
- Range
- On
- Enable

Figure 4.2 Source Table

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 also blink, and an audible alarm sounds from the speakers of the control PC. See "Source Errors" on page 6-14.

The first five columns contain the settings for each source:

Source	The source column in Figure 4.2 contains eight entries for eight sources. The standard naming scheme for the voltage sources is *VA*, *VB*, *VC*, and *VN*; the standard naming scheme for the current sources is *I1*, *I2*, *I3*, and *IN*.
Amplitude	Amplitude indicates the voltage or current value of a source. The range sets the maximum value for the amplitude. If the amplitude entered exceeds the maximum range value, an error message appears. To correct the error, reduce the amplitude or increase the range.
Phase	The phase indicates the phase angle in degrees. Enter a phase angle from –359.9° to 0° to +359.9°.

Frequency	The default system frequency is 50/60 Hz. Use the **Setup** display (Figure 3.3 on page 3-5) to change the default frequency. Use the spinner arrows in the *Frequency* column to select the AC harmonic 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 maximum compliance voltage, use the lowest current range that can produce the desired test current. See Appendix G "F6150 Specifications" for more details about range settings.

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

On	Click the **On** button to activate a source. 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 of the enabled sources turn on. The System Output button turns red, and 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 the potential for dangerous or fatal voltages.

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 does not turn off the battery simulator.

Ramp/Set Sources

The *Ramp/Set sources* section (Figure 4.3) contains five fields for varying 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

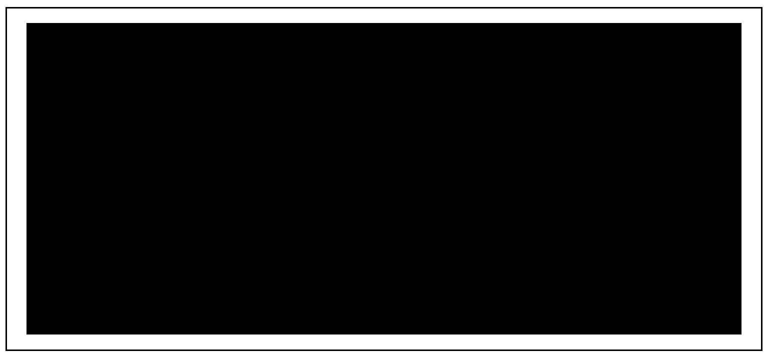

Figure 4.3 Ramp/Set Sources Section

NOTE

Use the source table and the *Ramp/Set* section to control the amplitude, phase angle, and frequency of each source. These capabilities enable the pickup, dropout, and time tests.

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.

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 7 vary together, and are harmonically related to each other.

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 eight sources in Figure 4.3 on page 4-6 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.

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 respectively clicked.
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.

AutoSensE is a *Ramp* mode feature (see "Inputs Tab" on page 4-13). The timers are a *Set* mode feature (see "Timers Tab" on page 4-16 and "Timers" on page 4-24).

Store and Recall

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

Phasor Diagram

The phasor diagram in the upper right-hand 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. Phasor I1 in Figure 4.4 indicates that current source I1 has an amplitude of 5 A and a phase angle of 30°.

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 4.4 Phasor Diagram

Range Settings

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

Fault Rotate

Click **Fault Rotate** to rotate a fault from phase to phase without rewiring the instrument front panel or relay under test. See Chapter 5 ″Basic Test Procedures″, for an example of how Fault Rotate works.

Fault Rotate works only if the following conditions are met:

- The source configuration must be 3 Voltages and 3 Currents, or 3 Voltages and 1 Current. (See ″Pre-set Configurations″ on page 3-10 or see Appendix C ″Source Configurations″.)
- All voltage sources must be on the same range.
- All current sources must be on the same range.

The Fault Rotate button in the phasor diagram is grayed out if one or more of these conditions is not met.

Use a simple A-to-ground fault to try the Fault Rotate procedure. To simulate the fault, the voltage VA drops and the current I1 goes up. For this example, VA = 40 V and I1 = 10 A (Table 4.2).

When the fault is rotated, the fault in A goes to B, the settings in phase B go to C, and the settings in C go to A:

A → B

B → C

C → A

When the fault is rotated, VB = 40 V and I2 = 10 A. Rotated again, VC = 40 V and I3 = 10 A (Table 4.2). Both the source table and the phasor diagram reflect these changes.

Table 4.2 Rotation of a Phase-to-Ground Fault

Source	Initial Setup: Fault in Phase A		Fault Rotated to Phase B		Fault Rotated to Phase C	
VA	40 V	0°	69 V	120°	69 V	240°
VB	69 V	240°	40 V	0°	69 V	120°
VC	69 V	120°	69 V	240°	40 V	0°
I1	10 A	330°	0 A	90°	0 A	210°
I2	0 A	210°	10 A	330°	0 A	90°
I3	0 A	90°	0 A	210°	10 A	330°

Multiple Phasors

When *Multiple Phasors* is checked, all the phasors for a set of voltage or current sources can be moved by dragging and dropping any one of them. (Each phasor maintains its position relative to the other two.) When dragging the phasors, the source table is continuously updated, but the new amplitude and phase angle values are not sent to the F6000 Instrument until the phasor selected is dropped. Figure 4.5, Figure 4.6, and Figure 4.7 show a configuration with three voltage sources and no current sources. The three figures illustrate how the phase angles for VA, VB, and VC change when the phasor for VA is shifted ~45° with *Multiple Phasors* checked.

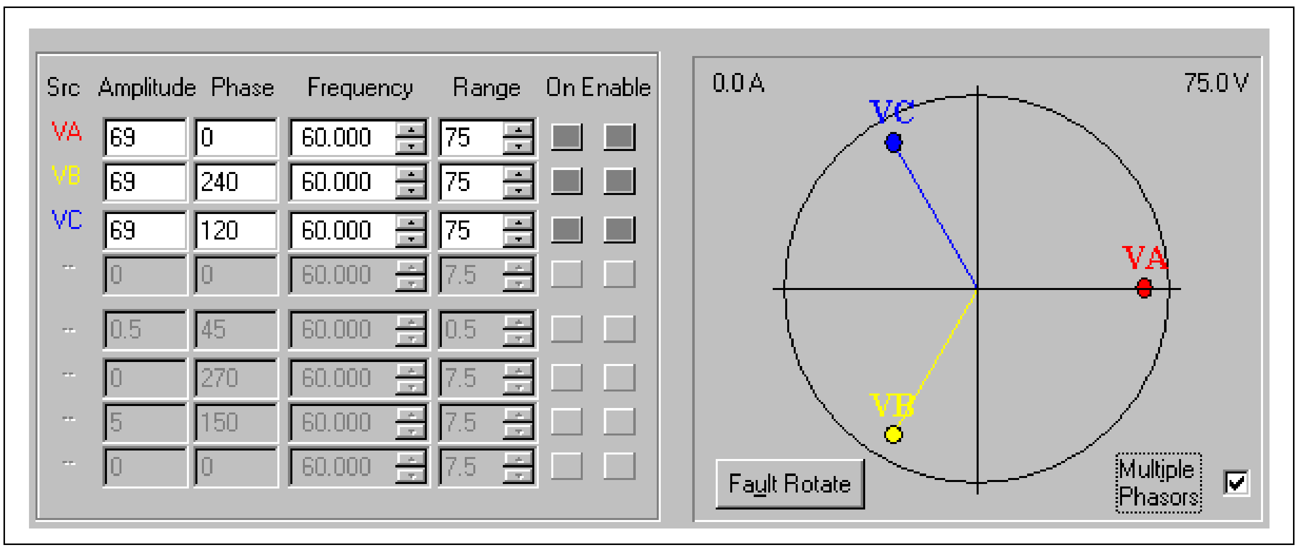

Figure 4.5 Phasors for Three Voltage Sources Separated 120°

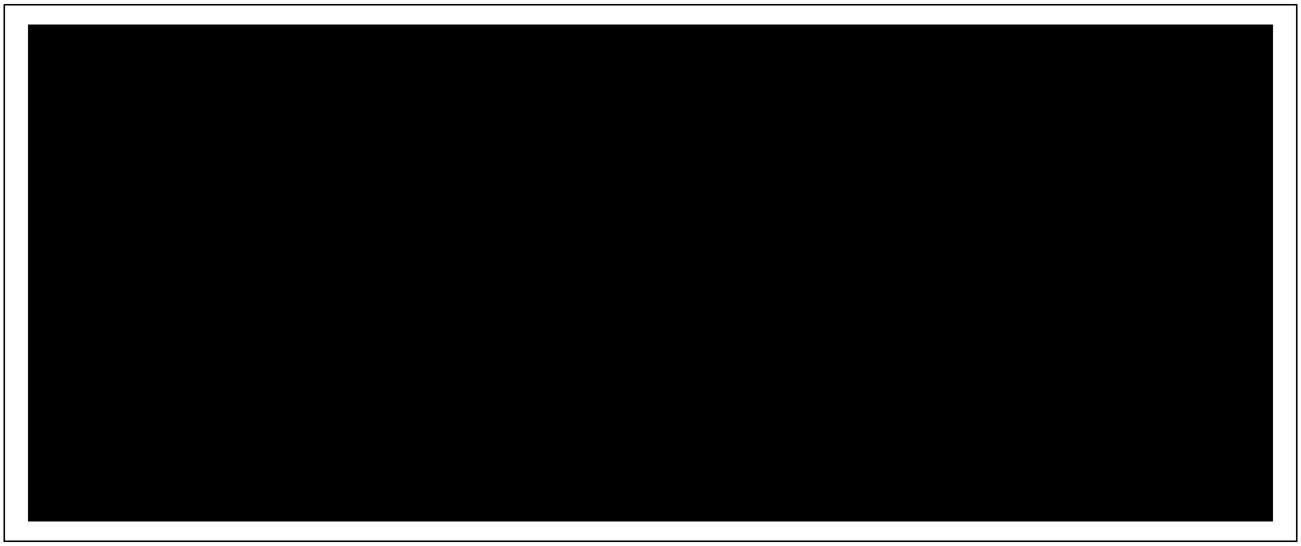

Figure 4.6 Dotted Lines Show New Position of Phasors Before Release

Figure 4.7 Phasors for Three Voltage Sources Shifted ~45°

Logic and Timer Settings

Click **Logic/Timer settings...** to bring up the **Settings** display (Figure 4.8). The **Settings** display has four tabs:

- Inputs
- Outputs
- Timers
- Notes

Inputs Tab

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

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. Table 4.3 summarizes these selections for a relay with normally open contacts. For normally closed output contacts, use inverse logic (i.e., instead of Off to On, use On to Off).

Table 4.3 Sense Conditions for Input Types

Type of Input	Sense Conditions	Description
Potential	Off → On	Relay responds
	On → Off	Relay drops out
Contact	Open → Close	Relay responds
	Close → Open	Relay drops out

The *AutoSensE* column lies to the right of the pick lists. Each logic input has an AutoSensE radio button. Selecting AutoSensE for an input freezes the ramping variable or variables when the required input condition is sensed.

NOTE

The default setting for the AutoSensE feature is Off. To enable the AutoSensE radio buttons, remove the check mark from the Off box at the bottom of the AutoSensE column.

Locate the *Threshold* section beneath the *Type* and *Sense Condition* columns. The *Threshold* section applies to relays that have potential present at their terminals.

The threshold setting of 15 V is provided to reduce sensitivity to circuit noise. Use the 1.5 V setting when the circuit does not have noise present, or 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.

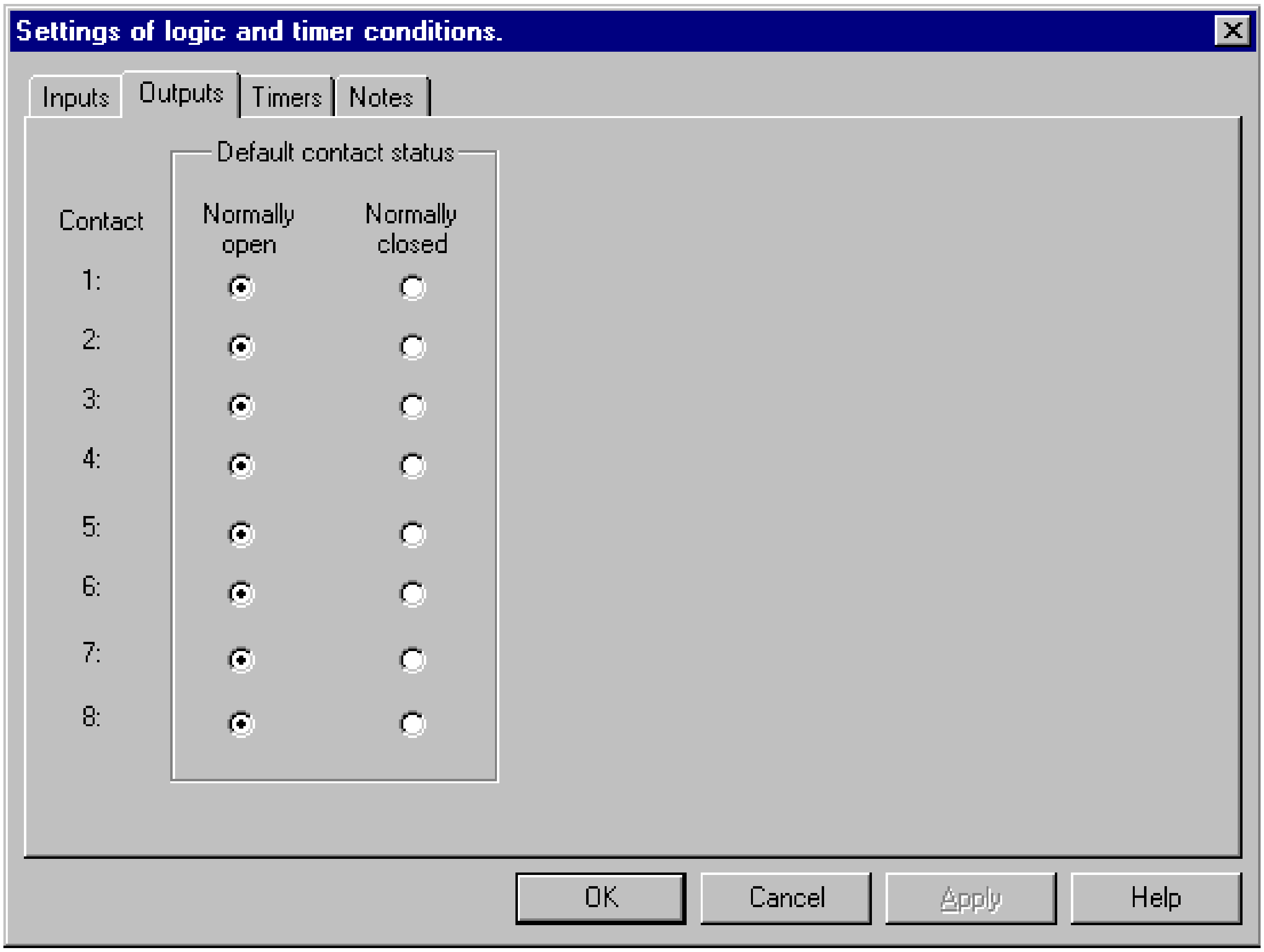

Figure 4.9 Outputs Tab

NOTE

The logic outputs change state with the status of their mapped output sources. See "Input and Output Indicators" on page 4-26.

Timers Tab

The Timers tab (Figure 4.10) contains functions that define the start and stop conditions for a particular timer. To set Timer 1, select the first radio button under *Set timer*. The start and stop conditions for each timer are set individually.

Figure 4.10 Timers Tab

Define Triggers

If a start condition or a stop condition requires an input signal from the relay under test or from any other source, specify the input via the **Triggers** display (Figure 4.11). To open the **Triggers** display, click **Define triggers...** in the Timers tab.

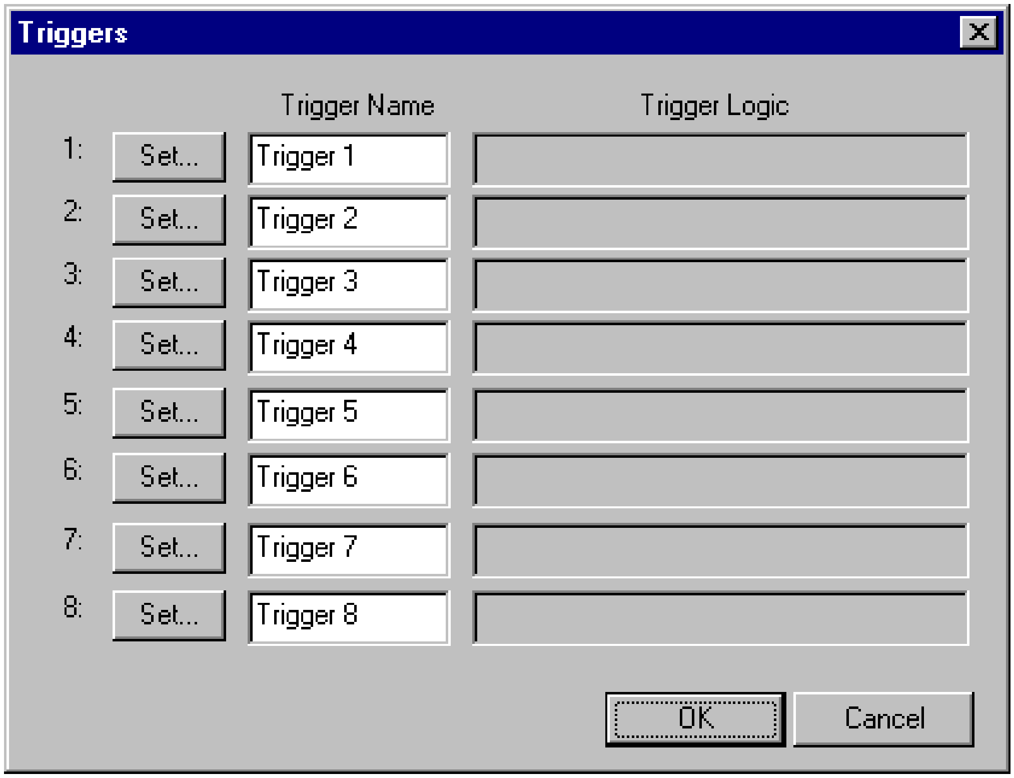

Figure 4.11 Triggers Display

Click **Set...** for Trigger 1 in the **Triggers** display to open **Set Trigger Logic** (Figure 4.12). Use the **Set Trigger Logic** display to select the inputs needed to make the trigger true. For instance, click **1** under *Choose input* to put In1 in the *Logic* field.

Figure 4.12 Set Trigger Logic

Multiple inputs can be configured as a trigger logic setting by using Boolean operators with the inputs. The Boolean operators used are And (*), Or (+), and Not (~). To put more than one input in the *Logic* field, select *And* or *Or* under *Mask Operator* to connect them logically.

- Connecting the logic inputs with the *And* operator requires that all the inputs be true to assert the trigger.
- Connecting the logic inputs with the *Or* operator requires that any of the inputs be true to assert the trigger.

Click the *Not Input* checkbox to place a tilde (~) before a logic input. In this case, the trigger is asserted when the logic input is *not* true.

In the **Set Trigger Logic** display, select the *And* operator (*) or the *Or* operator (+) under *Mask Operator* to set the logical relationship for two or more inputs. These three examples illustrate the logic for three distinct triggers:

In1*In2	The trigger is asserted when both Input 1 and Input 2 are true.
In1+In2	The trigger is asserted when either Input 1 or Input 2 is true.
In1*~In2	The trigger is asserted when Input 1 is true and Input 2 is not true.

Click **Group inputs** to place parentheses around a series of inputs in the *Logic* field. Then select a group operator to set the logical relationship between the group and another input or group of inputs. For example:

(In1*In2*In3*In4*In5*In6*In7)+In8

The trigger is asserted when Inputs 1 through 7 are true, *or* when Input 8 is true.

(In1+In2+In3+In4+In5+In6+In7)*In8

The trigger is asserted when *one* of the first seven inputs is true, *and* Input 8 is true.

Three restrictions govern the formation of logical expressions that use a group operator:

- The mask operator for all of the inputs inside the parentheses must be the same.
- The group operator outside the parentheses must be the opposite of the mask operator inside the parentheses.

Click **Delete last** to delete the last input entered in the *Logic* field. To clear all the inputs from the *Logic* field, click **Delete last** until all the inputs are deleted.

Set Timer Conditions

Click **OK** to close the **Set Trigger Logic** display. The text in the *Logic* field of the **Set Trigger Logic** display appears in the *Trigger Logic* field of the **Triggers** display (Figure 4.13).

Figure 4.13 Trigger Logic Set for Trigger 1

Click **OK** to close the **Triggers** display and return to the Timers tab (Figure 4.10 on page 4-16). The trigger named Trigger 1 appears in both the *Start on source* and the *Stop on source* pick lists.

Start on source	The *Start on source* pick list contains the voltage and current sources from the source table, plus the defined triggers. Click the source or trigger in the list required by the test protocol.
Start condition	The *Start condition* pick list contains three events or transitions: Off to On, On to Off, and On Change. The *On Change* option permits time tests that are initiated when there is a step change in the selected source variables. Click the start condition required by the test protocol. When the source or trigger selected in *Start on source* meets the specified start condition, the timer starts.
Stop on source	The *Stop on source* pick list contains the voltage and current sources from the source table, plus the defined triggers. Select the source or trigger from the list required by the test protocol.
Stop condition	The *Stop condition* pick list contains two events or transitions – Off to On, and On to Off. Click the stop condition required by the test protocol. When the source or trigger selected in *Stop on source* meets the specified stop condition, the timer stops.

NOTE

The timer start and stop conditions apply only to the voltage and current sources. If a trigger is selected in *Start on source*, the *Start condition* pick list is grayed out. Similarly, if a trigger is selected in *Stop on source*, the *Stop condition* pick list is grayed out.

Set and Reset

After selecting the desired entries from all four pick lists in the Timers tab, click **Set**. The start condition defined in the first two pick lists appears in the *Start condition* field in Figure 4.14. The stop condition defined in the third and fourth pick lists appears in the *Stop condition* field in Figure 4.14.

Figure 4.14 Start and Stop Conditions Set in the Timers Tab

To redefine the start and stop conditions for a timer, click the radio button for that timer. Then click **Reset** in the *Set timer conditions* section. The *Start condition* and *Stop condition* fields for that timer go blank, and new conditions from the pick lists can be selected.

Notes Tab

Use the Notes tab (Figure 4.15) to document any part of a test setup or test procedure by typing in text. For example, the Notes tab can be used to record timer conditions in the Timers tab, triggers defined in the **Triggers** display, or the reasons for key settings. When in simulator 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 4.15 Notes Tab

Timers

The *Timers* section contains readouts for eight timers (Figure 4.16). Using logic inputs and logic outputs, time tests are possible for up to eight separate events. The timers allow configuration of the logic inputs and outputs for specific relays or for an entire protection scheme. For example, use the timers to measure pickup and dropout times for relay under tests. Use any timer with any source, any input or output, and any trigger.

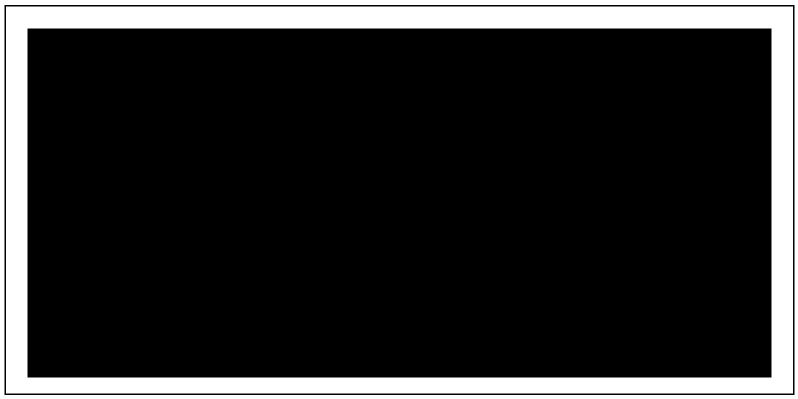

Figure 4.16 Timers Section

During a simple test of an overcurrent relay, the timer starts when the source turns on and stops when the relay responds. The timer therefore measures the response time of the relay.

NOTE

Active timers have white fields. The initial reading for an active timer is 0.00 seconds. If the settings for a timer have not been defined in the Timers tab, the readout for that timer is gray scaled. All of the timers are inactive when *Ramp* mode is selected.

Timing Status

The *Timers* section contains three *Timing Status* lights that function for any and all timers:

Reset	Active timers are reset to 0.00.
Running	Time test is in progress.
Stopped	Relay has responded. Timer shows elapsed time in milliseconds, seconds, or cycles.

When **System Output** is clicked, the enabled sources turn on and the enabled timers start. If the timer **Stop** button is then clicked, these sources are switched off and the **System Output** button returns to its previous status.

Timer Controls

Click **Stop** to stop timers that have not stopped due to a pre-defined stop condition. Click **Reset** to return all the active timers to 0.00.

If **Stop** is clicked while the timer is running, *NO-OP* appears in the field for that timer. *NO-OP* means No Operation. It appears in the timer readout after an unsuccessful or an interrupted test. For example, when a timer is started and then stopped manually during a test, *NO-OP* appears in the timer field because the relay under test did not respond.

Measurement Units

Set the measurement units for the timers with the radio buttons located along the bottom of the Timers section. The options are milliseconds, seconds, and cycles. The default selection is Seconds (*Sec.*).

To measure the elapsed time in milliseconds, click the radio button for *mSec*. To measure the number of cycles that elapse during a test, click the radio button for *Cycles*. For example, if the default system frequency of 60 Hz is set, the timer shows 90 cycles for a time test that lasts 1.5 seconds.

Input and Output Indicators

The Control Panel contains a status indicator for each logic output and each logic input. The status indicators are numbered 1 through 8 from left to right (Figure 4.17).

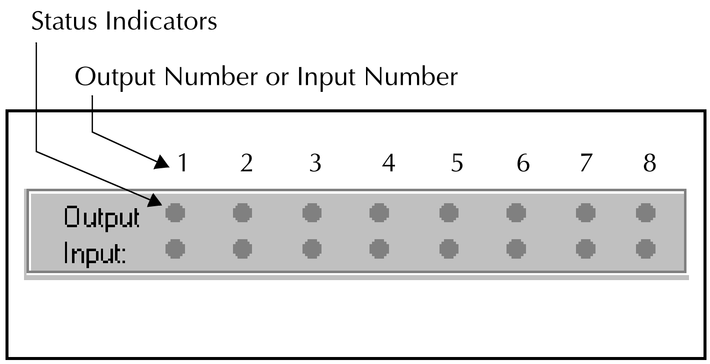

Figure 4.17 Output and Input Status Indicators

Each power source maps to one logic output and one logic input. The mapping of sources to inputs and outputs depends on the source configuration in effect. The mapping rule assigns the inputs and outputs to voltage and current sources in ascending order first from left to right, then from top to bottom. Figure 4.18, Figure 4.19, and Figure 4.20 illustrate how the rule works for three common source configurations.

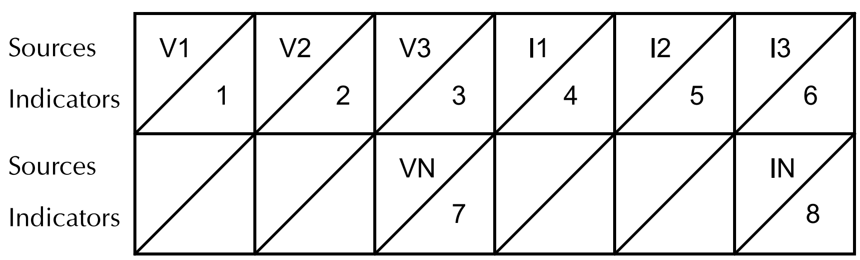

Figure 4.18 Input and Output Indicators for Four Voltage Sources and Four Current Sources

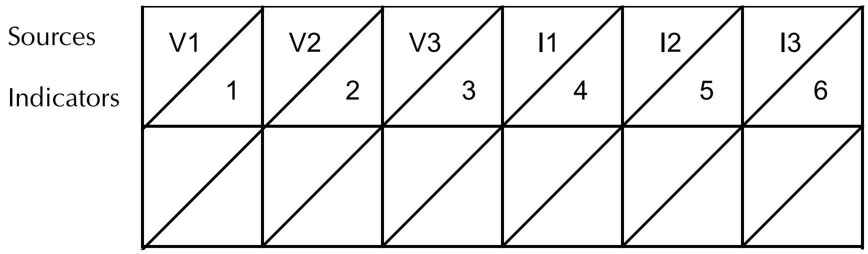

Figure 4.19 Input and Output Indicators for Three Voltage Sources and Three Current Sources

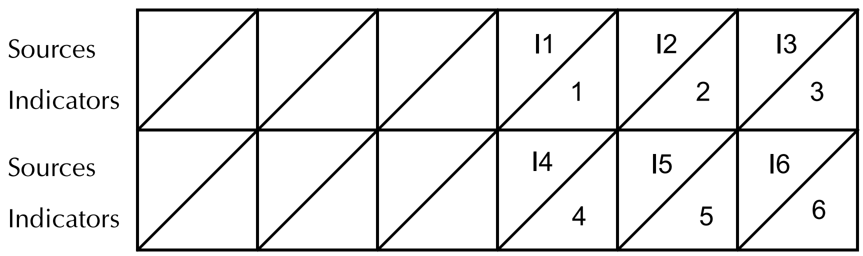

Figure 4.20 Input and Output Indicators for Six Current Sources

NOTE

If a ProTesT macro specifies source MA, the macro uses Input 1 and Output 1.

A logic output gives the F6000 the ability to send out its own signal. It is a logical relay that 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.

NOTE

The logic outputs can also be controlled in SSIMUL macro on a state to state basis. In this macro, the logic outputs are associated with the appropriate output sources (for example, VAI1). See the *ProTesT Macro Reference* in the *ProTesT User Guide* (72A-1585).

A logic input is a signal that originates with the relay under test and is sent to the instrument. Any trigger necessary to run a test can be programmed as a logic input. See ″Define Triggers″ on page 4-17 for examples of how to use logic inputs in actual tests.

Battery Simulator

Locate the *Battery* section (Figure 4.21) in the lower left-hand corner of the Control Panel. If the test protocol requires a DC voltage supply, use the pick list under *Battery* to set the voltage of the source. The options on the list are: 48 V, 125 V, and 250 V DC.

Figure 4.21 Battery Section

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 using the F6000 Control Panel, the battery simulator provides continuous output while the user conducts tests or changes logic and timer configurations.
- When using ProTesT test plans, the battery simulator provides continuous output when either the F6000 Control Panel or the F6000 Configuration display is selected, or when a third party application external to ProTesT is run.
- The battery simulator switches off if ProTesT is shut down 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.

Saving the F6000 Control Panel Configuration

To save a setup on the Control Panel, click **File | Save** in the ProTesT menu bar. To save a setup under a new name, click **File | Save As**. ProTesT saves the new information on the Control Panel 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.

Summary

The Control Panel provides full control over each voltage and current source, and maximum flexibility in preparing for and conducting tests of protective relays:

- Pre-programmed and user-defined ramp values eliminate manual errors in testing. The AutoSensE feature simplifies testing and eliminates errors.
- The phasor diagram shows source table settings in real time and allows the dragging and dropping of phasors to reset source table values.
- The Fault Rotate feature makes efficient testing of three-phase relays possible.
- The eight individual timers enable measurements of eight different timed events.

5. Basic Test Procedures

The test procedures in this chapter introduce the various controls on the F6000 Control Panel. Complete the basic setup procedure in "Setup and Configuration" on page 3-1 before conducting these tests. The following example uses an instantaneous overcurrent relay and assumes the following:

- The relay tap is set for greater than 5 A but less than 10 A.
- The relay has low burden characteristics.
- The relay output contact is normally open.
- The relay is electromechanical and does not require the use of the battery simulator.

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.

Prepare for a Pickup Test

1. Connect the instantaneous overcurrent relay to current source I1 and logic input 1 on the instrument front panel.
2. Turn the F6000 Instrument on.
3. Start ProTesT.

   To confirm that ProTesT is set up correctly, follow steps 4 to 6. If you are sure the setup is correct, proceed to step 7.
4. Click **Setup** in the ProTesT menu bar to open the **Setup** display (Figure 3.3 on page 3-5).
5. Verify that communications between the PC and the F6000 Instrument are set up properly. Under *Connect with*, click the *Serial* or *Ethernet* radio button, as appropriate.

NOTE

For a serial connection, enter the correct Comm Port (1 through 4). The baud rate for a serial connection must be 57,600 baud per second. For an Ethernet connection, verify that the IP Address in the Setup display correctly corresponds to the IP Address in the F6000 Instrument Display.

6. Click **OK** to close the **Setup** display.

7. Click **Tools|F6000 Configuration** in the menu bar at the top of the Control Panel.

   The **F6000 Configuration** display appears (Figure 5.1).

8. Verify that current source I1 on the instrument front panel is connected to the relay under test. Locate current source I1 in the **Configuration** display – it is the fourth source from the left in the top row – and verify that the lead from the relay goes to the same terminal on the instrument front panel.

9. Click **OK** to close the **Configuration** display.

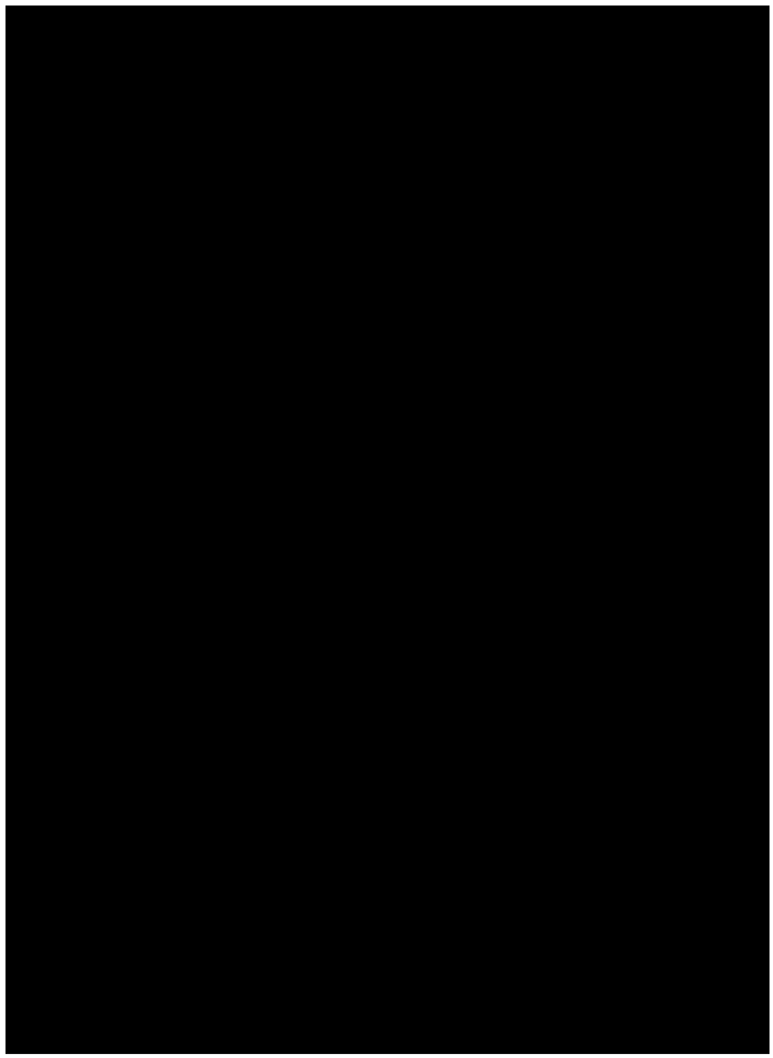

Figure 5.1 Configuration Display

Control Panel Operations

Use the F6000 Control Panel to carry out a simple pickup test:

- Set up the source table to use I1 as the active source.
- Use the Inputs tab of the **Settings** display to define the sense condition.
- Select the settings needed for the test in the *Ramp/Set sources* section.
- Activate I1, and increase the current until the relay responds.

To begin the test:

1. Click **Tools | F6000 Control Panel** in the top menu bar.

   The F6000 Control Panel appears (Figure 5.2).

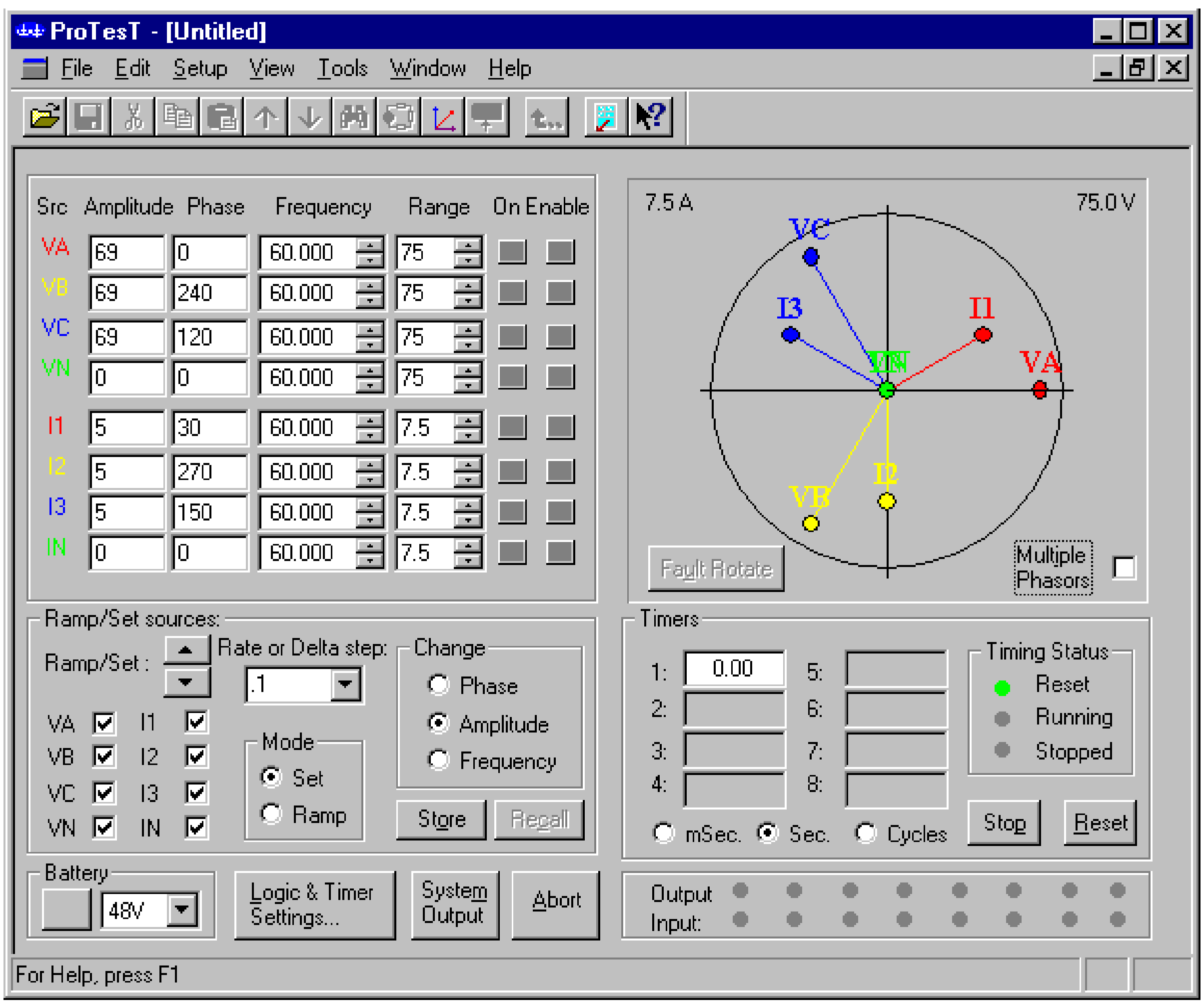

Figure 5.2 F6000 Control Panel

Source Table

2. Set the range for current source I1 at 15.
3. Verify that **5** is the amplitude of current source I1 in the source table. The source table should appear as it does in Figure 5.3.

Figure 5.3 Source Table Settings for the Pickup Test

NOTE

Use the minimum range setting that accommodates the maximum amplitude required.

Settings Display

4. Click **Logic/Timer settings...** in the lower left-hand portion of the Control Panel (Figure 5.3).

   The Inputs tab of the **Settings** display appears. Figure 4.8 on page 4-13 shows the default settings for the Inputs tab.

5. Uncheck the *Off* checkbox below the radio buttons to enable the AutoSensE feature.
6. Click the *AutoSensE* radio button for Input 1.
7. Select **Contact** from the pick list under *Type*.

   Leave Open → Close as the default *Sense Condition*.

8. Click **OK** to close the **Settings** display.

Figure 5.4 Inputs Tab of the Settings Display

Ramp/Set Sources

The *Ramp/Set sources* section is located underneath the source table in the Control Panel (Figure 5.3 on page 5-4).

9. Click the radio button for *Ramp* mode.

10. Click the radio button for *Amplitude*.

11. Select the ramp rate from the *Rate or Delta step* pick list.

For this example the ramp rate is set for .1 A per second. This value is user selectable and should provide sufficient resolution to determine the relay's operating characteristic with respect to tolerances.

12. Remove the checkmark from every source *except* current source I1.

After completing steps 9 through 12, the *Ramp/Set sources* section appears as shown in Figure 5.5.

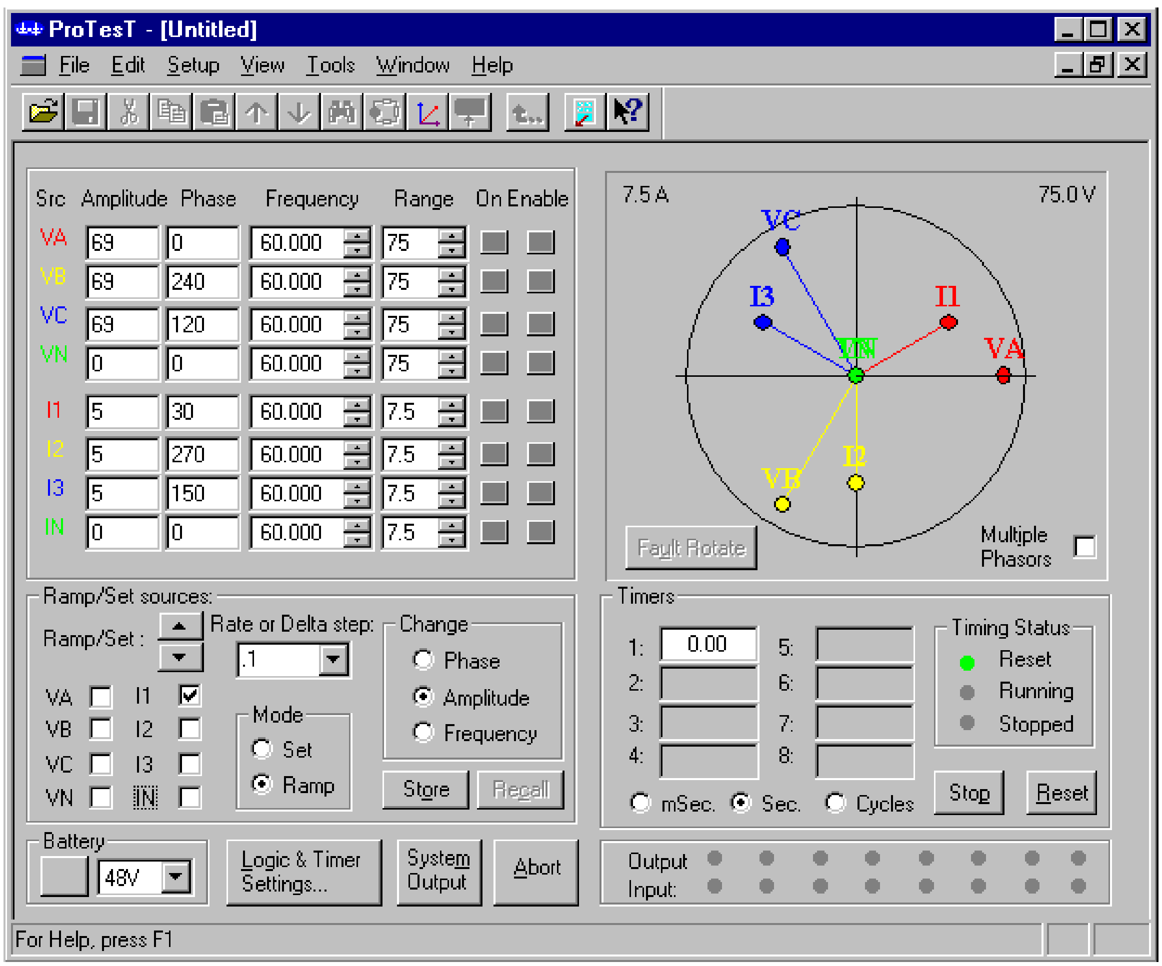

Figure 5.5 Settings in the Ramp/Set Sources Section

Conduct the Test

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.

13. Click the **On** button for current source I1 (see Figure 5.5 on page 5-6).

    The On button in the source table turns red and the Logic Output indicator light for this source turns red.

14. Click and hold the *Ramp/Set* up arrow until the relay responds.

    The indicator light for Logic Input 1 turns green.

    Since AutoSensE is enabled, the amplitude for I1 stops ramping when the relay responds, and the value is frozen at the pickup value.

15. Click the red **On** button for current source I1 in the source table to turn I1 off.

Time Test

Next, conduct a time test with the same relay. For this test, the phase angles for I1, I2, and I3 are 330°, 210°, and 90° respectively. Use a timer to determine how long the relay takes to close after the current has been applied.

1. Set the range for current source I1 at 15.
2. Enter **10** for the amplitude of current source I1.
3. Click the radio button for *Set* mode in the *Ramp/Set sources* section.

NOTE **The timers operate only when the sources are in *Set* mode, not in *Ramp* mode.**

4. Click the radio button for *mSec.* in the *Timers* section.

The Control Panel appears as it does in Figure 5.6.

Figure 5.6 Source Table Settings for Time Test

5. Click the **Logic & Timer Settings** button on the Control Panel (Figure 5.6).

   The Inputs tab of the **Settings** display appears (Figure 5.7). Use Input 1 for this test.

Figure 5.7 Inputs Tab

6. Select **Contact** from the pick list under *Type*.

   Leave Open → Close as the default Sense Condition.

   The start and stop conditions for the timer are defined in the Timers tab. The start condition for this test is true when the current source I1 turns on. The stop condition is true when the defined trigger is asserted. The trigger is asserted when the relay under test responds.

7. Click **Timers** to open the Timers tab of the **Settings** display (Figure 5.8).
8. Click the radio button for Timer 1 in the *Set timer* column.

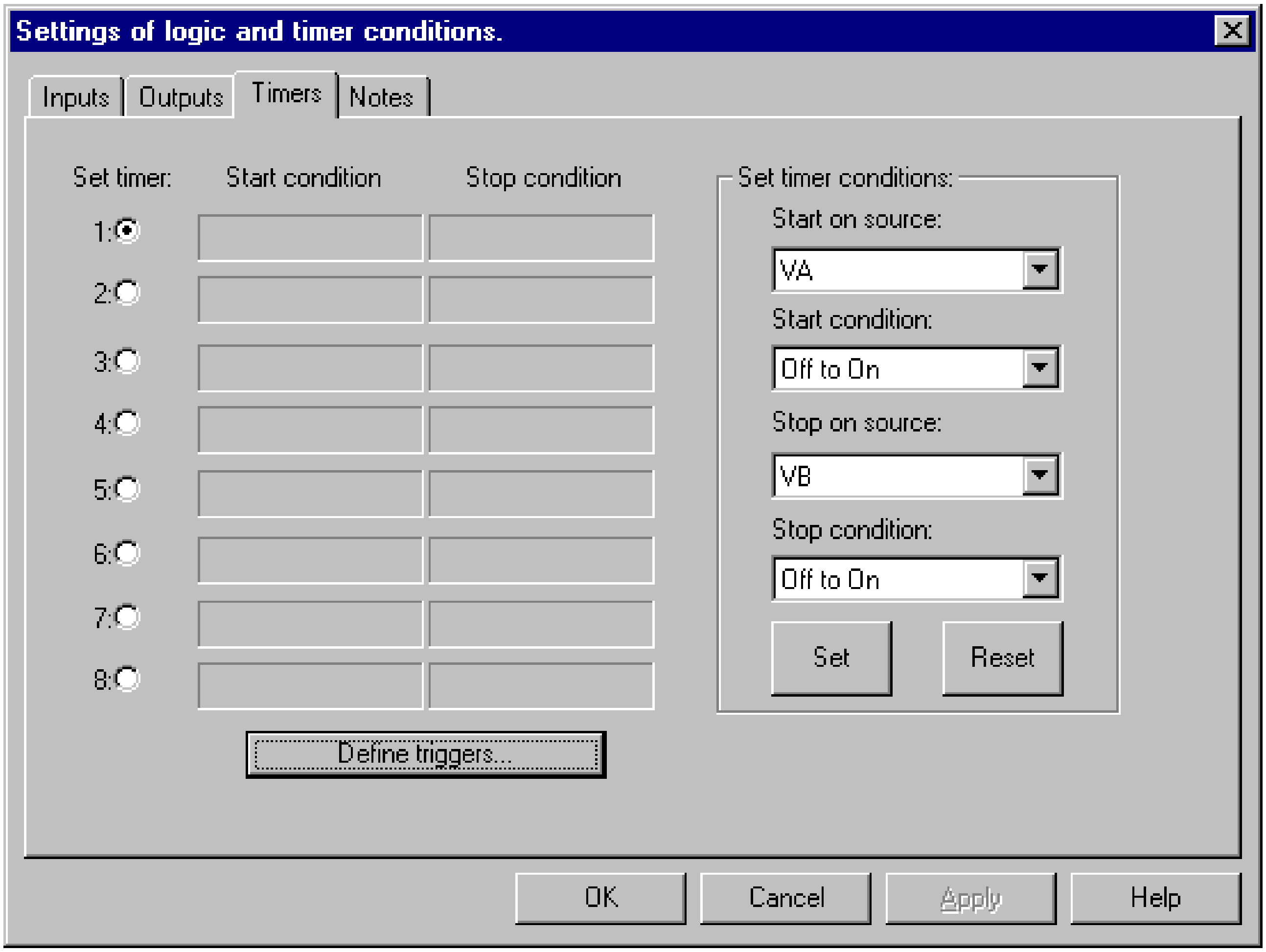

Figure 5.8 Timers Tab

9. Click **Define triggers...** (Figure 5.8).

The **Triggers** display appears (Figure 5.9).

Figure 5.9 Triggers Display

10. Click **Set...** for Trigger 1 (Figure 5.9).

The **Set Trigger Logic** display appears (Figure 5.10).

Figure 5.10 Set Trigger Logic

11. Click **1** under *Choose input.*

In1 appears in the *Logic* field (Figure 5.11).

Figure 5.11 Trigger Logic Set for Input 1

12. Click **OK** to close the **Set Trigger Logic** display.

13. Verify that In1 appears in the *Trigger Logic* column of the **Triggers** display (Figure 5.12).

Figure 5.12 Verify Trigger Logic

14. Click **OK** to close the **Triggers** display.

The Timers tab of the **Settings** display is now the active window.

15. In the *Set timer conditions* section of the **Settings** display, select **I1** from the *Start on Source* pick list.

Leave the *Start condition* as *Off to On*.

16. Select **Trigger 1** from the *Stop on Source* pick list.

17. Click **Set** (Figure 5.12).

I1 Off to On appears in the *Start Condition* column, and *Trigger 1* appears in the *Stop Condition* column (Figure 5.13).

Figure 5.13 Start and Stop Condition Definitions for Timer 1

18. Click **OK** to close the **Settings** display (Figure 5.13).

Timer 1 in the Control Panel is now enabled, with *mSec.* as the selection for the measurement units (Figure 5.14).

Figure 5.14 Timer 1 Enabled on the Control Panel

19. Click the **Enable** button for current source I1.

The button turns green to indicate the source is enabled.

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.

20. Click **System Output** to turn I1 on.

The System Output button turns red and the timer starts. When the relay responds, the timer stops and the elapsed time appears in the field for Timer 1. System Output is automatically switched off when the timer stops.

21. Click **Reset** to reset Timer 1 to 0.00.

Fault Rotate

Fault rotate assumes that the relay under test is three-phase, or a system of three single-phase relays. Ensure relay connections for current sources I2 and I3, and for logic input 1.

The Fault Rotate feature on the Control Panel allows a fault to be rotated from one phase to the next. Use a current relay with a tap value of 5 A and set the fault current in source I1 at 10 A. See the source table in Figure 5.15 on page 5-18.

To rotate this fault through all three phases, follow these steps:

1. Click **Tools | F6000 Configuration** in the ProTesT menu bar.

   The **Configuration** display appears (Figure 5.1 on page 5-2).

2. Select **3 Voltages and 3 Currents** from the *Pre-set Configurations* pick list.
3. Click **OK** to apply the configuration to the instrument and close the display.

   The Control Panel is again the active window.

4. In the source table, increase the range for current sources I1, I2, and I3 from 7.5 A to 15 A.
5. Verify that the Fault Rotate button in the phasor diagram is active.

   If the Fault Rotate button is grayed out, verify that 3 Voltages and 3 Currents is the selected source configuration. Also verify that all three voltage sources have a range of 75 V, and all three current sources have a range of 15 A.

   For this example the voltage sources are not required.

The Control Panel appears as it does in Figure 5.15.

Figure 5.15 Initial Setup for the Fault Rotate Test

6. Click the **Enable** button for current sources I1, I2, and I3.

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.

7. Click **System Output** to turn the current sources on.

   When the relay responds, the indicator light for Input 1 turns green.

8. Click **System Output** to turn the current sources off.

9. Click **Fault Rotate** to go to the second fault configuration.

The overcurrent fault rotates to current source I2 in the source table (Figure 5.16).

Figure 5.16 Fault Rotated to I2

10. Click **System Output** to turn the current sources on.

When the relay responds, the indicator light for Input 1 turns red.

11. Click **System Output** to turn the current sources off.

12. Click **Fault Rotate** to go to the third fault configuration (overcurrent in I3).

The overcurrent fault rotates to I3 in the source table (Figure 5.17.)

Figure 5.17 Fault Rotated to I3

13. Click **System Output** to turn the current sources on.

When the relay responds, the indicator light for Input 1 turns red.

14. Click **System Output** to turn the current sources off.

Reach Test

The last test in this series of examples is a reach test. Connect the test relay to voltage sources VA and VB and to logic input 1 on the instrument front panel.

To configure the sources for the test:

1. Click **Tools | F6000 Configuration** in the menu bar at the top of the Control Panel.

   The **F6000 Configuration** display appears (Figure 5.18).

2. Select **3 Voltages and 3 Currents** in the *Pre-set Configurations* drop-down list.

3. Click **OK** to close the **Configuration** display.

   Figure 5.19 on page 5-23 shows the correct source configuration.

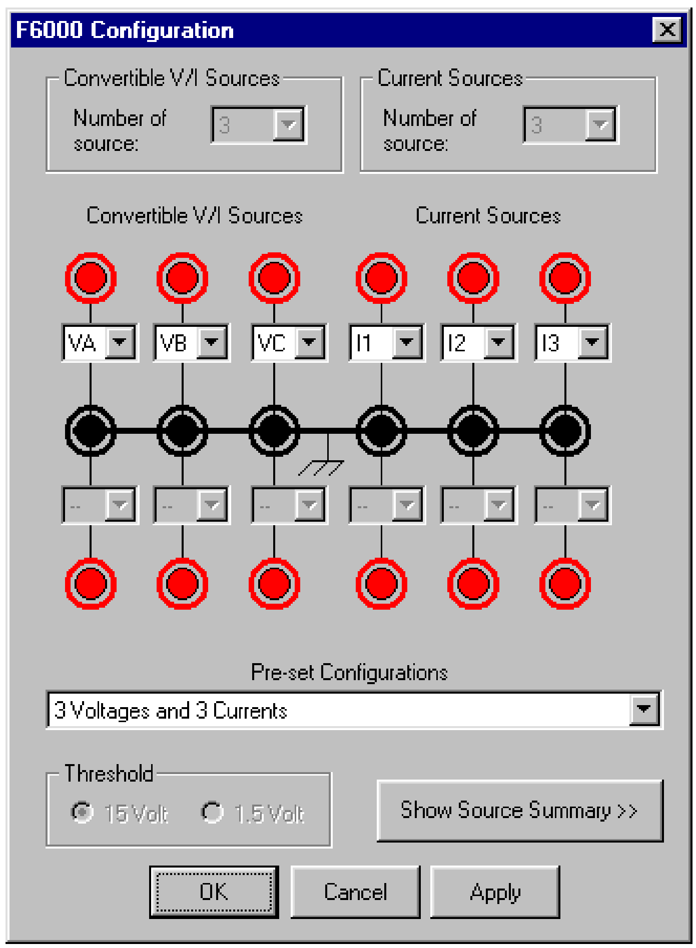

Figure 5.18 Configuration Display

Use the F6000 Control Panel to carry out the reach test. The test applies an AB fault to a distance relay:

- Set up the source table to use VA and VB as the active sources.
- Use the Inputs tab of the **Settings** display to define the sense condition.
- Select the settings needed for the test in the *Ramp/Set sources* section.
- Activate VA and VB, and decrease the voltage until the relay responds.

Source Table

To begin the test, type the required settings into the source table of the Control Panel:

1. Click **Tools|F6000 Control Panel** in the top menu bar.

   The F6000 Control Panel appears (Figure 5.2 on page 5-3).
2. Type these settings into the *Amplitude* column of the source table (I1 and I2 keep their default settings):

   VA = 30

   VB = 30

   VC = 67

   I3 = 0
3. Type these settings into the *Phase* column of the source table (VA, VB, and VC keep their default settings):

   I1 = 315

   I2 = 135

   I3 = 0

   The source table should appear as it does in Figure 5.19 on page 5-23.

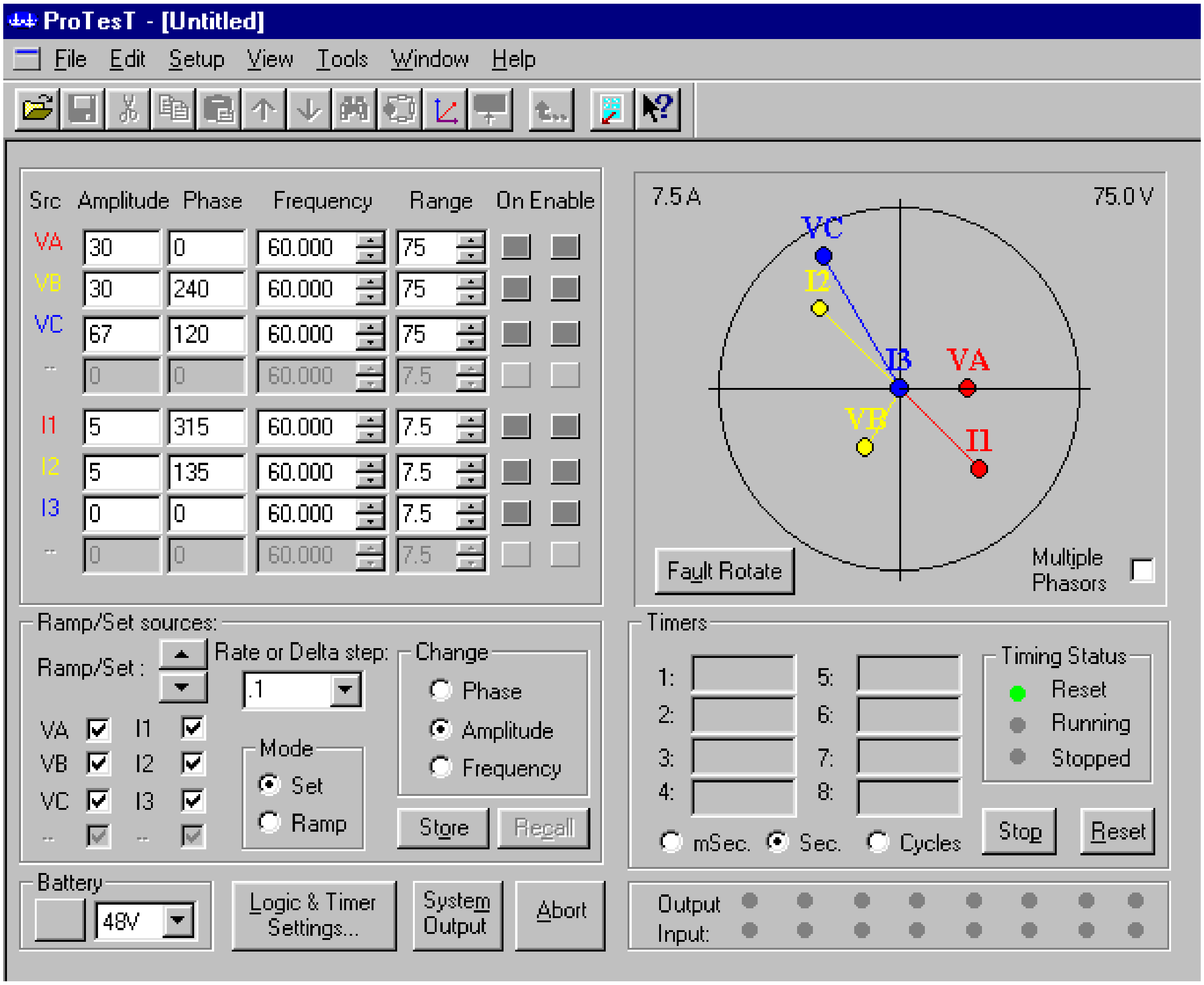

Figure 5.19 Source Table Settings for the Reach Test

Settings Display

4. Click **Logic/Timer settings...** in the lower left-hand portion of the Control Panel (Figure 5.19).

   The Inputs tab of the **Settings** display appears. Figure 4.8 on page 4-13 shows the default settings for the Inputs tab.

5. Uncheck the *Off* checkbox below the radio buttons to enable the AutoSensE feature.
6. Click the *AutoSensE* radio button for Input 1.
7. Select **Contact** from the pick list under *Type*.

   Leave Open → Close as the default *Sense Condition*.

8. Click **OK** to close the **Settings** display.

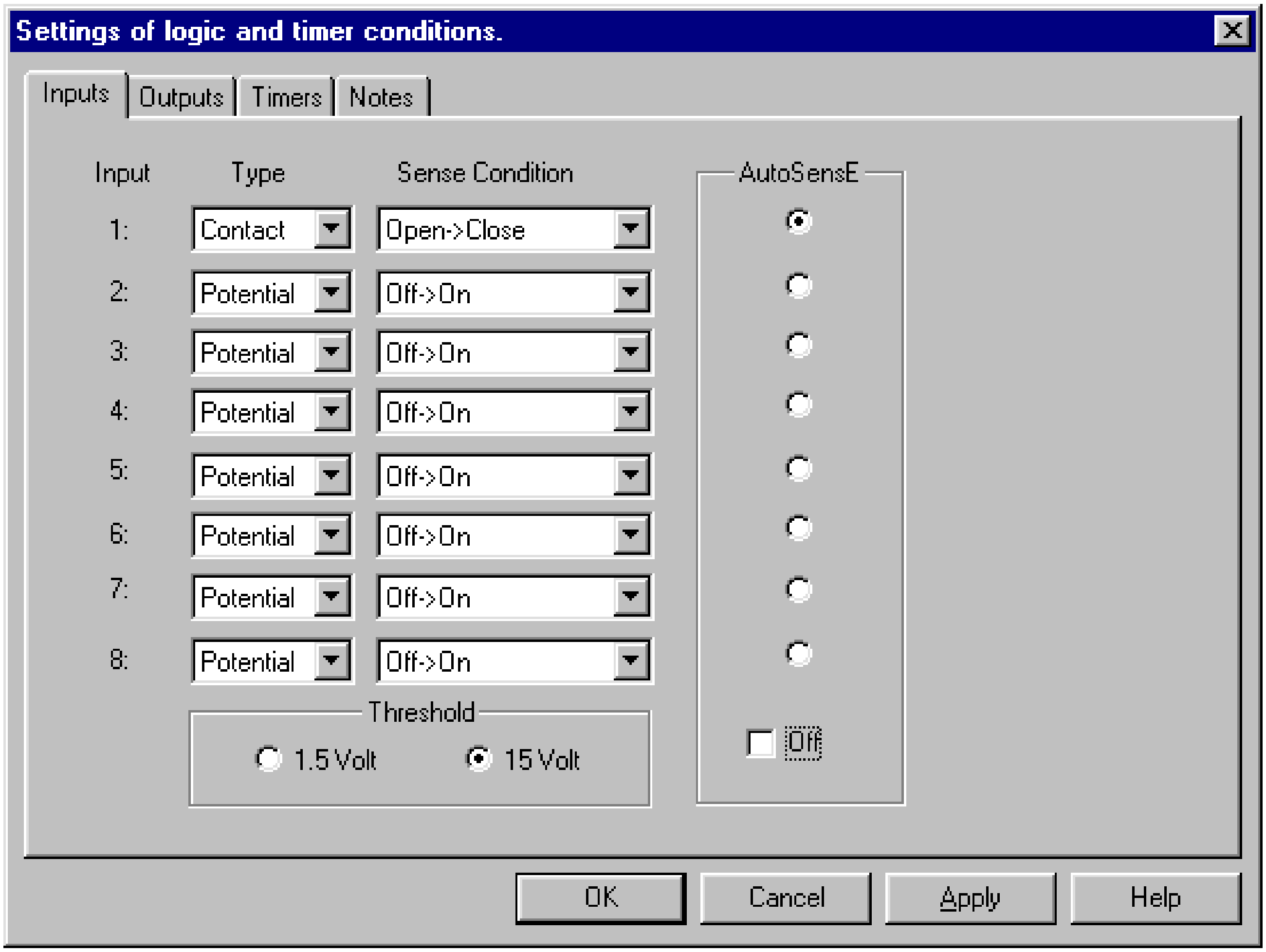

Figure 5.20 Inputs Tab of the Settings Display

Ramp/Set Sources

The *Ramp/Set sources* section is located below the source table in the Control Panel (Figure 5.19 on page 5-23).

9. Click the radio button for *Ramp* mode.

10. Click the radio button for *Amplitude*.

11. Select **.1** for the ramp rate from the *Rate or Delta step* pick list.

12. Remove the checkmark from VC, I1, I2, and I3.

VA and VB remain active sources.

After completing steps 9 through 12, the *Ramp/Set sources* section appears as shown in Figure 5.21.

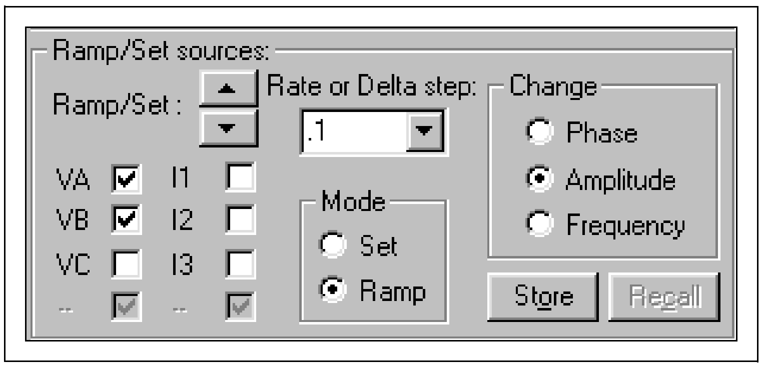

Figure 5.21 Settings in the Ramp/Set Sources Section

Conduct the Test

WARNING

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

13. Click the **On** button for voltage sources VA, VB, and VC.

14. Click the **Enable** button for current sources I1, I2, and I3.

Figure 5.22 shows the Control Panel settings required for the reach test.

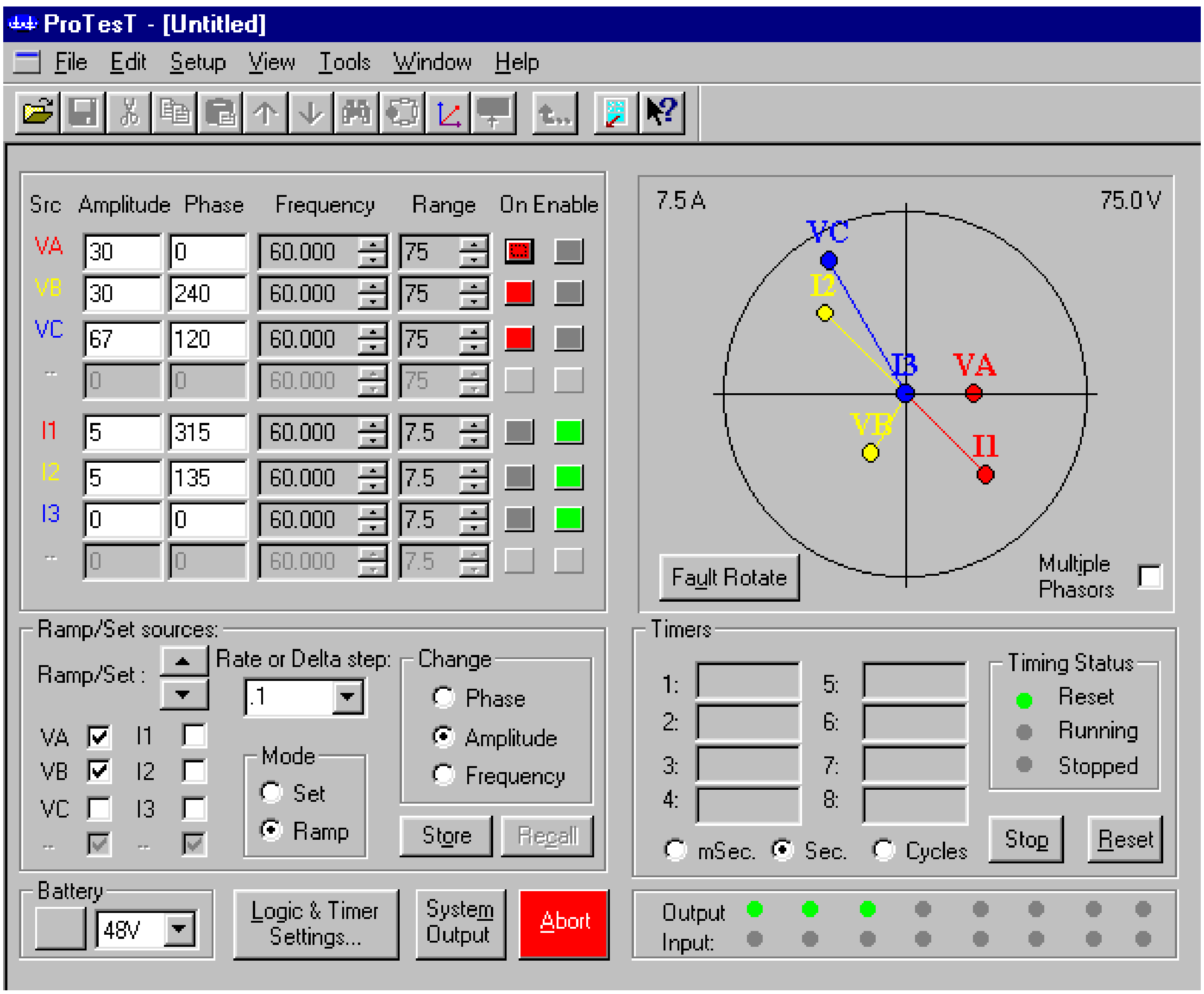

Figure 5.22 Control Panel Settings for the Reach Test

15. Click **System Output** at the bottom of the Control Panel.

    The indicator lights for outputs 1 through 6 in the lower right-hand corner of the Control panel are green.

16. Click and hold the *Ramp/Set* down arrow in the *Ramp/Set sources* section until the relay responds.

    In the source table, observe VA and VB ramp down in 0.1 V increments until the relay picks up. At that point, the values for VA and VB freeze, and the red indicator light for input 1 turns on.

17. Click **System Output** again to turn the sources off.

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.

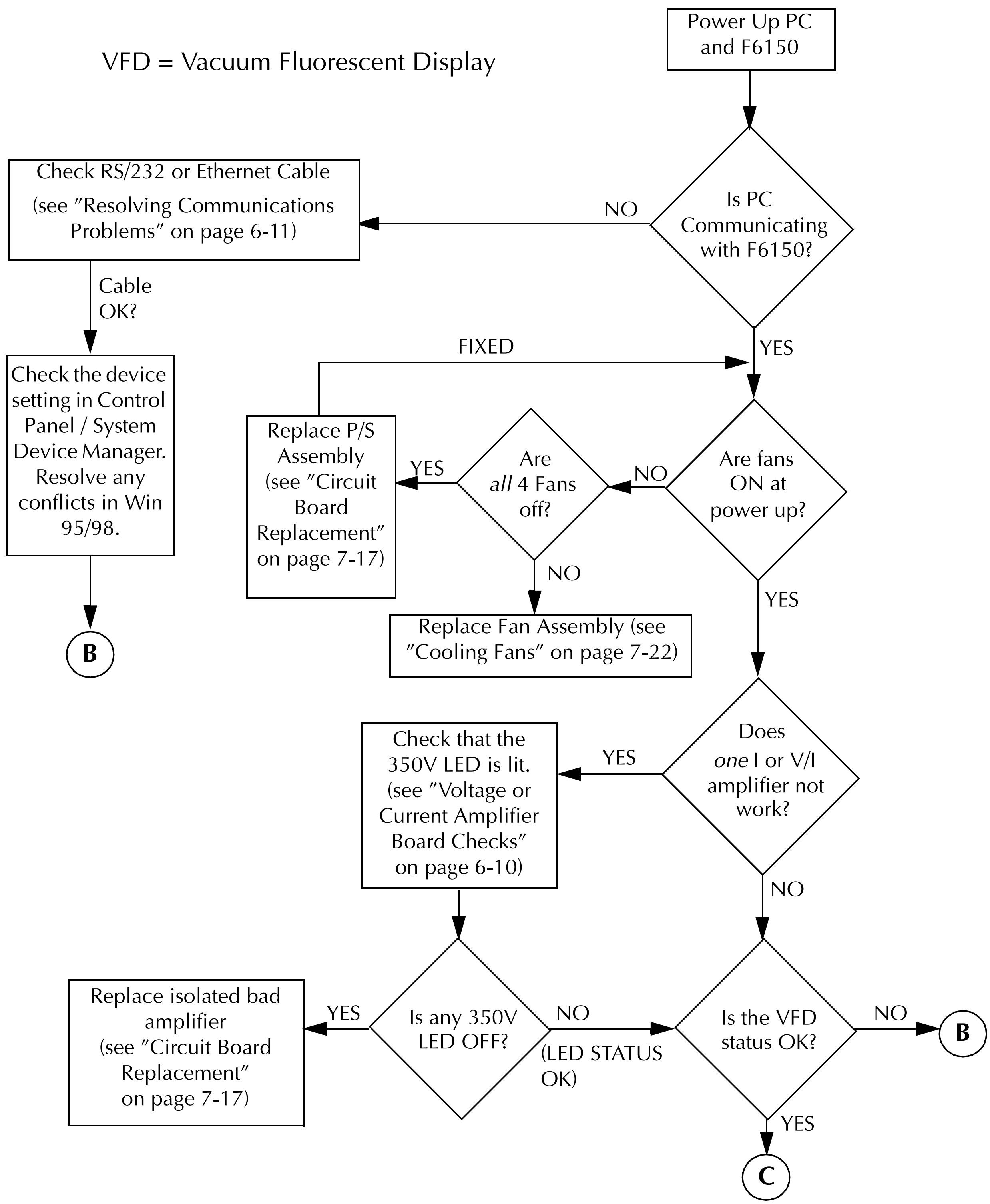

Figure 6.1 Troubleshooting Flow Chart — Part 1

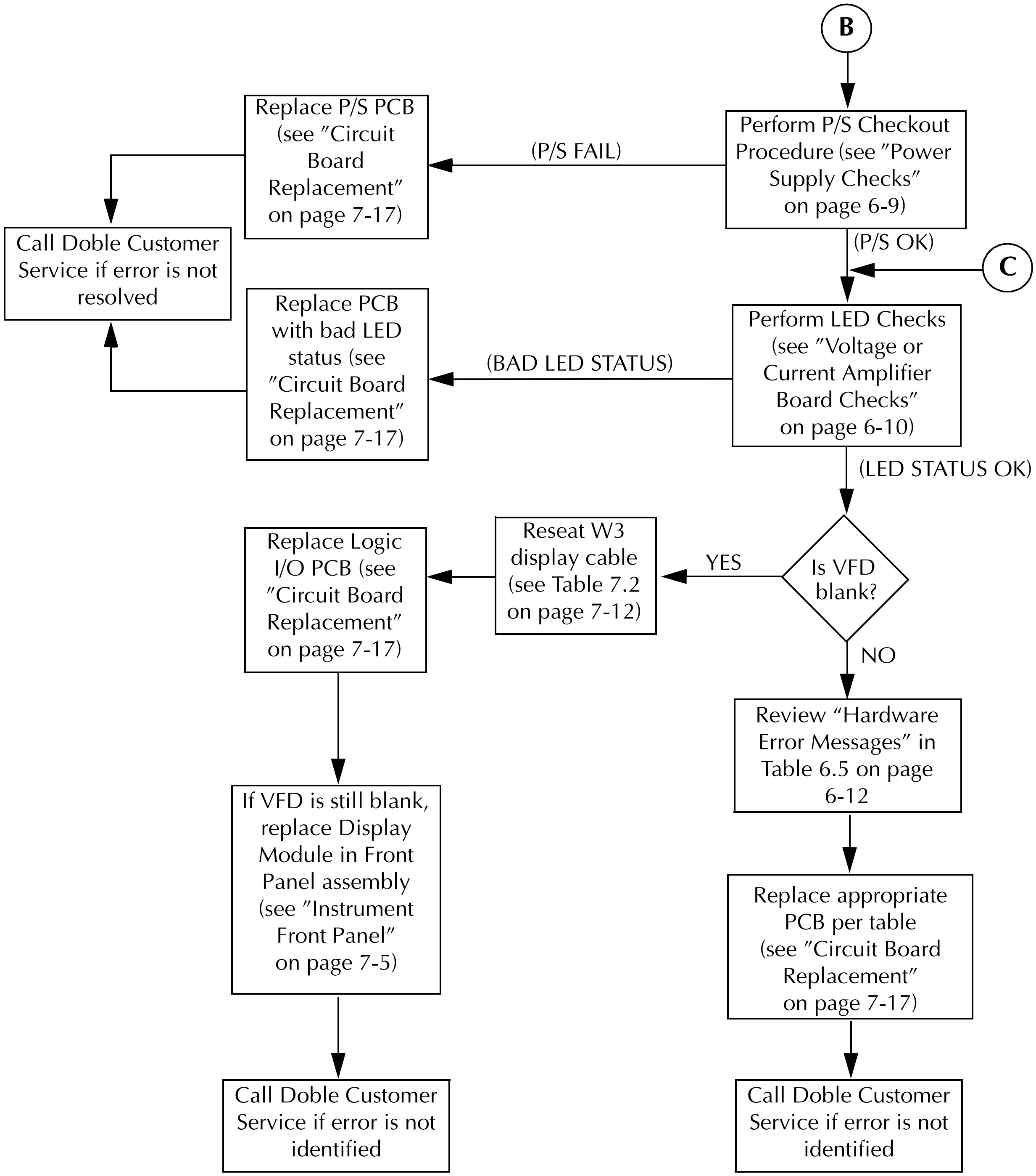

Figure 6.2 Troubleshooting Flow Chart — Part 2

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 ProTesT 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 7-2) 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 by ProTesT software, 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 7-17.

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.

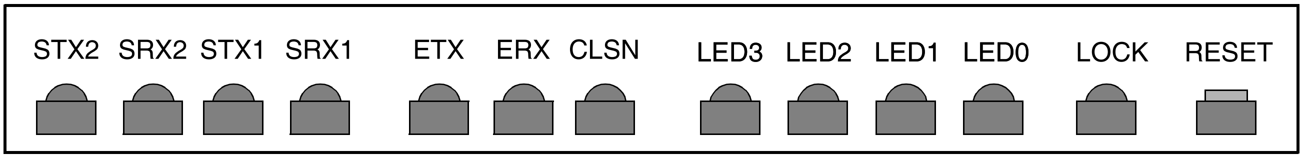

Figure 6.3 CPU Board Status Indicator LEDs and Push Button

- 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 7-17.

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 7-17.

Voltage or Current Amplifier Board Checks

To verify proper operation of the amplifier circuit boards:

1. From the ProTesT software, select three I's and three V's.
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 7-17.

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 7-2) 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 7-19.

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 7-2.
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 7-22.

Resolving Communications Problems

If communication fails or cannot be established between the F6150 and the ProTesT software, 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 ProTesT. 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 ProTesT.
   c. Check the Control Panel and Hardware Devices in Windows 95 or Windows 98 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 7-17), Analog I/O circuit board (page 7-17) or the Communications circuit board (page 7-13).

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 on page 6-12 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 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.

Table 6.5 Hardware Errors (Continued)

Error Message	Description	Action
Positive DAC readback failure	Positive digital to analog converter readback failure.	Replace the analog I/O board. Refer to "Circuit Board Replacement" on page 7-17.
Negative DAC readback failure	Negative digital to analog converter readback failure.	Replace the analog I/O board. Refer to "Circuit Board Replacement" on page 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.
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 7-17.

Table 6.5 Hardware Errors (Continued)

Error Message	Description	Action
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 7-17.
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 7-17.
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 7-17.

Source Errors

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

System errors display in a ProTesT dialog box. Figure 6.4 shows the first message that appears.

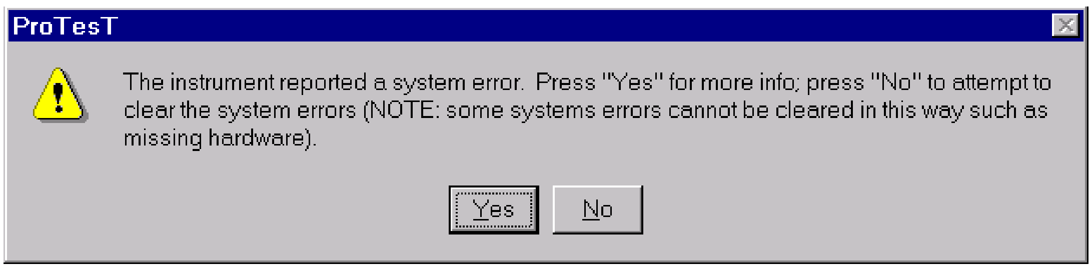

Figure 6.4 System Error Message

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

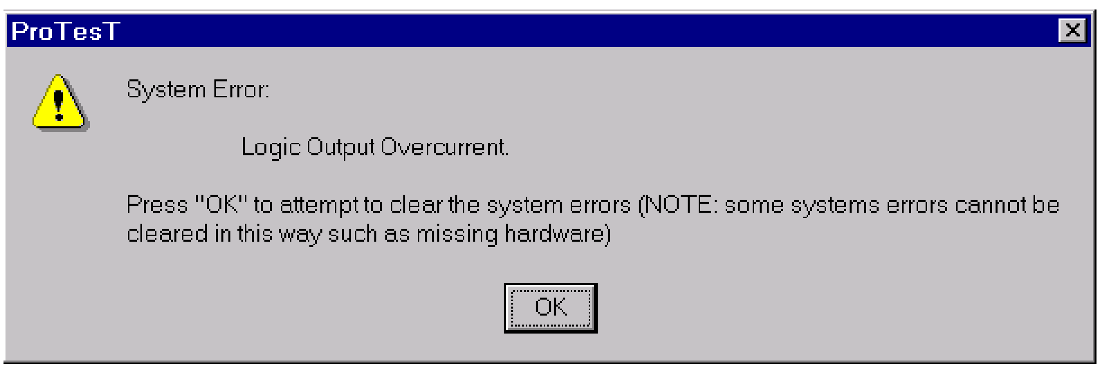

Figure 6.5 System Error Diagnostic Information

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.
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 7-17).
+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.

Table 6.7 System Errors (Continued)

Error	Explanation	Action
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 ProTesT. 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 6-10). Replace the fan assembly if required (page 7-22). If the fans are functioning, replace the power supply circuit board (page 7-17).
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".
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 6-9). Replace the board if necessary ("Circuit Board Replacement" on page 7-17).
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 7-17).

Table 6.7 System Errors (Continued)

Error	Explanation	Action
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 7-17).
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 7-17).
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 7-17).
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 7-17).
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 7-17).
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 7-17).
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 7-17).

Table 6.7 System Errors (Continued)

Error	Explanation	Action
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 7-19).
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 7-2).
3. Turn the instrument on and perform a visual check to identify the faulty component (page 7-5).
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 7-26).

The replaceable components in the F6150 are:

- Instrument front panel (page 7-5)
- Communications board (page 7-13)
- Circuit boards in slots 1 through 11 (page 7-17)
- Battery simulator (page 7-19)
- Cooling fans (page 7-22)

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.

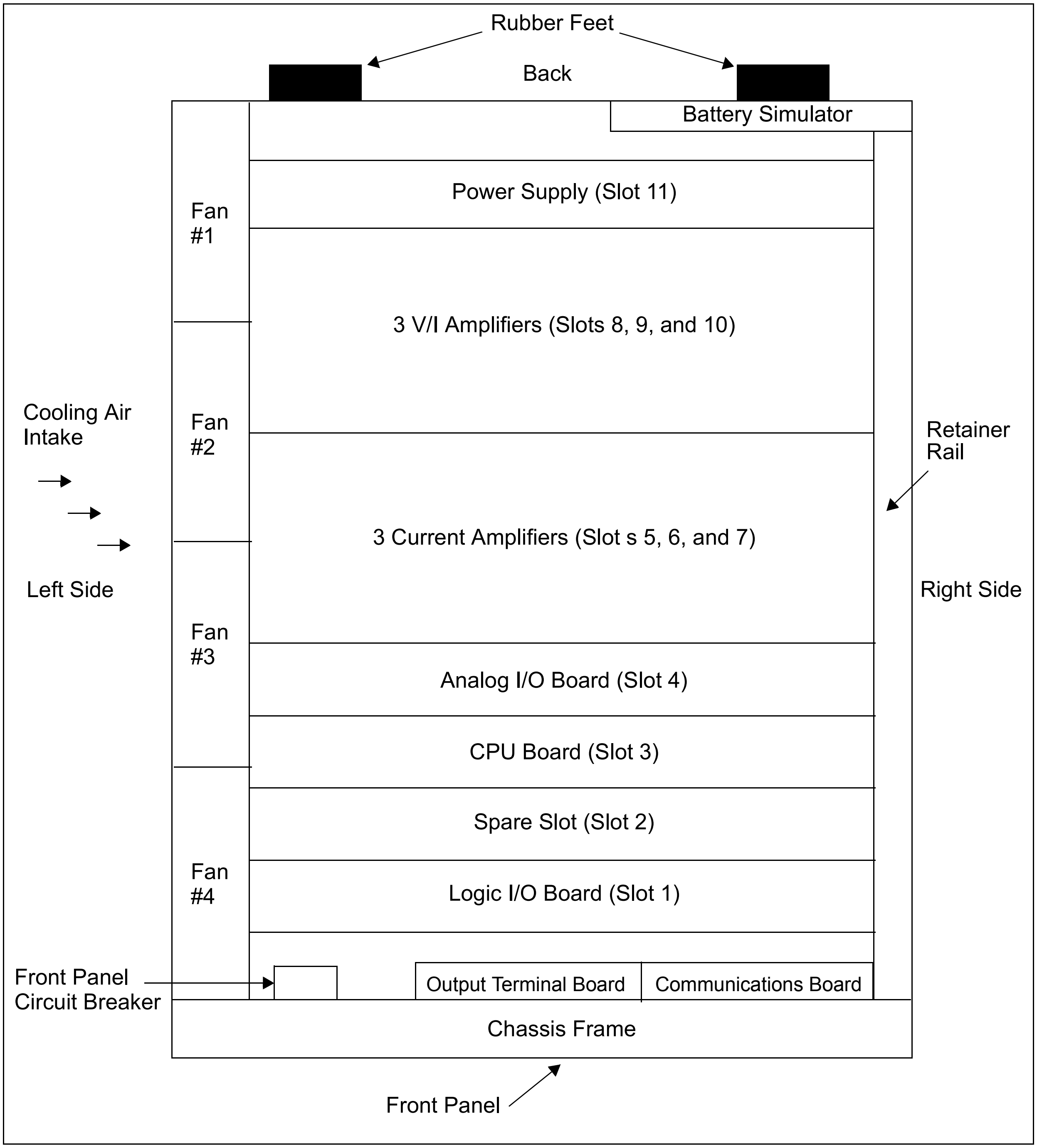

Figure 7.1 Top View of the F6150 Instrument

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).

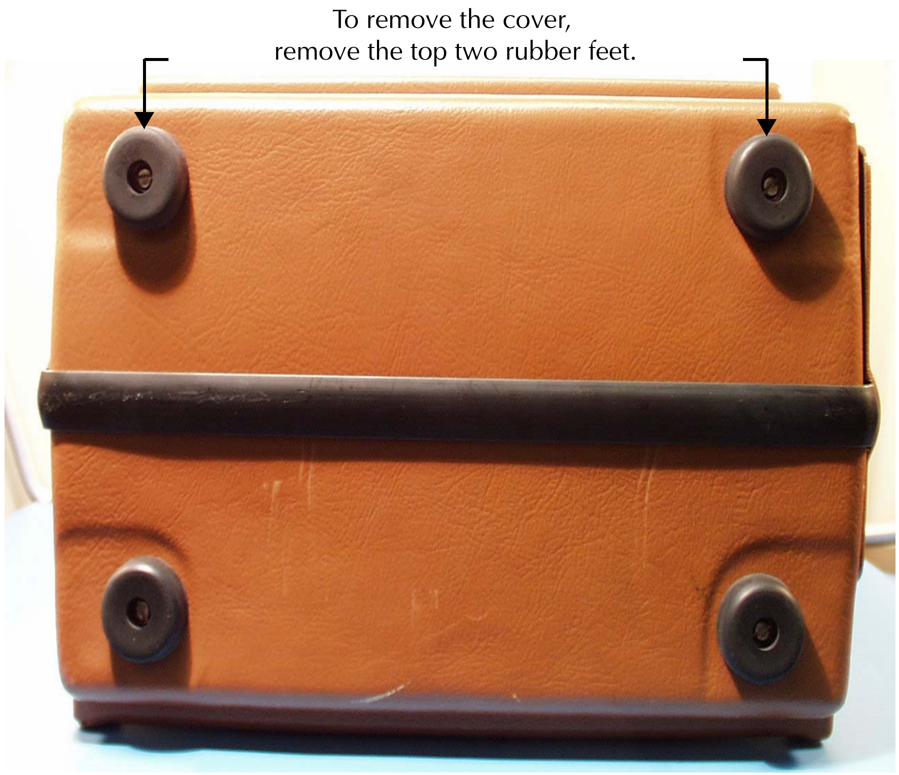

Figure 7.2 Rubber Feet at the Back of the Instrument

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

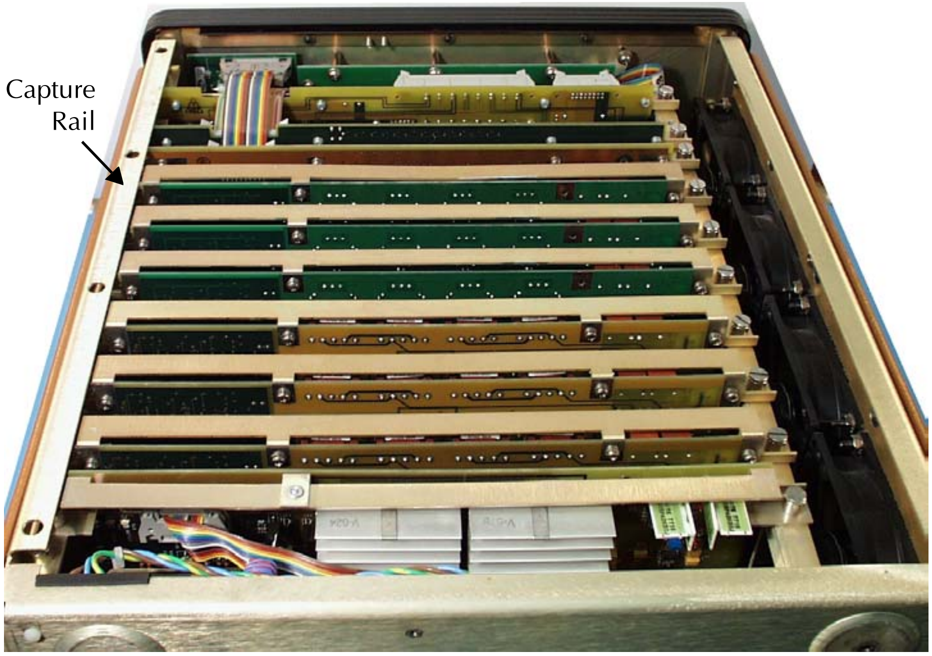

Figure 7.3 Instrument Rear with Cover Removed

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).

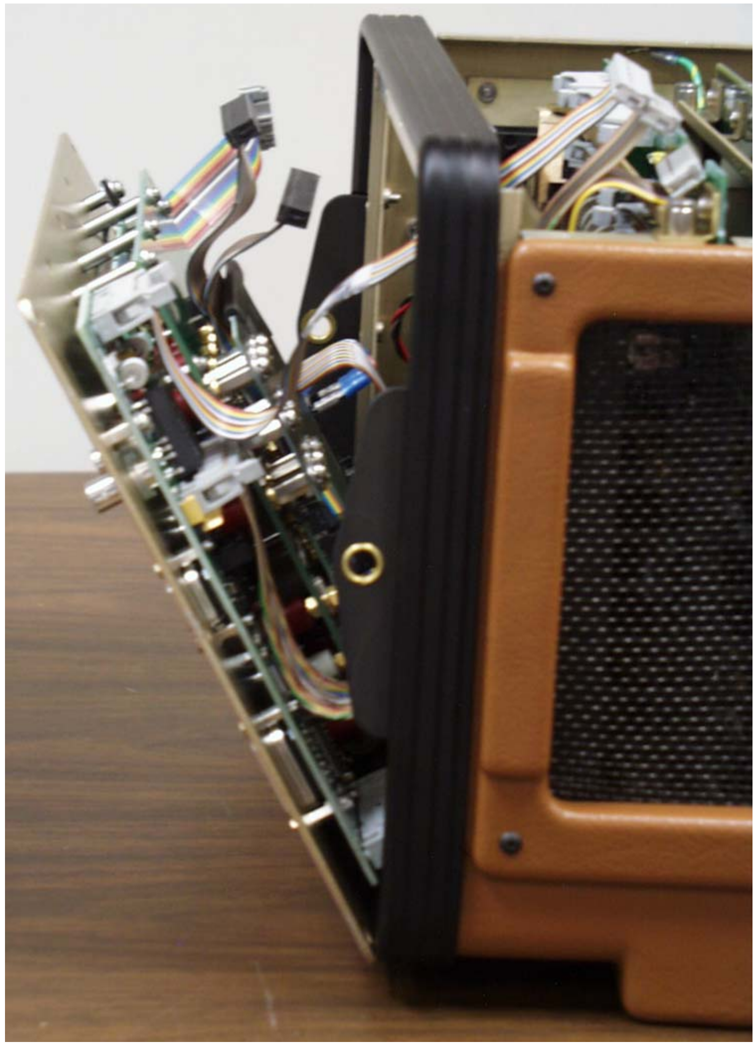

Figure 7.4 Instrument Front Panel Tilted Forward 30°

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).

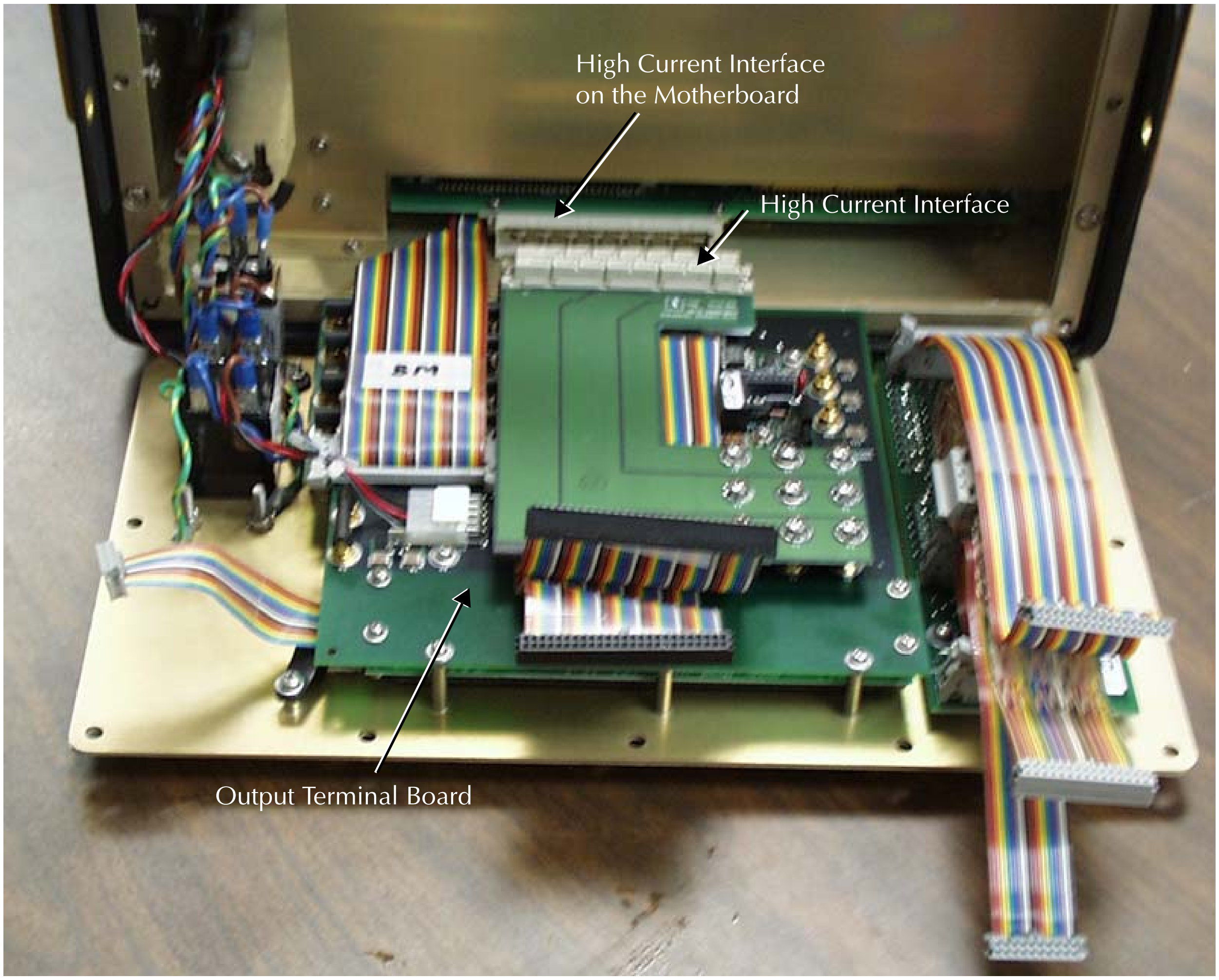

Figure 7.5 Front Panel Lying Face Down in Front of the Instrument

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 on page 7-8).

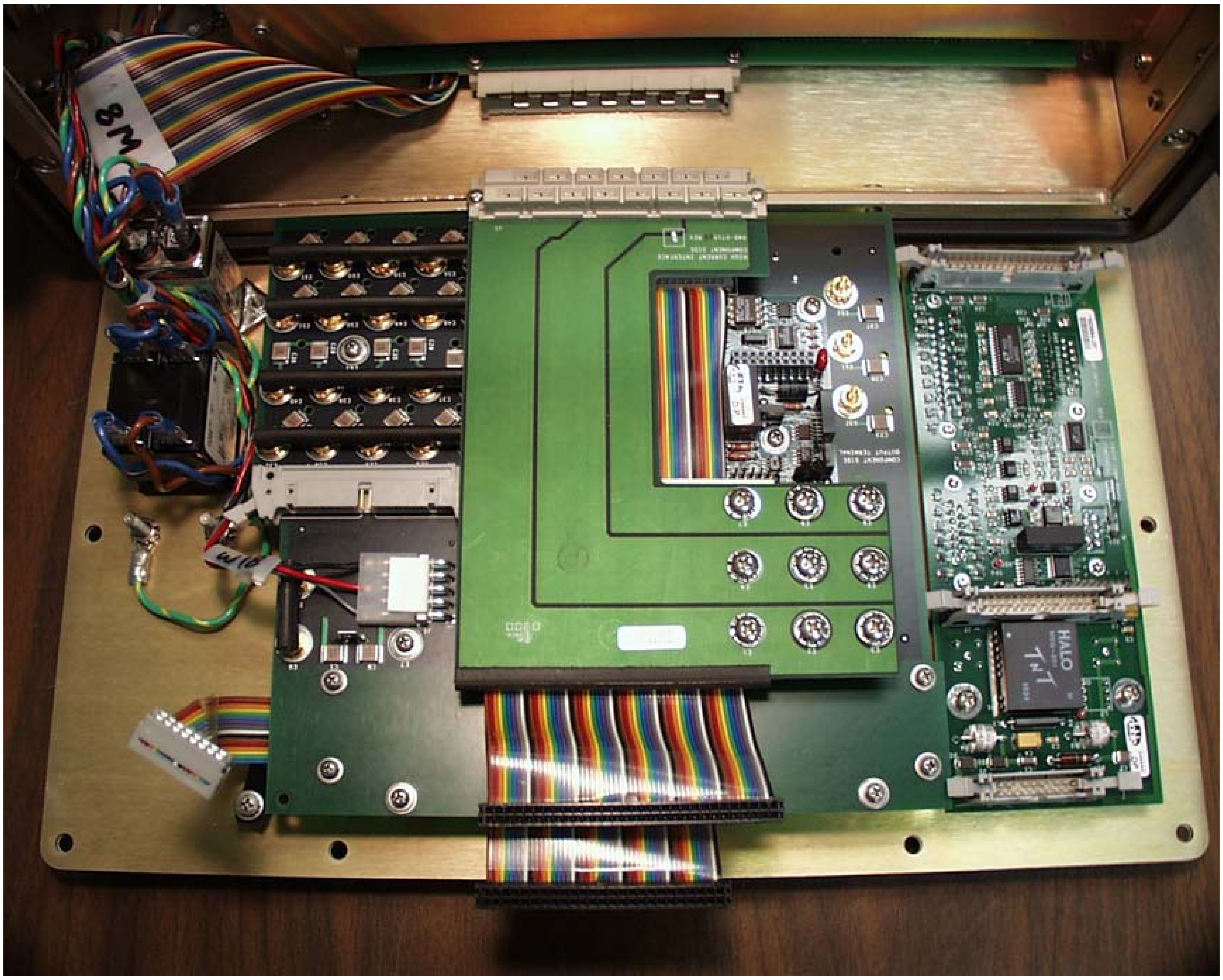

Figure 7.6 Instrument Front Panel with Wires Disconnected

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.

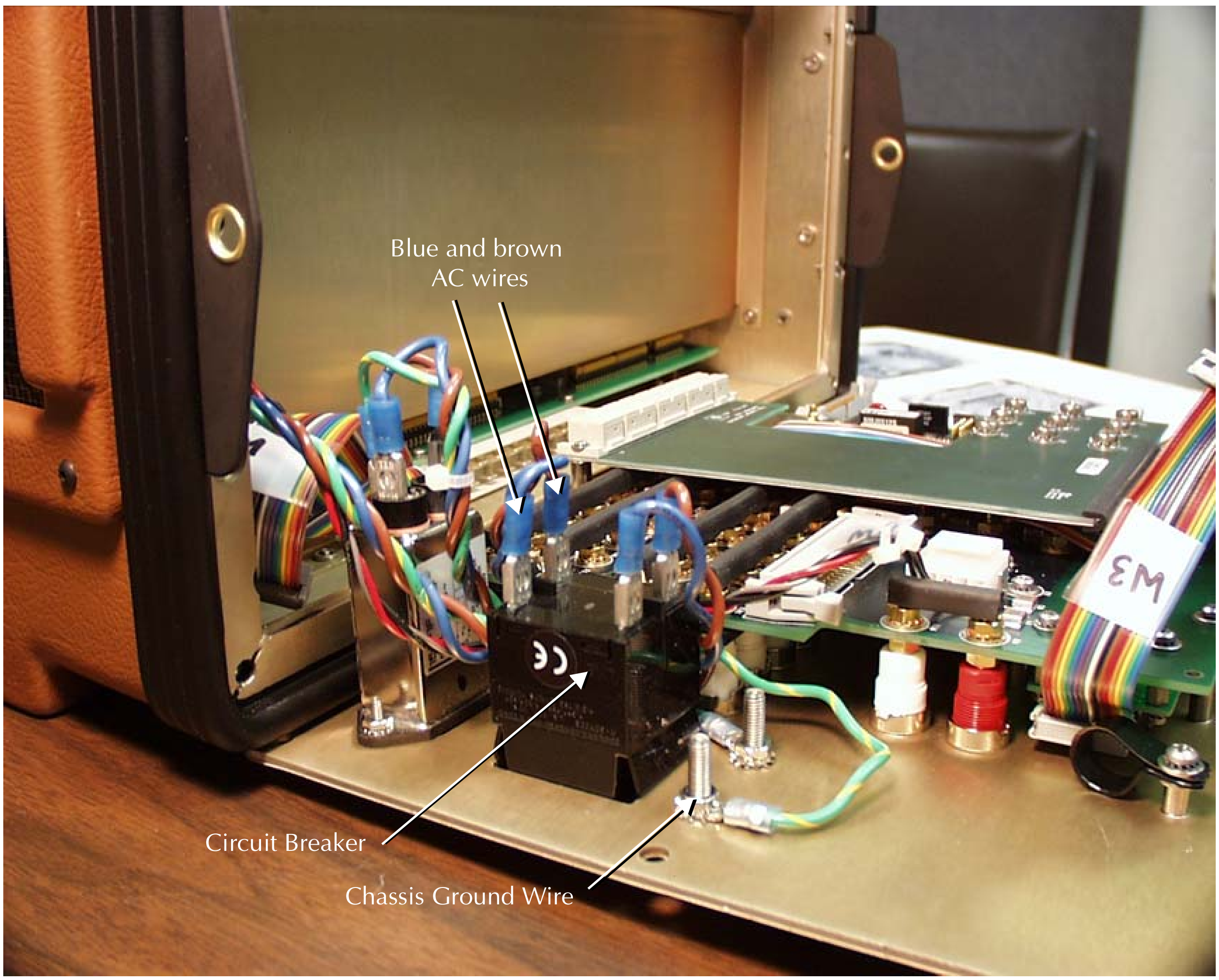

Figure 7.7 Wire Connections at the Front Panel Circuit Breaker

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

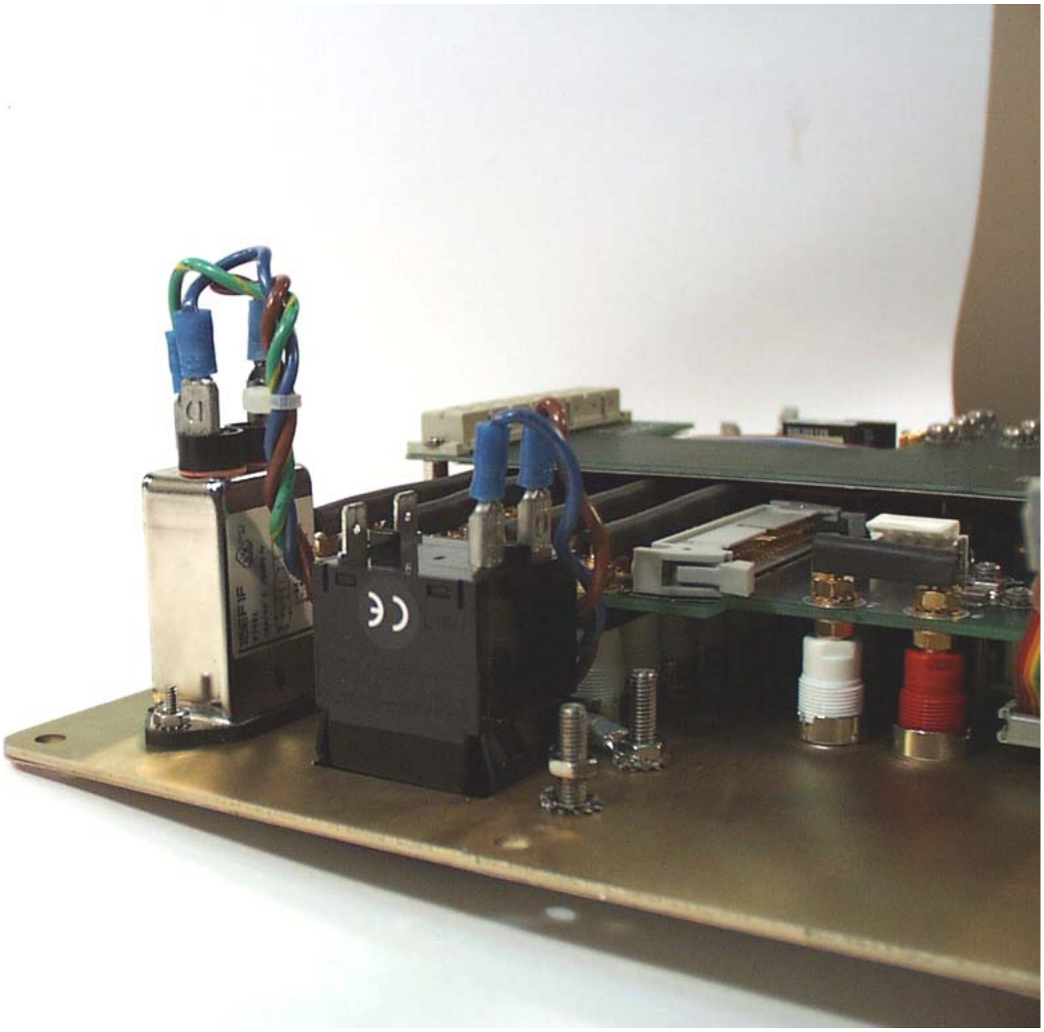

Figure 7.8 Circuit Breaker with Wires Disconnected

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 on page 7-12).
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 7-6).

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 7-7).
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 7-8).

The communications board is ready to be removed (Figure 7.9 on page 7-14).

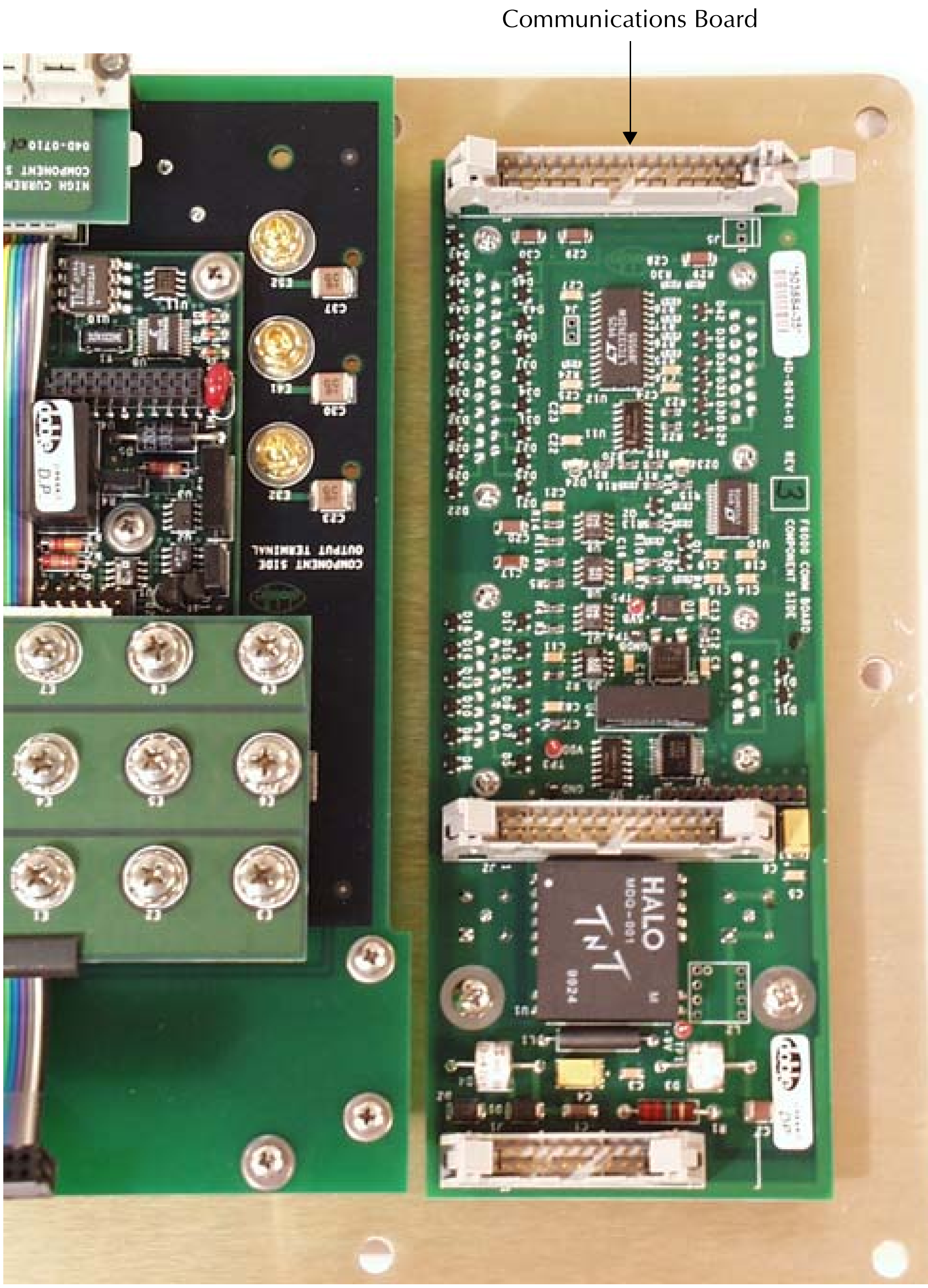

Figure 7.9 Communications Board Ready for Removal

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.

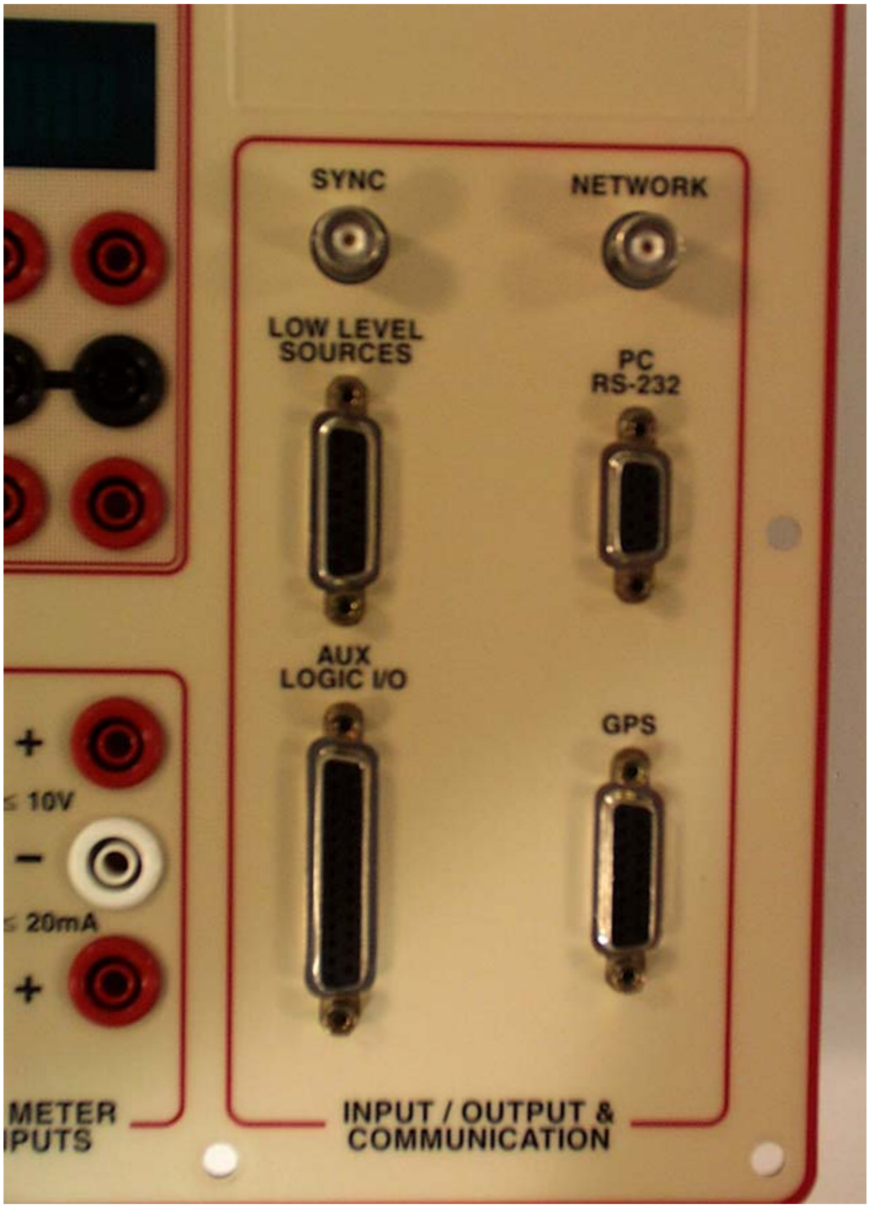

Figure 7.10 Right Side of the Instrument Front Panel

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 (see Table 7.2 on page 7-12).
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 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).

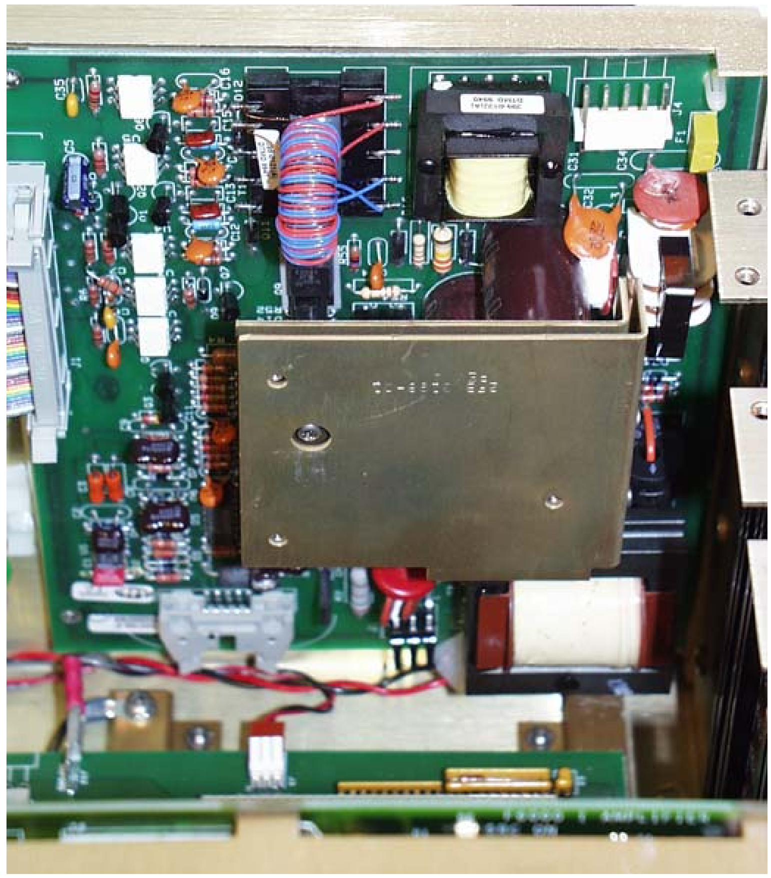

Figure 7.11 Battery Simulator Mounted at the Back of the Instrument

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).

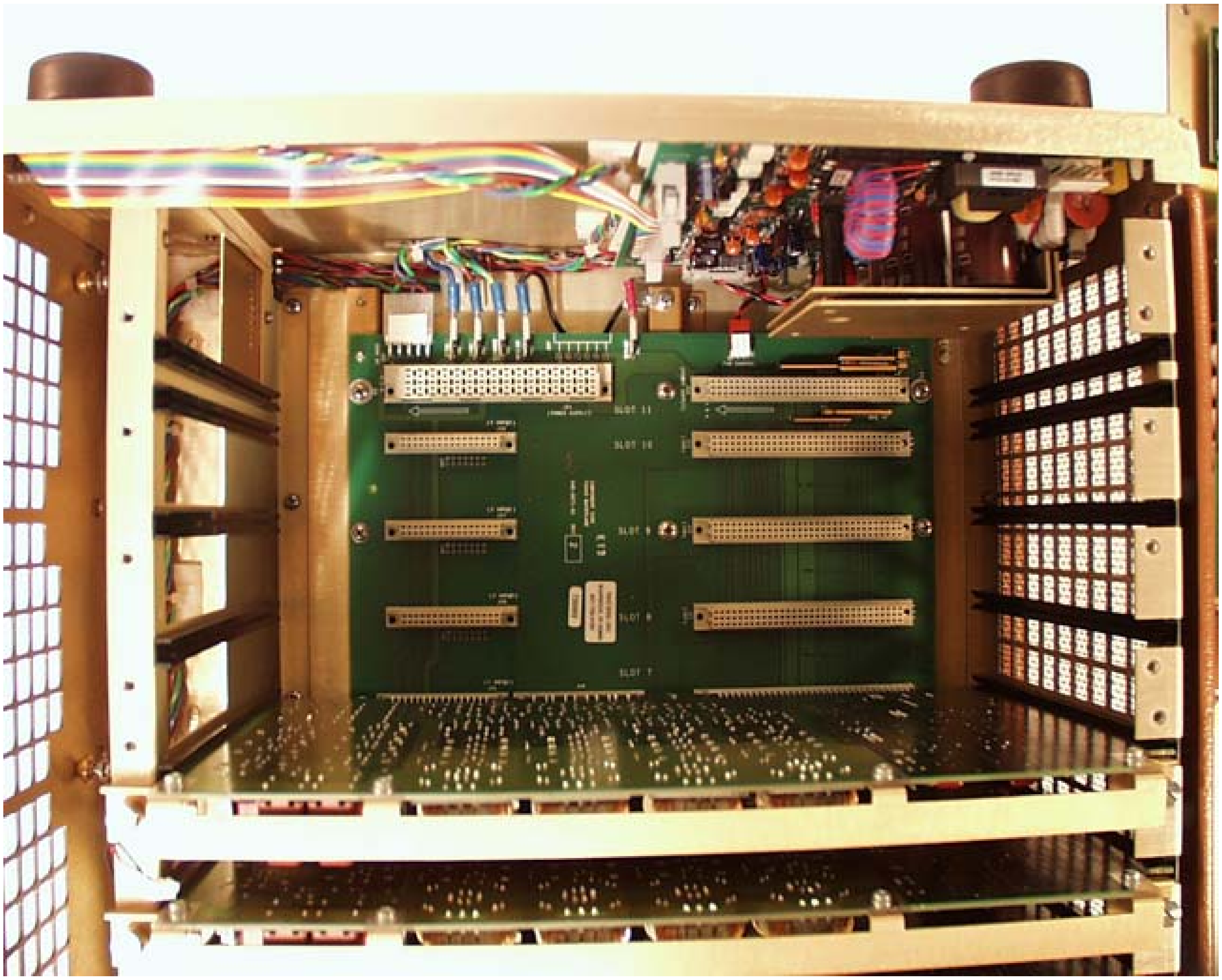

Figure 7.12 Removal of the Power Supply and Voltage Amplifiers for Access to the Battery Simulator

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-hand corner and the lower left-hand corner of the board.

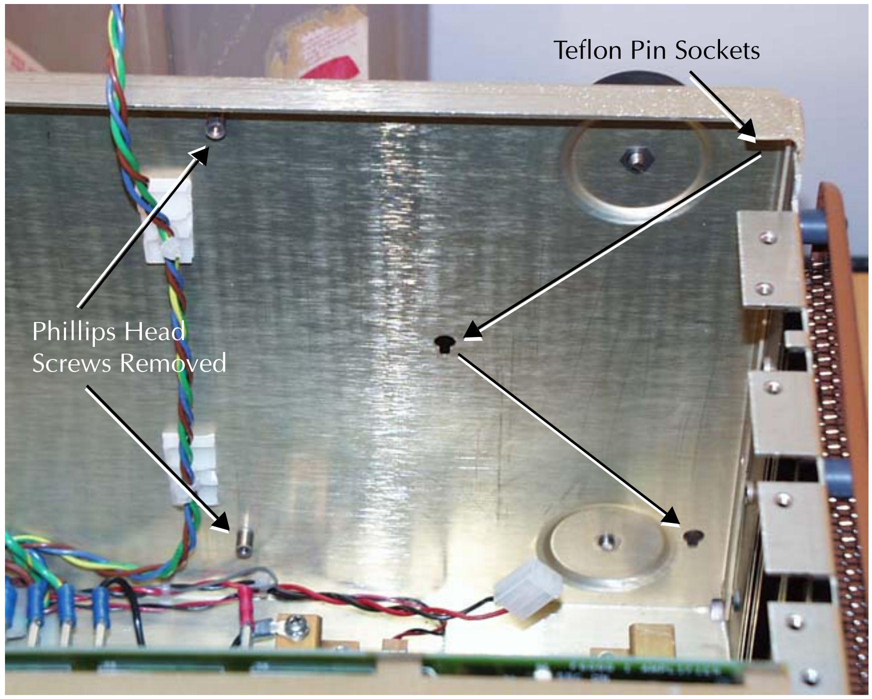

Figure 7.13 Back Panel After Removal of Battery Simulator

9. Disconnect the wire from connector J4 in the upper right-hand 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-hand corner, the center, and the lower right-hand 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).

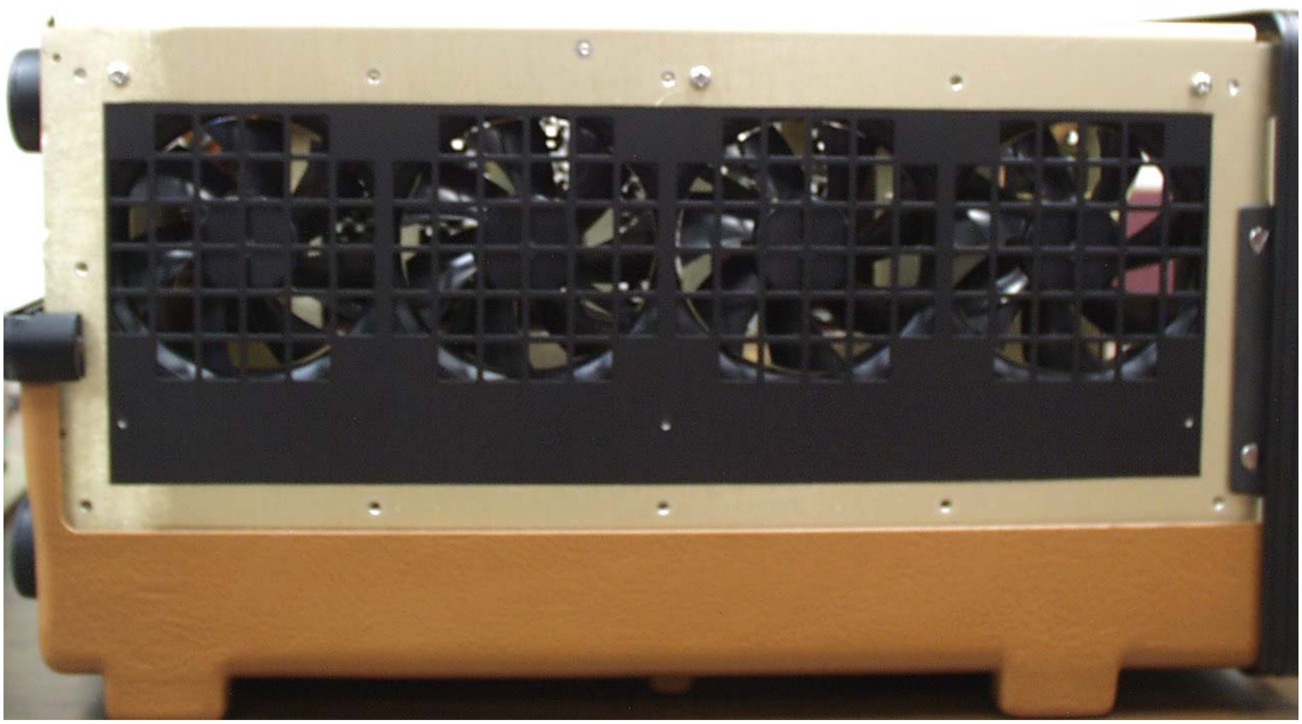

Figure 7.14 Side View of the Instrument Before Removal of Cooling Fans

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.

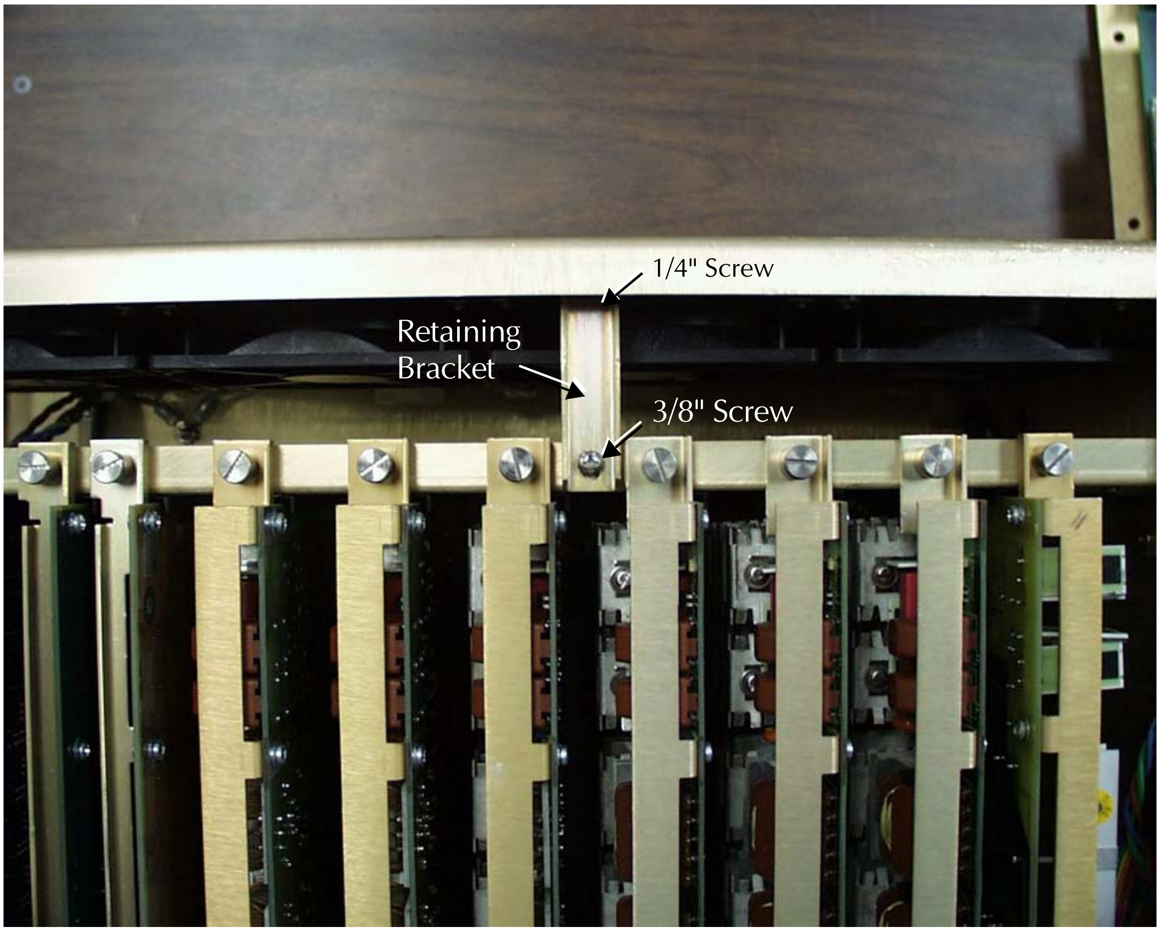

Figure 7.15 Retaining Bracket for Cooling Fans

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

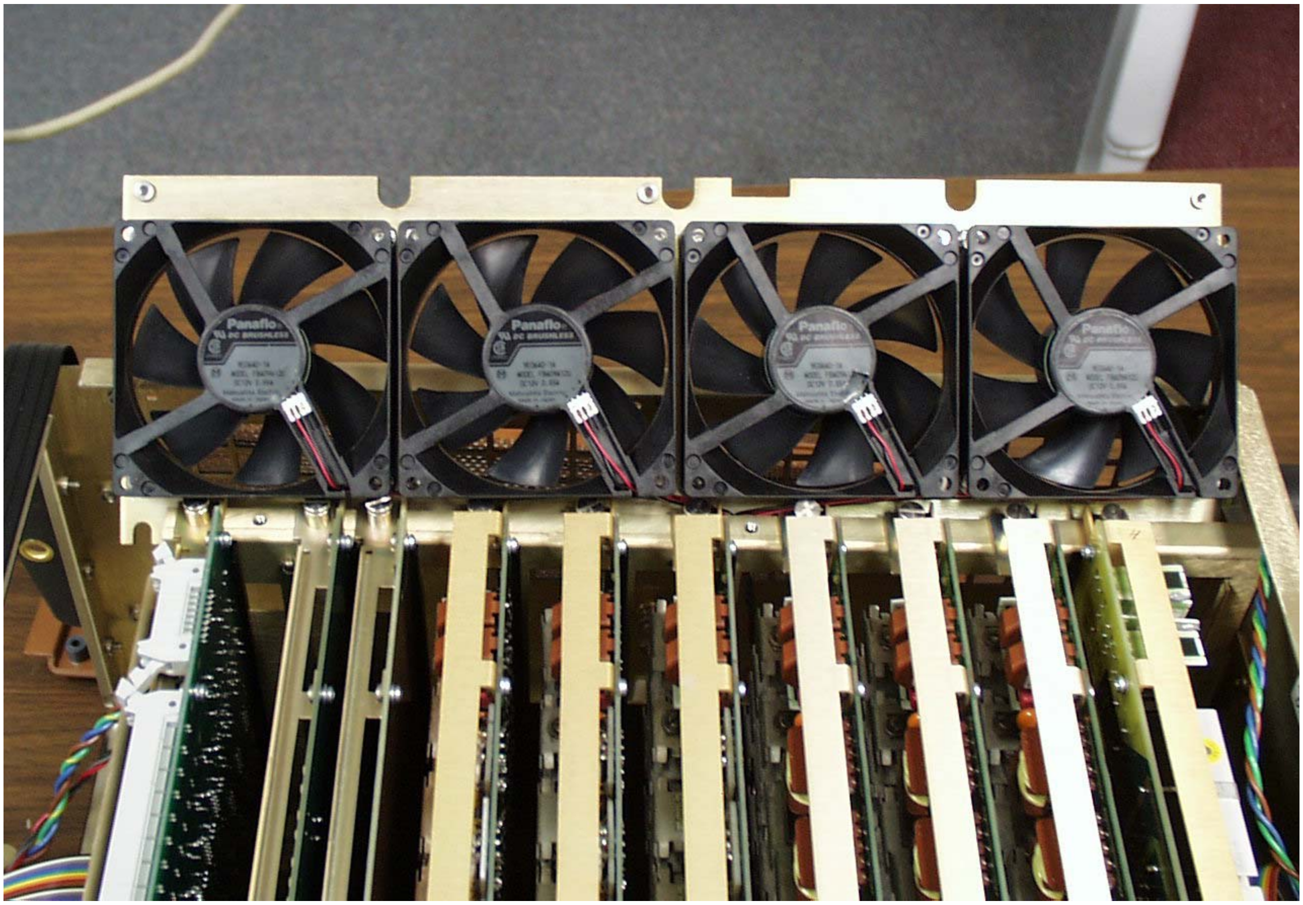

Figure 7.16 Cooling Fans with Wires Connected

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).

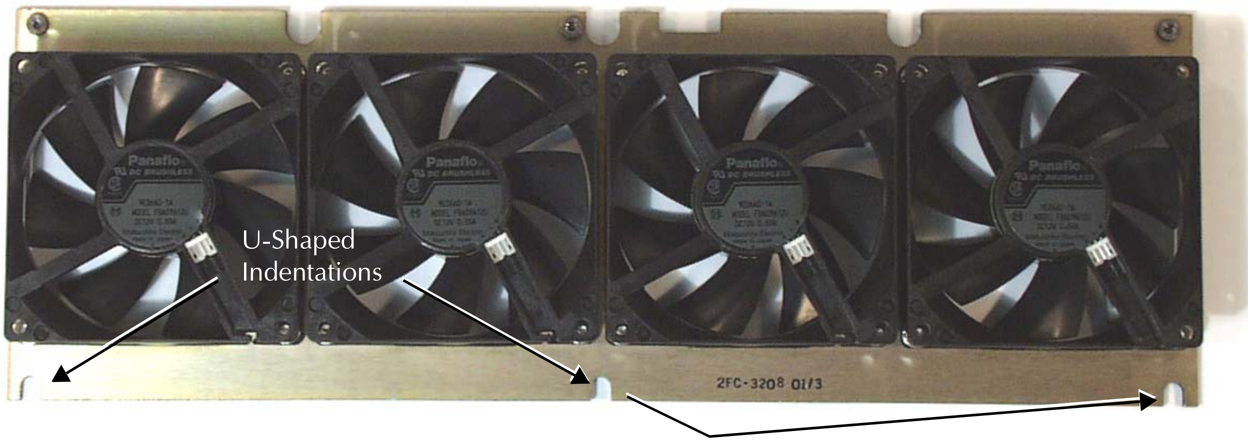

Figure 7.17 Cooling Fan Assembly

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 Control Panel in ProTesT 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 relay test and another instrument is available, try the test using the second instrument.
- If the instrument fails during a relay 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 ProTesT 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 ProTesT 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 ProTesT 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 ProTesT.

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 A.2).

Figure A.2 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 ProTest INI file. To do so:

1. Click **Save Settings**.

   The **FlashLoader** dialog box appears (Figure A.3).

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

   The **FlashLoader** dialog box closes.

Figure A.3 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 1-6). 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 ProTesT menu bar.

   The **Key Code Update** display appears (Figure A.4).

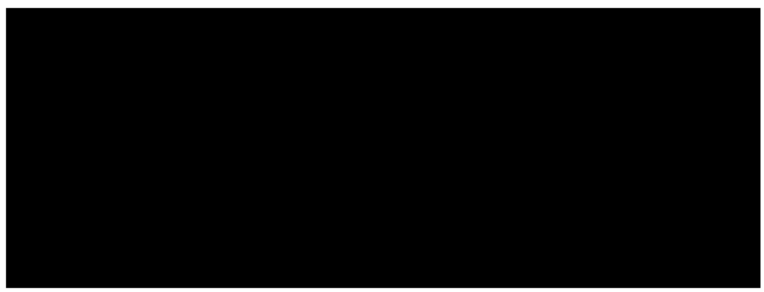

Figure A.4 Key Code Update

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.

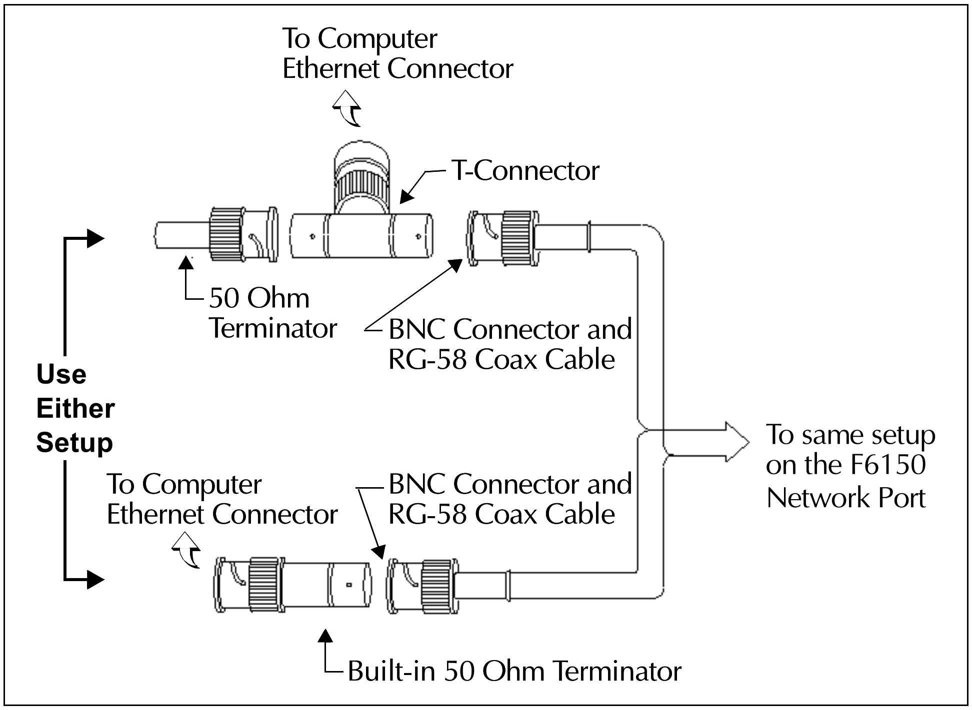

Figure B.1 Alternate 50 Ohm Terminator Connections for the Coax Cable

Configure the Control PC

To configure Windows 95/98/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).

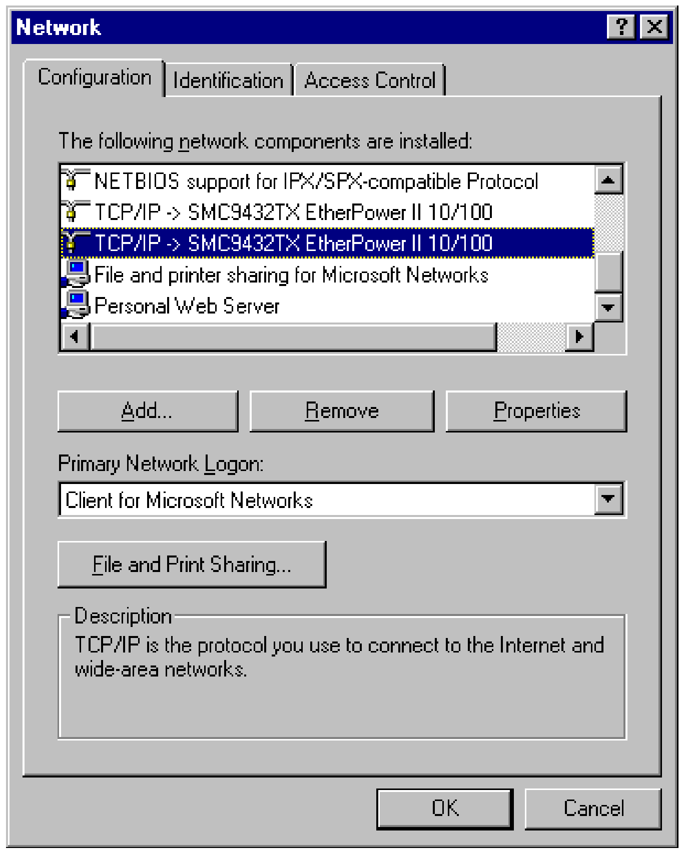

Figure B.2 Network Display: Scroll to the TCP/IP Network Component

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 on page B-4).

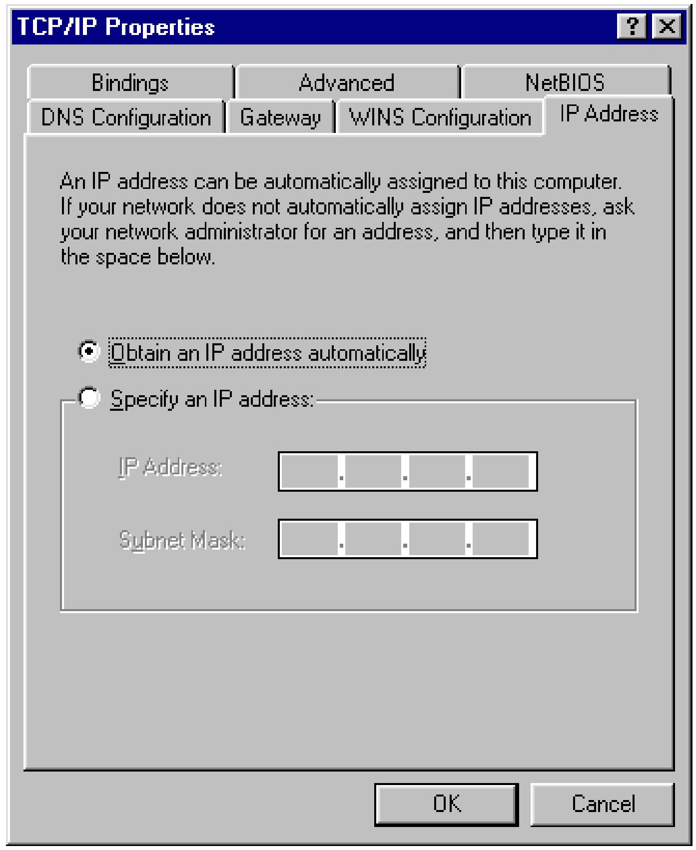

Figure B.3 TCP/IP Properties

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).

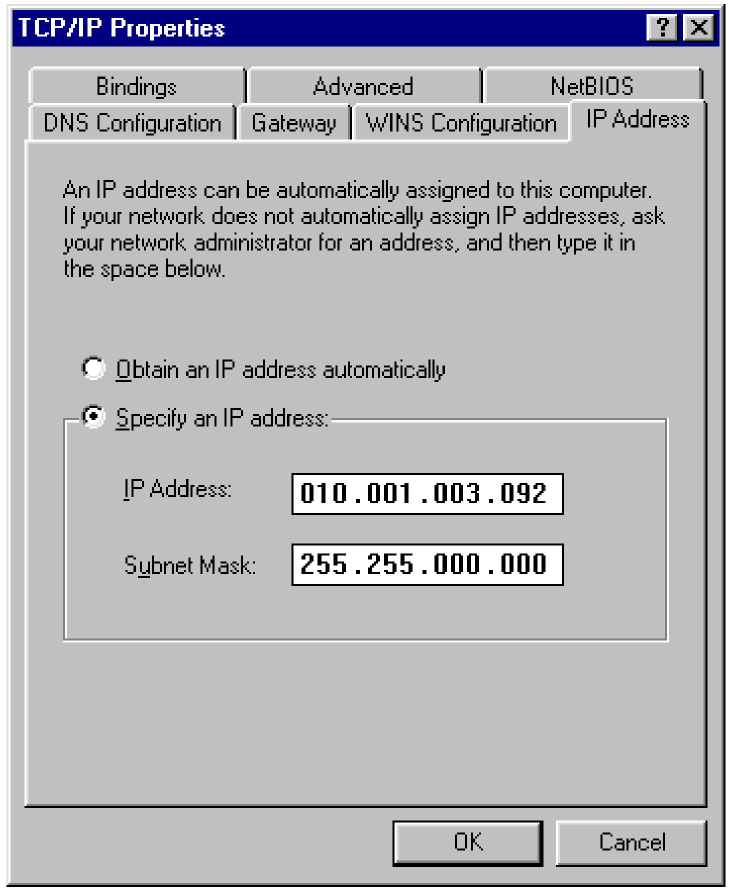

Figure B.4 IP Address Tab in TCP/IP Properties

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).

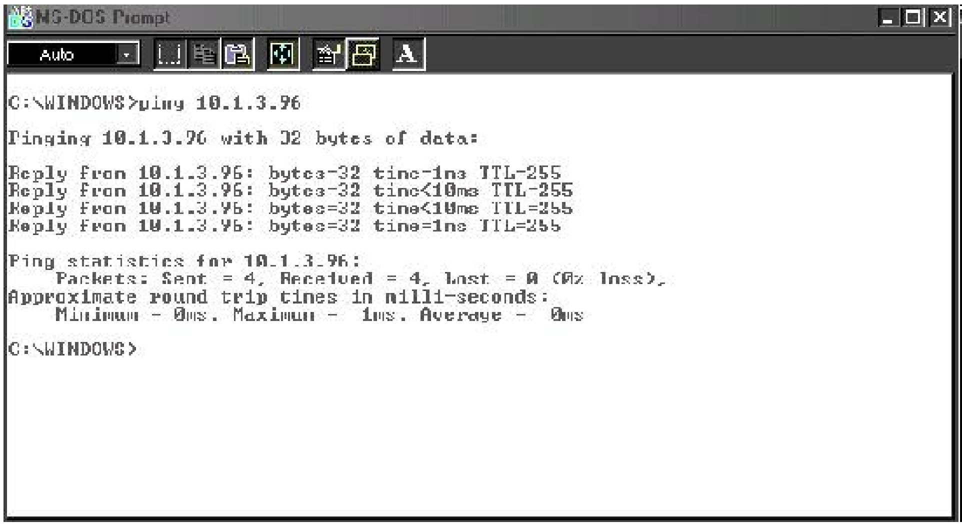

Figure B.5 Successful Ping

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

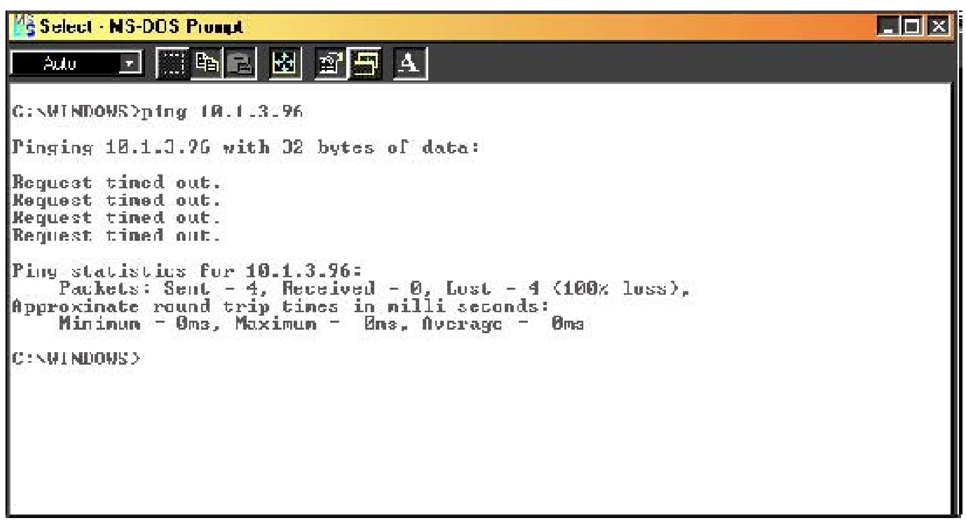

Figure B.6 Unsuccessful Ping

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

11. Open ProTesT and click **Setup** on the menu bar.

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

12. In the *Instrument Default* box, select *F6*.

13. In the *F6 Instrument* box, enter the IP Address of the instrument in the *IP Address* field.

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

14. In the *Connect with* box, select *Ethernet*.

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

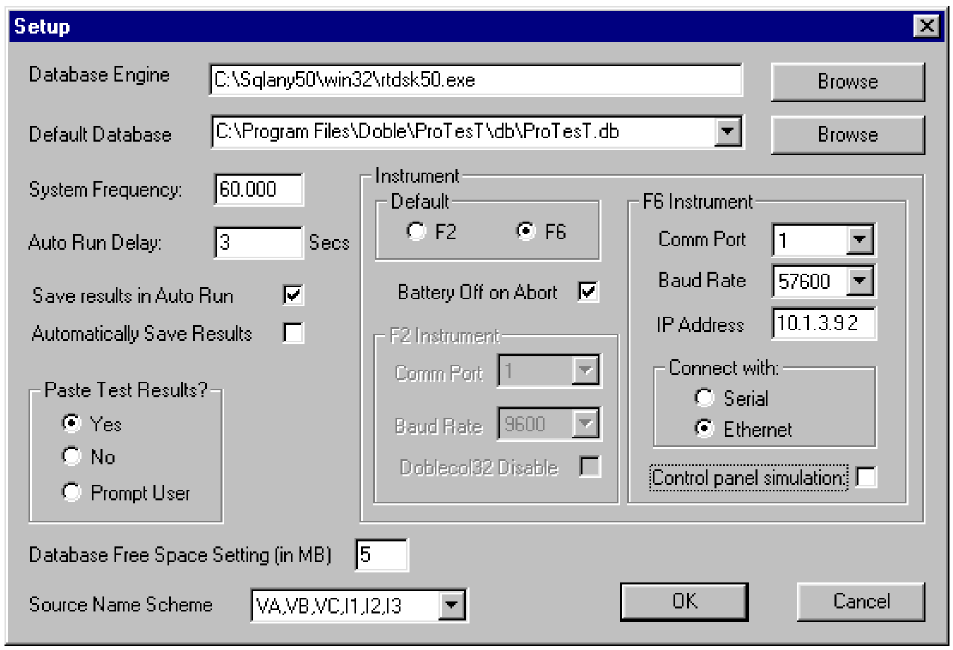

Figure B.7 Setup Display Configured for Ethernet Communications

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

16. Click **Tools | Control Panel** in the top menu bar of ProTesT.

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 ProTesT 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 ProTesT to meet protection scheme 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

	Maximum Compliance Voltage			
Current Range	**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

	Maximum Compliance Voltage			
Current Range	**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 3.4 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.

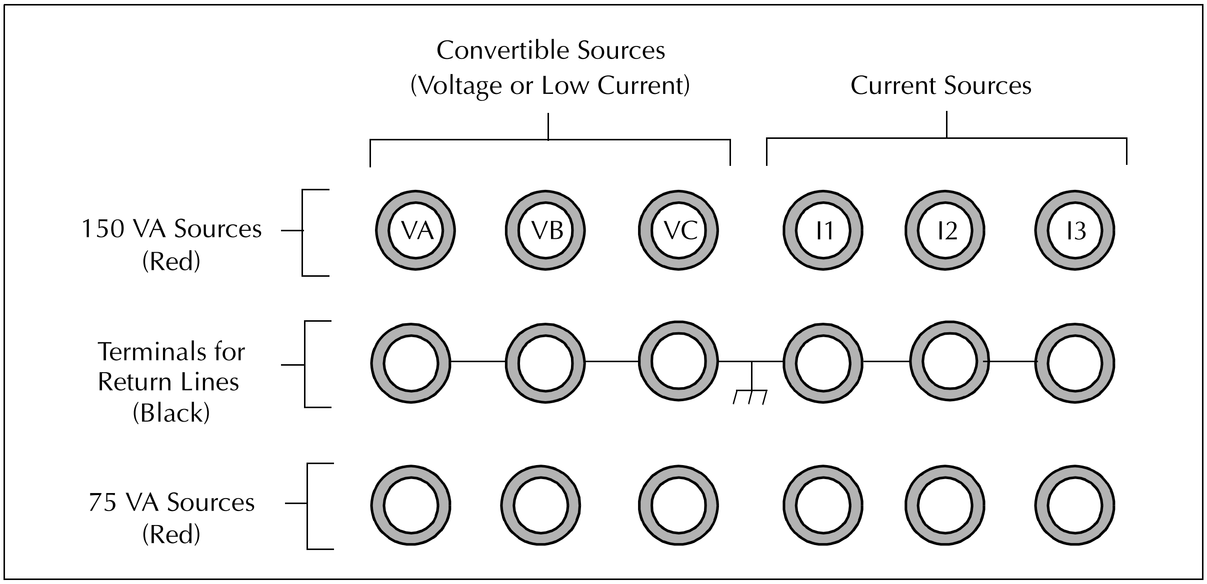

Figure C.1 3 Voltages and 3 Currents

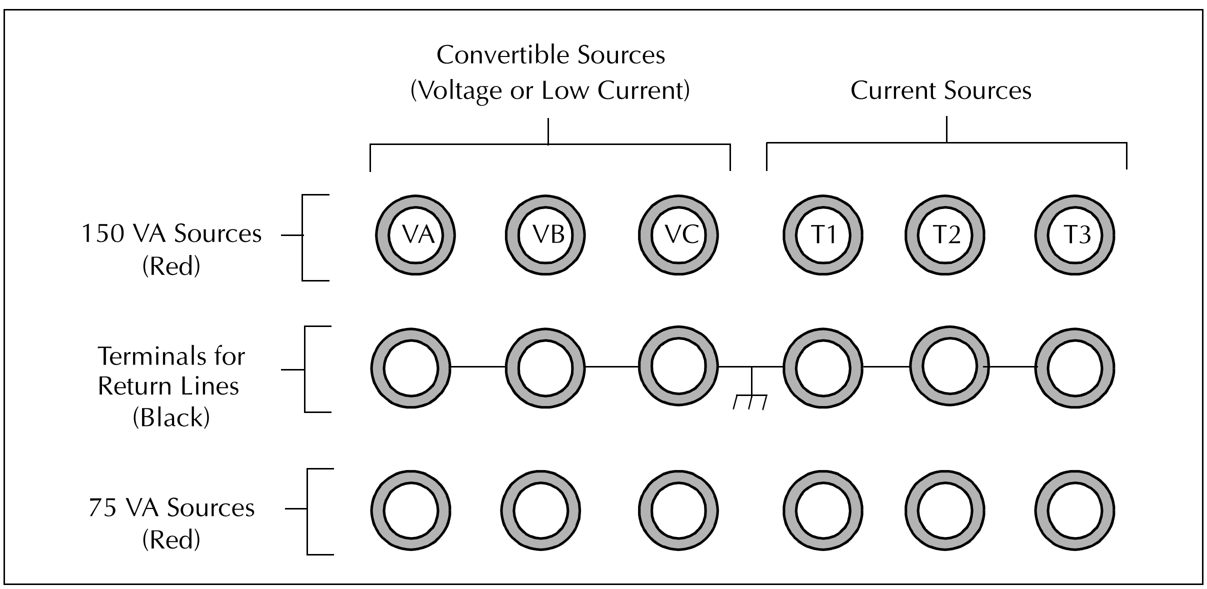

Figure C.2 3 Voltages and 3 Transient Currents

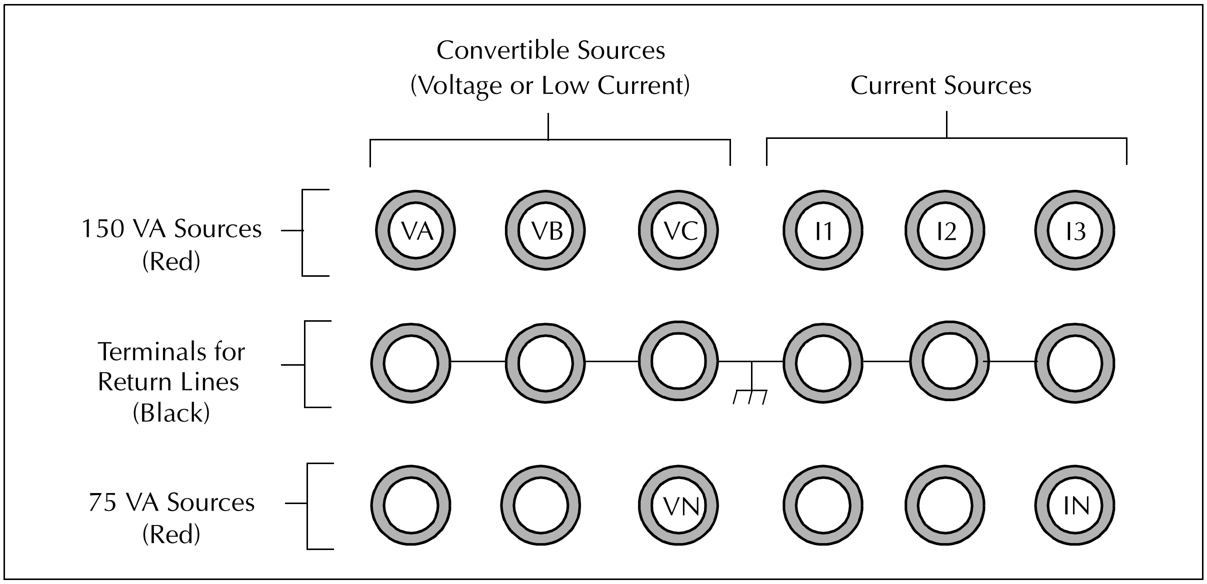

Figure C.3 4 Voltages and 4 Currents

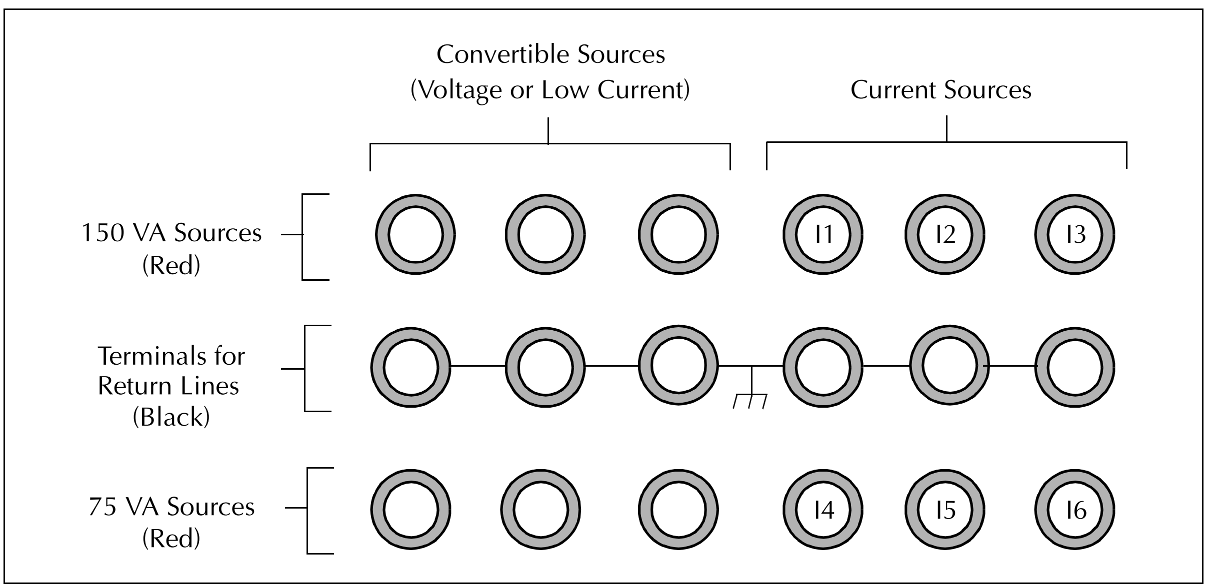

Figure C.4 6 Currents (right bank)

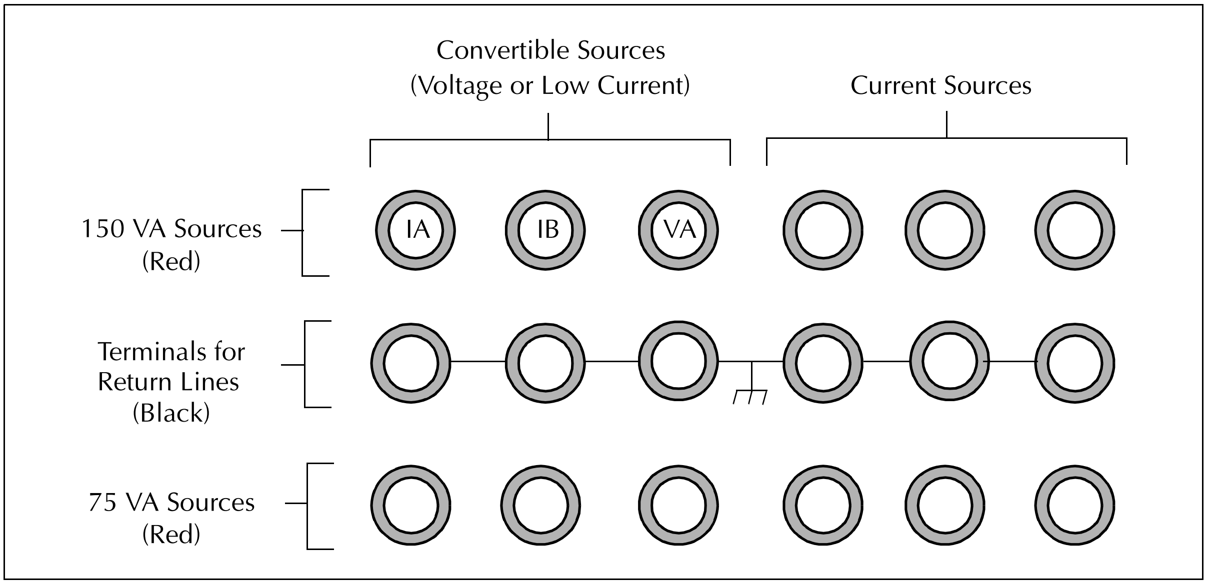

Figure C.5 1 Voltage and 2 Low Range Currents

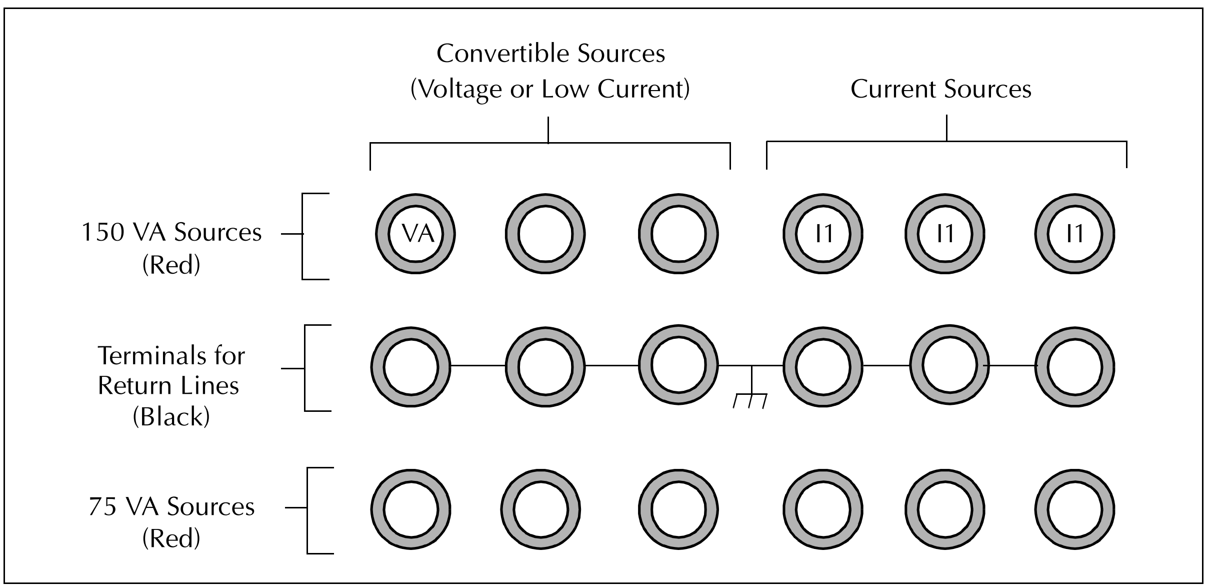

Figure C.6 1 Voltage 150 VA and 1 Current 450 VA

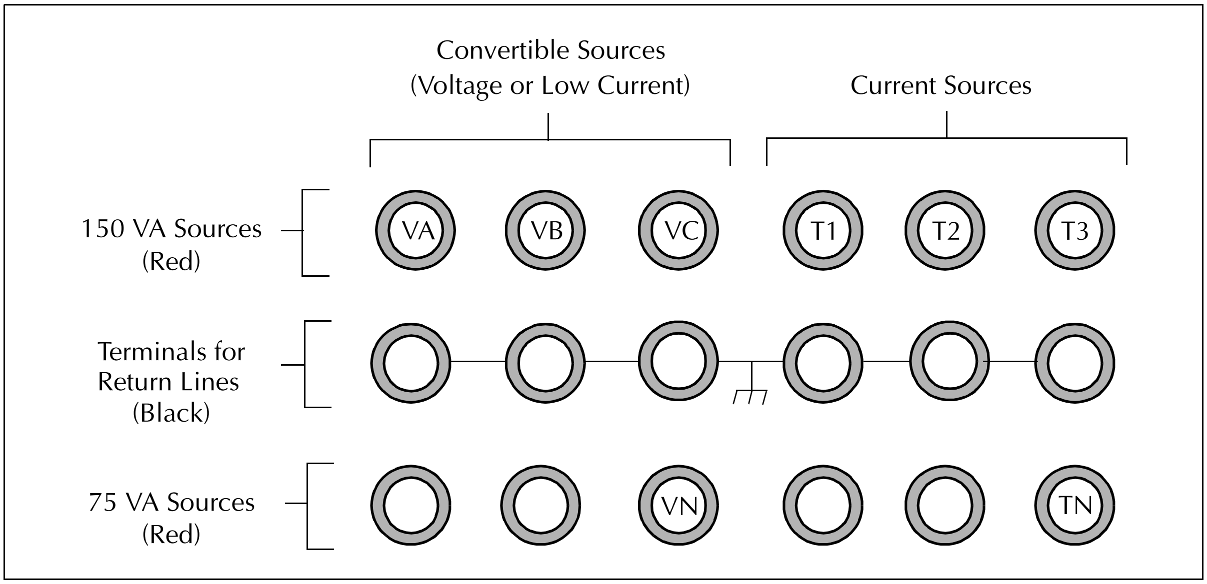

Figure C.7 4 Voltages and 4 Transient Currents

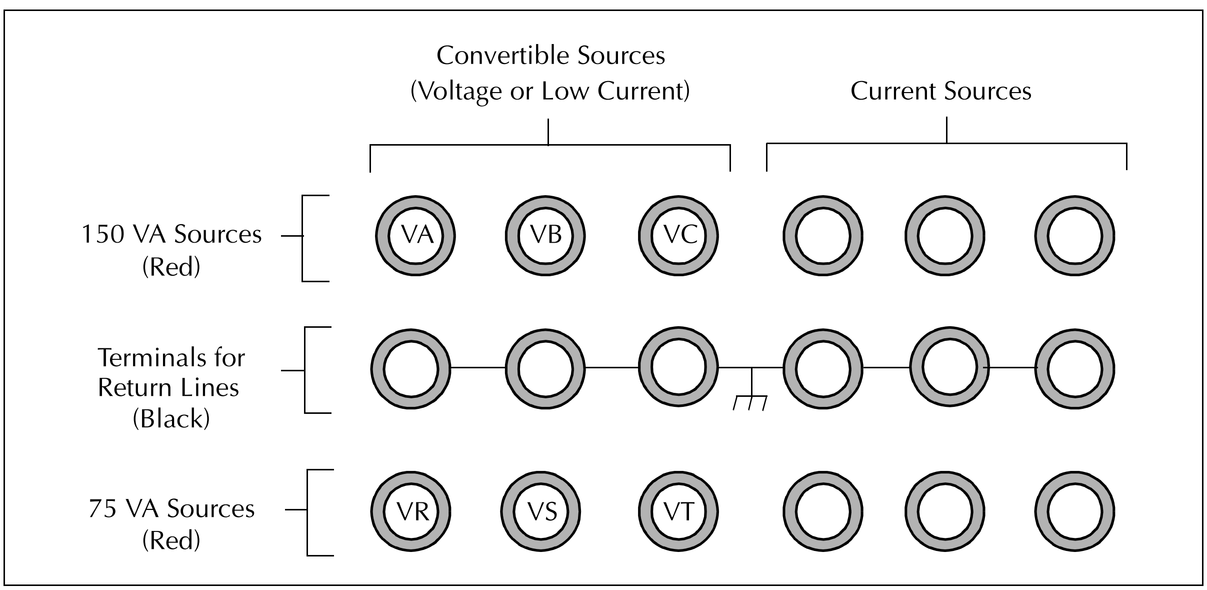

Figure C.8 6 Voltages

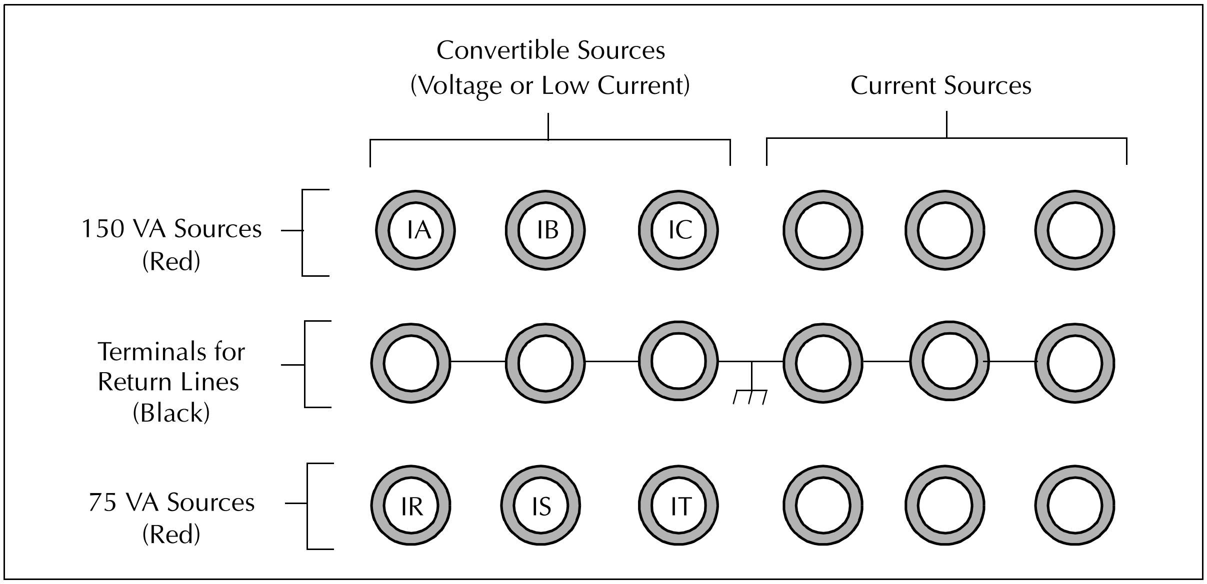

Figure C.9 6 Low Range Currents

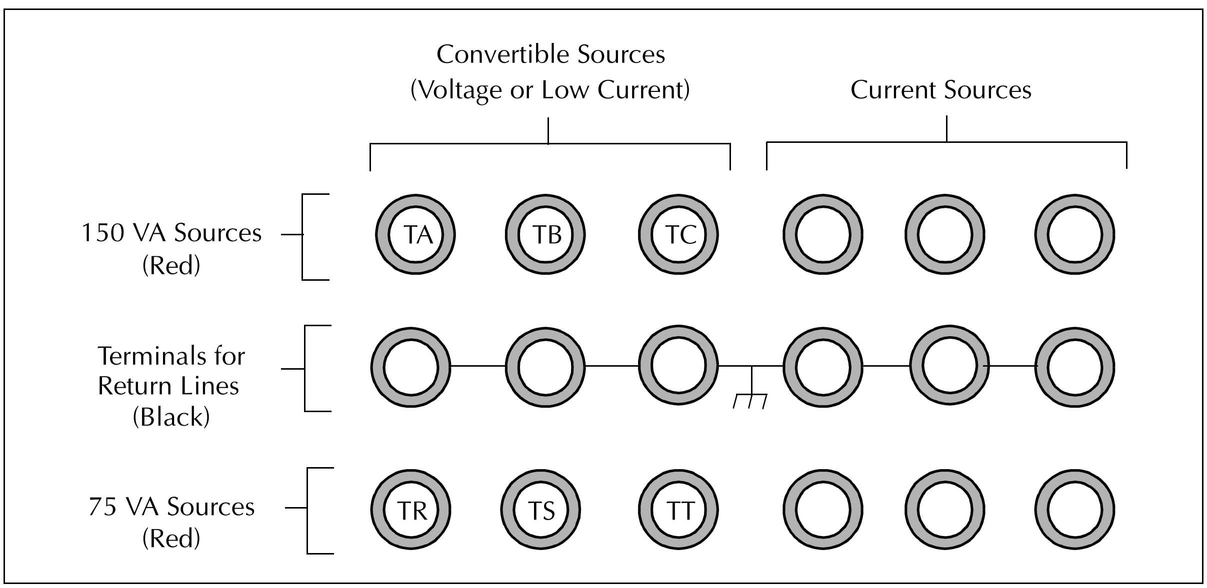

Figure C.10 6 Low Range Transients

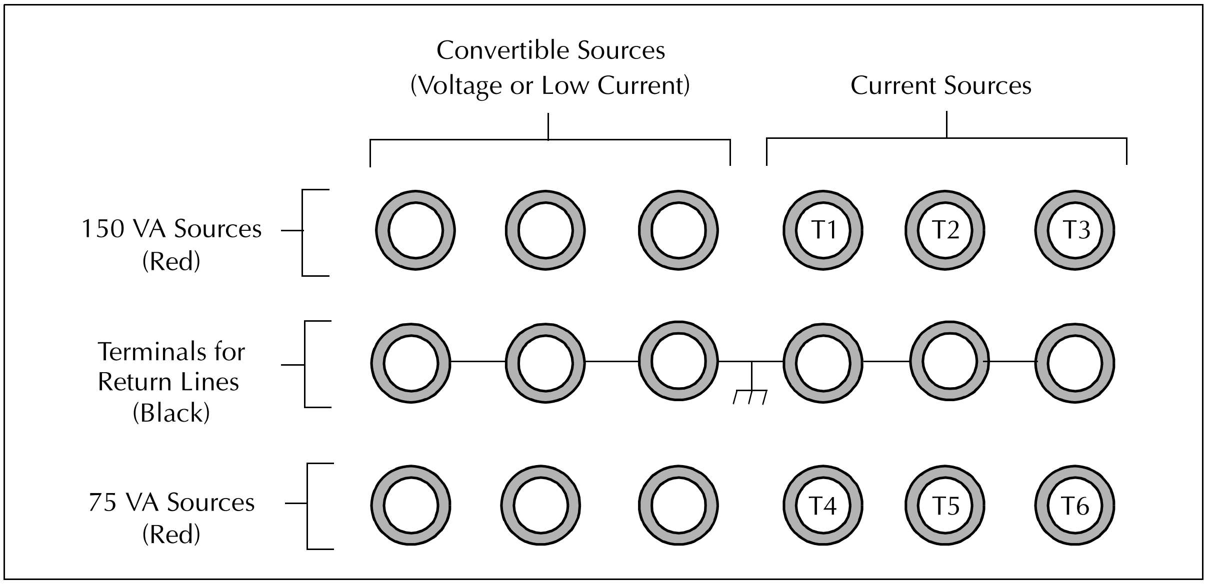

Figure C.11 6 Transient Currents

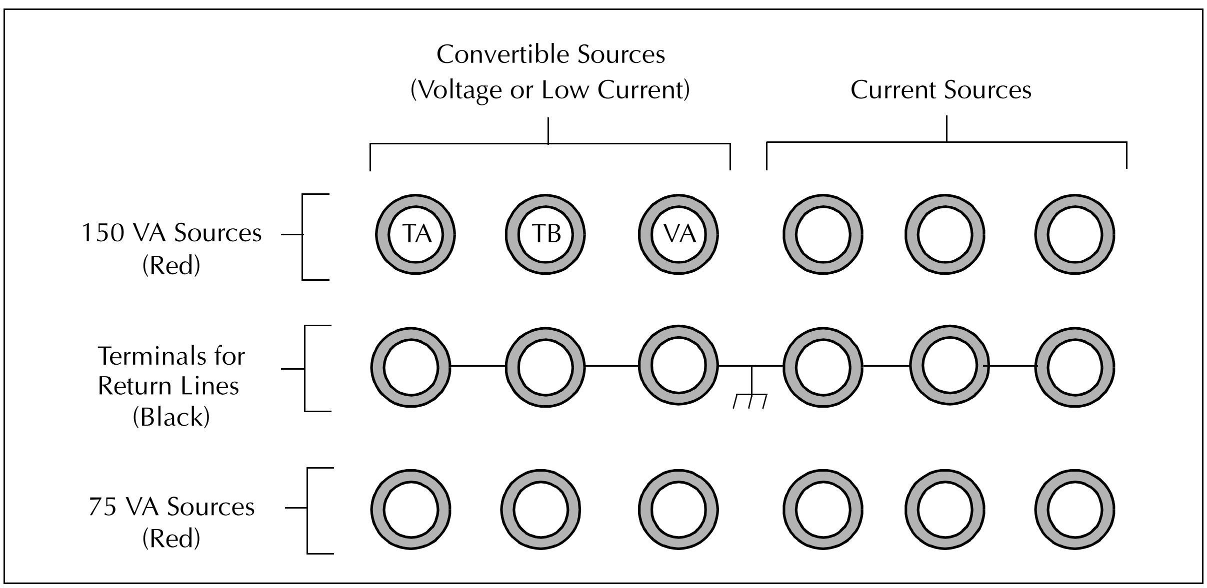

Figure C.12 1 Voltage and 2 Low Range Transients

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.

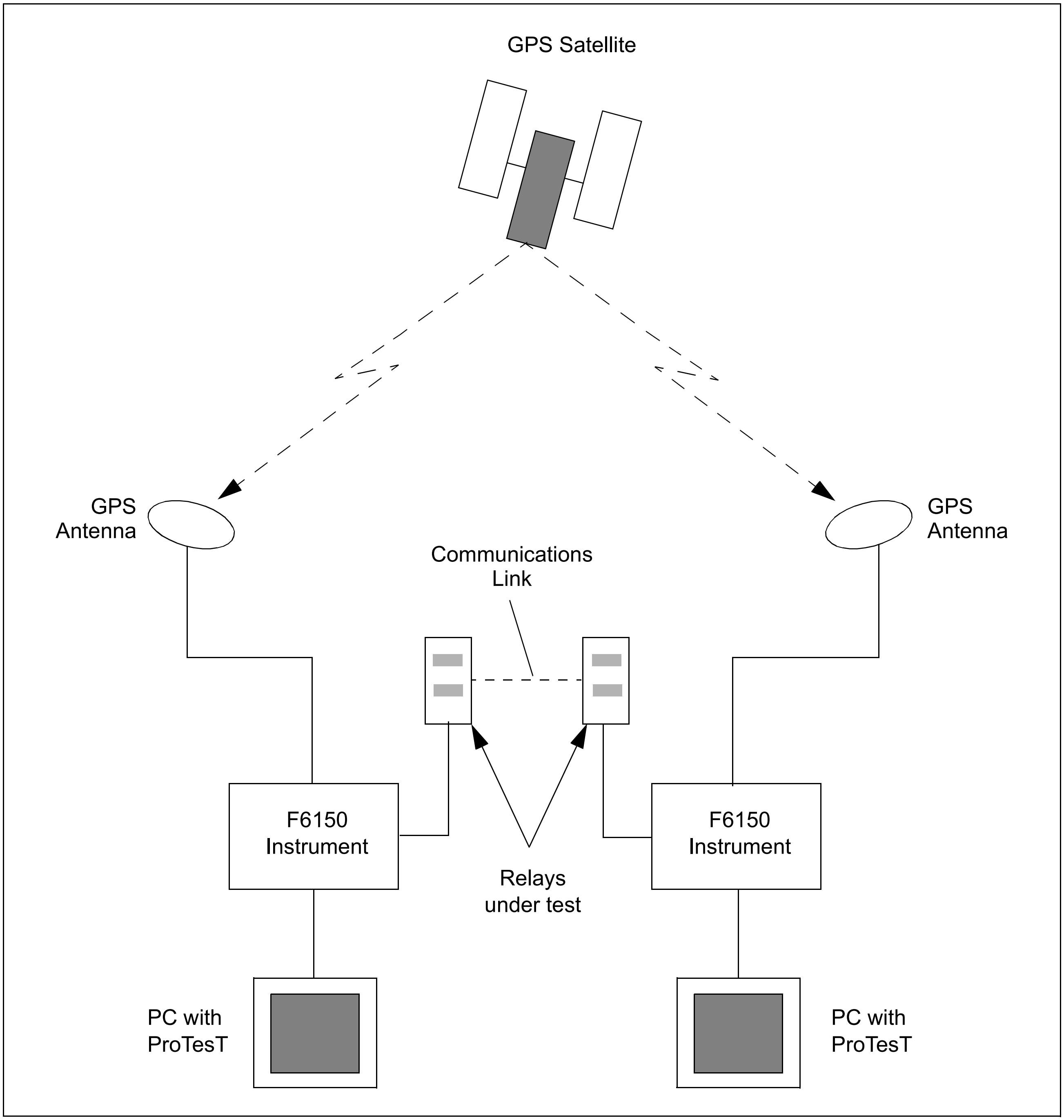

Figure D.1 End-to-End Testing with GPS Synchronization

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 on page D-4 shows all of the equipment required for the test.

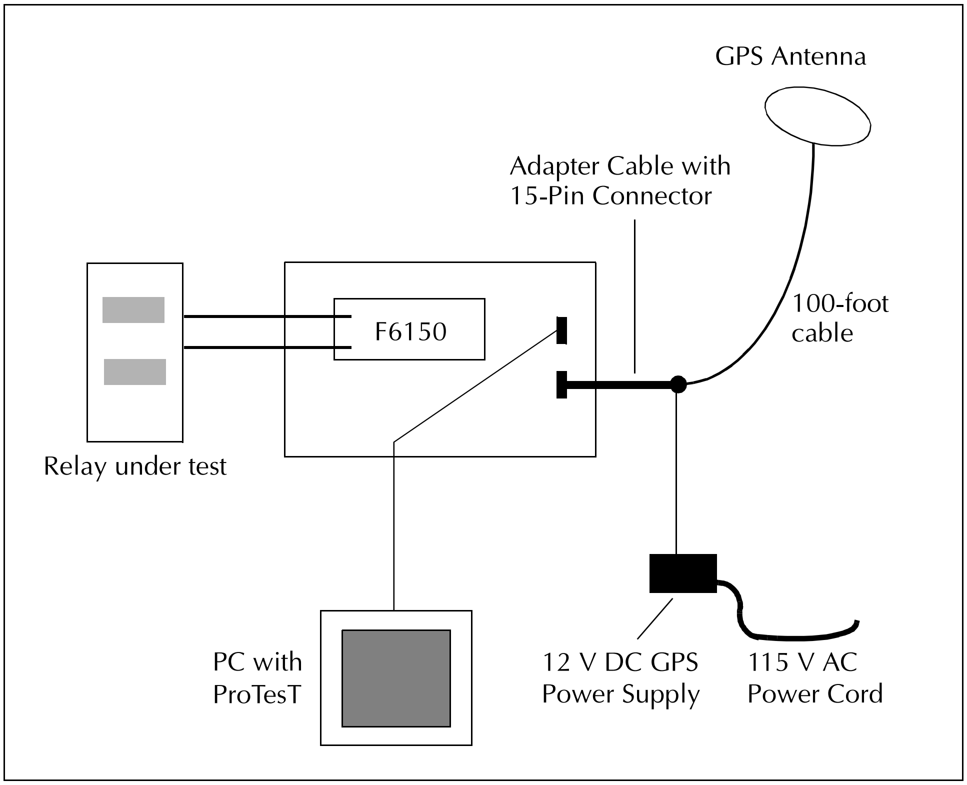

Figure D.2 Equipment Setup for GPS Synchronization

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 on page F-2.

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 in ProTesT.

   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.

   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.

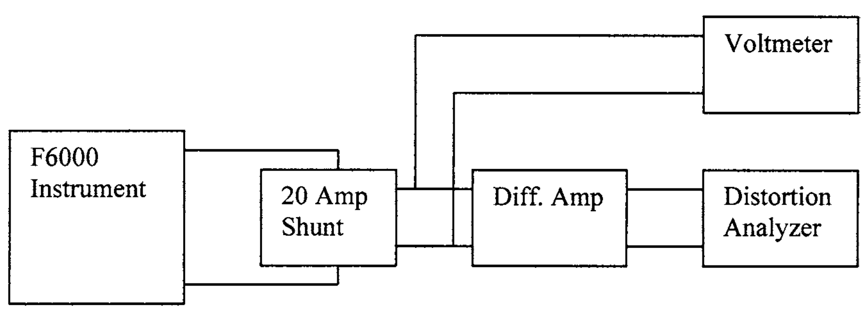

Figure F.1 75 VA High Current Source Measurement

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 in ProTesT.
   - 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.

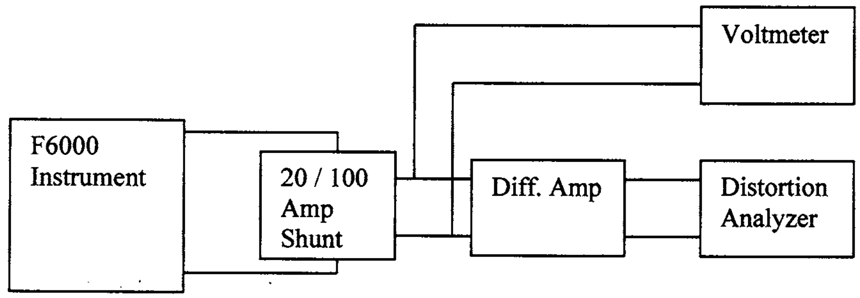

Figure F.2 150 VA High Current Source Measurement

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 in ProTesT.
   - 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.

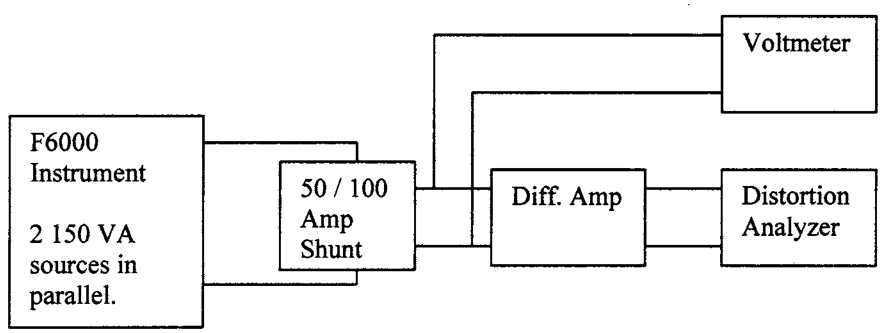

Figure F.3 300 VA High Current Source Measurement

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 in ProTesT.
   - 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.

   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.

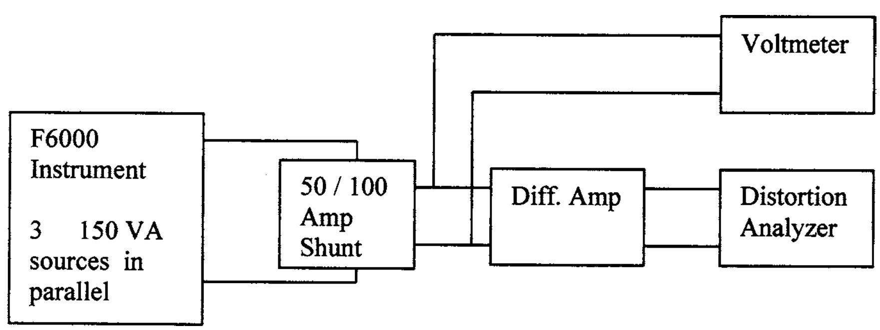

Figure F.4 450 VA High Current Source Measurement

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 in ProTesT.
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 measurements.

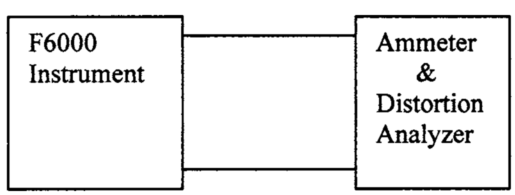

Figure F.5 75 VA Convertible Low Current Source Measurement

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 in ProTesT.
   - 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 on page F-10 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 and Distortion measurements.

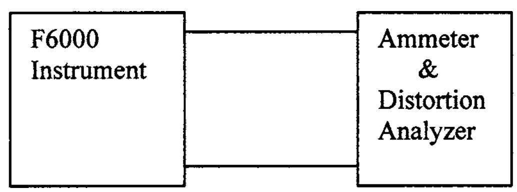

Figure F.6 150 VA Convertible Low Current Source Measurement

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 in ProTesT.
   - 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.

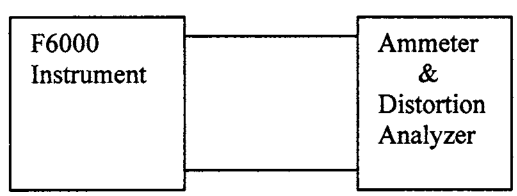

Figure F.7 300 VA Convertible Low Current Source Measurement

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 in ProTesT.
   - 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 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 on page F-13 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.

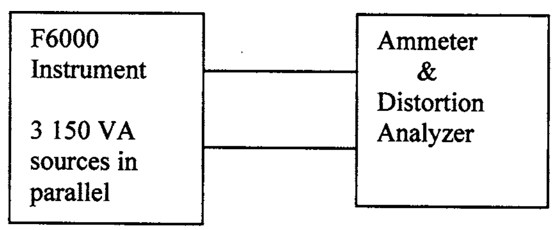

Figure F.8 450 VA Convertible Low Current Source Measurement

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 in ProTesT.
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.

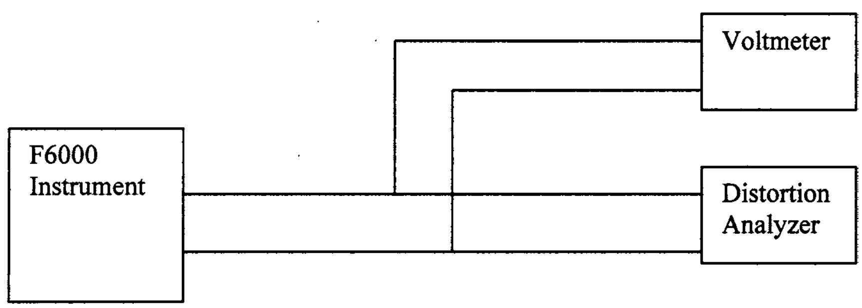

Figure F.9 75 VA Convertible Voltage Source Measurement

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 in ProTesT.
   - 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.

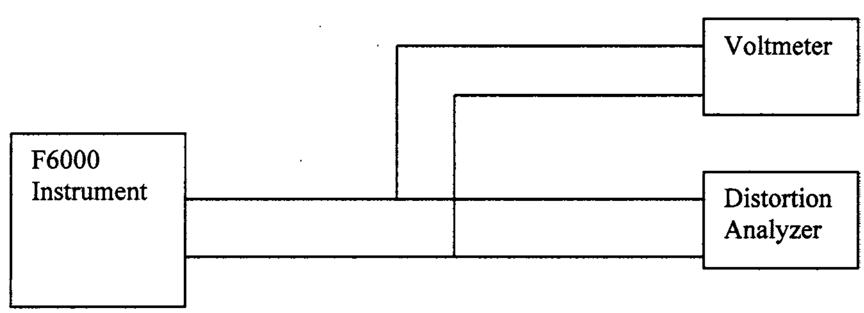

Figure F.10 150 VA Convertible Voltage Source Measurement

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 in ProTesT.
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.

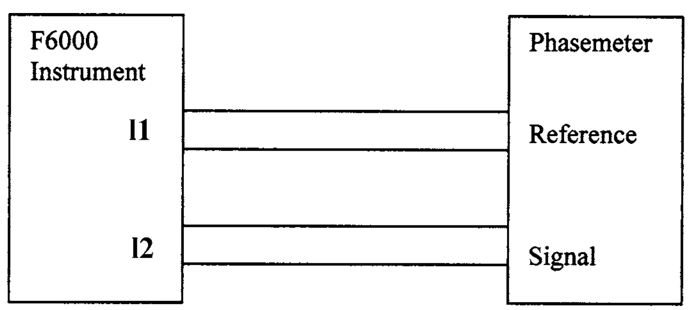

Figure F.11 Test Setup for Phase Testing Six Current Sources

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 in ProTesT.
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.

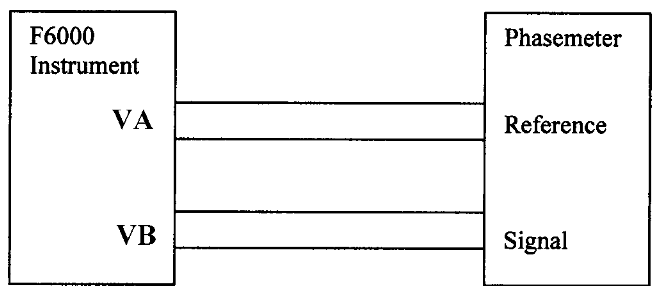

Figure F.12 Test Setup for Phase Testing Six Voltage Sources

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.
6*75 VA sources	6*97.5 VA sources
3*150 VA sources	3*195 VA sources
1*450 VA source	1*585 VA source
1*300 VA and 1*150 VA source	1*390 VA and 1*195 VA source

Ranges and Resolution

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)

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 into one 300 VA current source. Three 150 VA convertible low current sources can be combined into one 450 VA current source.

75 VA Source

	Ranges (Resolution)
AC Voltage	75, 150, V rms (0.01 V)
DC Voltage	106, 212 VDC (0.1 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)

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.**
6*75 VA sources	6*112 VA sources
3*150 VA sources	3*225 VA sources
1*450 VA source	1*675 VA source
1*300 VA and 1*150 VA source	1*450 VA and 1*225 VA source

Ranges and Resolution

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)

Each 150 VA current source can be split into two 75 VA sources. Two 150 VA current sources can be combined into one 300 VA current source. Three 150 VA current sources can be combined into one 450 VA current source.

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)

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)

Battery Simulator

Range: 48, 125, 250 VDC

Power: 60 Watts, 1.5 A maximum

50/60 Hz Ripple: <0.2% of range

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 801-2 I.E.C. 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.

AC Amplitude Accuracy at 50/60 Hz

From 20° to 30° C: ±0.3% of setting or ±0.03% of range

From 0° to 50° C: ±0.5% of setting or ±0.05% of range

Typically 0.1% of reading

Distortion

Low distortion sine waves; total harmonic distortion 0.1% typical; 2% 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

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.

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.

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

Accuracy: ±0.0005% of reading, ±50 microseconds

Resolution: 100 microseconds

Input Power Supply

115 V nominal at 15 A maximum (50 or 60 Hz)

230 V nominal at 10 A maximum (50 or 60 Hz)

Temperature

Operating temperature: 0° to 50° C

Storage temperature: –25° to +70° C

Humidity

Up to 95% relative humidity, non-condensing

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

T