♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

PRS-200 SERIES

High Precision
Manual or SCPI Programmable
Decade Resistance Substituters
(IEEE-488.2, RS232 or Ethernet)
Operation Manual

PRS200 IEEE.2 im/May 2015

IET LABS, INC.
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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

WARNING

OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

Dangerous voltages may be present inside this instrument. Do not open the case Refer servicing to qualified personnel

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND KEEP UNREQUIRED PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

CONTENTS

Chapter 1
INTRODUCTION

The PRS Series (Figure 1.1) is a broad line of high precision manual and programmable decade substituters. They provide direct resistance substitution as well as RTD (Resistance Temperature Detector) simulation, in a wide selection of ranges, tolerances and ratings.

The PRS substituter is a precision resistance source with excellent characteristics of stability, temperature coefficient, and power coefficient. High dynamic ranges are available, starting as low as 1 mΩ, and extending to as many as 10 decades. These features combined with a low virtually constant “zero resistance” make for very versatile instruments.

The PRS Series features two optional special settings. An “open circuit” and a “short circuit”. These modes are useful for obtaining reproducible transitions between settings, i.e. break-before-make or to short between settings. The “short circuit” setting also provides a reduced zero resistance.

Operation is both local using convenient direct-reading front panel thumbwheel switches, and remote with optional Ethernet, RS-232, or IEEE-488 interfaces. Both can provide an optional extra “10” position for each decade.

The PRS Series employs very low resistance, low thermal emf relays with gold-clad silver-alloy contacts. A special design keeps contact resistance to a minimum. The gold plating keeps the silver contacts from becoming tarnished when unused, or when only low currents are passed through them. This is most often the case when only minute test currents are drawn by digital multimeters and other test instruments. Contact resistance remains low and repeatable.

High-quality gold-plated tellurium-copper five-way binding posts serve to minimize the thermal emf effects, which would produce errors in dc resistance measurements. All other conductors within the instrument, as well as the solder employed contain no metals or junctions that could contribute to thermal emf problems.

With a resolution as low as 1 mΩ and a maximum available resistance of over 100 MΩ, the PRS-202 Series may be used for exacting precision measurement applications requiring high accuracy, good stability, and low zero resistance. They are suited for automatic and manual calibration and testing, simulation of RTD’S, programmable loads, and many other laboratory and industrial applications.

The PRS Series may be rack mounted to serve as components in measurement and control systems.

Figure 1.1: High Precision Manual or Programmable Decade Resistance Substituter

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PRS SERIES OPERATING GUIDE

CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Resistance Type: Metal film.
Range: 0 to 9,999,999 Ω, in 1 Ω steps.
Accuracy: ±(0.1% + 30 mΩ), after subtraction of zero setting resistance; traceable to NIST.
Zero Resistance: <450 mΩ, <410 mΩ, typical; <560 mΩ if **OC** (Open Circuit) option is present; <20 mΩ, with **SC** (Short Circuit) option activated.
Maximum Load: 0.5 A, or 200 V (dc + peak ac), or 1 W/step, whichever applies first.
Interface: IEEE-488.2-1987,SCPI 1994.0; front panel switch selects **REMOTE** or **LOCAL** operation; "`*IDN`" for S/N, Model & REV; "`CAL:DATe?`" for last calibration date.
Ground: GND terminal on front panel is connected to both chassis and earth ground.
Operation: Unit should be allowed to stabilize for one hour. For maximum stability, allow unit to warm-up over two hours and keep free from mechanical disturbances.

POWER: 105-125 V, 50-60 Hz
FUSE: 0.25 A

MODEL: PRS-201-1W-IEEE.2
SN: G2-XXXXXXX

WARNING

Observe all safety rules when working with high voltages or line voltages. Connect the shield to earth ground in order to maintain the case at a safe voltage. Whenever hazardous voltages (>45 V) are used, take all measures to avoid accidental contact with any live components: a) Use maximum insulation and minimize the use of bare conductors. b) Remove power when adjusting switches. c) Post warning signs and keep personnel safely away.

IET LABS, INC. • Long Island, NY • info@ietlabs.com • (516) 334-5959 • (800) 899-8438
CAGE CODE: 62015 **www.ietlabs.com** PRSBLBL/p27/PRS201-1W-IEEE.2/05-15

FIGURE 2.1 Typical OPERATING GUIDE Affixed to Unit
(Please see label affixed to your unit)

Chapter 3
OPERATION

3.1 Initial inspection and setup

This instrument was tested and carefully inspected before shipment. It should be in proper electrical and mechanical order upon receipt.

An **OPERATING GUIDE** is attached to the case of the instrument to provide ready reference to specifications.

Mount the unit in a standard 19” rack if the rack mount option is specified.

3.2 Connection

3.2.1 General Considerations

The PRS Series Decade unit is built in 3-terminal or 5-terminal versions. The binding posts are standard laboratory type and readily accept banana plugs, telephone tips, spade lugs, alligator clips, and bare wire. Binding posts are located on the front panel of the instrument unless specifically ordered with a Rear Output option.

The 3-terminal version posts are labeled **HI**, **LO**, and **GND**. The **HI** and **LO** terminals are connected to the ends of the internal impedance being set.

5-terminal models provide four Kelvin terminals consisting of a **CURRENT** and a **SENSE** pair, each labeled **HI** and **LO**. These minimize contact resistance.

The **GND** terminal on all models is connected to the case and to earth and chassis grounds. This may be used as a shield terminal.

3.2.2 Electrical Considerations

The performance of the PRS is directly affected by the quality of the connection to the system under test. This is particularly true with the precision series models having higher-accuracy and/or lower-impedance decades.

For optimum performance, contact resistance should be kept to a minimum by using the most substantial mating connection possible, and by assuring that the connection is well secured to the binding posts.

3.2.3 Four-Wire Kelvin Lead Connections

4-wire Kelvin leads minimize the effects of contact resistance and approach ideal performance. The **CURRENT** and **SENSE HI/LO** terminal pairs may be shorted together to provide a 2-terminal connection in instances where high accuracy is not a concern.

3.2.4 Thermal emf Considerations

The PRS Series uses high-quality, low-emf components. Thermal emf is primarily attributable to the temperature difference between the leads of the relay and the contacts when temperature is applied to the coil. This emf is of the order of 5 μV per relay, but is not usually additive. The typical worst case is <15 μV.

If the effect of tens of microvolts is significant to your application, connect to the instrument with low-thermal-emf materials only. Copper wire and copper alloys are recommended; brass and steel should be avoided. Tinned copper and solder are acceptable.

This emf will *not* be reflected if an ac measurement instrument is employed, and can be eliminated by using a meter with "True Ohm" capability. In other cases, the emf may represent a very small component of a dc resistance measurement.

3.3 Dial Setting

Each decade is manually controlled via a front panel thumbwheel that provides positions for "0" through "9". The total impedance is set/read directly from the dial setting. The decimal point, if any, is marked on the thumbwheel switches, and the steps are clearly marked on the panel. Short Circuit / Open Circuit mode control is only available using a Remote control option.

3.4 Environmental Conditions

The PRS is built, calibrated and intended for use in a laboratory environment with a nominal ambient temperature near 23°C. The accuracy of the unit may be affected when operated in non-laboratory environments. Always allow the instrument to stabilize at room temperature after unpacking or relocating the instrument. Humidity should be maintained at laboratory conditions.

3.5 Local Operation

Operation of the PRS substituter is straightforward and graphically represented on the front panel.

1. Turn on the **POWER** switch. The **POWER** indicator lamp, if present, should come on. If a REMOTE option is present, the **READY** and **LOCAL** indicators should illuminate.

2. Set the **REMOTE/LOCAL** switch to **LOCAL**.

3. Connect any desired instrumentation to the front panel binding posts. The **GND** terminal may be connected to the ground of external equipment. The **GND** terminal is connected to the case and to both chassis and earth grounds.

4. Make 4-terminal or 2-terminal connections as described previously. A shielded set of cables is recommended whenever ac operation or high resistance are involved.

5. Set the thumbwheel switches to provide the desired impedance in the units indicated on the front panel.

3.6 Remote Operation

The PRS includes a **REMOTE/LOCAL** switch on the front panel. The **REMOTE** position is a remote *enable*. When in **LOCAL** mode, the PRS supplies the impedance value selected using the front panel thumbwheel switches.

When the switch is in the **REMOTE** position, the PRS will supply the configured remote impedance value *only if* that option asserts remote control. If the option does not assert control, the front panel thumbwheel impedance value is supplied. The **REMOTE** and **LOCAL LEDs** always indicate which interface is controlling the impedance value.

Setting the front panel **REMOTE/LOCAL** switch to LOCAL *overrides* the REMOTE option settings and *always* sets the supplied impedance to the value selected using the front panel thumbwheels, regardless of the REMOTE option's assertion of control.

The REMOTE BCD option sets impedance values and asserts control using TTL logic. The impedance values are BCD encoded as shown in table 4.2.

For IEEE and RS232 units, the **LOCAL** indicator remains on until communication with the unit is initialized. The mode changes to **REMOTE** after controller commands are received.

Chapter 4
ETHERNET INTERFACE OPTION

4.1 Ethernet Programming

PRS units, with Ethernet interface option, come with Ethernet remote programming capability accessed through the RJ45 LAN connector. The connector is a RJ45 industry-standard connector found on the rear panel. The PRS's Ethernet connection is based upon the ICS 8003 LAN to Parallel Interface Card. More information can be found at www.icselect.com on the 8003 Ethernet Card.

4.1.1 Ethernet Protocols

The PRS supports Raw Socket and the VXI-11 protocol which makes it easy to control from a PC or over the company network.

Raw socket lets you telnet to it and is best used with direct PC to instrument applications. VXI-11 operates over Sun RPC and is a more secure protocol that mimics GPIB control of an instrument and provides secure communication over a company network or over the Internet.

4.1.2 Raw Socket Operation

The PRS is always ready for a telnet connection. When connected, the PRS outputs its IDN message to confirm the connection.

All raw socket messages are terminated with a linefeed. Carriage returns and ignored. A backspace character causes the prior character to be deleted. Communication timeout is two minutes and it is recommended that the client issue a Space-BS sequence on an occasional basis, less than the timeout, to reset the timeout counter.

4.1.3 VXI-11 Background

VXI-11 is a communication standard developed in conjunction with the VISA Specification. The specification defines a VXI-11.3 interface like the PRS as an instrument which can be controlled in Windows systems by programs that make VISA or SICL library calls and in UNIX/LINUX or similar operating system with RPC calls. The VXI-11 specification provides an RPCL (Remote Procedure Call Library) that can be used by virtually any operating system to control the PRS. Microsoft's RPC is not ONC compliant and cannot be used with a VXI-11.3 device like the PRS. An VXI-11.3 interface like the PRS will operate in an LXl system and it supports LXI's 'VXI Discovery Method'.

4.2 Network Setup

The PRS includes an internal WebServer with HTML web pages that can be accessed by a web browser from any computer. The web pages let the user quickly change the PRS network settings. The default IP address is 192.168.1.253 static.

4.3 Ethernet Test Keyboard

To assist the user in setup and communication the VXI-11kybd program can be used which includes defined RPC calls to change the PRS network settings. VXI-11 Keyboard Control Program provides interactive control of VXI-11 instruments from the computer keyboard without having to write a program. The VXI-11 Keyboard program is the ideal utility program for configuring and testing the PRS or any VXI-11 compatible instrument. Use the VXI-11kybd program to exercise the interface or to try out commands before using them in a program. The VXI-11kybd program can be found on the PRS product page at www.ietlabs.com

Versatile Programming

The PRS can be easily controlled by several programming techniques and languages because it is a VXI-11.3 instrument. If you program with LabVIEW, National Instruments' VISA supports VXI-11.3 instruments like the PRS. NI's Measurement and Automation Explorer treats the PRS as a TCP/IP compliant device. Agilent's VISA library supports VXI-11.3 instruments and the Agilent Connection Manager sees the PRS as a TCP/IP instrument.

If you are a Visual Basic, VB.Net or C/C++ programmer, you can write your program to call Agilent's or National Instruments' VISA or Agilent's SICL library in the Windows environment.

If you use LINUX or any other flavor of UNIX like SunOS, IBM-AIX, HP-UX, or Apple's OS X, you can communicate with the PRS through RPC over TCP/IP. RPC (or Remote Procedure Calls) provides an invisible communication medium for the developer. The VXI-11 specification provides an RPCL (Remote Procedure Call Library) that can be used by virtually any operating system to control the PRS.

If you program with Java then you can write a PRS control program that can be easily moved to many different operating systems.

The Java jGpibEnet project on SourceForge was developed using an ICS 8065 Controller similar to the PRS Controller.

4.4 Network Configuration

This paragraph configures the 8003 card in the PRS for operation on your network. The board's digital interface is configured later by sending commands as outlined in Appendix A.

When shipped, the boards are configured with default settings outlined in Table 4-1 Default Settings.

Command	Function	Factory Setting
IP Mode	Static or DHCP Mode	Static
IP Address	0.0.0.0 to 255.255.255.255.0	192.168.1.254
Net Mask	0.0.0.0 to 255.255.255.255.0	255.255.255.0
COMM Timeout	Sets socket timeout	120 sec.
Auto Disconnect	Aborts socket if link count goes to 0	Off

Table 4-1 Default Settings

Review the Table with your network administrator and decide on which settings, if any, that need to be changed. Table 4-1 provides detailed information about each network setting to help you with your decisions. The minimum change is to set a static IP address so your PC can communicate with the board.

The network configuration can be changed and the board's MAC Address can be read with a web browser, by running ICS's VXI-11 Confi guration Utility on a WIN32 or WIN98 PC. ,

4.5 Web Browser Configuration Method

This method uses a standard browser such as Firefox, Internet Explorer or Safari to view and change the current network settings.

1. Temporarily disconnect the computer from the company network. Connect the PRS and computer running the browser using a standard Ethernet Cables to a hub or switch. Temporarily disconnect the local network connection to avoid network conflicts until the board is configured.

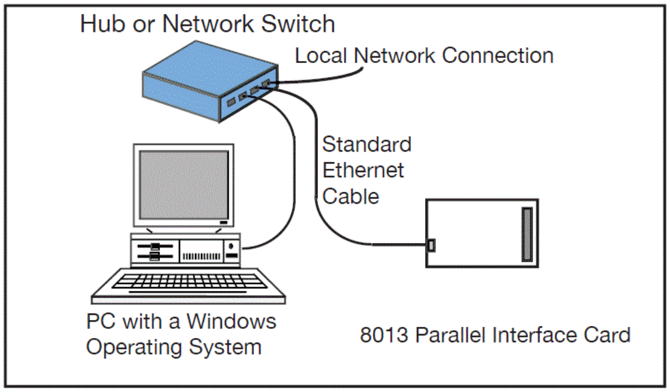

Figure 4-1 8003 Connected to the local hub

An alternate connection is to use an Ethernet Crossover Cable to connect the computer directly to the PRS for initial configuration. This will eliminate any potential network conflicts while configuring the PRS.

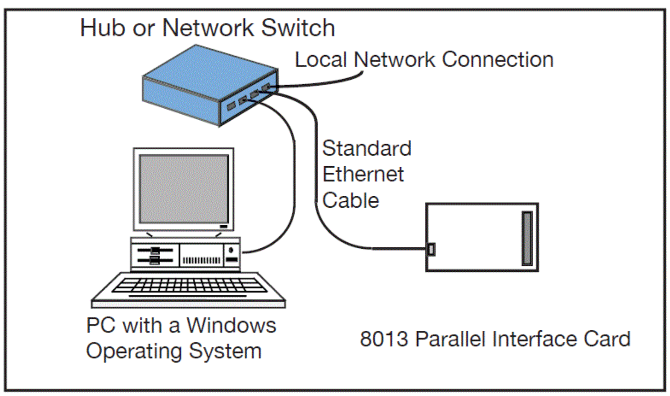

Figure 4-2 8003 Connected to the local hub

2. Apply power to the PRS. Set the Remote local switch to Remote.

3. Check your computer's network settings to be sure its IP address is in the 192.168.1.xxx range so it can communicate with the PRS Ethernet board's default IP address. If it is not, it must be set before proceeding. Use the values shown below. For Windows PCs, right-click on My Network Places and click on Properties. Right-click on Local Area Connection and click Properties. Highlight Internet Protocol (TCP/IP) and click Properties. If your PC's IP address is in a different range, record the current settings and temporarily set the following network values:

Check 'Use the following IP Address'
IP Address 192.168.1.254
Subnet mask 255.255.255.0

4. Open the browser and enter the default IP address of 192.168.1.254 for new units (or your last set address for older units) in the browser address window.

5. A Welcome Page similar to the one shown Figure 4-3 should appear in your browser.

6. If you want to change any of the settings, press the 'Update Configuration' button. A Configuration Page similar to the one shown in Figure 4-4 should appear in your browser.

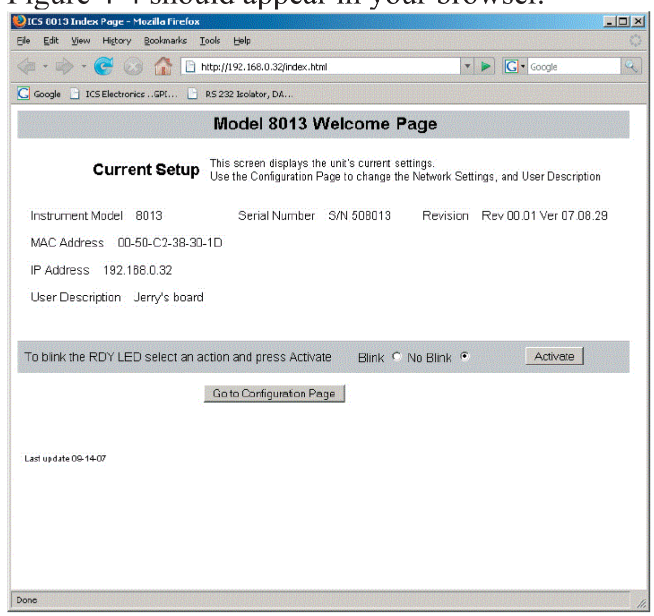

Figure 4-3 8003 Welcome Page

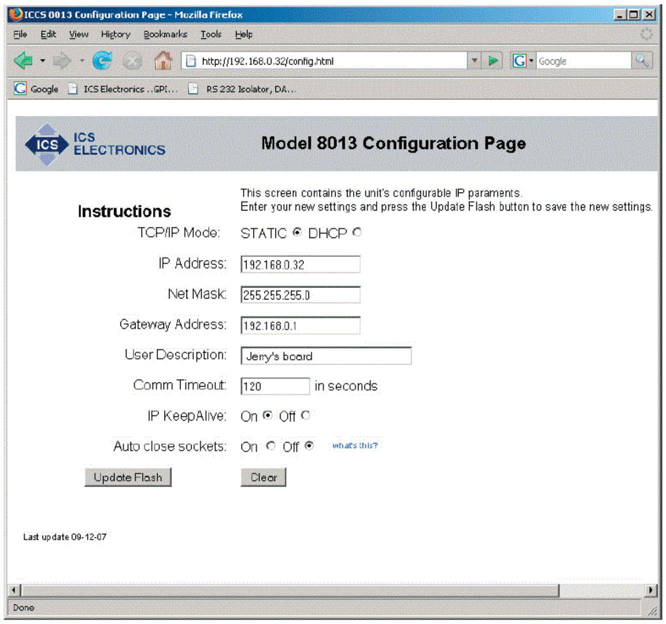

Figure 4-4 8003 Configuration Page

7. Enter the new settings as desired. If you select DHCP for the TCP/IP Mode, the page blanks out the IP, Net and Gateway addresses as they will be supplied by your DHCP server. Check the entered values carefully as the unit's webserver does minimal error checking. Press the 'Update Flash' button when done. A Confirmation Page similar to the one shown in Figure 4-5 will appear in your browser.

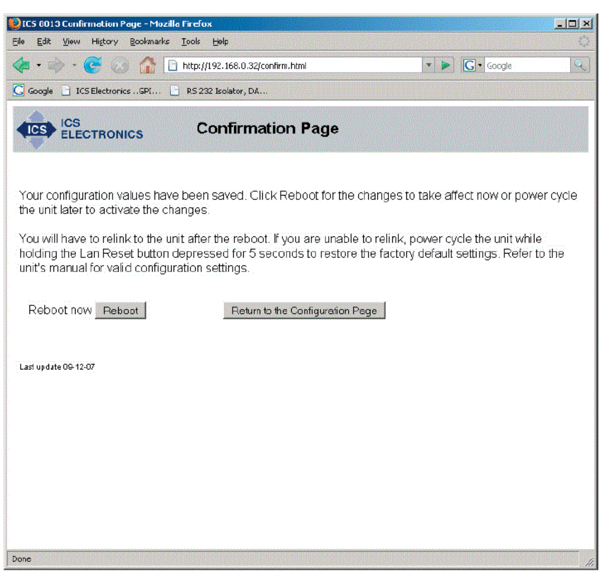

Figure 4-5 8003 Confirmation Page

8. Your new settings have been saved in the board's fl ash memory. You have to reboot the unit or power cycle it for the changes to take affect. Press the 'Reboot' button to reboot the unit now or the 'Return to the Configuration Page' button to revisit the new settings.

4.6 VXI-11 Configuration Utility Method

The VXI-11 Configuration Utility program is called 'VXI11_config.exe' and runs in any WIN32 PC with Windows 98, Me, 2K, XP, Vista, 7 and Server 2003 operating systems. The VXI11_config.exe program can be found on the PRS product page at www.ietlabs.com.

The VXI11_config program can be run from the CD or can be installed onto your hard disk and run from the installation directory.

VXI11_config.exe is a Visual Basic program and requires that either Microsoft's Visual Studio 6 or VBruntime6 be installed on your PC to run.

1. Connect the board directly to the WIN32 PC that will be running the Configuration Utility. Disconnect the PC from the company network and use the supplied Ethernet Crossover Cable to connect the PC to the board as shown in Figure 4-6. This will eliminate any potential network conflicts while configuring the board.

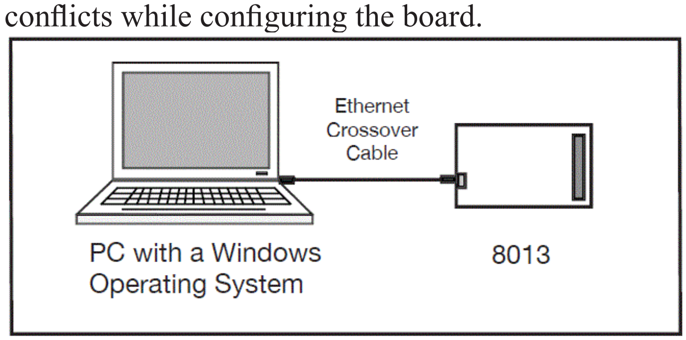

Figure 4-6 8003 Connected to PC with a Crossover Cable

Alternately, use a standard Ethernet patch cable to connect the 8003 to the same hub or switch that the PC running the Configuration Utility is connected to as shown in Figure 4-7. Temporarily disconnect the local network connection to avoid network conflicts until the board is configured.

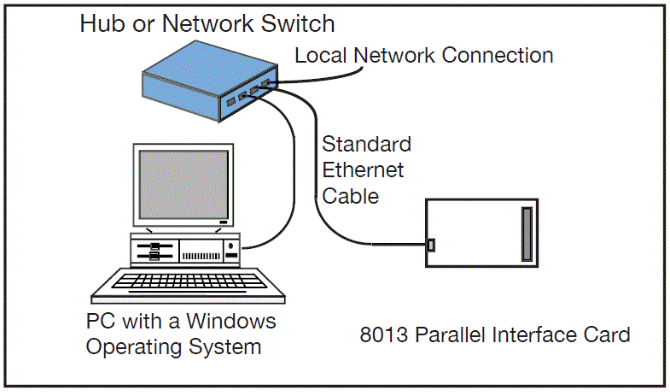

Figure 4-7 8013 Connected to the local hub

2. Apply power to the board

3. Check your PC's network settings to be sure its IP address is in the 192.168.1.xxx range so it can communicate with the board's default IP address. To check, right-click on My Network Places and click on Properties. Right-click on Local Area Connection and click Properties. Highlight Internet Protocol (TCP/IP) and click Properties. If your PC's IP address is in a different range, record the current settings and temporarily set the following network values:

Check 'Use the following IP Address'
IP Address 192.168.1.254
Subnet mask 255.255.255.0

4. Run the VXI11_config program. The Configuration Utility opens a window as shown in Figure 4-8. Initially only the Find Server, Help and Exit buttons are enabled on the program window. The other buttons will be enabled as you advance through the program.

5. Click on the Find Server button. The program scans for all VXI-11 Services connected to the local LAN or to your PC. (The 8003 is an RPC server which provide a VXI-11 Service) The results are displayed in the Results box.

6. When the servers(s) have been found, use the pulldown arrow in the Found Servers box to view the Found Server addresses. The board's default address is 192.168.1.254. Highlight the board's IP address and click the Create Link button. If the server is not found, you can enter the default IP address (192.168.1.254) in the Found Servers box. Click the Create Link button.

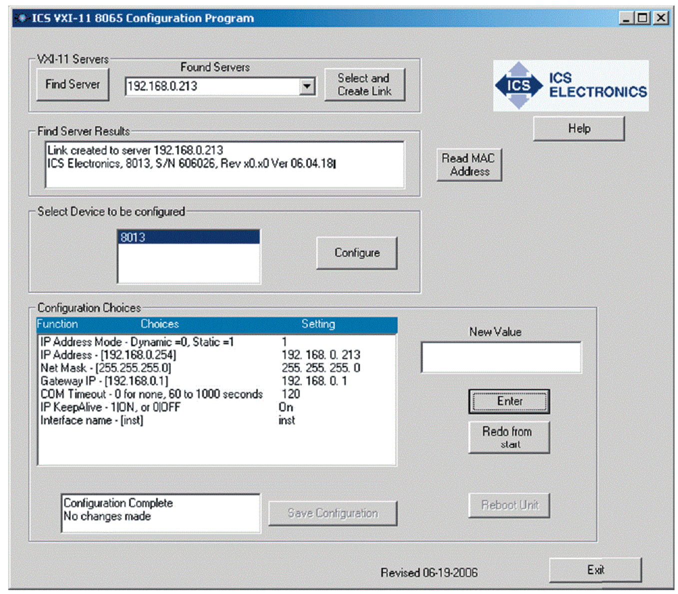

Figure 4-8 VXI-11 Configuration Utility (Showing all configuration choices with no changes)

7. When the link has been created, device model number(s) will appear in the 'Select Device to be Configured' box. Highlight the desired model number and click the Configure button to start the configuration process.

8. The Configuration Choices box displays only one line with the first parameter to be changed and its current setting. If you like the current setting, click Enter to advance to the next

parameter. If you want to change the setting, type a new value in the New Value box and click Enter. The program will send your setting to the board and read back the new setting. Repeat as needed to make another change or click Enter again to advance to the next parameter.

9. Repeat step 8 for each configuration parameter. Figure 4-8 shows the VXI-11 Configuration Utility after all parameters have been entered for a Model 8003. Click the Redo From Start button if you need to start over or if you want to change any of the prior settings

10. When done, the Save Configuration button is enabled if you changed any settings. Click the Save Configuration button to save the values in the board's flash memory. If you did not make any changes you can just exit the program.

11. The board has to be power cycled or rebooted before the configuration changes take affect. Click the Reboot button to reboot the board and use the new settings.

12. Press the Exit button to quit the VXI11_confi g program.

13. If the IP address was changed to an address outside the 192.168.1.xxx range in step 3, your PC's network settings will have to be changed to communicate with the board. Exit the VXI11_ config program and restore the PC's network settings.

4.7 Resetting Default Network Settings

The board can be reset to the default network settings listed in Table 4-2 at any time by holding the LAN Reset Button in for 5 seconds while applying power to the board. To accomplish this the top cover of the PRS must be removed to gain access to the 8003 Ethernet Board. The Digital I/O configuration values are not affected by the LAN Reset operation.

Command	Function	Factory Setting
IP Mode	Static or DHCP Mode	Static
IP Address	0.0.0.0 to 255.255.255.255.0	192.168.0.2
Net Mask	0.0.0.0 to 255.255.255.255.0	255.255.255.0
COMM Timeout	Sets socket timeout	120 sec.
Auto Disconnect	Aborts socket if link count goes to 0	Off

Table 4-2 Default Settings

4.8 PRS Programming

A PRS SCPI command reference is included in Appendix A. This gives a complete set of commands.

An example of commands to be sent to place the PRS in remote, this must be done first otherwise the will be no remote control of output impedance, and then configure the unit for a specific impedance value.

Where the command string is constructed as described in Chapter 7.

A command string might be, for example:

CONFigure:REMote 1
SOURce:DATA 0000564120

Chapter 5
IEEE INTERFACE OPTION

5.1 Introduction

The IEEE interface option makes the PRS-200 a IEEE-488.2-1987 and SCPI 1994.0 compatible instrument.

The IEEE STD 488.2 covers the electrical and mechanical bus specifications, and state diagrams for each GPIB bus function. It also establishes data formats, common commands for each 488.2 device and controller protocols. The standard is available on-line at http://www.ieee.org.

The SCPI standard provides a tree like series of standard commands for programmable instruments so that similar instruments by different manufacturers can be controlled by the same program. SCPI information and a command reference are located in Appendix A.

Other tutorials are available on-line; consult IET for additional information. A software GPIB "keyboard" may be requested from IET to perform elementary commands for training and testing. See Section 5.5.

Figure 5-1: Bus Address Switch

Decimal Address	SWITCH SETTINGS 5-4-3-2-1	Decimal Address	SWITCH SETTINGS 5-4-3-2-1
0	0-0-0-0-0	16	1-0-0-0-0
1	0-0-0-0-1	17	1-0-0-0-1
2	0-0-0-1-0	18	1-0-0-1-0
3	0-0-0-1-1	19	1-0-0-1-1
4	0-0-1-0-0	20	1-0-1-0-0
5	0-0-1-0-1	21	1-0-1-0-1
6	0-0-1-1-0	22	1-0-1-1-0
7	0-0-1-1-1	23	1-0-1-1-1
8	0-1-0-0-0	24	1-1-0-0-0
9	0-1-0-0-1	25	1-1-0-1-0
10	0-1-0-1-0	26	1-1-0-1-0
11	0-1-0-1-1	27	1-1-0-1-1
12	0-1-1-0-0	28	1-1-1-0-0
13	0-1-1-0-1	29	1-1-1-0-1
14	0-1-1-1-0	30	1-1-1-1-0
15	0-1-1-1-1	31	Reserved, do not use

Table 5.1 IEEE Bus Address Settings

5.2 Capabilities

The IEEE option provides remote control over all functions except **POWER**.

5.3 Address Switch and Communications Settings

Each GPIB bus device is identified by a five-bit binary address. There are 32 possible primary addresses 0 through 31; addresses 0 and 31 are reserved . The PRS **BUS ADDRESS** switch shown in Figure 5-1 establishes the GPIB address of the unit. Bus address settings are read at power up. Refer to table 5.1.

The T-L-S positions on the **BUS ADDRESS** switch are not used and should remain in the "OFF" position.

5.4 IEEE Option Operation

The IEEE controller asserts the remote mode upon receipt of a valid command. The **REMOTE** LED will light and impedance settings will be controlled through the IEEE interface if the **REMOTE/LOCAL** switch is in the **REMOTE** position. Remote control may be dropped by issuing an IEEE GTL command. Dropping remote sets the PRS output to the value set on the front thumbwheel switches. See Chapter 3 for information about **REMOTE/LOCAL** functionality.

5.5 GPIB Test Keyboard

To aid the user in operating the PRS, a GPIB "Keyboard" Controller program - the easiest way to control GPIB devices without writing a program - is available from IET. This GPIB Keyboard program automatically finds your device at start-up and it lets you enter just the data that you want to send to the device. This program works with ICS, Measurement Computing and National Instruments controllers.

To implement, request a download of **ICS_GPIBkybd_Install.zip** from IET Labs Tech Support.

Unzip the file and follow instructions to install.

Open the application. You may use the **Find Listeners** button to confirm that the PRS unit is recognized. Other instruments may also be recognized at this time.

Enter and set the **Address** to the PRS address. Use the window to send a **command string** to the PRS,

where the command string is constructed as described in Chapter 7. A command string might be, for example:

```
SOURce:DATA resistance string
```

Chapter 6
SERIAL INTERFACE OPTION

6.1 Introduction

The SERIAL option adds RS-232C and SCPI 1994.0 capability to the PRS series instruments. The SCPI standard provides a tree like series of standard commands for programmable instruments so that similar instruments by different manufacturers can be controlled by the same program. A PRS SCPI command reference is included in Appendix A.

Tutorials are available on-line; consult IET for additional information. A software Serial "keyboard" may be requested from IET to perform elementary commands for training and testing. See Section 6.5.

6.2 Capabilities

The SERIAL option provides remote control over all functions except **POWER**.

6.3 Signal Interface and Communications Settings

A 25 pin male DTE interface connector conforming with EIA-STD-RS-530 is located on the rear-panel. The default communications parameters are:

Parameter	Default	Range/Choices
Baud	9600	300 - 115,200
Data Bits	8	7 or 8
Stop Bits	1	1 or 2
Parity	None	Odd, Even, None

Connection of a PC to the PRS SERIAL option is typically made through a simple null-modem or "LapLink" cable.

IET Direction

Pin	RS232	Signal Name	In / Out
1	AA	Chassis	n/a
2	BA	Send Data	⇨
3	BB	Receive Data	⇦
4	CA	Request to Send	⇨
5	CB	Clear to Send	⇦
8	CF	Signal Detected	⇦
20	CD	Data Terminal Rdy	⇨

6.4 SERIAL Option Operation

The SERIAL option uses the same command set as the IEEE option. Additional commands exist for configuring the serial interface. Changes to the serial UART take place at power-on or after a reset.

SCPI command strings must be followed by a <CR> to terminate the message. Every command returns a response that includes a message terminator. The program/operator should wait for this message terminator before sending additional commands.

Command characters are not echoed to the interface on power up. Send <CTRL-E> to force the controller to echo commands back to the interface or <CTRL-F> to disable echo.

By default, the controller returns ">" and <LF> as a prompt after executing any command. When echo is turned 'On', the controller returns <CR><LF> and ">"as a prompt after executing any command.

Echo-back Mode	**RS232 Prompt**	**Message Terminator**
On	CR LF >	CR LF
Off	>LF	LF

6.5 Serial Test Keyboard

To aid the user in operating the PRS, a Serial “Keyboard” Controller program - the easiest way to control serial devices without writing a program - is available from IET. This Serial Keyboard program automatically finds your device at start-up and it lets you enter just the data that you want to send to the device. This program works with ICS, Measurement Computing and National Instruments controllers.

To implement, request a download of: **ICS_Serkybd_Install.zip,** from IET Labs Tech Support

Unzip the file and follow instructions to install.

Open the application. Initialize the COM PORT and use the Device Command window to send a **command string** to the PRS, where the command string is constructed as described in Chapter 7. A command string might be, for example:

`SOURce:DATA resistance string`

Chapter 7
PROGRAMMING

7.1 Introduction

PRS-200 units equipped with IEEE or SERIAL options implement a consistent SCPI interface. A SCPI command reference is included in Appendix A.

7.2 Command String Structure

Output is controlled in the form of a single SCPI command followed by a space and a 10 character **Resistance String.** Each character in the string represents the value of one decade, equivalent to one possible manual thumbwheel switch on the front of the unit.

This **Resistance String** is constructed as:

- **The number is in units of 0.1 Ω.**
- **All 10 characters must be provided; the active characters are the ones that match the front panel thumbwheel decades.**
- **The decade values are straight-reading, from left to right. All preceding and trailing zeros must be included to complete 10 characters; any other characters in those spaces will be ignored.**
- **A decimal point may not be included.**

The **Resistance String** has a minimum resolution of 0.1 Ω with this decade assigned to the right-most character in the string. To create the SCPI command:

- **Multiply the desired value, in ohms, by 10**
- **Convert the integer portion of the value to a string,**
- **Pre-pend 0's to create a 10 character Resistance String**
- **Combine with the "SOURce:DATA " command.**

For example:

Value	Command
600,567.9 Ω	`SOURce:DATA 0006005679`
2,700,000 Ω	`SOURce:DATA 0027000000`

Values sent for decades not implemented in the PRS are ignored. Setting a PRS with 4 decades and a minimum resolution of 1,000.0 Ω to 10,600,567.9 would result in an actual value of 600,000 Ω. For example:

Command	Value
`SOURce:DATA 0106005679`	600,000 Ω

Optional **Open Circuit (OC)** and **Short Circuit (SC)** are implemented as standard decades positioned at the Most Significant Decade plus one. For example, the **Resistance String** for the Open circuit and Short circuit modes for a unit with a total of 7 decades are:

Open circuit	`SOURce:DATA 001XXXXXXX`
Short circuit	`SOURce:DATA 002XXXXXXX`

(where X = any Resistance String)

OC and **SC** modes may be used to create a "controlled transition" between two values without concern for transitional switching of the relays.

- **Output command for R1.**
- **Output command for R1 plus a SC Mode Character.**
- **Output command for R2 plus a SC Mode Character.**
- **Output command for R2.**

This technique also applies to the Open circuit mode.

OC/SC mode Character =

0, 4, 8, or absent for NORMAL operation
1, 5, or 9 for OPEN CIRCUIT operation *-optional*
2, 3, 6, or 7 for SHORT CIRCUIT operation *-optional*

7.3 Advanced Programming - Software Drivers

Basic control of a PRS can be automated by writing a function that accepts a numeric value and converts it to the string using the method described previously.

If the PRS is to be used in an automated environment where various models and options may be installed or where interchangeability is a requirement, a *driver* can be written that abstracts the device specific functions from the test sequence.

The PRS family of instruments are available in many models (including inductance, resistance and capacitance) ranges, (1milliOhm to 10MegaOhm) and with various options. Information to create a more robust driver to control a PRS instrument is listed below.

7.3.1 Determining the PRS Configuration

The IEEE 488.2 specification defines the *IDN string as containing 4 sections separated by commas; the manufacturer, the model, the serial number and the revision of the instrument.

The Model section of the *IDN string of the PRS has been encoded to provide information about the characteristics of the specific instrument being used. For example, a *IDN query to a PRS might return:

```
    IET Labs, PRS-200-F-6-100m-0-0,
D6-0211201, D6
```

In our example above, the Manufacturer section contains “IET Labs”, the Model section contains “PRS-200-F-6-100m-0-0”, the Serial Number section “D6-0211201” and the Revision section “D6”. The model is split into 7 parts with dashes to identify:

Type
Version
Tolerance
Number of Decades
Least Significant Decade
Slot of LSD
Options

Type:

PRS	Resistance Substituter

Version:

200
201
202

Tolerance:

X:	0.01%
Q:	0.02%
A:	0.05%
B:	0.1%
C:	0.5%
F:	1%
G:	2%
H:	4%

LSD:

1m	1 milliOhm
10m	10 milliOhm
100m	100 milliOhm
1	1 Ohm
10	10 Ohm
100	100 Ohm
1K	1 KOhm
10K	10 KOhm
100K	100 KOhm
1M	1 MegaOhm
10M	10 MegaOhm

Note: micro and Mega Ohms use the same suffix letter; case indicates magnitude.

Open Cicuit / Short Circuit Option:

0	not equipped
1	Open Circuit option present
2	Short Circuit option present
3	Both OC/SC present

7.3.2 Instrument Initialization

Reset the unit to power up defaults using *RST

Check that the instrument is "in cal" by reading the calibration date and compare it to current date/time using CALibrate:DATe?

Read the IDN string from the PRS

Parse the IDN string to extract the IDN String Model (second) section. Parse this further to determine:

let iType= type of device (R,L,C,RTD; enum 0-3)
let iModel = model (200,201,202; enum 0-2)
let iTol = tolerance (see section 7.3.1; enum 0-10)
let iDec = value of "Number of Decades"
let nMin = numeric value of LSD (see section 7.3.1)
let locLSD = location of the LSD on system board
let iOption = options installed (see section 7.3.1)
let iMax =(iMin*10**nDec)

Calculate iMax. In our example, the LSD is 100m or 0.1 Ohms and the number of decades is 6

iMax =(0.1*10**6)-iMin ; or iMax = 99,999.9

7.3.3 Source Impedance

Range test the desired output value against iMin and iMax. Coerce the supplied value to the max or min, return an error code, or use optionally equipped OC/SC features per your needs.

Example 1:
let iModel = 0 (model 200/201 system board)
let iValue equal 123.51
iValue is < 99,999.9 and > 0.1;
therefore iValue = 123.51

Example 2:
let iModel = 1 (model 202 system board)
let iValue equal 1,000,000
iValue is > 99,999.9;
if iOption = 1 or 3 then iValue = 100,000.0
else iValue = 99,999.9

Multiply iValue by one over iMin to shift the digits below the operating range of the PRS to the right of the decimal point (in this case, 10). Select the integer portion of iValue

Example 1:
iValue=iValue*(1/iMin)
iValue=123.51*(1/.1); or iValue = 1235.1
iValint=int(iValue); or iValint = 1235

Example 2:
iValue=iValue*(1/iMin)
iValue=100,000*(1/.1); or iValue= 1,000,000.0
iValint = int(iValue); or iValint = 1000000

Shift this value to align it with the location of the first decade in the PRS. locLSD from our IDN string evaluation is 1, so:

Example 1:
iValint = iValint * (1*10^(locLSD))
iValint = 1235 * (1*10^(0))
iValint = 1235 * 1; or iValue = 1235

Example 2:
iValint = iValint * (1*10^(locLSD))
iValint = 1000000 * (1*10^(0))
iValint = 1000000 * 1; or iValue = 1000000

Convert the number to a string value using a “format” function that includes leading zeros. A 200/201 series unit has 10 decade locations, a 202 has 12.

prsCmd = “SOURce:DATA ” _
& format(iValue,“0000000000”)

Example 1:
“SOURce:DATA 0000001235”

Example 2:
“SOURce:DATA 000001000000”

Send the prsCmd string to the PRS.

Chapter 8
MAINTENANCE

8.1 Verification of Performance

8.1.1 Calibration Interval

The PRS Series instruments should be verified for performance at a calibration interval of twelve (12) months. This procedure may be carried out by the user, if a calibration capability is available, by IET Labs, or by a certified calibration laboratory. If the user should choose to perform this procedure, then the considerations below should be observed.

8.1.2 General Considerations

It is important, whenever testing the PRS Series Decade units, to be very aware of the capabilities and limitations of the test instruments used. Such instruments have to be significantly more accurate than the specified accuracy for all applicable ranges in order to perform this task, allowing for a band of uncertainty of the instrument itself, the test setup and the environment; consult IET Labs for information.

It is important to allow both the testing instrument and the PRS Substituter to stabilize for a number of hours at the nominal operating temperature of 23^0C, and at nominal laboratory conditions of humidity. There should be no temperature gradients across the unit under test.

In the case of a resistance substituter, substantial Kelvin type 4-wire test terminals should be used to obtain accurate low-resistance readings. It is convenient, once the zero-resistance has been determined, to subtract it from the remaining measurements. This can be done automatically in many instruments which have an offset subtraction capability.

Steps should be taken to minimize thermal-emf effects, by maintaining an even temperature and by using only low-emf connectors. Use of meters with a “True Ohm” function is recommended.

Proper metrology practices should be followed in performing this verification.

Appendix A
SCPI COMMAND REFERENCE

SCPI is an acronym for “Standard Commands for Programmable Instruments”. For additional information or an on-line copy of this standard, see:

http://www.scpiconsortium.org.

The IEEE 488.2 Standard was established in 1987 to standardize message protocols and status reporting and to define a set of common commands for use on the IEEE 488 bus. IEEE 488.2 devices are supposed to receive messages in a more flexible manner than they send. A message sent from GPIB controller to GPIB device is called: PROGRAM MESSAGE. A message sent from device to controller is called: RESPONSE MESSAGE. As part of the protocol standardization the following rules were generated:

(;) Semicolons separate messages.
(:) Colons separate command words.
(,) Commas separate data fields.
<nl> Line feed and/or EOI as last character terminates a ‘program message’.
Line feed (ASCII 10) and EOI terminates a RESPONSE MESSAGE.
(*) Asterisk defines a 488.2 common command.
(?) Ends a query where a reply is expected.

SCPI builds on the programming syntax of IEEE-488.2 to give the programmer the capability of handling a wide variety of instrument functions in a common manner. This gives all instruments a common “look and feel”. SCPI commands are not case-sensitive.

The portion of commands shown in capitals denotes the abbreviated form of the keyword. Either the abbreviated or whole keyword may be used when entering a complete command. There must be a space between the command and a parameter or channel list. Multiple SCPI commands may be concatenated together as a compound command by using semicolons as command separators.

Keywords shown inside braces [ ] are defaults, and are optional when constructing a PROGRAM MESSAGE.

Commands not recognized have no effect on the unit's operation and will set the corresponding bits in the Standard Event Status Register. SCPI commands that end with a question mark '?' are queries. All queries should be followed by reading their response to avoid data loss.

Keyword Commands	Parameter Form	Notes & Short Form
SYSTem		**System Address**
:COMMunicate		
:GPIB		*IEEE option only*
:MODE	SINGle | DUAL | SECondary	
:SERial		*SERIAL option only*
:EXTernal	0|1 or OFF|ON [0]	
:BAUD	<numeric value> [9600]	
:PARity	EVEN | ODD | [NONE]	
:BITS	7 | [8]	
:SBITs	[1] | 2	
:NETwork	0|1 or OFF|ON [0]	
:ADDRess	0-15 [4]	
:UPdate	no value-command only	
:RS485	0|1 or OFF|ON [0]	
:ERRor?	(0, "No error")	
:VERSion?	(1994.0)	
SOURce		**Port Output**
[:DIGital]		
:DATA		
[:VALue]	Serial and Ethernet 10 digits representing the possible decade values	PO
	GPIB 12 digits representing the possible decade values	PO
CALibrate		**Calibrate**
:DATe?	mm-dd-yyyy	
CONFigure		**Configure Strings**
:REMote	0 | 1 [0]	R

Appendix B
IEEE-488.2 COMMON COMMANDS

The PRS Series is compliant with the complete command set defined in the IEEE-488.2 specification. As an output device, the required input related commands such as SRQ and TRG are implemented in the controller but have no affect on the operation of the instrument.

COMMAND	NAME	DESCRIPTION
* CLS	Clear Status	Clears all event registers summarized in the status byte, except for “Message Available,” which is cleared only if *CLS is the first message in the command line.
*ESR?	Event Status Register Query	PRS returns the <value> of the “Event Status Register” and then clears it. <value> is an integer whose binary equivalent corresponds to the state (1 or 0) of bits in the register. Reading of this register resets the contents to zero.
*IDN?	Identification Query	Returns its identification code as four fields separated by commas. These fields are: manufacturer, model, serial number and hardware version.
*RST	Reset	Restores the PRS to power-up state; state of IEEE interface is unchanged, including: instrument address and Status Byte. Allow the REMOTE option 150 ms to complete command.
*SAV <value>	Save	Saves current configuration in the Flash. *SAV 0 saves the current setting as the new power on setting.
*STB?	Read Status Byte	Returns the value of the “Status Byte” with bit six as the “Master Summary” bit. The value is an integer whose binary equivalent corresponds to the state of bits in the register.

*ESR? bits:

Bit	Description
7	Power On
6	User Request
5	Command Error
4	Execution Error
3	Dev. Dep. Error
2	Query Error
1	Request Control
0	Operation Complete