PRS-200 SERIES

High Precision
Manual or Programmable
Decade Resistance Substituters

Operation Manual

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PRS200 im/July2005

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⚡ 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 qulified 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.

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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 parallel BCD, 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.
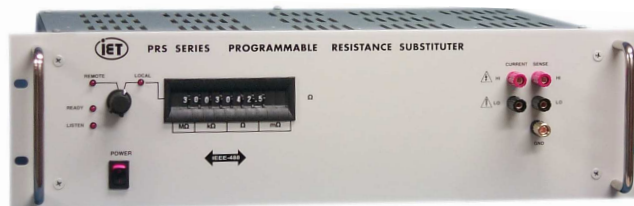

Figure 1.1: High Precision Manual or Programmable Decade Resistance Substituter

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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.
Zero Resistance: <450 mΩ.
Maximum Load: 0.5 A, or 200 V (dc + peak ac), or 0.2 W/step, or 2 W max., whichever applies first.
Interface: IEEE-488-1978.
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-IEEE
SN: D13-9931347

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.

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CAGE CODE: 62015
PRSBLBL/pc/p8/PRS201IEEE/04-22-99;13

FIGURE 2.1 Typical OPERATING GUIDE Affixed to 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.

PRS-202 IEEE.2/05-12-05

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

BCD INTERFACE OPTION

4.1 BCD Programming

PRS units, with BCD interface option, come with a BCD (**B**inary **C**oded **D**ecimal, 1-2-4-8 coding) remote programming capability accessed through the **BCD INPUT** connector

The connector is a 50-pin, female, parallel-interface industry-standard connector found on the rear panel. Table 4.1 shows the connector pin numbering . Table 4.2 gives the pin assignments for the BCD input for this connector. There can be as many as 10 digits to be input. For any unit with fewer than 10 digits, only the implemented subset of these will be operational. All other digits may be ignored, and the associated pins may be left open or shorted to ground.

Once the unit is switched to **REMOTE** with the front panel knob, it may be set to either **LOCAL** or **RE-MOTE** states under external control by properly selecting pins 21 and 22 on the **BCD INPUT** rear panel

connector as shown in Table 4.1. Note that both pins must be set. The **REMOTE** and **LOCAL** led's will respond accordingly. Once the PRS is set to **Re-mote**, the thumbwheel switches become disabled, and impedance control is transferred to the rear panel connector.

In addition, two special optional function pins are provided to set the unit to Open-circuit or (optional) Short-circuit states across the **HI** and **LO** terminals on the front panel. Applying a low to pin 34 activates an open circuit condition. If the short circuit option is present (this option provides a lower resistance short circuit than a zero setting), applying a high to pin 35 provides a short circuit. If these functions are not required, these two pins may be left open, or the opposite logic levels may be applied, i.e. high to pin 34 and low to pin 35. If both pins are activated, the system will be in the short-circuit mode. If the short-circuit option is not present, pin 20 may be left in any state.

25	24	…………….	2	1
50	49	…………….	27	26

(Viewed from rear of instrument)

Table 4.1 BCD INPUT Connector

Pin No.	BCD Code Weight	Function	Description		
30	1				
31	2				
32	4		0.01-0.09Ω		
33	8				
43	1				
42	2				
41	4		0.1-0.9 Ω		
40	8				
39	1				
38	2				
37	4		1-9 Ω		
36	8				
47	1				
46	2				
45	4		10-90 Ω		
44	8				
4	1				
3	2				
2	4		100-900 Ω		
1	8				
8	1				
7	2				
6	4		1-9 kΩ		
5	8				
12	1				
11	2				
10	4		10-9O kΩ		
9	8				
16	1				
15	2				
14	4		100-900 kΩ		
13	8				
20	1				
19	2				
18	4		1-9 M Ω		
17	8				
29	1				
28	2				
27	4		10-90 M Ω		
26	8				
34		Open-circuit control	Low to activate; otherwise high or open.		
35		Short-circuit control (optional)	High to activate; otherwise low or open; If option is absent, pin may be in any state.		
23		Earth ground			
24		+5V, l0 mA maximum			
25		Earth ground			
21		LOCAL/REMOTE select	High for LOCAL; Low for REMOTE		
22		LOCAL/REMOTE select	Low for LOCAL; High for REMOTE		
48		Reserved for IEEE-488			
49		Reserved for IEEE-488			
50		Reserved for IEEE-488			

Table 4.2 BCD INPUT Connector Pin Assignments

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Chapter 5

IEEE-488 PROGRAMMING

5.1 Introduction

The IEEE-488 Interface converts the PRS-200 Series Programmable Impedance Substituter into an instrument compatible with the standard IEEE-488-1978 interface bus. This capability allows the PRS-200 instrument to becomes part of a fully automated instrumentation system.

If necessary, it is strongly recommended that the user refer to documentation for background on the operation of this interface. In particular, the standard is available on-line at http://www.ieee.org or by contacting the IEEE at:

> IEEE Corporate Office
> 3 Park Avenue, 17th Floor
> New York, New York
> 10016-5997 U.S.A.
> Tel: +1 212 419 7900

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 4.5.1

5.2 Capabilities

The IEEE-488 interface provides remote control over all of the front panel functions except for the **POWER** switch. Table 4.1 lists the particular IEEE-488 capabilities implemented in this unit.

5.3 Address Switch Settings

The **BUS ADDRESS** DIP (dual in-line package) switch on the rear panel of the unit establishes the automatic address mode of the unit. These settings are read and saved only during power up. Changing these settings during operation will have no effect unless power is momentarily turned off.

For AUTO ADDRESSING, select an unused bus address between 0 and 30 decimal. Set the **BUS ADDRESS** for the desired address as described below. Set the switch actuators or rockers to the ON or OFF positions on the body of the switch to correspond respectively to logical "1" and a logical "0". To pro-

Table 5.1 IEEE-488 Bus Functions

Code	Description	Comments
SR0	Source Handshake	Not implemented
AHI	Acceptor Handshake	Included
RL1	Remote, Local	Included
SR0	Service Request	Not implemented
T0	Talker	Not implemented
TE0	Extended Talker	Not implemented
LI	Listener	Included
LE0	Extended Listener	Not implemented
PP0	Parallel Poll	Not implemented
DC1	Device Clear	Included
DT0	Device Trigger	Not implemented
C0	Controller	Not implemented

Table 5.2   Bus Address Switch Settings

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

gram the PRS-200 to the desired address, set switches "1" through "5" as shown in Table 5.2. Follow the switch legend imprinted on the rear panel and *not* on the body of the switch, if any.

The **T**, **L**, and **S** switches for **TALK ONLY**, **LISTEN ONLY**, and **SRQ ENABLE** respectively, are not implemented on this unit and must remain OFF at all times.

5.3.1   Bus Set-Up Procedure

1. Turn off the **POWER** switch.
2. Set the **BUS ADDRESS** switch as described above.
3. Turn on the **POWER** switch. This allows the unit to read the status of the rear panel **BUS ADDRESS** switch settings. They can only be read at turn on, so if they need to be changed, the unit must be reinitialized by being momentarily turned off.
4. The **READY** indicator lamp on the front panel should come on with turn on.

5.4 Controlling the Programmable Impedance Substituter

5.4.1 Preparation

After performing any necessary initialization related to the controller in the system, proceed as follows:

1. Set the PRS-200 unit to **LISTEN** using its preset address. The LISTEN indicator lamp on the front panel should come on.
2. Set the PRS-200 to **REMOTE** using its preset address. The **REMOTE** indicator lamp on the front panel should come on.
3. Output a command string as described below.

5.4.2   Command String Structure

The command string to the PRS-200 unit is in the form of an (n+1) character string where n is the number of decades on the front panel thumbwheel switches. This number is constructed as the following concatenation:

|Mode Command Digit | n character Impedance Command|

The Mode Command Digit is required only whenever it is desired to activate the optional OPEN CIRCUIT or SHORT CIRCUIT modes; otherwise it is not required.

For a device having neither option, the least significant characters up to a maximum of n are read as a command; the Mode Command Digit or any other additional characters to the 'left' or on the most significant end of the string are ignored by the device.

Whenever there are leading zeroes in the command, the command string in all cases can be shorter than n.

Mode Command Digit =
   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*
   X or absent for units without either option

Impedance Command =

    1 to n characters (0-9) for impedance value;
    **n characters (with leading zeros if necessary) are
    required if the Mode Command Digit is being
    transmitted.**

This Impedance Command must be provided as an
ASCII string made up of the characters "0"-"9", rep-
resenting the digits 0-9 or HEX 30-39 respectively.

For example, the command strings for the following
resistance settings for a unit with 7 decades and 1 Ω
minimum steps are as follows:

100 Ω	100 or 0100 or 00100 or 000100 or 0000100
600567 Ω	600567
Open circuit	1XY.XXY-X where X represents any digit
Short circuit	2XXXXXX where X represents any digit

For a second example, the command strings for the
following resistance settings for a unit with 5 decades
and .01 Ω minimum steps are as follows:

.99 Ω	99 or 099 or 0099 or 00099 or 00.99, etc. (decimal point is ignored)
100.00 Ω	10000
231.05 Ω	23105 or 231.05 (decimal point is ignored)
Open circuit	1XXXXXX where X represents any digit
Short circuit	2XXXXXX where X represents any digit

The command string may be output with or without
leading zeros in the normal, i.e. non short or open
circuit modes.

This command string must be followed by an appro-
priate terminator such as a **CR** (carriage return), **LF**
line feed), comma, or the presence of an **EOI** signal
on the bus which will terminate the LISTEN mes-
sage.

If there is a decimal point on the thumbwheel
switches, this decimal point may be optionally in-
cluded in the command string.

In the *optional* Open-circuit and Short-circuit modes,
the n-character Impedance Command must be given
in full including all leading zeros. The relays will be
set as commanded although these values will be over-
ridden by the short or open circuit modes. This fea-

ture *may* be used to provide a controlled transition
between two resistance values without being con-
cerned by the indeterminate transitional switching of
the various relays. This is done as follows to change
from resistance R1 to resistance R2:

1. Output a command for R1.
2. Output a command for R1 plus a short cir-
cuit Mode Command digit.
3. Output a command for R2 plus a short cir-
cuit Mode Command digit.
4. Output a command for R2.

Clearly the above example would also apply for the
Open circuit mode.

Illegal characters in the command string will be ig-
nored except for HEX 3B-3F which will result in an
open circuit or an erroneous resistance setting, de-
pending on the particular model configuration. If an
open circuit is desired, these characters may be tested
to determine if they produce an open circuit, or IET
may be consulted.

5.5 Testing and Programming

5.5.1 GPIB Test Keyboard

To aid the user in operating the PRS-200, 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 startup 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 from IET Labs Tech Support
a download of **ICS_GPIBkybd_Install.zip.**

Unzip the file and follow instructions to install.

Open the application. You may use the **Find Listen-
ers** 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 commands to the PRS as follows

PO   resistance string

where the resistance string is constructed as described above in Section 4.4.2.

5.5.2 DOS Programming (Legacy)

A sample BASIC program is given on the following page. It is used by a MetraByte Corporation Model MBC-488 Controller Board.

This program first initializes the controller, then sets the device to the **REMOTE** and **LISTEN** modes, then outputs a command string provided by the operator to the device, and finally sets the device to the **LOCAL** mode. Note that the variable BA0% refers to the controller board number.

```
100 '****************************************************************
110 '*      SAMPLE PRS-200 SERIES IEEE-488 COMMAND PROGRAM              *
120 '*                                                                  *
130 '* MX3                                                              *
140 '****************************************************************
150 CLEAR 20000, 40000!
160 CLS : KEY OFF
170 '
180 'This program let's you write a device dependent command string
190 'to any device number.
200 '
210 '---- Load link that calls DOS resident driver (REMOVE IF COMPILED)
220 '
230 DEF SEG = &H3600
240 BLOAD "GPIBBASI.BIN", 0
250 IE488 = 0
260 '
270 '------ Initialize MBC-488 board using "SYSCON" command
280 '
290 CMD$ = "SYSCON MAD=3, CIC=1, NOB=1, BA0=&H300" 'change to suit
300 A% = 0: FLAG% = 0: BRD% = 0
310 CALL IE488(CMD$, A%, FLAG%, BRD%)      'initialize
320 IF FLAG% <> 0 THEN PRINT "Error #"; HEX$(FLAG%); " in initialization": STOP
330 '
340 INPUT "Enter device number: ", DN
350 '
360 '------ Set device into REMOTE ------------------------
370 CMD$ = "REMOTE " + STR$(DN)
380 CALL IE488(CMD$, A%, FLAG%, BRD%)
390 IF FLAG% <> 0 THEN PRINT "Error in setting to remote. Error code "; HEX$(FLAG%): INPUT "Con-
tinue "; G$: IF G$ = "y" OR G$ = "Y" THEN 400 ELSE 100
400 '
410 '--------------- Send command to device ----------------
420 '
430 PRINT : INPUT "(type 'Q' to quit) Enter device command string: ", X$
435 IF X$ = "Q" THEN 530 ELSE IF X$ = "" THEN 430
440 CMD$ = "OUTPUT " + STR$(DN) + "[$]"
450 CALL IE488(CMD$, X$, FLAG%, BRD%)
460 IF FLAG% <> 0 THEN PRINT "Error in output of command. Error code "; HEX$(FLAG%): INPUT
"Continue "; G$: IF G$ = "y" OR G$ = "Y" THEN 400 ELSE 100
470 GOTO 350
530 RUN "MENUV"
```