PLS SERIES

**High Precision
Manual or SCPI Programmable
Decade Inductance Substituters
(IEEE-488.2 or RS232)
Operation Manual**

IEEE-488

SCPI

PLS Series im/Jun 2006

IET LABS, INC.

534 Main Street, Westbury, NY 11590

www.ietlabs.com

TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

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 MERCHANTIBILITY 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 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 PLS (Figure 1.1) Series is a broad line of high precision manual and programmable capacitance decade substituters. They provide straight capacitance in a wide selection of ranges, tolerances and ratings. IET Labs also supplies custom combination substituters for capacitance and resistance as well as sources for voltage and current.

The PLS Series is a precision substituter with excellent characteristics of stability, temperature coefficient, and power coefficient. High dynamic ranges are available, starting as low as 1 pF or lower and extending for as many as 10 decades. These features combined with a low virtually constant residual impedance make for very versatile instruments.

The PLS 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 setting resistance.

Operation is both local using convenient direct reading front panel thumbwheel switches, and remote with optional parallel BCD , RS-232 Serial or IEEE-488 interfaces.

The PLS Series employs very low capacitance relays. High quality gold plated tellurium copper five-way binding posts serve to minimize the thermal emf effects which would artificially reflect a change 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 low resolutions and high dynamic ranges, the

PLS Series may be used for exacting precision measurement applications requiring high accuracy, good stability, and low zero impedance. They are suited for automatic and manual calibration and testing, simulation of programmable loads, and many other laboratory and industrial applications.

The components employed in these substituters are accurate and stable. Low temperature coefficient capacitors are used. Capacitors are selected for best suitability to each decade.

The PLS Series offers an optional digital display to indicate the control command. The unit may be rack mounted to serve as a component in measurement and control systems.

Figure 1.1 High Precision Manual or Programmable Decade Impedance Substituter

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PLS SERIES OPERATING GUIDE
CONSULT INSTRUCTION MANUAL FOR PROPER INSTRUMENT OPERATION

Inductance Type: Toroidal inductors, for best field retention.
Range: 1 mH to 9.999 H, in 1 mH steps.
Accuracy: ±2%, after subtraction of "zero inductance", at 1 kHz, at 1 Vrms,
5-terminals, at 23°C; traceable to SI.
Zero Impedance: <50 μH, typical.
Maximum Load: 500 mA for 1 mH non switching;
300 mA for 10 mH steps, non switching;
100 mA for 100 mH steps, non switching;
20 mA for 1 H steps, non switching
or 200 V(ac+dc), whichever applies first.
Interface: RS232.SCPI 1994.0; "***IDN**" for S/N, Model & REV;   "**CAL:DATe?**" for last
calibra   tion date; 25 pin male interface conforming to EIA-STD-RS-530.
Terminals: Gold plated tellurium copper binding posts are provided for **HI** and **LO** terminals.
One additional binding post, **GND,** is connected to the case, to chassis ground,
and to earth ground.

POWER: 210-250 V
50-60 Hz; 0.5 A, 5x20 mm fuse.

MODEL: PLS-400-RS232
SN: H1-0625510

WARNING
Observe all safety rules when working with high voltages or line voltages.
ELECTRICAL SHOCK HAZARD. DO NOT OPEN CASE.
REFER SERVICING TO QUALIFIED PERSONNEL.

IET LABS, INC. • 534 Main Street, Westbury, NY 11590 • (516) 334-5959 • Fax: (516) 334-5988
CAGE CODE: 62015   **www.ietlabs.com**   PLS-400-RS232 specs pp3-4+lbls/68%/06-06

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 PLS 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 capacitance 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, and are used on units with high capacitance.

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 PLS 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

Thermal emf is not usually a concern for capacitance, since measurements are commonly made at ac. It is importance at dc, in particular, for resistance.

The PLS 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 power is applied to the coil.

This emf will *not* be reflected if an ac measurement instrument is employed.

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 PLS 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 PLS 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. Although the unit is ready to operate immediately, it is best to allow it to warm up for one hour to reach maximum stability.

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

3.6 Remote Operation

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

When the switch is in the **REMOTE** position, the PLS 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

PLS 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 PLS 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

Table 4.1 BCD INPUT Connector
(Viewed from rear of instrument)

Pin No.	BCD Code Weight	Function	Description			
30	1					
31	2					
32	4					
33	8					
43	1					
42	2					
41	4					
40	8					
39	1					
38	2					
37	4					
36	8					
47	1					
46	2					
45	4					
44	8					
4	1					
3	2					
2	4					
1	8					
8	1					
7	2					
6	4					
5	8					
12	1					
11	2					
10	4					
9	8					
16	1					
15	2					
14	4					
13	8					
20	1					
19	2					
18	4					
17	8					
29	1					
28	2					
27	4					
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

Chapter 5

IEEE INTERFACE OPTION

5.1 Introduction

The IEEE interface option makes the PLS Series an 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 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

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.

5.2 Capabilities

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

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

5.3 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 PLS **BUS ADDRESS** switch on the rear panel establishes the GPIB address of the unit. Bus address settings are read at power up. Refer to table 5.1.

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/LO-CAL** switch is in the **REMOTE** position. Remote control may be dropped by issuing an IEEE GTL command. Dropping remote sets the PLS 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 PLS, 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 PLS unit is recognized. Other instruments may also be recognized at this time.

Enter and set the **Address** to the PLS address. Use the window to send a **command string** to the PLS, where the command string is constructed as described in Chapter 7. A command string might be, for example:

SOURce:DATA inductance string

Chapter 6

SERIAL INTERFACE OPTION

6.1 Introduction

The SERIAL option adds RS-232C and SCPI 1994.0 capability to the PLS 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 PLS 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 PLS SERIAL option is typically made through a simple null-modem or "LapLink" cable.

IET Pin	RS232	Signal Name	Direction 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.

Serial SCPI command strings must be followed by a <lF> 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 PLS, 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 PLS, where the command string is constructed as described in Chapter 7. A command string might be, for example:

SOURce:DATA inductance string

CHAPTER 7

PROGRAMMING

7.1   Introduction

PLS 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 **Inductance 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 **Inductance String** is constructed as:

- **The number is in units of 1 μH**
- **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 **Inductance String** has a minimum resolution of 1 μH with this decade assigned to the right-most character in the string. To create the SCPI command:

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

For example:

Value	Command
600 μH	SOURce:DATA 0000000600
2,700 μH	SOURce:DATA 0000002700
99.9999 H	SOURce:DATA 0099999900

Values sent for decades not implemented in the PLS are ignored. Setting a PLS with 4 decades and a minimum resolution of 1mH to 53,200 μH would result in an actual value of 53,000 μH. For example:

Command	Value
SOURce:DATA 000053200	53,000 μH

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

Open circuit	SOURce:DATA 100XXXXXXX
Short circuit	SOURce:DATA 200XXXXXXX
	(where X = any Inductance 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 C1.**
- **Output command for C1 plus a SC Mode Character.**
- **Output command for C2 plus a SC Mode Character.**
- **Output command for C2.**

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*

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7.3 Advanced Programming - Software Drivers

Basic control of a PLS 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 PLS 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 PLS family of instruments are available in many models (including inductance, resistance and capacitance) ranges, (1pico Unit to 100 MegaUnit) and with various options. Information to create a more robust driver to control a PLS instrument is listed below.

7.3.1 Determining the PLS 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 PLS 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
PCS	Capacitance Substituter
PLS	Inductance Substituter

Version:

> 200
> 201
> 202
> 300
> 301
> 400

Tolerance:

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

LSD:

100p	100 pUnit
1n	1 nUnit
10n	10 nUnit
100n	100 nUnit
1u	1 uUnit
10u	10 uUnit
100u	100 uUnit
1m	1 milliUnit
10m	10 milliUnit
100m	100 milliUnit
1	1 Unit
10	10 Unit
100	100 Unit
1K	1 KUnit
10K	10 KUnit
100K	100 KUnit
1M	1 MegaUnit
10M	10 MegaUnit

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

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, 300,301,400; enum 0-5)
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 PLS 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 PLS. 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. The 200,201,300, 301 and 400 Series units have 10 decade locations, the 202 Series has 12.

    PLSCmd = "SOURce:DATA " _
     & format(iValue,"0000000000")

Example 1:
    "SOURce:DATA 0000001235"

Example 2:
    "SOURce:DATA 000001000000"

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, status reporting and 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 are used to separate messages.
(:)   Colons to separate command words.
(,)   Commas to 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 488.2 to give the programmer the capability 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 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	Notes & Short Parameter Form	Form Commands	
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]		BCD coded digits representing the possible decade values	PO
CALibrate			**Calibrate**
:DATe?		mm-dd-yyyy	

Appendix B

IEEE-488.2 COMMON COMMANDS

The PLS 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	PLS 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.

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

COMMAND	NAME	DESCRIPTION
*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 PLS to power-up state; state of IEEE interface is unchanged, including: instrument address and Status Byte. Allow the REMOTE option 150ms 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.