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Colby Instruments

PDL-100A Programmable Delay Line

Operating and Programming Manual

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Hardware Version 1.0 REV 1.0. Firmware Version 1.70.

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1.0 Description of the PDL-100A Programmable Delay Line Series

1.0.1 Introduction

The **PDL-100A** Programmable Delay Line (PDL) Instrument Series offers a range of variable and programmable delay beginning from 0 delay (DC) to a customer specified maximum delay limit of 100 nanoseconds (depending on specific model) in a single system unit. With resolution precision to 0.50 picoseconds per step and wideband signal frequency input from DC to 18 GHz, the PDL-100A is the finest programmable delay line instrument available in the marketplace.

The base model PDL-100A-625PS offers electrical delay through a patented electromechanical trombone unit with movement controlled by a high precision stepper motor. Resolution is to 0.50 picoseconds and repeatability to 0.10 picosecond accuracy. Total delay range of the trombone only model PDL-100A-000 is from DC to 625 picoseconds.

For models PDL-100A-1.25NS and above, delay range extensions consisting of microwave relays and low-loss semi-rigid coaxial cable are added to extend the delay range limit up to a customer specified maximum of 100 nanoseconds.

The Model Number of each specific instrument determines the maximum delay range available. The last few characters of each model number indicate the total delay range.

Model Number	Delay Range
PDL-100A-625PS	DC to 0.625 ns
PDL-100A-1.25NS	DC to 1.250 ns
PDL-100A-10.0NS	DC to 10.00 ns
PDL-100A-20.0NS	DC to 20.00 ns
PDL-100A-100.0NS	DC to 100.0 ns

All signal input and output connections are easily accessible at the front panel and are terminated with Female SMA (50 ohm impedance) connectors.

PDL-100A Series Instruments are programmable and can be locally controlled through a MT-100A Microterminal (optional accessory available separately) or remotely through GPIB (IEEE 488.2), TCP/IP Ethernet, or RS-232 Serial Port interfaces.

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1.0.2 Delay Line Structure and Design

The PDL Series of delay line instruments is based on an "electromechanical trombone" or moveable delay line. A high frequency signal passing through an expanded or contracted trombone experiences correspondingly more or less electrical delay. The trombone tubes consist of four flexible lines connected in series to achieve a total delay of 625 ps or 312.5 ps if used individually as a set of two. The trombone delay lines are exposed at the instrument front panel to allow access to each delay line pair. All PDL-100A Series instruments include a semi-rigid coaxial cable connecting the top pair in series to the bottom pair.

A high torque aerospace-grade high precision stepper motor with a custom precision lead screw is used to position a sled on which one part of the trombone tubing is attached. The PDL-100A's precision interfaces are designed to minimize impedance mismatches while a proprietary contact design achieves reliability while minimizing any signal loss or noise.

An embedded CPU microcontroller reads commands from either a Microterminal (numeric keypad with LCD display) or from GPIB (IEEE488.2), TCP/IP (Winsock), or RS-232 Serial Port interfaces. Commands are processed to move the stepper motor in high-resolution step increments to as fine as 0.50 picoseconds as measured across the series path of two trombone pairs (top and bottom). This is the Series Connected configuration. Removing a vertical coaxial cable on the front panel allows increased precision to 0.25 picoseconds as measured across only one trombone pair (top or bottom). This is the Parallel Connected configuration.

If required (as in PDL-100A-1.25NS and above), semi-rigid coaxial cable and low-loss microwave relay sections are also turned on or off (to add or remove delay) into the signal path to extend the total delay range of each instrument.

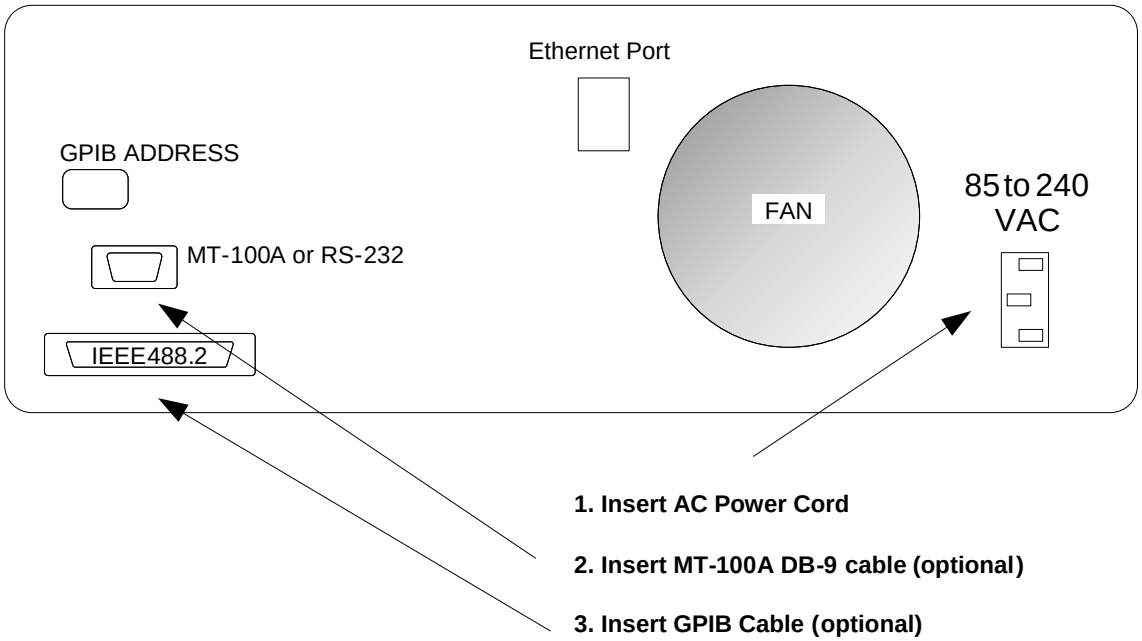
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2.0 Getting Started

2.0.1 Using the PDL-100A for the First Time

After unpacking the instrument, carefully inspect it for any shipping damage. Remove all standard accessories from the shipping carton.

PDL-100A BACKPANEL



The PDL-100A accepts AC line input voltage from 85VAC to 240VAC.

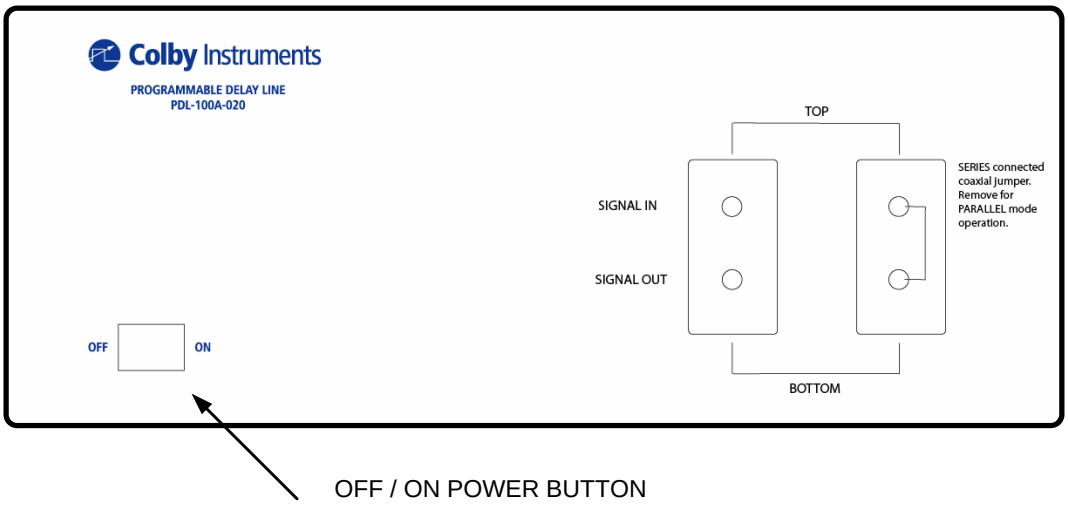
Connecting to the PDL-100A:

1. Plug in the PDL-100A to a power source by inserting the AC power cord into the 85 to 240 VAC power entry module located on the backpanel.

   Note: Models delivered to customers in North America include a power cord. Customers outside of North America must supply their own power cords. The power entry module uses a standard IEC connector.

2. If you have the optional MT-100A Microterminal, connect the mated cable to the PDL-100A and to the MT-100A Microterminal.
3. If you have a GPIB (IEEE488.2) interface cable, connect the cable into the IEEE488.2 connector.

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4. Push the flat rocker switch on the front panel to turn on the PDL-100A System Unit.

2.0.2 Self-Test After Power Up

Both the MT-100A Microterminal and the PDL-100A System Unit each use a embedded microprocessor to perform all necessary tasks. After you power up the PDL-100A System Unit, both microprocessors will initiate a self-test.

2.0.3 Self-Test without MT-100A Microterminal connected

The PDL-100A will now check the calibration of the unit by slowly moving the electromechanical trombone delay line towards its maximum setting (maximum delay) until it reaches an infrared light barrier set at a precise position. A full-speed test is then performed by moving the delay to 0 (relative) and then back to 625 ps and re-checking the calibration. If microwave relays are installed, a power cycle to OFF, ON, then OFF of all relays will be performed. The delay is reset to its zero delay (0 ps) position and the unit is ready to accept commands.

The PDL-100A is now ready to accept commands from any of the attached interfaces (GPIB, TCP/IP, or RS-232).

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2.0.4 Self-Test with MT-100A Microterminal connected

The following sequence is displayed on the Microterminal LCD:

1.
```
  MT-100A V1.0
COLBYINSTRUMENTS
```

2.
```
 PDL-100A-10.0NS
COLBYINSTRUMENTS
```

3.
```
 PDL-100A-10.0NS
..INITIALIZING..
```

See also Section 4.1.1 The MT-100A Microterminal at a glance.

The PDL-100A will now check the calibration of the unit by slowly moving the electromechanical trombone delay line towards its maximum setting (maximum delay) until it reaches an infrared light barrier set at a precise position. A full-speed test is then performed by moving the delay to 0 (relative) and then back to 625 ps and re-checking the calibration. If microwave relays are installed, a power cycle to OFF, ON, then OFF of all relays will be performed. The delay is reset to its zero delay (0 ps) position and the unit is ready to accept commands.

The MT-100A Microterminal LCD screen will display as shown below:

For Model PDL-100A-625ps (Trombone only):

```
      0.00ps |S| 0
```

For Model PDL-100A-1.25ns and above (with delay extensions):

```
    0.0000ns |S| 0
```

The PDL-100A is now ready to accept commands from the Microterminal or via any of the attached interfaces (GPIB, TCP/IP, or RS-232).

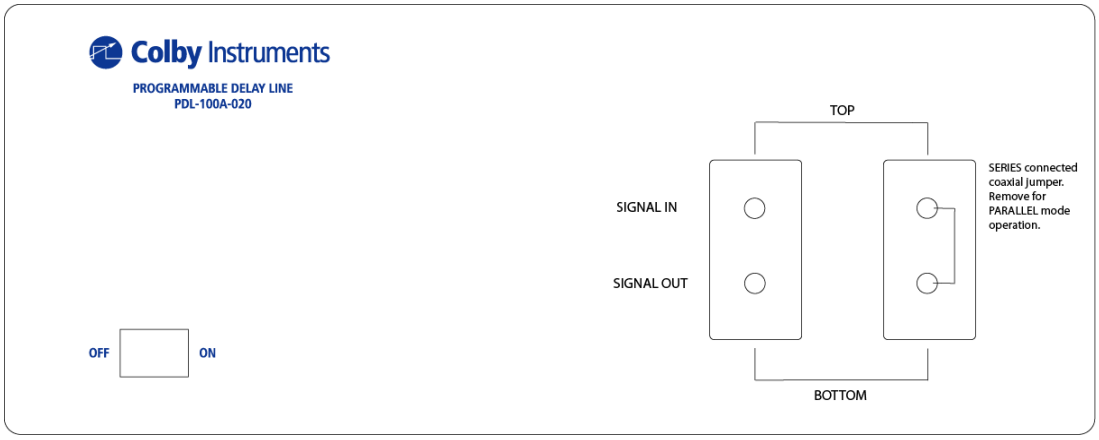
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3.0 Using the Front Panel Connections

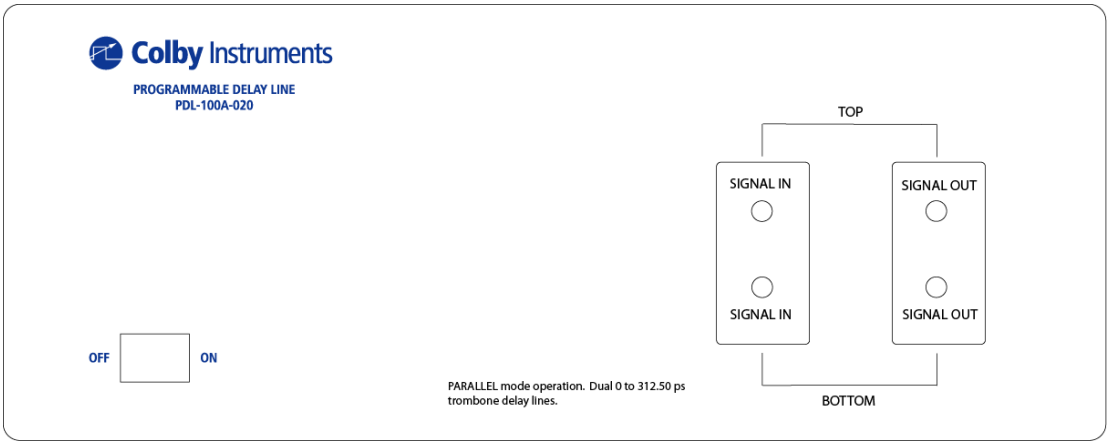
3.0.1 Overview of the Front Panel Connections

The electromechanical trombone unit, situated on the instrument's right side, has four connectors. In the illustration below a short semi-rigid coaxial cable (supplied with each PDL-100A unit) connects the two identical 312.50 picosecond (ps) delay sections in series for the full delay range up to 625 ps for a PDL-100A-000.



Model PDL-100A-625ps SERIES CONNECTED
0 to 625 ps delay from SIGNAL IN to SIGNAL OUT

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Model PDL-100A-625ps PARALLEL CONNECTED
0 to 312.50 ps delay from SIGNAL IN to SIGNAL OUT (Top or Bottom pair)

3.0.2 About Series Connected or Parallel Connected Mode

Refer to Model PDL-100A-625PS SERIES CONNECTED diagram. In Series Connected mode (normal operation), the electromechanical trombone offers delay from 0 to 625ps from SIGNAL IN to SIGNAL OUT with step resolution to 0.50 picoseconds. The in-series coaxial cable jumper ***MUST*** be installed.

Refer to Model PDL-100A-625PS PARALLEL CONNECTED diagram. In Parallel Connected mode, the electromechanical trombone offers delay from 0 to 312.50 ps from either the top or bottom SIGNAL IN to SIGNAL OUT pair with step resolution to 0.25 picoseconds. The in-series coaxial cable jumper should ***NOT*** be installed.

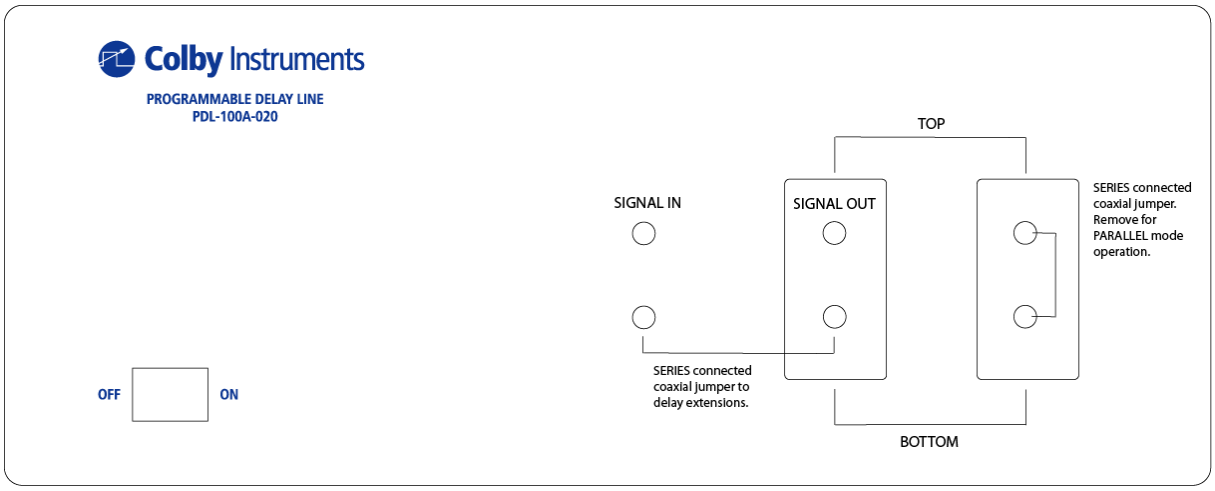
3.0.3 About Delay Extensions

The delay extension is made from precision phase matched semi-rigid coaxial cables and low-loss microwave relays. Each binary delay extension step length utilizes two microwave coaxial relays.

The standard PDL-100A-625PS has no extended delay while the model PDL-100A-10.0NS has 4 binary extensions: 625 ps, 1.25 ns, 2.5 ns, and 5.0 ns, to provide a total range of 10 nanoseconds when all delay sections, plus the trombone unit are added. Higher models with longer delay extensions simply add additional relays and coaxial cable in binary weighted step lengths.

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The PDL-100A Series of models offers a range up to 100 nanoseconds of total delay as specified by the customer at time or order.



PDL-100A-10.0NS SERIES CONNECTED WITH DELAY EXTENSIONS
0 to 10 ns delay (or device max) from SIGNAL IN to SIGNAL OUT.

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4.0 Setting Delay Values

There are two general methods to set delay values:

- Locally via the MT-100A Microterminal (numeric keypad entry)
- Remotely via the GPIB (IEEE488.2) Interface, the Ethernet TCP/IP Port interface, or via the Serial Port RS-232 interface.

4.1.0 Working with the MT-100A Microterminal

Make sure the PDL-100A is powered off. Connect the Microterminal to the instrument. After turning the ON/OFF switch located on the front panel of the PDL-100A unit, you will hear a short beep indicating that both the MT-100A and the PDL-100A units have successfully powered up.

The PDL-100A will then perform a self-initialization test and self-calibration. Upon successfully completing these tests, the Microterminal unit will display:

For Model PDL-100A-625ps (Trombone only):

```
     0.00ps |S| 0
```

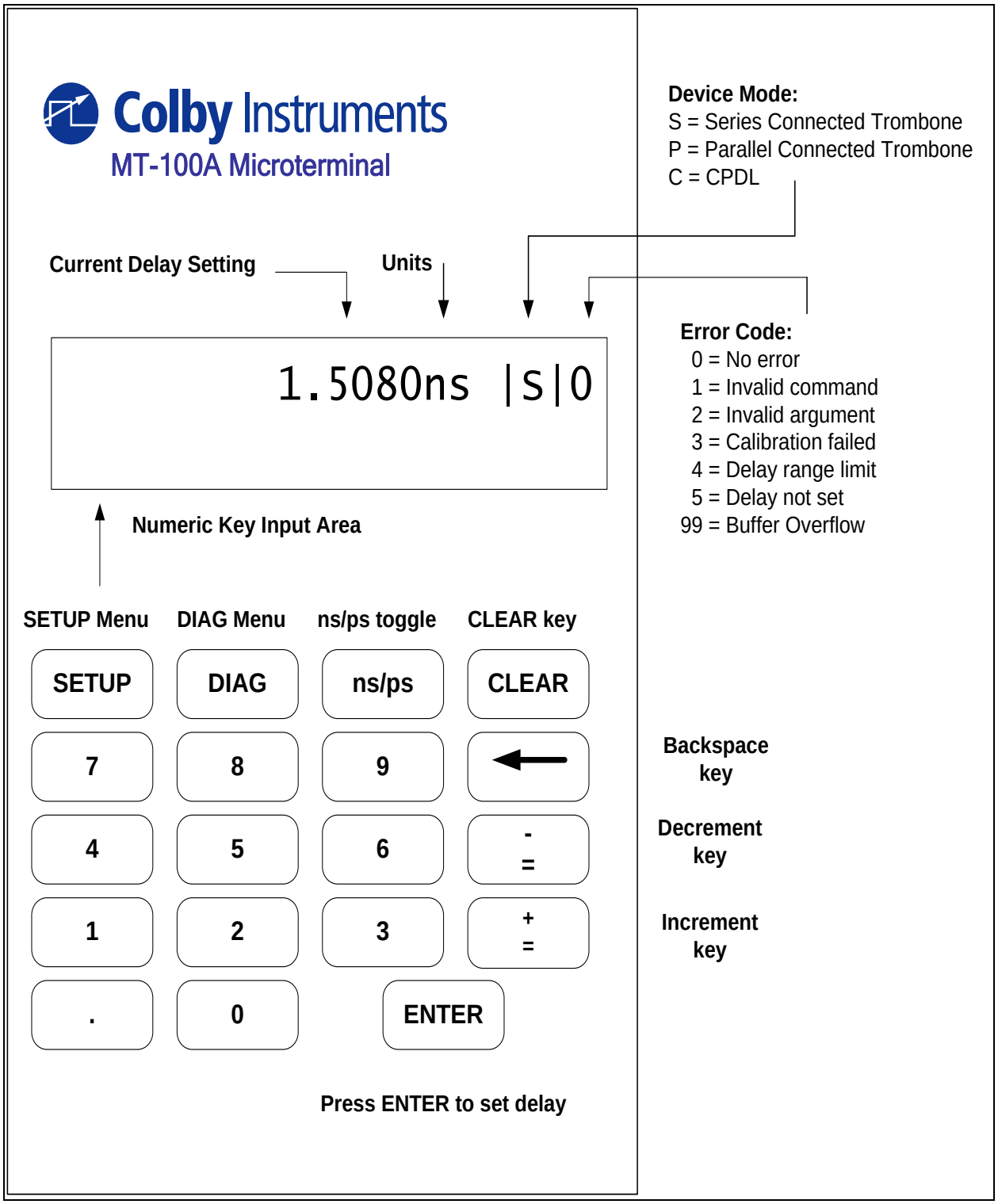
For Model PDL-100A-1.25ns and above (with delay extensions):

```
    0.0000ns |S| 0
```

The PDL-100A is now ready to accept delay settings.

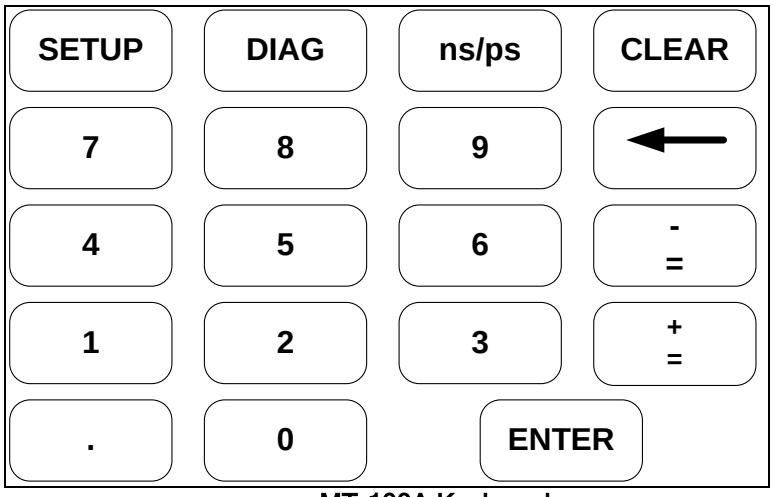
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4.1.1 The MT-100A Microterminal at a glance



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4.1.2 Working with the MT-100A Microterminal Keypad



MT-100A Keyboard

SETUP

SETUP Menu. The SETUP Menu offers these options:
1. Display GPIB Address and Set/Display Network address
2. Set Series Connected or Parallel Connected Mode
3. Turn OFF/ON Terminal or MT-100A mode

See Section 4.2.0 The MT-100A Menu Keys - SETUP

DIAG

DIAG Menu. The DIAG Menu offers these options:
1. Turn ON/OFF any or all relays if installed
2. Perform Calibration and self-test
3. Reset the PDL-100A

See Section 4.2.0 The MT-100A Menu Keys – DIAG

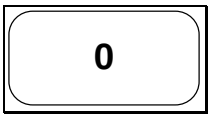
ns/ps

Toggles between display delay setting values in nanoseconds(ns) or picoseconds(ps) units.

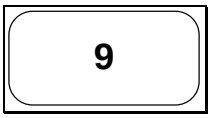
CLEAR

Clear the last entry and return to normal operating mode

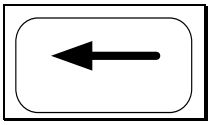
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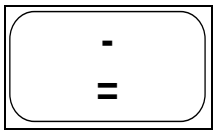
…

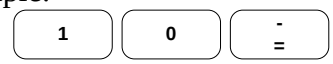


Numeric keypad to enter desired delay or set parameters

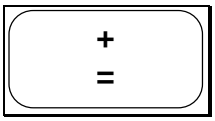


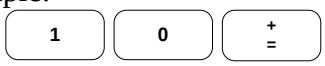
Backspace



Decrement current delay setting by a constant ***step size value*** (default is zero). Immediately pressing this key after entering a value will ***set*** the step size value.
Example:
Press 

to set a step size value of 10 ps and decrement the current delay by 10 ps.



Increment current delay setting by a constant ***step size value*** (default is zero). Immediately pressing this key after entering a value will ***set*** the step size value.
Example:
Press 

to set a step size value of 10 ps and increment the current delay by 10 ps.



Set Delay. Press this key after entering desired delay value.

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4.2.0 Setting Delay with the MT-100A Microterminal

To Enter Desired Delay:

Enter a desired delay setting by using the numeric keypad and pressing ENTER to set the desired delay.

EXAMPLES:

1. Set delay to 12.50 nanoseconds:

```
   0.5000ns |S|0
```

Press **12.50** and **ENTER** ***sets delay to 12.50 nanoseconds***

```
  12.5000ns |S|0
```

2. Toggle between nanoseconds (ns) or picoseconds (ps) units

```
  12.5000ns |S|0
```

Press **ns/ps** ***toggles units between nanoseconds(ns) or picoseconds(ps).***

```
 12500.00ps |S|0
```

3. Set delay to 10000 picoseconds

```
 12500.00ps |S|0
10000
```

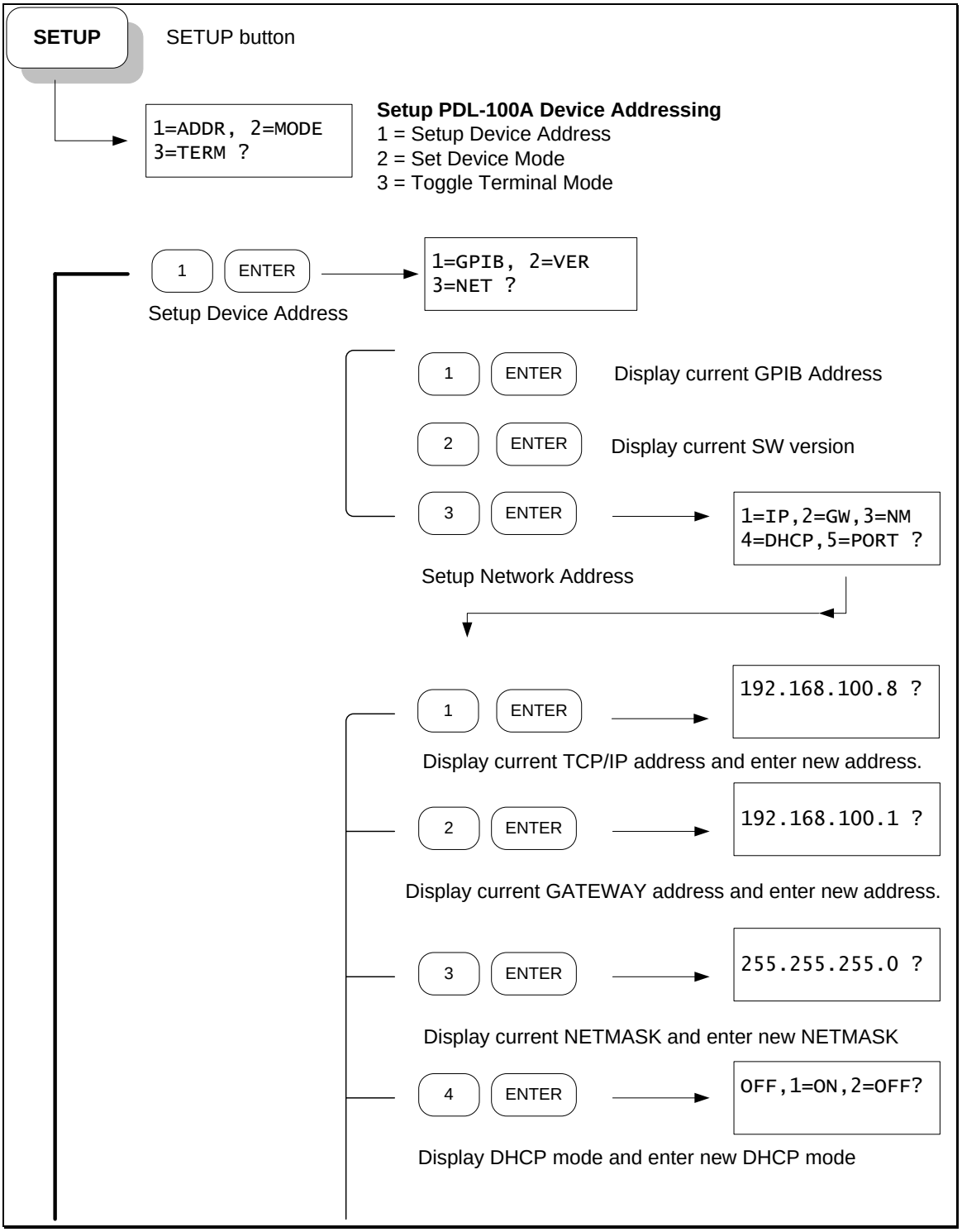
Press **10000** and **ENTER** ***sets delay to 10000 picoseconds***

```
 10000.00ps |S|0
```

NOTE: After pressing the ENTER key, the PDL-100A will attempt to set the desired delay and return an error code of zero (0) if the delay was set properly. A BEEP tone will indicate an error (if any) and that the desired delay was not set.

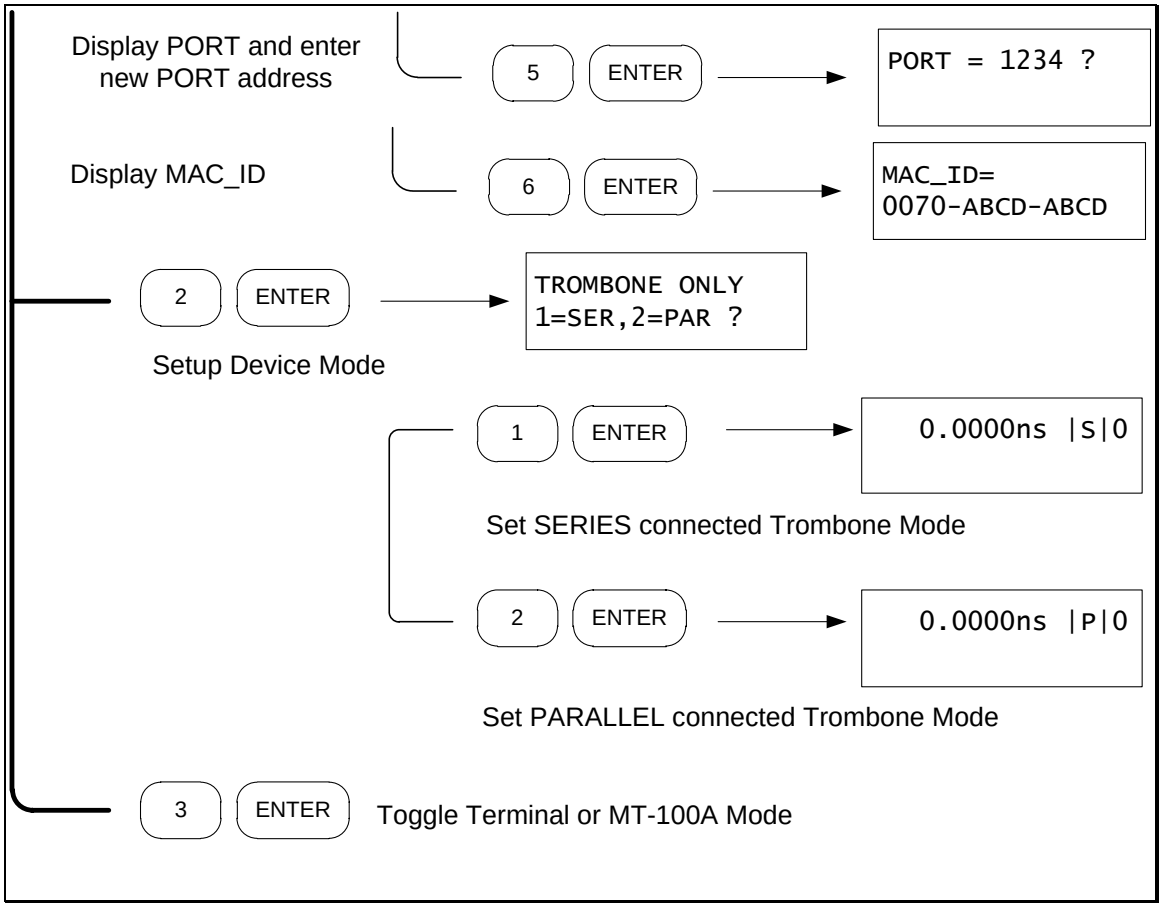
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4.3.0 The MT-100A Menu Keys – SETUP



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4.3.1 The MT-100A Menu Keys – SETUP cont.



4.3.2 About the SETUP Menu options

The Setup Menu allows you to configure your PDL-100A by specifying the GPIB instrument device address, the network device address, and to specify whether the RS-232 port is connected to the MT-100A Microterminal or a PC.

4.3.3 SETUP Menu – GPIB Address

The current GPIB address is displayed. Valid GPIB addresses must be from 1 through 31 and are specifed by setting the GPIB device address switches located on the instrument backpanel. ***See Section 7.0 Backpanel.***

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4.3.4 SETUP Menu – Network Addresses

The current network address, gateway address, network mask, DHCP, and network port number can be displayed or specified. If no Ethernet cable is attached or a network session could not be established, the network IP address reported will be invalid and display 0.0.0.0.

4.3.5 SETUP Menu – RS-232 Terminal Mode or MT-100A Mode

The PDL-100A has one RS-232 port that can be connected to either a MT-100A Microterminal or to a PC. You must command the PDL-100A to know which device you have attached else command prompts will not display correctly. The default mode is MT-100A Mode is ON (i.e. MT-100A Microterminal is connected the PDL-100A). You can toggle between Command Terminal Mode (connected to PC) or MT-100A Mode by selecting this option.

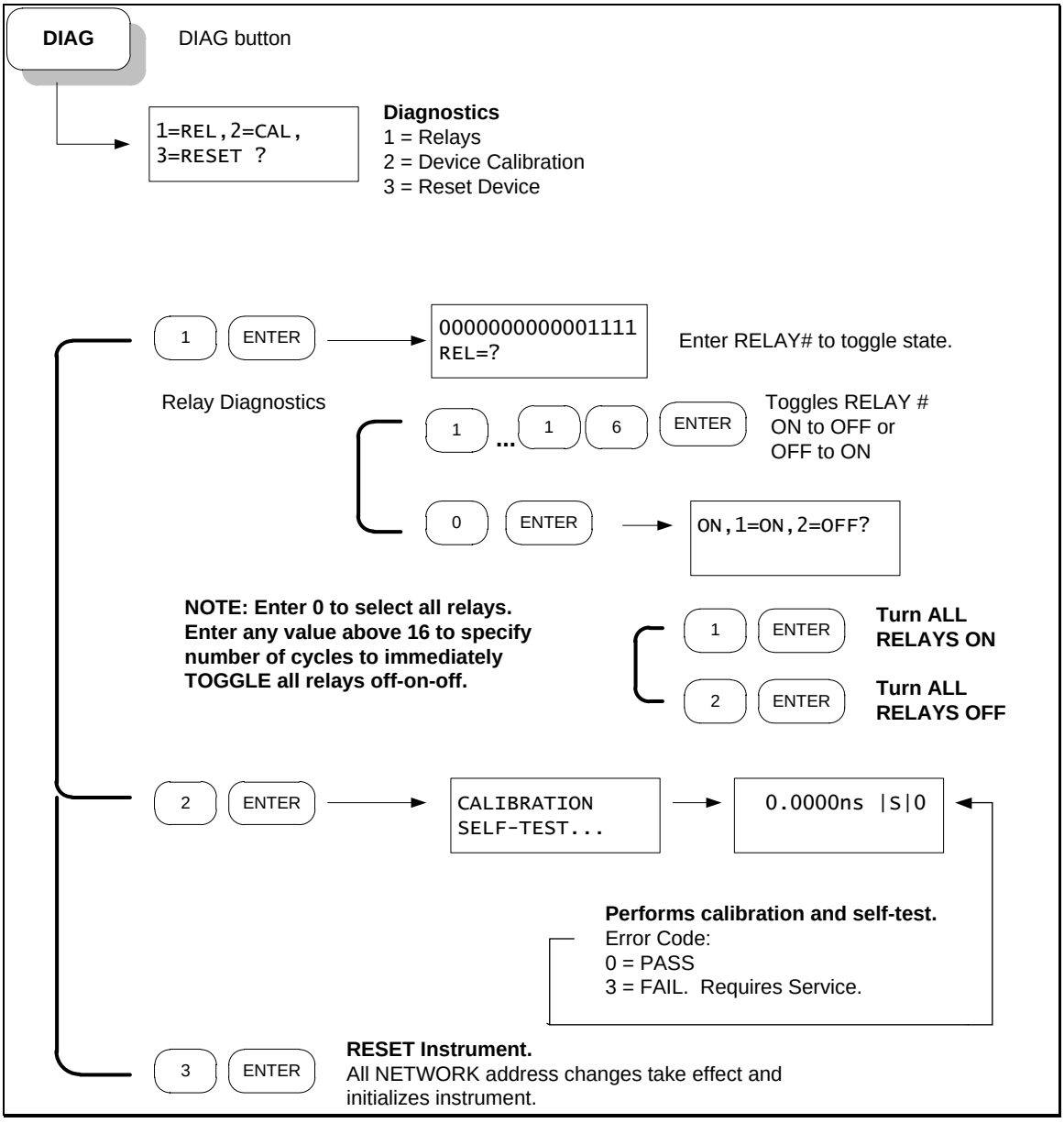
You can also turn off or on Command Terminal Mode by sending the MODE TERM OFF command via GPIB, TCP/IP or RS-232 interface.

MODE TERM OFF	specify PC is connected to RS-232 port
MODE TERM ON	specify MT-100A is connected to RS-232 port

Note: To revert to factory default settings for all device addresses and parameters, set the GPIB address switches located on the backpanel to ZERO (all OFF) then power-cycle (turn OFF then ON) the PDL-100A System Unit. Remember to set the GPIB address switches back to a valid address (1 to 31) after you configure your device settings.

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4.4.0 The MT-100A Menu Keys – DIAG



4.4.1 About the DIAG Menu options

The DIAG Menu allows you to perform basic diagnostics on the microwave relays (if delay extensions are attached), perform a device calibration, or to reset the PDL-100A instrument.

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4.4.1.1 DIAG MENU – Relays

The current state of the microwave relays is displayed (0 = OFF, 1=ON) from leftmost (Relay #16) thru rightmost (Relay #01):

16----------1
```
0000000000000000
REL?
```

See Specifications of PDL-100A located in front of this manual for your specific configuration of delay settings for your instrument.

You can specify any one relay to toggle (if ON will turn it OFF or if OFF will trun it ON) by entering the relay number and pressing ENTER.
Note: Enter 0 to select ALL the relays to either the ON or OFF state.

4.4.1.2 DIAG MENU – Device Calibration

An internal self-test and calibration diagnostic will be performed. The electromechanical trombone will perform a self-test, all relays will cycle OFF, ON, and OFF. Delay will be reset to 0.00. If an error occurs during self-test or calibration, the instrument requires servicing or repair.

4.4.1.3 DIAG MENU – Resetting the PDL-100A

The PDL-100A will reset to a known initial POWER-ON state. If network addresses were changed or set, the new settings will take effect.

Note: To revert to factory default settings for all device addresses and parameters, set the GPIB address switches located on the backpanel to ZERO (all OFF) then power-cycle (turn OFF then ON) the PDL-100A System Unit. Remember to set the GPIB address switches back to a valid address (1 to 31) after you configure your device settings.

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4.5.0 Working Remotely Through the GPIB Interface

There are three different ways to connect remotely to the PDL-100A:

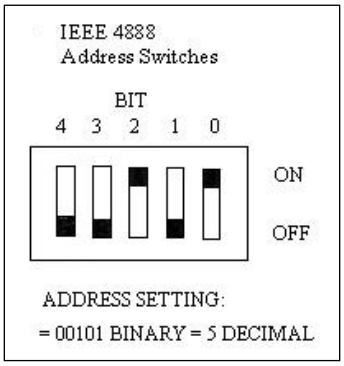
- GPIB (IEEE 488.2)
- Ethernet TCP/IP (Winsock)
- RS-232 Serial Port

4.5.1 Connecting remotely over GPIB (IEEE488.2)

Each instrument communicating using GPIB (IEEE488.2) protocol requires a unique hardware address in the range from 1 to 31.

4.5.2 Setting the GPIB (IEEE488.2) Address

The PDL-100A unit is shipped with the default GPIB address switch settings set to 5. You can modify this setting with the switches located on the instrument backpanel. See ***Section 7.0 Backpanel*** for diagram and location of GPIB address switches. The switches are coded in a 5 bit binary fashion where the right-most switch represents bit 0 (the Least Significant Bit). A bit is ON when the switch is in the UP position.



ADDR		ADDR		ADDR		ADDR	
0	0 0 0 0 0	8	0 1 0 0 0	16	1 0 0 0 0	24	1 1 0 0 0
1	0 0 0 0 1	9	0 1 0 0 1	17	1 0 0 0 1	25	1 1 0 0 1
2	0 0 0 1 0	10	0 1 0 1 0	18	1 0 0 1 0	26	1 1 0 1 0
3	0 0 0 1 1	11	0 1 0 1 1	19	1 0 0 1 1	27	1 1 0 1 1
4	0 0 1 0 0	12	0 1 1 0 0	20	1 0 1 0 0	28	1 1 1 0 0
5	0 0 1 0 1	13	0 1 1 0 1	21	1 0 1 0 1	29	1 1 1 0 1
6	0 0 1 1 0	14	0 1 1 1 0	22	1 0 1 1 0	30	1 1 1 1 0
7	0 0 1 1 0	15	0 1 1 1 0	22	1 0 1 1 0	31	1 1 1 1 1

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After setting the new GPIB address, you must reset the PDL-100A either by powering the instrument OFF then ON or resetting the device through the Microterminal. ***See Section 4.4.4 DIAG Menu – Resetting the PDL-100A.***

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4.5.3 Setting the delay using GPIB (IEEE488.2) Commands

GPIB commands can be sent to the PDL-100A by using one of many GPIB command Send and Receive programs available on the PC. This program should be included with the GPIB PC board.

4.5.4 Using National Instruments Measurement and Automation Explorer

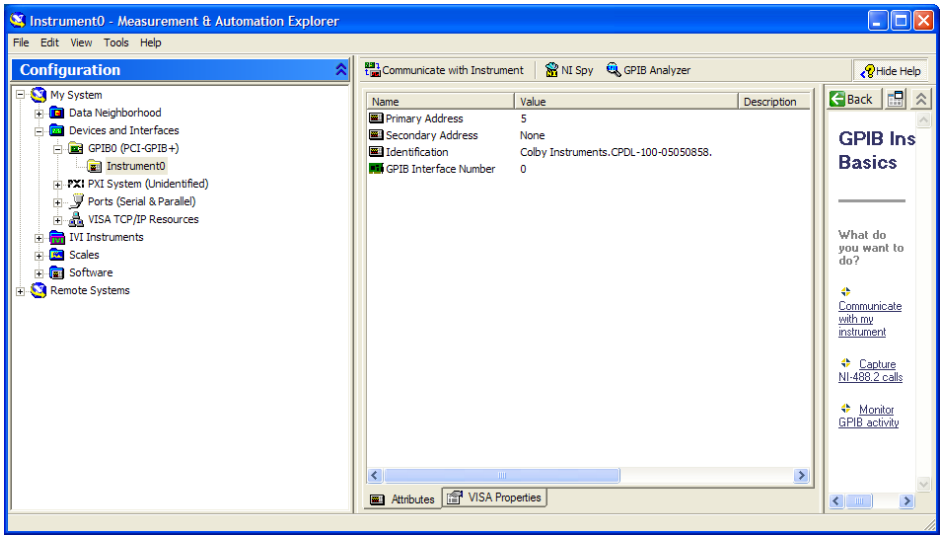
1. From Windows Desktop, double-click on the Measurement & Automation Explorer Icon.

2. In the Configuration Panel, click on Device and Interfaces under Devices

3. Click on your installed GPIB board e.g. GPIB0 (PCI-GPIB+) Folder

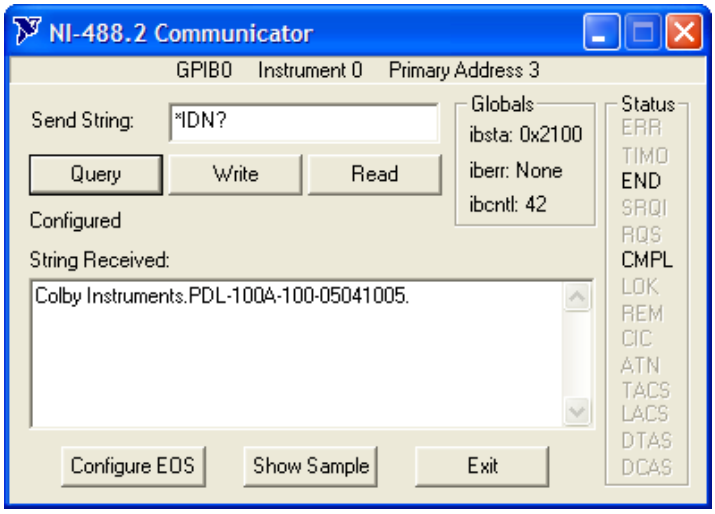
4. Click Scan For Instruments button

5. Double-click on Instrument0 (or corresponding instrument attached)



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6. Click on Communicate with Instrument button



7. Click Query to send *IDN? to the PDL-100A and view the response.

Now that NI-488.2 Communicator has started, you can enter commands and query the PDL-100A unit from this application. See Chapter 5.0 Common Commands and System Commands for specific commands supported.

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4.6.0 Communicating with the PDL-100A over Ethernet TCP/IP.

TCP/IP Protocol using Winsock sends data packets to individual IP addresses over a unique and pre-specified port. The PDL-100A supports fixed (static) and dynamic IP addresses and the Winsock interface. Network Addresses including IP address, Gateway IP, Netmask, DHCP, and Port Number can be specified or changed by sending commands to the PDL-100A using the GPIB, TCP/IP, or RS-232 interfaces.

To change the network addresses using a command interface, ***see Section 5.0 Command Commands for NET, NET? and NETM? Commands.***

To change the network addresses using the MT-100A Microterminal, ***see Section 4.3.4 SETUP Menu – Network Addresses.***

4.6.1 Default Network Addresses

IP Address	192.168.100.8
Gateway Address	192.168.100.1
Netmask	255.255.0.0
DHCP	OFF
Port Number	1234

These are the default network addresses at time of manufacture and are stored internally in non-volatile storage. If you are unable to communicate with the PDL-100A over Ethernet after changing a network address (no MT-100A Microterminal or GPIB communication available) and want to restore the default address settings, set the GPIB address switches to Zero (all OFF) and power-cycle (turn OFF then ON) the PDL-100A System Unit. The default address will take effect.

4.6.1.1 Programming over the Ethernet TCP/IP

When programming the instrument over the Ethernet TCP/IP interface, characters are ***NOT*** echoed (sent from the PDL-100A) back to the PC when sending the command string. For example, from your application program if you send the character string:

***IDN?<CR><LF>**

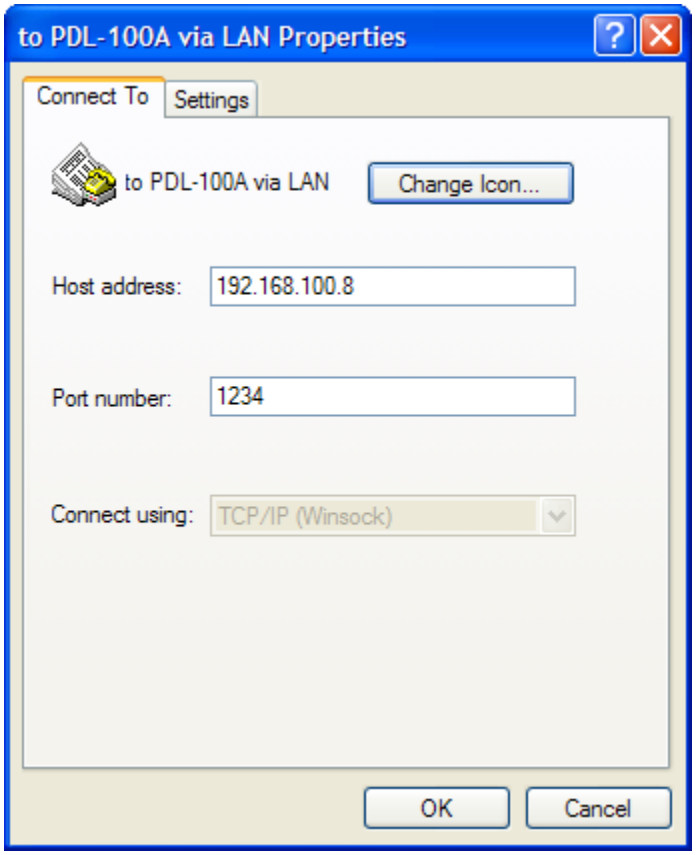
the PDL-100A will respond with:
Colby Instruments,PDL-100A-625.0PS-05111020.V1.10<CR><LF>

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4.6.2 Using HyperTerminal and Ethernet (TCP/IP)

1. From the Windows Desktop, start HyperTerminal on your PC.

2. Click on File and Properties



3. Select TCP/IP(Winsock) in Connect using: drop-down list box

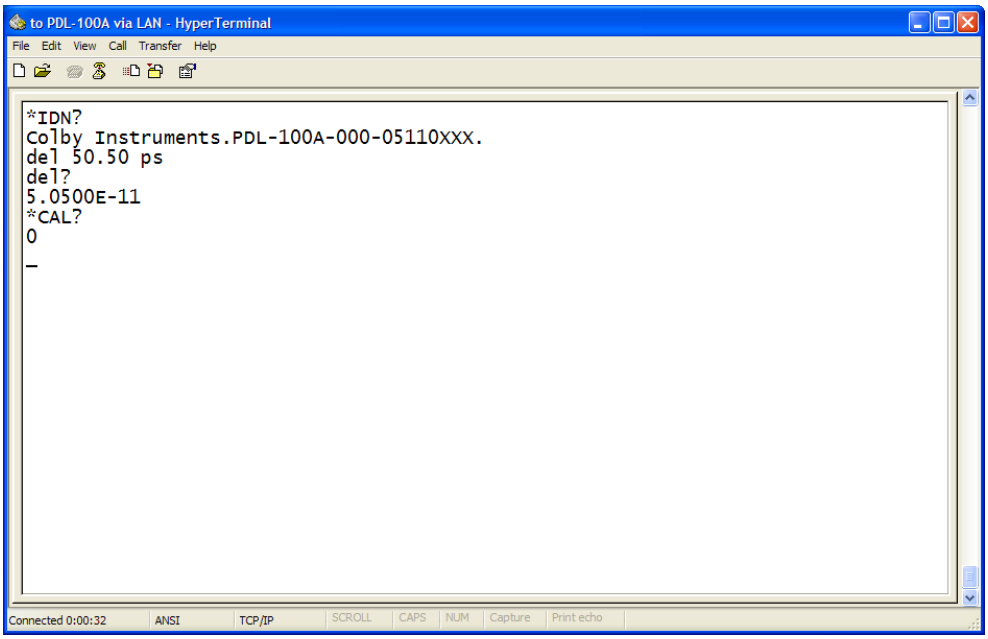
4. Enter the Port Number that corresponds to the Port Number for the PDL-100A.

5. Enter the Host address that corresponds to the Network IP address for the PDL-100A.

6. Click on OK to continue.

7. Click on Call to initiate the Winsock Session with the PDL-100A.

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Note: When communicating to the PDL-100A with HyperTerminal and Winsock protocol, command prompts are not displayed.

Now that HyperTerminal has started and is configured correctly, you can enter commands and query the PDL-100A unit from this application. See Chapter 5.0 Common Commands and System Commands for specific commands supported.

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4.7.0 Setting the delay over RS-232 Serial Port and PC

The RS-232 Serial Port is located on the backpanel of the PDL-100A System Unit ***(see Section 7.0 Backpanel for diagram)*** and is used to connect to either the MT-100A Microterminal (with the supplied DB-9 MALE to FEMALE cable) or to a PC (with a NULL MODEM DB-9 FEMALE to MALE cable). Port speed is 9600 baud, 8 data bits, and 2 stop bits.

The PDL-100A System Unit can operate (send command prompts and receive command data) in either Command Terminal Mode or in MT-100A Mode. You must specify the correct mode prior to attaching either the MT-100A Microterminal or the PC else command prompts will be displayed incorrectly. Default is MT-100A Mode with the Microterminal attached when the PDL-100A is first powered-on.

4.7.1 Attaching the MT-100A Microterminal to the RS-232 port

Ensure the MT-100A Mode is set by sending the command: MODE TERM ON to the PDL-100A. This command can be sent via GPIB, TCP/IP, or via RS-232. If the MT-100A is already connected, you can set the MT-100A Mode ON by pressing: SETUP 3 ENTER on the MT-100A.

Note: if the MT-100A Mode is OFF, command prompts from the PDL-100A will be displayed incorrectly.

Use the supplied DB-9 mated cable (supplied with MT-100A) to connect the MT-100A Microterminal to the PDL-100A System Unit. ***See Section 7.0 Backpanel for diagram.***

4.7.2 Attaching the PC to the RS-232 port

Ensure the MT-100A Mode is set by sending the command: MODE TERM OFF to the PDL-100A. This command can be sent via GPIB, TCP/IP, or via RS-232. If the MT-100A is already connected, you can set the MT-100A Mode OFF by pressing: SETUP 3 ENTER on the MT-100A.

You must use a NULL MODEM cable when connecting the PC to the PDL-100A System Unit. The NULL MODEM cable should have a MALE DB-9 connector TO the PDL-100A and a FEMALE DB-9

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connector TO the PC. ***See Section 7.0 Backpanel for diagram.*** RS-232 Port speed is 9600 baud, 8 data bits, and 2 stop bits.

4.7.2.1 Programming over the RS-232 connection

When programming the instrument over the RS-232 Serial connection, characters are echoed (sent from the PDL-100A) back to the PC when sending the command string. For example, from your application program if you send the character string:

```
*IDN?<CR><LF>
```

the PDL-100A will respond with:

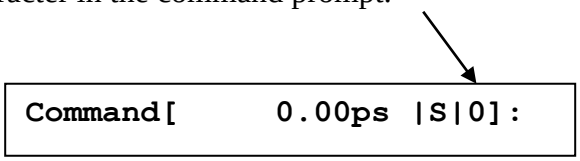
```
*IDN?<CR><LF>
Colby Instruments,PDL-100A-
625.0PS,07061234,V1.70<CR><LF>
Command[     0.00ps |S|0]:
```

4.7.2.2 Error Checking

After every command sent to the instrument, you should check the Error Return code in the Command Prompt to ensure the command was executed correctly.

Error Code	Reason
0	No error
1	Invalid command
2	Invalid argument
3	Calibration failed
4	Delay range limit
5	Delay not set
*	Input Buffer Overflow (RS-232)

The Error Return code is a one character field that is the second to last character in the command prompt.

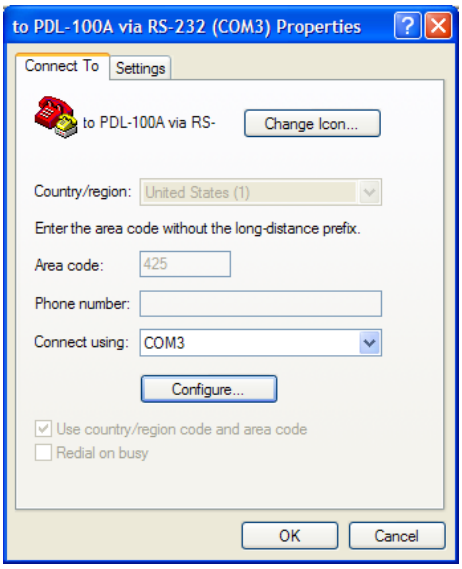


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4.7.3 Using HyperTerminal and RS-232 connection

From Windows Desktop, click on the Windows Start button, click on All Programs, click on Accessories, click on Communications, and click on HyperTerminal to start the HyperTerminal application.

1. Click on File, and click on Properties:



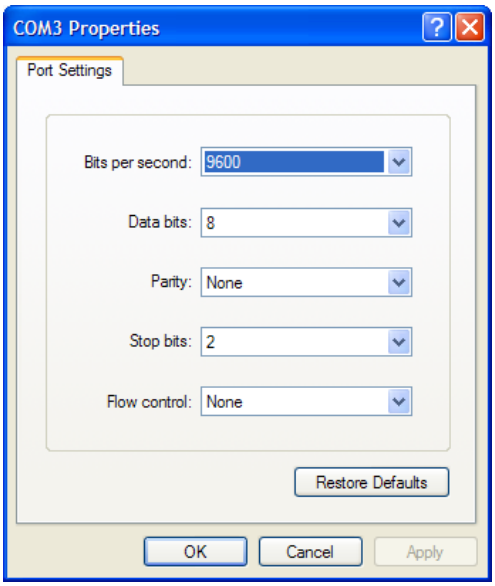
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2. Click on the Settings Tab to set the Port Settings.

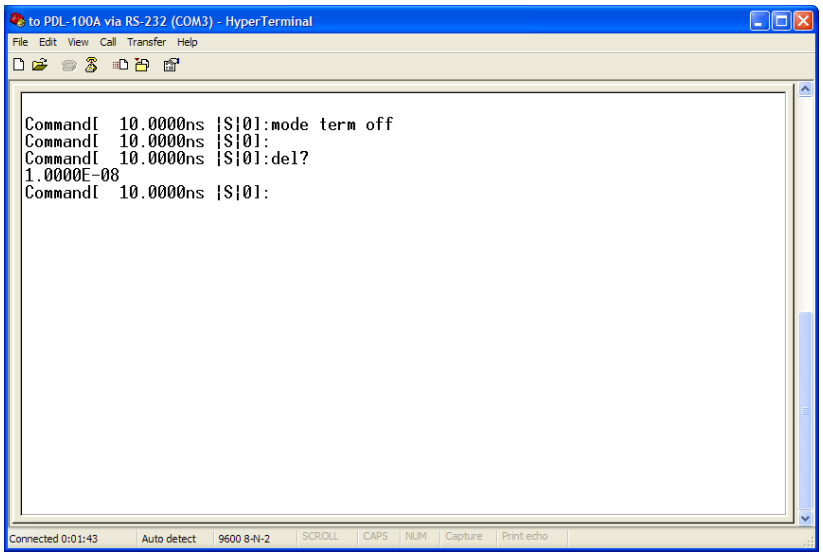
3. Select 9600 bits per second to connect to the PDL-100A.

4. Select 2 Stop bits.

5. Select None for Flow Control



6. Press OK button to continue.



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Now that HyperTerminal has started and is configured correctly, you can enter commands and query the PDL-100A unit from this application. See Chapter 5.0 Common Commands and Chapter 6.0 System Commands for specific commands supported.

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5.0 Common Commands

The IEEE 488.2 standard defines a set of Common Commands. Instruments that adhere to this standard will all respond to these commands in the same manner.

The Common Commands are used to set and query instrument status and the status enable registers. They also include commands to reset the instrument and to inquire about the manufacturer.

5.1.0 Summary of Common Commands

***CAL**	Calibrate Instrument
***CAL?**	Calibrate Instrument and Returns Status
***IDN?**	Identification String (model and serial number)
***RST**	Reset Command
***OPC**	Set Operation Complete Bit
***OPC?**	Query Operation Complete Bit
***TST?**	Test Relays and Returns Status
***ESE mask**	Enable Event Status Register and Set Mask
***ESE?**	Query Event Status Register (ESR) Mask
***ESR?**	Query Event Status Register (ESR)
***CLS**	Clears the Event Status Register (ESR)

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*CAL	Calibration	COMMAND

The *CAL command performs a calibration check on the electromechanical trombone and resets the delay position to 0.00 ps.

Command Syntax

*CAL

Example

*CAL

Returns

None

Programming Example

```
HP : OUTPUT 705;"*CAL"<NL>
NI : CWGPIB.Write "*CAL"
```


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*CAL? Calibration Query QUERY

The *CAL? query performs a calibration check and returns the result. Relays (if installed) are cycled OFF, ON, and then OFF.
Delay position is set to 0.00 ps.

Command Syntax

*CAL?

Example

*CAL?

Returns

<decimal integer><NL>

0 = Calibration test passed.
1 = Calibration test failed. Service Required.

Programming Example

```
HP : DIM RESPONSE$(50)
     OUTPUT 705;"*CAL?" <NL>
     ENTER 705; RESPONSE$
     PRINT RESPONSE$

NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*CAL?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Response is " & QUERY_RESPONSE)
```

Note: It may take up to 20 seconds to perform the calibration check. If you are commanding the unit via GPIB, this query may TIMEOUT before the instrument returns a status value.

*IDN? Identification QUERY

This command queries the PDL-100A for its identification string and returns:
Colby Instruments,PDL-100A-10.0NS,07061234,V1.70.

Colby Instruments,	Denotes manufacturer
PDL-100A-10.0NS, 07061234,	MODEL NAME-MODEL NUMBER-MAX DELAY, SERIAL NUMBER
V1.70	Software version.

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NOTE: VERSION 1.30 FIRMWARE and above returns comma separated values.

Command Syntax

*IDN?

Example

*IDN?

Returns

<string> <NL>
Colby Instruments,PDL-100A-10.0NS,07061234,V1.70.

Programming Example

```
HP : DIM ID$(50)
     OUTPUT 705;"*IDN?"<NL>
     ENTER 705;ID$
     PRINT(ID$)

NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*IDN?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Response is " & QUERY_RESPONSE)
```

*RST Reset COMMAND

The *RST (Reset) command performs a device reset and sets the PDL-100A to its initial POWER-ON state.
The following steps will be performed:

- Initialize Microterminal (if connected)
- Reset the delay line to zero delay, 0.00 ps
- All relays turned OFF (no delay)
- New Network IP addresses (if previously changed) take effect
- GPIB address switches (if changed) take effect

Command Syntax

*RST

Example

*RST

Returns

None

Programming Example

```
HP : OUTPUT 705;"*RST"<NL>
NI : CWGPIB.Write "*RST"
```


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*OPC Operation Complete COMMAND

The *OPC command will cause the PDL-100A to set the operation complete bit (bit 0) in the Standard Event Status Register (ESR) when all pending device operations have finished.

NOTE: The PDL-100A blocks (i.e. does not return) until all operations are completed.

Command Syntax *OPC

Example *OPC

Returns None

Programming Example

```
HP : OUTPUT 705;"*OPC"<NL>
NI : CWGPIB.Write "*OPC"
```

*OPC? Operation Complete Query QUERY

The *OPC? query returns the status of the operation complete bit (bit 0) in the Standard Event Status Register(ESR).

Command Syntax *OPC?

Example *OPC?

Returns <decimal integer><NL>
0 = Operation pending (not completed yet or not started yet)
1 = Operation completed

Programming Example

```
HP : DIM OPC$(50)
     OUTPUT 705;"*OPC?"<NL>
     ENTER 705;OPC$
     PRINT(OPC$)
NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*OPC?"
     QUERY_RESPONSE = CWGPIB.Read(250)
    MsgBox ("Response is " & QUERY_RESPONSE)
```


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*TST?	Test Operation Query	QUERY

The *TST? query initiates an internal self-test by setting all relays off, moving the electromechanical trombone to zero delay, and re-initializing all internal variables.

Command Syntax

*TST?

Example

*TST?

Returns

<decimal integer><NL>
0 = Internal self-test passed.
1 = Internal self-test failed.

Programming Example

```
HP : DIM TST$(50)
     OUTPUT 705;"*TST?"<NL>
     ENTER 705;TST$
     PRINT(TST$)
NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*TST?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Response is " & QUERY_RESPONSE)
```

Note: It may take up to 20 seconds to perform the calibration check. If you are commanding the unit via GPIB, this query may TIMEOUT before the instrument returns a status value.

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*ESE Event Status Enable COMMAND

The *ESE command sets the Standard Event Status Enable Register bits. The ESR Register contains a mask value for the bits to be enabled in the Standard Event Status Register. A one in the ESR mask will enable the corresponding bit in the ESR to be reported, a zero will disable the bit. For example, a mask value of 255 will enable all bits while a mask value of 1 will enable only the OPC bit to be set.

Command Syntax

*ESE **mask_value**

Where mask_value is

Bit #	Value	Enables
7	128	PON – Power on (not used)
6	64	URQ – User Request (not used)
5	32	CME – Command Error
4	16	EXE – Execution Error
3	8	DDE – Device Dependent Error
2	4	QYE – Query Error
1	2	RQC – Request Control (not used)
0	1	OPC – Operation Complete

Example

```
*ESE 1
```

Returns

None

Programming Example

```
HP : OUTPUT 705;"*ESE 255"
NI : CWGPIB.Write "*ESE 1"  'enable OPC bit
```


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*ESE? Event Status Enable Mask QUERY

The *ESE? query returns the ESE mask set for the ESR register.

Command Syntax

*ESE?

Example

*ESE?

Returns

<decimal integer><NL>

Example

```
HP : DIM ESE_MASK$(50)
     OUTPUT 705;"*ESE?"<NL>
     ENTER 705;ESE_MASK$
     PRINT(ESE_MASK$)
NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*ESE?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("ESR Mask is " & QUERY_RESPONSE)
```

*ESR? Operation Complete QUERY

The *ESR? Query returns the contents of the Standard Event Status Register (ESR). Reading this clears the Standard Event Status Register, as does the *CLS command.

NOTE: Use the *ESE command to set the mask value to determine which bits are reported in the ESR register.

Command Syntax

*ESR?

Example

*ESR?

Returns

<decimal integer><NL>

Example

```
HP : DIM ESR$(50)
     OUTPUT 705;"*ESR?"<NL>
     ENTER 705;ESR$
     PRINT(ESR$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*ESR?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Response is " & QUERY_RESPONSE)
```


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*CLS	Clear Status	COMMAND

The *CLS command clears the Standard Event Status Register (ESR) and resets any pending errors codes.

Command Syntax

*CLS

Example

*CLS

Returns

None

Example

```
HP : OUTPUT 705;"*CLS"<NL>
NI:  CWGPIB.Write "*CLS"
```


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6.0 System Commands

These System Commands are specific to the PDL-100A Series instruments:

6.1.0 Summary of System Commands

DEC	Decrement Command
DEL arg [PS | NS]	Delay Command
DEL?	Delay Query
DTIME?	Elapsed Time Query
ERR?	Error Query
EXEC	Execute Command
INC	Increment Command
MODE SER | PAR| 312.5PS | 625PS	Mode Command
MODE?	Mode Query
NET IP | GW | NM | PORT | DHCP arg	Network IP Command
NET?	Network Query
NETM?	Network MAC ID Query
RATE	Rate Command
RATE?	Rate Query
REL arg ON | OFF	Relay Command
REL?	Relay Query
STEP arg [PS | NS]	Step Command
STEP?	Step Query
STORE arg1 arg2	Store Command
STORE?	Store Query
XDD	Acceleration Limit Command
XDD?	Acceleration Limit Query

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DEC	DECREMENT	COMMAND

	Decrement the delay setting by step size amount.
Command Syntax	DEC
Example	DEC
Returns	None
Programming Example	`HP : OUTPUT 705;"DEC 100 ps"<NL>` `NI : CWGPIB.Write "DEC"`

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DEL	Delay	COMMAND

The DEL command sets the delay of the unit. The desired delay must be within the total delay range of the device.

Delay can be specified in picosecond (ps) and nanosecond (ns) units or in scientific notation. The PDL-100A will round DOWN to the nearest step size resolution if unable to provide exact delay as entered.

Command Syntax

DEL **arg [PS | NS]**

arg = desired delay value. For scientific notation, use <x.xxxxxE-yy> where (x..x) is a 4 digit mantissa and (yy) is a two digit exponent. E.g. 3.0000E-10 is 300.0 picoseconds.

PS = picoseconds
NS = nanoseconds

Note: Picoseconds is the units used if no units are specified in the command line.

Example

```
del 100.50 ps
DEL 123 NS
del 10.50e-12
```

Returns

None

Programming Example

```
HP : OUTPUT 705;"del 123 ps"<NL>
NI : CWGPIB.Write "DEL 123.50 PS"
```

Note: When programming or commanding the instrument over GPIB; sending a valid DEL command will also place the instrument in LOCAL LOCKOUT mode. The MT-100A Microterminal (if attached) will not accept any delay settings while in LOCAL LOCKOUT mode. LOCAL LOCKOUT mode can be released when any command query, e.g. DEL? or *OPC? is issued.

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DEL?	Delay	QUERY

The DEL? query command is used to return the current delay setting of the unit.

Command Syntax

DEL?

Example

DEL?

Returns

<x.xxxxxE-yy><NL>

(x..x) is a 4 digit mantissa and (yy) a two digit exponent.

For example, **3.0000E-10** is 300.00 picoseconds.

Programming Example

```
HP : OUTPUT 705;"DEL?"<NL>
     ENTER 705;Delay$
     PRINT (DELAY$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "DEL?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Delay is set at " & QUERY_RESPONSE)
```


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DTIME?	Delta Time Query	QUERY

The DTIME? query returns the elapsed time to perform the previous delay setting. Results are returned in units of milliseconds.

Command Syntax

DTIME?

Example

DTIME?

Returns

<DECIMAL INTEGER><NL>

Number of milliseconds elapsed to perform previous delay setting.

Programming Example

```
HP : OUTPUT 705;"DTIME?"<NL>
     ENTER 705;DTIME$
     PRINT (DTIME$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "DTIME?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("DTIME = " & QUERY_RESPONSE)
```


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ERR? ERROR QUERY

The ERR? query returns the last error number encountered.

Command Syntax

ERR?

Example

ERR?

Returns

<DECIMAL INTEGER><NL>

0 = No Error
1 = Invalid Command
2 = Invalid Argument
3 = Unit did not pass calibration
4 = Delay setting requested is beyond range of device.
5 = Delay not set
99 = Buffer overflow

Programming Example

```
HP : DIM Error$(100)
     OUTPUT 705;"ERR?"<NL>
     ENTER 705;Error$
     PRINT (ERROR$)
NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "ERR?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Last Error Code # " & QUERY_RESPONSE)
```

EXEC EXECUTE COMMAND

Sets the delay and stepper motor rate from settings defined in the next item in FIFO stack.

Command Syntax

EXEC

Example

```
EXEC
```

Returns

None

Programming Example

```
HP : OUTPUT 705;"EXEC"<NL>
NI : CWGPIB.Write "EXEC"
```


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INC	INCREMENT	COMMAND

Increment the delay setting by step size amount.

Command Syntax

INC

Example

INC

Returns

None

Programming Example

```
HP : OUTPUT 705;"INC"<NL>
NI : CWGPIB.Write "INC"
```

MODE	MODE	COMMAND

Set the operating mode for the PDL-100A.

- SERIAL mode step size increment is 0.50 ps
- PARALLEL mode step size increment is 0.25 ps and total delay range is 0 to 312.50 ps.

Command Syntax

MODE [SER | PAR | 312.5ps | 625ps]

SER	Set the PDL-100A to Serial Trombone Mode
PAR	Set the PDL-100A to Parallel Trombone Mode
312.5ps	Set the PDL-100A to Parallel Trombone Mode
625ps	Set the PDL-100A to Serial Trombone Mode

Example

```
MODE 312.50ps
MODE SER
MODE 625PS
```

Returns

None

Programming Example

```
HP : OUTPUT 705;"MODE SER"<NL>
NI : CWGPIB.Write "MODE PAR"
```


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MODE?	MODE	QUERY

The MODE? query command is used return the current Trombone operating mode for the PDL-100A.

Command Syntax

MODE?

Example

MODE?

Returns

<ASCII TEXT><NL>

625ps	Serial Trombone Mode
312.5ps	Parallel Trombone Mode

Programming Example

```
HP : OUTPUT 705;"MODE?"<NL>
     ENTER 705;MODE$
     PRINT (MODE$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "*ESR?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Current MODE is " & QUERY_RESPONSE)
```


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NET NETWORK COMMAND

The NET command sets the network addresses and other network settings for the instrument. Addresses are stored in non-volatile memory.

Command Syntax

NET **[IP | GW | NM | PORT | DHCP] arg**

IP = XXX.YYY.ZZZ.AAA
Set IP address

GW = XXX.YYY.ZZZ.AAA
Set Gateway IP address

NM = XXX.YYY.ZZZ.AAA
Set Network Mask address

PORT = XXXX
Set Network Port #

DHCP = ON | OFF
Set DHCP to ON or OFF

NOTE: Network values are stored in non-volatile memory and do not take effect until the next power cycle or *RST command is performed.

Example

NET IP 192.168.100.10
NET NM 255.255.0.0
NET PORT 5678
NET DHCP OFF

Returns

None

Programming Example

```
HP : OUTPUT 705;"NET DHCP ON"<NL>
NI : CWGPIB.Write "NET IP 192.168.100.11"
```


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NET?	NETWORK ADDRESS	QUERY

The NET? query retrieves the values for the ***currently set*** network addresses. Note: if no network cable is connected, the IP address returned is invalid (e.g. 0.0.0.0).

Command Syntax

NET?

Example

NET?

Returns

<ASCII TEXT><NL>

IP=192.168.100.8,NM=255.255.255.0,GW=192.168.100.1, PORT=1234,DHCP=OFF

Programming Example

```
HP : OUTPUT 705;"NET?"<NL>
     ENTER 705;NETWORK$
     PRINT (NETWORK$)
NI : DIM RESPONSE As Variant
     CWGPIB.Write "NET?"
     RESPONSE = CWGPIB.Read(250)
     MsgBox ("Network settings : " & RESPONSE)
```


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NETM? NETWORK MAC_ID ADDRESS QUERY

The NETM? query returns the network MAC address.

Command Syntax

NETM?

Example

NETM?

Returns

<ASCII TEXT><NL>

MAC_ID=0090-C2C4-CDCE

Programming Example

```
HP : OUTPUT 705;"NETM?"<NL>
     ENTER 705;NETWORK$
     PRINT (NETWORK$)
NI : DIM RESPONSE As Variant
     CWGPIB.Write "NETM?"
     RESPONSE = CWGPIB.Read(250)
     MsgBox ("Network MAC ID: " & RESPONSE)
```


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RATE	RATE	COMMAND

Set the stepper motor movement rate.

Command Syntax

RATE **arg**

arg **=** stepper motor rate. Rate value must be between 100 and 550. Default is 550 (max speed).

Example

RATE 500

Returns

None

Programming Example

```
HP : OUTPUT 705;"RATE 500"<NL>
NI : CWGPIB.Write "RATE 500"
```

RATE	RATE?	QUERY

Returns the current stepper motor rate setting.

Command Syntax

RATE?

Example

RATE?

Returns

<ASCII TEST><NL>

550

Programming Example

```
HP : OUTPUT 705;"RATE?"<NL>
     ENTER 705;RATE$
     PRINT (RATE$)
NI : DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "RATE?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Motor rate is:" & QUERY_RESPONSE)
```


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REL RELAY COMMAND

The REL command sets the relay #x to ON (delay) or OFF (no delay) state.

Command Syntax

REL **X ON | *OFF***

X = desired relay number 1 to 16. (0 sets ALL relays.)
ON = set relay X to ON
OFF = set relay X to OFF

NOTE: Relay numbering is from left to right. Relay # 16 (most delay) is on the left, while relay # 1 is on the right (least delay).

Example

REL 8 ON

Returns

None

Programming Example

```
HP : OUTPUT 705;"REL 1 ON"<NL>
NI : CWGPIB.Write "REL 1 OFF"
```


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REL?	RELAY	QUERY

The REL? query asks for the status of all relays, 16 (far left) through 1 (far right).

Command Syntax

REL?

Example

REL?

Returns

<ASCII text><NL>

0001000000101011, X.YYYY ns

0 = Relay OFF
1 = Relay ON

X.YYYY ns = total delay

Programming Example

```
HP : OUTPUT 705;"REL?"<NL>
     ENTER 705;REL$
     PRINT (REL$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "REL?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Relay status is:" & QUERY RESPONSE)
```


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RELC	RELC	COMMAND

	Toggles (turn on and off) all relays for the specified number of cycles.
Command Syntax	RELC ***arg*** **arg** is the number of cycles to toggle relays
Example	RELC 50
Returns	None
Programming Example	`HP : OUTPUT 705;"RELC 50"<NL>` `NI : CWGPIB.Write "RELC 50"`

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STEP	STEP	COMMAND

Sets the step size for the delay setting. Step size can be specified in picosecond (ps) or nanosecond (ns) units or using scientific notation. The PDL-100A will round DOWN to the nearest step size resolution if unable to provide exact step size as entered.

Command Syntax

STEP ***arg*** **[ps | ns]**

arg is the delay step size. For scientific notation, use <x.xxxxxE-yy> where (x..x) is a 4 digit mantissa and (yy) is a two digit exponent. E.g. 3.0000E-10 is 300.0 picoseconds.
ps sets the delay in picoseconds
ns sets the delay in nanoseconds

Example

STEP 100 PS
STEP 1 NS
step 3.0e-11

Returns

None

Programming Example

```
HP : OUTPUT 705;"STEP 100 ps"<NL>
NI : CWGPIB.Write "STEP 123.50 PS"
```

STEP?	STEP	QUERY

The STEP? query command is used to return the current delay setting step size.

Command Syntax

STEP?

Example

STEP?

Returns

<x.xxxxxE-yy><NL>
(x..x) is a 4 digit mantissa and (yy) a two digit exponent.
For example, **3.0000E-10** is 300.00 picoseconds.

Programming Example

```
HP : OUTPUT 705;"STEP?"<NL>
     ENTER 705;STEP$
     PRINT (STEP$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "STEP?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Step size is: " & QUERY_RESPONSE)
```


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STORE	STORE	COMMAND

Stores a delay setting and stepper motor rate pair into the First-In-First-Out (FIFO) stack of pre-stored delay settings. There is a maximum of 100 items in the FIFO stack.

Command Syntax

STORE **delay rate**

delay = desired delay in picoseconds.

Must be between >=0 and <= 625.0.

NOTE: The PDL-100A is capable of 0.5 ps step resolution, e.g. enter a delay of 312.5 for a setting of 312.5 ps. Do not specify a trailing zero, e.g. 312.50.

rate = stepper motor rate.
Must be integer >= 100 and <= 550.
Note: if rate is set to 0, the delay setting will be ignored. Use STORE 0 -1 to clear the FIFO stack.

Example

STORE 525.5 300

Returns

None

Programming Example

```
HP : OUTPUT 705;"STORE 525.50 300”<NL>
NI : CWGPIB.Write “STORE 525.50 300”
```

NOTE: Use the STORE command to pre-load delay settings into a FIFO stack. The EXEC command will execute the delay and motor rate settings from the next item in the stack.

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STORE?	STORE?	QUERY

The STORE? Query returns the contents of all the items in the FIFO stack.

Command Syntax

STORE?

Example

STORE?

Returns

<COUNT=C,XXX.XX,YYY><NL>

C = count of number of items in stack
XXX.XX = delay in picoseconds
YYY = stepper motor rate

STACK IS EMPTY If no items in stack.

COUNT=6,200.00,500,500.00,400,625.00,500,
0.00,550,625.00,550,388.50,300

Programming Example

```
HP : OUTPUT 705;"STORE?"<NL>
     ENTER 705;STACK$
     PRINT (STACK$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "STORE?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Stack contents: " & QUERY_RESPONSE)
```


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XDD	XDD COMMAND
	Set the stepper motor rate acceleration limit.
Command Syntax	XDD **arg** **arg** = stepper motor rate acceleration limit. Must be >= 500 and <=2000.
Example	`XDD 2000`
Returns	None
Programming Example	`HP : OUTPUT 705;"XDD 2000"<NL>` `NI : CWGPIB.Write "XDD 2000"`

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XDD?	XDD?	QUERY

XDD? query returns the stepper motor acceleration limit.

Command Syntax

XDD?

Example

XDD?

Returns

<ASCII TEXT><NL>

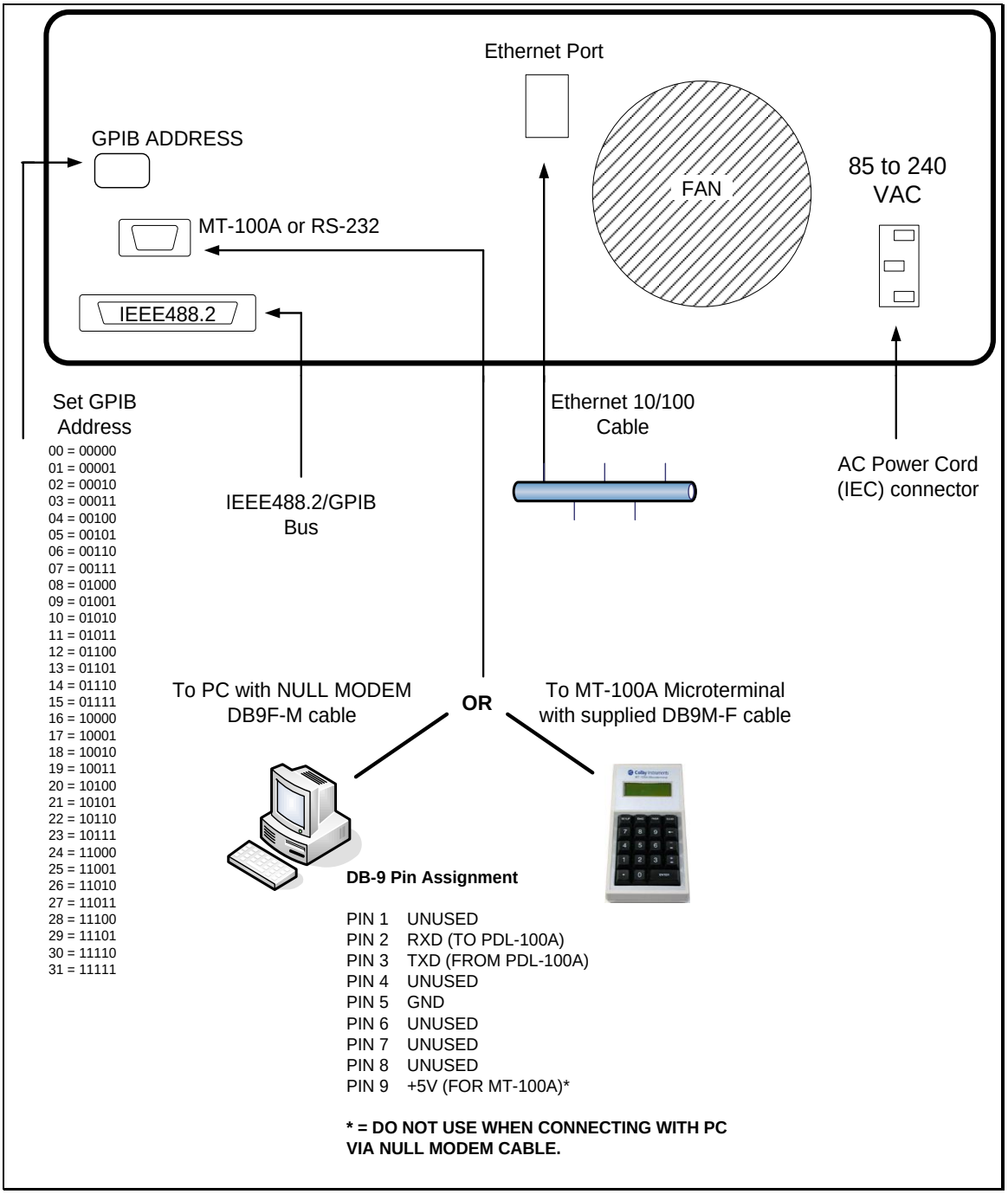
2000

Programming Example

```
HP : DIM ADDR$(10)
     OUTPUT 705;"XDD?"<NL>
     ENTER 705;XDD$
     PRINT (XDR$)
NI:  DIM QUERY_RESPONSE As Variant
     CWGPIB.Write "XDD?"
     QUERY_RESPONSE = CWGPIB.Read(250)
     MsgBox ("Accleration limit is " &
     QUERY_RESPONSE)
```


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7.0 Instrument Backpanel



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