

PDL-201

Polarization Dependent Loss Multimeter



User Guide

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SAFETY CONSIDERATIONS

The following safety precautions must be observed during operation of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. General Photonics assumes no liability for customers' failure to comply with these requirements.

Before operation, the user should inspect the product and review the manual carefully.

Properly ground the chassis and work space using the chassis ground terminal.

Use only in a safe work environment in terms of temperature, humidity, electrical power and risk of fire or shock. The product is designed for indoor use. Avoid exposure to liquids or water condensation. Provide adequate ventilation for cooling.

Operate the product on a stable surface. Avoid excess vibration.

Standard laser safety procedures should be followed during operation.

Never look into the light source fiber connector when the light source is turned on. THE OUTPUT LIGHT FROM A HIGH POWER LASER IS HARMFUL TO HUMAN EYES. Follow industry standard procedures when operating a high power laser source.

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Section 1.0 Overview

The PDL-201 measures polarization dependent loss (PDL), insertion loss (IL), and optical power. It combines General Photonics' PolaRite™ III polarization controller with an optical detection circuit and fast control electronics in a 2U-height, half-rack size enclosure, as shown in Figure 1. It uses a patented deterministic maximum/minimum search method which is independent of optical source wavelength and polarization state, and which accurately measures both high and low PDL. The instrument's range is limited only by the input laser power and the system noise floor.



Figure 1 PDL-201 PDL/IL Multimeter

1.1 Principle of Operation

The PDL-201 covers the 1260-1620 nm fiber transmission window. Its measurement principle is based on the physical definition of PDL:

$$PDL = 10 \log \frac{P_{\max}}{P_{\min}} \text{ (dB)} \quad (1)$$

where P_{\max} and P_{\min} are the maximum and minimum optical output, respectively, under stable, polarized input light, scanning over all polarization states.

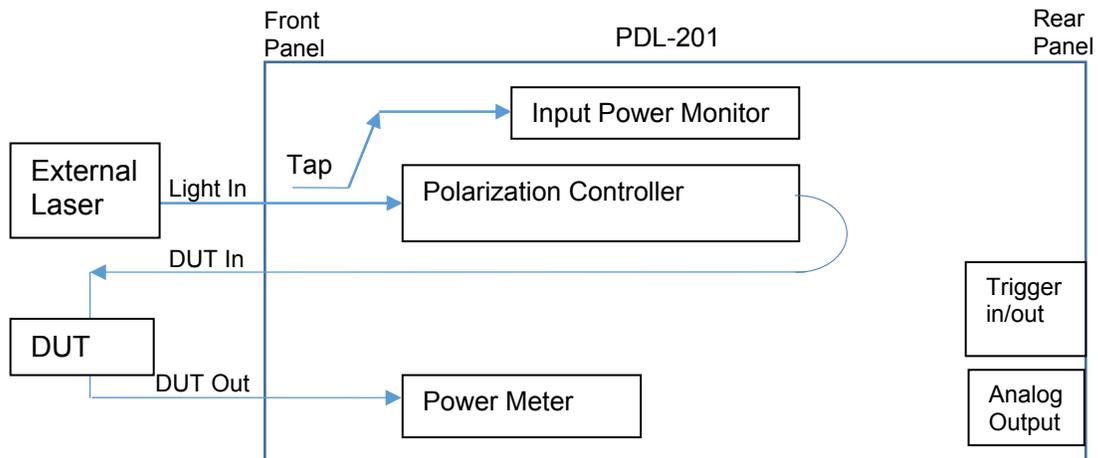


Figure 2 Schematic diagram of PDL-201 in basic setup for PDL/IL measurement.

Figure 2 is a schematic diagram of the PDL-201. At the light input port, there is a tap for an input power monitor. This internal reference power (P_{out}) can be used for IL measurement in PDL/IL measurement mode. The input light passes through a polarization controller which is used to vary the input polarization to the DUT for PDL measurement. A power meter monitors the DUT output power for PDL and IL measurement.

The maximum/minimum search method used by the instrument is a deterministic approach. A physical model of any passive optical component shows that the PDL of the component has a unique value. Polarization analysis shows that any passive optical component can be modeled as a partial polarizer plus a number of lossless polarization conversion elements. Therefore, no local or secondary maxima/minima exist. Using this approach, only the maximum and minimum optical power levels are needed. It is not necessary to scan over all possible input polarization states. Consequently, the measurement time is much smaller than that required by the all-state scanning method (TIA FOTP-157). In addition, the maximum/minimum search algorithm can be implemented for any input wavelength within the fiber transmission window. Unlike the Mueller matrix method, this measurement algorithm requires no wavelength calibration. These properties are particularly useful for broadband component characterization in a production environment.

The optical insertion loss measurement in PDL/IL measurement mode can be done relative to either an internal reference value (measured by the input power monitor) or to a user-defined reference value. The user can define a reference power value by connecting a good, low-loss patch cord between the PDL-201's DUT input and output ports and recording the power reference. The user-defined power reference is measured after the DUT (patch cord) output. The patch cord is then replaced by an actual DUT for the measurement. The PDL-201 calculates IL as follows:

$$IL = 10 \log \frac{P_{avg}}{P_{ref}} \text{ (dB)} \quad (2)$$

where P_{ref} is the reference power level and $P_{avg}=(P_{max}+P_{min})/2$ is the average power level (over input SOP) with the DUT in the optical path. If P_{avg} is lower than P_{ref} , the IL defined by Eq. 2 is negative.

Insertion loss can also be measured in power meter mode. In this mode, the polarization controller is not used, and the IL is calculated as:

$$IL = 10 \log \frac{P_{DUT}}{P_{ref}} \text{ (dB)} \quad (3)$$

Where P_{DUT} is the measured power after the DUT, and P_{ref} is the user-defined reference power value in power meter mode. Note that since there is no averaging of the DUT output power, the IL of a DUT with PDL, measured in this mode, can vary depending on input polarization. This measurement is best used for DUTs with low PDL or for DUTs with preferred alignments, such as polarizers.

The PDL-201 includes an optical power measurement function to facilitate optical power monitoring and connection checking. The PDL-201 includes power measurement calibration data for 1260-1360 and 1440-1620nm. The operation wavelength setting determines the power calibration data used for power measurement. If the operation wavelength setting does not match the light source wavelength, there will be some estimation error due to photodetector responsivity wavelength dependence. The operation wavelength setting affects only the accuracy of the power measurement. PDL and IL are relative measurements and are therefore not affected by the operation wavelength setting.

Section 2.0 Features

2.1 Front Panel and Optical Inputs

The front panel of the PDL-201 is shown in Figure 3.



Figure 3 PDL-201 front panel

Front panel features:

- OLED display: Displays data and operation mode information
- Power: Power on/off switch
- Input: FC/APC adapter for laser input
- DUT 1 (DUT Input) FC/APC adapter for connection to DUT input
- DUT 2 (DUT Output): FC/PC adapter for connection from DUT output
- PDL/IL: Switch to PDL/IL measurement mode
- PWR: Switch to optical power meter mode
- REF: Record power reference for IL measurement
- LOCAL Return to front panel control from remote control
- SETUP: Access the Setup menu.
- ◀ ▶: Navigate selections or move cursor position
- ENTER: Select menu option or move to setup for next parameter.

Fiber Connectors

The PDL-201 has three connector adapters on the front panel: light source input, DUT input, and DUT output. In the standard connector configuration, the light source and DUT input connectors are angled (APC) type connectors. Their adapters are universal connector interfaces (UCI), which feature a male-type adapter top piece that can be removed for direct access to the ferrule end for routine cleaning and maintenance without removing the entire adapter from the panel. This feature helps avoid high insertion loss, high return loss and measurement instability caused by dirty or contaminated connectors. In addition, the universal interchangeable adapter allows the user to switch to ST, SC, or FC connectors without opening the instrument panel. Although the PDL-201 is shipped with FC fiber adapters, other interchangeable inserts are available. For additional information on different input fiber adapter inserts, please contact General Photonics.

The DUT output is a FC free-space adapter to accept a flat (PC) connector. This adapter is not interchangeable and should not be opened by the user.

External fiber connectors should be cleaned using industry standard cleaning methods before connection to the PDL-201. If this procedure is followed before each connection, the instrument's internal connector ferrules should not need regular cleaning. However, high insertion loss or measurement instability that does not improve after cleaning the external connectors may indicate that the instrument's internal connector ferrules require cleaning.

Ferrule Cleaning Procedure

Each connector ferrule is contained in a universal connector interface consisting of a front piece that connects to the external fiber connector, and a base piece that is mounted on the front panel of the instrument, as shown in Figure 4. To clean a connector ferrule, first, make sure no external connector is connected to the universal connector interface. Then, using a Phillips screwdriver, remove the two small screws connecting the front and back parts of the adapter, and carefully pull the front flange straight out. (Note: never remove the adapter base from the front panel). The ferrule end should now be exposed. Clean the ferrule using standard cleaning procedures (compressed air or a fresh lint-free tissue and alcohol or other connector-cleaning solvent), taking care to avoid scratching the ferrule surface. Finally, replace the front flange (position it so that the key notch faces up, and the small alignment pin lines up with the hole in the base piece, before pushing it in) and the screws. For frequent measurements, we recommend that the user prepare a patch cord fiber to avoid wear on the internal connector.

Please note that for the PDL-201, this cleaning procedure applies only for the light input and DUT input connectors. The DUT output adapter should not be opened.

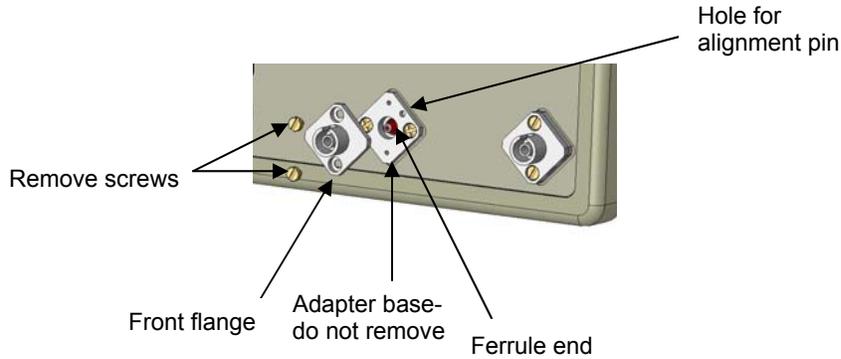


Figure 4 Diagram of universal connector interface

2.2 Rear Panel: Electrical and Remote Control Interfaces

The AC power plug, fuse, analog output, trigger and communication interface connectors are mounted on the rear panel, as shown in Figure 5.

The PDL-201 includes RS-232, USB, Ethernet, and GPIB interfaces for external computer operation of the system. Control commands and remote interface setup information are located in the appendices.

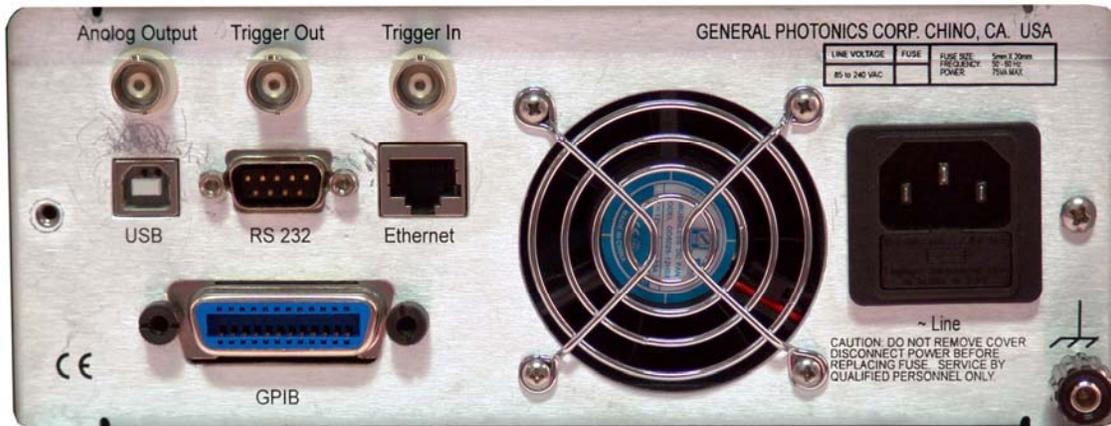


Figure 5 rear panel

Rear Panel Features:

Analog Output: BNC for PDL monitor voltage	Line: External AC input connector
Trigger Out: BNC for output trigger	Cooling fan air outlet
Trigger In: BNC for input trigger	⏏: Chassis ground
USB 2.0 interface port	
RS-232 serial interface port	
Ethernet interface port	
GPIB interface port	

Fuse location:

Figure 6 shows the location of the fuse compartment under the power cord plug. There are two fuses in the compartment- the one in use and a spare. The fuse further inside the compartment is active. The one closer to the compartment opening is the spare.

Replace the fuse with one with the exact rating of the original.



Figure 6 Fuse compartment

Section 3.0 Operation Instructions

3.1 Unpacking

Inspect PDL-201 for any physical damage due to shipping and transportation. Contact carrier if any damage is found. Check the packing list to see if any parts or accessories are missing.

Packing List

Item #	Description
1	PDL-201
2	Power cord
3	RS-232 cable (straight-wired)
4	USB cable
6	User guide
7	Software cd

3.2 Front Panel Operation

1. Connect power cord and plug it into wall receptacle. Make sure the ground pin of the power cord is connected to earth ground.
2. Connect light source and DUT. Make sure laser source is turned off while cleaning connectors and making connections.
3. Power on the light source. Make sure that the input power is within range.

It is important to use a zero or low polarization dependent loss (PDL) attenuator when input optical power exceeds the specified power limit (+6 dBm). The PDL of the components preceding the input connector can affect the measurement accuracy.

4. Turn on the instrument. It will run through an initialization sequence and then run a brief self-test before proceeding to the default measurement screen. If the optical power is out of range, it will display a "power low" or "power high" message.

3.3 Operation Modes

The PDL-201 has two main measurement modes.

PDL/IL measurement

In PDL/IL mode, the PDL-201 measures PDL, IL, and power. The setup for PDL measurement is shown below.

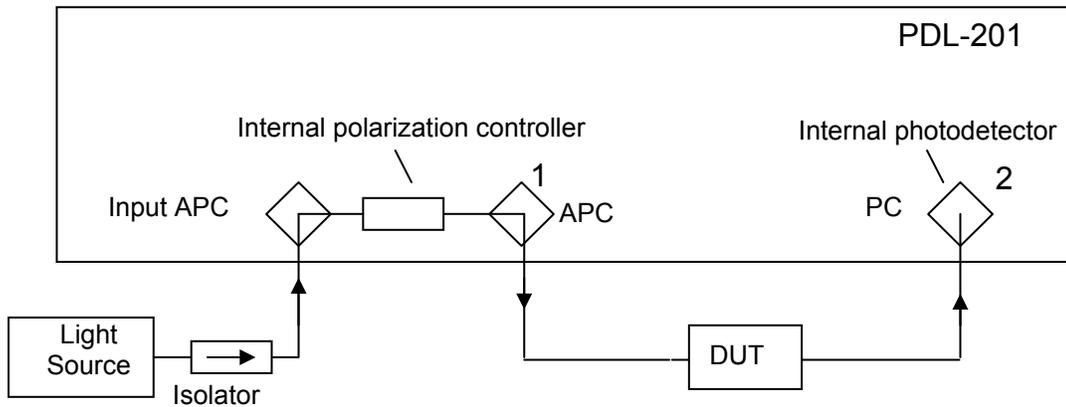


Figure 7 Test setup for PDL measurement

PDL/IL measurement is the default measurement mode. After the PDL-201 completes its self-test on power-up, it goes into PDL/IL measurement mode. This mode can also be accessed by pressing the PDL/IL button on the front panel.

Within PDL/IL mode, there are two alternate IL calculation methods. The arrow keys or thumb wheel can be used to switch between them.

PDL: dB	0.015	IL: dB	1.21	Local λ: 1550 T: 20 Ave: 26
P: mW	0.76	P _{ref} : mW	1.00	

IL relative to saved reference

PDL: dB	0.015	IL: dB	0.65	Local λ: 1550 T: 20 Ave: 26
P: mW	0.76	P _{out} : mW	0.88	

IL relative to internal reference

In the first screen, the IL is calculated relative to a saved reference power level.

Measured parameters:

- PDL: Measured PDL, in dB
- P: Measured power at the DUT output, in selected units (dBm or mW), averaged over all input SOPs
- IL: Measured IL, in dB, relative to saved power reference. If the user has not set a reference, the default reference level is 1 mW (0 dBm)
- P_{ref} : Saved power reference value, in selected units (mW or dBm). P_{ref} is measured after DUT connector 2, with a low-loss reference patch cord connected as the DUT.

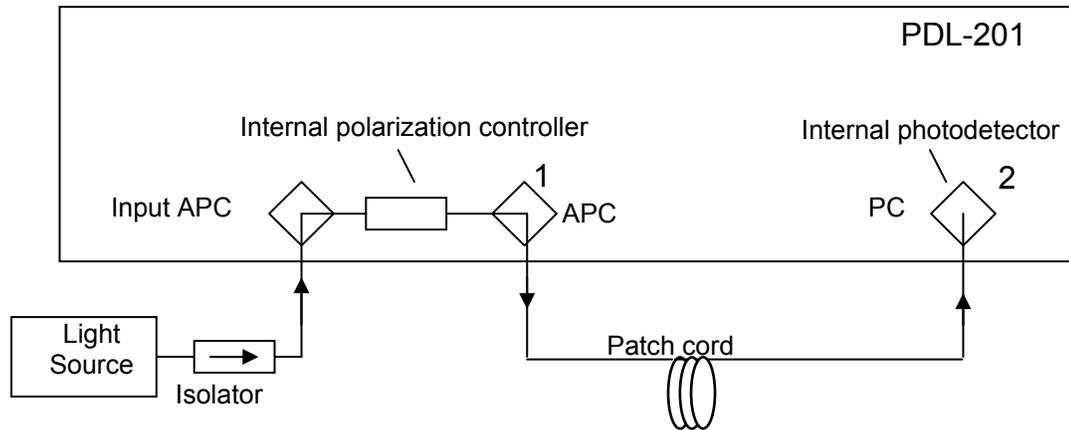


Figure 8 Setup for measurement of P_{ref} for IL measurement in PDL/IL mode

In the second screen, the IL is calculated relative to an internal power reference measured automatically by the input power monitor after the light source input port (see Figure 2).

Measured parameters:

- PDL: Measured PDL, in dB
- P: Measured power at the DUT output, in selected units (dBm or mW), averaged over all input SOPs
- IL: Measured IL, in dB, relative to the internal power reference value.
- P_{out} : Internal power reference, measured before the DUT input, in selected units (mW or dBm). This value is measured automatically.

On both measurement display screens, the right side of the screen displays several operation status and parameter settings:

- Control Mode: Local (front panel) or Remote
- λ : Wavelength setting for power measurement
- T: Measurement period (in ms) for power measurement. (Applies only to power measurement in PWR mode).
- Ave: Number of measurements to be averaged per displayed value (applies to PDL, IL, and power measurements in PDL/IL mode). One power measurement is $P = (P_{max} + P_{min})/2$, scanned over all input SOPs during one measurement cycle.

The wavelength, power measurement period, averaging, and power unit settings can be accessed from the Setup menu.

If the instrument is in remote control, the LOCAL button restores front panel control.

Power Reference

The REF button updates the saved power reference value (P_{ref}) to the power measured at the DUT output. To save a power reference for IL measurement in PDL/IL mode, connect a reference patch cord as shown in Figure 8, make sure the PDL meter is in PDL/IL mode, and press REF. Replace the patch cord with the DUT for PDL/IL measurement.

Note that a power reference saved in PDL/IL mode is used only for IL calculation in PDL/IL mode. The power reference for IL measurement in power meter mode is saved separately.

Power meter (PWR) function

In PWR mode, the PDL-201 acts as a power meter. Since there is no PDL measurement, the internal polarization controller is not needed. The signal under test is connected directly to DUT connector 2.

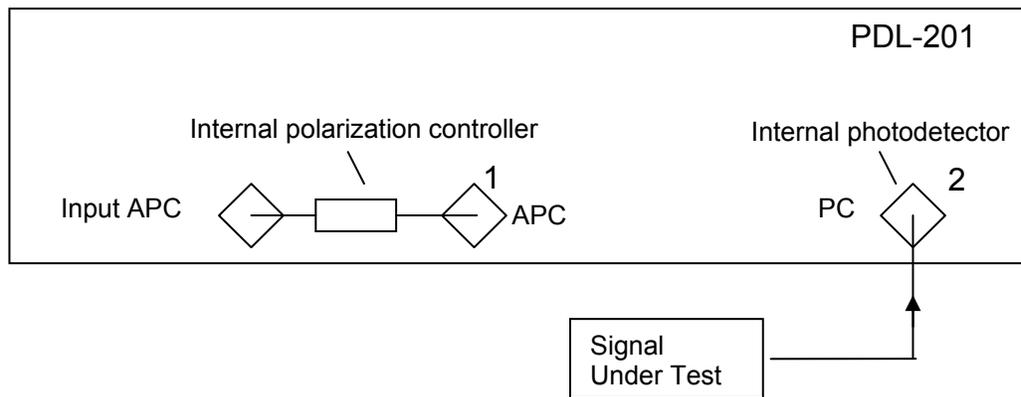


Figure 9 Setup for measurement in Power Meter Mode

The measurement screen displays measured power and IL calculated relative to a saved reference.

P:	-1.21	P:	0.76	Local
dBm		mW		λ : 1550
IL:	0.04	P_{ref} :	0.77	T: 20
dB		mW		Ave: 26

Measured parameters:

P (dBm): Measured power at DUT output port, in dBm

IL: Measured IL, in dB, relative to saved power reference. If the user has not set a reference, the default reference level is 1 mW (0 dBm)

P (mW): Measured power at the DUT output port, in mW
 P_{ref}: Saved power reference value, in selected units (mW or dBm).

Since the polarization controller is not used in power meter mode, the measured power does not include input SOP averaging.

The status and control parameter display on the right side of the screen is the same as for PDL/IL measurement mode.

Power Reference

The REF button updates the saved power reference value used for IL calculation to the power measured at the DUT output (DUT connector 2).

Note that a power reference saved in PWR mode is used only for IL calculation in PWR mode. The power reference for PDL/IL mode is saved separately.

Setup

The setup menu allows the user to set up several operation parameters.

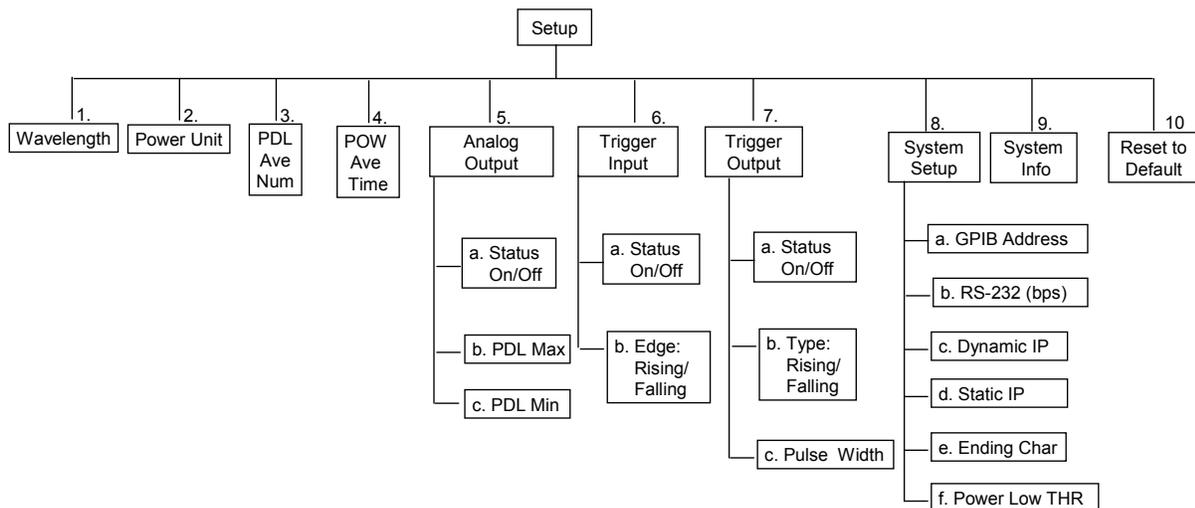


Figure 10 Setup menu hierarchy

Press the SETUP button on the front panel to bring up the Setup menu. The screen displays 2 options at a time:



Etc.

Use the wheel to scroll through options and the ENTER key to select an option.

Most setup parameters are written to nonvolatile memory and retained after power-off. Exceptions are noted in the descriptions below.

Wavelength:

The wavelength setting is used for power measurement calibrations. Matching the PDL-201's wavelength setting to the wavelength of the light source ensures the accuracy of the power measurement. The wavelength setting does not affect the accuracy of the PDL or IL measurements.



Wavelength(P)
1550 nm

Use the arrow keys to move the cursor, the wheel to change the value of the selected digit, and ENTER to execute the setting and return to the SETUP menu.

Calibrated Wavelength Range: 1260-1360 and 1440-1620nm

Default Value 1550nm

Power Units:

The measured power can be expressed in terms of dBm or Watts. The default setting is dBm.



Power Units
dBm

Rotate the wheel to toggle between dBm and Watts. Press ENTER to execute the setting and return to the SETUP menu.

PDL Ave. Num.:

The parameters (PDL, IL, power) measured in PDL/IL mode are averaged over the selected number of max/min search cycles.



Average Number
1

Use the arrow keys to move the cursor, the wheel to change the value of the selected digit, and ENTER to execute the setting and return to the SETUP menu.

Range: 1 to 256

Default value: 1

POW Ave. Time:

This setting determines the measurement period for power measurement in power meter mode.



Use the arrow keys to move the cursor, the wheel to change the value of the selected digit, and ENTER to execute the setting and return to the SETUP menu.

Range: 1 to 100 ms

Default value: 1

Analog Output:

The PDL meter has an analog monitor voltage output that can be used to monitor the PDL of the device under test. The voltage varies linearly with PDL over a 0 to 3.5V range. The user can specify the PDL limits PDL_{max} (corresponding to the maximum voltage 3.5V) and PDL_{min} (corresponding to the minimum voltage 0V). If the DUT output power drops below the power low threshold P_{th} , regardless of measured PDL, the analog output will automatically be set to 4V to act as a "power low" indicator.

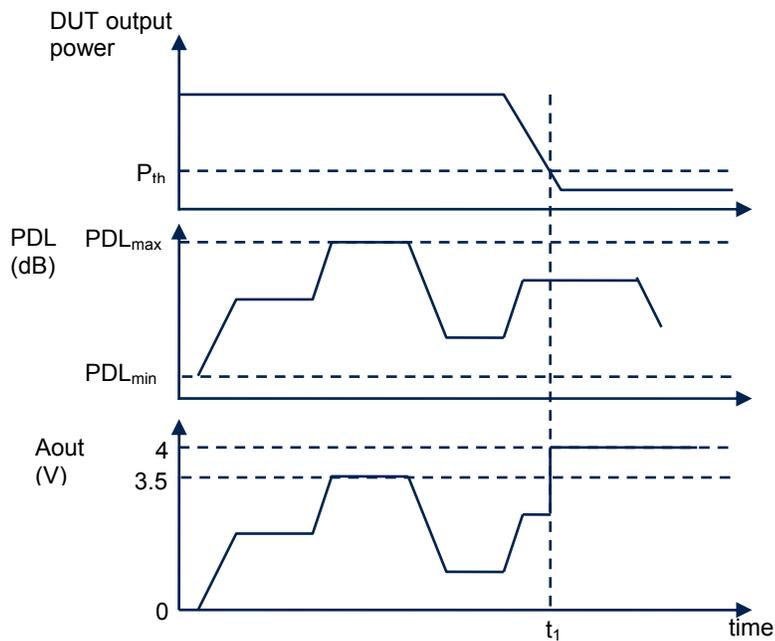


Figure 11 Relationship between PDL, power threshold, and analog monitor voltage.

Figure 11 shows how the analog output voltage responds to different combinations of measured PDL and DUT output power. For time $< t_1$, the DUT output power is above the threshold level P_{th} , and the analog voltage scales with the PDL over the range PDL_{min} to PDL_{max} . At time t_1 ,

the DUT output power drops below P_{th} . At that time, the analog voltage value is set to 4V and no longer responds to changes in PDL.

The default PDL scale settings are $PDL_{max} = 45$ dB and $PDL_{min} = 0.000$ dB, so 3.5V corresponds to $PDL = 45$ dB. However, if the PDL is expected to be between 10 and 20 dB, for example, the user can set PDL_{max} to 20 dB and PDL_{min} to 10 dB, such that the 0-3.5V range corresponds to a PDL range of 10 dB. This allows for better accuracy if the PDL range being monitored is small.

Output connector: BNC connector on rear panel

Monitor Voltage Range: 0-3.5V (varies linearly with PDL), 4V = "power low"

To use the monitor voltage,

1. Connect the analog voltage BNC connector to the monitoring circuit.
2. Set the analog voltage operation parameters:

There are 3 setup parameters:

5a: Analog Out: ON	Options: ON, OFF	Default: ON
5b: PDL_{Max} : 30.000 dB	Range: 0.000 to 45 dB	Default: 45 dB
5c: PDL_{Min} : 0.000 dB	Range: 0.000 to ($PDL_{Max} - 0.001$)	Default: 0.000

With the cursor on the index number, use the wheel to scroll between options. Use the ENTER key to move the cursor from index selection to parameter setting. With the cursor on the parameter to be set, use the arrow keys to move the cursor position and the wheel to change the value of the selected digit or parameter. When the parameter is set, use the ENTER key to move the cursor back to the index position.

The Min and Max PDL settings are retained after power-off, but the analog output enable/disable setting is not. On power-up, the analog output will be enabled.

Trigger Input:

With the input trigger enabled, the PDL meter takes one measurement when it receives a trigger pulse. This function can be used for synchronization with other equipment.

The user can select whether to trigger on the rising or falling edge of the input pulse.

6a: Trigger-In: OFF
6b: Trigger: Rising

With the cursor on the index number, use the wheel to scroll between options. Use the ENTER key to move the cursor from index selection to parameter setting. With the cursor on the parameter to be set, use the arrow keys to move the cursor position and the wheel to change the value of the selected digit or parameter. Use the ENTER key to execute the setting and move the cursor back to the index position.

Input trigger settings are not retained after power-off. On power-up, the input trigger will be set for rising edge, and the trigger will be disabled.

The amount of time needed per measurement depends on the average number setting, which determines the number of max/min search cycles required to complete one measurement.

Input trigger connector: BNC connector on rear panel.

Pulse voltage: TTL levels

Minimum pulse width: 2 ms

Minimum interval between pulses: 30 ms × average number setting

Triggered Array Measurement

In PDL/IL measurement mode with the input trigger enabled, each time the PDL-201 makes a triggered measurement, it saves the measured data set to a stored array. Each data set consists of 3 measured parameters: PDL, DUT output power (P), and internal power reference at the DUT input port (P_{out}). The array can contain up to 3330 sets of data. If the counter is not reset before it reaches 3330, subsequent sets of data will not be stored. The data can be queried by remote control only. The user can set the number of data sets to be retrieved in an array query (data array printout length). The response to the array query is all of the stored data in array positions 1 to the printout length, separated by commas. If the specified printout length exceeds the number of measured data sets, the PDL-201 will return NA for all requested array elements that do not contain data. For example, if the printout length is set to 3, and there are currently 2 sets of measured data in the array, the response to the array query will look like:

```
PDL1,P1,Pout1,PDL2,P2,Pout2,NA,NA,NA
```

The general procedure to use this function is:

1. Set up desired measurement parameters.
2. Reset counter.
3. Enable input trigger.
4. Set data array printout length.
5. Take data.
6. Send array query command to retrieve data.

A sample command sequence for this function is provided in Appendix 1.

Note: For GPIB, the PDL-201 sends one data set, followed by the EOS character, for each read operation. Therefore, to retrieve 10 sets of data, the user would set the array printout length to 10, take the data, send the array query command, and perform 10 read operations.

Stored array data is lost and the counter resets to zero when the instrument is powered off.

Trigger Output:

With the output trigger enabled, the PDL meter generates a trigger pulse each time it completes a measurement. This function can be used for synchronization with other equipment.

The user can set the width of the pulse and whether it is a rising  or falling  pulse.

There are 3 setup parameters:

7a: Trigger Out: OFF	Options: ON, OFF	Default: OFF
7b: Trigger: Rising	Options: Rising, Falling	Default: Rising
7c: Pulse-Wt: __1000us	Range: 1000 to 65535 μ s,	Default: 1000 μ s

With the cursor on the index number, use the wheel to scroll between options. Use the ENTER key to move the cursor from index selection to parameter setting. With the cursor on the parameter to be set, use the arrow keys to move the cursor position and the wheel to change the value of the selected digit or parameter. Use the ENTER key to execute the setting and move the cursor back to the index position.

Only the pulse width setting is retained after power-off. On power-up, the output trigger will be set for a rising pulse, and the trigger will be disabled.

Output trigger connector: BNC connector on rear panel.

Pulse voltage: TTL levels

Timing for Trigger In, Trigger Out, and Analog Output

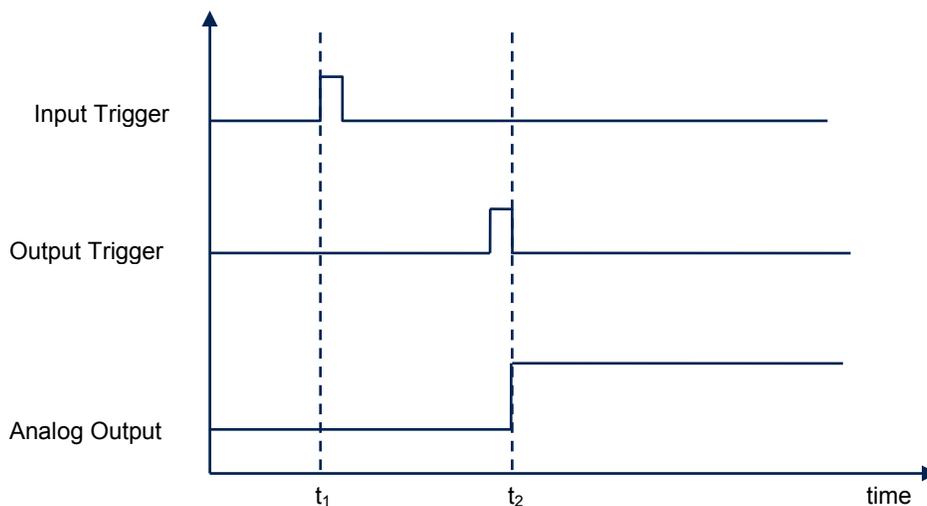


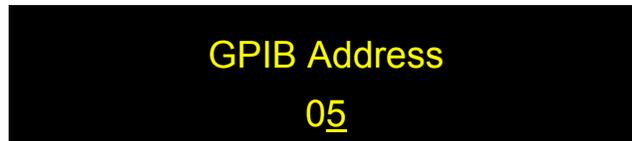
Figure 12 Timing diagram for input and output triggers and analog output

Figure 12 shows the timing sequence if the input and output trigger are used with the analog output voltage. In this example, the input trigger is on the rising edge, and the output trigger is a rising pulse. After the input trigger edge is received (t_1), the PDL-201 will take a measurement according to the current measurement setup parameters. The time required for measurement may vary depending on the power level and averaging setting. When the measurement is completed, the PDL meter sends an output trigger pulse. After the output trigger pulse is sent (t_2), the analog monitor voltage value will update, and the measured data can be queried via remote control command.

System Setup:

This section contains the setup options for remote control.

a. GPIB Address

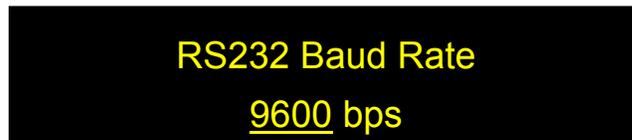


This option sets the instrument's GPIB address.

Range: 1-30
Default: 5

Use the wheel to change the GPIB address and press ENTER to execute the new setting.

b. RS-232 Baud rate



Use the wheel to change the RS-232 baud rate setting, and ENTER to execute the new setting.

Options: 110, 300, 600, 1200, 2400, 4800, 9600, 19200, 28800, 38400, 43000, 56000, 57600, 115200, 128000, 230400, 460800
Default: 9600

c. Dynamic IP

The instrument's IP address must be known in order to control it via Ethernet.

The "Dynamic IP" option sets the instrument for dynamic IP addressing and requests a dynamic IP address from the server.

From the Setup menu, select "Dynamic IP", then press the ENTER key to request a dynamic IP address from the server.

If the instrument is able to establish communication with the DHCP server and successfully retrieve an IP address, the address will be displayed on-screen.

Dynamic IP Address
192.168.2.150

If the instrument is unable to connect to the server, it may display 0.0.0.0. In this case, first, check the connection, and if necessary, re-send the request.

Dynamic IP addressing is the default Ethernet communication mode for this instrument. After power-off, it will revert to dynamic IP addressing when it is powered back on.

Each time this menu option is selected, the instrument requests a dynamic IP address from the server. If this menu option is selected while the instrument is already in communication using a dynamic IP address, the instrument may be assigned a dynamic IP address other than the one it is currently using. This may interrupt communication, and the address may not be displayed correctly on the front panel.

d. Static IP

Selecting "Static IP" allows the user to set the instrument for Ethernet communication using static IP addressing and to set the static IP address, Net Mask, Gateway, Name Server, and Port. The setup screens for this option are as follows:

IP Address	↓
a. 192.168.002.150	
Netmask	↑
b. 255.255.255.000	↓
Gateway	↑
c. 192.168.002.001	↓
Nameserver	↑
d. 192.168.002.001	↓
Port	↑
e. 023	↓



With the cursor on the index number (a-f), use the wheel to move between static IP setup parameter options.

Press the ENTER or ► keys to move to setup for the displayed parameter.

Use the arrow keys (◀▶) to move the cursor position and the wheel to change the value of the active digit. Once the parameter is set, press ENTER to move the cursor position back to the parameter index (a-f).

When all of the parameters are set, select “Yes” on the “Update Parameters” screen (index f) and press ENTER to apply the settings and set the instrument to static IP addressing.

The display will briefly show:



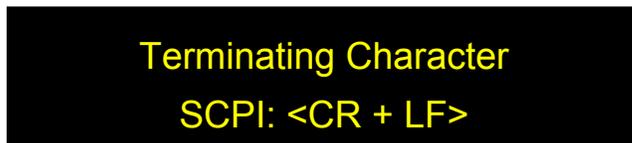
and then return to the Setup menu.

The default port setting is 23. In most cases, this does not need to be changed

If the instrument was originally in dynamic IP mode, it does not change to static IP mode until the user selects “yes” on the “Update Parameters” screen, regardless of whether any of the static IP addressing parameters were actually changed.

e. Ending Char

This option selects the remote control command format. It allows the user to select SCPI or GP command formats, and to specify the end-of-string (EOS) indicator for SCPI.



Options:	SCPI:<CR + LF>	SCPI format, EOS = carriage return and line feed
	GP	GP legacy command format
	SCPI:<CR>	SCPI format, EOS = carriage return
	SCPI:<LF>	SCPI format, EOS = line feed
Default:	SCPI: <CR + LF>	

Rotate the wheel to change the end-of-string indicator setting. Press ENTER to execute the new setting and return to the main menu.

Make sure the command format and EOS settings match the format of the remote control commands being used. Otherwise, the instrument will not recognize the commands.

f. Power Low THR

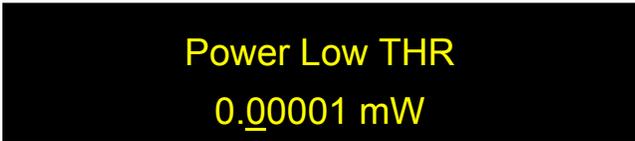
This option allows the user to set the threshold level for DUT output power at which the PDL-201 does not attempt to measure PDL, but simply indicates “power low”.

Under most circumstances, the power low threshold can be left at the default setting. However, because of changes in gain levels, measurement can take longer at lower power levels. The power low threshold can be set to a higher level to limit the variation in measurement cycle times due to power variation. This can be useful if a user is taking timed measurements at short intervals and wants to ensure that measurement periods do not exceed the query intervals.



Power Low THR
-50.0 dBm

or



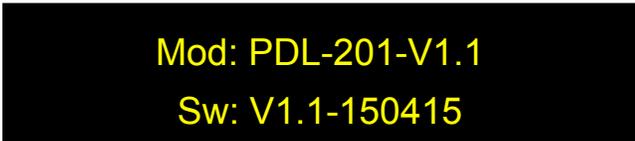
Power Low THR
0.00001 mW

Range:	-50 to -10 dBm	or	0.00001 to 0.1 mW
Default:	-50 dBm	or	0.00001 mW

Use the arrow keys to move the cursor and the wheel to change the value of the active digit. Press ENTER to execute the new setting and return to the main menu.

System Info.

This option displays the instrument’s model number and firmware version.



Mod: PDL-201-V1.1
Sw: V1.1-150415

Reset to Default

Select this option from the Setup menu and confirm update to restore all operation parameters to their initial factory settings, listed below.

Display Mode	PDL/IL
Run Mode	Continuous Measurement
Analog Output	ON
PDL Range for analog output	min = 0.000 dB, max = 45 dB
Trigger In	Disabled
Trigger Out	Disabled
Trigger Output Pulse Width	1000 μ s
Control	Local
Wavelength	1550 nm
PDL Average Number	10
Power Average Time	1 ms
Ending Character	SCPI <CR+LF>
Communication Indicator	OFF
GPIO Address	5
Power Unit	dBm
Power Low Threshold	-50 dBm
RS-232 Baud Rate	9600 bps
Ethernet communication	Dynamic IP

PDL/IL vs. Wavelength Measurement

Used with a tunable laser, the PDL-201 can be used to measure PDL or IL vs. wavelength.

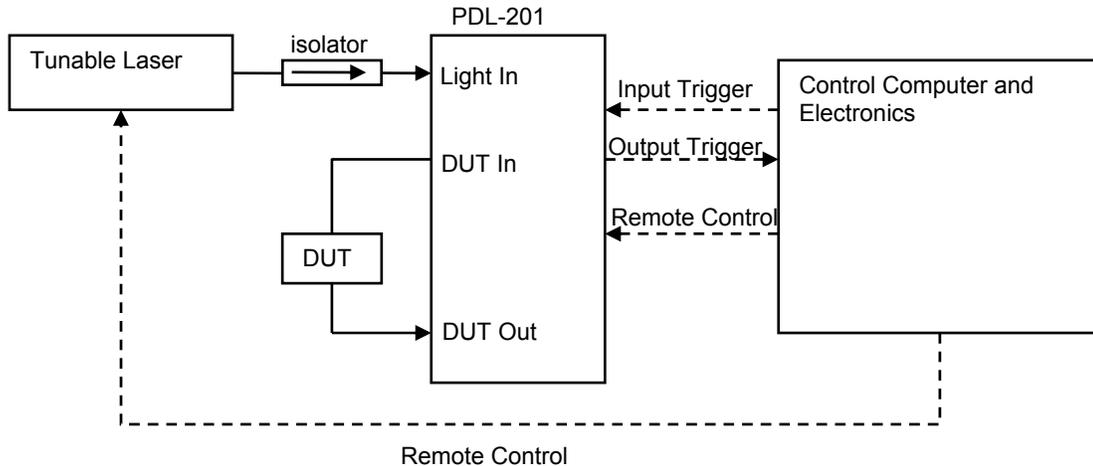


Figure 13 Sample setup for PDL/IL vs wavelength measurement

Figure 13 shows a sample setup to use the PDL-201 for a PDL/IL vs. wavelength measurement. Optical connections are shown as solid lines, and electrical ones as dashed lines. This measurement would use the input trigger, output trigger, and array measurement functions of the PDL-201.

The procedure for this measurement is:

Setup:

1. Make optical and electrical connections.
2. Set up desired measurement parameters (averaging, etc.).
3. Reset array counter.
4. Set up parameters for input and output triggers and enable the triggers.
5. Set data array printout length to number of wavelengths to be measured.

Measurement:

1. Set wavelength on tunable laser. Allow sufficient time to stabilize (depends on laser).
2. Send input trigger pulse to PDL-201.
3. Receive output trigger pulse from PDL-201 (measurement done).
4. Repeat (step to next wavelength on tunable laser, etc.).

Data retrieval:

1. The process is slightly different for different remote control interfaces.
 - a. All remote interfaces except GPIB: Send array query command to PDL-201 to retrieve data. The array query command will return the requested number of data

sets at once (each data set contains PDL, DUT output power (P), and internal power reference).

- b. GPIB: Each read operation returns one data set followed by an EOS character. Send the array query command, followed by the requisite number of read operations.
2. Match the retrieved data to the wavelength settings for plotting.

3.4 Troubleshooting

The performance of the PDL-201 can be tested using a stable, polarized light source and a PDL calibration standard or other DUT of known PDL.

General Guidelines

1. The light source used for PDL measurement must be highly stabilized, with a short-term stability similar to the intended PDL measurement accuracy. For example, if a PDL accuracy of 0.02 dB is to be achieved, the laser source's short-term power stability must be better than 0.02 dB.
2. An isolator at the input of the PDL-201 is recommended for minimizing the amount of back-reflected light from the downstream connectors and DUT that goes back into the light source. General Photonics' NoTail isolator, which has no fiber pigtailed, is a convenient option.
3. Only APC connectors should be used between the light source and the PDL-201 light input connector, in order to minimize back reflection to the light source, and consequently to minimize back reflection induced instability of the light source. The NoTail isolator described in step 2 should therefore have APC connectors.
4. The polarization of the light source should be relatively stable. Lasers with fast polarization fluctuation will cause measurement fluctuations.
5. The wavelength of the light source should be relatively stable, because fast wavelength fluctuation of the light source will cause fast polarization fluctuation due to the birefringence of the fiber cable connecting the laser and the instrument.
6. Fiber jumpers with low PDL should be used for connecting to the DUT.
7. To minimize the error contribution from double reflection, the PDL-201 has APC bulkhead connectors for light source and DUT input. For accurate measurement of low-PDL DUTs (less than 0.1 dB), index matching gel can be used at connectors to patchcords in the DUT light path to reduce back reflection and residual PDL.
8. To minimize connector PDL contributions, a PC type connector should be used to send the output light from the DUT to the PDL-201. Light from the PC connector will be directly incident onto a free space photodetector inside the instrument. If an APC connector were used here, a PDL error contribution of 0.03 ~ 0.04 dB would result.
9. There should be no sharp bending or tight coiling of any fiber cables between the PDL-201's DUT input and output connectors, because bending can introduce non-negligible PDL in the fiber cable.
10. To ensure a stable measurement result, place the setup on a stable surface and fix SM fibers in place.

11. Note that in PDL/IL measurement mode, the IL calculation uses the average DUT output power (with respect to input SOP variation).

Remote Control

Command Format

1. Make sure the "Command Type" setting (SCPI or GP) matches the format of the actual command format to be used.
2. SCPI format: Command strings without an end-of-string (EOS) character will not be executed. Make sure that the "Terminating Character" setting matches the EOS being used.
3. GP format: If the beginning ("*") or ending identifiers ("#" or "?") of a command are missing, the instrument will not respond.

RS-232

1. Make sure that the cable is straight-wired (pin-to-to pin wired) not cross-wired.
2. Verify active Comm Port (COM1, COM2, etc.).
3. Verify Comm Port settings: 8 data bits, 1 stop bit, no parity bits.
4. Make sure baud rate setting on instrument matches baud rate being used by control computer.

USB

1. Make sure that the USB driver is installed before communicating via USB.

Ethernet

1. Make sure that the Ethernet communication setting (Static or Dynamic) matches the Ethernet addressing type being used.
2. Make sure that the cable type is correct: cross-linked cable for static IP with direct instrument-to-computer connection, straight-linked cable for connection through a switch or router (for either static or dynamic IP).
3. Every time "Dynamic IP" is selected from the Setup menu, the instrument requests a new dynamic IP address from the server. If this happens while the instrument is already in communication via dynamic IP, the communication may be interrupted.

Section 4.0

Specifications

Optical

Operating wavelength range	1260-1620 nm
PDL resolution	0.01 dB
PDL Accuracy ^{1,2,3}	± (0.01 dB + 5% of PDL) dB
PDL Repeatability ¹	± (0.005 dB + 2% of PDL) dB
PDL Dynamic Range ⁴	0 to 45 dB
IL Accuracy ^{1, 5}	± (0.01+ 5% of IL) dB
IL Repeatability ¹	± (0.005 dB + 2% of IL) dB
IL Dynamic Range ⁴	0 to 45 dB
Optical Power Range (at DUT output port)	-40 to +6 dBm
Optical Power Accuracy	±0.25 dB
Wavelength Calibration for power measurement	1260 to 1360 and 1440 to 1620nm
Measurement Speed	30 ms/measurement for input power >-30 dBm

Notes:

1. For 10-sample average.
2. At 23±5°C.
3. Accurate PDL measurement also depends on test setup. See General Photonics' PDL measurement application note for suggestions.
4. For input power ≥0 dBm.
5. In power meter measurement mode with user-defined reference.

Electrical/Communication

Front panel display	OLED graphic display
Power Supply	100-240VAC, 50-60 Hz
Analog Output	0 to 4V PDL monitor voltage (0 to 3.5V linear with PDL, 4V indicates power low) User-configurable PDL range
Input/Output Triggers	TTL pulse, BNC connector
Communication Interfaces	RS-232, USB, Ethernet, GPIB
GPIB Address	1-30
RS-232 Baud Rate	110, 300, 600, 1200, 2400, 4800, 9600, 19200, 28800, 38400, 43000, 56000, 57600, 115200, 128000, 230400, 460800

Physical and Environmental

Dimensions	Standard 2U half-19" rack mount size ¹ 14" (L) × 8.5" (W) × 3.5" (H)
Optical Connectors	Light source and DUT input: FC/APC DUT output: FC/PC
Weight	7.5 lb
Operation temperature	0 to 50°C
Storage Temperature	-20 to 70°C

1. Rack mount kit available. Contact General Photonics for details.

Appendices

The following appendices include the remote control command lists, as well as setup information for different control interfaces.

Appendix 1.0 Remote Control Commands

The commands and responses listed in Table 1, Table 2, and Table 4 are the same for all communication protocols: RS-232, USB, Ethernet, and GPIB.

When the PDL-201 is in remote control, the front panel keypad is locked. Press the LOCAL key to return to front panel control. The top right section of the front panel display indicates whether the instrument is in remote or front-panel control.

The PDL-201 needs to be set to respond to a particular command format before it can receive commands. Use the "Terminating Character" setup screen under "System Setup" to select the command format (SCPI or GP), and for SCPI, the end of string (EOS) character, before sending commands.

For SCPI commands, multiple commands can be concatenated in one string, using semicolons as separators, up to a limit of 128 characters per string.

For GP format commands, only one command string can be sent at a time.

Results for data queries are average measurements. The number of max/min search cycles to be averaged for one result can be set from the front panel setup menu or using the corresponding remote control command. In continuous measurement mode, if a data query command is sent, the returned value is the average of the most recent set of x measurement cycles, where x is the average number setting. In single measurement mode, each time a data query command is sent, the instrument will perform the requisite number of max/min search cycles and return the average value. In triggered measurement mode, when a trigger pulse is received, the instrument will perform the requisite number of max/min search cycles and calculate the average value. This is the result that will be returned if a query command is sent before the next trigger pulse is received.

Command Lists

SCPI Commands

SCPI command notes:

1. Each command sequence can be queried by using "?" in place of set parameters to check the command's current parameter settings. There is no space between the command sequence and "?".
2. There is a space between a command sequence and a set parameter. Settable parameters are listed in the table using triangular brackets < >.

3. Command segments listed in the table in square brackets [] are optional; they are included for human interpretability.
4. Many command segments can be written out as full words or in pre-defined abbreviated forms consisting of 3 or 4 letters. The abbreviated commands are capitalized in the command sequences listed in the table. E.g. the firmware version query command can be written out as either :SYSTem:VERSion? or :SYST:VERS?
5. Multiple command strings can be concatenated using a semicolon “;”.
6. An end-of-string (EOS) is required to execute a complete command string, the EOS can be configured as Line Feed (LF), Carriage Return (CR), or both (LF+CR). The default EOS is CR + LF (0D 0A in HEX)

Table 1 SCPI Remote Control Command List

Command Sequence	Set Parameters	Description/Example
<i>System/Communications Setup</i>		
:SYSTem:ERRor?		Returns earliest error code in memory and clears location after readout. 20 error messages max. Errors read out in FIFO sequence.
:SYSTem:ERRor:COUNT?		Returns number of errors. This allows the control program to quickly determine if an error exists rather than querying the device after each command.
:SYSTem:VERSion?		Query Firmware Version Return Sample: PDL-201 V1.1 Sw V1.1-150415
:SYSTem:GPIB:ADDRess	<integer>	Set/query GPIB address. Range: 1 to 30. Ex: :SYST:GPIB:ADDR 10
:SYSTem:NET:IP	<String>	Set/query IP address, in format sss.sss.sss.sss
:SYSTem:NET:MASK	<String>	Set/query subnet mask, in format sss.sss.sss.sss
:SYSTem:NET:GWAY	<String>	Set/query default gateway, in format sss.sss.sss.sss
:SYSTem:NET:NSERver	<String>	Set/query name server, in format sss.sss.sss.sss
:SYSTem:NET:MODE	<SIP DHCP>	Set/query Ethernet mode (Static or Dynamic)
:SYSTem:SERial:BAUDrate	0~12	Set/query RS-232 baud rate. 0: 110; 1: 300; 2: 600; 3: 1200; 4: 2400; 5: 4800; 6: 9600; 7: 19200 8: 28800; 9: 38400; 10: 43000; 11: 56000; 12: 57600 :SYST:SER:BAUD 6 Note: Query returns actual baud rate (e.g. 9600, not 6)

Notes on communication setup:

- 1) NET commands (IP, MASK, GWAY, NSERver) are used to set parameters for static IP addressing. However, the query versions will return values for either static or dynamic IP depending on MODE setting.
- 2) If an Ethernet parameter query returns 0.0.0.0, it means that the PDL-201 does not have a valid value for the requested parameter. This can occur, for example, if the PDL-201 requests a dynamic IP address from the server, but the server is busy. In that case, the user should repeat the setup and query until the query returns a valid result.
- 3) Although commands are provided for communications setup, it is recommended that communications setup be done from the front panel to avoid communications interruptions. For example, if the instrument is being controlled via RS-232, sending a baud rate change command will disable communication until the corresponding settings are changed on the control computer.

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: CONFigure:WAVelength	<integer>	Set/query the operation wavelength, in units of nm. Wavelength range: 1260 to 1620 nm. Setting stored to nonvolatile memory. Factory reset value is 1550nm Note: Calibrated ranges 1260-1360 and 1440-1620nm.
: CONFigure:AVERage	<integer>	Set/query the number of measurement cycles averaged to obtain each PDL/IL and Power value when in PDL/IL Mode. Range: 1 to 256. Default: 10.
: CONFigure:ITIME	<integer>	Set/query the power meter integration time. (Integration time is used for measurement in power meter mode only.) Range 1ms to 100ms Default: 1ms
: CONFigure:UNIT	<dBm mW>	Set the power units to dBm or mW; Default is dBm
: CONFigure:MODE	<integer>	Set/query front panel measurement mode. 0 = Setup Mode 1 = PDL/IL Mode (Stored Power Reference) 2 = PDL/IL Mode (Internal Power Reference) 3 = Power-Meter Mode Default: 1
: CONFigure:SAMple	<integer>	Set/query sampling mode setting. 0 = Single Mode 1 = Continuous Mode 2 = Triggered Note: When in single mode, the data is updated when a data query is received. This mode can only be accessed using this command (no front panel access). If the instrument is in single measurement mode, pressing the LOCAL key will return it to continuous mode.
: CONFigure:POWLow	<float>	Set/query power low threshold For power unit dBm, range is -50 to -10. For power unit mW, range is 0.00001 to 0.1. Default: -50 dBm/0.00001 mW When DUT output power drops below the power low threshold, the front panel displays a "power low" message and the analog output voltage is set to 4V.

Measurement Setup and Query (PDL/IL Measurement)

<i>Measurement Setup and Query (PDL/IL Measurement)</i>		
[:PDLMeter]:PDL?		Query PDL; returned value will be in dB. Command valid only in PDL/IL mode (measurement modes 1 or 2) In any other mode, command will return N/A.
[:PDLMeter]:POWER?		Query Optical Power measured at DUT 2 connector in PDL/IL Mode. Command valid only in PDL/IL mode (measurement modes 1 or 2) In any other mode, command will return N/A. Value returned in mW or dBm, depending on unit setting.
[:PDLMeter]:POUT?		Query the internal power reference, measured before the DUT. (power into the DUT at DUT connector 1) Command valid only in PDL/IL Mode using internal power reference (measurement mode 2). In any other mode, command will return N/A. Value returned in mW or dBm, depending on unit setting.
[:PDLMeter]:ILOut?		Query the Insertion Loss relative to internal power reference. Command valid only in PDL/IL modes (modes 1 or 2) In any other mode, command will return N/A.

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[:PDLMeter]:ILRef?		Query the Insertion Loss relative to user-stored power reference. Command valid only in PDL/IL modes (modes 1 or 2) In any other mode, command will return N/A.
[:PDLMeter]:PREFERENCE		Set/query the user-stored power reference used for IL measurement in PDL/IL mode 1. The set command stores the power measured at DUT connector 2 as reference. Sending this command will switch the instrument to PDL/IL mode 1. Query value returned in mW or dBm, depending on unit setting.

<i>Data Array Setup and Query (PDL/IL Measurement in Triggered Measurement Mode)</i>		
[:PDLMeter]:CRESet	<N/A>	Reset data array counter to 0 (start a new data collection session).
[:PDLMeter]:COUNter?	<N/A>	Query data array counter. The counter indicates the current number of collected data sets.
[:PDLMeter]:ARRay?	<N/A>	Query contents of stored data array. The returned data will be the contents of the data array from index position 1 to the specified printout length. The data set at each index position contains three measured parameters: PDL, measured power at the DUT output, and internal power reference measured before the DUT input. If printout length exceeds the current counter number, the PDL-201 will return NA for the array elements at index numbers with no collected data. Note: For GPIB, the PDL-201 sends one data set, followed by the EOS character, for each read operation. To retrieve multiple data sets, send the array query command, followed by the requisite number of read operations.
[:PDLMeter]:LENGth	<integer>	Set/query data array printout length. This is the number of data sets in the array, starting with the first one, to be returned in response to the array query. Range: 1 to 3330 Default: 1

<i>Measurement Setup and Query (Power Meter Mode)</i>		
:PWRMeter:REFerence		Set/query reference power used for IL measurement in Power Meter Mode. The set command stores the power measured at DUT connector 2 as reference. Sending this command will switch the instrument to Power Meter Mode. Query value returned in mW or dBm, depending on unit setting.
:PWRMeter:IL?		Query the Insertion Loss measured in Power-Meter Mode, relative to stored reference power value for Power Meter Mode. Command valid only in Power Meter Mode (measurement mode 3) In any other mode, query will return N/A.
:PWRMeter:POWer?		Query Optical Power at DUT output connector (DUT 2: output from DUT). Command valid only in Power Meter Mode (measurement mode 3) In any other mode, query will return N/A. Value returned in mW or dBm, depending on unit setting.

<i>System Status</i>		
:STATus:QUEStionable:EVENT?		The query returns the value of the Questionable Event Register. Reading the register clears all bits. Query only.
:STATus:QUEStionable:CONDition?		The query returns the value of the Questionable Condition register.

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:STATus:QUESTionable:ENABLE	<integer>	Set corresponding bit in Questionable Event Enable register to 1. Range: 0 ~ 32767 Or query corresponding bit in Questionable Event Enable register.
:STATus:OPERation:EVENT?		The query returns the value of the Operation Event Register. Reading the register clears all bits.
:STATus:OPERation:CONDition?		The query returns the value of the Operation Condition register.
:STATus:OPERation:ENABLE	<integer>	Sets corresponding bit in Operation Event Enable register to 1. Range: 0 ~ 32767 Or query operation event enable register.

<i>Analog Output (PDL monitor voltage)</i>		
:OUTPut:STATe	<0 1>	Set/query analog output enable/disable status. 1: Enabled 0: Disabled
:OUTPut:RANGe:PDL	<float1>, <float2>	Set/query the PDL range corresponding to the 0-3.5V analog monitor voltage. <float1> = <i>minimum PDL</i> <float2> = <i>maximum PDL</i> PDL range for <float1> and <float2> is 0.000dB to 45.000dB, and <float1> must be less than <float2>. Analog monitor voltage will be set to 4V if measured power at DUT output is lower than power low threshold.

<i>Input Trigger</i>		
:TRIGger:INPut:STATe	<0 1>	Set/query input trigger enable/disable status 1: Enabled. Instrument takes one measurement per trigger edge received. 0: Disabled Default: Disabled
:TRIGger:INPut:TYPE	<0 1>	Set/query trigger edge type; 0: rising edge 1: falling edge.

<i>Output Trigger</i>		
:TRIGger:OUTPut:STATe	<0 1>	Set/query output trigger enable/disable status 1: output trigger enabled, 0: output trigger disabled
:TRIGger:OUTPut:TYPE	<0 1>	Set/query output trigger pulse type 0: rising pulse, 1: falling pulse.
:TRIGger:OUTPut:PWIDth	<integer>	Set/query output trigger pulse width. Range: 1000-65535 μ s Default = 1000 μ s.

Table 2 SCPI Common Commands and Queries (GPIB specific)

These commands are common to all GPIB-enabled devices.

Command	Description
*CLS	Clear Status Command
*ESE <NR1>	Standard Event Status Register Enable. Range: 0..255 Power-up default is last setting (stored to memory).
*ESE?	Standard Event Status Enable Query. Power-up default is last setting (stored to memory).
*ESR?	Standard Event Status Register Query
*IDN?	Identification Query returns: General Photonics,PDL-201,V1.1-150415,152000000xx

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*OPC	Operation Complete Command
*OPC?	Operation Complete Query. Returns a 1 if No Operation Pending flag is TRUE.
*RST	Reset Command
*SRE <NR1>	Service Request Enable Command. Range: 0..255 Power-up default is last setting (stored to memory).
*SRE?	Service Request Enable Query.
*STB?	Read Status Byte Query. Reads Instrument Summary Status Register.
*TST?	Self-Test Query. 0 if Pass.
*WAI	Wait-to-Continue Command. This instrument executes all commands in order so there are never any pending operations (this command has no effect).

Table 3 SCPI Error and Status Codes

Error code	Description
0	"No error"
-100	"Command error"
-101	"Invalid character"
-108	"Parameter not allowed"
-109	"Missing parameter"
-110	"Command Header Error"
-111	"Header Separator Error"
-112	"Program mnemonic too long"
-113	"Undefined header"
-114	"Header suffix out of range"
-115	"Unexpected number of parameters"
-120	"Numeric data error"
-121	"Invalid character in number"
-221	"Std Settings Conflict" Settings conflict - Indicates that a legal program data element was parsed but could not be executed due to the current device state.
-222,	"Data out of range"
-300	"Device-specific error"
-350	"Queue overflow"
-420	"Query Unterminated"

Programming Example: Data Array for PDL/IL Triggered Measurement

Step	Command	Function
1	*IDN?	Instrument identification query. Used to verify communication with instrument.
2	:CONF:AVER 1	Set number of measurement cycles averaged to obtain each PDL/Power value to 1
3*	:CONF:MODE 2	Set measurement mode to PDL/IL measurement using internal power reference.
4	:CONF:SAMP 2	Set sampling mode to triggered measurement.
5*	:CRES	Reset data array stored counter number to 0. Omit if continuing an ongoing measurement session.
6		Start triggered measurement. PDL-201 will measure one data set (PDL, DUT output power, power reference before DUT input) per trigger pulse received.
7*	:COUN?	Query counter number (number of measured data sets stored during current measurement session).
8	:LENG nnnn	Set data array printout length (number of data sets to be returned). Generally, this number should be \leq the counter number.
9	:ARR?	Query stored data array. The data returned is the data in the number of measured data sets specified by the previous command, starting at the beginning of the array. Data elements are separated by commas.

Note: Commands marked with a * are optional.

GP Format Commands

General Photonics also provides a command list using the GP legacy format to make it easier for PDL-101 users to modify existing programs for use with a PDL-201.

Notes for PDL-101 users:

- 1) Make sure that the PDL-201 is set to receive GP format commands (Setup →System Setup→Ending Char→GP from front panel). Otherwise, it won't recognize GP format commands. The PDL-201's default command setting is SCPI with <CR + LF> as EOS.
- 2) Indicators: The PDL-101 had indicators enabled by default. For example, it would respond to a PDL query with *PDL +8.23#. The PDL-201 has indicators disabled by default. If your program expects indicators in the response, use the *IND ENA# command to turn on the indicators. Note that the indicator enable/disable status is not saved after power-off.
- 3) Measurement mode setup/query: The measurement mode options are different on the PDL-101 and PDL-201. The corresponding setup/query commands have changed accordingly. Existing programs for the PDL-101 may need to be modified for use with the PDL-201.
- 4) IL query: The IL query command format has changed from the PDL-101 command list because the PDL-201 has 3 different operation modes that measure IL differently. Existing PDL-101 programs may need to be modified accordingly for use with the PDL-201.
- 5) Power reference query: The power reference query format has changed because the PDL-201 has separate power references for PDL/IL measurement mode (internal reference and user-stored reference) and power meter measurement mode (user-stored reference). Existing PDL-101 programs may need to be modified accordingly for use with the PDL-201.
- 6) Power query: The measured power query format has changed because the PDL-201 has two measurement modes (PDL/IL and power meter modes) that can measure power. Also, the PDL-201 can return measured power in either dBm or mW, depending on units setting. The PDL-101 returned measured power in dBm only. Existing PDL-101 programs may need to be modified accordingly for use with the PDL-201.
- 7) DOP query: The PDL-201 has no DOP measurement function.
- 8) Ethernet setup: On the PDL-201, Ethernet setup should be done from the front panel. There are no commands in the GP format for Ethernet setup.

Table 4 GP Format Commands

System Information		
Command	Description	Sample response with indicators disabled
*IND?	Query parameter indicator enable/disable status. ENA = enabled DIS = disabled Indicator status resets to disabled at power-up.	*DIS# (indicators off)
*IND ENA#	Enable parameter indicators. With indicators enabled, responses to query commands will include parameter labels before the values. Indicators do not affect the front panel display. Indicator status resets to disabled at power-up.	Example: Wavelength query response with Indicator enabled: *WAV 1550# Indicator disabled: *1550#
*IND DIS#	Disable parameter indicators. (Default state on instrument power-up)	Example: Response to wavelength query with indicator disabled is *1550#
*IDN?	Query product identification Information.	*General Photonics,PDL-201,V1.1-150415,1520000000xx# or *Enn# if error
*VER?	Query the Hardware/Firmware version	*PDL-201 V1.1,150415# (Response is Version Dependent)
*ADR?	Query the current GPIB address. Value stored in non-volatile memory. Range 1 – 30. Default: 5 (GPIB address can be set from front panel)	*5#
*WAV?	Query operating wavelength used for power measurement.	*1550#
*WAV wav#	Set operating wavelength. Range: 1260nm to 1620nm Default: 1550nm Note: Calibrated ranges 1260-1360 and 1440-1620nm	*E00# Else *Enn# (see error response list)
*AVE?	Query the number of measurement cycles averaged for each PDL/IL measurement. Range: 1 to 256	*5#
*AVE ave#	Set the cycle average number for PDL/IL measurement. Setting saved to nonvolatile memory. Range: 1 to 256. Factory reset value 10	*E00# Else *Enn# (see error response list).
*PAT?	Query the Power-Average-Time (in milliseconds) for sampling in Power Meter mode. The average of all samples taken during that time is returned. Range 1ms to 100ms. (Can be queried/set from any mode)	*5#
*PAT time#	Set the Power-Average-Time for power measurement in Power Meter mode. The average of all samples taken is returned when Power is queried. Setting saved to nonvolatile memory. Range: 1 to 100ms. Factory reset value 1;	*E00# Else *Enn# (see error response list).

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*POW:LOW?	Query power low threshold	*-50#
*POW:LOW xxxx#	<p>Set power low threshold For power unit dBm, range is -50 to -10 For power unit mW, range is 0.00001 to 0.1. Default value: -50 dBm or 0.00001 mW</p> <p>When DUT output power drops below the power low threshold, the front panel displays a "power low" message and the analog output voltage is set to 4V.</p>	*E00# Else *Enn# (see error response list).

Measurement Queries		
Query measured values		
PDL/IL Measurement		
Command	Description	Response/Example
*PDL?	Query PDL, in dB. Command valid only in PDL/IL Mode; otherwise, instrument will respond with **E11#	Returns PDL in dB Ex: *1.234# Else Enn# (see error response list)
*PDL:ILO?	Query the Insertion Loss relative to the internal reference power. Command valid only in PDL/IL Mode using internal power reference; otherwise. Instrument will respond with *E11#	Returns IL in dB. Ex: *2.21#
*PDL:ILR?	Query the Insertion Loss relative to the user-stored reference power. Command valid only in PDL/IL-Mode using stored power reference; otherwise. Instrument will respond with *E11#	Returns IL in dB. Ex: *2.21#
*PDL:POW?	Query measured optical power at DUT 2 connector in PDL/IL Mode. Command valid only in PDL/IL Mode; otherwise, instrument will respond with *E11# Units in dBm or mw depending on unit setting	Returns the POWER in selected units. Example: *2.214792 Else Enn# (see error response list)
*PDL:OUT?	Query the internal power reference, measured before the DUT. (power into the DUT at DUT connector 1) Command valid only in PDL/IL Mode using internal power reference; otherwise. Instrument will respond with *E11# Units in dBm or mw depending on unit setting	Response: *-27.214792# Else *Enn# (see error response list)
*PDL OUT#	Update the internal power reference value measured before the DUT. (power into the DUT at DUT connector 1) Sending this command will switch the instrument to PDL/IL Mode using internal power reference, if it is not already there.	Response: *E00# Else *Enn# (see error response list)
*PDL:REF?	Query the user-stored power reference, measured after the DUT (typically with reference patch cord connected as DUT). Units in dBm or mw depending on unit setting	Response: *-27.214792# Else *Enn# (see error response list)
*PDL REF#	Update the stored reference power (measured after the DUT). Sending this command will switch the instrument to PDL/IL mode using stored power reference, if it is not already there.	Response: *E00# Else *Enn# (see error response list)

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	Data Array Setup and Query (PDL/IL Measurement in Triggered Measurement Mode)	
*CRS#	Reset data array counter to 0 (start a new data collection session).	Response: *E00# Else *Enn# (see error response list)
*CNT?	Query data array counter. The counter indicates the current number of collected data sets.	Example: *0# For counter = 0 (no data stored)
*ARR?	Query contents of stored data array. The returned data will be the contents of the data array from index position 1 to the specified printout length. The data set at each index position contains three measured parameters: PDL, measured power at the DUT output, and internal power reference measured before the DUT input. If printout length exceeds the current counter number, the PDL-201 will return NA for the array elements at index numbers with no collected data. Note: For GPIB, the PDL-201 sends one data set, followed by the EOS character, for each read operation. To retrieve multiple data sets, send the array query command, followed by the requisite number of read operations.	Examples: *NA,NA,NA# if data array counter is 0 and data array print out length is 1. *0.123, -5.24, -5.20, 0.124, -5.24, -5.20# when data array counter is greater than or equal to 2 and data array print out length is 2.
*LEN?	Query data array printout length	*1#
*LEN nnnn#	Set data array printout length. This is the number of data sets in the array, starting with the first one, to be returned in response to the array query. Range: 1 to 3330 Default: 1	Response: *E00# Else *Enn# (see error response list)
Power Meter Mode		
*MET:POW?	Query Optical Power at DUT output connector (DUT 2: output from DUT). Command valid only in Power Meter Mode; otherwise, instrument will respond with *E11#	Measured power, in selected units, Else *Enn# (see error response list) *E09# if power under range and *E08# if power over range
*MET:REF?	Query Reference Power for Power Meter Mode. Can be queried from any mode. Units depend on unit setting.	Reference power, in selected units, Else *Enn# (see error response list) *E09# if power under range and *E08# if power over range
*MET REF#	Update the Reference Power for Power-Meter Mode. Sending this command will switch the instrument to Power Meter mode, if it is not there already.	Response: *E00# Else *Enn# (see error response list)
*MET:ILR?	Query the Insertion Loss relative to the Reference Value in Power Meter Mode. Command valid only in Power Meter Mode; otherwise, instrument will respond with *E11#	Insertion Loss in dB Else *Enn# (see error response list). *E09# if power under range and *E08# if power over range
*POW:UNI?	Query power unit setting. 0 = dBm, 1 = Watt	Response Example: *1#
*POW Wat#	Set power unit to Watts	Power will be displayed in mw or uw depending on the current value.
*POW dBm#	Set power unit to dBm	Power will be displayed or returned in dBm

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Operation Mode Commands		
Commands related to data sampling mode.		
Command	Description	Response/Example
*MOD?	Query measurement mode. Response: 0, 1, 2 or 3. 0= Setup Mode 1= PDL/IL Mode (Stored Power Reference) 2= PDL/IL Mode (Internal Power Reference) 3= Power Meter Mode	
*MOD:PDL REF#	Set measurement mode to PDL/IL Mode using stored power reference.	Response: *E00# Else *Enn# (see error response list)
*MOD:PDL OUT#	Set measurement mode to PDL/IL Mode using internal power reference.	Response: *E00# Else *Enn# (see error response list)
*MOD MET#	Set measurement mode to Power Meter mode.	Response: *E00# Else *Enn# (see error response list)
*MOD SET#	Set front panel measurement mode to SETUP	Response: *E00# Else *Enn# (see error response list)
*MOD:SAM?	Query the sampling mode; can be continuous, single, or triggered.	Response: 0=Single Mode 1= Continuous Mode 2 = Triggered
*MOD:SAM CON#	Set sampling mode to continuous measurement (default mode)	Response: *E00# Else *Enn# (see error response list)
*MOD:SAM SIN#	Set sampling mode to single measurement. Note: When in single mode the data is updated when a data query is received. This mode can only be accessed using this command (no front panel access). If the instrument is in single measurement mode, pressing the LOCAL key will return it to continuous mode.	Response: *E00# Else *Enn# (see error response list)
*MOD:SAM TRI#	Set sampling mode to triggered mode	Response: *E00# Else *Enn# (see error response list)
Input Trigger		
Trigger signal for externally triggered measurement		
*MOD:TRI?	Query the input trigger enable/disable status.	*1# if Enabled and *0# if disabled else see error response list
*MOD:TRI ENA#	Enable input trigger Instrument takes one measurement per trigger edge received.	Response: *E00# Else *Enn# (see error response list)
*MOD:TRI DIS#	Disable input trigger Instrument returns to continuous sampling mode (default)	Response: *E00# Else *Enn# (see error response list)
*MOD:TRI:EDG?	Query trigger edge type. Options: rising or falling edge.	Response: *0# For Rising Edge *1# For Falling Edge
*MOD:TRI FAL#	Set input trigger type to falling edge.	*E00# Else *Enn# see error response list)
*MOD:TRI RIS#	Set input trigger type to rising edge.	*E00# Else *Enn# see error response list)

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Analog Output Control		
Commands related to analog output monitor voltages		
Command	Description	Response/Example
*ANA:STA?	Query analog output monitor voltage enable/disable status.	Response: *1# = enabled *0# = disabled
*ANA ENA#	Enable analog output	*E00# Else *Enn# see error response list)
*ANA DIS#	Disable analog output	*E00# Else *Enn# see error response list)
*ANA <i>min,max</i> #	Set the PDL range corresponding to the 0-3.5V analog monitor voltage. PDL range for min and max is 0.000dB to 45.000dB, and <i>Min</i> < <i>Max</i> . Analog monitor voltage will be set to 4V if measured power at DUT output is lower than power low threshold	*E00# Else *Enn# see error response list)
*ANA:RNG?	Query the analog voltage PDL range settings. i.e. <i>minimum and maximum values</i> .	Response <i>*min,max</i> #. Else *Enn# (see error response list)
Output Trigger		
Trigger pulse to indicate measurement completed		
Command	Description	Response/Example
*TRI:OUT:STA?	Query output trigger enable/disable status. 1=enabled, 0 = disabled	Response: *1# or *0#
*TRI:OUT ENA#	Enable output trigger	*E00# Else *Enn# (see error response list)
*TRI:OUT DIS#	Disable output trigger	*E00# Else *Enn# (see error response list)
*TRI:OUT RIS#	Set output trigger type for rising pulse. Pulse type stored to memory.	*E00# Else *Enn# (see error response list)
*TRI:OUT FAL#	Set output trigger type for falling pulse. Pulse type stored to memory.	*E00# Else *Enn# (see error response list)
*TRI:OUT:EDG?	Query output trigger pulse type (rising or falling).	Response: *0# for rising pulse *1# for falling pulse
*TRI:OUT:WID?	Query the TRIGGER OUTPUT pulse WIDTH. Response in μ s.	Response: *1000# if setting is 1 ms.
*TRI:OUT:WID <i>w</i> #	Set TRIGGER OUTPUT pulse WIDTH. Setting stored to memory. Pulse Width range: 1000-65535 μ s Factory reset value: 1000 μ s	*E00# Else *Enn# see error response list)

Table 5 Command Response Codes

E00	No error (Correct command received and executed)
E01	Undefined Command
E02	Missing parameter
E03	Invalid syntax found in command string
E04	String of characters too long (>buffer limit)
E05	Parameter has too many digits after the decimal point
E06	Parameter outside the allowed range
E07	Failed Self Test
E08	Power too high
E09	Power too low
E10	Outside the operating wavelength range.
E11	Standard Settings Conflict (Display/Sampling Mode wrong)

Appendix 2.0 RS-232 connection and setup

1. The RS-232 connector on the rear panel of the PDL-201 is a DB9 male connector. Use a straight (not cross connected) RS-232 cable with DB9 female connectors to connect the PDL-201 to the control computer.

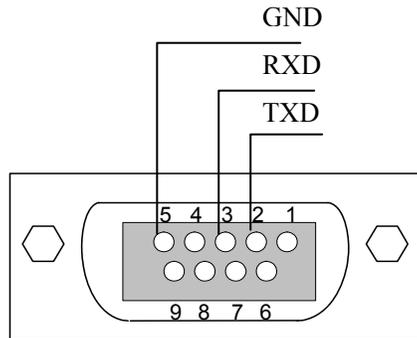


Figure 14 RS-232 connector pin assignment on PDL-201 rear panel.

2. Power on the instrument.
3. Set the RS-232 baud rate (Setup → System Setup → RS-232).
4. Select the command type and, for SCPI, command EOS (Setup → System Setup → Ending Char).
5. Send a command string to the instrument (See Appendix 1 for commands. Any program that supports RS-232 communication protocols can be used to send ASCII commands to the instrument. Many programming languages support serial communications, including Visual Basic, LabView and C.

RS-232 settings:

RS-232 port uses asynchronous framing, 8 data bits, no parity bit, and 1 stop bit.

RS-232 baud rate: configurable. Default is 9600 bps.

Appendix 3.0 USB connection and setup

USB drivers are included in the "USB Driver" folder on the cd. They need to be installed before USB communication can be established. The first time the USB is used, insert the cd into the control computer.

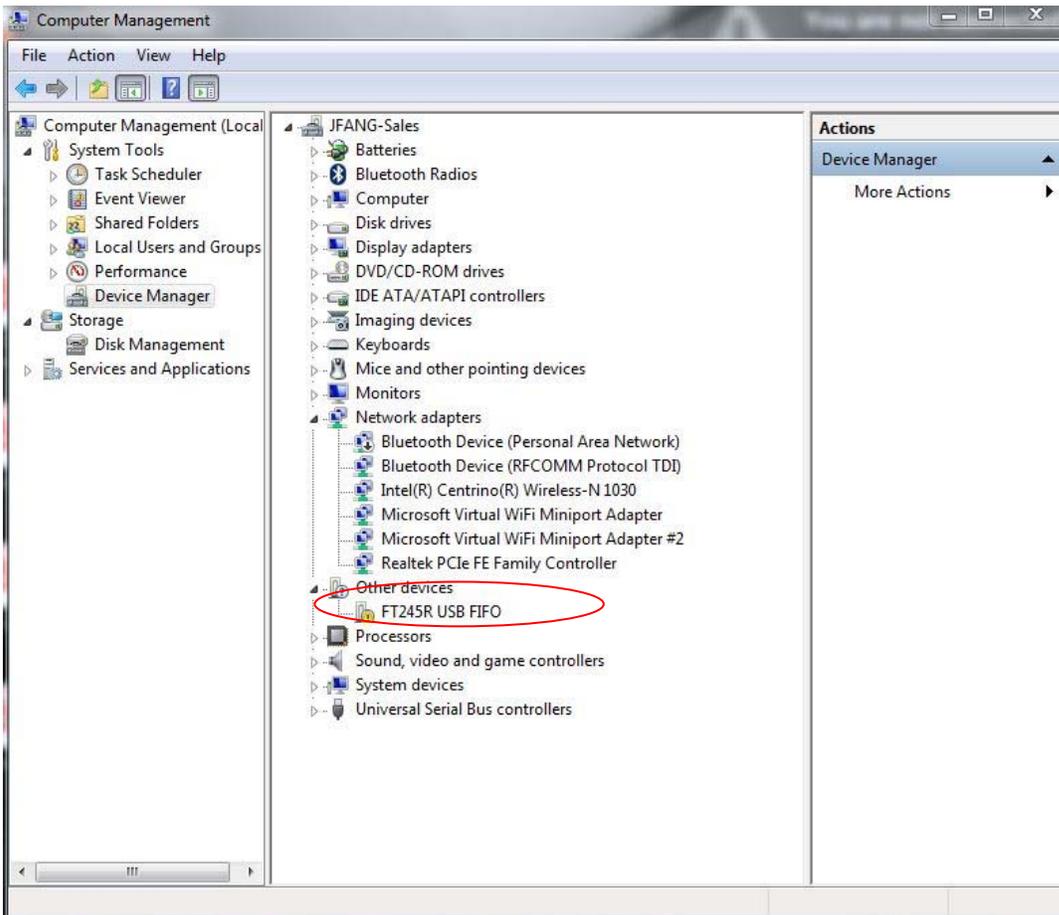
Connect the PDL-201 to the control computer using a standard USB cable.

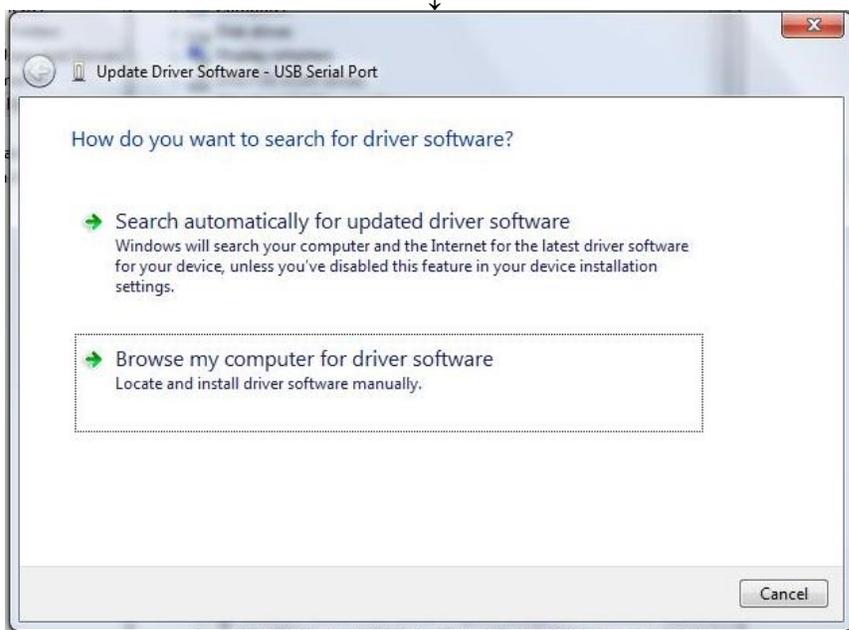
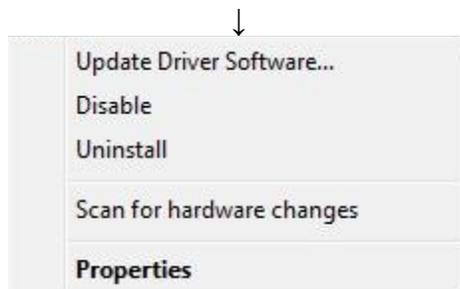
Power on the PDL-201.

USB Driver Installation

The first time the computer detects a USB connection to the instrument, the driver may install automatically (Windows 7/8) or a "Found New Hardware Wizard" window may appear (Windows XP). If neither of these things occur, the driver can be located and installed using Device Manager.

1. Open Device Manager. Look for "FT245R USB FIFO" under "Other Devices". Right-click it and select "Update Driver Software".





2. Select "Browse my computer for driver software":



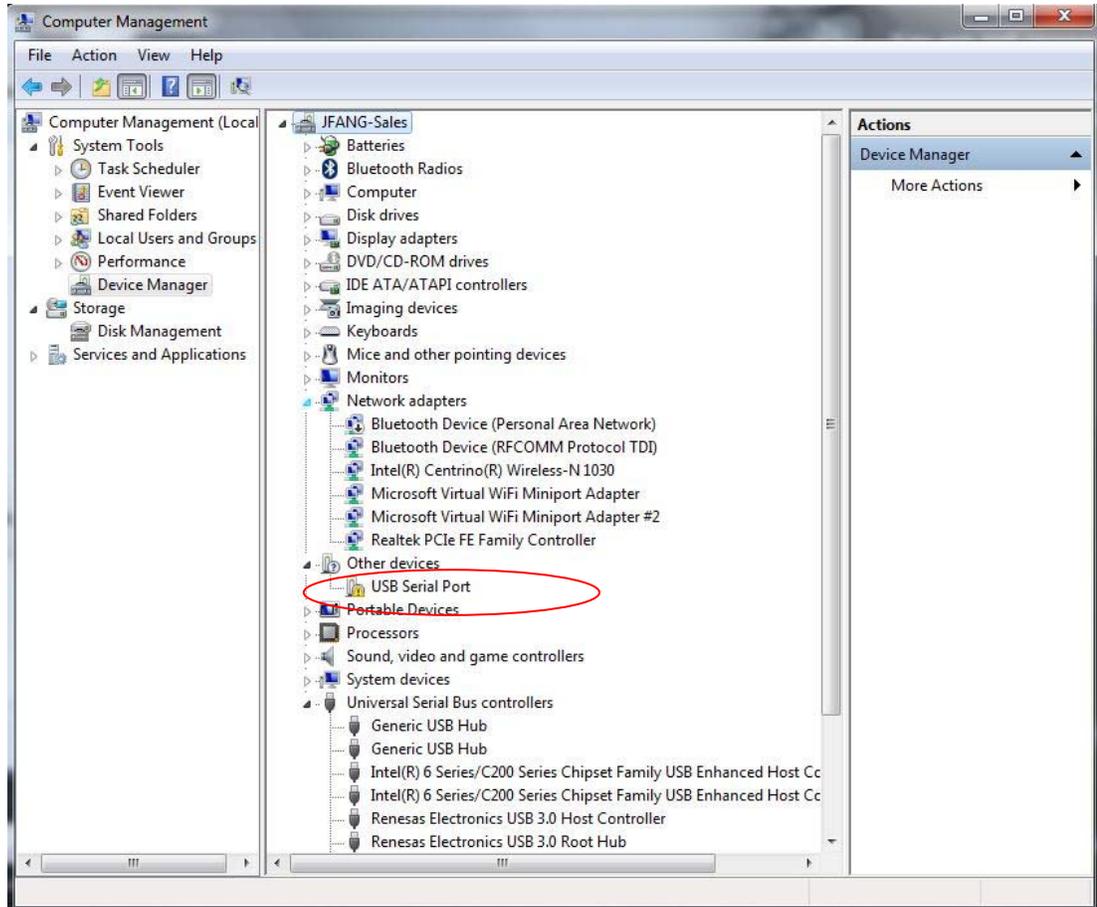
3. Make sure that the software cd is inserted. Click "Browse", navigate to the cd drive, and select the "USB Driver" folder. Make sure the "include subfolders" box is checked. Click "Next".



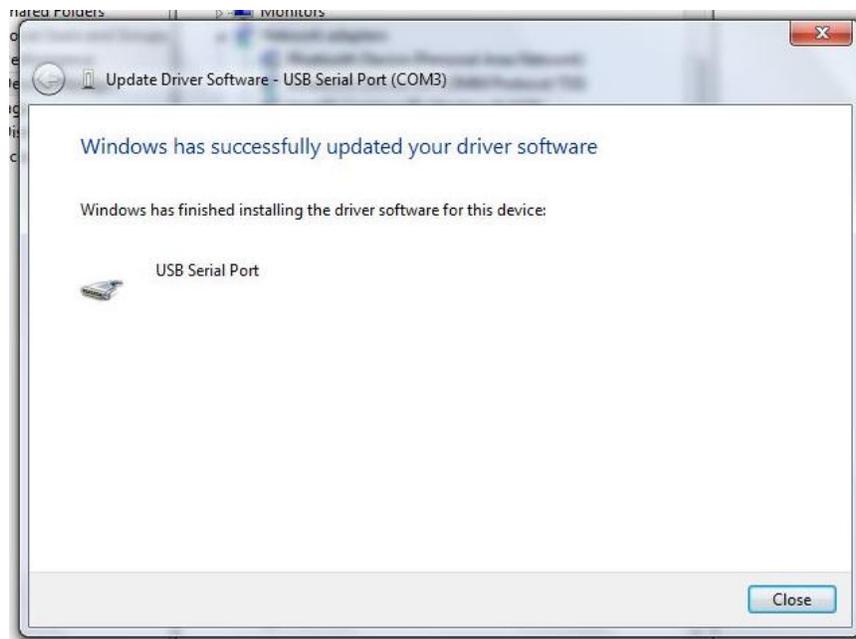
4. The computer will ask whether to install the software. Click "Install".



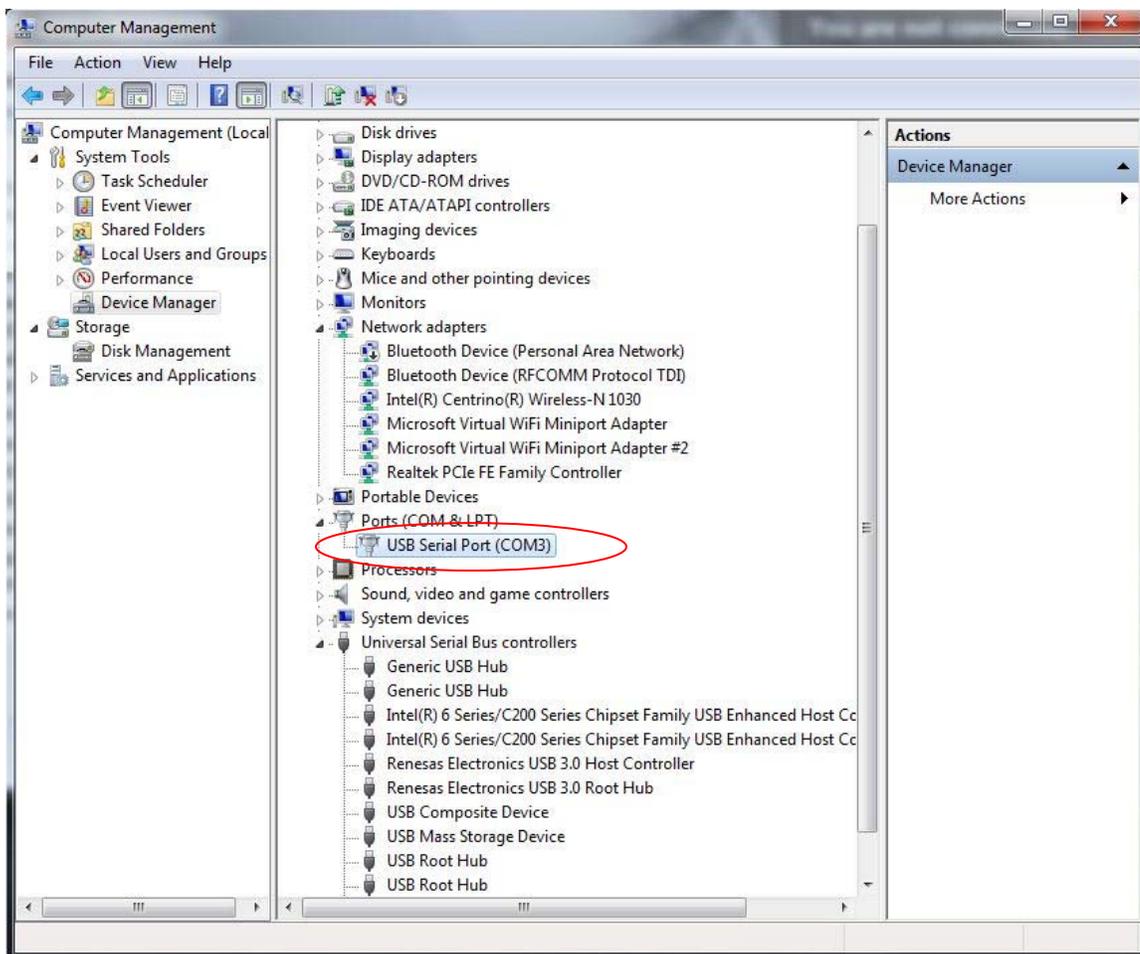
5. When the installation is finished, a "software successfully updated" message will appear. This completes the first part of the installation, during which the USB to serial converter is installed. The second part consists of the installation of the serial port driver.



6. In Device Manager, "USB Serial Port" should now appear under "Other Devices". Right-click it and select "Update Driver Software". Follow the same procedure as described above to specify the driver location and install the driver until the completion window for the USB serial port appears:



7. In "Device Manager", there should now be a USB Serial Port listed under "Ports (COM & LPT)":



Note the port number that the PDL-201 is using (COM3, in this example).

The USB driver can drive more than one instrument, but the instruments will be connected under different port numbers.

Appendix 4.0 Ethernet setup

There are two connection configurations for Ethernet control:

- a) Static IP: the administrator assigns the instrument a fixed IP address. In this mode the instrument can be directly connected to the control PC, as shown in Figure 15, or can be connected through a router. For a direct connection (Figure 15), a cross-linked network cable must be used. For a connection to a router, a standard straight-linked network cable would be used.
- b) Dynamic IP: the DHCP server assigns the instrument an available address when requested. Connect the instrument with a DHCP server (running on router or exchange server), as shown in Figure 16. For this configuration, a standard straight-linked network cable must be used.

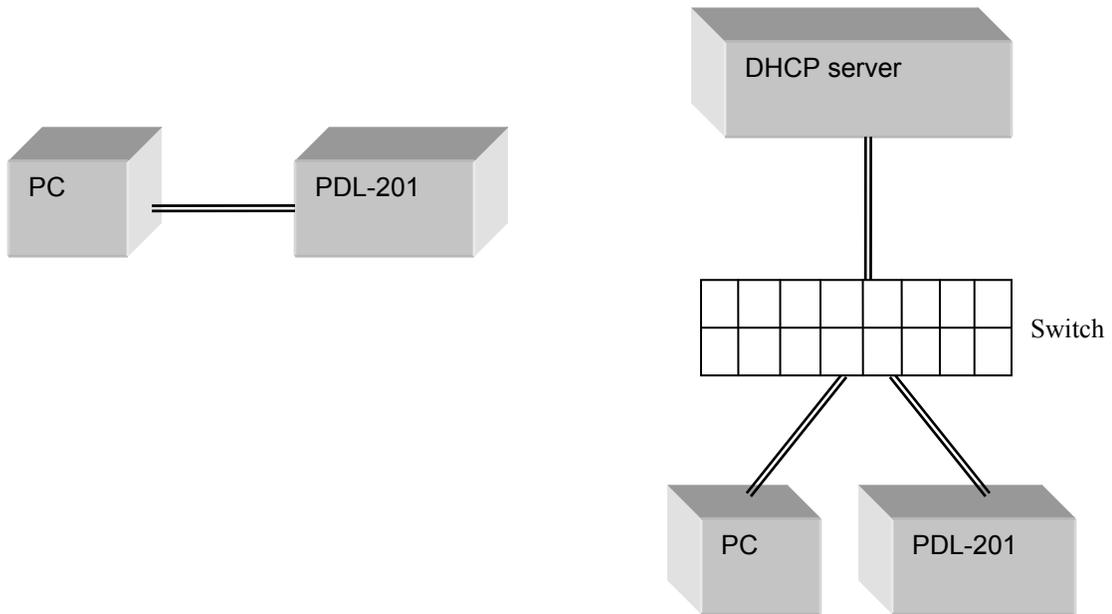


Figure 15 Direct connection: PDL-201 to PC

Figure 16 Connection with DHCP server

Once the physical connections are established, the instrument's Ethernet configuration can be set up from the front panel.

PDL-201 Setup for Ethernet communication:

The "Dynamic IP" function in the setup menu sets the PDL-201 for dynamic IP addressing and requests a dynamic IP address from the DHCP server.

The "Static IP" function in the setup menu allows the user to set the static IP address, net mask, gateway, name server, and port. After these parameters are set, select "Yes" on the Update Parameters?" screen to update the parameters and set the instrument for static IP addressing. See section 3.3 for a more detailed description.

The default Ethernet communication mode for the PDL-201 is dynamic IP addressing. When it is powered on, it will be in dynamic IP mode. However, it does not request a dynamic IP address from the server until the user selects the "Dynamic IP" function in the setup menu.

The PDL-201 saves static IP parameters (IP address, net mask, etc.) in nonvolatile memory, but since it powers on in dynamic IP mode, it is still necessary to select the "Static IP" function in the Setup menu, scroll through the setup screens, and select "Yes" on the "Update Parameters?" screen in order to switch the instrument to static IP mode, even if there are no parameter changes.

For static IP control, the net mask and gateway for the instrument should be the same as those for the control computer. The first 3 groups of numbers in the IP address should be the same as those for the control computer (192.168.2, for example). The last number can be any available number, but cannot be the same as the IP address of the control computer. The range of numbers is 1 to 254. In this example, $n = 0$, so the available IP addresses are 1 to 254. If the computer's IP address is 17, for example, the user can set the IP address for the PDL-201 to any number in the range 1-254 except 17.

For static IP control, make sure that the control computer is also set to use a static (defined) IP address (check the TCP/IP properties to find the computer's Ethernet setup information).

For dynamic IP control, make sure that the control computer is set to obtain its IP address automatically. This information is also under TCP/IP properties.

- To connect the instrument directly to a PC, use a PC to PC cable. To connect the instrument to a LAN, use a standard network cable.

Appendix 5.0 GPIB setup and control

Setting the GPIB Address

To set the instrument's GPIB address:

Setup → System setup (option 8) → GPIB address (option 8a)



GPIB Address
05

Rotate the wheel to change the GPIB address and press ENTER to save the new setting. The address is retained in memory after power-off.

Range: 1-30

Default: 5

GPIB control

Connect the instrument to the computer with a GPIB cable. After determining/setting the PDL-201's GPIB address, enter it in the communication program being used. The instrument will then be ready to receive commands. The command lists, responses, and error codes are given in Table 1 through Table 5 in Appendix 1.

To ensure proper communication, use a GPIB cable that is fully compatible with the IEEE 488.1 standard. All GPIB/IEEE 488 interface connections must be made before turning on the instruments.