OCA-1000

Optical Component Analyzer

User Guide

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General Photonics Corporation is located in Chino California.

For more information visit the company's website at:

www.generalphotonics.com

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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. Since the light from the OCA-1000 is invisible, it is safer to turn it off before changing connections and when the light source is not in use.

OPERATION CONSIDERATIONS

- **To ensure measurement accuracy, allow 20 minutes warm-up time before taking measurements.**
- **When powering the instrument off, wait at least 20-30 seconds before powering it back on to avoid damage to electrical components.**
- **The OCA-1000 control program should be closed before powering off the instrument.**

Section 1.0 Overview

The OCA-1000 is a multi-channel optical component analyzer capable of performing simultaneous insertion loss (IL), polarization dependent loss (PDL), and optical power (P) measurements on multiple optical paths. The measurement is based on the Mueller Matrix method, which offers fast characterization of wavelength dependent optical parameters. The base model can have up to 8 channels, and the system is expandable to additional sets of channels for maximum flexibility.

The instrument comes with a user-friendly control program with built-in functions to display measured power, IL, and PDL vs. wavelength or to monitor the time variation of power/IL for all channels simultaneously to determine their stability. Other functions available after post processing the data include calculation of the isolation between wavelength channels (adjacent and nonadjacent), pass band center frequency, bandwidth, and flatness.

The OCA-1000 is an ideal solution for easy, accurate characterization of components and modules with multiple outputs, including DWDMs, ROADMs, AWGs and PLCs. It can be used with various tunable lasers, such as those from Keysight or Santec. This flexibility offers the user the opportunity to make full use of existing laser resources and reduce the cost of making such measurements. Its fast measurement speed reduces the time required to characterize devices with large numbers of ports, enabling higher production throughput.

Figure 1 OCA-1000 Optical Component Analyzer

1.1 Principle of Operation

Structure

The OCA-1000 includes two basic optical measurement modules.

The solid-state polarization state generator (PSG) can generate the 6 Poincaré sphere pole points: linear horizontal and vertical (LHP, LVP), linear +45°, linear −45°, right hand circular and left hand circular (RHC and LHC) polarizations. These basis states are used for the Mueller-Stokes PDL measurement. The OCA-1000 has two PSGs- one covers the C and L bands, and the other the O band.

A bank of high accuracy, low-noise photodetectors are used for power measurements. These detectors are specially chosen and aligned to minimize interference caused by reflections from connector and detector surfaces. The detector input ports are free space and can accept either FC/PC or FC/APC connectors. In addition to the 8 measurement input ports, there is an internal power monitor that measures the output power of the PSG.

The detector bank can be used independently for power and IL measurement, or in conjunction with the PSG for Mueller Matrix based PDL measurement.

Mueller-Stokes Measurement

In the Mueller calculus, the state of any light signal can be represented by its Stokes vector $\vec{S} = \begin{pmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{pmatrix}$, where the term S_0 describes the power and the other Stokes parameters S_1, S_2, and S_3 describe the state of polarization (SOP) of the light. The effect of an optical component on a light signal can be described by its Mueller matrix **M**$= \begin{bmatrix} m_{00} & m_{01} & m_{02} & m_{03} \\ m_{10} & m_{11} & m_{12} & m_{13} \\ m_{20} & m_{21} & m_{22} & m_{23} \\ m_{30} & m_{31} & m_{32} & m_{33} \end{bmatrix}$, and the relationship between the input and output signals of the component is $\vec{S}_{out} = M * \vec{S}_{in}$.

The output power of the component is determined by the first row elements of the Mueller matrix:

$$S_{0,out} = m_{00}S_{0,in} + m_{01}S_{1,in} + m_{02}S_{2,in} + m_{03}S_{3,in}$$

It is therefore necessary to determine the first row Mueller matrix elements of the DUT.

A reference measurement is first made without the DUT in the light path. For each wavelength λ,

- The PSG generates six or four non-degenerate states, depending on the measurement method selected:
  LVP, −45°, RHC, LHC, LHP, and 45° for a 6-state measurement.
  LHP, +45°, RHC, and LHC for a 4-state measurement.
- The Stokes parameters (S_{PSG0}, S_{PSG1}, S_{PSG2}, S_{PSG3}, S_{PSG4} and S_{PSG5}) of these PSG output states are calculated for wavelength λ according to PSG calibration data.

- The PD measures the corresponding output power for each state (I_{PSG0}, I_{PSG1}, I_{PSG2}, I_{PSG3}, and, for a 6 state measurement, I_{PSG4} and I_{PSG5}) without DUT.

Then the DUT is inserted between the PSG and PD and the process is repeated for each wavelength λ.

- The PSG generates six or four non-degenerate states, depending on the measurement method selected:
  LVP, −45°, RHC, LHC, LHP, and 45° for a 6-state measurement.
  LHP, +45°, RHC, and LHC for a 4-state measurement.
- The Stokes parameters (S_{PSG0}, S_{PSG1}, S_{PSG2}, S_{PSG3}, S_{PSG4} and S_{PSG5}) of the PSG output states are calculated for wavelength λ according to PSG calibration data.
- The PD measures the corresponding output power for each state (I_{DUT0}, I_{DUT1}, I_{DUT2}, I_{DUT3}, and, for a 6-state measurement, I_{DUT4} and I_{DUT5}).

At each wavelength, the first row Mueller matrix $\mathbf{m_1}$ = (m_{00} m_{01} m_{02} m_{03}) is calculated from:

$\mathbf{I_{DUT}}$ = (I_{DUT0}, I_{DUT1}, I_{DUT2}, I_{DUT3}, I_{DUT4}, I_{DUT5}) = $\mathbf{m_1} * \mathbf{S_{PSG}} * \mathbf{I_{PSG}}$

$$= (m_{00} \quad m_{01} \quad m_{02} \quad m_{03}) \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 \\ S_{01} & S_{11} & S_{21} & S_{31} & S_{41} & S_{51} \\ S_{02} & S_{12} & S_{22} & S_{32} & S_{42} & S_{52} \\ S_{03} & S_{13} & S_{23} & S_{33} & S_{43} & S_{53} \end{pmatrix} \begin{pmatrix} I_{PSG0} & 0 & 0 & 0 & 0 & 0 \\ 0 & I_{PSG1} & 0 & 0 & 0 & 0 \\ 0 & 0 & I_{PSG2} & 0 & 0 & 0 \\ 0 & 0 & 0 & I_{PSG3} & 0 & 0 \\ 0 & 0 & 0 & 0 & I_{PSG4} & 0 \\ 0 & 0 & 0 & 0 & 0 & I_{PSG5} \end{pmatrix}$$

Where $\mathbf{S_{PSG}}$ is the matrix representing the calculated PSG output states S_{PSG0} to S_{PSG5}, and $\mathbf{I_{PSG}}$ is a matrix representing the corresponding measured reference power values.

$$\mathbf{m_1} = \mathbf{I_{DUT}} * \mathbf{I_{PSG}}^{-1} * \mathbf{S_{PSG}}^{T} * (\mathbf{S_{PSG}} * \mathbf{S_{PSG}}^{T})^{-1}$$

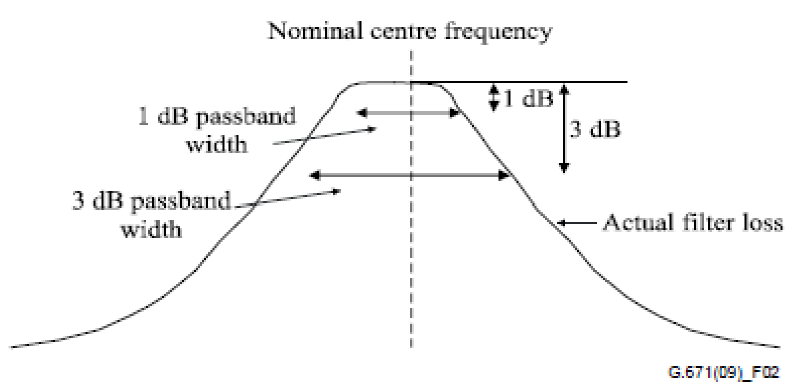
The PDL and IL can then be calculated from the first row Mueller matrix elements by

$$PDL = -10 \times \log(\frac{P_{Min}}{P_{Max}}) = -10 \times \log \frac{m_{00} - \sqrt{m_{01}^2 + m_{02}^2 + m_{03}^2}}{m_{00} + \sqrt{m_{01}^2 + m_{02}^2 + m_{03}^2}}$$

IL = 10log (m_{00}).

1.2 Definitions

The following definitions pertain to characterization of multichannel network components.[1 2]

ITU grid	The International Telecommunications Union (ITU) defines a set of center frequencies and frequency spacings[2] that can be used to define standard wavelength channels for DWDM systems. The 50GHz and 100 GHz channel spacing grids are commonly used.
DWDM	Dense wavelength division multiplexing- refers to a device or system in which different wavelength channels are used to carry separate data streams, and the wavelength channel spacing is ≤1000 GHz.
ROADM	Reconfigurable optical add drop multiplexer- a device that uses wavelength selective switches to add or drop signals on one or more wavelength channels from a transport fiber. The channels to be added or dropped are not fixed, but can be changed as needed.
PLC	Planar lightwave circuit- devices in which multiple optical and sometimes electrical components are fabricated on the same substrate rather than being assembled from discrete components.
AWG	Arrayed waveguide grating- A PLC device consisting of input and output star couplers and an array of evenly spaced waveguides with a constant path length difference between adjacent waveguides. This device is most commonly used as a multiplexer/demultiplexer.
Channel frequency range	The frequency range within which a DWDM device is required to operate with a specified performance.
3 dB passband width[1]	The 3 dB passband width D_3 of an optical filter is the total frequency range over which the filter is required to have less than 3 dB of loss with respect to the minimum loss within that range. The 3 dB passband width is symmetrical with respect to the nominal centre frequency f_c of the filter, i.e., the loss is required to be within 3 dB of the minimum at all frequencies between f_c – $D_3/2$ and $f_c + D_3/2$.  Other passbands (e.g. 10 dB or 20 dB) are defined similarly.
Channel nonuniformity	The difference in power between the highest power channel and the lowest power channel, in dB.
Ripple	The peak to peak difference in insertion loss within a channel frequency range.
Adjacent crosstalk	The highest transmission in an adjacent channel passband (over different polarization states), referenced to the lowest transmission in the selected channel passband (over different polarization states).

[1] Rec. ITU-T G.671 (02/2012), Transmission characteristics of optical components and subsystems
[2] Rec. ITU-T G.694.1 (02/2012), Spectral grids for WDM applications: DWDM frequency grid

Nonadjacent crosstalk	The highest transmission in any channel passband nonadjacent to the selected channel (over different polarization states), referenced to the lowest transmission in the selected channel passband (over different polarization states).

Section 2.0 Features

2.1 Front Panel and Optical Inputs

The front panel of the OCA-1000 is shown in Figure 2.

Figure 2 OCA-1000 front panel

Front panel features:

Power:	Power on/off switch
Unit:	Identification number for the OCA-1000, used to differentiate units when multiple 8-channel units are used together. The number can be set using buttons on the rear panel.
PSG IN:	Adapter (narrow-key PM FC/APC standard) for external laser input to the PSG. PM connector keys are aligned to the slow axis of the PM fiber.
PSG OUT:	Adapter (narrow-key SM FC/APC standard) for PSG output. The PSG output is connected to the device or system under test.
Channel 1-8 in:	Adapters for measurement channel inputs. These are free space inputs and can accept either FC/PC or FC/APC connectors.

Note: There are two sets of PSG IN/PSG OUT adapters- one for the C/L band PSG (1480-1620nm) and one for the O band PSG (1260-1360nm). The PSG used should correspond to the wavelength(s) of the laser being used for measurement. Only one PSG can be used at a time.

Fiber Connectors

It is important to follow proper connector handling procedures when making connections to the OCA-1000. Mismatched, dirty or contaminated connectors can cause high insertion loss, high return loss and measurement instability. External fiber connectors should be cleaned using industry standard cleaning methods before connection to the OCA-1000.

The front panel adapters for PSG IN/OUT are connected to internal fiber connectors. These connectors can be cleaned using connector cleaners designed to be used with bulkhead adapters.

The measurement inputs are free space; there are no internal ferrules.

All connectors and adapters should be capped when not in use.

2.2 Rear Panel: Electrical and Remote Control Interfaces

The rear panel of the OCA-1000 is shown in Figure 3.

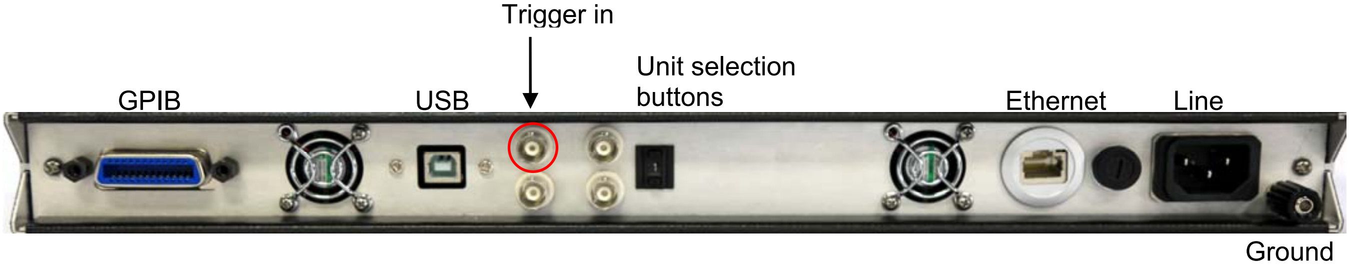


Figure 3 Rear panel

Rear Panel Features:

GPIB: Connection to external laser	Unit Selection buttons: Select module identification number for OCA-1000
USB 2.0 interface port:* connection to control computer	Ethernet Port: Not used
BNC Connector (Trigger In): Connected to Trigger Out from the laser	Cooling fans
Other BNC connectors: Not used	Line: External AC input connector
	⏚ : Chassis ground

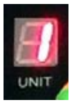
* Note: Connect to USB 2.0 port on control computer. Do not use a USB 3.0 port.

The OCA-1000 uses a USB 2.0 interface to communicate with the control computer. Instructions on installing the control program and drivers are provided in Appendix 1.

The external laser is connected to the OCA-1000 via GPIB. This allows the control program to control the external laser through the OCA-1000. The trigger output of the laser should also be connected to the OCA-1000 (BNC) for synchronization of swept wavelength measurements.

The unit selection buttons are used to set the identification number for a particular OCA-1000 when multiple units are used together and controlled by the same computer. The selected unit number is also displayed on the front panel.

Selector on rear panel



Display on front panel

Section 3.0 Operation Instructions

3.1 Unpacking

Inspect OCA-1000 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	OCA-1000
2	Power cord
3	USB cable
4	GPIB cable
5	User guide
6	Software

3.2 Setup

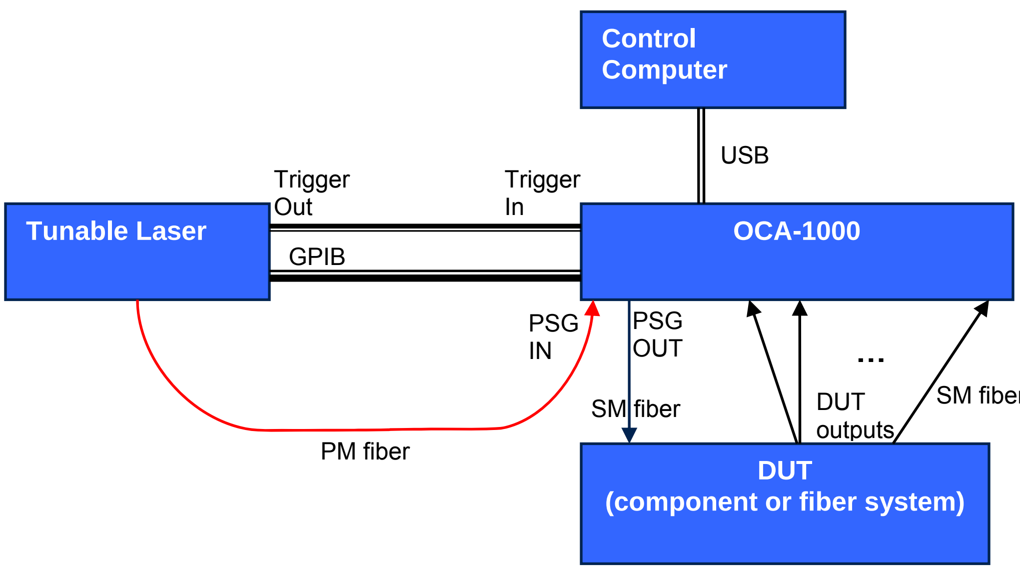


Figure 4 Setup diagram for PDL/IL measurement

1. Install the control software and drivers on the control computer (see Appendix 1.0).
2. If using an external laser for PDL or swept measurement, connect the external laser as shown in Figure 4.
    a. Connect OCA-1000 to external laser via GPIB.
    b. Connect laser output trigger to OCA-1000 Trigger In port with a BNC cable. This connection is necessary for continuous swept wavelength measurements.

c. Clean all optical connectors before making connections. Make sure that the laser is off while cleaning connectors and making connections.

d. Connect laser output to corresponding PSG input using a PM fiber patchcord. The PSG IN connector is an FC/APC narrow key PM connector with the key aligned to the slow axis of the internal PM fiber.

e. Connect the PSG output to the DUT input.

3. Connect the DUT output(s) to the OCA-1000 inputs.

   a. Fix all fibers in place (for example, by taping them down to the table).

4. Power on control computer, OCA-1000, and tunable laser. Allow the laser and OCA-1000 to warm up for their recommended warm-up periods (20 minutes for OCA-1000) before taking measurements.

5. Connect the OCA-1000 to a USB 2.0 port on the control computer. Make sure that the computer is powered on and has fully completed its initialization process before connecting it to the OCA-1000.

6. Run the OCA-1000 control program. The first time the program is used with a particular OCA-1000 unit, it takes about 20 seconds to initialize, load calibration data, and write the calibration data to the system files folder in the control computer. Subsequently, when the program is used to control the same OCA-1000 unit, as long as the calibration data is unchanged, the program accesses it from the system files rather than reloading it from the instrument, so the program starts much faster. After the program finishes initialization, it displays the main interface screen. Note: The interface window can be resized, but has a minimum size of 1200 ×600 pixels.

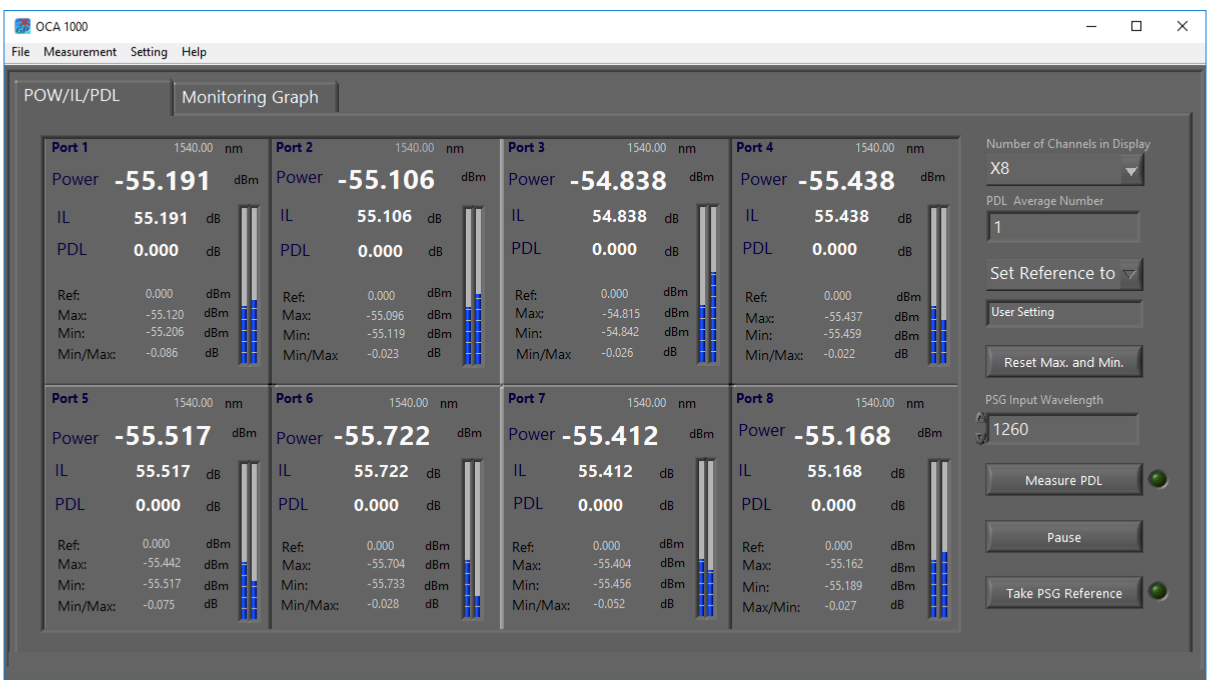
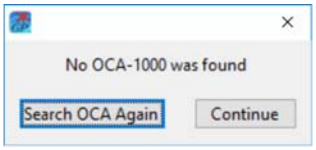
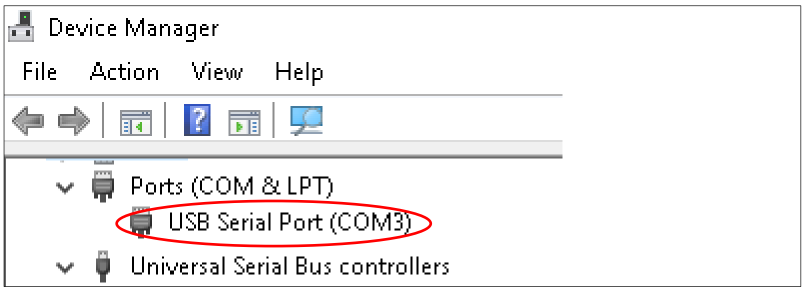


Figure 5 Main program interface

If the program fails to detect the OCA-1000, it will display the following message:



If this message appears while an OCA-1000 is connected to the computer, check the USB connection. Make sure that the OCA-1000 is connected to the USB 2.0 port of the computer and is powered on. The connection between the OCA-1000 and the control computer can be confirmed from Device Manager. Open Device Manager on the control computer and check the ports. There should be one standard USB Serial Port under "Ports (COM & LPT)".



If the port is listed, then the USB connection and drivers are functioning correctly.

After verifying the USB connection, click "Search OCA Again" to retry the detection process. If the OCA-1000 is successfully detected, the program will complete its initialization and display the main screen.

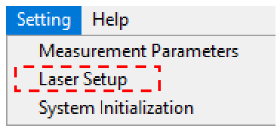
The "Continue" option on the pop-up can be used to run the program in data analysis mode. This allows the user to load saved data for display and analysis without having the OCA-1000 connected.

3.3 Software Interface Quick Reference

This is a quick reference guide for the software interface. Individual features and functions are described in more detail in the following sections.

Laser Setup

The laser setup window can be accessed by selecting "Laser Setup" from the "Settings" menu.



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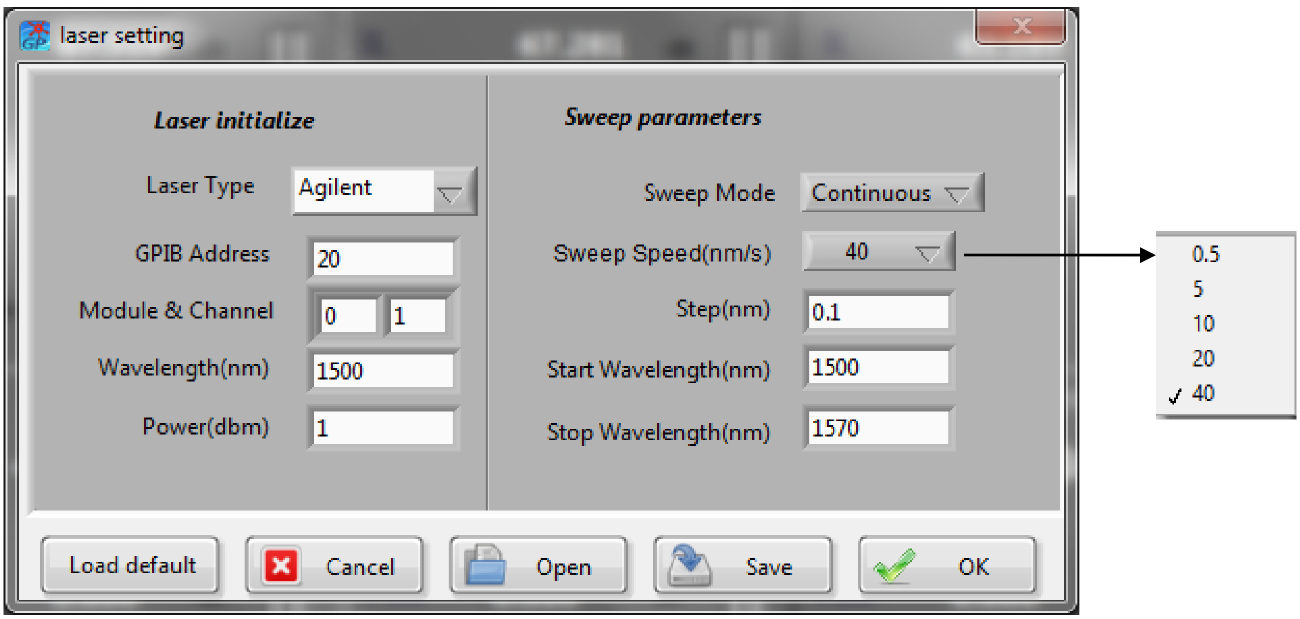


The parameters on the left side of the screen are needed for basic laser setup and communication.

Laser Initialization Parameters

Laser Type	Select the tunable laser. Options are: Agilent (default) Santec EXFO Yenista Newport
GPIB Address	Input the GPIB address of the laser. If this setting does not match the actual GPIB address of the laser, the OCA-1000 will not be able to control the laser.
Module/Channel	If the laser is a module in a mainframe (e.g. many Agilent/Keysight lasers), input the module or channel number corresponding to the laser's position in the mainframe.

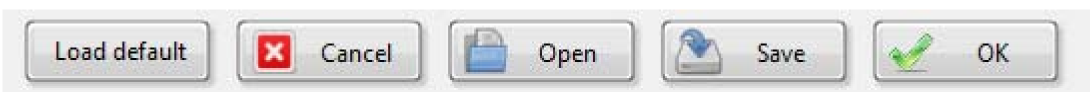
Wavelength	Set the wavelength (in nm) to be used for measurement. Make sure it is a value within the range of the laser.
Power	Set the output power of the laser. Select a value within the range of the laser that is high enough for accurate measurement (for example, DUT input power should be >−10 dBm for a DUT with IL ≤20 dB.

The parameters on the right side of the screen are used for swept wavelength measurements. These can also be set from the swept wavelength measurement screen.

Laser Sweep Parameters

Sweep Mode	Select the type of wavelength sweep to be used. Options are: Continuous (default) Step
Sweep Speed	Select sweep speed (continuous scan only). Options: 0.5, 5, 10, 20, 40 nm/s (depends on laser) Default: 40 nm/s
Step	Select wavelength step for stepped scan or trigger intervals for continuous scan. Range: depends on the precision of the laser Default: 0.1nm
Start Wavelength	Starting point for wavelength sweep. Make sure that the selected value is within range for the laser.
Stop Wavelength	Ending point for wavelength sweep. Make sure that the selected value is within range for the laser and that stop wavelength>start wavelength.

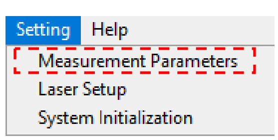
Buttons



Load default	Reset all setup parameters to default values.
Cancel	Cancel setup; program will not change setup values.
Open	Load saved setup file.
Save	Save current setup parameters to a file.
OK	Apply current setup.

Measurement Parameters Setup

The measurement parameter setup window can be accessed by selecting "Measurement Parameters" from the "Settings" menu.



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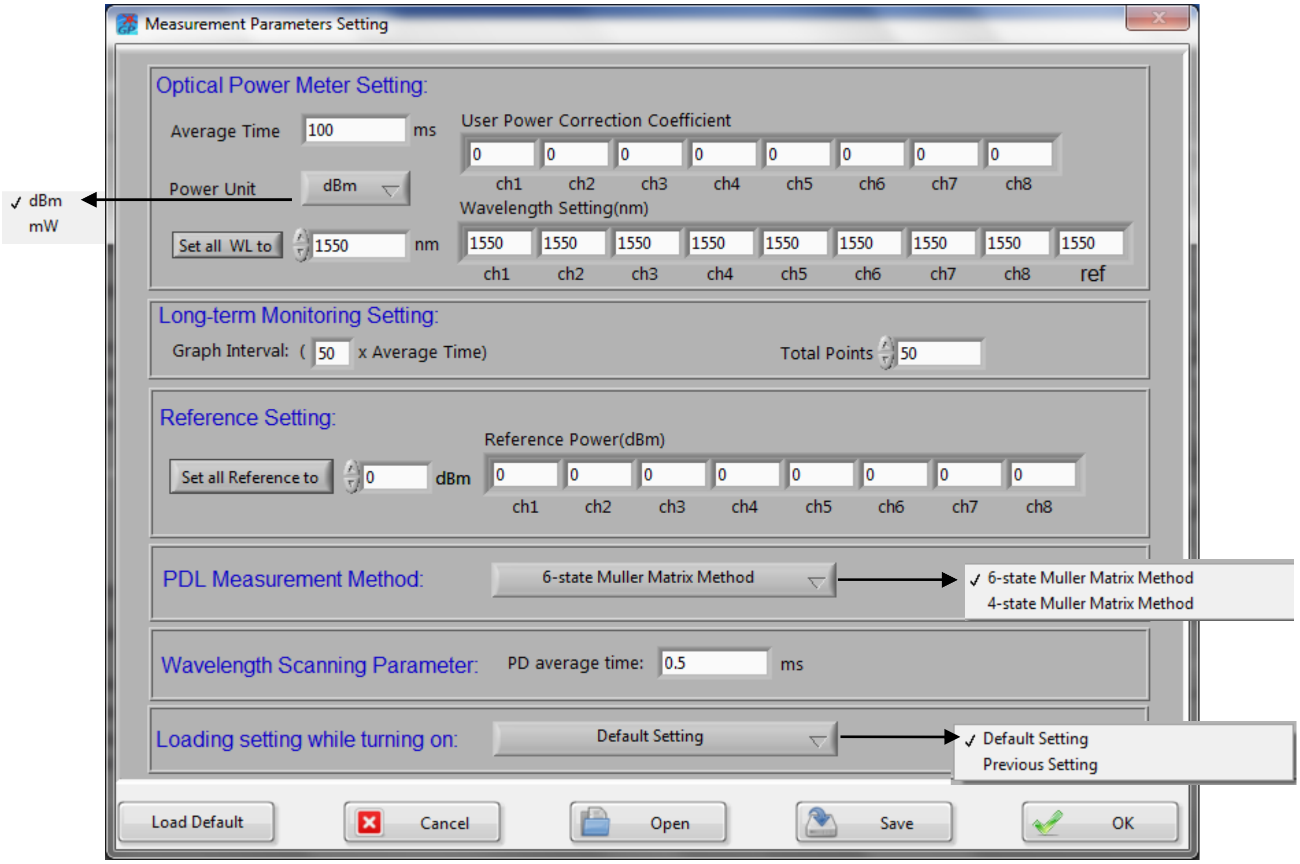


Optical Power Meter Settings (for power measurement)

Average Time	Average time for power measurement Range: 0.5 to 1000 ms Default: 100 ms
Power Unit	Select the units for power display. Options: dBm (default), mW
User power correction coefficient	User power correction coefficients allow users to manually calibrate the measured power for each channel using an external power meter. The power offsets (in dB) for each channel should be entered here. Power correction coefficients are added to uncorrected values.
Set all WL to	Shortcut button to set all channels to the same wavelength. Input the new value in the box next to the button and click the button.
Wavelength Setting	This section displays the current wavelength settings for all 8 measurement channels and the internal monitor (ref) channel. Wavelength settings (in nm) for individual channels can be changed by typing values in the boxes.

Long Term Monitoring Settings (for power vs. time measurement)

Graph interval	Sets the interval between points for the power monitor graph and the long-term monitoring saved data file. The interval is defined here as a multiple of the average time defined at the top of the screen. Multiplier range: ≥ 1 Multiplier default value: 50
Total Points	Maximum number of points that will be plotted on the monitor graph before the graph resets.

Reference Settings (for IL measurement with user set reference values)

Reference power (dBm)	Shows the current user-set reference values for all 8 channels, in dBm. Individual channel settings can be changed by typing the new value in the corresponding box.
Set all Reference to	Shortcut button to set the reference power for all channels (in dBm) to the same value. Input the new value in the box next to the button and click the button.

Several reference sources are available for use in IL measurement. Reference power values in the “Reference Setting” block are used to calculate IL if the user selects “User setting” from the “Set Reference to” pull-down on the POW/IL/PDL measurement setup pane on the main interface screen.

The PDL Measurement Method pull-down menu allows the user to select either the 6-state Mueller Matrix method or the 4-state Mueller Matrix method for PDL measurement. The 6-state measurement is more precise, but takes longer.

Options: 6-state Mueller Matrix (default), 4-state Mueller Matrix

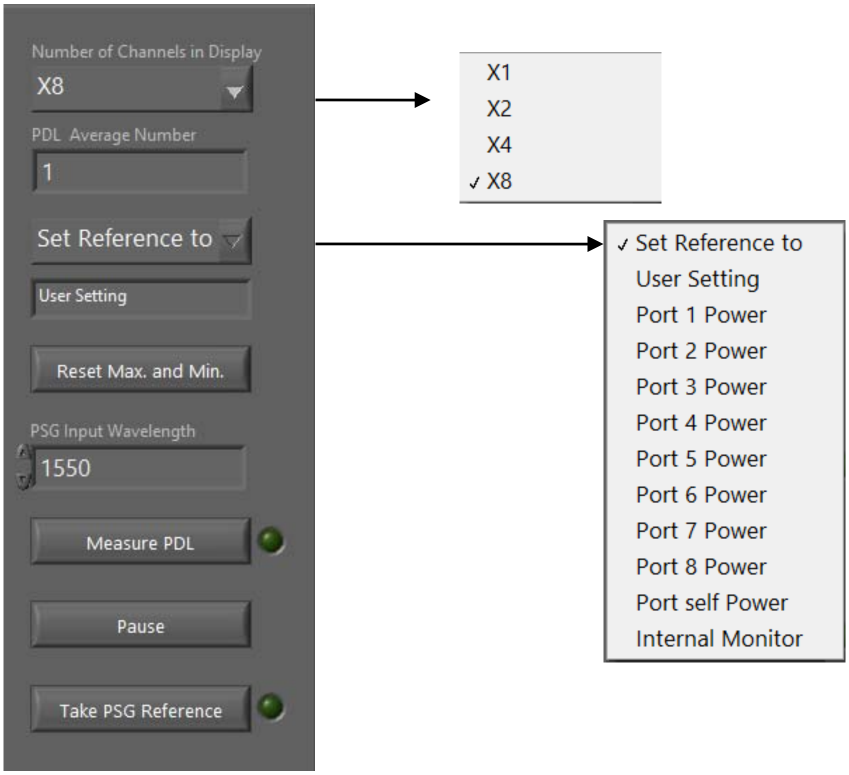
The PD average time per point for swept wavelength measurements can be set either from the measurement parameter setup screen or from the swept wavelength measurement screen. It should be chosen to be ≤ half the time between wavelength steps. For example, if the wavelength sweep rate is 40nm/s and the wavelength step is 0.1nm, then the time between steps is 2.5ms, so the averaging time should be chosen to be ≤1.25ms. If a longer averaging time is set, the program will automatically default to half the wavelength step time.

The initial setup selection pull-down menu allows the user to select which set of measurement parameters are loaded when the program is started. If “default setting” is selected, the program loads the default values on startup. If “previous setting” is selected, the program records the measurement setup before shutdown and uses that setup the next time the program is started.

The button bar at the bottom of the screen has the same functions as the one on the laser setup screen.

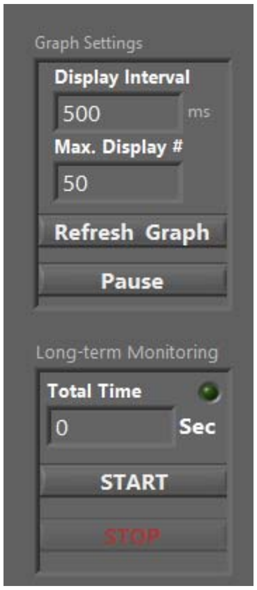
Note: The laser setup and measurement parameter setup screens save setup parameters to the same file. To save a complete set of measurement parameters, make sure to use the same file path and filename to save both sets of setup parameters.

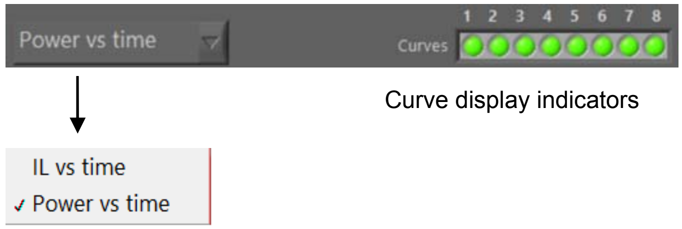
POW/IL/PDL Setup/Display Options (POW/IL/PDL tab, right side of screen)



Channels to Display	Pull-down menu to select the number of channels for which to display measurement results. Up to 8 channels can be displayed at once.
PDL Average Number	Number of PDL measurements to be averaged to generate one displayed value. Range: ≥1 Default: 1
Set Reference to	Pull-down menu to select reference source to be used for IL measurement. The user can set the reference values manually (on the "Measurement Parameters Setting" window, set the reference for all 8 channels to the power measurement from any of the 8 measurement channels or the internal monitor, or set the reference for each channel to the measured power at that channel (port self power). Reference values are set to the measured or set values from the selected source at the time the menu option is selected.
Reset Max. and Min.	Resets the maximum and minimum power values for each channel to the current measured power level and restarts max/min tracking.
PSG Input Wavelength	Set the laser input wavelength to the PSG for PDL measurement. This wavelength setting is used for the PSG reference measurement and for the actual PDL measurement for all channels.
Measure PDL	Take a PDL measurement. The indicator light will blink during the measurement and will turn solid green when the measurement is done.
Pause	Pauses updating of the power measurement results.
Take PSG Reference	PDL measurement requires a reference measurement to calibrate out the effects of the PSG. Clicking this button takes the PSG reference measurement. The indicator light will blink during the measurement and will turn solid green when the measurement is done.

Monitoring Graph Controls





Graph Settings

Display Interval	Set the interval, in ms, between points plotted on the graph or measured for long term monitoring. Interval must be a multiple of the power meter averaging time. Any entered value will be automatically rounded to the nearest multiple.
Max Display #	Maximum number of points shown on the graph before it resets. This graph is similar to an oscilloscope display- it will update the measured data until the set number of points is reached, then reset the graph.
Refresh Graph	Clears the graph and restarts the plot.
Pause/Continue	Pause measurement without clearing already plotted points. Continue a paused measurement. New points will be added to an existing graph.

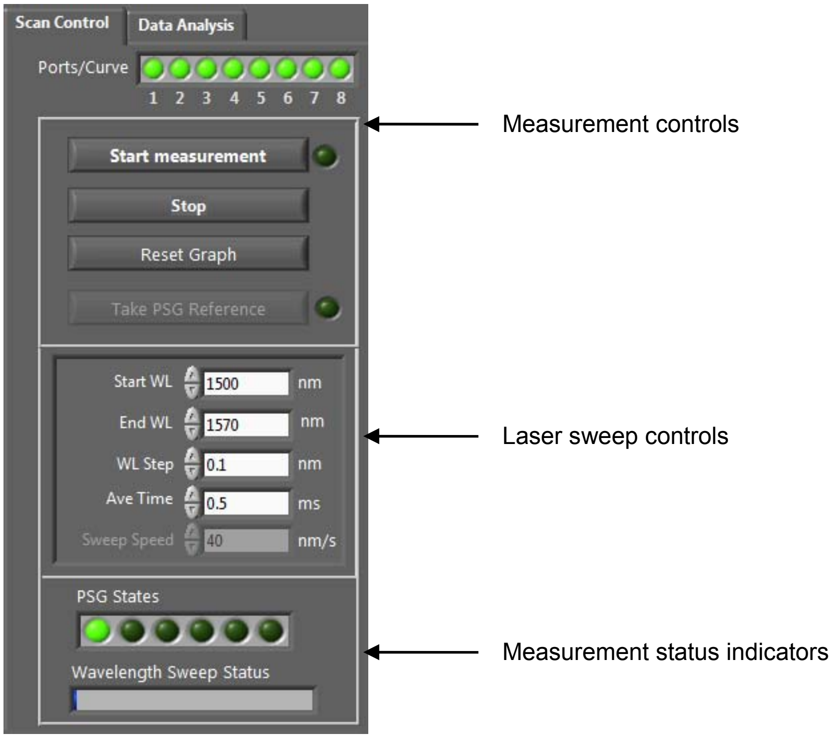
Long-term Monitoring

Total Time	Set the duration, in seconds, for a power/ IL measurement session.
Start	Start power/IL monitoring. The plot will stop updating when the measurement is done.
Stop	Stops a measurement in progress.

Plot Display Options

Plot display pull-down	Pull-down menu to select the parameter to be displayed. The plot can display either power vs. time (in dBm or mW) or IL vs. time (in dB), for any combination of channels.
Curves	Curve display indicators for channels 1-8. Indicator is green if the curve is displayed and dark if it is not. Clicking on an indicator displays/hides the corresponding curve.

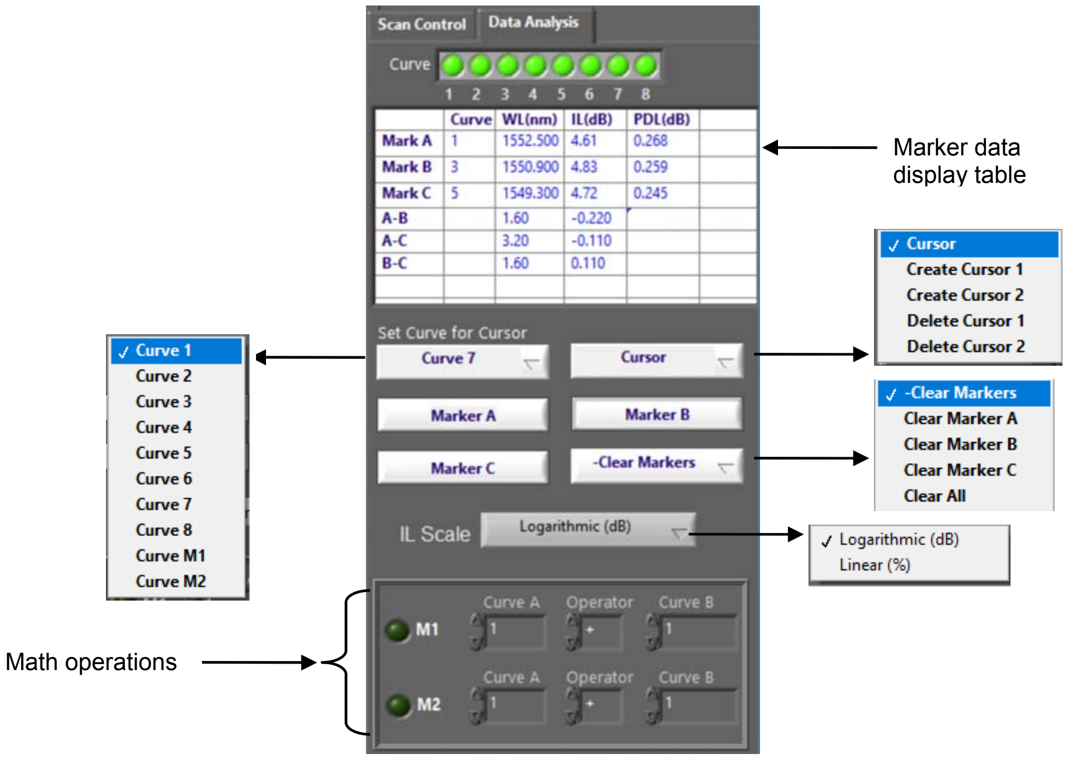
Wavelength Scan- Scan Controls



Ports/Curve	Select the curves to be displayed. Indicators for displayed curves are green, and indicators for hidden curves are dark. Click an indicator to toggle that curve on or off.
Start Measurement	Start PDL/IL vs. wavelength measurement. During measurement, the indicator will blink. When the measurement is completed, the indicator will turn solid green. The measurement can also be tracked via the PSG states and wavelength sweep status indicators.
Stop	Stop a measurement in progress.
Reset Graph	Clear all plotted data.
Take PSG Reference	PDL measurement requires a reference measurement to calibrate out the effects of the PSG. Clicking this button takes the PSG reference measurement. The indicator light will blink during the measurement and will turn solid green when the measurement is done. The measurement can also be tracked via the PSG states and wavelength sweep status indicators.
Start WL	Set start wavelength for wavelength sweep. Make sure value is within range of the laser.
End WL	Set end wavelength for wavelength sweep. Make sure value is within range of the laser.
WL Step	Set wavelength step for PDL/IL measurements. Range: Depends on the laser Default: 0.1 nm
Ave. Time	Set averaging time for one point during a swept wavelength measurement. Time should be chosen to be be ≤ half the time between wavelength steps.
Sweep Speed	Set laser sweep speed for continuous scan. Make sure speed setting is within range of the laser.

PSG States	Indicator shows the current PSG output SOP.
Wavelength Sweep Status	One measurement run requires one laser wavelength sweep per PSG state used in the measurement (for continuous scan) or a measurement at each PSG state at each step in a stepped scan. The wavelength sweep status bar shows the progress of each wavelength sweep.

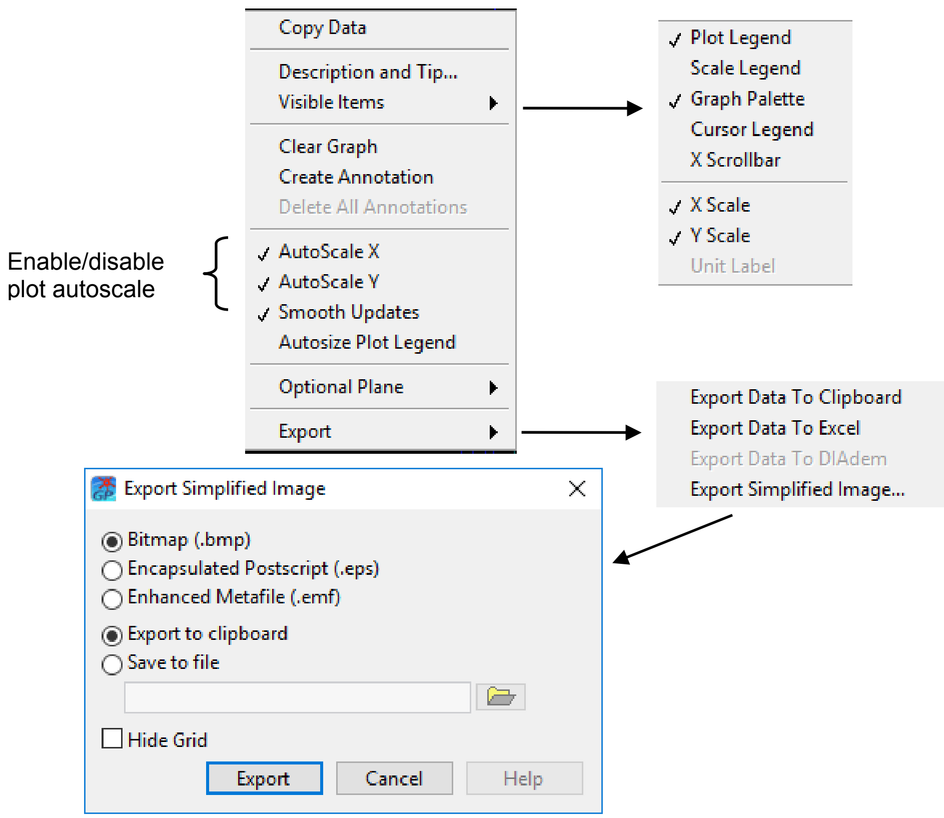
Wavelength Scan- Data Analysis Controls



Curve Indicators	Select the curves to be displayed. Indicators for displayed curves are green, and indicators for hidden curves are dark. Click an indicator to toggle that curve on or off.
Marker data	The data display table shows marker position data and differences in x and y positions of different markers. For each marker, the table shows the curve on which the marker is placed, and the x (wavelength) and y (IL and PDL) values corresponding to the marker position.
Curve pull-down (for cursor placement)	The curve selection pull-down selects the active curve for cursor placement. The cursors are placed on the selected curve.
Cursor pull-down	The cursor pull-down menu allows the user to add or remove cursors on the plots. Cursors are placed on the active curve and can be dragged once they are on-screen. The cursor moves on both the IL and PDL plots at the same time such that the x-position (wavelength) of the cursor is the same on both plots.
Marker X buttons	The marker buttons place the corresponding marker (A, B, or C) at the position of the most recently moved cursor on the active curve. If a marker is already on screen, clicking the marker button again moves it to the current cursor position.
Clear Markers pull-down	The "Clear Markers" pull down menu allows the user to clear any or all markers.

IL scale	The IL vs. wavelength curve can be displayed with either a logarithmic (dB) or linear (% transmission) y-scale. Note: Linear y-scale only available on PDL/IL tab.
Math operations	The Math functions allow the user to perform arithmetic operations on any two measured curves. Math operators available for: IL (logarithmic scale): +, − IL (linear scale): +, −, ×, / Math functions only available on PDL/IL tab.

Plot Options



Plot options allow the user to customize plot appearance and add annotations, as well as to export data from the selected plot.

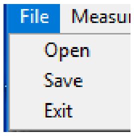
To bring up the plot options menu, right click on any graph window (monitoring graph, PDL, IL, or DWDM).

The first several menu items provide options to clear the graph, to display or hide various plot elements, or to add additional information.

The "Autoscale X" and "Autoscale" Y" options turn on and off the plot autoscaling. With autoscale off, the plot zoom functions and manual x and y rescaling are enabled.

Export options allow the user to export displayed data on the plot (for all visible curves) to the clipboard or to an Excel file, or to export a simplified image of the plot. Because the "Export Data" options only export displayed data, if the displayed plot is altered (e.g. by zooming in on a section of the plot), only the data for the currently displayed (zoomed) section is exported, not the full set of measured data.

Save/Load Data



Data can be saved or loaded for display from the file menu. This function works with both the power/IL vs time measurement (long term monitoring) and the swept wavelength PDL/IL measurement.

3.4 Measurements

The OCA-1000 can perform several types of measurements, including power and IL monitoring, PDL measurement, and PDL and IL vs. wavelength. Setup descriptions, procedures, and results analysis for each type of measurement are described in this section.

Power/IL Measurement and Monitoring

The OCA-1000 can provide real-time measurement of power and IL, as well as power/IL measurement vs. time.

Measurement Setup

For power and/or IL measurement, the measurement setup depends on the reference source. The OCA-1000 has an internal power monitor that can be used as a reference for IL measurements. This is convenient because it does not require an additional referencing step. To use the internal monitor, one of the OCA-1000’s PSG modules must be in the optical path before the device under test (dotted lines in Figure 6).

For simple power measurements, or for IL measurements using a reference source other than the internal monitor, the PSG is not required. The light source can be connected directly to the DUT, and the DUT outputs to the OCA-1000 inputs.

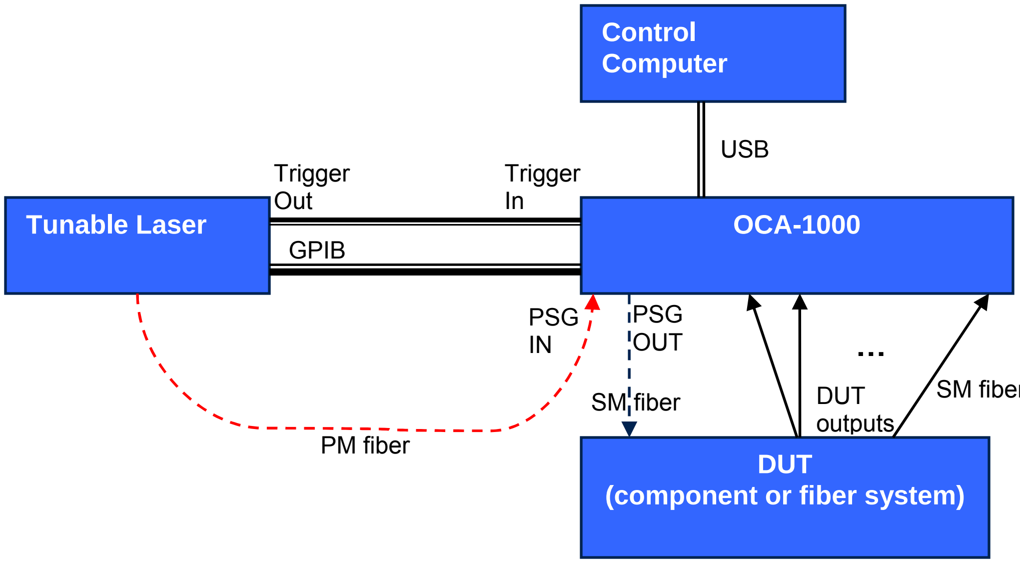
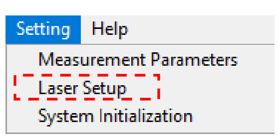


Figure 6 Power / IL measurement setup.
Dotted lines are only necessary to use the internal monitor as the reference source.

Measurement Procedure

1. Set up equipment and DUT as shown in Figure 6. If using a PSG, make sure to use the PSG IN/OUT corresponding to the wavelength range being used for measurement. For single-wavelength measurements, the laser trigger signal is not needed.
2. Make sure fibers are stable and fixed in place.
3. Run the OCA-1000 control program.
4. If the OCA-1000 is being used to control the external laser, select "Laser Setup" from the "Settings" menu and input the laser communications parameters, wavelength, and power settings.



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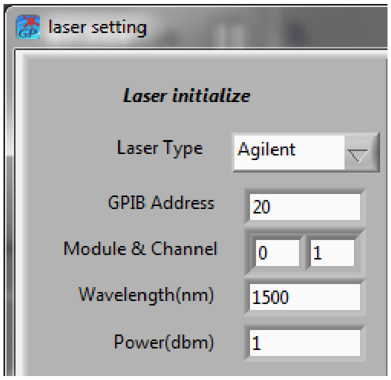
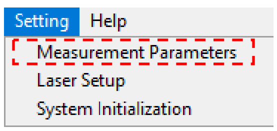


Click "OK" and verify that the laser is under remote control and its settings are updated.

5. Select "Measurement Parameters" from the "Settings" menu and set the power meter average time, units, wavelength, reference settings, and if desired, correction coefficients. Click "OK".



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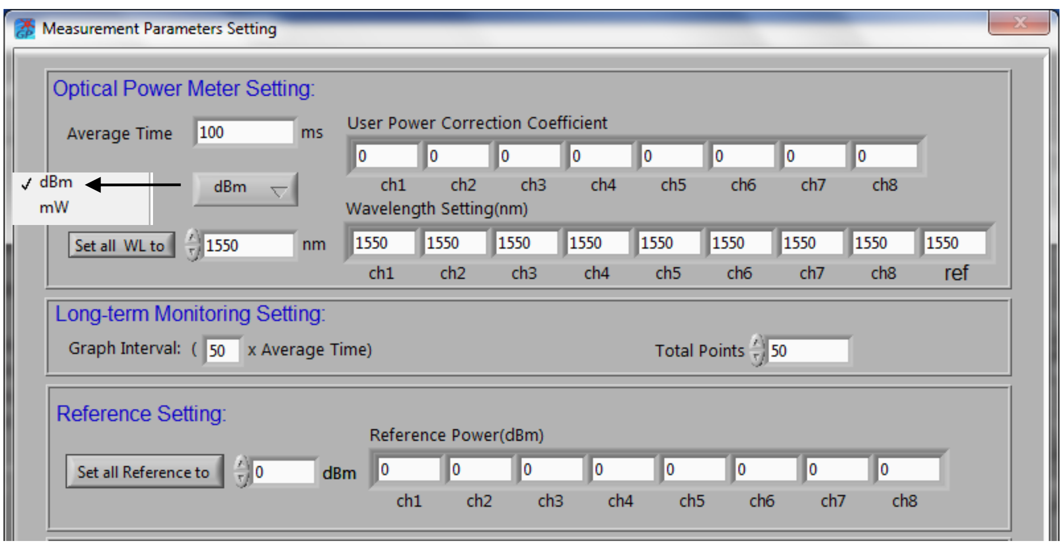

6. The program should display the POW/IL/PDL measurement screen.

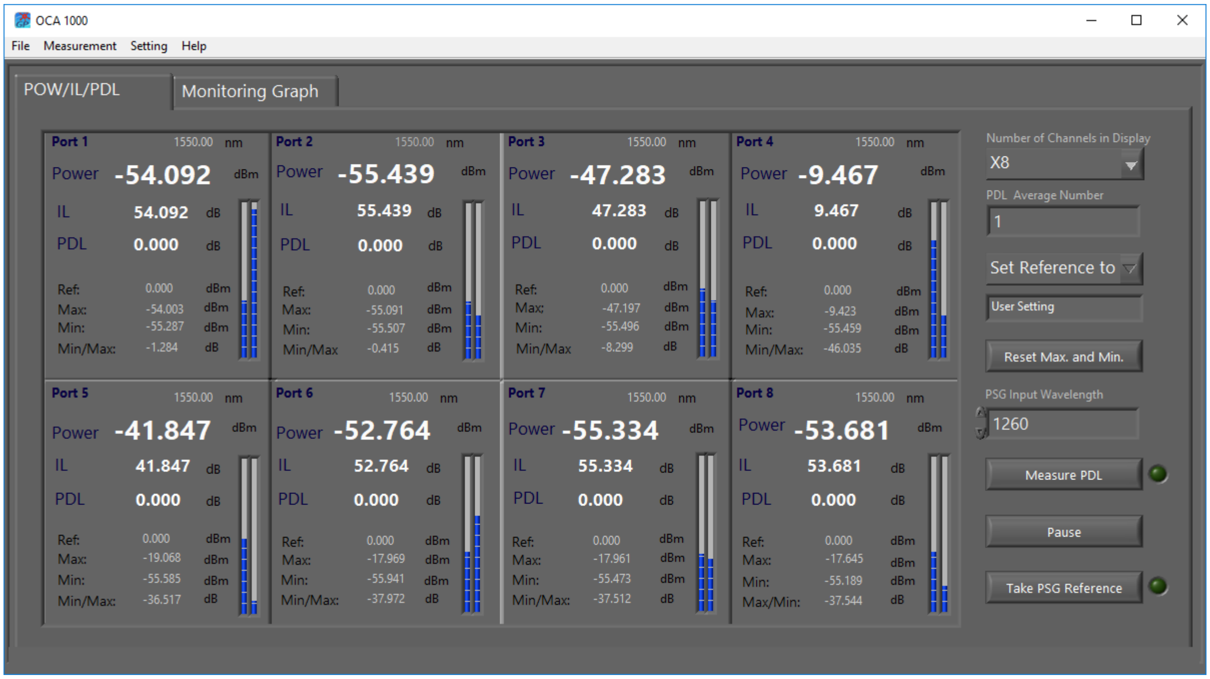

Figure 7 POW/IL/PDL measurement screen, 8-channel view. DUT is an AWG.

7. Select the number of channels to be displayed from the pull-down menu at the top right of the screen. If fewer than 8 channels are displayed, the user can select the channel to be displayed in each panel by using the up/down arrows or by typing a number in the port display field. The 2-channel display is shown below as an example.

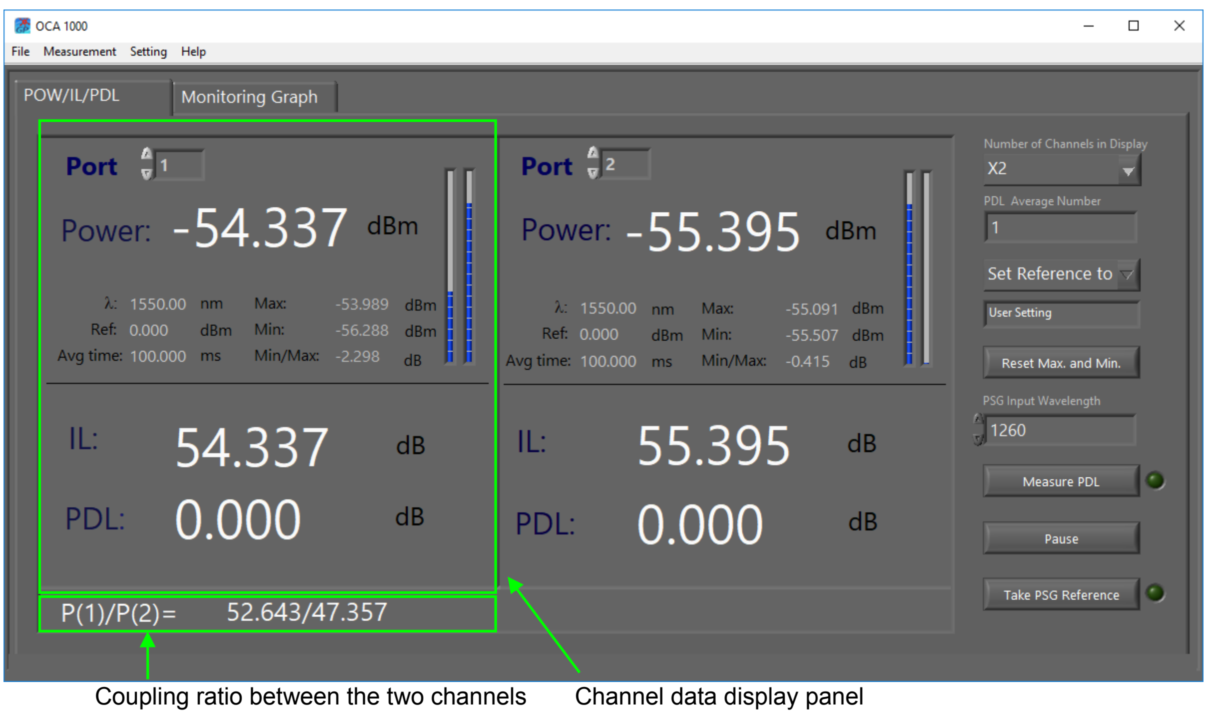

Figure 8 POW/IL/PDL screen, 2-channel view.

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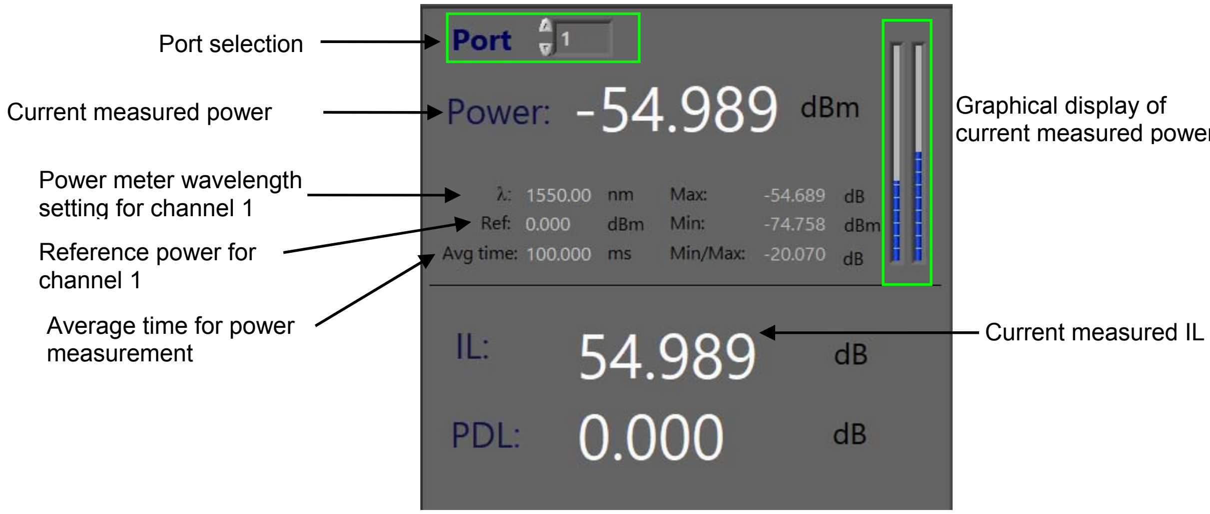


Figure 9 Closeup of a data display panel from the 2-channel display

Each port measurement display panel contains the following information:

Port number	The port for which data is displayed in this panel. On the 1, 2, or 4-channel displays, use up/down arrows to set the channel or enter it directly.
Power	Displays the current measured power for the selected port, in real time. Power can be displayed in dBm or mW. The power display unit can be set from the measurement parameters setup screen or from the 1-channel display screen. The power measurement display is continuously updated. Updating can be stopped by clicking the "Pause" button on the right side of the screen.
Power level bar display	The two bars to the right of the power display provide a graphical representation of the measured power level. It is useful as an analog indicator of whether the power is increasing or decreasing, and can be used, for example, to monitor power during component alignment. The left bar represents the number to the left of the decimal point, and the right bar the number to the right of the decimal point.
λ	Wavelength setting, in nm, for the selected channel. This can be set from the measurement parameters setup screen.
Ref	Reference power for IL measurement. The reference source is selected from the pull-down menu at the right of the screen. Options on the menu include "user setting", any of the 8 ports, "Port self power", or "internal monitor". User Setting: User manually sets the reference values from the measurement parameters setup screen. Port X power: The current measured power from port X (where X = 1-8) is set as the IL reference for all ports. Port self power: Sets the reference power for each port to the current measured power for that port. This function can be used for manual referencing – connect a low-loss patch cord between the light source and the input port(s), select "Port self power" from the pull-down menu, then replace the patch cords with the DUT.

	Internal Monitor: The OCA-1000 has an internal power monitor that measures the output power of the PSG. Selecting this option sets the current measured power from the monitor as the reference for all channels. The wavelength setting for the internal monitor can be set from the measurement parameters setup screen. To update the value for any measured reference option (port 1-8, self reference, or internal monitor), reselect the option from the pull-down menu.
Avg. time	Averaging time for power measurement. This can be set from the measurement parameters setup screen. Range: 0.5 to 1000 ms Default: 100 ms
Max. Min. Min/Max	The program tracks the maximum and minimum power measured on each channel during the current measurement session. It displays the maximum and minimum, in dBm, as well as the ratio of min to max power, expressed in dB. Max/min tracking can be reset by clicking the "Reset Max and Min" button on the right side of the screen.
IL	Displays the current measured insertion loss for the selected port, in real time. IL is measured relative to the reference value displayed in the "Ref" field. The IL measurement display is continuously updated. Updating can be stopped by clicking the "Pause" button on the right side of the screen.
PDL	Displays the most recent measured PDL value. PDL measurement will be described in the next section.

Coupling Ratio Measurement (2-channel display only)

In addition to the common parameters displayed on all of the power measurement screens, the 2-channel display also has a coupling ratio calculation function designed specifically for 2-output DUTs. The coupling ratio calculation assumes that the total output power of the device is the sum of the output powers of the two selected channels and provides the power ratio of each channel to the total as a percentage.

For example, if channels 1 and 2 are displayed, and the measured power for channel 1 is equal to the measured power for channel 2, the program will display

P(1)/P(2)=50/50

Monitoring Graph

The Monitoring Graph function plots measured power or IL vs. time. To use this function, first, set up the power or IL measurement parameters from the POW/IL/PDL tab, then switch to the Monitoring Graph tab for the graph view. The program begins plotting data as soon as the Monitoring Graph tab is clicked. The graph continuously updates, and the plot axes automatically autoscale as data is added.

Figure 10 Monitoring graph display for power measurement
DUT = 8-channel AWG

The graph can display either power or IL vs. time. The default display parameter is power. The displayed parameter can be changed using the pull-down menu at the top left of the screen. Power is plotted in either dBm (log scale) or mW (linear scale), depending on the power unit selected. Power unit can be set from the Measurement Parameters screen or from the 1-channel power meter display. IL is always plotted in dB.

The default display shows data for all 8 channels. Individual channel plots can be toggled on and off by clicking the corresponding indicators.

Measurement parameters can be set from the "Graph Settings" area on the left of the screen.

Graph Settings

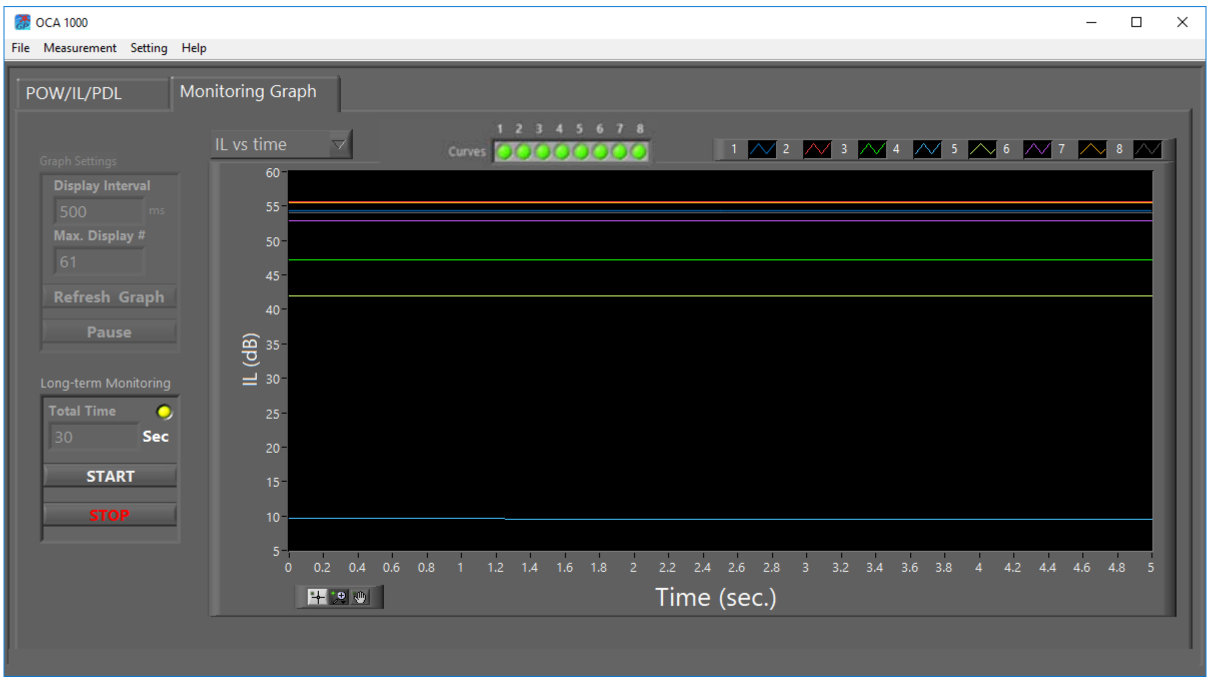
Display Interval	Set the interval, in ms, between points plotted on the graph or logged in a long-term measurement. The interval must be a multiple of the power meter averaging time. Entered values are automatically rounded to the nearest multiple.
Max Display #	Maximum number of points plotted before the graph resets. As in an oscilloscope display, measured data is added to the plot until the set number of points is reached, then the graph is reset.
Refresh Graph	Clears the graph and restarts the plot.
Pause/Continue	Pause measurement without clearing already plotted points. Continue a paused measurement. New points are added to the existing graph.

In addition to plotting the measured data, the program can perform a long-term power/IL measurement and save the data to a file. For this function, the interval between points is the same as the display interval for the graph.

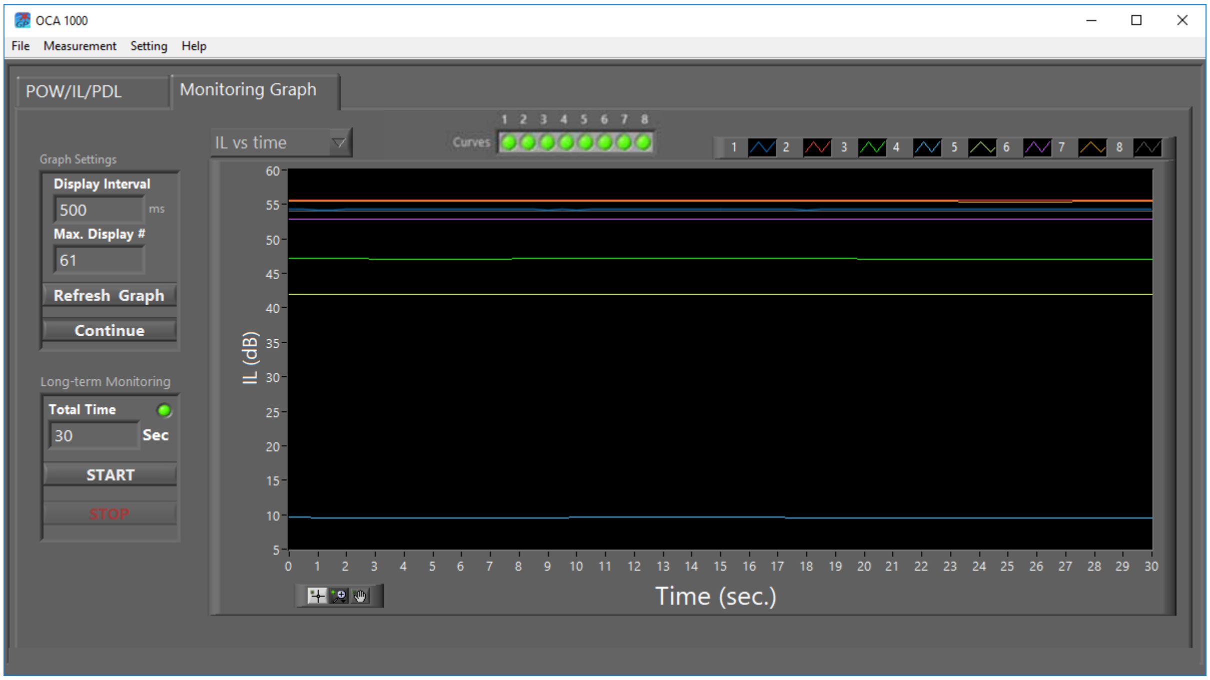
Long-term Monitoring

Total Time	Set the duration, in seconds, for data logging. After this value is set, the maximum display # will automatically update to match the interval and total time settings.
Start	Start measurement.
Stop	Stop a measurement in progress.

During measurement, most of the setup controls are disabled.



When the measurement is finished or stopped, the graph stops updating and the setup controls become active again.



After a long-term measurement is finished or stopped, data can be saved to a file by selecting “Save” from the File menu. The user can select the channels to be included in the saved file. The saved data includes power and IL for the selected channels. Previously saved data can also be loaded for display by selecting “Open” from the File menu.

While the graph is stationary (no data being added), the graph palette can be enabled for data analysis by right clicking in the plot area and disabling the x and y autoscaling.

PDL Measurement

PDL measurement can also be done from the POW/IL/PDL screen, but requires an additional reference step. Unlike the power/IL measurements, PDL measurement is not done in real time.

Measurement Setup

PDL measurement requires the PSG to be in the optical path; however, a single-wavelength PDL measurement does not require control of the laser by the OCA-1000. The optical connections to the laser should be set up as shown below, but the remote control connection is only necessary if the user wants to control the laser from the OCA-1000 interface.

The laser source used must be stable, narrow band, and fully polarized (DOP = 100%), with a PM fiber output.

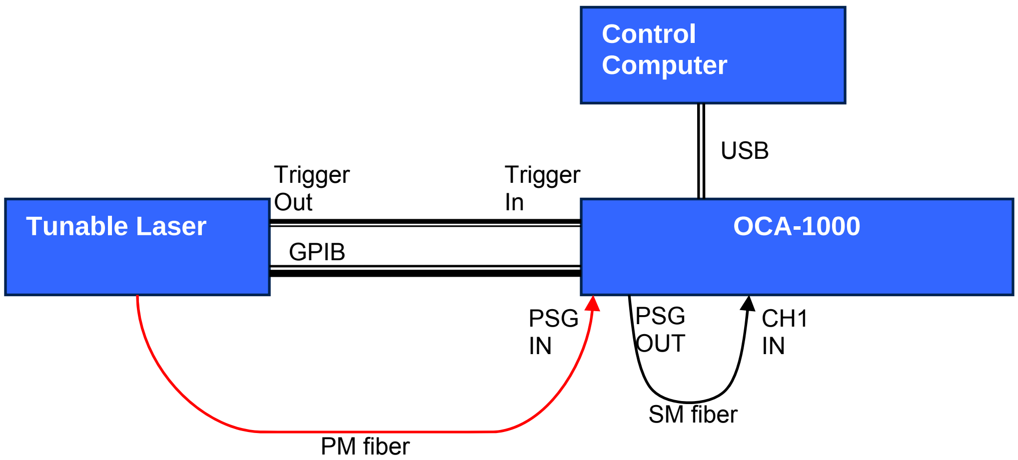


Figure 11 Setup diagram for PSG reference

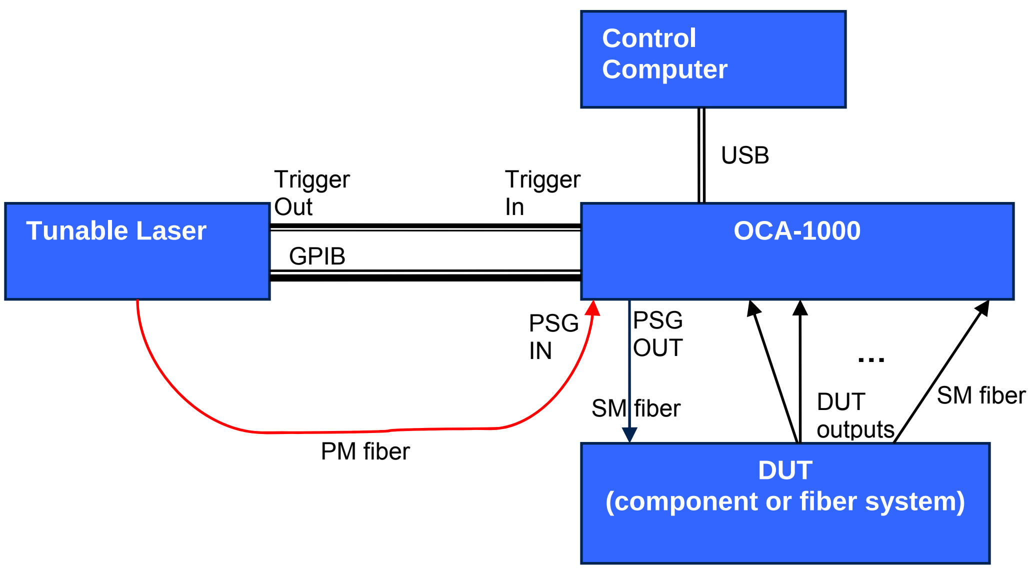
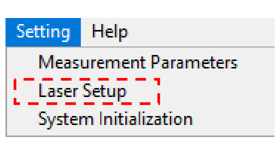


Figure 12 Setup for PDL measurement

Measurement Procedure

1. Set up the OCA-1000, control computer, and laser source as shown above.
2. If the laser is being controlled by the OCA-1000, check the laser settings from the laser setup screen and make any necessary changes. If not, manually set the wavelength and power for the laser.



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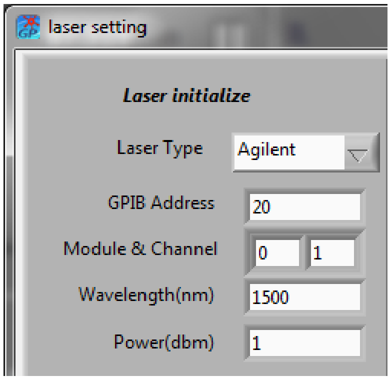
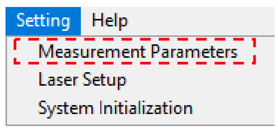


3. Set the PDL measurement method from the measurement parameter setup screen.



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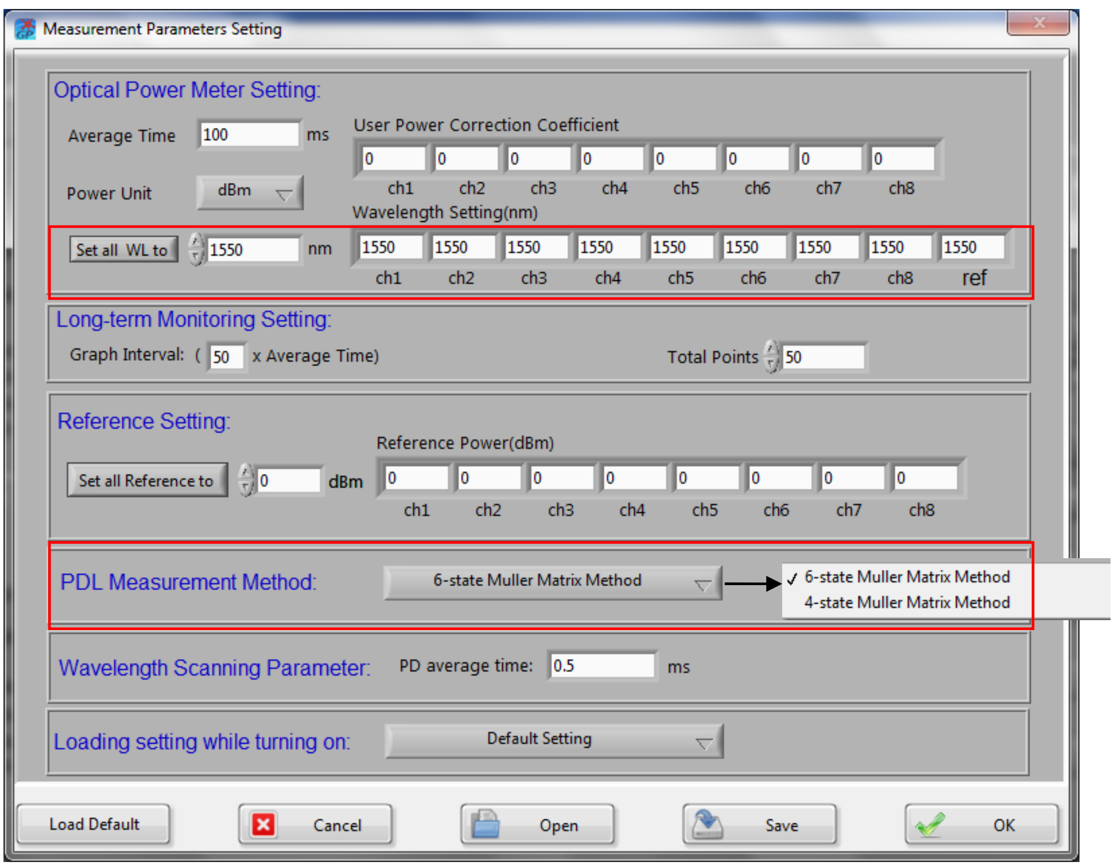
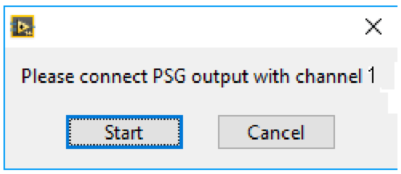


4. Set the measurement wavelengths for all ports used for PDL measurement to match the laser wavelength. This can be done either from the measurement parameter setup screen

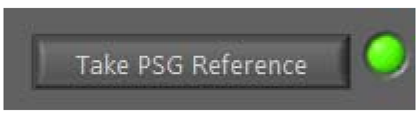
(see above) or by setting the "PSG Input Wavelength" on the measurement screen to the laser wavelength.

5. Take a reference measurement. The reference is used to calibrate out the effects of the PSG from the measured value. The reference measurement needs to be done only once during a measurement session, unless the laser or PSG setup is changed. Connect a good, low-loss SM fiber patchcord as the DUT between the PSG output and the channel 1 input (Figure 11).
6. Click the "Take PSG Reference" button on the lower right of the screen. You will be prompted to connect the patchcord.

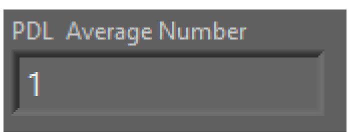


Click "Start".

7. The indicator next to the "Take PSG Reference" button will blink during the reference measurement and will turn solid green after the measurement is done.



8. Remove the patchcord and connect the DUT between the PSG output and the OCA-1000's measurement input ports (Figure 12).
9. Set the PDL Average Number on the right side of the screen. This is the number of measurements averaged to generate one displayed value. The default value is 1.



10. Click "Measure PDL". The indicator next to the button will blink during the measurement. When the measurement is done, the indicator will turn solid green, and the measured values will be displayed in the PDL data fields.

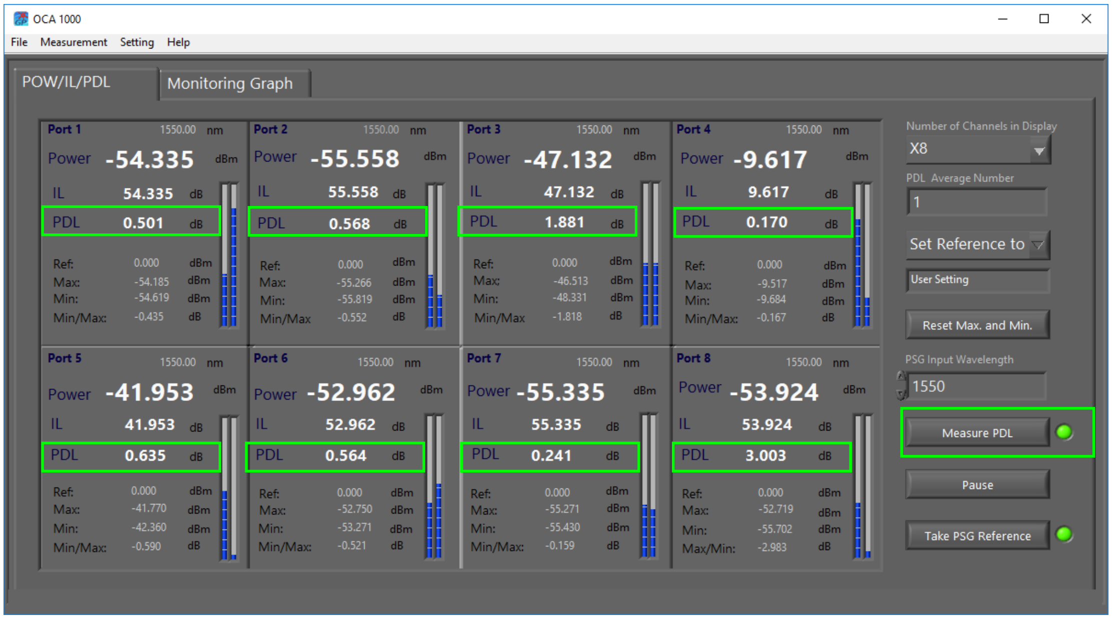


Figure 13 PDL measurement result.
DUT = 8-channel AWG. PDL of all channels measured at 1550nm.
IL and PDL are lowest for channel 4, whose pass band includes the measurement wavelength.

Swept Wavelength Measurements

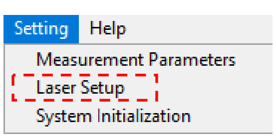
In addition to performing single-wavelength measurements, the OCA-1000 can measure and plot PDL and IL vs. wavelength. For a swept wavelength measurement, IL is always referenced to the internal power monitor. The setup is similar to that for single-wavelength PDL measurement, but requires a tunable laser that can be controlled by the OCA-1000. Therefore, the GPIB and, for continuous sweep, trigger connections between the laser and OCA-1000 are required.

Measurement Setup

The reference and measurement setups are shown in Figure 11 and Figure 12, respectively.

Measurement Procedure

1. Set up the OCA-1000, control computer, and laser source as shown in Figure 11.
2. Check the laser settings from the laser setup screen and make any necessary changes.



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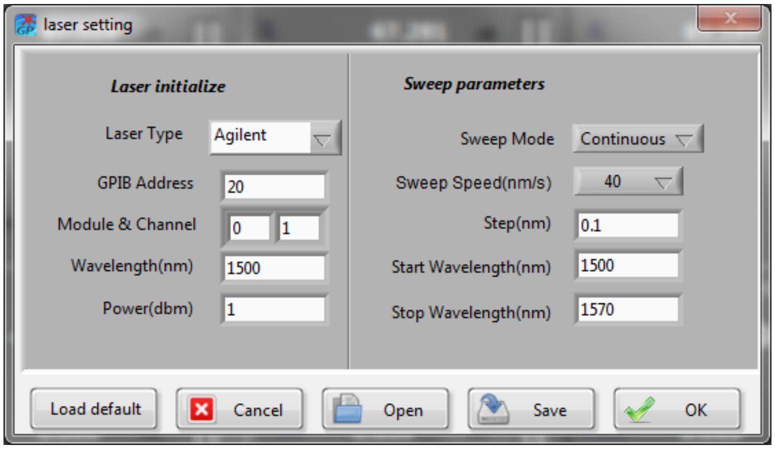
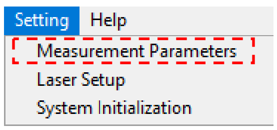


Make sure that the communication setup is correct and that the power level is within the range of the laser used. Sweep settings can be set either from this screen or directly from the measurement screen.

3. Set the PDL measurement method from the Measurement Parameters setup screen. The 6-state Mueller Matrix Method is more precise, but takes longer than the 4-state Mueller Matrix Method. The PD average time can be set either from the Measurement Parameters setup screen or directly from the measurement screen. It should be consistent with the sweep settings (PD average time ≤0.5 × time between wavelength steps). If it is larger than that, the program will automatically reset the value to 0.5 × time between wavelength steps.



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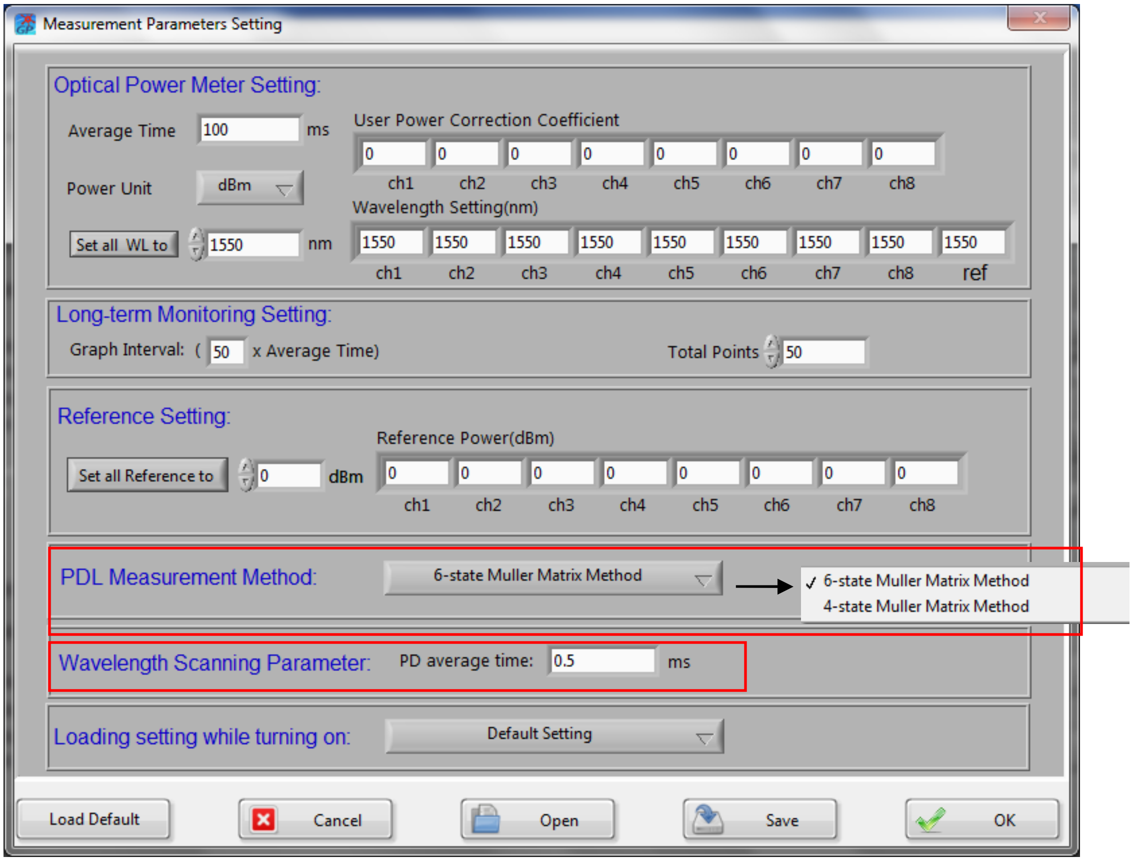
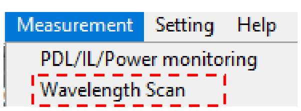
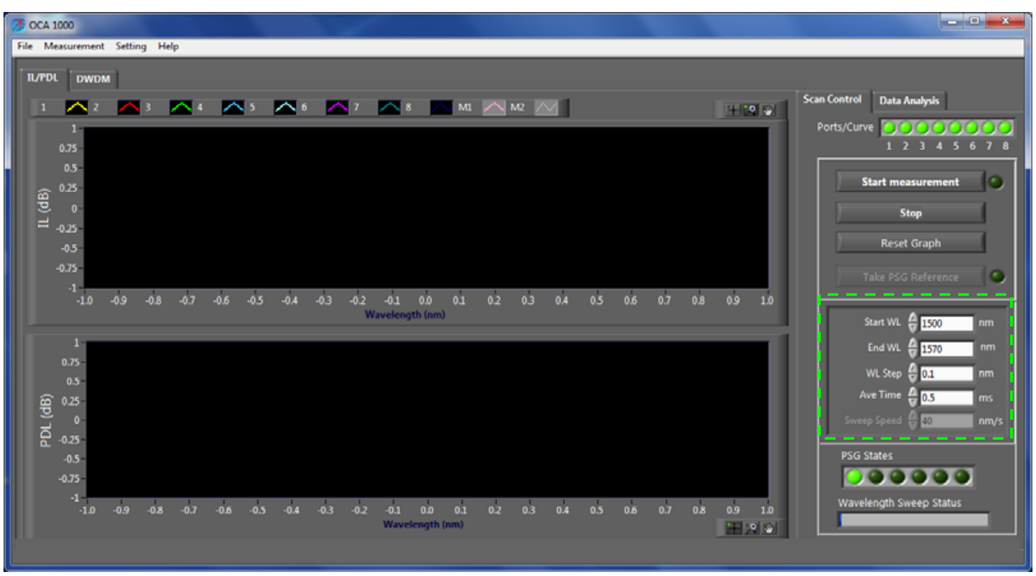


4. Select "wavelength scan" from the Measurement menu.



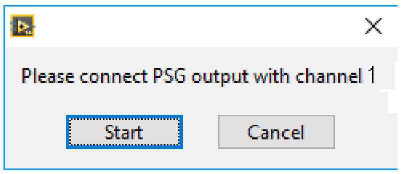
This will bring up the IL/PDL vs. wavelength measurement screen.



Laser sweep control

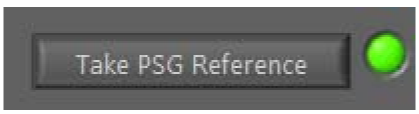
Note that laser sweep parameters and PD averaging time can also be set from the control pane on the right of the screen.

5. Take a reference measurement. The reference is used to calibrate out the effects of the PSG from the measured values. The reference measurement needs to be done only once during a measurement session, unless the laser or PSG setup is changed. Connect a good, low-loss SM fiber patchcord as the DUT between the PSG output and the channel 1 input (Figure 11).
6. Click the "Take PSG Reference" button on the middle right of the screen. You will be prompted to connect the patchcord.



Click "Start".

7. The indicator next to the "Take PSG Reference" button will blink during the reference measurement and will turn solid green after the measurement is done.



In addition, the PSG states indicators and wavelength sweep status bar can be used to track the progress of the measurement.

The PSG will generate either 4 or 6 states, depending on the measurement method being used. For a continuous sweep, one wavelength sweep is done for each SOP generated by the PSG. For a stepped sweep, the PSG will step through all 4 or 6 SOPs at each wavelength step.

8. Remove the patchcord and connect the DUT between the PSG output and the OCA-1000's measurement input ports (Figure 12).
9. Click "Start Measurement". The indicator will blink during measurement and will turn solid green after the measurement is done. As with the reference measurement, the PSG states indicators and wavelength sweep status bar can be used to track the progress of the measurement. When the measurement is done, the results will be displayed in the plot windows.

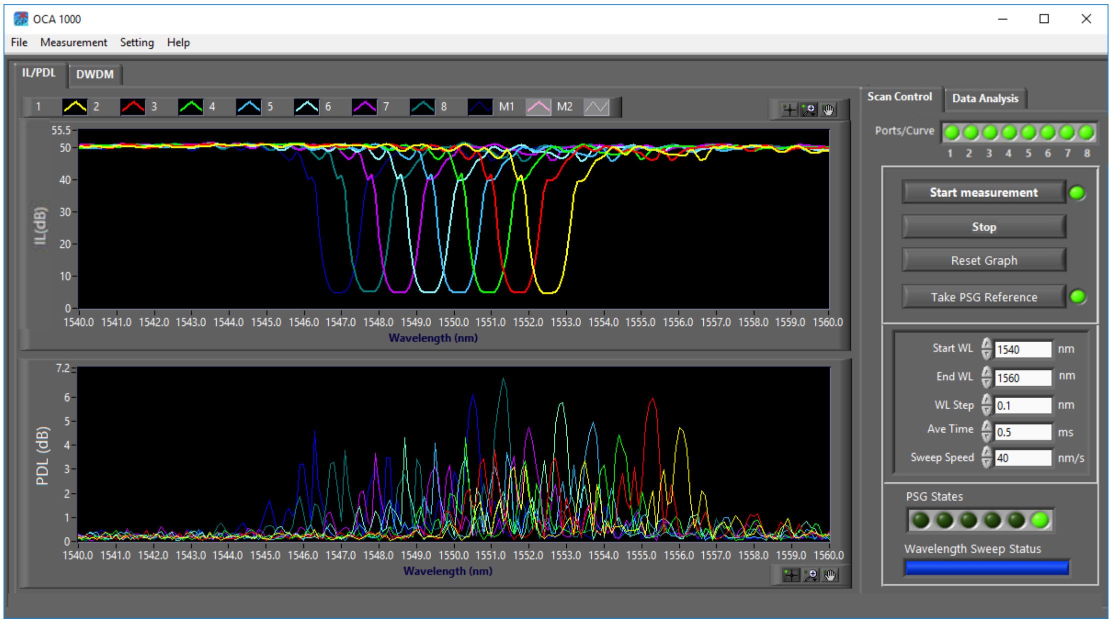


Figure 14 IL/PDL vs. wavelength measurement of an 8-channel C-band AWG measured with a 1540-1560nm wavelength sweep

10. The Data Analysis tab can be used to access cursor and marker options.

3.5 Data Analysis

Graph Operations

Using the graph operation functions shown in Figure 15, the user can zoom in and out in the data plots, use cursors to read the coordinates of measured points, place markers on the curves and measure the coordinate differences between the markers.

Cursor and marker functions are available only on wavelength scan measurement plots, but the plot scaling options (zoom, pan, and manual editing of x and y scale limits) can also be used with the power/IL monitoring graph plot when the plot data is not being actively updated (measurement paused, stopped, or completed). For the monitoring graph, x and y autoscaling is enabled by default. It can be disabled from the plot options menu (right click on the plot area to bring up the plot options, then disable "AutoScale X" and "AutoScale Y").

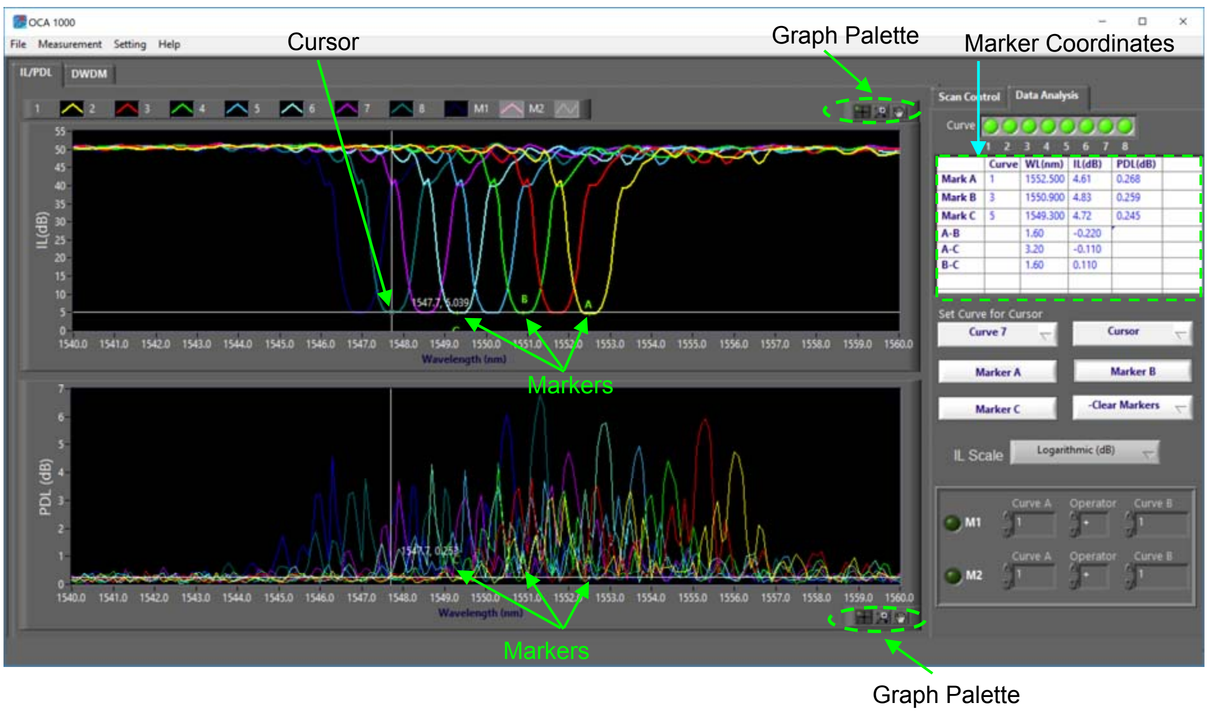
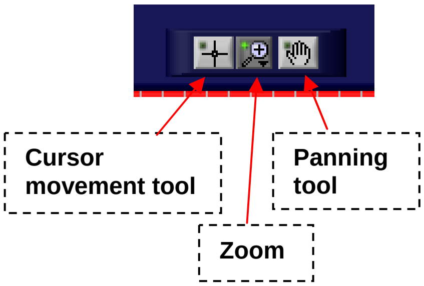
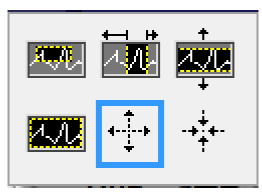
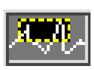
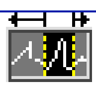
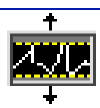
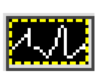
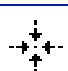
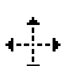


Figure 15 Wavelength scan IL/PDL graph example (DUT is an 8-channel C-band AWG) with 1 cursor and 3 markers on screen

Graph Palette

	The graph palette can be used to move cursors and to zoom and pan the graph display. Click the corresponding button in the graph palette to enable cursor movement, display zooming, or display panning. Each button has a status indicator in its upper left corner which turns green when that option is enabled. • **Cursor Movement Tool**—Allows cursor to be dragged on the display. • **Zoom**—Zooms in and out on the display. • **Panning Tool**—Picks up the plot and moves it around on the display.
	The Zoom tool (middle button on the graph palette) allows the user to zoom in or out on the graph. When the Zoom tool is clicked, a pop-up menu of zoom options appears. This menu is shown below. 
	Zoom by selection rectangle. Only the area in the selected rectangle is displayed.
	Zoom by rectangle, with zooming restricted to *x* data (the *y* scale remains unchanged).
	Zoom by rectangle, with zooming restricted to *y* data (the *x* scale remains unchanged).
	Undo zoom. Resets the graph to full data display.
	Zoom in about a point. If you hold down the mouse on a specific point, the graph continuously zooms in until you release the mouse button.
	Zoom out about a point. If you hold down the mouse on a specific point, the graph continuously zooms out until you release the mouse button.

Note: The IL and PDL plots are linked in order to keep the x-axis scales the same. When one plot is zoomed with respect to the x axis, the other plot is simultaneously zoomed.

Graph Scale Options

X and Y scale limits

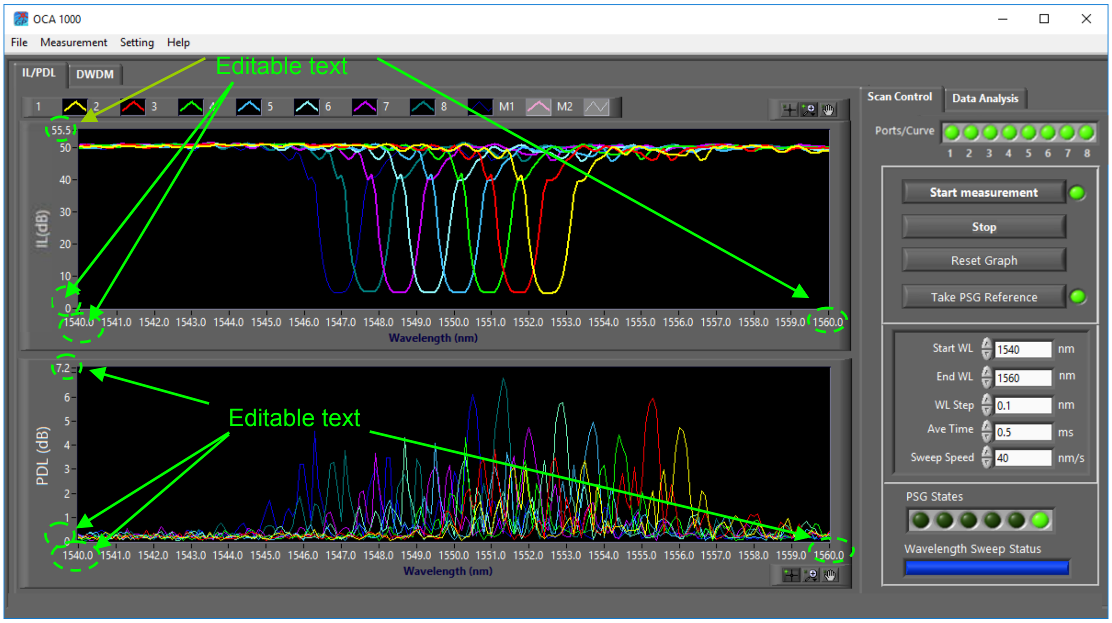


Figure 16 Plot limit editing options

Both the x and y scale limits can be edited by selecting the text and typing in new values. This can be a more precise way of rescaling the plot than using the zoom options.

Linear / Log Y scale

The PDL plot is always displayed on a log (dB) scale, but the IL plot Y-axis can be either log scale (IL, expressed in dB), or linear scale (transmission, expressed in %). The scale can be selected using the IL scale pull-down menu below the cursor and marker controls in the control pane on the right of the screen.

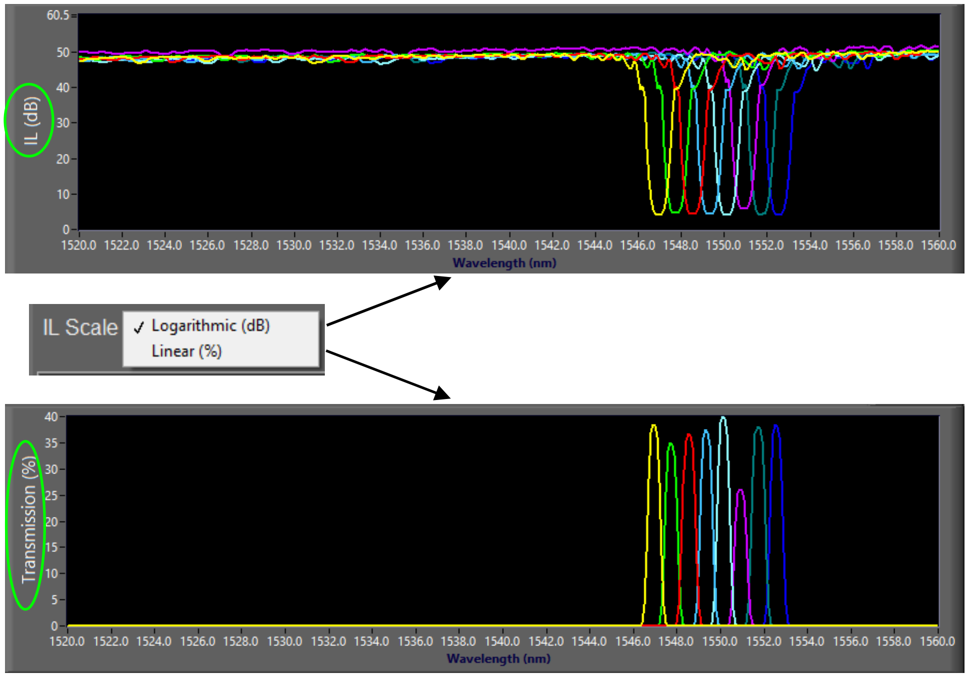
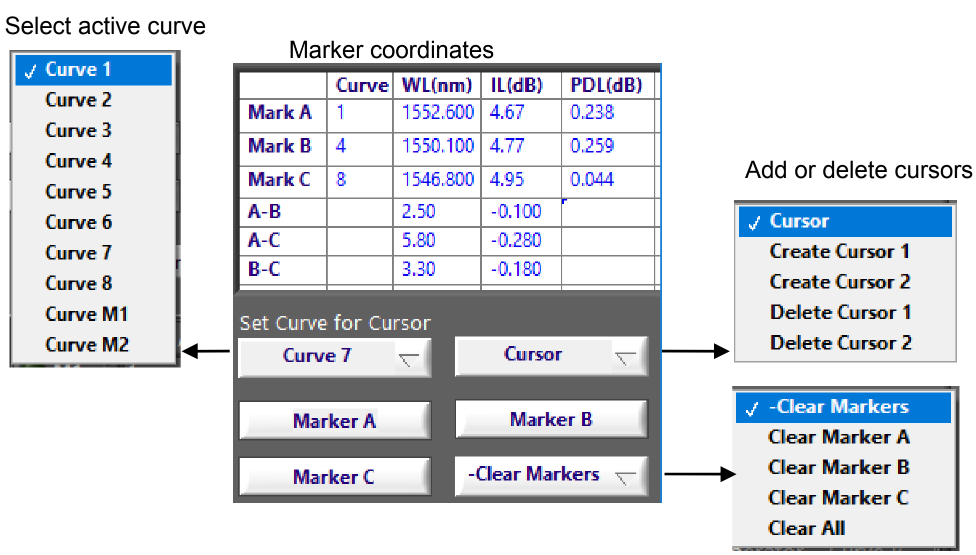


Figure 17 Wavelength scan IL plot y-scale options

Cursor and Marker Controls



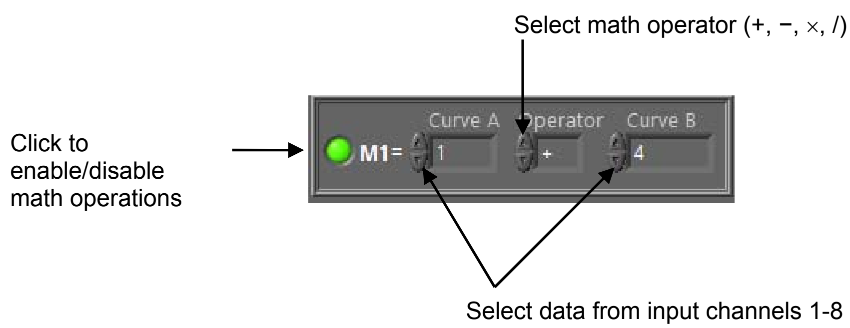
Curve pull-down menu	Selects the active curve for cursor placement.
Cursor pull-down menu	Adds or deletes cursors. Cursors are always placed on the active curve. Once the cursors are on-screen, they can be dragged to the desired position. Cursors move simultaneously on the IL and PDL plots. Cursor x and y positions are displayed next to the cursors.
Marker A, B, C buttons	The marker buttons place the corresponding markers at the position of the most recently moved cursor. If a marker is already on-screen, clicking its button again moves it to the current cursor position.

	Markers can be placed on different curves. For example, to place Marker A on curve 1 and Marker B on curve 2: 1. Select curve 1 as the active curve. 2. Add a cursor and drag it to the desired position. 3. Click the "Marker A" button. 4. Select curve 2 as the active curve. 5. Drag the cursor to the desired position. 6. Click the "Marker B" button. As with the cursors, markers are placed simultaneously on the IL and PDL plots at the same x (wavelength) position.
Clear Markers pull-down menu	The "Clear Markers" pull-down menu allows the user to remove any or all markers.

The marker coordinates display area shows the position of each marker that has been placed- which curve it is on, and the wavelength, IL, and PDL values at the marker position on that curve. It also shows the position differences between markers. This is useful, for example, to compare peak positions on different curves.

Math Functions

The math functions allow the user to perform math operations on measured curves. The measured data from any two channels can be added, subtracted, multiplied, or divided, and the resulting data displayed as a new curve (M1 or M2). The math operations controls are located below the IL scale controls in the control pane on the right side of the screen.



To use the math function:

1. Click the indicator to enable the math function and display the results curve.
2. Select the channel to be used for Curve A (ch 1-8).
3. Select the operator (+, − for log scale plots, or +, −, ×, / for linear scale plots).
4. Select the channel to be used for Curve B (ch 1-8).

The resulting data will be displayed as curve M1 or M2. The plots below show examples of math operations on curves 1 and 4.

Curve 1 + Curve 4 (log scale):

Curve 1 – Curve 4 (log scale:

Curve 1 + Curve 4 (linear scale):

Curve 1 − Curve 4 (linear scale):

Curve 1 × Curve 4 (linear scale):

Curve 1 / Curve 4 (linear scale):

DWDM Display

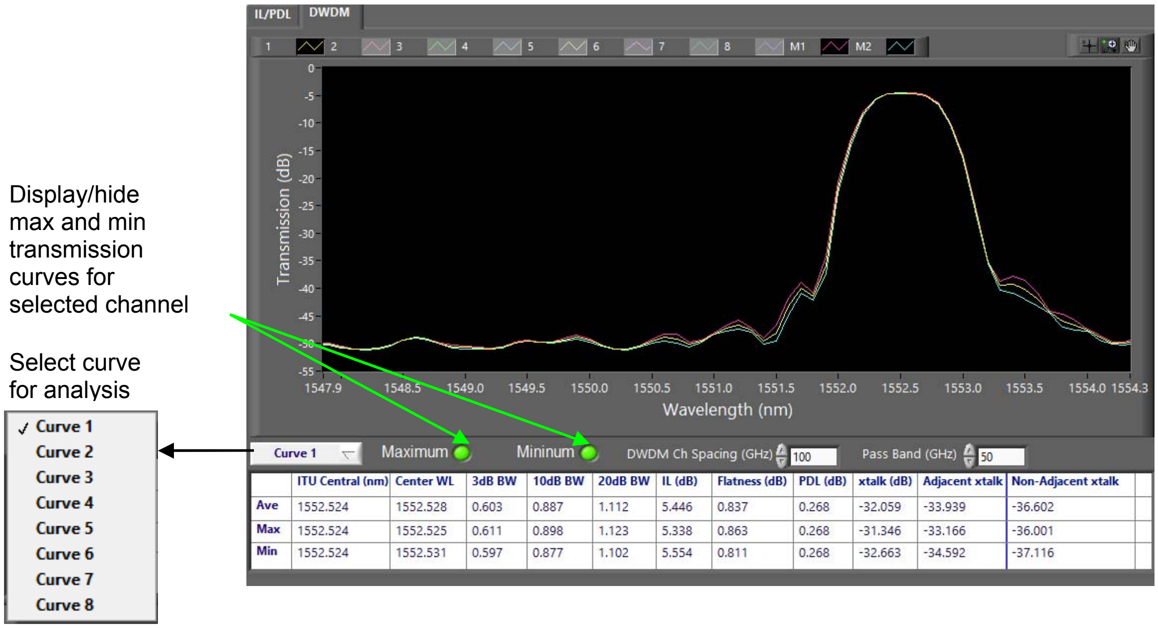
The DWDM display is designed specifically for analysis of multichannel DWDM components, and can help characterize the passbands of different channels and the crosstalk between channels.

To use this function, click the DWDM tab after a swept wavelength measurement is completed or data has been loaded from a saved file.

The plot shows the transmission (in dB) vs. wavelength for all displayed channels. Curves can be displayed or hidden by clicking the corresponding indicators in the control pane on the right of the screen.

The cursor and marker functions are the same as on the IL/PDL plots.

In addition, the DWDM function can perform more detailed analysis of individual channels. Select the curve to be analyzed from the pull-down menu below the plot window. In the example below, channel 1 is selected.



The table displays the following data for the selected curve:

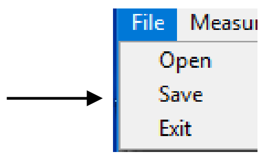
ITU Central	Closest ITU grid channel to the measured center wavelength for the selected input channel.
Center WL	Measured center wavelength (in nm) of the passband for the selected input channel.
3 dB BW	Wavelength range (in nm) calculated from where the transmission drops off 3 dB from the value at the measured center wavelength.
10 dB BW	Wavelength range (in nm) calculated from where the transmission drops off 10 dB from the value at the measured center wavelength.
20 dB BW	Wavelength range (in nm) calculated from where the transmission drops off 20 dB from the value at the measured center wavelength.
IL	Insertion loss at center wavelength, relative to the OCA-1000's internal monitor.
Flatness	Difference between the maximum and minimum transmission (in dB) for the selected channel over the pass band width input in the fields above the table.
PDL	Measured PDL at the center wavelength.
Xtalk	Average crosstalk between the selected channel and all other channels, using the DWDM channel spacing and pass band width input in the fields above the table.
Adjacent xtalk	Crosstalk between the selected channel and the channels immediately adjacent to it, using the DWDM channel spacing and pass band width input in the fields above the table.
Non-adjacent xtalk	Average crosstalk between the selected channel and all channels except the ones immediately adjacent to it, using the DWDM channel spacing and pass band width input in the fields above the table.

Since the transmission is measured at different input polarization states as part of the measurement process, the program is able to show the polarization variation of the parameters in the table. The 3 rows of the table list the average, maximum, and minimum values of the parameters when measured over different polarization states. The maximum and minimum transmission curves for the selected channel can also be displayed (as M1 and M2, respectively) by clicking the "Maximum" and "Minimum" indicators above the data table.

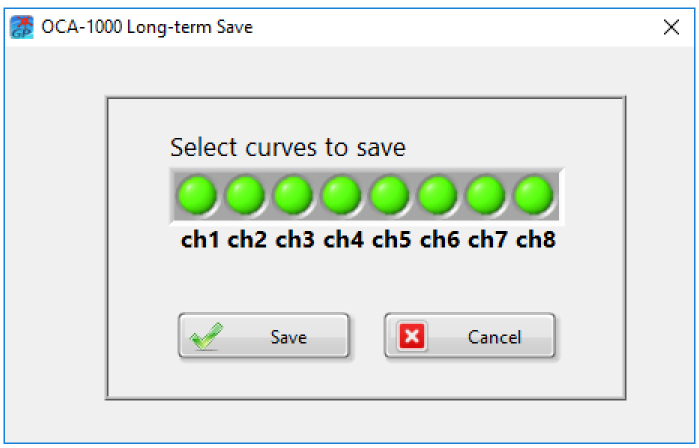
The crosstalk values in the table can be recalculated using different values of the DWDM channel spacing and pass band width by changing the values in the fields above the table. The defined pass band width must be less than the channel spacing.

Saving Data

Data from a completed wavelength scan or power/IL long term monitoring measurement can be saved to a file by selecting "Save" from the File menu.



A curve selection window will appear.



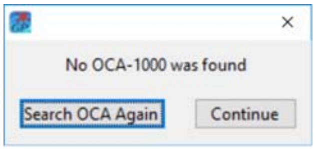
Select the curves to be saved and click "Save".

Specify a filename and location to which to save the data. Although the saved file has file extension .OCA, the data is saved as text, and the file can be opened using applications like Notepad or Excel.

Each data file contains a header describing measurement setup parameters. Data columns for a swept wavelength measurement contain the laser sweep wavelengths and the IL and PDL values for the selected channels. Data columns for a monitoring graph measurement contain the time stamps and the power (in dBm) and IL (in dB) values for the selected channels. Columns are tab delimited.

A saved data file can be recalled for display and analysis by selecting "Open" from the File menu and browsing for the saved data file. Saved data from a wavelength scan measurement can be displayed and analyzed on either the IL/PDL tab or the DWDM tab.

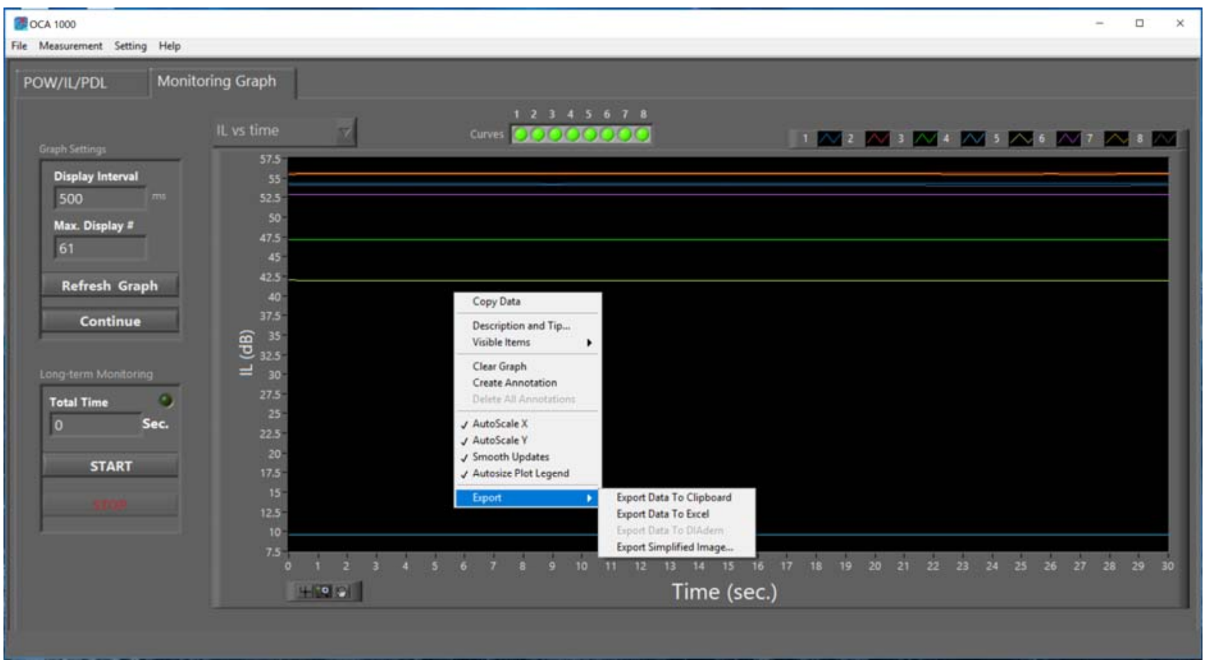
The OCA-1000 does not need to be connected to the computer to run the program to analyze saved data. If the program is run without the OCA-1000 connected, the following pop-up will appear:



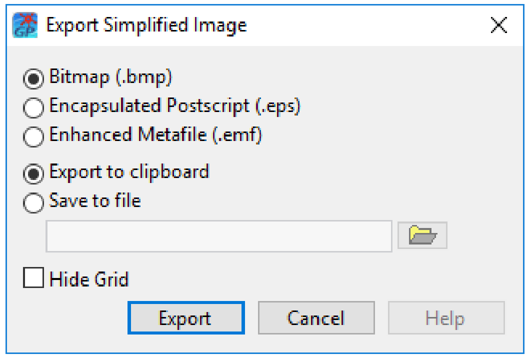
Click "Continue" to run the program in analysis mode. Saved data can be loaded for display and analysis, but all measurement functions will be disabled.

Plot Data Export Options

Plot data or images can also be exported from the plot options menu. These functions are available for any measured data plot (monitoring graph, wavelength scan IL or PDL graphs, or DWDM transmission graph).



Right-click in the plot area to bring up the plot options menu, then select "Export". Data can be copied to the clipboard or exported to Excel. The plot can also be exported as a simplified image in various file formats.

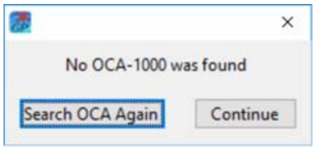


The plot export options export the data that is currently displayed in the plot. If some of the curves are hidden, or if the plot has been zoomed, the displayed data is not necessarily the full set of measured data.

Note also that a saved data file generated using plot export options is not correctly formatted to be reloaded for display by the OCA-1000 control program. If data is to be reloaded for display, it should be saved using the "Save" function from the File menu.

3.7 Troubleshooting

The following tables list some common issues and probable causes.

Symptom	**Probable Cause**
"No OCA-1000 found" error message 	If this message appears with the OCA-1000 connected to the computer, check the USB connection. Make sure that the computer is on and has completed its startup sequence, and that the OCA-1000 is powered on before connecting a USB 2.0 compatible cable between the OCA-1000 and the computer's USB 2.0 port and clicking "Search OCA Again".
Program cannot communicate with laser (laser settings do not change after the user clicks "OK" on the laser setup screen).	1. Check that the laser is connected to the OCA-1000. 2. Check that the laser type and GPIB address are correctly entered on the setup screen. 3. Check that laser setup parameters (wavelength, power) are within range of the laser.
Swept wavelength measurement cannot be completed.	1. If using continuous sweep, check that laser output trigger is connected to "trigger in" port of OCA-1000. 2. Check that laser sweep parameters are correct (sweep range is within range of the laser, averaging time $\leq 0.5 \times$ time between wavelength steps).
Program does not respond to function buttons.	Check whether the program is running. If the interface screen shows a white arrow between the top title bar and the program area, then the program is open, but not running. Click the white arrow to run the program.
Measurement cannot complete	The program may have been started before the DAQ was detected. In this case, select "System Initialization" from the Settings menu to re-run the device detection and initialization.
Measurement functions not available	If the program is running in analysis mode, it can load and analyze saved data, but all measurement functions will be grayed out. To perform new measurements quit the program, connect the OCA-1000 to the computer, and restart the program, making sure that the OCA-1000 is detected before proceeding.

Section 4.0 Specifications

Optical

Number of channels	8 channels in base unit; Can be expanded to more channels
Operating wavelengths	1260 ~1360 nm (O-band) and 1480 ~ 1620 nm (C + L bands)
Optical power range[1]	−60 dBm to +8 dBm
Optical power accuracy[1]	± 0.5 dB
Optical power variation for different channels[1]	± 0.1 dB
Integration time of power meter	0.5 ~ 1000 ms
PDL measurement range[2]	0 ~ 20 dB
PDL measurement uncertainty[2]	± (0.02 + 2% of PDL) dB @PDL<10dB ± (0.02 + 5% of PDL) dB @10<PDL<20dB
PDL resolution	0.01 dB
PDL repeatability[2]	± 0.02 dB
IL measurement range[3]	0 to 60 dB (single point or stepped wavelength sweep mode) 0 to 55 dB (continuous wavelength sweep mode)
IL measurement uncertainty[3]	± (0.01 + IL× 0.5%) dB
IL resolution	0.002 dB
IL repeatability[2]	± 0.005 dB
Sweep period of 6-state PDL/IL measurement (typ.)	(2+wavelength sweep range (nm)/40)×6 seconds when laser sweep speed is 40 nm/s

Electrical/Communication

Power Supply	100-240VAC, 50-60 Hz
Communication Interfaces	USB 2.0 (to control computer) GPIB (to external laser)
Trigger In	BNC (connects to output trigger of laser)
Software	OCA-1000 control program

Physical and Environmental

Mechanical Dimensions (One unit)	1U 19” rack mountable enclosure, 12” depth
Fiber type	C/L band PSG in: PM 1550 Panda fiber O band PSG in: PM 1300 Panda fiber PSG outputs: SMF-28
Optical Connector Type	PSG in/out: FC/APC standard Detector inputs: FC free space
Operating temperature	10 to 40 °C
Storage temperature	−20 to 60 °C
Operating humidity	< 80 %, non-condensing

Notes:
1. At 23 ± 5°C.
2. With DUT input power >−10dBm, DUT IL <20dB, and integration time = 10ms.
3. With DUT input power >5dBm, integration time = 100ms.
4. Recommended laser brands:
   - Any Keysight/Agilent tunable laser with trigger output.
   - Santec 5 and 7 series tunable lasers with trigger output (confirm with GP).

WARRANTY

All of General Photonics' products have been inspected and found to comply with our quality assurance standards before shipping. If any damage occurs during shipment, please contact the carrier and inform us or your distributor as soon as possible.

Do not attempt repair of any General Photonics product. Repair of defective products must be performed by factory trained engineers.

General Photonics warrants that this product will be free from defects in materials or workmanship for a period of one year from the date of shipment. A product found to be defective during the warranty period will be repaired or replaced, at no charge, at General Photonics' option.

If a problem is found, please contact General Photonics for assistance and instructions for any necessary returns.

General Photonics Customer Service
T: 909-590-5473
Email: support@generalphotonics.com

www.generalphotonics.com

You will be provided with a problem report form. Please complete the form with as complete a description of the problem and the conditions under which it occurred as possible. If the product is found to require factory repair, General Photonics will issue an RMA number for the return. Please label the product clearly with the RMA number. Failure to follow this procedure may delay the evaluation and repair of the product.

The above warranty specifically excludes products that have been repaired or modified by non-manufacturer-authorized personnel, products with a broken warranty seal or opened enclosure, and damage caused by misuse, abuse, improper storage or handling, or acts of nature. This warranty is in lieu of all other warranties, expressed or implied. General Photonics will not be liable for any indirect or consequential damages or losses resulting from the use of its products.

Appendices

Appendix 1.0 Software Installation

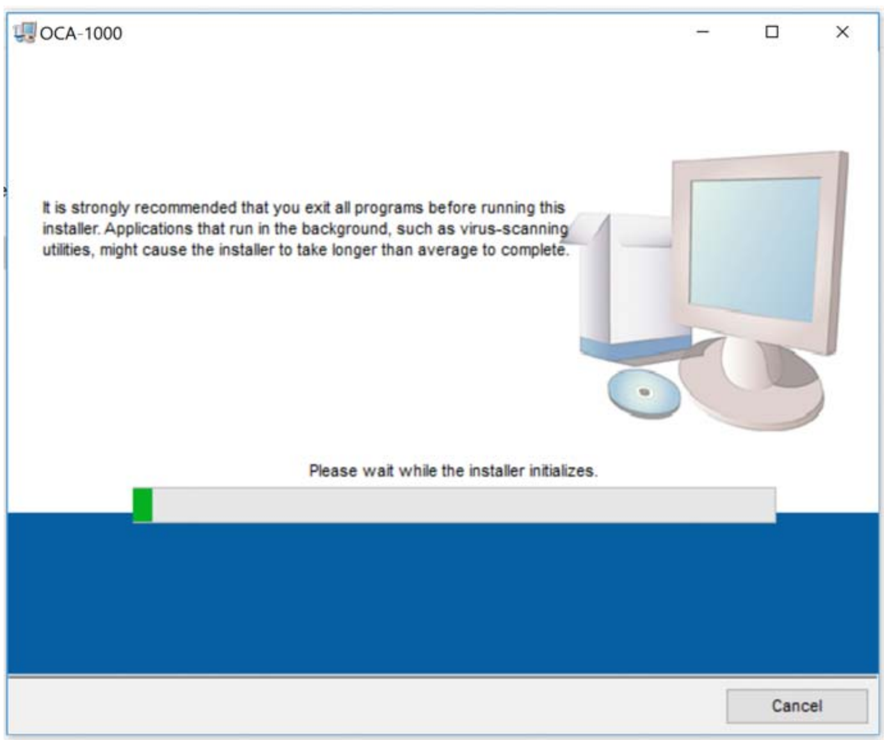
Computer Requirements

The OCA-1000 control program requires the following computer/system specifications:

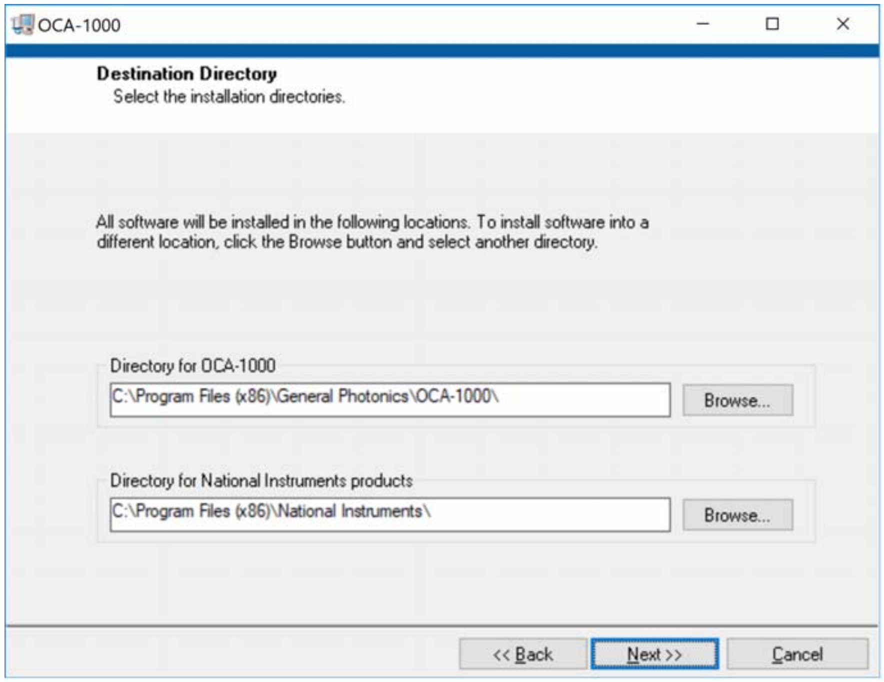
RAM:	4 GB
Hard Drive Space:	3 GB + data storage (typically at least 100 MB)
CPU:	1 GHz or faster x86 or x64-bit processor
System:	Windows 7, 8, 10
Screen Resolution:	1280 × 800 min.
Communication Interface:	USB 2.0

Installation of Control Program and NI Drivers

To install the control program and support drivers, run the setup.exe program. This will start an installation wizard that will guide the user through the main installation process.

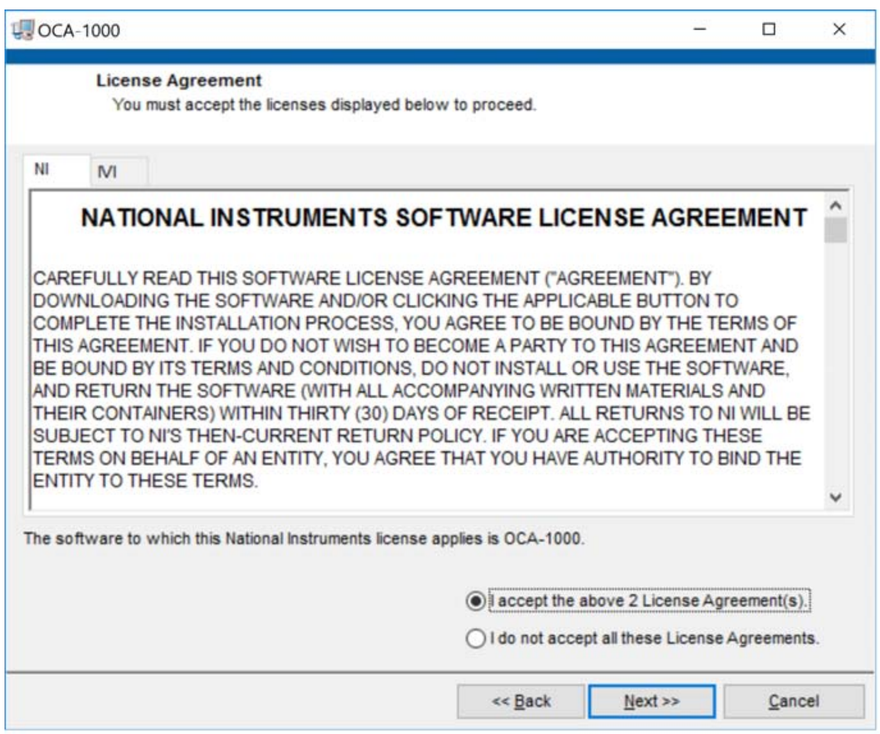


↓



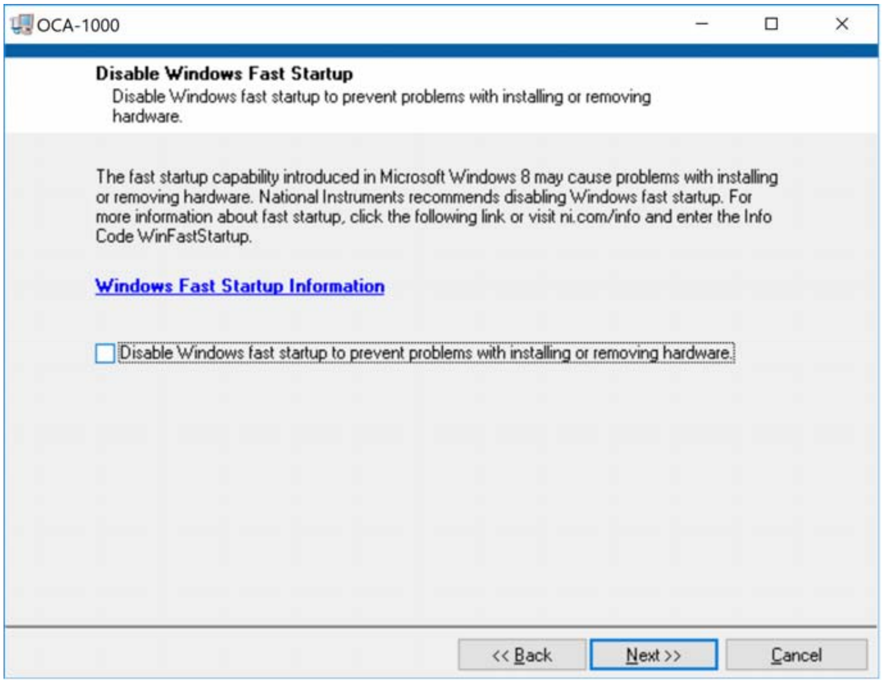
Use the default destination directories suggested by the installation wizard. **Do not change them.** The locations of these files are important to the function of the control program.

↓



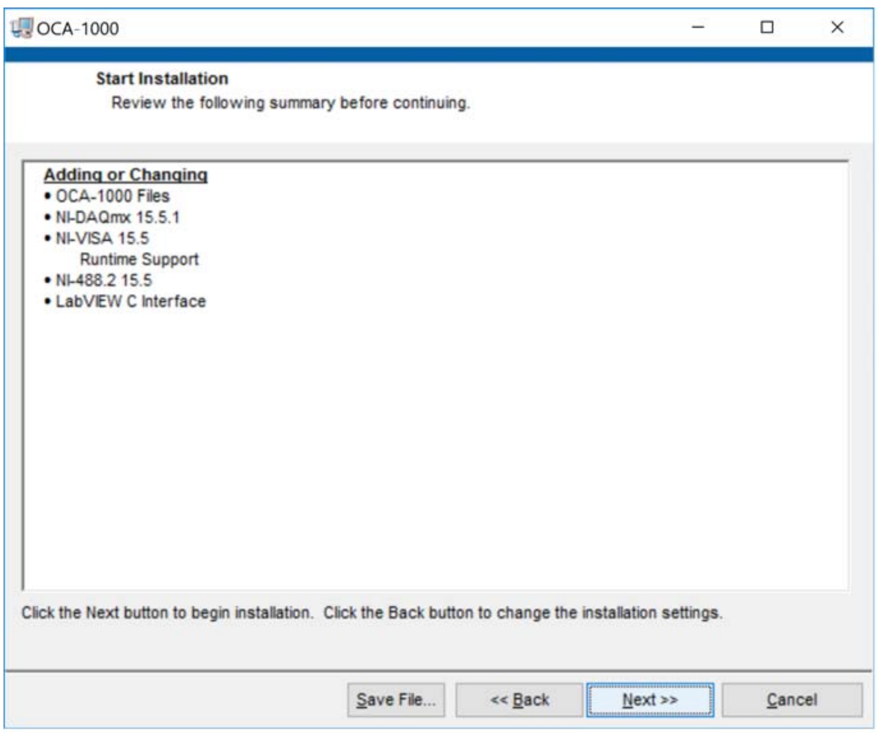
The NI drivers require license agreements to be installed. Accept the license agreements and click "Next".

↓



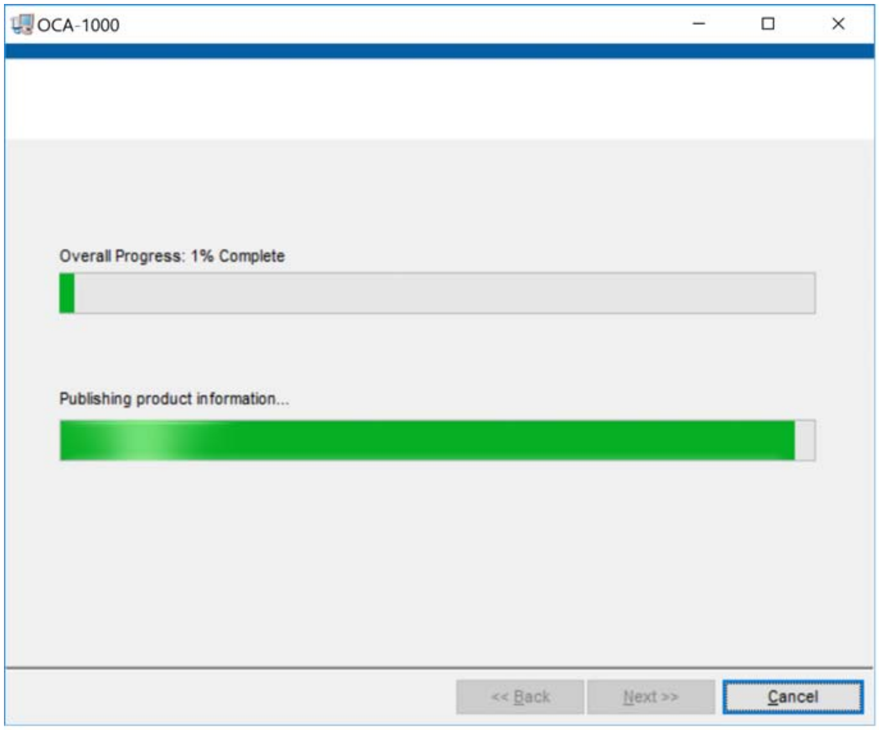
Generally, it is not necessary to disable Windows Fast Startup. Whether the box is checked or not does not affect the software installation. Click "Next".

↓

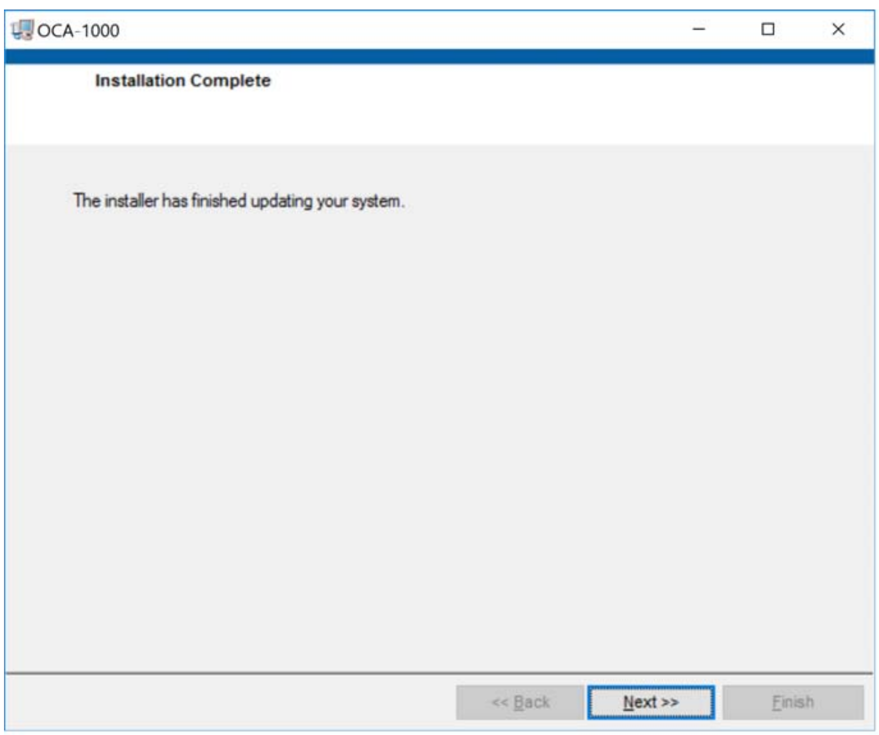


The wizard will list the files that will be added or changed by this installation. Click "Next".

↓

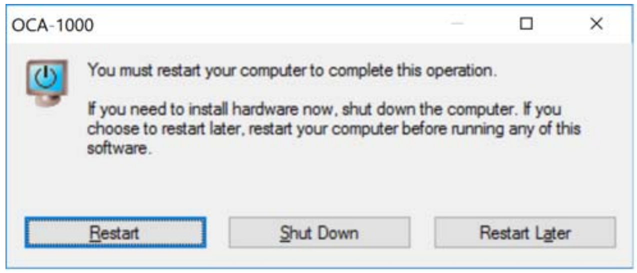

OCA-1000
Overall Progress: 1% Complete
Publishing product information...
<< Back
Next >>
Cancel

↓


OCA-1000
Installation Complete
The installer has finished updating your system.
<< Back
Next >>
Finish

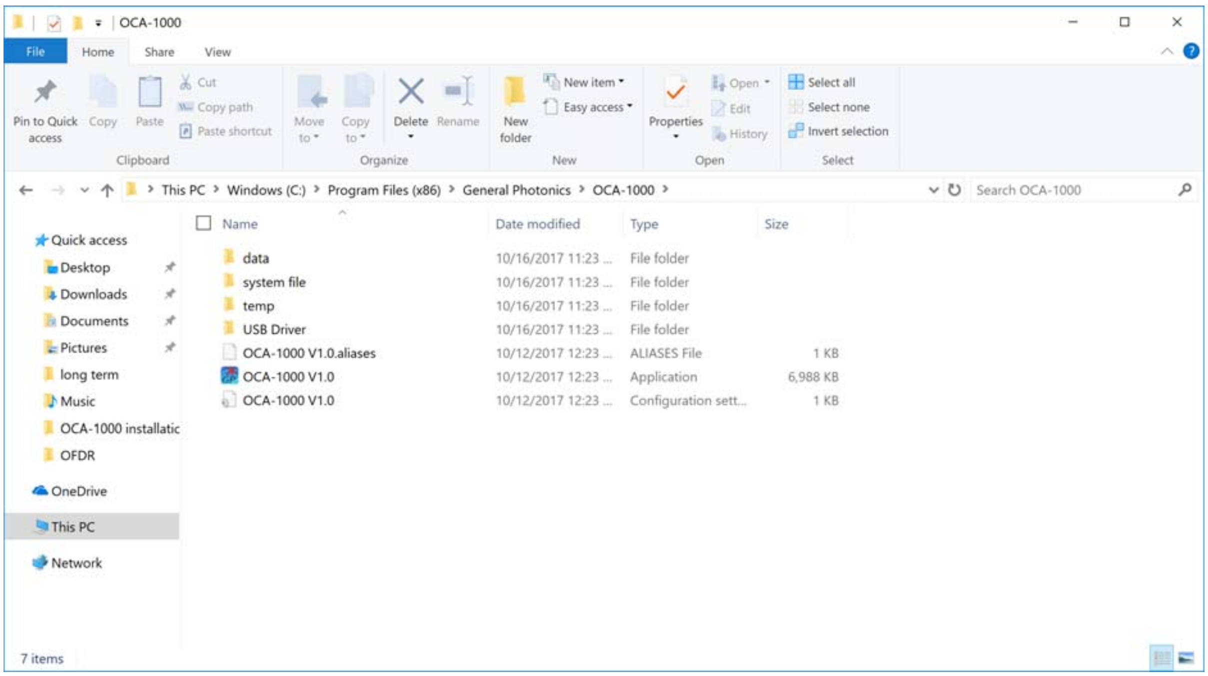
Click “Next”.

↓



It is necessary to restart the computer to complete the installation.

After the installation is complete, the following files should be installed on the control computer:



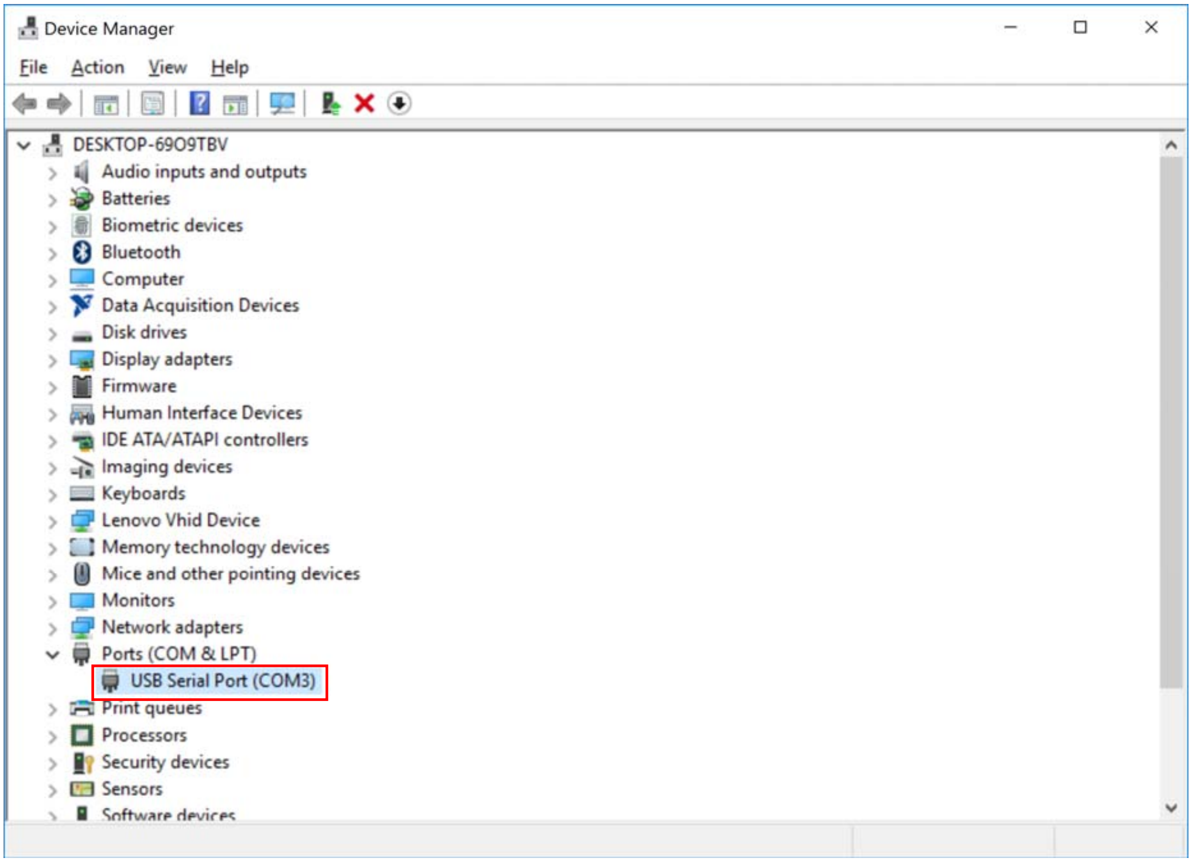
Installation of Additional USB Driver

In addition to the NI drivers installed by the setup file, the OCA-1000 control program requires the installation of an additional USB driver. The setup file copies the driver to the control computer, but on some systems, installing them may require some additional steps.

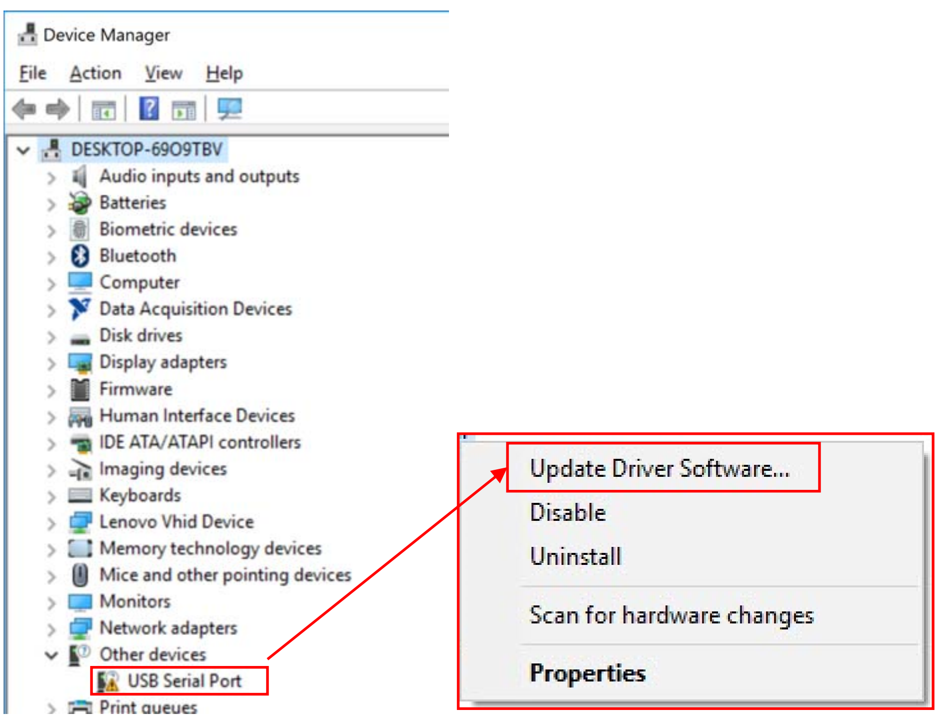
Connect the OCA-1000 to the control computer with a USB cable and power on the instrument. Wait for it to be detected.

Open Device Manager.

On some systems, the driver may install automatically. If this happens, the OCA-1000 will show up as a USB Serial Port under "Ports (COM &LPT)".

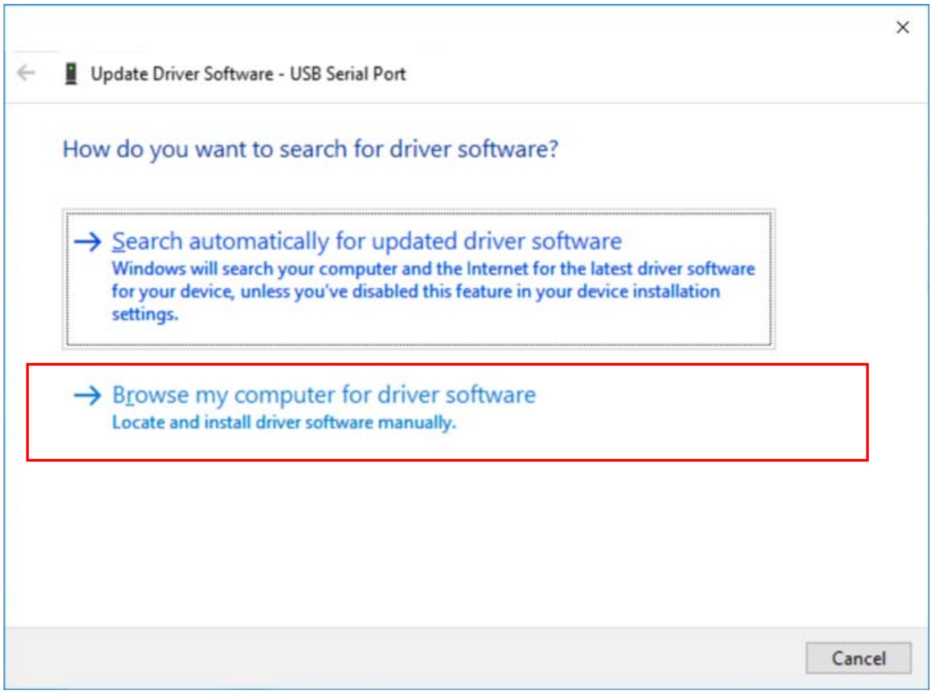


If it does not install automatically, it will show up under "Other Devices".

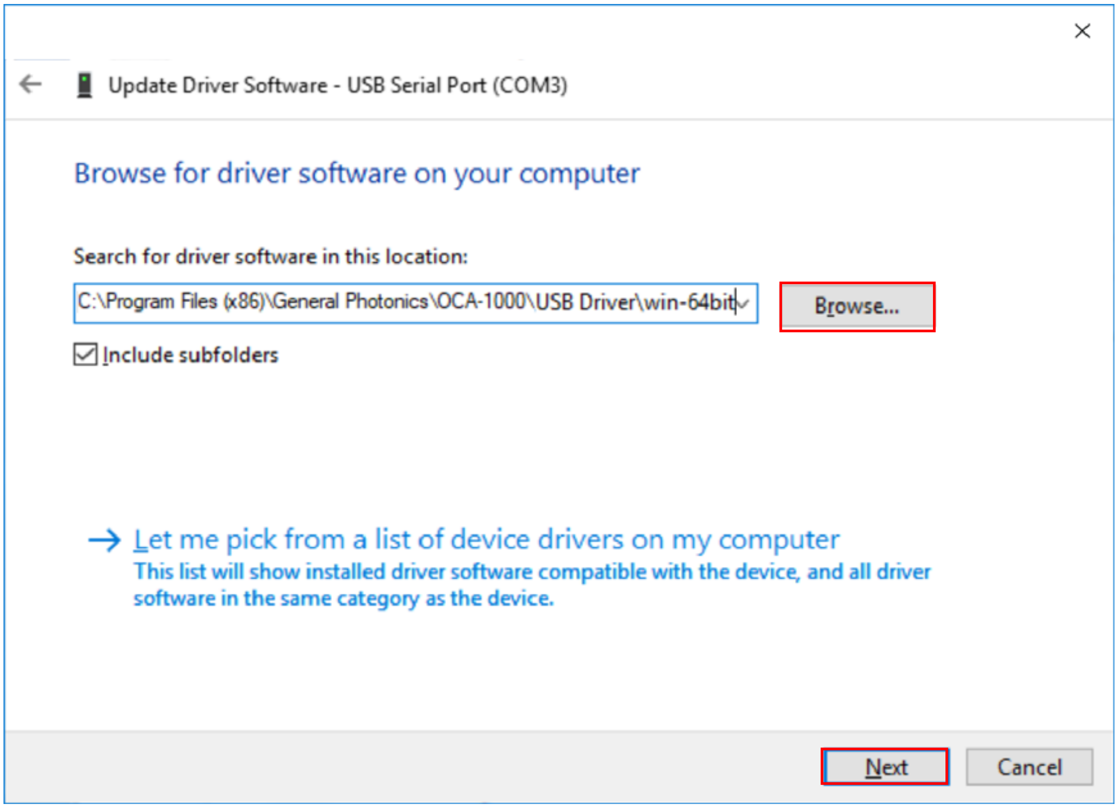


To install the USB driver, right click the item and select "Update Driver Software".

↓

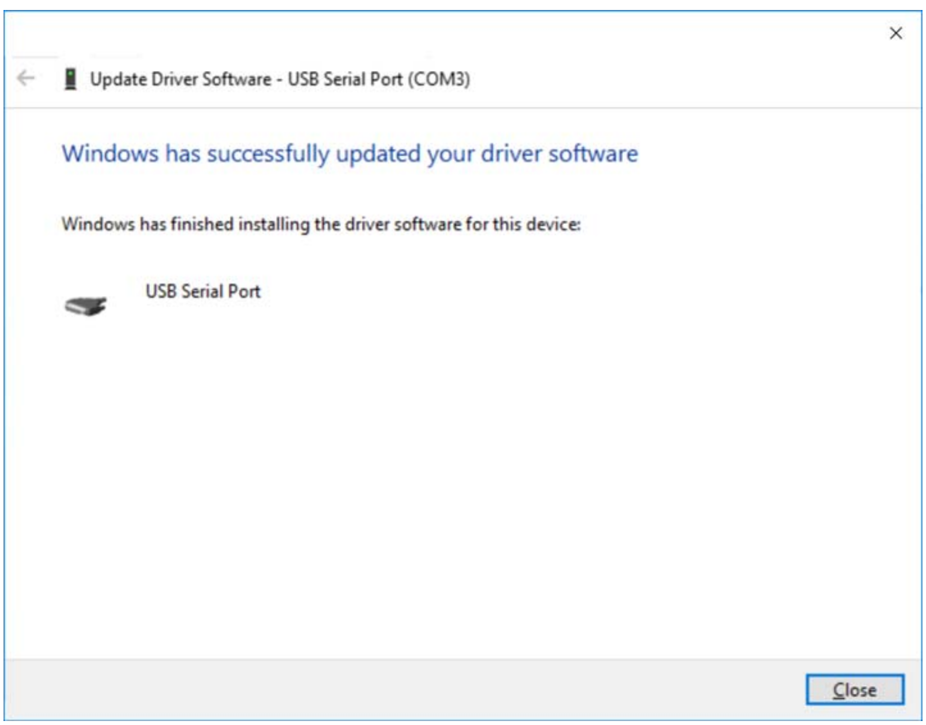


The update wizard will ask whether to search automatically for the driver or browse for the location. Click "Browse my computer for driver software". On the next screen, click "Browse" and find the location where the installation wizard saved the USB driver files. The default location is C:\Program Files (x86)\General Photonics\OCA-1000\USB Driver.



Select the folder that corresponds to the control computer's operating system. Make sure "Include Subfolders" is checked, then click "Next" at the bottom of the screen.

If the installation is successful, the following screen should appear.



Open Device Manager. There should now be a USB Serial Port listed under "Ports (COM &LPT)".

Appendix 2.0 ITU Grid Channels

The following table lists the frequencies and corresponding wavelengths for the C and L band 50 and 100 GHz spaced ITU grid channels. For the 100 GHz grid channels in the C or L band, refer to the corresponding column labeled "100 GHz Grid". For the 50 GHz grid channels in the C or L band, refer to both the "100 GHz Grid" and "50 GHz Offset" columns.

Table 1 C and L band ITU Grid

C band				L band			
100 GHz grid		50 GHZ offset		100 GHz grid		50 GHZ offset	
nm	THz	nm	THz	nm	THz	nm	THz
1528.77	196.1	1529.16	196.05	1568.77	191.1	1569.18	191.05
1529.55	196	1529.94	195.95	1569.59	191	1570.01	190.95
1530.33	195.9	1530.72	195.85	1570.42	190.9	1570.83	190.85
1531.12	195.8	1531.51	195.75	1571.24	190.8	1571.65	190.75
1531.9	195.7	1532.29	195.65	1572.06	190.7	1572.48	190.65
1532.68	195.6	1533.07	195.55	1572.89	190.6	1573.3	190.55
1533.47	195.5	1533.86	195.45	1573.71	190.5	1574.13	190.45
1534.25	195.4	1534.64	195.35	1574.54	190.4	1574.95	190.35
1535.04	195.3	1535.43	195.25	1575.37	190.3	1575.78	190.25
1535.82	195.2	1536.22	195.15	1576.2	190.2	1576.61	190.15
1536.61	195.1	1537	195.05	1577.03	190.1	1577.44	190.05
1537.4	195	1537.79	194.95	1577.86	190	1578.27	189.95
1538.19	194.9	1538.58	194.85	1578.69	189.9	1579.1	189.85
1538.98	194.8	1539.37	194.75	1579.52	189.8	1579.93	189.75
1539.77	194.7	1540.16	194.65	1580.35	189.7	1580.77	189.65
1540.56	194.6	1540.95	194.55	1581.18	189.6	1581.6	189.55
1541.35	194.5	1541.75	194.45	1582.02	189.5	1582.44	189.45
1542.14	194.4	1542.54	194.35	1582.85	189.4	1583.27	189.35
1542.94	194.3	1543.33	194.25	1583.69	189.3	1584.11	189.25
1543.73	194.2	1544.13	194.15	1584.53	189.2	1584.95	189.15
1544.53	194.1	1544.92	194.05	1585.36	189.1	1585.78	189.05
1545.32	194	1545.72	193.95	1586.2	189	1586.62	188.95
1546.12	193.9	1546.52	193.85	1587.04	188.9	1587.46	188.85
1546.92	193.8	1547.32	193.75	1587.88	188.8	1588.3	188.75
1547.72	193.7	1548.11	193.65	1588.73	188.7	1589.15	188.65
1548.51	193.6	1548.91	193.55	1589.57	188.6	1589.99	188.55
1549.32	193.5	1549.72	193.45	1590.41	188.5	1590.83	188.45
1550.12	193.4	1550.52	193.35	1591.26	188.4	1591.68	188.35
1550.92	193.3	1551.32	193.25	1592.1	188.3	1592.52	188.25
1551.72	193.2	1552.12	193.15	1592.95	188.2	1593.37	188.15
1552.52	193.1	1552.93	193.05	1593.79	188.1	1594.22	188.05
1553.33	193	1553.73	192.95	1594.64	188	1595.06	187.95
1554.13	192.9	1554.54	192.85	1595.49	187.9	1595.91	187.85
1554.94	192.8	1555.34	192.75	1596.34	187.8	1596.76	187.75

1555.75	192.7	1556.15	192.65	1597.19	187.7	1597.62	187.65
1556.55	192.6	1556.96	192.55	1598.04	187.6	1598.47	187.55
1557.36	192.5	1557.77	192.45	1598.89	187.5	1599.32	187.45
1558.17	192.4	1558.58	192.35	1599.75	187.4	1600.17	187.35
1558.98	192.3	1559.39	192.25	1600.6	187.3	1601.03	187.25
1559.79	192.2	1560.2	192.15	1601.46	187.2	1601.88	187.15
1560.61	192.1	1561.01	192.05	1602.31	187.1	1602.74	187.05
1561.42	192	1561.83	191.95	1603.17	187	1603.6	186.95
1562.23	191.9	1562.64	191.85	1604.03	186.9	1604.46	186.85
1563.05	191.8	1563.45	191.75	1604.88	186.8	1605.31	186.75
1563.86	191.7	1564.27	191.65	1605.74	186.7	1606.17	186.65
1564.68	191.6	1565.09	191.55	1606.6	186.6	1607.04	186.55
1565.5	191.5	1565.9	191.45	1607.47	186.5	1607.9	186.45
1566.31	191.4	1566.72	191.35	1608.33	186.4	1608.76	186.35
1567.13	191.3	1567.54	191.25	1609.19	186.3	1609.62	186.25
1567.95	191.2	1568.36	191.15	1610.06	186.2	1610.49	186.15