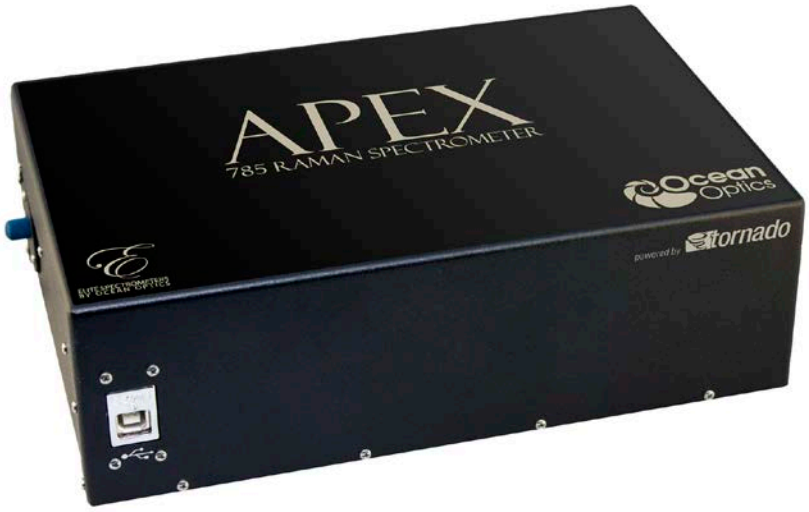
APEX

785 RAMAN SPECTROMETER

Installation and Operation Manual



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ELITE SPECTROMETERS BY OCEAN OPTICS

powered by tornado

Using a design exclusive to Ocean Optics, the Apex spectrometer features patented, high-throughput virtual slit or HTVS technology licensed from Tornado Spectral Systems.

Table of Contents

About This Manual

Document Purpose and Intended Audience

This document provides the user of the Apex Spectrometer with instructions for setting up, calibrating and performing experiments with their spectrometer.

What's New in this Document

This version of the *Apex Installation and Operation Manual* updates information for OceanView.

Document Summary

Chapter	Description
Chapter 1: *Introduction*	Contains descriptive information about the Apex Spectrometer and how sampling works. It also provides a list of system requirements, interface options, and shipment components.
Chapter 2: *Installing*	Provides installation and configuration instructions.
Chapter 3: *Troubleshooting*	Contains recommended steps to isolate and correct common problems.
Appendix A: *Calibrating the Wavelength of Apex*	Provides instructions for calibrating the Apex Spectrometer.
Appendix B: *Specifications*	Contains technical specifications for the Apex Spectrometer.

Product-Related Documentation

You can access documentation for Ocean Optics products by visiting our website at **http://www.oceanoptics.com**. Select *Technical Operating Instructions*, then choose the appropriate document from the available drop-down lists.

Document for...	Document Location
OceanView software	http://oceanoptics.com///wp-content/uploads/OceanViewIO.pdf
SpectraSuite software	http://oceanoptics.com///wp-content/uploads/SpectraSuite.pdf
HR-4 Breakout Box	http://oceanoptics.com///wp-content/uploads/HR-4-Breakout-Box.pdf

Document for…	Document Location
External triggering for firmware versions 3.0 and above	http://oceanoptics.com///wp-content/uploads/External-Triggering-Options_Firmware3.0andAbove.pdf

Ocean Optics offers a Glossary of spectroscopy terms to help you further understand your state-of-the-art products and how they function, located at: **http://oceanoptics.com/glossary/**.

Upgrades

Occasionally, you may find that you need Ocean Optics to make a change or an upgrade to your system. To facilitate these changes, you must first contact Customer Support and obtain a Return Merchandise Authorization (RMA) number. Please contact Ocean Optics for specific instructions when returning a product.

Warranty

Our 3-Year Warranty covers Ocean Optics miniature fiber optic spectrometers, light sources and sampling accessories – regardless of the application – from manufacturing defects. It also covers fibers and probes for a full 12 months: **http://www.oceanoptics.com/warranty.asp**

This comprehensive warranty ensures you of the highest level of craftsmanship and reliability for years to come. No other manufacturer offers such a solid guarantee of quality and reliability.

The Ocean Optics 3-Year Warranty applies to Ocean Optics equipment (excluding OEM configurations) purchased on or after July 1, 2010. The warranty covers parts and labor needed to repair manufacturing defects that occur during the warranty period. We also will cover the costs of shipping warranty-related repairs from our customers to Ocean Optics and from us to our customers.

ISO Certification

Ocean Optics, the industry leader in miniature photonics, has been certified for ISO 9001:2008 certification applicable to the design and manufacture of electro-optical equipment since 2009.

WARNING

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

FCC COMPLIANCE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

WARNING: The authority to operate this equipment is conditioned by the requirement that no modifications will be made to the equipment unless the changes or modifications are expressly approved by the manufacturer.

Chapter 1

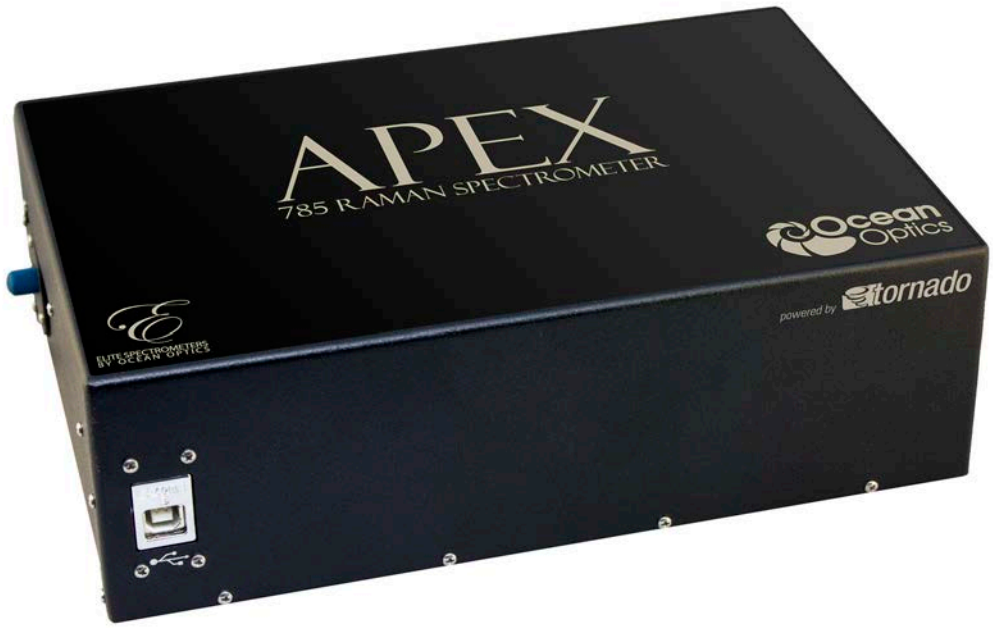
Introduction

Product Overview

The Apex 785 Raman Spectrometer is part of the Ocean Optics Elite family of modular, high-performance fiber optic spectrometers. Its exclusive design maintains high resolution, high sensitivity, and high throughput for low-light level applications such as 785 nm Raman analysis and fluorescence. This spectrometer uses proprietary beam reformatting and anamorphic expansion technology with a High Throughput Virtual Slit (HTVS) design to eliminate the tradeoffs between throughput, resolution and spectral range, providing high sensitivity with great optical resolution and shorter integration time over a wide Raman shift range of 780 – 1120 nm.

The integrated 2048 pixel linear CCD array is powered and read out through the integrated USB port and Ocean Optics spectrometer operating software. A complimentary single-use software license is included with the purchase of an Apex spectrometer.

Apex's modular design is ideal for those looking for a cost-effective alternative to expensive integrated systems to measure low-light level Raman and fluorescence samples. Applications include life sciences, clinical diagnostics, pharmaceutical R&D, counterfeit detection, and many more.



Ocean Optics Apex 785 Raman Spectrometer

Apex 785 Kit

Ocean Optics offers the Apex 785 Spectrometer in a convenient kit (order APEX-RAMAN-785-KIT) with all the tools needed for a fully integrated Raman System:

- Apex 785 Spectrometer
- 785 nm diode laser (with FC connector) and safety glasses
- Raman probe
- Raman sample holder
- OceanView software

Features

- High-throughput Virtual Slit
- Resolution (FWHM): <12 cm^{-1} @ full range
- Electrical Performance
  - 16 bit A/D converter
- Communications: USB
- Software compatibility:
  - OceanView (1 complimentary license included with purchase)
  - OmniDriver (sold separately)
  - SeaBreeze (sold separately)
- Optical input: SMA 905
- Regulations:
  - CE Mark
  - RoHS

System Requirements

You can use the Apex's USB connectivity with any computer that meets the requirements for the spectrometer operating software being used (Windows XP/Vista/Windows 7, Mac OS X and Linux).

EEPROM Utilization

An EEPROM memory chip in each Apex contains wavelength calibration coefficients, linearity coefficients, and a serial number unique to each individual spectrometer. The OOI software application reads these values directly from the spectrometer, enabling the ability to "hot-swap" spectrometers between computers without entering the spectrometer coefficients manually on each computer.

About OceanView Software

OceanView is the latest generation of operating software for all Ocean Optics spectrometers. It is a completely modular, Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems. The software can control any Ocean Optics USB spectrometer and device.

OceanView is a user-customizable, advanced acquisition and display program that provides a real-time interface to a variety of signal-processing functions. With OceanView, you have the ability to perform spectroscopic measurements (such as absorbance, reflectance, and emission), control all system parameters, collect and display data in real time, and perform reference monitoring and time acquisition experiments. Consult the OceanView manual for hardware requirements when using OceanView (see *Product-Related* Documentation).

Sampling System Overview

How Sampling Works

Ocean Optics components function in a sampling system as follows:

1. The user stores reference and dark measurements to correct for instrument response variables.
2. The light transmits through an optical fiber to the sample.
3. The light interacts with the sample.
4. Another optical fiber collects and transmits the result of the interaction to the spectrometer.
5. The spectrometer measures the amount of light and transforms the data collected by the spectrometer into digital information.
6. The spectrometer passes the sample information to the spectrometer operating software.
7. The software compares the sample to the reference measurement and displays processed spectral information.

Modular Sampling Accessories

Ocean Optics offers a complete line of spectroscopic accessories for use with Apex. Most of our spectroscopic accessories have SMA connectors for application flexibility. Accordingly, changing the sampling system components is as easy as unscrewing a connector and replacing an accessory.

Interface Options

The Apex has a USB connector, enabling you to connect the spectrometer to a desktop or notebook computer via a USB port.

Computer Interface	Operating System Requirements	Part Needed	Description of Part
Computer via USB Port	OceanView: Windows 2000/XP/7; 32-bit and 64-bit and Windows Vista (32-bit only); OS X version 10.5 Intel or later; Linux any version released for an x86 or amd64 platform since 2010	USB-CBL-1 (included)	Cable that connects from USB port on Apex to a USB port on desktop or notebook PC

Shipment Components

- Apex Spectrometer
- USB cable
- Manufacturing Acceptance Test Certificate

The following information and documentation also ships with the Apex Spectrometer:

- **Packing List**

  The packing list is inside a plastic bag attached to the outside of the shipment box (the invoice arrives separately). It lists all items in the order, including customized components in the spectrometer (such as the grating, detector collection lens, and slit). The packing list also includes the shipping and billing addresses, as well as any items on back order.

- **Wavelength Calibration Data Sheet**

  Each spectrometer is shipped with a Wavelength Calibration Data Sheet that contains information unique to your spectrometer. Your spectrometer operating software reads this calibration data from your spectrometer when it interfaces to a computer via the USB port.

  Note

  Please save the Wavelength Calibration Data Sheet for future reference.

- **Apex Raman Spectrometer Quick Start Guide**

Other Accessories Available

Visit us at **www.OceanOptics.com** for a complete list of products available for all of your spectroscopy needs.

- **Fibers**
- **Light Sources**
- **Integrated Sampling Systems**
- **Cuvettes**
- **Filter Holders**
- **Analyze IQ chemometric software**

Chapter 2

Installing Apex

Overview

You must install the operating software application prior to connecting the Apex Spectrometer to the computer. The Ocean Optics spectrometer operating software installs the drivers required for the Apex spectrometer installation. If you do not install the software first, the system will not properly recognize the Apex.

If you have already connected the Apex to the computer prior to installing the operating software, consult *Chapter 3: Troubleshooting* for information on correcting a corrupt Apex installation.

Apex Installation

This section contains instructions for connecting the Apex in USB mode. To connect the Apex to a computer via the USB port, the computer must be running a Windows 2000/XP/7 (32- or 64-bit) or 32-bit Vista, Mac OS X or Linux operating system.

► *Procedure*

Follow the steps below to connect the Apex to a computer via the USB port:

1. Install the spectrometer operating software on the destination computer.
2. Locate the USB cable (USB-CBL-1) provided with the Apex.
3. Insert the square end of the cable into the side of the Apex.
4. Insert the rectangular end of the cable into the USB port of the PC.

If you installed the spectrometer operating software prior to connecting the Apex, the software installs the Apex drivers. If the drivers do not successfully install (or if you connected the Apex to the computer before installing the software), consult *Chapter 3: Troubleshooting*.

The Apex can be used with OceanView operating software when connected to the USB port.

If you have followed the previous steps and started OceanView, the spectrometer is already acquiring data.

Connect Spectroscopic Accessories

To find operating instructions for Apex-compatible products (such as light sources, sampling chambers, and probes), consult the Ocean Optics website at http://oceanoptics.com/support/technical-documents/.

Chapter 3

Troubleshooting

Overview

The following sections contain information on troubleshooting issues you may encounter when using the Apex Spectrometer.

Apex Connected to Computer Prior to Software Installation

Windows Operating Systems

If you connected your Ocean Optics Apex device to the computer prior to installing your spectrometer operating software application (OceanView) on a Windows platform, you may encounter installation issues that you must correct before your Ocean Optics device will operate properly.

Follow the applicable steps below to remove the incorrectly installed device, device driver, and installation files.

Note

If these procedures do not correct your device driver problem, you must obtain the *Correcting Device Driver Issues* document from the Ocean Optics website: http://oceanoptics.com///wp-content/uploads/Correcting-Device-Driver-Issues.pdf.

Remove the Unknown Device from Windows Device Manager

► ***Procedure***

1. Open Windows Device Manager. Consult the Windows operating instructions for your computer for directions, if needed.
2. Locate the **Other Devices** option and expand the **Other Devices** selection by clicking on the "+" sign to the immediate left.

Note

Improperly installed USB devices can also appear under the Universal Serial Bus Controller option. Be sure to check this location if you cannot locate the unknown device.

3. Locate the unknown device (marked with a large question mark). Right-click on the **Unknown Device** listing and select the **Uninstall** or **Remove** option.
4. Click the **OK** button to continue. A warning box appears confirming the removal of the Unknown Device. Click the **OK** button to confirm the device removal.
5. Disconnect the Apex from your computer.
6. Locate the section in this chapter that is appropriate to your operating system and perform the steps in the following *Remove Improperly Installed Files* section.

Remove Improperly Installed Files

► ***Procedure***

1. Open Windows Explorer.
2. Navigate to the **Windows | INF** directory.

Note

If the INF directory is not visible, you must disable the Hide System Files and Folders and Hide File Extensions for Known File Types options in Windows Folder Options. Access Windows Folder Options from Windows Explorer, under the **Tools | Folder Options** menu selection.

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3. Delete the **OOI_USB.INF** in the INF directory. If your computer is running either the Windows 2000 or XP operating system, you must also delete the **OOI_USB.PNF** file in the INF directory.
4. Navigate to the **Windows | System32 | Drivers** directory.
5. Delete the **EZUSB.SYS** file.
6. Reinstall your Ocean Optics application and reboot the system when prompted.
7. Plug in the USB device.

The system is now able to locate and install the correct drivers for the USB device.

Mac Operating Systems

Since there are no device files for the Apex Spectrometer in a Mac operating system, you should not encounter any problems if you installed the spectrometer before the operating software.

Linux Operating Systems

For Linux operating systems, all you need to do is install the software, then unplug and replug in the spectrometer. Technically, the driver files for Linux simply give nonprivileged users permission to use newly connected hardware. There isn't any long-term harm to plugging in the device before installing the software.

Appendix A

Calibrating the Wavelength of Apex

Overview

This appendix describes how to calibrate the wavelength of your spectrometer. Though each spectrometer is calibrated before it leaves Ocean Optics, the wavelength for all spectrometers will drift slightly as a function of time and environmental conditions. Ocean Optics recommends periodically recalibrating the Apex.

About Wavelength Calibration

You are going to be solving the following equation, which shows that the relationship between pixel number and wavelength is a third-order polynomial:

$$\lambda_p = I + C_1 p + C_2 p^2 + C_3 p^3$$

Where:

λ = the wavelength of pixel p

I = the wavelength of pixel 0

C_1 = the first coefficient (nm/pixel)

C_2 = the second coefficient (nm/pixel^2)

C_3 = the third coefficient (nm/pixel^3)

You will be calculating the value for I and the three Cs.

Calibrating the Spectrometer

Preparing for Calibration

To recalibrate the wavelength of your spectrometer, you need the following components:

- A light source capable of producing spectral lines

Note

Ocean Optics' HG-1 Mercury-Argon lamp is ideal for recalibration for wavelengths up to 922 nm. For wavelengths above 922 nm, we recommend the XE-1 Xenon Light Source. If you do not have an HG-1, you need a light source that produces several (at least 4-6) spectral lines in the wavelength region of your spectrometer.

- An Apex spectrometer
- An optical fiber (for spectrometers without a built-in slit, a 50-μm fiber works best)
- A spreadsheet program (Excel or Quattro Pro, for example) or a calculator that performs third-order linear regressions

Note

If you are using Microsoft Excel, choose **Tools | Add-Ins** and check **AnalysisToolPak** and **AnalysisTookPak-VBA**.

Calibrating the Wavelength of the Spectrometer

► *Procedure*

Perform the steps below to calibrate the wavelength of the spectrometer:

1. Place the spectrometer operating software into Scope mode and take a spectrum of your light source. Adjust the integration time (or the A/D conversion frequency) until there are several peaks on the screen that are not off-scale.
2. Move the cursor to one of the peaks and position the cursor so that it is at the point of maximum intensity.
3. Record the pixel number that is displayed in the status bar or legend (located beneath the graph). Repeat this step for all of the peaks in your spectrum.
4. Use the spreadsheet program or calculator to create a table like the one shown in the following figure. In the first column, place the exact or true wavelength of the spectral lines that you used.

   In the second column of this worksheet, place the observed pixel number. In the third column, calculate the pixel number squared, and in the fourth column, calculate the pixel number cubed.

Independent Variable

Dependent Variables

Values Computed from the Regression Output

True Wavelength (nm)	Pixel #	Pixel # ^{2}	Pixel # ^{3}	Predicted Wavelength	Difference
253.65	175	30625	5359375	253.56	0.09
296.73	296	87616	25934336	296.72	0.01
302.15	312	97344	30371328	302.40	-0.25
313.16	342	116964	40001688	313.02	0.13
334.15	402	161604	64964808	334.19	-0.05
365.02	490	240100	117649000	365.05	-0.04
404.66	604	364816	220348864	404.67	-0.01
407.78	613	375769	230346397	407.78	0.00
435.84	694	481636	334255384	435.65	0.19
546.07	1022	1044484	1067462648	546.13	-0.06
576.96	1116	1245456	1389928896	577.05	-0.09
579.07	1122	1258884	1412467848	579.01	0.06
696.54	1491	2223081	3314613771	696.70	-0.15
706.72	1523	2319529	3532642667	706.62	0.10
727.29	1590	2528100	4019679000	727.24	0.06
738.40	1627	2647129	4306878883	738.53	-0.13
751.47	1669	2785561	4649101309	751.27	0.19

5. Use the spreadsheet or calculator to calculate the wavelength calibration coefficients. In the spreadsheet program, find the functions to perform linear regressions.
   - If using Quattro Pro, look under **Tools | Advanced Math**
   - If using Excel, look under **Analysis ToolPak**
6. Select the true wavelength as the dependent variable (Y). Select the pixel number, pixel number squared, and the pixel number cubed as the independent variables (X). After executing the regression, you will obtain an output similar to the one shown below. Numbers of importance are noted.

Regression Statistics

Multiple R	0.999999831
R Square	0.999999663
Adjusted R Square	0.999999607
Standard Error	0.125540214
Observations	22

R Squared

Intercept

	Coefficients	Standard Error
Intercept	190.473993	0.369047536
X Variable 1	0.36263983	0.001684745
X Variable 2	-1.174416E-05	8.35279E-07
X Variable 3	-2.523787E-09	2.656608E-10

First coefficient

Second coefficient

Third coefficient

7. Record the Intercept, as well as the First, Second, and Third Coefficients. Additionally, look at the value for R squared. It should be very close to 1. If not, you have most likely assigned one of your wavelengths incorrectly.

   Keep these values at hand.

Saving the New Calibration Coefficients

Ocean Optics programs wavelength calibration coefficients unique to each Apex onto an EEPROM memory chip in the Apex.

You can overwrite old calibration coefficients on the EEPROM if you are using Apex via the USB port.

► *Procedure*

To save wavelength calibration coefficients using the USB mode, perform the following steps:

1. Ensure that the Apex is connected to the PC and that you have closed all other applications.
2. Point your browser to http://oceanoptics.com/support/software-downloads/ and scroll down to **Microcode**. Select **USB EEPROM Programmer**.
3. Save the setup file to your computer.
4. Run the **Setup.exe** file to install the software. The **Welcome** screen appears.
5. Click the **Next** button. The **Destination Location** screen appears.
6. Accept the default installation location, or click the **Browse** button to specify a directory. Then, click the **Next** button. The **Program Manager Group** screen appears.
7. Click the **Next** button. The **Start Installation** screen appears.
8. Click the **Next** button to begin the installation. Once the installation finishes, the **Installation Complete** screen appears.
9. Click the **Finish** button and reboot the computer when prompted.
10. Navigate to the **USB EEPROM Programmer** from the Start menu and run the software.
11. Click on the desired Apex device displayed in the left pane of the **USB Programmer** screen.
12. Double-click on each of the calibration coefficients displayed in the right pane of the USB Programmer screen and enter the new values acquired in Steps 5 and 6 of the *Calibrating the Wavelength of the Spectrometer* section in this appendix.
13. Repeat Step 12 for all of the new values.
14. Click on the **Save All Values** button to save the information, and then **Exit** the USB Programmer software.

The new wavelength calibration coefficients are now loaded onto the EEPROM memory chip on the Apex.

The new wavelength calibration coefficients are now loaded onto the EEPROM memory chip on the Apex.

Appendix B

Specifications

Overview

This appendix contains information on spectrometer specifications.

Apex Specifications

The following sections provide specification information for the CCD detector in the Apex Spectrometer, as well as the Apex Spectrometer itself.

CCD Detector Specifications

Specification	Value
Detector	Hamamatsu S11510-1106 Back-thinned FFT-CCD
Usable wavelength range	780-1120 nm (>3800 cm^{-1})
Pixels	2048 x 64 (effective); 2068 x 70 (total)
Pixel size	14 µm square
Well depth	300 Ke^{-}

Apex Spectrometer Specifications

Specification	Value
Dimensions (LxWxH)	254 mm (10 in.) x 167.6 mm (6.6 in.) x 81 mm (3.2 in.)
Weight	2.36 kg (5.2 lbs.)
Temperature	

Specification	Value
Operation Storage	0 °C to +50 °C –30 °C to +70 °C
Humidity	0 – 90% noncondensing
Power consumption	500 mA @ VDC
Signal-to-noise ratio	>440:1
Gratings	1200 lmm volume phase holographic blazed at 830 nm
Optical input	SMA 905
Slit	HTVS
Fiber diameter	Optimized for 200µm, NA = 0.22 fiber input
Focal length	f/4, 101.6 mm (input and output)
Optical resolution (FWHM)	< 12 cm^{-1} @ full range
Stray light	<1% @ 800 nm
Signal-to-noise ratio	450:1
A/D	16 bit
Dynamic range	15000:1 (typical)
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)
Integration time	7.2 ms to 5 s
Nonlinearity corrected	<1.0%
Thermal stability Wavelength	 3 pixels over operating temperature range
Interface	USB 2.0

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