NIR Near Infrared

Fiber Optic Spectrometers

Installation and Operation Manual

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About This Manual

Document Purpose and Intended Audience

This document provides you with instructions to get your system up and running. In addition to the NIR Spectrometer installation and operation instructions, this manual also includes information for locating the OOIBase32 installation instructions (see *Product-Related Documentation* below).

What's New in this Document

This version of the *NIR Near Infrared Fiber Optics Spectrometers Installation and Operation Manual* removes references to the Spectrometer Configuration Diskette.

Document Summary

Chapter	Description
Chapter 1: *Introduction*	Introduces the product features. Also contains a list of items included in the shipment.
Chapter 2: *Installing the NIR Spectrometer*	Contains information for installing and configuring your NIR Spectrometer. These instructions include information on using your NIR Spectrometer with the OOIBase32 software.
Chapter 3: *Troubleshooting*	Contains typical problems and suggested resolutions.
Chapter 4: *Sample Experiments*	Provides procedures for conducting sample experiments with your NIR Spectrometer (absorbance, reflection, transmission, relative irradiance, and time acquisition).
Appendix A: *Calibrating the Wavelength of the NIR Spectrometer*	Contains instructions for calibrating your NIR Spectrometer.
Appendix B: *Specifications*	Contains technical specifications for the NIR Spectrometer and the NIR Detector.
Appendix C: *NIR256-2.5μm Sensitivity*	Provides some additional sensitivity specifications for the NIR256-2.5 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. Or, use the **Search by Model Number** field at the bottom of the web page.

You can also access operating instructions for Ocean Optics products on the *Software and Technical Resources* CD included with the system.

Engineering-level documentation is located on our website at *Technical → Engineering Docs.*

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.

Chapter 1

Introduction

Product Description

The NIR (Near Infrared) Fiber Optic Spectrometer connects to a notebook or desktop PC via a USB port. It requires an external +5VDC power supply (USB-CBL-PS) to power the spectrometer's high-performance InGaAs array detector. The NIR Spectrometer and the 16-bit A/D converter share a single housing, forming a small-footprint plug-and-play system.

The NIR Spectrometer can connect via the USB port to any PC that uses a Windows 98/Me/2000/XP operating system and has OOIBase32 installed and configured for use with your NIR Spectrometer. Furthermore, the NIR Spectrometer has a serial port for interfacing to PCs, PLCs, and other devices that support the RS-232 communication protocol.

An EEPROM memory chip in each NIR Spectrometer contains wavelength calibration coefficients, linearity coefficients, and the serial number unique to each spectrometer. Ocean Optics OOIBase32 spectrometer operating software reads these values from the spectrometer, which allows "hot-swapping" of spectrometers among multiple PCs.

As with all other Ocean Optics user-configured spectrometers, you can choose from six slit sizes and hundreds of fiber optic accessories (such as light sources, probes, and optical fibers) to create the system just right for your application.

About the Modular Approach

Ocean Optics fiber optic spectrometer systems are based on low-cost, modular data acquisition principles. A typical NIR Spectrometer system contains four basic elements:

- The NIR Spectrometer
- The Ocean Optics OOIBase32 operating software
- A light (excitation source)
- A variety of sampling optics (depending on application need)

The light (excitation source) sends light through an optical fiber to the sample. The light interacts with the sample, and the results of that interaction are collected and transmitted through another optical fiber to the spectrometer. The spectrometer measures the amount of light and transforms the data collected by the spectrometer into digital information. Finally, the spectrometer passes that information to the OOIBase32 operating software.

OOIBase32 is the latest generation of operating software for all Ocean Optics spectrometers. OOIBase32, which is free to all customers, is a 32-bit, user-customizable, advanced acquisition and display program that provides a real-time interface to a variety of signal-processing functions. With OOIBase32, users 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.

Ocean Optics also offers a complete line of spectroscopic accessories to use with the NIR Spectrometer. Most spectroscopic accessories have SMA connectors for application flexibility. Thus, changing the sampling system is as easy as unscrewing a connector and adding a new component or accessory. A partial list of Ocean Optics spectroscopic accessories includes light sources, sampling holders, filter holders, flow cells, fiber optic probes and sensors, collimating lenses, attenuators, diffuse reflectance standards, integrating spheres and an extensive line of optical fibers.

This modular approach, where components are easily mixed and matched, offers remarkable applications flexibility. You can select from hundreds of products to create distinctive systems for an almost endless variety of optical-sensing applications.

Interface Options

Because the NIR Spectrometer has both a USB and a serial port, you can connect the NIR Spectrometer to a desktop or notebook PC via a USB port or to a desktop or notebook PC via a serial port.

Computer Interface	Operating System Requirements	Cable Needed	Description of Cable
Desktop or Notebook PC via USB Port	Windows 98/Me/ 2000/XP	USB-CBL-1 (included)	Cable connects from USB port on NIR Spectrometer to USB port on desktop or notebook PC
Desktop or Notebook PC via Serial Port	Any 32-bit Windows operating system	ADC-USB-SER (not included)	Cable connects from serial port on NIR Spectrometer to serial port on desktop or notebook PC

Items Included with Shipment

Important information and documentation accompany your NIR Spectrometer upon shipment. This includes:

- Packing List – The packing list is located inside a plastic bag attached to the outside of the shipment box (the invoice is mailed separately). The items listed on the packing slip include all of the components in the order, including customized items installed in the spectrometer, such as the slit. The packing list also includes important information, such as the shipping and billing addresses, as well as any components on back order.
- Wavelength Calibration Data Sheet – Each spectrometer is shipped with a Wavelength Calibration Data Sheet that contains information unique to your spectrometer. OOIBase32 Operating Software reads this calibration data from your spectrometer when it interfaces to a PC via the USB port. Any other interface requires that you manually enter the calibration data in OOIBase32 (select **Spectrometer | Configure | Wavelength Calibration** tab). See the OOIBase32 documentation for more information (refer to *Product-Related Documentation* for instructions on accessing OOIBase32 documentation).

Note

Please save the Wavelength Calibration Data Sheet for future reference.

- Software and Resources Library CD – Each spectrometer order comes with Ocean Optics' *Software and Resources Library* CD. This disc contains all Ocean Optics software and manuals for software operation, spectrometers, and spectroscopic accessories. Documentation is provided in Portable Document Format (PDF). You need Adobe Acrobat Reader version 6.0 or higher to view these files. Adobe Acrobat Reader is included on the CD.

  With the exception of OOIBase32 Spectrometer Operating Software, all Ocean Optics software is password protected. Passwords for other software applications can be found on the back of the *Software and Resources Library* CD package.

Chapter 2

Installing the NIR Spectrometer

Overview

You must install the OOIBase32 software application prior to connecting the NIR Spectrometer to the PC. The OOIBase32 software installation installs the drivers required for NIR Spectrometer installation. If you do not install OOIBase32 first, the system will not properly recognize the NIR Spectrometer.

If you have already connected the NIR Spectrometer to the PC prior to installing OOIBase32, consult Chapter 3: *Troubleshooting* for information on correcting a corrupt NIR Spectrometer installation.

NIR Spectrometer Installation

This section contains instructions for connecting the NIR Spectrometer via both USB and serial modes.

USB Mode

Follow the steps in this section to interface the NIR Spectrometer via the USB port to a desktop or notebook PC.

To connect the NIR Spectrometer to a PC via the USB port, the PC must be running the Windows 98/ME/2000/XP operating system.

► ***Procedure***

1. Install OOIBase32 on the destination PC, and then reboot the system.
2. Plug the +5VDC wall adapter (USB-CBL-PS) into an electrical outlet, then connect the power cord to the 2.5 mm power jack (older versions may have a 1.3 mm power jack) on the rear of the NIR Spectrometer.
3. Locate the USB cable (USB-CBL-1) that came with the NIR Spectrometer.
4. Insert the square end of the cable into the rear of the NIR Spectrometer, and then insert the rectangular end into the USB port of the PC.

If OOIBase32 was installed prior to connecting the NIR Spectrometer, the **Add New Hardware Wizard** appears and installs the NIR Spectrometer drivers. If the drivers do not successfully install, or if you connected the NIR Spectrometer to the PC before installing OOIBase32, consult Chapter 4: *Troubleshooting*.

Note

Windows XP users may encounter a **Hardware Installation** warning window regarding Windows XP driver testing. Click the **Continue Installation** button at this screen, as this is an expected warning.

Serial Port Mode

To use the serial port capacity of the NIR Spectrometer, the PC must be running a 32-bit version of the Windows operating system.

► *Procedure*

Follow the steps below to connect the NIR Spectrometer to the PC via serial port:

1. Connect one end of the serial cable to the RS-232 connector on the rear of the NIR Spectrometer, and then connect the other end to a serial port on the PC.
2. Note the serial port number (also called COM Port) on the PC to which the NIR Spectrometer is connected (some PCs may not have numbered ports).
3. Plug the +5VDC wall adapter (USB-CBL-PS) into an electrical outlet, then connect the power cord to the 2.5 mm power jack (older versions may have a 1.3 mm power jack) on the rear of the NIR Spectrometer.

The NIR Spectrometer is now connected to the PC's serial port.

Note

Connecting the spectrometer to the PC's serial port requires that you manually enter the calibration coefficients from the Wavelength Calibration Data Sheet into OOIBase32 software (select **Spectrometer | Configure | Wavelength Calibration** tab). See the OOIBase32 documentation for more information (refer to *Product-Related Documentation* for instructions on accessing OOIBase32 documentation).

Configuring the NIR Spectrometer in OOIBase32

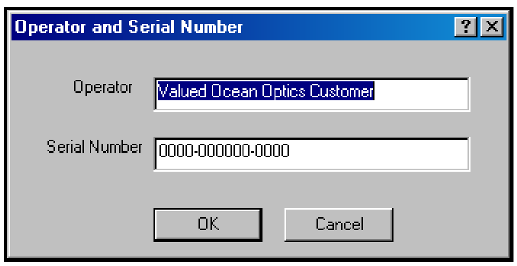
Once the NIR Spectrometer is installed, you must configure OOIBase32's **Configure Spectrometer** options so that the application recognizes the connected NIR Spectrometer.

The following sections contain instructions on initially configuring the NIR Spectrometer the first time you start OOIBase32. Consult the *OOIBase32 Spectrometer Operating Software Operating Instructions* for detailed instructions on configuring the spectrometer in OOIBase32 (see *Product-Related Documentation*).

Start the OOIBase32 software application. The following configuration screens appear the first time OOIBase32 runs with the NIR Spectrometer attached.

Operator and Serial Number Dialog Box

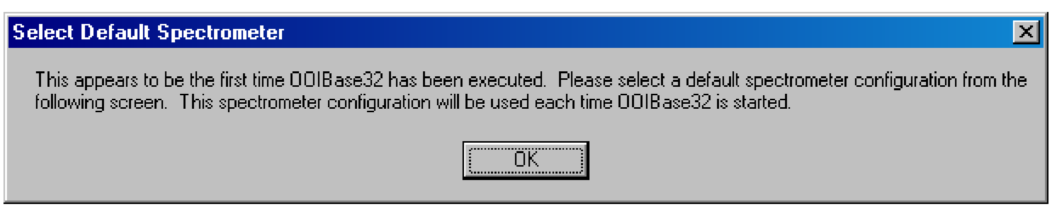
The operator and serial number dialog box prompts you to enter a user name and software serial number into OOIBase32. Some data files use this information in the data file headers.



Default Spectrometer Configuration File

The default spectrometer configuration file screen prompts you to select a default .SPEC file to use with the NIR Spectrometer. The .SPEC file extension is preceded by the unique serial number of the NIR Spectrometer (for example, HRA001.SPEC).

Navigate to the OOIBase32 installation directory and select the default .SPEC file, then proceed. Do not specify a .SPEC file located on removable media (e.g., a floppy disk).



Configure Hardware Screen

The **Configure Hardware** screen prompts you to enter spectrometer-specific information into OOIBase32 the first time you run the program. Typically, you need only enter this information the first time you run OOIBase32. However, you can alter the hardware configuration at any time using the **Spectrometer Configuration** screen. Select **Spectrometer | Configure** from the OOIBase32 menu bar to access the **Spectrometer Configuration** screen.

Configuring Hardware in USB Mode

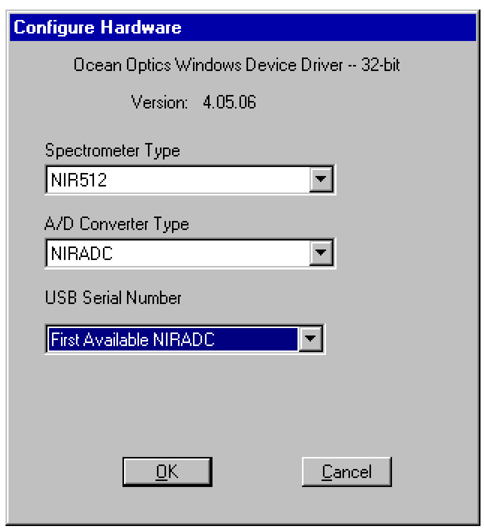
► *Procedure*

Follow the steps below to configure the NIR Spectrometer:

1. Specify NIR Spectrometer in the **Spectrometer Type** drop-down menu.

2. Specify NIR Spectrometer in the **A/D Converter Type** drop-down menu.

3. Specify the serial number of the NIR Spectrometer under the **USB Serial Number** drop-down menu.



4. Click the **OK** button to finish.

The spectrometer should be able to acquire data and respond to light. If not, exit and restart the OOIBase32 application.

Configuring Hardware in Serial Port Mode

1. Select the NIR Spectrometer option from the **Spectrometer Type** drop-down menu.

2. Select the **Serial (RS-232) A/D** option from the **A/D Converter Type** drop-down menu. This selection enables serial-specific options in the lower portion of the **Configure Hardware** screen.

3. Select the COM port that NIR Spectrometer is connected to in the **Serial Port** drop-down menu. See Chapter 3: *Troubleshooting* for information on identifying serial ports.

4. Select the NIR Spectrometer's operating speed from the **Baud Rate** drop-down menu (115,200 baud is recommended).

5. Specify the pixel resolution (from 1 to 500) in the **Pixel Resolution** box. This value specifies that every *n*th pixel of the spectrometer will transmit from the NIR Spectrometer to the PC.

Note

You can sacrifice pixel resolution to gain speed. The transfer of one complete spectra requires ~0.3 seconds at 115,200 baud.

6. Enable the **Compress Data** function to minimize the amount of data transferred over the RS-232 connection. The transmission of spectral data over the serial port is a relatively slow process. Enabling this function ensures that the NIR Spectrometer compresses every scan that it transmits. This greatly increases the data transfer speed of the NIR Spectrometer.

7. Click the **OK** button to complete the setup.

The spectrometer should now be able to acquire data and respond to light. Exit and restart OOIBase32 to save configuration data to disk.

Spectrometer Configuration Screen

The Spectrometer Configuration screen prompts you to configure specific channel-level spectrometer information, if necessary.

► ***Procedure***

1. Select **Spectrometer | Configure** from the menu and set system parameters.

2. Select the **Wavelength Calibration** tab. If you have connected your spectrometer to the PC's USB port, OOIBase32 pre-fills the coefficients for the NIR Spectrometer from information on a memory chip in the spectrometer. Otherwise, you must manually type the coefficients as they are printed on the Wavelength Calibration Data Sheet that accompanied your spectrometer.

3. Verify that the calibration coefficients match the coefficients from the Wavelength Calibration Data Sheet. If necessary, modify these values using the USB Programmer utility.

4. Additionally, ensure that you select both the **Master** and **Channel Enabled** boxes.

5. In the **A/D Interface** tab, enter the same values as in the **Configure Hardware** screen. OOIBase32 stores this information for future use once you close the program.

Connect Spectroscopic Accessories

To find operating instructions on NIR Spectrometer-compatible products such as light sources, sampling chambers, probes, fibers or any other Ocean Optics spectroscopic accessories, check the *Software and Technical Resources* CD or the Ocean Optics website at:

http://www.oceanoptics.com/Technical/OperatingInstructions.asp.

Chapter 1: *Introduction* contains a list of NIR Spectrometer-compatible products. You can find information related to these products on **http://www.oceanoptics.com/**.

External Triggering Options

You can trigger the NIR Spectrometer using the External Software Triggering option through the 15-pin accessory connector on the spectrometer. Only the External Software Trigger mode is available with the NIR Spectrometer.

The External Triggering Options document contains instructions on configuring External Triggering with the NIR Spectrometer. The External Triggering Options document is located at the following web site:

http://www.oceanoptics.com/technical/externaltriggering.PDF

If you do not have web access, you can retrieve this document from the Software and Technical Resources CD included with your spectrometer shipment.

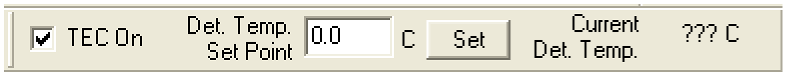
OOIBase32 NIR512 Controls

The NIR toolbar in OOIBase32 allows you to control a variety of options on the NIR Spectrometer. These options are also applicable to the NIR256.

Note

If the NIR512 Toolbar in your version of OOIBase32 does not have the options listed below, you should upgrade your version of OOIBase32 to the latest release.

Visit **http://www.oceanoptics.com/technical/softwaredownloads.asp** to obtain the latest software version.



Control	Description
TEC On	Check this box to enable (recommended setting for laboratory conditions) or uncheck to disable the thermoelectric cooler.
Det. Temp. Set Point	Enter the target temperature of the NIR Spectrometer detector as follows: • NIR512: Minimum is –10 ºC, Recommended is –5 ºC • NIR256: Minimum is –15 ºC, Recommended is –10 ºC The TEC and fans will operate until the detector reaches this temperature.
Apply	Click this button to apply the changes made in this toolbar to the NIR Spectrometer.
Current Det. Temp.	Displays the current temperature of the detector in the NIR Spectrometer.

Chapter 3

Troubleshooting

Overview

The following sections contain information on troubleshooting issues you may encounter when using the HR4000 Spectrometer.

NIR Spectrometer Connected to PC Prior to OOIBase32 Installation

If you connected your NIR Spectrometer to the computer prior to installing your Ocean Optics software application, 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://www.oceanoptics.com/technical/engineering/correctingdevicedriverissues.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.

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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 NIR Spectrometer 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.

Troubleshooting the Serial Port Configuration

Occasionally, you may encounter problems with the serial port connection and/or software. Perform the following procedure to troubleshoot the serial port connection.

► ***Procedure***

1. Cycle the power on the NIR Spectrometer and restart the OOIBase32 software. This ensures that the software and the hardware synchronize properly.

2. Determine the serial port (COM port) number:

Operating System	Instructions
Windows 95/98/ME/XP	1. Right-click on **My Computer** 2. Select **Properties** 3. Click the **Device Manager** tab
Windows 2000	1. Select **Start | Settings | Control Panel | System** 2. Select the **Hardware** tab 3. Click the **Device Manager** button.
Windows NT	Select **Start | Programs | Administrative Tools (common) NT Diagnostics**

3. Double-click on the **Ports** (COM & LPT) option to display COM port numbers. Ensure that no warning icon appears next to the NIR Spectrometer's COM port.

4. Verify that the NIR Spectrometer's COM port is active. If the ports on the PC are not labeled and you do not know the COM port number, use trial-and-error to find the correct COM port. Open OOIBase32 and view the displayed graph. If the correct COM port is selected, you will see a dynamic trace responding to light near the bottom of the graph. If the correct COM port is not selected, you will see a straight line at zero counts.

5. Disable virus protection to ensure timely and complete data transfer (optional – some computers require this step).

Old Version of OOIBase32 Installed

If the PC to be used to interface to your NIR Spectrometer already has an older version of OOIBase32 software installed, you must install the latest version of OOIBase32. You can download the latest version of OOIBase32 from the *Software and Technical Resources* CD or from the Ocean Optics website at **http://www.oceanoptics.com/technical/softwaredownloads.asp**.

You do not need to uninstall previous versions of OOIBase32 when upgrading to the latest version.

Chapter 4

Sample Experiments

The following sections contain information on conducting sample experiments using the NIR Spectrometer and OOIBase32.

Preparing for Experiments

► *Procedure*

Follow the steps below to configure the NIR Spectrometer and OOIBase32 for experiments:

1. Double-check that you have correctly installed the NIR Spectrometer, installed OOIBase32, and configured the light source and other sampling optics.

2. Open the OOIBase32 application.

3. Select **Spectrometer | Configure** from the menu bar and double-check that **A/D Interface** settings are correct.

4. Check your spectrometer setup configurations in OOIBase32:

    a. Locate the Wavelength Calibration Data sheet that came with the HR4000.

    b. Select **Spectrometer | Configure** from the menu and choose the **Wavelength Calibration** page.

    c. For each spectrometer channel in the system, enable the channel and make sure the First Coefficient, Second Coefficient, Third Coefficient and Intercept correspond to those of the system.

5. Adjust the acquisition parameters using the **Acquisition Parameters** dialog bar or select **Spectrum | Configure Data Acquisition** from the menu.

   If you have followed the previous steps and started OOIBase32, the spectrometer is already acquiring data. Even with no light in the spectrometer, there should be a fluctuating trace near the bottom of the graph. If you put light into the spectrometer, the graph trace should rise with increasing light intensity. If this occurs, the software and hardware are correctly installed.

Once you installed and configured your hardware and software and have set up your system, you are ready to take measurements. There are four basic optical measurements from which to choose: absorbance, transmission, reflection, and relative irradiance measurements. The type of measurements you wish to make determines the configuration of the sampling optics for your system. The choice of reference and data analysis determines how the answer is presented.

Taking Measurements

There are four basic optical measurements from which to choose:

- Absorbance (see *Absorbance Experiments*)
- Transmission (see *Transmission Experiments*)
- Reflection (see *Reflection Experiments*)
- Relative irradiance (see *Relative Irradiance Experiments*)

The type of measurement you take determines the configuration of the sampling optics for your system. Furthermore, your choice of reference and data analysis determines how the OOIBase32 presents the results.

Note

For each measurement, you must first take a reference scan and a dark spectrum scan. After you take a reference scan and a dark spectrum scan, you can take as many measurement scans as needed. However, if you change any sampling variable (integration time, averaging, smoothing, angle, temperature, fiber size, etc.), you must store new reference and dark spectrum scans.

Application Tips

If the signal you collect is saturating the spectrometer (peaks are off the scale), you can decrease the light level on scale in scope mode by:

- Decreasing the integration time
- Attenuating the light going into the spectrometer
- Switching to a smaller diameter fiber
- Using a neutral density filter with the correct optical density

If the signal you collect has too little light, increase the light level on scale in scope mode by:

- Increasing the integration time
- Switching to a larger diameter fiber
- Avoiding the use of any optical filters

Absorbance Experiments

Absorbance spectra are a measure of how much light is absorbed by a sample. For most samples, absorbance is linearly related to the concentration of the substance. The software calculates absorbance (Al) using the following equation:

$$A_\lambda = -\log_{10}\left(\frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda}\right)$$

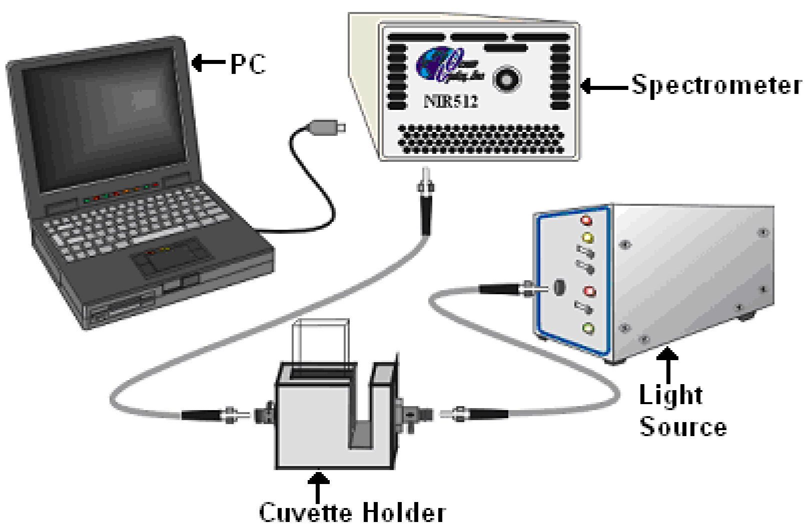
Where:

S_λ = the sample intensity at wavelength λ

D_λ = the dark intensity at wavelength λ

R_λ = the reference intensity at wavelength λ

The figure below shows a typical absorbance setup. The light source sends light via an input fiber into a cuvette in a cuvette holder. The light interacts with the sample. The output fiber carries light from the sample to the spectrometer, which is connected to the PC.



Absorbance can also be expressed as proportional to the concentration of the substance interacting with the light, known as Beer's Law. Common applications include the quantification of chemical concentrations in aqueous or gaseous samples.

► *Procedure*

Follow the steps below to take an absorbance measurement using OOIBase32:

1. Place OOIBase32 in scope mode by either clicking the scope mode icon on the toolbar, or selecting **Spectrum | Scope Mode** from the menu.

2. Ensure that the signal is on scale. The peak intensity of the reference signal should be about 50,000 counts.

3. Ensure that nothing is blocking the light path from the sample to the spectrometer, and then take a reference spectrum. You must take a reference spectrum before calculating absorbance.

Note

The material to measure must be absent while taking a reference spectrum.

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4. Click the **Store Reference** spectrum icon on the toolbar or selecting **Spectrum | Store Reference** from the menu to take the reference. This command merely stores a reference spectrum. You must select **File | Save | Reference** from the menu to permanently save the spectrum to disk.

5. Block the light path to the sample and take a dark spectrum by clicking the **Store Dark Spectrum** icon on the toolbar or by selecting **Spectrum | Store Dark** from the menu bar. This command merely stores a dark spectrum. Storing a dark spectrum is required before the software can calculate absorbance spectra.

   You must select **File | Save | Dark** from the menu to permanently save the spectrum to disk.

Note

If possible, do not turn off the light source. If you must turn off your light source to store a dark spectrum, make sure to allow enough time for the lamp to warm up before continuing your experiment.

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6. Ensure that the sample is in place and the light path is clear, and then take an absorbance measurement. Click the Absorbance Mode icon on the toolbar or select **Spectrum | Absorbance Mode** from the menu. To save the spectrum, click the save icon on the toolbar or select **File | Save | Processed** from the menu.

Note

If at any time any sampling variable changes (including integration time, averaging, boxcar smoothing, etc.), you must store a new reference and dark spectrum.

Transmission Experiments

Transmission is the percentage of energy passing through a sample relative to the amount that passes through the reference. Transmission Mode is also used to show the portion of light *reflected* from a sample. Transmission and reflection measurements require the same mathematical calculations. The transmission is expressed as a percentage ($\%T_\lambda$) relative to a standard substance (such as air). The software calculates %T (or $\%R_\lambda$) by the following equation:

$$\%T_\lambda = \frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda} \times 100\%$$

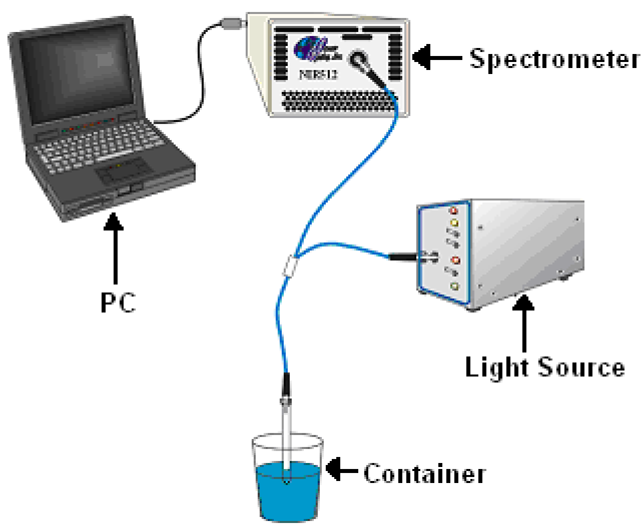
Where:

S_λ = the sample intensity at wavelength λ

D_λ = the dark intensity at wavelength λ

R_λ = the reference intensity at wavelength λ

The following figure shows a typical transmission setup. The light source sends light via the input leg of a transmission probe into a container. The light interacts with the sample. The output leg of the transmission probe carries the information to the spectrometer, which transmits the information to the PC.



Common applications include measurement of transmission of light through solutions, optical filters, optical coatings, and other optical elements such as lenses and fibers.

► *Procedure*

Perform the following steps to take a transmission measurement using OOIBase32:

1. Verify that OOIBase32 is in scope mode by clicking the scope mode icon on the toolbar, or by selecting **Spectrum | Scope Mode** from the menu bar.

2. Verify that the signal is on scale. The peak intensity of the reference signal should be about 50,000 counts.

3. Ensure that nothing is blocking the light path from the sample to the spectrometer, and then take a reference spectrum. You must take a reference spectrum before calculating transmission.

Note

The material to measure must be absent while taking a reference spectrum.

---

4. Click the **Store Reference** spectrum icon on the toolbar or selecting **Spectrum | Store Reference** from the menu to take the reference. This command merely stores a reference spectrum. You must select **File | Save | Reference** from the menu to permanently save the spectrum to disk.

5. Block the light path to the sample and take a dark spectrum by clicking the **Store Dark Spectrum** icon on the toolbar or by selecting **Spectrum | Store Dark** from the menu bar. This command merely stores a dark spectrum. Storing a dark spectrum is required before the software can calculate transmission spectra.

   You must select **File | Save | Dark** from the menu to permanently save the spectrum to disk.

Note

If possible, do not turn off the light source. If you must turn off your light source to store a dark spectrum, make sure to allow enough time for the lamp to warm up before continuing your experiment.

---

6. Ensure that the sample is in place and the light path is clear, and then take a transmission measurement. Click the Transmission Mode icon on the toolbar or select **Spectrum | Transmission Mode** from the menu. To save the spectrum, click the save icon on the toolbar or select **File | Save | Processed** from the menu.

Note

If at any time any sampling variable changes (including integration time, averaging, boxcar smoothing, etc.) you must store a new reference and dark spectrum.

Reflection Experiments

Reflection is the return of radiation by a surface, without a change in wavelength and can be:

- Specular, in which the angle of incidence is equal to the angle of reflection.
- Diffuse, in which the angle of incidence is not equal to the angle of reflection.

Every surface returns both specular and diffuse reflections. Some surfaces may return mostly specular reflection, others more diffuse reflection. Specular reflection increases proportionately with the glossiness of a surface.

Reflection is expressed as a percentage ($\%R_\lambda$) relative to the reflection from a standard reference substance:

$$\%R_\lambda = \frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda} \times 100\%$$

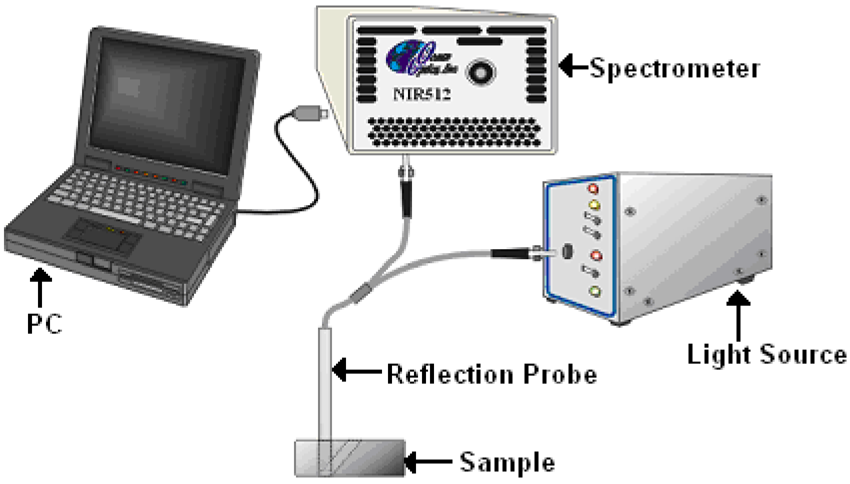
Where:

S_λ = the sample intensity at wavelength λ

D_λ = the dark intensity at wavelength λ

R_λ = the reference intensity at wavelength λ

The following figure shows a typical reflection setup. A light source sends light via the input leg of a reflection probe onto a sample. A reflection probe holder holds the probe in either a 90 or 45-degree angle from the surface. The output leg of the reflection probe carries light from the sample to the spectrometer, which is connected to the PC.



Common applications include measuring the reflection properties of mirrors and coatings, and measuring the visual properties of the color in paints, plastics, and food products.

► *Procedure*

Perform the following steps to take a reflection measurement using OOIBase32:

1. Verify that OOIBase32 is in scope mode by clicking the scope mode icon on the toolbar, or by selecting **Spectrum | Scope Mode** from the menu bar.

2. Verify that the signal is on scale. The peak intensity of the reference signal should be about 50,000 counts.

3. Ensure that nothing is blocking the light path from the sample to the spectrometer, and then take a reference spectrum. You must take a reference spectrum before calculating reflection.

   Note

   The material to measure must be absent while taking a reference spectrum.

   Click the **Store Reference** spectrum icon on the toolbar or selecting **Spectrum | Store Reference** from the menu to take the reference. This command merely stores a reference spectrum. You must select **File | Save | Reference** from the menu to permanently save the spectrum to disk.

4. Block the light path to the sample and take a dark spectrum by clicking the **Store Dark Spectrum** icon on the toolbar or by selecting **Spectrum | Store Dark** from the menu bar. This command merely stores a dark spectrum. You must select **File | Save | Dark** from the menu to permanently save the spectrum to disk.

   Note

   If possible, do not turn off the light source. If you must turn off your light source to store a dark spectrum, make sure to allow enough time for the lamp to warm up before continuing your experiment.

   ---

5. Ensure that the sample is in place and the light path is clear, and then take a reflection measurement. Click the Transmission Mode icon on the toolbar or select **Spectrum | Transmission Mode** from the menu. The mathematical calculations used to calculate transmission and reflection are identical. To save the spectrum, click the save icon on the toolbar or select **File | Save | Processed** from the menu.

   Note

   If at any time any sampling variable changes (including integration time, averaging, boxcar smoothing, etc.) you must store a new reference and dark spectrum.

Relative Irradiance Experiments

Irradiance is the amount of energy at each wavelength from a radiant sample. In relative terms, it is the fraction of energy from the sample compared to the energy collected from a lamp with a blackbody energy distribution, normalized to one at the energy maximum. Relative irradiance is calculated by the following equation:

$$\mathbf{I_\lambda = B_\lambda \left(\frac{S_\lambda - D_\lambda}{R_\lambda - D_\lambda}\right)}$$

Where:

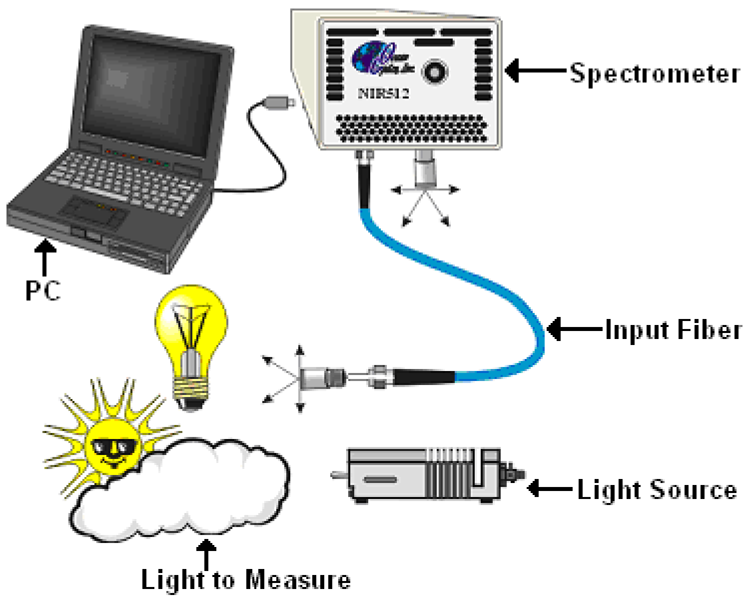
B_λ = the relative energy of the reference (calculated from the color temperature) at wavelength λ

S_λ = the sample intensity at wavelength λ

D_λ = the dark intensity at wavelength λ

R_λ = the reference intensity at wavelength λ

The figure below shows a typical Relative Irradiance setup.



Common applications include characterizing the light output of LEDs, incandescent lamps, and other radiant energy sources such as sunlight. Also included in relative irradiance measurements is fluorescence, in which case the spectrometer measures the energy given off by materials that have been excited by light at a shorter wavelength.

► *Procedure*

Perform the following steps to take a relative irradiance measurement using OOIBase32:

1. Verify that OOIBase32 is in scope mode by clicking the scope mode icon on the toolbar, or by selecting **Spectrum | Scope Mode** from the menu bar.

2. Verify that the signal is on scale. The peak intensity of the reference signal should be about 50,000 counts.

Note

The light source must be a blackbody of known color temperature.

---

3. Ensure that nothing is blocking the light path from the sample to the spectrometer, and then take a reference spectrum. You must take a reference spectrum before calculating relative irradiance.

Note

The material to measure must be absent while taking a reference spectrum.

Click the **Store Reference** spectrum icon on the toolbar or selecting **Spectrum | Store Reference** from the menu to take the reference. This command merely stores a reference spectrum. You must select **File | Save | Reference** from the menu to permanently save the spectrum to disk.

4. Block the light path to the sample and take a dark spectrum by clicking the **Store Dark Spectrum** icon on the toolbar or by selecting **Spectrum | Store Dark** from the menu bar. This command merely stores a dark spectrum. You must select **File | Save | Dark** from the menu to permanently save the spectrum to disk.

Note

If possible, do not turn off the light source. If you must turn off your light source to store a dark spectrum, make sure to allow enough time for the lamp to warm up before continuing your experiment.

---

5. Position the fiber at the light source you wish to measure, then choose the **Irradiance** mode icon on the toolbar or select **Spectrum | Relative Irradiance Mode** from the menu bar.

6. In the **Reference Color Temperature** dialog box, enter the color temperature of the light source (in Kelvin) and click the **OK** button.

7. Click the **Save** icon on the toolbar or select **File | Save | Processed** from the menu bar to save the spectrum.

Note

If at any time any sampling variable changes (including integration time, averaging, boxcar smoothing, etc.) you must store a new reference and dark spectrum.

Time Acquisition Experiments

OOIBase32 allows you to perform time acquisition experiments. Time acquisition experiments track processes, perform kinetic analyses, and monitor spectral events all as a function of time. You can collect, as a function of time, spectral data from up to six single wavelengths (designated as Channels A through F) and up to two mathematical combinations of these wavelengths (designated as Combinations 1 and 2). Additionally, you can acquire data in any mode (transmission, absorbance, etc.).

For more details about this and other OOIBase32 functions, refer to the *OOIBase32 Spectrometer Operating Software Online Help System*.

► *Procedure*

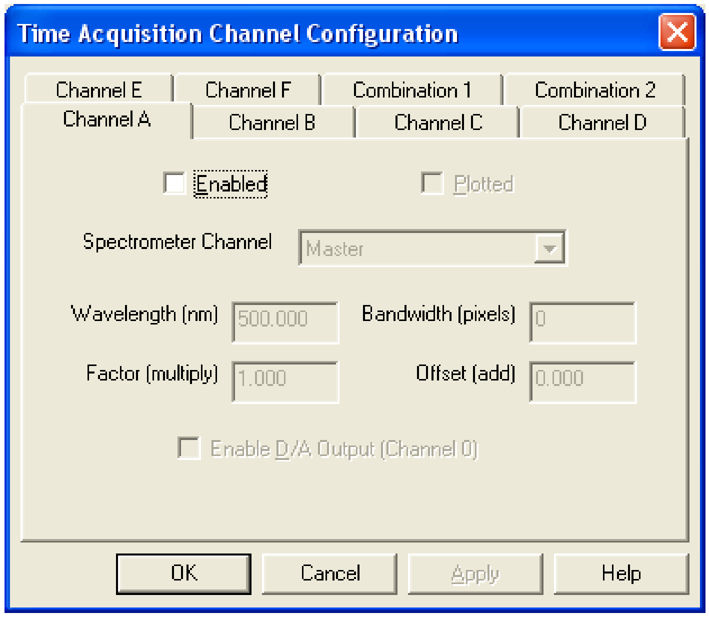
Follow the steps below to perform a time series experiment in OOIBase32:

1. Enter scope mode and store a reference spectra and dark spectra.

2. Choose the measurement mode (absorbance, transmission, etc.) and select **Time Acquisition | Configure | Configure Time Channels** from the menu bar to access the **Time Acquisition Channel Configuration** screen.

   Proceed to the *Configuring the Time Acquisition Configuration Screen* section below.

Configuring the Time Acquisition Channel Configuration Screen



► *Procedure*

Perform the following steps on the **Time Acquisition Channel Configuration** screen:

1. Select **Enabled** to set the time acquisition calculation for the wavelength. The time acquisition process will not calculate data if you do not select this option for at least

2. Select **Plotted** to see a real-time graph of the acquired data in a spectral window.

3. Select a **Spectrometer Channel** for the time acquisition process

4. Specify the analysis wavelength in the **Wavelength (nm)** box.

5. Specify the number of pixels around the analysis wavelength to average in the **Bandwidth (pixels)** box.

6. Select a multiplicative factor to apply to the data before plotting or storing. Then, select an additive constant or offset to apply to the data. OOIBase32 applies the additive constant or offset after applying the factor but before plotting or storing data.

   The equation for the Factor and Offset functions is: **Results = (Factor * Data) + Offset**

7. Configure a time acquisition process for the second single wavelength (if desired). Select the **Channel B** page and repeat Steps 1-3 for Channel B.

8. To configure a time acquisition process for the third, fourth, fifth, and sixth single wavelengths, select the **Channel C**, **Channel D**, **Channel E**, and **Channel F** pages, respectively, and set the necessary parameters.

Configuring for a Combination of Two Time Channels

Configure a time acquisition process for a combination of two time channels (if desired) by selecting the **Combination 1** tab on the **Time Acquisition Channel Configuration** screen.

► *Procedure*

Perform the steps below to configure a combination:

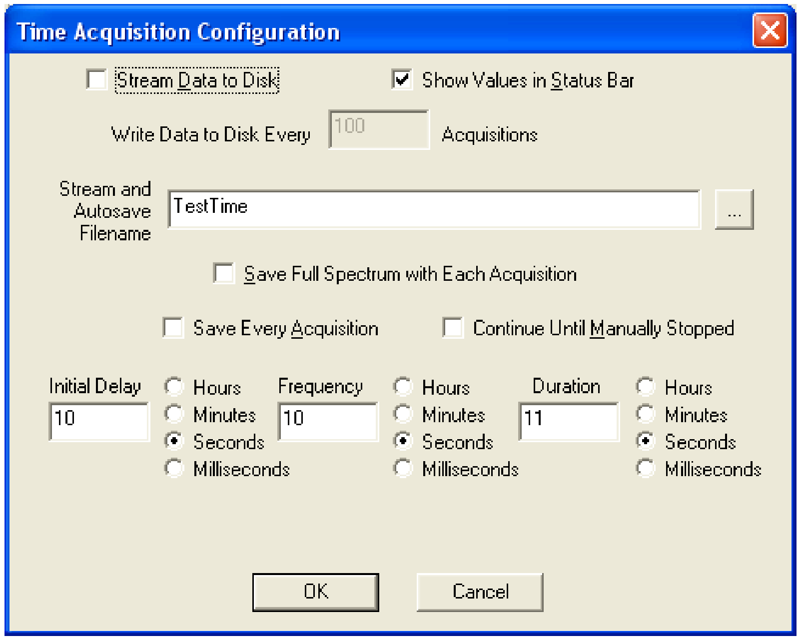
1. Select **Enabled** to set the time acquisition calculation for the wavelength.
2. Enable **Plotted** to see a real-time graph of the acquired data in a spectral window.
3. Specify Time Channel A through F for the First Channel.
4. Select the mathematical operation to produce the data for Combination 1.
5. Specify Time Channel A through F for the Second Channel.
6. Select a multiplicative factor to apply to the data before plotting or storing. Then, select an additive constant or offset to apply to the data. OOIBase32 applies the additive constant or offset after applying the factor but before plotting or storing data.

   The equation for the Factor and Offset functions is: **Results = (Factor * Data) + Offset**
7. Configure a time acquisition process for the Combination 2 page, if desired. This page is virtually identical to the Combination 1 page, with the exception that you can choose Combination 1 for the first or second channel in Combination 2.
8. Click the **Apply** button to apply the changes, and then click the **OK** button to close the Time Acquisition Channel Configuration screen.
9. Proceed to the *Configuring the Time Acquisition Configuration Screen* section below.

Configuring the Time Acquisition Configuration Screen

► *Procedure*

1. Select Time Acquisition | Configure | Configure Acquisition from the menu bar to open the Time Acquisition Configuration screen.



2. Enable **Stream Data to Disk** to save time acquisition data.

3. Enter a value in the **Write Data to Disk Every** *x* **Acquisitions** box to set the frequency for saving data. OOIBase32 saves data more frequently if the number is smaller, or less frequently if the number is larger. Entering a large number enhances the performance of the time acquisition process.

Note

At specified time intervals, OOIBase32 stores data into time acquisition channels or combination channels. OOIBase32 can plot the data in a spectral window, or stream the data to disk, or both. OOIBase32 can display up to 2048 acquisitions in a spectral window. If OOIBase32 collects more than 3684 acquisitions, it only displays the last 2048. To store more than 2048 acquisitions, you must stream the data to disk.

Writing data to the disk is a slow process (relative to the speed of some spectral acquisitions) and causes a decrease in system performance. However, writing data to disk more frequently gives a larger margin of safety.

---

4. Enable **Show Values in Status Bar** to see the time acquisition values in the status bar. These values replace the cursor values.

5. Name the **Stream Filename** for the time acquisition process. Clicking on the ellipsis to the right of this box opens a File Save dialog box, allowing you to navigate to a designated folder.

6. Enable **Save Every Acquisition** to store data for every spectral acquisition during a time acquisition process (optional).

Note

OOIBase32 has options to either store data for each acquisition, or to collect data only after a specified delay. Several factors affect the minimum time acquisition frequency, including integration time, number of spectrometer channels, samples averaged, and computer speed. If you instruct OOIBase32 to store data every 100 milliseconds, the delay between data acquisitions will be 100 milliseconds or more, depending on your experimental configuration. OOIBase32 spends a large amount of time calculating, rendering, and displaying the spectra in a spectral window. You can suspend the graph display, which greatly improves the performance of OOIBase32.

7. Enter an **Initial Delay** to set the delay preceding the time acquisition process. Keep in mind that the delay countdown does not begin until you start the time acquisition process. Be sure to select Hours, Minutes, Seconds, or Milliseconds immediately to the right of the initial delay entry.

8. Enter a value to set the **Frequency** of the data collected in a time acquisition process. OOIBase32 stamps data from a time acquisition with a time accurate to one millisecond. Be sure to select Hours, Minutes, Seconds, or Milliseconds immediately to the right of the frequency entry. You can enable the **Save Every Acquisition** box to store the acquisitions that occur at this frequency. See Step 6 for more information.

9. Enter a value to set the **Duration** for the entire time acquisition process. Be sure to select Hours, Minutes, Seconds, or Milliseconds to the right of the duration entry. Click the **OK** button to close the **Time Acquisition Configuration** dialog box. Then, enable **Continue Until Manually Stopped**, which instructs OOIBase32 to store data until you manually stop the acquisition process (optional).

Appendix A

Calibrating the Wavelength of the NIR Spectrometer

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.

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)

R_λ = the reference intensity at wavelength λ

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 will need the following:

- A light source capable of producing spectral lines.

  Ocean Optics' AR-1 Argon lamp or HG-1 Mercury-Argon lamp are ideal for this purpose. If you do not have an AR-1 or HG-1, you will need a spectral line source that produces several (at least 4-6) spectral lines in the wavelength region of your spectrometer.

- The NIR 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.
- 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 OOIBase32 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 → True Wavelength (nm)

Dependent Variables → Pixel #, Pixel # ², Pixel # ³

Values computed from the regression output → Predicted Wavelength, Difference

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 your spreadsheet or calculator to calculate the wavelength calibration coefficients. In your 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 you execute the regression, an output similar to the one shown below is obtained.

Regression Statistics

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

	Coefficients	**Standard Error**
Intercept	190.473993 ← intercept	0.369047536
X Variable 1	0.36263983 ← first coefficient	0.001684745
X Variable 2	-1.174416E-05 ← second coefficient	8.35279E-07
X Variable 3	-2.523787E-09 ← third coefficient	2.656608E-10

The numbers of importance are indicated in the above figure.

7. Record the Intercept as well as the First, Second, and Third Coefficients. Also, look at the value for R squared. It should be *very* close to one. If it is not, you have probably assigned one of your wavelengths incorrectly. Keep these values at hand.

Saving the New Calibration Coefficients: USB Mode

Wavelength calibration coefficients unique to each NIR Spectrometer are programmed into an EEPROM memory chip on the NIR Spectrometer.

You can save over old calibration coefficients with new ones and OOIBase32 can read these coefficients, *but only if you are using the NIR Spectrometer via the USB port*. If you are using the NIR Spectrometer via the serial port, see the *Saving the New Calibration Coefficients: Serial Mode* section later in this Appendix.

► *Procedure*

To Save Wavelength Calibration Coefficients Using the USB Mode

1. Ensure that the NIR Spectrometer is connected to the PC and that no other applications are running.
2. Point your browser to http://www.oceanoptics.com/technical/softwaredownloads.asp and scroll down to Microcode. Double-click on **USB EEPROM Programmer**.
3. Save the setup file to your computer.
4. Run the **Setup.exe** file to install the software
5. At the **Welcome** screen, click the **Next** button.
6. At the **Destination Location** screen, accept the default or click the **Browse** button to pick a directory. Then, click the **Next** button.
7. Select a Program Manager Group and click the **Next** button. The Start Installation screen appears. Click the **Next** button.
8. Click the **Finish** button when the Installation Complete screen appears.
9. Reboot the computer when prompted.
10. Navigate to USB EEPROM Programmer and open the software.
11. Click on the NIR Spectrometer device, located 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.

12. Repeat Step 12 for all of the new values.

13. 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 NIR Spectrometer.

Saving the New Calibration Coefficients: Serial Mode

If you are interfacing the NIR Spectrometer to your PC via the serial cable, you need to save the wavelength calibration coefficients to the **.**SPEC file that OOIBase32 accesses when opened.

Note

You cannot save the calibration coefficients to the EEPROM memory chip on the NIR Spectrometer when using the serial mode.

► *Procedure*

To save Wavelength Calibration Coefficients using the Serial mode:

1. Open the OOIBase32 application.
2. Select **Spectrometer | Configure** from the OOIBase32 menu bar. The **Configure Spectrometer** screen appears.
3. Select the **Wavelength Calibration** tab to update the wavelength coefficients within OOIBase32.
4. Enter in the new values acquired from Steps 5 and 6 of the *Calibrating the Wavelength of the Spectrometer* section in this appendix.
5. Click the **OK** button to save the information in OOIBase32.

Appendix B

Specifications

How the Spectrometer Works

Light passes through the NIR Spectrometer through a fixed optical path. The optical bench of the NIR Spectrometer has no moving parts that can wear or break; all the components are fixed in place at the time of manufacture.

The following table describes each component in the NIR Spectrometer. Items marked with an asterisk (*) can be user-specified (consult an Applications Scientist for more information):

NIR Spectrometer Component Table

Name	Description
SMA Connector	Light from a fiber enters the optical bench through the SMA connector.
Slit*	Light passes through the installed slit, which acts as the entrance aperture. Entrance slits are rectangular apertures, with the width determining the amount of light entering the optical bench. A slit is permanent and can only be changed by an Ocean Optics technician. You can also use the NIR Spectrometer without a slit installed. In this case, the diameter of the fiber connected to the NIR Spectrometer determines the size of the entrance aperture.
Installed Filter*	Light passes through a filter installed in the SMA connector. Both bandpass and longpass filters are available to restrict radiation to certain wavelength regions. Filters are permanently installed in the bulkhead of the SMA connector.
Collimating Mirror	Light coming in from the entrance aperture reflects from this mirror, as a collimated beam, toward the grating.
Grating*	Light is diffracted by the fixed grating and directed to the focusing mirror. Instead of the grating rotating (as it does in scanning monochromators and other instruments), the grating in the NIR Spectrometer is fixed in place at the time of manufacture.
Focusing Mirror	Diffracted light hits this second mirror, which reflects and focuses the light on the detector array.

Name	Description
InGaAs Detector	Each pixel on the detector responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

NIR Detector Specifications

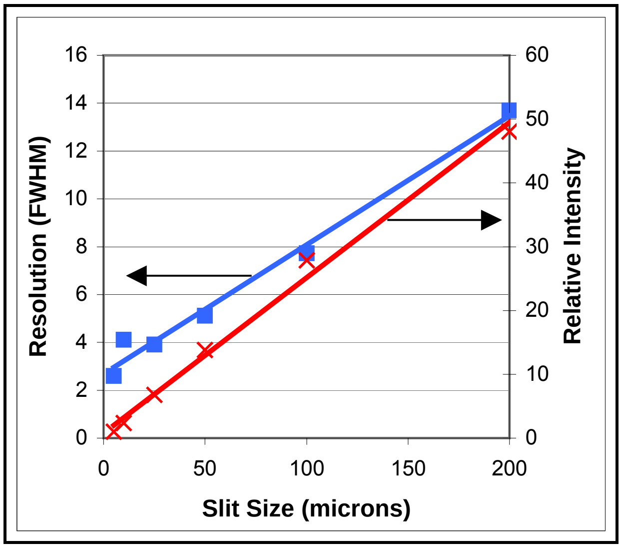
	NIR512	NIR256-2.1	NIR256-2.5
Detector	Hamamatsu G9204 512-element InGaAs cooled array Hamamatsu G9024 512-element InGaAs cooled array	Hamamatsu G9206 256-element InGaAs cooled array	Hamamatsu G9208 256-element InGaAs cooled array
Number of elements	512 pixels	256 pixels	256 pixels
Detector temperature specifications	Cooling 30 ºC below ambient, stable temperature to within ± .1 ºC	Cooling 40 ºC below ambient, stable temperature to within ± .1 ºC	
Responsivity range	0.85 – 1.7µm	0.9 – 2.05µm	0.9 – 2.55µm
Responsivity peak	1.6µm	1.95µm	2.3µm
Pixel size	25 µm x 500 µm	50 µm x 250 µm	50 µm x 250 µm
Pixel well depth	187,000,000 electrons		
Dark signal RMS[1]	<12 counts	<14 counts	<14 counts
Defective pixels[2]	None Max Dark Current = 60pA at 25 ºC	2% Max Dark Current = 120pA at -20 ºC	5% Max Dark Current = 2000pA at 25 ºC
Signal-to-noise ratio	4000:1 at full signal		
Above zero integration Time[3]	1000 msec	N/A	N/A

Notes:

1. Does not include first or last pixels.
2. Defective Pixels are specified at the specific test conditions.
3. As integration time increases, the dark value of a pixel may decrease. The “Above Zero Integration Time” figure is the maximum integration time at which all pixels have a dark value greater than zero A/D counts. Longer integration times are possible if these pixel values are ignored or interpolated.

NIR Spectrometer – Slit Size vs. Resolution and Throughput

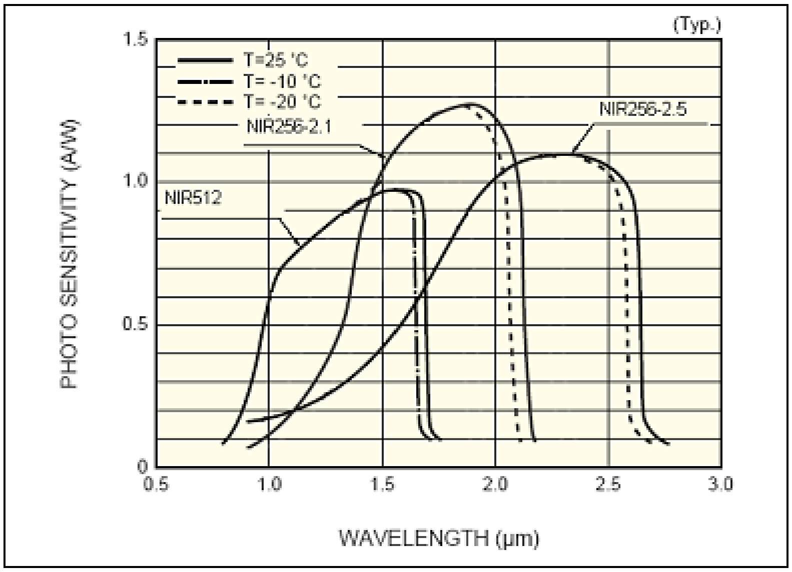
The following chart illustrates the effect that varying slit sizes have on NIR512 Spectrometer resolution and throughput:



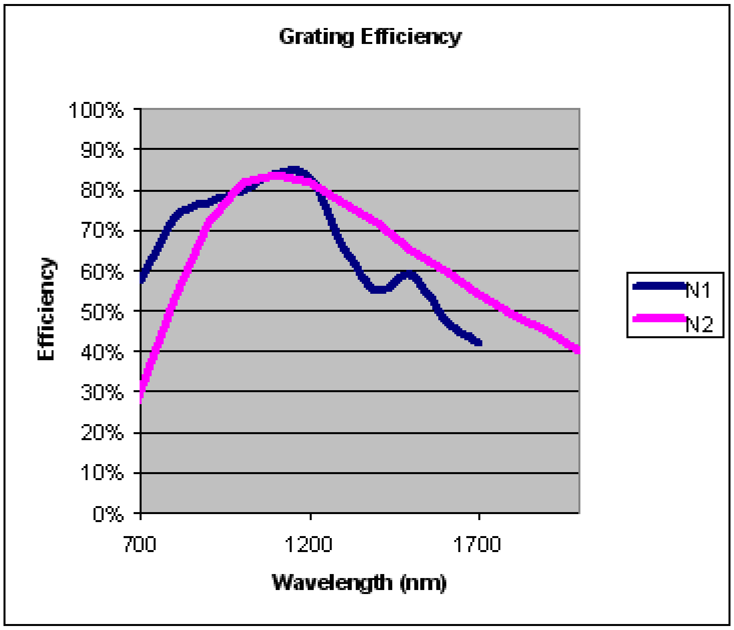
NIR Spectrometer Specifications

	NIR512	NIR256-2.1	NIR256-2.5
Dimensions	105 mm x 127 mm x 80 mm		
Weight	190 g (without cable)		
Power consumption	2A @ 5V DC	4A @ 5V DC	
Detector range	850 nm to 1.7 μm	900 nm to 2.05 μm	900 nm to 2.5 μm
Gratings	N1: 300 lines/mm blazed at 1 μm	N2: 150 lines/mm blazed at 1.6 μm or N1: 300 lines/mm blazed at 1 μm	
Entrance aperture	5, 10, 25, 50, 100, or 200 mm wide slits or fiber (no slit)		
Order-sorting filters	Installed longpass and bandpass filters		

	NIR512	NIR256-2.1	NIR256-2.5
Optical resolution	~3.0 - 4.0 nm FWHM	~12.0 nm FWHM	
Focal length	f/4, 40mm		
Dynamic range	5000:1 for a single scan		
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)		
A/D converter:	16-bit internal - 500 KHz		
Data transfer rate	Full scans into memory every 10 milliseconds (USB interface)		
Integration time	≥1 msec		
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)		
Operating systems	Windows 98/Me/2000/XP - USB interface Any 32-bit Windows operating system – Serial port		



Spectral Response Curves



Grating Efficiency Curves

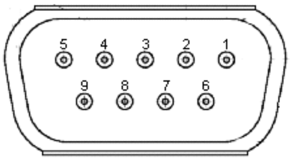
Compatibility for Desktop or Notebook PCs

To use the NIR Spectrometer with your PC, the computer must meet the following requirements:

- IBM-compatible PC with Pentium or better microprocessor
- 32 MB RAM
- OOIBase32™ 32-bit Spectrometer Operating Software
- Windows 98/Me/2000/XP operating system
- Any 32-bit Windows operating system (when connecting the NIR Spectrometer to a notebook or desktop PC via the serial (RS-232) port)

9-pin RS-232 Serial Port Pinout

When facing the 9-pin RS-232 Serial Port connector on the NIR Spectrometer, the pins are numbered as:

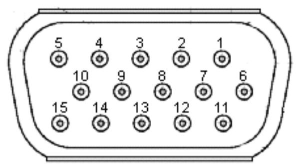


9-pin RS-232 Serial Port Connector – Pin Definitions

Pin #	Description
2	RS232 Transmit
3	RS232 Receive
5	Ground

15-pin Accessory Connector Pinout

When facing the 9-pin RS-232 Serial Port connector on the NIR Spectrometer, the pins are numbered as:



15-pin Accessory Connector – Pin Definitions

Pin #	Description
3	+5V DC
8	External Software trigger pin
10	Ground

LED Information

The LED on the NIR Spectrometer has two states: Blinking and Solid. A blinking LED indicates that the thermo-electric cooler (TEC) is not active. A solid LED indicates that the TEC is active, which means the TEC is in the process of reaching (or has reached) the set temperature.

The LED indicator is present on Revision C (and higher) NIR Spectrometers. The last letter in your NIR serial number (for example, NIRXX**A**001 for Revision A) represents the revision code of the spectrometer.

The NIR Spectrometer is designed to keep the internal temperature within 0.1 °C of the set temperature.

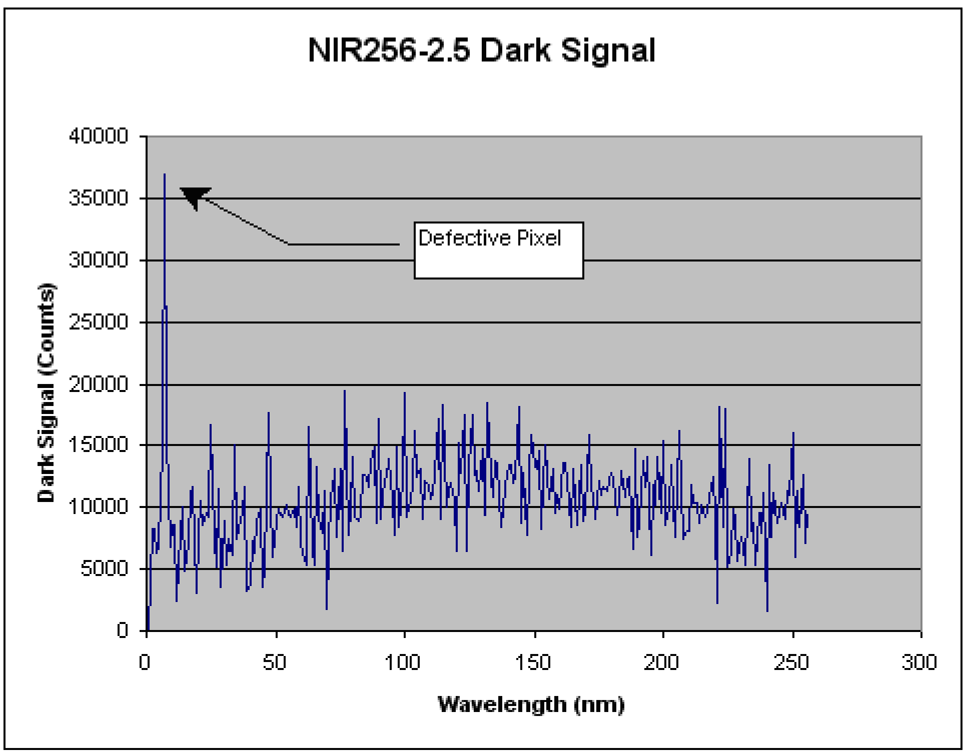
Appendix C

NIR256-2.5µm Sensitivity

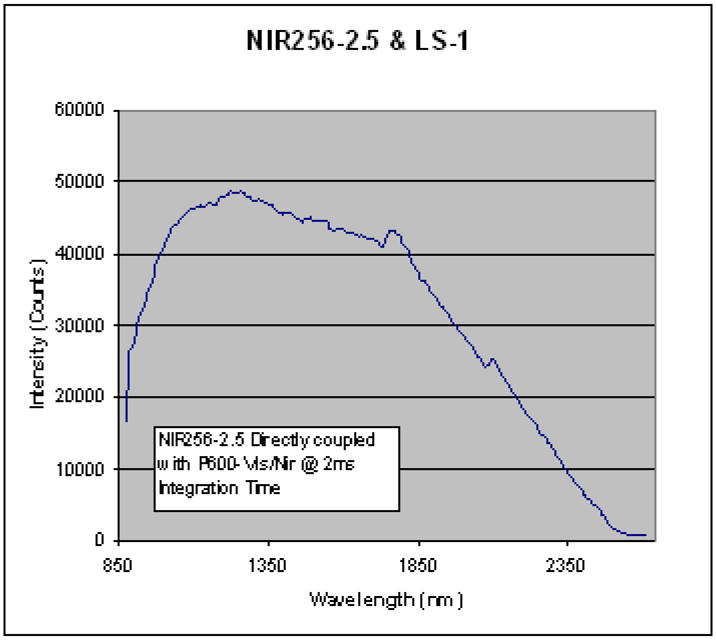
When configuring a system for operation out to 2.5µm it is important that you consider the following details:

- Short Integration Times: For the detector to be sensitive out to 2.5µm, the detector's band gap energy must be small. Unfortunately, this raises the absolute level of the detectors dark signal. A typical dark signal at 34ms is shown below. While the detector functions at integration times greater than 50ms, this seems to be the realistic limit.
- Fiber Selection: For maximum signal intensity, alternative fiber materials should be used for wavelengths greater than 2.2µm.

The figure below shows a dark signal at 24ms integration time. Full Scale is 65,535 counts. The spectra shows the presence of a defective pixel.



The figure below shows the relative intensity of a NIR256-2.5 Spectrometer with a 25um slit directly coupled to an LS-1 Light Source with a 600um fiber.



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