

QE65000 Spectrometer

Installation and Operation Manual

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About This Manual

Document Purpose and Intended Audience

This document provides the user of the QE65000 Spectrometer with instructions for setting up, calibrating and performing experiments with their spectrometer.

Document Summary

Chapter	Description
Chapter 1: Introduction	Contains descriptive information about the QE65000 Spectrometer and how sampling works. It also provides a list of system requirements, interface options, and shipment components.
Chapter 2: Installing the QE65000	Provides installation and configuration instructions.
Chapter 3: Troubleshooting	Contains recommended steps to isolate and correct common problems.
Chapter 4: Sample Experiments	Offers instructions for preparing for and taking measurements with the QE65000 Spectrometer.
Appendix A: Calibrating the Wavelength of the QE65000	Provides instructions for calibrating the QE65000 Spectrometer.
Appendix B: Specifications	Contains technical specifications and connector pinouts for the QE65000 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.

- Detailed instructions for the OOIBase32 Spectrometer Operating Software are located at: <http://www.oceanoptics.com/technical/ooibase32bit.pdf>.

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

You can also access operating instructions for Ocean Optics products from the *Software and Technical Resources* CD that ships with the product.

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 Overview

The Ocean Optics QE65000 Spectrometer is a novel combination of detector, optical bench and electronics technologies that provide you with a remarkably sensitive system for demanding, low-light level applications such as fluorescence, DNA sequencing and Raman spectroscopy. The QE65000 is Ocean Optics' most sensitive spectrometer, achieving up to 90% quantum efficiency with high signal-to-noise and improved signal processing speed.



Ocean Optics QE65000 High-Sensitivity Fiber Optic Spectrometer

The QE65000 features a Hamamatsu back-thinned detector with a 2-D arrangement of pixels (1044 horizontal x 64 vertical) that is responsive from 200-1100 nm. The detector's columns are binned, or summed, inside the detector prior to the readout process, thereby minimizing readout noise. Additionally, the detector can be cooled down to -15°C with the onboard TE-Cooler to reduce dark noise. The reduction of noise and dark signal allows integration times of the spectrometer (analogous to the shutter speed of a camera) of up to 15 minutes, which greatly enhances the detection limit in low-light level applications. The back-illuminated detector has great response in the UV.

The combination of the spectrometer's low-noise detector and 16-bit A/D Converter delivers a dynamic range of 25000:1 and a signal-to-noise ratio of 1000:1.

1: Introduction

The QE65000's onboard module has 10 user-programmable digital I/O lines for interfacing to other equipment; and a pulse generator for triggering other devices. You can use the I/Os to flash a lamp, stop/start a process, and send a message/alarm during the spectrometer's integration period. The spectrometer's operating parameters can be controlled through software. In fact, wavelength calibration coefficients unique to each spectrometer are programmed into a memory chip right on the spectrometer.

The QE65000's high-speed electronics have been designed for considerable flexibility in connecting to various modules and external interfaces, including PCs, PLCs and other embedded controllers, through USB 2.0 or RS-232 communications. Its USB 2.0 interface enables full spectral scans into memory every 7 milliseconds.

The QE65000 operates via USB interface. A +5 VDC external power supply is required for the TE Cooler (TEC) and to operate the spectrometer via an RS-232 interface. This power supply is included with your spectrometer.

Features

- Hamamatsu S7031-1006 Detector
 - Peak QE: 90%
 - Back-thinned for good UV sensitivity
 - MPP operation for low noise
 - TE Cooled
- Spectrometer Design
 - Symmetrical Crossed Czerny Turner
 - 101mm focal length
 - 14 gratings
 - 6 slit widths
- Electrical Performance
 - 16 bit, 500KHz A/D converter
 - Integration times from 7ms to ~15min
- Embedded microcontroller allows programmatic control of all operating parameters and standalone operation
 - USB 2.0 480Mbps (high-speed) & 12Mbps (full speed)
 - RS232 115Kbaud
 - Multiple communication standards for digital accessories (SPI, I2C)
- Onboard Pulse Generator
 - 2 programmable strobe signals for triggering other devices
 - Software control of nearly all pulse parameters
- Onboard GPIO
 - 10 user-programmable digital I/Os

- EEPROM storage for
 - Wavelength Calibration Coefficients
 - Linearity Correction Coefficients
 - Absolute Irradiance Calibration (optional)
- Plug-n-play interface for PC applications
- 30-pin connector for interfacing to external products
- CE certification

System Requirements

You can use the QE65000's USB connectivity with any PC that meets the following requirements:

- Windows 98/Me/2000/XP operating system (or Windows CE 2.11 or later for handheld PCs)
- Ocean Optics OOIBase32 software application installed and configured for use with the QE65000 (OOIPS2000 software if using a handheld PC). See the [Configuring the QE65000 in OOIBase32](#) section of *Chapter 2: Installing the QE65000* for specific configuration instructions.

Alternately, the QE65000 has a serial port for connecting to PCs, PLCs, and other devices that support the RS-232 communication protocol. However, this connection method requires an external power supply to power the QE65000, the HR4000 Breakout Box, and a serial cable.

EEPROM Utilization

An EEPROM memory chip in each QE65000 contains wavelength calibration coefficients, linearity coefficients, and a serial number unique to each individual spectrometer. The OOIBase32 software application reads these values directly from the spectrometer, enabling the ability to “hot-swap” spectrometers between PCs without entering the spectrometer coefficients manually on each PC.

About OOIBase32

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

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 OOIBase32.
7. OOIBase32 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 the QE65000. 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 QE65000 has both USB and serial port connectors (with the use of an adapter), enabling you to connect the spectrometer to a desktop or notebook PC via a USB port or serial port.

Computer Interface	Operating System Requirements	Part Needed	Description of Part
Desktop or Notebook PC via USB Port	Windows 98/Me/2000/XP	USB-CBL-1 (included)	Cable that connects from USB port on QE65000 to USB port on desktop or notebook PC
Desktop or Notebook PC via Serial Port	Any 32-bit Windows operating system	HR4-BREAKOUT (not included)	Adapter block that enables connection from serial port on QE65000 to serial port on desktop or notebook PC; comes with 5 VDC power supply (required when connecting to serial port)

Shipment Components

- ❑ QE65000 Spectrometer
- ❑ + 5VDC power supply

The following information and documentation also ships with the QE65000 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. 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 Technical Resources CD**

Each order ships with the Ocean Optics *Software and Resources CD*. This disc contains software, operating instructions, and product information for all Ocean Optics software, spectrometers, and spectroscopic accessories. You need Adobe Acrobat Reader version 6.0 or higher to view these files. Ocean Optics includes the Adobe Acrobat Reader on the *Software and Technical Resources CD*.

With the exception of OOIBase32 Spectrometer Operating Software, all Ocean Optics software requires a password during the installation process. You can locate passwords for the other software applications on the back of the *Software and Technical Resources CD* package.

1: Introduction

Installing the QE65000

Overview

You must install the OOIBase32 software application prior to connecting the QE65000 Spectrometer to the PC. The OOIBase32 software installation installs the drivers required for QE65000 installation. If you do not install OOIBase32 first, the system will not properly recognize the QE65000.

If you have already connected the QE65000 to the PC prior to installing OOIBase32, consult *Chapter 3: [Troubleshooting](#)* for information on correcting a corrupt QE65000 installation.

QE65000 Installation

This section contains instructions for connecting the QE65000 in USB mode. To connect the QE65000 to a PC via the USB port, the PC must be running the Windows 98/ME/2000/XP operating system.

► **Procedure**

Follow the steps below to connect the QE65000 to a PC via the USB port:

1. Install OOIBase32 on the destination PC.
2. Locate the USB cable (USB-CBL-1) provided with the QE65000.
3. Insert the square end of the cable into the side of the QE65000.
4. Insert the rectangular end of the cable into the USB port of the PC.
5. If you intend to run the TE Cooler, plug the +5 VDC power supply into the QE65000.

If you installed OOIBase32 prior to connecting the QE65000, the **Add New Hardware Wizard** appears and installs the QE65000 drivers. If the drivers do not successfully install (or if you connected the QE65000 to the PC before installing OOIBase32), consult *Chapter 3: [Troubleshooting](#)*.

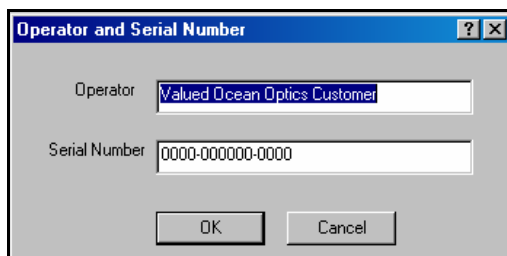
Configuring the QE65000 in OOIBase32

Once you install the QE65000, you must configure OOIBase32's **Configure Spectrometer** options so that OOIBase32 recognizes the QE65000 Spectrometer. Consult the *OOIBase32 Spectrometer Operating Software Operating Instructions* for detailed instructions on configuring the spectrometer in OOIBase32 (see [Product-Related Documentation](#)).

The following sections contain instructions on initially configuring the QE65000 the first time you start OOIBase32.

Operator and Serial Number Dialog Box

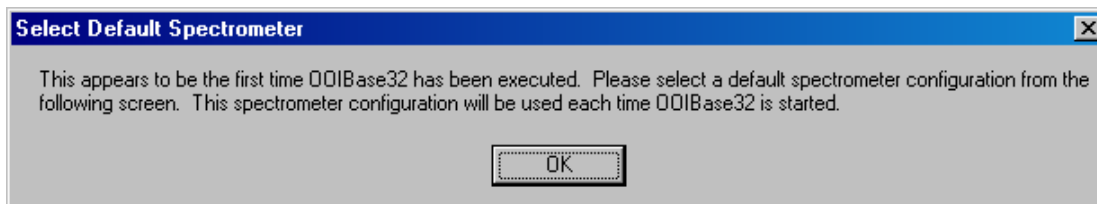
The **Operator and Serial Number** screen prompts you to enter a user name and software serial number into OOIBase32. Some data files created by OOIBase32 during sampling procedures use this information in the file headers.



Default Spectrometer Configuration File

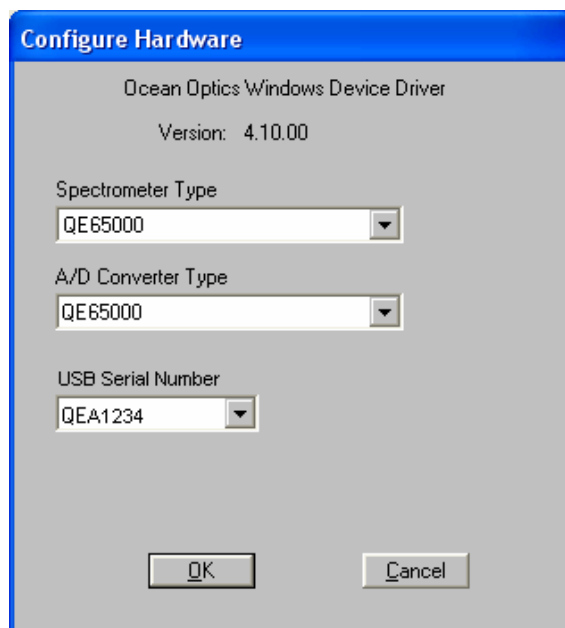
The **Default Spectrometer Configuration File** screen prompts you to select a spectrometer configuration (.SPEC) file for use with the QE65000. The unique serial number of the QE65000 precedes the file extension (for example, DEFAULT.SPEC).

Navigate to the OOIBase32 installation directory and select the spectrometer configuration file.



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.



► Procedure

To configure hardware in USB mode,

1. Specify QE65000 in the **Spectrometer Type** drop-down menu.
2. Specify QE65000 in the **A/D Converter Type** drop-down menu.
3. Specify the serial number of the QE65000 under the **USB Serial Number** drop-down menu.

Note

The system pre-fills this drop-down menu with the serial numbers of all discovered QE65000 Spectrometers.

4. Click the **OK** button to accept the selected options.
5. 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. OOIBase32 pre-fills the coefficients for the QE65000 from information on a memory chip in the spectrometer.

2: Installing the QE65000

3. Verify that the calibration coefficients match the coefficients from the Wavelength Calibration Data Sheet that accompanied the spectrometer. 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.

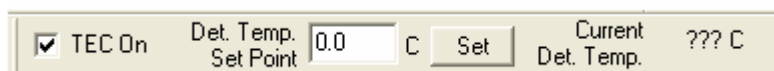
QE65000 Controls

The QE65000 toolbar in OOIBase32 allows you to control a variety of options on the QE65000 Spectrometer. Click your right mouse button while in the OOIBase32 toolbar to display the QE65000 toolbar.

Note

If 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.



The toolbar contains the following elements from left to right: a checked checkbox labeled 'TEC On'; a text input field labeled 'Det. Temp. Set Point' with the value '0.0' and a unit 'C'; a 'Set' button; and a display area labeled 'Current Det. Temp.' showing '??? C'.

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 spectrometer detector as follows: <ul style="list-style-type: none"> • Minimum is -15°C, • Recommended is -5°C 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 QE65000 Spectrometer.
Current Det. Temp.	Displays the current temperature of the detector in the spectrometer.

Connect Spectroscopic Accessories

To find operating instructions for QE65000-compatible products (such as light sources, sampling chambers, and probes), consult the *Software and Technical Resources* CD or the Ocean Optics website at <http://www.oceanoptics.com/technical/operatinginstructions.asp>.

2: Installing the QE65000

Troubleshooting

Overview

The following sections contain information on troubleshooting issues you may encounter when using the QE65000 Spectrometer.

QE65000 Connected to PC Prior to OOIBase32 Installation

If you connected your Ocean Optics USB device 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.

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 QE65000 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.

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.

Older Version of OOIBase32 Installed

If the PC to be used to interface to your QE65000 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.

3: Troubleshooting

Sample Experiments

Overview

The following sections contain information on conducting sample experiments using the QE65000 and OOIBase32.

Preparing for Experiments

Follow the procedure below to configure the QE65000 and OOIBase32 for experiments.

► **Procedure**

1. Double-check that you have correctly installed the QE65000, 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 QE65000.
 - 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 dynamic trace displayed in the bottom of the graph. If you allow light into the spectrometer, the graph trace should rise with increasing light intensity. This means the software and hardware are correctly installed.

Once you install the hardware, configure the software, and establish your sampling system, you are ready to take measurements.

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 (intensity greater than 4000 counts), you can decrease the light level on scale in scope mode by:

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

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

- Increasing the integration time
- Using a larger diameter fiber
- Removing any optical filters

Absorbance Experiments

Absorbance spectra are a measure of how much light a sample absorbs. For most samples, absorbance is linearly related to the concentration of the substance. OOIBase32 calculates absorbance (A_λ) using the following equation:

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

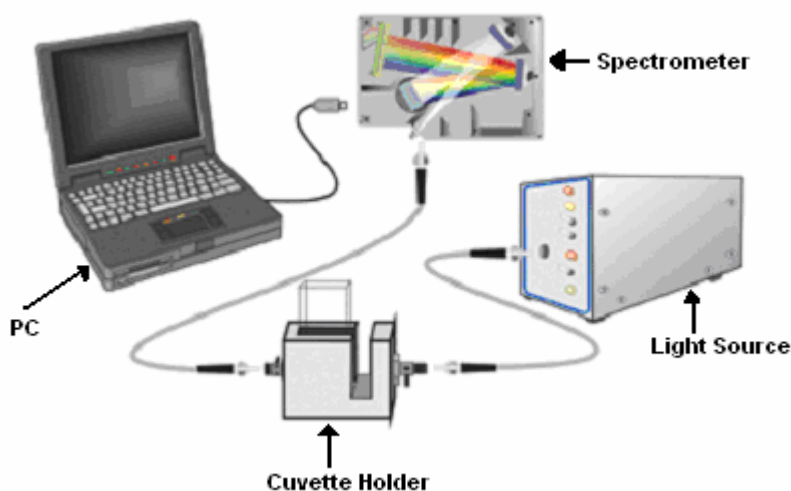
Where:

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.



Typical Absorbance Setup

Absorbance is also proportional to the concentration of the substance interacting with the light (this is known as Beer's Law). Common absorption applications include the quantification of chemical concentrations in aqueous or gaseous samples.

► **Procedure**

To take an absorbance measurement using OOIBase32, follow the steps below:

1. Place OOIBase32 in Scope mode by clicking the scope mode icon on the toolbar or selecting **Spectrum | Scope Mode** from the menu bar.
2. Ensure that the entire signal is on scale. The intensity of the reference signal should peak at about 50,000 counts. If necessary, adjust the integration time until the intensity is approximately 50,000 counts.
3. Place a sample of the solvent into a cuvette and take a reference spectrum. You must take a reference spectrum before measuring absorbance.

Note

Do not put the sample itself in the path when taking a reference spectrum, only the solvent.

4. Click the **Store Reference** spectrum icon on the toolbar or select **Spectrum | Store Reference** from the menu bar to store the reference. This command merely stores a reference spectrum in memory. You must select **File | Save | Reference** from the menu bar to permanently save the spectrum to disk.
 5. Block the light path to the spectrometer. Then, 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 in memory. 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 when taking a dark spectrum. If you must turn off your light source to store a dark spectrum, allow enough time for the lamp to warm up again before continuing your experiment. After the lamp warms up again, store a new reference scan.

You must take a dark spectrum scan before measuring absorbance.

6. Put the sample in place and ensure that the light path is clear. Then, take an absorbance measurement by clicking on the **Absorbance Mode** icon on the toolbar or selecting **Spectrum | Absorbance Mode** from the menu. To permanently save the spectrum to disk, click the **Save** icon on the toolbar or select **File | Save | Processed** from the menu bar.
-

Note

If you change any sampling variable (integration time, averaging, smoothing, angle, temperature, fiber size, etc.), you must store a new dark and reference spectrum.

Transmission Experiments

Transmission is the percentage of energy passing through a sample relative to the amount that passes through the reference. Transmission Mode also displays the portion of light *reflected* from a sample, since transmission and reflection measurements use the same mathematical calculations. The transmission is expressed as a percentage (%T_λ) relative to a standard substance (such as air). OOIBase32 calculates %T_λ (or %R_λ) with the following equation:

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

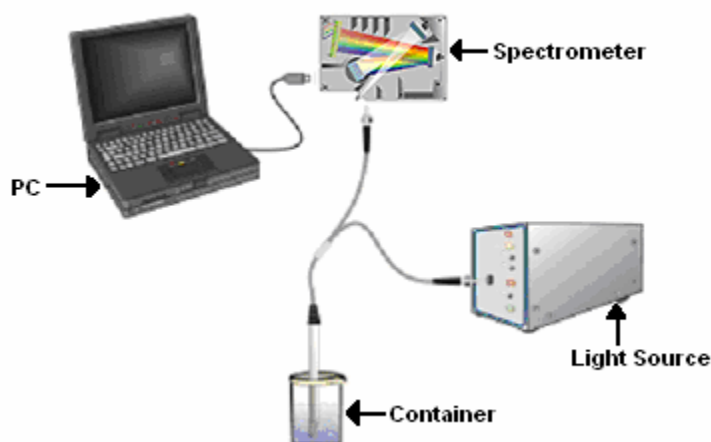
Where:

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.



Typical Transmission Setup

Common transmission applications include measuring 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. Place OOIBase32 in Scope mode by clicking the **Scope Mode** icon on the toolbar or by selecting **Spectrum | Scope Mode** from the menu bar.
2. Ensure that the entire signal is on scale. The intensity of the reference signal should peak at about 14,000 counts. If necessary, adjust the integration time until the intensity is approximately 14,000 counts.
3. Place a sample of the solvent into a cuvette and take a reference spectrum. You must take a reference spectrum before measuring transmission.

Note

Do not put the sample itself in the path when taking a reference spectrum, only the solvent.

4: Sample Experiments

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

4. Block the light path to the spectrometer. Then, 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 in memory. 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 when taking a dark spectrum. If you must turn off your light source to store a dark spectrum, allow enough time for the lamp to warm up again before continuing your experiment.

You must take a dark spectrum before measuring transmission.

5. Put the sample in place and verify that the light path is clear. Then, take a transmission measurement by clicking the **Transmission Mode** icon on the toolbar or selecting **Spectrum | Transmission Mode** from the menu bar. To save the spectrum to disk, click the **Save** icon on the toolbar or select **File | Save | Processed** from the menu bar.

Note

If you change any sampling variable (integration time, averaging, smoothing, angle, temperature, fiber size, etc.), you must store a new dark and reference spectrum.

Reflection Experiments

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

- Specular (the angle of incidence is equal to the angle of reflection)
- Diffuse (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, while others may return mostly diffuse reflection. Specular reflection increases proportionately with the amount of gloss on a surface.

Reflection is expressed as a percentage (% R_λ) relative to the reflection from a standard reference substance:

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

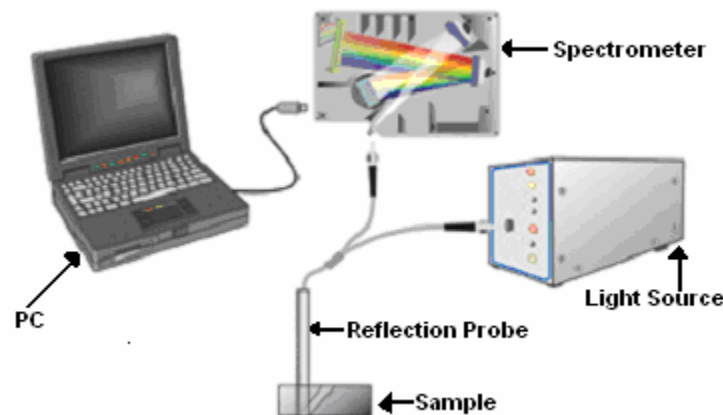
Where:

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.



Typical Reflection Setup

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

► Procedure

Perform the following steps to take reflection measurements using OOIBase32:

1. Place OOIBase32 in Scope mode by clicking the **Scope Mode** icon on the toolbar, or by selecting **Spectrum | Scope Mode** from the menu bar.
2. Ensure that the entire signal is on scale. The intensity of the reference signal should peak at about 50,000 counts.
3. Take a reference spectrum with the WS-1 Diffuse Reflectance Standard or the STAN-SSH High-reflectivity Reference Standard. You must take a reference spectrum before measuring reflection.

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

4. Block the light path to the spectrometer. Then, 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 in memory. 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 when taking a dark spectrum. If you must turn off your light source to store a dark spectrum, allow enough time for the lamp to warm up again before continuing your experiment.

You must take a dark spectrum before measuring transmission.

- Put the sample in place and ensure that the light path is clear. Then, take a reflection measurement by clicking on the **Transmission Mode** icon on the toolbar or selecting **Spectrum | Transmission Mode** from the menu bar (since the mathematical calculations used to calculate transmission and reflection are identical). To save the spectrum to disk, click the **Save** icon on the toolbar or select **File | Save | Processed** from the menu bar.

Note

If you change any sampling variable (integration time, averaging, smoothing, angle, temperature, fiber size, etc.), you must store a new dark and reference spectrum.

Relative Irradiance Experiments

Irradiance is the amount of energy at each wavelength emitted from a radiant sample. In relative terms, it is a comparison of the fraction of energy the sample emits and the energy the sampling system collects from a lamp with a blackbody energy distribution (normalized to 1 at the energy maximum). OOIBase32 calculates relative irradiance with the following equation:

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

Where:

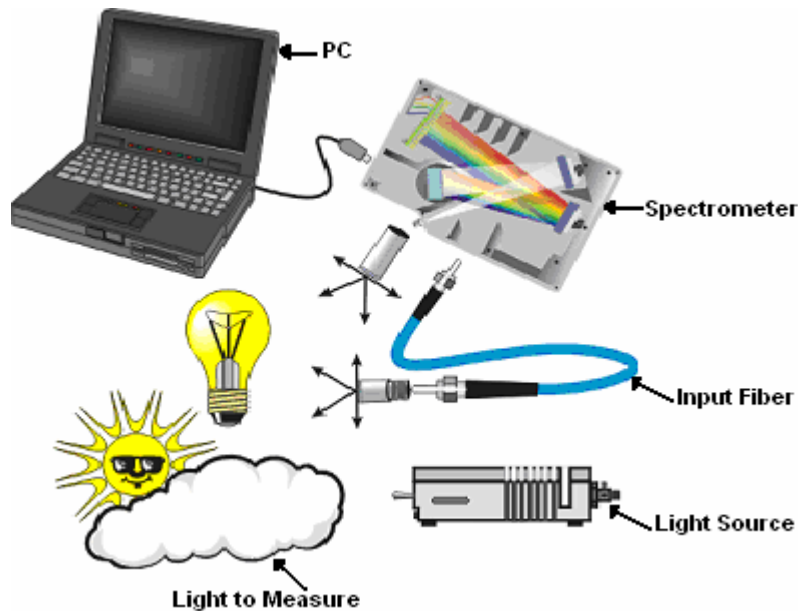
B_{λ} = the relative energy of the reference (calculated from the color temperature) at wavelength λ

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 following figure shows a typical relative irradiance setup. A light source with a known color temperature (such as the LS-1 or LS-1-LL) is used to take a reference spectrum. The light to measure is accumulated through a CC-3 Cosine Corrector (or FOIS integrating sphere) into an input fiber, which carries the light information to the spectrometer. The spectrometer then transmits the information to the PC, which compares the measured spectra against the reference spectrum, thus removing wavelength-dependent instrument response from the measurement.



Typical Relative Irradiance Setup

Common applications include characterizing the light output of LEDs, incandescent lamps, and other radiant energy sources such as sunlight. Relative irradiance measurements also include fluorescence measurements, which measure the energy given off by materials that have been excited by light at shorter wavelengths.

► Procedure

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

1. Place OOIBase32 in Scope mode by clicking the **Scope Mode** icon on the toolbar, or by selecting **Spectrum | Scope Mode** from the menu bar.
2. Ensure that the entire signal is on scale. The intensity of the reference signal should peak at about 50,000 counts.

Note

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

3. In the **Reference Color Temperature** dialog box, enter the color temperature of the light source (in Kelvin) and click the **OK** button.
4. Take a reference spectrum using a light source with a black body of a known color temperature, such as the LS-1.

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

4: Sample Experiments

5. Block the light path to the spectrometer. Then, 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 in memory. 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 when taking a dark spectrum. If you must turn off your light source to store a dark spectrum, allow enough time for the lamp to warm up again before continuing your experiment.

You must take a dark spectrum before measuring relative irradiance.

6. 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.
7. Click the **Save** icon on the toolbar or select **File | Save | Processed** from the menu bar to save the spectrum to disk.

Note

If you change any sampling variable (integration time, averaging, smoothing, angle, temperature, fiber size, etc.), you must store a new dark and reference 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**.

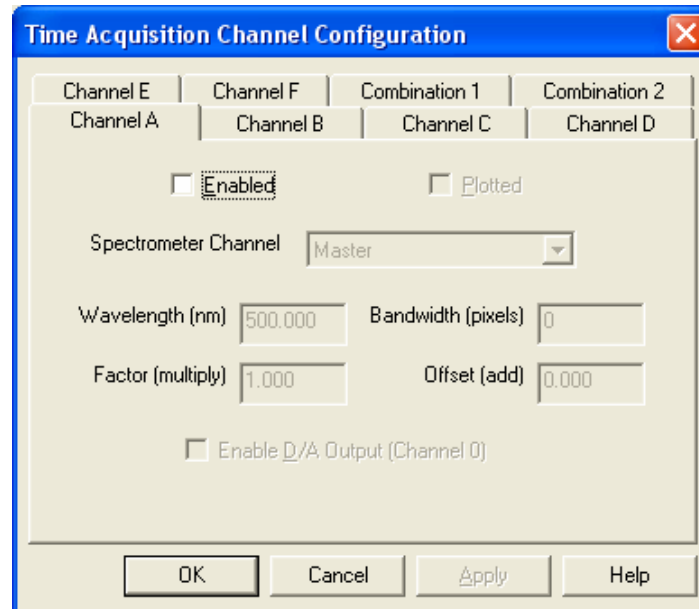
► Procedure

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.

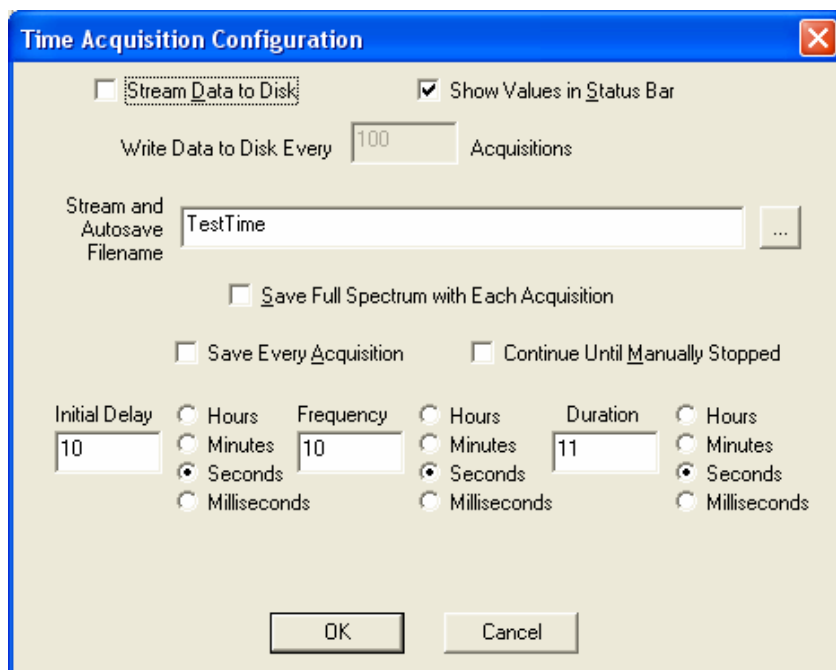
The equation for the Factor and Offset functions is: **Results = (Factor * Data) + Offset**

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.



The dialog box is titled "Time Acquisition Configuration". It contains the following settings:

- ☐ Stream Data to Disk
- ☒ Show Values in Status Bar
- Write Data to Disk Every Acquisitions
- Stream and Autosave Filename: ...
- ☐ Save Full Spectrum with Each Acquisition
- ☐ Save Every Acquisition
- ☐ Continue Until Manually Stopped
- Initial Delay:
 - ☐ Hours
 - ☐ Minutes
 - ☒ Seconds
 - ☐ Milliseconds
- Frequency:
 - ☐ Hours
 - ☐ Minutes
 - ☒ Seconds
 - ☐ Milliseconds
- Duration:
 - ☐ Hours
 - ☐ Minutes
 - ☒ Seconds
 - ☐ Milliseconds

Buttons: OK, Cancel

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 1024 acquisitions in a spectral window. If OOIBase32 collects more than 1024 acquisitions, it only displays the last 1024. To store more than 1024 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 QE65000

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 QE65000.

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/pixel²)

C_3 = the third coefficient (nm/pixel³)

R_λ = the reference intensity at wavelength λ

You will be calculating the value for I and the three C s.

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. 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.

- A QE65000 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 **AnalysisToolPak-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	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

- 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**
- 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 ← R Squared
 Adjusted R Square 0.999999607
 Standard Error 0.125540214
 Observations 22

	<u>Coefficients</u>	<u>Standard Error</u>	
Intercept	190.473993	0.369047536	First coefficient
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	Second coefficient

Third coefficient

- 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: USB Mode

Ocean Optics programs wavelength calibration coefficients unique to each QE65000 onto an EEPROM memory chip in the QE65000.

You can overwrite old calibration coefficients on the EEPROM if you are using the QE65000 via the USB port.

► Procedure

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

- Ensure that the QE65000 is connected to the PC and that you have closed all other applications.
- Point your browser to <http://www.oceanoptics.com/technical/softwaredownloads.asp> and scroll down to **Microcode**. Select **USB EEPROM Programmer**.
- Save the setup file to your computer.
- Run the **Setup.exe** file to install the software. The **Welcome** screen appears.
- Click the **Next** button. The **Destination Location** screen appears.
- 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.
- Click the **Next** button. The **Start Installation** screen appears.
- Click the **Next** button to begin the installation. Once the installation finishes, the **Installation Complete** screen appears.
- Click the **Finish** button and reboot the computer when prompted.
- Navigate to the **USB EEPROM Programmer** from the Start menu and run the software.
- Click on the desired QE65000 device displayed in the left pane of the **USB Programmer** screen.
- 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.
- Repeat Step 12 for all of the new values.
- 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 QE65000.

Appendix B

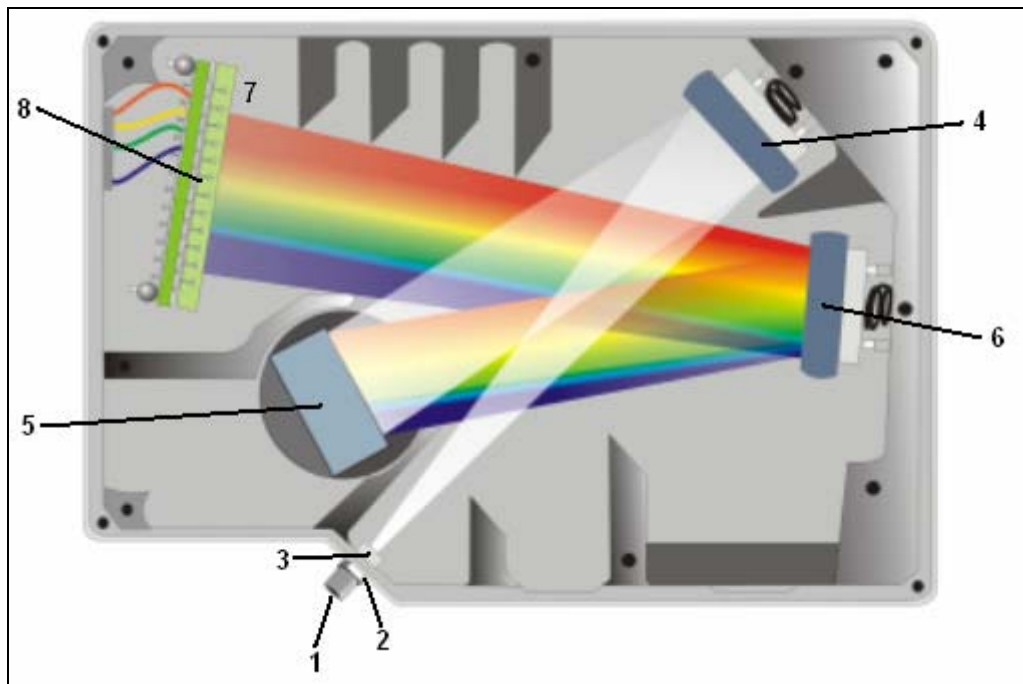
Specifications

Overview

This appendix contains information on spectrometer operation, specifications, and system compatibility. It also includes accessory connector pinout diagrams and pin-specific information.

How the QE65000 Works

Below is a diagram of how light moves through the optical bench of a QE65000 Spectrometer. The optical bench has no moving parts that can wear or break; all the components are fixed in place at the time of manufacture. Items with an asterisk (*) are user-specified.



QE65000 Spectrometer with Components

See [QE65000 Components Table](#) on the following page for an explanation of the function of each numbered component in the QE65000 Spectrometer in this diagram.

QE65000 Components Table

Ocean Optics permanently secures all components in the QE65000 at the time of manufacture. Only Ocean Optics technicians can replace interchangeable components, where noted.

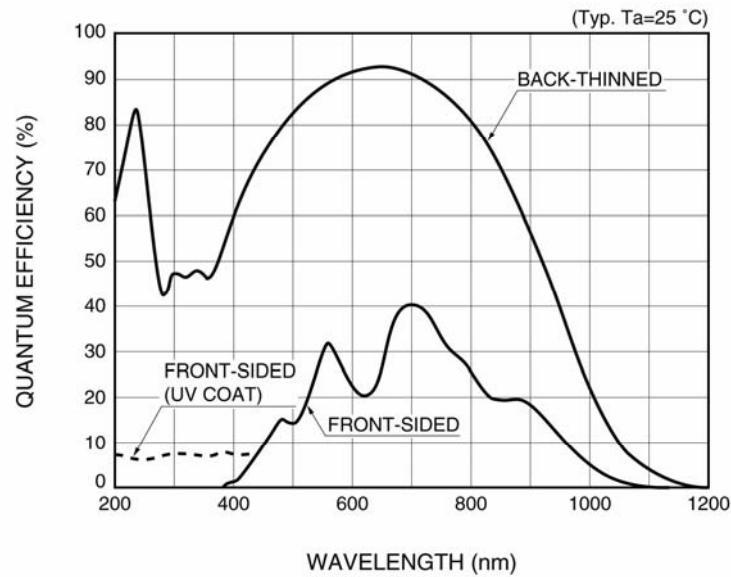
Item	Name	Description
1	SMA Connector	Secures the input fiber to the spectrometer. Light from the input fiber enters the optical bench through this connector.
2	Slit	<p>A dark piece of material containing a rectangular aperture, which is mounted directly behind the SMA Connector. The size of the aperture regulates the amount of light that enters the optical bench and controls spectral resolution.</p> <p>You can also use the QE65000 without a Slit. In this configuration, the diameter of the fiber connected to the QE65000 determines the size of the entrance aperture.</p> <p>Only Ocean Optics technicians can change the Slit.</p>
3	Filter	<p>Restricts optical radiation to pre-determined wavelength regions. Light passes through the Filter before entering the optical bench. Both bandpass and longpass filters are available to restrict radiation to certain wavelength regions.</p> <p>Only Ocean Optics technicians can change the Filter.</p>
4	Collimating Mirror	<p>Focuses light entering the optical bench towards the Grating of the spectrometer.</p> <p>Light enters the spectrometer, passes through the SMA Connector, Slit, and Filter, and then reflects off the Collimating Mirror onto the Grating.</p>
5	Grating	<p>Diffraction light from the Collimating Mirror and directs the diffracted light onto the Focusing Mirror. Gratings are available in different groove densities, allowing you to specify wavelength coverage and resolution in the spectrometer.</p> <p>Only Ocean Optics technicians can change the Grating.</p>
6	Focusing Mirror	Receives light reflected from the Grating and focuses the light onto the CCD Detector or L2 Detector Collection Lens (depending on the spectrometer configuration).
7	L2 Detector Collection Lens	<p>An optional component that attaches to the CCD Detector. It focuses light from a tall slit onto the shorter CCD Detector elements.</p> <p>The L2 Detector Collection Lens should be used with large diameter slits or in applications with low light levels. It also improves efficiency by reducing the effects of stray light.</p> <p>Only Ocean Optics technicians can add or remove the L2 Detection Collection Lens.</p>
8	CCD Detector (UV or VIS)	<p>Collects the light received from the Focusing Mirror or L2 Detector Collection Lens and converts the optical signal to a digital signal.</p> <p>Each pixel on the CCD Detector responds to the wavelength of light that strikes it, creating a digital response. The spectrometer then transmits the digital signal to the OOIBase32 application.</p>

QE65000 Specifications

The following sections provide specification information for the CCD detector in the QE65000, as well as the QE65000 Spectrometer itself.

CCD Detector Specifications

Specification	Value
Detector	Hamamatsu S7031-1006, symmetric crossed Czerny-Turner design
Spectral range	200-1100 nm with window, VUV option available (150nm). VUV option includes purge port and window removal (no TE cooling). 200-925 nm with HC1 grating.
Active area	24.576 x 1.392mm
Pixel size	24.6 μm square
Pixel well depth	300K electrons each well, ~1.5M electrons column summing well
Dark Current	4000 e/pixel/sec @ 25 °C; 200 e/pixel/sec @ 0 °C
Dark noise	2.5 RMS counts
Readout noise	1.5 counts RMS (40 electrons)
Linearity	
Uncorrected	1% max. nonlinearity
Corrected	< 0.5% nonlinearity
Quantum efficiency	90% peak (see <i>Quantum Efficiency of Detector</i> graph below)



Quantum Efficiency of Detector

QE65000 Spectrometer Specifications

Specification	Value
Dimensions (LxWxH)	185 mm (7.28 in.) x 115 mm (4.53 in.) x 50 mm (1.97 in.)
Weight	
QE65000	1.18 kg (2.6 lbs.)
Power Supply	0.45 kg (1 lb.)
Temperature	TE Cooler can only cool 40 °C below ambient temperature
Operation	–0 °C to +50 °C
Storage	–30 °C to +70 °C
Humidity	0 – 90% noncondensing
Power consumption	
No TE Cooler	500 mA @ 5 VDC
With TE Cooler	3.5A at 5V
Supply Voltage	4.5 – 5.5 V
Power-up Time	~ 2s depending on code size
Signal-to-noise ratio	1000:1 (single acquisition)

Specification	Value
Gratings	14 gratings available
Entrance aperture	5, 10, 25, 50, 100 or 200 μm wide slits
Order-sorting filters	6 OF series available
Focal length (input)	f/4, 101 mm
Optical resolution (FWHM)	Depends on grating and size of entrance aperture
Stray light	<0.05% at 600 nm; <0.10% at 435 nm
Dynamic range	7.5×10^9 (over integration range); 25000:1 for a single integration period
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)
Integration time	7 ms to 10 minutes
Interfaces	USB 2.0, 480 Mbps (USB 1.1 compatible); RS-232 (3-wire)

System Compatibility

The following sections provide information on hardware and software requirements for the QE65000.

Compatibility for Desktop or Notebook PCs

To use the QE65000, you must have a PC that meets the following minimum requirements:

- IBM-compatible PC with Pentium (or higher) processor
- 32 MB RAM
- OOIBase32 Spectrometer Operating Software
- Windows 98/ME/2000/XP operating system (when connecting the QE65000 to a PC via USB port)

OR

Any 32-bit version of Windows (when connecting the QE65000 to a PC via serial port)

30-Pin Accessory Connector Pinout

The QE65000 features a 30-pin Accessory Connector, located on the side of the unit as shown:



Location of QE65000 30-Pin Accessory Connector

30-Pin Accessory Connector Pinout Diagram

When facing the 30-pin Accessory Connector on the front of the vertical wall of the QE65000, pin numbering is as follows:

USB Port	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29

30-Pin Accessory Connector Pinout Diagram

30-Pin Accessory Connector – Pin Definitions and Descriptions

The following table contains information regarding the function of each pin in the QE65000's 30-Pin Accessory Connector:

Pin #	Function	Input/Output	Description
1	RS232 Rx	Input	RS232 receive signal – Communicates with a PC over DB9 Pin 3
2	RS232 Tx	Output	RS232 transmit signal – Communicates with a PC over DB9 Pin 2
3	GPIO (2)	Input/Output	General purpose software-programmable, digital input/output (channel number)

Pin #	Function	Input/Output	Description
4	N/A	N/A	Reserved
5	Ground	Input/Output	Ground
6	I ² C SCL	Input/Output	I ² C clock signal for communication to other I ² C peripherals
7	GPIO (0)	Input/Output	General purpose software-programmable, digital input/output (channel number)
8	I ² C SDA	Input/Output	I ² C data signal for communication to other I ² C peripherals
9	GPIO (1)	Input/Output	General purpose software-programmable, digital input/output (channel number)
10	Ext. Trigger In	Input	TTL input trigger signal
11	GPIO (3)	Input/Output	General purpose software-programmable, digital input/output (channel number)
12	V _{CC} or 5V _{IN}	Input or Output	Input power pin for QE65000 – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications (no TEC power)
13	SPI Data Out	Output	SPI Master Out Slave In (MOSI) signal for communication to other SPI peripherals
14	V _{CC} or 5V _{IN}	Input or Output	Input power pin for QE65000 – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications (no TEC power)
15	SPI Data In	Input	SPI Master In Slave Out (MISO) signal for communication to other SPI peripherals
16	GPIO (4)	Input /Output	General purpose software-programmable, digital input/output (channel number)
17	Single Strobe	Output	TTL output pulse used as a strobe signal – Has a programmable delay relative to the beginning of the spectrometer integration period
18	GPIO (5)	Input/Output	General purpose software-programmable, digital input/output (channel number)
19	SPI Clock	Output	SPI clock signal for communication to other SPI peripherals
20	Continuous Strobe	Output	TTL output signal used to pulse a strobe – Divided down from the master clock signal

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Pin #	Function	Input/Output	Description
21	SPI Chip Select	Output	SPI Chip/Device Select signal for communication to other SPI peripherals
22	GPIO (6)	Input/Output	General purpose software-programmable, digital input/output (channel number)
23	N/A	N/A	Reserved
24	N/A	N/A	Reserved
25	Lamp Enable	Output	TTL signal driven Active HIGH when the Lamp Enable command is sent to the spectrometer
26	GPIO (7)	Input/Output	General purpose software-programmable, digital input/output (channel number)
27	Ground	Input/Output	Ground
28	GPIO (8)	Input/Output	General purpose software-programmable, digital input/output (channel number)
29	Ground	Input/Output	Ground
30	GPIO (9)	Input/Output	General purpose software-programmable, digital input/output (channel number)

30-Pin J2 Accessory Connector - Part Numbers

The part numbers for the 30-pin accessory connector on the QE65000 Spectrometer are as follows:

- The connector is Pak50™ model from 3M Corp. Headed Connector – Part Number **P50-030P1-RR1-TG**.
- The mating connector is Part Number **P50-030S-TGF**.
- Mating the two components requires two 1.27 mm (50 mil) flat ribbon cables (3M 3365 Series is recommended).

QE65000 15-Pin Accessory Cable Pinout

Pin #	Description	Pin #	Description
1	Single_strobe	9	GPIO-9
2	ContStrobe	10	GND_SIGNAL
3	V5_SW	11	SDA
4	ExtTrigIn	12	SCL
5	ExtTrigIn	13	LampEnable
6	GPIO-8	14	A_IN
7	A_OUT	15	GPIO-7
8	ExtTrigIn		

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