HR4000 and HR4000CG-UV-NIR Series High-Resolution Fiber Optic Spectrometers

HR4000 / HR4000CG-UV-NIR

Installation and Operation Manual

Document Number 210-00000-000-02-1006

Offices: **Ocean Optics, Inc. World Headquarters**
830 Douglas Ave., Dunedin, FL, USA 34698
Phone 727.733.2447
Fax 727.733.3962
8 a.m.– 8 p.m. (Mon-Thu), 8 a.m.– 6 p.m. (Fri) EST

E-mail:	**Info@OceanOptics.com**	**(General sales inquiries)**
	Orders@OceanOptics.com	**(Questions about orders)**
	TechSupport@OceanOptics.com	**(Technical support)**

A HALMA GROUP COMPANY

Additional Offices:

Ocean Optics Asia

137 Xianxia Road, Suite 1802, Changning District, Shanghai, PRC. 200051

Phone **86.21.5206.8686**
Fax **86.21.5206.8686**
E-Mail **Sun.Ling@OceanOptics.com**

Ocean Optics B.V. (Europe)

Geograaf 24, 6921 EW DUIVEN, The Netherlands

Phone **31-(0)26-3190500**
Fax **31-(0)26-3190505**
E-Mail **Info@OceanOpticsBV.com**

Table of Contents

About This Manual

Document Purpose and Intended Audience

This document provides the user of HR4000 Series Spectrometers (both HR4000 and HR4000CG-UV-NIR) with instructions for setting up, calibrating and performing experiments with their spectrometer.

What's New in this Document

This version of the *HR4000 and HR4000CG-UV-NIR Series High-Resolution Fiber Optic Spectrometers HR4000 / HR4000CG-UV-NIR Installation and Operation Manual* adds SpectraSuite information and updates the Ocean Optics list of offices.

Document Summary

Chapter	Description
Chapter 1: *Introduction*	Contains descriptive information about the HR4000 Spectrometer and how sampling works. It also provides a list of system requirements, interface options, and shipment components.
Chapter 2: *Installing the HR4000*	Provides installation and configuration instructions.
Chapter 3: *Troubleshooting*	Contains recommended steps to isolate and correct common problems.
Appendix A: *Calibrating the Wavelength of the HR4000*	Provides instructions for calibrating the HR4000 Series Spectrometer.
Appendix B: *Specifications*	Contains technical specifications and connector pinouts for the HR4000 Series Spectrometer.
Appendix C: *HR4000CG-UV-NIR Spectrometer*	Contains features and specifications unique to the HR4000CG-UV-NIR 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 SpectraSuite Spectrometer Operating Software are located at: **http://www.oceanoptics.com/technical/SpectraSuite.pdf**.
- Detailed instructions for OOIBase32 Operating Software are located at:
- **http://www.oceanoptics.com/technical/ooibase32.pdf**.
- Detailed instructions for the Breakout Box are located at: **http://www.oceanoptics.com/technical/HR4_breakout.pdf**.
- Detailed instructions for external triggering are located at: **http://www.oceanoptics.com/technical/External-Triggering.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 HR4000 High-Resolution Miniature Fiber Optic Spectrometer provides optical resolution as good as 0.025 nm (FWHM). The HR4000 is responsive from 200-1100 nm, but the specific range and resolution depends on your grating and entrance slit selections.

The HR4000 is perfect for applications where high resolution is necessary, such as absorbance of gases or atomic emission lines (for solution chemistry or for color measurements, the USB4000 is more appropriate).

Data programmed into a memory chip on each HR4000 includes wavelength calibration coefficients, linearity coefficients, and the serial number unique to each spectrometer. Our spectrometer operating software simply reads these values from the spectrometer — a feature that enables hot swapping of spectrometers among computers.

The HR4000 Spectrometer connects to a notebook or desktop computer via USB port or serial port. When connected to the USB port of a computer, the HR4000 draws power from the host computer, eliminating the need for an external power supply.

Ocean Optics HR4000 High-Resolution Fiber Optic Spectrometer

System Requirements

You can use the HR4000's USB connectivity with any computer that meets the requirements for the spectrometer operating software being used (Windows 98/Me/2000/XP, Mac OS X and Linux). See *About Ocean Optics Software*.

Alternately, the HR4000 has a serial port for connecting to PCs, PLCs, and other devices with a Windows 32-bit operating system that support the RS-232 communication protocol. However, this connection method requires an external power supply to power the HR4000, the Breakout Box, and a serial cable.

EEPROM Utilization

An EEPROM memory chip in each HR4000 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 Ocean Optics Software

SpectraSuite is the latest generation of operating software for all Ocean Optics spectrometers. It is a completely modular, Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems. The software can control any Ocean Optics USB spectrometer and device, as well as any other manufacturer's USB instrumentation using the appropriate drivers.

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

OOIBase32 software has been discontinued, but still functions with the HR4000 Spectrometer. Consult the OOIBase32 manual for hardware requirements when using OOIBase32 (see *Product-Related Documentation*).

Sampling System Overview

How Sampling Works

Ocean Optics components function in a sampling system as follows:

1. The user stores reference and dark measurements to correct for instrument response variables.
2. The light from the light source 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 OOI software.
7. OOI software compares the sample to the reference measurement and displays processed spectral information.

Modular Sampling Accessories

Ocean Optics offers a complete line of spectroscopic accessories for use with the HR4000. 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 HR4000 has both USB and serial port connectors (with the use of an adapter), enabling you to connect the spectrometer to a desktop or notebook computer via a USB port or to a desktop, notebook, or to handheld PC via a serial port. However, you must create custom software if using the serial port. SpectraSuite software is available if you are connecting via the USB port.

Computer Interface	Operating System Requirements	Part Needed	Description of Part
Computer via USB Port	SpectraSuite: Windows2000/XPfor PC, OS X version 10.0 or later for Mac, or Red Hat 9 or later, Fedora (any version), Debian 3.1 (Sarge), and SUSE (9.0 or later) for Linux OOIBase32: Windows 98/Me/ 2000/XP	USB-CBL-1 (included)	Cable that connects from USB port on HR4000 to USB port on the computer
Desktop or Notebook PC via Serial Port	Any 32-bit Windows operating system	USB-ADP-PC (not included)	Adapter block that enables connection from serial port on HR4000 to serial port on desktop or notebook PC; comes with 5 VDC power supply (required when connecting to serial port)
Handheld PC via Serial Port	Windows CE 2.11 or higher	USB-ADP-H (not included)	Adapter block that enables connection (with standard 9-pin serial cable) from serial port on HR4000 to serial port on handheld PC; comes with 5 VDC power supply (required when connecting to serial port)

Breakout Box

Ocean Optics also offers the Breakout Box (HR4-BREAKOUT), a passive module that separates the signals from their 30-pin port to an array of standard connectors and headers, enabling easy access to a variety of features found in Ocean Optics' HR4000 Spectrometer. In addition to the accessory connector, the breakout box features a circuit board based on a neutral breadboard pattern that allows custom circuitry to be prototyped on the board itself.

Note

The HR4000 Breakout Box is compatible with HR4000 Spectrometers with Revision B or greater. HR4000 Spectrometers with serial numbers beginning with HR4**A** are *not* compatible with the HR4000 Breakout Box.

Shipment Components

The following information and documentation ships with the HR4000 Spectrometer:

- **Packing List**

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

- **Wavelength Calibration Data Sheet**

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

Other Accessories Available

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

- **Fibers**
- **Light Sources**
- **Integrated Sampling Systems**
- **Cuvettes**
- **Filter Holders**
- **Lithium Ion Battery Pack**
- **HR4-BREAKOUT Breakout Box**

Chapter 2

Installing the HR4000

Overview

You must install the operating software application prior to connecting the HR4000 Spectrometer to the computer. The Ocean Optics spectrometer operating software installs the drivers required for the HR4000 spectrometer installation. If you do not install the software first, the system will not properly recognize the HR4000.

If you have already connected the HR4000 to the computer prior to installing the operating software, consult *Chapter 3: Troubleshooting* for information on correcting a corrupt HR4000 installation.

HR4000 Installation

This section contains instructions for connecting the HR4000 via both USB and serial modes.

USB Mode

To connect the HR4000 to a computer via the USB port, the PC must be running a Windows 98/Me/2000/XP, Mac OS X or Linux operating system.

Note

The USB port on a computer can power up to five HR4000 spectrometer channels. Systems with more than five channels require a powered USB hub.

► *Procedure*

Follow the steps below to connect the HR4000 to a computer via the USB port:

1. Install the spectrometer operating software on the destination computer.
2. Locate the USB cable (USB-CBL-1) provided with the HR4000.
3. Insert the square end of the cable into the side of the HR4000.
4. Insert the rectangular end of the cable into the USB port of the PC.

If you installed the spectrometer operating software prior to connecting the HR4000, the software installs the HR4000 drivers. If the drivers do not successfully install (or if you connected the HR4000 to the computer before installing the software), consult *Chapter 3: Troubleshooting*.

Serial Port Mode

To use the serial port capacity of the HR4000 Spectrometer, the PC must be running a 32-bit version of the Windows operating system (or Windows CE 2.11 or higher for handheld PCs).

► *Procedure*

Follow the steps below to connect the HR4000 to the PC via serial port:

1. Connect the serial cable adapter block to the appropriate pins of the HR4000's 30-Pin Accessory Connector.
2. Connect one end of the 9-pin serial cable to the adapter block on the HR4000, and then connect the other end to a serial port on the PC.
3. Note the number of the serial port (COM Port) to which you connected the HR4000 (some PCs may not have numbered ports; handheld PCs typically have only one serial port).
4. Plug the 5 VDC external power supply into an outlet and connect it to the HR4000.

Configuring the HR4000

The HR4000 can be used with either SpectraSuite or OOIBase32 software when connected to the USB port. The configuration process differs, depending on whether you are running SpectraSuite or OOIBase32 software.

Configuring the HR4000 in SpectraSuite

If you have followed the previous steps and started SpectraSuite, 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.

Note the spectrometer(s) that you have installed are listed in the Data Sources pane.

Configuring the HR4000 in OOIBase32

Once you install the HR4000, you must configure OOIBase32's **Configure Spectrometer** options so that OOIBase32 recognizes the HR4000 Spectrometer. Consult the *OOIBase32 Spectrometer Operating Software Operating Instructions* for detailed instructions on configuring the spectrometer in OOIBase32 (see *Product-Related Documentation*).

Connect Spectroscopic Accessories

To find operating instructions for HR4000-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**.

External Triggering Options

You can trigger the HR4000 using a variety of External Triggering options through the 30-pin Accessory Connector on the spectrometer. See the External Triggering Options document located at **http://www.oceanoptics.com/technical/externaltriggering.pdf**. This document contains instructions for configuring External Triggering options for the HR4000.

Note

Only the external software triggering option is available when using a handheld PC.

Chapter 3

Troubleshooting

Overview

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

Note

For issues encountered when using a handheld PC, consult the OOIPS2000 manual.

HR4000 Connected to Computer Prior to Operating Software Installation

Windows Operating Systems

If you connected your Ocean Optics HR4000 device to the computer prior to installing your spectrometer operating software application (SpectraSuite or OOIBase32) on a Windows platform, you may encounter installation issues that you must correct before your Ocean Optics device will operate properly.

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

Note

If these procedures do not correct your device driver problem, you must obtain the *Correcting Device Driver Issues* document from the Ocean Optics website: **http://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 HR4000 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.

Mac Operating Systems

Since there are no device files for the HR4000 Spectrometer in a Mac operating system, you should not encounter any problems if you installed the spectrometer before the SpectraSuite software.

Linux Operating Systems

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

Older Version of OOIBase32 Installed

If the PC to be used to interface to your HR4000 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.

Appendix A

Calibrating the Wavelength of the HR4000

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 HR4000.

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 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.

- An HR4000 spectrometer
- An optical fiber (for spectrometers without a built-in slit, a 50-μm fiber works best)
- A spreadsheet program (Excel or Quattro Pro, for example) or a calculator that performs third-order linear regressions

---

Note

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

Calibrating the Wavelength of the Spectrometer

► *Procedure*

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

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

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

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

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

Regression Statistics

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

R Squared

Intercept

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

First coefficient

Second coefficient

Third coefficient

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

   Keep these values at hand.

Saving the New Calibration Coefficients: USB Mode

Ocean Optics programs wavelength calibration coefficients unique to each HR4000 onto an EEPROM memory chip in the HR4000.

You can overwrite old calibration coefficients on the EEPROM if you are using the HR4000 via the USB port. If you are using the HR4000 via the serial port, consult the *Saving the New Calibration Coefficients: Serial Mode* section later in this appendix.

► *Procedure*

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

1. Ensure that the HR4000 is connected to the PC and that you have closed all other applications.
2. Point your browser to **http://www.oceanoptics.com/technical/softwaredownloads.asp** and scroll down to **Microcode**. Select **USB EEPROM Programmer**.
3. Save the setup file to your computer.
4. Run the **Setup.exe** file to install the software. The **Welcome** screen appears.
5. Click the **Next** button. The **Destination Location** screen appears.
6. Accept the default installation location, or click the **Browse** button to specify a directory. Then, click the **Next** button. The **Program Manager Group** screen appears.
7. Click the **Next** button. The **Start Installation** screen appears.
8. Click the **Next** button to begin the installation. Once the installation finishes, the **Installation Complete** screen appears.
9. Click the **Finish** button and reboot the computer when prompted.
10. Navigate to the **USB EEPROM Programmer** from the Start menu and run the software.
11. Click on the desired HR4000 device displayed in the left pane of the **USB Programmer** screen.
12. Double-click on each of the calibration coefficients displayed in the right pane of the USB Programmer screen and enter the new values acquired in Steps 5 and 6 of the *Calibrating the Wavelength of the Spectrometer* section in this appendix.
13. Repeat Step 12 for all of the new values.
14. Click on the **Save All Values** button to save the information, and then **Exit** the USB Programmer software.

The new wavelength calibration coefficients are now loaded onto the EEPROM memory chip on the HR4000.

Saving the New Calibration Coefficients: Serial Mode

If you are connecting the HR4000 Spectrometer to the serial port of the PC, you need to save the new 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 HR4000 when using the serial mode.

► *Procedure*

To save Wavelength Calibration Coefficients using the Serial mode, perform the following steps:

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

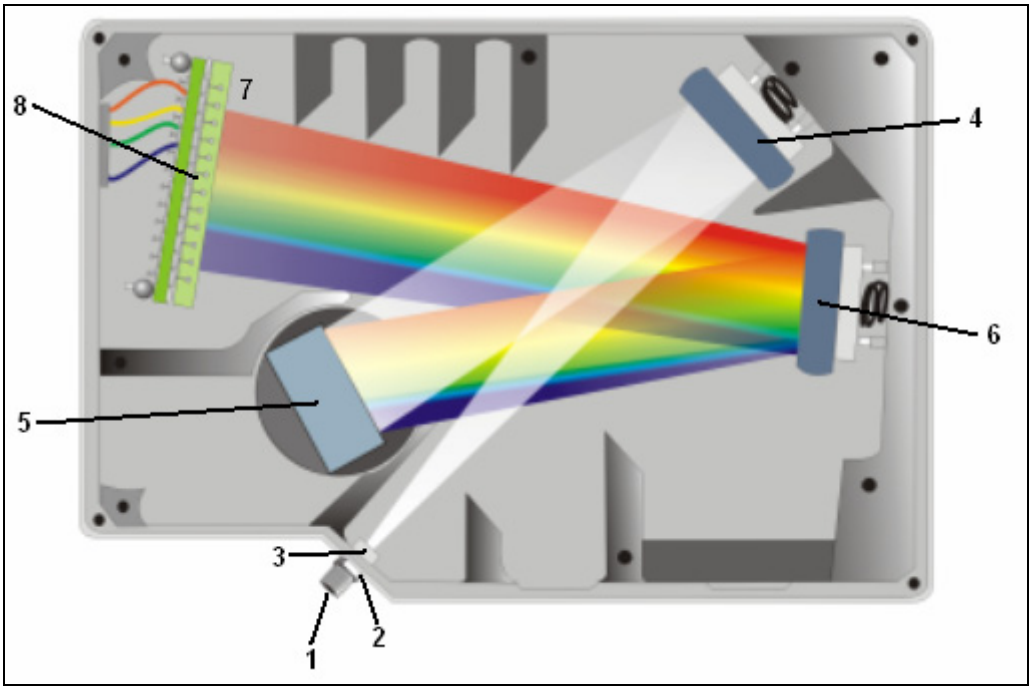
Specifications

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 HR4000 Works

Below is a diagram of how light moves through the optical bench of an HR4000 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.



HR4000 Spectrometer with Components

See *HR4000 Components Table* on the following page for an explanation of the function of each numbered component in the HR4000 Spectrometer in this diagram.

HR4000 Components Table

Ocean Optics permanently secures all components in the HR4000 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	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. You can also use the HR4000 without a Slit. In this configuration, the diameter of the fiber connected to the HR4000 determines the size of the entrance aperture. Only Ocean Optics technicians can change the Slit.
3	Filter	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. Only Ocean Optics technicians can change the Filter.
4	Collimating Mirror	Focuses light entering the optical bench towards the Grating of the spectrometer. Light enters the spectrometer, passes through the SMA Connector, Slit, and Filter, and then reflects off the Collimating Mirror onto the Grating.
5	Grating	Diffracts 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. Only Ocean Optics technicians can change the Grating.
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	An optional component that attaches to the CCD Detector. It focuses light from a tall slit onto the shorter CCD Detector elements. 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. Only Ocean Optics technicians can add or remove the L2 Detection Collection Lens.
8	CCD Detector (UV or VIS)	Collects the light received from the Focusing Mirror or L2 Detector Collection Lens and converts the optical signal to a digital signal. 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.

HR4000 Specifications

The following sections provide specification information for the CCD detector in the HR4000, as well as the HR4000 Spectrometer itself. HR4000CG-UV-NIR specifications are listed in *Appendix C: HR4000CG-UV-NIR Spectrometer*.

CCD Detector Specifications

Specification	Value
Detector	Toshiba TCD1304AP linear CCD array
No. of elements	3648 pixels
Sensitivity	100 photons per count at 800 nm
Pixel size	8 µm x 200 µm
Pixel well depth	-100,000 electrons
Signal-to-noise ratio	300:1 (at full signal)
A/D resolution	14 bit
Dark noise	8 RMS counts
Corrected linearity	>99.8%
Maximum pixel rate	Rate at which pixels are digitized is 1 MHz

HR4000 Spectrometer

Specification	Value
Dimensions	148.6 mm x 104.8 mm x 45.1 mm
Weight	570 g
Power consumption	450 mA @ 5 VDC
Detector	3648-element linear silicon CCD array
Detector range	200-1100 nm
Gratings	14 gratings available
Entrance aperture	5, 10, 25, 50, 100 or 200 µm wide slits

Specification	Value
Order-sorting filters	Installed longpass and bandpass filters
Focal length	f/4, 101 mm
Optical resolution	Depends on grating and size of entrance aperture
Stray light	<0.05% at 600 nm; <0.10% at 435 nm
Dynamic range	2 x 10^9 (system); 2000:1 for a single acquisition
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)
Data transfer rate	Full scans into memory every 4 milliseconds with USB 2.0 port, every 600 milliseconds with the serial port
Integration time	10 microseconds to 65 seconds
Interfaces	USB 2.0, 480 Mbps (USB 1.1 compatible); RS-232 (2-wire); SPI (3-wire); I^2C Inter-Integrated Circuit 2-wire serial bus
Operating systems	Windows 98/Me/2000/XP, Mac OS X, and Linux when using the USB port Any 32-bit Windows operating system when using the serial port
Onboard GPIO	10 user-programmable digital I/Os
Analog channels	One 13-bit analog input and one 9-bit analog output

System Compatibility

The following sections provide information on hardware and software requirements for the HR4000.

Compatibility for Desktop or Notebook PCs

To use the HR4000, 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 HR4000 to a PC via USB port)

  OR

  Any 32-bit version of Windows (when connecting the HR4000 to a PC via serial port)

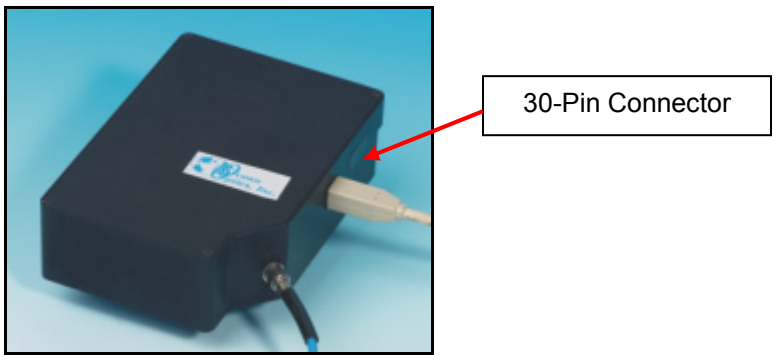
Compatibility for Handheld PCs

To use the HR4000 with your handheld PC, the computer must meet the following minimum requirements:

- Handheld PC running Windows CE 2.11 or later
- 32 MB RAM
- OOIPS2000 Spectrometer Operating Software
- Serial port connectivity

30-Pin Accessory Connector Pinout

The HR4000 features a 30-pin Accessory Connector, located on the side of the unit as shown:



Location of HR4000 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 HR4000, 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 HR4000'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)
4	V5_SW	Output	Regulated 5 Volt power pin – Supplies 50 mA (maximum)
5	Ground	Input/Output	Ground
6	I^2C SCL	Input/Output	I^2C clock signal for communication to other I^2C peripherals
7	GPIO (0)	Input/Output	General purpose software-programmable, digital input/output (channel number)
8	I^2C SDA	Input/Output	I^2C data signal for communication to other I^2C peripherals
9	GPIO (1)	Input/Output	General purpose software-programmable, digital input/output (channel number)
10	Ext. Trigger In	Input	TTL input trigger signal – See External Triggering Options document for info.
11	GPIO (3)	Input/Output	General purpose software-programmable, digital input/output (channel number)
12	V_{CC}, V_{USB}, or $5V_{IN}$	Input or Output	Input power pin for HR4000 – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications
13	SPI Data Out	Output	SPI Master Out Slave In (MOSI) signal for communication to other SPI peripherals
14	V_{CC}, V_{USB}, or $5V_{IN}$	Input or Output	Input power pin for HR4000 – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications
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)

Pin #	Function	Input/Output	Description
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
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	Analog In (0-5V)	Input	13-bit analog-to-digital input with a 0-5V range
24	Analog Out (0-5V)	Output	9-bit programmable output voltage with a 0-5V range
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 HR4000 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).

If you are customizing your HR4000 Spectrometer system or configuring External Triggering, you may need these part numbers to complete your setup.

HR4000 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		

Appendix C

HR4000CG-UV-NIR Spectrometer

The HR4000CG-UV-NIR Composite Grating Spectrometer has a new proprietary grating and order-sorting filter to provide a 200-1100 nm wavelength range with 0.5 nm optical resolution in one spectrometer.

The HR4000-CG-UV-NIR is functionally similar to the standard HR4000 Spectrometer. Follow the instructions in *Chapter 2*: *Installing the HR4000* to configure the HR4000CG-UV-NIR.

HR4000CG-UV-NIR Features

The HR4000CG-UV-NIR contains the following features that differ from the standard HR4000:

New HC-1 Landis Composite Grating

The HR4000CG-UV-NIR uses the new HC-1 Landis grating designed to provide a 200-1100 nm wavelength range. The HC-1 is fixed in place at the time of manufacture.

Variable Order-Sorting Filter

The HR4000CG-UV-NIR contains a new OFLV-200-1000 variable order sorting filter to eliminate second and third order effects.

HR4000CG-UV-NIR Spectrometer Specifications

Specification	Value
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight	570 g
Power consumption	450 mA @ 5 VDC
Detector	3648-element linear silicon CCD array
Wavelength range	200-1100 nm
Optical resolution	0.75 nm FWHM

Specification	Value
Gratings	HC-1, 300 lines per nm grating
Entrance aperture	5 μm-wide slit
Order-sorting filters	OFLV-200-1100 installed
Focal length	f/4, 101 mm
Dynamic range	2 X 10^9 (system); 2000:1 for a single acquisition
Stray light	<0.05% at 600 nm; <0.10% at 435 nm
Fiber optic connector	SMA 905 to single-strand optical fiber (0.22 NA)
Data transfer rate	Full scans into memory every 4 milliseconds with the USB 2.0, every 18 ms with the USB 1.1, every 600 milliseconds with the serial port
Integration time	Continuous – 4 milliseconds to 20 seconds Shutter – 10 microseconds to 4 milliseconds
Operating systems	Windows 98/Me/2000/XP, MAC OS X, and Linux when using the USB port Any 32-bit Windows operating system when using the serial port
Onboard GPIO	10 user-programmable digital I/Os
Analog channels	One 13-bit analog input and one 9-bit analog output

Index

Numbers

A

B

C

D

E

F

G

H

I

L

M

O

P

S

T

U

W