### Additional Offices:

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>E-Mail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ocean Optics Asia</strong></td>
<td>666 Gubei Road, Kirin Tower, Suite 601B, Changning District, Shanghai, PRC. 200336</td>
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<td>86.21.5206.8686</td>
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<tr>
<td><strong>Ocean Optics Europe</strong></td>
<td>Sales and Support Center Geograaf 24, 6921 EW DUIVEN, The Netherlands</td>
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</tr>
<tr>
<td></td>
<td>Regional Headquarters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maybachstrasse 11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>73760 Ostfildern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phone 49-711 34 16 96-0</td>
<td></td>
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<td></td>
<td>Fax 49-711 34 16 96-85</td>
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<tr>
<td></td>
<td>E-Mail <a href="mailto:Sales@Mikropack.de">Sales@Mikropack.de</a></td>
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</table>

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About This Manual

Document Purpose and Intended Audience

This document provides the users of USB4000 Spectrometers with instructions for setting up, calibrating and performing experiments with their spectrometer.

What’s New in This Document

This version of the *USB4000 Fiber Optic Spectrometer Installation and Operation Manual* adds the USB-ADP-BB adapter for the Breakout Box.

Document Summary

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1: <em>Introduction</em></td>
<td>Contains descriptive information about the USB4000 Spectrometer and how sampling works. It also provides a list of system requirements, interface options, and shipment components.</td>
</tr>
<tr>
<td>Chapter 2: <em>Installing the USB4000</em></td>
<td>Provides installation instructions.</td>
</tr>
<tr>
<td>Chapter 3: <em>Troubleshooting</em></td>
<td>Contains recommended steps to isolate and correct common problems.</td>
</tr>
<tr>
<td>Appendix A: <em>Calibrating the Wavelength of the USB4000</em></td>
<td>Provides instructions for calibrating the USB4000 Spectrometer.</td>
</tr>
<tr>
<td>Appendix B: <em>External Triggering</em></td>
<td>Contains information about external triggering for the USB4000.</td>
</tr>
<tr>
<td>Appendix C: <em>Specifications</em></td>
<td>Contains technical specifications and connector pinouts for the USB4000 Spectrometer.</td>
</tr>
</tbody>
</table>

Product-Related Documentation

You can access documentation for Ocean Optics products by visiting our website at [http://www.oceanoptics.com](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.

About This Manual

- Detailed instructions for the Breakout Box are located at: http://www.oceanoptics.com/technical/HR4_breakout.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 USB4000 Spectrometer is our next generation, high-performance, miniature fiber-optic spectrometer designed from our popular USB2000 model to include an advanced detector and powerful high-speed electronics. New features consist of the 3648-element detector with shutter, high-speed electronics, and interface capabilities to Linux, Macintosh and Windows operating systems. The USB4000 is responsive from 200-1100 nm, but the specific range and resolution depends on your grating and entrance slit selections.

The USB4000 is perfect for applications where enhanced electronics, high resolution and fast integration times are required.

Data programmed into a memory chip on each USB4000 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 USB4000 Spectrometer connects to a computer via the USB port or serial port. When connected through a USB 2.0 or 1.1, the spectrometer draws power from the host computer, eliminating the need for an external power supply. The USB4000, like all USB devices, can be controlled by our SpectraSuite software, a completely modular, Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems.

Ocean Optics USB4000 Fiber Optic Spectrometer
Features

- TCD1304AP Detector
- Responsive from 200 to 1100 nm, specific range and resolution depends on your grating and entrance slit choices
- Sensitivity of up to 130 photons/count at 400 nm; 60 photons/count at 600 nm
- An optical resolution of ~0.3 (FWHM)
- A wide variety of optics available
  - 14 gratings
  - 6 slit widths
  - 3 detector coatings
  - 6 optical filters
- Integration times from 3.8 ms to 10 seconds
- Embedded microcontroller allows programmatic control of all operating parameters and standalone operation
  - USB 2.0 480Mbps (high speed) and 12Mbps (full speed)
  - RS232 115K baud
  - Multiple communication standards for digital accessories (SPI, I²C)
- EEPROM storage for
  - Wavelength Calibration Coefficients
  - Linearity Correction Coefficients
  - Absolute Irradiance Calibration (optional)
- Low power consumption of only 250 mA @ 5 VDC
- 16 bit, 3MHz A/D Converter
- 5 triggering modes
- 2 programmable strobe signals for triggering other devices
- 22-pin connector for interfacing to external products
- Programmable for Standalone Operation
- CE Certification

System Requirements

You can use the USB4000’s USB connectivity with any computer that meets the following requirements:

- Operating system is one of the following:
  - Windows – 98/Me/2000/XP
  - Apple Macintosh – OS X version 10.0 or later
  - Linux – Red Hat 9 or later, Fedora (any version), Debian 3.1 (Sarge), and SUSE (9.0 or later)
- Ocean Optics’ SpectraSuite software application installed and configured for use with the USB4000.
EEPROM Utilization

An EEPROM memory chip in each USB4000 contains wavelength calibration coefficients, linearity coefficients, and a serial number unique to each individual spectrometer. The SpectraSuite software application reads these values directly from the spectrometer, enabling the ability to “hot-swap” spectrometers between computers without entering the spectrometer coefficients manually on each computer.

About SpectraSuite

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).

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 SpectraSuite.
7. SpectraSuite compares the sample to the reference measurement and displays processed spectral information.

Modular Light Sources and Sampling Accessories

Ocean Optics offers a complete line of spectroscopic accessories for use with the USB4000. 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. Available accessories include the following:

- USB-ISS-UV-VIS Integrated Sampling System for Cuvettes (200–1100 nm)
1: Introduction

- USB-ISS-VIS Integrated Sampling System for Cuvettes (390–900 nm)
- USB-LS-450 Pulsed Blue LED Module
- USB-DT Deuterium Tungsten Light Source (200–2000 nm)
- HR4-BREAKOUT Breakout Box for controlling devices (see Breakout Box) plus USB-ADP-BB adapter

Interface Options

The USB4000 has both USB and serial port connectors (with the use of an adapter), enabling you to connect the spectrometer to a computer via a USB or 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.

Breakout Box

Ocean Optics also offers the Breakout Box (HR4-BREAKOUT), a passive module that separates the signals from their 22-pin port to an array of standard connectors and headers, enabling easy access to a variety of features found in Ocean Optics’ USB4000 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. An adapter (USB-ADP-BB) is required to connect the 22-pin USB port connector on the USB4000 to the 30-pin connector on the Breakout Box.

Shipment Components

The following information and documentation ships with the USB4000 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.

- **USB Cable (USB-CBL-1)**
  Use this cable to connect your spectrometer to a computer running on a Windows, Mac or Linux operating system.

- **Wavelength Calibration Data Sheet**
  Each spectrometer is shipped with a Wavelength Calibration Data Sheet that contains information unique to your spectrometer. SpectraSuite Operating Software reads this calibration data from your spectrometer when it interfaces to a computer via the USB port.

---

Note

Please save the Wavelength Calibration Data Sheet for future reference.
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.

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.

Additional Equipment Needed

SpectraSuite Operating Software
See About SpectraSuite for more information.

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
See Breakout Box for more information.
Chapter 2

Installing the USB4000

Overview

You must install the SpectraSuite software application prior to connecting the USB4000 Spectrometer to the computer. The SpectraSuite software installation installs the drivers required for USB4000 installation. If you do not install SpectraSuite first, the system will not properly recognize the USB4000.

If you have already connected the USB4000 to a computer running on a Windows platform prior to installing SpectraSuite, consult Chapter 3: Troubleshooting for information on correcting a corrupt USB4000 installation.

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

USB4000 Installation

This section contains instructions for connecting the USB4000 via both USB and serial modes.

USB Mode

**Note**

The USB port on a computer can power up to five USB4000 spectrometer channels. Systems with more than five channels require a powered USB hub.

**Procedure**

Follow the steps below to connect the USB4000 to a computer via the USB port:

1. Install SpectraSuite on the destination computer.
2. Locate the USB cable (USB-CBL-1) provided with the USB4000.
3. Insert the square end of the cable into the side of the USB4000.
4. Insert the rectangular end of the cable into the USB port of the computer.

If you installed SpectraSuite prior to connecting the USB4000, the SpectraSuite installs the USB4000 drivers. If the drivers do not successfully install (or if you connected the USB4000 to the computer before installing SpectraSuite), consult Chapter 3: Troubleshooting.
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.

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

**Serial Port Mode**

To use the serial port capacity of the USB4000 Spectrometer, the computer must be running a 32-bit version of the Windows operating system.

► *Procedure*

Follow the steps below to connect the USB4000 to the computer via serial port:

1. Connect the serial cable adapter block to the appropriate pins of the USB4000’s 22-Pin Accessory Connector.
2. Connect one end of the 9-pin serial cable to the adapter block on the USB4000, and then connect the other end to a serial port on the computer.
3. Note the number of the serial port (COM Port) to which you connected the USB4000 (some computers may not have numbered ports; handheld computers typically have only one serial port).
4. Plug the 5 VDC external power supply into an outlet and connect it to the USB4000.

**Connect Spectroscopic Accessories**

To find operating instructions for USB4000-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](http://www.oceanoptics.com/technical/operatinginstructions.asp).

**External Triggering Options**

You can trigger the USB4000 using a variety of External Triggering options through the 22-pin Accessory Connector on the spectrometer. See Appendix B: *External Triggering* for more information.
Overview

The following sections contain information on troubleshooting issues you may encounter when using the USB4000 Spectrometer.

USB4000 Connected to Computer Prior to SpectraSuite Installation

Windows Operating Systems

If you connected your Ocean Optics USB4000 device to the computer prior to installing your Ocean Optics software application 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**


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.
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 USB4000 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 USB4000 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.
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 USB4000.

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:

- \( \lambda \) = 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\(^3\))
- \( R_\lambda \) = the reference intensity at wavelength \( \lambda \)

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.

- An USB4000 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 SpectraSuite 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.
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 |

#### Coefficients

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<td>Intercept</td>
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<tr>
<td>X Variable 2-1.174416E-05</td>
<td>8.35279E-07</td>
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<td>X Variable 3-2.523787E-09</td>
<td>2.656608E-10</td>
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<tr>
<td>296.73</td>
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<tr>
<td>302.15</td>
<td>-0.25</td>
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<tr>
<td>313.16</td>
<td>0.13</td>
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<td>334.15</td>
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<td>751.27</td>
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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 USB4000 onto an EEPROM 
memory chip in the USB4000.

You can overwrite old calibration coefficients on the EEPROM if you are using the USB4000 via the 
USB port.

► **Procedure**

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

1. Ensure that the USB4000 is connected to the computer and that you have closed all other 
applications.

2. Point your browser to [http://www.oceanoptics.com/technical/softwaredownloads.asp](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 USB4000 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 
USB4000.
Appendix B

External Triggering

Overview

The USB4000 supports five triggering modes, which are set with the Trigger Mode command. A detail of each triggering mode follows.

Normal (Free Running)

In this mode, the USB4000 uses the user-defined integration clock and continuously scans the CCD array. All of the signals described in the previous section are provided by the spectrometer to the CCD automatically based on the integration time selected in the software by the user.

External Software Trigger

In this mode, the ExtTrigIn signal acts as an enable switch. If ExtTrigIn is kept HIGH, the USB4000 will acquire spectra as if it was in the normal free running mode. If ExtTrigIn is kept LOW, the USB4000 will not acquire spectra.

External Hardware Trigger

In this mode, the USB4000 uses the software (user) defined integration clock; however, the integration period doesn’t begin until the External Trigger Input Signal (ExtTrigIn) goes HIGH. If no External Trigger Input Signal is applied, the spectrometer will not take any spectra, and the software will appear “frozen” until an External Trigger Input Signal is detected. With ExtTrigIn going HIGH, the spectrometer will provide the required signals to the CCD as shown below (note that in the following diagram, the spectrometer is in non-shutter mode):
External Hardware Trigger Mode (non-shutter mode)

There is a small delay from when ExtTrigIn goes HIGH to when the integration period begins. This time is defined as $t_{SU-HT}$, and is specified to be between $10\mu s-12\mu s$. The External Hardware Trigger Mode cannot run in shutter mode ($t_{INT} < 3800\mu s$). SH continues to run while waiting for ExtTrigIn in order to keep the detector from acquiring spectral data. For more information, see the engineering note HR4000 and USB4000 Shutter Mode Performance in Hardware Trigger Mode.

External Hardware Trigger Delay

The delay between the rising edge of ExtTrigIn and the beginning of the integration period can be extended through the External Hardware Trigger Delay feature accessible through the software user interface. The External Hardware Trigger Delay is adjustable in 500ns increments. The actual delay is the value set by the External Hardware Trigger Delay plus $t_{SU-HT}$ ($10\mu s-12\mu s$). So, for example, if the Hardware Trigger Delay is set to 65us, the integration period will begin 75us-77us after ExtTrigIn goes HIGH.

External Synchronization Trigger

In this mode of the USB4000, the integration clock is essentially input into the spectrometer. The synchronized trigger must have a frequency range of 5ms to 60s (shutter mode cannot be used in External Synchronization Trigger mode). If no External Trigger Input Signal is applied, the spectrometer will not take any spectra, and the software will appear “frozen” until an External Trigger Input Signal is detected. With a continuous ExtTrigIn, the spectrometer will provide the required signals to the CCD as shown below:
External Synchronization Trigger

The time between when ExtTrigIn goes HIGH and the beginning of the integration period is specified to be between $8 \mu s < t_{SU-ST} < 10 \mu s$. The ExtTrigIn signal does not need to have an even duty cycle, but the time between rising edges should remain constant for a given integration time.
Appendix C

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 USB4000 Works

Below is a diagram of how light moves through the optical bench of an USB4000 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.

See USB4000 Components Table on the following page for an explanation of the function of each numbered component in the USB4000 Spectrometer in this diagram.
## USB4000 Components Table

Ocean Optics permanently secures all components in the USB4000 at the time of manufacture. Only Ocean Optics technicians can replace interchangeable components, where noted.

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SMA 905 Connector</td>
<td>Secures the input fiber to the spectrometer. Light from the input fiber enters the optical bench through this connector.</td>
</tr>
<tr>
<td>2</td>
<td>Slit</td>
<td>A dark piece of material containing a rectangular aperture, which is mounted directly behind the SMA Connector. The size of the aperture (from 5 µm to 200 µm) regulates the amount of light that enters the optical bench and controls spectral resolution. You can also use the USB4000 without a Slit. In this configuration, the diameter of the fiber connected to the USB4000 determines the size of the entrance aperture. Only Ocean Optics technicians can change the Slit.</td>
</tr>
<tr>
<td>3</td>
<td>Filter</td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Collimating Mirror</td>
<td>Focuses light entering the optical bench towards the Grating of the spectrometer. Specify standard or SAG+. Light enters the spectrometer, passes through the SMA Connector, Slit, and Filter, and then reflects off the Collimating Mirror onto the Grating.</td>
</tr>
<tr>
<td>5</td>
<td>Grating</td>
<td>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.</td>
</tr>
<tr>
<td>6</td>
<td>Focusing Mirror</td>
<td>Receives light reflected from the Grating and focuses first-order spectra onto the detector plane.</td>
</tr>
<tr>
<td>7</td>
<td>L4 Detector Collection Lens</td>
<td>An optional component that attaches to the Detector to increase light-collection efficiency. It focuses light from a tall slit onto the shorter Detector elements. The L4 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 L4 Detection Collection Lens.</td>
</tr>
<tr>
<td>8</td>
<td>Detector (UV or VIS)</td>
<td>Collects the light received from the Focusing Mirror or L4 Detector Collection Lens and converts the optical signal to a digital signal. Each pixel on the Detector responds to the wavelength of light that strikes it, creating a digital response. The spectrometer then transmits the digital signal to the SpectraSuite application.</td>
</tr>
</tbody>
</table>
### USB4000 Specifications

The following sections provide specification information for the CCD detector in the USB4000, as well as the USB4000 Spectrometer itself.

#### CCD Detector Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector</td>
<td>Toshiba TCD1304AP linear CCD array</td>
</tr>
<tr>
<td>No. of elements</td>
<td>3648 pixels</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>130 photons per count at 400 nm; 60 photons/count at 600 nm</td>
</tr>
<tr>
<td>Pixel size</td>
<td>8 µm x 200 µm</td>
</tr>
<tr>
<td>Pixel well depth</td>
<td>~100,000 electrons</td>
</tr>
<tr>
<td>Signal-to-noise ratio</td>
<td>300:1 (at full signal)</td>
</tr>
<tr>
<td>A/D resolution</td>
<td>16 bit</td>
</tr>
<tr>
<td>Dark noise</td>
<td>50 RMS counts</td>
</tr>
<tr>
<td>Corrected linearity</td>
<td>&gt;99.8%</td>
</tr>
</tbody>
</table>

#### USB4000 Spectrometer

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>89.1 mm x 63.3 mm x 34.4 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>190 g</td>
</tr>
<tr>
<td>Power consumption</td>
<td>250 mA @ 5 VDC</td>
</tr>
<tr>
<td>Specification</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Detector</td>
<td>3648-element linear silicon CCD array</td>
</tr>
<tr>
<td>Detector range</td>
<td>200-1100 nm</td>
</tr>
<tr>
<td>Gratings</td>
<td>14 gratings available</td>
</tr>
<tr>
<td>Entrance aperture</td>
<td>5, 10, 25, 50, 100 or 200 µm wide slits</td>
</tr>
<tr>
<td>Order-sorting filters</td>
<td>Installed longpass and bandpass filters</td>
</tr>
<tr>
<td>Focal length</td>
<td>42 mm input; 68 mm output</td>
</tr>
<tr>
<td>Optical resolution</td>
<td>Depends on grating and size of entrance aperture</td>
</tr>
<tr>
<td>Stray light</td>
<td>&lt;0.05% at 600 nm; &lt;0.10% at 435 nm</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>$2 \times 10^8$ (system); 1300:1 for a single acquisition</td>
</tr>
<tr>
<td>Fiber optic connector</td>
<td>SMA 905 to single-strand optical fiber (0.22 NA)</td>
</tr>
<tr>
<td>Data transfer rate</td>
<td>Full scans into memory every 4 milliseconds with USB 2.0 port</td>
</tr>
<tr>
<td>Integration time</td>
<td>3.8 ms to 10 seconds (detector’s limit is ~15 sec)</td>
</tr>
<tr>
<td>Interfaces</td>
<td>USB 2.0, 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud</td>
</tr>
<tr>
<td>Operating systems</td>
<td>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.</td>
</tr>
<tr>
<td>Onboard GPIO</td>
<td>8 user-programmable digital I/Os</td>
</tr>
<tr>
<td>Analog channels</td>
<td>No</td>
</tr>
</tbody>
</table>
22-Pin Accessory Connector Pinout

The USB4000 features a 22-pin Accessory Connector, located on the front of the unit as shown:

22-Pin Accessory Connector Pinout Diagram

When facing the 22-pin Accessory Connector on the front of the vertical wall of the USB4000, pin numbering is as follows:

```
<table>
<thead>
<tr>
<th>Pin orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 18 15 14 12 10 8 6 4 2 A2</td>
</tr>
<tr>
<td>19 17 15 13 11 9 7 5 3 1 A1</td>
</tr>
</tbody>
</table>
```

Looking at Front of USB4000

22-Pin Accessory Connector Pinout Diagram
# 22-Pin Accessory Connector – Pin Definitions and Descriptions

The following table contains information regarding the function of each pin in the USB4000’s 22-Pin Accessory Connector:

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Function</th>
<th>Input/Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V&lt;sub&gt;CC&lt;/sub&gt;, V&lt;sub&gt;USB&lt;/sub&gt;, or 5V&lt;sub&gt;IN&lt;/sub&gt;</td>
<td>Input or Output</td>
<td>Input power pin for USB4000 – When operating via USB, this pin can power other peripherals – Ensure that peripherals comply with USB specifications</td>
</tr>
<tr>
<td>2</td>
<td>RS232 Tx</td>
<td>Output</td>
<td>RS232 transmit signal – Communicates with a computer over DB9 Pin 2</td>
</tr>
<tr>
<td>3</td>
<td>RS232 Rx</td>
<td>Input</td>
<td>RS232 receive signal – Communicates with a computer over DB9 Pin 3</td>
</tr>
<tr>
<td>4</td>
<td>Lamp Enable</td>
<td>Output</td>
<td>TTL signal driven Active HIGH when the Lamp Enable command is sent to the spectrometer</td>
</tr>
<tr>
<td>5</td>
<td>Continuous Strobe</td>
<td>Output</td>
<td>TTL output signal used to pulse a strobe – Divided down from the master clock signal</td>
</tr>
<tr>
<td>6</td>
<td>Ground</td>
<td>Input/Output</td>
<td>Ground</td>
</tr>
<tr>
<td>7</td>
<td>External Trigger In</td>
<td>Input</td>
<td>TTL input trigger signal – See External Triggering Options document for info</td>
</tr>
<tr>
<td>8</td>
<td>Single Strobe</td>
<td>Output</td>
<td>TTL output pulse used as a strobe signal – Has a programmable delay relative to the beginning of the spectrometer integration period</td>
</tr>
<tr>
<td>9</td>
<td>I&lt;sup&gt;2&lt;/sup&gt;C SCL</td>
<td>Input/Output</td>
<td>The I&lt;sup&gt;2&lt;/sup&gt;C clock signal for communications to other I&lt;sup&gt;2&lt;/sup&gt;C peripherals.</td>
</tr>
<tr>
<td>10</td>
<td>I&lt;sup&gt;2&lt;/sup&gt;C SDA</td>
<td>Input/Output</td>
<td>The I&lt;sup&gt;2&lt;/sup&gt;C Data signal for communications to other I&lt;sup&gt;2&lt;/sup&gt;C peripherals.</td>
</tr>
<tr>
<td>11</td>
<td>MOSI</td>
<td>Output</td>
<td>SPI Master Out Slave In (MOSI) signal for communication to other SPI peripherals</td>
</tr>
<tr>
<td>12</td>
<td>MISO</td>
<td>Input</td>
<td>SPI Master In Slave Out (MISO) signal for communication to other SPI peripherals</td>
</tr>
<tr>
<td>13</td>
<td>GPIO-1(1P)*</td>
<td>Input/Output</td>
<td>General purpose software-programmable, digital input/output (channel number)</td>
</tr>
<tr>
<td>14</td>
<td>GPIO-0(2P)*</td>
<td>Input/Output</td>
<td>General purpose software-programmable, digital input/output (channel number)</td>
</tr>
</tbody>
</table>
### Pin # | Function | Input/Output | Description
---|---|---|---
15 | GPIO-3(1N)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
16 | GPIO-2(2N)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
17 | GPIO-5(3P)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
18 | GPIO-4(4P)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
19 | GPIO-7(3N)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
20 | GPIO-6(4N)* | Input/Output | General purpose software-programmable, digital input/output (channel number)
A1 | SPI_CLK | Output | SPI clock signal for communication to other SPI peripherals
A2 | SPICS OUT | Output | The SPI Chip/Device Select signal for communications to other SPI peripherals

*NOTE: GPIO nP and nN are for future LVDS capability*

---

### 22-Pin Accessory Connector - Part Numbers

The part numbers for the 22-pin accessory connector on the USB4000 Spectrometer are as follows:

- The connector is a Samtec Part Number **IPT1-111-01-S-D-RA**.
- The vertical mating connector is Part Number **IPS1-111-01-S-D-VS**.
- The right-angle PCB mount is Part Number **IPS1-111-01-S-D-RA**.

If you are customizing your USB4000 Spectrometer system or configuring External Triggering, you may need these part numbers to complete your setup.
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