Ocean Insight

OceanDirect

Programming Manual

For product: OceanDirect

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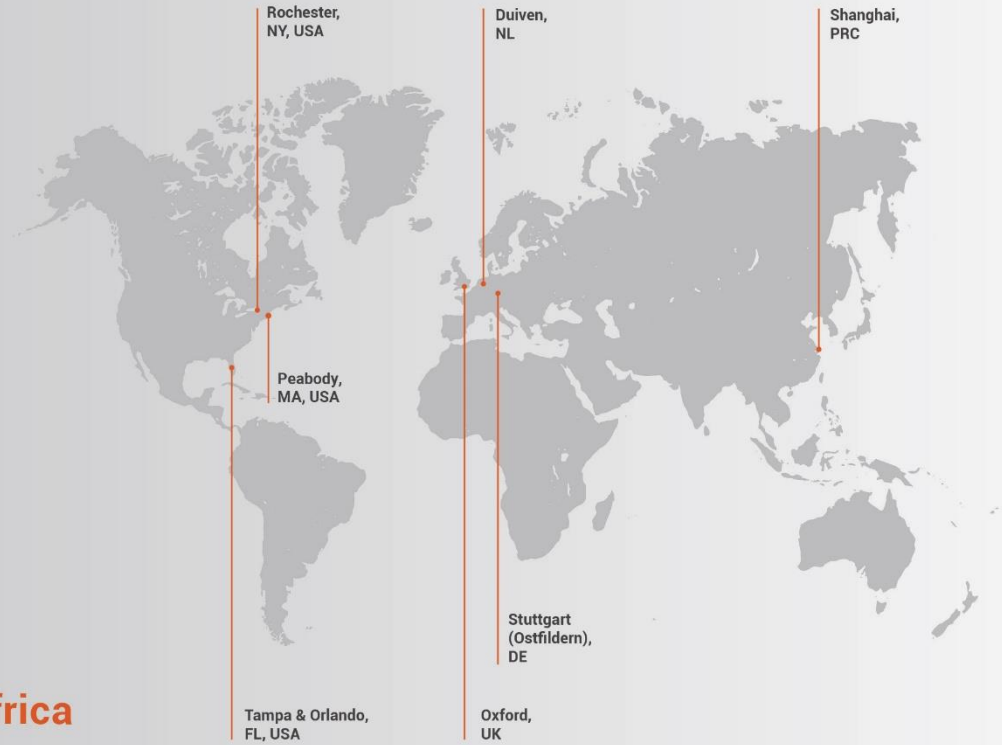

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Introduction

OceanDirect™ is a powerful Software Developer's Kit (SDK) that allows you to easily write custom software solutions for your Ocean Insight spectrometers. An Application Programming Interface (API) provides functions to communicate with and control Ocean Insight spectrometers. With this product you can connect to spectrometers, set acquisition parameters such as integration time, and acquire spectra. By integrating OceanDirect into your own software application, you have complete control over spectrometers and devices.

This document discusses the capabilities of OceanDirect and provides high level information on developing software using the SDK. Detailed information on the API is documented on the Ocean Insight website. In addition, sample code using the SDK may be found on the Ocean Insight website.

OceanDirect was developed in the C++ language and includes native libraries for Windows operating systems.

Operating System Support

- Windows 10 & 11, 64 bit intel processor
- Ubuntu Linux 20.04, 64 bit intel processor
- MacOS Monteray 12.3.1, 64 bit Intel
- MacOS Monteray 12.4, 64 bit M1

Language Support

You can develop OceanDirect-based applications in the following languages:

- C/C++/C#/Microsoft Visual Studio environment)
- C (standard interface environment)
- LabVIEW (Windows only, Version 8 or greater)
- MATLAB
- Python (version 3 or later)

Windows Development

For purposes of programming in Windows, you can access OceanDirect functionality via two DLL files:

- OceanDirect.dll contains the functions that allow you to control all spectrometer settings and acquire spectra. For example, you can set the integration time, scans to average, enable electric dark correction, etc.
- NetOceanDirect.dll is a similar DLL but specifically for development using the Microsoft .NET Framework.

LabVIEW Development

For LabVIEW developers, OceanDirect provides a set of VI files that expose its functionality in a fashion that is natural to the LabVIEW development environment. Behind the scenes, these VIs invoke the .NET methods contained in the DLL files that comprise OceanDirect.

MATLAB Development

For MATLAB developers, OceanDirect provides an 'm' file script that exposes its functionality in a fashion that is natural to the MATLAB development environment. Behind the scenes, these scripts invoke the .NET methods contained in the DLL files that comprise OceanDirect.

Python Development

A wrapper is provided specifically for developing applications in Python. This wrapper provides a Python interface into the functions provided by OceanDirect.DLL.

Installation

Upon purchasing the software, you will be provided a link for downloading the software. Click on the link to access the installation file. If you did not receive the link, or have misplaced it, request a replacement email via the technical support request form.

When the installation process is finished, the following subdirectories will be created beneath the OceanDirect "home" directory:

Subdirectory	Contents
doc	Documentation relating to OceanDirect and its API
include	Header files for use with C/C++ application development
lib	Libraries for client applications

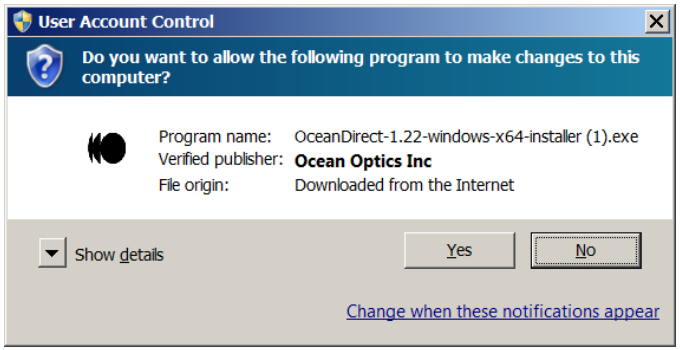
Once you have installed the software, you'll want to verify your installation, look at the samples located at the OceanDirect product page at OceanInsight.com to get an idea of how the objects and methods for OceanDirect are organized and then run a sample program.

Installing OceanDirect Software

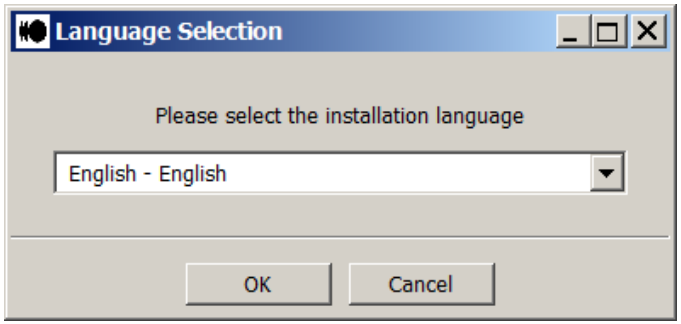
Simply download the file and double-click it in Windows Explorer to begin the installation procedure. The installer will guide you through the install process.

1. Start your Internet browser.
2. Navigate to the link provided to you and select the OceanDirect software (e.g., OceanDirect-x.xx-windows-64-installer.exe).
3. Save the software installer to the desired location.
4. Double-click on the file. The installer wizard guides you through the installation process. The default installation directory is c:\Program Files\Ocean Insight\OceanDirect SDK.

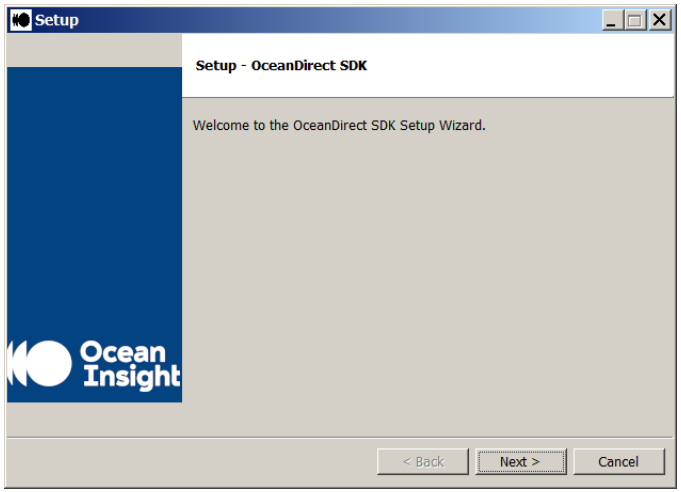
a. Allow the installation to begin by clicking “Yes.”



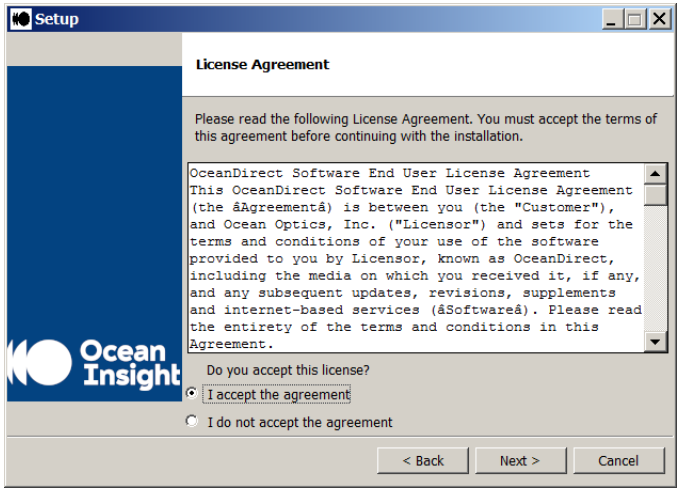
b. Choose your preferred language and click “OK.”



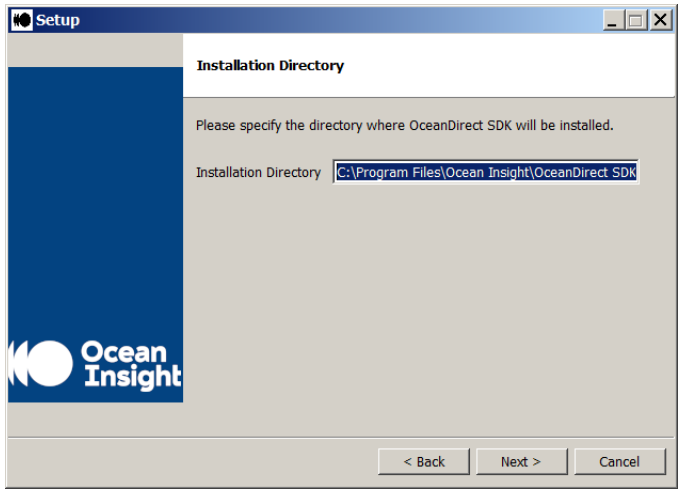
c. The Setup window is displayed. Click “Next” to continue.



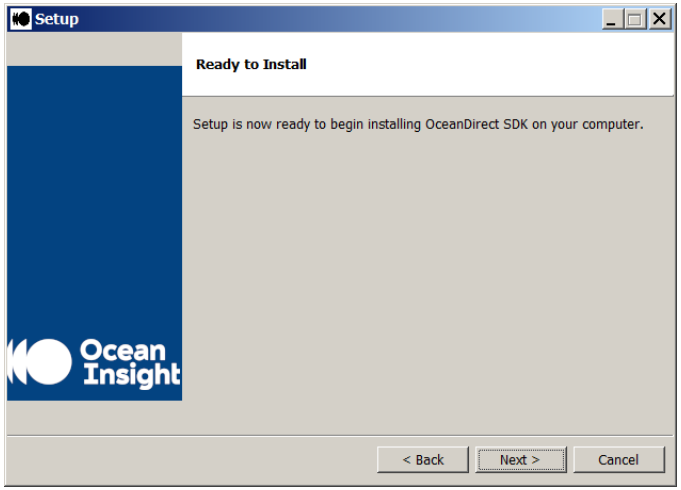
d. Review the License Agreement and select the “I accept the agreement” button, then click “Next.”



e. Choose the directory in which the software will be installed.

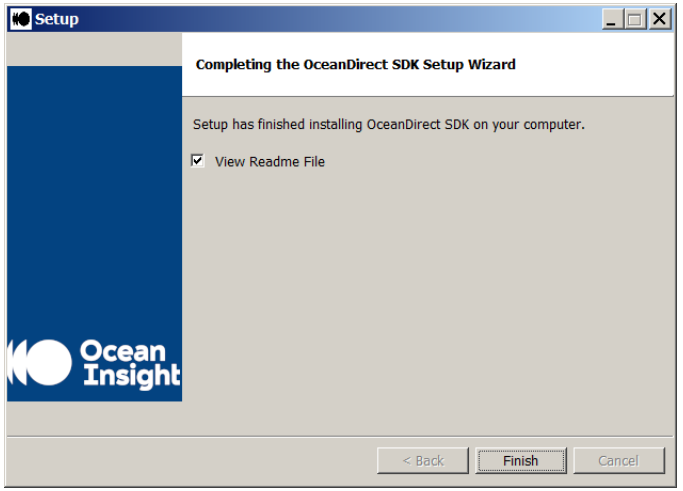


f. You are now ready to being the installation. Click “Next” to continue.

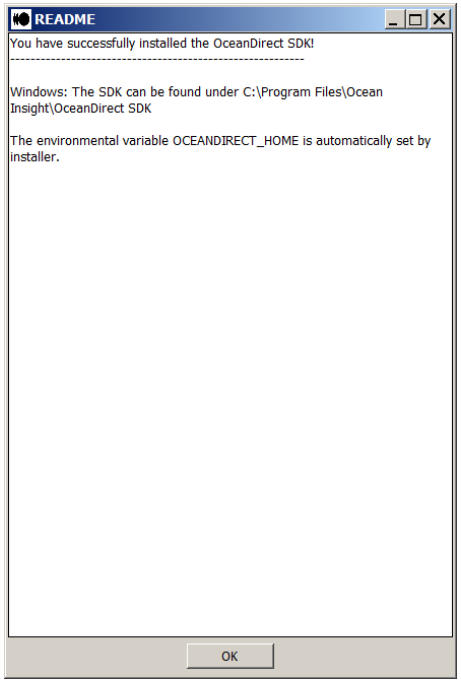


g. A progress bar is displayed showing the status of the installation.

h. Upon completion you have the option of reviewing the Readme file. Click “Finish” to conclude.



i. If chosen, the Readme file is displayed. Click “OK” to close the window.



Installing the Spectrometer Driver Software

NOTE

Do not plug your spectrometer in until after you have finished installing the OceanDirect software on your system.

Each spectrometer has unique steps for installing its drivers. Refer to your spectrometer's installation guide for details on how to install the driver software.

Installation Troubleshooting

Problem	Possible Cause(s)	Suggested Solution(s)
You have installed the latest version of OceanDirect while your computer is plugged in to your spectrometer, but your application does not see it.	The old driver (ezusb.sys) for your spectrometer must be uninstalled.	Uninstall the old spectrometer driver.
You have installed the latest version of OceanDirect and plugged into your spectrometer, but your application does not see it.	The USB device needs to be enumerated.	Unplug the USB cable. Wait 5 seconds. Plug the USB cable back in.

Basic Sequence of Operations

This chapter describes the typical sequence of operations that the application must perform to control a spectrometer and acquire spectra. The functions described here are common to all Ocean Insight spectrometers.

This chapter provides generic syntax for C# method calls, created in the .Net development environment. Refer to the sample code at the OceanDirect product page at OceanInsight.com for specific examples for additional languages.

There are also a number of optional features offered by some, but not all, spectrometers. Refer to Advanced Features for more information on these.

Further in the document, the Developing Your Application section discusses how to set up your development environment prior to creating your application.

Create an Instance of the Object

Before you can control your spectrometer, you must create an instance of the object. This is your gateway into all of the capabilities of the spectrometer.

NOTE

Your application must create only ONE instance of the object. The object may then be used to control all Ocean Insight spectrometers attached to the computer. If your application uses multiple threads, then all threads that interact with the spectrometers should share the single object. Only one thread may communicate with a given spectrometer at a time. Separate threads may communicate with separate spectrometers concurrently. Furthermore, there may only be ONE application running on your computer that creates an object to control the attached spectrometers. All interaction with any Ocean Insight spectrometers attached to your computer must be performed with this single application.

After importing the library, simply declare an instance for different languages. In the example below, we use “ocean” as the name of the instantiated object. The example in the function descriptions in this section are shown are in C#. Refer to the sample code on the product page for additional languages.

```
var ocean = OceanDirect.getInstance();
```

Find All Spectrometers

Next, you want to discover any spectrometers that are connected, either by USB or Ethernet, by using the findDevices method. The *findDevices()* method returns a tracked handle to a list of Devices objects containing metadata for all detected/known devices on USB and/or Ethernet.

Device Information returned includes: ID, name, if the device is in use, bus type, port number, IP address, and spectrum length.

```
Devices[] devs = ocean.findDevices();
if (0 == devs.Length)
{
Console.WriteLine("Nothing attached - press any key to exit!");
return;
}
```

Get Device ID

Each device found with *findDevices()* has a device ID, a number that is used in the function calls to address a given spectrometer, particularly if multiple spectrometers are attached. The default device ID returned if one spectrometer is attached is 2. Note that the device array is 0 based, so the first value in the array is at position 0.

```
int deviceID = 0;
int firstDevice = 0;
deviceID = devs[firstDevice].Id; // Get device ID of the device
```

Open Spectrometer

A spectrometer may be opened with the ***ocean.openDevice****(int deviceID, int% errorCode)*, which then allows operations to be performed on it. After being opened, the spectrometer should not be opened again until it is first closed using ***ocean.closeDevice*** (*int deviceID, int% errorCode*). The errorCode can be examined after the function is called. It will remain 0 if the function succeeds as the comment below indicates. In general, the errorCode can be tested after every function call.

```
int errorCode = 0;  // This variable can be tested after the function
```

Acquire a Spectrum

Now you are ready to acquire a spectrum. A spectrum is simply a one-dimensional array of pixel values, stored as “doubles”. The number of elements in this array varies for each spectrometer.

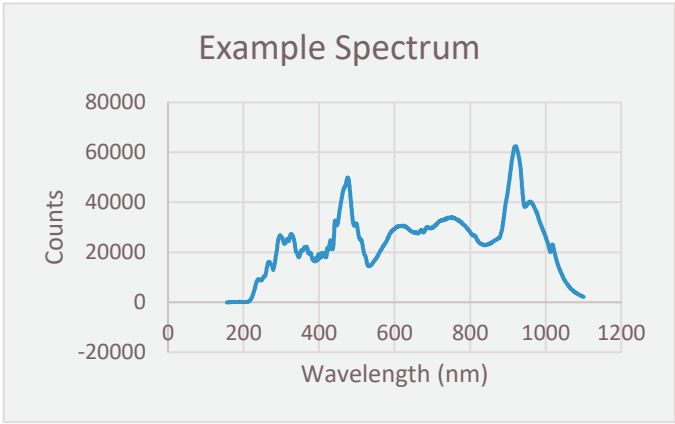
The function call is *getSpectrum(int deviceID, int% errorCode).*

```
double[] spectrum = ocean.getSpectrum(deviceId, ref errorCode);
```

When you call the *getSpectrum()*method, the spectrometer will return the next available spectrum to your application, assuming the spectrometer is in its default normal mode. The amount of time for the function to return may vary based on when the spectrometer completes the acquisition of a spectrum. See FAQ: Why doesn’t getSpectrum() return when I think it should? for a discussion of the timing of the *getSpectrum()* method.

Next, you need to call the function to get the wavelengths that correspond to the pixels in the spectrum.

```
double[] allWaveLengths = ocean.getWavelengths(deviceID,
ref errorCode);
```



The two arrays returned from *getSpectrum()* and *getWavelengths()* can be imported to an external program (Microsoft Excel, for instance) and plotted with wavelengths on the x-axis and spectrum on the y-axis, to visualize the spectrum observed by the spectrometer.

There are a number of convenient calls to get one or more indices within the spectrum one-dimensional array given any particular wavelength(s). For example, asking for the index at 340 nm will give the closest approximation based on the spectrometer used.

```
double wl = 0;
double approximateWavlength = 340;
var p_index = ocean.getIndexAtWavelength(deviceId, ref errorCode, ref wl, approximateWavlength);
```

Now the variable p_index can be used to find the pixel value from the array given by *getSpectrum()* call.
In the case where you want many indexes that are not contiguous you can use:

```
double[] waves = { 389, 420, 600 };
       int wvlen = waves.Length;
```

```
int[] inx = ocean.getIndicesAtAnyWavelength(deviceId, ref errorCode, ref waves, wvlen);
for (int i = 0; i < wvlen; i++)
{
     Console.Write("Wavelength Index at: {0}  == ", inx[i]);
      Console.WriteLine("Wavelength Value is: {0}\n", waves[i]);
}
```

If a contiguous range is desired, use the following call:

```
double lo = 400;
double hi = 413;
Console.WriteLine("Wavelengths from approx {0} nm to {1} nm.", lo, hi);
int[] inxR = ocean.getIndicesAtWavelengthRange(deviceId, ref errorCode, ref waves, ref
rangeLength, lo, hi);
     for (int i = 0; i < inxR.length; i++)
       {
           Console.Write("Range Index at: {0}  == ", inxR[i]);
             Console.WriteLine("Range Value is: {0}\n", waves[i]);
       }
```

Correct for Detector Nonlinearity

All Ocean Insight spectrometers are calibrated at the factory to maximize accuracy. One of the calibrations performed is to correct for detector nonlinearity.

This calibration consists of eight numbers used as the coefficients of a 7^{th} order polynomial that adjusts for the fact that the CCD detectors don't respond to stimuli photons uniformly as more electrons are drained from the well. In other words, the efficiency of the CCD detectors may be 30% when the well is half-full, but may be only 20% when the well is completely drained of electrons.

By "efficiency" we mean the probability that an incoming photon will drain an electron from the CCD well; 100% efficiency means every incoming photon will drain one electron, while 50% efficiency means an incoming photon has only a 50% chance of causing an electron to drain.

Nonlinearity calibration is made by averaging all pixels of the CCD array. Thus, we are assuming that all pixels respond about the same.

By default, both electric dark and nonlinearity corrections are enabled.

To ensure that the nonlinearity correction is applied, use the following call:

```
bool nonLinearityOn = true;
ocean.applyNonLinearityCorrection(deviceID, ref errorCode, nonLinearityOn);
```

Testing the state of the nonlinearity correction can be done by calling

```
bool readNonLinearityState = ocean.getNonLinearityCorrectionUsage(deviceID, ref errorCode);
```

Set Integration Time

Integration time is simply the length of time during which we allow light to pass into the spectrometer's detector. In low-light level situations you may want to lengthen this period to obtain a meaningful spectrum. In high-light level situations you may want to shorten this period to avoid saturation. Saturation occurs when the one or more CCD pixels or wells has been completely drained (or filled on some detector models). When this occurs, additional photons entering the "well" have no effect, and the spectrum becomes increasingly distorted. If you plot a saturated spectrum on a graph, it will appear clipped at the peaks.

Integration time is specified in units of microseconds. See the documentation for your spectrometer to determine the allowable minimum and maximum integration times it will support.

To set integration time to 200 msec (200000 microseconds):

```
uint newIntegrationTime = 200000;
ocean.setIntegrationTimeMicros(deviceId, ref errorCode, newIntegrationTime);
```

To retrieve the integration time:

```
var itime = ocean.getIntegrationTimeMicros(deviceId, ref errorCode);
```

Scans to Average

Scans to average is another method used to perform noise-reduction (smoothing) on the spectra returned by a spectrometer. With this technique, multiple sequential spectra are averaged to produce a single averaged spectrum. The algorithm uses corresponding pixels from each spectrum when computing the average for a given pixel value. For example, if Scans to Average is set to 5, the

pixel[0] values from each of five consecutive scans are added together, and then divided by 5. The resulting value will be reported in pixel[0] of the spectrum returned to the user. This procedure is repeated for each pixel in the spectrum.

NOTE

In the following function call, if you specify a value of 1 for the *setScansToAverage()* argument, no smoothing will be performed. Each spectrum will be reported as is, without any averaging.

Use this call to set the number of scans to average equal to 5 and check the number of spectra averaged:

```
ushort newScansToAverage = 5;
ocean.setScansToAverage(deviceID, ref errorCode, newScansToAverage);
ushort readScansToAverage = ocean.getScansToAverage(deviceID, ref errorCode);
```

External Trigger Modes

The trigger mode setting of your spectrometer gives you more precise control over the timing of a spectrum capture.

Not all spectrometers support all trigger modes, so be sure to see the documentation for your particular spectrometer. You set the trigger mode of your spectrometer by specifying an integer corresponding to the desired mode as described below.

```
ocean.setTriggerMode(deviceID, ref errorCode, mode)
```

Close Spectrometer

When your application is ready to terminate, call the *closeDevice (int deviceID, int% errorCode)* method.

```
ocean.closeDevice(deviceID, ref errorCode);
```

Advanced Features

All spectrometers support basic functions including setting the integration time and acquiring a spectrum. Some spectrometer models offer additional, advanced features.

A characteristic of these features is that the methods or functions you must call to use them are not provided directly in the NetOceanDirect class. Instead, for each feature, NetOceanDirect provides a pair of related methods you can call to determine if a feature is supported by your spectrometer and methods needed to use or control that feature.

Thus, in OceanDirect, you will see a number of methods whose names look something like *isFeatureEnabled(xxx)* where "*xxx*" is the name of the feature. These methods return a Boolean true/false to indicate whether that spectrometer supports that feature. It is recommended to call the *isFeatureEnabled(xxx)* method *before* attempting to use a feature. If you attempt to use a feature that is not supported by your spectrometer, nothing will happen. See the examples in this section for the correct syntax to call these functions.

After calling the *isFeatureEnabled(xxx)* method (and assuming it returns a "true" value, errorCode=0), the second step is to call the methods unique to that feature. If the errorCode returned is 5 or 24, the feature is not available on the device or command not supported.

The following example shows the syntax for testing the availability of a feature (Board Temperature) and calling a function that is a member of that feature.

Board Temperature

Some spectrometers contain one or more temperature sensor chips mounted on the printed circuit board (PCB). Your application can read out this temperature value, in degrees Celsius, by means of this feature. Do not confuse this feature with the Thermoelectric Cooling feature, described later in this chapter. Please refer to the spectrometer's documentation to determine which component temperature is returned - e.g., detector temperature or PCB temperature by each sensor.

First check the *isFeatureEnabled* value.

```
bool temperatureInfo = ocean.isFeatureEnabled(deviceID, OceanDirect.FeatureID.FEATURE_ID_TEMPERATURE,
ref errorCode);
```

This will return a true or false.

Then find out how many temperature sensors are available on the spectrometer.

```
int numberOfTempSensors = ocean.AdvancedFeatures().TemperatureController().getCount(deviceID, ref
errorCode);
```

Finally, read the temperature of one of the sensors. The sensors are indexed starting with zero – this example gets the temperature of the 0th sensor,

```
int indexZero = 0;

double currentTemperature = ocean.AdvancedFeatures().TemperatureController().getTemperature(deviceID,
ref errorCode, indexZero);
```

Below is a list of the advanced features, but be sure to see the documentation for your spectrometer to determine if it supports that specific feature. Details of the API for each advanced feature are documented on the Ocean Insight website.

Analog In

AnalogIn provides access to information about the device's input pin voltage settings.

To check if AnalogIn is available on your spectrometer, use feature ID: ANALOG_IN.

Analog Out

AnalogOut provides access to information about the device's output pin voltage settings.

To check if AnalogOut is available on your spectrometer, use feature ID: ANALOG_OUT.

Back to Back

BacktoBack provides access to the device's back-to-back scan buffering functionality.

To check if BacktoBack is available on your spectrometer, use feature ID: BACK_TO_BACK.

Continuous Strobe

ContinuousStrobe provides access to the strobe characteristics (e.g., minimum, maximum, width, and period).

To check if ContinuousStrobe is available on your spectrometer, use feature ID: CONTINUOUS_STROBE.

Data Buffer

DataBuffer provides access to onboard memory, allowing you to retrieve stored spectra.

To check if DataBuffer is available on your spectrometer, use feature ID: DATA_BUFFER.

EEPROM

The EEPROM function provides access to EEPROM storage for wavelength calibration and linearity correction coefficients.

To check if EEPROM is available on your spectrometer, use feature ID: EEPROM.

IPv4

This parameter provides access to the device's IPv4 address functionality, allowing the DHCP client to be turned on or off, and to read, add, or delete IP addresses,

To check if IPv4 is available on your spectrometer, use feature ID: IPV4_ADDRESS.

Lamp Enable

This parameter controls the shutter on a light source. These light sources attach directly to an electrical connector on your spectrometer. The lamp will turn on when set to true and turn off when set to false.

To check if Lamp Enable is available on your spectrometer, use feature ID: LIGHT_SOURCE.

LED Activity

Some spectrometers have indicator lights to show power and data transfer status. This feature allows you to access the state of the LEDs.

To check if LED Activity is available on your spectrometer, use feature ID: LED_ACTIVITY.

Raw Bus Access

Raw Bus Access allows you to read and write raw bus data.

To check if Raw Bus Access is available on your spectrometer, use feature ID: RAW_BUS_ACCESS.

Thermoelectric Cooling

Some spectrometers such as the QE *Pro* have a thermoelectrically cooled (TEC) CCD that can be controlled by the software.

Be careful to observe the allowable temperature range supported by your spectrometer's TE cooler. For example, the TE cooler of the QE *Pro* is capable of dropping the temperature of the CCD by 30-43 degrees Celsius below the ambient temperature. Thus, if the ambient temperature happens to be 25 degrees Celsius, the range of values you may pass in to the *setDetectorSetPointCelsius()* method will be +5 to -18 degrees Celsius. In this example, if you (erroneously) attempt to specify a value of -3 degrees Celsius, the TE cooler will not function properly and the temperature of the CCD will not approach -3 degrees Celsius.

To check if Thermoelectric Cooling is available on your spectrometer, use feature ID: THERMOELECTRIC.

Triggering Modes

Mode 0: Normal Mode

Sometimes called "free running" mode, this is the default mode for all spectrometers. In this mode, the spectrometer is continuously acquiring new spectra, using default power-up settings for integration time, etc.

The integration time is controlled by calls to the `setIntegrationTimeMicros()` method.

When you call the `getSpectrum()` method, it returns the next available spectrum, subject to delay due to the length of integration time, number of scans to average, and possibly a stability scan. It is also possible that `getSpectrum()` returns almost immediately, even if you specified a lengthy integration period, because the spectrometer is continuously acquiring spectra. See **Appendix A: *FAQs*** for more information.

The `getSpectrum()` method will block (i.e., not return) until the spectrometer finishes acquiring the current spectrum.

Mode 1: External Software Trigger Mode

In this mode, the trigger signal acts like an "enable." As long as the input trigger signal pin on your spectrometer is held electrically high, spectra will be continuously acquired. When the signal goes low, the spectrometer no longer acquires spectra, and `getSpectrum()` will remain blocked (i.e., not return) until the signal goes high again.

This mode is similar to Mode 0 (Normal mode) in that as long as the trigger signal remains high, the spectrometer is continuously acquiring new spectra, irrespective of when you call *getSpectrum()*. In this situation, *getSpectrum()* simply returns the next available spectrum.

The integration time is controlled by calls to the *spectrometerSetIntegrationTimeMicros()* method.

Mode 2: External Synchronization Trigger Mode

In this mode, spectra acquisition is initiated by an external synchronizing TTL trigger signal. The purpose of this mode is to allow multiple spectrometers to be synchronized in terms of the start of their acquisition period, and the duration of the integration period. The integration time is determined based on an average of the length of time between the input trigger signal pulses. See your spectrometer's documentation for the allowed frequency range for this input signal.

Mode 3: Hardware Trigger Mode

In this mode, the spectrometer does not begin to acquire a new spectrum until the rising edge of an external TTL input signal. When you call *getSpectrum()*, this method blocks (i.e., does not return to the caller) until the trigger signal occurs and the spectrum has been acquired.

The integration time is controlled by calling the *setIntegrationTimeMicros()* method.

NOTE

Once you put the spectrometer in Hardware Trigger Mode it is impossible to programmatically change the trigger mode after a spectrum has been requested until the trigger has been received and the spectrum is successfully retrieved. If a spectrum request has been made in Hardware Trigger Mode the only alternative mechanism for changing trigger mode pior to a successful completion of the acquisition is to power-cycle the spectrometer.

Mode 4: Single-Shot Trigger Mode (Quasi Realtime Mode)

This mode is designed to provide more precise software control over when a spectrum acquisition is initiated. This is especially valuable when you need to use very long integration periods, but also want precise control over when the acquisition period begins.

This mode is only available on certain spectrometers.

In this mode, the spectrometer automatically sets its integration time to a very short integration period and then begins to continuously acquire spectra using this minimal integration time. When *`setIntegrationTimeMicros()`* is called to specify the desired integration period, this value is stored in the spectrometer, but the spectrometer continues to acquire spectra using the minimal integration period.

When *`getSpectrum()`* is called, the spectrometer completes the current acquisition (which should happen very quickly since the integration time is so short). The spectrometer then sets its integration time to the value requested and initiates a new spectrum acquisition. When this acquisition completes, *`getSpectrum()`* returns the new spectrum. The spectrometer once again reverts to the minimal integration period and continues to acquire spectra in the background.

Developing Your Application

You may develop your application in any environment of your choosing. We will focus on Microsoft Visual Studio examples due to its availability and cross-platform capabilities.

Microsoft Visual Studio

To use the .NET assembly interface you must add a reference to the assembly as follows:

1. In your application, click on the **Project** menu item, and then choose **Add Reference**.
2. Click on the **Browse** tab.

3. Navigate to the OCEANDIRECT_HOME directory.
4. Highlight **NetOceanDirect.dll** and click **OK**.

Creating a New C# Project That Uses the .NET Interface to OceanDirect

1. Create new project of type C# “Windows Console”.
2. Add a reference to NetOceanDirect.dll:
    1. In Solution Explorer, right-click on **References** and choose **Add Reference…**
    2. Click the **Browse** tab.
    3. Navigate to the OCEANDIRECT_HOME folder.
    4. Highlight **NetOceanDirect.dll** and click **OK**.

Deploying Your C# Application

Normally, all that is needed to deploy your C# application is the EXE file containing the application itself. And you will also need to deploy the appropriate OceanDirect “redistributable” installer.

However, if your C# application uses the OceanDirect .NET assembly interface, you must also ensure that a copy of NETOceanDirect.dll and OceanDirect.dll is placed in the same folder as your application’s EXE file. You can obtain the DLL file from the OCEANDIRECT_HOME directory.

LabVIEW

OceanDirect provides a .NET 4.0 interface. We recommend that all LabVIEW applications use the .NET 4.0 interface when accessing OceanDirect functions.

LabVIEW is able to show all the methods in a class as well as each method’s inputs and outputs with default named variables. This graphical representation clearly documents the .NET interface within the LabVIEW environment.

The following steps must be performed when starting a new LabVIEW projects:

1. The first step is to place an “Invoke Node (.NET)” on the Block Diagram panel. Do this in the Functions window by selecting **Connectivity -> .NET -> Invoke Node (.NET)** and dragging it to the panel. Right-click the node and then choose **Select Class -> .NET -> Browse**. Navigate to the NetOceanDirect.dll. The default location for the DLL is C:\Program Files\Ocean Insight\OceanDirect SDK\lib\.
2. In the **Select Object From Assembly** window, select the **OceanDirect** object on the panel, click **OK**. This updates the node on the block diagram to “OceanDirect”. Right-click on the node and choose **Select Method.** A list of all available methods is displayed. Select **[S]getInstance**. This returns a .NET object, which will be your primary OceanDirect object that you call all further methods from.
3. Create another Invoke Node of class `OceanDirect` and select the method **findDevices**. This method returns an array of devices that OceanDirect knows how to communicate with. You must subset the array and call the Property Node (ID) to find each device’s assigned **deviceID**. The **deviceID** will be used for all function calls that perform an action on a specific device.
4. You must then call **openDevice** from the OceanDirect .NET object that was returned earlier from **getInstance**. The **openDevice** method requires you to pass in the **deviceID** and a number as a reference (LabVIEW handles the reference part automatically). It will return an **errorCode,** which you should verify is 0 (0=no error) before performing your next function.
5. Once the device is open you can call any of the standard methods found in the returned instance, e.g., **getWavelength**, **getSpectrum**,**setIntegrationTimeMicro**, etc.

Visual Basic

Using the .NET Interface to OceanDirect

To use the .NET assembly interface to OceanDirect in your Visual Basic application, you must add a reference to your assembly as follows:

1. Click on the **Project** menu item and choose **Add Reference**.
2. Click on the **Browse** tab.
3. Navigate to the **OCEANDIRECT_HOME** directory.
4. Highlight the **NetOceanDirect.dll** and click **OK**.

Sample Programs

A collection of sample programs for OceanDirect demonstrating basic functionality may be downloaded from the OceanDirect product page at OceanInsight.com.

Appendix A - Error Codes

The following are error codes that may be returned from a function call. The possible return values for each method are described in the detailed API documentation, to be found on the Ocean Insight website.

Error Code	Description	Error Code	Description
0	Successful/no error	16	Empty Vector (Check Input Parameter)
1	Undefined error	17	Color Conversion Error (Check Values)
2	No device found	18	No Peak Found Error (Input Spectrum Has No Peaks)
3	Could not close device	19	Illegal State Error (Unexpected State)
4	Feature not implemented	20	Minimum Integration Time Reached (Lamp is too bright)
5	No such feature on device	21	Maximum Integration Time Reached (Lamp is too dim)
6	Data transfer error	22	Please ensure that your lamp is on
7	Invalid user buffer provided	23	Not enough buffer space
8	Input was out of bounds	24	Command not supported by device
9	Spectrometer was saturated	25	Integration time is below the “safe” minimum when averaging is enabled.
10	Value not found		
11	Divide By Zero Error (Cannot Divide by Zero)		
12	Non-Invertible Matrix Error (Matrix Has No Inverse)		
13	Array Length Error (Array Lengths Don't Match)		
14	Array Index Out of Bounds (Check Your Array Length? Is it Zero?)		
15	Invalid Argument (Check Input Parameter)		

Appendix B - Improving Performance

Windows is not a real-time operating system and cannot guarantee a level of responsiveness. But there are a few things you can do to improve the performance of your application.

- You can increase the priority of the thread in which getSpectrum() is called. However, this only affects the priority of that thread WITHIN your application, and not relative to OTHER applications running on Windows. Often the problem is that some *other* application (or Windows service) is performing activity that interferes with the speed of your application. Try setting the priority of your OceanDirect application to "RealTime." To do this:

    1. Type control+alt+delete to bring up the Windows Task Manager.
    2. Select the **Processes** tab.
    3. Right-click on your OceanDirect application and choose **Set Priority | RealTime**.

- Determine what applications and services are running on your PC and shut down all unnecessary applications. If you have a backup utility such as Carbonite, you should pause it. Check your anti-virus application to see if it is configured in some way that might result in bursts of disk I/O.
- If bursts of disk I/O are interfering with your application, there is a good chance this disk I/O is due to "page faults". Page faults occur when Windows does not have enough RAM/memory to run all of the applications that are currently active. So Windows “borrows” some disk space to "simulate" additional RAM. If this causes your OceanDirect application a problem, then the solution is to either shut down as many applications as possible, or to install additional RAM.
- Try running your application on another PC that has nothing else installed.

Appendix C - FAQs

How fast can I acquire spectra?

The speed at which you can acquire spectra depends on the following factors:

- Minimum integration time.
- Communication speed of the USB connection. Most PCs use USB 3.0, but some may still be using USB 2.0, which is much slower.
- Number of pixels of data. Some detectors return as few as 256 pixels of data, others may return up to 4096 pixels. The greater the number of pixels, the longer it takes to transmit the data.
- Speed of your PC.
- The number of spectrometers operating in parallel.

Consider each of these factors carefully when estimating the maximum rate at which you can acquire spectra on your PC. It is always best to perform actual real-world measurements.

Why doesn't getSpectrum() return when I think it should?

When you set the integration time for a spectrometer, and then call *getSpectrum(),* you might expect that the duration of the call to *getSpectrum()* would match the integration time exactly. This is rarely the case, and there are several reasons why:

- When you first power up the spectrometer by plugging it in to your PC, the spectrometer immediately begins acquiring spectra using default settings for integration time and other acquisition parameters. This is called Normal mode. As long as the spectrometer remains in Normal mode, and remains plugged in to your PC, it will continuously acquire spectra.

  When your application calls *getSpectrum(),* the spectrometer may be just beginning to acquire a new spectrum, or it may be nearly finished acquiring a spectrum, or it may be anywhere in between these two extremes. As a consequence, *getSpectrum()* may return almost immediately, or it may not return until the full integration period has elapsed; it just depends on how far along the spectrometer happened to be in its acquisition process at the moment you called *getSpectrum()*.

  If your application calls *getSpectrum()* repeatedly (in a tight loop), the duration of subsequent calls to *getSpectrum()* will exactly match the integration time. This is because once you have called *getSpectrum(),* you are effectively synchronized with the operation of the spectrometer. Your first call to *getSpectrum()* will return at the exact moment that the

spectrometer has completed a spectrum acquisition. Your second call to *getSpectrum()* occurs just as the spectrometer is beginning the next spectrum acquisition. Thus, your second (and all subsequent) calls to *getSpectrum()* must wait for the full integration period to elapse before the spectrometer has finished acquiring the next spectrum.

- There is a second reason why the duration of the *getSpectrum()* method may not match the integration time setting. Whenever you change one of the acquisition parameters that can affect the spectrum data (e.g., changing the integration time), OceanDirect will automatically take a stability scan. This means OceanDirect will ignore the spectrum that was being acquired at the moment when you called *getSpectrum()*. This spectrum was acquired using previous settings for the acquisition parameters, and thus is invalid. OceanDirect will return the *following* spectrum, which is based on the new acquisition parameter settings.

If I change spectrometer models, do I need to change my program?

No. As long as you stay within the Wrapper API, your software does not need to be modified when you change to a different type of Ocean Insight spectrometer.

However, keep in mind that certain features (e.g., “thermoelectric cooling”) are only available on selected spectrometers.

What happens if the timeout period is shorter than the integration time?

Some of the calls to *getSpectrum()* will time out, and some will return valid spectra. The ratio of valid spectra to timeouts will depend on the ratio of your timeout period to the integration time. However, this situation should not cause you to miss spectral acquisitions, unless the integration time is so short your program cannot call *getSpectrum()* soon enough to capture the next spectrum.

What happens in the following scenario?

1. Set spectrometer to one of the external trigger modes
2. Call getSpectrum()
3. Timeout occurs before the trigger occurs
4. Trigger event happens before you call getSpectrum() a second time
5. Call getSpectrum()

The second call to *getSpectrum()* will return immediately with the spectrum that was acquired when the trigger event occurred.

If multiple trigger events happen after the first *getSpectrum()* has timed-out and before you call getSpectrum() a second time, when you do call getSpectrum() the second time, it immediately returns with the spectrum from the FIRST trigger event. Data from any additional trigger events during this window will be lost.

If a timeout occurs before the spectrum can be acquired, the spectral array returned by *getSpectrum()* will contain all zeroes.

How do I use Ethernet to send commands to my spectrometer?

The OceanDirect commands can be executed through an Ethernet interface on Ocean FX and Ocean HDX spectrometers. First, however, the spectrometer must be configured using the USB connection to obtain the IP address. Please refer to the Ocean FX or Ocean HDX User Manuals Setup and Installation section to obtain the IP address.

Unlock the Unknown

Ocean Insight exists to end guessing. We equip humanity with technology and data to make precisely informed decisions providing transformational clarity for human advancement in health, safety, and the environment.

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