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# External Triggering Options for Ocean FX

## Overview

Ocean FX is a powerful spectrometer with features and functionality that make it our fastest and most “communicative” spectrometer yet. With a fast detector and redesigned and upgraded electronics, Ocean FX achieves acquisition speed up to 4,500 scans per second, has onboard processing for improved SNR and reduced data transfer time, and offers robust communications via USB, SPI, Gigabit Ethernet and Wi-Fi. Ocean FX is an excellent choice for high-speed process applications, measurement of fast events such as flicker and color cycling in LEDs, and reaction monitoring.

Ocean FX is ideal for:

- UV-Vis applications in food and agriculture where acquisition speed helps with online food sorting and processing
- Applications in the biomedical sciences especially for absorbance measurements requiring enhanced UV sensitivity
- Rapid event measurements including flicker and fast color cycling in LEDs
- Security and authenticity applications where multiple communication interface options enable handheld, point-of-use instruments

Like other Ocean Optics spectrometers, Ocean FX provides different modes for acquiring data. The default acquisition mode is Normal mode where the spectrometer is “free running” and continuously scanning, acquiring and transferring data to the computer according to user-specified acquisition parameters set in the software. This mode is used for applications that do not require the synchronization of data acquisition with an external event like a button push, lever activation or laser pulse. Synchronizing the spectrometer with an external event requires the use of triggering.

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# External Triggering

Triggering with a spectrometer typically falls into two broad categories.

- **External Triggering** -- Synchronization between an external event and spectral acquisition. An event outside the measurement system (such as a push button, lever activation or laser pulse) increases or decreases the voltage level going to the spectrometer's trigger pin, instructing the spectrometer to begin or end a spectral acquisition.
  
- **Triggering an External Event** – Controlling an external device with the spectrometer. The spectrometer instructs an external device (typically a lamp such as the PX-2 pulsed xenon or other light source) to illuminate immediately prior to spectral acquisition. The Ocean FX has several triggering signals useful for synchronizing with other Ocean Optics spectrometers and light sources. These include:
  - **Lamp Enable:** This signal is useful for enabling and disabling light sources with a TTL enable input. Typically used to open and close shutters and turn lamps on and off.
  - **External Trigger:** This signal is useful for synchronizing trigger events with other external equipment. Examples include triggering other spectrometers, controlling shutters and light sources and daisy chaining spectrometers.
  - **Single Strobe:** This signal is useful for sending a discrete pulse to enable a light source or trigger another device. Single strobe is sometimes tied to the external trigger input of another spectrometer to synchronize the integration periods of each device. Examples include pulsing LEDs and pulsed xenon sources, synchronizing spectral acquisition of multiple spectrometers.
  - **Continuous Strobe:** This signal is useful for synchronizing pulsed light sources, such as pulsed xenon, with the period of integration. Examples include pulsing LEDs and pulsed xenon sources, synchronizing spectral acquisition of multiple spectrometers.
  - **General Purpose Software Programmable Digital Inputs/Output, Analog Output GPIOs:** Ocean FX has 8 GPIOs that can be used to trigger external event. Digital outputs are 3.3 V. Analog outputs can be programmed to 2.5 V or 5.0 V maximum. See the **DD4 Accessory Connector Pinout** table below for the pin location for the GPIOs.

# When to Use Triggering

When synchronization with external events is required, Ocean Optics spectrometers have multiple triggering modes available. These modes enable automation of spectral acquisition with an external event, whether it's a light source illuminating or an event happening during a process. This makes Ocean FX ideal for use in process environments or for unattended data collection.

For example, data logging combined with triggering can be used to monitor a parameter over time. By adding a software trigger to this measurement, a signal can be sent back to the system when a certain threshold or level of the parameter has been reached resulting in complete automation of the process.

There are several examples of when synchronization and precise time are needed:

- **LIBS Spectroscopy.** In laser induced breakdown spectroscopy (LIBS), a laser is used to generate a plasma at the surface of a material, generating a unique spectral signature of atomic emission lines that can be used to determine elemental composition. The spectral acquisition must be carefully timed relative to the laser pulse to capture atomic emission during the short lifetime of the plasma.
- **Measurement of Fast Phenomena.** Spectroscopy can be used to look at the characteristics of sparks, explosions, gunfire and other rapid events. Triggering to synchronize with these events allows for more detailed characterization and measurements at different time points during these rapid events.
- **Production Line Measurements.** Processes or products in motion (for example, on a conveyor belt or rollers) need to be measured at very specific points in time to ensure the right samples or proper sample location is measured. Synchronization with other measurements within the process is sometimes needed as well to ensure maximum yield of the highest quality products.

# External Triggering with Ocean FX

The triggering functions for the Ocean FX provide accurate timing and synchronization between the spectrometer and other devices. Multiple low-jitter trigger modes (21 ns max jitter) are available in addition to the normal, free-running spectral acquisition mode. Triggering provides precise timing between devices. A spectrometer can be triggered causing it to turn a light off or on, pulse a light source, or start or end a spectral acquisition.

Several modes are available to enable the synchronization of data acquisition with an event outside the measurement system. These external triggering modes involve connecting an external triggering device to the spectrometer and then providing an external trigger to the spectrometer. The length of the integration time (time over which spectral data is acquired) and the source controlling the data acquisition cycle depend upon the external trigger mode chosen. A description for each of the Ocean FX triggering modes is shown in the table below.

## Ocean FX Triggering Modes

Triggering Mode	Description	Use This Trigger Mode When You...
Normal/Free-Run  <b>On Demand</b> triggering mode in OceanView	<p>Spectrometer is continuously acquiring spectra, back-to-back, based on the acquisition parameters set in the software.</p> <p>When the software requests a spectrum from the spectrometer, the spectrometer waits for the current acquisition to complete. At the start of the next acquisition, the spectrum collected during the previous acquisition is transferred to the software.</p>	Do not need to synchronize spectrometer acquisition to an external event

<p>External Hardware Level Trigger</p> <p><b>Level</b> triggering mode in OceanView</p>	<p>Spectrometer is idle until a trigger is applied to the spectrometer as a continuous voltage. When the spectrometer receives the trigger, it acquires a spectrum for the integration time specified by the user. The spectrum is then transferred to the software.</p> <p>If the voltage is still high after spectral acquisition and transfer, the spectrometer will acquire another spectrum and transfer it to the software.</p> <p>When the voltage decreases to zero, the spectrometer returns to an idle state.</p>	<p>Need continuous acquisition whenever a certain condition is met such as:</p> <ul style="list-style-type: none"> <li>• When reacting to a sample being present</li> <li>• When a sample reaches a specific state you want to measure</li> </ul> <p>Note: External Hardware Level Trigger is not as precise as the External Hardware Edge Trigger (described below). Acquisitions continue at the user specified integration time as long as the voltage is high. Use this mode to acquire as many spectra as possible when the voltage is high.</p>
<p>External Hardware Edge Trigger</p> <p><b>Falling Edge</b> or <b>Rising Edge</b> triggering mode in OceanView</p>	<p>Spectrometer is idle until a trigger is received as a voltage pulse (voltage increases from 0 to 3.3 V or decreases from 3.3 to 0 V). When the spectrometer receives the voltage pulse, it acquires a spectrum for the user specified integration time. The spectral data is then transferred to the software.</p> <p>If data transfer is followed by a new voltage pulse, the spectrometer will acquire another spectrum and transfer it to the software.</p> <p>If no voltage pulse is received after data transfer, the spectrometer will go back to an idle state until a new voltage pulse is received.</p>	<p>Are using a pulsed excitation source or light source in your experiment such as a laser or flash lamp</p> <p>Are doing LIF (fluorescence with pulsed excitation) or phosphorescence experiments</p> <p>Need to synchronize an acquisition with an external event</p> <p>Note: The External Hardware Edge Trigger is the most precise triggering mode. With each trigger, only one spectrum is acquired. A voltage pulse is required for each spectral acquisition. The trigger is on the voltage</p>

		transition (Rising Edge 0 to 3.3 V and Falling Edge 3.3 to 0 V).
<p>Synchronous Hardware Triggering</p> <p>Mode requires commands available only in OmniDriver, SeaBreeze or Ocean Binary Protocol (OBP)*. See below for more details.</p>	<p>Spectrometer is idle until a trigger is applied to the spectrometer as a voltage pulse (voltage increases from 0 to 3.3 V). When the spectrometer receives the voltage pulse, it acquires a spectrum until it receives a second voltage pulse.</p> <p>With the second pulse, the acquisition is terminated, spectral data is transferred to the computer and a new spectral acquisition begins until another pulse is received.</p> <p>Integration time is determined by the distance between the pulses.</p>	<p>Must synchronize your scans to an external clock source</p> <p>Are using a lock-in amplifier</p> <p>Are using a chopper</p> <p>Note: Use Synchronous Hardware Triggering when you do not know how long an event is (do not know what integration time is needed). This trigger mode is used to control the integration time with the trigger pulses.</p>
<p>Synchronous Hardware Start/Stop Triggering</p> <p>Mode requires commands available only in OmniDriver, SeaBreeze or Ocean Binary Protocol (OBP)*. See below for more details.</p>	<p>Spectrometer is idle until a trigger is applied to the spectrometer as a voltage pulse (voltage increases from 0 to 3.3 V). When the spectrometer receives a voltage pulse, it acquires a spectrum until it receives a second voltage pulse.</p> <p>With the second pulse, the acquisition is terminated and spectral data is transferred to the computer.</p> <p>Once the acquisition is complete, another pulse must be sent to start an acquisition followed by a second pulse to terminate it.</p> <p>Integration time is determined by the distance between the pulses.</p>	<p>Must synchronize your scans to an external clock source</p> <p>Are using a lock-in amplifier</p> <p>Are using a chopper</p> <p>Note: Use Synchronous Hardware Triggering when you do not know how long an event is (do not know what integration time is needed). This trigger mode is used to control the integration time with the trigger pulses.</p>

\*Ocean Binary Protocol is a communication protocol used by the Ocean FX spectrometer and other devices. OBP allows stateless communication with a device over any bus (USB, RS232, Ethernet, Wi-Fi, AP Wi-Fi, SPI) by encapsulating command-specific data in an explicit header and footer structure (including protocol version, message length, and status flags).

# Trigger delay

The trigger delay setting allows for a user specified delay in spectral acquisition after a trigger is received by the spectrometer. Users can specify a delay range from 0 to 1,000,000  $\mu\text{s}$  with a 1  $\mu\text{s}$  resolution.

A trigger delay is used with LIBS measurements. Triggering is required to ensure careful synchronization between when the laser is fired and when the spectrometer begins acquiring spectral data. The initial LIBS spectrum is characterized by a bright, broadband continuum spectrum. As the continuum fades, the emission lines indicative of the elements present in the sample appear. A trigger delay is used to acquire spectral data several  $\mu\text{s}$  after the laser is fired. This delay allows the continuum to fade so the emission lines from ions, atoms and molecular species can be measured. The delay length used for the LIBS measurements can be adjusted to enable spectral acquisition at different times after the laser fires to enable detection of the different emission line types (ions, atoms, molecular species).

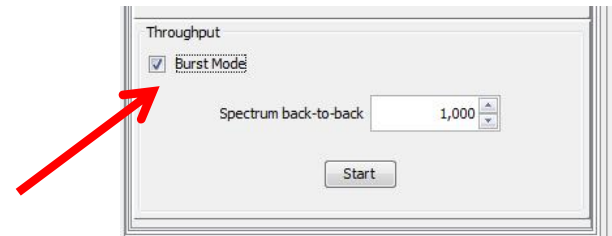
# Buffering

The Ocean FX has a large onboard memory that can store up to 50,000 timestamped spectra. This buffer enables the Ocean FX to acquire multiple spectra into its onboard buffer for each trigger event that occurs. Using the buffer, a single trigger event can result in the acquisition of up to 50,000 spectra at the maximum rate for the Ocean FX (10  $\mu\text{s}$  integration time). The trigger event may be a software or hardware trigger. Spectra can then be read out from the onboard buffer to OceanView software.



# Burst Mode

In OceanView, Burst Mode is used to acquire spectral data at the fastest rate possible with the Ocean FX (as fast as 4,500 scans per second). When Burst Mode is enabled, the user specified number of spectra are acquired and written to the onboard buffer of the Ocean FX. Once all the spectra have been acquired, the data can be written to a file by OceanView. Additional details on using Burst Mode are available in the [Ocean FX Miniature Spectrometer User Manual](#).



## External Triggering with the Ocean FX and OceanView

You can trigger the Ocean FX through the DD4 40-pin Accessory Connector on the spectrometer. This connector is used to connect sampling accessories and light sources to the Ocean FX for triggering.



Several accessories are available to facilitate triggering including:

- Breakout Box (**HR4-BREAKOUT**) a passive module that separates the signals from the 40-pin port of the Ocean FX to an array of standard connectors and headers providing access to a variety of Ocean FX functions including External triggering.
- DB15 Cable (**FLAME-CBL-DD4-DB15P**) to connect the Ocean FX to a DB15 type connector which can then be used to control light sources such as the PX-2 and DH-mini.
- PAK50P Cable (**FLAME-CBL-DD4-PAK50P**) to connect the Ocean FX to the 30 pin PAK50P type connector.
- Breakout Board (**FLAME-DD4-BREAKOUT-BOARD**) a small PCB board that plugs into the Ocean FX providing access to all 40 pins on the Ocean FX DD4 connector. This option is ideal for prototyping, quick and easy triggering and do-it-yourself cables.

## **IMPORTANT: Voltage Regulation**

The *maximum* recommended voltage on the Triggering Pin is 5.5 V. If your triggering device exceeds this voltage, you must regulate or condition the signal (via transistor buffering, transformer isolation or opto-isolation, for example) or isolate the signal from the spectrometer.

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### **Note**

To use one of the External Triggering options, you must know the specifications and limitations of the triggering device. The design of the triggering device may prevent you from using one of the external triggering modes as it is described in these pages.

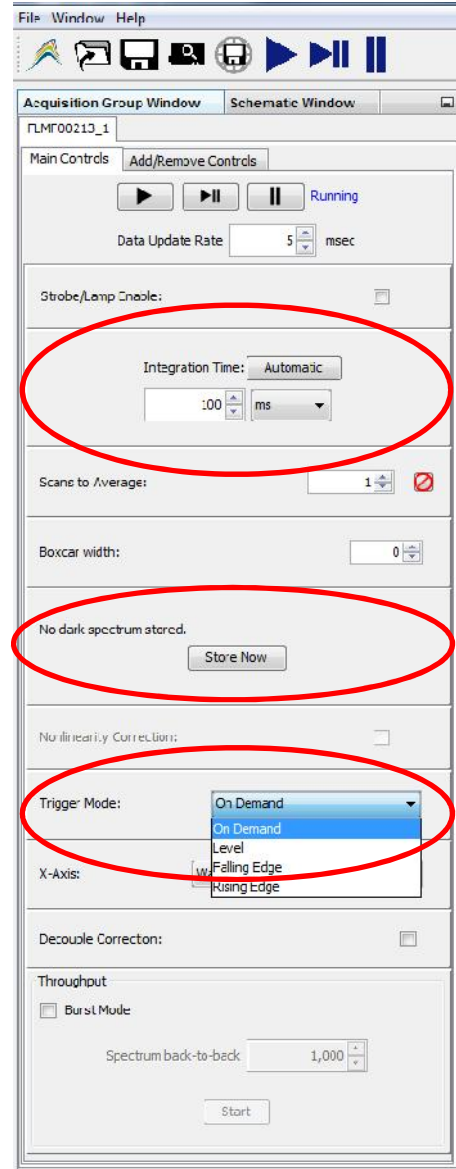
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The first step in setting up a measurement using triggering is to configure your hardware. **Make sure to connect all the hardware before powering the spectrometer.**

1. Connect the **External Trigger In** pin (pin #2) of the Ocean FX DD4 external connector to your triggering source. Use one of the cable/connector accessories described above for easy access to the **External Trigger In** pin.
2. Connect a Ground to the Ground pin (for example pin #1). Use one of the cable/connector accessories described above for easy access to the **Ground** pin.  
Set the trigger mode in OceanView to Rising Edge. In this example, the trigger occurs on the rising edge of the voltage change so you need one rising edge per spectral acquisition. Additional acquisitions are initiated by bringing the voltage down and then back up again.
3. After all the hardware connections have been made, power the spectrometer.

Before selecting a trigger mode, you will need to set the Integration Time and other acquisition parameters in OceanView.

1. Set the **Integration Time** and other acquisition parameters in the **Main Controls** tab of the **Acquisition Group Window**. The **Automatic** button automatically adjusts the spectrometer’s integration time to bring the highest point of the signal to 85% of full saturation value. This value is represented by the horizontal blue line on the preview graph. Integration time may also be set manually by using the numeric spinner control and the drop-down units menu. Note that the **Nonlinearity Correction** control is grayed out until a Dark Spectrum is stored by clicking the **Store Now** button. Make sure there is no light entering the spectrometer before you click the **Store Now** button.
2. Once the acquisition parameters are set, use the drop menu in the **Trigger Mode** panel of the **Acquisition Group Window** to select the trigger mode for the Ocean FX.
3. Once a triggering mode for the spectrometer has been set, the device will wait for an external trigger before continuing. It will appear as though the spectrometer has locked up and no further data acquisitions will occur until the spectrometer receives an external trigger.
4. Send a trigger signal for each acquisition. Note if “Averaging” has been applied in the acquisition parameters using the **Scans to Average** control, you must send multiple trigger pulses (equal to the number of averages set in the software) to obtain the averaged spectrum. For example, if you set **Scans to Average** to 5, a total of 5 trigger pulses must be sent to acquire the averaged spectrum.



**Note**

Once you select an external trigger mode, your software will appear unresponsive. This is normal, as the spectrometer is waiting for a trigger to begin acquiring spectral data. If you select a new trigger mode, you must apply one more trigger to the spectrometer to change to the new trigger mode. **If you want to go back to Normal mode, you will have to send one more trigger to the spectrometer.**

# External Triggering Example: Synchronizing Spectrometer Acquisition to a Pulsed Laser for LIBS

Laser Induced Breakdown Spectroscopy (LIBS) is a powerful technique for rapid, real-time elemental analysis of a wide range of materials, from metal and gemological samples to chemical and biological agents. With LIBS, there is virtually no sample preparation necessary and detection sensitivity is possible to parts-per-million and parts-per-picogram levels.

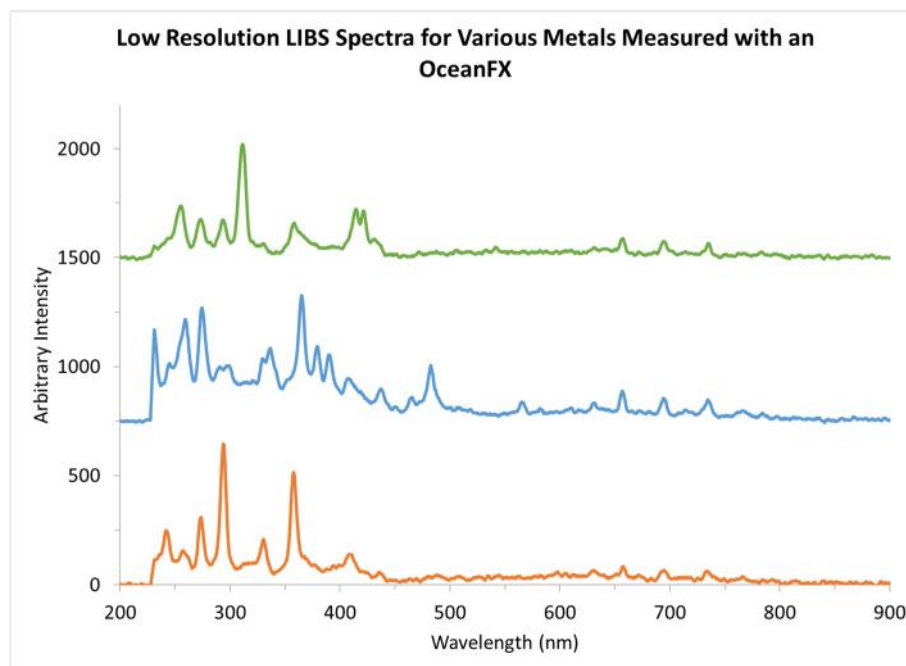
LIBS measurements are made using a high-intensity, pulsed laser beam focused on the sample. From 50 to 200 millijoules of power are delivered to the sample using a 10 nanosecond-wide laser pulse. The power of this focused laser energy creates a plasma at the surface on the sample. This plasma ablates and incorporates a small amount of the sample into the plasma. As the plasma cools (~1.0 microsecond after the laser pulse), excited atoms from the sample material that was ablated into the plasma emit light at wavelengths specific to the elements present in the sample. With a plasma that changes very quickly, precise timing and triggering is a critical part of LIBS measurements. Accurate synchronization between the spectrometer and laser pulse are required to ensure data acquisition at specific timepoints during the plasma lifetime.

We used an Ocean FX spectrometer in a LIBS setup to capture LIBS spectra for various metal samples. We used **External Hardware Edge Trigger** mode with the trigger occurring on the **Rising Edge** of the voltage increase. The laser provided the external trigger to ensure that the spectrometer acquisition was synchronized with the laser pulse. A **Trigger Delay** was used to delay acquisition until the bright continuum faded as the plasma cooled. The laser was used to trigger the Ocean FX by connecting the “Lamp Sync” port of the Laser to the **External Trigger In pin** (pin #2) of the Ocean FX DD4 external connector and the “Ground” port of the Laser to the **Ground pin** (for example, pin #1) of the Ocean FX DD4 external connector.

Figure 1 shows low resolution LIBS spectra acquired for metal samples with a single Ocean FX spectrometer and 50 mJ Nd:YAG laser. In this example, we used an Ocean FX covering the

region where all elements emit. This wide spectral range with a single Ocean FX spectrometer yielded very low resolution LIBS spectra. Higher resolution LIBS spectra could be acquired with an Ocean FX configured to cover a much narrower spectral range. The other feature to note in these spectra is the intensity of the UV peaks. The detector used in the Ocean FX has enhanced UV sensitivity to improve the detection of UV emission lines.

Figure 1. Optimizing LIBS measurements requires synchronizing the laser pulse with spectral acquisition.



# Troubleshooting

## **Why isn't my spectrometer acquiring data?**

Once you select an external trigger mode, your software will appear unresponsive. This is normal, as the spectrometer is waiting for a trigger to begin acquiring spectral data. If you select a new trigger mode, you must apply one more trigger to the spectrometer to change to the new trigger mode. **If you want to go back to Normal mode, you will have to send one more trigger to the spectrometer after changing the trigger mode in the software.**

## **Why do I have to restart the software and power cycle my spectrometer to change the triggering mode? How do I return my spectrometer to normal mode?**

Anytime you change the trigger mode in the software, you must apply one more trigger to the spectrometer. The spectrometer and software appear unresponsive because they are waiting for a trigger. You will have to apply one more trigger for the new trigger mode to take effect.

If you want to go back to Normal mode, you will have to send one more trigger to the spectrometer after changing the trigger mode in the software.

## **I sent a trigger to the spectrometer. Why isn't it working?**

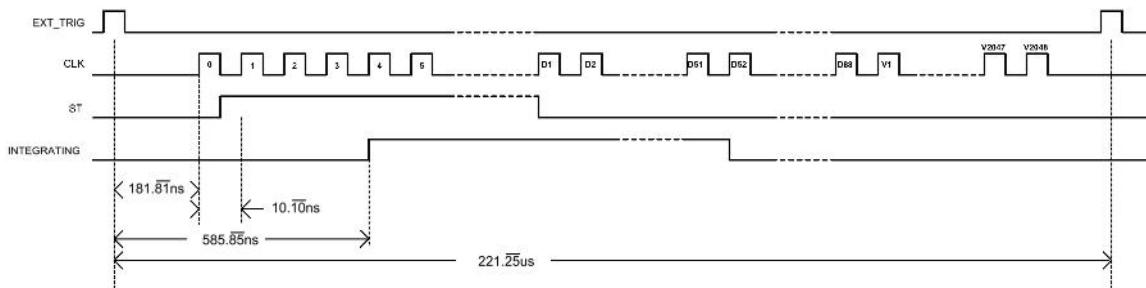
Configuring a triggering measurement requires careful attention to detail. If your spectrometer is not responding to a trigger, please check the following:

- Have you connected the device sending the trigger to the correct pin on the Ocean FX? The pin out for the Ocean FX external connector are found in the **DD4 Accessory Connector Pinout** table below.
- Are you sending the correct voltage to the trigger pin on the Ocean FX? Refer to the **DD4 Accessory Connector Pinout** table for the correct voltage for each of the pins.
- Is your pulse width long enough?

# Specifications and Technical Details

## Ocean FX Timing Diagram – Normal Mode

The timing diagram below illustrates the maximum readout speed of the Ocean FX when the integration time is set to 10  $\mu\text{s}$  and buffering is enabled. There is a fixed delay of 585.85 ns from the time a trigger event is received to the time that integration starts.



Ocean FX Scan Rate Timing Diagram

# DD4 Accessory Connector Pinout

PIN #	SIGNAL NAME	VOLTAGE	DESCRIPTION
1	GND	0	System Ground
2	IO_TRIG-EXT	+3.3	Programmable Hardware Trigger
3	IO_STROBE_CONT_EXT	+3.3	Programmable Continuous Strobe
4	IO_STROBE_SINGL_EXT	+3.3	Programmable Single Strobe
5	LAMP_EN	+3.3	Programmable Discrete Output
6	GPIO_0	+3.3/+5.0	General Purpose Software Programmable Digital Inputs/Output, Analog Output. Digital Outputs are 3.3V. Analog Outputs Can Be Programmed to 2.5 V or 5.0 V Max.
7	GPIO_1		
8	GPIO_2		
9	GPIO_3		
10	GND		
11	GPIO_4		
12	GPIO_5		
13	GPIO_6		
14	GPIO_7		
15	GND	0	System Ground
16	SPI_SCLK	+3.3	Master Clock
17	SPI_MOSI	+3.3	The SPI Master Out Slave In (MOSI) signal is for communications to other SPI peripherals.
18	SPI_CS	+3.3	SPI Chip Select signal
19	SPI_MISO	+3.3	The SPI Master In Slave Out (MISO) signal is for communications to other SPI peripherals.
20	GND	0	System Ground
21	I2C4_SCL	+3.3	I2C Master Clock
22	I2C4_SDA	+3.3	I2C Master Data
23	GND	0	System Ground
24	RS232_TX	-6 to +6	RS232 Transmit Signal
25	RS232_RX	-25 to +25	RS232 Receive Signal
26	RS232_CTS	-6 to +6	RS232 Clear To Send
27	RS232_RTS	-25 to +25	RS232 Request To Send
28	IO_RESET#	+5.0	Pull Low to reset device
29	IO_PWR_DIR#	+5.0	IO Power Direction. Pull down to request power.
30	IO_PWR_LVL	+3.3	IO Power Level - Low Indicates 100mA Available - High Indicates 1A Available
31	Reserved		Reserved
32	+5V_GPIO	+5.0	5V Input/Output
33	+5V_GPIO		
34	+5V_GPIO		
35	+5V_GPIO		
36	+5V_GPIO		
37	+5V_GPIO		
38	+5V_GPIO		
39	GND	0	System Ground
40	+5V_GPIO	+5.0	5V Input/Output



Additional details on the Accessory Connector pinouts is available in [Ocean FX Miniature Spectrometer User Manual](#).

## Ocean Binary Protocol (OBP) Commands for Triggering

Ocean Binary Protocol (OBP) is a communication protocol used by certain Ocean Optics devices, including the Ocean FX spectrometer. OBP allows stateless communication with a device over any bus (USB, RS232, Ethernet, WiFi, AP WiFi, SPI) by encapsulating command specific data in an explicit header and footer structure (including protocol version, message length, and status flags).

Message	Purpose	Input Parameter(s)	Output Parameter(s)	Notes
0x001 101 00	Get trigger mode		U8: Trigger Mode	
0x001 101 02	Get number of back-to-back spectra per trigger event		U32: Number of back-to-back spectra per trigger event.	See note below
0x001 101 10	Set trigger mode	U8: Trigger Mode		See note below
0x001 101 12	Set number of back-to-back spectra per trigger event	U32: Number of continuous samples per trigger event.		Max Value 65535

### Note: Number of back-to-back spectra per trigger event

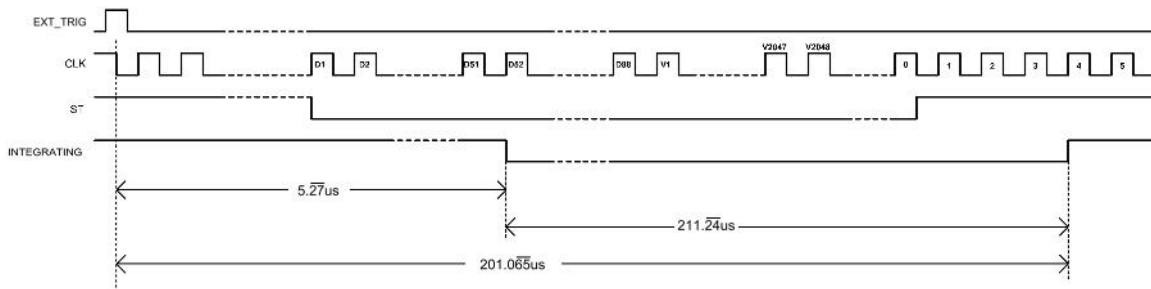
Number of back-to-back spectra per trigger is a feature unique to the Ocean FX spectrometer (unique among Ocean Optics spectrometers). For each trigger event received, whether hardware or software trigger, the spectrometer will retrieve this many spectra back-to-back at its maximum acquisition rate of about 1 spectrum every 222 microseconds. This feature requires that buffering is enabled.

# Ocean FX Trigger Modes

Mode	Purpose
0x00	<b>Software Trigger Mode (Default)</b> Trigger events occur with each request for spectrum. Number of back to back spectra is ACTIVE.
0x01	<b>Hardware Rising Edge</b> Trigger events occur on the rising edge of the external trigger signal. Number of back to back spectra is ACTIVE.
0x02	<b>Hardware Falling Edge</b> Trigger events occur on the falling edge of the external trigger signal. Number of back to back spectra is ACTIVE.
0x03	<b>Hardware Level</b> Trigger events occur while the external trigger signal is held high. Number of back to back spectra is ACTIVE.
0x04	<b>Legacy Synchronous Triggering</b> The previous integration time ends and the next integration time begins on the rising edge of the pulse. Thus, integration time is determined by the time between rising edges. Number of back to back spectra is IGNORED.
0x05	<b>Synchronous Start-Stop Triggering</b> Integration time begins on the rising edge of the pulse and ends on the next rising edge. This cycle repeats where each rising edge either starts an integration time or ends an integration time (but never both). Thus, the integration time and the delay between integration times are defined by the delta between pulses. Number of back to back spectra is IGNORED.
0xFF	<b>Disabled</b> In this mode all spectral triggers are disabled. This mode allows spectra to be read out of the buffer without refilling it (via software trigger, for example).

# Ocean FX Synchronous Hardware Trigger Mode

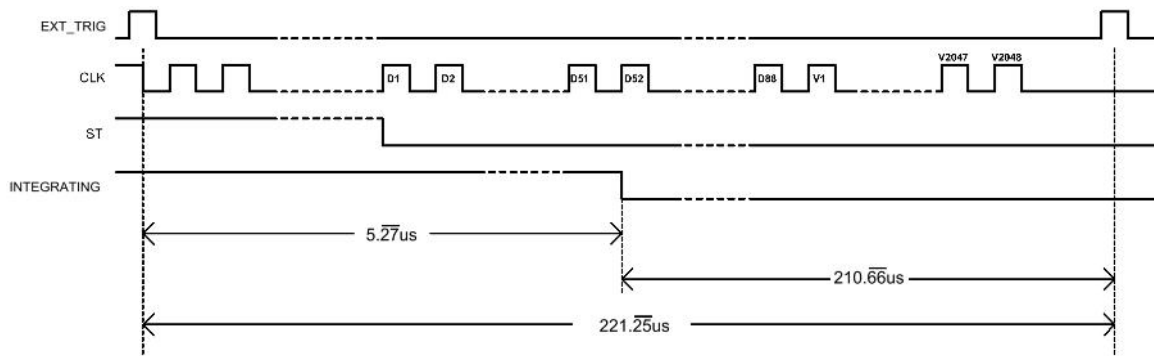
When synchronous hardware trigger mode is enabled, the first rising edge on the external trigger line will be treated as a trigger event. Each subsequent trigger will pull the ST line low, so that the pixel data can be shifted out of the detector. Upon completion of the detector readout period, a new integration period will start. The back-to-back trigger mode settings are ignored when synchronous trigger mode is enabled. The timing is defined in the timing diagram below.



Ocean FX Synchronous Hardware Trigger Mode

# Ocean FX Synchronous Hardware Start/Stop Trigger Mode

When synchronous hardware start/stop trigger mode is enabled, an acquisition will begin following the detection of a pulse on the external trigger line. Upon receiving a second pulse, the ST line will be driven low and the pixel data will be read out. The next acquisition will occur following a subsequent trigger. The timing diagram below illustrates the time between receiving the second trigger and the time at which integration actually stops. The back-to-back trigger mode settings are ignored when synchronous start/stop trigger mode is enabled.



Ocean FX Synchronous Hardware Start/Stop Trigger Mode