

Transitioning Your Application to the New *QE Pro*

Whitepaper by Ocean Optics Staff

Introduction

We have introduced new features with the release of the *QE Pro* Spectrometer; all of which enhance data integrity and trouble-free operation as compared to prior versions of spectrometers in the *QE* series. Some of these new features include:

- Noise has been reduced by more than a factor of 2.
- TEC stability has improved and there is no longer a minimum delta.
- The device includes status LEDs to indicate operating status of the *QE Pro*.
- The *QE Pro* has a buffer capable of storing up to 15,000 spectra to ensure that you will not miss collected spectra.



Implementation of these new features necessitates differences in how this *QE Pro* operates as to prior *QE* series spectrometers. The major differences between the operation of the *QE Pro* and other spectrometers in the *QE* series include:

- The *QE Pro* does not operate with either SpectraSuite or the USB programmer. Use OceanView and **UpdateQEPro** instead.
- Operation of the *QE Pro* buffer requires new commands to control the data buffer and the acquisition timing. This is especially important because the timing of spectral acquisition in relation to the receipt of the **GetSpectrum** command has changed.
- The *QE Pro* saturation value is 200,000 instead of 65,535 for other *QE* series spectrometers. Note when using OceanView that E-dark is on by default and can cause saturation values to appear less than 200,000.
- Pixel data is 32 bits wide instead of 16 bits wide.
- The Ocean Binary Protocol (OBP) is now used for both USB and RS232 communications. Also the PID/VID/GUID have changed.
- The *QE Pro* is not powered via the USB cable.



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Purpose

The purpose of this whitepaper is to provide detail on the difference between the hardware and software control and functionality of the QE *Pro* compared to the QE65 Pro and QE65000. This document is designed to help with the transition between older versions of the QE series and the QE *Pro* and address the differences in:

- Power requirements
- Buffer and spectrum acquisition
- USB 2.0 and Serial Communications
- 18-bit Digitization

Please contact the Ocean Optics product support team or your OEM sales contact for more detailed information and troubleshooting.

Power Requirements

While previous QE series spectrometers offered limited functionality when powered solely by the USB connection, the adaptive cooling for the detector will not function without the 5V connection on these spectrometers.

The QE *Pro* does not offer limited functionality when powered solely by the USB connection. Therefore, you must use a 5V power supply to operate the QE *Pro*.

Buffer and Spectrum Acquisition

We have implemented a data buffer on the QE *Pro*, thereby allowing the storage of up to 15,000 spectra on board the QE *Pro* device for later retrieval. This is a significant change from previous QE models, which each could only store up to 3 spectra in the buffer.

The buffer on the QE *Pro* ensures that any spectral data will not be missed due to USB transfer delays caused by a host computer. Data integrity is ensured because the spectrometer is always capturing and storing data in the large buffer.

Buffer Operation on Previous QE Models

QE65000 and QE65 Pro spectrometers with firmware version 3.0 and greater normally operate in an idle mode by waiting for a command to get spectrum.

When these spectrometers receive a get spectrum command, they start their measurement cycle. When the first measurement (at the integration time) is complete, the resulting spectrum is stored in the first slot of the 3-deep buffer. At the end of the first integration period, the spectrometer automatically starts the next integration period and places that result into the next slot in the buffer. The spectrometer will continue automatically integrating and placing data into the buffer until all three buffer slots are filled.

After the buffer is filled, the device clears the buffer and returns to an idle state.

A command sent to change the integration time will also automatically stop the acquisition and clear the buffer.

Buffer Operation on the QE Pro

In the normal mode the QE *Pro* continuously collects spectra at the set integration time (as compared to being idle like the previous spectrometers in the QE family). At the end of each integration period, the spectrum is digitized and stored in the buffer. The spectrometer will continue automatically integrating and placing data into the buffer.

When the QE *Pro* spectrometer receives a request to read a spectrum, the oldest spectrum in the buffer is returned. If the buffer is set to a very large capacity then this returned spectrum will be old (compared to the current measurement). Even with the buffer capacity set to the minimum buffer of 1, a request to read a spectrum can retrieve a spectrum that was collected up to two (2) integration times earlier, and at a minimum one integration time earlier.

New commands have been created for you to change how the QE *Pro* operates with respect to its buffer.

New QE Pro Commands for Use with Expanded Buffer Capability

New commands have been developed to allow the user to make the QE *Pro* operate similarly to the previous spectrometers in the QE series. All of these new commands can be accessed via OmniDriver and are located in the **FeatureController** object called `dataBuffer`. To access this feature controller, call the wrapper function **getFeatureControllerDataBuffer** (`int spectrometerIndex`). The return object is a **DataBuffer** object. This object contains the following commands:

Command	Description	Result
abortAcquisition()	Stops the continuous acquisition cycle and puts the spectrometer into an idle state	Returns nothing
clearBuffer()	Empties the buffer	Returns nothing
getBufferCapacity()	Gets the current capacity of the buffer	Returns int32
getBufferCapacityMaximum()	Gets the maximum possible buffer capacity	returns int32
getBufferCapacityMinimum()	Gets the minimum possible buffer capacity	returns int32
getNumberOfElements()	Gets current number of spectra in the buffer	returns int32
setBufferCapacity(int32)	Sets the current buffer capacity	returns nothing
startAcquisition()	Starts the continuous acquisition cycle	returns nothing

Consult the QE *Pro* Data Sheet for the appropriate commands to control the buffer if you plan to use direct USB communications to the device without the aid of OmniDriver.

Spectrum Acquisition on the QE Pro

In the normal mode the QE *Pro* continuously collects spectra at the set integration time (as compared to being idle like the previous spectrometers in the QE family). At the end of each integration period, the spectrum is digitized and stored in the buffer. Spectra are stored in the buffer until the buffer capacity defined by the **setBufferCapacity(int32)** command is reached. The buffer is designed to operate in a first-in-first-out (FIFO) mode; once the buffer is full and a new spectrum is ready to be stored, the oldest spectrum is dropped from the buffer and replaced with the newest acquisition.

The **getSpectrum(int32)** command causes the device to return the oldest spectrum in the buffer. Even with a small buffer, the returned spectrum will not be from the most recent integration cycle. Furthermore, if a request for a spectrum is quickly followed by another request for a spectrum and there is not a spectrum in the buffer, the spectrometer will wait for the completion of the current integration and then return that data.

When using OmniDriver software, the following procedure can be used to achieve the same acquisition behavior as the QE series spectrometers on the QE *Pro* spectrometer.

1. Call the `DataBuffer` feature controller
2. Call the `abortAcquisition()` command to stop data acquisition
3. Send the `clearBuffer()` command to reset the buffer

After this sequence, the spectrometer will be placed in an idle state with an empty buffer. To begin spectral data acquisition again:

1. Issue the **startAcquisition()** command to start data acquisition. Receipt of this command effectively defines the start of the integration period.
2. Follow this with the wrapper `getSpectrum(int)` command to get a spectrum

When the data acquisition is operating, if the **getSpectrum(int32)** command is issued before the buffer has a stored spectrum, the spectrometer will wait until a spectrum has been transferred to the buffer then write that spectrum to the USB port. The OmniDriver software will wait until it receives the spectrum and will then return it to the user application.

****Note for OmniDriver users. OmniDriver does not send the **setIntegrationTime** command until a **getSpectrum** command has been issued. This will result in the next spectrum being taken at the old integration time since the start acquisition command has already started the integration process before sending the new integration time.*

A similar sequence of commands can be issued with direct USB communications.

USB and Serial Protocols

USB Speed

The QE65000 and QE65 Pro are both USB 2.0 devices that operate in either full speed (12 Mb/s) or high speed (480 Mb/s). If the USB host does not support high speed USB communications, these spectrometers revert back to full speed as required by the USB 2.0 specification.

The QE Pro is a USB 2.0 device that will only operate at full speed and will not transfer data faster than USB 2.0 standards allow (60 MB/s). All compliant USB 2.0 hosts are required to support full speed communication; therefore the QE Pro is supported by all USB 2.0 and 1.0 compliant hosts.

Restricting the QE Pro to full speed USB communication does not affect data throughput from the device to a host computer. The spectrometer will not be the bottleneck for USB communications unless four spectrometers were attached to the same USB hub.

****The QE Pro generates 2048 bytes per spectrum. The minimum integration time for the QE Pro is 8 ms which translates to 125 spectra per second. Given these operating conditions, the QE Pro generates just over 2 Mb/s. Assuming a generous 50% overhead on USB communications, the transfer rate could be as high as 3 Mb/s. This is still a factor of four less than full speed USB communications at 12 Mb/s.*

USB Protocol

Customers using direct USB communication with the QE Pro spectrometer, instead of using the OmniDriver interface, should note that the QE Pro uses the Ocean Binary Protocol (OBP). This protocol is detailed in the QE Pro Data Sheet located at www.oceanoptics.com.

Previous QE models used a version of Ocean Optics' legacy protocol. The detail of this old protocol is in the Data Sheets for the QE65000 and QE65 Pro.

Serial Protocol

The serial protocol for the QE Pro is the same OBP protocol that is used for the USB communication of the QE Pro. As a result, the commands and command structure are identical. This simplifies programming as to switch from one bus to the other only requires the appropriate bus change and not a total protocol rewrite.

Previous QE models did not use the OBP and instead used a legacy Ocean Optics serial protocol which differed from the USB protocol.

18-bit Digitization

The QE65000 and QE65 Pro use a 16-bit A/D converter. The QE Pro has been upgraded to an 18-bit A/D converter. As a result the scale of output values has increased (from 65,535 counts to 262,144 counts) with the new QE Pro. This means that the data can no longer be fully represented by a single word (2 bytes). Applications written to use a single two-byte word will have to be changed to address this difference. Recommended methods for using the 18-bit data are provided below.

The following issues only apply to code that was written without the use of Omnidriver. Since the Omnidriver **getspectrum** command already returns a double float, any program written with Omnidriver does not have problems with the 18 bit data.

Change Your Existing Code to Use the Full 18-bit Information

The QE Pro was designed to be a high performance scientific grade miniature spectrometer. In order to leverage the its full capability, applications should be edited to use a larger integer format to allow the QE Pro to reach the full potential provided by the QE Pro.

Remove the Last Two Bits of Data

Removing the last two bits of data will not result in a loss of sensitivity since sensitivity is determined by the low-signal noise limit. It will, however, reduce the single acquisition dynamic range by about a factor of 3, and the single acquisition signal to noise ratio (SNR) by a factor of 1.8.

Removing the last two bits of data will also result in hitting the practical saturation limit of 65,535 counts with much shorter integration times. Averaging multiple spectra together is recommended to bring the dynamic range and SNR back up.

Divide Down the Numbers

Since the 18-bit noise on the QE Pro is so low, typically about 2.5 counts, dividing by a factor of four (4) will introduce more quantization error. The added quantization error will cause a loss of dynamic range and sensitivity. The SNR, however, will stay the same because the high-signal noise is greatly shot noise dominated. The dramatic decrease in SNR makes this option the least desirable for accommodating the change to 18-bits.

****Note for Windows XP 32-bit users. The QE Pro uses the WinUSB driver. There is a conflict between OmniDriver 2.37 and OceanView which makes only one or the other able to operate at a time.*

****OmniDriver 2.37 does not update the OOI_HOME environment variable from a previous installation. In some cases this may need to be updated manually.*

