OtO Photonics

Red Bullet Series Product Sheet

Introduction

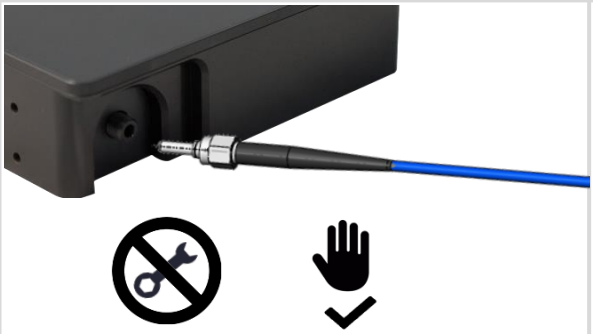
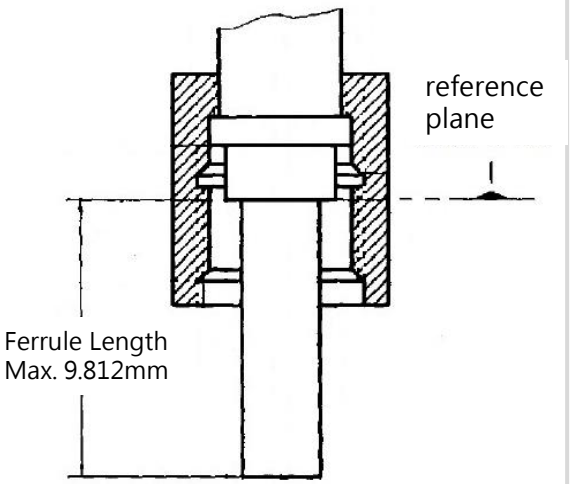
The Red Bullet (RB) Series spectrometers consist of CMOS sensors and 32-bit RISC microcontrollers. This series features a new concave mirror optical design with an improved integrated small, light and handy body. The CPU of RB series is 8051, which can provide shorter integration time, faster readout speed, high Accuracy of sensor trigger timing and low power consumption.

The RB series uses a concave mirror with Czerny-Turner optical design to deliver extreme small body.

The RB series is powered by USB and connected to a computer via USB. In addition, it provides an interface with six I/O pins for connecting external devices.

With RISC microcontrollers, the RB Series spectrometers can be operated using the software provided by OtO Photonics.

Precautions

Picture	Description
	To prevents over tightening and damaging of the slit in the spectrometer. Please Hand tightening the optical fiber only. **Do not** use any tool including wrench to tighten up the optical fiber and SMA905 connector. Apply adhesive to optical fiber connector after hand tightening is recommend if the fiber needs to be fixed robustly for a long time operation.
	Due to the design of SMA905 connector of spectrometer is based on IEC 874-2:1993 and to prevent damaging of the slit in the spectrometer, please note the ferrule length of SMA905 Optical fiber must **shorter than 9.812mm**.

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Red Bullet Product Sheet

Overview

► 1.1 RB Series Products

Model	Wavelength range (nm)	SNR		Dynamic Range*1		A/D	Stray Light	Thermal Stability Test
	NIRC	High Gain	Low Gain	High Gain	Low Gain			
	900 ~ 1700							
RB4524	√	2000	6000	6250	7200	16 bits	N/A	N/A

*1 : 65535/Dark Noise(average)

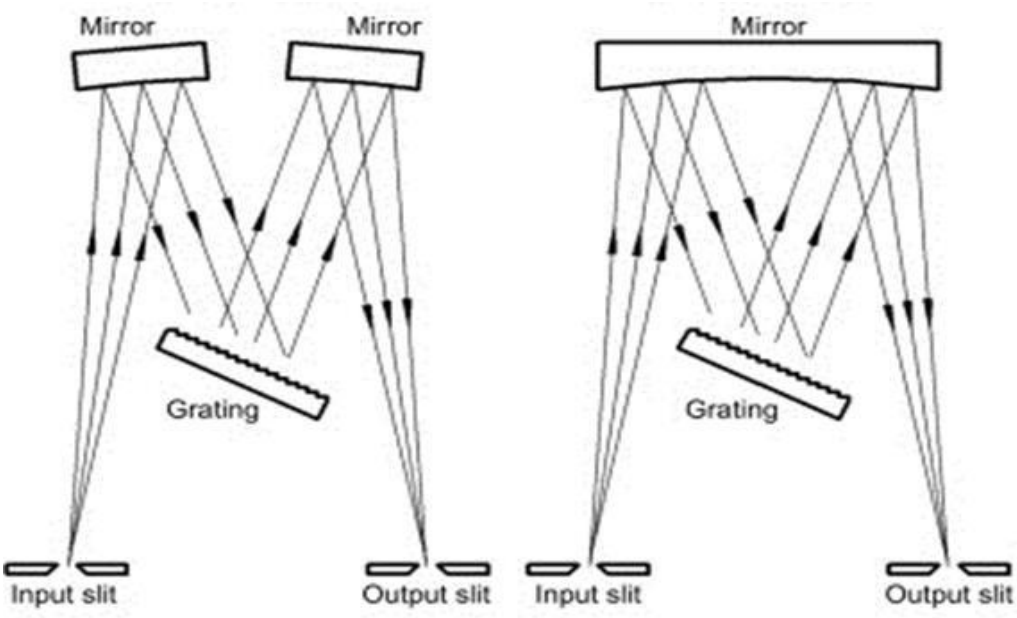


Fig. 1 : Concave Mirror Czerny-Turner Optical Design

► 1.2 Response Curves

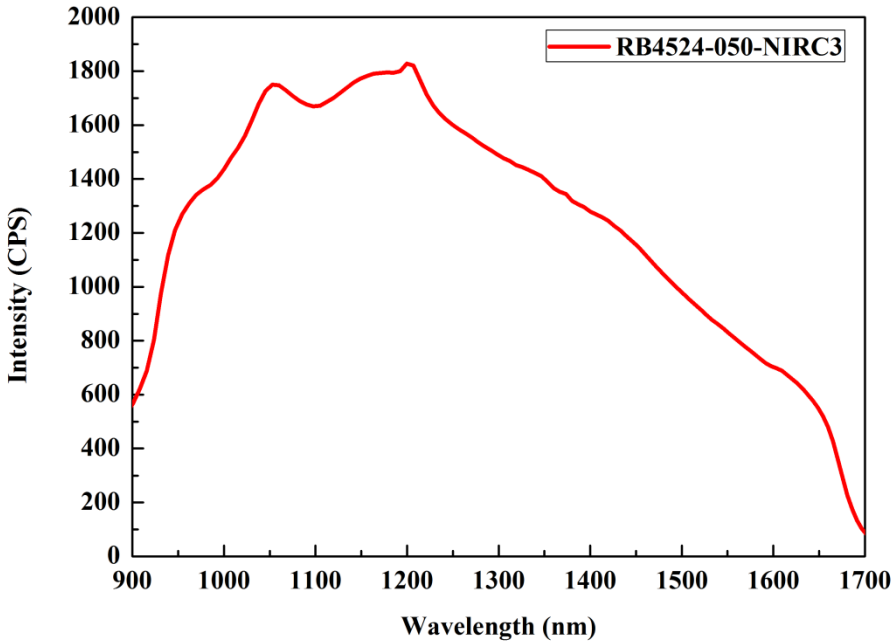


Fig. 2 : RB Series Deuterium Lamp & Halogen Lamp Response

Key Features

► 2.1 Characteristics

- Wavelength range: 900-1700nm
- Resolution <15nm (slit:50), depending on the combination of various slits and gratings.
- Sensor:
  - 128 pixels InGaAs sensor
- Customizable modular components: grating and inlet slit
- Integration time: 100μs-24sec
- 16 bit, 15MHz A/D converter
- Micro USB, 4pin USB connector
- An 8-pin external I/O port (with a built-in LED indicator) for connecting external devices
  - 6 pins for digital I/O data acquisition
- Plug-n-Play computer application support
- Ultra-precise continuous exposure, holding up to 4,000 records of spectrum data in memory
- Flash ROM storage
  - Wavelength calibration parameters
  - Linearity correction parameters
  - Intensity correction parameters

► 2.2 Specifications

Features		Specifications
		RB4524
Sensor		128 pixel InGaAs
Dark noise (Max)		<14 (High gain) <10 (Low gain)
Dynamic range		6250 (High gain) 7200 (Low gain)
SNR		2000 (High gain) 6000 (Low gain)
Wavelength range		900~1700nm
Optical system characteristics		f/# : 4.5 NA : 0.11
Optical design		Czerny-Turner Optical design, 2nd & 3rd harmonics removed
Dimensions		51.4 (L) x 36.4 (W) x 29 (H) mm
Slit width		50µm
Integration time		100µs ~ 24sec
Resolution (FWHM		15nm (slit: 50µm)
Fiber optic interface		SMA905
Environmental requirements	Storage temperature	-30°C to +70°C
	Operating temperature	0°C to +50°C
	Relative Humidity	0% - 90% non-condensing
Data transfer interface		Micro USB
Power specifications		Power supply: USB, 500mA at +5VDC Voltage: 4.75-5.25V

Mechanical Designs

► 3.1 Outlines and Dimensions

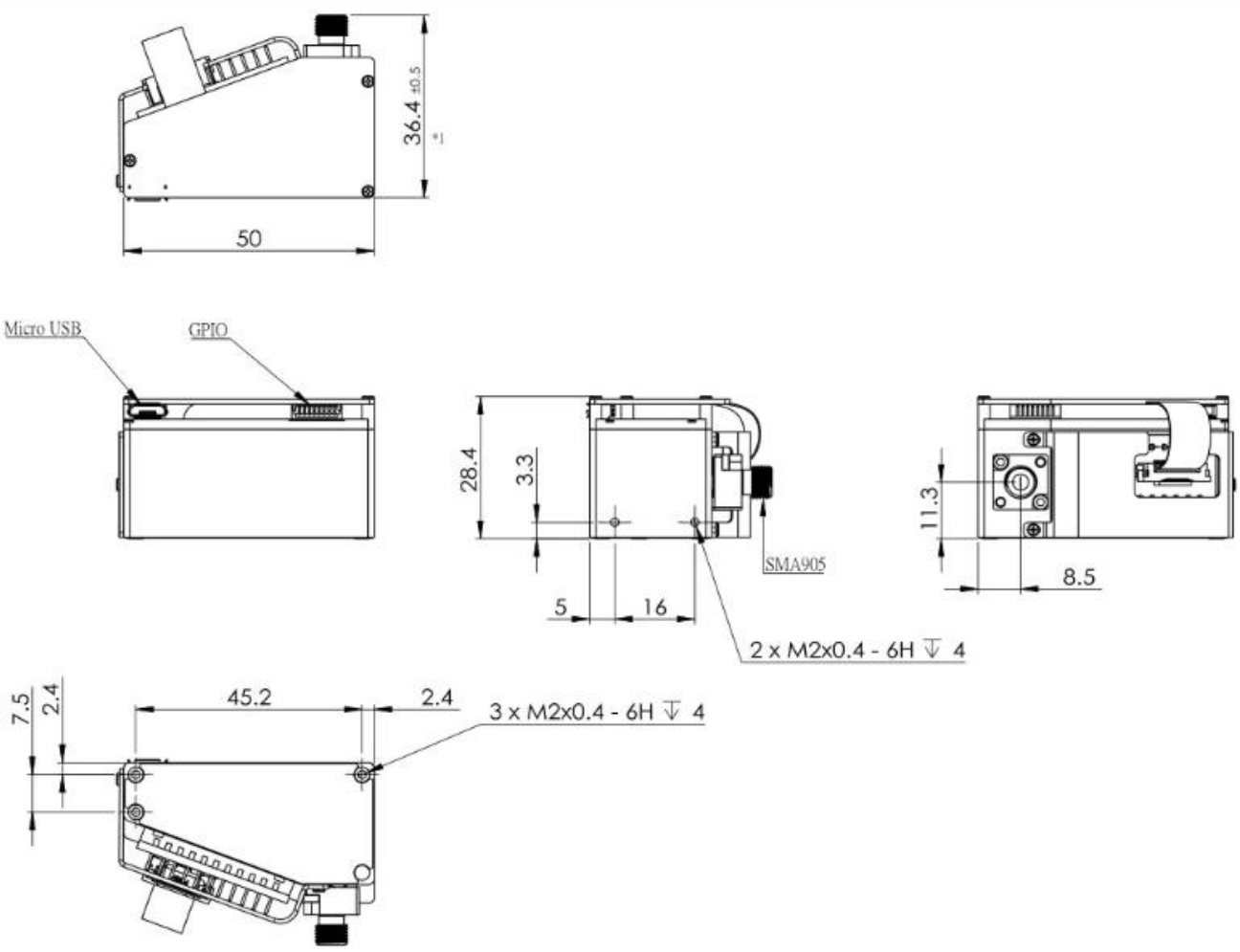
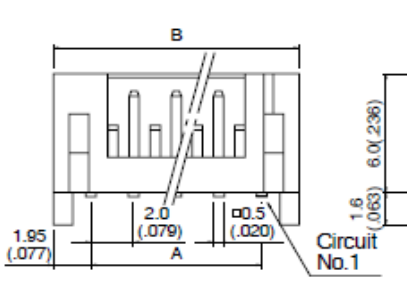


Fig. 3 : RB outlines and dimensions

► 3.2 Electronic Output Pin Assignments

The RB Series provides an 8-pin 2.0mm rear external I/O port.

Side entry type



Cir-cuits	Model No.		Dimensions mm(in.)		Q'ty / box	
	Top entry type	Side entry type	A	B	Top entry type	Side entry type
8	B 8B-PH-K-S	S 8B-PH-K-S	14.0(.551)	17.9(.705)	500	250

Figure 4. The 8-pin 2.0 mm rear external I/O port

External Ports

The following figure shows the external ports on the RB Series.
From left to right: the rear external I/O port, the PC USB port, and the LED indicator.

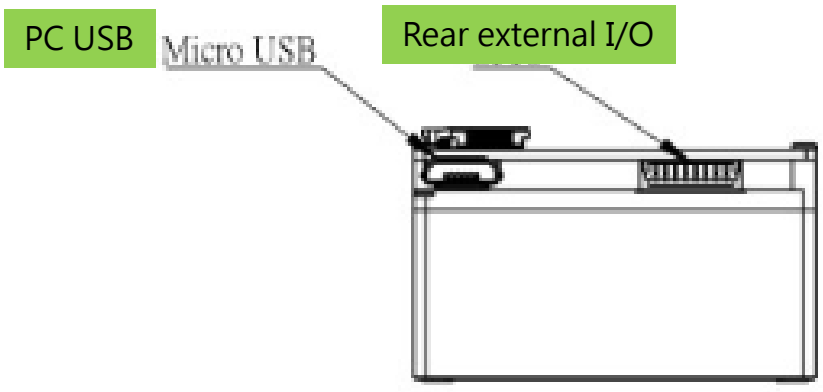


Figure 5. External ports on the RB Series

Pin Assignments on the External I/O Port

Pin #	Type	Name	Description
1	Power	5V Input/Output	When the spectrometer is connected via USB to a computer, this pin connects to the VBUS so that the spectrometer can provide 0.1A of power to the external device.
2	Output	TX	UART TX. TX is the output from the RISC microcontroller.
3	Input	RX	UART RX. RX is the input to the RISC microcontroller.
4	Output	GPIO0	General purpose output #0.
5	Output	GPIO1	General purpose output #1.
6	Output	LS_ON	Lamp on.
7	Input	Trigger_IN	External trigger signal.
8	GND	GND	Ground.

► 3.3 Sensor Overview

Sensor / System Noise

The three key factors that affect the noise level of the output signal are: stability of the light source, electronic noise, and the sensor noise. Excluding the effect of the external light source, the first thing to check is the dark noise of the measurement system. Dark noise is defined as the voltage output (Vout RMS) over a period of 10ms integration time in a completely dark environment. So the dark noise level is solely determined by the electronic noise in the readout and the CCD/CMOS sensor itself.

Another way to determine the quality of the signal is signal-to-noise ratio (SNR). SNR is defined as the maximum signal level (65535) divided by RMS. Higher SNR means the signal is cleaner, and differences between signals are more discernible when signal levels are low.

Signal Averaging

In general, there are two ways to obtain a smooth curve for a signal: signal averaging and boxcar filter. Signal averaging can reduce the influence of noise on individual pixels. It is natural that increasing the number of samples taken for averaging creates a better averaged curve, but then it takes more time get the final spectrum. On the time-based curve, the signal-to-noise ratio (SNR) increases in proportion to the square root of the number of samples taken. For example, if the number of samples taken is 100, the SNR is increased 10 times.

The second method, boxcar filter, uses neighboring pixels for averaging to get a smooth curve for the signal, but it negatively impacts the optical resolution. This method is not recommended if you need to find the peak values of the signal. These two methods can be combined together in a single measurement if required.

Operations

► 4.1 Pixel Signal Intensity

The spectrometer is shipped with a baseline signal intensity at 1,000 counts. In cases where the user needs to modify this baseline intensity, it can be done using control commands. There is a command for the user to adjust the AFE OFFSET. Another way to change the baseline signal intensity is to use the "background removal" feature in the software. Which one to use depends on the way the user wants to use the baseline signal intensity.

► 4.2 Digital Input/Output

General purpose input/output (GPIO)

The RB Series comes with six 3.3V digital input/output pins that can be used for data acquisition on the 8-pin external I/O port. Using software, these I/O pins can be defined for different application purposes. To support some OEM customization needs, the RB Series provides the flexibility to use a special clock generator (such as single pulse or PWM).

GPIO recommended voltages:

VIL(max) = 0.8V

VIH(min) = 2.0V

GPIO maximum/minimum voltages:

VIN(min) = -0.3V

VIN(max) = 5.5V

Data transfer interface

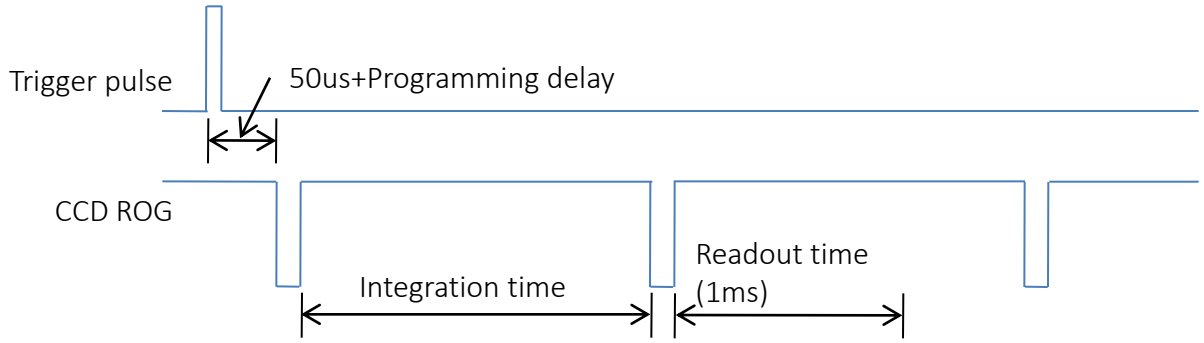
USB 2.0

The 480Mbit/s USB (Universal Serial Bus) is a widely used data transfer standard for computers. The spectrometer control software provided by OtO Photonics uses USB to connect to multiple RB Series spectrometers. The energy-saving RB Series can be powered via a USB cable over its VBUS line.

► 4.3 Trigger Modes

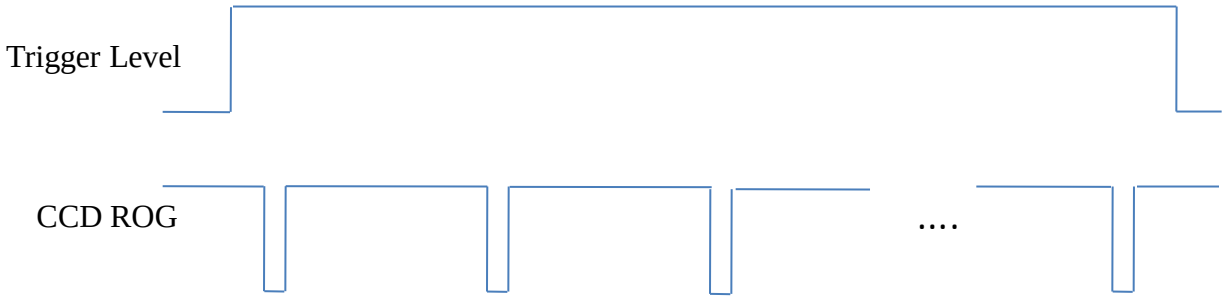
- **Single trigger/single capture**

  In the single trigger/single capture mode (with preconfigured integration time), the spectrometer waits for a trigger pulse and captures the spectrum once upon receiving the trigger pulse. It can be triggered on a rising edge or a falling edge. An integration time programming delay can also be configured.



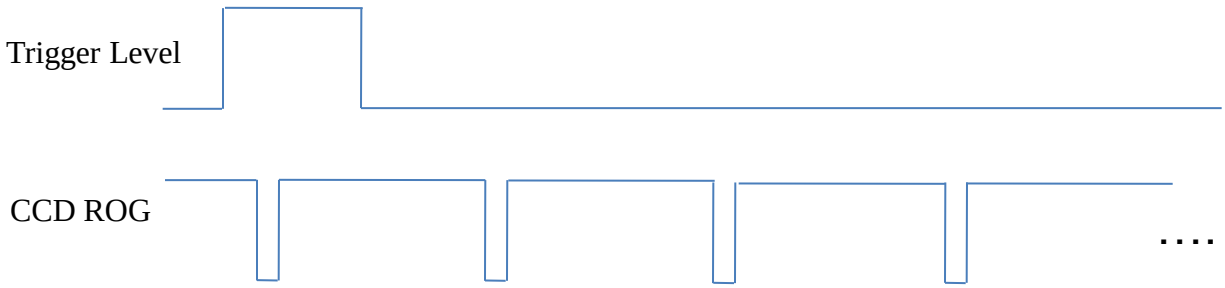
- **Software trigger**

  In the software trigger mode (with preconfigured integration time), the spectrometer waits for the external trigger signal level to go up then starts and continues to capture the spectrum using preconfigured integration time till the signal level drops.



- **Software trigger/multiple capture**

  In the software trigger/multiple capture mode (with preconfigured integration time and software commands to capture the spectrum), the spectrometer continues to capture the spectrum with the preconfigured integration time even when the trigger pulse drops.



USB Data Transfer and Controls

► Overview

The RB Series is a compact spectrometer with an embedded microcontroller and supports USB data transfer. This section provides the computer programming details on how to control the RB Series vial USB. This information is intended only for those who intend to develop their own software instead of using the standard software provided by OtO Photonics (SpectraSmart).

● Hardware Description

The RB Series leverages the built-in 32-bit RISC microcontroller in the USB 2.0 chip. The program codes and data are store in the SPI Flash. This RISC microcontroller provides 64MByte of DDR and 64Mbits of Flash.

● USB Information

RB Series USB Vendor ID: 0x0638; Product ID: 0x0AAC
The RB Series supports USB 2.0 connection and uses USB bulk streams for data transfer between the spectrometer and the computer. For more information on USB, please visit the USBIF website: http://www.usb.org

Programming Guide

Application Programming Interface (API)

The following section provides a list of APIs and their functions.

Open RB Series Spectrometer

Description: Connecting the computer to an RB Series spectrometer.

a. Function name: UAI_SpectrometerOpen

b. Parameters:

dev: Since one computer can connect up to eight RB Series spectrometers simultaneously, the 'dev' parameter specifies which device to connect to.

handle: A unique identifier returned by the API to identify the connected spectrometer. Each connected device is assigned a different handle. This handle is used by the API to identify which device to control in subsequent operations.

Get Frame Size

Description: Getting the frame size of the sensor in the spectrometer.

a. Function name: UAI_SpectromoduleGetFrameSize

b. Parameters:

device_handle: The unique identifier for the spectrometer to be controlled.

size: Returning the frame size in 16-bit format.

Acquire Wavelengths

Description: Starting to acquire wavelengths. The RB Series can acquire the complete distribution of wavelengths.

a. Function name: UAI_SpectrometerWavelengthAcquire

b. Parameters:

device_handle: The unique identifier for the spectrometer to be controlled.

buffer: The buffer to receive the data acquired.

☐ Acquire Spectrum

Description: Starting to acquire the spectrum. The RB Series can acquire the complete spectrum corresponding to the data acquired by the "UAI_SpectrometerWavelengthAcquire" function.

a. Function name: UAI_SpectrometerDataAcquire

b. Parameters:

device_handle: The unique identifier for the spectrometer to be controlled.

integration_time_us: Specifying the integration time in 32-bit format (μs).

buffer: The buffer to receive the data acquired.

average: The number of samples to take for signal averaging to reduce noise.

☐ Get Wavelength Range

Description: Getting the supported maximum and minimum wavelengths.

a. Function name: UAI_SpectromoduleGetWavelengthStart

UAI_SpectromoduleGetWavelengthEnd

b. Parameters:

device_handle: The unique identifier for the spectrometer to be controlled.

lambda: Returning the maximum/minimum wavelength (nm) supported by the RB Series in 32-bit format.

☐ Get Integration Time Range

Description: Getting the maximum/minimum integration time.

a. Function name: UAI_SpectromoduleGetMaximumIntegrationTime
UAI_SpectromoduleGetMinimumIntegrationTime

b. Parameters:

device_handle: The unique identifier for the spectrometer to be controlled.

Integration Time: Returning the maximum/minimum integration time supported by the RB Series in 16-bit format.

Note: The minimum integration time is specified in microseconds (μs). The maximum integration time is specified in thousand seconds (ks).

☐ Close RB Series Spectrometer

Description: Disconnect the computer from the RB Series spectrometer.

a. Function name: UAI_SpectrometerClose

b. Parameters:

handle: The unique identifier for the spectrometer to be disconnected. The disconnected spectrometer will stop all of its operations when this command is executed.