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Phekda Series
Phekda-NIR Series Product Sheet

<u>Introduction</u>

The Phekda & Phekda-NIR (PD & PD-NIR) Series spectrometers consist of CCD, CMOS, InGaAs sensors and 32-bit RISC microcontrollers. This series features a new T-R-T (Transmissive-Reflection-Transmissive) optical design, simple and optimized for LIBS or high resolution requirement. The optical bench is very rigid and stable for measurement system and has outstanding stability of thermo-hydro variation, vibration and shock on resolution and wavelength shift performance.

The PD & PD-NIR series uses a reflection grating and Czerny-Turner optical design to deliver high resolution, high sensitivity, low dispersion, and high-speed spectrum response.

The PD & PD-NIR 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.

This document provides detailed information on the PD & PD-NIR series and how to work with it.

With RISC microcontrollers, the PD & PD-NIR Series spectrometers can be operated using the software provided by OtO Photonics.
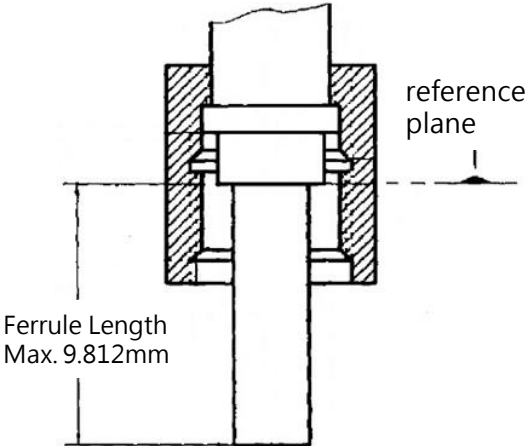

This document is intended for sales and marketing purposes only and may not serve as a product specification document for shipping or contracts. If a customer requires a formal document for product approval or incoming quality control (IQC), OtO can discuss the specification details with the customer and provide a formal document for such purposes.

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Precautions

Picture	Description
	Screw in the fiber optic connector with fingers. Do not use any tool to tighten it. Using tools such as wrenches to tighten the connector may cause the connector to press against and damage the inlet slit of the spectrometer. Such damage is not covered by the warranty. In cases where the connector needs to be firmly in place for long-term use, it is advised to apply a little glue to where the SMA905 connector is connected to the spectrometer.
reference plane Ferrule Length Max. 9.812mm	The SMA905 connectors on all spectrometers made by OtO Photonics is manufactured in accordance with international standards. Customers should ensure that the ferrule length of the fiber used is not longer than 9.812mm to avoid damaging the slit in the SMA950 connector. Such damage is not covered by the warranty.

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■ Overview

► 1.1 PD & PD-NIR Series Products

	Model	Wavelength Range(nm)					SNR		Dynamic Range[1]		A/D	Stray Light	Thermal Stability
		V25 535 ~ 650	V30 548 ~ 658	V32 625 ~ 818	NIRT 1A 802 ~ 878	NIRQ 1522 ~ 1578							
PD Series	PD1050	√	√	√	√		500		4700		16 bits	0.2%	N/A
	PD1080 PD2080	√	√	√	√		350		3500			0.2%	N/A
PD-NIR Series	PD2570					√	High Gain 2500	Low Gain 4000	High Gain 5600	Low Gain 8200		0.2%	N/A

*1. The dynamic range is calculated using the upper limit dark noise value of multiple spectrometers.

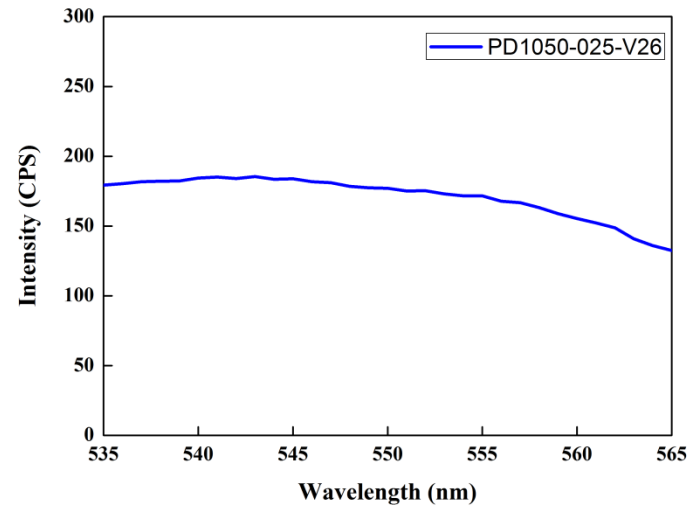► **1.2 Wavelength Response Curve**
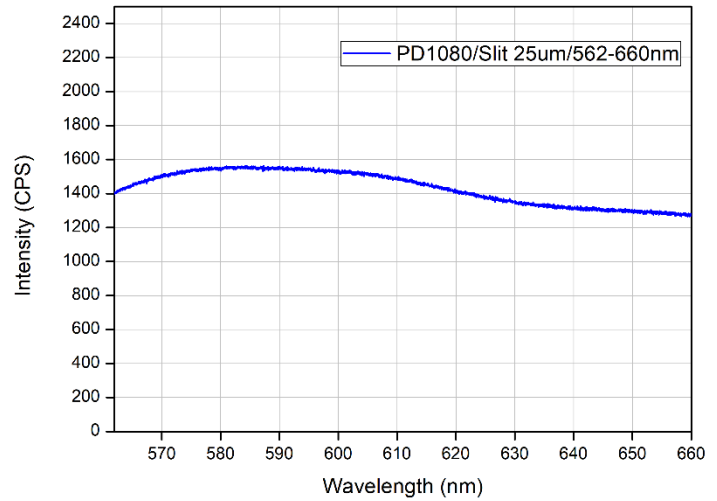
Fig. 1 : PD1050-025-V26 with Halogen lamp
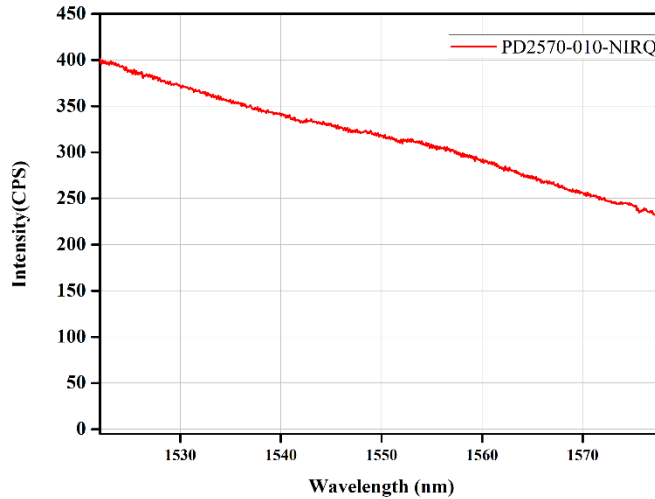
Fig. 2 : PD2080-010-V25 with Halogen lamp

Fig. 3 : PD2570-010-V26 with Halogen lamp

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■ Key Features

► 2.1 Characteristics

- PD Series: Wavelength range for LIBS application, 535~565nm, 535~650nm. Wavelength range customizable from 400 to 1000nm.
- PD-NIR Series: Wavelength range for LIBS application, 1522~1578 nm. Wavelength range customizable from 900 to 1700nm.
- High resolution PD-V25 & PD-V30 <0.1nm @slit 10um.
    - PD-V32 <0.35nm@slit 25um
    - PD-NIRQ <0.25nm@slit 10um
- A variety of sensor can be chosen for specific application:
    - □ 2048 Pixels CCD Sensor
    - □ 4096 Pixels CMOS Sensor
    - □ 512 Pixels InGaAs Sensor
- Customizable modular components: grating, sensor, and inlet slit
- Integration time: PD1050: 5ms~65s, PD1080: 0.1ms~65s, PD2570: 0.1ms~24s
- 16 bit, 15MHz A/D converter
- USB 2.0 @ 480 Mbps (High Speed)
- An 8-pin external I/O port 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

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► 2.2 Specifications

Features	Specifications		
	PD1050	PD1080/2080	PD2570
Sensor	2048 Pixel CCD	4096 Pixel CMOS	512 Pixel InGaAs
Dark noise (Average)	14	19	High Gain / Low Gain: 11 / 7
SNR	500	350	High Gain / Low Gain: 2500 / 4000
Dynamic Range	4700	3500	High Gain / Low Gain: 5600 / 8200
Wavelength Range	535~565 nm, 535~650 nm customizable from 400 to 1000nm		1522~1578nm customizable from 900nn-1700nm
Optical system characteristics	f/#: 5, NA: 0.1 Effective focal length (R1-R2): 85-101.5mm		
Optical design	Czerny-Turner optical design, 2nd and 3rd harmonics removed		
Dimensions	180 (L) x 175 (W) x 60.7 (H) mm		
Grating	1500g 600nm / 2400g 300nm		830g 1200nm
Slit width	10/25μm		
Integration time	5ms~65s	0.1ms~65s	0.1ms~24s
Resolution (FWHM)	Depends on the combination of slit, grating, and wavelength range depends		
Fiber optic interface	SMA905, FCPC		
Environmental requirements — Storage temperature	-30°C to +70°C		
Environmental requirements — Operating temperature	0°C to +50°C		
Environmental requirements — Relative Humidity	0% - 90% non-condensing		
Data transfer interface	USB 2.0 @ 480 Mbps		
Power specifications	Power supply: 300mA at +5 VDC, Voltage: 4.75-5.25		

■ Mechanical Designs
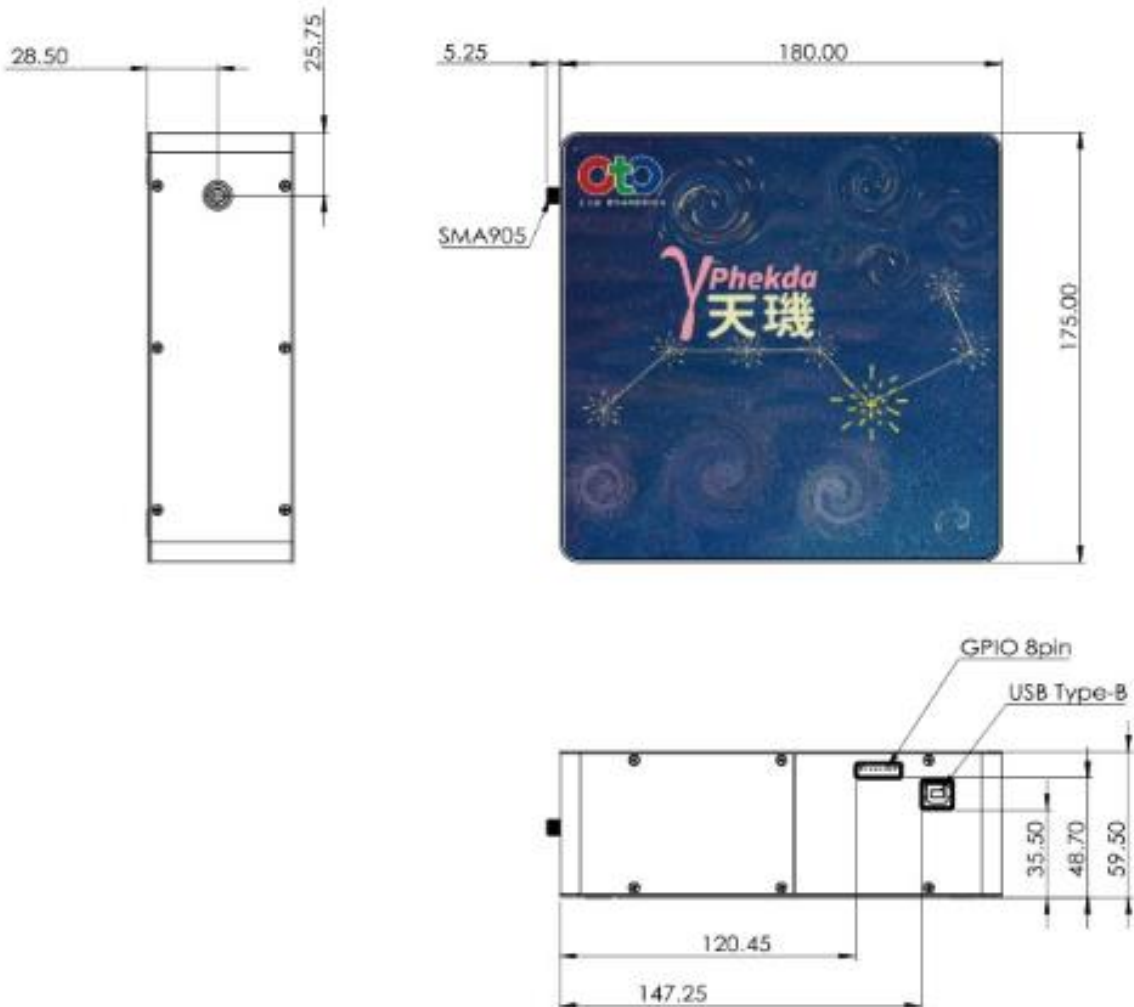
► 3.1 Outlines and Dimensions

Figure 4. PD & PD-NIR series outlines and dimensions

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► **3.2 Electronic Output Pin Assignments**

The PD & PD-NIR 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
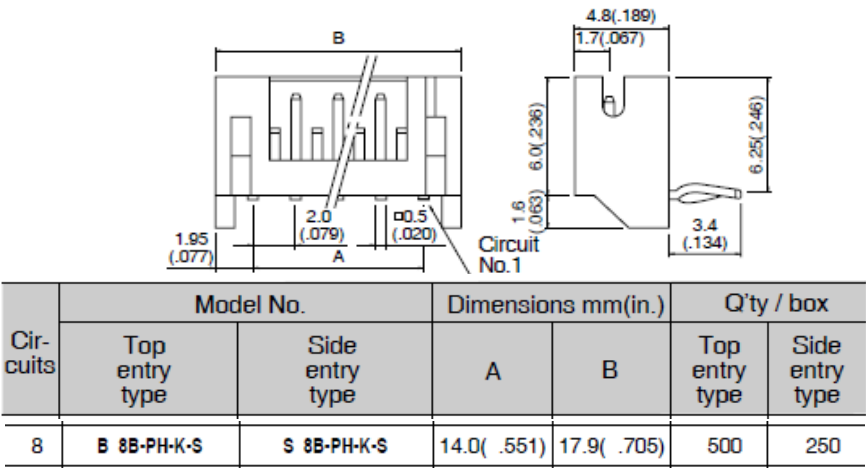
Figure 5. The 8-pin 2.0 mm rear external I/O port

- **External Ports**

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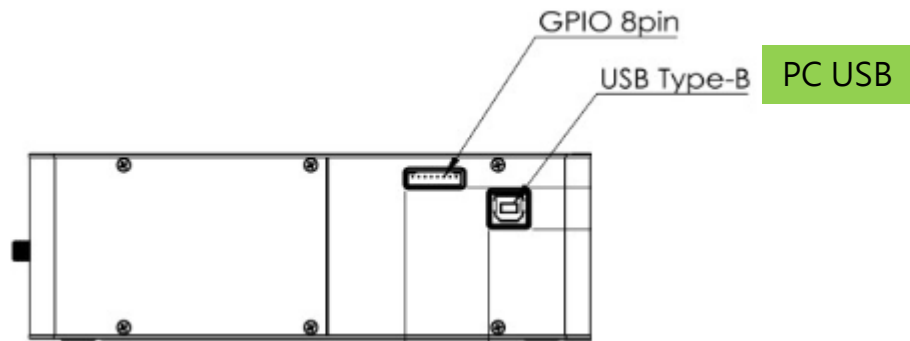

Figure 6. External ports on the PD & PD-NIR Series

- **Rear Extension Port Pin# Description Alt Function**

#Pin	Direct	Pin name	description
1	Power	5V Input/Output	When connecting to PC USB port, this pin is also connected to VBUS. This pin can provide around 0.1A power for external device.
2	Output	TX	UART TX. TX is the output from the RISC controller.
3	Input	RX	UART RX. RX is the input for the RISC controller.
4	Output	GPIO0	General Purpose Output 0.
5	Output	GPIO1	General Purpose Output 1.
6	Output	LS_ON	Light Source Turn ON.
7	Input	Trigger_IN	External Trigger Input Signal.
8	GND	GND	GND

► **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 PD & PD-NIR 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 PD & PD-NIR 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 PD & PD-NIR Series spectrometers. The energy-saving PD & PD-NIR Series can be powered via a USB cable over its VBUS line.
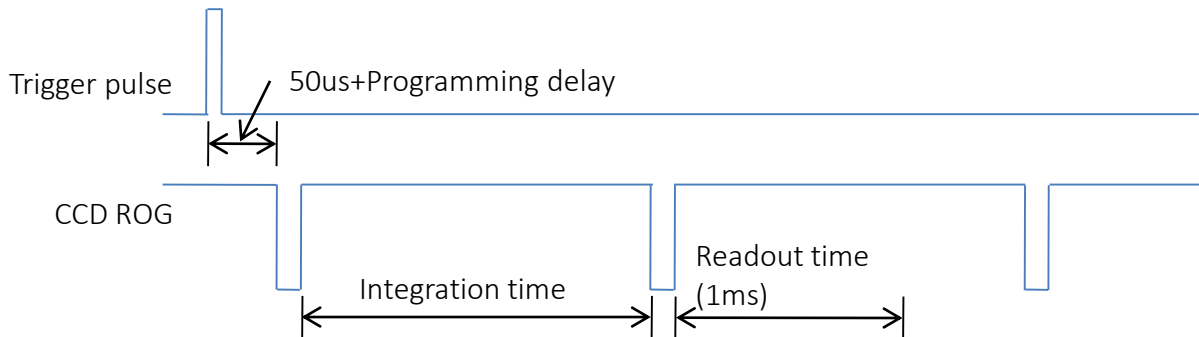
► **4.3 Trigger Modes**

● **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.

Trigger pulse

50us+Programming delay

CCD ROG

Integration time

Readout time (1ms)

● **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.

Trigger Level

CCD ROG

....
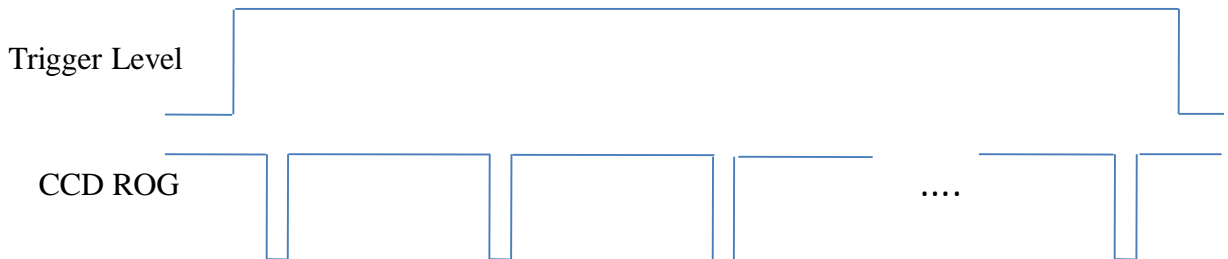
● **Software trigger/multiple capture**

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.

Trigger Level

CCD ROG

....
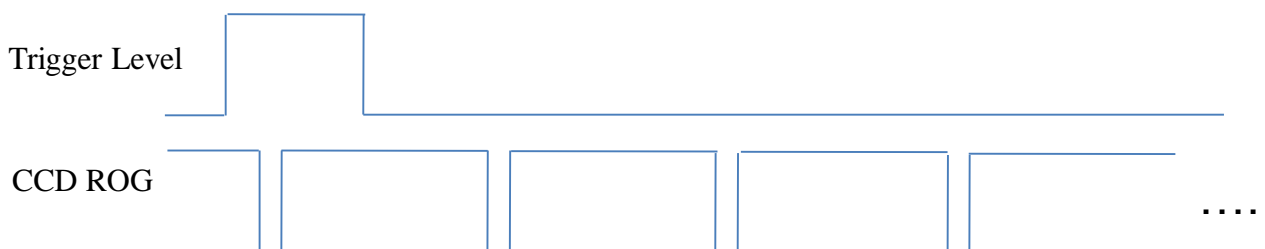
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■ USB Data Transfer and Controls

► Overview

The PD & PD-NIR 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 PD & PD-NIR 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 PD & PD-NIR 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

PD & PD-NIR Series USB Vendor ID: 0x0638; Product ID: 0x0AAC
The PD & PD-NIR 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 PD & PD-NIR Series Spectrometer

Description: Connecting the computer to an PD & PD-NIR Series spectrometer.

a. Function name: UAI_SpectrometerOpen

b. Parameters:

- **dev:** Since one computer can connect up to eight PD & PD-NIR 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 PD & PD-NIR 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.

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❑ Acquire Spectrum

Description: Starting to acquire the spectrum. The PD & PD-NIR 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 PD & PD-NIR 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 PD & PD-NIR 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 PD & PD-NIR Series Spectrometer

Description: Disconnect the computer from the PD & PD-NIR 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.