OtO Photonics

Phekda Series

Phekda-NIR Series Product Sheet

Introduction

The Phekda (PD) and Phekda-NIR (PD-NIR) series spectrometers combine CCD/CMOS or InGaAs sensors in a Transmissive-Reflection-Transmissive (T-R-T) Czerny-Turner optical design.

PD and PD-NIR models deliver high resolution, high sensitivity, low dispersion, and high speed - making these spectrometers ideally suited for a range of high resolution applications.

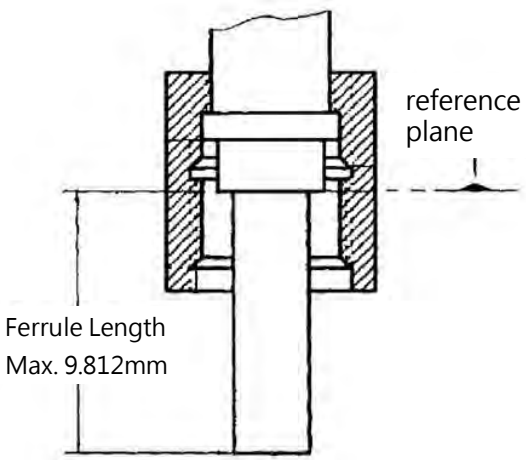
Phekda's compact and rigid optical bench design provides a stable measurement platform offering excellent thermal and humidity cycling performance, together with minimum variation of resolution and wavelength shift due to shock and vibration.

The PD & PD-NIR series are powered by USB connection with a computer and can be operated using OtO Photonics' SpectraSmart GUI spectral measurement software, which comes with a full software development kit (SDK).

In addition, these spectrometers provide an interface with six I/O pins for connecting external devices.

Example code for other operating systems is available along with a full DLL library and comprehensive software support.

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.
	The SMA905 connectors on all spectrometers made by OtO Photonics are manufactured in accordance with international standards. Customers should ensure that the ferrule length of the fiber used is no 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	V30	V36	V32	NIRT 1A	NIRT 20	NIRQ							
		535 ~ 650	548 ~ 658	535 ~ 685	625 ~ 818	802 ~ 878	840 ~ 1050	1522 ~ 1578							
PD Series	PD1030	√	√	√		√	√		350		4600(2.5MHz) /3100(10MHz)		16 bits	N/A	N/A
	PD1110	√	√		√	√			500		4700			0.2%	N/A
	PD1080 PD2080	√	√		√	√			350		3500			0.2%	N/A
PD-NIR Series	PD2570							√	High Gain	Low Gain	High Gain	Low Gain		0.2%	N/A
									2500	4000	5600	8200			

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

► 1.2 Wavelength Response Curve

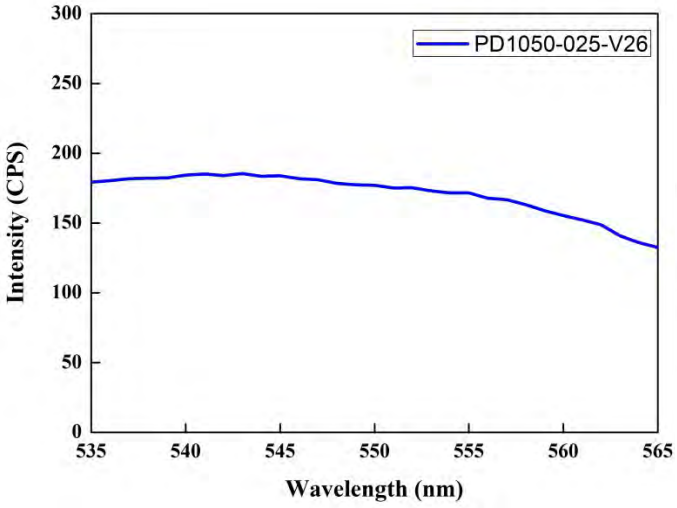


Fig. 1： PD1050 with Halogen lamp

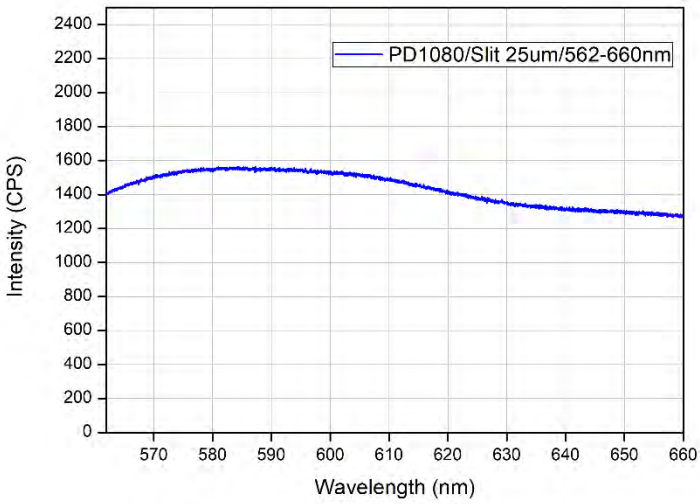


Fig. 2： PD2080 with Halogen lamp

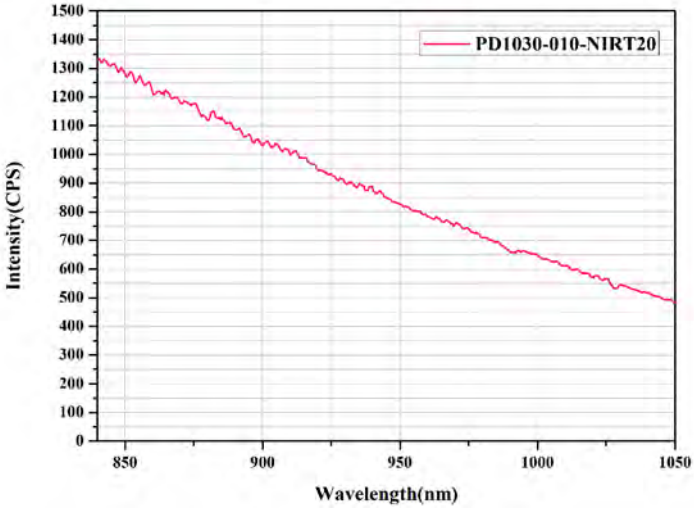


Fig. 3： PD1030-010-NIRT20 鹵燈響應

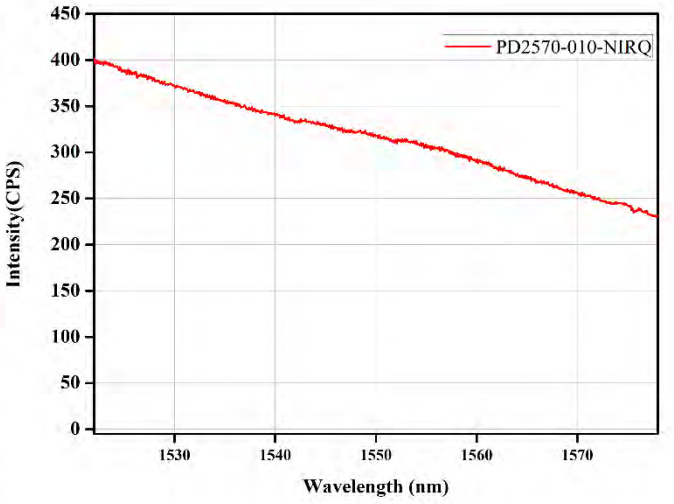


Fig. 4： PD2570-010-NIRQ with Halogen lamp

Key Features

2.1 Characteristics

- PD Series: Wavelength range for LIBS application, 535~565nm, 535~650nm. Wavelength range customizable from 400 to 1100nm.
- 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/CMOS Sensor
  - 4096 Pixels CMOS Sensor
  - 512 Pixels InGaAs Sensor
- Customizable modular components: grating, sensor, and inlet slit
- Integration time: PD1050: 5ms~65s, PD1030/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

► 2.2 Specifications

Features		Specifications				
		PD1030	PD1050	PD1080/2080	PD2570	
Sensor		2048 Pixel CMOS	2048 Pixel CCD	4096 Pixel CMOS	512 Pixel InGaAs	
Dark noise (Average)		14(2.5MHz) 21(10MHz)	14	19	High Gain: 11	Low Gain: 7
Dynamic Range		4600(2.5MHz) /3100(10MHz)	4700	3500	High Gain: 5600	Low Gain: 8200
SNR		350	500	350	High Gain: 2500	Low Gain: 4000
Wavelength Range		customizable from 400 to 1000nm			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				
Slit width		10/25μm				
Integration time		0.1ms`65s	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				
	Operating temperature	0°C to +50°C				
	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

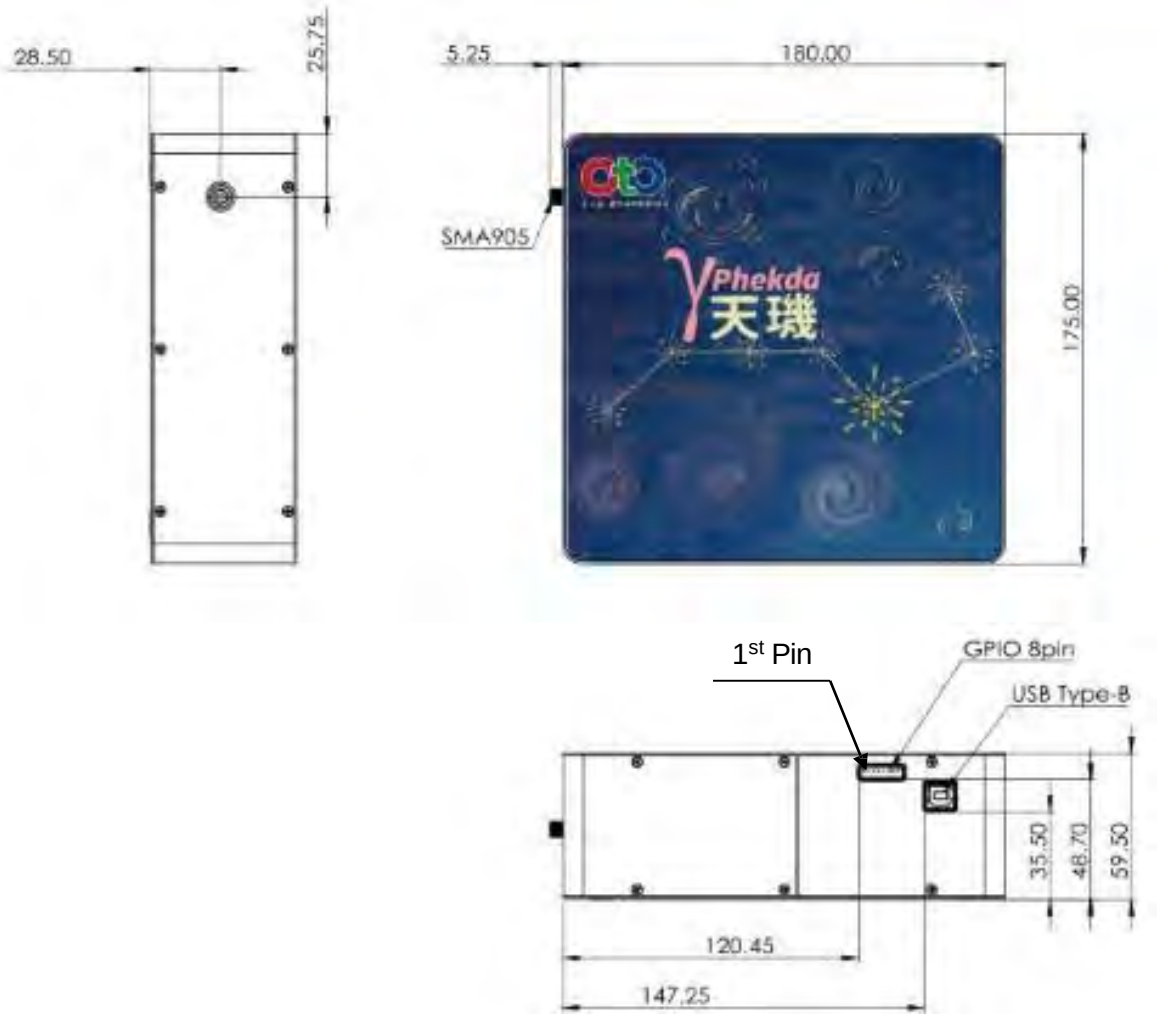
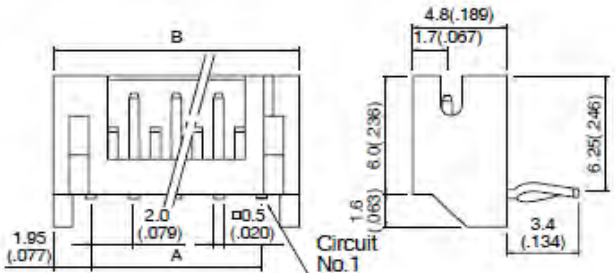


Figure 5. PD & PD-NIR series outlines and dimensions

► 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 6. 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.

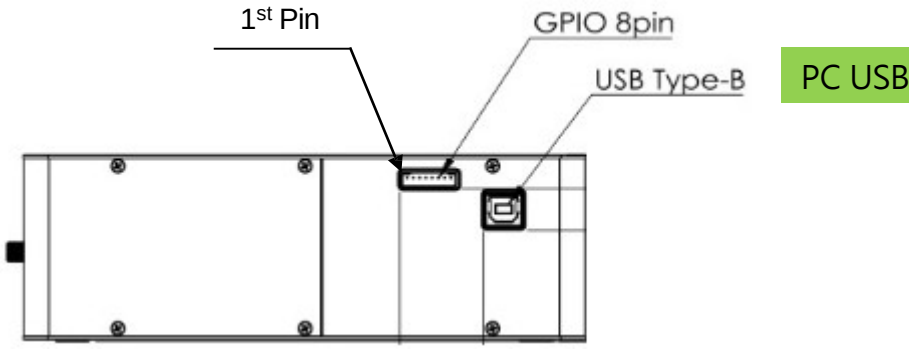


Figure 7. External ports on the PD & PD-NIR Series

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.

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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.

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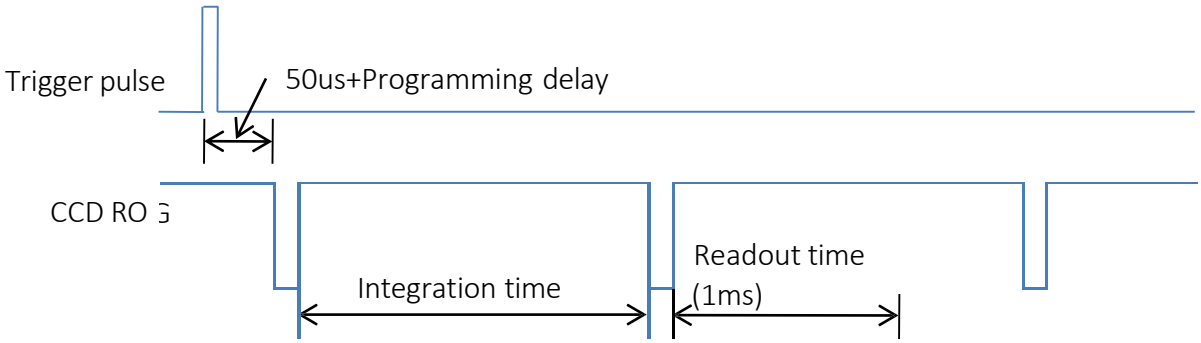
► 4.3 Trigger Modes

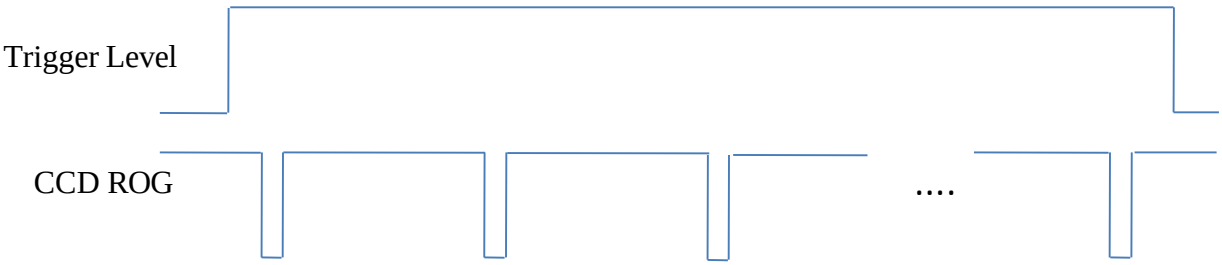
- **Single trigger/single capture**

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.



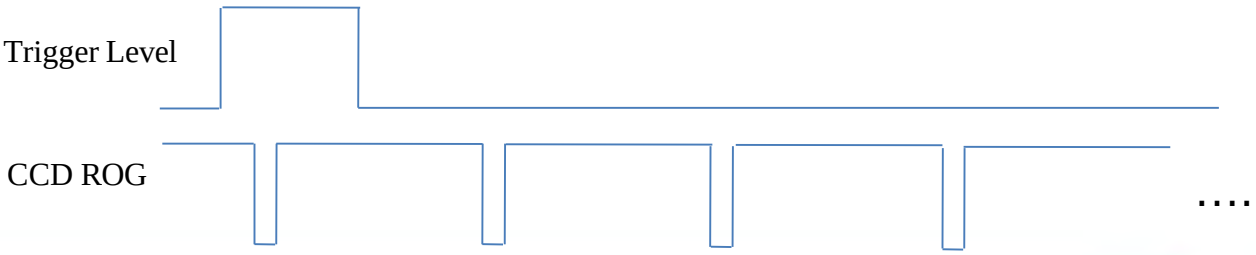
- **Software trigger**

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.



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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

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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.