# OtO Photonics

## Pocket Hawk - Near-infrared (PH-NIR) Series Product sheet

### Description

PH-NIR Series spectrometer is built with the InGaAs linear array sensor and 32bits RISC controller. By simplification of the optical engine and specific sensor, the further miniaturized spectrometer is achieved. External MB type of PH-NIR Series can be chosen to enhance heat dissipation. The compact size and various of screw holes is very flexible for system integration.

PH-NIR Series spectrometer is constructed by the Crossed Czerny-Turner optical design and can provide the high optical resolution, high sensitivity, low stray light, and fast spectral response.

The electronics system is powered by USB port and PH-NIR Series communicates with the PC through the USB port. It also provides 8 pin or 4pin I/Os for external interface extension.

PH-NIR Series electronics operation is controlled by the RISC controller. So the user can communicate to the main program through the PC software and the protocol provided by OtO Photonics.
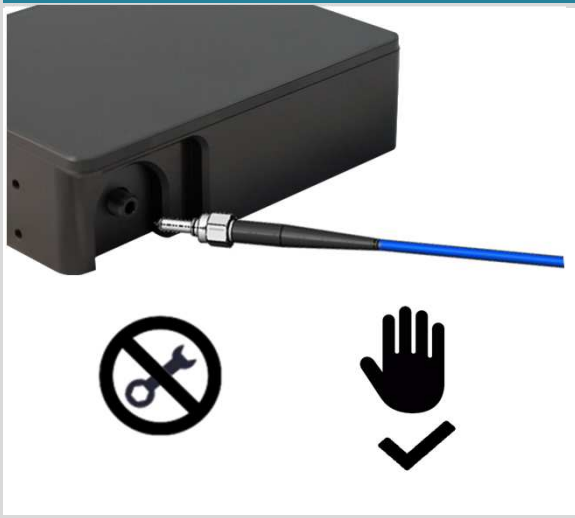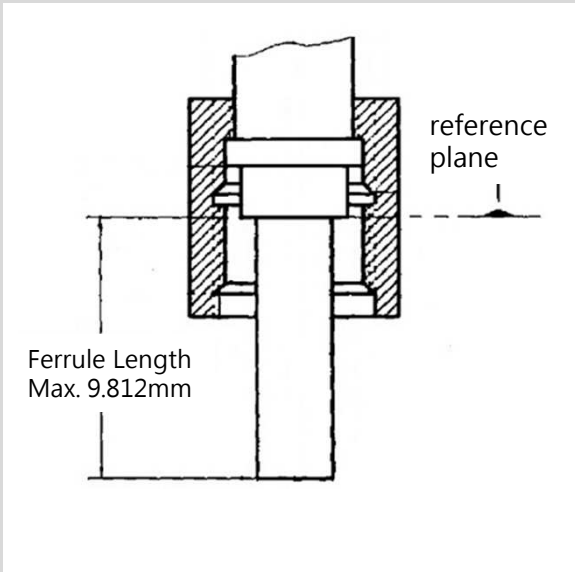
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## Pocket Hawk - Near-infrared (PH-NIR) Series

## Attention

| Picture | Description |
|---|---|
|  | To prevents over tightening and <u>damaging of the slit</u> 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.<br><br>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 <u>IEC 874-2:1993</u> 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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## Pocket Hawk - Near-infrared (PH-NIR) Series

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## Pocket Hawk - Near-infrared (PH-NIR) Series

## ■ Main Features

### ► 1.1 Feature

- Wavelength range : from 900 to 1700 nm
- Optical resolution (PH25x4): from 5 to 30 nm, depending on the combination of various slits and gratings
- InGaAs linear array sensor
- Modular configuration with various slit options
- Integration times from 100μs to 15sec
- 16 bit, 15MHz A/D Converter
- Micro USB 2.0 @ 480 Mbps (High speed)
- 4pin customized USB connector
- 8-pin connector for interfacing to external
  - □ 6 user programmable digital I/O
- Plug-n-play interface for PC application
- Extremely precise continuous multiple exposures, providing up to 4,000 spectra buffering
- Flash ROM storage for
  - □ Wavelength Calibration Coefficients
  - □ Linearity Correction Coefficients
  - □ Intensity Calibration Coefficients

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## Pocket Hawk - Near-infrared (PH-NIR) Series

► **1.2 Specification**

| SPEC | | Content | |
|---|---|---|---|
| | | **PH2524** | **PH2534** |
| Sensor | | InGaAs linear sensor 128 Pixels | InGaAs linear sensor 256 Pixels |
| Parameters of Optical System | | f/# : 4.5, NA :0.11, Focal Length(R1-R2) :39-44 (It is recommended that the Incident NA should larger than the NA of spectrometer.) | |
| Dark Noise (Upper Limit) | High Gain | 15 | |
| | Low Gain | NA | |
| Dynamic Range (avg.)[1] | High Gain | 6250 | |
| | Low Gain | Na.(>7200) | |
| SNR (Single acquisition) | High Gain | 2000 | |
| | Low Gain | 6000 | |
| Spectrometer | | Crossed Czerny-Turner Optical Structure  2nd & 3rd order rejection | |
| Dimension | | 65(L) x 65(W) x 29.8(H) mm | |
| Grating | | 2 grating options | |
| Wavelength | | 900-1700nm | |
| Slit Size | | 50, 100, 200 um | |
| Integration Time | | 100μs ~ 15 sec , depending on the sensor type | |
| Wavelength Repeatability | | +/- 0.2 nm (Argon lamp 100 times) | |
| Wavelength accuracy | | <±1.5nm | |
| Resolution(FWHM) | | From  5 nm  to  30 nm, depending on different configuration | |
| Thermal Stability | | <0.069nm/℃ | |
| Environment Conditions | Storage | -30℃ to +70℃ | |
| | Operation | 0℃ to +50℃ | |
| | Humidity | 0% - 90% non-condensing | |

*1 : 65535/Dark Noise(average)

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## Pocket Hawk - Near-infrared
## (PH-NIR) Series

| Interfaces | Micro USB 2.0 @ 480 Mbps (High speed) |
|---|---|
| Input Fiber Connector | SMA905: Φ3.20±0.01mm |
| | |
| Recommend Tightening Torque | 0.15 Nm ( Mating Part : 5mm thick, Flatness 0.1mm, Aluminum sheet) |
| Power | Supply voltage: 4.75V-5.25V |

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## Pocket Hawk - Near-infrared (PH-NIR) Series
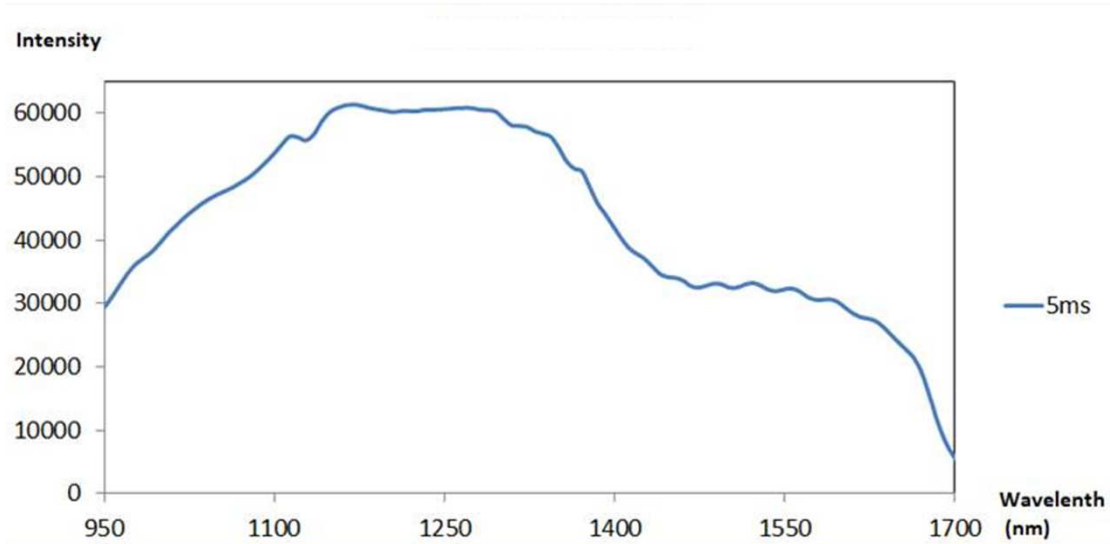
► **1.3 Wavelength Response**



**Fig. 1: PH2524  Wavelength Response**

► **1.4 Lineup of PH-NIR Series**

| Model | Spectral  Response Range (nm) | | Sensor | SNR[1] | | A/D | Stray Light | Thermal Stability |
|---|---|---|---|---|---|---|---|---|
| | NIRC1/C2 | | | Low Gain Mode | High Gain Mode | | | |
| | 900 ~ 1700 | | | | | | | |
| PH2524 /PH2534 | √ | | InGaAs Sensor | 6000 | 2000 | 16 bits | <0.2% | < 0.069nm/℃ |

*1 : Single acquisition

## Pocket Hawk - Near-infrared
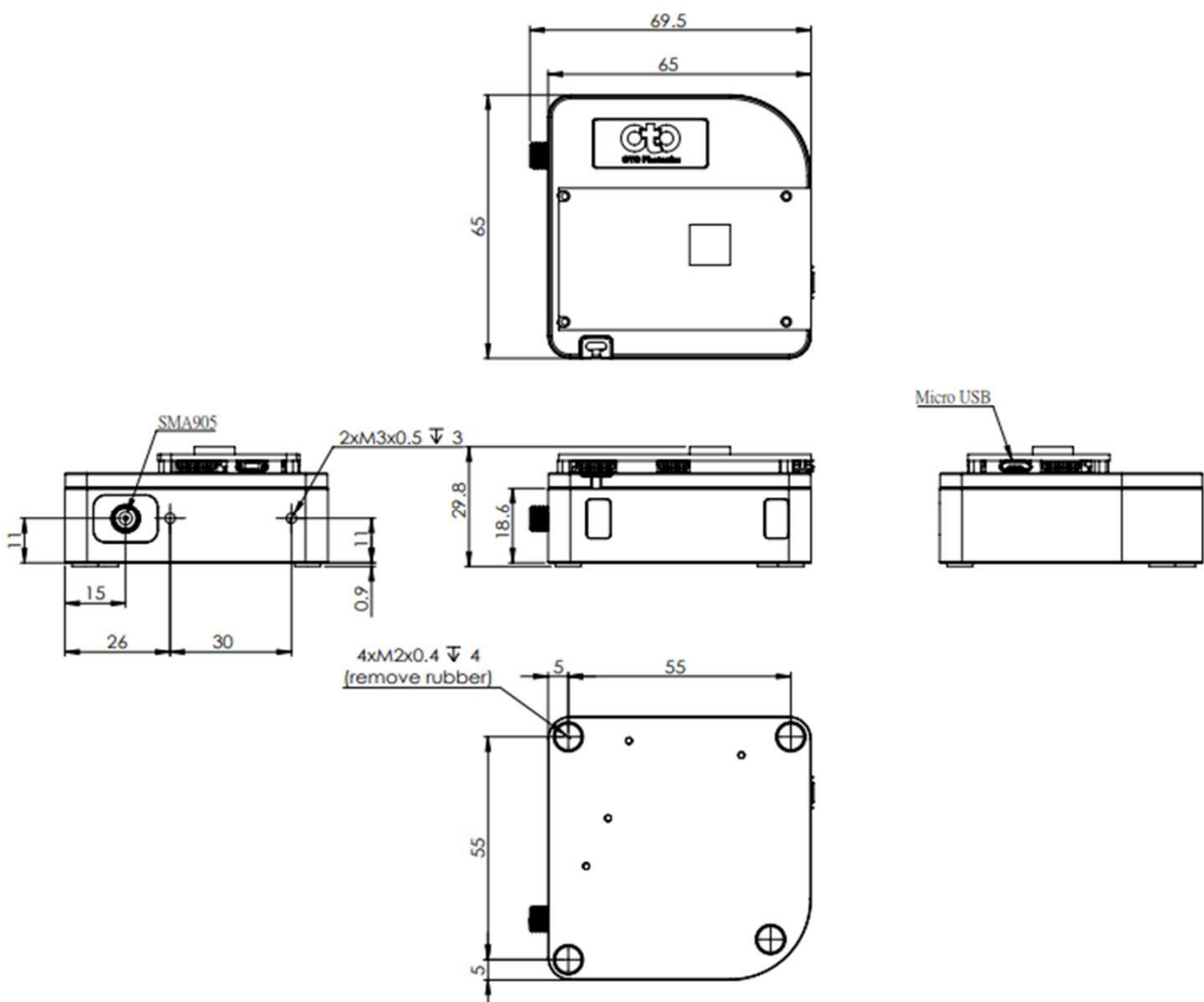## (PH-NIR) Series

## ■ Structure

► **2.1 Mechanical Diagram**



**Fig. 2: PH-NIR outer dimensions**

► **2.2 Electrical Pinout**

The following listed is the pin description for the PH-NIR Series Extension Connectors. There are two Extension Port (8 pin 1.0mm connector for GPIO, one of them is for OtO debug use), one Micro USB, one USB(4 pin, for special use)

● **Pin orientation**

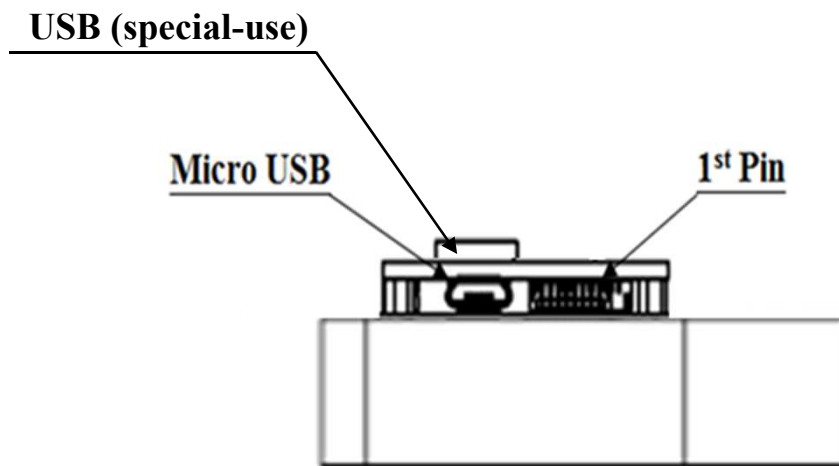Looking PH-NIR Series connector side, from right to left are GPIO Extension Port, Micro USB, USB

**USB (special-use)**

**Micro USB**          **1st Pin**

Fig. 3 : PH-NIR Series: the front-view of connector mechanical graph

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## Pocket Hawk - Near-infrared (PH-NIR) Series

### Back Extension Port Pin# Description Alt Function

*All I/Os are TTL-level input/output

| Pin No. | Direction | Pin Name | Function Description |
|---------|-----------|----------|----------------------|
| 1 | Power | 3.3V | 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 |
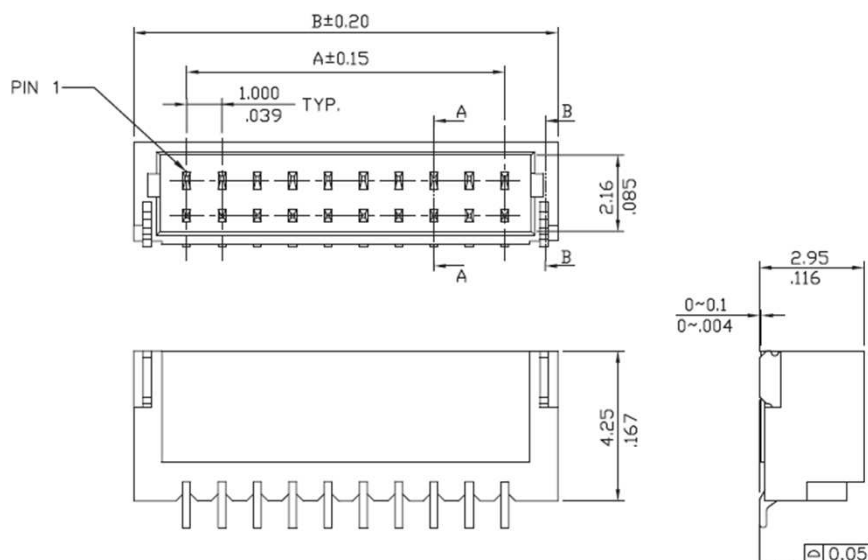


**Fig. 4 : Back Extension Port 1.0 mm 8 pin drawing**

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## Pocket Hawk - Near-infrared (PH-NIR) Series

**USB Port (Special –use)**
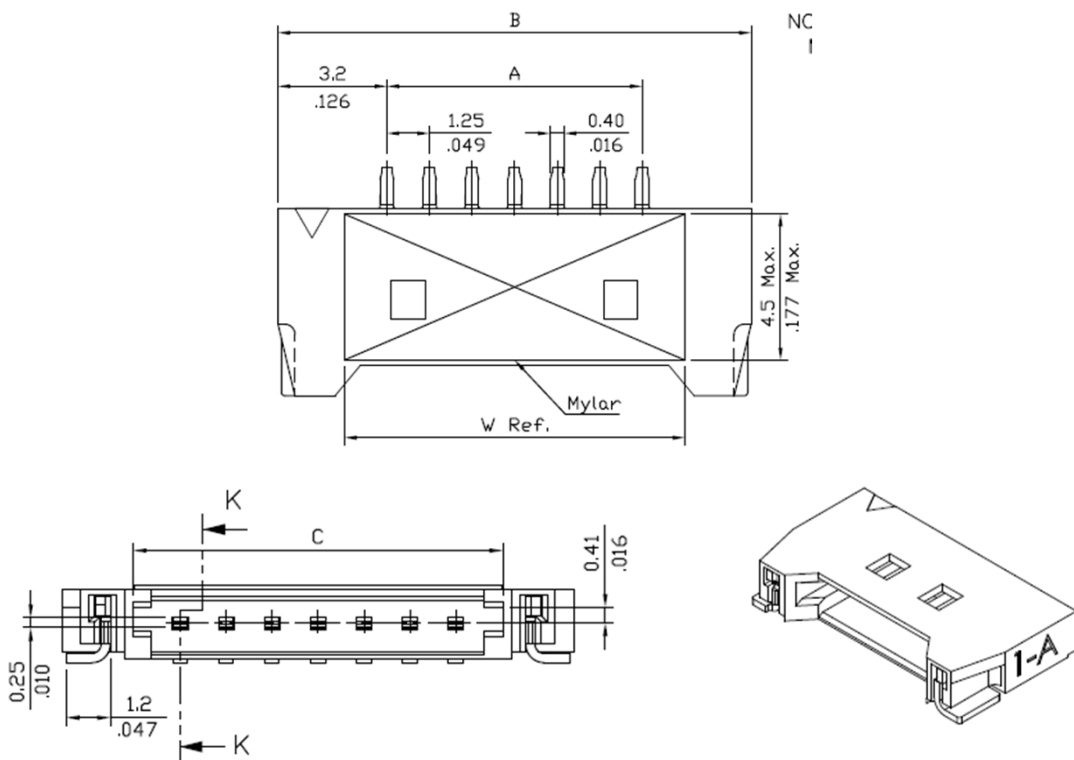


**Fig. 5: USB(Special-use) 1.0 mm 4 pin drawing**

☐ **Pin# Description**

| Pin No. | Direction | Pin Name |
|---------|-----------|----------|
| 1 | +3.3V | +3.3V |
| 2 | Data- | USB- |
| 3 | Data+ | USB+ |
| 4 | GND | GND |

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► **3.5 Sensor Overview**

● **InGaAs DETECTOR**

InGaAs sensor is high sensitive in NIR region. The linear array type is suitable for quick and accurate spectrum measurement. A built-in timing generator and clock-drivers ensure single 5V power supply for use.
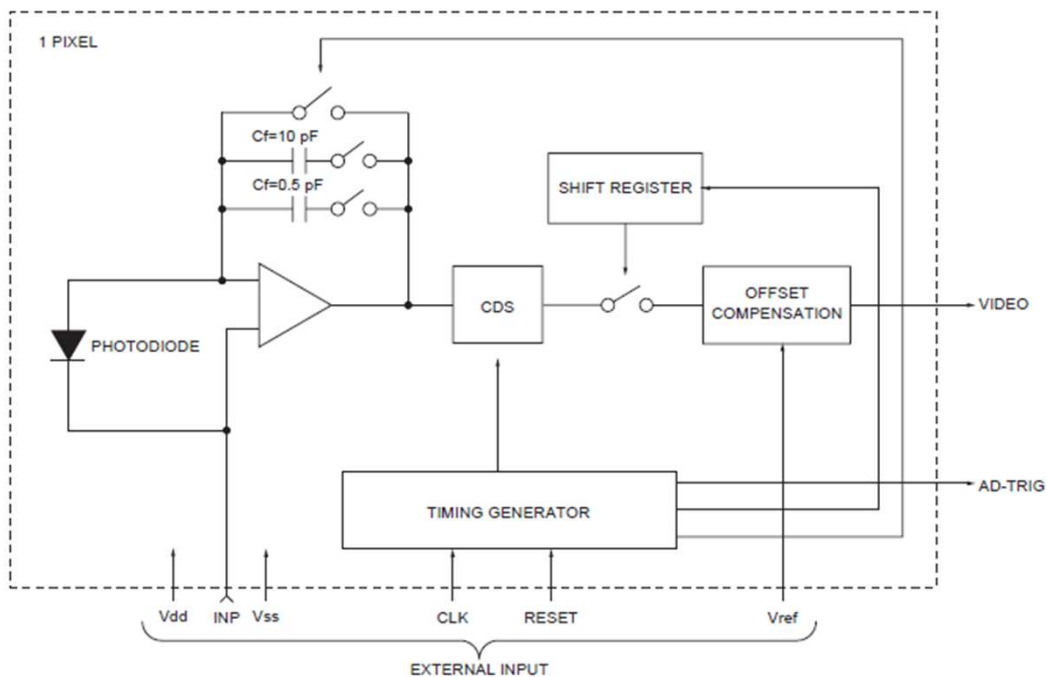


**Fig. 6: InGaAs Sensor Block Diagram**

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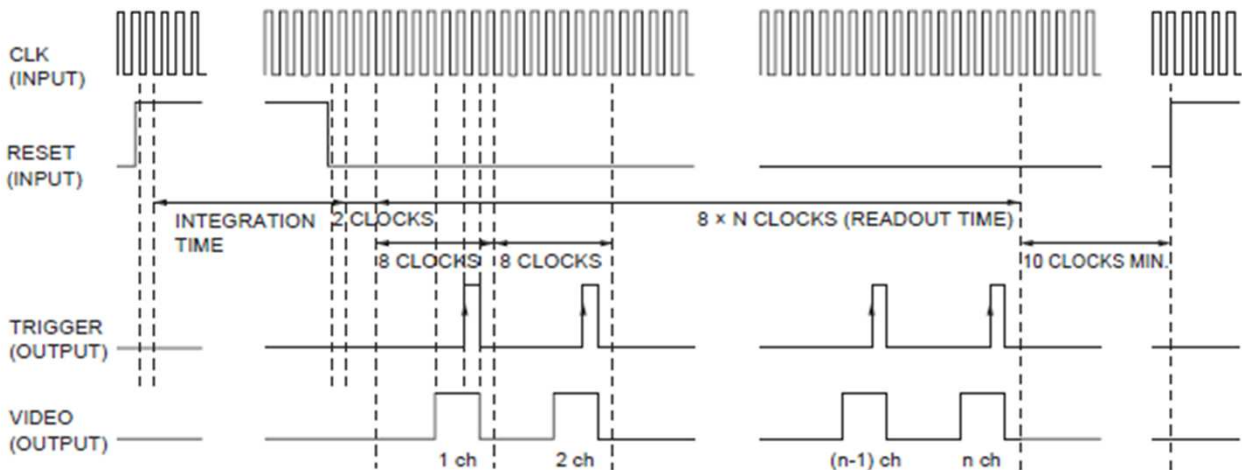## Pocket Hawk - Near-infrared
## (PH-NIR) Series



**Fig.7: InGaAs sensor operation timing waveform**

The output signal is proportion to the integration time. When the light power or integration time is long enough to fully charge the pixel, the sensor output will be saturated. Per the characteristic of the sensor, the over-saturated condition may cause the abnormal response.

### ● CCD/SYSTEM NOISE

There are three major sources impact the Vout signal reading. One is the light source stability, the second is the electronics noise, and the other is CCD detector noise. If we don't consider the outer light source influence, we can check the dark noise performance of this system first. The dark noise we define here is the RMS of Vout signal under 1ms integration time in dark condition. So the dark noise will be only contributed by electronics readout noise and the CCD sensor.

The other major parameter to define the noise performance is the SNR. The SNR we define here is the ratio of the full signal (65535 counts) to the RMS value under the full signal condition. The higher SNR performance indicates the readout signal is more stable. It will be helpful for the low signal differentiation.

### ● SIGNAL AVERAGING

The software-SpectraSmart provides two options for the signal curve operations. The first one is the signal averaging. By the averaging method, we can reduce the noise impact on each pixel. Surely, more sampling points will bring the better averaging performance. But it will need more time to get one spectra. When we use the time-base type of signal averaging, the S:N increases by the square root of the number of samples. Thus, a S:N is readily 10x achieved by averaging 100 spectra.

The other curve smoothing is boxcar filter. It can average the adjacent points to show the smoother curve, but it will lower optical resolution. So if the target signal is peak type, the boxcar may not be suitable for this.

These two methods can be enabled at the same time if the measurement target is suitable for this operation. But if the user would like to check all the original data and performance, time-based average or boxcar smoothing needs to be un-checked. The default setting for these two average methods is un-checked.

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## Pocket Hawk - Near-infrared (PH-NIR) Series

## ■ Internal Operation

### ► 3.1 Pixel Definition

The baseline signal is around 1,000 counts in our current system. We can provide the tool/command to manually adjust the baseline. (adjust the AFE OFFSET) The other baseline adjustment method is to enable the background removal from the software. It depends on the user how to use the baseline. Normal output signal is not obtained immediately after device switch on. Use the output signal added 22500 pulses or above to CLK clock pulse.

● The following is a description of all of the pixels

| Pixel | Description |
|-------|-------------|
| 1–13 | Dummy pixels |
| 14–31 | Optical black pixels |
| 32 | Dummy pixels |
| 33–3032 | Optical active pixels |
| 3033-3038 | Dummy pixels |

### ► 3.2 Digital Inputs & Outputs

● **General Purpose Inputs/Outputs (GPIO)**

PH-NIR Series has 6 user programmable 3.3V digital Input/Output pins, which can be accessed at the 8-pin Extension connector. Through software, the state of these I/O pins can be defined and used for multi-purpose applications. If the user needs the special timing generation (like single pulse or PWM), PH-NIR Series provides the flexibility to implement this.

## ■ USB Port Interface Communications and Control Information

### ► 4.1 Overview

PH-NIR Series is a microcontroller-based Miniature Fiber Optic Spectrometer that can communicate via the Universal Serial Bus. This section contains the necessary programming information for controlling PH-NIR Series via the USB interface. This information is only pertinent to users who wish to not utilize SpectraSmart software to interface to PH-NIR Series.

### ● Hardware Description

PH-NIR Series utilizes a 32 bit RISC controller built in USB 2.0. Program code and data coefficients are stored in SPI Flash. The RISC controller supports 32 MByte DDR and 64 Mbits Flash.

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## Pocket Hawk - Near-infrared (PH-NIR) Series

● **INSTRUCTION SET**

**Application Programming Interface**

The list of the APIs is shown in the following table followed by a detailed description of each function call.

☐ **Open PH-NIR Series Spectrometer**

Description: To connect Windows host to PH-NIR Series

**a.Function Name:** UAI_SpectrometerOpen

**b.Arguments:**

**dev:** 8 PH-NIR Series spectrometers can be attached to one host at the same time. dev is the device number to specify which one will be opened.

**handle:** the unique Windows identifier to operate devices. Windows will return the identification number which is necessary for further operation.

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☐ **Query Frame Size**

Description: To get the data frame size of the spectrometer.

**a.Function Name:** UAI_SpectromoduleGetFrameSize

**b.Arguments:**

**device_handle:** a pointer to the device information structure which is returned

when device open.

**size:** a 16-bit unsigned integer will be returned to indicate the data length.

☐ **Acquire Wavelength**

Description: Initiates a wavelength acquisition. PH-NIR Series will acquire a complete wavelength distribution.

**a.Function Name:** UAI_SpectrometerWavelengthAcquir**e**

**b.Arguments:**

**device_handle:** a pointer to the device information structure which is returned when

device open.

**buffer:** the storage buffer acquired data.

# Pocket Hawk - Near-infrared
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☐ **Acquire Spectra**

Description: Initiates a spectra acquisition. PH-NIR Series will acquire a complete

intensity distribution which corresponds to the wavelength which is acquired by

OtO_UAI_SpectrometerWavelengthAcquire.

a. **Function Name:** UAI_SpectrometerDataAcquire

b. **Arguments:**

 **device_handle:** a pointer to the device information structure which is
 returned when

 device open.

 **integration_time_us:** a 32-bit unsigned variable to determine the
 integration time

 of the micro-seconds.

 **buffer:** the storage buffer acquired data.

 **average:** the spectrum could be averaged by several continuous
 acquisitions to

 reduce the noise.

☐ **Query Wavelength Range**

Description: To get the minimum and maximum wavelength

a. **Function Name:** UAI_SpectromoduleGetWavelengthStart

 **Function Name:** UAI_SpectromoduleGetWavelengthEnd

b. **Arguments:**

 **device_handle:** a pointer to the device information structure which is
 returned when

 device open.

 **lambda:** a 32-bit floating type data which is indicate the minimum or
 maximum

 wavelength, in nm, of PH-NIR Series will be returned.

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## Pocket Hawk - Near-infrared
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☐ **Query Integration Time Range**

Description: To get the minimum and maximum integration time.

**a.Function Name:** UAI_SpectromoduleGetMinimumIntegrationTime

    **Function Name:** UAI_SpectromoduleGetMaximumIntegrationTime

**b.    Arguments:**

    **device_handle:** a pointer to the device information structure which is returned when

    device open.

    **Integration Time:** a 16-bit integer type data which indicates the minimum or

    maximum integration time of PH-NIR Series will be returned. The minimum integration

    time is in micro-second and the maximum Integration time is in milli-second.

☐ **Close PH-NIR Series Spectrometer**

Description: To connect Windows host to PH Series

**a.Function Name:** UAI_SpectrometerClose

**b.Arguments:**

    **handle:** the unique Windows identifier to operate devices.  Windows will detach

    the device and any operation is invalid after this function is executed.