OtO Photonics

SideWinder™ Series

Product sheet

Description

SW (Sidewinder™) Series spectrometer ,built with the InGaAs type sensor and high performance 32bits RISC controller in, is specially designed for long wavelengths range. The optical engine is very simple and optimized for the spectrometer. The optical bench is very rigid and stable for measurement system, especially SW series has outstanding stability of thermo-hygro variation, vibration and shock on resolution and wavelength shift performance. The compact size is very flexible for system integration.

SW 5 Series : SW25X0 (900-1700nm)
SW 8 Series : TECooling version SW28X0 (900-1700nm)
SW 9 Series : TECooling version SW29X0 (900-2500nm)

The electronics system is powered by USB port and SW Series communicates with the PC through the USB port. It also provides 6 I/Os for external interface extension.

The optical detector used in SW Series spectrometer is a high-sensitivity InGaAs linear sensor. We provide the related information and the detailed instructions of how to operate with SW Series in this guide.

SW Series electronics operation is controlled by the RISC controller. So users can communicate to the main program through the PC software and the protocol provided by OtO Photonics.

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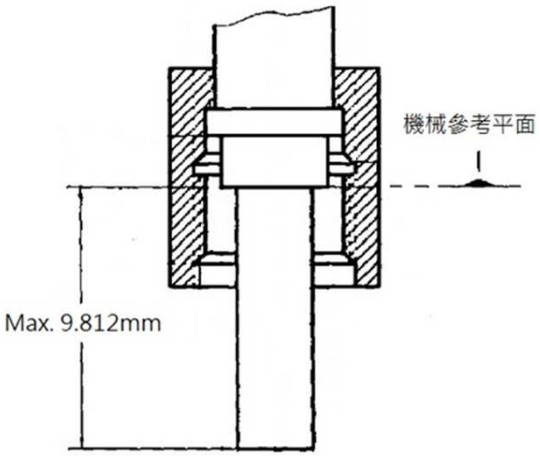
Attention

#	Picture	Description
1		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.
2		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.
3	According to the notification from Hamamatsu Photonics, there will be 0~5% defect pixels in the linear image sensor. On the defect pixel, spectral response is noun-uniformity and readout noise or dark current is out of the specification. Once we found the defect pixels, we will inform customer before product shipping and provide technical advisory service. Defect Pixel≤1% : SE2560, SW2570, SW2860, SW2870 Defect Pixel≤2% : SW2520 Defect Pixel≤5% : SW2960	

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Overview

► 1.1 Lineup of SW Series

Model		Spectral Response Range (nm) NIRC 900 ~ 1700	Spectral Response Range (nm) NIRD 900 ~ 2500	Sensor type	SNR*1 (Single acquisition) High Gain	SNR*1 (Single acquisition) Low Gain	Dynamic Range*2 (Single acquisition) High Gain	Dynamic Range*2 (Single acquisition) Low Gain	A/D	Stray Light*4	Thermal Stability
SW 5 Series	SW2520	√		InGaAs Sensor	2000	4000	4100	6000	16 bits	<0.2	<0.2
	SW2560	√			2800	5400	6000	8700			<0.1
	SW2570	√			2600	4300	5850	8200			
SW 8 Series	SW2860	√		InGaAs TEC Sensor	3300	5500	7800	11000			
	SW2870	√			2800	3500	7700	9300			
SW 9 Series	SW2960*3		√		1600	3500	5600	7800		<0.45	<0.2

*1 : The value of SNR & Dynamic Range on the table above are obtained under microsecond or millisecond level of integration time. Dynamic Range=65535 / DarkNoise (Measurement Condition : TECooled @ 0。C)

*2 : The performance of TECooling will be more obvious under long integration time. (SW2960 Measurement Condition : Integration Time 100us, Sensor TECooled @-20。C)

*3 : Due to the characteristic of the Sensor of SW2960, the performance of SNR and recommend integration time are both different with SW2860 or SW25X0.

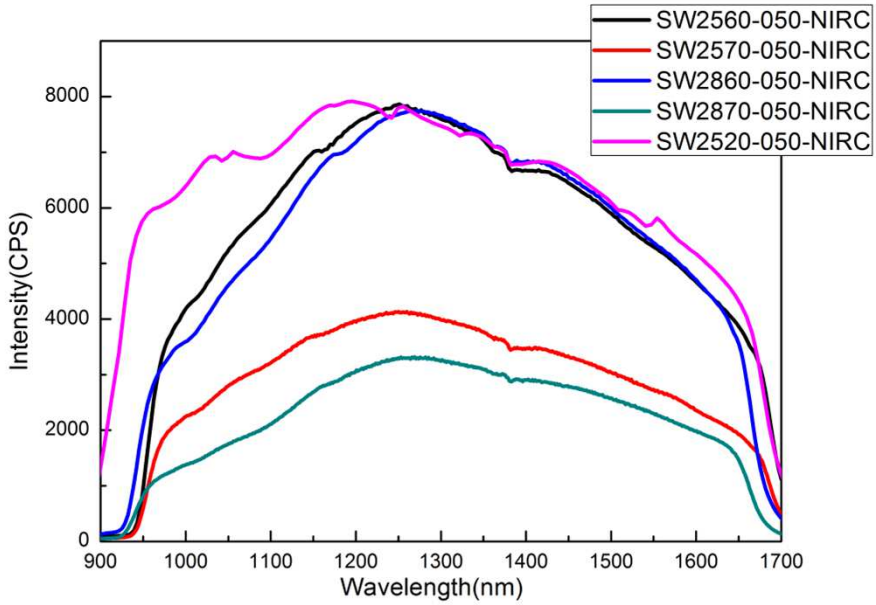
*4 : Stray light <0.2%, <0.45% at 1000nm, detected with FEL1300 longpass filter.

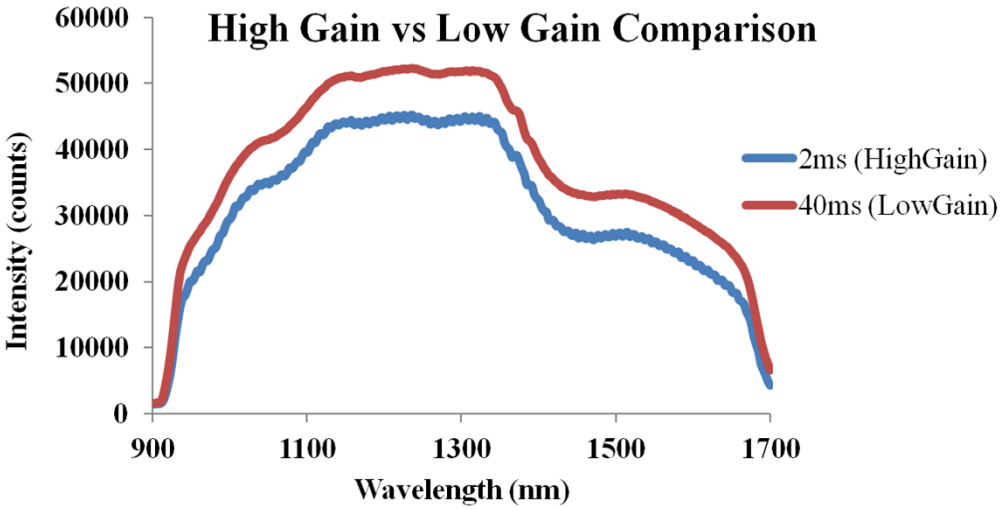
	Background	
	avg. counts @1sec	avg. counts @10sec
SW 8 Series	500	1000
SW 5 Series	1500	4000

*Lower Background is better.

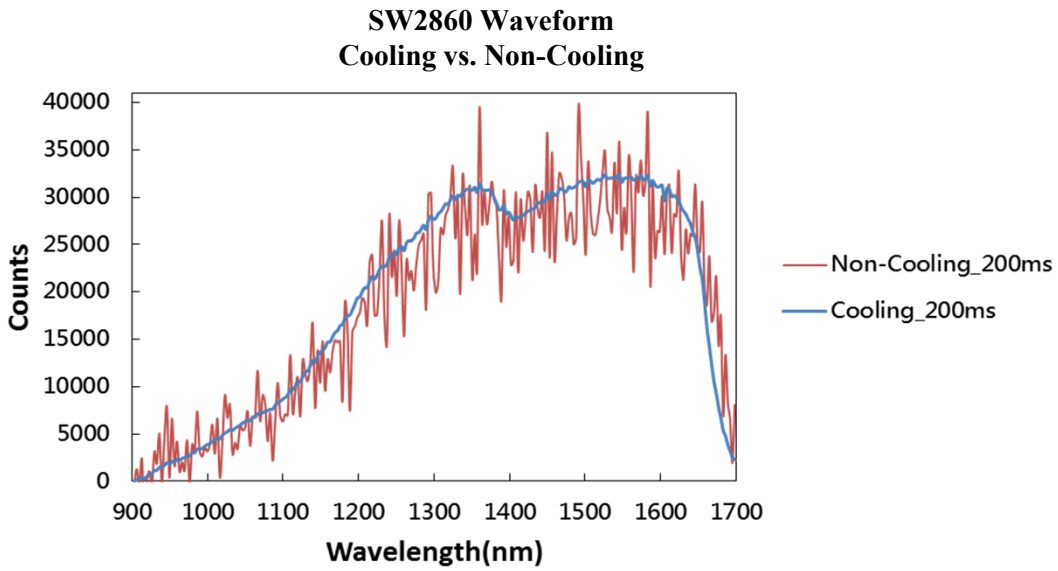
- As the table above, the Background of SW 8 are obviously better than SW 5 under long integration time.

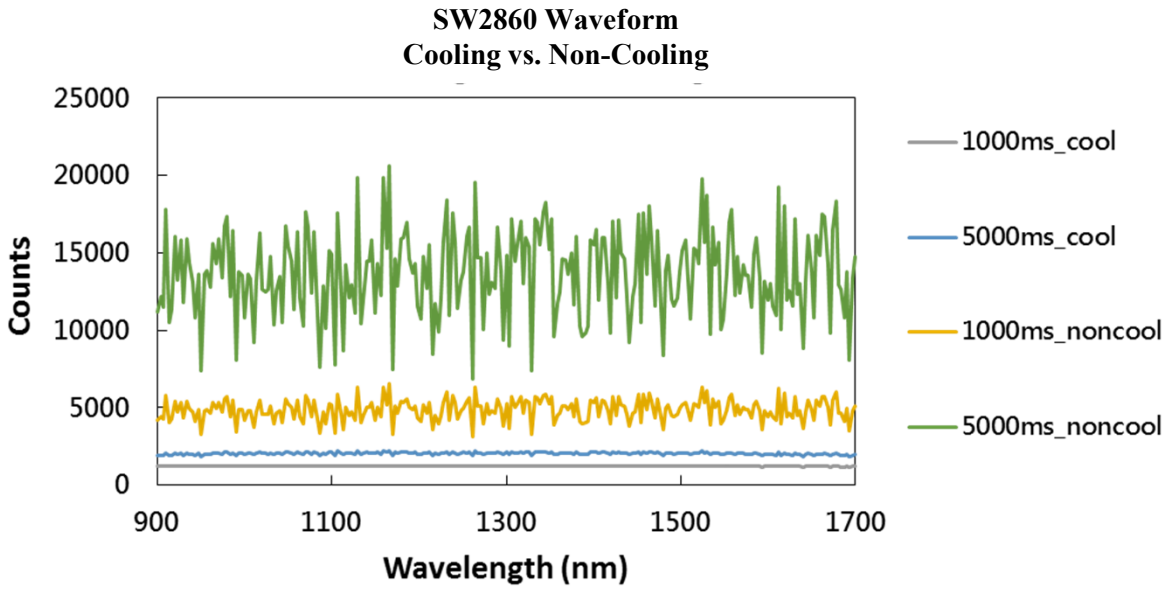
► 1.2 Efficiency Output





- SW series provide two different sensitivity modes for customers to choose from: (High Gain) and (Low Gain). As shown above, the average sensitivity of High Gain mode is about 18 times greater than counterpart of Low Gain mode, but SNR and dynamic range values are also adjusted in two different modes. Please refer to the chart in P2 1.1-1 ,SW series. In the High Gain mode, the maximum integration time we suggest customers to set up is 500ms. If customers did not specify when placing orders, the gain mode is preset to low gain mode when SW series are shipped.





- With TECooling, the noise resulted from long integration times can be significantly reduced and it result in smooth and normalized waveform. The Dark Noise decreased from >15000 count & >5000 count to 2000 count & 1000 count under integration time 1000ms & 5000ms.

Main Features

► 2.1 Feature

- Responsive wavelength range :

SW 5 & 8 Series (SW25X0、SW2860)_900~1700 nm

SW 9 Series (SW2960)_900~2500 nm

- Optical resolution: from 2 to 22 nm, depending on the combination of various slits, sensors and gratings.
- A variety of sensor can be chosen for specific application:
  - High SNR and high sensitivity 128-pixel InGaAs linear sensor
  - High SNR and high sensitivity 256-pixel InGaAs linear sensor
  - High SNR and high sensitivity 512-pixel InGaAs linear sensor
- Modular configuration with various grating, sensor, and slit options
- Integration times from 100 μs ~ 24 sec, depending on sensors
- 16 bit, 15MHz A/D Converter
- USB 2.0 @ 480 Mbps (High speed)
- 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
- TECooling
  - One Stage TEC: Default : 0 ◦ C at Ambient of 25 ◦ C
  - Two Stage TEC: Default : -20 ◦ C at Ambient of 25 ◦ C

► 2.2 Specification

Specification		Value					
		SW2520	SW2560	SW2570	SW2860	SW2870	SW2960
Sensor		128Pixel	256Pixel	512Pixel	256Pixel	512Pixel	256Pixel
		None-Cooling			One stage cooling		Two stage cooling
Spectrometer		SW series; Czerny-Turner Optical Layout, 2nd & 3rd order elimination					
Dimension		110(L) x 86(W) x 32.4(H) mm			130(L) x 96(W) x 58.3(H) mm		
Parameters of Optical System		f/# : 5, NA :0.1, Focal Length(R1-R2) :60-60 (It is recommended that the Incident NA should larger than the NA of spectrometer.)					
Wavelength		900-1700 nm					900-2500nm
Slit (um)		50/100/150	50/100/ 150/200	25/50/100 /150/200	50/100/150 /200	25/50/100/ 150/200	50/100
Integration time	High Gain	100μs ~ 15sec, depending on sensors			100 μs ~ 24s		100us-20ms
	Low Gain				100 μs ~ 24s		100us-200ms
Dark Noise*1 (Upper Limit)	High Gain	13.5	14	14	14		15(average, High Gain)
	Low Gain		10	10	10		12(average, Low Gain) (@100us, -20 ◦ C)
SNR (Single acquisition)	High Gain	2000	2800	2600	3300 (0 ◦ C)	2800	1600 (100us, -20 ◦ C)
	Low Gain	4000	5400	4300	5500 (0 ◦ C)	3500	3500 (100us, -20 ◦ C)
Dynamic range (avg.)*2	High Gain	4100	6000	5850	7800	7700	5600 (100us, -20 ◦ C)
	Low Gain	6000	8700	9200	11000	9300	7800 (100us, -20 ◦ C)
Wavelength repeatability		+/- 0.2 nm, Continuous 100 measurements (Ar Light Source)					
Wavelength accuracy		± 1 nm (Testing environment is based on SW2530-050-NIRA's parameter, and accuracy may be up to ± 1.5nm according to different environment such as severe temperature change and long-time vibration. OtO can provide wavelength calibration software if customers needed.)					

*1 : Dark Noise under High Gain *2:DynamicRange=65535/Dark Noise(average), Single acquisition

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Specification		Value				
		SW2520	SW2560	SW2570	SW2870	SW2960
Thermal stability		<<0.2nm/℃				
Environmental Conditions	Storage	-30˚C to +70˚C				
	Operation	0˚C to +50˚C				
	Humidity	0% - 90% non-condensing				
Interfaces		USB 2.0 @ 480 Mbps (High speed)				
Input fiber connector		SMA905: Φ3.18±0.005mm				
		SMA905: Φ3.20±0.01mm				
Power		Power requirement (master): 300mA at +5 VDC Supply voltage: 4.75-5.25 Power-up time : < 4s Maximum USB input power Vcc : +5.25VDC Maximum I/O signal voltage : +5.5VDC			Power requirement (master): 350mA at +5 VDC DC Jack for TEC : 1300mA at 5VDC	Power requirement (master): 350mA at +5 VDC DC Jack for TEC : 2200mA at 5VDC

- Customized design for your various special requirements including higher resolution, specific wavelength range, higher SNR, special gratings or sensors not in the list, specific software or hardware design, or special exposure modes, is welcome and will be elaborately built and tested by our R&D team.

Structure

► 3.1 Mechanical Diagram

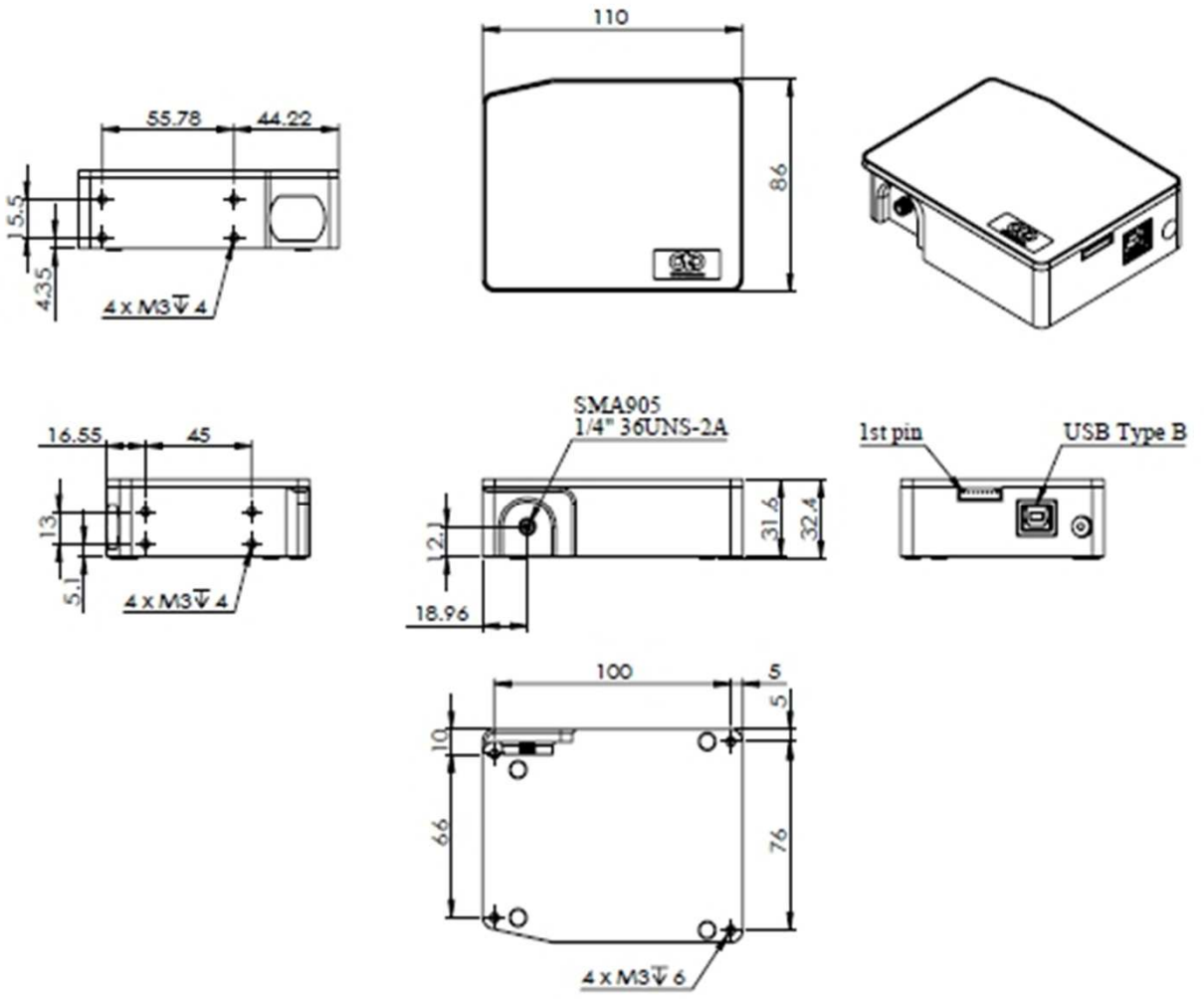

Fig. 1: SW 5 Series outer dimensions(TYPE I)

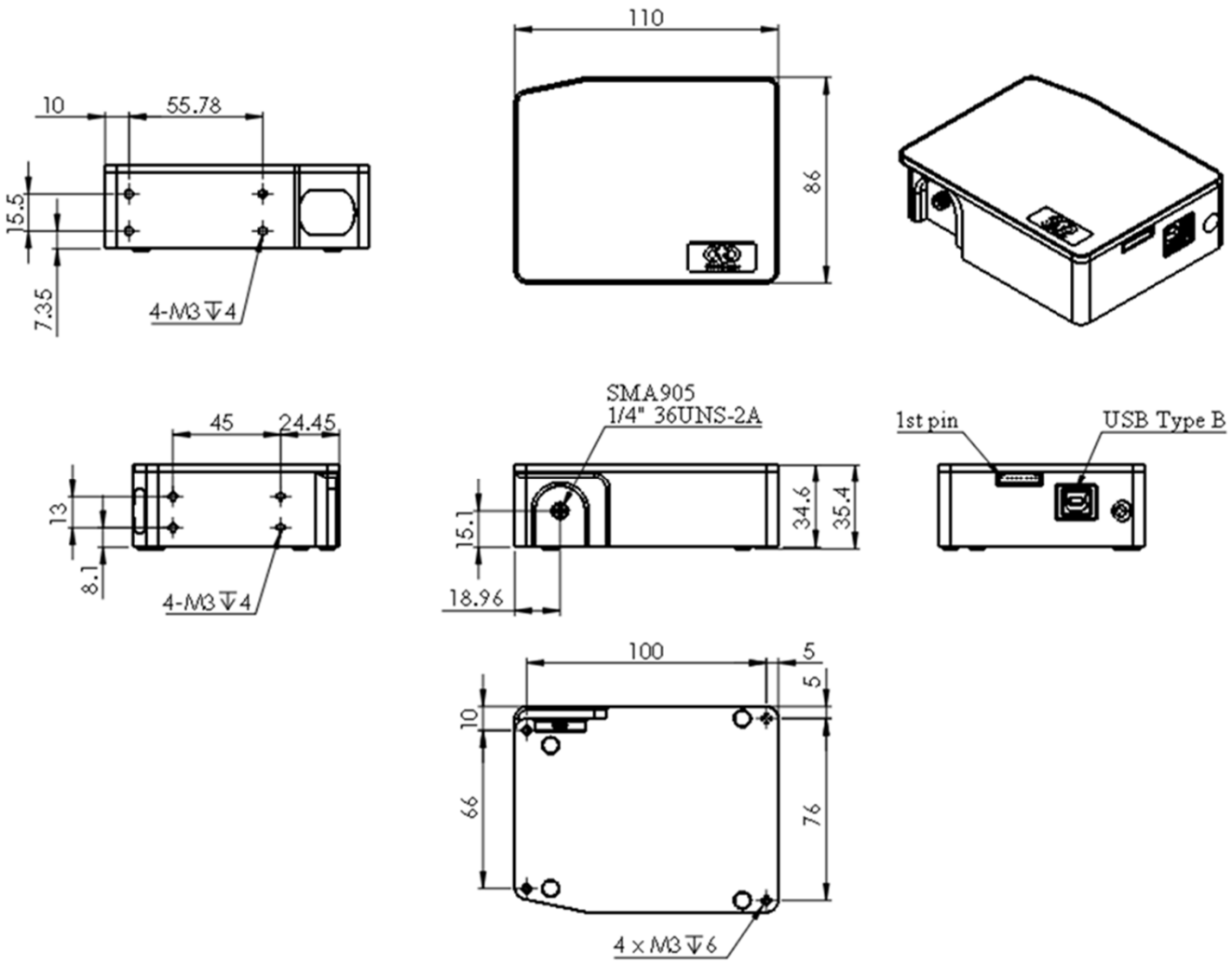

Fig. 2: SW 5 Series outer dimensions(TYPE II)

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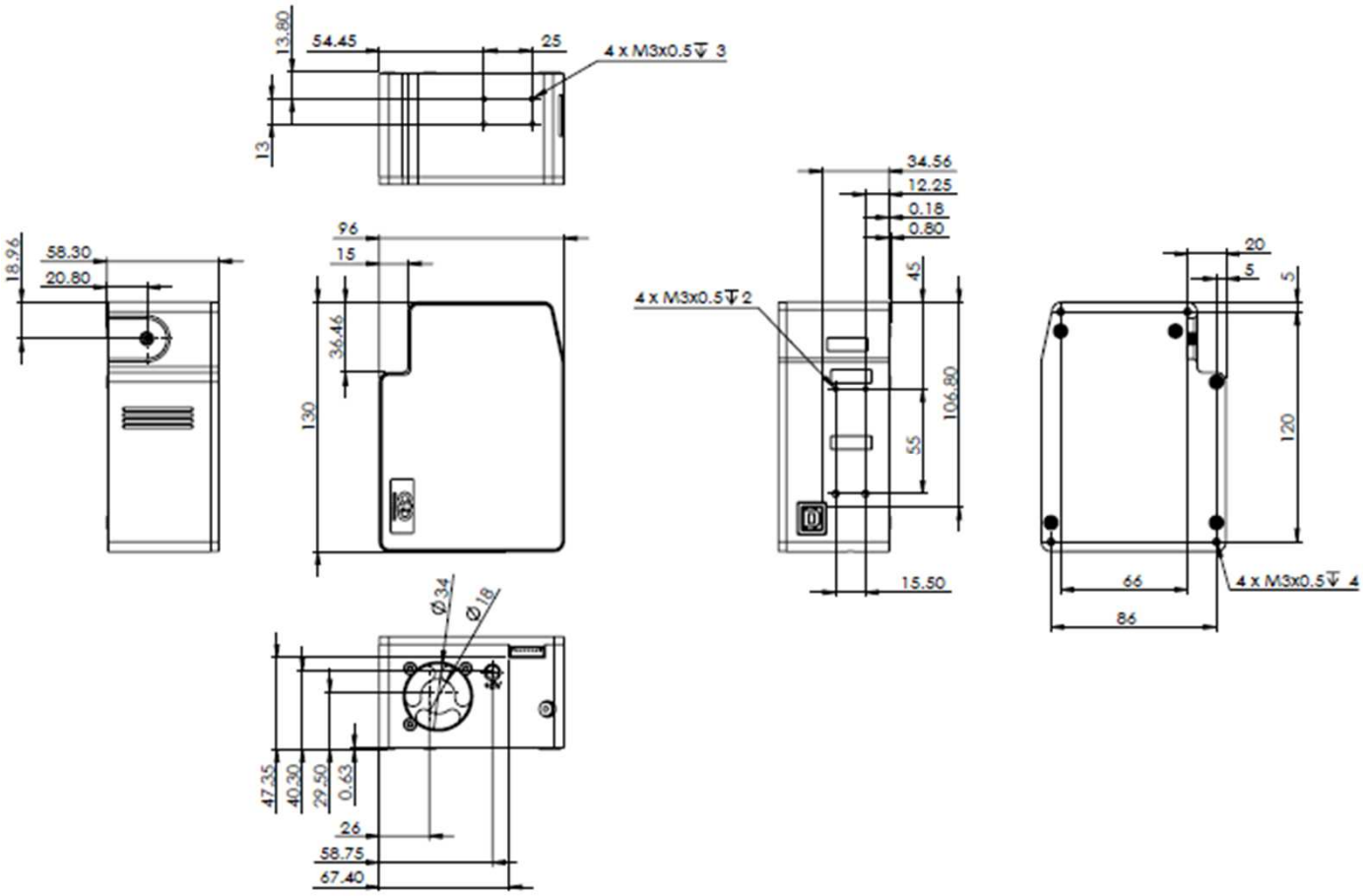

Fig. 3: SW 8 & 9 Series outer dimensions

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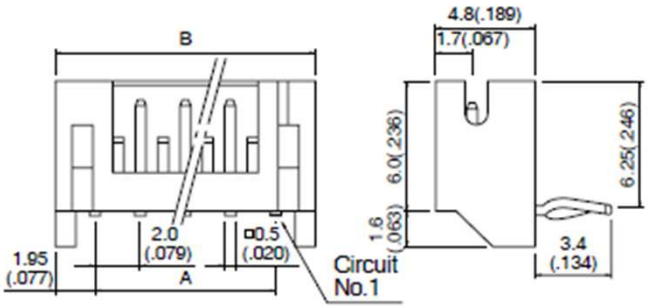
► 3.2 Electrical Pinout

The following list is the pin description for the SW Series Extension Connectors. The Back Extension Port is a 8 pin 2.0mm connector.

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

Fig. 4 : Back Extension Port 2.0 mm 8 pin drawing

Back Extension Port Pin# Description Alt Function

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

Pin No.	Direction	Pin Name	Function Description
1	Power	5V 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

- **Pin orientation**

Looking at Front of SW Series connector side, from left to right are Back Extension Port and PC USB.

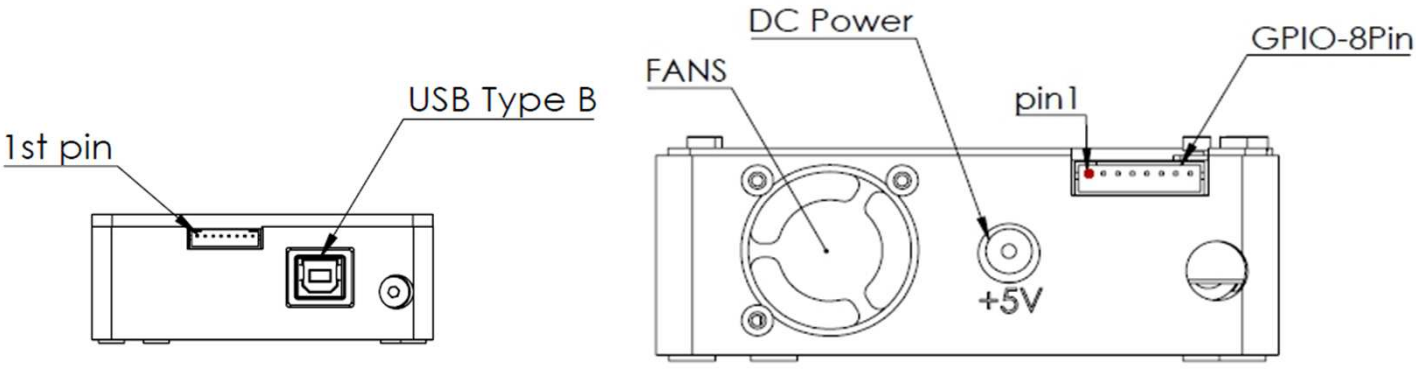


Fig. 5 : SW Series the front-view of connector mechanical graph

► 3.3 Detector 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.

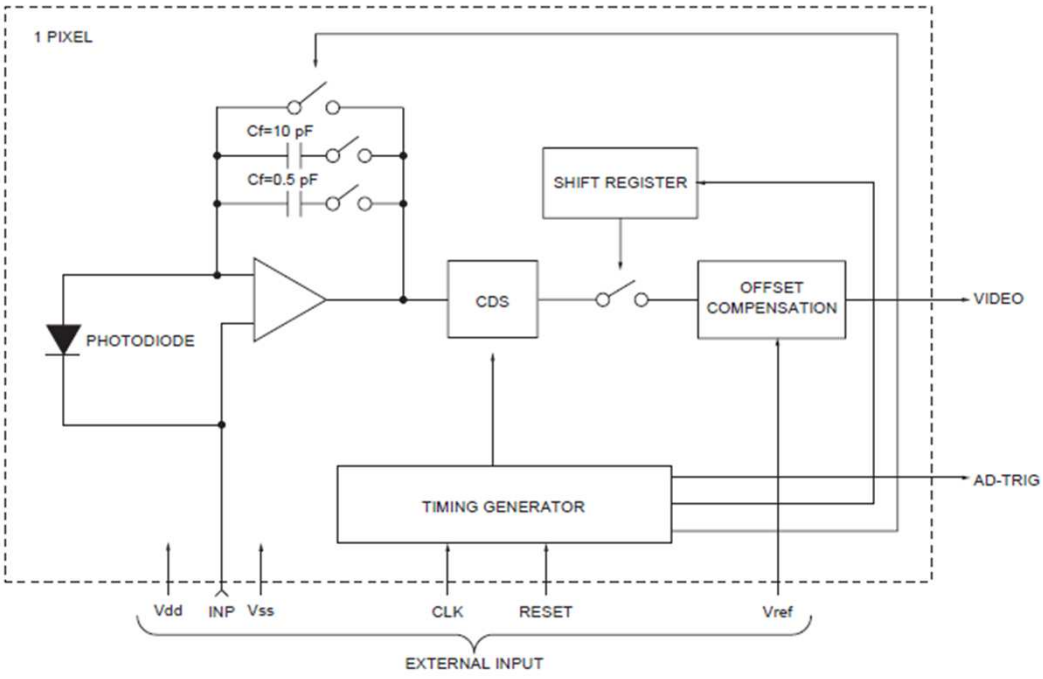


Fig. 6: InGaAs Sensor Block Diagram

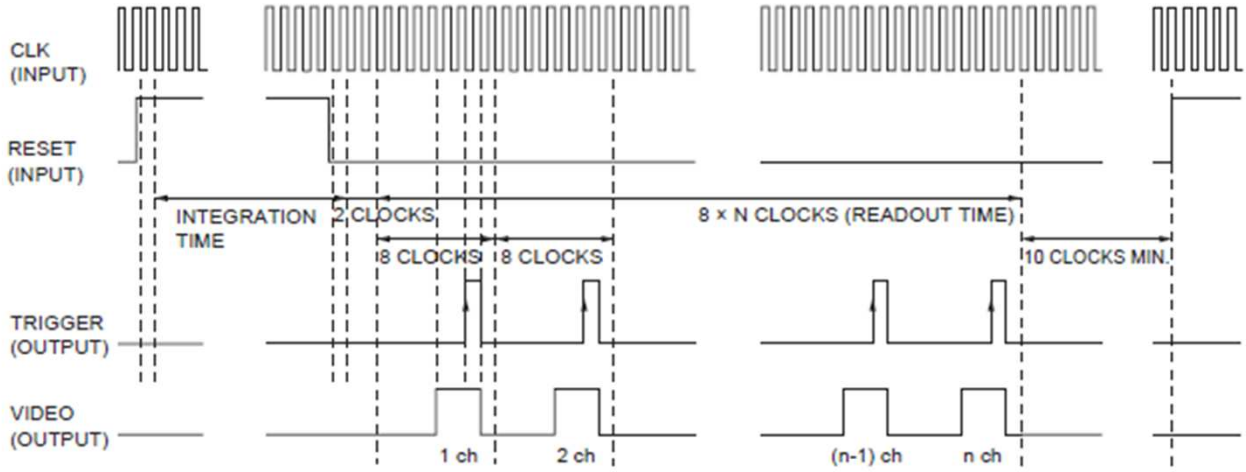


Fig.7: InGaAs sensor operation timing waveform

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.

Sesnor/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 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 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.

Internal Operation

► 4.1 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.

► 4.2Digital Inputs & Outputs

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

SW 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), SW Series provides the flexibility to implement this.

GPIO Recommended Operating Levels:

VIL(max) = 0.8V

VIH(min) = 2.0V

GPIO Absolute Maximum/Minimum Ratings are as follows:

VIN(min) = -0.3V

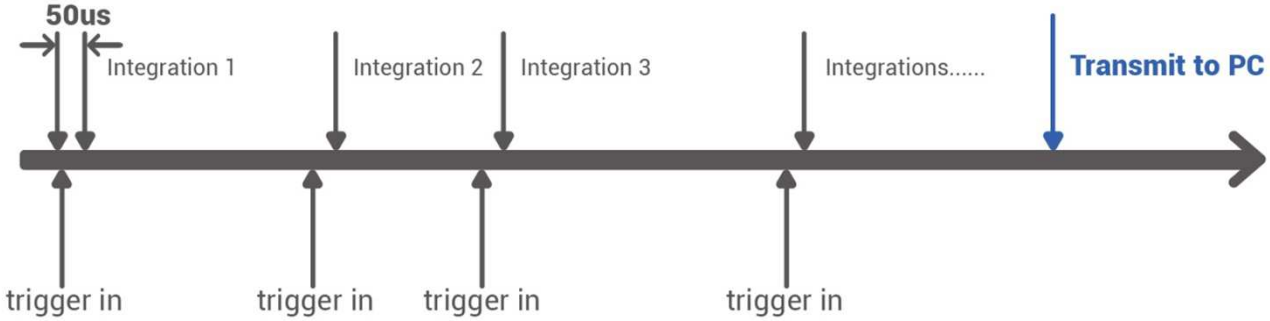
VIN(max) = 5.5V

Communication and Interface

USB 2.0

480-Mbit **U**niversal **S**erial **B**us is the standard and popular communication interface in PC. Our PC software allows connecting multiple SW Series via USB and monitors multiple SW Series spectra. The low power requirement allows operating the SE Series through the USB cable and VBUS.

Extremely Precise Continuous Multiple Exposures



- Arbitrary integration times
- Spectra are stored in the huge memory on our board, providing up to 4000 spectra buffering
- After all integrations are done, the spectra are transmitted to your PC

USB Port Interface Communications and Control Information

► Overview

SW 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 SW Series via the USB interface. This information is only pertinent to users who wish to not utilize SpectraSmart software to interface to SW Series.

Hardware Description

SW 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 64 MByte DDR and 64 Mbits Flash.

USB Info

SW Series USB Vendor ID number is 0x0638 and the Product ID is 0x0AAC. SW Series is USB 2.0 compliance. The data exchange between host and spectrometer is via bulk streams. The detail USB information please refer USBIF @ http://www.usb.org.

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 SW Series Spectrometer

Description: To connect Windows host to SW Series

a.Function Name: UAI_SpectrometerOpen

b.Arguments:

dev: 8 SW 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.

☐ **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. SW Series will acquire a complete wavelength distribution.

a.Function Name: UAI_SpectrometerWavelengthAcquire

b.Arguments:

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

buffer: the storage buffer acquired data.

☐ **Acquire Spectra**

Description: Initiates a spectra acquisition. SW 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 SW Series will be returned.

☐ **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 SW Series will be returned. The minimum integration time is in micro-second and the maximum Integration time is in milli-second.

☐ **Close SW Series Spectrometer**

Description: To connect Windows host to SW 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.