

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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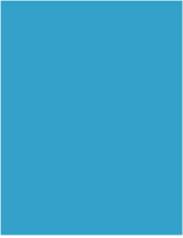
SW Series-010 Rev.1
www.otophotonics.com

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Attention

Picture	Description
	<p>To prevent over tightening and <u>damaging of the slit</u> in the spectrometer. Please <u>Hand tightening</u> the optical fiber only. Do not use any tool including wrench to tighten up the optical fiber and SMA905 connector.</p> <p>Apply adhesive to optical fiber connector after hand tightening is recommended if the fiber needs to be fixed robustly for a long time operation.</p>



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Overview

1.1 Lineup of SW Series

Model	Spectral Response Range (nm)		Sensor type	SNR ^{*1} (Single acquisition)		Dynamic Range ^{*1} (Single acquisition)		A/D	Stray Light ^{*4}	Thermal Stability
	NIRC	NIRD		High Gain Mode	Low Gain Mode	High Gain Mode	Low Gain Mode			
	900 ~ 1700	900 ~ 2500								
SW25X0			InGaAs	2000	4000	4100	6000	16 bits	<0.2%	<0.069nm/°C
SW2860 ^{*2}	√		InGaAs	2700	4100	4854	5242			N/A
SW2960 ^{*3}		√	TEC	1400	2000	4256	5461			

*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 : Integration Time 100us, Sensor TECooled @-10 ° C)

*2 : Due to the side effect of the circuit of TECooling, the SNR & Dynamic Range of SW2860 may lower than SW2530, and the performance of TECooling will be more obvious under long integration time.

(Measurement Condition : Integration Time 100us, Sensor TECooled @-10 ° 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 <0.15% at 1000nm, detected with FEL1300 longpass filter.

Model	Dynamic Range		Background	
	@1sec	@10sec	avg. counts @1sec	avg. counts @10sec
SW2860	5000	3700	300	1600
SW2530	3800	1400	5000	19000

*Higher Dynamic Range is better. Lower Background is better.

- As the table above, the Dynamic Range and Background of SW2860 are obviously better than SW2530 under long integration time.

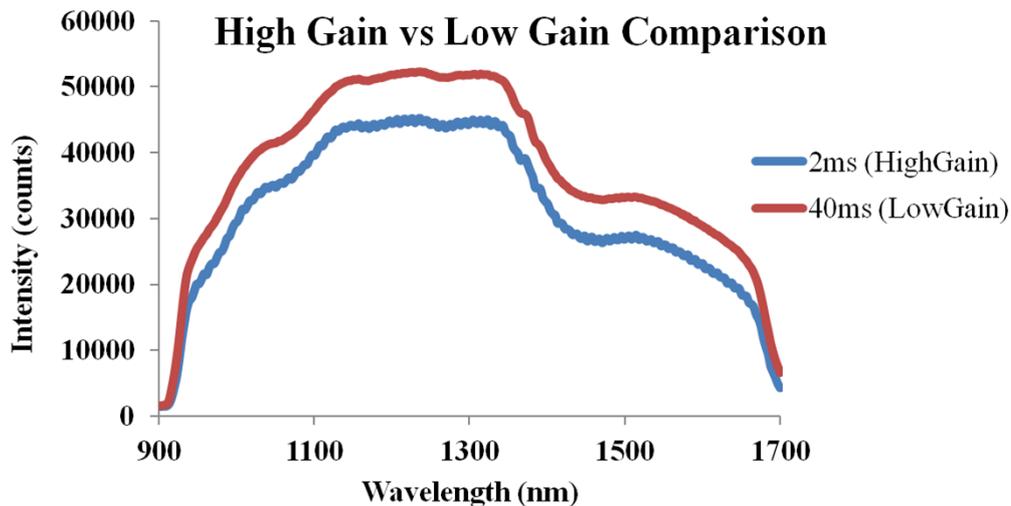
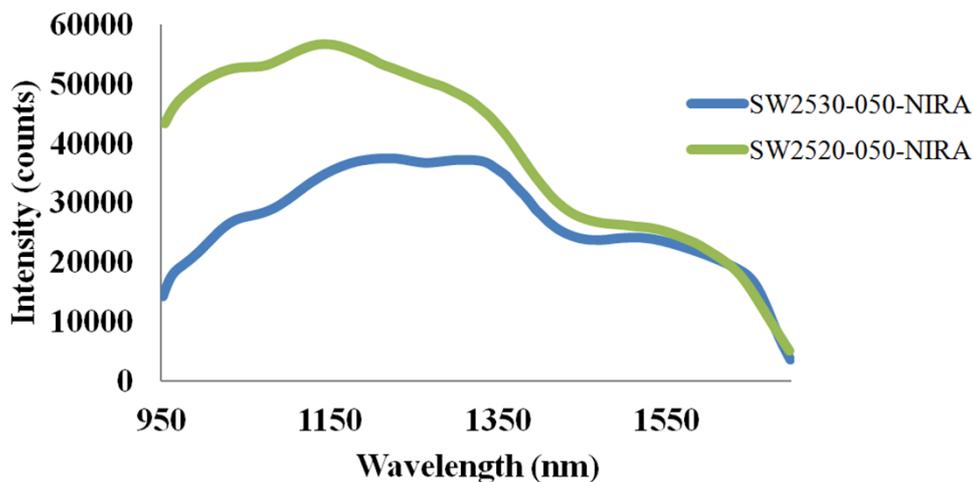
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► 1.2 Efficiency Output

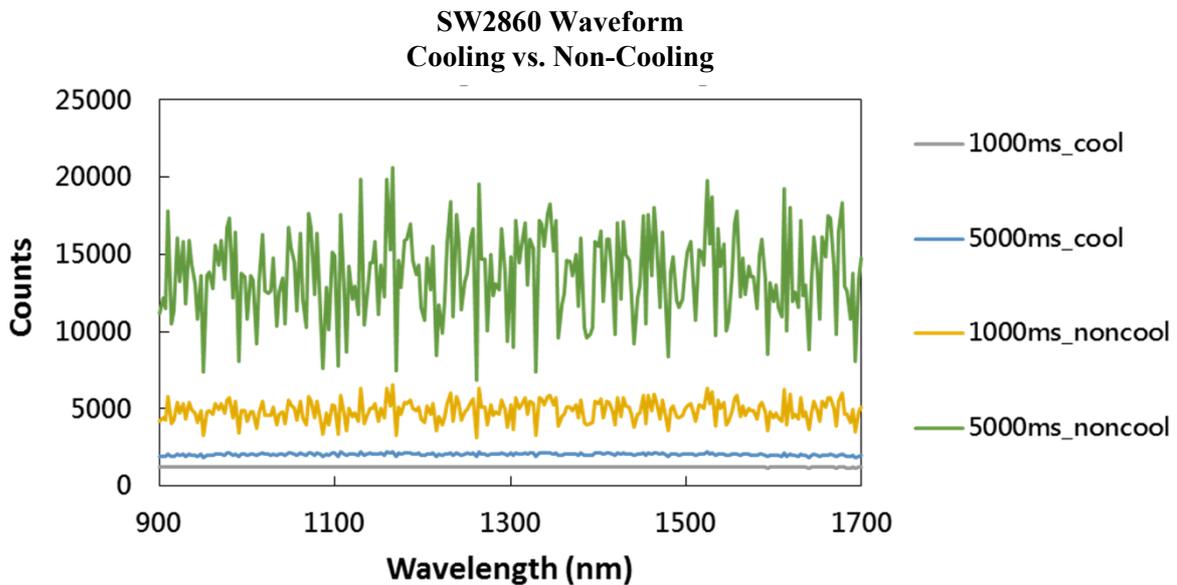
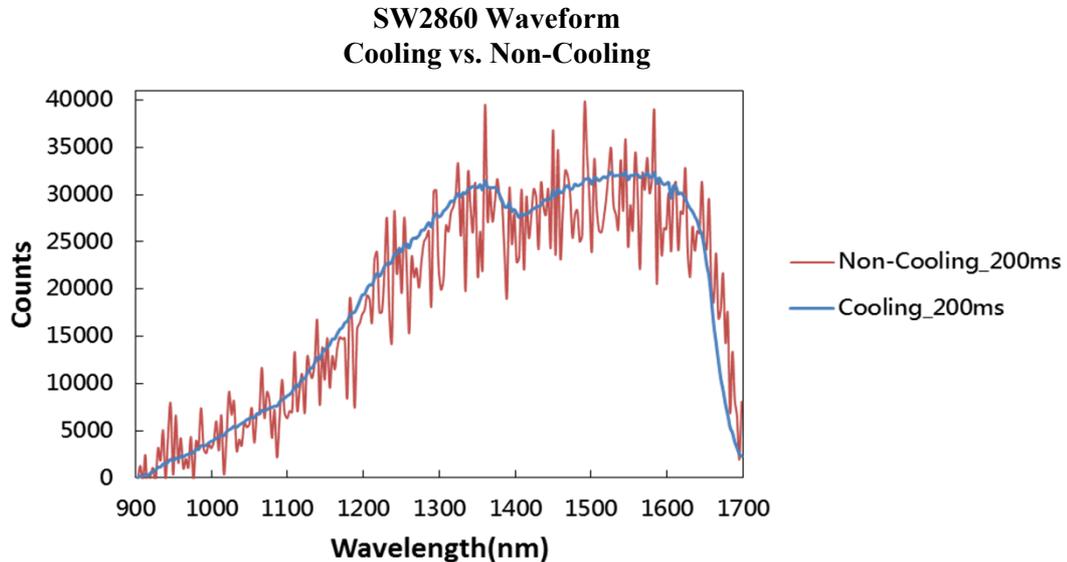
SW2530 vs. SW2520 (100ms)



- 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.

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- 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.

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■ 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 8 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 ~ 15 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 5,000 spectra buffering
- Flash ROM storage for
 - Wavelength Calibration Coefficients
 - Linearity Correction Coefficients
 - Intensity calibration coefficients
- TECooling
 - One Stage TEC: Default : 5 ° C at Ambient of 25 ° C
 - Two Stage TEC: Default : -10 ° C at Ambient of 25 ° C (Lowest -20 ° C)

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► 2.2 Specification

Specification		Value				
		SW2520	SW2530	SW2540	SW2860	SW2960
Sensor		128 Pixel	256 Pixel	512 Pixel	256 Pixel	256 Pixel
		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 55(H) mm	
Parameters of Optical System		f/# : 5, NA :0.1 Focal Length(R1-R2) :60-60				
Wavelength		900 -1700 nm			900-2500nm	
Slit size		10, 25, 50, 100, 200 um				
Inte-Gratation 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			13.5 (average)	16 (average)
	Low Gain				12.5 (average)	12 (average)
SNR (Single acquisition)	High Gain	2000			2700 (0 ° C)	1400 (100us, -10 ° C)
	Low Gain	4000			4100 (0 ° C)	2000 (300us, -10 ° C)
Dynamic range (avg.)*2	High Gain	4100			4854	3640 (100ns, -10 ° C)
	Low Gain	6000			5242	5461 (100ns, -10 ° 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:DynamicRnage=65535/Dark Noise(average), Single acquisition

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Specification		Value				
		SW2520	SW2530	SW2540	SW2860	SW2960
Resolution(FWHM)		From 2 nm to 8 nm, depending on different modular configuration				
Thermal stability		<0.069nm/°C			N/A	
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: $\Phi 3.18 \pm 0.005 \text{mm}$				
		SMA905: $\Phi 3.20 \pm 0.01 \text{mm}$				
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	

- 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.

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■ Structure

▶ 3.1 Mechanical Diagram

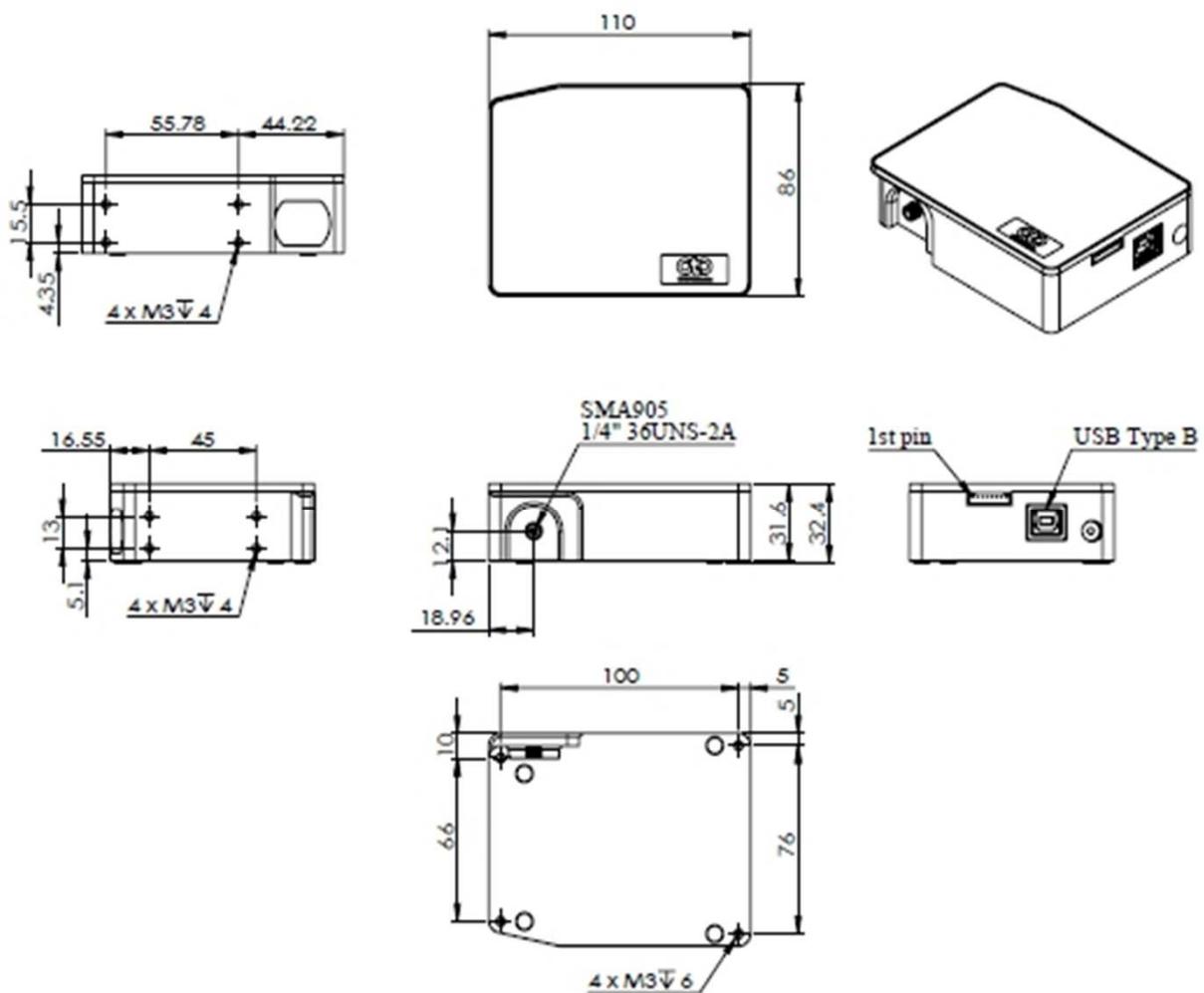


Fig. 1: SW 5 Series outer dimensions

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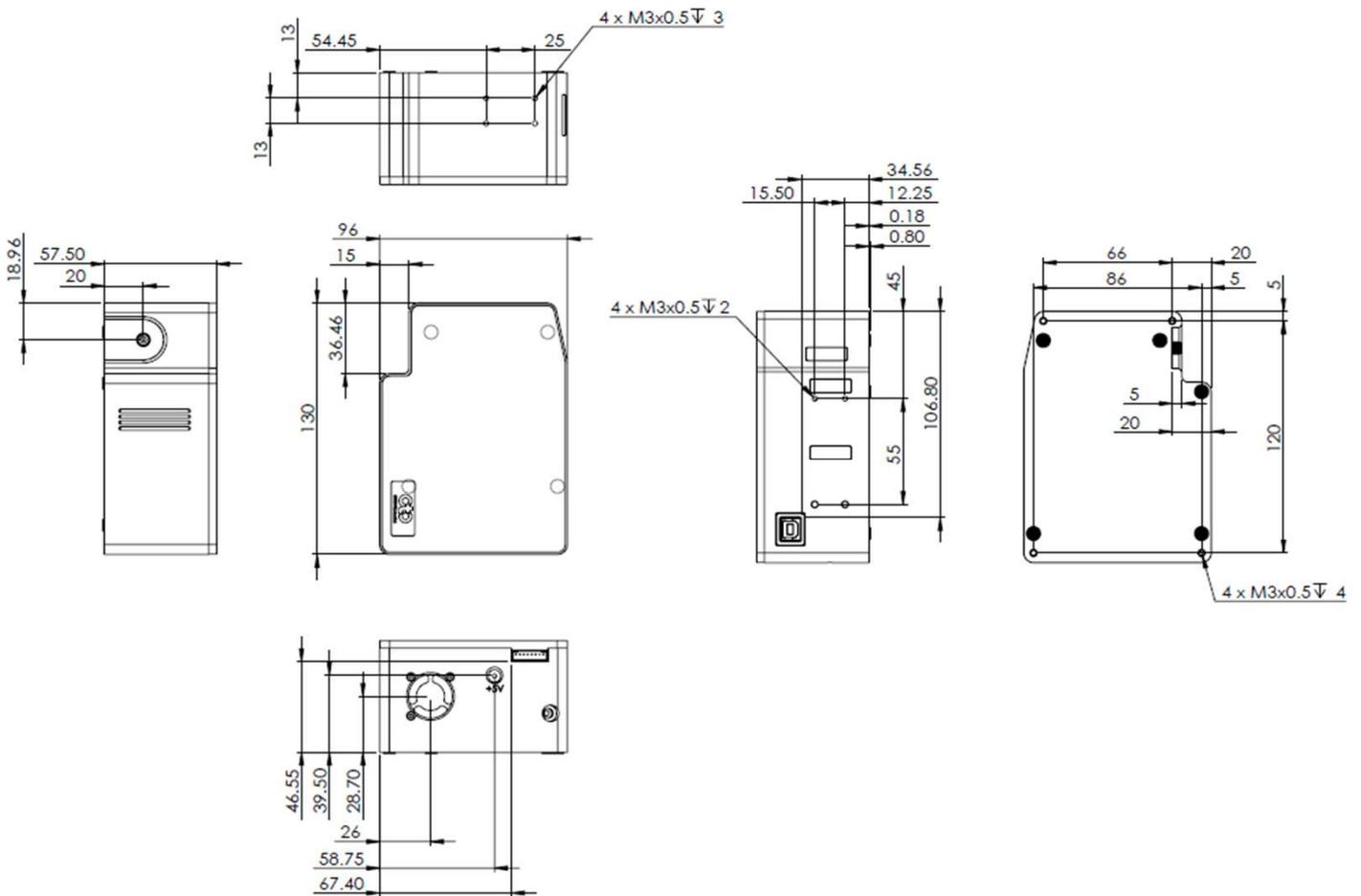


Fig. 2: SW 8 & 9 Series outer dimensions

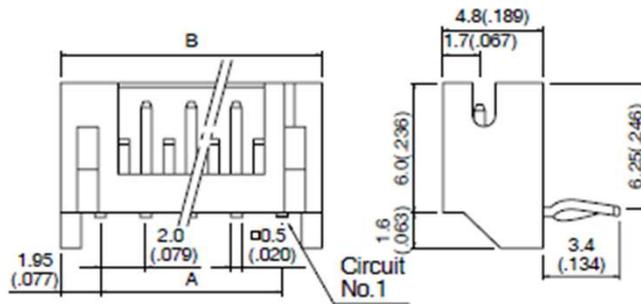
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► 3.2 Electrical Pinout

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. 2 : Back Extension Port 2.0 mm 8 pin drawing

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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.

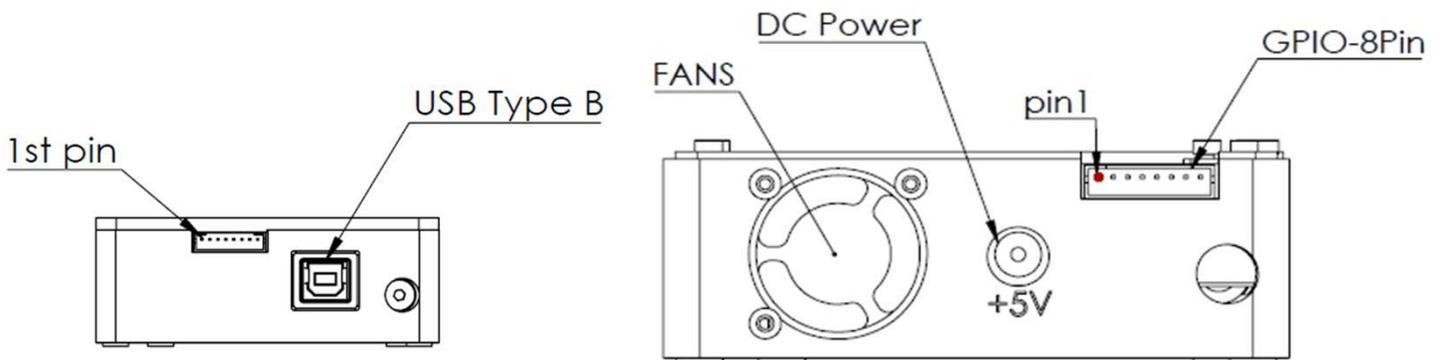


Fig. 3 : SW Series the front-view of connector mechanical graph

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► 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.

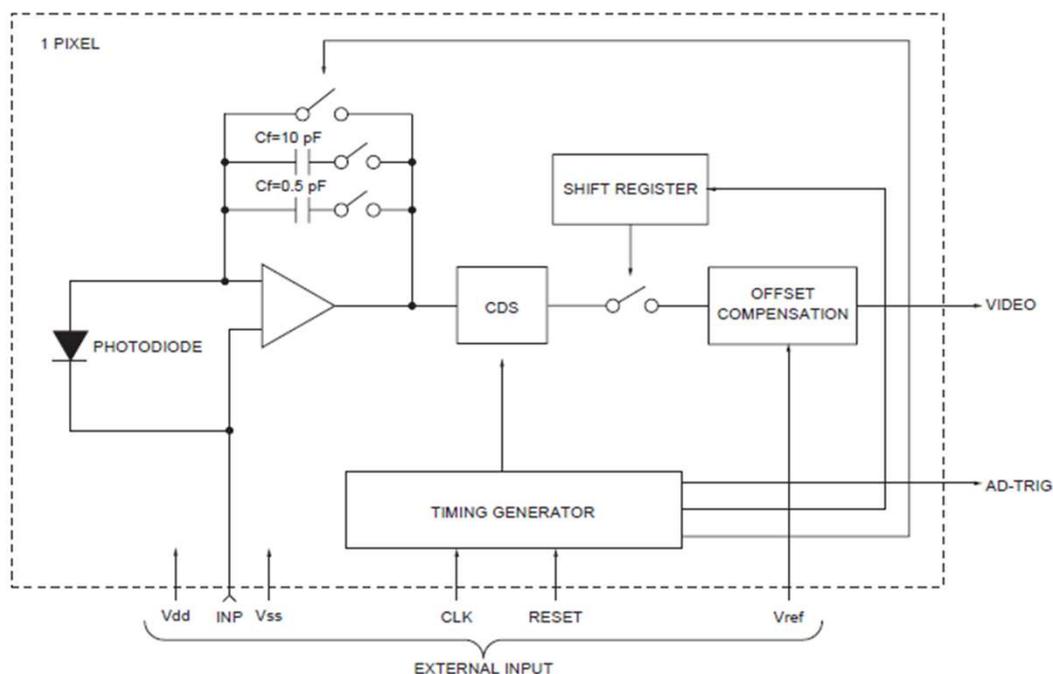


Fig. 4: InGaAs Sensor Block Diagram

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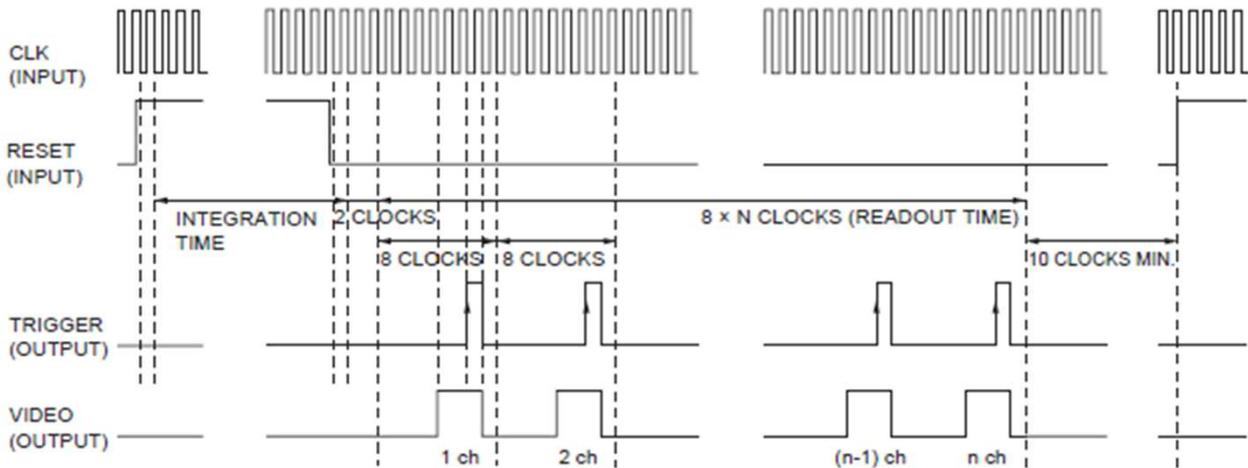
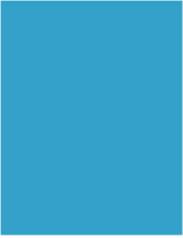


Fig.5: InGaAs sensor operation timing waveform

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.



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● **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.



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■ 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.

▶ 4.2 Digital 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.

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GPIO Recommended Operating Levels:

VIL(max) = 0.8V

VIH(min) = 2.0V

GPIO Absolute Maximum/Minimum Ratings are as follows:

VIN(min) = -0.3V

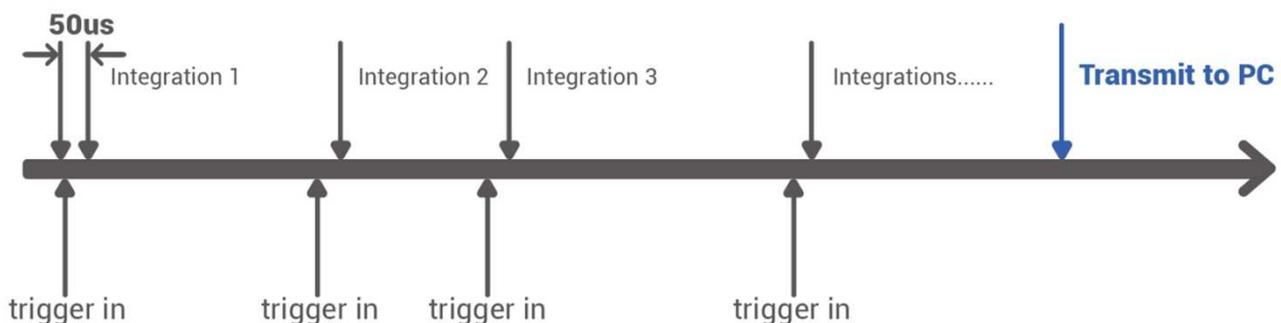
VIN(max) = 5.5V

● Communication and Interface

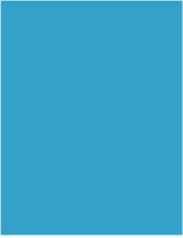
USB 2.0

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



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■ **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.



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- **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.



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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. 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.



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□ **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.



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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 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.