OtO Photonics

SmartEngine-FX2
(SE-FX2) Series Product sheet

Description

SE-FX2 Series spectrometers combine a Hamamatsu S11639 fast exposure CMOS linear sensor with a 8051 8-bit controller in an optimized Czerny-Turner cavity for high resolution, high sensitivity, low stray light and fast spectral response.

SE-FX2's 8051 controller provides integration times as short as 6µs with high accuracy trigger timing and low power consumption. In combination with the high sensitivity sensor SE-FX2 is ideal for rapid detection applications.

A wide range of standard gratings and wavelength ranges combine with a choice of slit widths to help system integrators optimize resolution and sensitivity for their application.

SmartEngine's compact and rigid package 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. Thermal stability also benefits from the low power consumption of the 8051 controller.

PC communication and power interface with the SE-FX2 is via USB with an additional 6 I/Os for external connections.

The SE-FX2's controller can be addressed via OtO's "SpectraSmart" fully-featured spectral measurement software which includes a full Windows SDK and other example code.

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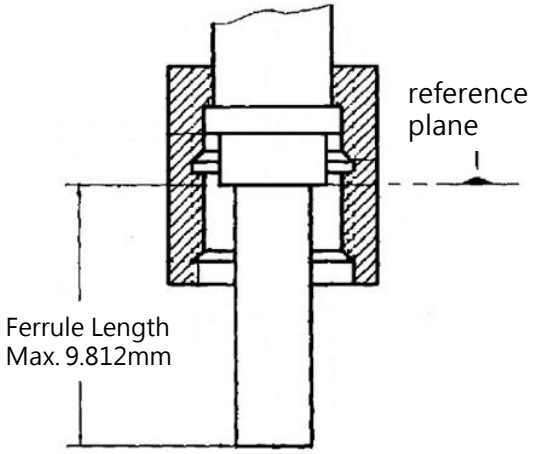
Attention

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 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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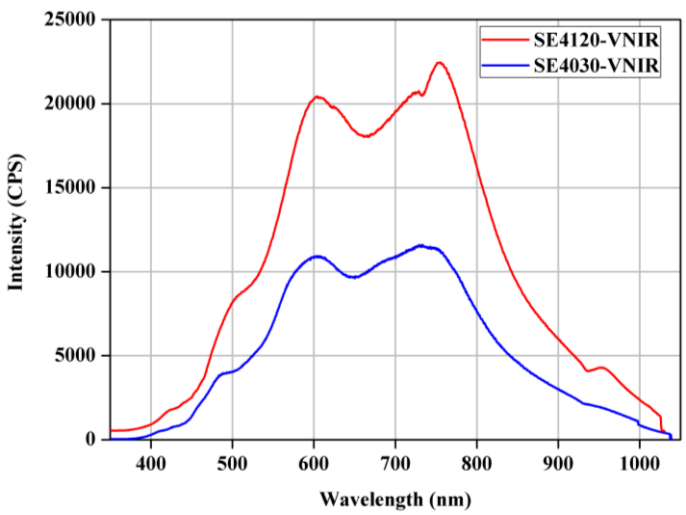
Overview

► 1.1 Lineup of SE-FX2 Series

Model	Spectral Response Range (nm)					SNR*1	Dynamic Range*2	Stray Light	A/D	Thermal Stability
	DUVN	FUV	FUVN	VNIR	NIR1					
	200 ~ 1025	180 ~ 850	180 ~ 1100	350 ~ 1020	790 ~ 1010					
SE3030/4030	√	√	√	√	√	350	4300	0.2%	16 bits	<0.04 nm/℃
SE3120/4120	√	√	√	√	√		4300	0.2%	16 bits	<0.04 nm/℃

*1 : Single acquisition
*2 : 65535/Dark Noise(average)

► 1.2 Efficiency Output & USB Transfer Speed Comparison _SE4120 vs SE4030(for reference)



Integration time (ms)	USB transmission speed(ms)		
	SE2030	SE4030	SE4120
0.1/0.2	1.68~1.73	0.87~0.92	0.5~0.58
0.5/0.6	1.95~2.05	1.10~1.17	0.91~1.97
1.0/1.1	2.67~2.82	1.59~1.69	1.48~1.55

*for reference

	SE4120	SE4030
Pixel number	1024	2048
Pixel size (W x H, um)	28x200	14x200

- Due to the pixel size of SE4120 is twice as large as SE4030, SE4120 has a higher sensitivity performance, approximately twice that of SE4030
- As shown in the table above, the FX2 version of SE4030 demonstrates a significant improvement in USB transmission speed compared to the Z5 version of SE2030. Additionally, due to SE4120 having half the number of pixels compared to SE4030, its transmission speed is also notably enhanced.

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Main Features

► 2.1 Feature

- Wavelength range: from 180 to 1100 nm
- Optical resolution: from 0.2 to 10.5nm, depending on the combination of various slits and gratings.
- High sensitivity 1024 or 2048 pixel CMOS array sensor
- Modular configuration with various grating, sensor, and slit options
- Integration times from 6us to 65sec (10MHz)
- 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
- CCD clock rate can be adjusted to meet the demand of wavelength repeatability or processing speed.
- Flash ROM storage for
  - Wavelength Calibration Coefficients
  - Linearity Correction Coefficients
  - Intensity Calibration Coefficients
- The position of silt is able to change to the left side of spectrometer (SE4032) , provide the flexibility of integration with OEM product.

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► 2.2 Specification

SPEC	Content	
	SE3030/4030	SE3120/4120
CCD	Fast-Exposure CMOS 2048 Pixel	Fast-Exposure CMOS 1024 Pixel
Dark Noise (avg.)	15	
Dynamic Range (avg.)*2	4300*1	
SNR*3	350	
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.)	
Spectrometer	SE-FX2 series; Czerny-Turner Optical Structure 2nd & 3rd order rejection	
Dimension	Type I : 110(L) x 86(W) x 32.4(H) mm Type II : 110(L) x 86(W) x 35.4(H) mm	
Grating	15 grating options ; spectral range from UV to NIR	
Wave -length	From 180 to 1100 nm with a variety of wavelength range	
Slit Size	10, 25, 50, 100, 200,300 um	
Integration Time	6us ~ 65sec (10MHz)	
Data transfer Speed	1ms/frame (Max 0.8ms/frame, 1frame=4KB)	
Wavelength Repeatability	+/- 0.05 nm Continuous 100 measurements (Hg-Ar Light Source)	

*1 : Sensor clock rate 9.6MHz
*2 : 65535/Dark Noise(average)
*3 : Single acquisition

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SPEC		Content
Wavelength accuracy		± 0.3 nm (Testing environment is based on SE1020-050-VNIR's parameter, and accuracy may be up to ± 1.0nm according to different environment such as severe temperature change and long-time vibration. OtO can offer free software for WL calibration if customer needed.)
Resolution(FWHM)		From 0.2 nm to 10.5 nm, depending on different modular configuration
Thermal Stability		<0.04nm/℃
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
Recommend Tightening Torque		0.3 Nm (Mating Part : 5mm thick, Flatness 0.1mm, Aluminum sheet)
Power		Power requirement (VBUS): 190mA at +5 VDC Supply voltage: 4.75-5.25 Power-up time : < 2s Maximum USB input power Vcc : +5.25VDC Maximum I/O signal voltage : +5.5VDC

- 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

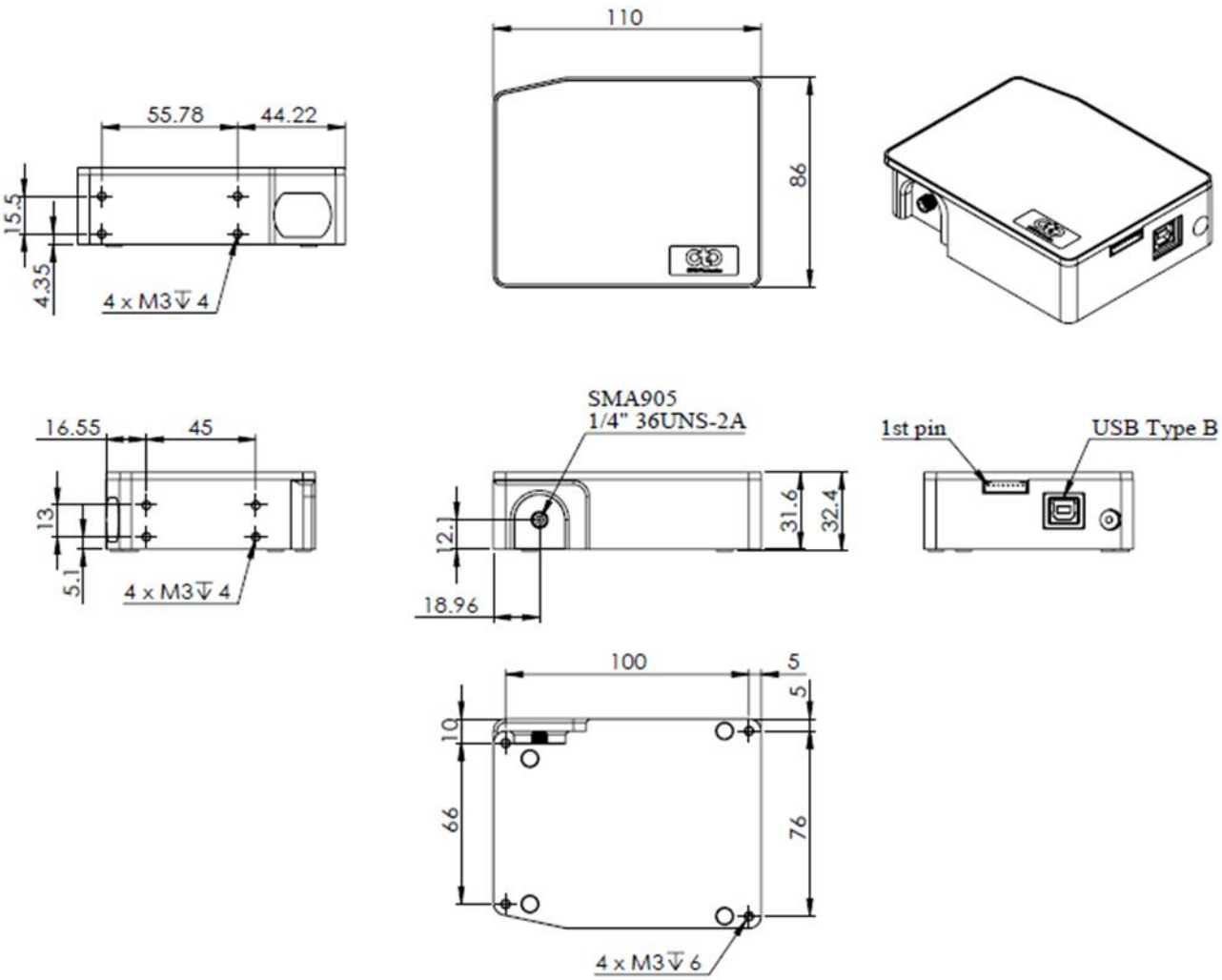

Fig. 1: SE-FX2 Series outer dimensions (Type I)

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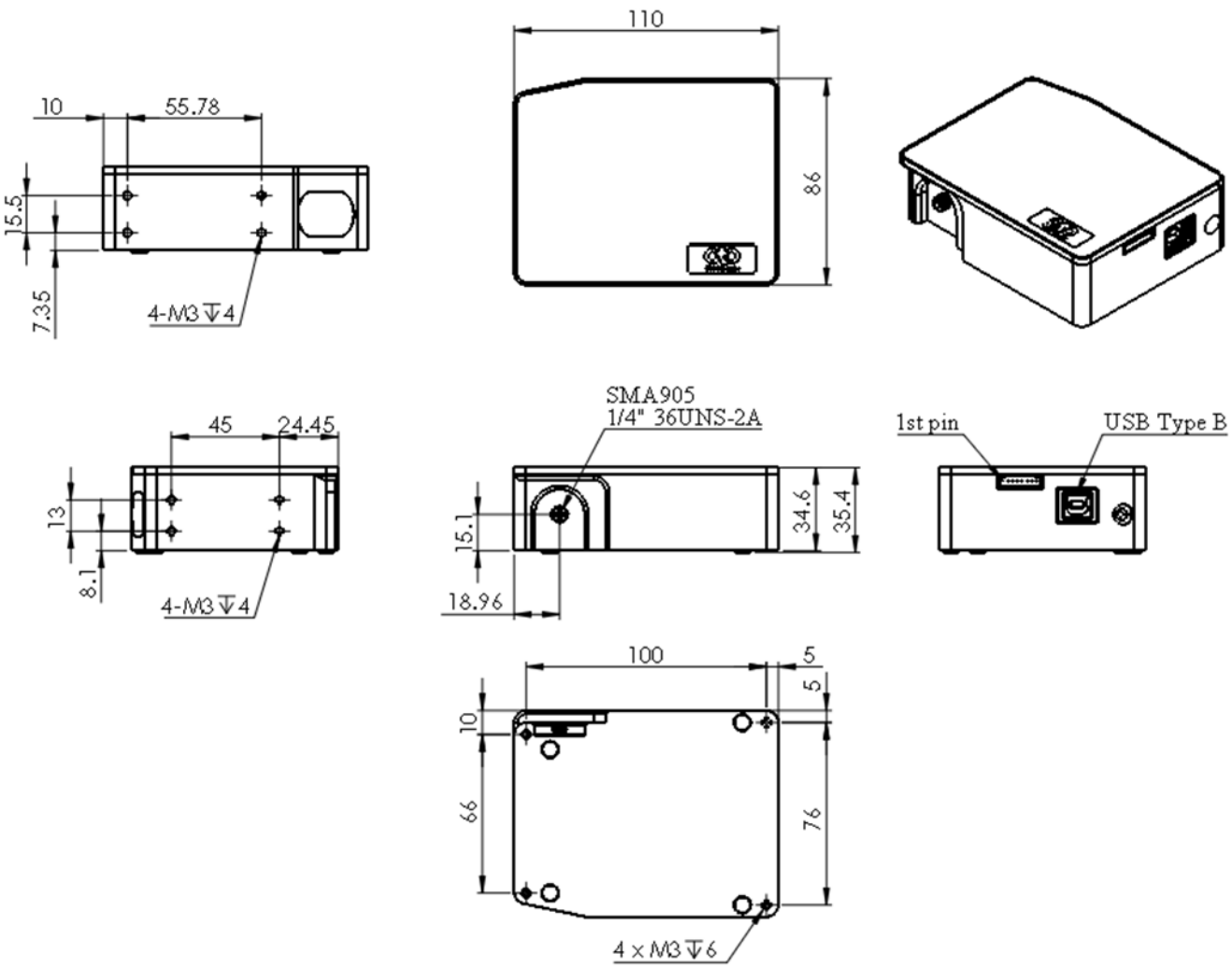

Fig. 2: SE-FX2 Series outer dimensions (Type II)

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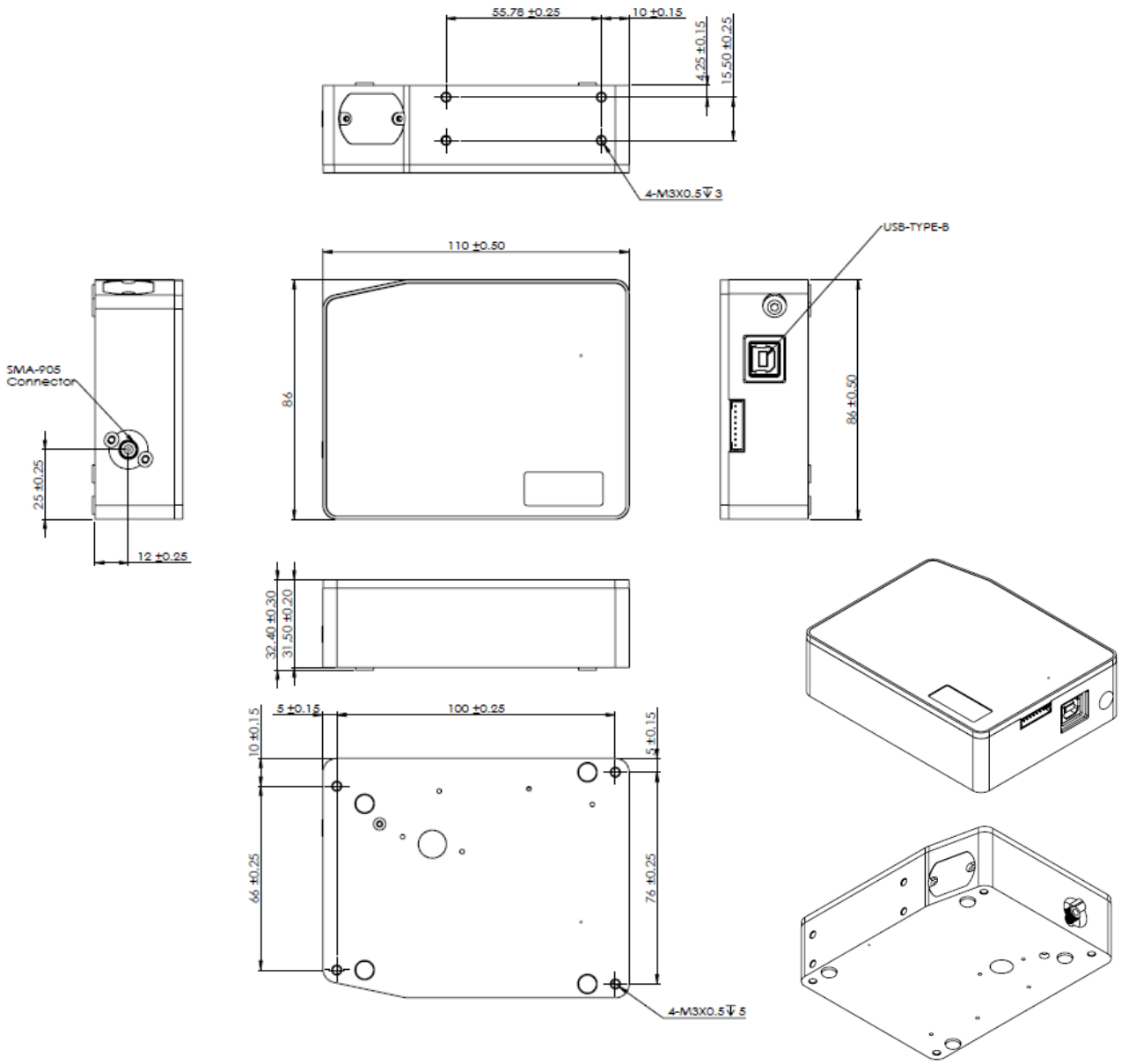
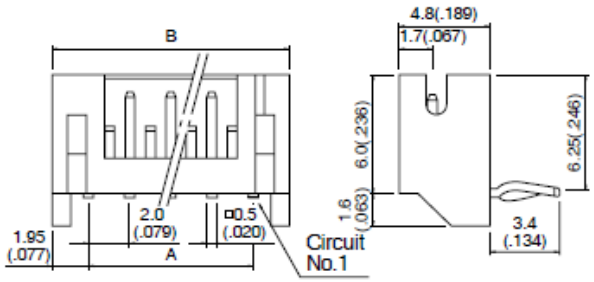


Fig. 3: SE4032 outer dimensions (slit on the left side)

► 3.2 Electrical Pinout

The following listed is the pin description for the SE-FX2 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

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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 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 8051 controller.
3	Input	RX	UART RX. RX is the input for the 8051 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 SE-FX2 Series connector side, from left to right are Back Extension Port and PC USB.

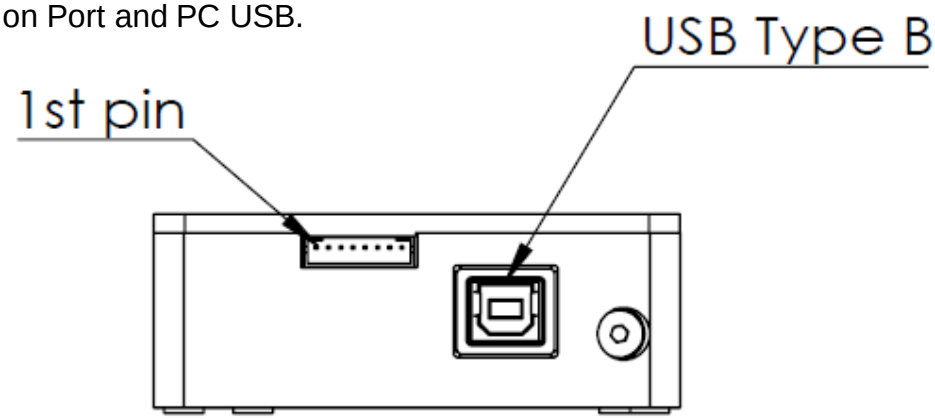

Fig. 5 : SE-FX2 series the front-view of connector mechanical graph

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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.

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. 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
1-2048	Dummy pixels

► 4.2 Digital Inputs & Outputs

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

SE-FX2 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), SE-FX2 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**

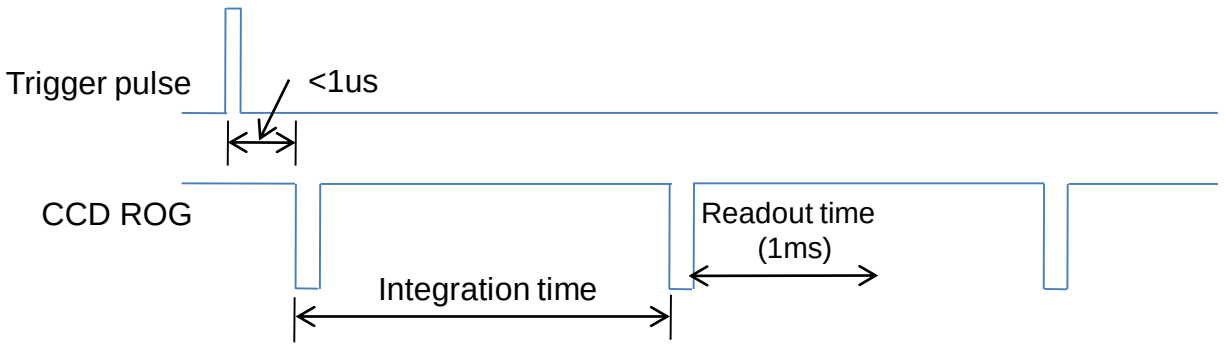
USB 2.0

480-Mbit **U**niversal **S**erial **B**us is the standard and popular communication interface in PC. Our PC software allows connecting multiple SE-FX2 series via USB and monitors multiple SE-FX2 series spectra. The low power requirement allows operating the SE-FX2 series through the USB cable and VBUS.

► 4.3 Trigger Mode

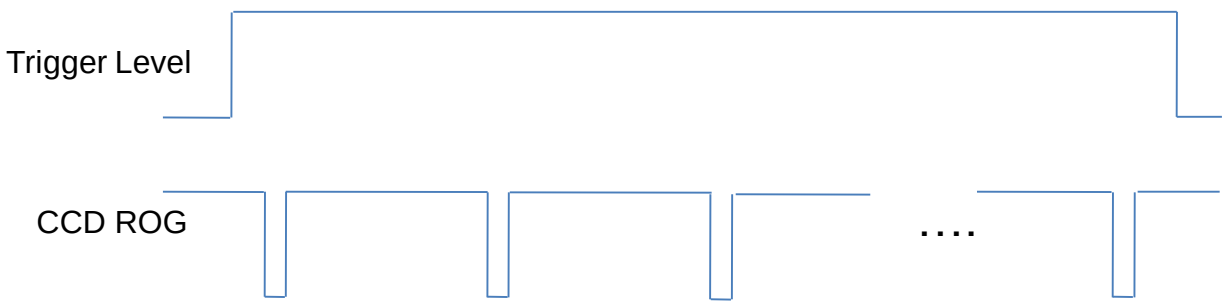
- **Single Trigger Single Data**

Single Trigger Single Data (integration time has been set by the command first). Spectrometer waits for single pulse to acquire one spectrum. The trigger edge can be set by rising edge or falling edge.



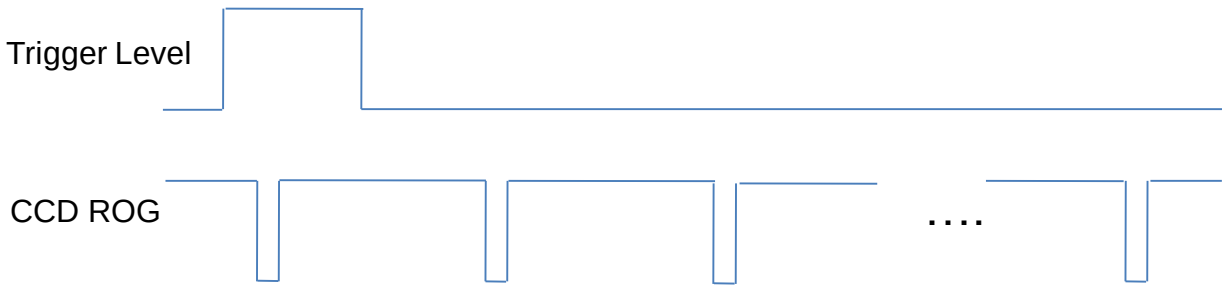
- **Software Level Trigger**

Software Level Trigger (integration time has been set by the command first, spectrometer waits for external trigger signal). When the trigger signal is high, software will continue to capture the spectrums.



- **Software Level Trigger continuous data**

  Software Level Trigger continuous data(integration time has been set by the command first, spectrometer acquires data by command). When the trigger signal is high, software will continue to capture the spectrums even the trigger level is changed to low later.



USB Port Interface Communications and Control Information

► Overview

SE-FX2 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 SE-FX2 series via the USB interface. This information is only pertinent to users who wish to not utilize SpectraSmart software to interface to SE-FX2 series.

Hardware Description

SE-FX2 series utilizes a 8 bit 8051 controller built in USB 2.0. Program code and data coefficients are stored in I2C EEPROM.

USB Info

SE-FX2 series USB Vendor ID number is 0x0638 and the Product ID is 0x0AAC. SE-FX2 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 SE-FX2 series Spectrometer

Description: To connect Windows host to SE-FX2 series

a.Function Name: UAI_SpectrometerOpen

b.Arguments:

dev: 8 SE-FX2 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. SE-FX2 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.

- **Acquire Spectra**

Description: Initiates a spectra acquisition. SE-FX2 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 16-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 16-bit floating type data which is indicate the minimum or maximum
wavelength, in nm, of SE-FX2 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 SE-FX2 series will be returned. The minimum integration time is in micro-second and the maximum Integration time is in milli-second.

- **Close SE-FX2 series Spectrometer**

Description: To connect Windows host to SE-FX2 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.