OtO Photonics
SmartEngine-FX2
(SE-FX2) Series Product sheet

Description

SE-FX2 Series spectrometer is built with the linear CMOS type sensor and 8 bits MCU in. The CPU of SE-FX2 series is 8051, which can provide shorter integration time, faster readout speed, high Accuracy of sensor trigger timing and low power consumption. With a high-sensitivity sensor, SE-FX2 series is very suitable for the needs of rapid detection. Due to the low power consumption, SE-FX2 has more thermal stability.

SE-FX2 series has outstanding stability of thermo-hydro variation, vibration and shock on resolution and wavelength shift performance. The compact size is very flexible for system integration.

SE-FX2 Series spectrometer is constructed by the 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 SE-FX2 Series communicates with the PC through the USB port. It also provides 6 I/Os for external interface extension.

SE-FX2 Series electronics operation is controlled by the 8051 controller. So the user can communicate to the main program through the PC software and the protocol provided by OtO Photonics.
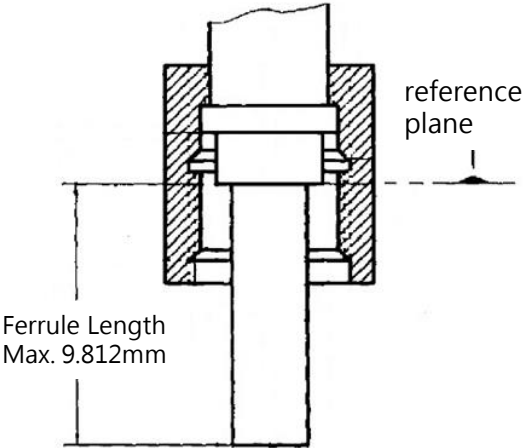

- This Document is for business promotion use only.
- For customer's Specification Approval or IQC need, we will provide official Approval Sheet.

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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. Apply adhesive to optical fiber connector after hand tightening is recommend if the fiber needs to be fixed robustly for a long time operation.
 reference plane Ferrule Length Max. 9.812mm	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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■ 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 200, 1025	FUV 180, 850	FUVN 180, 1100	VNIR 350, 1020	NIR1 790, 1010					
SE3030/4030	√	√	√	√	√	400	4300 (3 MHz) /3600 (9.6 MHz)	0.2%	16 bits	<0.04 nm/℃

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

► 1.2 Efficiency Output Comparison (for reference)

SE3020/3040 and SE4020/4040 Comparison Plot
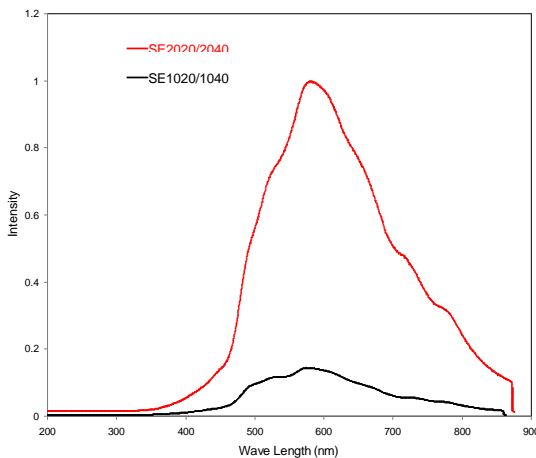
SE3020 and SE4020 Comparison Plot
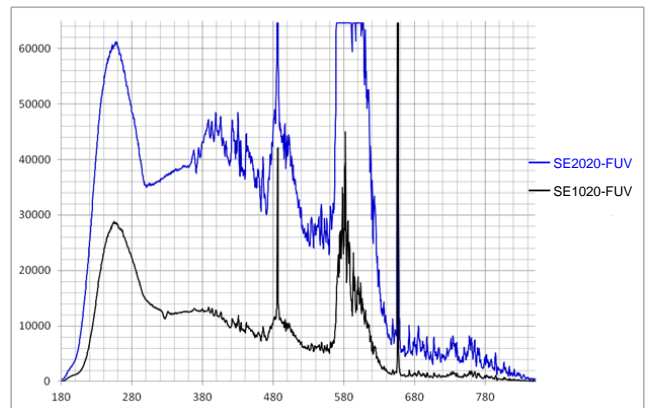
● New optical design spectrometer of SE4020 shows 7.5 times efficiency toward standard type spectrometer. (@570nm as shown on the upper left chart)

● SE4020 shows 3 times sensitivity enhancement toward SE3020 on UV range. (Upper right chart)

● SE4xxx series has new optical design provides higher sensitivity performance.

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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 2048-pixel CMOS array sensor
- Modular configuration with various grating, sensor, and slit options
- Integration times from 17us s to 24 seconds(3MHz) & 6us to 24sec (9.6MHz)
- 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
	SE 4030
CCD	Fast-Exposure CMOS
Dark Noise (avg.)	15^{*1} 18^{*22}
Dynamic Range (avg.)[*3]	4300^{*1} 3600^{*2}
SNR[*4]	400
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	110(L) x 86(W) x 32.4(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	17us ~ 24sec(3MHz) 6us ~ 24sec (9.6MHz)
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 3MHz
*2 : Sensor clock rate 9.6MHz
*3 : 65535/Dark Noise(average)
*4 : 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℃ to +70℃
	Operation	0℃ to +50℃
	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.

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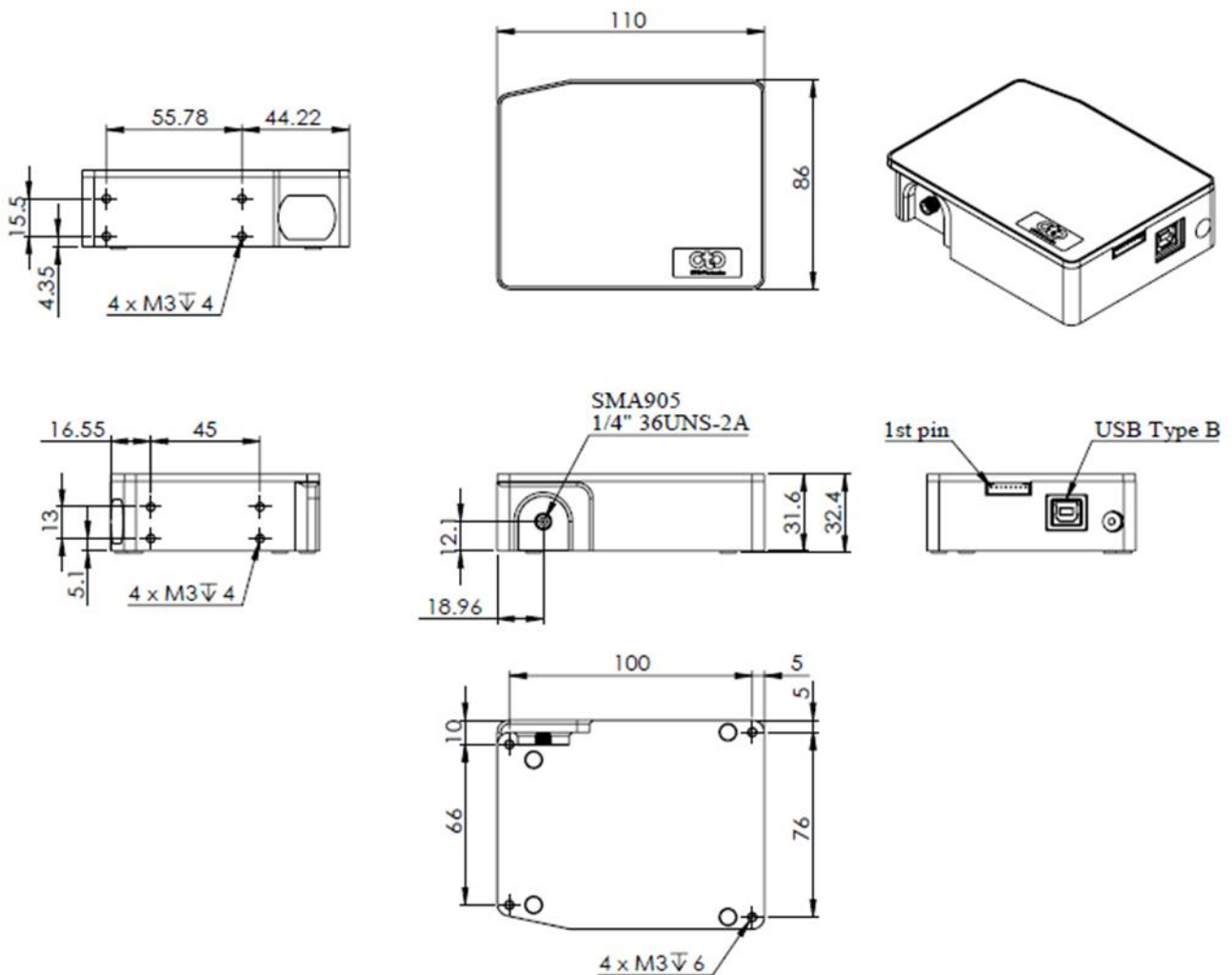## Product sheet

◼ Structure

► **3.1 Mechanical Diagram**

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

SmartEngine-FX2 (SE-FX2) Series
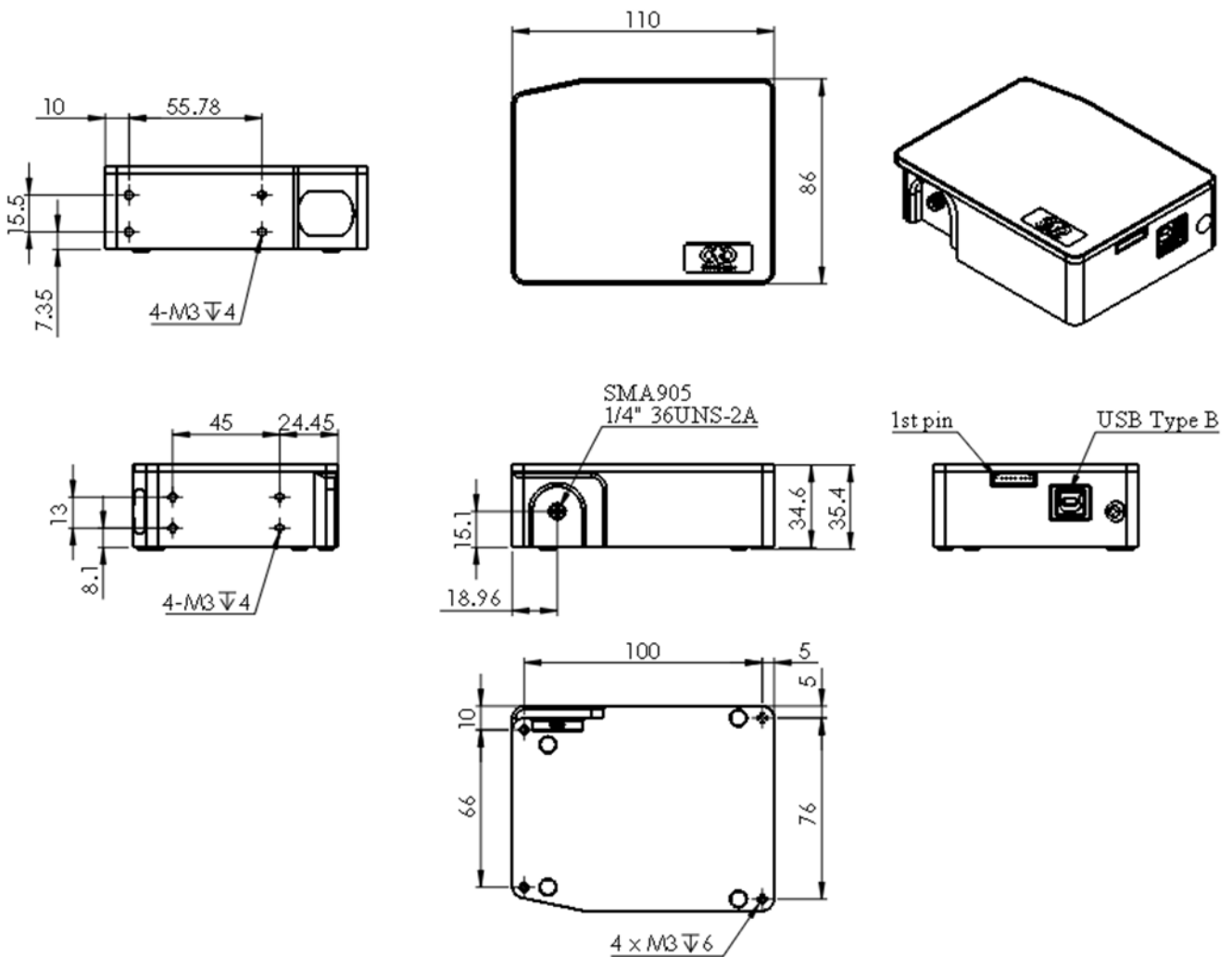## Product sheet

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

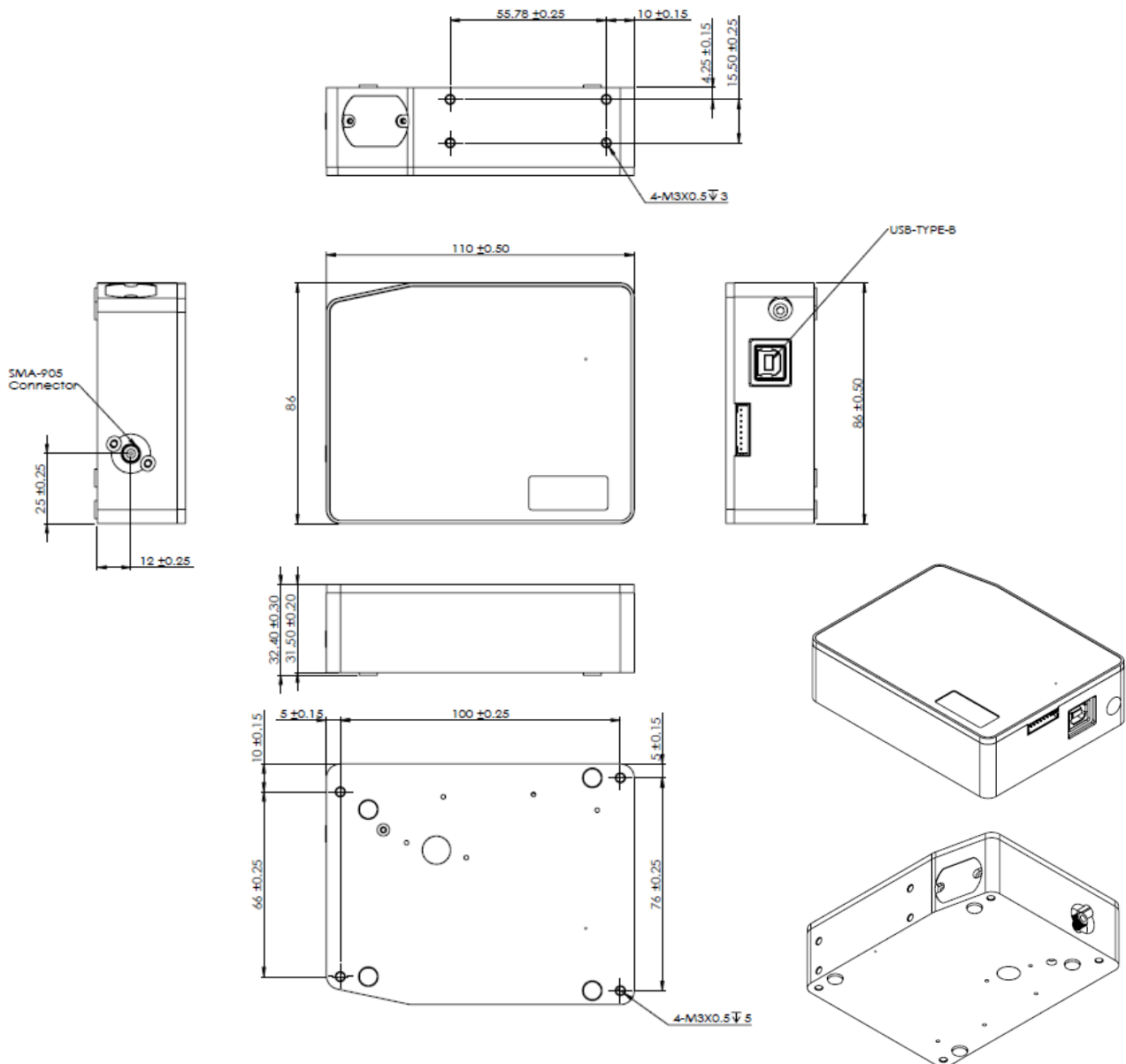# OtO Photonics

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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
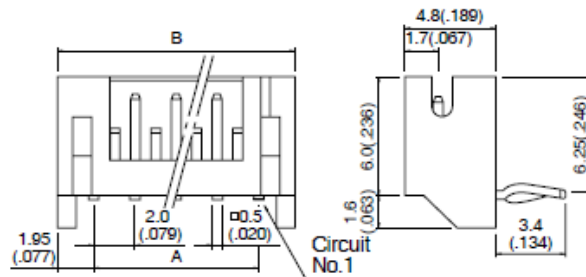
Cir-cuits	Model No.		Dimensions mm(in.)		Q'ty / box	
	Top entry type	Side entry type	A	B	Top entry type	Side entry type
8	B 8B-PH-K-S	S 8B-PH-K-S	14.0(.551)	17.9(.705)	500	250

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**

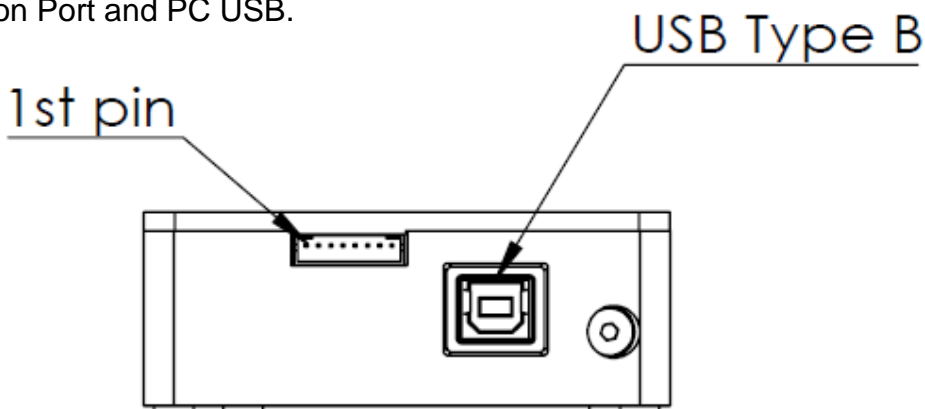Looking at Front of SE-FX2 Series connector side, from left to right are Back Extension Port and PC USB.

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

● **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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■ 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.

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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 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.
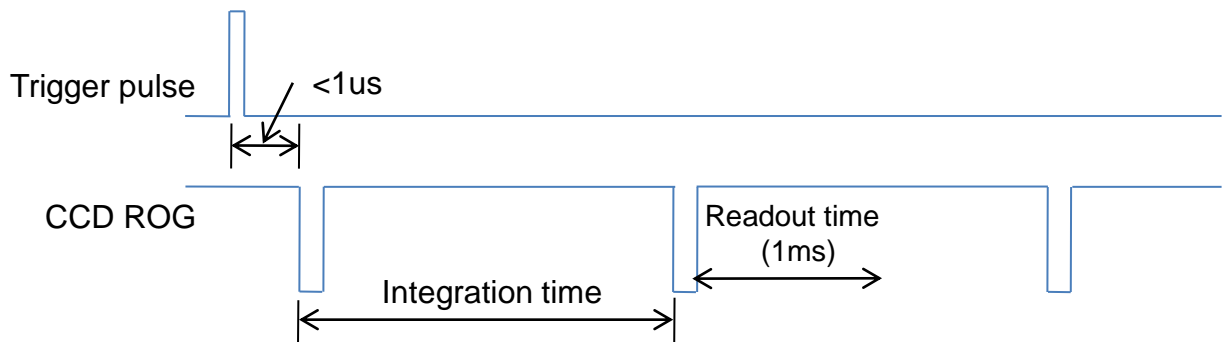
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► **4.3 Trigger Mode**

● **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.

Trigger pulse   <1us

CCD ROG   Readout time (1ms)

Integration time

● **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.

Trigger Level

CCD ROG   ….

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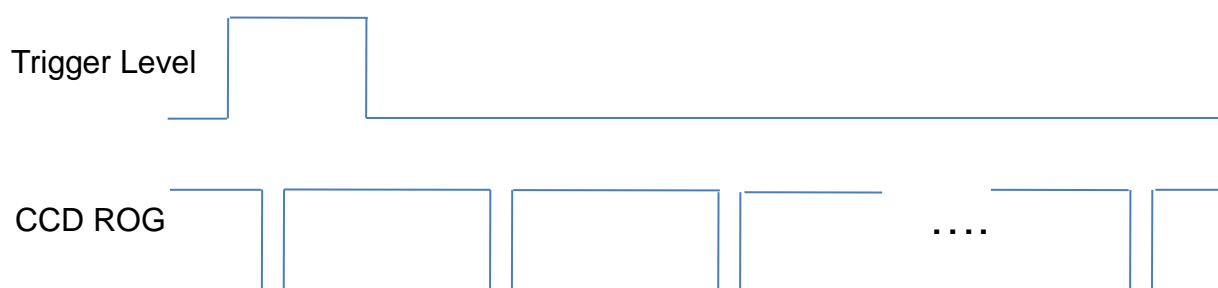## SmartEngine-FX2 (SE-FX2) Series
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● **Software Level Trigger continuous data**

　　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.

Trigger Level

CCD ROG　　　　　　　　　　　　　　　　　　　　. . . .

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■ 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.

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● **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.

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❑ **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.

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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 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.