# OtO Photonics

## Dual Spectrometer (DS) Series
## Product sheet

### Description

DS Series spectrometer is integrated two different linear sensor and Y-splitter optical fiber. The optical engine is very simple and rigid. The spectral responded range of DS Series is wide and can be customized by customer's need, from UV to NIR (180-1700nm).

DS 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. DS 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.

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

We provide the related information and the detailed instructions of how to operate with DS Series in this guide.
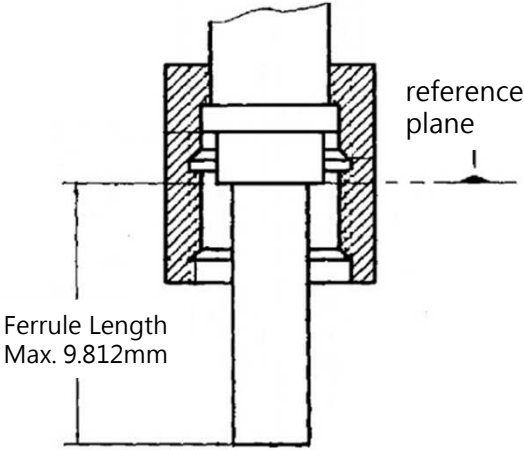
DS Series electronics operation is controlled by the RISC controller. So the user can communicate to the main program through the PC software and the protocol provided by OtO Photonics.

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## 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. |
| <br>reference plane<br>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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## Dual Spectrometer (DS) Series

### ■ Overview

#### ► 1.1 Lineup of DS Series

DS series is combined with one UV-VIS or VIS spectrometer and one NIR spectrometer. Clients are able to choose spectrometers according the table below.
e.g. DS2686= EE2060 + SW2860

| Model | | Spectral Response Range (nm) | | | | | | SNR[1] | | Dynamic Range[2] | | Stray Light |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DUVN | FUV | FUVN | VNIR | NIR1 | NIRC | mode | | mode | | |
| | | 200 | 180 | 180 | 350 | 790 | 900 | High Gain | Low Gain | High Gain | Low Gain | |
| | | ~ 1025 | ~ 850 | ~ 1100 | ~ 1020 | ~ 1010 | ~ 1700 | | | | | |
| DS Series | UV-VIS | SE1030/2030 | √ | √ | √ | √ | √ | | 330 | | 3450/3000 | | 0.2% |
| | | SE1040/2040 | √[3] | | | √ | | | 200 | | 2220 | | 0.2% |
| | | SE1050/2050 | | | | √ | | | 500 | | 4400 | | 0.45% |
| | | SE1060/2060 | | √ | √ | √ | | | 500 | | 4700 | | 0.2% |
| | | SE1070/2070 | √ | | | √ | √ | | 400 | | 2200 | | 0.2% |
| | | SE1080/2080 | √ | | | √ | √ | | 350 | | 2200 | | 0.2% |
| | | SE1090/2090 | | √ | √ | √ | | | 500 | | 3120 | | 0.45% |
| | UV-VIS + TEC | EE2053[4] | | | | √ | √ | | 500 | | 4700 | | 0.45% |
| | | EE2063[4] | √ | √ | √ | | | | 500 | | 4096 | | 0.45% |
| | NIR | SW2520 | | | | | | √ | 2000 | 4000 | 4100 | 60000 | 0.2% |
| | | SW2530 | | | | | | √ | | | | | |
| | | SW2540 | | | | | | √ | | | | | |
| | NIR + TEC | SW2860 (TEC -1 Stage)[4] | | | | | | √ | 2700 | 4100 | 4256 | 5461 | |

*1 : Single acquisition
*2 : 65535/Dark Noise(average)
*3 : For SE2040, 275~1100nm only
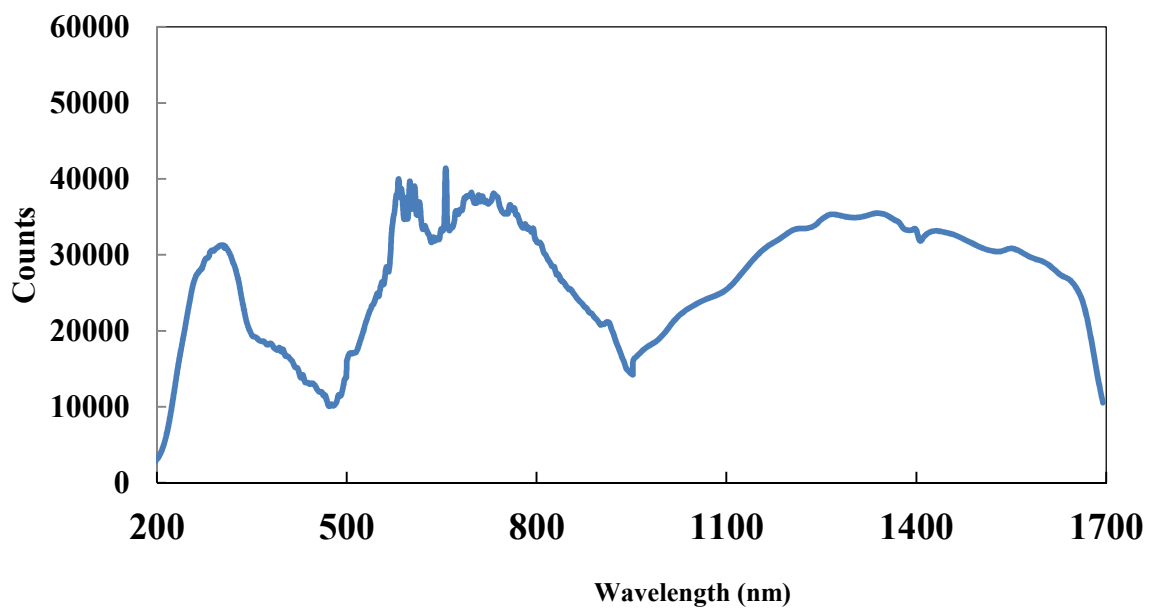*4 : TECooling 1 stage, Default : 0 °C at Ambient of 25 °C

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► **1.2 Intensity test**

**DS1252 + LS-DH-2**
**slit : 50um, Integration time 25ms**



- Intensity test of DS2252-VNIRxNIRA (Integrated SE2020-VNIR and SW2520-NIRA, SE2020 has been phased out)。

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## Dual Spectrometer (DS) Series

■ **Main Features**

► **2.1 Feature**

● Wavelength range: from 180 to 1700 nm

● Optical resolution: from 0.9 to 10.5nm, depending on the combination of various slits and gratings.

● A variety of sensor can be chosen for specific application:

   ❑ High speed, high sensitivity, back-thinned

   ❑ CCD, CMOS and InGaAs

   ❑ TECooling CCD and TECooling InGaAs Sensor

● Modular configuration with various grating, sensor, and slit options

● Integration times from 0.2 ms to 65 seconds, 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

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## Dual Spectrometer (DS) Series

► **2.2 Specification**

| SPEC | DS Series | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SE 2030 | SE 2040 | SE 2050 | SE 2060 | SE 2070 | SE 2080 | SE 2090 | SW 2520 | SW 2530 | SW 2540 |
| Sensor | 2048 | 2048 | 2048 | 2048 | 3648 | 4096 | 2048 | 128 | 256 | 512 |
| | CMOS | CCD | CCD | CCD | CCD | CMOS | CCD | InGaAs | | |
| Dark Noise (Upper Limit) | 30[*1] 36[*2] | 34 | 20 | 20 | 40 | 50 | 29 | 13.5 | | |
| Dynamic Range[*3] | 3450[*1] 3000[*2] | 2200 | 4700 | 4700 | 2200 | 2200 | 3540 | 6000 (Low Gain) 4100 (High Gain) | | |
| SNR[*4] | 330 | 200 | 500 | 500 | 400 | 350 | 500 | 4000 (Low Gain) 2000 (High Gain) | | |
| Structure | DS series; Czerny-Turner Optical Structure 2nd & 3rd order rejection | | | | | | | | | |
| Grating | 15 grating options ; spectral range from UV to NIR | | | | | | | 2 grating options ; NIR spectral range | | |
| Wave-length | From 180 to 1100 nm with a variety of wavelength range | | | | | | | From 900 to 1700 nm with a variety of wavelength range | | |
| Slit Size | 10, 25, 50, 100, 200,300 um | | | | | | | 10, 25, 50, 100. 200 um | | |
| Integration Time | 0.2ms ~ 65sec, depending on sensors | | | | | | | 50 μs ~ 15sec, depending on sensors | | |

*1: Sensor clock rate 2.5MHz
*2 :Sensor clock rate 10MHz
*3 : 65535/Dark Noise(average)
*4 : Single acquisition

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| SPEC | DS-TECooling Series | | |
|---|---|---|---|
| | EE2053 | EE2063 | SW2860 |
| Sensor | 2048 Pixels | 2048 Pixels | 256 Pixels |
| | NIR-Enhanced Back thinned TEC sensor | UV-Enhanced Low noise type Back thinned TEC sensor | NIR InGaAs TEC Sensor |
| Dark Noise (Upper Limit) | 20 | 25 | 12.5(Low Gain) 13.5(High Gain) |
| Dynamic Range[3] | 4700 | 4000 | 5242(Low Gain) 4854(High Gain) |
| SNR[4] | 500 | 500 | 4100(Low Gain) 2700(High Gain) |
| Structure | DS series; Czerny-Turner Optical Structure 2nd & 3rd order rejection | | |
| Grating | 15 grating options ; spectral range from UV to NIR | | 2 grating options ; NIR spectral range |
| Wave-length | From 180 to 1100 nm with a variety of wavelength range | | From 900 to 1700 nm with a variety of wavelength range |
| Slit Size | 10, 25, 50, 100. 200 um | | |
| Integration Time | 5ms ~ 65sec, depending on sensors | | 50 µs ~ 15sec, depending on sensors |

*1: Sensor clock rate 2.5MHz
*2 :Sensor clock rate 10MHz
*3 : 65535/Dark Noise(average)
*4 : Single acquisition

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## Dual Spectrometer (DS) Series

| SPEC | Content | |
| --- | --- | --- |
| | **DS Series** | |
| | **SE/EE Series** | **SW Series** |
| Wavelength Repeatability | +/- 0.05 nm<br>Continuous 100 measurements (Hg-Ar Light Source) | +/- 0.2 nm<br>Continuous 100 measurements (Hg-Ar Light Source) |
| Wavelength accuracy | $\pm$ 0.3 nm ( Testing environment is based on SE1020-050-VNIR's parameter, and accuracy may be up to $\pm$ 1.0nm according to different environment such as severe temperature change and long-time vibration.<br>OtO can offer free software for WL calibration if customer needed.) | $\pm$ 1 nm ( Testing environment is based on SW2530-050-NIR's parameter, and accuracy may be up to $\pm$ 1.5nm according to different environment such as severe temperature change and long-time vibration.<br>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 | From 2 nm to 8 nm, depending on different modular configuration |
| Thermal Stability | <0.04nm/°C | <0.069nm/°C |
| Environmental Conditions — Storage | -30°C to +70°C | |
| Environmental Conditions — Operation | 0°C to +50°C | |
| Environmental Conditions — Humidity | 0% - 90% non-condensing | |
| Interfaces | USB 2.0 @ 480 Mbps (High speed) | |
| Input Fiber Connector | SMA 905 | |
| Power | Power requirement (VBUS): 300mA at +5 VDC<br>Supply voltage: 4.75-5.25<br>Power-up time : < 4s<br>Maximum USB input power Vcc : +5.25VDC<br>Maximum I/O signal voltage : +5.5VDC<br>TEC Power requirement: 500mA at 5VDC | |

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## Dual Spectrometer (DS) Series
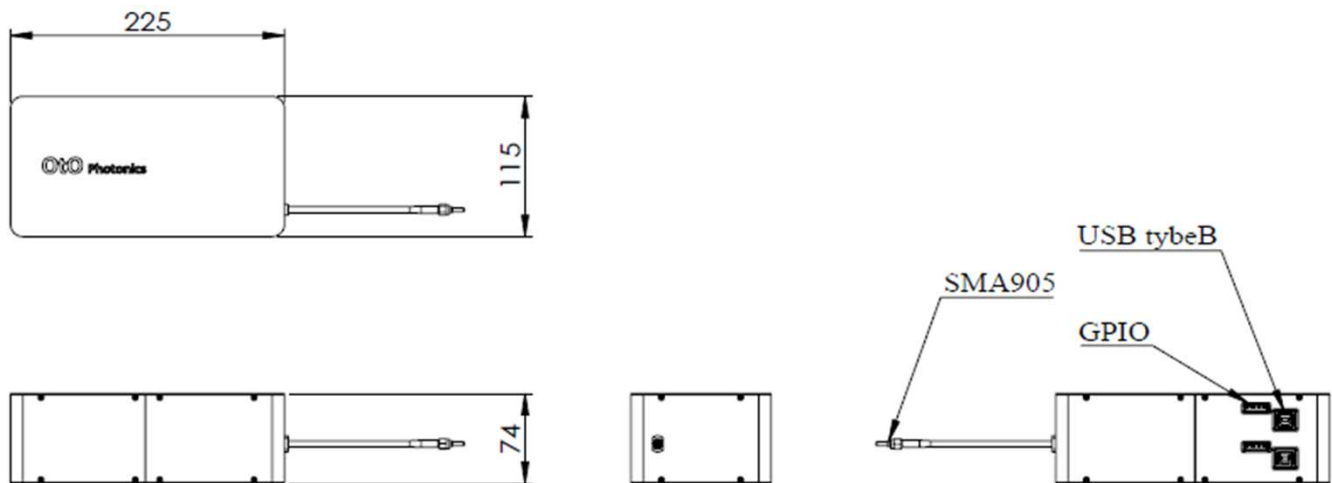
## ■ Structure

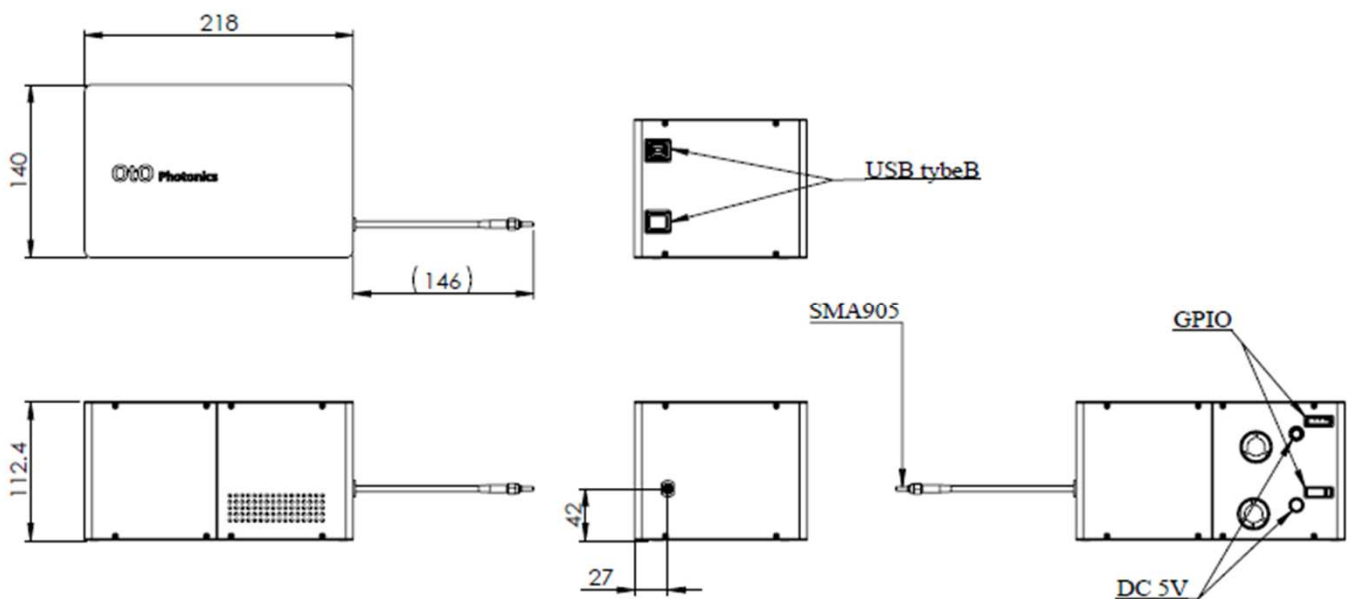### ► 3.1 Mechanical Diagram



**Fig. 1a: DS Series outer dimensions**


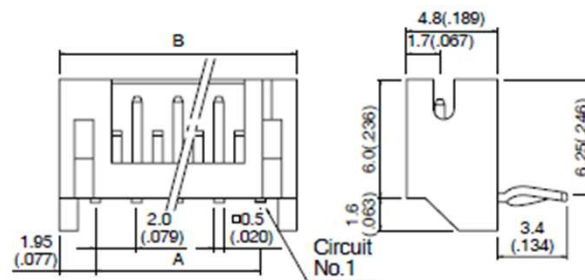
**Fig. 1b :DS-TEC Series outer dimensions**

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► **3.2 Electrical Pinout**

The following listed is the pin description for the DS Series Extension Connectors. The Back Extension Ports are 8 pin 2.0mm connectors.

**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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## Dual Spectrometer (DS) 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 | 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**

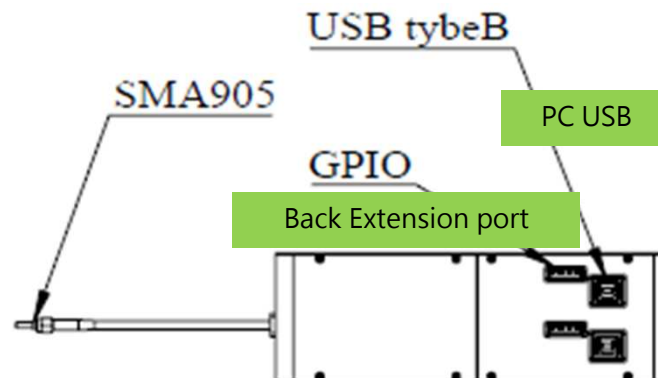Looking at Front of DS Series connector side, from left to right are Back Extension Port and PC USB.



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

- **SENSOR/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. Normal output signal is not obtained immediately after device switch on. Use the output signal added 22500 pulses or above to CLK clock pulse.

### ► 4.2 Digital Inputs & Outputs

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

DS 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), DS 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 DS Series via USB and monitors multiple DS Series spectra. The low power requirement allows operating the DS Series through the USB cable and VBUS.

● **Extremely Precise Continuous Multiple Exposures**
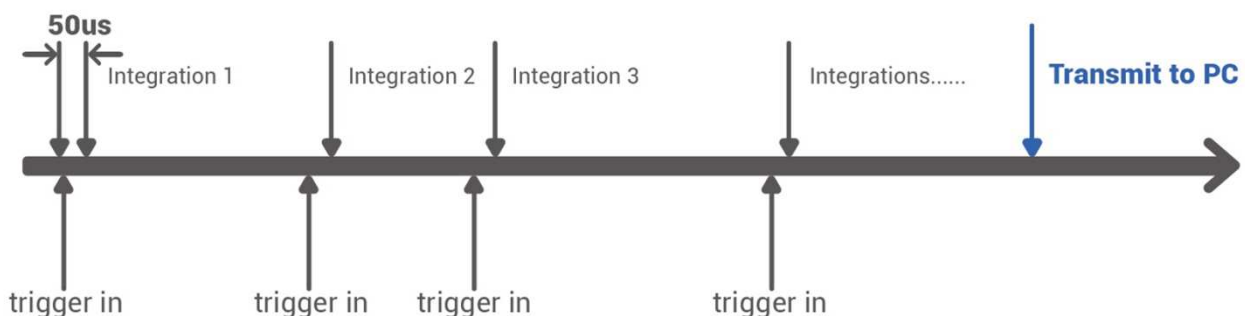


□ Arbitrary integration times

□ 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

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

### ● Hardware Description

DS 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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● **USB Info**

DS Series USB Vendor ID number is 0x0638 and the Product ID is 0x0AAC. DS 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 DS Series Spectrometer**

Description: To connect Windows host to DS Series

**a.Function Name:** UAI_SpectrometerOpen

**b.Arguments:**

**dev:** 8 DS 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. DS 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. DS 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 DS Series will be returned.

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## Dual Spectrometer (DS) Series

☐ **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 DS Series will be returned. The minimum integration

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

☐ **Close DS Series Spectrometer**

Description: To connect Windows host to DS 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.