OtO Photonics

Linear Camera Module (CM) Series Datasheet

Description

CM Series is built with the linear back-thinned 2048 x 64 pixels CCD type sensor and high performance 32bits RISC controller in. CM series contains a Thermal Electric Cooler (TEC) along with cooling system design to reduce dark current and maintain a lower stable operating temperature. CM Series has outstanding sensitivity, high SNR ratio, high dynamic range, low electrical-heat noise and fast spectrum responds, suitable for 785 nm laser 2800 cm^{-1} (790~1010nm)或3500 cm^{-1}(790~1090 nm) Raman application and long wavelength measurement (180~1100 nm).

CM Series is powered by USB port and communicates with the PC through the USB port. Cooling system should by supported by additional 5V DC power supply. It also provides 2 SMA905 GPIO pin for external interface extension.

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Main Features

► 1.1 Feature

- A variety of sensor can be chosen for specific application:
  - CM 5 series : NIR Enhanced/ Back thinned/ 2048-pixel /TEC sensor
  - CM 6 series :UV-Enhanced/ Low noise type Back thinned/ TEC sensor
- Integration times from 1.5 ms to 65 seconds, depending on sensors
- 16 bit, 15MHz A/D Converter
- USB 2.0 @ 480 Mbps (High speed)
- 2 pin SMA connector for (Trigger in & out)
- Extremely precise continuous multiple exposures, providing up to 4,000 spectra buffering
- Flash ROM storage for
  - Linearity Correction Coefficients
  - Background Correction Coefficients

(OtO also provide Wavelength Correction Coefficients & related FW/SW

► 1.2 Lineup of CM Series

Model		Spectral Response Range (nm)						SNR*1	Dynamic Range*2	A/D
		FUV	FUVN	DUVN	VNIR	NIR1	NIR4			
		180 ~ 850	180 ~ 1100	200 ~ 1025	350 ~ 1020	790 ~ 1010	790 ~ 1090			
CM	CM 5 series (+mini)					√	√	500	4700	16 bits
	CM 6 series			√	√				4096	

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

SPEC		Content	
		CM 5 series	CM 6 series
CCD		HAMAMATSU S11511	HAMAMATSU S11850
		(NIR) Back thinned TEC sensor	UV) Low noise type Back thinned TEC sensor
CCD Cooling		Default : 5 ◦ C at Ambient of 25 ◦ C (cooling time: 1min)	
TEC Range		20 ◦ C- 25 ◦ C below ambient	
Dimension		86.5(L) x 120 (W) x 83(H) mm CM Mini Series : 66.5 x 110 x 83 mm	
Integration Time		1.5ms ~ 65sec, depending on sensors	
Environmental Conditions	Storage	-30°C to +70°C	
	Operation	-10°C to +50°C	
	Humidity	0% - 90% non-condensing	

*Note
UV : UV-Enhanced
NIR : NIR-Enhanced

Spec	Content		
	CM2051	CM2061	CM2091
Interfaces	USB 2.0 @ 480 Mbps (高速)		
Power	Power requirement (VBUS): 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		

- OtO can provide customized design for your various special requirements including but not limited to 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

► 2.1 Mechanical Diagram

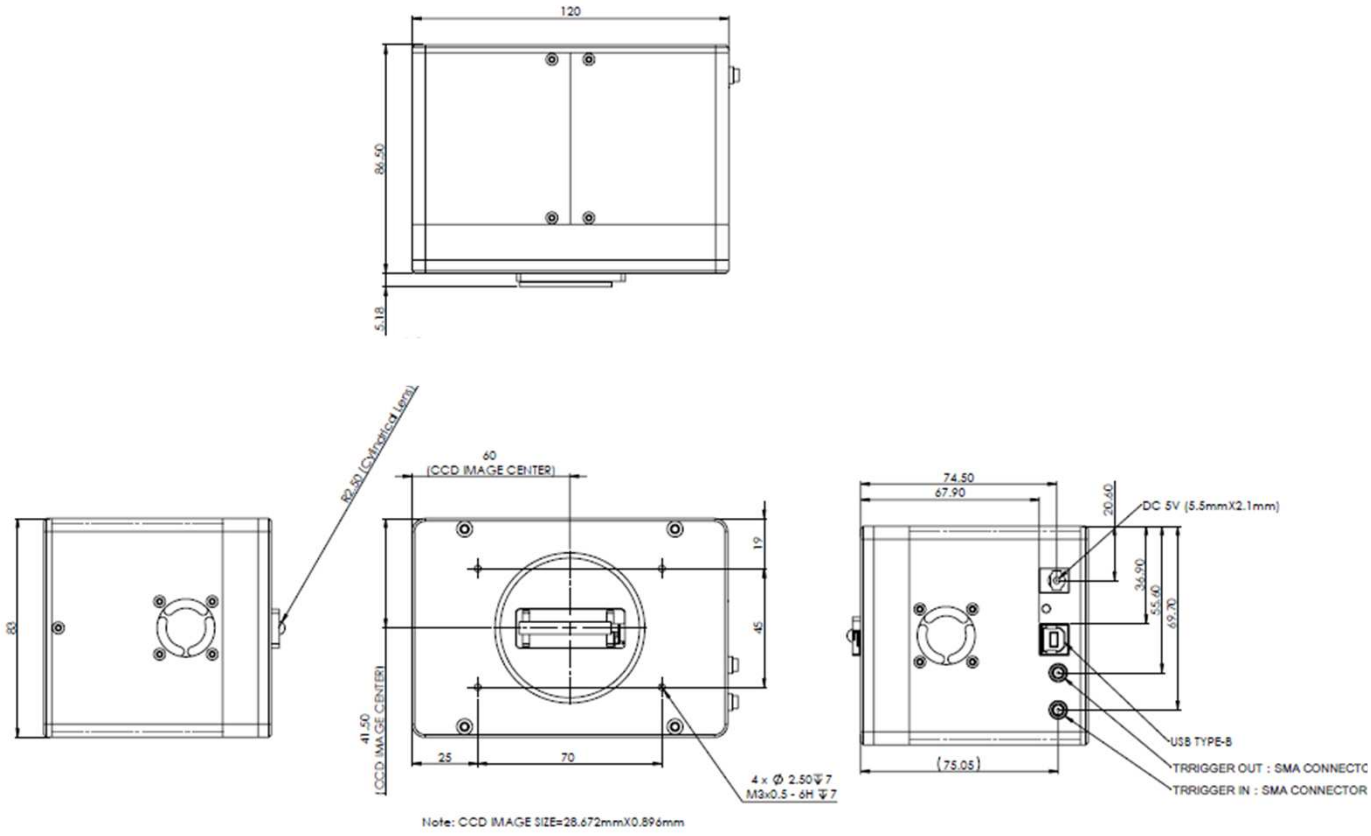


Fig. 1: CM Series outer dimensions

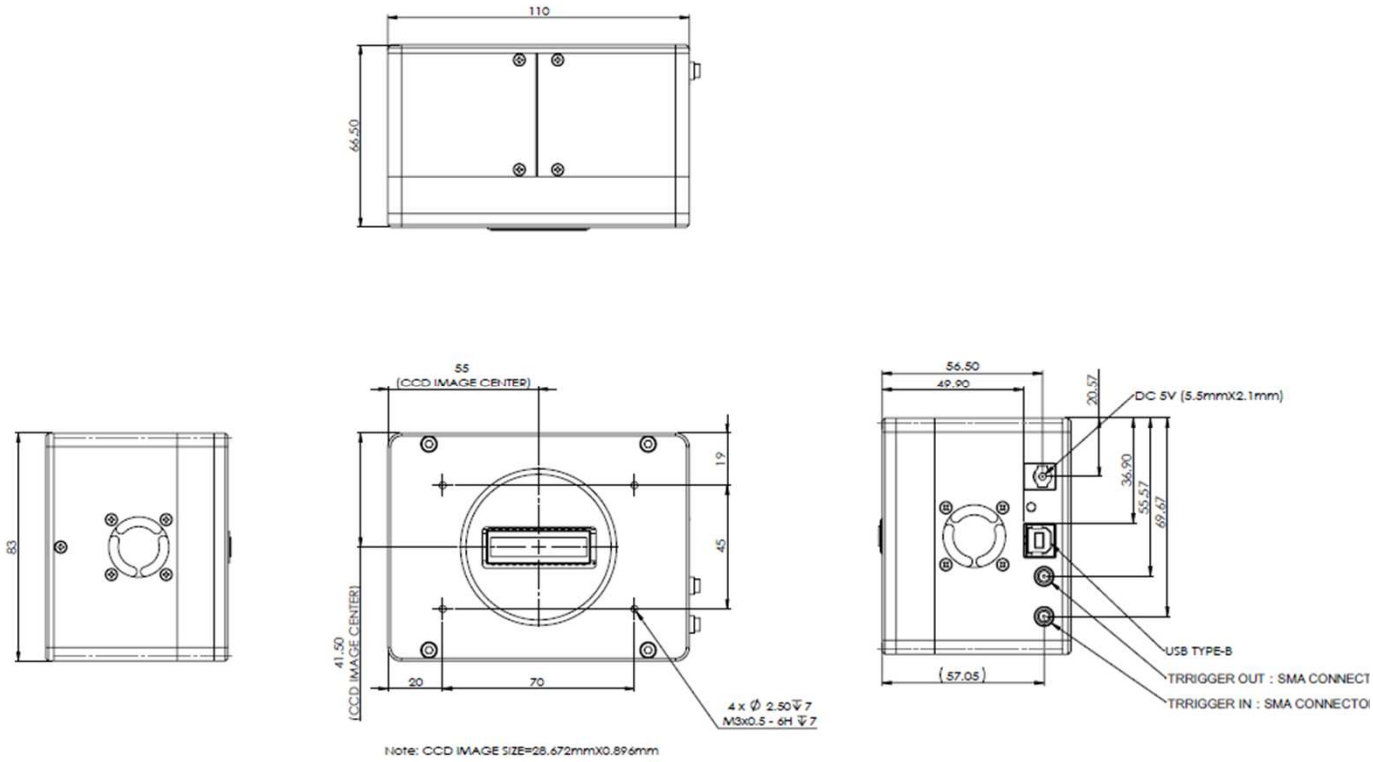


Fig. 1: CM Mini Series outer dimensions

► 2.2 Electrical Pinout

The following listed is the pin description for the CM Series SMA Connectors.

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

Direction	Pin Name	Function Description
Input	Trigger_IN	External Trigger Input Signal.
out	Trigger_OUT	External Trigger output Signal.

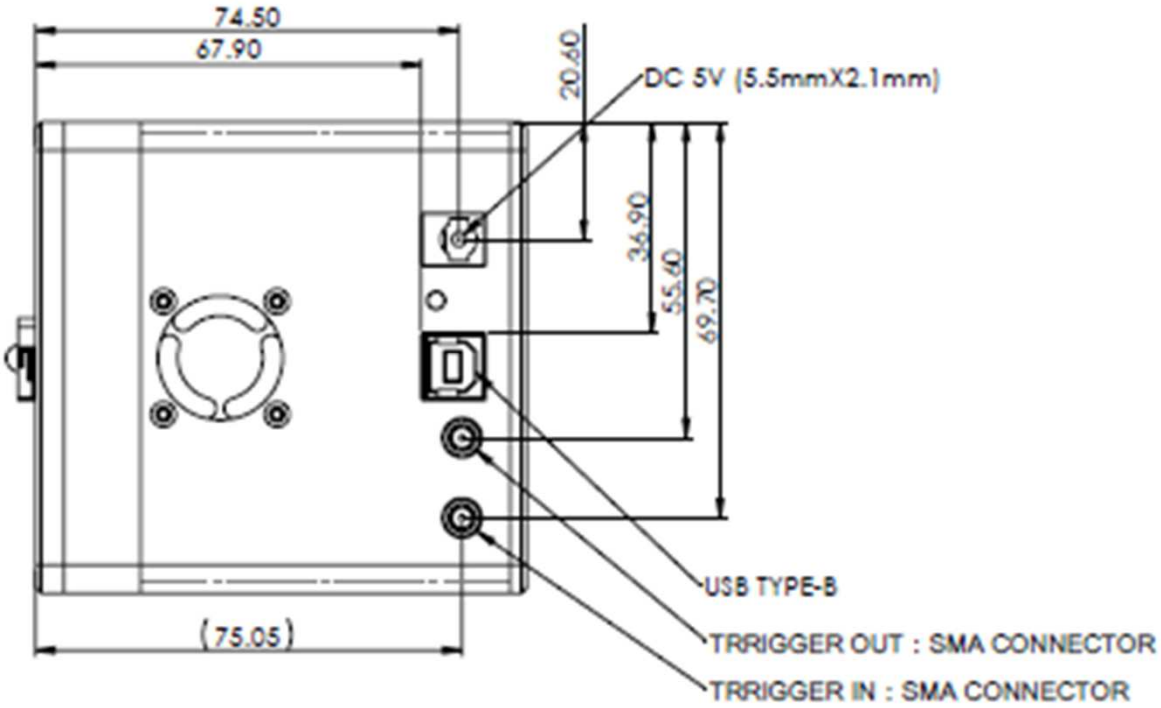


Fig. 3 : CM Series the front-view of connector mechanical graph

► 2.3 CCD Overview

● CCD DETECTOR

TEC sensors are back-thinned CCD image sensors with high quantum efficiency from UV to near infrared region. A thermoelectric cooler is placed inside the package to keep the element temperature constant during operation.

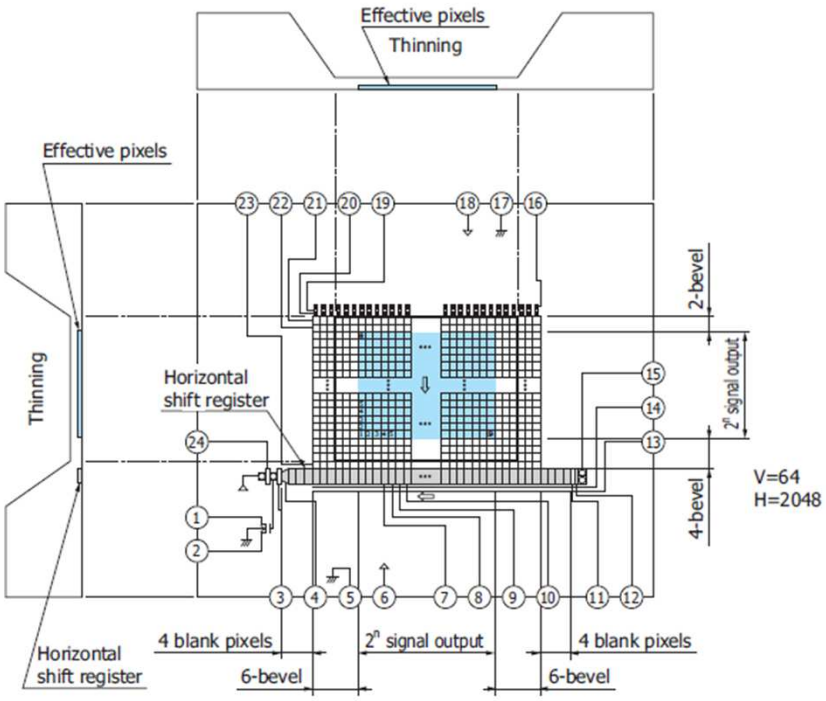


Fig. 4: TEC Sensor Block Diagram (S11850)

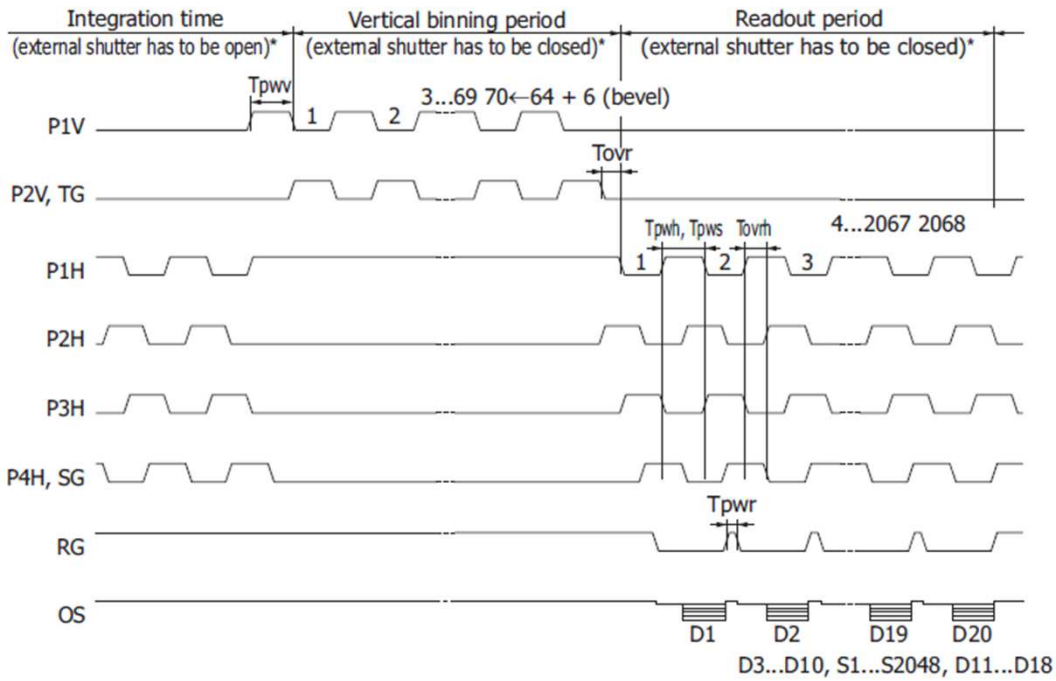


Fig.5: TEC sensor operation timing waveform

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 different sensors, the over-saturated condition may cause the abnormal response.

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

► 3.1 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
1–10	Dummy Pixel
11–2058	Optical active pixel
2059-2068	Dummy Pixel

► 3.2 Digital Inputs & Outputs

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

CM Series has 1 optical coupler Input and 1 5V Output pins, which can be accessed at the SMA male connector. Through software, the state of these I/O pins can be defined and used for multi-purpose applications.

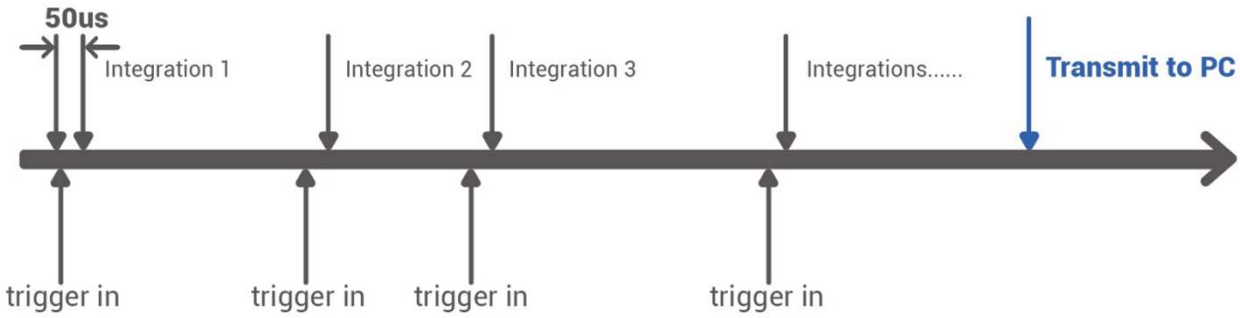
- **LED Signal**

CM Series has an dual color LED. The LED blinks red when power is applied. The LED blinks orange when the sensor is cooling down at setting value.

- **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 Series via USB and monitors multiple SE Series spectra. The low power requirement allows operating the SE Series through the USB cable and VBUS.



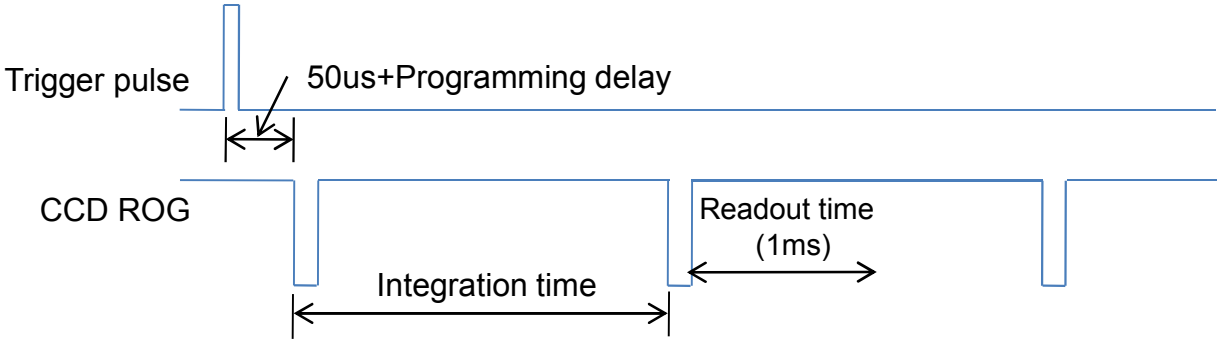
- **Extremely Precise Continuous Multiple Exposures**

- ☐ 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

► 3.3 Trigger Mode

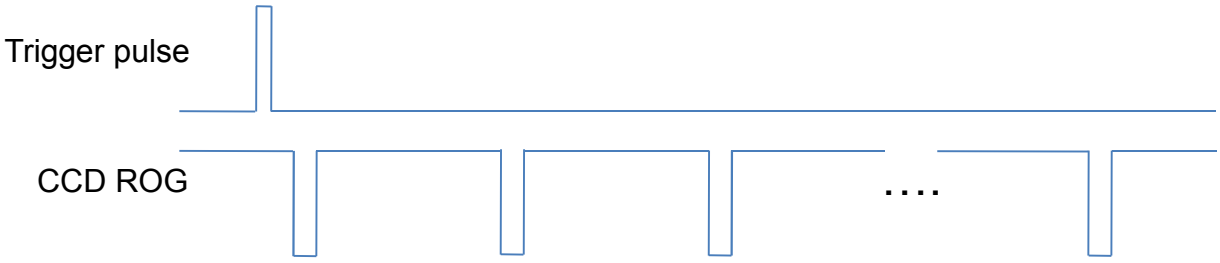
- **Single Trigger Single Data**

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.



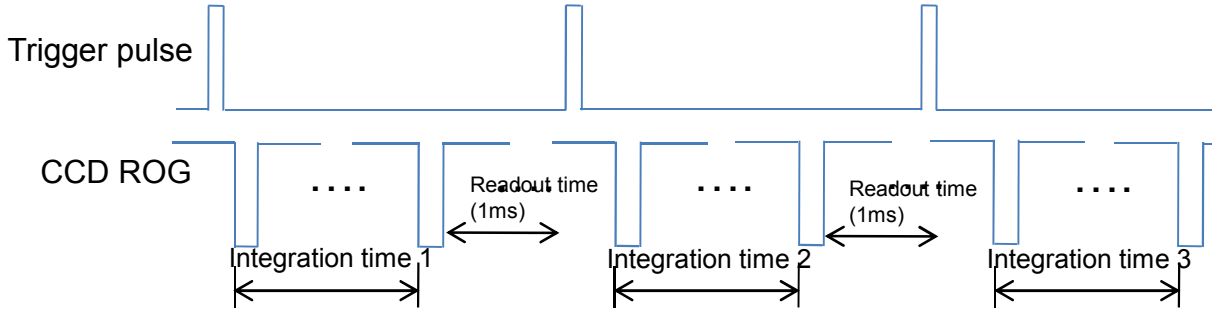
- **Single Trigger Multiple Data**

Single Trigger Multiple Data (integration time and frame number has been set by the command first). Based on single trigger pulse, the system will continue to capture the spectrums. The data is continuous.



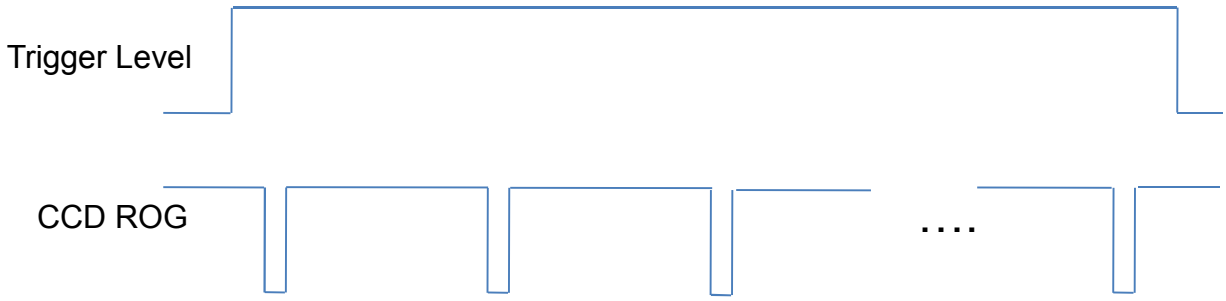
- **Multiple Trigger Multiple Data**

Multi Trigger Multi Data (different integration times have been set by the command first). Based on pre-setting different integration times, the spectrums will be captured for each trigger pulse.



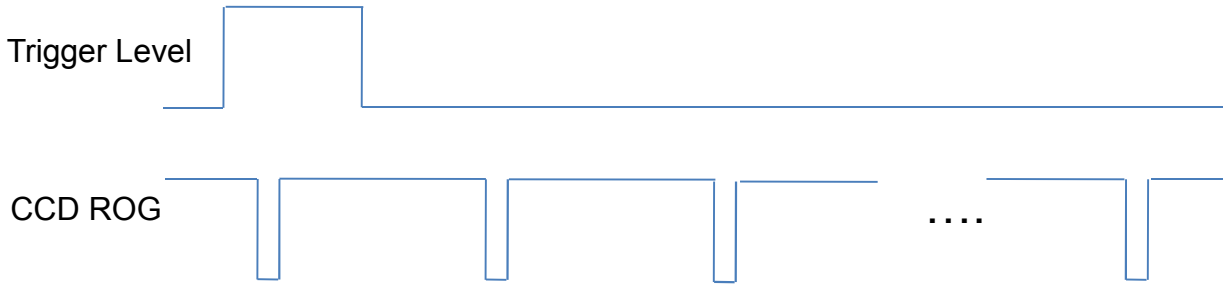
- **Software Level Trigger**

  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.



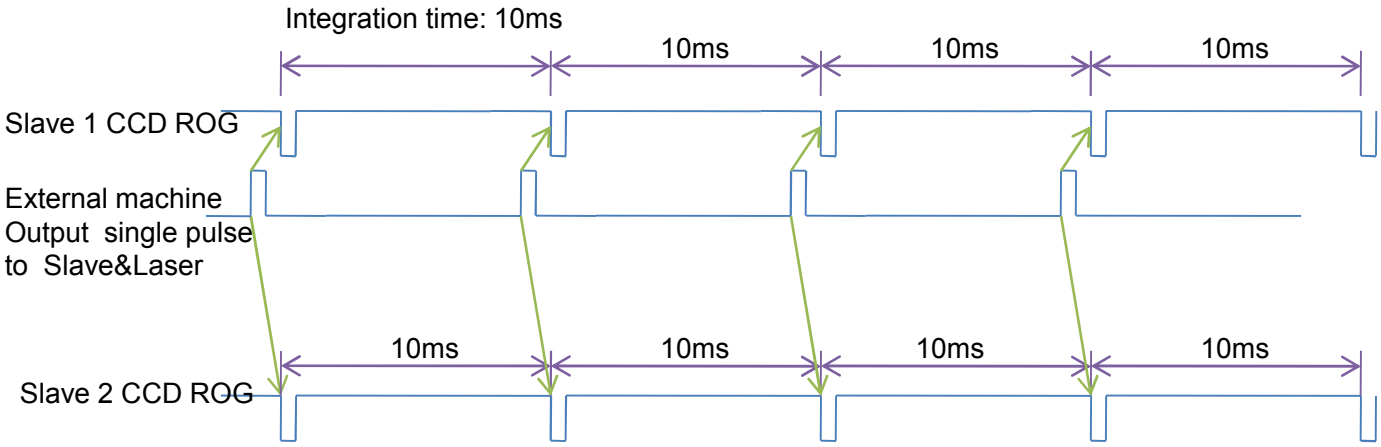
- **Software Level Trigger continuous data**

  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.



- **External Trigger control integration time**

In multiple external trigger modes, SE series can support the integration time is controlled by the external trigger signal. Customer can request this kind of trigger mode when placing an order (currently support in SE1020/2020). If customer uses this kind of the spectrometer, the user can configure the SE spectrometer in this kind of operation mode through USB. Then send the external trigger pulse to the spectrometer. The time internal of two trigger pulses is equal to the integration time.



USB Port Interface Communications and Control Information

► Overview

CM Series is a microcontroller-based linear camera module that can communicate via the Universal Serial Bus. This section contains the necessary programming information for controlling CM Series via the USB interface. This information is only pertinent to users who wish to not utilize SpectraSmart software to interface to SE Series.

● Hardware Description

CM 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.

USB Info

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

Description: To connect Windows host to CM Series

a.Function Name: UAI_SpectrometerOpen

b.Arguments:

dev: 8 CM Series 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. CM 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. CM 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 CM 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 CM Series will be returned.

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

☐ Close CM Series Spectrometer

Description: To connect Windows host to CM 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.