sMAX16AM sCMOS Camera Manual

Version 1.0
2024.08.12

Camera Model	sMAX16AM-U3-CL	sMAX16AM U3-CL-GPS
GPS Model	non-adjustable	adjustable

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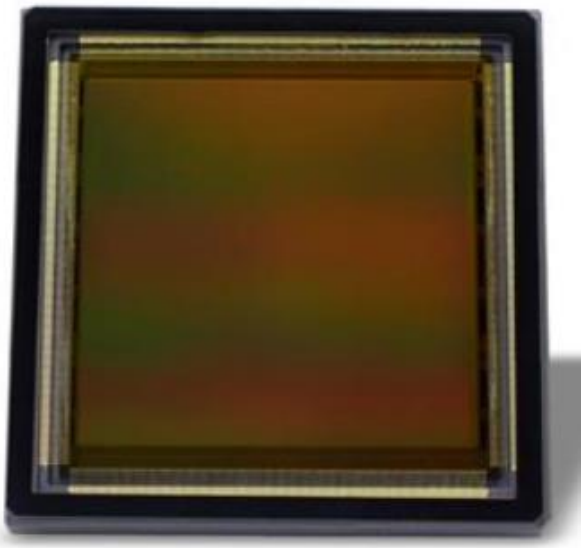
content

1 The basic characteristics of the camera

sMAX16AM is powered by GSENSE4040 3.2-inch image sensor. In view of the inherent thermal noise of the sensor, an efficient cooling module is specially designed to make the camera sensor work at 35-40 degrees lower than the ambient temperature.An anti-fogging mechanism is designed to prevent the fogging of the sensor and filter surface at low temperature. sMAX16AM video and image data is transmitted through the USB3 or CameraLink ultra high speed transfer interface for fast preview.

The basic characteristics of sMAX16AM Camera are listed below:

- GSENSE4040 CMOS sensor
- 300nm-1000nm Wide spectral range
- Peak QE：73.94%@600nm
- Supports ultraviolet, visible, and near-infrared band applications
- Precise temperature control, the temperature difference can reach 40 degrees Celsius below the ambient temperature
- Resolution: 4096 x 4096
- 9um pixel size
- Rolling shutter
- USB3 / CameraLink interface, supports output from two interfaces at the same time
- 12-bit ADC / 16-bit combined HDR
- USB3 / CameraLink frame rate of 20fps / 23fps
- 8Gb RAM
- Support HCG / LCG / HDR mode
- Support Global Reset mode
- Ultra-low readout noise: 4.0e-
- Maximum SNR：49.3dB(LCG 2.8x)
- Dynamic Range：82.5dB(16BIT HDR12HL)
- Supports external I/O trigger control



2 Camera parameters and performance

2.1 Camera Specification

Table 1 sMAX16AM camera specification

Parameter \ Model		sMAX16AM-U3-CL sMAX16AM-U3-CL-GPS
Camera		
Sensor model		GSENSE4040
Sensor type		CMOS
Spectral range		300nm - 1000nm
pixel size		9 μm x 9 μm
Target size		3.2"
Resolution		4096 x 4096
Frame Rate	USB3	20fps@4096x4096, 80fps@2048x2048
	CameraLink	23fps@4096x4096, 90fps@2048x2048
Memory		1024MB (8Gb)
Conversion gain	12bit	0.86e-/DN(HCG 16.5x) 20.94e-/DN (LCG 2.8x)
	12bit Global reset	TBD
	HDR16	0.94e-/DN
Dynamic Range	12bit	58.5dB(HCG 16.5x) 67.5dB(LCG 2.8x)
	12bit Global reset	TBD
	HDR16	82.5dB
Read noise	12bit	4.06e-(HCG 16.5x) 35.61e-(LCG 2.8x)
	12bit Global reset	TBD
	HDR16	4.59e-
Full well charge	12bit	3.45ke-(HCG 16.5x) 84.33ke-(LCG 2.8x)
	12bit Global reset	TBD
	HDR16	61.49ke-
SNR	12bit	35.4dB(HCG 16.5x) 49.3dB(LCG 2.8x)
	12bit Global reset	TBD
	HDR16	47.9dB
Sensitivity		23.82 V/(lux-s)@600nm
Dark current		0.15e-/s/pix
QE		74% @ 600nm
Dark signal inhomogeneity		0.5e-
Optical signal inhomogeneity		0.2%
Exposure time range		12us-3600s
Gain Range		1x – 16.5x
Shutter mode		Rolling shutter / Global reset
Binning mode		Software 2x2, 3x3. 4x4, Hardware 2x2
Data interface		USB3.0 / CameraLink
Digital I/O		One optical-coupling isolated input, one optical-coupling isolated output, tow non-isolated input and output
Data Format		RAW8 / RAW12 / HDR16
Cooling temperature difference		Below room temperature 40 degrees Celsius
General parameters		
Power supply		DC19V 4.74A power supply
Power consumption		TEC ON：58.7W；TEC OFF：16.2W；TEC OFF + CameraLink Only：8.2W
Temperature		Working temperature -30 ~ 45 ℃, storage temperature - 40 ~ 60 ℃
Humidity		0-95%
Size		100*100*127.7
Weight		1317g
Lens mount		M54 x 0.75

Software	ToupView, CLView software based on Delsa acquisition card, LabView, MATLAB, etc
SDK	C, C++, C#, Python
Operating system	Windows, Linux

2.2 Sensor Quantum Efficiency

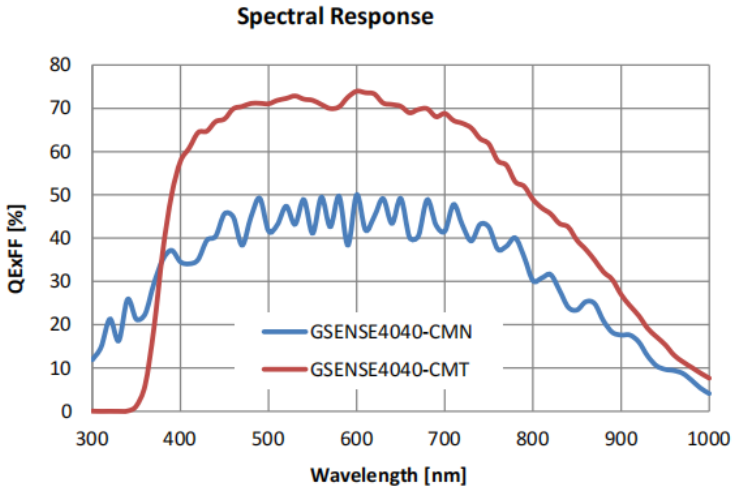


Figure 1 The spectral QE of GSENSE4040

2.3 Camera capture mode

Camera operation mode support: Video Mode or Trigger Mode.

Camera Trigger Mode supports: Soft Trigger Mode(Software) or External Trigger Mode(Isolated input, GPIO0, GPIO1, Counter or PWM).

2.4 DDR3 buffer

Camera has a built-in 1024MB (8Gb) DDR3 buffer, which can effectively the camera does not lose frames when working.

2.5 Binning

sMAX16AM supports additive or averaged 1x1 to 8x8 digital binning, and averaged 1x1 to 2x2 hardware binning. Hardware binning can achieve higher frame rates than software binning.

2.6 Conversion Gain

Camera supports HCG and LCG mode. HCG has low Readout Noise, LCG has higher Full Well. Users can choose different modes according to different applications.

Figure 2 HCG and LCG mode

2.7 DC19V power supply and cooling system

When the DC19V power supply is plugged in, both the camera cooling system and the imaging system use a unified 19V power supply.

When the DC19V power supply is disconnected, the camera cant work.

The cooling system is TEC cooling. It uses an external heat dissipation structure and a fan to assist heat dissipation. The working temperature can be adjusted to a specific value, and the effective cooling temperature can be lower than the ambient temperature by 35 - 40 °C. The efficient cooling system guarantees extremely low dark current levels.

The TEC system is controlled by PID algorithm, so that the TEC can be accurately adjusted to the target temperature, and the temperature deviation is 0.1°C.

2.8 Window glass

The sMAX16AM uses AR anti-reflection protection glass with a size of 52.00mm*50.00mm*1.10mm. The transmittance curve is shown below.

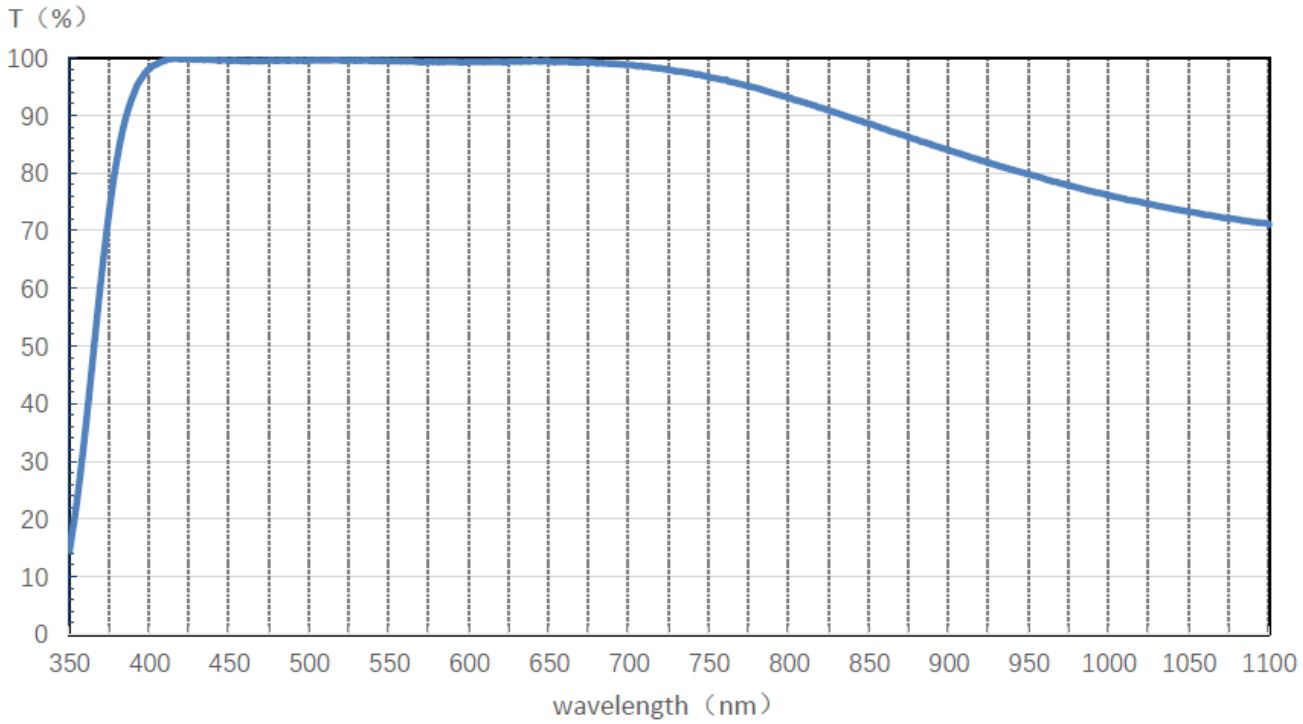


Figure 3 Transmittance curve

Table 2 Transmittance

λ (nm)	T（%）	λ (nm)	T（%）	λ (nm)	T（%）	λ (nm)	T（%）
350	14.58	570	99.15	790	93.85	1010	75.47
360	35.38	580	99.21	800	93.04	1020	74.90
370	61.78	590	99.26	810	92.23	1030	74.33
380	82.87	600	99.28	820	91.33	1040	73.79
390	93.54	574	99.28	794	90.39	1014	73.27
400	98.02	584	99.20	804	89.42	1024	72.78
410	99.50	594	99.34	814	88.56	1034	72.31
420	99.66	604	99.38	824	87.62	1044	71.96
430	99.72	578	99.34	798	86.67	1018	71.50
440	99.55	660	99.29	880	85.73	1100	71.07
450	99.46	670	99.21	890	84.80		
460	99.41	680	99.00	900	83.91		
470	99.42	690	98.94	910	83.06		
480	99.47	700	98.70	920	82.13		
490	99.50	710	98.43	930	81.34		

500	99.51	720	98.11	940	80.53		
510	99.53	730	97.66	950	79.77		
520	99.49	740	97.22	960	78.94		
530	99.50	750	96.59	970	78.16		
540	99.42	760	96.24	980	77.44		
550	99.41	770	95.40	990	76.77		
560	99.38	780	94.68	1000	76.05		

3 Dimension and layout of camera

3.1 Dimension of the camera

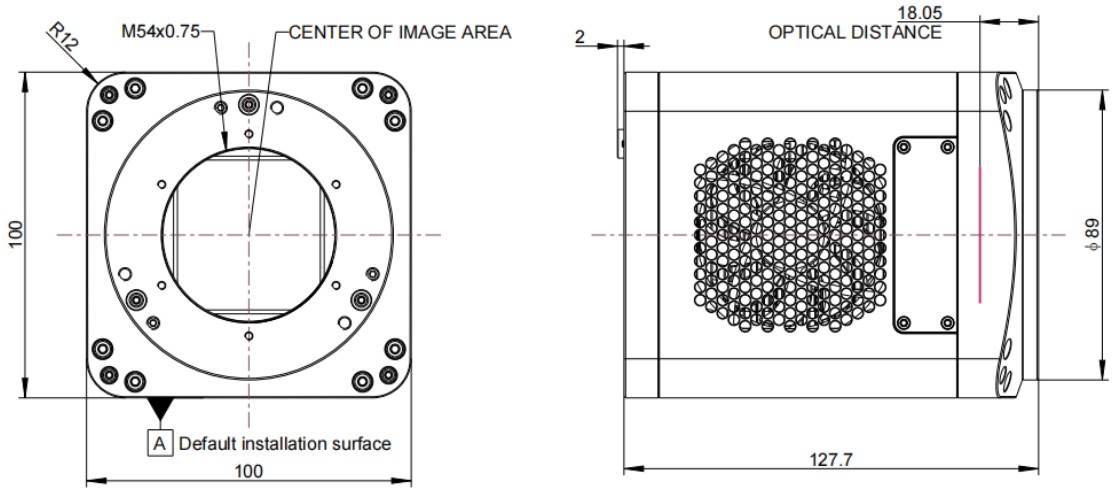


Figure 4 The dimensions of the sMAX16AM

Table 3 The Dimension of camera

Parameter	Specification
Dimension	100*100*127.7mm
Camera lens interface	M54 x 0.75

3.2 Camera Ports For Connection and Power Supply

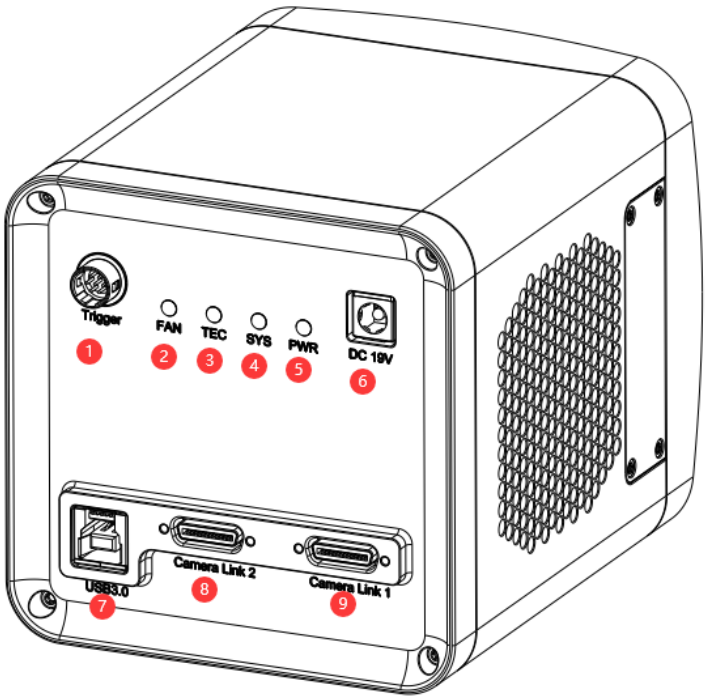


Figure 5 sMAX16AM ports

Table 4 sMAX16AM ports

Item	Specification
1	Trigger 7PIN
2	FAN LED indicators
3	TEC LED indicators
4	System LED indicators
5	Power LED indicators
6	DC 19V power port
7	USB 3.0 port
8/9	CameraLink port

3.3 The packing information

Figure 6 The packing information of the sMAX16AM

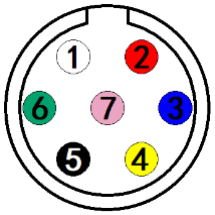
Table 5 The packing information of the sMAX16AM

Standard Packing information	
A	3-A equipment case: L:28cm W:23cm H:15.5cm (1pcs, 2.8Kg/ box)
B	One sMAX16AM Camera
C	Power cord. National standard, American standard, European standard, British standard power cord for choosing
D	Power adapter: input: AC 100~240V 50Hz/60Hz, output: DC19 V 4.74A
E	One USB3.0 cable
F	One external trigger control cable
G	2 CameraLink cables(**Optional Accessory**)
H	capture card(**Optional Accessory**)

4 External IO connector and electrical characteristics

4.1 Pin signal

Table 6 Trigger pin signal definitions



Color	Pin	Signal	Description of the signal
White	1	GDN	Direct-coupled signal ground
Red	2	12V	12VDC power input
Blue	3	OPTO_GND	Opto-isolated signal ground
Yellow	4	DIR_GPIO0	Direct-coupled General Purpose I/O (Software configurable input/output) (line2)
Black	5	DIR_GPIO1	Direct-coupled General Purpose I/O (Software configurable input/output) (line3)
Green	6	OPTO_IN	Opto-isolated input signal (line0)
Pink	7	OPTO_OUT	Opto-isolated output signal (line1)

4.2 I/O electrical characteristics

4.2.1 Opto-isolated input circuit (line0)

In the I/O control of the camera, the opto-isolated input circuit is shown in

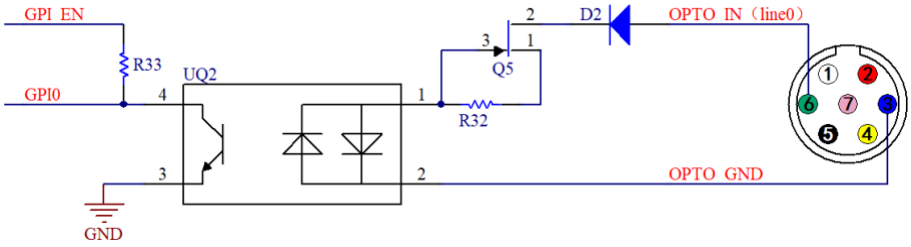


Figure 7 Opto-isolated input circuit

Logic 0 input level: 0~2.2VDC (OPTO_IN pin)

Logic 1 input level: 3.3~24VDC (OPTO_IN pin)

Maximum input current: 30mA

When the input level is between 2.2V and 3.2V, the circuit operation state is uncertain, please do not let SWIR camera work within this voltage range.

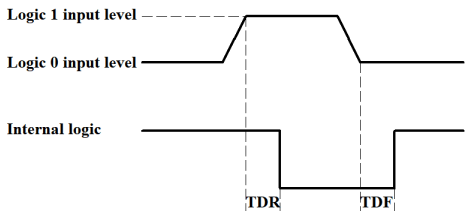


Figure 8 Input logic levels

Input rise delay (TDR): 6us

Input fall delay (TDF): 6us

4.2.2 Opto-isolated output circuit (line1)

In the camera I/O control, the opto-isolated output circuit is shown in Figure 9.

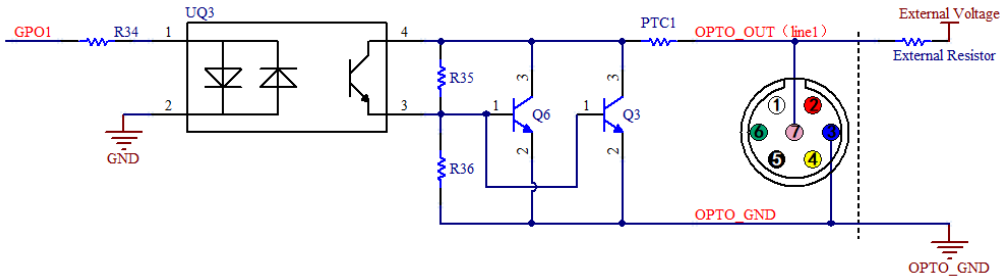


Figure 9 Optocoupler output circuit

The opto-isolated output maximum current is 30mA.

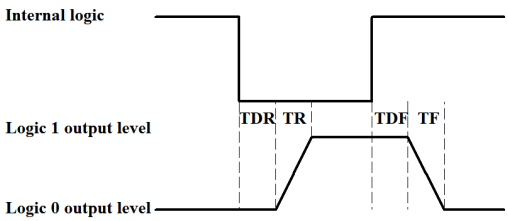


Figure 10 Output logic levels

The electrical characteristics of the opto-isolated output (external voltage 5V, external resistor 1K) are shown in Table 7.

Table 7 Opto-isolated output signal's electrical characteristics

Parameter name	Parameter notation	Parameter value
Output logic low	VL	742mV
Output logic high	VH	4.134V
Output rise time	TR	4us
Output fall time	TF	1.8us
Output rise delay	TDR	12us
Output fall delay	TDF	2us

The output of the corresponding output current and VL when using different voltages and resistors in external circuit are shown in Table 8.

Table 8 Opto-isolated output logic's low levels parameters

External voltage	External resistor	VL	Output current
3.3V	1KΩ	510mV	2.82mA
5V	1KΩ	742mV	4.31mA
12V	2.4KΩ	795mV	4.68mA
24V	4.7KΩ	850mV	4.97mA

4.2.3 Input and output I/O circuit (line2/line3)

The non-isolated configurable input and output I/O circuits are shown in Figure 11 and Figure 12.

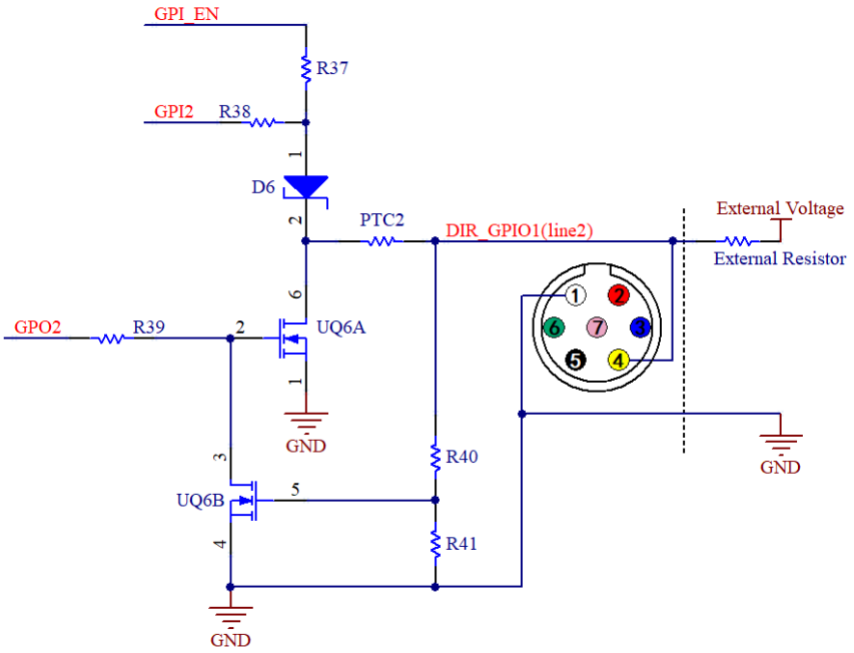


Figure 11 Non-isolated configurable input and output I/O circuit (line2)

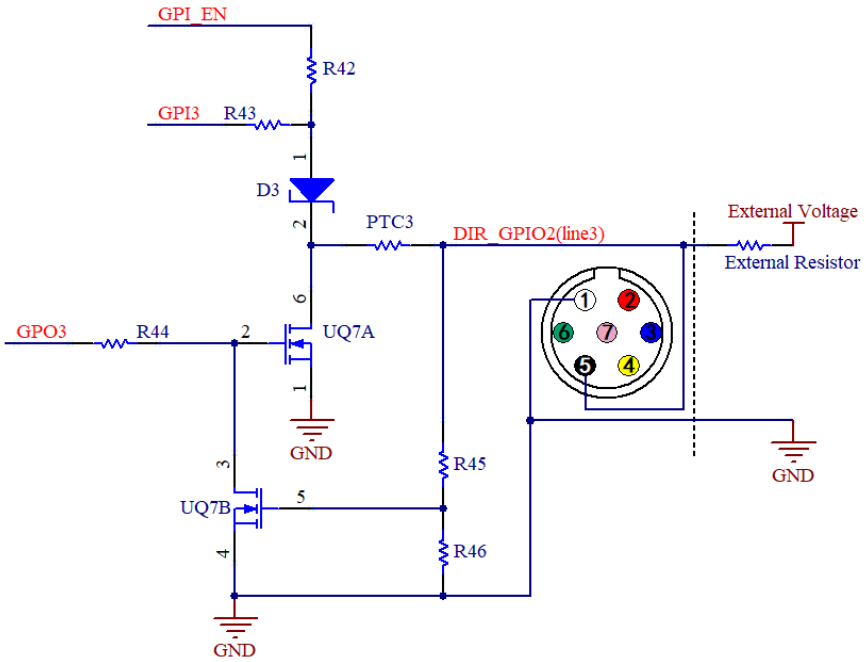


Figure 12 Non-isolated configurable input and output I/O circuit (line3)

1. Line2/line3 is set as input pin

Logic 0 input level: 0~0.6VDC (DIR_GPIO1/DIR_GPIO2 pins)

Logic 1 input level: 2.0~24VDC (DIR_GPIO1/DIR_GPIO2 pins)

Maximum input current: 25mA

When the input level is between 0.6V and 2.0V, the circuit action state is uncertain, please avoid the input voltage

range working in this range.

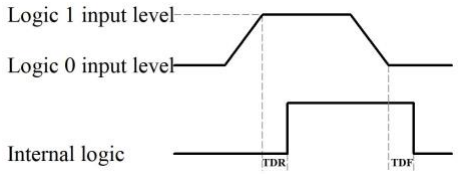


Figure 13 Input logic levels

To prevent damage to the GPIO pins, please connect the pin GND first, and then input voltage to the Line2 pin.

Input rise delay (TDR): 0.02us

Input fall delay (TDF): 0.02us

2.Line2/line3 are set as output pins

The maximum current allowed through this pin is 25mA.

When the ambient temperature is 25 degrees Celsius, the relationship between the external voltage, resistance and low-level valtage output is shown in Table 9.

Table 9 Non-isolated output Logic's low level parameters

External voltage	External resistor	VL (GPIO)
3.3V	1KΩ	0.11V
5V	1KΩ	0.167V
12V	2.4KΩ	0.184V
24V	4.7KΩ	0.385V

The external pull-up voltage is 5V, the pull-up resistor is 1KΩ, and the GPIO is configured to output the logic level and electrical characteristics as shown in Figure 14.

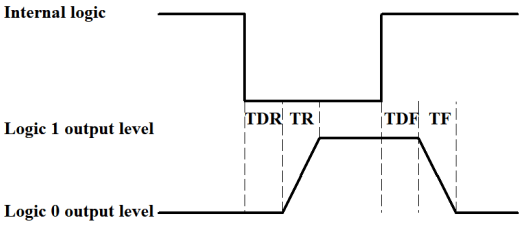


Figure 14 Output logic levels

Table 10 Non-isolated output electrical characteristics

Parameter name	Parameter notation	Parameter value
Output rise time	TR	0.08us
output fall time	TF	0.02us
Output rise delay	TDR	0.1us
Output fall delay	TDF	0.04us

5 Cooling

There is a Cooling group on the left sidebar in ToupView. To enable the Cooling function, an external 19V power supply is required. By default, the TEC is turned on. One can set the Target Temperature. After entering the value, click "Apply", and the sensor temperature will gradually approach to the Target Temperature. At the same time, ToupView can display the current temperature in real time. And the cooling effect can reach about 35-40 degrees lower than the ambient temperature, as shown in Figure 15.

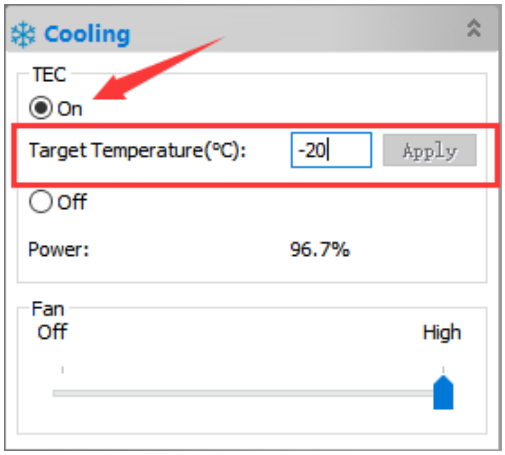


Figure 15 TEC settings

The Fan has two gears from Off to High. When High, the Fan speed reaches the highest. When Off, the Fan is turned off, the TEC is also turned off, and the power is 0, as shown in Figure 16.

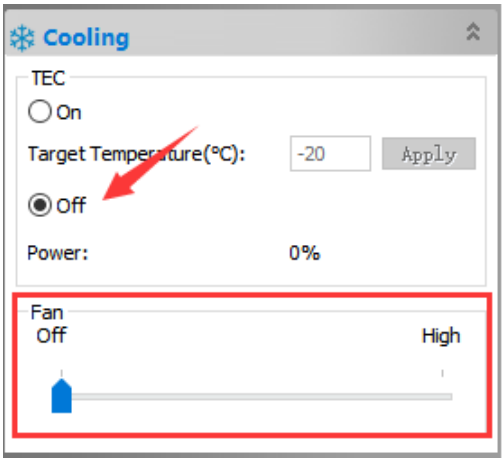


Figure 16 Fan settings

When the TEC is turned on, the Fan will automatically turn on preventing the abnormal situation such as the housing temperature is too high if the Fan stops running when the TEC is working; when the Fan is turned off, the TEC will automatically turn off.

6 sMAX16AM Camera USB Port application

6.1 Trigger Mode and its Configuration

6.1.1 Video mode and Trigger mode

The trigger function can be found on the Capture & Resolution group on the Camera Sidebar in ToupView. When the camera is opened, it is in Video Mode as shown in Figure 17 on the left. In Video Mode, Auto Exposure, Exposure Target, Exposure Time and Gain can be set. One can switch to Trigger Mode by checking the Trigger Mode check box.

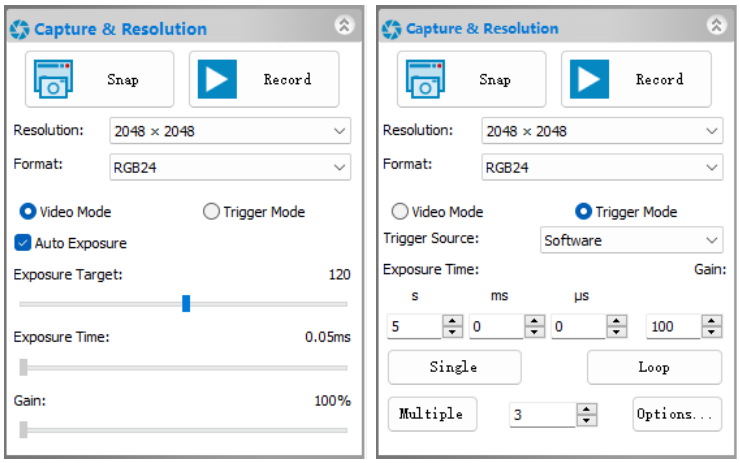


Figure 17 Video Mode and Trigger Mode on the Capture & Resolution group in ToupView

After the Trigger Mode is checked, the Capture & Resolution group will switch to Trigger Mode as shown in Figure 17 on the right. Where, the Trigger Source, Exposure Time, Gain, Single, Loop, Multiple, Frame Box, and Options can be set.

6.1.2 Trigger Sources and their capture style

The Trigger Source can be any external input signal inputted into the camera which is called Hardware (Trigger Source), it can also be a command from the application which is called Software (Trigger Source). For the Software Trigger Source, it can be Single, Loop, Multiple, or Sequence style. Figure 18 shows the possible Trigger Sources. Table 11 shows the designed Trigger Source descriptions and possible capture styles for ToupTek camera.

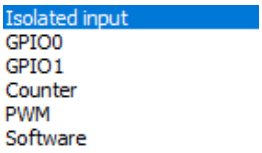
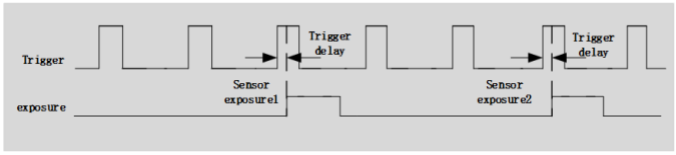
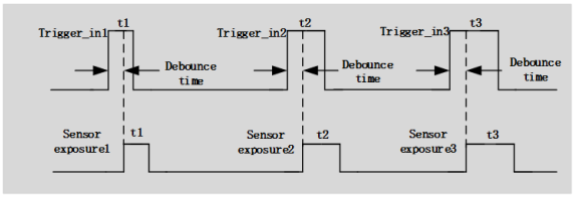
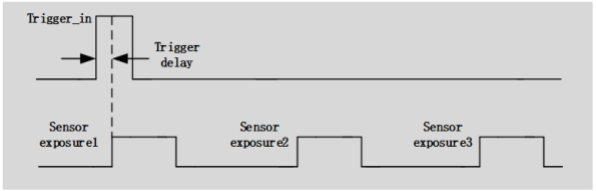


Figure 18 Possible Trigger Sources

Table 11 Description of possible Trigger Sources and their capture styles

Trigger Source	Description
Isolated input	Logic 0 input level: 0~2.2VDC; Logic 1 input level: 3.3~24VDC;. Maximum input current: 30mA;
GPIO0	Logic 0 input level: 0~0.6VDC (DIR_GPIO0/DIR_GPIO1 pins); Logic 1 input level: 2.0~24VDC (DIR_GPIO0/DIR_GPIO1 pins); Maximum input current: 25mA; If **GPIO0** is chosen as **Trigger Source**, it should be configurated as **Input** in the **GPIO Mode**'s combo box on the **Options>IO Control** page;
GPIO1	Logic 0 input level: 0~0.6VDC (DIR_GPIO0/DIR_GPIO1 pins); Logic 1 input level: 2.0~24VDC (DIR_GPIO0/DIR_GPIO1 pins);

	Maximum input current: 25mA; If **GPIO1** is chosen as **Trigger Source**, it should be configurated as **Input** in the **GPIO Mode**'s combo box on the **Options>IO Control** page;
Counter	**Counter** refers to the operation mode in which the camera can divide the frequency of the external input trigger signal through the preset **Counter Value** and perform image acquisition according to the customer's logic. For example, when the counter value() is set to 3, the camera needs to receive 3 trigger signals to trigger once;  When **Counter** is chosen in **Trigger Source** combo box in the **Capture & Resolution** group, the **Counter Source** can be **Isolated input**, **GPIO0** or **GPIO1** which can be chosen on **Options>IO Control** page; If **GPIO0** or **GPIO1** is chosen in the **Counter Source** combo box on **Options>IO Control** page. It should be configured as **Input** in the **GPIO Mode** combo box; Check **Options>IO Control** page's **Line Select** related items and **Counter** related items for details;
PWM	**PWM** refers to the operation mode in which the camera exposure time is controlled by the input trigger signal's pulse width;  **PWM Trigger Source** can be **Isolated input**, **GPIO0** or **GPIO1**. If **GPIO0** or **GPIO1** is chosen in the **PWM Source** combo box on the **Options>IO Control** page, it should be configured as **Input** in the **GPIO Mode** combo box; Check **Options>IO Control** page's **Line Select** related items and **PWM** related items for details;
Software	When **Software** trigger is chosen, the client software can send the command through USB3.0 to trigger, acquire and transfer images, In ToupView, **Single**, **Loop**, **Multiple,** or **Sequence** can be used to send the **Software** trigger command; If the **Plan** or **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Multiple** button will switch to **Sequence** button and the camera will use the **Exposure Time** and **Gain** in the **Sequence table** on this page one by one to capture the specified frames. Check **Single**, **Loop**, **Multiple,** or **Sequence** on **Capture & Resolution** group for the **Software** capture operations; Check **Options>Sequence** page and **Options>Advanced** page for the related **Sequence** and **Software** capture setup options;
Single	When **Single** is clicked, the camera will start to capture the image. At the same time the **Single** button will switch to **Stop** button. Clicking **Stop** button to stop the current **Single** capture operation, the **Stop** button will switch to **Single** button again for the next capture operation; **Note**: 1) The captured frames will always **Show in the video window** to prevent too many captures; 2) Enabled when **Software** in the **Trigger Source** combo box is chosen or **Always enable software trigger** checkbox is checked on the **Options>Advanced** property page;
Loop	When **Loop** is clicked, the camera will start to capture the image continuously and the **Loop** button will switch to **Stop** button. Clicking **Stop** button to stop **Loop** captures and the **Stop** button will switch to **Loop** button for the next **Loop** capture operation; **Note**: 1)The captured frames will always **Show in the video window** to prevent too many captures; 2)Enabled to capture continually when **Software** in the **Trigger Source** combo box is chosen or **Always enable software trigger** checkbox is checked on the **Options>Advanced** property page;
Multiple	**Multiple** refers to the operation mode in which the camera receives **Software** trigger signal or command and exports multiple frames of images. An edit box with spin(we call it **Frames Box**) is designed and affiliated to the **Multiple** button () for the setting of the frames to be captured; The **Frames Box** can be set in the range of 1~ 65535. If the **Frames Box** is 3, a three-frame image will be captured and exported;  **Note**: 1)**Multiple** capture is enabled to capture continually when **Software** in the **Trigger Source** combo box is chosen; 2) **Multiple** capture is enabled when **Always enable software trigger** is checked on the **Options>Advanced** property page, no matter whether **Trigger Source** is **Software** or **Hardware** on the **Capture & Resolution** group; 3) If the **Plan** or **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Multiple** button

	will switch to **Sequence** button and the camera will use the **Exposure Time** and **Gain** in the **Sequence table** on this page. The captured frames will be displayed either in **Show in the video window**, or **Show in a new window** or **Save to disk** which can be specified on **Options>Output** page;
Sequence	When **Sequence** is clicked, the camera will start to capture the image until the specified frames in the **Frames Box** are captured. At the same time the **Sequence** button will switch to **Stop** button. Clicking **Stop** button will stop the current **Sequence** capture and the **Stop** button will switch to **Sequence** again for the next **Sequence** capture operation; **Note**: 1) Switched from **Multiple** to **Sequence** to capture the specified frames in the edit box with spin(**Frames Box**) when **Plan** or **Hardware** in the **Type** combo box is chosen on the **Options>Sequence** property page; 2)If the **Plan** or **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Sequence** button will be enabled and the capture will use the **Exposure Time** and **Gain** in the **Sequence table** list below one by one on the **Options>Sequence** page; 3) If the **Plan** or **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page and **Always enable software trigger** is checked on the **Options>Advanced** property page, the **Sequence** button will not switch to **Multiple** button and will be enabled only when the still in Sequence enable 4)If the **Plan** is chosen in the **Type** combo box on the **Options>Sequence** page and the **Software** is chosen in the **Trigger Source** combo box, the **Sequence** button will be enabled. 5)If the **Hardware** is chosen in the **Trigger Source** combo box, the **Sequence** button will be disabled, but the **Frame Box** will still be enabled and the **Sequence** will switch to the **Hardware Sequence** capture. One **Hardware** trigger signal will capture the specified frames on the **Frame Box** using the **Exposure Time** and **Gain** in the **Sequence table** on **Options>Sequence** page; 6)Check **Options>Sequence** page for the related **Sequence** setup options;

6.1.3 The trigger capture and IO Control configurations

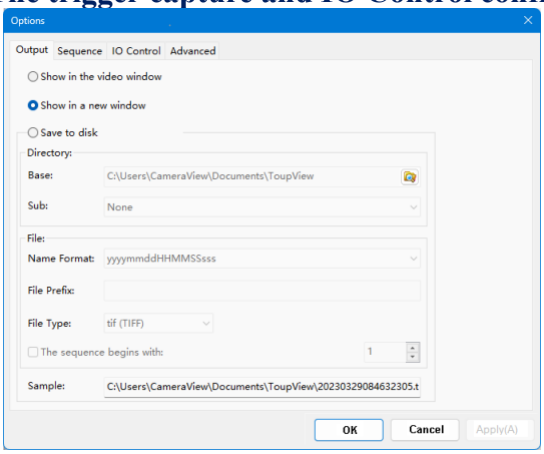


Figure 19 Options>Output page

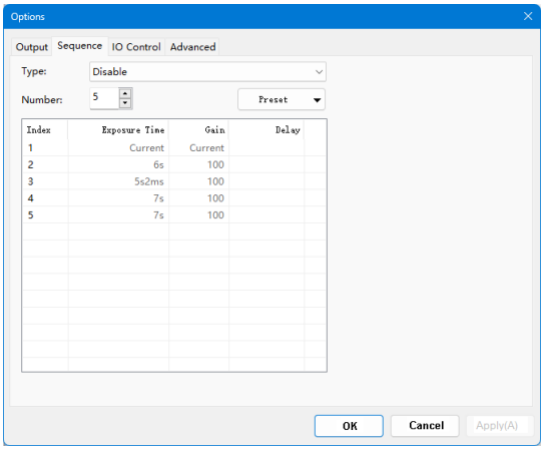


Figure 20 Options>Sequence page

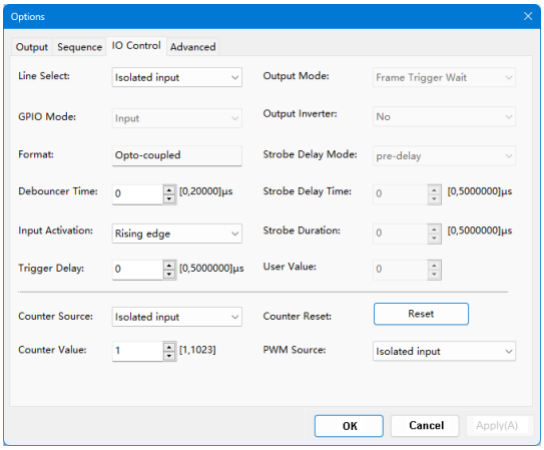


Figure 21 Options>IO Control page

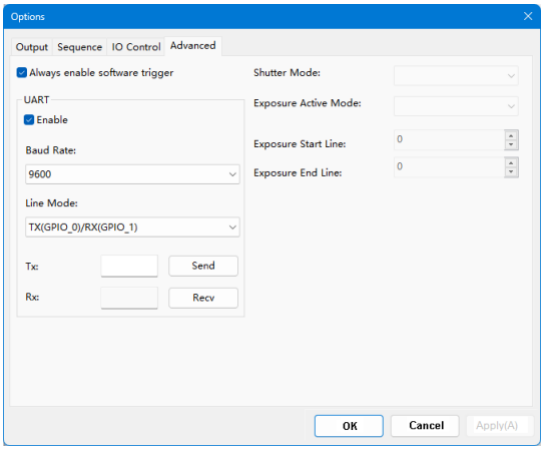


Figure 22 Options>Advanced page

The Trigger Source can be Isolated input, GPIO0, GPIO1(when configured as input), Counter, or PWM which can be configurated on the Options property sheet. Also the camera's Isolated output, GPIO0 or GPIO1(can be configurated

as Output) can be used as Output or UART (GPIO0, GPIO1 only) applications. All of these configurations can be realized on the Options property sheet described in Table 12 below.

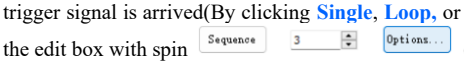
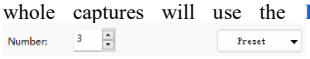
About the captured file operation style, one can find it on the Option>Output page;

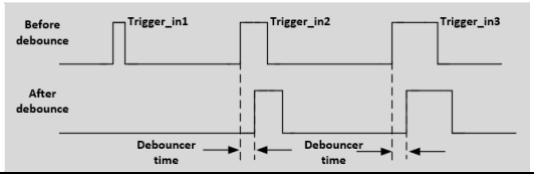
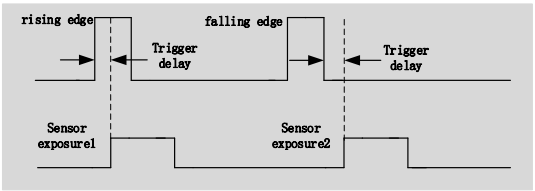
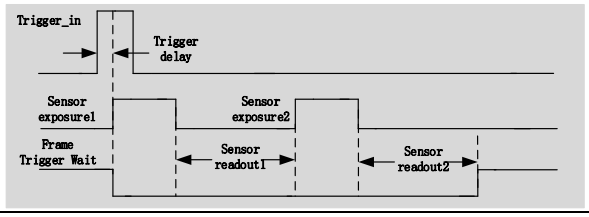
About the Sequence setup, one can find it on the Option>Sequence page;

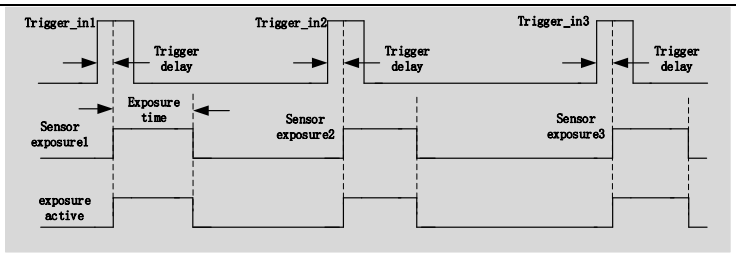
About the camera pin IO Control style, one can find it on the Options>IO Control page;

About the Always enable software trigger and UART setup, Shutter Mode, and Exposure Active Mode, one can find it on the Options>Advance page.

Table 12 Options property sheet for Trigger Source or camera pin configuration

Pages	Items	Descriptions
Output page	**Output Destination**	Used to set the captured frame's **Output** destination, can be **Show in the video window**, **Show in a new window** or **Save to disk**; When **Save to disk** is checked, the  button will be enabled clicking it to choose the **Base** directory, clicking the **Sub** combo box's dropdown button to choose the **Sub** directory; The **File Name Format**, **File Prefix**, **File Type,** and even **The sequence begin with** can be chosen, set, or defined. **Note**: 1)Valid only for **Sequence** or **Multiple** capture setup; 2)For **Single** or **Loop** capture, the captured image will be always displayed on the video window;
Sequence page	**Type** Disable Plan Hardware	**Disable**: If the **Disable** button is chosen in the **Type** combo box on the **Options>Sequence** page, the **Sequence** button on the **Capture & Resolution** page will switch to **Multiple** button;
		Plan: 1)If **Plan** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Multiple** button on the **Capture & Resolution** group will switch to **Sequence** button; 2) If the **Software Trigger Source** is chosen in the **Capture & Resolution** group or the **Always enable software trigger** is checked on the **Options>Advanced** property page, the **Sequence** button will be enabled After the **Software** trigger signal is arrived(By clicking **Single**, **Loop,** or **Sequence** button), the camera will capture frames specified in the edit box with spin  (we call it **Frames Box**) affiliated to the **Sequence** button; The whole captures will use the **Exposure Time**, **Gain** and **Delay** in the **Sequence table** list under  one by one by the software; 3) If the **Disable** button is chosen in the **Type** combo box on the **Options>Sequence** page, the **Sequence** button on the **Capture & Resolution** page will switch to **Multiple** button; 4) The **Sequence** button will be enabled only when a) the **Plan** in the **Type** combo box is chosen on the **Options>Sequence** page and b) he **Software Trigger Source** is chosen in the **Capture & Resolution** group or c) **Always enable software trigger** is checked on the **Options>Advanced** property page;
		Hardware: 1) if **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Multiple** button on the **Capture & Resolution** group will switch to **Sequence** button and will be disabled for **Hardware** trigger. But users can still set the frames number in the **Frame Box** on the **Capture & Resolution** group; 2) After the **Hardware** trigger signal arrives, the camera will capture frames specified in the edit box with spin  (we call it **Frame Box**) affiliated to the **Sequence** button; The whole capture will use the **Exposure Time**, **Gain** (**Delay** is not used) in the **Sequence table** list under  one by one but stored in the camera hardware for the quick operation; 3) If the **Disable** button is chosen in the **Type** combo box on the **Options>Sequence** page, the **Sequence** button on the **Capture & Resolution** page will switch to **Multiple** button. 4) The **Sequence** button is always disabled if a) The **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page and b)the **Hardware Trigger Source** is chosen in the **Capture & Resolution** group; 5) The **Sequence** button will be enabled if a) the **Software Trigger Source** is chosen in the **Capture & Resolution** group or b) the **Always enable software trigger** checkbox is checked on the **Options>Advanced** property page, in this case, both the **Plan** and **Hardware Sequence** capture are supported;
	Number	The possible **Sequence**(capture) frames to be captured. If the **Number** is larger than the **Sequence Number** in the **Frames Box** on the **Capture & Resolution** group, the other **Indices** will be executed at the next **Sequence** operation one by one recycled;
	Index	The order of the **Number** group;
	Exposure Time	The camera **Exposure Time** for the specified capture **Index** in the **Sequence** capture;
	Gain	The camera **Gain** for the specified capture **Index** in the **Sequence** capture;
	Delay	The **Delay** time for the specified capture **Index** in the **Plan Sequence** capture(Valid for **Plan Sequence** capture only);

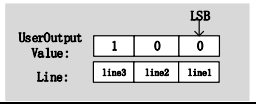
	Preset	Choosing **Save** to save the current **Sequence table**'s settings; Clicking **Management** to **Rename** the saved **Sequence table**'s setting files or **Remove** them from the **Management** list;
IO Control page	**Line Select**	Choosing which line to set. Can be **Isolated input**, **Isolated output**, **GPIO0** or **GPIO1 et al**;
	GPIO Mode	To configure whether the line selected in **Line Select** is for **Input** or **Output**. Only **GPIO0** or **GPIO1** can be configured as either **Input** or **Output**; If **Isolated input** or **Isolated output** is chosen, the **GPIO Mode** will be specified as **Input** or **Output** (Not configurable) respectively;
	Format	Specify the current selected signal's **Format** in the **Line Select** combo box, can be **Opto-coupled**(**Isolated input**, **Isolated output**)or **TTL** (**GPIO0** or **GPIO1**)for clarity(Unconfigurable);
	Debouncer Time	Since there may be a glitch in the external trigger input signal if it directly enters into the internal logic circuit of the camera, it will cause false triggering, so the input trigger signal should be debounced. In addition, the effective pulse width of the trigger signal input by the user should be greater than the **Debouncer Time**, otherwise, the trigger signal will be ignored; When **Isolated input**, **GPIO0** or **GPIO1** is chosen in the **Line Select** combo box and **GPIO0** or **GPIO1** is configured as **Input** in the **GPIO Mode** combo box, the **Debouncer Time** will be enabled for the user to input the **Debounter Time** between 0 to 20000us; 
	Input Activation	When **Isolated input**, **GPIO0** or **GPIO1** is chosen in the **Line Select** combo box and **GPIO0** or **GPIO1** is configured as **Input** in the **GPIO Mode** combo box; The **Input Activation** combo box will be enabled to configure the **Input Activation** as either **Rising Edge** or **Falling Edge**; 
	Trigger Delay	When **Isolated input**, **GPIO0** or **GPIO1** is chosen in the **Line Select** combo box and **GPIO0** or **GPIO1** is configured as **Input** in the **GPIO Mode** combo box, the **Trigger Delay** will be enabled for the user to input the **Trigger Delay** time between 0 to 5000000us; If the **Trigger Delay** time is set to 1000000us, the camera will wait for 1s to capture the image after receiving the trigger signal;
	Output Mode Frame Trigger Wait Exposure Active Strobe User Output	When **Isolated output**, **GPIO0** or **GPIO1** is selected in the **Line Select** combo box and **GPIO0** or **GPIO1** is configured as **Output** in the **GPIO Mode** combo box, the **Output Mode** will be enabled. It can be **Frame Trigger Wait**, **Exposure Active**, **Strobe,** or **User Output**. The chosen mode can be used for diversified applications; The **Frame Trigger Wait** signal is pulled low at the start of exposure and pulled high when the last frame of data is read out. The trigger signal input by the user should be in the valid period. If the user inputs a trigger signal when the signal is low, the trigger signal input at this time will be ignored. The following example is the case when Burst Count = 2, as shown below;  **Exposure Active**: when this signal is high, it means the sensor is exposing. This signal can be used to control an external mobile device to remain stationary or move at low speed while the camera is at exposure. The timing diagram of the exposure valid signal is shown below;



When the relative position of the camera and the object to be photographed changes, you can refer to **Exposure Active** signal to prevent the captured image from being affected by movement and focus adjustment during the exposure process;

When **Strobe** is chosen, **Strobe Delay Mode**, **Strobe Delay Time**, **Strobe Duration** will be enabled;

When **User Output** is chosen, **User Value** will be enabled. lines3, line2, line1 are the combination of **GPIO1, GPIO0** and **Isolated output** respectively. If **User Value** is 001, then line **GPIO1** and **GPIO0** will be disabled and **Isolated output** will be enabled;



Output Inverter

When **Isolated output**, **GPIO0** or **GPIO1** is selected in the **Line Select** combo box and **Output** is chosen for **GPIO0** or **GPIO1** in the **GPIO Mode** combo box, the **Output Inverter** will be enabled to configure the current selected line's output as either inverted or not(**Yes** or **No**).

Strobe Delay Mode

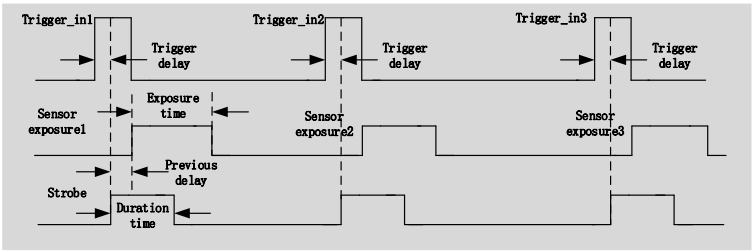
Strobe can be used to control external devices such as the strobe, and the effective level duration, delay time, and pre-delay time of the strobe signal can be set;

When the **Output Mode** is **Strobe**, **Strobe Delay Mode** will be enabled. It can be **pre-delay** or **delay**;

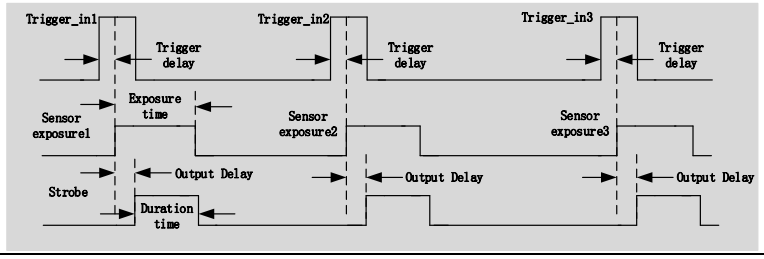
Strobe Delay Time

When exposure starts, the strobe does not take effect immediately, and the output is delayed according to the value set by **Strobe Delay Time** which is between 0 to 5000000us. The **Strobe Delay Mode** can be **pre-delay** or **delay**; It is described below;

pre-delay:

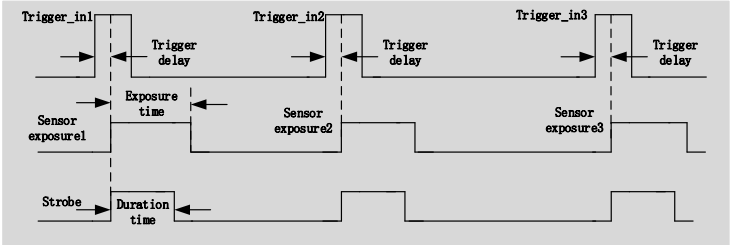


delay:



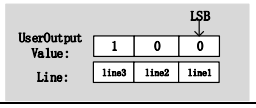
Strobe Duration

The high level duration of the strobe is determined by the **Strobe Duration** which is between 0 to 5000000us as shown below;



User Value

Users can input a value at **User Value** edit box with spin to control the line as disable or enable. Enabled when **User Output** is chosen in the **Output Mode** combo box. The logical value 0 or 1's combination of **GPIO1**(line3),

		GPIO0(line2) and **Isolated output**(line1); When the output mode is selected as **User Output**, the user can input a value at **User Value** edit box to control the corresponding line output with 0 or 1; The value here is only valid for the lower three bits of a binary. For example, when line 1 and line 3 are set to **User Output** mode, and its **User Value** is set to 4 ('b100), then line 3 outputs 1, and line 1 outputs 0, as shown below. 
	Counter Source	When **Counter** is chosen in the **Trigger Source** combo box in the **Capture & Resolution** group, the **Counter Source** can be chosen from **Isolated input**, **GPIO0** or **GPIO1** in this combo box on the **Option>IO Control** page;
	Counter Value	The **Counter Value** is used to divide the frequency of the external input trigger signal when the **Counter Trigger Source** is chosen in the **Capture & Resolution** group; See **Counter** in Table 11 for detail;
	Counter Reset	Click **Reset** button can clear the current counting process and begin a new one;
	PWM Source	When **PWM** is chosen in the **Trigger Source** combo box in the **Capture & Resolution** group, the **PWM Source** can be from **Isolated input, GPIO0,** or **GPIO1** in this combo box et al. ;
Advanced page	**Always enable software trigger**	When this button is checked, no matter whether **Trigger Source** is **Software** or **Hardware**, the software trigger buttons(**Single**, **Loop**, **Multiple**) are always enabled; If the **Plan** or **Hardware** is chosen in the **Type** combo box on the **Options>Sequence** page, the **Multiple** button will switch to **Sequence** button; The **Sequence** button will be enabled if a)the **Software Trigger Source** is chosen in the **Capture & Resolution** group or b) the **Always enable software trigger** checkbox is checked on the **Options>Advanced** property page, in this case, both the **Plan** and **Hardware Sequence** captures are supported;
	UART	There is a serial port function on the **Advanced** page, which can be used to communicate with external devices via serial port. Check **Enable** to enable this function. When enabled, **GPIO0** and **GPIO1** can only be used as **UART** transfers; The **Baud Rate** supports 9600-115200. **Cable Select** can configure **GPIO0** and **GPIO1**, which can be configured as **TX** or **RX** respectively. Setting a value at **TX**, clicking **Send** to send the set value out; click **Accept** at **RX** to receive the value from the external device;
	Shutter Mode	Enabled if the camera supports. Users can select **Rolling Shutter** or **Global Reset**;
	Exposure Active Mode	Enabled if the camera supports. Users can select **Specified lines** or **Common exposure time**;
	Exposure Start Line	Enabled when **Specified lines** in the **Exposure Active Mode** combo box is selected. To configure when the Exposure Active signal is valid;
	Exposure End Line	Enabled when **Specified lines** in the **Exposure Active Mode** combo box is selected. To configure when the Exposure Active signal is invalid;

6.2 Application installation

In terms of software, customers are welcome to visit our website: https://touptek.com/download/ to download the latest ToupView. SWIR series can also be used with ASCOM, DirectShow interface. If the third-party software is compatible with these interfaces, customers can also download software drivers from our website and install them into the third-party software.

6.3 Introduction to ToupView

ToupView is a professional software that integrates camera control, image acquisition and processing, image browsing and analysis functions. ToupView has the following characteristics:

- x86: XP SP3 and above ; CPU supports SSE2 and above
- x64: Win7 and above
- Support video mode and Trigger Mode (Raw format or RGB format)
- Automatic capture and quick recording capabilities
- Supports multiple languages
- Hardware ROI and digital binning capabilities
- Rich image processing functions, such as image stitching, real-time overlay, flat field correction, dark field correction, etc.
- Supports all ToupTek cameras

6.3.1 User interface design

- The menus and toolbars are properly set to ensure quick operation
- Professionally integrated with 5 sidebars - Camera, Folders, Undo/Redo, Layers, Measure
- Comfortable operation method (double-click or right-click context menu)
- Detailed help manual

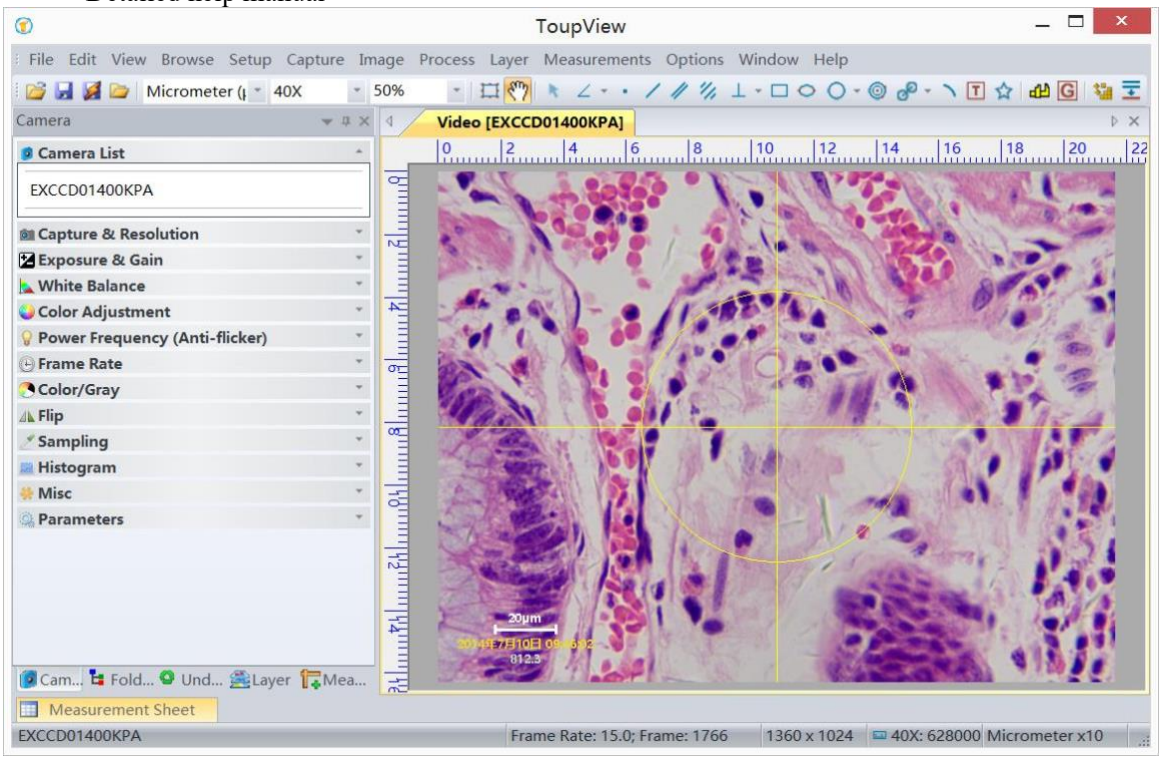


Figure 23 ToupView video window

6.3.2 Professional Camera Control Sidebar

Capture & Resolution	Set up live and still capture, snap images, or record video
Exposure & Gain	Auto exposure (preset exposure target value), manual exposure (exposure time can be manually entered and set by slider); gain up to 5 times
White Balance	Advanced one-click smart white balance settings, and you can adjust white balance by manually setting color temperature and color
Color Adjustment	Color, saturation, brightness, contrast, gamma initial high-speed adjustment function
Frame Rate Control	For different computer and USB performance, the camera can be super compatible by adjusting the frame rate
Flip	Select "Horizontal" or "Vertical" to adjust the sample orientation to ensure the same orientation as the visual system
Sampling	Neighborhood averaging can improve the signal-to-noise ratio of the video stream; while the sampling extraction mode can ensure the sharpness of the video stream. Supports histogram expansion of video stream, image negative and positive switching, grayscale calibration, and sharpness factor calculation to facilitate video focusing
Bit Depth	8, 12-bit switching, 8-bit is the basic Windows image format. 12-bit has higher image quality but reduces frame rate
Roi	ROI, Region of interest. This function can set the ROI value of the video window. After the ROI group is expanded, a rectangular box will appear in the middle of the video window, and the ROI can be changed. The mouse can adjust the size of the ROI. If there is no problem with the ROI, click "Apply" to set the video to the size of the ROI, and the default value will be restored to the original size.
Dark Field Correction	To enable darkfield correction, you should first capture a field image, then click Enable. Check Enable to enable darkfield correction. Uncheck it to disable darkfield correction
Cooling	Set TEC Target Temperature, fan on/off

Parameter Save	Load, save, overwrite, load, export custom camera panel controls (including calibration information, exposure parameters and color settings information, etc.)

6.3.3 Professional and practical image processing functions

Video Function	Various video professional processing functions: video broadcasting, timing capture, video recording, video watermarking, watermark mobile alignment, watermark rotation alignment, video grid overlay, video measurement, video scaling, gray scale calibration, video high dynamic (HDR), video depth of field extension, video image stitching, video scale, date, etc.
Image Processing and Enhancement	Image contrast control and adjustment, image denoising, various image filtering algorithms, image mathematical morphology algorithms, image rotation, image scaling and image printing, etc.
Image Overlay	The ToupView image overlay denoising function introduces advanced image matching technology. Users only need to record a short video of the image to be superimposed, and they can superimpose and output high fidelity in the case of displacement, rotation and magnification change between multiple frames of the video. images, easy to use

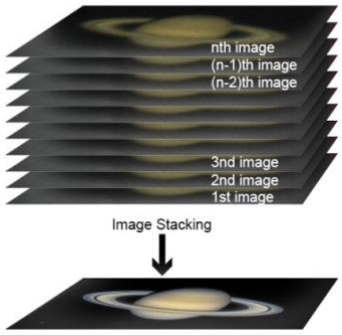


Figure 24 Image overlay denoising

6.3.4 Super compatibility

Camera Video Interface	Provide Twain, DirectShow, Labview, SDK installation package (native C++, C#)
Supported Operating Systems	Compatible with Microsoft® Windows® XP / Vista / 7 / 8 /10 /11(32 & 64 bit), Mac OSX, Linux
Language Support	Language support can be added manually, currently supports English, Simplified Chinese, Traditional Chinese, German, Japanese, Russian, French, Italian, Polish, Turkish

6.3.5 Basic hardware requirements

PC Basic Configuration Requirements	CPU: Intel Core 2 2.8GHz or higher
	RAM: 2GB or more
	USB Port: USB3.0 / USB 2.0
	Monitor: 17" or higher
	CD-ROM

6.4 Software development instructions

6.4.1 SDK description

The download link of the SDK is as follows:

http://www.touptek.com/download/showdownload.php?lang=en&id=32

6.4.2 SDK support platform

- Win32:

  x86: XP SP3 and above; the CPU needs to support at least the SSE2 instruction set.

  x64: Win7 and above.

  arm: Win10 and above.

  arm64: Win10 and above.

- WinRT: x86, x64, arm, arm64; Windows 10 and above.
- macOS: x86 and x64 bundle; macOS 10.10 and above.
- Linux: core 2.6.27 and above.
  x86: The CPU needs to support at least the SSE3 instruction set; GLIBC 2.8 and above.

  x64: GLIBC 2.14 and above.

  armel: GLIBC 2.17 and above; compiled by toolchain arm-linux-gnueabi (version 4.9.2).

  armhf: GLIBC 2.17 and above; compiled by toolchain arm-linux-gnueabihf (version 4.9.2).

  arm64: GLIBC 2.17 and above; compiled by toolchain aarch64-linux-gnu (version 4.9.2).
- Android: arm, arm64, x86, x64; compiled by android-ndk-r18b.

6.4.3 Introduction to SDK content

ToupCam series cameras support a variety of APIs, including: Native C/C++,.NET/C#/VB.NET, Python, Java, DirectShow, Twain, LabView, Matlab, etc. Compared with other APIs, Native C/C++ API as a low-level API is characterized by using pure C/C++ development without relying on other runtime libraries. The interface is simple and the control is flexible. This SDK zip package contains all the resources and information needed. The directory is as follows:

- inc:
  toupcam.h, the C/C++ header file.
- win: Microsoft Windows platform file
  - dotnet:

    toupcam.cs, supports C#. toupcam.cs uses P/Invoke to call toupcam.dll. Please copy toupcam.cs to your C# project for use.

    toupcam.vb, supports VB.NET. toupcam.vb uses P/Invoke to call toupcam.dll. Please copy toupcam.vb to your VB.NET project for use.

  - x86:

    toupcam.lib, x86 lib file.

    toupcam.dll, x86 dynamic library file.

    democpp.exe, x86 C++ demo execute the procedure.
- x64:
  toupcam.lib, x64 lib file.

  toupcam.dll, x64 dynamic library file.

  democpp.exe, x64 C++ demo execute the procedure.
- arm:
  toupcam.lib, arm lib file.

  toupcam.dll, arm dynamic library file.
- arm64:
  toupcam.lib, arm64 lib file.

  toupcam.dll, arm64 dynamic library file.
- winrt:
  They can be applied for Dynamic library files of WinRT/ UWP (Universal Windows Platform)/ Windows Store App. They are compatible with Windows Runtime and can be referenced by Universal Windows Platform apps. If you use C# to develop UWP, you can use the toupcam.cs wrapper class.

  Please pay attention to the Device Capability of uwp. Refer to how to add USB device capabilities to the

app manifest. (Microsoft seems to limit the Device entry under DeviceCapability to no more than 100) demouwp.zip is a simple example of uwp. Please modify vid and pid. under DeviceCapability in the file Package.appxmanifest before compiling the run example.

- Drivers: (Cameras produced after 2017.1.1 support WinUSB, and drivers no longer need to be installed on Windows 8 and above)

The x86 folder contains the x86 kernel-mode driver files, including toupcam.cat, toupcam.inf and toupcam.sys.

The x64 folder contains the x64 kernel-mode driver files, including toupcam.cat, toupcam.inf and toupcam.sys.

- samples:

1. democpp, C++ example. This example demonstrates enumerating devices, opening devices, previewing videos, capturing images, setting resolution, triggering, saving images to files in various image formats (.bmp,.jpg,.png, etc.), wmv format video recording, Trigger ModeTrigger Mode, IO control and so on. This example uses the Pull Mode mechanism. To keep the code clean, the WTL library used by the examples can be downloaded from this link http://sourceforge.net/projects/wtl/.

2. demopush, C++ example, using the Push Mode mechanism, StartPushModeV3.

3. demomfc, a simple C++ example, uses MFC as a GUI library, supports opening devices, previewing videos, capturing images, setting resolution, saving images to files in various image formats (.bmp,.jpg,.png, etc.), etc. This example uses the Pull Mode mechanism.

4. demowinformcs1, take C# winform for example, it supports opening devices, previewing videos, capturing images, saving images to files, and setting white balance. This example uses the Pull Mode mechanism, StartPullModeWithWndMsg.

5. demowinformcs2, take C# winform for example, it supports opening devices, previewing videos, capturing images, saving images to files, and setting white balance. This example uses the Pull Mode mechanism, StartPullModeWithCallback.

6. demowinformcs3, take C# winform for example, it supports opening devices, previewing videos, capturing images, saving images to files, and setting white balance. This example uses the Push Mode mechanism, StartPushMode.

7. demowinformvb, take VB.NET winform for example, it supports opening devices, previewing videos, capturing images, saving images to files, and setting white balance. This example uses the Pull Mode mechanism.

- linux: Linux platform files

Udev: 99-toupcam.rules, udev rule file.

Please refer to: http://reactivated.net/writing_udev_rules.html.

- c#: toupcam.cs, Support. Net Core C#. toupcam.cs uses P/Invoke to call libtoupcam.so. Please copy toupcam.cs to your C# project for use.
- x86: libtoupcam.so, x86 version so file.
- x64: libtoupcam.so, x64 version so file.
- armel: libtoupcam.so, armel version so file, toolchain is arm-linux-gnueabi.
- armhf: libtoupcam.so, armhf version so file, toolchain is arm-linux-gnueabihf.
- arm64: libtoupcam.so, arm64 version so file, toolchain is aarch64-linux-gnu.
- android: libtoupcam.so for four architectures of Android platform arm, arm64, x86, x64.
- mac: macOS platform files.
- python: toupcam.py and example code.
- java: toupcam.java and example code (console and Swing).
- doc: SDK usage documentation, Simplified Chinese, English.
- sample:

- de emosimplest, the simplest example, is about 60 lines of code.
- demoraw, RAW data and still shots, about 120 lines of code.

6.4.4 Third-party interface software

- directshow: DirectShow SDK and demo program.
- twain: TWAIN SDK.
- labview: Labview SDK and demo program.
- matlab: MatLab demo program.
- Micromanager.

7 sMAX16AM Camera CameraLink Port application

7.1 Connection to the CameraLink

Connect the two CameraLink cables: the SDR1 port on the camera is connected to the CL1 port on the capture card, the SDR2 port on the camera is connected to the CL2 port on the capture card.

Attention: if the camera and the acquisition card cross-linking, camera will not work. Please pay special attention.

7.2 Software installation

7.2.1 Install SDK

Windows 10 system can directly select the exe shown in Figure 25 to install SDK; For Windows 7, please install the driver shown in Figure 26.

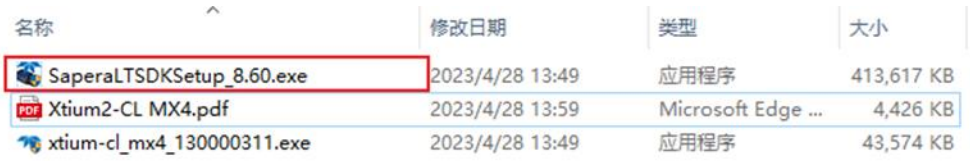


Figure 25

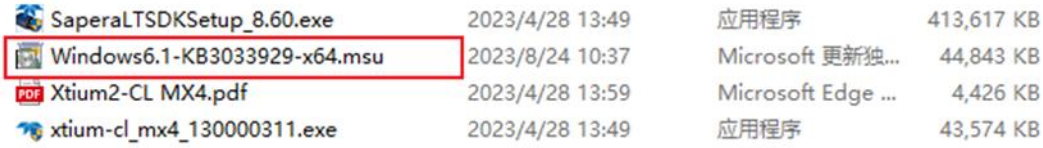


Figure 26

7.2.2 Install options

The following is the interface to be selected, and the rest of the steps can be directly clicked next.

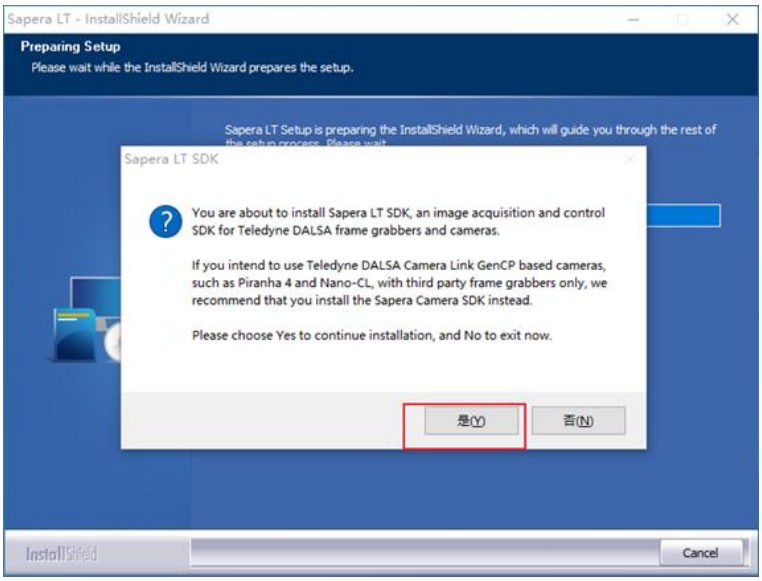


Figure 27

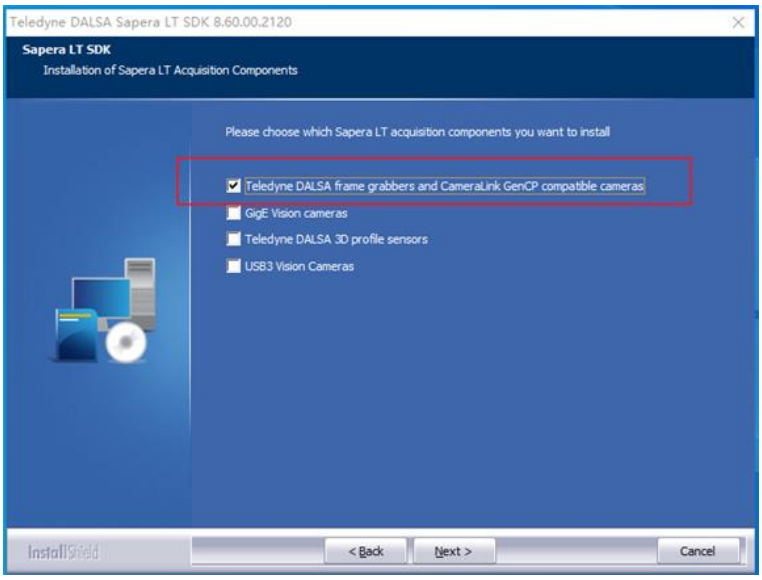


Figure 28

7.2.3 Install the driver

The exe shown in Figure 29 is the driver of the capture card (xtium-cl_mx4) currently used by our company, and the drivers of dalsa acquisition cards are different.

Capture card driver installation steps can be all click Next.

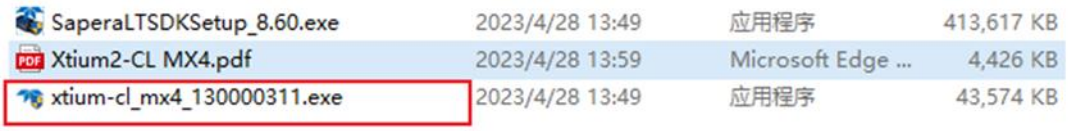


Figure 29

Restart your computer after the installation is complete.

7.3 Configure the Delsa capture card

7.3.1 Serial port configuration

Find the software Sapera Configuration in Figure 30 of the DALSA supporting tool, open it, change COM port mapping (optional) to the required port (currently COM2) as shown in Figure 31, and restart the computer according to the program requirements.

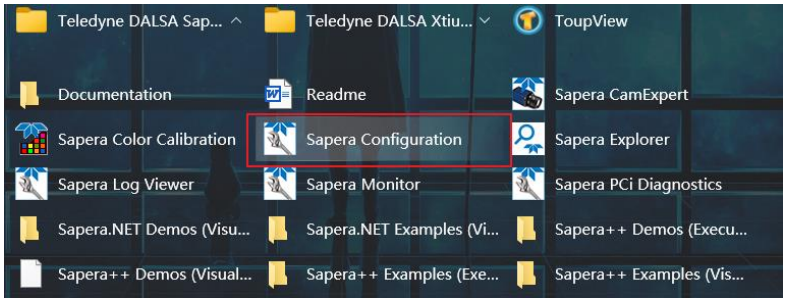


Figure 30

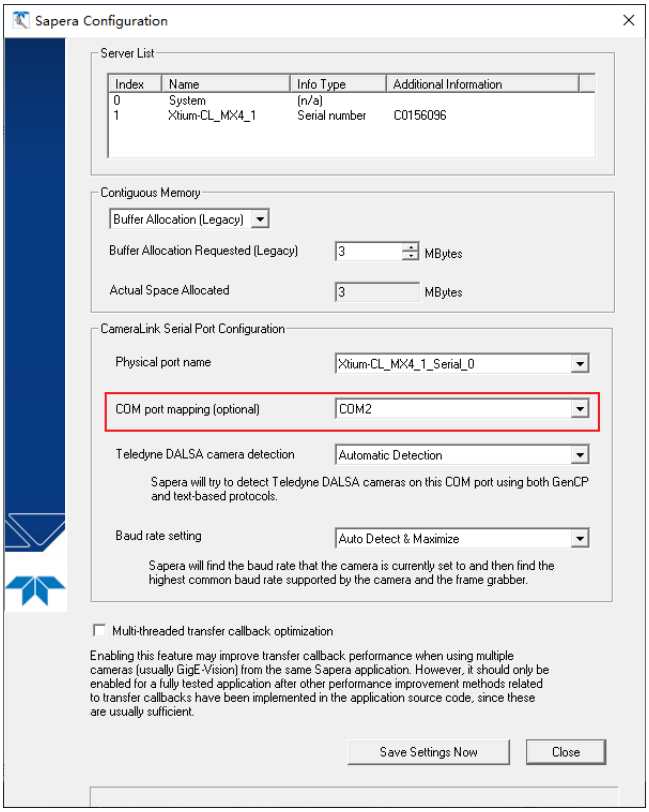


Figure 31 Serial port configuration dialog box

7.3.2 CameraLink mode configured

Open the software in Figure 32 and verify that it looks like Figure 33. If not, please click the Manual button in Figure 20 to modify the tart as shown in Figure 34, and click the tart Updat button to wait for the completion of the update. If an error occurs, please confirm whether the serial port control is turned off.

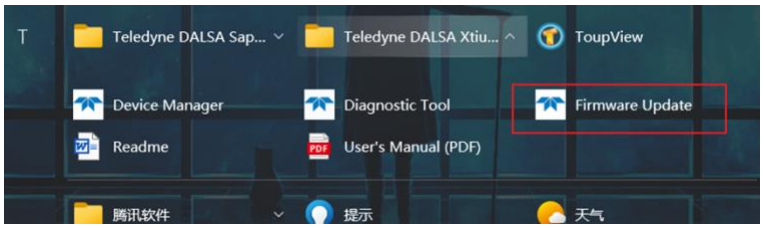


Figure 32

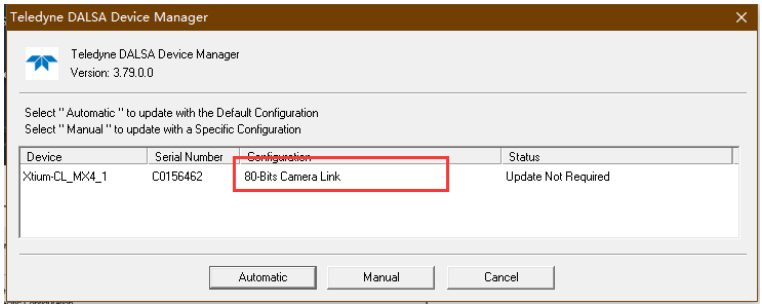


Figure 33

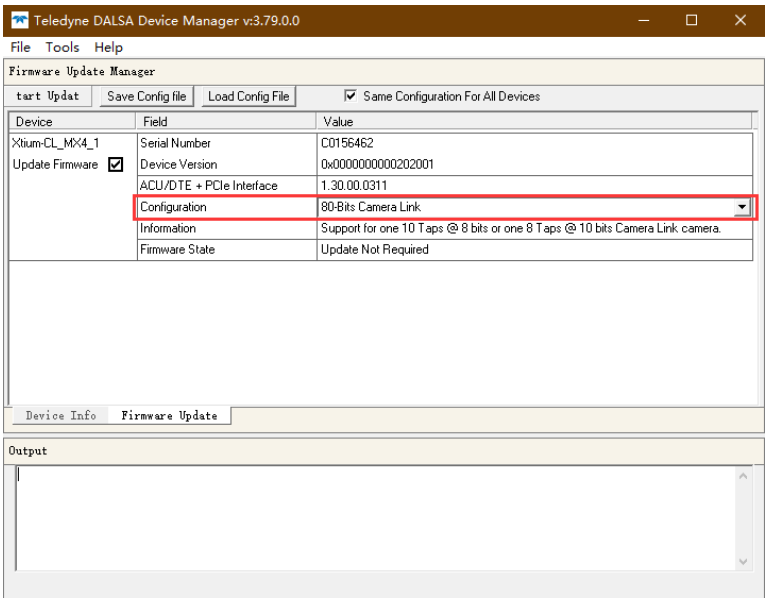


Figure 34

7.3.3 Configuring CameraLink Receiving

Opening the Sapera CamExpert software of DALSA, click the arrow position in Figure 35 and select sMAX16AM_CL_10bit_8Ports_V1.0.ccf to load the configuration information of the receiving format of CameraLink.

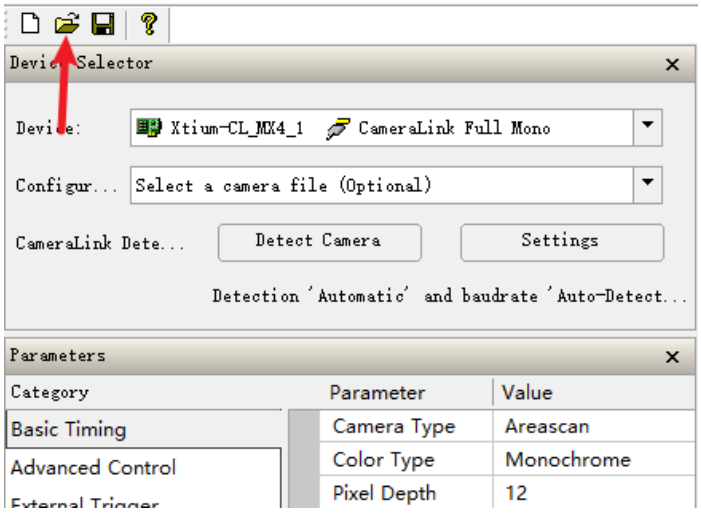


Figure 35 Load the CameraLink receive format configuration information

The arrangement is shown in Figure 36(You do not need to change the arrangement of the ccf files mentioned above).

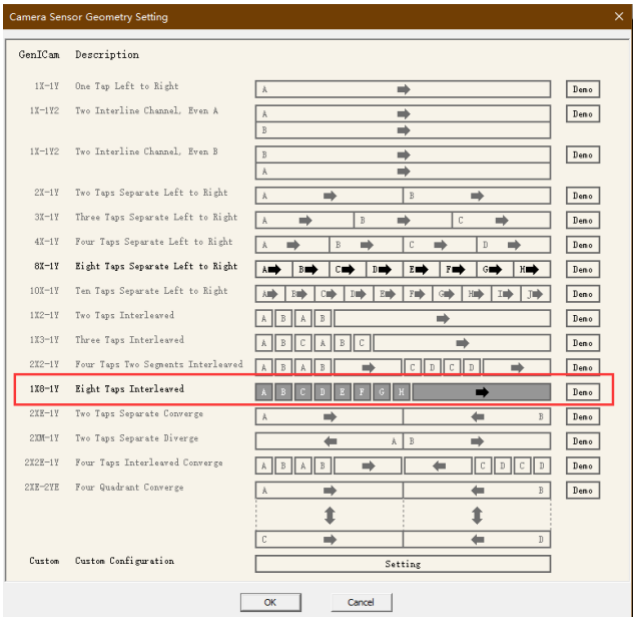


Figure 36 Arrangement

7.3.4 CameraLink Receiving the configuration content

The image below shows the resolution and bit depth Settings.

Parameter	Value
Camera Type	Areascan
Color Type	Monochrome
Horizontal Activ...	2048
Horizontal Offs...	0
Vertical Active (...	2048
Vertical Offset (...	0
Pixel Clock Inp...	85
Camera Sensor...	1X8-1Y
PoCL	Disabled
PoCL Status	Not Active

Figure 37

The steps of Camera Sensor Geometry Setting are shown in Figure 38 and Figure 39.

Parameter	Value
Camera Type	Areascan
Color Type	Monochrome
Horizontal Activ...	2048
Horizontal Offs...	0
Vertical Active (...	2048
Vertical Offset (...	0
Pixel Clock Inp...	85
Camera Sensor...	1X8-1Y
PoCL	Disabled
PoCL Status	Not Active

Figure 38

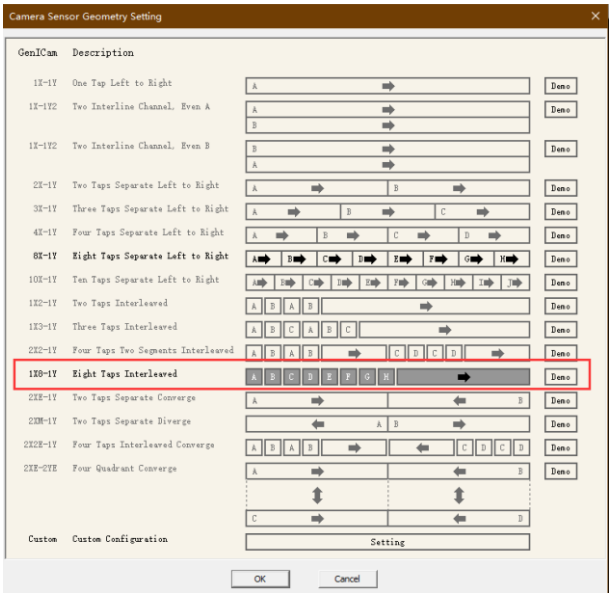


Figure 39

7.4 Using GenIcam

7.4.1 Communication Settings

Enter the interface shown in Figure 40 and set the content as shown in Figure 41.

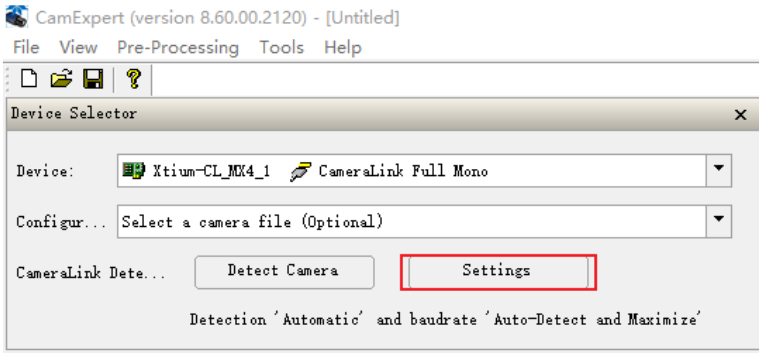


Figure 40

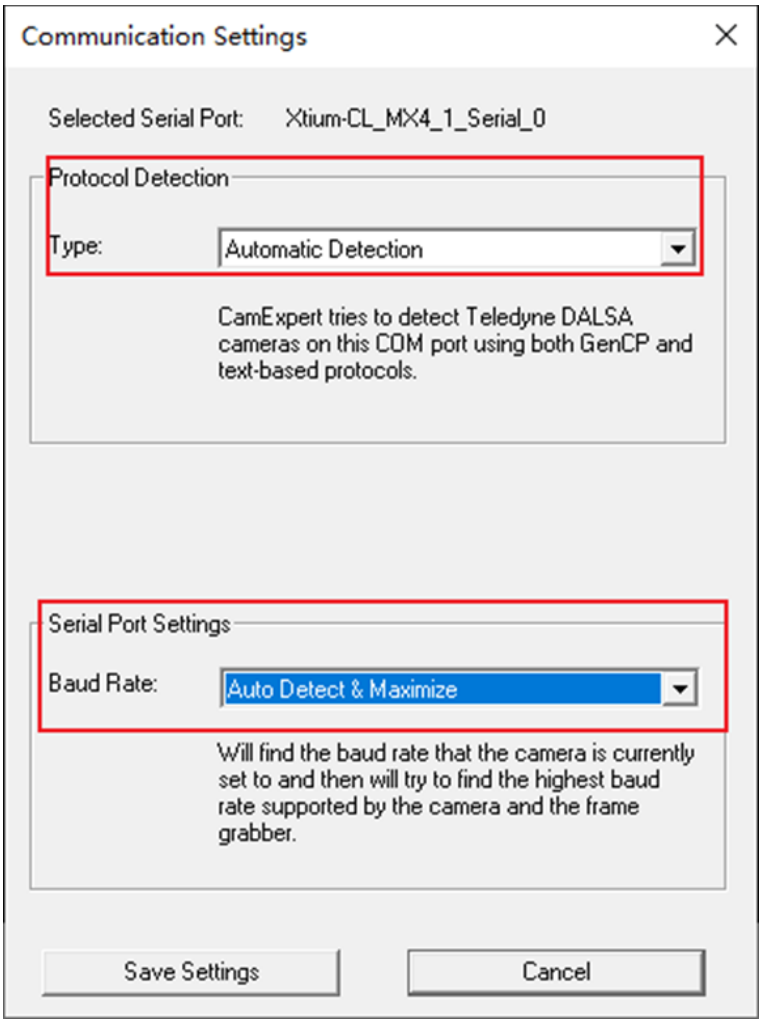


Figure 41

After the Settings are complete, properly connect the camera and restart CamExpert. Figure 42 will appear on the software interface.

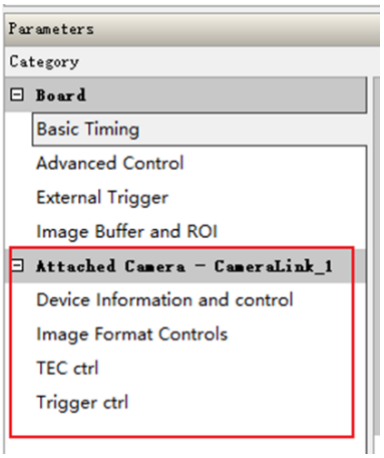


Figure 42

7.5 Description of GenIcam

7.5.1 Device Information and control

As shown in Figure 43, it contains the basic information of the equipment, including exposure time control, gain control, frame rate control and TEC temperature display.

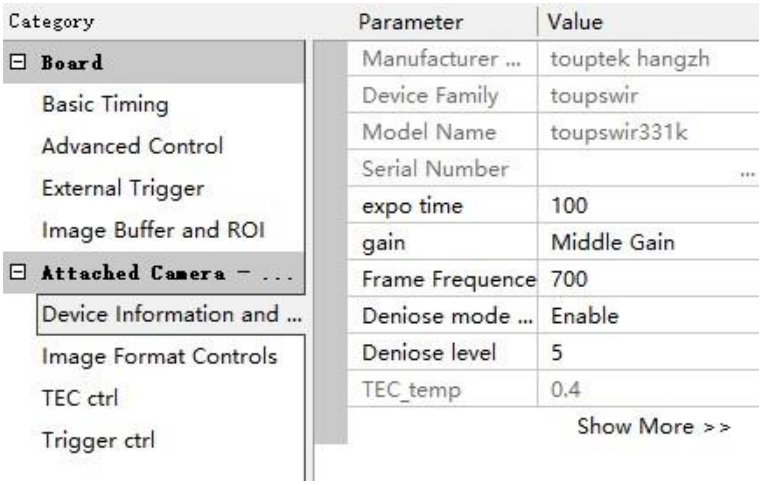


Figure 43

7.5.2 Image Format Controls

Figure 44 shows the ROI control.

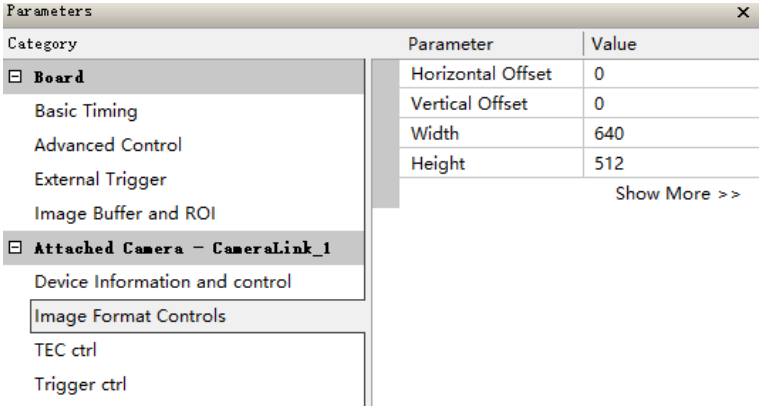


Figure 44

7.5.3 TEC Ctrl

As shown in Figure 45, TEC Ctrl contains TEC temperature control, TEC switch, fan switch, and TEC temperature display in degrees Celsius.

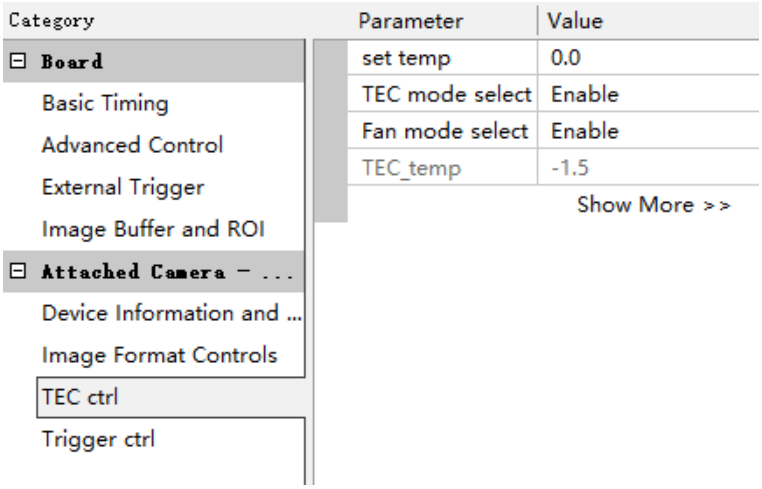


Figure 45

7.5.4 Trigger ctrl

The trigger control content Settings are shown in Figure 46 and contain the basic trigger Settings.

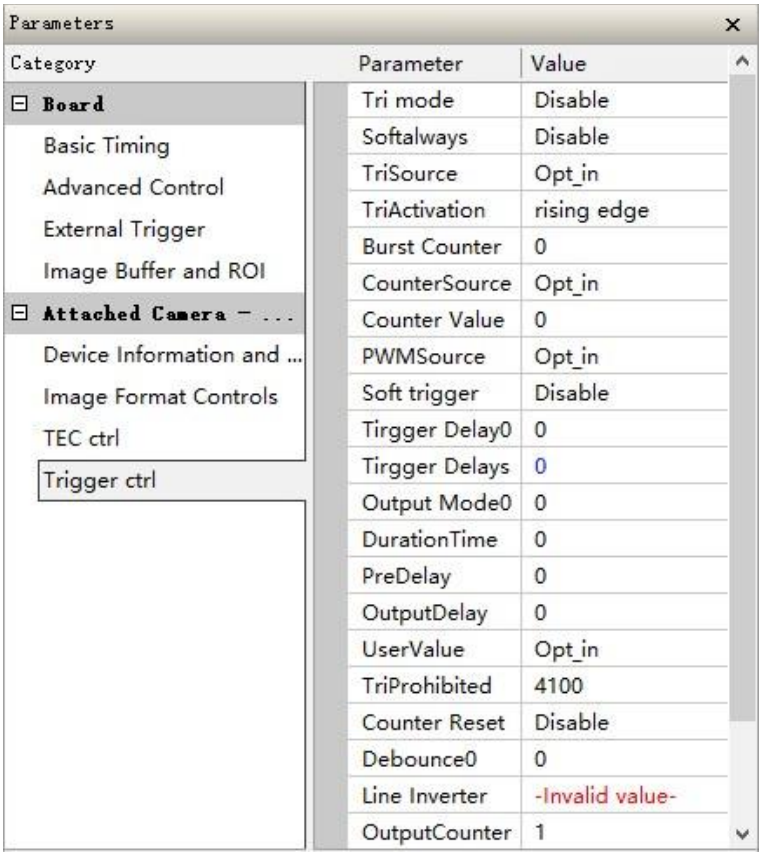


Figure 46

7.6 Camera Commands

7.6.1 Basic Formats

The serial port of the camera CameraLink is used as the communication port. The baud rate of the serial port is 115200, and the serial port has 8 bits without check bit mode.

The protocol format is compatible with GENICAM gencp 1.0. For details, refer to GENICAM protocol.

The protocol instruction is realized by register access, each function is distinguished and defined by different register addresses, and the protocol data is divided into general part and special part. The protocol data is preceded by the general part and followed by the special part. The general part is fixed to the length of 16 bytes, and the length of the special part is variable according to the different length of the function.

The general 16-byte format is described as follows (all fields in the general part are in Big-Endian format with high bytes before them) :

Suppose the sixteen bytes of data are D0, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15. For command execution, the protocol stipulates that the host computer is the active initiator and the device is the passive responder.

1. D0, D1 is two prefix bytes, fixed as 0x01 and 0x00.
2. D2 and D3 are the check words of the universal partial data. The check part ranges from D6, D7 to D14, and D15 adopts double-byte CRC redundancy check, with the high byte coming first (Big-Endian).
3. D4 and D5 are the check words for the total protocol data. The check part runs from D6 and D7 to the end of the entire protocol data. Double-byte CRC redundancy check is also adopted, with the high byte in the front (Big-Endian).
4. D6 and D7 are channel ids. At present, the device channel is fixed to 0, and the data is 0x00 and 0x00.
5. D8 and D9 are common flag fields. For the upper computer, if the value is 0x40, 0x01 indicates that the normal function request is sent and the device needs to respond. If the value is 0x00, 0x01 indicates that the normal function request is sent and the device does not need to respond. For the response of the device, the field is 0x00. 0x00 indicates that the device receives the response correctly and there is no exception.
6. D10 and D11 are command ids, which are general command definition fields. For the upper computer, the values are 0x08 and 0x00 when reading data and 0x08 and 0x02 when writing data. For the device, the value is 0x08, 0x01 when it responds to read data, 0x08, 0x03 when it responds to write data.
7. D12, D13 indicates the length of the dedicated part data.
8. D14 and D15 are sequence ids. For the upper computer, the sequence ID needs to be increased by one for each command sent. The sequence ID remains the same for a device-side response to ensure that the host machine receives confirmation that the device-side instruction is executed correctly.

7.6.2 Dedicated Part Format

For the special part of the format is mainly divided into two read and write registers (register and length field is fixed in the Big-Endian format before the high byte, the rest of the data can be Big-Endian or Little-Endian, according to the custom)

1. Format description of the special part when the upper computer reads the register data

The whole dedicated data length is 12 bytes, if the data is R0, R1, R2, R3, R4, R5, R6, R7, X0, X1, X2, X3, where R0~R7 is the register address that needs to be read; X0, X1 is fixed to 0x00, 0x00; X2, X3 are the length of the data to be read (the length is the legal length defined by the register, and the length of each register is specified).

2. Format description of the special part when the device responds to the upper computer reading register data

The whole private data is the data that needs to be read, there are no other fields; The length varies according to the length of the data read, such as X1, X2, X3..... Xn; The length of the read data is n.

3. Format description of the special part of the upper computer when writing register data

When the upper computer writes register data, the special part of the data consists of two parts: register and data, such as R0, R1, R2, R3, R4, R5, R6, R7, X1, X2, X3..... Xn; R0 to R7 indicates the register address (REG_ADDR). X1 to Xn indicates the data to be written. The length of the data to be written is n, which is the legal length specified by the register.

4. Format description of the special part when the device responds to the host computer to write register data

When the device successfully writes data from the host computer, the dedicated data part of the device response is fixed as 0x00, 0x00, 0x00, 0x00.

7.6.3 Definition of each register

ADDR_BASE =0x0000000020000000

REG_ADDR= ADDR_BASE + ADDR_OFFSET

Number	Register function	Register address (ADDR_OFFSET)	Register value	default parameters	data length	R/W	Data sequence
1	ROI columns	0x070	0-2047	0	4byte	RW	little
2	ROI column starting position	0x080	0-2047	2048	4byte	RW	little
3	ROI rows	0x090	0-2047	0	4byte	RW	little
4	ROI row starting position	0x0A0	0-2047	2048	4byte	RW	little
5	Exposure	0x200	16~100000(us)	100	4byte	RW	Big
6	Gain	0x230	1~700	700	4byte	RW	Big
7	Frame rate control	0x280	1~10	5	4byte	RW	Big
8	Denoising level	0x330	T（℃）=data/10，二进制补码	0	4byte	RW	Big
9	Algorithm control	0x340	T（℃）=data/10，二进制补码		4byte	R	Big
10	Defective pixel reload	0x350	1 为开，0 为关	1	4byte	RW	Big
11	TEC Temperature Setting	0x360	1 为开，0 为关	1	4byte	RW	Big
12	TEC temperature reading	0x390	1 为开，0 为关（暂不支持）	0	4byte	RW	Big
13	TEC switch control	0x400	0-Normal Mode 1-Trigger Mode	0	4byte	RW	Big
14	Fan control	0x410	0-soft disable 1-soft always enable	0	4byte	RW	Big
15	Automatic dark field switch	0x420	trigger source: 0-Opt_in 1-GPIO_0 2-GPIO_1 3-counter 4-PWM 5-software	0	4byte	RW	Big
16	Manual dark field selection	0x430	0-rising edge; 1-falling edge; 2-level high; 3-level low	0	4byte	RW	Big
17	Auto exposure switch	0x440	continuous acquisition 0-65535	0	4byte	RW	Big
18	tri_mode	0x450	0-Opt_in 1-GPIO_0 2-GPIO_0	0	4byte	RW	Big
19	soft_always_en	0x460	Frequency division	0	4byte	RW	Big

			coefficient				
20	tri_source_i	0x470	0-Opt_in 1-GPIO_0 2-GPIO_1	0	4byte	RW	Big
21	tri_activation_i	0x430	0bit：GPIO_0: 0-input,1-output 1bit：GPIO_1: 0-input,1-output	0	4byte	RW	Big
22	burst_counter_i	0x440	software trigger	0	4byte	W	Big
23	counter_source_i	0x450	when the Opt_in tirgger assert, the start of exposure will delay 0-32xffff_ffff（cycle）	0	4byte	RW	Big
24	counter_value_i	0x460	when the GPIO_0 tirgger assert, the start of exposure will delay 0-32xffff_ffff（cycle）	0	4byte	RW	Big
25	pwm_source_i	0x470	when the GPIO_1 tirgger assert, the start of exposure will delay 0-32xffff_ffff（cycle）	0	4byte	RW	Big
26	IO_link	0x480	when the software tirgger assert, the start of exposure will delay 0-32xffff_ffff（cycle）	0	4byte	RW	Big
27	soft_start	0x490	Opt_out output mode: 0-Frame Trigger Wait 1-Exposure Active 2-Strobe 3-User output	0	4byte	RW	Big
28	tri_delay_0_i	0x4a0	GPIO_0 Output mode: 0-Frame Trigger Wait 1-Exposure Active 2-Strobe 3-User output	0	4byte	RW	Big
29	tri_delay_1_i	0x4b0	GPIO_1 output mode: 0-Frame Trigger Wait 1-Exposure Active 2-Strobe 3-User output	0	4byte	RW	Big
30	tri_delay_2_i	0x4c0	Strobe duration time:effective time 0-32xffff_ffff（cycle）	0	4byte	RW	Big
31	tri_delay_s_i	0x4d0	advance the exposure time 0-32xffff_ffff（cycle）	0	4byte	RW	Big
32	output_mode_0_i	0x4e0	later than exposure time 0-32xffff_ffff（cycle）	0	4byte	RW	Big
33	output_mode_1_i	0x4f0	Opt_out--user value	0	4byte	RW	Big
34	output_mode_2_i	0x500	next trigger rising prohibited time 4100~32xffff_ffff（cycle）	4100	4byte	RW	Big
35	duration_time_i	0x510	When counter_reset assert, the counter of trigger will be reseted	0	4byte	W	Big
36	pre_delay_i	0x520	debounce time: 0-20000us	0	4byte	RW	Big
37	output_delay_i	0x530	debounce time: 0-20000us	0	4byte	RW	Big

38	user_value	0x540	debounce time: 0-20000us	0	4byte	RW	Big
39	tri_prohibited_i	0x550	1-enable	3‘b111	4byte	RW	Big
40	counter_reset	0x560		1	4byte	RW	Big
41	debounce_0	0x570		0	4byte	RW	Big
42	debounce_1	0x580	MCU 版本+最高帧率+固件版本+固件日期		16byte	R	Big
43	debounce_2	0x590	2bit=0,降噪关；2bit=1,降噪开	0	4byte	W	Big
44	line_inverter	0x5a0	8,像素位深度为 8bit 8*8Full 10,像素位深度为 10bit 10*8 80bit 12,像素位深度为 12bit 12*4 Medium 16,像素位深度为 16 *1 Base	10	4byte	W	Big
45	output_counter_i	0x5b0	2bit=0，12bit 2bit=1，11bit 2bit=2，11bit 高速率	2	4byte	W	Big
46	pause	0x5c0	该模式只能在 12bit 下切换 1 为 global reset 模式，0 为 12bit 模式	0	4byte	W	Big
47	Frame count cleared to zero	0x5d0	该模式只能在 12bit 下切换 1 为 2-CMS 模式，0 为 12bit 模式	0	4byte	W	Big
48	Frame count display switch	0x5e0	HDR 计算参数	2359	4byte	W	Big
49	Dark field threshold control	0x5f0	0-16384	2657	4byte	W	Big
50	Version	0x3a0	MCU Version + maximum frame rate + Firmware version + Firmware date	4000	4byte	W	Big
51	Read mode switching	0x1f0	0-2100	100	4byte	RW	Big
52	锐化开关/等级	0x290	0：锐化关闭 锐化等级：1-100	0	8byte	W	Big

7.7 SDK & CLView application

7.7.1 SDK

The camera control supports two modes: 1) Controlled through private SDK development kit; 2) Controlled by GenICam interface.

7.7.2 CLView application

Figure 47 Software interface

CLView software can achieve complete control of the camera, and open source to customers to use, while providing technical support.

Description of the main functions of CLView software:

Serial port control;

Exposure time control;

Gain mode control;

ROI control;

Frame rate control;

Trigger mode control;

Dark field correction control;

TEC and Fan control;

Refrigeration temperature control;

Real-time frame rate display;

Real-time temperature monitoring;

Save picture;

Video;

Update online;

Accept customer OEM functions customized.

7.7.3 CLCtrl software

The camera can capture and display images through the software CameraLink capture card, and use the CLCtrl software to control. Start the CLCtrl software first, and then start the acquisition card software after obtaining the control of the serial port.