



Camera Technology
Focused on Scientific Imaging
and Challenging Inspection

www.tucsen.com

Dhyana 95 V2

User Manual

V1.0.0



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1. Introduction

1.1. Disclaimer

To protect the legitimate rights and interests of users, please carefully read our accompanying instructions, disclaimers, and safety instructions before using our company's products. This camera user manual document contains basic information about the camera, installation instructions, product features, and maintenance, aiming to make it more convenient for users to use the TUCSEN's camera. This document is only disclosed for the above purposes. Please make sure to follow the instructions and safety instructions when operating this product.

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1.2. Safety and warning information

Operation and Use



Caution

- Do not drop, disassemble, repair or replace internal components on your own. Such action may damage the camera components or cause personal injury.
- In the event of spillage on the equipment, please disconnect the equipment and immediately contact the nearest dealer or manufacturer for technical assistance.
- Do not touch the device with wet hands, as it may cause electric shock.
- Do not let children touch the device without supervision.
- Ensure that the temperature of the camera is within the specified temperature range for use to avoid damage.

Installation and maintenance



Caution

- Please do not install it in dusty and dirty areas or near air conditioning or heaters to reduce the risk of camera damage.
- Avoid installation and operation in extreme environments such as vibration, high temperature, humidity, dust, strong magnetic fields, explosive/corrosive gases or gases.
- Do not apply excessive vibration and impact to the equipment. This may damage the equipment.
- Do not install equipment under unstable lighting conditions. Severe lighting changes can affect the quality of the images generated by the device, avoiding high-energy lasers directly hitting the camera chip.
- Do not use solvents or diluents to clean the surface of the equipment, as this will damage the surface of the casing.
- Please ensure that there is at least 10 cm of space around the device ventilation opening to ensure airflow flow. Do not block the ventilation openings of the equipment during use, otherwise it may cause internal temperature to be too high and damage the equipment.

Power



Caution

- Please use the original power adapter of the camera, as using an mismatched power source may damage the camera.
- If the voltage applied to the camera is greater than or less than the nominal voltage of the camera, the camera may be damaged or malfunction.
- Please refer to the specification table for the nominal voltage of the camera.

2. Product specifications

2.1. Packaging List

Standard Item Name	Specification	Quantity	Image
sCMOS scientific grade camera	Dhyana 95 V2	1	
Power adapter	12V/8A	1	
Power adapter power cord	Three core 250V/2.5A	1	
USB3.0 data cable	2 m	1	
USB flash drive	Software and Drivers	1	
Water pipes	2 m, OD: 8 mm, ID: 5 mm	2	
SMA trigger cable	3 m, SMA inner screw inner needle-SMA inner screw inner needle, wire RG178	4	

Optional Item Name	Specification	Quantity	Image
CameraLink frame grabber	Firebird	1	
Frame grabber cable	3 m	2	
Level conversion box	Standard	1	

2.2. Quantum efficiency curve

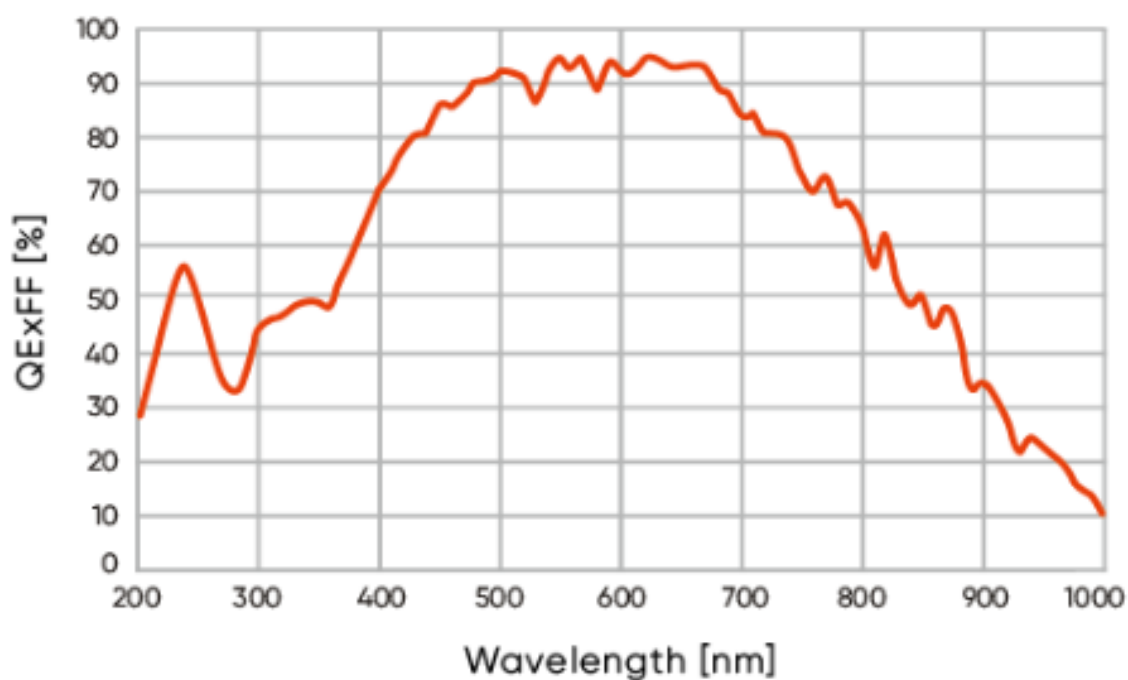


Figure 2-1 Quantum efficiency curve of Dhyana 95 V2

2.3. Window curve

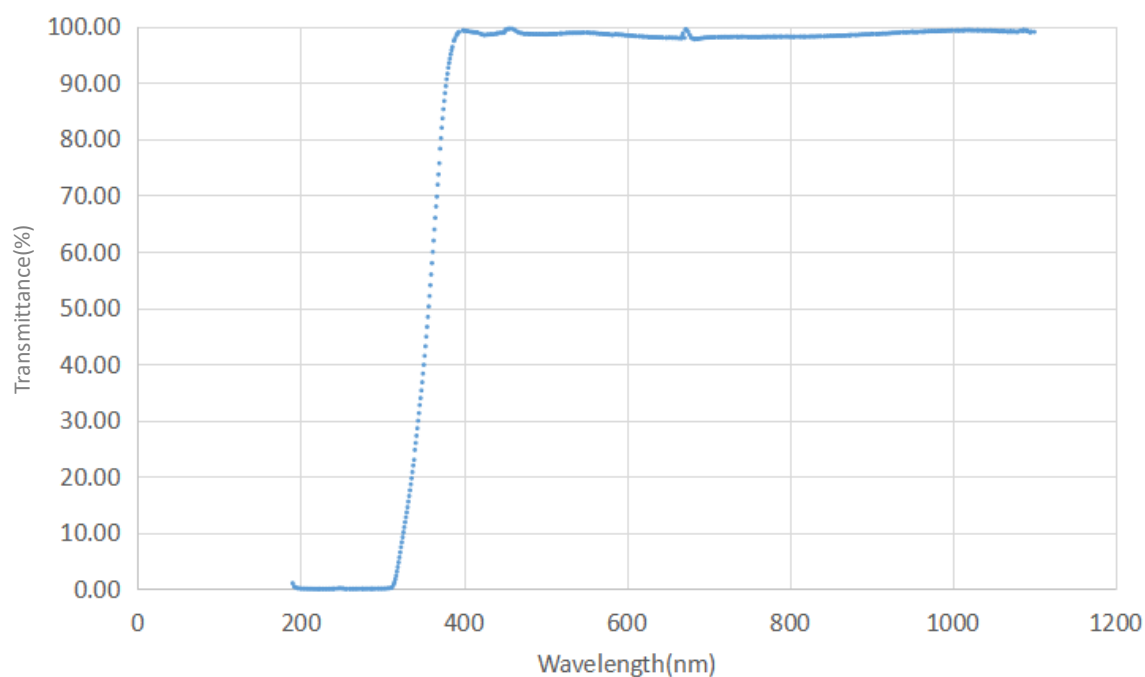


Figure 2-2 Transmission curve of a standard glass window

2.4. Quartz window curve

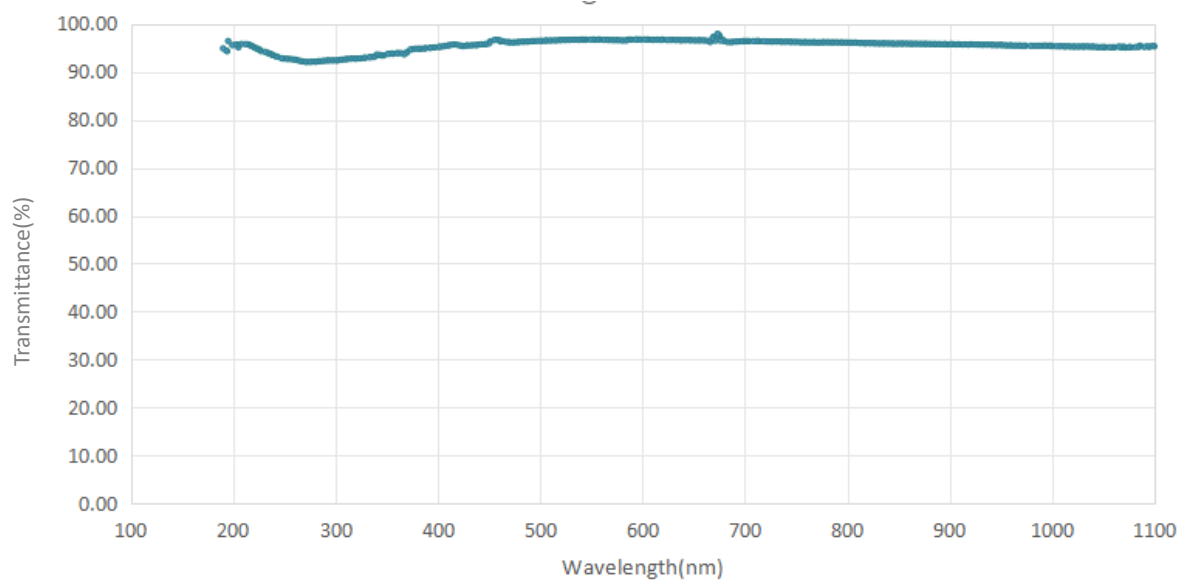


Figure 2-3 Transmission curve of a quartz window

2.5. Camera power and signal connection

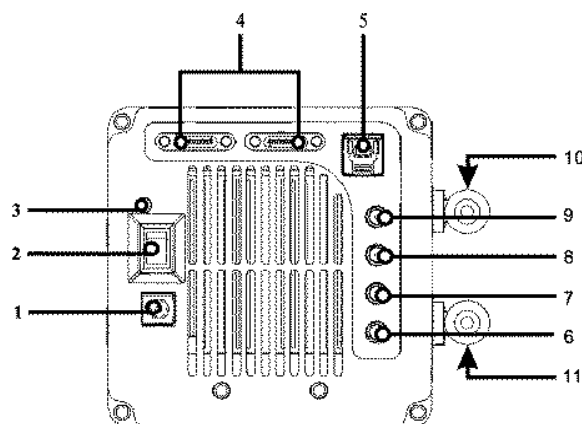


Figure 2-4 Camera interface diagram

No.	Name	Fuction
1	DC12V	Power interface
2	Switch	Control camera power
3	Indicator light	Indicate the camera status, press F2 to control the light on or off of the indicator light Red: Camera powered on Orange *: Normal operation
4	CameraLink interface	Camera data transfer
5	USB 3.0 interface	Camera data transfer
6	TRIG.IN	External trigger input interface (SMA interface)
7-9	TRIG.OUT	External trigger output port, 6-8 corresponds to TRIG OUT 1-3, the default output signal is as follows: TRIG OUT1: Readout end signal TRIG OUT2: Global exposure signal TRIG OUT3: Exposure start signal The above trigger output signal types support customer customization settings
10-11	Water cooling pipe joint	water cooling

*Note:

If the software has been shut down but the camera light remains orange, it indicates that the camera has not been fully released and needs to be completely exited from the camera thread or be restarted before the indicator light will return to red.

3. Features and Functions

3.1. Camera Introduction

The Dhyana 95 V2 is an ultra-high sensitivity backside-illuminated sCMOS camera. It features a broad spectral response capability, allowing it to capture images in the wavelength range of 200 nm to 1100 nm. With a peak quantum efficiency of up to 95%, it efficiently converts light signals into electrical charges. Coupled with large $11\ \mu\text{m} \times 11\ \mu\text{m}$ pixels, it ensures ultra-high sensitivity. Additionally, the Dhyana 95 V2 has a readout noise of only 1.6 electrons and a full well capacity of approximately 100,000 electrons. This gives it a high dynamic range, enabling it to measure both strong and weak signals simultaneously, making it ideal for use in complex light intensity environments.

3.2. Structure and Operation of sCMOS

Scientific grade complimentary metal-oxide semiconductor (sCMOS) cameras are specialized cameras used for scientific research and high-performance imaging. They combine the advantages of CMOS and Charge coupled device (CCD) technologies, featuring high speed, low noise, and high sensitivity, and are widely used in scientific research, biomedical imaging, optical microscopy, and other fields.

The structure of an sCMOS camera sensor typically includes the following components:

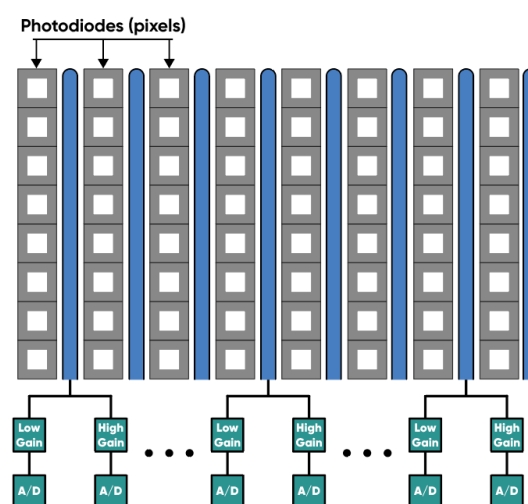


Figure 3-1 sCMOS camera sensor structure

- 1) Light-sensitive sensor array: sCMOS cameras use sCMOS sensor arrays (also known as image sensors) to capture light signals. These sensors consist of many photosensitive units that

convert light into charge signals.

- 2) Gain amplifier: Each photosensitive unit in an sCMOS camera is equipped with an independent gain amplifier to amplify the charge signal and convert it into a voltage signal.
- 3) Analog-to-digital converter (ADC): The amplified analog signal is digitized through an analog-to-digital converter (ADC) inside the camera, converting it into a digital signal for further processing and storage.

sCMOS cameras typically also include an image processing unit for performing image enhancement, correction, and other image processing algorithms. The digitized image undergoes these processes to obtain higher-quality images.

The operation process of an sCMOS camera is as follows:

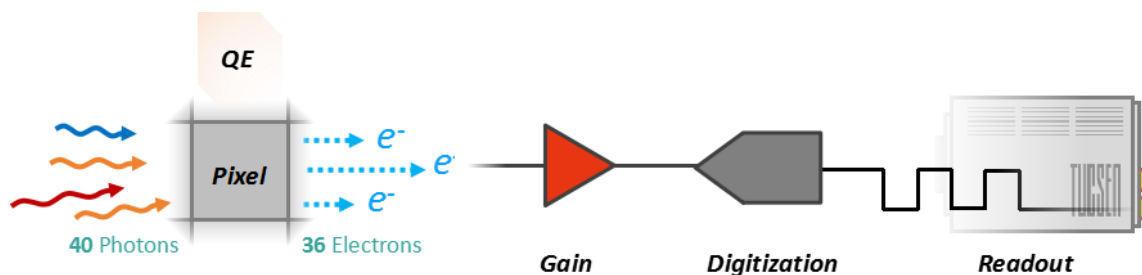


Figure 3-2 sCMOS operation process

- 1) Light signal capture: When photosensitive units are exposed to light, the light is converted into charge signals and stored in each unit.
- 2) Signal amplification: The charge signals from each photosensitive unit are amplified by corresponding gain amplifiers and converted into voltage signals.
- 3) Digitization: The amplified analog signals are converted into digital signals by an ADC for processing and storage.
- 4) Image processing: The digital signals undergo various algorithmic processes such as denoising, enhancement, and color correction through the image processing unit.
- 5) Data output: Processed image data can be transmitted to computers or other devices for display, analysis, and storage through various interfaces such as USB, Ethernet, etc.

3.3. Shutter Mode

The 95 V2 camera uses a rolling shutter readout mode. In this mode, the camera reads out rows sequentially, with consistent exposure time for each row, but different starting exposure time point for different rows. The difference in exposure time points between adjacent rows is also known as the line time (T_{line}).

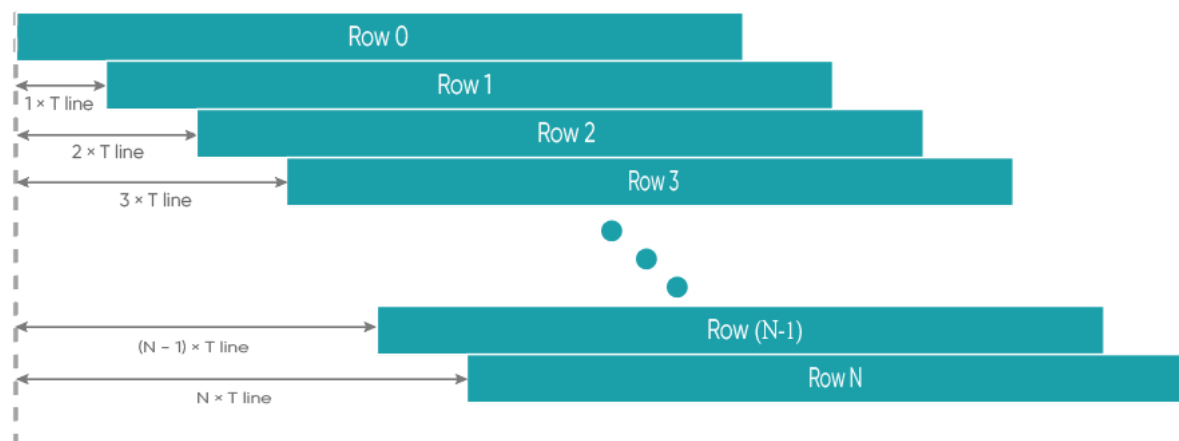


Figure 3-3 Rolling shutter diagram

In rolling shutter mode, if the camera is not synchronized with external light sources or if flickering light sources are present, it may result in striped images. This effect is especially noticeable with short exposure times (Please refer to the FAQs for solutions).

3.4. Front-Illuminated and Back-Illuminated sCMOS Technology

Cameras based upon sCMOS technology typically use two types of chips: front-illuminated (FSI) and back-illuminated (BSI). In front-illuminated cameras, light entering the pixels must pass through metal circuit structures before being detected. Due to the non-transparency of metal circuit structures, early cameras had only about 30-40% quantum efficiency (QE). Later, with the introduction of microlenses, light was focused through the conductors onto the photosensitive silicon, increasing QE to around 70%. Some advanced front-illuminated cameras can even achieve a peak QE of around 84%.

Back-illuminated cameras reverse this sensor design by placing the metal circuitry behind the photosensitive silicon layer, allowing incident photons to directly strike the thin photosensitive silicon layer. This process innovation significantly increases the peak QE of back-illuminated cameras and improves imaging quality in low-light environments. Due to the thin photosensitive silicon layer of back-illuminated pixels, there are higher process requirements and production difficulties compared to front-illuminated ones.

The 95 V2 camera adopts a back-illuminated chip, achieving a peak QE of around 95%.

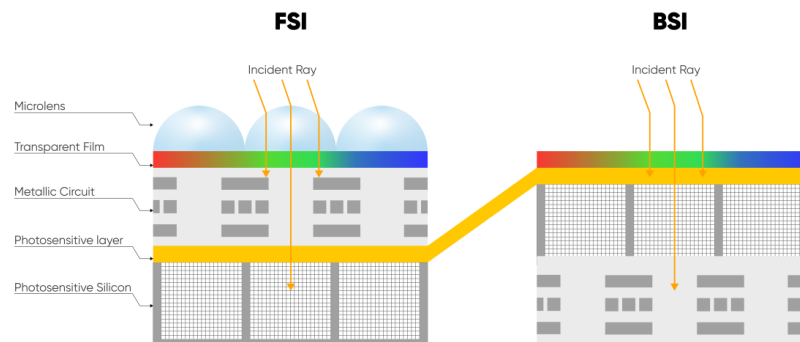


Figure 3-4 Front-Illuminated and Back-Illuminated diagram

3.5. Readout Noise

Readout noise is the noise introduced by the readout of the signal through the circuit. In CCD camera, since the readout circuit is the same for all pixels, the standard deviation (σ) for each pixel is generally consistent. Therefore, in CCD camera parameter tables, a single value—the root mean square (RMS) of the standard deviation of all pixels—can represent the readout noise.

However, each pixel in sCMOS corresponds to a different readout circuit, forming a distribution curve, shown in Figure 3-5. To illustrate the characteristics of this curve, sCMOS camera parameter tables typically provide two values—median and RMS. The median is the median of the standard deviations of all pixels, while the RMS is the root mean square of the standard deviations of all pixels. Since there are usually a few pixels with exceptionally high readout noise on the sCMOS camera chip—having less impact on the median than on the RMS—median values are generally lower than RMS values.

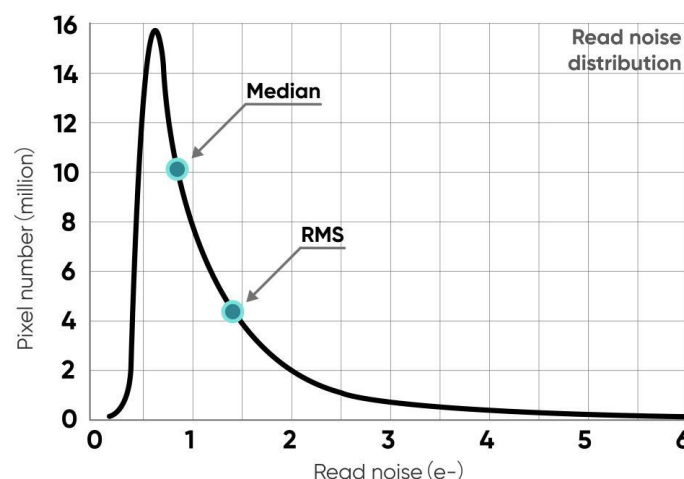


Figure 3-5 Readout noise distribution of an typical sCMOS camera

To measure and calculate readout noise from images, it's necessary to eliminate or minimize the influence of thermal noise and photon shot noise, retaining only the readout noise generated during the circuit readout process. Therefore, when measuring readout noise, it's typically done in an environment without light signals, with the exposure time set to the minimum value (to minimize the accumulation of dark current) to obtain dark-field images (called dark images). By capturing N such images, each pixel obtains N readout values—their standard deviation (σ) reflects the value of the readout noise for the corresponding pixel.

3.6. Defective Pixel Correction (DPC)

There are always a few abnormal values on the sCMOS camera chip. Through the camera's Defective Pixel Correction (DPC) function, these abnormal points can be corrected, removing defective pixels from the image. However, this may cause flickering pixels in some single-molecule imaging applications. It is not recommended to use the DPC function for these applications or to use only the weakest correction level.

The Dhyana 95 V2 adopts dynamic defective pixel correction, correcting using a 3x3 matrix of pixels. Currently, four correction levels are available, each corresponding to different thresholds, thereby controlling the intensity of defective pixel correction.

3.7. Dark Signal Non-Uniformity (DSNU)

When the camera captures images in complete darkness, ideally, all pixel grayscale values should be close to zero and equal. However, in reality, when the camera captures images in darkness, subtle differences in the performance of each pixel in the sensor will cause some variations in the pixel grayscale values outputted from the camera.

In practical applications, when there are no photons incident on the camera, the obtained image usually does not show a grayscale value of 0 (DN). This is because manufacturers typically set a offset value, such as 100 grayscale values, to account for the influence of noise on measurements based on this baseline in the absence of light. However, without careful calibration and correction, this fixed offset may also vary between different pixels. This variation is called "fixed pattern noise" and can be measured by DSNU (Dark Signal Non-Uniformity). It represents the standard deviation of pixel bias, measured in charge units.

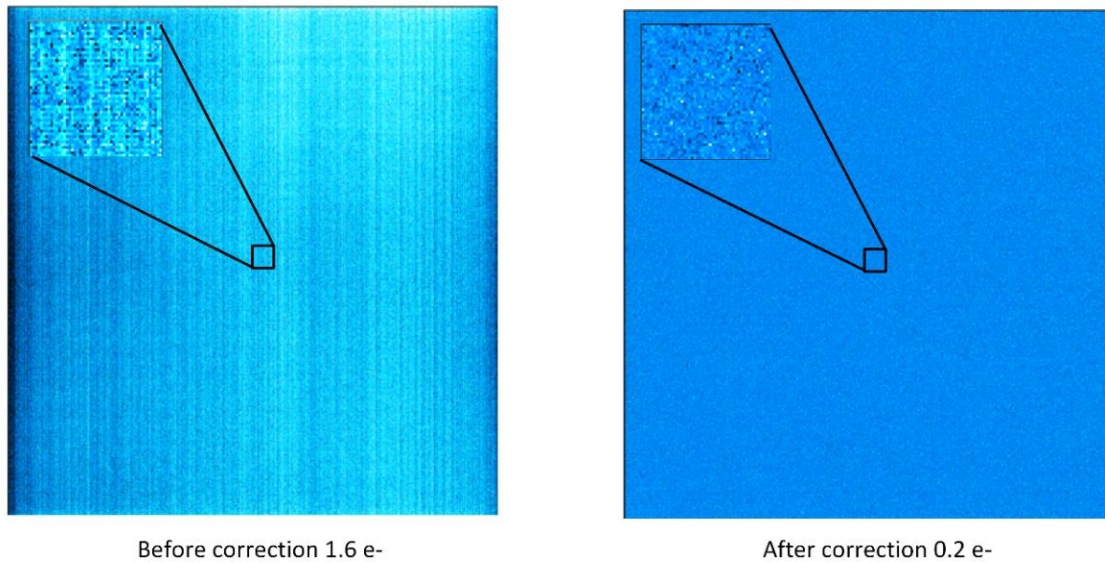


Figure 3-6 DSNU correction comparison before(left) and after(right)

For many low-light imaging cameras, DSNU is typically less than 0.5 e-. This means that in medium or high light level applications (where each pixel can typically capture hundreds or thousands of photons), the influence of this noise can be completely negligible. Moreover, even for low-light applications, if DSNU is lower than the camera's readout noise (typically 1-3 e-), this fixed pattern noise is unlikely to affect image quality.

3.8. Photo Response Non-Uniformity (PRNU)

When a camera captures uniformly illuminated light targets under bright light conditions, ideally, all pixel grayscale values should be close to the maximum grayscale value and equal. However, in reality, there are subtle differences in the performance of camera pixels, causing changes in pixel grayscale values outputted from the camera due to variations in lenses or illumination.

When the camera detects light signals, the number of photoelectrons captured by each pixel during the exposure process is measured and transmitted as digital grayscale values (DN) to the computer. The conversion from electrons to DN follows a certain proportion, called the system gain (K) or conversion gain, plus a fixed offset (usually 100 DN). These values are determined by both the analog-to-digital converters and amplifiers used for conversion. sCMOS cameras use parallel transmission, with one or more analog-to-digital converters per column of the camera and one amplifier per pixel, resulting in slight variations in pixel gain and offset.

Under dark field or low light conditions, differences in offset can be measured by DSNU as mentioned in Section 3.7. In bright environments, the influence of gain also needs to be considered. Differences in gain and offset changes are measured by Photo Response Non-Uniformity (PRNU), which is the ratio of detected electrons to displayed DN. Given that the intensity values produced will vary depending on the signal size, PRNU is expressed as a percentage.

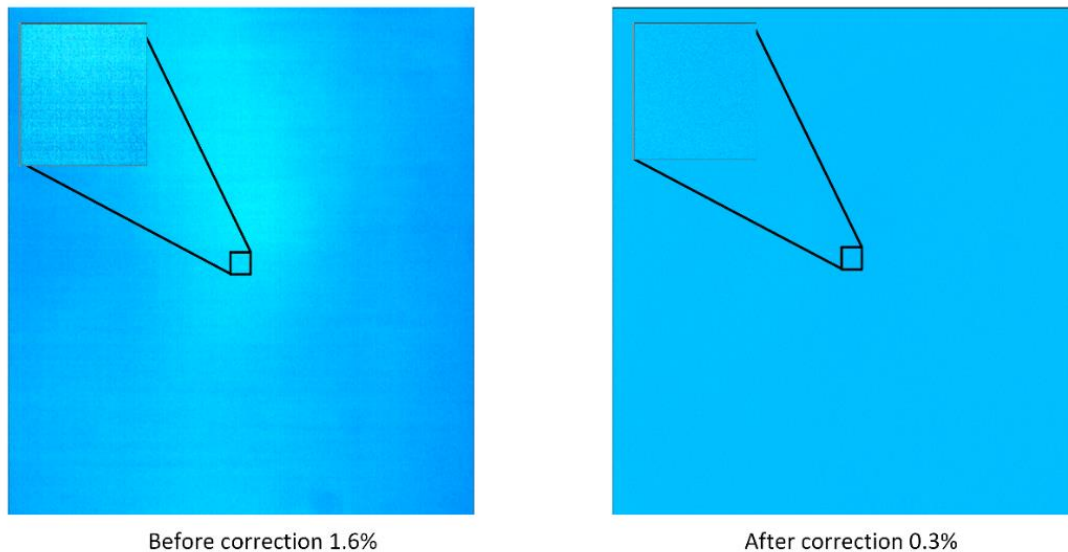


Figure 3-7 PRNU correction comparison before(left) and after(right)

Typical PRNU values are $< 1\%$. For all low-light and medium-intensity light source imaging (signals of 1000 e⁻ or less), this variation is negligible compared to readout noise and other sources of noise. Similarly, when imaging at high light levels, this variation is not significant compared to other noise sources in the image (such as photon shot noise). However, in high light level imaging applications requiring very high measurement accuracy, especially those using frame averaging or frame summation, PRNU values $< 1\%$ are highly necessary.

3.9. Gain Mode

The 95 V2 camera has five gain modes: High Dynamic Range (HDR) mode, High Gain/Low Gain (HG/LG) mode under HDR, High Gain/Low Gain_High Speed (HG/LG_HS) mode. Each mode has differences in synthesis principles, line times, gain values, and readout noise. Selecting the appropriate mode based on the actual scenario is essential to obtain high-quality imaging results.

Table 3-1 Typical gain mode parameter table*

Mode	HDR (16bit)	HG (12bit)	LG (12bit)	HG_HS (12bit)	LG_HS (12bit)
System gain (DN/e-)	0.75	1.98	0.043	1.94	0.036
Full-Well Capacity (e-)	80000	1900	89000	2000	100000
Readout noise(e-)	2.4(Median) 2.5(RMS)	1.6(Median) 1.7(RMS)	45(Median) 50(RMS)	1.8(Median) 1.9(RMS)	45(Median) 50(RMS)

***Note:**

The values in this table are typical and may vary between different cameras. Please refer to the factory photoelectric report for specific details.

3.9.1. High Dynamic Range

High Dynamic Range (HDR) mode synthesizes images with different analog gains but the same exposure time. It includes Low Gain (LG) mode with high full well capacity and high noise suitable for imaging strong signals, and High Gain (HG) mode with low full well capacity and low readout noise suitable for imaging weaker signals. Combining high and low gain images through algorithms generates an HDR image. This mode is suitable for applications with large variations in signal strength.

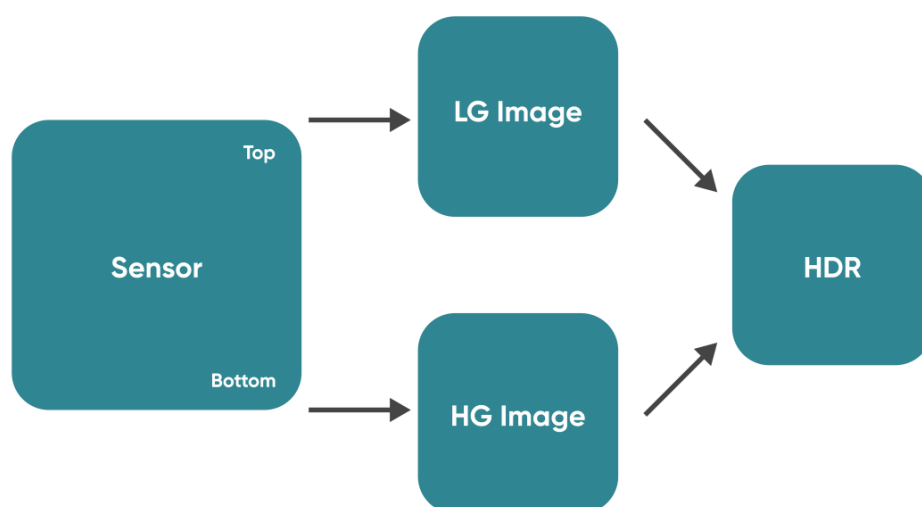


Figure 3-8 Schematic diagram of HDR mode

3.9.2. High Speed

Unlike the normal rolling shutter readout method, the High-Speed (HS) mode sets the high gain (HG) channel and the low gain (LG) channel to identical parameters, enabling simultaneous readout of odd and even lines, thereby doubling the readout speed.

The high-speed mode can be configured into two gain modes: "High Gain_High Speed (HG_HS)" and "Low Gain_High Speed (LG_HS)". The "High Gain High Speed" mode is optimized for readout noise, while the "Low Gain High Speed" mode is optimized for full well capacity.

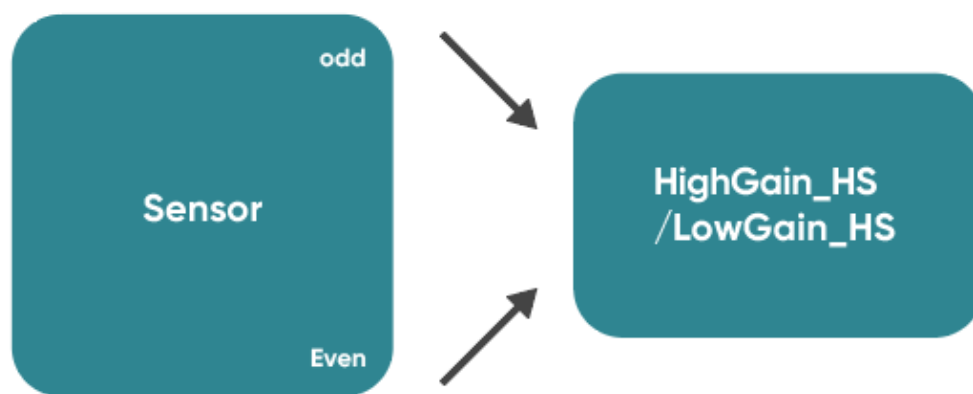


Figure 3-9 Schematic diagram of High Speed mode

Note:

This mode is also referred to as STD mode, with HG_HS and LG_HS corresponding to STDH and STDL, respectively.

3.10. Region of Interest Readout

In imaging applications, ROI (Region of Interest) defines a subregion of interest within the camera sensor's resolution range, and selecting an ROI allows only the images within this subregion to be read out. Rolling shutter cameras can increase the camera's readout speed by reducing the number of rows. The software sets preset subregions and also supports manual settings, where the row window must be a multiple of 4, and the column window must be a multiple of 8.

Table 3-2 Typical ROI area measured frame rate table for Dhyana 95 V2 camera under USB 3.0/ CameraLink

Column(Pixel)	Row(Pixel)	USB3.0 (fps)		CameraLink (fps)	
		HDR/HG/LG	HighGain_HS/ LowGain_HS	HDR/HG/LG	HighGain_HS /LowGain_HS
2048	2048	24	48	24	48
2048	1024	48	95	48	95
2048	512	95	188	95	188
2048	256	187	374	187	374
2048	128	372	727	369	727
2048	64	727	1391	727	1391
2048	8	4430	6961	4430	6961

Note:

- 1) The minimum supported ROI for Dhyana 95 V2 on Mosaic V3 is 48 (columns) × 8 (rows).
- 2) Frame rates are affected by computer system configuration, and it is recommended to use a computer with an i5 processor or above and a 64-bit system.
- 3) For high-speed image acquisition, it is recommended to uncheck automatic levels and turn off the Image Adjustment module.
- 4) The frame rates in the above table are the measured maximum values under the shortest exposure time.

3.11. Binning Readout

Binning is a readout mode that recombines camera pixels, which can improve sensitivity but may also reduce resolution. For example, 2 x 2 binning combines every 4 pixels (2 rows 2 columns) into one "large pixel", and the camera outputs one pixel intensity value.

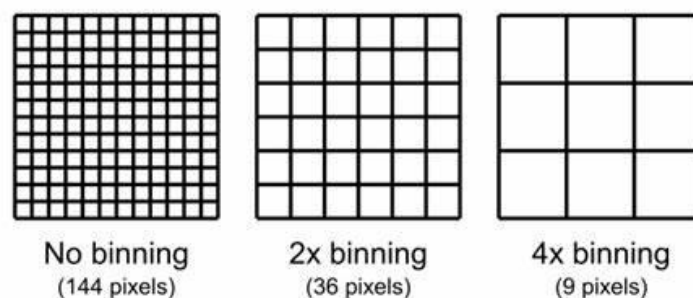


Figure 3-10 Schematic diagram of Binning

Binning can be performed by the camera's FPGA or by the camera operating software. Combining signals in this way can improve the signal-to-noise ratio, enabling the detection of weaker signals, improving image quality, or shortening exposure times. However, the effective pixel size of the camera also increases, which may reduce the camera's resolution of target details.

Binning data processing can be divided into Sum Binning and Average Binning. In 2 x 2 Binning, for example, Sum Binning adds the grayscale values of four pixels, while Average Binning adds the grayscale values of four pixels and then divides by 4 to obtain the average grayscale value.

The software Binning selection on Mosaic V3 is shown below:

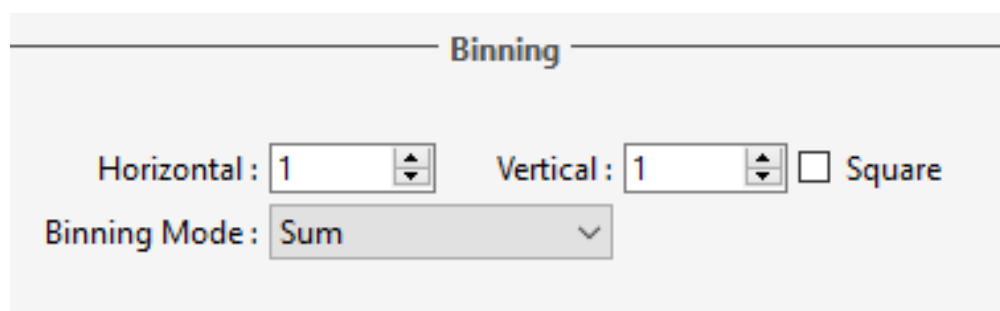


Figure 3-11

The FPGA Binning selection on Mosaic V3 is shown below:

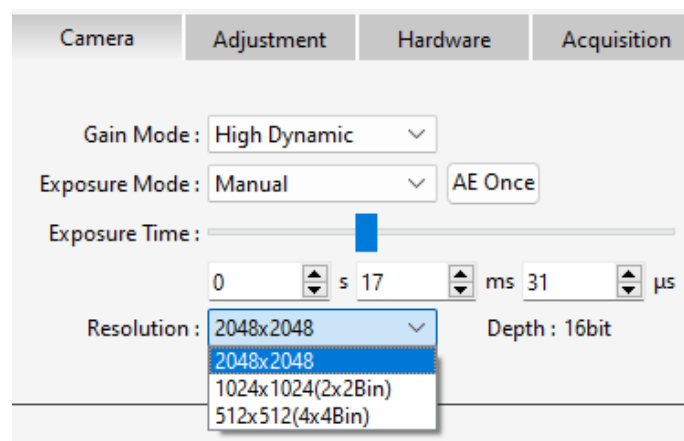


Figure 3-12

3.12. Timestamp

The camera accurately reads the start time of each frame with a time precision of 1 μs. In Mosaic V3 software, images are saved in .sen format, and timestamp information is displayed in the image information, supporting the export of image information to .csv format files.

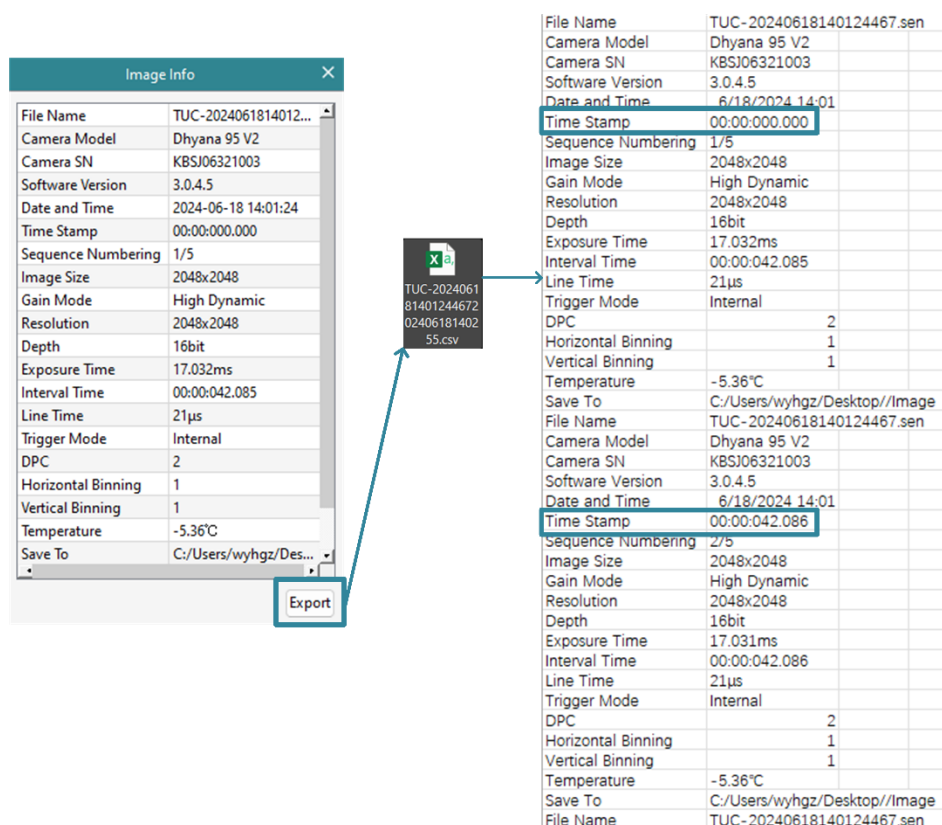


Figure 3-13 Timestamp export schematic

Note:

Applications requiring timestamp functionality generally have high time precision requirements, and it is recommended to use the To RAM image storage mode.

3.13. Frame Rate Calculation

The camera's frame rate is affected by the readout time and the exposure time. The theoretical frame rates can be calculated using the formulas provided in Tables 3-3.

The line time and theoretical full-width minimum readout time for each mode of the Dhyana 95 V2 are shown in the following table.

Table 3-3

Gain mode	Line time (T_{line})	Readout Time ($T_{readout}$)
HDR/HG/LG	20.52 μ s	$2048 \times 20.52 \mu\text{s} = 42.02496 \text{ ms}$
HighGain_HS/LowGain_HS	20.52 μ s	$2048/2 \times 20.52 \mu\text{s} = 21.01248 \text{ ms}$

Typical frame rate calculations for USB 3.0 & CameraLink

Hn: The number of rows selected horizontally;

Vn: The number of rows selected vertically;

T_{line}: Line time;

T_{exp}: The set exposure time.

Table 3-4 Calculation of frame rate for Dhyana 95 V2 camera

Gain mode	Line time T _{line}	Calculation formula	Horizontal (Hn)	Vertical (Vn)	Frame rate (fps)
HDR/HG/LG	20.52 μs	$1/(Vn * T_{line})$	2048	2048	23.8
				1024	47.6
				512	95.2
				256	190.4
				128	380.7
				64	761.4
HighGain_HS /LowGain_HS	20.52 μs	$1/(Vn/2 * T_{line})$	2048	2048	47.6
				1024	95.2
				512	190.4
				256	380.7
				128	761.4
				64	1522.9

Note:

1) The frame rate is affected by actual transmission bandwidth and computer system configuration. To prevent frame loss, intervals in units of line times are added during actual transmission, increasing the readout time and causing the calculated frame rate to potentially be higher than the actual frame rate.

2) When $T_{exp} > T_{readout}$, the frame rate = $1/T_{exp}$ (s).

3.14. Frame Rate Adjustment

Each frame image readout has a fixed blanking time, and frame rate adjustment is achieved by changing the blanking time (T blanking) to control the frame rate.

For example, if the exposure time < readout time, considering a frame rate of 40 fps, setting the frame rate to 20 fps adds 25 ms of blanking time during image output.

Similarly, if the exposure time > readout time, considering an exposure time of 100 ms, setting the frame rate to 5 fps adds 100 ms of blanking time during image output.

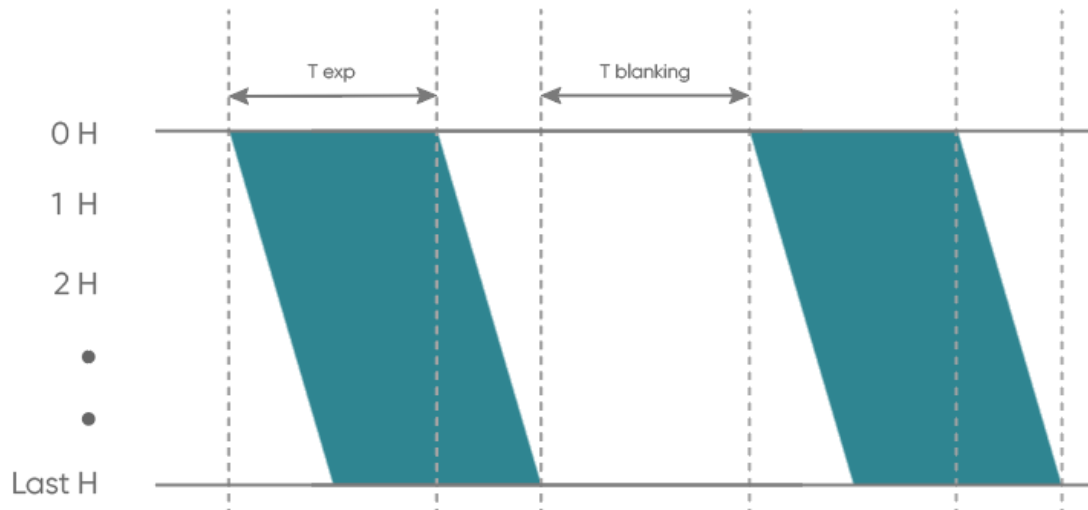


Figure 3-14

3.15. Incident Photon Calculation

Scientific camera imaging involves the conversion of photons, electrons, voltage, and grayscale values. Therefore, it is possible to reverse calculate the incident number of photons from the grayscale values. The calculation formula is as follows:

$$P = \frac{(DN - Offset)/K}{Q(\lambda)}$$

Where: P represents the incident number of photons. DN is the grayscale value of the light signal. K is the system gain (refer to Table 3-1) in (DN/e-). Q(λ) corresponds to the quantum efficiency at the wavelength. Offset is the camera's background value in DN.

3.16. Acquisition Mode

3.16.1. Live mode

Live mode is suitable for real-time preview, providing data stream output. Images are continuously output like a flowing stream. In this mode, users can freely modify settings such as exposure time, gain mode, region of interest, etc., for real-time preview and image capture

operations.

After successfully installing the Mosaic V3 software and drivers, the hardware trigger mode defaults to "internal trigger" (live mode), the user can click Preview/Stop to control the opening and closing of the camera live mode, and click Capture to obtain the image.

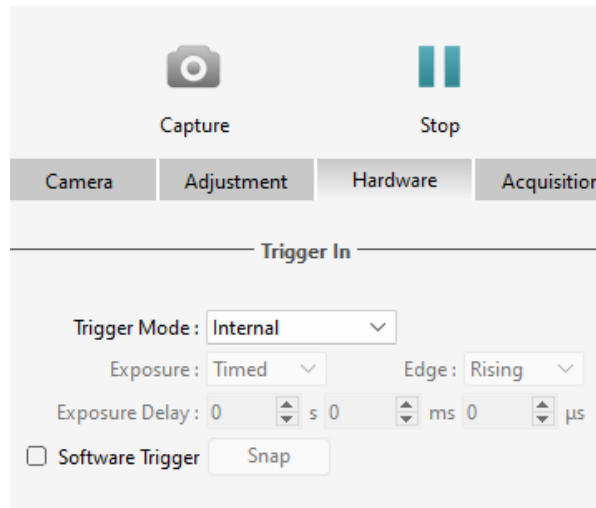


Figure 3-15

Users can set the exposure time, gain mode and other camera parameters, and preview them in real time through the preview window to get a suitable image.

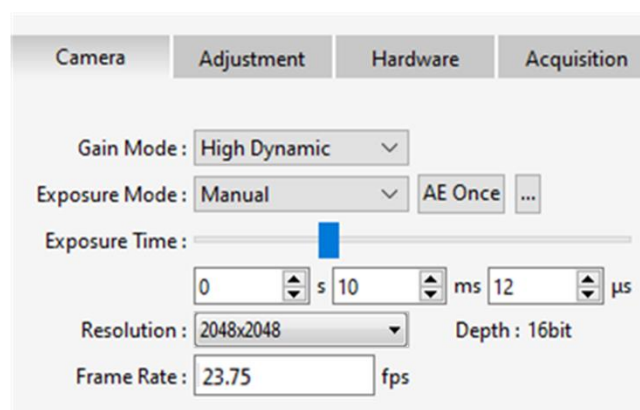


Figure 3-16

In the acquisition module, users can set the save path, file name, total number of frames and other information, and the image can be taken after the setting is completed.

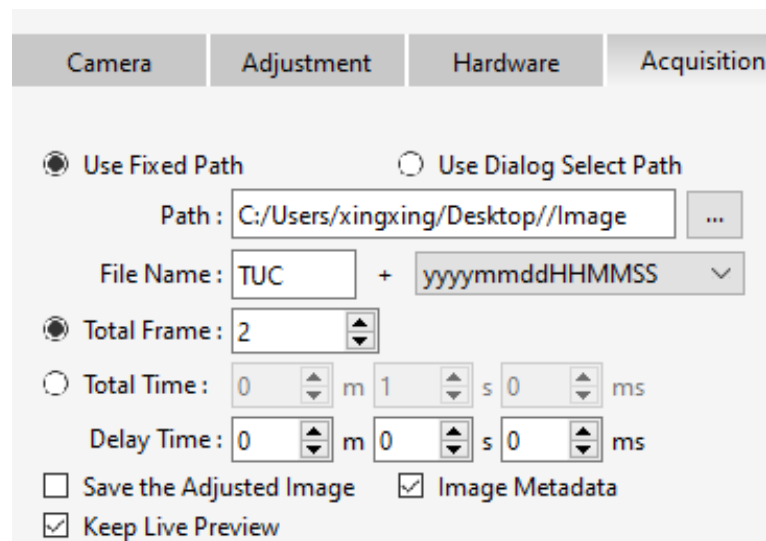


Figure 3-17

3.16.2. Software Trigger Mode

When the camera is in Software trigger mode, the software gives the camera a command to take a picture, and when the camera receives the signal, it starts the exposure and outputs the image.

To use the software trigger mode in Mosaic V3, check the software trigger, click Capture to enter the waiting trigger state, and then click the **Snap** to execute the image capture command, and only output one image at a time.

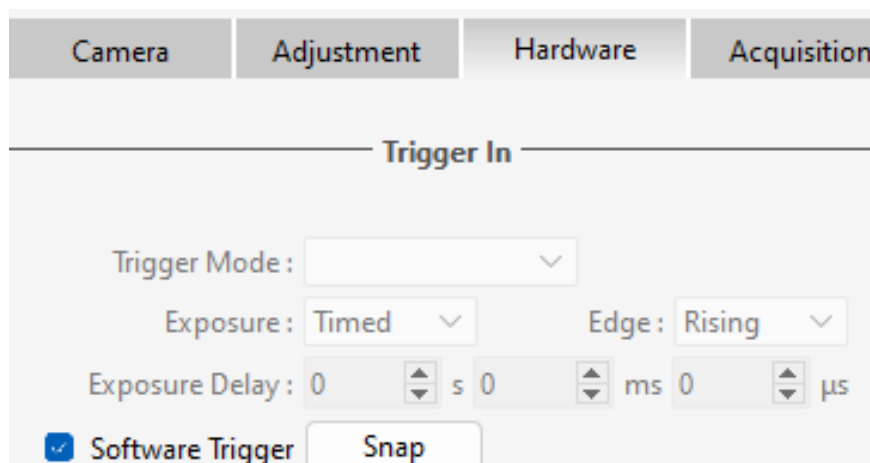


Figure 3-18

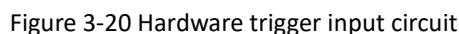
3.16.3. Hardware Trigger Mode

Hardware trigger mode waits for an external level trigger signal command to capture an image.

It includes three modes: Standard Overlap, Standard Non-Overlap, and Synchronization.

Camera	Adjustment	Hardware	Acquisition
Trigger In			
Trigger Mode : Standard(Overlap) ▾			
Frames/Signal : 1		Stop	
Exposure : Timed ▾		Edge : Rising ▾	
Exposure Delay : 0 ▴ ▾ s		0 ▴ ▾ ms 0 ▴ ▾ μ s	
Signal Filter : 0 ▴ ▾ μ s			
☐ Software Trigger		Snap	

3.16.3.1. Hardware Trigger input circuit



- 1) *The valid external trigger signal recognized by the imager must be a level signal of 3.3 to 5 V. Exceeding the maximum voltage limit may cause permanent damage;*
- 2) *The pulse width of the recognized level signal must be greater than 1 μ s.*

To suppress interference in the external trigger signal, external trigger filtering supports high and low-level filtering. This function filters out spikes in the level signal. The filtering time range can be set to [0, 1000000] μ s, with the default being 0.

The following figure takes the filtering time set to 1 ms as an example:

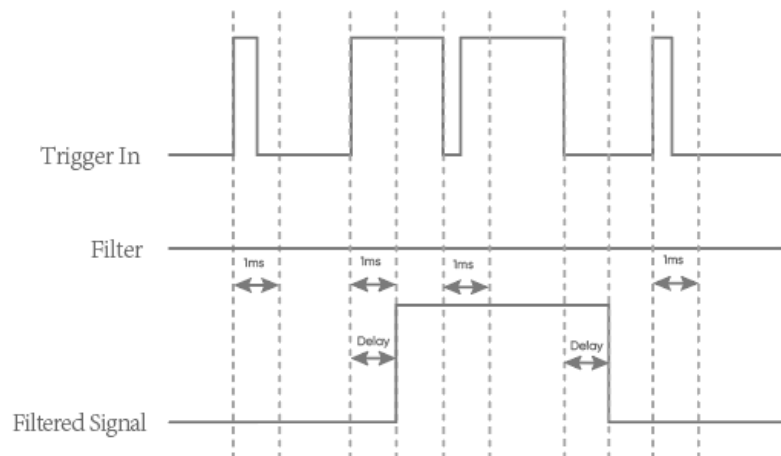


Figure 3-21 Trigger Filter function schematic

Note:

After the camera receives a valid trigger signal, the filter signal will lag behind the last edge of the jitter time period, with the lag time = the set filter time.

3.16.3.3. Trigger Delay and Jitter

The trigger delay and jitter for the HDR, High Sensitivity, and High Speed modes are shown below. When the external trigger signal arrives, there is a nanosecond-level delay T_{iso} through the hardware circuitry. After the delay through the hardware circuitry, the level signal input to the camera's internal undergoes conversion, resulting in some jitter T_{logic} , ranging from 0-1 minimum exposure unit T_{line} . Therefore, the total delay time from external trigger input to exposure start is $T_{delay} = T_{iso} + T_{logic}$, within the range of two line times. If the Trigger Filter function is used, a Trigger Filter Delay Time T_{filter} is added to this.

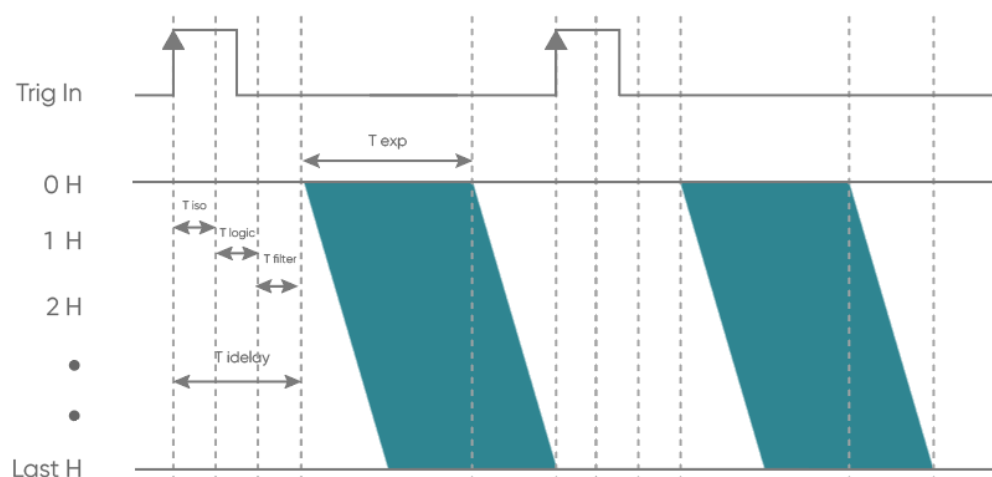


Figure 3-22 Schematic of trigger delay

T_{exp} : exposure time; T_{iso} : hardware circuit delay; T_{logic} : trigger jitter; T_{delay} : total delay time; T_{filter} : trigger filter delay time; $1H$: one T_{line} .

3.16.3.4. Standard Trigger Mode

Standard trigger mode is divided into Standard (Overlap) trigger mode and Standard (Non-Overlap) trigger mode.

Standard (Overlap) Trigger Mode: In this mode, when the camera is in live mode, it responds to the trigger signal immediately after the first row of exposure ends.

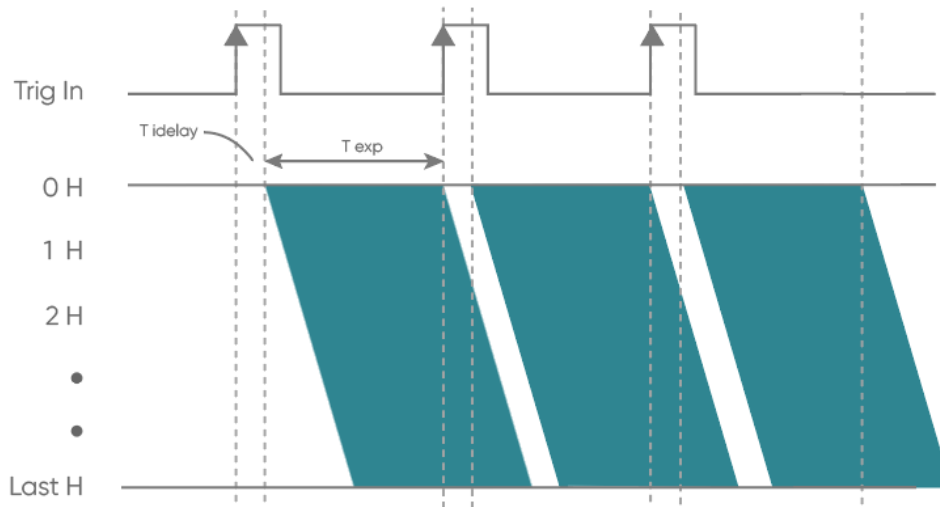


Figure 3-23 Standard (Overlap) Trigger timing

Standard (Non-Overlap) Trigger Mode: In this mode, when the camera is in live mode, it responds to the external trigger signal only after the readout ends.

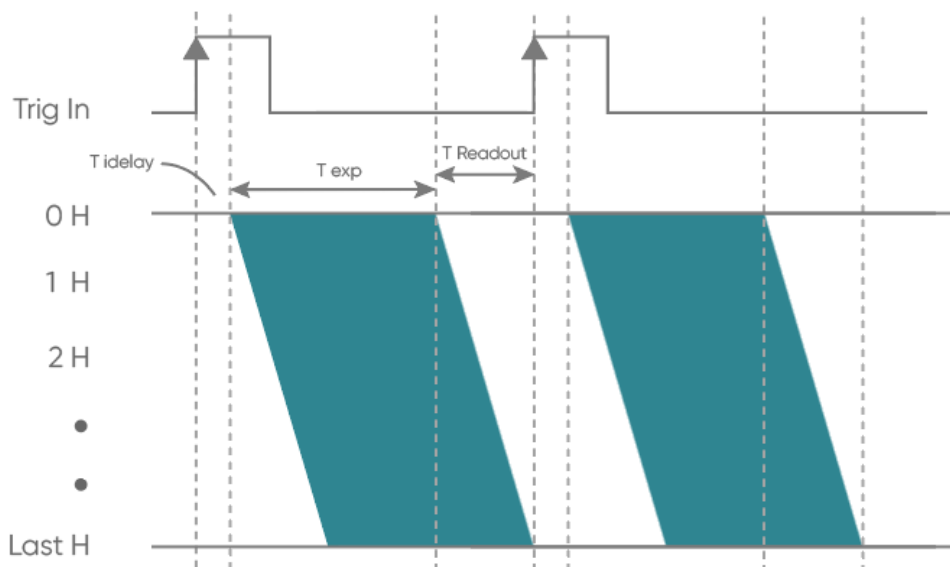


Figure 3-24 Standard (Non-Overlap) Trigger timing

Both of these modes support both level and edge triggering. In Standard (Non-Overlap) Trigger Mode, for example, in level trigger mode (i.e., the exposure type is selected as Width in the software), exposure start and end are controlled by the duration of the trigger signal's high or low level. Level trigger mode is not continuous shooting; it is commonly used to capture stationary or slowly moving objects.

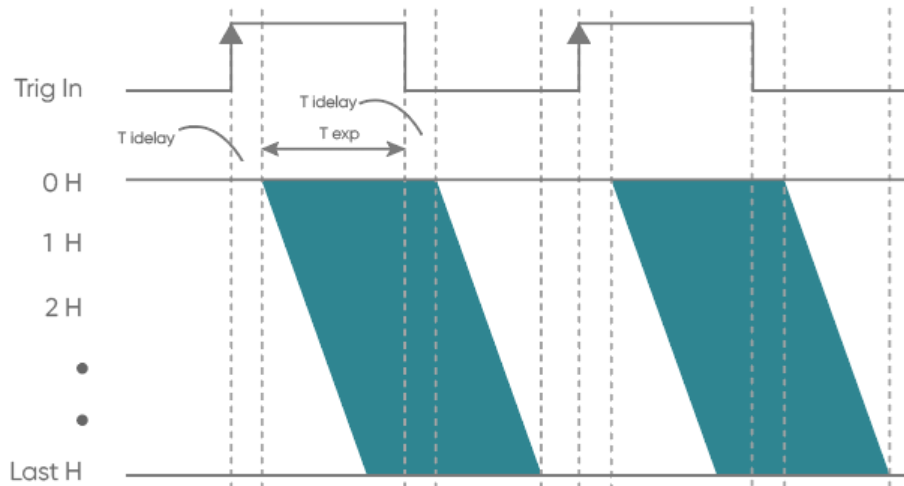


Figure 3-25 Level Trigger timing diagram

In the edge trigger mode (i.e., the exposure type is selected as Timed in the software), the length of the exposure time is set directly on the software interface. When using, it should be noted that the time of each pulse cycle of the trigger signal (pulse duration + pulse interval) must be greater than or equal to the total time used for each frame of image output (i.e., the reciprocal of the frame rate) to ensure that a frame of image is complete and error-free.

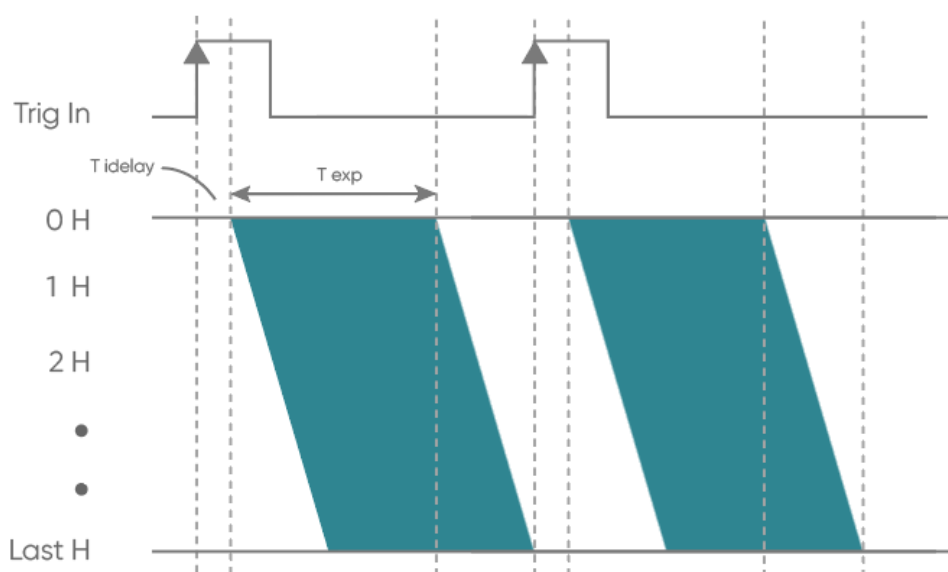


Figure 3-26 Edge Trigger timing diagram

Dhyana 95 V2 camera supports single-trigger multi-frame acquisition function, you can modify the number of triggering out of the picture by setting the frame/signal in the standard triggering mode (refer to Figure 3-19), for example, by setting the number of 2, the triggering timing diagram is as follows:

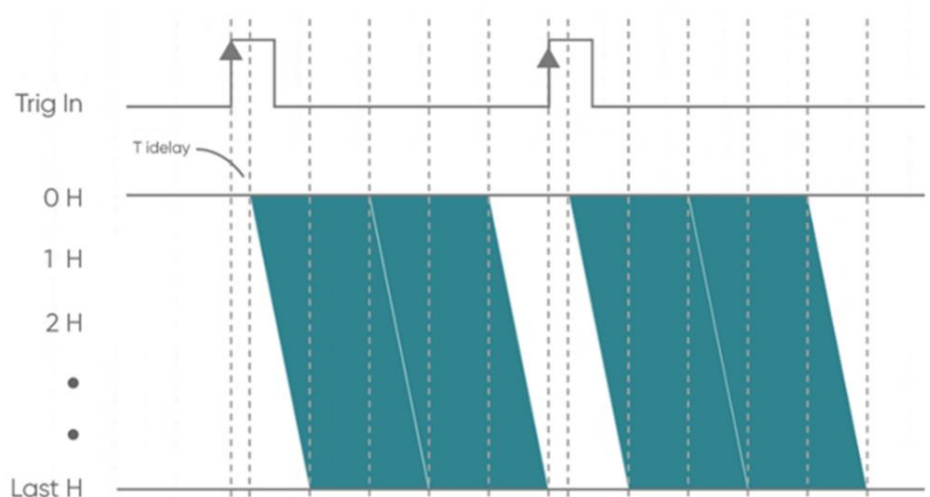


Figure 3-27 Single-trigger multi-frame acquisition timing diagram

3.16.3.5. Synchronization Trigger Mode

In this mode, when the camera receives a certain level signal, it starts exposure capture. When it receives the next level signal, it ends exposure, starts readout, and begins a new exposure cycle. This mode ensures complete synchronization of exposure start and readout with the external trigger signal.

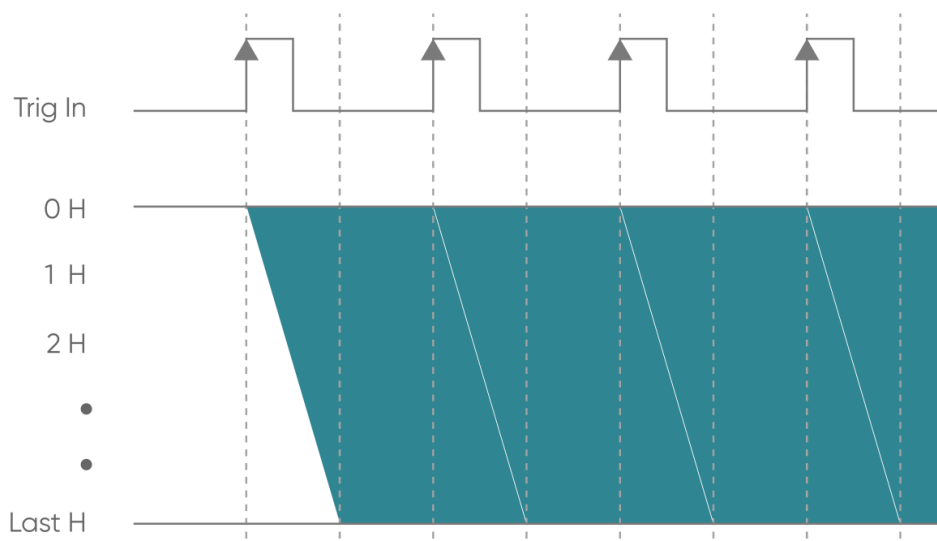


Figure 3-28 Synchronization Trigger mode timing diagram

The length of exposure time in this mode is determined by the time interval between the arrival of two trigger signal edges. After entering this mode, the camera starts the first frame

exposure when the first trigger signal edge is detected, and does not terminate the first frame exposure and output the image until the trigger signal edge is detected for the second time, and at the same time starts the second frame exposure, and so on; that is, there is no image data for the first trigger signal after entering this mode, and there is an image output for each of the subsequent trigger signals, and the exposure time for each frame is the time interval between the arrival of the two trigger signal edges. The exposure time corresponding to each frame is the time interval between the arrival of the two trigger signal edges. The same mechanism is followed when the trigger signal is single pulse or multi-pulse.

This mode is very useful for confocal microscopy as it enables simultaneous control of the camera's exposure time and spinning disk confocal speed to eliminate the effects of inhomogeneous light.

3.17. Trigger Output

3.17.1. Hardware Trigger output circuit

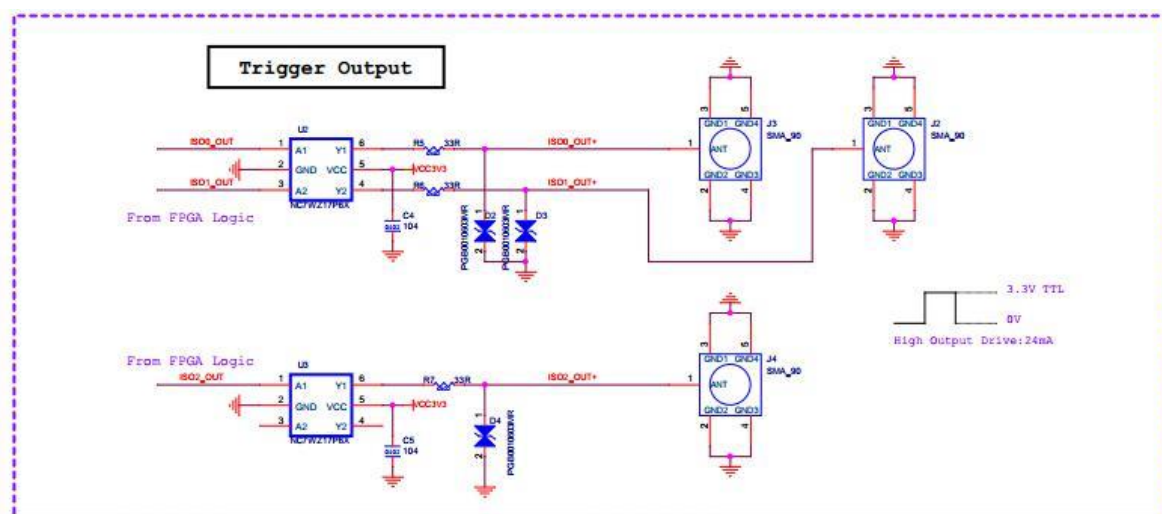


Figure 3-29

3.17.2. Trigger Output Timing Diagram

The camera has three external trigger output interfaces, each independently capable of outputting six timing signals. Each output signal can be independently configured on the three output ports and can simultaneously output to different devices.

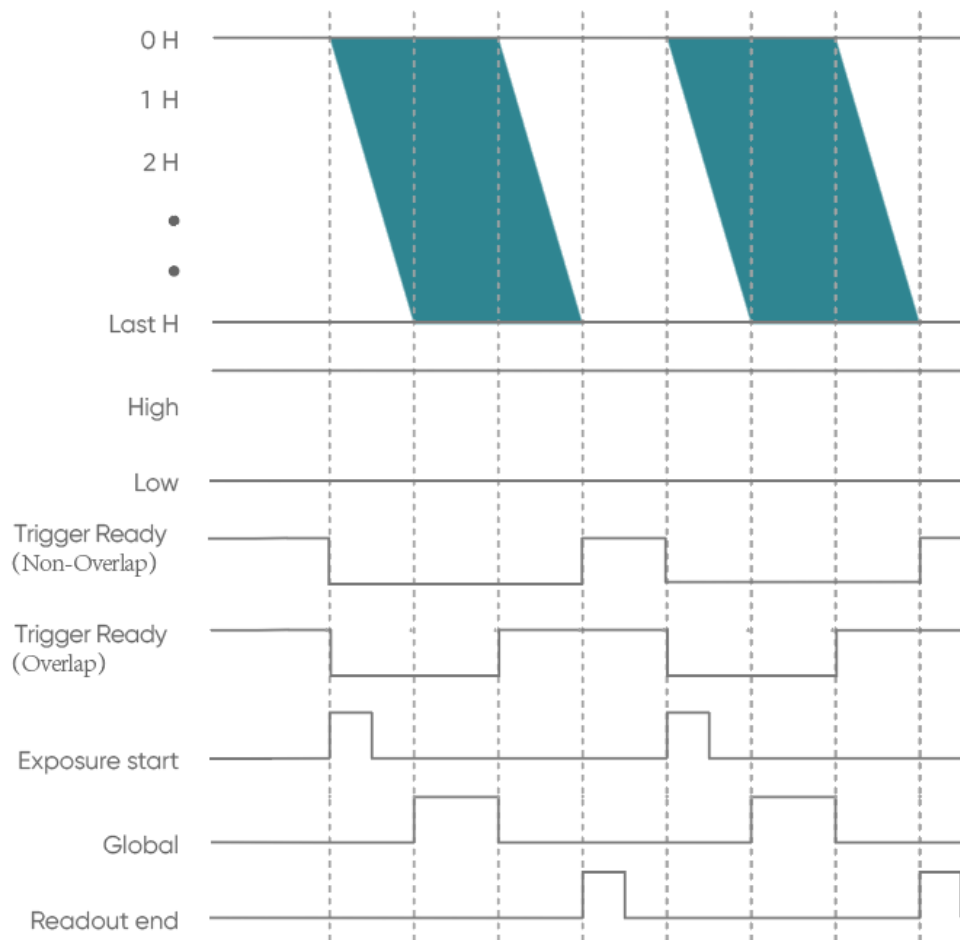


Figure 3-30 Trigger output timing diagram

- **High:** always output high level.
- **Low:** always output low level.
- **Trigger Ready:** when the camera is in the open-current state and can respond instantly to external triggers, the trigger ready output is high level.
- **Exposure Start:** output starting from the first line of exposure, the default pulse width is 5ms, which is customizable. And the output is in the TRIG.OUT3 interface by default.
- **Readout End:** output starting from the last line of exposure end, the default pulse width is 5ms, which is customizable. And the output is in the TRIG.OUT1 interface by default.
- **Global:** output from the beginning of the last line of exposure to the end of the first line of exposure end (valid when the exposure time is larger than the readout time), the default pulse width is 5ms, which is customizable. And the output is in the TRIG.OUT2 interface by default.

3.18. Cooling

Camera cooling effectively reduces "dark current noise" and the impact of hot pixels. The camera adopts semiconductor cooling using the Peltier effect, where an N-type and P-type material form a thermocouple. When a DC current is passed through the thermocouple, heating and cooling phenomena occur at the junctions due to the direction of the DC current. The cooling module is placed close to the chip to lower the chip's temperature and reduce dark current, while the hot end is connected to a metal heat sink to dissipate heat efficiently.

Both air cooling and water cooling are commonly used cooling methods. In air cooling, a fan exchanges excess heat with the surrounding air via airflow, while in water cooling, a liquid circulation system transfers excess heat. Dhyana 95 V2 camera supports both air cooling and water cooling modes, allowing users to choose the appropriate cooling method based on the actual usage environment. In air cooling mode, the inlet and outlet vents are indicated as shown in the figure.

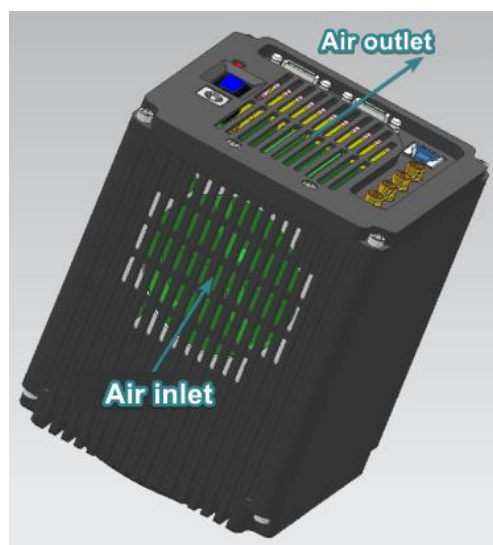


Figure 3-31 Schematic diagram of air inlet and outlet

Air cooling can achieve cooling effects of $\sim 35^{\circ}\text{C}$ below ambient temperature, while water cooling can achieve cooling effects of $\sim 45^{\circ}\text{C}$ below ambient temperature. The camera fan speed can be controlled variably, generally supporting High, Medium, and Low speed options. The higher the fan speed, the better the heat dissipation performance, while lower speeds result in lower vibration transmission. For complete low-vibration performance, the fan of the Dhyana 95 V2 camera can be completely turned off in the software, and a water cooling port is provided (refer to section 4.3 for installing water cooling).

4. Installation

4.1. Recommended computer configurations

Camera Interface	USB3.0	CameraLink
CPU	I5 and above performance, with a main frequency of 2.6GHz and above	
Operating system	Windows 10/11 64 bit PC	
Memory	8GB and above	
PCIe specifications	/	PCIe3.0*16

Note:

In CameraLink, sufficient bandwidth is required. If you see obvious image scrolling when opening the camera software, it is recommended to first confirm whether the bandwidth of the acquisition card is sufficient.

4.2. Camera installation

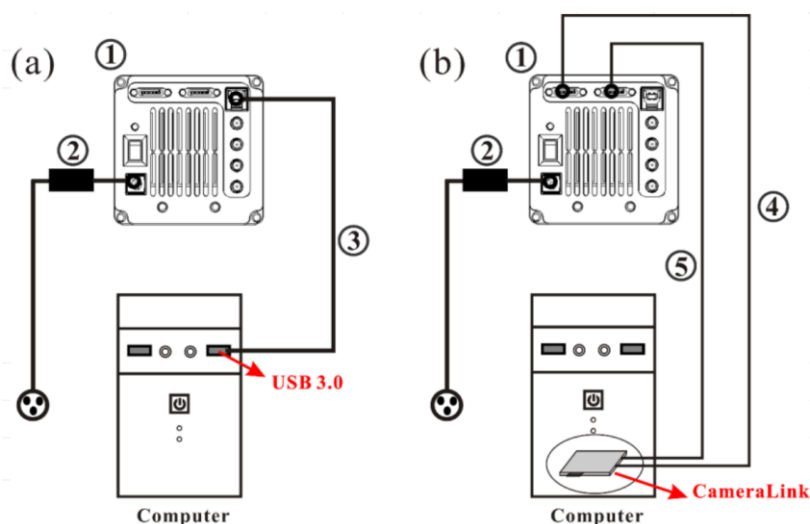


Figure 4-1 Dhyana 95 V2 camera connection diagram

- ① Dhyana 95 V2 camera
- ② Power adapter
- ③ USB 3.0 data cable
- ④ CameraLink cable 1
- ⑤ CameraLink cable 2

Connect one end of the USB 3.0 data cable or CameraLink data cable to the PC, and connect the USB to the USB 3.0 interface on the back of the host. Connect the other end to the sCMOS camera, lock the screw, then plug in the power cord, turn on the power switch, and you will see the indicator light lit up in red.

Note:

- 1) *To prevent the camera from overheating, do not cover the camera with cloth or any other material, nor block the camera's ventilation openings in any way.*
- 2) *If operating the camera in an enclosed environment, ensure there is at least a 10 cm gap between the camera's air intake and exhaust vents for safe operation and optimal cooling performance. If the camera is placed on a desk or platform, make sure the camera's vents are not facing downwards.*
- 3) *The depth of the C-mount is 7 mm. Over-tightening the base may scratch the glass surface.*
- 4) *Before connecting and disconnecting cables, please turn off the power to the camera and surrounding devices.*

4.3. Water cooling pipe installation

4.3.1. Connect the water cooling pipe

Operation steps:

- (1) Place the camera on a stable workbench;
- (2) Connect the water cooling pipe to the water pipe joint on the camera and make sure it is inserted in place, as shown in Figure 4-2 below;



Figure 4-2

- (3) Insert the water pipe into the water nozzle of the cooling water circulation machine and lock it with a clamp;
- (4) The cooling water circulating machine water pipe is connected to the camera water pipe through an adapter valve.

4.3.2. Software Fan Status

- (1) After installing the water cooling pipe, it is necessary to switch the cooling mode on the software. The default cooling method for the camera is air cooling, which can be switched to water cooling by adjusting the fan gear;

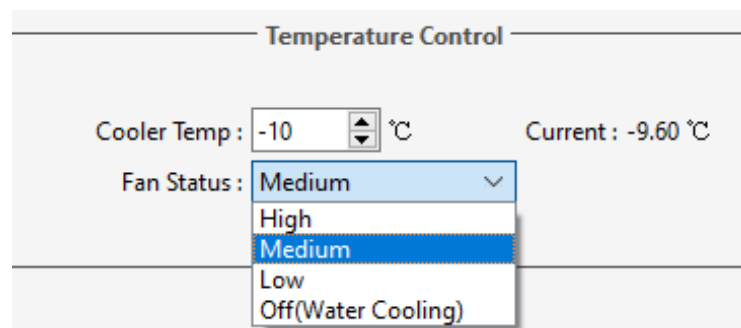


Figure 4-3

- (2) If you choose to turn off the fan, the software will prompt you as follows. Click "Yes" to turn off the fan. Please ensure that the water cooling system is functioning properly before proceeding with this operation.

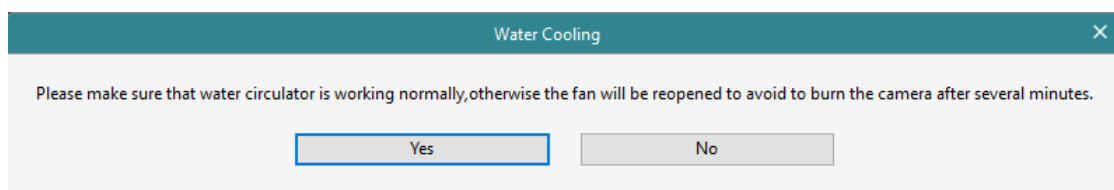


Figure 4-4

4.3.3. Disconnect the water cooling pipe

- (1) Disconnect the power supply to the camera and all other equipment, including the recirculating water chiller;
- (2) Following the instructions for the recirculating water chiller, unplug the water hose from the chiller and drain the water from the chiller;
- (3) Press the adapter valve sleeve and remove the water hose from the recirculating water chiller to drain the internal water;

(4) Press the water connector and remove the camera's water hose from the hose connector. First, position the side with the water valve facing sideways (not upwards). When removing the hose, ensure the water valve is facing downwards. Use an absorbent towel or paper towel to protect the area (as shown in Figure 4-5) to ensure no water leaks into the camera.



Figure 4-5 Removing the water-cooling pipes

Note:

- 1) *Selection of cooling water: Deionized water is recommended;*
- 2) *Water temperature: Generally, a water temperature of 20°C is recommended. Inappropriate environmental conditions can cause condensation on the water valves and hoses, posing a risk of equipment damage. To ensure proper operation, the water temperature should not be below the dew point. Refer to the dew point in the appendix for the dew point;*
- 3) *Pressure: The maximum water pressure entering the camera should not exceed 2 bar;*
- 4) *Recirculating water chiller: Use the chiller and cooling water correctly according to the chiller's instructions;*
- 5) *Properly install the water-cooling pipeline to ensure no leakage at the connections on both the camera and chiller ends;*
- 6) *Before operating the camera, ensure the correct installation of the recirculating water chiller and the camera's water valves, and that the water flow rate reaches 1L/min;*
- 7) *After operation, turn off the power to the camera and chiller, and drain the water from both the chiller and the camera.*

Warning:

- 1) **Do not turn off the recirculating water chiller during camera operation, as this may**

cause the chip to run at a high temperature continuously, leading to damage;

2) During camera operation, the water cooling and fan can be operated simultaneously, but they must not both be turned off simultaneously. At least one cooling method must be running to prevent the chip from running at high temperatures and being damaged.

4.4. Frame grabber installation

Turn off the computer and open the cover of the computer host, as shown in Figure 4-6.

Choose a PCIe slot with a transmission bandwidth greater than 850MB/s, insert the Frame grabber, secure it with screws, and then restart the computer. Connect the interface between the camera and the computer Frame grabber through a data transmission cable.

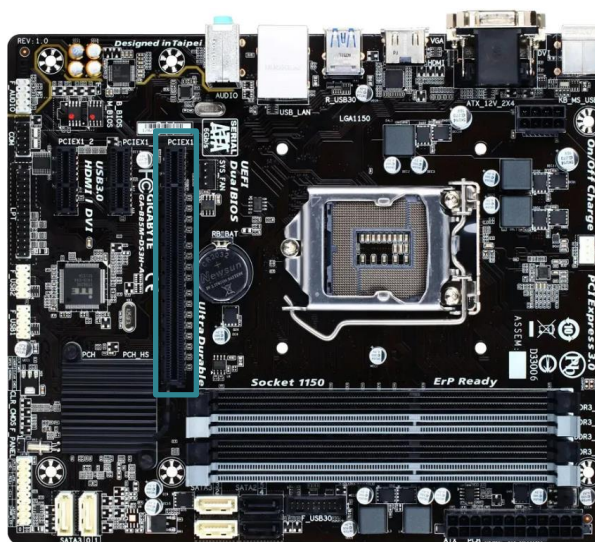


Figure 4-6 Computer motherboard diagram

Table 4-1 Maximum transfer rate corresponding to different PCIe slots

PCIe	X1	X4	X8	X16
1.0	250MB/s	1GB/s	2GB/s	4GB/s
2.0	500MB/s	2GB/s	4GB/s	8GB/s
3.0	985MB/s	3.9GB/s	7.8GB/s	15.7GB/s

Note:

- 1) When installing and disassembling the Frame grabber, be sure to operate with power off;
- 2) When connecting the CamraLink cable, please operate with the camera power off and do not hot plug or unplug.

4.5. Driver installation and uninstallation

This section will introduce the installation of camera USB driver, Frame grabber driver installation and uninstallation.

4.5.1. Camera USB driver installation

Operation steps:

- (1) Connect the camera to the computer and open the matching USB drive;
- (2) Double click to run the driver installation package;
- (3) Follow the prompts to click [Next] for default installation;

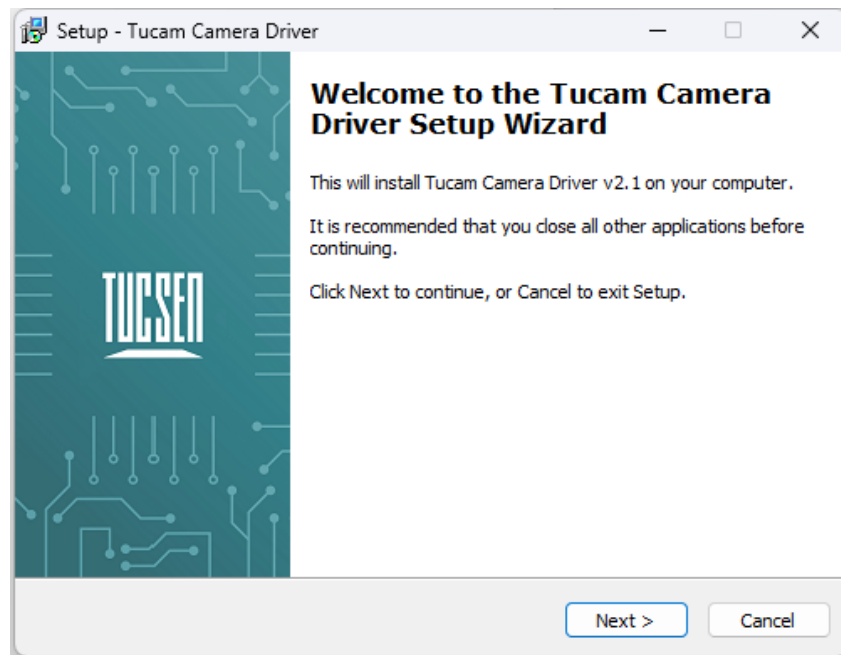


Figure 4-7

- (4) Selecting the contents of the installation, by default check the box to install Microsoft runtime libraries vcredist_2008 and vcredist_2013, unchecking the box may result in the software or third-party plug-ins not working;

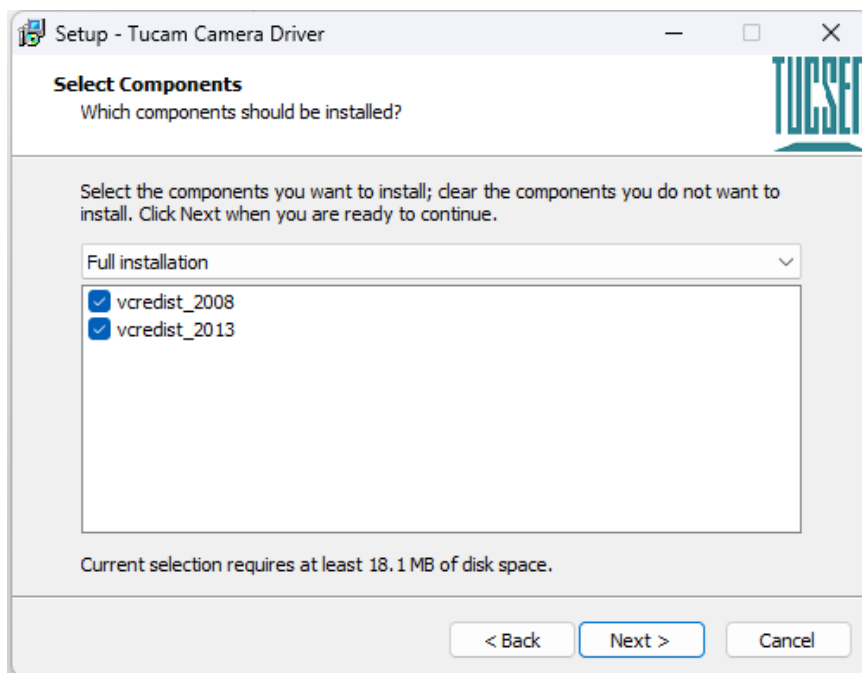


Figure 4-8

(5) Waiting for the driver installation to be completed;

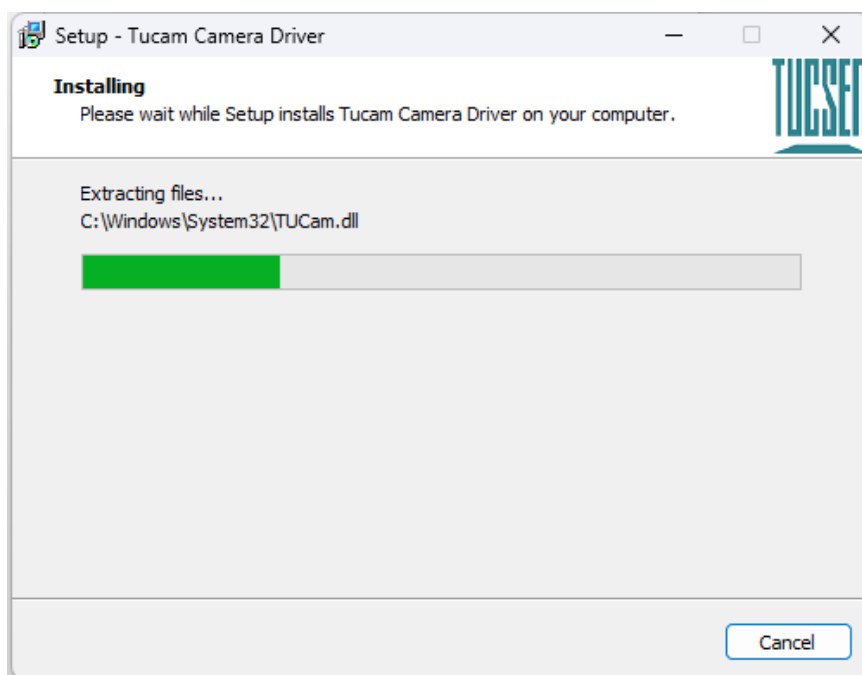


Figure 4-9

(6) Click "Finish" to complete the driver installation;

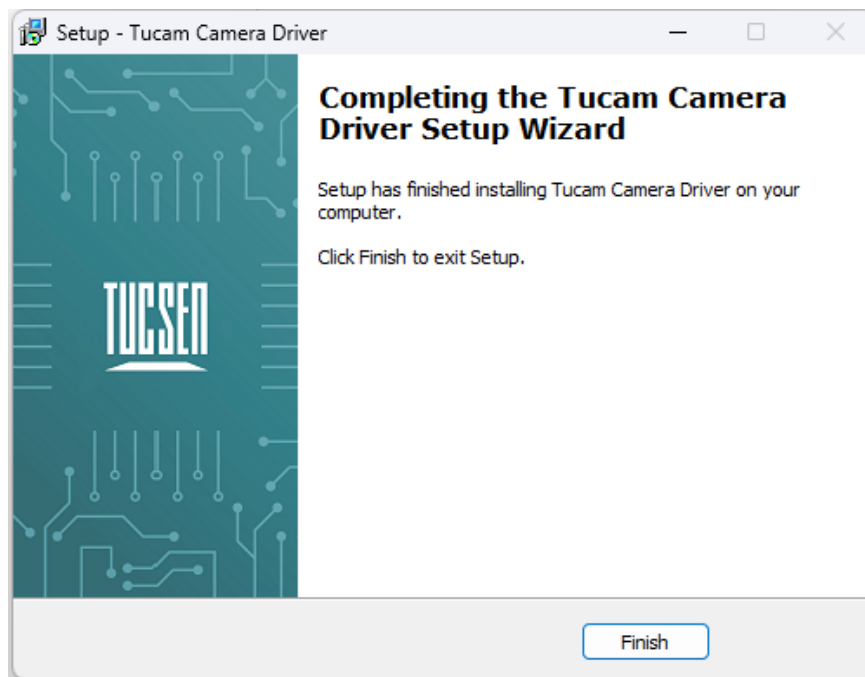


Figure 4-10

After installing the camera USB 3.0 driver, open the device manager on the computer. When the driver is successfully installed, the camera will appear under the image device without any yellow markings, as shown in the picture. If a yellow symbol appears, it indicates that the driver needs to be reinstalled.

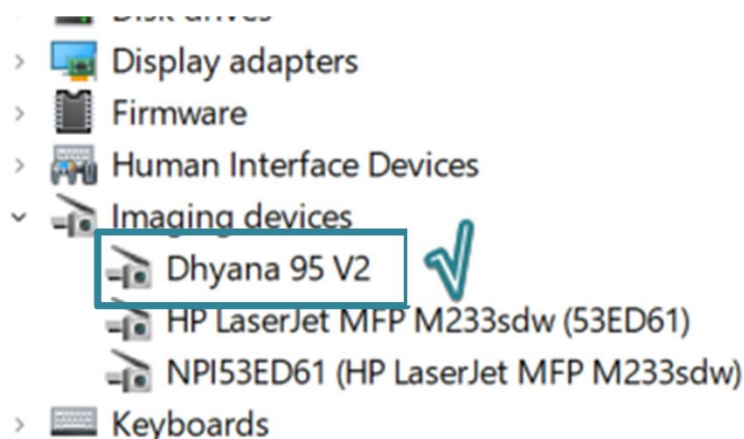


Figure 4-11 Device Manager Display

4.5.2. CameraLink driver installation

Installation steps:

- (1) The camera is connected to the installed CameraLink Frame grabber CameraLink1 and CameraLink2 interfaces on the computer host through two CameraLink cables, and the interface sequence needs to be one-to-one corresponding;

- (2) Open the matching USB flash drive. Find the installation package for the acquisition card driver;
- (3) Double click to run the CameraLink acquisition card driver, follow the prompts to click [Next] for default installation, and finally click [Finish]. After restarting the computer host, the driver installation is completed.
- (4) After the driver installation is completed, please restart the computer;

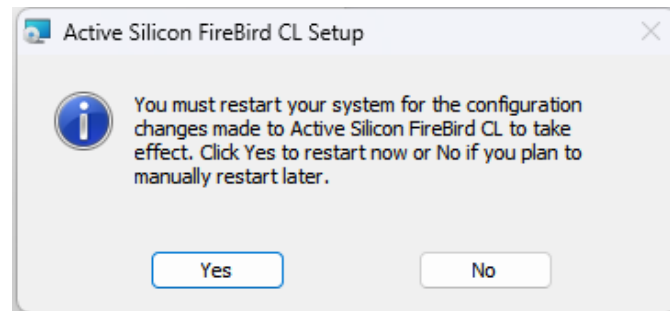


Figure 4-12

After installing the CameraLink driver, open the device manager on your computer. When the driver installation is successful, the CameraLink Frame grabber will appear in the device manager and display FireBird Baseboard. After connecting the camera, it will occupy the COM port, as shown in the following figure.

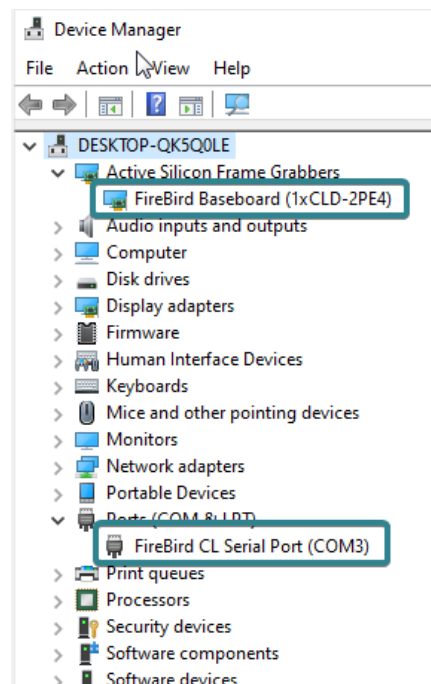


Figure 4-13

4.5.3. CameraLink driver uninstallation

Taking the Windows 11 system as an example, in the computer settings, click on Applications>Installed Applications, find Active Silicon FireBird CL, click on the three points on the right to uninstall, and follow the prompts to complete the uninstallation.

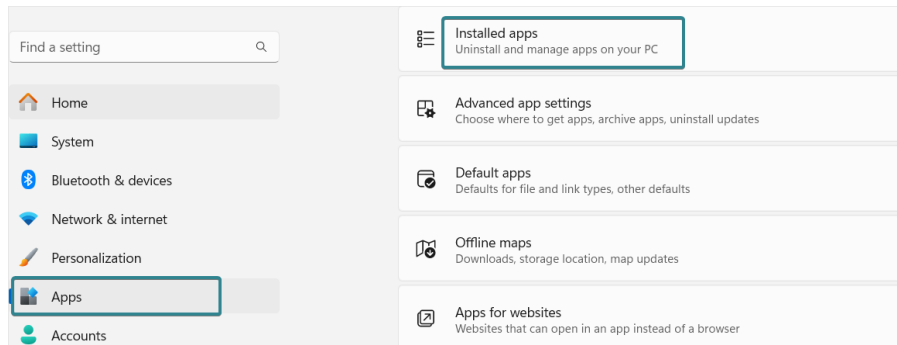


Figure 4-14

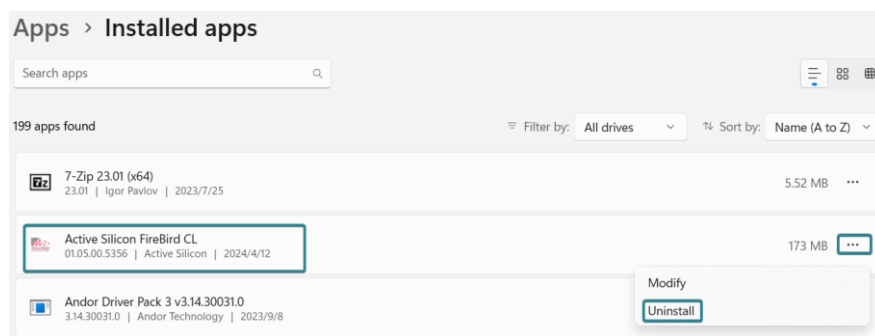


Figure 4-15

4.6. Software installation and uninstallation

4.6.1. Installation

Operation steps:

- (1) Open the supporting USB drive, double-click to run Mosaic V3 software;
- (2) Select the installation path, default to C drive, users can customize the installation path according to your needs;

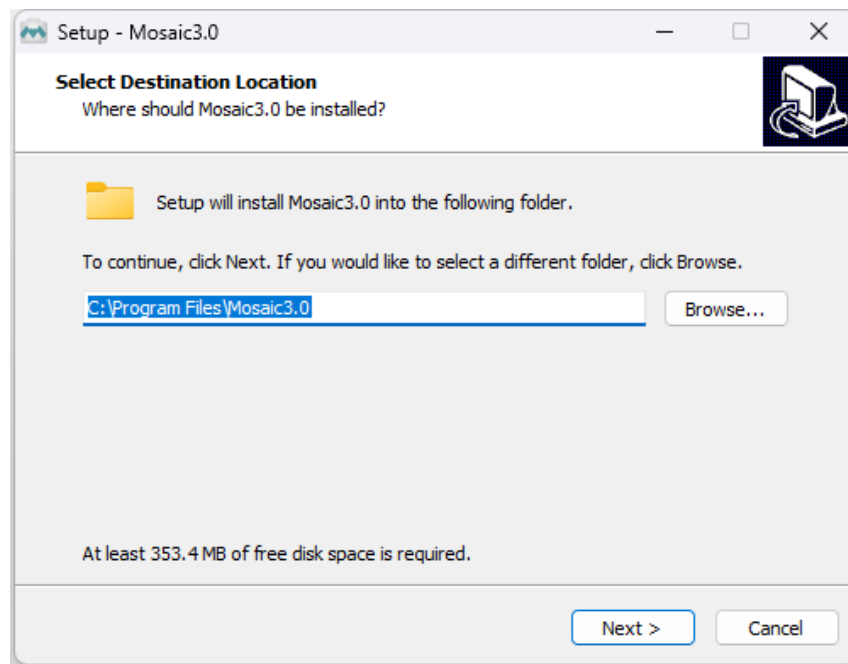


Figure 4-16

(3) Select the installation content. By default, select the option to install drivers and Microsoft runtime library vc_redist_2015, canceling the installation can result in the camera not being recognized by the software;

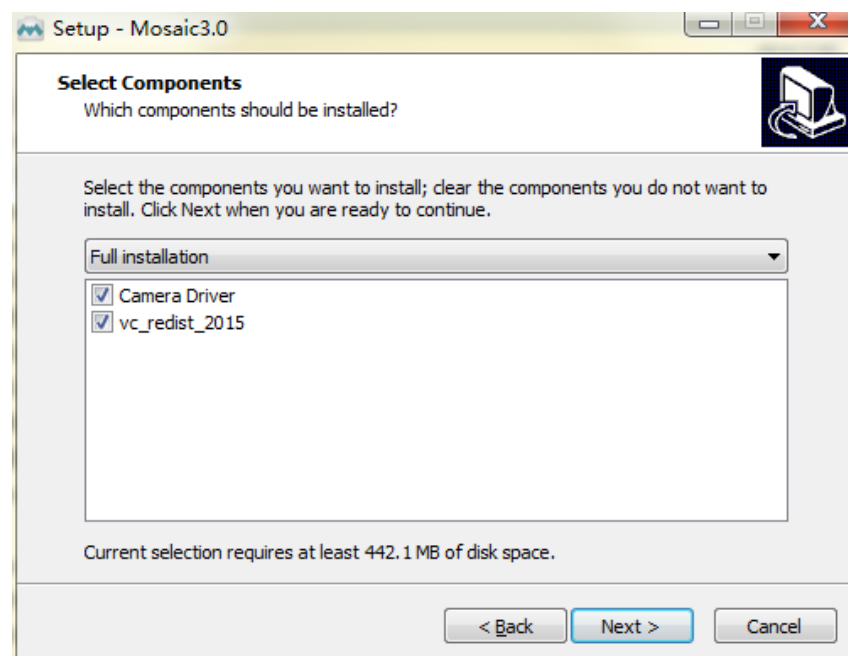


Figure 4-17

(4) Configure installation parameters and select whether to generate desktop shortcuts;

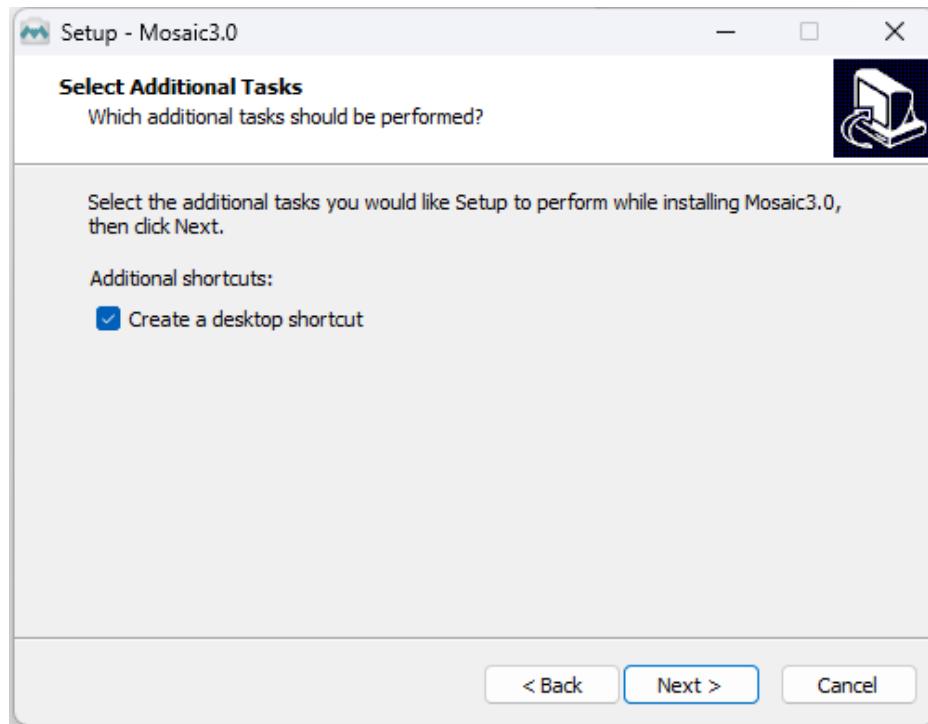


Figure 4-18

(5) After confirming all installation parameters, click "Install" to start executing the installation action;

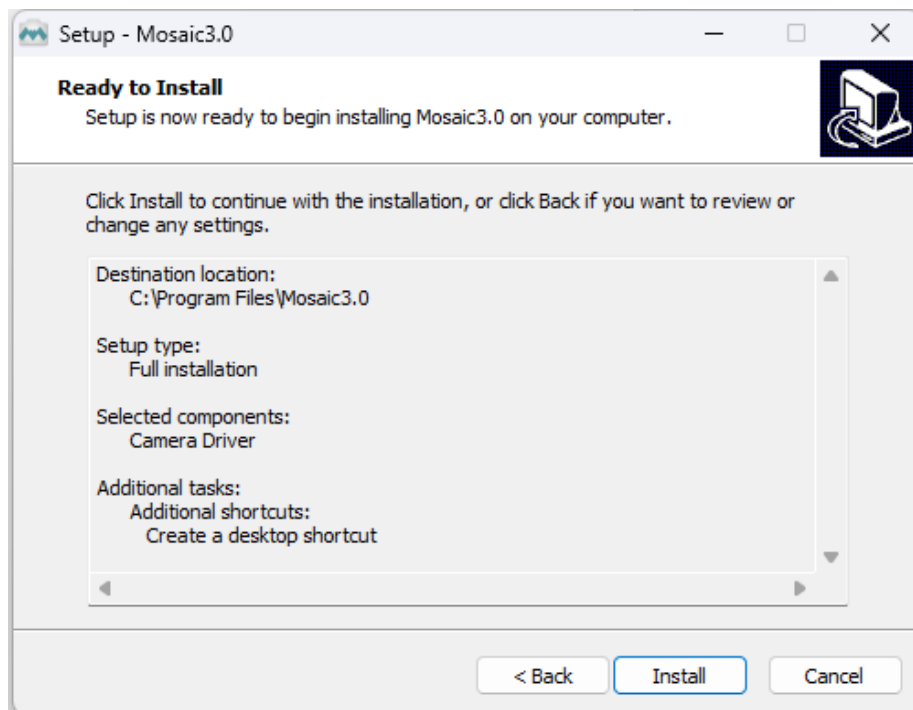


Figure 4-19

(6) Waiting for installation to complete;

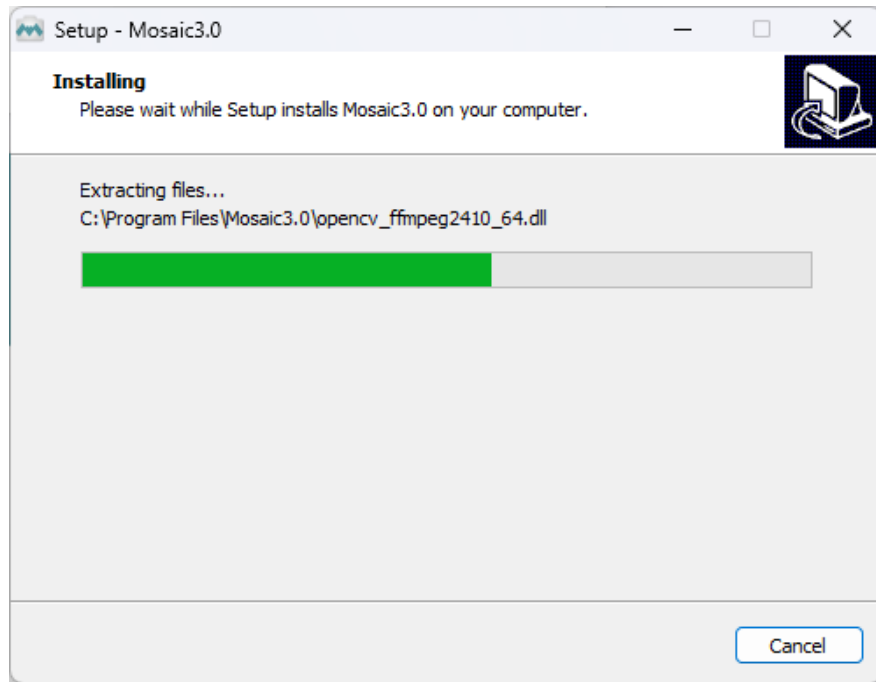


Figure 4-20

4.6.2. Uninstallation

There are three ways to uninstall Mosaic software:

- (1) By uninstalling through the installation package, the existing version on the computer will be uninstalled when the installation package runs, and the default C drive path will take effect;

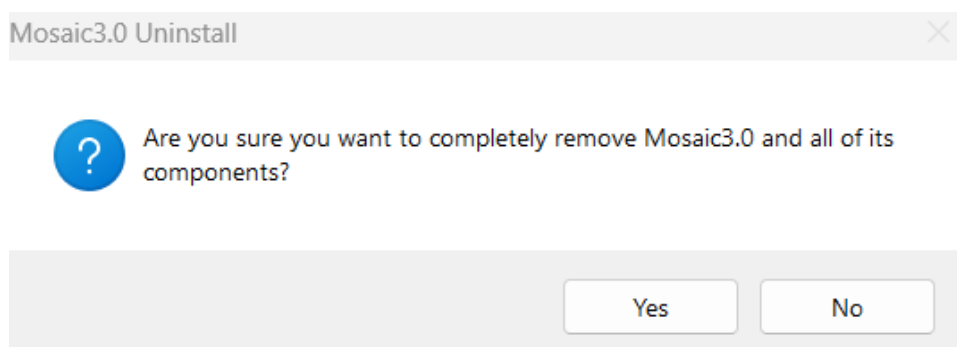


Figure 4-21 Uninstalling through installation package

- (2) Under the installation path, find ununs000.exe to uninstall, double-click uninstall;

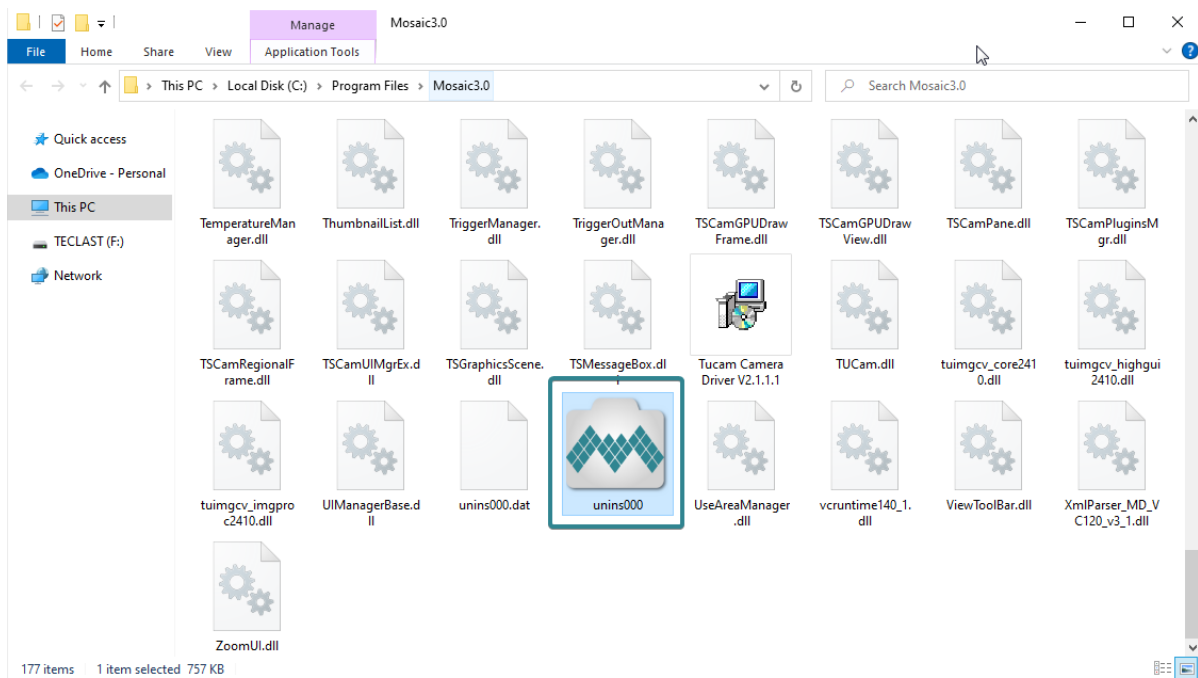


Figure 4-22

(3) Uninstall from the computer program management interface;

Note:

After uninstalling and reinstalling the software, all software configuration information and calibration table data will be deleted.

5. Maintenance

Damage caused by unauthorized maintenance or procedures will void the warranty.

5.1. Regular inspections

The product status should be regularly checked, especially the integrity of the external power supply and main cable, as well as the integrity of the power cord. Do not use damaged equipment.

5.2. Electrical safety inspection

- It is recommended to check the insulation and protective grounding integrity of the AC/DC converter every year
- Do not use damaged equipment

5.3. Cooling hoses and connectors

Users should regularly check all coolant hoses and connections for signs of leakage, damage, or wear. All seals must be intact before the camera system can be turned on, and any worn or damaged components must be replaced immediately.

5.4. Basic usage

- (1) Avoid opening the lens dust cover in dusty environments;
- (2) When opening the lens dust cover and installing the lens, keep the camera mouth facing downwards to prevent dust from falling on the surface of the windows;
- (3) When not in use for a long time, please keep the dust cover installed.

5.5. Window cleaning

When stains or spots are found in the images captured by the camera, please rule out whether the surface of the lens/microscope/objective at the camera interface is dirty.

If none of the above are true, it is certain that the camera itself brought it, and the window cleaning can be carried out according to the following steps:

- 1) Priority is given to the use of air blowing, the use of ear washing ball or air blowing off the general dust; together with the brush can remove most of the dust;

- 2) For stubborn oily dust, you need to prepare dust-free cotton swabs (or special mirror paper, non-woven fabric, etc.) and special tools such as anhydrous ethanol;
- 3) Use dust-free cotton swabs dipped in an appropriate amount of anhydrous ethanol to wipe along the surface of the window film, do not use too much force when wiping, and always in one direction, avoid back and forth wipe;
- 4) After wiping, use air blowers and other items to let the alcohol evaporate completely before continuing to use the window surface.

Note:

- 1) If you cannot guarantee to complete the cleaning steps independently or do not have the required items, please be sure to contact us;*
- 2) If the dirt still exists after following the above steps, try wiping again by following the above steps. If this does not solve the problem, consider that the chip is internally dirty. Please be sure to contact us at this time.*

6. Troubleshooting

6.1. The computer cannot recognize the camera

- 1) Confirm that the camera is powered on and turned on normally;
- 2) Confirm that the camera is connected to the computer normally;
 - ① Confirm the connection sequence of the two cables through CameraLink connection;
 - ② USB connection, please use the USB 3.0 interface on the backend of the desktop computer;
- 3) Confirm that the driver is working properly and check if the image device recognizes the camera in the computer device manager.

6.2. Software pauses or freezes

- 1) The computer may have turned on the energy-saving mode, the system CPU performance is reduced, resulting in the software can not work properly, there are dropped frames or software jamming and so on. You can check to ensure that the computer is in high-performance mode.
- 2) The computer has opened too many applications, resulting in the computer CPU occupation is too high, the software CPU utilisation is low and can not work properly. Can close the redundant applications.
- 3) Abnormal data cable connection, when the data cable is loose, or extended by the transfer too long will also lead to abnormal software connection, can not work properly.

6.3. The camera cannot reach the target cooling temperature

- 1) Confirm the ambient temperature, the maximum cooling temperature difference of the camera is -45 °C (water-cooled);
- 2) Confirm if the air outlet is blocked;
- 3) Confirm whether the fan rotates normally;
- 4) If water-cooling is used, make sure that the water-cooling cycle is functioning properly.

6.4. The frame rate cannot reach the nominal level

- 1) Confirm whether the exposure time affects the frame rate, and set the minimum exposure

time to confirm the frame rate;

2) The frame rate in the table is the measured frame rate under ideal bandwidth, and the actual frame rate in the usage scenario will be affected by data transmission, which is related to the type of data interface used and the length of the transmission line;

3) Confirm that you are using the correct data transfer interface, USB requires a USB 3.0 interface, if you use a non-3.0 interface, the frame rate may not reach the nominal frame rate;

4) If you are using the USB3.0 interface but have switched to HUB/extension/expansion operations, it will also result in the inability to achieve the nominal frame rate;

5) If the frame rate cannot reach the nominal value using the CameraLink interface, it is necessary to check whether the bandwidth of the grabber card is limited/whether the recommended grabber card interface is used.

7. FAQs

7.1. Why is the brightness of the captured image inconsistent with the preview window?

When using the camera for the first time and the target is dark, the software preview may show an all-black image. It is recommended to check Auto Left Scale (Auto Min) and Auto Right Scale((Auto Max) in the Histogram setting area, in which case the software preview will show the most suitable brightness and contrast. However, when you save the image, the default image saved by the software will not save the effect of auto colour gradation, resulting in inconsistency between the preview image and the captured image.

You can try the following solutions:

- 1) Disable the automatic colour gradation function of the software, the preview image will be consistent with the saved image;
- 2) Use professional image viewing tools such as ImageJ to open the tif image and adjust the colour gradation.
- 3) Use Mosaic V3 software to tick "Save the Adjusted Image" in the Capture section (can be used when you don't need the original image data value).

7.2. Stripe like flicker appears in the camera preview image

May be caused by an unsynchronised external light source. There may be a strobe light source in the environment, which can be judged by extending the exposure time. If it is an ambient light source, switching off the illumination source is sufficient. If from an irradiated sample light source, a regulated light source is required for illumination.

8. After-sales Support

1) Log in to the official website, click on the [Technical Support] module, and get answers to common questions.

2) Warranty:

- The quality assurance period starts from the date of shipment and lasts for a total of 24 months. During this period, any damage that meets the warranty requirements will be repaired free of charge;
- The warranty scope is limited to defects in product materials and manufacturing. Damage caused by self disassembly, water ingress, littering, or natural disasters is not covered by the warranty.

3) Contact professionals for technical support:

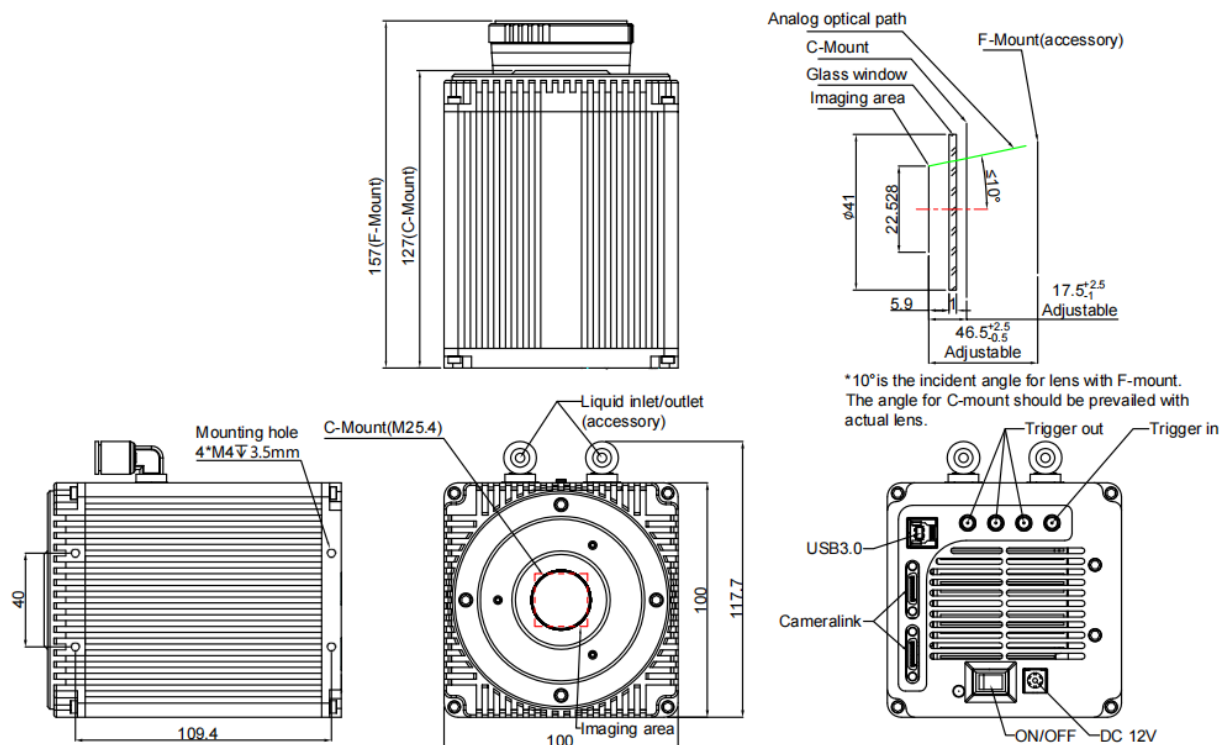
- TEL: +86-591-28055080-818
- Email: service@tucsen.com
- Visiting the official website to leave a message: <http://www.tucsen.com>

4) Please prepare the following information in advance:

- Camera model and S/N (product serial number);
- Software version number and computer system information;
- Description of the problem and any related images.

Appendix 1 : Dimensions

Unit: mm, Diameter: ϕ .



Appendix 2 : Specifications

Camera

Model	Dhyana 95 V2
Sensor Type	BSI sCMOS
Sensor Model	Gpixel GSENSE400BSI
Peak QE	95% @ 560 nm
Color / Mono	Mono
Array Diagonal	31.9 mm
Effective Area	22.5 mm x 22.5 mm
Resolution	2048 (H) x 2048 (V)
Pixel Size	11 μm x 11 μm
Full-Well Capacity	Typ.: 80 ke- @ HDR, 100 ke- @ STD
Dynamic Range	Typ.: 90 dB
Frame Rate	48 fps
Readout Noise	24 fps @ 16 bit HDR, 48 fps @ 12 bit STD
Shutter Type	Rolling
Exposure Time	21 μs ~ 10 s
DSNU	0.2 e-
PRNU	0.3 %
Cooling Method	Air , Liquid
Max. Cooling	45 °C below ambient (Liquid)
Dark Current	0.6 e-/pixel/s @-10°C
Binning	2 x 2, 4 x 4
ROI	Support
Timestamp Accuracy	1 μs
Trigger Mode	Hardware , Software
Output Trigger	Exposure start, Global, Readout end, High level, Low level , Trigger

Signals	ready
Trigger Interface	SMA
Data Interface	USB 3.0, CameraLink
Bit Depth	12 bit, 16 bit
Optical Interface	C-mount / F-mount
Power Supply	12 V / 8 A
Power Consumption	60 W
Dimensions	C-mount: 100 mm x 118 mm x 127 mm F-mount: 100 mm x 118 mm x 157 mm
Weight	1613 g
Software	Mosaic, SamplePro, LabVIEW, MATLAB, Micro-Manager2.0
SDK	C, C++, C#, Python
Operating System	Windows, Linux
Operating Environment	Temperature 0~40°C, Humidity 10~85%

Frame grabber

Brand	Active Silicon
Model	AS-FBD-1XCLD-2PE4-M
Operating System	Windows、Linux
Bus	PCIe 2x4, supports 2GB/s transfer from motherboard to computer
Transmission Speed	1.7 GB/s
Format	Half length PCI Express

Note: The parameters in this table are typical values and are subject to change without notice.

Appendix 3 : Third party software applications

Provide plugins for calling third-party software (LabVIEW, Matlab, Micro-Manager, etc.), please click on the link to download the configuration: [Tucsen camera software download – Tucsen](#)

Appendix 4 : Third party certification





Certificate of Compliance

Certificate No. : FQII-DZ-22011

Certificate Holder : FUZHOU TUCSEN PHOTONICS CO.,LTD

Address : 5# building, Wanwushe Smart Industrial Park , No.2 Yangqi Branch Rd,
Gaishan Town, Cangshan Area, Fuzhou, Fujian, PRC

Product Description : Scientific Camera

Model Reference : Dhyana 95V2

Brand Name : TUCSEN

Report No. : (2022) DZ10076

Standard/Directive :
EC Electromagnetic Compatibility Directive 2014/30/EU
EN 55032: 2015+A11:2020+A1:2020 , EN 55035: 2017+A11:2020 ,
EN IEC 61000-3-2:2019+A1:2021 , EN 61000-3-3:2013+A1:2019+A2:2021

This certificate applies specifically to the sample investigated in our test report number only. The test results apply only to the particular sample tested and to the specific tests carried out.

The CE marking can be affixed on the product after preparation of necessary conformity documentation.

CE


 Authorized Signatory
 Date of Issue : Nov. 24, 2022

FUJIAN INSPECTION AND RESEARCH INSTITUTE FOR PRODUCT QUALITY
No.:121 Shantoujiao, West Yangqiao Road, Fuzhou, Fujian, P.R.China

Appendix 5 : Dew point table

		Humidity							
		20%	30%	40%	50%	60%	70%	80%	90%
Temperature	5							1.8	3.5
	6							2.8	4.5
	7						1.9	3.8	5.5
	8						2.9	4.8	6.5
	9					1.6	3.8	5.7	7.4
	10					2.6	4.8	6.7	8.4
	11					3.5	5.7	7.7	9.4
	12				1.9	4.5	6.7	8.7	10.4
	13				2.8	5.4	7.7	9.6	11.4
	14				3.7	6.4	8.6	10.6	12.4
	15			1.5	4.7	7.3	9.6	11.6	13.4
	16			2.4	5.6	8.2	10.5	12.6	14.4
	17			3.3	6.5	9.2	11.5	13.5	15.3
	18			4.2	7.4	10.1	12.4	14.5	16.3
	19		1.0	5.1	8.4	11.1	13.4	16.4	18.3
	20		1.9	6.0	9.3	12.0	14.4	16.4	18.3
	21		2.8	6.9	10.2	12.9	15.3	17.4	19.3
	22		3.6	7.8	11.0	13.9	16.3	18.4	20.3
	23		4.5	8.7	12.0	14.8	17.2	19.4	21.3
	24		5.4	9.6	12.9	15.8	18.2	20.3	22.3
	25	0.5	6.2	10.5	13.9	16.7	19.1	21.3	23.2
	26	1.3	7.1	11.4	14.8	17.6	20.1	22.3	24.2
	27	2.1	8.0	12.3	15.7	18.6	21.1	23.3	25.2
	28	3.0	8.8	13.2	16.6	19.5	22.0	24.2	26.2
	29	3.8	9.7	14.0	17.5	20.4	23.0	25.2	27.2



Appendix 6 : Update log

Version	Date	Modified Content
V1.0.0	2024-2-26	Create this document.