



Camera Technology
Focused on Scientific Imaging
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FL 9BW 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
CMOS scientific grade camera	FL 9BW	1	
Power adapter	12V/6A	1	
Power adapter power cord	Three core 250V/2.5A	1	
USB 3.0 data cable	2 m	1	
USB flash drive	Software and Drivers	1	
Silver cross recessed pad screw (cross recessed head with pad screw)	M3*14 mm	2	
Hexagon socket cap screw	M3*6+3 mm; Diameter of opposite side: Φ 4.7 mm	2	

2.2. Quantum efficiency curve

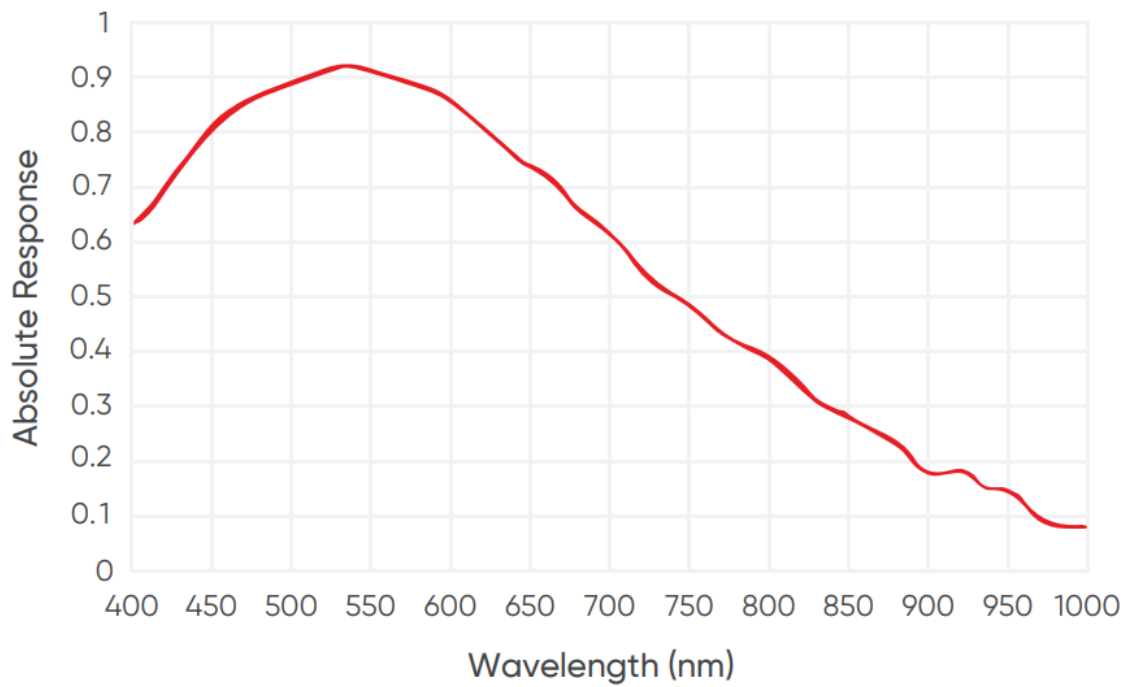


Figure 2-1 Quantum efficiency curve of FL 9BW

2.3. Window curve

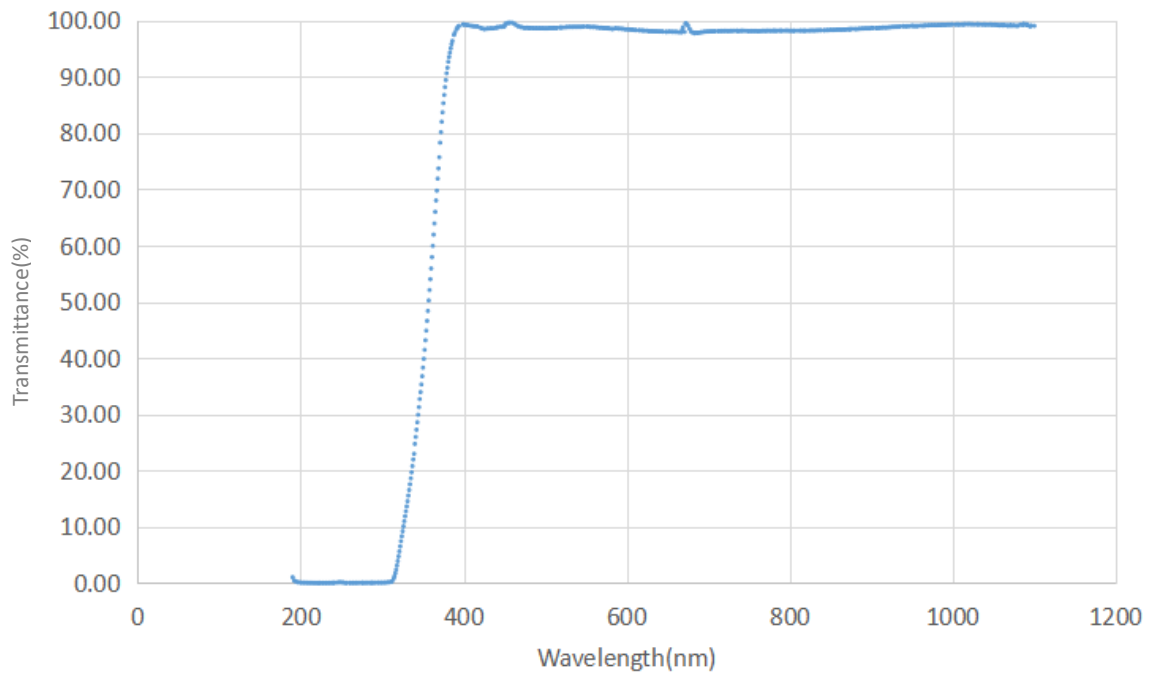


Figure 2-2 Transmission curve of a standard glass window

2.4. Camera power and signal connection

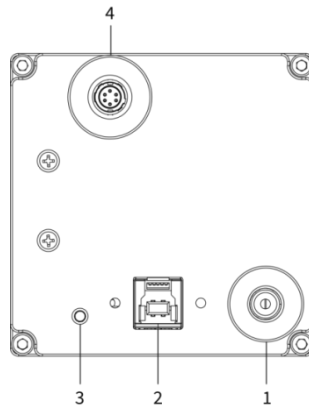
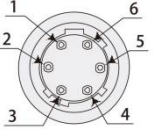


Figure 2-3 Camera interface diagram

No.	Name	Fuction
1	DC12V	Power interface
2	USB 3.0 interface	Camera data transfer
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	External trigger interface	External Trigger Input and Output: Hirose-6-pin trigger interface , Model: HR10A-7R-6PB(73):  Pin1: Trigger In, Pin2, Pin3: GND, Pin4: Exposure Start Default corresponds to Port3 of the software Pin5: Readout End Default corresponds to Port1 of the software Pin6: Global Exposure Default corresponds to Port2 of the software

***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 repowered before the indicator light will return to red.

3. Features and Functions

3.1. Camera Introduction

FL 9BW is Tucsen's new generation deep-cooled CMOS camera developed specifically for long exposure applications. It utilizes Sony's latest back-illuminated CMOS chip technology, offering high sensitivity and speed typical of modern CMOS sensors. Integrated with advanced Tucsen cooling and noise reduction technologies, it achieves dark current levels comparable to traditional CCDs, supporting exposures as long as 60 minutes. The camera employs advanced cooling sealing technology to ensure long-term stable operation and prevent condensation. With over 90% quantum efficiency, less than 1 e- readout noise, and excellent glare suppression capability, it maintains uniform backgrounds and precise quantitative analysis during extended exposures, comparable to traditional CCDs.

3.2. Structure and Operation of CMOS

Complementary Metal-Oxide-Semiconductor (CMOS) cameras have the advantages of low power consumption and fast readout, and they offer higher integration and better energy efficiency. CMOS cameras are widely used in medical imaging, microscopy, industrial inspection, and other fields. Due to their ease of integration, CMOS cameras exhibit flexibility and scalability across various applications.

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

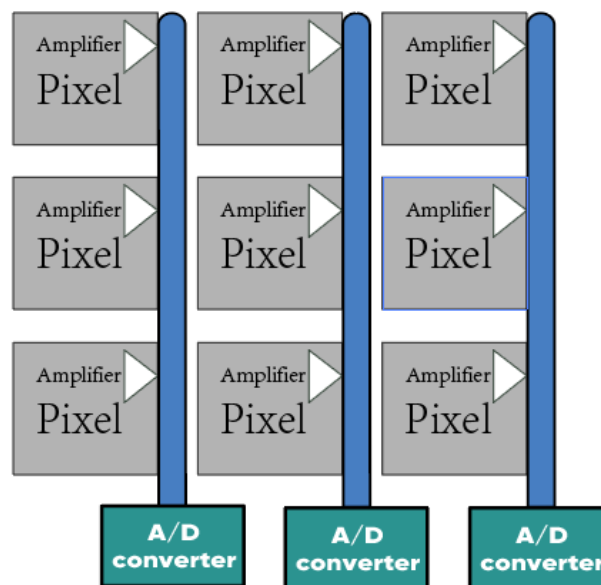


Figure 3-1 CMOS camera sensor structure

The charge on each image element of a CMOS sensor is first converted to a voltage signal by a transistor and then transferred to a row of A/D converter arrays for output via a column transfer line.

The operation process of an CMOS camera is as follows:

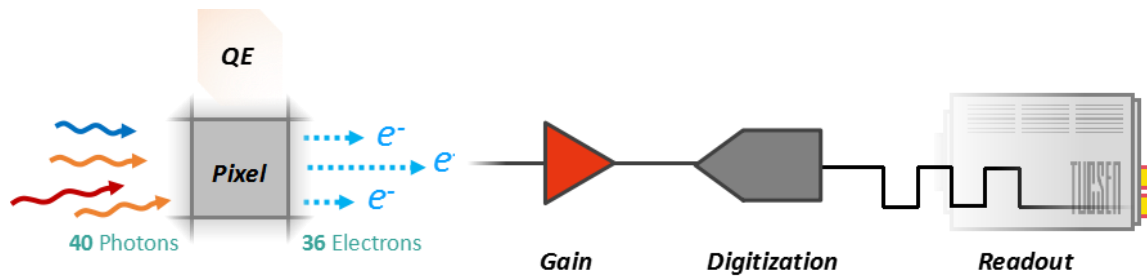


Figure 3-2 CMOS operation process

- 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 FL 9BW 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}).

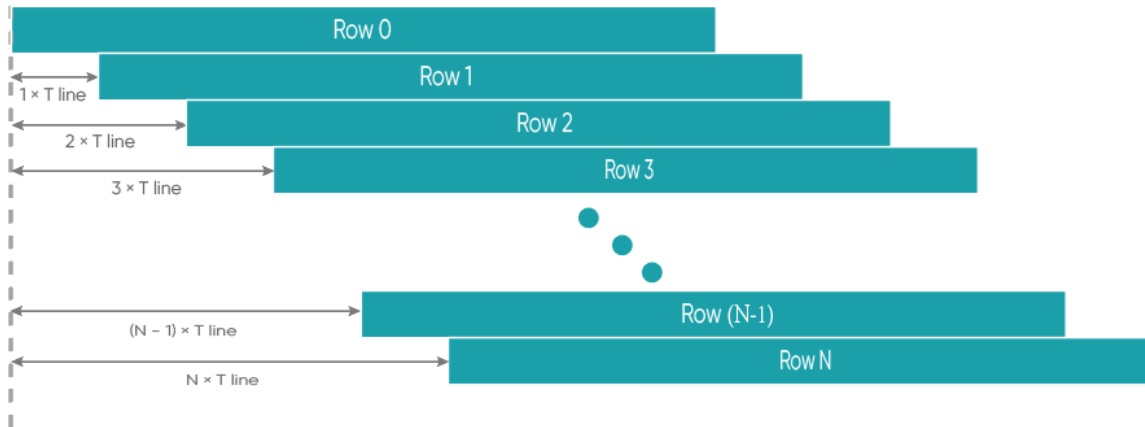


Figure 3-3 Rolling shutter diagram

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 CMOS Technology

Cameras based upon CMOS 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 FL 9BW camera adopts a back-illuminated chip, achieving a peak QE of around 92%.

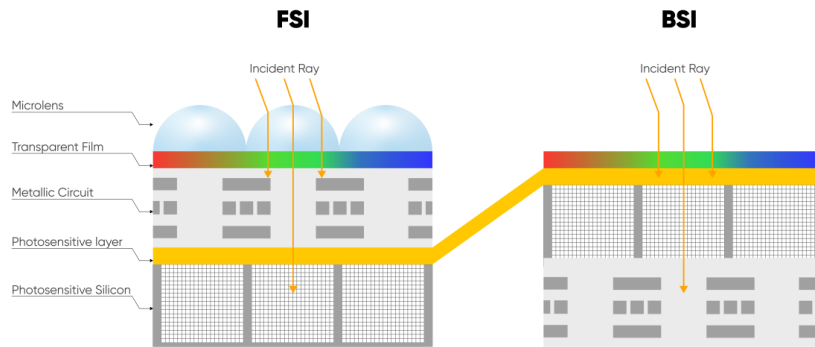


Figure 3-4 Front-Illuminated and Back-Illuminated diagram

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 CMOS corresponds to a different readout circuit, forming a distribution curve, shown in Figure 3-5. To illustrate the characteristics of this curve, CMOS 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 CMOS camera chip—having less impact on the median than on the RMS—median values are generally lower than RMS values.

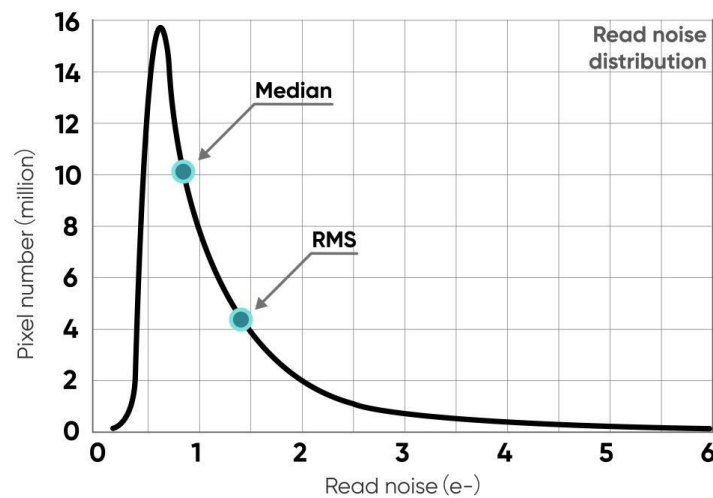


Figure 3-5 Readout noise distribution of a typical CMOS camera

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 CMOS 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 FL 9BW 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. Gain Mode

The FL 9BW camera has three gain modes: Low Noise (16Bit) mode, Low Noise (14Bit) mode and Standard mode. In each mode, there are four selectable gain values. Each mode has differences in line times and readout noise. Selecting the appropriate mode based on the actual scenario is essential to obtain high-quality imaging results. The Low Noise mode has a low noise level and, combined with deep cooling, is suitable for long exposure applications. The Standard mode has a shorter line cycle time, making it suitable for applications with slightly higher frame rate requirements.

Table 3-1 Typical gain mode parameter table*

Mode	Standard (14Bit)			
	Gain0	Gain1	Gain2	Gain3
Gain level	Gain0	Gain1	Gain2	Gain3
System gain (DN/e-)	0.32	0.98	2.0	4.9
Full-Well Capacity (e-)	48000	16000	7800	3100
Readout noise(e-)	3.0(Median)	1.1(Median)	0.95(Median)	0.8(Median)
	3.3(RMS)	1.3 (RMS)	1.1 (RMS)	0.9 (RMS)

Mode	Low Noise (14Bit) /Low Noise (16Bit)			
Gain level	Gain0	Gain1	Gain2	Gain3
System gain (DN/e-)	1.28(16bit)	3.92(16bit)	8.0(16bit)	19.6(16bit)
	0.32(14bit)	0.98(14bit)	2.0(14bit)	4.9(14bit)
Full-Well Capacity (e-)	48000	16000	7800	3100
Readout noise(e-)	2.5(Median)	1.0(Median)	0.85(Median)	0.75(Median)
	2.8(RMS)	1.1(RMS)	1.0(RMS)	0.8 (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.

3.8. 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.

Typical ROI area measured frame rate (fps) table for FL 9BW camera under USB 3.0 is as follows:

Table 3-2

Column (Pixel)	Row (Pixel)	Standard	Low Noise (14Bit/16Bit)
3000	3000	19	12
3000	2000	28	18
3000	1500	38	24
3000	1000	57	36
3000	500	114	70
3000	200	261	153
3000	100	435	256
3000	32	797	469

Note:

- 1) *The minimum supported ROI for FL 9BW on Mosaic V3 is 32 (columns) × 32(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.*

3.9. 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.

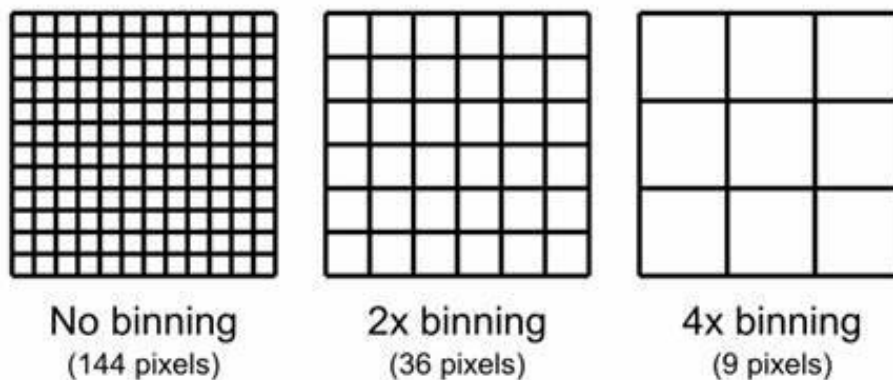


Figure 3-6 Schematic diagram of Binning

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:

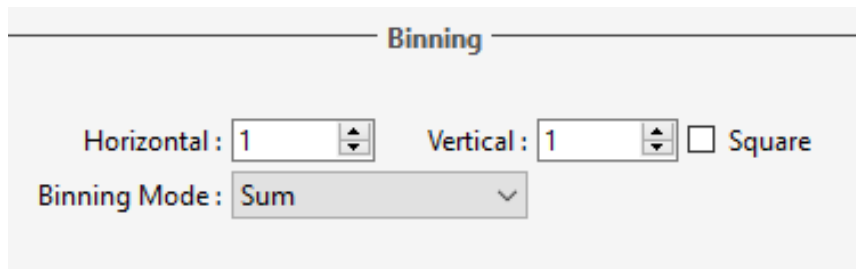


Figure 3-7

3.10. Timestamp

The camera accurately reads the start time of each frame with a time precision of 1 μ s. 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.

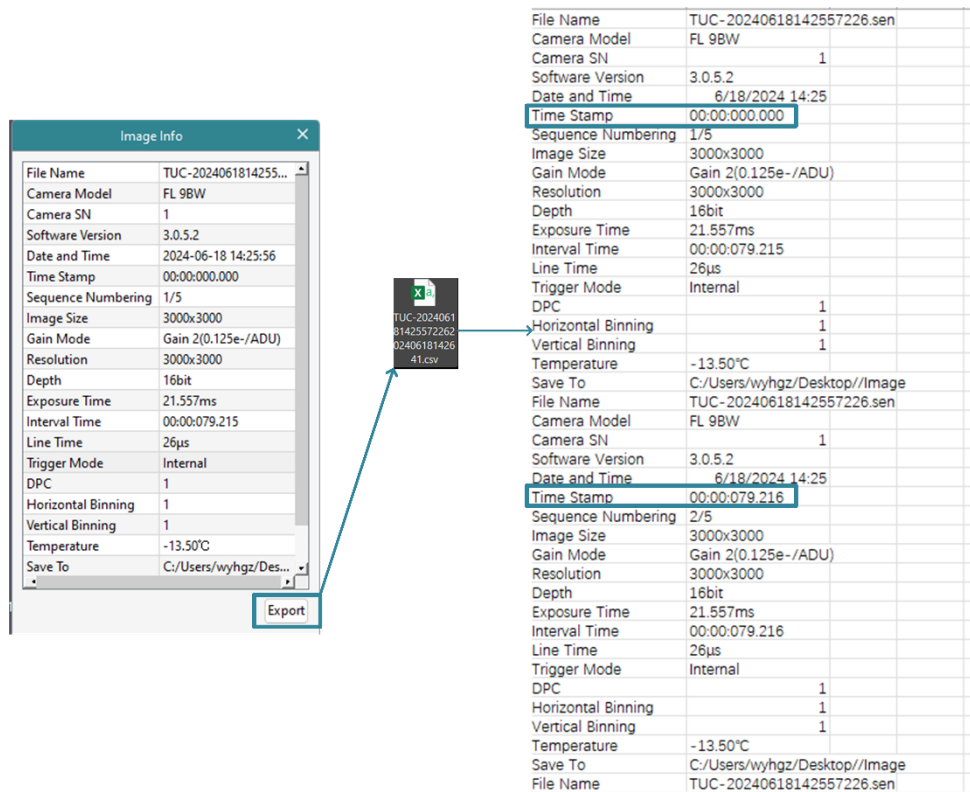


Figure 3-8 Timestamp export schematic

Note:

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

3.11. 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 with the following table.

Typical frame rate calculations for USB 3.0 (U3)

Hn: The number of rows selected horizontally;

Vn: The number of rows selected vertically;

T_{line}: Line time;

Y_{U3}: 19 fps (Maximum frame rate at full frame in U3)

Table 3-3 Calculation of frame rate for FL 9BW camera in USB3.0

Gain mode	Line time T _{line}	Calculation formula	Horizontal (Hn)	Vertical (Vn)	Frame rate (fps)
Standard	15.278 μs	$\min\{1/(Vn/3000/Y_{U3}) , 1/(T_{line}*(Vn+50))\}$	3000	3000	19.0
				2800	20.3
				2500	22.8
				2000	28.5
				1500	38.0
				1000	57.0
				500	114.0
Low Noise (14Bit/16Bit)	25.972 μs	$1/(T_{line}*(Vn+50))$	3000	3000	12.6
				2800	13.5
				2500	15.4
				2000	18.7
				1500	24.8
				1000	36.6
				500	70.0

Note:

- 1) The values in the frame rate table are calculated based on the minimum exposure time. When the set exposure time (T_{exp}) is greater than the readout time, the frame rate = 1/T_{exp} (s).
- 2) The above calculation formulas are for reference only. In Standard mode, the frame rate is influenced by both the sensor and bandwidth (U3 bandwidth is approximately 330M/s). The actual frame rate is determined by the minimum value calculated from the two formulas.
- 3) The frame rate is also affected by the computer system configuration. Additionally, to prevent frame loss, the actual frame rate may be lower than the calculated value.
- 4) In external trigger mode, there is a pre-exposure time of less than six line times inside the camera, so the external trigger frame rate will be slightly lower than in live mode. When using external trigger, the actual frame rate should be taken as the standard.

3.12. 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.

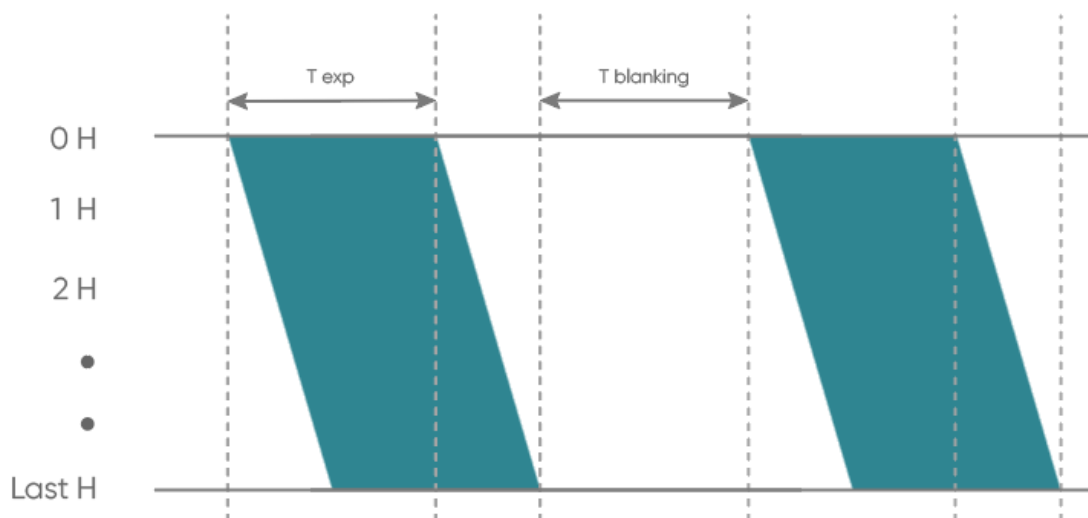


Figure 3-9 Frame rate adjustment timing diagram

3.13. 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 s the camera's background value in DN.

3.14. Acquisition Mode

3.14.1. 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.

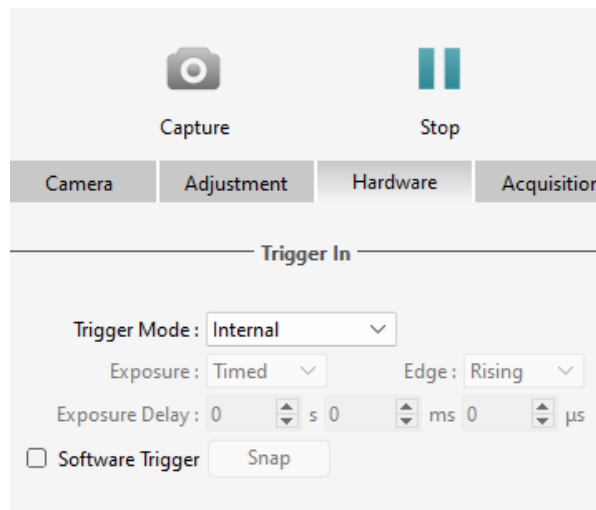


Figure 3-10

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.

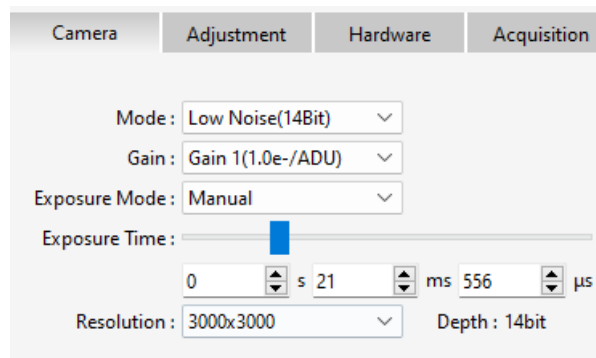


Figure 3-11

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.

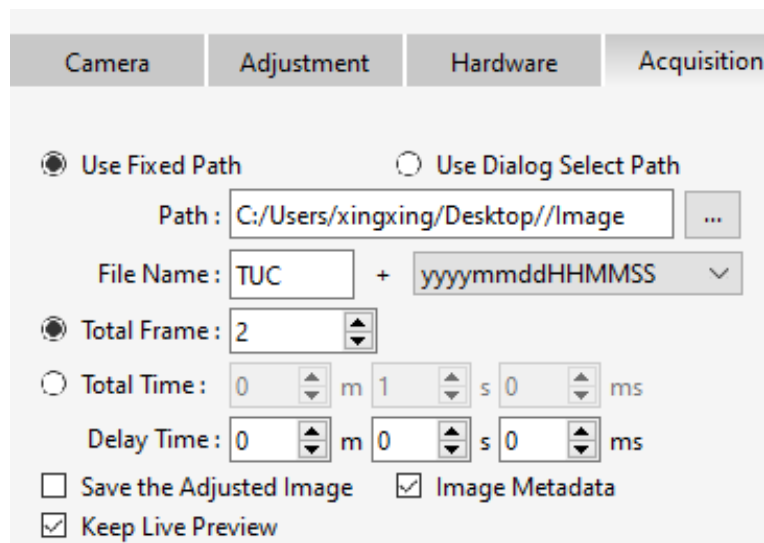


Figure 3-12

3.14.2. 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.

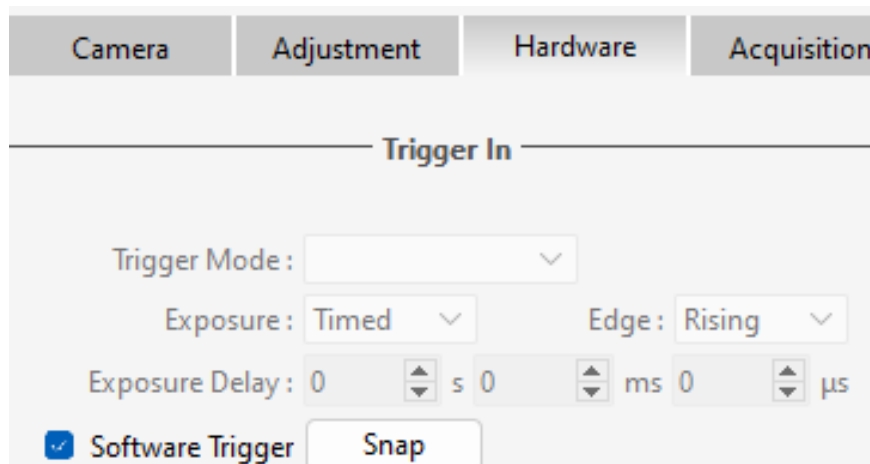


Figure 3-13

3.14.3. Hardware Trigger Mode

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

The Mosaic V3 software provides configurations such as mode, frames/signal, exposure, edge, exposure delay, etc., to control the number of triggered images captured continuously

according to the set quantity.

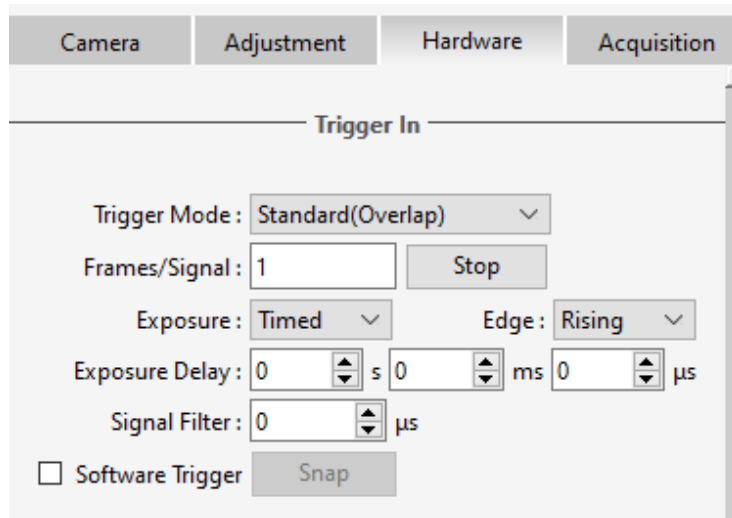


Figure 3-14

3.14.3.1. Hardware Trigger input circuit

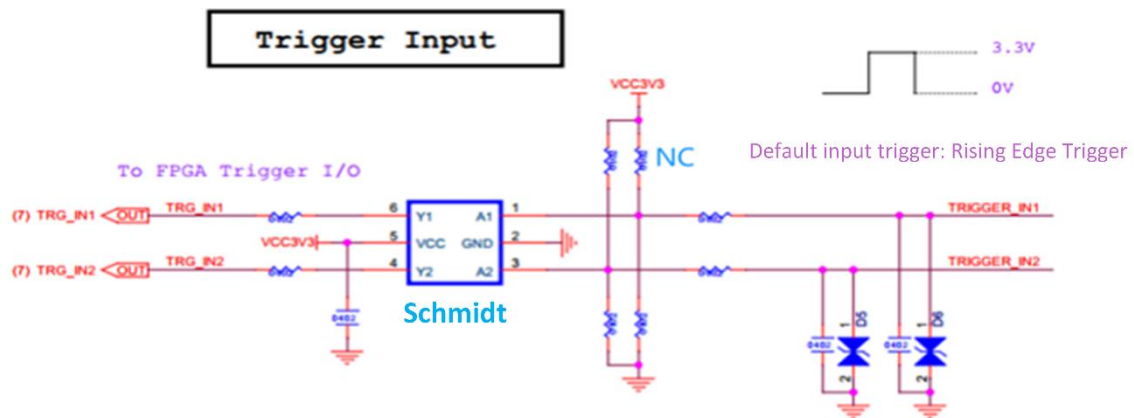


Figure 3-15 Hardware trigger input circuit

Note:

It is recommended that the external trigger input high voltage be 2.6 to 3.3 V, with a maximum not exceeding 5.0 V. Exceeding the maximum voltage limit may cause permanent damage. The recommended low voltage is < 0.6 V. The camera can recognize level signal pulse widths greater than 1 μs.

3.14.3.2. Trigger Delay and Jitter

As shown in the figure below, when the external trigger level signal arrives, there is a nanosecond-level delay T_{iso} as it passes through the hardware circuit. After this hardware circuit delay, there is an additional delay of 8 to 12 line times T_{logic} from when the camera receives the trigger signal to when the first row starts actual exposure. Therefore, the total

delay time from the external trigger input to the start of exposure is $T_{idelay} = T_{iso} + T_{logic}$.

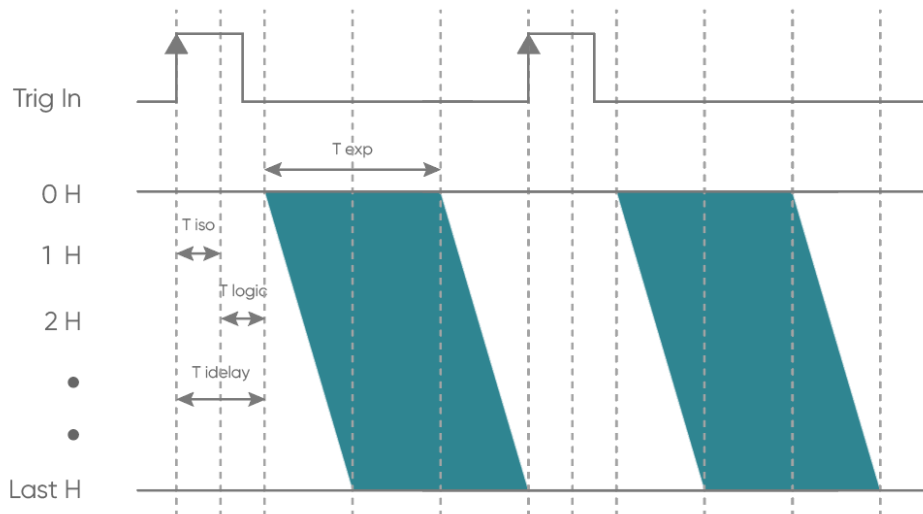


Figure 3-16 Schematic of trigger delay

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

3.14.3.3. Standard Trigger Mode

Standard 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.

Both of these modes support both level and edge triggering. 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.

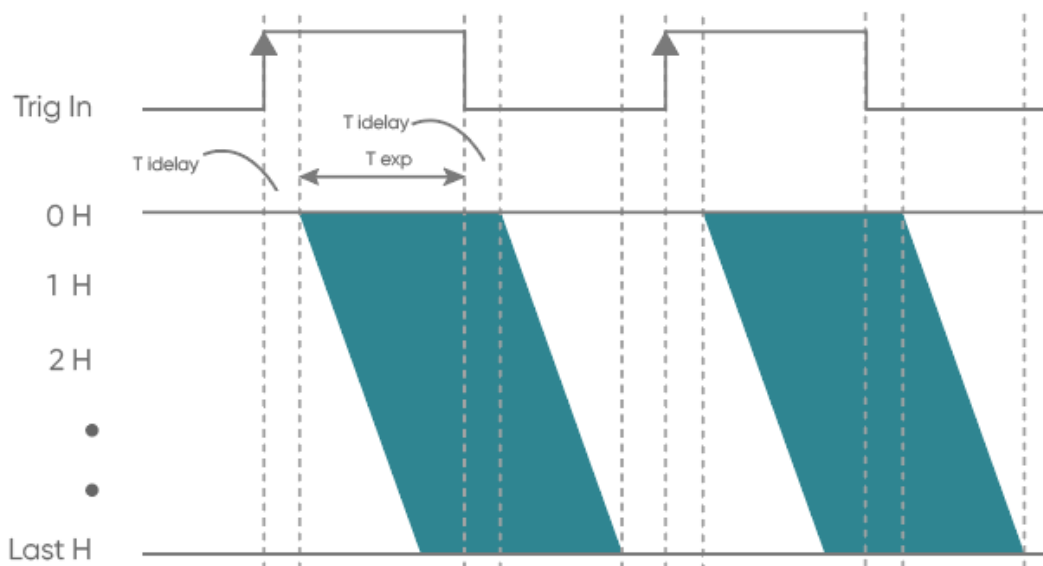


Figure 3-17 Level Trigger timing diagram

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.

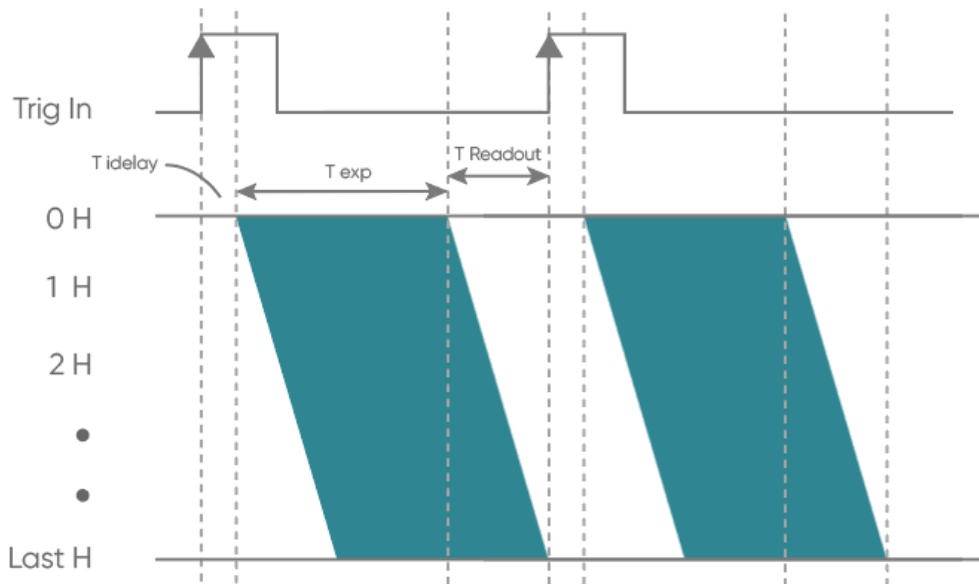


Figure 3-18 Edge Trigger timing diagram

FL 9BW 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 3-14), for example, by setting the number of 2, the triggering timing diagram is as follows:

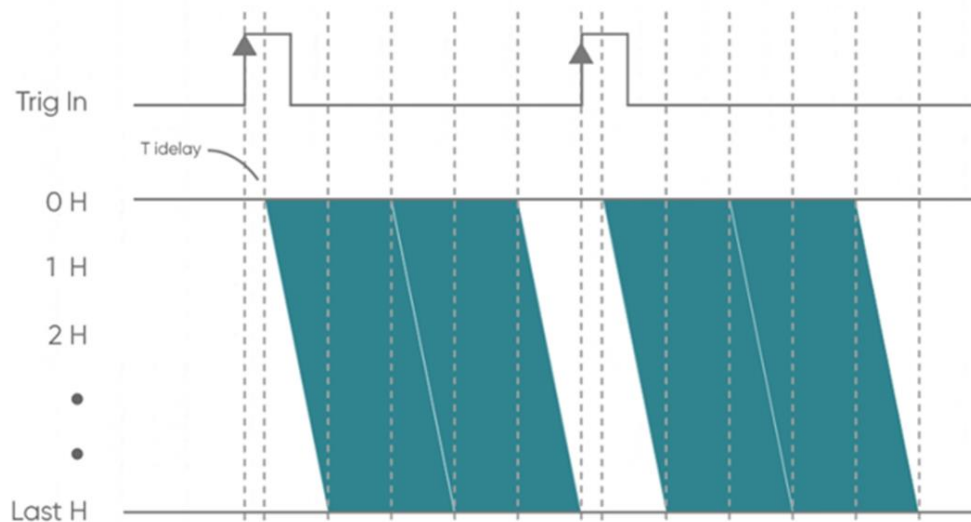


Figure 3-19 Single-trigger multi-frame acquisition timing diagram

3.15. Trigger Output

3.15.1. Hardware Trigger output circuit

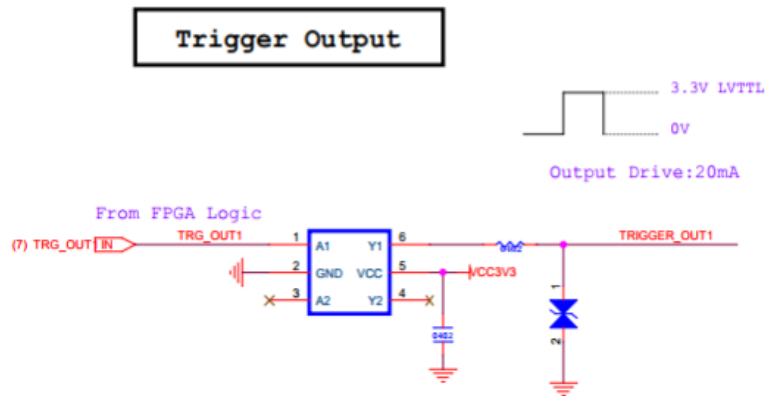


Figure 3-20

Note:

The camera's external trigger output level is a fixed value of 3.3 V, supporting a maximum drive current of 20 mA.

3.15.2. Trigger Output Timing Diagram

The camera uses a Hirose interface for trigger output, with the trigger output signal corresponding to pin 4, pin 5, and pin 6. It can output the following five types of signal timing.

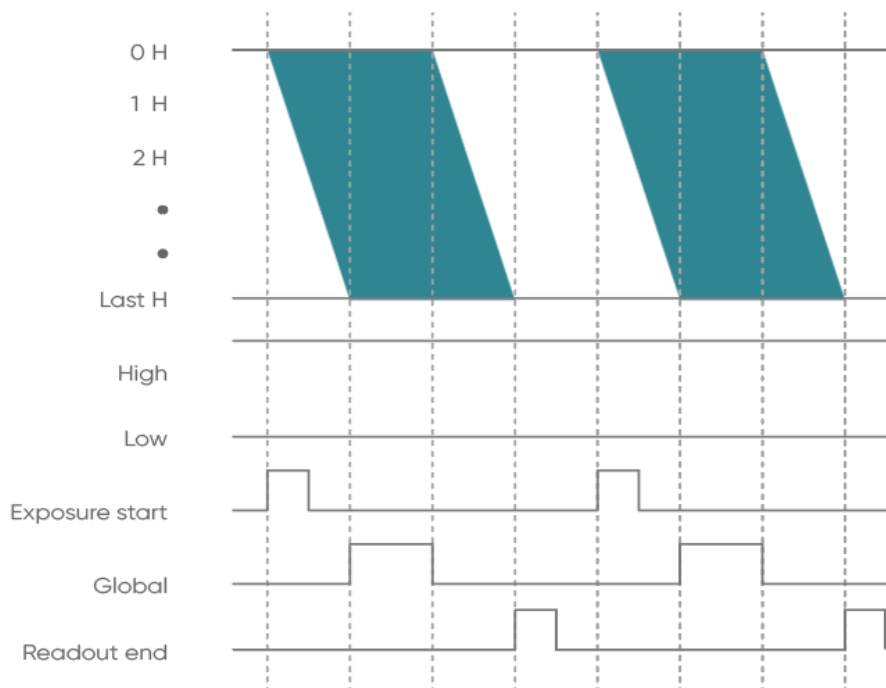


Figure 3-21 Trigger output timing diagram

- **High:** always output high level.
- **Low:** always output low 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 Pin4 correspond to Port3 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 Pin5 correspond to Port1 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 Pin6 correspond to Port2 by default.

3.16. 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. FL 9BW camera supports air cooling modes, the inlet and outlet vents are indicated as shown in the figure.

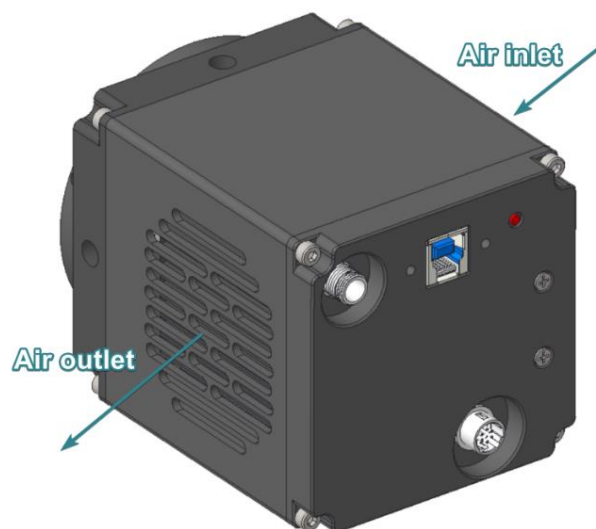


Figure 3-22 Schematic diagram of air inlet and outlet

If the camera is used in an environment with high temperatures and high humidity, the low

internal temperature due to cooling can cause water vapor to condense into fog, leading to condensation on the camera.

In applications with high environmental temperature and humidity (e.g., >70%), the FL 9BW will not condense if the temperature difference is within 50°C as the cooling temperature lowers (by default, -25°C will not cause condensation). If the temperature difference is between 50°C and 55°C, there is a low risk of condensation, and if the temperature difference exceeds 55°C, there is a high risk of condensation. (The recommended values above are influenced by actual environmental temperature and humidity and are for reference only.)

Note:

The camera's default temperature setting is -25°C. Users are allowed to set the temperature as low as -35°C, but when the temperature is set below -25°C, there will be a "risk of fogging" on the camera window. Users can prevent fogging by increasing the sensor cooling temperature or reducing the environmental humidity.

4. Installation

4.1. Camera installation

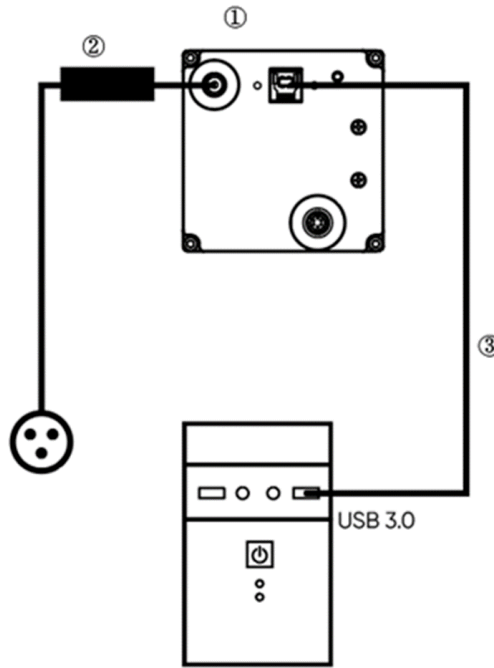


Figure 4-1 FL 9BW camera connection diagram

- ① FL 9BW camera
- ② Power adapter
- ③ USB 3.0 data cable

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 CMOS 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.*

4.1.1. 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;

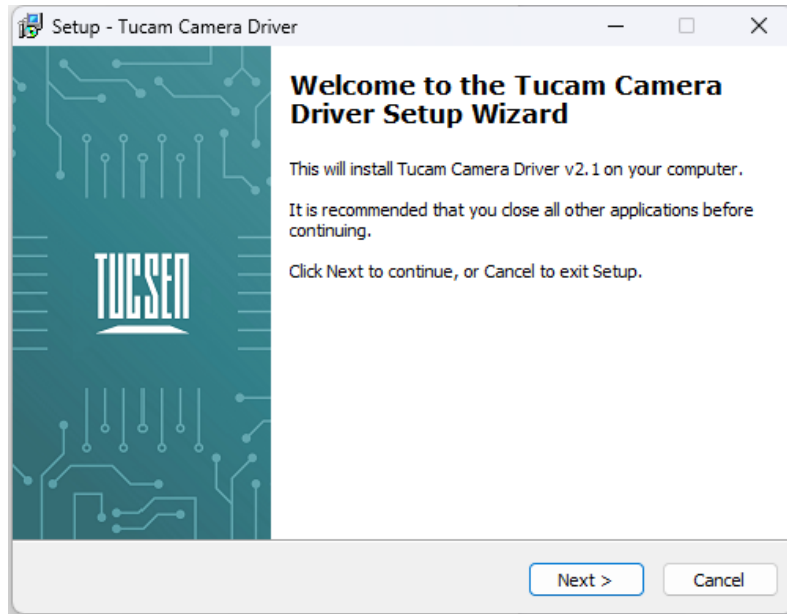


Figure 4-2

- (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;

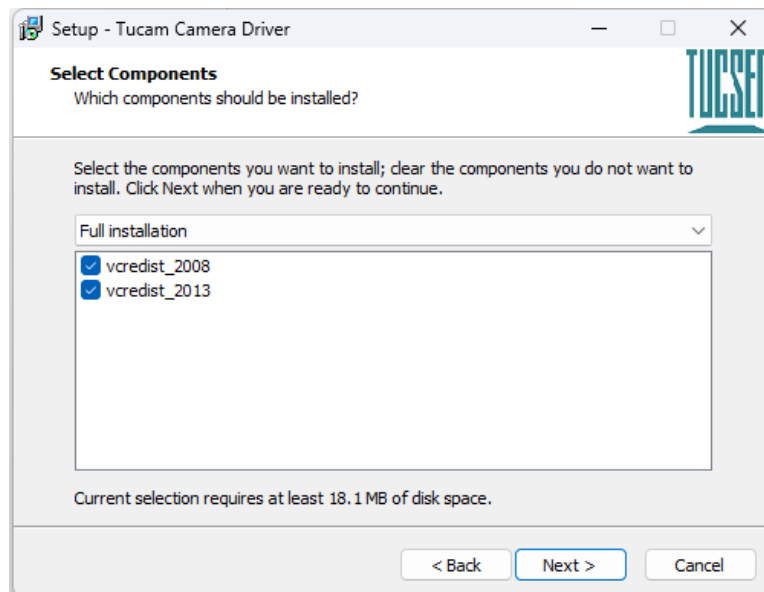


Figure 4-3

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

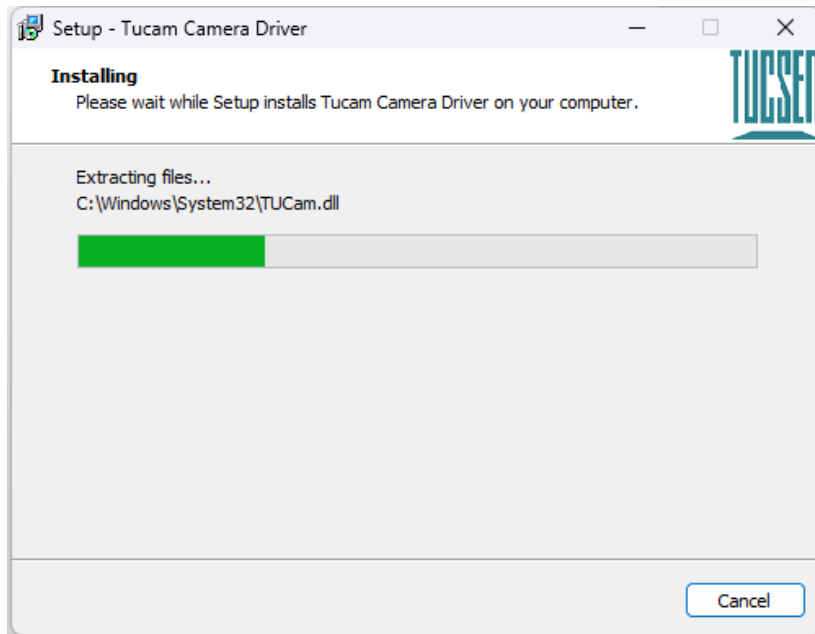


Figure 4-4

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

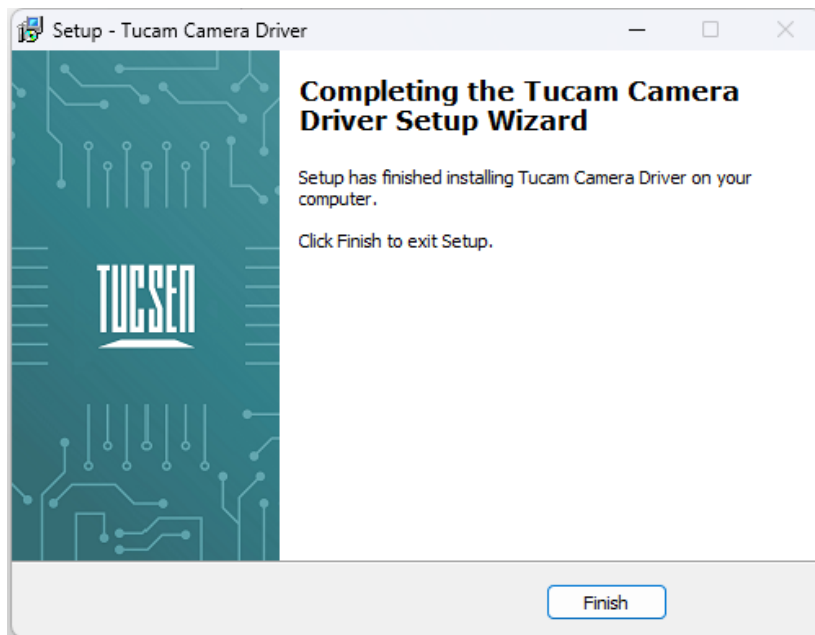


Figure 4-5

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 4-6 Device Manager Display

4.2. Software installation and uninstallation

4.2.1. 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;

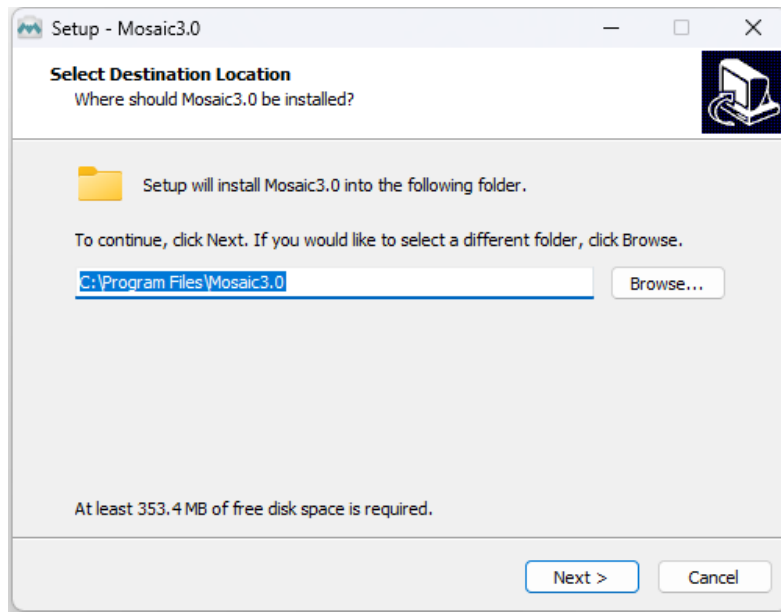


Figure 4-7

- (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;

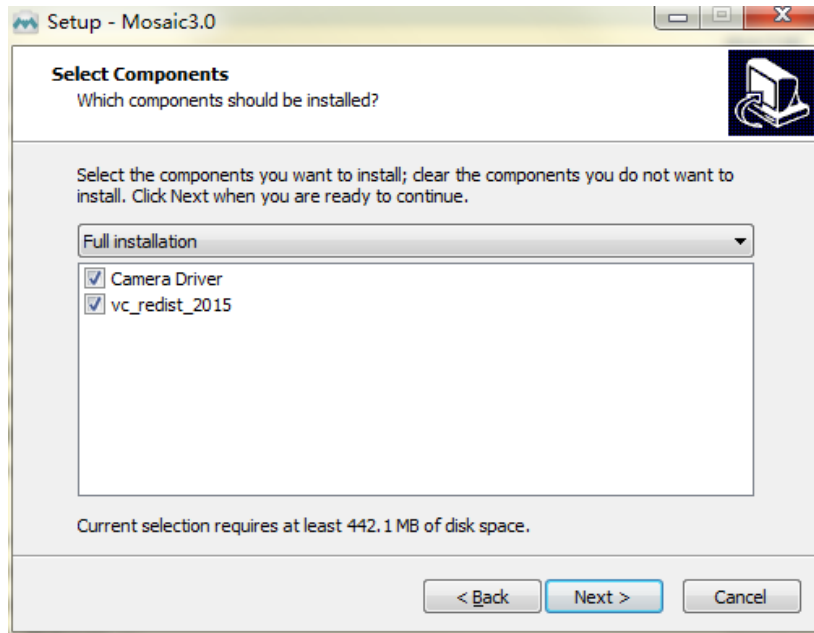


Figure 4-8

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

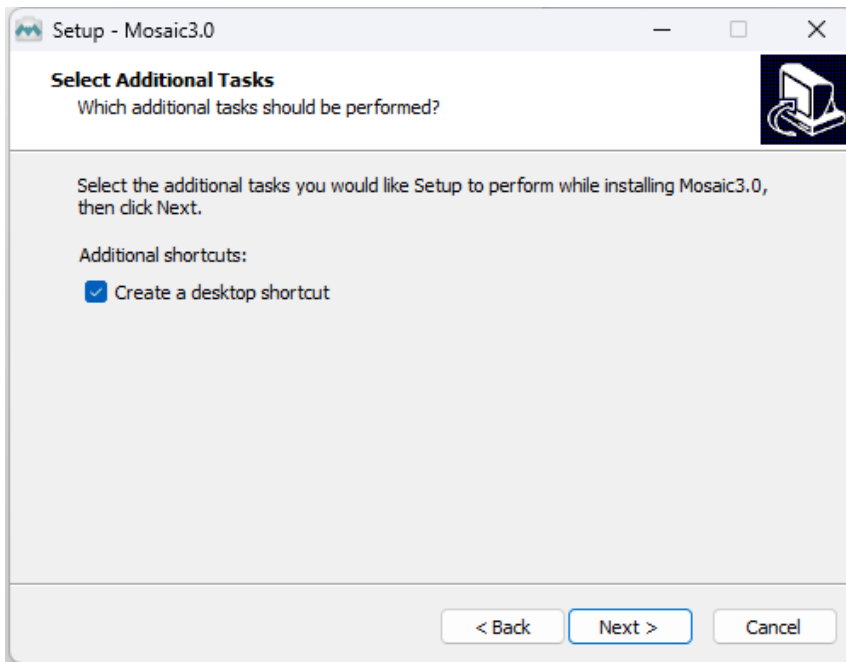


Figure 4-9

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

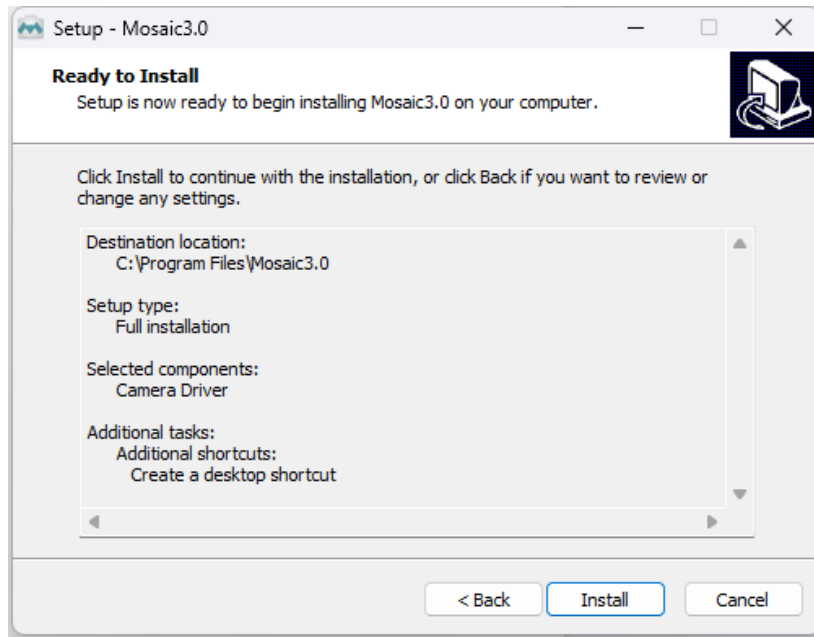


Figure 4-10

(6) Waiting for installation to complete;

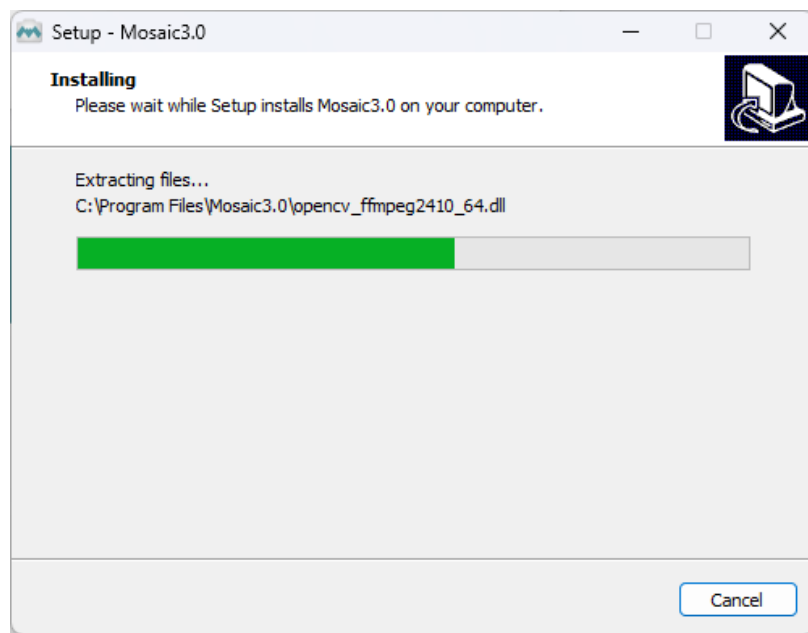


Figure 4-11

4.2.2. 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;

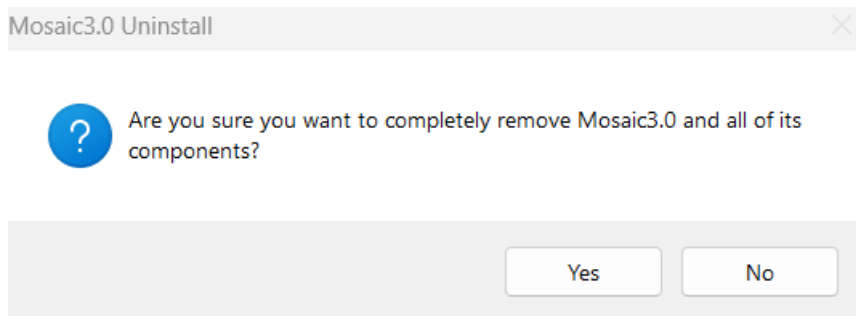


Figure 4-12 Uninstalling through installation package

(2) Under the installation path, find unins000.exe to uninstall, double-click uninstall;

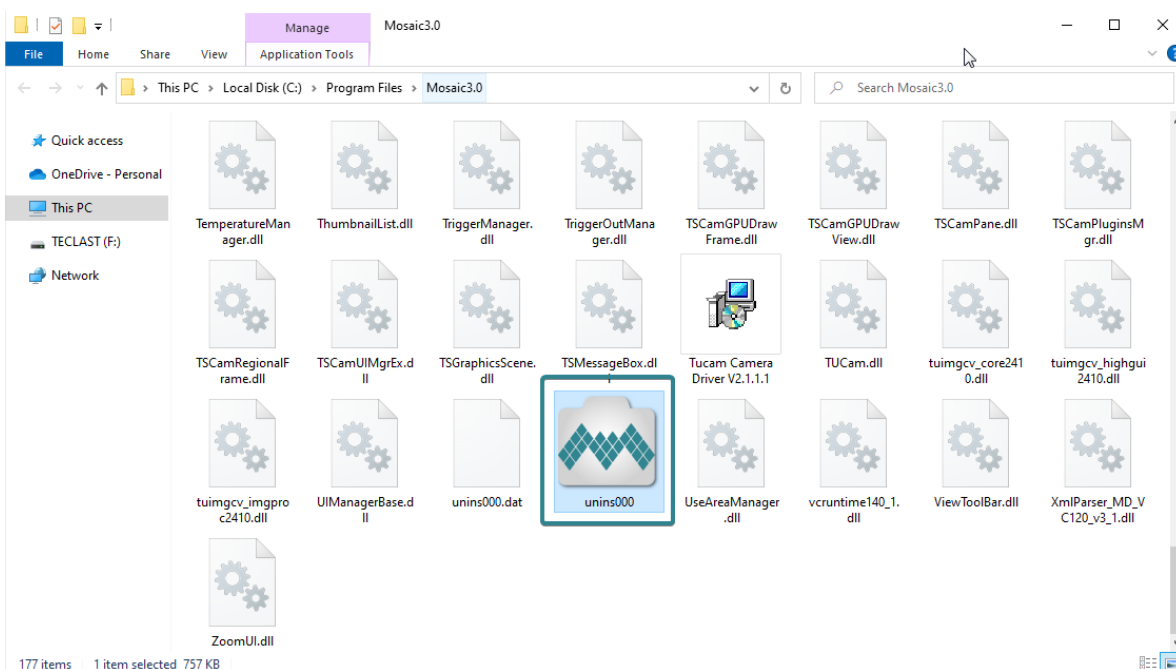


Figure 4-13

(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. 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.

5.4. 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;
- 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 ;
- 2) Confirm if the air outlet is blocked;
- 3) Confirm whether the fan rotates normally.

6.4. The frame rate cannot reach the nominal level

- 1) 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;
- 2) Confirm whether the exposure time affects the frame rate, and set the minimum exposure time to confirm the frame rate;
- 3) 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;

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;

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:

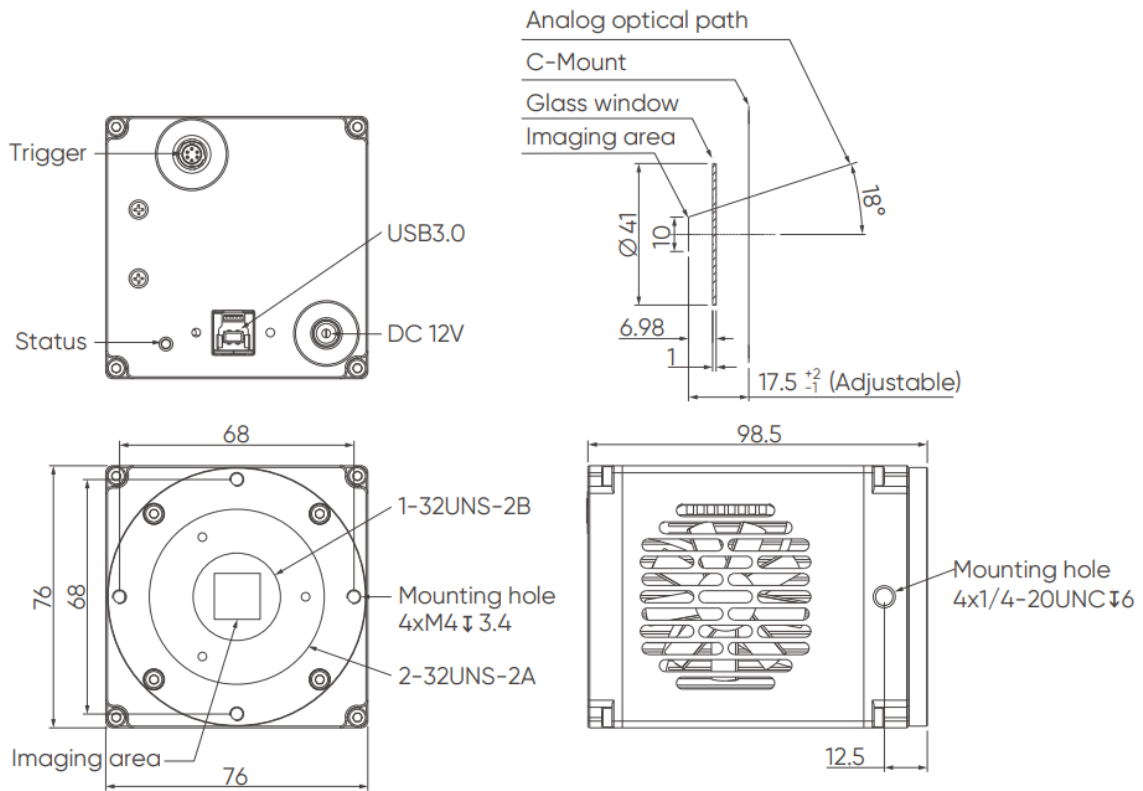
- TEL: +86-591-28055080-818
- Email: service@tucsen.com
- Visiting the official website to leave a message: <http://www.tucsen.com>

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

Model	FL 9BW
Sensor Type	BSI CMOS
Sensor Model	SONY IMX533CLK-D
Color / Mono	Mono
Array Diagonal	15.96 mm (1")
Effective Area	11.28 mm × 11.28 mm
Pixel Size	3.76 μm × 3.76 μm
Resolution	3000 × 3000, 9MP
Peak QE	92% @ 540 nm
Dark Current	<0.0005 e-/p/s
Gain Mode	Gain 0, Gain 1, Gain 2, Gain 3
Full-Well Capacity	48 ke- @ Gain0; 16 ke- @ Gain1; 7.8 ke- @ Gain2; 3.1 ke- @ Gain3;
Readout Noise	2.5 e- @ Gain0; 1.0 e- @ Gain1; 0.85 e- @ Gain2; 0.7 e- @ Gain3
Frame Rate	19 fps @ Standard Mode, 12fps @ Low Noise Mode
Shutter Type	Rolling
Exposure Time	15 μs ~ 60 min
Image Processing	DPC
ROI	Support
Binning	2 x 2 , 3 x 3 , 4 x 4 , 6 x 6 , 8 x 8 , 12 x 12 , 16 x 16 , 24 x 24

Cooling Method	Air
Max. Cooling	55 °C below ambient
Output Trigger Signals	Exposure start, Global, Readout end, High level, Low level
Trigger Interface	Hirose-6-Pin
Data Interface	USB 3.0
Optical Interface	C-mount, Support customization
Bit Depth	14 bit ,16 bit
Power Supply	12 V/6A
Power Consumption	≤ 46W
Dimensions	76 mm x 76 mm x 98.5 mm
Weight	835 g
Software	Mosaic V3 , SamplePro , LabVIEW , MATLAB , Micro-Manager2.0
SDK	C, C++, C#, Python
Operating System	Windows/Linux
Operating Environment	Operating: Temperature 0~40°C, Humidity 10~85% Storage: Temperature -10~60°C, Humidity 0~85%

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





Appendix 5 : Update log

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