Dhyana 9KTDI
User Manual

V1.3.3

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Catalogs

1. Preface

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Tucsen Photonics Co., Ltd.

1.2. Cautions

Proper Usage and Precautions

Caution

- Never attempt to drop, disassemble, repair, or replace internal components on your own. This could cause irreparable damage to the camera or pose a risk of electric shock.
- If any liquids such as water, beverages, or chemicals make contact with the equipment, immediately stop using it and seek technical assistance from the nearest distributor or manufacturer.
- Avoid touching the device with wet hands to prevent electric shock.
- Supervision is essential when children are around the equipment. Do not allow them to touch it unattended.
- Ensure that the camera is used within the specified temperature range. Exposure to extreme temperatures may cause damage to the equipment.

Installation & Maintenance

Caution

- Avoid installing the camera in dusty or dirty areas, or near air conditioners or heaters to minimize the risk of damage.
- Do not operate in extreme environments where there is vibration, extreme temperatures, high humidity, dust, strong magnetic fields, explosive/corrosive gases, or other harmful substances.
- Minimize exposure to excessive vibration and shock as this may cause damage to the equipment.
- Ensure stable lighting conditions when installing the equipment to avoid impacting the quality of the images captured.
- Avoid using solvents or thinners to clean the surface of the equipment as this may damage the housing material.
- Please ensure that there is at least a 20cm gap around the vents to allow proper airflow. Blocking the vents may cause overheating

	and damage to the unit.

Power Supply

 **Caution**	● Please use the original power adapter provided with the camera. Using a mismatched power supply may cause damage to the camera. ● If the voltage applied to the camera is higher or lower than the rated voltage, it may result in damage to the camera or cause it to malfunction. ● Please refer to the specification sheet included with the camera for the rated voltage.

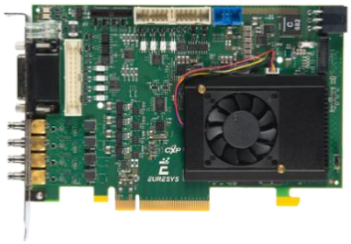
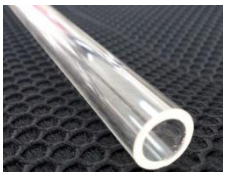
2. Product Specifications

This section will introduce the specifications of the Dhyana 9KTDI camera, including the packing list, camera overview, chip characteristics, interface functions, and accessory list.

2.1. Package List

Items	Specification/ Model	QTY	Pictures
TDI Camera	Dhyana 9KTDI	1	
Power cables	DC12V/HR-10A-6P-PB	1	
USB Flash disk	Included Software & Drivers	1	

Optional Items	Specification/ Model	QTY	Pictures
M72 to F-port adapter	M72x1	1	

CoaXPress frame grabber	Euresys /KAYA / Matrox	1	
CoaXPress cable	3m	4	
External trigger cable	HR10A-7P-4P	1	
water cooling tube	Length: 2m; Material: PU, transparent O.D: φ8mm, I.D: φ5mm pressure resistance 10 bar	2	

2.2. Introduction

The Dhyana 9KTDI is a high-speed TDI camera equipped with a back-illuminated, highly sensitive image sensor that is responsive to the UV band. The image element size is 5μm×5μm, offering a horizontal resolution of 9072 pixels. It supports up to 256 TDI levels and provides line frequencies of 510kHz at 8-bit, 368kHZ at 10-bit, and 299kHZ at 12-bit with full resolution output. The Dhyana 9KTDI camera can be easily programmed and updated in the field, adhering to the GenICam standard. Users can quickly operate the camera to acquire images that cater to diverse application scenarios.

2.3. Interface and Functionality

The Interfaces of the Dhyana 9KTDI are shown in Figure 2-2, and the corresponding Functional Descriptions are shown in Table 2-1. The pin definitions for the power and trigger interfaces, are shown in Figure 2-3, and the trigger input and output circuit diagrams are shown in Figure 2-4 and Figure 2-5."

Note: *The trigger level is 3.3V and must not exceed 5V.*

Figure 2-1 Dhyana 9KTDI interface

Tab 2-1 Functions of the Dhyana 9KTDI interface

No.	Interface	Functions		
1	Indicator	Indicates the camera status	Red ON	The camera is not initialized
			Red flashing	CXP connection configuration not completed
			Orange flashing	Low-speed link information is being transmitted
			Green ON	CXP connection configuration complete
			Alternating orange and green	Simultaneously transmit low-speed link information

				and high-speed image data.
			Green flashing	High-speed image data is being transmitted
2	Trigger	The interface for external trigger input has a trigger level of 3.3V, which cannot exceed 5V. HR10A-7P-4P.		
3	DC12V	Power interface, 12V/8A. The pin definitions for the power and trigger interfaces are shown in Figure 2-3.		
4	CXP12	HDBNC x4, the serial numbers of the 4 interface must correspond to the frame grabber interface one by one.		

Description of the trigger interface

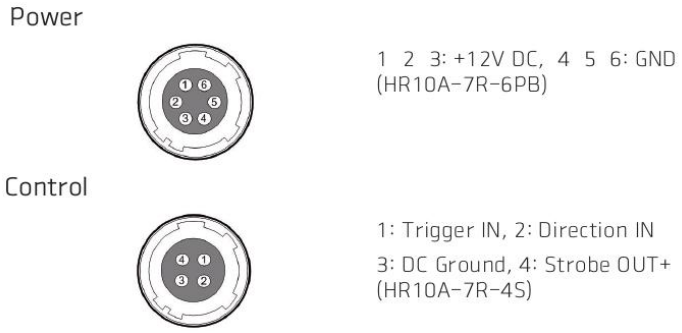


Figure 2-2 Power and trigger pin definitions

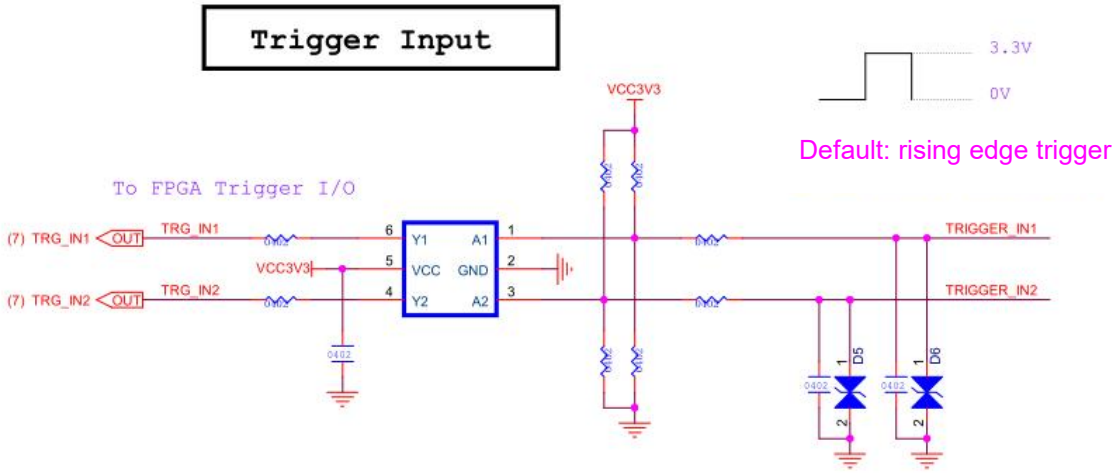


Figure 2-3 Trigger input circuit diagram

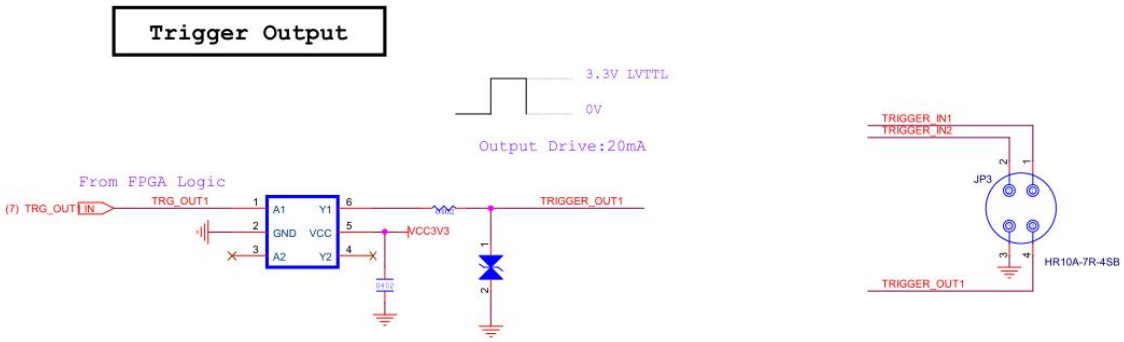


Figure 2-4 Trigger output circuit diagram

1) *The trigger level is 3.3V and must not exceed 5V;*

2) *When the trigger level is higher than 2.6V, it is judged as high level; when the trigger level is lower than 0.6V, it is judged as low level; and 0.6-2.5V is an indeterminate state, which may indicate a disordered trigger state.*

3. Installation

This chapter will introduce the installation of cameras and frame grabber, the installation of camera capture software, as well as how to connect the water-cooled camera to the water-cooling machine.

3.1. Recommended Computer Configurations

The computer configurations shown in this section are those that have been tested by our company and can support the highest resolution and highest line frequency of Dhyana 9KTDI Pro. It is for reference only.

Configuration I

Main components	Details
CPU	Intel Xeon Gold 5218 @ 2.30GHz
Motherboard	Inspur NP5570M5 (C621 Series chipset)
GPU	ASPEED ASPEED Graphics Family (ASPEED)
RAM	96 GB (Samsung DDR4 2933MHz 16GB x 6)
Hard Disk	Seagate ST2000NM000A-2J2100 (2 TB)

Configuration 2

Main components	Details
CPU	Intel i9-10900X
Motherboard	ASUS X299 SAGE
RAM	64 GB (Kingston Fury DDR4 3200MHz 8GB*8)
Hard Disk	Samsung 980 Pro

3.2. Installation of Frame Grabber

Turn off the computer, open the cover of the computer mainframe, as shown in Figure 3-2. Choose a PCIe slot with a transmission bandwidth exceeding 850MB/s, insert the frame grabber, secure it with screws, and restart the computer. The maximum transfer frame rate for different PCIe slots is shown in Table 3-1.

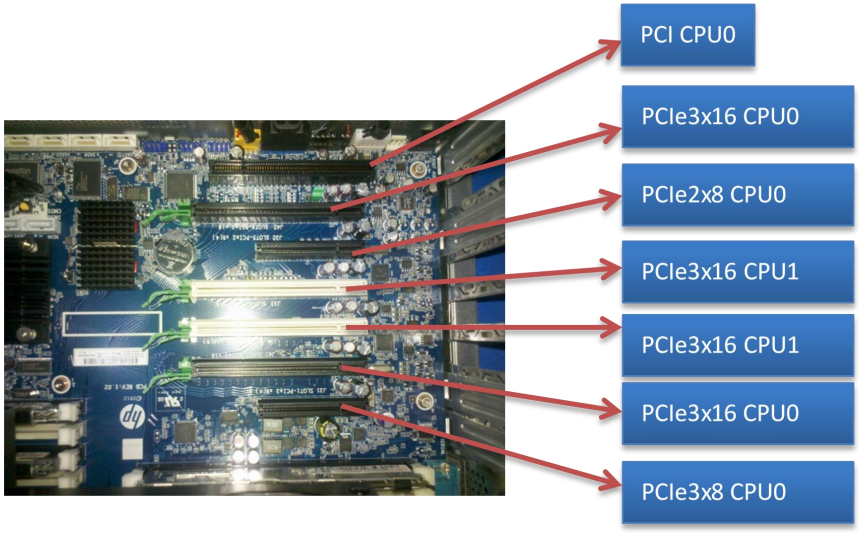


Figure 3-1 Motherboad

Tab 3-1 Maximum transfer rates for 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

The brands and models of frame currently supported by the test are shown in Table 3-2

Tab 3-2 Supported Frame Grabber

Brand	Model	Firmware	Driver
TUCSEN	Samadhi Quad CXP12 Frame Grabber	1d1s	TucsenSetup1.1.4.11.exe

KAYA	KY-FGK-II-CXP Komodo II 4CH CoaXPress 12G Frame Grabber CXP12x4	Firmware: 6.3.1 (2023-09-07 15:49:06)	egrabber-win10-x86_64-23.10.3.77.exe
Euresys	Coaxlink Quad CXP-12	Firmware: 1-camera, line-scan	mlxv22h1x64_fic.exe
Matrox	Matrox--RAP 4G 4C12		KAYA_Vision_Point_Setup_2023.1_SP_3_Windows_64

Note:

If there is a compatibility problem with the frame grabber, please confirm the firmware version and use the correct firmware version.

3.3. Installation of Camera

Connect one end of the CXP cable to the frame grabber and the other end to the Dhyana 9KTDI camera (it is recommended to use a removal tool to assist in installing the CXP cable). Lock the retaining ring, then plug in the power cable and turn on the power switch to see the light come on.

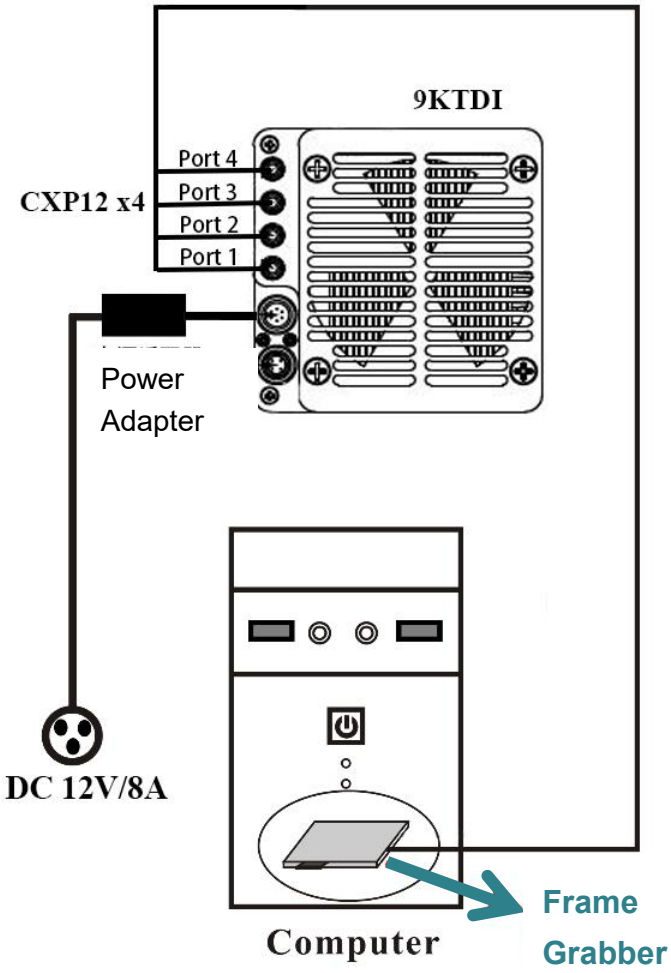


Figure 3-2 Dhyana9KTDI Connection Diagram

Note:

When wiring, please ensure that the serial numbers of the 4 CXP ports on the camera match the serial numbers of the frame grabber ports.

3.4. Installation of Frame Grabber's Driver

This section describes the driver installation for the three brands of frame Grabbers currently supported.

3.4.1. Samadhi

The Samadhi frame grabber driver is supported for installation on the Windows

10 (x64) operating system. The currently installed driver version is: TucsenSetup1.1.4.11.exe. The firmware version is: 4d4s.

Operation Steps

1) Double-click the Samadhi frame grabber driver to begin installation.

Figure 3-3

2) Select the installation language. The options include ’Simplified Chinese’ and 'English' Click 'OK'.

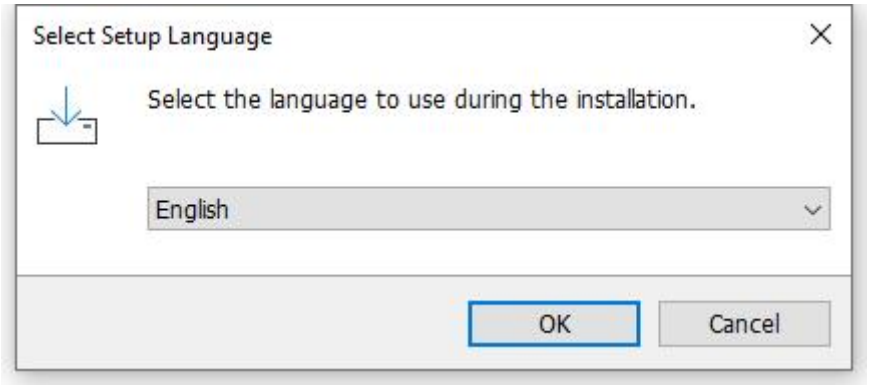


Figure 3-4

3) Choose the installation location. If you want to select a different folder, click 'Browse' After selection, click 'Next'.

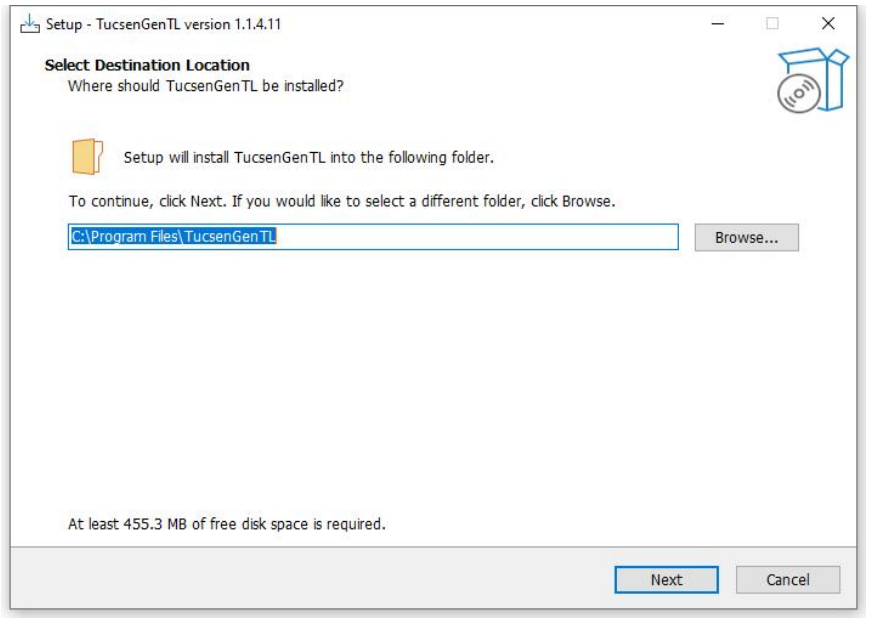


Figure 3-5

4) Select additional tasks, deciding whether to create a desktop shortcut; it is not checked by default. After making your choice, click 'Next'.

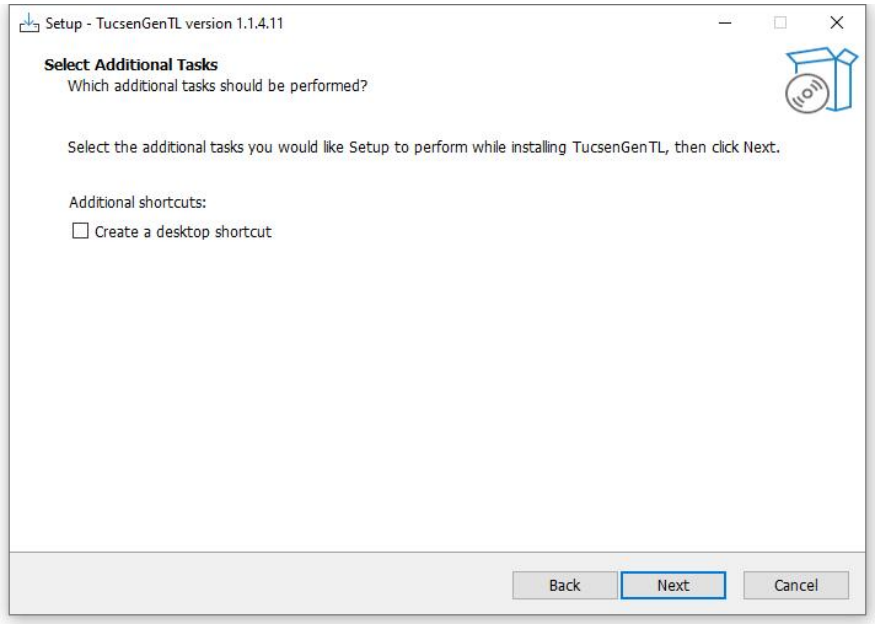


Figure 3-6

5) Prepare for installation confirmation, check if the settings are correct. Once confirmed, click 'Install'.

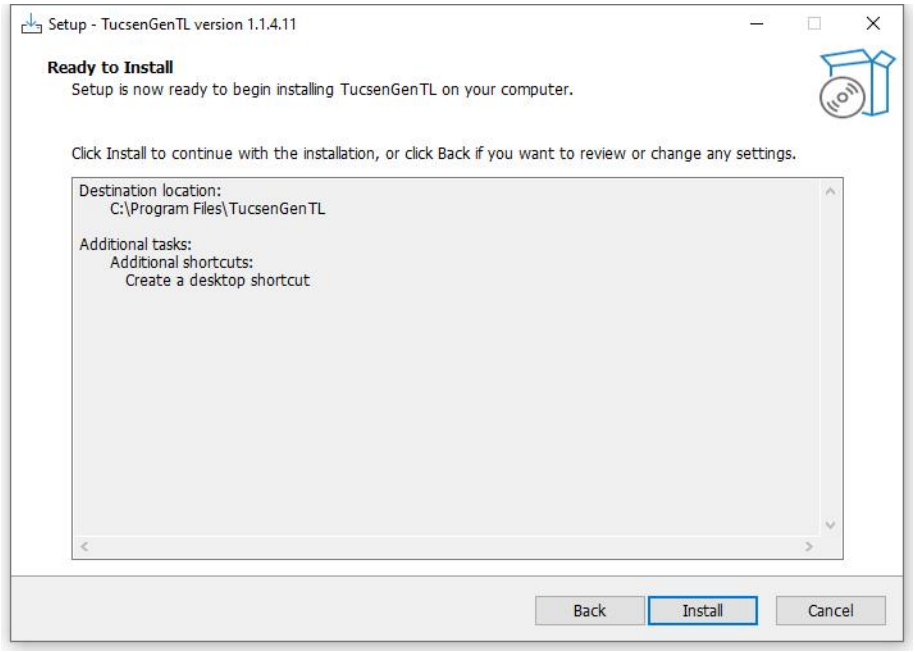


Figure 3-7

6) Click 'Finish' to complete the installation. Note: After finishing, please shut down the computer and then turn it back on (do not restart directly, as this may cause the driver installation to fail). The driver installation will complete upon booting up.

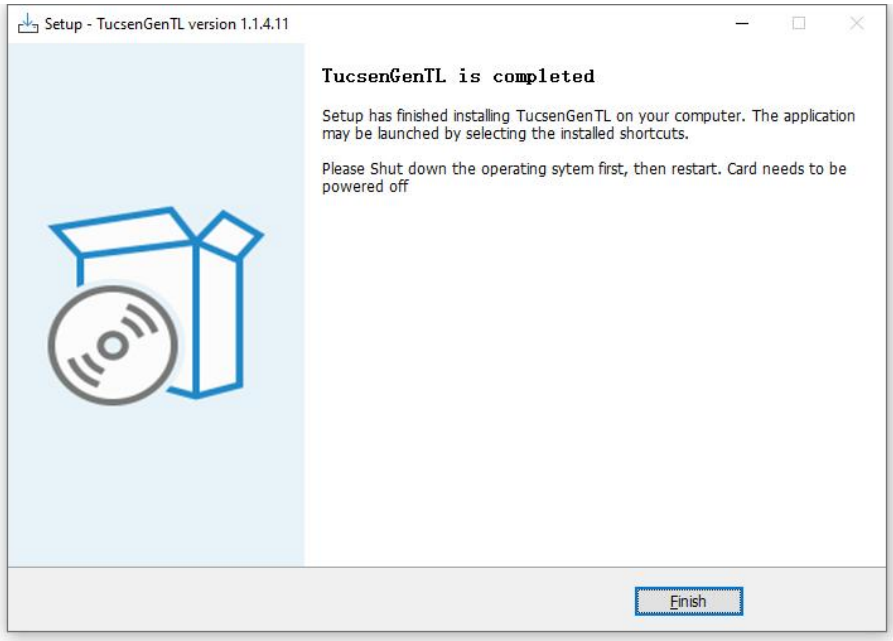


Figure 3-8

7) After the Samadhi driver installation is complete, open the Device Manager on your computer. When the driver is installed successfully, the Samadhi frame grabber will appear under Device Manager, displaying 'Samadhi Coaxlink QSFP+', as shown in the image below:

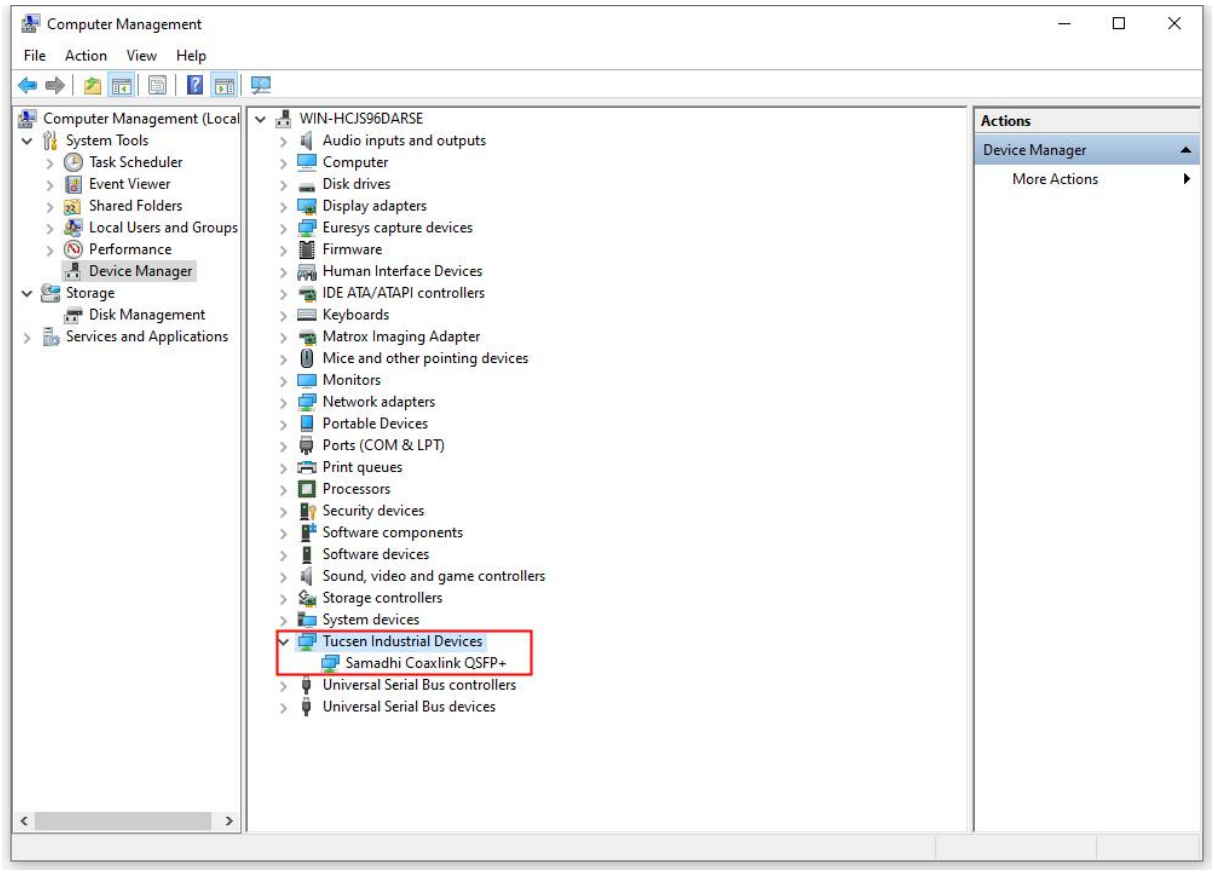


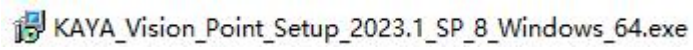
Figure 3-9

3.4.2. KAYA

The Kaya frame grabber only supports Windows 10 (x64). Currently, the following compatible version 2023.1 is the recommended: KAYA_Vision_Point_Setup_2023.1_SP_3_Windows_64.exe.

Operation Steps

1) Double-click the KAYA frame grabber driver to begin the installation;



2) Click "Next" to proceed with the installation guide;

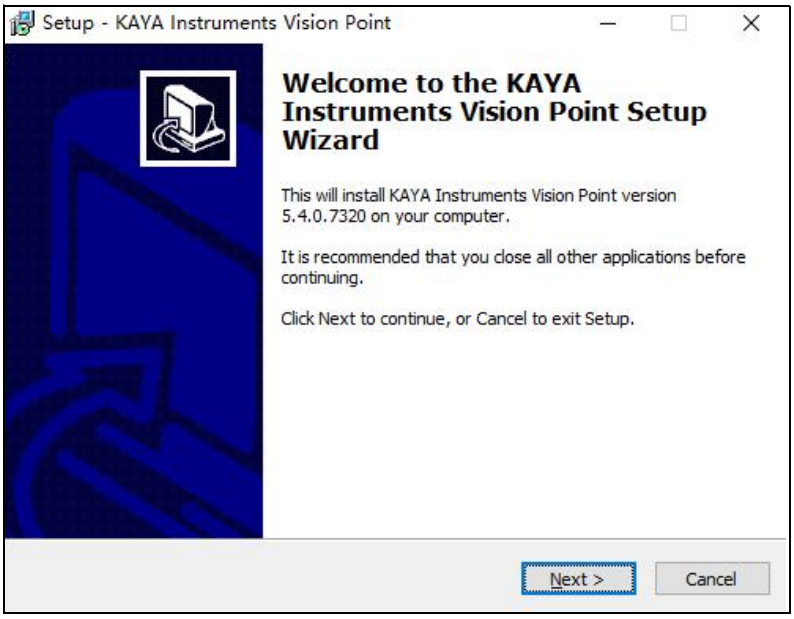


Figure 3-10

3) Select the driver installation location, use the default configuration, and click "Next";

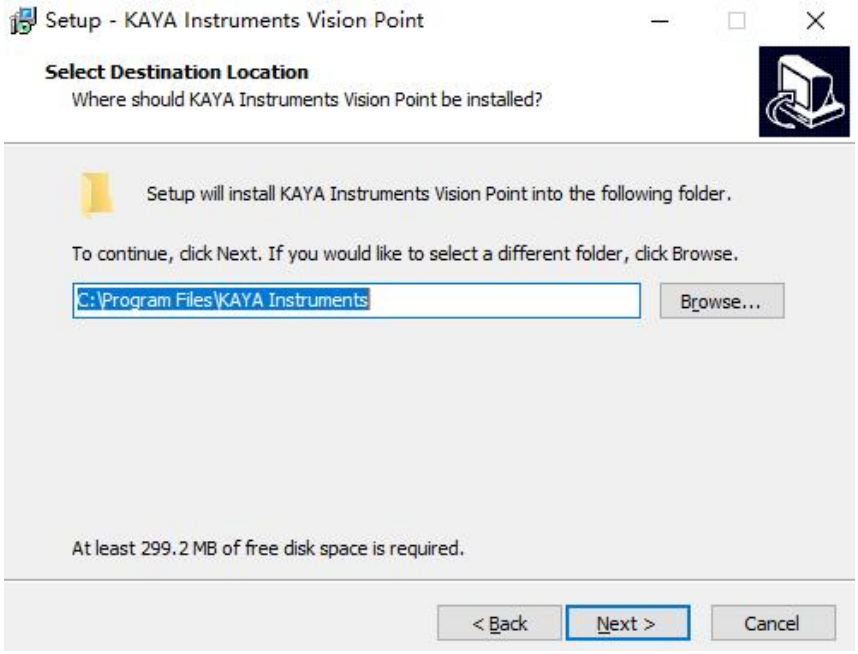


Figure 3-11

4) Select the components to install and click "Next" to proceed to the next step;

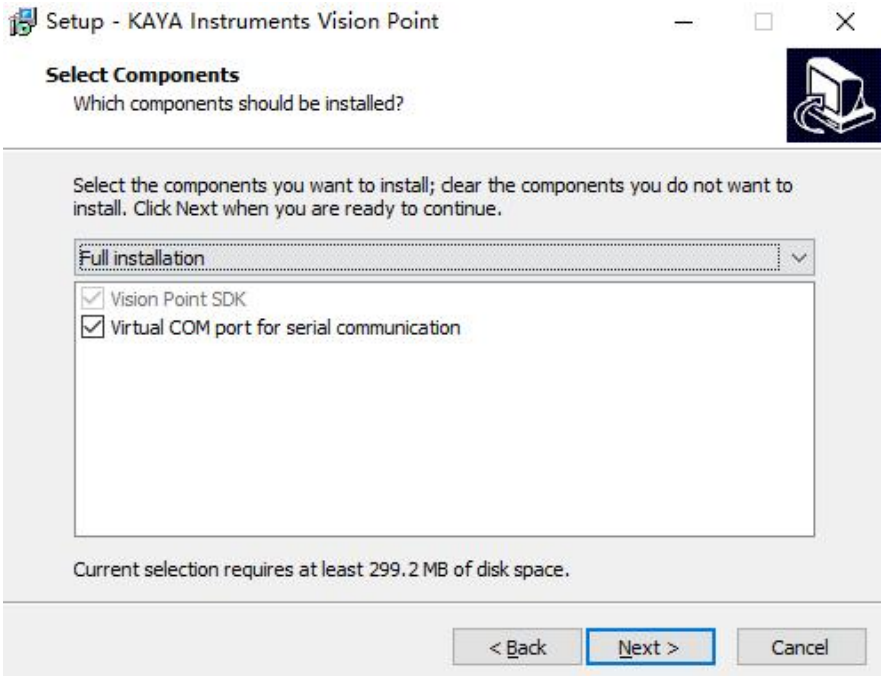


Figure 3-12

5) A default folder is created in the Start menu. It is recommended to use the default settings. Users can also choose other folders according to their needs, and click "Next>" to proceed to the next step;

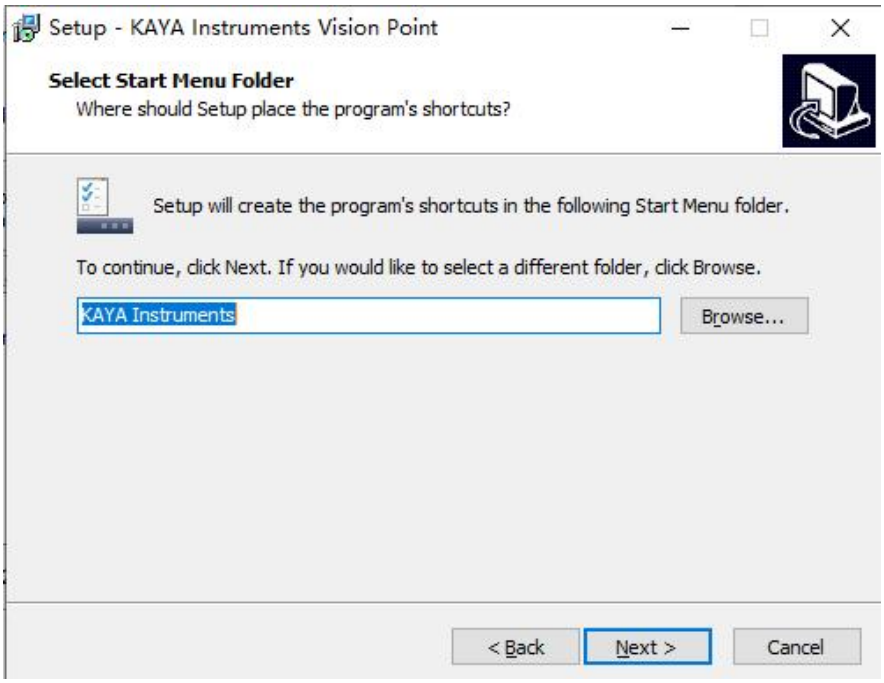


Figure 3-13

6) Confirm that all settings are correct and click "Install" to start the driver installation

process;

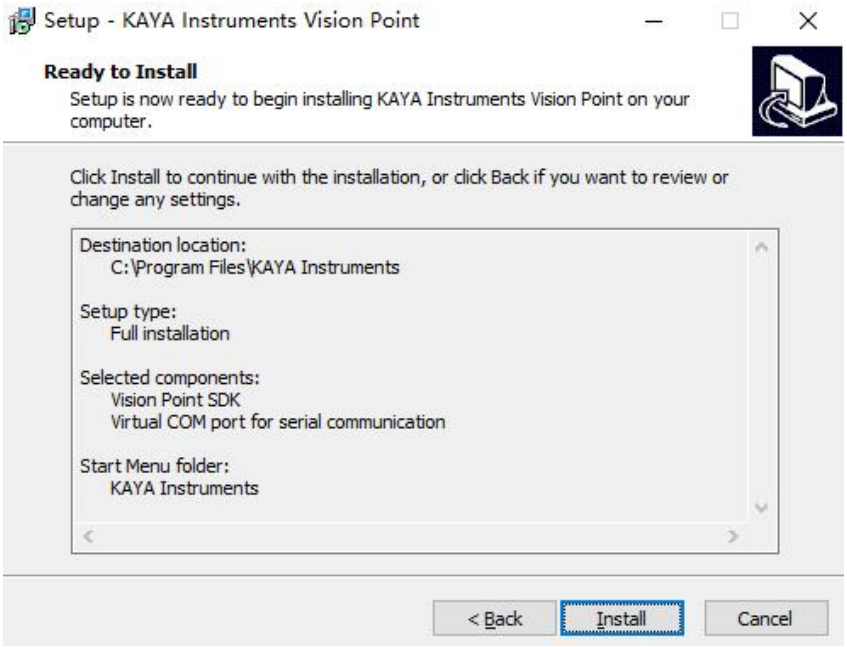


Figure 3-14

7) During the installation process, click "Next" to continue the installation according to the prompts;

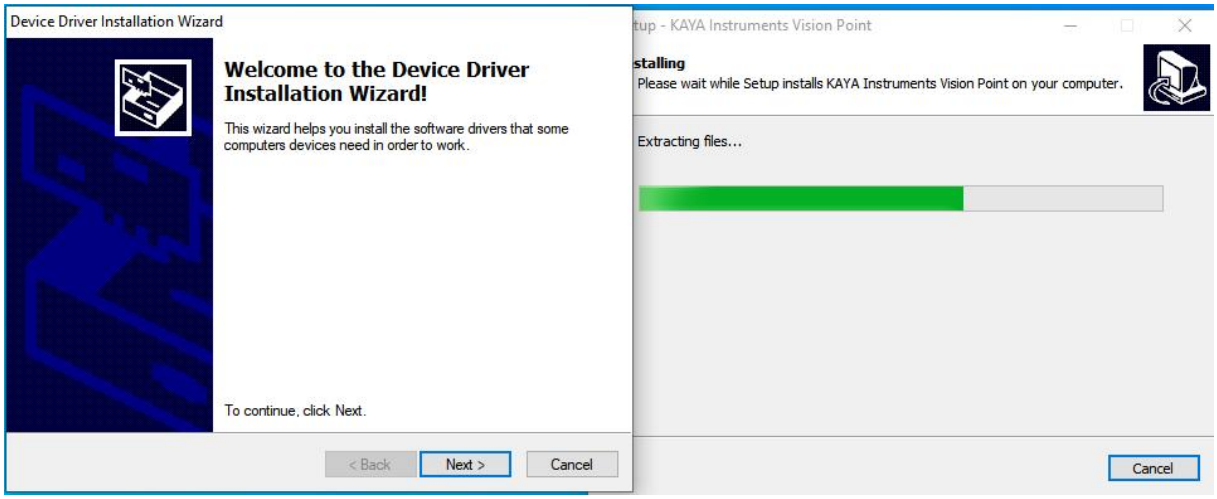


Figure 3-15

8) Click "Finish" to proceed to the next step;

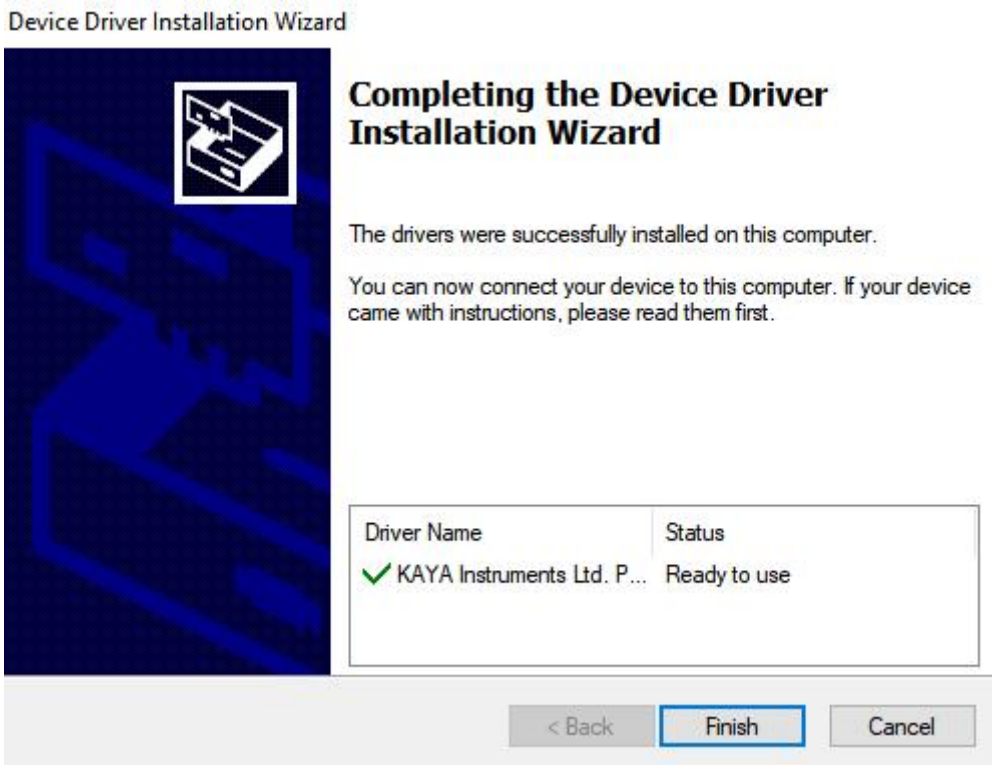


Figure 3-16

9) After the installation is complete, the software system needs to be restarted for the driver to take effect.

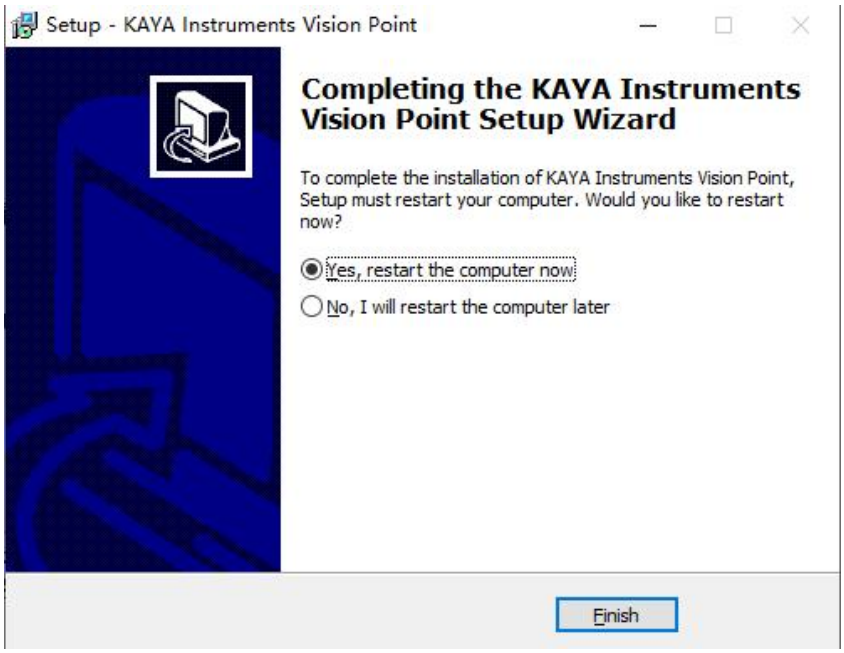


Figure 3-17

3.4.3. Euresys

The Euresys frame grabber only supports Windows 10 (x64). Currently, the follo wing compatible version 23.10.3.77 is the recommended: egrabber-win10-x86_64 -23.10.3.77.exe。

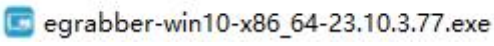


Figure 3-18

Operating Procedure

1) Double click on the driver to begin the installation, select the path and click "Next" to proceed to the next step;

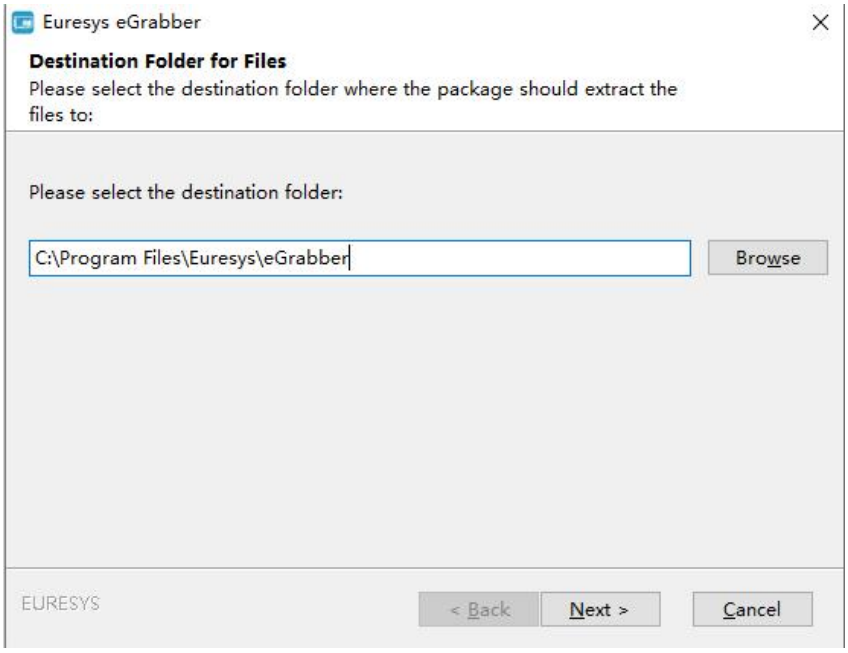


Figure 3-19

2) Wait for the installation to complete, and then click "OK";

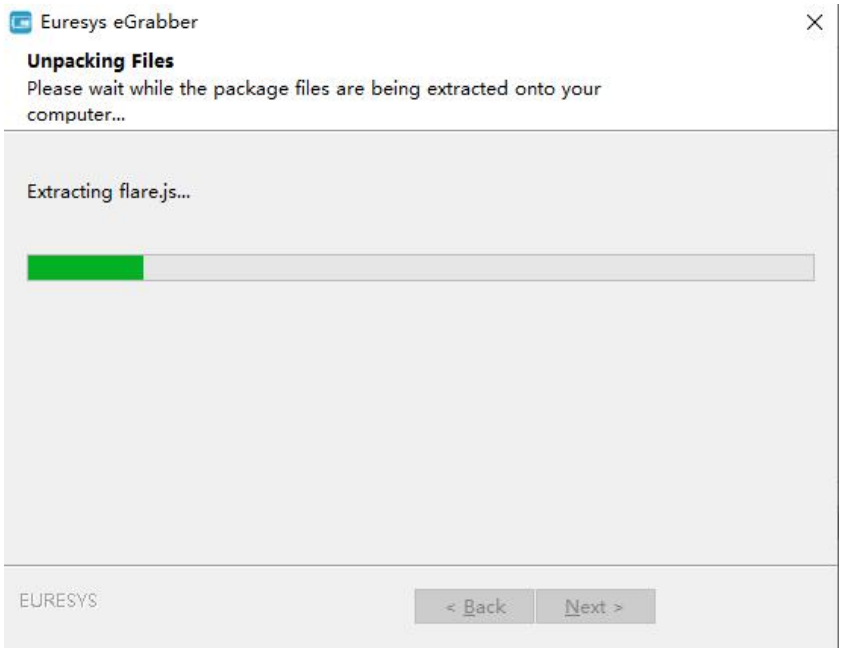


Figure 3-20

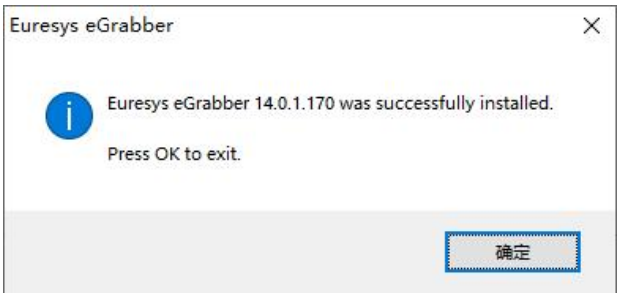


Figure 3-21

3.4.4. Matrox

Matrox U118 only supports the Windows 10 operating system and cannot be installed on the Home Edition. We recommend using the Professional version or Ultimate Edition for optimal performance. The following operation instructions are based on the Windows 10 operating system

Installation Sequence:

1) mlxv2102x64_fic.exe

2) MLiteXSP5B728EAx64

3) MXU118B11EAx64_Signed_with_Expiry

Operation Steps:

1) Double click the driver to begin the installation, select the installation path, and click "Install" to proceed to the next step;

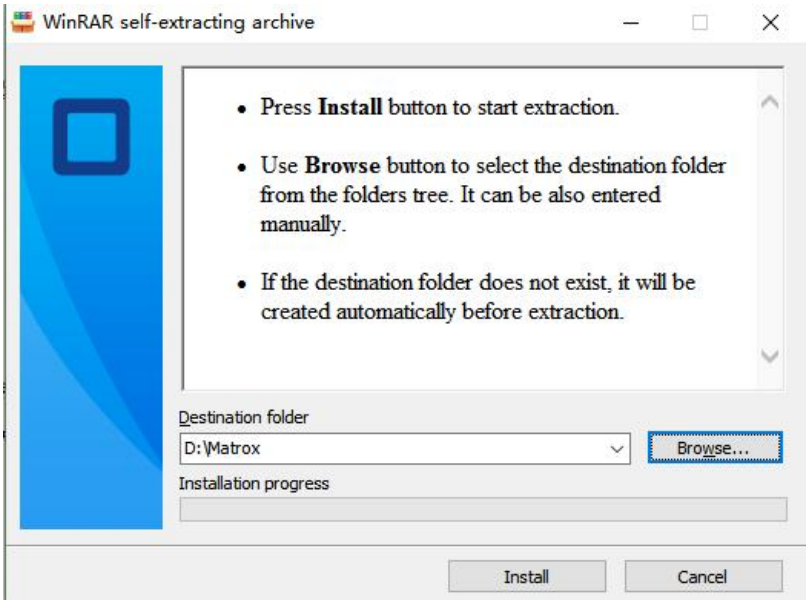


Figure 3-22

2) Wait for the installation to complete, and click "OK" as shown in the picture to proceed to the next step;

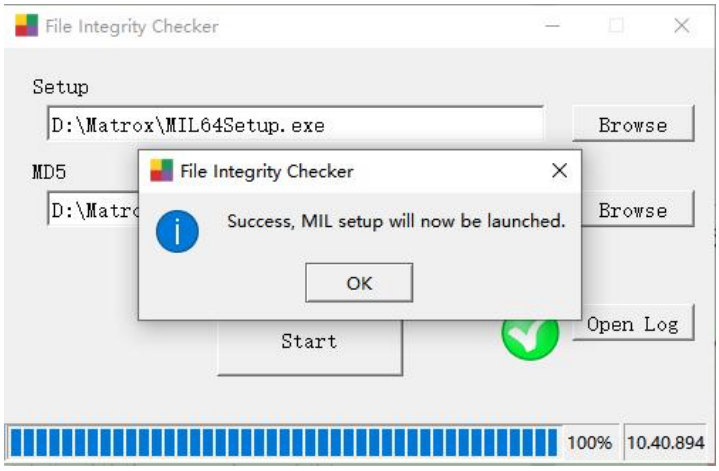


Figure 3-23

3) Select “Matrox Rapixo CXP” and click "Next" to wait for the installation to complete;

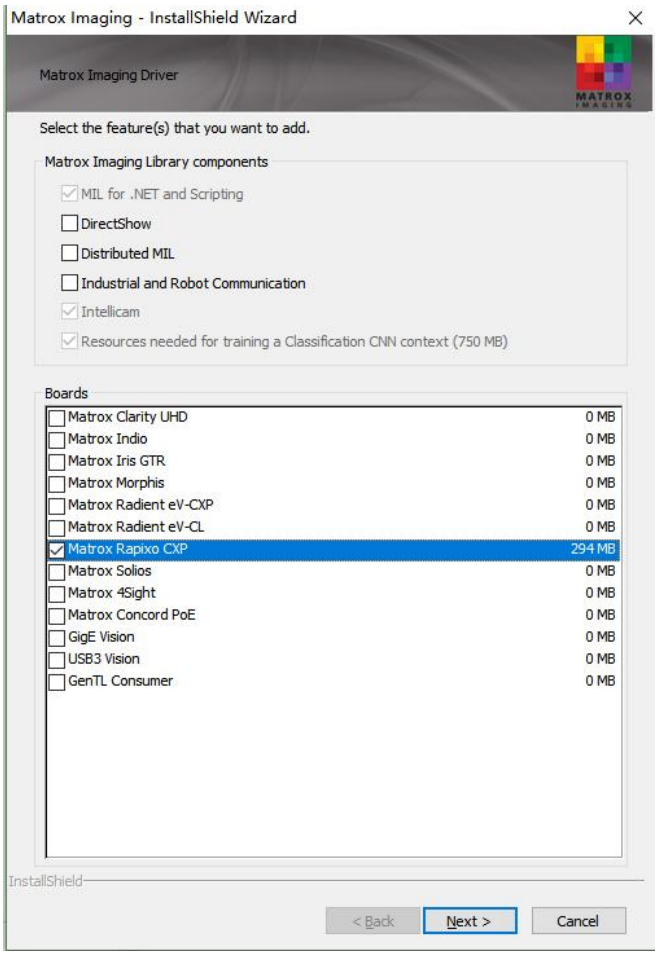
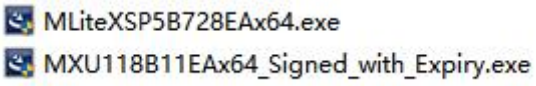


Figure 3-24

4) Select U118 for installation, open the frame grabber software after installation to update the firmware, and restart the computer.



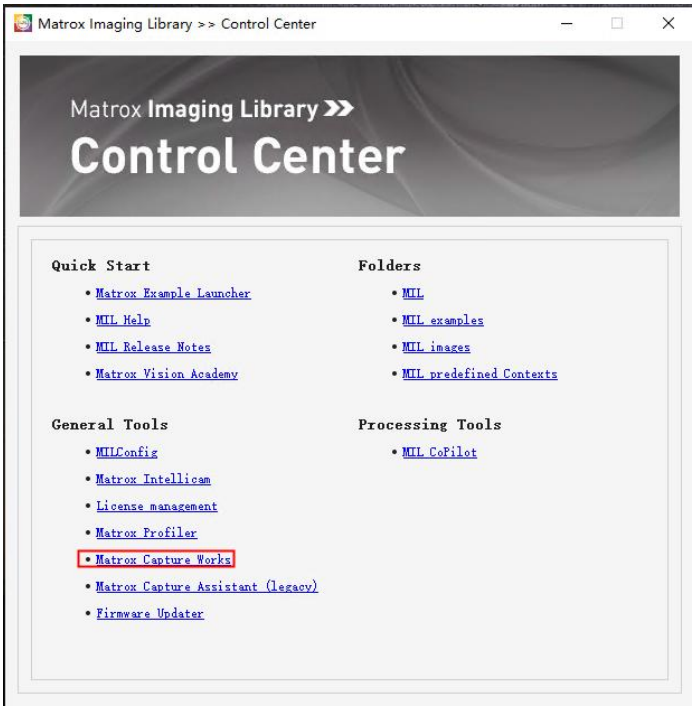


Figure 3-25

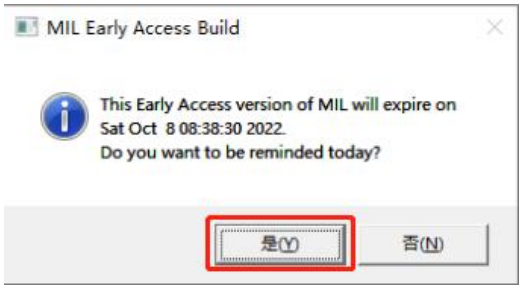


Figure 3-26

3.5. Installation of Software

The camera software SamplePro is included in the enclosed USB drive as a green software version, which can be used directly after extraction without installation.

For software functions and operating instructions, please refer to Chapter 5.

Note:

1) *When running for the first time, right-click on the SamplePro software icon, and select "Run as administrator" from the pop-up menu.;*

2) *The frame grabber software and SamplePro software cannot be run simultaneously, otherwise, the camera may not function properly or be recognized by the software.*

3) *When the green light flashes, it indicates that the camera is operating normally; when the red light flashes, it indicates an issue or error with the camera..*

4) *When the software prompts No Camera, try the following steps*

① *Whether the cable sequence of the camera and the frame grabber matches;*

② *Reinstall the frame grabber driver;*

③ *Restart the computer system;*

④ *Confirm the version of the computer system. The frame grabber only supports Windows 10 systems.*

3.6. Installation of Water-cooling Tubes

This section introduces the relevant functions of water-cooling for cameras, including water-cooling tubes connection, recommended water temperature, and recommended flow rate.

Water-cooling Tubes Connection Steps

1) LLoosen the 2 M3 screws on the camera's cover and remove the water-cooled pipe protective cover, as shown in Figures 3-20 and 3-21.

Figure 3-27

Figure 3-28

2) Press the left circular handle of the water tube connector into the position shown below, and then attach it to the water tube connector on the camera. A crisp sound indicates successful connection. When you are finished using it, press the left circular handle at the same time to detach the water tube.

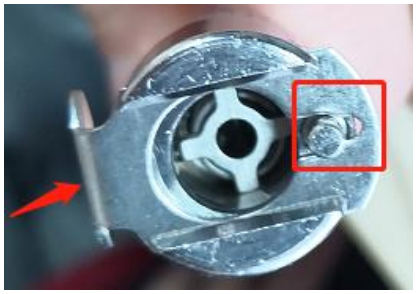


Figure 3-29

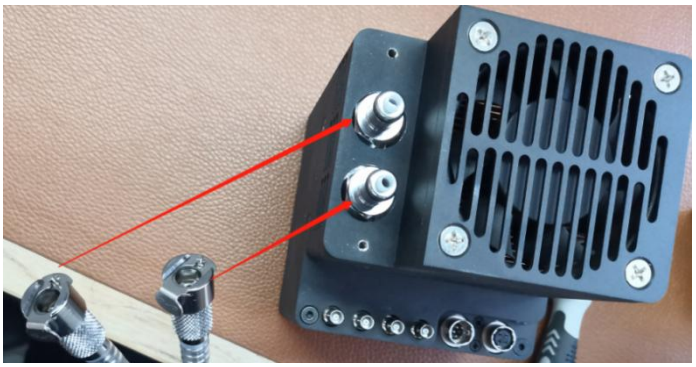


Figure 3-30

3) Connect to the water cooler with the connector shown below;

Figure 3-31

Recommended water temperature and flow rate

1) Minimum water flow rate: 1L/Min;
2) It is recommended to maintain the circulating water temperature between 15℃ and 20℃. If the water temperature is too low, it may cause condensation on the window, potentially leading to damage of the chip.

The water temperature of the water cooler needs to be selected based on the actual temperature and humidity of the environment. You can refer to the table of dew point corresponding to temperature and humidity in the attachment. The recommended water temperature should be higher than the dew point temperature value in the table. For example, when the ambient temperature is 25°C and the relative humidity is 70%, the water temperature should not be lower than 19°C.

4. Introduction of Camera Functions

This section will introduce the main functional modules of the camera, introduce test images of the camera, and explain how to update the firmware of the camera.

4.1. Working Principle of TDI Line Scan Sensor

TDI (Time Delayed and Integration) is a scanning technique that increases the sensitivity of line scan sensors.

Working Principle

TDI line scan cameras are a new type of photo detector camera with a linear array structure but a line scan output. Compared to regular line scan cameras, they have the function of multiple-stage delayed integration.

The charge accumulation in TDI occurs along the Y direction, with integration stages from the bottom to the top, from the 1st stage to the Nth stage. During the imaging process, as the camera (or sample) moves, the light is sequentially captured and charges are accumulated from the Nth stage to the 1st stage. The accumulated charges are then amplified and converted to output signals through operational amplifiers and ADC. TDI is a unidirectional scanning imaging device that, compared to regular line scan sensors, utilizes variable integration stages to increase exposure time, thereby achieving higher sensitivity in low-light conditions without compromising scanning speed.

Advantages

Compared to regular line scan sensors, TDI offers several advantages:

1) Higher sensitivity, high responsivity, and wide dynamic range. It can output signals with a certain signal-to-noise ratio even in low-light conditions.

2) When imaging moving targets with TDI, it allows for increased scanning speed under limited light intensity or reduced brightness of the illumination source during constant-speed scanning. This reduces power consumption and lowers costs.

4.2. Spectral Response Curve

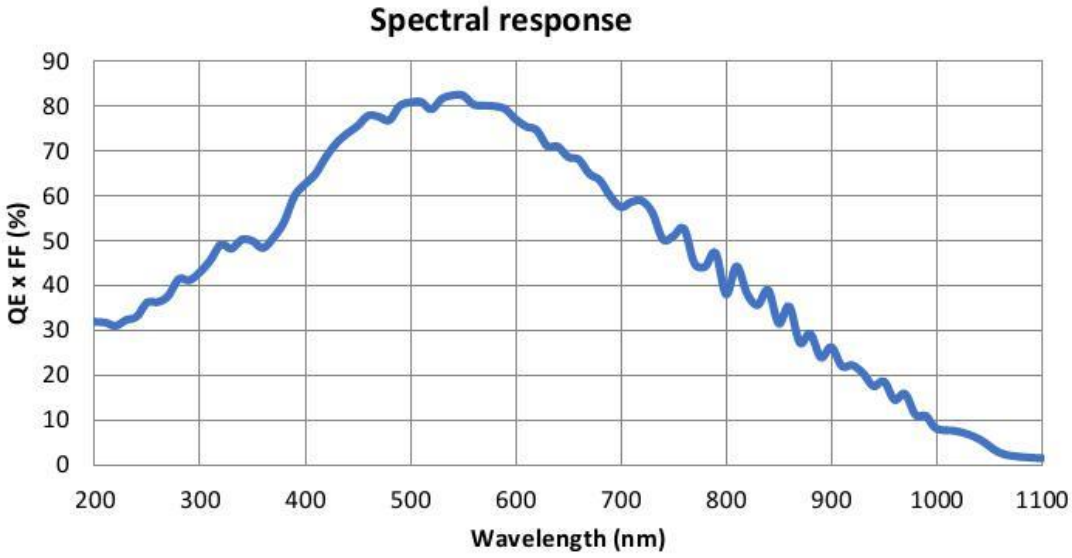


Figure 4-1 Chip spectral response curve* (provided by chip manufacturer)

4.3. Operation Mode and TDI Stages

The Dhyana 9KTDI Pro has two distinct operating modes: Area and TDI.

When the "Operation Mode" parameter is set to "TDI," the camera functions as a high-sensitivity line scan camera. Conversely, if the "Operation Mode" is set to "Area," the camera utilizes a two-dimensional pixel array as an area camera; the area mode is primarily used for camera focusing and does not guarantee consistent image quality.

In TDI mode, the "TDI Stages" parameter is utilized to determine the number of integrations executed by the camera. For instance, selecting a "TDI Stages" value of 256 implies that the line data has been integrated 256 times. On the other hand, in area mode, the "TDI Stages" parameter dictates the height of the Dhyana 9KTDI Pro. Specifically, setting the "Operation Mode" to "Area" and adjusting the "TDI Stages" to 256 enables the camera to capture images with a resolution of 9072×256.

4.4. DeviceScanType

Linescan mode: The camera outputs using the CXP protocol for line scanning. The computer receives one line of image and generates an interrupt signal. This interrupt frequency is very high and consumes a lot of CPU resources. By setting the buffer of the frame grabber, the interrupt response frequency can be reduced. The larger the buffer, the lower the interrupt frequency, the less likely it is to drop frames, and the larger the memory required.

Areascan mode: The camera uses the area scan CXP protocol to output images. After receiving the image, the computer generates an interrupt signal. Therefore, in Areascan mode, the interrupt response frequency can be reduced by setting the camera's Height. The higher the Height, the lower the interrupt frequency, the less likely it is to drop frames, and the larger the memory space required.

Figure 4-2 Linescan mode transmission of N-line images

Figure 4-3 Areascan mode transmission of N-row images

There is no difference between the images acquired in the 'Linescan' and 'Areascan' modes, except for the packaging format when the images are transmitted through CXP. In Line mode, a frame header is transmitted for each line, while in Areascan mode, a frame header is transmitted every N lines. This increases the effective bandwidth, allowing the Areascan mode to operate at a higher line frequency with the same resolution and other configurations."

4.5. Scan Direction

In TDI mode, the "Scan Direction" parameter is used to set the scanning direction of the Dhyana 9KTDI. The Dhyana 9KTDI scans in the default forward direction, as shown in Figure 4-4. Users can adjust the installation direction of the camera according to their usage environment. The camera supports three direction control modes.

Figure 4-4 Definition of camera direction

1) Forward: The application scenario is that the subject will move from the bottom of the camera to the top of the camera.

2) Reverse: The application scenario is that the subject moves from the top of the camera to the bottom of the camera.

3) LineIn1: The application scenario is to control the scanning direction using external trigger signals (low level = forward, high level = reverse).

Note:

1) *In the Area mode, when the "Scan Direction" parameter is set to "Reverse", a vertically flipped image can be obtained;*

2) *The trigger signal that controls the scanning direction is connected to Pin2 of the trigger port. For specific information, please refer to Figure 2-3 for the definition of the trigger pins.*

3) *Changing the scanning direction during image acquisition can cause some reversal delays, resulting in 3000 rows of erroneous images for 8&10bit and 1500 rows of erroneous images for 12bit. Users will need to handle this on their own.*

4.6. Pixel Format

Users can view and set the bit depth format of the camera output image data through the "Pixel Format";

1) Mono8 sets the pixel format to 8 bits;

2) Mono10 sets the pixel format to 10 bits;

3) Mono12 sets the pixel format to 12 bits;

Note:

When selecting Mono10 and Mono12, the image properties display as 16 bits (zero-padded high bits).

4.7. Horizontal Flipped

The Dhyana 9KTDI camera can achieve horizontal mirroring through the "Reverse X" function, which can be used in Area and TDI modes.

Figure 4-5 Original image

Figure 4-6 “Reverse X” image

4.8. Region of Interest

In imaging applications, the ROI (Region of Interest) is a sub-region of interest defined within the resolution of the camera sensor. Once the ROI is selected, only the image

within this sub-region is read out. During operation, only the pixel information from the specified region is read from the sensor and transmitted from the camera to the frame grabber.

"Offset X" is the starting point for setting the ROI. The location and dimensions of the ROI are determined by adjusting the "Offset X" and "Width" settings. For example, with an Offset X set to 96 and a Width set to 256, the camera will capture and transmit pixel values from pixels 97 to 352.You can adjust the size and position of the ROI by modifying the parameter values of "Offset X" and "Width"

Note:

1) *The sum of the "Offset X" and "Width" parameter values must not exceed the width of the camera's imaging sensor.*

2) *The "Offset X" setting can be set to an integer multiple of 0 and 16. The "Width" setting must be at least 256 and an integer multiple of 16.*

3) *The CXP frame grabber may have additional restrictions on the location and size of the ROI. Please refer to the user manual of the CXP frame grabber you are using for further information.*

4.9. Binning

Binning is an image readout mode that combines adjacent pixels and reads them out as a single pixel. Binning can increase sensitivity and frame rate, but it also reduces the resolution of the image.

The Dhyana 9KTDIPro achieves the Binning function through both FPGA and the sensor.

BinningHorizontal supports X1, X2, X4, and X8. When set to X2, the image resolution is halved while the frame rate remains unchanged.

BinningVertical supports X1, X2, X4, and X8. When set to X2, the image resolution remains unchanged while the frame rate is halved.

SensorBinning supports X1 and X2. When set to X2, both the image resolution and frame rate remain unchanged.

Using Sensor Binning X2, there are two situations:

a. When the sample speed remains constant, the line frequency needs to be halved to ensure clear imaging;
b. When the line frequency remains constant, the sample speed needs to be doubled to ensure clear imaging.

There are two ways of FPGA Binning, Sum Bin and Avr Bin. The differences between them are as follows:

FPGA Avr Bin: The saturation capacity increases proportionally, the system gain decreases proportionally, the dark current increases proportionally, and the saturation gray value remains unchanged.

FPGA Sum Bin: The saturation capacity remains unchanged, the system gain remains unchanged, and the saturation gray value remains unchanged.

Note:

SensorBinning only supports 8-bit and 10-bit, and it only doubles the saturation capacity in AnalogGain1 mode. The saturation capacity remains unchanged in other AnalogGain modes.

4.10. Gain & Black Level

The "Gain" parameter adjusts the slope of the Dhyana 9KTDI's light response curve, thereby enhancing or reducing the grayscale values of the camera's output image. When it is difficult to see the object to be photographed under weak signal conditions, you can increase the "Gain" parameter value to see the details of the dark part. When the output image is too bright in a scene with strong signal, you can reduce the "Gain" value to avoid overexposure.

The increase of analog gain will result in proportional increase of system gain, proportional decrease of saturation capacity, reduction of readout noise, decrease of absolute sensitivity threshold, decrease of signal-to-noise ratio, and decrease of DSNU and PRNU.

The increase of digital gain will cause proportional increase of system gain, proportional decrease of saturation capacity, reduction of dynamic range, decrease of signal-to-noise ratio, increase of dark current, decrease of DSNU, and increase of PRNU.

The two gain modes are as follows:

1) Analog Gain: supports 2~8 switching, with a step size of 0.5，The default value is 2;

2) Digital Gain: supports switching from 0.5~10, with a step size of 1,The default value is 1;

3) Black Level: The black level adjusts the background grayscale value of the image.

The chip background is subject to fluctuations, and it varies under different line frequencies, gains, TDI levels, and temperatures. For example, the 12bit background is about 150DN at a 1KHz and about 70DN at a 300KHz. We obtain our 8bit values by truncating the 10bit values, so they are related to the chip's 10bit background. Similarly, the 10bit values are also related to line frequency, gain, TDI level, and temperature.

If DSNU is performed under the current line frequency, gain, TDI level, and temperature, the 12bit background will become 100DN. Similarly, the 10bit background will be 100/4 = 25DN, and the 8bit background will be 100/16 = 6DN.

Note:

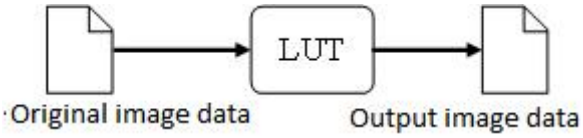
The 8bit and 10bit values cannot be saturated with DSNU enabled.

The gray value increases when DSNU is enabled for 12bit.

Taking 8bit as an example, DSNU first subtracts the chip background value (e.g., 20), and then adds the correction value (-20+6=-14). Therefore, the maximum gray value is 255-14=241. Different chips may have slightly different specific values. If a gray value of 255 is required, DSNU should be turned off or BlackLevel should be used with the corresponding value. The same applies for 12bit.

4.11. Lookup Table

The lookup table (LUT) conversion is a basic image processing function that highlights details containing important information. These functions include histogram equalization, gamma correction, logarithmic correction, and exponential correction. The grayscale values of the output image will be mapped one-to-one to those of the original image. Users can set the corresponding values according to their application scenarios.



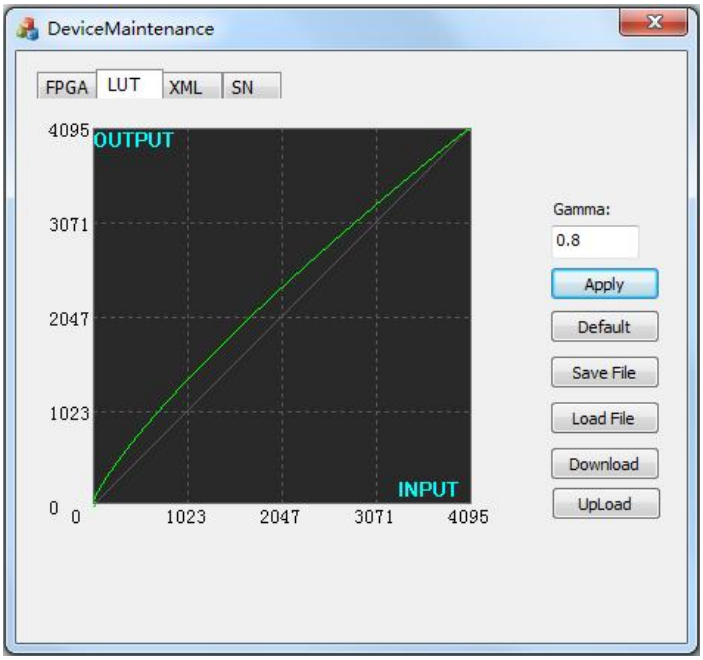


Figure 4-7 LUT at Gamma=0.8

4.12. Dark Field Correction (DSNU)

Dhyana 9KTDI provides DSNU correction function and storage of DSNU correction values.

When a camera captures an image in complete darkness, in an ideal image, all pixel grayscale values should be close to zero and equal. However, in practice, when a

camera takes a picture in the dark, subtle differences in the performance of each pixel in the sensor will cause some variation in the pixel grayscale values output from the camera. This variation is known as dark signal non-uniformity(DSNU).

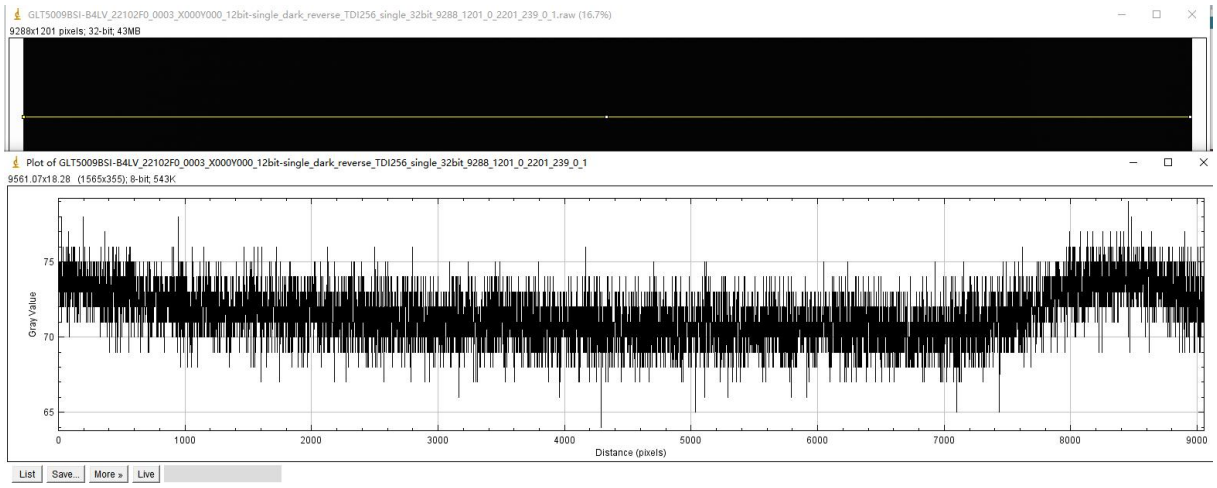


Figure 4-8 dark field gray value without corrected

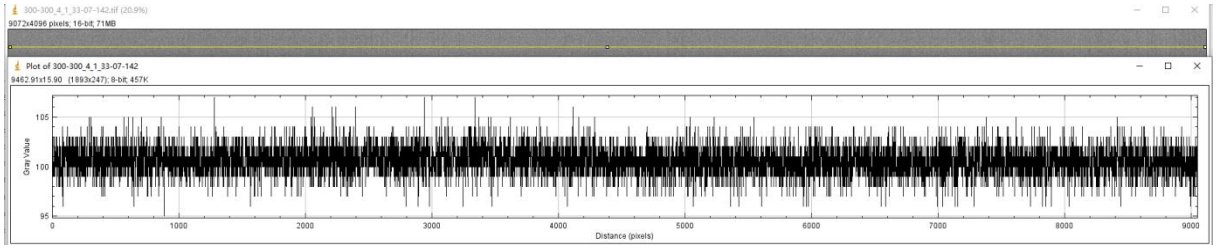


Figure 4-9 dark field gray value with corrected

4.13. Bright Field Correction(PRNU)

Dhyana 9KTDI provides PRNU correction function and storage of PRNU correction values.

When a camera captures a uniform, light-colored target in bright light, in an ideal image, all pixel grayscale values should be close to the maximum grayscale value and equal. However, in reality, subtle differences in the performance of the image pixels in the camera, as well as changes in the lens or lighting, can cause variations in the pixel grayscale values output from the camera. This variation is known as photo response non-uniformity (PRNU).

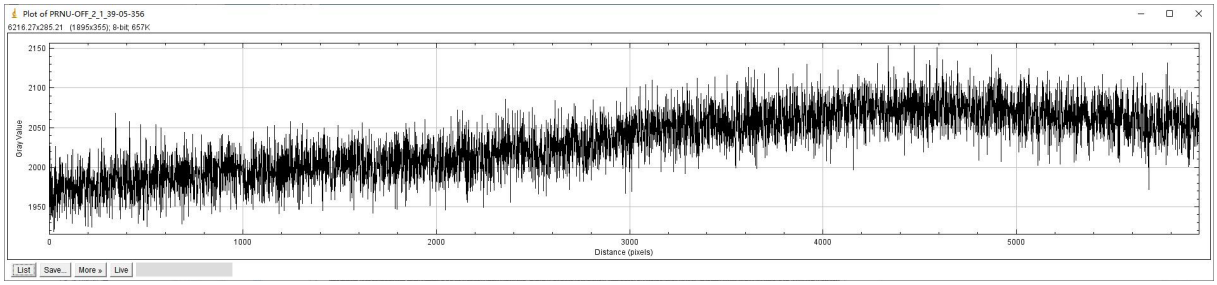


Figure 4-10 bright field gray value without corrected

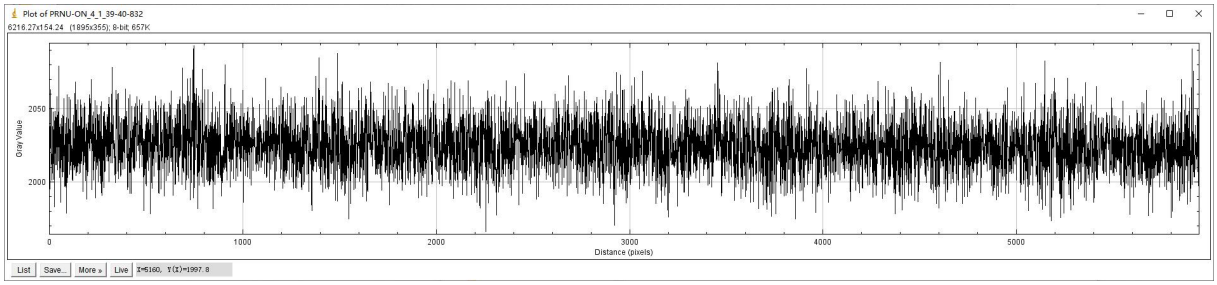


Figure 4-11 bright field gray value with correct

4.14. Digital I/O Control

When it is necessary to provide source signals to external devices, Dhyana 9KTDI can output pulse signals by controlling the I/O socket. You can select the trigger output level through the "StrobeMode" option, including On, Timed, and PulseWidth; you can also toggle the output signal's high and low levels, set the output signal delay time, and set the high-level output signal time (effective under Timed).

4.15. Test Patterns

To check the status of the camera, the Dhyana 9KTDI can output a test pattern created internally. There are three types of test modes:

- Grey Horizontal Ramp: the preview is a static grayscale gradient in the horizontal direction.

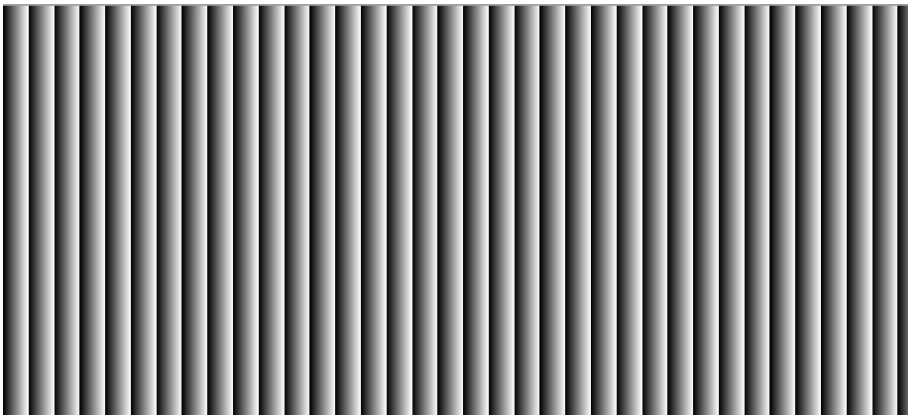


Figure 4-12 Horizontal grayscale gradient test pattern

- Grey Diagonal Ramp: preview as a static grayscale gradient in the horizontal diagonal direction.

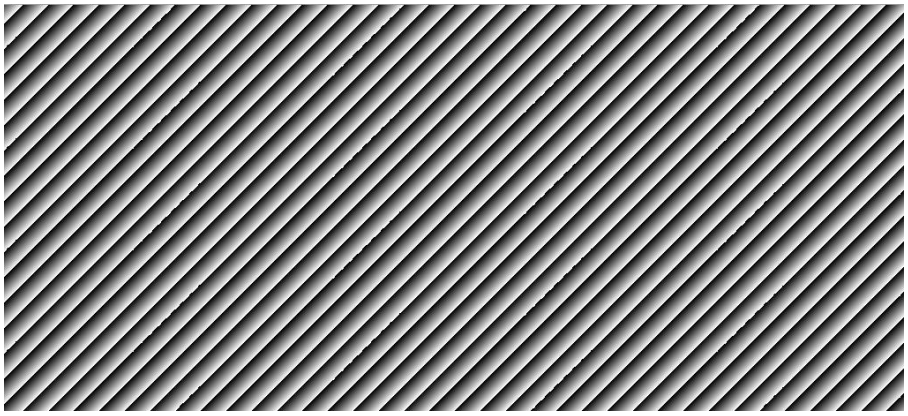


Figure 4-13 Horizontal grayscale diagonal gradient test pattern

- Grey Diagonal Ramp Moving: preview as a grayscale gradient map of the movement in the horizontal diagonal diagonal direction.

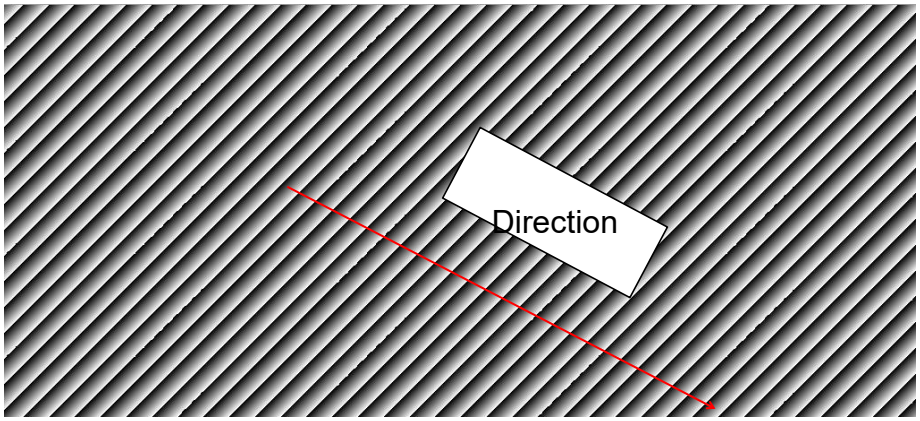


Figure 4-14 Horizontal grayscale diagonal moving gradient test pattern

- Sensor Test Image:Preview is a horizontal static grayscale gradient.。

Figure 4-15 Horizontal gray gradient test pattern

Note：

Grey Horizontal Ramp, Grey Diagonal Ramp, and Grey Diagonal Ramp Moving are generated by FPGA and are mainly used to verify whether there are any problems with the camera FPGA to PC link. Sensor Test Image is generated by sensor and is mainly used to verify whether the sensor is working properly.

4.16. Firmware Upgrade

The Dhyana9KTDI camera can be updated with firmware online through the "UpdateTool" software.

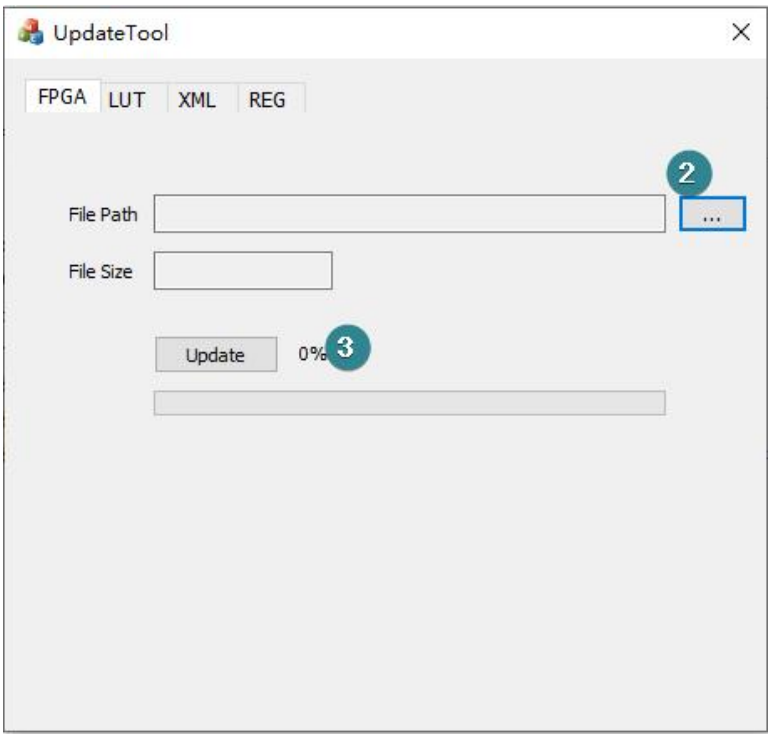


Figure 4-16 Update Tool interface

Tool Preparation:

Software: UpdateTool;

Firmware file: .bin format;

Operation steps:

1) Double-click to run the "UpdateTool" , and the interface is shown in Figure 4-15;

2) Select the firmware file path;

3) Click the "Update" button to wait for the update to complete;

4) After the update is complete, power off and restart the camera for the new firmware to take effect, or use the software's "DeviceReset" to restart it;

5) After the camera is rebooted, confirm that the DeviceVersion matches the firmware being upgraded, indicating a successful upgrade.

5. Camera Software Description

SamplePro is a camera control software that allows users to set camera parameters, preview, and acquire images through this software.

Double-click SamplePro to open the camera software. The software opening interface is shown in Figure 5-1. After the loading is complete, the functions will be displayed on the left side of the screen;

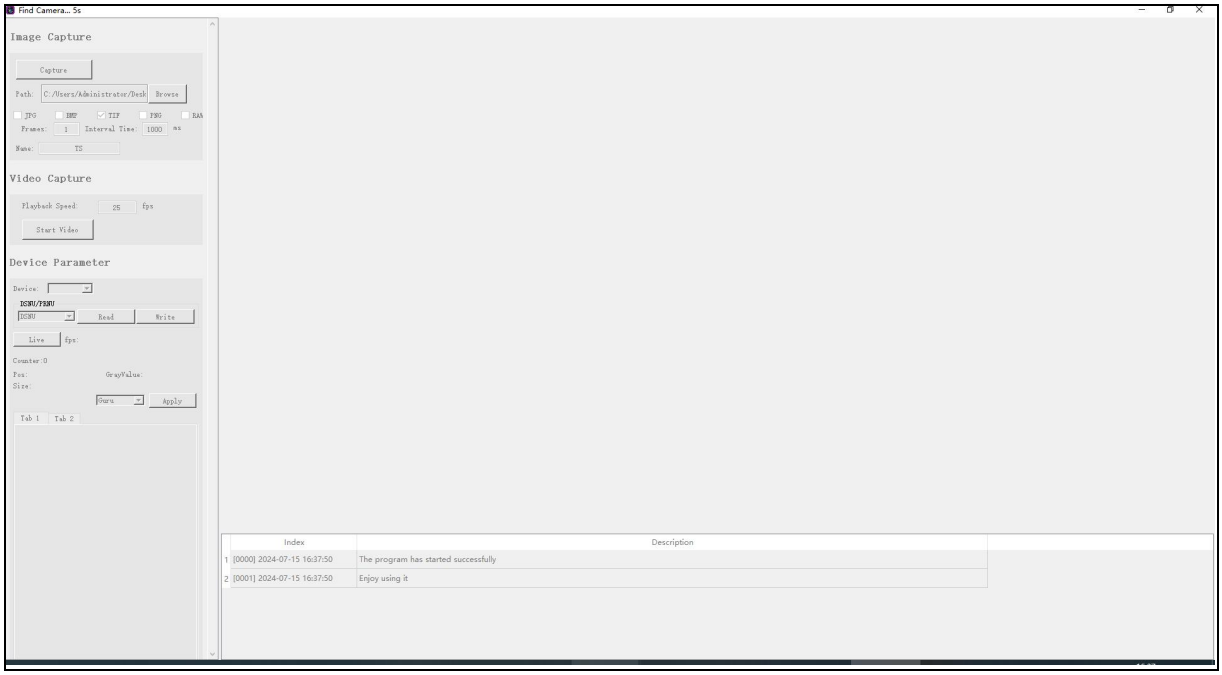


Figure 5-1 Startup Interface

Note:

When starting the SamplePro software for the first time, run it as an administrator with the right click, and subsequently use the software by double-clicking directly;

5.1. Window compositions

The main interface of SamplePro software consists of five parts: "Preview Window", "Software Window", "Image Capture", "Device Parameters" ,"Software Log" and "Image Adjustment", as shown in Figure 5-2.

This section briefly introduces the functions of each window.

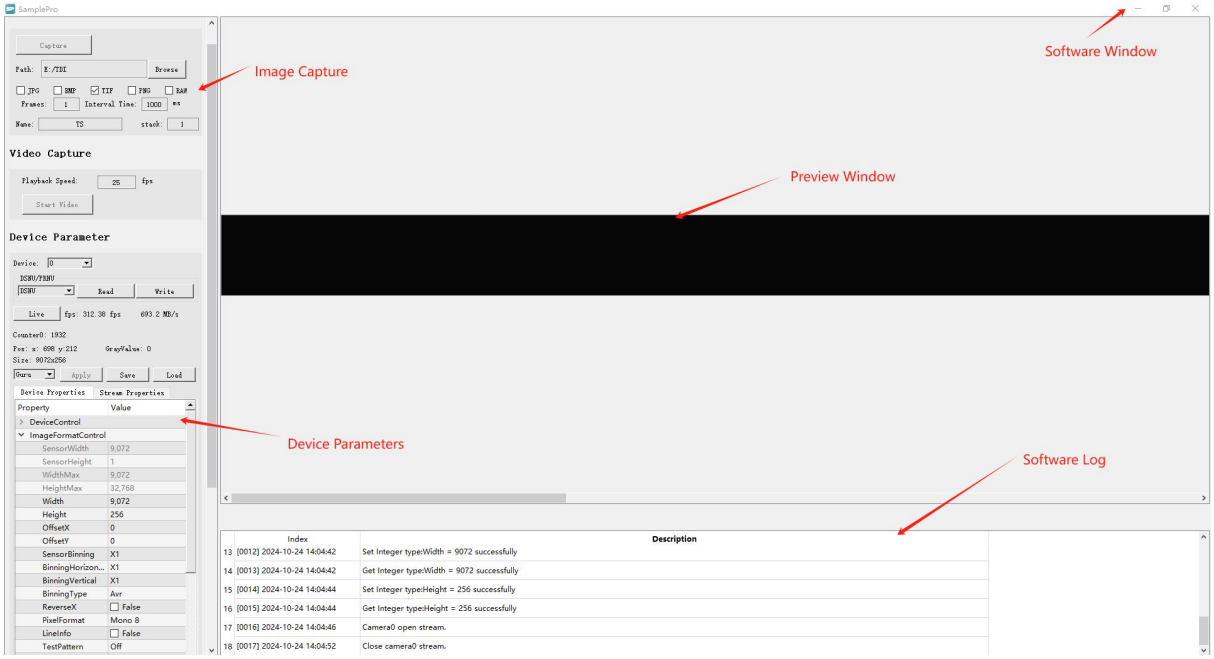


Figure 5-2 Software Window Interface Layout1

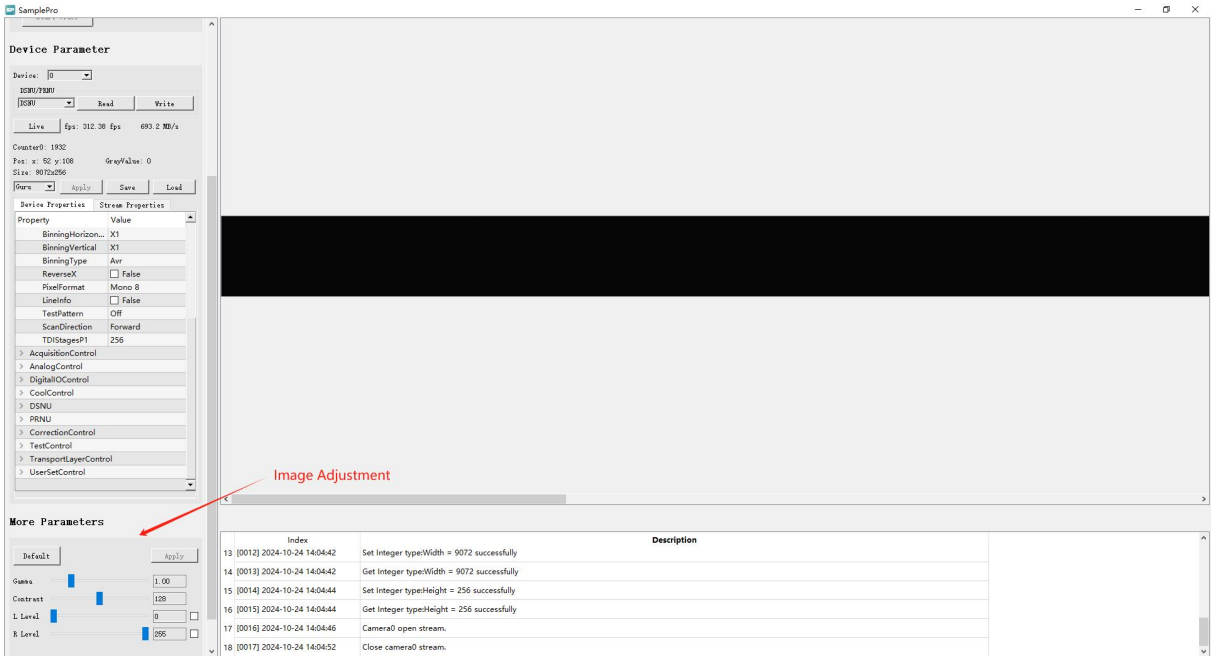


Figure 5-3 Software Window Interface Layout2

5.1.1. Preview Window

The preview window displays the live camera feed under the streaming module. The preview window supports real-time zooming, allowing users to enlarge or shrink the preview window image through the mouse wheel based on their actual needs.

The lower left corner of the preview window will display the pixel grayscale value, coordinates, and image resolution size of the mouse position in the live image based on the mouse position. As shown in Figure 5-4.

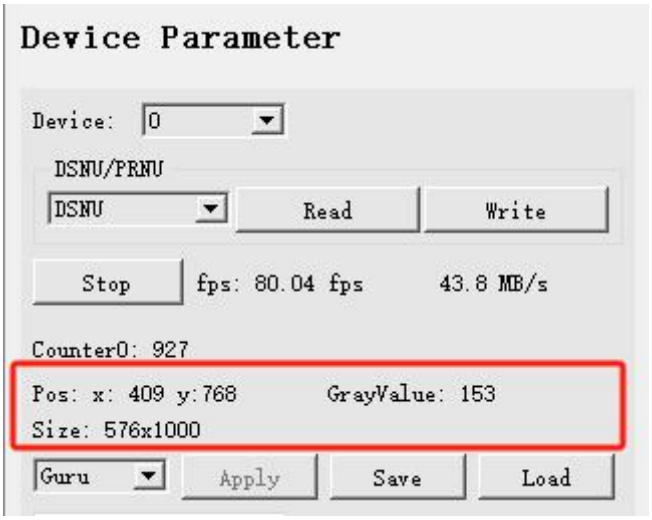


Figure 5-4

5.1.2. Window Control

The functions of the window control are the common ones of minimizing, maximizing, and closing the window.

5.1.3. Image Capture

The image capture module provides basic photo and video functions for the camera. Users can choose different image formats for capturing photos and customizing video length according to their needs. The images are saved by default in the img folder under the software root directory.

5.1.4. Parameters

The main functions and parameters of the camera are all expanded under this module, and the output method of the camera is also controlled here. Users can expand and use the corresponding function modules according to their needs.

5.1.5. Image Adjustment

Users can adjust the image gamma value, contrast value, and set left and right color

levels on the image adjustment interface based on the difference between the real-time preview effect and the actual sample to achieve the desired image effect.

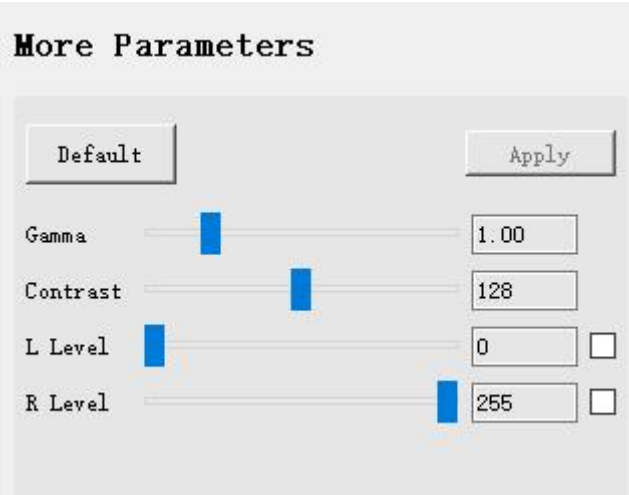


Figure 5-5

5.1.6. Software Log

Record the user's interaction with the software in real-time, including user actions and response results, to provide reference information for troubleshooting common issues.

5.2. image capture

This section provides a detailed introduction to the functions of the image capture module, including the steps for some functions.

As shown in Figure 5-6, the image capture module supports the basic camera functions of taking pictures and recording videos.

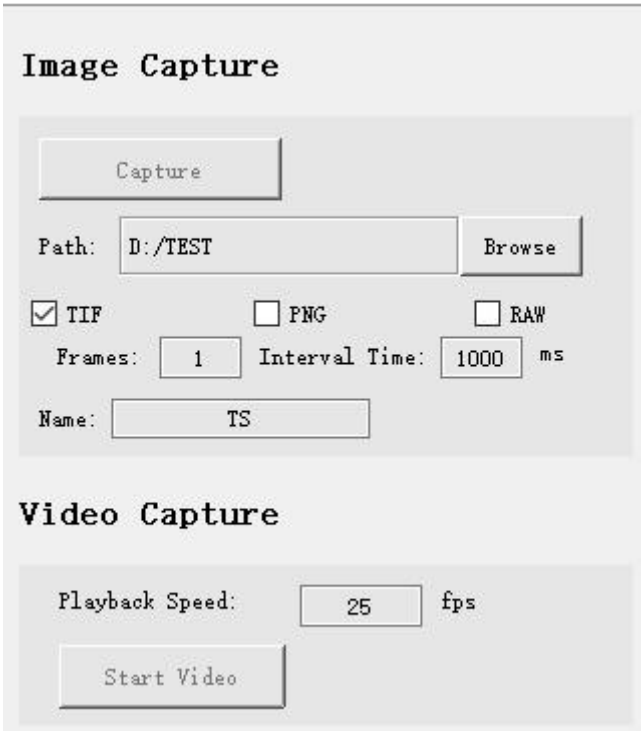


Figure 5-6 Image capture interface

1) **Capture:** The "Capture" button is clicked to take a photo.

2) **Path:** Set the default storage path for images and videos, and click ... to modify.

3) **Image Name:** The default prefix for image names, which can be customized.

4) **RAW/PNG/TIF:** Picture format selection, supports RAW ,PNG and TIF formats for original images, default TIF format, supports simultaneous selection.

5) **Total Frames:** Set the number of photos taken at a time, with one photo saved by default.

6) **Interval Time:**Image capture interval, default is 1000 ms, minimum is 0.

7) **Playback Speed:** Video recording frame rate control, default is 25 fps.

8) **Start Record:** Start recording button; clicking it again will stop the recording. Saved as .avi video format.

Note:

1) *When storing RAW format images, the first 1024 bytes of data are header information for the image, which needs to be skipped.*

2) *When storing tif format images, all image adjustment algorithms need to be set to*

default, as shown in Figure 5-5. Otherwise, the saved image will be processed by the processing software, such as color grading.

3) *Streaming mode for saving images may result in missing frames, so it is recommended to use triggered mode for saving images.*

4) *When using external trigger to save images, the number of triggered images needs to be consistent with the number of saved images, otherwise image overwrite will occur.*

*For example, if you want to save 100 images (9072*1024), then the triggered number should be 100*1024.*

5) *Triggered mode for saving images pre-allocates memory, so sufficient memory is required.*

5.3. Parameters

This functional module includes all the settings and parameters interfaces for the camera and frame grabber, and the preview switch for the camera is also reflected in this module. "Device Properties" is the parameter setting module for the camera, and "Steam Properties" is the parameter setting module for the frame grabber.

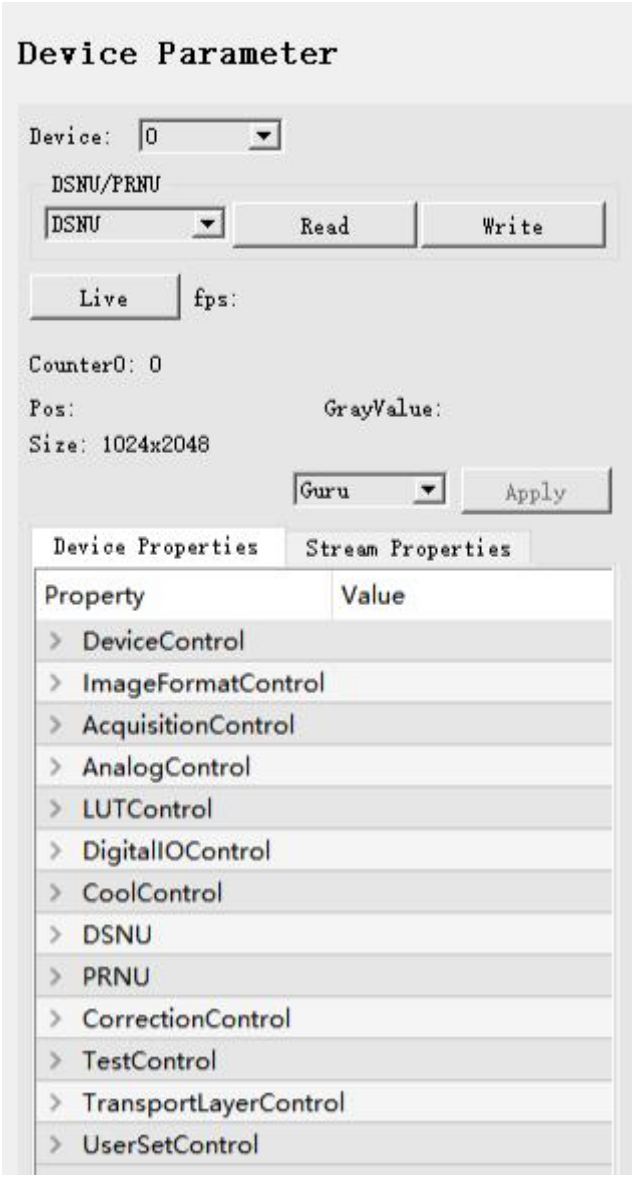


Figure 5-7

1) Device: Select one of the currently connected cameras; the list will display the parameters of the selected camera.

2) Live/Stop: The preview toggle button, when displaying "Live", indicates that the camera is connected properly but the preview is not turned on. When displaying "Stop", it indicates that the camera is connected properly and the preview is turned on.

Note: *Every time LIVE opens the stream, it needs to skip the first 3000 lines (8&10bit) or 1500 lines (12bit). Because the sensor is always exposed, the charge will keep accumulating, leading to overexposure of the first 300 lines. Waiting for 3000 lines or*

1500 lines is to wait for the circuit to stabilize completely.

3) Counter: Display the number of images captured by the camera.

4) DSNU/PRNU Read & Write: DSNU and PRNU both support reading and writing of background data. Read extracts correction data from the camera's memory, while Write writes correction data to the camera's memory. To save, click on DSNUSave or PRNUSave. The export and write formats are TXT. Two lines constitute one pixel's DSNU or PRNU correction data. The first line to line 9072*2 contains the correction data of the positive scan, while line 20481 to line (20480 + 9072*2) contains the correction data of the reverse scan. The remaining data is reserved for fill and is not genuine correction data, so it can be ignored directly.

5) Apply: When multiple cameras are connected, you can apply the current camera's device parameters to other cameras while in a stopped state.

5.3.1. DeviceControl

Property	Value
DeviceControl	
DeviceScanType	Areascan
DeviceVendorN...	Tucsen
DeviceModelN...	Dhyana 9KTDI Pro
DeviceManufac...	Tucsen CXP Camera
DeviceVersion	2E0124061801
DeviceSerialNu...	RBSE15124002
DeviceUserID	D-Sensor
DeviceSFNCVer...	2
DeviceSFNCVer...	0
DeviceSFNCVer...	0
DeviceManifest...	0
DeviceManifest...	1
DeviceManifest...	0
DeviceManifest...	4
DeviceManifest...	1
DeviceManifest...	0
DeviceManifest...	Local:TDI.zip;2000...
DeviceTLType	Coa X Press
DeviceTLVersio...	1
DeviceTLVersio...	0
DeviceLinkSelec...	0
DeviceLinkSpeed	0.00000
DeviceLinkThro...	0.00000
DeviceLinkCom...	0.00000
DeviceReset	{Command}
DeviceIndicator...	Active
DeviceTempera...	54.77856
SensorTemper...	10.11812
Timestamp	2,256,275,542,136
TimestampIncr...	8
TimestampReset	{Command}
TimestampRes...	0

Figure 5-8

It is used to display camera parameter information and settings, including basic information (read-only), UserID settings, camera reset, temperature display for the

Device and Sensor, timestamp display, and so on. As shown in Figure 5-8.

Device Scan Type: The acquisition card type selection supports "Linescan" and "Areascan". Linescan mode cameras have only one line of data at height, and the Height cannot be changed; Areascan camera height data can be set freely, up to 32768; The height settings of slave and master are independent, and different heights can be selected for preview or capture;

DeviceVersion: Displays the firmware version number of the camera (read-only);
DeviceSerialNumber: Displays the serial number of the camera (read-only);
DeviceUserID: User-defined input, saved to the non-volatile memory inside the camera. It will not be lost after power-on next time. When integrating multiple cameras into a system, the parameter can be modified to distinguish different cameras;
DeviceReset: Device reset button. Clicking this button will perform an online restart operation on the camera. After the camera restarts, it will load the selected UserSetDefault parameter;

DeviceTemperature: Displays the real-time temperature of the camera's motherboard (read-only);
SensorTemperature: Displays the real-time temperature of the sensor (read-only).

5.3.2. ImageFormatControl

This module can be used to set the width, starting OffsetX, OffsetY, horizontal, vertical binning, horizontal mirroring, bit depth switching, test mode, line scanning direction, TDI stage, and other settings for images.

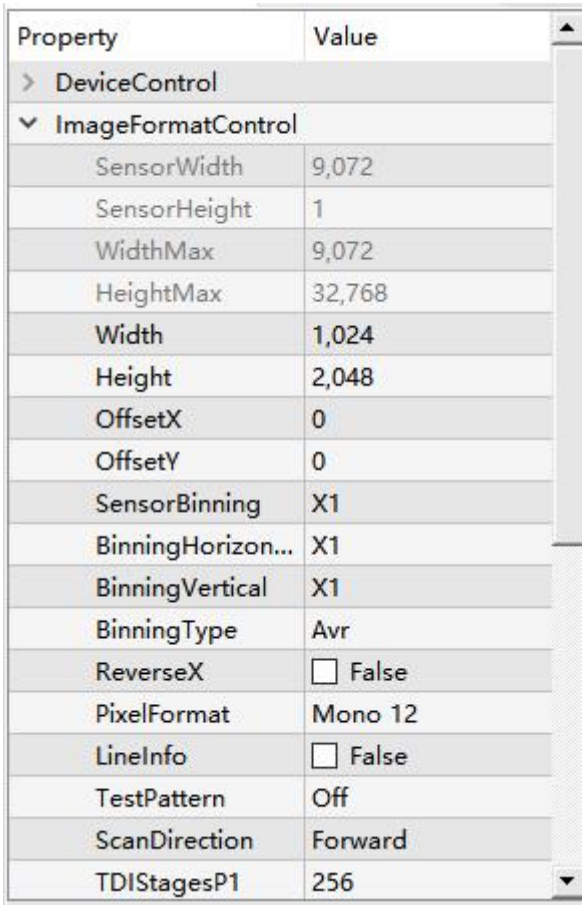


Figure 5-9

SensorWidth: Display of the width of the camera sensor;

SensorHeight: Display of the height of the camera sensor;

WidthMax: Maximum width that can be set by the camera;

HeightMax: Maximum height that can be set by the camera;

Width: Set the horizontal width of the image. The allowed input range is 256-9072, with a minimum step size of 16. The maximum value after binning will change. Please refer to "WidthMax".

Height: Set the vertical height of the image. It cannot be set to 1 in Linescan. The actual vertical resolution of the image is Height * BufferHeight. Areascan can be set to a maximum of 32768.

OffsetX: Set the horizontal starting point of the image. Offset+Width ≤ 9072, with a minimum input of 0 and a step size of 16;

OffsetY: Sets the vertical starting point of the image, that is, the number of lines from which the image starts to output. For example, OffsetY=256 means that the first 256 signals scanned are filtered and not included in the data. The input range is 0-32768, with a step size of 1. This setting is only valid in TDI mode.

Sensorbinning: Vertical Binning supports X1 and X2. After binning, it is necessary to either double the motion speed or halve the line frequency to ensure proper image quality.

BinningHorizotal: Supports X1, X2, X4, X8 modes. After binning, the resolution is reduced. You can choose whether to output Sum or Avr by "BinningType".

BinningVertical: Supports X1, X2, X4, X8 modes. After binning, the resolution is reduced. You can choose whether to output Sum or Avr by "BinningType".

BinningType: Binning type switching, supports Sum and Avr. Sum is to add and sum up the pixels of several rows or columns as the output pixel of binning; Avr is to average the pixels of several rows or columns as the output pixel of binning.

ReverseX: Flip the image horizontally.

PixelFormat: Bit depth switching, supports 8bit, 10bit and 12bit. When selecting 8bit, the output bit depth of the image is 8bit; when selecting 10bit and 12bit, the output bit depth of the image is 16bit， because the data on PC side needs to be aligned by bytes.

LineInfo: Camera line information. When enabled, 64 additional pixels are added after each line of data to facilitate debugging information between lines.

TestPattern: Test mode, support "horizontal grayscale gradient" as shown in Figure 4-12, "horizontal grayscale bevel gradient" as shown in Figure 4-13, "horizontal grayscale bevel moving gradient" as shown in Figure 4-14, "sensor test image" as shown in Figure 4-15.

ScanDirection: Set the camera line scanning direction. Supports Forward, Reverse, LineIn (externally triggered control) modes. Users can switch modes based on actual usage scenarios to match the line scanning direction.

TDIStagesP1: TDI stage P1 array setting. Supports 4, 8, 16, 32, 64, 96, 128, 160, 192,

224, 240, 248, 252, 256 stages. In TDI mode, under the same light intensity, the higher the TDI level, the higher the sensitivity. It can capture more light signals in weak light environments.

Note:

1) *Only in the preview-stopped state can you set Width, OffsetX, bit depth, Binning switching, etc.;*

2) *The Width and OffsetX must be a multiple of 16. If the setting is incorrect, the software automatically returns to the last correct value set;*

5.3.3. AcquisitionControl

This module is used to set the camera's motion mode, line frequency, external trigger mode, trigger readjustment, and output mode, as well as trigger statistics display, etc. The settings interface is shown in Figure 5-10.

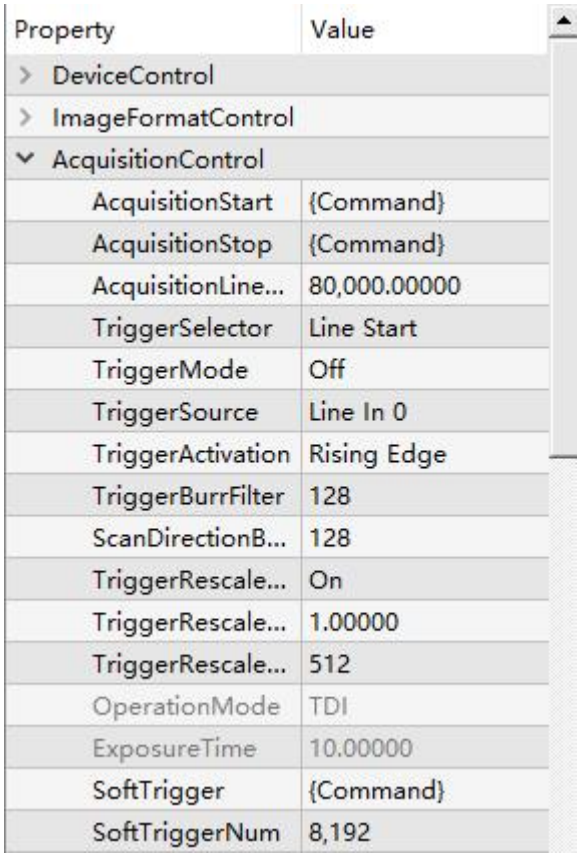


Figure 5-10

AcquisitionStart: In streaming mode, the scan start button;

AcquisitionStop: In streaming mode, the scanning pause button;

AcquisitionLineRate: Line frequency setting, valid in TDI mode, not supported in Area mode. The conversion relationship between line frequency and exposure time is as follows: exposure time = TDI progression/line frequency (s), maximum exposure time 256ms;

TriggerMode: trigger mode setting, which turns on the trigger mode when it is in the On state. In TDI mode, one pulse triggers one line of data. In Area mode, one pulse triggers one frame of image, and the height of the image is determined by TDIStagesP1;

TriggerSource: Trigger type selection supports three types of triggers: Line In0 external trigger, Software trigger, and CXPin frame grabber trigger. When using Line In0, the trigger source connects to the camera trigger port via a Hirose line to trigger the image output. When using Software, the trigger is triggered by clicking on SoftTrigger. When using CXPin, the trigger source connects to the capture card via a trigger line on the capture card to trigger the image output.

TriggerActivation: Trigger condition setting, supporting rising edge, falling edge, and double edge triggering (trigger frequency, doubled pulse count);

TriggerBurrFilter: The burr filtering function specifies the effective pulse width of the trigger signal, with the unit of ns. For 8bit and 10bit, it is 11.5ns, and for 12bit precision, it is 13.9ns. For instance, when set to 100 in 12bit, the actual value is: 100/13.9 ≈ 7.2 >> 13.9*7 = 97.3ns. The trigger signal is considered valid only when its level remains above the threshold for a duration longer than the set value. If the signal quality is poor, resulting in a pulse width shorter than the set value, it will be filtered out, leading to the actual number of pulses received by the camera being less than the number of pulses given by the customer. Increasing this value will simultaneously increase the trigger delay.

ScanDirectionBurrFilter: The threshold adjustment of the scanning direction control signal is measured in ns. For 8bit and 10bit, it is 11.5ns, and for 12bit precision, it is 13.9ns. For instance, when set to 100 in 12bit, the actual value is: 100/13.9 ≈ 7.2 >> 13.9*7 = 97.3ns. This means that the reversing signal must last for 97.3 ns to trigger a change in direction. Increasing this value will result in a synchronous increase in the

reversing delay.

TriggerRescalerMode: Amplify or reduce the frequency of external trigger signals;

TriggerRescalerRate: Set the rescaler coefficient to adjust the external trigger signal frequency. You can enter a value from 0.01 to 100. For example, if the external trigger frequency is 100kHz and the rescaler coefficient is 2, the final actual trigger frequency is 200kHz;

Note:

If the re-adjusted frequency is not within the camera's supported frequency range, frame loss may occur.

TriggerRescalerFilter: Setting for the trigger retune filter coefficient. It is used to stabilize the external trigger signal jitter after retune. A larger value results in a more stable frequency after retune. Values can be selected from 16, 32, 64, 128, 256, and 512.

Note:

1) *Setting "TriggerRescalerFilter" can cause an increase in trigger signal delay. For example, if the rescaling factor is set to 512, it will take 512 trigger pulses before an image line is output. Therefore, the overall pulse output will be delayed by 512 pulse times, regardless of the value set for "TriggerRescalerRate";*

2) *After TriggerRescalerFilter, the number displayed in RxTriggerNum will be greater than the actual number of pulses sent. The higher the frequency, the greater the number, and vice versa;*

3) *TriggerRescalerFilter is suitable for platforms that move at a constant speed, but the quality of the output signal is jittery. If the motion speed of the platform is not constant, this feature is not recommended*.

OperationMode: Mode selection, supports TDI and Area modes. Area mode is recommended for focusing on fixed object distances for still images.

ExposureTime: exposure time adjustment in the Area mode, can be entered from 1 to 10000ms;

SoftTrigger: Soft trigger command button;

SoftTriggerNum: The setting for the number of triggers per soft trigger, with an input range of 1 to 4294967295;

TriggerStatistics: The statistical function module is activated, and the function interface is shown in Figure 5-11.

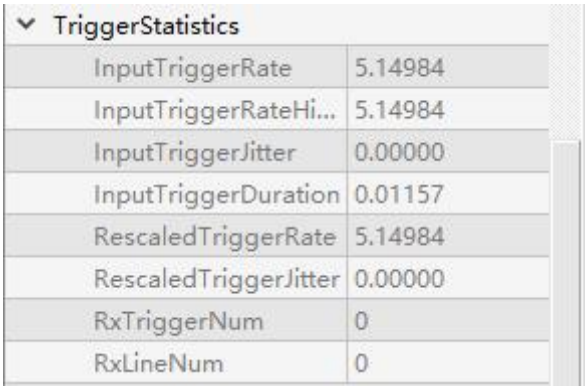


Figure 5-11

InputTriggerRate: Displays the frequency of the trigger input;

InputTriggerRateHighest: Displays the maximum frequency of the trigger input.;

InputTriggerJitter: Displays the jitter of the trigger input signal, the smaller the value, the better the signal quality;

InputTriggerDuration: Displays the time until the trigger input signal is high;

RescaledTriggerRate: Displays the signal jitter after trigger input re-adjusted;

RescaledTriggerJitter: Displays the signal jitter after trigger input re-adjusted;

RxTriggerNum: The number of pulses in the external trigger input signal, which is reset once when starting the acquisition;

RxLineNum: The number of image lines sent by the camera through the CXP interface, which is reset once when starting the acquisition;

Note:

There are usually two reasons for RxTriggerNum >= RxLineNum

1) *The actual frequency is higher than the frequency supported by theory;*

2) *This situation can also occur when the signal is within a reasonable range, but due to the quality of signal transmission, the time interval between the two trigger edges is less than the minimum line period;*

5.3.4. DigitalIOControl

This module is utilized to configure the camera's external trigger output function, and the function interface is presented in Figure 5-12.

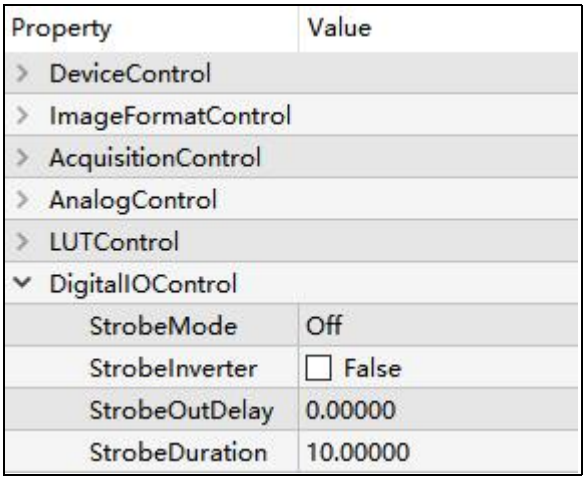


Figure 5-12

StrobeMode: Trigger output gear selection, supporting Off/On/Timed/PulseWidth;

1) OFF: low- level;

2) On: high- level 3.3V;

3) Timed: Configure the pulse period through StrobeDuration, with a duty cycle of 50%;

4) PulseWidth: Equivalent to copying the signal of TriggerInput1, adjusting the delay time through StrobeOutDelay;

StrobeInverter: Output signal high and low level reversal;

StrobeOutDelay: Output signal delay time μs;

StrobeDuration: High-level output signal time (effective under Timed mode)us;

5.3.5. AnalogControl

This function module is used to set the analog and digital gain of the camera and adjust the black level as shown in Figure 5-13.

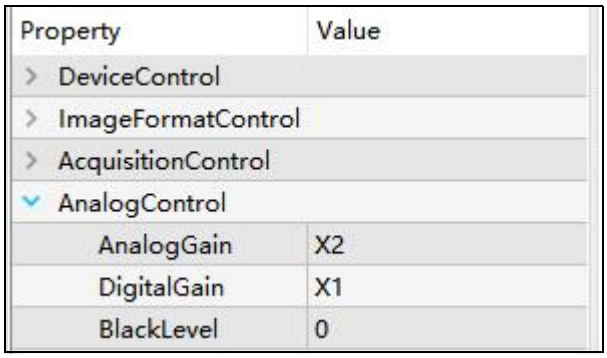


Figure 5-13

AnalogGain: Supports 2 to 8 switching, in steps of 0.5;

DigitalGain: Supports 0.5~10 switching,in steps of 1;

BlackLevel: Increase or decrease the background grayscale value of the image, adjustable from -255 to 255.

5.3.6. LUTControl

This module is used to set the LUT , and the setting interface is shown in Figure 5-14.

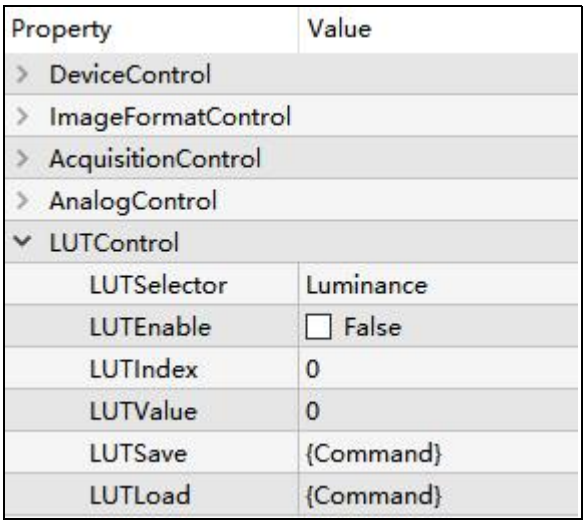


Figure 5-14

LUTEnable: LUT control switch, not enabled by default;

LUTIndex: Input value, which is automatically loaded with the output value corresponding to the applied curve after input, in the range 0 to 4095;

LUTValue: Output value, loaded according to the inputted LUTIndex value, can be

manually modified and saved, range 0 to 4095;

LUTSave: Saving of the modified curve.;

LUTLoad: Loading of LUT curves written by the application;

Note:

Before using the LUT function, users would need to open the UpdateTool software to write LUT configuration according to actual use.

LUT settings on UpdateTool

The software operation interface is shown in Figure 5-15.

Gamma: The corresponding INPUT-OUTPUT curve is adjustable after inputting the value;

Apply: Applies the current call to the LUT curve;

Default: Restores the state of the LUT curve to its default settings (Gamma=1);

Save File: Saves the current LUT curve to the specified file path;

Load File: Loads the saved LUT curve file;

Download: Configuration of the currently applied LUT curve into the camera;

Upload: Loading and reading the applied LUT curve from the camera (the LUT curve needs to be saved in SamplePro before it can be loaded and read);

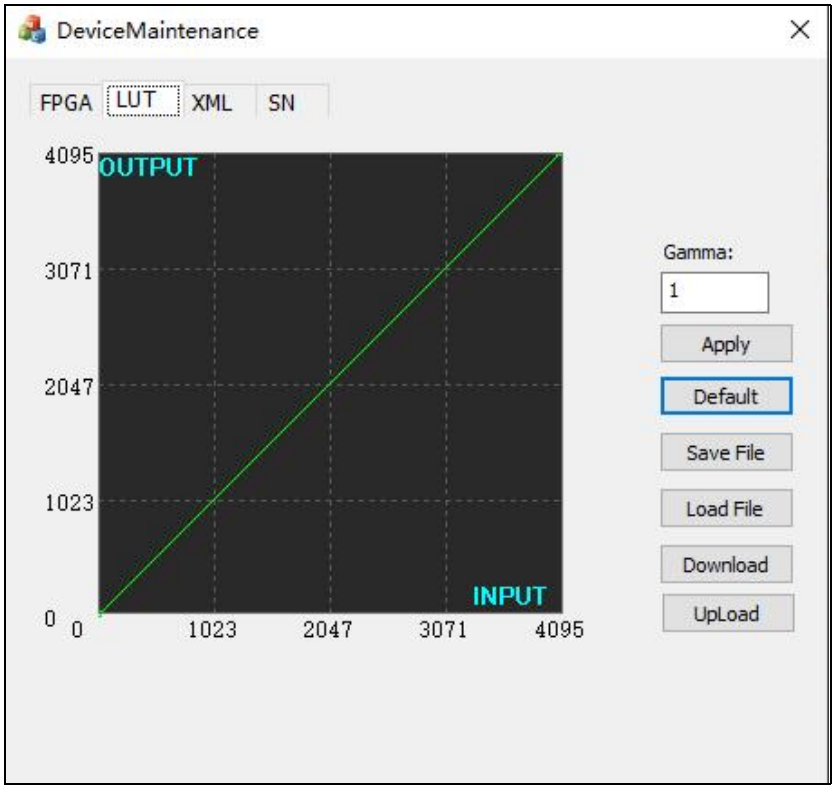


Figure 5-15

The process of writing the LUT configuration

1) Open the "UpdateTool" tool and select the "LUT" interface as shown;

2) At first enter the required “Gamma” value;

3) Click “Apply” to apply the selected curve;

4) Click “Download” to configure the curve into the camera.

5.3.7. CoolControl

It is used to set the cooling function of the camera. The setting interface is shown in Figure 5-16.

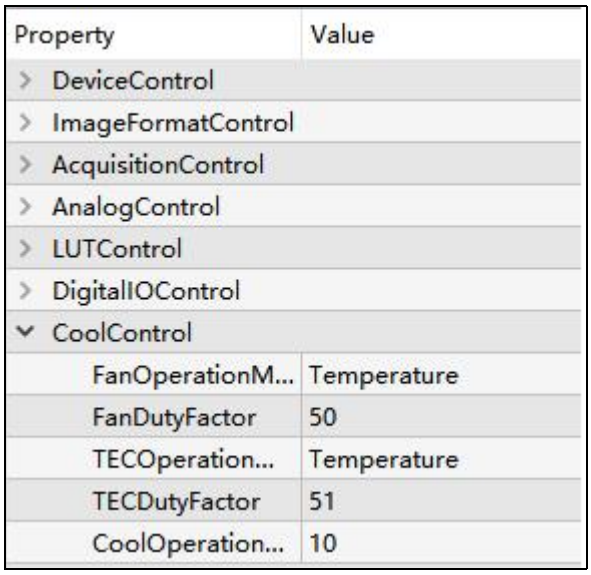


Figure 5-16

FanOperationMode: Off (turn off the fan), On (turn on the fan), Temperature (constant temperature mode);

Fan duty factor: fan speed gear, adjustable from 20 to 100%;

TECOperationMode: Off (turn off the fan), On (turn on the fan), Temperature (constant temperature mode);

TECDutyFactor: TEC power gear, adjustable from 0 to 100%;

CoolOperationTemperature: Refrigeration target temperature, adjustable range -30~75℃, default 10℃;

Note：

1) *The target of temperature control is the sensor temperature;*

2) *When the sensor temperature exceeds 75°C or device temperature exceeds 85°C, the TEC is forced to turn off and the fan runs at 100%. When the temperature is re-cooled below 75°C, users who select the "Temperature" mode will switch to the "Temperature" mode, while other modes continue to run at 100% and the TEC continues to turn off until the parameters are reset;*

3) *When set to the "Temperature" mode, the FanDutyFactor and TECDutyFactor are not applicable.*

5.3.8. DSNU

DSNU is used to calibrate the camera's dark field non-uniformity..The settings interface is shown in Figure 5-17.

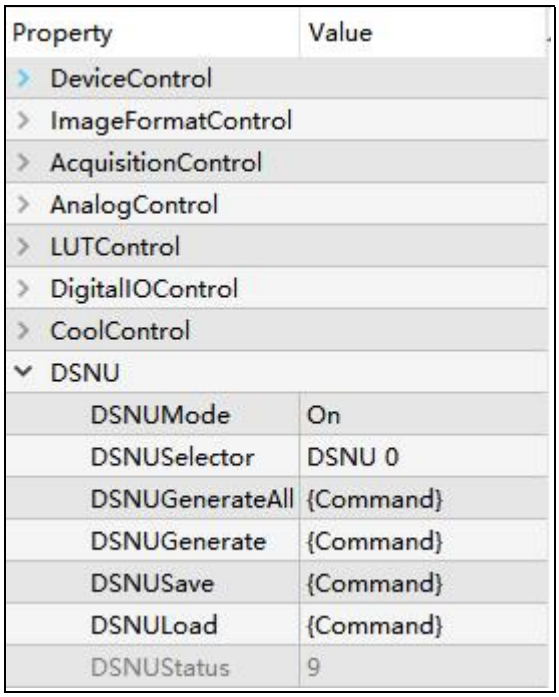


Figure 5-17

DSNUMode: DSNU correction enabling switch, Off position turns off DSNU, the ON position turns on DSNU;

DSNUGenerateAll: When the camera is in a dark environment with the current exposure time, click to perform online DSNU correction for all analog gains and bit depths;

DSNUGenerate: When the camera's current exposure time is in a dark, lightless environment, click to perform online DSNU correction for the current analog gain and bit depth;

DSNUSave: Save the current DSNU results to non-volatile memory, which will not be lost during power off. The next time, the saved DSNU data can be directly loaded and used from the non-volatile memory;

DSNULoad: loads the saved DSNU data from non-volatile storage;

The DSNU operation counter, when using DSNUGenerateall, DSNUGenerate, **DSNUStatus**：DSNUSave, and DSNULoad to switch bit depth, simulate gain, and DSNU counter, will increment.

Operation steps

1) Set the camera parameters according to the actual application;

2) Place the camera in a dark environment without light;

3) Open the camera preview;

4) Click "DSNUGenerateAll" to perform DSNU calibration on all simulated gain modes, and automatically save the calibration results; or click "DSNUGenerate" to perform DSNU calibration on the currently set gain mode. Click "DSNUSave" to save the results, otherwise the calibration data will be lost after power off;

Note:

1) *DSNU should be performed under dark field and no light conditions;*

2) *The background data is different under different line frequencies, different TDI stages, and different temperature backgrounds, and needs to be calibrated again;*

3) *If you choose DSNUGenerate, you need to re-calibrate DSNU when switching gain modes or* bit depth*;*

5.3.9. PRNU

DSNU is used to calibrate the Photo Response Non-Uniformity of the camera, and the settings interface is shown in Figure 5-18.

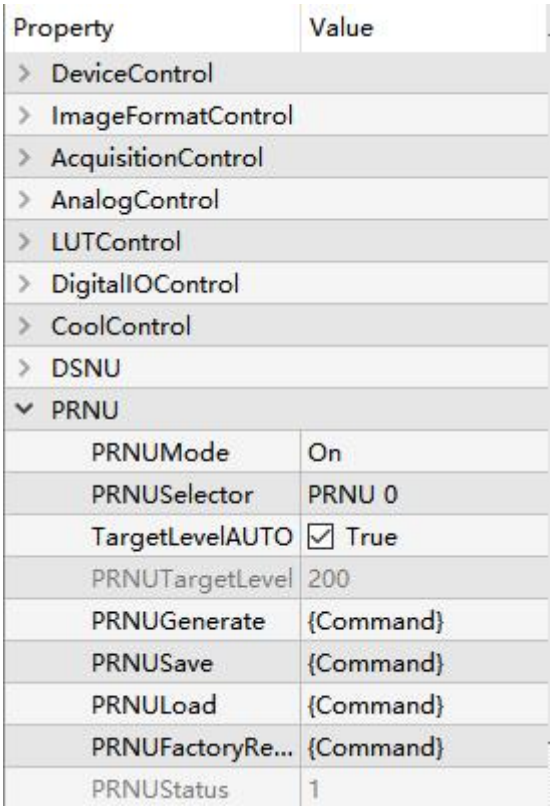


Figure 5-18

PRNUMode: PRNU correction enabling switch, Off position turns off PRNU, ON position turns on PRNU;

PRNUSelector: Select the PRNU number for the operation, supporting a total of 5 sets of data from PRNU0 to PRNU4;

TargetLevelAUTO: Automatic mode (the system automatically calculates the current image brightness mean), check to enable, click PRNUGenerate under bright uniform light to automatically generate PRNU correction data;

PRNUTargetLevel: In manual PRNU mode, after unchecking "TargetLevelAUTO," the camera will correct the current gray value to the set PRNUTargetLevel value. Click "PRNUGenerate" to automatically generate PRNU correction data;

PRNUGenerate: Click to perform PRNU correction online;

PRNUSave: Save the current PRNU results to non-volatile memory and bind with the selected PRNUSelector parameters;

PRNULoad: Load the PRNU correction data of the selected PRNU number from the non-volatile memory into the memory based on the PRNUSelector selection;

PRNUFactoryReset: Restore the PRNU number selected by the PRNUSelector to the factory default parameters;

PRNUStatus： The PRNU operation counter, when utilizing PRNUGenerate, PRNUSave, PRNULoad, and PRNUFactoryReset to toggle PRNUSelector, will increment. Nevertheless, adjusting bit depth or simulating gain will not enhance the PRNU counter.

Operation steps

1) EEnable PRNU;

2) Select which group to save the parameters by the "PRUNSelector";

3) Set the target. You can choose automatic or manual. Manually set grayscale value should match the actual light source grayscale, i.e., if the actual uniform light environment grayscale is 100, the target should be set to 100;

4) Click "PRNUGenerate" to perform PRNU correction. During the correction process, the preview screen may flicker. When the preview screen stabilizes, it indicates that the correction has been completed;

5) Click "PRNUSave" to save the correction results to the group selected by "PRNUSelector".

Note:

1) *PRNU correction should be performed after DSNU correction;*

2) *Under different line frequencies, different TDI stages, and different temperature backgrounds, the background data is different and needs to be calibrated again;*

3) *Correction should be performed in preview mode;*

4) *Correction should be performed under bright uniform light brightness.*

5.3.10. CorrectionControl

The CorrectionControl module is used to modify the corrected DSNU and RPNU values. The setup interface is shown in Figure 5-19;

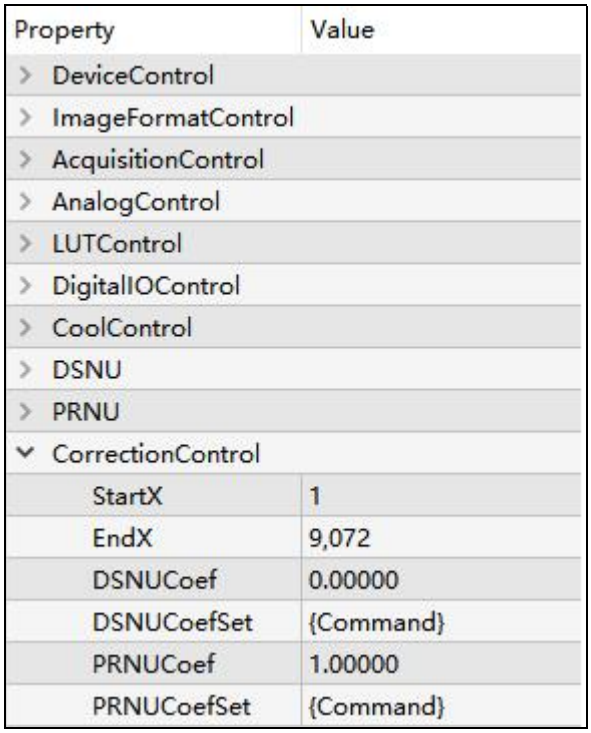


Figure 5-19

StartX: Selects the X coordinate of the starting pixel and can be entered in the range 1 to 9072;

EndX: elects the X coordinate of an ending pixel, which can be entered in the range 1 to 9072;

DSNUCoef: Set an additional DSNU correction value for the selected area gray value minus the set value (example: under DSNU, the average gray value of the image is 100, set DSNUCoef=100, then after Correction, the average gray value of the image is 0);

DSNUCoefSet: Configuration according to the set DSNUCoef value;

PRNUCoef: Set an additional PRNU correction value, multiplying the gray value of the selected area by the set value (example: under PRNU, the average gray value of the image is 2000, set PRNUCoef=1.024, then after Correction, the average gray value of the image is 2048);

PRNUCoefSet: Configuration according to the set PRNUCoef value;

Note:

1) *When doing PRNUCoefSet and DSNUCoefSet, switch DSNU and PRNU to the On gear to see the effect of CoefSet;*
2) *Correction parameters are not saved after the camera is powered off;*
3) *Corrections for multiple areas can be made;*

5.3.11. CoaXPress

This module is used to display and set up the connection to the CXP. The setup interface is shown in Figure 5-20.

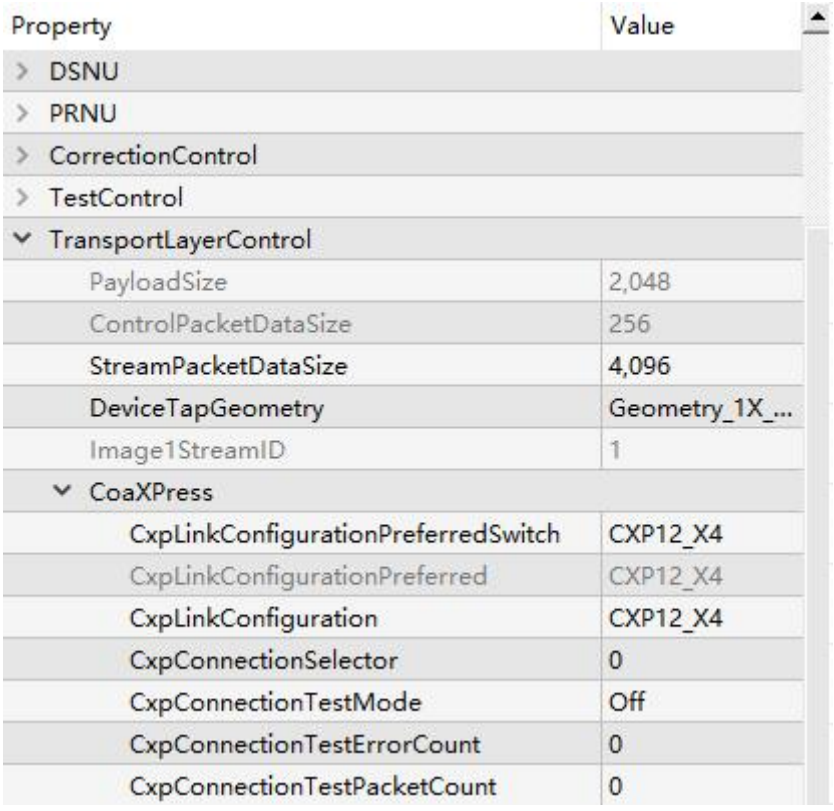
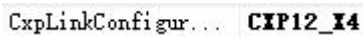


Figure 5-20



:CXP default connection setting;

:CXP mode switching, default CXP12_X4,

cannot be switched in streaming state;

5.3.12. UserSetControl

This module is used to save the parameters set by the user, and supports up to 2 groups. The settings interface is shown in Figure 5-21;

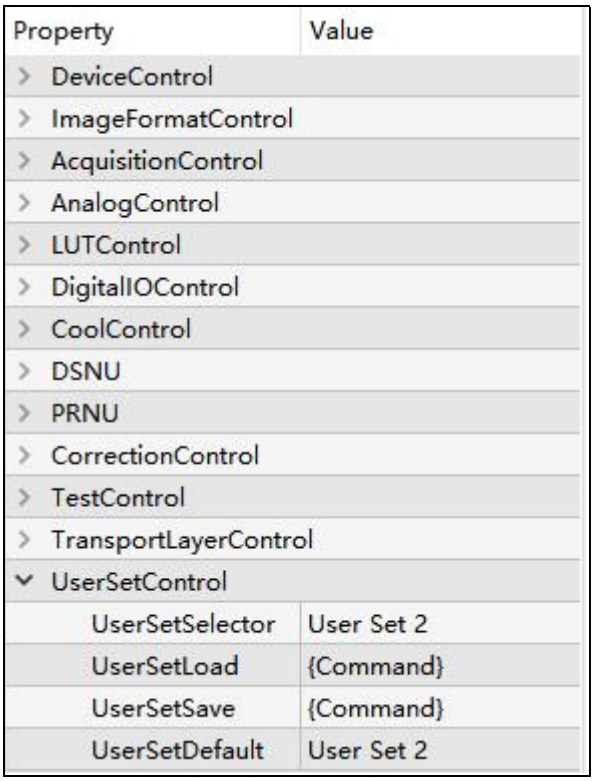


Figure 5-21

UserSetSelector: User Settings Storage offers three configurations: Default, User Set1, and User Set2. The Default setting is the factory default parameter and cannot be modified. User Set1 and User Set2 can be saved through the UserSetSave command;

UserSetLoad: The camera loads the camera configuration parameters selected by UserSetSelector;

UserSetSave: Saves the modified configuration parameters in the camera configuration selected by UserSetSelector. Saving is invalid when Default is selected;

UserSetDefault: A set of user configurations that are loaded by default after the

camera is reset or restarted. If the default load setting for the user configuration module is User Set1, the parameters loaded after the camera is reset or restarted are those of User Set1;

5.3.13. Steam Properties

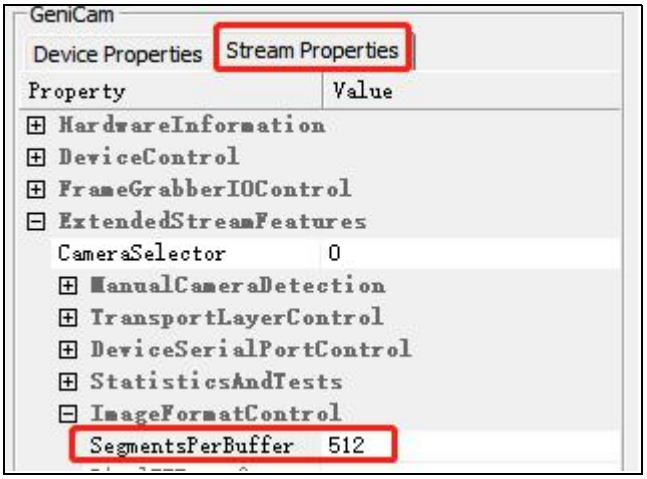


Figure 5-22 KAYA Frame Grabber

This module is used to set theframe grabber connected to the camera, and the vertical resolution of the acquired image needs to be set at this setting. Different frame grabber setting interfaces are different, the setting interface of the KAYA frame grabber is shown in Figure 5-21, the interface of the Euresys frame grabber is shown in Figure 5-22, and the vertical resolution of the Matrox frame grabber is fixed at 1024 and cannot be modified. The maximum BufferHeight can be set to 65535. When the camera mode is set to "Area", the BufferHeight value is recommended to be set to an integer multiple of 256.

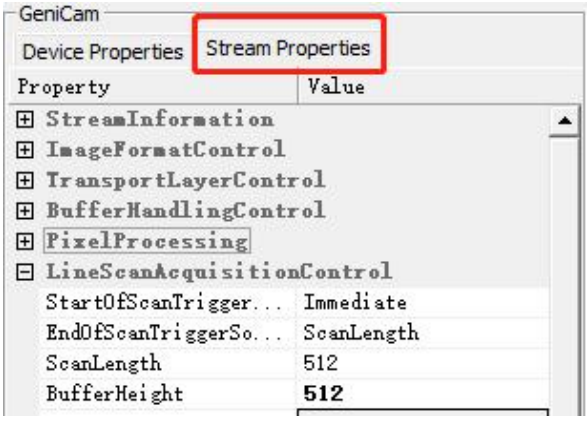


Figure 5-23 Euresys Frame Grabber

When the trigger mode CXPin is enabled, the setting interface and Pins definition of the two frame grabbers are also different.

KAYA frame grabber

Tab 5-1 KAYA frame grabber pin definition

J18	Signal Name	I/O Standard	Description
1	Din[0]	LVDS	Pin 1 of this header is the positive signal and pin 2 in the negative signal of this LVDS. The differential pair is converted to a single input on the FPGA.
2			
3	Din[1]	LVDS	Pin 3 of this header is the positive signal and pin 4 in the negative signal of this LVDS. The differential pair is converted to a single input on the FPGA.
4			
5	Rout[0]	LVDS	Pin 5 of this header is the positive signal and pin 6 in the negative signal of this LVDS. The differential pair is converted to a single input on the FPGA.
6			
7	Rout[1]	LVDS	Pin 7 of this header is the positive signal and pin 8 in the negative signal of this LVDS. The differential pair is converted to a single input on the FPGA.
8			
9	io_out[0]	3.3-V LVTTL	Optically isolated outputs
10	io_out[1]	3.3-V LVTTL	Optically isolated outputs
11	io_out[2]	3.3-V LVTTL	Optically isolated outputs
12	io_out[3]	3.3-V LVTTL	Optically isolated outputs
13	io_in[0]	3.3-V	Optically isolated inputs

		LVTTL	
14	io_in[1]	3.3-V LVTTL	Optically isolated inputs
15	io_in[2]	3.3-V LVTTL	Optically isolated inputs
16	io_in[3]	3.3-V LVTTL	Optically isolated inputs
17	OptoCoupled GND	-	Ground signal for opto-isolated signals on this connector
18	GND	-	Reference ground signal - Board GND
19	gpio_vt[0]	TTL	General Purpose IO
20	gpio_vt[1]	TTL	
21	gpio_vt[2]	TTL	
22	gpio_vt[3]	TTL	
23	gpio[0]	3.3-V LVTTL	
24	gpio[1]	3.3-V LVTTL	
25	gpio[2]	3.3-V LVTTL	
26	gpio[3]	3.3-V LVTTL	

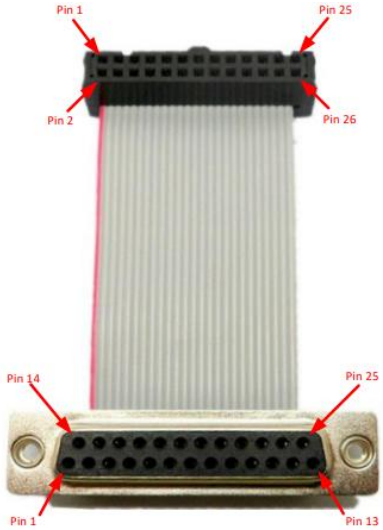


Figure 5-24 KAYA Frame Grabber Interface

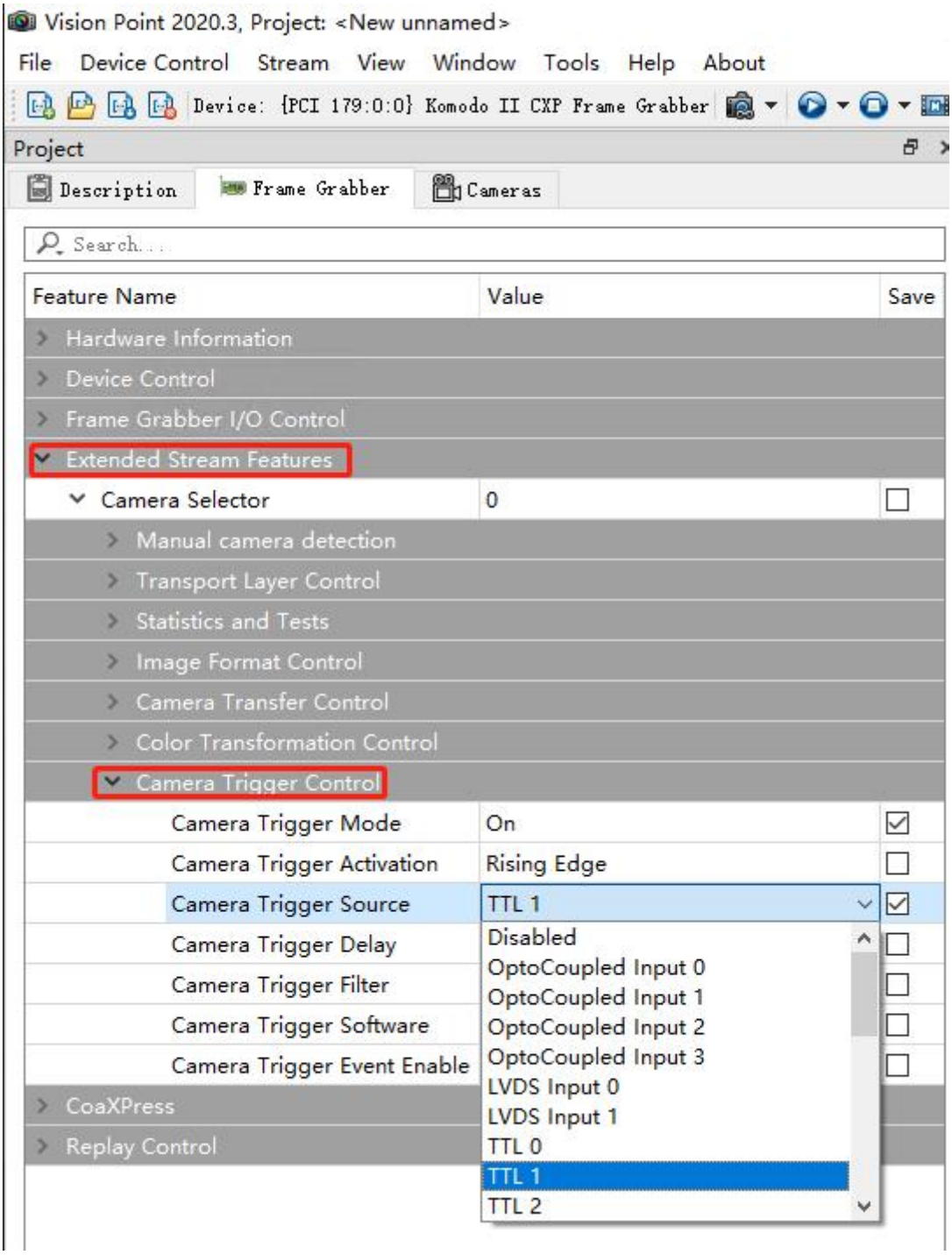


Figure 5-25

1) Under Camera Trigger Activation, select the trigger polarity RisingEdge, FallingEdge, and AllEdge according to the trigger needs;

2) Select according to interface definition under Camera Trigger Source (TTL1 is recommended).

Euresys Frame Grabber

Figure 5-26 Euresys Frame Grabber Interface

Tab 5-2 Euresys frame grabber pin definition

Pin	Signal	Usage
1	GND	Ground
2	DIN12+	High-speed differential input #12 - Positive pole
3	IIN11+	Isolated input #11 - Positive pole
4	IIN13-	Isolated input #13 - Negative pole
5	IIN14-	Isolated input #14 - Negative pole
6	IOUT12-	Isolated contact output #12 -Negative pole
7	GND	Ground
8		Not connected
9	GND	Ground
10	GND	Ground
11	DIN12-	High-speed differential input #12 - Negative pole
12	IIN11-	Isolated input #11 - Negative pole
13	IIN12+	Isolated input #12 - Positive pole
14	IIN13+	Isolated input #13 - Positive pole
15	IIN14+	Isolated input #14 - Positive pole
16	IOUT12+	Isolated contact output #12 - Positive pole
17	TTLIO12	TTL input/output #12
18	GND	Ground
19	DIN11-	High-speed differential input #11- Negative pole
20	DIN11+	High-speed differential input #11 - Positive pole
21	IIN12-	Isolated input #12 - Negative pole
22	IOUT11-	Isolated contact output #11 - Negative pole

23	IOUT11+	Isolated contact output #11 - Positive pole
24	GND	Ground
25	TTLIO11	TTL input/output #11
26	+12V	+12V Power output

The interface settings and steps are as follows:

1) Use TTL trigger signal (3.3V trigger level, not exceeding 5V), high voltage pin connected to 25TTLIO11, ground pin connected to 24GND;

2) Open the Eureysys acquisition card Demo software setting interface as follows;

3) Under Device, you need to set CameraControlMethod to RC (frame grabber trigger mode);

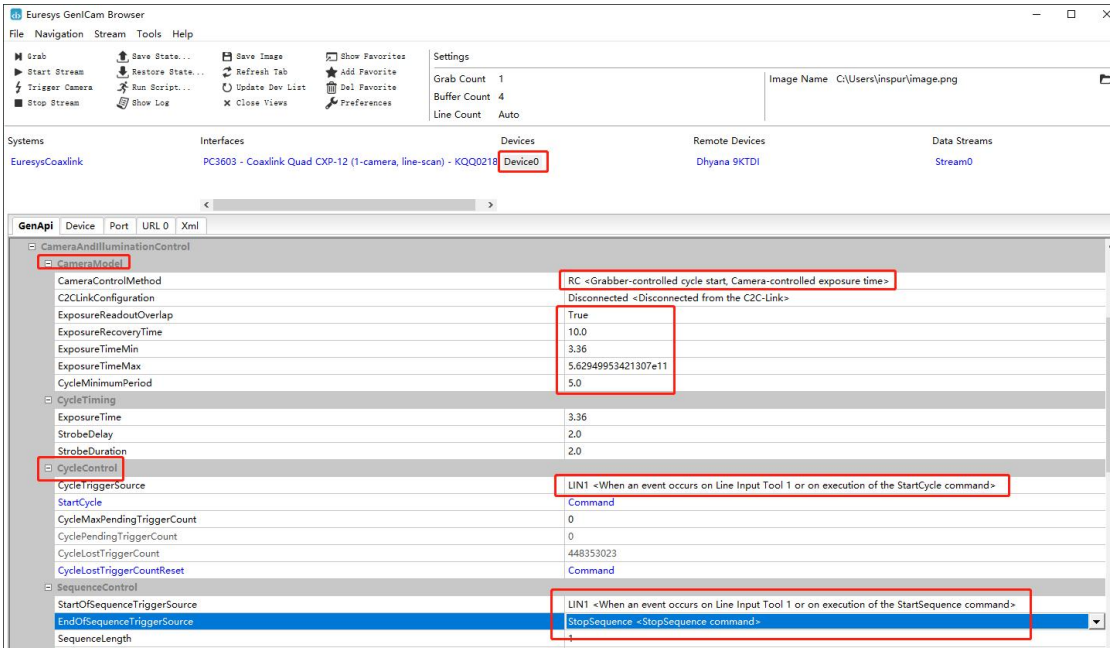


Figure 5-27

4) The corresponding setting on the frame grabber is LIN1;

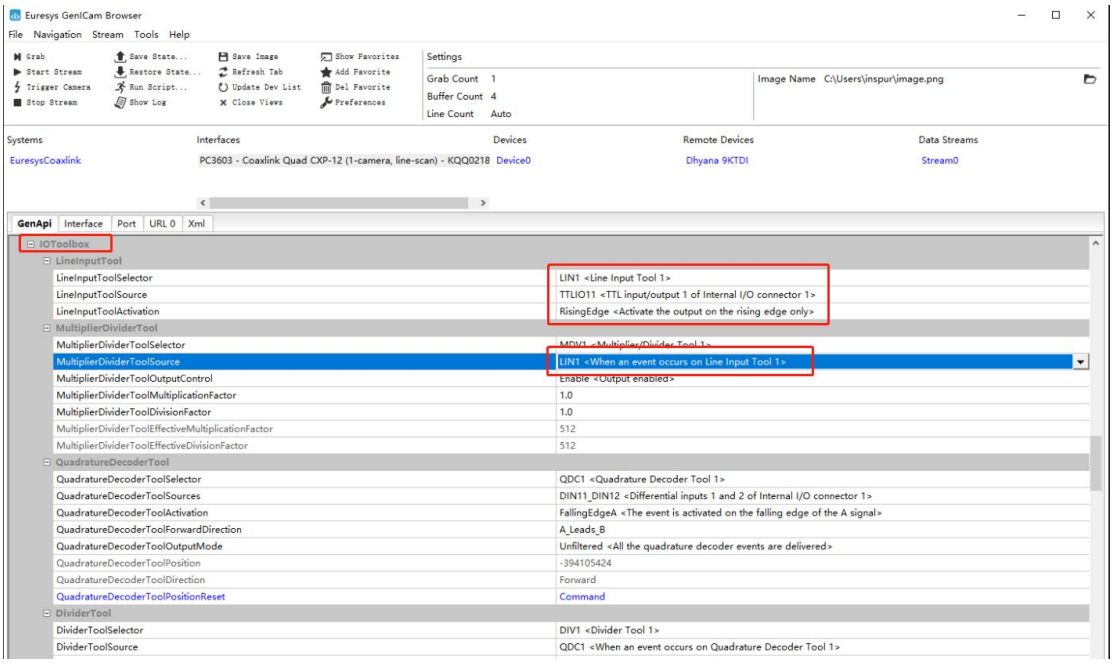


Figure 5-28

5) Under Stream, the corresponding setting is LIN1;

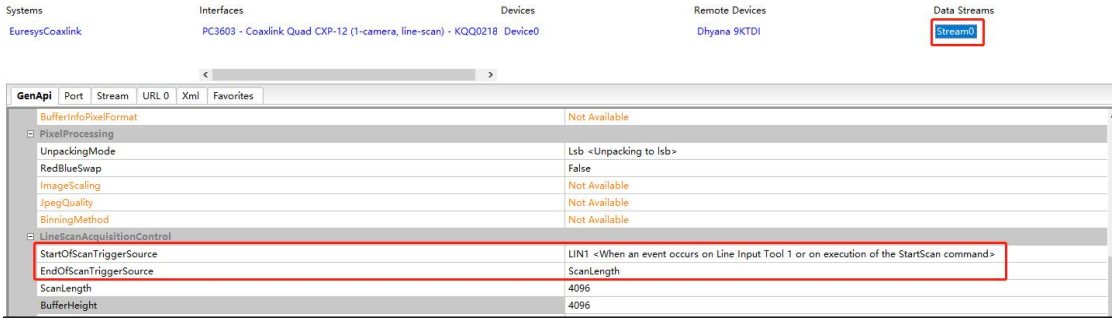


Figure 5-29

6) After the setup, configure the bit depth and resolution of the camera, and use the trigger board to generate an image.

5.4. Image Adjustment

This module includes histogram, gamma, and contrast settings. The settings interface is shown in Figure 5-30.

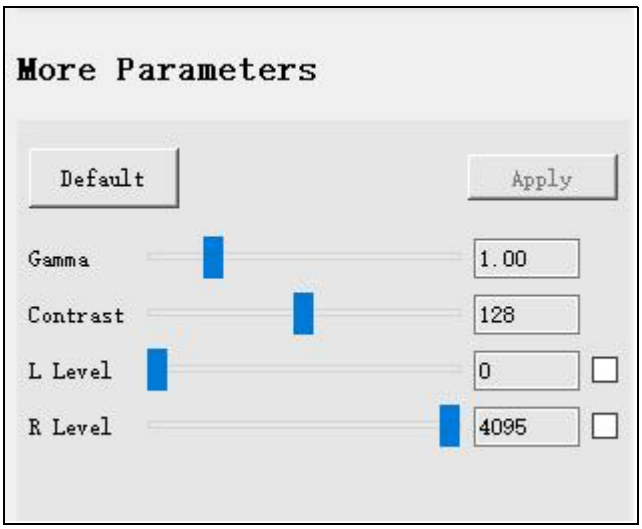


Figure 5-30

LevelL: Users can change the left color level value by manually entering or dragging the color level slider;

LevelR: Users can change the right color level value by manually entering or dragging the color scale slider;

Auto: Automatically defines the brightest and darkest pixels in each channel as white and black, and then reallocates the pixel values between them proportionally;

Gamma: The gamma value can change the brightness of the image and increase the contrast. The larger the value, the greater the grayscale and higher the brightness. The range is 0.64-2.55, with a default value of 1.00;

Contrast: The difference in brightness levels between the brightest white and the darkest black in an image, ranging from 0 to 255, with a default of 128;

Default: Click the default button to restore the parameters of the image adjustment module to the default values set by the software;

Default: Clicking the "Default" button will restore the parameters of the image adjustment module to the default values set by the software.

Note:

When capturing images in the TIFF format, it is necessary to set the parameters to

"Default" to ensure that the saved images are not processed by any algorithms. Otherwise, the saved images will be processed and may not reflect the original captured data.

6. Frequently Asked Questions

How to calculate the readout time?

The readout time of a frame of an image can be calculated according to the "row period multiplied by the number of lines",row period is the reciprocal of the line frequency.

How to calculate the line frequency?

Line rate (Hz) = sample movement speed (mm/s) / pixel interval width (mm)

For example:

Line frequency (Hz) = sample movement speed (mm/s) / pixel interval width (mm).
For example:
The width of 386 pixels is 10mm, so the width of a single pixel is 0.026mm, and the sample speed is 100mm/s.
Then the line frequency = 100/0.026 = 3846Hz
Then the trigger signal frequency needs to be set to 3846Hz.

What factors affect the camera line speed (line frequency)?

BufferHeight: affects frame rate but not line speed.
Width: the larger the width, the lower the line frequency
Binning: The line speed of the vertical 2bin is halved compared to the original, while the horizontal 2bin is independent of the line speed.
Transmission bandwidth: The default is CXP12_X4. When the bandwidth is insufficient, the software will automatically reduce it, and the line speed will be limited.limited.

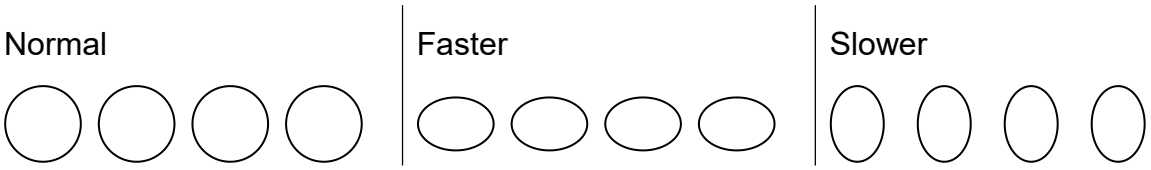
When the TDI Stage is less than 256, which rows of data on

the Sensor are read out?

When the TDI Stage is less than 256, data is read from both ends. For example, if TDI stage is set to 32 and scanned from top to bottom, the data from the bottom 32 rows is captured. If it's scanned from bottom to top, the data from the top 32 rows is captured. The readout circuits of the chip are at the top and bottom.

Why the preview image is stretched or compressed?

The camera line frequency does not match the motion speed of the object. If there is compression, it means that the motion speed is greater than the scanning speed, and if there is stretching, it means that the motion speed is less than the scanning speed.



Why is the smearing more serious when the exposure time is shorter in Area mode?

This is a normal phenomenon, as the Area mode of a line-scan camera is different from a true area-scan camera. It is processed from single-line data and is only used for focusing. For normal image acquisition, it is recommended to use the TDI mode;

What is the maximum length of CXP cable?

The recommended maximum distance is 20 meters. For longer distances, consider the Dhyana 9KTDI, which uses a fiber optic port to support longer distances.

How is the frame rate calculated in Area mode?

Actual results may vary due to computer performance fluctuations

9KTDI frame rate = 1000 / frame period / (height / TDI stage)
Frame period = FPGA internal logic time + exposure time
FPGA internal logic time = (4096 / maximum line frequency * 0.9) ms

For example, Dhyana 9KTDI PRO quad channel (CXP12*2), TDI stage is 256, resolution 2272 (W) * 10000 (H), exposure time is 10ms
FPGA internal logic time = (4096 / 600 * 0.9) = 7.585185 ms
Frame period = 7.585185 + 10 = 17.585185 ms
Frame rate = 1000 / 17.585185 / (10000 / 256) = 1.455

Why is there a partially white area in the first image captured using TDI external trigger acquisition?

This is because in external trigger mode, when there is no pulse, the camera remains in an exposed state. This is related to the TDI level, where 256 levels correspond to 256 bright lines, which manifest as partially white areas in the image. However, due to the current chip's anti-blooming feature, this issue may affect several hundred lines of data.
Solution:
The standard version of the firmware has been updated to include the deletion of the first n lines of data when starting the acquisition. The number of lines to be deleted can be set through the offsetY parameter in the interface. This deletion operation takes effect in two scenarios:

① when the acquisition starts;

② when the trigger signal stops for more than 2ms and restarts.

Why doesn't the saturated gray value reach 255 in 8-bit mode?

The reason the saturated gray value does not reach 255 in 8-bit mode is due to DSNU correction.

DSNU correction first subtracts the chip's background value, such as 15, and then adds the correction value, which is -15 + 6 (100DN in 12-bit mode is converted to 6DN in 8-bit mode), resulting in -9. Therefore, the saturation value is 255 - 9 = 246.
If you want to achieve a saturated value of 255, you can either turn off DSNU or increase the BlackLevel by the corresponding value.

Why is there abnormal grayscale (too bright or too dark) in the first or last row in area scan mode?

This is a normal phenomenon due to the inherent characteristics of the sensor.

When the camera outputs an 8-bit image, how is each gray value converted from 10-bit to 8-bit?

Take the upper 8 bits of the 10-bit data.

7. After-sales

1) Login to the official website and click on the [Technical Support] module to get the FAQ.

2) Warranties：
   - The warranty period for the product starts from the date of shipment and lasts for 24 months. During this period, any damage that meets the warranty requirements will be repaired free of charge;
   - The scope of the warranty is limited to defects in the materials and manufacture of the product. Self-disassembly, water ingress, throwing and other human damage, as well as damage caused by natural disasters, are not covered by the warranty.

3) Contact a professional for technical support:
   - Tel: 400-075-8880　+86 591-88194580-811
   - Email: service@tucsen.com
   - Tucsen's website to leave a message: http://www.tucsen.com .

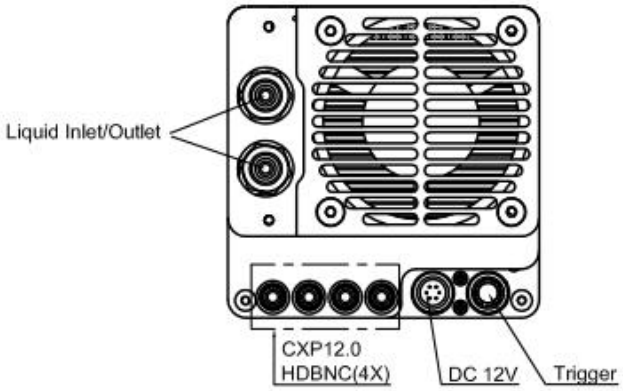
4) Please prepare the following information in advance:
   - Camera model and S/N (product serial number);
   - Software version number and computer system information;
   - A description of the problem and any images related to the problem.

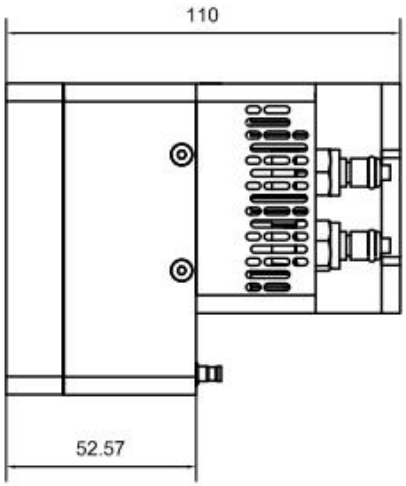
Appendix 1: Table of dew point corresponding to temperature and humidity

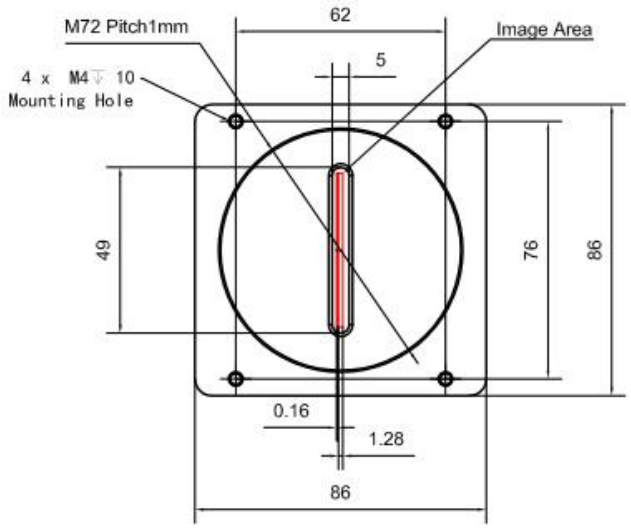
Temperature	Humidity							
	20%	30%	40%	50%	60%	70%	80%	90%
5							1.8	3.5
6							2.8	4.5
7						1.9	3.8	5.5
8						2.9	4.8	6.5
9					1.6	3.8	5.7	7.4
10					2.6	4.8	6.7	8.4
11					3.5	5.7	7.7	9.4
12				1.9	4.5	6.7	8.7	10.4
13				2.8	5.4	7.7	9.6	11.4
14				3.7	6.4	8.6	10.6	12.4
15			1.5	4.7	7.3	9.6	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

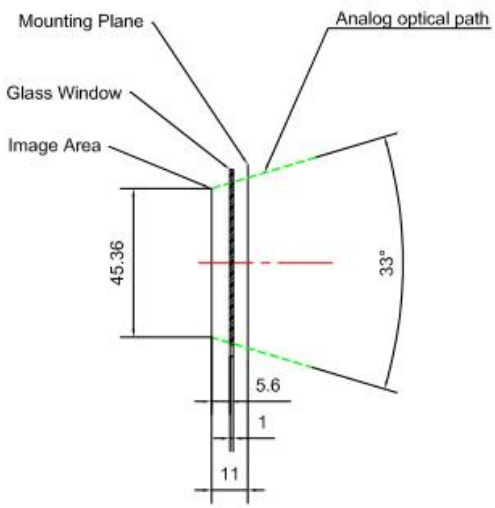
Appendix 2: Structural Dimensions

Unit: mm，Diameter: ø









Appendix 3: Camera Parameter Table

	Dhyana 9KTDI
Sensor	BSI sensor
Color/Mono	Mono
Resolution	9072 (H) x256 (V)
Pixel Size	5μm x 5μm
Effective Area	45.36 mm x 1.28 mm
Quantum Efficiency	82.4%@550nm 、 38%@800nm 、 38%@266nm* 、 51%@355nm*
TDIStages	4/8/16/32/64/96/128/160/192/224/240/248/252/256
Max.Line Rate	299kHZ@12bit; 345kHZ@10bit; 510kHZ@8bit
Scan Direction	Forward/Reverse/Trigger Control
Dynamic Range	Typ.68.7dB@12bit; 63.6dB@10bit
CTE	≥0.99993
Full-Well Capacity	Typ.15.5ke-@12bit; 14ke-@10bit
Readout Noise (Median Value)	Typ.7.2e-@12bit; 11.4e-@10bit
Analog Gain	x2 ~ x8 step 0.5
Digital Gain	x0.5 ~ x10 step 1
DSNU	1.5e-@12bit; 3.5e-@10bit(Typ.)
PRNU	0.3% (Typ.)
Cooling Method	AIr & liquid cooling
Temperature Differences	Air 20 ℃ (ambient temperature 25 ℃); Water 35 ℃ (water temperature 20 ℃)

Dark Current	950e-/s/pixel@Chip temperature 10℃
Binning	Horizontal Binning supports x1、x2、X4、X8 Vertical Binning supports x1、x2、X4、X8
ROI	Support
Trigger Mode	Trigger Input, Scan Direction Input
Output Trigger Signal	Strobe out
Trigger interface	Horison, HR10A-7R-4S
TimeStamp Accuracy	8 ns
Data Interface	CoaxPress2.0 (CXP-12)
SDK	GenICamTM
Bit Depth	8bit; 10bit; 12bit
Optiona Interface	M72 x1
Power Supply	12V±1V/5A
Dimensions	86mm*86mm*109mm
Software	SamplePro; Matlab
Operating System	Windows; Linux
Operating Environment	Temperature: 0-40°C，Humidity: 0%-90%

* Values are estimated based on the QE curve.

Appendix 4: Update Log

版本	日期	修改内容
V1.0	20230131	Create a document
V1.1	20230630	1. 1. Added FAQ chapter; 2. 2. Added water flow rate recommendation; 3. 3. Added DSNU, PRNU, LUT operation steps and precautions; 4. 4. Added the communication protocol schedule; 5. 5. Adjust the order of some chapters; 6. 6. Modify "Area mode, one pulse triggers one frame image", 2904 version firmware begins to support; 7. 5. Change to new external document format;
V1.2	20230807	1. Added temperature control instructions; 2. Added CXP cable distance; 3. Added detailed descriptions of Linescan and areascan;
V1.3	20240202	1. Added description of the delay in changing scanning directions. 2. Added description of the upper temperature limit of the device. 3. Added description of the Sensor Test Image. 4. Updated the description of LineInfo. 5. Added description of the DSNU/PRNU read and write functions. 6. Added description of the soft trigger software function for trigger types. 7. Added description of the threshold adjustment function for scanning signal trigger high levels. 8. Added description of the DSNU/PRNU operation counter function. 9. Added Description of skipping the first part of the data before opening the flow.

		10. Added description of avr & sum bin. 11. Added description of analog gain & digital gain. 12. Added description of DSNU correction before and after the background gray value. 13. Added matters needing attention for saving images. 14. Updated description of the trigger setting of Euresys frame grabber. 15. Updated Frequently Asked Questions Explanation
V1.3.1	20240328	1. Improved CoolControl operation instructions; 2. Added factory PRNU calibration instructions; 3. Updated frequently asked questions;
V1.3.2	20240429	1. Instructions for updating the firmware and drivers of the frame grabber; 2. Added explanations for the precision of the new filtering parameters; 3. Updated instructions for the DSNU and PRNU counters.
V1.3.3	20241024	1. Added compatibility information for the Samadhi capture card; 2. Updated user manual for the new version of Samplepro; 3. Added explanation for the Sensor Binning feature； 4. Corrected TDI stage information;