# Dhyana 9KTDI Pro
# User Manual

V1.1.0



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# 1. Preface

## 1.1. Disclaimer

To safeguard the legitimate rights and interests of users, kindly ensure to review our enclosed instructions, disclaimers, and safety guidelines thoroughly before utilizing our products. This user manual provides fundamental information, installation instructions, product features, and maintenance tips, aiming to facilitate the use of TUCSEN cameras. Please adhere to the provided instructions and safety guidelines when operating this product.

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**disclaimer before using our products. We wish you a pleasant user experience. Thank you!**

**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. |

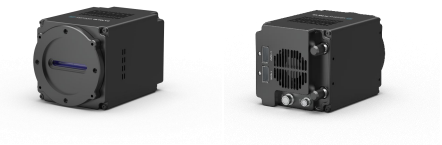
**Power Supply**

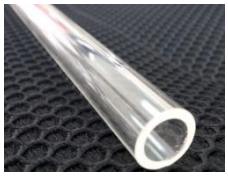
| | |
|---|---|
|  **Caution** | ● Please use the original power adapter provided with the camera. Using a mismatched power supply may cause damage to the camera.<br>● If the voltage applied to the camera is higher or lower than the rated voltage, it may result in damage to the camera or cause it to malfunction.<br>● 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 Pro camera, including the packaging list, camera introduction, and camera interfaces and functions.

## 2.1. Package List

| Items | Specification/ Model | QTY | Pictures |
|---|---|---|---|
| TDI Camera | Dhyana 9KTDI Pro | 1 |  |
| Power cables | XS9F-4A ,1.5m | 1 |  |
| Power Adapter | 1.2m | 1 | |
| USB Flash disk | Included Software & Drivers | 1 |  |
| SFP+ | AXS85-192-M3 | 8 |  |
| QSFP+ | QSFP-SR4 | 2 |  |

| | | | |
|---|---|---|---|
| tubes for water coolers | Inner diameter 5mm, outer diameter 8mm (material PU), length 2 meters<br>MCD1703 (female end) pressure resistance 10bar | 2 |  |

| Optional Items | Specification/ Model | QTY | Pictures |
|---|---|---|---|
| M72 to F-port adapter | M72x1 | 1 |  |
| CoaXPress over Fiber frame grabber | Komodo II CoaXPress over Fiber | 1 |  |
| Fiber Optic Cable | 20m | 2 |  |
| External trigger cable | HR10A-7P-4P, 3m | 1 |  |

## 2.2. Introduction

The Dhyana 9KTDI Pro 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 Pro 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. Camera Interfaces & Features

The interfaces of the Dhyana 9KTDI Pro camera are shown in Figure 2-1 and the corresponding functional descriptions are shown in Table 2-1.


Figure 2-1 Dhyana 9KTDI Pro interface

Tab 2-1

| No. | Interface | Functions | | |
|---|---|---|---|---|
| 1 | Indicator | Indicates the camera status | Red ON | The camera is not initialized |
| | | | Red flashing | Configuration is not completed |
| | | | Orange flashing | Checking the configuration status of the CXP connection |
| | | | Green ON | CXP connection configuration is complete |
| | | | Alternating orange and green | Checking the configuration status of the CXP connection and transferring data is being |

| | | | | |
|---|---|---|---|---|
| | | | | done simultaneously |
| | | | Green flashing | The camera is transmitting data |
| 2 | Water cooling Interface | The water-cooled input/output connections | | |
| 3 | Trigger | The interface for external trigger input has a trigger level of 3.3V, which cannot exceed 5V. HR10A-7P-4P. | | |
| 4 | QSFP+ | The interface for data transmission, with its serial number corresponding to the interface of the frame grabber. | | |
| 5 | Power | Power interface, 12V/8A, the pin definitions of the power and trigger interfaces are shown in Figure 2-2. | | |

### 2.3.1. Power Connector Description

It is recommended to use the standard power adapter. The camera's standard power supply voltage is 12V DC with a tolerance of ±1V fluctuation.

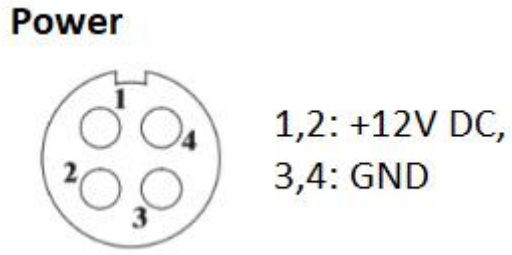



Figure 2-2 Power Pin Definitions

**Note:**

*To ensure a stable power supply, it is necessary to connect two +12V DC and two GND pins simultaneously, as the current carrying capacity of a single +12V DC or GND pin is insufficient.*

### 2.3.2. Trigger Connector Description

**1)** 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.


Figure 2-3 Trigger Pin Definitions

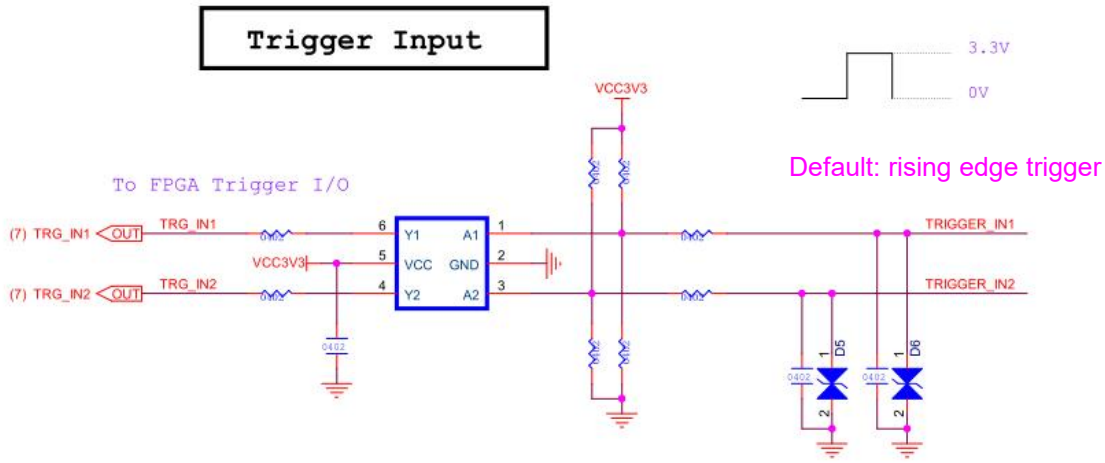



Figure 2-4 Trigger input circuit diagram

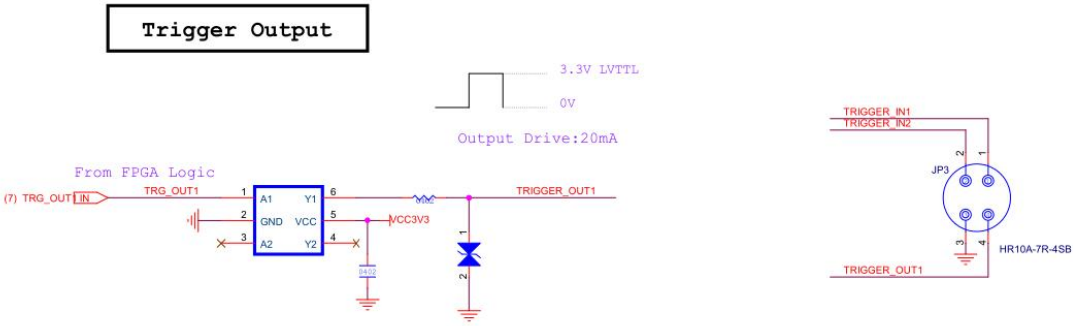



Figure 2-5 Trigger output circuit diagram

### 2.3.3. Water-cooling Interface Description

The water temperature for the water cooler needs to be selected based on the actual environmental temperature and humidity. You can refer to the table of temperature and humidity corresponding to the dew point in the appendix for guidance. It is recommended that the water temperature be higher than the dew point temperature value listed in the table. For example, if the ambient temperature is 25℃ and the relative humidity is 70%, the water temperature should not be lower than 19℃.

1) Minimum water flow rate: 1L/Min;
2) The recommended of circulating water temperature is 15~20℃, too low water temperature will cause fogging of the window piece, which may lead to chip damage;

# 3. Installation

This section introduces the functions related to water-cooling, including the connection of water cooling tubes and camera, water temperature, and recommended flow rates.

## 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. Camera Installation

Dhyana 9KTDI Pro can support dual-channel and quad-channel (firmware is different), the connections are shown in Figure 3-1 and Figure 3-2.

Connect the QSFP+ module to the Dhyana 9KTDI Pro camera interface and the SFP+ module to the frame grabber interface in this order.

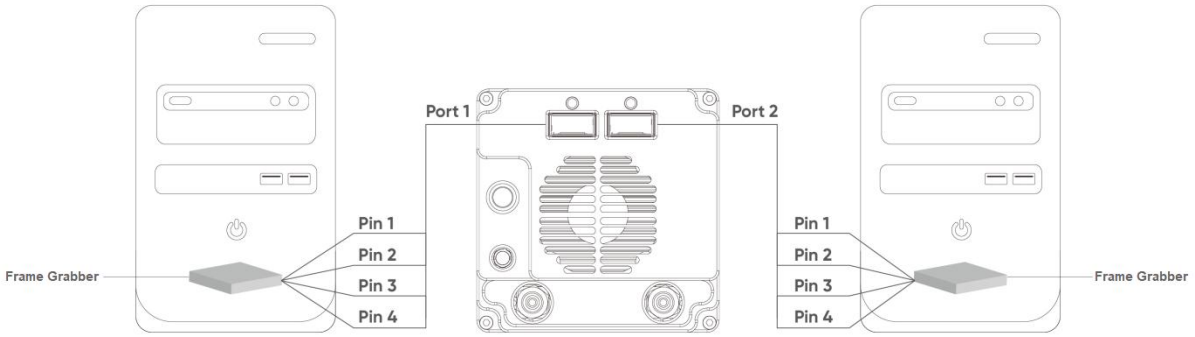



Figure 3-1 Schematic diagram of the dual-channel connection

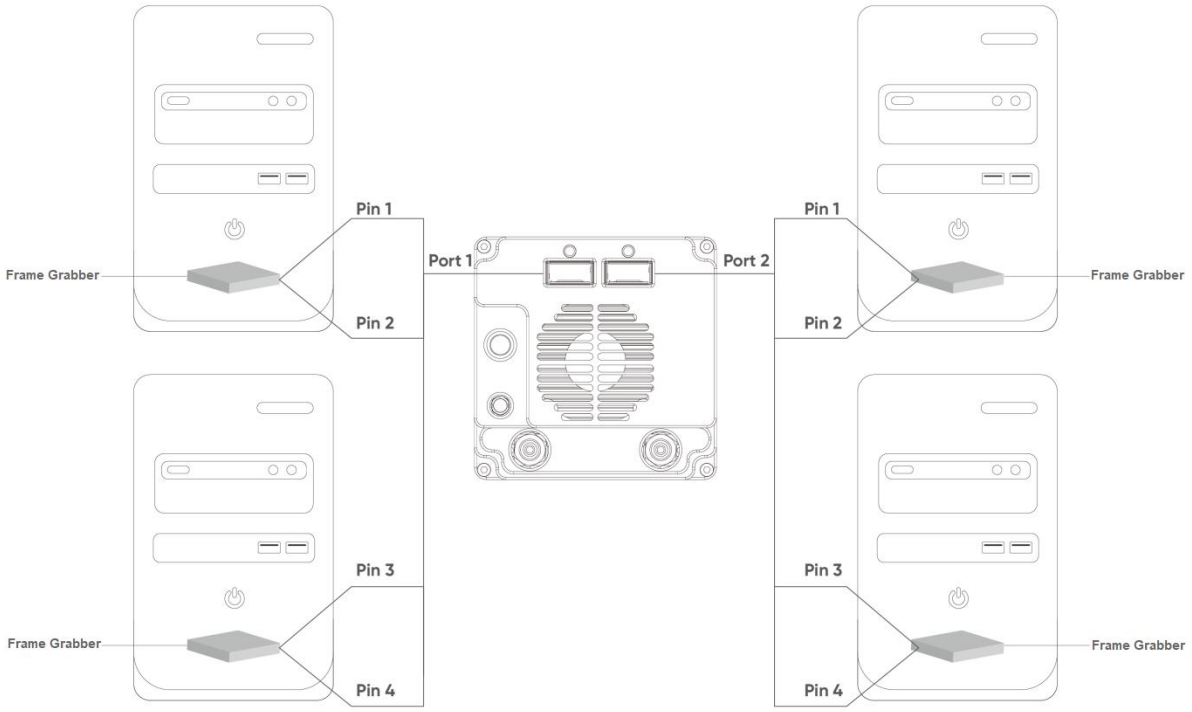



Figure 3-2 Schematic diagram of the quad-channel connection

**Operation steps**

**1)** Insert the QSFP+ end of the fiber cable into the standard QSFP+ optical module, as shown in Figure 3-3. The interface has a fool-proof design, so pay attention to the direction of insertion. After insertion, you should hear a "click" sound, indicating that the connector is fully inserted.

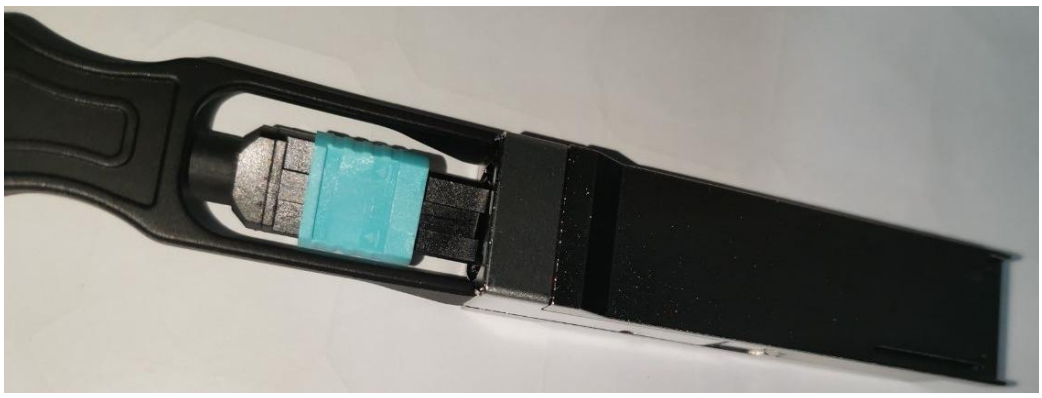


Figure 3-3

**2)** Insert the optical module into the QSFP+ 1 port of the camera, as shown in Figure

3-4. After insertion, you should hear a "click" sound, indicating that the connector is fully inserted.

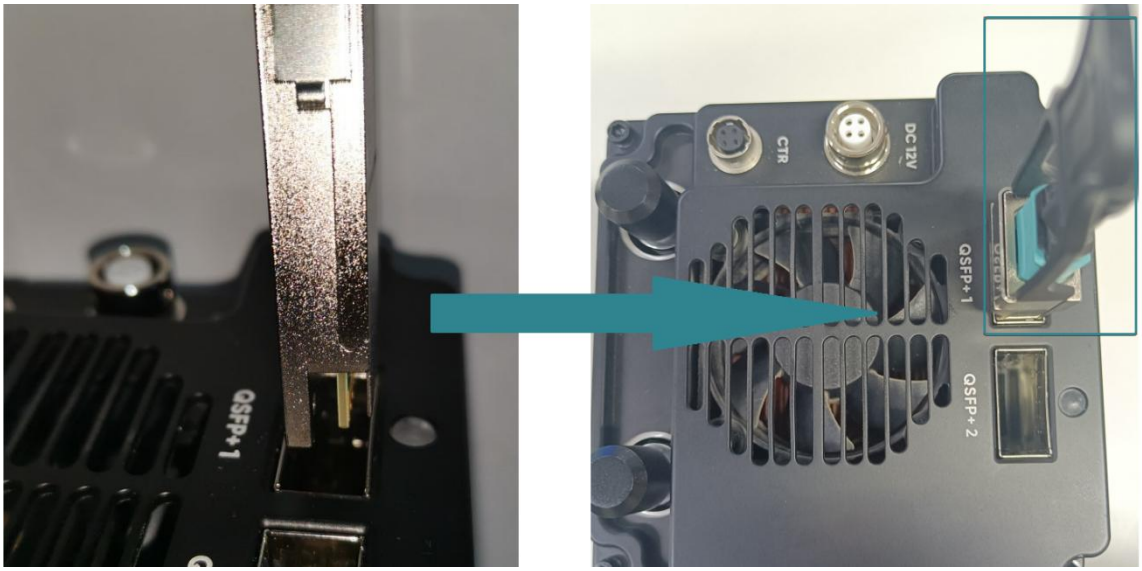



Figure 3-4

**3)** Insert the SFP+ into the standard SFP+ optical module, as shown in Figure 3-5. The interface has a foolproof design, so pay attention to the direction of insertion. After insertion, you should hear a "click" sound, indicating that the connector is fully inserted.

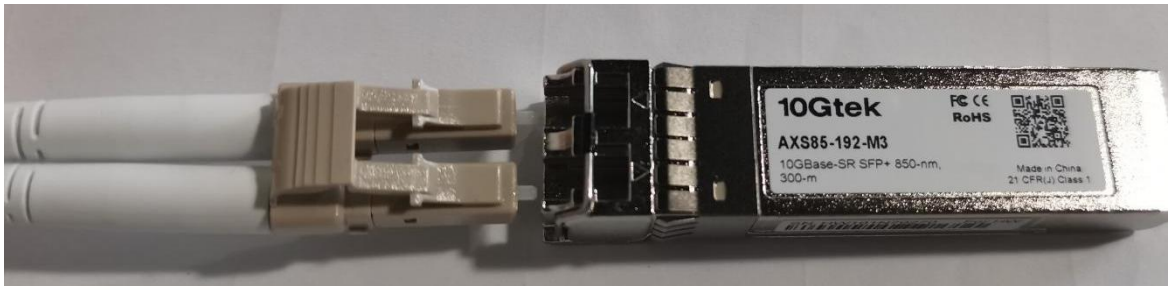



Figure 3-5

**4)** Insert the SFP+ optical module with the optical fiber cable installed into the frame grabber interface. The gold finger of the optical module must be connected with the gold finger of the frame grabber in the direction shown in Figure 3-6 and Figure 3-7. Pay attention to ensuring that the interface sequence of the frame grabber card corresponds to the optical cable number, as shown in Figure 3-8.

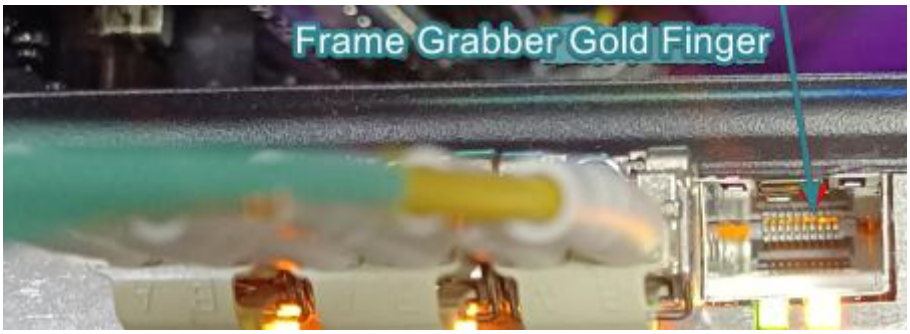



Figure 3-6 Direction of the gold finger of frame grabber


Figure 3-7 Direction of the gold finger of the optical module

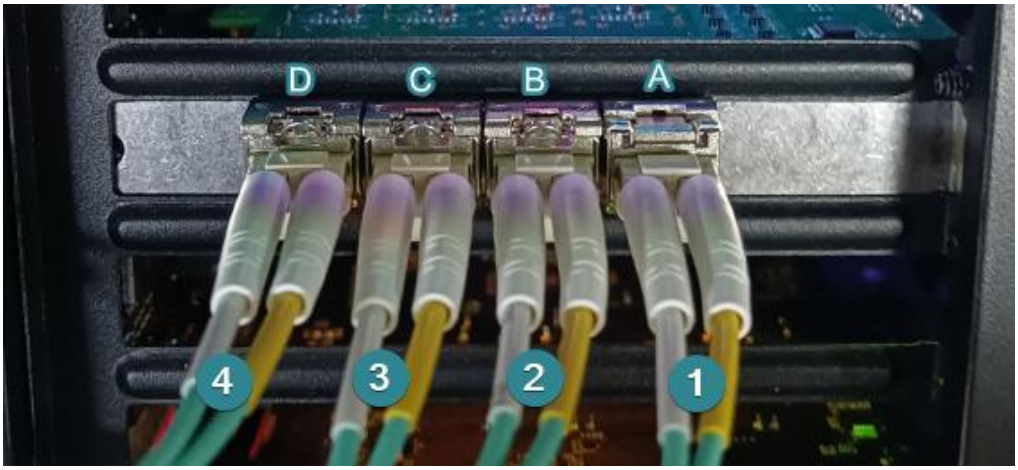



Figure 3-8 Connection of SFP+ optical module and frame grabber

**Note:**

***1)*** *QSFP+ 1 is the master interface of the camera, while QSFP+ 2 is the slave interface. When the camera is connected to a single frame grabber, the optical fiber*

*interface must be QSFP+ 1. If only QSFP+ 2 is connected, the camera cannot be recognized normally. There is no specific order for opening the master and slave interfaces, and it is related to the sequence of PCIE recognition of the frame grabber.*

***2)** The optical fiber head is a sensitive and fragile material that should be minimally exposed to air during plugging and unplugging. It is prohibited to perform improper operations such as touching or rubbing, which can cause losses and affect optical fiber transmission and communication.*

***3)** Each fiber optic cable has 4 groups of interfaces, with two lines per interface and two values in each group in ascending order. Please refer to the smaller value as shown in Figure 3-9.*

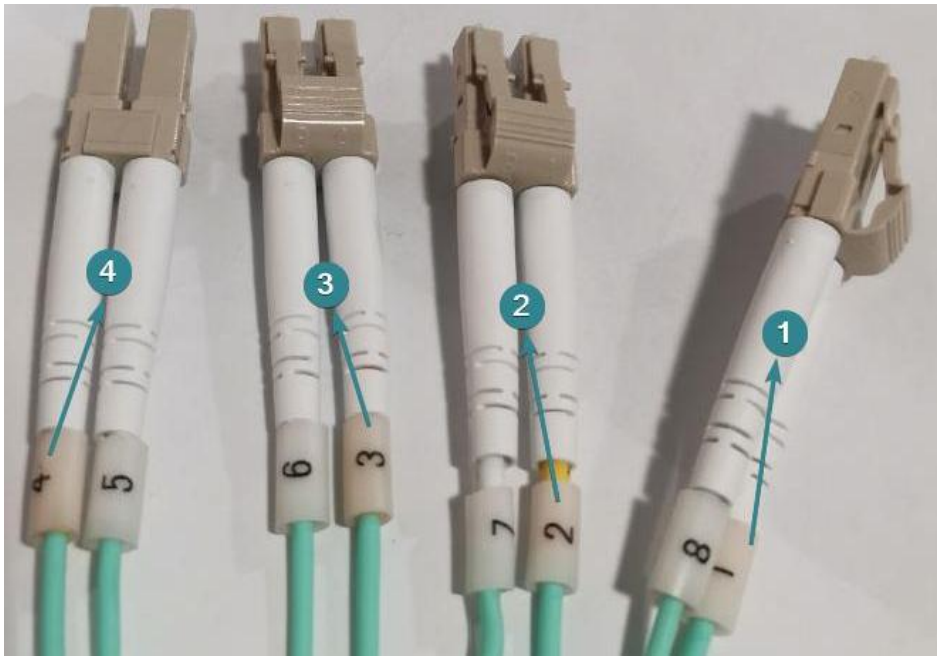



Figure 3-9

## 3.3. 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.

## Connection steps for water-cooling tubes

**1)** Remove the protective covers from the water cooling interfaces on the camera, as shown in Figure 3-10 and Figure 3-11.

Figure 3-10

Figure 3-11

**2)** Press the left circular handle of the water tube connector into the position shown in Figure 3-12, 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 3-12

Figure 3-13

**3)** Connect the water cooling camera's connector to the inlet and outlet water tubes of the water cooling machine, as shown in Figure 3-14.

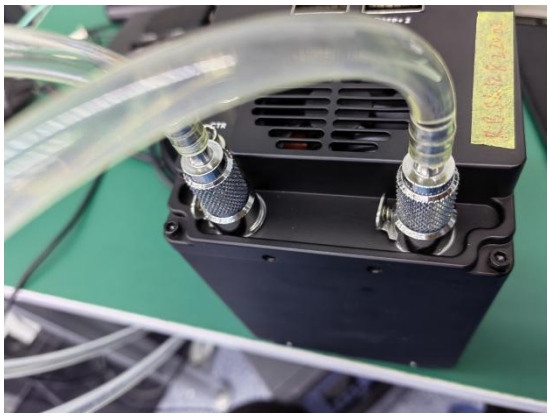


Figure 3-14

**Explanation:**

**1)** The water cooling port on the camera does not differentiate between 'in' and 'out'.

**2)** Minimum water flow rate: 1L/Min.

**Note:**

*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.*

## 3.4. Installation of frame grabber

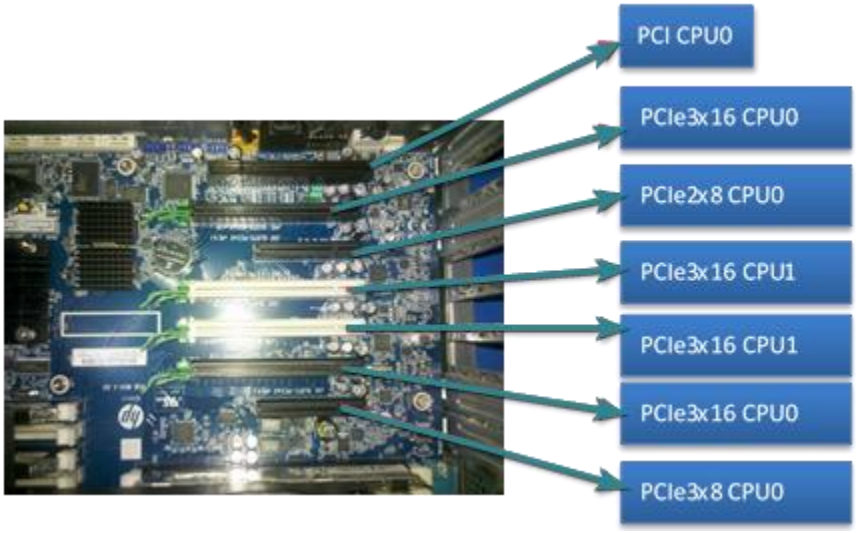



Figure 3-15 Computer motherboard diagram

Turn off the computer, open the cover of the computer mainframe, as shown in Figure 3-15. Choose a PCIe 3.0*8 slot , insert the frame grabber, secure it with screws, and restart the computer. Connect the camera to the frame grabber interface using the data transmission cables.

***Note:****The current PCIe slot supported by the frame grabber is 3.0*8, and not support or not compatible with higher bandwidths such as PCIe4.0 and above.*

Table 3-1 Maximum transmission rates corresponding to different PCIe slots

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

The current test supports the following brands, models, and firmware of frame

grabbers.

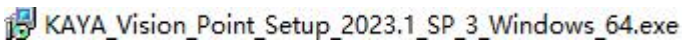
| Brand | Model | Firmware | Driver |
|---|---|---|---|
| KAYA | Komodo II CXP Fiber Frame Grabber | Komodo_II_5_0_57 | KAYA_Vision_Point_Setup_2023.1_SP_3_Windows_64 |

## 3.5. Installation of frame grabber's driver

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;

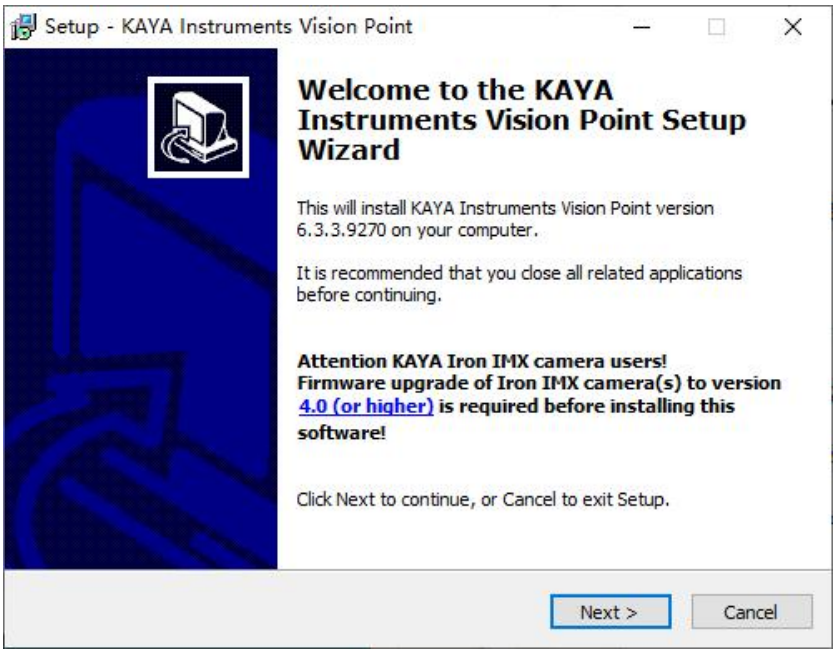



Figure 3-16

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

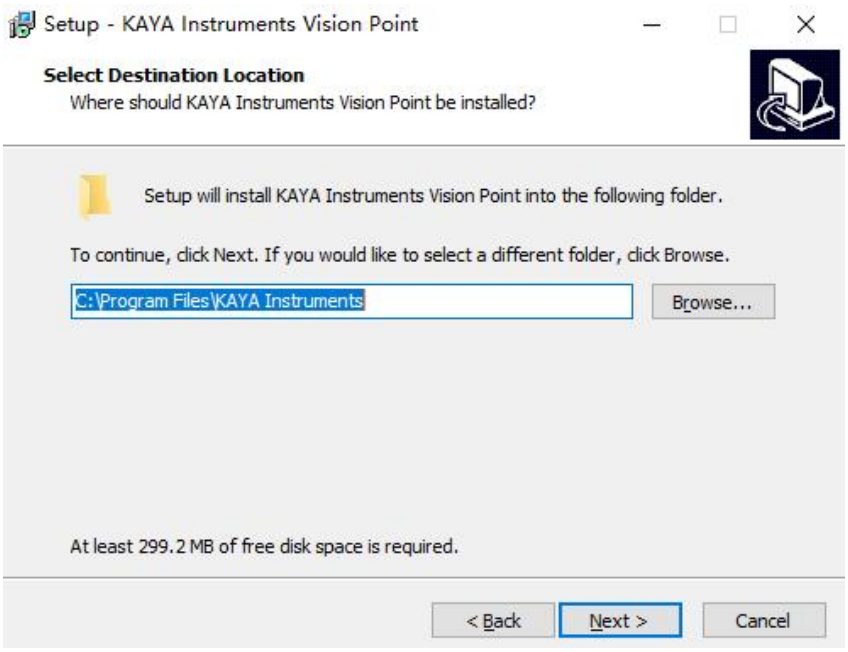



Figure 3-17

**4)**Select the installation components, click "Next" to proceed to the next step.

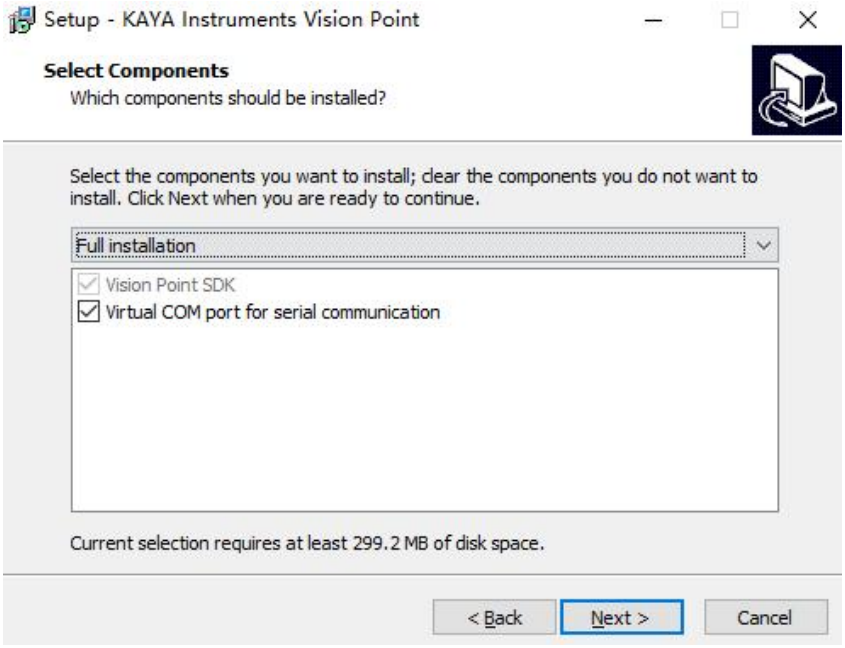



Figure 3-18

**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.

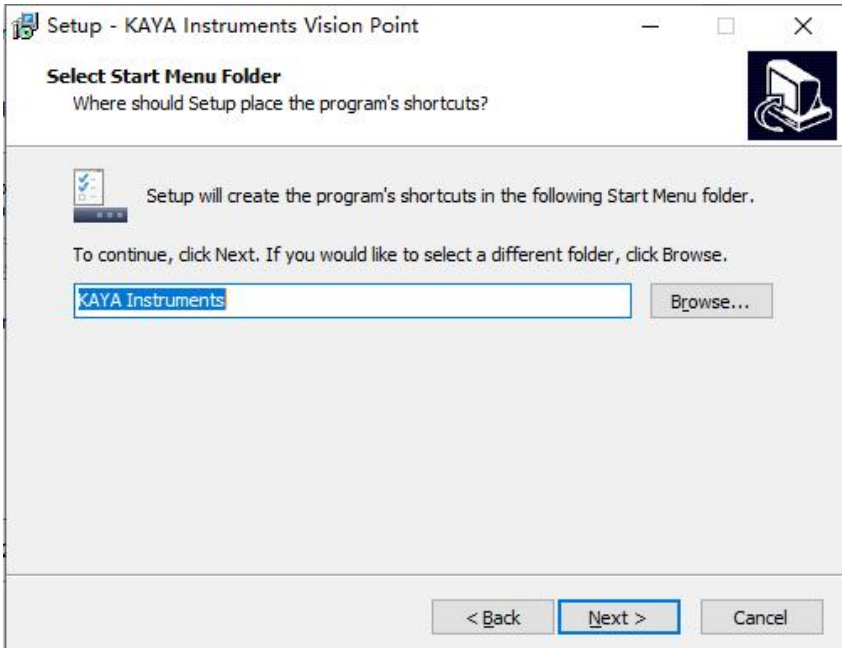



Figure 3-19

**6)**After confirming that all the settings are correct, click "Install" to start the driver installation process.

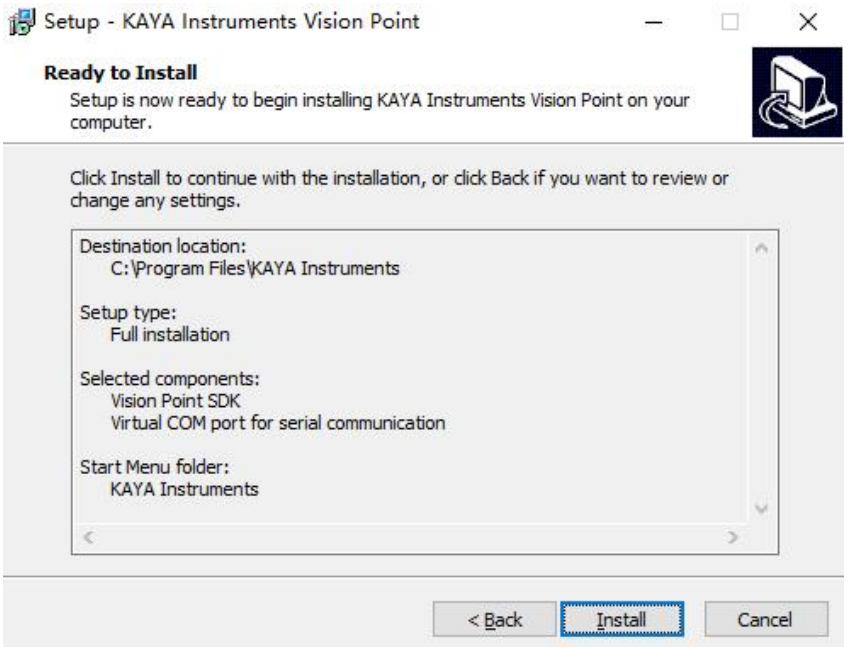



Figure 3-20

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

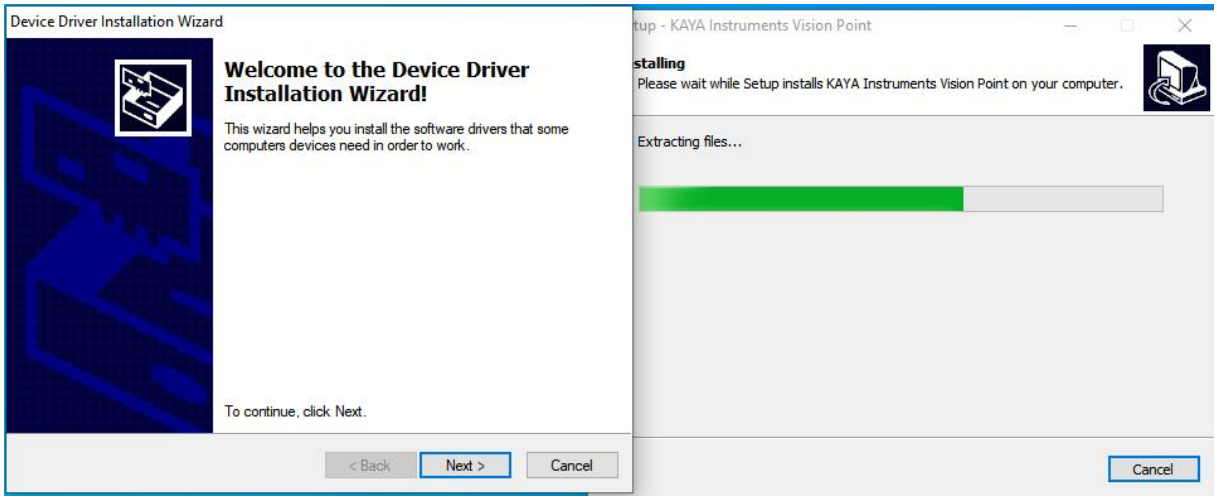



Figure 3-21

**8)**Click "Finish" to proceed to the next step.

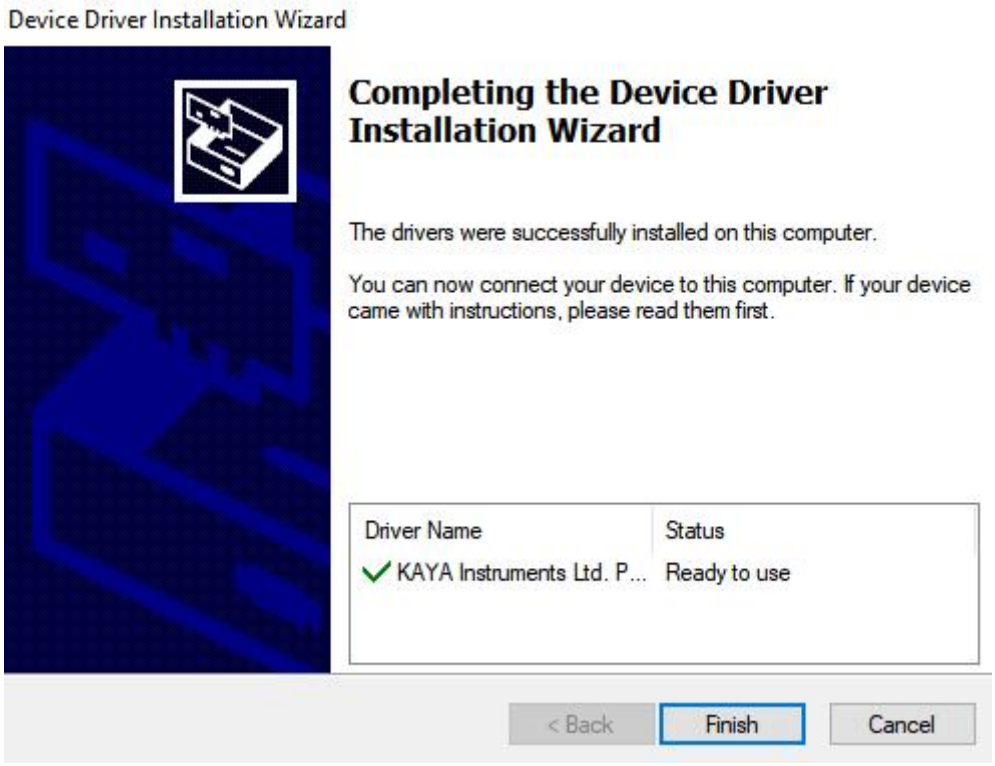



Figure 3-22

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

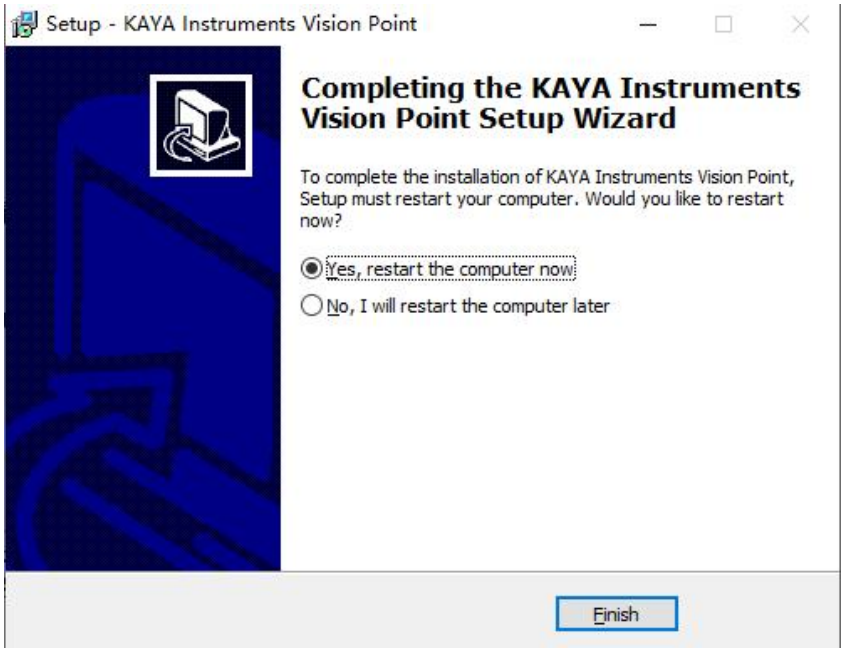



Figure 3-23

## 3.6. 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.*

# 4. Introduction to 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

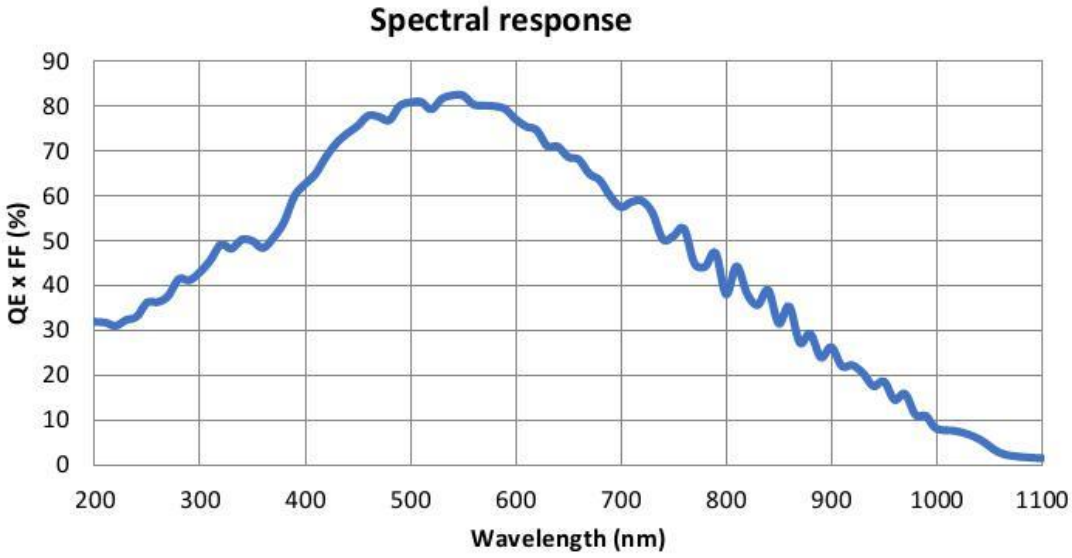



Figure 4-1 Chip spectral response curve* (provided by chip manufacturer)

## 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

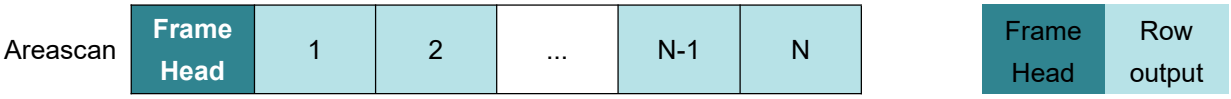



Figure 4-3 Areascan mode transmission of N-row images

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.

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).

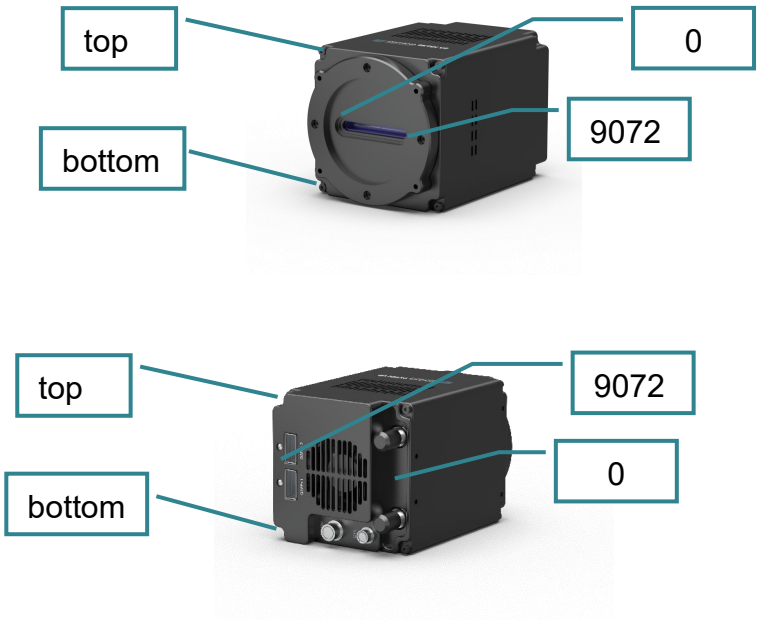



Figure 4-4 Definition of camera direction

**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 Mirror

The Dhyana 9KTDI Pro 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 Horizontal mirror 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 99 and a Width set to 256, the camera will capture and transmit pixel values from pixels 100 to 355. By default, the ROI utilizes the full resolution of the camera's imaging sensor. However, you can adjust the size and position of the ROI by modifying the parameter values of "Offset X" and "Width"

**Row frequency data after ROI**

| Horizontal resolution | Bit Depth | Sensor Theoretically | Actual Measurement |
|---|---|---|---|
| 9K | 8bit | 608K | 510K |
| | 10bit | 608K | 345K |
| | 12bit | 300K | 299K |
| 8K | 8bit | 608K | 581K |
| | 10bit | 608K | 417K |
| | 12bit | 300K | 299K |
| 6K | 8bit | 608K | 600K |
| | 10bit | 608K | 556K |
| | 12bit | 300K | 299K |
| 4.5K | 8bit | 608K | 600K |
| | 10bit | 608K | 600K |
| | 12bit | 300K | 299K |

| | | | |
|---|---|---|---|
| 4K | 8bit | 608K | 600K |
| | 10bit | 608K | 600K |
| | 12bit | 300K | 299K |
| 2K | 8bit | 608K | 600K |
| | 10bit | 608K | 600K |
| | 12bit | 300K | 299K |

**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 offers horizontal binning support for x1, x2, x4, and x8, as well as vertical binning support for x1, x2, x4, and x8 through the FPGA. When set to x2 binning, the resolution of the camera's output image is halved, and the image's grayscale value doubles.

## 4.10. Gain and Black Level

The "Gain" parameter adjusts the slope of the Dhyana 9KTDI Pro'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 two gain modes are as follows:**

**1)** Analog Gain: supports 2~8 switching, with a step size of 0.5;

**2)** Digital Gain: supports switching from 0.5~10, with a step size of 1;

**3)** Black Level: The black level adjusts the background grayscale value of the image. For 8-bit, the background grayscale value is 6; for 10-bit, it is 25; and for 12-bit, it is 100.

## 4.11. The Lookup Table（LUT）

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.

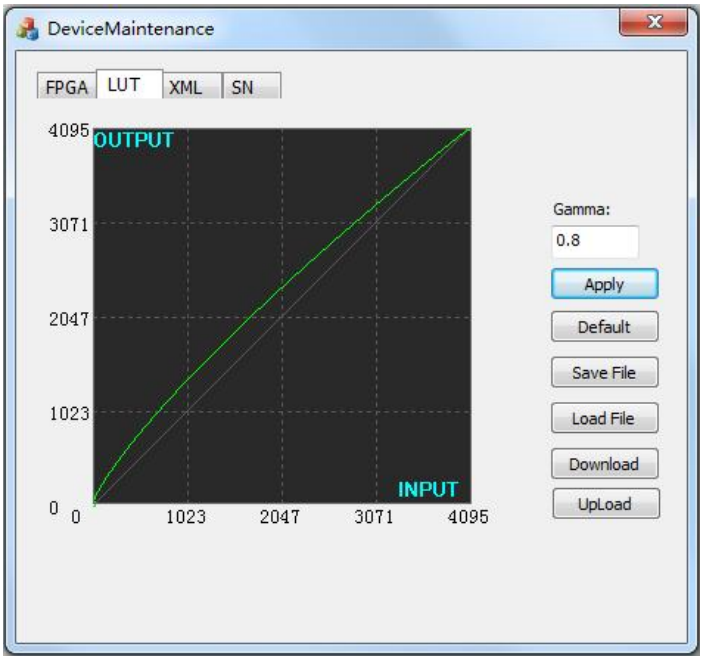



Figure 4-7 LUT at Gamma=0.8

## 4.12. DSNU

Dhyana 9KTDI Pro 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).

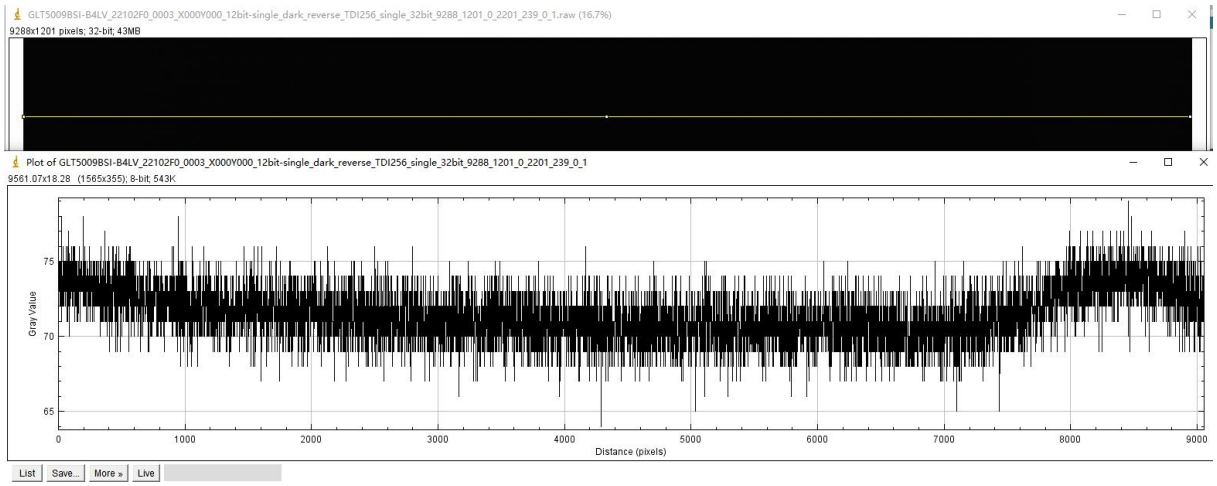



Figure 4-8 Dark Field Grayscale Value Curve Before Correction

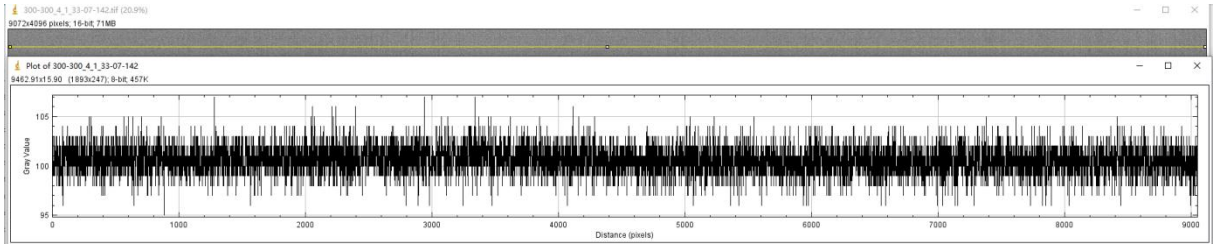



Figure 4-9 Dark field gray value curve after DSNU correction

## 4.13. 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).

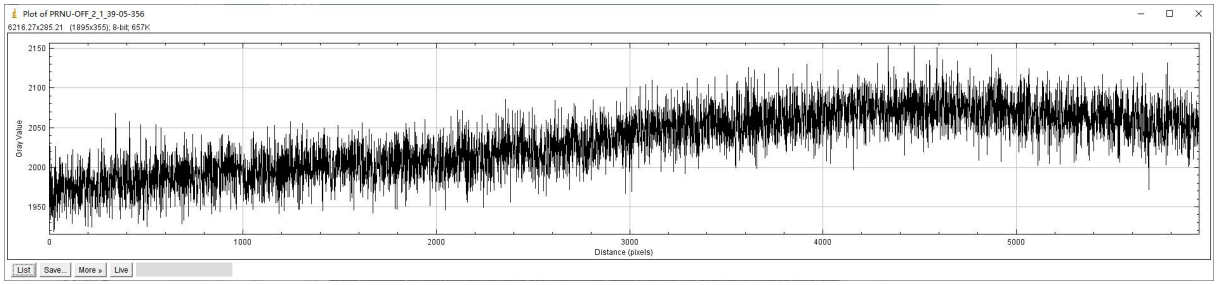


Figure 4-10 Bright field grayscale value curve before correction

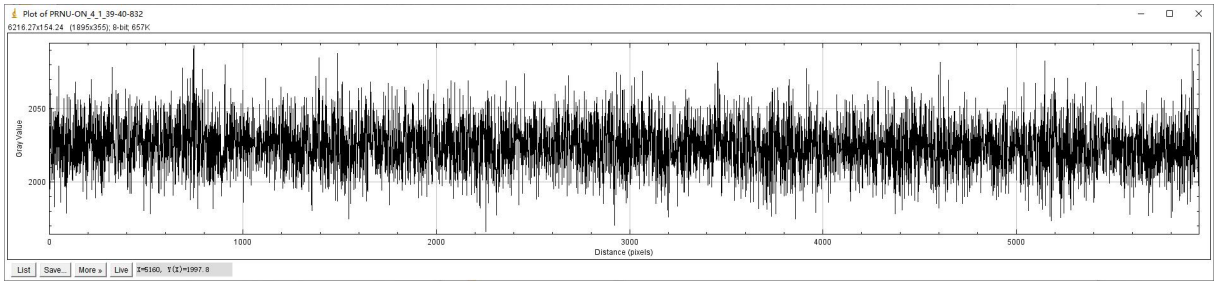



Figure 4-11 Bright field gray value curve after correction

## 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 image

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

- Grey Horizontal Ramp: Preview is a horizontal static grayscale gradient.

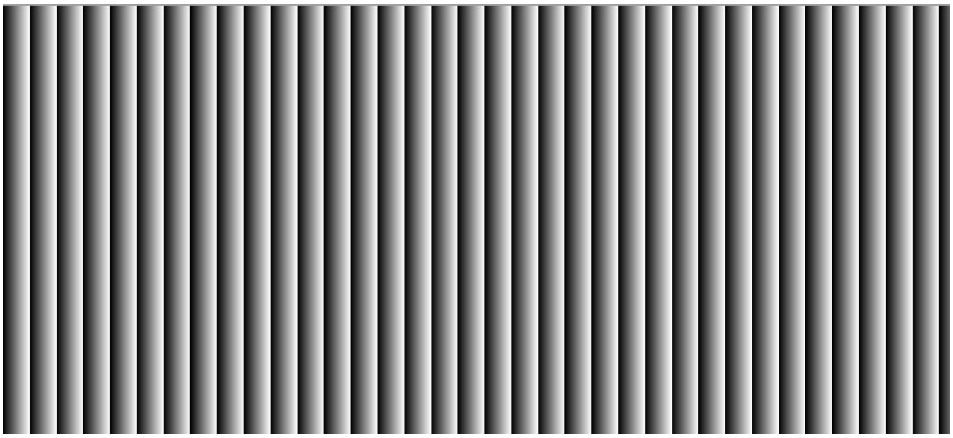


Figure 4-12 Horizontal gray gradient test pattern

- Grey Diagonal Ramp: Preview a static grayscale gradient image in a horizontal diagonal direction.

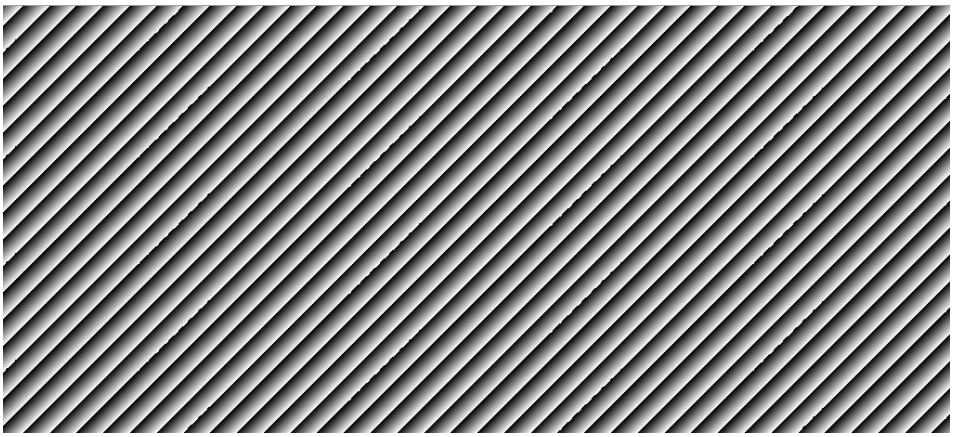


Figure 4-13 Test pattern for horizontal grayscale inclination gradient

- Grey Diagonal Ramp Moving : preview the moving grayscale gradient image in horizontal diagonal direction.

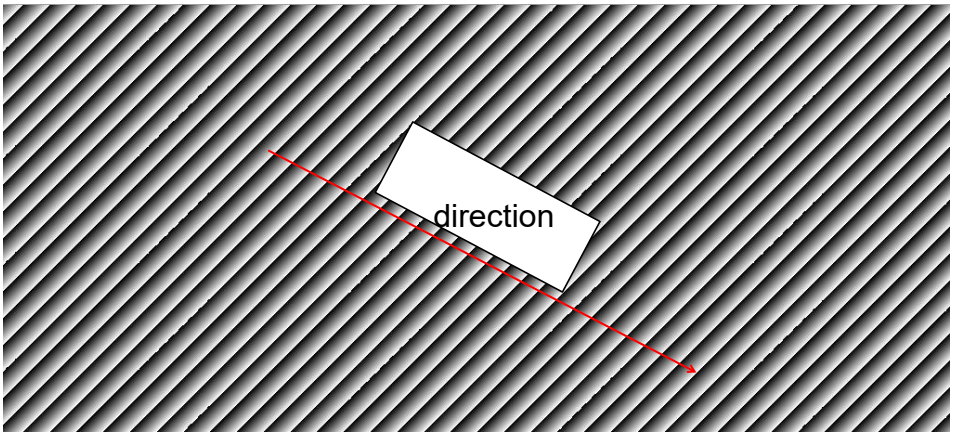



Figure 4-13 Test pattern for horizontal grayscale inclination gradient

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

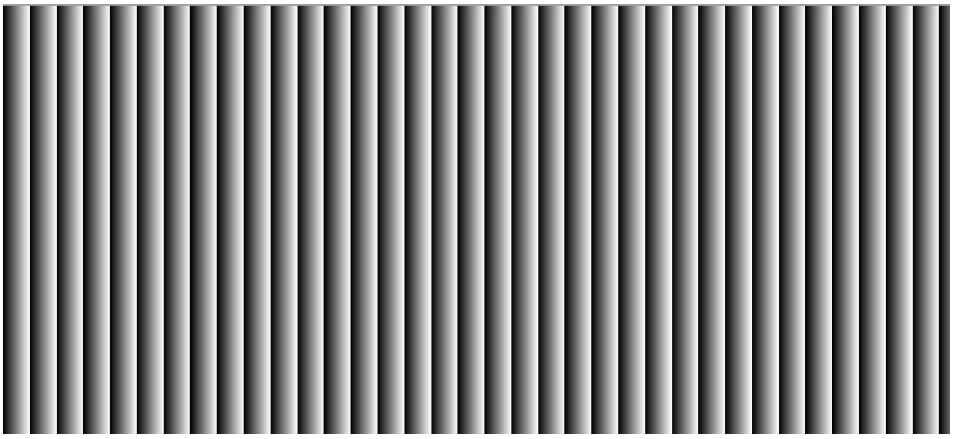


Figure 4-15 Horizontal gray gradient test pattern

**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 Pro camera can be updated with firmware online through the "UpdateTool" software.

**Tool Preparation:**

Software: UpdateTool;
Firmware file: .bin format;

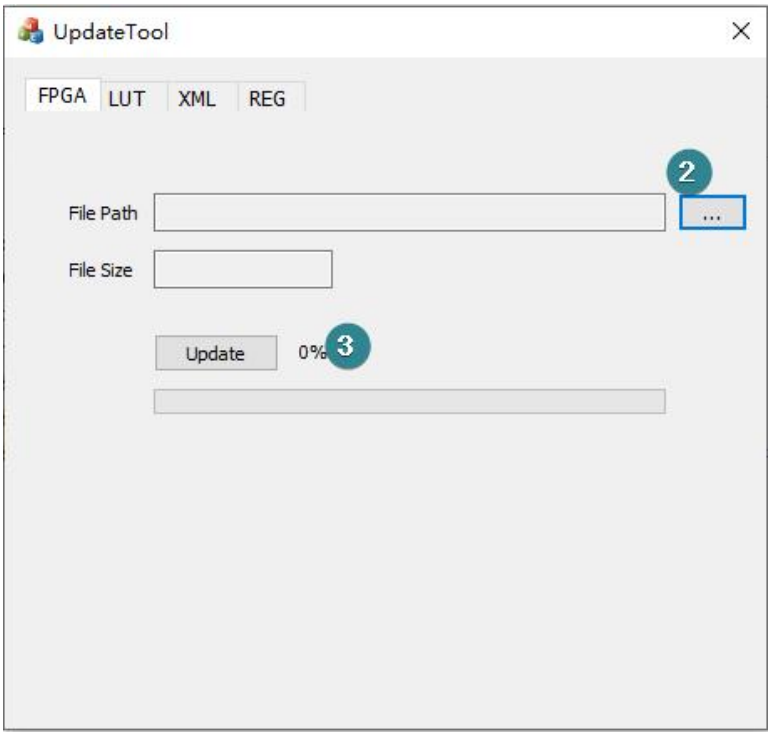



Figure 4-15 UpdateTool interface

**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. 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 Software opening interface

**Note:**

***1)*** *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;*

***2)*** *The use of multiple frame grabber requires opening SamplePro twice. There is no specific order for the host and slave to be opened, which is related to the order of PCIE recognition of the frame grabber. For example, when powering up the dual frame grabber, the software is first identified as the host when it is first launched, and then the slave is identified when it is launched a second time. After reversing the wiring order of the two frame grabber, the software is first identified as the slave when*

*it is launched a first time, and then the host is identified when it is launched a second time.*

## 5.1. Window composition

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

This section briefly introduces the functions of each window.


Figure 5-2 Distribution of master window interface

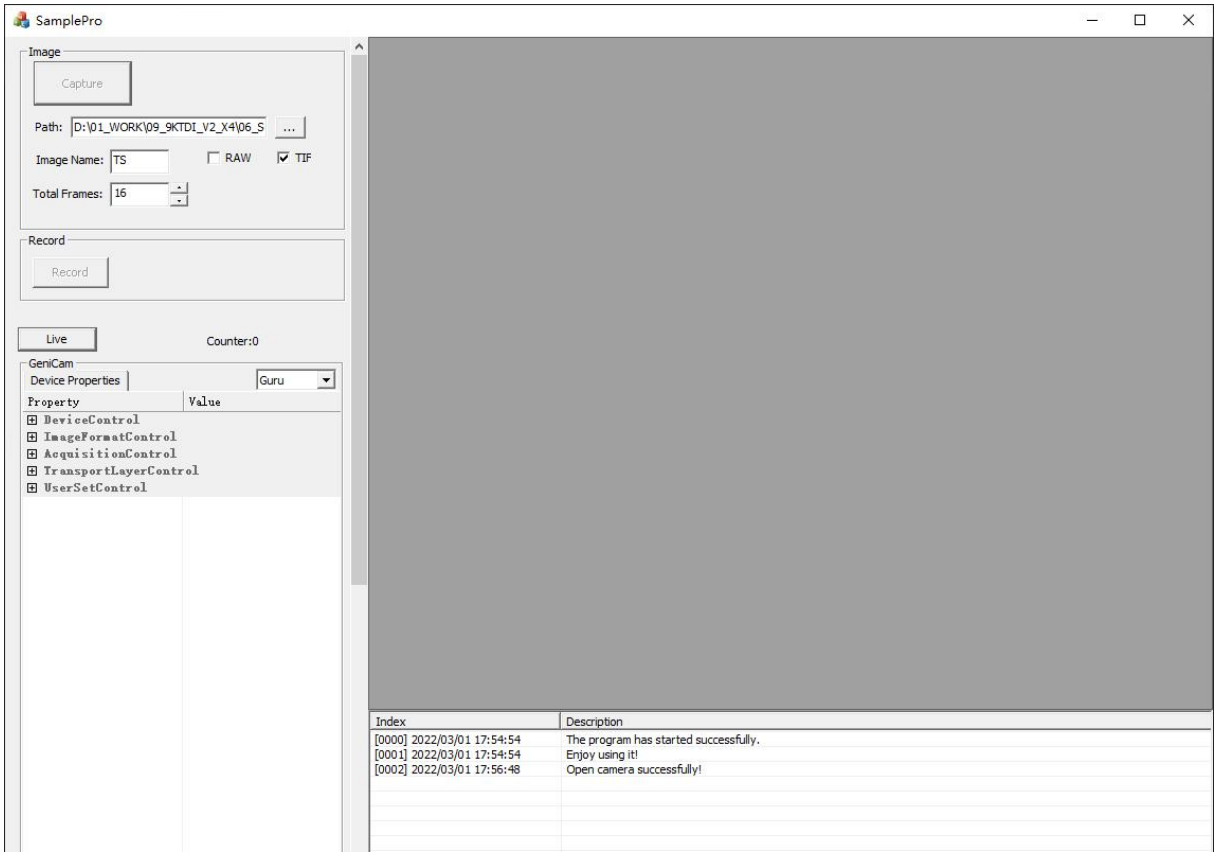



Figure 5-3 Distribution of slave window interface

### 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. Windows Control

The functions of the windows Control are the common ones of minimizing, maximizing,

and closing the window.

### 5.1.3. Image Capture

The image photography 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 of the parameters 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.

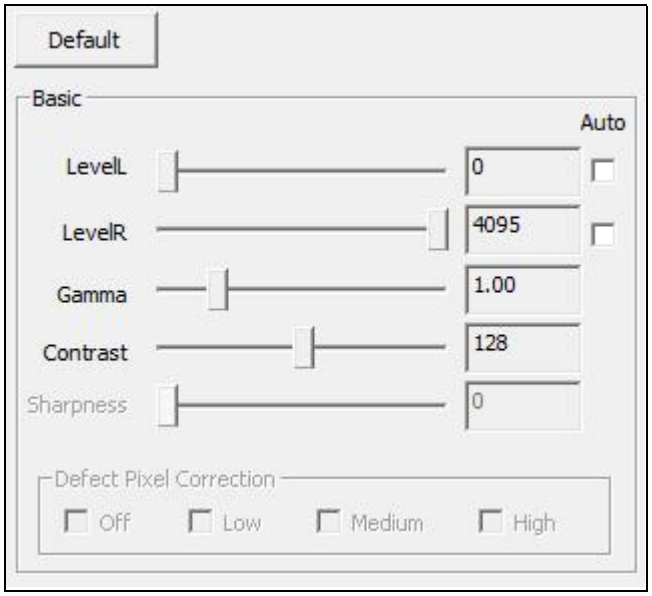



Figure 5-5

## 5.2. 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.

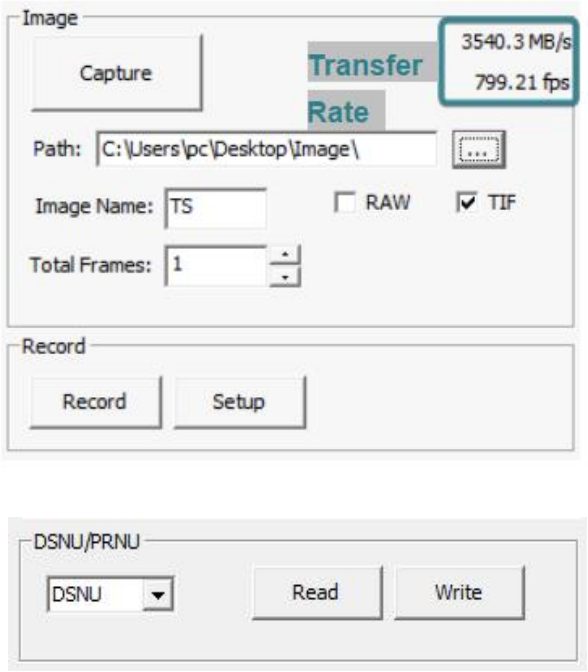



Figure 5-6 Image capture interface

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

**2)** Transmission rate: It displays the camera's flow rate and frame rate, which are updated in real-time;

**3)** Path: The default storage path for images and videos can be set and modified by clicking on it. 

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

**5)** RAW/TIF: picture format selection, supports RAW and TIF formats for original images, default TIF format, supports simultaneous selection;

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

**7)** Record: Start recording manually;

**8)** Stop Record: Stop recording Manually;

**9)** Setup: The compression format selection for video recording only supports Full Frame (No Compression) lossless compression;

**10)** DSNU/PRNU Read & Write: Both DSNU and PRNU support reading and writing of background data, Read is to export calibration data from flash, Write is to write calibration data to flash, click DSNUSave or PRNUSave when you need to save, the format of export and write is .txt file; DSNU/PRNU coefficients are 20480 in total, which contains positive 10240 and reverse 10240 data, 10240 in only the first 9072 for valid data (coefficient unit design 2048 integer multiples, 9072/2048 up to take the integer multiplied by 2048 to get 10240) corresponds to .txt file, the positive data for the first line to the 18175th line ((18175 + 1)/2 = 9072 + 16) because the Width Step is 32, so you need to 9072/32 upward rounding multiplied by 32 = 9072 + 16 data, the valid data to take the first line to 18143; reverse data for the 20481 line to the 38655 line data ((38655-20480 +1)/2 = 9072 + 16), the valid data to take the 20481 line to 38623, in addition to the valid data for the correction data The valid data is taken from line 20481 to 38623, except for the valid data which is corrected data, the rest of the data is filled data, not real corrected data.


## 5.3. Setting up the camera and frame grabber

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.

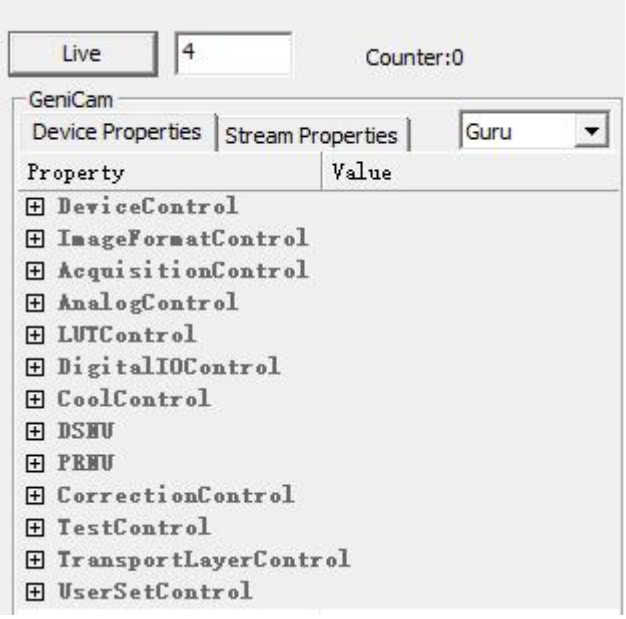



Figure 5-7

**1)** 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;

**2)** The value next to "Live/Stop" indicates the number of memory allocation buffers requested. The larger the value, the less likely it is to lose frames during image storage, but the software will run slower. The smaller the value, the higher the risk of losing frames during high-speed image storage, but the software will run smoothly. It is recommended to set the high-frame rate value to a large value when storing images, and set the value to 4 when previewing without storing.

**3)** Counter: Display the number of images captured by the camera. Note: Only the number of images captured;

### 5.3.1. DeviceControl

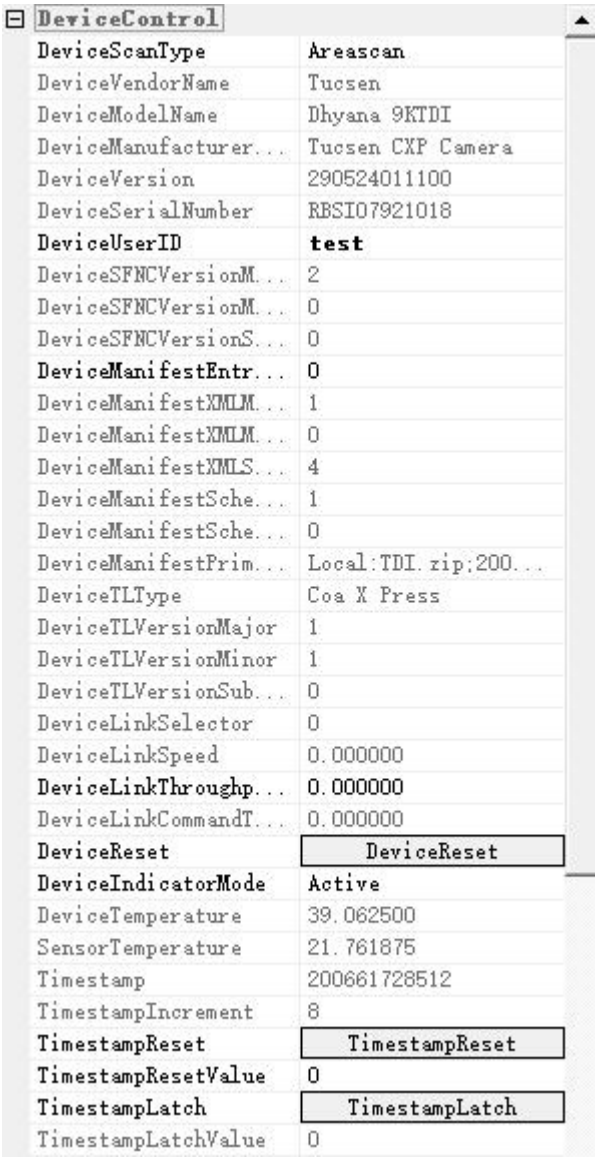



Figure 5-8

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;

**DeviceUserID:** User-defined input;

**DeviceReset:** Device reset button, click to restart the camera online, and restore the default configuration parameters of the camera;

**DeviceTemperature:** Display the camera's real-time temperature (read-only);

**SensorTemperature:** Display Sensor's real-time temperature (read-only);

**Timestamp:** Display timestamp with an accuracy of 8ns (read-only);
**TimestampIncrement:** timestamp accuracy, default is 8ns, cannot be modified;
**TimestampReset:** Reset the timestamp, and re-calculate the timestamp from the current captured frame;
**Timestamp Latch:** captures the current timestamp ;

### 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.

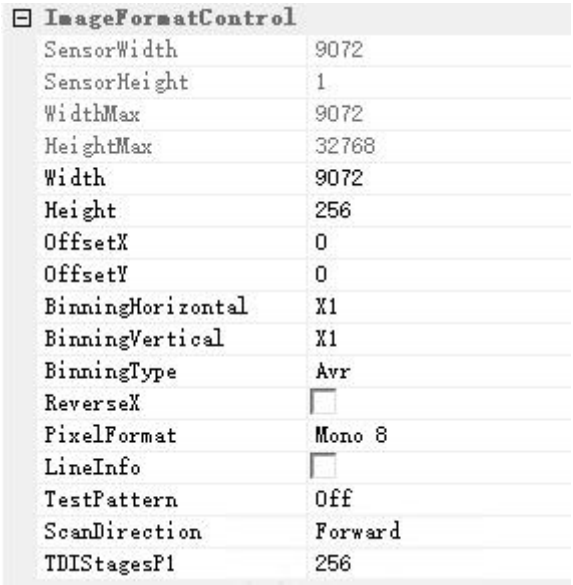



Figure 5-9

**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.
**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.
**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, set the image height to 256/1024/4096 respectively under 8/10/12bit to enable normal test mode.
**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, 124, 240, 248, 252, 256 stages. Under TDI mode, at the same light intensity, the higher the TDI stage number, the longer the integration time and the brighter the image will be.

**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.

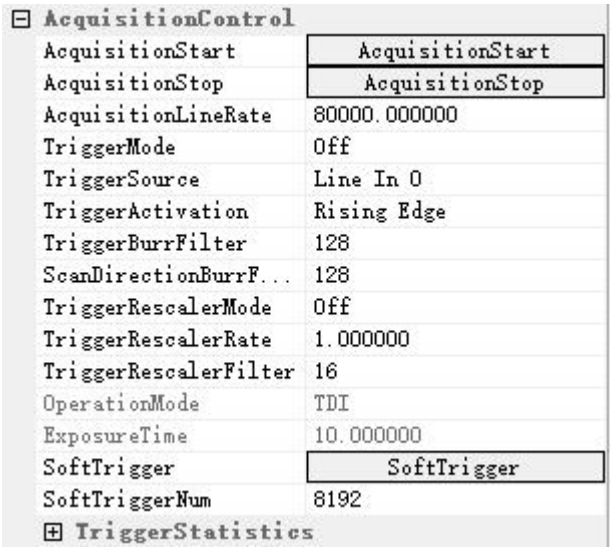



Figure 5-10

**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 source selection**, supporting three trigger modes: Line In0, Software trigger and CXPin frame grabber trigger. When using Line In0, the trigger source connects to the camera trigger port through the Hirose cable to trigger the image. When using Software, by clicking the SoftTrigger trigger. When using CXPin, the trigger source connects to the frame grabber through the frame grabber trigger cable to trigger the image.
**TriggerActivation:**Trigger condition setting, supporting rising edge, falling edge, and double edge triggering (trigger frequency, doubled pulse count);
**TriggerBurrFilter:**Trigger signal filtering. The larger the value, the more likely it is to cause signal distortion. For stable signals, it is recommended to use a smaller value, in ns. The default value is 128, which can be entered from 32 to 100000000. If the signal has burrs, then this value needs to be slightly larger than the width of the burr signal and smaller than the width of the trigger level. For example, if the external trigger frequency is 256kHz, the duty cycle is 50%, and the signal quality is good without burrs, the BurrFilter setting can be set to no more than 1s ÷ 256000 × 50%=1,953.125ns to trigger normally;

**ScanDirectionBurrFilter:**Scanning signal trigger high level adjustment threshold, unit:ns, such as the threshold is set 10000, the device scanning signal duty cycle is 50%, it means that the high level exceeds 50000ns (1s ÷ 10000ns × duty cycle 50%), no longer receive scanning signals, the external trigger signal is no longer switching direction;

**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;

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

| TriggerStatistics | |
|---|---|
| InputTriggerRate | 8.583070 |
| InputTriggerRat... | 8.583070 |
| InputTriggerJitter | 0.000000 |
| InputTriggerDur... | 0.006944 |
| RescaledTrigger... | 8.583070 |
| RescaledTrigger... | 0.000000 |
| RxTriggerNum | 62440093 |
| RxLineNum | 62440093 |

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.

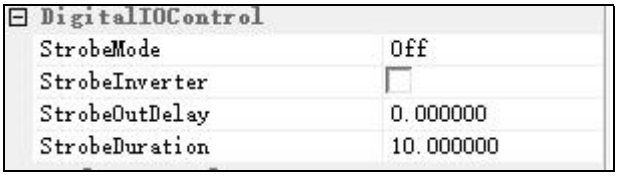



Figure 5-12

**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.

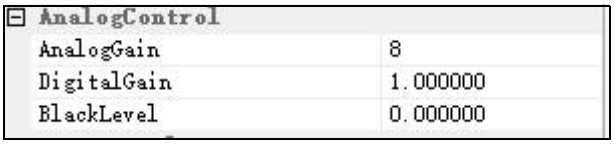



Figure 5-13

**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, 8bit background grayscale value: 6, 10bit background grayscale value: 25, 12bit background grayscale value: 100;

### 5.3.6. LUTControl

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

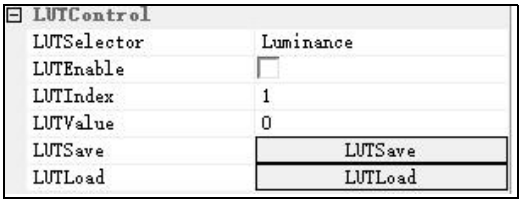



Figure 5-14

**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);

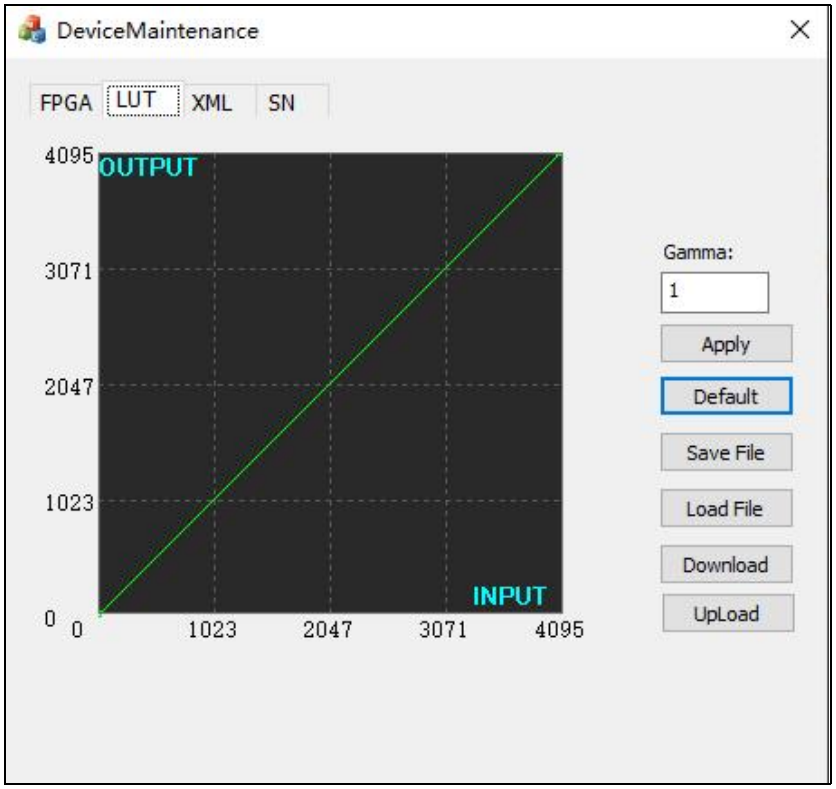



Figure 5-15

**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.

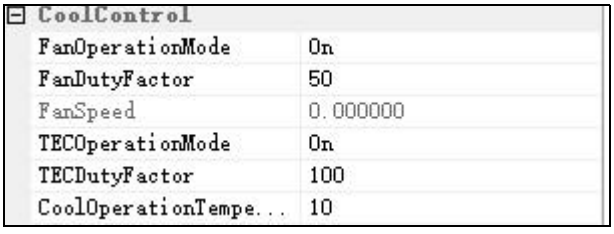


Figure 5-16

**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, 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, which stands for Dark Signal Non-Uniformity, is used to calibrate the camera.The settings interface is shown in Figure 5-17.

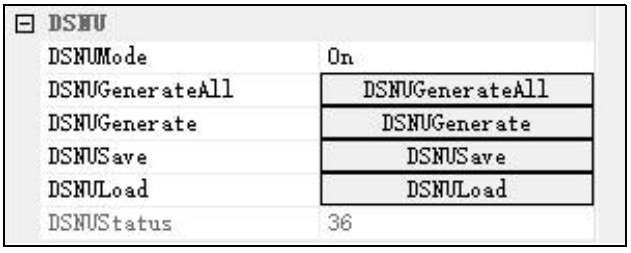



Figure 5-17

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

**DSNUGenerateAll:** When the camera is in a dark and lightless environment with a current exposure time, click to perform online DSNU correction on all gain modes, and the correction results are automatically saved to non-volatile memory;
**DSNUGenerate:** When the camera is in a dark and lightless environment with the current exposure time, click to initiate online DSNU correction for the current gain mode;
**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;

**DSNUStatus：** DSNU operation counters, using DSNUGenerateall, DSNUGenerate, DSNUSave, and DSNULoad, toggle the bit depth, analog gain, and the DSNU counters all add one.

**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;*

## 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.

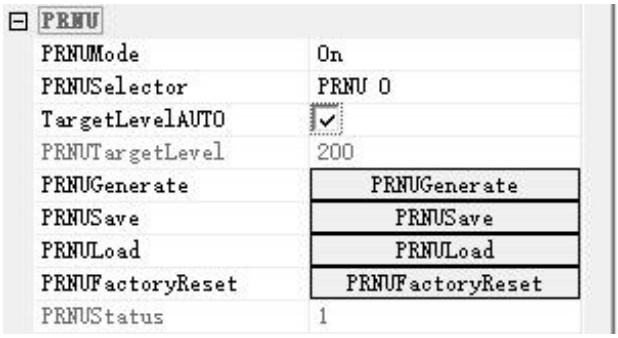



Figure 5-18

**PRNUMode:** PRNU correction enabling switch, Off position turns off PRNU, ON position turns on PRNU;
**PRNUSelector:** Selects the location where PRNU data is saved, supports for 5 groups of data (PRNU0-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:** Manual mode, uncheck the automatic mode, set the PRNU grayscale value, adjust the brightness of the bright uniform light to the set grayscale 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 saved PRNU data from the selected PRNU0~PRNU4 in non-volatile memory;
**PRNUFactoryReset:** Restore the selected PRNU0~PRNU4 to factory backup parameters;

**PRNUStatus：** PRNU operation counters, using PRNUGenerate, PRNUSave, PRNULoad, PRNUFactoryReset, switching PRNUSelector, PRNU counter will all be increased by one; however, switching the bit depth, analog gain PRNU counter will not be increased.

**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;

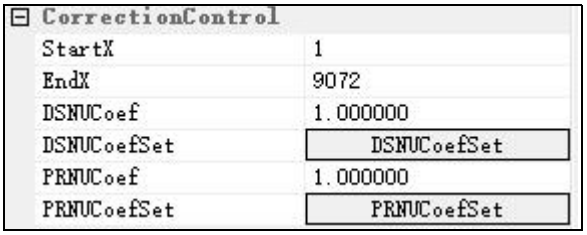



Figure 5-19

**StartX:** Select the X-coordinate of the starting pixel, with an input range of 1~9072;
**EndX:** Select the X-coordinate of the ending pixel, with an input range of 1~9072;
**DSNUCoef:** Set an additional DSNU correction value, subtract the set value from the grayscale values of the selected region (e.g., under DSNU, if the average grayscale value of the image is 100 and the DSNUCoef is set to 100, then after Correction, the average grayscale value of the image will be 0);
**DSNUCoefSet:** Configure based on the set DSNUCoef value;
**PRNUCoef:** Set an additional PRNU correction value, multiply the grayscale values of the selected region by the set value (e.g., under PRNU, if the average grayscale value of the image is 2000 and the PRNUCoef is set to 1.024, then after Correction, the average grayscale value of the image will be 2048);
PRNUCoefSet: Configure based on the set PRNUCoef value.

Note:

**1)** When making PRNUCoefSet and DSNUCoefSet, switch DSNU and PRNU to the On position to view the effect after CoefSet;

**2)** The calibration parameters will not be saved after the camera is powered off;

**3)** It can perform calibration for multiple areas;

### 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.

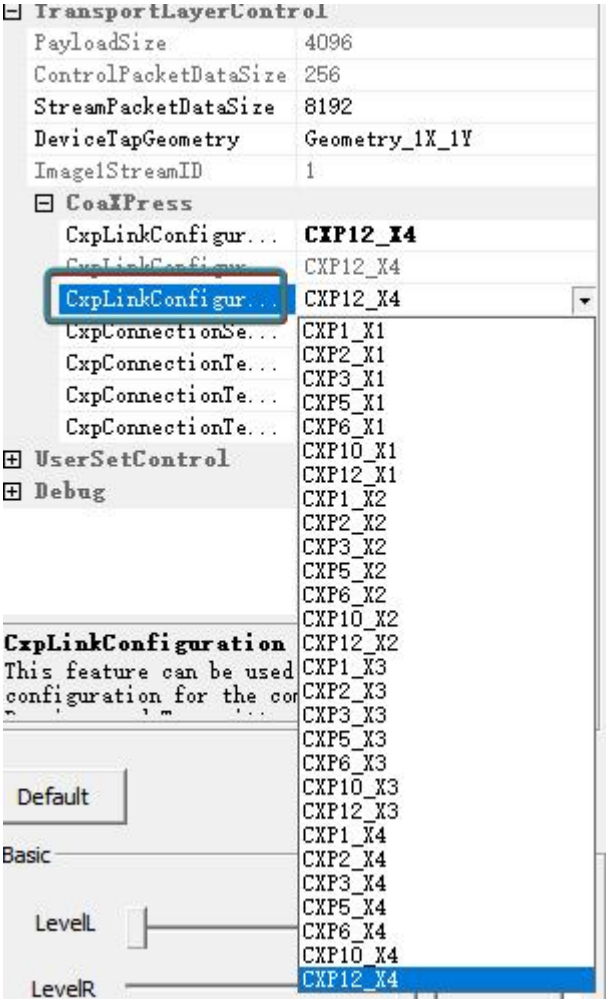



Figure 5-20

CxpLinkConfigur... CXP12_X4 :CXP default connection setting;

CxpLinkConfigur... CXP12_X4 :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;

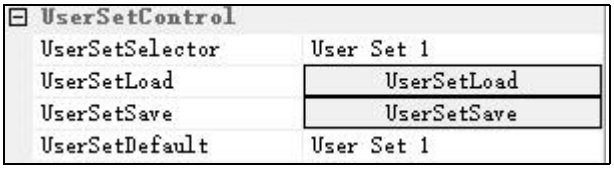



Figure 5-21

**UserSetSelector:** User configuration selection, used to save or load configuration parameters, providing three groups of Defalt, UserSet1, UserSet2;

**UserSetLoad:** Load the selected user configuration;

**UserSetSave:** Save the modified parameter configuration in the selected user configuration;

**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;

## 5.4. Image Adjustment

This module includes histogram, gamma, and contrast settings. The settings interface is shown in Figure 5-28.

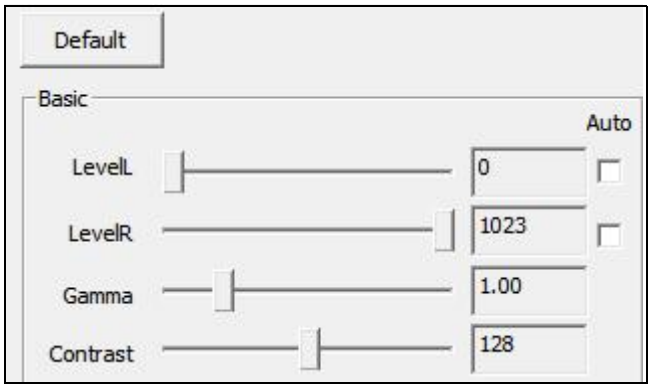



Figure 5-22

**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;

# 6. Frequently Asked Questions

**How to calculate the readout time?**

The readout time of a frame of image can be calculated by multiplying the line period by the number of lines. The line frequency is the reciprocal of the line period.

**How to calculate line frequency?**

Line frequency (Hz) = sample movement speed (mm/s) divided by 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.

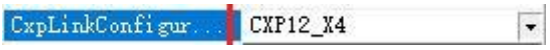
**What are the factors that affect the camera line speed (line frequency)?**

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.



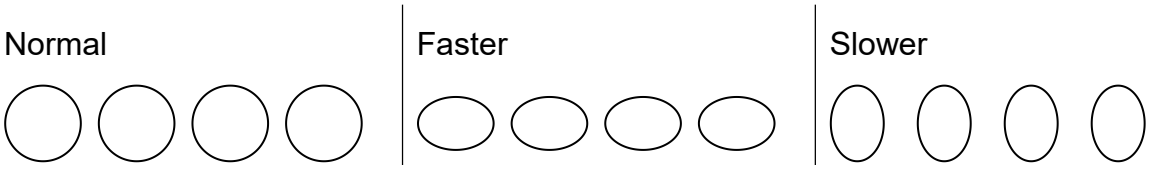

**When the TDI Stage is less than 256, which rows of data on the Sensor are read out?**

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 is the preview image stretched or compressed relative to the actual sample in TDI mode?**

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;

**How long can the optical fiber cable support?**

At present, the longest distance tested is 70 meters.

**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

# 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:

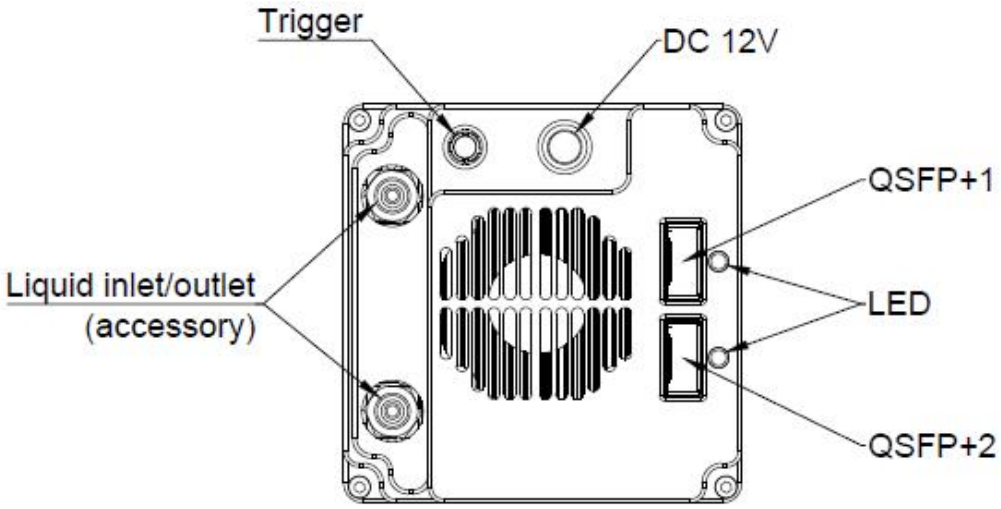
- Camera model and S/N (product serial number);
- Software version number and computer system information;
- A description of the problem and any images related to the problem.

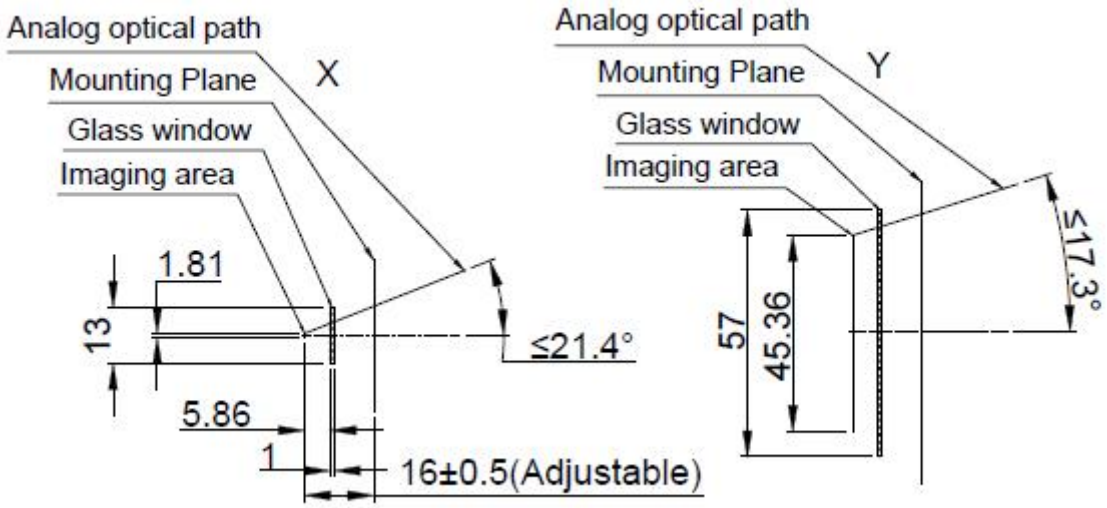
# Appendix 1: Table of dew point corresponding to temperature and humidity

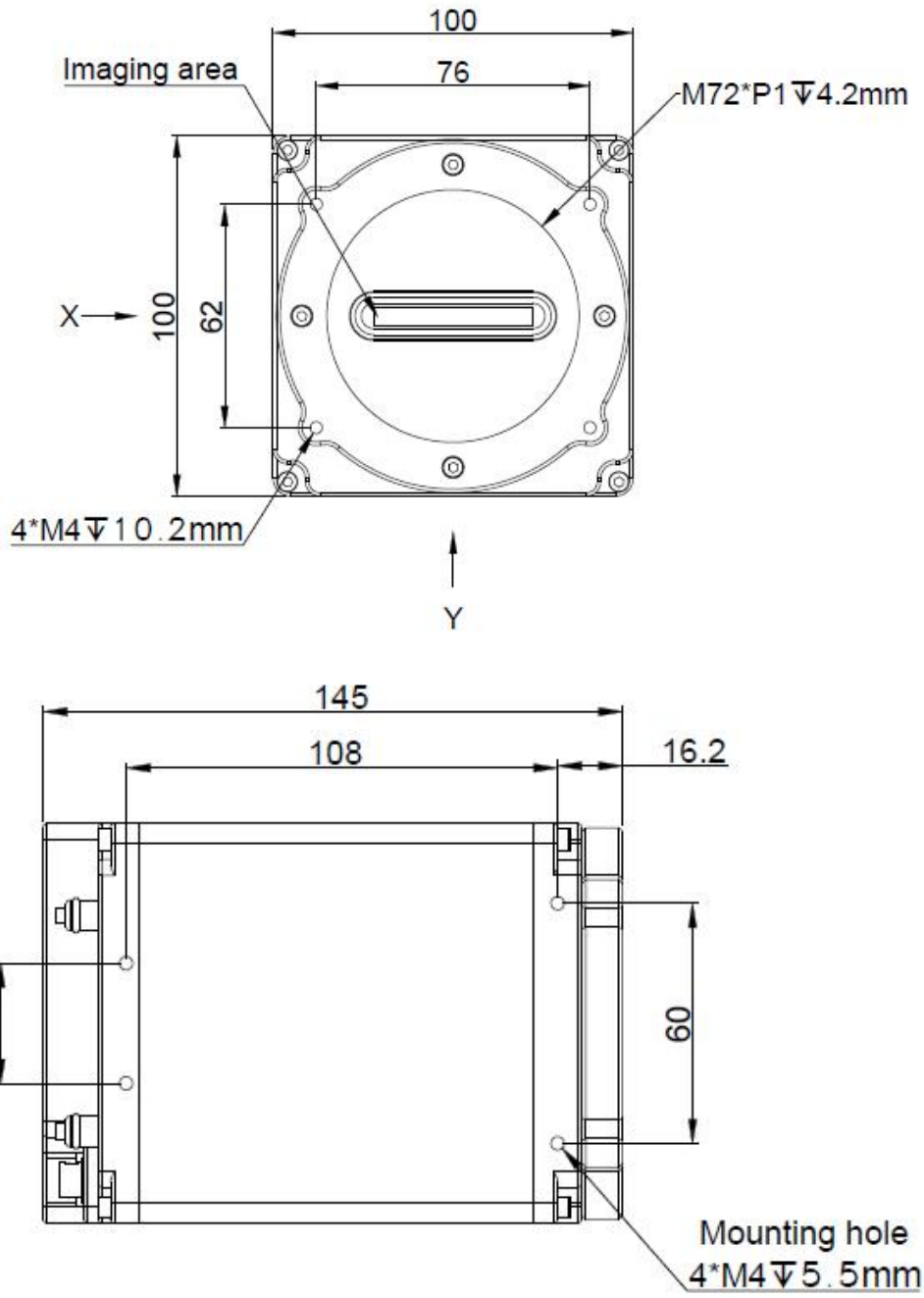
| | | Humidity | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% |
| Temperature | 5 | | | | | | | 1.8 | 3.5 |
| | 6 | | | | | | | 2.8 | 4.5 |
| | 7 | | | | | | 1.9 | 3.8 | 5.5 |
| | 8 | | | | | | 2.9 | 4.8 | 6.5 |
| | 9 | | | | | 1.6 | 3.8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

# Appendix 2: Structural Dimensions

Unit: mm，Diameter: ø.




100
76
Imaging area
M72*P1↧4.2mm
X
100
62
4*M4↧10.2mm
Y
145
108
16.2
30
60
Mounting hole
4*M4↧5.5mm

# Appendix 3: Camera Parameter Table

| Model | Dhyana 9KTDI Pro |
|---|---|
| Sensor Type | 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%@550nm；50%@350nm;38%@800nm |
| TDI Stages | 4/8/16/32/64/128/192/256 |
| Max. Line Rate | 510kHz@8bit、 368kHz@10bit、299kHz@12bit<br>600KHz@8bit、600kHz@10bit、299kHz@12bit（ROI） |
| Scan Direction | Forward/Reverse/Trigger Control |
| Dynamic Range | Typ.69dB@12bit；64dB@10bit |
| Charge Transfer Efficiency | ≥0.99993 |
| Full-Well Capacity | Typ.15.5ke-@12bit；14ke-@10bit |
| vibration coefficient | FAN=100，Fan vibration ≤0.5um |
| Readout Noise (Median Value) | Typ.7.2e-@12bit；11.4e-@10bit |
| Analog Gain | x2 ~ x8 |
| Digital Gain | x0.5 ~ x10 |
| DSNU | Typ.1.5e-@12bit；3.5e-@10bit |
| PRNU | Typ.0.30% |
| Refrigeration method | air cooling, water cooling |
| temperature differences | Air 20 ℃ (ambient temperature 25 ℃);<br>Water 35 ℃ (water temperature 20 ℃) |
| Binning | Horizontal Binning supports x1、x2、X4、X8<br>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 | CoaxPress-Over-Fiber 2 x QSFP+ |
| SDK | GenICamTM |
| Pixel Data Format | 8bit,10bit,12bit |
| Optiona Interface | M72 x1 |
| Operating Voltage/Current | 12V/8A |
| Dimension | 100mm*100mm*145mm |
| Weight | 1.820kg |
| Application Software | SamplePro；Matlab |
| Operating System | Windows；Linux |
| Operating Environment | Temperature: 0-40°C，Humidity: 0%-90% |

# Appendix 4: Update Log

| Version | Date | Updated Content |
|---|---|---|
| V1.0.0 | 20230918 | Create the document. |
| V1.1.0 | 20240117 | Added description of the delay in changing the scanning direction;<br>Added description of the upper temperature limit of the device;<br>Added description of Sensor Test Image;<br>Update the Lineinfo description;<br>Added specifications for PCIe slots supported by frame grabber;<br>Added description of DSNU/PRNU read and write ;<br>Add description of a new trigger type Software;<br>Added description of ScanDirectionBurrFilter;<br>Added description of DSNUStatus/PRNUStatus. |