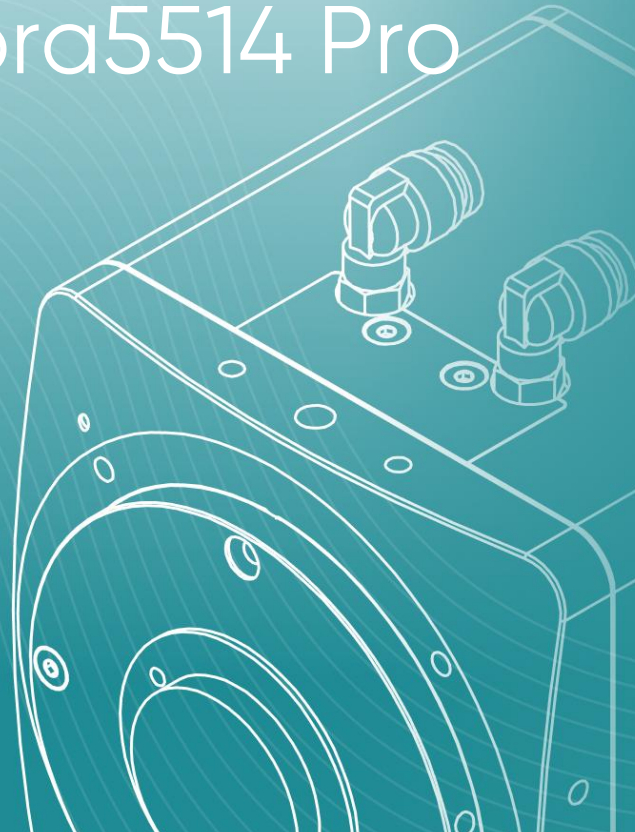




# Libra 5514 & Libra5514 Pro User Manual



Tucsen Photonics →

V 1.0.2

[www.tucsen.com](http://www.tucsen.com)

# Contents

- 1. INTRODUCTION ..... 5**
  - 1.1. DISCLAIMER ..... 5
  - 1.2. SAFETY AND WARNING INFORMATION ..... 6
  
- 2. PRODUCT SPECIFICATIONS ..... 7**
  - 2.1. PACKAGING LIST ..... 7
  - 2.2. QUANTUM EFFICIENCY CURVE ..... 9
  - 2.3. WINDOW CURVE ..... 9
  - 2.4. CAMERA POWER AND SIGNAL CONNECTION ..... 10
    - 2.4.1. TRIGGER INTERFACE PIN DEFINITIONS ..... 11
    - 2.4.2. POWER INTERFACE PIN DEFINITIONS ..... 12
  
- 3. FEATURES AND FUNCTIONS ..... 12**
  - 3.1. CAMERA INTRODUCTION ..... 12
  - 3.2. STRUCTURE AND OPERATION OF sCMOS ..... 12
    - 3.2.1. STRUCTURAL COMPOSITION OF sCMOS CAMERA SENSORS ..... 13
    - 3.2.2. IMAGE ACQUISITION AND PROCESSING FLOW ..... 13
  - 3.3. SHUTTER MODE ..... 14
  - 3.4. FRONT-ILLUMINATED AND BACK-ILLUMINATED sCMOS TECHNOLOGY ..... 15
  - 3.5. READOUT NOISE ..... 15
  - 3.6. DEFECTIVE PIXEL CORRECTION (DPC) ..... 16
  - 3.7. DARK SIGNAL NON-UNIFORMITY (DSNU) ..... 17
  - 3.8. PHOTO RESPONSE NON-UNIFORMITY (PRNU) ..... 18
  - 3.9. GAIN MODE ..... 19
    - 3.9.1. HIGH DYNAMIC RANGE ..... 19
    - 3.9.2. STANDARD ..... 20
  - 3.10. REGION OF INTEREST READOUT ..... 20
  - 3.11. MULTIROI ..... 21
  - 3.12. BINNING READOUT ..... 25
  - 3.13. TIMESTAMP ..... 25
  - 3.14. FRAME RATE CALCULATION ..... 26
    - 3.14.1. FULL-RESOLUTION CALCULATION ..... 26
    - 3.14.2. ROI FRAME RATE CALCULATION ..... 26
  - 3.15. FRAME RATE ADJUSTMENT ..... 27
  - 3.16. INCIDENT PHOTON CALCULATION ..... 27
  - 3.17. ACQUISITION MODE ..... 28
    - 3.17.1. FREERUNNING ..... 28
    - 3.17.2. SOFTWARE TRIGGER MODE ..... 28
    - 3.17.3. HARDWARE TRIGGER MODE ..... 28
      - 3.17.3.1. Hardware Trigger input circuit ..... 28
      - 3.17.3.2. Trigger Delay and Jitter ..... 29
      - 3.17.3.3. Standard Trigger Mode ..... 29
    - 3.17.4. TRIGGER OUTPUT TIMING DIAGRAM ..... 30
  - 3.18. COOLING ..... 31
  
- 4. INSTALLATION ..... 32**
  - 4.1. RECOMMENDED COMPUTER CONFIGURATIONS ..... 32
  - 4.2. CAMERA INSTALLATION ..... 33
  - 4.3. WATER COOLING PIPE INSTALLATION ..... 33
    - 4.3.1. CONNECT THE WATER COOLING PIPE ..... 33
    - 4.3.2. SOFTWARE FAN STATUS ..... 34
    - 4.3.3. DISCONNECT THE WATER COOLING PIPE ..... 35

4.4. FRAME GRABBER INSTALLATION .....	36
4.5. DRIVER INSTALLATION .....	37
4.6. SAMPLEPRO SOFTWARE INSTALLATION .....	40
<b>5. SAMPLEPRO OPERATING INSTRUCTIONS .....</b>	<b>41</b>
5.1. LAUNCH INTERFACE .....	41
5.2. WINDOW COMPOSITION .....	42
5.2.1. PREVIEW WINDOW .....	42
5.2.2. WINDOW CONTROL .....	43
5.2.3. IMAGE CAPTURE .....	43
5.2.4. PARAMETERS .....	43
5.2.5. BASIC .....	43
5.3. IMAGE CAPTURE .....	44
5.4. DEVICE PARAMETERS .....	45
5.4.1. DEVICE CONTROL .....	46
5.4.2. IMAGEFORMATCONTROL .....	47
5.4.3. ACQUISITIONCONTROL .....	49
5.4.4. ANALOGCONTROL .....	52
5.4.5. USERSETCONTROL .....	52
5.4.6. CHUNKDATACONTROL .....	53
5.4.7. CUSTOMCONTROL .....	54
5.4.8. MULTIROICONTROL .....	54
5.4.9. DPCCONTROL .....	55
5.4.10. DSNUCONTROL .....	56
5.4.11. DSNUCONTROL .....	56
5.4.12. TRANSPORTLAYERCONTROL .....	56
5.5. IMAGE ADJUSTMENT .....	56
<b>6. MAINTENANCE .....</b>	<b>57</b>
6.1. REGULAR INSPECTIONS .....	57
6.2. ELECTRICAL SAFETY INSPECTION .....	57
6.3. COOLING HOSES AND CONNECTORS .....	57
6.4. BASIC USAGE .....	57
6.5. WINDOW CLEANING .....	58
<b>7. TROUBLESHOOTING .....</b>	<b>58</b>
7.1. THE COMPUTER CANNOT RECOGNIZE THE CAMERA .....	58
7.2. SOFTWARE PAUSES OR FREEZES .....	59
7.3. THE CAMERA CANNOT REACH THE TARGET COOLING TEMPERATURE .....	59
7.4. THE FRAME RATE CANNOT REACH THE NOMINAL LEVEL .....	59
<b>8. FAQs .....</b>	<b>60</b>
8.1. WHY IS THE BRIGHTNESS OF THE CAPTURED IMAGE INCONSISTENT WITH THE PREVIEW WINDOW? .....	60
8.2. WHY IS THE OFFSETY OF LIBRA 5514 AND LIBRA 5514 PRO CAMERAS NOT CONFIGURABLE? .....	60
<b>9. AFTER-SALES SUPPORT .....</b>	<b>60</b>
<b>APPENDIX 1: DIMENSIONS .....</b>	<b>62</b>
<b>APPENDIX 2 : SPECIFICATIONS .....</b>	<b>65</b>
<b>APPENDIX 3 : CERTIFICATION .....</b>	<b>68</b>



## Release Notes

Version	Date	Modifications
V1.0.0	Dec.2025	Crate document
V1.0.1	Jan 2026	<ol style="list-style-type: none"> <li>1. The following modifications have been made to the user manual in accordance with changes in firmware functionality:               <ol style="list-style-type: none"> <li>1) The functionality of the Socket pins has been modified to align with other cameras.</li> <li>2) Adjustment of the ROI (Region of Interest) frame rate.</li> <li>3) Revision of the minimum exposure time.</li> <li>4) Update to the frame rate calculation formula.</li> </ol> </li> <li>2. Updates to Water Cooling Tube Structure Dimensional Information and Related Images. Dimensional details and associated diagrams of the water cooling tube structure have been revised.</li> <li>3. Optimization of Popular Science Content in the Third Chapter: Features and Functions</li> <li>4. Revision of Camera Storage Temperature and Humidity Ranges</li> <li>5. Addition of New Information: RoHS certification information has been added.</li> <li>6. Dimensional outline drawings for C-mount and F-mount interfaces have been included.</li> </ol>
V1.0.2	Apr 2026	<ol style="list-style-type: none"> <li>1. Revision of Model Name</li> <li>2. Addition of Product Name</li> <li>3. Addition of Multi-ROI Feature Description and Frame Rate Calculation Formula</li> </ol>

# 1. Introduction

## 1.1. Disclaimer

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

Under no circumstances shall any content in this document constitute any express, implied, statutory or other form of warranty, including but not limited to any warranties of merchantability, non infringement or suitability for a specific purpose.

In any case, TUCSEN shall not be liable for any losses or damages arising from or related to the unauthorized use of the content of this document, whether direct, indirect, special, incidental, consequential or other reasons, whether caused by infringement or other reasons.

### **Product usage restrictions:**

The product can only be used according to the instructions in the user manual, and unauthorized modifications, tampering, or reverse engineering are not allowed. Users are reminded that if they do not use the product according to the instructions in the user manual, resulting in product damage or malfunction, the responsibility shall be borne by the user. During the actual operation of the product, users should adjust and apply according to the content of the product manual, disclaimer, and safety instructions, combined with their own actual situation and needs. Our company does not assume any legal responsibility for any personal injury or property damage caused by users violating the product manual, disclaimer, safety instructions, or improper operation.

### **Quoting third-party content:**

- 1) The user manual may contain content or links provided by third parties, which are for user reference and convenience only. TUCSEN only directly references the content or links of third parties and does not guarantee their authenticity, accuracy, and completeness, and does not assume any responsibility.
- 2) The publication of information in this document does not imply that TUCSEN Company or any third party automatically waives any patent or exclusive rights.
- 3) This document may contain technical or printing errors. Under no circumstances shall TUCSEN be




liable for any loss or damage caused by unauthorized use of the content of this document, whether direct, indirect, special, incidental, consequential or otherwise.

### Copyright and Protection Statement:

The copyright of this document and related drawings belongs to TUCSEN, and TUCSEN reserves all rights including interpretation. This document and related drawings shall not be copied, reprinted, or copied without authorization, and the relevant content shall not be disclosed without authorization.

### Trademark and Patent Information:



鑫图, , ,  are trademarks of TUCSEN, and no one shall infringe upon the trademark rights of TUCSEN. All other trademarks are the property of their trademark owners, and TUCSEN is not responsible for any infringement by others.

### Update of user manual:

TUCSEN does not promise to notify updates or maintain the information contained in this document at any time. If changes are made to the product, the relevant change information will be included in the new version of the manual. Without prior notice.

**In summary, before using our company's products, please carefully read and understand the above disclaimer. Wishing you a pleasant use, thank you!**

**Tucsen Photonics Co., Ltd.**

## 1.2. Safety and warning information

### Operation and Use



Caution

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

- Ensure that the temperature of the camera is within the specified temperature range for use to avoid damage.

### Installation and maintenance



Caution

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

### Power





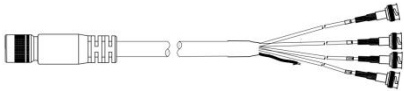






Caution

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

## 2. Product Specifications

### 2.1. Packaging List

Standard Items	Specification	Quantity	Image
Camera	Libra 5514 or Libra 5514 Pro	1	
Power adapter	24V/6.67A, R7B connector, 1-meter DC cable	1	
Power adapter power cord	Cable length: 1.8m; Chinese national standard flat pin plug power cord; AC power cable; Rated current: 10A; Rated voltage: AC250V	1	
USB flash drive	TUCSEN 4GB	1	
12-pin Trigger Cable	Model: HIROSE-BNC Trigger Cable. 12-pin trigger cable (HR10A-10P-12S female connector; 12C*26AWB color-coded cable, length: 3 m; insulation stripped 30 mm, conductor stripped 5 mm). BNC interface coaxial cable (single-ended BNC-JJ coaxial cable; length: 0.5 m, BNC male connector). Total cable length L = 3.5 m	1	
QSFP+ Optical Transceiver Module	Model: AMQ10-SR4-M1, Data Rate: 40Gb/s, Interface: MPO, Wavelength: 850nm, Operating Temperature: 0 to 70°C	2	
Adapter Ring	F-Mount Adapter or T-Mount Adapter	1	
Optical Fiber Cable	Model: MPO/F-MPO/F-OM3-8B (B3m) Specifications: 3-meter long, 8-core armored OM3 fiber optic patch cable, MPO female to MPO female connector.	1	
Frame Grabber	Model: Samadhi Coaxlink QSFP+ Frame Grabber Features: Four-channel CoaXPress-over-Fiber transmission, QSFP+ port compliant with 40Gbps optical module specifications, PCIe 3.0 (Gen3) x8 bus interface. Performance: Sustained bus bandwidth of 6,700 MB/s.	1	

## 2.2. Quantum Efficiency Curve

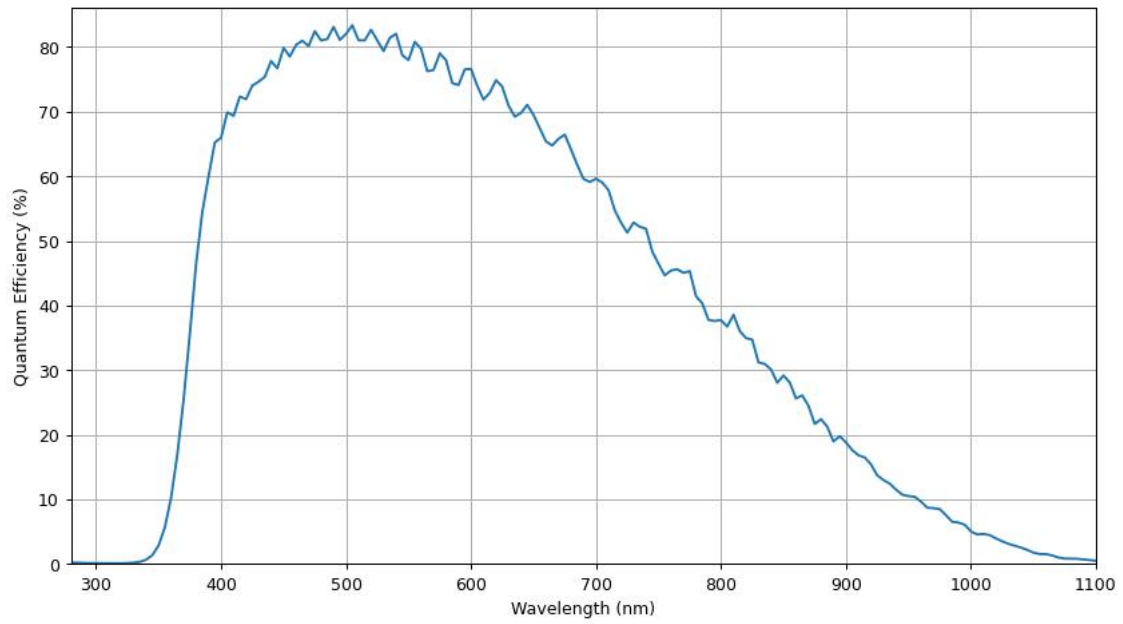


Figure 2-1 Quantum efficiency curve of Aries 6510 6506

## 2.3. Window Curve

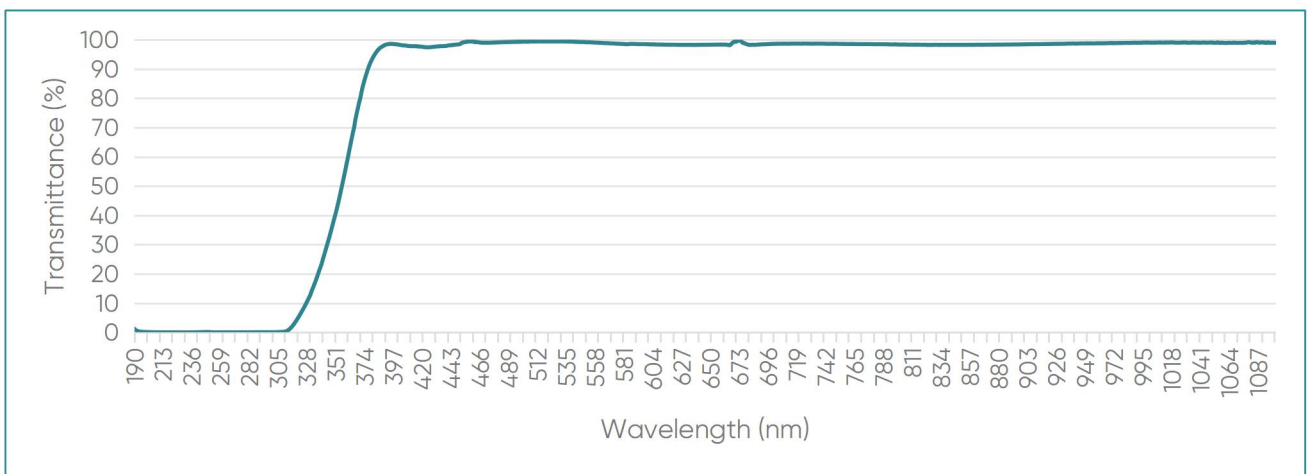


Figure 2-2 Transmission curve of a quartz window

## 2.4. Camera Power and Signal Connection

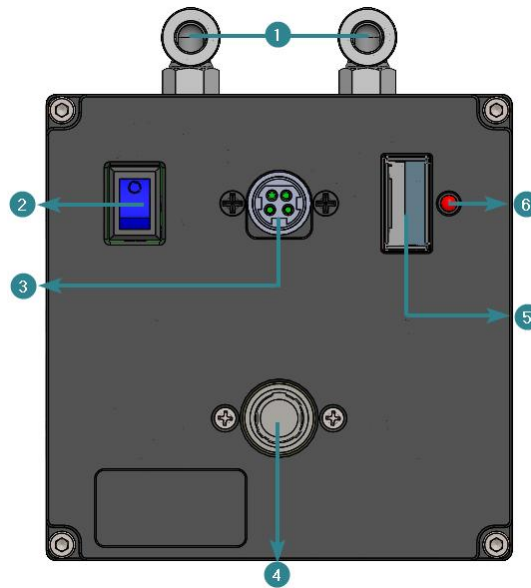


Figure 2-3

No	Name	Functions		
①	Water cooling pipe joint	Water cooling		
②	Switch	Control camera power,		
③	Power	Power interface, 24V/6.6A. Pin definitions refer to Section 2.4.2,		
④	Trigger	Camera Trigger Interface for trigger input/output functions. Pin definitions refer to Section 2.4.1.		
⑤	QSFP+	Data Transmission Interface		
⑥	Indicator	Indicates the camera status	Red ON	The camera is not initialized
			Red flashing	Configuration is not completed
			Amber flashing	Low-speed link information is being transmitted
			Green ON	CXP connection configuration is complete
			Alternating amber and green	Simultaneously transmit low-speed link information and high-speed image data.
			Green flashing	High-speed image data is being transmitted

### Note:

During camera connection and initialization, the status of the indicator light is related to driver recognition and link establishment. The specific operating procedures are as follows:

- 1) When the camera is initially powered on, the indicator light shows red (indicating a not ready state). After the driver completes recognition (or the driver has been correctly installed), the indicator will turn green (indicating a ready state). At this point, the software can be started normally and the camera functions can be used.
- 2) The link establishment mechanisms differ among different models of frame grabbers: Some frame grabbers require starting the camera control software first, and the connection link is established via a software command, after which the indicator turns green. Other frame grabbers can automatically complete link handshake and recognition after the camera is physically connected, and the indicator turns green directly.
- 3) If the software is started and the system prompts "No camera" (no camera device detected), the software should be closed immediately. Wait patiently for 20-30 seconds, then restart the software and proceed with the operation.

### 2.4.1. Trigger Interface Pin Definitions

The trigger interface and the pin layouts for Libra 5514 and Libra 5514 pro cameras are shown as Figure 2-4. And the functional definitions are detailed in Table 2-1: Trigger Interface Pin Definitions.

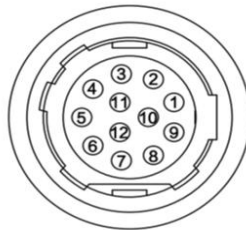


Figure 2-4

Table 2-1 Trigger Interface Pin Definitions

Pins	Signal	Descriptions
1	GND	Signal Ground
2	LINE0_P	Digital I/O Interface Line0, Differential Input/Output P-Terminal, Single-Ended Input/Output
3	NC	
4	LINE0_N	Digital I/O Interface Line0, Differential Input/Output N-Terminal
5	GND	Signal Ground
6	LINE3_P	Digital I/O Interface Line3, Differential Input/Output P-Terminal, Single-Ended Input/Output
7	LINE3_N	Digital I/O Interface Line3, Differential Input/Output N-Terminal
8	LINE2_P	Digital I/O Interface Line2 Differential Input/Output P-Terminal, Single-Ended Input/Output
9	LINE1_P	Digital I/O Interface Line1, Differential Input/Output P-Terminal, Single-Ended Input/Output
10	LINE1_N	Digital I/O Interface Line1, Differential Input/Output N-Terminal
11	NC	
12	LINE2_N	Digital I/O Interface Line2, Differential Input/Output N-Terminal

## 2.4.2. Power Interface Pin Definitions

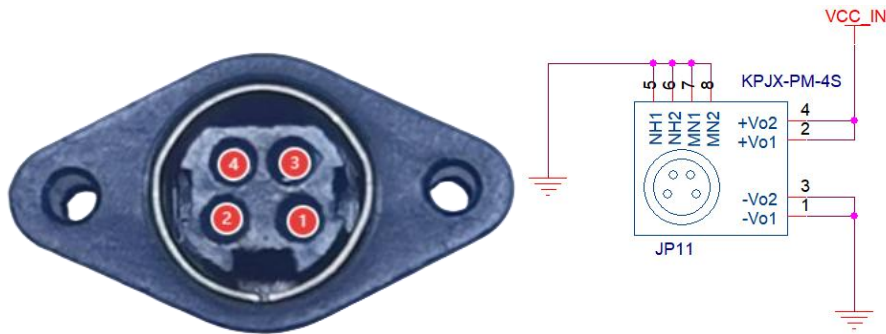


Figure 2-5 Power Interface Diagram

pins	Signal	I/O	Descriptions
1	GND	GND	Power Ground
2	VCC	24V	Power Positive (DC+), Input Voltage Range: 21V~27V
3	GND	GND	Power Ground
4	VCC	24V	Power Positive (DC+), Input Voltage Range: 21V~27V

## 3. Features and Functions

### 3.1. Camera Introduction

The Libra 5514 and Libra 5514 Pro cameras represent the industry's first high-speed global-shutter scientific-grade camera solution. Equipped with a back-illuminated global-shutter sensor, 5.5  $\mu\text{m}$  pixels and a peak quantum efficiency of 83%, it achieves outstanding sensitivity through high-light-capture design and precise pixel architecture. The camera uses a 40G CoF high-speed interface, supporting stable transmission of 8-bit images at 330 fps to meet demanding high-speed imaging requirements. Combined with a compact, low-vibration mechanical design that effectively minimizes external interference, the camera is ideally suited for high-throughput scientific imaging applications, such as dynamic sample capture and high-speed experimental monitoring.

### 3.2. Structure and Operation of sCMOS

Scientific Complementary Metal-Oxide-Semiconductor (sCMOS) cameras are advanced imaging devices specifically designed for high-precision scientific research and high-performance image acquisition tasks. They combine the high-speed readout capability of traditional CMOS technology with the high sensitivity and low-noise advantages of CCD sensors, featuring core characteristics such as high-speed imaging, extremely low read noise, and high dynamic range. As a critical component of modern scientific imaging systems, sCMOS cameras are widely used in cutting-edge research fields such as biomedical imaging, optical microscopy, astrophysics, neuroscience, and spectral analysis, thanks to

their excellent signal-to-noise ratio and stability.

### 3.2.1. Structural Composition of sCMOS Camera Sensors

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

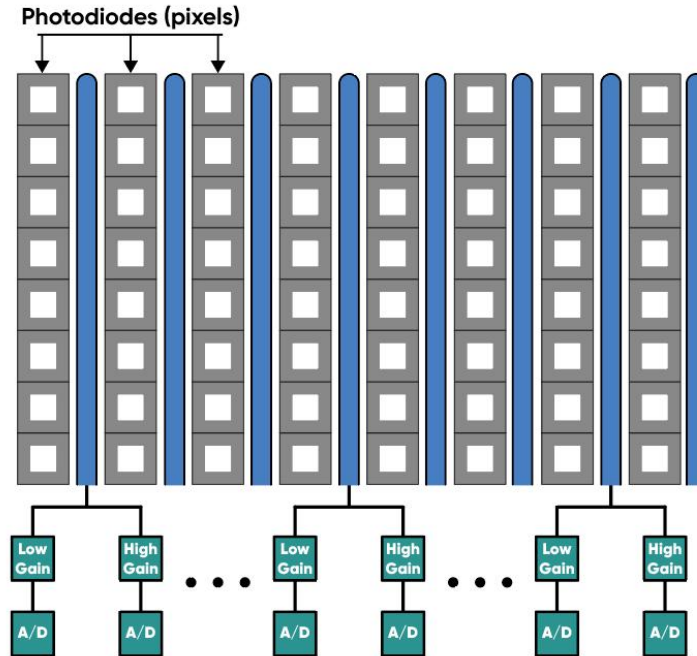


Figure 3-1 sCMOS camera sensor structure

- 1) Light-sensitive sensor array: sCMOS cameras use sCMOS sensor arrays (also known as image sensors) to capture light signals. These sensors consist of many photosensitive units that convert light into charge signals.
- 2) Gain amplifier: Each photosensitive unit in an sCMOS camera is equipped with an independent gain amplifier to amplify the charge signal and convert it into a voltage signal.
- 3) Analog-to-digital converter (ADC): The amplified analog signal is digitized through an analog-to-digital converter (ADC) inside the camera, converting it into a digital signal for further processing and storage.

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

### 3.2.2. Image Acquisition and Processing Flow

sCMOS camera operation follows the technical chain of photoelectric signal conversion →

amplification → digitization → processing → transmission, and the complete process is as follows:

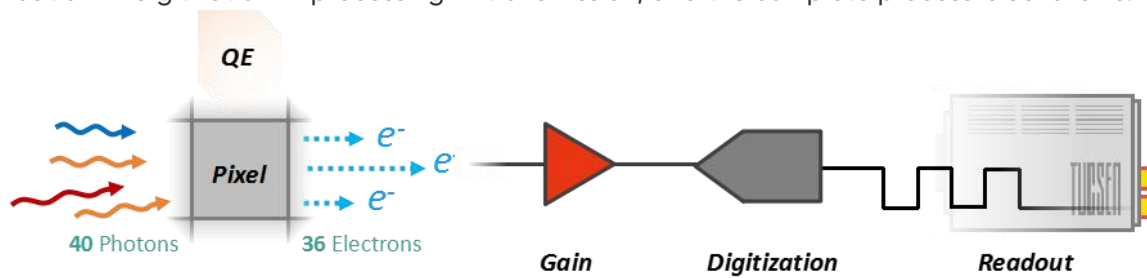


Figure 3-2 sCMOS operation process

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

### 3.3. Shutter Mode

Unlike the traditional rolling shutter's "row-by-row exposure scanning," global shutter sensors equip each pixel unit with an independent charge storage node. When the exposure signal is triggered, the entire pixel array (from the first to the last row) simultaneously starts to receive photons and accumulate charge. After exposure ends, the charge from all pixels is transferred to the readout circuit, ultimately producing a complete image with no temporal misalignment. This "full-array synchronized operation" ensures that each pixel in the image corresponds to exactly the same physical moment, effectively avoiding distortions, smearing, or uneven brightness caused by exposure timing discrepancies—especially in high-dynamic scenarios such as high-speed sample movement or pulsed-light excitation.

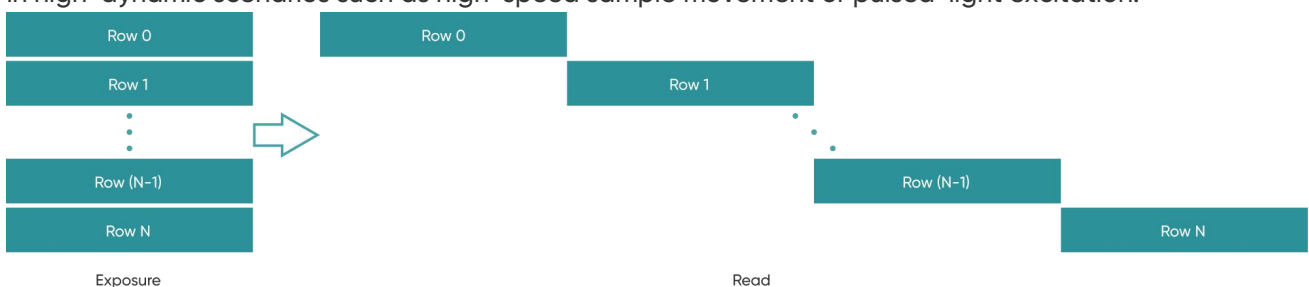


Figure 3-3 Global shutter diagram

### 3.4. Front-Illuminated and Back-Illuminated sCMOS Technology

In the field of scientific-grade imaging, the performance of sCMOS cameras is closely linked to the structural design of their core sensor chips. Currently, the chips used in sCMOS sensors are primarily divided into two types: Front-Side Illumination (FSI) and Back-Side Illumination (BSI). The fundamental difference between these two structures lies in the relationship between the optical path and the physical layout inside the sensor, which directly determines photon capture efficiency, Quantum Efficiency (QE), and overall imaging sensitivity.

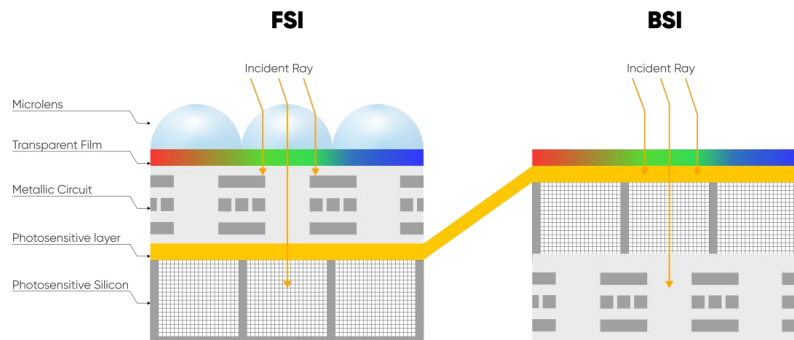


Figure 3-4 Front-Illuminated and Back-Illuminated diagram

### 3.5. Readout Noise

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

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

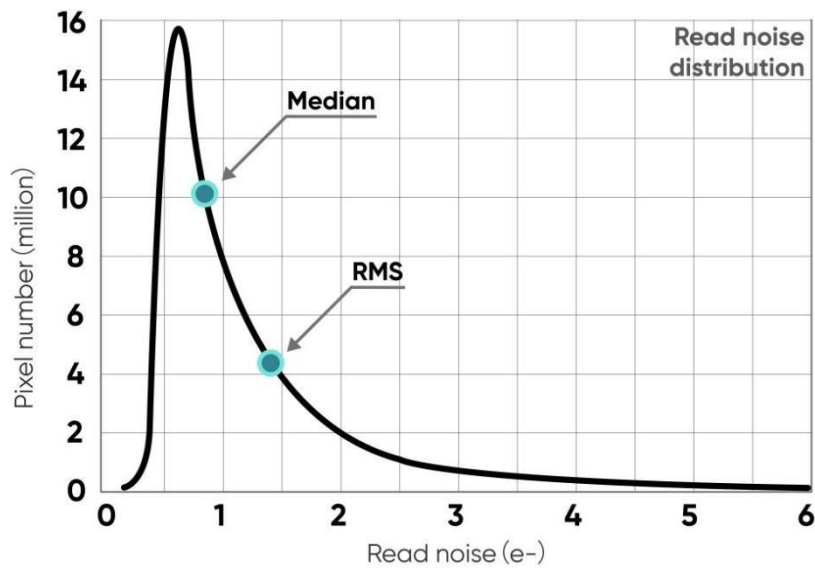


Figure 3-5 Readout noise distribution of an typical sCMOS camera

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

### 3.6. Defective Pixel Correction (DPC)

During manufacturing or long-term operation, sCMOS camera chips may occasionally develop a small number of pixel-level abnormal response points (known as “defective pixels,” which appear as fixed-position over-bright/dark spots, signal non-response, or random signal jumps). To improve image quality, the camera integrates a Defective Pixel Correction (DPC) function that identifies and suppresses these abnormal points via algorithm: for static defective pixels, they are directly replaced with the average value of surrounding pixels; for dynamic abnormal points, temporal filtering is applied to smooth the signal. Ultimately, the visibility of defective pixels is eliminated in the output image, thereby enhancing frame uniformity.

Although DPC can effectively handle most defective pixels, its algorithmic logic may potentially interfere with weak transient signals, especially in scenarios such as single-molecule imaging, where its use should be considered with caution.

Libra 5514 and Libra 5514 Pro support both dynamic and static defective pixel correction, using a  $3 \times$

3 pixel matrix for correction. Currently, three correction levels are available, each corresponding to a different threshold, allowing control over the intensity of defective pixel correction.

### 3.7. Dark Signal Non-Uniformity (DSNU)

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

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

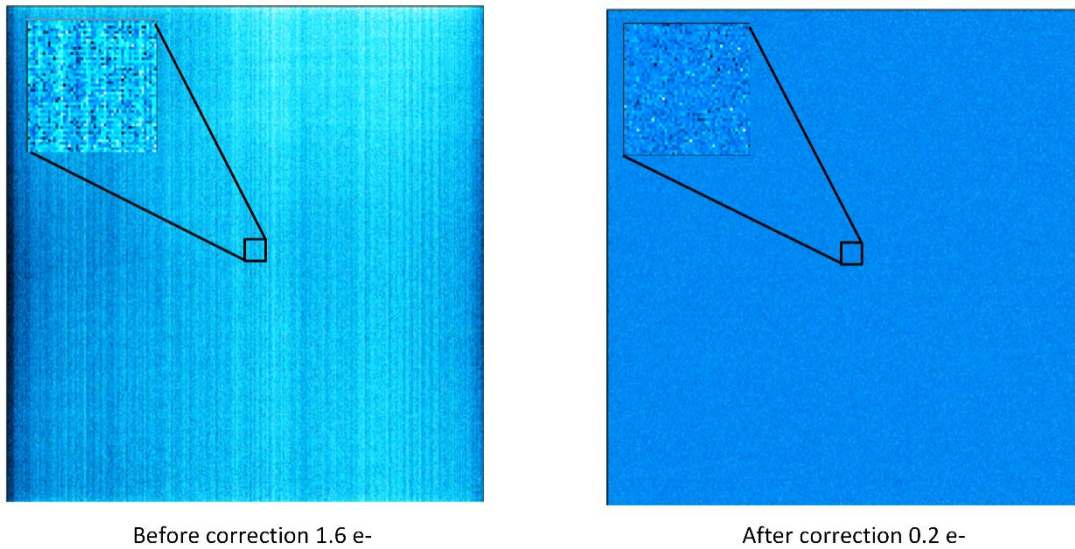


Figure 3-6 DSNU correction comparison before(left) and after(right)

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

### 3.8. Photo Response Non-Uniformity (PRNU)

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

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

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

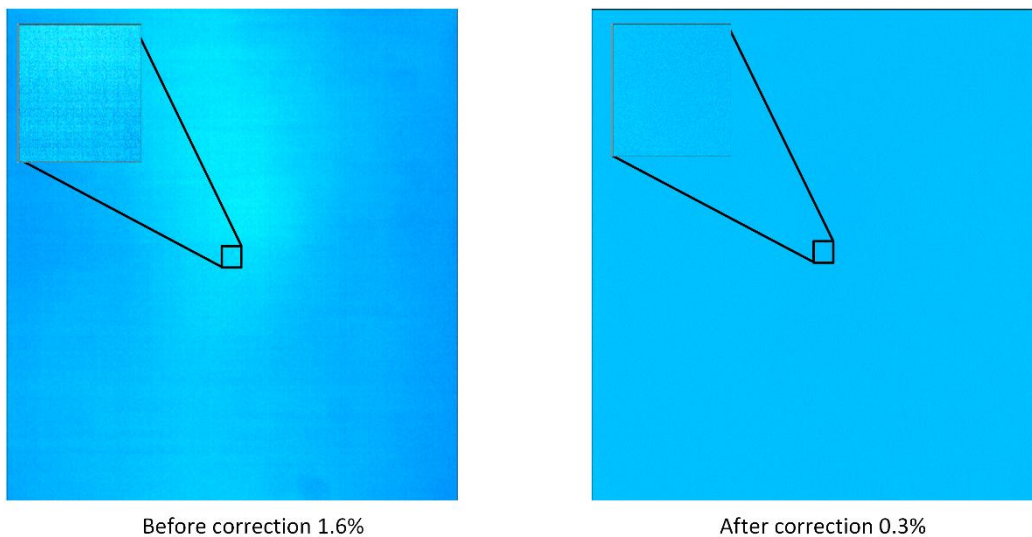


Figure 3-7 PRNU correction comparison before(left) and after(right)

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

### 3.9. Gain Mode

The Libra 5514 and Libra 5514 Pro cameras offer three operating modes: Dynamic (HDR), Standard, and StandardBin2. The synthesis principles, system gain values, and readout noise differ across these modes. The appropriate mode should be selected based on the actual imaging scenario to achieve high-quality results.

Table 3-1 Typical gain mode parameter table\*

	Dynamic (16-bit)	Standard (12-bit)				
		Gain 0	Gain 1	Gain 2	Gain 3	Gain 4
System gain (DN/e-)	4.9	0.256	0.404	0.575	0.73	1.30
Full-Well Capacity (ke-)	12.9	15.1	9.48	6.63	5.2	2.88
Readout noise (Median e-)	1.65	6.85	4.7	3.5	2.51	1.84
Readout noise (RMS e-)	1.7	6.9	4.75	3.8	2.6	1.9

**\*Note:**

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

#### 3.9.1. High Dynamic Range

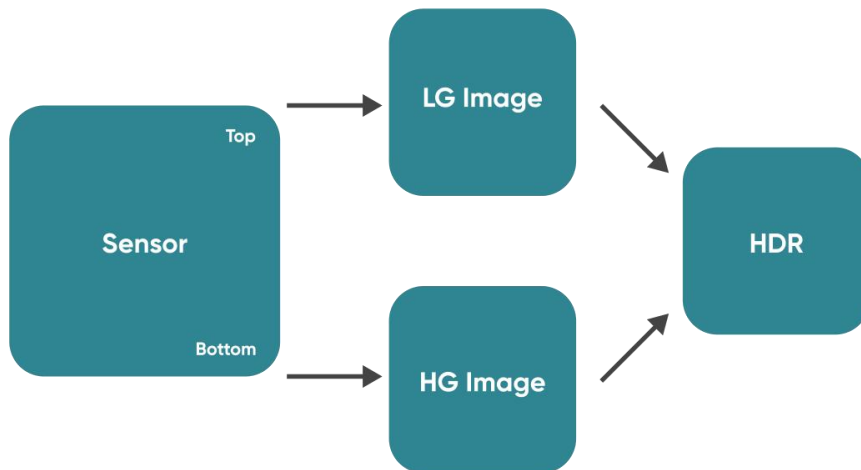


Figure 3-8 Schematic diagram of HDR mode

High Dynamic Range (HDR) Image Mode - the synthesis principle is illustrated in the figure below. After the chip is exposed, the image is read out with two different gain settings, and the two resulting frames are interleaved and transmitted in the format 0 HG - 1 HG - 0 LG - 1 LG. Among them, the Low Gain (LG) mode offers a higher full-well capacity and higher noise, making it suitable for imaging scenes

with strong signals. The High Gain (HG) mode provides lower full-well capacity and lower readout noise, making it suitable for imaging scenes with weaker signals. By algorithmically combining the high-gain and low-gain images, an HDR image is generated. This mode is well-suited for application scenarios where the signal strength varies significantly.

### 3.9.2. Standard

The principle of Standard mode is illustrated in the figure below. The chip simultaneously reads out the top and bottom readout chains, outputting the upper and lower halves of the image respectively. This two-row parallel output enhances the frame rate. Standard mode is typically suitable for application scenarios that require a certain frame rate, such as dynamic observation.

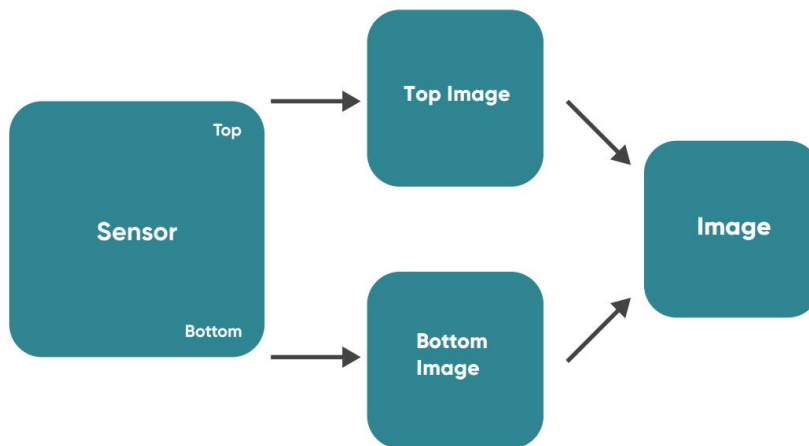


Figure 3-9 Schematic Diagram of High Gain in Speed Mode

## 3.10. Region of Interest Readout

In imaging applications, ROI (Region of Interest) is a core function: by defining a sub-region within the effective resolution range of the camera sensor (such as the local structure of a sample or the spatial extent where a dynamic event occurs), the camera performs image readout only for that sub-region after the ROI is selected, rather than conducting global acquisition of the full-resolution sensor array. Reducing the effective resolution can increase the camera's readout speed and frame rate.

The measured frame rates (fps) for typical ROI settings of the Libra 5514 camera are shown in the table below.

Table 3-2 Standard ROI ROI

Resolution	Width	Height	Dynamic (16-bit)	Standard (8-bit)	Standard (10-bit)	Standard (12bit)
4608 (H) x	4608	3072	80	330.52	236.42	220.14

3072 (V)	4608	1536	160	647.97	463.78	431.89
	4608	768	309.42	1246.63	893.34	832.09
	4608	384	579.81	2316.63	1663.89	1550.39
	4608	192	1029.76	4059.76	2925.69	2727.77
	4608	96	1682.32~1683.65	6504.49~6510.49	4711.29~4716.29	4395.61~4399.60
	4608	32	2913.09~2916.08	10875.12~10888.12	7946.05~7954.05	7426.57~7432.57
	256	32	2913.09~2916.06	10878.12~10882.12	10878.13~10883.23	10878.12~10886.11
2x2bin	2304	1536	80	330.52	330	330
4x4bin	1152	768	80	330.52	330	330

Table 3-3 StandardBin2 ROI

Resolution	Width	Height	StandardBin2 (8-bit)	StandardBin2 (10-bit)	StandardBin2 (12-bit)
2304 (H) x 1536 (V)	2304	1536	330.52	330	330
	2304	768	647.97	647.97	647.97
	2304	384	1246.63	1246.63	1246.63
	2304	192	2316.96	2316.96	2316.96
	2304	96	4059.76	4059.76	4059.76
	2304	32	8136.85~8149.85	8139.32~8147.32	8136.32~8147.32
	256	32	8136.85~8145.85	8136.82~8146.85	8137.85~8145.85
2x2bin	1152	768	330.52	330	330
4x4bbin	576	384	330.52	330	330

### 3.11. MultiROI

Libra 5514 and Libra 5514 Pro support the Multi- ROI (Multi- Region of Interest) function, which is implemented through the coordinated operation of sensor- level hardware ROI and FPGA- based algorithmic ROI:

- **Sensor-Level Hardware ROI:** Supports configurable cropping only in the height direction (the width is fixed at the full 4608 pixels). By adjusting the start and end positions of the sensor readout rows, it selects the vertical region of interest, thereby reducing the output of invalid data.
- **FPGA -Based Algorithmic ROI:** Based on the ROI image output by the sensor, it further performs column-wise cropping (removing irrelevant horizontal columns) and invalid-region padding (setting pixel values in non-ROI areas to black), ultimately outputting a precise ROI image that meets user

requirements.

Among these, the Sensor-Level Hardware ROI is the core factor affecting the frame rate—the smaller the cropped height, the less data the sensor needs to read out, leading to increase in frame rate. The FPGA-based algorithmic processing primarily optimizes the validity and format compliance of the image data, and its impact on the frame rate is negligible.

To achieve high-frame-rate performance, the sensor of the 5514 adopts a top-and-bottom partition parallel-output design:

The pixel array is divided into two independent top and bottom regions (each occupying, for example, half of the height in the vertical direction). The data channels of the two regions are completely independent and can transmit data outward simultaneously. The pixel positions output by the two regions are mirror-symmetric (i.e., the N-th row of the upper region corresponds to the N-th row of the lower region with the same horizontal coordinate, but opposite vertical direction). Mirror correction (if a unified coordinate system is required) must be performed via the FPGA or backend software before the two regions can be stitched into a complete ROI image.

This design breaks through the bandwidth limitation of a single channel by means of parallel data paths and is a key enabler of the ROI function in high-frame-rate scenarios.

### 1) Sensor Output Characteristics in Single-ROI Scenarios

Using diagrammatic examples, the following illustrates two different single-ROI cases. The sensor-level hardware ROI employs a top-/bottom-partition parallel-output and mirror-symmetric mechanism; the output image size is jointly determined by the ROI configurations of the Top and Bottom regions:

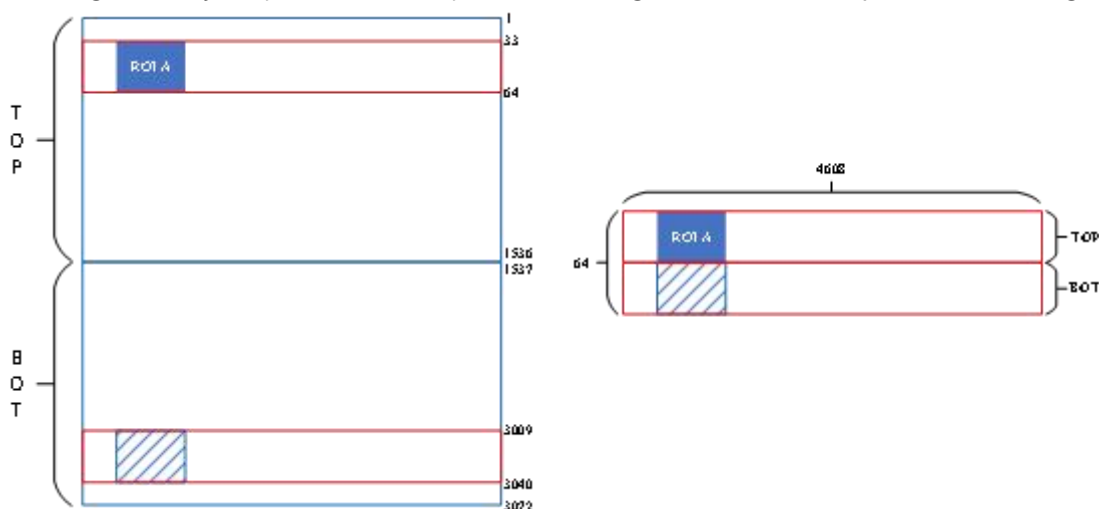


Figure 3-10

As shown in Figure 3-10, when ROI A (width: 256, height: 32) is configured in the Top region. To

maintain the symmetric output between the top and bottom partitions, the Bot region automatically outputs the area mirror-corresponding to Top ROI A. Consequently, the actual size of the image output by the Sensor is 64 pixels in height (Top 32 + Bot 32) and 4608 pixels in width (full width) - i.e., the complete area outlined by the red box (including non-ROI portions).

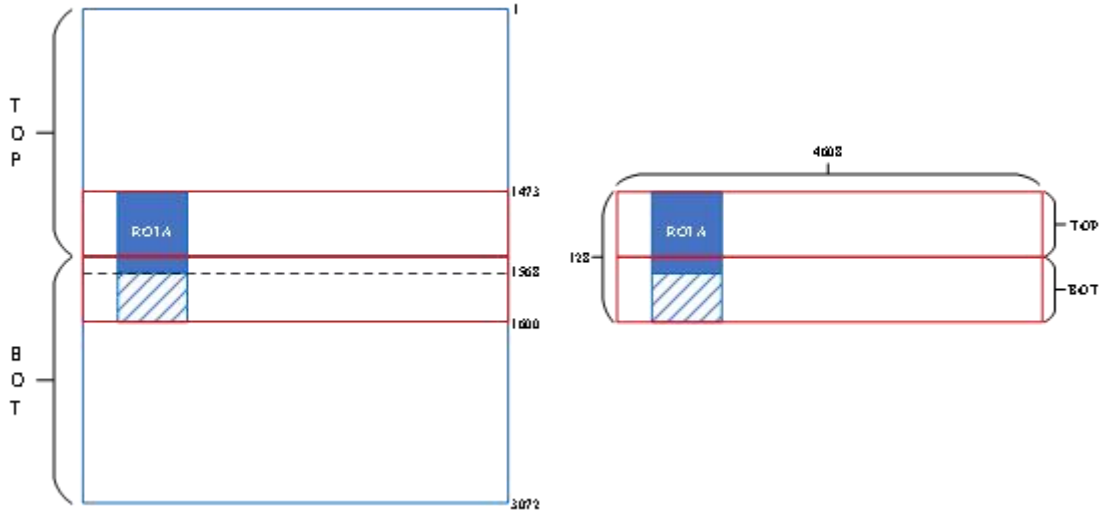


Figure 3-11

As shown in Figure 3-11, the ROI in the Top region has a height of 64 pixels, and the ROI in the Bot region has a height of 32 pixels. Constrained by the mirror-symmetric relationship, the output of the Bot region must extend upward to match the total height of the Top region (i.e., the actual output height of the Bot region is 64 pixels, of which 32 rows belong to the ROI area and 32 rows are the mirror-extended area). Consequently, the final output size from the Sensor is 128 pixels in height (Top 64 + Bot 64) and 4608 pixels in width.

## 2) Sensor Output Characteristics in Multi-ROI Scenarios

In Multi-ROI mode, the Sensor will encompass all configured ROI areas and their mirrored areas. The output size is determined by the total coverage range of all ROIs.

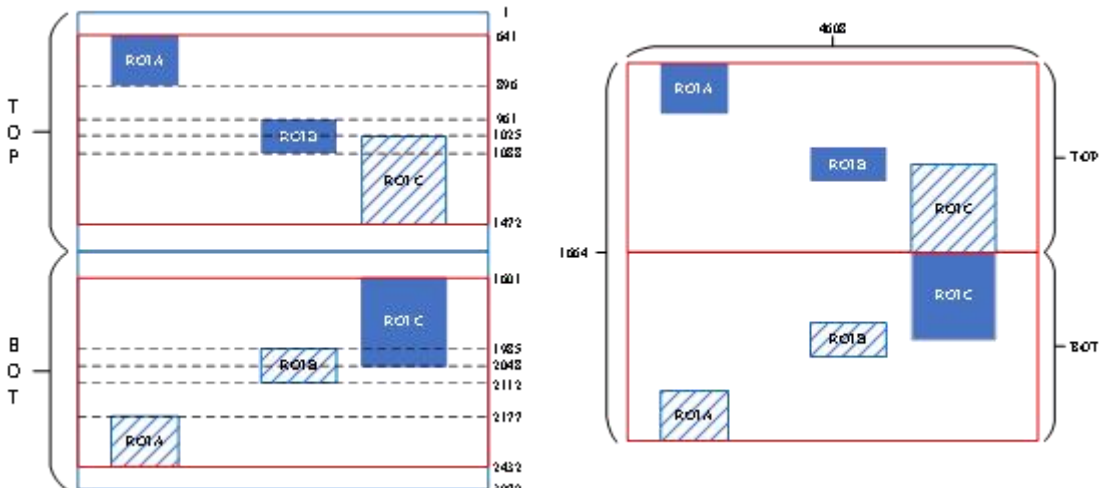


Figure 3-12

As illustrated in the example in Figure 3-12: ROI A (width: 256, height: 256) and ROI B (width: 256, height: 128) are configured in the Top region; ROI C (width: 256, height: 448) is configured in the Bot region. The Sensor will include the A+B ROIs in the Top region, ROI C in the Bot region, and all their mirrored areas in the output range. The final output image size is 1664 pixels in height and 4608 pixels in width (specific calculation logic: total height of Top region = 256 + 128 = 384; the Bot region, after mirror-based extension, matches the Top region's height, and the total combined height = 384 × 2 + additional alignment padding = 1664).

### 3) FPGA Preprocessing Flow for Sensor Output Images

The raw image output by the Sensor contains a large amount of non-ROI invalid areas (such as mirror-extended regions and uncropped column-direction redundancy), which require the FPGA to perform a two-stage preprocessing:

- **Invalid Area Cropping:** First, irrelevant pixels in the row and column directions (such as blank rows outside the Top/Bot regions and redundant columns beyond the ROI width) are removed, retaining only the valid pixel set of all ROIs.
- **Non-ROI Area Blackout:** The pixel values of areas in the cropped image that still do not belong to any ROI (such as gaps between ROIs or residual edge pixels) are uniformly set to 0 (blackened), ensuring the output image contains only the user-defined ROI regions and adheres to format standardization.

Taking as Figure 3-13 an example, the FPGA precisely extracts the valid pixels of the three ROIs (A, B, and C) from the 4608 × 1664 image output by the Sensor, blackens the remaining areas, and finally outputs a multi-ROI image that meets the user's size requirements.

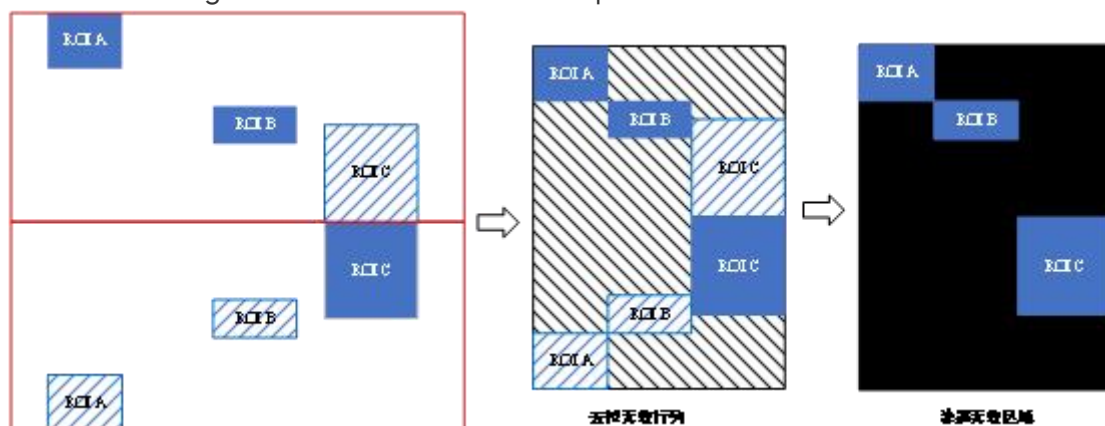


Figure 3-13

### 3.12. Binning Readout

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



Figure 3-14 Schematic diagram of Binning

Binning operations can be performed either by the camera's FPGA alone or jointly by the sensor and the FPGA. The FPGA supports 2x2 and 4x4 binning. The Libra 5514 and Libra 5514 Pro sensor supports 1x2 binning, which halves the height. In Standard mode, binning is performed by the FPGA. In Standardbin2 mode, 1x2 binning is first performed by the sensor, followed by 2x1 binning by the FPGA, ultimately producing a 2x2 binned image. Based on this image, the FPGA can further perform additional 2x2 or 4x4 binning.

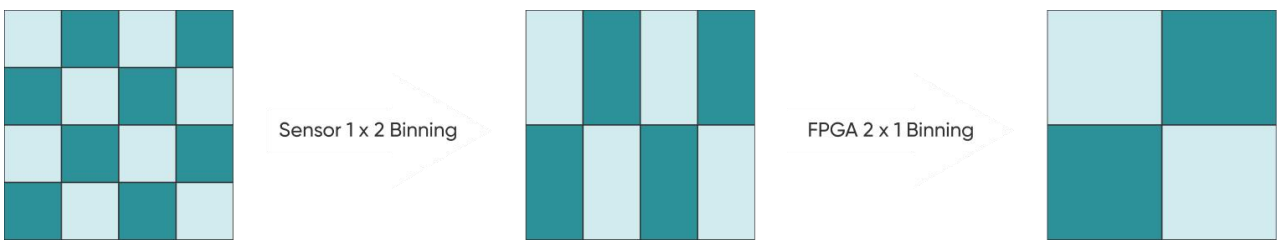


Figure 3-15 Schematic diagram of StandardBin2

Pixel binning enhances the signal-to-noise ratio, thereby enabling the detection of weaker signals, improving image quality, or reducing exposure time. However, the effective pixel size of the camera also increases, which may lower the camera's spatial resolution for fine details.

Binning data processing can be divided into Sum Binning and Average Binning. Taking 2x2 Binning as an example, Sum Binning sums the pixel values of the four pixels, while Average Binning performs averaging on the pixel values of the four pixels.

### 3.13. Timestamp

The camera provides a time precision of 1 μs, enabling accurate recording of the start moment (timestamp) of each frame and ensuring precise inter-frame timing during dynamic imaging.

**Note:**

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

## 3.14. Frame Rate Calculation

### 3.14.1. Full-Resolution Calculation

Camera frame rate is affected by readout time and exposure time. Theoretical frame rate reference calculation.

Modes	T <sub>line</sub> (μs)	T <sub>FOT</sub> (μs)	T <sub>read</sub> (μs)	T <sub>frame</sub> (ms)
HDR	7.85	217.5	T <sub>line</sub> *(V <sub>n</sub> /2)	T <sub>FOT</sub> +T <sub>read</sub>
Standard12bit	Max [(580-(4608-H <sub>n</sub> )/8)/200, 1.93]	7 + 28*T <sub>line</sub>	T <sub>line</sub> *(V <sub>n</sub> /2)	T <sub>FOT</sub> +T <sub>read</sub>
Standard10bit	Max [(540-(4608-H <sub>n</sub> )/8)/200, 1.93]	7 + 28*T <sub>line</sub>	T <sub>line</sub> *(V <sub>n</sub> /2)	T <sub>FOT</sub> +T <sub>read</sub>
Standard8bit	1.93	7 + 28*T <sub>line</sub>	T <sub>line</sub> *(V <sub>n</sub> /2)	T <sub>FOT</sub> +T <sub>read</sub>
Standardbin2 12bit	Max [(580-(4608-H <sub>n</sub> )/8)/200, 1.93]	7 + 28*T <sub>line</sub>	T <sub>read</sub> =T <sub>line</sub> *V <sub>n</sub>	T <sub>FOT</sub> +T <sub>read</sub>
Standardbin2 10bit	Max [(540-(4608-H <sub>n</sub> )/8)/200, 1.93]	7 + 28*T <sub>line</sub>	T <sub>read</sub> =T <sub>line</sub> *V <sub>n</sub>	T <sub>FOT</sub> +T <sub>read</sub>
Standardbin2 8bit	1.93	7 + 28*T <sub>line</sub>	T <sub>read</sub> =T <sub>line</sub> *V <sub>n</sub>	T <sub>FOT</sub> +T <sub>read</sub>

- FOT: Exposure is ended by globally sampling the pixel values from all capacitors within the pixel array.
- T<sub>line</sub>: Row readout time;
- T<sub>FOT</sub>: Sampling time;
- T<sub>read</sub>: Readout time;
- T<sub>frame</sub>: Frame time;

### 3.14.2. ROI Frame Rate Calculation

The frame rate calculation formula is:

$$FPS = \frac{1}{T_{fot} + T_{line} * \frac{V_n}{2}}$$

Among these, T<sub>fot</sub> is the sampling time after the end of exposure, and its value varies depending on the mode. T<sub>line</sub> is the line time, which also differs by mode. V<sub>n</sub> is the number of rows output by the sensor. Note that this row count may not be the same as the number of rows in the final FPGA output by the camera, because the ROI image output by the sensor is further processed by the FPGA.

Taking standard 12-bit mode as an example, with the ROI shown in Figure 3-13, the values are:  $T_{\text{tot}} = 88.2 \mu\text{s}$ ,  $T_{\text{line}} = 2.9 \mu\text{s}$ ,  $V_n = 1664$  rows.

Thus, the frame rate is calculated as:

$$FPS = \frac{1}{(88.2 + 2.9 * \frac{1664}{2})\mu\text{s}} \approx 399.84$$

**Note:**

- 1) The frame rate values in the above table are calculated at the minimum exposure time. For other scenarios, please contact Technical Support to obtain the frame rate calculator;
- 2) Actual frame rates are subject to interface bandwidth and computer system configuration. To prevent data loss, additional line-period-based intervals are added during transmission, resulting in increased readout time. Thus, calculated frame rates may exceed actual achievable rates.

### 3.15. Frame Rate Adjustment

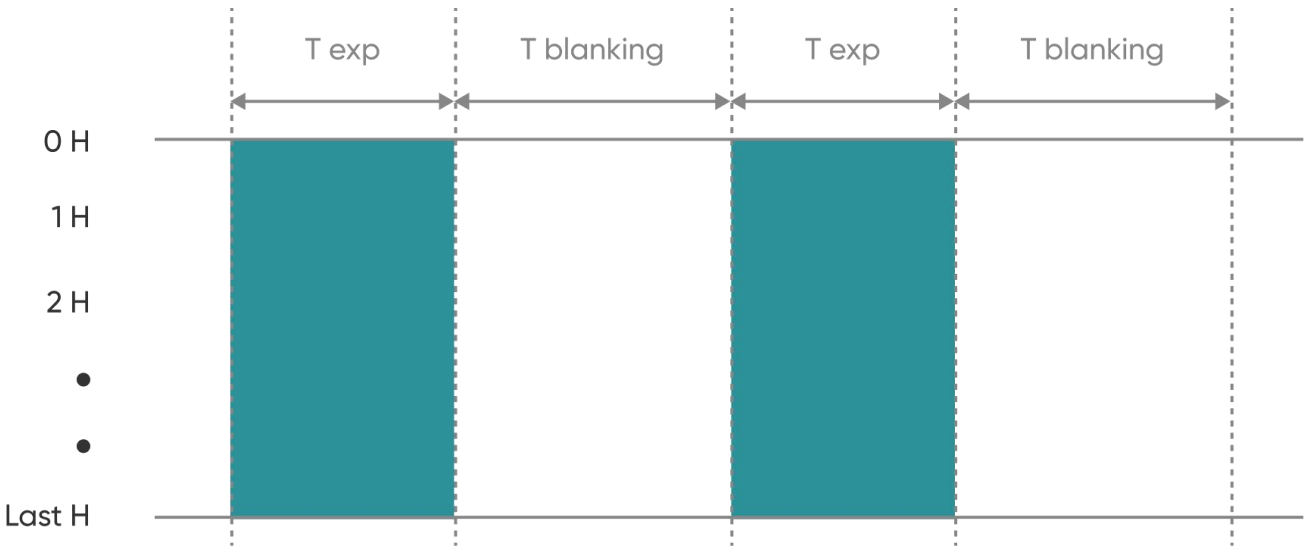


Figure 3-16 Frame Rate Adjustment Schematic Diagram

If the exposure time is less than the readout time, the blanking time equals the FOT time. If the exposure time is greater than the readout time, the blanking time equals the exposure time minus the readout time plus the FOT time.

### 3.16. Incident Photon Calculation

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

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

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

## 3.17. Acquisition Mode

### 3.17.1. FreeRunning

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

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

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

### 3.17.2. Software Trigger Mode

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

### 3.17.3. Hardware Trigger Mode

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

#### 3.17.3.1. Hardware Trigger input circuit

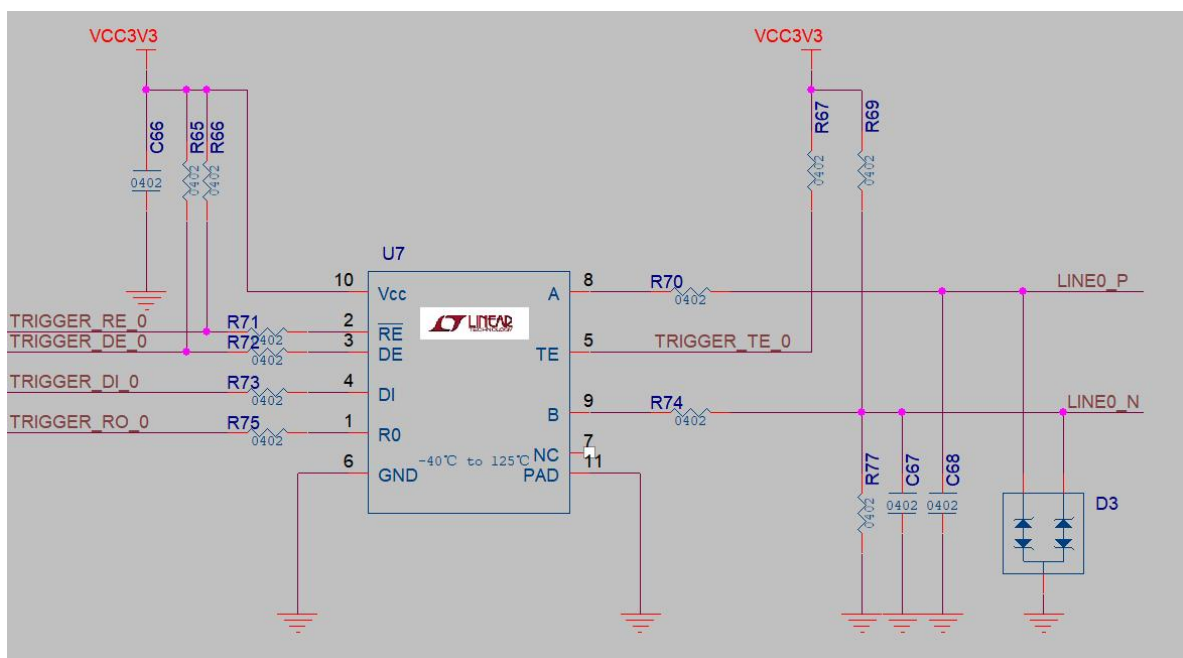


Figure 3-17 Hardware Trigger Input/Output Circuit Diagram

Note:

- 1) The valid external trigger signal recognized by the imager must be a level signal of 3.3 to 5 V. Exceeding the maximum voltage limit may cause permanent damage;
- 2) Differential signals support LVDS, RS422, and RS485 standards.
- 3) The pulse width of the recognized level signal must be greater than 1  $\mu$  s.

3.17.3.2. Trigger Delay and Jitter

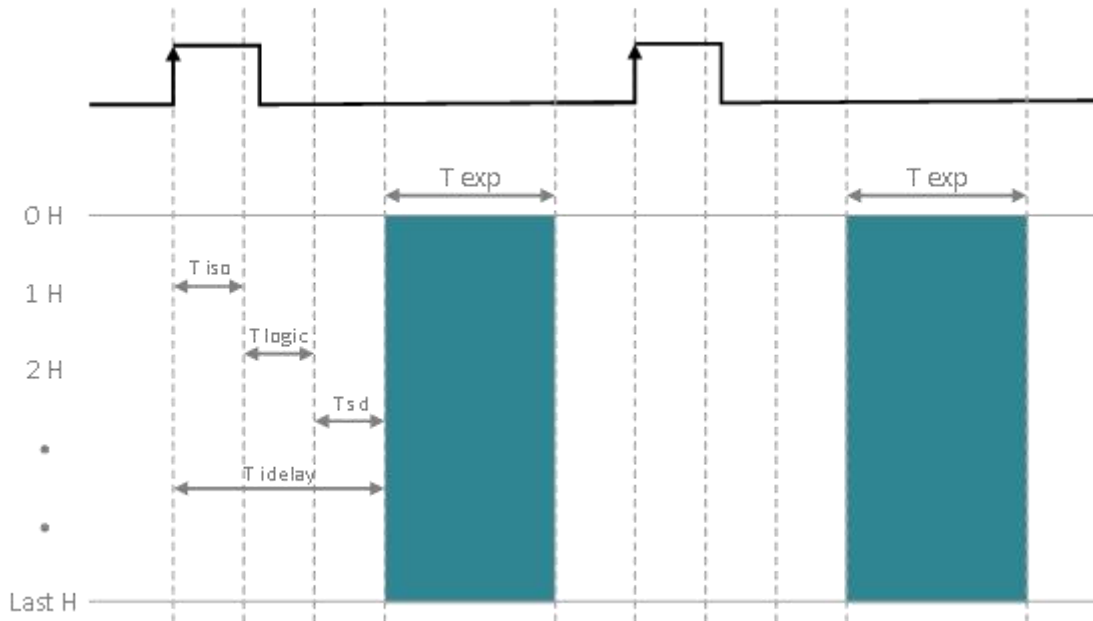


Figure 3-18 Trigger Delay Schematic Diagram

$T_{exp}$ : Exposure time;  $T_{delay}$ : Delay; 1H: One line period.

The trigger delay and jitter for the global shutter type are illustrated in Figure 3-18. When an external trigger level signal arrives, it first experiences a nanosecond-level hardware circuit delay,  $T_{iso}$ . After this hardware delay, the signal is converted internally by the camera, incurring a certain jitter delay,  $T_{logic}$ . This value is 480 ns to 520 ns in Width mode and 560 ns to 600 ns in Time mode. Additionally, the sensor has a shutter delay,  $T_{sd}$ , before the actual exposure begins, which is 6.3  $\mu$ s for 12-bit mode and 5.9  $\mu$ s for 10-bit mode. Therefore, the total delay from external trigger input to the start of exposure is  $T_{delay} = T_{iso} + T_{logic} + T_{sd}$ . If the trigger filter function is enabled, an additional trigger filter delay,  $T_{filter}$ , is added. This value is user-configurable, with a range of 0 to 10,000,000 ns (i.e., 0 ms to 10 ms), a step size of 40 ns, and a default value of 0 ns (filter disabled).

3.17.3.3. Standard Trigger Mode

Standard Trigger Mode: In this mode, when the camera is in FreeRunning, it responds to external trigger signals only when the trigger frequency is lower than the currently configured maximum frame rate.

Both of these modes support both level and edge triggering.

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

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

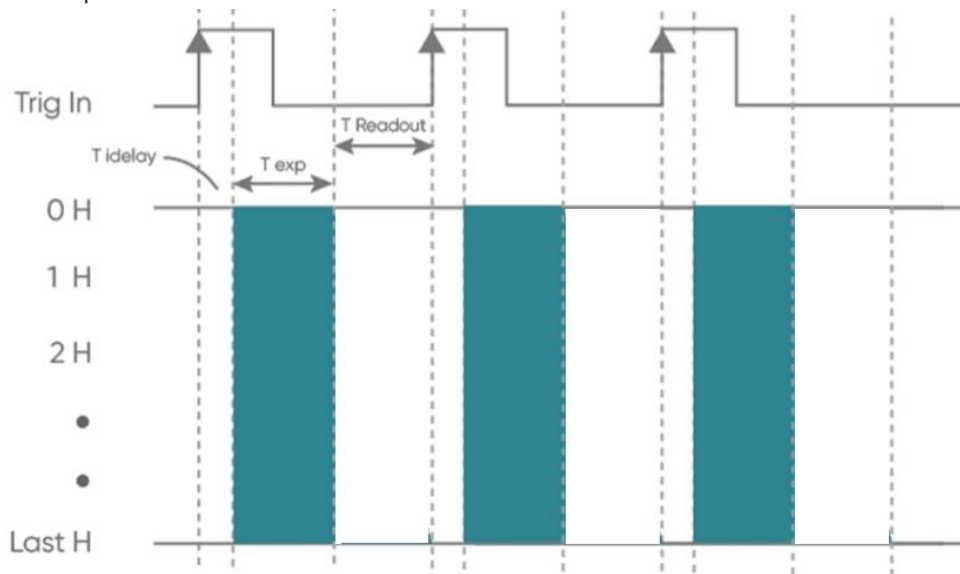


Figure 3-19 Trigger Delay Schematic Diagram

#### 3.17.4. Trigger Output Timing Diagram

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

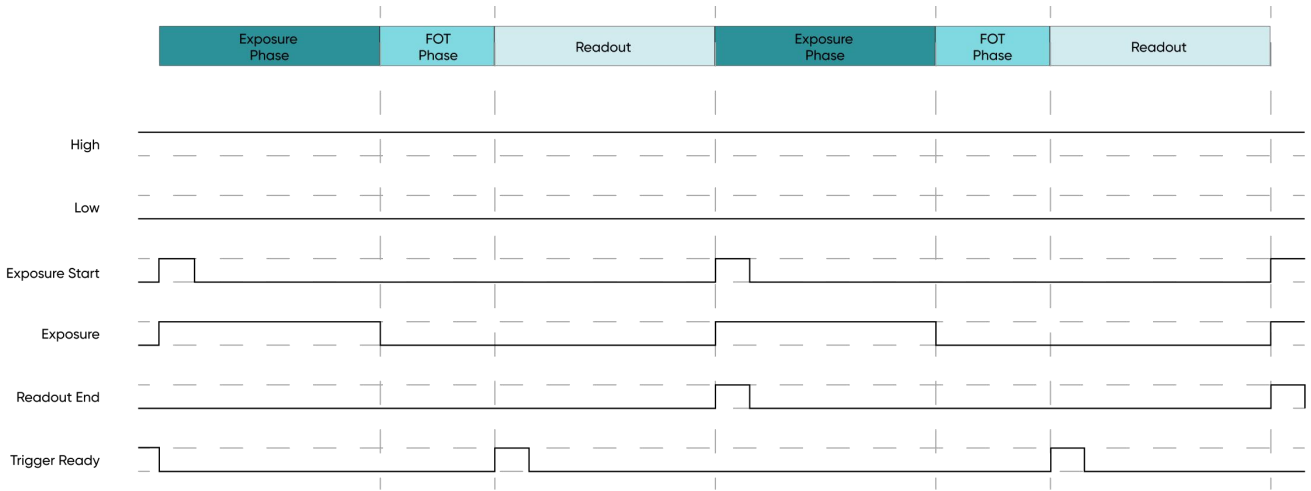


Figure 3-20 Trigger Output Timing Diagram

- **High:** always output high level.
- **Low:** always output low level.
- **Exposure Start:** output starting from the first line of exposure, the default pulse width is 5ms, which is customizable.
- **Readout End:** output starting from the last line of exposure end, the default pulse width is 5ms, which is customizable.
- **Trigger Ready:** when the camera is in the live state and can respond external triggers, the trigger ready output is high level.

**Note:**

The output timing of the Trigger Ready signal shown in Figure 3-20 is only a conceptual schematic. In practical applications, the timing relationship between the camera’s exposure time and readout time may cause a phase shift in the signal output.

### 3.18. Cooling

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

Both air cooling and water cooling are commonly used cooling methods. In air cooling, a fan exchanges excess heat with the surrounding air via airflow, while in water cooling, a liquid circulation

system transfers excess heat. The Libra 5514 and Libra 5514 Pro support both air cooling and water cooling modes, allowing users to choose the appropriate cooling method based on the actual usage environment. In air cooling mode, the inlet and outlet vents are indicated as shown in the figure.

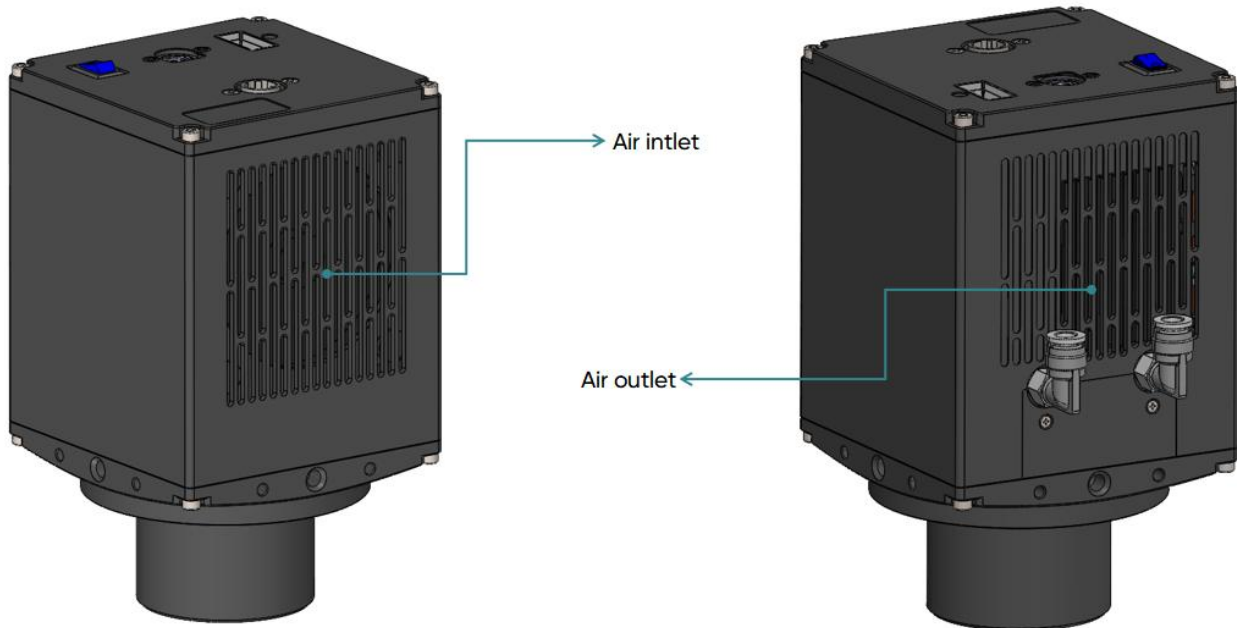


Figure 3-21 Schematic diagram of air inlet and outlet

Air cooling can achieve cooling effects of  $\sim 20^{\circ}\text{C}$  below ambient temperature, while water cooling can achieve cooling effects of  $\sim 25^{\circ}\text{C}$  below ambient temperature. The camera fan speed can be controlled variably, generally supporting High, Medium, and Low speed options. The higher the fan speed, the better the heat dissipation performance, while lower speeds result in lower vibration transmission. For complete low-vibration performance, the fan of the Libra 5514 and Libra 5514 Pro can be completely turned off in the software, and a water cooling port is provided (refer to section 4.3 for installing water cooling).

## 4. Installation

### 4.1. Recommended computer configurations

To ensure stable operation and optimal performance of the camera, it is recommended that the computer configuration meets the following minimum requirements.

Camera Interface	40 G QSFP+
CPU	Intel Core i7-14700
OS	Windows 10 Pro 64-bit ( DirectX 12 )
RAM	128 GB or higher (DDR4 3200 MHz)
PCIe	PCIe4.0*8

Motherboard	ASUS PRIME B760-PLUS (Intel B760 Chipset)
Primary Storage	Samsung SSD 990 PRO 2TB (2 TB / Solid State Drive)

## 4.2. Camera installation

The schematic diagram of the camera data cable connection is shown below.

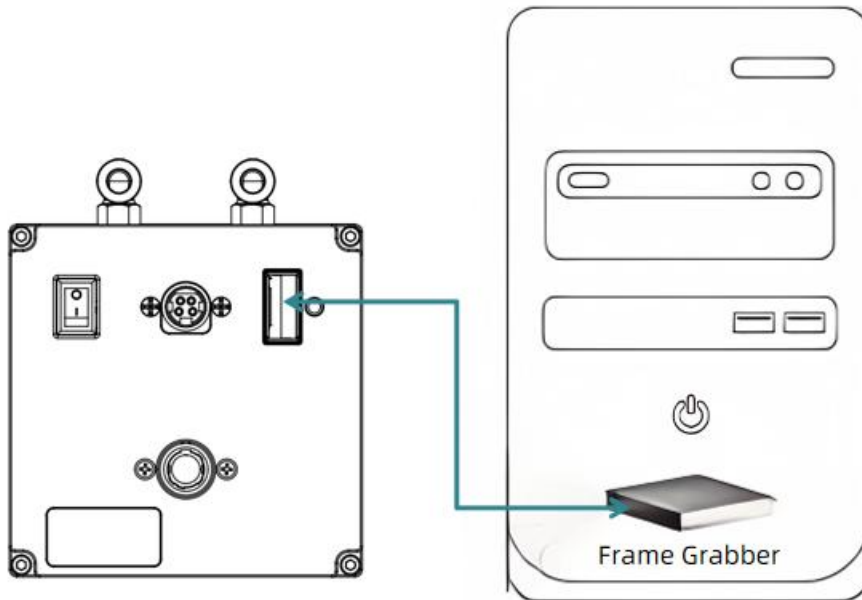


Figure 4-1 Camera Installation Diagram

### Note:

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

## 4.3. Water cooling pipe installation

### 4.3.1. Connect the water cooling pipe

#### Operation steps:

- 1) Securely place the camera on a level work surface, ensuring the camera body remains free from

vibration (to prevent loosening of subsequent water-cooling connections due to vibration).

- 2) Take the water cooling tube provided with the camera and insert one end into the water pipe interface on the top of the camera (as shown in Figure 4-2 below). Ensure that it is fully inserted.



Figure 4-2

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

#### 4.3.2. Software Fan Status

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

PeripheralControl	
DeviceTemperatureTarget	0
DeviceWarningTemperature	90.0
DeviceFanEnable	<input checked="" type="checkbox"/> True
DeviceFanSpeed	Medium ▾
DeviceLedEnable	Low
MultiROIControl	Medium
	High

Figure 4-3

- 2) If you choose to turn off the fan, please ensure that the water cooling system is functioning properly before proceeding with this operation.

### 4.3.3. Disconnect the Water Cooling Pipe

- 1) Disconnect the power supply to the camera and all other equipment, including the recirculating water chiller;
- 2) Following the instructions for the recirculating water chiller, unplug the water hose from the chiller and drain the water from the chiller;
- 3) Press the adapter valve sleeve and remove the water hose from the recirculating water chiller to drain the internal water;
- 4) Press the water connector and remove the camera's water hose from the hose connector. First, position the side with the water valve facing sideways (**not upwards**). When removing the hose, ensure the water valve is facing downwards. Use an absorbent towel or paper towel to protect the area to ensure no water leaks into the camera.



Figure 4-4 Removing water-cooled pipes

#### Note:

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

camera's water valves, and that the water flow rate reaches 1L/min;

- 7) After operation, turn off the power to the camera and chiller, and drain the water from both the chiller and the camera.

**Warning:**

- 1) Do not turn off the recirculating water chiller during camera operation, as this may cause the chip to run at a high temperature continuously, leading to damage;
- 2) During camera operation, the water cooling and fan can be operated simultaneously, but cannot be disabled at the same time. At least one cooling method must be running to prevent the chip from running at high temperatures and being damaged.

## 4.4. Frame Grabber Installation

Turn off the computer and open the cover of the computer host, as shown in Figure 4-5. Install the frame grabber into a compatible PCIe 4.0x8, ensuring proper alignment and secure connection, secure it with screws, and then restart the computer. Connect the interface between the camera and the frame grabber through cable.

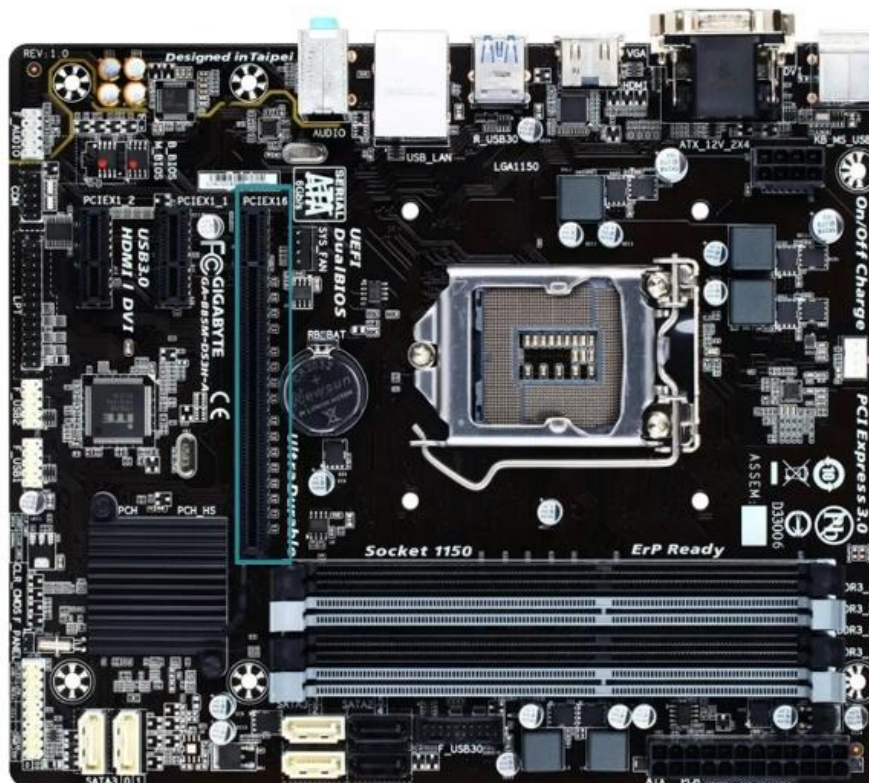


Figure 4-5 Computer motherboard diagram

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

PCIe	X1	X4	X8	X16
1.0	250MB/s	1GB/s	2GB/s	4GB/s
2.0	500MB/s	2GB/s	4GB/s	8GB/s
3.0	985MB/s	3.9GB/s	7.8GB/s	15.7GB/s
4.0	1969MB/s	7.8GB/s	15.7GB/s	31.5GB/s

**Note:**

- 1) When installing and disassembling the Frame Grabber, be sure to operate with power off;
- 2) When connecting cables, operate with the camera power turned off. Hot-plugging is prohibited.

### 4.5. Driver Installation

This section will introduce the installation of the frame grabber driver.

Taking the installation package TucsenSetup 1.1.4.18.exe as an example, the Samadhi frame grabber driver is installed on the Windows 10 (64-bit) operating system.

**Note:**

The Libra 5514 camera recommends using version 1.1.4.19 or later.

#### Operation Steps

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



Figure 4-6

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

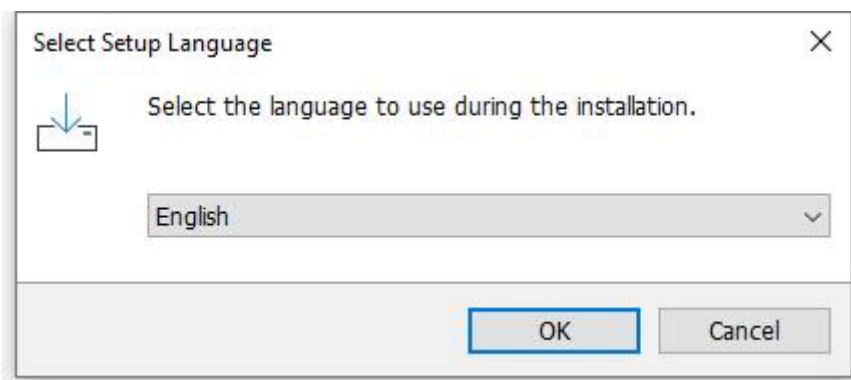


Figure 4-7

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

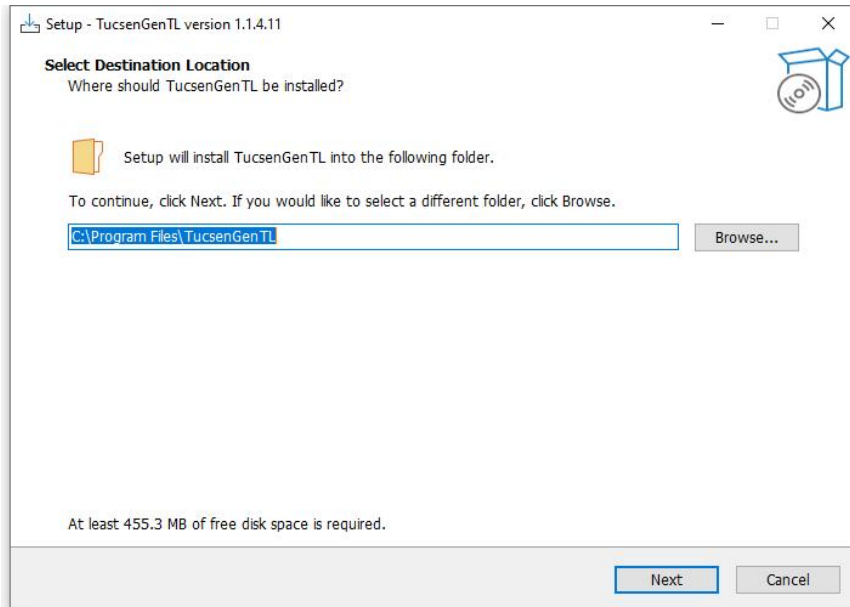


Figure 4-8

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

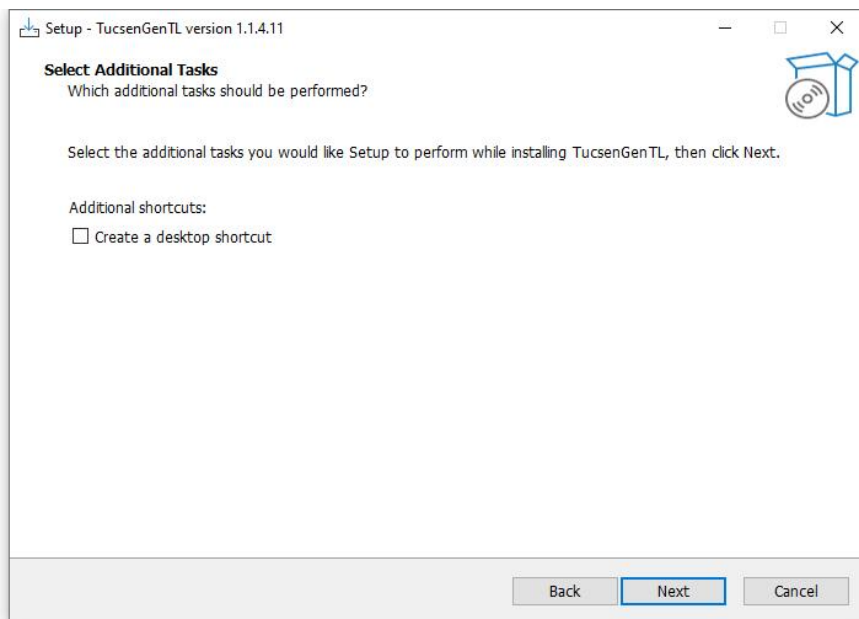


Figure 4-9

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

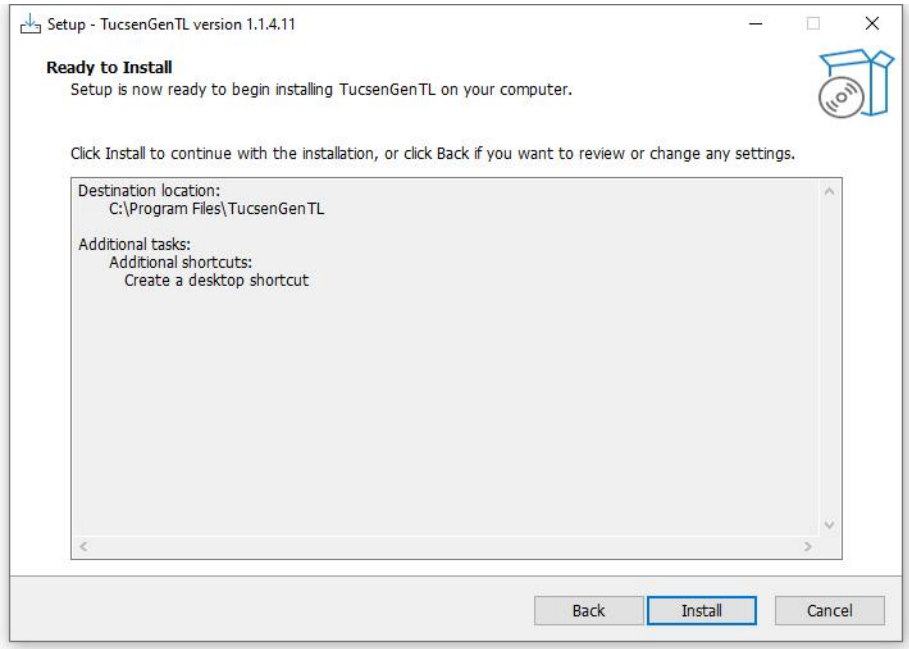


Figure 4-10

- 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.

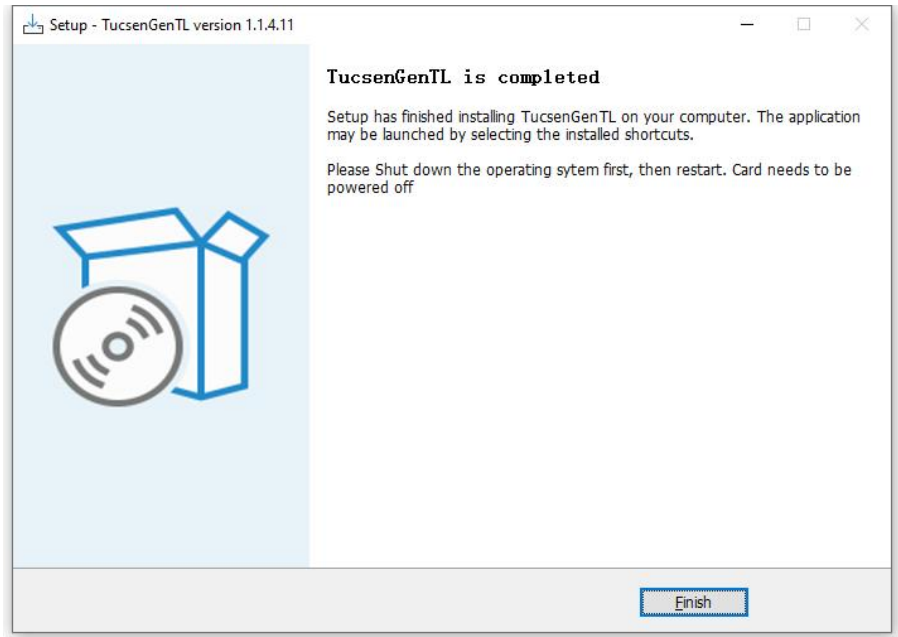


Figure 4-11

- 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:

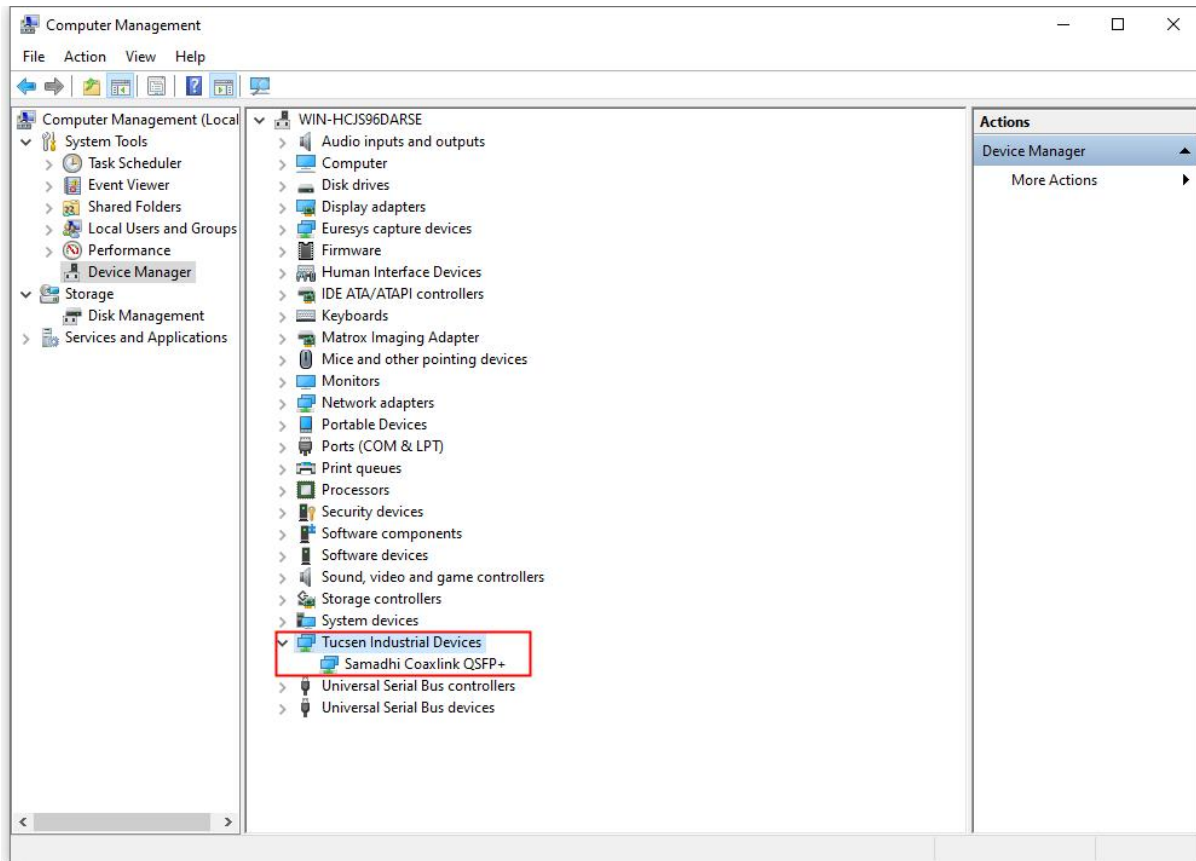


Figure 4-12

## 4.6. SamplePro Software Installation

Open the provided USB drive and double-click to run the SamplePro application;

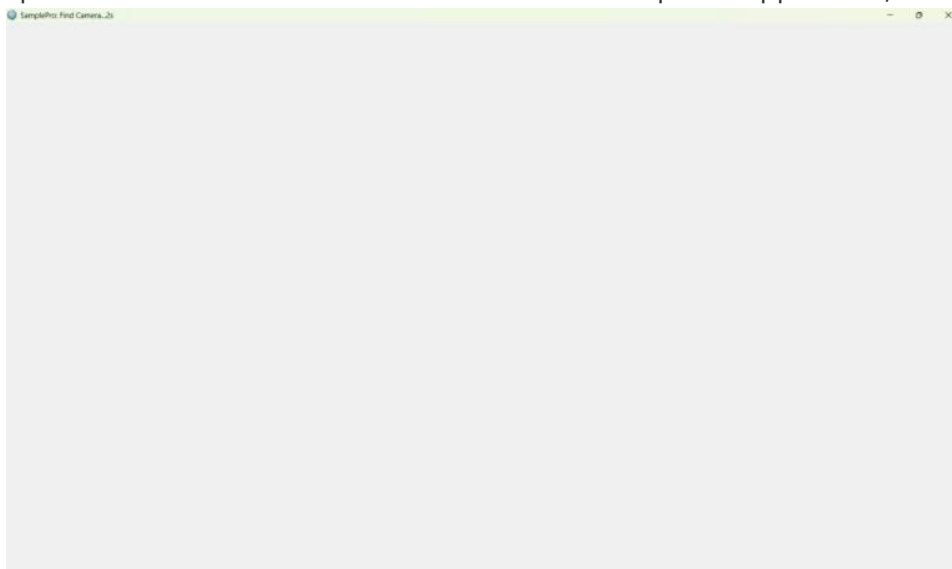


Figure 4-13

After a few seconds, the camera connection will be established. Launch the software setting menu and click the **Live** button to initiate real-time preview. The current mode's frame rate will be displayed.

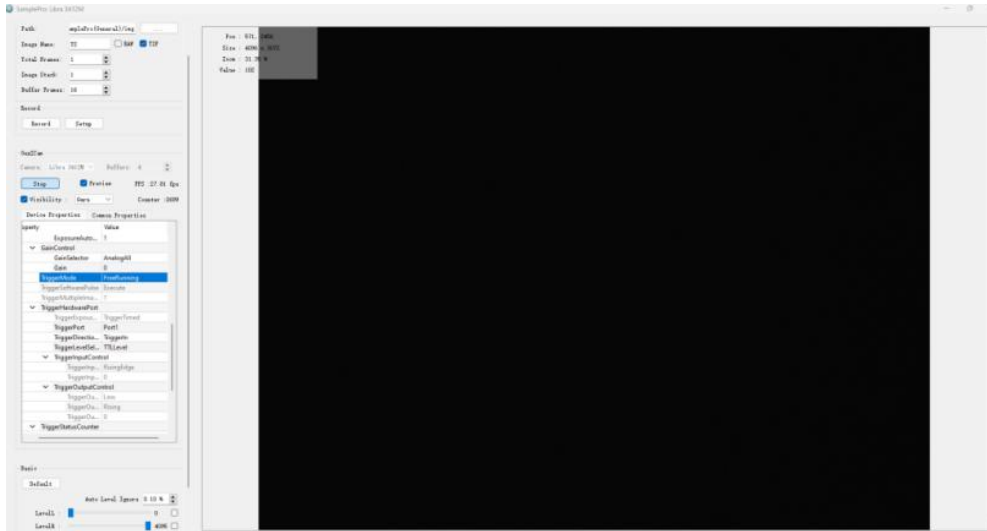


Figure 4-14

**Note:**

- 1) If the screen appears as a solid white image without preview, check the network adapter configuration.
- 2) If the software repeatedly fails to detect the camera or displays file corruption warnings, please contact our Technical Support team.

## 5. SamplePro Operating Instructions

SamplePro is the basic control software used for fundamental camera control, parameter configuration, and image storage. Our standard commercial software, Mosaic V3, will add support for this camera model in future version updates.

**Note:**

The SamplePro software interface may be adjusted due to firmware updates. If there is any discrepancy between the interface described in this manual and the actual display, please refer to the actual interface. The content of this chapter may be updated in future versions without prior notice.

### 5.1. Launch Interface

Double-click SamplePro to start the software. The launch interface is shown in Figure 5-1. Wait for the loading process to complete.



Figure 5-1

**Note:**

- 1) During the first launch, right-click and select "Run as Administrator". For subsequent use, double-click normally to start the software.

## 5.2. Window Composition

The main interface of SamplePro software consists of five sections: "Preview Window", "Control Panel", "Image Capture", "Device Parameters", and "Basic", as shown in Figure 5-2.

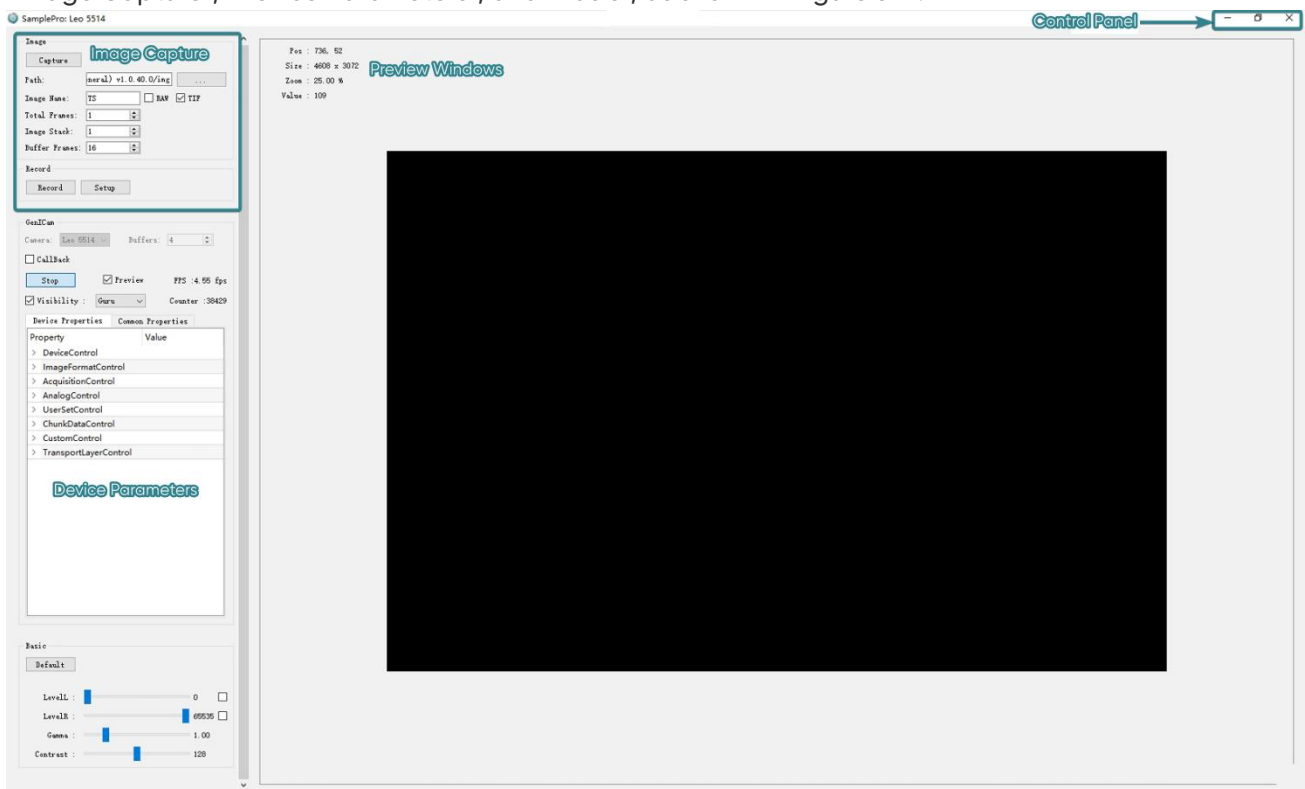


Figure 5-2

This section briefly introduces the functions of each window.

### 5.2.1. Preview Window

The Preview Window displays live camera in FreeRunning. It supports real-time scaling, allowing users to zoom in or out using the mouse wheel according to their needs.

The top-left corner of the window shows: Image Resolution, Zoom Ratio, Pixel Grayscale Value & Coordinates dynamically displayed based on the cursor position over the live image.

```
Pos : 744, 416  
Size : 3200 x 3200  
Zoom : 12.50 %  
Value : 106
```

Figure 5-3

### 5.2.2. Window Control

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

### 5.2.3. 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.

### 5.2.4. 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.

### 5.2.5. Basic

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.

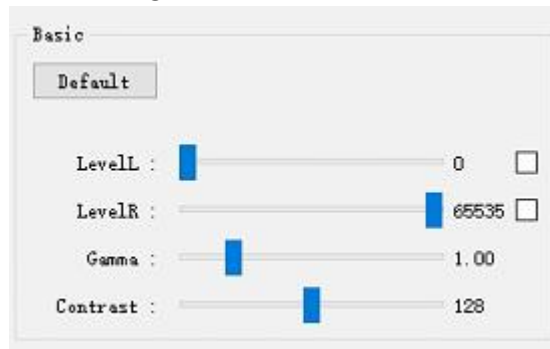


Figure 5-4

### 5.3. 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 5-5, the image capture module supports the basic camera functions of taking images and recording videos.

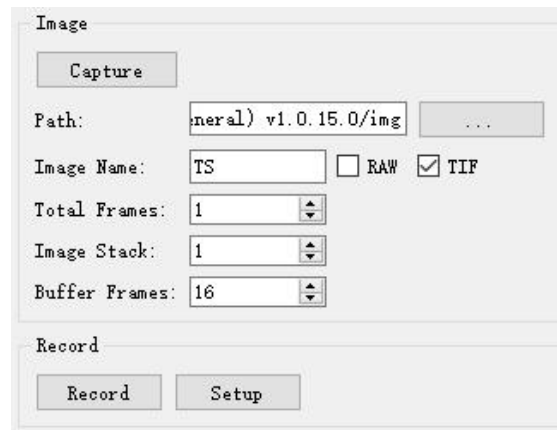



Figure 5-5

- 1) Capture: Click the button to take a single image. During continuous capture, click **Stop Capture** to manually interrupt the process.
- 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) Image Format: Select the image file format. Supports raw sensor data (RAW) and TIFF formats. Default is TIFF (single selection only).
- 5) Total Frames: Set the number of images to capture. Default is 1 image.
- 6) Image Stack: Set the stack frame count. Default is 1 (no stacking). If set to any value other than 1, multiple captured images will be merged into a single stacked image for storage.
- 7) Buffer Frames: Default is 16. Increase this value appropriately during high-speed acquisition to prevent frame loss. Generally set equal to or higher than the frame rate.
- 8) Record: Click to manually start video recording. Click **Stop Record** during capture to manually stop.
- 9) Setup: As shown in Figure 5-6, configure video compression format and playback rate. Compression options include Full Frame (No Compression) and MPEG-4.

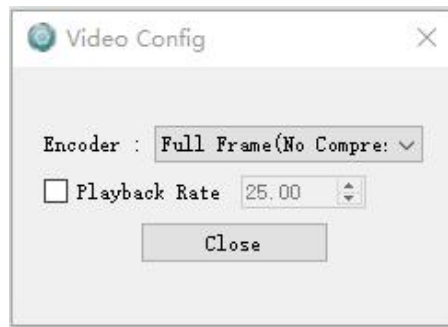


Figure 5-6

## 5.4. Device Parameters

This functional module includes all the settings and parameters interfaces for the camera.

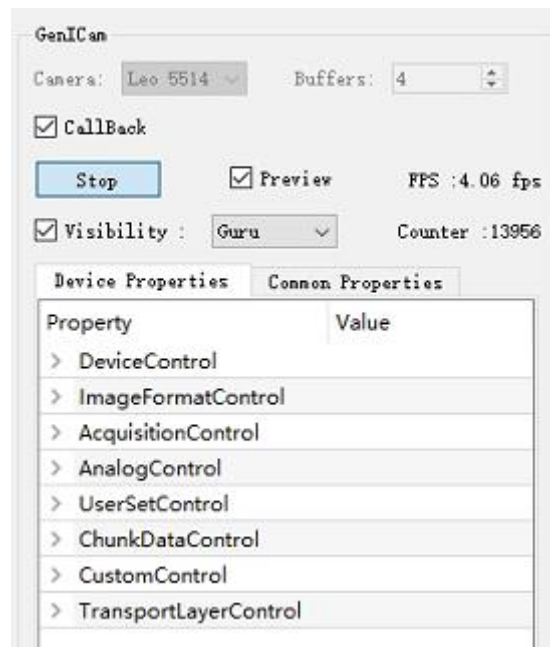


Figure 5-7

- 1) Camera: Used to switch between connected cameras when multiple cameras are connected.
- 2) Buffer: Sets the number of memory buffer frames. Increase this value when capturing large image sequences.
- 3) CallBack: When checked, it indicates that the preview image data is acquired from the CallBack interface. After checking, the [Basic] module functions become unavailable, and therefore its interface is hidden.
- 4) Stop: Halts the camera's FreeRunning, stopping real-time image display in the preview window. In external trigger mode, stops image acquisition based on trigger signals.

- 5) Live: Resumes normal camera operation from a halted live state.
- 6) Preview: When checked, the preview area refreshes images in real time. When unchecked, streaming continues but preview refresh is disabled.
- 7) FPS Displays the current frame rate.
- 8) Visibility: When checked, the Properties panel is displayed. When unchecked, the Properties panel is hidden.
- 9) Counter: Real-time count of frames received by the PC software.

#### 5.4.1. Device Control

This module displays camera basic information (read-only), User ID editing, camera reset, and temperature monitoring. (Refer to Figure 5-7)

▼ DeviceControl	
DeviceScanType	Areascan
DeviceVendorName	Tucsen
DeviceModelName	Leo 5514
DeviceManufacture...	Tucsen CXP Ca...
DeviceVersion	1A0125091200...
DeviceSerialNumber	5514sensor27
<b>DeviceUserID</b>	
DeviceSFNCVersion...	2
DeviceSFNCVersion...	5
DeviceSFNCVersion...	0
DeviceTLType	CoaXPress
DeviceTLVersionM...	1
DeviceTLVersionMi...	1
DeviceTLVersionSu...	0
<b>DeviceReset</b>	<b>Execute</b>
<b>DeviceTemperature...</b>	<b>Sensor</b>
DeviceTemperature...	5.00
<b>TimestampReset</b>	<b>Execute</b>

Figure 5-8

- 1) DeviceScanType: Displays the camera scanning mode: Area scan (read-only);
- 2) DeviceVendorName: Displays device vendor;
- 3) DeviceModeName: Displays camera model;
- 4) DeviceManufactureInfo: Displays device manufacture;
- 5) DeviceVersion: Displays camera firmware version
- 6) DeviceSeriaNumber: Displays camera SN;
- 7) DeviceUserID: Supports customization;

- 8) DeviceReset: Click Execute to perform a soft reset of the camera.
- 9) DeviceTemperatureSelector: Temperature selector offering three options: Sensor, FPGA, and PHY;
- 10) DeviceTemperature: Displays the temperature of the type selected in the temperature selector;
- 11) TimestampReset: Click Execute to refresh and reset the TimestampLatchValue;
- 12) TimestampLatch: Click to record the current moment, which is then displayed in TimestampLatchValue;
- 13) TimestampLatchValue: Displays the value of TimestampLatchValue;

### 5.4.2. ImageFormatControl

The camera's gain mode, image width, starting offset, binning, mirroring, bit depth, and test pattern generator modules are featured in this section, as shown in Figure 5-8.

ImageFormatControl	
SensorOperationM...	Dynamic
WidthMax	4,608
HeightMax	3,072
Width	4,608
Height	3,072
OffsetX	0
OffsetY	0
BinningSelector	BinOff
BinningMode	Sum
ReverseX	<input type="checkbox"/> False
ReverseY	<input type="checkbox"/> False
PixelFormat	Mono16
TestPattern	Off
SenTestPattern	Off

Figure 5-9

- 1) SensorOperationMode: Used to set the camera's operating mode. Default is Dynamic. Available modes include: Dynamic (16-bit), Standard (8-bit, 10-bit, 12-bit), and StandardBin2 (8-bit, 10-bit, 12-bit).
- 2) WidthMax: Displays the maximum horizontal resolution (Width), the value of which is affected by [SensorOperationMode].
- 3) HeightMax: Displays the maximum vertical resolution (Height), the value of which is affected by [SensorOperationMode].
- 4) Width: Sets the horizontal ROI under the current resolution. Maximum value cannot exceed WidthMax, minimum is 256, adjustable in steps of 32.
- 5) Height: Sets the vertical ROI under the current resolution. Maximum value cannot exceed HeightMax,

minimum is 32, adjustable in steps of 32.

- 6) OffsetX: Sets the horizontal starting position of the ROI under the current resolution. Minimum is 0, adjustable in steps of 32.
- 7) OffsetY: The vertical starting position of the ROI under the current resolution. This parameter is automatically calculated by the system (fixed at the center position) and users cannot manually adjust it.
- 8) BinningSelector: Supports BinOff, Bin2x2, and Bin4x4. Bin2x2 reduces horizontal and vertical resolution by half; Bin4x4 reduces to 1/4 of original.
- 9) BinningMode: Sets the Binning mode, it supports Sum or Average. When set to Sum, the pixel value increases to 4 times the original when BinningSelector is Bin2x2, and to 16 times when BinningSelector is Bin4x4.
- 10) ReverseX: Horizontal mirroring. Enabled when checked.
- 11) ReverseY: Vertical mirroring. Enabled when checked.
- 12) PixelFormat: sets the image pixel data format. Its available options are constrained by the **SensorOperationMode** parameter. The specific rules are as follows:
  - (1) When SensorOperationMode is set to Dynamic, only the Mono16 format is supported.
  - (2) When SensorOperationMode is set to Standard or StandardBin2, the Mono8, Mono10, and Mono12 formats are supported.
- 13) TestPattern: Selects the camera's output image mode. Options include: Off (real-time data), Horizontal Grayscale Gradient, Vertical Grayscale Gradient, Diagonal Grayscale Gradient, Moving Diagonal Grayscale Gradient.

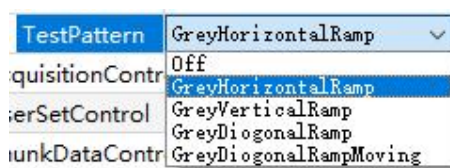
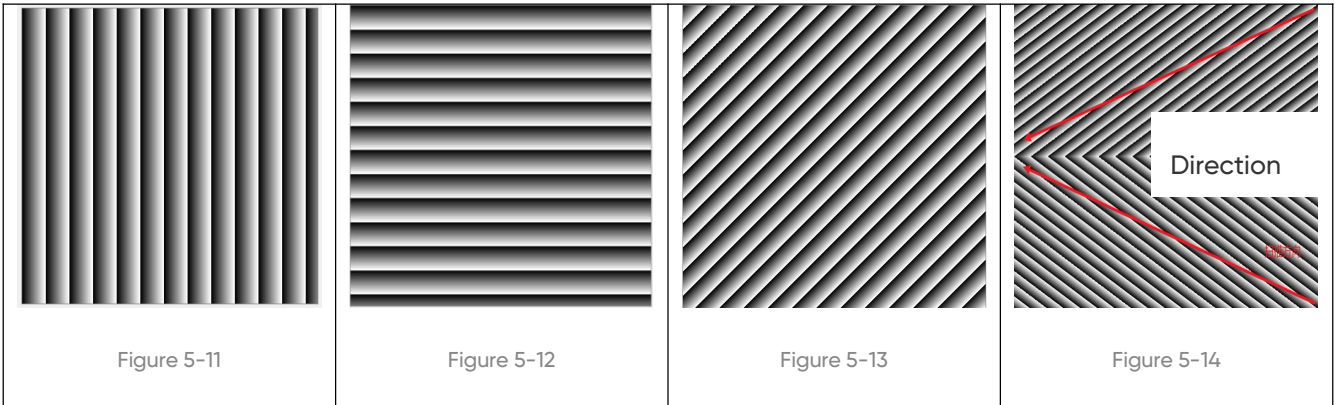


Figure 5-10

- Horizontal Grayscale Gradient: As shown in Figure 5-11, the preview displays a static grayscale gradient pattern along the horizontal direction.
- Vertical Grayscale Gradient: As shown in Figure 5-12, the preview displays a static grayscale gradient pattern along the vertical direction.
- Diagonal Grayscale Gradient: As shown in Figure 5-13, the preview displays a static grayscale gradient pattern along the diagonal direction.
- Moving Diagonal Grayscale Gradient: As shown in Figure 5-14, the preview displays a

dynamically moving grayscale gradient pattern along the diagonal direction.



14) TestPattern: Sensor image output mode selection, supporting Off (real-time data) and Gradient Grey as shown in Figure 5-15.

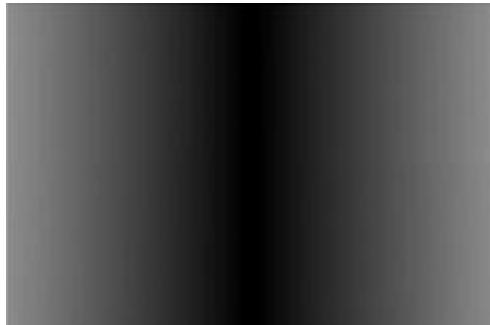


Figure 5-15

### 5.4.3. AcquisitionControl

Camera Frame Rate, Exposure, and Trigger Configuration Module is shown in Figure 5-16.

▼ AcquisitionControl		▼ TriggerHardwarePort	
AcquisitionMode	Continuous	TriggerExposur...	TriggerTimed
AcquisitionStart	Execute	TriggerPort	Port1
AcquisitionStop	Execute	TriggerPortEna...	<input checked="" type="checkbox"/> True
AcquisitionMaxFrameRat...	87.63	TriggerDirectio...	TriggerIn
AcquisitionFrameRate(Hz)	40.17	TriggerLevelSel...	TTLLevel
CurrentFrameRate(Hz)	40.17	▼ TriggerInputControl	
BlackLevel	100	TriggerInput...	0
AutoTargetGray(%)	90	TriggerInput...	RisingEdge
AutoMeteringRatio(%)	0.10	TriggerInput...	0
▼ ExposureControl		▼ TriggerOutputControl	
ExposureTime(us)	181	TriggerOutp...	Low
ExposureAuto	Once	TriggerOutp...	Rising
ExposureAutoOnceP...	Execute	TriggerOutp...	0
AutoControlStatus	Idle	TriggerOutp...	5,000,000
TriggerMode	FreeRunning		
TriggerMultipleImages	100		
TriggerSoftwarePulse	Execute		
> TriggerHardwarePort			

Figure 5-16

- 1) AcquisitionMode: Acquisition mode, default is Continuous and cannot be modified.
- 2) AcquisitionStart: Resumes streaming after pausing in FreeRunning. The Counter will not reset.
- 3) AcquisitionStop: Pauses streaming in FreeRunning. Streaming can be resumed by executing AcquisitionStart again.
- 4) AcquisitionMaxFrameRate (Hz): Displays the maximum frame rate.
- 5) AcquisitionFrameRate (Hz): Sets the frame rate. Minimum: 0.01 Hz, maximum: up to MaxFrameRate.
- 6) CurrentFrameRate (Hz): Displays the currently frame rate.
- 7) BlackLevel: Adjusts the image's base grayscale value (bias). Adjustable range: 12-bit: -255 to 255, 16-bit: -65535 to 65535
- 8) AutoTargetGray(%): Target value for auto exposure. Range: 10% to 90%. Default: 90%.
- 9) AutoMeteringRatio(%): Pixel ratio for metering. Range: 0.01% to 50%. Default: 0.10%.
- 10) ExposureControl: Used to control the camera's exposure.
  - (1) ExposureTime(  $\mu$  s): Sets the exposure time.
  - (2) ExposureAuto: Auto exposure. The software automatically adjusts exposure time based on image brightness and locks the exposure time.
    - Off: Disabled
    - Once: Enabled (requires coordination with the Execute button in ExposureAutoOncePulse parameter)
  - (3) ExposureAutoOncePulse: Clickable only when ExposureAuto is set to Once.
  - (4) AutoControlStatus: Displays auto exposure status (read-only).
- 11) TriggerMode: Selects data streaming mode. Options:
  - FreeRunning (internal trigger)
  - Standard (hardware trigger)
  - Software (software trigger)
- 12) TriggerMultipleImages: Sets the total number of images to capture automatically upon receiving a trigger signal. Default: 1. Range: 1 to 65535.
- 13) TriggerSoftwarePulse: Clickable only when TriggerMode is set to Software.
- 14) TriggerHardwarePort: Used to configure the camera's external trigger function module; it can be set when TriggerMode is set to Standard.
  - (1) TriggerExposureType: Selects trigger input signal type. Options:
    - TriggerTimed (exposure time determined by software settings)

- TriggerWidth (exposure time determined by external trigger pulse width)
- (2) TriggerPort: Used to select the input port for the external trigger signal. Available ports include Port1, Port2, Port3, and Port4 (a total of four interfaces).
  - (3) TriggerPortEnable: Enables or disables trigger output signals. Port2, Port3, and Port4 can be controlled individually; Port1 does not support this setting.
  - (4) TriggerDirectionSelect: Read-only. Automatically displays TriggerIn or TriggerOut based on the TriggerPort configuration.
  - (5) TriggerLevelSelect: User trigger signal selection, supporting TTL, LVDS, and RS422/RS485.
  - (6) TriggerInputControl: Trigger input settings module, configurable only when TriggerDirection is set to TriggerIn.
    - TriggerInputFilterWidth (ns): Used to filter out glitch interference (spikes) on the low and high levels of the trigger signal (suppressing external trigger noise). The parameter unit is nanoseconds (ns), with a configurable range from 0 to 10,000,000 ns (i.e., 0~10 ms), an adjustment step of 40 ns, and a default value of 0 ns (filter disabled).
    - TriggerInputEdge: Selects trigger input. Options: Rising (rising edge) or Falling (falling edge).
    - TriggerInputDelay (ns): Configures delay for trigger input signals. Adjustable range: 0 to 10,000,000,000 ns. Not supported for TriggerWidth signals.
  - (7) TriggerOutputControl: Trigger output settings module, configurable only when TriggerDirection is set to TriggerOut.
    - TriggerOutputSignal: Trigger output signal selection. As shown in Figure 5-17, it supports 6 types of signals: High, Low, ReadoutEnd, ExposureStart, Exposure, and TriggerReady.

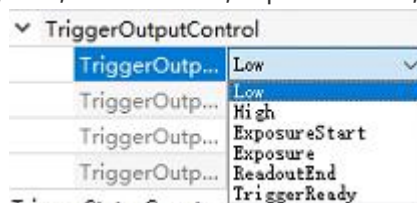


Figure 5-17

- TriggerOutputEdge: Trigger output signal polarity selection, supports Rising and Falling.
- TriggerOutputDelay (ns): Trigger output signal delay configuration. The parameter unit is nanoseconds (ns), with a configurable range from 0 to 10,000,000,000 ns (i.e., 0~10 s) and an adjustment step of 40 ns.
- TriggerOutputWidth (ns): Trigger output signal pulse width configuration. The parameter unit is nanoseconds (ns), with a configurable range from 40 to 10,000,000,000 ns (i.e., 40 ns~10 s) and an adjustment step of 40 ns.

- 15) TriggerStatusCounter: Module related to trigger input/output functionality.
- (1) CounterClear: Click Execute to clear statistical data.
  - (2) FrameTriggerCounter: Statistics on the number of triggers received by the camera.
  - (3) ExposureStartCounter: Statistics on the number of exposure-start triggers output by the camera.
  - (4) SensorReadOutCounter: Statistics on the number of readout-end triggers output by the camera.
  - (5) FrameTransferEndCounter: Statistics on the number of image frames output by the camera.

#### 5.4.4. AnalogControl

The AnalogControl module is used to display analog gain and digital gain parameters, as shown in Figure 5-18. The related parameters are not adjustable in Dynamic mode. In Standard/StandardBin2 modes, AnalogGain can be set from Gain0 to Gain4, and DigitalGain can be set from 1 to 16.

AnalogControl	
AnalogGain	Gain2
DigitalGain	1.0000

Figure 5-18

#### 5.4.5. 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;

UserSetControl	
UserSetSelector	Default
UserSetLoad	Execute
UserSetSave	Execute
UserSetDefault	Default

Figure 5-19

- 1) 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;
- 2) UserSetLoad: The camera loads the camera configuration parameters selected by UserSetSelector;
- 3) UserSetSave: Saves the modified configuration parameters in the camera configuration selected by UserSetSelector. Saving is invalid when Default is selected;
- 4) 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;

## 5.4.6. ChunkDataControl

**Serial Port Data Display.** This entire module is read-only, as shown in Figure 5-20.



▼ ChunkDataControl	
ChunkModeActive	<input type="checkbox"/> False
ChunkFrameCounter	-1
ChunkTimestamp	-1
ChunkExposureTime	-1
ChunkOffsetX	-1
ChunkOffsetY	-1
ChunkWidth	-1
ChunkHeight	-1
ChunkBitDepth	-1
ChunkAutoExposure	-1
ChunkAnalogGain	-1
ChunkDigitalGain	-1.0000
ChunkHorizontal	-1
ChunkVertically	-1
ChunkOverallSystemGainK	-1.00
ChunkAverageBlackLevel	-1.00

Figure 5-20

- 1) ChunkModeActive: Function enable button.
- 2) ChunkFrameCounter: Frame count of the current transmission.
- 3) ChunkTimeStamp: Timestamp function.
- 4) ChunkExposureTime: Total time from exposure start to exposure end during internal sensor operation.
- 5) ChunkOffsetX: Starting offset in the X-direction of the image.
- 6) ChunkOffsetY: Starting offset in the Y-direction of the image.
- 7) ChunkWidth: Image width.
- 8) ChunkHeight: Image height.
- 9) ChunkBitDepth: Bit depth display.
- 10) ChunkAutoExposure: Auto-exposure status flag. A value of 1 indicates the image is currently being exposed.
- 11) ChunkAnalogGain: Analog gain value.
- 12) ChunkDigitalGain: Digital gain value.
- 13) ChunkHorizontal: Image horizontal flip flag. A value of 1 indicates the image is flipped in the X-direction.
- 14) ChunkVertically: Image vertical flip flag. A value of 1 indicates the image is flipped in the Y-direction.
- 15) ChunkOverallSystemGainK: Image system gain coefficient (GainK) value.
- 16) ChunkAverageBlackLevel: Average black level of the image.

### 5.4.7. CustomControl

Resolution, Camera Runtime, and Calibration Settings Module.

- 1) DeviceMonitor: Camera basic information setting and display module.
  - (1) DeviceWorkingDuration(H): Used to display the cumulative working hours of the camera.
- 2) Peripheral Control: This module is used for temperature setting and monitoring of the camera.

PeripheralControl	
DeviceCoolingEnable	<input checked="" type="checkbox"/> True
DeviceTemperatureTarget	5
DeviceWarningTemperature...	93.0
DeviceFanEnable	<input checked="" type="checkbox"/> True
DeviceFanSpeed	20
DeviceLedEnable	<input checked="" type="checkbox"/> True

Figure 5-21

- (1) DeviceCoolingEnable: Camera cooling switch, enabled by default.
- (2) DeviceTemperatureTarget (°C): Sets the target temperature for the sensor. Supports selection of -5°C, 5°C or 10°C;
- (3) DeviceWarningTemperature (°C): Displays the warning threshold temperature. When the FPGA temperature reaches this value, a buzzer alarm is triggered. If the FPGA temperature continues to rise to 93°C, a protection mechanism is activated: the TEC is automatically shut down, and the fan operates at maximum speed for cooling. When the FPGA temperature drops back to 70°C, the system returns to its original state.
- (4) DeviceFanEnable: Controls the fan switch. Enabled when checked, disabled when unchecked.
- (5) DeviceFanSpeed: Fan speed setting, adjustable (supports numerical value input) when DeviceFanEnable is checked.
- (6) DeviceLedEnable: Controls the status indicators for the port and camera. The light is on when checked and off when unchecked.

### 5.4.8. MultiROIControl

MultiROI Control is used to configure the camera's ROI (Region of Interest) settings. The Libra 5514 and Libra 5514 Pro support multiple ROI configurations. The specific setup interface is shown in Figure 5-22.

▼ MultiROIControl	
MultiROIControl	<input type="checkbox"/> False
MultiROISelector	Region0
MultiROIWidth	3,200
MultiROIHeight	3,200
MultiROIOffsetX	0
MultiROIOffsetY	0

Figure 5-22

- 1) MultiROIControl: Enables/disables multi-ROI functionality. When checked, parameters can be configured and multi-ROI is activated.
- 2) MultiROISelector: Selects the multi-ROI group. Supports up to 16 groups (Region 0 to 15) for simultaneous parameter settings.
- 3) MultiROIWidth: Sets the width dimension. Maximum value cannot exceed WidthMax. Minimum values: Region 0: 8; Regions 1–15: 0; Adjustable in steps of 8.
- 4) MultiROIHeight: Sets the height dimension. Maximum value cannot exceed HeightMax. Minimum values: Region 0: 6; Regions 1–15: 0; Adjustable in steps of 2.
- 5) MultiROIOffsetX: Sets the horizontal starting position. Minimum value: 0. Adjustable in steps of 8.
- 6) MultiROIOffsetY: Sets the vertical starting position. Minimum value: 0. Adjustable in steps of 2

#### 5.4.9. DPCControl

The Libra 5514 and Libra 5514 Pro support both dynamic and static bad pixel correction. The configuration interface in SamplePro is shown in the corresponding figure.

▼ DPCControl	
▼ DDPCC	
DDPCEnable	<input checked="" type="checkbox"/> True
DDPCLLevel	Medium
▼ SDPC	
SDPCEnable	<input checked="" type="checkbox"/> True

Figure 5-23

- 1) DDPCCEnable: Dynamic Defective Pixel Correction enable switch. Reduces image artifacts caused by defective pixels.
- 2) DDPCLLevel: Supports three correction levels: Low, Medium, and High.
- 3) SDPCEnable: Static Defective Pixel Correction enable switch. Supports only On or Off

- 4) SDPCLevel: Supports selection of three levels: Low, Medium, and High.

#### 5.4.10. DSNUControl

DSNU Interface in SamplePro is shown in Figure 5-24.

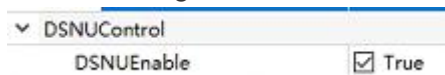


Figure 5-24

- 1) DSNUEnable: DSNU enable switch. When checked, DSNU is activated.

#### 5.4.11. PRNUControl

PRNU Interface in SamplePro is shown in Figure 5-25.

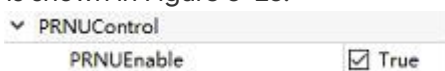


Figure 5-25

- 1) PRNUEnable: PRNU enable switch. When checked, PRNU is activated.

#### 5.4.12. TransportLayerControl

This module follows the CoaXPress Standard protocol. For detailed specifications, please refer to the official CoaXPress Standard documentation.

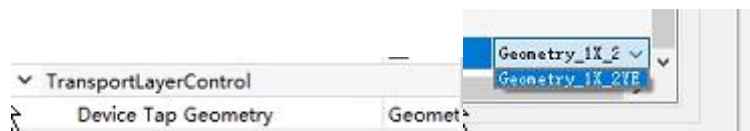


Figure 5-26

## 5.5. Image Adjustment

This module includes histogram, gamma, and contrast settings. The settings interface is shown in Figure 5-27.

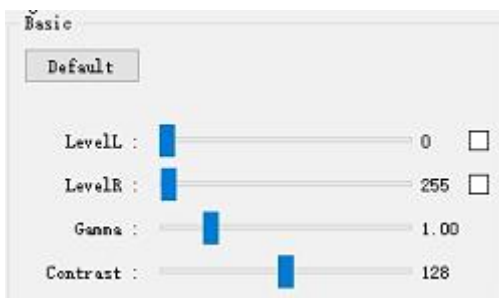


Figure 5-27

- 1) Default: Clicking the "Default" button will restore the parameters of the image adjustment module to the default values set by the software.
- 2) LevelL: Users can change the left color level value by manually entering or dragging the color level slider;
- 3) LevelR: Users can change the right color level value by manually entering or dragging the color scale slider;
- 4) 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;
- 5) 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;

## 6. Maintenance

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

### 6.1. Regular Inspections

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

### 6.2. Electrical Safety Inspection

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

### 6.3. Cooling Hoses and Connectors

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

### 6.4. Basic Usage

- 1) Avoid opening the lens dust cover in dusty environments;

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

## 6.5. Window Cleaning

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

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

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

Note:

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

## 7. Troubleshooting

### 7.1. The Computer Cannot Recognize the Camera

- 1) Confirm that the camera is powered on and turned on normally;
- 2) Confirm that the camera is connected to the computer normally;
  - (1) Confirm the connection sequence of the two cables through CameraLink connection;
  - (2) USB connection, please use the USB 3.0 interface on the backend of the desktop computer;

- 3) Confirm that the driver is working properly and check if the image device recognizes the camera in the computer device manager.

## 7.2. Software Pauses or Freezes

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

## 7.3. The Camera Cannot Reach the Target Cooling Temperature

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

## 7.4. The Frame Rate Cannot Reach the Nominal Level

- 1) Confirm whether the exposure time affects the frame rate, and set the minimum exposure time to confirm the frame rate;
- 2) The frame rate in the table is the measured frame rate under ideal bandwidth, and the actual frame rate in the usage scenario will be affected by data transmission, which is related to the type of data interface used and the length of the transmission line;
- 3) Confirm whether the correct PCIe slot is being used. We recommend using PCIe 4.0 slots. Otherwise, the frame rate may not reach the specification.
- 4) If bandwidth is confirmed to be sufficient, but the frame rate during image saving is significantly lower than during preview, it is necessary to check whether the disk write speed is adequate. For example, with an image resolution of 3200 \* 3200 and a frame rate of 83 fps, saving the image data

to the hard drive requires a disk write speed of at least 1620 MB/s.

## 8. FAQs

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

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

**You can try the following solutions:**

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

### 8.2. Why is the OffsetY of Libra 5514 and Libra 5514 Pro cameras not configurable?

This sensor adopts a zonal synchronous readout mechanism, and only symmetrical data can be transmitted correctly. Due to this limitation, ROI (Region of Interest) can only be selected from the center.

## 9. After-sales Support

- 1) Log in to the official website, click on the [Technical Support] module, and get answers to common questions.
- 2) Warranty:
  - The quality assurance period starts from the date of shipment and lasts for a total of 24 months.

During this period, any damage that meets the warranty requirements will be repaired free of charge;

- The warranty scope is limited to defects in product materials and manufacturing. Damage caused by self disassembly, water ingress, littering, or natural disasters is not covered by the warranty.

3) Contact professionals for technical support:

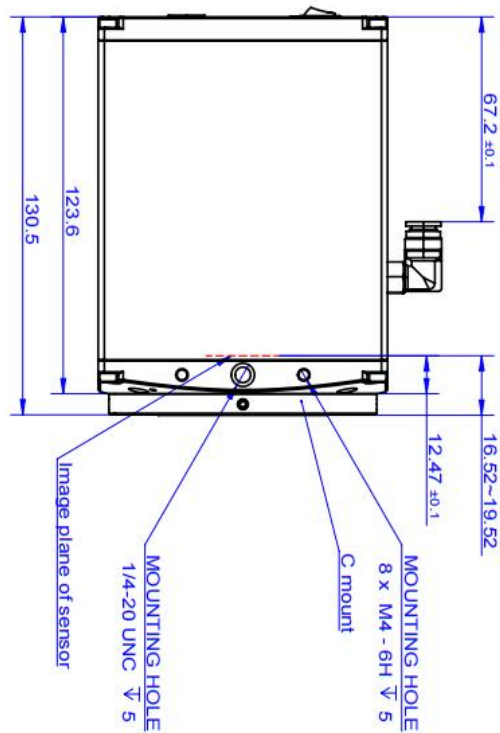
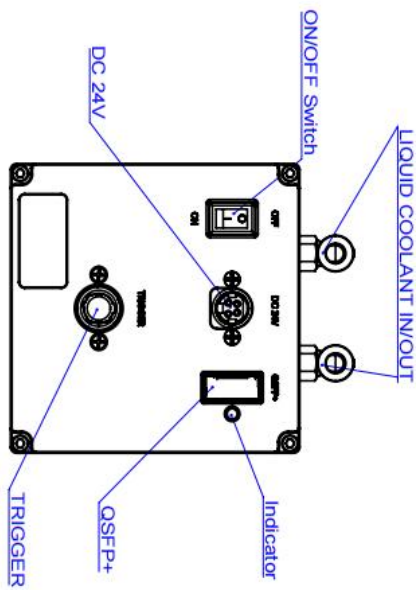
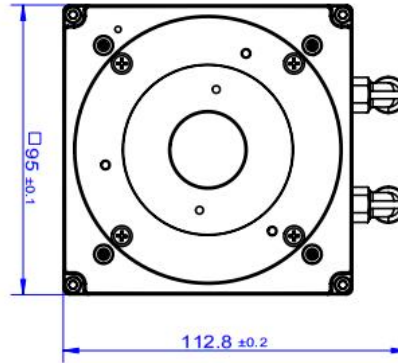
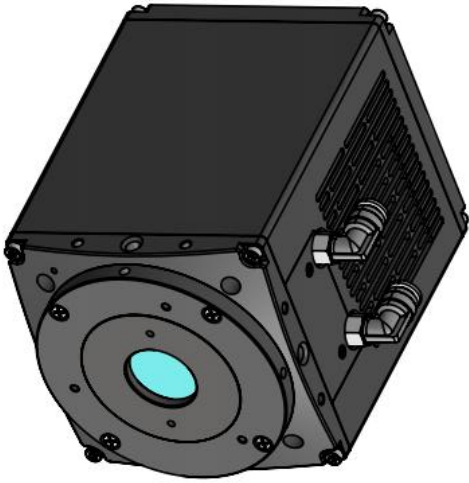
- TEL: +86-591-28055080-818
- Email: [service@tucsen.com](mailto:service@tucsen.com)
- Visiting the official website to leave a message: <http://www.tucsen.com>

4) Please prepare the following information in advance:

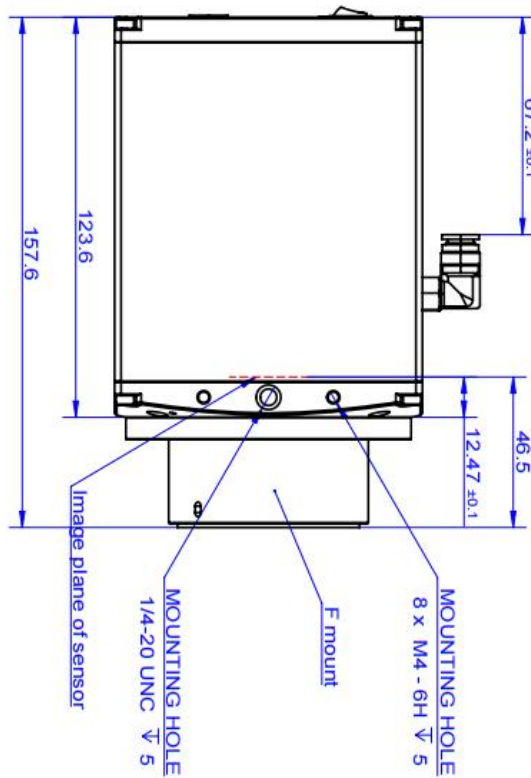
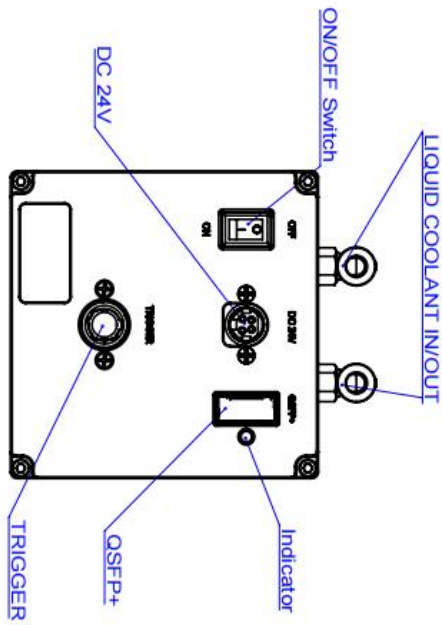
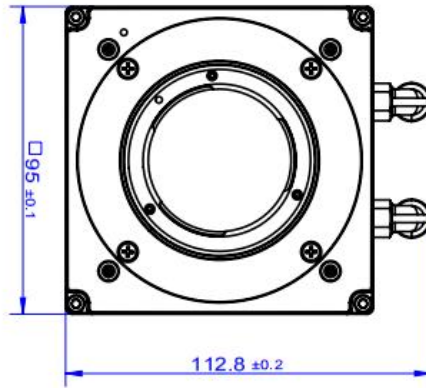
- Camera model and S/N (product serial number);
- Software version number and computer system information;
- Description of the problem and any related images.

# Appendix 1: Dimensions

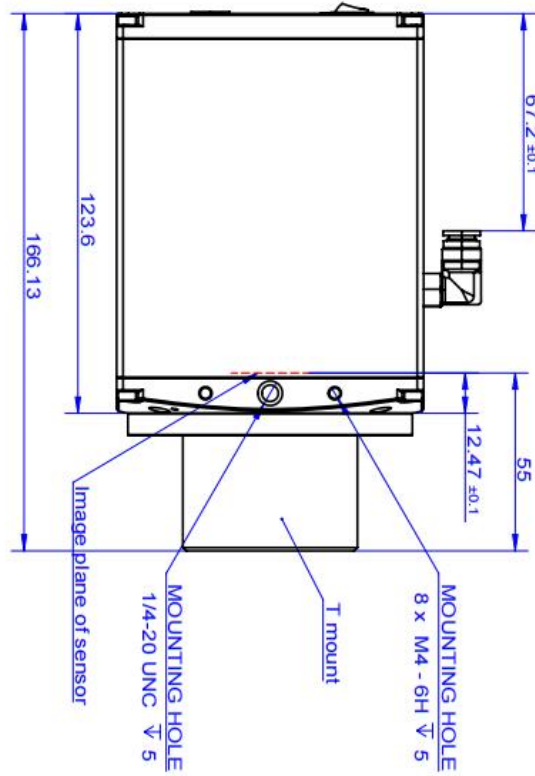
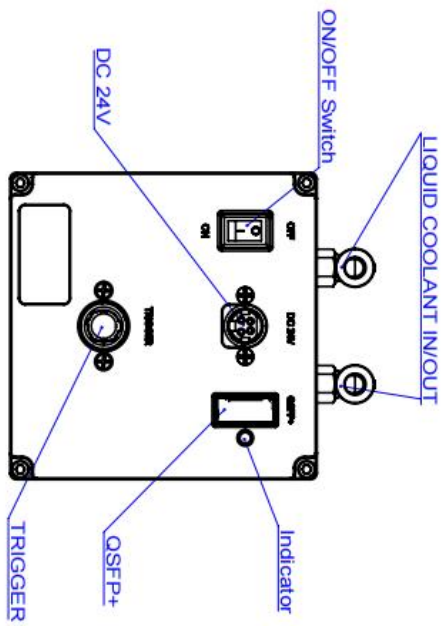
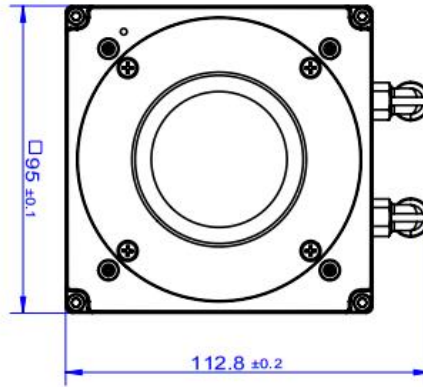
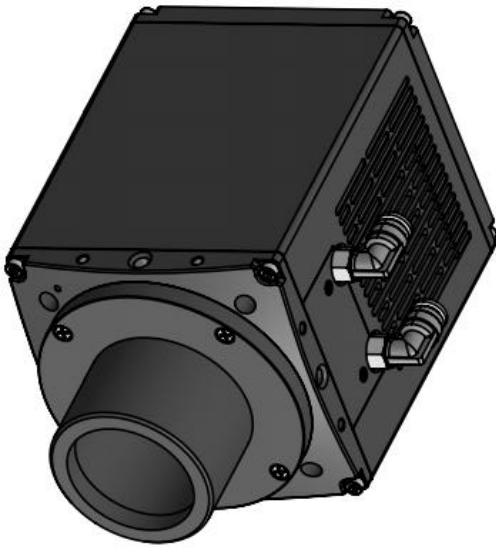
C-mount.



F-mount.



T-mount.



## Appendix 2 : Specifications

### Camera

Model	Libra 5514			
Product Name	L5514			
Sensor Type	BSI sCMOS			
Peak QE	83%			
Color / Mono	Mono			
Array Diagonal	30.5 mm			
Effective Area	25.34 mm x 16.90 mm			
Resolution	4608 (H) x 3072 (V)			
Pixel Size	5.5 $\mu\text{m}$ x 5.5 $\mu\text{m}$			
Readout Mode	Standard 8 bit	Standard 10 bit	Standard 12 bit	HDR
Bit Depth	8 bit	10 bit	12 bit	16 bit
Frame Rate	330 fps	230 fps	220 fps	80 fps
Readout Noise(Middle)	< 2 e <sup>-</sup> (HDR & Standard 12 bit Gain 4)			
Full-Well Capacity	15 Ke <sup>-</sup> @ HDR; 30 Ke <sup>-</sup> @ After Binned			
Dynamic Range	66.4 dB (12-, 10-, 8-bit) 78.2 dB (Dual 12-bit HDR)			
Shutter Type	Global			
Exposure Time	2 $\mu\text{s}$ - 10 s			
Cooling Method	Air , Liquid			
Max. Cooling	20°C below ambient (Air), 25°C below ambient (Liquid)			
Dark Current	< 1 e <sup>-</sup> /pixel/s @ -5°C; < 5 e <sup>-</sup> /pixel/s @ 5°C			
Image Calibration	DPC			
Binning	2 x 2, 4 x 4			
ROI	Support			
Timestamp Accuracy	1 $\mu\text{s}$			
Trigger Mode	Hardware, Software			
Output Signals	Trigger	Low, High, Readout End, Exposure, Exposure Start, TriggerReady		
Trigger Interface	Hirose-12-pin			
Data Interface	40 G QSFP+			

Optical Interface	T / F / C Mount
Power Supply	24 V / 6.67 A
Power Consumption	≤100W
Dimensions*	95 mm (H) x 95mm (W) x 123.6 mm (L)
Weight	1850g
Software	Mosaic V3, SamplePro, LabVIEW, MATLAB, Micro-manager 2.0
SDK	C / C++ / C# / Python
Operating System	Windows, Linux
Operating Environment	Working: Temperature 0~40°C, Humidity 10~85% Storage: Temperature 15~30°C, Humidity 35~75%

Model	Libra 5514 Pro			
Product Name	L5514 Pro			
Sensor Type	BSI sCMOS			
Peak QE	83%			
Color / Mono	Mono			
Array Diagonal	30.5 mm			
Effective Area	25.34 mm x 16.90 mm			
Resolution	4608 (H) x 3072 (V)			
Pixel Size	5.5 μm x 5.5 μm			
Readout Mode	Standard 8 bit	Standard 10 bit	Standard 12 bit	HDR
Bit Depth	8 bit	10 bit	12 bit	16 bit
Frame Rate	670 fps	480 fps	350 fps	80 fps
Readout Noise(Middle)	< 2 e <sup>-</sup> (HDR & Standard 12 bit Gain 4)			
Full-Well Capacity	15 Ke <sup>-</sup> @ HDR; 30 Ke <sup>-</sup> @ After Binned			
Dynamic Range	77.5 dB			
Shutter Type	Global			
Exposure Time	1 us - 10 s			
Cooling Method	Air , Liquid			
Max. Cooling	20°C below ambient (Air), 25°C below ambient (Liquid)			
Dark Current	< 1 e <sup>-</sup> /pixel/s @ -5°C; < 5 e <sup>-</sup> /pixel/s @ 5°C			

Image Calibration	DPC
Binning	2 x 2, 4 x 4
ROI	Support
Timestamp Accuracy	1 $\mu$ s
Trigger Mode	Hardware, Software
Output Signals Trigger	Low, High, Readout End, Exposure, Exposure Start, TriggerReady
Trigger Interface	Hirose-12-pin
Data Interface	100 G QSFP28
Optical Interface	T / F / C Mount
Power Supply	24 V / 6.67 A
Power Consumption	$\leq$ 120W
Dimensions*	95 mm (H) x 95mm (W) x 123.6 mm (L)
Weight	2000g
Software	Mosaic V3, SamplePro, LabVIEW, MATLAB, Micro-manager 2.0
SDK	C / C++ / C# / Python
Operating System	Windows, Linux
Operating Environment	Working: Temperature 0~40°C, Humidity 10~85% Storage: Temperature 15~30°C, Humidity 35~75%

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

• The camera dimensions listed in this table refer to the bare camera dimensions, excluding the dimensions of water cooling connectors, adapters, and camera interfaces. For detailed structural parameters, please refer to the structural outline drawing.

### Frame Grabber

Brand	TUCSEN
Model	Samadhi Coaxlink QSFP+ Frame Grabber
OS	Windows
PCIe	PCIe 3.0 x 8

## Appendix 3 : Certification



### Certificate of Compliance

Certificate No. : FQI I-DZ-25021

Certificate Holder : FUJIAN TUCSEN PHOTONICS CO., LTD

Address : West 1# Building, Zone D, Fuzhou Software Park, 89 Software Avenue,  
Gulou District, Fuzhou City, 350003, Fujian Province, PRC

Product Description : Scientific Level High Sensitive Camera

Model Reference : Leo 5514

Brand Name : TUCSEN

Report No. : (2025) MJDZ-E0069

Standard/Directive :  
EC Electromagnetic Compatibility Directive 2014/30/EU  
EN 55032:2015+A1:2020+A11:2020 , EN 55035: 2017+A11:2020 ,  
EN IEC 61000-3-2:2019+A1:2021+A2:2024 ,  
EN 61000-3-3:2013+A1:2019+A2:2021+AC:2022

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

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



Authorized Signatory  
Date of Issue: Nov. 07 , 2025



FUJIAN INSPECTION AND RESEARCH INSTITUTE FOR PRODUCT QUALITY  
No.6, Shuangfeng Road, Hongshan, Gulou District, Fuzhou, Fujian, China



Verification Report No.: CANEC25030424905 Date: Mar 30, 2026 Page 1 of 26

Client Name: FUJIAN TUCSEN PHOTONICS CO.,LTD
Client Address: West Building No.1, Zone D, 89 Ruanjian Avenue, Gulou Area, Fuzhou, Fujian 350003, China Scientific Level High Sensitive Camera

Sample Name: Scientific Level High Sensitive Camera
Tested Basic Model No.: L5514 Pro-100G
Client Ref. Information: L5514; L5514 Pro-40G

The above sample(s) and information were provided by the client.

SGS Job No.: XMP25-005724
Sample Receiving Date: Dec 05, 2025
Verification Period: Dec 05, 2025 ~ Mar 27, 2026
Verification Requested: With reference to RoHS Directive (EU) 2015/863 amending 2011/65/EU.
Verification Method(s): Please refer to next page(s).
Verification Result(s): Please refer to next page(s).

Test Result Summary:

Table with 2 columns: Test Items, Conclusion. Row 1: EU RoHS Directive (EU) 2015/863 amending Annex II to Directive 2011/65/EU - Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE), Bis(2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP). Conclusion: Pass

Signed for and on behalf of
SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch

Tyler Zhang (signature)

Tyler-Y Zhang
Approved Signatory

Scan to see the report



Unless otherwise agreed in writing, this document is issued by the Company subject to its General Conditions of Service printed overleaf, available on request or accessible at https://www.sgs.com/en/Terms-and-Conditions. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. This document cannot be reproduced except in full, without prior written approval of the Company. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law. Unless otherwise stated the results shown in this test report refer only to the sample(s) tested. Attention: To check the authenticity of testing /inspection report & certificate, please contact us at telephone: (86-755) 8307 1443, or email: CN.Doccheck@sgs.com

SGS-CSTC Standards Technical Services Co., Ltd.
Guangzhou Branch

No.198, Kezhu Road, Science City, Economic & Technological Development Area, Guangzhou, Guangdong, China 510663
中国·广东·广州高新技术产业开发区科学城科珠路198号 邮编: 510663

t (86-20) 82155555 www.sgs.com
t (86-20) 82155555 sgs.china@sgs.com

Member of the SGS Group (SGS SA)

## **Tucsen Photonics Co., Ltd.**

West Building No.1, Zone D, 89 Ruanjian Avenue,  
Gulou Area, Fuzhou, Fujian 350003, China  
Tel: +86-591-28055080  
E-mail: Support@tucsen.com  
Website: www.tucsen.com

### **Notice**

"Tucsen" and related logos are trademarks of Tucsen Photonics Co., Ltd.  
Other trademarks and product names are the property of their respective owners.  
Information in this document is for reference only and may be changed without notice.

### **Copyright Statement**

Copyright © 2025 Tucsen Photonics Co., Ltd. All rights reserved.  
No part may be reproduced without prior written permission.

二级标题



二级副标题

三级标题

四级标题

正文

表格



1	1	1	1
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6