TS31MSCXP-35M Area Scan Camera User Manual

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Hefei I-TEK Optoelectronics Co., LTD.

http://www.i-tek.cn/

Revision History

Revision	Date	Description
0.1	2022/07/30	● Initial version
0.2	2023/02/11	● Update company address
0.3	2023/08/08	● Update chapter 7 ● Add input signal trigger voltage requirement
0.4	2025/03/14	● Update the structural diagram

Manufacturer Information

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Contents

1 Precautions

- **General**

① Do not drop, damage, disassemble the camera.
② Do not let children touch the camera without supervision.
③ Do not use the camera for other purposes than those specified herein.
④ If there is any problem with the camera, please contact us in time for technical support.

- **Installation and Maintenance**

① Do not install the camera in an environment with direct sunlight, high humidity or heavy dust.
② Keep the camera away from an environment with strong electromagnetic interference.
③ Keep the camera away from heat sources.
④ Be careful not to let the camera soak in liquid, such as water and drinks.
⑤ Clean dust on the surface of the camera as often as possible to avoid dust entering the camera, otherwise it may cause fault to the camera.
⑥ To clean the dust on the camera surface, do not wash with water. Please use a soft object dipped in a small amount of 70% alcohol to wipe it off.

- **Power Supply**

① Camera can be powered through CXP cable in PoCXP mode or external power supply. The recommended voltage is +12~24V (±10%), and the current must be 2.0A.
② Hefei I-TEK Optoelectronics Co., LTD. does not provide external power supply. Users need to connect power supply by themselves.

- **Document**

① Hefei I-TEK Optoelectronics Co., LTD. does not warrant that the document is the final version. The document may be updated after product upgrade. Please contact market@i-tek.cn for the latest version, which is provided for the authorized users.

2 Camera Models

- **Camera Product Model**

Abbreviation	Name	Description
Line Scan Camera:		
PA	Panther	Panther (Single line industrial line scan camera)
PL	Plasma	Plasma (Multi-line industrial line scan camera)
PH	Phoenix	Phoenix (TDI industrial line scan camera)
TPH	TEC-Phoenix	TEC-Phoenix (TEC-TDI industrial line scan camera)
PN	Pneuma	Pneuma (Basic industrial line scan camera)
PR	Prometheus	Prometheus (High resolution industrial line scan camera)
PU	PupMaya	PupMaya (High width industrial line scan camera)
PT	Ptepare	Ptepare (Special custom industrial line scan camera)
PM	Prism	Prism line scan camera
Area Scan Camera:		
TM	Taurus-Prism	Prism area scan camera
HS	Hercules	Hercules (CCD industrial area scan camera)
TS	Taurus	Taurus (CMOS industrial area scan camera)
THS	TEC-Hercules	TEC-Hercules (CCD TEC industrial area scan camera)
TTS	TEC-Taurus	TEC-Taurus (CMOS industrial area scan camera)
XS	XStream	XStream (Super high speed camera)

- **Interface Specification**

Abbreviation	Interface Type
GV	GigE Vision
CL	Camera Link
CXP/CXP10/CXP12	CoaXPress
U30	USB3.0
XGV	10 GigE Vision
PCIe	PCI-Express
SFP	Small Form Pluggable

- **Color Form**

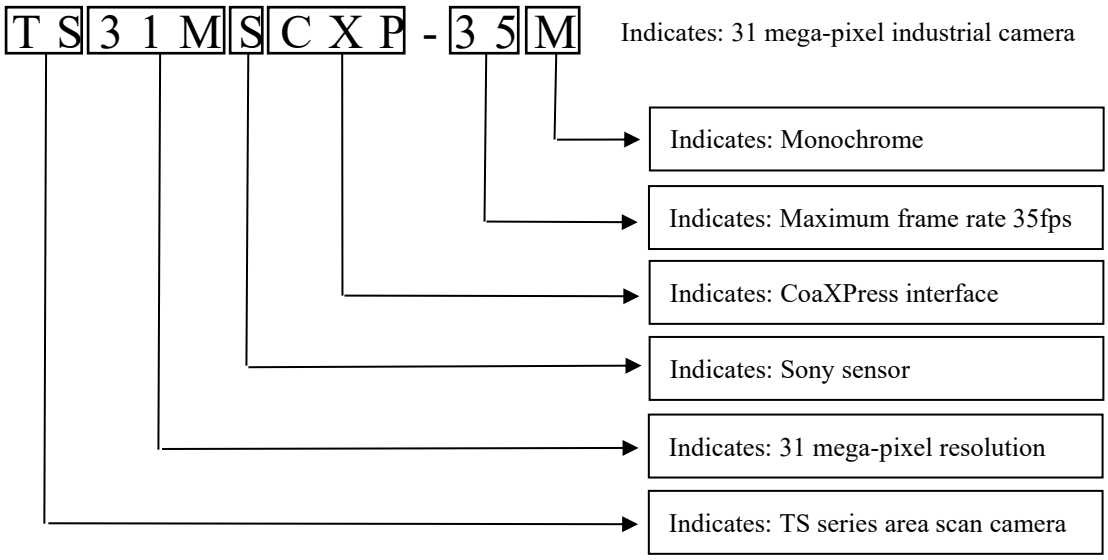
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

S	SWIR (Short Wave Infrared)
W	MWIR (Middle Wave Infrared)
L	LWIR (Long Wave Infrared)

- **Line Rate or Frame Rate**

Camera Type	Description
Line Scan Camera	Maximum line rate, e.g. 30kHz
Area Scan Camera	Maximum frame rate, e.g. 4000fps

e.g.



3 Product Appearance

Fig. 1 Product Appearance

Note:

① The front and the side of camera provide threaded holes for mounting camera.

② Please refer to “Mechanical Dimensions and Interfaces” below for detailed camera dimensions.

4 Product Specifications

TS31MSCXP camera adopts advanced global shutter CMOS image sensor and CoaXPress data interface. It is a high-speed area scan camera designed for industrial measurement and inspection. It has high reliability and stability, and is very suitable for occasions with high requirements (high resolution, high speed) for image acquisition, such as surface inspection, electronic placement inspection, etc.

4.1 Main Features

- Global Shutter CMOS Sensor
- 31 Mega-Pixel Resolution
- Full Frame Rate up to 35fps
- High Sensitivity and Low Noise
- ROI
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Minimum Exposure Time: 5us; Exposure Time Step: 6us
- Output Pixel Format: 8/10/12bit
- Binning
- LUT
- Defect Pixel Correction
- Flat Field Correction
- Analog Gain / Digital Gain / Offset Control
- File Access
- Real-Time Temperature Monitor

4.2 Camera Specifications

Table 1 TS31MSCXP-35M Product Specifications

Model	TS31MSCXP-35M
Product Description	31 mega-pixel industrial camera
Resolution	6464 x 4852
Pixel Size	3.45um x 3.45um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	27.88mm (diagonal)
Dynamic Range	≥70.8dB
SNR	40.6dB
Data Rate	1200MB/s
Analog Gain	0~24
Analog Offset	0~4095
Digital Gain	0.004~8
Black Level	-4095~4095
Lens Mount	M42

Max Frame Rate	35.85fps@8bit, 30.57fps@10bit, 25.52fps@12bit
Trigger Mode	Free-Run, External Trigger
External Trigger	External IO / CXP signal
Exposure Control	Pulse Width Control, Timed
Exposure Time	5us ~ 10s (step: 6us)
Data Format	8/10/12bit
Operation Temperature	0~55°C
Data Interface	CoaXPress BNCx2
Power Supply	DC 12~24V (±10%) 2.0A or PoCXP supply
Power Consumption	12.3W (DC power supply) or 12.4W (PoCXP power supply)
Mechanical	62mm x 62mm x 61.1mm (without adapter)

Note: This table is for 1.13-5.1 version of TS31MSCXPcamera specifications, which may vary slightly from version to version.

4.3 Camera Structure

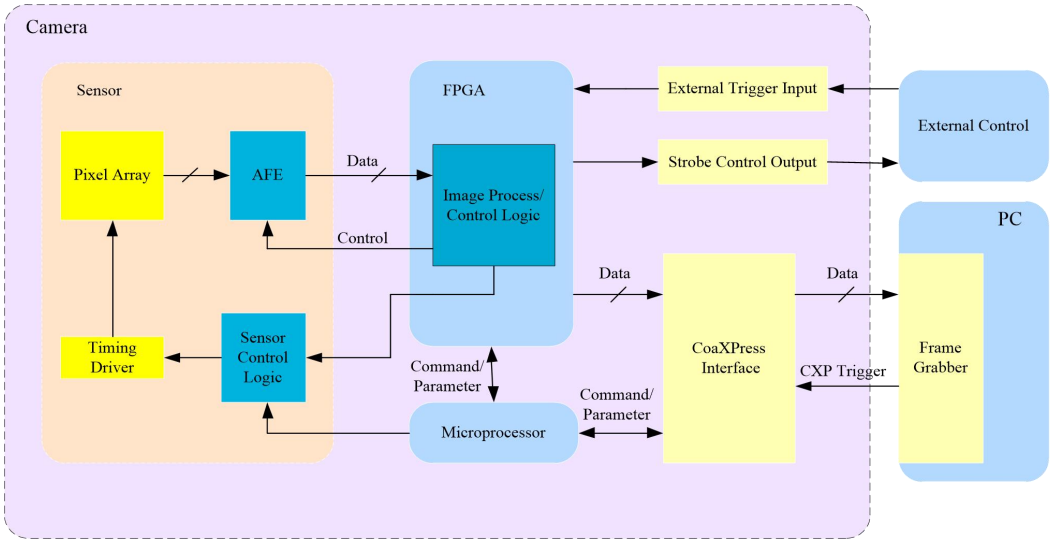


Fig. 2 Internal Implementation Structure of Camera

TS31MSCXP camera uses a unified architecture to achieve image sensor control, data transmission and embedded algorithm processing with different resolutions. The internal structure of camera is shown in figure above. The pixel array is uniformly sampled and maintained by global shutter control system, converted into digital signals by analog front end, and then transmitted to PC frame grabber through CoaXPress interface after processed by FPGA and microprocessor.

TS31MSCXP camera can receive external signal trigger acquisition, from IO signal , CXP signal of CoaXPress interface or software trigger signal.

4.4 Spectral Response

The spectral response of TS31MSCXP camera is shown in figure below.

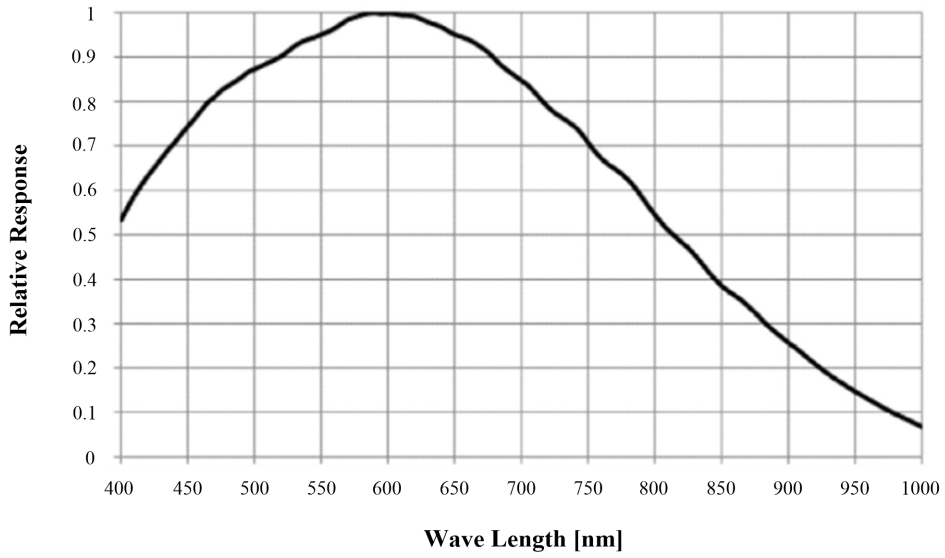


Fig. 3 Spectral Response of Camera

4.5 Environmental Requirements

(1) Operating temperature: 0℃~55℃, humidity: 10% ~ 80%; Storage temperature: -20℃~75℃.

(2) The sensor in the camera has dust proof sealing setting, which can effectively prevent dust from entering sensor surface. If lens cap is open, dust may enter. Therefore, tighten the lens cap when the camera is not in use.

4.6 RoHS Certification

All camera components (including electronic components, PCB, and shell) are RoHS compliant.

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

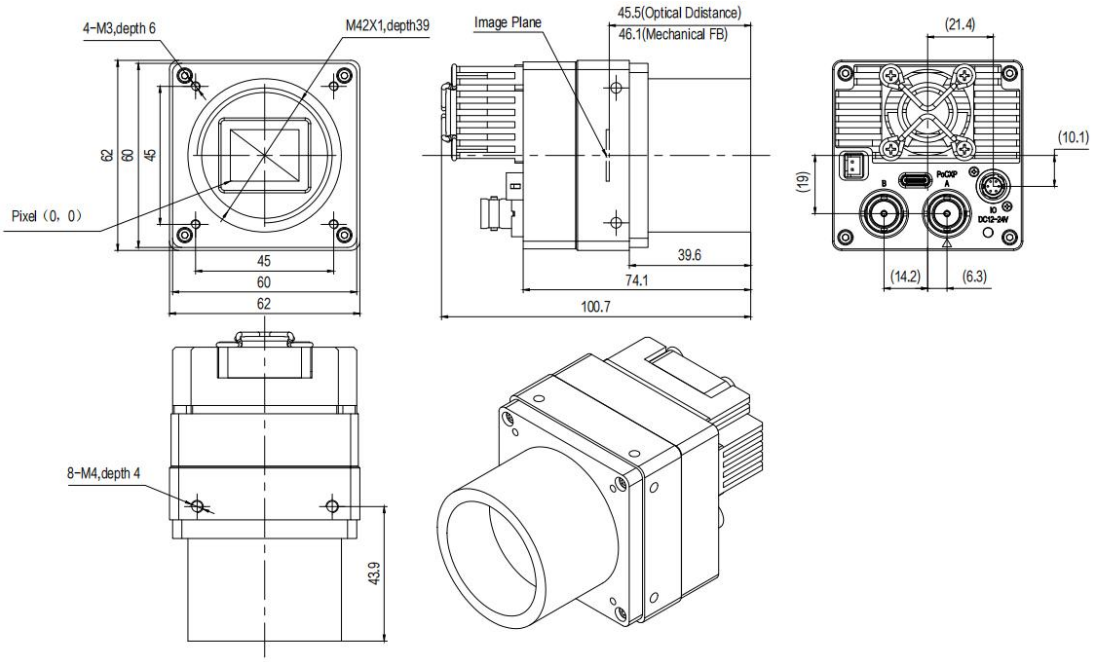


Fig. 4 Camera Mechanical Dimensions

5.2 Camera Interface

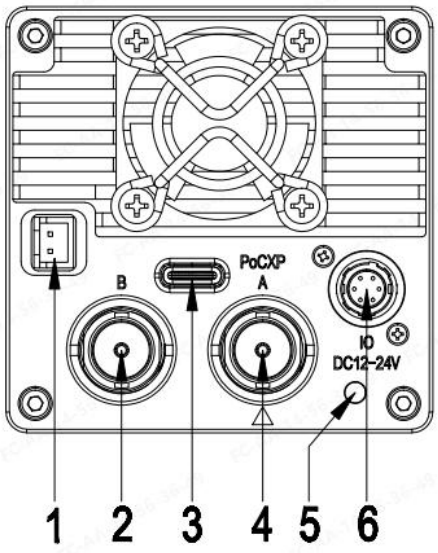


Fig. 5 Interfaces of Camera

① Fan Power Interface
② CoaXPress Connection B
③ Type-C Interface
④ CoaXPress Connection A **(Master, PoCXP power supply)**
⑤ Camera Status Indicator

⑥ 6-pin Power Input and Control Interface

5.2.1 Camera Status Indicator

The camera status indicator is used to indicate real-time status of camera, as shown in the table below:

Table 2 Camera Status Indicators

LED Status Indicators	Camera Status
Solid Green	Normal
Blinking Green	No trigger input within three seconds in external trigger mode
Solid Red	Processor is starting or in error
Blinking Red	Camera fatal error (need contact technical support)
Solid Yellow	Camera is initializing or executing command

5.2.2 Power & Control Interface

Power and control interface adopts a 6-pin connector with the model:
Hirose HR10A-7R-6PB(Male).

Corresponding connector on the cable model:
Hirose HR10A-7P-6S(Female).

Power and control interface on the back of the camera is shown as follows:

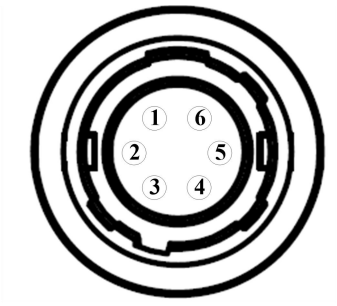


Fig. 6 Pin Assignments for Interface

Table 3 Interface Pin Definition

Signal	Pin	Signal	Pin
Power_VCC	1	Strobe Out	4
Trigger In+	2	IO_GND	5
Trigger In-	3	Power_GND	6

External trigger input is as follows:

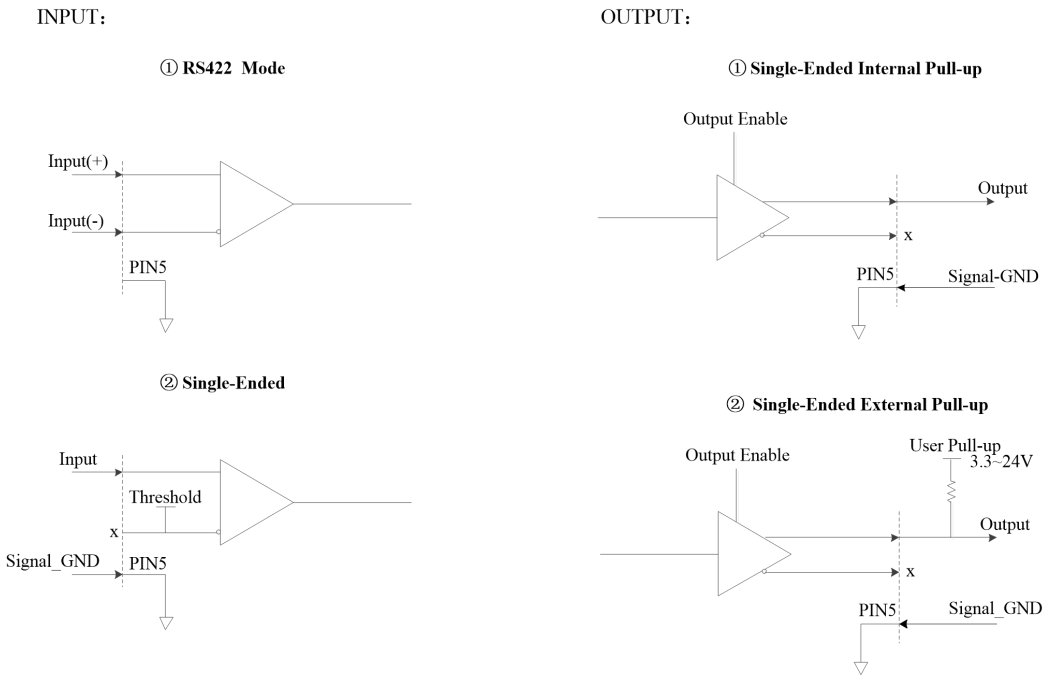


Fig. 7 Trigger Input Circuit Schematic

- Trigger voltage range: 3.3~24V
- Strobe signal pull-up voltage range: 3.3~24V

5.2.3 Data Interface

TS31MSCXP camera implements standard CoaXPress protocol, and data interface is two BNC sockets on the back of camera. The data interface on the back of camera is shown in the red box below:

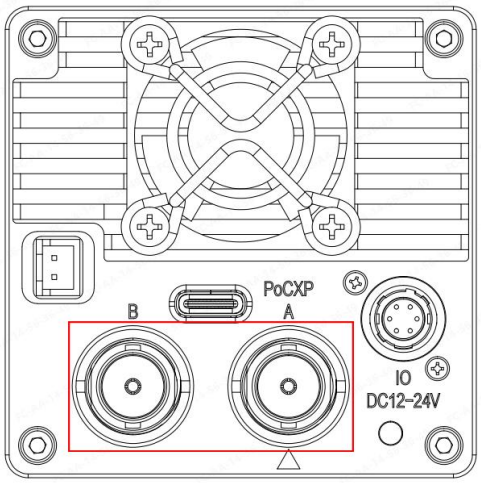


Fig. 8 Data Interface

The mechanical drawing of BNC socket is as follows:

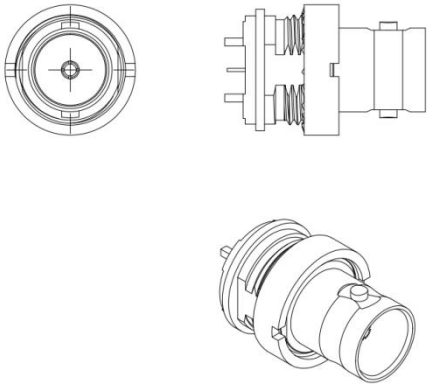


Fig. 9 BNC Socket

6 Camera Features

This chapter introduces the main features of TS31MSCXPcamera.

6.1 Trigger Mode

TS31MSCXP camera supports three trigger modes: Free-Run mode, External Pulse mode and External PWM mode.

6.1.1 Free-Run Mode

In Free-Run mode, camera generates relevant control sequence internally according to frame period and exposure time parameters configured by users and outputs image.

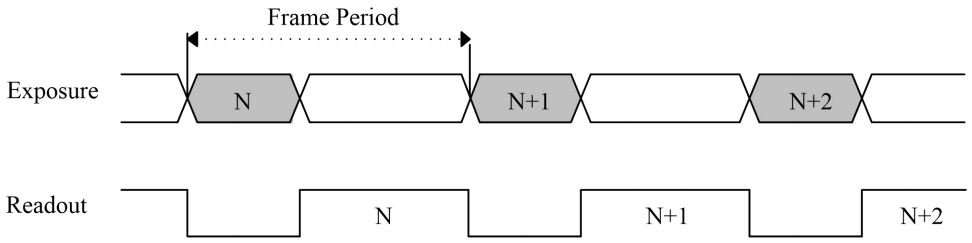


Fig. 10 Free-Run Mode

To achieve normal image output, TS31MSCXP camera limits the range of frame period and exposure time. The minimum frame period should be greater than both exposure time and readout time of a frame.

6.1.2 External Pulse Mode

In External Pulse mode, camera starts to expose at rising edge of trigger signal, and exposure time length is set by users command (consistent with Free-Run mode). At this point, frame rate of camera output image is determined by interval between rising edge of external trigger pulse, as shown in the figure below.

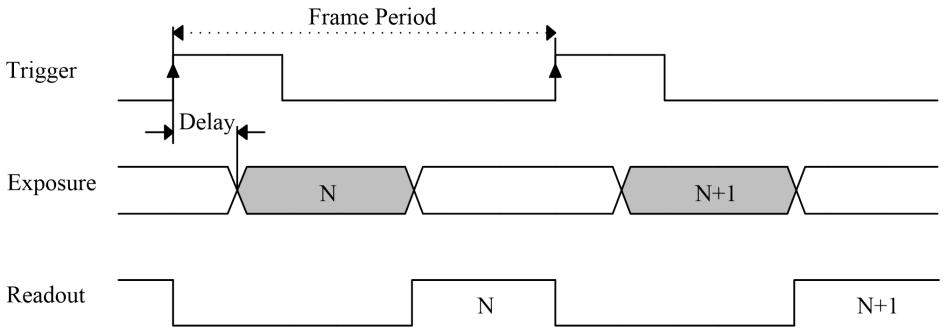


Fig. 11 External Pulse Mode

External trigger signal can be input from CoaXPress interface or control interface. Input source can be selected by users through instruction. To get a higher frame rate, a new trigger pulse can be fired at the

same time the camera reads data after the last frame exposure. In this fast mode, since it is necessary to ensure that reading stages of two frames do not conflict, external trigger with an interval less than 1 frame readout time will be automatically ignored by camera, as shown in the figure below.

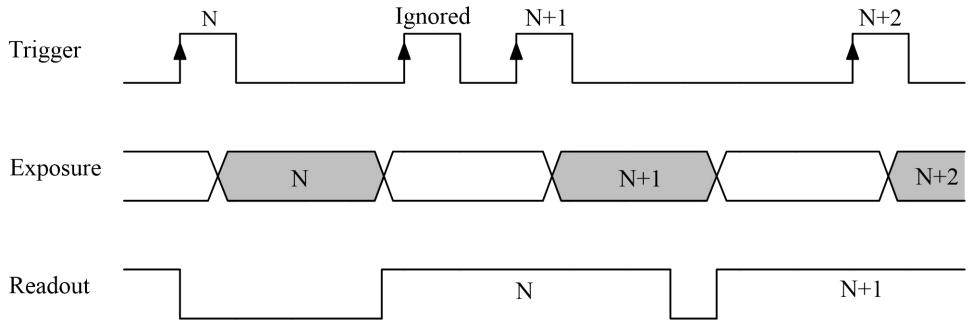


Fig. 12 External Trigger Interval is Too Short

6.1.3 External PWM Mode

In External PWM mode, camera exposure starts at the rising edge of external trigger and ends at the falling edge of trigger signal. That is, the actual exposure time is equal to the externally triggered high level duration, and the frame period is equal to pulse interval.

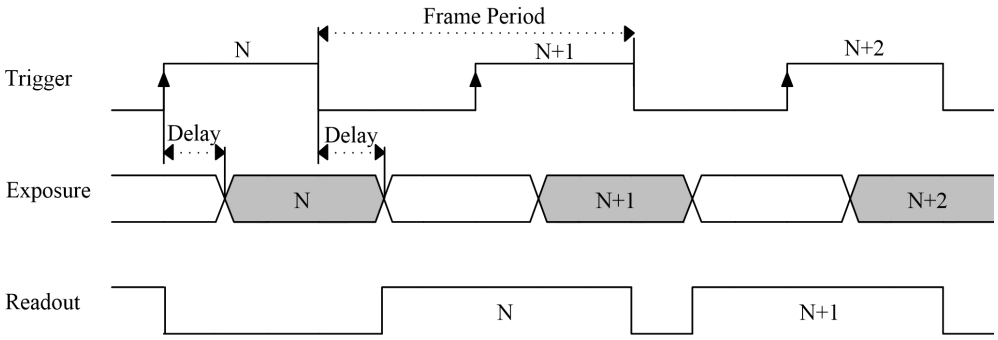


Fig. 13 External PWM Mode

Please note that in this mode, the width of external trigger high level should be greater than minimum exposure time. In fact, for pulses less than minimum exposure time, camera will always process them according to minimum exposure time.

If external trigger interval is too short, it will lead to readout time conflict of two frames before and after camera. At this time, pulse that does not meet requirement will be ignored inside camera, so that camera can maintain normal operation. Therefore, in this mode, it should be ensured that the frame period between the falling edges of adjacent external triggers is greater than one-frame readout time.

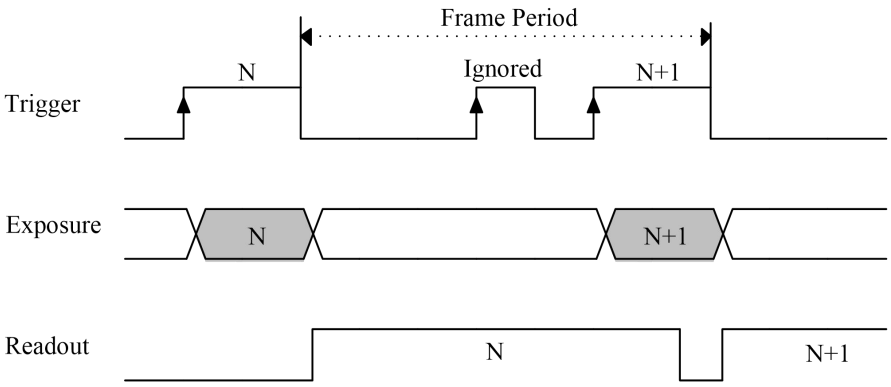


Fig. 14 External Trigger Interval is Too Short

6.2 ROI

Region of interest (ROI) is part of the specified sensor array. Users can obtain frame data from the specified part of sensor array with the same frame quality as from the entire sensor array. When the starting point and the number of pixel lines are specified in both horizontal and vertical directions, ROI is determined to be an overlap of the two regions, as shown in the figure below.

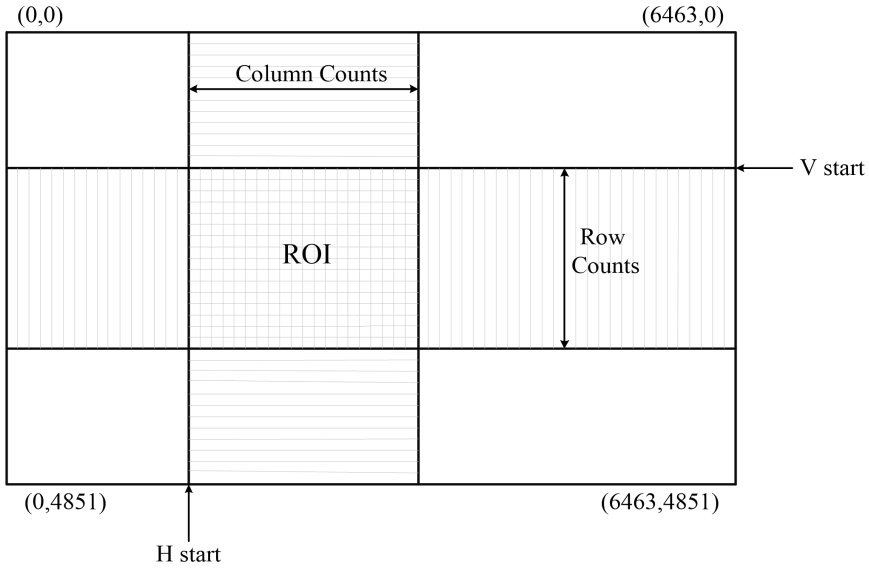


Fig. 15 ROI

Table 4 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	10bit	12bit
6464	4852	35.85fps	30.57fps	25.52fps
5952	4852	35.85fps	33.18fps	26.14fps
4992	4852	35.85fps	35.85fps	26.14fps
3968	4852	35.85fps	35.85fps	26.14fps
2944	4852	35.85fps	35.85fps	26.14fps
1984	4852	35.85fps	35.85fps	26.14fps
960	4852	35.85fps	35.85fps	26.14fps

448	4852	35.85fps	35.85fps	26.14fps
128	4852	35.85fps	35.85fps	26.14fps
6464	4000	43.31fps	36.93fps	30.86fps
6464	3000	57.30fps	48.87fps	40.88fps
6464	2000	84.67fps	72.21fps	60.56fps
6464	1000	162.05fps	138.22fps	116.73fps
6464	500	298.42fps	254.52fps	217.68fps
6464	128	798.08fps	680.74fps	610.50fps
960	960	168.21fps	168.21fps	124.15fps
448	448	327.12fps	327.12fps	244.98fps

6.3 Binning

Binning supports 2X2 binning. After normal exposure acquisition, camera sums the values of adjacent pixels and outputs them as a single pixel value. By using binning function, the pixel response value can be improved, and the effective pixels of one frame can be reduced to one fourth of the original.

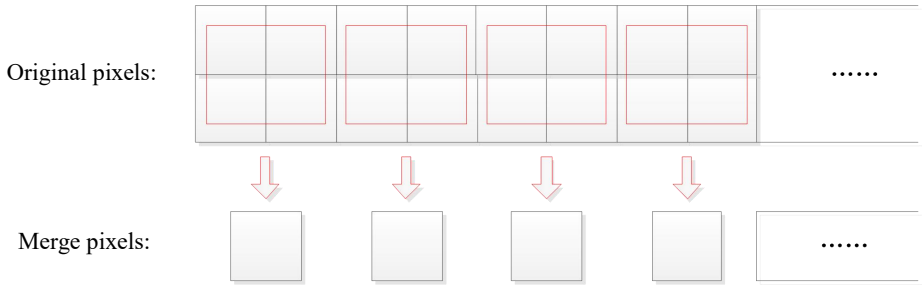
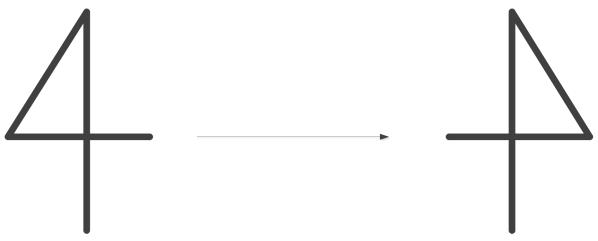


Fig. 16 Binning_2X2

6.4 Image Flip

TTS31MSCXP camera's scanning direction is divided into horizontal scanning direction and vertical scanning direction. The horizontal scanning direction supports two types: left to right and right to left, while the vertical scanning direction supports two types: top to bottom and bottom to top.

Schematic diagram of horizontal and vertical scanning directions is shown below, and they can also be used in combination.



Left to Right Right to Left

Fig. 17 Horizontal Scanning Direction

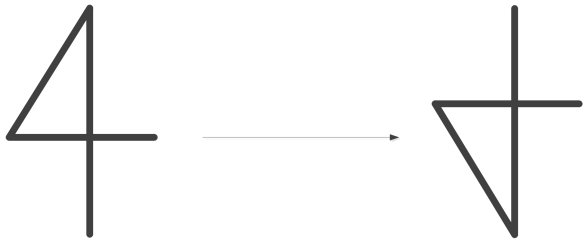


Fig. 18 Vertical Scanning Direction

6.5 LUT

The LUT uses a 12bit input and 12bit output LUT to map and convert the values of the original image. Users can use this function to implement gamma correction.

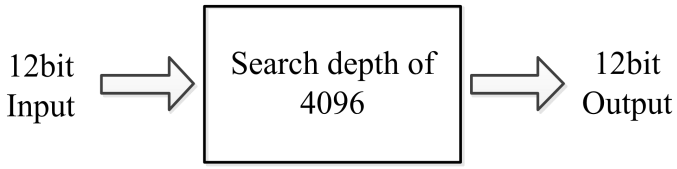


Fig. 19 LUT Structure

The following figure is the LUT mapping curve with Gamma = 0.5:

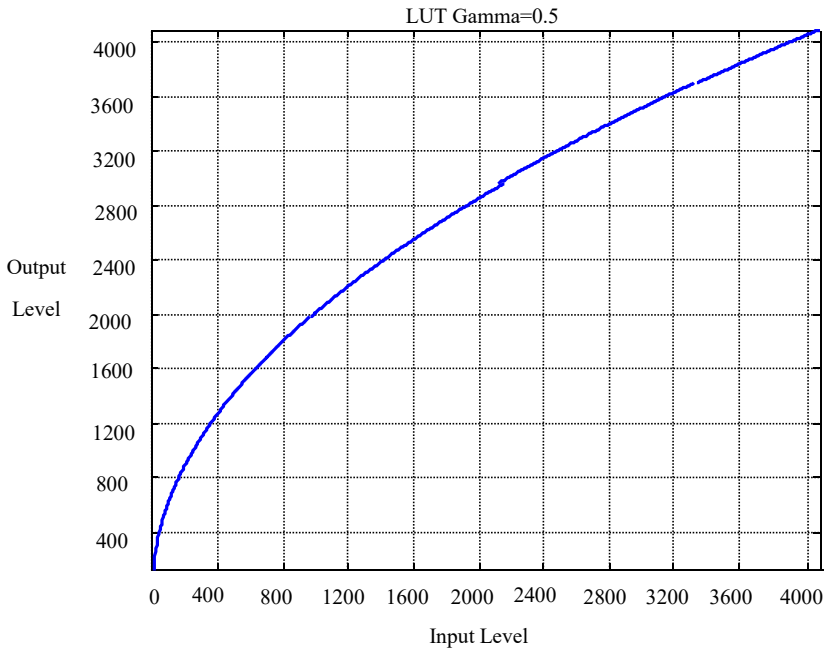


Fig. 20 LUT: Gamma=0.5

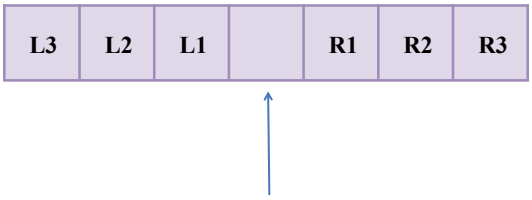
6.6 Defect Pixel Correction

Due to defects of the material itself and the issue with the process flow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response

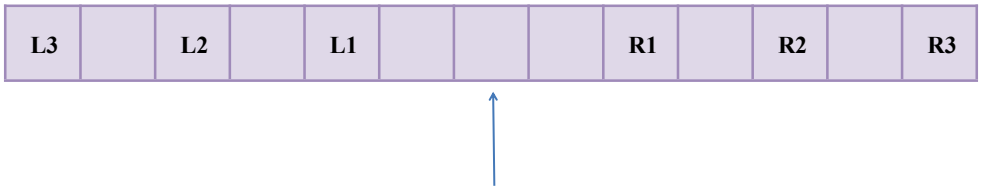
to the input light, which we call defect pixels. TS31MSCXP camera provides with defect pixel automatic correction feature. The defect pixel information of imaging sensor is written into the camera before the camera is delivered out of the factory. Users can control whether to enable the defect pixel correction, add new defect pixels and read out the current defect pixel list from camera.

Correction method of defect pixels is based on calculation and output of adjacent valid pixel values in the same line. The correction methods of monochrome and color camera are different:

- For monochrome camera, defect pixel values are replaced by adjacent pixel values.
- For color camera, defect pixel values are replaced by separated pixel values.



(a) Monochrome Camera



(b) Color Camera

Fig. 21 Defect Pixel Correction Methods for Different Cameras

In the figure above, the modified value of defect pixels will be calculated according to whether the surrounding pixels are defect pixels, as the rules shown in the following table.

Table 5 Calculation Defect Pixel Correction Value

Adjacent Defect Pixel(s)	Correction value of Current Pixel
None	L1
L1	R1
R1	L1
L1,R1	L2
L1,R1,L2	R2
L1,R1,L2,R2	L3
L1,R1,L2,R2,L3	R3

6.7 Flat Field Correction

Generally, in the application process of area scan camera, due to the vignetting effect of lens and the inconsistency of illumination, there is a certain difference between image output by camera and actual

signal, that is, the output data of camera is different for signal with the same brightness. TS31MSCXP camera provides flat field correction function to correct this problem. Users can realize flat field effect by correcting signal parameters of uniform intensity target.

Taking into account the pixel array scale and vignetting effect of area scan cameras, this camera uses 32 x 32 pixel block data, combined with image algorithms to achieve real-time flat field correction algorithms. The fundamental is shown in the figure below:

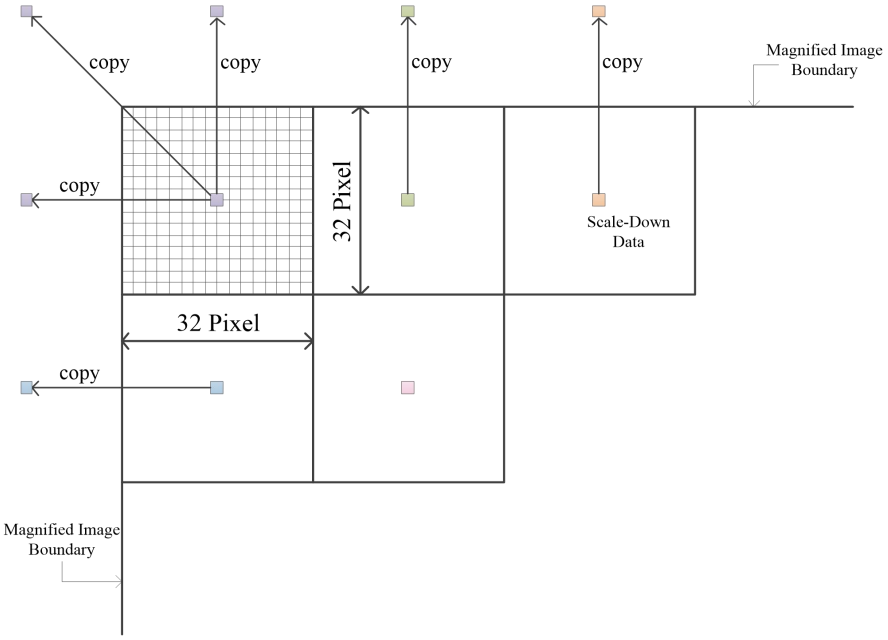


Fig. 22 Flat Field Correction Schematic

6.8 Test Image

Different from the collected images whose data comes from sensors, test images are fixed pattern images that are pre-edited and stored inside camera, independent of the scene shot by camera, and can be used to test whether data link is smooth.

This camera provides a horizontal grayscale gradient test image, as shown in the following figure.

Fig. 23 Test Image

6.9 Strobe

Strobe signal is used to synchronize external light sources with the camera. The timing of strobe signal is exactly the same as the camera exposure timing. When the camera exposure starts, the strobe signal will be pulled down/up; The camera exposure ends, and the strobe signal will return to its initial level.

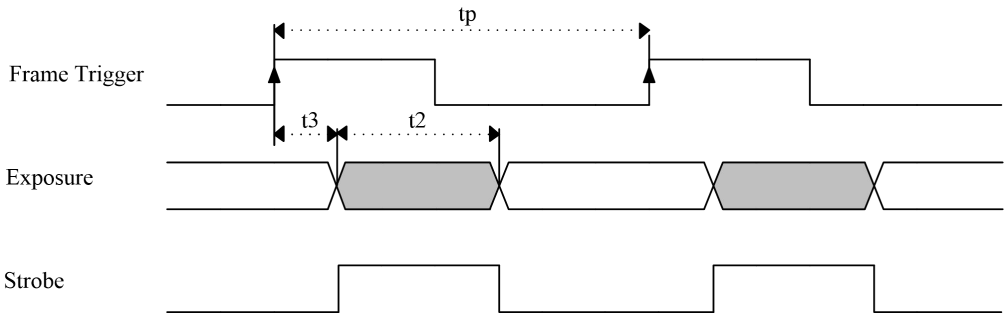


Fig. 24 Strobe Signal

6.10 Data Format

TS31MSCXP camera processes data in 12bit data format, but provides 8bit, 10bit and 12bit output. When camera outputs 8bit data, the lowest 4bit data will be deleted. When the camera outputs 10bit of data, the lowest 2bit will be deleted.

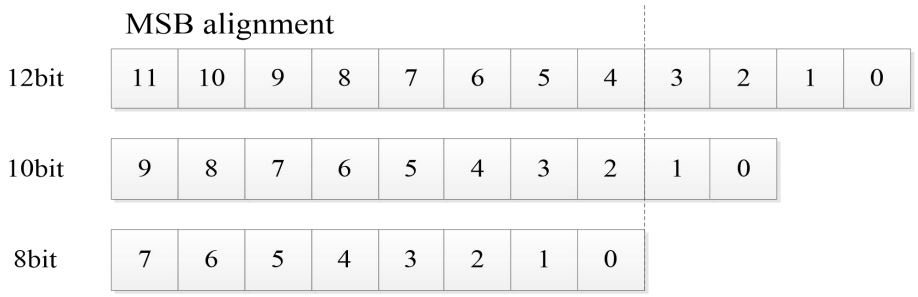


Fig. 25 Data Format

6.11 Gain and Offset

Camera gain is divided into the analog gain and digital gain.

Analog gain acts on the analog signal. By increasing analog gain, a stronger response can be generally obtained under weak illumination, thus realizing a higher SNR. Users can configure camera's analog gain. Similarly, analog offset is generally used to adjust the black level position of the front-end sensor.

Digital gain amplifies or reduces the data of the photoelectric conversion signal after AD, which is usually used to increase the dynamic range of the output image. Digital gain can also be used to adjust the brightness of the image. Digital offset is commonly used to adjust the overall background brightness of an image.

The effect of digital gain can be summarized by the following equation:

Data value (Output) = Data value (digital gain=1 & digital offset=0) x Digital gain value

The effect of digital gain can be summarized by the following equation (Data values less than 0 will be output as 0) :

Data value (Output) = Data value (digital offset=0) + Digital offset value

Digital offset is set for 12bit data. If the image data is 10bit or 8bit, the actual digital offset will be divided by 4 or 16.

6.12 Camera Temperature

TS31MSCXP supports real-time acquisition of camera temperature. Users can read camera temperature value to monitor the current temperature value of sensor or make some responses according to temperature value.

The recommended operating environment temperature of the camera is 0~55°C. If users detect an abnormal internal temperature (such as over 65°C), it is recommended to stop the camera immediately to avoid component damage. Power off and contact our technical support in time.

6.13 Load/Save Configuration

TS31MSCXP camera provides three working parameter sets to meet the use demand in most scenarios. Among them, the factory parameter set has already been optimized and cannot be modified by users. The camera is provided with two user operating parameter sets, among which the internal parameters can be modified and saved by users. The saved operating parameter set will be automatically loaded upon power-on next time.

If the camera is found abnormal after modification of the parameters, users can restore the camera to the factory parameter set.

7 Camera Control

7.1 GenICam Standard

GenICam standard, promulgated by European Machine Vision Association (EMVA), provides a unified programming interface for all types of industrial cameras. The programming interface (API) is the same regardless of which transmission protocol the camera uses or which functions it implements. It mainly contains the following three modules:

- GenAPI: Responsible for parsing XML files and solving problem of how to configure camera
- GenTL: Transport layer, for device enumeration, attribute control, and image acquisition
- SFNC: Standard for naming camera features

Camera XML description file is stored locally on the PC, and collection software will select the most appropriate XML file according to camera model. Application and camera communicate with each other through SFNC, GenAPI, and GigEVision, as shown in the figure.

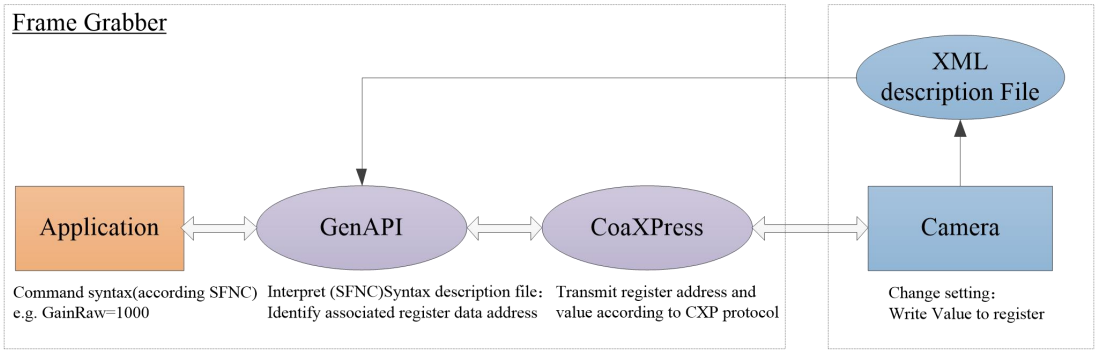


Fig. 26 Communication Principle Diagram Between Application and Camera

In fact, if users want to change camera settings, such as gain, GenICam (SFNC) specifies a standardized syntax:

```
if( IsAvailable(Camera.GainRaw) )
    Camera.GainRaw = 1000;
```

GenAPI can parse these commands through the description file. For example, to set the gain to 1000, the value of 0x3E8 (HEX) must be written to the register at address 0x0815 (HEX). Other tasks involved may be to check whether the camera has gain characteristics in advance and check whether the new value are consistent with the allowable gain range. This register message is transmitted and parsed by protocol and applied to camera.

7.2 GenAPI Parameter Attributes

The actual method of controlling camera is related to software implementation of frame grabber and SDK. Most frame grabber software provides a graphical user interface (GUI) that is automatically generated from XML files. This manual focuses on functions of camera, detailing the specific commands and their impact on operation of camera, listing the name, interface, access, description, range and default value of each GenAPI parameter.

(1) Register name

Each parameter is identified by a unique name. Most names are part of SFNC, and use camera custom names for non-standard parameters.

(2) Register address

This parameter represents the address value of the register (hexadecimal format).

(3) Register size

This parameter represents the size of the register value (in byte).

(4) Register interface

The parameter interface represents the type of parameter, which is mainly used for GUI of frame grabber to assign a display type to parameter.

Table 6 Overview of Parameter Interface

Interface	Interface Name	Description
Integer	I	Integer with value, minimum, maximum, and increment
Float	F	Float with value, minimum, maximum, and physical unit
String	S	String
Enumeration	E	Enumerate type
Command	C	Command type
Boolean	B	Boolean type

(5) Parameter access

This parameter represents whether users can read (RO), write (WO) or read/write (RW) parameters.

(6) Default parameter value and range

When setting the parameter, it will check whether the input value is within the valid range of parameter.

7.3 Register Classification

7.3.1 Bootstrap CoaXPress Registers

Table 7 Bootstrap CoaXPress Registers

Name	Address	Size	Interface	Access	Visibility
Standard	0x0	4	I	RO	Beginner
Revision	0x4	4	I	RO	Beginner
XmlManifestSize	0x8	4	I	RO	Guru
XmlManifestSelector	0xc	4	I	RW	Guru
XmlVersion	0x10	4	I	RO	Guru
XmlSchemeVersion	0x14	4	I	RO	Guru

XmlUrlAddress	0x18	4	I	RO	Guru
Iidc2Address	0x1c	4	I	RO	Guru
ConnectionReset	0x4000	4	I	RW	Guru
DeviceConnectionID	0x4004	4	I	RO	Guru
MasterHostConnectionID	0x4008	4	I	RW	Guru
ControlPacketSizeMax	0x400c	4	I	RO	Guru
StreamPacketSizeMax	0x4010	4	I	RW	Guru
ConnectionConfig	0x4014	4	E	RW	Beginner
ConnectionConfigDefault	0x4018	4	E	RO	Beginner
TestMode	0x401c	4	E	RW	Guru
TestErrorCountSelector	0x4020	4	I	RW	Guru
TestErrorCount	0x4024	4	I	RW	Guru
TestPacketCountTx	0x4028	8	I	RW	Guru
TestPacketCountRx	0x4030	8	I	RW	Guru
ElectricalCompliancyTest	0x4038	4	E	RW	Guru
WidthAddress	0x3000	4	I	RO	Guru
HeightAddress	0x3004	4	I	RO	Guru
AcquisitionModeAddress	0x3008	4	I	RO	Guru
AcquisitionStartAddress	0x300c	4	I	RO	Guru
AcquisitionStopAddress	0x3010	4	I	RO	Guru
PixelFormatAddress	0x3014	4	I	RO	Guru
DeviceTapGeometryAddress	0x3018	4	I	RO	Guru
Image1StreamIDAddress	0x301c	4	I	RO	Guru
HsUpconnection	0x403c	4	I	RO	Guru

- **Standard**
  Unique identification of CoaXPress standard.

- **Revision**
  CoaXPress protocol version number.

- **XmlManifestSize**
  The number of XML files available.

- **XmlManifestSelector**
  Select XML manifest entry.

- **XmlVersion**
  The version of XML file referenced by XmlManifestSelector.

- **XmlSchemeVersion**
  The version of XML file format scheme referenced by XmlManifestSelector.

- **XmlUrlAddress**

  The URL address of XML file referenced by XmlManifestSelector.

- **Iidc2Address**

  If device supports IIDC 2 protocol, this register should provide start address of IIDC 2 register space.

- **ConnectionReset**

  Reset all connections to device.

- **DeviceConnectionID**

  Provide ID of device connection from which this register is read.

- **MasterHostConnectionID**

  ID of host device.

- **ControlPacketSizeMax**

  Provide maximum control packet data size, which is defined in bytes and should be multiples of 4 bytes.

- **StreamPacketSizeMax**

  Provide maximum flow packet data size that host can accept. The size is defined in bytes and should be a multiple of 4 bytes.

- **ConnectionConfig**

  Current device link speed and number of link channels. The enumeration names and values are as follows:

  - CXP3_X2 (0x00020038)
  - CXP6_X2 (0x00020048)

- **ConnectionConfigDefault**

  Default link speed and number of link channels. The enumeration names and values are as follows:

  - CXP3_X1 (65592)
  - CXP5_X1 (65600)
  - CXP6_X1 (65608)
  - CXP3_X2 (131128)
  - CXP5_X2 (131136)
  - CXP6_X2 (131144)
  - CXP3_X4 (262200)
  - CXP5_X4 (262208)
  - CXP6_X4 (262216)

- **TestMode**

Enable the transmission of test data packets from the device to the host. The enumeration names and values are as follows:

- Off (0)
- Mode1 (1)

- **TestErrorCountSelector**

  Test mode selection. The parameter range is as follows:

  - Maximum: 3
  - Minimum: 0
  - Increment: 1

- **TestErrorCount**

  Number of testing errors.

- **TestPacketCountTx**

  Number of test error frames.

- **TestPacketCountRx**

  Test the number of data frames read.

- **ElectricalCompliancyTest**

  Electrical compatibility testing. The enumeration names and values are as follows:

  - NormalOperatingMode (0)
  - CXP3_X1 (65592)
  - CXP5_X1 (65600)
  - CXP6_X1 (65608)
  - CXP3_X2 (131128)
  - CXP5_X2 (131136)
  - CXP6_X2 (131144)
  - CXP3_X4 (262200)
  - CXP5_X4 (262208)
  - CXP6_X4 (262216)

- **WidthAddress**

  Address of camera width register.

- **HeightAddress**

  Address of camera height register.

- **AcquisitionModeAddress**

  The address of camera acquisition mode register.

- **AcquisitionStartAddress**

  The camera start grabbing address of register.

- **AcquisitionStopAddress**
  The camera stops grabbing address of register.

- **PixelFormatAddress**
  The address of camera pixel format register.

- **DeviceTapGeometryAddress**
  The address of camera Tap arrangement register.

- **Image1StreamIDAddress**
  Address of data stream register.

- **HsUpconnection**
  Whether camera supports address of uplink channel register.

7.3.2 Device Control Registers

Table 8 Device Control Registers

Name	Address	Size	Interface	Access	Visibility
DeviceVendorName	0x2000	32	S	RO	Beginner
DeviceModelName	0x2020	32	S	RO	Beginner
DeviceManufacturerInfo	0x2040	48	S	RO	Beginner
DeviceVersion	0x2070	32	S	RO	Beginner
DeviceSerialNumber	0x20b0	16	S	RO	Expert
DeviceUserID	0x20c0	16	S	RW	Beginner
SensorTemperature	0xa004	4	F	RO	Beginner

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceManufacturerInfo**
  Device manufacturer information.

- **DeviceVersion**
  Device version.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceUserID**

User-defined ID.

- **SensorTemperature**
  Sensor temperature.

7.3.3 Image Format Control Registers

Table 9 Image Format Control Registers

Name	Address	Size	Interface	Access	Visibility
Width	0xa800	4	I	RW	Beginner
Height	0xa804	4	I	RW	Beginner
SensorWidth	0xa808	4	I	RO	Expert
SensorHeight	0xa828	4	I	RO	Expert
Binning	0xa810	4	E	RW	Beginner
PixelFormat	0xa830	4	E	RW	Beginner
VideoMode	0xa834	4	E	RW	Beginner
ReverseX	0xa838	4	B	RW	Expert
ReverseY	0xa850	4	B	RW	Expert
OffsetX	0xa80c	4	I	RW	Beginner
OffsetY	0xa82c	4	I	RW	Beginner
DeviceTapGeometry	0xa008	4	E	RW	Beginner

- **Width**
  Actual camera output width.The parameter range is as follows:
  - Minimum: 128
  - Increment: 64

- **Height**
  Actual camera output height. The parameter range is as follows:
  - Minimum: 128
  - Increment: 4

- **SensorWidth**
  Sensor width.

- **SensorHeight**
  Sensor height.

- **Binning**
  Binning. The enumeration names and values are as follows:
  - Binning_1X1 (0)
  - Binning_2X2 (1)

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:
  - Mono8 (0x01080001): Monochrome 8bit
  - Mono10 (0x01100003): Monochrome 10bit
  - Mono12 (0x1100005): Monochrome 12bit

- **VideoMode**

  Output image format. The enumeration names and values are as follows:
  - Original (0): Original image
  - Corrected (1): Corrected image
  - MonochromePattern(2): Monochrome test image

- **ReverseX**

  Horizontal flipping.

- **ReverseY**

  Vertical flipping.

- **OffsetX**

  Horizontal offset.The parameter range is as follows:
  - Minimum: 0
  - Increment: 128

- **OffsetY**

  Vertical offset.The parameter range is as follows:
  - Minimum: 0
  - Increment: 16

- **DeviceTapGeometry**

  Tap arrangement. The enumeration names and values are as follows:
  - Geometry_1X_1Y (0)

7.3.4 Acquisition Control Registers

Table 10 Acquisition Control Registers

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0xb050	4	E	RO	Beginner
AcquisitionStart	0xb054	4	C	RW	Beginner
AcquisitionStop	0xb058	4	C	RW	Beginner
AcquisitionFrameRate	/	/	F	/	Beginner
AcquisitionFramePeriod	0xb028	4	F	RW	Beginner
AcquisitionFrameRateEnable	0xb02c	4	B	RW	Expert
ExposureMode	0xb03c	4	E	RW	Beginner

ExposureTime	0xb040	4	I	RW	Beginner
FrameAverageMode	0xb05c	4	E	RW	Beginner
TriggerSource	0xb014	4	E	RW	Beginner
TriggerSoftware	0xb004	4	C	WO	Expert
LinePolarity	0xb030	4	E	RW	Beginner
LineDetectionLevel	0xf850	4	E	RW	Expert
LineDebouncingPeriod	0xf830	4	I	RW	Beginner
LineDelayPeriod	0xf834	4	I	RW	Beginner
LineTriggerInputFrequency	0xf83c	4	I	RO	Beginner
FlashStrobeActivation	0xf84c	4	E	RW	Beginner
FlashStrobePullUp	0xf85c	4	E	RW	Beginner

- **AcquisitionMode**

  Acquisition mode, usually default to continuous acquisition. The enumeration names and values are as follows:

  - Continuous (0): Continuous acquisition

- **AcquisitionStart**

  Start acquisition.

- **AcquisitionStop**

  Stop acquisition.

- **AcquisitionFrameRate**

  Acquisition frame rate in Hz. The parameter range is as follows:

  - Minimum: 0.02

- **AcquisitionFramePeriod**

  Acquisition frame period, unit is us. The parameter range is as follows:

  - Maximum: 11000000
  - Increment: 1

- **AcquisitionFrameRateEnable**

  Enable frame rate acquisition settings. By selecting this option, users can set acquisition frame rate themselves. Otherwise, the frame rate will be set to the maximum allowed value by default.

- **ExposureMode**

  Exposure mode, please refer to section 6.1 for specific description. The enumeration names and values are as follows:

  - Timed(1): Free-Run mode
  - TriggerPulse (2): External pulse mode
  - TriggerWidth(3): External PWM mode

- **ExposureTime**

Exposure time, the unit is us. The parameter range is as follows:

- Maximum: 10000000
- Minimum: 2

- **FrameAverageMode**

Set frame average mode. The enumeration names and values are as follows:

- AverageOfThreeFrame (1): Turn on the three frame image averaging mode, and the frame rate will be reduced to one-third of the original
- Off (0): Off

- **TriggerSource**

Trigger source selection. The enumeration names and values are as follows:

- CXPIn (1): CXP signal
- Line1 (0): 6-pin interface signal
- Software (2): Software trigger signal

- **TriggerSoftware**

Software trigger, click on this option to generate a software trigger signal.

- **LinePolarity**

Trigger polarity. The enumeration names and values are as follows:

- Low (1): Low level trigger acquisition
- High (0): High level trigger acquisition

- **LineDetectionLevel**

Input signal detection level, i.e. input voltage range. The enumeration names and values are as follows:

- Threshold_for_3V3_to_5V (1): Voltage range 3.3~5V
- Threshold_for_6V_to_24V (0): Voltage range 6~24V

- **LineDebouncingPeriod**

Input the signal to shake the window length, signals below this pulse width will be considered as gross signals and filtered out,unit is us. The parameter range is as follows:

- Maximum: 6553
- Minimum: 0

- **LineDelayPeriod**

Trigger delay time. The parameter range is as follows:

- Maximum: 6553
- Minimum: 0

- **LineTriggerInputFrequency**

Trigger signal rate, unit is Hz.

- **FlashStrobeActivation**

  Strobe signal polarity. The enumeration names and values are as follows:

  - FallingEdge (1): Default high level, pull-down level when generating strobe signal
  - RisingEdge (0): Default low level, pull-up level when generating strobe signal

- **FlashStrobePullup**

  Strobe signal pull-up voltage. The enumeration names and values are as follows:

  - Internal_3V3 (1): 3.3V internal pull up voltage
  - External_5V_to_24V (0): 5~24V external pull up voltage

7.3.5 Analog Control Registers

Table 11 Analog Control Registers

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0xb808	4	F	RW	Beginner
AnalogOffset	0xb80c	4	I	RW	Beginner

- **AnalogGain**

  Analog gain. The parameter range is as follows:

  - Maximum: 24
  - Minimum: 0
  - Increment: 0.1

- **AnalogOffset**

  Analog offset. The parameter range is as follows:

  - Maximum: 4095
  - Minimum: 0
  - Increment: 1

7.3.6 Digital Control Registers

Table 12 Digital Control Registers

Name	Address	Size	Interface	Access	Visibility
DigitalGain	/	/	F	/	Beginner
GainRaw	0xc028	4	I	RW	Beginner
BlackLevel	0xc004	4	I	RW	Beginner

- **DigitalGain**

  Digital gain. The parameter range is as follows:

  - Maximum: 8
  - Minimum: 0.004
  - Increment: 0.004

- **GainRaw**

Digital gain of raw data. The meaning and function of this parameter are consistent with the DigitalGain parameter, inherited from the old version of the camera, and only differentiated in naming. The parameter range is as follows:

  - Maximum: 65535
  - Minimum: 0
  - Increment: 1

- **BlackLevel**

Black level, used to adjust the bottom value of camera output under dark field conditions. The smaller the black level value, the smaller the grayscale value of the image in a dark field environment.The parameter range is as follows:

  - Maximum: 4095
  - Minimum: -4095
  - Increment: 1

7.3.7 LUT Control Registers

Table 13 LUT Control Registers

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0xd004	4	B	RW	Expert
LUTSelector	0xd000	4	I	RW	Expert
LUTIndex	0xd008	4	I	RW	Expert
LUTValue	0xd00c	4	I	RW	Expert
Gamma	0xd010	4	F	RW	Beginner

- **LUTEnable**

Enable LUT function.

- **LUTSelector**

Select LUT. The parameter range is as follows:

  - Maximum: 8
  - Minimum: 0
  - Increment: 1

- **LUTIndex**

Lookup table data index, that is, the gray value of image before mapping lookup table. The parameter range is as follows:

  - Maximum: 4095
  - Minimum: 0
  - Increment: 1

- **LUTValue**

Lookup table data value, that is, the gray value of image after mapping lookup table. The parameter range is as follows:

- Maximum: 4095
- Minimum: 0
- Increment: 1

- **Gamma**

  Gamma correction value. The parameter range is as follows:

  - Maximum: 127
  - Minimum: 0.01

7.3.8 Flat Field Correction Registers

Table 14 Flat Field Correction Registers

Name	Address	Size	Interface	Access	Visibility
PRNUEnable	0xd800	4	B	RW	Expert
PRNUStart	0xd814	4	C	WO	Expert
PRNUReset	0xd818	4	C	WO	Expert

- **PRNUEnable**

  Enable flat field correction.

- **PRNUStart**

  Execute flat field correction.

- **PRNUReset**

  Restore factory settings for flat field correction.

7.3.9 Defect Pixel Registers

Table 15 Defect Pixel Registers

Name	Address	Size	Interface	Access	Visibility
DefectPixelCorrectionEnable	0xe000	4	B	RW	Expert
DefectPixelTestMode	0xe008	4	E	RW	Expert
DefectPixelTotal	0xe010	4	I	RO	Expert
DefectPixelSelect	0xe014	4	I	RW	Expert
DefectPixelReadX	0xe018	4	I	RO	Expert
DefectPixelReadY	0xe01c	4	I	RO	Expert
DefectPixelWriteX	0xe020	4	I	RW	Expert
DefectPixelWriteY	0xe024	4	I	RW	Expert
DefectPixelAdd	0xe028	4	C	WO	Expert
DefectPixelRemove	0xe02c	4	C	WO	Expert
DefectPixelClearAll	0xe030	4	C	WO	Expert

DefectPixelSave	0xe034	4	C	WO	Expert

- **DefectPixelCorrectionEnable**

  Enable defect pixel correction function.

- **DefectPixelTestMode**

  Selection of defect pixel testing mode. The enumeration names and values are as follows:

  ➢ Replace (0): Alternative mode, which can use horizontal interpolation, vertical interpolation, or horizontal nearest neighbor value to replace defective pixels, depending on the local defect distribution

  ➢ MarkDefectsWhiteOnVideo (1): Mark defect pixels

- **DefectPixelTotal**

  Total number of defect pixel.

- **DefectPixelSelect**

  Select index of defect pixel. The parameter range is as follows:

  ➢ Minimum: 0

  ➢ Increment: 1

- **DefectPixelReadX**

  Read the X coordinate of current defect pixel.

- **DefectPixelReadY**

  Read the Y coordinate of current defect pixel.

- **DefectPixelWriteX**

  Write the X coordinate of defect pixel. The parameter range is as follows:

  ➢ Minimum: 0

  ➢ Increment: 1

- **DefectPixelWriteY**

  Write the Y coordinate of defect pixel. The parameter range is as follows:

  ➢ Minimum: 0

  ➢ Increment: 1

- **DefectPixelAdd**

  Add defect pixel.

- **DefectPixelRemove**

  Remove current defect pixels.

- **DefectPixelClearAll**

  Remove all defect pixels.

- **DefectPixelSave**

  Save defect pixels.

7.3.10 User Set Control Registers

Table 16 User Set Control Registers

Name	Address	Size	Interface	Access	Visibility
UserSetSelector	0xe800	4	E	RW	Beginner
UserSetLoad	0xe804	4	C	WO	Beginner
UserSetSave	0xe808	4	C	WO	Beginner

- **UserSetSelector**

  User configuration selector. The enumeration names and values are as follows:

  - Default (0): Factory configuration
  - UserSet1(1): User configuration 1
  - UserSet2(2): User configuration 2

- **UserSetLoad**

  Load selected camera configuration.

- **UserSetSave**

  Save selected camera configuration.

7.3.11 File Access Registers

Table 17 File access registers

Name	Address	Size	Interface	Access	Visibility
FileSelector	0x6600	4	E	RW	Guru
FileOperationSelector	0x6604	4	E	RW	Guru
FileOperationExecute	0x6608	4	C	WO	Guru
FileOpenMode	0x660c	4	E	RW	Guru
FileAccessOffset	0x6a10	4	I	RW	Guru
FileOperationStatus	0x6a18	4	E	RO	Guru
FileOperationResult	0x6a1c	4	I	RO	Guru
FileFreeSpace	0x6a20	4	I	RO	Guru
FileTotalSpace	0x6a24	4	I	RO	Guru
FileSize	0x6a28	4	I	RO	Guru

- **FileSelector**

  Select the file that needs to be executed. The enumeration names and values are as follows:

  - CalibrationData (0)
  - DevData1 (0x30)

- DevData2 (0x31)
- DevData3 (0x32)

- **FileOperationSelector**

Select the operation that needs to be performed on the file. The enumeration names and values are as follows:

- Open(0): On file
- Close(1): Off file
- Read(0x10): Read file
- Write(0x11): Write file

- **FileOperationExecute**

Execute operations on files.

- **FileOpenMode**

File open mode. The enumeration names and values are as follows:

- Read(0x10): Read only mode
- Write(0x11): Write only mode
- Append (0x12)：Read write mode

- **FileAccessOffset**

File offset position. The parameter range is as follows:

- Minimum: 0
- Increment: 1

- **FileOperationStatus**

File operation status. The enumeration names and values are as follows:

- FileOperationSuccess(0): Operation successful
- FileOperationFailure(1): Operation failed
- FileOperationOffsetBeyondEnd(5): File offset exceeds the file size

- **FileOperationResult**

File operation result. When a file is read or written, the number of bytes successfully read or written is returned.

- **FileFreeSpace**

Camera file free space.

- **FileTotalSpace**

Total camera file space.

- **FileSize**

Camera file size.

8 FAQ

- **If the camera cannot be connected to computer,**

① Ensure that CoaXPress interface cable is OK

② Ensure that serial port channel parameters of CoaXPress interface are correctly set.

- **If CoaXPress interface cannot receive camera clock signal,**

① Ensure that the camera has been turned on properly (i.e. the status indicator should be normally green).

② If a third-party frame grabber is used to grab images, ensure that frame grabber and supporting software are operating properly, which can be checked by restarting the machine.

③ Ensure that CoaXPress interface cable is OK.

- **If the camera has no image output in External Pulse mode,**

① Ensure that external input pulse is normal.

② Ensure that the camera has received trigger pulse correctly (it can be confirmed by status indicator display).

③ If CoaXPress interface signal is used as trigger input signal, ensure that frame grabber is configured correctly.

- **If temperature of camera casing is abnormal,**

① Ensure that voltage range of external connected power supply is normal.

② If the casing is hot or the camera emits smoke, immediately cut off power and stop using camera, then contact us for technical support.

- **If images are dark,**

① Ensure that sensor aperture on the casing is not blocked.

② Ensure that exposure time and gain are set properly.

- **If the images are not clear,**

① Ensure that sensor glass is clean.

② Ensure that camera status indicator is normal.

- **If the camera cannot output images,**

① Check whether CoaXPress interface is normal by the test image.

② Check whether the power supply is normal by camera indicator status.

③ Check whether external trigger input is normal in External Trigger mode by camera indicator.

If users have any problems during the use of the camera, please contact our technical support in time, we will provide you with the service as soon as possible.