TS31MSGV-6M/C 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	2023/09/27	● Initial version

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 supports external power supply or PoE power supply. The recommended voltage is +12~24V (±10%), and the current must be 1.0A.
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**

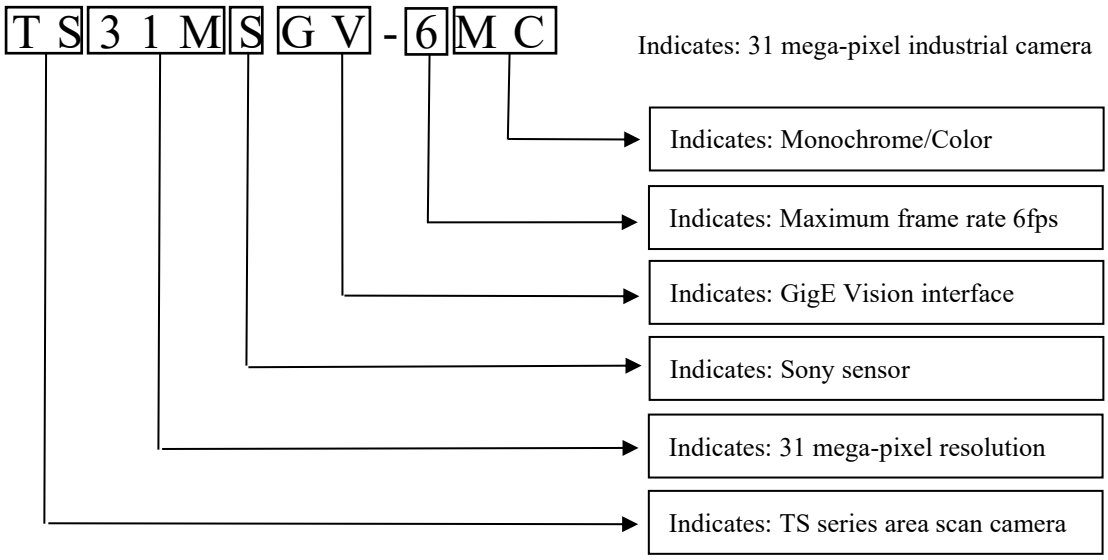
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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

TS31MSGV camera adopts advanced global shutter CMOS image sensor and GigE Vision data interface. It is a 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
- High Sensitivity and Low Noise
- ROI
- Binning
- Rich Exposure Control Modes (External Trigger, Free-Run)
- LUT
- Defect Pixel Correction
- Flat Field Correction
- White Balance
- Analog Gain / Digital Gain / Offset Control
- User-configurable Scanning Direction
- Real-time Temperature Monitor
- Gigabit Ethernet Interface, suitable for Long Distance Transmission
- Compatible with GigEVision V2.0 Protocol and GenICam Standard

4.2 Camera Specifications

Table 1 TS31MSGV-6M/C Product Specifications

Model	TS31MSGV-6M/C
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/Color
Sensor Size	27.88mm (diagonal)
Dynamic Range	≥ 70.7dB
SNR	40.6dB
Data Rate	Non compressed mode: 125MB/s Compressed mode: 188MB/s
Analog Gain	0~24
Digital Gain	0.004~8
Digital Offset	-4095~4095
Lens Mount	F Mount/M42/M58

Max Frame Rate	4fps (6fps with SAccel$^{TM)}$
Trigger Mode	Free-Run, External Trigger
External Trigger	External IO / Software trigger
Exposure Control	Pulse Width Control, Timed
Exposure Time	2us ~ 10s (step: 1us)
Data Format	8/10/10p/12/12p
Operation Temperature	0~55°C
Data Interface	GigE Vision
Power Supply	DC 12~24V (±10%) 1.0A or PoE supply
Power Consumption	5.5W (DC power supply) or 6.1W (PoE power supply)
Mechanical	F Mount: 62mm x 62mm x 89.6mm M42: 62mm x 62mm x 55.1mm M58: 62mm x 62mm x 54.6mm

Note: This table is for 1.21-7.2 version of TS31MSGV camera specifications, which may vary slightly from version to version.

4.3 Camera Structure

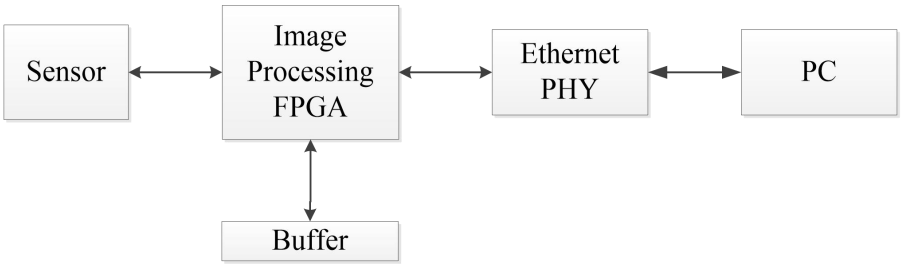


Fig. 2 Internal Implementation Structure of Camera

TS31MSGV 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 network card through Ethernet after processed by FPGA.

TS31MSGV camera can receive external signal trigger acquisition, from IO signal. At the same time, camera can also output synchronization signals during exposure, which facilitates external strobe control.

4.4 Spectral Response

The spectral response of TS31MSGV camera is shown in figure below.

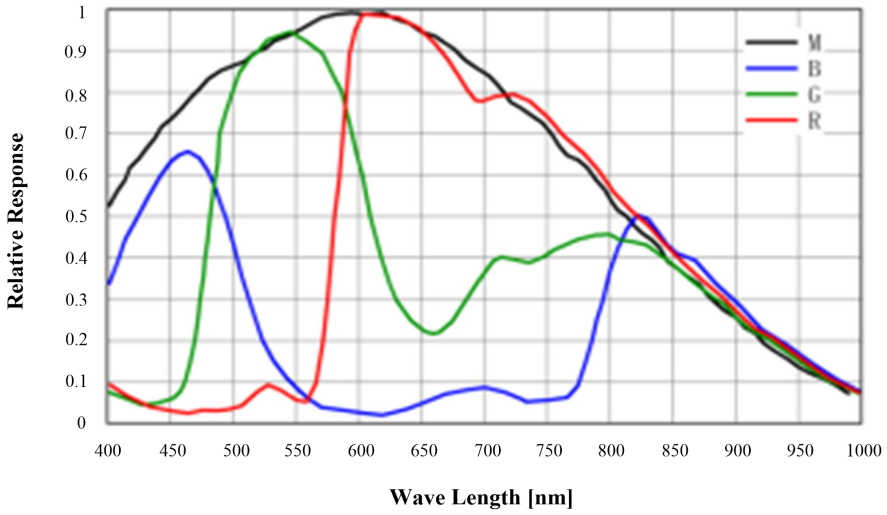


Fig. 3 Spectral Response of Camera

4.5 Camera Bayer Arrangement

Bayer arrangement of TS31MSGV color camera is shown in the following figure (HR is horizontal resolution, VR is vertical resolution).

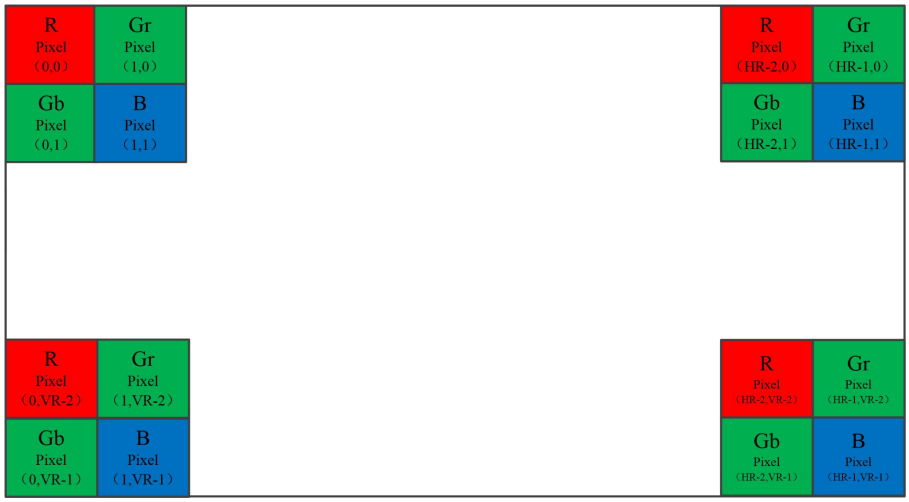


Fig. 4 Camera Bayer Arrangement

4.6 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.

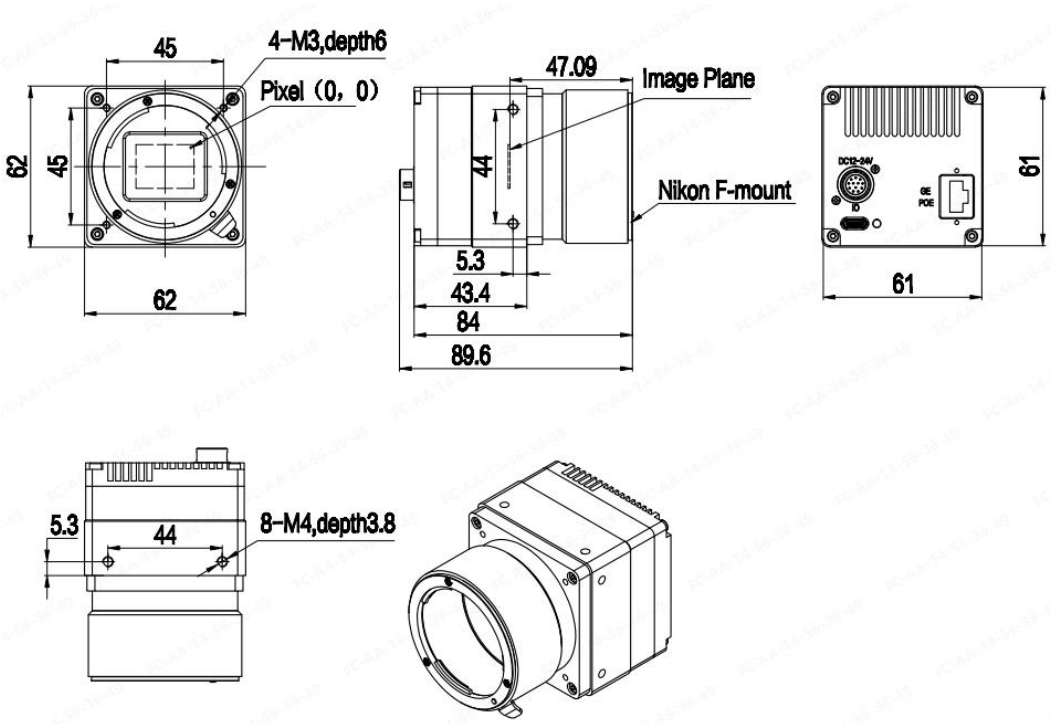
4.7 RoHS Certification

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

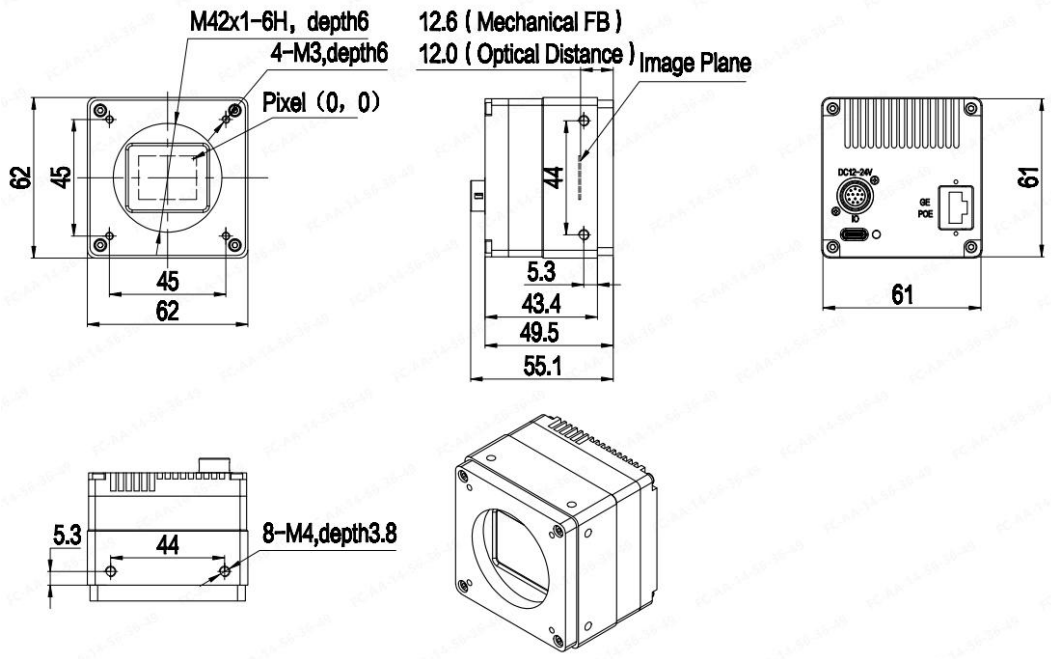
5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

F mount:



M42 mount:



M58 mount:

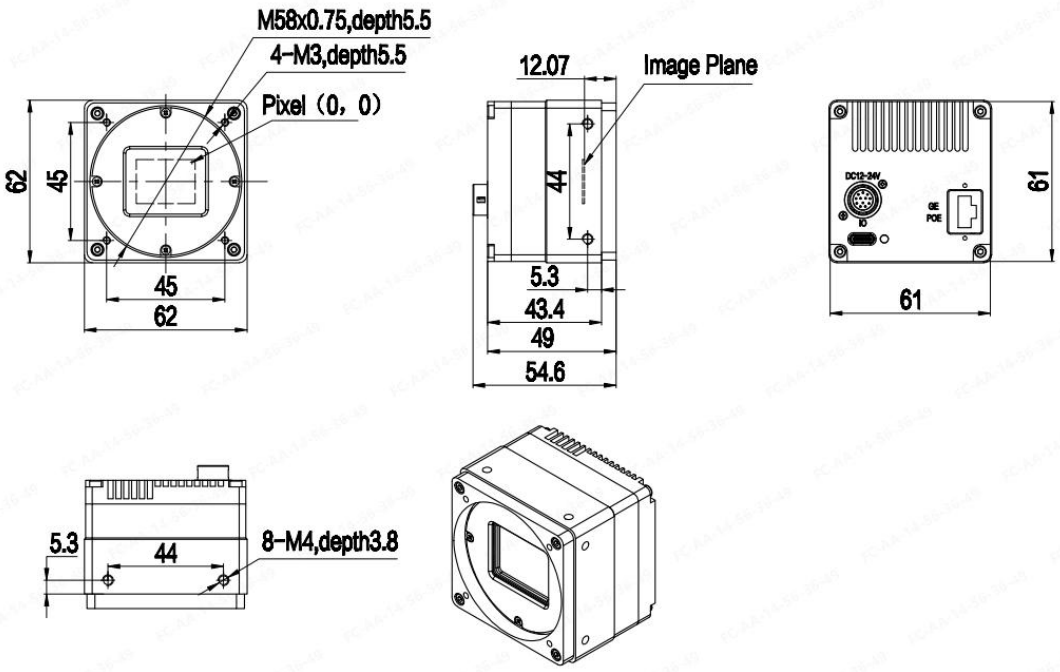


Fig. 5 Camera Mechanical Dimensions

5.2 Camera Interface

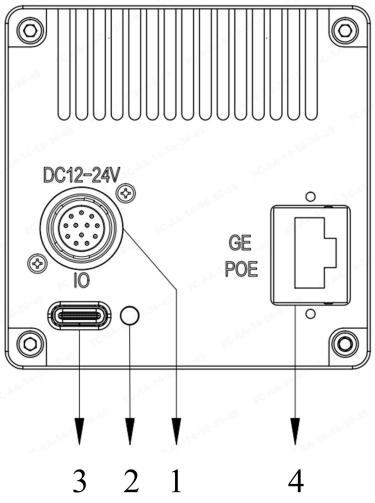


Fig. 6 Interfaces of Camera

① Power and Control Interface
② Camera Status Indicator
③ Type-C Interface
④ Ethernet Data and PoE Power 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 12-pin connector with the model:
HR10A-10R-12PB(71) (Male).

Corresponding connector on the cable model:
HR10A-10P-12S(73) (Female).

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

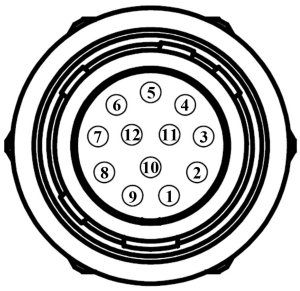


Fig. 7 Pin Assignments for Interface

Table 3 Interface Pin Definition

Signal	Pin	Signal	Pin
Line 1+	1	Line 2-	7
Power_GND	2	Line 2+	8
Line 1-	3	Reserved (reserve)	9
Power_VCC	4	Power_GND	10
Line 3	5	Reserved (reserve)	11
Line 4	6	Reserved (reserve)	12

External trigger input is as follows:

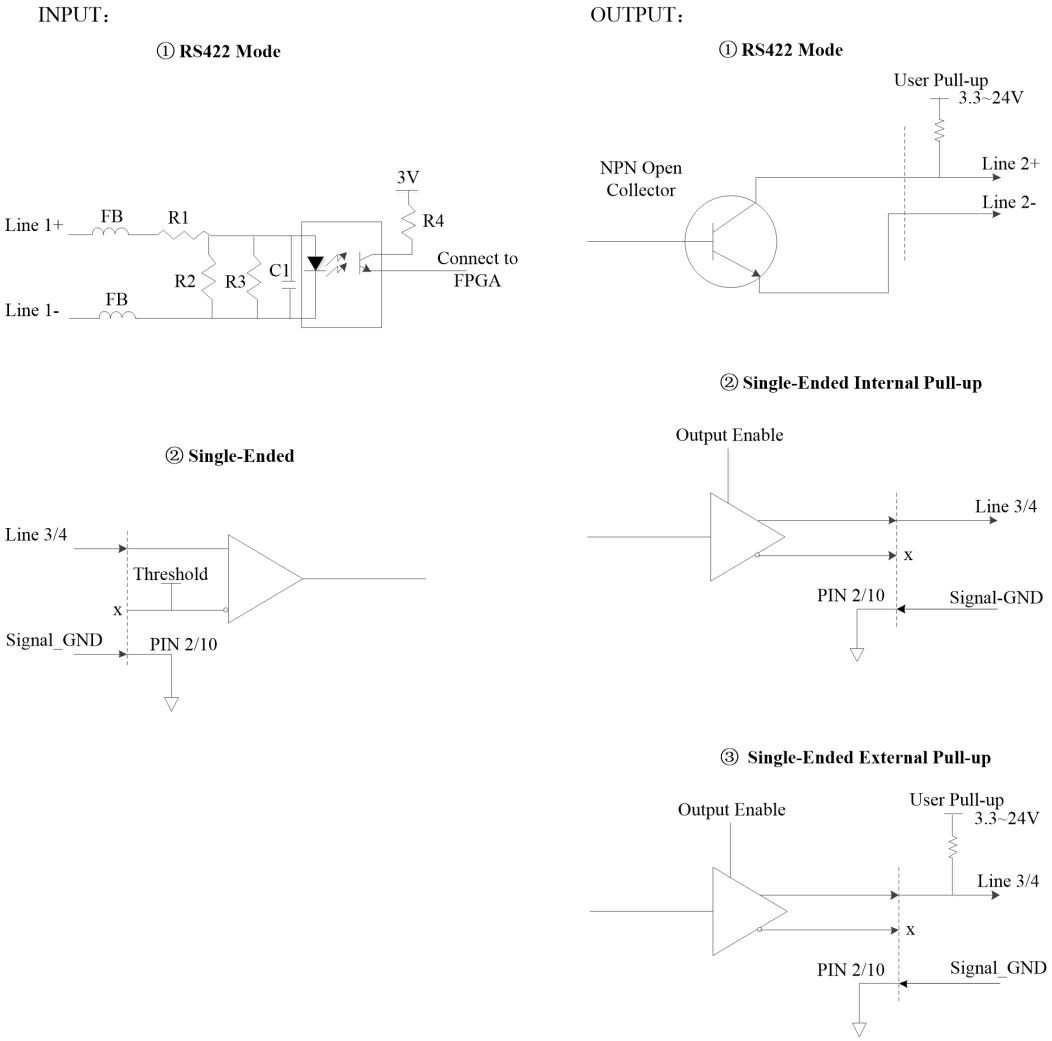


Fig. 8 Trigger Input Circuit Schematic

- Trigger voltage range: Above 3V
- Strobe signal pull-up voltage range: 3.3~24V

6 Camera Features

This chapter introduces the main features of TS31MSGV camera.

6.1 Trigger Mode

TS31MSGV 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 (Trigger Mode = Off， Exposure Mode = Timed), camera generates relevant control sequence internally according to frame period and exposure time parameters configured by users and outputs image.

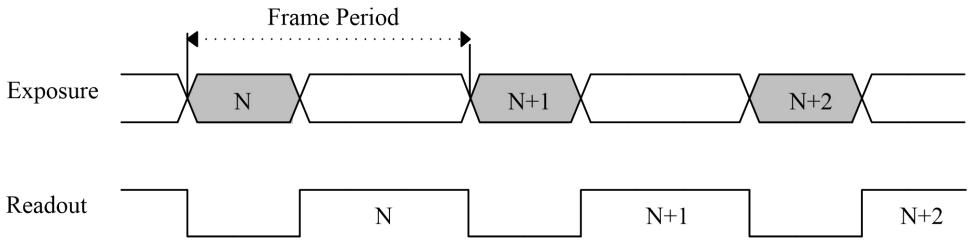


Fig. 9 Free-Run Mode

To achieve normal image output, TS31MSGV 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 (Trigger Mode = On， Exposure Mode = Timed), camera starts to expose at rising edge of trigger signal, and exposure time length is set by users command (consistent with Free-Run mode).

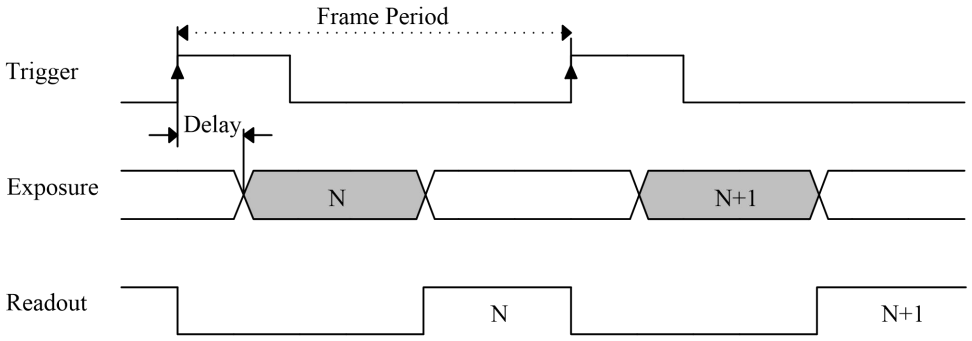


Fig. 10 External Pulse Mode

Camera provides trigger delay and image stabilization functions, both of which delay the trigger signal. The difference is that the image stabilization function eliminates some trigger signals with smaller

pulse widths.

The number of frames triggered for image acquisition is determined by the Trigger Frames Count, and its running timing is shown in the following figure (Trigger Frames Count=2).

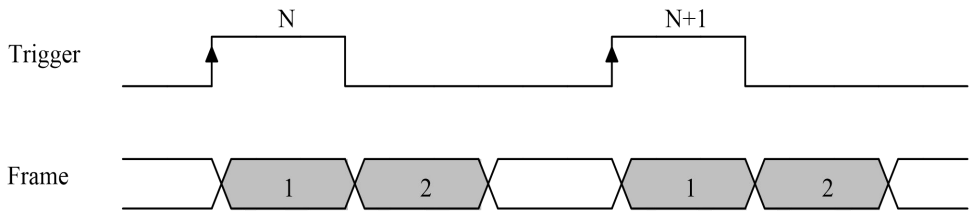


Fig. 11 Trigger Frame Rate for Image Acquisition

In order to achieve higher frame rate, a new trigger pulse can be initiated while the camera reads data after the previous frame exposure ends. In the external pulse mode, the frame period parameter is the minimum triggering interval. External trigger signals smaller than this interval will be automatically ignored by the camera, as shown in the following figure.

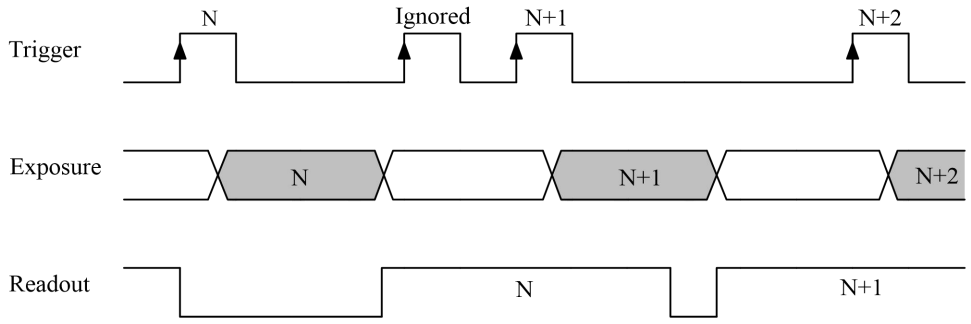


Fig. 12 External Trigger Interval is Too Short

6.1.3 External PWM Mode

In External PWM mode (Trigger Mode = On，Exposure Mode = TriggerWidth), 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.

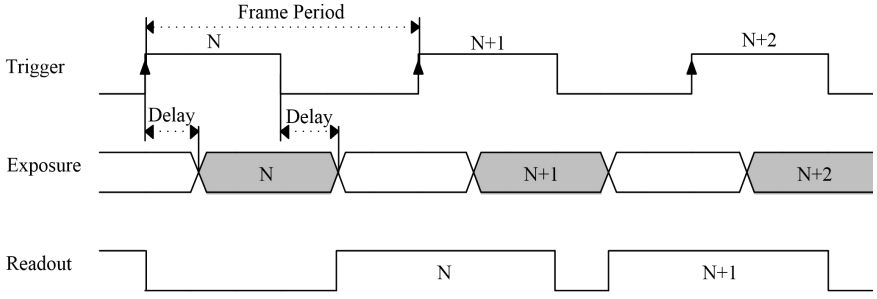


Fig. 13 External PWM Mode

Please note that in this mode, the width of external trigger high level should be greater than minimum exposure time. For pulses that are less than the minimum exposure time of the camera, the camera may ignore them.

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. In external PWM mode, frame period parameter is the minimum trigger interval. External trigger signals smaller than this interval will be automatically ignored by the camera, as shown in the following figure.

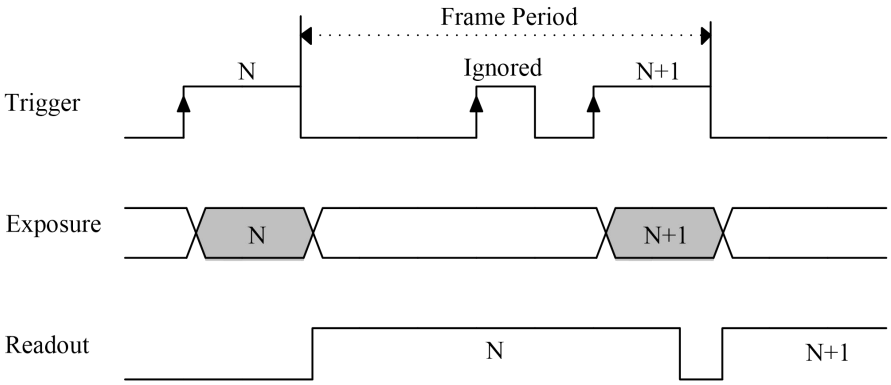


Fig. 14 External Trigger Interval is Too Short

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.

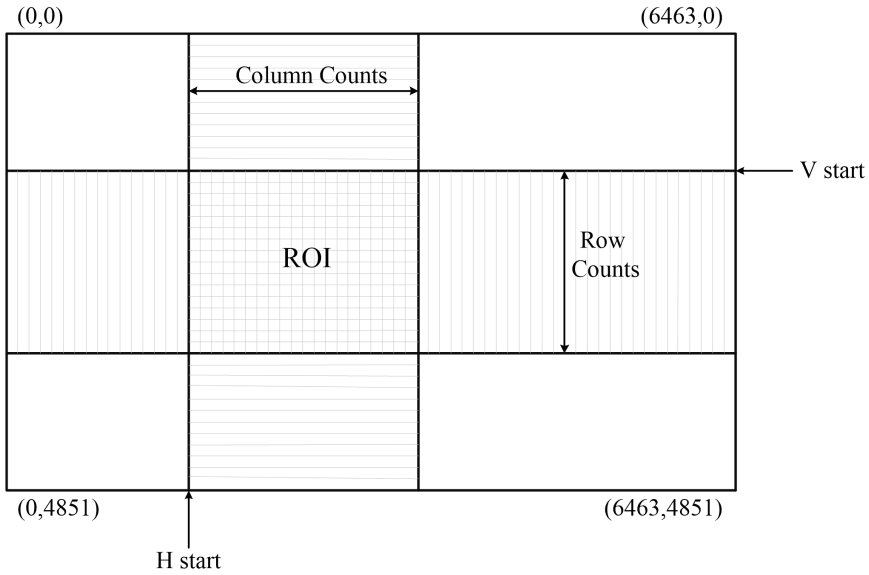


Fig. 15 ROI

Table 4 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	10/12bit
6464	4852	3.938fps	1.969fps
6000	4852	4.240fps	2.121fps
5000	4852	5.090fps	2.545fps
4000	4852	6.152fps	3.181fps
3000	4852	6.152fps	4.240fps
2000	4852	6.152fps	6.152fps
1000	4852	6.152fps	6.152fps
4	4852	6.152fps	6.152fps
6464	4000	4.773fps	2.387fps
6464	3000	6.352fps	3.176fps
6464	2000	9.501fps	4.750fps
6464	1000	18.833fps	9.416fps
6464	4	548.546fps	548.546fps
4	4	548.546fps	548.546fps

6.3 Binning

TS31MSGV camera supports 2x2 or 4x4 binning. After normal exposure acquisition, camera sums the values of adjacent pixels and outputs them as a single pixel value.

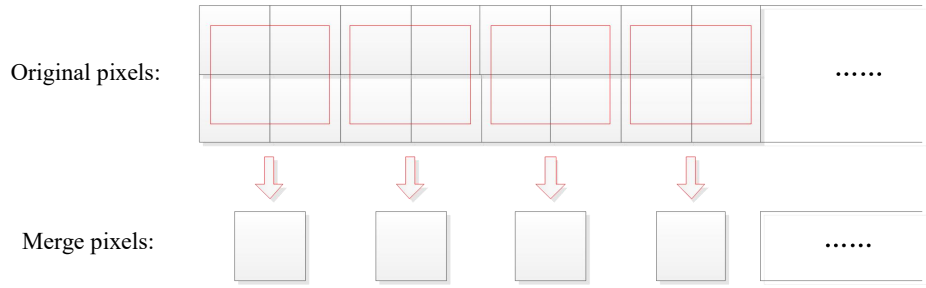


Fig. 16 Binning_2X2

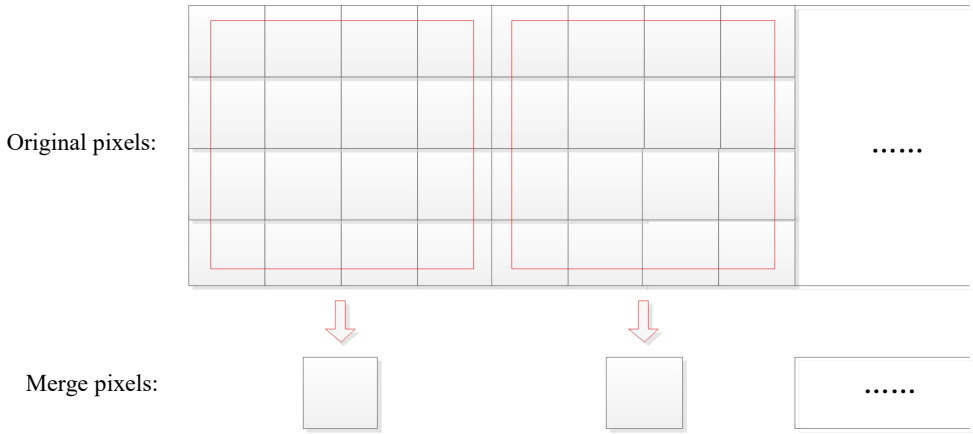
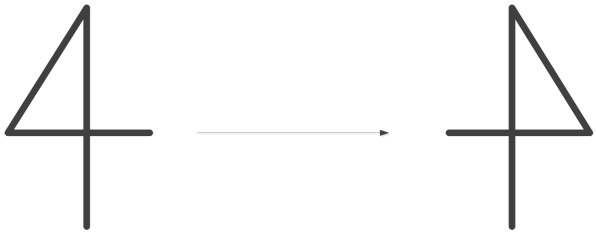


Fig. 17 Binning_4X4

6.4 Image Flip

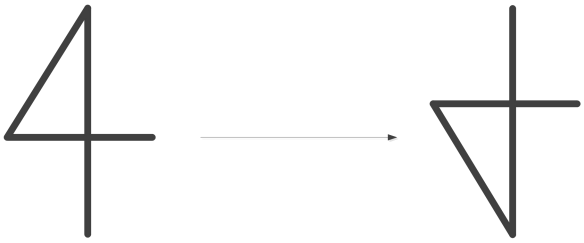
TS31MSGV camera's scanning direction is divided into horizontal scanning direction and vertical scanning direction. The horizontal scanning direction supports two types: left to right and right to left, while the vertical scanning direction supports two types: top to bottom and bottom to top.

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. 18 Horizontal Scanning Direction



Top to Bottom Bottom to Top

Fig. 19 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.

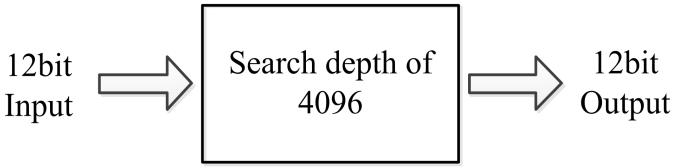


Fig. 20 LUT Structure

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

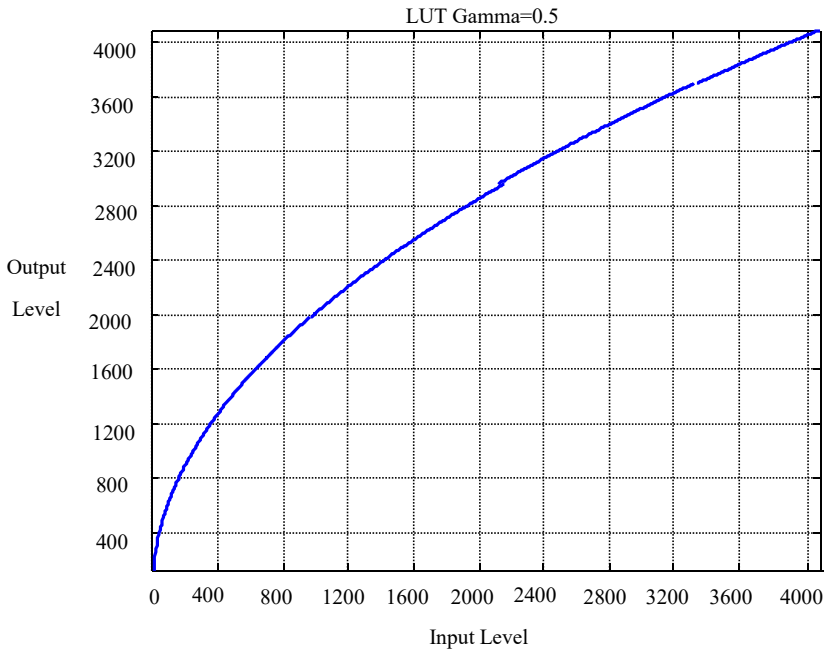


Fig. 21 LUT: Gamma=0.5

6.6 Flat Field Correction

Generally, in the application process of area scan cameras, 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. TS31MSGV camera provides a 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, TS31MSGV camera is measured in pixels of a specific size area, combined with image algorithms to achieve real-time flat field correction algorithms. The fundamental is shown in the figure below:

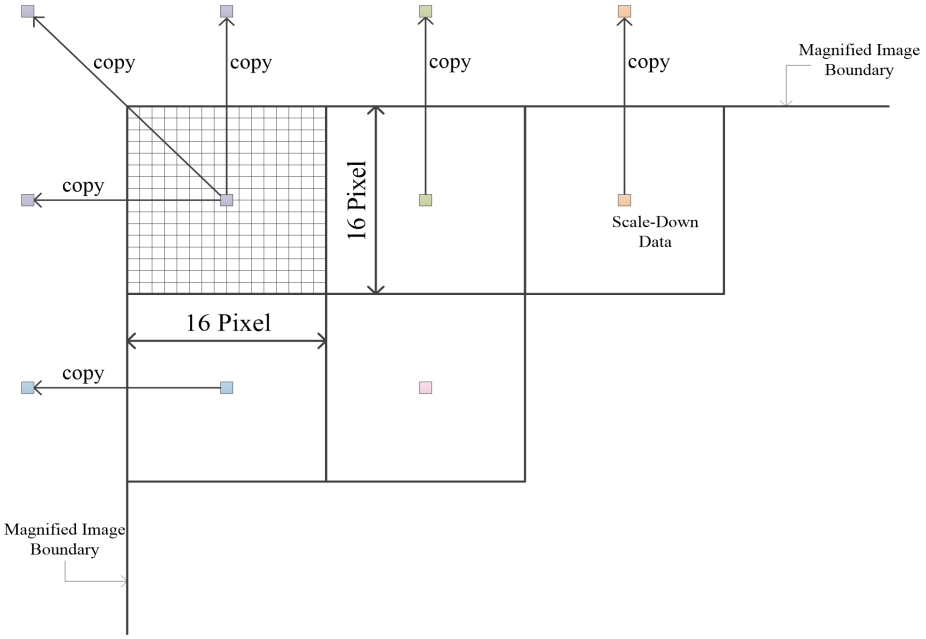


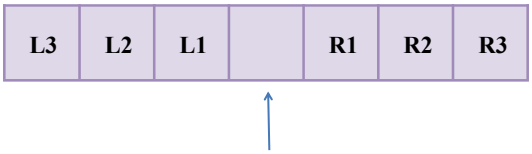
Fig. 22 Flat Field Correction Schematic

6.7 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. TS31MSGV 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.



< Defect pixel >

(a) Monochrome Camera

< Defect pixel >

(b) Color Camera

Fig. 23 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.

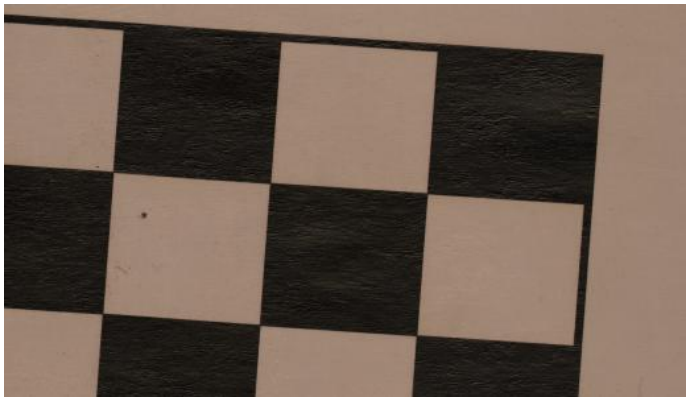
Table 5 Calculation Defect Pixel Correction Value

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

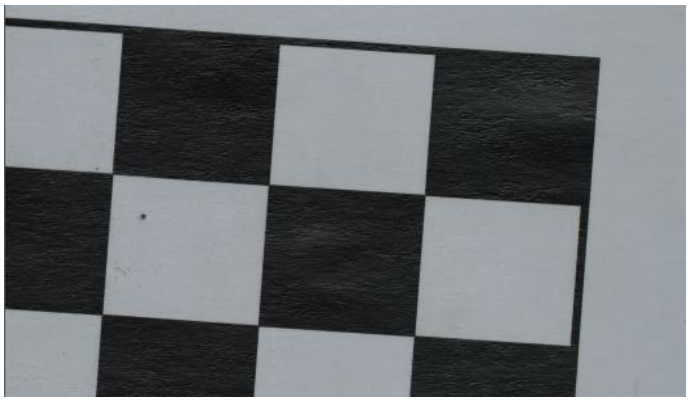
6.8 White Balance

White balance is an important parameter of color industrial camera, it directly affects the color effect of the reproduced image, when the white balance of the industrial camera is not set properly, color reproduction will occur when the image is reproduced.

TS31MSGV color camera provides white balance function, which balances the output value of each channel of the sensor. Automatic white balance calculates the white balance coefficient by sampling local pixels in the sensor, then adjust each component of the image according to the coefficient to make the red, green and blue components of the output image have the same value. Its function diagram is as follows:



(a)Before White Balance



(b) After White Balance

Fig.24 White Balance

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.

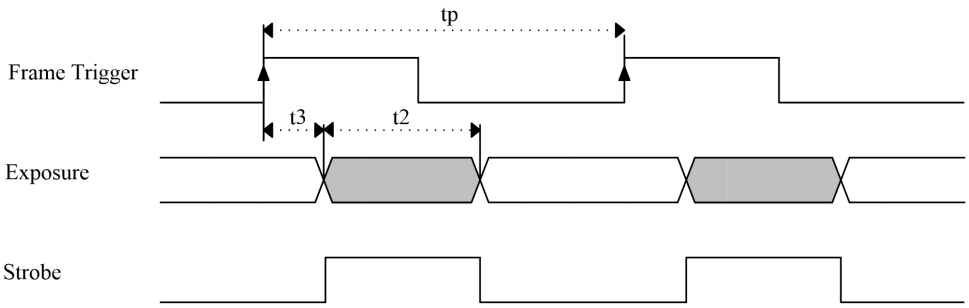


Fig. 25 Strobe Signal

6.10 Test Image

TS31MSGV camera supports three types of image outputs to better adapt to different scenes:

- Original image
- Image after correction algorithm
- Three test images

Test images are generally used to test whether the data link is unobstructed, which facilitates various debugging by users.

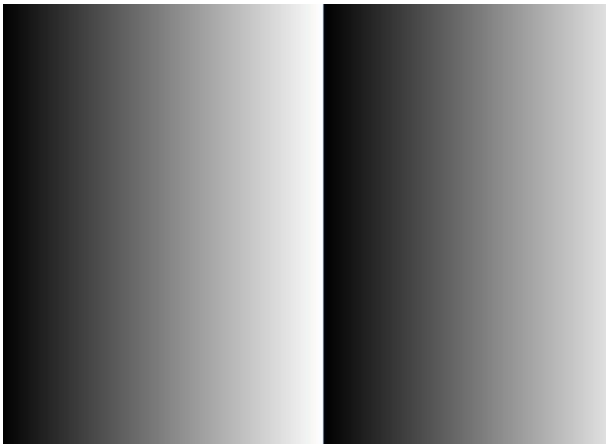


Fig. 26 Monochrome Test Image

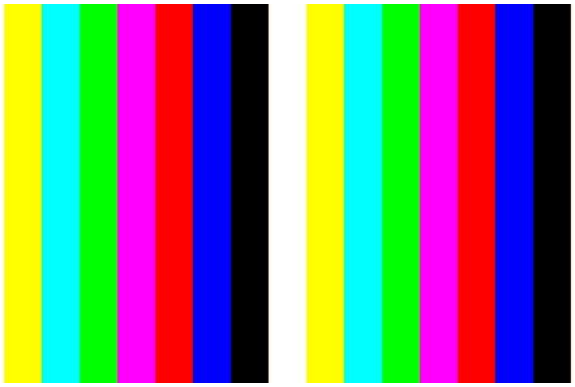


Fig. 27 Color Test Image1

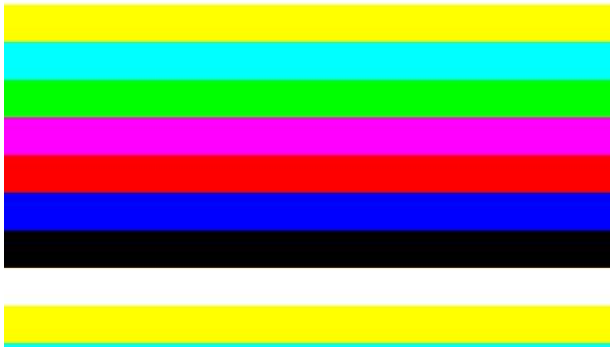


Fig. 28 Color Test Image2

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 Data Format

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.

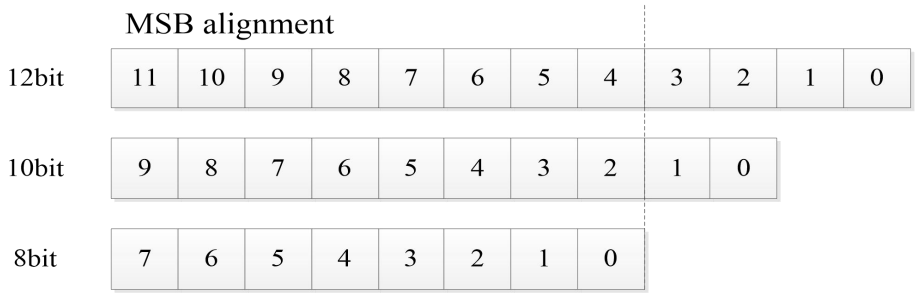


Fig. 29 Data Format

6.13 Camera Temperature

TS31MSGV supports real-time acquisition of camera temperature. Users can read camera temperature value through commands.

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.

6.14 Load/Save Configuration

TS31MSGV 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.

6.15 Set Camera IP Address

TS31MSGV camera communicates with the host by Gigabit Ethernet, a suitable IP address must be set before using the camera. Only when the camera and the host are on the same local area network can they communicate normally.

TS31MSGV camera supports three IP configuration methods, namely static IP, DHCP, and LLA, with decreasing priority. Static IP and DHCP allow users to switch between them. If DHCP fails, the camera will use LLA to allocate IP.

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.

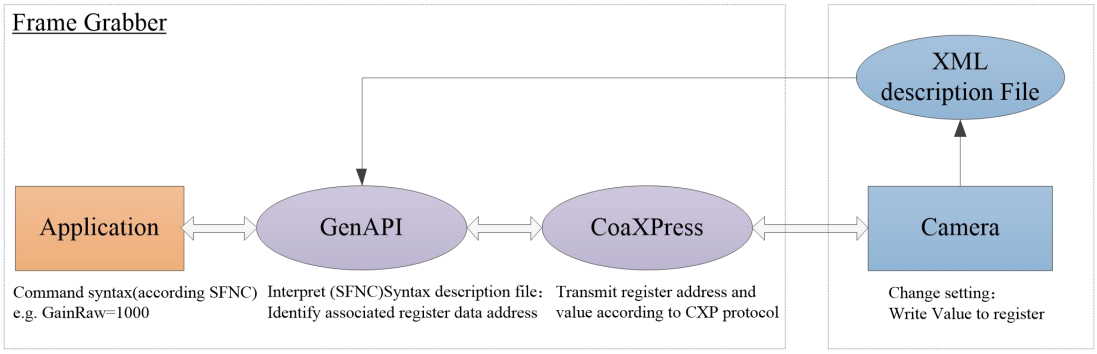


Fig. 30 Communication Principle Diagram Between Application and Camera

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 Device Control Registers

Table 7 Device Control Registers

Name	Address	Size	Interface	Access	Visibility
DeviceVendorName	0x0048	32	S	RO	Beginner
DeviceModelName	0x0068	32	S	RO	Beginner
DeviceManufacturerInfo	0x00a8	48	S	RO	Beginner
DeviceVersion	0x0088	32	S	RO	Beginner
DeviceSerialNumber	0x00d8	16	S	RO	Expert
DeviceUserID	0x00e8	16	S	RW	Beginner

SensorTemperature	0xa004	4	F	RO	Beginner
DeviceLinkSpeed	0x0670	4	I	RO	Expert

- **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.

- **DeviceLinkSpeed**
  Device link speed,unit is Mbps.

7.3.2 Image Format Control Registers

Table 8 Image Format Control Registers

Name	Address	Size	Interface	Access	Visibility
Width	0xa800	4	I	RW	Beginner
Height	0xa804	4	I	RW	Beginner
OffsetX	0xa80c	4	I	RW	Beginner
OffsetY	0xa844	4	I	RW	Beginner
Binning	0xa810	4	E	RW	Beginner
PixelFormat	0xa84c	4	E	RW	Beginner
VideoMode	0xa834	4	E	RW	Beginner
HorizontalScanDirection	0xa838	4	E	RW	Beginner
VerticalScanDirection	0xa848	4	E	RW	Beginner

- **Width**
  Actual camera output width.The parameter range is as follows:

- Minimum: 256

- **Height**

  Actual camera output height. The parameter range is as follows:
  - Minimum: 4
  - Increment: 2

- **OffsetX**

  Horizontal offset.The parameter range is as follows:
  - Minimum: 0
  - Increment: 4

- **OffsetY**

  Vertical offset.The parameter range is as follows:
  - Minimum: 0
  - Increment: 2

- **Binning**

  Binning. The enumeration names and values are as follows:
  - Binning_1X1 (0)
  - Binning_2X2 (1)
  - Binning_4X4 (2)

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:
  - BayerRG8 (0x0): Bayer RGGB 8bit
  - BayerRG10 (0x1): Bayer RGGB 10bit
  - BayerRG10Packed (0x2): Bayer RGGB packed 10bit
  - BayerRG12 (0x3): Bayer RGGB 12bit
  - BayerRG12Packed (0x4): Bayer RGGB packed 12bit
  - Mono8 (0x7): Monochrome 8bit
  - Mono10 (0x8): Monochrome 10bit
  - Mono10Packed (0x9): Monochrome packed 10bit
  - Mono12 (0xA): Monochrome 12bit
  - Mono12Packed (0xB): Monochrome packed 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
  - ColorPattern1 (3): Color test image 1
  - ColorPattern2 (4): Color test image 2

- **HorizontalScanDirection**

  Horizontal scanning direction. The enumeration names and values are as follows:

  - LeftToRight (0): Left to right
  - RightToLeft (1): Right to left

- **VerticalScanDirection**

  Vertical scanning direction. The enumeration names and values are as follows:

  - TopToBottom (0): Top to bottom
  - BottomToTop (1): Bottom to top

7.3.3 Acquisition Control Registers

Table 9 Acquisition Control Registers

Name	Address	Size	Interface	Access	Visibility
AcquisitionStart	0xb000	4	C	RW	Beginner
AcquisitionStop	0xb000	4	C	RW	Beginner
AcquisitionFrameRate	/	/	F	/	Beginner
AcquisitionFramePeriod	0xb028	4	I	RW	Beginner
AcquisitionMaxFrameRate	0xb02c	4	C	WO	Beginner
ExposureTime	0xb040	4	I	RW	Beginner
ExposureTimeStep	0xb044	4	I	RO	Beginner
CompressionTransfer	0xb048	4	B	RW	Expert

- **AcquisitionStart**

  Start acquisition.

- **AcquisitionStop**

  Stop acquisition.

- **AcquisitionFrameRate**

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

  - Minimum: 0.1

- **AcquisitionFramePeriod**

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

  - Maximum: 12000000
  - Minimum: 1

- **AcquisitionMaxFrameRate**

  Acquisition maximum frame rate, click on this option to set the collection frame rate to the maximum allowed value under current conditions.

- **ExposureTime**

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

- Maximum: 10000000
- Minimum: 1

- **ExposureTimeStep**

  Exposure time step, unit is us. The parameter range is as follows:
  - Maximum: 1000000
  - Minimum: 1

- **CompressionTransfer**

  Enable compressed transmission mode.

7.3.4 IO Control Registers

Table 10 IO Control Registers

Name	Address	Size	Interface	Access	Visibility
TriggerMode	0xb008	4	E	RW	Beginner
TriggerSource	0xb014	4	E	RW	Beginner
TriggerDelay	0xb020	4	I	RW	Beginner
TriggerActivation	0xb030	4	E	RW	Beginner
TriggerSoftware	0xb004	4	C	WO	Expert
TriggerFrameCount	0xf800	4	I	RW	Beginner
ExposureMode	0xb03c	4	E	RW	Beginner
TriggerDebouncingPeriod	0xf830	4	I	RW	Beginner
TriggerFrequency	0xf83c	4	I	RO	Beginner
TriggerThreshold	0xf850	4	E	RW	Beginner
Line2StrobeActivation	0xf84c	4	E	RW	Beginner
Line3StrobeActivation	0xf854	4	E	RW	Beginner
Line4StrobeActivation	0xf858	4	E	RW	Beginner
Line2OutputFunction	0xf868	4	E	RW	Beginner
Line3OutputFunction	0xf86c	4	E	RW	Beginner
Line4OutputFunction	0xf870	4	E	RW	Beginner
Line3Selection	0xf860	4	E	RW	Beginner
Line4Selection	0xf864	4	E	RW	Beginner

- **TriggerMode**

  Trigger mode. The enumeration names and values are as follows:
  - Off (0): Off trigger mode
  - On (1): On trigger mode

- **TriggerSource**

  Trigger source selection. The enumeration names and values are as follows:
  - Line1 (0): Line1
  - Line3 (1): Line3

- Line4 (2): Line4
- Software (3): Software trigger

- **TriggerDelay**

  Trigger time delay. The parameter range is as follows:
  - Maximum: 1000000
  - Minimum: 0
  - Increment: 1

- **TriggerActivation**

  Trigger polarity. The enumeration names and values are as follows:
  - RisingEdge (0): Rising edge trigger
  - FallingEdge (1): Falling edge trigger

- **TriggerSoftware**

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

- **TriggerFrameCount**

  Number of acquisition trigger, that is, the number of frames grabbed by the camera for each trigger signal received. The parameter range is as follows:
  - Maximum: 65536
  - Minimum: 1

- **ExposureMode**

  Exposure mode. The enumeration names and values are as follows:
  - Timed (2): Timed
  - TriggerWidth (3): Pulse width control

- **TriggerDebouncingPeriod**

  Trigger 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: 2600
  - Minimum: 0

- **TriggerFrequency**

  Trigger signal rate,unit is Hz.

- **TriggerThreshold**

  Trigger signal detection level, i.e. input voltage range. The enumeration names and values are as follows:
  - Threshold_3V (1): Available when the voltage above 3V
  - Threshold_5V (0): Available when the voltage above 5V

- **Line2StrobeActivation**

Line 2 strobe signal polarity. The enumeration names and values are as follows:

- FallingEdge (1): Exposure timing falling edge generates strobe signal
- RisingEdge (0): Exposure timing rising edge generates strobe signal

- **Line3StrobeActivation**

Line 3 strobe signal polarity. The enumeration names and values are as follows:

- FallingEdge (1): Exposure timing falling edge generates strobe signal
- RisingEdge (0): Exposure timing rising edge generates strobe signal

- **Line4StrobeActivation**

Line 4 strobe signal polarity. The enumeration names and values are as follows:

- FallingEdge (1): Exposure timing falling edge generates strobe signal
- RisingEdge (0): Exposure timing rising edge generates strobe signal

- **Line2OutputFunction**

Line 2 output type. The enumeration names and values are as follows:

- FlashStrobe (0): Output strobe signal
- OutputHigh (1): Default low level, changes to high level when outputting strobe signal
- OutputLow (2): Default high level, changes to low level when outputting strobe signal

- **Line3OutputFunction**

Line 3 output type. The enumeration names and values are as follows:

- FlashStrobe (0): Output strobe signal
- OutputHigh (1): Default low level, changes to high level when outputting strobe signal
- OutputLow (2): Default high level, changes to low level when outputting strobe signal

- **Line4OutputFunction**

Line 4 output type. The enumeration names and values are as follows:

- FlashStrobe (0): Output strobe signal
- OutputHigh (1): Default low level, changes to high level when outputting strobe signal
- OutputLow (2): Default high level, changes to low level when outputting strobe signal

- **Line3Selection**

Line 3 mode selection. The enumeration names and values are as follows:

- Input (0): Input signal terminal
- OutputInternalPullUp (2): Output strobe signal, select internal pull-up voltage
- OutputExternalPullUp (3): Output strobe signal, select external pull-up voltage

- **Line4Selection**

Line 4 mode selection. The enumeration names and values are as follows:

- Input (0): Input signal terminal
- OutputInternalPullUp (2): Output strobe signal, select internal pull-up voltage
- OutputExternalPullUp (3): Output strobe signal, select external pull-up voltage

7.3.5 Analog Control Registers

Table 11 Analog Control Register

Name	Address	Size	Interface	Access	Visibility
PGAGain	0xb808	4	F	RW	Beginner
AnalogOffset	0xb810	4	I	RW	Beginner

- **PGAGain**

  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
DigitalOffset	0xc004	4	I	RW	Beginner
WhiteBalanceRedGain	0xc008	4	I	RW	Expert
WhiteBalanceG1Gain	0xc00c	4	I	RW	Expert
WhiteBalanceG2Gain	0xc010	4	I	RW	Expert
WhiteBalanceBlueGain	0xc014	4	I	RW	Expert
WhiteBalanceEnable	0xc018	4	B	RW	Expert
WhiteBalanceInitialize	0xc01c	4	C	WO	Expert
WhiteBalanceCalibrate	0xc020	4	C	WO	Expert
Denoise	0xc07c	4	F	RW	Expert
Sharpen	0xc088	4	I	RW	Expert

- **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: 32767
- Minimum: 0
- Increment: 1

- **DigitalOffset**

  Digital offset. The parameter range is as follows:

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

- **WhiteBalanceRedGain**

  White balance R channel gain, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceG1Gain**

  White balance G1 channel gain, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceG2Gain**

  White balance G2 channel gain, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceBlueGain**

  White balance B channel gain, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceEnable**

  Enable white balance function, only allowed to be set for color camera.

- **WhiteBalanceInitialize**

  Initialization of white balance correction can restore the white balance parameters to factory settings. Only allowed to be set for color camera.

- **WhiteBalanceCalibrate**

  Execute white balance correction to perform white balance correction function under current conditions. Only allowed to be set for color camera.

- **Denoise**

  Noise reduction, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 1
  - Minimum: 0
  - Increment: 0.001

- **Sharpen**

  Sharpen, only allowed to be set for color camera. The parameter range is as follows:

  - Maximum: 255
  - Minimum: 0
  - 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
LUTIndex	0xd008	4	I	RW	Expert
LUTValue	0xd00c	4	I	RW	Expert
GammaCorrectionEnable	0xd010	4	B	RW	Expert
GammaCorrectionValue	0xd014	4	F	RW	Expert

- **LUTEnable**

  Enable LUT function.

- **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

- **GammaCorrectionEnable**

  Enable gamma correction.

- **GammaCorrectionValue**

  Gamma correction coefficient. The parameter range is as follows:
  - Maximum: 4
  - Minimum: 0.1

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.

- **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.

- **DefectPixelWriteY**
  Write the Y coordinate of defect pixel.

- **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 Transport Layer Control Register

Table 17 Transport Layer Control Registers

Name	Address	Size	Interface	Access	Visibility
GevLinkSpeedConfig	0xa400	4	E	RO	Guru
PayloadSize	0xa018	4	I	RO	Expert
GevVersionMajor	/	/	I	/	Expert
GevVersionMinor	/	/	I	/	Expert
GevDeviceModeIsBigEndian	/	/	B	/	Guru
GevDeviceModeCharacterSet	/	/	E	/	Guru
GevInterfaceSelector	/	/	I	/	Beginner
GevMACAddress	/	/	I	/	Beginner
GevSupportedOptionSelector	/	/	E	/	Expert
GevSupportedOption	/	/	B	/	Expert
GevCurrentIPConfigurationLLA	/	/	B	/	Beginner
GevCurrentIPConfigurationDHCP	/	/	B	/	Beginner
GevCurrentIPConfigurationPersistentIP	/	/	B	/	Beginner
GevCurrentIPAddress	0x0024	4	I	RO	Beginner
GevCurrentSubnetMask	0x0034	4	I	RO	Beginner
GevCurrentDefaultGateway	0x0044	4	I	RO	Beginner
GevFirstURL	/	/	S	/	Guru
GevSecondURL	/	/	S	/	Guru
GevNumberOfInterfaces	/	/	I	/	Expert
GevPersistentIPAddress	0x064c	4	I	RW	Beginner

GevPersistentSubnetMask	0x065c	4	I	RW	Beginner
GevPersistentDefaultGateway	0x066c	4	I	RW	Beginner
GevMessageChannelCount	0x0900	4	I	RO	Expert
GevStreamChannelCount	0x0904	4	I	RO	Expert
GevHeartbeatTimeout	0x0938	4	I	RW	Guru
GevTimestampTickFrequency	/	/	I	/	Expert
GevTimestampControlLatch	0x0944	4	C	RW	Expert
GevTimestampValue	/	/	I	/	Expert
GevCCP	/	/	E	/	Guru
GevSCPHostPort	/	/	I	/	Guru
GevSCPSFireTestPacket	/	/	C	/	Guru
GevSCPSDoNotFragment	/	/	B	/	Guru
GevSCPSBigEndian	/	/	B	/	Guru
GevSCPSPacketSize	/	/	I	/	Expert
GevSCPD	0x0d08	4	I	RW	Expert
GevSCDA	0x0d18	4	I	RW	Guru
GevGVCPPendingAck	/	/	B	/	Expert

- **PayloadSize**
  Payload size transferred.

- **GevVersionMajor**
  GigE Vision major version.

- **GevVersionMinor**
  GigE Vision minor version.

- **GevDeviceModeIsBigEndian**
  Whether device stores data in big-endian mode.

- **GevDeviceModeCharacterSet**
  Type of the storage character set.

- **GevMACAddress**
  Device MAC address.

- **GevSupportedOptionSelector**
  GigE Vision function list.

- **GevSupportedOption**
  Whether function is supported.

- **GevCurrentIPConfigurationLLA**

Enable LLA configuring IP.

- **GevCurrentIPConfigurationDHCP**
  Enable DHCP configuring IP.

- **GevCurrentIPConfigurationPersistentIP**
  Enable static configuring IP.

- **GevCurrentIPAddress**
  Current IP address.

- **GevCurrentSubnetMask**
  Current subnet mask.

- **GevCurrentDefaultGateway**
  Current default gateway.

- **GevFirstURL**
  XML storage address first selection.

- **GevSecondURL**
  XML storage address second selection.

- **GevPersistentIPAddress**
  Static IP address.

- **GevPersistentSubnetMask**
  Static subnet mask.

- **GevPersistentDefaultGateway**
  Static default gateway.

- **GevMessageChannelCount**
  Control channel count.

- **GevStreamChannelCount**
  Data channel count.

- **GevHeartbeatTimeout**
  Heartbeat timeout time, unit is ms.

- **GevTimestampTickFrequency**
  Timestamp rate.

- **GevTimestampControlLatch**
  Timestamp latch.

- **GevTimestampValue**
  Timestamp value.

- **GevCCP**
  Device Access rights.

- **GevSCPHostPort**
  Communication host data port.

- **GevSCPSFireTestPacket**
  Send test packet.

- **GevSCPSDoNotFragment**
  Prohibit IP subcontracting.

- **GevSCPSBigEndian**
  Big-endian sequence of data channel.

- **GevSCPSPacketSize**
  Packet size.

- **GevSCPD**
  Packet delay.

- **GevSCDA**
  Image data destination address.

- **GevGVCPPendingAck**
  Whether device supports request suspension.

8 FAQ

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

① Ensure that internet interface cable is OK

② Ensure that camera IP address and computer IP address are on the same subnet.

③ Ensure that the network card is working in duplex gigabit network mode.

- **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).

- **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 GigE 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.