TS65MPXGV-19M/C Area Scan Camera User Manual

(V0.3 Oct. 22, 2024)

Hefei I-TEK Optoelectronics Co., Ltd.

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

Revision History

Revision	Date	Description
0.1	2023/10/31	● Initial version
0.2	2024/05/08	● Add TS65MPXGV-19C camera information ● Update product appearance and mechanical dimensions
0.3	2024/10/22	● Supplementary F mount version structure 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, wipe it with lint-free cloth.

- **Power Supply**

① 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**

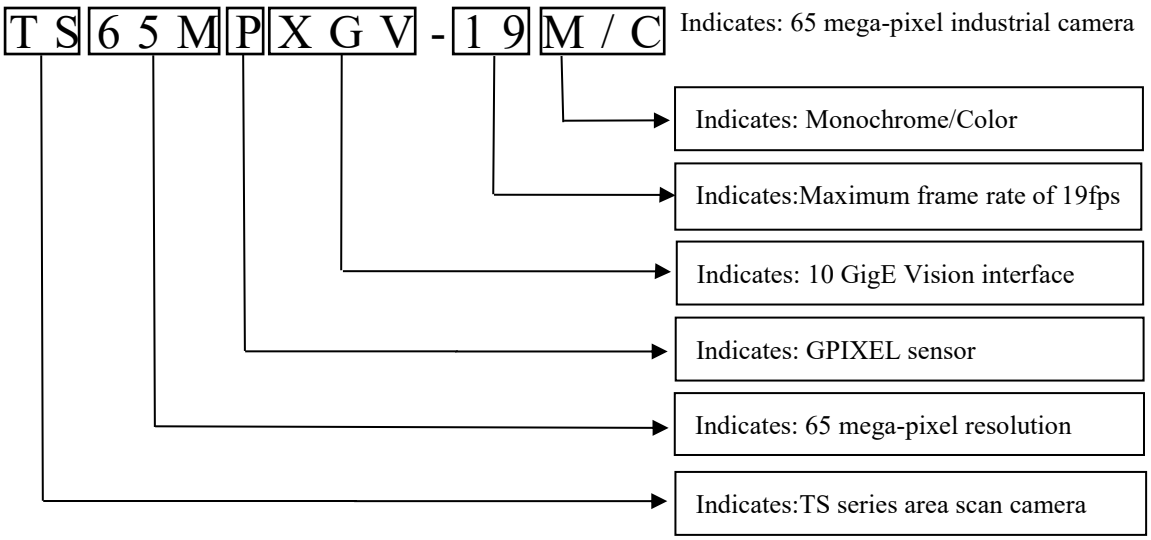
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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 sides of camera provides threaded holes for mounting and fixing.

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

4 Product Specifications

TS65MPXGV camera adopts advanced global shutter CMOS image sensor and 10 GigE Vision data interface, which is area scan camera specializing in the field of industrial measurement and detection. It has high reliability and stability, and is suitable for image acquisition with high requirements (high resolution, high speed), such as surface detection, electronic mount detection, etc.

4.1 Main Features

- Global Shutter CMOS Sensor
- 65 Mega-pixel Resolution
- High Sensitivity and Low Noise
- ROI
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Minimum Exposure Time: 14us; Exposure Time Step: 1us
- LUT
- Data Format: 8/12p bit
- Defect Pixel Correction
- Flat Field Correction
- Strobe
- White Balance
- Analog Gain / Digital Gain / Offset Control
- User-Configurable Scanning Direction
- Real-time Temperature Monitoring

4.2 Camera Specifications

Table 1 TS65MPXGV-19M/C Product Specifications

Model	TS65MPXGV-19M/C
Product Description	65 mega-pixel industrial camera
Resolution	9344 x 7000
Pixel Size	3.2um x 3.2um
Sensor Type	Global shutter CMOS
Image Type	Monochrome / Color
Sensor Size	37.36mm(diagonal)
Dynamic Range	≥ 63.2dB
SNR	40dB
Analog Gain	0~64
Black level	0~256
Digital Gain	0.1~8
Digital Offset	-4096~4096
Lens Mount	M58/F Mount
Max Frame Rate	18.602fps@8bit, 12.375fps@12p bit

Data Rate	1216MB/s
Trigger Mode	Free-Run, External trigger
Trigger Signal	External IO/Software trigger
Exposure Control	Pulse Width Control, Timed
Exposure Time	14us~10s (step: 1us)
Data Format	8/12p bit
Operation Temperature	0~55°C
Data Interface	10 GigE Vision
Power Supply	DC 12~24V (±10%) 2.0A
Power Consumption	15.1W
Mechanical	M58: 65mm x 65mm x 81.68mm F Mount: 65mm x 65mm x 116.7mm

Note: This table is for 0101-8101 version of TS65MPXGV camera specifications, which may vary slightly from version to version.

4.3 Camera Structure

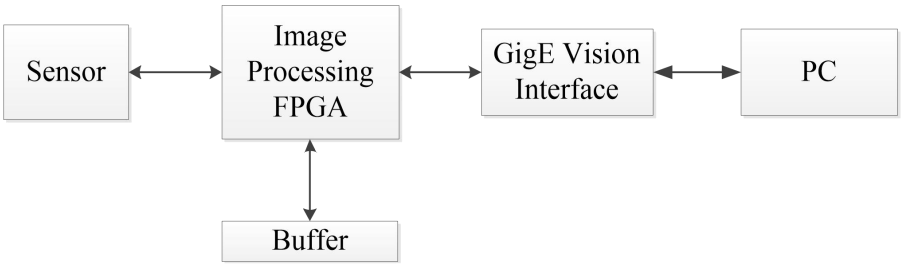


Fig.2 Internal Implementation Structure of Camera

TS65MPXGV camera uses a unified architecture to realize image sensor control, data transmission and embedded algorithm processing with different resolutions. The internal structure of camera is shown in the 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 GigE Vision interface after relevant algorithm processing by FPGA.

TS65MPXGV camera can accept external trigger acquisition, the source is IO signal. At the same time, the camera can also output synchronization signal during exposure, which is convenient for external strobe control.

4.4 Spectral Response

The following is spectral response curve of TS65MPXGV camera.

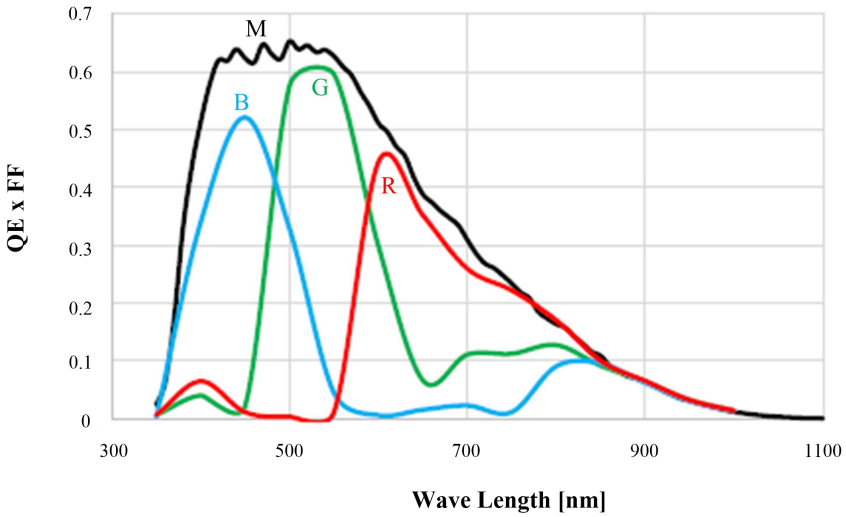


Fig.3 Spectral Response Curve of Camera

4.5 Camera Bayer Arrangement

TS65MPXGV camera supports color mode, and Bayer arrangement as shown in the following figure (HR is the horizontal resolution, VR is the vertical resolution):

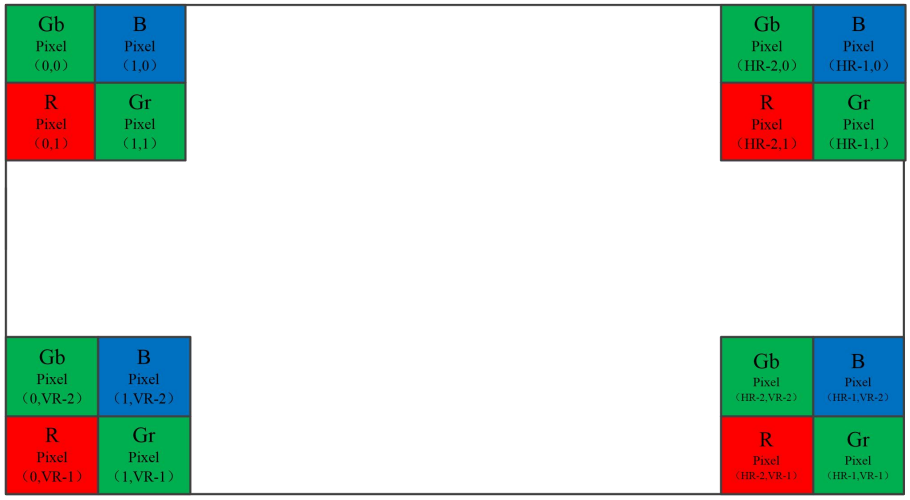


Fig.4 Camera Bayer Arrangement

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.

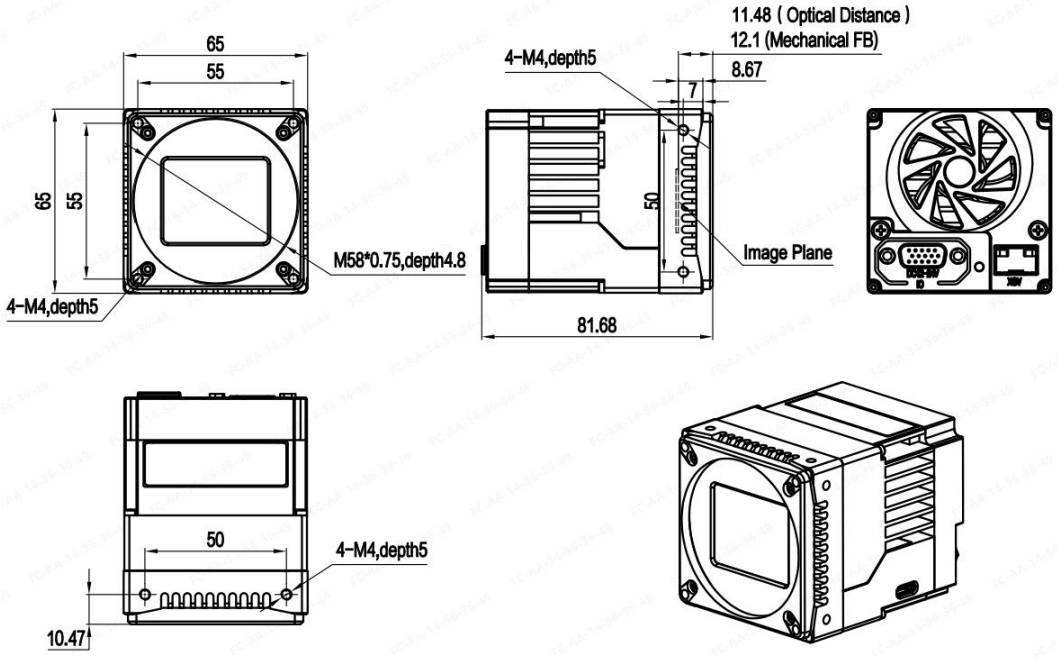
4.7 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

- M58:



- F mount:

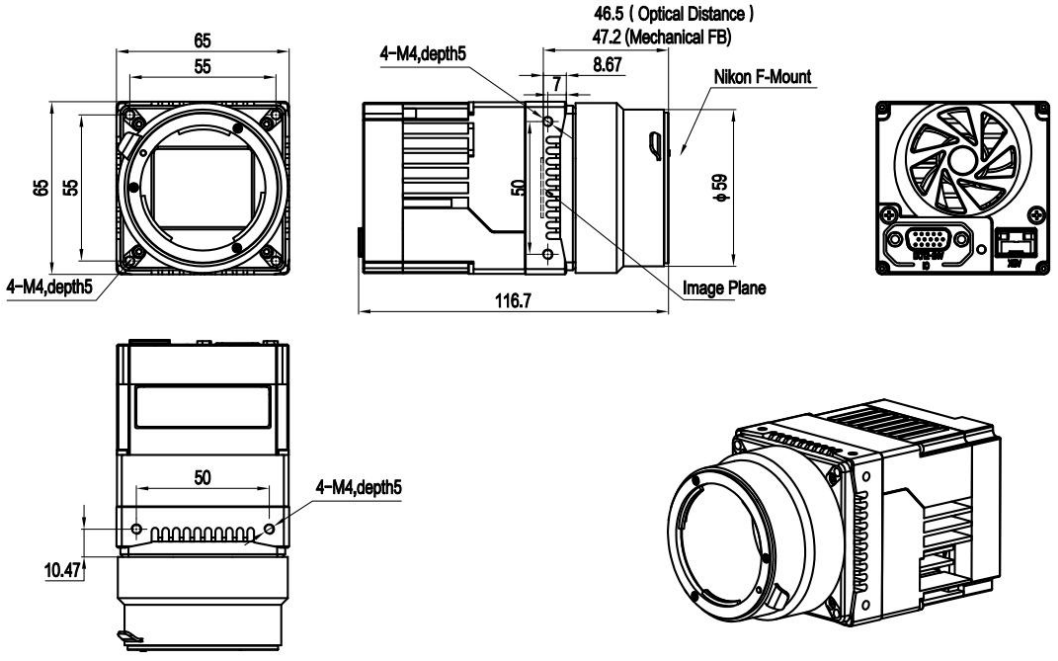


Fig.5 Camera Mechanical Dimensions

5.2 Electrical Interface

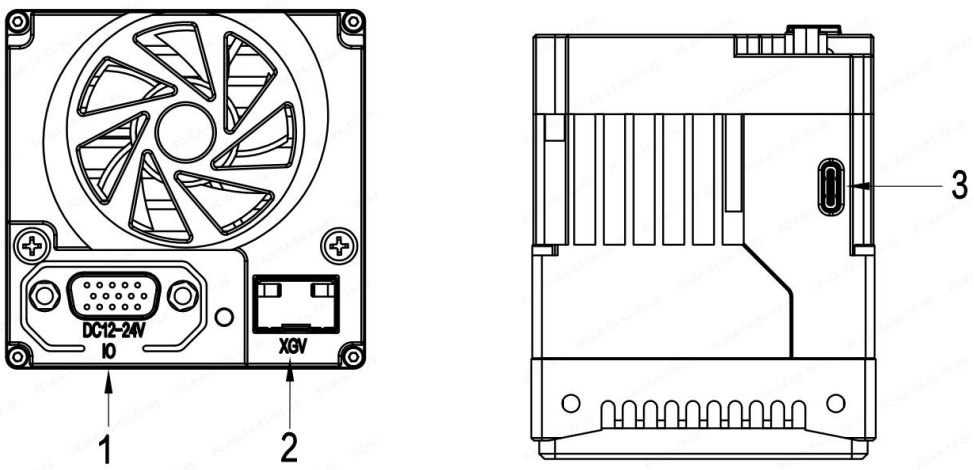


Fig.6 External Interfaces of Camera

① Power and Control Interface
② 10 GigE Vision Data Interface
③ Type-C Interface

5.2.1 Status Indicator

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

Table 2 Camera Status Indicator

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 and Control Interface

A single RJ45 Ethernet connector for controlling and video data to the host Gigabit network interface card. For industrial environments, Hefei I-TEK Optoelectronics Co., LTD. GigE supports the use of screws to lock Ethernet cable.

A single HD15 female connector for all I/O and DC power source.

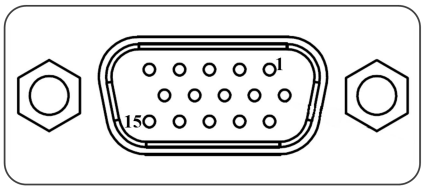


Fig.7 HD15 Connector

The detail of HD15 connector are shown in the following table:

Table 3 HD15 Connector Interface Definition

Pin Number	Pin Name	Direction	Definition
1	Line 1+	In	RS-422/Single ended Input Port 1+
2	Line 1-	In	RS-422 Input Port 1-
3	Line 2+	In	RS-422/Single ended Input Port 2+
4	Line 2-	In	RS-422 Input Port 2-
5	Signals Ground		Signals Ground
6	Line 3+	In	RS-422/Single ended Input Port 3+
7	Line 3-	In	RS-422 Input Port 3-
8	Line 4+	Out	RS-422/Single ended Output Port 4+
9	Line 4-	Out	RS-422 Output Port 4-
10	PWR-GND		Camera Power Ground
11	Line 5+	Out	RS-422/Single ended Output Port 5+
12	Line 5-	Out	RS-422 Output Port 5-
13	Line 6+	Out	RS-422/Single ended Output Port 6+
14	Line 6-	Out	RS-422 Output Port 6-
15	PWR-VCC	-	Camera Power DC +12~24 Volts

The description of connector interface signal is as follows:

- Frame trigger signal: Line 1
- Exposure output signal: Line 4
- IO input signal: 2~24V, all signals support single-ended signal TTL level and differential signals
- IO output signal: all signals support single-ended signal output and differential signal output

The connection method of single-ended signal or differential signal is as follows:

- Single-ended signal connection: connect the positive of the signal line, such as Line 1+ and Signals Ground
- Differential signal connection: connect the positive and negative of the signal line, such as Line 1+ and Line 1-

The circuit diagram of trigger interface is as follows:

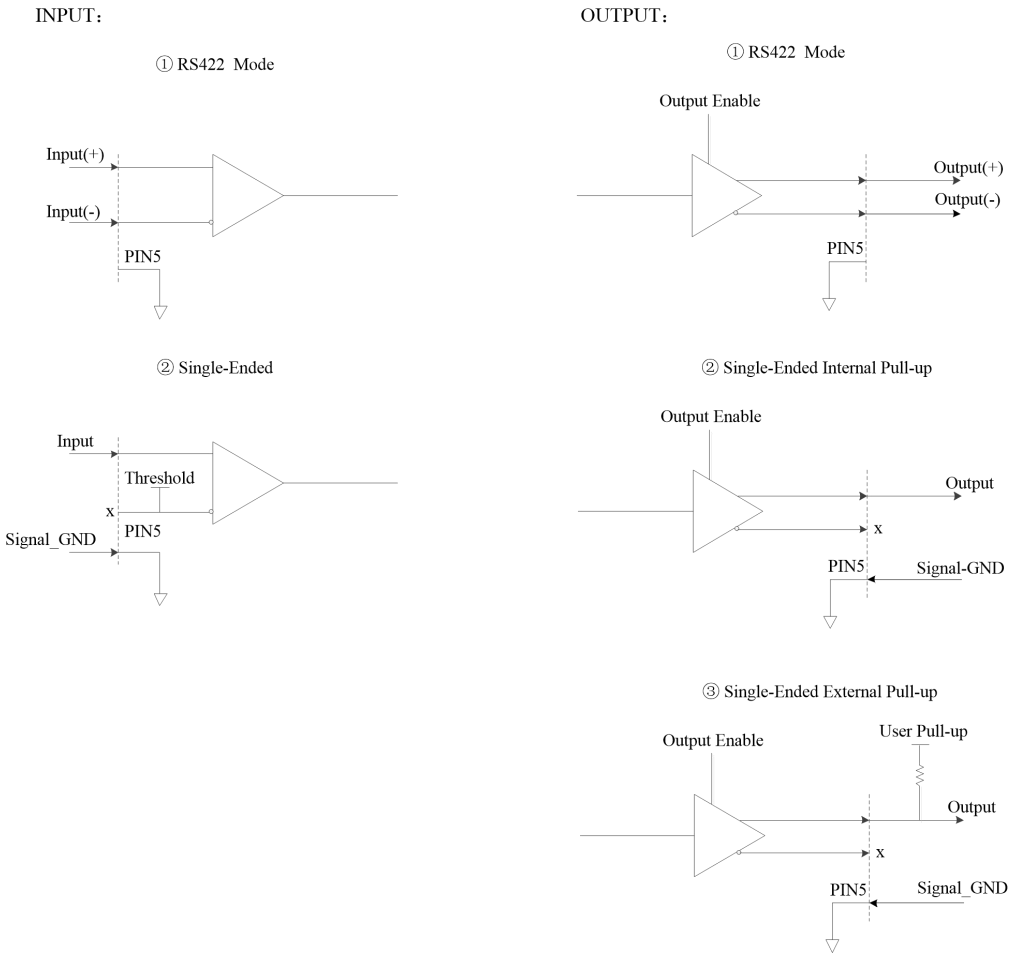


Fig.8 Trigger Circuit Diagram

Note: In the figure, "x" represents suspended, and "PIN5" represents the 5th pin of the Ethernet camera.

6 Camera Features

This chapter introduces the main features of TS65MPXGV camera.

6.1 Trigger Mode

TS65MPXGV camera supports three timing control modes: Free-Run mode, External Pulse mode and External PWM mode.

6.1.1 Free-Run Mode

In the Free-Run mode(TriggerMode = Off，ExposureMode = Timed), the camera generates the relevant control sequence internally according to the frame period and exposure time parameters configured by users and outputs the image.

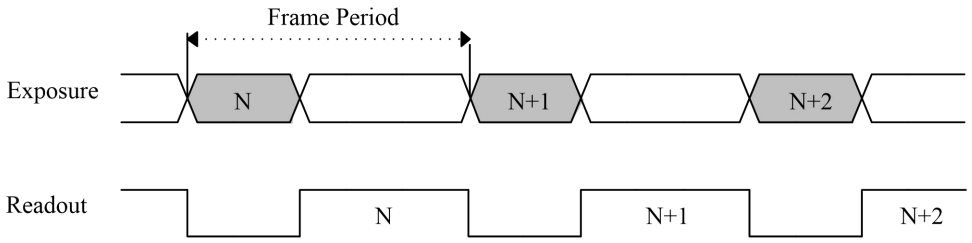


Fig.9 Free-Run Mode

To achieve normal image output, TS65MPXGV camera limits the range of frame periods and exposure time. Minimum frame period should be longer than both exposure time and readout time of a frame data.

6.1.2 External Pulse Mode

In the External Pulse mode (TriggerMode = On， ExposureMode = Timed), the camera starts exposure at the rising edge of the external trigger signal, while the exposure time is set by users command (consistent with the Free-Run mode).

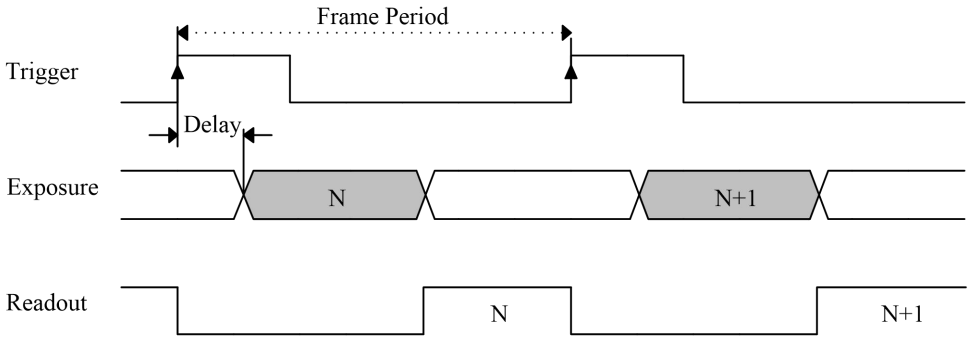


Fig.10 Fixed Exposure Time Mode

Camera provides trigger delay and anti shake functions, both of which delay the trigger signal. However, the anti shake function eliminates some trigger signals with smaller pulse widths.

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

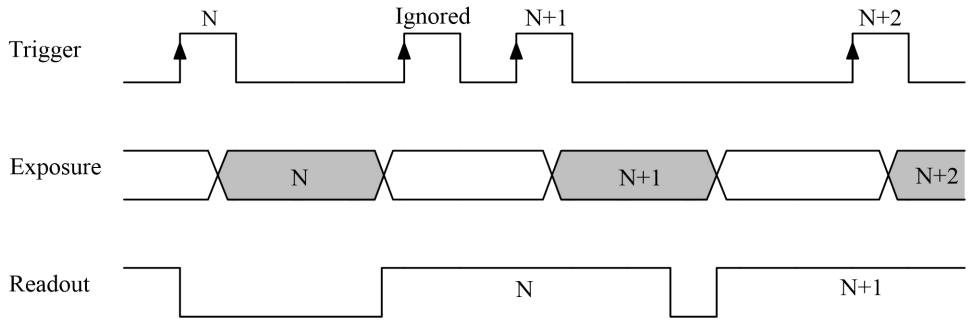


Fig.11 External Trigger Interval Too Short

6.1.3 External PWM Mode

In the External PWM mode (TriggerMode = On，ExposureMode = TriggerWidth), the camera exposure starts at the rising edge and ends at the falling edge of the external trigger signal. That is, the actual exposure time is equal to the high level duration of the external trigger, and the frame period is equal to the pulse interval.

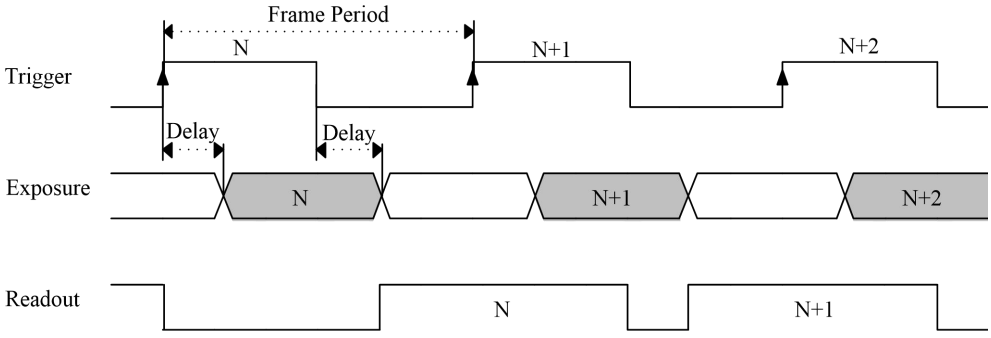


Fig.12 External PWM mode

Please note that in this model, the width of the external trigger high-level should be ensured to be greater than the minimum exposure time of the camera. For pulses smaller than the minimum exposure time of the camera, the camera may ignore them.

Too short frame period of external trigger will lead to the conflict between the data readout of the previous and current frames of the camera. The pulses that do not meet the requirements will be ignored inside the camera, so that the device can maintain its normal operation. In the External PWM mode, the 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.

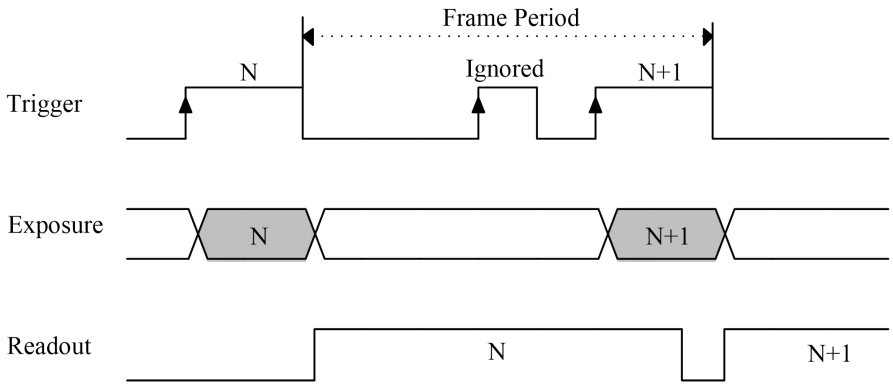


Fig. 13 Frame Period of External Trigger is Too Short

6.2 ROI

Region of interest (ROI) is part of a specified sensor array. Users can obtain frame data from a specified part of the 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, the ROI is determined to be an overlap of the two regions, as shown in the figure below.

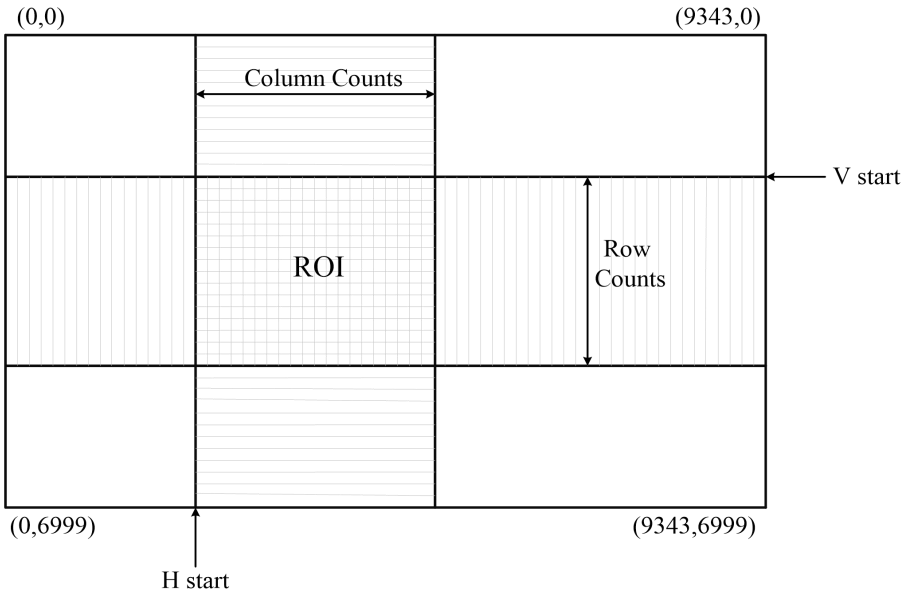


Fig. 14 ROI

Table 4 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	12p bit
9344	7000	18.602fps	12.375fps
8960	7000	19.361fps	12.937fps
8000	7000	21.726fps	14.448fps
6976	7000	24.966fps	16.644fps
5952	7000	29.041fps	19.494fps
4992	7000	31.624fps	23.139fps

3968	7000	31.624fps	29.042fps
2944	7000	31.624fps	31.624fps
1984	7000	31.624fps	31.624fps
960	7000	31.624fps	31.624fps
9344	6000	21.688fps	14.491fps
9344	5000	26.003fps	17.373fps
9344	4000	32.453fps	21.687fps
9344	3000	43.457fps	28.979fps
9344	2000	64.910fps	43.465fps
9344	1000	130.685fps	86.934fps

6.3 Image Flipping

TS65MPXGV camera can make the image flip along the X/Y direction. Users can use this function to change the camera scan direction, the effect is shown below:

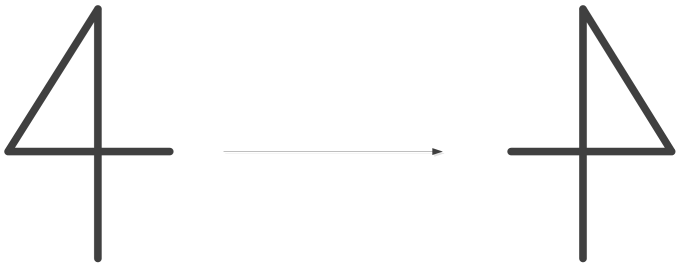


Fig. 15 Flip in X Direction

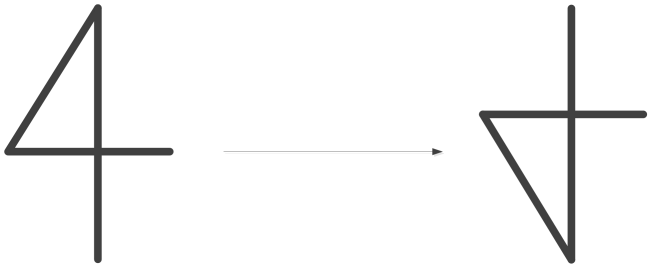


Fig. 16 Flip in Y Direction

6.4 LUT

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

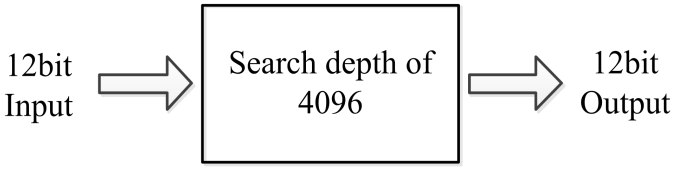


Fig.17 LUT Structure

The LUT mapping curve for Gamma=0.5 is shown below:

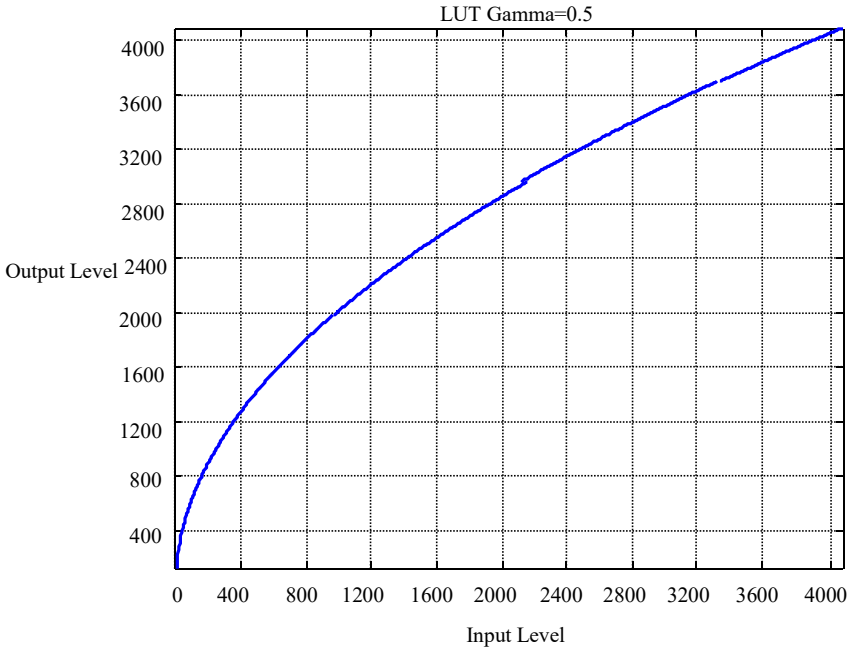


Fig.18 LUT Gamma = 0.5

6.5 Strobe

Strobe signal is used to synchronize the external light source with the camera. The timing of the strobe signal is exactly the same as that of the camera exposure. When the camera exposure begins, the strobe signal will pull down/up the level. It will return to its initial level when the camera exposure is over.

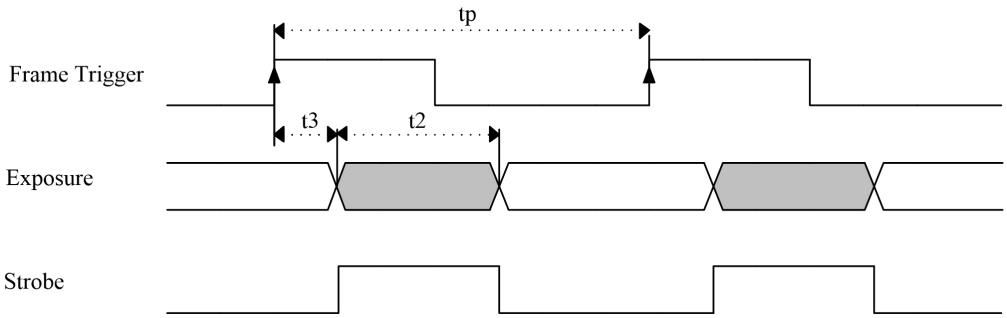


Fig. 19 Strobe Signal

6.6 Flat Field Correction

Generally, in the application process of area scan cameras, due to the vignetting effect of the lens and the inconsistency of illumination, there is a certain difference between the image output by the camera and the actual signal, that is, the output data of the camera is different for the signal with the same brightness. TS65MPXGV camera provides a flat field correction function to correct this problem. Users can achieve a flat field effect by correcting the signal parameters of uniform intensity targets during actual use.

Taking into account the pixel array scale and vignetting effect of area scan cameras, this camera uses 64 x 64 pixel block data, combined with image algorithms to achieve real-time flat field correction algorithms. The fundamental is shown in the figure below:

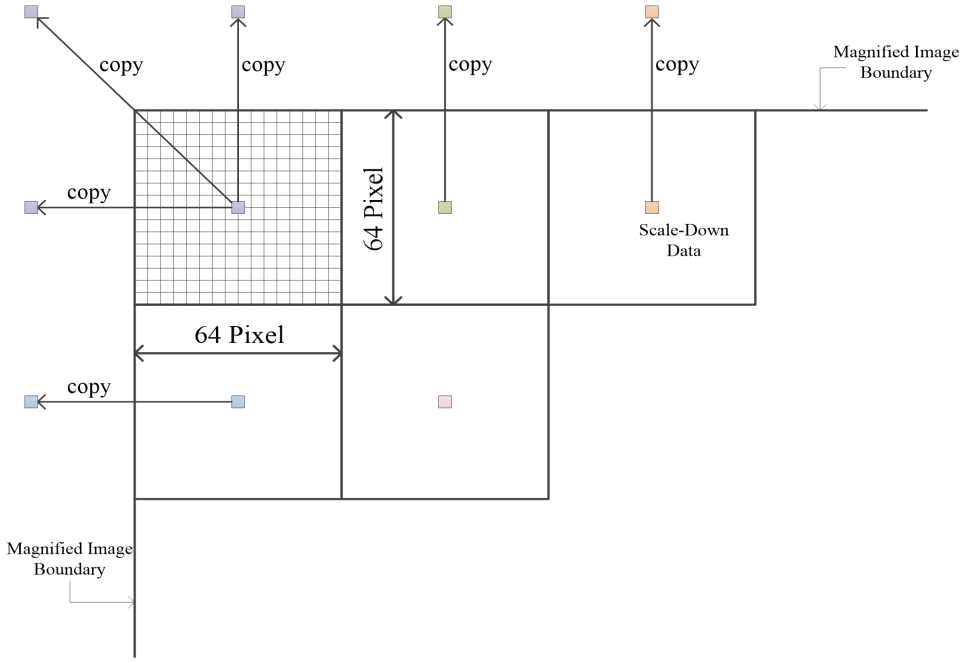


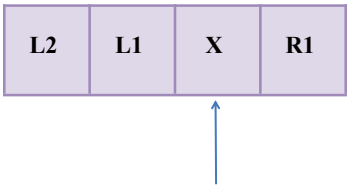
Fig.20 Flat Field Correction Schematic

6.7 Defect Pixel Correction

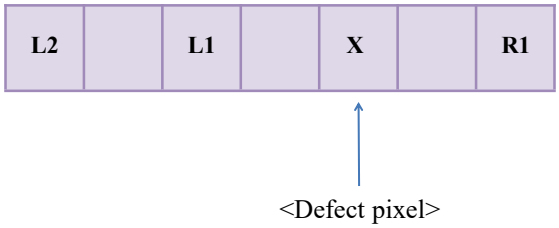
Due to the defects of the material itself and the issue with the process flow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response to the input light, which we call defect pixels. TS65MPXGV camera provides with defect pixel automatic correction feature. The defect pixel information of the 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 the camera.

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

- For monochrome cameras, the defective pixel values are replaced by adjacent pixel values.
- For color cameras, the defective pixel values are replaced by separated pixel values.



(a) Monochrome Camera



(b) Color Camera

Fig. 21 Defective Pixel Correction Methods for Different Cameras

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

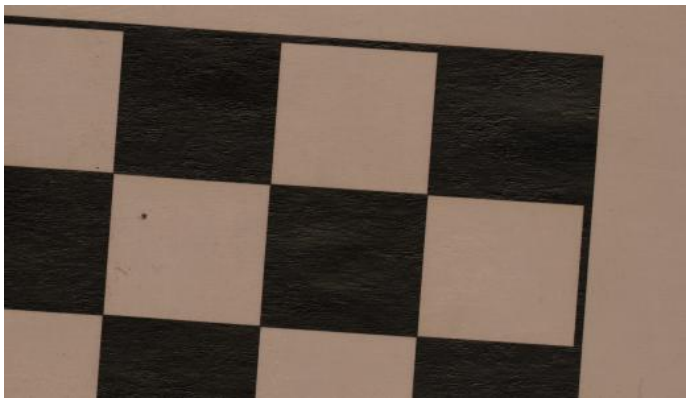
Table 5 Calculation Defect Pixel Correction Value

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

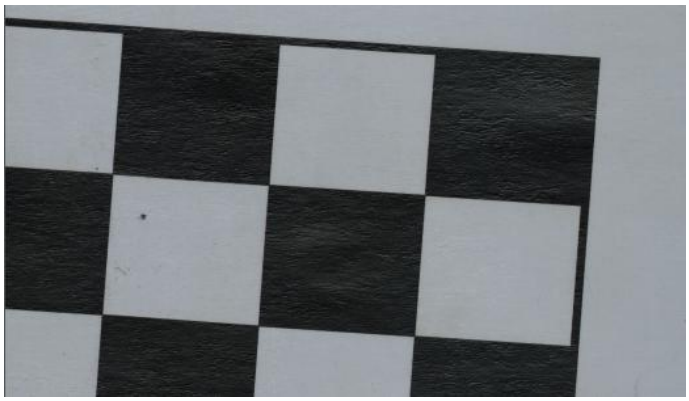
6.8 White Balance

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.

TS65MPXGV 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. 22 White Balance

6.9 Test Image

The test image is generally used to test whether the data link is smooth, and also for users to perform various debugging.

The camera provides test images as shown in the figure below:

- Vertical test image: fixed image with horizontal gray gradient.
- Horizontal test image: scroll image with vertical gray gradient.

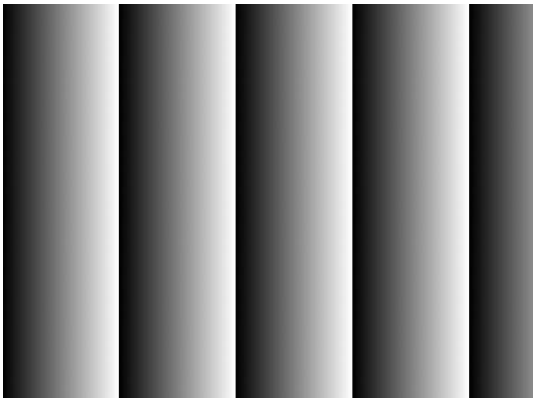


Fig. 23 Vertical test image

Fig.24 Horizontal Test Image

6.10 Gain and Offset

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

Analog gain acts on analog signal. By increasing analog gain, a stronger response can be generally obtained under weak illumination, thus realizing a higher signal-to-noise ratio.

Digital gain amplifies or reduces data after photoelectric conversion signal passes through AD. It is usually used to increase dynamic range of output image. Digital gain can also be used to adjust brightness of image. Digital offset is often used to adjust overall background brightness of 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 offset 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 image data is 8bit, actual digital offset is divided by 16.

6.11 Data Format

TS65MPXGV camera processes data in 12bit data format, but provides 8bit, 12bit output data formats. When camera outputs 8bit data, the higher 8bit output will be truncated.

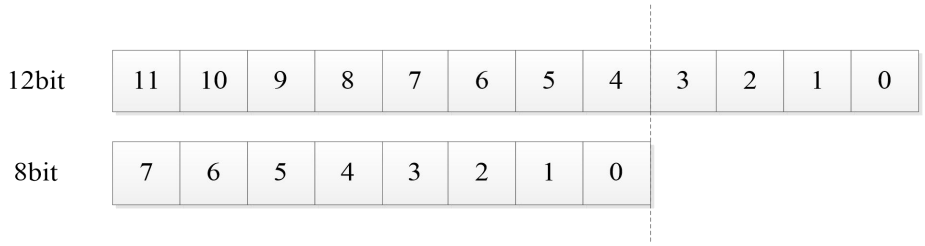


Fig.25 Data Format

6.12 Camera Temperature

TS65MPXGV camera supports real-time temperature acquisition of camera. Users can read temperature of the camera to monitor working status of the sensor.

The recommended operating temperature range of the camera is 0~55℃. If users detect an abnormal temperature (such as over 65℃), it is recommended to stop the camera immediately and contact our technical support.

6.13 Load/Save Configuration

TS65MPXGV camera supports three working parameter sets, but the factory parameter set does not allow users to modify it. The parameters have been optimized and configured to meet the needs of most scenarios. To meet the specific differences in user usage environments, this camera also provides two

sets of user working parameter sets, whose internal parameters can be modified and saved by users; The saved working parameter set will be automatically loaded after the next power on.

If the camera malfunctions after the user modifies and saves the parameters, the user can restore it to the factory default parameter set and then reconfigure it based on this.

6.14 Camera IP Address

TS65MPXGV camera communicates with the host through 10 Gigabit Ethernet, so a suitable IP address must be set before using the camera. Only when the camera and host are in the same local area network can they communicate normally.

TS65MPXGV camera supports three IP configuration methods, namely static IP, DHCP, and LLA, with decreasing priority. Static IP and DHCP allow users to switch on and off. If DHCP fails, the camera will allocate IP using LLA method.

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 no matter what transport protocol the camera uses or what functionality 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 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.

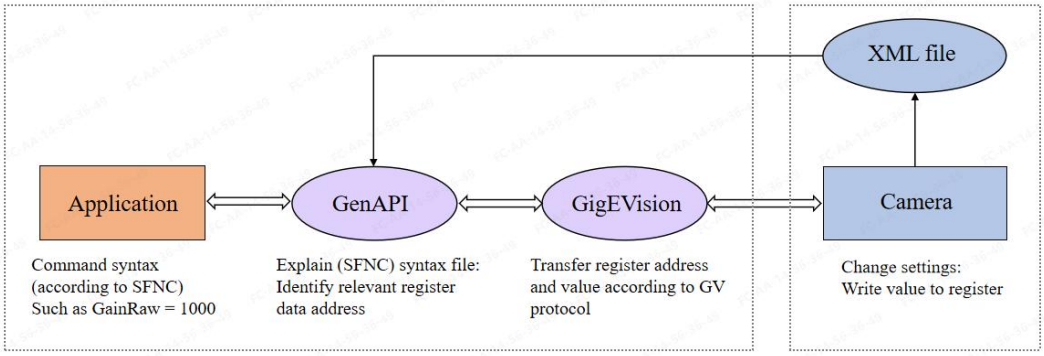


Fig.26 Communication Schematic between Application and Camera

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 a description file, for example, to set the gain to 1000, the value 0x3E8 (HEX) must be written to a register at address 0x0815 (HEX). Other tasks involved may be to check in advance whether the camera has gain feature and to check that the new values are consistent with the allowed gain range. The register message is transmitted and parsed by protocol and applied to camera.

7.2 GenAPI Parameter Attribute

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

range, and default values of each GenAPI parameter.

(1) Register name

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

(2) Register address

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

(3) Register size

This parameter represents register value size (in bytes).

(4) Register interface

The parameter interface represents type of parameter, which is mainly used for the GUI of frame grabber and 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	Execute the command
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 parameter, it checks whether input value is in valid range of parameter.

7.3 Register Classification

7.3.1 Device Control Register

Table 7 Device Control Register

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

DeviceScanType	/	/	E	/	Expert
DeviceUserID	0x00e8	16	S	RW	Beginner
DeviceMCUTemperature	0x6118	4	F	RO	Beginner
DeviceSensorTemperature	0x6038	4	F	RO	Beginner

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceManufacturerInfo**
  Device manufacturer information.

- **DeviceVersion**
  Device version.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceScanType**
  Device scan type. The enumeration names and values are as follows:
  - AreaScan (0): Area scan

- **DeviceUserID**
  User-defined ID.

- **DeviceMCUTemperature**
  Device MCU temperature.

- **DeviceSensorTemperature**
  Device sensor temperature.

7.3.2 Image Format Control Register

Table 8 Image Format Control Register

Name	Address	Size	Interface	Access	Visibility
Width	0x6000	4	I	RW	Beginner
Height	0x6004	4	I	RW	Beginner
OffsetX	0x6010	4	I	RW	Beginner
OffsetY	0x6014	4	I	RW	Beginner
PixelFormat	0x6020	4	E	RW	Beginner
ReverseX	0x613c	4	B	RW	Beginner

ReverseY	0x6140	4	B	RW	Beginner
VideoMode	0x602c	4	E	RW	Beginner

- **Width**

  Actual width of output image. The parameter range is as follows:
  - Minimum: 512
  - Increment: 64

- **Height**

  Actual height of output image. The parameter range is as follows:
  - Minimum: 32
  - Increment: 8

- **OffsetX**

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

- **OffsetY**

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

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:
  - Mono8 (17301505): Monochrome 8bit
  - Mono12Packed (0x010C0006): Monochrome packed 12bit
  - BayerBG8 (17301515): Bayer BGGR 8bit
  - BayerBG12Packed (0x010C002D): Bayer BGGR packed 12bit
  - BayerGB8 (17301514): Bayer GBRG 8bit
  - BayerGB12Packed (0x010C002C): Bayer GBRG packed 12bit
  - BayerGR8 (17301512): Bayer GRBG 8bit
  - BayerGR12Packed (0x010C002A): Bayer GRBG packed 12bit
  - BayerRG8 (17301513): Bayer RGGB 8bit
  - BayerRG12Packed (0x010C002B): Bayer RGGB packed 12bit

- **ReverseX**

  Horizontal flipping.

- **ReverseY**

  Vertical flipping.

- **VideoMode**

  Output image mode. The enumeration names and values are as follows:

- Original (0): Original image
- Corrected (1): Corrected image
- VerticalPattern (2): Vertical test image
- HorizontalPattern (3): Horizontal test image

7.3.3 Acquisition Control Register

Table 9 Acquisition Control Register

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0x603c	4	E	RW	Beginner
AcquisitionStart	0x6040	4	C	RW	Beginner
AcquisitionStop	0x6044	4	C	RW	Beginner
AcquisitionFrameRateEnable	0x61f4	4	B	RW	Expert
AcquisitionFrameRate	0x6164	4	F	RW	Beginner
ExposureMode	0x605c	4	E	RW	Beginner
ExposureTime	0x6060	4	F	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.

- **AcquisitionFrameRateEnable**

  Enable frame rate settings for acquisition. Check this option, users can set acquisition frame rate by themselves, otherwise the frame rate will be set to the current maximum allowed value by default.

- **AcquisitionFrameRate**

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

  - Maximum: 50000
  - Minimum: 0.001

- **ExposureMode**

  Exposure mode. The enumeration names and values are as follows:

  - Timed (0): Timed
  - TriggerWidth (1): Pulse width control

- **ExposureTime**

  Exposure time, unit is us.

7.3.4 IO Control Register

Table 10 IO Control Register

Name	Address	Size	Interface	Access	Visibility
TriggerMode	0x61f8	4	E	RW	Beginner
TriggerSource	0x6050	4	E	RW	Beginner
TriggerDelay	0x6058	4	I	RW	Beginner
TriggerActivation	0x6054	4	E	RW	Beginner
TriggerSoftware	0x611c	4	C	WO	Expert
FlashStrobePolarity	0x6064	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 selector. The enumeration names and values are as follows:
  - IO (0): External trigger signal
  - Software (1): 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 this parameter to generate a software trigger signal.

- **FlashStrobePolarity**

  Strobe signal polarity. The enumeration names and values are as follows:
  - Low (0): Default high level, pull low level when generating strobe signal
  - High (1): Default low level, pull high level when generating strobe signal

7.3.5 Digital Control Registers

Table 11 Digital Control Registers

Name	Address	Size	Interface	Access	Visibility
DigitalGain	0x6068	4	F	RW	Beginner
DigitalOffset	0x606c	4	I	RW	Beginner
WhiteBalanceRedGain	0x6070	4	F	RW	Expert
WhiteBalanceGreenGain	0x6074	4	F	RW	Expert
WhiteBalanceBlueGain	0x607c	4	F	RW	Expert
WhiteBalanceEnable	0x608c	4	B	RW	Expert
WhiteBalanceInitialize	0x6080	4	C	WO	Expert
WhiteBalanceCalibrate	0x6080	4	C	WO	Expert
BlackLevel	0x6168	4	I	RW	Guru

- **DigitalGain**

  Digital gain. The parameter range is as follows:
  - Maximum: 8
  - Minimum: 0.1

- **DigitalOffset**

  Digital offset. The parameter range is as follows:
  - Maximum: 4095
  - Minimum: -4095
  - Increment: 1

- **WhiteBalanceRedGain**

  White balance R channel gain, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 4
  - Minimum: 0.1

- **WhiteBalanceGreenGain**

  White balance G channel gain, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 4
  - Minimum: 0.1

- **WhiteBalanceBlueGain**

  White balance B channel gain, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 4
  - Minimum: 0.1

- **WhiteBalanceEnable**

  Enable white balance function, only color camera can set this parameter.

- **WhiteBalanceInitialize**

  Initialize white balance correction, which can reset white balance parameters to default setting. Only color camera can set this parameter.

- **WhiteBalanceCalibrate**

  Execute white balance correction, that is, execute white balance correction in current condition. Only color camera can set this parameter.

- **BlackLevel**

  Black level, used to adjust the bottom value of camera output in dark field condition. The smaller black level is, the smaller gray value of image in dark field condition is. The parameter range is as follows:

  - Maximum: 256
  - Minimum: 0
  - Increment: 1

7.3.6 Analog Control Register

Table 12 Analog Control Register

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0x6088	4	I	RW	Beginner

- **AnalogGain**

  Analog gain. The enumeration names and values are as follows:

  - Maximum: 64
  - Minimum: 0
  - Increment: 1

7.3.7 Defect Pixel Register

Table 12 Defect Pixel Register

Name	Address	Size	Interface	Access	Visibility
DefectPixelCorrectionEnable	0x60d0	4	B	RW	Guru
DefectPixelTotal	0x60d8	4	I	RO	Expert
DefectPixelSelect	0x60dc	4	I	RW	Expert
DefectPixelReadX	0x60e0	4	I	RO	Expert
DefectPixelReadY	0x60e4	4	I	RO	Expert
DefectPixelWriteX	0x60e8	4	I	RW	Expert
DefectPixelWriteY	0x60ec	4	I	RW	Expert
DefectPixelAdd	0x60f0	4	C	WO	Expert
DefectPixelRemove	0x60f4	4	C	WO	Expert
DefectPixelClearAll	0x60f8	4	C	WO	Expert
DefectPixelSave	0x60fc	4	C	WO	Expert

- **DefectPixelCorrectionEnable**
  Enable defect pixel correction function.

- **DefectPixelTotal**
  Total number of defect pixel.

- **DefectPixelSelect**
  Select index of defect pixel. The parameter range is as follows:
  - Maximum: 16383
  - 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.
  - Maximum: 9344
  - Minimum: 0
  - Increment: 1

- **DefectPixelWriteY**
  Write the Y coordinate of defect pixel.
  - Maximum: 7000
  - Minimum: 0
  - Increment: 1

- **DefectPixelAdd**
  Add defect pixel.

- **DefectPixelRemove**
  Remove current defect pixel.

- **DefectPixelClearAll**
  Remove all defect pixels.

- **DefectPixelSave**
  Save defect pixels.

7.3.8 LUT Control Register

Table 14 LUT Control Register

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0x60c0	4	B	RW	Beginner
LUTIndex	0x60c4	4	I	RW	Expert
LUTValue	0x60c8	4	I	RW	Expert

- **LUTEnable**
  Enable LUT function.

- **LUTIndex**
  Lookup table data index, that is, the gray value of image before mapping lookup table.
  - Maximum: 4095
  - Minimum: 0
  - Increment: 1

- **LUTValue**
  Lookup table data value, that is, the gray value of image after mapping lookup table.
  - Maximum: 4095
  - Minimum: 0
  - Increment: 1

7.3.9 Flat Field Correction Register

Table 15 Flat Field Correction Register

Name	Address	Size	Interface	Access	Visibility
FlatFieldCorrectionEnable	0x6100	4	B	RW	Beginner
FlatFieldCorrectionCalibrate	0x6104	4	C	WO	Beginner
FlatFieldCorrectionReset	0x6104	4	C	WO	Beginner

- **FlatFieldCorrectionEnable**
  Enable flat field correction.

- **FlatFieldCorrectionCalibrate**
  Execute flat field correction.

- **FlatFieldCorrectionReset**
  Reset flat field correction to default setting.

7.3.10 User Set Control Register

Table 16 User Set Control Register

Name	Address	Size	Interface	Access	Visibility
UserSetSelector	0x6108	4	E	RW	Beginner

UserSetLoad	0x610c	4	C	WO	Beginner
UserSetSave	0x6110	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.

7.3.12 Transport Layer Control Register

Table 17 Transport Layer Control Register

Name	Address	Size	Interface	Access	Visibility
PayloadSize	0x6018	4	I	RO	Expert
GevVersionMajor	/	/	I	/	Expert
GevVersionMinor	/	/	I	/	Expert
GevDeviceModeIsBigEndian	/	/	B	/	Guru
GevDeviceModeCharacterSet	/	/	E	/	Guru
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	0x0200	512	S	RO	Guru
GevSecondURL	0x0400	512	S	RO	Guru
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
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	0x0954	4	B	RW	Expert
GevDeviceLinkSpeed	0x0670	4	I	RO	Expert
GevBandwidthUtilization	0x61c8	4	F	RW	Beginner

- **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.

- **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.

- **GevDeviceLinkSpeed**
  Link speed.

- **GevBandwidthUtilization**
  Bandwidth utilization rate.

8 FAQ

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

① Ensure that the network interface cable is OK.
② Ensure that the camera IP address and computer IP address are on the same subnet.
③ Ensure that the network card is working in Gigabit Ethernet mode.

- **If the camera has no image output in external trigger mode,**

① Ensure that the external input pulse is normal.
② Ensure that the camera has received the trigger pulse correctly (it can be confirmed by the status indicator display).

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

① Ensure that the voltage range of external connected power supply is normal.
② If the casing is hot or the camera emits smoke, immediately cut off the power and stop using the camera, then contact us for technical support.

- **If images are dark,**

① Ensure that the sensor aperture on the casing is not blocked.
② Ensure that the exposure time and gain are set properly.

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

① Ensure that the sensor glass is clean.
② Ensure that the camera status indicator is normal.

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

① Check that the Gigabit Ethernet interface is normal, it can be confirmed by the test image.
② Check whether the power supply is normal by the camera indicator status.
③ Check whether the external pulse input is normal in the external trigger mode by the 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.