TPL-GV Series Line 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	2023/12/06	● Initial version
0.2	2024/01/25	● Add strobe output on/off function ● Add photosensitive band parameter ● Update exposure time, signal-to-noise ratio, dynamic range, and power consumption parameters ● Update spectral response curve
0.3	2024/06/18	● Merge camera manuals from the same series
0.4	2024/12/20	● Add TPL1KBGV-40KS camera information ● Update TPL512GV and TPL1KGV parameter table

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 The recommended voltage is +12~24V (±10%).
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**

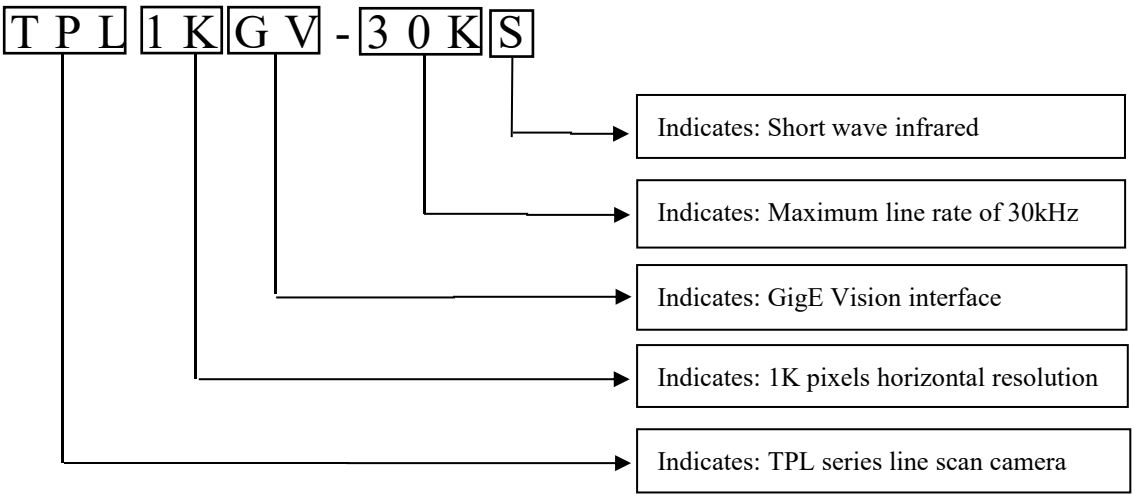
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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. Indicates: 1K short wave infrared TEC line scan camera



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

TPL-GV series camera adopts the advanced global shutter InGaAs image sensor and GigE Vision data interface, which is infrared line 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 InGaAs Sensor
- High Sensitivity and Low Noise
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Binning
- LUT
- Flat Field Correction
- Strobe
- Sequence Control
- Timer
- Counter
- Analog Gain / Digital Gain / Offset Control
- User-Configurable Scanning Direction
- Thermal Electric Cooling
- Real-time Temperature Monitoring

4.2 Camera Specifications

Table 1 TPL512GV-30KS2 Product Specifications

Model	TPL512GV-30KS2
Product Description	512 short wave infrared TEC line scan camera
Resolution	512 x 2
Pixel Size	25um x 25um
Sensor Type	Global shutter InGaAs
Photosensitive Band	950nm~1700nm
Image Type	Monochrome
Sensor Size	12.8mm
Dynamic Range	≥ 62.2dB
SNR	61.5dB
Data Rate	30MB/s
Analog Gain	x1/x2/x5/x11/x17/x25/x50/x100
Digital Gain	0.1~8
Digital Offset	-16383~16383
Lens Mount	M42

Max Line Rate	29.4kHz
Trigger Mode	Free-Run, Line trigger control, Frame trigger control
Trigger Signal	RS422 input
Exposure Control	Pulse Width Control, Timed
Exposure Time	0.064us~19982us (step: 0.1us)
Data Format	8/10/10p/12/12p/14bit
Operation Temperature	0~55°C
Data Interface	GigE Vision
Power Supply	DC 12~24V (±10%) 1.0A
Power Consumption	TEC off: 4.0W TEC on: 5.5W
Mechanical	60mm x 60mm x 73mm
Cooling Method	TEC with an external fan
Cooling Performance	About 22 ℃ below ambient temperature

Table 2 TPL1KGV-30KS Product Specifications

Model	**TPL1KGV-30KS**
Product Description	1K short wave infrared TEC line scan camera
Resolution	1024 x 1
Pixel Size	12.5um x 12.5um
Sensor Type	Global shutter InGaAs
Photosensitive Band	950nm~1700nm
Image Type	Monochrome
Sensor Size	12.8mm
Dynamic Range	≥ 65dB
SNR	62dB
Data Rate	53MB/s
Analog Gain	x1/x2/x5/x11/x17/x25/x50/x100
Digital Gain	0.1~8
Digital Offset	-16383~16383
Lens Mount	M42
Max Line Rate	29.4kHz
Trigger Mode	Free-Run, Line trigger control, Frame trigger control
Trigger Signal	RS422 input
Exposure Control	Pulse Width Control, Timed
Exposure Time	0.064us~19982us (step: 0.064us)
Data Format	8/10/10p/12/12p/14bit
Operation Temperature	0~55°C
Data Interface	GigE Vision

Power Supply	DC 12~24V (±10%) 1.0A
Power Consumption	TEC off: 4.0W TEC on: 7.0W
Mechanical	60mm x 60mm x 73mm
Cooling Method	TEC with an external fan
Cooling Performance	About 22 ℃ below ambient temperature

Table 3 TPL1KBGV-40KS Product Specifications

Model	**TPL1KBGV-40KS**
Product Description	1K short wave infrared TEC line scan camera
Resolution	1024 x 1
Pixel Size	12.5um x 12.5um
Sensor Type	Global shutter InGaAs
Photosensitive Band	950nm~1700nm
Image Type	Monochrome
Sensor Size	12.8mm
Dynamic Range	≥ 66.7dB
SNR	66.6dB
Data Rate	72MB/s
Analog Gain	x1/x5/x25/x50
Digital Gain	0.1~8
Digital Offset	-16383~16383
Lens Mount	M42
Max Line Rate	40.1kHz
Trigger Mode	Free-Run, Line trigger control, Frame trigger control
Trigger Signal	RS422 input
Exposure Control	Pulse Width Control, Timed
Exposure Time	0.064us~6581us (step: 0.128us)
Data Format	8/10/10p/12/12p/14bit
Operation Temperature	0~55°C
Data Interface	GigE Vision
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	TEC off: 5.3W TEC on: 10.0W
Mechanical	60mm x 60mm x 82.8mm
Cooling Method	TEC with an external fan
Cooling Performance	About17 ℃ below ambient temperature

4.3 Camera Structure

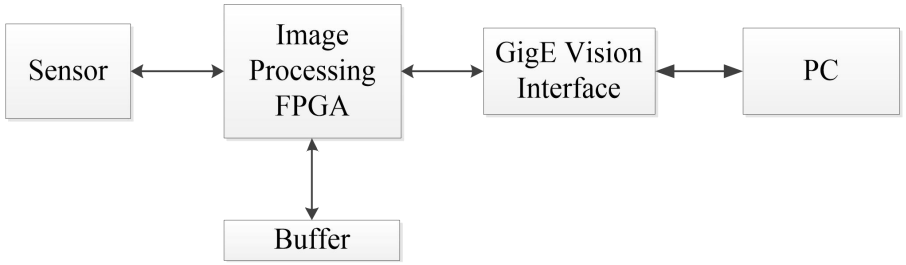


Fig.2 Internal Implementation Structure of Camera

TPL-GV series 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.

TPL-GV series 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 TPL-GV series camera.

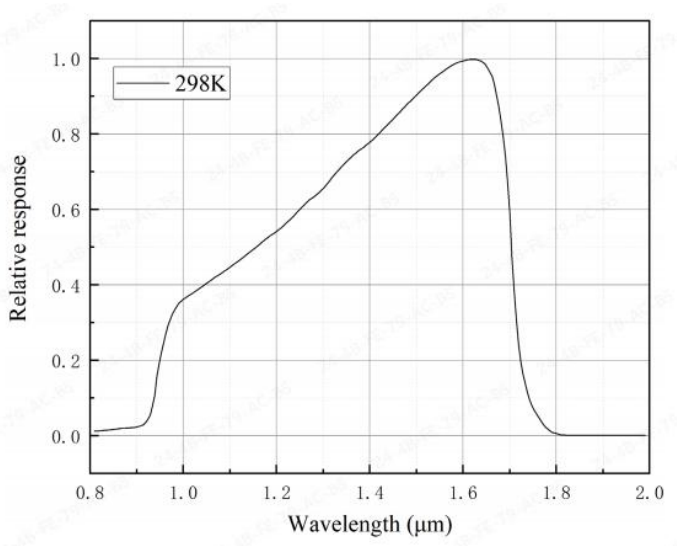


Fig.3 Spectral Response Curve of Camera

4.5 Environmental Requirements

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

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

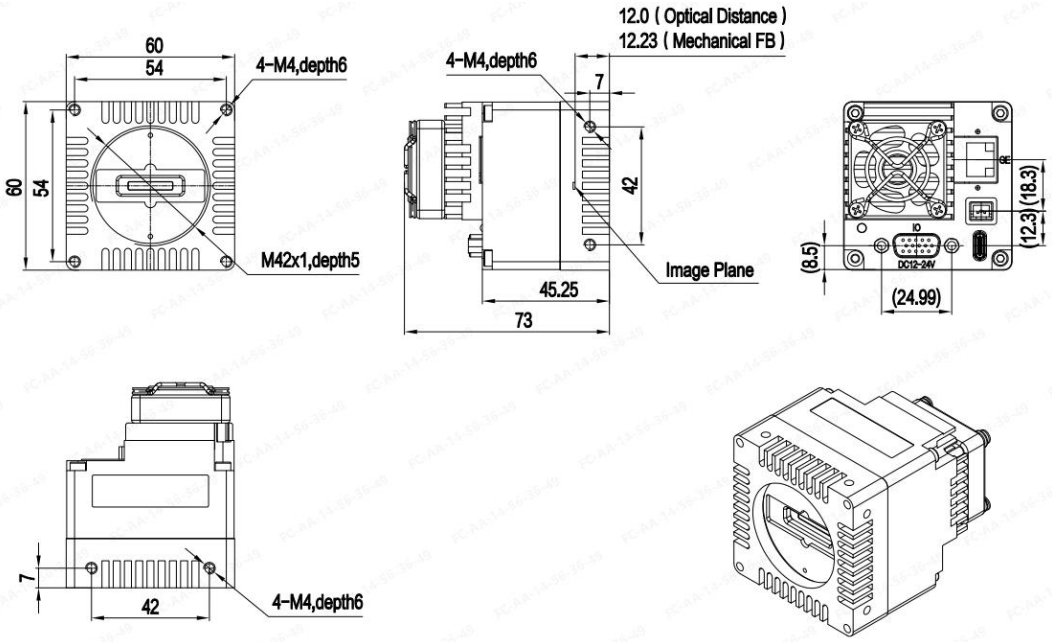
4.6 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

- TPL512GV/TPL1KGV camera:



- TPL1KBGV camera:

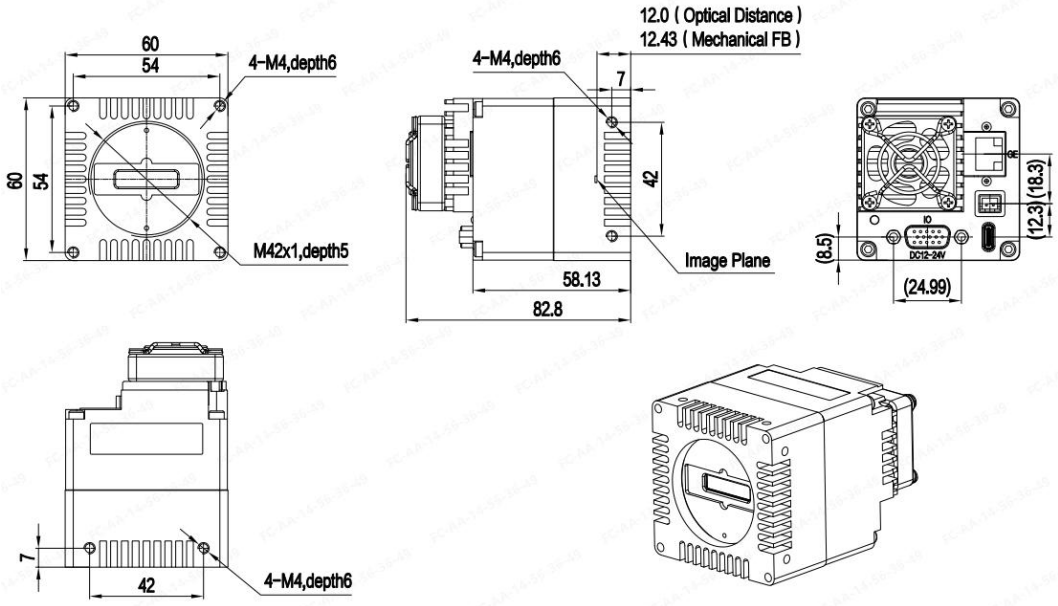


Fig.4 Camera Mechanical Dimensions

5.2 Camera Interface

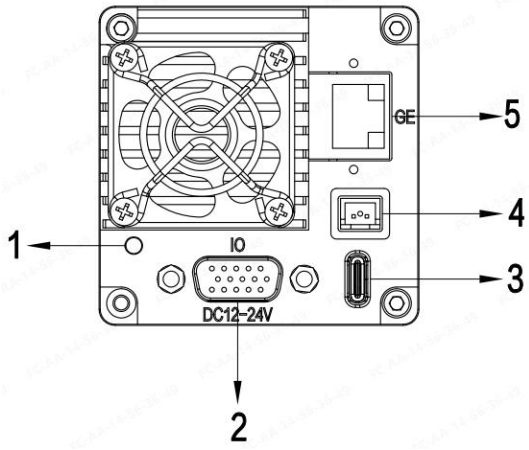


Fig.5 External Interfaces of Camera

① Camera Status Indicator
② Power and Control Interface
③ Type-C Interface
④ Fan Power Interface
⑤ Gigabit Ethernet Data Interface

5.2.1 Camera Status Indicator

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

Table 4 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 & 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.

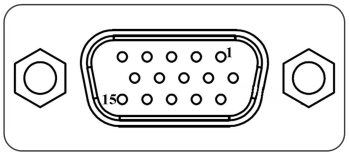


Fig.6 HD15 Connector

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

Table 5 HD15 Connector Interface Definition

Pin Number	GigE	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 Volts

The description of connector interface signal is as follows:

- Line trigger signal: Line 1, Line 2
- Frame trigger signal: Line 3
- Exposure output signal: Line 4, Line 5, Line 6, and the output signal source can be customized
- 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-
- Encoder signal: Line 1 is connected to encoder signal phase A, and Line 2 is connected to encoder signal phase B

The circuit diagram of trigger interface is as follows:

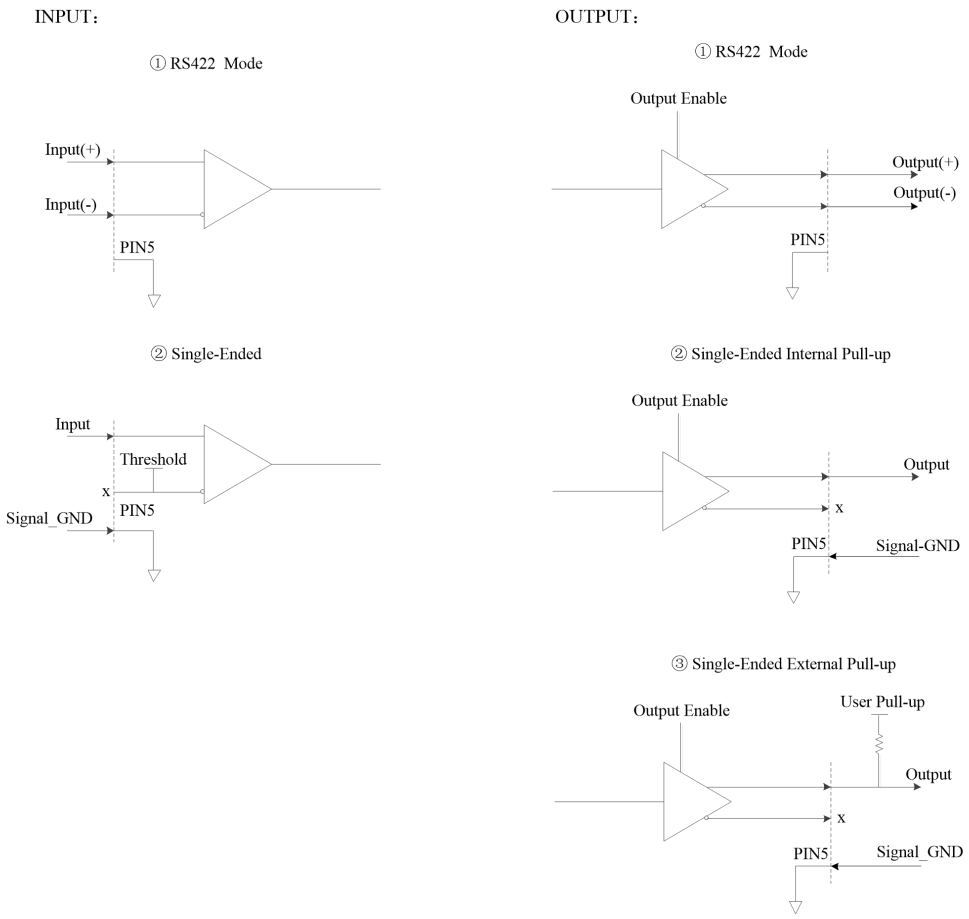


Fig.7 Trigger Circuit Diagram

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 TPL-GV series camera.

6.1 Trigger Mode

TPL-GV series camera supports three timing control modes: Free-Run, Line Trigger and Frame Trigger.

6.1.1 Free-Run Mode

In Free-Run mode, camera's internal logic automatically generates camera control timing, so that it can produce normal image output without external trigger signal.

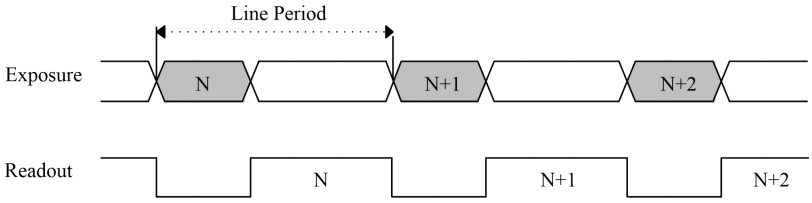


Fig.8 Free-Run Mode

In Free-Run mode, both exposure time and line period (the reciprocal of line rate) can be set by instructions. It should be noted that line period should be no less than readout time of one line, and should be greater than the sum of exposure time and minimum exposure interval parameter. The internal operating sequence of camera is shown in the figure above.

6.1.2 Line Trigger Mode

In Line Trigger mode, it supports setting fixed exposure time, and also supports PWM pulse width to control exposure time. Users need to provide an external trigger signal to control line trigger. At this time, Exposure Mode is valid, and Exposure Mode switch is used to select fixed exposure time mode or PWM pulse width control mode.

In fixed exposure time mode (LineStart: on, Exposure Mode: Timed), camera starts exposure at the rising edge of external trigger signal, while exposure time is determined by the value of “Exposure Time”. At this time, the line rate of camera is determined by the interval between rising edges of external trigger pulse, and its operation timing is shown in the figure below.

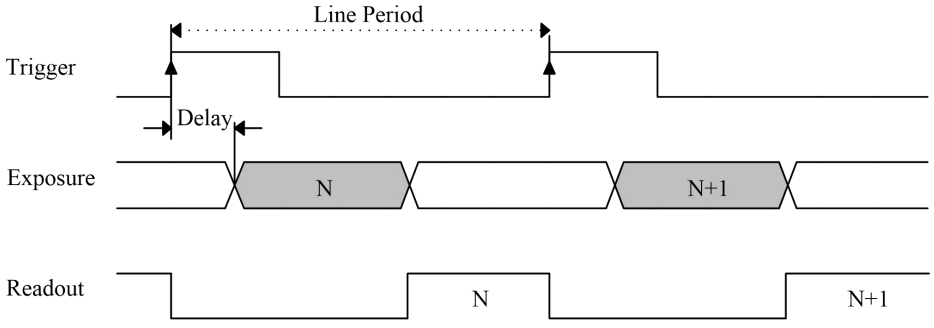


Fig.9 Fixed Exposure Time Mode

In PWM pulse width control mode (LineStart: on, Exposure Mode: TriggerWidth), camera exposure starts at the rising edge and ends at the falling edge of external trigger signal. The operation timing is shown in the figure below.

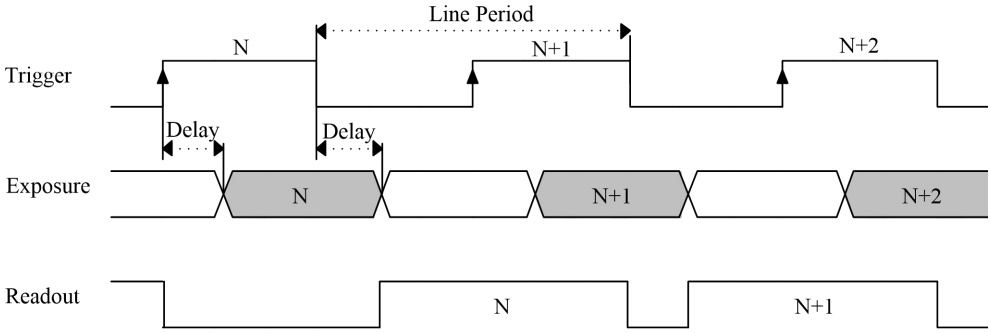


Fig.10 PWM Pulse Width Control Mode

6.1.3 Frame Trigger Mode

Frame Trigger mode is controlled by external signal, that is, the starting point of each image is controlled during continuous acquisition. The camera starts grabbing images from the rising edge of external trigger signal. The number of frames to be triggered at a time is determined by Trigger Frames Count. Its running sequence is shown in the figure below (Trigger Frames Count=2).

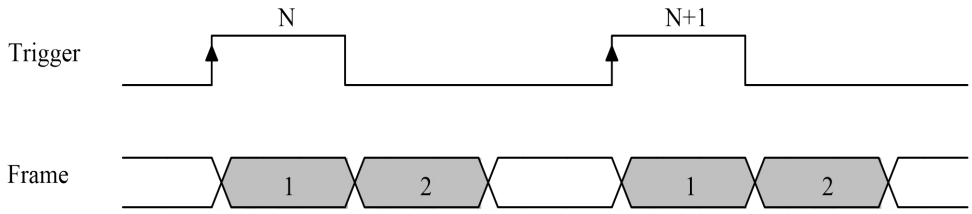


Fig.11 Frame Trigger Mode

6.2 Image Flipping

TPL-GV series camera can make image flip along X direction. Users can use this function to change camera scanning direction, the effect is shown below:

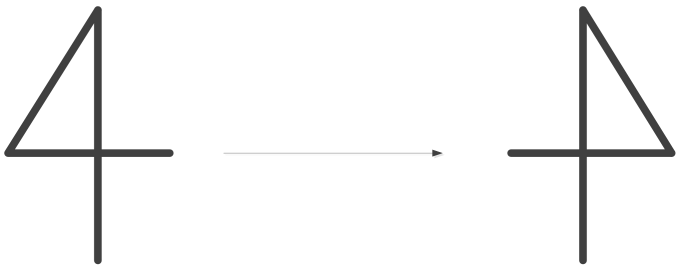


Fig.12 Horizontal Flipping

6.3 Binning

After normal exposure acquisition, TPL-GV series cameras sum the values of adjacent pixels and output them as a single pixel value.

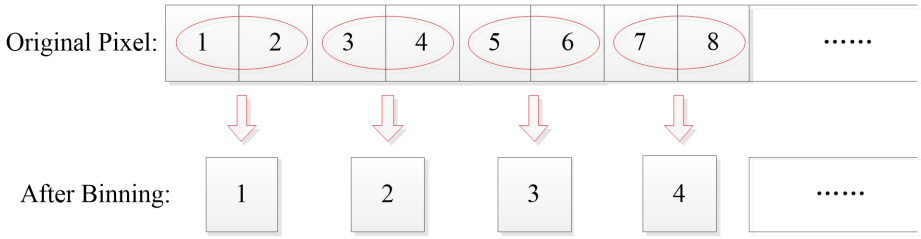


Fig.13 Horizontal Binningx2

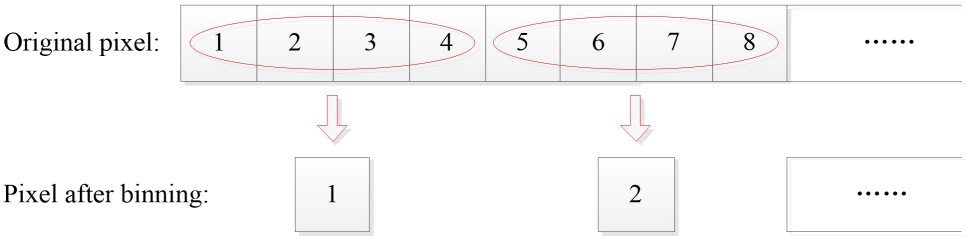


Fig.14 Horizontal Binningx4

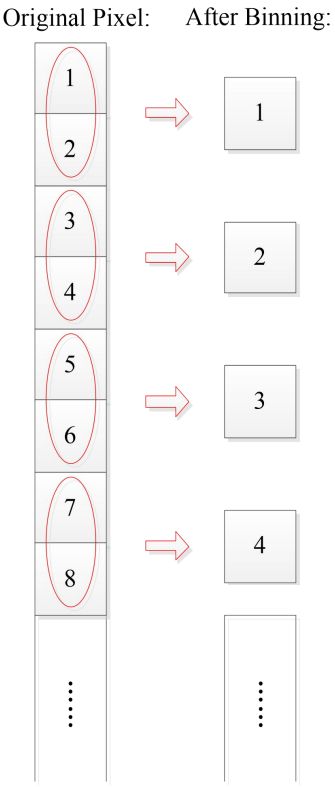


Fig.15 Vertical Binningx2

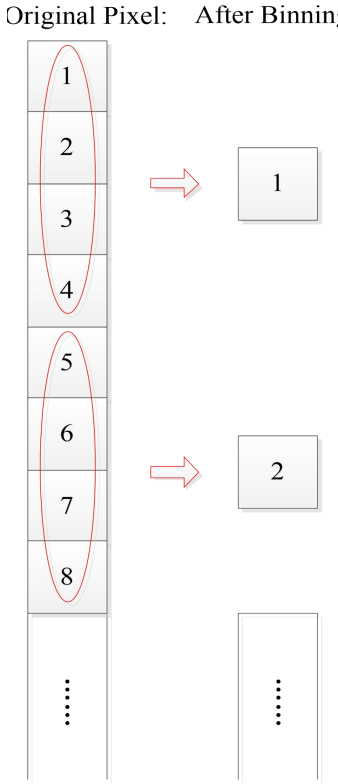
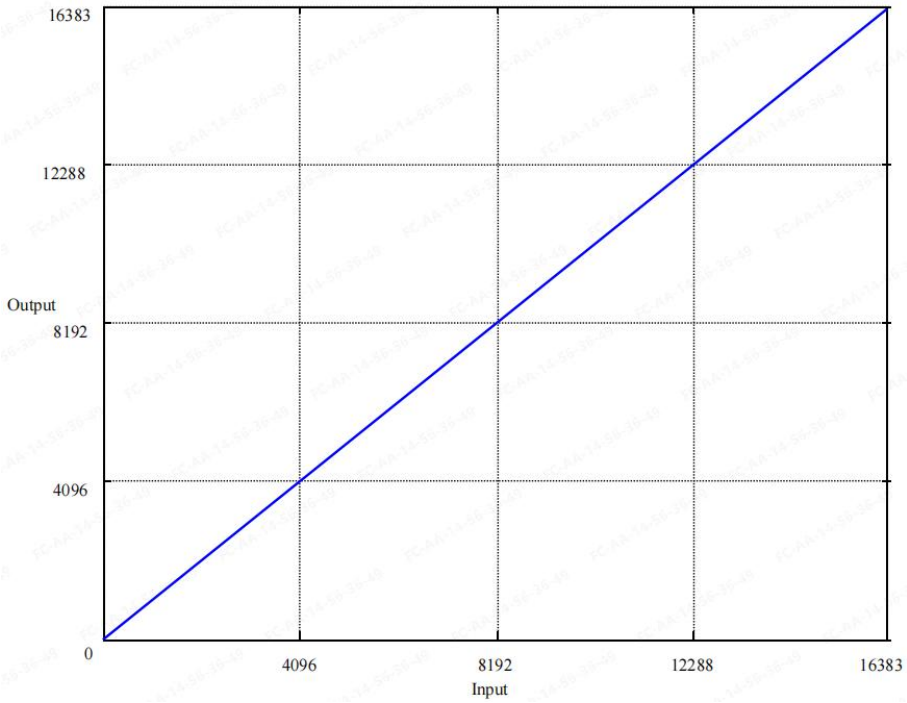


Fig.16 Vertical Binningx4

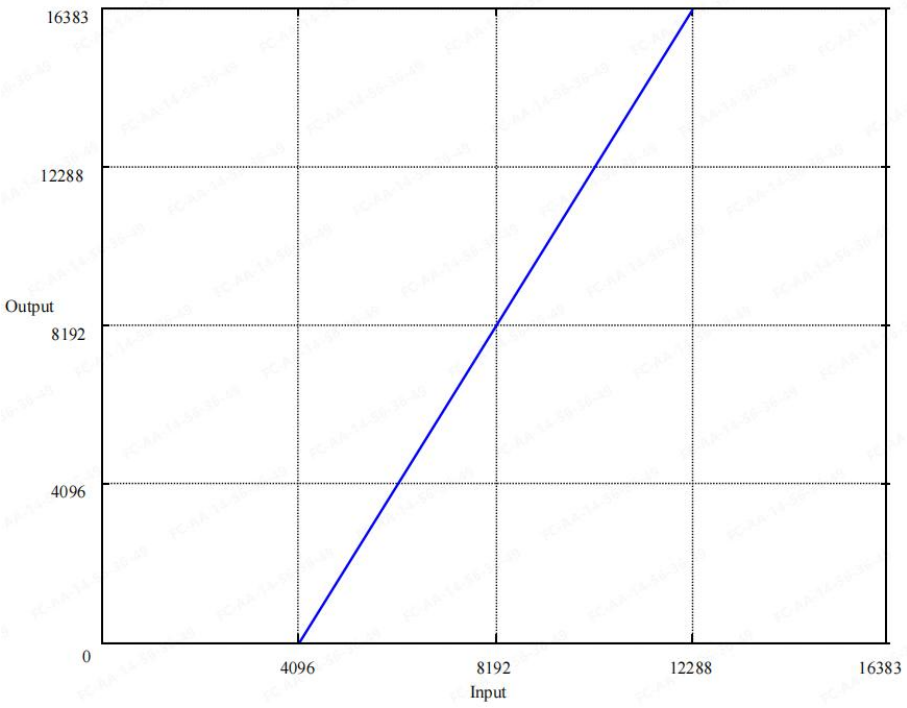
6.4 Contrast

In practical applications, users may need to adjust the brightness and darkness of the grabbed images to obtain images that meet their needs. The contrast function of TPL-GV series cameras can meet the needs of users. By modifying the contrast parameters, the degree of difference in grayscale values between light and dark areas in the image can be adjusted. The larger the contrast parameter, the more pronounced the difference in brightness and darkness.

Using a contrast parameter of 4096 as an explanation, for pixels with input grayscale values below 4096, the output grayscale value is 0; The input grayscale value is higher than 12287 pixels (i.e. overexposed grayscale value 16383 minus contrast parameter 4096), and the grayscale value output is 16383. The effect of brightness difference is as follows:



(a) Before Adjusting the Contrast



(b) Before Adjusting the Contrast

Fig.17 Contrast Effect

6.5 LUT

LUT uses a look-up table with 14bit input and 14bit output to map and convert the values of the original image. Users can use this function to implement gamma correction.

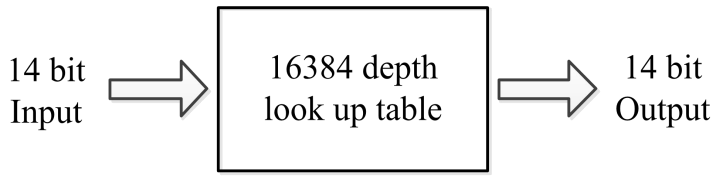


Fig.18 LUT Structure

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

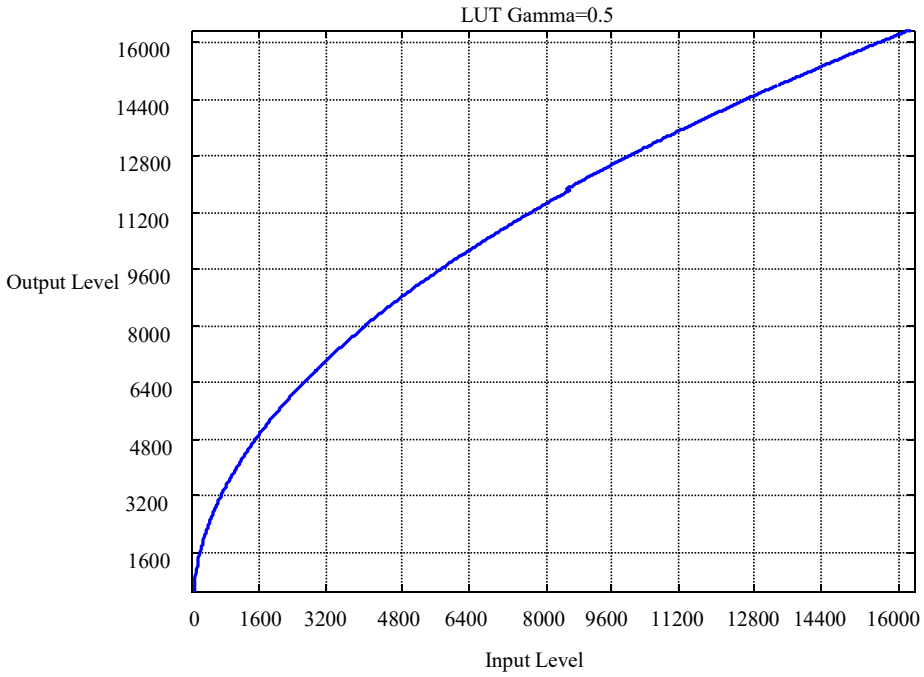


Fig.19 LUT Gamma = 0.5

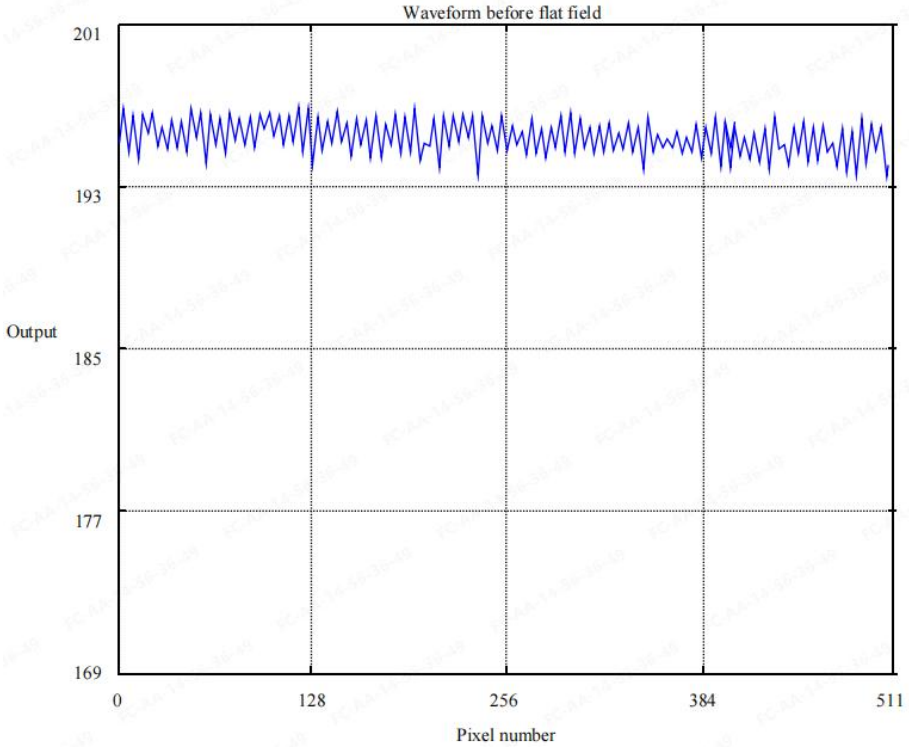
6.6 Flat Field Correction

Ideally, when camera imitates a uniform target, gray value of all pixels in resulting image should theoretically be the same. However, values of each pixel in image often vary considerably. These differences may result from uneven illumination, inconsistent light transmittance between lens center and lens edge, and inconsistent response of camera sensor pixels. The difference of sensor pixel response has been corrected before delivery. In general, it is mainly to correct dark brightness between two sides of image caused by lens. The camera calculates correction parameters of each pixel and stores them in camera for image correction. In some cases, lens and lighting conditions are better and better images can be obtained without flat field correction.

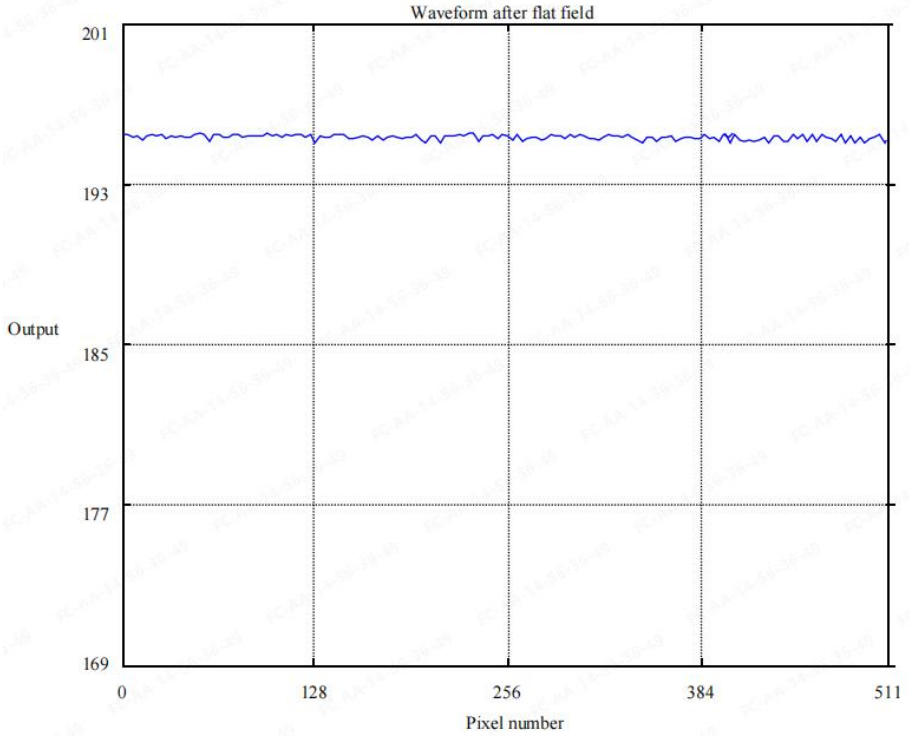
Note: The sensor of TPL-GV series camera has different responses to different wavelength light sources, and factory correction is under full band of halogen light source. If users need to use TPL-GV series camera under a fixed wavelength light source, flat field correction is required.

Flat field correction effect is shown in the figure below:

(1)TPL512GV camera:

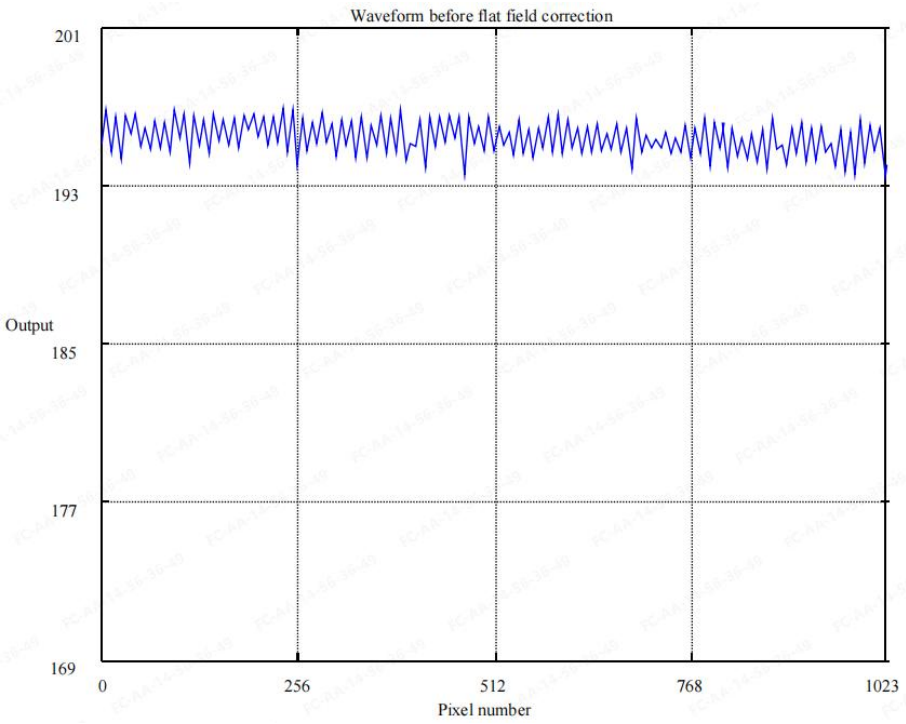


(a)Before Flat Field Correction

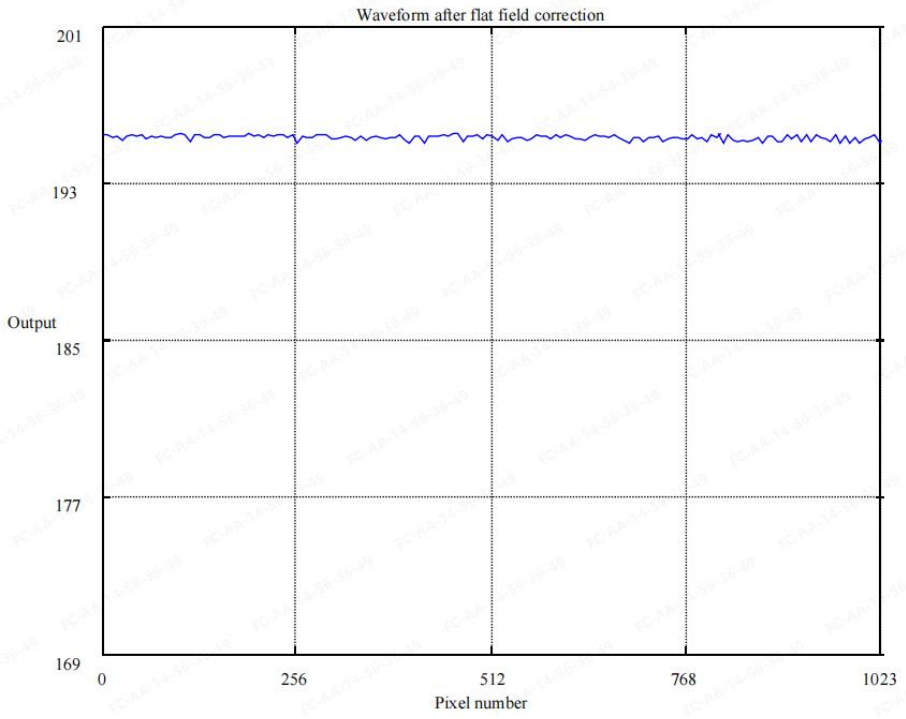


(b)After Flat Field Correction

(2)TPL1K(B)GV camera:



(a)Before Flat Field Correction



(b)After Flat Field Correction

Fig.20 Flat Field Correction Effect

6.7 Shaft Encoder Module

The shaft encoder module of TPL-GV series camera is designed to receive shaft encoder signal from channel A or channel B. The main parameters of shaft encoder module are as follows:

➢ RotaryEncoderMultiplier/Divider: When the image is compressed or elongated, it can be improved by adjusting the frequency doubling/dividing coefficient of the encoder.

➢ RotaryEncoderCounterMode: Set the counter mode of rotary encoder, which can be divided into "Follow Direction" and "Any Direction". If the current value of the encoder counter does not change in the process of grabbing, it means that the camera does not receive the signal in accordance with the rules. When the count reaches the maximum value set, the count starts from zero again. Users can click reset button when need to return to zero.

There are two main attributes that affect the camera's reception of the encoder's positive and negative signals: Rotary Encoder Working Mode and Rotary Encoder Reverse Counter Max.

➢ If the Rotary Encoder Working Mode is set to ForwardOnly and the counter value does not increase or decrease, the camera will receive the image when the forward signal is received.

➢ When the Rotary Encoder Working Mode is set to AnyDirection, if the value of the counter does not increase or decrease, the camera will grabbing when receiving every line trigger signal. If the value of the counter is increasing or decreasing, the camera stops grabbing.

To understand how these rules affect the operation of the encoder software module, consider the following:

- **Scene 1**

The maximum value of the reverse counter of the encoder is set to zero. The reverse counter never increases or decreases. It will not affect the operation of the encoder software module. In this case, if the working mode of the encoder is set to forward only, when the camera receives the forward signal from the encoder, the camera will normally pick the image, but when it receives the reverse signal, the camera will not pick the image. If the working mode of the encoder is set to either direction, the camera will pick the image when it receives the forward or reverse signal from the encoder.

- **Scene 2**

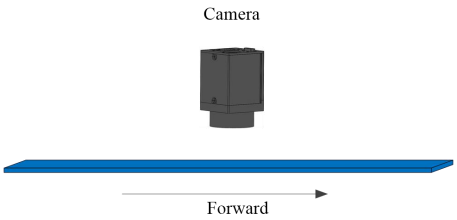
First make the following assumptions:

➢ The camera is fixed, the conveyor belt carries the object forward, and the encoder rotates along with it, generating differential signals.

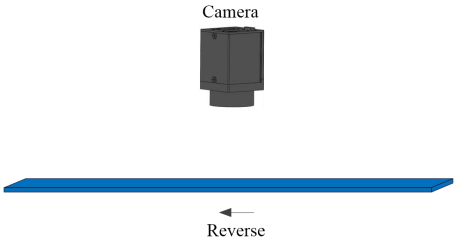
➢ The conveyor belt may jitter, in which case it may move backward, and the encoder will send out, for example, 10 reverse signals.

In this case, the encoder working mode parameter should be set to forward only, and the maximum value of the reverse counter of the encoder module should be set to a value higher than the expected jitter. Here we can set the maximum value of the reverse count to 15.

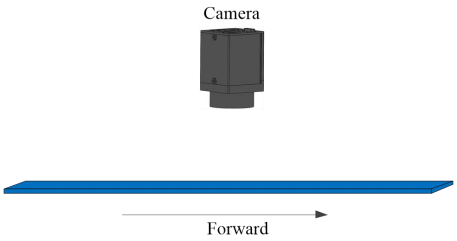
Look at the picture below:



Conveyor belt forward movement, the camera normal drawing, at this time the reverse counter is 0.



The conveyor belt produces jitter, and the reverse counter accumulates 10 reverse signals. As the reverse counter is increasing, the camera will not take pictures. At this time, the reverse counter is 10.



As the conveyor belt continues to move forward, the value of the reverse counter decreases. As the value of the reverse counter is decreasing, the camera will not take pictures at this time until the reverse counter returns to 0 and the material returns to the position before the jitter and continues to take pictures.

- **Scene 3**

First make the following assumptions:

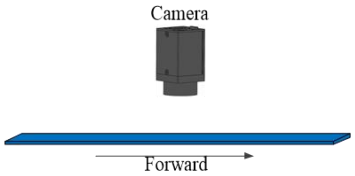
➢ The camera is fixed, the conveyor belt carries the object forward, and the encoder rotates along with it and generate differential signals.

➢ The conveyor belt may jitter, in which case it may move backward, and the encoder will send out, for example, 10 reverse signals.

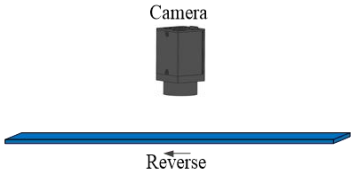
➢ After the conveyor belt moves the object completely past the camera's range, it comes back and grabs it again. Forward grabbing requires complete grabbing and reverse grabbing requires complete grabbing.

In this case, the working mode parameter of the encoder should be set to any direction, and the maximum value of the reverse counter of the encoder module should be set to a value higher than the expected jitter. Here we can set the maximum value of the reverse count to 15.

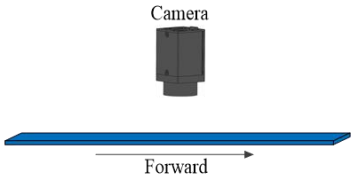
Look at the picture below:



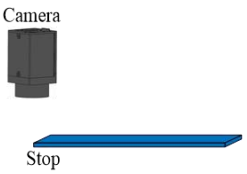
Conveyor belt forward movement, the camera normal drawing, at this time the reverse counter is 0.



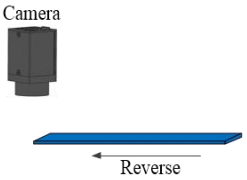
The conveyor belt produces jitter, and the reverse counter accumulates 10 reverse signals. As the reverse counter is increasing, the camera will not take pictures at this time, and the reverse counter is 10.



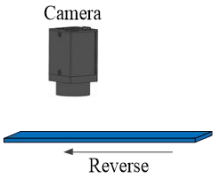
As the conveyor belt continues to move forward, the value of the reverse counter decreases. Because the value of the reverse counter is decreasing, the camera will not take pictures until the reverse counter returns to 0 and the material returns to the position before the jitter and continues to take pictures.



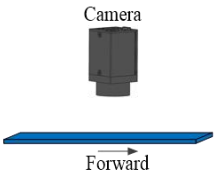
The conveyor belt completed the first forward movement, the camera finished drawing, at this time the reverse counter is 0.



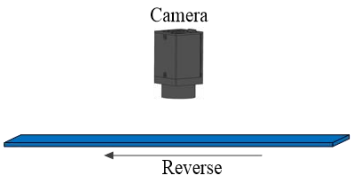
As the belt moves in the opposite direction for the first time, the counter increases, and as the belt keeps moving in the opposite direction, the counter quickly accumulates to 15. And the camera doesn't take pictures at this time.



The reverse counter accumulates to a maximum of 15. This time is so short that it doesn't affect the second image. And since the counter is limited to 15, the value does not increase and the camera starts to take pictures normally.



The conveyor belt produces jitter, producing 10 forward signals, and the reverse counter will decrease to 5. Since the counter is decreasing, the camera will not take pictures at this time.



The conveyor belt continues to move in the opposite direction, increasing the counter until it reaches 15. Since the counter is passing, increasing, the camera does not take pictures at this time. After 15 counts continue normal drawing, and so on.

6.8 Sequence Control

In practical applications, users may need to grab images with different grayscale values to obtain specific information about the target object under different brightness levels. In this case, a set of data cannot meet the user's needs. TPL-GV series camera supports sequence control function, and users can configure multiple sets of parameters to make the camera shoot and output images with different grayscale values in a specific order.

Taking the example of alternating between three sets of sequence parameter sets for imaging. When configuring sequence parameters, first set the sequence mode to off, set the sequence configuration mode to on, and set the number of sequence parameter sets to 3. Then select the parameter set index through the sequence parameter set selector, and configure the corresponding parameters. Click the sequence set save button to save the configured parameters. After completing the configuration of three sequence parameter sets, set the sequence mode to on to start image acquisition. The first image will use the first set of sequence parameter sets, the second image will use the second set of sequence parameter sets, the third image will use the third set of sequence parameter sets, and the fourth image will use the first set of sequence parameter sets again, and so on.

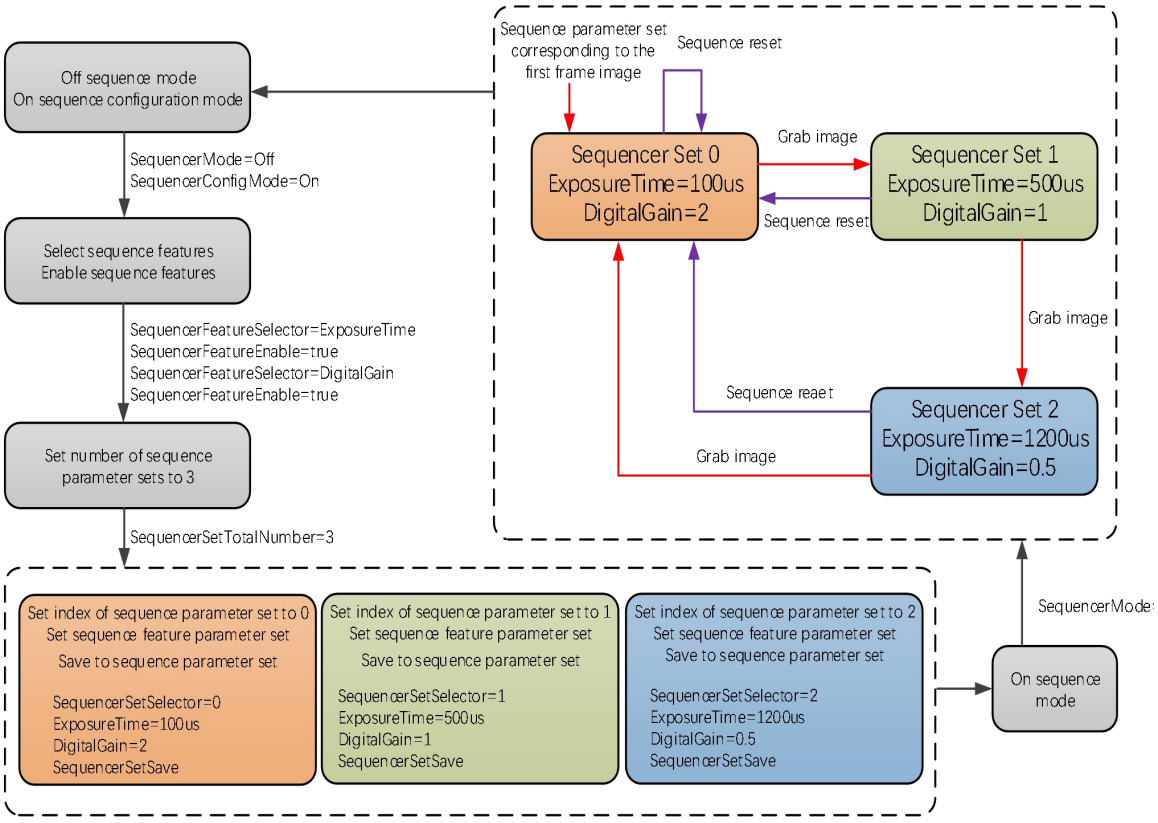


Fig.21 Sequence Control Process

After disabling sequence control, users can load the parameters of the current sequence set into their parameters through the sequence set loading button, thus implementing another form of parameter saving function for sequence sets.

Note: When clicking on sequence reset during the acquisition process, regardless of which set of sequence parameters are currently being used, the next frame of acquisition will start from the first set of sequence parameters and loop again.

6.9 Test Image

TPL-GV series camera supports three image types to better adapt to different scenarios:

- Sensor outputs original image
- Sensor outputs original image after correction algorithm
- Test image

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

As shown in the following figure, it is scroll diagonal stripe mode. The output horizontal data of image keeps increasing. After reaching the maximum value, it starts to count again from 0, and cycle repeats.

Fig.22 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 14bit data. If image data is 8bit, 10bit or 12bit, actual digital offset is divided by 64, 16 or 4.

6.11 Data Format

TPL-GV series camera processes data in 14bit data format, but provides 8bit, 10bit, 12bit, 14bit output data formats. When camera outputs 8bit data, the lowest 6bit data will be deleted. When camera outputs 10bit of data, the lowest 4bit will be deleted. When camera outputs 12bit of data, the lowest 2bit will be deleted.

Fig.23 Data Format

6.12 Camera Temperature

TPL-GV series 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

TPL-GV series camera supports three working parameter sets, including one factory default parameter set and two user parameter sets. Factory default parameter set can be used in most occasions. Users can also configure parameters based on actual requirements and save in user parameter set for self-loading after power on. The camera will automatically load the last saved parameter set each time.

Due to the correlation between parameters of camera, if camera does not work properly after modifying parameters, users can restore the factory default parameter set, and then reset parameters and save settings.

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.

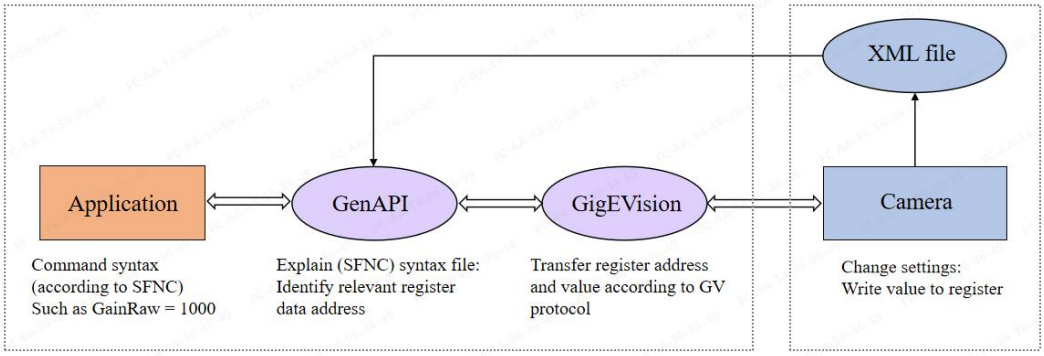


Fig.24 Communication Schematic between Application and Camera

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

DeviceUserID	0x00e8	16	S	RW	Beginner
DeviceMCUTemperature	0xa000	4	F	RO	Beginner
DeviceSensorTemperature	0xa004	4	F	RO	Beginner
DeviceScanType	0x30000	4	E	RO	Beginner
TDILineSelector	0xb814	4	E	RW	Beginner

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceManufacturerInfo**
  Device manufacturer information.

- **DeviceVersion**
  Device version.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceUserID**
  User-defined ID.

- **DeviceMCUTemperature**
  Device MCU temperature.

- **DeviceSensorTemperature**
  Device sensor temperature.

- **DeviceScanType**
  Device scan type. The enumeration names and values are as follows:
  - AreaScan (0): Area scan
  - LineScan (1): Line scan

- **TDILineSelector**
  TDI line selector. The enumeration names and values are as follows:
  - Sum(0): Sum
  - Line1(1): Line1
  - Line2(2): Line2

7.3.2 Image Format Control Register

Table 8 Image Format Control Register

Name	Address	Size	Interface	Access	Visibility
Width	0xa900	4	I	RW	Beginner
Height	0xa904	4	I	RW	Beginner
OffsetX	0xa918	4	I	RW	Beginner
BinningHorizontalMode	0xa928	4	E	RW	Beginner
BinningHorizontal	0xa910	4	E	RW	Beginner
BinningVerticalMode	0xa92c	4	E	RW	Beginner
BinningVertical	0xa91c	4	E	RW	Beginner
PixelFormat	0xa914	4	E	RW	Beginner
VideoMode	0xa920	4	E	RW	Beginner
ReverseX	0xa924	4	B	RW	Beginner

- **Width**

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

- **Height**

  Actual height of output image. The parameter range is as follows:
  - Minimum: 1
  - Increment: 1

- **OffsetX**

  Horizontal offset. The parameter range is as follows:
  - Minimum: 0
  - Increment: 8

- **BinningHorizontalMode**

  Horizontal binning mode. The enumeration names and values are as follows:
  - Average(1): Average
  - Sum(0): Sum

- **BinningHorizontal**

  Horizontal binning. The enumeration names and values are as follows:
  - Binning_X1(1)
  - Binning_X2(2)
  - Binning_X4(4): Partial camera support, subject to actual camera specifications

- **BinningVerticalMode**

  Vertical binning mode. The enumeration names and values are as follows:
  - Average(1): Average
  - Sum(0): Sum

- **BinningVertical**

  Vertical binning. The enumeration names and values are as follows:

  - Binning_X1(1)
  - Binning_X2(2)
  - Binning_X4(4): Partial camera support, subject to actual camera specifications

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:

  - Mono8 (0x01080001): Monochrome 8bit
  - Mono10 (0x01100003): Monochrome 10bit
  - Mono10Packed (0x010C0004): Monochrome packed 10bit
  - Mono12 (0x01100005): Monochrome 12bit
  - Mono12Packed (0x010C0006): Monochrome packed 12bit
  - Mono14 (0x01100025): Monochrome 14bit

- **VideoMode**

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

  - Original (0): Original image
  - Corrected (1): Corrected image
  - TestPattern (2): Test image

- **ReverseX**

  Enable horizontal flipping.

7.3.3 Acquisition Control Register

Table 9 Acquisition Control Register

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0xb000	4	E	RW	Beginner
AcquisitionStart	0xb004	4	C	RW	Beginner
AcquisitionStop	0x6044	4	C	RW	Beginner
AcquisitionLineRate	0xb018	4	F	RW	Beginner
AcquisitionLineRateEnable	0xb050	4	B	RW	Beginner
ResultingLineRate	0xb054	4	F	RO	Beginner
ExposureMode	0xb01c	4	E	RW	Beginner
ExposureTime	0xb020	4	F	RW	Beginner
MaxExposureTimeEnable	0xb010	4	B	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.

- **AcquisitionLineRate**
  Acquisition line rate, unit is Hz.

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

- **ResultingLineRate**
  Actual acquisition of line rate, unit is Hz.

- **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. The parameter range is as follows:
  - Increment: 0.128

- **MaxExposureTimeEnable**
  Enable maximum exposure time, check this enumeration to set exposure time to the maximum allowed under the current condition.

7.3.4 IO Control Register

Table 10 IO Control Register

Name	Address	Size	Interface	Access	Visibility
TriggerSoftware	0xf800	4	C	WO	Expert
TriggerSelector	/	/	E	/	Beginner
TriggerMode	FrameActive: 0xf808 LineStart: 0xf804 FrameStart: 0xf80c	4	E	RW	Beginner
TriggerFrameCount	0xf810	4	I	RW	Beginner
TriggerSource	FrameActive: 0xf818 LineStart: 0xf814 FrameStart: 0xf818	4	E	RW	Beginner

FrameTriggerIgnoreCounter	0xf960	4	I	RO	Expert
FrameTriggerIgnoreCounterReset	0xfa00	4	C	WO	Expert
FrameTriggerCounter	0xf964	4	I	RO	Expert
FrameTriggerCounterReset	0xfa04	4	C	WO	Expert
TriggerDelaySource	0xf81c	4	E	RW	Expert
TriggerDelay	0xf820	4	I	RW	Beginner
TriggerDelayLines	0xf824	4	I	RW	Beginner
RotaryEncoderDirection	0xf834	4	E	RO	Beginner
RotaryEncoderMultiplier	0xf82c	4	E	RW	Expert
RotaryEncoderDivider	0xf830	4	I	RW	Beginner
RotaryEncoderCounterMode	0xf840	4	E	RW	Expert
RotaryEncoderCounterMax	0xf848	4	I	RW	Beginner
RotaryEncoderCounter	0xf844	4	I	RO	Beginner
RotaryEncoderCounterReset	0xf84c	4	C	WO	Expert
RotaryEncoderWorkingMode	0xf854	4	E	RW	Expert
RotaryEncoderReverseCounter	0xf828	4	I	RO	Beginner
RotaryEncoderReverseCounterMax	0xf858	4	I	RW	Beginner
RotaryEncoderReverseCounterReset	0xf850	4	C	WO	Expert
InputLineSelector	/	/	E	/	Beginner
InputLineDetectionLevel	0xf870	4	E	RW	Expert
InputLinePolarity	Line1: 0xf860 Line2: 0xf864 Line3: 0xf868	4	E	RW	Beginner
InputLineDebouncingPeriod	Line1: 0xf878 Line2: 0xf87c Line3: 0xf880	4	I	RW	Beginner
InputLineTriggerFrequency	Line1: 0xf884 Line2: 0xf888 Line3: 0xf88c	4	I	RO	Beginner
FlashStrobeEnable	0xf8cc	4	B	RW	Beginner
OutputLineSelector	/	/	E	/	Beginner
OutputLineSource	Line4: 0xf8a8 Line5: 0xf8ac Line6: 0xf8b0	4	E	RW	Expert
OutputLinePolarity	Line4: 0xf890 Line5: 0xf894 Line6: 0xf898	4	E	RW	Beginner
OutputLinePullUp	Line4: 0xf8c0 Line5: 0xf8c4 Line6: 0xf8c8	4	E	RW	Beginner

- **TriggerSoftware**

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

- **TriggerSelector**

  Trigger mode selector. The enumeration names and values are as follows:
  - LineStart (1): Line trigger
  - FrameActive (0): Frame active
  - FrameStart (2): Frame trigger

- **TriggerMode**

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

- **TriggerFrameCount**

  The number of frame trigger acquisition, that is, the number of image frames grabbed by camera for each frame trigger signal received. The parameter range is as follows:
  - Maximum: 65535
  - Minimum: 1

- **TriggerSource**

  Trigger source selector. The enumeration names and values are as follows:
  - Line1 (0): Line1, only be optional in line trigger mode
  - Line2 (1): Line2, only be optional in line trigger mode
  - RotaryEncoder1 (2): Shaft encoder signal, only be optional in line trigger mode
  - Line3 (3): Line3, only be optional in frame trigger mode
  - Software (4): Software trigger, only be optional in frame trigger mode

- **FrameTriggerIgnoreCounter**

  Frame triggered ignore counter.

- **FrameTriggerIgnoreCounterReset**

  Reset frame triggers ignore counter.

- **FrameTriggerCounter**

  Frame triggered counter.

- **FrameTriggerCounterReset**

  Reset the frame trigger counter.

- **TriggerDelaySource**

  Frame trigger delay type. The enumeration names and values are as follows:
  - InternalClock (0): Time delay
  - lineTriggerSignal (1): Line delay

- **TriggerDelay**

Frame trigger time delay. The parameter range is as follows:

- Maximum: 65000
- Minimum: 0
- Increment: 1

- **TriggerDelayLines**

Frame trigger line delay. The parameter range is as follows:

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

- **RotaryEncoderDirection**

Shaft encoder signal direction. The enumeration names and values are as follows:

- CounterClockwise (1): Phase A ahead of phase B
- Clockwise (0): Phase B ahead of phase A

- **RotaryEncoderMultiplier**

Shaft encoder multiplier. The enumeration names and values are as follows:

- x1 (0)
- x2 (1)
- x4 (2)
- x8 (3)
- x16 (4)
- x32 (5)
- x64 (6)
- x128 (7)
- x256 (8)

- **RotaryEncoderDivider**

Shaft encoder divider. The parameter range is as follows:

- Maximum: 255
- Minimum: 1

- **RotaryEncoderCounterMode**

Shaft encoder counter mode. The enumeration names and values are as follows:

- FollowDirectionMode (0): Forward increasing and backward decreasing
- IgnoreDirectionMode (1): Incremental in any direction

- **RotaryEncoderCounterMax**

The maximum value of shaft encoder counter, beyond which the counter value does not increase. The parameter range is as follows:

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

- **RotaryEncoderCounter**

The current value of shaft encoder counter, that is, the number of shaft encoder signals currently received that meet the requirement. The parameter range is as follows:

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

- **RotaryEncoderCounterReset**

Reset shaft encoder counter, click this parameter to clear shaft encoder counter value to zero.

- **RotaryEncoderWorkingMode**

Shaft encoder counter working mode. The enumeration names and values are as follows:

  - ForwardOnly (0): Only forward
  - AnyDirection (1): Any direction

- **RotaryEncoderReverseCounter**

The current value of shaft encoder reverse counter, which is the number of currently received reverse encoder signals that meet the requirements. The parameter range is as follows:

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

- **RotaryEncoderReverseCounterMax**

The maximum value of shaft encoder reverse counter, beyond which the reverse counter value does not increase. The parameter range is as follows:

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

- **RotaryEncoderReverseCounterReset**

Reset shaft encoder reverse counter, click this parameter to clear shaft encoder reverse counter value to zero.

- **InputLineSelector**

Trigger line selector, which is used to select the line that need to be configured. The enumeration names and values are as follows:

  - Line1 (0): Line1
  - Line2 (1): Line2
  - Line3 (2): Line3

- **InputLineDetectionLevel**

Trigger signal detection level, which is input voltage range. The enumeration names and values are as follows:

- Threshold_for_2V (0): Voltage should be greater than 2V
- Threshold_for_5V (1): Voltage should be greater than 5V

- **InputLinePolarity**

  Trigger polarity. The enumeration names and values are as follows:
  - High (1): Signal high level trigger acquisition
  - Low (0): Signal low level trigger acquisition

- **InputLineDebouncingPeriod**

  Trigger signal to shake window length. Signals lower than this pulse width will be filtered out as gross signal, and the unit is us. The parameter range is as follows:
  - Maximum: 65535
  - Minimum: 0

- **InputLineTriggerFrequency**

  Trigger signal rate, unit is Hz.

- **FlashStrobeEnable**

  Enable strobe output signal.

- **OutputLineSelector**

  Output signal line selector. The enumeration names and values are as follows:
  - Line4 (0): Line4
  - Line5 (1): Line5
  - Line6 (2): Line6

- **OutputLineSource**

  Output signal source. The enumeration names and values are as follows:
  - ExposureActive (0): Follow exposure, output signal generated during camera exposure
  - FrameActive (1): Follow frame, output signal generated when camera grabs a frame

- **OutputLinePolarity**

  Output signal polarity. The enumeration names and values are as follows:
  - SameToSource (0): Same as signal source
  - OppositeToSource (1): Opposite to signal source

- **OutputLinePullUp**

  Strobe signal pull-up voltage. The enumeration names and values are as follows:
  - Internal_3V3 (1): Strobe signal internal 3.3V pull-up voltage
  - External_5V_to_24V (0): Strobe signal external 5~24V pull-up voltage

7.3.5 Counter Control Register

Table 11 Counter Control Register

Name	Address	Size	Interface	Access	Visibility
CounterSelect	0xf700	4	E	RW	Beginner
CounterMode	0xf8d0	4	E	RW	Beginner
CounterStatus	0xf8d4	4	E	RO	Beginner
CounterStartSource	0xf8d8	4	E	RW	Beginner
CounterStartLineActivation	0xf8dc	4	E	RW	Beginner
CounterIncrementalSource	0xf8e0	4	E	RW	Beginner
CounterIncrementalLineActivation	0xf8e4	4	E	RW	Beginner
CounterResetSource	0xf8e8	4	E	RW	Beginner
CounterResetLineActivation	0xf8ec	4	E	RW	Beginner
CounterReset	0xf8f0	4	C	WO	Beginner
CounterDuration	0xf8f4	4	I	RW	Beginner
CounterValueAtReset	0xf01c	4	I	RO	Beginner
CounterCurrentValue	0xf8f8	4	I	RO	Beginner

- **CounterSelect**

  Counter selector. The enumeration names and values are as follows:

  - Counter_1(0): Counter 1

- **CounterMode**

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

  - Off(0): Off
  - On(1): On

- **CounterStatus**

  Counter status. The enumeration names and values are as follows:

  - CounterIdle(0): Counter idle
  - CounterTriggerWait(1): Counter waiting for signal
  - CounterActive(2): Counter counting
  - CounterCompleted(3): Counter completes counting
  - CounterOverflow(4): Counter value overflow

- **CounterStartSource**

  The counter starts the signal source, and upon receiving the signal, the counter begins counting work. The enumeration names and values are as follows:

  - Off(0): Off
  - AcquisitionStart(1): Acquisition starts
  - ExposureStart(2): Exposure starts
  - ExposureEnd(3): Exposure ends
  - FrameStart(4): Frame starts
  - Line1(5): Line1 signal
  - Line2(6): Line2 signal

- Line3(7): Line3 signal
- Encoder(8): Encoder signal
- InternalClock(9): Internal clock signal
- Timer1End(10): Timer ends
- Counter1End(11): Counter ends

- **CounterStartLineActivation**

Counter start signal source polarity. The enumeration names and values are as follows:

- RisingEdge(0): Rising edge
- FallingEdge(1): Falling edge
- AnyEdge(2): Any edge

- **CounterIncrementalSource**

Counter increase signal source, the counter value increases upon receiving the signal. The enumeration names and values are as follows:

- Off(0): Off
- AcquisitionStart(1): Acquisition starts
- ExposureStart(2): Exposure starts
- ExposureEnd(3): Exposure ends
- FrameStart(4): Frame starts
- Line1(5): Line1 signal
- Line2(6): Line2 signal
- Line3(7): Line3 signal
- Encoder(8): Encoder signal
- InternalClock(9): Internal clock signal
- Timer1End(10): Timer ends
- Counter1End(11): Counter ends

- **CounterIncrementalLineActivation**

Counter increases signal source polarity. The enumeration names and values are as follows:

- RisingEdge(0): Rising edge
- FallingEdge(1): Falling edge
- AnyEdge(2): Any edge

- **CounterResetSource**

Counter reset signal source. The enumeration names and values are as follows:

- ResetCmd(0): Reset Command
- AcquisitionStart(1): Acquisition starts
- ExposureStart(2): Exposure starts
- ExposureEnd(3): Exposure ends
- FrameStart(4): Frame starts
- Line1(5): Line1 signal
- Line2(6): Line2 signal
- Line3(7): Line3 signal

- Timer1End(8): Timer ends
- Counter1End(9): Counter ends

- **CounterResetLineActivation**

  Counter reset signal source polarity. The enumeration names and values are as follows:
  - RisingEdge(0): Rising edge
  - FallingEdge(1): Falling edge
  - AnyEdge(2): Any edge

- **CounterReset**

  Reset counter command.

- **CounterDuration**

  The total value of the counter is.

- **CounterValueAtReset**

  The count value when the counter is reset.

- **CounterCurrentValue**

  The current value of the counter.

7.3.6 Timer Control Register

Table 12 Timer Control Register

Name	Address	Size	Interface	Access	Visibility
TimerSelect	0xf704	4	E	RW	Beginner
TimerMode	0xf8fc	4	E	RW	Beginner
TimerStatus	0xf000	4	E	RO	Beginner
TimerStartSource	0xf004	4	E	RW	Beginner
TimerStartLineActivation	0xf008	4	E	RW	Beginner
TimerResetCmd	0xf00c	4	C	WO	Beginner
TimerDelay	0xf010	4	I	RW	Beginner
TimerDuration	0xf014	4	I	RW	Beginner
TimerCurrentValue	0xf018	4	I	RO	Beginner

- **TimerSelect**

  Timer selection. The enumeration names and values are as follows:
  - Timer_1(0): Timer 1

- **TimerMode**

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

- **TimerStatus**

  Timer status. The enumeration names and values are as follows:

  - TimerIdle(0): Timer idle
  - TimerTriggerWait(1): Timer waiting for signal
  - TimerDelay(2): Timer delay
  - TimerActive(3): Timer in progress
  - TimerCompleted(4): Timer completed timing

- **TimerStartSource**

  The timer starts the signal source, and upon receiving the signal, the timer begins to count. The enumeration names and values are as follows:

  - ResetCmd(0): Reset Command
  - AcquisitionStart(1): Acquisition starts
  - ExposureStart(2): Exposure starts
  - ExposureEnd(3): Exposure ends
  - Line1(4): Line1 signal
  - Line2(5): Line2 signal
  - Line3(6): Line3 signal
  - Timer1End(7): Timer ends
  - Counter1End(8): Counter ends

- **TimerStartLineActivation**

  Timer start signal source polarity. The enumeration names and values are as follows:

  - RisingEdge(0): Rising edge
  - FallingEdge(1): Falling edge
  - AnyEdge(2): Any edge

- **TimerResetCmd**

  Reset timer command.

- **TimerDelay**

  Timer delay time, unit is us.

- **TimerDuration**

  Timer counts the total time.

- **TimerCurrentValue**

  Current value of timer.

7.3.7 Analog Control Register

Table 13 Analog Control Register

Name	Address	Size	Interface	Access	Visibility

AnalogGain	0xb800	4	E	RW	Beginner

- **AnalogGain**

  Analog gain. The specific supported analog gain multiples are subject to the actual camera.The enumeration names and values are as follows:

  - Gain_x1 (0)
  - Gain_x2 (1)
  - Gain_x5 (2)
  - Gain_x11 (3)
  - Gain_x17 (4)
  - Gain_x25 (5)
  - Gain_x50 (6)
  - Gain_x100 (7)

7.3.8 Digital Control Register

Table 14 Digital Control Register

Name	Address	Size	Interface	Access	Visibility
DigitalGain	0xc000	4	F	RW	Beginner
DigitalOffset	0xc004	4	I	RW	Beginner
Contrast	0xc084	4	I	RW	Expert
SharpeningIntensity	0xc088	4	I	RW	Expert
BlackLevel	0xc028	4	I	RW	Guru
RowInterleaveDirection	0xbaac	4	E	RW	Expert
RowInterleaveFactor	0xbaa8	4	F	RW	Expert

- **DigitalGain**

  Digital gain. The parameter range is as follows:

  - Maximum: 8
  - Minimum: 0.1

- **DigitalOffset**

  Digital offset.

- **Contrast**

  Contrast. The parameter range is as follows:

  - Maximum: 8191
  - Minimum: 0
  - Increment: 1

- **SharpeningIntensity**

  Sharpen amount. The parameter range is as follows:

  - Maximum: 8191

- Minimum: 0
- Increment: 1

- **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:

- Minimum: 0
- Increment: 1

- **RowInterleaveDirection**

Row interpolation direction. The enumeration names and values are as follows:

- Forward(0): Forward
- Backward(1): Backward
- Auto(2): Automatic

- **RowInterleaveFactor**

Row interpolation coefficient.

7.3.9 Sequence Control Register

Table 15 Sequence Control Register

Name	Address	Size	Interface	Access	Visibility
SequencerMode	0xf900	4	E	RW	Guru
SequencerConfigurationMode	0xf970	4	E	RW	Expert
SequencerSetCount	0xf904	4	I	RW	Expert
SequencerIncrementalSource	0xf908	4	E	RW	Guru
SequencerRepeater	0xf90c	4	I	RW	Guru
SequencerIncrementalMode	0xf910	4	E	RW	Guru
SequencerResetSource	0xf914	4	E	RW	Guru
SequencerReset	0xf918	4	C	WO	Guru
SequencerSetStart	0xf944	4	I	RW	Expert
SequencerFeatureSelector	0xf920	4	E	RW	Guru
SequencerFeatureEnable	0xf924	4	B	RW	Expert
SequencerSetSelector	0xf928	4	I	RW	Guru
SequencerExposureTime	0xf934	4	F	RW	Guru
SequencerDigitalGain	0xf938	4	F	RW	Beginner
SequencerFFCSet	0xf940	4	E	RW	Guru
SequencerSetLoad	0xf930	4	C	WO	Expert
SequencerSetSave	0xf92c	4	C	WO	Expert
SequencerSetNext	0xf95c	4	I	RO	Expert
SequencerSetActive	0xf91c	4	I	RO	Guru

- **SequencerMode**

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

  - Off(0): Off sequence mode
  - On(1): On sequence mode

- **SequencerConfigurationMode**

  Sequence configuration mode. The enumeration names and values are as follows:

  - Off(0): Off sequence configuration mode
  - On(1): On sequence configuration mode

- **SequencerSetCount**

  Number of sequence parameter sets. The parameter range is as follows:

  - Maximum: 4
  - Minimum: 1
  - Increment: 1

- **SequencerIncrementalSource**

  Sequence count increases signal source. The enumeration names and values are as follows:

  - StartOfLine(0): Line starts
  - StartOfFrame(1): Frame starts
  - Line1(2): Line1 signal
  - Line2(3): Line2 signal
  - Software(4): Software trigger signal

- **SequencerRepeater**

  Sequence count repetition times. The parameter range is as follows:

  - Maximum: 65535
  - Minimum: 1

- **SequencerIncrementalMode**

  Sequence count increase mode. The enumeration names and values are as follows:

  - NextLine(0): Next line
  - NextFrame(1): Next frame

- **SequencerResetSource**

  Sequence reset signal source. The enumeration names and values are as follows:

  - StartOfFrame(0): Fame start
  - Software(1): Software trigger signal

- **SequencerReset**

  Reset sequence acquisition.

- **SequencerSetStart**

  Sequence start acquisition index.

- **SequencerFeatureSelector**

  Sequence feature selection. The enumeration names and values are as follows:
  - ExposureTime(0): Exposure time
  - Gain(1): Digital gain
  - FlatFieldCorrection(2): Flat field correction parameter set

- **SequencerFeatureEnable**

  Enable sequence features.

- **SequencerSetSelector**

  Selection of sequence parameter set.

- **SequencerExposureTime**

  Sequence controlled exposure time. The parameter range is as follows:
  - Increment: 0.128

- **SequencerDigitalGain**

  Sequence controlled digital gain. The parameter range is as follows:
  - Maximum: 8
  - Minimum: 0.1

- **SequencerFFCSet**

  Parameter set for sequence control flat field correction. The enumeration names and values are as follows:
  - UserFlatfield1(0): User flat field correction 1
  - UserFlatfield2(1): User flat field correction 2
  - UserFlatfield3(2): User flat field correction 3
  - UserFlatfield4(3): User flat field correction 4

- **SequencerSetLoad**

  Load the sequence control parameter set.

- **SequencerSetSave**

  Save the set of sequence control parameters.

- **SequencerSetNext**

  The sequence set number used for the next frame image.

- **SequencerSetActive**

  The sequence set number used for the current image.

7.3.10 Defect Pixel Register

Table 16 Defect Pixel Register

Name	Address	Size	Interface	Access	Visibility
DefectPixelCorrectionEnable	0xe000	4	B	RW	Guru
DefectPixelReplacementAlgorithm	0xe010	4	E	RW	Beginner
DefectPixelTotal	0xe004	4	I	RO	Expert
DefectPixelSelect	0xe008	4	I	RW	Expert
DefectPixelReadX	0xe00c	4	I	RO	Expert
DefectPixelWriteX	0xe014	4	I	RW	Expert
DefectPixelAdd	0xe01c	4	C	WO	Expert
DefectPixelRemove	0xe020	4	C	WO	Expert
DefectPixelClearAll	0xe024	4	C	WO	Expert
DefectPixelSave	0xe028	4	C	WO	Expert

- **DefectPixelCorrectionEnable**

  Enable defect pixel correction function.

- **DefectPixelReplacementAlgorithm**

  Defect pixel replacement algorithm. The enumeration names and values are as follows:

  - Method1(0): Adjacent pixel replacement
  - Method2(1): Take the average of two adjacent pixels

- **DefectPixelTotal**

  Total number of defect pixel.

- **DefectPixelSelect**

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

  - Maximum: 16
  - Minimum: 0
  - Increment: 1

- **DefectPixelReadX**

  Read the X coordinate of current defect pixel.

- **DefectPixelWriteX**

  Write the X coordinate of defect pixel.

- **DefectPixelAdd**

  Add defect pixel. Note that defect pixels can only be added in Line 1 or Line 2 mode.

- **DefectPixelRemove**

  Remove current defect pixel.

- **DefectPixelClearAll**

  Remove all defect pixels.

- **DefectPixelSave**

  Save defect pixels.

7.3.11 Flat Field Correction Register

Table 17 Flat Field Correction Register

Name	Address	Size	Interface	Access	Visibility
FlatFieldCorrectionEnable	0xd800	4	B	RW	Beginner
FlatFieldSelect	0xd838	4	E	RW	Guru
FlatFieldCorrectionCalibrate	0xd804	4	C	WO	Beginner
FlatFieldCorrectionReset	0xd808	4	C	WO	Beginner
FlatFieldCorrectionOffsetX	0xd80c	4	I	RW	Expert
FlatFieldCorrectionWidth	0xd810	4	I	RW	Expert
FlatFieldCorrectionReferenceMode	0xd814	4	B	RW	Expert
FlatFieldCorrectionLineSelect	0xd818	4	E	RW	Beginner
FlatFieldCorrectionMonoTarget	0xd81c	4	I	RW	Expert
FlatFieldCorrectionLowPassFilterWindow	0xd82c	4	I	RW	Expert
DSNUCorrectionEnable	0xd830	4	B	RW	Expert
DSNUCorrectionStart	0xd834	4	C	WO	Expert
DSNUCorrectionReset	0xd83c	4	C	WO	Expert

- **FlatFieldCorrectionEnable**

  Enable flat field correction.

- **FlatFieldSelect**

  Selection of flat field correction parameter set. The enumeration names and values are as follows:

  - UserFlatfield1(0): User flat field correction 1
  - UserFlatfield2(1): User flat field correction 2
  - UserFlatfield3(2): User flat field correction 3
  - UserFlatfield4(3): User flat field correction 4

- **FlatFieldCorrectionCalibrate**

  Execute flat field correction.

- **FlatFieldCorrectionReset**

  Reset flat field correction to default setting.

- **FlatFieldCorrectionOffsetX**

  Horizontal offset of the flat field correction area. The parameter range is as follows:

  - Minimum: 0
  - Increment: 2

- **FlatFieldCorrectionWidth**

  Width of flat field correction area. The parameter range is as follows:

  - Minimum: 16
  - Increment: 2

- **FlatFieldCorrectionReferenceMode**

  Flat field correction reference mode, check this option to correct the grayscale value of the selected area to the target value.

- **FlatFieldCorrectionLineSelect**

  Selection of flat field correction line. The enumeration names and values are as follows:

  - Mono(3): Monochrome

- **FlatFieldCorrectionMonoTarget**

  Flat field correction of monochrome channel target values. The parameter range is as follows:

  - Maximum: 16383
  - Minimum: 0

- **FlatFieldCorrectionLowPassFilterWindow**

  Flat field correction low-pass filtering. The parameter range is as follows:

  - Maximum: 64
  - Minimum: 0
  - Increment: 2

- **DSNUCorrectionEnable**

  Enable dark field correction.

- **DSNUCorrectionStart**

  Execute dark field correction.

- **DSNUCorrectionReset**

  Reset dark field correction to default setting.

7.3.12 LUT Control Register

Table 18 LUT Control Register

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

- **LUTEnable**

Enable LUT function.

- **LUTIndex**
  Lookup table data index, that is, the gray value of image before mapping lookup table.

- **LUTValue**
  Lookup table data value, that is, the gray value of image after mapping lookup table.

- **GammaCorrectionEnable**
  Enable gamma correction.

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

7.3.13 Cooling Control Registers

Table 19 Cooling Control Registers

Name	Address	Size	Interface	Access	Visibility
FanSpeed	0xa600	4	E	RW	Expert
TECCoolerEnable	0xa604	4	B	RW	Expert
TECTemperature	0xa608	4	I	RW	Expert

- **FanSpeed**
  Fan speed. The enumeration names and values are as follows:
  - Speed_0 (0)
  - Speed_33 (1)
  - Speed_66 (2)
  - Speed_100 (3)

- **TECCoolerEnable**
  Enable TEC cooling function.

- **TECTemperature**
  Set TEC cooling target temperature. The parameter range is as follows:
  - Maximum: 55
  - Minimum: -10
  - Increment: 1

7.3.14 User Set Control Registers

Table 20 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.

7.3.15 Transport Layer Control Registers

Table 21 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	0x0200	512	S	RO	Guru
GevSecondURL	0x0400	512	S	RO	Guru
GevNumberOfInterfaces	0x0600	4	I	RW	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
GevGVCPHeartbeatDisable	0xb100	4	B	RW	Beginner
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	0x0954	4	B	RW	Expert

- **GevLinkSpeedConfig**
  Camera link speed configuration.

- **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.

- **GevInterfaceSelector**
  Device interface selector.

- **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.

- **GevNumberOfInterfaces**
  Number of device interface.

- **GevPersistentIPAddress**
  Static IP address.

- **GevPersistentSubnetMask**
  Static subnet mask.

- **GevPersistentDefaultGateway**
  Static default gateway.

- **GevMessageChannelCount**
  Control channel count.

- **GevStreamChannelCount**
  Data channel count.

- **GevGVCPHeartbeatDisable**
  Disable the device heartbeat packet function.

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

- **GevTimestampTickFrequency**
  Time stamp frequency.

- **GevTimestampControlLatch**
  Time stamp latch.

- **GevTimestampValue**
  Time stamp 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 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.

9 After Sales and Warranty Policy

Our products strictly follow the national “three guarantees” policy, with a one-year warranty period for the entire machine (if there are special agreements, the contract or agreement shall prevail). For problems caused by non use reasons during the warranty period, our company can provide free repairs; Any problems caused by usage reasons can be repaired for a fee by our company. The warranty period for repaired parts shall be recalculated from the date of replacement.

If there are problems with the product beyond the warranty period, our company can provide paid repairs, and the warranty period for the repaired parts is 3 months.

For any problems that users encounter during the use of the camera, please contact our technical support in a timely manner, and we will provide you with service as soon as possible.