TPL-CL Series Line Scan Camera User Manual

(V0.3 Jun. 18, 2024)

Hefei I-TEK Optoelectronics Co., Ltd.

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

Revision History

Revision	Date	Description
0.1	2023/11/09	● Initial version
0.2	2024/01/24	● Update exposure time range and spectral response curves ● Add photosensitive band parameter
0.3	2024/06/18	● Merge camera manuals from the same series ● Add camera information of TPL512CL-30KS2 and TPL1KCL-30KS

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%), TPL1KCL-40KS camera requires a current of 1.5A, while other cameras require current of 1.0A.
② Hefei I-TEK Optoelectronics Co., LTD. does not provide external power supply. Users need to connect power supply by themselves.

- **Document**

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

2 Camera Models

- **Camera Product Model**

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

- **Interface Specification**

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

- **Color Form**

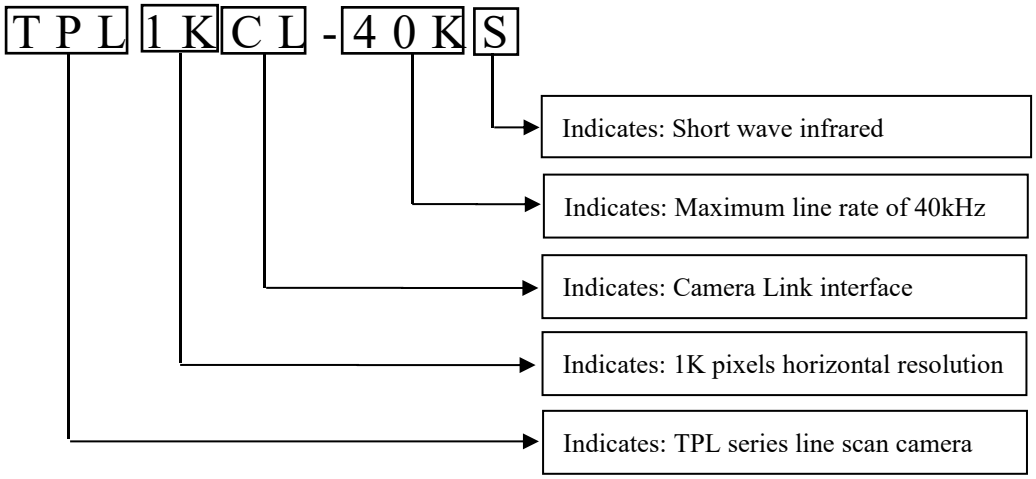
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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

- **Line Rate or Frame Rate**

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

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



3 Product Appearance

TPL512CL/TPL1KCL-30KS:

TPL1KCL-40KS:

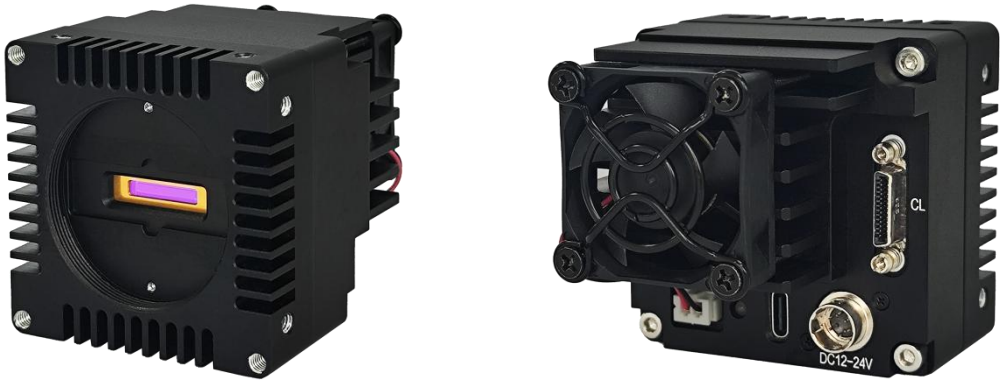


Fig.1 Product Appearance

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-CL series camera is designed for high-speed line scan applications in industrial automation inspection and is developed and manufactured by Hefei I-TEK Optoelectronics Co., LTD.. Camera integrates international leading high-speed linear array image sensor, large-scale field programmable logic gate array parallel processor, and outputs data through Camera Link interface. It also has features of high speed, high sensitivity and low noise.

4.1 Main Features

- Global Shutter InGaAs Sensor
- Maximum Line Rate 40kHz
- High Sensitivity and Low Noise
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Data Format: 8/10/12/14bit
- LUT
- Flat Field Correction
- User-Configurable Scanning Direction
- Analog Gain / Digital Gain / Offset Control
- Real-time Temperature Monitoring
- Thermal Electric Cooling

4.2 Camera Specifications

Table 1 TPL512CL-30KS2 Product Specifications

Model	TPL512CL-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	≥ 59.6dB
SNR	58.9dB
Data Rate	30MB/s
Analog Gain	x1/x2/x5/x11/x17/x25/x50/x100
Analog Offset	0~4095
Digital Gain	0.01~8
Digital Offset	-16383~16383
Lens Mount	M42
Max Line Rate	29.4kHz
Trigger Mode	Free-Run, External Trigger

Trigger Signal	Camera Link CC1
Exposure Control	External PWM, Timed
Exposure Time	0.1us~19982us (step: 0.1us)
Data Format	8/10/12/14bit
Operation Temperature	0~55°C
Data Interface	Camera Link
Pixel Clock	43M/85MHz
Power Supply	DC 12~24V (±10%) 1.0A
Cooling Method	TEC with a external fan
Cooling Performance	About 25 degrees below ambient temperature
Power Consumption	TEC on: 4.1W TEC off: 3.1W
Mechanical	60mm x 60mm x 73.2mm

Table 2 TPL1KCL Product Specifications

Model	**TPL1KCL-30KS**	**TPL1KCL-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	≥ 65.2dB	
SNR	63.1dB	
Data Rate	54MB/s	71MB/s
Analog Gain	x1/x5/x25/x50	
Analog Offset	0~4095	
Digital Gain	0.01~8	
Digital Offset	-16383~16383	
Lens Mount	M42	
Max Line Rate	29.4kHz	40kHz
Trigger Mode	Free-Run, External Trigger	
Trigger Signal	Camera Link CC1	
Exposure Control	External PWM, Timed	
Exposure Time	0.1us~19982us (step: 0.1us)	
Data Format	8/10/12/14bit	
Operation Temperature	0~55°C	
Data Interface	Camera Link	
Pixel Clock	43M/85MHz	
Power Supply	DC 12~24V (±10%) 1.0A	DC 12~24V (±10%) 1.5A

Cooling Method	TEC with a external fan	
Cooling Performance	About 22 degrees below ambient temperature	About 17 degrees below ambient temperature
Power Consumption	TEC on: 4.2W TEC off: 3.1W	TEC on: 10.2W TEC off: 6.0W
Mechanical	60mm x 60mm x 73.2mm	60mm x 60mm x 75.76mm

Note: This table is for 4.1d-1.24 version of TPL-CL series camera specifications, which may vary slightly from version to version.

4.3 Camera Structure

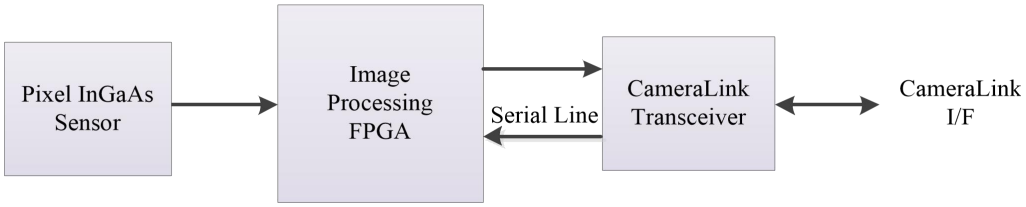


Fig.2 Internal Implementation Structure of Camera

TPL-CL series camera is designed based on high-speed line scan image sensor. The pixel array is uniformly sampled and maintained by global shutter control system, and converted from analog front end to digital signal. After relevant algorithm processing by FPGA, it is transmitted to PC frame grabber through Camera Link interface.

TPL-CL series camera can accept external signal trigger acquisition, and the source is CC1 signal from Camera Link interface.

4.4 Spectral Response

The following is spectral response curve of TPL-CL series camera.

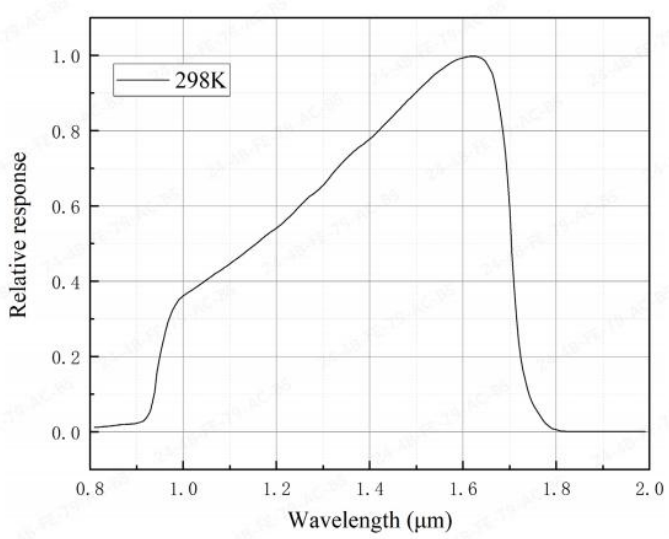


Fig.3 Spectral Response Curve of Camera

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.

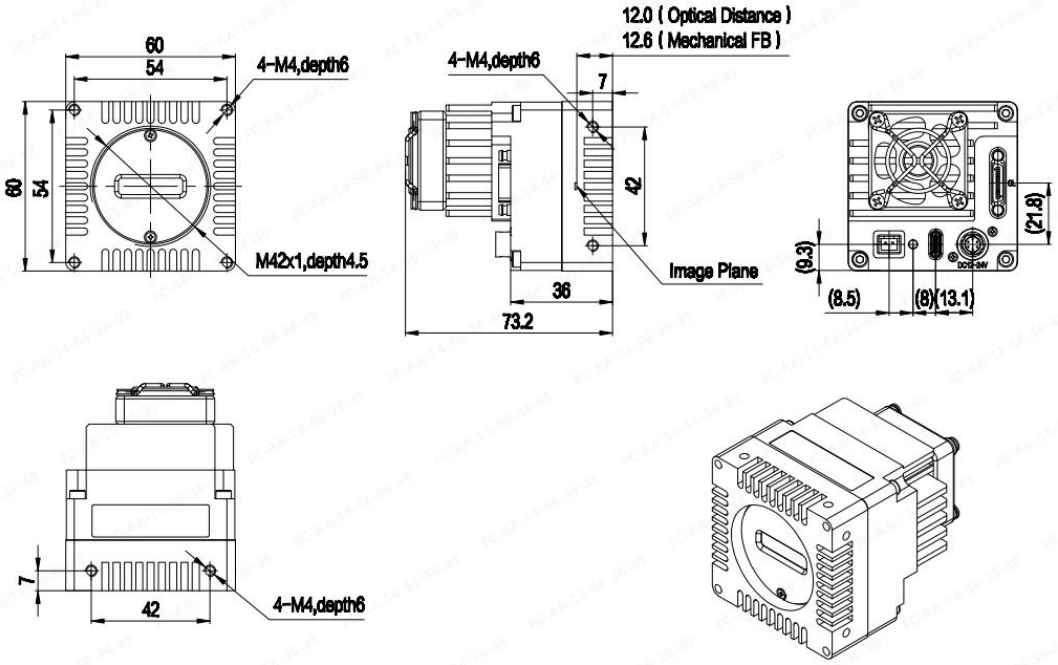
4.6 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

TPL512CL/TPL1KCL-30KS:



TPL1KCL-40KS:

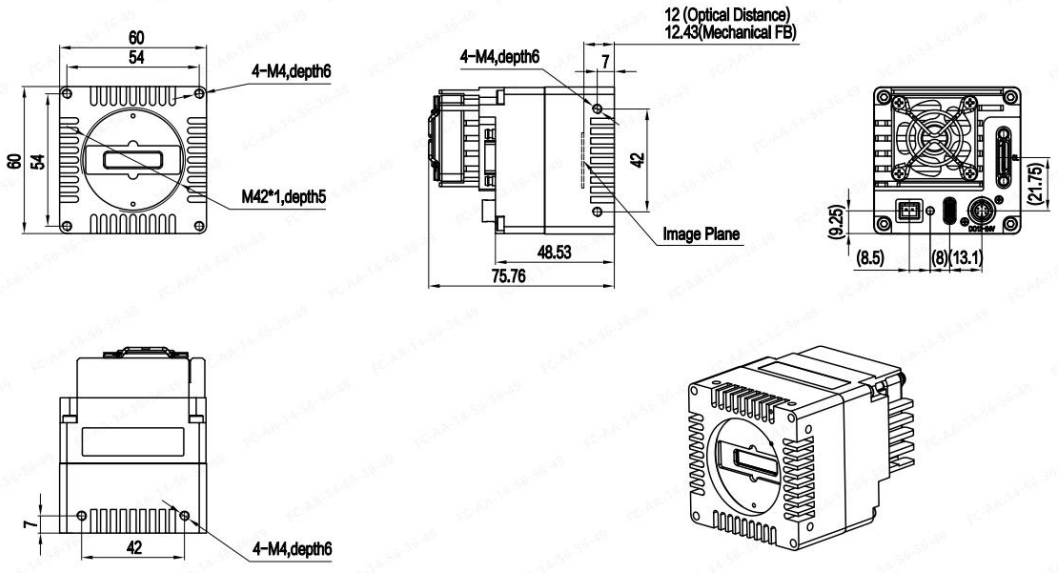


Fig.4 Camera Mechanical Dimensions

5.2 Camera Interface

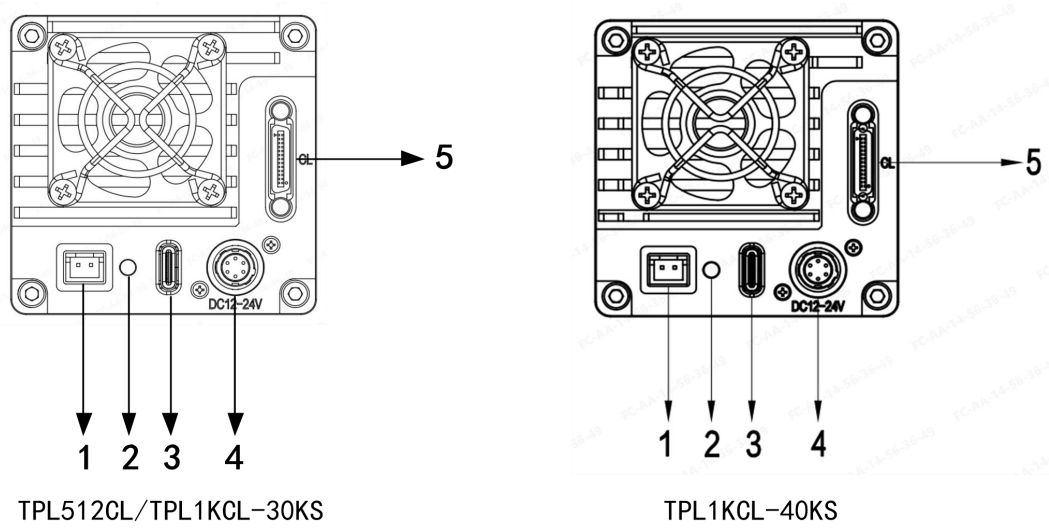


Fig.5 External Interfaces of Camera

① Fan Power Interface
② Camera Status Indicator
③ Type-C Interface
④ 6-pin Power Input
⑤ Camera Link 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 3 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 Interface

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

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

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

Fig.6 Pin Assignments for Power Interface

Table 4 Power Interface Pin Definition

Signal	Pin	Signal	Pin
PWR_VCC	1	PWR_GND	4
PWR_VCC	2	PWR_GND	5
PWR_VCC	3	PWR_GND	6

5.2.3 Data Interface

TPL-CL series camera uses Mini Camera Link interface as data output interface. Mini Camera Link interface is an industry standard interface. The signal definition is as follows:

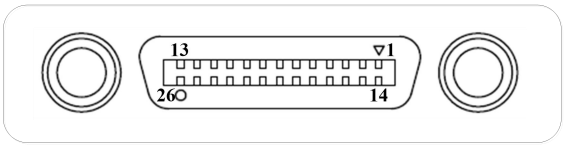


Fig.7 Mini Camera Link Connector

Table 5 Pin Assignments for Mini Camera Link Connector

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	X0-	LVDS-Out	Camera Link Transmitter
	15	X0+	LVDS-Out	Camera Link Transmitter
PAIR 2	3	X1-	LVDS-Out	Camera Link Transmitter
	16	X1+	LVDS-Out	Camera Link Transmitter
PAIR 3	4	X2-	LVDS-Out	Camera Link Transmitter
	17	X2+	LVDS-Out	Camera Link Transmitter
PAIR 4	5	XCLK-	LVDS-Out	Camera Link Transmitter
	18	XCLK+	LVDS-Out	Camera Link Transmitter
PAIR 5	6	X3-	LVDS-Out	Camera Link Transmitter
	19	X3+	LVDS-Out	Camera Link Transmitter
PAIR 6	7	UART_RX+	LVDS-In	Serial Data Receiver
	20	UART_RX-	LVDS-In	Serial Data Receiver
PAIR 7	8	UART_TX-	LVDS-Out	Serial Data Transmitter

	21	UART_TX+	LVDS-Out	Serial Data Transmitter
PAIR 8	9	CC1-	LVDS-In	Software External Trigger
	22	CC1+	LVDS-In	Software External Trigger
PAIR 9	10	CC2+	LVDS-In	Software External Trigger
	23	CC2-	LVDS-In	Software External Trigger
PAIR 10	11	CC3-	LVDS-In	Software External Trigger
	24	CC3+	LVDS-In	Software External Trigger
PAIR 11	12	CC4+	LVDS-In	Software External Trigger
	25	CC4-	LVDS-In	Software External Trigger
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

The corresponding relationship between signals and ports in each output mode is shown in the following table:

Table 6 Port Assignments (1tap @ 8/10/12/14bit)

	8bit	10bit	12bit	14bit
	1tap/8bit	1tap/10bit	1tap/12bit	1tap/14bit
Port A0	A0	A0	A0	A0
Port A1	A1	A1	A1	A1
Port A2	A2	A2	A2	A2
Port A3	A3	A3	A3	A3
Port A4	A4	A4	A4	A4
Port A5	A5	A5	A5	A5
Port A6	A6	A6	A6	A6
Port A7	A7	A7	A7	A7
Port B0	-	A8	A8	A8
Port B1	-	A9	A9	A9
Port B2	-	-	A10	A10
Port B3	-	-	A11	A11
Port B4	-	-	-	A12
Port B5	-	-	-	A13
Port B6	-	-	-	-
Port B7	-	-	-	-

Table 7 Port Assignments (2tap @ 8/10/12bit)

	8bit	10bit	12bit
	2tap/8bit	2tap/10bit	2tap/12bit
Port A0	A0	A0	A0
Port A1	A1	A1	A1
Port A2	A2	A2	A2
Port A3	A3	A3	A3
Port A4	A4	A4	A4
Port A5	A5	A5	A5
Port A6	A6	A6	A6
Port A7	A7	A7	A7
Port B0	B0	A8	A8
Port B1	B1	A9	A9
Port B2	B2	-	A10
Port B3	B3	-	A11
Port B4	B4	B8	B8
Port B5	B5	B9	B9
Port B6	B6	-	B10
Port B7	B7	-	B11
Port C0	-	B0	B0
Port C1	-	B1	B1
Port C2	-	B2	B2
Port C3	-	B3	B3
Port C4	-	B4	B4
Port C5	-	B5	B5
Port C6	-	B6	B6
Port C7	-	B7	B7

6 Camera Features

This chapter introduces the main features of TPL-CL series camera.

6.1 Trigger Mode

TPL-CL series camera supports three trigger modes: Free-Run, External Pulse and External PWM.

6.1.1 Free-Run Mode

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

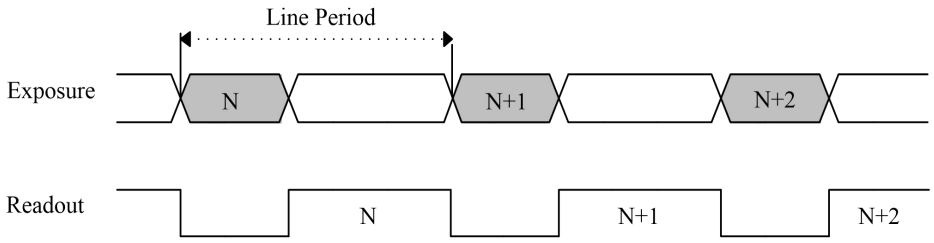


Fig.8 Free-Run Mode

In Free-Run mode, both exposure time and line rate (reciprocal of line period) can be set through commands. It should be noted that line period should be not less than the readout time of one line, and should be greater than the sum of the exposure time and the minimum exposure interval. The camera operation timing is shown in the figure above.

6.1.2 External Pulse Mode

In External Pulse mode, camera starts exposure on the rising edge of external trigger signal, and exposure time is configured by writing registers. At this time, line rate is determined by interval between the rising edges of external trigger pulse.

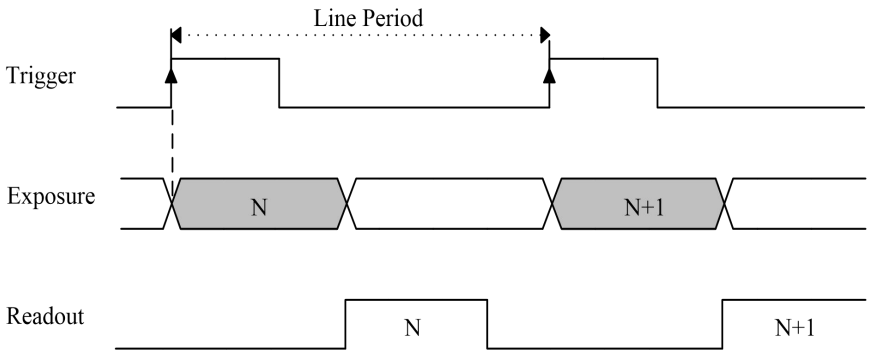


Fig.9 External Pulse Mode

In order to obtain a higher line rate, a new trigger pulse can be initiated to start the next exposure when the camera is reading current line. Since the reading phase of the previous and next lines must not conflict with each other, the external trigger with a line period of less than one-line readout time will be automatically ignored by the camera, which is shown in the figure below.

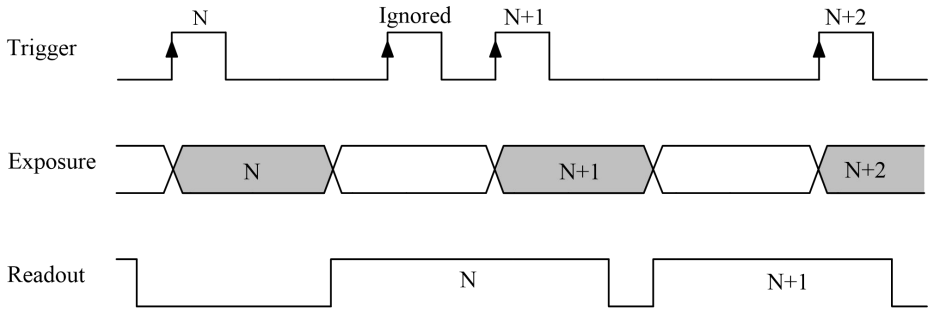


Fig.10 External Trigger Interval is Too Short

6.1.3 External PWM Mode

In this mode, exposure starts on the rising edge of external trigger, and ends on the falling edge, so the exposure time is equal to the high-level duration of the external trigger, and the line period is equal to the pulse interval.

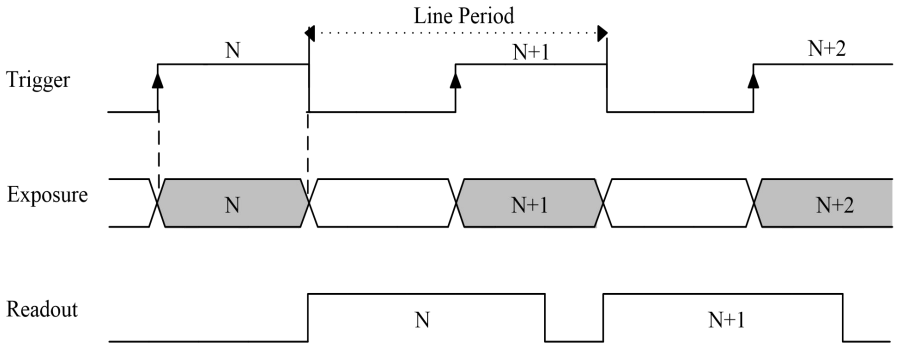


Fig.11 External PWM Mode

In this mode, external trigger high level should ensure a time greater than the minimum exposure time. For pulses lower than this width, camera will treat them as the minimum exposure time.

In this mode, exposure interval must meet the minimum exposure time, so it should last more than the minimum exposure time between falling edge of this external trigger and rising edge of the next external trigger.

If external trigger interval is too short, it will lead to a conflict between readout time of two lines before and after camera. The pulse which does not meet requirements will be ignored inside camera, so that camera can maintain normal operation, as shown in the figure below. The interval between adjacent falling edges should be greater than readout time of each line.

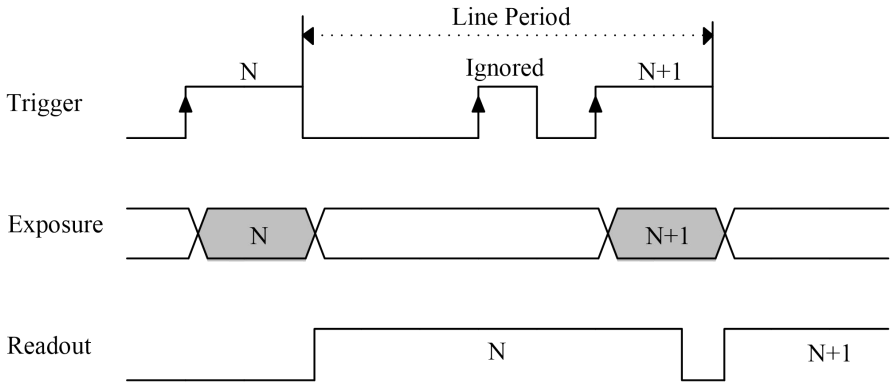


Fig.12 External Trigger Interval is Too Short

6.2 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.

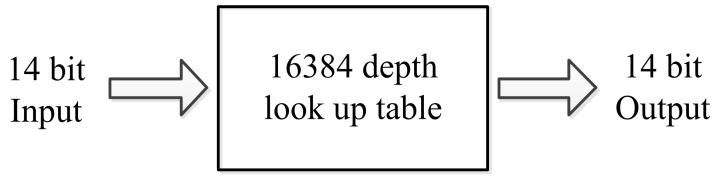


Fig.13 LUT Structure

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

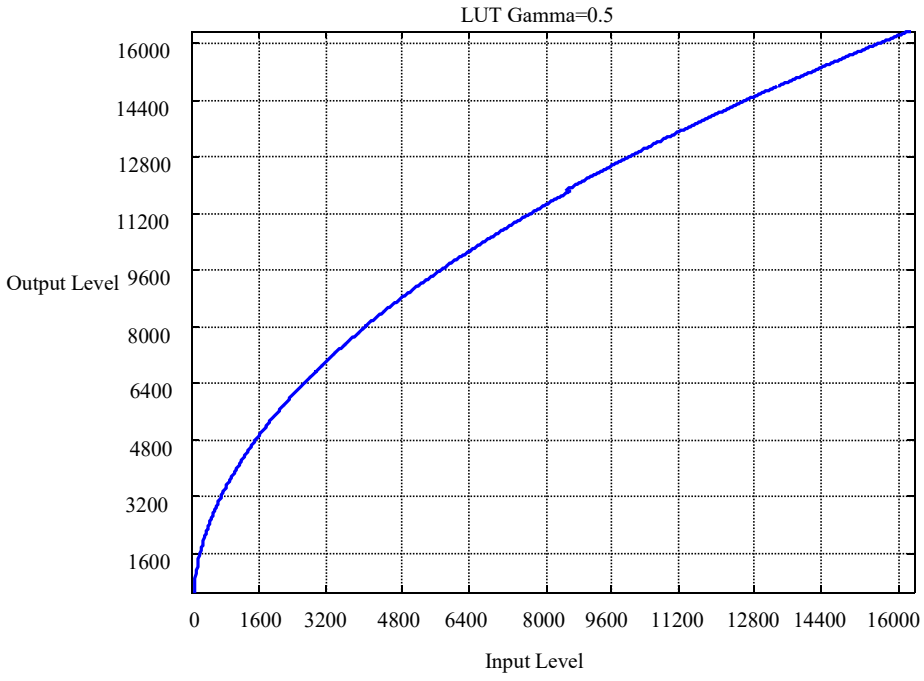
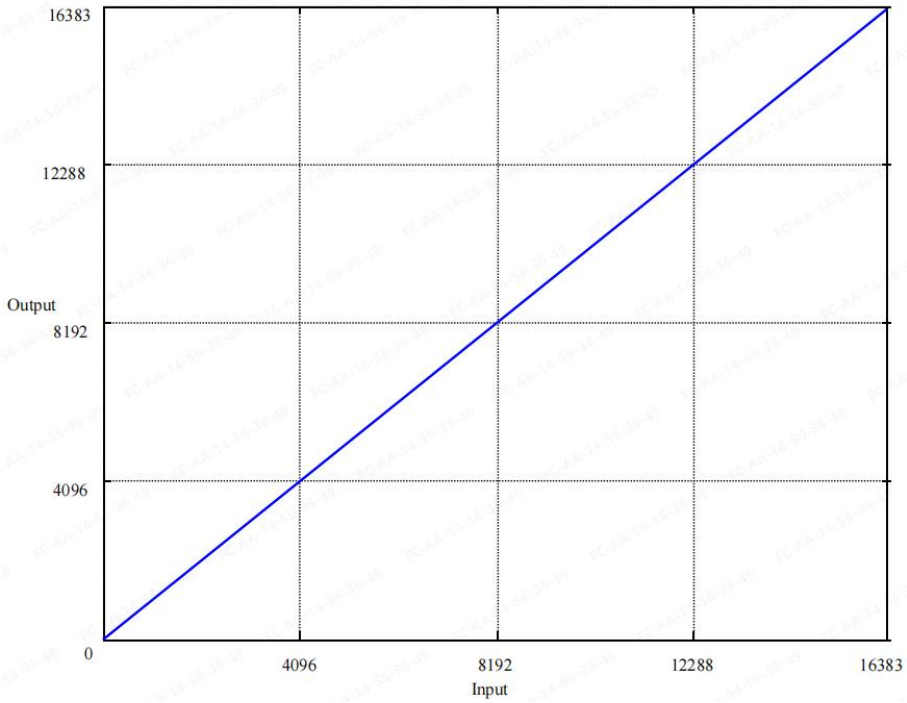


Fig.14 LUT Gamma = 0.5

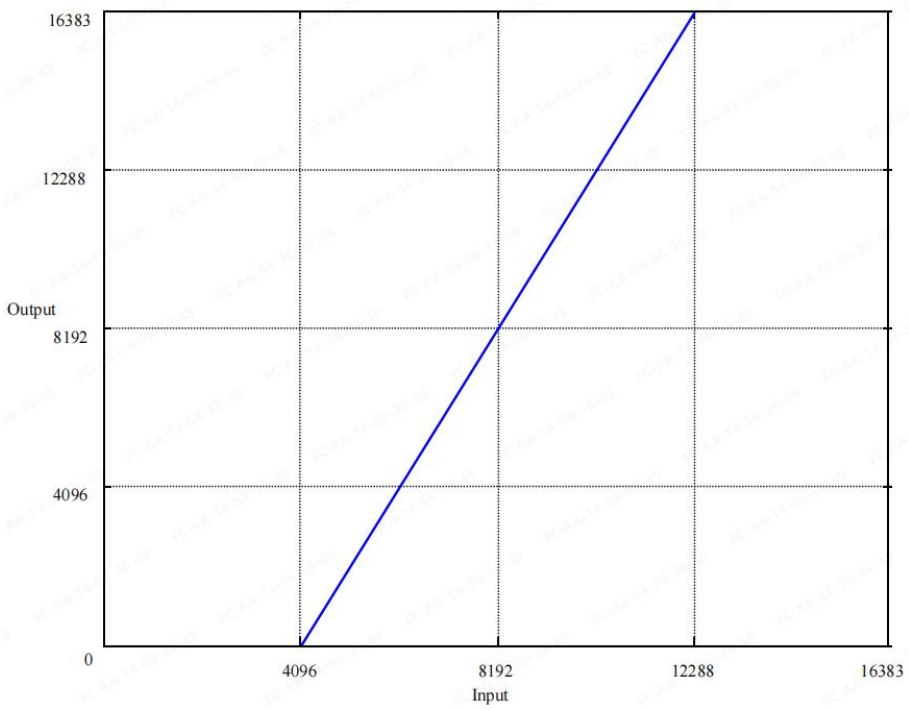
6.3 Contrast

In practical application process, users may need to adjust light and dark areas of image to meet requirement. The contrast function of TPL-CL series camera can meet this need. By modifying contrast parameter, the difference of gray value between light and dark areas can be adjusted. The larger the contrast parameter is, the more obvious light and dark difference is.

For example, when contrast parameter is 4096, if the input gray value is below 4096, the output gray value is 0. If the input gray value is above 12287 (that is the overexposed gray value 16383 minus the contrast parameter 4096), the output gray value is 16383. The effects of light and dark difference is as follows:



(a) Before Adjust Contrast

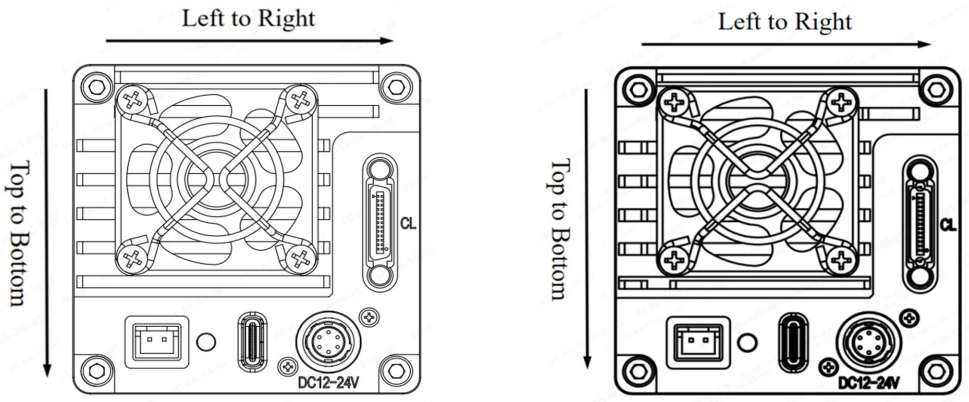


(b) After Adjust Contrast

Fig.15 Contrast Effect

6.4 Camera Scanning Direction

The scanning direction of TPL-CL series camera is horizontal scanning direction and vertical direction. As shown in the figure below:



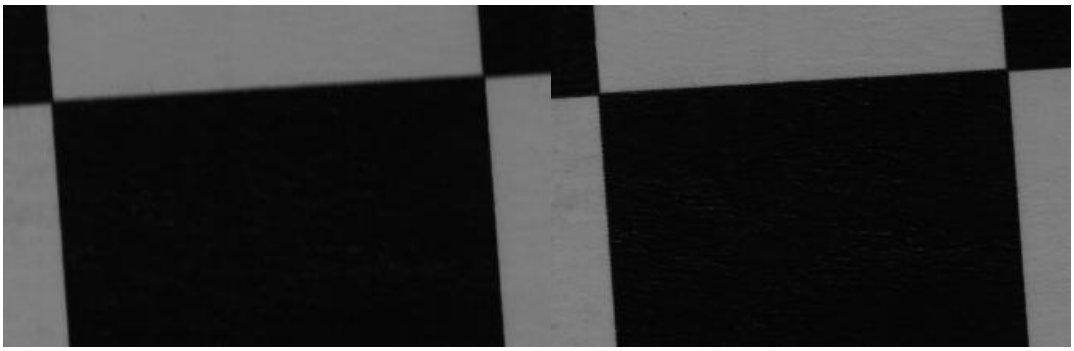
TPL512CL/TPL1KCL-30KS TPL1KCL-40KS

Fig.16 Camera Scanning Direction

The horizontal scanning direction supports both left-to-right and right-to-left directions.

The vertical scanning direction supports outputting images from top to bottom or from bottom to top, which can be controlled internally by the camera or externally via the CC3 signal.

Note: When camera is in multi-line mode and the motion direction does not match, image edge blurring may occur.When camera sets to single line mode, the clarity is not affected by the scanning direction.

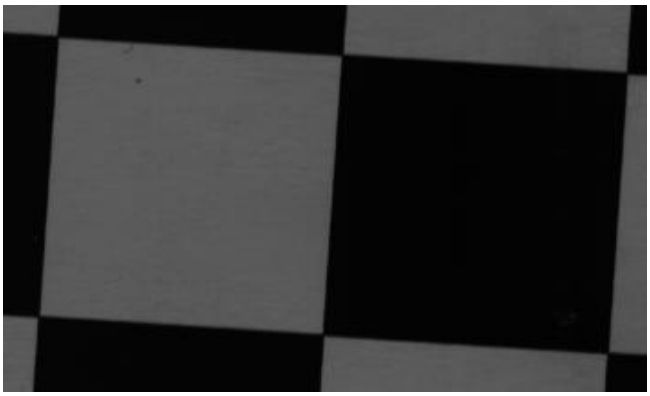


(a) Mismatched Motion Direction **(b) Matched Motion Direction**

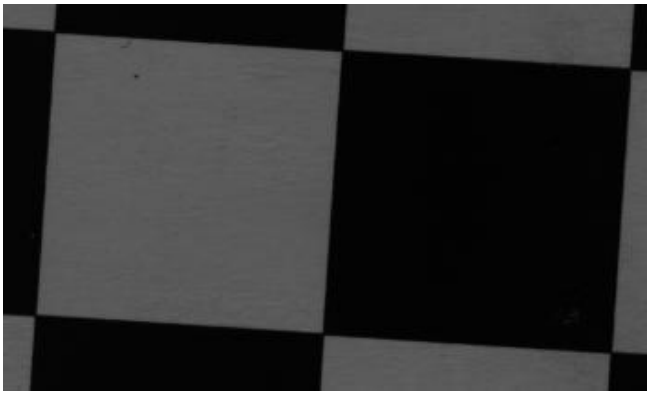
Fig.17 Vertical Scanning Direction

6.5 Time Delay Integration

Cameras using multi-line sensors allow multiple rows of pixels to be exposed at the same position during consecutive exposures, adding their values together to increase pixel response. Averaging multiple rows of pixels can improve the image signal-to-noise ratio. To ensure that multiple rows of pixels are in the same position during consecutive exposures, the image aspect ratio needs to be 1:1, and the vertical scanning direction must be correctly set; otherwise, image edge blurring may occur.



(a) Blurred Edges



(b) Clear Edges

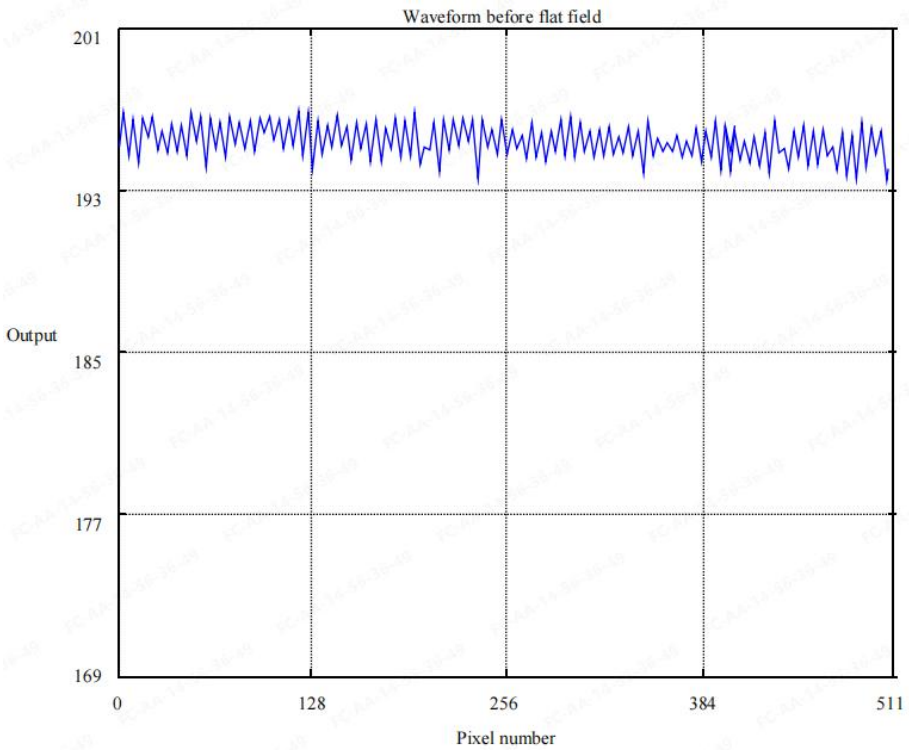
Fig.18 Time Delay Integration

6.6 Flat Field Correction

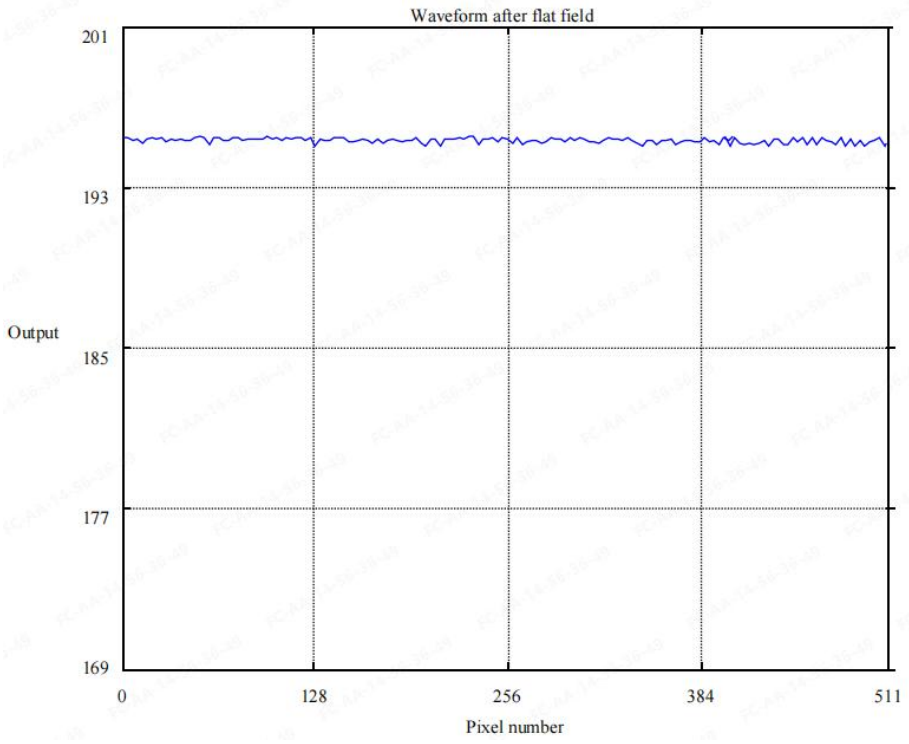
Ideally, when camera imitates a uniform target, gray value of all pixels in resulting image should theoretically be the same. However, values of each pixel in image often vary considerably. These differences may result from uneven illumination, inconsistent light transmittance between lens center and 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: TPL-CL series camera sensor has different responses to light sources of different wavelengths, and factory calibration is performed using flat field calibration across the entire wavelength range of halogen light sources. If users need to use TPL-CL series camera under a fixed wavelength light source, they need to perform flat field calibration again.

(1) TPL512CL camera:

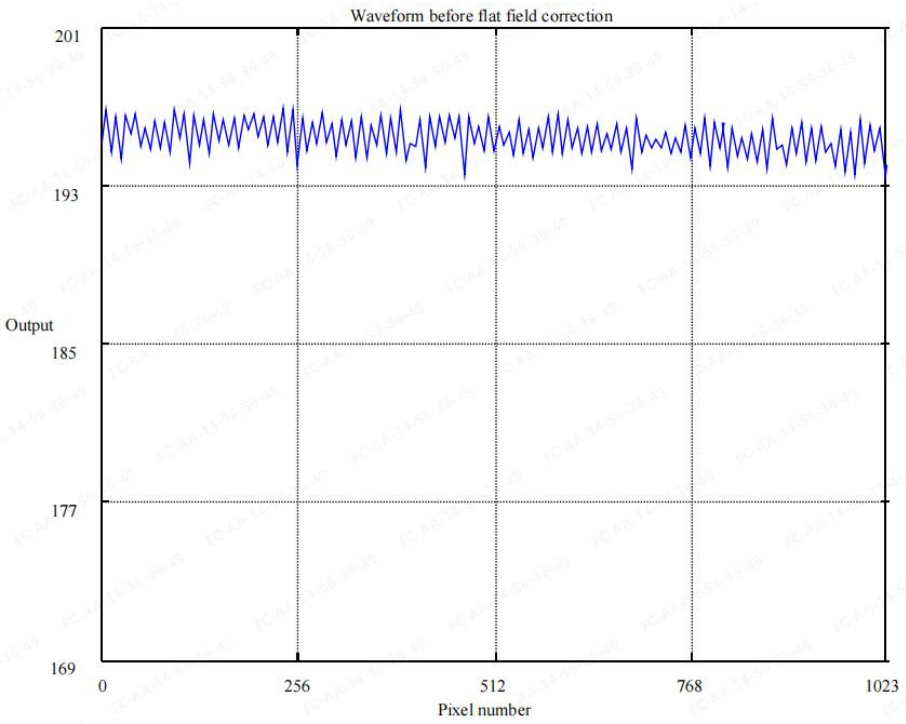


(a) Before Flat Field Correction

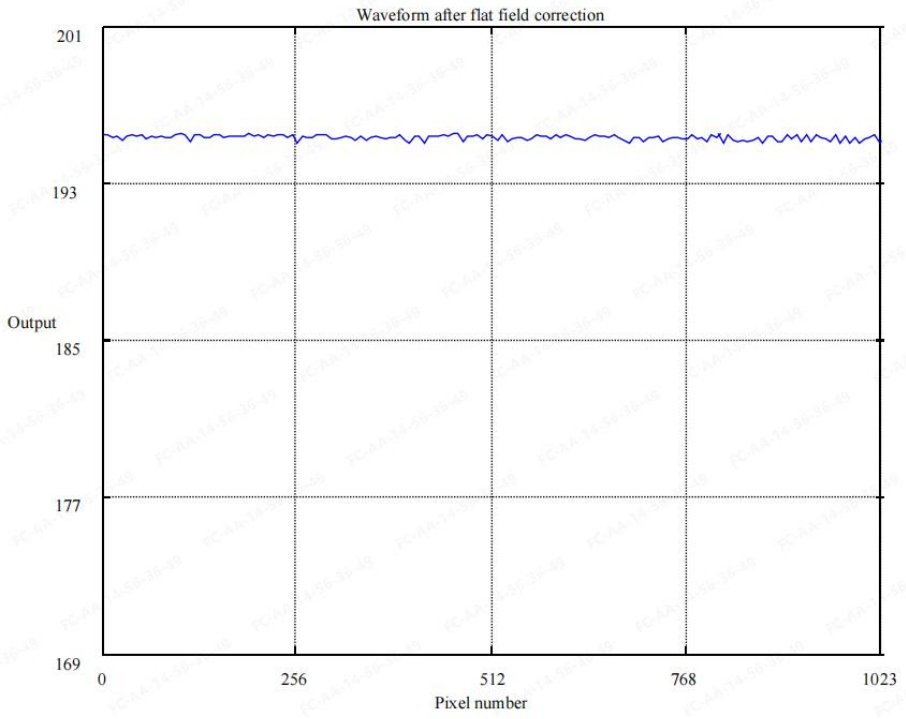


(b) After Flat Field Correction

(2) TPL1KCL camera:



(a) Before Flat Field Correction



(b) After Flat Field Correction

Fig.19 Flat Field Correction Effect

6.7 Test Image

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

- Original image

- Image after correction algorithm
- Test image

Test images are generally used to test whether the data link is unobstructed, making it easier for users to perform various debugging tasks. The following figure shows the oblique stripe scrolling mode, where the output image's horizontal data continuously increases until it reaches its maximum value, and then starts counting again from 0, repeating the cycle.

Fig.20 Test Image

6.8 Data Format

TPL-CL 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.

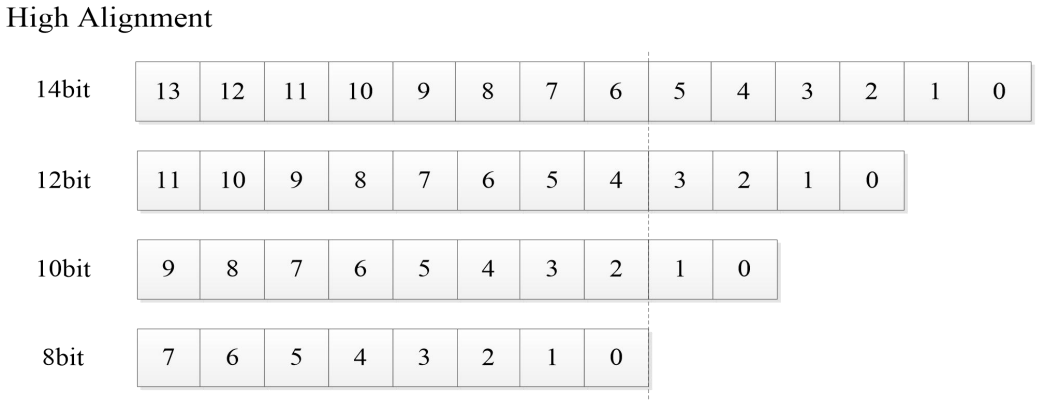


Fig.21 Data Format

6.9 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.

6.10 Camera Temperature

TPL-CL 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.

6.11 Load/Save Configuration

TPL-CL series camera supports multi working parameter sets, including one factory default parameter set and multi 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

TPL-CL series camera supports users to send control commands to the camera through the serial channel of Camera Link interface, and configure the camera working mode.

7.1 Serial Port Parameters

Table 8 Serial Port Parameter

Serial Port Parameter	Value
Baud Rate	9600
Data Bit	8
Parity Bit	None
Stop Bit	1
Flow Control	None

7.2 Command Format

The commands received by the camera have the following two formats depending on whether the command has parameter:

- **Pure command**
  [CMD][CR]
- **Data configuration command**
  [CMD]=[VAL][CR]

After receiving the command, the camera will return message in three formats:

- **Format 1**
  After receiving the general command, the camera will execute the command and return > OK
  For example, input: load=0[CR]
  Output: >Ok[CR]
- **Format 2**
  After receiving the command to read the internal message, the camera will output the corresponding message before >Ok
  For example, input: list[CR]
  Output: >[MEM][CR]>Ok[CR]
- **Format 3**
  After receiving the command to read the internal message, the camera will output the corresponding message before >Ok
  For example, input: clnk[CR]
  Output: >[VAL][CR]>Ok[CR]

Note:

[CMD] Command, 4byte
[VAL] Data, no more than 4 decimal digits
[MEM] Memory data
[CR] 0x0D, enter

If the input command is in wrong format, an error code will be returned in stead of Ok, as shown in the table below:

Table 9 Error Codes Returned upon Failure of Command Execution

Return Code	Description
Ok	Correct
0	Correct, Equivalent to Ok
128	Command does not exist
130	Conflict with other parameters
131	Parameter value is out of range or does not meet requirements
132	Command is not allowed to be executed in the current status
133	Input command syntax error

7.3 Command List

The list of serial commands supported by TPL-CL series camera is as follows. After connecting the camera through serial port, you can input relevant commands to configure the camera.

Table 10 TPL512CL-30KS Camera Instruction List

Command	Description
help	Show this information
list	Show Current Configurations
load	Load Configuration From Flash 0/1/2: Factory/User1/User2
save	Save Current Configuration To Flash 1/2: User1/User2
temp	Get Current Camera Temperature
fsyn	Set Frame Sync Mode (0/1/2: Internal Free Run/External Pulse/External PWM)
anos	Set Camera Analog Offset (0~4095)
angn	Set Camera Analog Gain (0/1/2/3/4/5/6/7:X1/X2/X5/X11/X17/X25/X50/X100)
pclk	Set Camera Link Pixel Clock (0/1: 43/85 MHz)
clpr	Set Camera Link Protocol (0/1: Standard/I-Tek protocol)
clnk	Set Camera Link Mode (0/1/2/3/4/5/6/: 1tap@8/10/12/14bit,2tap@8/10/12bit)
tmax	Enable Max Exposure Time (0/1: Disable/Enable)
texp	Set Exposure Time in microsecond (0.058824us to 1s)
tprd	Set Line Period Time in microsecond (34us to 20ms)
dmod	Set Data Mode (0/1/2/3: Original/Corrected/Pattern_1/Pattern_2)
dign	Set Digital Gain x0.01~x8.0
dios	Set Digital Offset (-16383 to +16383)
hdir	Set Horizontal Scan Direction (0/1: Left to Right/Right to Left)
vdir	Set vertical Scan Direction (0/1: Top to Down/Down to Top)
vext	Set Vertical Scan Direction External Control (0/1/2: Internal/CC3 High/CC3 Low)
rics	Set ROI Window Start Column Address (0~504) (multiples of 8)
ricc	Set ROI Window Column Count (256~512) (multiples of 8)

bpcr	Bad Pixel Correction (0/1: Disable/Enable)
bplt	List Bad Pixel Array
adbp	Add A New Bad Pixel into Camera (column)
rmbp	Remove A Bad Pixel from Camera (column)
bpsv	Save the defect pixel list as a user list to the non-volatile memory of the device.
bpcl	Clear all defect pixels from RAM.
ctst	Set Contrast Parameter (0 to 8191)
ffcr	Flat Field Correction (0/1: Disable/Enable)
ffcl	Flat Field Correction Calibration (0/1: Init/Calibrate)
dscl	Dark Signal Non-uniformity Correction Start.
dsnu	DSNU Noise Correction (0/1 Disable/Enable)
dscr	Dark signal non-uniformity correction reset.
rffp	Readout Flat Field Correction Data
wffp	Write Flat Field Correction Data (addr,data)
enlt	Look up Table (0/1 Disable/Enable)
rlut	Readout Current Look up Table
wlut	Write Current Look up Table Data (addr,data)
ftpr	Set Trigger Input Polarity (0/1: rising/falling edge)
tgdp	Set input line debouncing period in microsecond(0~1000us)
tftd	Set Frame Trigger Delay in microsecond (0~65000us)
envt	TEC Cooler Control (0/1: Disable/Enable)
tset	Set Sensor Temperature (0~40C)
baud	Set Camera Link Serial Port Baudrate (4800~460800bps)
lmod	Select output type(0/1/2: Sum/Line1/Line2)
ldly	Set Line Delay to Correct Chromatic Aberration(0 to 2.0)

Table 11 TPL1KCL-30KS Camera Instruction List

Command	Description
help	Show this information
list	Show Current Configurations
load	Load Configuration From Flash 0/1/2: Factory/User1/User2
save	Save Current Configuration To Flash 1/2: User1/User2
temp	Get Current Camera Temperature
fsyn	Set Frame Sync Mode (0/1/2: Internal Free Run/External Pulse/External PWM)
anos	Set Camera Analog Offset (0~4095)
angn	Set Camera Analog Gain (0/1/2/3/4/5/6/7:X1/X2/X5/X11/X17/X25/X50/X100)
pclk	Set Camera Link Pixel Clock (0/1: 43/85 MHz)
clpr	Set Camera Link Protocol (0/1: Standard/I-Tek protocol)
clnk	Set Camera Link Mode (0/1/2/3/4/5/6/: 1tap@8/10/12/14bit,2tap@8/10/12bit)
tmax	Enable Max Exposure Time (0/1: Disable/Enable)
texp	Set Exposure Time in microsecond (0.058824us to 1s)

tprd	Set Line Period Time in microsecond (34us to 20ms)
dmod	Set Data Mode (0/1/2/3: Original/Corrected/Pattern_1/Pattern_2)
dign	Set Digital Gain x0.01~x8.0
dios	Set Digital Offset (-16383 to +16383)
hdir	Set Horizontal Scan Direction (0/1: Left to Right/Right to Left)
rics	Set ROI Window Start Column Address (0~1016) (multiples of 8)
ricc	Set ROI Window Column Count (256~1024) (multiples of 8)
bpcr	Bad Pixel Correction (0/1: Disable/Enable)
bplt	List Bad Pixel Array
adbp	Add A New Bad Pixel into Camera (column)
rmbp	Remove A Bad Pixel from Camera (column)
bpsv	Save the defect pixel list as a user list to the non-volatile memory of the device.
bpcl	Clear all defect pixels from RAM.
ctst	Set Contrast Parameter (0 to 8191)
ffcr	Flat Field Correction (0/1: Disable/Enable)
ffcl	Flat Field Correction Calibration (0/1: Init/Calibrate)
dscl	Dark Signal Non-uniformity Correction Start.
dsnu	DSNU Noise Correction (0/1 Disable/Enable)
dscr	Dark signal non-uniformity correction reset.
rffp	Readout Flat Field Correction Data
wffp	Write Flat Field Correction Data (addr,data)
enlt	Look up Table (0/1 Disable/Enable)
rlut	Readout Current Look up Table
wlut	Write Current Look up Table Data (addr,data)
ftpr	Set Trigger Input Polarity (0/1: rising/falling edge)
tgdp	Set input line debouncing period in microsecond(0~1000us)
tftd	Set Frame Trigger Delay in microsecond (0~65000us)
envt	TEC Cooler Control (0/1: Disable/Enable)
tset	Set Sensor Temperature (0~40C)
baud	Set Camera Link Serial Port Baudrate (4800~460800bps)

Table 12 TPL1KCL-40KS Camera Instruction List

Command	Description
help	Show this information
list	Show Current Configurations
load	Load Configuration From Flash 0/1/2: Factory/User1/User2
save	Save Current Configuration To Flash 1/2: User1/User2
temp	Get Current Camera Temperature
fsyn	Set Frame Sync Mode (0/1/2: Internal Free Run/External Pulse/External PWM)
anos	Set Camera Analog Offset (0~4095)
angn	Set Camera Analog Gain (0/1/2/3:X1/X5/X25/X50)

pclk	Set Camera Link Pixel Clock (0 to 4: 43/85MHz
clpr	Set Camera Link Protocol (0/1: Standard/I-Tek protocol)
clnk	Set Camera Link Mode (0/1/2/3/4/5/6/: 1tap@8/10/12/14bit,2tap@8/10/12bit)
texp	Set Exposure Time in microsecond (2us to 1s)
tprd	Set Line Period Time in microsecond (25us to 10s)
dmod	Set Data Mode (0/1/2/3: Original/Corrected/Pattern_1/Pattern_2)
dign	Set Digital Gain x0.01~x8.0
dios	Set Digital Offset (-16383 to +16383)
hdir	Set Horizontal Scan Direction (0/1: Left to Right/Right to Left)
rics	Set ROI Window Start Column Address (0~1016) (multiples of 8)
ricc	Set ROI Window Column Count (256~1024) (multiples of 8)
ffcr	Flat Field Correction (0/1: Disable/Enable)
ffcl	Flat Field Correction Calibration (0/1: Init/Calibrate)
rffp	Readout Flat Field Correction Data
wffp	Write Flat Field Correction Data (addr,data)
enlt	Look up Table (0/1 Disable/Enable)
rlut	Readout Current Look up Table
wlut	Write Current Look up Table Data (addr,data)
ftpr	Set Trigger Input Polarity (0/1: rising/falling edge)
tgdp	Set input line debouncing period in microsecond(0~1000us)
tftd	Set Frame Trigger Delay in microsecond (0~65535us)
envt	TEC Cooler Control (0/1: Disable/Enable)
tset	Set Sensor Temperature (0~40C)
baud	Set Camera Link Serial Port Baudrate (4800~460800bps)
ctst	Set Contrast Parameter (0 to 8191)

8 Camera Configure

Hefei I-TEK Optoelectronics Co., LTD. has implemented a library IKapC.lib for camera configuration based on Gen<i>Cam standard, which allows users to use all Hefei I-TEK Optoelectronics Co., LTD. cameras based on IKapC.lib without re-writing codes for each camera. For more information about IKapC.lib, please refer to IKapC user manual.

Hefei I-TEK Optoelectronics Co., LTD. provides visual camera feature configuration tool IKapCViewer.exe. The following shows how to configure the supported camera features. For more information about IKapCViewer.exe, please refer to IKapCViewer user manual.

8.1 Device Control Category

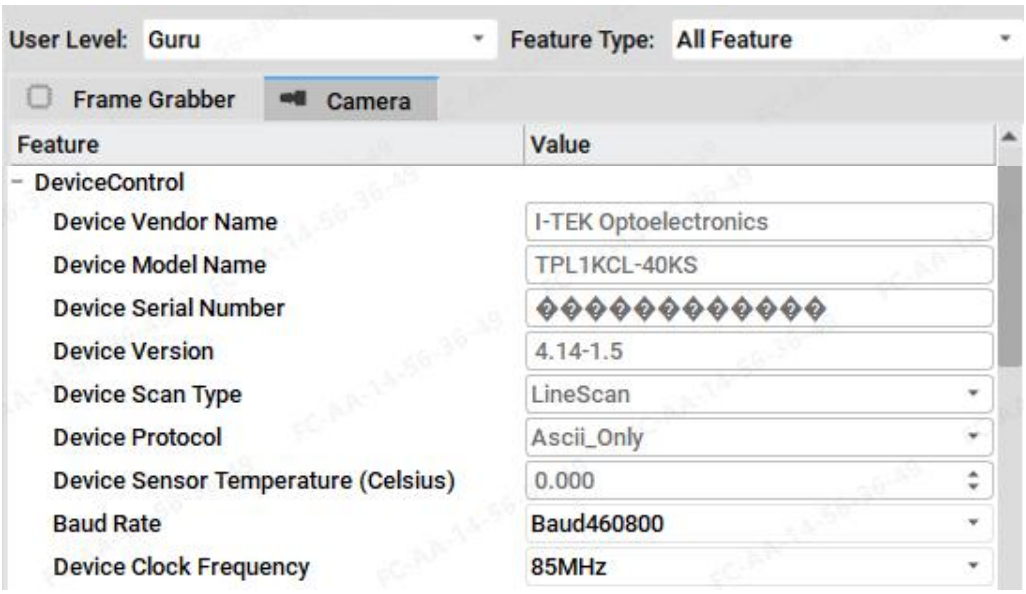


Fig.22 Device Control Category

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceVersion**
  Device version.

- **DeviceScanType**
  Device scan type.

- **DeviceProtocol**
  Device protocol.

- **DeviceSensorTemperature**
  Sensor temperature.

- **DeviceSerialPortBaudRate**
  Device serial port rate. The enumeration names as follows:
  - Baud9600
  - Baud19200
  - Baud38400
  - Baud57600
  - Baud115200
  - Baud230400
  - Baud460800

- **DeviceClockFrequency**
  Device clock frequency. The enumeration names as follows:
  - 43MHz
  - 85MHz

8.2 Image Format Control Category

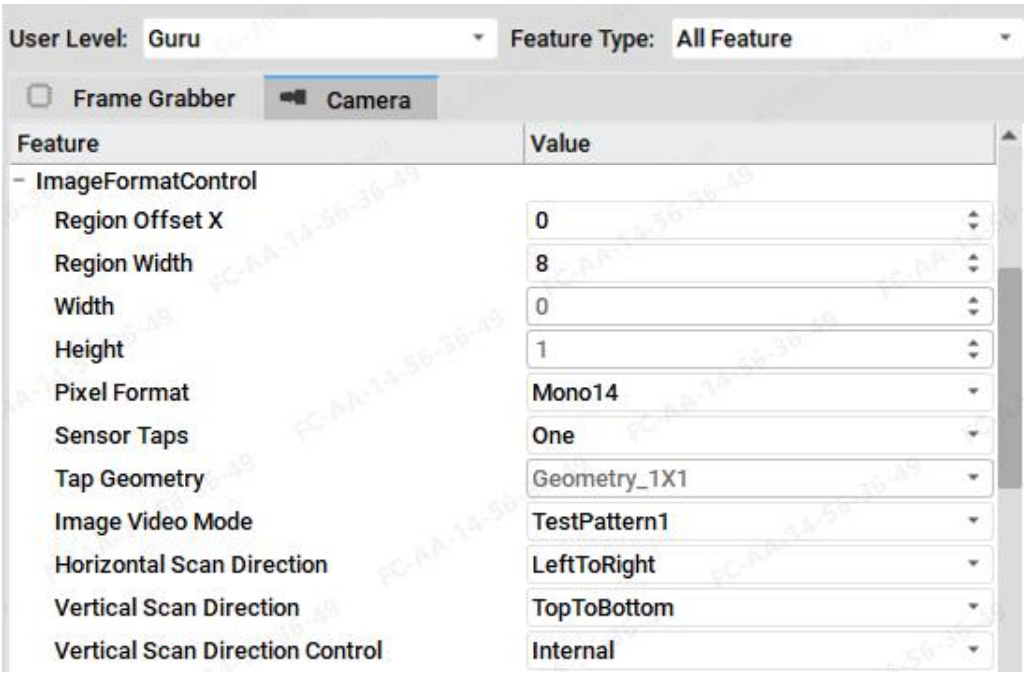


Fig.23 Image Format Control Category

- **RegionOffsetX**
  ROI horizontal offset.

- **RegionWidth**
  ROI width.

- **Width**
  Actual width of output image.

- **Height**
  Actual height of output image.

- **PixelFormat**
  Pixel format. The enumeration names as follows:
  - Mono8: Monochrome 8bit
  - Mono10: Monochrome 10bit
  - Mono12: Monochrome 12bit
  - Mono14: Monochrome 14bit

- **SensorTaps**
  Number of sensor taps. The enumeration names as follows:
  - One
  - Two

- **DeviceTapGeometry**
  Tap arrangement.

- **VideoMode**
  Output image mode. The enumeration names as follows:
  - Original: Original image
  - Corrected: Corrected image
  - TestPattern1: Test image

- **HorizontalScanDirection**
  Horizontal scanning direction. The enumeration names as follows:
  - LeftToRight: From left to right
  - RightToLeft: From right to left

- **VerticalScanDirection**
  Vertical scanning direction. The enumeration names as follows:
  - TopToBottom: From top to bottom
  - BottomToTop: From bottom to top

- **VerticalScanDirectionControl**
  Vertical scanning direction control source. The enumeration names as follows:
  - Internal: Internal control

- CC3Positive: CC3 high level signal
- CC3Negative: CC3 low level signal

8.3 Acquisition Control Category

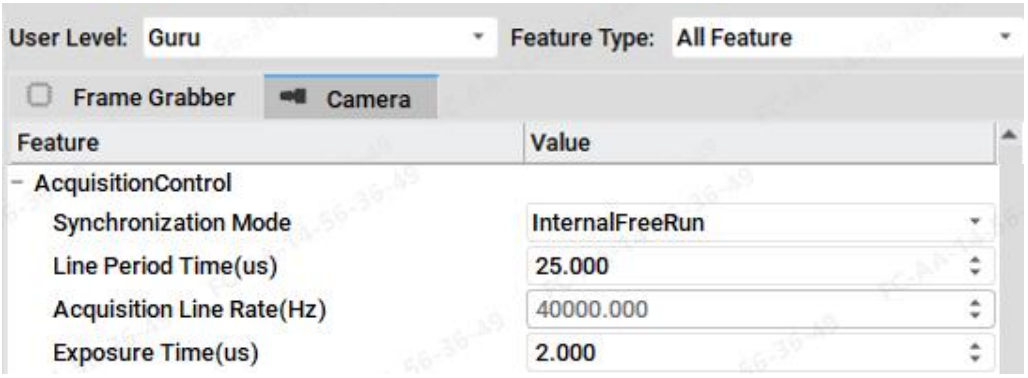


Fig.24 Acquisition Control Category

- **SynchronizationMode**

  Synchronization mode. The enumeration names as follows:
  - InternalFreeRun: Free-Run
  - ExternalPulse: External pulse
  - ExternalPWM: External PWM

- **LinePeriodTime**

  Acquisition line period, unit is us.

- **AcquisitionLineRate**

  Acquisition line rate, unit is Hz.

- **ExposureTime**

  Exposure time, unit is us.

8.4 IO Control Category

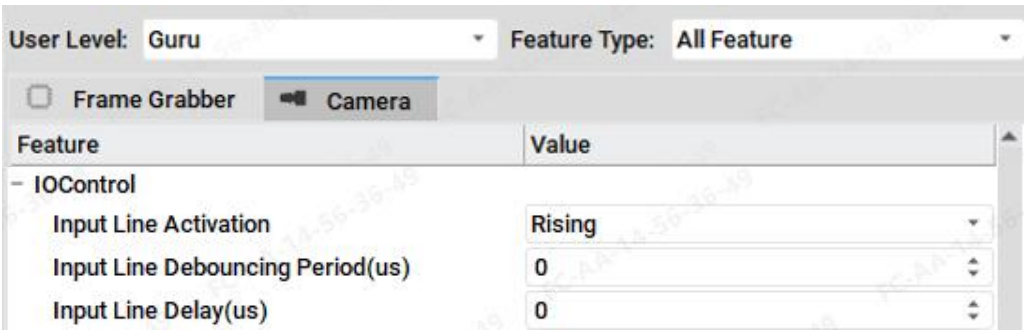


Fig.25 IO Control Category

- **InputLinePolarity**

Trigger polarity. The enumeration names as follows:

- Rising: Trigger at rising edge
- Falling: Trigger at falling edge

- **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.

- **InputLineDelay**

Trigger time delay.

8.5 Analog Control Category

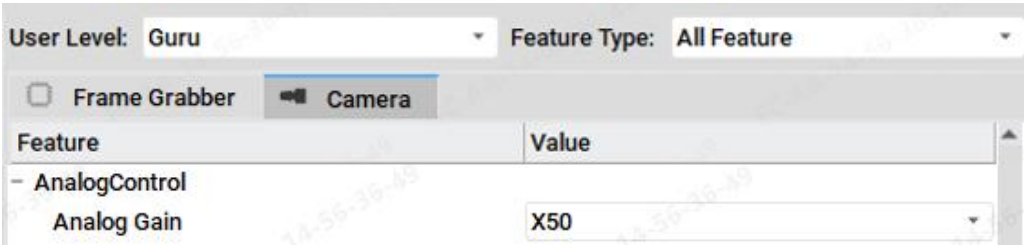


Fig.26 Analog Control Category

- **AnalogGain**

Analog gain. The enumeration names as follows:

- X1
- X5
- X25
- X50

8.6 Digital Control Category

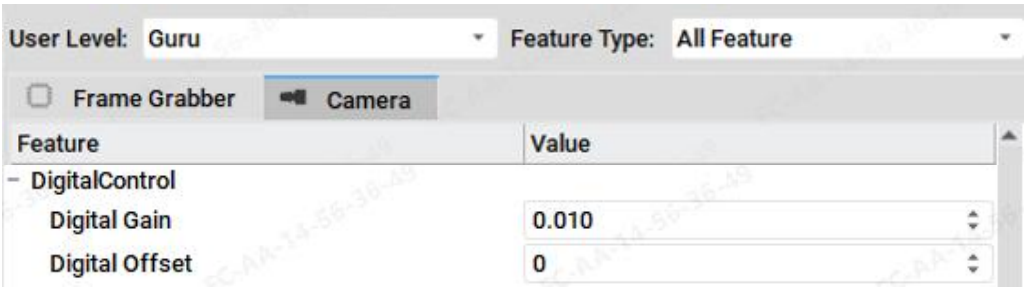


Fig.27 Digital Control Category

- **DigitalGain**

Digital gain.

- **DigitalOffset**

Digital offset.

8.7 LUT Control Category

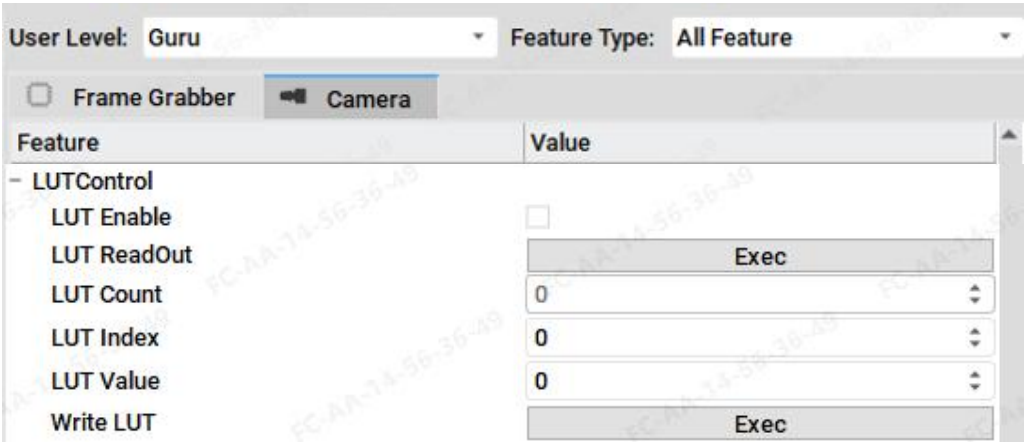


Fig.28 LUT Control Category

- **LUTEnable**
  Enable LUT function.

- **LUTReadOut**
  Read out LUT data.

- **LUTCount**
  The number of lookup table.

- **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.

- **LUTWrite**
  Write into LUT data.

8.8 Flat Field Correction Category

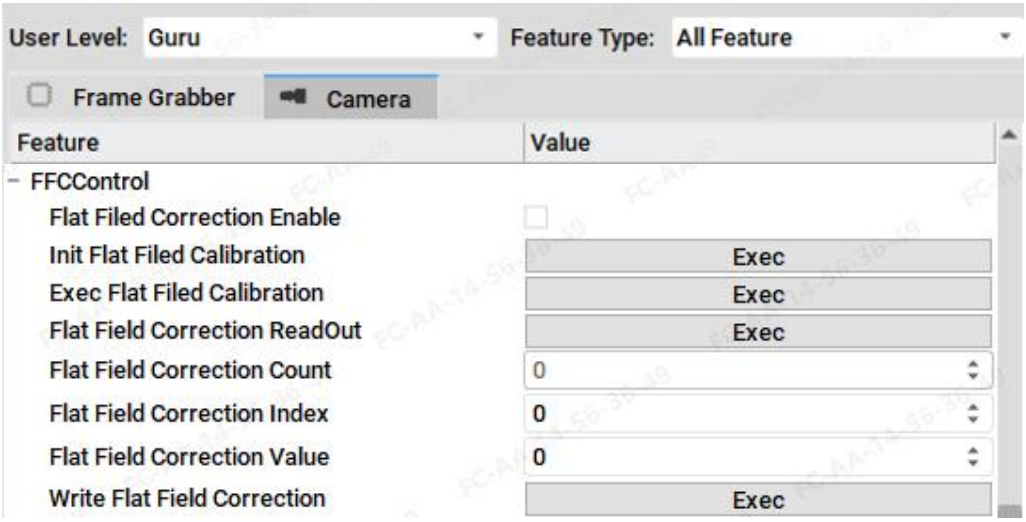


Fig.29 Flat Field Correction Category

- **FFCEnable**
  Enable flat field correction.

- **FFCInit**
  Initialize flat field correction.

- **FFCExec**
  Execute flat field correction.

- **FFCReadOut**
  Read out flat field correction parameter.

- **FFCCount**
  The number of flat field correction configuration.

- **FFCIndex**
  The index of flat field correction configuration.

- **FFCValue**
  The value of flat field correction data.

- **FFCWrite**
  Write into flat field correction parameter.

8.9 TEC Control Category

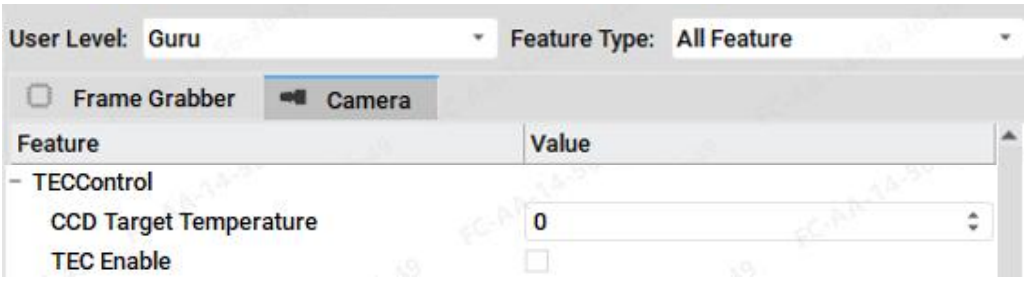


Fig.30 TEC Control Category

- **CCDTargetTemperature**
  TEC target temperature.

- **TECEnable**
  Enable TEC function.

8.10 User Set Control Category

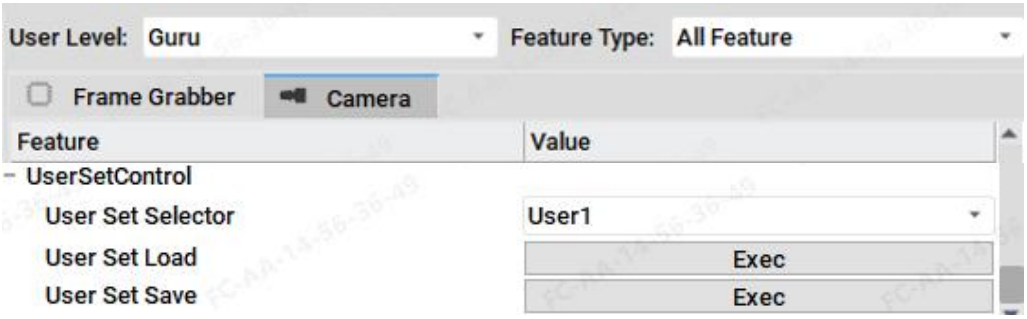


Fig.31 User Set Control Category

- **UserSetSelector**
  User configuration selector. The enumeration names as follows:
  - Factory: Factory configuration
  - User1: User configuration 1
  - User2: User configuration 2

- **UserSetLoad**
  Load selected camera configuration.

- **UserSetSave**
  Save selected camera configuration.

9 FAQ

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

① Ensure that the Camera Link interface cable is OK.
② Ensure that Base and Medium/Full configurations of the Camera Link interface are not reversed.
③ Ensure that the serial port channel parameters in the Camera Link interface are set correctly.

- **If the Camera Link interface cannot receive camera clock signal,**

① Ensure that the camera has started properly (i.e. the status indicator should be normally green).
② If a third-party frame grabber is used to acquire images, ensure that the frame grabber and supporting software are operating properly, which can be checked by restarting the computer.
③ Ensure that Base and Medium configurations of the Camera Link interface are not reversed.
④ Ensure that the Camera Link interface cable is OK.

- **If the camera has no image output in External Pulse 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).
③ If the Camera Link interface CC1 signal is used as the trigger input signal, ensure that the frame grabber is configured correctly.

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

① Ensure that the voltage range of external connected power supply is normal.
② If the case is hot or the camera is smoking, cut off the power immediately and stop using the camera. 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 is 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 whether the Camera Link interface is normal 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 Pulse mode by the camera indicator.

If you 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.