(T)PH16KCXP12 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	2022/06/30	● Initial version
0.2	2022/12/19	● Add camera information
0.3	2023/02/11	● Update company address
0.4	2023/08/02	● Update chapter 7 ● Add description of trigger rescale and area mode
0.5	2023/10/07	● Add exposure time and frame rate setting function of area mode ● Update analog gain parameter range
0.6	2024/02/27	● Add information of TPH16KCXP12-250KT camera
0.7	2024/10/22	● Add UV version camera information
0.8	2025/02/24	● Update maximum line rate ● Update the register list

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%). The current of non-TEC camera must be 2.0A, and the current of TEC camera must be 3.5A.
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**

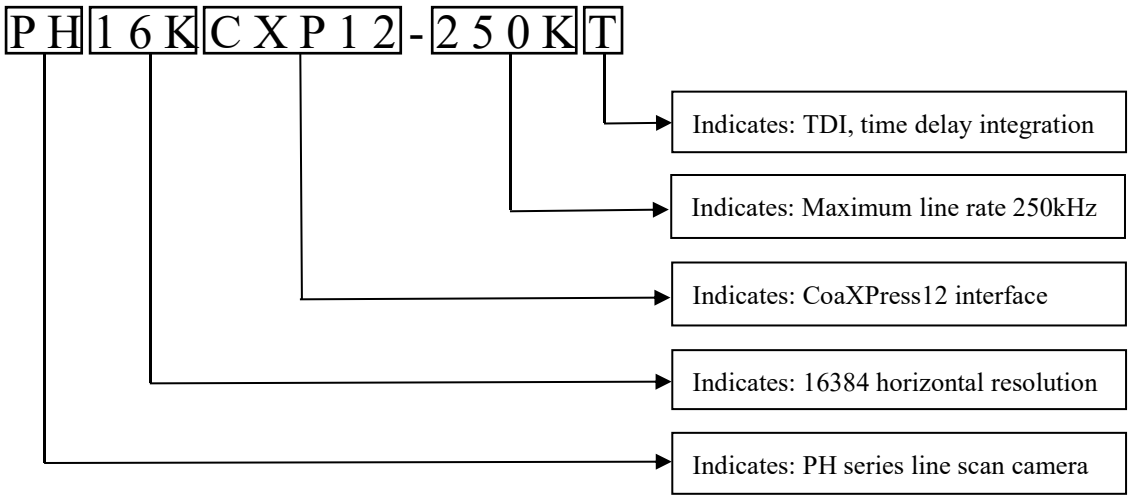
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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: 16K 256-line monochrome TDI line scan camera



3 Product Appearance

- PH16KCXP12 camera:

- TPH16KCXP12 camera:

Fig.1 Product Appearance

Note:

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

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

4 Product Specifications

(T)PH16KCXP12 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.. The camera integrates international leading high-speed linear array image sensor, large-scale field programmable logic gate array parallel processor, and external output data through CoaXPress interface. It also has features of high speed, high sensitivity and low noise.

4.1 Main Features

- Backshot CCD Sensor
- 16384 Horizontal Resolution
- Maximum Line Rate 280kHz
- High Sensitivity and Low Noise
- Minimum Exposure Time: 4us Exposure Time Step: 0.01us
- Pixel Format 8/10/12bit
- Analog Gain / Digital Gain / Digital Offset
- Scanning Direction Configurable
- Trigger Rescale
- Area Mode
- LUT
- Flat Field Correction
- Real-time Temperature Monitoring
- Thermal Electric Cooling - about 17 degrees below ambient temperature

4.2 Camera Specifications

Table 1 (T)PH16KCXP12-250KT Product Specifications

Model	PH16KCXP12-250KT	TPH16KCXP12-250KT
Product Description	16K 256-line monochrome TDI line scan camera	
Resolution	16384 x 256	
Pixel Size	5um x 5um	
Sensor Type	Backshot CCD	
Image Type	Monochrome	
Sensor Size	81.92 mm	
Dynamic Range	≥ 53.7dB	
SNR	43.1dB	
Lens Mount	M95	
Max Line Rate	280.9kHz@8bit, 234.7kHz@10bit, 198.0kHz@12bit	
Analog Gain	x1/x2/x4/x8	
Digital Gain	0.001~7.998	
Digital Offset	-4095~4095	
Trigger Mode	Free-Run, External Pulse	

Trigger Signal	External IO/CXP	
Exposure Control	External PWM, Timed	
Exposure Time	4us~1s (step: 0.01us)	
Data Format	8/10/12bit	
Operation Temperature	0~65℃	
Data Interface	CoaXPress12	
Data Rate	4079MB/s	
Power Supply	DC 12~24V (±10%) 2.0A	DC 12~24V (±10%) 2.0A
Power Consumption	15.1W	TEC off: 17.0W TEC on: 43.0W
Mechanical Dimensions	99mm x 99mm x 71mm	103.5mm x 103.5mm x 71mm
Cooling Method	/	Thermal electric cooling with a fan

Table 2 (T)PH16KCXP12-250KU Product Specifications

Model	**PH16KCXP12-250KU**	**TPH16KCXP12-250KU**
Product Description	16K 256-line UV TDI line scan camera	
Resolution	16384 x 256	
Pixel Size	5um x 5um	
Sensor Type	Backshot CCD	
Image Type	Monochrome	
Sensor Size	81.92 mm	
Dynamic Range	≥ 53.7dB	
SNR	43.1dB	
Lens Mount	M95	
Max Line Rate	280.9kHz@8bit, 234.7kHz@10bit, 198.0kHz@12bit	
Analog Gain	x1/x2/x4/x8	
Digital Gain	0.001~7.998	
Digital Offset	-4095~4095	
Trigger Mode	Free-Run, External Pulse	
Trigger Signal	External IO/CXP	
Exposure Control	Line rate control, Timed	
Exposure Time	4us~1s (step: 0.01us)	
Data Format	8/10/12bit	
Operation Temperature	0~65℃	
Data Interface	CoaXPress12	
Data Rate	4079MB/s	
Power Supply	DC 12~24V (±10%) 2.0A	DC 12~24V (±10%) 2.0A
Power Consumption	15.1W	TEC off: 17.0W TEC on: 43.0W
Mechanical Dimensions	99mm x 99mm x 71mm	103.5mm x 103.5mm x 71mm
Cooling Method	/	TEC with a external fan

Note: This table is for 9.6-15.15 version of (T)PH16KCXP12 camera specifications, which may vary slightly from version to version.

4.3 Camera Block Diagram

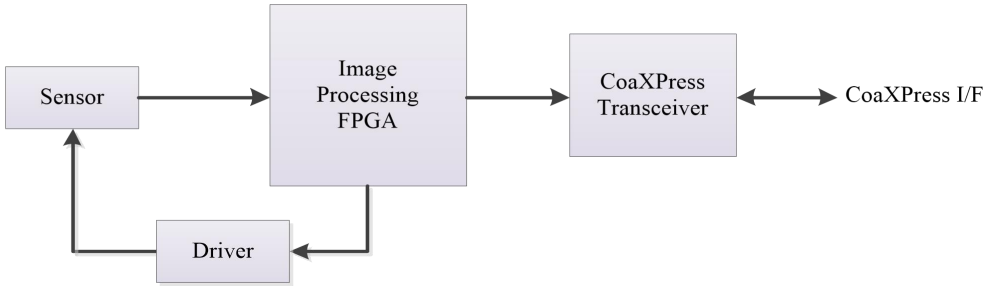


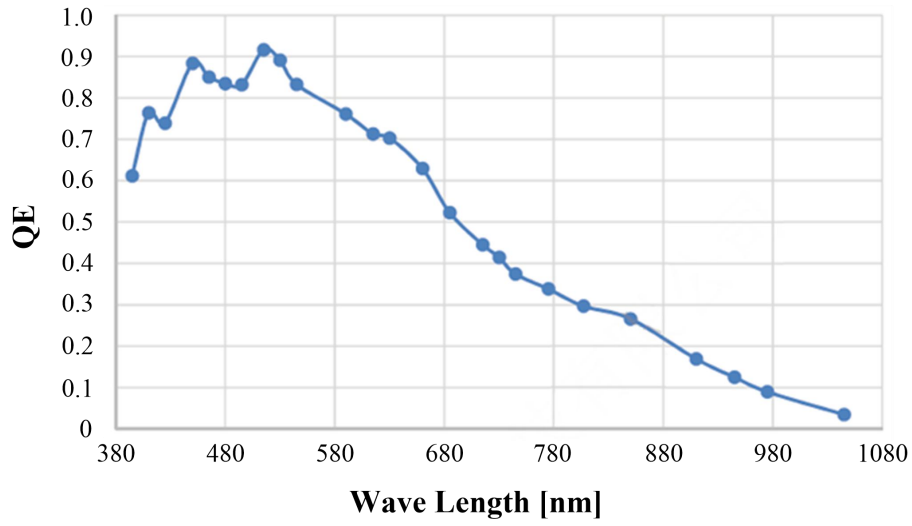
Fig.2 Internal Implementation Structure of Camera

(T)PH16KCXP12 camera is designed based on high-speed line scan image sensor. The pixel array is uniformly sampled and maintained by backshot 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 CoaXPress interface.

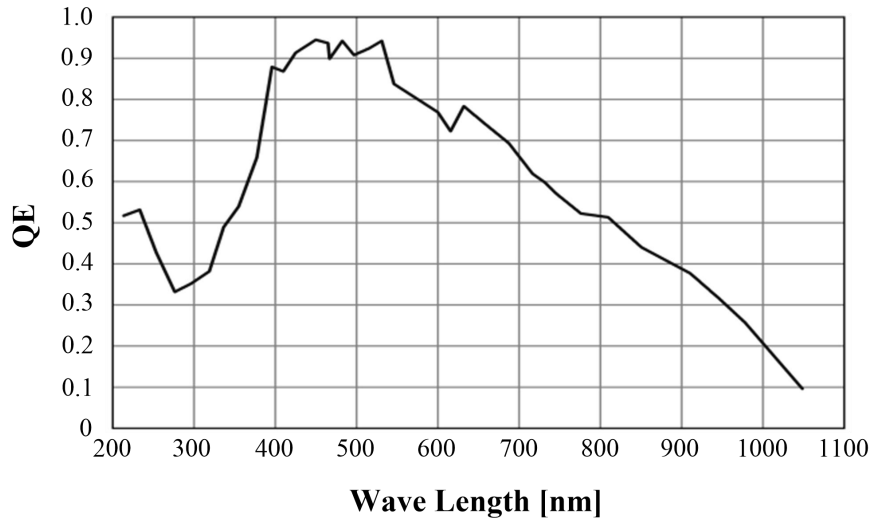
(T)PH16KCXP12 camera can accept external signal trigger acquisition, and the source is 4-pin interface signal or CXP signal from CoaXPress interface.

4.4 Spectral Response

The following is spectral response curve of (T)PH16KCXP12 camera.



(a) (T)PH16KCXP12-250KT Camera



(b) (T)PH16KCXP12-250KU Camera

Fig.3 Spectral Response of Camera

4.5 Environmental Requirements

(1) Operating temperature: 0℃~65℃, humidity: 10% ~ 90%; 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.

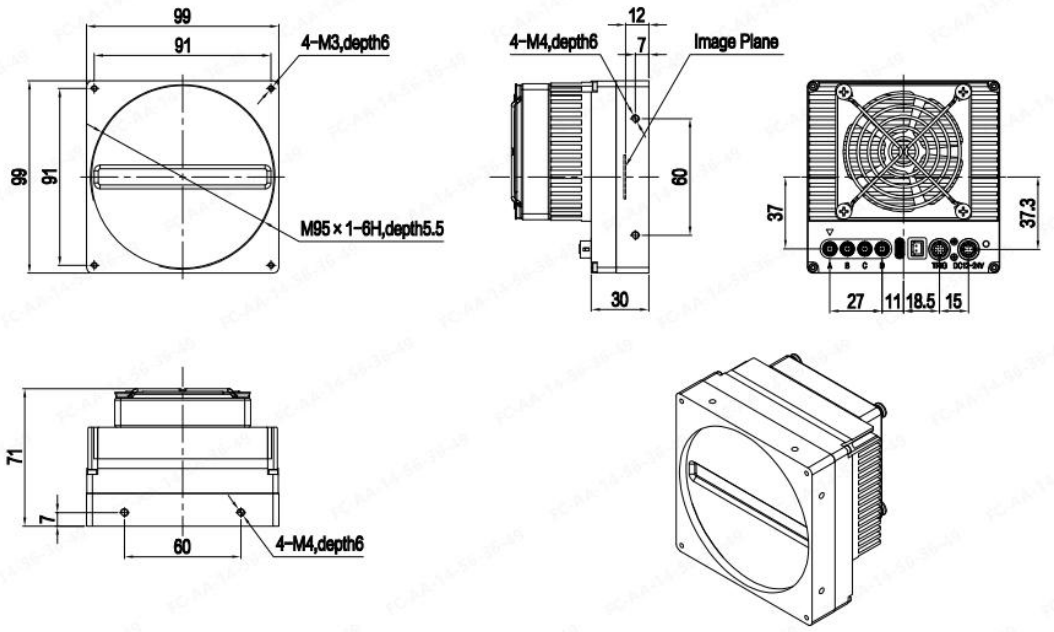
4.6 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

PH16KCXP12 camera:



TPH16KCXP12 camera:

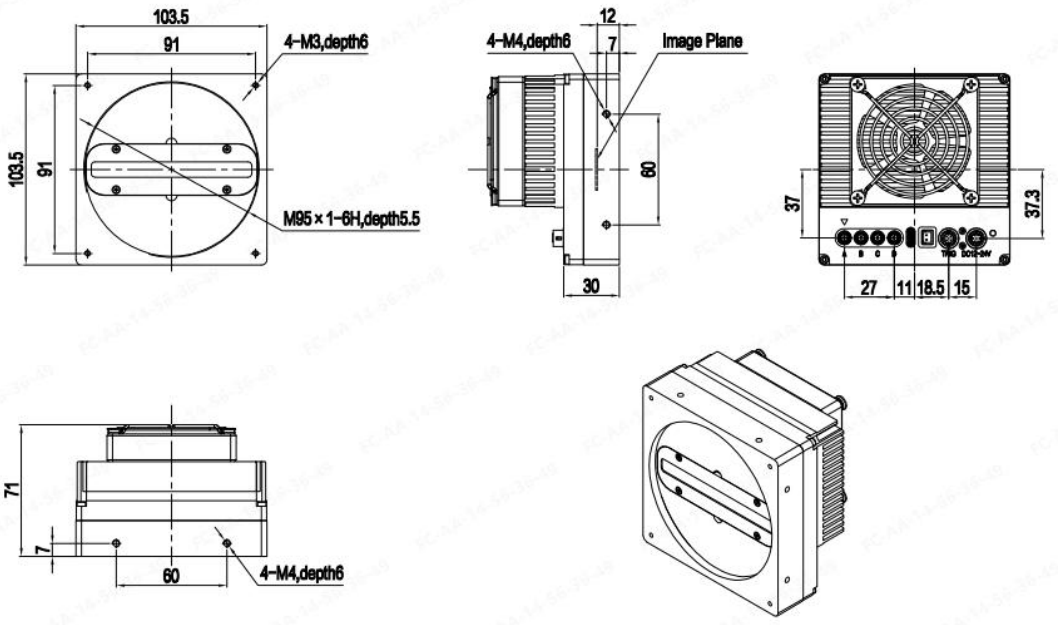


Fig.4 Camera Mechanical Dimensions

5.2 Camera Interface

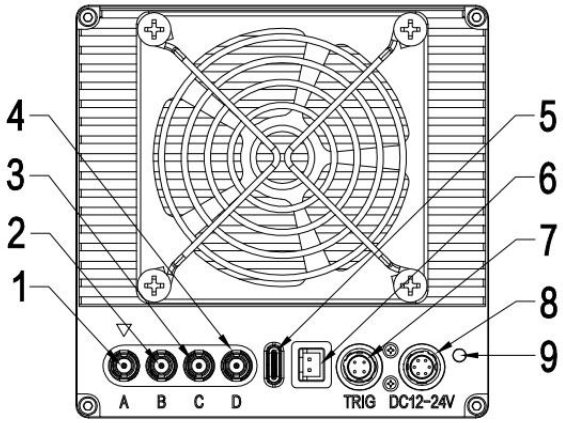


Fig.5 External Interfaces of Camera

① CoaXPress Connection A
② CoaXPress Connection B
③ CoaXPress Connection C
④ CoaXPress Connection D **(Master)**
⑤ Type-C Interface
⑥ Fan Power Interface
⑦ 4-pin Control Interface
⑧ 6-pin Power Input
⑨ Camera Status Indicator

5.2.1 Camera Status Indicator

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

Table 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

The power input interface adopts a 6-pin connector with the model:
Hirose HR10A-7R-6PB(Male).

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

The 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
VCC	1	GND	4
VCC	2	GND	5
VCC	3	GND	6

5.2.3 Control Interface

The control interface adopts a 4-pin connector with the model:
Hirose HR10A-7R-4PB(Male).

Corresponding connector on the cable model:
Hirose HR10A-7P-4S(Female).

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

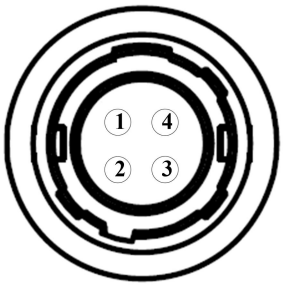


Fig.7 Pin Assignments for Control Interface

Table 5 Control Interface Pin Definition

Signal	Pin	Signal	Pin
Trigger In +	1	GND	3
Trigger In -	2	Reserved	4

The external trigger circuit is shown as follows:

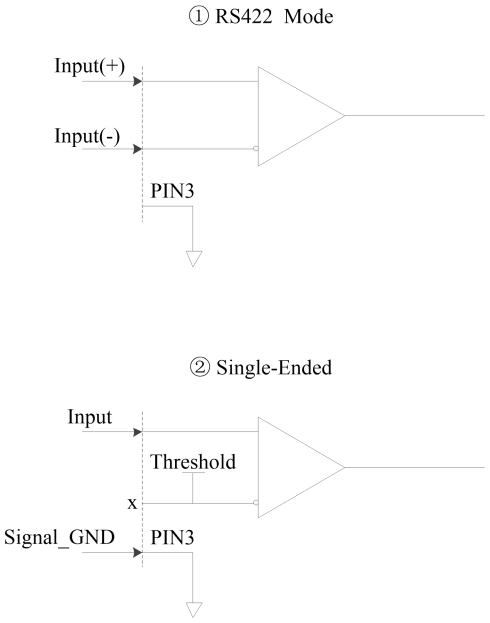


Fig.8 Trig Input Circuit Diagram

- Input Voltage Range: 3.3~24V

5.2.4 Data Interface

(T)PH16KCXP12 camera implements standard Quad CoaXPress protocol, and data interface is four Micro BNC sockets on the back of the camera. The data interface on the back of the camera is shown in the red box below:

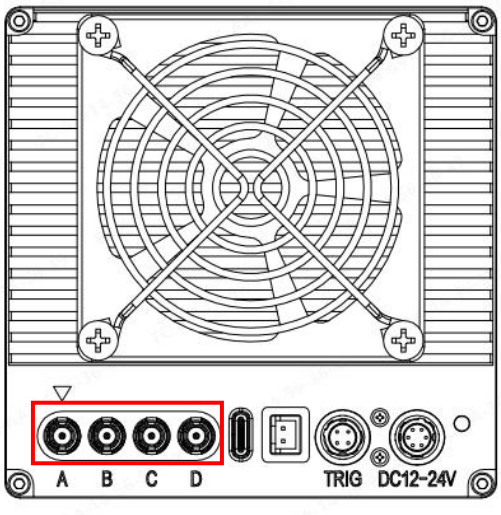


Fig.9 Data Interface

The mechanical diagram of Micro BNC interface is as follows:

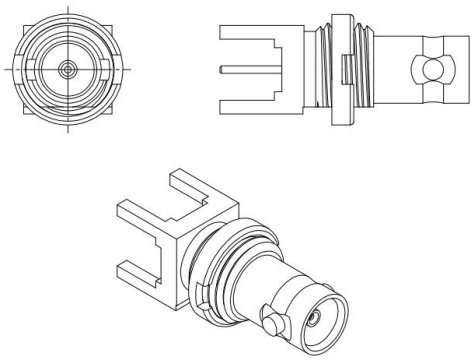


Fig.10 Micro BNC Interface

6 Camera Features

This chapter introduces the main features of (T)PH16KCXP12 camera.

6.1 Trigger Mode

(T)PH16KCXP12 camera supports two trigger modes: Free-Run mode and External Pulse mode.

6.1.1 Free-Run Mode

In Free-Run mode, the internal logic of camera automatically generates camera control sequence, so that camera produces normal image output without users providing external trigger signal.

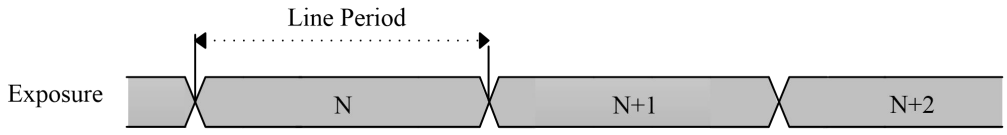


Fig.11 Free-Run Mode

In Free-Run mode, exposure time can be controlled by line rate (reciprocal of line period). The running sequence of camera is shown in the figure above.

6.1.2 External Pulse Mode

In External Pulse mode, camera starts exposure at the rising edge of external trigger signal, and the line period is determined by interval between rising edges of external trigger pulses.

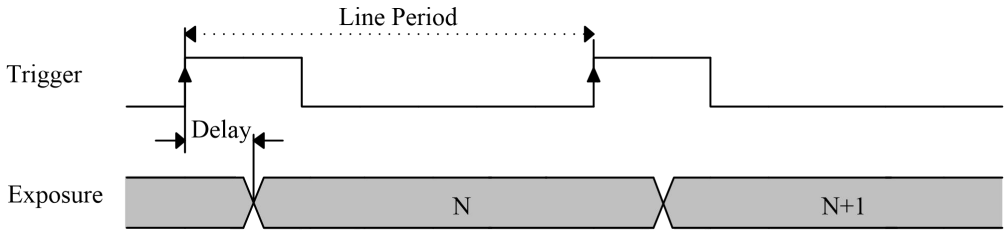


Fig.12 External Pulse Mode

6.2 Trigger Rescale

Ideally, when camera grabs images for uniformly moving objects, the quality of image can meet users' requirement. In fact, due to non-uniform motion of object, motion speed and speed of grabbing images are not accurately matched, users need to adjust trigger frequency to achieve ideal grabbing conditions.

(T)PH16KCXP12 camera can perform frequency averaging processing by selecting a specified number of trigger signals through smooth window to obtain a frequency-stable trigger signal. At the same time, the frequency of trigger signal can be accurately adjusted through frequency division, frequency multiplier and smoothing coefficient, so that the motion speed of object completely matches camera grabbing speed, so as to meet the requirement of users for high-quality acquisition.

6.3 Area Mode

The resolution of (T)PH16KCXP12 camera is 16384*256, which can be used as both TDI line scan camera and area scan camera. When used as area scan camera, image height can be modified by TDIStage parameter with maximum value of 256.

6.4 Camera Scanning Direction

(T)PH16KCXP12 camera supports two scanning directions: horizontal direction and vertical direction, as shown in the figure below.

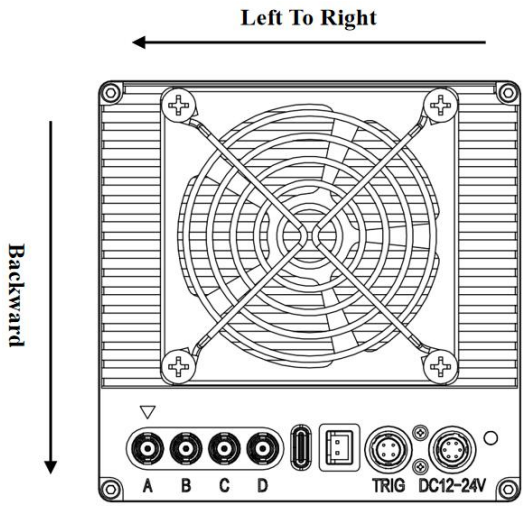
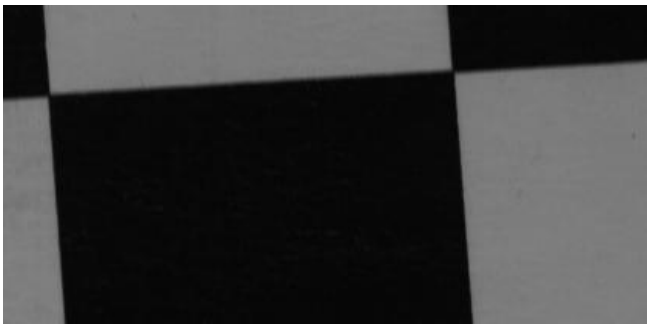


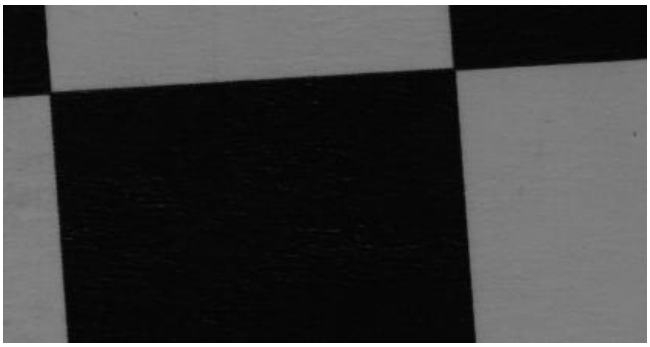
Fig.13 Camera Scanning Direction

Horizontal scanning supports left to right and right to left directions.

Vertical scanning supports forward and backward output image, note that when vertical scanning direction and object movement direction do not match, it will lead to blurred image edge.



(a) Opposite to Object Motion Direction



(b) Same as Object Motion Direction

Fig.14 Vertical Scanning Direction

6.5 LUT

LUT uses a 12bit input and 12bit output lookup table to map and convert values of the original image. Users can use this feature to achieve gamma correction.

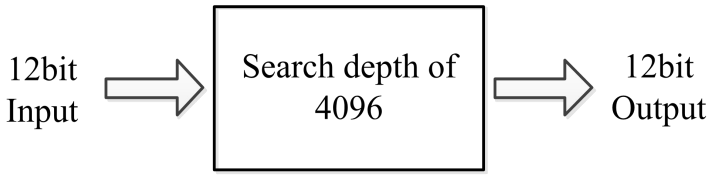


Fig.15 LUT Structure

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

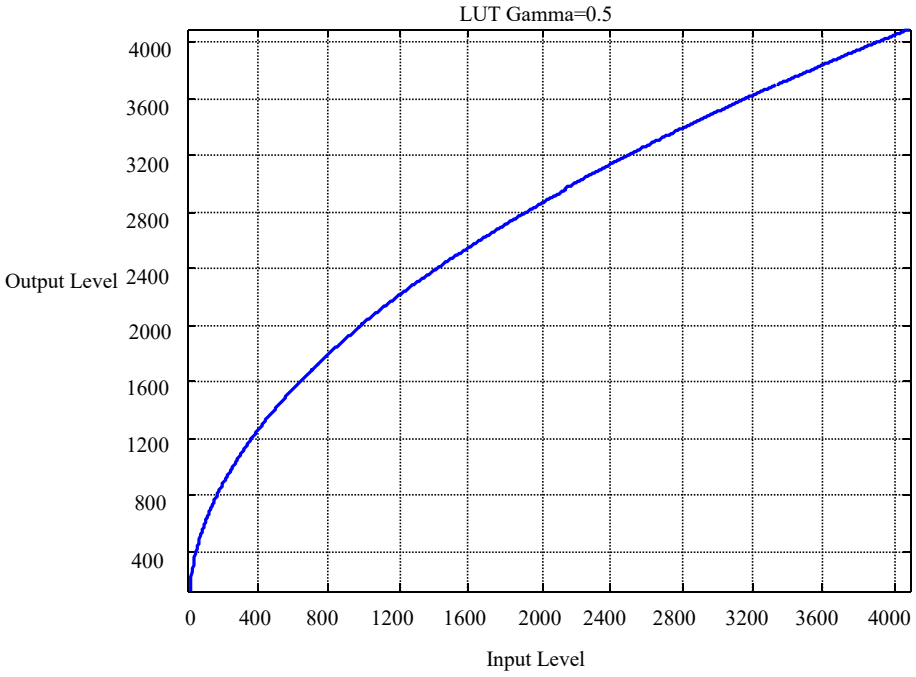


Fig.16 LUT: Gamma=0.5

6.6 Binning

(T)PH16KCXP12 camera sums up values of adjacent pixels and outputs them as a single pixel value after normal exposure acquisition.

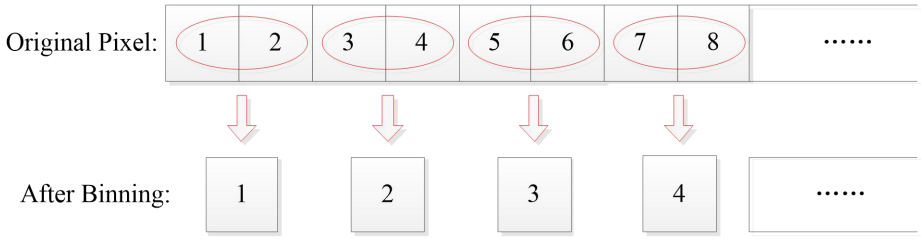


Fig.17 Horizontal Binningx2

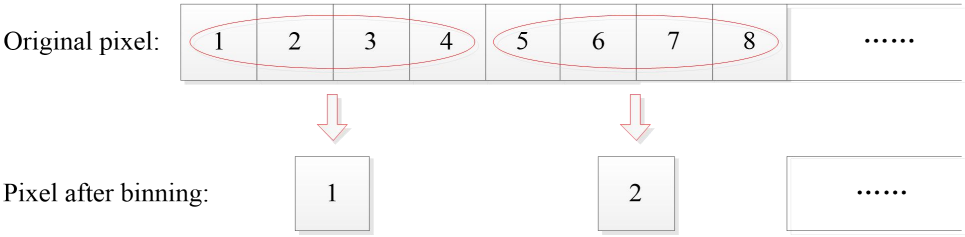


Fig.18 Horizontal Binningx4

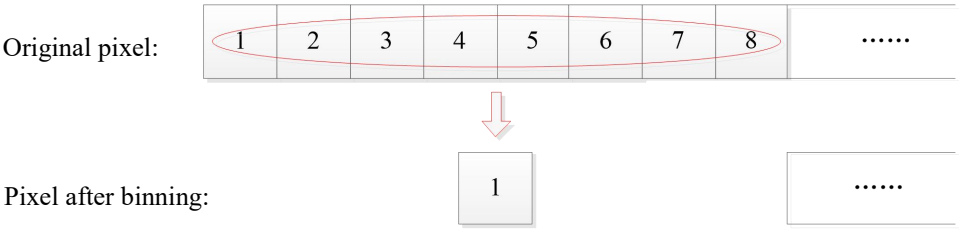


Fig.19 Horizontal Binningx8

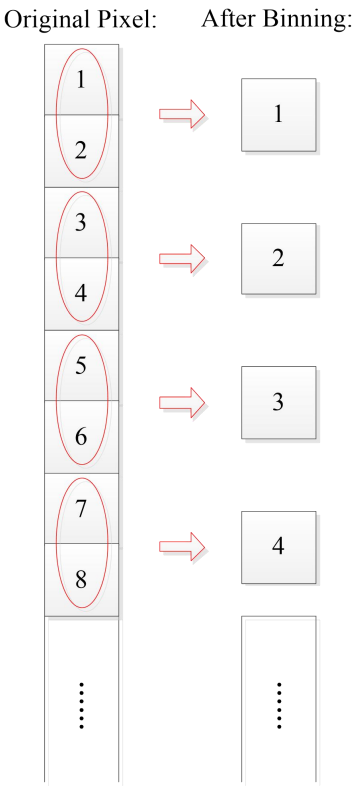


Fig.20 Vertical Binningx2

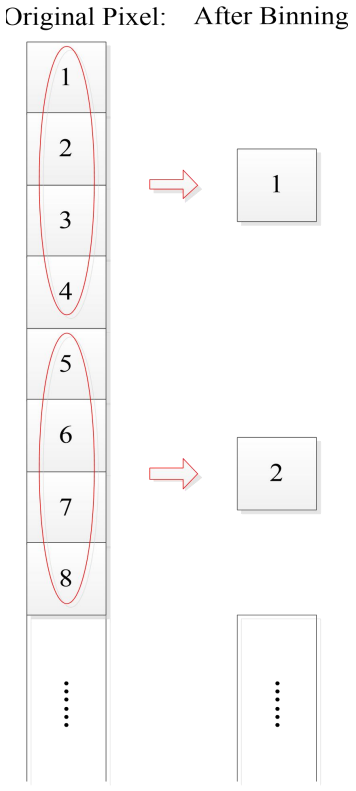


Fig.21 Vertical Binningx4

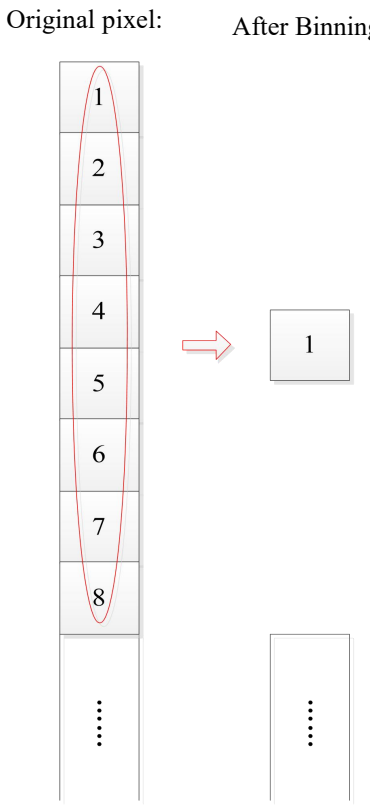
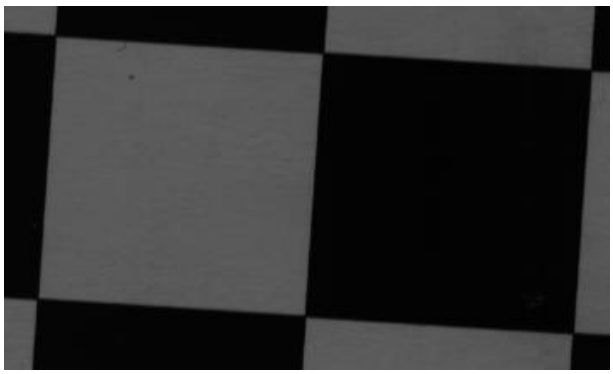


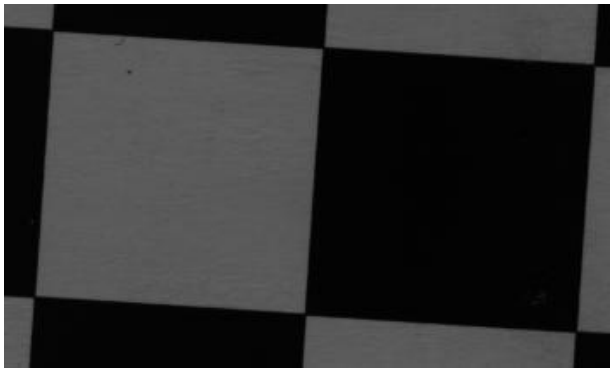
Fig.22 Vertical Binningx8

6.7 Time Delay Integration

For camera adopts multiple-line sensor, two adjacent exposures can make multiple lines of pixels in the same position, and the response of pixels can be increased by adding their values, while SNR of images can be improved. In order to make two adjacent lines of pixels in the same position, the image length to width ratio should be 1:1, and the vertical scanning direction should be set correctly, otherwise the image edge will be blurred.



(a) Edge Blur



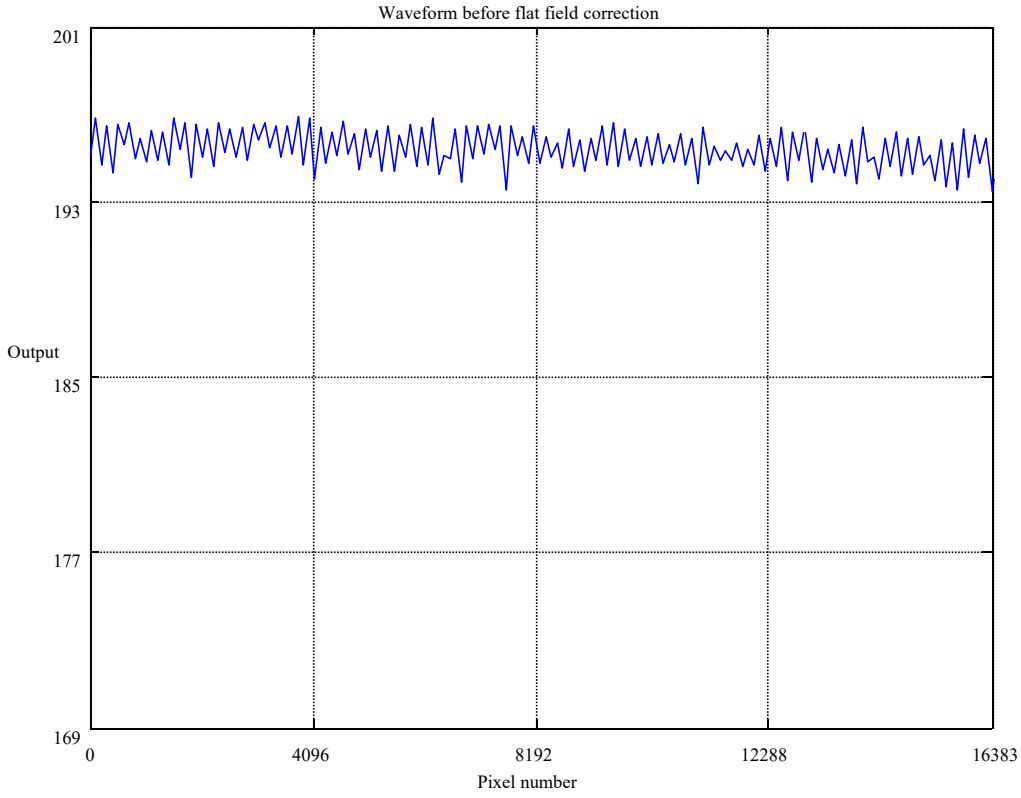
(b) Edge Clear

Fig.23 Time Delay Integration Effect

6.8 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.

Flat field correction effect is shown in the figure below:



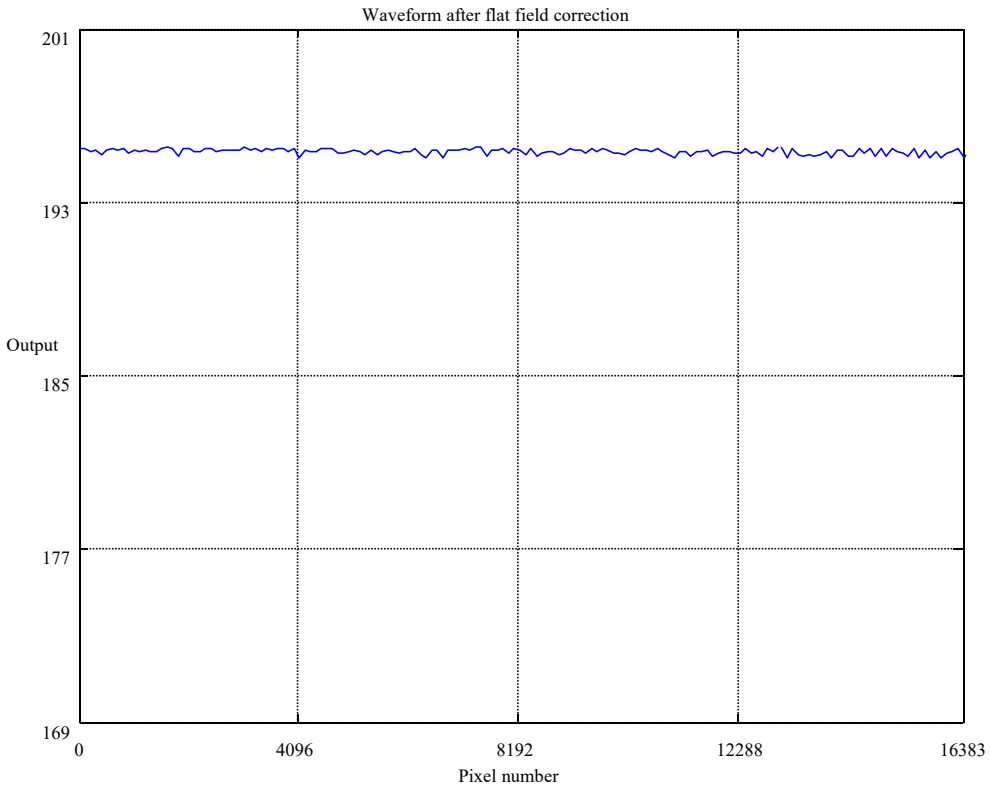


Fig.24 Flat Field Correction Effect

6.9 Test Image

Unlike images collected from sensors, test images are fixed style images that are pre-edited and stored inside camera. The test image can be used to test whether data link is open.

As shown in the following figure, it is rolling oblique 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.

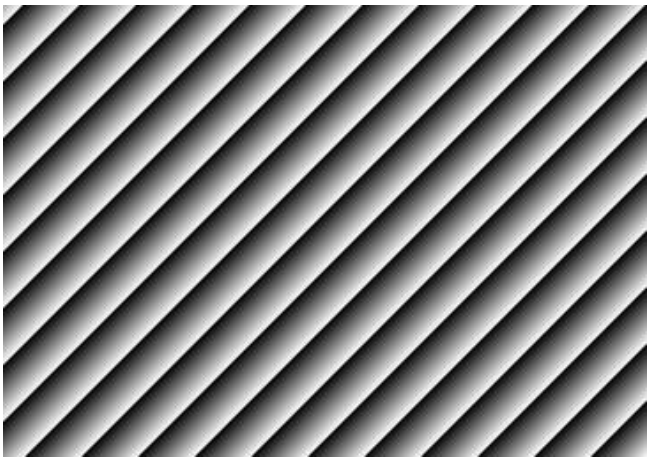


Fig.25 Test Image

6.10 Data Format

(T)PH16KCXP12 camera processes data in 12bit data format, but provides 8bit, 10bit, 12bit output three data formats. When camera outputs 8bit data, the lowest 4bit data will be deleted. When camera outputs 10bit of data, the lowest 2bit will be deleted.

Fig.26 Data Format

6.11 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) * Digital gain value

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

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

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

6.12 Camera Temperature

(T)PH16KCXP12 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 0~65℃. If users detect an abnormal temperature (such as over 70℃), it is recommended to stop the camera immediately and contact our technical support.

6.13 Load / Save Configuration

(T)PH16KCXP12 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 CoaXPress, as shown in the figure.

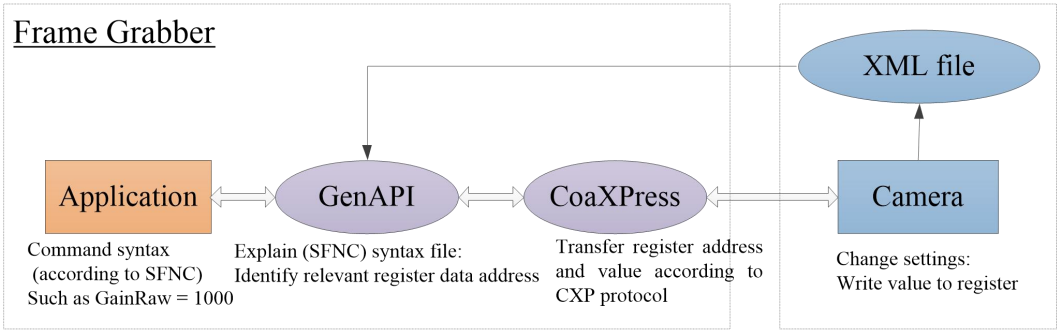


Fig.27 Communication Schematic between Application and Camera

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 Bootstrap CoaXPress Register

Table 7 Bootstrap CoaXPress Register

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

XmlUrlAddress	0x18	4	I	RO	Guru
Iidc2Address	0x1c	4	I	RO	Guru
ConnectionReset	0x4000	4	I	RW	Guru
DeviceConnectionID	0x4004	4	I	RO	Guru
MasterHostConnectionID	0x4008	4	I	RW	Guru
ControlPacketSizeMax	0x400c	4	I	RO	Guru
StreamPacketSizeMax	0x4010	4	I	RW	Guru
ConnectionConfig	0x4014	4	E	RW	Beginner
ConnectionConfigDefault	0x4018	4	E	RO	Beginner
ConnectionConfigPreferred	0xa108	4	E	RW	Beginner
TestMode	0x401c	4	E	RW	Guru
TestErrorCountSelector	0x4020	4	I	RW	Guru
TestErrorCount	0x4024	4	I	RW	Guru
TestPacketCountTx	0x4028	8	I	RW	Guru
TestPacketCountRx	0x4030	8	I	RW	Guru
ElectricalCompliancyTest	0x4038	4	E	RW	Guru
WidthAddress	0x3000	4	I	RO	Guru
HeightAddress	0x3004	4	I	RO	Guru
AcquisitionModeAddress	0x3008	4	I	RO	Guru
AcquisitionStartAddress	0x300c	4	I	RO	Guru
AcquisitionStopAddress	0x3010	4	I	RO	Guru
PixelFormatAddress	0x3014	4	I	RO	Guru
DeviceTapGeometryAddress	0x3018	4	I	RO	Guru
Image1StreamIDAddress	0x301c	4	I	RO	Guru
HsUpconnection	0x403c	4	I	RO	Guru

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

- **Revision**
  CoaXPress protocol version number.

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

- **XmlManifestSelector**
  Select XML manifest entry.

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

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

- **XmlUrlAddress**

  The URL address of XML file referenced by XmlManifestSelector.

- **Iidc2Address**

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

- **ConnectionReset**

  Reset all connections to device.

- **DeviceConnectionID**

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

- **MasterHostConnectionID**

  ID of host device.

- **ControlPacketSizeMax**

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

- **StreamPacketSizeMax**

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

- **ConnectionConfig**

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

  - CXP3_X1（0x00010038）
  - CXP5_X1（0x00010040）
  - CXP6_X1（0x00010048）
  - CXP10_X1（0x00010050）
  - CXP12_X1（0x00010058）
  - CXP3_X2（0x00020038）
  - CXP5_X2（0x00020040）
  - CXP6_X2（0x00020048）
  - CXP10_X2（0x00020050）
  - CXP12_X2（0x00020058）
  - CXP3_X4（0x00040038）
  - CXP5_X4（0x00040040）
  - CXP6_X4（0x00040048）
  - CXP10_X4（0x00040050）
  - CXP12_X4（0x00040058）

- **ConnectionConfigDefault**

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

- CXP3_X1（65592）
- CXP5_X1（65600）
- CXP6_X1（65608）
- CXP10_X1（0x00010050）
- CXP12_X1（0x00010058）
- CXP3_X2（131128）
- CXP5_X2（131136）
- CXP6_X2（131144）
- CXP10_X2（0x00020050）
- CXP12_X2（0x00020058）
- CXP3_X4（262200）
- CXP5_X4（262208）
- CXP6_X4（262216）
- CXP10_X4（0x00040050）
- CXP12_X4（0x00040058）

- **ConnectionConfigPreferred**

Preferred default mode for device connection speed and dynamic connection count. The enumeration names and values are as follows:

- CXP3_X1（0x00010038）
- CXP5_X1（0x00010040）
- CXP6_X1（0x00010048）
- CXP10_X1（0x00010050）
- CXP12_X1（0x00010058）
- CXP3_X2（0x00020038）
- CXP5_X2（0x00020040）
- CXP6_X2（0x00020048）
- CXP10_X2（0x00020050）
- CXP12_X2（0x00020058）
- CXP3_X4（0x00040038）
- CXP5_X4（0x00040040）
- CXP6_X4（0x00040048）
- CXP10_X4（0x00040050）
- CXP12_X4（0x00040058）

- **TestMode**

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

- Off (0)
- Mode1 (1)

- **TestErrorCountSelector**

  Test mode selection. The parameter range is as follows:

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

- **TestErrorCount**

  Number of test errors.

- **TestPacketCountTx**

  Number of test error frames.

- **TestPacketCountRx**

  Number of test data frames.

- **ElectricalCompliancyTest**

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

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

- **WidthAddress**

  Address of camera width register.

- **HeightAddress**

  Address of camera height register.

- **AcquisitionModeAddress**

  The address of camera acquisition mode register.

- **AcquisitionStartAddress**

  The address of camera acquisition register.

- **AcquisitionStopAddress**

  The camera stops grabbing address of register.

- **PixelFormatAddress**

The address of camera pixel format register.

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

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

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

7.3.2 Device Control Register

Table 8 Device Control Register

Name	Address	Size	Interface	Access	Visibility
DeviceVendorName	0x2000	32	S	RO	Beginner
DeviceModelName	0x2020	32	S	RO	Beginner
DeviceManufacturerInfo	0x2040	48	S	RO	Beginner
DeviceVersion	0x2070	32	S	RO	Beginner
DeviceSerialNumber	0x20b0	16	S	RO	Expert
DeviceUserId	0x20c0	16	S	RW	Beginner
DeviceTemperature	0xa004	4	F	RO	Beginner
DeviceHumidity	0xa014	4	F	RO	Beginner
DeviceTapGeometry	0xa008	4	E	RO	Beginner
CoolingTargetTemperature	0xa00c	4	I	RW	Beginner
CoolingEnable	0xa010	4	B	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.

- **DeviceTemperature**
  Device temperature.

- **DeviceHumidity**
  Device humidity.

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

- **CoolingTargetTemperature**
  Device target temperature, only TPH16KCXP12 camera supports this function. The parameter range is as follows:
  - Maximum: 50
  - Minimum: -30
  - Increment: 1

- **CoolingEnable**
  Enable TEC function, only TPH16KCXP12 camera supports this function.

7.3.3 Image Format Control Register

Table 9 Image Format Control Register

Name	Address	Size	Interface	Access	Visibility
Width	0xa800	4	I	RW	Beginner
Height	0xa804	4	I	RW	Beginner
SensorWidth	0xa808	4	I	RO	Expert
BinningHorizontal	0xa810	4	E	RW	Beginner
BinningVertical	0xa828	4	E	RW	Beginner
BinningAverage	0xa860	4	B	RW	Beginner
PixelFormat	0xa830	4	E	RW	Beginner
VideoMode	0xa834	4	E	RW	Beginner
HorizontalScanDirection	0xa838	4	E	RW	Beginner
OffsetX	0xa80c	4	I	RW	Beginner
TDIStage	0xa850	4	I	RW	Beginner

- **Width**
  Actual camera output width. The parameter range is as follows:
  - Minimum: 256
  - Increment: 16

- **Height**

  Actual camera output height. The parameter range is as follows:

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

- **SensorWidth**

  Sensor width.

- **BinningHorizontal**

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

  - Binning_X1 (1)
  - Binning_X2 (2)
  - Binning_X4（4）
  - Binning_X8（8）

- **BinningVertical**

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

  - Binning_X1 (1)
  - Binning_X2 (2)
  - Binning_X4（4）
  - Binning_X8（8）

- **BinningAverage**

  Pixel binning average, check this option to change the width and height of the image with pixel binning, while keeping the grayscale value unchanged.

- **PixelFormat**

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

  - Mono8 (0x01080001): Monochrome 8bit
  - Mono10 (0x01100003): Monochrome 10bit
  - Mono12 (0x01100005): Monochrome 12bit

- **VideoMode**

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

  - Original (0): Original image
  - Corrected (1): Corrected image
  - MonochromePattern (2): Horizontal test image

- **HorizontalScanDirection**

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

  - LeftToRight (0): From left to right
  - RightToLeft (1): From right to left

- **OffsetX**

  Horizontal offset. The parameter range is as follows:

  - Minimum: 0
  - Increment: 16

- **TDIStage**

  Time delay integration stage, used to set image height in area mode. The parameter range is as follows:

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

7.3.4 Acquisition Control Register

Table 10 Acquisition Control Register

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0xb050	4	E	RO	Beginner
AcquisitionStart	0xb054	4	C	RW	Beginner
AcquisitionStop	0xb058	4	C	RW	Beginner
AcquisitionLineRate	/	/	F	/	Beginner
AcquisitionLinePeriod	0xb028	4	F	RW	Beginner
AcquisitionMaxLineRate	0xb02c	4	C	WO	Beginner
AreaMode	0xa854	4	B	RW	Beginner
AreaExposureTime	0xb05c	4	I	RW	Beginner
AreaFramePeriod	0xb060	4	I	RW	Beginner
AreaShadowCorrection	0xa858	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. The parameter range is as follows:

  - Minimum: 1

- **AcquisitionLinePeriod**

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

- Maximum: 1000000
- Increment: 0.01

- **AcquisitionMaxLineRate**

  Set acquisition line rate to the maximum value.

- **AreaMode**

  Enable area mode, check this item to use camera as area scan type.

- **AreaExposureTime**

  Exposure time in area mode. The parameter range is as follows:

  - Maximum: 50000
  - Minimum: 500
  - Increment: 1

- **AreaFramePeriod**

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

  - Maximum: 262143
  - Minimum: 3840
  - Increment: 1

- **AreaShadowCorrection**

  Area mode shadow correction.

7.3.5 IO Control Register

Table 11 IO Control Register

Name	Address	Size	Interface	Access	Visibility
TriggerMode	0xb008	4	E	RW	Beginner
TriggerSource	0xb014	4	E	RW	Beginner
TriggerRescaleEnable	0xb034	4	B	RW	Expert
TriggerRescaleWindowSize	0xb038	4	E	RW	Expert
TriggerRescaleFactor	0xb048	4	F	RW	Expert
TriggerMultDivEnable	0xb03c	4	B	RW	Expert
TriggerMultiplier	0xb040	4	E	RW	Expert
TriggerDivider	0xb044	4	I	RW	Expert
LinePolarity	0xb030	4	E	RW	Beginner
LineDetectionLevel	0xf850	4	E	RW	Expert
LineDebouncingPeriod	0xf830	4	I	RW	Beginner
LineTriggerInputFrequency	0xf83c	4	I	RO	Beginner

- **TriggerMode**

Turn on/off trigger mode. The enumeration names and values are as follows:

- Off (0)
- On (1)

- **TriggerSource**

Select trigger source. The enumeration names and values are as follows:

- CXPIn (1): CXP signal
- Line1 (0): Line1 signal of IO interface

- **TriggerRescaleEnable**

Enable trigger frequency rescale function.

- **TriggerRescaleWindowSize**

Trigger signal smoothing window size, selecting the number of samples of trigger signals that need frequency averaging processing by smoothing window. The enumeration names and values are as follows:

- Window_1 (0)
- Window_2 (1)
- Window_4 (2)
- Window_8 (3)
- Window_16 (4)
- Window_32 (5)
- Window_64 (6)
- Window_128 (7)
- Window_256 (8)
- Window_512 (9)
- Window_1024 (10)

- **TriggerRescaleFactor**

Trigger signal smoothing coefficient, which is used to fine adjust frequency of trigger signal. The parameter range is as follows:

- Maximum: 1.3
- Minimum: 0.7

- **TriggerMultDivEnable**

Enable trigger signal multiple and division function.

- **TriggerMultiplier**

Trigger signal multiple function, which is used to coarse increase frequency of trigger signal. The enumeration names and values are as follows:

- Multiplier_1 (0)
- Multiplier_2 (1)
- Multiplier_4 (2)
- Multiplier_8 (3)

- **TriggerDivider**

Trigger signal division function, which is used to coarse decrease frequency of trigger signal. The parameter range is as follows:

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

- **LinePolarity**

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

  - High (0): Trigger acquisition during high level
  - Low (1): Trigger acquisition during low level

- **LineDetectionLevel**

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

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

- **LineDebouncingPeriod**

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: 655
  - Minimum: 0

- **LineTriggerInputFrequency**

Trigger signal frequency, unit is Hz.

7.3.6 Analog Control Register

Table 12 Analog Control Register

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0xb810	4	E	RW	Beginner

- **AnalogGain**

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

  - Gain_x1 (0)
  - Gain_x2 (1)
  - Gain_x4 (2)
  - Gain_x8 (3)

7.3.7 Digital Control Register

Table 13 Digital Control Register

Name	Address	Size	Interface	Access	Visibility
DigitalGain	/	/	F	/	Beginner
GainRaw	0xc028	4	I	RW	Beginner
DigitalOffset	0xc004	4	I	RW	Beginner
VerticalScanDirection	0xc02c	4	E	RW	Expert
VerticalScanControl	0xc038	4	E	RW	Beginner
TargetExposureEnable	0xc030	4	B	RW	Expert
TargetExposureTime	0xc034	4	I	RW	Expert
Denoise	0xc03c	4	I	RW	Expert
Sharpen	0xc040	4	I	RW	Expert

- **DigitalGain**

  Digital gain. The parameter range is as follows:

  - Maximum: 7.998
  - Minimum: 0.001
  - Increment: 0.002

- **GainRaw**

  Digital gain raw data. The meaning and function of this parameter is the same as DigitalGain, and only be different in name. The parameter range is as follows:

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

- **DigitalOffset**

  Digital offset. The parameter range is as follows:

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

- **VerticalScanDirection**

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

  - Forward (0): Forward
  - Backward (1): Backward

- **VerticalScanControl**

  Vertical scanning direction control, which is used to select signal to control vertical scanning direction. The enumeration names and values are as follows:

  - Internal (0): Internal signal
  - CXP_Positive (1): CXP positive signal
  - CXP_Negative (2): CXP negative signal
  - IO_Positive (3): IO interface positive signal
  - IO_Negative (4): IO interface negative signal

- **TargetExposureEnable**

  Enable target exposure time function, check this item to set exposure time.

- **TargetExposureTime**

  Target exposure time. The parameter range is as follows:

  - Maximum: 655
  - Minimum: 5

- **Denoise**

  Denoise coefficient. The parameter range is as follows:

  - Maximum: 100
  - Minimum: 0

- **Sharpen**

  Sharpen coefficient. The parameter range is as follows:

  - Maximum: 100
  - Minimum: 0

7.3.8 LUT Control Register

Table 14 LUT Control Register

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0xd004	4	B	RW	Expert
LUTIndex	0xd008	4	I	RW	Expert
LUTValue	0xd00c	4	I	RW	Expert

- **LUTEnable**

  Enable LUT function.

- **LUTIndex**

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

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

- **LUTValue**

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

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

7.3.9 Flat Field Correction Register

Table 15 Flat Field Correction Register

Name	Address	Size	Interface	Access	Visibility
PRNUCorrSelector	0xd838	4	I	RW	Expert
PRNUCorrEnable	0xd800	4	B	RW	Expert
PRNUCorrOffsetX	0xd804	4	I	RW	Expert
PRNUCorrWidth	0xd808	4	I	RW	Expert
PRNUCorrReferenceMode	0xd80c	4	B	RW	Expert
PRNUCorrReferenceTarget	0xd810	4	I	RW	Expert
PRNUCorrLowPassFilter	0xd834	4	I	RW	Expert
PRNUCorrStart	0xd814	4	C	WO	Expert
PRNUCorrReset	0xd818	4	C	WO	Expert
DSNUCorrEnable	0xd83c	4	B	RW	Expert
DSNUCorrStart	0xd840	4	C	WO	Expert
DSNUCorrReset	0xd844	4	C	WO	Expert
DSNUCorrReferenceTarget	0xd848	4	I	RW	Expert

- **PRNUCorrSelector**

  Selection of flat field correction parameter set. The parameter range is as follows:

  - Maximum: 3
  - Minimum: 0

- **PRNUCorrEnable**

  Enable flat field correction.

- **PRNUCorrOffsetX**

  Horizontal offset of flat field correction region, which is used to set start position of flat field correction region. The parameter range is as follows:

  - Minimum: 0
  - Increment: 16

- **PRNUCorrWidth**

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

  - Minimum: 16
  - Increment: 16

- **PRNUCorrReferenceMode**

  Flat field correction reference mode. Check this parameter to correct gray value of the selected region to the set value.

- **PRNUCorrReferenceTarget**

  Target value of flat field correction. The parameter range is as follows:

- Maximum: 4095
- Minimum: 0

- **PRNUCorrLowPassFilter**

  Flat field correction low-pass filtering. The parameter range is as follows:
  - Maximum: 64
  - Minimum: 0
  - Increment: 2

- **PRNUCorrStart**

  Execute flat field correction.

- **PRNUCorrReset**

  Reset flat field correction to default setting.

- **DSNUCorrEnable**

  Enable dark field correction.

- **DSNUCorrStart**

  Start dark field correction.

- **DSNUCorrReset**

  Restore dark field correction parameters to factory settings.

- **DSNUCorrReferenceTarget**

  Dark field correction target value. The parameter range is as follows:
  - Maximum: 4095
  - Minimum: 0

7.3.10 User Set Control Register

Table 16 User Set Control Register

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
  - UserSet3 (3): User configuration 3
  - UserSet4 (4): User configuration 4

- UserSet5 (5): User configuration 5
- UserSet6 (6): User configuration 6
- UserSet7 (7): User configuration 7
- UserSet8 (8): User configuration 8
- UserSet9 (9): User configuration 9
- UserSet10 (10): User configuration 10
- UserSet11 (11): User configuration 11
- UserSet12 (12): User configuration 12
- UserSet13 (13): User configuration 13
- UserSet14 (14): User configuration 14
- UserSet15 (15): User configuration 15
- UserSet16 (16): User configuration 16

- **UserSetLoad**
  Load selected camera configuration.

- **UserSetSave**
  Save selected camera configuration.

8 FAQ

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

① Ensure that CoaXPress interface cable is OK

② Ensure that serial port channel parameters of CoaXPress10 interface are correctly set.

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

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

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

③ Ensure that the CoaXPress interface cable is OK.

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

① Ensure that external input pulse is normal.

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

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

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

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

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

- **If images are dark,**

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

② Ensure that exposure time is set properly.

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

① Ensure that sensor glass is clean.

② Ensure that camera status indicator is normal.

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

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

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

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

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.