PN-CXP10 Series Line Scan Camera User Manual

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Hefei I-TEK Optoelectronics Co., Ltd.

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

Revision History

Revision	Date	Description
0.1	2023/01/18	● Initial version
0.2	2023/03/05	● Update parameter of camera
0.3	2023/05/04	● Update parameter list
0.4	2023/08/16	● Update chapter 7 ● Add requirement of voltage and current for line trigger interface
0.5	2023/10/16	● Add vertical compression ratio arbitrary adjustment function

Manufacturer Information

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Contents

1 Precautions

- **General**

① Do not drop, damage, disassemble the camera.

② Do not let children touch the camera without supervision.

③ Do not use the camera for other purposes than those specified herein.

④ If there is any problem with the camera, please contact us in time for technical support.

- **Installation and Maintenance**

① Do not install the camera in an environment with direct sunlight, high humidity or heavy dust.

② Keep the camera away from an environment with strong electromagnetic interference.

③ Keep the camera away from heat sources.

④ Be careful not to let the camera soak in liquid, such as water and drinks.

⑤ Clean dust on the surface of the camera as often as possible to avoid dust entering the camera, otherwise it may cause fault to the camera.

⑥ To clean the dust on the camera surface, do not wash with water, wipe it with lint-free cloth.

- **Power Supply**

① The recommended voltage is +12~24V (±10%), and the current must be 1.5A.

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**

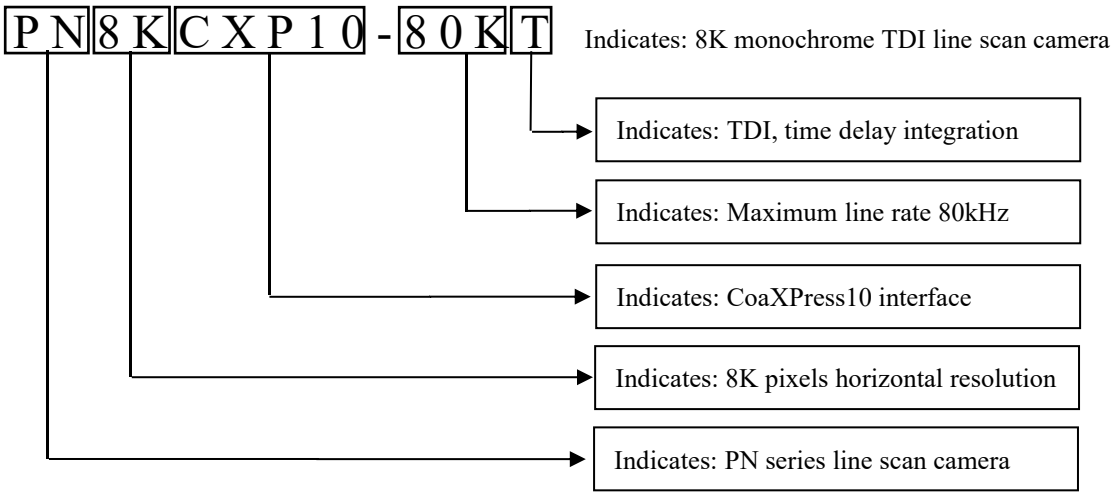
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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.



3 Product Appearance

Fig.1 Product Appearance

Note:

① The front and the sides of camera provides threaded holes for mounting and fixing.

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

4 Product Specifications

PN-CXP10 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.. The camera integrates international leading high-speed linear array image sensor, large-scale field programmable logic gate array parallel processor, and outputs data through CoaXPress10 interface. It also has features of high speed, high sensitivity and low noise.

4.1 Main Features

- Global Shutter CMOS Sensor
- Line Resolution 8192 / 16384 Pixels
- Maximum Line Rate 220kHz
- High Sensitivity and Low Noise
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Minimum Exposure Time: 3.2us Exposure Time Step: 0.013us
- Data Format: 8/10bit
- Scanning Direction Configurable
- Binning
- Flat Field Correction
- Spatial Correction
- Parallax Correction
- Analog Gain / Digital Gain / Offset Control
- White Balance
- Real-time Temperature Monitoring

4.2 Camera Specifications

Table 1 PN8KCXP10-37KC2 Product Specifications

Model	PN8KCXP10-37KC2
Product Description	8K color TDI line scan camera
Resolution	8192 x 6
Pixel Size	7um x 7um
Sensor Type	Global shutter CMOS
Image Type	Color
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	1155 MB/s
Analog Gain	X1/X2/X3/X4/X5/X6/X7/X8
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023

Lens Mount	M72
Max Line Rate	37 .6kHz@8/10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	RGB/BGR@8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	7.9W
Mechanical	76mm x76mm x 54.5mm

Table 2 PN8KCXP10-50KT4 Product Specifications

Model	**PN8KCXP10-50KT4**
Product Description	8K monochrome TDI line scan camera
Resolution	8192 x 4
Pixel Size	7um x 7um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	512 MB/s
Analog Gain	X1/X2/X3/X4/X5/X6/X7/X8
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	50.0kHz@8/10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A

Power Consumption	7.3W
Mechanical	76mm x76mm x 54.5mm

Table 3 PN8KCXP10-62KC Product Specifications

Model	**PN8KCXP10-62KC**
Product Description	8K color line scan camera
Resolution	8192 x 3
Pixel Size	7um x 7um
Sensor Type	Global shutter CMOS
Image Type	Color
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	1908 MB/s
Analog Gain	X1/X2/X3/X4/X5/X6/X7/X8
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	62.1kHz@8/10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	RGB/BGR@8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	9.0W
Mechanical	76mm x76mm x 54.5mm

Table 4 PN8KCXP10-80KT Product Specifications

Model	**PN8KCXP10-80KT**
Product Description	8K monochrome TDI line scan camera
Resolution	8192 x 2
Pixel Size	7um x 7um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	57.34mm

Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	650 MB/s
Analog Gain	X1/X2/X3/X4/X5/X6/X7/X8
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	79.4kHz@8/10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	8.2W
Mechanical	76mm x76mm x 54.5mm

Table 5 PN8KCXP10-220KM Product Specifications

Model	**PN8KCXP10-220KM**
Product Description	8K monochrome line scan camera
Resolution	8192 x 1
Pixel Size	7um x 7um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	1960 MB/s
Analog Gain	X1/X2/X3/X4
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	222.2kHz@8bit, 191.4kHz@10bit
Trigger Mode	Line Trigger, Frame Trigger

Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	11.3W
Mechanical	76mm x76mm x 54.5mm

Table 6 PN16KCXP10-50KT Product Specifications

Model	**PN16KCXP10-50KT**
Product Description	16K monochrome TDI line scan camera
Resolution	16384 x 2
Pixel Size	3.5um x 3.5um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	1958 MB/s
Analog Gain	X1/X2/X3/X4
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	50.0kHz@8bit, 47.8kHz@10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	8.2W
Mechanical	76mm x76mm x 54.5mm

Table 7 PN16KCXP10-79KM Product Specifications

Model	PN16KCXP10-79KM
Product Description	16K monochrome line scan camera
Resolution	16384 x 1
Pixel Size	3.5um x 3.5um
Sensor Type	Global shutter CMOS
Image Type	Monochrome
Sensor Size	57.34mm
Dynamic Range	≥ 65.7dB
SNR	45.0dB
Data Rate	1622 MB/s
Analog Gain	X1/X2/X3/X4
Black Level	0~31
Digital Gain	0.1~8
Digital Offset	-1023~1023
Lens Mount	M72
Max Line Rate	79.2kHz@8/10bit
Trigger Mode	Line Trigger, Frame Trigger
Trigger Signal	External IO/CXP
Exposure Control	External PWM, Timed
Exposure Time	3.2us ~ 63997us (step: 0.013us)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 1.5A
Power Consumption	9.2W
Mechanical	76mm x76mm x 54.5mm

Note: This table is for 0103-8105 version of PN-CXP10 series camera specifications, which may vary slightly from version to version.

4.3 Camera Block Diagram

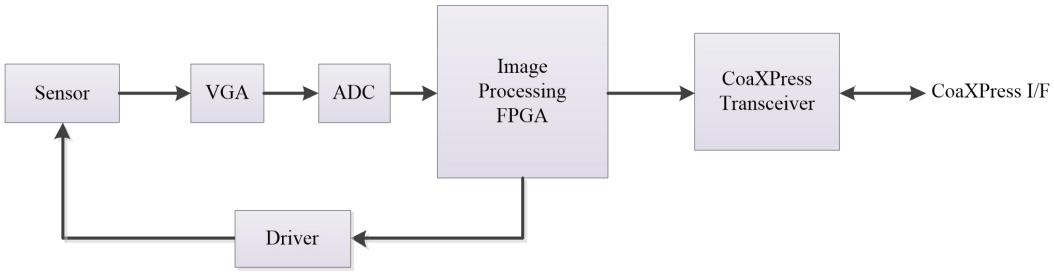


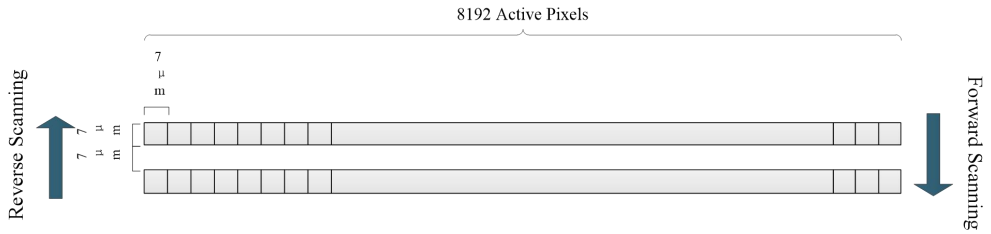
Fig.2 Internal Implementation Structure of Camera

PN-CXP10 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 CoaXPress interface.

PN-CXP10 series camera can accept external signal trigger acquisition, and the source is 4-pin interface signal, 6-pin interface signal or CXP signal from CoaXPress interface.

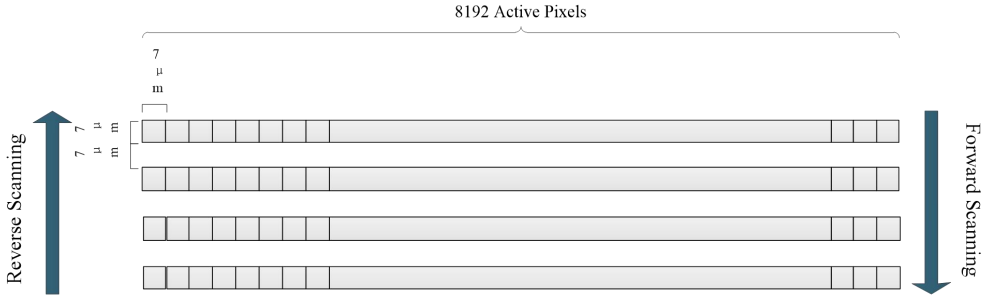
4.4 Pixel Arrangements

Different types of PN-CXP10 series camera has different line counts. Depending on line counts, pixels of camera are arranged in different ways. Here introduces pixel arrangements of multi-line cameras, as shown in the figure below.

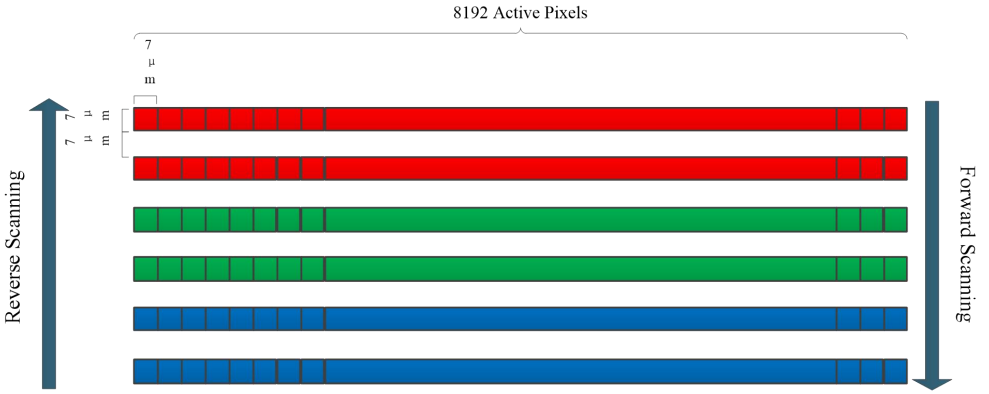


(a) 8K Double-Line Monochrome

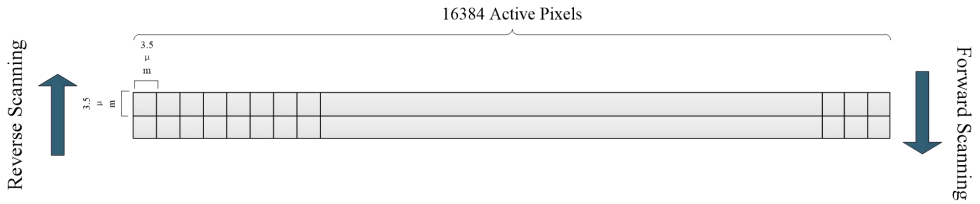
(b) 8K Triple-Line Color



(c) 8K Four-Line Monochrome



(d) 8K Six-Line Color



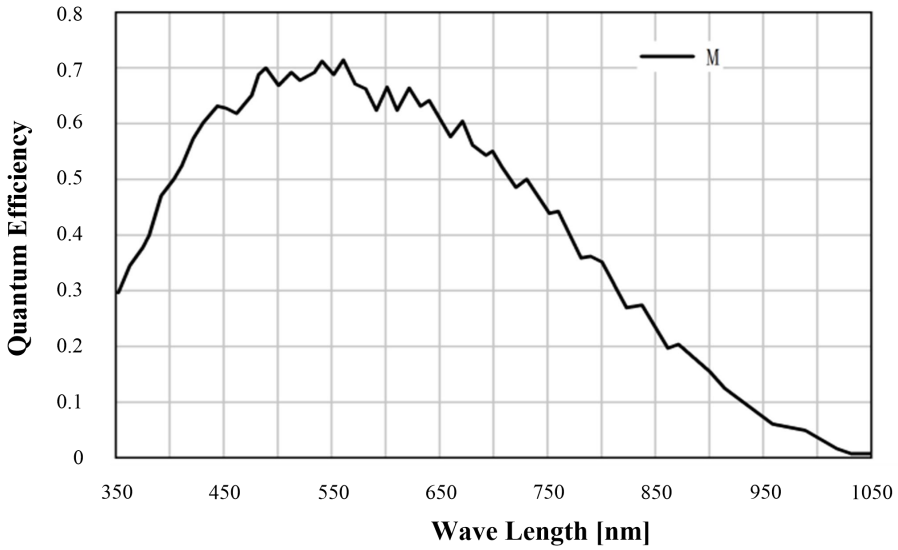
(e) 16K Double-Line Monochrome

Fig.3 Pixel Arrangements

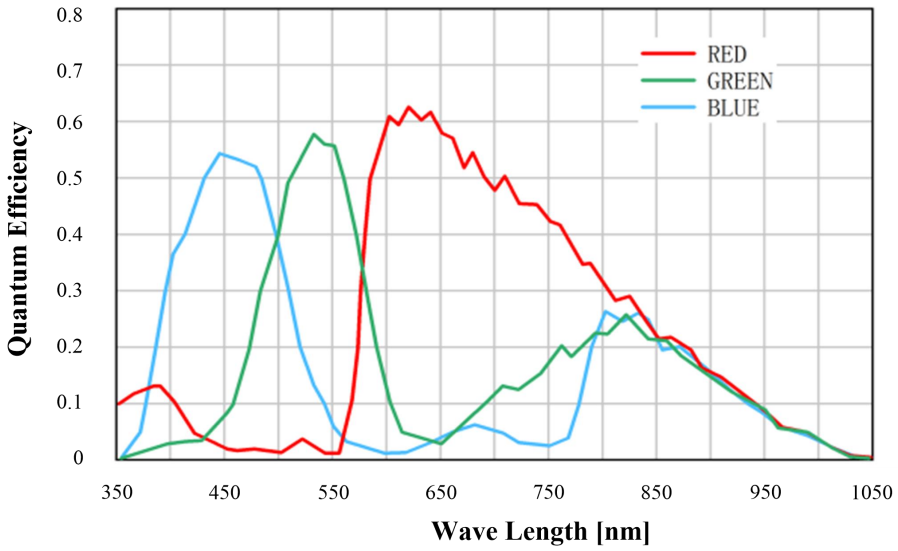
4.5 Spectral Response

The following is spectral response curve of PN-CXP10 series camera.

(1) PN8KCXP10 camera:

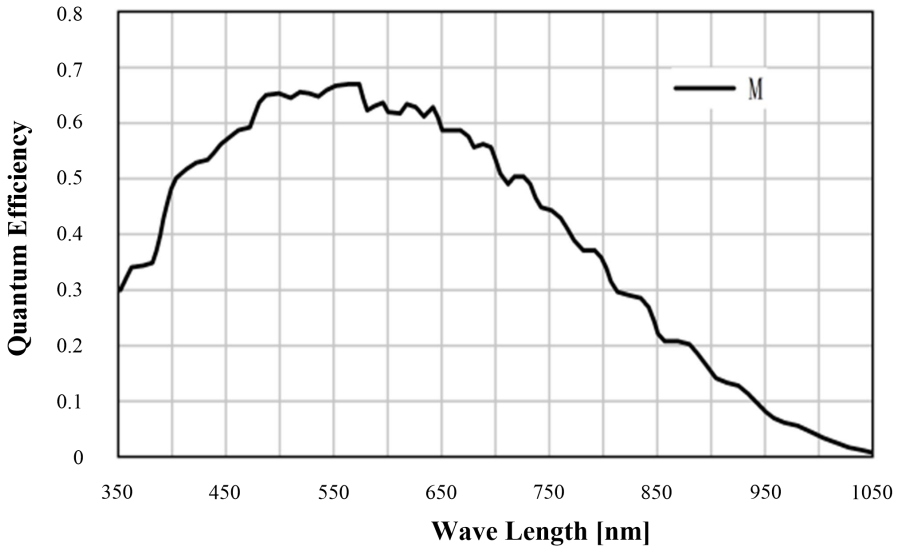


(a) Monochrome Camera



(b) Color Camera

(2) PN16KCXP10 camera:



(a) Monochrome Camera

Fig.4 Spectral Response of Camera

4.6 Environmental Requirements

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

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

4.7 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

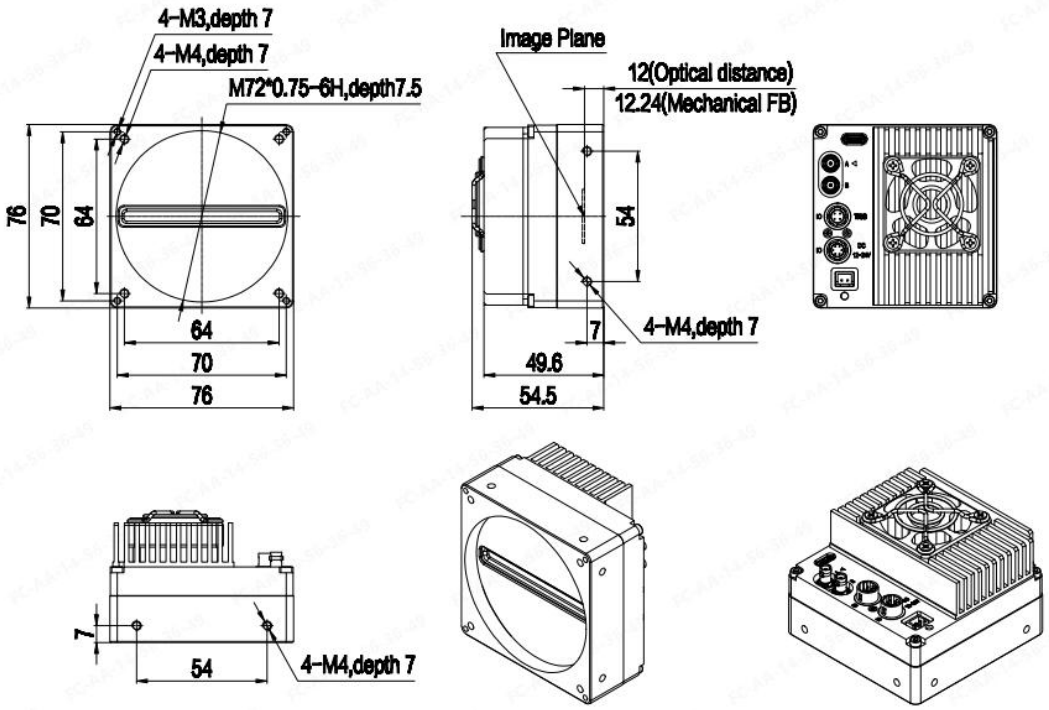


Fig.5 Camera Mechanical Dimensions

5.2 Camera Interface

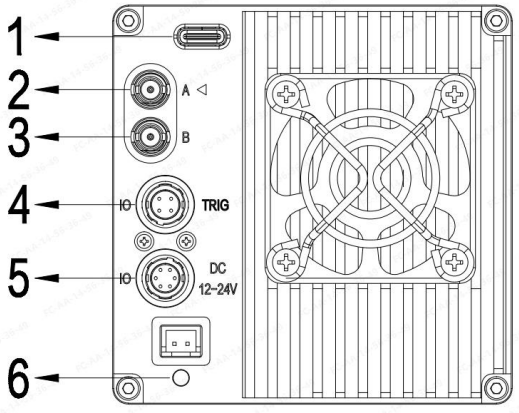


Fig.6 External Interfaces of Camera

(1) Type-C Interface

(2) CoaXPress Connection A **(Master)**

(3) CoaXPress Connection B

(4) 4-pin Line Trigger Control Interface

(5) 6-pin Power Input and Frame Trigger Control Interface

(6) Fan Power Interface

5.2.1 Camera Status Indicator

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

Table 8 Camera Status Indicator

LED Status Indicators	Camera Status
Solid Green	Normal
Blinking Green	No trigger input within three seconds in external trigger mode
Solid Red	Processor is starting or in error
Blinking Red	Camera fatal error (need contact technical support)
Solid Yellow	Camera is initializing or executing command

5.2.2 Power and Frame Trigger Interface

The power input and frame trigger 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).

The power input and frame trigger interface on the back of the camera is shown as follows:

Fig.7 Pin Assignments for Power and Frame Trigger Interface

Table 9 Power and Frame Trigger Interface Pin Definition

Signal	Pin	Signal	Pin
Power	1	GeneralInput2+	4
General Input1	2	GeneralInput2-	5
General Input1_GND	3	GND	6

The frame trigger interface circuit is shown as follows:

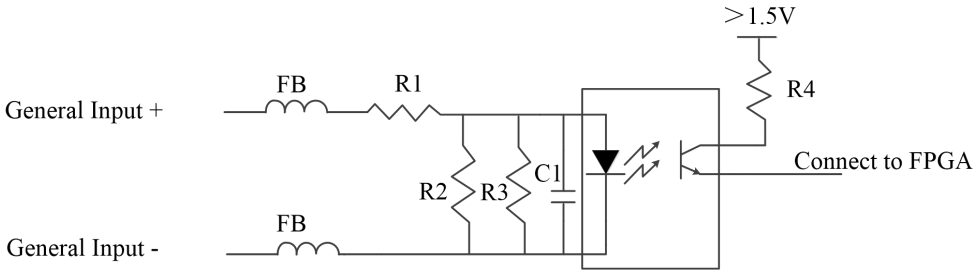


Fig.8 Frame Trigger Interface Circuit Diagram

- Level Standard: 1.5~24V, the interface is compatible with single end and differential input signal
- Drive Current: above 10mA

5.2.3 Line Trigger Interface

The line trigger 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:

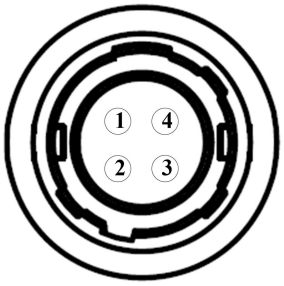


Fig.9 Pin Assignments for Line Trigger Interface

Table 10 Line Trigger Interface Pin Definition

Signal	Pin	Signal	Pin
ShaftEncoder_A+	1	ShaftEncoder_B+	3
ShaftEncoder_A-	2	ShaftEncoder_B-	4

The line trigger interface circuit is shown as follows:

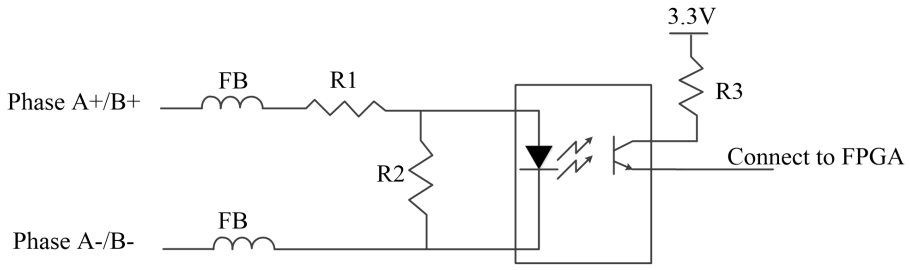


Fig.10 Line Trigger Interface Circuit Diagram

- Level Standard: 3.3~24V, differential input signal
- Drive Current: above 10mA

5.2.4 Data Interface

PN-CXP10 series camera implements standard CoaXPress 2.0 protocol, and data interface is two Micro BNC sockets on the back of camera. The data interface on the back of camera is shown in the red box below:

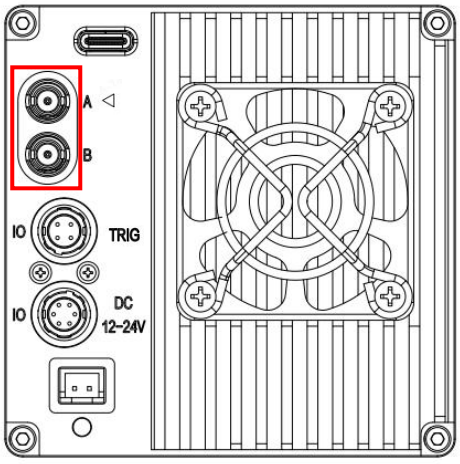


Fig.11 Data Interface

The mechanical diagram of Micro BNC interface is as follows:

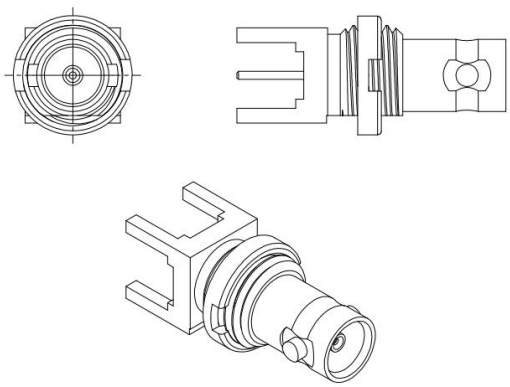


Fig.12 Micro BNC Interface

6 Camera Features

This chapter introduces the main features of PN-CXP10 series camera.

6.1 Trigger Mode

PN-CXP10 series camera supports two trigger modes: line trigger mode and frame trigger mode. Line trigger mode supports Free-Run, External Pulse and External PWM. Frame trigger mode supports Edge Trigger and Level Trigger.

6.1.1 Line Trigger Mode

Line trigger mode supports Free-Run, External Pulse and External PWM, which are shown as follows:

- **Free-Run Mode**

In Free-Run mode (Exposure Mode: Timed), internal logic of camera automatically generates camera control timing, so that camera produces normal image output without users providing external trigger signal.

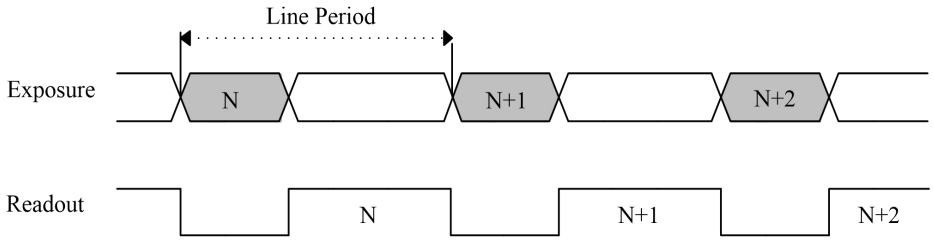


Fig.13 Free-Run Mode

In this mode, exposure time and line rate (reciprocal of line period) can be set by instructions. Note that line period should not be less than readout time of a line and should be greater than the sum of the set exposure time and the minimum exposure interval parameters. The internal running sequence of camera is shown in the figure above.

- **External Pulse Mode**

In External Pulse mode (Exposure Mode: TriggerPulse), camera starts to expose on the rising edge of external trigger signal, and exposure duration is determined by ExposureTime value. At this time, camera line rate is determined by interval between rising edge of external trigger pulse, and its running sequence is shown in the figure below.

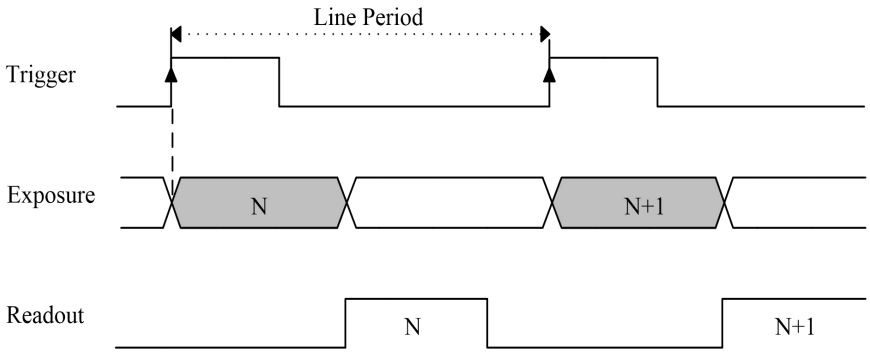


Fig.14 External Pulse Mode

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

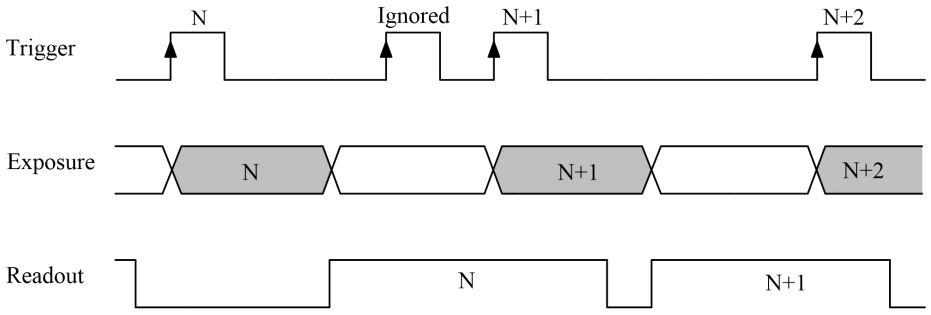


Fig.15 External Trigger Interval is Too Short

- **External PWM Mode**

In External PWM mode (Exposure Mode: Trigger Width), camera starts to expose at the rising edge of external trigger and ends at the falling edge, that is, exposure time is equal to high level duration of external trigger and line period is equal to pulse interval. Its running sequence is shown in the figure below.

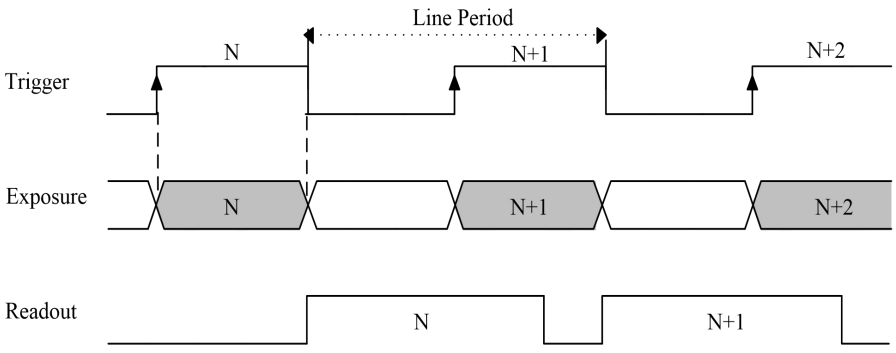


Fig.16 External PWM Trigger Mode

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.

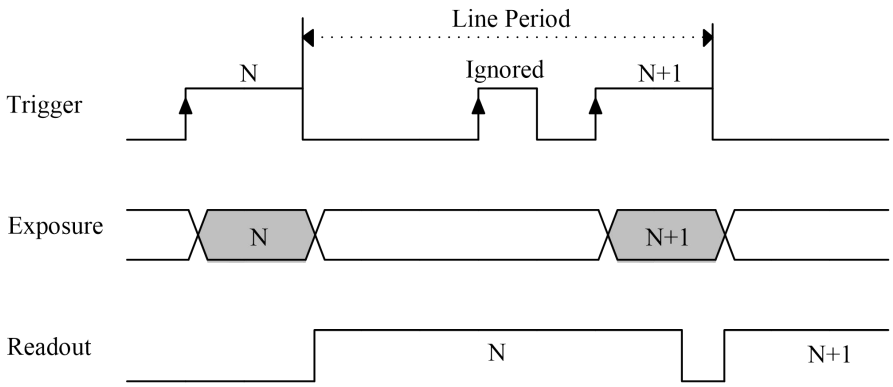


Fig.17 External Trigger Interval is Too Short

6.1.2 Frame Trigger Mode

Frame trigger mode supports Edge Trigger and Level Trigger, which are shown as follows:

- **Edge Trigger Mode**

In Edge Trigger mode, users need to provide external trigger signal. The trigger polarity can be the default polarity or reversed polarity. When trigger signal is detected, camera starts grabbing a frame of image. The number of lines is determined by FrameTriggerLines, no matter whether trigger signal width is larger than user-set FrameTriggerLines or not.

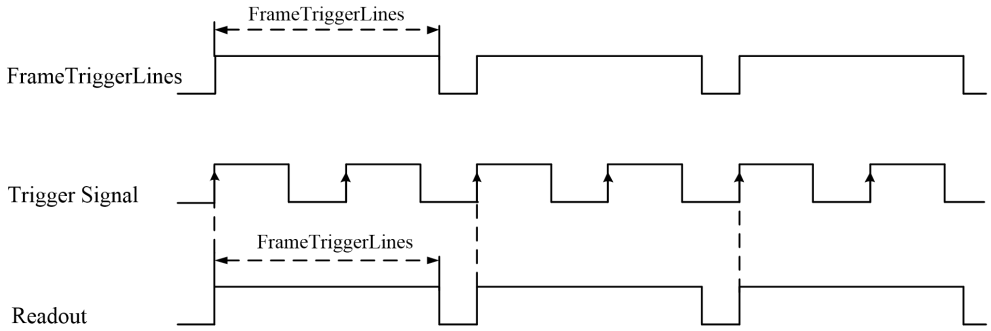


Fig. 18 Edge Trigger Mode

- **Level Trigger Mode**

In Level Trigger mode, users also need to provide external trigger signal. The trigger polarity can be the default polarity or reversed polarity. When trigger signal is detected, camera starts grabbing a frame of image. When trigger signal width is larger than user-set FrameTriggerLines, the number of image lines is limited by FrameTriggerLines. When trigger signal width is smaller than user-set FrameTriggerLines, the number of image lines is limited by trigger signal width, and the number of current readout image lines will be splice to the number of last read image lines until user-set FrameTriggerLines is reached.

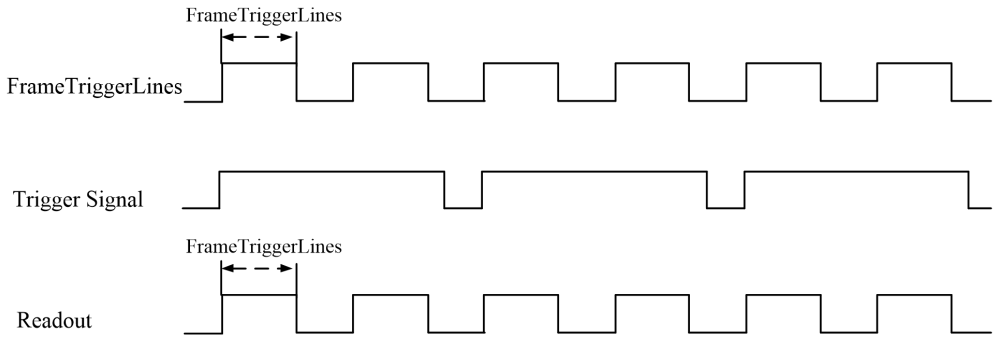


Fig.19 Level Trigger Mode, Trigger Signal Width is Larger than FrameTriggerLines

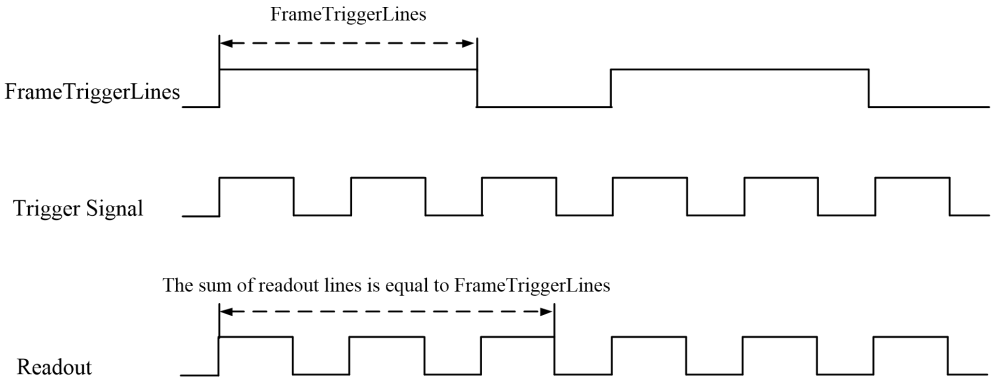


Fig.20 Level Trigger Mode, Trigger Signal Width is Smaller than FrameTriggerLines

6.2 Camera Scanning Direction

The scanning direction of PN-CXP10 series camera is vertical scanning direction, supporting image output from top to bottom or from bottom to top, which can be controlled by camera internally or by CXP signal or IO signal externally.

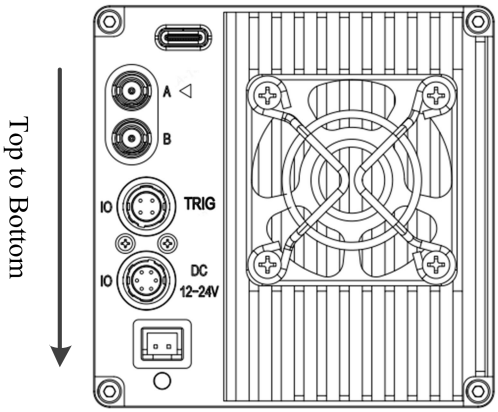
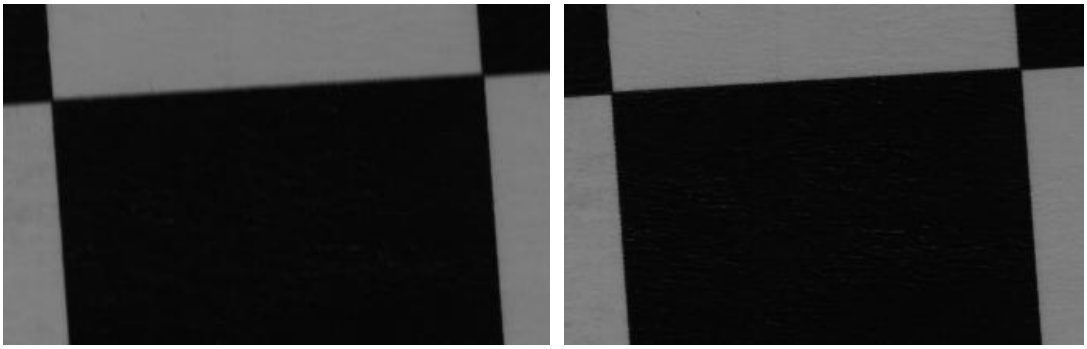


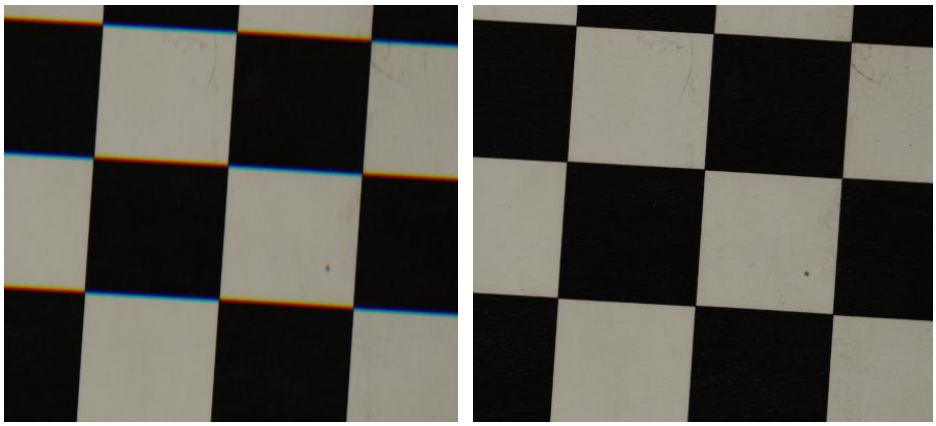
Fig.21 Camera Scanning Direction

Note: For monochrome camera, when camera is set to multi line mode and motion direction does not match, image edge will be blurred. When camera is set to single line mode, sharpness is not affected by scanning direction. For color camera, when vertical scanning direction does not match the direction of the object's movement, it will cause image edge dispersion.



(a) Multi Line Mode and Motion Direction does not Match (b) Multi Line Mode and Motion Direction Matches

Fig.22 Vertical Scanning Direction of Monochrome Camera



(a) Motion Direction does not Match (b) Motion Direction Matches

Fig.23 Vertical Scanning Direction of Color Camera

6.3 Horizontal Binning

PN-CXP10 series camera horizontal binning supports two pixels binning. After normal exposure acquisition, camera sums up values of two adjacent pixels and outputs them as a single pixel value.

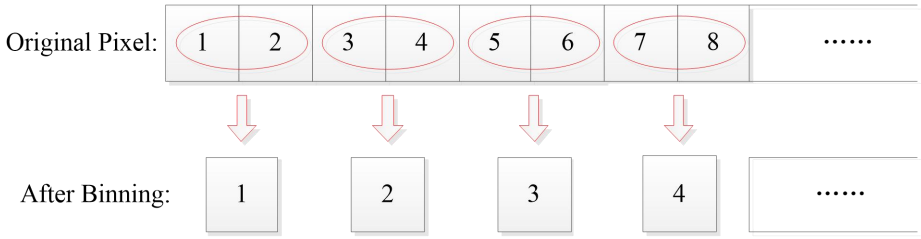


Fig.24 Horizontal Binning_2x1

6.4 Horizontal Flipping

The image is flipped along X direction. Users can use this function to change scanning direction of camera, as shown in the figure below:

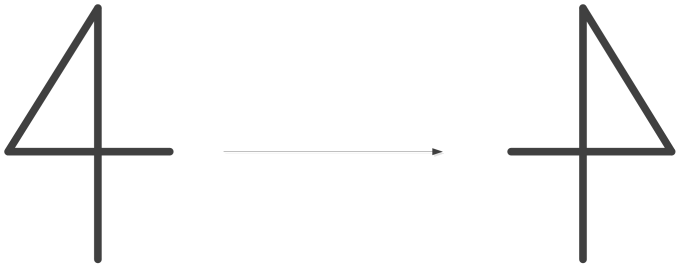
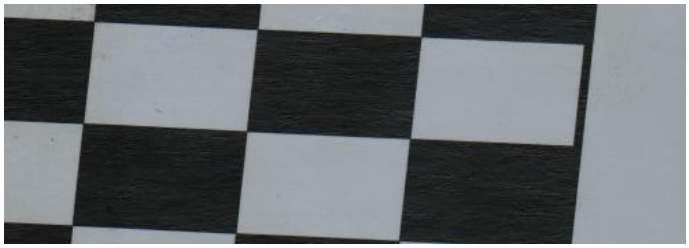


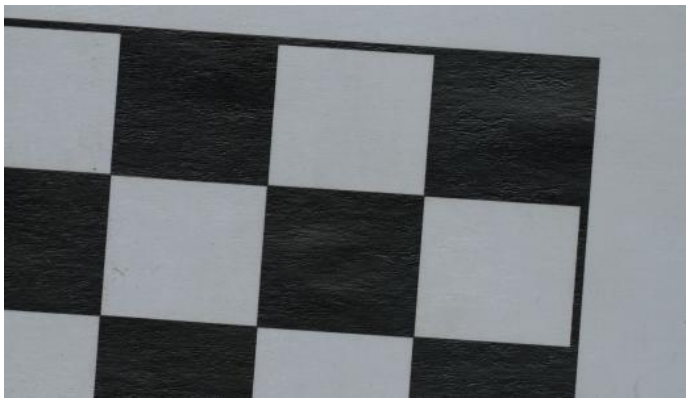
Fig.25 Horizontal Flipping

6.5 Spatial Correction

When horizontal and vertical magnification of camera are the same, a square object should remain square after being photographed. However, in actual situation, external trigger signal cannot be completely transformed to the most accurate proportion in most cases, a little error will lead to square being stretched or compressed, object in the same position cannot be superimposed to the same pixel, and edge transition is shown as artifacts. The spatial correction function compensates camera acquisition speed proportionally according to received line signal, which can ensure that a square object should remain square after being photographed as an image.



(a) Before Spatial Correction

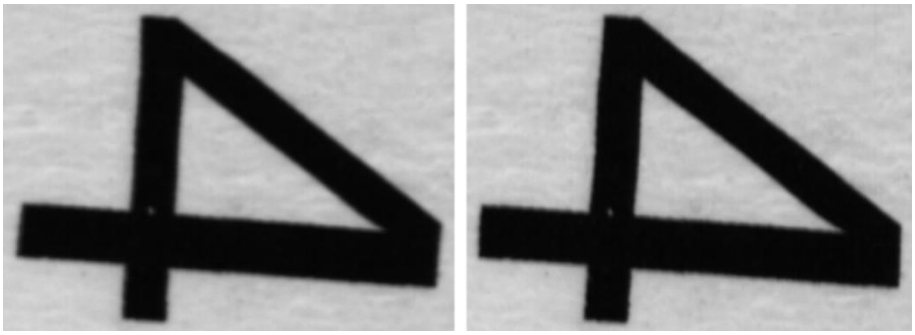


(b) After Spatial Correction

Fig. 26 Spatial Correction Effect

6.6 Parallax Correction

When camera has a large inclination angle with horizontal plane in the direction of object motion, actual optical magnification is different due to the difference of sensor position, which leads to edge blurring at the left and right ends of image. Parallax correction solves the problem of blurred edges by different horizontal stretching so that the left and right ends of image can be aligned.

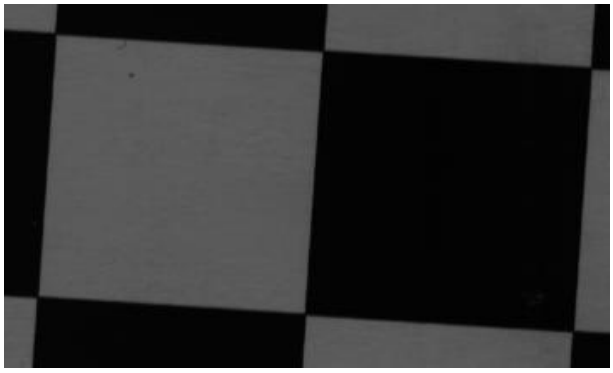


(a) Before Parallax Correction (b) After Parallax Correction

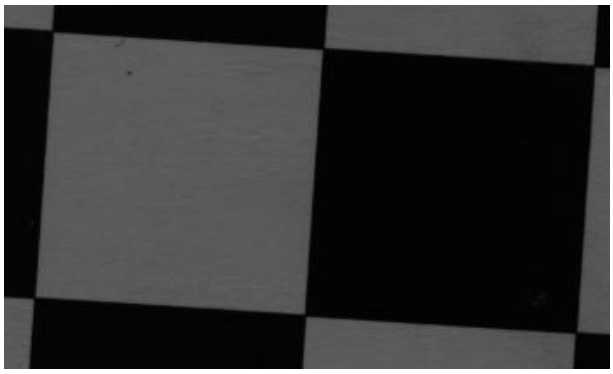
Fig. 27 Parallax Correction Effect

6.7 Time Delay Integration

For camera adopts multi line sensor, two adjacent exposures can make two 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



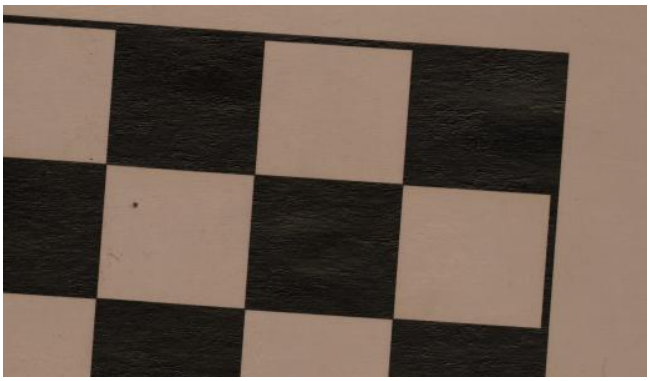
(b) Edge Clear

Fig.28 Time Delay Integration Effect

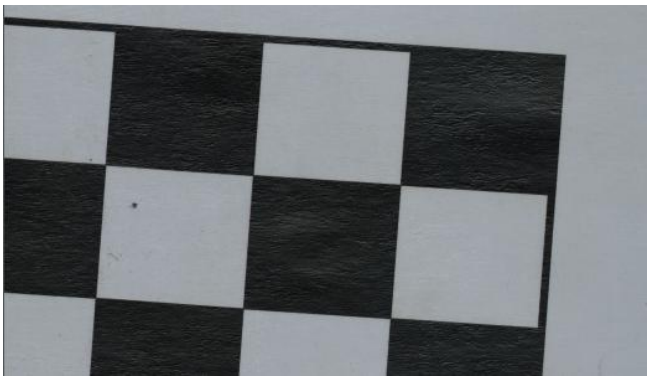
6.8 White Balance

White balance is an important parameter of color industrial camera, which directly affects color effect of reconstructed image. When white balance of industrial camera is not properly set, reconstructed image will appear color deviation phenomenon. Ideally, white objects should remain white after being photographed by color camera. However, due to inconsistent response of light source band and sensor RGB channel, image obtained by shooting white objects is generally not completely white. White balance correction redefines white by adjusting compensation coefficient of each RGB channel. When a change in external lighting or in optics causes a white object not to be white, users need to perform white balance function.

Color camera internally provides white balance function, which balances output values of each channel of sensor. Automatic white balance calculates white balance coefficient by sampling local pixels in sensor, and then adjusts each component of image according to coefficient, so that values of Red, Green and Blue components in output image are consistent.



(a) Before White Balance



(b) After White Balance

Fig.29 White Balance Effect

6.9 Shaft Encoder Module

The shaft encoder module of PN-CXP10 series camera is designed to receive shaft encoder signal from channel A or channel B, and use signal to synthesize integration control signal as trigger signal source of line trigger function.

The main parameters of shaft encoder module are as follows:

- ShaftEncoderUseSingleChannel: Use shaft encoder single channel. If this parameter is selected, camera receives shaft encoder signals from single channel.
- ShaftEncoderSource: Shaft encoder trigger source. Users can select signals from channel A or channel B.
- ShaftEncoderMultiplier: Shaft encoder multiple frequency, which can be set as 1/2/4/8/16/32.
- ShaftEncoderDivider: Shaft encoder divide frequency, which can be set from 1 to 255.
- ShaftEncoderWorkingMode: Shaft encoder working mode, which is used to set image output direction when shaft encoder is grabbing images. When Both is selected, both forward and backward motion are effective. When Forward/Backward is selected, only forward / backward motion is valid.
- ShaftEncoderReverseCompensation: Enable shaft encoder reverse compensation. Only after shaft encoder one-way image collection is turned on, this parameter can be modified. When this option is selected, camera compensates for shaft encoder reverse signal, causing collection to discard duplicate parts.
- ShaftEncoderReverseCompensationLimit: Shaft encoder reverse compensation limit. Shaft encoder will no longer compensate reverse signals if its counter is beyond this value.

- ShaftEncoderMinValidWidth: The minimum valid width of received signal. Signals less than the set value do not cause a trigger, which is equivalent to filtering function. When interference is large, users can increase this value to ensure the stability of trigger.

In the process of object transmission, due to the interference of external factors, conveyor belt may shake, causing object to reverse a certain distance. Shaft encoder reverse compensation function is used to record the distance of object moving backwards. Images grabbing will continue until object is transferred to the position before jitter occurs again, so as to avoid the repeated grabbing of reverse displacement caused by jitter.

Shaft encoder reverse compensation function is only valid when frequency is 4 times or above and channel A and channel B are used at the same time. The main parameters are Shaft Encoder Working Mode and Shaft Encoder Reverse Compensation Limit. For specific applications, please refer to the following scenes:

- **Scene1**

Set parameters as follows:

- ShaftEncoderWorkingMode: Forward/Backward
- ShaftEncoderReverseCompensationLimit: 0

The maximum value of shaft encoder reverse compensation is set to 0, and reverse displacement of object caused by jitter is recorded as 0, so the operation of shaft encoder module will not be affected. In this case, if Shaft Encoder Working Mode is set to Forward, when object is moving forward, camera will normally grab images; when object is moving backward, camera will not grab images. If Shaft Encoder Working Mode is set to Backward, when object is moving backward, camera will normally grab images; when object is moving forward, camera will not grab images.

- **Scene2**

Set parameters as follows:

- ShaftEncoderWorkingMode: Forward/Backward
- ShaftEncoderReverseCompensationLimit: Larger than the number of reverse signals produced by jitter

The camera normally grabs images when shaft encoder moves forward/backward, but does not grab images when shaft encoder moves back/forward. For example, camera grabs images when shaft encoder moves forward and does not grab images when shaft encoder moves backward:

① When object moves forward with conveyor belt, shaft encoder turns forward and generates forward signals. At this time, camera grabs images normally.

② When conveyor belt is reversed due to jitter, object follows conveyor belt to reverse displacement, and shaft encoder turns backward, producing backward signals. At this time, camera does not grab images, and shaft encoder module records the number of backward signals.

③ When conveyor belt returns to normal and continues to move forward with object, shaft encoder turns forward and generates forward signals. These forward signals are used to offset backward signals recorded by shaft encoder module previously. At this time, camera still does not grab images.

④ When the number of forward signals used for compensation completely cancels the number of backward signals recorded, object returns to the position before jitter occurred. At this point, forward

signal of shaft encoder is received, and camera will continue to grab images, and reverse displacement part will not repeat.

- **Scene3**

Set parameters as follows:

➢ ShaftEncoderWorkingMode: Both

➢ ShaftEncoderReverseCompensationLimit: Users can not enable reverse compensation function, and this parameter does not need to set

The camera needs to grab images when shaft encoder turns both forward and backward:

① When object moves forward with conveyor belt, shaft encoder turns forward and generates forward signals. At this time, camera grabs images normally.

② When conveyor belt reverses due to jitter, object follows conveyor belt to reverse displacement, and shaft encoder reverses to produce backward signals. Because shaft encoder reverse compensation function is disabled, camera still grabs images.

③ When object moves backward with conveyor belt, shaft encoder turns backward and generates backward signals. At this time, camera grabs images normally.

④ When conveyor belt moves forward due to jitter, object follows conveyor belt to moves displacement, and shaft encoder moves forward to produce forward signals. Because shaft encoder reverse compensation function is disabled, camera still grabs images.

6.10 Test Image

PN-CXP10 series provides two test images. Unlike images acquired from sensor data, test images are pre-edited and stored inside the camera as a fixed style. Test images can be used to test whether the data link works well.

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

- Vertical test image: Fixed image with gray gradient in horizontal direction.
- Horizontal test image: Scroll image with gray gradient in the vertical direction.

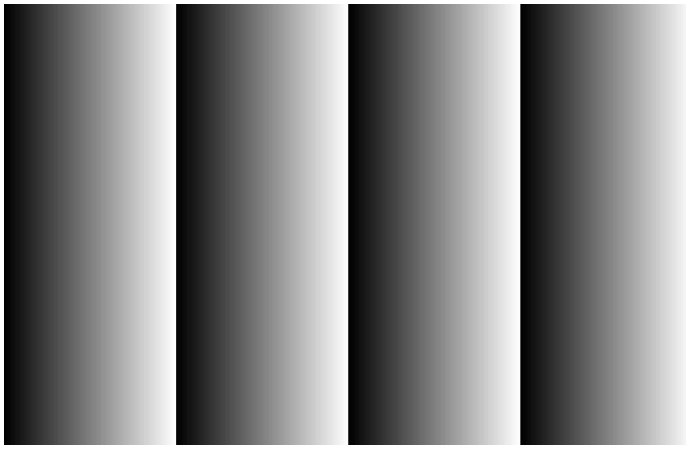


Fig.30 Vertical Test Image

Fig.31 Horizontal Test Image

6.11 Data Format

PN-CXP10 series camera provides 8bit and 10bit pixel data bit widths. If it is 8bit width, it is equivalent to intercept the upper 8 bits of 10bit data.

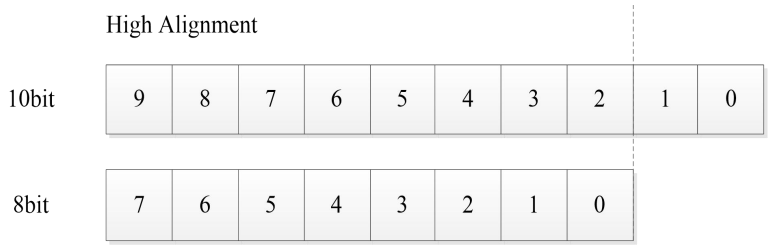


Fig.32 Data Format

6.12 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 10 bit of data. If image data is 8bit, actual digital offset is divided by 4.

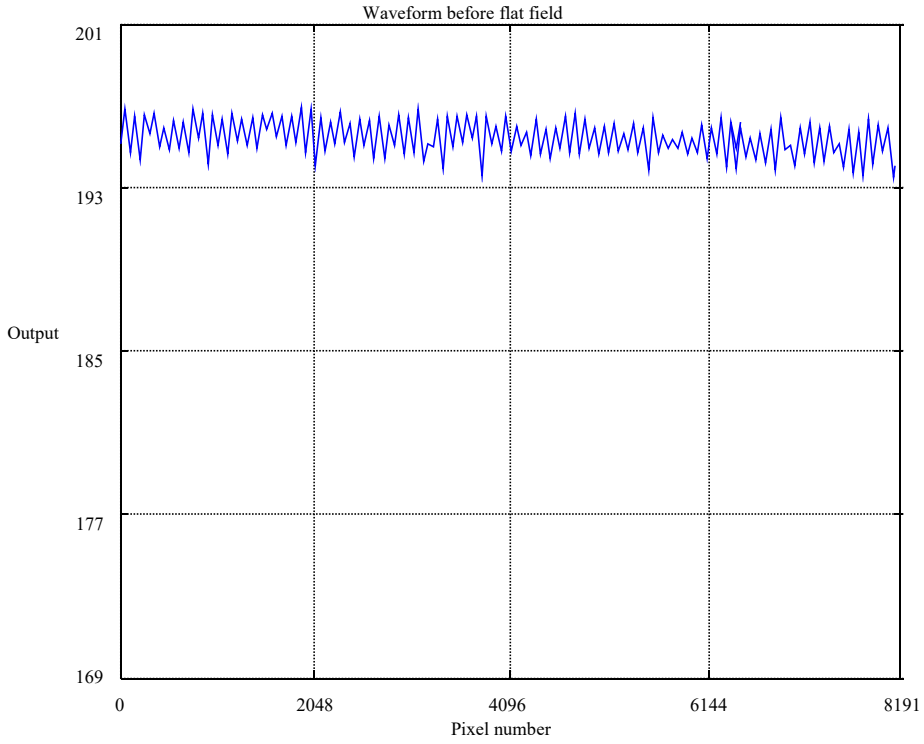
6.13 Flat Field Correction

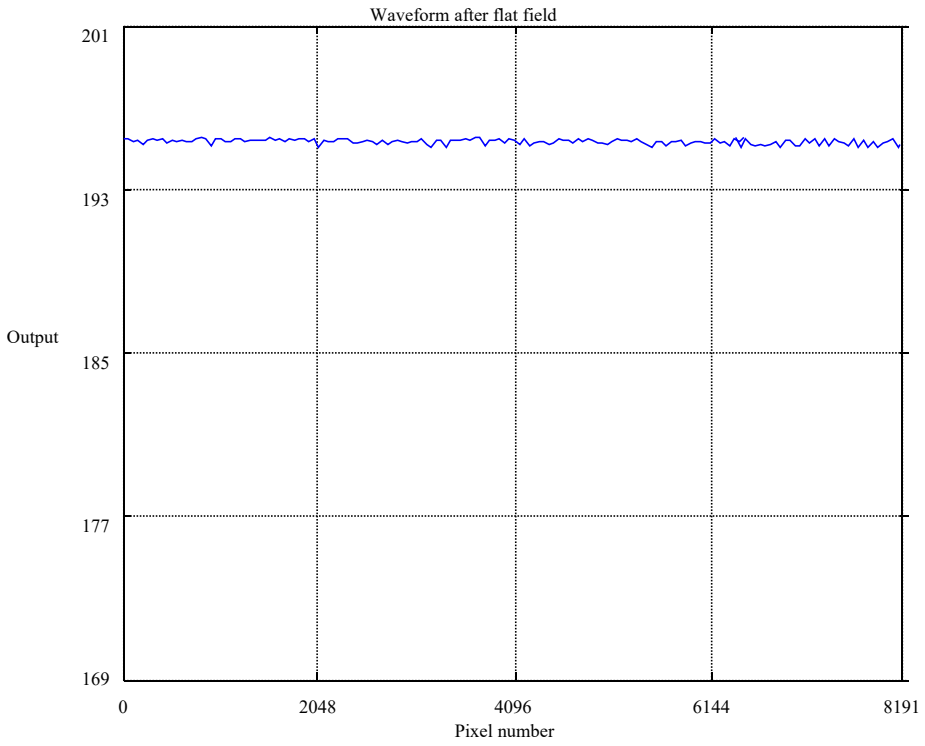
Due to inconsistency of semiconductor technology, response of each pixel of array image sensor is different to some extent, which is reflected in the difference of output data for the same brightness signal. PN-CXP10 series camera internal provides flat field correction function, users can use to achieve flat field effect through the uniform intensity target signal correction parameters.

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.

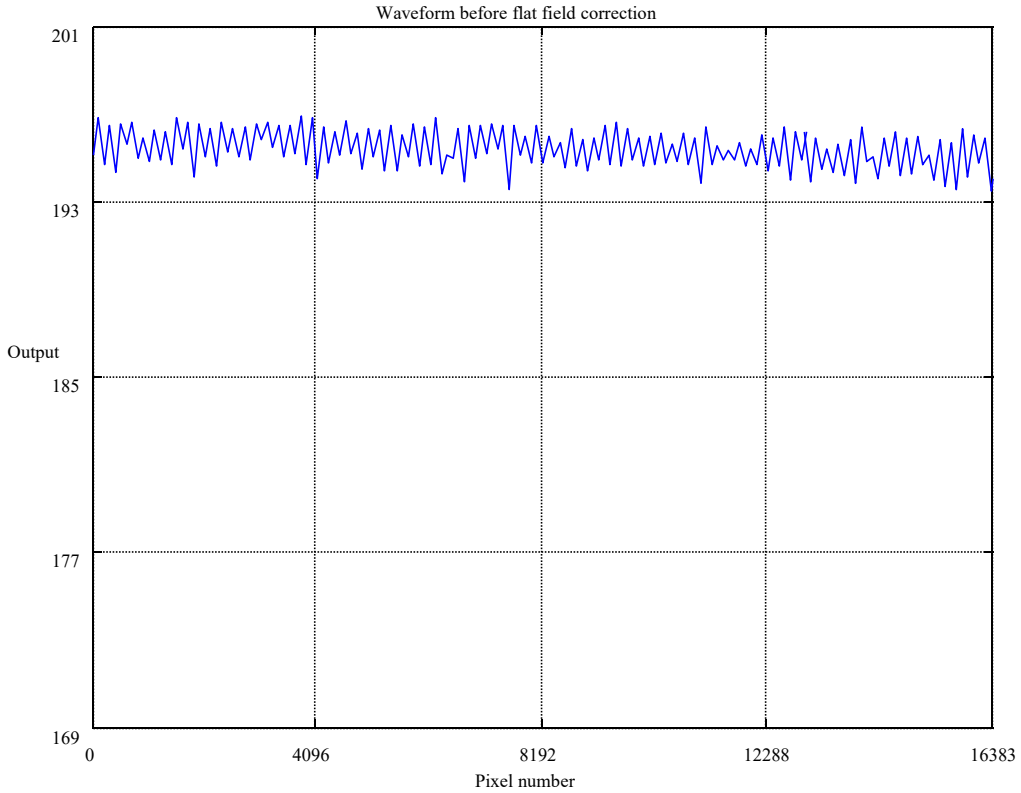
Flat field correction effect is shown in the figure below:

(1) PN8KCXP10:





(2) PN16KCXP10:



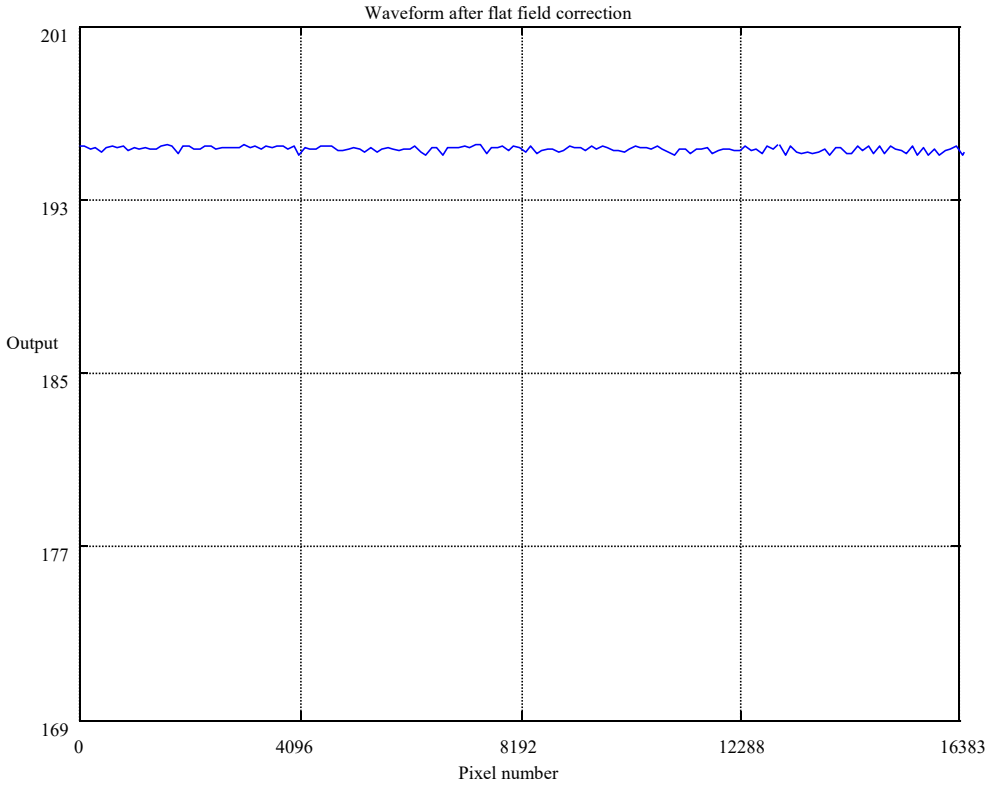


Fig.33 Waveform of Flat Field Correction

6.14 Camera Temperature

PN-CXP10 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.

6.15 Load / Save Configuration

PN-CXP10 series camera supports three working parameter sets, including one factory default parameter set and two user parameter sets. Factory default parameter set can be used in most occasions. Users can also configure parameters based on actual requirements and save in user parameter set for self-loading after power on. The camera will automatically load the last saved parameter set each time.

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

7 Camera Control

7.1 GenICam Standard

GenICam standard, promulgated by European Machine Vision Association (EMVA), provides a unified programming interface for all types of industrial cameras. The programming interface (API) is the same no matter what transport protocol the camera uses or what functionality it implements. It mainly contains the following three modules:

- GenAPI: Responsible for parsing XML files and solving problem of how to configure camera
- GenTL: Transport layer, for device enumeration, attribute control, and image acquisition
- SFNC: Standard for naming camera features

Camera XML file is stored locally on the PC, and collection software will select the most appropriate XML file according to camera model. Application and camera communicate with each other through SFNC, GenAPI, and CoaXPress, as shown in the figure.

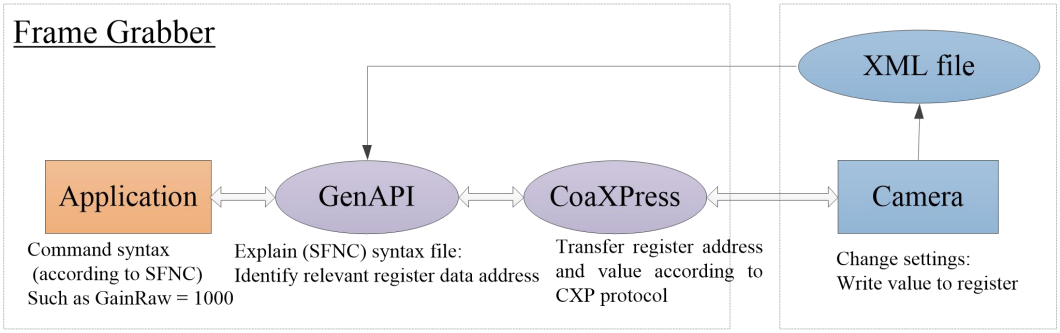


Fig.34 Communication Schematic between Application and Camera

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 11 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 12 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
ConnectionConfigDefaultPreferred	0x6008	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 (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)
  - CXP10_X1 (65616)
  - CXP10_X2 (131152)
  - CXP10_X4 (262224)
  - CXP12_X1 (65624)
  - CXP12_X2 (131160)
  - CXP12_X4 (262232)

- **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)
  - CXP3_X2 (131128)
  - CXP5_X2 (131136)
  - CXP6_X2 (131144)
  - CXP3_X4 (262200)
  - CXP5_X4 (262208)
  - CXP6_X4 (262216)
  - CXP10_X1 (65616)
  - CXP10_X2 (131152)
  - CXP10_X4 (262224)
  - CXP12_X1 (65624)
  - CXP12_X2 (131160)
  - CXP12_X4 (262232)

- **ConnectionConfigDefaultPreferred**

Set the preferred default mode combination of device connection speed and number of active connections. The enumeration names and values are as follows:

  - CXP6_X1 (65608)
  - CXP6_X2 (131144)
  - CXP10_X1 (65616)
  - CXP10_X2 (131152)

- **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)
  - CXP10_X1 (65616)
  - CXP10_X2 (131152)
  - CXP10_X4 (262224)
  - CXP12_X1 (65624)
  - CXP12_X2 (131160)
  - CXP12_X4 (262232)

- **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 13 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	0x6f00	16	S	RW	Beginner
MCUTemperature	0x6118	4	F	RO	Expert
SensorType	0x6050	4	E	RW	Beginner
TDILineSelector	0x6054	4	E	RW	Beginner

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceManufacturerInfo**
  Device manufacturer information.

- **DeviceVersion**
  Device version.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceUserID**
  User-defined ID.

- **MCUTemperature**
  MCU temperature.

- **SensorType**
  Sensor type. The enumeration names and values are as follows:

- 8KMonoSingleLine (0): 8K monochrome single line
- 8KMonoDualLine (1): 8K monochrome double line
- 8KMonoFourLine (5): 8K monochrome four line
- 8KRGBTripleLine (4): 8K color triple line
- 8KRGBSixLine (8): 8K color six line
- 16KMonoSingleLine (3): 16K monochrome single line
- 16KMonoDualLine (6): 16K monochrome double line
- 8KMonoSingleLine_High_Speed (9): 8Kmonochrome high speed single line

- **TDILineSelector**

  TDI working mode selector. The enumeration names and values are as follows:

  - Average (0): Average. For monochrome camera, it means average of each line. For color camera, it means average of lines of each channel.

7.3.3 Image Format Control Register

Table 14 Image Format Control Register

Name	Address	Size	Interface	Access	Visibility
Width	0x6000	4	I	RW	Beginner
Height	0x6004	4	I	RO	Beginner
Binning	0x61b0	4	E	RW	Beginner
PixelFormat	0x6020	4	E	RW	Beginner
OffsetX	0x6010	4	I	RW	Beginner
VideoMode	0x602c	4	E	RW	Beginner
ReverseX	0x613c	4	B	RW	Beginner
DeviceTapGeometry	0x6030	4	E	RO	Expert
Image1StreamID	0x6034	4	I	RO	Guru

- **Width**

  Actual camera output width.

- **Height**

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

  - Maximum: 1
  - Minimum: 1

- **Binning**

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

  - Binning_1x1 (0)
  - Binning_2x1 (1)

- **PixelFormat**

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

- Mono8 (0x01080001): Monochrome 8bit
- Mono10 (0x01100003): Monochrome 10bit
- RGB8 (0x02180014): RGB color 8bit
- RGB10 (0x02300018): RGB color 10bit
- BGR8 (0x02180015): BGR color 8bit
- BGR10 (0x02300019): BGR color 10bit

- **OffsetX**

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

- **VideoMode**

  Output image format. The enumeration names and values are as follows:
  - Original (0): Original image
  - Corrected (1): Corrected image
  - VerticalPattern (2): Vertical test image
  - HorizontalPattern (3): Horizontal test image

- **ReverseX**

  Horizontal flipping.

- **DeviceTapGeometry**

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

- **Image1StreamID**

  Data stream1 index.

7.3.4 Acquisition Control Register

Table 15 Acquisition Control Register

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0x603c	4	E	RW	Beginner
AcquisitionStart	0x6040	4	C	RW	Beginner
AcquisitionStop	0x6044	4	C	RW	Beginner
AcquisitionLineRate	0x61a0	4	F	RW	Beginner
ExposureMode	0x605c	4	E	RW	Beginner
ExposureTime	0x6060	4	F	RW	Beginner

- **AcquisitionMode**

  Acquisition mode, usually default to continuous acquisition. The enumeration names and values are as follows:
  - Continuous (0): Continuous acquisition

- **AcquisitionStart**
  Start acquisition.

- **AcquisitionStop**
  Stop acquisition.

- **AcquisitionLineRate**
  Acquisition line rate.

- **ExposureMode**
  Exposure mode. The enumeration names and values are as follows:
  - Timed (0): Free-run mode
  - TriggerPulse (1): External pulse mode
  - TriggerWidth (2): External PWM mode

- **ExposureTime**
  Exposure time.

7.3.5 IO Control Register

Table 16 IO Control Register

Name	Address	Size	Interface	Access	Visibility
FrameTriggerEnable	0x6370	4	B	RW	Beginner
FrameTriggerSource	0x6300	4	E	RW	Beginner
FrameTriggerLines	0x61ec	4	I	RW	Beginner
FrameTriggerType	0x6304	4	E	RW	Beginner
FrameTriggerReverse	0x6308	4	B	RW	Beginner
FrameTriggerDelayType	0x630c	4	E	RW	Beginner
FrameTriggerMinWidth	0x6310	4	F	RW	Beginner
FrameTriggerDelayInUs	0x6314	4	F	RW	Beginner
ShaftEncoderUseSingleChannel	0x631c	4	B	RW	Beginner
ShaftEncoderSource	0x6324	4	E	RW	Expert
ShaftEncoderMultiplier	0x6320	4	E	RW	Expert
ShaftEncoderDivider	0x6328	4	I	RW	Beginner
ShaftEncoderWorkingMode	0x632c	4	E	RW	Expert
ShaftEncoderReverseCompensation	0x6330	4	B	RW	Expert
ShaftEncoderReverseCompensationLimit	0x6374	4	I	RW	Expert
ShaftEncoderMinWidth	0x6334	4	F	RW	Expert
IntegrationTriggerSource	0x6338	4	E	RW	Expert
IntegrationTriggerBypassMode	0x633c	4	B	RW	Expert
IntegrationTriggerPolarity	0x6340	4	E	RW	Expert
IntegrationTriggerDelay	0x6344	4	F	RW	Expert

IntegrationTriggerWidth	0x6348	4	F	RW	Expert
LineTriggerSource	0x634c	4	E	RW	Expert
ScanDirectionWorkingMode	0x6350	4	E	RW	Expert
ScanDirectionIntType	0x6354	4	E	RW	Expert
ScanDirectionExtTriggerSource	0x6358	4	E	RW	Expert
ScanDirectionExtTriggerPolarity	0x635c	4	E	RW	Expert

- **FrameTriggerEnable**

  Enable frame trigger.

- **FrameTriggerSource**

  Frame trigger source. The enumeration names and values are as follows:
  - GeneralInput1 (0): General input1 signal
  - GeneralInput2 (1): General input2 signal

- **FrameTriggerLines**

  Frame trigger lines. The parameter range is as follows:
  - Maximum: 65535
  - Minimum: 1
  - Increment: 1

- **FrameTriggerType**

  Frame trigger type. The enumeration names and values are as follows:
  - EdgeSensitive (0): Edge trigger
  - LevelSensitive (1): Level trigger

- **FrameTriggerReverse**

  Frame trigger polarity reverse. Check this parameter to set frame trigger polarity to reverse.

- **FrameTriggerDelayType**

  Frame trigger delay type. The enumeration names and values are as follows:
  - DelayInUS (1): Time delay

- **FrameTriggerMinWidth**

  Frame trigger minimum pulse width. The parameter range is as follows:
  - Maximum: 819
  - Minimum: 0

- **FrameTriggerDelayInUs**

  Frame trigger delay time, unit is us. The parameter range is as follows:
  - Maximum: 654
  - Minimum: 0

- **ShaftEncoderUseSingleChannel**

Use single channel of shaft encoder. Check this parameter to set single channel of shaft encoder as trigger source.

- **ShaftEncoderSource**

  Shaft encoder trigger source. The enumeration names and values are as follows:
  - A (0): A phase
  - B (1): B phase

- **ShaftEncoderMultiplier**

  Shaft encoder multiple frequency. The enumeration names and values are as follows:
  - x1 (0)
  - x2 (1)
  - x4 (2)
  - x8 (3)
  - x16 (4)
  - x32 (5)

- **ShaftEncoderDivider**

  Shaft encoder divide frequency. The parameter range is as follows:
  - Maximum: 65535
  - Minimum: 1

- **ShaftEncoderWorkingMode**

  Shaft encoder working mode. The enumeration names and values are as follows:
  - Both (0): Any direction
  - ForwardOnly (1): Only forward
  - Backward (2): Only backward

- **ShaftEncoderReverseCompensation**

  Enable shaft encoder reverse compensation function.

- **ShaftEncoderReverseCompensationLimit**

  The maximum value of shaft encoder reverse counter, beyond which the reverse counter value does not increase.The parameter range is as follows:
  - Maximum: 1048575
  - Minimum: 1
  - Increment: 1

- **ShaftEncoderMinWidth**

  Shaft encoder minimum pulse width. The parameter range is as follows:
  - Maximum: 819
  - Minimum: 1

- **IntegrationTriggerSource**

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

- ShaftEncoder (2): Shaft encoder signal

- **IntegrationTriggerBypassMode**

Integration signal trigger bypass mode. Check this parameter means bypass function follows signal generated by trigger source without integration processing.

- **IntegrationTriggerPolarity**

Integration signal polarity. The enumeration names and values are as follows:

- Original (0): Same as source
- Reverse (1): Opposite to source

- **IntegrationTriggerDelay**

Integration signal trigger delay time. The parameter range is as follows:

- Maximum: 819
- Minimum: 0

- **IntegrationTriggerWidth**

Integration signal trigger pulse width. The parameter range is as follows:

- Maximum: 26843545
- Minimum: 1

- **LineTriggerSource**

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

- IntegrationSignal (0): Integration signal
- GeneralInput1 (2): General input1 signal
- CXPIn (4): CXP signal

- **ScanDirectionWorkingMode**

Scan direction working mode. The enumeration names and values are as follows:

- InternalControl (0): Internal control
- ExternalControl (1): External control

- **ScanDirectionIntType**

Scan direction internal control type. The enumeration names and values are as follows:

- BottomToTop (0): From bottom to top
- TopToBottom (1): From top to bottom

- **ScanDirectionExtTriggerSource**

Scan direction external trigger source. When scanning direction is external control and trigger source is Generalinput1, frame trigger type must be level trigger; otherwise image cannot be displayed. The enumeration names and values are as follows:

- IntegrationSignal (0): Integration signal
- FixedLow (1): Fixed low level

- GeneralInput1 (2): General input1 signal
- CXPIn (4): CXP signal

- **ScanDirectionExtTriggerPolarity**

  Scan direction external trigger polarity. The enumeration names and values are as follows:
  - Original (0): Same as source
  - Reverse (1): Opposite to source

7.3.6 Image Correction Register

Table 17 Image Correction Register

Name	Address	Size	Interface	Access	Visibility
ParallaxCorrectionFactor	0x60c0	4	F	RW	Beginner
SpatialCorrectionEnable	0x60c4	4	B	RW	Expert
SpatialCorrectionFactor	0x60c8	4	F	RW	Beginner
SpatialAlignment	0x6380	4	F	RW	Expert
TDIMode(Fine)	0x60cc	4	F	RW	Expert
ColorCorrectionEnable	0x60d0	4	B	RW	Expert
ColorCorrectionRRGain	0x61b4	4	I	RW	Beginner
ColorCorrectionRGGain	0x61b8	4	I	RW	Beginner
ColorCorrectionRBGain	0x61bc	4	I	RW	Beginner
ColorCorrectionGRGain	0x61c0	4	I	RW	Beginner
ColorCorrectionGGGain	0x61c4	4	I	RW	Beginner
ColorCorrectionGBGain	0x61c8	4	I	RW	Beginner
ColorCorrectionBRGain	0x61cc	4	I	RW	Beginner
ColorCorrectionBGGain	0x61d0	4	I	RW	Beginner
ColorCorrectionBBGain	0x61d4	4	I	RW	Beginner

- **ParallaxCorrectionFactor**

  Parallax correction coefficient. The parameter range is as follows:
  - Maximum: 15
  - Minimum: -15

- **SpatialCorrectionEnable**

  Enable spatial correction. Check this parameter to enable spatial correction function.

- **SpatialCorrectionFactor**

  Spatial correction coefficient. The parameter range is as follows:
  - Maximum: 2.0
  - Minimum: 0.5

- **SpatialAlignment**

  vertical compression ratio. The parameter range is as follows:

- Maximum: 2.0
- Minimum: 0

- **TDIMode(Fine)**

  TDI mode (fine). The parameter range is as follows:
  - Maximum: 0.998
  - Minimum: -0.998

- **ColorCorrectionEnable**

  Enable color correction. Check this parameter to enable color correction function and only color camera can set this parameter.

- **ColorCorrectionRRGain**

  Red gain of R channel for color correction, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 2047
  - Minimum: 256
  - Increment: 1

- **ColorCorrectionRGGain**

  Green gain of R channel for color correction, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 2047
  - Minimum: -2047
  - Increment: 1

- **ColorCorrectionRBGain**

  Blue gain of R channel for color correction, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 2047
  - Minimum: -2047
  - Increment: 1

- **ColorCorrectionGRGain**

  Red gain of G channel for color correction, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 2047
  - Minimum: -2047
  - Increment: 1

- **ColorCorrectionGGGain**

  Green gain of G channel for color correction, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 2047

- Minimum: 256
- Increment: 1

- **ColorCorrectionGBGain**

Blue gain of G channel for color correction, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 2047
- Minimum: -2047
- Increment: 1

- **ColorCorrectionBRGain**

Red gain of B channel for color correction, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 2047
- Minimum: -2047
- Increment: 1

- **ColorCorrectionBGGain**

Green gain of B channel for color correction, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 2047
- Minimum: -2047
- Increment: 1

- **ColorCorrectionBBGain**

Blue gain of B channel for color correction, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 2047
- Minimum: 256
- Increment: 1

7.3.7 Analog Control Register

Table 18 Analog Control Register

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0x612c	4	E	RW	Beginner

- **AnalogGain**

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

- X1 (1)
- X2 (2)
- X3 (3)
- X4 (4)
- X5 (5): Only PN8KCXP10-37KC2/50KT4/62KC/80KT support this enumeration

- X6 (6): Only PN8KCXP10-37KC2/50KT4/62KC/80KT support this enumeration
- X7 (7): Only PN8KCXP10-37KC2/50KT4/62KC/80KT support this enumeration
- X8 (8): Only PN8KCXP10-37KC2/50KT4/62KC/80KT support this enumeration

7.3.8 Digital Control Register

Table 19 Digital Control Register

Name	Address	Size	Interface	Access	Visibility
DigitalGain	0x6068	4	F	RW	Beginner
DigitalOffset	0x606c	4	I	RW	Beginner
WhiteBalanceRedGain	0x6070	4	I	RW	Expert
WhiteBalanceGreenGain	0x6074	4	I	RW	Expert
WhiteBalanceBlueGain	0x607c	4	I	RW	Expert
WhiteBalanceEnable	0x608c	4	B	RW	Expert
WhiteBalanceInitialize	0x6080	4	C	WO	Expert
WhiteBalanceCalibrate	0x6080	4	C	WO	Expert
BlackLevel	0x6058	4	I	RW	Guru

- **DigitalGain**

  Digital gain. The parameter range is as follows:
  - Maximum: 8.0
  - Minimum: 0.1

- **DigitalOffset**

  Digital offset. The parameter range is as follows:
  - Maximum: 1023
  - Minimum: -1023
  - Increment: 1

- **WhiteBalanceRedGain**

  White balance R channel gain, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 4096
  - Minimum: 256
  - Increment: 1

- **WhiteBalanceGreenGain**

  White balance G channel gain, only color camera can set this parameter. The parameter range is as follows:
  - Maximum: 4096
  - Minimum: 256
  - Increment: 1

- **WhiteBalanceBlueGain**

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

  - Maximum: 4096
  - Minimum: 256
  - Increment: 1

- **WhiteBalanceEnable**

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

- **WhiteBalanceInitialize**

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

- **WhiteBalanceCalibrate**

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

- **BlackLevel**

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

  - Maximum: 31
  - Minimum: 0
  - Increment: 1

7.3.9 LUT Control Register

Table 20 LUT Control Register

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0x6360	4	B	RW	Beginner
LUTIndex	0x6364	4	I	RW	Expert
LUTValue	0x6368	4	I	RW	Expert

- **LUTEnable**

Enable LUT function. PN-CXP10 series camera has not support lookup table function yet.

- **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

7.3.10 Flat Field Correction Register

Table 21 Flat Field Correction Register

Name	Address	Size	Interface	Access	Visibility
FFC_Enable	0x6100	4	B	RW	Beginner
FFC_ReferenceMode	0x60d8	4	B	RW	Beginner
FFC_TargetRed	0x60e0	4	I	RW	Beginner
FFC_TargetGreen	0x60e4	4	I	RW	Beginner
FFC_TargetBlue	0x60e8	4	I	RW	Beginner
FFC_TargetMono	0x60f8	4	I	RW	Beginner
FFC_OffsetX	0x60ec	4	I	RW	Beginner
FFC_Width	0x60f0	4	I	RW	Beginner
FFC_LineSelect	0x60d4	4	E	RW	Beginner
FFC_State	0x61e8	4	E	RO	Beginner
FFC_Start	0x6104	4	C	WO	Expert
FFC_Reset	0x6104	4	C	WO	Expert

- **FFC_Enable**

Enable flat field correction.

- **FFC_ReferenceMode**

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

- **FFC_TargetRed**

Target value of flat field correction R channel, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 1023
- Minimum: 128
- Increment: 1

- **FFC_TargetGreen**

Target value of flat field correction G channel, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 1023
- Minimum: 128

- Increment: 1

- **FFC_TargetBlue**

Target value of flat field correction B channel, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 1023
- Minimum: 128
- Increment: 1

- **FFC_TargetMono**

Target gray value of flat field correction monochrome channel, only monochrome camera can set this parameter. The parameter range is as follows:

- Maximum: 1023
- Minimum: 128
- Increment: 1

- **FFC_OffsetX**

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

- Minimum: 0
- Increment: 16

- **FFC_Width**

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

- Minimum: 1024
- Increment: 16

- **FFC_LineSelect**

Select which line to set flat field correction. The enumeration names and values are as follows:

- Red (1): R channel
- Green (2): G channel
- Blue (4): B channel
- Mono (3): monochrome channel
- All (7): All channel

- **FFC_State**

Flat field correction state. The enumeration names and values are as follows:

- Success (0): Success
- InvalidArgument (1): Invalid parameter
- AccessDeny (2): Access deny
- ExposureTimeTooLow (3): Exposure time is too low
- ExposureTimeTooHigh (4): Exposure time is too high
- ValidPixelTooFew (5): Valid pixels are too few

- **FFC_Start**

Start flat field correction.

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

7.3.11 User Set Control Register

Table 22 User Set Control Register

Name	Address	Size	Interface	Access	Visibility
UserSetSelector	0x6108	4	E	RW	Beginner
UserSetLoad	0x610c	4	C	WO	Beginner
UserSetSave	0x6110	4	C	WO	Beginner

- **UserSetSelector**
  User configuration selector. The enumeration names and values are as follows:
  - Default (0): Factory configuration
  - UserSet1 (1): User configuration 1
  - UserSet2 (2): User configuration 2

- **UserSetLoad**
  Load selected camera configuration.

- **UserSetSave**
  Save selected camera configuration.

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.

If users have any problems during the use of the camera, please contact our technical support in time, we will provide you with the service as soon as possible.