TTS103MCXP10-24M/C Area 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	2023/04/06	● Initial version
0.2	2023/09/12	● Update chapter 7

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 5.0A.

② Hefei I-TEK Optoelectronics Co., LTD. does not provide external power supply. Users need to connect power supply by themself.

- **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**

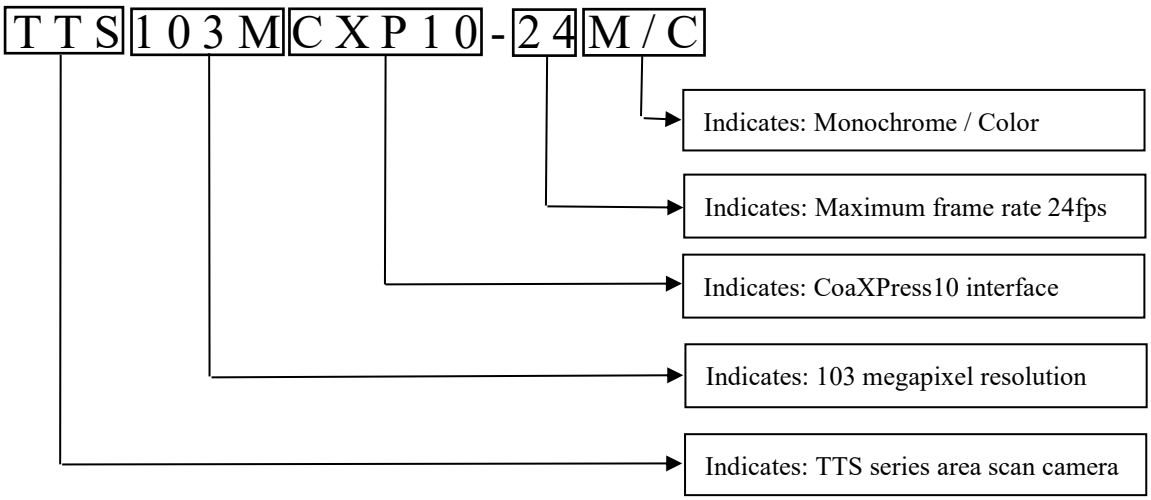
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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: 103 mega-pixel TEC industrial camera



3 Product Appearance

Fig.1 Product Appearance

Note:

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

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

4 Product Specifications

TTS103MCXP10 camera adopts advanced global shutter CMOS image sensor and CoaXPress10 data interface. It is a high-speed area scan camera designed for industrial measurement and inspection. It has high reliability and stability, suitable for image acquisition with high requirements (high resolution, high speed), such as surface inspection, electronic mount inspection, etc.

4.1 Main Features

- Global Shutter CMOS Sensor
- Full Frame Rate up to 24fps
- High Sensitivity and Low Noise
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Pixel Format: 8/10/12bit
- ROI
- Binning
- LUT
- Defect Pixel Correction
- White Balance
- Flat Field Correction
- Strobe
- Analog Gain / Digital Gain / Offset Control
- Scanning Direction Configurable
- Temperature Monitor
- Thermal Electric Cooling

4.2 Camera Specifications

Table 1 TTS103MCXP10-24M/C Product Specifications

Model	TTS103MCXP10-24M/C
Product Description	103 mega-pixel TEC industrial camera
Resolution	11248 x 9200
Pixel Size	3.2um x 3.2um
Sensor Type	Global shutter CMOS
Image Type	Monochrome/Color
Sensor Size	46.50mm (diagonal)
Dynamic Range	≥ 64.5dB
SNR	38.9dB
Data Rate	3700MB/s
Analog Gain	X1/X2/X3.7
Digital Gain	0.004~8
Digital Offset	-4095~4095
Lens Mount	M72

Max Frame Rate	24.85fps@8/10bit, 23.87fps@12bit
Trigger Mode	External Trigger, Free-Run
External Trigger	External IO/CXP
Exposure Control	Pulse Width Control, Timed
Exposure Time	19us~548s (step: 1us)
Data Format	8/10/12bit
Operation Temperature	0~55°C
Data Interface	CoaXPress10
Power Supply	DC 12~24V (±10%) 5.0A
Power Consumption	42.5W (TEC on)
Mechanical	111mm x 111mm x 89.27mm (without lens adapter)
Cooling Method	Thermal electric cooling with a fan
Cooling Performance	About 20°C below ambient temperature

Note: This table is for 1.3-2.0 version of TTS103MCXP10 camera specifications, which may vary slightly from version to version.

4.3 Camera Structure

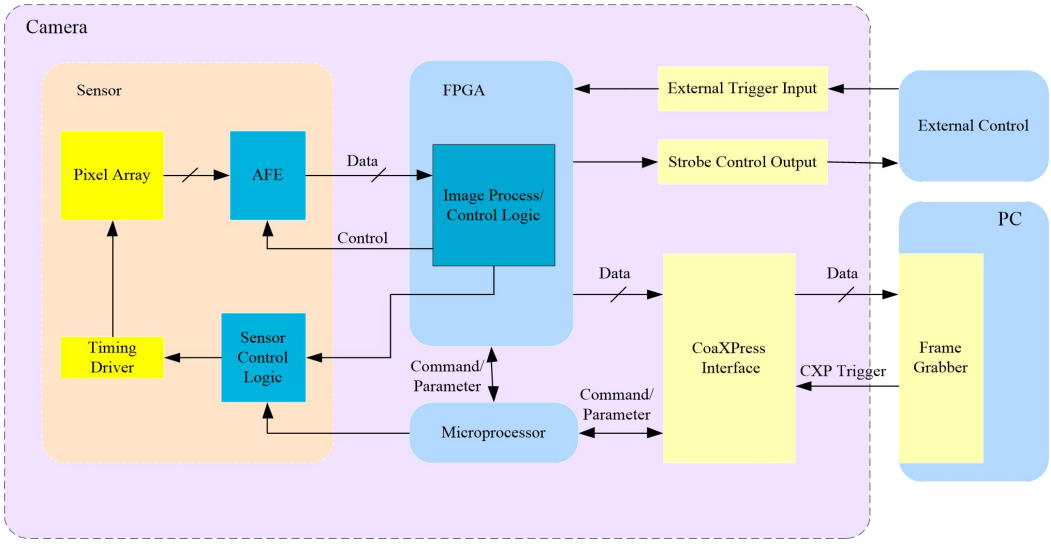


Fig.2 Internal Implementation Structure of Camera

TTS103MCXP10 camera uses a unified architecture to realize image sensor control, data transmission and embedded algorithm processing of different resolutions. The internal structure of camera is shown in the figure above. The pixel array is uniformly sampled and maintained by global shutter control system, converted into digital signals by analog front end, and then transmitted to PC frame grabber through CoaXPress interface after relevant algorithm processing by FPGA and microprocessor.

The camera can accept external trigger, from IO signal or CXP signal of CoaXPress interface.

4.4 Spectral Response

The following is spectral response curve of TTS103MCXP10 camera.

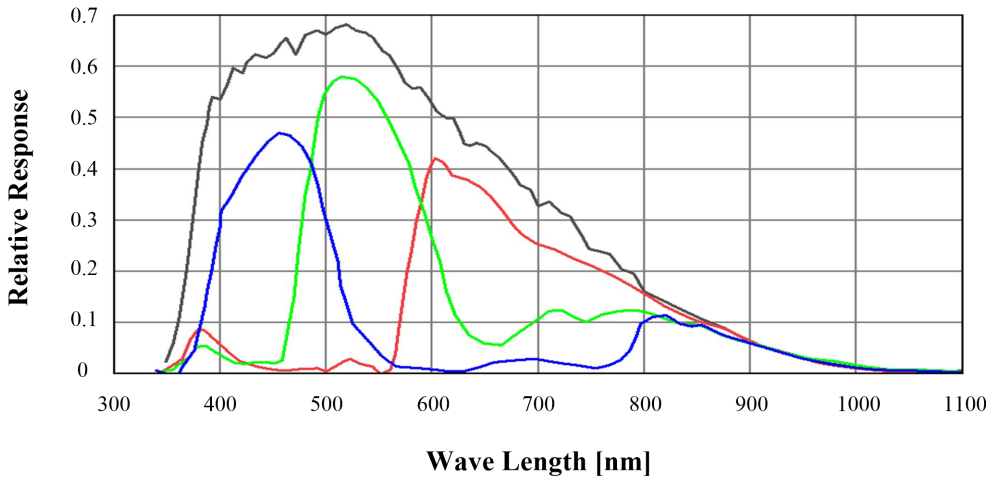


Fig.3 Spectral Response of Camera

4.5 Camera Bayer Pattern

TTS103MCXP10 camera supports color mode, Bayer pattern is shown in the figure below (HR is horizontal resolution, VR is vertical resolution).

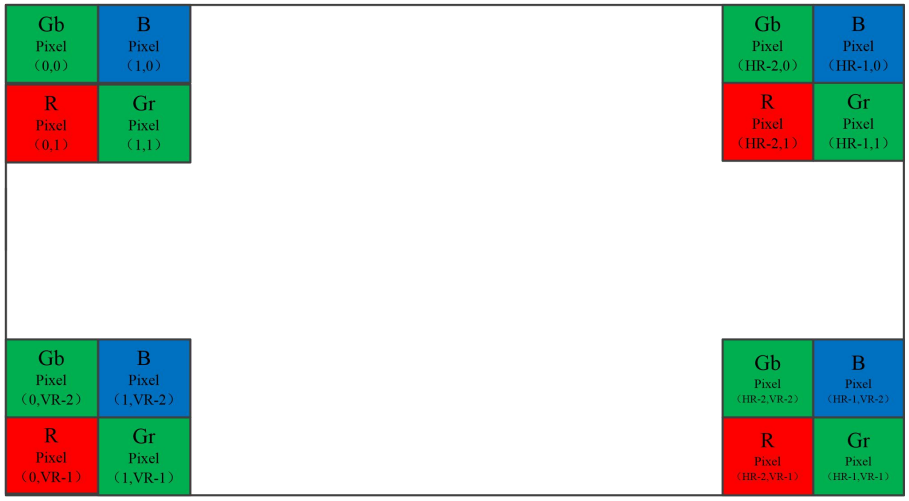


Fig.4 Camera Bayer Pattern

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

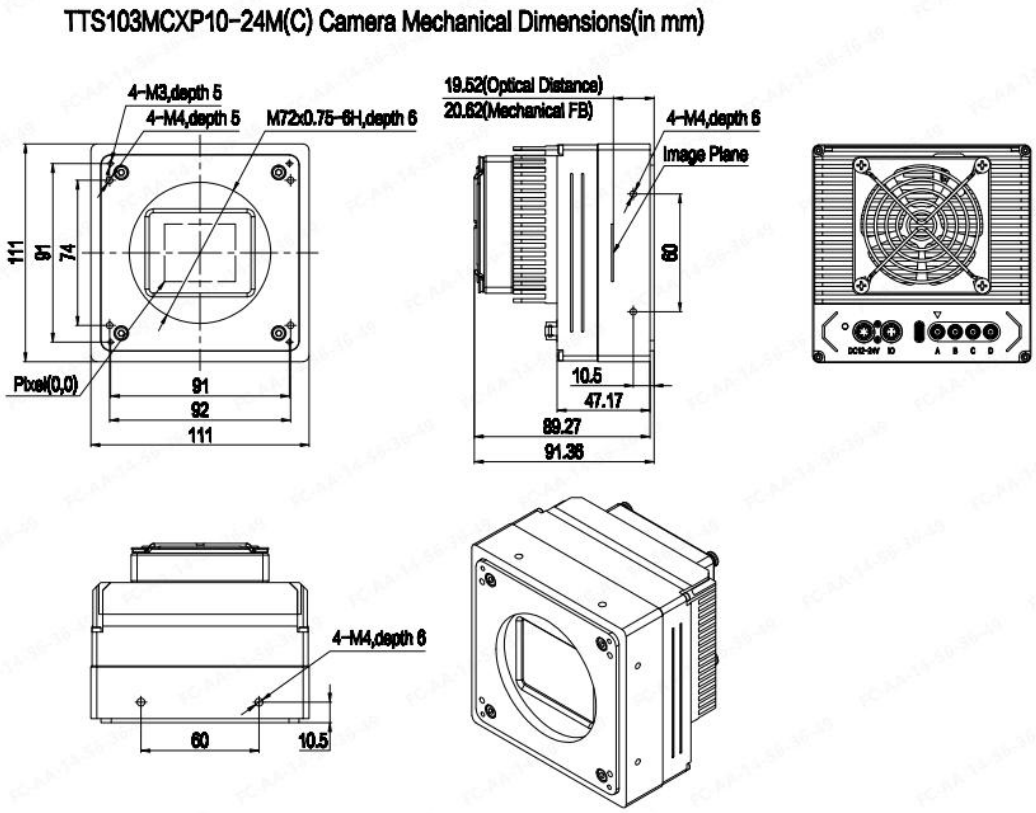


Fig.5 Camera Mechanical Dimensions

5.2 Camera Interface

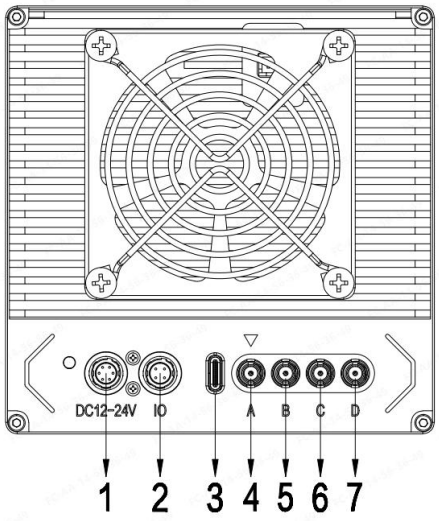


Fig.6 External Interfaces of Camera

① 6-pin Power Input

② 4-pin Control Interface (Trigger Input and Strobe Output)

③ Type-C Interface
④ CoaXPress Connection A **(Master)**
⑤ CoaXPress Connection B
⑥ CoaXPress Connection C
⑦ CoaXPress Connection D

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 2 Camera Status Indicators

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 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.7 Pin Assignments for Interface

Table 3 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:

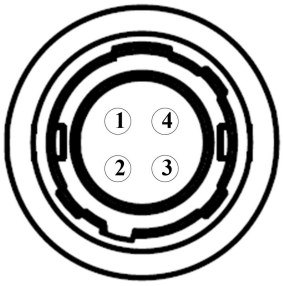


Fig.8 Assignments for Interface

Table 4 Interface Pin Definition

Signal	Pin	Signal	Pin
Trigger In +	1	GND	3
Trigger In -	2	Strobe Out	4

The external trigger circuit is shown as follows:

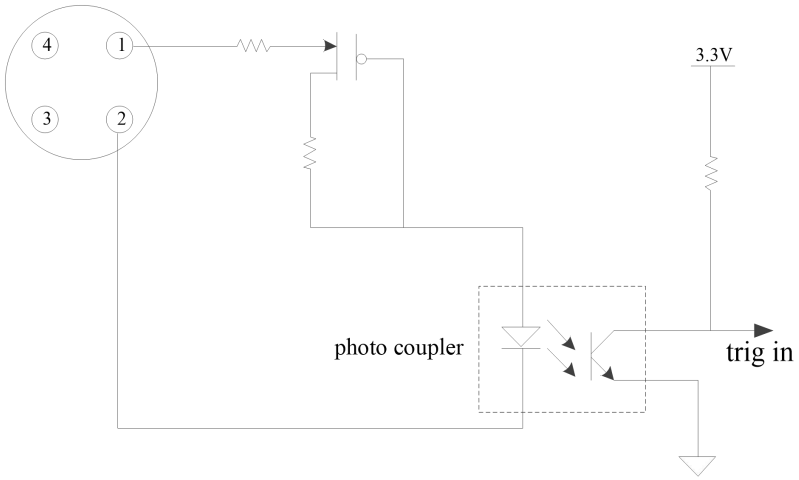


Fig.9 Trigger Input Circuit Schematic

- External Trigger Voltage Range: Above 3.3V

The strobe output circuit is shown below:

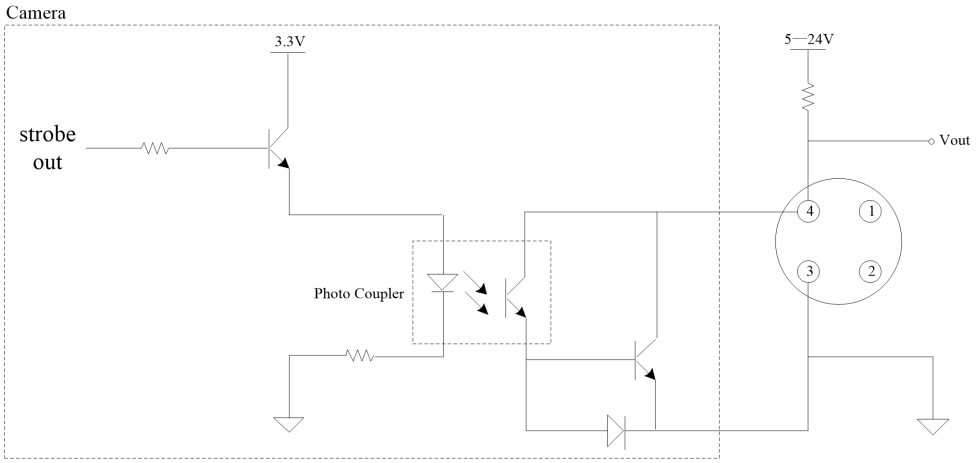


Fig.10 Strobe Output Circuit Schematic

- Strobe Signal Pull-up Voltage Range: 5~24V

5.2.4 Data Interface

TTS103MCXP10 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:

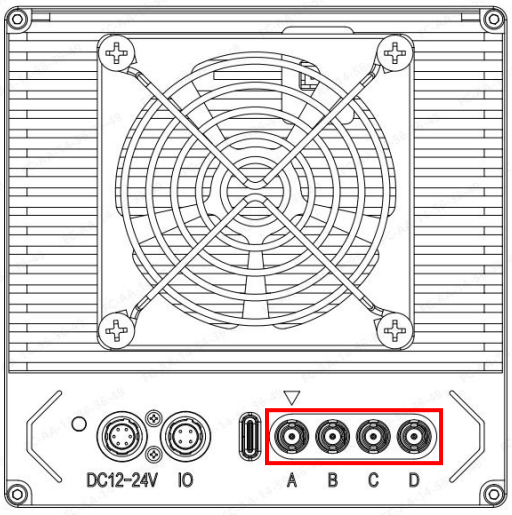


Fig.11 Data Interface

The mechanical drawing of Micro BNC socket is as follows:

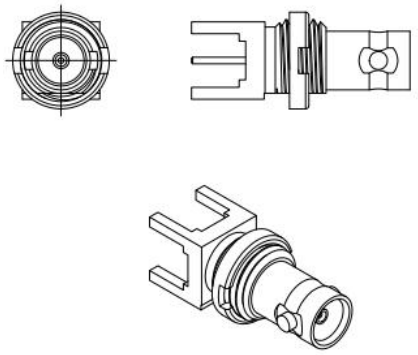


Fig.12 Micro BNC Socket

6 Camera Features

This chapter introduces the main features of TTS103MCXP10 camera.

6.1 Trigger Mode

TTS103MCXP10 camera supports three trigger modes: Free-Run mode, External Pulse mode and External PWM mode.

6.1.1 Free-Run Mode

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

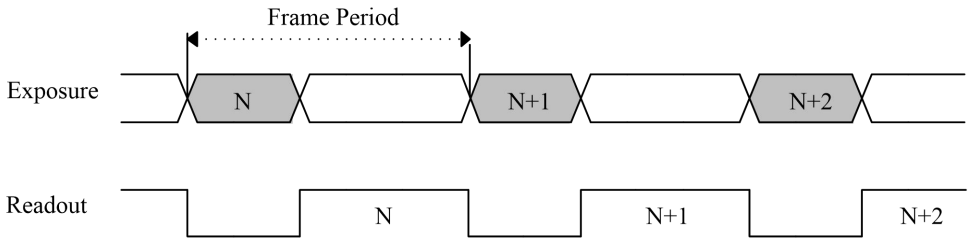


Fig.13 Free-Run Mode

To achieve normal image output, TTS103MCXP10 camera limits the range of frame period and exposure time. The minimum frame period should be greater than both exposure time and readout time of a frame.

6.1.2 External Pulse Mode

In External Pulse mode Trigger=On, Exposure Mode=Timed), camera starts to expose at rising edge of trigger signal, and exposure time length is set by users command (consistent with Free-Run mode). At this point, frame rate of camera output image is determined by the interval between rising edge of external trigger pulse, as shown in the figure below.

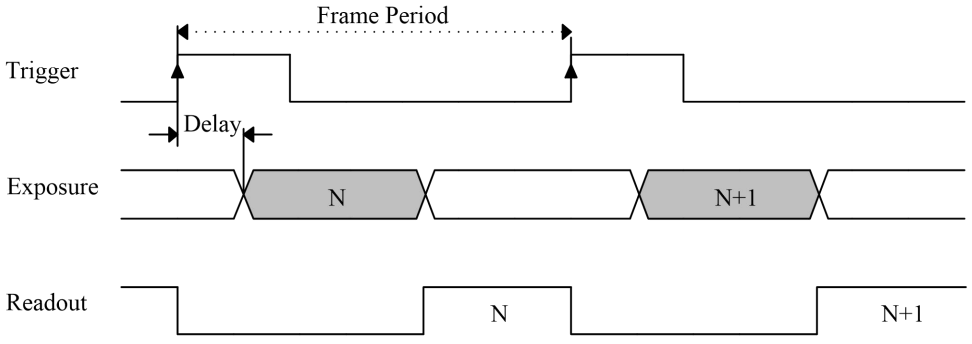


Fig.14 External Pulse Mode

External trigger can be input from CoaXPress interface or 4-pin control interface. Input source can be selected by users through instruction.To get a higher frame rate, a new trigger pulse can be fired at the same time the camera reads data after the last frame exposure. In this fast mode, since it is necessary to ensure that reading stages of two frames do not conflict, external trigger with an interval less than one frame readout time will be automatically ignored by camera, as shown in the figure below.

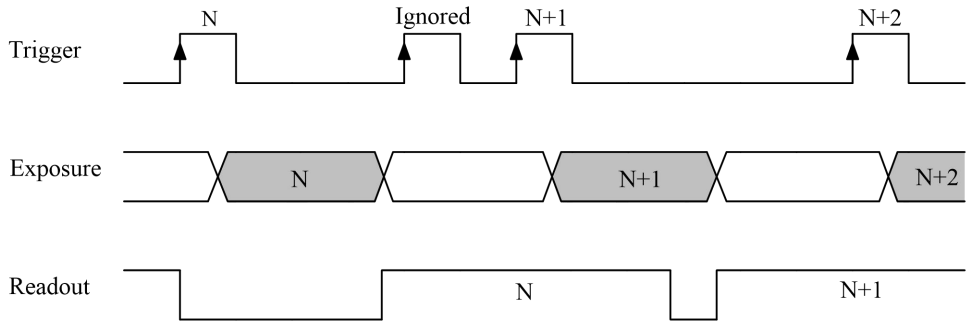


Fig.15 Frame Period of External Trigger is Too Short

6.1.3 External PWM Mode

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

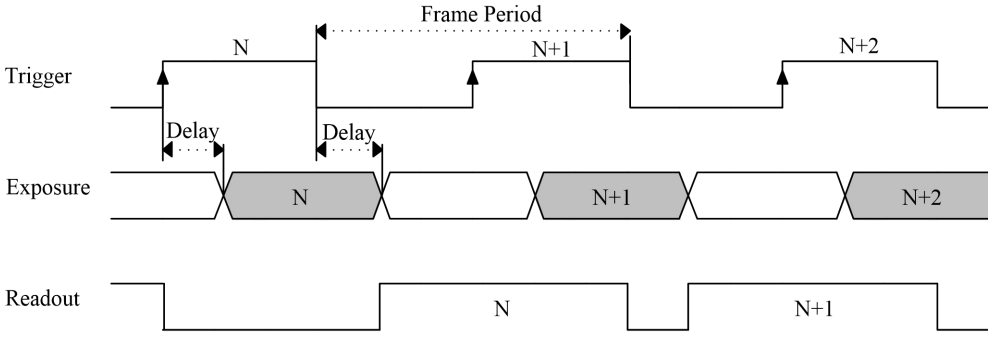


Fig.16 External PWM Mode

It should be noted that the external trigger high level width in this mode should be guaranteed to be greater than the minimum exposure time. In fact,for pulses with minimum exposure time,the camera will always be processed by the minimum exposure time.

If external trigger interval is too short, it will lead to readout time conflict of two frames. At this time, pulse that does not meet the requirements will be ignored inside camera, so that camera can maintain normal operation. Therefore, in External PWM mode, the falling edge spacing of adjacent external triggers should be greater than one frame readout time.

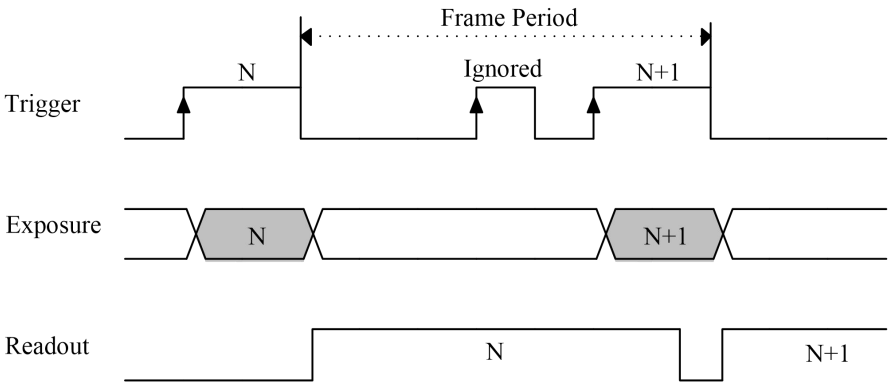


Fig.17 Frame Period of External Trigger is Too Short

6.2 Region of Interest

Region of interest (ROI) is part of the specified sensor array. Users can obtain frame data from the specified part of sensor array with the same frame quality as from the entire sensor array. When the starting point and the number of pixel lines are specified in both horizontal and vertical directions, ROI is determined to be an overlap of the two regions, as shown in the figure below.

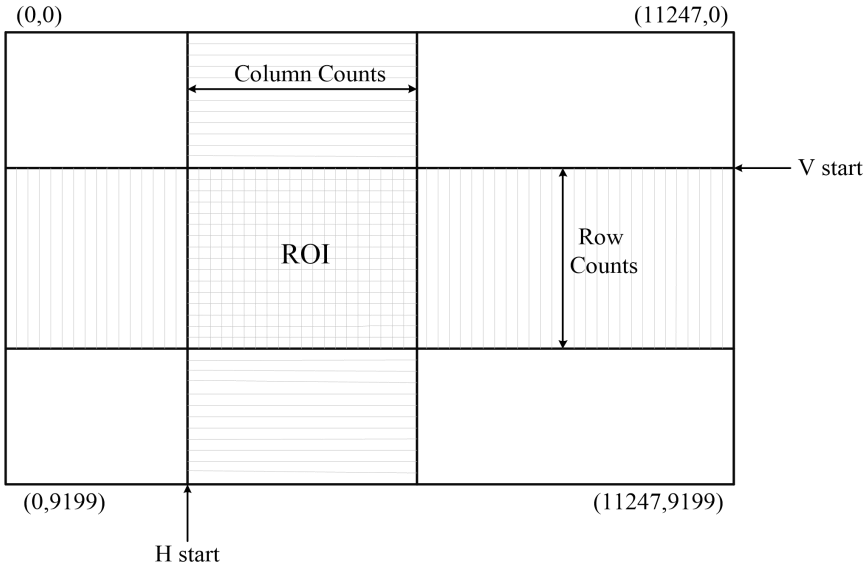


Fig.18 ROI

Table 5 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	10bit	12bit
11248	9200	24.851fps	24.851fps	23.869fps
8992	9200	24.851fps	24.851fps	23.869fps
8000	9200	24.851fps	24.851fps	23.869fps
6992	9200	24.851fps	24.851fps	23.869fps
6000	9200	24.851fps	24.851fps	23.869fps
4992	9200	24.851fps	24.851fps	23.869fps
4000	9200	24.851fps	24.851fps	23.869fps

2992	9200	24.851fps	24.851fps	23.869fps
2000	9200	24.851fps	24.851fps	23.869fps
992	9200	24.851fps	24.851fps	23.869fps
11248	8000	28.458fps	28.458fps	27.333fps
11248	7000	32.373fps	32.373fps	31.094fps
11248	6000	37.538fps	37.538fps	36.054fps
11248	5000	44.663fps	44.663fps	42.898fps
11248	4000	55.127fps	55.127fps	52.949fps
11248	3000	71.994fps	71.994fps	69.152fps
11248	2000	103.734fps	103.734fps	99.641fps
11248	1000	185.529fps	185.529fps	178.221fps

6.3 Binning

TTS103MCXP10 monochrome camera supports 2x2 binning and 4x4 binning. After normal exposure acquisition, camera sums up the values of adjacent pixels and outputs them as a single pixel value.

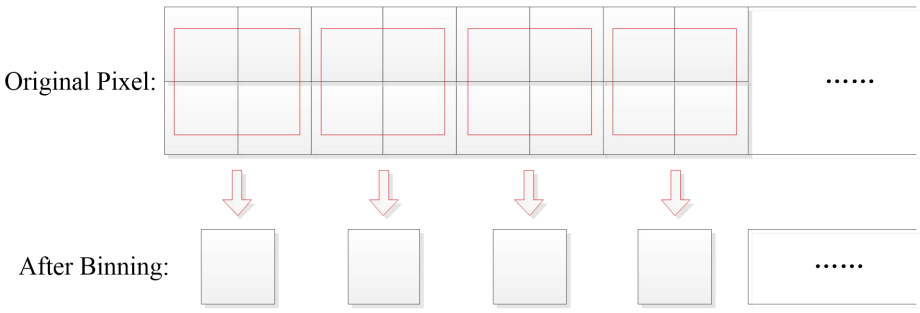


Fig.19 2x2 Binning

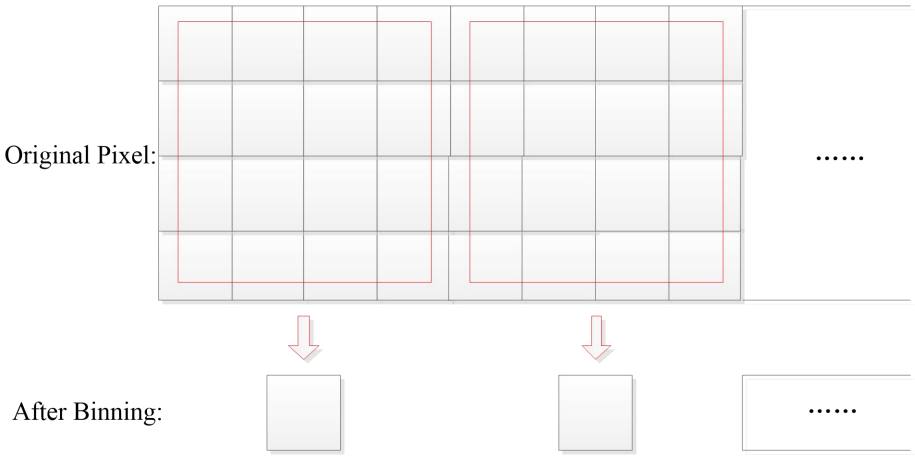
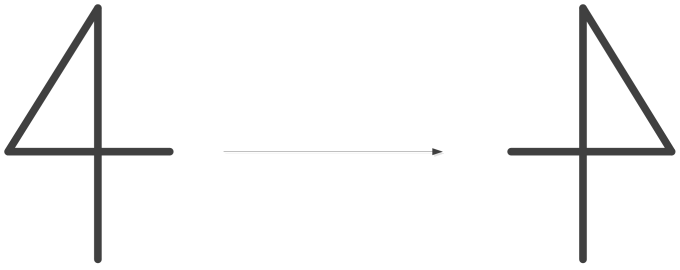


Fig.20 4x4 Binning

6.4 Scanning Direction

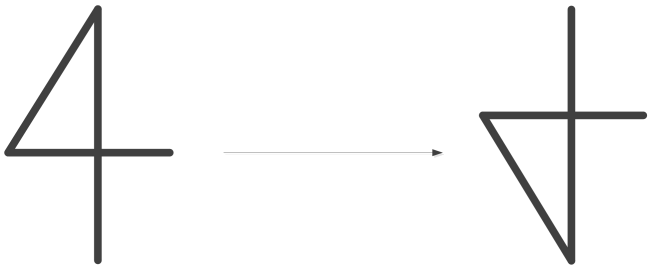
TTS103MCXP10 camera can be scanned in horizontal and vertical directions. The horizontal direction supports left to right and right to left, and the vertical direction supports top to bottom and bottom to top.

Horizontal and vertical scan directions are shown below, and they can also be combined.



Left to Right Right to Left

Fig.21 Horizontal Scanning Direction



Top to Bottom Bottom to Top

Fig.22 Vertical Scanning Direction

6.5 LUT

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

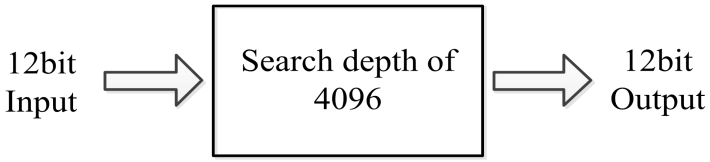


Fig.23 LUT Structure

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

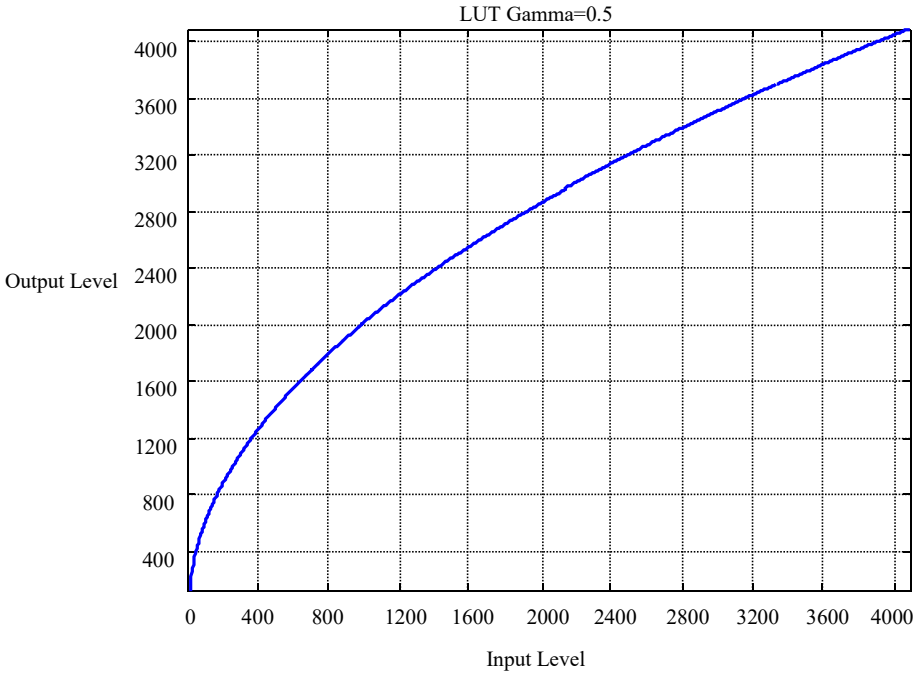


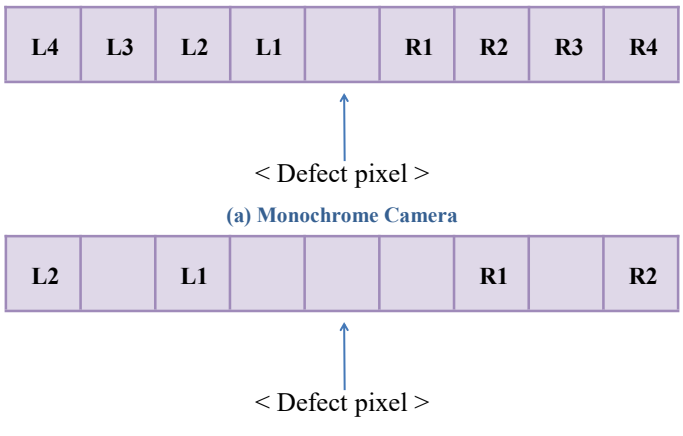
Fig.24 LUT: Gamma=0.5

6.6 Defect Pixel Correction

Due to defects of material itself and issue with workflow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response to input light, which we call defect pixels. TTS103MCXP10 camera provides with defect pixel automatic correction function. The defect pixel information of the imaging sensor is written into camera before camera is delivered out of the factory. Users can control whether to enable the defect pixel correction, add new defect pixels and read out the current defect pixel list from the camera.

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

- For monochrome cameras, defect pixels are replaced by adjacent pixels.
- For color cameras, defect pixels are replaced by separated pixels.



(a) Monochrome Camera

(b) Color Camera

Fig.25 Different Camera Defect Pixel Correction Methods

As shown in the table below, modified value of defect pixels will be calculated according to whether the surrounding pixels are defect pixels.

Table 6 Defect Pixel Value Calculation Table

Adjacent Defect Pixel (s)	Correction value of Current Pixel
None	L1
L1	R1
R1	L1
L1,R1	L2
L1,R1,L2	R2
L1,R1,L2,R2	L3
L1,R1,L2,R2,L3	R3
L1,R1,L2,R2,L3,R3	L4
L1,R1,L2,R2,L3,R3,L4	R4

6.7 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.

TTS103MCXP10 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. The renderings are as follows:

(a) Before White Balance

(b) After White Balance

Fig.26 White Balance Effect

6.8 Flat Field Correction

Generally, in the application process of area scan cameras, due to the vignetting effect of the lens and the inconsistency of illumination, there is a certain difference between image output by camera and the actual signal, that is, the output data of the camera is different for the signal with the same brightness. TTS103MCXP10 camera provides a flat field correction function to correct this problem. Users can realize flat field effect by correcting signal parameters of uniform intensity target.

Considering the pixel array size and vignetting effect of area scan cameras, this camera realizes real-time flat field correction algorithm by using block data of 64*64 pixels and combining with image algorithm. The basic principle is shown in the figure below:

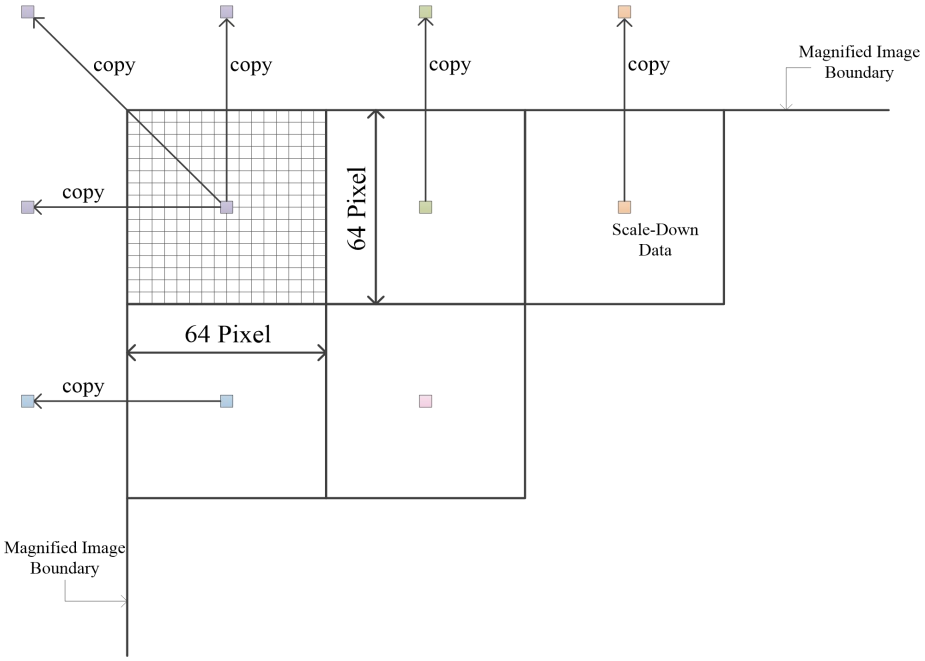


Fig.27 Flat Field Correction Schematic

6.9 Test Image

The camera provides test images. Different from the collected images whose data comes from sensors, test images are fixed images that are pre-edited and stored inside camera, independent of the scene shot by camera, and can be used to test whether data link is smooth.

This camera provides a test image as shown below:

- Horizontal test image: fixed image with horizontal gray gradient.
- Vertical test image: fixed image with vertical gray gradient.
- Diagonal Stripe image:scrolling diagonal stripe image.

Fig.28 Horizontal Test Image

Fig.29 Vertical Test Image

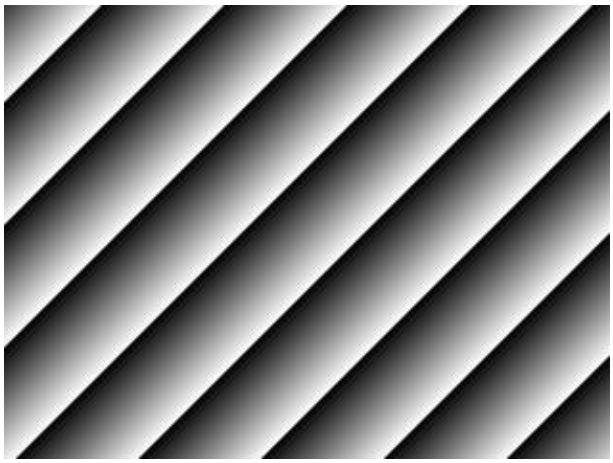


Fig.30 Diagonal Stripe Image

6.10 Strobe

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

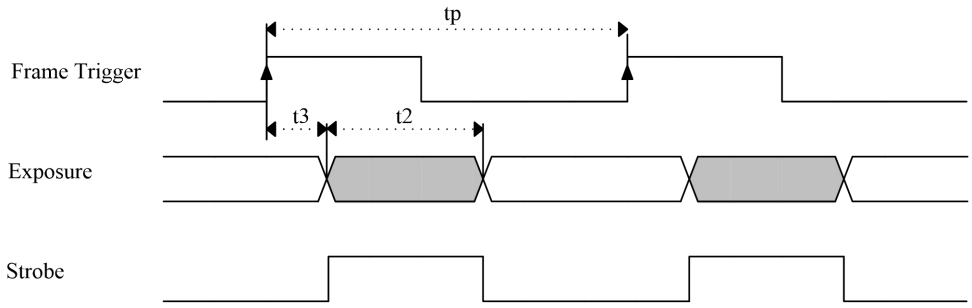


Fig.31 Strobe Signal

6.11 Data Format

TTS103MCXP10 camera processes data in 12bit data format, but provides 8bit and 10bit output format. When camera outputs 8bit data, the lowest 4bit data will be discard. When camera outputs 10bit data, the lowest 2bit data will be discard.

Fig.32 Data Format

6.12 Gain and Offset

Camera gain is divided into 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 SNR. Users can configure the camera's analog gain.

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 the brightness of image. Digital offset is often used to adjust the 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 value (Output) = Data value (digital offset=0) + Digital offset value

Digital offset is set for 12bit data format, if the image data is 8bit or 10bit, the actual digital offset will be divided by 16 or divided by 4.

6.13 Camera Temperature

TTS103MCXP10 camera supports real-time temperature acquisition. 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.

6.14 Load/Save Configuration

TTS103MCXP10 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.

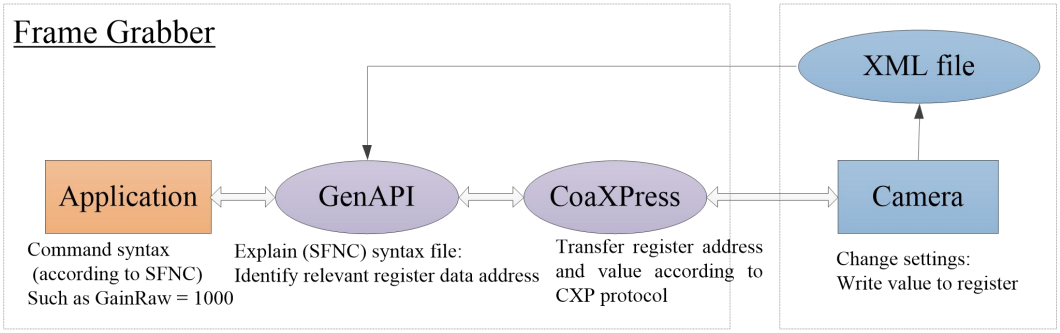


Fig.33 Communication Schematic between Application and Camera

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 7 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 8 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
Image2StreamIDAddress	0x3020	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:

  - CXP1_X1 (0x00010028)
  - CXP2_X1 (0x00010030)
  - CXP3_X1 (0x00010038)
  - CXP5_X1 (0x00010040)
  - CXP6_X1 (0x00010048)
  - CXP10_X1 (0x00010050)
  - CXP1_X2 (0x00020028)
  - CXP2_X2 (0x00020030)
  - CXP3_X2 (0x00020038)
  - CXP5_X2 (0x00020040)
  - CXP6_X2 (0x00020048)
  - CXP10_X2 (0x00020050)
  - CXP1_X4 (0x00040028)
  - CXP2_X4 (0x00040030)
  - CXP3_X4 (0x00040038)

- CXP5_X4 (0x00040040)
- CXP6_X4 (0x00040048)
- CXP10_X4 (0x00040050)

- **ConnectionConfigDefault**

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

- CXP1_X1 (0x00010028)
- CXP2_X1 (0x00010030)
- CXP3_X1 (0x00010038)
- CXP5_X1 (0x00010040)
- CXP6_X1 (0x00010048)
- CXP10_X1 (0x00010050)
- CXP1_X2 (0x00020028)
- CXP2_X2 (0x00020030)
- CXP3_X2 (0x00020038)
- CXP5_X2 (0x00020040)
- CXP6_X2 (0x00020048)
- CXP10_X2 (0x00020050)
- CXP1_X4 (0x00040028)
- CXP2_X4 (0x00040030)
- CXP3_X4 (0x00040038)
- CXP5_X4 (0x00040040)
- CXP6_X4 (0x00040048)
- CXP10_X4 (0x00040050)

- **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 (0x00010048)
- CXP6_X2 (0x00020048)
- CXP6_X4 (0x00040048)
- CXP10_X1 (0x00010050)
- CXP10_X2 (0x00020050)
- CXP10_X4 (0x00040050)

- **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 1 register.

- **Image2StreamIDAddress**
  Address of data stream 2 register.

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

7.3.2 Device Control Register

Table 9 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	0xa008	4	F	RO	Beginner
DeviceTapGeometry	0xa00c	4	E	RO	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.

7.3.3 Image Format Control Register

Table 10 Image Format Control Register

Name	Address	Size	Interface	Access	Visibility
Width	0xa800	4	I	RW	Beginner
Height	0xa804	4	I	RW	Beginner
OffsetX	0xa80c	4	I	RW	Beginner
OffsetY	0xa82c	4	I	RW	Beginner
SensorWidth	0xa808	4	I	RO	Expert
SensorHeight	0xa828	4	I	RO	Expert
Binning	0xa810	4	E	RW	Beginner
PixelFormat	0xa830	4	E	RW	Beginner
VideoMode	0xa834	4	E	RW	Beginner
HorizontalScanDirection	0xa838	4	E	RW	Beginner
VerticalScanDirection	0xa850	4	E	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:
  - Minimum: 8
  - Increment: 2

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

- **OffsetY**
  Vertical offset. The parameter range is as follows:

- Minimum: 0
- Increment: 2

- **SensorWidth**

  Sensor width.

- **SensorHeight**

  Sensor height.

- **Binning**

  Binning. The enumeration names and values are as follows:
  - Binning_1X1 (1)
  - Binning_2X2 (2): Only monochrome camera supports this enumeration
  - Binning_4X4 (4): Only monochrome camera supports this enumeration

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:
  - Mono8 (0x01080001): Monochrome 8bit
  - Mono10 (0x01100003): Monochrome 10bit
  - Mono12 (0x01100005): Monochrome 12bit
  - BayerGB8 (0x0108000A): Bayer GBRG 8bit
  - BayerGB10 (0x0110000E): Bayer GBRG 10bit
  - BayerGB12 (0x01100012): Bayer GBRG 12bit

- **VideoMode**

  Output image format. The enumeration names and values are as follows:
  - Original (0): Original image
  - Corrected (1): Corrected image
  - VerticalPattern (3): Vertical test image
  - HorizontalPattern (2): Horizontal test image
  - DiagonalPattern (4): Diagonal 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

- **VerticalScanDirection**

  Vertical scanning direction. The enumeration names and values are as follows:
  - TopToBottom (0): From top to bottom
  - BottomToTop (1): From bottom to top

7.3.4 Acquisition Control Register

Table 11 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
AcquisitionFrameRateEnable	0xb064	4	B	RW	Expert
AcquisitionFrameRate	/	/	F	/	Beginner
AcquisitionFramePeriod	0xb028	4	I	RW	Beginner
AcquisitionMaxFrameRate	0xb02c	4	C	WO	Beginner
ExposureMode	0xb03c	4	E	RW	Beginner
ExposureTime	0xb040	4	I	RW	Beginner

- **AcquisitionMode**

  Acquisition mode, usually default to continuous acquisition. The enumeration names and values are as follows:

  - Continuous (0): Continuous acquisition

- **AcquisitionStart**

  Start acquisition.

- **AcquisitionStop**

  Stop acquisition.

- **AcquisitionFrameRateEnable**

  Enable acquisition frame rate setting. Users can set acquisition frame rate by checking this item, otherwise frame rate is set to the maximum value currently allowed by default.

- **AcquisitionFrameRate**

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

  - Minimum: 0.002

- **AcquisitionFramePeriod**

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

  - Maximum: 549000000
  - Increment: 1

- **AcquisitionMaxFrameRate**

  Set acquisition frame rate to maximum value.

- **ExposureMode**

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

  - Timed (2): Timed
  - TriggerWidth (3): Trigger width control

- **ExposureTime**

  Exposure time, unit is us. The parameter range is as follows:

  - Maximum: 548000000
  - Minimum: 19
  - Increment: 1

7.3.5 IO Control Register

Table 12 IO Control Register

Name	Address	Size	Interface	Access	Visibility
TriggerMode	0xb008	4	E	RW	Beginner
TriggerSource	0xb014	4	E	RW	Beginner
TriggerDelay	0xb020	4	I	RW	Beginner
TriggerActivation	0xb030	4	E	RW	Beginner
TriggerFrameCount	0xf800	4	I	RW	Beginner
TriggerDebouncingPeriod	0xf830	4	I	RW	Beginner
FlashStrobeEnable	0xf848	4	B	RW	Beginner
FlashStrobePolarity	0xf854	4	E	RW	Beginner

- **TriggerMode**

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

  - Off (0): Turn off trigger mode
  - On (1): Turn on trigger mode

- **TriggerSource**

  Trigger source selector. The enumeration names and values are as follows:

  - CXP (0): CXP signal
  - IO (1): 4-pin interface signal

- **TriggerDelay**

  Trigger delay time, unit is us. The parameter range is as follows:

  - Maximum: 1000000
  - Minimum: 0
  - Increment: 1

- **TriggerActivation**

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

  - FallingEdge (1): Trigger acquisition at falling edge
  - RisingEdge (0): Trigger acquisition at rising edge

- **TriggerFrameCount**

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

  - Maximum: 65536

- Minimum: 1

- **TriggerDebouncingPeriod**

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: 2600
- Minimum: 0

- **FlashStrobeEnable**

Enable strobe signal.

- **FlashStrobePolarity**

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

- Low (1): Default high level, pull down when generating strobe signal
- High (0): Default low level, pull up when generating strobe signal

7.3.6 Analog Control Register

Table 13 Analog Control Register

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0xb808	4	E	RW	Beginner

- **AnalogGain**

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

- Gain_x1 (14)
- Gain_x2 (28)
- Gain_x3p7 (52)

7.3.7 Digital Control Register

Table 14 Digital Control Register

Name	Address	Size	Interface	Access	Visibility
BlackLevel	0xc000	4	I	RW	Beginner
DigitalGain	/	/	F	/	Beginner
GainRaw	0xc028	4	I	RW	Beginner
DigitalOffset	0xc004	4	I	RW	Beginner
WhiteBalanceRedGain	0xc008	4	I	RW	Expert
WhiteBalanceG1Gain	0xc00c	4	I	RW	Expert
WhiteBalanceG2Gain	0xc010	4	I	RW	Expert
WhiteBalanceBlueGain	0xc014	4	I	RW	Expert
WhiteBalanceEnable	0xc018	4	B	RW	Expert
WhiteBalanceInitialize	0xc01c	4	C	WO	Expert
WhiteBalanceCalibrate	0xc020	4	C	WO	Expert

- **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: 4095
  - Minimum: 0
  - Increment: 1

- **DigitalGain**

  Digital gain. The parameter range is as follows:

  - Maximum: 8
  - Minimum: 0.004
  - Increment: 0.004

- **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: 32768
  - Minimum: 0
  - Increment: 1

- **DigitalOffset**

  Digital offset. The parameter range is as follows:

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

- **WhiteBalanceRedGain**

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

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceG1Gain**

  White balance G1 channel gain, only color camera can set this parameter. The parameter range is as follows:

  - Maximum: 28671
  - Minimum: 0
  - Increment: 1

- **WhiteBalanceG2Gain**

White balance G2 channel gain, only color camera can set this parameter. The parameter range is as follows:

- Maximum: 28671
- Minimum: 0
- Increment: 1

- **WhiteBalanceBlueGain**

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

- Maximum: 28671
- Minimum: 0
- 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.

7.3.8 LUT Control Register

Table 15 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 16 Flat Field Correction Register

Name	Address	Size	Interface	Access	Visibility
PRNUEnable	0xd800	4	B	RW	Expert
PRNUStart	0xd814	4	C	WO	Expert
PRNUReset	0xd818	4	C	WO	Expert

- **PRNUEnable**
  Enable flat field correction.

- **PRNUStart**
  Execute flat field correction.

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

7.3.10 Vertical Correction Register

Table 17 Vertical Correction Register

Name	Address	Size	Interface	Access	Visibility
VFPNEnable	0xd900	4	B	RW	Expert
VFPNStart	0xd904	4	C	WO	Expert
VFPNReset	0xd908	4	C	WO	Expert

- **VFPNEnable**
  Enable vertical correction.

- **VFPNStart**
  Execute vertical correction.

- **VFPNReset**
  Reset vertical correction to default setting.

7.3.11 Defect Pixel Register

Table 18 Defect Pixel Register

Name	Address	Size	Interface	Access	Visibility
DefectPixelCorrectionEnable	0xe000	4	B	RW	Expert
DefectPixelTestMode	0xe008	4	E	RW	Expert
DefectPixelTotal	0xe010	4	I	RO	Expert
DefectPixelSelect	0xe014	4	I	RW	Expert
DefectPixelReadX	0xe018	4	I	RO	Expert
DefectPixelReadY	0xe01c	4	I	RO	Expert
DefectPixelWriteX	0xe020	4	I	RW	Expert
DefectPixelWriteY	0xe024	4	I	RW	Expert
DefectPixelAdd	0xe028	4	C	WO	Expert
DefectPixelRemove	0xe02c	4	C	WO	Expert
DefectPixelClearAll	0xe030	4	C	WO	Expert
DefectPixelSave	0xe034	4	C	WO	Expert

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

- **DefectPixelTestMode**
  Defect pixel test mode selection. The enumeration names and values are as follows:
  - Replace (0): Replace mode
  - MarkDefectsWhiteOnVideo (1): Mark defect pixel

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

- **DefectPixelSelect**
  Select index of defect pixel.

- **DefectPixelReadX**
  Read the X coordinate of current defect pixel.

- **DefectPixelReadY**
  Read the Y coordinate of current defect pixel.

- **DefectPixelWriteX**
  Write the X coordinate of defect pixel.

- **DefectPixelWriteY**
  Write the Y coordinate of defect pixel.

- **DefectPixelAdd**
  Add defect pixel.

- **DefectPixelRemove**
  Remove current defect pixel.

- **DefectPixelClearAll**
  Remove all defect pixels.

- **DefectPixelSave**
  Save defect pixels.

7.3.12 Cooler Register

Table 19 Cooler Register

Name	Address	Size	Interface	Access	Visibility
FanSpeed	0xe700	4	I	RW	Expert
TECCoolerEnable	0xe704	4	B	RW	Expert
TECTemperature	0xe708	4	I	RW	Guru

- **FanSpeed**
  Fan speed. The parameter range is as follows:
  - Maximum: 3
  - Minimum: 0
  - Increment: 1

- **TECCoolerEnable**
  Enable TEC refrigeration function.

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

7.3.13 User Set Control Register

Table 20 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

- **UserSetLoad**

  Load selected camera configuration.

- **UserSetSave**

  Save selected camera configuration.

8 FAQ

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

① Ensure that CoaXPress10 interface cable is OK

② Ensure that serial port channel parameters of CoaXPress 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 the device.

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.