TTS127MSCXP10-22M/C Area Scan Camera User Manual

(V0.4 May. 10, 2024)

Hefei I-TEK Optoelectronics Co., LTD.

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

Revision History

Revision	Date	Description
0.1	2022/05/25	● Initial version
0.2	2023/02/11	● Update company address
0.3	2023/09/19	● Update chapter 7
0.4	2024/05/10	● Open binning can increase the maximum frame rate of camera

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 Should there be any problem with the camera, please contact us in time for technical support.

- **Installation and Maintenance**

① Do not install the camera in an environment with direct sunlight, high humidity or heavy dust.
② Keep the camera away from an environment with strong electromagnetic interference.
③ Keep the camera away from heat sources.
④ Be careful not to let the camera soak in liquid, such as water and drinks.
⑤ Clean dust on the surface of the camera as often as possible to avoid dust entering the camera, otherwise it may cause fault to the camera.
⑥ To clean the dust on the camera surface, do not wash with water. Please use a soft object dipped in a small amount of 70% alcohol to wipe it off.

- **Power Supply**

① The recommended voltage is +12V±10%, and the current must be 5.0A.
② Hefei I-TEK Optoelectronics Co., LTD. does not provide 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 free of charge.

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**

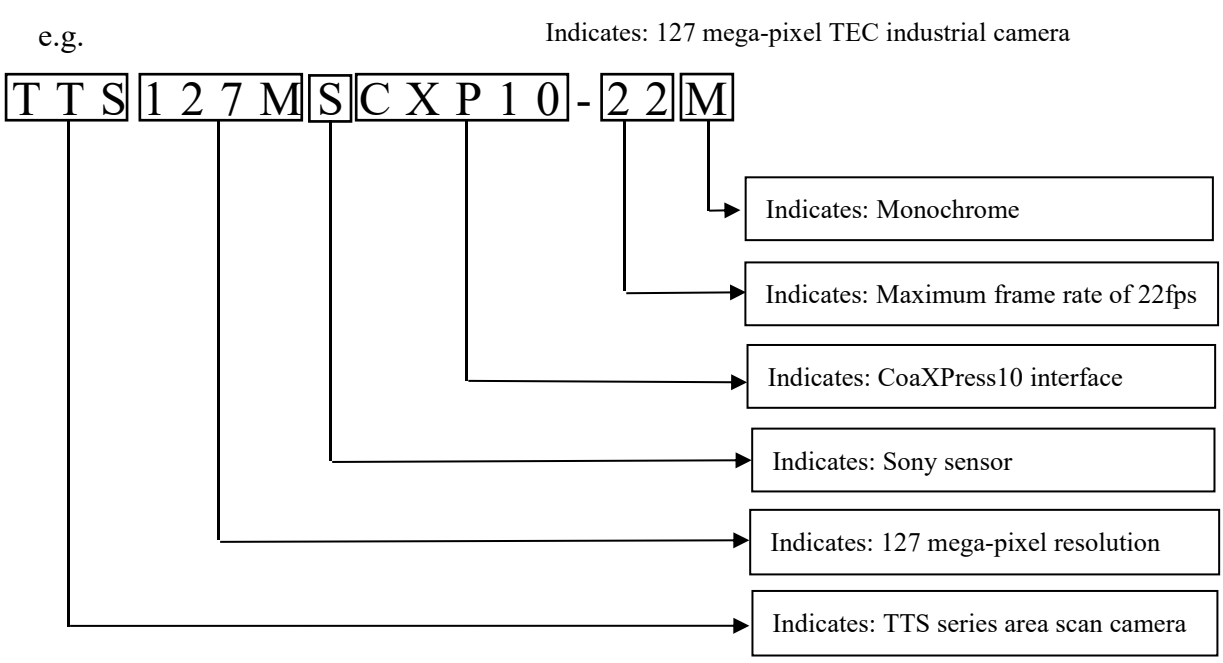
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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 side of the camera provide threaded holes for mounting camera.

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

4 Product Specifications

TTS127MSCXP10 camera adopts advanced global shutter CMOS image sensor and CoaXPress data interface. It is a high-speed area scan camera designed for industrial measurement and inspection. It has high reliability and stability, and is very suitable for occasions with high requirements (high resolution, high speed) for image acquisition, such as surface inspection, electronic placement inspection, etc.

4.1 Main Features

- Global Shutter CMOS Sensor
- High Sensitivity and Low Noise
- ROI
- Minimum Exposure Time 443us
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Output Pixel Format: 8/10/12bit
- Binning
- Defect Pixel Correction
- Flat Field Correction
- Analog Gain / Digital Gain / Offset Control
- White Balance
- Strobe
- Real Time Temperature Monitor
- Support CoaXpress 2.0 Protocol
- TEC - about 12 degrees below ambient temperature

4.2 Camera Specifications

Table 1 TTS127MSCXP10-22M/C Product Specifications

Model	TTS127MSCXP10-22M/C
Product description	127 mega-pixel TEC industrial camera
Resolution	13440 x 9536
Pixel Size	3.45um x 3.45um
Sensor Type	Global shutter CMOS
Image Type	Monochrome / Color
Sensor Size	56.85mm (diagonal)
Dynamic Range	≥71dB
SNR	40.6dB
Data Rate	3547MB/s
Analog Gain	0~36
Analog Offset	0~4095
Digital Gain	0.004~7.996
Digital Offset	-4095~4095
Lens Mount	M72

Max. Frame Rate	Binning1x1: 22.14fps@8/10bit, 18.98fps@12bit Binning2x2/4x4: 42.43fps@8/10bit, 38.28fps@12bit
Trigger Mode	External Pulse, Free-Run
Trigger Signal	External IO/ CXP signal
Exposure Control	Timed, Pulse Width Control
Exposure Time	443us~50s (Step: 8.91us@8/10bit, 10.43us@12bit)
Data Format	8/10/12 bit
Operating Temperature	0~50℃
Data Interface	CoaXPress10
Power Supply	DC 12V±10%　5.0A
Power Consumption	TEC off: 23.1W TEC on: 47.9W
Mechanical	111mm x 111mm x 91.6mm
Cooling Method	TEC with a external fan
Cooling Performance	About 12 degrees below ambient temperature

Note: This table is for 1.27-4.14 version of TTS127MSCXP10 camera specifications, which may vary slightly from version to version.

4.3 Camera Block Diagram

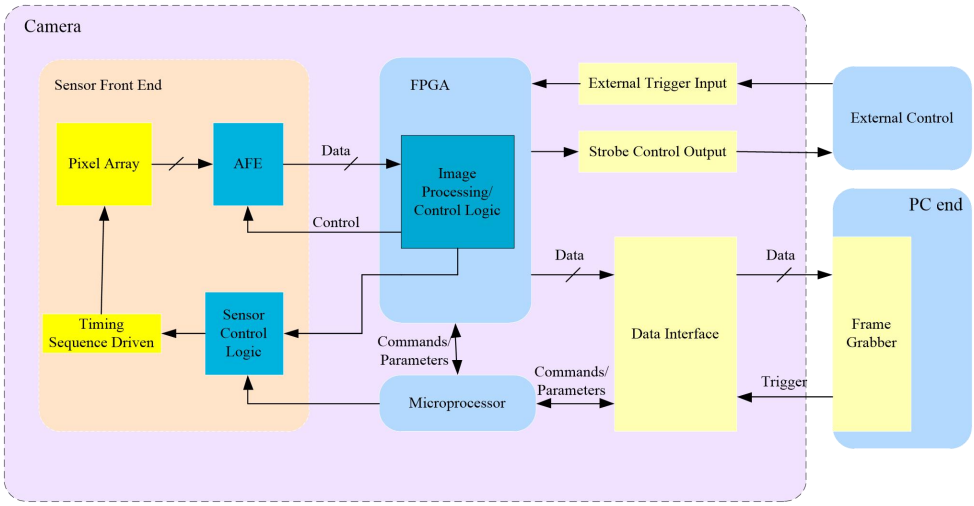


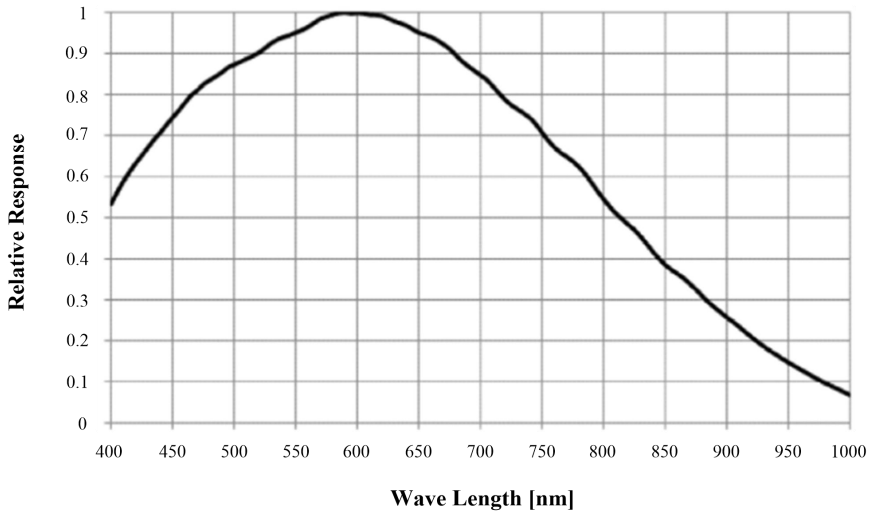
Fig. 2 Internal Implementation Structure of Camera

TTS127MSCXP10 camera uses a unified architecture to achieve image sensor control, data transmission and embedded algorithm processing with different resolutions. The internal structure of the camera is shown in 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 processed by FPGA and microprocessor.

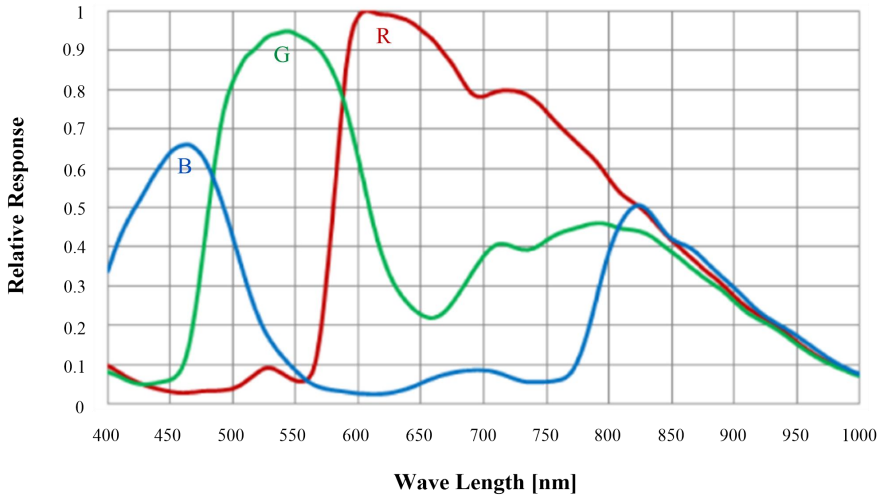
TTS127MSCXP10 camera can receive external signal trigger acquisition, from the IO signal or CXP signal of CoaXPress10 interface.

4.4 Spectral Response

The spectral response of TTS127MSCXP10 camera is shown below.



(a)Monochrome Camera



(b)Color Camera

Fig. 3 Spectral Response

4.5 Camera Bayer Pattern

TTS127MSCXP10 camera supports color mode, Bayer pattern is shown in figure below (HR is horizontal resolution, VR is vertical resolution).

Fig. 4 Camera Bayer Pattern

4.6 Environmental Requirements

(1) Operating temperature: 0℃~50℃, humidity: 10%~80%; Storage temperature: -20℃~75℃.

(2) The dust-proof sealing for the sensor in camera may effectively prevent dust from entering camera. Dust may enter camera when lens cap is opened, so keep lens cap closed when 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

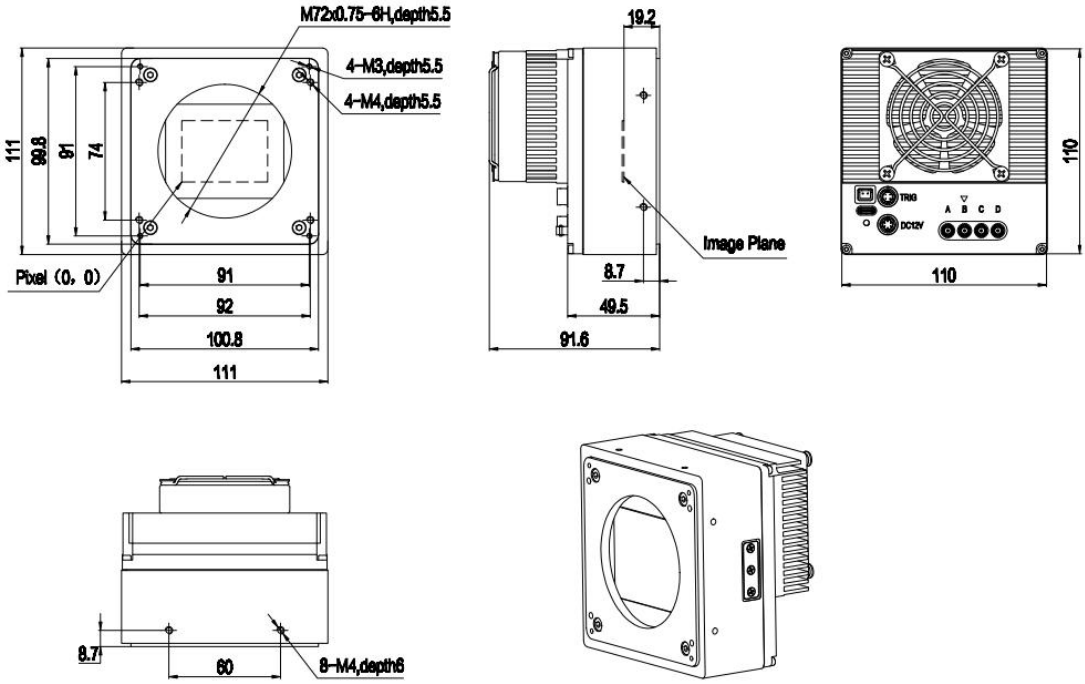


Fig. 5 Camera Mechanical Dimensions

5.2 Camera Interface

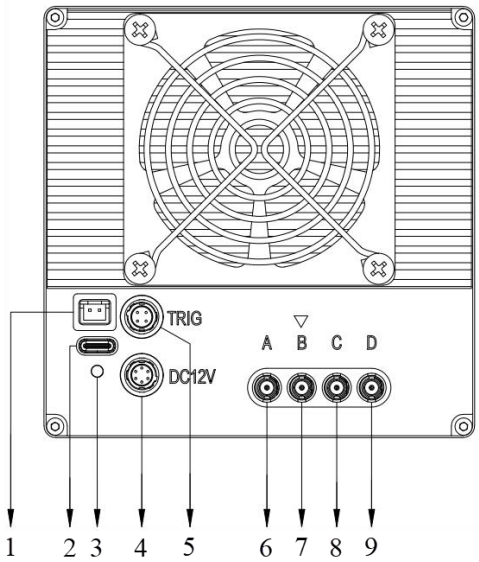


Fig. 6 Interfaces of Camera

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

⑥ CoaXPress Connection A
⑦ CoaXPress Connection B **(Master)**
⑧ CoaXPress Connection C
⑨ 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 Indicator

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

5.2.2 Power Interface

Power interface 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:

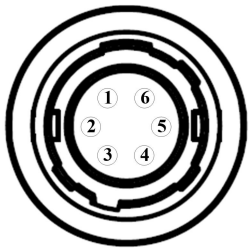


Fig.7 Pin Assignments for Interface

Table 3 Pin Configurations for Interface

Signal	Pin	Signal	Pin
VCC	1	GND	4
VCC	2	GND	5
VCC	3	GND	6

5.2.3 Control Interface

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).

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

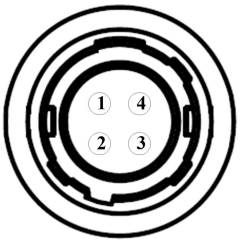


Fig.8 Pin Assignments for Interface

Table 4 Pin Configurations for Interface

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

External triggering circuit is as follows:

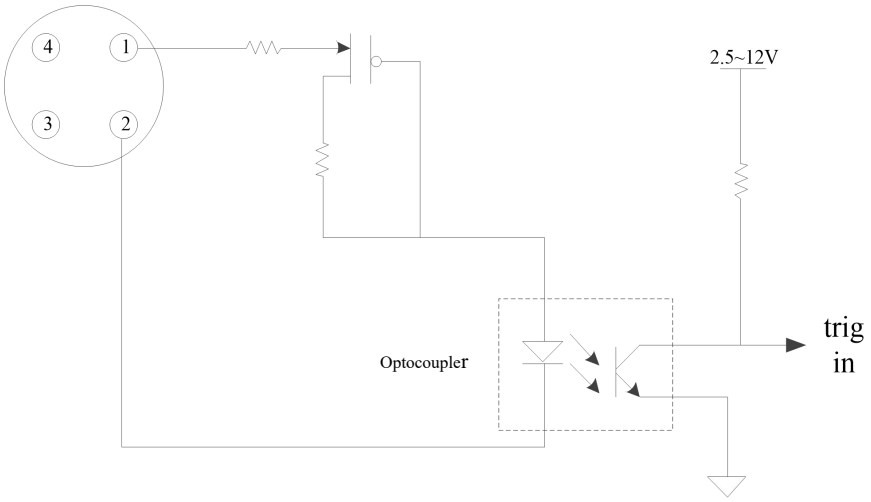


Fig.9 Trigger Input Circuit Diagram

- Trigger signal voltage range: 2.5~12V
- Minimum pulse width of trigger signal: 1us

Strobe output circuit is shown below:

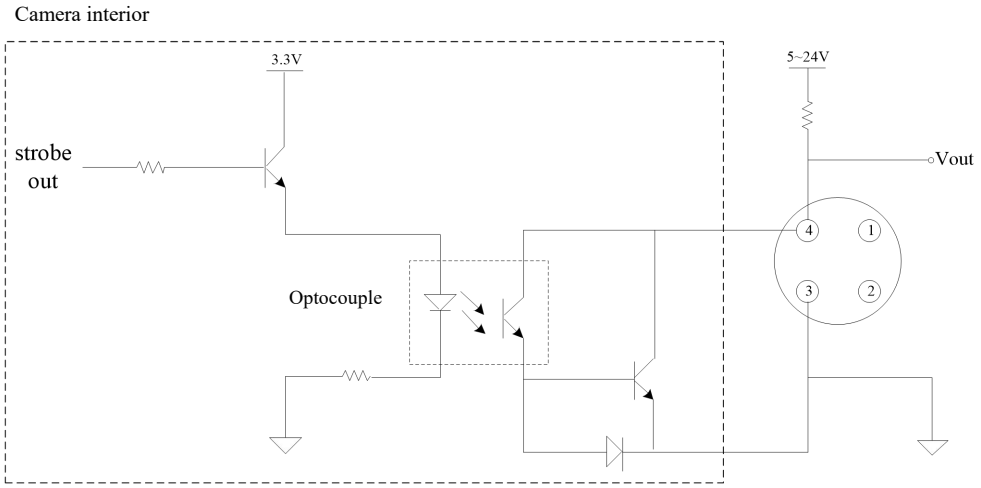


Fig.10 Strobe Output Circuit Diagram

- Strobe signal pull-up voltage range: 5~24V

5.2.4 Data Interface

TTS127MSCXP10 camera implements the standard Quad CoaXPress protocol, and the data interface is four Micro BNC sockets on the back of camera. The data interface on the back of camera is shown in the red box below:

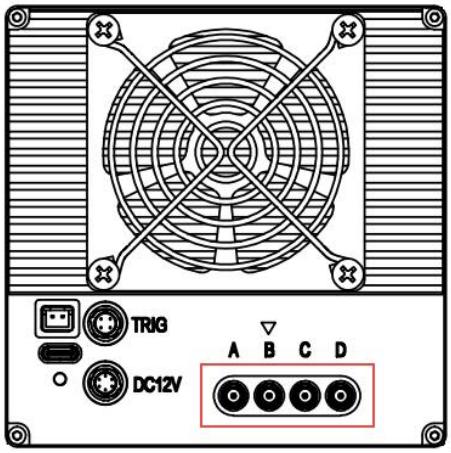


Fig.11 Data Interface

The mechanical diagram of Micro BNC interface is as follows:

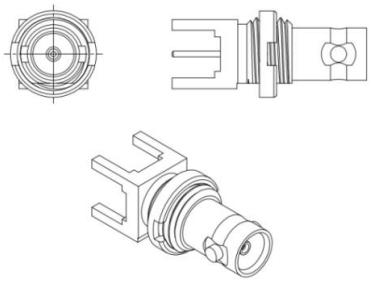


Fig.12 Micro BNC Interface

6 Camera Features

This chapter details the internal features of TTS127MSCXP10 camera.

6.1 Trigger Mode

TTS127MSCXP10 camera supports three trigger modes: Free-Run mode, External Pulse mode, and External PWM mode.

6.1.1 Free-Run Mode

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

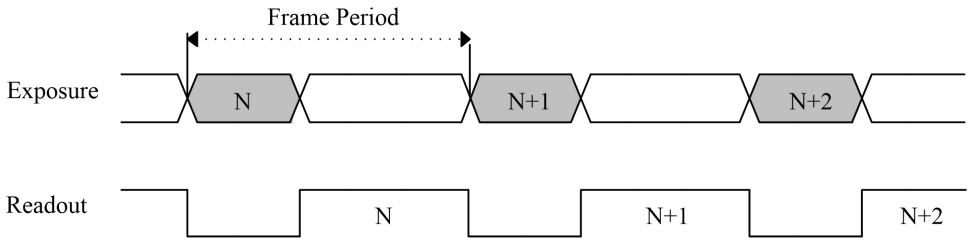


Fig. 13 Free-Run Mode

To achieve normal image output, TTS127MSCXP10 camera limits the range of frame periods and exposure time. The minimum frame period should be longer than both exposure time and readout time of a frame data.

6.1.2 External Pulse Mode

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

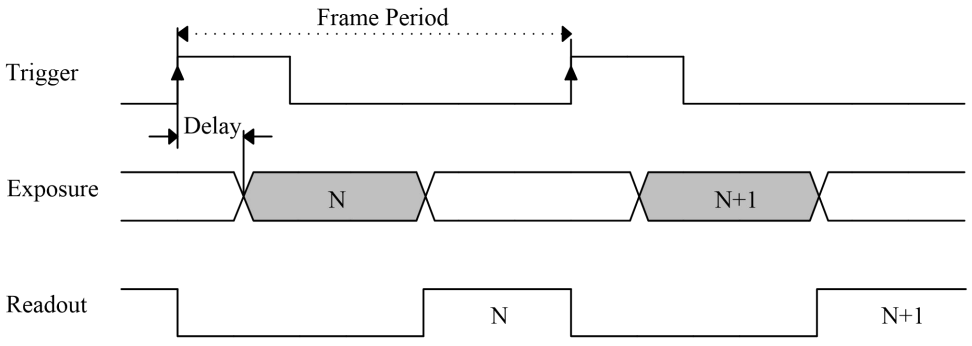


Fig. 14 External Pulse Mode

The external trigger signal can be input from CoaXPress interface or control interface, and the input

source could be selected by users.

To get a higher frame rate, a new trigger pulse can be fired at the same time camera reads data after the last frame exposure. In this fast mode, since it is necessary to ensure that the readout stages of two frames do not conflict, the external trigger with an interval less than 1 frame readout time will be automatically ignored by camera, as shown in the figure below.

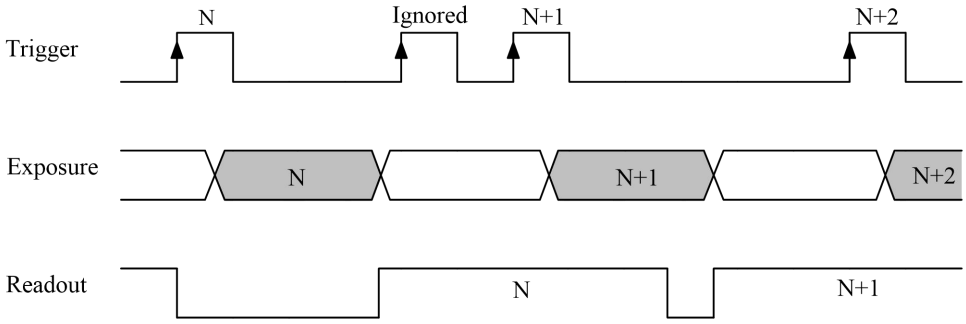


Fig. 15 External Trigger Interval is Too Short

6.1.3 External PWM Mode

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

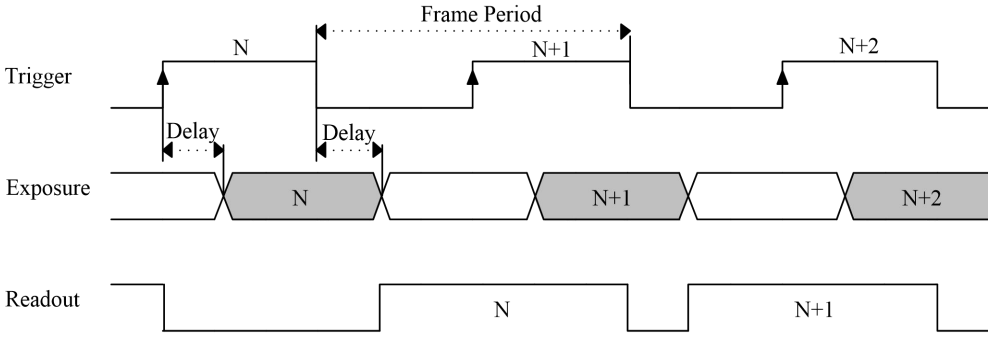


Fig. 16 High Level Trigger Mode

Please note that in this mode, the width of external trigger high level should be greater than minimum exposure time. In fact, for pulses less than minimum exposure time, camera will always process them according to minimum exposure time.

If external trigger interval is too short, it will lead to readout time conflict of two frames before and after camera. At this time, pulse that does not meet requirement will be ignored inside camera, so that camera can maintain normal operation. Therefore, in this mode, it should be ensured that the frame period between the falling edges of adjacent external triggers is greater than one-frame readout time.

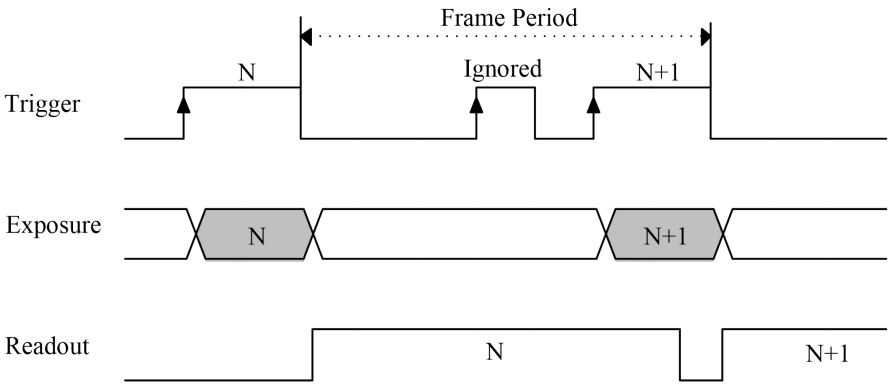


Fig. 17 External Trigger Interval is Too Short

6.2 Binning

TTS127MSCXP10 camera supports 2x2 or 4x4 binning. After normal exposure acquisition, the camera sums the values of adjacent pixels and outputs them as a single pixel value. Binning can increase the maximum frame rate of TTS127MSCXP10 camera.

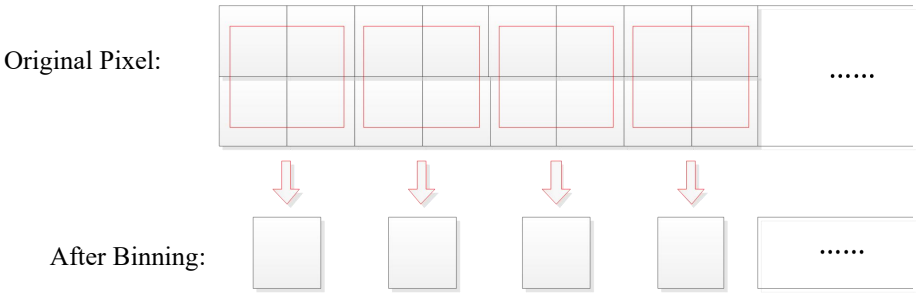


Fig. 18 2x2 Binning

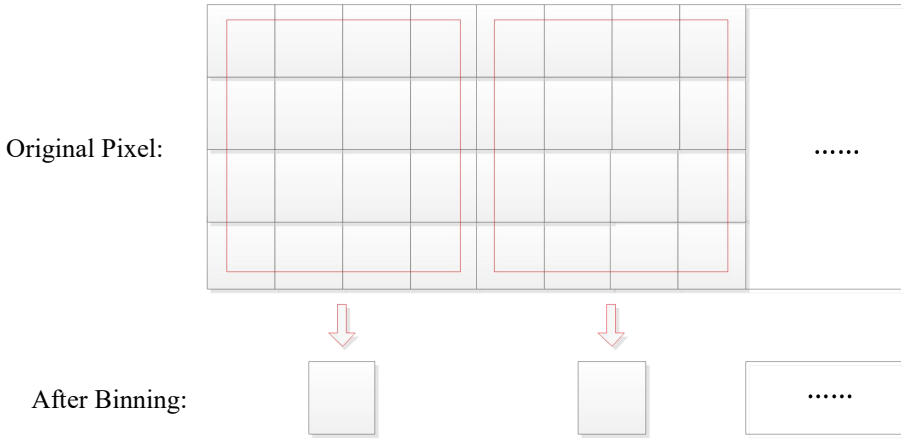
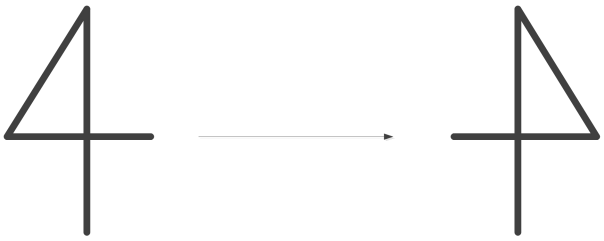


Fig. 19 4x4 Binning

6.3 Camera Scanning Direction

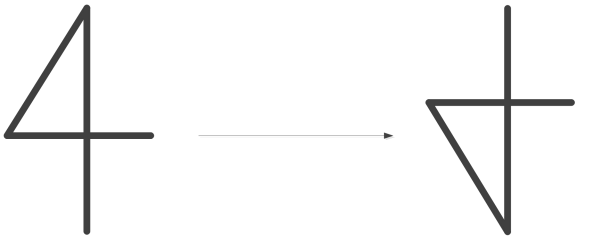
Scanning direction of TTS127MSCXP10 camera is divided into horizontal scanning direction and vertical scanning direction. The horizontal scanning direction supports two types: left to right and right to left, while the vertical scanning direction supports two types: top to bottom and bottom to top.

The schematic diagram of horizontal and vertical scanning directions is shown below, and they can also be used in combination.



Left to Right Right to Left

Fig. 20 Horizontal Scanning Direction



Top to Bottom Bottom to Top

Fig. 21 Vertical Scanning Direction

6.4 LUT

LUT uses a 12bit input and 12bit output look-up table to map and convert the values of the original image. Users can use this function to implement gamma correction.

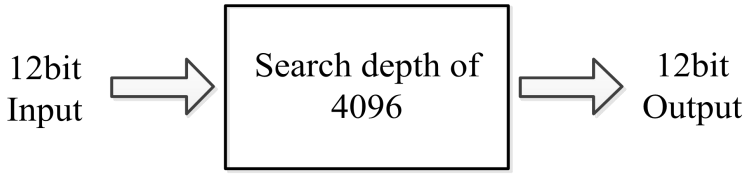


Fig. 22 LUT Structure

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

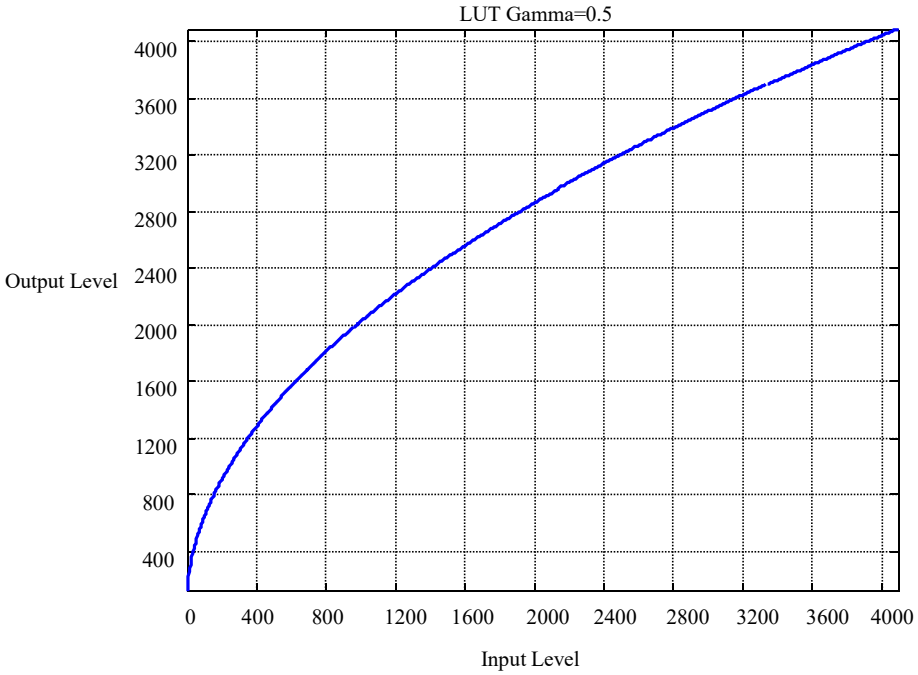


Fig. 23 LUT: Gamma = 0.5

6.5 ROI

Region of interest (ROI) is part of a specified sensor array. Users can obtain frame data from a specified part of the 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, the ROI is determined to be an overlap of the two regions, as shown in the figure below.

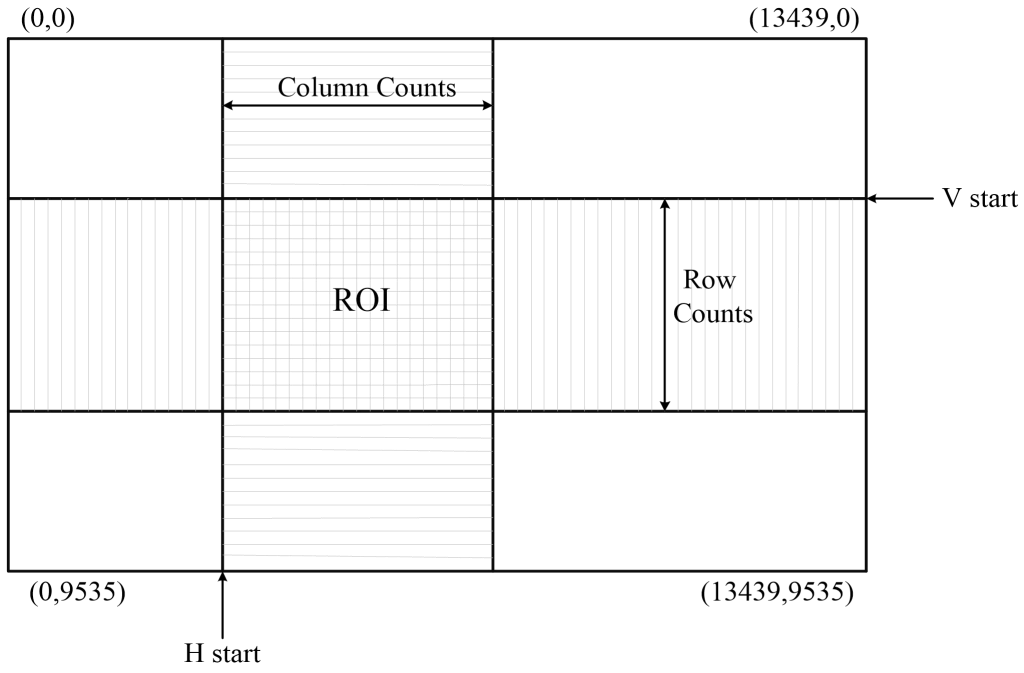


Fig. 24 Region of Interest

Table 5 Maximum Frame Rate Depending on ROI Values

Binning1x1:

ROI Size H	ROI Size V	8/10bit	12bit
13440	9536	22.136fps	18.984fps
11968	9536	22.136fps	19.900fps
9984	9536	22.136fps	19.900fps
8000	9536	22.136fps	19.900fps
5952	9536	22.136fps	19.900fps
3968	9536	22.136fps	19.900fps
1984	9536	22.136fps	19.900fps
256	9536	22.136fps	19.900fps
13440	8000	26.086fps	22.387fps
13440	6000	33.981fps	29.204fps
13440	4000	48.730fps	41.990fps
13440	2000	86.095fps	74.694fps
13440	64	334.113fps	303.490fps
256	64	334.113fps	318.066fps

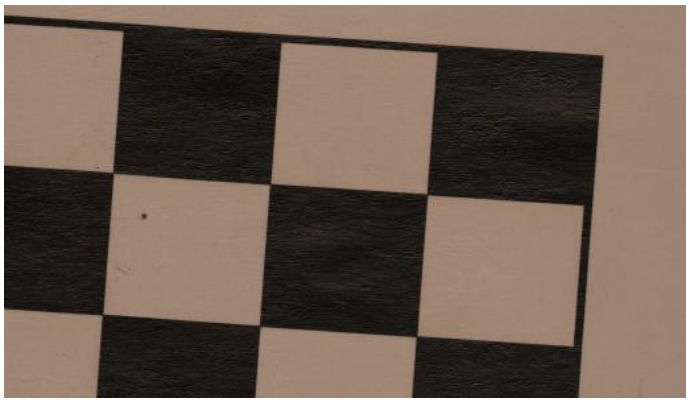
Binning2x2/4x4:

ROI Size H	ROI Size V	8/10bit	12bit
3328	2368	42.430fps	38.285fps
1984	2368	42.430fps	38.285fps
960	2368	42.430fps	38.285fps
256	2368	42.430fps	38.285fps
3328	992	88.402fps	80.425fps
3328	64	328.192fps	312.207fps
256	64	328.192fps	312.207fps

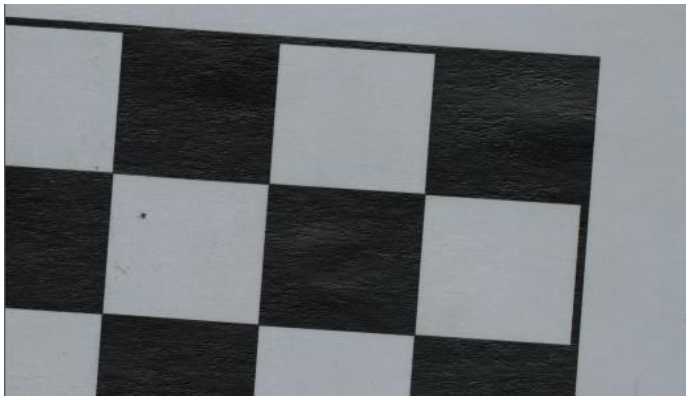
6.6 White Balance

White balance is an important parameter of color industrial camera, it directly affects the color effect of the reproduced image. When the white balance of the industrial camera is not set properly, color reproduction will occur when the image is reproduced.

TTS127MSCXP10 color camera provides white balance function, which balances the output value of each channel of the sensor. Automatic white balance calculates the white balance coefficient by sampling local pixels in the sensor, then adjust each component of the image according to the coefficient to make the red, green and blue components of the output image have the same value. Its function diagram is as follows:



(a) Before White Balance



(b) After White Balance

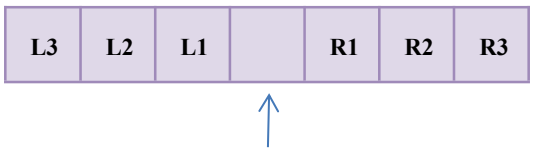
Fig. 25 White Balance

6.7 Defect Pixel Correction

Due to defects of the material itself and the issue with the process flow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response to the input light, which we call defect pixels. TTS127MSCXP10 camera provides with defect pixel automatic correction feature. The defect pixel information of imaging sensor is written into the camera before the 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 camera.

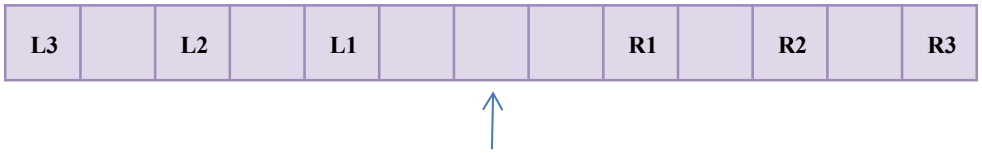
Correction method of defect pixels is based on calculation and output of adjacent valid pixel values in the same line. The correction methods of monochrome and color camera are different:

- For monochrome camera, defect pixel values are replaced by adjacent pixel values.
- For color camera, defect pixel values are replaced by separated pixel values.



< Defect pixel >

(a) Monochrome Camera



(b) Color Camera

Fig. 26 Defect Pixel Correction Methods for Different Cameras

In the figure above, the modified value of defect pixels will be calculated according to whether the surrounding pixels are defect pixels, as the rules shown in the following table.

Table 6 Calculation Defect Pixel Correction Value

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

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 the image output by the camera and the actual signal, that is, the output data of the camera is different for the signal with the same brightness. TTS127MSCXP10 camera provides a flat field correction function to correct this problem. Actually, users can achieve flat field effect by by flat field correction.

Taking into account the pixel array scale and vignetting effect of area scan cameras, this camera uses 64 x 64 pixel block data, combined with image algorithms to achieve real-time flat field correction algorithms. The fundamental is shown in the figure below:

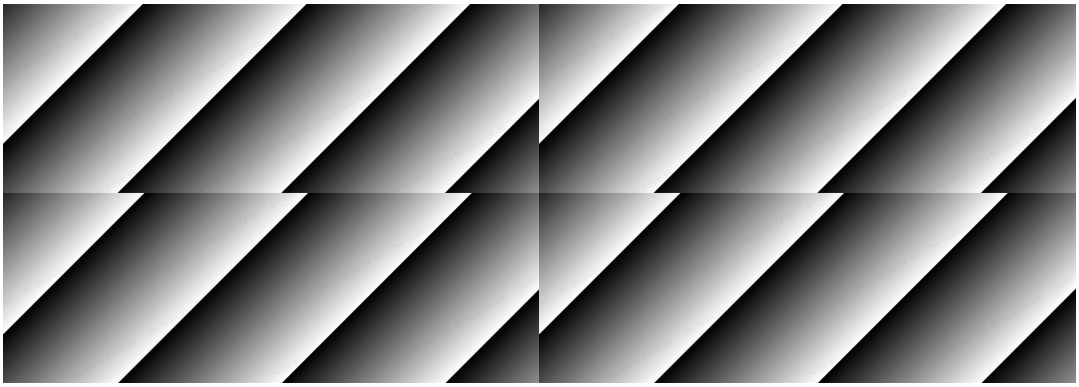
Fig. 27 Flat Field Correction Schematic

6.9 Test Image

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

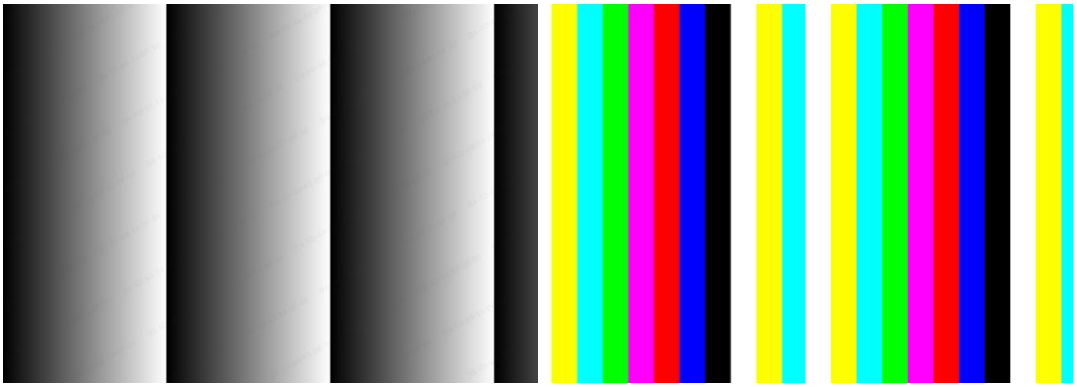
The camera provides test images as shown in the figure below.

- Test image 1: scroll diagonal stripe image.
- Test image 2: fixed image with horizontal gray gradient.
- Test image 3: fixed image with vertical gray gradient.



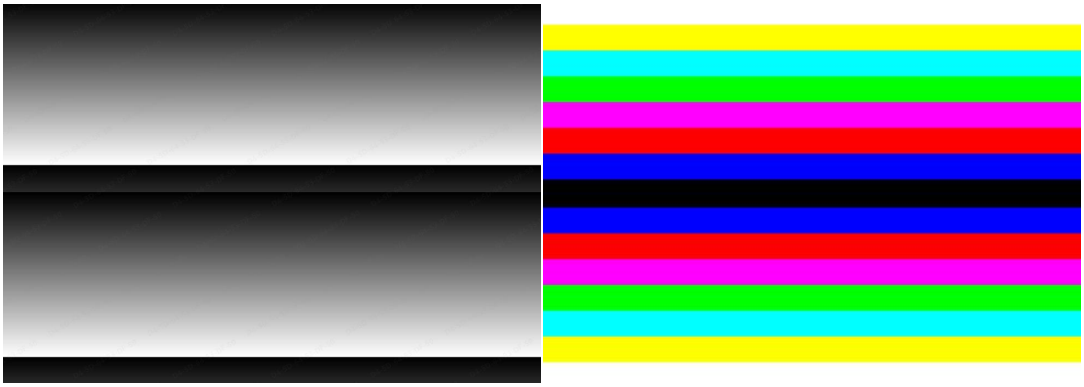
(a) Monochrome (b) Color

Fig. 28 Test Image 1



(a) Monochrome (b) Color

Fig. 29 Test Image 2



(a) Monochrome (b) Color

Fig. 30 Test Image 3

6.10 Strobe

Strobe signal is used to synchronize external light sources with the camera. The timing of the strobe signal is exactly the same as the camera exposure timing. When the camera exposure starts, the strobe signal will be pulled down/up; The camera exposure ends, and the strobe signal will return to its initial level.

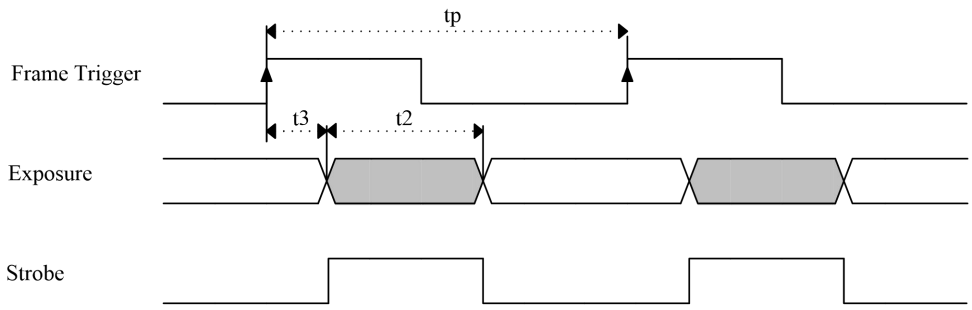


Fig. 31 Strobe Signal

6.11 Data Format

TTS127MSCXP10 camera processes data in 12bit data format, but provides 8bit, 10bit and 12bit

output. When the camera outputs 8bit data, the lowest 4bit data will be deleted. When the camera outputs 10 bit of data, the lowest 2 bit will be deleted.

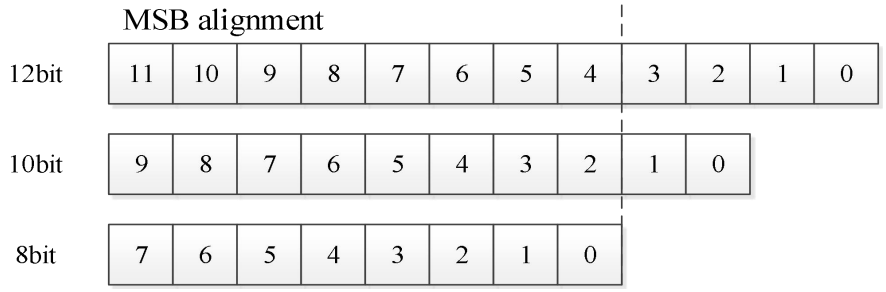


Fig. 32 Data Format

6.12 Gain and Offset

The camera gain is divided into the analog gain and digital gain.

Analog gain acts on analog signals, and usually increasing the analog gain can achieve stronger response under weak lighting, thereby achieving higher signal-to-noise ratio. Users can configure the analog gain of this camera. Analog offset is generally used to adjust the black level position of front-end sensors.

Digital gain amplifies or reduces the data of the photoelectric conversion signal after AD, which is usually used to increase the dynamic range of the output image. Digital gain can also be used to adjust the brightness of the image. Digital offset is commonly used to adjust the overall background brightness of an image.

The effect of digital gain can be summarized by the following equation:

Data value (Output) = Data value (digital gain=1 & digital offset=0) * Digital gain value

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

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

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

6.13 Camera Temperature

TTS127MSCXP10 camera supports real-time acquisition of temperature. Users can read the camera temperature value to monitor the current temperature value of the sensor or make some responses according to the temperature value.

The recommended operating environment temperature of the camera is 0~50°C. If users detect an abnormal internal temperature (such as over 60°C), it is recommended to stop the camera immediately to avoid component damage. Power off and contact our technical support in time.

6.14 Load / Save Configuration

TTS127MSCXP10 camera provides three working parameter sets to meet the use demand in most scenarios. Among them, the factory parameter set has already been optimized and cannot be modified by users. The camera is provided with two user operating parameter sets, among which the internal parameters can be modified and saved by users. The saved operating parameter set will be automatically loaded upon power-on next time.

If the camera is found abnormal after modification of the parameters, users can restore the camera to the factory parameter set.

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 regardless of which transmission protocol the camera uses or which functions 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 description file is stored locally on the PC, and collection software will select the most appropriate XML file according to camera model. Application and camera communicate with each other through SFNC, GenAPI, and GigEVision, as shown in the figure.

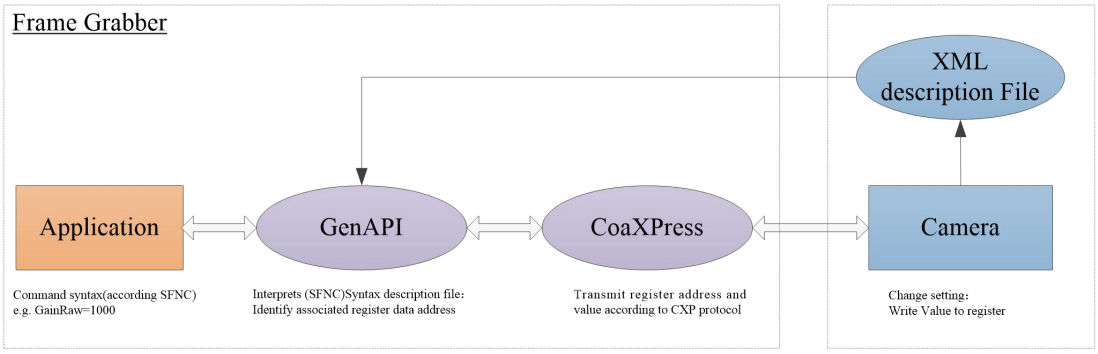


Fig. 33 Communication Principle Diagram Between Application and Camera

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 the description file. For example, to set the gain to 1000, the value of 0x3E8 (HEX) must be written to the register at address 0x0815 (HEX). Other tasks involved may be to check whether the camera has gain characteristics in advance and check whether the new value are consistent with the allowable gain range. This register message is transmitted and parsed by protocol and applied to camera.

7.2 GenAPI Parameter Attributes

The actual method of controlling camera is related to software implementation of frame grabber and SDK. Most frame grabber software provides a graphical user interface (GUI) that is automatically generated from XML files. This manual focuses on functions of camera, detailing the specific commands and their impact on operation of camera, listing the name, interface, access, description, range and default value 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 the 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 the frame grabber to 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) Parameter range

When setting parameter, it checks whether input value is in valid range of parameter.

7.3 Register Classification

7.3.1 Bootstrap Customized Registers

Table 8 Bootstrap Customized Registers

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
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:

  - CXP3_X4 (0x00040038)
  - CXP5_X4 (0x00040040)
  - CXP6_X4 (0x00040048)
  - CXP10_X4 (0x00040050)
  - CXP10_X2 (0x00020050)

- **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_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 camera data stream 1 register.

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

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

7.3.2 Device Control Registers

Table 9 Device Control Registers

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
BoardTemperature	0xa018	4	F	RO	Beginner
DeviceHumidity	0xa00c	4	F	RO	Beginner
CoolingTargetTemperature	0xa014	4	I	RW	Beginner
CoolingEnable	0xa010	4	B	RW	Beginner
DeviceTapGeometry	0xa008	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.

- **Deviceemperature**
  Device temperature.

- **BoardTemperature**
  Board temperature.

- **DeviceHumidity**
  Device humidity.

- **CoolingTargetTemperature**
  Cooling target temperature.The parameter range is as follows:
  - Maximum: 50
  - Minimum: -30
  - Increment: 1

- **CoolingEnable**
  Enable electronic TEC.

- **DeviceTapGeometry**
  Device Tap arrangement. The enumeration names and values are as follows:
  - Geometry_1X_1Y (0)
  - Geometry_1X_2YE (10)

7.3.3 Image Format Control Registers

Table 10 Image Format Control Registers

Name	Address	Size	Interface	Access	Visibility
Width	0xa800	4	I	RW	Beginner
Height	0xa804	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
OffsetX	0xa80c	4	I	RW	Beginner

- **Width**

  Actual camera output width.The parameter range is as follows:
  - Minimum: 256
  - Increment: 64

- **Height**

  Actual camera output height. The parameter range is as follows:
  - Minimum: 192
  - Increment: 128

- **SensorWidth**

  Sensor width.

- **SensorHeight**

  Sensor height.

- **Binning**

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

- **PixelFormat**

  Pixel format. The enumeration names and values are as follows:
  - Mono8 (0x01080001): Monochrome 8bit
  - Mono10 (0x01100003): Monochrome 10bit
  - Mono12 (0x01100005): Monochrome 12bit
  - BayerRG8 (0x01080009): Bayer RGGB 8bit
  - BayerRG10 (0x0110000D): Bayer RGGB 10bit
  - BayerRG12 (0x01100011): Bayer RGGB 12bit

- **VideoMode**

  Output image format. The enumeration names and values are as follows:
  - Original (0): Original image
  - Corrected (1): Corrected image

- DiagonalPattern (2): Diagonal stripe test image
- VerticalPattern (3): Vertical test image
- HorizontalPattern (4): Horizontal test image

- **HorizontalScanDirection**

  Horizontal scanning direction. The enumeration names and values are as follows:
  - LeftToRight (0): Left to right
  - RightToLeft (1): Right to left

- **VerticalScanDirection**

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

- **OffsetX**

  Horizontal offset.The parameter range is as follows:
  - Minimum: 0
  - Increment: 64

7.3.4 Acquisition Control Registers

Table 11 Acquisition Control Registers

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0xb050	4	E	RO	Beginner
AcquisitionStart	0xb054	4	C	RW	Beginner
AcquisitionStop	0xb058	4	C	RW	Beginner
AcquisitionFrameRate	/	/	F	/	Beginner
AcquisitionFramePeriod	0xb028	4	F	RW	Beginner
AcquisitionMaxFrameRate	0xb02c	4	C	WO	Beginner
ExposureMode	0xb03c	4	E	RW	Beginner
ExposureTime	0xb040	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.

- **AcquisitionFrameRate**

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

- Minimum:0.02

- **AcquisitionFramePeriod**

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

  - Maximum: 50005000
  - Increment: 1

- **AcquisitionMaxFrameRate**

  Acquisition the maximum frame rate, click on this option to set the collection frame rate to the maximum value allowed under the current conditions。

- **ExposureMode**

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

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

- **ExposureTime**

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

  - Maximum: 50000000

7.3.5 IO Control Registers

Table 12 IO Control Registers

Name	Address	Size	Interface	Access	Visibility
TriggerMode	0xb008	4	E	RW	Beginner
TriggerSource	0xb014	4	E	RW	Beginner
TriggerSoftware	0xb004	4	C	WO	Expert
LinePolarity	0xb030	4	E	RW	Beginner
LineDebouncingPeriod	0xf830	4	I	RW	Beginner
LineDelayPeriod	0xf834	4	I	RW	Beginner
LineTriggerInputFrequency	0xf83c	4	I	RO	Beginner
FlashStrobeActivation	0xf84c	4	E	RW	Beginner

- **TriggerMode**

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

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

- **TriggerSource**

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

  - CXPIn (1): CXP signal
  - Line1 (0): 4-pin interface signal
  - Software (2): Software trigger signal

- **TriggerSoftware**

  Software trigger, click on this option to generate a software trigger signal.

- **LinePolarity**

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

- **LineDebouncingPeriod**

  Input the signal to shake the window length, signals below this pulse width will be considered as gross signals and filtered out, unit is us. The parameter range is as follows:
  - Maximum: 6553
  - Minimum: 0

- **LineDelayPeriod**

  Trigger delay time. The parameter range is as follows:
  - Maximum: 6553
  - Minimum: 0

- **LineTriggerInputFrequency**

  Trigger signal rate,unit is Hz.

- **FlashStrobePolarity**

  Strobe signal polarity. The enumeration names and values are as follows:
  - FallingEdge (1): Default high level, pull-down level when generating strobe signal
  - RisingEdge (0): Default low level, pull-up level when generating strobe signal

7.3.6 Analog Control Registers

Table 13 Analog Control Registers

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0xb808	4	F	RW	Beginner
AnalogOffset	0xb80c	4	I	RW	Beginner

- **AnalogueGain**

  Analog gain. The parameter range is as follows:
  - Maximum: 36
  - Minimum: 0
  - Increment: 0.1

- **AnalogOffset**

  Analog offset. The parameter range is as follows:
  - Maximum: 4095

- Minimum: 0
- Increment: 1

7.3.7 Digital Control Registers

Table 14 Digital Control Registers

Name	Address	Size	Interface	Access	Visibility
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

- **DigitalGain**

  Digital gain. The parameter range is as follows:
  - Maximum: 8
  - Minimum: 0.004
  - Increment: 0.004

- **GainRaw**

  Digital gain of raw data. The meaning and function of this parameter are consistent with the DigitalGain parameter, inherited from the old version of the camera, and only differentiated in naming. The parameter range is as follows:
  - Maximum: 32767
  - 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 Registers

Table 15 LUT Control Registers

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0xd004	4	B	RW	Expert
LUTIndex	0xd008	4	I	RW	Expert
LUTValue	0xd00c	4	I	RW	Expert
GammaCorrectionEnable	0xd010	4	B	RW	Expert
GammaCorrectionValue	0xd014	4	F	RW	Expert

- **LUTEnable**

  Enable LUT.

- **LUTIndex**

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

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

- **LUTValue**

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

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

- **GammaCorrectionEnable**

  Enable Gamma correction.

- **GammaCorrectionValue**

  Gamma coefficient. The parameter range is as follows:

  - Maximum: 4
  - Minimum: 0.1

7.3.9 Flat Field Correction Registers

Table 16 Flat Field Correction Registers

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**

  Restore factory settings for flat field correction.

7.3.10 Defect Pixel Registers

Table 17 Defect Pixel Registers

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.

- **DefectPixelTestMode**

  Selection of defect pixel test mode. The enumeration names and values are as follows:

  ➢ Replace (0): Alternative mode, which can use horizontal interpolation, vertical interpolation, or horizontal nearest neighbor value to replace defect pixels, depending on the local defect distribution

  ➢ MarkDefectsWhiteOnVideo (1): Mark defect pixels

- **DefectPixelTotal**

  Total number of defect pixel.

- **DefectPixelSelect**

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

  ➢ Minimum: 0

  ➢ Increment: 1

- **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. The parameter range is as follows:

  ➢ Minimum: 0

  ➢ Increment: 1

- **DefectPixelWriteY**

  Write the Y coordinate of defect pixel.
  - Minimum: 0
  - Increment: 1

- **DefectPixelAdd**

  Add defect pixel.

- **DefectPixelRemove**

  Remove current defect pixels.

- **DefectPixelClearAll**

  Remove all defect pixels.

- **DefectPixelSave**

  Save defect pixels.

7.3.11 User Set Control Registers

Table 18 User Set Control Registers

Name	Address	Size	Interface	Access	Visibility
UserSetSelector	0xe800	4	E	RW	Beginner
UserSetLoad	0xe804	4	C	WO	Beginner
UserSetSave	0xe808	4	C	WO	Beginner

- **UserSetSelector**

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

- **UserSetLoad**

  Load selected camera configuration.

- **UserSetSave**

  Save selected camera configuration.

8 FAQ

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

① Ensure that the CoaXPress interface cable is OK.

② Ensure that the serial port channel parameters in the CoaXPress interface are set correctly.

- **If the 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 acquire images, ensure that the Frame Grabber and supporting software are operating properly, which can be checked by restarting the computer.

③ Ensure that the CoaXPress interface cable is OK.

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

① Ensure that the external input pulse is normal.

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

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

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

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

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

- **If images are dark,**

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

② Ensure that the exposure time and gain are set properly.

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

① Ensure that the sensor glass is clean.

② Ensure that the camera status indicator is normal.

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

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

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

③ Check whether the external pulse input is normal in the External Pulse mode by the camera indicator.

If 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.