TS65MCXP-71M/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	2022/01/14	● Initial version
0.2	2022/04/25	● Update the logo of company
0.3	2023/02/11	● Update company address
0.4	2023/10/13	● Update chapter 7 ● Update camera parameter table

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%, the current must be 3.0A.
② Hefei I-TEK Optoelectronics Co., LTD. does not provide power supply with the camera, users may prepare the power supply on their own.

- **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**

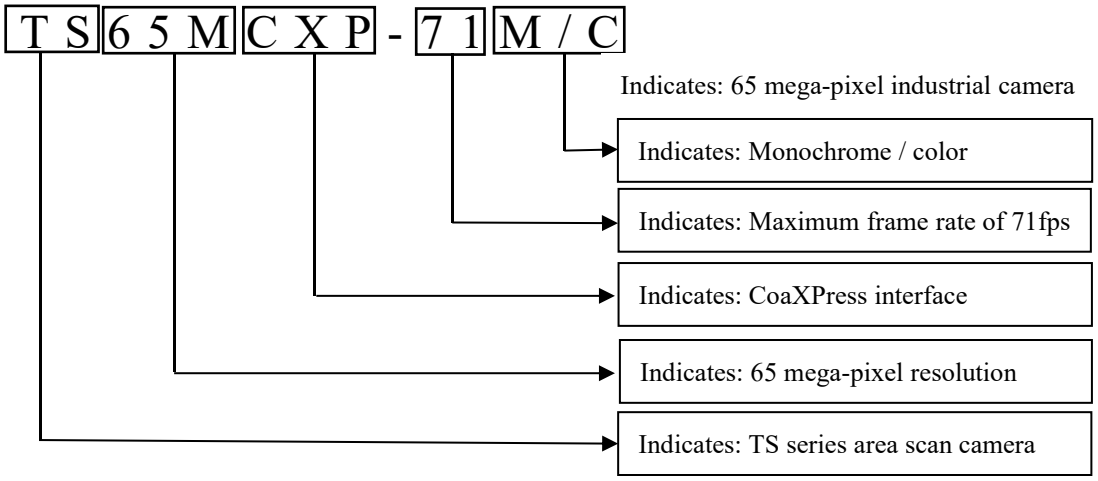
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

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 camera provide threaded holes for mounting camera.

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

4 Product Specifications

TS65MCXP camera adopts advanced global shutter CMOS image sensor and CoaXPress12 data interface. It is a high-speed area scan camera designed specifically for industrial measurement and inspection. It has high reliability and stability, and is 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
- 65 Mega-Pixel Resolution
- Full Frame Rate Maximum Frame Rate to 71fps
- High Sensitivity and Low Noise
- ROI
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Minimum Exposure Time: 12us
- Output Pixel Format: 8/10bit
- LUT
- Defect Pixel Correction
- White Balance
- Flat Field Correction
- Analog Gain / Digital Gain / Offset Control
- User-Configurable Scanning Direction
- Real-time Temperature Monitor

4.2 Camera Specifications

Table 1 TS65MCXP-71M/C Product Specifications

Model	TS65MCXP-71M/C
Product Description	65 mega-pixel industrial camera
Resolution	9344 x 7000
Pixel Size	3.2um x 3.2um
Sensor Type	Global shutter CMOS
Image Type	Monochrome / Color
Sensor Size	37.36mm (diagonal)
Dynamic Range	≥62dB
SNR	40dB
Data Rate	4750MB/s
Analog Gain	0~32
Analog Offset	0~4095
Digital Gain	0.1~8
Digital Offset	-4095~4095

Lens Mount	M58/F Mount
Max Frame Rate	71.04fps@8bit, 58.13fps@10bit
Trigger Mode	External trigger, Free-Run
External Trigger	External IO / CXP
Exposure Control	Pulse Width Control, Timed
Exposure Time	12us~10s (Step: 4us@8bit, 5us@10bit)
Data Format	8/10bit
Operating Temperature	0~65°C
Data Interface	CoaXPress12
Power Supply	DC 12V±10%　3.0A
Power Consumption	21.4W
Mechanical	85mm x 85mm x 89.2mm

Note: This table is for 031D-8207 version of TS65MCXP camera specifications, which may vary slightly from version to version.

4.3 Camera Block Diagram

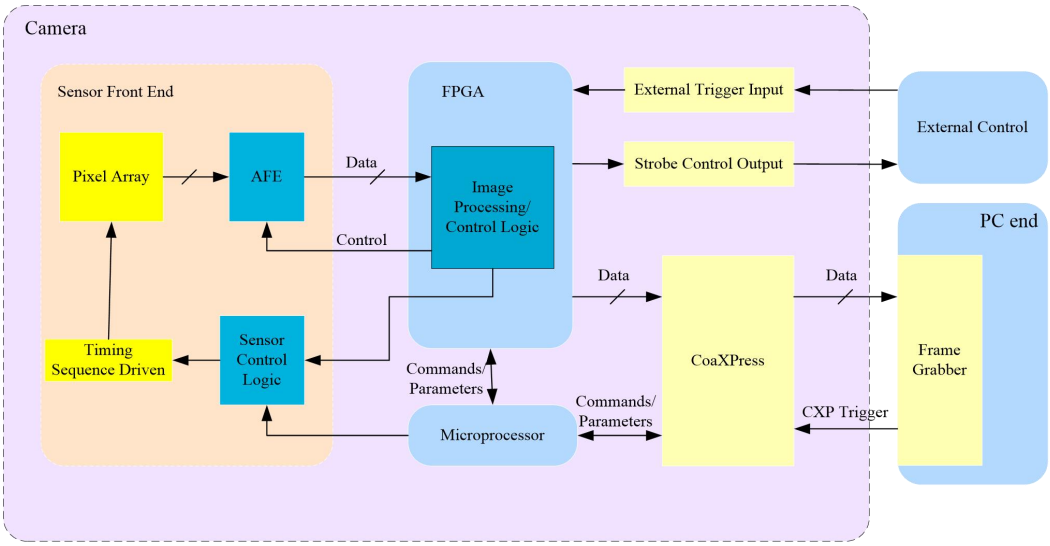


Fig. 2 Internal Implementation Structure of Camera

TS65MCXP 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 the 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.

TS65MCXP camera can receive external signal trigger acquisition, from the IO signal or the CXP signal of the CoaXPress interface.

4.4 Spectral Response

The spectral response of TS65MCXP camera is shown below.

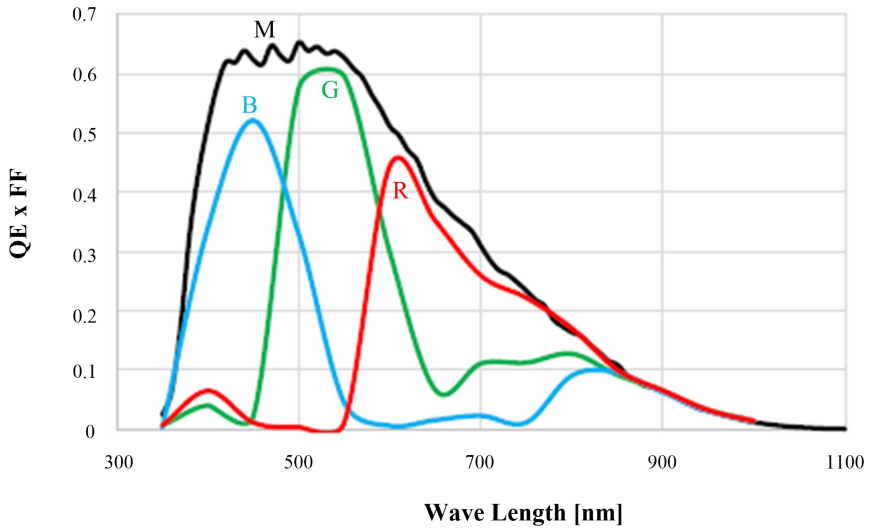


Fig. 3 Spectral Response

4.5 Camera Bayer Pattern

TS65MCXP camera supports color mode, the Bayer pattern is shown in figure below (HR is horizontal resolution, VR is vertical resolution):

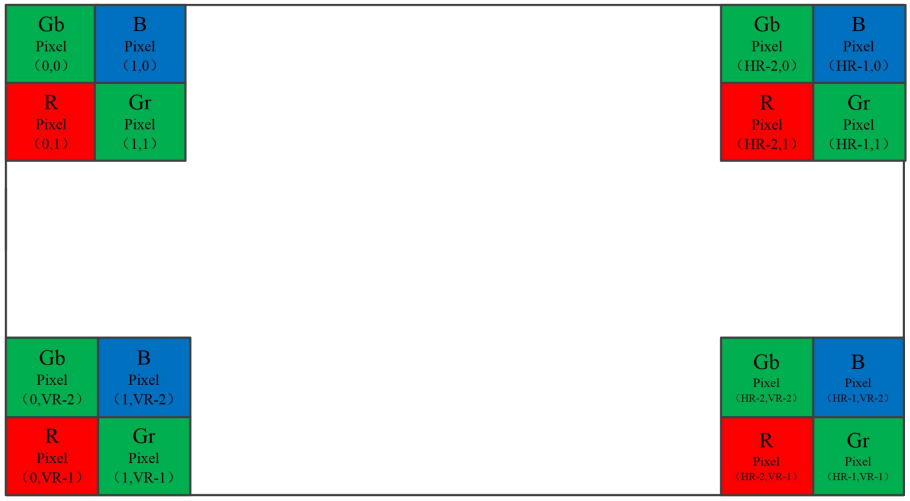


Fig. 4 Camera Bayer Pattern

4.6 Environmental Requirements

(1) Operating temperature: 0℃~65℃, humidity: 10%~80%; Storage temperature:-20℃~75℃.

(2) The sensor in the camera has dustproof sealing setting, which can effectively prevent dust from entering the sensor surface. If the 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

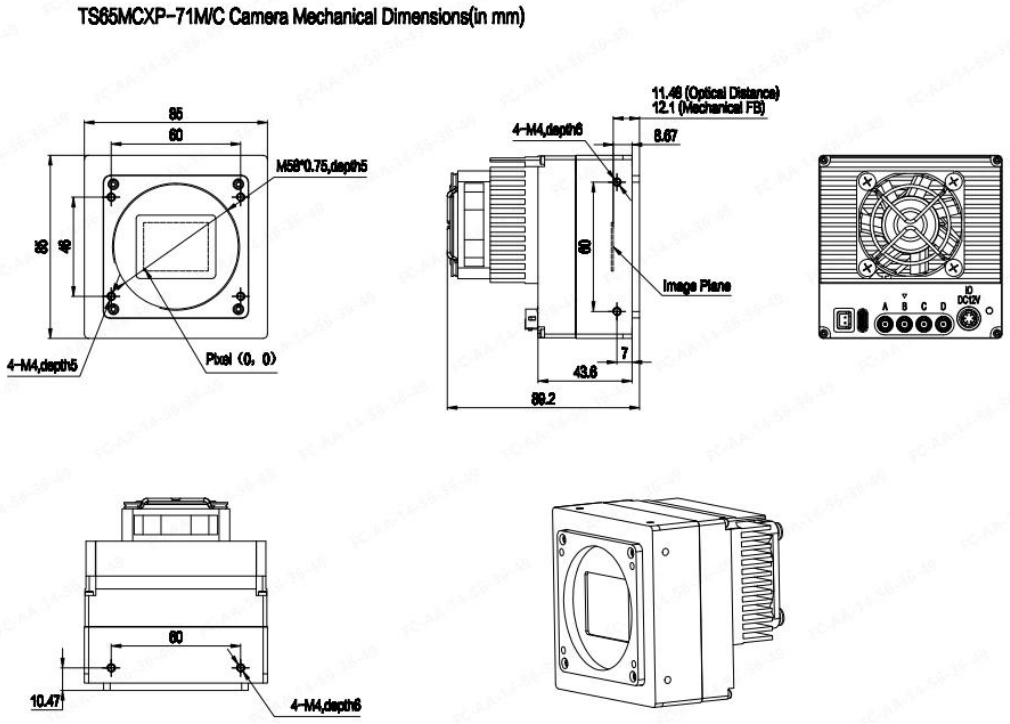


Fig. 5 Camera Mechanical Dimensions

5.2 Camera Interface

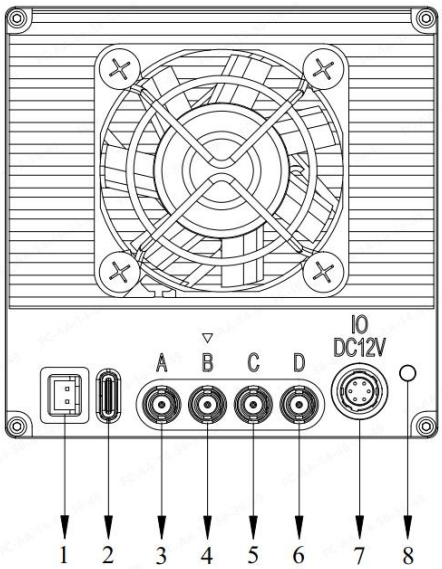


Fig. 6 External Interfaces of Camera

① Fan Power Interface
② Type-C Interface
③ CoaXPress Connection A

④ CoaXPress Connection B **(Master)**
⑤ CoaXPress Connection C
⑥ CoaXPress Connection D
⑦ 6-pin Power Interface
⑧ Camera Status Indicator

Note: If users are using an Euresys acquisition card, they need to connect channel A of the acquisition card to channel B of the camera, otherwise the software will not be able to scan the camera.

5.2.1 Camera Status Indicator

The camera status indicator is used to indicate the real-time status of the 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 & Control Interface

The power and control interface is a 6-pin interface with the model:
Hirose HR10A-7R-6PB (Male).

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

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

Fig. 7 Pin Assignments for Interface

Table 3 TS65MCXP Power Connector Pin Definition

Signal	Pin	Signal	Pin
Power	1	Trigger in_GND	4
Power	2	GND	5

Trigger in	3	GND	6

The schematic diagram of trigger input circuit is shown below:

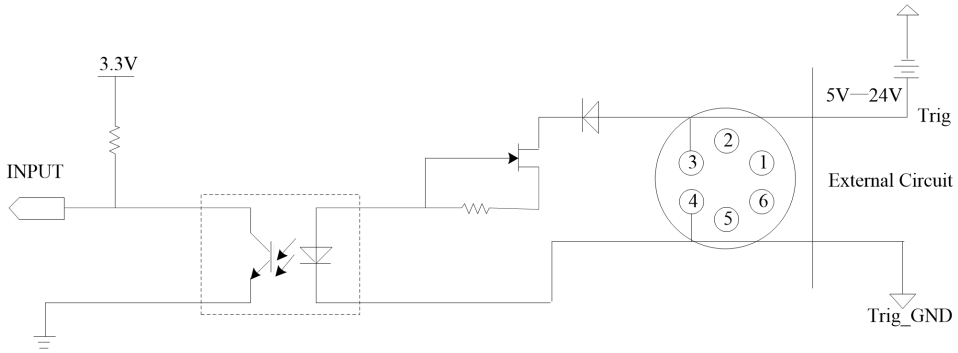


Fig.8 Trigger Input Circuit Schematic

- Trigger voltage range: 5~24V

5.2.3 Data Interface

TS65MCXP camera implements the standard Quad CoaXPress protocol, and the data interface is four Micro BNC sockets on the back of the camera. The data interface on the back of the camera is shown in the red box below:

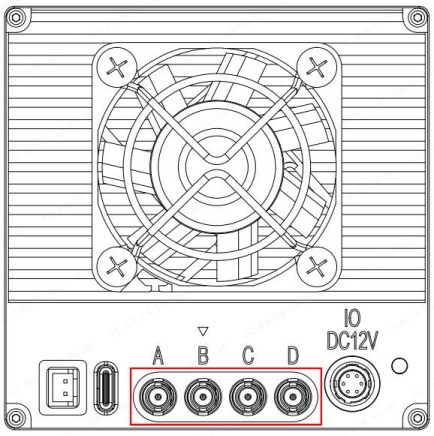


Fig. 9 Data Interface

The mechanical drawing of Micro BNC socket is as follows:

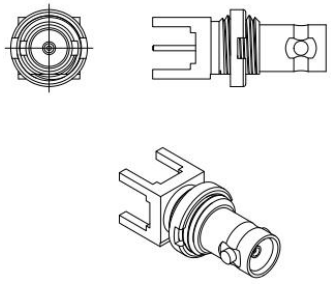


Fig. 10 Micro BNC Socket

6 Camera Features

This chapter details the internal features of TS65MCXP camera.

6.1 Trigger Mode

TS65MCXP 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, the camera generates the relevant control sequence internally according to the frame period and exposure time parameters configured by users and outputs the image.

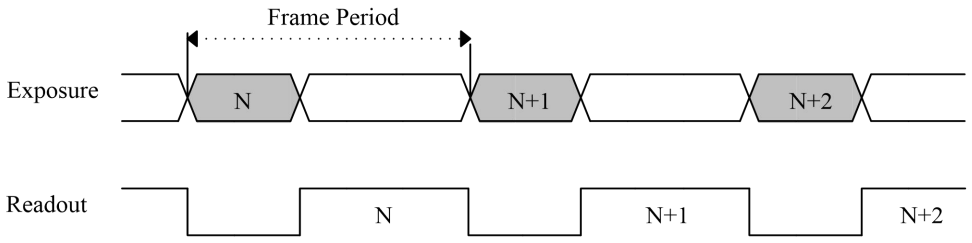


Fig. 11 Free-Run Mode

To achieve normal image output, TS65MCXP camera limits the range of frame periods and exposure time. Minimum frame period should be longer than both exposure time and readout time of a frame data. The operation sequence of the camera is shown in the figure above.

6.1.2 External Pulse Mode

In the External Pulse mode, the camera starts exposure at the 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 the camera is determined by the frame period between the rising edges of the external trigger pulse, as shown in the figure below.

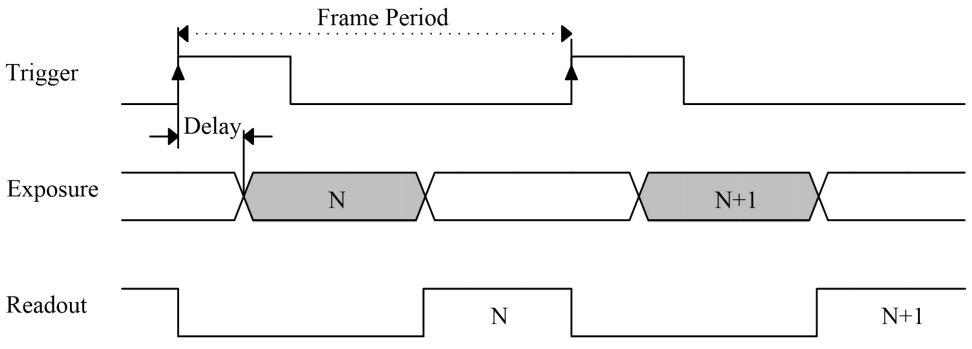


Fig. 12 External Pulse Mode

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 the camera reads the 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 the camera, as shown in the figure below.

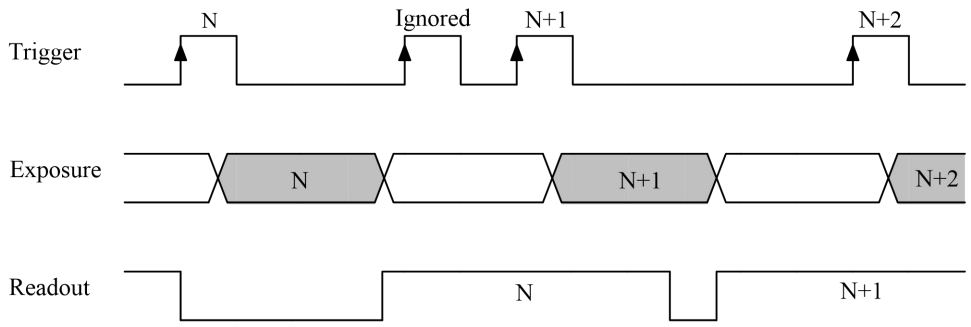


Fig. 13 Frame Period of External Trigger is Too Short

6.1.3 External PWM Mode

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

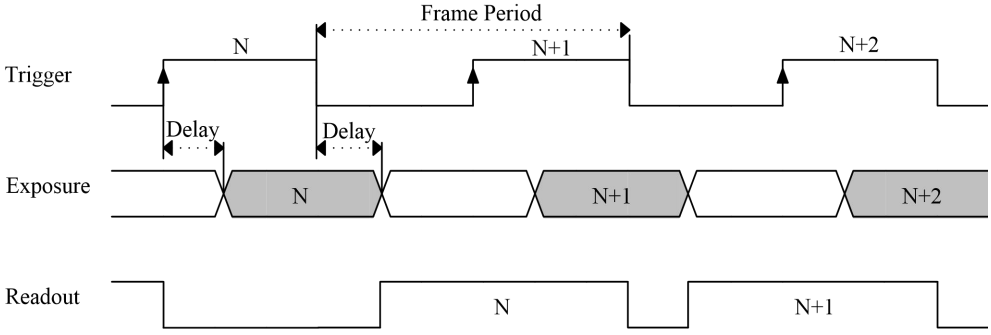


Fig. 14 High Level Trigger Mode

Please note that in this model, external trigger signal 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.

Too short frame period of external trigger will lead to the conflict between the data readout of the previous and current frames of the camera. The pulses that do not meet the requirements will be ignored inside the camera, so that the device can maintain its 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.

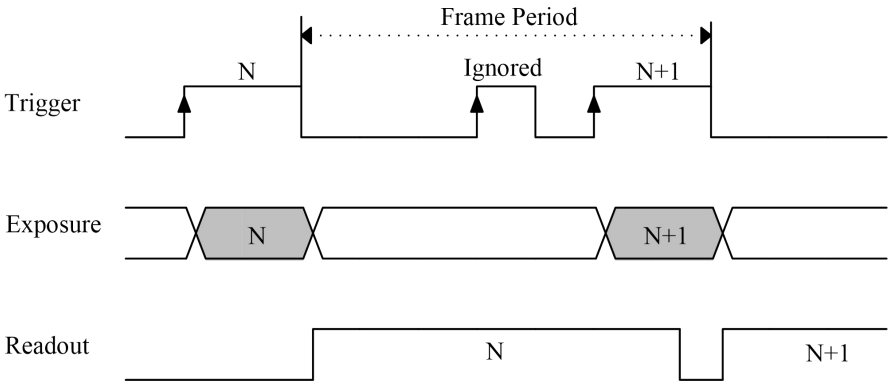


Fig. 15 Frame Period of External Trigger is Too Short

6.2 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.

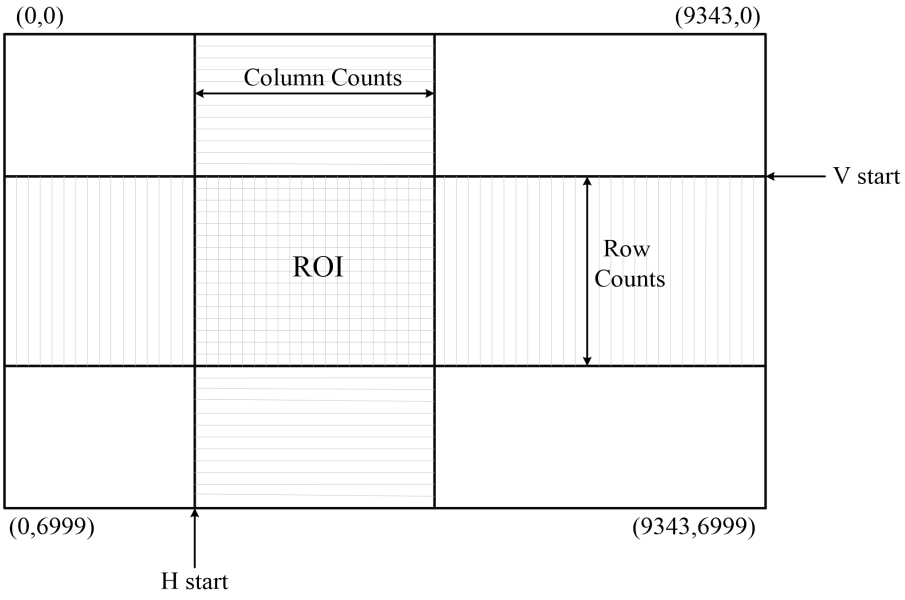


Fig. 16 ROI

Table 4 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	10bit
9344	7000	71.04fps	58.13fps
8960	7000	71.04fps	58.13fps
8000	7000	71.04fps	58.13fps
6976	7000	71.04fps	58.13fps
5952	7000	71.04fps	58.13fps
4992	7000	71.04fps	58.13fps

3968	7000	71.04fps	58.13fps
2944	7000	71.04fps	58.13fps
1984	7000	71.04fps	58.13fps
1024	7000	71.04fps	58.13fps
9344	6000	82.81fps	67.75fps
9344	5000	99.25fps	81.20fps
9344	4000	123.82fps	101.31fps
9344	3000	164.58fps	134.64fps
9344	2000	245.34fps	200.72fps
9344	1000	481.70fps	394.01fps
9344	500	929.37fps	759.88fps

6.3 Image Flipping

TS65MCXP camera can make the image flip along the X/Y direction. Users can use this function to change the camera scan direction, the effect is shown below:

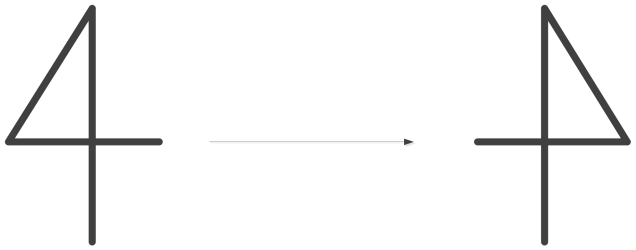


Fig. 17 Flip in X Direction

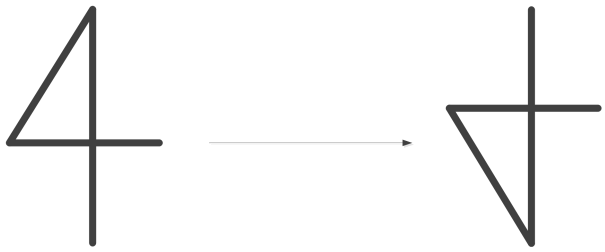


Fig. 18 Flip in Y Direction

6.4 LUT

LUT uses a look-up table with 10bit input and 10bit output to map and convert the values of the original image. Users can use this function to implement gamma correction.

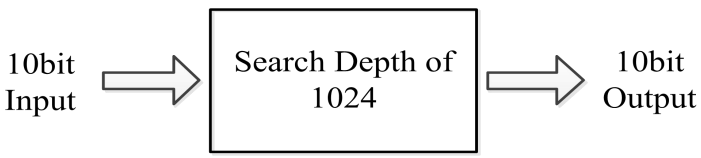


Fig.19 LUT Structure

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

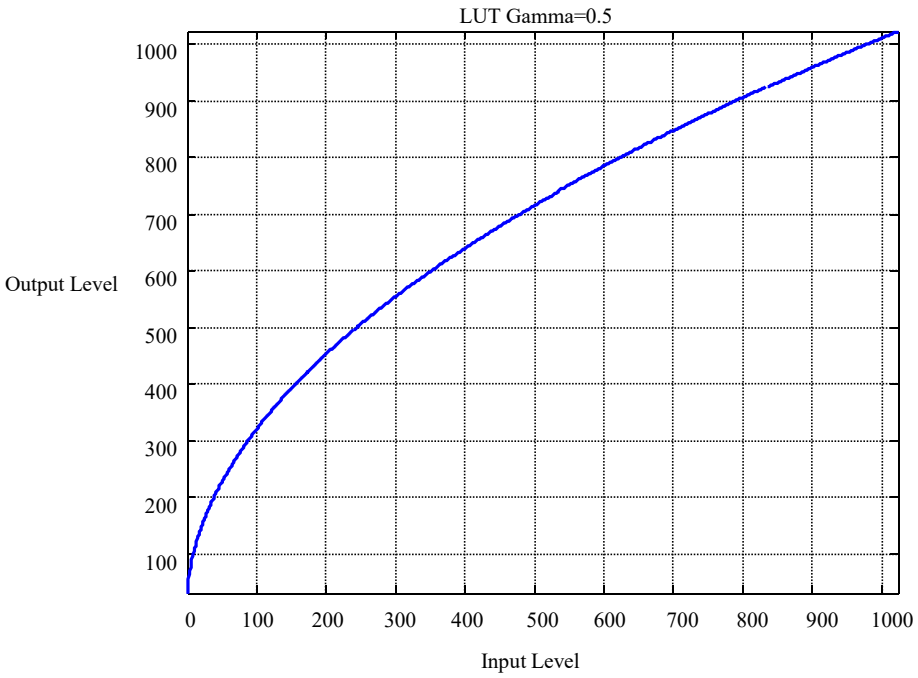


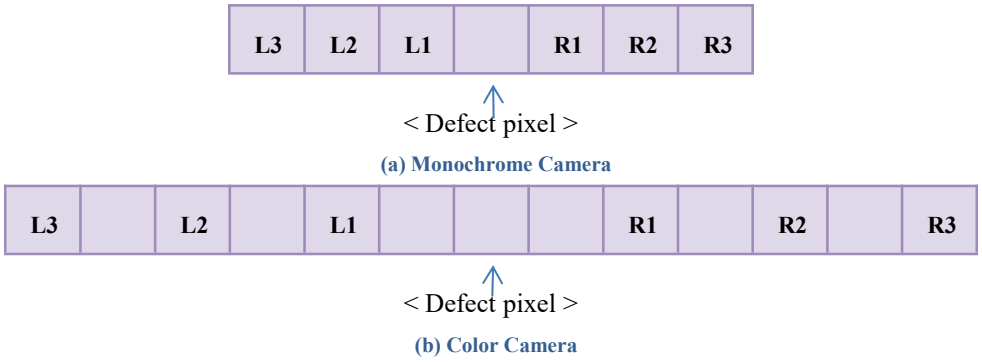
Fig.20 LUT Gamma = 0.5

6.5 Defect Pixel Correction

Due to the 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. TS65MCXP camera provides with defect pixel automatic correction feature. The defect pixel information of the 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 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 methods of monochrome and color cameras are different:

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



(a) Monochrome Camera

(b) Color Camera

Fig. 21 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.

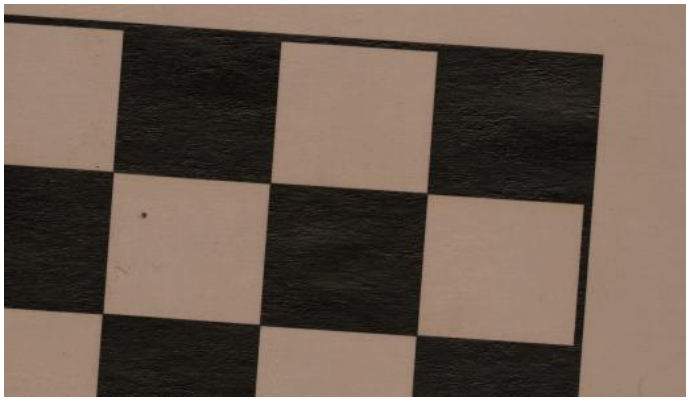
Table 5 Calculation Defect Pixel Correction Value

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

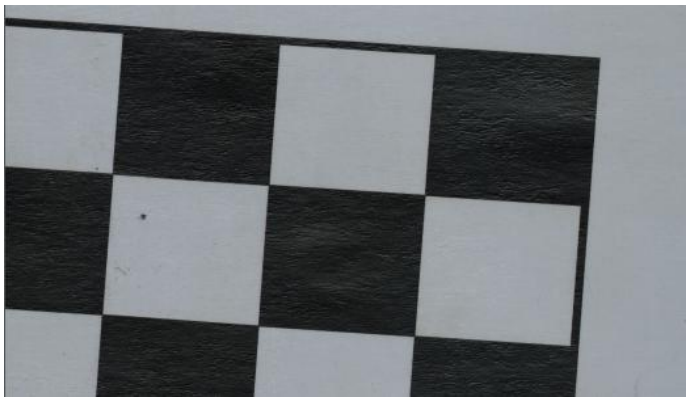
6.6 White Balance

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.

TS65MCXP 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. 22 White Balance Effect

6.7 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. TS65MCXP 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:

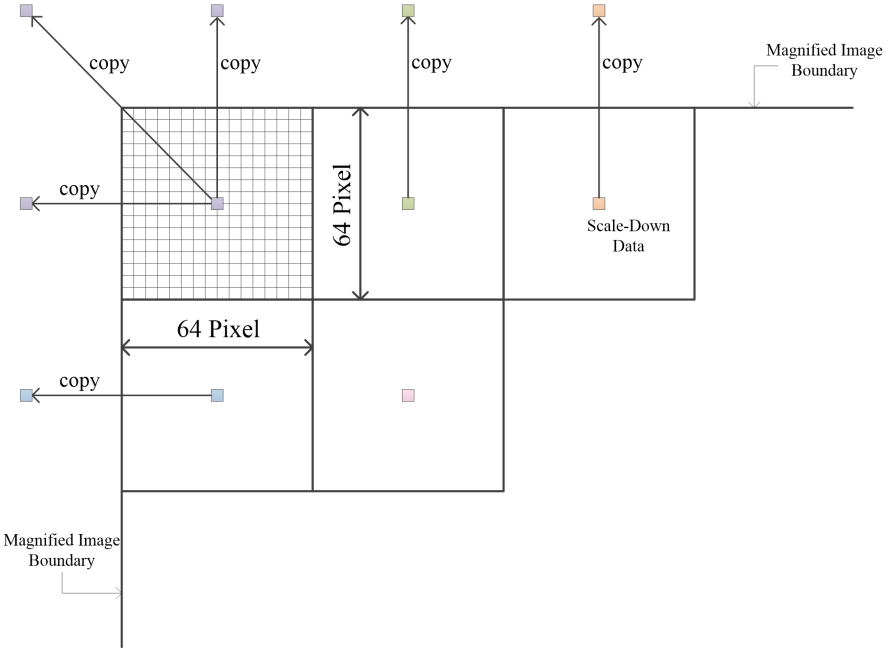


Fig. 23 Flat Field Correction Schematic

6.8 Test Image

Camera provides 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 Image1: fixed image with horizontal gray gradient.
- Test Image2: scroll image with vertical gray gradient.
- Test Image3: fixed image with the same gray scale for all pixels.

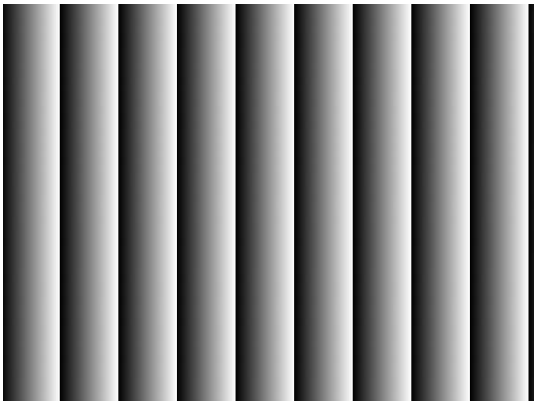


Fig. 24 Test Image1

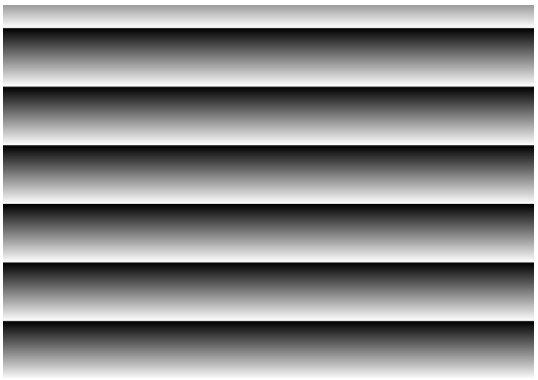


Fig. 25 Test Image2

Fig. 26 Test Image3

6.9 Data Format

TS65MCXP camera provides two pixel data bit width, 8bit and 10bit. If bit width is 8bit, it is equivalent to truncating the top 8bit of 10bit.

Fig. 27 Data Format

6.10 Gain and Offset

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

Analog gain acts on the analog signal. By increasing analog gain, a stronger response can be generally obtained under weak illumination, thus realizing a higher SNR. Users can configure camera's analog gain. Similarly, the analog offset is commonly used to adjust the black level position of the front-end sensor.

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) x Digital gain value

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

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

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

6.11 Camera Temperature

TS65MCXP camera supports real-time acquisition of camera 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 operating environment temperature of the camera is recommended to be 0~65°C. If users detect abnormal internal temperature (such as over 75°C), it is recommended to stop the camera immediately to avoid component damage. Power off and contact our technical support in time.

6.12 Load / Save Configuration

TS65MCXP 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 below.

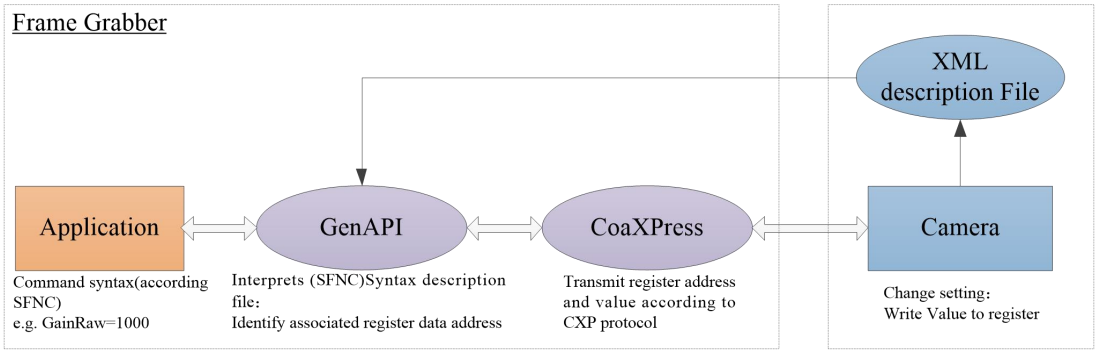


Fig. 28 Communication Principle Diagram Between Application and Camera

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, in order 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 is consistent with the allowable gain range. This register message is transmitted and parsed via the CoaxPress protocol, and is used in the camera.

7.2 GenAPI Parameter Attributes

The actual method of controlling the camera is closely related to the software implementation of the frame grabber and SDK. Most of the frame grabber software provides a graphical user interface (GUI) that is automatically generated from an XML file. The focus of this manual is on the functions of the camera. It describes in detail the specific commands and their effects on camera operations. It lists 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 names are part of SFNC, and (T)TS65MCXP custom names are used for non-standard parameters.

(2) Register address

This parameter represents the address value of the register (hexadecimal format).

(3) Register size

This parameter represents the size of the register value (in byte).

(4) Register interface

The parameter interface represents the type of parameter, which is mainly used for the GUI of the frame grabber to assign a display type to the parameter.

Table 6 Overview of Parameter Interface

Interface	Interface Name	Description
Integer	I	Integer with value, minimum, maximum, and increment
Float	F	Float with value, minimum, maximum, and physical unit
String	S	String
Enumeration	E	Enumerate type
Command	C	Execute the command
Boolean	B	Boolean type

(5) Parameter access

This parameter represents whether the user can read (RO), write (WO) or read/write (RW) parameters.

(6) Default parameter value and range

When setting the parameter, it will check whether the input value is within the valid range of the parameter.

7.3 Register Classification

7.3.1 Bootstrap CoaXPress Registers

Table 7 Bootstrap CoaXPress 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
HsUpconnection	0x403c	4	I	RO	Guru

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

- **Revision**
  CoaXPress protocol version number.

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

- **XmlManifestSelector**
  Select XML manifest entry.

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

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

- **XmlUrlAddress**

  The URL address of XML file referenced by XmlManifestSelector.

- **Iidc2Address**

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

- **ConnectionReset**

  Reset all connections to device.

- **DeviceConnectionID**

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

- **MasterHostConnectionID**

  ID of host device.

- **ControlPacketSizeMax**

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

- **StreamPacketSizeMax**

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

- **ConnectionConfig**

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

  - CXP3_X1 (65592)
  - CXP5_X1 (65600)
  - CXP6_X1 (65608)
  - CXP12_X1 (65624)
  - CXP3_X2 (131128)
  - CXP5_X2 (131136)
  - CXP6_X2 (131144)
  - CXP12_X2 (131160)
  - CXP3_X4 (262200)
  - CXP5_X4 (262208)
  - CXP6_X4 (262216)
  - CXP10_X4 (262224)
  - CXP12_X4 (262232)

- **ConnectionConfigDefault**

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

- CXP3_X1 (65592)
- CXP5_X1 (65600)
- CXP6_X1 (65608)
- CXP12_X1 (65624)
- CXP3_X2 (131128)
- CXP5_X2 (131136)
- CXP6_X2 (131144)
- CXP12_X2 (131160)
- CXP3_X4 (262200)
- CXP5_X4 (262208)
- CXP6_X4 (262216)
- CXP10_X4 (262224)
- CXP12_X4 (262232)

- **TestMode**

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

- Off (0)
- Mode1 (1)

- **TestErrorCountSelector**

Test mode selection. The parameter range is as follows:

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

- **TestErrorCount**

Number of test errors.

- **TestPacketCountTx**

Number of test error frames.

- **TestPacketCountRx**

Number of test data frames

- **ElectricalCompliancyTest**

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

- NormalOperatingMode (0)
- CXP3_X1 (65592)
- CXP5_X1 (65600)
- CXP6_X1 (65608)
- CXP3_X2 (131128)
- CXP5_X2 (131136)
- CXP6_X2 (131144)

- CXP3_X4 (262200)
- CXP5_X4 (262208)
- CXP6_X4 (262216)

- **WidthAddress**
  Address of camera width register.

- **HeightAddress**
  Address of camera height register.

- **AcquisitionModeAddress**
  The address of camera acquisition mode register.

- **AcquisitionStartAddress**
  The address of camera acquisition register.

- **AcquisitionStopAddress**
  The camera stops grabbing address of register.

- **PixelFormatAddress**
  The address of camera pixel format register.

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

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

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

7.3.2 Device Control Registers

Table 8 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	RO	Beginner
MCUTemperature	0x6118	4	F	RO	Expert
SensorTemperature	0x6038	4	F	RO	Expert
BoardTemperature	0x6114	4	F	RO	Expert

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceManufacturerInfo**
  Device manufacturer information.

- **DeviceVersion**
  Device version.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceUserID**
  User-defined ID.

- **MCUTemperature**
  MCU temperature.

- **SensorTemperature**
  Sensor temperature.

- **BoardTemperature**
  Board temperature.

7.3.3 Image Format Control Registers

Table 9 Image Format Control Registers

Name	Address	Size	Interface	Access	Visibility
Width	0x6000	4	I	RW	Beginner
Height	0x6004	4	I	RW	Beginner
OffsetX	0x6010	4	I	RW	Beginner
OffsetY	0x6014	4	I	RW	Beginner
PixelFormat	0x6020	4	E	RW	Beginner
VideoMode	0x602c	4	E	RW	Beginner
ReverseX	0x613c	4	B	RW	Beginner
ReverseY	0x6140	4	B	RW	Beginner
DeviceTapGeometry	0x6030	4	E	RO	Expert
Image1StreamID	0x6034	4	I	RO	Guru

- **Width**

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

- Minimum: 1024
- Increment: 64

- **Height**

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

- Minimum: 500
- Increment: 20

- **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

- **PixelFormat**

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

- Mono8 (17301505): Monochrome 8bit
- Mono10 (17825795): Monochrome 10bit
- BayerBG8 (17301515): Bayer BGGR 8bit
- BayerBG10 (17825807): Bayer BGGR 10bit
- BayerGB8 (17301514): Bayer GBRG 8bit
- BayerGB10 (17825806): Bayer GBRG 10bit
- BayerGR8 (17301512): Bayer GRBG 8bit
- BayerGR10 (17825804): Bayer GRBG 10bit
- BayerRG8 (17301513): Bayer RGGB 8bit
- BayerRG10 (17825805): Bayer RGGB 10bit

- **VideoMode**

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

- Original (0): Original image
- Corrected (1): Corrected image
- VerticalPattern (2): Vertical test image
- HorizontalPattern (3): Horizontal test image
- Uniform (4): Uniform test image

- **ReverseX**

Horizontal flipping.

- **ReverseY**

Vertical flipping.

- **DeviceTapGeometry**

  Device tap geometry. The enumeration names and values are as follows:

  - Geometry_1X_1Y（0）

- **Image1StreamID**

  Image data stream 1 index.

7.3.4 Acquisition Control Registers

Table 10 Acquisition Control Registers

Name	Address	Size	Interface	Access	Visibility
AcquisitionMode	0x603c	4	E	RW	Beginner
AcquisitionStart	0x6040	4	C	RW	Beginner
AcquisitionStop	0x6044	4	C	RW	Beginner
AcquisitionFrameRate	0x6164	4	F	RW	Beginner
TriggerSource	0x6050	4	E	RW	Beginner
TriggerActivation	0x6054	4	E	RW	Beginner
TriggerDelayTime	0x6058	4	I	RW	Beginner
ExposureMode	0x605c	4	E	RW	Beginner
ExposureTime	0x6060	4	F	RW	Beginner

- **AcquisitionMode**

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

  - Continuous (0): Continuous acquisition

- **AcquisitionStart**

  Start acquisition.

- **AcquisitionStop**

  Stop acquisition.

- **AcquisitionFrameRate**

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

  - Maximum: 1000
  - Minimum: 0

- **TriggerSource**

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

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

- **TriggerActivation**

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

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

- **TriggerDelayTime**

  Trigger delay time. The parameter range is as follows:

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

- **ExposureMode**

  Exposure mode. Please refer to Section 6.1 for specific descriptions. The enumeration names and values are as follows:

  - Timed (0): Free-Run mode
  - TriggerPulse (1): External pulse mode
  - TriggerWidth (2): External PWM mode

- **ExposureTime**

  - Exposure time, the unit is us.

7.3.5 Digital Control Registers

Table 11 Digital Control Registers

Name	Address	Size	Interface	Access	Visibility
Gain	0x6068	4	F	RW	Beginner
Offset	0x606c	4	I	RW	Beginner
WhiteBalanceRedGain	0x6070	4	I	RW	Expert
WhiteBalanceGreenGain	0x6074	4	I	RW	Expert
WhiteBalanceBlueGain	0x607c	4	I	RW	Expert
WhiteBalanceEnable	0x608c	4	B	RW	Expert
WhiteBalanceInitialize	0x6080	4	C	WO	Expert
WhiteBalanceCalibrate	0x6080	4	C	WO	Expert
BlackLevel	0x6168	4	I	RW	Guru

- **Gain**

  Digital gain. The parameter range is as follows:

  - Maximum: 8
  - Minimum: 0.1

- **Offset**

  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: 16384
- Minimum: 1024
- Increment: 1

- **WhiteBalanceGreenGain**

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

- Maximum: 16384
- Minimum: 1024
- Increment: 1

- **WhiteBalanceBlueGain**

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

- Maximum: 16384
- Minimum: 1024
- Increment: 1

- **WhiteBalanceEnable**

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

- **WhiteBalanceInitialize**

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

- **WhiteBalanceCalibrate**

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

- **BlackLevel**

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

- Maximum: 8191
- Minimum: -8191
- Increment: 1

7.3.6 Analog Control Register

Table 12 Analog control register

Name	Address	Size	Interface	Access	Visibility
AnalogGain	0x6088	4	I	RW	Beginner
AnalogOffset	0x6130	4	I	RW	Beginner

- **AnalogGain**

  Analog gain. The parameter range is as follows:
  - Minimum: 0
  - Incerment: 1

- **AnalogOffset**

  Analog offset. The parameter range is as follows:
  - Maximum: 4095
  - Minimum: 0
  - Incerment: 1

7.3.7 Defect Pixel Registers

Table 13 Defect Pixel Registers

Name	Address	Size	Interface	Access	Visibility
DefectPixelCorrectionEnable	0x60d0	4	B	RW	Guru
DefectPixelTotal	0x60d8	4	I	RO	Expert
DefectPixelSelect	0x60dc	4	I	RW	Expert
DefectPixelReadX	0x60e0	4	I	RO	Expert
DefectPixelReadY	0x60e4	4	I	RO	Expert
DefectPixelWriteX	0x60e8	4	I	RW	Expert
DefectPixelWriteY	0x60ec	4	I	RW	Expert
DefectPixelAdd	0x60f0	4	C	WO	Expert
DefectPixelRemove	0x60f4	4	C	WO	Expert
DefectPixelClearAll	0x60f8	4	C	WO	Expert
DefectPixelSave	0x60fc	4	C	WO	Expert

- **DefectPixelCorrectionEnable**

  Enable defect pixel correction function.

- **DefectPixelTotal**

  Total number of defect pixel.

- **DefectPixelSelect**

  Select index of defect pixel. The parameter range is as follows:
  - Maximum: 16383
  - Minimum: 0
  - Increment: 1

- **DefectPixelReadX**
  Read the X coordinate of current defect pixel. The parameter range is as follows:

- **DefectPixelReadY**
  Read the Y coordinate of current defect pixel. The parameter range is as follows:

- **DefectPixelWriteX**
  Write the X coordinate of defect pixel. The parameter range is as follows:
  - Maximum: 9344
  - Minimum: 0
  - Increment: 1

- **DefectPixelWriteY**
  Write the Y coordinate of defect pixel. The parameter range is as follows:
  - Maximum: 7000
  - Minimum: 0
  - Increment: 1

- **DefectPixelAdd**
  Add defect pixel.

- **DefectPixelRemove**
  Remove current defect pixels.

- **DefectPixelClearAll**
  Remove all defect pixels.

- **DefectPixelSave**
  Save defect pixels.

7.3.8 LUT Control Registers

Table 14 LUT Control Registers

Name	Address	Size	Interface	Access	Visibility
LUTEnable	0x60c0	4	B	RW	Beginner
LUTSelector	0x6134	4	I	RW	Expert
LUTIndex	0x60c4	4	I	RW	Expert
LUTValue	0x60c8	4	I	RW	Expert
Gamma	0x6138	4	F	RW	Beginner

- **LUTEnable**
  Enable LUT function.

- **LUTSelector**

  LUT selection, enter the desired LUT index. The parameter range is as follows:

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

- **LUTIndex**

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

  - Maximum: 1023
  - Minimum: 0
  - Increment: 1

- **LUTValue**

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

  - Maximum: 1023
  - Minimum: 0
  - Increment: 1

- **Gamma**

  Gamma correction coefficient The parameter range is as follows:

  - Maximum: 127
  - Minimum: 0.01

7.3.9 Dark Field Correction Registers

Table 15 Dark Field Correction Registers

Name	Address	Size	Interface	Access	Visibility
DF_TargetValue	0x61c0	4	I	RW	Expert
DF_Calibrate	0x61c4	4	C	WO	Expert
DF_RestoreFactory	0x61c4	4	C	WO	Expert

- **DF_TargetValue**

  Dark field correction target value. The parameter range is as follows:

  - Maximum: 1023
  - Minimum: 0
  - Increment: 1

- **DF_Calibrate**

  Perform dark field correction.

- **DF_RestoreFactory**

  Restore factory settings for dark field correction.

7.3.10 Flat Field Correction Registers

Table 16 Flat Field Correction Registers

Name	Address	Size	Interface	Access	Visibility
FF_Enable	0x6100	4	B	RW	Beginner
FF_Calibrate	0x6104	4	C	WO	Beginner
FF_RestoreFactory	0x6104	4	C	WO	Beginner

- **FF_Enable**
  Enable flat field correction.

- **FF_Calibrate**
  Perform flat field correction.

- **FF_RestoreFactory**
  Restore factory settings for flat field correction.

7.3.11 Cooler Control Registers

Table 17 Cooler Control Register

Name	Address	Size	Interface	Access	Visibility
FanSpeed	0x61c8	4	I	RW	Expert
TECCoolerEnable	0x6124	4	B	RW	Expert
TECTemperature	0x6128	4	I	RW	Guru

- **FanSpeed**
  Fan speed. The parameter range is as follows:
  - Maximum: 127
  - Minimum: 0
  - Increment: 1

- **TECCoolerEnable**
  Enable TEC cooling function.

- **TECTemperature**
  Set TEC cooling target temperature. The parameter range is as follows:
  - Maximum: 40
  - Minimum: -10
  - Increment: 1

7.3.12 User Set Control Registers

Table 18 User Set Control Registers

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

- **UserSetSelector**

  User configuration selector. The enumeration names and values are as follows:

  - Default(0): Factory configuration
  - UserSet1(1): User configuration 1
  - UserSet2(2): User configuration 2

- **UserSetLoad**

  Load selected camera configuration.

- **UserSetSave**

  Save selected camera configuration.

8 FAQ

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

① Ensure that 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 is set properly.

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

① Ensure that the sensor glass is clean.

② Ensure that the camera status indicator is normal.

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

① Check whether the 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.