TS65MCL-12M/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	2022/08/23	● Initial version
0.2	2023/02/11	● Update company address
0.3	2023/12/14	● Update camera parameter information ● Update chapter 7

Manufacturer Information

Hefei I-TEK Optoelectronics Co., LTD.

Tel.: +86-551-65318597

Fax: +86-551-65318597

Website: www.i-tek.cn

Address: 3F, Building #J2, Phase II, Zhong'an Chuanggu Technology Park, Wangjiang West Road, High-tech Industry Development Zone, Hefei, Anhui

Zip Code: 230088

Contents

1 Precautions

- **General**

① Do not drop, damage, disassemble the camera.

② Do not let children touch the camera without supervision.

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

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

- **Installation and Maintenance**

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

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

③ Keep the camera away from heat sources.

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

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

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

- **Power Supply**

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

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

- **Document**

① Hefei I-TEK Optoelectronics Co., LTD. does not warrant that the document is the final version. The document may be updated after product upgrade. Please contact market@i-tek.cn for the latest version, which is provided for the authorized users.

2 Camera Models

- **Camera Product Model**

Abbreviation	Name	Description
Line Scan Camera:		
PA	Panther	Panther (Single line industrial line scan camera)
PL	Plasma	Plasma (Multi-line industrial line scan camera)
PH	Phoenix	Phoenix (TDI industrial line scan camera)
TPH	TEC-Phoenix	TEC-Phoenix (TEC-TDI industrial line scan camera)
PN	Pneuma	Pneuma (Basic industrial line scan camera)
PR	Prometheus	Prometheus (High resolution industrial line scan camera)
PU	PupMaya	PupMaya (High width industrial line scan camera)
PT	Ptepare	Ptepare (Special custom industrial line scan camera)
PM	Prism	Prism line scan camera
Area Scan Camera:		
TM	Taurus-Prism	Prism area scan camera
HS	Hercules	Hercules (CCD industrial area scan camera)
TS	Taurus	Taurus (CMOS industrial area scan camera)
THS	TEC-Hercules	TEC-Hercules (CCD TEC industrial area scan camera)
TTS	TEC-Taurus	TEC-Taurus (CMOS industrial area scan camera)
XS	XStream	XStream (Super high speed camera)

- **Interface Specification**

Abbreviation	Interface Type
GV	GigE Vision
CL	Camera Link
CXP/CXP10/CXP12	CoaXPress
U30	USB3.0
XGV	10 GigE Vision
PCIe	PCI-Express
SFP	Small Form Pluggable

- **Color Form**

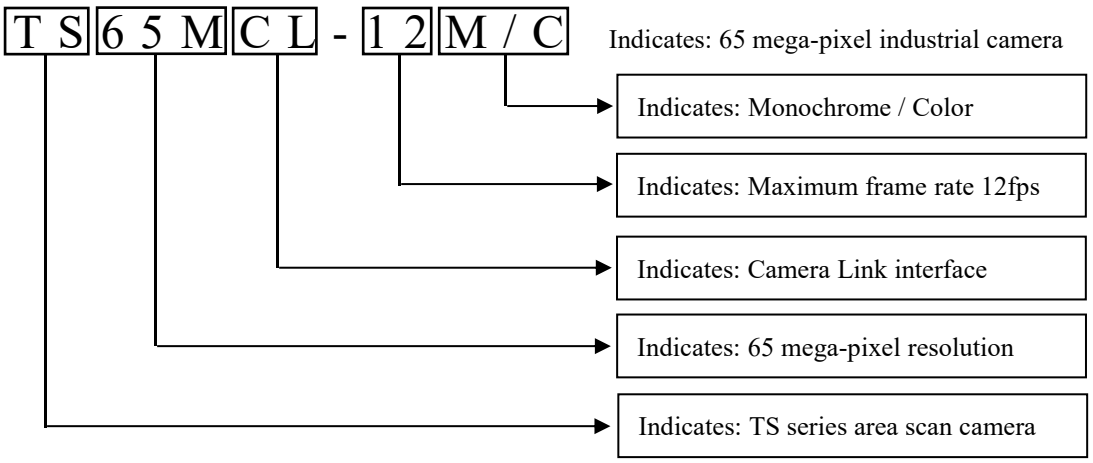
Abbreviation	Image Mode
M	Monochrome
C	Color
F	Full Color
T	Monochrome TDI (Time Delay Integration)
X	Time Division Camera
U	UV (Ultraviolet)
N	NIR (Near Infrared)

S	SWIR (Short Wave Infrared)
W	MWIR (Middle Wave Infrared)
L	LWIR (Long Wave Infrared)

- **Line Rate or Frame Rate**

Camera Type	Description
Line Scan Camera	Maximum line rate, e.g. 30kHz
Area Scan Camera	Maximum frame rate, e.g. 4000fps

e.g.



3 Product Appearance

Fig.1 Product Appearance

Note:

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

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

4 Product Specifications

TS65MCL camera adopts advanced global shutter CMOS image sensor and Camera Link data interface. It is a high-speed area scan camera designed for industrial measurement and inspection. It has high reliability and stability, which 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 Megapixel Resolution
- Full Frame Rate up to 12fps
- High Sensitivity and Low Noise
- Region of Interest
- LUT
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Output Pixel Format: 8/10/12bit
- Defect Pixel Correction
- Flat Field Correction
- Analog Gain / Digital Gain / Offset Control
- White Balance
- User-Configurable Scanning Direction
- Real-time Temperature Monitoring

4.2 Camera Specifications

Table 1 TS65MCL-12M/C Product Specifications

Model	TS65MCL-12M/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
Lens Mount	M58
Analog Gain	0~64
Digital Gain	0.01~8
Digital Offset	-4095~4095
Max Frame Rate	12.47fps@8bit, 10.16fps@10bit, 5.08fps@12bit
Data Rate	830MB/s
Trigger Mode	Free-Run, External Trigger

External Trigger	External IO / Camera Link CC1
Exposure Control	Timed, External PWM
Exposure Time	37us~10s (step: 1us)
Data Format	8/10/12bit
Operating Temperature	0~65°C
Data Interface	Camera Link
Pixel Clock	85MHz
Power Supply	DC12V±10%　1.5A
Power Consumption	8.6W
Mechanical	67mm x 67mm x 71.4mm

Note:

① This table is for 0802-8103 version of TS65MCL camera specifications, which may vary slightly from version to version.

② Under different Tap number, the minimum exposure time of TS65MCL camera is different, including 37us@10Tap, 43us@8Tap, and 71us@4Tap.

4.3 Camera Structure

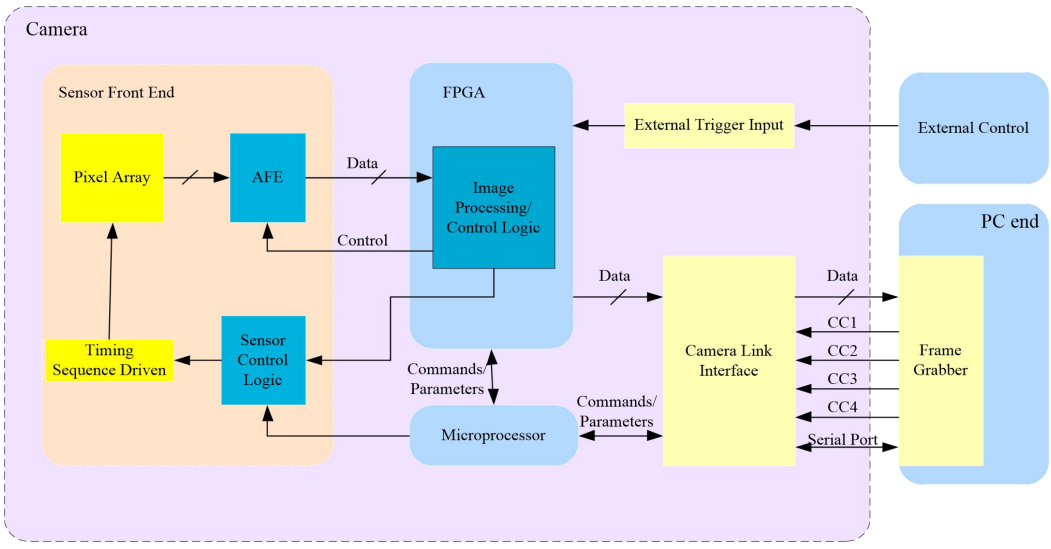


Fig.2 Internal Implementation Structure of Camera

TS65MCL 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 Camera Link interface after processed by FPGA and microprocessor.

The camera can receive external signal trigger acquisition, from IO signal or Camera Link signal.

4.4 Spectral Response

The spectral response of TS65MCL camera is shown below.

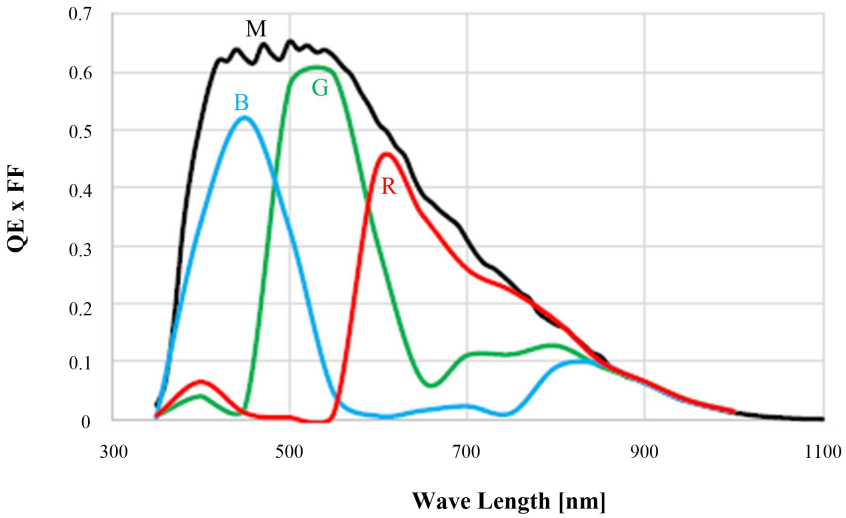


Fig.3 Spectral Response

4.5 Camera Bayer Pattern

TS65MCL camera supports color mode, Bayer pattern is shown as follows (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 dust proof 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

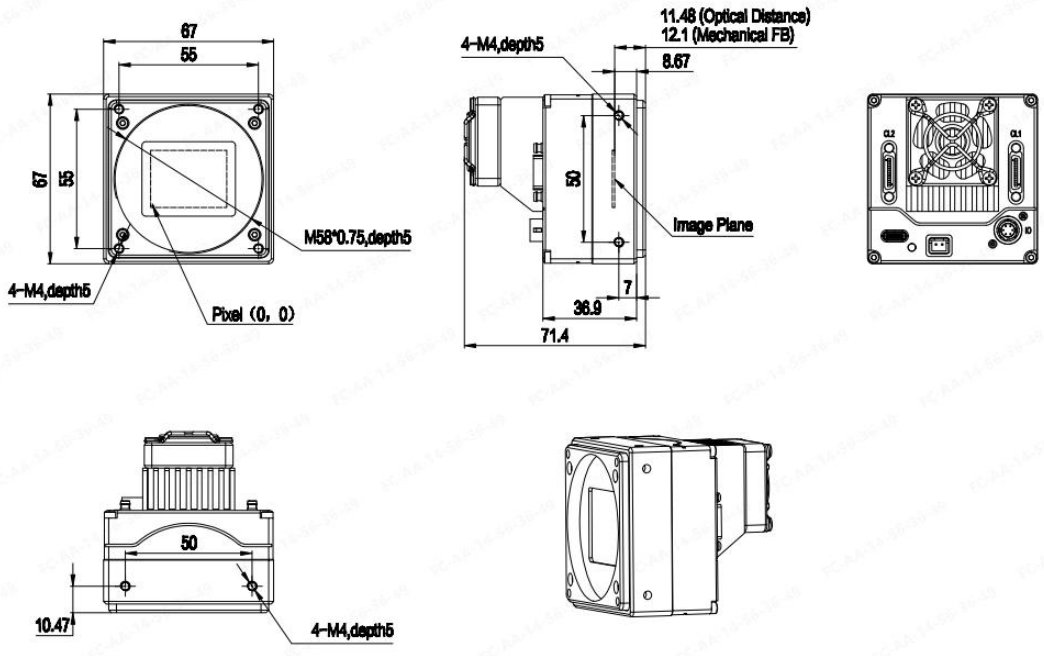


Fig.5 Camera Mechanical Dimensions

5.2 Camera Interface

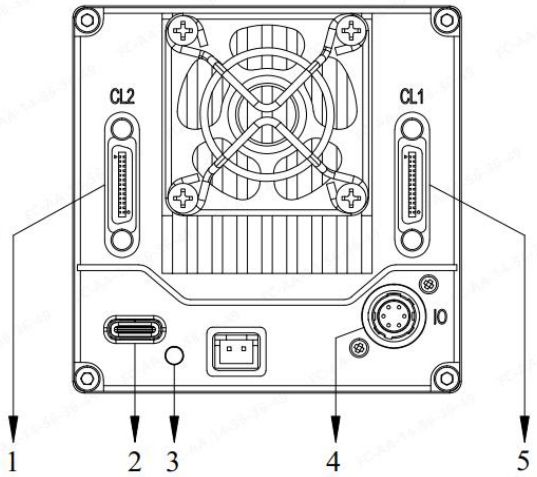


Fig.6 External Interfaces of Camera

(1) Camera Link Connector 2 (Medium/Full)
(2) Type-C Interface
(3) Camera Status Indicator
(4) 6-pin Power Input and Control Interface
(5) Camera Link Connector 1 (Base)

5.2.1 Camera Status Indicator

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

Table 2 Camera Status Indicators

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

5.2.2 Power Input and Control Interface

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

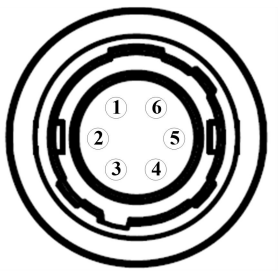


Fig.7 Pin Assignments for Interface

Table 3 Pin Configurations for Interface

Signal	Pin	Signal	Pin
Power	1	Trigger in_GND	4
Power	2	GND	5
Trigger in	3	GND	6

External trigger circuit is shown as follows:

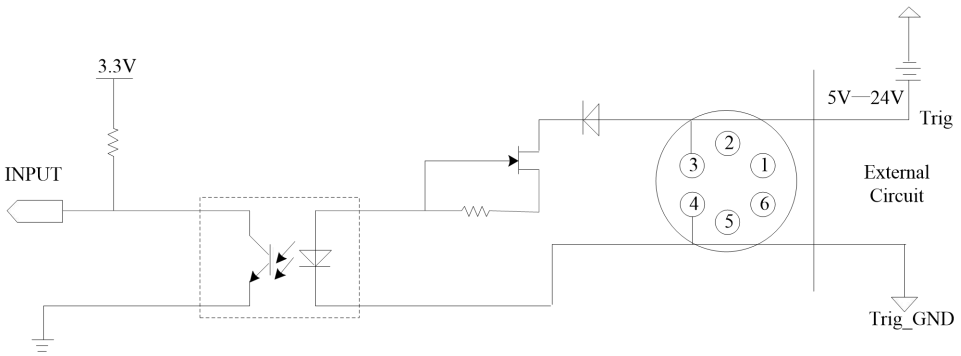


Fig.8 External Trigger Circuit

- Trigger signal voltage range: 5~24V

5.2.3 Data Interface

TS65MCL uses Mini Camera Link connector as its data interface. Mini Camera Link connector complies with the industry standard shown as follows:

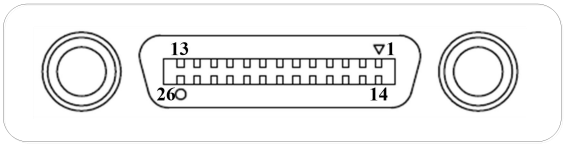


Fig.9 Mini Camera Link Connector

Table 4 Pin Assignments for Mini Camera Link Connector 1

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	X0-	LVDS-Out	Camera Link Transmitter
	15	X0+	LVDS-Out	Camera Link Transmitter
PAIR 2	3	X1-	LVDS-Out	Camera Link Transmitter
	16	X1+	LVDS-Out	Camera Link Transmitter
PAIR 3	4	X2-	LVDS-Out	Camera Link Transmitter
	17	X2+	LVDS-Out	Camera Link Transmitter
PAIR 4	5	XCLK-	LVDS-Out	Camera Link Transmitter
	18	XCLK+	LVDS-Out	Camera Link Transmitter
PAIR 5	6	X3-	LVDS-Out	Camera Link Transmitter
	19	X3+	LVDS-Out	Camera Link Transmitter
PAIR 6	7	UART_RX+	LVDS-In	Serial Data Receiver
	20	UART_RX-	LVDS-In	Serial Data Receiver
PAIR 7	8	UART_TX-	LVDS-Out	Serial Data Transmitter
	21	UART_TX+	LVDS-Out	Serial Data Transmitter
PAIR 8	9	CC1-	LVDS-In	Software External Trigger
	22	CC1+	LVDS-In	Software External Trigger

PAIR 9	10	CC2+	LVDS-In	Software External Trigger
	23	CC2-	LVDS-In	Software External Trigger
PAIR 10	11	CC3-	LVDS-In	Software External Trigger
	24	CC3+	LVDS-In	Software External Trigger
PAIR 11	12	CC4+	LVDS-In	Software External Trigger
	25	CC4-	LVDS-In	Software External Trigger
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

Table 5 Pin Assignments for Mini Camera Link Connector 2

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	Y0-	LVDS-Out	Camera Link Transmitter
	15	Y0+	LVDS-Out	Camera Link Transmitter
PAIR 2	3	Y1-	LVDS-Out	Camera Link Transmitter
	16	Y1+	LVDS-Out	Camera Link Transmitter
PAIR 3	4	Y2-	LVDS-Out	Camera Link Transmitter
	17	Y2+	LVDS-Out	Camera Link Transmitter
PAIR 4	5	YCLK-	LVDS-Out	Camera Link Transmitter
	18	YCLK+	LVDS-Out	Camera Link Clock Tx
PAIR 5	6	Y3-	LVDS-Out	Camera Link Channel Tx
	19	Y3+	LVDS-Out	Camera Link Channel Tx
PAIR 6	7	-	Not Used	Connected with 100 ohm
	20	-	Not Used	
PAIR 7	8	Z0-	LVDS-Out	Camera Link Transmitter
	21	Z0+	LVDS-Out	Camera Link Transmitter
PAIR 8	9	Z1-	LVDS-Out	Camera Link Transmitter
	22	Z1+	LVDS-Out	Camera Link Transmitter
PAIR 9	10	Z2-	LVDS-Out	Camera Link Transmitter
	23	Z2+	LVDS-Out	Camera Link Transmitter
PAIR 10	11	ZCLK-	LVDS-Out	Camera Link Transmitter
	24	ZCLK+	LVDS-Out	Camera Link Clock Tx
PAIR 11	12	Z3-	LVDS-Out	Camera Link Channel Tx
	25	Z3+	LVDS-Out	Camera Link Channel Tx
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

Note: The Base interface (CL1) and the Medium/Full interface (CL2) must be correctly connected to their respective interfaces on the Frame Grabber according to the instructions on the back of the camera.

The corresponding relationship between signals and ports in each output mode is shown in the following table:

Table 6 Port Assignments (4tap @ 8/10/12bit)

	8bit	10bit	12bit
	4tap/8bit	4tap/10bit	4tap/12bit
Port A0	A0	A0	A0
Port A1	A1	A1	A1
Port A2	A2	A2	A2
Port A3	A3	A3	A3
Port A4	A4	A4	A4
Port A5	A5	A5	A5
Port A6	A6	A6	A6
Port A7	A7	A7	A7
Port B0	B0	A8	A8
Port B1	B1	A9	A9
Port B2	B2	-	A10
Port B3	B3	-	A11
Port B4	B4	B8	B8
Port B5	B5	B9	B9
Port B6	B6	-	B10
Port B7	B7	-	B11
Port C0	C0	B0	B0
Port C1	C1	B1	B1
Port C2	C2	B2	B2
Port C3	C3	B3	B3
Port C4	C4	B4	B4
Port C5	C5	B5	B5
Port C6	C6	B6	B6
Port C7	C7	B7	B7

	8bit	10bit	12bit
	4tap/8bit	4tap/10bit	4tap/12bit
Port D0	D0	D0	D0
Port D1	D1	D1	D1
Port D2	D2	D2	D2
Port D3	D3	D3	D3
Port D4	D4	D4	D4
Port D5	D5	D5	D5
Port D6	D6	D6	D6
Port D7	D7	D7	D7
Port E0	-	C0	C0
Port E1	-	C1	C1
Port E2	-	C2	C2
Port E3	-	C3	C3
Port E4	-	C4	C4
Port E5	-	C5	C5
Port E6	-	C6	C6
Port E7	-	C7	C7
Port F0	-	C8	C8
Port F1	-	C9	C9
Port F2	-	-	C10
Port F3	-	-	C11
Port F4	-	D8	D8
Port F5	-	D9	D9
Port F6	-	-	D10
Port F7	-	-	D11

Table 7 Port Assignments (8tap @ 8/10bit)

	8bit	10bit
	8tap/8bit	8tap/10bit
Port A0	A0	A2
Port A1	A1	A3
Port A2	A2	A4
Port A3	A3	A5
Port A4	A4	A6
Port A5	A5	A7
Port A6	A6	A8
Port A7	A7	A9
Port B0	B0	B2
Port B1	B1	B3
Port B2	B2	B4
Port B3	B3	B5
Port B4	B4	B6
Port B5	B5	B7
Port B6	B6	B8
Port B7	B7	B9
Port C0	C0	C2
Port C1	C1	C3
Port C2	C2	C4
Port C3	C3	C5
Port C4	C4	C6
Port C5	C5	C7
Port C6	C6	C8
Port C7	C7	C9
Port D0	D0	D2
Port D1	D1	D3
Port D2	D2	D4
Port D3	D3	D5
Port D4	D4	D6
Port D5	D5	D7
Port D6	D6	D8
Port D7	D7	D9
Port E0	E0	E2
Port E1	E1	E3
Port E2	E2	E4
Port E3	E3	E5
Port E4	E4	E6
Port E5	E5	E7
Port E6	E6	E8
Port E7	E7	E9

	8bit	10bit
	8tap/8bit	8tap/10bit
Port F0	F0	F2
Port F1	F1	F3
Port F2	F2	F4
Port F3	F3	F5
Port F4	F4	F6
Port F5	F5	F7
Port F6	F6	F8
Port F7	F7	F9
Port G0	G0	G2
Port G1	G1	G3
Port G2	G2	G4
Port G3	G3	G5
Port G4	G4	G6
Port G5	G5	G7
Port G6	G6	G8
Port G7	G7	G9
Port H0	H0	H2
Port H1	H1	H3
Port H2	H2	H4
Port H3	H3	H5
Port H4	H4	H6
Port H5	H5	H7
Port H6	H6	H8
Port H7	H7	H9
Port I0	-	A0
Port I1	-	A1
Port I2	-	B0
Port I3	-	B1
Port I4	-	C0
Port I5	-	C1
Port I6	-	D0
Port I7	-	D1
Port J0	-	E0
Port J1	-	E1
Port J2	-	F0
Port J3	-	F1
Port J4	-	G0
Port J5	-	G1
Port J6	-	H0
Port J7	-	H1

Table 8 Port Assignments (10tap @ 8bit)

	8bit
	10tap/8bit
Port A0	A0
Port A1	A1
Port A2	A2
Port A3	A3
Port A4	A4
Port A5	A5
Port A6	A6
Port A7	A7
Port B0	B0
Port B1	B1
Port B2	B2
Port B3	B3
Port B4	B4
Port B5	B5
Port B6	B6
Port B7	B7
Port C0	C0
Port C1	C1
Port C2	C2
Port C3	C3
Port C4	C4
Port C5	C5
Port C6	C6
Port C7	C7
Port D0	D0
Port D1	D1
Port D2	D2
Port D3	D3
Port D4	D4
Port D5	D5
Port D6	D6
Port D7	D7
Port E0	E0
Port E1	E1
Port E2	E2
Port E3	E3
Port E4	E4
Port E5	E5
Port E6	E6
Port E7	E7

	8bit
	10tap/8bit
Port F0	F0
Port F1	F1
Port F2	F2
Port F3	F3
Port F4	F4
Port F5	F5
Port F6	F6
Port F7	F7
Port G0	G0
Port G1	G1
Port G2	G2
Port G3	G3
Port G4	G4
Port G5	G5
Port G6	G6
Port G7	G7
Port H0	H0
Port H1	H1
Port H2	H2
Port H3	H3
Port H4	H4
Port H5	H5
Port H6	H6
Port H7	H7
Port I0	I0
Port I1	I1
Port I2	I2
Port I3	I3
Port I4	I4
Port I5	I5
Port I6	I6
Port I7	I7
Port J0	J0
Port J1	J1
Port J2	J2
Port J3	J3
Port J4	J4
Port J5	J5
Port J6	J6
Port J7	J7

6 Camera Features

This chapter introduces the internal features of TS65MCL camera.

6.1 Trigger Mode

TS65MCL camera supports three trigger modes: Free-Run mode, External Pulse mode and External PWM mode.

6.1.1 Free-Run Mode

In Free-Run mode, the camera generates relevant control sequence internally according to frame period and exposure time parameters configured by users and outputs the image.

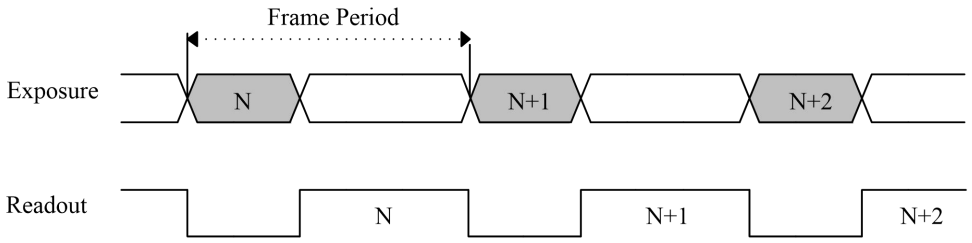


Fig.10 Free-Run Mode

To achieve normal image output, TS65MCL camera limits the range of frame periods and exposure time. The minimum frame period should be longer than both exposure time and reading time of a frame data. The operation sequence of the camera is shown in the figure above.

6.1.2 External Pulse Mode

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

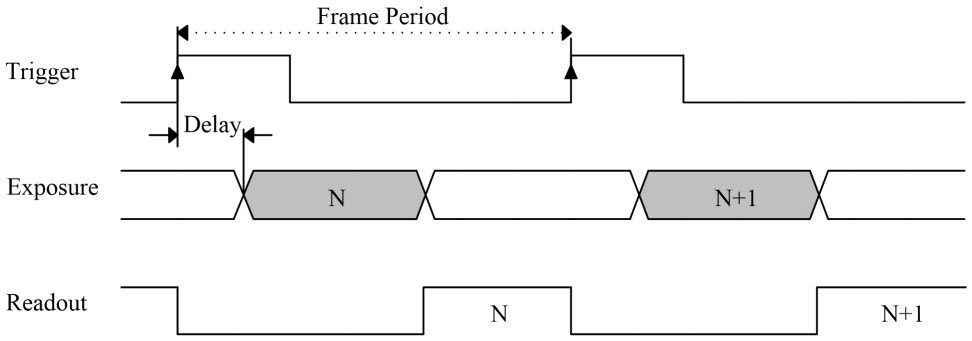


Fig.11 External Pulse Mode

The external trigger signal can be input from Camera Link CC1 interface or IO 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.

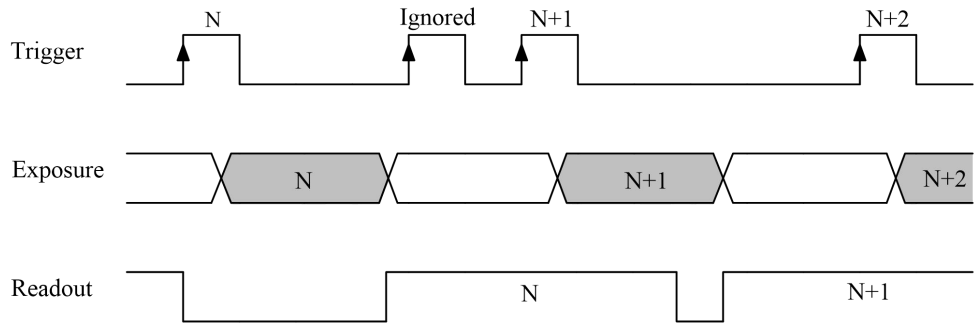


Fig.12 Frame Period of External Trigger is Too Short

6.1.3 External PWM Mode

In 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.

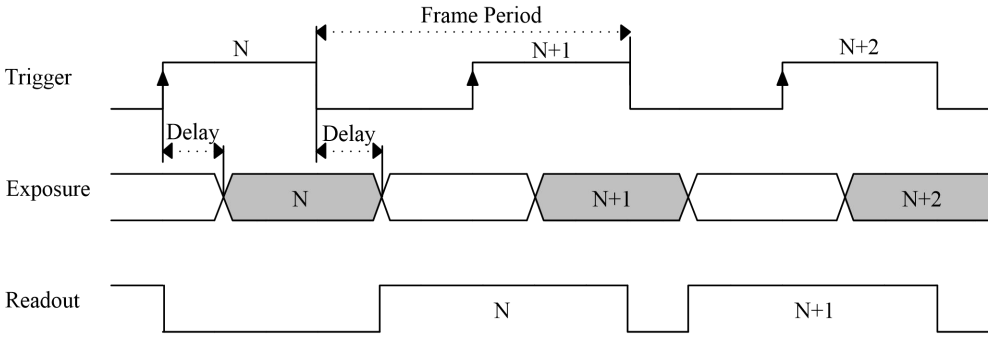


Fig.13 High Level Trigger Mode

In this mode, external trigger high level should ensure a time greater than the minimum exposure time. For pulses lower than this width, camera will treat them as the minimum exposure time.

If external trigger interval is too short, it will lead to a conflict between readout time of two frames before and after camera. The pulse which does not meet requirements will be ignored inside camera, so that camera can maintain normal operation, as shown in the figure below. The interval between adjacent falling edges should be greater than readout time of each frame.

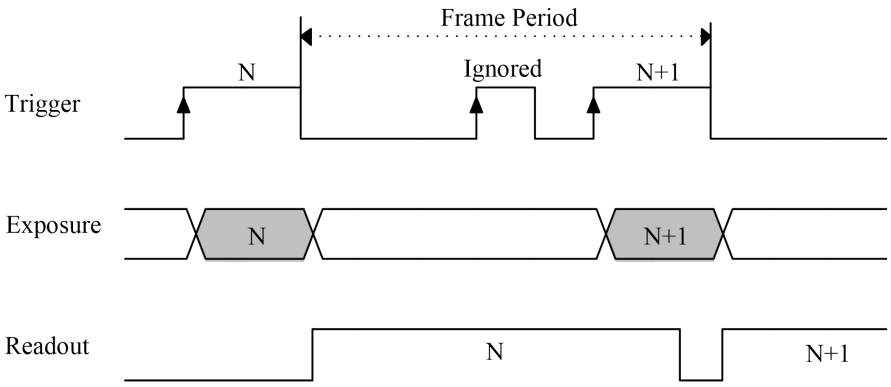


Fig.14 Frame Period of External Trigger is Too Short

6.2 Region of Interest

ROI feature allows users to specify only a portion of the sensor array output data. Users can obtain data from only a specified part of the sensor array so that the camera can have a higher frame rate. ROI is determined by three parameters, namely the coordinates of the starting point, the number of lines and the number of columns, as shown in the figure below.

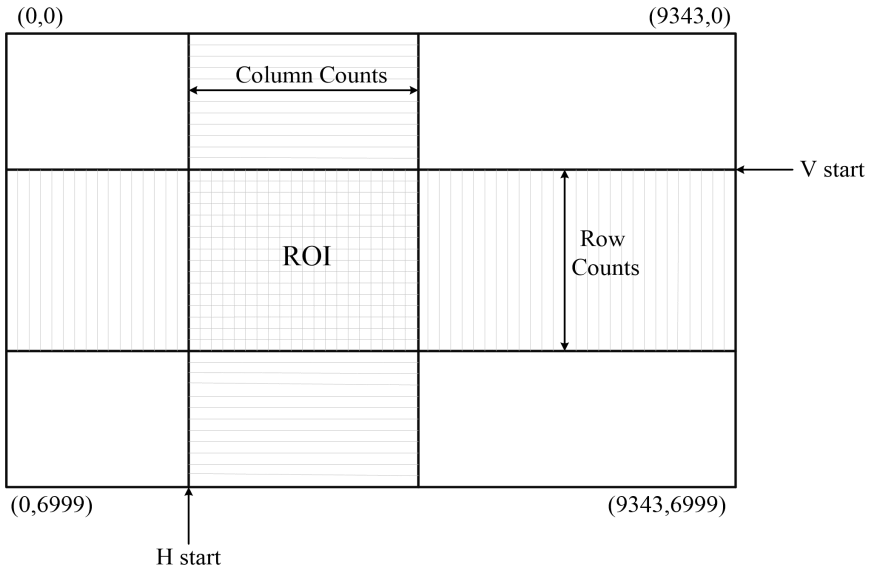


Fig.15 ROI

Table 9 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	8bit	10bit	12bit
9344	7000	12.47fps	10.16fps	5.08fps
8960	7000	12.47fps	10.16fps	5.08fps
8000	7000	12.47fps	10.16fps	5.08fps
6976	7000	12.47fps	10.16fps	5.08fps
5952	7000	12.47fps	10.16fps	5.08fps
4992	7000	12.47fps	10.16fps	5.08fps
3968	7000	12.47fps	10.16fps	5.08fps

2944	7000	12.47fps	10.16fps	5.08fps
1984	7000	12.47fps	10.16fps	5.08fps
1024	7000	12.47fps	10.16fps	5.08fps
9344	6000	14.54fps	11.84fps	5.92fps
9344	5000	17.43fps	14.19fps	7.10fps
9344	4000	21.75fps	17.71fps	8.85fps
9344	3000	28.92fps	23.55fps	11.77fps
9344	2000	43.14fps	35.13fps	17.56fps
9344	1000	84.87fps	69.11fps	34.56fps
9344	500	164.42fps	133.89fps	66.94fps

6.3 LUT

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

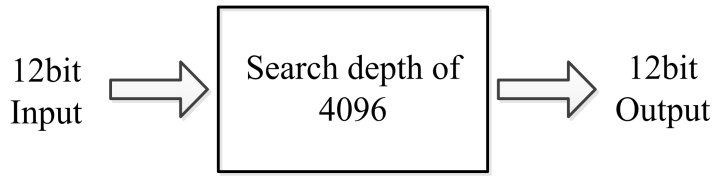


Fig.16 LUT

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

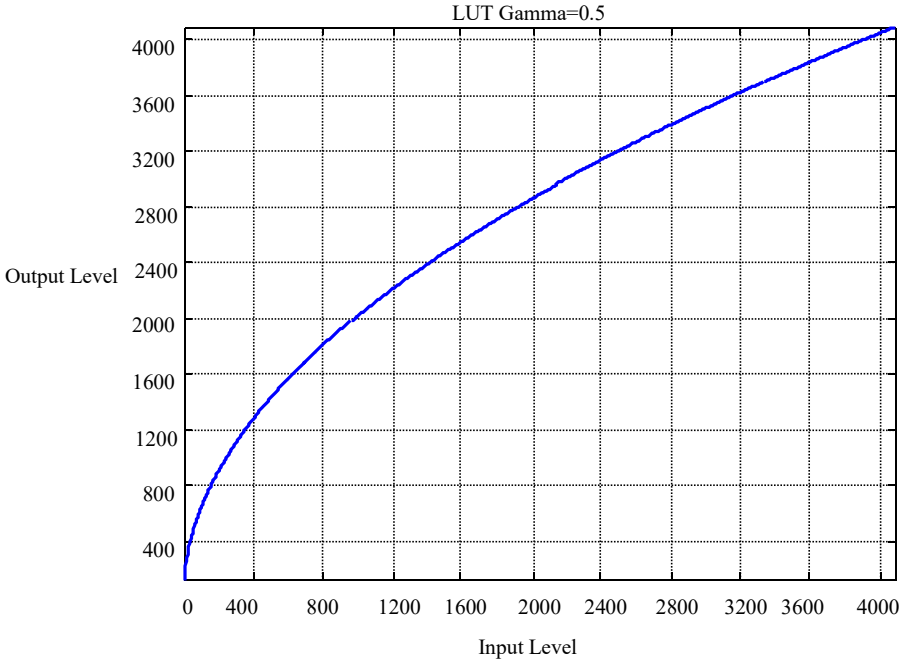


Fig.17 LUT: Gamma = 0.5

6.4 Image Flipping

TS65MCL camera can flip the image along the X/Y direction, or be combined. Users can use this feature to change the direction of the camera scan, as shown below:

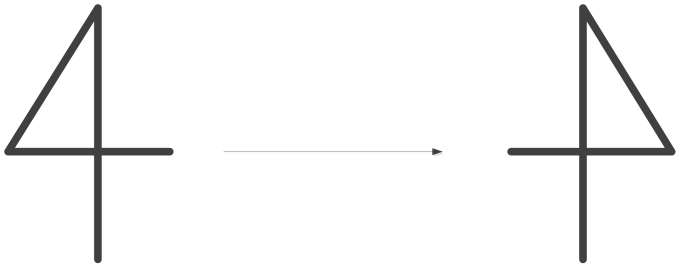


Fig.18 Flip in X Direction

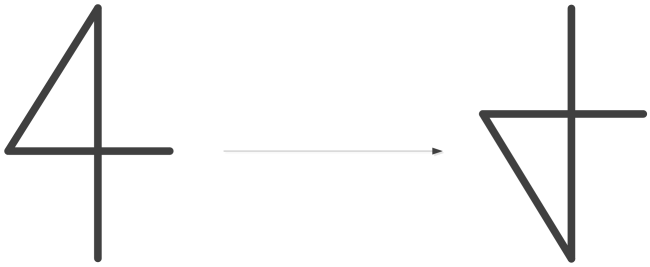


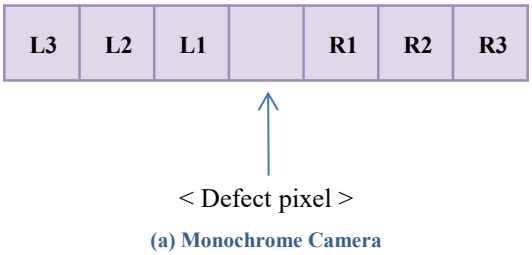
Fig.19 Flip in Y Direction

6.5 Defect Pixel Correction

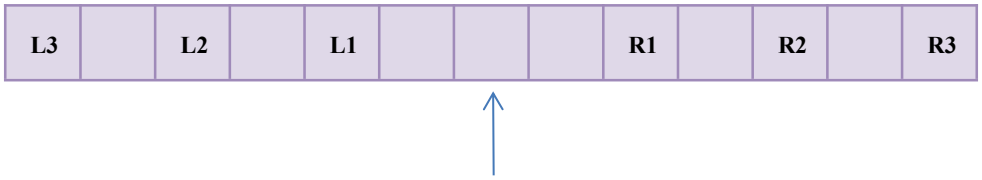
Due to the defects of material itself and issue with the process flow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response to input light, which we call defect pixels. TS65MCL camera provides with defect pixel automatic correction feature. The defect pixel information of imaging sensor is written into camera before it is delivered out of factory. Users can control whether to enable defect pixel correction, add new defect pixels and read out the current defect pixel list from camera.

The 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 cameras are different:

- Monochrome camera: The defect pixel values are replaced by adjacent pixel values.
- Color camera: The defect pixel values are replaced by separated pixel values.



(a) Monochrome Camera



(b) Color Camera

Fig.20 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 rules shown in the following table.

Table 10 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 white balance of industrial camera is not set properly, color reproduction will occur when the image is reproduced.

TS65MCL color camera provides white balance function, which balances the output value of each channel of sensor. Automatic white balance calculates white balance coefficient by sampling local pixels in sensor, then adjust each component of image according to coefficient to make the red, green and blue components of output image have the same value. Its function diagram is as follows:

(a) Before White Balance

(b) After White Balance

Fig.21 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. TS65MCL 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*64 pixel block data, combined with image algorithms to achieve real-time flat field correction algorithms. The fundamental is shown in the figure below:

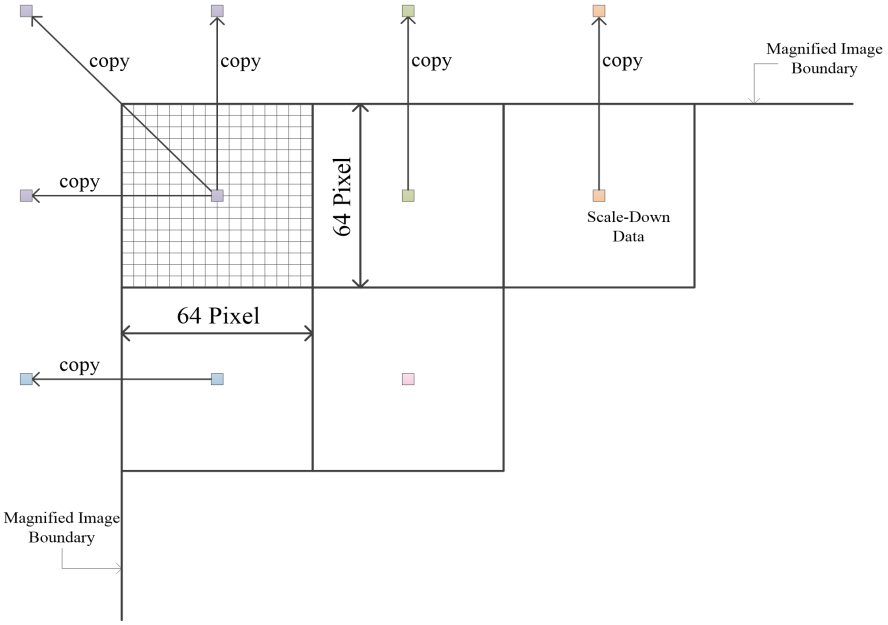


Fig.22 Flat Field Correction Schematic

6.8 Test Image

TS65MCL camera provides two 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 data link works normal.

- Test image 1: fixed image with horizontal gray gradient.
- Test image 2: rolling image with vertical gray gradient.

Fig.23 Test Image 1

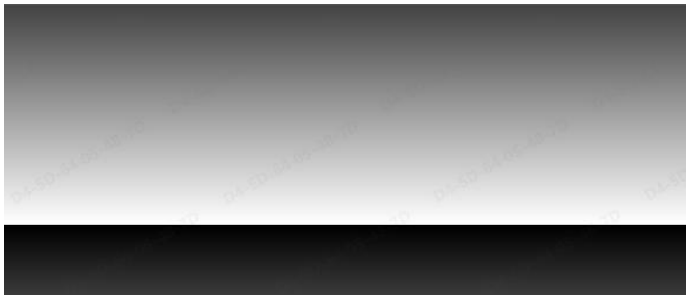


Fig.24 Test Image 2

6.9 Data Format

TS65MCL 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 bits of data, the lowest 2 bits will be deleted.

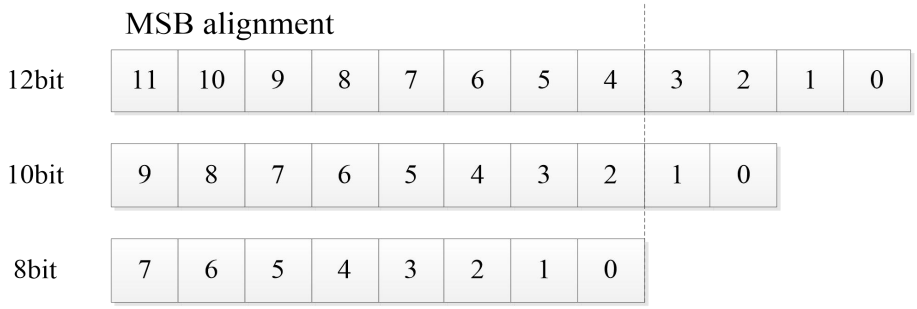


Fig.25 Data Format

6.10 Gain and Offset

Camera gain is divided into the analog gain and digital gain.

Analog gain acts on analog signal. By increasing analog gain, a stronger response can be generally obtained under weak illumination, thus realizing a higher signal-to-noise ratio.

Digital gain amplifies or reduces data after photoelectric conversion signal passes through AD. It is usually used to increase dynamic range of output image. Digital gain can also be used to adjust brightness of image. Digital offset is often used to adjust overall background brightness of image.

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

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

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

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

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

6.11 Camera Temperature

TS65MCL camera supports real-time temperature acquisition. Users can read temperature of the camera to monitor working status of the sensor.

The recommended operating temperature range of the camera is 0~65℃. If users detect an abnormal temperature (such as over 75℃), it is recommended to stop the camera immediately and contact our technical support.

6.12 Load / Save Configuration

TS65MCL camera supports three working parameter sets, including one factory default parameter set and two user parameter sets. Factory default parameter set can be used in most occasions. Users can also configure parameters based on actual requirements and save in user parameter set for self-loading after power on. The camera will automatically load the last saved parameter set each time.

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

7 Camera Configure

Hefei I-TEK Optoelectronics Co., LTD. has implemented a library IKapC.lib for camera configuration based on Gen< I >Cam standard, which allows users to use all Hefei I-TEK Optoelectronics Co., LTD. cameras based on IKapC.lib without re-writing codes for each camera. For more information about IKapC.lib, please refer to IKapC user manual.

Hefei I-TEK Optoelectronics Co., LTD. provides visual camera feature configuration tool IKapCViewer.exe. The following shows how to configure the supported camera features. For more information about IKapCViewer.exe, please refer to IKapCViewer user manual.

7.1 Device Control Category

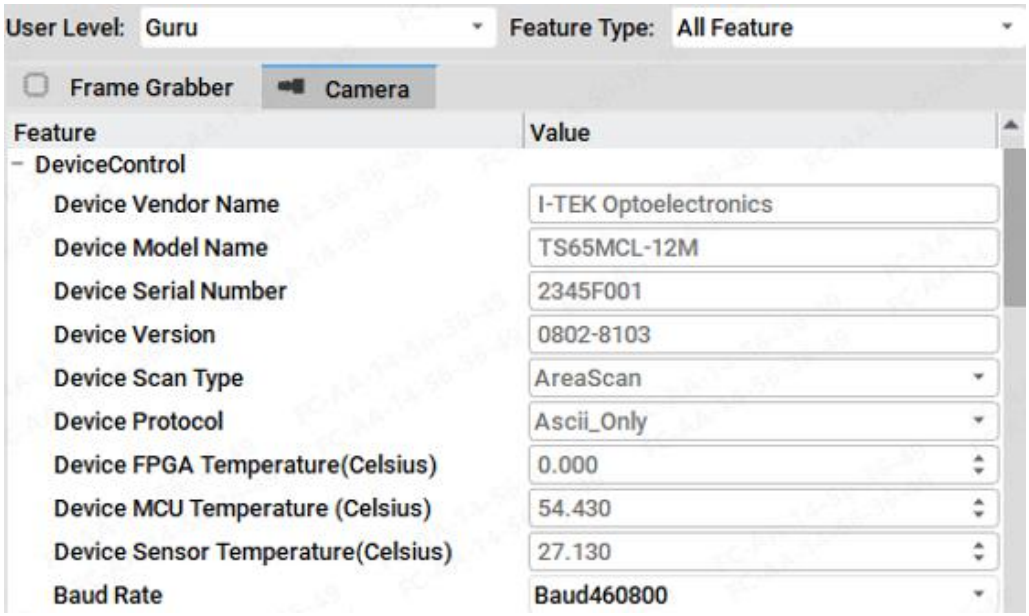


Fig.26 Device Control Category

- **DeviceVendorName**
  Device vendor name.

- **DeviceModelName**
  Device model name.

- **DeviceSerialNumber**
  Device serial number.

- **DeviceVersion**
  Device version.

- **DeviceScanType**
  Device scan type.

- **DeviceProtocol**
  Device protocol.

- **DeviceFPGATemperature**
  Device FPGA temperature.

- **DeviceMCUTemperature**
  Device MCU temperature.

- **DeviceSensorTemperature**
  Device sensor temperature.

- **DeviceSerialPortBaudRate**
  Device serial port rate. The enumeration names as follows:
  - Baud9600
  - Baud19200
  - Baud38400
  - Baud57600
  - Baud115200
  - Baud230400
  - Baud460800

7.2 Image Format Control Category

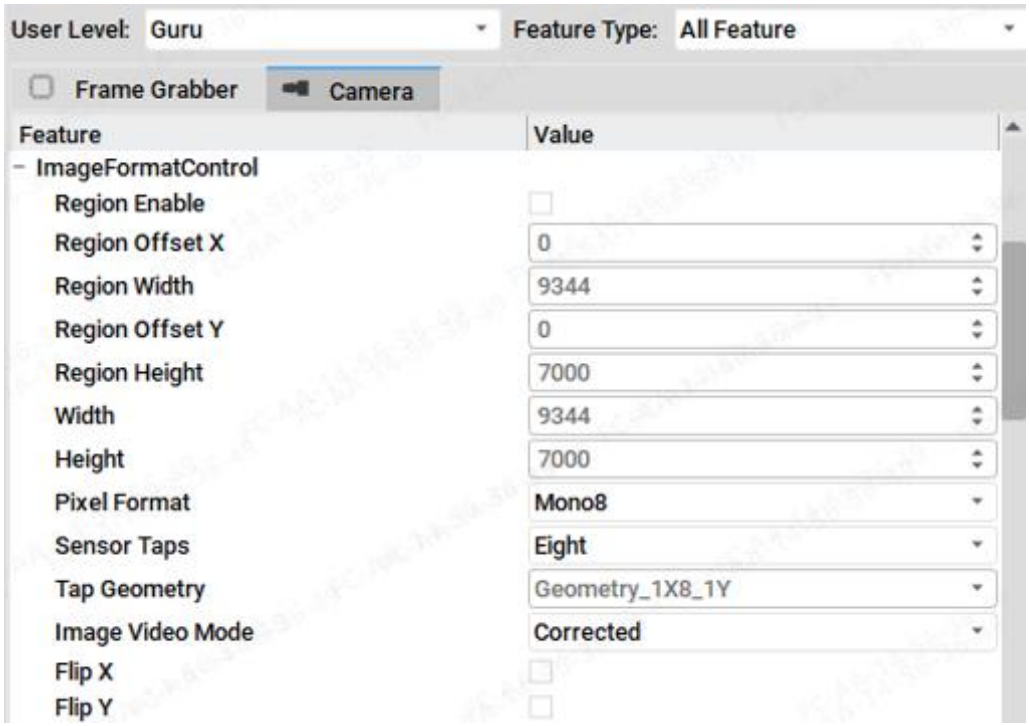


Fig.27 Image Format Control Category

- **RegionEnable**
  Enable region of interest.

- **RegionWidth**
  ROI width.

- **RegionOffsetX**
  ROI horizontal offset.

- **RegionHeight**
  ROI height.

- **RegionOffsetY**
  ROI vertical offset.

- **Width**
  Actual width of output image.

- **Height**
  Actual height of output image.

- **PixelFormat**
  Pixel format. The enumeration names as follows:
  - Mono8: Monochrome 8bit
  - Mono10: Monochrome 10bit
  - Mono12: Monochrome 12bit

- **SensorTaps**
  Number of sensor taps. The enumeration names as follows:
  - Four: 4Tap
  - Eight: 8Tap
  - Ten: 10Tap

- **DeviceTapGeometry**
  Tap arrangement.

- **VideoMode**
  Output image mode. The enumeration names as follows:
  - Original: Original image
  - Corrected: Corrected image
  - TestPattern1: Test image 1
  - TestPattern2: Test image 2

- **FlipX**

Horizontal flipping.

- **FlipY**
  Vertical flipping.

7.3 Acquisition Control Category

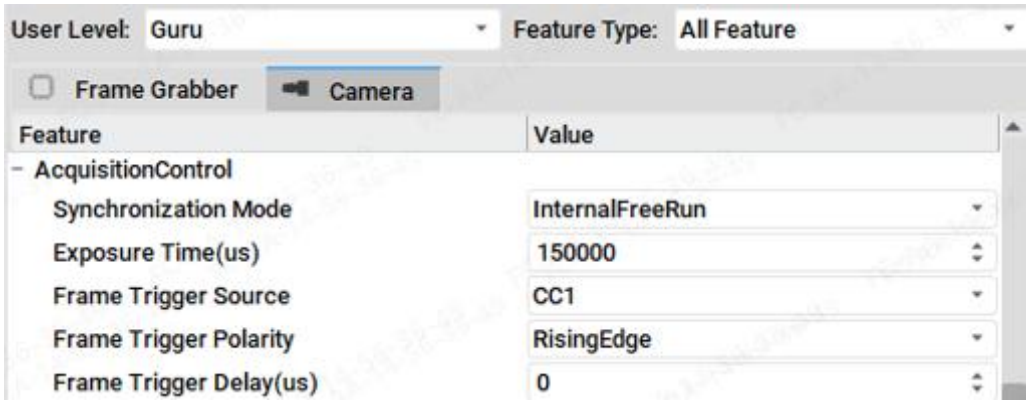


Fig.28 Acquisition Control Category

- **SynchronizationMode**
  Synchronization mode. The enumeration names as follows:
  - InternalFreeRun: Free-Run
  - ExternalPulse: External pulse
  - ExternalPWM: External PWM

- **ExposureTime**
  Exposure time, unit is us.

- **FrameTriggerSource**
  Frame trigger signal source. The enumeration names as follows:
  - CC1: Camera Link CC1 trigger
  - IO0: IO trigger

- **FrameTriggerPolarity**
  Frame trigger polarity. The enumeration names as follows:
  - RisingEdge: Trigger at rising edge
  - FallingEdge: Trigger at falling edge

- **FrameTriggerDelay**
  Frame trigger delay time.

7.4 Analog Control Category

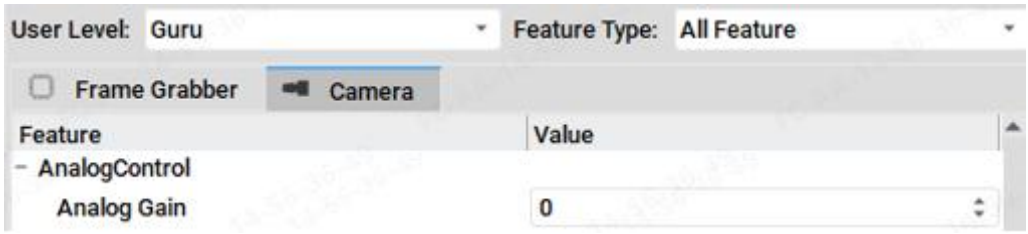


Fig.29 Analog Control Category

- **AnalogGain**
  Analog gain.

7.5 Digital Control Category

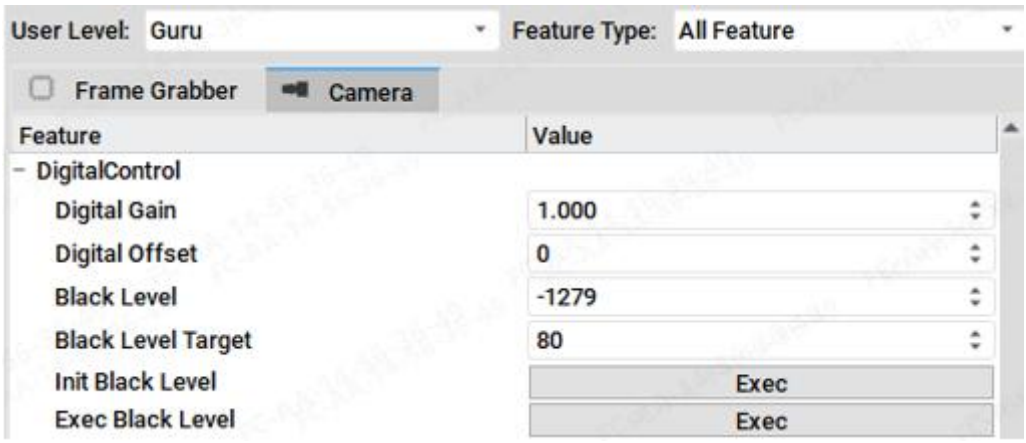


Fig.30 Digital Control Category

- **DigitalGain**
  Digital gain.

- **DigitalOffset**
  Digital offset.

- **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.

- **BlackLevelTarget**
  Black level target value.

- **BlackLevelInit**
  Initialize black level function.

- **BlackLevelExec**
  Execute black level function.

7.6 Lookup Table Category

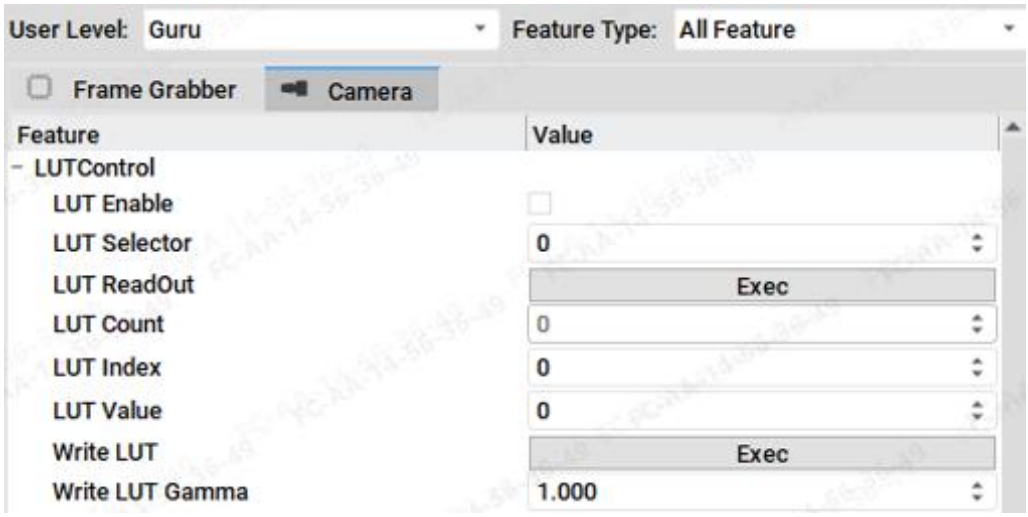


Fig.31 Lookup Table Category

- **LUTEnable**
  Enable LUT function.

- **LUTSelector**
  LUT selector.

- **LUTReadOut**
  Read LUT from camera.

- **LUTCount**
  The number of LUT.

- **LUTIndex**
  Lookup table data index, that is, the gray value of image before mapping lookup table.

- **LUTValue**
  Lookup table data value, that is, the gray value of image after mapping lookup table.

- **LUTWrite**
  Write LUT to camera.

- **LUTGamma**
  Gamma correction coefficient.

7.7 Defect Pixel Control Category

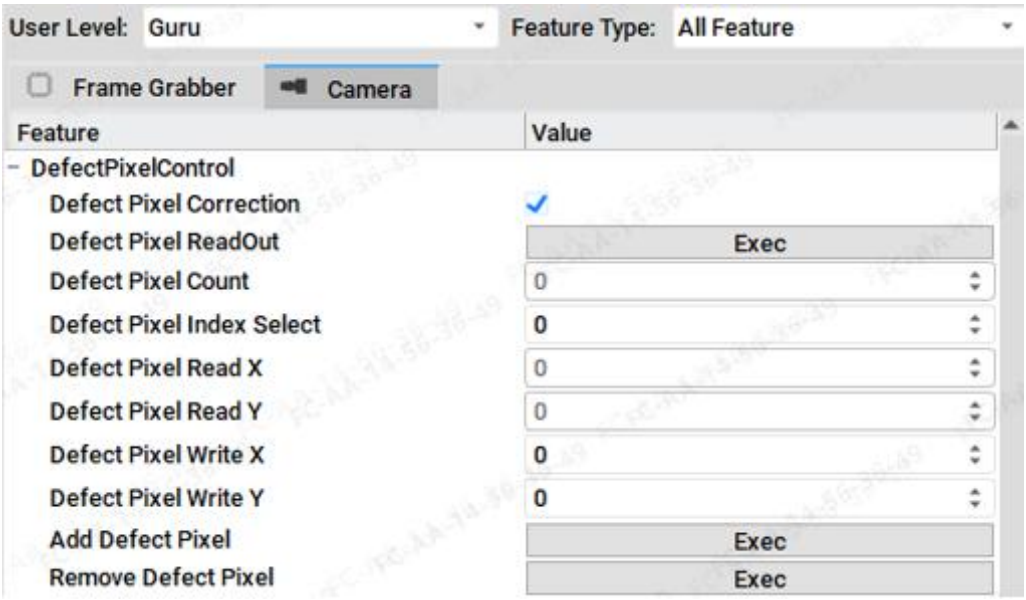


Fig.32 Defect Pixel Control Category

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

- **DefectPixelReadOut**
  Read defect pixels from camera.

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

- **DefectPixelSelect**
  Select defect pixel index.

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

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

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

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

- **DefectPixelAdd**
  Add defect pixel.

- **DefectPixelRemove**
  Remove current defect pixel.

7.8 Flat Field Correction Category

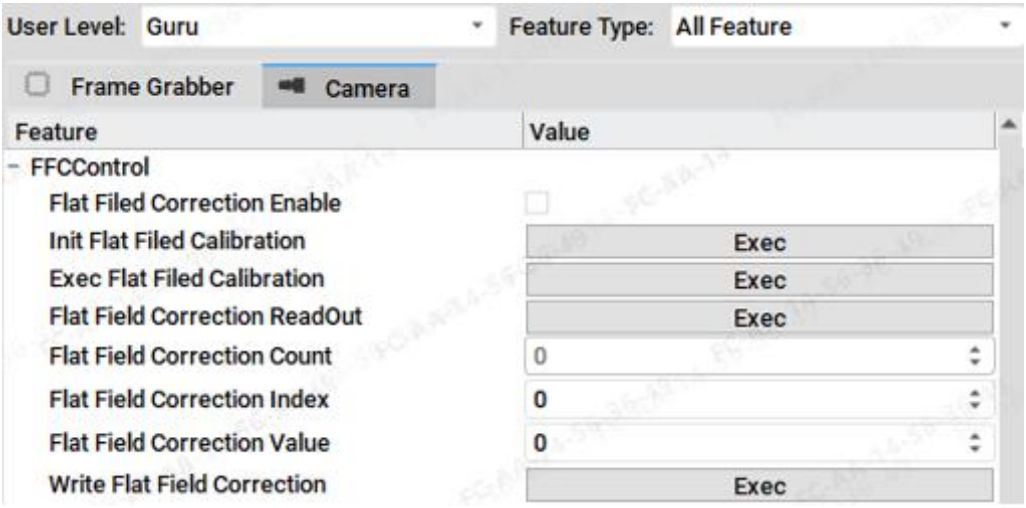


Fig.33 Flat Field Correction Category

- **FFCEnable**
  Enable flat field correction.

- **FFCInit**
  Initialize flat field correction.

- **FFCExec**
  Execute flat field correction.

- **FFCReadOut**
  Read flat field correction data from camera.

- **FFCCount**
  The number of flat field correction.

- **FFCIndex**
  Flat field correction index.

- **FFCValue**
  Flat field correction value.

- **FFCWrite**
  Write flat field correction data to camera.

7.9 User Configuration Category

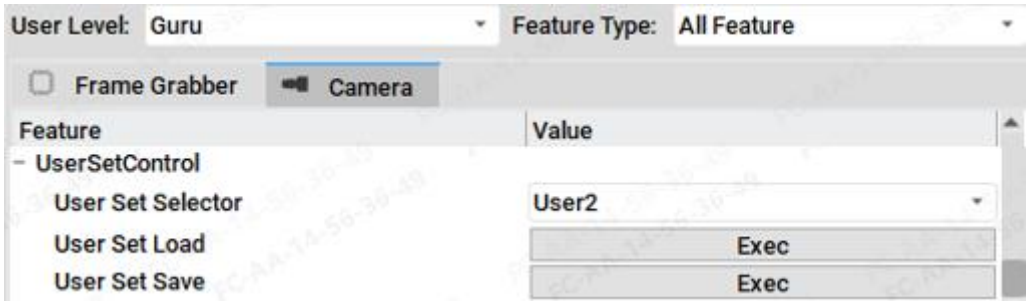


Fig.34 User Configuration Category

- **UserSetSelector**

  User configuration selector. The enumeration names as follows:

  - Factory: Factory configuration
  - User1: User configuration 1
  - User2: 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 Camera Link interface cable is OK

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

- **If Camera Link interface cannot receive camera clock signal,**

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

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

③ Ensure that the Camera Link interface cable is OK.

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

① Ensure that external input pulse is normal.

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

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

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

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

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

- **If images are dark,**

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

② Ensure that exposure time is set properly.

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

① Ensure that sensor glass is clean.

② Ensure that camera status indicator is normal.

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

① Check whether Camera Link interface is normal by the test image.

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

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

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