TTS120MCL-7M/C Area Scan Camera User Manual

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Hefei I-TEK Optoelectronics Co., LTD.

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

Revision History

Revision	Date	Description
0.1	2023/03/16	● Initial version

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, wipe it with lint-free cloth.

- **Power Supply**

① +12~24V (±10%) voltage and 4.0A current are recommended for the camera.
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.

2 Camera Models

Description of camera models:

The models of line scan camera and area scan camera are described as follows:

Cameras of various types:

Line scan camera

PA: Panther (Panther - Industrial line scan camera)

PL: Plasma (Plasma - Industrial line scan camera)

PH: Phoenix (Phoenix - Industrial line scan camera)

TPH: TEC-Phoenix (Thermal Electric Cooling - Phoenix - Industrial line scan camera)

PU: PupMaya (PupMaya - Industrial line scan camera)

PR: Prometheus (Prometheus - Industrial line scan camera)

Area scan camera

HS: Hercules (Hercules - CCD industrial area scan camera)

THS: TEC-Hercules (Thermal Electric Cooling - Hercules - CCD industrial area scan camera)

TS: Taurus (Taurus - CMOS industrial area scan camera)

TTS: TEC-Taurus (Thermal Electric Cooling - Taurus CMOS industrial area scan camera)

XS: XStream (XStream - Super high speed camera)

Interface specification:

GV: GigE Vision CL: Camera Link

CXP: CoaXPress U30: USB3.0

PCIe: PCI Express XGV: 10 GigE Vision

Color form:

M: Monochrome C: Color

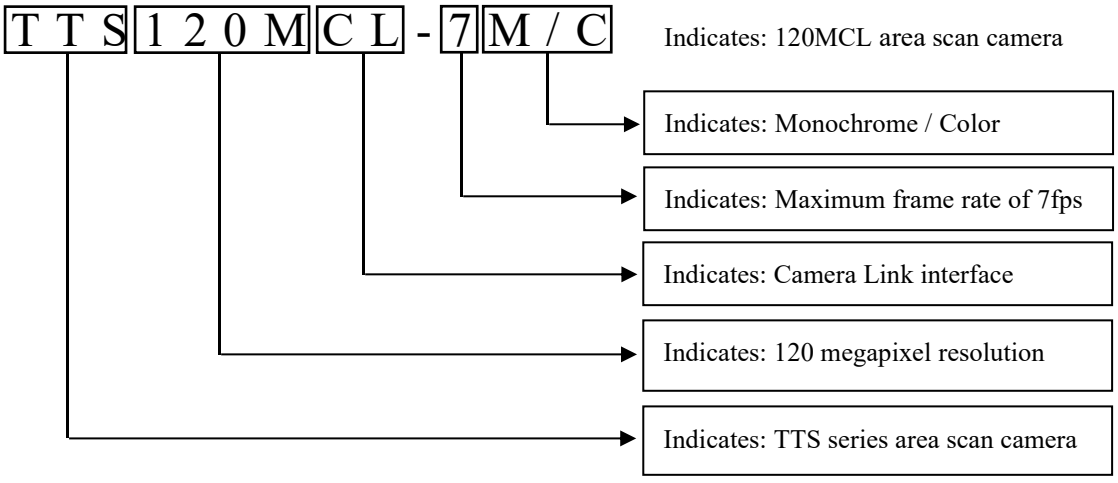
F: Full Color T: TDI (time delay integration)

Line rate or frame rate:

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 camera provides threaded holes on the front and the sides for fixing of the device.

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

4 Product Specifications

TTS120MCL camera is designed for high-speed line scan applications in industrial automation inspection and is developed and manufactured by Hefei I-TEK Optoelectronics Co., LTD.. The camera integrates international leading high-speed linear array image sensor, large-scale field programmable logic gate array parallel processor, and outputs data through Camera Link interface. It also has features of high speed, high sensitivity and low noise.

4.1 Main Features

- Rolling Shutter CMOS Sensor
- 120 Megapixel Resolution
- Maximum Frame Rate 7fps
- High Sensitivity and Low Noise
- Rich Exposure Control Modes (External Trigger, Free-Run)
- Minimum Exposure Time: 94μs Minimum Exposure Time Step: 16μs
- Data Format: 8/10bit
- ROI
- Flat Field Correction
- Defect Pixel Correction
- LUT
- White Balance
- Digital Gain / Analog Gain / Offset Control
- Real-time Temperature Monitoring
- Electric Cooling: about 18 Degrees below Environment Temperature

4.2 Camera Specifications

Table 1 TTS120MCL-7M/C camera Product Specifications

Model	TTS120MCL-7M/C
Product Description	120 mega-pixel industrial area scan camera
Resolution	13248 x 9176
Pixel Size	2.2μm x 2.2μm
Sensor Type	Rolling shutter CMOS
Image Type	Monochrome/Color
Sensor Size	35.45mm (diagonal)
Dynamic Range	≥ 61.0dB
SNR	37.0dB
Analog Gain	X1/X2/X4
Digital Gain	0~7.99
Digital Offset	-1023~1023
Lens Mount	M72 / F Mount
Max Frame Rate	6.92 fps@8bit, 5.54fps@10bit

Trigger Mode	External Trigger, Free-Run,
Trigger Signal	External IO/Camera Link CC1
Exposure Control	Timed, External PWM
Exposure Time	94μs ~10s (step: 16μs)
Data Format	8/10bit
Operation Temperature	0~55°C
Data Interface	Camera Link
Power Supply	DC 12~24V (±10%) 4.0A
Power Consumption	29.0W
Mechanical	90mm x 90mm x 88.3mm (without lens adapter)
Pixel Clock	40M/72M/80M/85MHz
Data Rate	840MB/s
Cooling Method	Thermal electric cooling with a fan
Cooling Performance	About 18°C below environmental temperature
Weight	908.8g

4.3 Camera Block Diagram

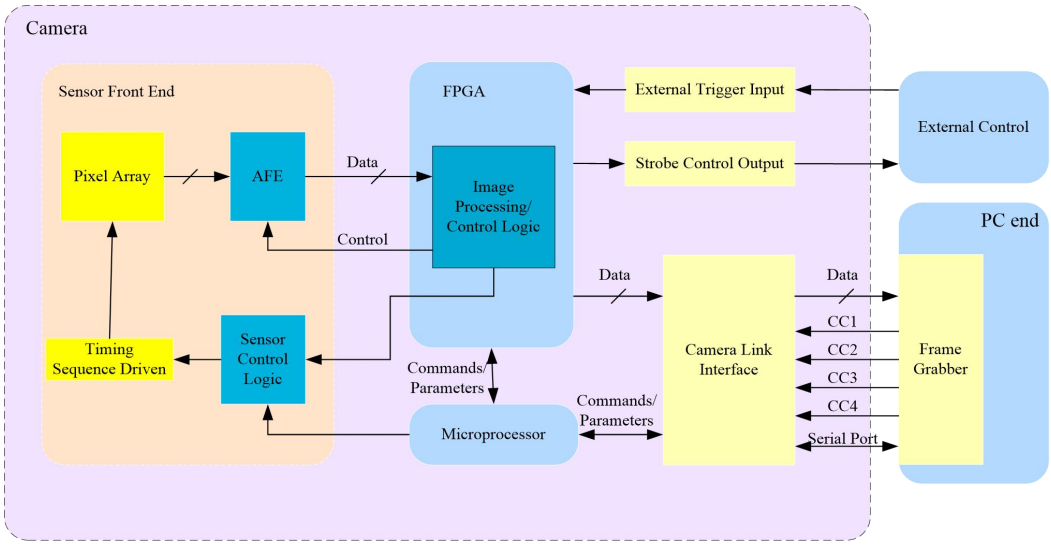
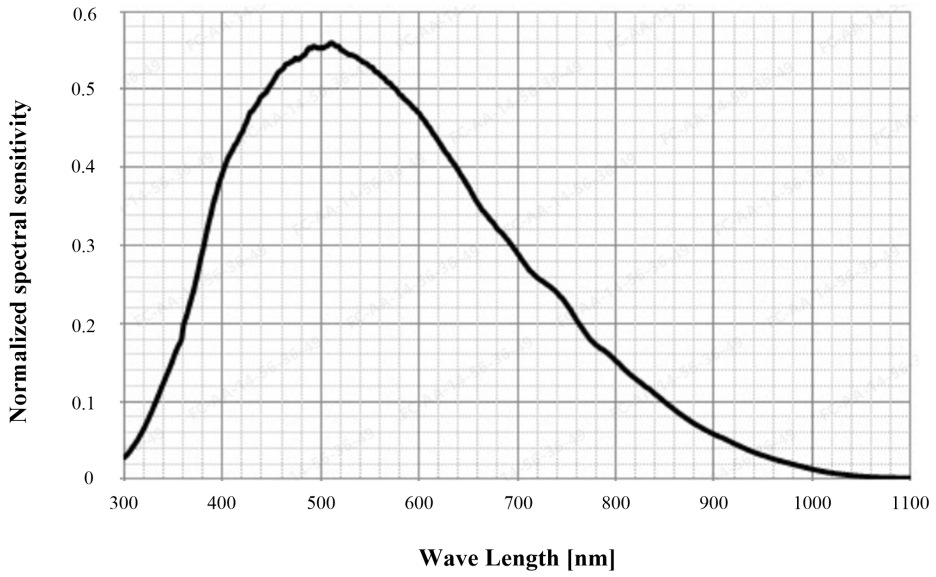


Fig. 2 Internal Implementation Structure of Camera

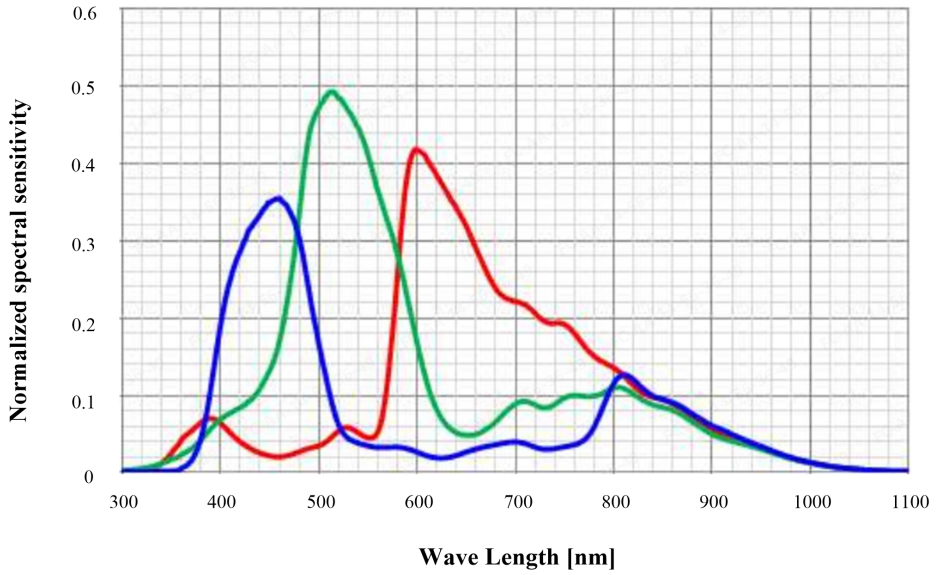
TTS120MCL camera is designed based on 120 megapixel area scan image sensor. The pixel array is sampled uniformly by the progressive scan control system, and the sampled data is converted from analog front-end to digital signal. The digital signal is processed by FPGA and microprocessor, and then transmitted to the frame grabber through Camera Link interface. The camera can receive external trigger signals for acquisition by CC1 channel of Camera Link interface or external IO signal.

4.4 Spectral Response

The following figure is the spectral response curve of TTS120MCL camera.



(a) Monochrome Camera



(b) Color Camera

Fig. 3 Spectral Response of Camera

4.5 Camera Bayer Pattern

TTS120MCL camera supports color mode, and Bayer pattern is shown in the figure below (HR is horizontal resolution and VR is vertical resolution):

Fig. 4 Camera Bayer Pattern

4.6 Environmental Requirements

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

(2) The sensor in the camera has 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.

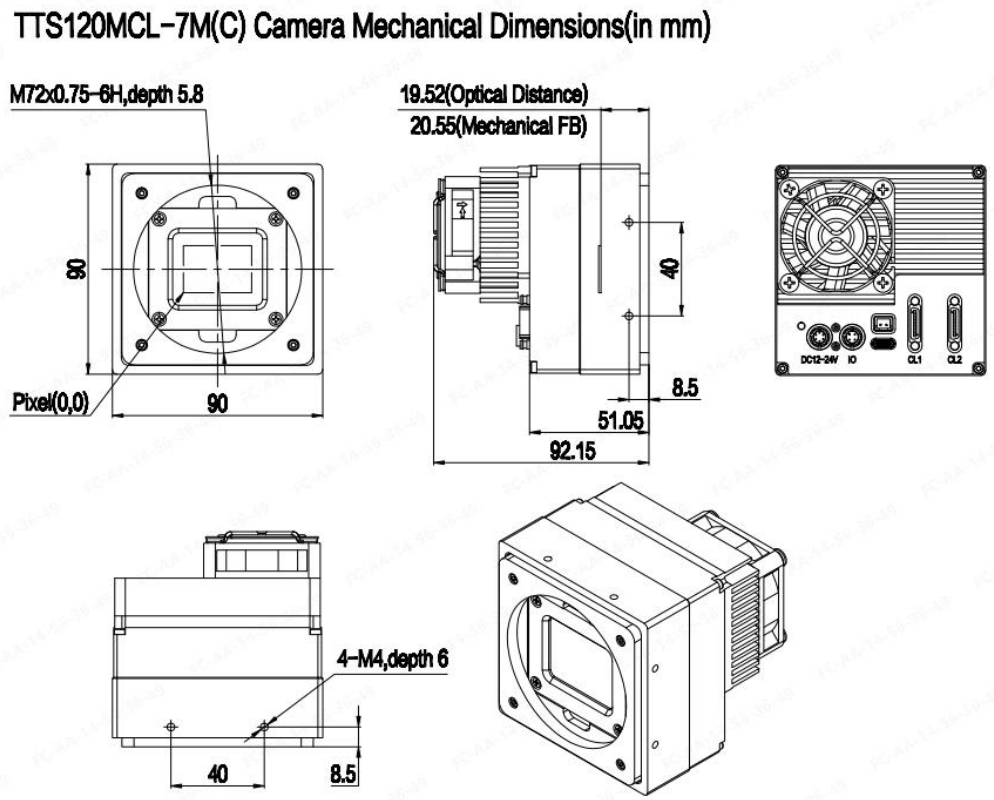
4.7 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

M72 mount:



F mount:

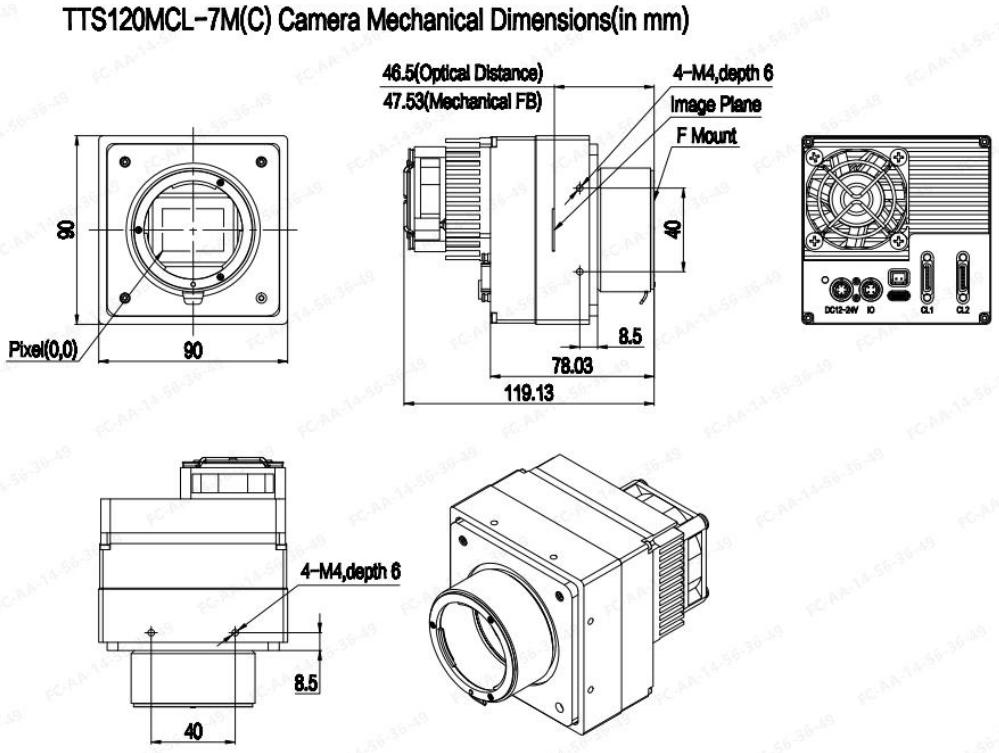


Fig. 5 Camera Mechanical Dimensions

5.2 Camera Interface

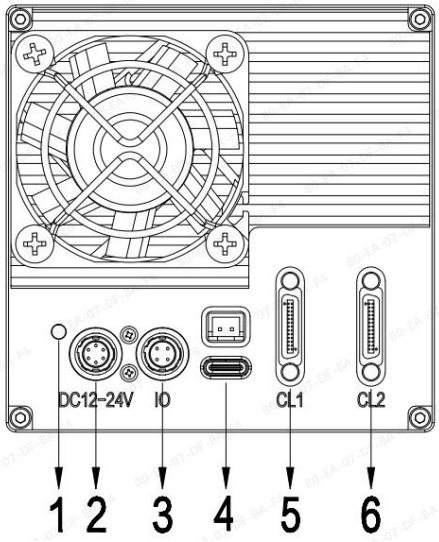


Fig. 6 External Interfaces of Camera

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

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 Interface

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

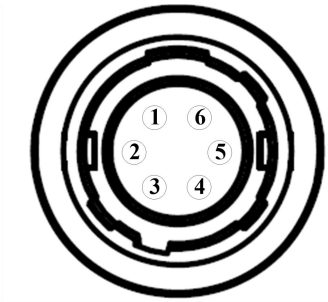


Fig. 7 Pin Assignments for Power Input Interface

Table 3 Pin Configurations for Power Input Interface

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

5.2.3 Camera Link Connector

TTS120MCL camera uses Mini Camera Link connector as its data interface. Mini Camera Link connector complies with the industry standard shown as follows:

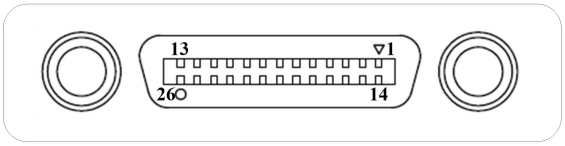


Fig. 8 Mini Camera Link Connector

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/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 output mode supported by TTS120MCL camera is 2tap@8/10bit, 4tap@8/10bit, 8tap@8/10bit; 10tap@8bit. Port Assignments in each output mode is shown in the table below:

Table 6 Port Assignments (2tap @ 8/10bit)

	8bit	10bit
	2tap/8bit	2tap/10bit
Port A0	A0	A0
Port A1	A1	A1
Port A2	A2	A2
Port A3	A3	A3
Port A4	A4	A4
Port A5	A5	A5
Port A6	A6	A6
Port A7	A7	A7
Port B0	B0	A8
Port B1	B1	A9
Port B2	B2	-
Port B3	B3	-
Port B4	B4	B8
Port B5	B5	B9
Port B6	B6	-
Port B7	B7	-
Port C0	-	B0
Port C1	-	B1
Port C2	-	B2
Port C3	-	B3
Port C4	-	B4
Port C5	-	B5
Port C6	-	B6
Port C7	-	B7

Table 7 Port Assignments (4tap @ 8/10bit)

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

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

Table 8 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 9 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

5.2.4 Control Interface

The control interface adopts a 4-pin interface with the model:
Hirose HR10A-7R-4PB (Male).

Corresponding connector on the cable model:
Hirose HR10A-7P-4S (Female).

The control I/O interface on the back of the camera is shown as follows:

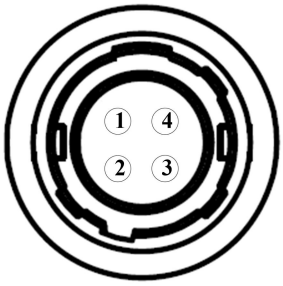


Fig. 9 Pin Assignments for Control I/O Interface

Table 10 Pin Configurations for Control I/O Interface

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

The following figure shows trigger signal input circuit of the 4 pin connector. Transmitted trigger signal is applied to the internal circuit through a photo coupler. The minimum trigger width that can be recognized by the camera is 1μs. If transmitted trigger signal is less than 1μs, the camera will ignore the trigger signal. The external trigger circuit example is shown below.

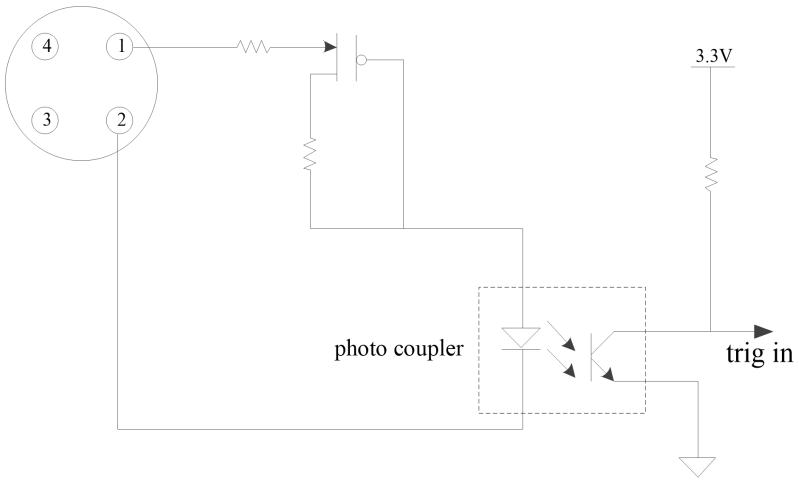


Fig. 10 Trigger Input Schematic

The strobe output signal comes out through a 3.3V output level of TTL Driver IC. A pulse width of signal is synchronized with an exposure (shutter) signal of the camera.

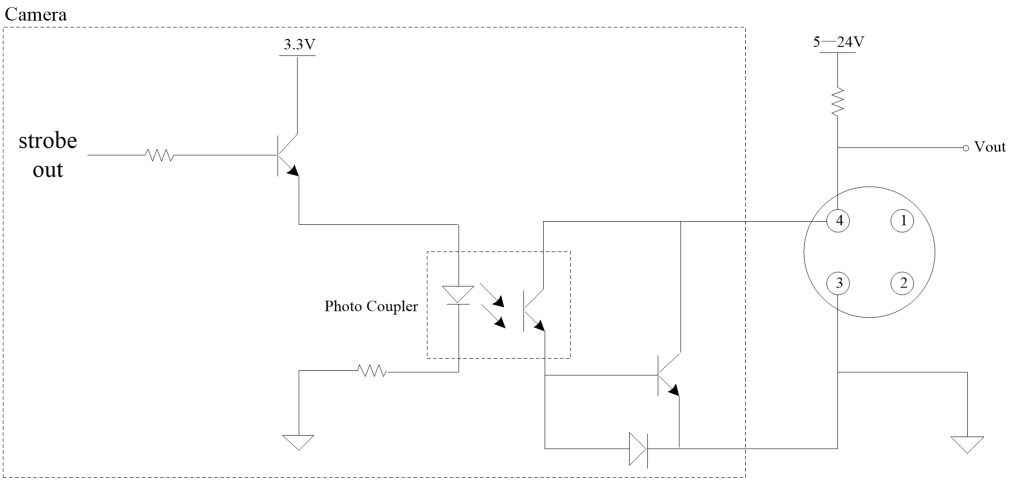


Fig. 11 Strobe Output Schematic

6 Camera Features

This chapter introduces the internal features of TTS120MCL camera in detail.

6.1 Trigger Mode

TTS120MCL camera 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 the relevant control sequence internally according to the frame period and exposure time parameters configured by users and outputs the image.

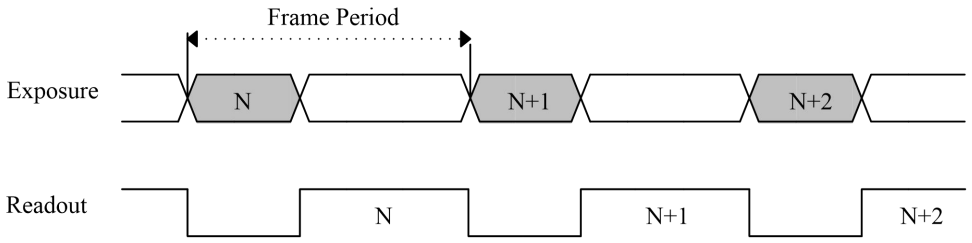


Fig. 12 Free-Run Mode

In order to achieve normal image output, TTS120MCL camera limits the range of frame period and exposure time. In Free-Run mode, the minimum frame period should be greater than both the exposure time and the readout time of a frame of data.

The frame period and exposure time commands are sent to camera through serial port of Camera Link, and the detailed instructions are in Section 7.

6.1.2 External Pulse Mode

In External Pulse mode, camera starts exposure at the rising edge of the external trigger signal, while the exposure time is set by user 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.

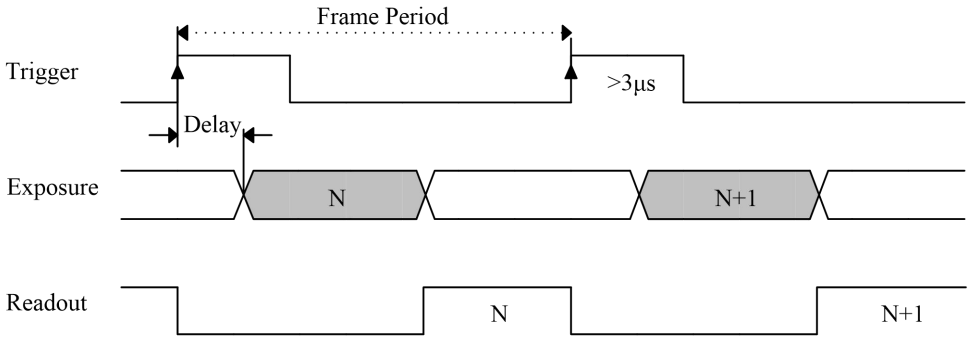


Fig. 13 External Pulse Mode

The external trigger signal can be CC1 signal of Camera Link or external pins from 4-pin 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 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.

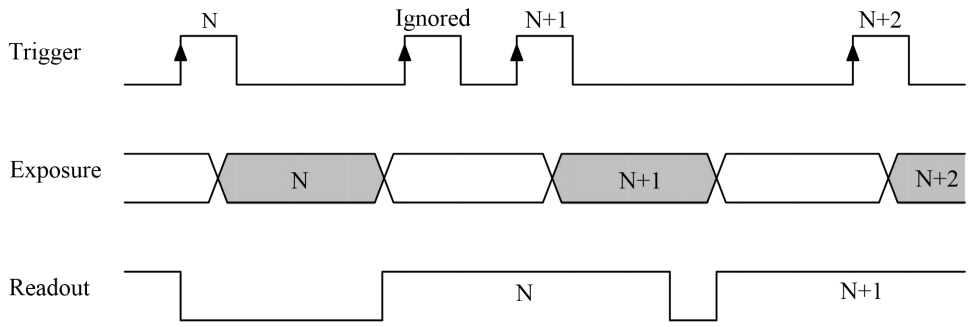


Fig. 14 Frame Period of External Trigger is Too Short

6.1.3 External PWM Mode

In External PWM mode, 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.

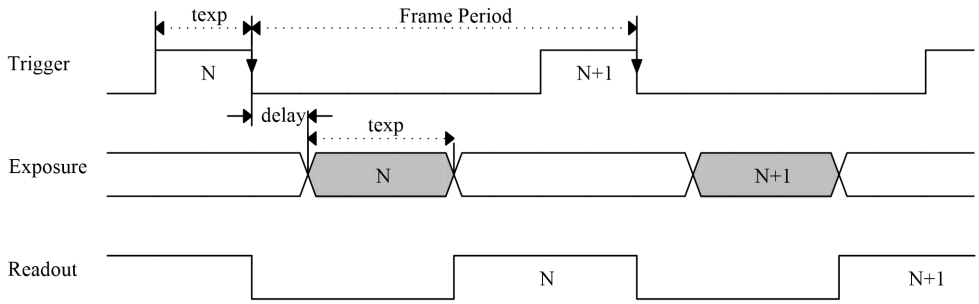


Fig. 15 High Level Trigger Mode

Please note that the external trigger signal should be wider than the minimum exposure time in this mode. In fact, the camera will always process to the minimum exposure time if the pulse width is less than the 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.

TTS120MCL camera provides rich timing sequence parameter control features for external trigger mode, including external trigger polarity, delay etc.

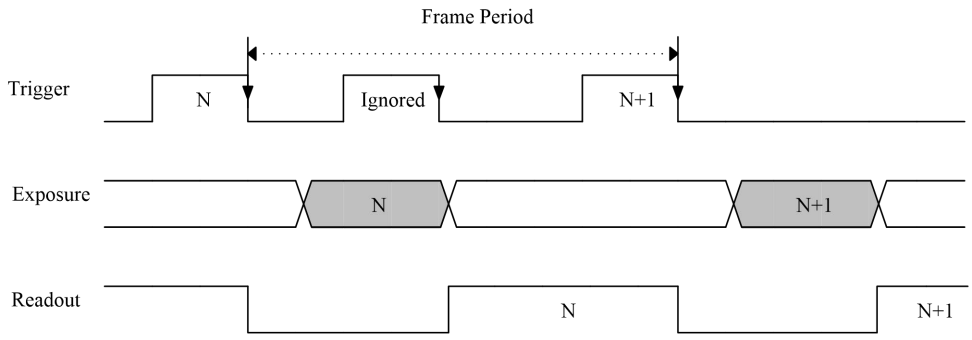


Fig. 16 Frame Period of External Trigger is Too Short

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.

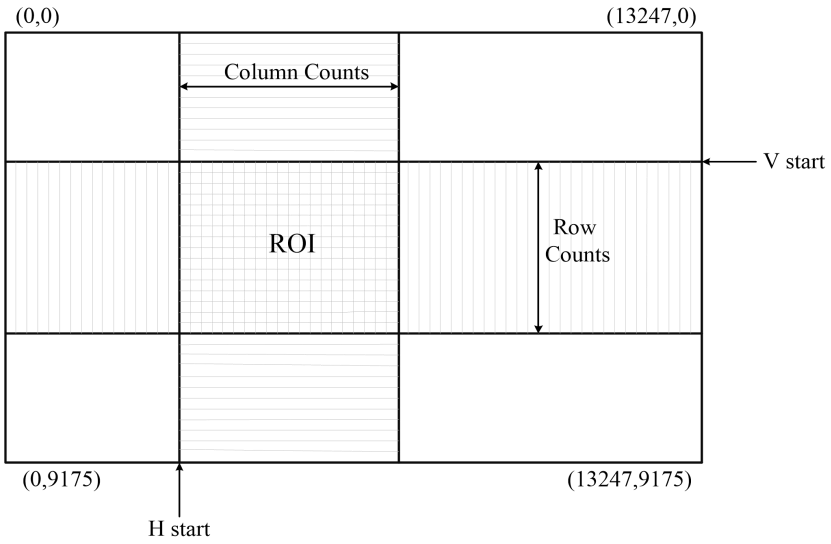


Fig. 17 Region of Interest

6.3 LUT

LUT uses a 10-bit input and 10-bit output look-up table to map and convert the values of the original image. Users can use this function to implement gamma correction. The camera has a factory-configured look-up table and also provides two user-configured look-up tables space.

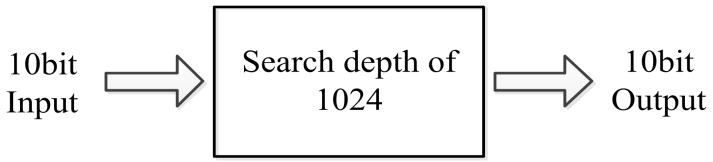


Fig. 18 LUT

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

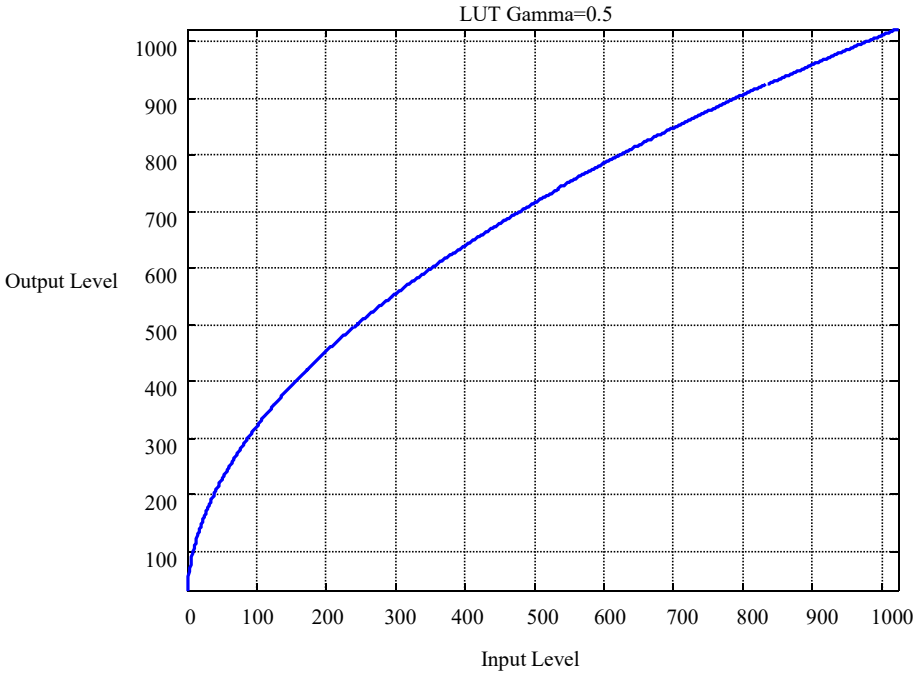


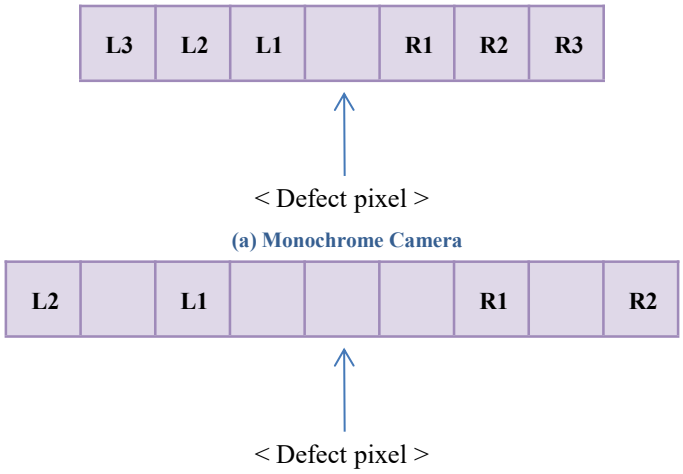
Fig. 19 LUT: Gamma = 0.5

6.4 Defect Pixel Correction

Due to the defects of 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. TTS120MCL 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 defective pixel values are replaced by adjacent pixel values.
- For color cameras, the defective pixel values are replaced by separated pixel values.



(a) Monochrome Camera

(b) Color Camera

Fig. 20 Defective Pixel Correction Methods for Different Cameras

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

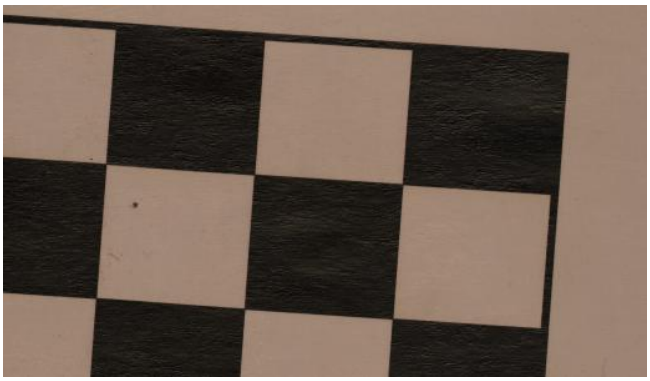
Table 11 Calculation Defect Pixel Correction Value

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

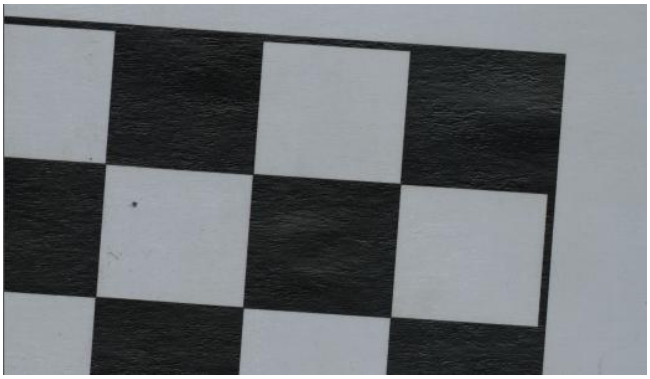
6.5 White Balance

White balance is an important parameter of color industrial camera, which directly affects the color effect of reconstructed image. When the white balance of industrial camera is not properly set, the reconstructed image will appear color deviation phenomenon.

TTS120MCL-7C camera internally provides a white balance function, which balances the output values of each channel of the sensor. Automatic white balance calculates the white balance coefficient by sampling the local pixels in the sensor, and then adjusts each component of the image according to the coefficient, so that the values of the red, green and blue components in the output image are consistent. The renderings are as follows:



(a) Before White Balance



(b) After White Balance

Fig. 21 White Balance

6.6 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. TTS120MCL 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:

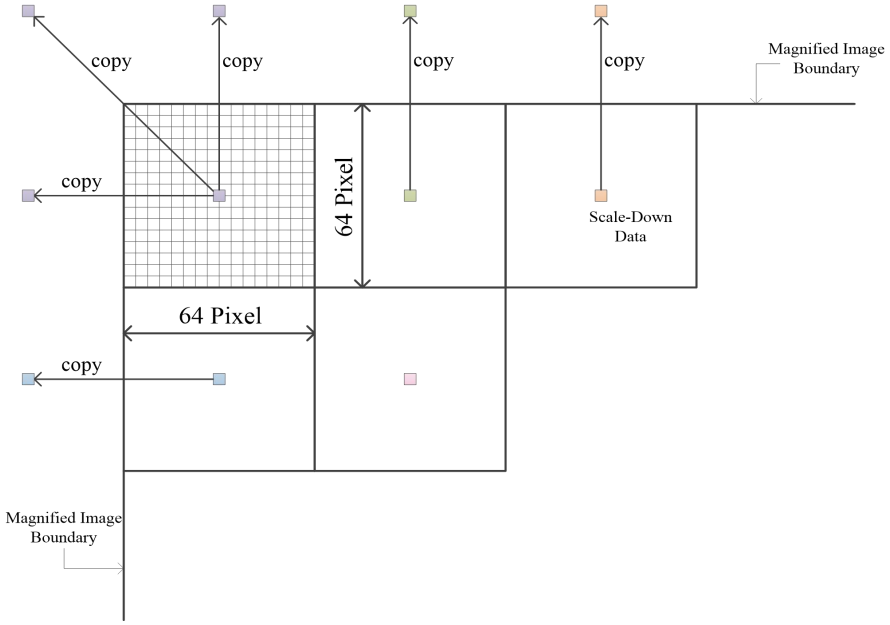


Fig. 22 Flat Field Correction Schematic

6.7 Test Image

The camera provides test image. Unlike images collected from sensors, test images are fixed style images that are pre-edited and stored inside the camera. The test image can be used to test whether the data link is open.

The camera provides the test image as shown below.

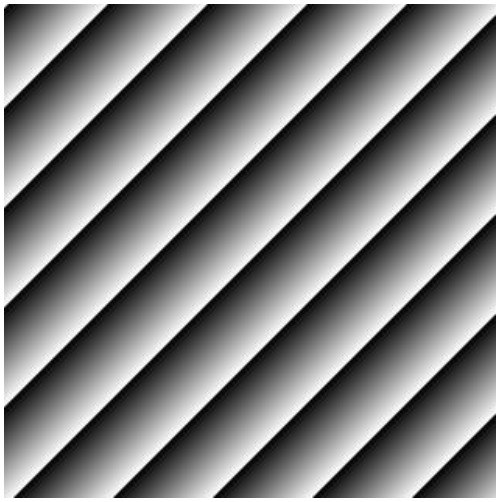


Fig. 23 Test Image 1

6.8 Strobe

The strobe signal is used to synchronize the external light source with the camera. As a Rolling Shutter type camera, TTS120MCL camera requires the camera or the target to stand still during exposure, otherwise smearing may happen. The strobe signal can be used as a basis to judge whether the exposure is over.

6.8.1 Strobe Signal Type

TTS120MCL camera provides two modes of strobe signal: Wide Strobe and Narrow Strobe.

- Wide Strobe: Strobe signal goes high when the exposure time for the top line of pixels begins and goes low when the exposure time for the bottom line of pixels ends.
- Narrow Strobe: Strobe signal goes high when the exposure time for the bottom line of pixels begins and goes low when the exposure time for the top line of pixels ends.

The narrow strobe mode is only valid when the exposure time is greater than the readout time. The following figure shows strobe output timing sequence for Wide Strobe mode / Narrow Strobe mode.

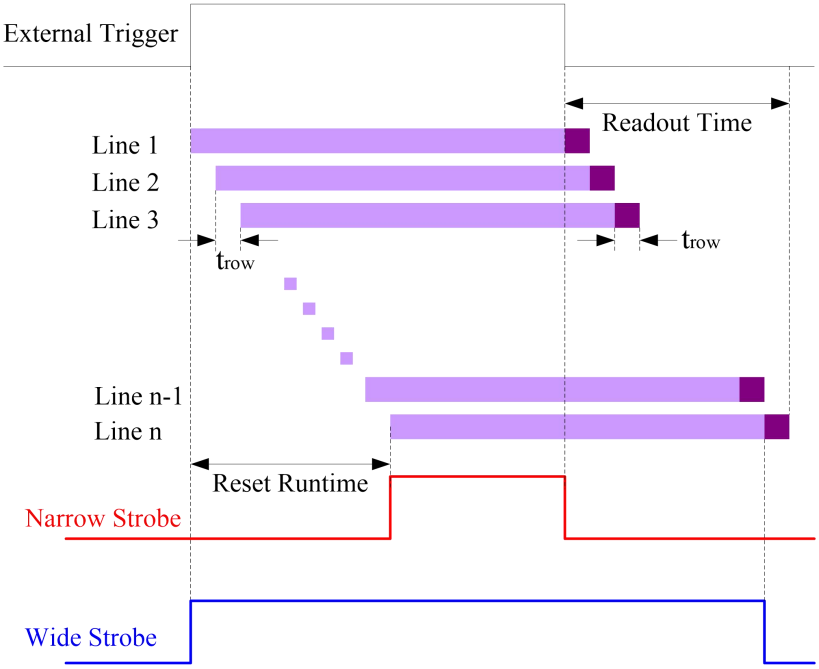


Fig. 24 Strobe Signal (Polarity：High)

6.8.2 Strobe Signal Polarity

TTS120MCL camera supports setting of the polarity of strobe output signal. Refer to the command list below for the setting command. Strobe polarity settings comprise high or low.

- High: Specifies that a falling edge of the strobe output signal will be valid.
- Low: Specifies that a rising edge of the strobe output signal will be valid.

6.9 Camera Link Output Mode

The camera data is output through the Camera Link interface and Medium, Full, Full+ modes are supported. Their Tap arrangements are shown as follows:

Base：

Medium：

Full：

Full+：

Fig. 25 Camera Link Output Mode

6.10 Data Format

TTS120MCL camera processes data in 10bit data format, but provides 8bit and 10bit output. When the camera outputs 8bit data, the lowest 2bit data will be deleted.

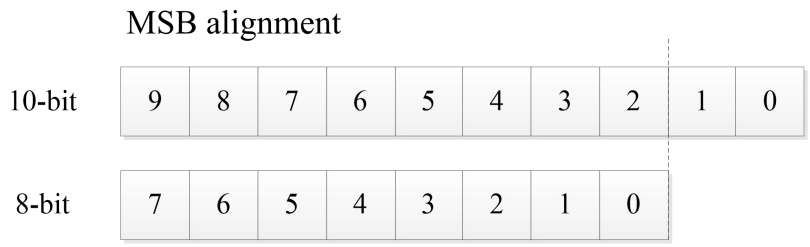


Fig. 26 Data Format

6.11 Gain & Offset

Camera gain is divided into analog gain and digital gain.

Analog gain acts on the analog signal, and usually a stronger response under weak light can be obtained by increasing analog gain, thus obtaining a higher SNR.

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

The influence of digital gain on output data can be summarized as follows:

Output value = Output value when digital gain is 1 and digital offset is 0 * digital gain parameter

The effect of digital bias on the output data can be summed up in the following formula (the part of the output value <0 will be output 0) :

Output value = Output value when digital offset is 0 + digital offset parameter

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

6.12 Camera Temperature

TTS120MCL camera supports real-time acquisition of camera temperature. Users can read the camera temperature value to monitor the current temperature value of the front-end sensor or make some responses according to the temperature value.

The operating environment temperature of the camera is recommended to be 0°C to 40°C, and the internal operating temperature is recommended to be 0°C to 55°C. If users detect abnormal internal temperature (such as over 60°C), it is recommended to stop the camera immediately to avoid damage caused by faults. Power off and contact our technical support in time.

6.13 Load / Save Configuration

TTS120MCL camera supports multi sets of working parameters, among which the factory parameter set is not allowed to be modified by users. The parameters have been optimized and can be used in most scenarios. In order to meet the difference of users' specific use environment, the camera also provides multi sets of users' working parameters, whose internal parameters can be modified and saved by users. The saved working parameter set will be automatically loaded after the next power-on.

If the camera does not work properly after users modify the saving parameters, they can restore the factory default parameter set and reconfigure the camera based on this parameter set.

7 Camera Configuration

TTS120MCL camera supports users to send command to the camera through the serial port channel of Camera Link interface, and configure the camera working mode and related parameters.

7.1 Communication Serial Port Parameters

Table 12 Communication Serial Port Parameters

Serial port parameters	Configuration parameter
Baud rate	9600
Data bit	8
Parity bit	None
Stop bit	1
Stream control	None

7.2 Command Format

The commands received by the camera end are divided into the following two types depending on whether the command carries data:

- **Pure command**

[CMD][CR]

- **Data configuration command**

[CMD]=[VAL][CR]

After receiving the command, the camera will return message in three formats:

- **Format 1**

After receiving the general command, the camera will execute the command and return >Ok

For example, input: load=0[CR]

Return: >Ok[CR]

- **Format 2**

After receiving the command to read the internal message, the camera will insert the corresponding message before >Ok

For example, input: list[CR]

Return: >[MEM][CR] >Ok[CR]

- **Format 3**

After receiving the command to read the internal message, the camera will insert the corresponding message before >Ok

For example, input: clnk[CR]

Return: [VAL][CR]>Ok[CR]

Note:

[CMD] command, 4byte

[VAL] data, no more than 4 decimal digits

[MEM] memory data

[CR] 0x0D, enter

If the input command is in wrong format, an error code will be returned in stead of Ok, as shown in the table below:

Table 13 Error Codes Returned upon Failure of Command Execution

Return Code	Description
Ok	Correct
0	Correct, equivalent to Ok
128	Command does not exist.
130	Conflict with other parameters.
131	Parameter value is out of range or does not meet requirements.
132	Command is not allowed to be executed in the current status.
133	Input command syntax error.

7.3 Command List

The list of serial commands supported by TTS120MCL camera camera is as follows. After connecting the camera through serial port, you can input relevant commands to configure the camera.

Table 14 List of Camera Commands

Command	Syntax	Description	
HELP	HELP	Show this information	
LIST	LIST	Show Current Configurations	
LOAD	LOAD= 0/1-8	Load Configuration From Flash 0/1-8: Factory/User1-User8	
SAVE	SAVE=1/2	Save Current Configuration To Flash 1/2: User1/User2	
TEMP	TEMP	Get Current Camera Temperature	
HMDT	HMDT	Get Current Camera Humidity	
ANGN	ANGN=0/1/2 (set command)	Set Camera Analog Gain (0/1/2: x1/x2/x4)	
	ANGN (get command)	0	x1
		1	x2
		2	x4
FSYN	FSYN=0/1/2 (set command)	Set Frame Sync Mode (0/1/2: Internal Free Run/External Pulse/External PWM)	
	FSYN (get command)	0	Internal Free Run
		1	External Pulse
		2	External PWM
CLNK	CLNK=2/4/8/10 (set command)	Set Camera Link tap mode (2/4/8/10)	
	CLNK (get command)	2	2tap
		4	4tap
		8	8tap

		10	10tap
PCLK	PCLK=0/1/2/3 (set command)	Set Camera Link Pixel Clock (0/1/2/3: 85/80/72/40 MHz)	
	PCLK (get command)	0	85MHz
		1	80MHz
		2	72MHz
		3	40MHz
FTSC	FTSC=0/1 (set command)	Set trigger source (0/1: IO/CC1)	
	FTSC (get command)	0	IO
		1	CC1
FTPR	FTPR=0/1 (set command)	Set trigger polarity (0/1: rising/falling edge)	
	FTPR (get command)	0	Rising edge
		1	Falling edge
FTDL	FTDL=[0,6000] (set command)	Set trigger delay (0-6000 us)	
	FTDL (get command)	Get current value	
FTDB	FTDB=[0,6000] (set command)	Set trigger debounce (0-6000 us)	
	FTDB (get command)	Get current value	
SOMD	SOMD=0/1 (set command)	Set flash strobe output mode (0/1: cover mode/overlap mode)	
	SOMD (get command)	0	Cover mode
		1	Overlap mode
SOPR	SOPR=0/1 (set command)	Set flash strobe output polarity (0/1: rising/falling edge)	
	SOPR (get command)	0	Rising edge
		1	Falling edge
TEXP	TEXP=[15,9000000] (set command)	Set Exposure Time in microsecond (15us to 9s)	
	TEXP (get command)	Get current value	
TPRD	TPRD=[144000,10000000] (set command)	Set Frame Period Time in microsecond (144ms to 10s)	
	TPRD (get command)	Get current value	
TSET	TSET=[-10,30] (set command)	Set cooling target temperature (-10 to 30)	
	TSET (get command)	Get current value	
ENVT	ENVT=0/1 (set command)	Turn on/off cooling	
	ENVT (get command)	Get current value	
DIGN	DIGN=[0,8] (set command)	Set digital gain (0 to 8)	
	DIGN (get command)	Get current value	
DIOS	DIOS=[-1023,1023] (set command)	Set digital offset (-1023 to 1023)	
	DIOS (get command)	Get current value	
DMOD	DMOD=0/1/2 (set command)	Set Data Mode (0/1/2: Original/Corrected/Test pattern)	

	DMOD (get command)	0	Original
		1	Corrected
		2	Test pattern
BITS	BITS=8/10 (set command)	Set pixel width (8/10)	
	BITS (get command)	8	8 bit
		10	10 bit
RICS	RICS=[0, 13248] (set command)	Set ROI start column number	
	RICS (get command)	Get current value	
RICC	RICC=[0, 13248] (set command)	Set ROI width	
	RICC (get command)	Get current value	
RIRS	RIRS=[0, 9176] (set command)	Set ROI start row number	
	RIRS (get command)	Get current value	
RIRC	RIRC=[0, 9176] (set command)	Set ROI height	
	RIRC (get command)	Get current value	
BPCR	BPCR=0/1 (set command)	Turn on/off bad pixel correction 0/1	
	BPCR (get command)	0	Disable
		1	Enable
BPLT	BPLT	List all bad pixels	
ADBP	ADBP=column,row	Add a bad pixel (adbp=column,row)	
RMBP	RMBP=column,row	Remove a bad pixel (rmbp=column,row)	
BPCL	BPCL	Clear bad pixel list	
BPSV	BPSV	Save bad pixel list to flash	
SLUT	SLUT=0/1 (set command)	Set Lookup Table Mode (0/1: Disable/Enable)	
	SLUT (get command)	0	Table 0
		1	Table 1
RLUT	RLUT	Read Lookup Table Data	
WLUT	WLUT=addr,data	Write Lookup Table Data (addr,data)	
FFCR	FFCR=0/1 (set command)	Turn on/off flat field correction	
	FFCR (get command)	0	Disable
		1	Enable
FFCL	FFCL=0/1	Flat field calibration (0/1: Init/Calibrate)	
ANOS	ANOS=[0, 1023] (set command)	Set Analog Offset (0 to 1023)	
	ANOS (get command)	Get current value	
In addition, the color camera has the following commands:			
WBPR	WBPR=[0,4096] (set command)	White balance red parameter (0~4096: gain*1024)	
	WBPR (get command)	Get current value	
WBPG	WBPG=[0,4096] (set command)	White balance green parameter (0~4096: gain*1024)	
	WBPG (get command)	Get current value	
WBPB	WBPB=[0,4096] (set command)	White balance blue parameter (0~4096: gain*1024)	
	WBPB (get command)	Get current value	
WBCL	WBCL=0/1	White balance calibration (0/1: Init/Calibrate)	

WBCR	WBCR=0/1 (set command)	Turn on/off white balance correction	
	WBCR (get command)	0	Disable
		1	Enable

8 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.

8.1 Device Control Category

Basic information, such as camera model, serial number and sensor temperature, is grouped into basic information category, and the application can determine the current camera model by obtaining these features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

Basic information of device will be different due to the difference of device model. Users can decide features displayed in main interface by selecting display level (Beginner, Expert, Guru).

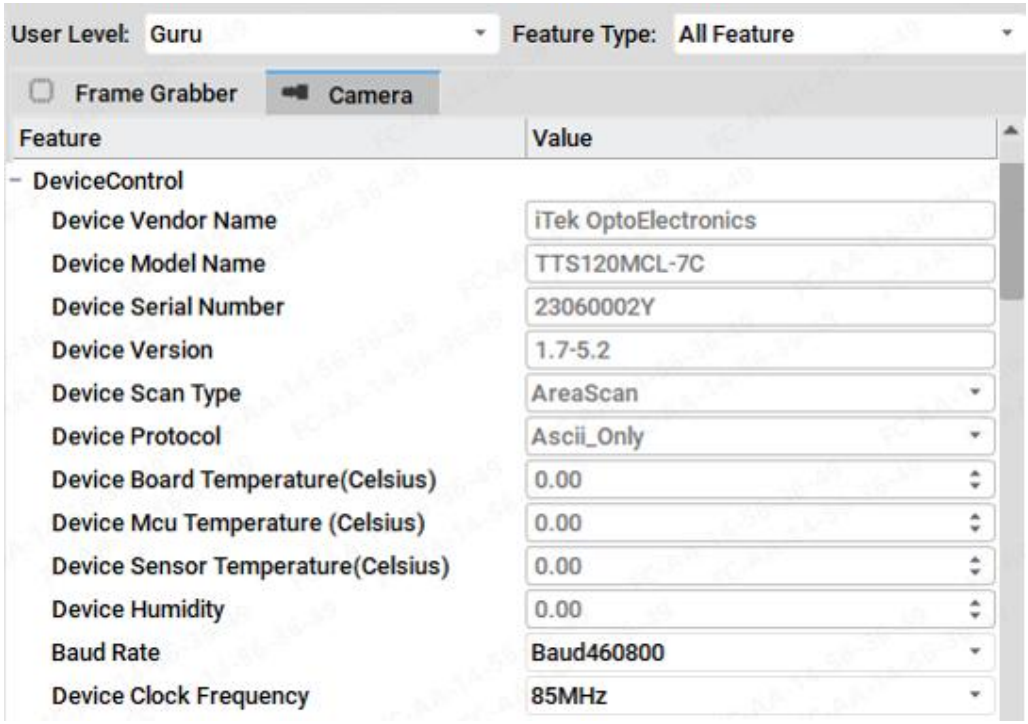


Fig. 27 Device Control Category

The following table describes types of features covered by camera device control category as well as the specific description and access attributes of features. Different camera versions may support different list of features.

Table 15 Device Control Category List

Feature Name	Feature Description	Camera Version & Visibility
DeviceVendorName	Vendor name (RO)	1.7-5.2 Beginner
DeviceModelName	Module name (RO)	1.7-5.2 Beginner
DeviceSerialNumber	Camera serial number (RO)	1.7-5.2 Beginner
DeviceVersion	Current camera version (RO)	1.7-5.2 Beginner
DeviceScanType	Camera scan type (RO)	1.7-5.2 Beginner
DeviceProtocol	Camera protocol (RO)	1.7-5.2 Beginner
DeviceManufacturerInfo	Camera manufacturer information (RO)	1.7-5.2 Beginner
DeviceBoardTemperature	Camera board temperature (RO)	1.7-5.2 Beginner
DeviceMCUTemperature	Camera MCU temperature (RO)	1.7-5.2 Beginner
DeviceSensorTemperature	Camera sensor temperature (RO)	1.7-5.2 Beginner
DeviceHumidity	Camera humidity (RO)	1.7-5.2 Beginner
DeviceSerialPortBaudRate **Baud9600** **Baud19200** **Baud57600** **Baud115200** **Baud230400** **Baud468000**	Camera baud rate Baud9600 Baud19200 Baud57600 Baud115200 Baud234000 Baud460800	1.7-5.2 Expert
DeviceClockFrequency **85MHz** **80MHz** **72MHz** **40MHz**	Camera pixel clock 85MHz 80MHz 72MHz 40MHz	1.7-5.2 Expert

8.2 Image Format Category

The type of image output by camera, such as width, height and pixel format are all attributed to image attribute category. Applications can change output image format by modifying these features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports image output in test mode. Users can select camera output mode from "Image Video Mode" drop-down box. "RegionWidth", "RegionHeight", "RegionOffsetX" and "RegionOffsetY" parameters of camera are used to configure ROI.

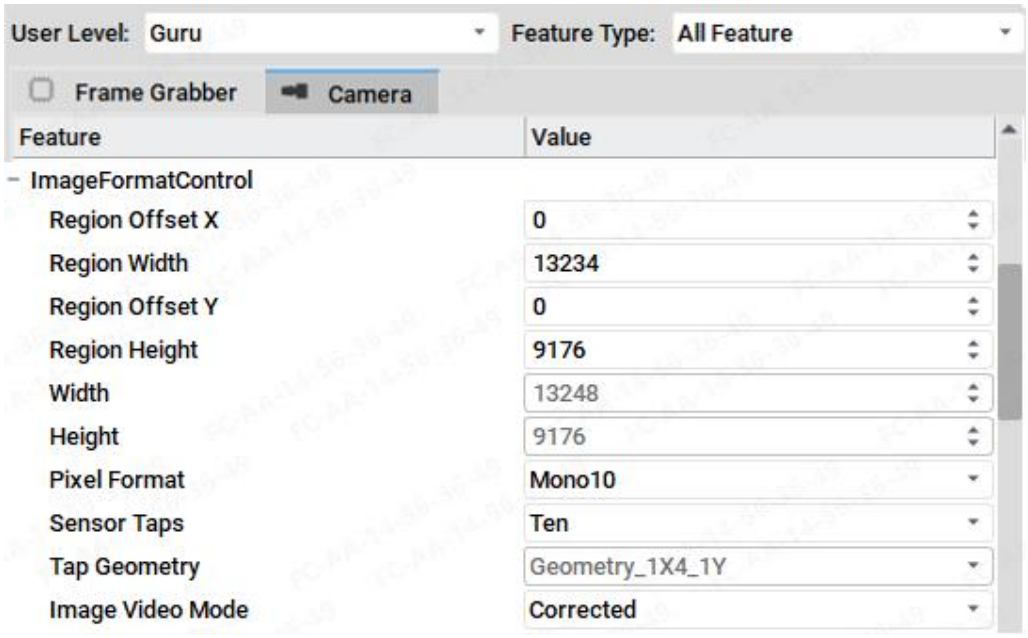


Fig.28 Image Format Category

The following table describes types of features covered by camera image format category and the specific description and access attributes of features. Different camera versions may support different list of features.

Table 16 Image Format Category List

Feature Name	Feature Description	Camera Version & Visibility
RegionOffsetX	Horizontal offset of ROI	1.7-5.2 Beginner
RegionWidth	ROI width	1.7-5.2 Beginner
RegionOffsetY	Vertical offset of ROI	1.7-5.2 Beginner
RegionHeight	ROI height	1.7-5.2 Beginner
Width	Actual width of camera (RO)	1.7-5.2 Beginner
Height	Actual height of camera (RO)	1.7-5.2 Beginner
PixelFormat **Mono8**	Pixel format Mono8	1.7-5.2 Beginner

Mono10	Mono10	
SensorTaps **2** **4** **8** **10**	Count of sensor taps 2Tap 4Tap 8Tap 10Tap	1.7-5.2 Beginner
DeviceTapGeometry	Tap arrangement method (RO)	1.7-5.2 Beginner
VideoMode **Original** **Corrected** **TestPattern**	Output image type Original Corrected TestPattern	1.7-5.2 Beginner

8.3 Acquisition Control Category

Parameters involved in camera image acquisition, such as frame rate, exposure time, external trigger input and other information are summed up in image acquisition category, and the application can change the mode of image acquisition by modifying these features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

The minimum exposure time of TTS120MCL camera is 94μs and the maximum of that is 10s. Users can set proper exposure time in “Exposure Time”.

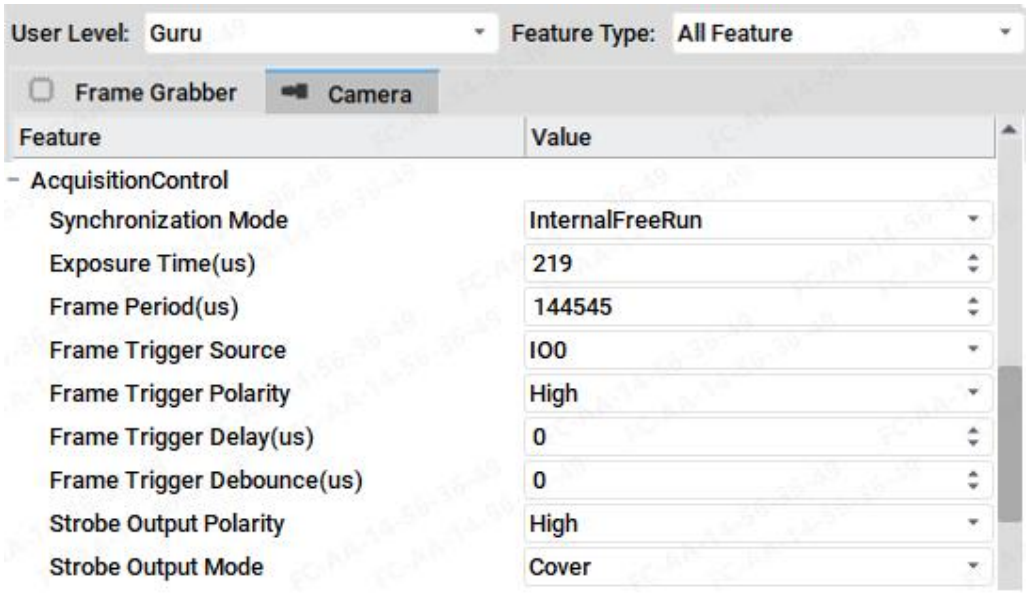


Fig.29 Acquisition Control Category

The following table describes the types of features covered by acquisition control category and the specific description and access attributes of features. Different camera versions may support different list of features.

Table 17 Acquisition Control Category List

Feature Name	Feature Description	Camera Version & Visibility
SynchronizationMode **InternalFreeRun** **ExternalPulse** **ExternalPWM**	Camera synchronization mode InternalFreeRun ExternalPulse ExternalWidth	1.7-5.2 Expert
ExposureTime	Exposure time	1.7-5.2 Beginner
FramePeriod	Frame period	1.7-5.2 Beginner
FrameTriggerSource **IO0** **CC1**	Frame trigger source IO0 CC1	1.7-5.2 Beginner
FrameTriggerPolarity **High** **Low**	Frame trigger polarity High Low	1.7-5.2 Beginner
FrameTriggerDelay	Frame trigger delay time	1.7-5.2 Beginner
FrameTriggerDebounce	Frame trigger debounce time	1.7-5.2 Beginner
StrobeOutputPolarity **High** **Low**	Strobe signal output polarity High Low	1.7-5.2 Beginner
StrobeOutputMode **Cover** **Overlap**	Strobe signal output mode Cover Overlap	1.7-5.2 Beginner

8.4 Analog Control Category

Analog gain acts on analog signal, and has a greater impact on SNR. Application can obtain better quality images by modifying these parameters. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports analog gain configuration. Generally speaking, the larger analog gain before AD is, the higher image SNR is. Users can set it in “AnalogGain”.

Note: The gain of TTS120MCL camera has been optimized for delivery. For non-professional users, it is not recommended to modify these parameters.

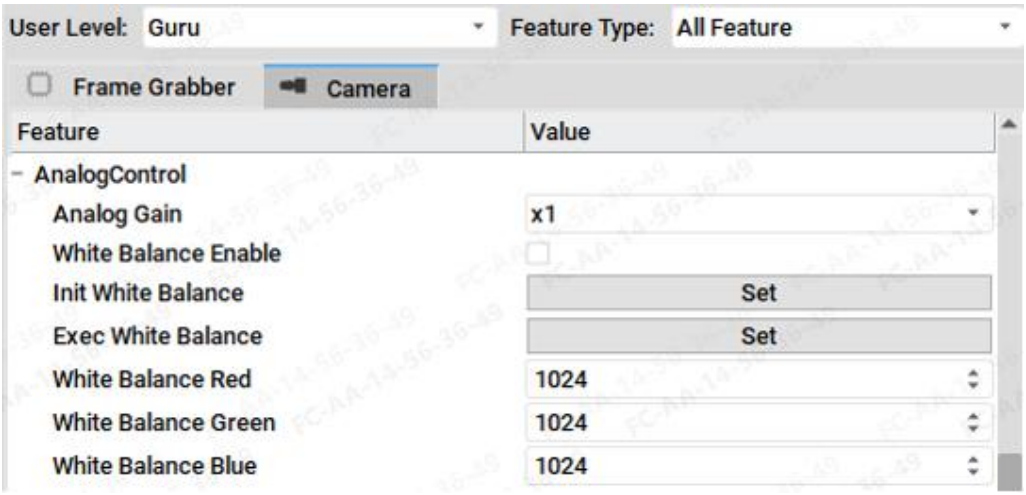


Fig.30 Analog Control Category

The following table describes the types of features covered by analog control category and the specific description and access attributes. Different camera versions may support different list of features.

Table 18 Analog Control Category List

Feature Name	Feature Description	Camera Version & Visibility
AnalogGain **x1** **x2** **x4**	Analog gain x1 x2 x4	1.7-5.2 Beginner
WhiteBalanceEnable	Enable white balance	1.7-5.2 Expert
WhiteBalanceInit	Initialize white balance	1.7-5.2 Expert
WhiteBalanceExec	Execute white balance	1.7-5.2 Expert
WhiteBalanceR	Set red channel of white balance	1.7-5.2 Expert
WhiteBalanceG	Set green channel of white balance	1.7-5.2 Expert
WhiteBalanceB	Set blue channel of white balance	1.7-5.2 Expert

8.5 Digital Control Category

Parameters involved in digital signal acquisition, such as digital gain and offset, are grouped into digital signal category, and application can modify these features to change digital signal output of the camera. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports adjusting digital gain “Digital Gain” and digital offset “Digital Offset” to change the quality of camera output image. See Section 6.11 for detailed description.

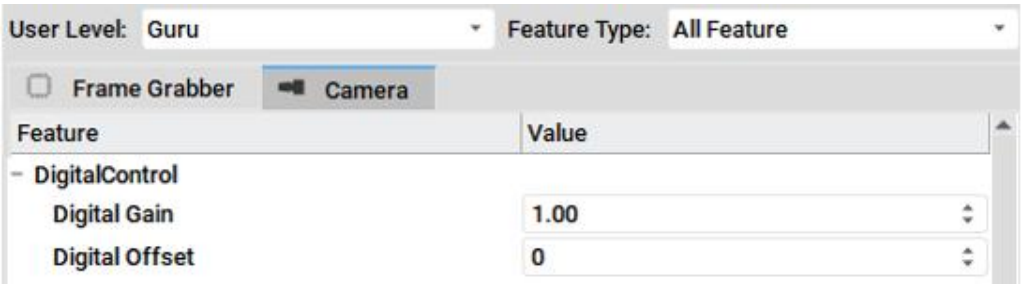


Fig.31 Digital Control Category

The following table describes the types of features covered by digital control category and the specific description and access attributes. Different camera versions may support different list of features.

Table 19 Digital Control Category List

Feature Name	Feature Description	Camera Version & Visibility
DigitalGain	Digital gain	1.7-5.2 Beginner
DigitalOffset	Digital offset	1.7-5.2 Beginner

8.6 Lookup Table Category

Camera lookup table algorithms, such as lookup table parameters, lookup table enable and so on are all grouped into this category. Applications can modify these features to enable or disable lookup table functionality. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports 10bit input-10bit output lookup table, which allows users to complete gamma correction. IKapCViewer allows users to enable lookup table function by checking “LUT Enable” check box and modify/access each value of lookup table through “LUT Index”. See Section 6.3 for detailed description.

Due to the large number of lookup table entries, users can also read/write lookup table data in batches in IKapCViewer.exe for convenience. For how to read and write lookup table in batches, please refer to IKapCViewer user manual.

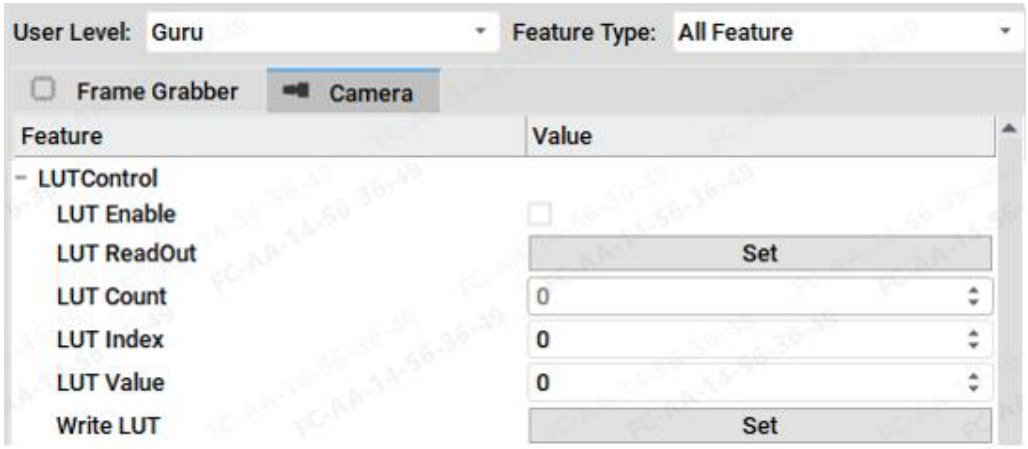


Fig.32 Lookup Table Category

The following table describes the types of features covered by lookup table category and the specific description and access attributes. Different camera versions may support different list of features.

Table 20 Lookup Table Category List

Feature Name	Feature Description	Camera Version & Visibility
LUTEnable	Enable lookup table algorithm	1.7-5.2 Expert
LUTReadOut	Read lookup table from camera (WO)	1.7-5.2 Guru
LUTCount	Lookup table count (RO)	1.7-5.2 Guru
LUTIndex	Lookup table index	1.7-5.2 Guru
LUTValue	Lookup table value	1.7-5.2 Guru
LUTWrite	Write lookup table to camera (WO)	1.7-5.2 Guru

8.7 Defect Pixel Correction Category

Parameters involved in camera defect pixel correction, such as defect pixel correction enable, are all classified into defect pixel correction category. Applications can modify these features to enable defect pixel correction features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports online update of defect pixel correction parameters. See Section 6.4 for more information on defect pixel correction. Defect pixel correction can replace defect pixels with horizontal nearest neighbor values, depending on the local defect distribution.

Up to 8192 defect pixel coordinates can be stored in non-volatile memory, and the camera supports at most 7 continuous defect pixels in horizontal direction.

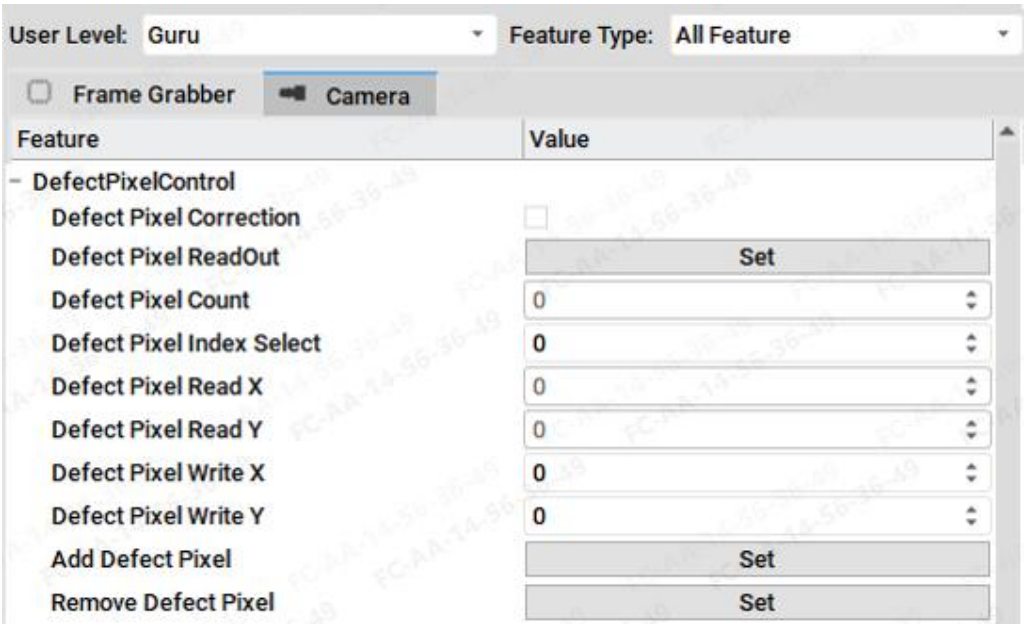


Fig.33 Defect Pixel Correction Category

The following table describes the types of features covered by defect pixel correction category and the specific description and access attributes of features. Different camera versions may support different list of features.

Table 21 Defect Pixel Correction List

Feature Name	Feature Description	Camera Version & Visibility
DefectPixelCorrectionEnable	Enable defect pixel correction	1.7-5.2 Expert
DefectPixelReadOut	Read defect pixels from camera (RO)	1.7-5.2 Guru
DefectPixelTotal	Total number of defect pixels	1.7-5.2 Guru
DefectPixelSelect	Select defect pixel	1.7-5.2 Guru
DefectPixelReadX	Read X coordinate of defect pixel (RO)	1.7-5.2 Guru
DefectPixelReadY	Read Y coordinate of defect pixel (RO)	1.7-5.2 Guru
DefectPixelWriteX	Write X coordinate of defect pixel	1.7-5.2 Guru
DefectPixelWriteY	Write Y coordinate of defect pixel	1.7-5.2 Guru

DefectPixelAdd	Add defect pixel (WO)	1.7-5.2 Guru
DefectPixelRemove	Remove defect pixel (WO)	1.7-5.2 Guru

8.8 Flat Field Correction Category

Parameters involved in camera flat field correction, such as flat field correction enable, are classified into flat field correction category. Applications can modify these features to enable flat field correction features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera supports online update of flat field correction parameters. Users can automatically perform flat field correction by clicking “Exec Flat Field Calibration” button. Refer to Section 6.6 for more information about flat field correction.

Note: The flat field correction must be completed under uniform illumination conditions.

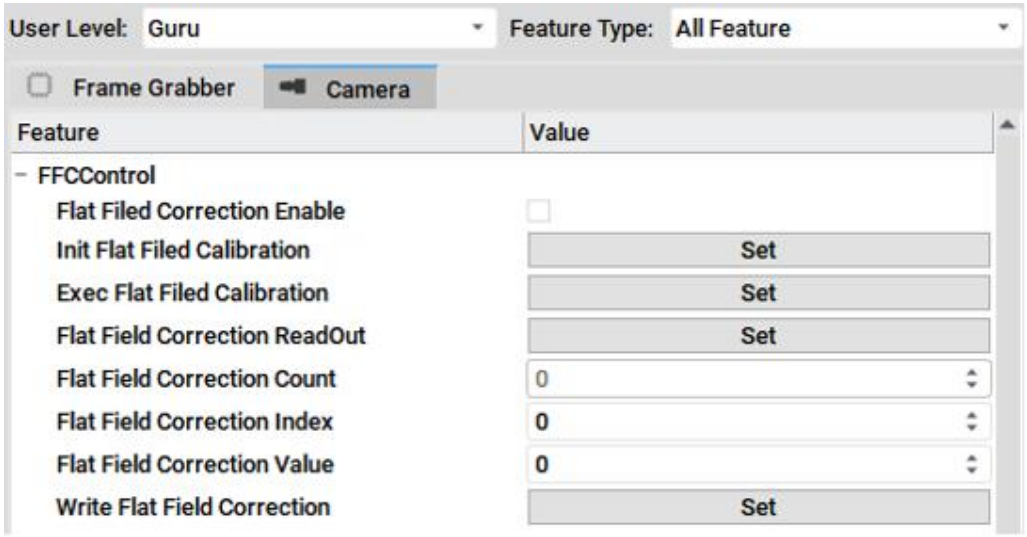


Fig.34 Flat Field Correction Category

The following table describes the types of features covered by flat field correction category and the specific description and access attributes. Different camera versions may support different list of features.

Table 22 Flat Field Correction Category List

Feature Name	Feature Description	Camera Version & Visibility
FFCEnable	Enable flat field correction	1.7-5.2 Expert
FFCInit	Initialize flat field correction (WO)	1.7-5.2 Expert

FFCExec	Execute flat field correction (WO)	1.7-5.2 Expert
FFCReadOut	Read flat field correction data from camera (WO)	1.7-5.2 Guru
FFCCount	Flat field correction count (RO)	1.7-5.2 Guru
FFCIndex	Flat field correction index	1.7-5.2 Guru
FFCValue	Flat field correction value	1.7-5.2 Guru
FFCWrite	Write flat field correction data to camera (WO)	1.7-5.2 Guru

8.9 Cooler Control Category

Parameters involved in camera TEC control, such as TEC enable and TEC target temperature settings, are all classified into TEC control category. Applications can modify these features to enable refrigeration control features. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

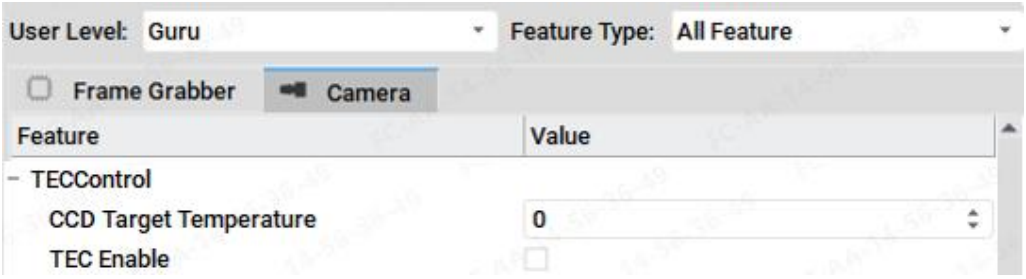


Fig.35 Cooler Control Category

The following table describes the types of features covered by cooler control category and the specific description and access attributes. Different camera versions may support different list of features.

Table 23 Cooler Control Category List

Feature Name	Feature Description	Camera Version & Visibility
CCDTargetTemperature	Set target temperature	1.7-5.2 Beginner
TECEnable	Electronic cooling enable	1.7-5.2 Expert

8.10 User Configuration Category

TTS120MCL camera supports saving/loading user configurations. It has a default factory configuration and two sets of user defined configurations. In the following figure, the gray font indicates that it is currently read-only, and the black font indicates that it can be modified by users.

TTS120MCL camera can save user configurations as follows:

- Select “User1” in “User Set Selector”.
- Click “User Set Save” button.

All current camera parameters are saved to User1 and enabled after the next power-on.

TTS120MCL camera can load user configurations as follows:

- Select “User1” in “User Set Selector”.
- Click “User Set Load” button.

AllUser1 parameters will be imported into the current camera.

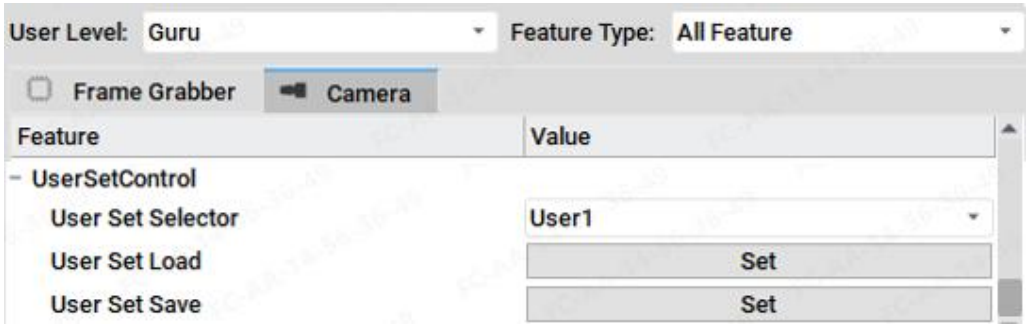


Fig.36 User Configuration Category

The following table describes the types of features covered by user configuration category and the specific descriptions and access attributes of the features. Different camera versions may support different list of features.

Table 24 User Configuration Category List

Feature Name	Feature Description	Camera Version & Visibility
UserSetSelector **Factory** **User1** **User2** **User3** **User4** **User5** **User6** **User7** **User8**	Select user configuration Factory User1 User2 User3 User4 User5 User6 User7 User8	1.7-5.2 Beginner
UserSetLoad	Load camera configuration (WO)	1.7-5.2 Beginner
UserSetSave	Save camera configuration (WO)	1.7-5.2 Beginner

9 FAQ

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

① Ensure that the Camera Link interface cable is OK.
② Ensure that Base and Medium configurations of the Camera Link interface are not reversed.
③ Ensure that the serial port channel parameters in the Camera Link interface are set correctly.

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

① Ensure that the camera has been turned on properly (i.e. 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 Base and Medium/Full configurations of Camera Link interface are not reversed.
④ Ensure that the Camera Link 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 trigger pulse correctly (it can be confirmed by status indicator display).
③ If Camera Link interface CC1 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 Camera Link interface is normal by the test image.
② Check whether the power supply is normal by the camera indicator status.
③ Check whether external pulse input is normal in 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.