TTS26MCL-31M/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	2022/07/12	● Initial version
0.2	2023/02/11	● Update company address

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 5.0A.
② Hefei I-TEK Optoelectronics Co., LTD. does not provide external power supply. Users need to connect power supply by themself.

- **Document**

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

2 Camera Models

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)

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

Color form:

M: Monochrome C: Color

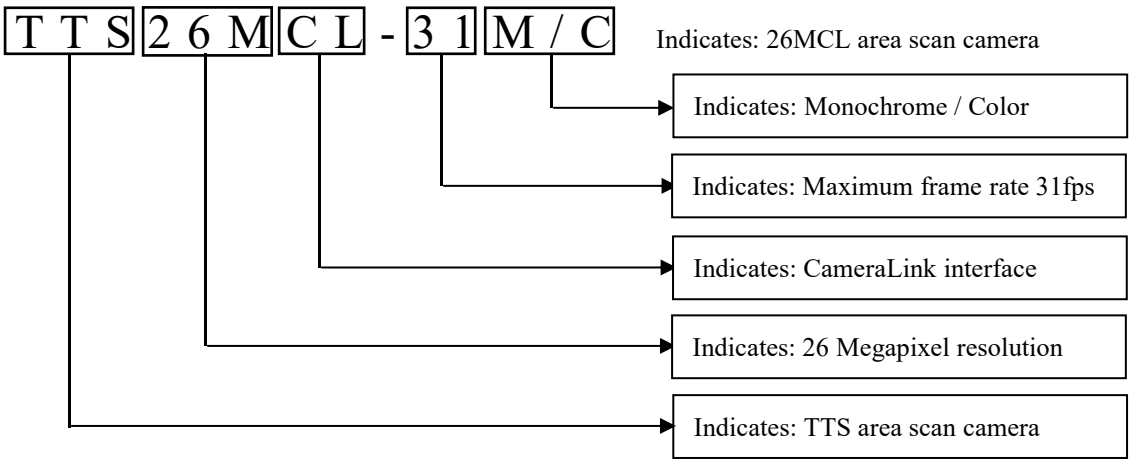
F: Full Color T: TDI (time delay integration)

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 front and the side of the camera provide threaded holes for mounting camera.

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

4 Product Specifications

TTS26MCL camera adopts advanced rolling 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

- Rolling Shutter CMOS Sensor
- 26 Megapixel Resolution
- Full Frame Rate up to 31fps
- High Sensitivity and Low Noise
- Region of Interest
- Rich Exposure Control Modes
- Output Pixel Format: 8/10/12bit
- Defect Pixel Correction
- Flat Field Correction
- Analog Gain / Digital Gain / Offset Control
- Auto White Balance
- Temperature Monitor
- Thermal Electric Cooling: about 20 Degrees below Environment Temperature

4.2 Camera Specifications

Table 1 TTS26MCL-31M/C Product Specifications

Model	TTS26MCL-31M/C
Product description	26 mega-pixel industrial area scan camera
Resolution	6240 x 4168
Pixel Size	3.76μm × 3.76μm
Sensor Type	Rolling shutter CMOS
Image Type	Monochrome / Color
Sensor Size	28.21mm (diagonal)
Dynamic Range	≥76dB
SNR	46dB
Lens Mount	C Mount
Max Frame Rate	31fps@10Tap, 24fps@8Tap, 12fps@4Tap
Trigger Mode	Free-Run, External Trigger
External Trigger	2.5 V~12 V logic level input, optically isolated
External Trigger Channel	External IO / Camera Link CC1 input
Strobe Output	3.3V logic level output, optically isolated
Exposure Control	Timed, External PWM
Exposure Time	4Tap: 39μs ~ 300s (step: 39μs)

	8Tap: 39μs ~ 300s (step: 20μs) 10Tap: 46μs ~ 300s (step: 15μs)
Data Format	8/10/12bit
Operating Temperature	0~65°C
Data Interface	Camera Link
Power Supply	DC12V±10%　5.0A
Power Consumption	TEC on: 40.0W TEC off: 13.0W
Mechanical	111mm x 111mm x 103mm
Data Rate	850MB/s
Pixel Clock	85MHz
Cooling Method	Thermal electric cooling with a fan
Cooling Performance	About 20°C below ambient temperature
Weight	1480.1g

4.3 Camera Block Diagram

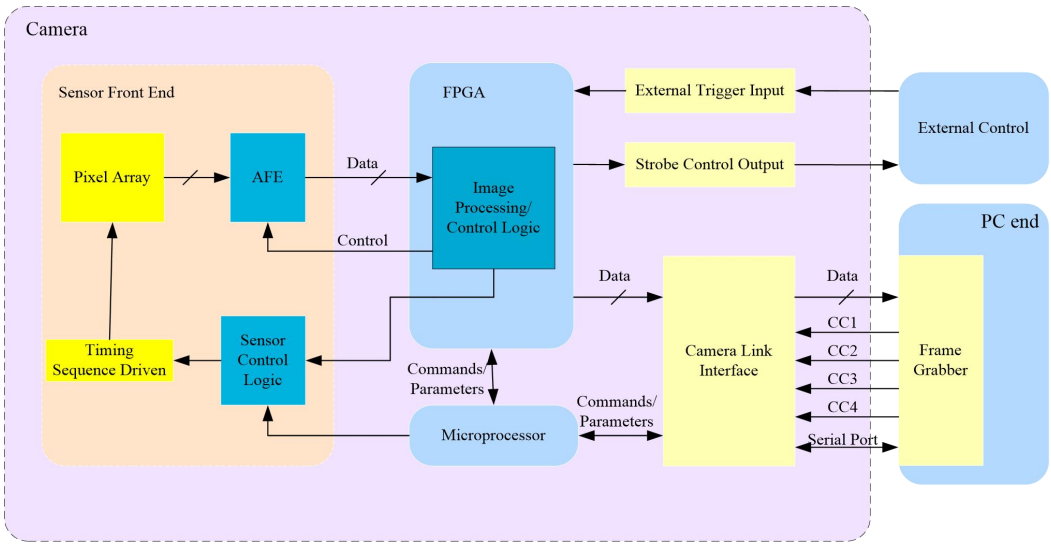
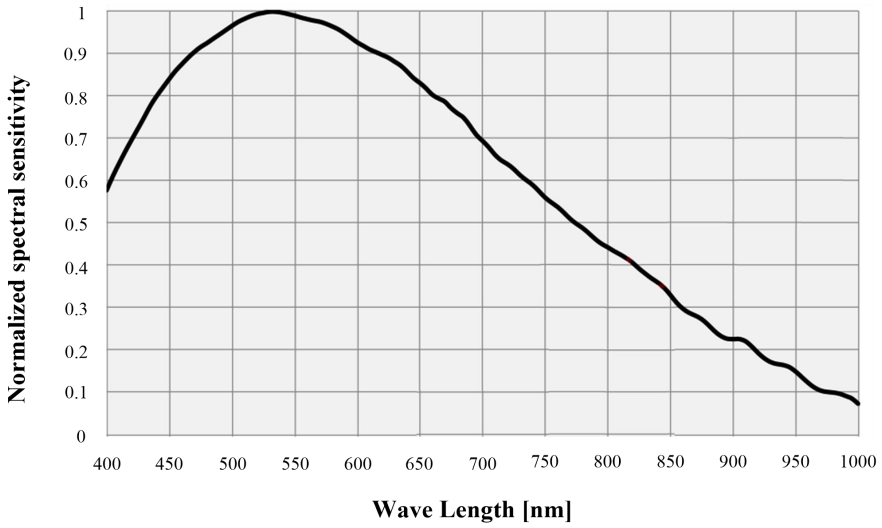


Fig. 2 Internal Implementation Structure of Camera

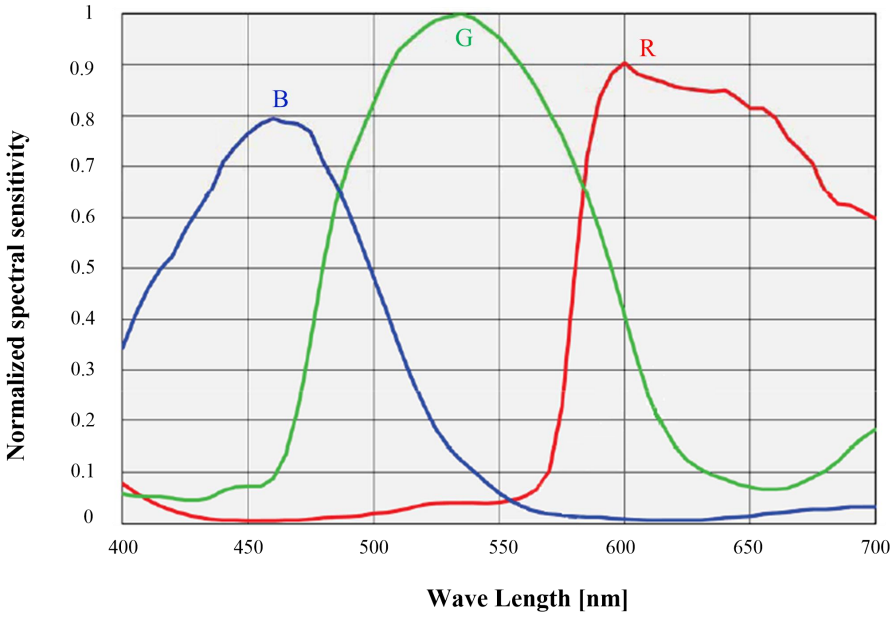
TTS26MCL is designed based on 26 megapixel area scan image sensor. The pixel array is sampled uniformly by the progressive scan control system, and the sampled data is converted from analog front-end to digital signal. The digital signal is processed by FPGA and microprocessor, and then transmitted to the frame grabber through Camera Link interface. The camera can also receive external trigger signals for acquisition from CC1 channel of Camera Link or independent IO port (Trigger) of camera.

4.4 Spectral Response

The spectral response of TTS26MCL camera is shown below.



(a) Monochrome Camera



(b) Color Camera

Fig. 3 Spectral Response

4.5 Camera Bayer Pattern

TTS26MCL camera supports color mode, Bayer pattern is shown as follows (HR is horizontal resolution, VR is vertical resolution).

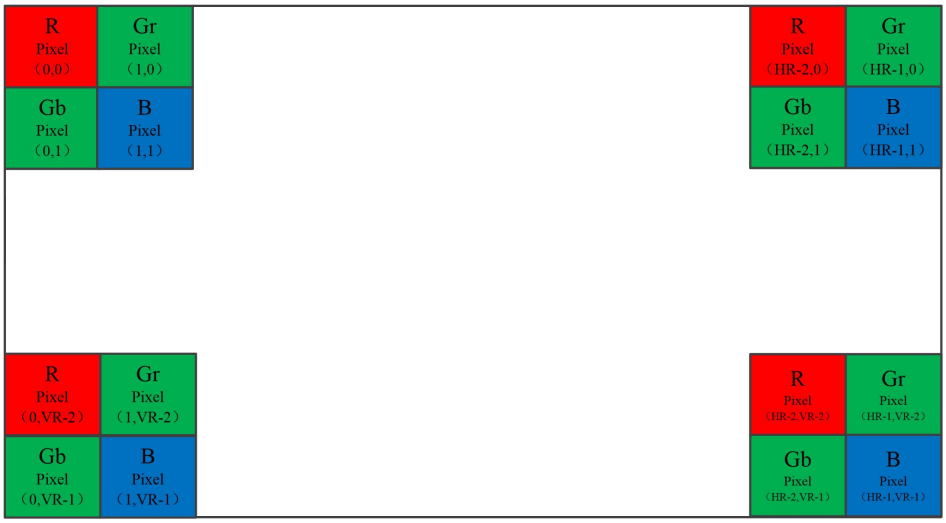


Fig. 4 Camera Bayer Pattern

4.6 Environmental Requirements

(1) Operating temperature: 0℃~65℃, humidity: 10%~90%; 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

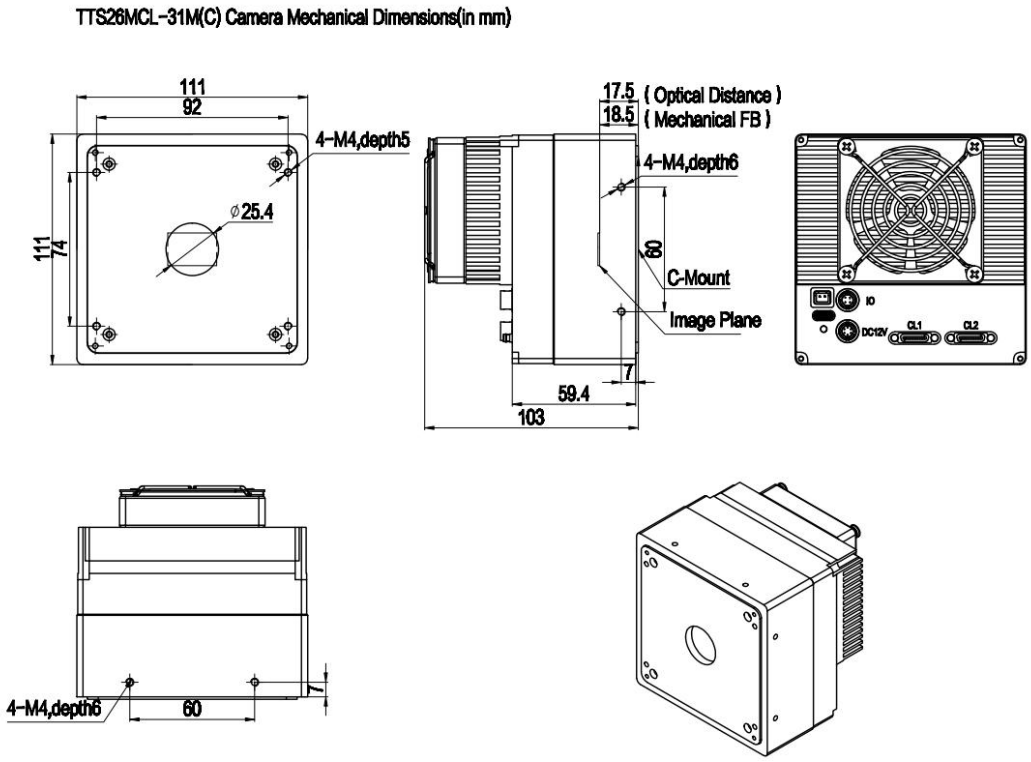


Fig. 5 Camera Mechanical Dimensions

5.2 Camera Interface

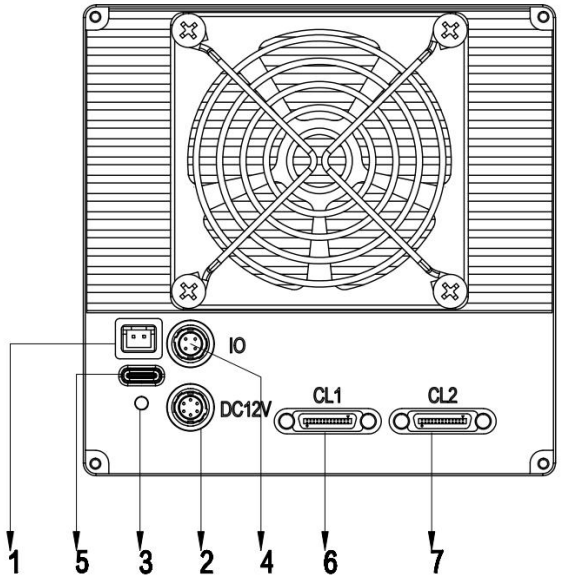


Fig. 6 External Interfaces of Camera

（1）Fan Power Socket

（2）6-pin 12V Power Input

（3）Camera Status Indicator
（4）4-pin control connector (Trigger input and Strobe output)
（5）Type-C Interface
（6）Camera Link Connector 1 (Base)
（7）Camera Link Connector 2 (Medium/Full/Full+)

5.2.1 Camera Status Indicator

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

Table 2 Camera Status Indicators

LED Status Indicators	Camera Status
Solid Green	Normal
Blinking Green	No trigger input within three seconds in external trigger mode
Solid Red	Processor is starting
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 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:

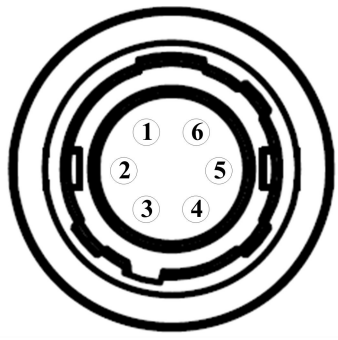


Fig. 7 Pin Assignments for Interface

Table 3 Pin Configurations for Interface

Signal	Pin	Signal	Pin
+12 V	1	GND	4
+12 V	2	GND	5

+12 V	3	GND	6

5.2.3 Data Interface

TTS26MCL uses Mini Camera Link connector as its data interface. Mini Camera Link connector complies with the industry standard shown as follows:

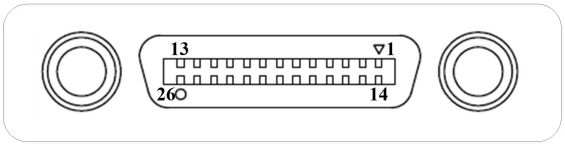


Fig. 8 Mini Camera Link Connector

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: Base interface (CL1) and Medium 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 TTS26MCL is 4tap@8/10/12bit, 8tap@8/10bit, 10tap@8bit. Port assignments in each output mode is shown in the table below:

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

5.2.4 Control Interface

The control I/O interface adopts 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:

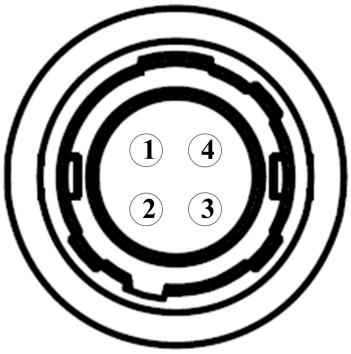


Fig. 9 Pin Assignments for Control I/O Interface

Table 9 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 4 pin connector. Transmitted trigger signal is applied to internal circuit through a photo coupler. The minimum trigger width that can be recognized by camera is 1μs. If transmitted trigger signal is less than 1μs, the camera will ignore the trigger signal. Trigger input voltage range is 2.5V~12V, an external trigger circuit example is shown below.

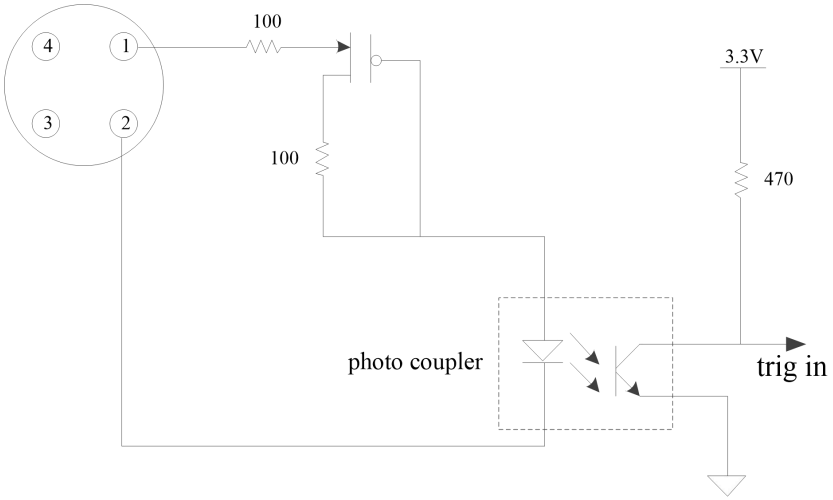


Fig. 10 Trigger Input Schematic

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.

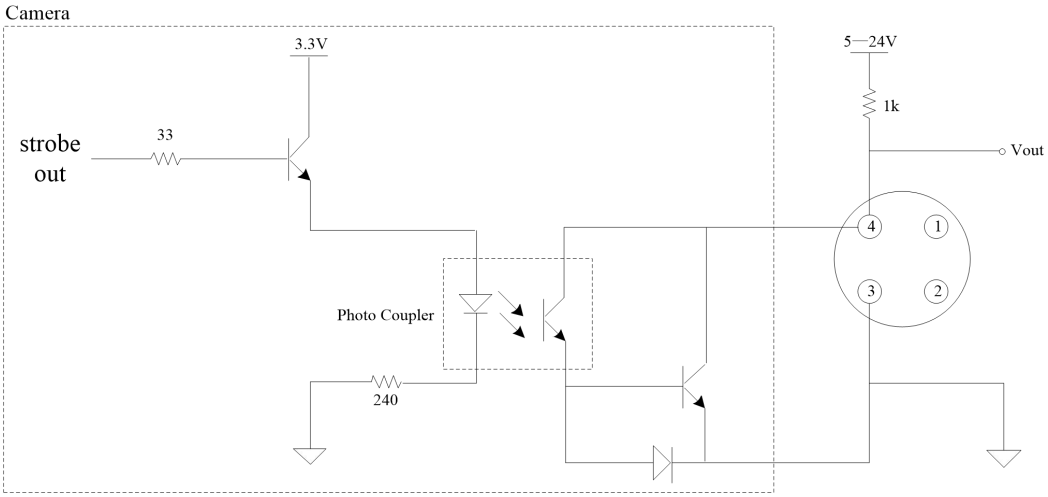


Fig. 11 Strobe Output Schematic

6 Camera Features

This chapter details the internal features of TTS26MCL camera.

6.1 Trigger Mode

TTS26MCL camera supports three trigger modes: Free-Run mode (Timed), External Pulse mode (TriggerPulse) and External PWM mode (TriggerWidth).

6.1.1 Free-Run Mode

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

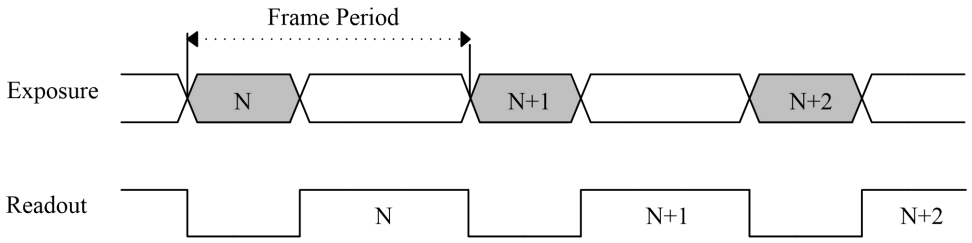


Fig.12 Free-Run Mode

To achieve normal image output, TTS26MCL camera limits the range of exposure time. In Free-Run mode, camera can be configured with exposure time range of 39μs to 300s (4Tap, 8Tap) or 46μs ~ 300s (10Tap). The operation sequence of camera is shown in the figure above.

6.1.2 External Pulse Mode

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

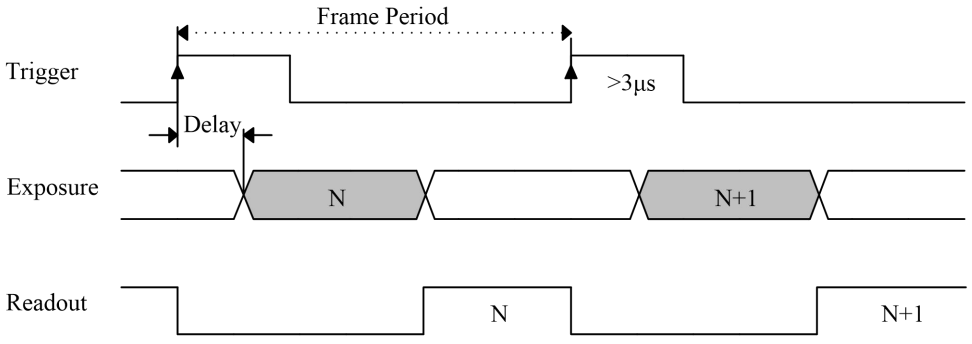


Fig. 13 External Pulse Mode

The external trigger signal can be CC1 signal of Camera Link or external pins from 4-pin control I/O interface, and input source could be selected by users. To ensure that camera correctly detects each external trigger pulse, external trigger pulse must have a width greater than 3μs.

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

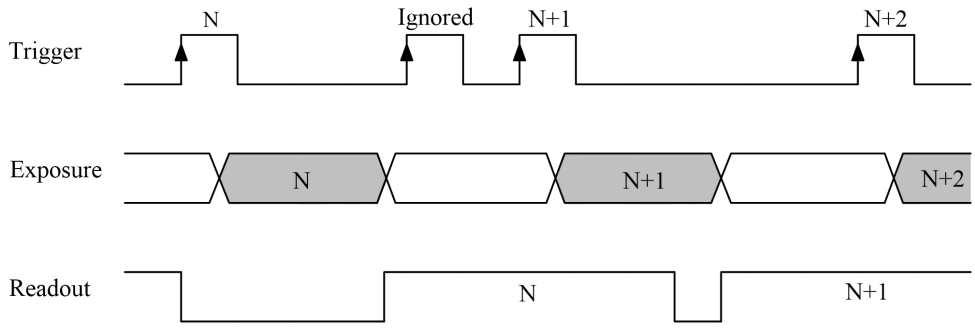


Fig. 14 Frame Period of External Trigger is Too Short

6.1.3 External PWM Mode

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

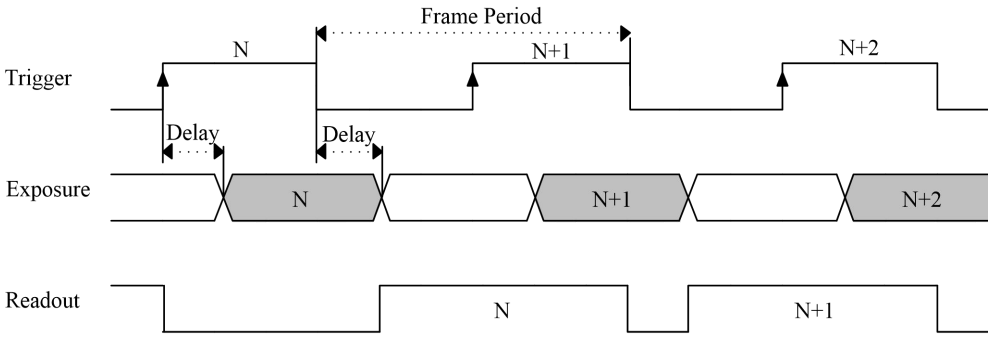


Fig. 15 High Level Trigger Mode

Please note that the minimum exposure time of camera is 39μs (4Tap, 8Tap) or 46μs (10Tap), so external trigger signal should be wider than 39μs or 46μs in this mode. In fact, camera will always process to 39μs or 46μs exposure time if pulse width is less than 39μs or 46μs.

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

TTS26MCL camera provides rich timing sequence parameter control features for external trigger mode, including external trigger polarity, delay.

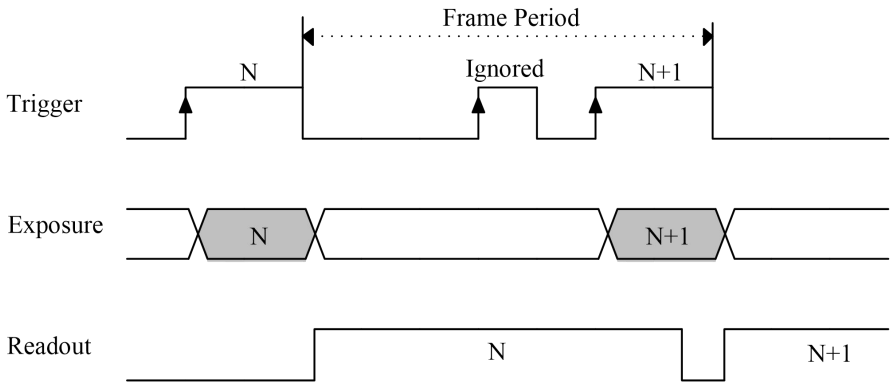


Fig. 16 Frame Period of External Trigger is Too Short

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.

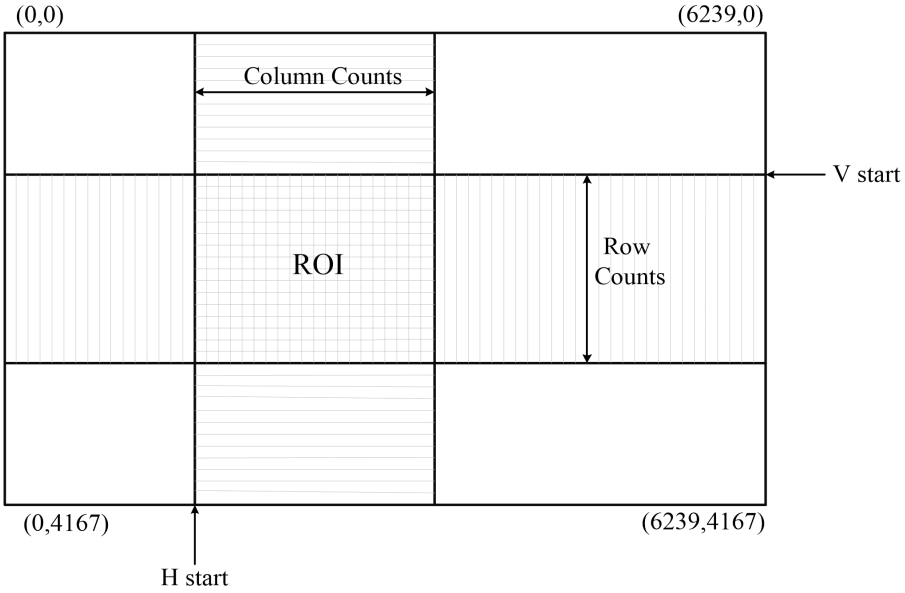


Fig. 17 Region of Interest

Note: The pixel coordinates in the horizontal direction must be a multiple of 16. If not so, it will automatically jump to the closest multiple of 16. The pixel coordinates in the vertical direction must be a multiple of 2. If not so, it will automatically jump to the closest multiple of 2.

Table 10 Maximum Frame Rate Depending on ROI Values

ROI Size H	ROI Size V	4Tap	8Tap	10Tap
6240	4168	12.19fps	24.37fps	31.51fps
6000	4168	12.19fps	24.37fps	31.51fps
4992	4168	12.19fps	24.37fps	31.51fps
4000	4168	12.19fps	24.37fps	31.51fps
2992	4168	12.19fps	24.37fps	31.51fps
2000	4168	12.19fps	24.37fps	31.51fps
1024	4168	12.19fps	24.37fps	31.51fps
6240	4000	12.69fps	25.38fps	32.81fps
6240	3000	16.84fps	33.68fps	43.55fps
6240	2000	25.03fps	50.07fps	64.73fps
6240	1024	47.66fps	95.32fps	123.22fps
6240	512	90.62fps	181.23fps	234.29fps
6240	200	201.06fps	402.11fps	519.84fps

6.3 LUT

LUT uses a 12-bit input and 12-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.

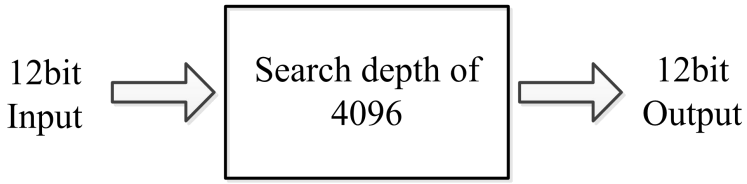


Fig. 18 LUT

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

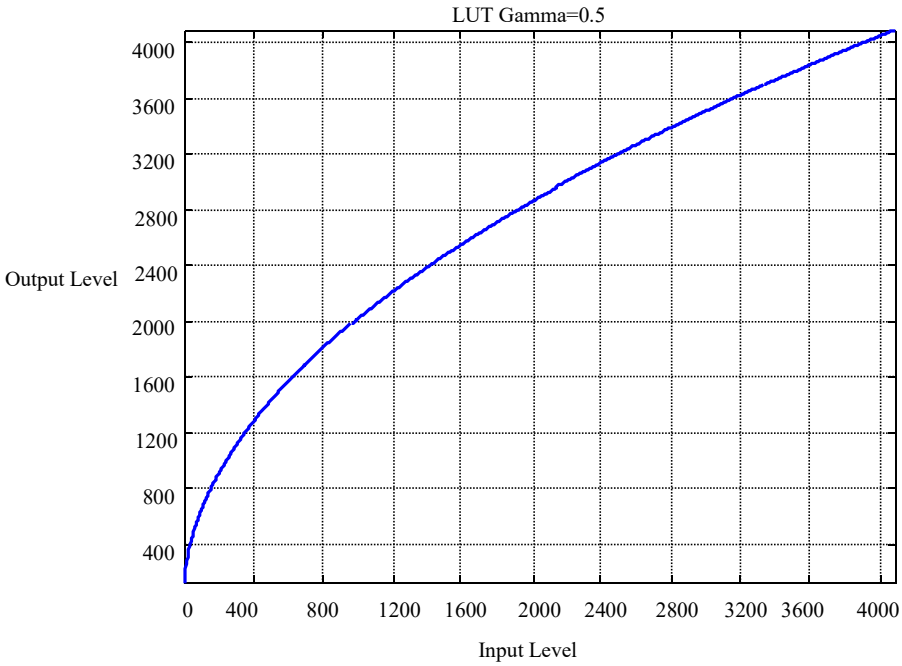


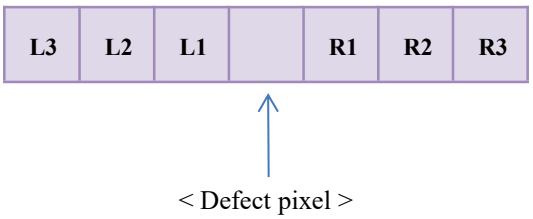
Fig. 19 LUT: Gamma = 0.5

6.4 Defect Pixel Correction

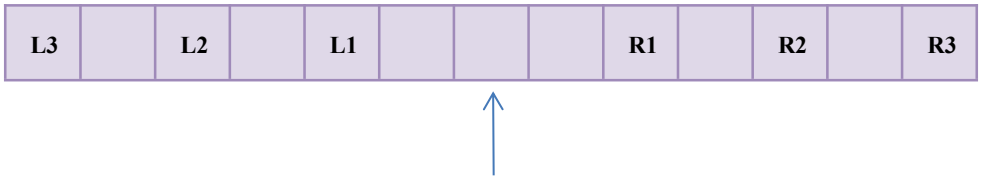
Due to the defects of material itself and issue with the process flow of semiconductor production, there are usually a certain number of pixels in area scan imaging sensors that cannot properly response to input light, which we call defect pixels. TTS26MCL camera provides with defect pixel automatic 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 11 Calculation Defect Pixel Correction Value

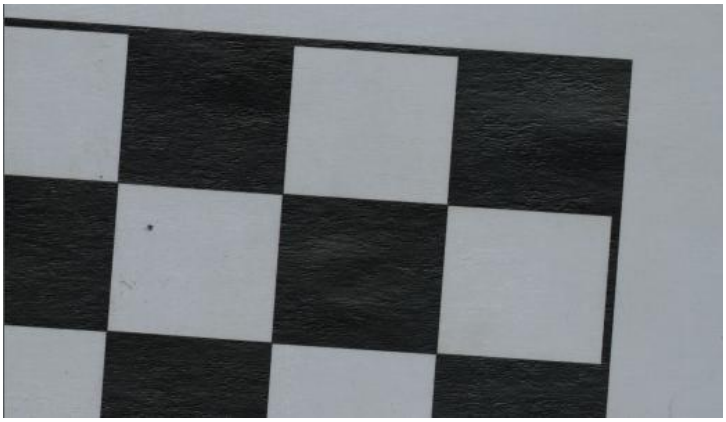
Adjacent Defect Pixel(s)	Correction value of Current Pixel
None	L1
L1	R1
R1	L1
L1,R1	L2
L1,R1,L2	R2
L1,R1,L2,R2	L3
L1,R1,L2,R2,L3	R3

6.5 White Balance

White balance is an important parameter of color industrial camera, 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.

TTS26MCL-31C 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

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. TTS26MCL 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:

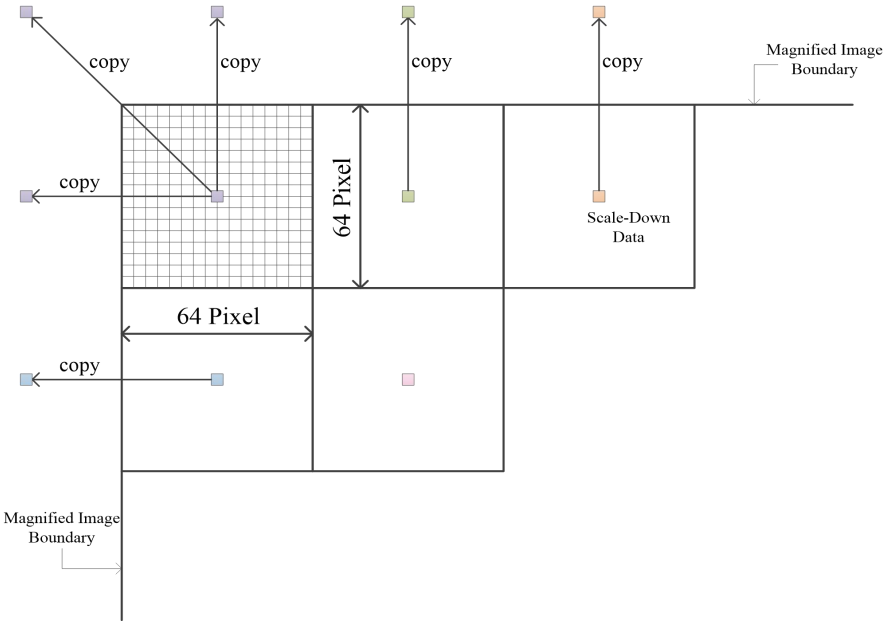


Fig. 22 Flat Field Correction Schematic

Note: Flat field correction must be performed in Free-Run mode and image format is full resolution.

6.7 Test Image

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

- Test image 1: fixed image with horizontal gray gradient.
- Test image 2: fixed image with vertical gray gradient.
- Test image 3: fixed image with the same gray scale for all pixels.

Fig. 23 Test Image 1

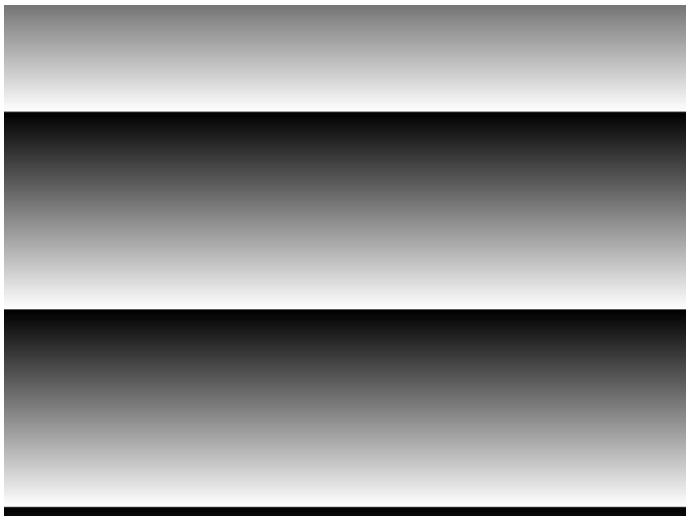


Fig. 24 Test Image 2

Fig. 25 Test Image 3

6.8 Strobe

The strobe signal is used to synchronize external light source with camera. As a Rolling Shutter type camera, TTS26MCL camera requires 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 exposure is over.

6.8.1 Strobe Signal Type

TTS26MCL camera provides two modes of strobe signal: Wide Strobe and Narrow Strobe.

- Wide Strobe: The 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: The 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.

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

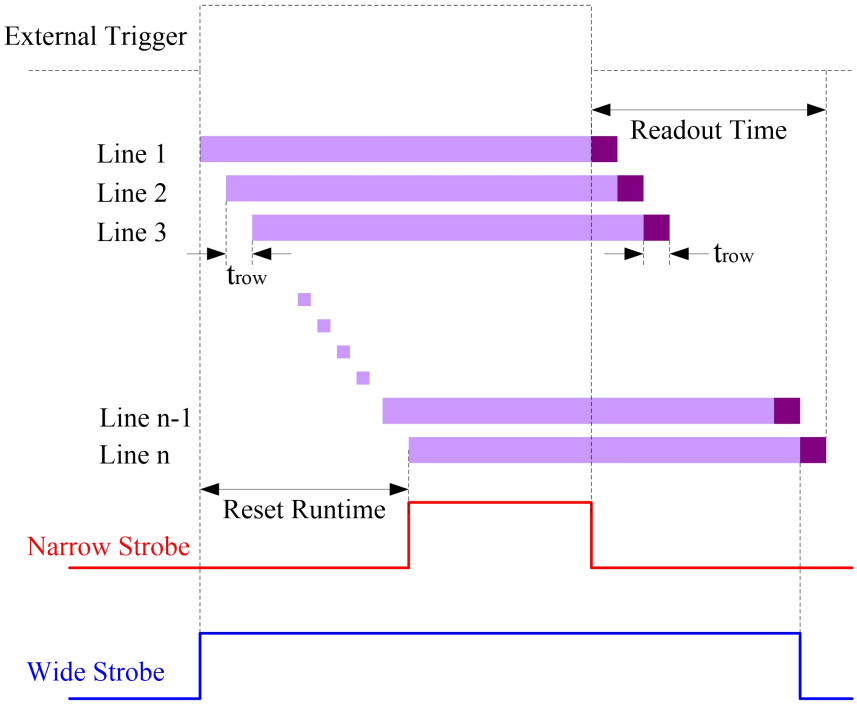


Fig. 26 Strobe Signal (Polarity: High)

6.8.2 Strobe Signal Polarity

TTS26MCL 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.

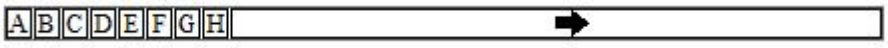
- High: Act at high level, where strobe signal defaults to low and switches to high at the start of exposure.
- Low: Act at low level, where strobe signal defaults to high and switches to low at the start of exposure.

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:

Medium：

Full：



Full+：

Fig. 27 Camera Link Output Mode

6.10 Data Format

TTS26MCL 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.

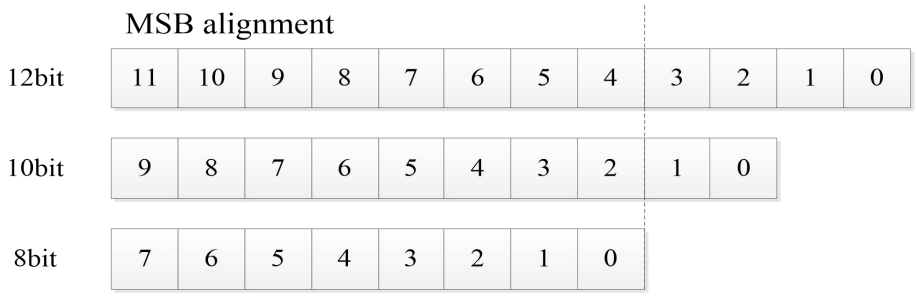


Fig. 28 Data Format

6.11 Gain and Offset

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

The analog gain acts on the analog signal. By increasing the analog gain, a stronger response can be generally obtained under weak illumination, thus realizing a higher signal-to-noise ratio. Users can configure the camera's analog gain.

The analog gain parameters range from 0 to 96, linearly corresponding to 0 to 18dB.

The influence of analog gain on camera response curve is shown in the figure below:

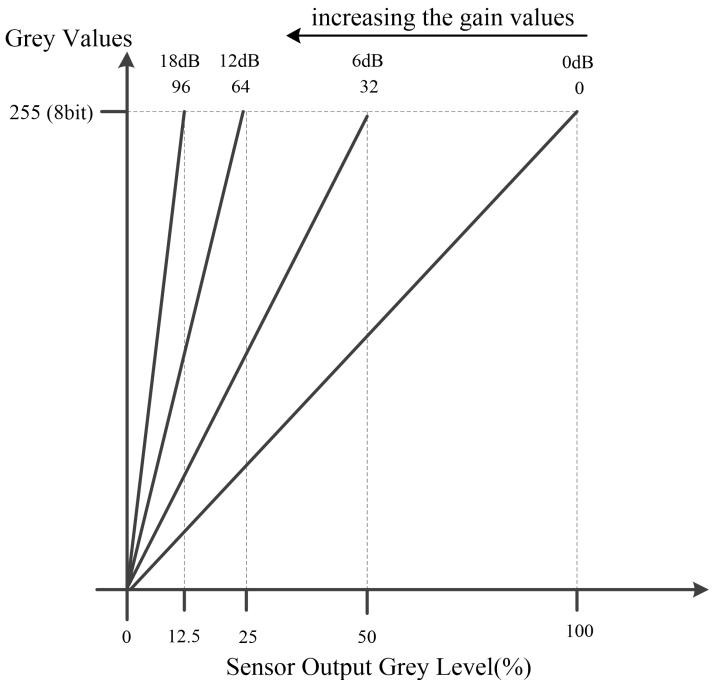


Fig. 29 Analog Gain

Analog offset is generally used to adjust the black level position of the front-end sensor. The analog offset can be set in a range from 0 to 4095 with 4096 steps. The analog offset parameters are based on 12 bit data format.

The digital gain is usually used to expand the dynamic range, to perform automatic white balance, or to simply change the brightness of the image. The digital offset parameter is usually used to adjust the overall background of image.

The digital gain can be set in a range from 0.01 to 8.00 with 800 steps. 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 digital offset can be set in a range from -4095 to 4095 with 8191 steps. The digital offset parameters are based on 12 bit data format.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

6.12 Camera Temperature

TTS26MCL supports real-time acquisition of camera temperature. Users can read the camera temperature value to monitor the current temperature value of the sensor or make some responses according to the temperature value.

The operating environment temperature of the camera is recommended to be 0°C to 40°C, and the internal operating temperature is recommended to be 0°C to 65°C. If users detect abnormal internal temperature (such as over 70°C), it is recommended to stop the camera immediately to avoid component damage. Power off and contact our technical support in time.

6.13 Load / Save Configuration

TTS26MCL camera provides three working parameter sets to meet the use demand in most scenarios. Among them, the factory parameter set has already been optimized and cannot be modified by users. The camera is provided with two user operating parameter sets, among which the internal parameters can be modified and saved by users. The saved operating parameter set will be automatically loaded upon power-on next time.

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

7 Camera 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

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).

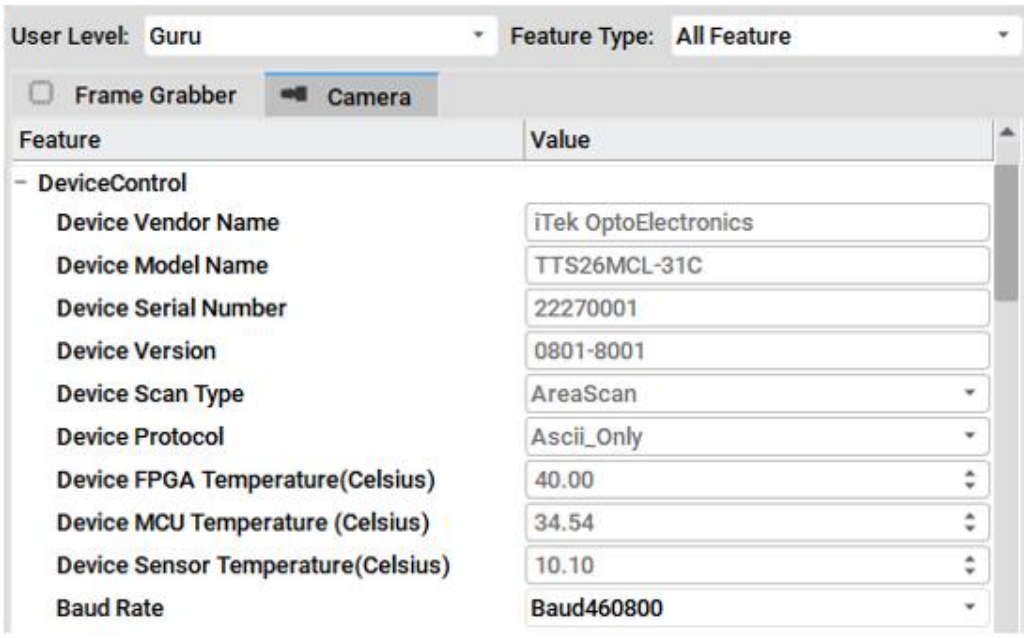


Fig. 30 Device Control Category

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 12 Device Control Category List

Feature Name	Feature Description	Camera Version &

		Visibility
DeviceVendorName	Vendor name (RO)	0801-8001 Beginner
DeviceModelName	Module name (RO)	0801-8001 Beginner
DeviceSerialNumber	Camera serial number (RO)	0801-8001 Beginner
DeviceVersion	Current camera version (RO)	0801-8001 Beginner
DeviceScanType	Camera scan type (RO)	0801-8001 Beginner
DeviceProtocol	Camera protocol (RO)	0801-8001 Beginner
DeviceFPGATemperature	Camera FPGA temperature (RO)	0801-8001 Beginner
DeviceMCUTemperature	Camera MCU temperature (RO)	0801-8001 Beginner
DeviceSensorTemperature	Camera sensor temperature (RO)	0801-8001 Beginner
DeviceSerialPortBaudRate **Baud9600** **Baud19200** **Baud38400** **Baud57600** **Baud115200** **Baud234000** **Baud460800**	Camera baud rate Baud9600 Baud19200 Baud38400 Baud57600 Baud115200 Baud234000 Baud460800	0801-8001 Expert

7.2 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.

TTS26MCL camera has a fixed image width of 6240 pixels and a fixed image height of 4168 pixels. It supports image output in test mode. Users can select camera output mode from “Image Video Mode” drop-down box.

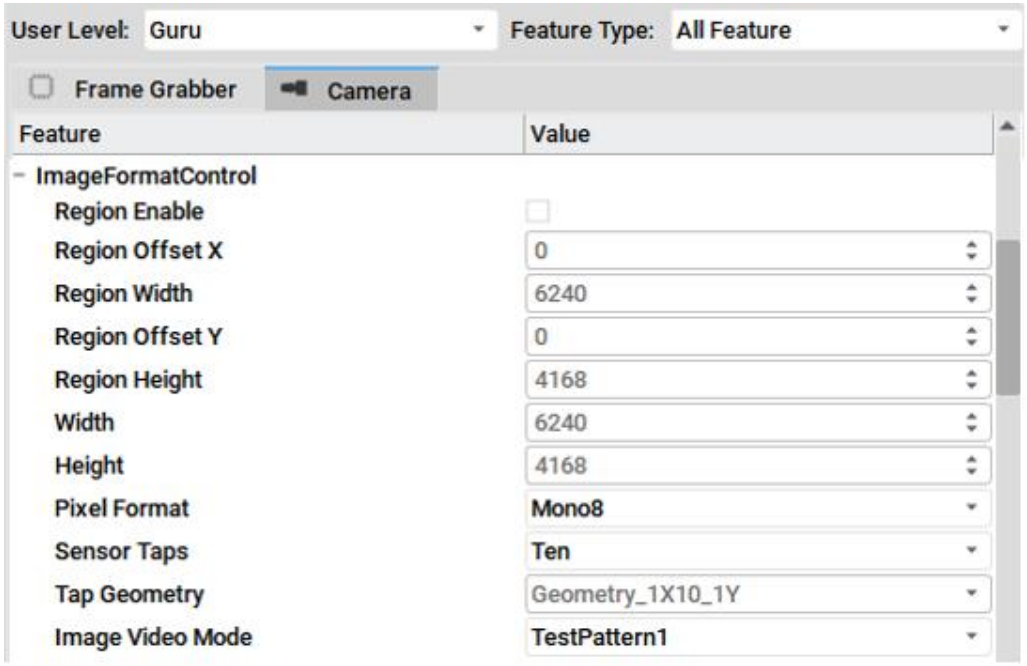


Fig.31 Image Format Category

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 13 Image Format Category List

Feature Name	Feature Description	Camera Version & Visibility
RegionEnable	Enable region of interest	0801-8001 Beginner
RegionOffsetX	Horizontal offset of ROI	0801-8001 Beginner
RegionWidth	ROI width	0801-8001 Beginner
RegionOffsetY	Vertical offset of ROI	0801-8001 Beginner
RegionHeight	ROI height	0801-8001 Beginner
Width	Actual width of camera (RO)	0801-8001 Beginner
Height	Actual height of camera (RO)	0801-8001 Beginner
PixelFormat **Mono8** **Mono10** **Mono12**	Pixel format Mono8 Mono10 Mono12	0801-8001 Beginner

SensorTaps	Count of sensor taps	
Four	4Tap	0801-8001
Eight	8Tap	Beginner
Ten	10Tap	
DeviceTapGeometry	Tap arrangement method (RO)	0801-8001 Beginner
VideoMode	Output image type	
Original	Original	
Corrected	Corrected	0801-8001
TestPattern1	TestPattern1	Beginner
TestPattern2	TestPattern2	
TestPattern3	TestPattern3	

7.3 Acquisition Control Category

Parameters involved in camera image acquisition, such as frame rate, exposure time 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.

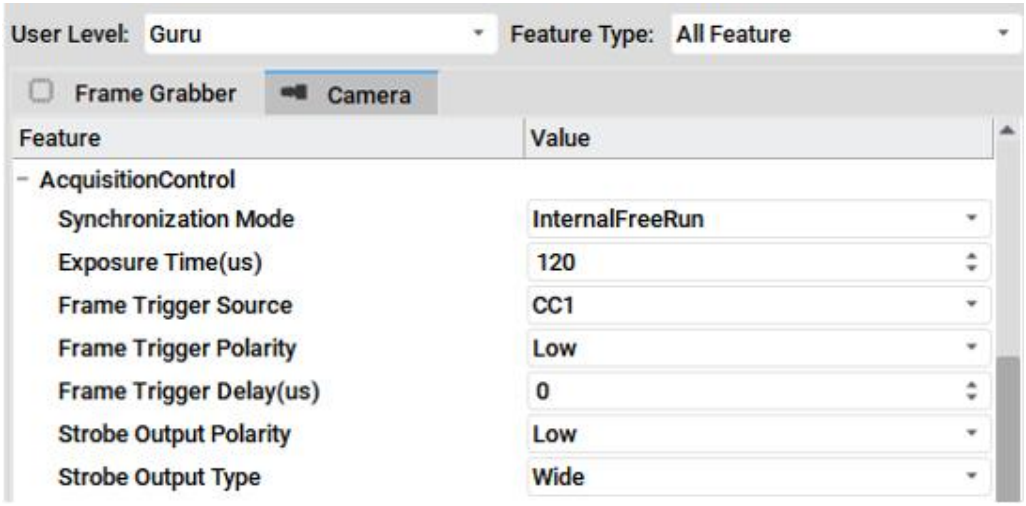


Fig.32 Acquisition Control Category

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 14 Acquisition Control Category List

Feature Name	Feature Description	Camera Version & Visibility
SynchronizationMode	Camera trigger mode	0801-8001
InternalFreeRun	InternalFreeRun	Expert

ExternalPulse **ExternalWidth**	ExternalPulse ExternalWidth	
ExposureTime	Exposure time	0801-8001 Beginner
FrameTriggerSource **CC1** **IO0**	Frame trigger source CC1 IO0	0801-8001 Beginner
FrameTriggerPolarity **High** **Low**	Frame trigger polarity High Low	0801-8001 Beginner
FrameTriggerDelay	Frame trigger delay time	0801-8001 Beginner
StrobeOutputPolarity **High** **Low**	Strobe signal output polarity High Low	0801-8001 Beginner
StrobeOutputType **Wide** **Narrow**	Strobe signal output type Wide Narrow	0801-8001 Beginner

7.4 Analog Control Category

Parameters involved in analog signal acquisition, such as analog gain and offset, are all grouped into analog control category. Application program can modify these features to change analog 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.

TTS26MCL camera supports adjusting analog gain “Analog Gain” and analog offset “Analog Offset” to change the quality of camera output image. See Section 6.11 for detailed description.

Note: The gain of TTS26MCL camera has been optimized for delivery. For non-professional users, it is not recommended to modify these parameters.

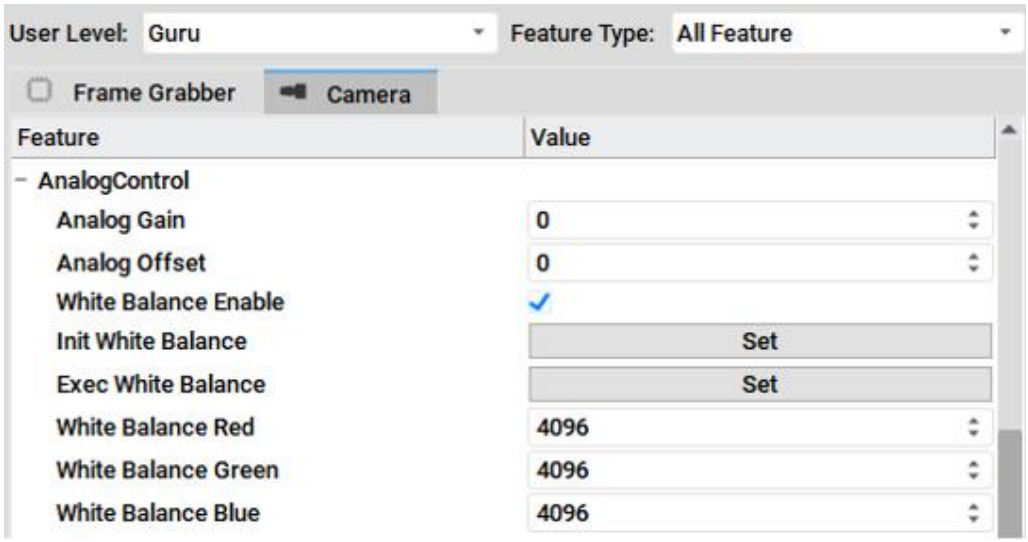


Fig.33 Analog Control Category

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 15 Analog Control Category List

Feature Name	Feature Description	Camera Version & Visibility
AnalogGain	Analog gain	0801-8001 Beginner
AnalogOffset	Analog offset	0801-8001 Beginner
WhiteBalanceEnable	Enable white balance	0801-8001 Expert
WhiteBalanceInit	Initialize white balance	0801-8001 Expert
WhiteBalanceExec	Execute white balance	0801-8001 Expert
WhiteBalanceR	Set red channel of white balance	0801-8001 Expert
WhiteBalanceG	Set green channel of white balance	0801-8001 Expert
WhiteBalanceB	Set blue channel of white balance	0801-8001 Expert

7.5 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.

TTS26MCL 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.

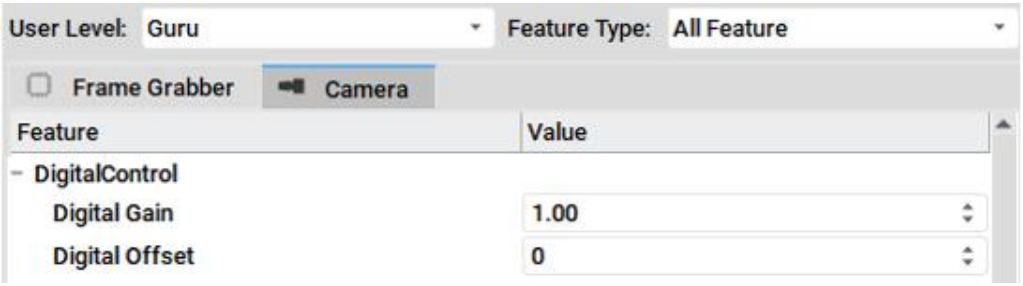


Fig.34 Digital Control Category

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 16 Digital Control Category List

Feature Name	Feature Description	Camera Version & Visibility
DigitalGain	Digital gain	0801-8001 Beginner
DigitalOffset	Digital offset	0801-8001 Beginner

7.6 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.

TTS26MCL camera supports 12bit input-12bit 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.

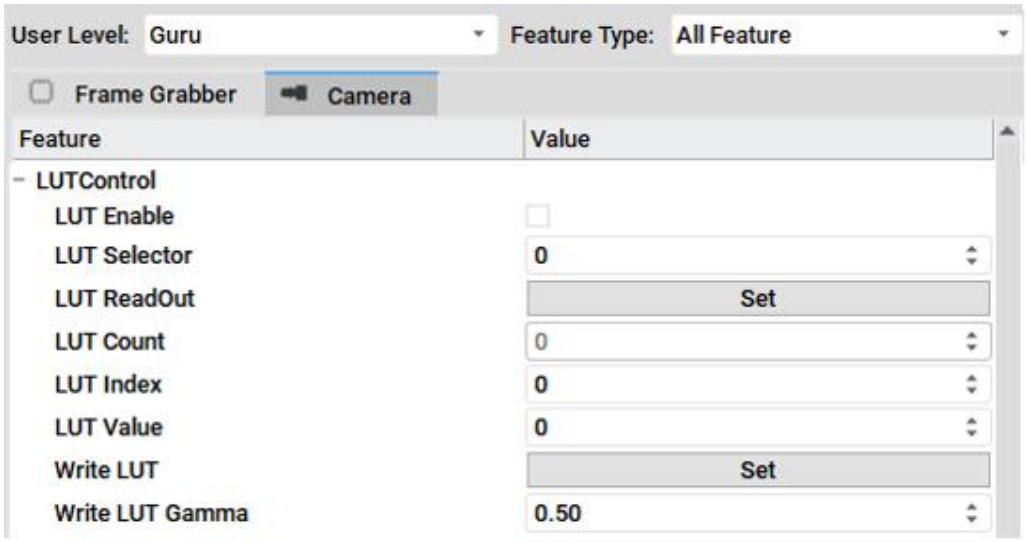


Fig.35 Lookup Table Category

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 17 Lookup Table Category List

Feature Name	Feature Description	Camera Version & Visibility
LUTEnable	Enable lookup table algorithm	0801-8001 Expert
LUTSelector	Select lookup table	0801-8001 Expert
LUTReadOut	Read lookup table from camera	0801-8001 Guru
LUTCount	Lookup table count	0801-8001 Guru
LUTIndex	Lookup table index	0801-8001 Guru
LUTValue	Lookup table value	0801-8001 Guru
LUTWrite	Write lookup table to camera	0801-8001 Guru
LUTGamma	Gamma value	0801-8001 Guru

7.7 Defect Pixel Correction Category

Parameters involved in camera defect pixel correction, such as defect pixel correction parameter, defect pixel correction enable and so on, 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.

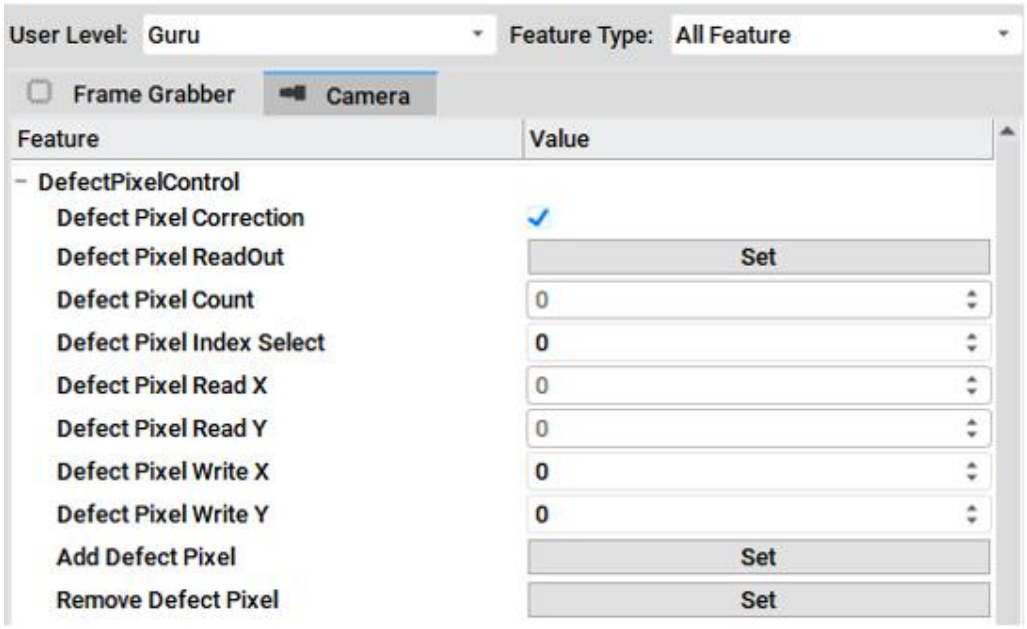


Fig.36 Defect Pixel Correction Category

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 18 Defect Pixel Correction List

Feature Name	Feature Description	Camera Version & Visibility
DefectPixelCorrectionEnable	Enable defect pixel correction	0801-8001 Expert
DefectPixelReadOut	Read defect pixels from camera	0801-8001 Guru
DefectPixelTotal	Total number of defect pixels	0801-8001 Guru
DefectPixelSelect	Select defect pixel	0801-8001 Guru
DefectPixelReadX	Read X coordinate of defect pixel	0801-8001 Guru
DefectPixelReadY	Read Y coordinate of defect pixel	0801-8001 Guru
DefectPixelWriteX	Write X coordinate of defect pixel	0801-8001 Guru
DefectPixelWriteY	Write Y coordinate of defect pixel	0801-8001 Guru
DefectPixelAdd	Add defect pixel	0801-8001 Guru

DefectPixelRemove	Remove defect pixel	0801-8001 Guru

7.8 Flat Field Correction Category

Parameters involved in camera flat field correction, such as flat field correction parameter, 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.

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

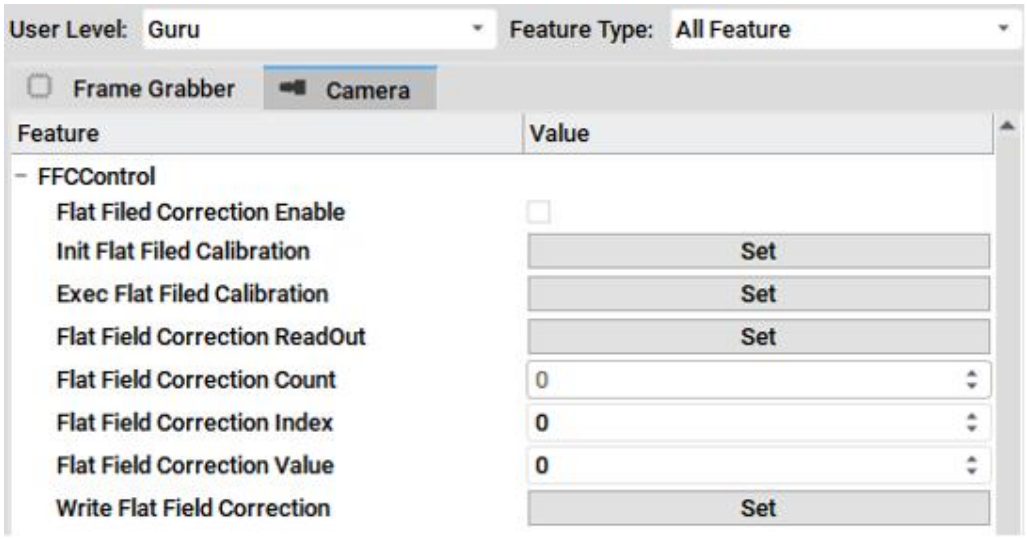


Fig.37 Flat Field Correction Category

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 19 Flat Field Correction Category List

Feature Name	Feature Description	Camera Version & Visibility
FFCEnable	Enable flat field correction	0801-8001 Expert
FFCInit	Initialize flat field correction	0801-8001 Expert
FFCExec	Execute flat field correction	0801-8001 Expert
FFCReadOut	Read flat field correction data from camera	0801-8001 Guru
FFCCount	Flat field correction count	0801-8001 Guru

FFCIndex	Flat field correction index	0801-8001 Guru
FFCValue	Flat field correction value	0801-8001 Guru
FFCWrite	Write flat field correction data to camera	0801-8001 Guru

7.9 Cooler Control Category

Camera electronic cooling, which allows users controlling target temperature of CCD image sensor. 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.

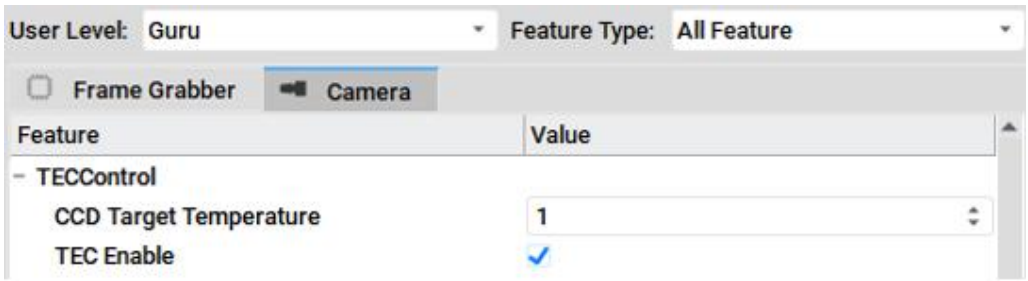


Fig.38 Cooler Control Category

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 20 Cooler Control Category List

Feature Name	Feature Description	Camera Version & Visibility
CCDTargetTemperature	Set target temperature of CCD sensor	0801-8001 Beginner
TECEnable	Electronic cooling enable	0801-8001 Expert

7.10 User Configuration Category

TTS26MCL 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.

TTS26MCL 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.

TTS26MCL 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.

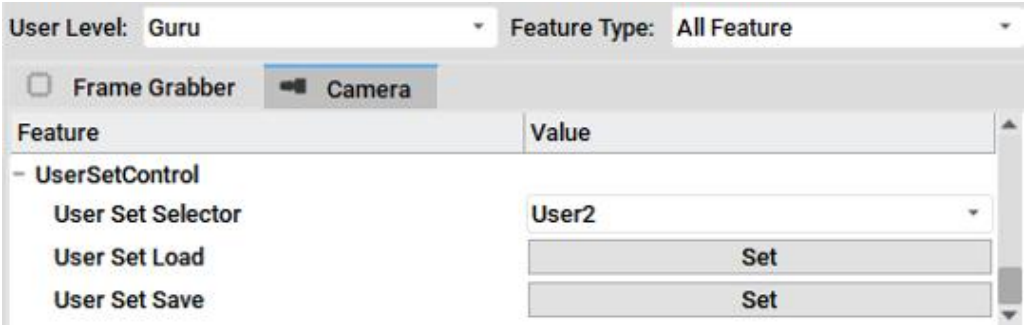


Fig.39 User Configuration Category

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 21 User Configuration Category List

Feature Name	Feature Description	Camera Version & Visibility
UserSetSelector **Default** **UserSet1** **UserSet2**	Select user configuration Default UserSet1 UserSet2	0801-8001 Beginner
UserSetLoad	Load camera configuration (WO)	0801-8001 Beginner
UserSetSave	Save camera configuration (WO)	0801-8001 Beginner

8 FAQ

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

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

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

① Ensure that 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 frame grabber and supporting software are operating properly, which can be checked by restarting computer.
③ Ensure that Base and Medium configurations of Camera Link interface are not reversed.
④ Ensure that Camera Link interface cable is OK.

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

① Ensure that external input pulse is normal.
② Ensure that camera has received trigger pulse correctly (it can be confirmed by the status indicator display).
③ If Camera Link interface CC1 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 casing is hot or 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 casing is not blocked.
② Ensure that exposure time is set properly.

- **If 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 power supply is normal by camera indicator status.
③ Check whether external pulse input is normal in the External Pulse 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.