PH4KCL-200KU Line Scan Camera User Manual

（V0.1　Jun. 25, 2023）

Hefei I-TEK Optoelectronics Co., Ltd.

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

Revision History

Revision	Date	Description
0.1	2023/06/25	● Initial version

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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 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 +12~24V (±10%) voltage and 1.0A current are recommended for the camera.

② Hefei I-TEK Optoelectronics Co., LTD. does not provide power supply with the camera, you may prepare the power supply on your own.

- **Document**

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

2 Camera Models

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

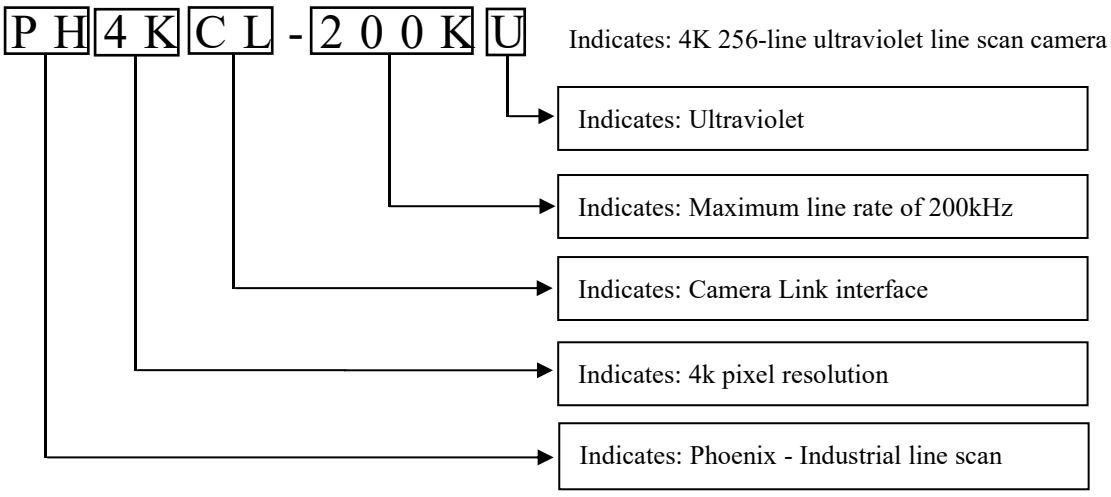
T: TDI (time delay integration) U: Ultraviolet

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 of the camera provides four M4 threaded holes for fixing the camera.

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

4 Product Specifications

PH4KCL camera is specially designed for high-speed line scanning applications in the field of industrial automation inspection. It is independently developed and produced by Hefei I-TEK Optoelectronics Co., LTD.. The camera integrates a world's leading high-speed line scan image sensor, and a Field Programmable Gate Array (FPGA) for parallel processing. The FPGA outputs data through high-speed industrial Camera Link bus, and the camera has characteristics of high speed, high sensitivity and low noise.

4.1 Main Features

- Backshot CCD Sensor
- Maximum Line Rate 200kHz
- High Sensitivity and Low Noise
- Minimum Exposure Time: 5μs, and Exposure Time Step: 0.01μs
- Output Pixel Format: 8/10/12bit
- ROI
- Binning
- Analog Gain / Digital Gain / Offset Control
- User-configurable Scanning Direction
- Flat Field Correction
- LUT
- Support Multiple Camera Link Output Modes
- Real-time Temperature Monitoring

4.2 Camera Specifications

Table 1 PH4KCL-200KU Product Specifications

Model	PH4KCL-200KU
Product Description	4K 256-line ultraviolet line scan camera
Resolution	4096 x 256
Pixel Specifications	5μm x 5μm
Sensor Type	Backshot CCD
Image Type	Monochrome
Sensor Length	20.48mm
Dynamic Range	≥63.5dB
SNR	43.4dB
Data Rate	819MB/s
Analog Gain	X1/X2/X4/X8
Digital Gain	0.01~7.998
Digital Offset	-4095~4095
Lens Mount	M42 x 1
Max. Line Rate	41.2kHz@2Tap, 81.4kHz@4Tap, 161.2kHz@8Tap, 200.0kHz@10Tap

Synchronously	Free-Run, External Pulse
External Trigger	IO/CCI
Exposure Control	Controlled by line period
Exposure Time	5μs ~ 10s (step: 0.01μs)
Data Format	8/10/12bit
Operation Temperature	0~55°C
Data Interface	Camera Link
Pixel Clock	72M/80M/85MHz
Power Supply	DC 12~24V (±10%) 1.0A
Power Consumption	5.5W
Mechanical	60mm x 60mm x 35mm
Weight	190.9g

4.3 Camera Block Diagram

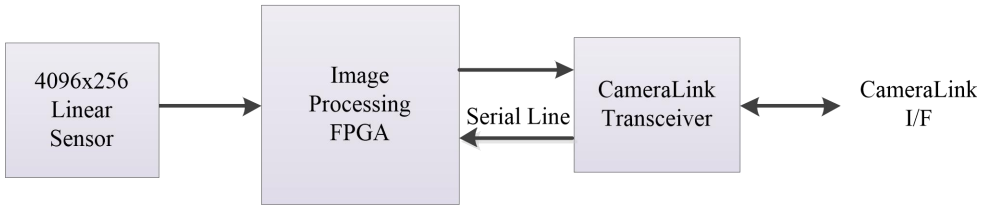


Fig.2 Internal Implementation Structure of Camera

PH4KCL camera is built based on 4096 x 256 resolution high-speed line scan image sensor design. The pixel array is uniformly sampled and held by the global shutter control system, converted from analog front-end to digital signals, and processed by FPGA and microprocessor. The image data is transmitted to the PC-side frame grabber through Camera Link interface. The camera can accept external signals to trigger the acquisition. Trigger source can be the IO input or CC1 signal line of the Camera Link interface.

The camera integrates image processing algorithms including flat field correction and flip, all implemented in FPGA in real time.

4.4 Spectral Response

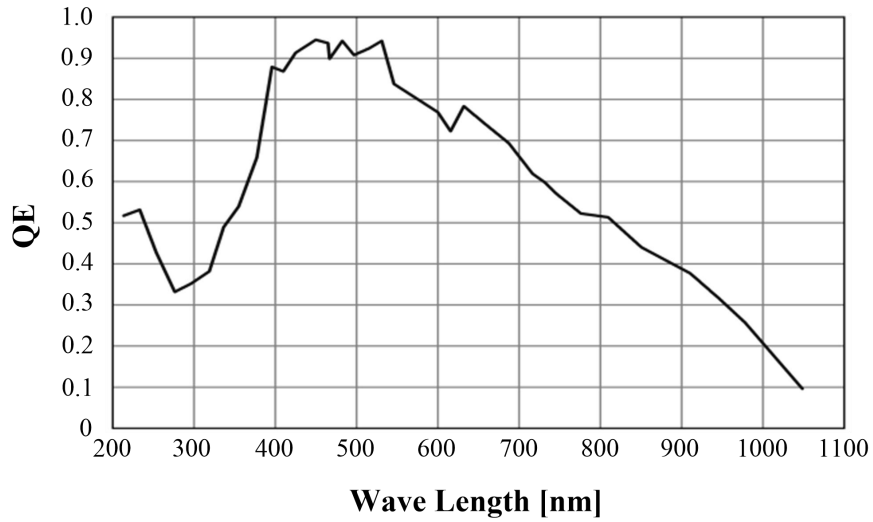


Fig.3 Spectral Response of Camera

4.5 Environmental Requirements

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

(2) The dust-proof sealing for the sensor in the camera may effectively prevent dust from entering the camera and falling on the sensor surface. Dust may enter the camera when the lens cap is opened, so keep the lens cap closed when the camera is not in use.

4.6 RoHS Certification

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

5 Mechanical Dimensions and Interfaces

5.1 Mechanical Dimensions

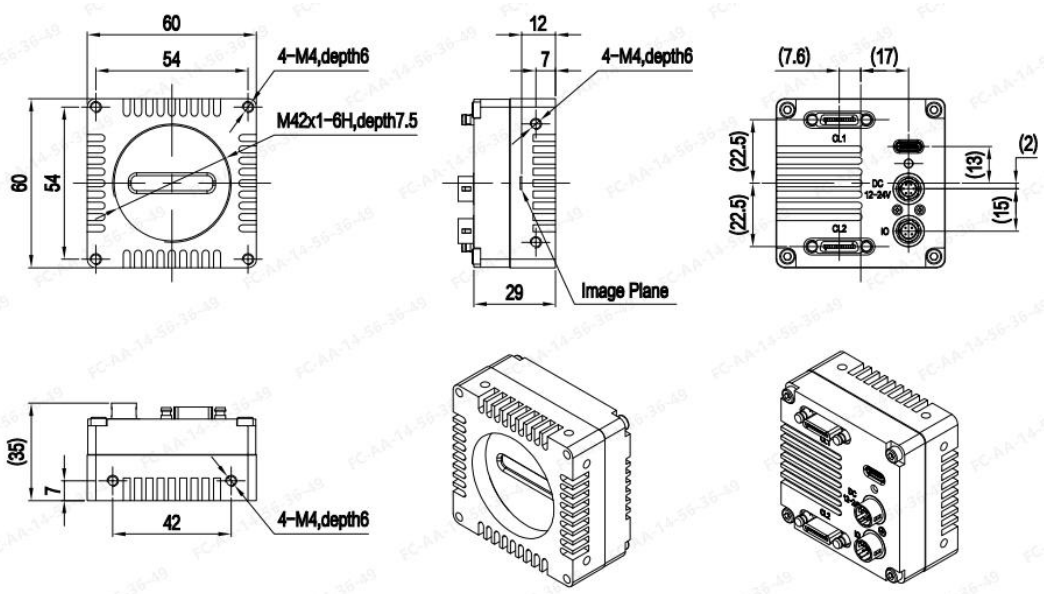


Fig.4 Camera Mechanical Dimensions

5.2 Camera Interface

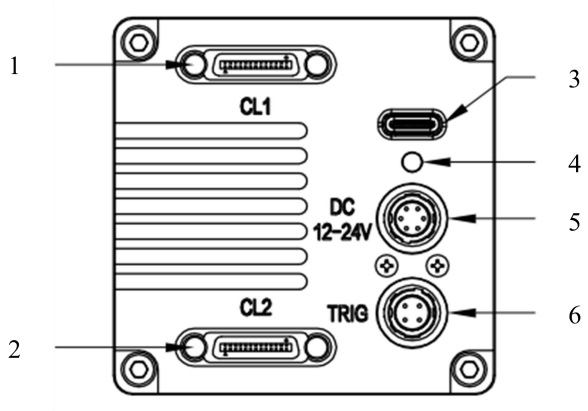


Fig.5 External Interfaces of Camera

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

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 Indicator

LED Status Indicator	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 Receptacle

The power input interface is a 6-pin connector 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:

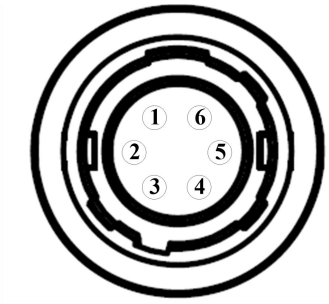


Fig. 6 Pin Assignments for Power Input Interface

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 Control Interface

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

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

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

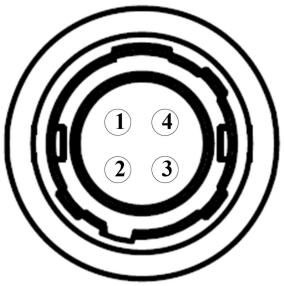


Fig.7 Pin Assignments for Interface

Table 4 Interface Pin Definition

Signal	Pin	Signal	Pin
Trigger In +	1	GND	3
Trigger In -	2	Reserved	4

The external trigger circuit is shown as follows:

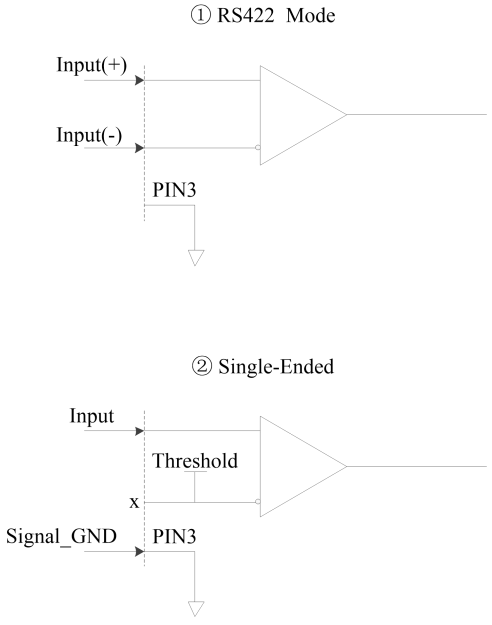


Fig.8 Trigger Input Circuit Diagram

5.2.4 Camera Link Connector

PH4KCL camera uses a Mini Camera Link connector as a data output interface. The Mini Camera Link connector is an industry standard interface. The signal definition is as follows:

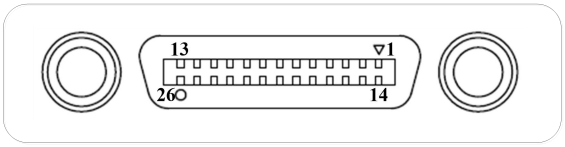


Fig.9 Mini Camera Link Connector

Table 5 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	SerTC+	LVDS-In	Serial Data Receiver
	20	SerTC-	LVDS-In	Serial Data Receiver
PAIR 7	8	SerTFG-	LVDS-Out	Serial Data Transmitter
	21	SerTFG+	LVDS-Out	Serial Data Transmitter
PAIR 8	9	CC1-	LVDS-In	Software External Trigger
	22	CC1+	LVDS-In	Software External Trigger
PAIR 9	10	N/C	N/C	N/C
	23	N/C	N/C	N/C
PAIR 10	11	N/C	N/C	N/C
	24	N/C	N/C	N/C
PAIR 11	12	N/C	N/C	N/C
	25	N/C	N/C	N/C
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

Table 6 Pin Assignments for Mini Camera Link Connector 2

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	Y0-	LVDS-Out	Camera Link Transmitter
	15	Y0+	LVDS-Out	Camera Link Transmitter
PAIR 2	3	Y1-	LVDS-Out	Camera Link Transmitter

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

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

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

Table 7 Port Assignments (2tap @ 8/10/12bit)

	8bit	10bit	12bit
	2tap/8bit	2tap/10bit	2tap/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	-	B0	B0
Port C1	-	B1	B1
Port C2	-	B2	B2
Port C3	-	B3	B3
Port C4	-	B4	B4
Port C5	-	B5	B5
Port C6	-	B6	B6
Port C7	-	B7	B7

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

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

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

Table 9 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 10 Port Assignments (10tap @ 8bit)

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

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

6 Camera Features

This chapter gives a detailed introduction to the feature of PH4KCL-200KU.

6.1 Trigger Mode

PH4KCL-200KU camera supports two trigger modes: Free-Run, External Pulse Trigger (External Pulse). External trigger signal can be selected between the external I/O interface input or CC1 signal line of the Camera Link interface, input source is selected by the user through instructions.

6.1.1 Free-Run Mode

In the Free-Run control mode, the camera's internal logic automatically generates the camera control timing, so that the camera can produce normal image output without external trigger signal.

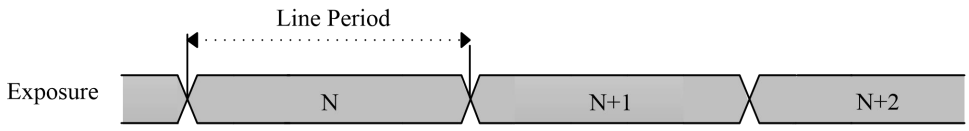


Fig.10 Free-Run Mode

In Free-Run mode, exposure time can be controlled by line rate (reciprocal of line period), from 5μs to 1s. The running sequence of camera is shown in the figure above.

The line period command are sent to the camera through the Camera Link serial port. Detailed instructions are described in Chapter 7.

6.1.2 External Pulse Mode

In this mode, the camera starts the exposure on the rising edge of the external trigger signal. At this time, the line period is determined by the interval between the rising edges of the external trigger pulse.

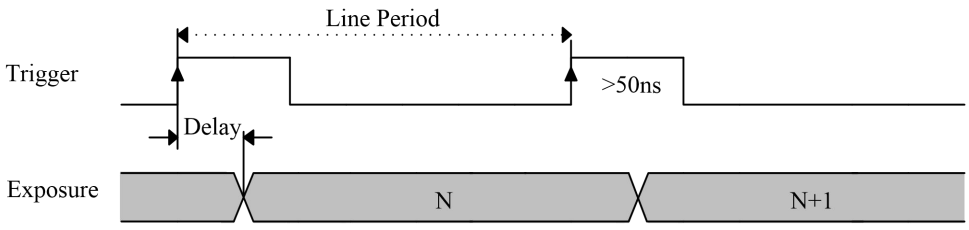


Fig.11 External Pulse Trigger Mode

Note that there is an exposure delay from the rising edge of the external trigger to the actual exposure of the camera. In addition, in order for the camera to correctly detect each external trigger pulse, the external trigger pulse width must be greater than 50ns.

6.2 Camera Scanning Direction

The camera scan direction of PH4KCL is divided into horizontal scanning direction and vertical scanning direction, as shown in the figure below.

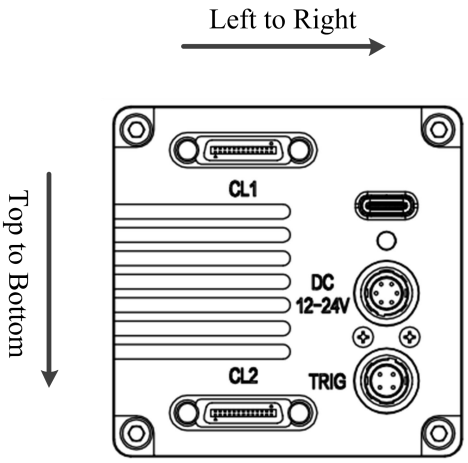
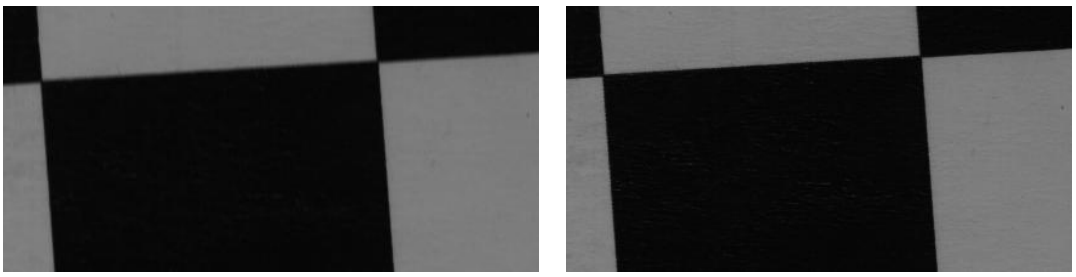


Fig.12 Camera Scanning Direction

The horizontal scanning direction can be left to right or right to left.

The vertical direction supports the output of images from top to bottom or bottom to top. The direction can be controlled internally by the camera or externally by the CC3 channel of the Camera Link cable.

Note that when the vertical scanning direction and the object motion direction do not match, the image edge will be blurred.



(a) Contrary to the direction of motion of the object (b) Identical to the direction of motion of the object

Fig.13 Diagram of Vertical Scanning Direction

6.3 Binning

PH4KCL camera supports binning function. After normal exposure acquisition, camera sums up values of two adjacent pixels and outputs them as a single pixel value. With binning feature, SNR can be improved by about 1.4 times and the number of effective pixels in a frame can be reduced by half.

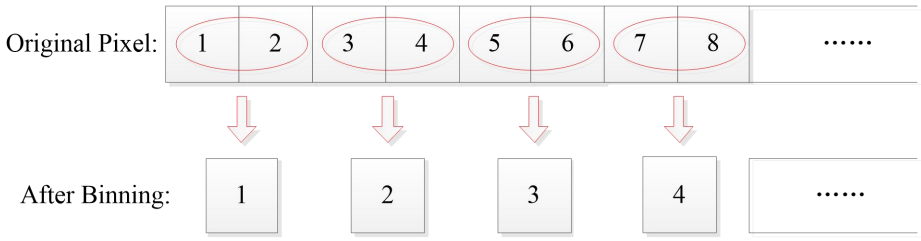


Fig.14 Horizontal Binning_2x1

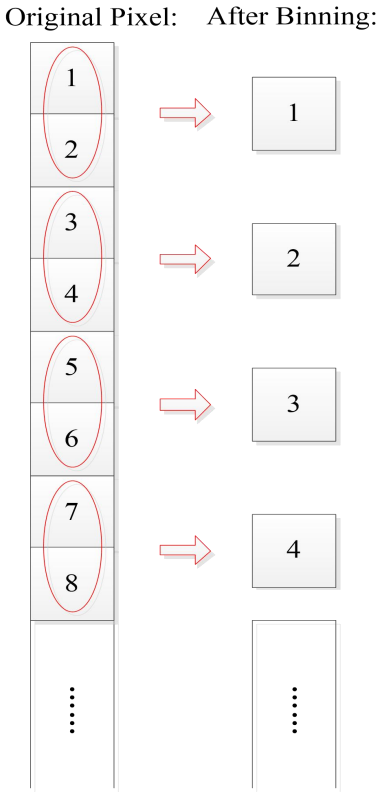


图 15 Vertical Binning_2x1

6.4 LUT

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

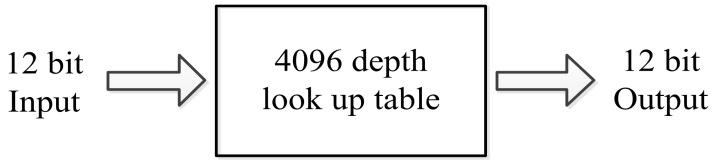


Fig.16 LUT Structure

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

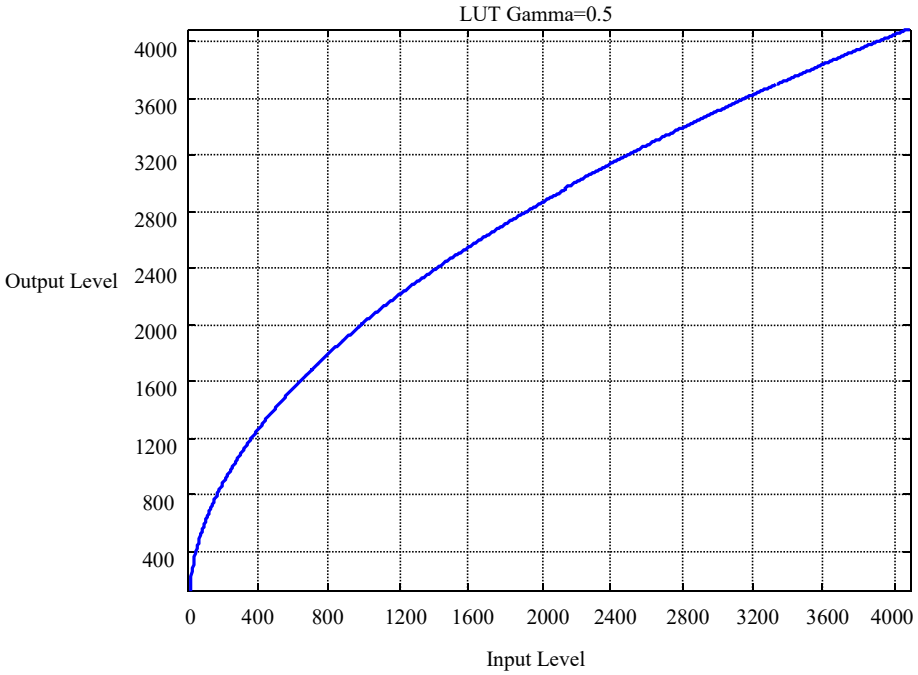


Fig.17 Look Up Table for Gamma=0.5

6.5 Flat Field Correction

Ideally, when the camera captures a uniform target, the gray value of all pixels in the image should be the same. However, the values of each pixel in the real image often vary greatly. These differences may result from uneven illumination, inconsistent transmittance between lens center and lens edge, and inconsistent pixel response of camera sensor, etc. The difference of sensor pixel response has been corrected before delivery. Flat field correction is mainly used to correct the dark edge on both sides of the image caused by the lens. The camera will calculate the correction parameters of each pixel and store them in the camera to correct the image.

The flat field correction result is shown in the following figure:

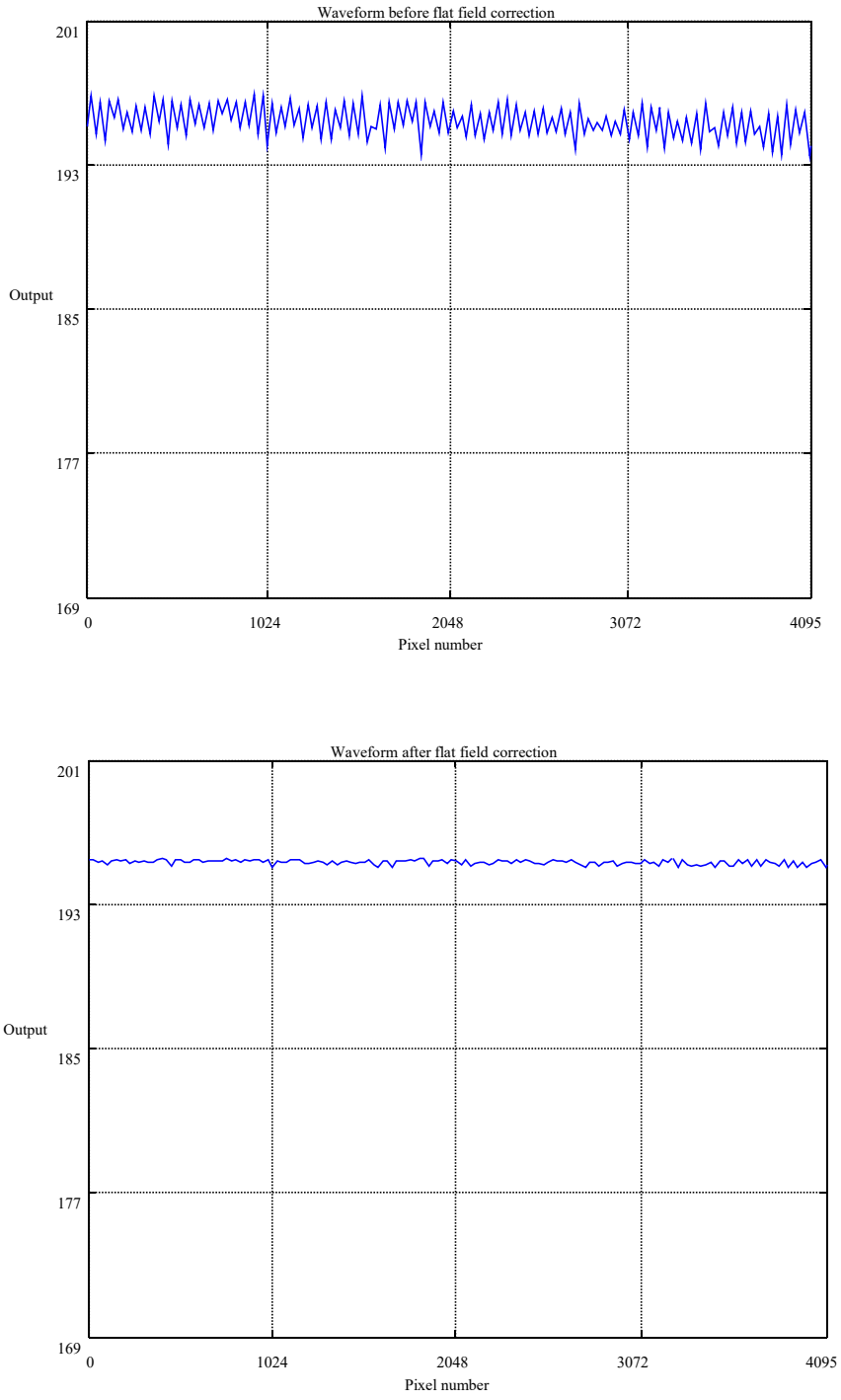


Fig.18 Flat Field Correction

6.6 Test Image

In order to better adapt to different scenes, PH4KCL camera supports three types of image output:

- Original image
- Corrected image
- Test image

The test image is generally used to test whether the data link is smooth, and also for users to perform various debugging.

The figure below shows the rolling diagonal stripe mode. The horizontal image data of the output image is continuously increasing. After reaching the maximum value, it starts counting from 0 again and repeats the cycle.

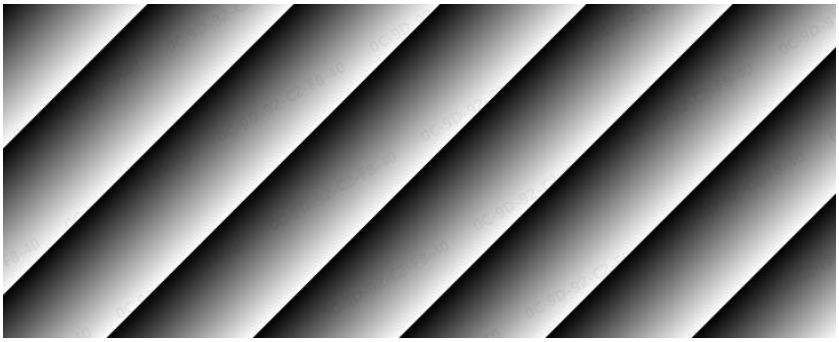


Fig.19 Test Image

6.7 Camera Link Output Mode

Data outputs from Camera Link interface. The camera supports multiple modes of Base, Medium, Full and Full+. Their tap arrangements are as follows:

Base:

Medium:

Full:

Full+

Fig.20 Camera Link Output Mode

6.8 Data Format

PH4KCL-200KU camera processes image data in the unit of 12 bit. You can determine the data format (8 bit, 10 bit or 12 bit) of image data transmitted from the camera by using command. When the camera is set for 8 bit or 10 bit data format, the 4 or 2 least significant bits will be dropped from overall 12 bits.

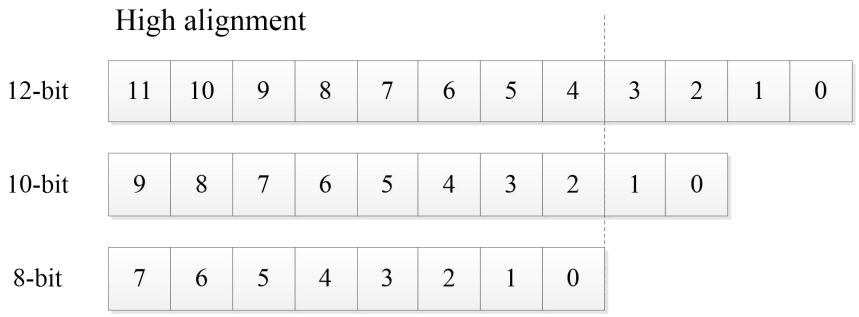


Fig.21 Data Format

6.9 Gain & Offset

Camera gain is divided into analog gain and digital gain.

The analog gain acts on the analog signal. Generally, increasing the analog gain can obtain a stronger response under weak illumination, thereby obtaining a higher signal-to-noise ratio. Users can configure the analog gain of the camera.

Digital gain can adjust the range of data output from AD converter. It is usually used to increase the dynamic range of the output image. It can also be used to adjust the brightness of the image. Digital offset is usually used to adjust the overall background brightness of an image.

The digital gain parameter range is 0.01~7.998. The influence of the digital gain on the output data can be summed up as the following formula:

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

The digital offset parameter range is -4095 to 4095. The influence of digital offset on the output data can be attributed to the following formula (the part with output value <0 will be output as 0) :

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

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

6.10 Camera Temperature

PH4KCL supports real-time acquisition of camera temperature, and users can monitor the working status of front-end sensor by reading camera temperature value.

The recommended ambient temperature range of the camera is from 0℃ to 55℃. If the user detects an abnormal temperature (such as over 70℃), it is recommended to stop the camera immediately and contact our technical support.

6.11 Load / Save Configuration

The camera supports three sets of working parameter sets, including one factory default parameter set and two user parameter sets. The factory parameter set is not allowed to modify. The parameters have

been optimized and can be used in most scenarios. In order to meet the differences of users' specific use environment, the camera provides two sets of user working parameters, which 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 you modify the saved parameters, you can restore the factory default parameter set and reconfigure it.

7 Camera Configuration

PH4KCL camera supports users to send control commands to the camera through the serial channel of the Camera Link interface, and configure the camera working mode.

7.1 Serial Port Parameters

Table 11 Serial Port Parameters

Serial Port Parameters	Value
Baud Rate	9600
Data Bit	8
Parity Bit	N/A
Stop Bit	1
Flow Control	N/A

7.2 Command Format

The commands received by the camera have the following two formats depending on whether the command has parameter:

- **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]

Output: >Ok[CR]

- **Format 2**

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

For example, input: list[CR]

Output: >[MEM][CR]>Ok[CR]

- **Format 3**

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

For example, input: clnk[CR]

Output: >[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 12 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 PH4KCL camera is as follows. After connecting the camera through serial port, you can input relevant commands to configure the camera.

Table 13 Camera Instruction List

Command	Syntax	Description
HELP	HELP	Show this information
LOAD	LOAD=0/1/2	Load configuration from flash (0/1/2: Factory/User1/User2
SAVE	SAVE=1/2	Save current configuration to flash (1/2: User1/User2)
LIST	LIST	Show current configuration parameters
TEMP	TEMP	Get current camera temperature
ANGN	ANGN=1/2/4/8	Set camera analog gain (0/1/2/3:1x/2x/4x/8x)
PXGN	PXGN=0/1	Set camera pixel gain (0/1: Low, High)
SYNC	SYNC=0/1	Set synchronization mode (0/1: Internal Free Run/External Pulse)
CLNK	CLNK=2/4/8/10	Set Camera Link tap mode (2/4/8/10)
PCLK	PCLK=0/1/2	Set Camera Link pixel clock (0/1/2: 85/80/72 MHz)
FTSC	FTSC=0/1	Set trigger source (0/1: IO/CC1)
FTPR	FTPR=0/1	Set trigger polarity (0/1: rising/falling edge)
FTDP	FTDP=[0,10000]	Set input line debouncing period in microsecond
TPRD	TPRD=[5,10000000]	Set line period time in microsecond (5us to 10s)
DIGN	DIGN=[0,4095]	Set digital gain ([1,4095]: [1/512:(8-1/512)])
DIOS	DIOS=[-4095,+4095]	Set digital offset (-4095~4095)
DMOD	DMOD=0/1/2	Set data mode (0/1/2: Original/Corrected/Test pattern)
BITS	BITS=8/10/12	Set pixel width 8/10/12
BINX	BINX=1/2	Set horizontal binning mode (1/2 x1/x2)
BINY	BINY=1/2	Set vertical binning mode (1/2 x1/x2)
ROIX	ROIX=[0,4080]	Set ROI start column number (0-4080)

ROIW	ROIW=[16,4096]	Set ROI width (16-4096)
SLUT	SLUT=0/1	Set lookup table mode (0/1: Disable/Enable)
WLUT	WLUT=(addr,data)	Write lookup table data (addr,data)
RLUT	RLUT	Read lookup table data
FFCR	FFCR=0/1	Turn on/off flat field correction
FFCL	FFCL=0/1	Flat field calibration (0/1: Init/Calibrate)
FFCM	FFCM=0/1	Set flat field calibration mode (0/1: Auto adjust/Adjust to DREF)
FFCS	FFCS=[0,4080]	Set flat field calibration offset (0-4080)
FFCW	FFCW=[16,4096]	Set flat field calibration width (16-4096)
DREF	DREF=[0,4096]	Set flat field calibration reference (0-4096)
LPFW	LPFW=[0,255]	Set flat field low-pass filter width (0-255)
MLGN	MLGN=[1,256]	Set Multi-Line Gain (1-256)
VDIR	VDIR=0/1	Set vertical scan direction (0/1: Top to Bottom/Bottom to Top)
VEXT	VEXT=0/1/2	Set vertical scan direction external control (0/1/2: Internal/CC3 High/ CC3 Low)
HDIR	HDIR=0/1	Set horizontal scan directory (0/1: Left to Right/Right to Left)
BAUD	BAUD=[9600,460800]	Set Camera Link Serial Port Baudrate (9600 to 460800 bps)
AREA	AREA=0/1	Turn on/off area mode
GENCP	GENCP=0/1	Switch to gencp mode (0/1)

8 Camera Configuration Tool

Hefei I-TEK Optoelectronics Co., LTD. designed a special camera configuration tool software IKTool, it is used for users to directly perform related operations such as parameter setting and command configuration on the camera.

8.1 IKTool Interface

The main window of IKTool includes menu bar, camera configuration area and status bar, as shown in the figure below.

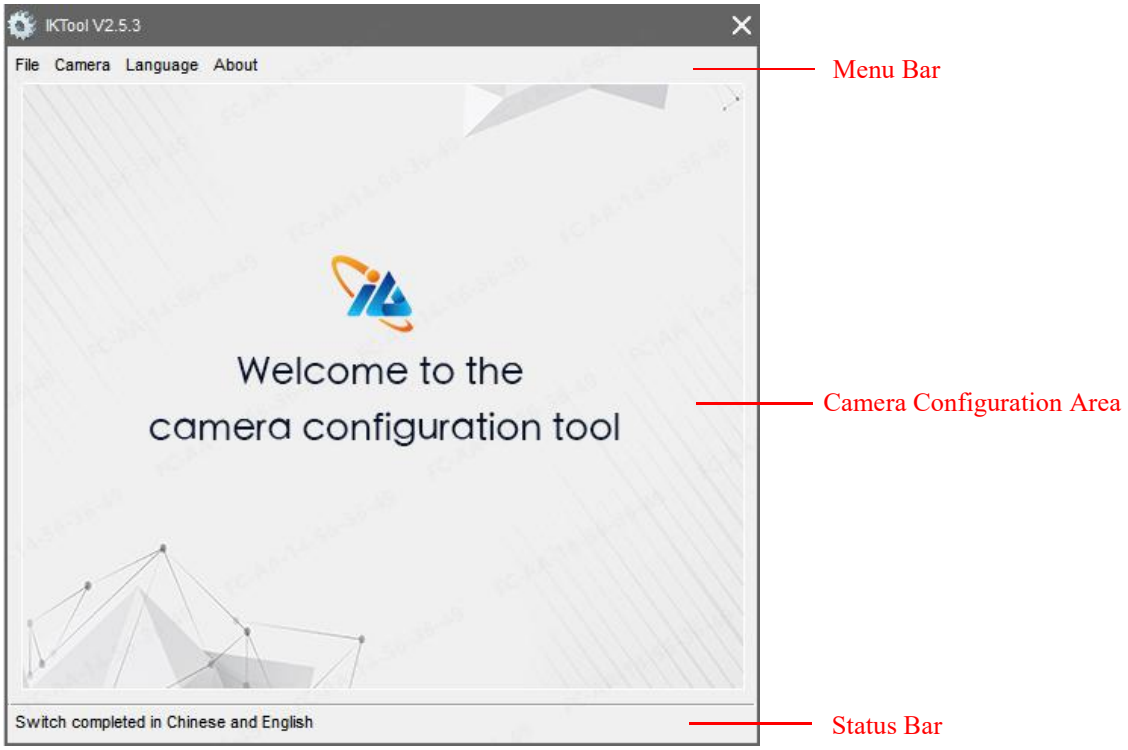


Fig.22 Graphic Interface

8.2 Menu Bar

IKTool menu bar includes four main menus: “File”, “Camera”, “Language” and “About”, and each main menu contains several sub-menus. Among them, the “File” menu provides camera parameter loading, saving and reading features. The “Camera” menu provides camera probing and control dialog boxes. The “Language” menu provides Chinese and English switching functions. The “About” menu provides information of software and currently connected cameras.

8.2.1 File

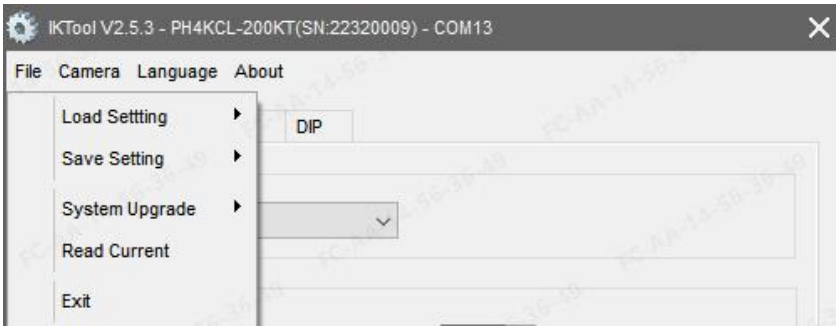


Fig.23 “File” Menu

- **Load Setting**

Read and load configuration parameters from camera. You can choose to load factory setting parameters or user parameters.

- **Save Setting**

Save the current camera configuration parameters to camera. Be noted that only user parameters can be saved.

- **System Upgrade**

Upgrade the camera firmware. The user can choose to upgrade the camera firmware.

- **Read Current**

Read the current configuration parameters of the camera and update the software display.

- **Exit**

Exit IKTool software.

8.2.2 Camera

Fig.24 “Camera” Menu

- **Camera Scan**

Click this option to pop up the Camera Scan window, which is used to search for the camera connected to the computer, and select the camera to be configured for connection and operation.

The Camera Scan window is shown in the figure below. A list of cameras recognized by the software is shown. You can select the camera to be configured and click the “OK” button to return. The software will read and display the configuration parameters of the selected camera. You can also click the Probe button to search the camera again.

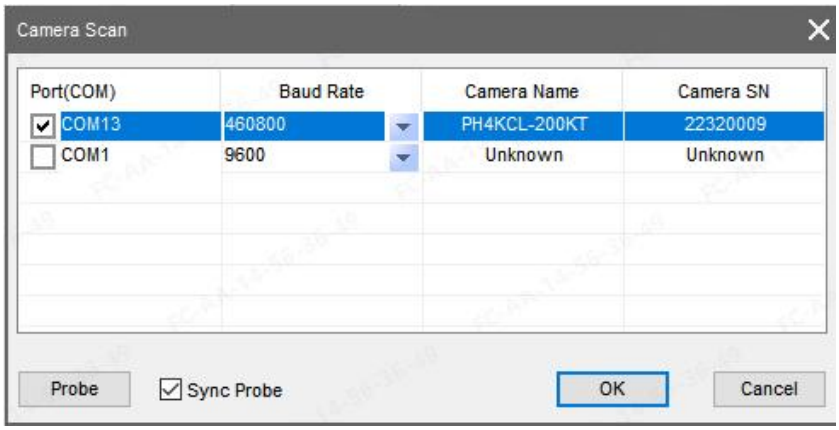


Fig.25 Camera Scan Window

- **Control Terminal**

Click this option to pop up the Control Terminal window, in which you can manually enter the configuration command to change the parameters or configure the camera, as shown in the figure below (Refer to 7.3 for configuration commands).

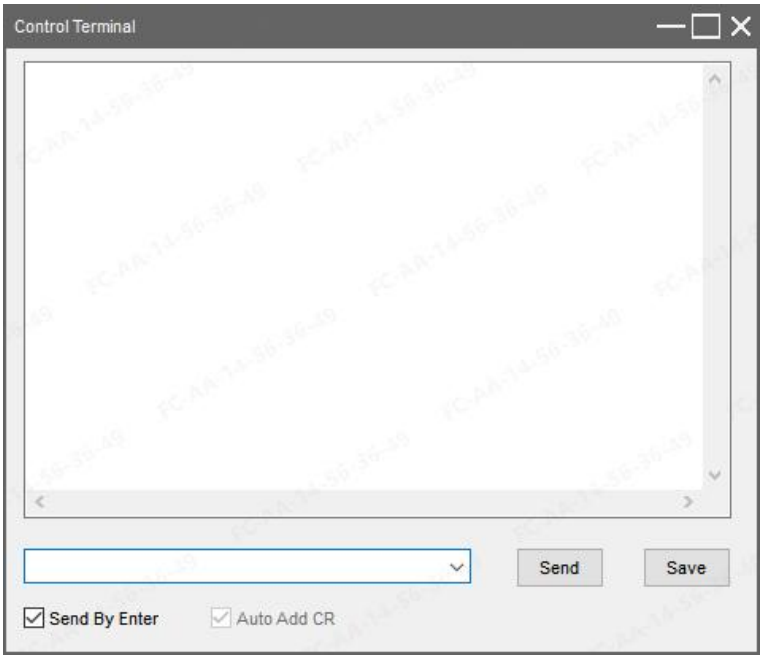


Fig.26 Control Terminal Window

- **Send By Enter**

Select whether to enable the “Enter” key for sending.

8.2.3 Language

Fig.27 “Language” Menu

For the convenience of users, IKTool has added Chinese and English switching functions, which solves the language barriers in the use of software.

8.2.4 About

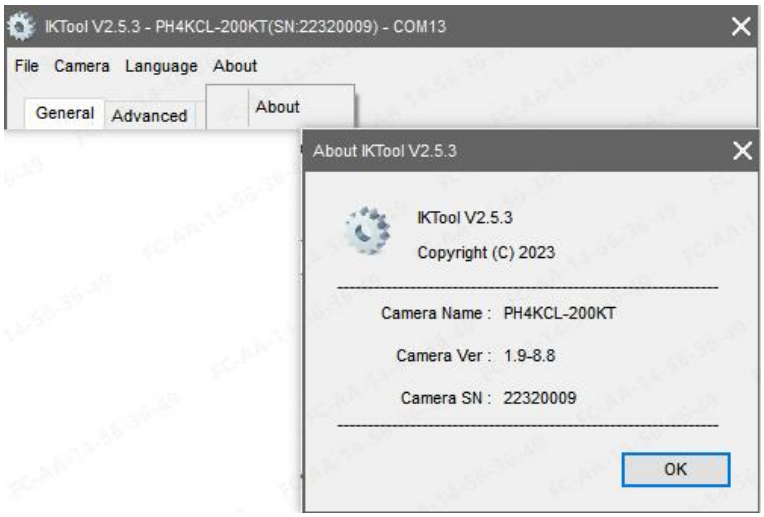


Fig.28 “About” Menu

- **About**

Display information of software and current connected camera (model, serial number, version, etc.)

8.3 Camera Configuration Area

When the camera is connected, the camera configuration area will display camera related parameters on several pages. The configuration area of PH4KCL-200KU camera includes four tabs: “General”, “Advanced”, “LUT” and “DIP”.

8.3.1 General

The “General” tab is used to set the camera's general parameters, including: analog gain, ROI, Camera Link mode .etc.

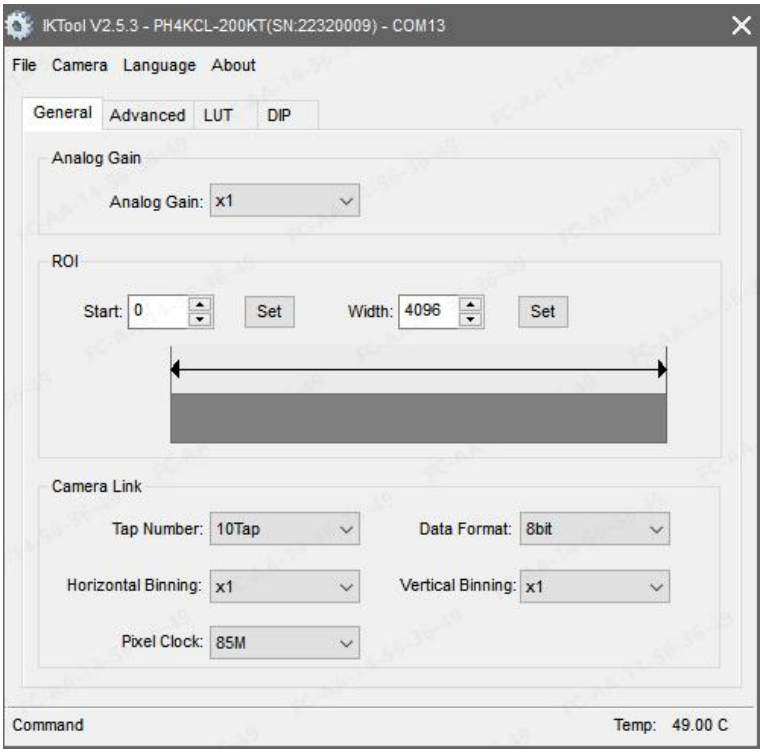


Fig.29 General

< Analog Gain >

- **Analog Gain**

Set camera analog gain, there are four options: X1/X2/X4/X8.

< ROI >

- **Start**

Set the image display starting position pixel, the setting range is 0 to 4080.

- **Width**

Set the image display width in pixels, 16 ≤ setting value ≤ 4096- start value.

Note: The gray area is the area of interest set by the user. The starting coordinate must be a multiple of 16. If not, it will automatically jump to the nearest multiple of 16. The width must be a multiple of 16. If the width is not satisfied, the value is automatically changed to a multiple of 16 closest to the input value.

<Camera Link>

- **Tap Number**

Users can select tap specifications here, there are 2/4/8/10 four options. Different tap modes are available for different bit widths. The more tap counts, the higher the maximum line rate that the camera can support.

- **Data Format**

The user can choose the bit width here. There are three options: 8/10/12.

At this time, the user should pay attention to the tap and bit settings of the frame grabber should also match the mode of the camera, otherwise, abnormal drawing will be caused.

- **Horizontal Binning**

Set camera horizontal binning, there are two options: X1 and X2.

- **Vertical Binning**

Set camera vertical binning, there are two options: X1 and X2.

- **Pixel Clock**

Select the pixel clock frequency of the Camera Link bus. The PH4KCL-200KU camera supports three different pixel clocks of 85/80/72MHz, reducing the user's requirements for cables.

8.3.2 Advanced

The “Advanced” tab is used to set advanced camera parameters, including: scan direction, exposure, line trigger.

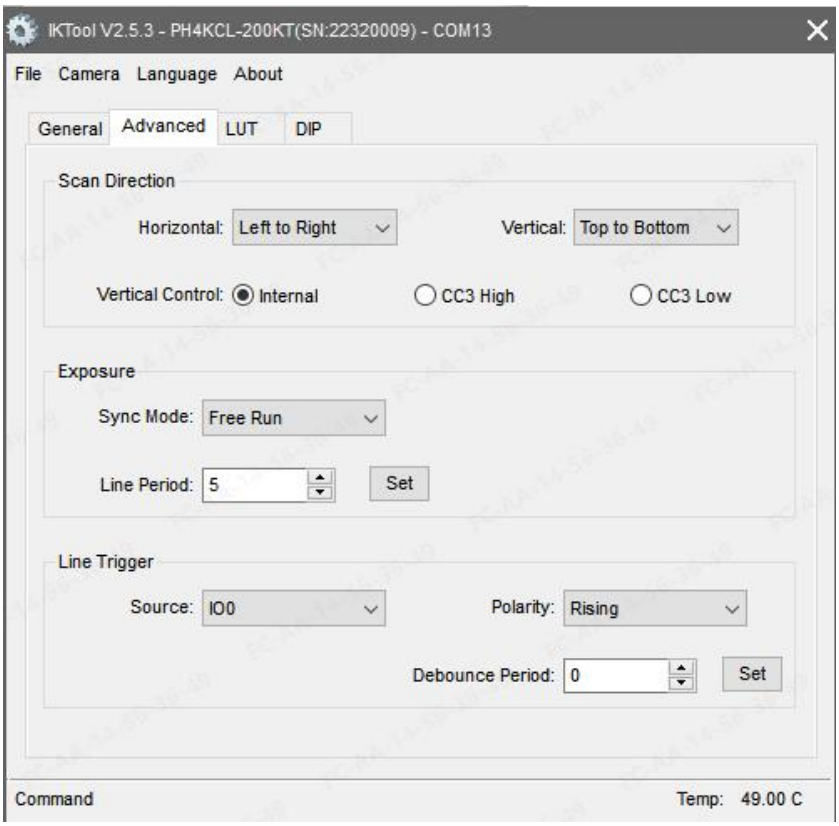


Fig.30 Advanced

< Scan Direction >

- **Horizontal**

Set the horizontal scanning direction of the camera. PH4KCL camera supports users to choose from left to right and right to left, which makes it easy for users to adapt to the mechanical installation direction.

- **Vertical**

Set the vertical scanning direction of the camera. PH4KCL camera supports users to choose from top to bottom and bottom to top.

- **Vertical Control**

There are three options for setting the camera's vertical scanning direction control mode: internal, CC3 high and CC3 low. The user can internally control the image output sequence from top to bottom or bottom to top, and can also control the camera's vertical scanning direction by switching the CC3 high and low levels.

< Exposure >

- **Sync Mode**

By selecting camera trigger mode, users can set the camera to one of three modes: internal free running, external pulse trigger, and external pulse width modulation trigger. In free-run mode, the control timing sequence is generated automatically inside the camera without external trigger signal provided by the user. When an external trigger signal is generated, the camera outputs one line of image, and then scans multiple lines to form a complete image. The number of scanned lines is specified by the user.

- **Line Period**

Set the camera line scan period, the unit is “μs”, and the range of line period is from 5 to 10000000. In Free-Run mode, the line period is the time required to scan one line. Users can control the exposure time through the line period.

< Line Trigger >

- **Source**

Select the Camera trigger source, users can select an external I/O or CC1 signal cable through the Camera Link interface to trigger the Camera.

- **Polarity**

Select camera trigger polarity, there are two options: rising edge/falling edge.

- **Debounce Period**

Set debouncing delay time, this option is used to remove part of the burr signal. The unit is μs. The value ranges from 0 to 10000.

8.3.3 LUT

The “LUT” tab is primarily for user lookup table settings. Users can read the lookup table of the camera or file and display it. They can also store the lookup table as a CSV file or write it to the camera, as shown in the following figure.

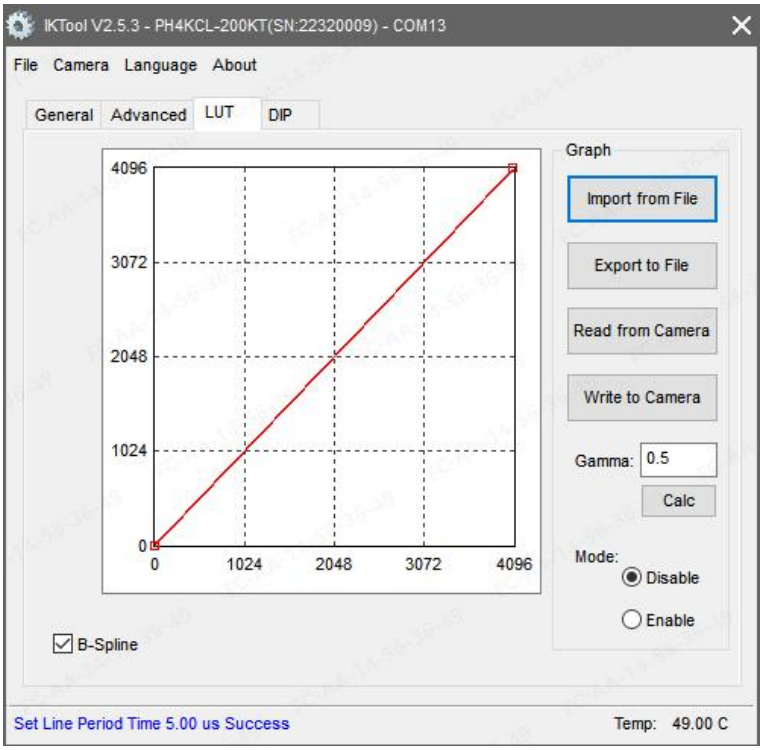


Fig.31 LUT

- **B-spline**

Select whether to enable B-spline. When this function is enabled, users can customize the mapping curve.

< Graph >

- **Import from File**

Load lookup table data file from computer (CSV file).

- **Export to File**

Save the current lookup table to a CSV file.

- **Read from Camera**

Read lookup table data from camera.

- **Write to Camera**

Save the current lookup table data to the camera.

- **Gamma**

Write the gamma value in the text box, and then click the “Calc” button. IKTool will calculate the lookup table corresponding to the gamma value and then display it in the image box.

- **Mode**

Select whether lookup table is enabled in the camera.

8.3.4 DIP

On the “DIP” tab, parameter settings include: flat field correction, data mode, baud rate, digital gain and digital offset, etc.

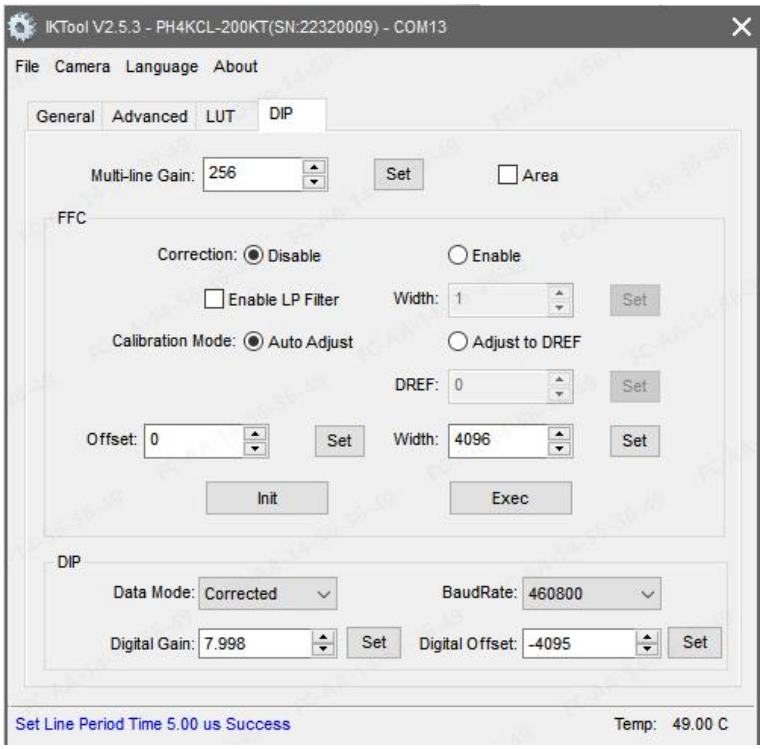


Fig.32 DIP

- **Multi-line Gain**

The camera can support 1~ 256 line time delay integration.

- **Area**

The camera can output an image with 4096*256 resolution in area array mode.

< FFC >

- **Correction**

Users can choose whether to enable flat field correction.

- **Enable LP Filter**

Users can choose whether to enable low-pass filter, and the filter width needs to be set when enabling.

- **Calibration Reference Mode**

In the flat field correction, the reference value is adaptive or the reference value manually set by the user.

- **DREF**

Set the reference value manually by the user.

- **Offset**

Set the pixel value of the offset from the starting position of the flat field correction to the left. Set the values between 16 and 4080.

- **Width**

Set the width of the flat field correction area in pixels, 16≤ setting value ≤ 4096-offset.

- **Init**

Restore the flat field correction parameters to factory correction parameters.

- **Exec**

Perform flat field correction.

< DIP >

- **Data Mode**

By selecting image data mode, users can select the original image, corrected image and test image for output.

- **Baud Rate**

Users can set the baud rate from 9600bps to 460800bps in the drop-down list box. The higher the baud rate, the faster the communication rate over a serial port.

- **Digital Gain**

The user can set the digital gain amount through the fine-tuning button or directly in the edit box, and then click the “Set” button to configure the parameters to the camera.

- **Digital Offset**

The user can set the digital offset value through the fine-tuning button or directly in the edit box, and then click the “Set” button to configure the parameters to the camera.

8.4 Status Bar

The status bar of IKTool allows you to display the execution status of the configured camera parameters (lower left corner) and to display the real-time temperature of the camera (lower right corner), as shown in the figure below.

Fig.33 Status Bar

Note: A “cancel” button will appear in the status bar during parameter configuration. If a parameter configuration lasts too long, click this button to cancel the operation.

Fig.34 “Cancel” Button

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 the Camera Link interface cannot receive camera clock signal,**

① Ensure that the camera has started properly (i.e. the status indicator should be normally green).
② If a third-party Frame Grabber is used to acquire images, ensure that the Frame Grabber and supporting software are operating properly, which can be checked by restarting the computer.
③ Ensure that Base and Medium configurations of the 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 the trigger pulse correctly (it can be confirmed by the status indicator display).
③ If the 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 case is hot or the camera is smoking, cut off the power immediately and stop using the camera. 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 the external pulse input is normal in the External Pulse mode by the camera indicator.

If you 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.