China Daheng Group, Inc. Beijing Image Vision Technology Branch

MARS CoaXPress Cameras

User Manual

Version: V1.0.0

Date: 2023-09-25

Web: www.daheng-imaging.com/en

Sales Email: isales@daheng-imaging.com

Sales Tel: +86 10 8282 8878-8081

Support Email: isupport@daheng-imaging.com

Preface

We really appreciate your choosing of DAHENG IMAGING products.

The MARS CoaXPress camera is DAHENG IMAGING's latest area scan industrial digital camera with large and high-quality sensor, featuring high resolution, high definition and extremely low noise. The camera is equipped with standard CoaXPress interface for high transmission speed and high transmission stability.

The MARS CoaXPress cameras are especially suitable for machine vision applications such as industrial inspection, medical, scientific research, education and so on.

This manual describes in detail on how to install and use the MARS CoaXPress digital cameras.

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1. Introduction

1.1. Series Introduction

The MARS CoaXPress camera is DAHENG IMAGING's latest industrial digital camera, featuring high quality images, low power, high transmission speed, stable operating capability, and rapid cooling characteristics. The cameras are available in a variety of resolutions and frame rates, and are available with multiple cooling options: Thermoelectric Cooling (TEC) with a fan, fan and passive cooling. The camera with TEC system can quickly reduce the camera image sensor temperature to 15 degrees below ambient temperature within 5 minutes under room temperature, so that the sensor can work in a stable operating condition, thus significantly reducing hot pixel noise and achieving better image quality.

The MARS CoaXPress camera transmits image data through the CoaXPress data interface and can secure the reliability of cameras deployed in harsh industrial environments. These cameras are especially suitable for machine vision applications such as FPD, PCB, and consumer electronics inspections.

1.2. Naming Rules

Details of the MARS CoaXPress camera are given in the general specifications below. Each camera model name is determined by its sensor's maximum resolution, maximum frame rate at maximum resolution, the color/monochrome type of the sensor, etc.

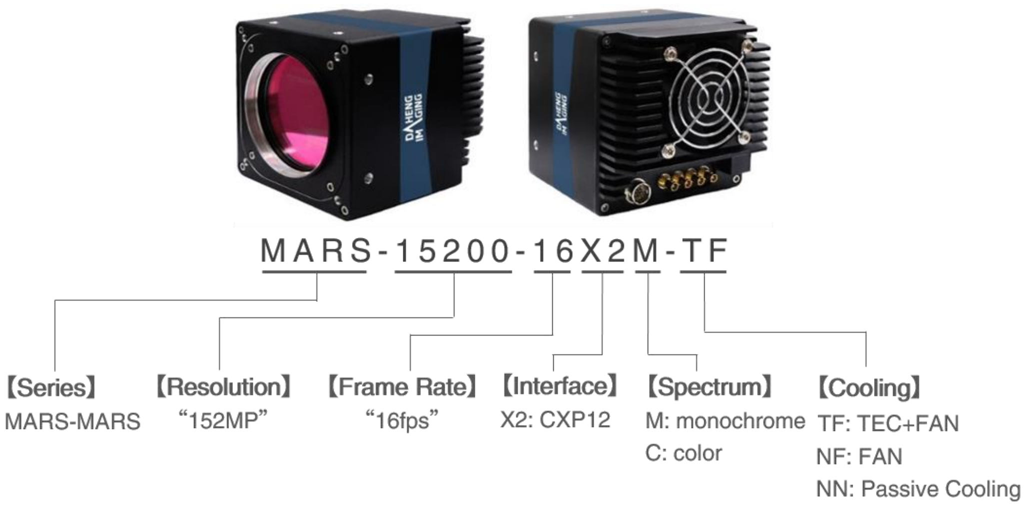


Figure 1-1 Naming rules

1.3. Standards

The camera follows the CoaXPress2.0 standard, and can cooperate with the mainstream manufacturer's frame grabbers such as Matrox, Euresys, DAHENG IMAGING for image acquisition and control.

1.4. Document, CAD/Technical Drawing and Software Downloads

Product related document, CAD/Technical drawing and software can be downloaded from the Downloads of DAHENG IMAGING website.

2. Precautions

2.1. Safety Claim

Before installing and using DAHENG IMAGING products, please carefully read this manual and strictly comply with the usage requirements. And ensure to use the product in specified conditions, otherwise it may cause equipment malfunction. Our company will not bear any legal responsibility for any damage or injury caused by improper use of this product and disregard of safety instructions.

The symbols that may be found in this document are defined as follows:

Symbol	Description
(Note icon)	Note: Provides additional information to emphasize or supplement important points of the main text
(Warning icon)	Caution: Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance degradation, or unexpected results
	Warning: Indicates a potential risk that, if not avoided, could result in injury accidents, equipment damage, or business interruption
	Danger: Indicates a hazard with a high level of risk, which if not avoided, will result in death or serious injury

2.2. Safety Instruction

Usage	
Warning	1) Do not install and operate the product in extreme environments with vibration, high temperature, humidity, dust, strong magnetic fields, explosive/corrosive smoke or gases, as it may damage the camera, cause a fire or electric shock. 2) Do not aim at the product with high intensity light sources directly, as it may damage the sensor. 3) If the device damaged, emits smoke, odor or noise, please turn off the power and unplug the power cord immediately, and contact our technical support engineer. 4) Unauthorized disassembly, repair, or modification of products is prohibited as it may damage the camera or cause a risk of electric shock. 5) In the use of the device, you must be in strict compliance with the electrical safety regulations of the nation and region. 6) Please use the power supply provided by reputable manufacturers that meets the camera power limit requirements, otherwise, it will damage the camera.
Caution	1) Check whether the device's package is in good condition, whether there is damage, deformation, etc. before unpacking. 2) After unpacking, please carefully inspect the quantity and appearance of the product and accessories for any abnormalities. 3) Please store and transport the product according to the specified storage and transportation conditions, ensure that the storage temperature and humidity meet the requirements.

Personal Safety	
Warning	1) It is strictly prohibited to perform device wiring, dismantling, maintenance and other operations while powered on, otherwise there may be a risk of electric shock. 2) It is prohibited to touch the camera directly during using, otherwise there may be a risk of burns. 3) Please install and use the camera in accordance with regulations, otherwise there may be a risk of falling and get injured. 4) The edges of the lens mount and fan are relatively sharp, so pay attention to the risk of scratches during installation or use.

2.3. Guideline for Avoiding EMI and ESD

You should consider the EMI (Electro Magnetic Interference) and ESD (Electro-Static discharge) problem in the process of using the camera, to guarantee the camera to work in a relatively good electromagnetic environment. The main measures are as follows:

1) CoaXPress cables certificated by CoaXPress IF are recommended.

2) Using shielded cable can avoid electro-magnetic interface. Shielding layer of the cable should conduct to ground nearby and not until stretched too long. When many devices need conduct to ground, using single point grounding to avoid earth loop.

3) Keep your cameras away from equipment with high voltage, or high current (such as motor, inverter, relay, etc.). If necessary, use additional shielding.

4) ESD (electro-static discharge) may damage cameras permanently, so use suitable clothing (cotton) and shoes, and touch the metal to discharge the electro-static before operating cameras.

5) If condition permit, try to ground the camera housing (e.g., the installation point's mounting rack conduct to ground).

2.4. Environmental Requirements

1) Housing temperature during operation: 0°C ~ 45°C, humidity during operation: 10% ~ 80%.

   Storage temperature: -20°C ~ 70°C.

2) To avoid collecting dust in the optical filter, always keep the plastic cap on cameras when no lens is mounted.

3) Select the CXP frame grabber that matches the camera frame rates, such as DAHENG IMAGING, Matrox, Euresys frame grabber.

4) Multi-channel cameras should use 75Ω coaxial cable certificated by CoaXPress IF.

5) Make sure that cameras are transported in the original factory packages.

2.5. Camera Mechanical Installation Precautions

1) Camera installation requirements:

- MARS-6500-31X2M/C-TF，MARS-6501-31X2M/C-TF，MARS-10300-24X2M/C-TF，MARS-15200-16X2M/C-TF: The front mounting holes M4 screw and the camera should have a screwing length between 4.5mm and 5mm. The four-side mounting holes M5 screw and the camera should have a screwing length between 4.5mm and 5mm.

- MARS-2625-150X2M/C(-NF)，MARS-2626-150X2M/C(-NF)，MARS-6502-71X2M/C(-NF)，MARS-6503-71X2M/C(-NF): The front mounting holes and four-side mounting holes M4 screw and the camera should have a screwing length between 3.5mm and 3.8mm.

2) The M5 screw assembly torque ≤ 6N·M, and the M4 screw assembly torque ≤ 5N·M. If the screw assembly torque is too large, it may cause the camera thread stripping.

2.6. Certification and Declaration

1) CE, RoHS

We declare that DAHENG IMAGING MARS CoaXPress digital cameras have passed the following EU certifications:

- 2014/30/EU—Electromagnetic Compatibility Restriction

- 2011/65/EU—Restriction of Hazardous Substances (RoHS) and its revised directive 2015/863/EU

Equipment meeting Class A requirements may not offer adequate protection to broadcast services within a residential environment.

3. Installation

3.1. Host Preparation

3.1.1. Software Package

Users need to install the installation package provided by the frame grabber manufacturer first, and use the demonstration program and API interface corresponding to the frame grabber to control the camera. At present, Matrox and Euresys frame grabbers are mainly supported. DAHENG IMAGING also provides demonstration program (GalaxyView.exe), which used to display the camera control, image acquisition and image processing functions. The user can control the camera directly by loading the TL library of different frame grabber manufacturers through the demonstration program, but due to the differences in the implementation of TL library of frame grabbers from different manufacturers, there may be some compatibility problems between GalaxyVie.exe and frame grabber, for details, please refer to Chapter 10: FAQ. The Matrox frame grabber recommends using the LUT and static defect correction tool to control the camera.

You can contact our support team for the demonstration program that supports the MARS CoaXPress cameras.

3.1.2. User Software Interface

After installing the camera software package, users can not only use the demonstration program, LUT and static defect correction tool to choose to load the TL library of the frame grabber manufacturer, but also write their own programs to control the camera based on the API interface provided by the frame grabber manufacturer. The user can select the suitable one for use according to their own requirements:

1) GenTL Interface

This interface is developed according to the standard of general transport layer in GEN<i>CAM standard, DAHENG IMAGING follows the GEN<i>CAM standard and provides the GenTL interface for the user, and the user can use the GenTL interface directly to develop their own control program.

2) CoaXPress Vision interface

The camera is compatible with the CoaXPress Vision2.0 protocol, which allows the user to control the camera directly through the CoaXPress Vision protocol.

- Note

GEN<i>CAM standard: GEN<i>CAM is administered by the European Machine Vision Association (EMVA). GenICam provides a generic programming interface for all kinds of cameras and devices. It provides a standard application programming interface (API), no matter what interface technology is being used. It mainly includes the following modules:

- GenAPI: an XML description file format defining how to capture the features of a device and how to access and control these features in a standard way

- GenTL: a generic Transport Layer Interface, between software drivers and libraries, that transports the image data from the camera to the application running on a PC

- SFNC: common naming convention for camera features, which promotes interoperability between products from different manufacturers

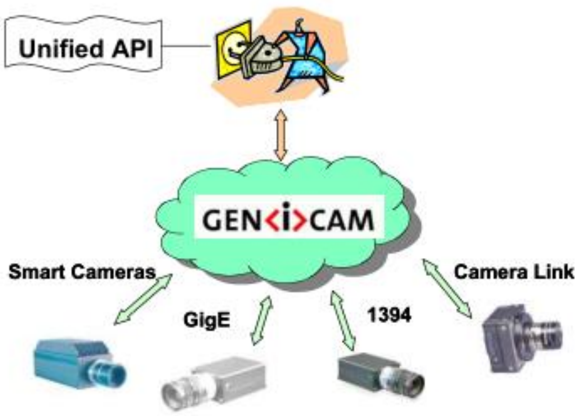


Figure 3-1 GEN<i>CAM standard schematic diagram

3.2. Camera Power

The MARS CoaXPress camera can get power in either of two different ways: via Hirose I/O port or via PoCXP (Power over CoaXPress). When you supply power to the camera via both ways at the same time, the camera will get power via the Hirose I/O port.

1) Via the Hirose I/O port

- For high resolution camera, AC-DC or DC-DC typical operating voltage is +24VDC (±10%), output current is recommended above 2A

- For high speed camera, AC-DC or DC-DC typical operating voltage is 12-24 VDC, output current is recommended above 2A

- Hirose I/O cable Pin4 (purple) and Pin11 (white orange) must be parallel connected to the external AC-DC power supply or the positive electrode of DC-DC power supply output.

- If use 24V extend power cable, the American Wire Gauge of cable need greater than 24AWG (The cross section is greater than 0.2047mm^2, and the resistance value is less than 89.4Ω/km)

2) Via PoCXP (Power over CoaXPress)

- For high resolution MARS CoaXPress camera, the CH1, CH2, CH3 and CH4 of the CXP connector must connect to their correct channels before power on.

- For high speed MARS CoaXPress camera, the CH1 and CH2 of the CXP connector must connect to their correct channels before power on.

3) With Hirose I/O port connection and the frame grabber supports PoCXP

- It is recommended that the camera be powered up via the Hirose I/O port before connecting the corresponding CXP cable.

3.3. Camera Connection

Make sure that you have installed a CoaXPress 2.0 frame grabber in your computer including related software. Then you can prepare to configure a link between a camera and CXP-12 Frame Grabber by using four coaxial-cables.

To connect the camera to your computer, follow the steps below:

1) Plug one end of a coaxial-cable into the CH1 of the CXP connector on the camera and the other end of the coax cable into the CH1 of the CXP-12 frame gabber in your computer. Then, connect the CH2, CH3 and CH4 of the CXP connector on the camera to the CH2, CH3 and CH4 of the CXP-12 Frame Grabber respectively using the other three coaxial-cables.

- Connect the plug of the HR10A-10R-12PB to the Hirose on the camera.
- Connect the external power pin of the HR10A-10R-12PB to the 24V DC power supply.

2) Verify all the cable connections are secure.

3) To power a camera via PoCXP Frame Grabber, you must connect the power interface of the frame grabber to the power supply of the computer first before the computer is powered on. When the camera is powered via PoCXP, no external power supply needed.

3.4. Open Third-party TL Library

GalaxyView software supports the function to open third-party TL library. The steps are as follows:

1) Open the GalaxyView software, right click on the device list to load GenTL, pop up the menu bar to "Add Cti File" and "Clear Cti File".

2) Choose "Add Cti File", pop up the menu bar to "Add Cti File"

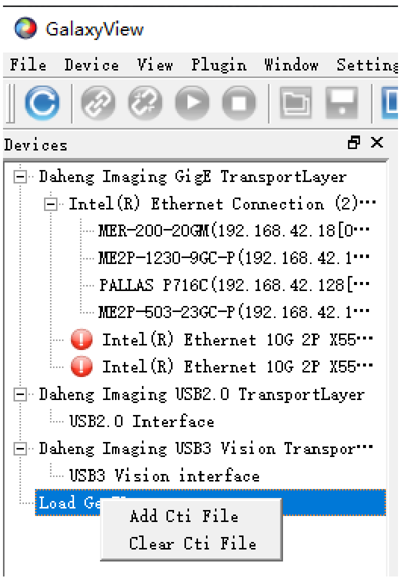


Figure 3-2 add TL file

3) After open the TL file, GalaxyView will automatically load the currently selected .cti file.

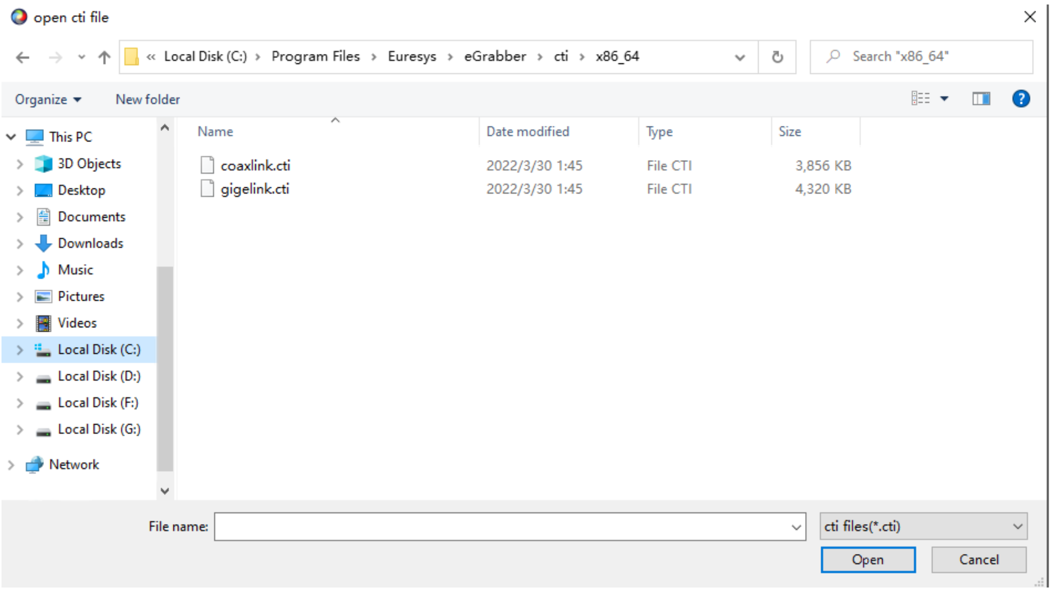


Figure 3-3 Euresys frame gabber add TL file

4) The name of the current frame gabber will be displayed under "Load GenTL". Double-click the name of the current frame gabber to load the CXP camera connected to the frame gabber.

⚠ To use the CXP camera, user need to load the TL file corresponding to the CXP frame gabber.

4. General Specification

4.1. Explanation of Important Parameters

4.1.1. About Spectral Response

QE: Quantum efficiency, which is the ratio of the average number of photoelectrons produced per unit time to the number of incident photons at a given wavelength.

Sensitivity: The change of the sensor output signal relative to the incident light energy. The commonly used sensitivity units are V/((W/m2)·s), V/lux·s, e-/((W/m2)·s) or DN/ ((W/m2)·s).

The spectral response graphs given by different manufacturers are different. Some graphs' ordinate is relative sensitivity response, and abscissa is wavelength. Some graphs' ordinate is QE, and abscissa is wavelength.

4.2. MARS-CXP Series

4.2.1. MARS-6500-31X2M/C-TF \ MARS-6501-31X2M/C-TF

Specifications	MARS-6500-31X2C-TF MARS-6501-31X2C-TF	MARS-6500-31X2M-TF MARS-6501-31X2M-TF
Resolution	9344 × 7000	
Sensor	Gpixel GMAX3265 65MP global shutter CMOS	
Max. Image Circle	29.9mm × 22.4mm	
Pixel Size	3.2μm × 3.2μm	
Frame Rate	31.6fps @ 9344 × 7000	
ADC Bit Depth	12bit	
Pixel Bit Depth	8bit, 12bit	
Mono/Color	Color	Mono
Pixel Formats	Bayer GB8/Bayer GB12	Mono8/Mono12
Signal Noise Ratio	40.3dB	40.1dB
Exposure Time	14μs~1s, Actual Steps: 1 row period	
Gain	0dB~16dB, Default: 0dB, Steps: 0.1dB	
Binning	1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Decimation	Horizontal FPGA, Vertical Sensor: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	

Synchronization	Hardware trigger, software trigger
I/O	1 input and 1 output with opto-isolated, 1 programmable GPIOs, 1 RS232
Operating Temp.	0°C~45°C
Storage Temp.	-20°C~70°C
Operating Humidity	10%~80%
Cooling Method	Thermoelectric Cooling (TEC) with a fan
Cooling Temp.	Typ.: 15°C±0.5°C below ambient temp.@room temp. Max.: 24°C below ambient temp.@room temp.
Power Consumption	Typ.: 24W@24V, ambient temp. 25°C, sensor constant temp. 10°C, TEC&FAN (ON) Max.: 27W@fast cooling (TEC&FAN (ON))
Lens Mount	M58
Data Interface	CXP-12 × 4 (HDBNC)
Dimensions	85mm × 85mm × 114.1mm
Weight	1231g
Operating System	Windows Win7/Win8/Win10/Win11
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity
Conformity	CE, CoaXPress2.0, GenTL

Table 4-1 MARS-6500-31X2M/C-TF \ MARS-6501-31X2M/C-TF camera specifications

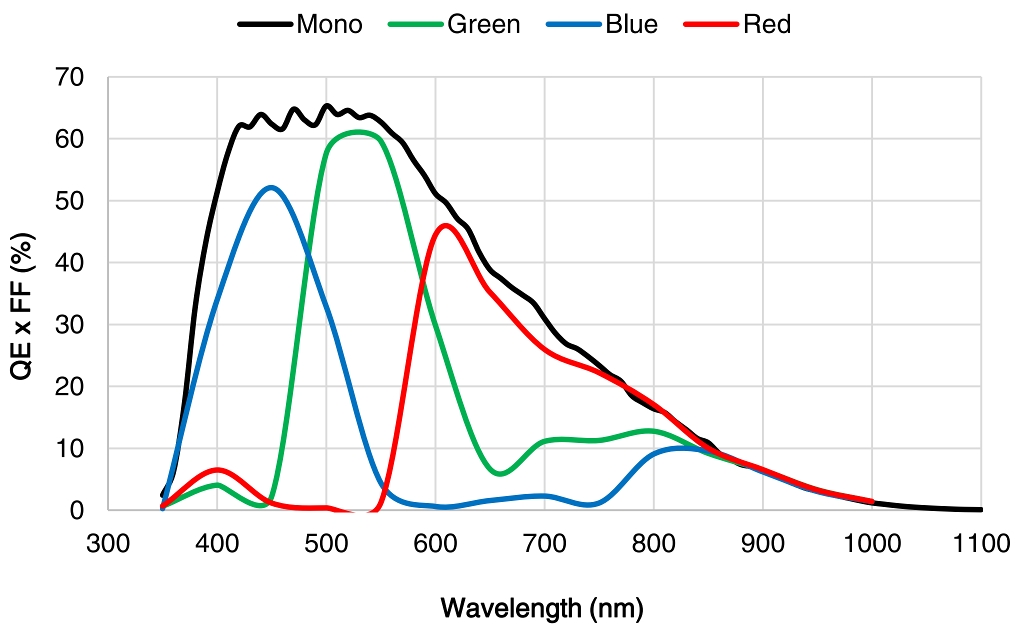


Figure 4-1 MARS-6500-31X2M/C-TF \ MARS-6501-31X2M/C-TF sensor spectral response

4.2.2. MARS-10300-24X2M/C-TF

Specifications	MARS-10300-24X2C-TF	MARS-10300-24X2M-TF
Resolution	11264 × 9200	
Sensor	Gpixel GMAX32103 103MP global shutter CMOS	
Max. Image Circle	36.1mm × 29.4mm	
Pixel Size	3.2μm × 3.2μm	
Frame Rate	24fps @ 11264 × 9200	
ADC Bit Depth	12bit	
Pixel Bit Depth	8bit, 12bit	
Mono/Color	Color	Mono
Pixel Formats	Bayer GB8/Bayer GB12	Mono8/Mono12
Signal Noise Ratio	40.3dB	40.3dB
Exposure Time	20μs~1s, Actual Steps: 1 row period	
Gain	0dB~16dB, Default: 0dB, Steps: 0.1dB	
Binning	1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Decimation	Horizontal FPGA, Vertical Sensor: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Synchronization	Hardware trigger, software trigger	
I/O	1 input and 1 output with opto-isolated, 1 programmable GPIOs, 1 RS232	
Operating Temp.	0°C~45°C	
Storage Temp.	-20°C~70°C	
Operating Humidity	10%~80%	
Cooling Method	Thermoelectric Cooling (TEC) with a fan	
Cooling Temp.	Typ.: 15°C±0.5°C below ambient temp.@room temp. Max.: 24°C below ambient temp.@room temp.	
Power Consumption	Typ.: 22W@24V, ambient temp. 25°C, sensor constant temp. 10°C, TEC&FAN (ON) Max.: 30W@fast cooling (TEC&FAN (ON))	
Lens Mount	M72	

Data Interface	CXP-12 × 4 (HDBNC)
Dimensions	100mm × 100mm × 112.3mm
Weight	1610g
Operating System	Windows Win7/Win8/Win10/Win11
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity
Conformity	CE, CoaXPress2.0, GenTL

Table 4-2 MARS-10300-24X2M/C-TF camera specifications

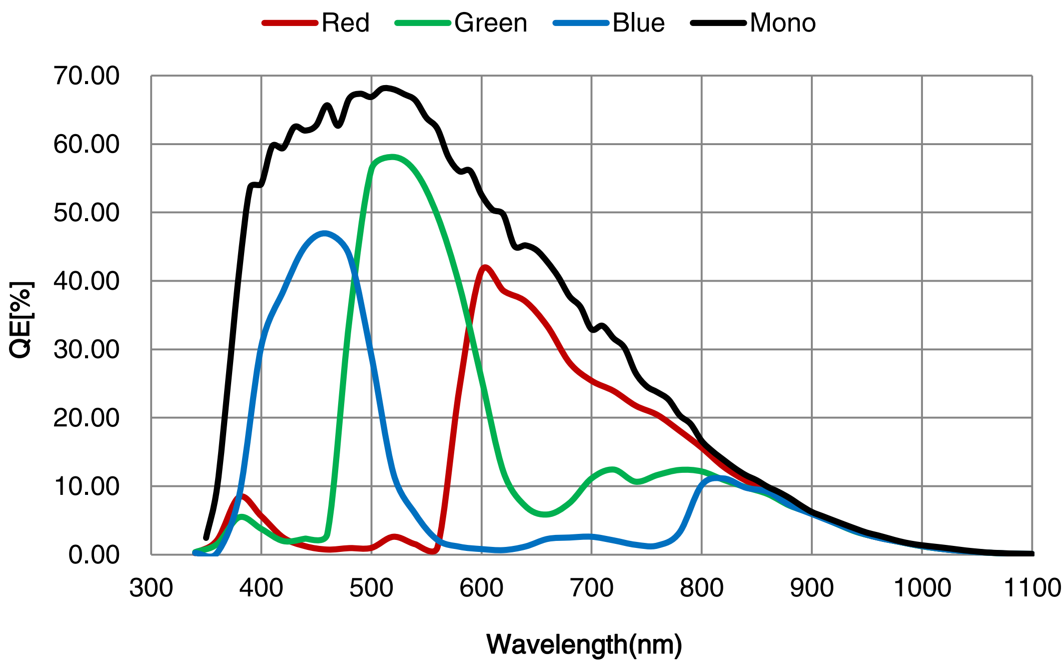


Figure 4-2 MARS-10300-24X2M/C-TF sensor spectral response

4.2.3. MARS-15200-16X2M/C-TF

Specifications	MARS-15200-16X2C-TF	MARS-15200-16X2M-TF
Resolution	16544 × 9200	
Sensor	Gpixel GMAX32152 152MP global shutter CMOS	
Max. Image Circle	53.0mm × 29.4mm	
Pixel Size	3.2μm × 3.2μm	
Frame Rate	16.3fps @ 16544 × 9200	
ADC Bit Depth	12bit	

Pixel Bit Depth	8bit, 12bit	
Mono/Color	Color	Mono
Pixel Formats	Bayer GB8/Bayer GB12	Mono8/Mono12
Signal Noise Ratio	40.4dB	39.5dB
Exposure Time	20μs~1s, Actual Steps: 1 row period	
Gain	0dB~16dB, Default: 0dB, Steps: 0.1dB	
Binning	1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Decimation	Horizontal FPGA, Vertical Sensor: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Synchronization	Hardware trigger, software trigger	
I/O	1 input and 1 output with opto-isolated, 1 programmable GPIOs, 1 RS232	
Operating Temp.	0°C~45°C	
Storage Temp.	-20°C~70°C	
Operating Humidity	10%~80%	
Cooling Method	Thermoelectric Cooling (TEC) with a fan	
Cooling Temp.	Typ.: 15°C±0.5°C below ambient temp.@room temp. Max.: 24°C below ambient temp.@room temp.	
Power Consumption	Typ.: 22W@24V, ambient temp. 25°C, sensor constant temp. 10°C, TEC&FAN (ON) Max.: 30W@fast cooling (TEC&FAN (ON))	
Lens Mount	M72	
Data Interface	CXP-12 × 4 (HDBNC)	
Dimensions	100mm × 100mm × 111.9mm	
Weight	1610g	
Operating System	Windows Win7/Win8/Win10/Win11	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, CoaXPress2.0, GenTL	

Table 4-3 MARS-15200-16X2M/C-TF camera specifications

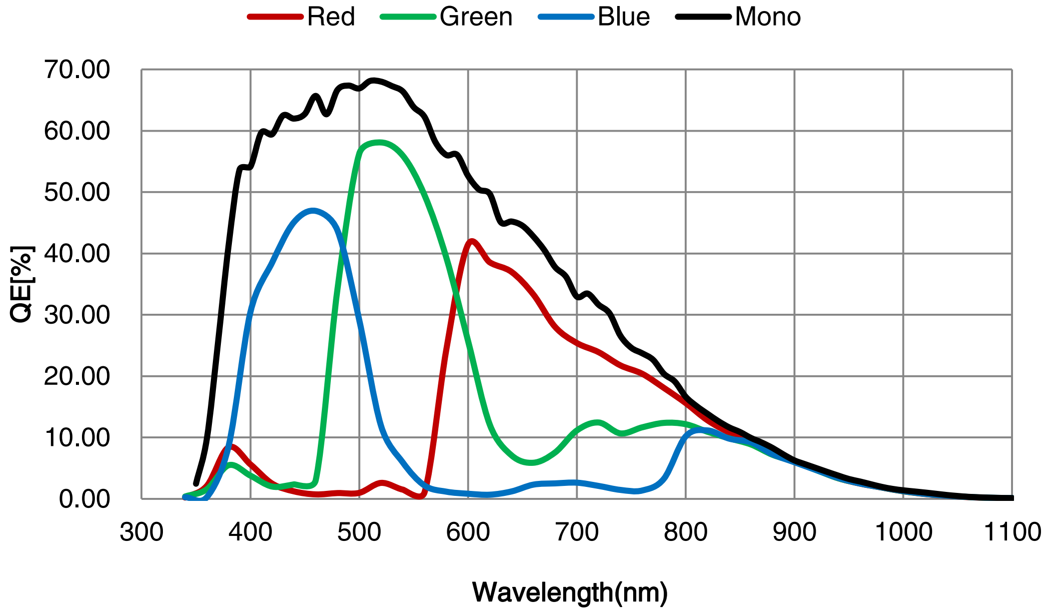


Figure 4-3 MARS-15200-16X2M/C-TF sensor spectral response

4.2.4. MARS-2625-150X2M/C(-NF) \ MARS-2626-150X2M/C(-NF)

Specifications	MARS-2625-150X2C MARS-2626-150X2C	MARS-2625-150X2M MARS-2626-150X2M	MARS-2625-150X2C-NF MARS-2626-150X2C-NF	MARS-2625-150X2M-NF MARS-2626-150X2M-NF
Resolution	5120 × 5120			
Sensor	Gpixel GMAX0505 25MP global shutter CMOS			
Max. Image Circle	12.8mm × 12.8mm			
Pixel Size	2.5μm × 2.5μm			
Frame Rate	150.1fps @ 5120 × 5120			
ADC Bit Depth	10bit			
Pixel Bit Depth	8bit, 10bit			
Mono/Color	Color	Mono	Color	Mono
Pixel Formats	Bayer GB8 Bayer GB10	Mono8/Mono10	Bayer GB8 Bayer GB10	Mono8/Mono10
Signal Noise Ratio	37.0dB	37.7dB	37.0dB	37.7dB
Exposure Time	9μs~1s, Actual Steps: 1 row period			
Gain	0dB~16dB, Default: 0dB, Steps: 0.1dB			
Binning	1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4			
Decimation	Horizontal FPGA, Vertical Sensor: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4			

Synchronization	Hardware trigger, software trigger	
I/O	1 input and 1 output with opto-isolated, 1 programmable GPIOs, 1 RS232	
Operating Temp.	0°C~45°C	
Storage Temp.	-20°C~70°C	
Operating Humidity	10%~80%	
Cooling Method	Passive cooling	Fan
Power Consumption	Typ.: 15W@24V, ambient temp. 25°C, FAN (ON) 13W@24V, ambient temp. 25°C, FAN (OFF)	
Lens Mount	M58, C	
Data Interface	CXP-12 × 4 (HDBNC)	
Dimensions	M58: 74mm × 74mm × 64.70mm C: 74mm × 74mm × 70.20mm	M58: 74mm × 74mm × 75.45mm C: 74mm × 74mm × 81mm
Weight	M58: 515g, C: 459g	M58: 567g, C: 511g
Operating System	Windows Win7/Win8/Win10/Win11	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, CoaXPress2.0, GenTL	

Table 4-4 MARS-2625-150X2M/C(-NF) \ MARS-2626-150X2M/C(-NF) camera specifications

Note: MARS-2626-150X2M/C(-NF) is the Grade2 sensor, MARS-2625-150X2M/C(-NF) is the Grade1 sensor. The only difference between the two cameras is the grade of the sensor. The difference between Grade1 and Grade2 sensors defined by sensor manufacturers is: Grade1 have no consecutive defect pixel cluster, and Grade2 may have up to 12 consecutive defect pixel cluster. The camera has static defect pixel correction function, and it will calibrated for the default factory parameters. If the scene parameters are changed, you can use the static defect pixel correction plugin to re-calibrate. For details please see section 9.3 Static Defect Correction Plugin.

1) Monochrome camera

As shown below, cluster with 4 consecutive defect pixels in a row is not allowed (NOK).

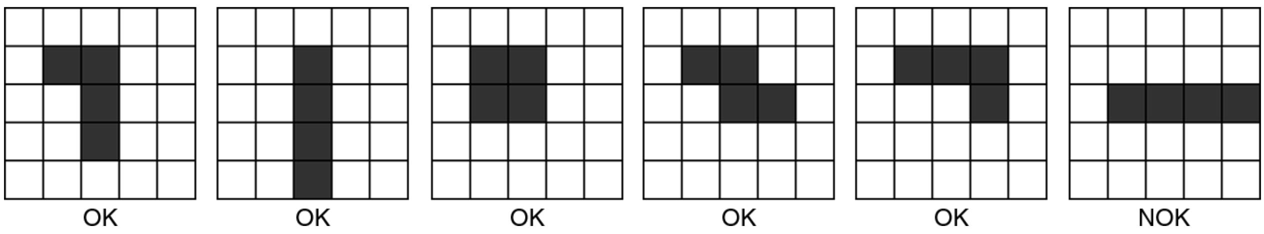


Figure 4-4 MARS-2626-150X2M(-NF) clusters distribution diagram

2) Color camera

Examples 1: Cluster with 4 consecutive defect pixels within the same Bayer color plane in a row is not allowed.

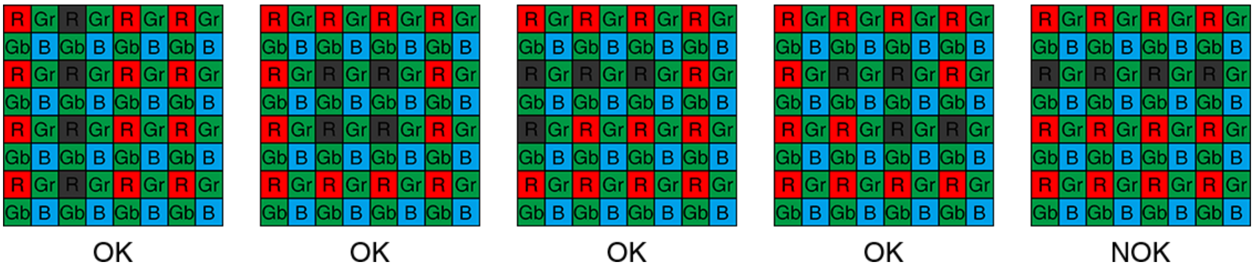


Figure 4-5 MARS-2626-150X2C(-NF) clusters within same Bayer color plane distribution diagram

Examples 2: When different Bayer color plane combined, maximum cluster size is 8 in any given 5x5 pixel array.

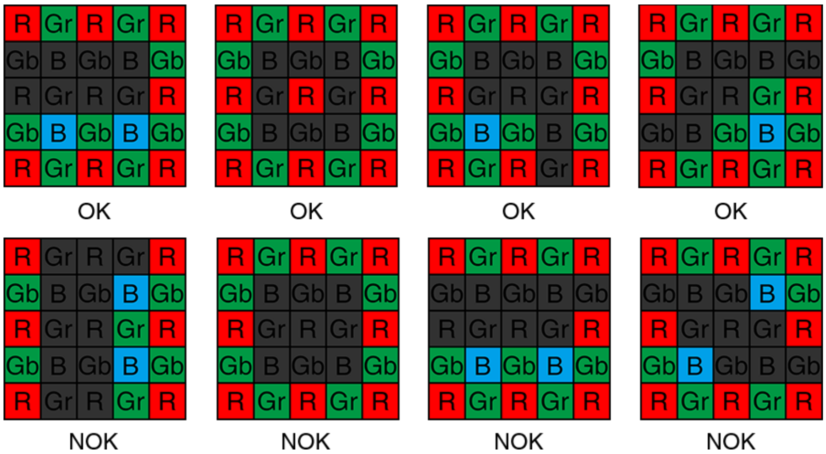


Figure 4-6 MARS-2626-150X2C(-NF) clusters within different Bayer color plane distribution diagram

*OK is allowed, NOK is not allowed.

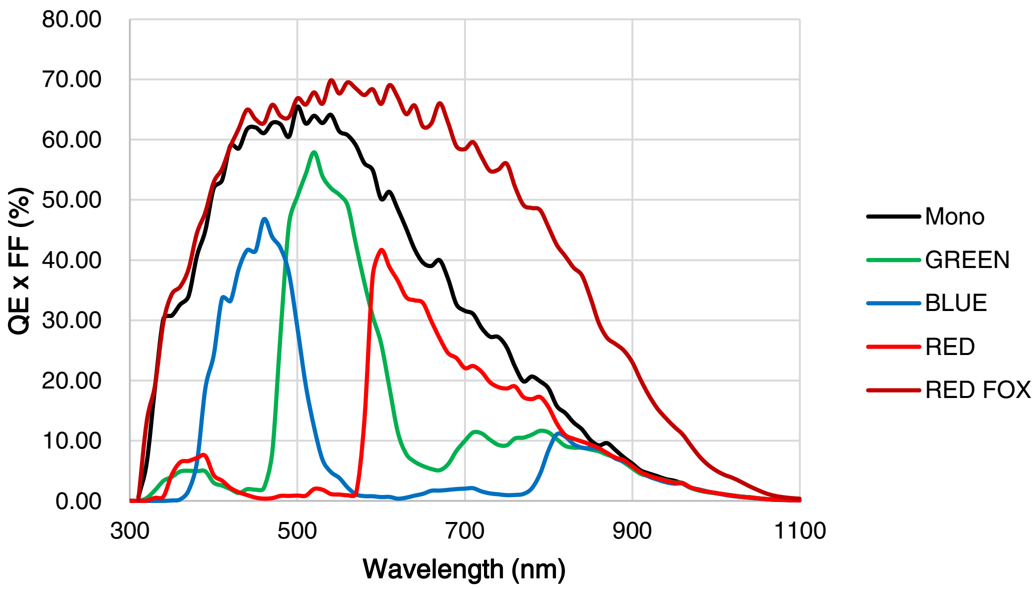


Figure 4-7 MARS-2625-150X2M/C(-NF) \ MARS-2626-150X2M/C(-NF) sensor spectral response

4.2.5. MARS-6502-71X2M/C(-NF) \ MARS-6503-71X2M/C(-NF)

Specifications	MARS-6502-71X2C MARS-6503-71X2C	MARS-6502-71X2M MARS-6503-71X2M	MARS-6502-71X2C-NF MARS-6503-71X2C-NF	MARS-6502-71X2M-NF MARS-6503-71X2M-NF
Resolution	9344 × 7000			
Sensor	Gpixel GMAX3265 65MP global shutter CMOS			
Max. Image Circle	29.9mm × 22.4mm			
Pixel Size	3.2μm × 3.2μm			
Frame Rate	71.1fps @ 9344 × 7000			
ADC Bit Depth	10bit			
Pixel Bit Depth	8bit, 10bit			
Mono/Color	Color	Mono	Color	Mono
Pixel Formats	Bayer GB8 Bayer GB10	Mono8/Mono10	Bayer GB8 Bayer GB10	Mono8/Mono10
Signal Noise Ratio	40.2dB	40.4dB	40.2dB	40.4dB
Exposure Time	13μs~1s, Actual Steps: 1 row period			
Gain	0dB~16dB, Default: 0dB, Steps: 0.1dB			
Binning	1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4			
Decimation	Horizontal FPGA, Vertical Sensor: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4			
Synchronization	Hardware trigger, software trigger			
I/O	1 input and 1 output with opto-isolated, 1 programmable GPIOs, 1 RS232			
Operating Temp.	0°C~45°C			
Storage Temp.	-20°C~70°C			
Operating Humidity	10%~80%			
Cooling Method	Passive cooling		Fan	
Power Consumption	Typ.: 16W@24V, ambient temp. 25°C, FAN (ON) 14W@24V, ambient temp. 25°C, FAN (OFF)			
Lens Mount	M58			
Data Interface	CXP-12 × 4 (HDBNC)			

Dimensions	74mm × 74mm × 69.80mm	74mm × 74mm × 80.55mm
Weight	521g	573g
Operating System	Windows Win7/Win8/Win10/Win11	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, CoaXPress2.0, GenTL	

Table 4-5 MARS-6502-71X2M/C(-NF) \ MARS-6503-71X2M/C(-NF) camera specifications

Note: MARS-6503-71X2M/C(-NF) is the Grade2 sensor, MARS-6502-71X2M/C(-NF) is the Grade1 sensor. The only difference between the two cameras is the grade of the sensor. The difference between Grade1 and Grade2 sensors defined by sensor manufacturers is: Grade1 have no consecutive defect pixel cluster, and Grade2 may have up to 12 consecutive defect pixel cluster. The camera has static defect pixel correction function, and it will calibrated for the default factory parameters. If the scene parameters are changed, you can use the static defect pixel correction plugin to re-calibrate. For details please see section 9.3 Static Defect Correction Plugin.

1) Monochrome camera

As shown below, cluster with 4 consecutive defect pixels in a row is not allowed (NOK).

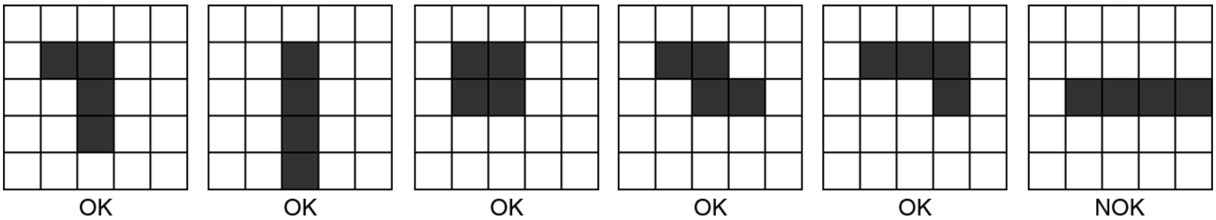


Figure 4-8 MARS-6503-71X2M(-NF) clusters distribution diagram

2) Color camera

Examples 1: Cluster with 4 consecutive defect pixels within the same Bayer color plane in a row is not allowed.

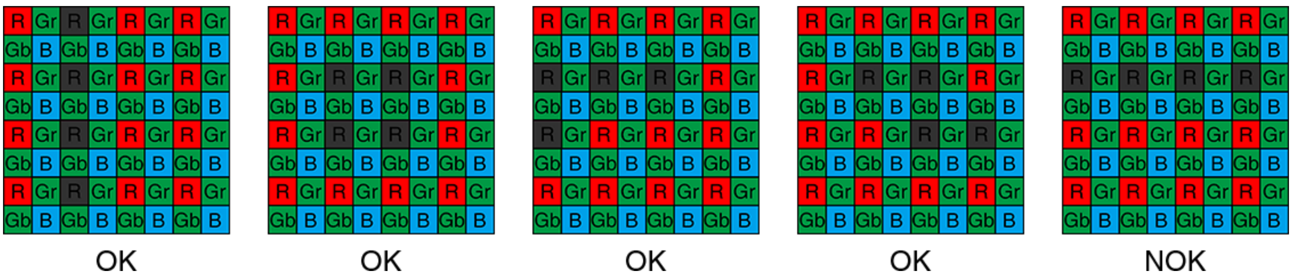


Figure 4-9 MARS-6503-71X2C(-NF) clusters within same Bayer color plane distribution diagram

Examples 2: When different Bayer color plane combined, maximum cluster size is 8 in any given 5x5 pixel array.

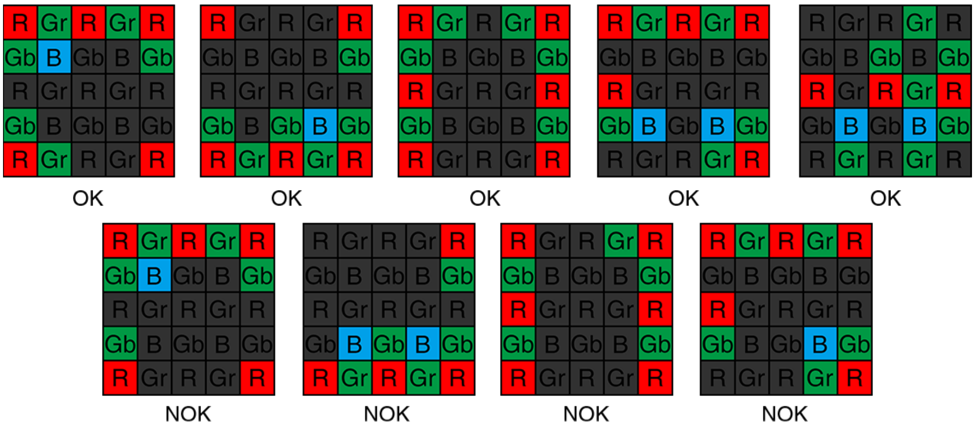


Figure 4-10 MARS-6503-71X2C(-NF) clusters within different Bayer color plane distribution diagram

*OK is allowed, NOK is not allowed.

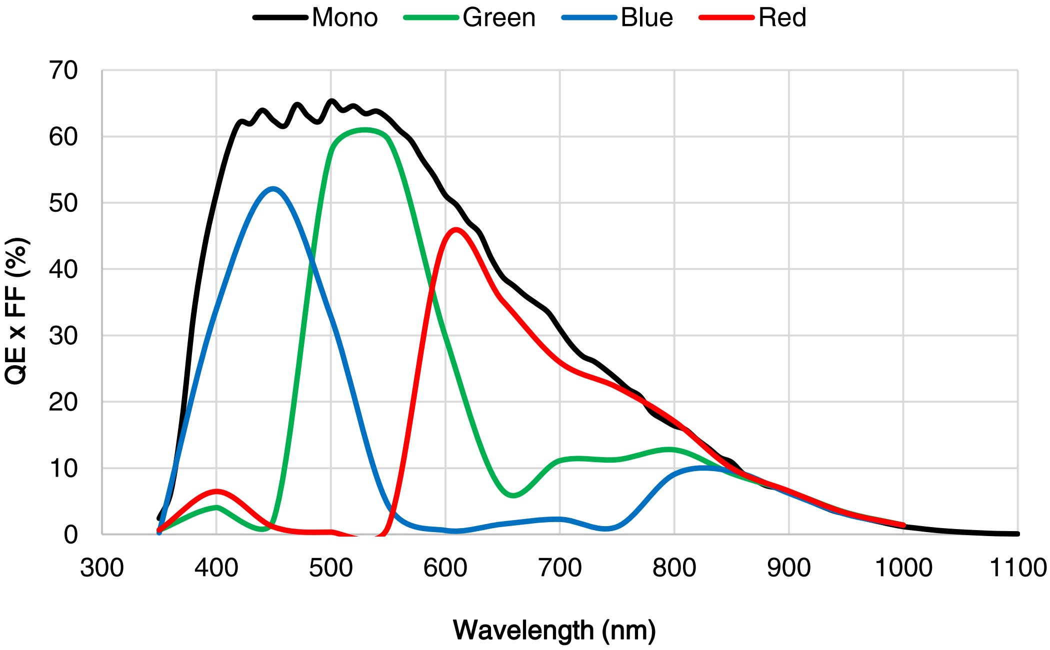


Figure 4-11 MARS-6502-71X2M/C(-NF) \ MARS-6503-71X2M/C(-NF) sensor spectral response

5. Dimensions

5.1. Camera Dimensions

The corresponding mechanical dimensions for each model of the MARS-CXP camera are shown in the table below.

Model	Lens Mount	Cooling	Mechanical Dimensions
MARS-6500-31X2M/C-TF MARS-6501-31X2M/C-TF	M58	TEC + Fan	A
MARS-10300-24X2M/C-TF MARS-15200-16X2M/C-TF	M72	TEC + Fan	B
MARS-2625-150X2M/C(-NF) MARS-2626-150X2M/C(-NF)	M58	Passive cooling	C
		Fan	D
	C	Passive cooling	E
		Fan	F
MARS-6502-71X2M/C(-NF) MARS-6503-71X2M/C(-NF)	M58	Passive cooling	G
		Fan	H

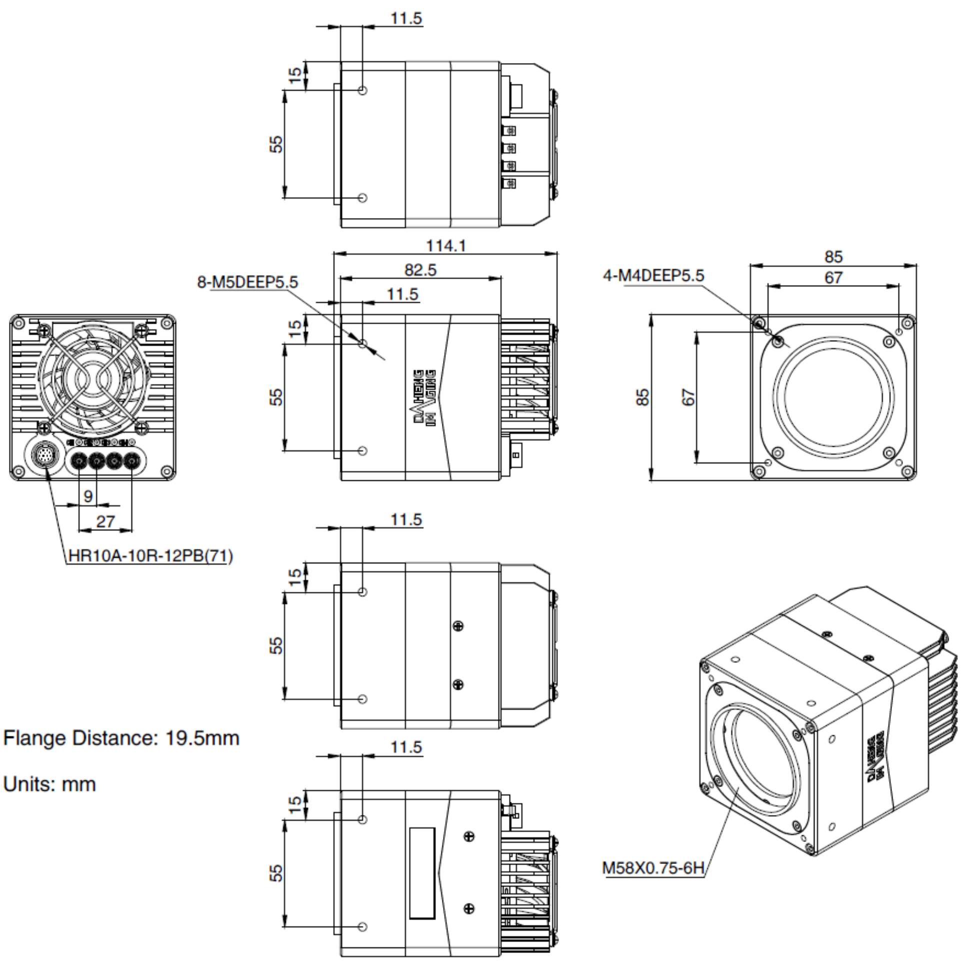
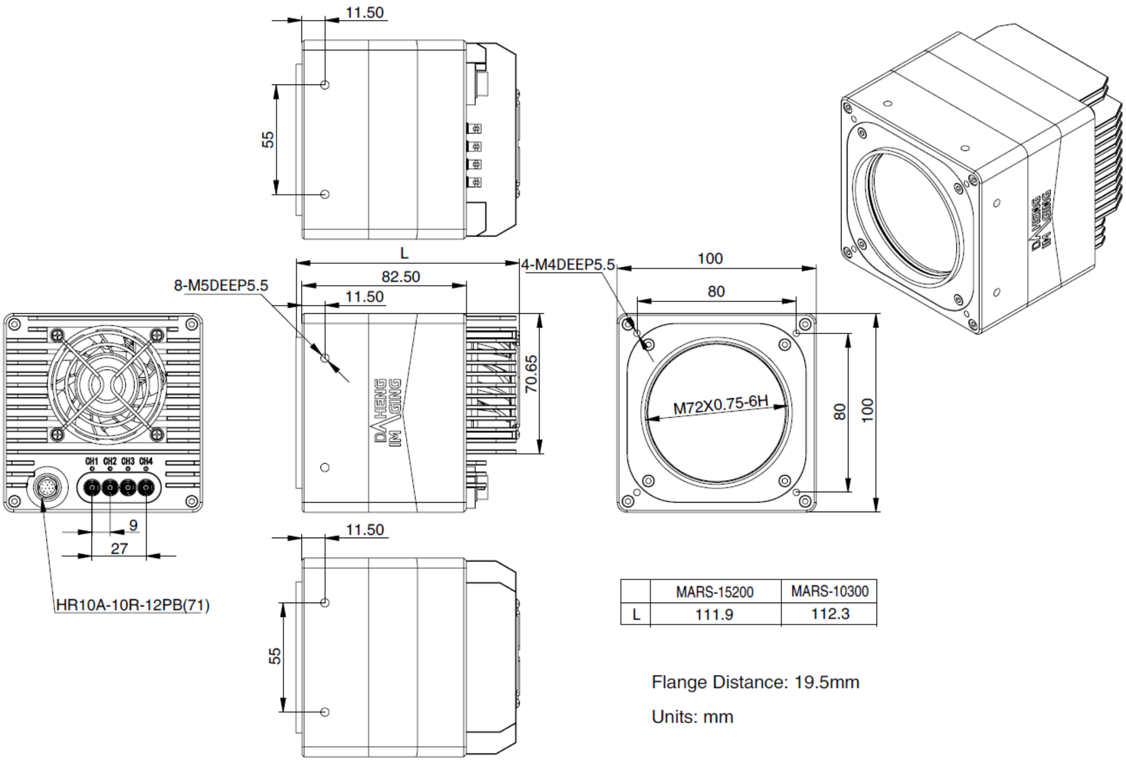


Figure 5-1 MARS-CXP mechanical dimensions A



	MARS-15200	MARS-10300
L	111.9	112.3

Figure 5-2 MARS-CXP mechanical dimensions B

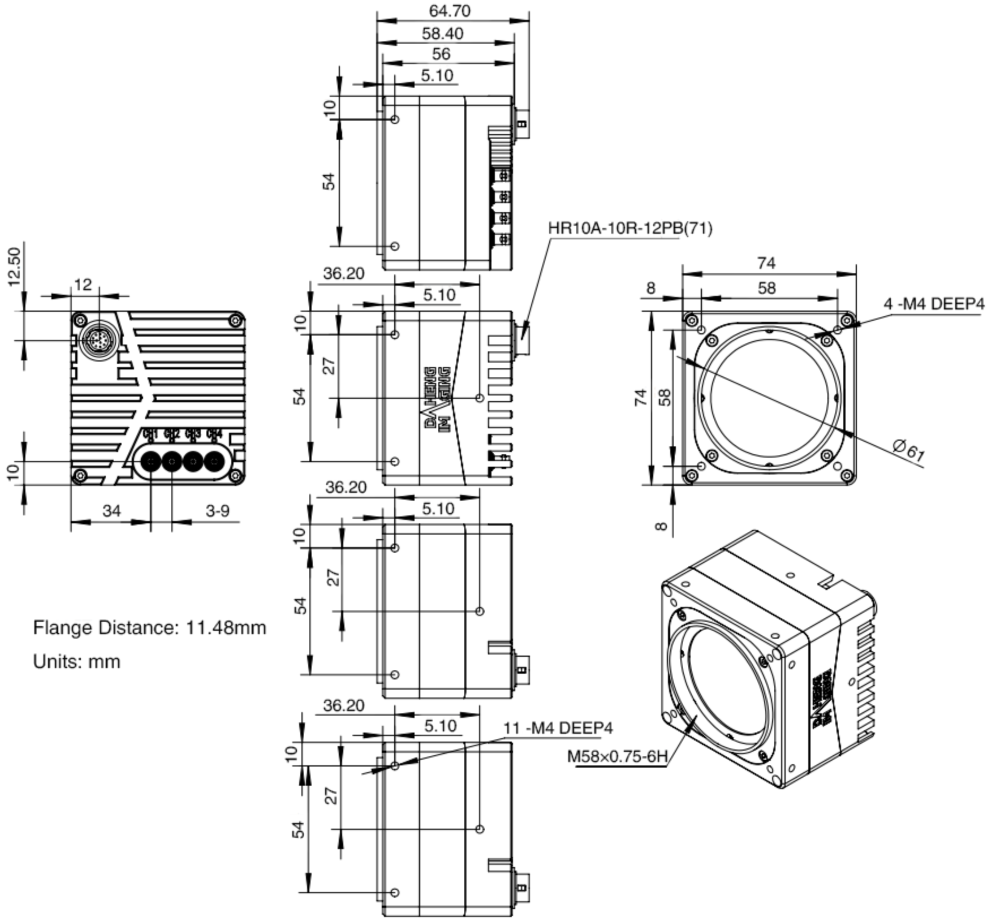


Figure 5-3 MARS-CXP mechanical dimensions C

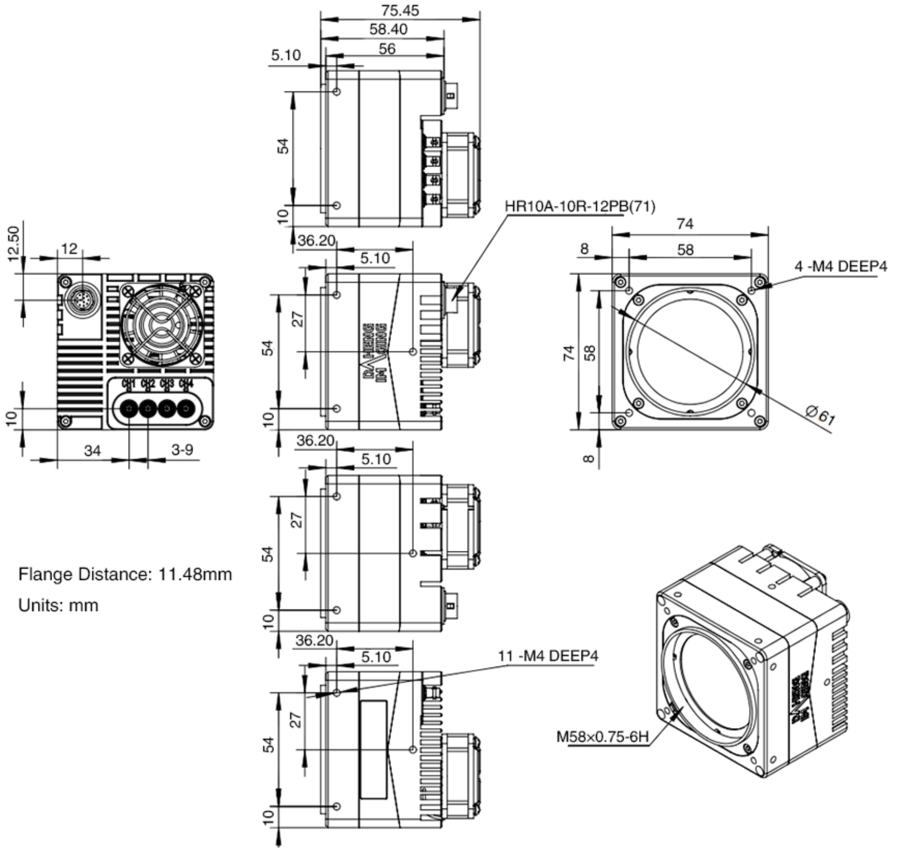


Figure 5-4 MARS-CXP mechanical dimensions D

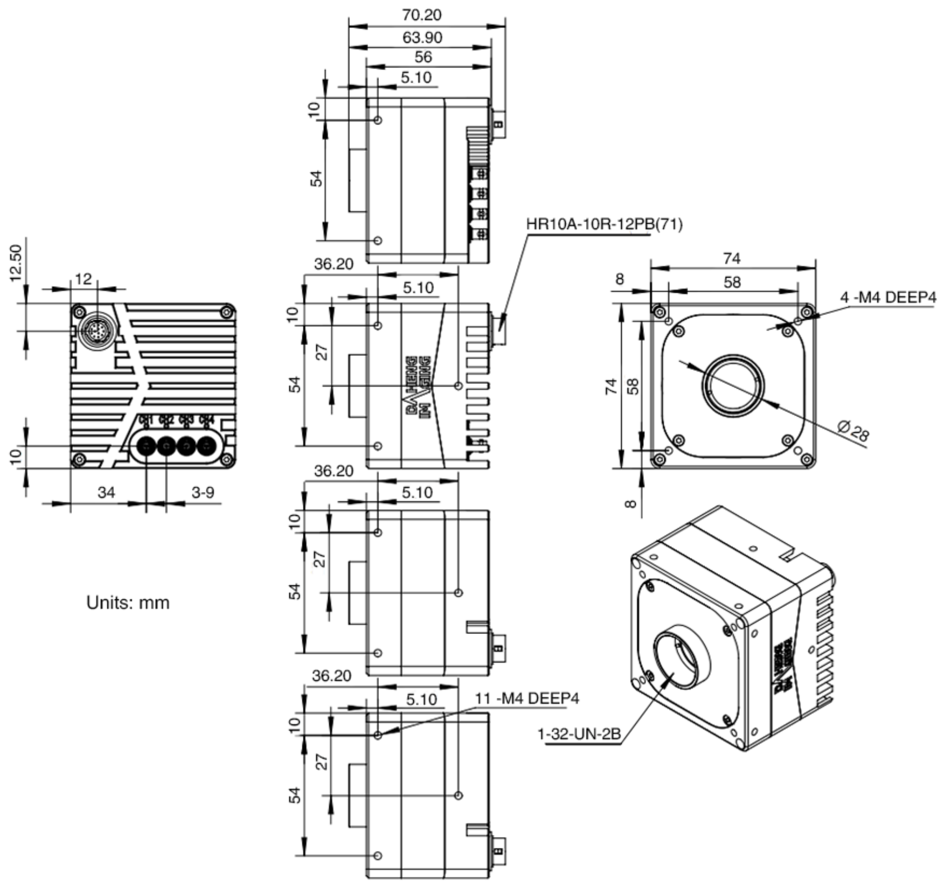


Figure 5-5 MARS-CXP mechanical dimensions E

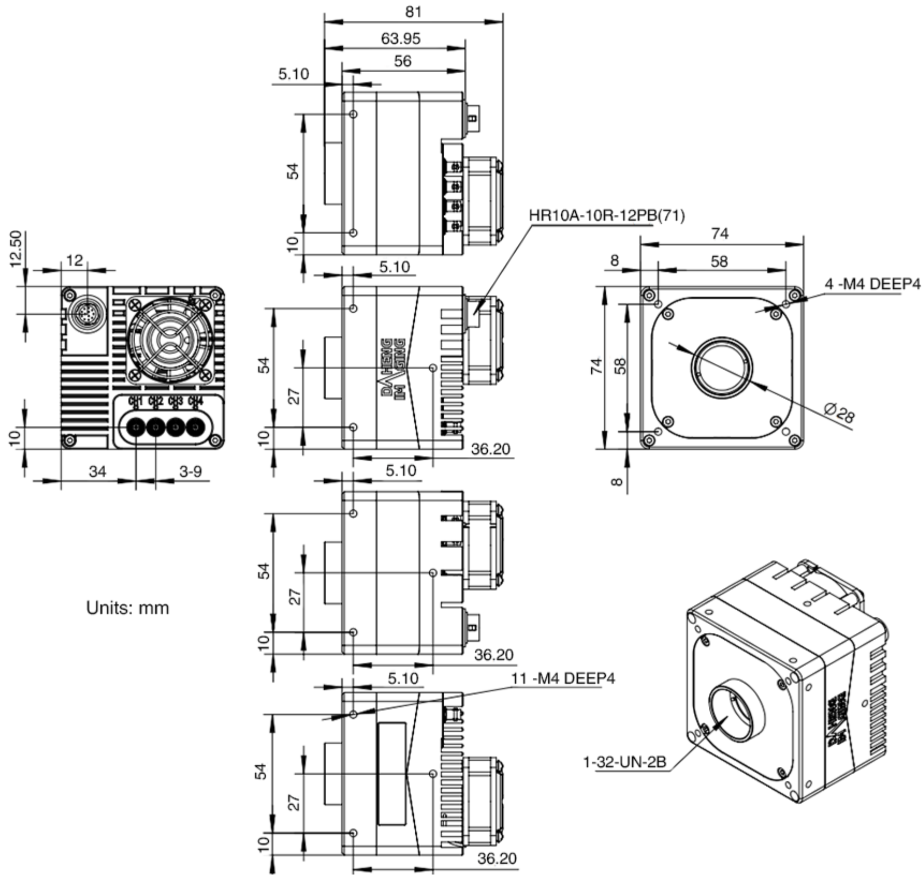


Figure 5-6 MARS-CXP mechanical dimensions F

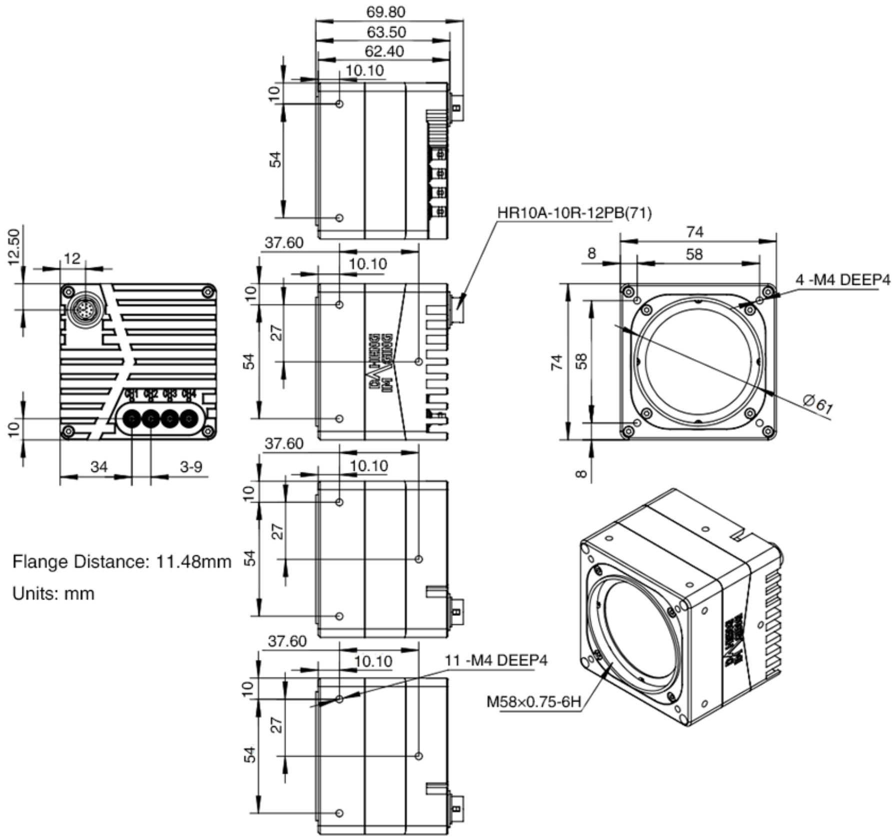


Figure 5-7 MARS-CXP mechanical dimensions G

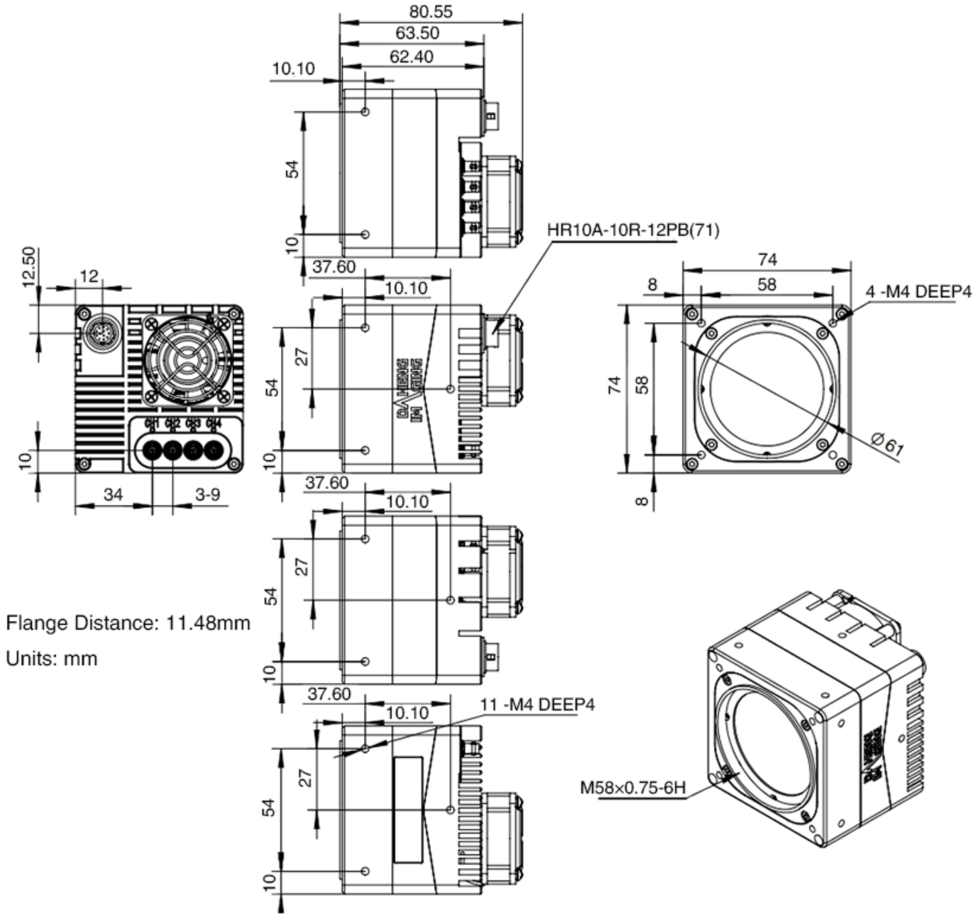


Figure 5-8 MARS-CXP mechanical dimensions H

5.2. Optical Interface

The back-flange distance and maximum lens allowed thread length for each model are shown in the table below. (If other Lens mount are required, please contact sales or technical support for information).

Model	Lens mount	Back-flange distance (in air)	Maximum lens allowed thread length	Optical interface diagram
MARS-6500-31X2M/C-TF MARS-6501-31X2M/C-TF	M58	19.5 mm	< 9 mm	A
MARS-10300-24X2 M/C-TF MARS-15200-16X2M/C-TF	M72	19.5 mm	< 6.5 mm	B
MARS-2625-150X2M/C(-NF) MARS-2626-150X2M/C(-NF)	C	17.526 mm	< 11.1 mm	C
	M58	11.48 mm	< 5 mm	D
	F (adapter)	46.5 mm	-	-
MARS-6502-71X2M/C(-NF) MARS-6503-71X2M/C(-NF)	M58	11.48 mm	< 5 mm	D
	F (adapter)	46.5 mm	-	-

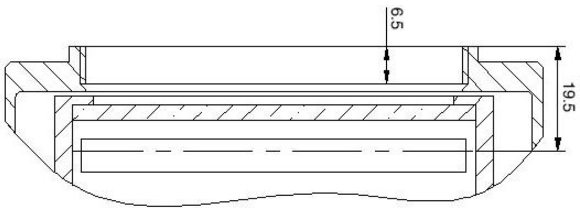


Figure 5-9 Optical interface A

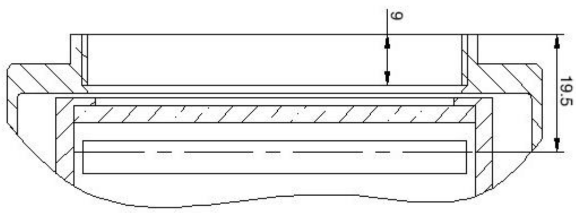


Figure 5-10 Optical interface B

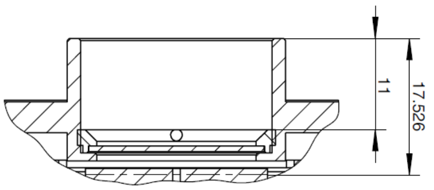


Figure 5-11 Optical interface C

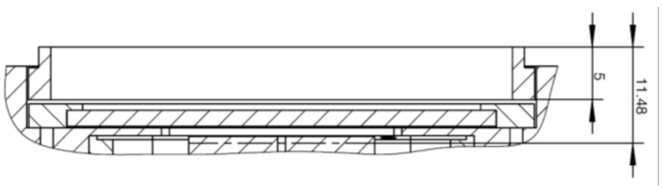


Figure 5-12 Optical interface D

The color models are equipped with an IR filter and the cut-off frequency is 700nm. The mono models are equipped with a transparent glass. Remove IR-filter or transparent glass will defocus the image plane.

Contact our technical support when the glass needed to be removed.

5.3. Tripod Adapter Dimensions

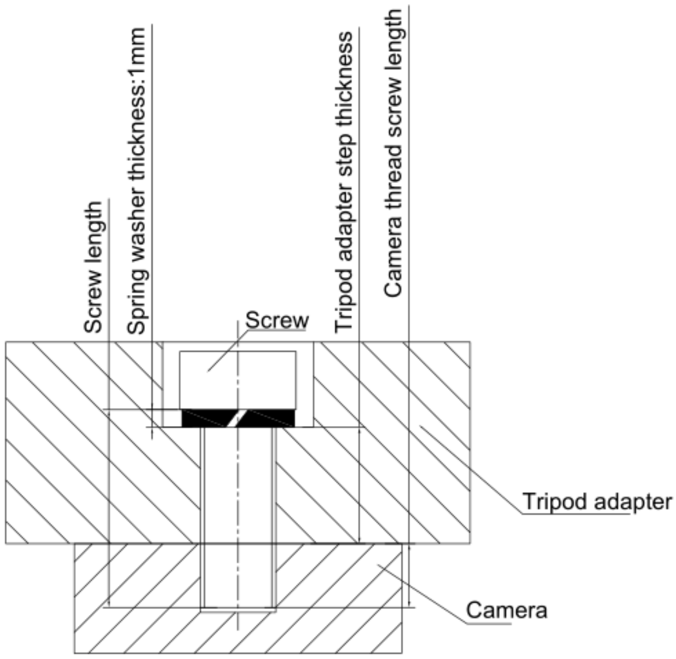


Figure 5-13 Schematic diagram of screw specification, tripod adapter step thickness and spring washer thickness

It is recommended that you select the screw specifications and the tripod adapter step thickness from the table below:

MARS-6500-31X2M/C-TF, MARS-6501-31X2M/C-TF, MARS-10300-24X2M/C-TF, MARS-15200-16X2M/C-TF front mounting holes:

Screw specification	Tripod adapter step thickness	Spring washer thickness	Screwing length of camera screw thread
M4*8 hexagon socket head cap screw	2 mm	1.1 mm	4.9 mm
M4*10 hexagon socket head cap screw	4 mm	1.1 mm	4.9 mm
M4*12 hexagon socket head cap screw	6 mm	1.1 mm	4.9 mm

MARS-6500-31X2M/C-TF, MARS-6501-31X2M/C-TF, MARS-10300-24X2M/C-TF, MARS-15200-16X2M/C-TF four-side mounting holes:

Screw specification	Tripod adapter step thickness	Spring washer thickness	Screwing length of camera screw thread
M5*8 hexagon socket head cap screw	2 mm	1.3 mm	4.7 mm
M5*10 hexagon socket head cap screw	4 mm	1.3 mm	4.7 mm
M5*12 hexagon socket head cap screw	6 mm	1.3 mm	4.7 mm

MARS-2625-150X2M/C-(NF), MARS-2626-260X2M/C-(NF), MARS-6502-71X2M/C-(NF), MARS-6503-71X2M/C-(NF) front and four-side mounting holes:

Screw specification	Tripod adapter step thickness	Spring washer thickness	Screwing length of camera screw thread
M4*8 hexagon socket head cap screw	3.3 mm	1.1 mm	3.6 mm
M4*10 hexagon socket head cap screw	5.3 mm	1.1 mm	3.6 mm

If the screw specification and the thickness of the tripod adapter do not conform to the above table, it may cause the camera thread hole through or thread stripping.

6. Filters

The MARS color models are equipped with IR filters. The monochrome models are equipped with transparent glasses.

Contact our technical support when the glass needed to be removed.

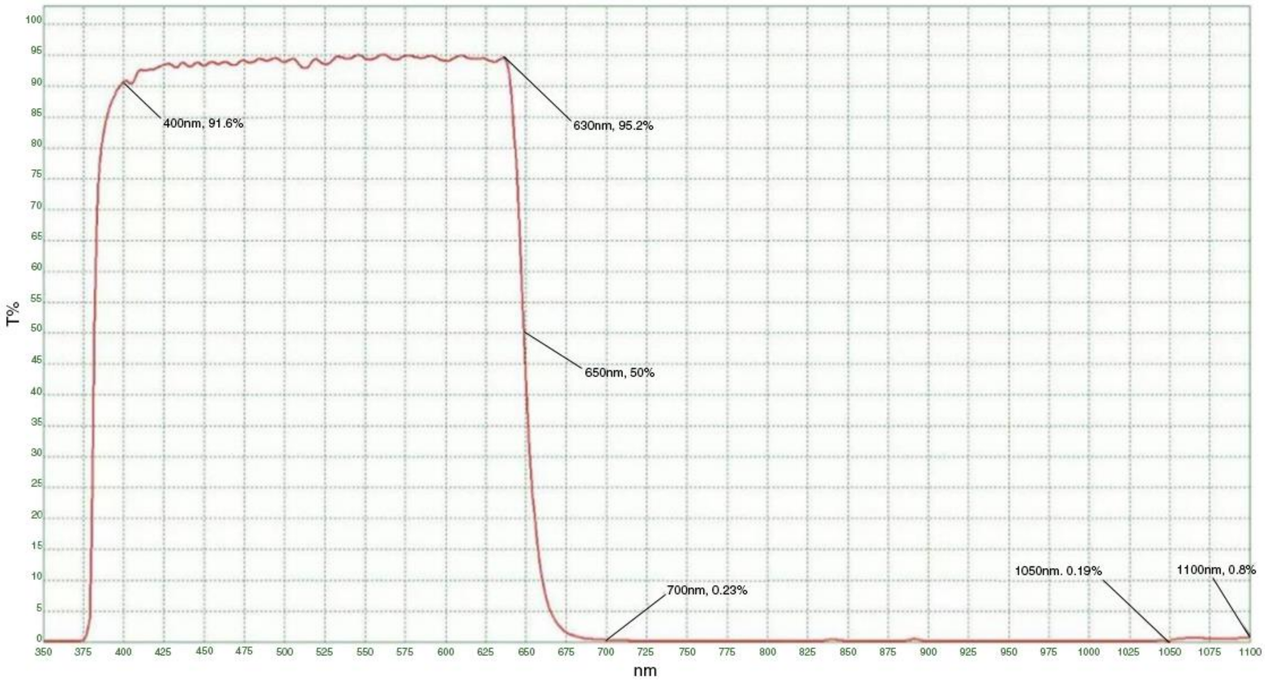


Figure 6-1 Infrared cut-off filter transmittance curve

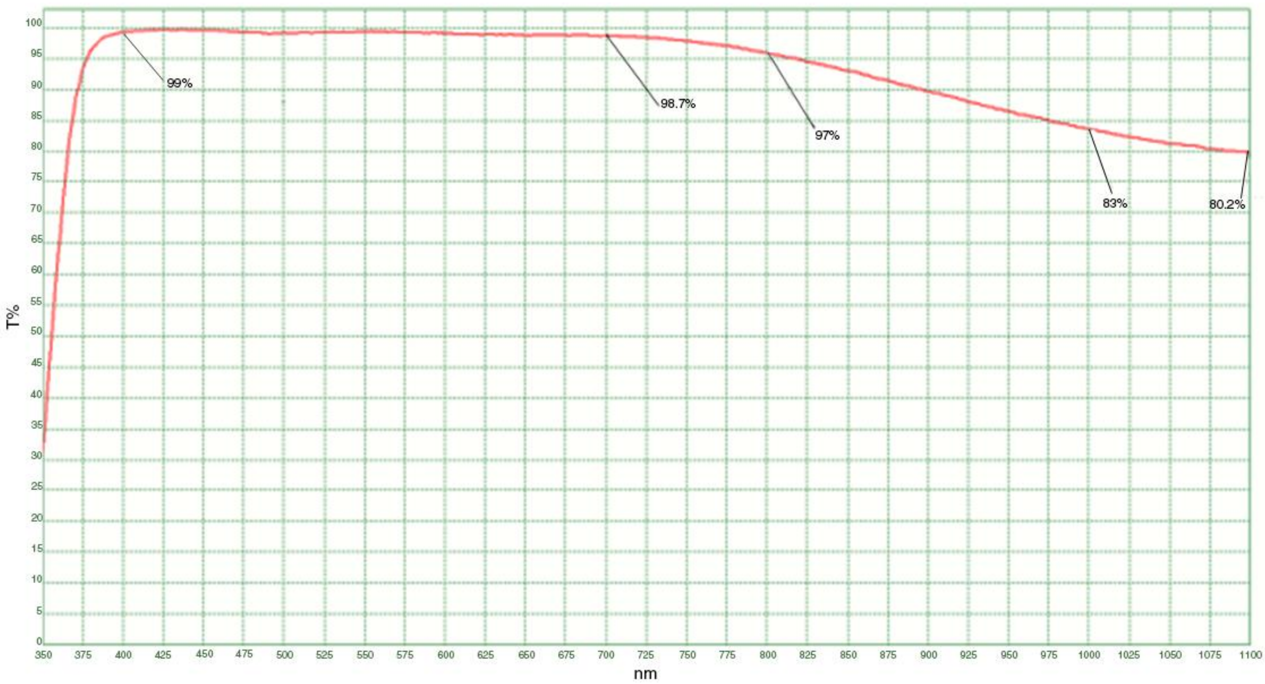


Figure 6-2 Transparent glass transmittance curve

7. Electrical Interface

7.1. LED Light

Four LED lights are set on the back cover of camera which indicates camera's status, as shown in Table 7-1. LED light can display 3 colors: red, yellow and green.

LED status	Camera status
Off	The camera is powered off / The connection is not enabled
Solid yellow	The camera is not boot-loaded
Flashing alternately yellow and green at 12.5Hz	The power over CoaXPress link is connected.
Flashing yellow at 12.5Hz	The external power link is connected.
Flashing red at 1Hz	The camera is disconnected
Solid green	The camera has been connected, but no data is being transmitted
Flashing green at 12.5Hz	Data is being transmitted
Flashing yellow at 1Hz	The camera is waiting trigger signal
Flashing alternately yellow and green at 0.5Hz	The camera is connecting to test
Flashing alternately red and green at 0.5Hz	PoCXP protocol match anomaly
Flashing alternately red and yellow at 0.5Hz	External power supply protocol match anomaly
Flashing yellow at 0.5Hz	The camera's initialization failed
Flashing red at 12.5Hz	The camera internal exception occurs

Table 7-1 Camera status

7.2. CoaXPress Port

The connection to the camera is 4 channels HD-BNC port with 12.5 Gbps bit rate and the connection to the frame grabber from the different manufacturers may different (usually DIN or HD-BNC). Users can select proper cables according to the actual types of frame grabber connectors. Recommend to use the cables officially recognized by CoaXPress IF. For example, the HD-BNC to HD-BNC interface CoaXPress cable (L is the cable length) is shown below.

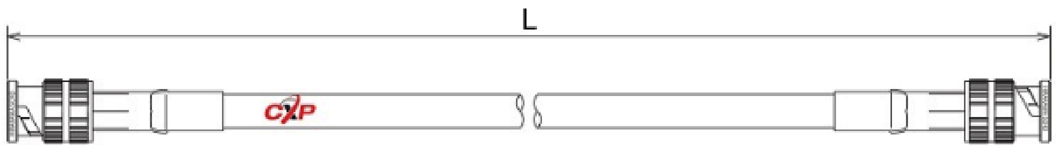


Figure 7-1 the HD-BNC to HD-BNC interface CoaXPress cable

7.3. I/O Port

7.3.1. I/O Connector Pin Definition

I/O port is implemented by Hirose 12-pin receptacle (No. HR10A-10R-12PB), and the corresponding plug is HR10A-10P-12S(73).

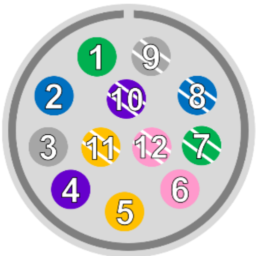
Diagram	Pin	Definition	Core Color	Description
	1	Line0+	Green	Opto-isolated input +
	2	GND	Blue	PWR GND & GPIO GND
	3	Line0-	Grey	Opto-isolated input -
	4	POWER_IN	Purple	Camera external power, +24V±10%
	5	Line2	Orange	GPIO input/output
	6	RS232 Rx	Pink	RS232 receive
	7	Line1-	White Green	Opto-isolated output -
	8	Line1+	White Blue	Opto-isolated output +
	9	GND	White Grey	PWR GND & GPIO GND
	10	GND	White Purple	PWR GND & GPIO GND
	11	POWER_IN	White Orange	Camera external power, +24V±10%
	12	RS232 Tx	White Pink	RS232 transmit

Table 7-2 I/O port definition (back sight of the camera)

⚠ The polarity of GPIO pins cannot be reversed, otherwise, camera or other peripherals could burn out.

7.3.2. I/O Electrical Features

7.3.2.1. Line0 (Opto-isolated Input) Circuit

Hardware schematics of opto-isolated input circuit is shown as Figure 7-2.

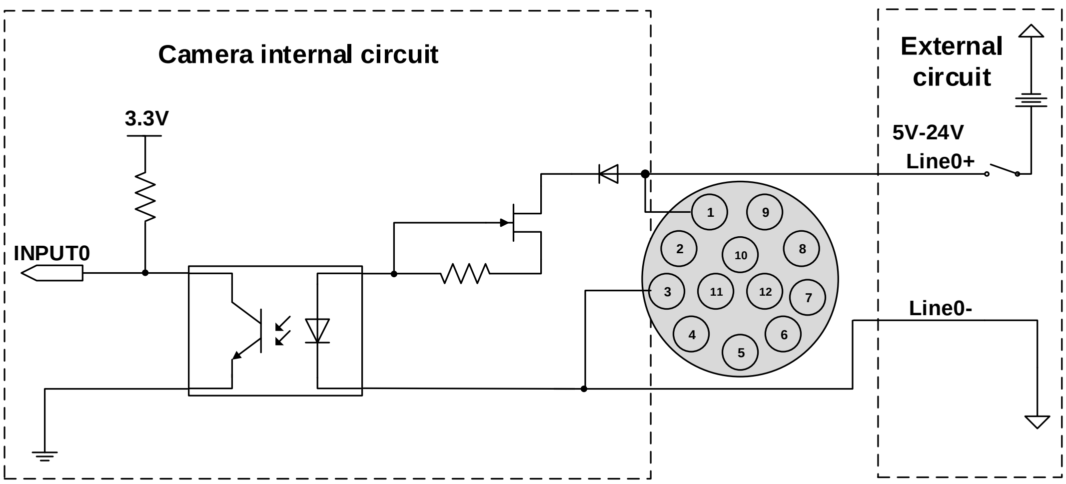


Figure 7-2 Opto-isolated input circuit

- Logic 0 input voltage: 0V~+2.5V (Line0+ voltage)
- Logic 1 input voltage: +5V~+24V (Line0+ voltage)
- Minimum input current: 7mA
- The status is unstable when input voltage is between 2.5V and 5V, which should be avoided
- When the external input voltage is 5V, there is no need for circuit-limiting resistance in the external input. But if there is a series resistance, please ensure the value is less than 90Ω. In order to protect the Line0+ while the external input voltage is higher than 9V, a circuit-limiting resistance is needed in the external input. The recommended values are shown in Table 7-3

External input voltage	Circuit-limiting resistance (Rlimit)	Line0+ input voltage
5V	Non or <90Ω	About 5V
9V	680Ω	About 5.5V
12V	1kΩ	About 6V
24V	2kΩ	About 10V

Table 7-3 Circuit-limiting resistor value

The connection method of the opto-isolated input circuit and the NPN and PNP photosensor is shown in Figure 7-3 and Figure 7-4. The relationship between the pull-up resistor and the external power supply voltage is shown in Table 7-3.

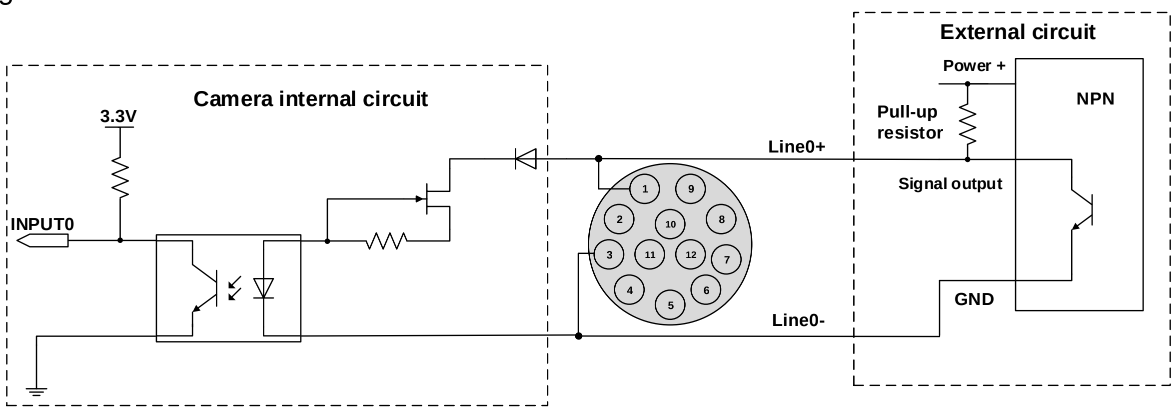


Figure 7-3 NPN photosensor connected to opto-isolated input circuit

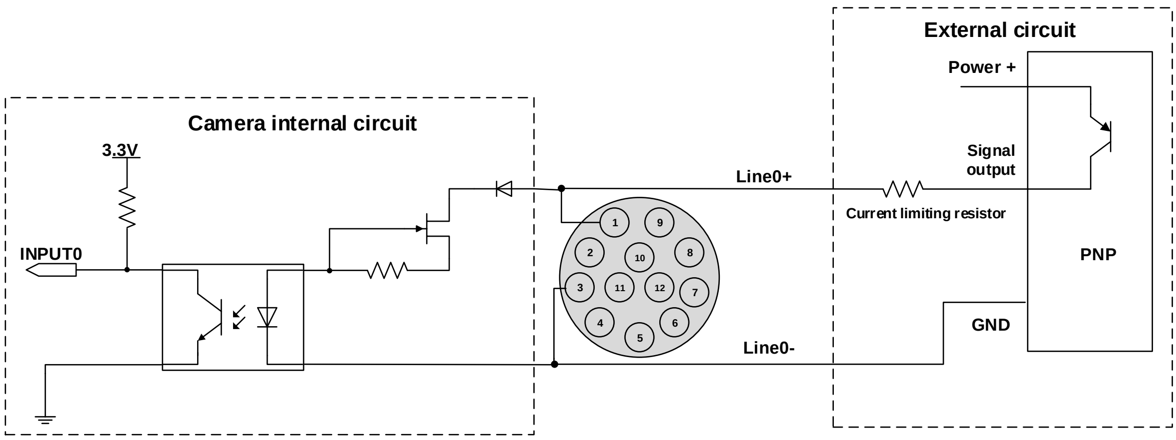


Figure 7-4 PNP photosensor connected to opto-isolated input circuit

- Rising edge delay: <50μs (0°C~45°C), parameter description as shown in Figure 7-5
- Falling edge delay: <50μs (0°C~45°C), parameter description as shown in Figure 7-5
- Different environment temperature and input voltage have influence on delay time of opto-isolated input circuit. Delay times in typical application environment (temperature is 25°C) is as shown in Table 7-4

Parameter	Test condition	Value (μs)		
Rising edge delay	VIN=5V	3.02	~	6.96
	VIN=12V	2.46	~	5.14
Falling edge delay	VIN=5V	6.12	~	17.71
	VIN=12V	8.93	~	19.73

Table 7-4 Delay time of opto-isolated input circuit in typical application environment

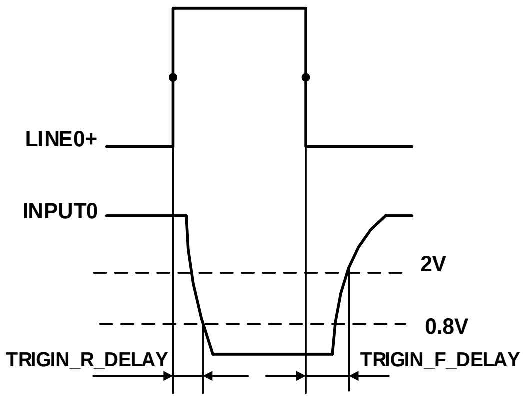


Figure 7-5 Parameter of opto-isolated input circuit

- Rising time delay (TRIGIN_R_DELAY): the time required for the response to the decrease to 0.8V of INPUT0 from 50% rising of LINE0+
- Falling time delay (TRIGIN_F_DELAY): the time required for the response to the rise to 2V of INPUT0 from 50% falling of LINE0+

7.3.2.2. Line1 (Opto-isolated Output) Circuit

Hardware schematics of opto-isolated output circuit is shown as Figure 7-6.

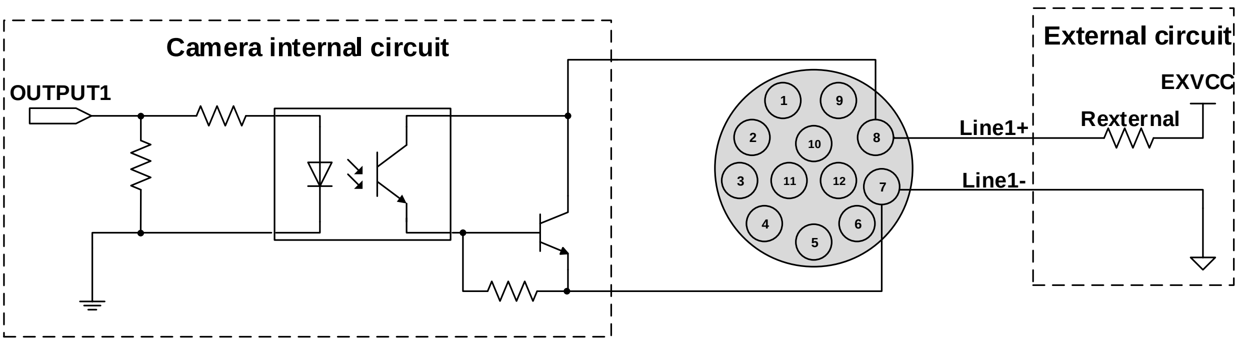


Figure 7-6 Opto-isolated output circuit

- Range of external voltage (EXVCC) is 5~24V
- Maximum output current of Line1 is 25mA
- Transistor voltage drop and output current of opto-isolated output circuit in typical application environment (temperature is 25°C) is as shown in Table 7-5

External voltage (EXVCC)	External resistance (Rexternal)	Transistor voltage drop (turn on, unit V)	Output current (mA)
5V	1kΩ	0.90	4.16
12V	1kΩ	0.97	11.11
24V	1kΩ	1.04	23.08

Table 7-5 Transistor voltage drop and output current of opto-isolated output circuit in typical application environment

- Rising time delay = tr+td: <50μs (0°C~45°C) (parameter description is shown in Figure 7-7)
- Falling time delay = ts+tf: <50μs (0°C~45°C) (parameter description is shown in Figure 7-7)
- Delay time in typical application conditions (environment temperature is 25°C) are shown in Table 7-6

Parameter	Test Condition	Value (μs)		
Storage time (ts)	External power is 5V, pull-up resistor is 1kΩ	6.16	~	13.26
Delay time (td)		1.90	~	3.16
Rising time (tr)		2.77	~	10.60
Falling time (tf)		7.60	~	11.12
Rising time delay = tr+td		4.70	~	13.76
Falling time delay = tf+ts		14.41	~	24.38

Table 7-6 Delay time of opto-isolated output circuit in typical application environment

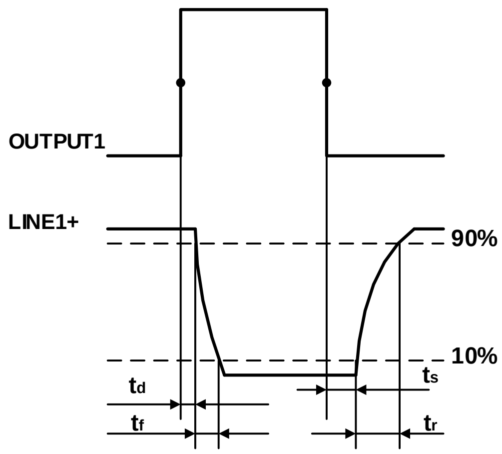


Figure 7-7 Parameter of opto-isolated output circuit

- Delay time (td): the time required from 50% rising of OUTPUT1 to the decrease to 90% of the maximum value of LINE1+
- Falling time (tf): the time taken for the amplitude of LINE1+ to decrease from 90% to 10% of the maximum value
- Storage time (ts): the time required from 50% falling of OUTPUT1 to the rise to 10% of the maximum value of LINE1+
- Rising time (tr): the time for the response of LINE1+ to rise from 10% to 90% of its final value

7.3.2.3. Line2 GPIO (Bidirectional) Circuit

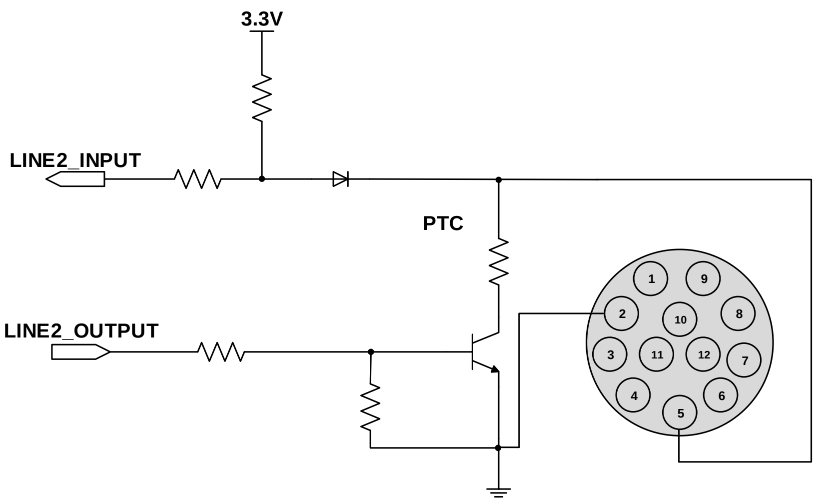


Figure 7-8 GPIO 2/3 (bidirectional) circuit

7.3.2.3.1. Line2 is Configured as Input

- When Line2 is configured as input, the internal equivalent circuit of camera is shown in Figure 7-9, taking Line2 as an example

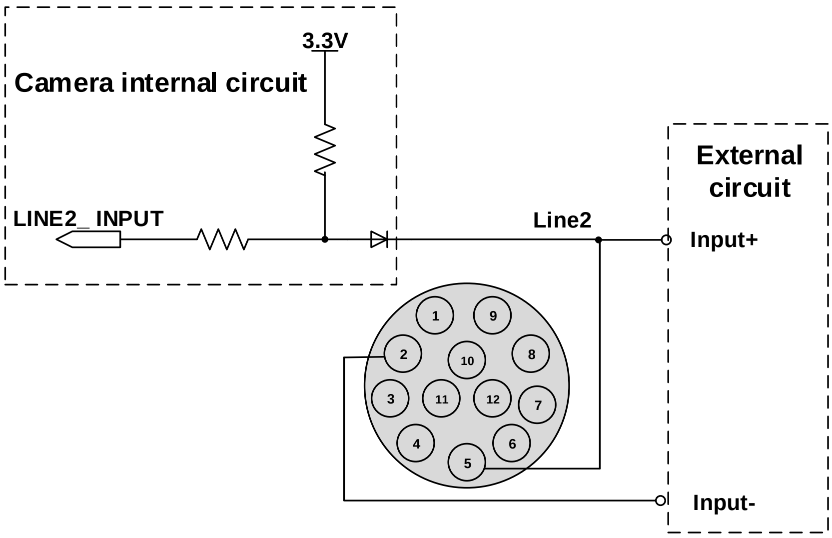


Figure 7-9 Internal equivalent circuit of camera when Line2 is configured as input

⚠ To avoid the damage of GPIO pins, please connect GND pin before supplying power to Line2.

- Logic 0 input voltage: 0V~+0.6V (Line2/3 voltage)
- Logic 1 input voltage: +1.9V~+24V (Line2/3 voltage)
- The status is unstable when input voltage is between 0.6V and 1.9V, which should be avoided
- When input of Line2/3 is high, input current is lower than 100μA. When input of Line2/3 is low, input current is lower than -1mA. When Line2 is configured as input. The connection method between them and NPN and PNP photoelectric sensors is shown in Figure 7-10 and Figure 7-11. The relationship between the pull-up resistor value and the external input voltage is shown in Table 7-3

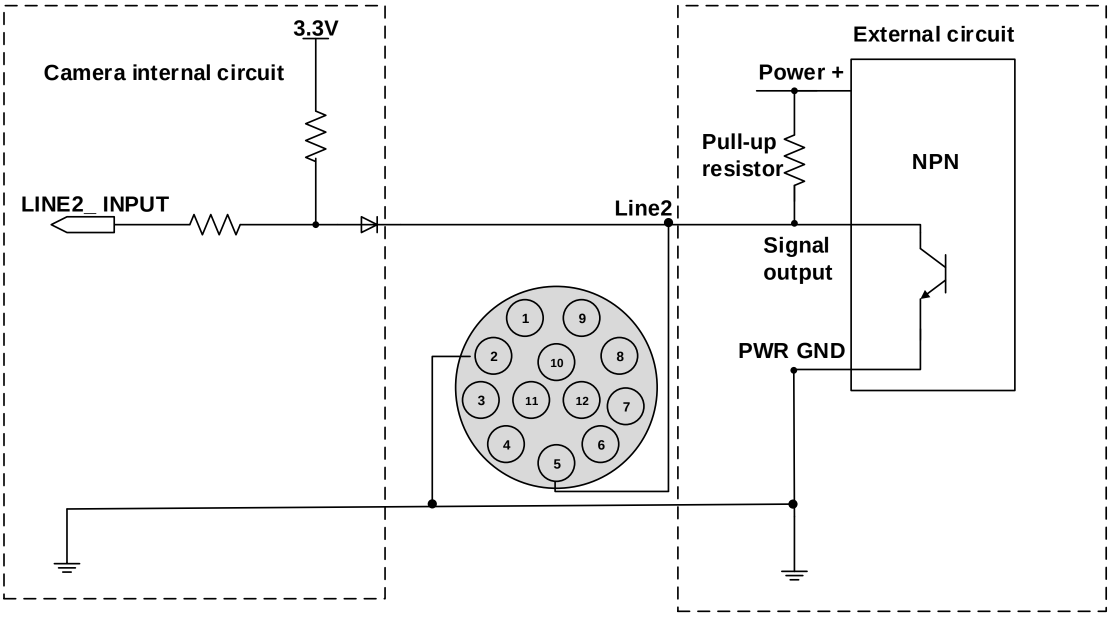


Figure 7-10 NPN photoelectric sensor connected to Line2 input circuit

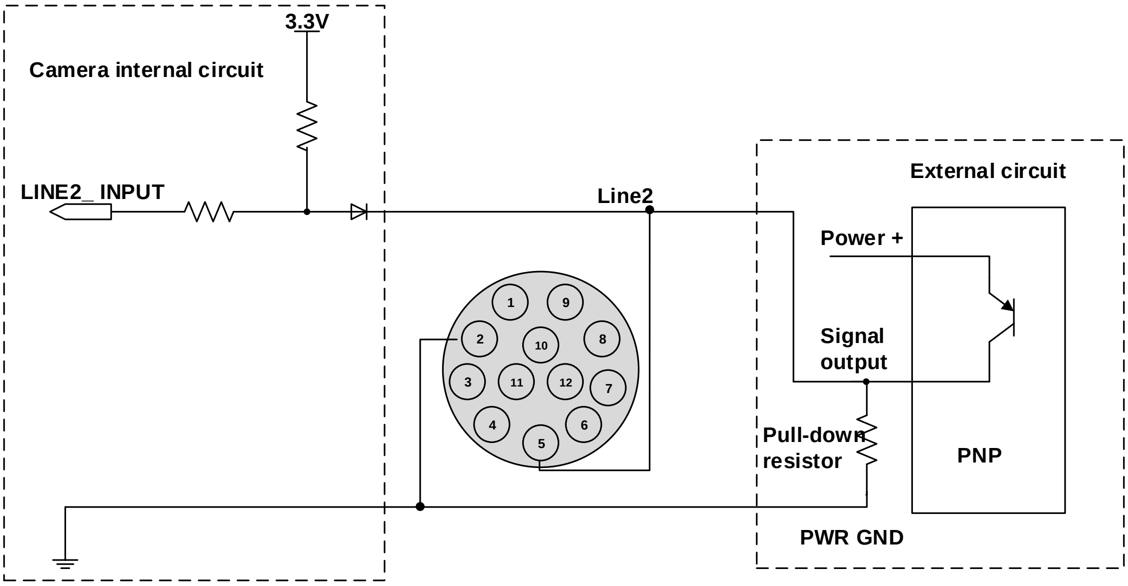


Figure 7-11 PNP photoelectric sensor connected to Line2 input circuit

- When LIine2 is configured as input, pull-down resistor over 1K should not be used, otherwise the input voltage of Line2 will be over 0.6V and logic 0 cannot be recognized stably

- Input rising time delay: <2μs (0°C~45°C), parameter description as shown in Figure 7-12
- Input falling time delay: <2μs (0°C~45°C), parameter description as shown in Figure 7-12

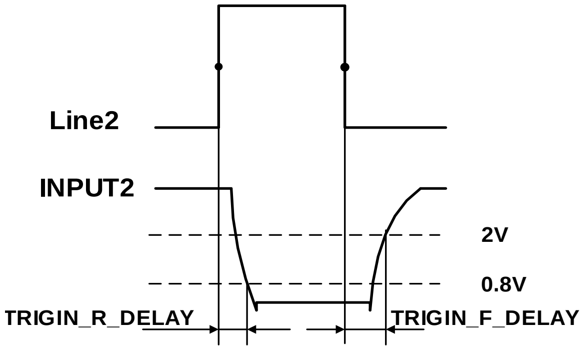


Figure 7-12 Parameter of Line2 input circuit

7.3.2.3.2. Line2 is Configured as Output

- Range of external voltage (EXVCC) is 5~24V
- Maximum output current of Line2/3 is 25mA, output impedance is 40Ω
- Transistor voltage drop and output current in typical application conditions (temperature is 25°C) are shown in Table 7-7

External voltage (EXVCC)	External resistance (Rexternal)	Transistor voltage drop (turn on, unit V)	Output current (mA)
5V	1kΩ	0.19	4.8
12V		0.46	11.6
24V		0.92	23.1

Table 7-7 Transistor voltage drop and output current of Line2 in typical conditions

- Rising time delay = tr+td: <20μs (0°C~45°C) (parameter description as shown in Figure 7-13)
- Falling time delay = ts+tf: <20μs (0°C~45°C) (parameter description as shown in Figure 7-13)

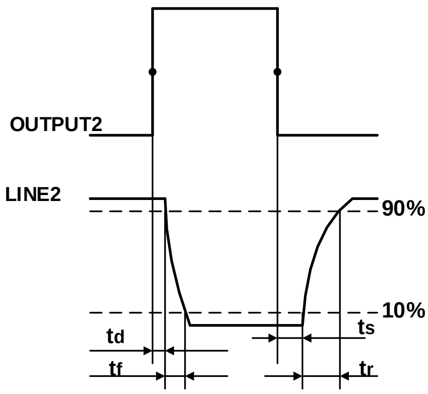


Figure 7-13 Parameter of Line2 output circuit

- Delay parameters are affected greatly by external voltage and external pull-up resistor, but little by temperature. Output delay time in typical application conditions (temperature is 25°C) are shown in Table 7-8

Parameter	Test Conditions	Value (μs)		
Storage time (ts)	External power is 5V, pull-up resistor is 1kΩ	0.17	~	0.18
Delay time (td)		0.08	~	0.09
Rising time (tr)		0.11	~	0.16
Falling time (tf)		1.82	~	1.94
Rising time delay = tr+td		0.19	~	0.26
Falling time delay = tf+ts		1.97	~	2.09

Table 7-8 Delay time when GPIO is configured as output in typical conditions

- When Line2 is configured as output, the internal equivalent circuit of camera is shown in Figure 7-14, taking Line2 as an example

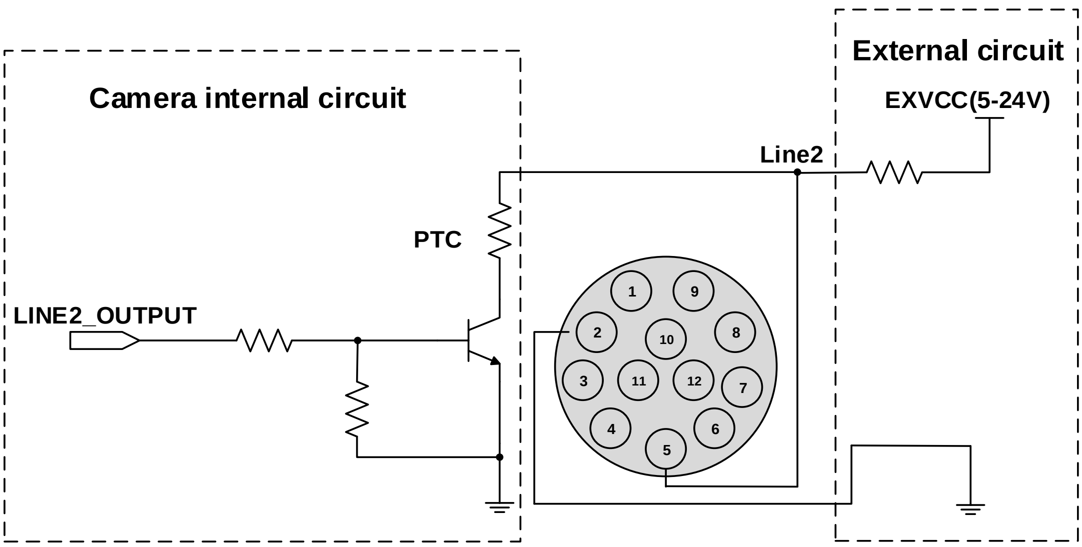


Figure 7-14 Internal equivalent circuit of camera when Line2 is configured as output

7.3.2.4. RS232 Serial Port

MARS CoaXPress cameras support RS-232 port (RX: receive, TX: transmit). The camera currently reserves hardware interface only, and not supports software function.

8. Features

MARS CoaXPress camera support a variety of standard and advanced functions. The function support of different models varies slightly. Please refer to the DAHENG Cameras Feature List for details.

8.1. I/O Control

8.1.1. Input Mode Operation

1) Configuring Line as input

The camera has two input signals: Line0 and Line2. In which the Line0 is uni-directional opto-isolated input, Line2 is bi-directional lines which can be configured as input or output.

The camera's default input is Line0 when the camera is powered on. Line2 is input by default, which can be configured to be input or output by LineMode.

2) Input Debouncer

In order to suppress the interference signals from hardware trigger, the camera has the hardware trigger filtering feature, including rising edge filtering and falling edge filtering. The user can set the trigger filter feature by setting the " TriggerFilterRaisingEdge " and the " TriggerFilterFallingEdge ". The range of the trigger filter feature is [0, 5000] μs, step: 1μs.

Example 1: Setting the rising edge filter width to 1ms, the pulse width less than 1ms in the rising edge will be filtered out, as shown in Figure 8-1:

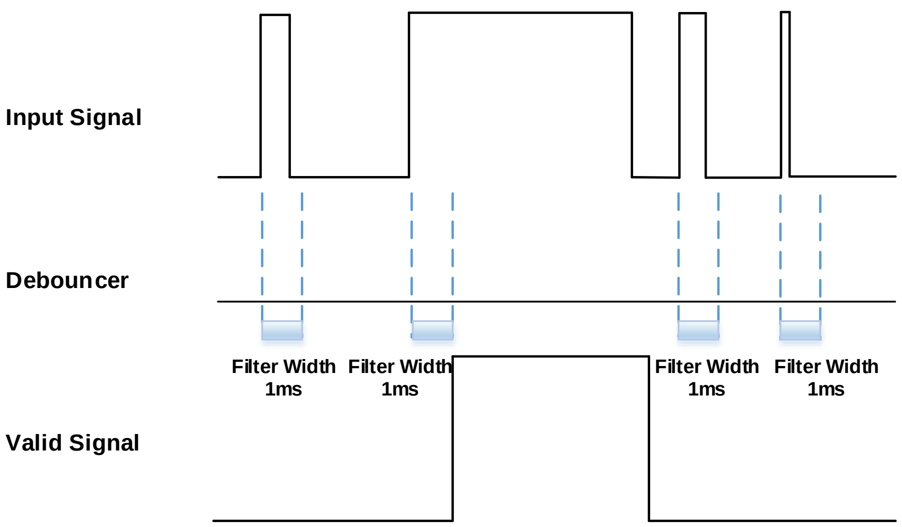


Figure 8-1 Input debouncer schematic diagram

3) Trigger Delay

The camera has trigger delay feature. The user can set the trigger delay feature by setting "TriggerDelay". The range of the trigger delay feature is [0, 3000000] μs, step: 1μs.

Example 1: Setting the trigger delay value to 1000ms, and the trigger signal will be valid after 1000ms delay, as shown in Figure 8-2.

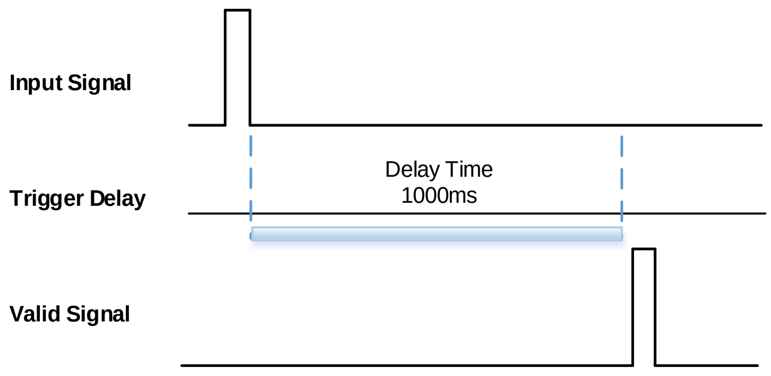


Figure 8-2 Trigger delay schematic diagram

4) Input Inverter

The signal level of input lines is configurable for the camera. The user can select whether the input level is reverse or not by setting "LineInverter".

For the camera, the default input line level is false when the camera is powered on, indicating that the input line level is not reversed. If it is set as true, indicating that the input line level is reversed. As shown in the Figure 8-3:

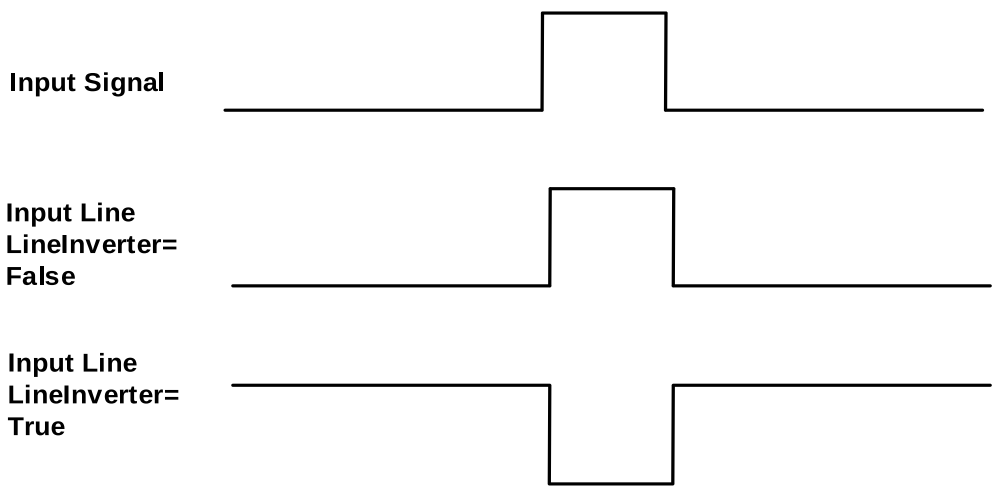


Figure 8-3 Setting input line to reverse

8.1.2. Output Mode Operation

1) Configuring Line as output

The camera has two output signals: Line1 and Line2. In which the Line1 is a uni-directional opto-isolated output I/O, Line2 is bi-direction configurable I/Os.

The Line1 is camera's default output when the camera is powered on. Line2 can be configured to be output by changing the "LineMode" of this line.

Each output source of the two output lines is configurable, and the output source includes: Strobe, UserOutput0, UserOutput1, UserOutput2, ExposureActive, FrameTriggerWait, AcquisitionTriggerWait, Timer1Active.

The default output source of the camera is UserOutput0 when the camera is powered on.

What status (high or low level) of the output signal is valid depends on the specific external circuit. The following signal diagrams are described as examples of active low.

- Strobe

In this mode the camera sends a trigger signal to activate the strobe. The strobe signal is active low. After receiving the trigger signal, the strobe signal level is pulled low. In global shutter mode and global reset release shutter mode, the strobe signal low level lasting time is the sum of the exposure delay time and the exposure time. In electronic rolling shutter mode, the strobe signal low level lasting time is the common exposure time for all lines, and the strobe signal outputs only when the "exposure time > frame period".

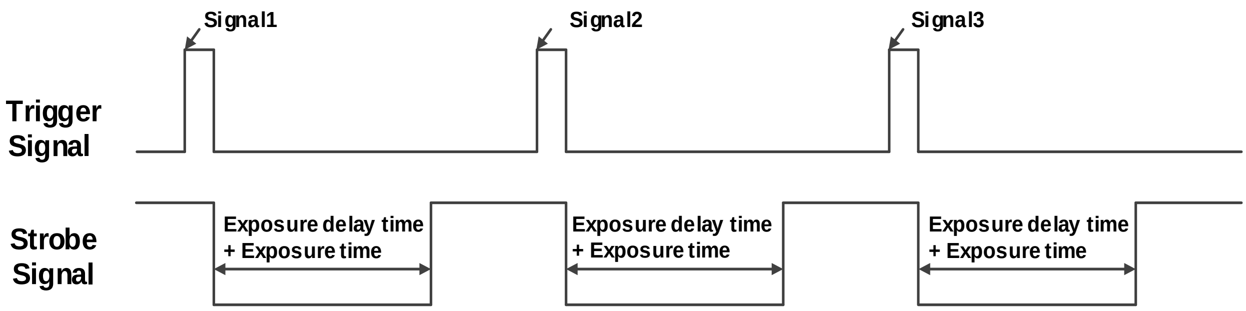


Figure 8-4 Strobe signal schematic diagram (global shutter and global reset release shutter)

- UserOutput

In this mode, the user can set the camera's constant output level for special processing, such as controlling the constant light source or the alarm light (two level types are available: high level or low level).

For example: select Line2 as the output line, the output source is selected as UserOutput1, and the output value is defined as true.

"LineSelector" is selected as "Line2", "LineMode" is set to "Output", "LineSource" is set to "UserOutput1", "UserOutputSelector" is selected as "UserOutput1", and "UserOutputValue" is set to "true".

- ExposureActive

You can use the "ExposureActive" signal to check whether the camera is currently exposing. The signal goes low at the beginning of the exposure and the signal goes high at the end of the exposure. In electronic rolling shutter and global reset release shutter modes, the signal goes high when the exposure of the last line ends.

The electronic rolling shutter mode supports overlapped exposure and is in overlapping exposure mode when the "frame period - exposure time ≤ readout time", at which time the "ExposureActive" signal is always low.

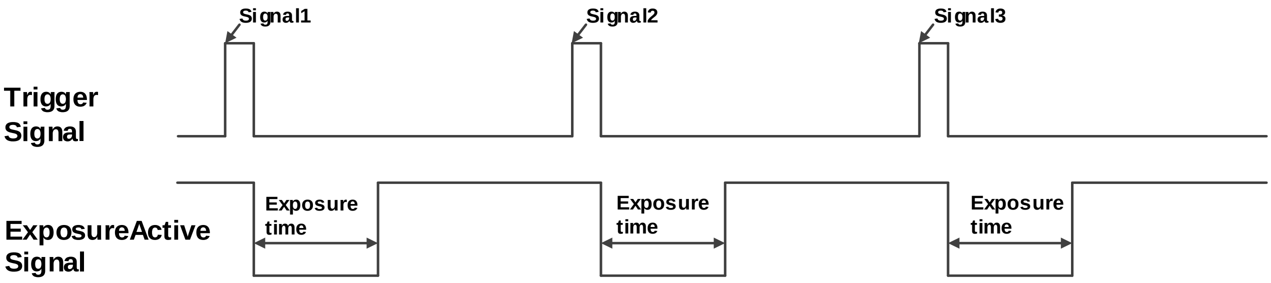


Figure 8-5 Global shutter mode "ExposureActive" signal schematic diagram

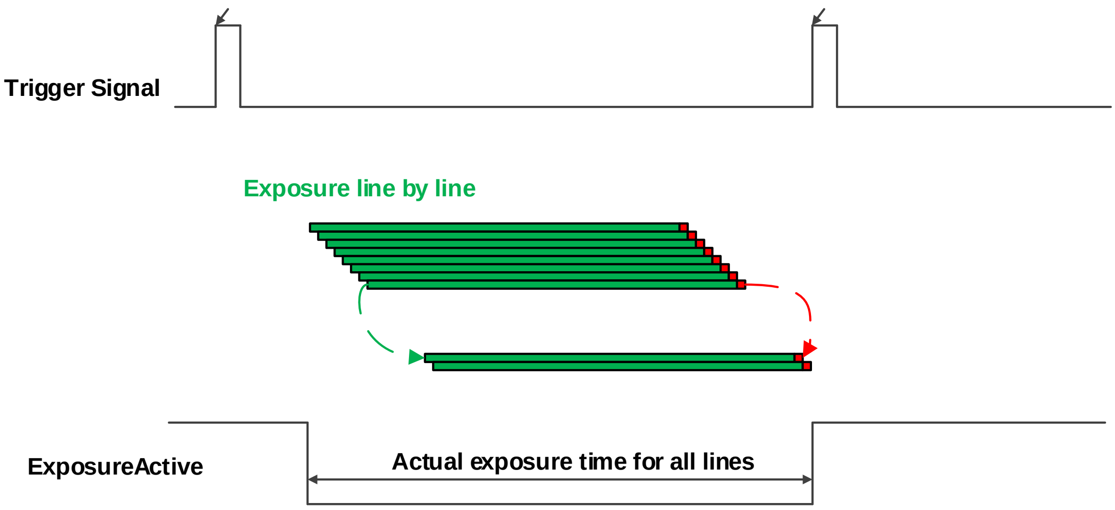


Figure 8-6 Electronic rolling shutter mode "ExposureActive" signal schematic diagram

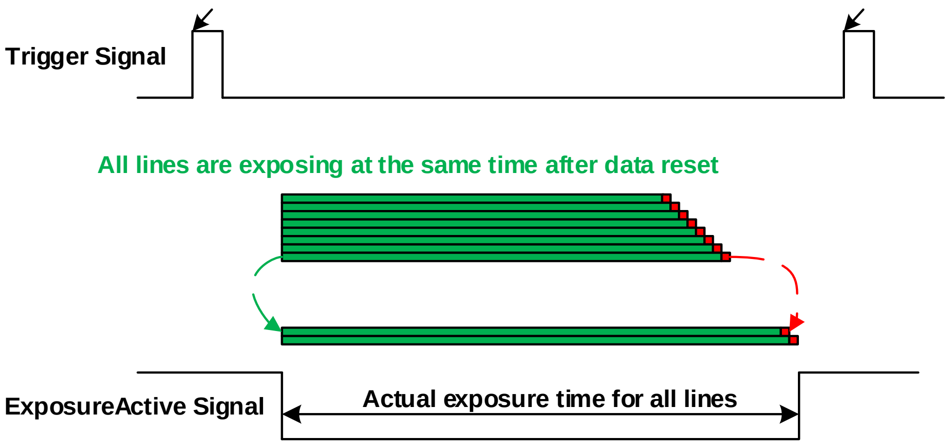


Figure 8-7 Global reset release shutter mode "ExposureActive" signal schematic diagram

This signal is useful when the camera or target object is moving. For example, suppose the camera is mounted on a robotic arm that can move the camera to different position. Generally, it is not desirable for the camera to move during the exposure. In this case, you can check the exposure activity signal to know the exposure time so you can avoid moving the camera during this time.

- TriggerWait

The "TriggerWait" signal can be used to optimize the acquisition of the trigger image and to avoid excessive triggering.

It is recommended to use the "TriggerWait" signal only when the camera is configured for hardware trigger. For software trigger, please use the "AcquisitionStatus". When the camera is ready to receive a trigger signal of the corresponding trigger mode, the "TriggerWait" signal goes low. When the corresponding trigger signal is used, the "TriggerWait" signal goes high. It remains high until the camera is ready to receive the next trigger.

When the trigger mode is "FrameStart", the camera acquires only one frame of image when it receives the trigger signal. After receiving the trigger signal, the "FrameTriggerWait" signal is pulled low and the camera starts exposure transmission. After the transfer is complete, the "FrameTriggerWait" signal is pulled high.

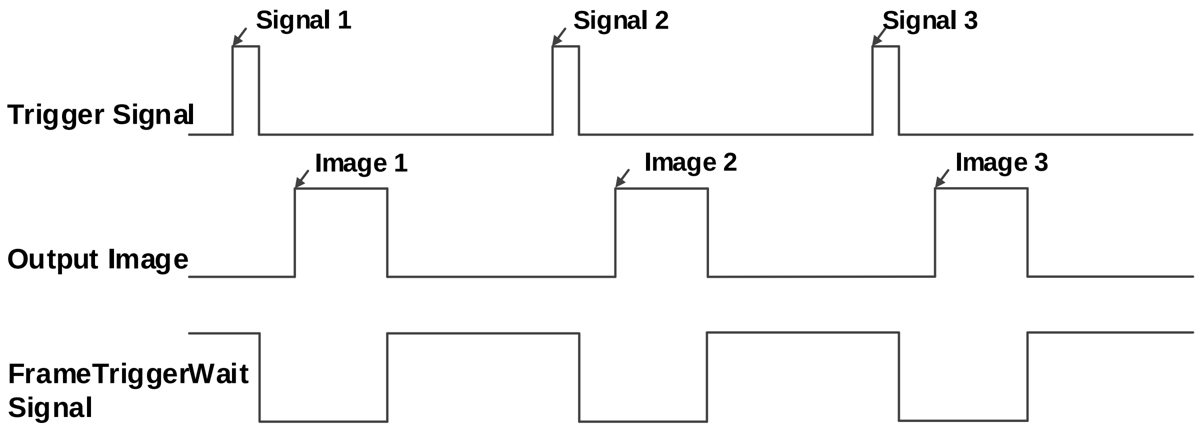


Figure 8-8 "FrameTriggerWait" signal schematic diagram

When the trigger mode is "FrameBurstStart", each time the camera receives a trigger signal, it will acquire multiple frames of image (the number of frames can be obtained by the function "AcquisitionFrameCount"). After receiving the trigger signal, the "AcquisitionTriggerWait" signal is pulled low and the camera starts the exposure transmission. When the transfer is completed, the "AcquisitionTriggerWait" signal will be pulled high.

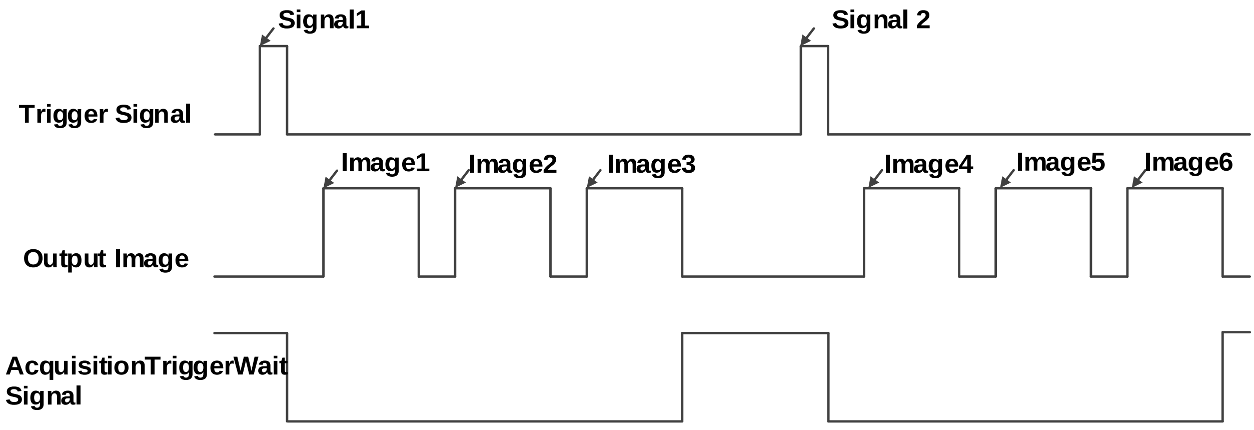


Figure 8-9 "AcquisitionTriggerWait" signal schematic diagram

2) Setting the user-defined status for the output lines

The camera can select the user-defined output by setting "LineSource", by setting "UserOutputValue" to configure the output signal.

By setting "UserOutputSelector" to select UserOutput0, UserOutput1 or UserOutput2.

By setting "UserOutputValue" to set the user-defined output value, and the default value is false when the camera is powered on.

3) Output Inverter

In order to facilitate the camera IO configuration and connection, the MARS series camera can configure output signal level. The user can select whether the output level is reverse or not by setting "LineInverter".

The default output signal level is false when the camera is powered on, indicating that the output line level is not reversed. If it is set as true, indicating that the output line level is reversed. As shown in the Figure 8-10.

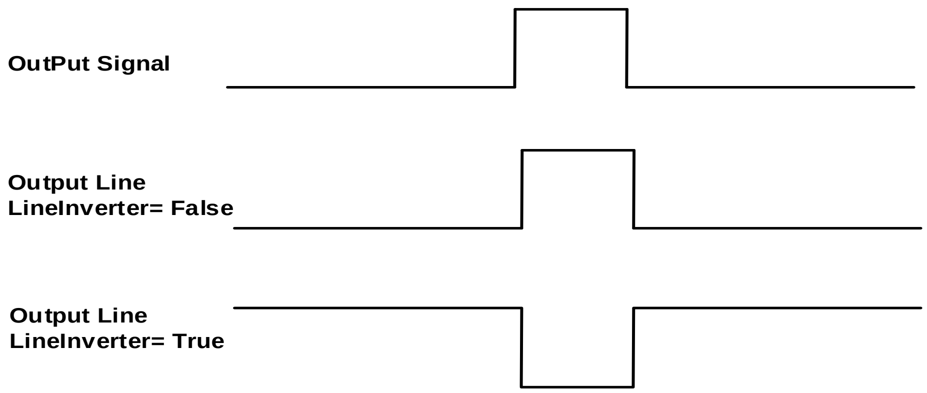


Figure 8-10 Set output line reversion

8.1.3. Read the LineStatus

1) Read the level of single line

The camera can get the line's signal status. When the device is powered on, the default status of Line0 is false, and the default status of Line1 and Line2 is true.

2) Read all the lines level

The camera can get the current status of all lines. On the one hand, the signal status is the status of the external I/O after the reversal of the polarity. On the other hand, signal status level can reflect the external I/O level.

All the lines level status bit of the camera are shown in Table 8-1. The default polarity does not reverse, and the default value is 0x6.

Line2	Line1	Line0
1	1	0

Table 8-1 Camera line status bit

8.2. Image Acquisition Control

8.2.1. Acquisition Start and Stop

8.2.1.1. Acquisition Start

It can send **AcquisitionStart** command immediately after opening the camera. The acquisition process in continuous mode is illustrated in Figure 8-11, and the acquisition process in trigger mode is illustrated in Figure 8-12.

- **Continuous Acquisition**

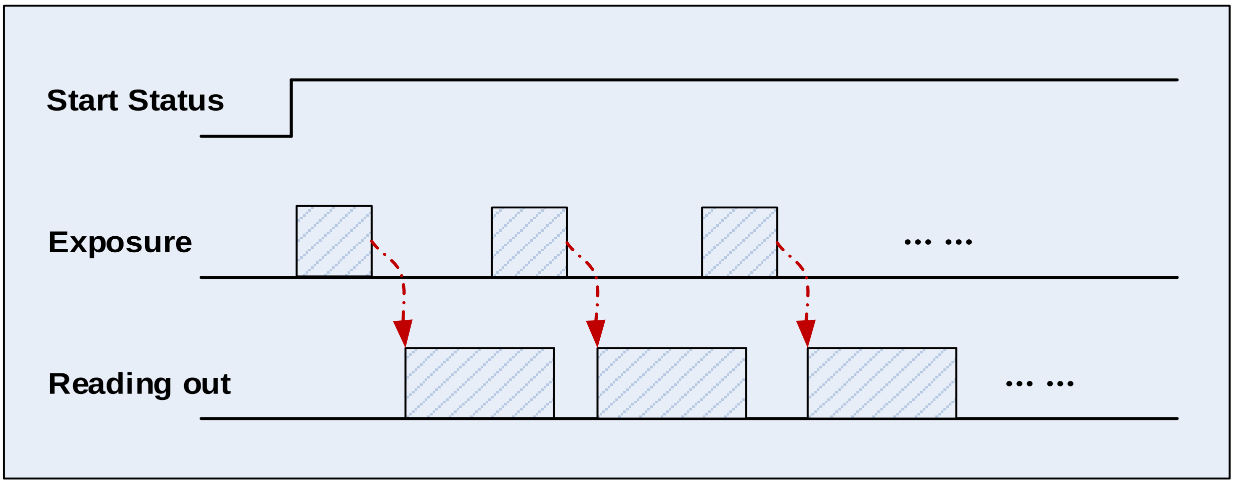


Figure 8-11 Continuous acquisition process

In continuous mode, a camera starts to expose and read out after receiving the **AcquisitionStart** command. The frame rate is determined by the exposure time, ROI and some other parameters.

- **Trigger Acquisition**

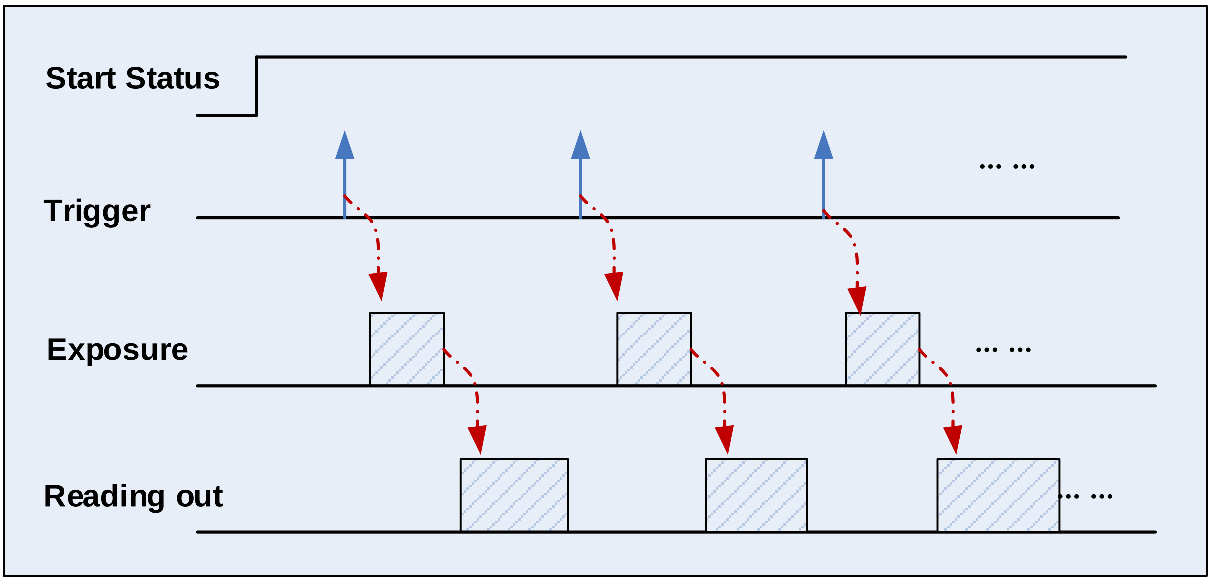


Figure 8-12 Trigger acquisition process

In trigger mode, sending **AcquisitionStart** command is not enough, a trigger signal is also needed. Each time a frame trigger is applied (including software trigger and hardware trigger), the camera will acquire and transmit a frame of image.

8.2.1.2. Acquisition Stop

It can send **AcquisitionStop** command to camera at any time. The acquisition stop process is irrelevant to acquisition mode. But different stop time will result in different process, as shown in Figure 8-13 and Figure 8-14.

- **Acquisition stop during reading out**

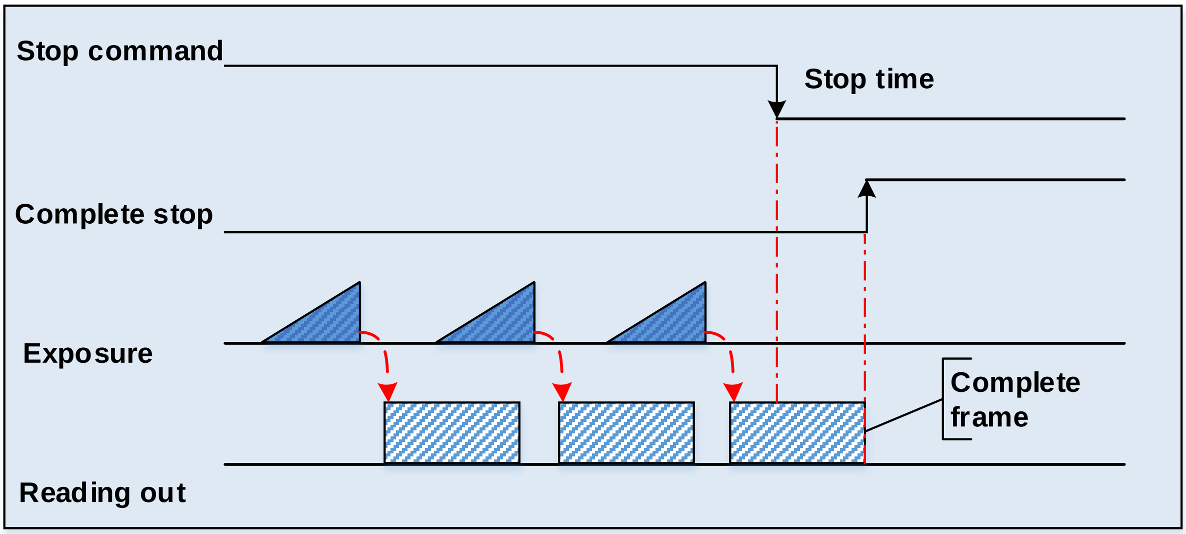


Figure 8-13 Acquisition stop during reading out

As shown in Figure 8-13, when the camera receives an **AcquisitionStop** command during reading out, it will not starts to expose again, and the currently transferred frame data continues to complete the transmission.

- **Acquisition stop during exposing**

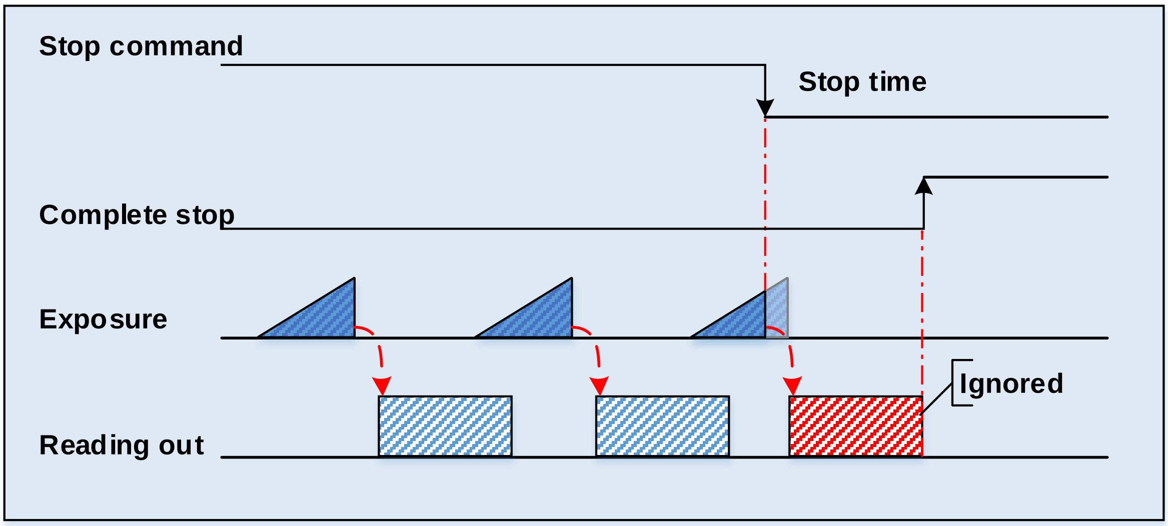


Figure 8-14 Acquisition stop during exposing

After the camera transferred a whole frame, the camera goes into exposure state. When user sends an **AcquisitionStop** command during exposing, the camera will immediately stop currently exposure state and return to stop acquisition state after finish the readout of incomplete frame. The camera will not send exception frames to users.

8.2.2. Acquisition Mode

Two camera acquisition modes are available: single frame acquisition mode and continuous acquisition mode.

- Single frame acquisition mode: In single frame acquisition mode, the camera will only acquire one frame of image at a time.

1) When the trigger mode is set to On, the trigger type is arbitrary

After executing the **AcquisitionStart** command, the camera waits for a trigger signal, which may be a software trigger or a hardware trigger of the camera. When the camera receives the trigger signal and acquires an image, the camera will automatically stop image acquisition. If you want to acquire another frame of image, you must execute the **AcquisitionStart** command again.

2) When the trigger mode is set to Off

After executing the **AcquisitionStart** command, the camera acquires one frame of image and then automatically stops image acquisition. If you want to acquire another frame of image, you must execute the **AcquisitionStart** command again.

⚠ In single frame acquisition mode, you must execute the **AcquisitionStop** command to set the functions that cannot be set in the acquisition status, such as ROI, packet size, etc.

- Continuous acquisition mode: In continuous acquisition mode, the camera continuously acquires and transmits images until the acquisition is stopped.

1) When the trigger mode is set to On, the trigger type is **FrameStart**

After executing the **AcquisitionStart** command, the camera waits for a trigger signal, which may be a software trigger or a hardware trigger of the camera. Each time the camera receives a trigger signal, it can acquire a frame of image until the **AcquisitionStop** command is executed. It is not necessary to execute the **AcquisitionStart** command every time.

2) When the trigger mode is set to On, the trigger type is **FrameBurstStart**

After executing the **AcquisitionStart** command, the camera waits for a trigger signal, which may be a software trigger or a hardware trigger of the camera. Each time the camera receives a trigger signal, it can continuously acquire the set **AcquisitionFrameCount** frames of image. If the **AcquisitionStop** command is received during the acquisition process, the image being transmitted may be interrupted, resulting in the number of images acquired this time not reaching the **AcquisitionFrameCount** frames of image.

3) When the trigger mode is set to Off

After executing the **AcquisitionStart** command, the camera will continuously acquire images until it receives the **AcquisitionStop** command.

You can check if the camera is in the waiting trigger status by the camera's trigger wait signal or by using the acquisition status function.

8.2.3. Trigger Type Selection

Two camera trigger types are available: **FrameStart** and **FrameBurstStart**. Different trigger types correspond to their respective set of trigger configurations, including trigger mode, trigger delay, trigger source, trigger polarity, and software trigger commands.

- FrameStart trigger mode

The **FrameStart** trigger is used to acquire one image. Each time the camera receives a **FrameStart** trigger signal, the camera begins to acquire an image.

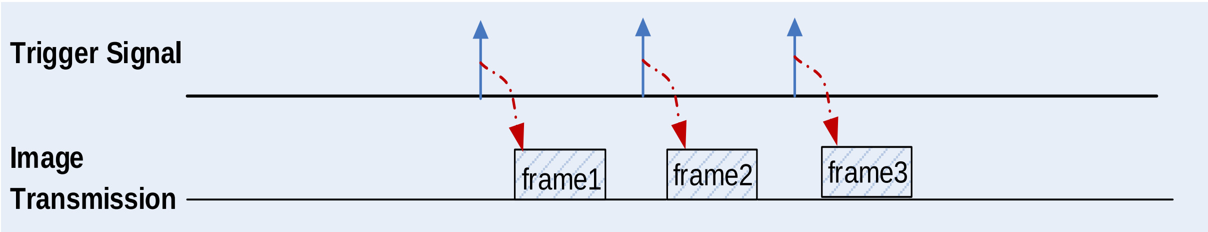


Figure 8-15 FrameStart trigger

- FrameBurstStart trigger mode

You can use the **FrameBurstStart** trigger signal to acquire a series of images ("continuous shooting" of the image). Each time the camera receives a **FrameBurstStart** trigger signal, the camera will start acquiring a series of images. The number of acquired image frames is specified by the "Acquisition burst frame count" parameter. The range of "Acquisition burst frame count" is 1~65535, and the default value is 1.

For example, if the "Acquisition burst frame count" parameter is set to 3, the camera automatically acquires 3 images. Then, the camera waits for the next **FrameBurstStart** trigger signal. After receiving the next trigger signal, the camera will take another 3 images, and so on.

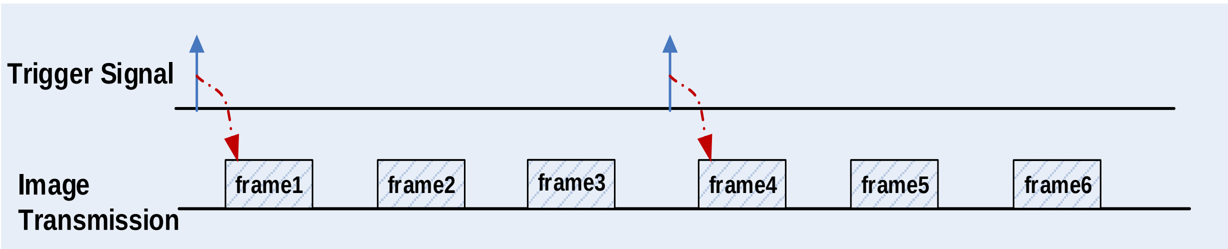


Figure 8-16 FrameBurstStart trigger

- FrameStart trigger mode and FrameBurstStart trigger mode are selected at the same time

If the **FrameStart** trigger mode and the **FrameBurstStart** trigger mode are selected at the same time, the trigger sequence is: first send the **FrameBurstStart** trigger signal, then send the **FrameStart** trigger signal. Each time a **FrameStart** trigger signal is sent, an image is acquired until the value of the "Acquisition burst frame count" parameter is reached.

For example, the **FrameStart** trigger mode and the **FrameBurstStart** trigger mode are selected at the same time. If the "Acquisition burst frame count" parameter is set to 3, when the camera receives a **FrameBurstStart** trigger signal, no image will be acquired. When the **FrameStart** trigger signal is received, the camera will acquire1 image, each time a **FrameStart** trigger signal is received, the camera will acquire 1 image. When 3 images are acquired, the camera will wait for the next **FrameBurstStart** trigger signal, and so on.

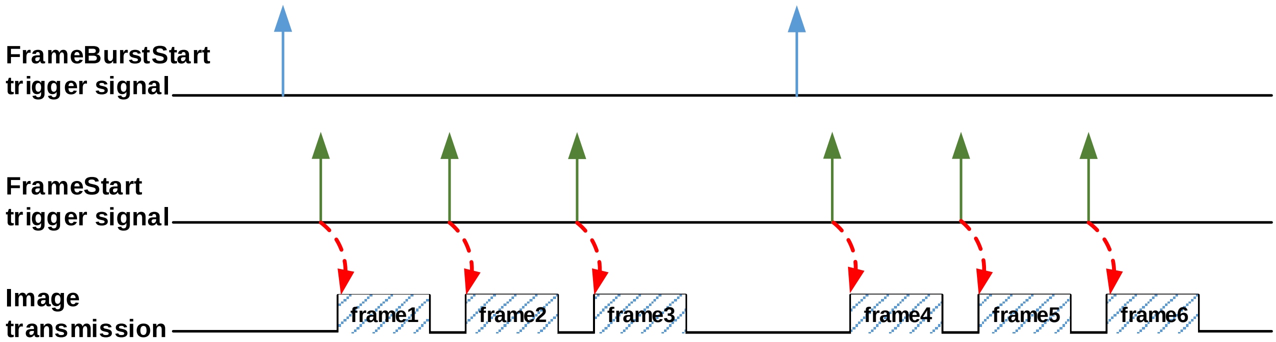


Figure 8-17 Two trigger modes are selected at the same time

8.2.4. Switching Trigger Mode

During the stream acquisition process, the user can switch the trigger mode of the camera without the **AcquisitionStop** command.

As shown below, switching the trigger mode at different positions will have different results.

- Switch trigger mode during frame reading out

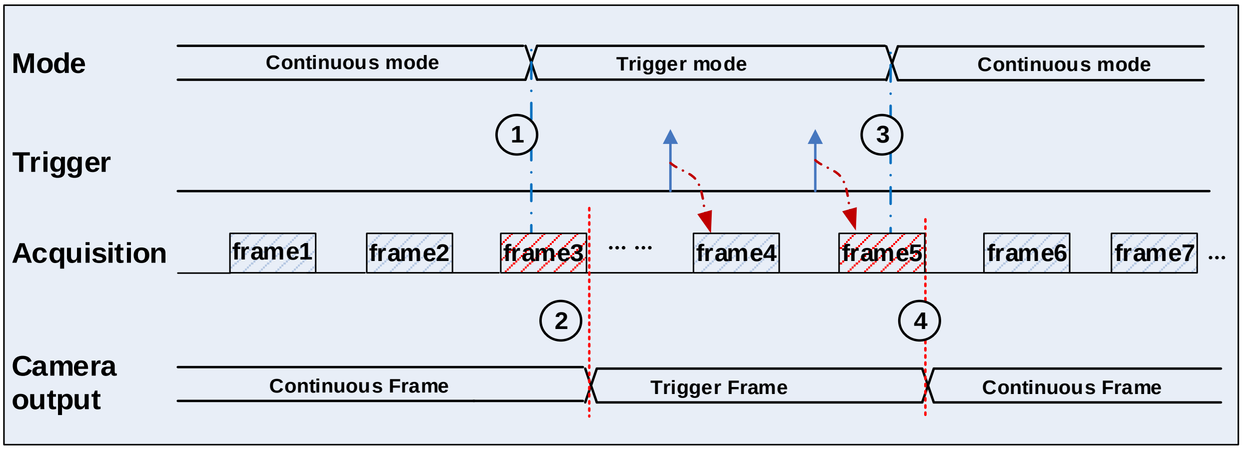


Figure 8-18 Switch trigger mode during frame reading out

As shown in Figure 8-18, the camera starts with trigger mode **OFF** after receiving acquisition start command.

At point 1, the camera gets a command of setting trigger mode **ON** while transferring the 3rd frame in trigger mode **OFF**. The trigger mode is not active until the 3rd frame is finished, at point 2, and then the trigger signal will be accepted. At point 3, the camera gets a command of switching back to **OFF**. It is also not active until the 5th frame is finished, it should wait a complete reading out. The camera switches from trigger mode to continuous mode at point 4, and then the camera works in continuous mode.

- **Switch trigger mode during blanking**

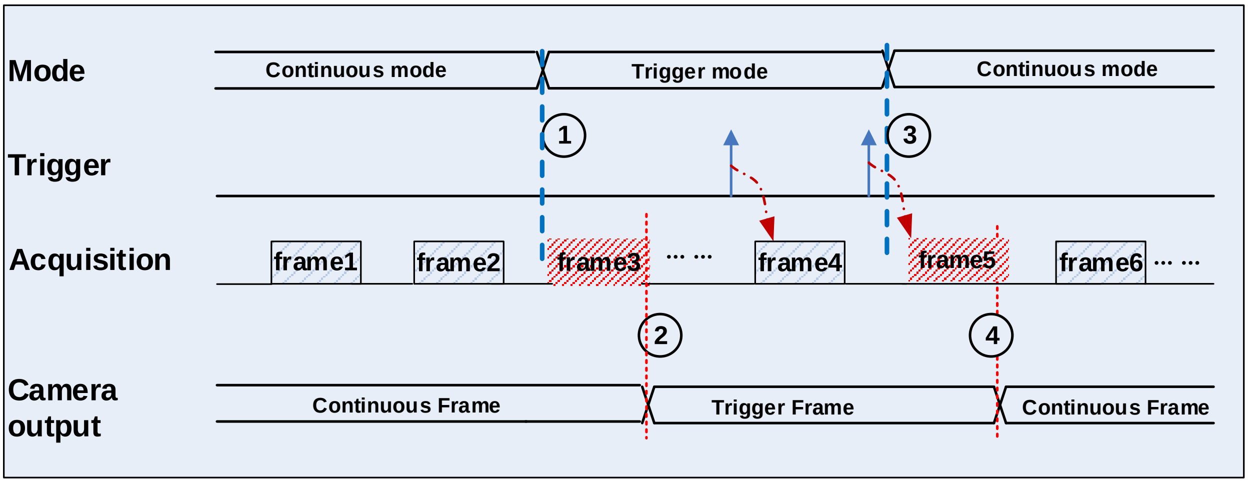


Figure 8-19 Switch trigger mode during blanking

As shown in Figure 8-19, the camera with trigger mode **OFF** begins after receiving an **AcquisitionStart** command.

At point 1, the camera gets a command of setting trigger mode **ON** while it is in wait state. The trigger mode is not active until the 3rd frame is finished, i.e., point 2. Please note that the 3rd frame does not belong to trigger mode. All trigger frames need trigger signals or software trigger commands. At point 3, the camera gets a command of switching back to continuous mode. It is also not active until the 5th frame is finished, it should wait a complete frame. The camera switches from trigger mode to continuous mode at point 4, and then the camera works in continuous mode.

8.2.5. Continuous Mode and Configuration

- Continuous mode configuration

The default value of **Trigger Mode** is **OFF** in default user set. If the camera is opened with default user set, the camera works in continuous mode directly. Otherwise, user can set **Trigger Mode** to **OFF** to work in continuous mode.

Other parameters also can be changed in **Trigger Mode OFF**.

- **Continuous mode features**

In continuous acquisition mode, the camera acquires and transmits images according to camera parameter set.

⚠ In continuous mode, ROI size may have effects on frame rate.

8.2.6. Software Trigger Acquisition and Configuration

- **Software trigger acquisition configuration**

The camera supports software trigger acquisition mode. Three steps followed should be ensured.

1) Set the Trigger Mode to ON.

2) Set the Trigger Source to Software.

3) Send Software Trigger command.

All the software trigger commands are sent by the host through the CoaXPress protocol, to trigger the camera to acquire and transmit images.

- **Software trigger acquisition features**

In software trigger acquisition mode, the camera begins to acquire one image after receiving software trigger commands. In general, the number of frames is equal to the number of software trigger commands. The relative features are illustrated below:

1) In software trigger acquisition mode, if the trigger frequency is lower than permissible maximal FPS (Frame per Second) of the camera, the current frame rate is trigger frequency. If the trigger frequency is higher than permissible maximal FPS (Frame per Second) of the camera, some software triggers are ignored and the current frame rate is lower than trigger frequency.

2) The trigger delay feature can control the camera delay interval between your triggers and the camera acquiring frames. The default value of trigger delay time is zero.

8.2.7. Hardware Trigger Acquisition and Configuration

- **Hardware trigger acquisition configuration**

The camera supports hardware trigger acquisition mode. Three steps followed should be ensured:

1) Set the Trigger Mode to ON.

2) Set the Trigger Source to Line0 or Line2.

3) Connect hardware trigger signal to Line0.

If the Trigger Source is set by Line2, it should be ensured that the corresponding Line is set as Input.

Please refer to section 8.1.1 for more information of the camera programmable GPIOs.

- **Hardware trigger acquisition features**

The relative features about the camera's trigger signal process are illustrated below:

1) The polarity of lines can be set to inverted or not inverted, and the default setting is not inverted.

2) Improper signal can be filtered by setting appropriate value to trigger filter. Raising edge filter and falling edge can be set separately. The default configuration is not use trigger filter.

3) The time interval between trigger and exposure can be set through the trigger delay feature. The default value of trigger delay time is zero.

The features, like trigger polarity, trigger delay and trigger filter, can be select in the GalaxyView.

> ⚠ The camera's trigger source Line0 uses opto-isolated circuit to isolate signal. Its internal circuit delay trigger signal and rising edge's delay time is less than falling edge's. There are a dozen clock cycles delay of rising edge and dozens clock cycles delay of falling edge. If you use Line0 to trigger the camera, the positive pulse signal's positive width will be wider (about 20μs~40μs) and the negative pulse signal's negative width will be narrower (about 20μs~40μs). You can adjust filter parameter to accurately filter trigger signal.

8.2.8. CXPTrigger Acquisition and Configuration

- **CXPTrigger acquisition configuration**

The camera supports LinkTrigger trigger acquisition mode (CXPTrigger). Three steps followed should be ensured.

1) Set the Trigger Mode to ON.

2) Set the Trigger Source to CXPTrigger0 or CXPTrigger1.

3) According to the Trigger Source selection, configure the CXPTrigger sending function of the CoaXPress frame grabber (select the same mode as the Trigger Source).

- **CXPTrigger acquisition features**

The relative features about the camera's CXPTrigger signal process are illustrated below:

1) The time interval between trigger and exposure can be set through the trigger delay feature. This feature configuration does not affect the camera's response to the CXPTrigger response.

> ⚠ CXPTrigger is a high real-time control packet sent by the frame grabber to the camera in the form of command packet. However, due to the limitation of UpDataLink transmission rate and the time consumption of camera control packet resolving, there is still a delay of 1.5μs~3μs between the CXPTrigger sent by the frame grabber and the trigger signal received and resolved by the camera.

8.2.9. Overlapping Exposure and Non-overlapping Exposure

There are two stages in image acquisition of the camera: exposure and readout. Once the camera is triggered, it begins to integrate and when the integration is over, the image data will be read out immediately.

The camera supports two exposure modes: overlapping exposure and non-overlapping exposure. The user cannot assign the overlapping exposure or non-overlapping exposure directly, it depends on the frequency of trigger signal and the exposure time. The two exposure mode are described as below.

- Non-overlapping exposure

In non-overlapping exposure mode, after the exposure and readout of the current frame are completed, then the next frame will expose and read out. As shown in the Figure 8-20, the N^{th} frame is read out, after a period of time, the $N+1^{th}$ frame to be exposed.

The formula of non-overlapping exposure frame period:

non-overlapping exposure frame period > exposure time + readout time

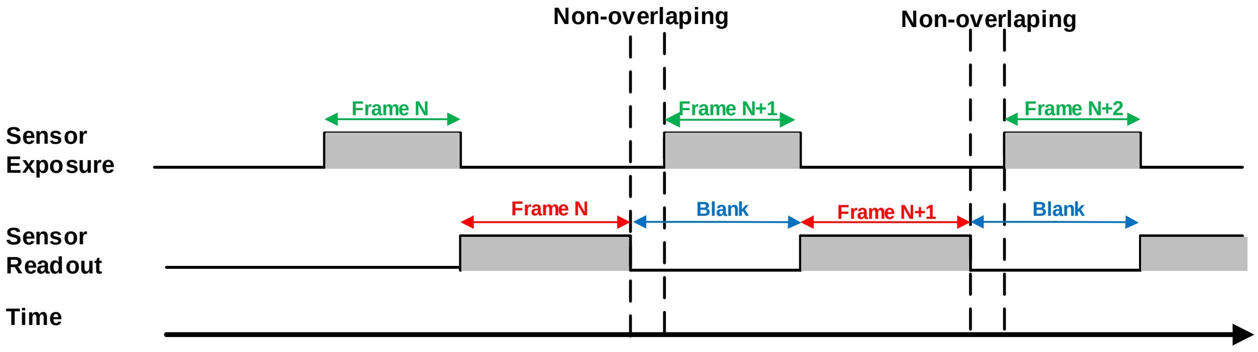


Figure 8-20 The exposure sequence diagram in non-overlapping exposure mode

- **Trigger acquisition mode**

If the interval between two triggers is greater than the sum of the exposure time and readout time, overlapping exposure will not occur, as shown in Figure 8-21.

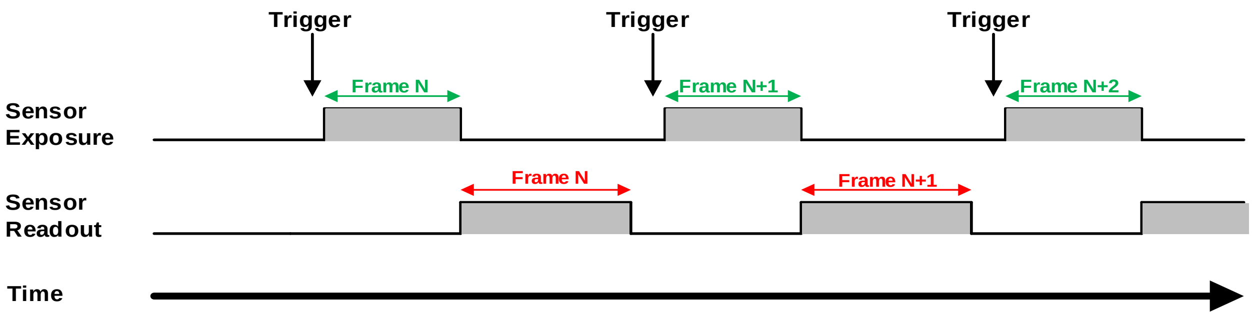


Figure 8-21 The trigger acquisition exposure sequence diagram in non-overlapping exposure mode

- **Overlapping exposure**

In overlapping exposure mode, the current frame image exposure process is overlap with the readout of the previous frame. That is, when the previous frame is reading out, the next frame image has been started exposure. As shown in the Figure 8-22, when the Nth frame image is reading out, the N+1th frame image has been started exposure.

The formula of overlapping exposure frame period:

$$\text{overlapping exposure frame period} \leq \text{exposure time} + \text{readout time}$$

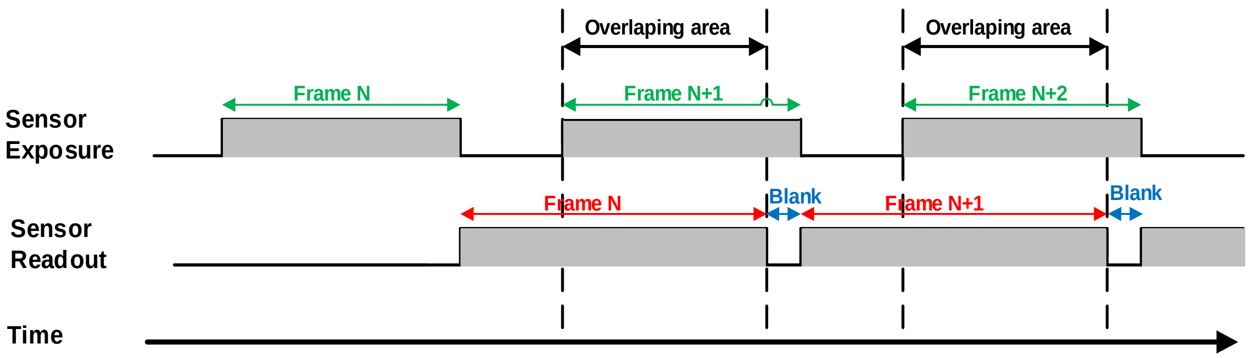


Figure 8-22 The exposure sequence diagram in overlapping exposure mode

- **Continuous acquisition mode**

If the exposure time is greater than the frame blanking time, the exposure time and the readout time will be overlapped. As shown in the Figure 8-22.

- **Trigger acquisition mode**

When the interval between two triggers is less than the sum of exposure time and the readout time, overlapping exposure will occur, as shown in Figure 8-23.

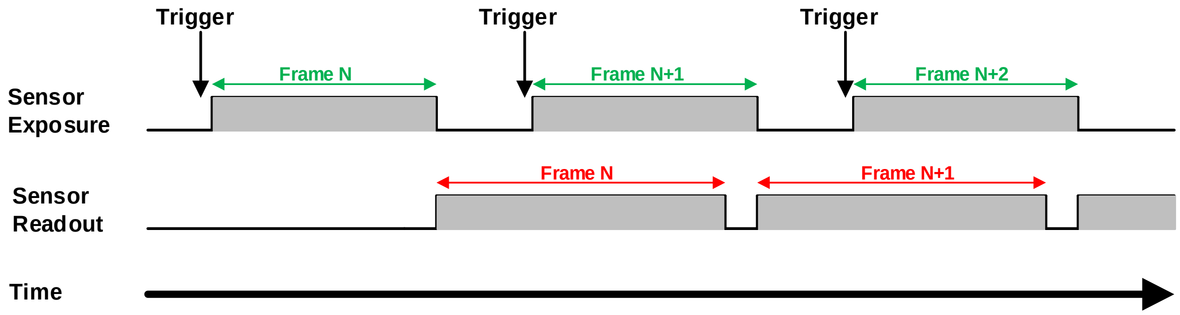


Figure 8-23 The trigger acquisition exposure sequence diagram in overlapping exposure mode

Compared with non-overlapping exposure mode, in overlapping exposure mode, the camera can obtain higher frame rate.

8.2.10. Set Exposure

8.2.10.1. Set Exposure Mode

Two Exposure Mode are available: Timed exposure mode and TriggerWidth exposure mode. Among them, the TriggerWidth exposure mode determines the exposure time when the camera is configured for hardware triggering. And the exposure time depends on the width of the trigger signal, which is triggered by the rising edge (falling edge) set by the Trigger Activation.

1) **Available exposure mode**

a) Timed exposure mode

Timed exposure mode is available on all camera models. In this mode, the exposure time is determined by the camera's Exposure Time setting. If the camera is configured for software triggering, exposure starts when the software trigger signal is received and continues until the exposure time has expired.

If the camera is configured for hardware trigger:

- If rising edge triggering is enabled, exposure starts when the trigger signal rises and continues until the exposure time has expired, as shown in Figure 8-24

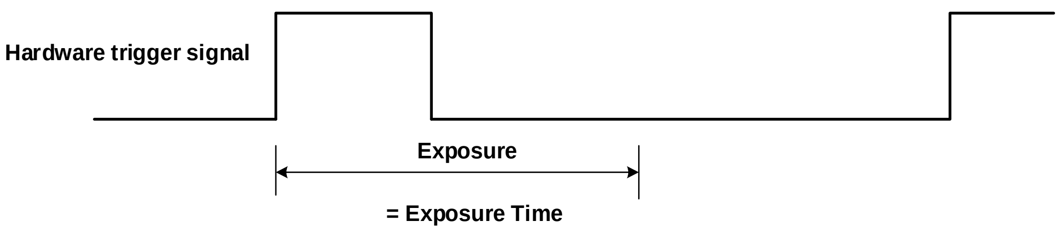


Figure 8-24 The sequence diagram in rising edge trigger of Timed exposure mode

- If falling edge triggering is enabled, exposure starts when the trigger signal falls and continue until the exposure time has expired, as shown in Figure 8-25

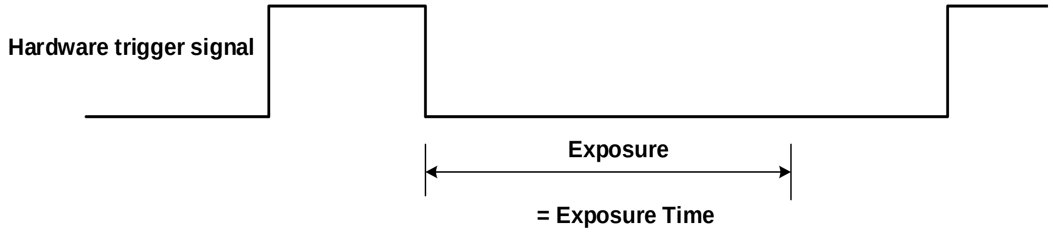


Figure 8-25 The sequence diagram in falling edge trigger of Timed exposure mode

Avoid overtriggering in Timed exposure mode. If the Timed exposure mode is enabled, do not attempt to send a new trigger signal while the previous exposure is still in progress. Otherwise, the trigger signal will be ignored, and a FrameStartOvertrigger event will be generated.

b) TriggerWidth exposure mode

In TriggerWidth exposure mode, the length of exposure is determined by the width of the hardware trigger signal. This function can meet the needs of users to change the exposure time of each frame of image.

- If rising edge triggering is enabled, exposure starts when the trigger signal rises and continue until the trigger signal falls, as shown in Figure 8-26

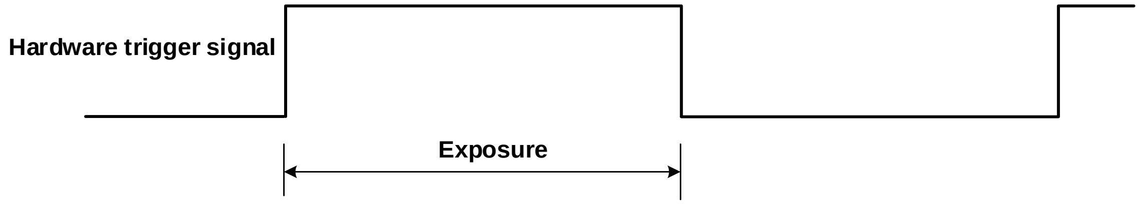


Figure 8-26 The sequence diagram in rising edge trigger of TriggerWidth exposure mode

- If falling edge triggering is enabled, exposure starts when the trigger signal falls and continue until the trigger signal rises, as shown in Figure 8-27

Figure 8-27 The sequence diagram in falling edge trigger of TriggerWidth exposure mode

Avoid overtriggering in TriggerWidth exposure mode. If the TriggerWidth exposure mode is enabled, do not send trigger signals at too high a rate. Otherwise, trigger signals will be ignored, and a FrameStartOvertrigger event will be generated.

The Exposure Overlap Time Max feature can optimize the acquisition of overlapping images. This parameter is especially useful if the user wants to maximize the camera's frame rate, i.e., if the user wants to trigger at the highest rate possible.

- **Prerequisites**

a) Set the TriggerMode parameter to On.

b) Set the TriggerSource parameter to one of the available hardware trigger source, e.g., Line0.

c) Set the ExposureMode parameter to TriggerWidth exposure mode.

- **How it works**

The user can use overlapping image acquisition to increase the frame rate of the camera. With overlapping image acquisition, the exposure of a new image begins while the camera is still reading out the sensor data of the previous image.

In TriggerWidth exposure mode, the camera does not "know" how long the image will be exposed before the trigger period is complete. Therefore, the camera cannot fully optimize overlapping image acquisition. To avoid this problem, the user can enter a value for the ExposureOverlapTimeMax parameter, which represents the shortest exposure time the user intends to use (in μs). This helps the camera optimize the overlapping image acquisition.

- **Set ExposureOverlapTimeMax**

To optimize the frame rate of the camera, the exposure mode should be set to TriggerWidth:

a) Set the ExposureMode parameter to TriggerWidth.

b) Enter a value for the ExposureOverlapTimeMax parameter, which represents the shortest exposure time the user intends to use (in μs).

Example: Assume that the user wants to trigger the camera to apply exposure times in the range of 3000 μs to 5500 μs, the user needs to set the ExposureOverlapTimeMax parameter of the camera to 3000.

1) The trigger signal width of the hardware triggering should not be shorter than the value of the entered ExposureOverlapTimeMax parameter.

2) The maximum value of the ExposureOverlapTimeMax parameter is related to camera connection configuration, image ROI height, et. Modify these parameters could affect the current value of the input ExposureOverlapTimeMax parameter.

8.2.10.2. Set Exposure Value

- **Global Shutter**

The implementation process of global shutter is as shown in Figure 8-28, all the lines of the sensor are exposed at the same time, and then the sensor will read out the image date one by one.

The advantage of the global shutter is that all the lines are exposed at the same time, and the images do not appear offset and distortion when capturing moving objects.

The time width of the flash signal can be got by the following formula:

$$T_{strobe} = T_{exposure}$$

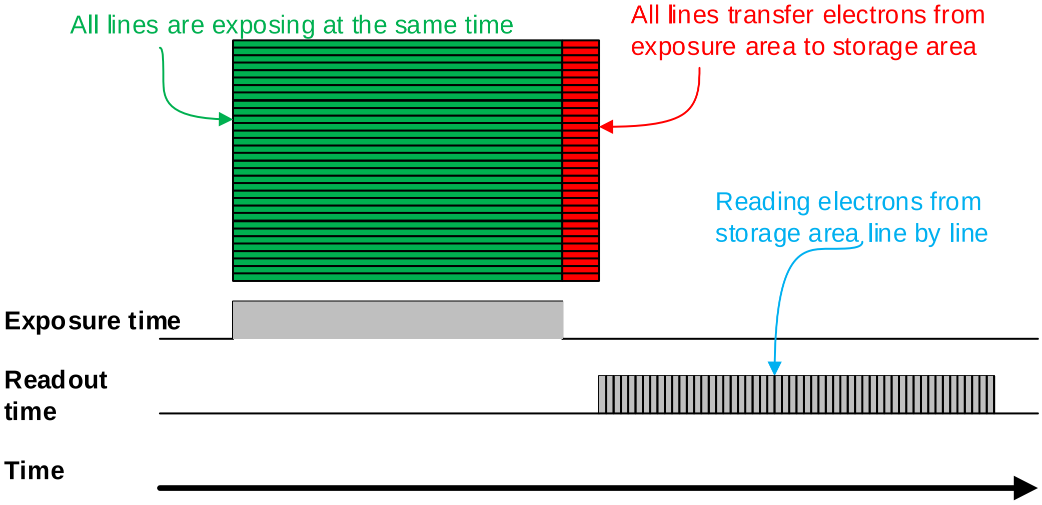


Figure 8-28 Global shutter

- **Electronic Rolling Shutter**

The implementation process of electronic rolling shutter is as shown in Figure 8-29, different from the global shutter, electronic rolling shutter exposures from the first line, and starts the second line exposure after a row period. And so on, after N-1 line, the N line starts exposing. When the first line exposure ends, it begins to read out the data, and it need a row period time to read out one line (including the line blanking time). When the first line reads out completely, the second line just begins to read out, and so on, when the N-1 line is read out, the N line begins to read out, until the whole image is read out completely.

The electronic rolling shutter has low price and high resolution, which is a good choice for some static image acquisition.

The time width of the flash signal can be got by the following formula:

$$T_{strobe} = T_{exposure} - (N-1) \times T_{row}$$

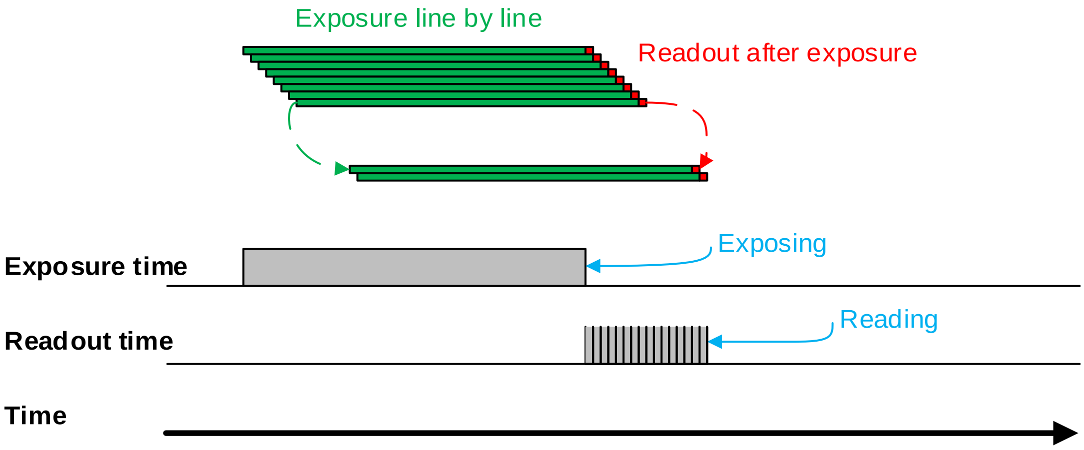


Figure 8-29 Electronic rolling shutter

- **Global Reset Release Shutter**

As the sensor starts exposure line by line, all of the pixels in the sensor start exposing at the same time. However, the end time of upper lines and lower lines of the same frame of image is different when capturing fast moving objects, so the distortion will occur. The Global Reset Release (GRR) shutter mode can effectively avoid the distortion. If the camera is operated in the GRR shutter mode, you must use flash lighting.

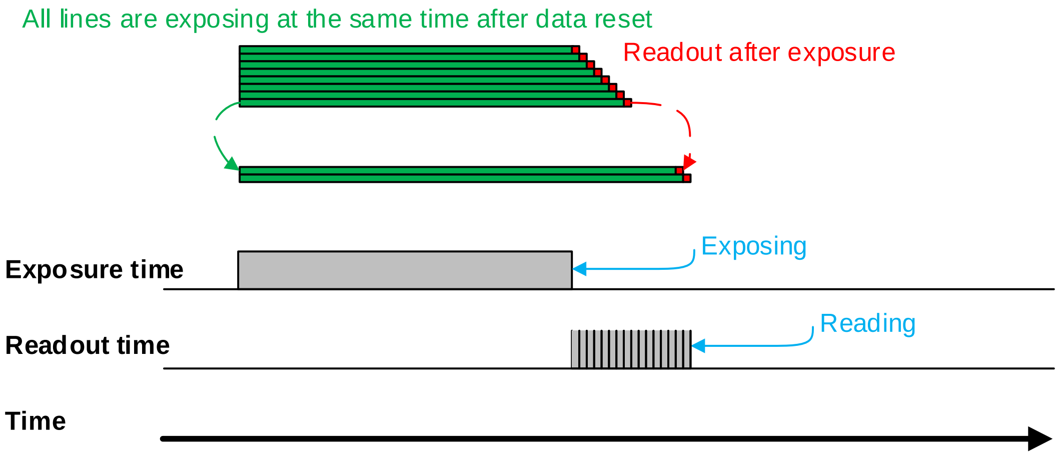


Figure 8-30 Global Reset Release shutter

Line-by-line exposure sensor starts exposure at the same time in GRR mode, and the exposure ends successively from top to bottom. As shown in the Figure 8-30, the exposure time is the common exposure interval, which is also the interval that the flash lighting needs to be opened. That is, the exposure time signal goes high when you can start the flash lighting, and the exposure time signal goes low when you should stop the flash lighting. Otherwise, the brightness in the acquired images will vary significantly from top to bottom due to the differences in the exposure time of the individual lines. In addition, the image will be distortional due to different exposure end time of the individual lines.

The exposure delay is supported in GRR mode. At the same time, there is a certain delay due to the flash lighting, and the actual duration of the flash is as follows:

$$T_{strobe} = T_{exposure} + T_{\exp\_delay} + T_{row} \times 18$$

Settings:

1) Set the SensorShutterMode to Global Reset.

2) Connect the camera to the flash lighting.

8.2.10.3. Exposure Time Mode

According to the length of the exposure time, two exposure time modes of the camera are available: Standard exposure time mode and UltraShort exposure time mode.

In Standard exposure time mode, three exposure time adjustment modes are available: manual adjustment, one-time automatic adjustment and continuous automatic adjustment. The standard exposure time mode is the default setting. For the manual adjustment, please refer to section 8.2.9. For the automatic adjustment and continuous automatic adjustment, please refer to section 8.3.5.

In UltraShort exposure time mode, the camera only supports manual adjustment of the exposure time. Since standard exposure time mode is the default setting, if you want to set the UltraShort exposure time mode, you first need to adjust the visibility level to guru and set the ExposureTimeMode to UltraShort under the acquisition control features window, as shown in Figure 8-31.

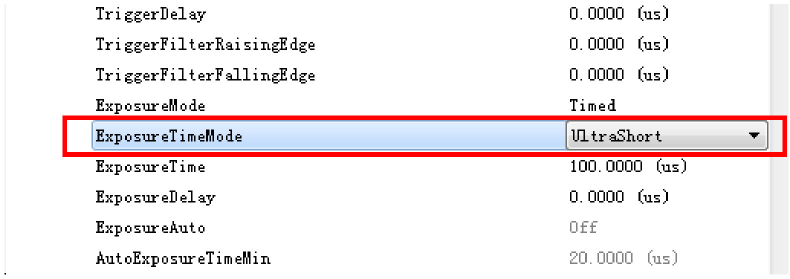


Figure 8-31 UltraShort exposure time mode

In UltraShort exposure time mode, the camera does not support automatic adjustment of the exposure time, only support manual adjustment of the exposure time.

8.2.10.4. Set Exposure Time

The camera supports setting the exposure time, step: 1μs.

The exposure precision of the camera is limited by the sensor, when the steps in the user's interface and the demo display as 1μs, actually the steps are one row period. When the value of the ExposureTime cannot be divisible by the row period, round up to an integer should be taken, such as the row period is 36μs, setting exposure time to 80μs, and the actual exposure time is 108μs.

When the external light source is sunlight or direct current (DC), the camera has no special requirements for the exposure time. When the external light source is alternating current (AC), the exposure time must synchronize with the external light source (under 100Hz light source, the exposure time must be a multiple of 1/100s.), to ensure better image quality (The frequency of fluorescent in common is 50Hz.).

The camera supports Auto Exposure feature. If the Auto Exposure feature is enabled, the camera can adjust the exposure time automatically according to the environment brightness. See section 8.3.5 for more details.

8.2.11. Exposure Delay

The exposure delay function can effectively solve the strobe delay problem. Most strobes have a delay of at least tens of microseconds from trigger to light. When the camera is working in a small exposure mode, the fill light effect of the strobe will be affected. The exposure delay is achieved by the strobe signal and the delay of the actual exposure starting.

The unit of exposure delay is μs, the range is 0 ~ 5000μs, and the minimum value is 0.

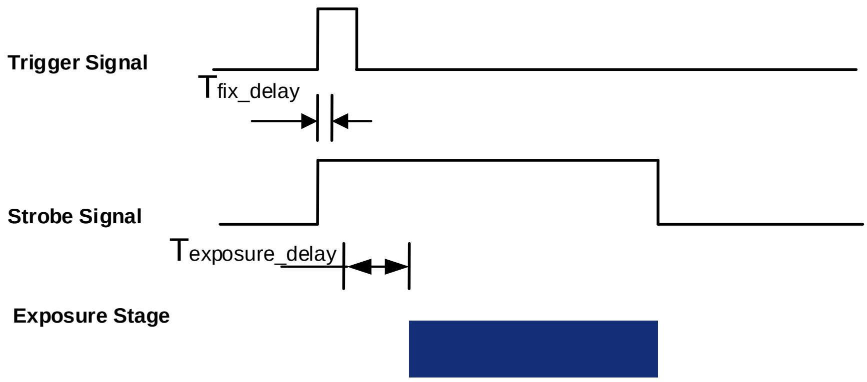


Figure 8-32 The exposure delay sequence diagram in overlaping exposure mode

When a trigger signal is received to the sensor to start exposure, there is a small delay, which is called the exposure delay and consists of five parts of time.

T1: The delay introduced by the hardware circuit when the external signal passes through the optocoupler or GPIO. The value is generally in the range of several to several tens of μs. The delay is mainly affected by the connection mode, driving intensity and temperature. When the external environment is constant, the delay is generally stable.

T2: Delay introduced by the trigger filter. For example, if the trigger filter time is set to 50μs, T2 is 50μs and CXPTrigger is not affected.

T3: Trigger delay (trigger_delay), the camera supports trigger delay feature. If the trigger delay is set to 200μs, T3 is 200μs.

T4: Exposure delay (exposure_delay), the exposure delay time mentioned above. If the exposure delay is set to 200μs, T4 is 200μs.

T5: The sensor timing sequence delay, the internal exposure of the sensor is aligned with the row timing sequence, so T5 has a maximum row cycle jitter. The value of each sensor is different.

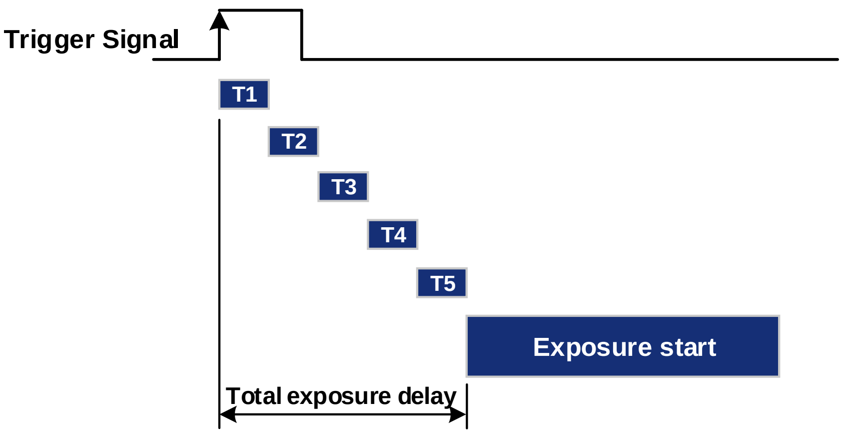


Figure 8-33 Exposure delay

The following table shows the total exposure delay time for each sensor.

T1 is calculated according to the typical delay (5μs) of Line0. If it is Line2 or CXPTrigger, T1 can be ignored.

T2/3/4 is calculated as 0μs.

T5 is calculated according to the ROI settings and features of each sensor.

The exposure delay data for each model is as follows:

Model	Exposure delay (μs)
MARS-6500-31X2M/C MARS-6501-31X2M/C	Non-overlapping Exposure: 5~6, Overlapping Exposure: 14~15
MARS-10300-24X2M/C	Non-overlapping Exposure: 5~6, Overlapping Exposure: 13~14

MARS-15200-16X2M/C	Non-overlapping Exposure: 5~6, Overlapping Exposure: 18~19
MARS-2625-150X2M/C MARS-2626-150X2M/C	Non-overlapping Exposure: 5~6, Overlapping Exposure: 7.6~8.6
MARS-6502-71X2M/C MARS-6503-71X2M/C	Non-overlapping Exposure: 5~6, Overlapping Exposure: 14~15

8.3. Basic Features

8.3.1. Gain

The camera can adjust the analog gain, and the range of analog gain is as shown in section 4 General Specification. When the analog gain changes, the response curve of the camera changes, as shown in Figure 8-34. The horizontal axis represents the output signal of the sensor in the camera, and the vertical axis represents the gray value of the output image. When the amplitude of the sensor output signal remains constant, increasing the gain makes the response curve steeper, and that makes the image brighter. For every 6dB increases of the gain, the gray value of the image will double. For example, when the camera has a gain of 0dB, the image gray value is 126, and if the gain is increased to 6dB, the image gray will increase to 252. Thus, increasing gain can be used to increase image brightness. When the environment brightness and exposure time keep constant, another way to increase the image brightness is to change the camera's digital gain by modifying the lookup table, for more details please see section 8.4.5.

Note that increasing the analog gain or digital gain will amplify the image noise.

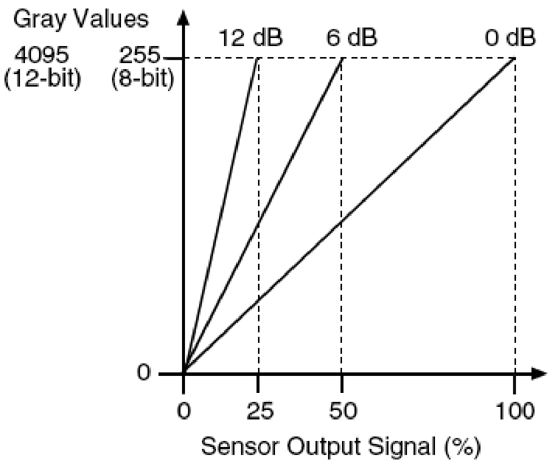


Figure 8-34 The cameras response curve

8.3.2. PGA Gain

Compared to digital gain, PGA (programmable-gain amplifier) gain does not amplify the noise caused by ADC, so it has a smaller impact on SNR. The steps set by the user is different from the actual steps. For example, the PGA gain of the MARS-15200-16X2M/C camera in the remove standard parameter range is [0.5x-5.2x]. In [0.5x-2.8x], the steps and actual steps are 0.1x. In [2.8x-5.2x], the steps are 0.1x and actual steps are 0.4x. When the set value is in the parameter range, the parameter will take the lower limit value of the interval as the valid parameter. For example, when the setting value is 3.1x, the parameter will be taken down to 2.8x as the effective PGA gain and take effect.

Model	Standard Parameter Range		Remove Standard Parameter Range	
	Range	Actual Steps	Range	Actual Steps
MARS-6500-31X2M/C MARS-6501-31X2M/C	[0.75x-6x]	0.25x	[0.75x-6x]	0.25x
MARS-10300-24X2M/C	[0.5x-2.8x]	0.1x	[0.5x-2.8x]	0.1x
			[2.8x-5.2x]	0.4x
MARS-15200-16X2M/C	[0.5x-2.8x]	0.1x	[0.5x-2.8x]	0.1x
			[2.8x-5.2x]	0.4x
MARS-2625-150X2M/C MARS-2626-150X2M/C	[1x-2.5x]	0.5x	[1x-2.5x]	0.5x
MARS-6502-71X2M/C MARS-6503-71X2M/C	[0.75x-1.25x]	0.25x	[0.75x-1.25x]	0.25x

8.3.3. Pixel Format

By setting the pixel format, the user can select the format of output image. The image data starts from the upper left corner, and each pixel is output brightness value of each pixel line from left to right and from top to bottom.

- **Mono8**

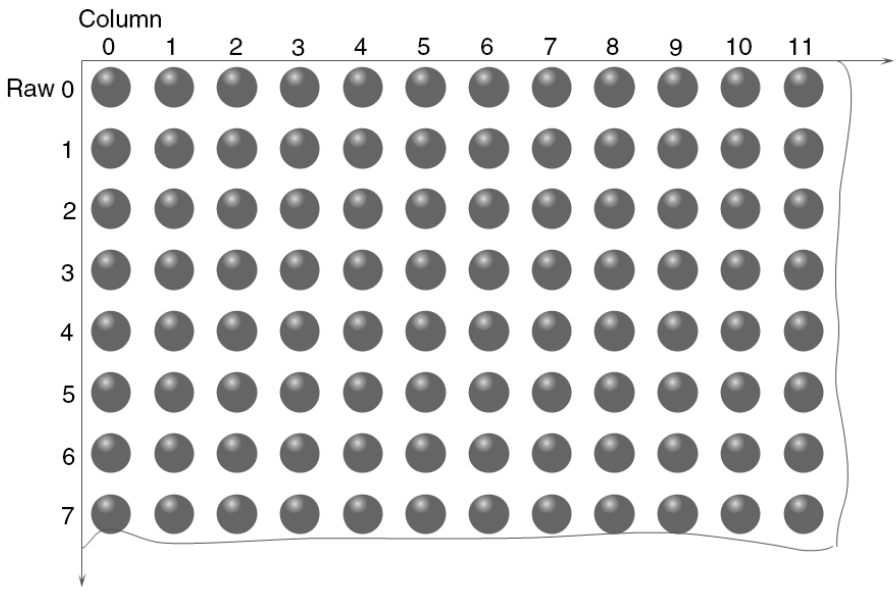


Figure 8-35 Mono8 pixel format

When the pixel format is set to Mono8, the brightness value of each pixel is 8 bits. The format in the memory is as follows:

Y00	Y01	Y02	Y03	Y04	……
Y10	Y11	Y12	Y13	Y14	……
……					

Among them Y00, Y01, Y02 … are the gray value of each pixel that starts from the first row of the image. Then the gray value of the second row pixels of the images is Y10, Y11, and Y12…

- **Mono10/Mono12**

When the pixel format is set to Mono10 or Mono12, each pixel is 16 bits. When Mono10 is selected, the effective data is only 10 bits, the six unused most significant bits are filled with zero. When Mono12 is selected, the effective data is only 12 bits, the 4 of the MSB 16 bits data are set to zero. Note that the brightness value of each pixel contains two bytes, arranged in little-endian mode. The format is as follows:

Y00	Y01	Y02	Y03	Y04	……
Y10	Y11	Y12	Y13	Y14	……
……					

Among them Y00, Y01, Y02…are the gray value of each pixel that start with the first row of the image. The first byte of each pixel is low 8 bits of brightness, and the second byte of each pixel is high 8 bits of brightness.

- **BayerRG8**

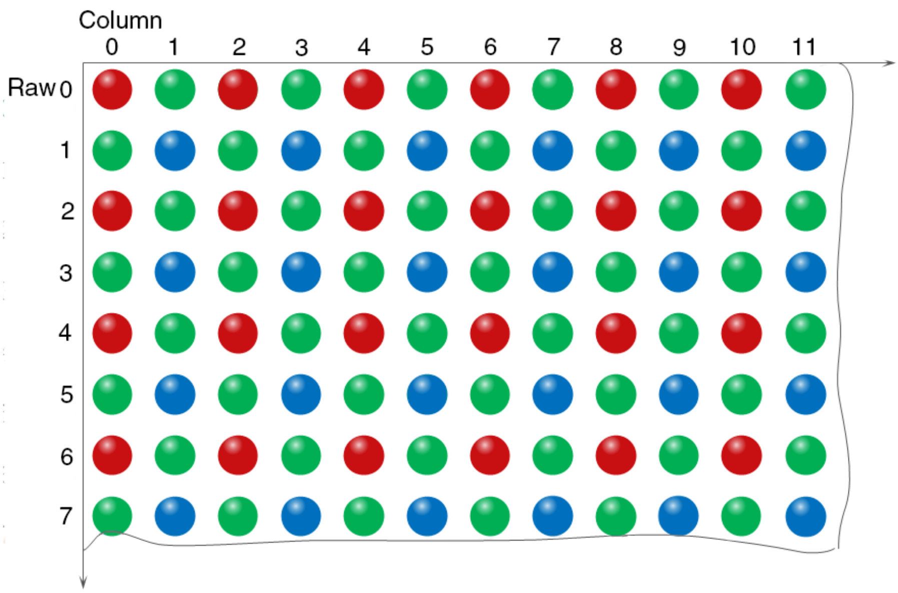


Figure 8-36 BayerRG8 pixel format

When the pixel format is set to BayerRG8, the value of each pixel in the output image of the camera is 8 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

R00	G01	R02	G03	R04	……
G10	B11	G12	B13	G14	……
……					

Where R00 is the first pixel value of the first row (for the red component), G01 represents the second pixel value (for the green component), and so on, so that the first row pixel values are arranged. G10 is the first pixel value of the second row (for the green component), the B11 is the second pixel value (for the blue component), and so on, and the second row of pixel values are arranged.

- **BayerRG10/BayerRG12**

When the pixel format is set to BayerRG10 or BayerRG12, the value of each pixel in the output image of the camera is 16 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

R00	G01	R02	G03	R04	……
G10	B11	G12	B13	G14	……
……					

Each pixel is the same as BayerRG8, the difference is that each pixel is made up of two bytes, the first byte is the low 8 bits of the pixel value, and the second byte is the high 8 bits of the pixel value.

- **BayerGR8**

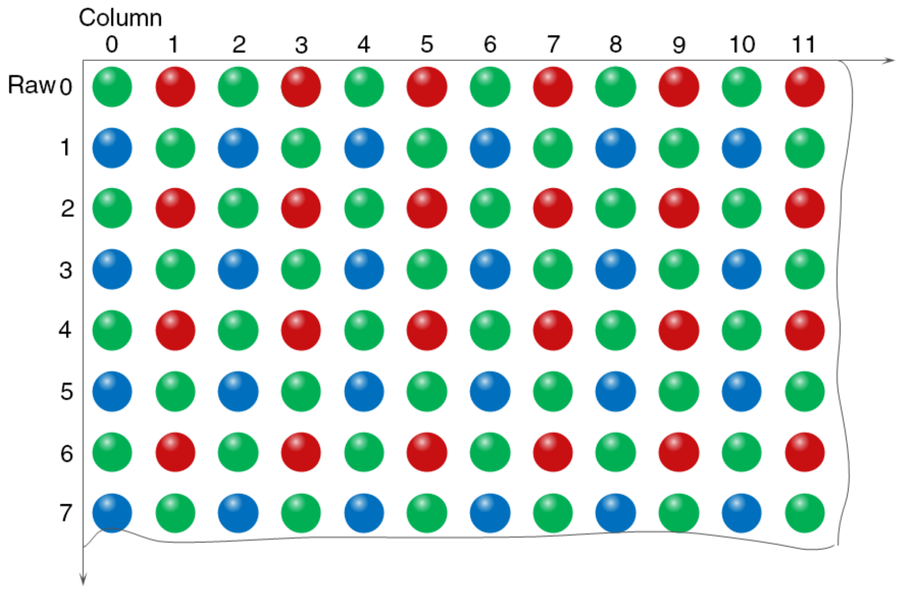


Figure 8-37 BayerGR8 pixel format

When the pixel format is set to BayerGR8, the value of each pixel in the output image of the camera is 8 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

G00	R01	G02	R03	G04	……
B10	G11	B12	G13	B14	……
……					

Where G00 is the first pixel value of the first row (for the green component), R01 represents the second pixel value (for the red component), and so on, so that the first row pixel values are arranged. B10 is the first pixel value of the second row (for the blue component), the G11 is the second pixel value (for the green component), and so on, and the second row of pixel values are arranged.

- **BayerGR10/BayerGR12**

When the pixel format is set to BayerGR10 or BayerGR12, the value of each pixel in the output image of the camera is 16 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

G00	R01	G02	R03	G04	......
B10	G11	B12	G13	B14	......
......					

Each pixel is the same as BayerRG8, the difference is that each pixel is made up of two bytes, the first byte is the low 8 bits of the pixel value, and the second byte is the high 8 bits of the pixel value.

- **BayerGB8**

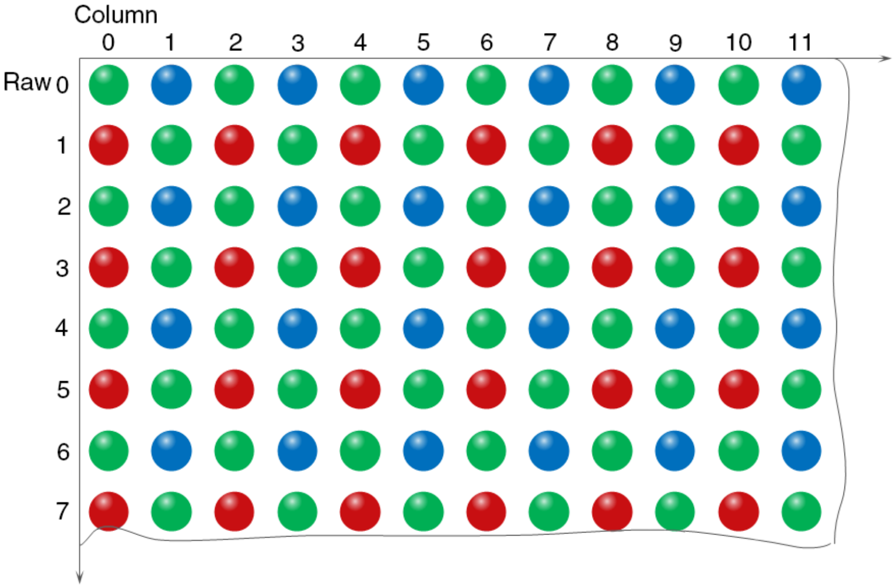


Figure 8-38 BayerGB8 pixel format

When the pixel format is set to BayerRG8, the value of each pixel in the output image of the camera is 8 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

G00	B01	G02	B03	G04	......
R10	G11	R12	G13	R14	......
......					

Where G00 is the first pixel value of the first row (for the green component), B01 represents the second pixel value (for the blue component), and so on, so that the first row pixel values are arranged. R10 is the first pixel value of the second row (for the red component), the G11 is the second pixel value (for the green component), and so on, and the second row of pixel values are arranged.

- **BayerGB10/BayerGB12**

When the pixel format is set to BayerGB10 or BayerGB12, the value of each pixel in the output image of the camera is 16 bits. According to the location difference, the three components of red, green and blue are respectively represented. The format in the memory is as follows:

G00	B01	G02	B03	G04	......
R10	G11	R12	G13	R14	......
......					

Each pixel is the same as BayerGB8, the difference is that each pixel is made up of two bytes, the first byte is the low 8 bits of the pixel value, and the second byte is the high 8 bits of the pixel value.

8.3.4. ROI

By setting the ROI of the image, the camera can transmit the specific region of the image, and the output region's parameters include OffsetX, OffsetY, width and height of the output image. The camera only reads the image data from the sensor's designated region to the memory, and transfer it to the host, and the other regions' image of the sensor will be discarded.

By default, the image ROI of the camera is the full resolution region of the sensor. By changing the OffsetX, OffsetY, width and height, the location and size of the image ROI can be changed. The OffsetX refers to the starting column of the ROI, and the OffsetY refers to the starting row of the ROI. Among them, the step of OffsetX and width vary from one camera to another, and the step of OffsetY and height is 2.

The coordinates of the ROI of the image are defined the 0th raw and 0th column as the origin of the upper left corner of the sensor. As shown in the figure, the OffsetX of the ROI is 4, the OffsetY is 4, the height is 8 and the width is 12.

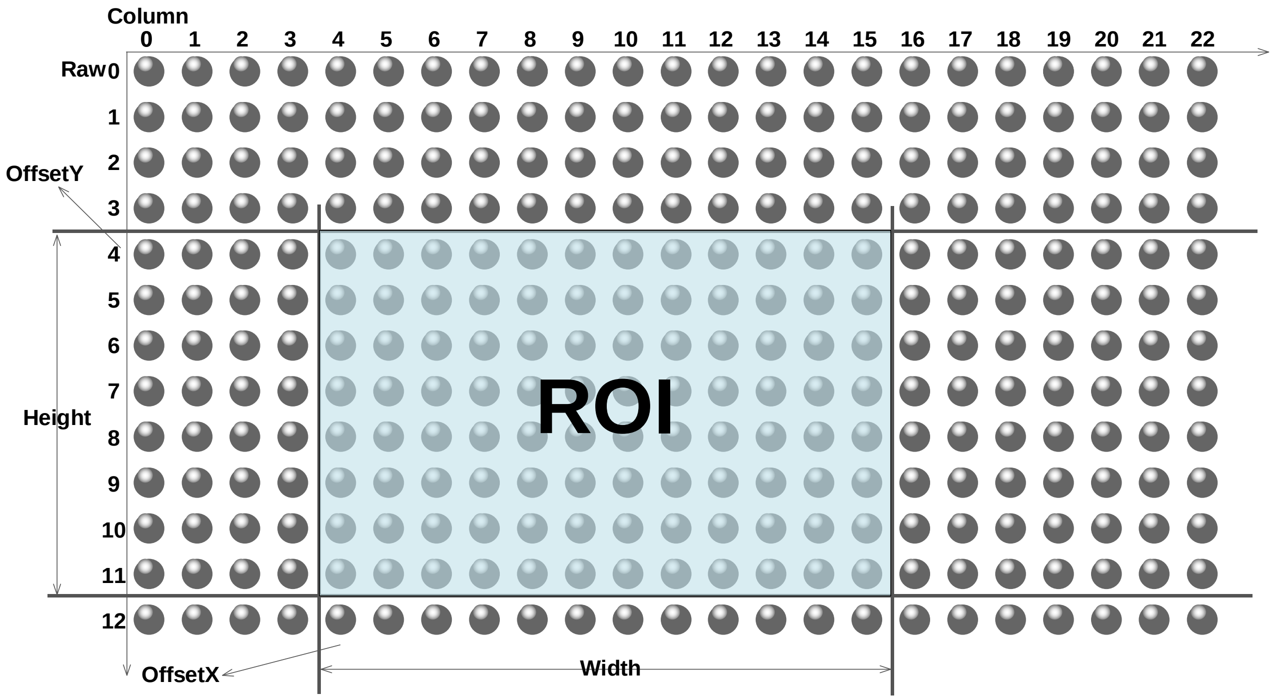


Figure 8-39 ROI

When reducing the height of the ROI, the maximum frame rate of the camera will be raised. Please refer to section 8.5.1 for specific effects on the acquisition frame rate.

8.3.5. Auto Exposure/Auto Gain

- **ROI Setting of Auto Exposure/Auto Gain**

For Auto Exposure and Auto Gain, you can specify a portion of the sensor array and only the pixel data from the specified portion will be used for auto function control.

AAROI is defined by the following way:

AAROIOffsetX:	The offset of the X axis direction.
AAROIOffsetY:	The offset of the Y axis direction.
AAROIWidth:	The width of ROI.
AAROIHeight:	The height of ROI.

Offset is the offset value that relative to the upper left corner of the image. The setting of the horizontal and vertical steps are respectively consistent with the horizontal and vertical steps of the ROI. The setting of the AAROI depends on the size of the current image and cannot exceed the range of the current image. That is to say, assuming the Width and Height are parameters for users captured image, then the AAROI setting need to meet the condition 1:

$$AAROIWidth + AAROIOffsetX \leq Width$$

$$AAROIHeight + AAROIOffsetY \leq Height$$

If condition 1 is not met, the user cannot set the ROI.

The default value of ROI is the entire image, you can set the ROI according to your need. Where the minimum value of AAROIWidth is equal to the horizontal steps of the ROI, and the maximum value is equal to the current image width. The minimum value of AAROIHeight is equal to the vertical steps of the ROI, and the maximum value is equal to the current image height, they are all need to meet the condition1.

For example: the current image width is 1024, the height is 1000, and then the ROI setting is:

AAROIOffsetX	=	100
AAROIOffsetY	=	50
AAROIWidth	=	640
AAROIHeight	=	480

The relative position of the ROI and the image is shown in Figure 8-40.

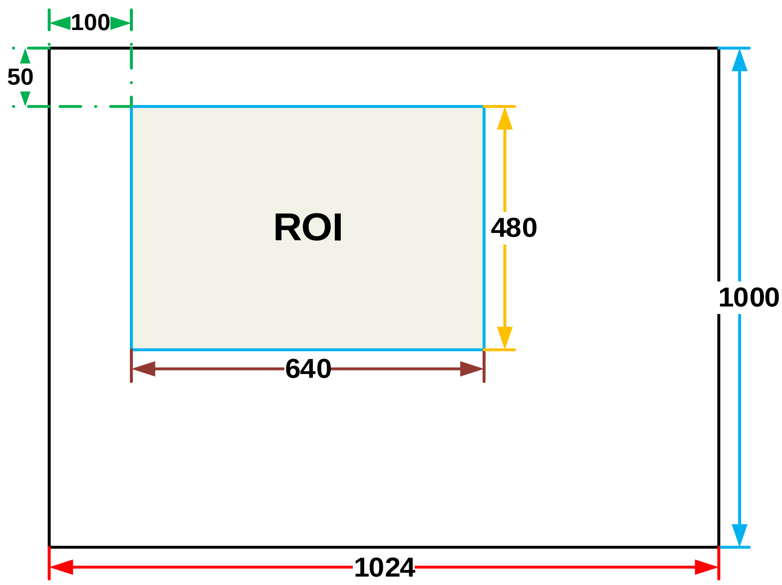


Figure 8-40 An example for the relative position between the ROI and the current image

- **Auto Exposure/Auto Gain**

The auto gain can adjust the camera's gain automatically and the auto exposure can adjust the camera's exposure time automatically, so that the average gray value in AAROI is achieved to the expected gray value. The auto gain and auto exposure both can be controlled by "Once" and "Continuous" mode.

When using the "Once" mode, the camera adjusts the image data in the AAROI to the expected gray value once, then the camera will close the auto gain/auto exposure feature. When using the "Continuous" mode, the camera will continuous adjust the gain value/exposure time according to the data of the AAROI, so that the data in the AAROI is kept near to the expected gray level.

The expected gray value is set by the user, and it is related to the data bit depth. For 8bit pixel data, the expected gray value range is 0-255, for 10bit pixel data, the expected gray value range is 0-1023, and for 12bit pixel data, the expected gray value range is 0-4095.

The camera adjusts the gain value and exposure time within the range [minimum gain value, maximum gain value] which is set by the user.

The auto gain feature can be used with the auto exposure at the same time, when target grey is changed from dark to bright, the auto exposure adjust is prior to auto gain adjust. Vice versa, when target grey is changed from bright to dark, the auto gain adjust is prior to auto exposure adjust.

8.3.6. Test Pattern

The MARS CoaXPress camera supports three test images: gray gradient test image, static diagonal gray gradient test image, and moving diagonal gray gradient test image. When the camera captures in RAW12 mode, the gray value of test image is: the pixel gray value in RAW8 mode multiplies by 16, as the output of pixel gray value in RAW12 mode.

The following three test images are illustrated in the RAW8 mode.

- GrayFrameRampMoving

In the gray gradient test image, all the pixels' gray values are the same in the frame. In the adjacent frame, the gray value of the next frame increases by 1 compared to the previous frame, until to 255, and then the next frame gray value returns to 0, and so on. A printscreen of a single frame is shown in Figure 8-41.

Figure 8-41 Gray gradient test image

- SlantLineMoving

In the moving diagonal gray gradient test image, the first pixel value of adjacent row in each frame increases by 1, until the last row. When the pixel gray value increases to 255, the next pixel gray value returns to 0. The first pixel gray value of adjacent column increases by 1, until the last column. When the pixel gray value increases to 255, the next pixel gray value returns to 0.

In the moving diagonal gray gradient test image, in the adjacent frame, the first pixel gray value of the next frame increases by 1 compared to the previous frame. So, in the dynamic image, the image is scrolling to the left. A printscreen of the moving diagonal gray gradient test image is shown in Figure 8-42:

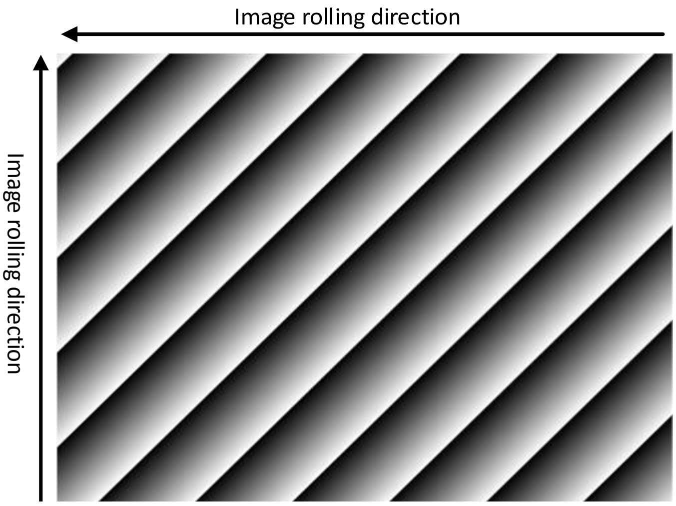


Figure 8-42 Moving diagonal gray gradient test image

- SlantLine

In the static diagonal gray gradient test image, the first pixel gray value is 0, the first pixel gray value of adjacent row increases by 1, until the last row. When the pixel gray value increases to 255, the next pixel gray value returns to 0. The first pixel gray value of adjacent column increases by 1, until the last column. When the pixel gray value increases to 255, the next pixel gray value returns to 0.

Compared to the moving diagonal gray gradient test image, in the adjacent image of the static diagonal gray gradient test image, the gray value in the same position remains unchanged. A printscreen of the static diagonal gray gradient test image is shown in Figure 8-43.

Figure 8-43 Static diagonal gray gradient test image

8.3.7. User Set Control

By setting various parameters of the camera, the camera can perform the best performance in different environments. There are two ways to set parameters: one is to modify the parameters manually, and the other is to load parameter set. In order to save the specific parameters of the users, avoiding to set the parameters every time when you open the camera, the MARS camera provides a function to save the parameter set, which can easily save the parameters that the user use, including the control parameters that the camera needed. There three types of configuration parameters: the currently effective configuration parameters, the vendor default configuration parameters (Default), and the user configuration parameters (UserSet0, UserSet1 and UserSet2).

Three operations can be performed on the configuration parameters, including save parameters (UserSetSave), load parameters (UserSetLoad), and set the startup parameter set (UserSetDefault). The UserSetSave is to save the effective configuration parameters to the user configuration parameter set which is set by the user. The UserSetLoad is to load the vendor default configuration parameters (Default) or the user configuration parameters (UserSet) to the current effective configuration parameters. The UserSetDefault is refer to the user can specify a set of parameters which to be loaded into the effective configuration parameters automatically when the camera is reset or powered on. And the camera can work under this set of parameters. This set of parameters can be vendor default configuration parameters or user configuration parameters.

1) The type of configuration parameters

The type of configuration parameters includes: the current effective configuration parameters, vendor default configuration parameters, user configuration parameters.

The current effective configuration parameters: Refers to the current control parameters used by the camera. Using API function or Demo program to modify the current control parameters of the camera is to modify the effective configuration parameters. The effective parameters are stored in volatile memory of the camera, so when the camera is reset or powered on again, the effective configuration parameters will be lost.

The vendor default configuration parameters (Default): Before the camera leaves the factory, the camera manufacturer will test the camera to assess the camera's performance and optimize the configuration parameters of the camera. The vendor default configuration parameters are the camera configuration parameters optimized by the vendor in a particular environment, these parameters are stored in the non-volatile memory of the camera, so when the camera is reset or powered on again, the effective configuration parameters will not be lost, and these parameters cannot be modified.

The user configuration parameters (UserSet0, UserSet1 and UserSet2): The effective parameters are stored in volatile memory of the camera, so when the camera is reset or powered on again, the effective configuration parameters will be lost. You can store the effective configuration parameters to the user configuration parameters, the user configuration parameters are stored in the non-volatile memory of the camera, so when the camera is reset or powered on again, the user configuration parameters will not be lost. The MARS CoaXPress camera can store three sets of user configuration parameters.

2) The operation of configuration parameters

The operations for configuration parameters include the following three types: save parameters, load parameters and set the UserSetDefault.

Save parameters (UserSetSave): Save the current effective configuration parameters to the user configuration parameters. The storage steps are as follows:

1) Modify the camera's configuration parameters, until the camera runs to the user's requirements.

2) Use UserSetSelector to select UserSet0. Execute UserSetSave command.

The camera's configuration parameters which are saved in the user parameter set include:

- TECEnable, TECTargetTemperature
- DeviceLinkThroughputLimitMode, DeviceLinkThroughputLimit
- BinningHorizontalMode, BinningHorizontal, BinningVerticalMode, BinningVertical, DecimationHorizontal, DecimationVertical
- ReverseX, ReverseY
- AcquisitionMode, AcquisitionBurstFrameCount
- ExposureTime, ExposureMode, ExposureDelay
- PixelFormat
- OffsetX, OffsetY, Width, Height
- TriggerMode, TriggerSource, TriggerActivation, TriggerDelay
- TriggerFilterRaisingEdge, TriggerFilterFallingEdge
- LineMode, Line Inverter, LineSource, UserOutputValue
- TestPatternGeneratorSelector
- TimerDuration, TimerDelay, TimerTriggerSource, CounterEventSource, CounterResetSource
- ExpectedGrayValue
- ExposureAuto, AutoExposureTimeMax, AutoExposureTimeMin
- Gain, PGAGain, GainAuto, AutoGainMax, AutoGainMin
- AAROIOffsetX, AAROIOffsetY, AAROIWidth, AAROIHeight
- BalanceWhiteAuto
- AWBROIOffsetX, AWBROIOffsetY, AWBROIWidth, AWBROIHeight)
- BalanceRatio
- HotPixelCorrection
- LUTControl, Gamma
- BlackLevel, BlackLevelAuto
- RemoveParameterLimitControl

- StaticDefectCorrection
- FlatFieldCorrection, FFCCoefficient
- DSNUControl
- PRNUControl
- ColorTransformationEnable, ColorTransformationValue, LightSourcePreset, SaturationMode, Saturation

Load parameters (UserSetLoad): Load the vendor default configuration parameters or the user configuration parameters into the effective configuration parameters. After this operation is performed, the effective configuration parameters will be covered by the loaded parameters which are selected by the user, and the new effective configuration parameters are generated. The operation steps are as follows:

1) Use UserSetSelector to select Default or UserSet (UserSet0, UserSet1 and UserSet2).

2) Execute UserSetLoad command to load the UserSet specified by UserSetSelector to the device and makes it active.

Change startup parameter set (UserSetDefault): The user can use UserSetDefault to select Default or UserSet (UserSet0, UserSet1 and UserSet2) as the UserSetDefault. When the camera is reset or powered on again, the parameters in the UserSetDefault will be loaded into the effective configuration parameters.

8.3.8. Device User ID

The MARS CoaXPress camera provides programmable device user ID function, the user can set a unique identification for the camera, and can open and control the camera by the unique identification.

The user-defined name is a string which maximum length is 16 bytes, the user can set it by the following ways:

1) Set by the GalxyView, as shown in the Figure 8-44.

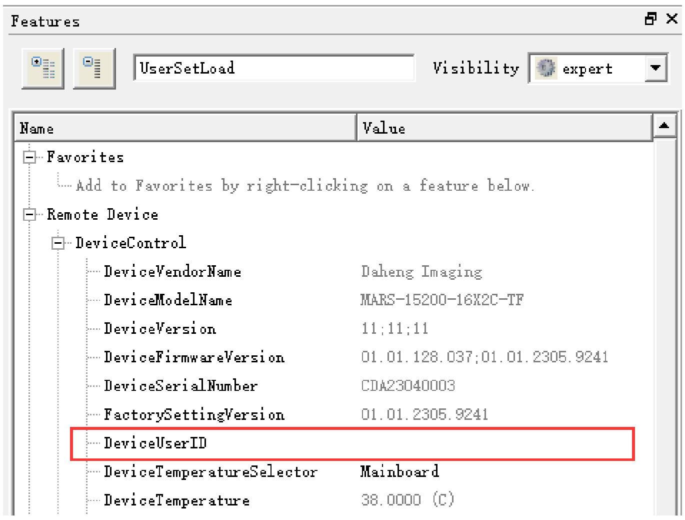


Figure 8-44 GalxyView software

2) Set by calling the software interface, for details please see the Programmer's Guide.

When using multi-cameras at the same time, it is necessary to ensure the uniqueness of the user-defined name of each camera, otherwise, an exception will occur when the camera is opened.

8.3.9. Binning

The feature of Binning is to combine multiple pixels adjacent to each other in the sensor into a single value, and process the average value of multiple pixels or sum the multiple pixel values, which may increase the signal-to-noise ratio or the camera's response to light.

- **How Binning Works**

On color cameras, the camera combines (sums or averages) the pixel values of adjacent pixels of the same color:

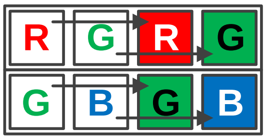


Figure 8-45 Horizontal color Binning by 2

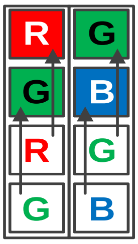


Figure 8-46 Vertical color Binning by 2

When the horizontal Binning factor and the vertical Binning factor are both set to 2, the camera combines the adjacent 4 sub-pixels of the same color according to the corresponding positions, and outputs the combined pixel values as one sub-pixel.

Figure 8-47 Horizontal and vertical color Binning by 2×2

On monochrome cameras, the camera combines (sums or averages) the pixel values of directly adjacent pixels:

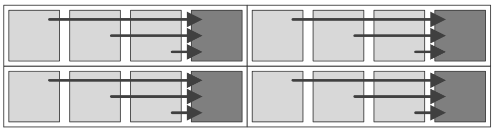


Figure 8-48 Horizontal mono Binning by 4

- **Binning Factors**

Two types of Binning are available: horizontal Binning and vertical Binning. You can set the Binning factor in one or two directions.

Horizontal Binning is the processing of pixels in adjacent rows.

Vertical Binning is the processing of pixels in adjacent columns.

Binning factor 1: Disable Binning.

Binning factor 2, 4: Indicate the number of rows or columns to be processed.

For example, the horizontal Binning factor 2 indicates that the Binning is enabled in the horizontal direction, and the pixels of two adjacent rows are processed.

- **Binning Modes**

The Binning mode defines how pixels are combined when Binning is enabled. Two types of the Binning mode are available: Sum and Average.

Sum: The values of the affected pixels are summed and then output as one pixel. This improves the signal-to-noise ratio, but also increases the camera's response to light.

Average: The values of the affected pixels are averaged. This greatly improves the signal-to-noise ratio without affecting the camera's response to light.

- **Considerations when Using Binning**

1) Effect on ROI settings

When Binning is used, the value of the current ROI of the image, the maximum ROI of the image, the auto function ROI, and the auto white balance ROI will change. The changed value is the original value (the value before the setting) divided by the Binning factor.

For example, assume that you are using a camera with a 1200×960 sensor. Horizontal Binning by 2 and vertical Binning by 2 are enabled. In this case, the maximum ROI width is 600 and the maximum ROI height is 480.

2) Increased response to light

Using Binning with the Binning mode set to **Sum** can significantly increase the camera's response to light. When pixel values are summed, the acquired images may look overexposed. If this is the case, you can reduce the lens aperture, the intensity of your illumination, the camera's exposure time setting, or the camera's gain setting.

3) Possible image distortion

Objects will only appear undistorted in the image if the numbers of binned rows and columns are equal. With all other combinations, objects will appear distorted. For example, if you combine vertical Binning by 2 with horizontal Binning by 4, the target objects will appear squashed.

4) Mutually exclusive with Decimation

Binning and Decimation cannot be used simultaneously in the same direction. When the horizontal Binning value is set to a value other than 1, the horizontal Decimation feature cannot be used. When the vertical Binning value is set to a value other than 1, the vertical Decimation feature cannot be used.

8.3.10. Decimation

The Decimation can reduce the number of sensor pixel columns or rows that are transmitted by the camera, reducing the amount of data that needs to be transmitted and reducing bandwidth usage.

- **How Vertical Decimation Works**

On mono cameras, if you specify a vertical Decimation factor of n, the camera transmits only every nth row. For example, when you specify a vertical Decimation factor of 2, the camera skips row 1, transmits row 2, skips row 3, and so on.

On color cameras, if you specify a vertical Decimation factor of n, the camera transmits only every nth pair of rows. For example, when you specify a vertical Decimation factor of 2, the camera skips rows 1 and 2, transmits rows 3 and 4, skips rows 5 and 6, and so on.

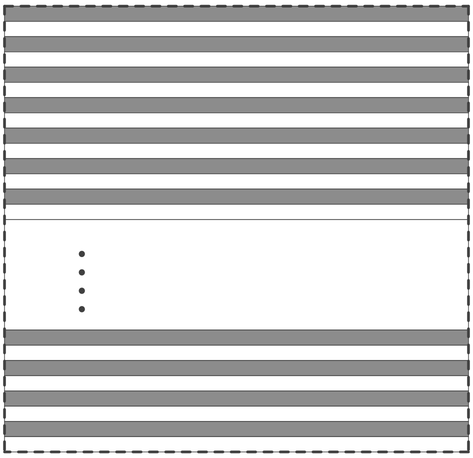


Figure 8-49 Mono camera vertical Decimation

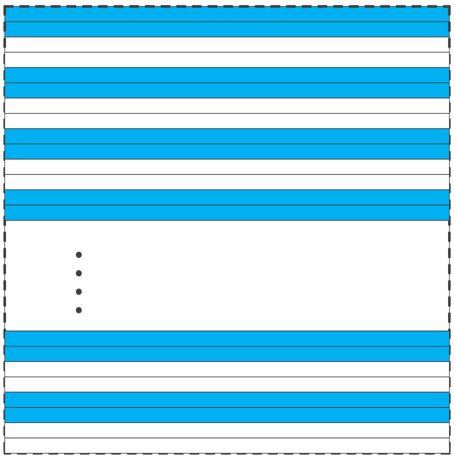


Figure 8-50 Color camera vertical Decimation

As a result, the image height is reduced. For example, enabling vertical Decimation by 2 halves the image height. The camera automatically adjusts the image ROI settings.

Vertical Decimation significantly increases the camera's frame rate. For details, please refer to the section 9.2 Frame Rate Calculation Tool.

- **How Horizontal Decimation Works**

On mono cameras, if you specify a horizontal Decimation factor of n, the camera transmits only every nth column. For example, if specify set a horizontal Decimation factor of 2, the camera skips column 1, transmits column 2, skips column 3, and so on.

On color cameras, if you specify a horizontal Decimation factor of n, the camera transmits only every nth pair of columns. For example, if you specify a horizontal Decimation factor of 2, the camera skips columns 1 and 2, transmits columns 3 and 4, skips columns 5 and 6, and so on.

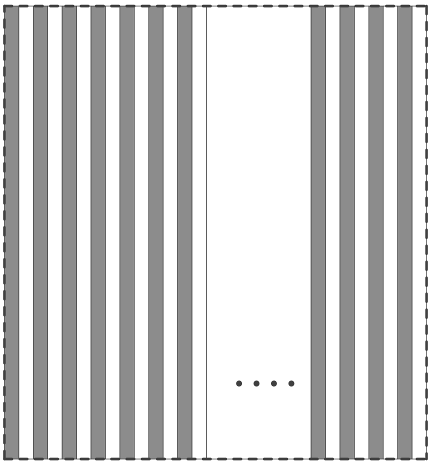


Figure 8-51 Mono camera horizontal Decimation

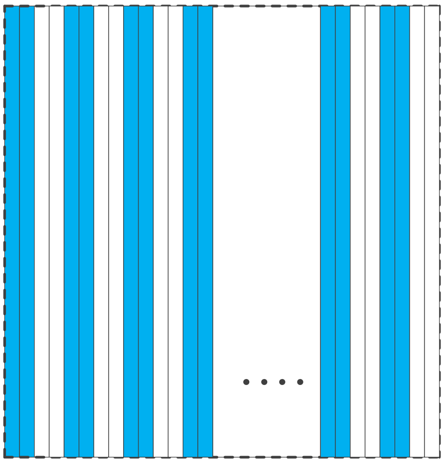


Figure 8-52 Color camera horizontal Decimation

As a result, the image width is reduced. For example, enabling horizontal Decimation by 2 halves the image width. The camera automatically adjusts the image ROI settings.

Horizontal Decimation does not (or only to a very small extent) increase the camera's frame rate.

- **Configuring Decimation**

To configure vertical Decimation, enter a value for the DecimationVertical parameter. To configure horizontal Decimation, enter a value for the DecimationHorizontal parameter.

The value of the parameters defines the Decimation factor. Depending on your camera model, the following values are available:

1) Disable Decimation.

2) Enable Decimation.

- **Considerations When Using Decimation**

1) Effect on ROI settings

When you are using Decimation, the settings for your image ROI refer to the resulting number of rows and columns. Taking MARS-6500-31X2M/C as an example, the camera's default resolution is 9344×7000. When horizontal Decimation by 4 and vertical Decimation by 4 are enabled, the maximum ROI width would be 2336 and the maximum ROI height would be 1750.

2) Reduced resolution

Using Decimation effectively reduces the resolution of the camera's imaging sensor. Taking MARS-6500-31X2M/C as an example, the camera's default resolution is 2448×2048. When horizontal Decimation by 4 and vertical Decimation by 4 are enabled, the effective resolution of the sensor is reduced to 2336×1750.

3) Possible image distortion

The displayed image will not be distorted if the vertical and horizontal Decimation factors are equal. When only horizontal Decimation or vertical Decimation is used, the displayed image will be reduced in width or height.

4) Mutually exclusive with Binning

Decimation and Binning cannot be used simultaneously in the same direction. When the horizontal Decimation value is set to a value other than 1, the horizontal Binning feature cannot be used. When the vertical Decimation value is set to a value other than 1, the vertical Binning feature cannot be used.

On some camera models, user can select to perform Sensor or FPGA decimation. The difference is that Sensor decimation may increase the camera's frame rate.

8.3.11. Reverse X and Reverse Y

The Reverse X and Reverse Y features can mirror acquired images horizontally, vertically, or both.

- **Enabling Reverse X**

To enable Reverse X, set the **ReverseX** parameter to **true**. The camera mirrors the image horizontally.

Figure 8-53 The original image

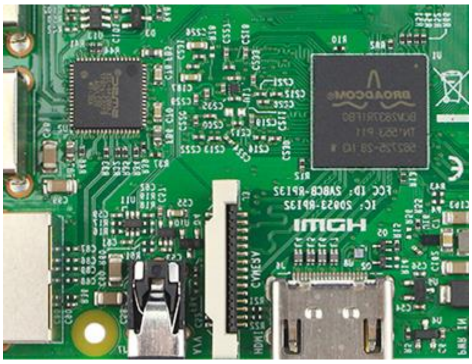


Figure 8-54 Reverse X enabled

- **Enabling Reverse Y**

To enable Reverse Y, set the **ReverseY** parameter to **true**. The camera mirrors the image vertically.

Figure 8-55 The original image

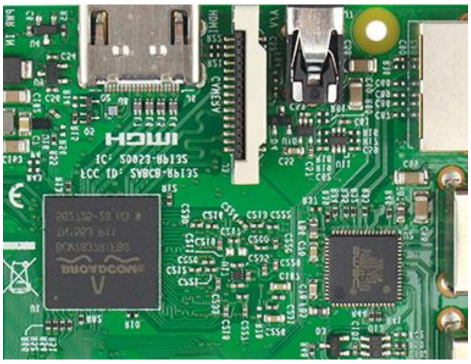


Figure 8-56 Reverse Y enabled

- **Enabling Reverse X and Y**

To enable Reverse X and Y, set the **ReverseX** and **ReverseY** parameters to **true**. The camera mirrors the image horizontally and vertically.

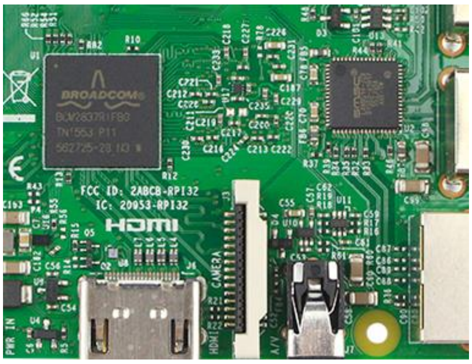


Figure 8-57 The original image

Figure 8-58 Reverse X and Y enabled

- **Using Image ROI with Reverse X or Reverse Y**

If you have specified an image ROI while using Reverse X or Reverse Y, you must bear in mind that the position of the ROI relative to the sensor remains the same. Therefore, the camera acquires different portions of the image depending on whether the Reverse X or the Reverse Y feature are enabled:

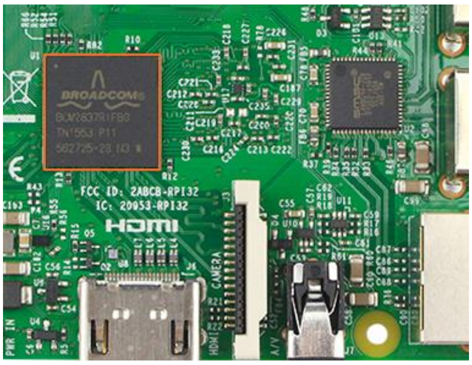


Figure 8-59 The original image

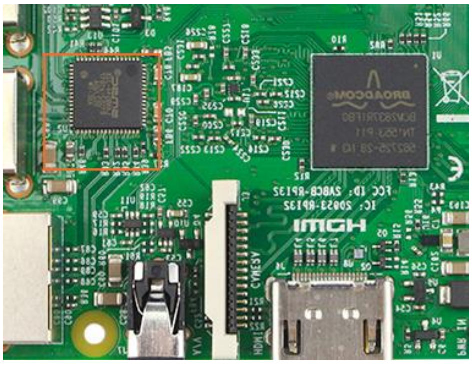


Figure 8-60 Reverse X enabled

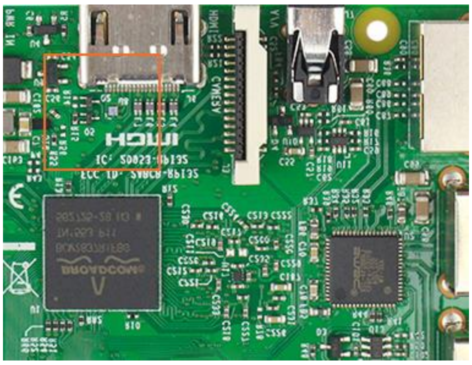


Figure 8-61 Reverse Y enabled

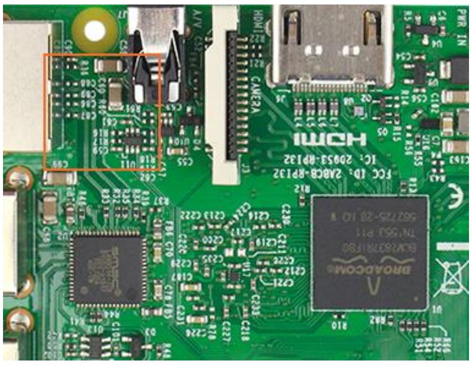


Figure 8-62 Reverse X and Y enabled

- **Pixel Format Alignment**

When camera is using the reverse feature, the alignment of the Bayer format of some cameras does not change, and the others is change.

8.3.12. Acquisition Status

The Acquisition Status feature can determine whether the camera is waiting for trigger signals. This is useful if you want to optimize triggered image acquisition and avoid over triggering.

To determine if the camera is currently waiting for trigger signals.

a) Set the **AcquisitionStatusSelector** parameter to the expected trigger type. Two trigger types are available: **FrameTriggerWait** and **AcquisitionTriggerWait**. For example, if you want to determine if the camera is waiting for **FrameStartTrigger** signals, set the **AcquisitionStatusSelector** to **FrameTriggerWait**. If you want to determine if the camera is waiting for **FrameBurstStartTrigger** signals, set the **AcquisitionStatusSelector** to **AcquisitionTriggerWait**.

b) If the **AcquisitionStatus** parameter is **true**, the camera is waiting for a trigger signal of the trigger type selected. If the **AcquisitionStatus** parameter is **false**, the camera is busy.

8.3.13. Black Level and Auto Black Level

8.3.13.1. Black Level

The black level can change the overall brightness of an image by changing the gray values of the pixels by a specified amount. Currently, the application range of the black level value can only be selected as all pixels, and pixel selection is not supported.

The lower the black level, the darker the corresponding image, the higher the black level, the brighter the corresponding image.

8.3.13.2. Auto Black Level

The dark current is greatly affected by the ambient temperature and individual differences are greater for high resolution camera models. The default mode is "Continuous" and the black level automatically adjusting. If it is "Once" mode, the auto black level mode will automatically change to OFF after once adjustment. If it is "Off" mode, the auto black level is disabled.

8.3.14. Remove Parameter Limits

The range of camera parameters is usually limited, and these factory limits are designed to ensure the best camera performance and high image quality. However, for certain use cases, you may want to specify parameter values outside of the factory limits. You can use the remove parameter limits feature to expand the parameter range. The features of the extended range supported by different cameras may be different and the range may be different, as shown in Table 8-2.

Model	Features	Set the switch to off	Set the switch to on
MARS-6500-31X2M/C MARS-6501-31X2M/C	Exposure	14~1000000	14~60000000
	Auto Exposure	14~1000000	14~1000000
	Gain	0~16	0~24
	Auto Gain	0~16	0~24

	PGA Gain	0.75~6.0	0.75~6.0
	Black Level	-1023~1024	-1023~1024
	White Balance component	0~15.998	0~31.998
	Auto White Balance	0~15.998	0~31.998
MARS-10300-24X2M/C	Exposure	20~1000000	20~60000000
	Auto Exposure	20~1000000	20~1000000
	Gain	0~16	0~24
	Auto Gain	0~16	0~24
	PGA Gain	0~2.8	0~5.2
	Black Level	-2047~2048	-2047~2048
	White Balance component	0~15.998	0~31.998
	Auto White Balance	0~15.998	0~31.998
MARS-15200-16X2M/C	Exposure	20~1000000	20~60000000
	Auto Exposure	20~1000000	20~1000000
	Gain	0~16	0~24
	Auto Gain	0~16	0~24
	PGA Gain	0~2.8	0~5.2
	Black Level	-2047~2048	-2047~2048
	White Balance component	0~15.998	0~31.998
	Auto White Balance	0~15.998	0~31.998
MARS-2625-150X2M/C MARS-2626-150X2M/C	Exposure	9~1000000	9~60000000
	Auto Exposure	9~1000000	9~1000000
	Gain	0~16	0~24
	Auto Gain	0~16	0~24
	PGA Gain	1~2.5	1~2.5
	Black Level	-512~1023	-512~1023
	White Balance component	0~15.998	0~31.998
	Auto White Balance	0~15.998	0~31.998

MARS-6502-71X2M/C MARS-6503-71X2M/C	Exposure	13~1000000	13~60000000
	Auto Exposure	13~1000000	13~1000000
	Gain	0~16	0~24
	Auto Gain	0~16	0~24
	PGA Gain	0.75~1.25	0.75~1.25
	Black Level	-1023~1024	-1023~1024
	White Balance component	0~15.998	0~31.998
	Auto White Balance	0~15.998	0~31.998

Table 8-2 Parameter range of features supported before and after Remove Parameter Limits

8.3.15. User Data Area

The user data area is a FLASH data area reserved for the user, and the user can use the area to save algorithm factors, parameter configurations, etc.

The user data area is 16K bytes and is divided into 4 data segments, each of which is 4K bytes. The user can access the user data area through the API interface. The data is saved to the camera flash area immediately after being written, and the data will not disappear after the camera is powered off.

8.3.16. Timer

The camera only supports one timer (Timer1), which can be started by a specified event or signal (only ExposureStart signal is supported). The Timer can configure a timer output signal that goes high on a specific event or signal and goes low after a specific duration. And the timer is cleared when the output signal goes low. A schematic diagram of the timer working process is as follows:

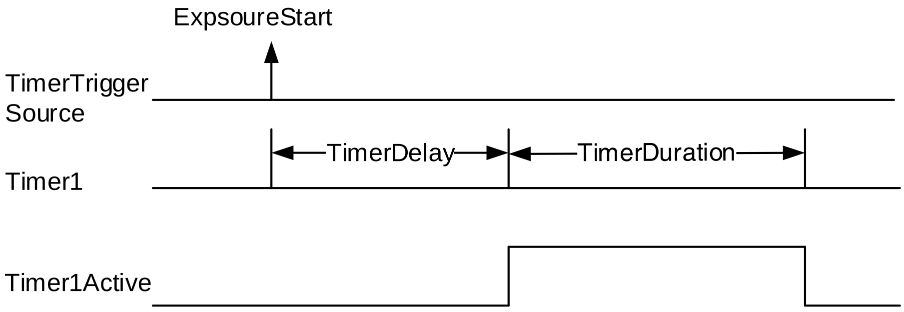


Figure 8-63 Timer1Active schematic diagram

The timer configuration process is as follows:

1) Set TimerSelector, currently only Timer1 supported.

2) Set LineSelector.

3) Set the LineSource to Timer1Active.

4) Set TimerTriggerSource, currently only ExposureStart supported.

5) Set TimerDelay, the range of TimerDelay is [0, 16777215], the unit is μs.

6) Set TimerDuration, the range of TimerDuration is [0, 16777215], the unit is μs.

    1) From the start of the timer to the full output of Timer1Active, this process will not be interrupted by the ExposureStart signal, and Timer1Active must be completely output to start timing according to the next ExposureStart signal. As shown in the figure below, the red ExposureStart signals are ignored.

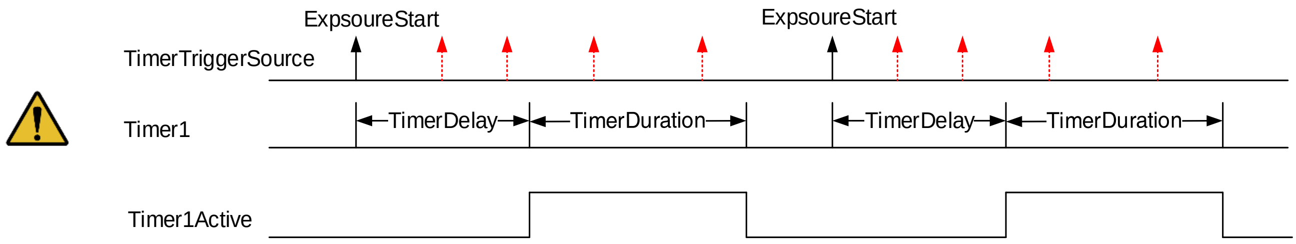


Figure 8-64 The relationship of Timer1Active and ExposureStart signal

    2) After the acquisition is stopped, the timer is immediately cleared and the Timer1Active signal goes low immediately.

8.3.17. Counter

The camera only supports one counter (Counter1), which can count the number of FrameTrigger, AcquisitionTrigger and FrameStart signals received by the camera. The counter starts counting from 0. You can select one of the above three signals to count by CounterEventSource. The FrameTrigger and AcquisitionTrigger signals of the counter statistics refer to the signals that have been triggered for filtering without a trigger delay.

If CounterValue is enabled, the statistical data can be inserted into the frame information and output with the image.

The counter can be reset by an external signal. The reset source is selected by CounterResetSource. Currently, the CounterResetSource option supports Off, SoftWare, Line0, Line2, CXPTrigger0 and CXPTrigger1. Among them, Off means no reset, SoftWare means software reset, Line0, Line2 means reset through I/O port input signal, CXPTrigger0 and CXPTrigger1 means reset through CXPTrigger send by frame grabber. The polarity of the reset signal only supports RisingEdge, which means reset the Counter on the rising edge of the reset signal.

Counter configuration:

1) Set CounterSelector, currently only Counter1 supported.

2) Set CounterEventSource, the values that can be set are FrameStart, FrameTrigger, AcquisitionTrigger.

3) Set CounterResetSource, the values that can be set are Off, SoftWare, Line0, Line2, CXPTrigger0, CXPTrigger1

4) Set CounterResetActivation, currently only RisingEdge supported.

1) After the acquisition is stopped, the Counter continues to work, will not be cleared, and it will be cleared when the camera is powered off.

2) CounterReset is used to software reset the counter.

8.4. Image Processing

8.4.1. Light Source Preset

The cameras support light source preset function, and provides Off mode, Custom mode, and four specified common color temperature light source modes.

- **Off Mode**

The camera does not perform white balance and color conversion processing on the image by default, and you need to input the white balance coefficient manually or use the auto white balance function. Perform color correction in Off mode is the same as without color correction.

- **Custom Mode**

Users can manually input white balance coefficients, and it supports manually input color conversion coefficients.

- **Daylight-6500K**

When the user selects **Daylight-6500K** in the light source preset, the camera will perform white balance processing on the image by default, and it supports manually modify white balance coefficients or enable white balance. If the external environment light source used is D65 light source, the image will not produce color deviation.

Even if the current light source is selected as the light source preset, users can also manually adjust the white balance coefficient.Users can turn on the color conversion enable switch and calibrate according to the color conversion coefficient of the Daylight-6500K light source (manual input of color correction coefficients is not supported).

The option operation of Daylight5000K, CoolWhiteFluorescence, INCA is the same as Daylight-6500K.

8.4.2. Auto White Balance

- **Auto White Balance ROI**

Auto White Balance feature use the image data from AWBROI to calculate the white balance ratio, and then the white balance ratio is used to adjust the components of the image.

ROI is defined in the following way:

AWBROIOffsetX: The offset of the X axis direction.

AWBROIOffsetY: The offset of the Y axis direction.

AWBROIWidth: The width of ROI.

AWBROIHeight: The height of ROI.

Offset is the offset value that relative to the upper left corner of the image. The step is consistent with the ROI step.

The ROI default setting is the whole image, users can set up in accordance with the needs. The step is consistent with the ROI step.

- **Auto White Balance Adjustment**

The auto white balance can be set to "Once" or "Continuous" mode. When using the "Once" mode, the camera just adjusts the white balance ratio once, when using the "Continuous" mode, the camera continuously adjusts the white balance ratio based on the data in AWBROI.

The auto white balance feature is only available on color sensors.

8.4.3. Color Transformation Control

The Color Transformation is used to correct the color information delivered by the sensor, improve the color reproduction of the camera, and make the image closer to the human visual perception.

Figure 8-65 Color template

The user can use a color template containing 24 colors and shoot this color template with a camera, the RGB value of each color may be different from the standard RGB value of the standard color template, the vendor can use the software or hardware to convert the RGB value that is read to the standard RGB value. Because the color space is continuous, all the other RGB values that are read can be converted to the standard RGB values by using the mapping table created by the 24 colors.

1) Prerequisites

For the color transformation to work properly, the white balance must first be configured appropriately.

2) Configuring color transformation

There are one mode for configuring color transformation: default mode (RGBtoRGB)

RGBtoRGB: Default color transformation parameters provided to the camera when it leaves the factory.

3) How it works

The color transformation feature uses a transformation matrix to deliver modified red, green, and blue pixel data for each pixel.

The transformation is performed by premultiplying a 3×1 matrix containing R, G, and B pixel values by a 3×3 matrix containing the color transformation values:

$$\begin{bmatrix} Gain00 & Gain01 & Gain02 \\ Gain10 & Gain11 & Gain12 \\ Gain20 & Gain21 & Gain22 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

4) Effect images

Figure 8-66 Before color transformation

Figure 8-67 After color transformation

8.4.4. Gamma

The Gamma can optimize the brightness of acquired images for display on a monitor.

1) Prerequisites

If the **GammaEnable** parameter is available, it must be set to **true**.

2) How it works

The camera applies a Gamma correction value (γ) to the brightness value of each pixel according to the following formula (red pixel value (R) of a color camera shown as an example):

$$R_{corrected} = \left(\frac{R_{uncorrected}}{R_{max}}\right)^{\gamma} \times R_{max}$$

The maximum pixel value (R_{max}) equals, e.g., 255 for 8-bit pixel formats and 4095 for 12-bit pixel formats.

3) Enabling Gamma correction

After enabling Gamma correction, set **GammaValue** to change the image brightness. The range of **GammaValue** is 0 to 4.00.

a) Gamma = 1.0: the overall brightness remains unchanged.

b) Gamma < 1.0: the overall brightness increases.

c) Gamma > 1.0: the overall brightness decreases.

In all cases, black pixels (gray value = 0) and white pixels (gray value = maximum) will not be adjusted.

If you enable Gamma correction and the pixel format is set to a 12-bit, some image information will be lost. Pixel data output will still be 12-bit, but the pixel values will be interpolated during the Gamma correction process, resulting in loss of accuracy and loss of image information. If the Gamma feature is required and no image information is lost, avoid using the Gamma feature in 12-bit pixel format.

4) Additional parameters

Depending on your camera model, the following additional parameters are available:

a) GammaEnable: Enable or disable Gamma correction.

b) GammaMode: You can select one of the following Gamma correction modes:

User: The Gamma correction value can be set as expected.

sRGB: The camera's internal default Gamma correction value. This feature is used with the color transformation feature to convert images from RGB to sRGB. It is recommended to adjust Gamma to sRGB mode after enabling the color transformation feature.

8.4.5. Lookup Table

When the analog signal that is read out by the sensor has been converted via ADC, generally, the raw data bit depth is larger than 8 bits, there are 12 bits, 10 bits, etc. The feature of lookup table is to replace some pixel values in the 8 bits and 12 bits images by values defined by the user.

The lookup table can be a linear lookup table or a non-linear lookup table, created entirely by the user.

You can also use the **LUTValueAll** function to create an entire lookup table.

1) How it works

a) LUT is short for "lookup table", which is basically an indexed list of numbers.

b) In the lookup table you can define replacement values for individual pixel values. For example, you can replace a gray value of 0 (= minimum gray value) by a gray value of 255 (= maximum gray value for 8-bit pixel formats). This changes all black pixels in your images to white pixels.

c) Setting a user-defined LUT can optimize the luminance of images. By defining the replacement values in advance and storing them in the camera to avoid time-consuming calculations. The camera itself has a factory default lookup table, and the default lookup table does not affect image luminance.

2) Creating the user-defined LUT

To create a lookup table, the **LUTIndex** and the **LUTValue** range is [0,255] in both 8-bit and 12-bit pixel bit depth.

Create a user-defined lookup table with the following steps:

a) Select the lookup table to use. Since there is only one user-defined lookup table in the camera, there is no need to select it by default.

b) Set the **LUTIndex** parameter to the pixel value that you want to replace with a new value.

c) Set the **LUTValue** parameter to the new pixel value.

d) Repeat steps 1 and 2 for all pixel values that need to be changed to set the parameters to the target pixel values in turn.

e) Set the **LUTEnable** parameter to **true** means that the lookup table feature is enabled. The default is disabled.

If you want to replace all pixel values, it is recommended to use the **LUTValueAll** function. See the **LUTValueAll** sample code in the Development User Manual for details.

8.4.6. Photo Response Non-Uniformity (PRNU) Correction

For cameras with high resolution and large format, the edge column pixel value may lower than the center column pixel value. Photo Response Non-Uniformity (PRNU) Correction feature is performed correcting the difference between pixels of the acquired (column) images. After PRNU correction, darker or brighter columns are adjusted to about the average gray value of the image.

Figure 8-68 Before PRNU correction

Figure 8-69 After PRNU correction

PRNU correction supports 17 sets parameters (default and Set0~Set15). When user choose "default", the PRNU correction will be executed but PRNU correction values cannot be saved in the device. After clicking PRNULoad, the image will be restored to the uncalibrated state. When user choose " Set0~Set15", the PRNU correction values will be saved in the device through "PRNUSave" after the PRNU correction. User can load the parameters saved in different modes through "PRNULoad". When PRNUGenerateStatus is "WaitingImage", it indicate the camera is waiting for images to calculate correction value, it is forbidden to execute other operations of PRNU correction. The default mode of PRNU correction is "default".

- Please calibrate PRNU correction in full frame
- In trigger mode, if there is no trigger signal and no image acquired, the user needs to send trigger signal, and execute PRNU correction after acquiring an image
- Do not overexpose the image. The gray value of the brightest area of the brightfield is recommended to be less than 250
- The image should not be too dark. The gray value of the darkest area of the brightfield is recommended to be greater than 20

8.4.7. Dark Signal Non-Uniformity (DSNU) Correction

The ADC accuracy and resolution of the sensor will cause the variations in the pixel values output from the camera when the camera is acquiring in darkness. And limited by the production process, there may be some variation from pixel to pixel in sensor and the response is also different at different temperatures and exposure times. When the camera is acquiring in darkness, there will have some variations in the pixel values output. Dark Signal Non-Uniformity (DSNU) Correction can correct the dark field bias caused by exposure, gain and temperature, and improve the uniformity of the dark signal of the image.

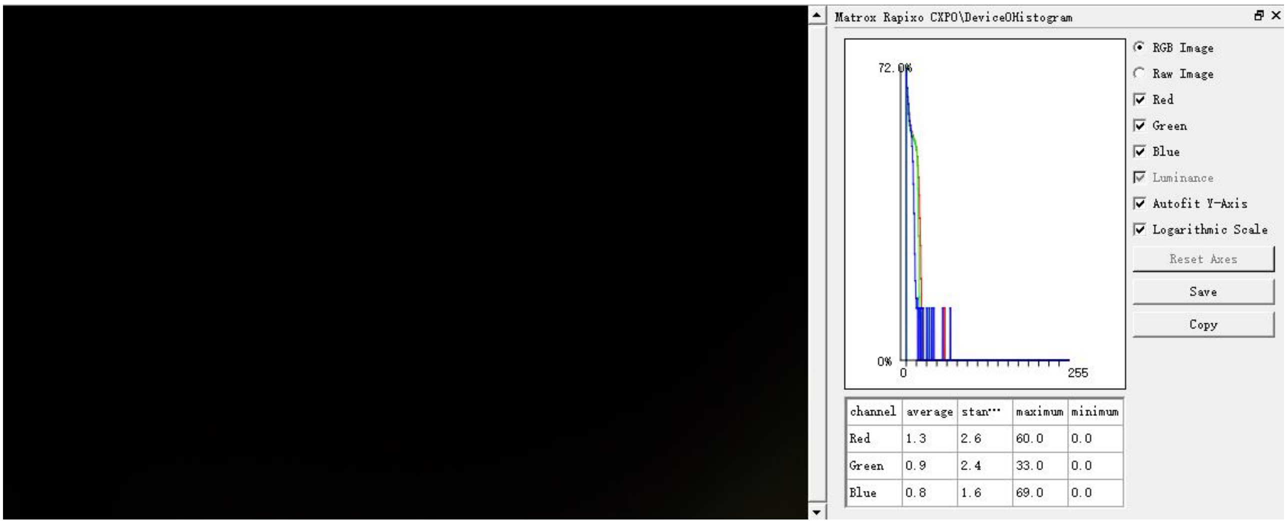


Figure 8-70 Before DSNU correction

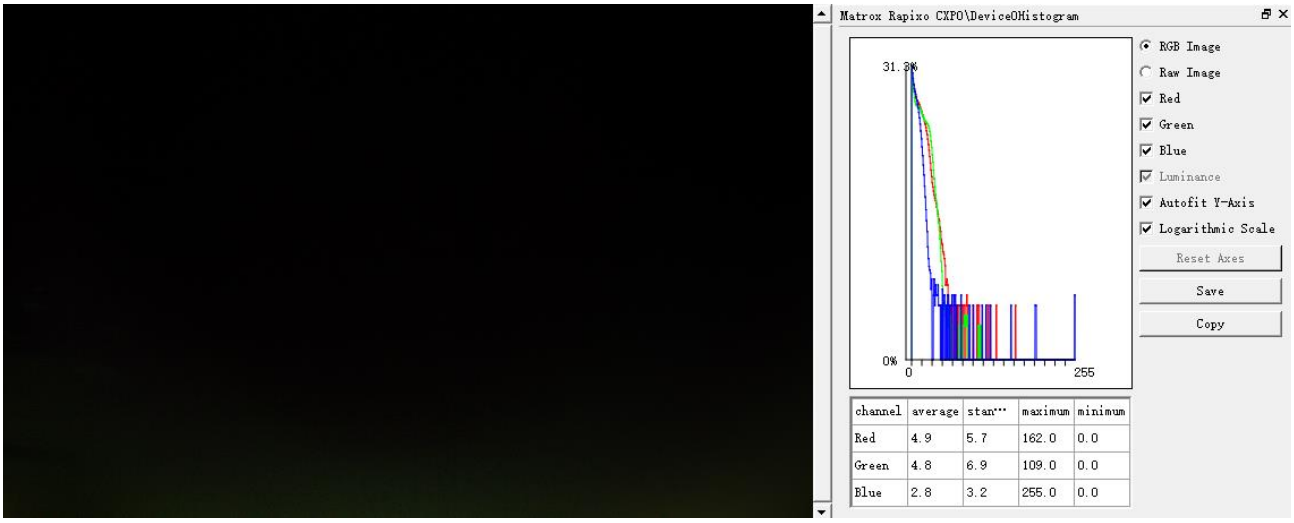


Figure 8-71 After DSNU correction

DSNU correction supports 17 sets parameters (default and Set0~Set15). When user choose "default", the DSNU correction will be executed but DSNU correction values cannot be saved in the device. After clicking DSNULoad, the image will be restored to the uncalibrated state. When users choose " Set0~Set15", the DSNU correction values will be saved in the device through "DSNUSave" after the DSNU correction. Users can load the parameters saved in different modes through "DSNULoad". When DSNUGenerateStatus is "WaitingImage", it indicate the camera is waiting for images to calculate correction value, it is forbidden to execute other operations of DSNU correction.

- Please use DSNU correction function in full frame mode for calibration
- In trigger mode, if there is no trigger signal and no image acquired, the user needs to send trigger signal, and execute DSNU correction after acquiring the images
- Ensure that the camera will executing DSNU correction in darkness. The gray value of the brightest area of the brightfield is recommended to be less than 20

8.4.8. Hot Pixel Correction

Hot pixels are pixels that cannot react to light or incident light. The saturation, sensitivity, noise, and other characteristics of hot pixels are different from normal pixels, usually related to prolonged exposure, high gain settings, or sensors at high temperatures.

The hot pixel correction function can dynamically correct defect pixels through adjacent pixels without prior calibration. In scenarios where the camera is exposed to high temperatures, high gain, and other factors that can generate more hot pixels, it is recommended to turn on the hot pixel correction function to improve image quality. This function is disabled by default.

Figure 8-72 Hot pixel correction effect

8.4.9. Static Defect Pixel Correction

Due to the technical defects of the image sensor, the camera has more or less defect pixels. Some of these defect pixels are fixed at the same gray value and do not change with the scene, which are called dead pixels. While some pixels may appear significantly brighter or darker than the rest, resulting in a significant difference between the gray value and the surrounding pixels, which is called noise.

Bright field calibration, which uses the difference of the average grayscale value of the entire image and the grayscale value of each pixel. If the difference value is higher than the threshold set by the user, it is determined as a dead pixel and is suitable for scenes with relatively uniform grayscale values image. In actual scenarios, the difference between the current pixel and adjacent neighbor pixels compare with the threshold, if the difference value is greater than the threshold, it is determined as noise.

Static defect pixel correction requires click "Catch" to acquire an image and click "Count" to obtain the coordinates of the defect pixel and noise point. When the number of the defect pixel and noise point is less than or equal to 8192, click "SavetoDevice" for defect pixel correction (hardware correction). At this time, the coordinate information of the calibrated defect will be saved in the camera and these pixels will be corrected. When the number of the defect pixel and noise point exceeds 8192, static defect pixel correction is performed on the software side when clicking "Count". In this case, the coordinates of the marked pixels cannot be saved to the device, and when the defect pixel and noise point exceeds 500000, it cannot be saved to the file. When there are fewer defects and their positions are relatively fixed, it is suitable to enable the static defect pixel correction function, which is enabled by default.

Before brightfield correction　　　　After brightfield correction

Figure 8-73 Bright field correction effect

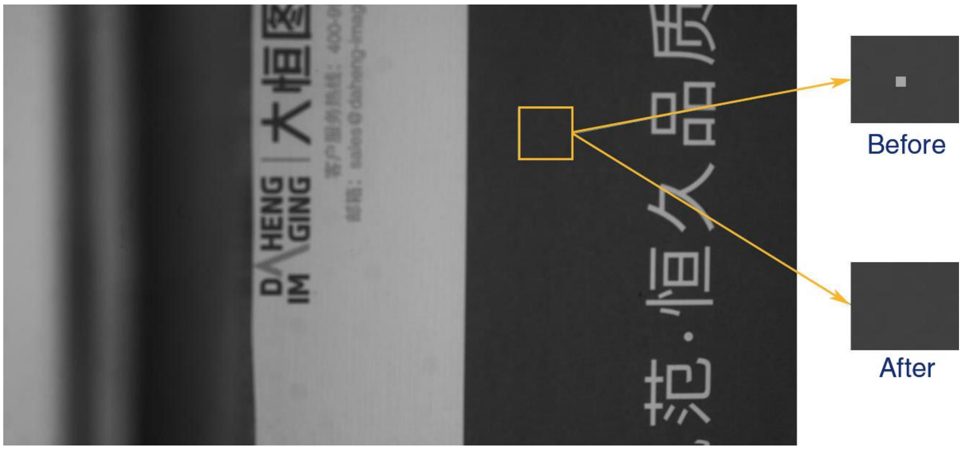


Figure 8-74 Defect pixel correction effect in actual scenario

⚠ Please use static defect pixel correction function in full frame mode for calibration.

8.4.10. Flat Field Correction

During the use of the camera, there may be various inconsistencies in the image, which are mainly reflected in the following aspects:

1) Inconsistent response of every individual pixels.
2) The difference in gray value between the image center and the edge.
3) Non-uniform illumination.

The Flat Field Correction (FFC) feature can correct the inconsistency of the image. As shown below, the FFC can adjust the pixel values of different positions to the same gray value.

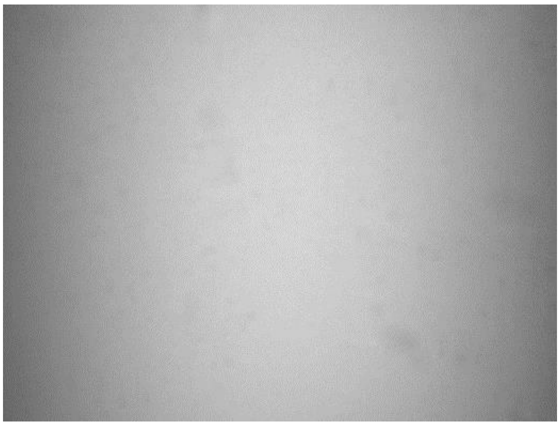


Figure 8-75 Before FFC

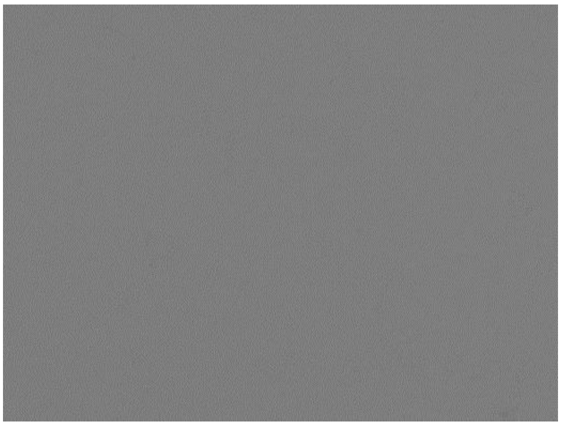


Figure 8-76 After FFC

FFC supports 16 sets parameters from Set0 to Set15. When users choose "Set0~Set15", the FFC correction values will be saved in the device through "FFCFlashSave" after the FFC correction. Users can load the parameters saved in different modes through "FFCFlashLoad". Differ from DSNU and PRMU, Users need to set the Flat Field Correction to On to apply the FFC to the camera.

When the "FFCExpectedGrayValueEnable" is On, executing FFC and achieving image gray value to the expected average gray value.

FFC calibration needs a long time, when the FFCGenerateStatus is "WaitImaging", it is forbidden to execute other operations, because the camera is waiting for images to calculate FFC coefficient.

There are two ways to obtain the FFC coefficient:

- According to the current environment
- Read from device

There are one way to save the FFC factor:

- Write to device

The following will describe: FFC coefficient calculation, FFC coefficient reading and saving.

8.4.10.1. FFC Coefficient Calculation

Before the FFC coefficient is obtained, it is recommended to determine the aperture of the lens and the gain of the camera. In the following cases, the coefficient needs to be re-calculated.

- ➢ Lens is replaced
- ➢ If the requirement for FFC accuracy is high (if the purpose is to correct the inconsistency of the pixels), it is recommended to recalculate the FFC coefficient after modifying the gain of the camera

- Please use FFC function in full frame mode for calibration
- Non-essential step: Use default value in the general case
- It is recommended to aim at the white paper or flat light source (ensuring consistent light input in different areas of the sensor) and adjust the distance between the camera and the white paper/flat light source to fill the entire field of view
- Do not overexpose the image. It is recommended that the grayscale value of the brightest area in the bright field be less than 250
- The image should not be too dark, and the grayscale value of the darkest area in the bright field is recommended to be greater than 20
- It is recommended to control the bright field grayscale value by adjusting the exposure time or light source, rather than the aperture

Execute FFC: Calculate the FFC coefficient using the acquired images. After execution, the subsequent images automatically use the calculated coefficients for FFC.

8.4.10.2. Read/Save Coefficient

- Read coefficient: The saved correction coefficient can be read from the device
- Save coefficient: Save the current FFC coefficient to the device. The coefficient can still be saved after the camera is powered down

8.4.11. Saturation

Saturation function can changes the colorfulness (intensity) of the colors to achieve the goal image effect.

1) Prerequisites

If the **SaturationEnable** parameter is available, it must be set to **On**.

2) Configuring saturation

Enter the expected value for the Saturation parameter and the range is 0 to 128. By default, the parameter is set to 64 (no saturation perform)

3) How it works

The saturation adjustment is performed by a 3×3 matrix. When the saturation intensity is modified, the saturation can be changed by modifying the adjustment matrix A.

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} RR & GR & BR \\ RG & GG & BG \\ RB & GB & BB \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix} + \begin{bmatrix} R_{offset} \\ G_{offset} \\ B_{offset} \end{bmatrix} \quad A = \begin{bmatrix} RR & GR & BR \\ RG & GG & BG \\ RB & GB & BB \end{bmatrix}$$

Saturation adjustment and color correction adjustment both adopt the form of a matrix, so the saturation is adjusted at the same time after color correction is enabled.

4) **Effect images**

Figure 8-77 Before saturation

Figure 8-78 After saturation

8.4.12. Sharpness

The sharpness algorithm integrated in the camera can significantly improve the definition of the edges of the image. The higher the definition, the clearer the contour corresponding to the image. This feature can improve the accuracy of image analysis, thus improving the recognition rate of edge detection and OCR.

The sharpness supported by the camera include sharpness and sharpness with noise suppression

- Enable sharpness

ON means that the sharpness feature is enabled. Set the sharpness parameter to adjust the sharpening effects.

ImageQualityControl	
SharpnessMode	Off
Sharpness	0.0000

Figure 8-79 GUI

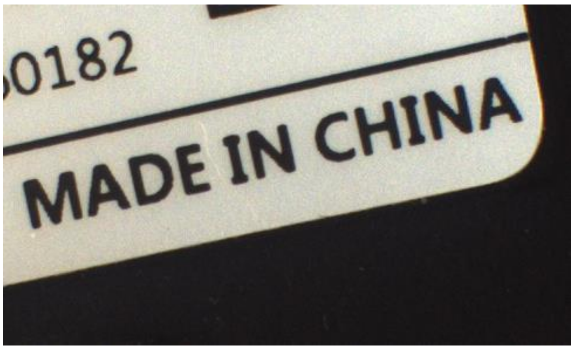


Figure 8-80 Before sharpness adjustment

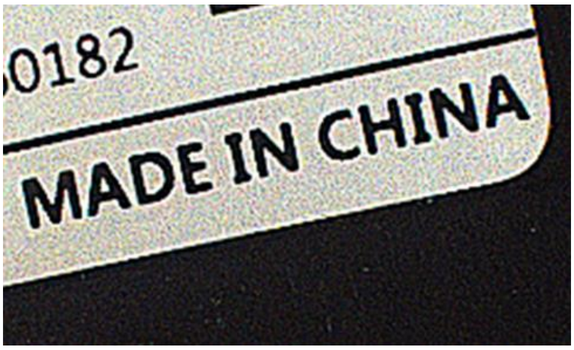


Figure 8-81 After sharpness adjustment

- Sharpness adjustment

Adjust the sharpness value can adjust the camera's sharpness to the image. The adjustment range is 0-7.0. The larger the value, the higher the sharpness.

● Sharpness noise suppression threshold adjustment

Adjust the sharpness noise suppression threshold can reduce the noise of homogeneous area. It is suitable for noise caused by high intensity sharpness. The adjustment range is 0-1. The larger the value, the higher the noise suppression.

Figure 8-82 GUI

Figure 8-83 After sharpness noise suppression

8.4.13. Fixed Pattern Noise Correction

As the process and internal structure of image sensors may cause streak and checker pattern problems.

Fixed pattern noise correction is a processing algorithm based on this regular fixed pattern noise. This function removes streak and checker pattern while preserving the edges of the image, and improving the visual effect of the image.

● Enable fixed pattern noise correction

ON means that the fixed pattern noise correction feature is enabled. The default correction ratio is 1.

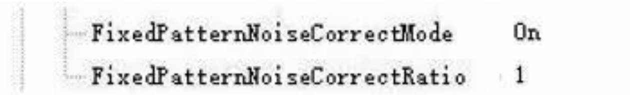


Figure 8-84 GUI

Figure 8-85 Before fixed pattern noise correction

Figure 8-86 After fixed pattern noise correction

- Fixed pattern noise correction ratio adjustment

After enabled the remove parameter limits, users can adjust the fixed pattern noise correction ratio, the adjustment range is 1~5, the larger the value, the better the stripe and checker pattern removal effect, but the greater the loss of sharpness.

8.5. Image Transmission

8.5.1. Calculate Frame Rate

1) Frame Period

You can calculate the frame period of the MARS CoaXPress camera by the following formula:

$$T_f = \mathrm{Max}\left(\frac{\mathrm{ImageSize} \times 10^6}{\mathrm{BandWidth}_{\mathrm{CoaXPress}}}, \frac{\mathrm{ImageSize} \times 10^6}{\mathrm{DeviceLinkThroughputLimit}}, T_{acq}, T_{exp}\right)$$

Among them:

$$\mathrm{ImageSize} = (\mathrm{Width} \times \mathrm{Height} \times \mathrm{PixelSize}) \div 8 + 25 + 2 \times \mathrm{Height} + \mathrm{PacketNum} \times 32$$

T_f: The camera's frame period, unit: μs.

Width: The current image width.

Height: The current image height.

PixelSize: The size of the pixel, in 8bit mode, the value is 8, in 10bit mode, the value is 10, and in 10bit mode, the value is 12.

$\mathrm{BandWidth}_{\mathrm{CoaXPress}}$:The bandwidth of the CoaXPress interface, unit: Bps.

DeviceLinkThroughputLimit: The limit of the device link throughput bandwidth, unit: Bps.

T_{acq}: The acquisition time of the camera, unit: μs.

T_{exp}: The exposure time of the camera, unit: μs.

2) Frame rate (Unit: fps)

$$F = \frac{10^6}{T_f}$$

It is recommended to use the frame rate calculation tool, the frame rate will be calculated automatically after the configuration parameters are filled.

8.5.2. CoaXPress Bandwidth

The theoretical bit rates of the MARS CoaXPress camera interface is as follows:

CXP Speed	Bit Rate(Gbps)
CXP-3	3.125
CXP-6	6.250
CXP-12	12.500

Table 8-3 Supports high-speed connection bit rates

The MARS CoaXPress camera can be used by using multiple coaxial cables to increase the maximum speed mentioned above (no more than 4).

8.5.3. DeviceLinkThroughputLimit

The MARS CoaXPress camera provides bandwidth limit function, in order to control the upper limit bandwidth of single device. When the DeviceLinkThroughputLimit is greater than the current device acquisition bandwidth, the current device acquisition bandwidth will not change, when the DeviceLinkThroughputLimit is less than the current device acquisition bandwidth, the current device acquisition bandwidth will be reduced to the limit of the DeviceLinkThroughputLimit.

When the camera is working in trigger mode, the bandwidth limit will restrict the maximum trigger frequency.

Example 1:

The MARS-15200-16X2M/C-TF is working in continuous mode, the DeviceLinkCurrentThroughput is 2500000000Bps, the DeviceLinkThroughputLimit is 5000000000Bps, and then the DeviceLinkCurrentThroughput is still 2500000000Bps. If the DeviceLinkCurrentThroughput is 2500000000Bps, the DeviceLinkThroughputLimit is 2000000000Bps, and then the DeviceLinkCurrentThroughput will be 2000000000Bps.

Example 2:

The MARS-15200-16X2M/C-TF is working in continuous mode, the DeviceLinkCurrentThroughput is 5000000000Bps, the maximum trigger frequency is 16.3Hz@full resolution (8bit), when the DeviceLinkCurrentThroughput is 1000000000Bps, and the maximum trigger frequency is 6.46Hz@full resolution (8bit).

8.5.4. Camera Acquisition Time

The acquisition time of the camera is related to the OffsetY and height of the image ROI. When the OffsetY and height change in the ROI setting, it will affect the frame period captured by the camera front end, which will affect the acquisition frame rate.

The formulas are as follows:

- MARS-6500-31X2M/C \ MARS-6501-31X2M/C

When the sensor bit depth is 8bit, the row period (unit: μs):

$$T_{row}=\frac{360}{80}=4.50$$

When the sensor bit depth is 12bit, the row period (unit: μs):

$$T_{row}=\frac{204}{80}=5.10$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height \times VerticalBinning + 12) \times T_{row}+T_{FOT}$$

- MARS-10300-24X2M/C

When the sensor bit depth is 8bit, the row period (unit: μs):

$$T_{row}=\frac{340}{80}=4.25$$

When the sensor bit depth is 12bit, the row period (unit: μs):

$$T_{row}=\frac{340}{80}=4.25$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height \times VerticalBinning + 12) \times T_{row}+T_{FOT}$$

Height: The camera's image height

VerticalBinning: Vertical Binning value

T_{row}: Actual row period, unit: μs.

T_{FOT} : Actual TOF time, unit: ns

- MARS-15200-16X2M/C

When the sensor bit depth is 8bit, the row period (unit: μs):

$$T_{row}=\frac{552}{80}=6.90$$

When the sensor bit depth is 12bit, the row period (unit: μs):

$$T_{row}=\frac{824}{80}=10.30$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height \times VerticalBinning + 12) \times T_{row}+T_{FOT}$$

- MARS-2625-150X2M/C \ MARS-2626-150X2M/C

When the sensor bit depth is 8bit, the row period (unit: μs):

$$T_{row}=\frac{124}{96}=1.29$$

When the sensor bit depth is 10bit, the row period (unit: μs):

$$T_{row}=\frac{128}{96}=1.334$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height \times VerticalBinning + 12) \times T_{row} + T_{FOT}$$

Height: The camera's image height

VerticalBinning: Vertical Binning value

T_{row}: Actual row period, unit: μs.

T_{FOT} : Actual TOF time, unit: ns

- MARS-6502-71X2M/C \ MARS-6503-71X2M/C

When the sensor bit depth is 8bit, the row period (unit: μs):

$$T_{row}=\frac{552}{80}=6.90$$

When the sensor bit depth is 10bit, the row period (unit: μs):

$$T_{row}=\frac{824}{80}=10.30$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height \times VerticalBinning + 12) \times T_{row} + T_{FOT}$$

Height: The camera's image height

VerticalBinning: Vertical Binning value

T_{row}: Actual row period, unit: μs.

T_{FOT} : Actual TOF time, unit: ns

8.6. Sequencer

The Sequencer feature allows you to define sets of parameter settings and apply them to a sequence of image acquisitions. As the camera acquires images, it applies one sequence set after the other, as shown below.

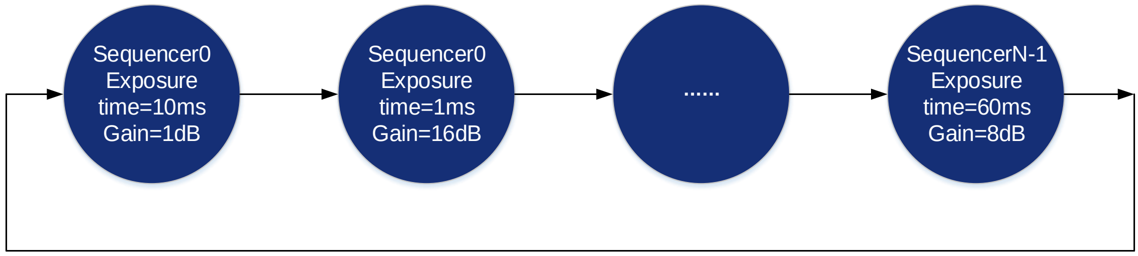


Figure 8-87 Sequencer feature schematic diagram

8.6.1. GUI

The GUI layout and function descriptions are as follows:

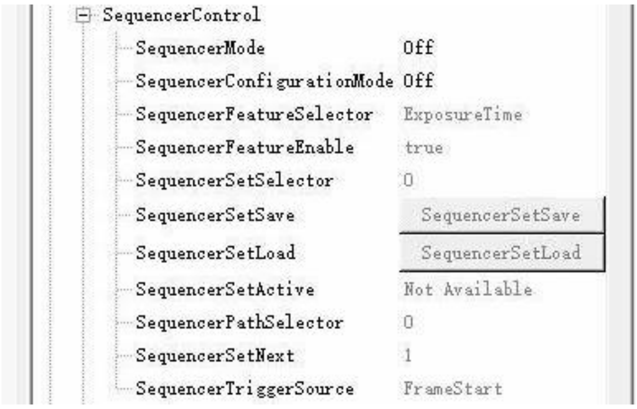


Figure 8-88 GUI

[SequencerMode] Set the parameter to "On", enable the sequencer. Set the parameter to "Off", disable the sequencer. When enabled, the sequencer controls image acquisitions, switch to next sequence set after each image is acquired. When disabled, the sequencer is not controlling image acquisitions and cannot switch parameters.

[SequencerConfigurationMode] Set the parameter to "On", "SequencerSetSave" and "SequencerSetLoad" are enabled. Set the parameter to "Off", "SequencerSetSave" and "SequencerSetLoad" are disabled and parameters cannot be saved to the sequence sets.

[SequencerFeatureSelector] Configure the feature that support sequence, like ExposureTime, Gain, Gamma and FCC.

[SequencerFeatureEnabled] Set the parameter to “true”, the feature in "SequencerFeatureSelector" is supported sequence, currently only true are supported and cannot be changed.

[SequencerSetSelector] Set the sequence set number. The range is determined by the camera model.

[SequencerSetSave] Save parameters to the sequence set in "SequencerSetSelector"

[SequencerSetLoad] Click "SequencerSetLoad", the values of sequence set parameters are overwritten and replaced by the values stored in the selected sequence set.

[SequencerSetActive] When "SequencerMode" is set to "On", displays the sequence set number currently in use, as shown below. The advance from one sequence set to the next occurs automatically as FrameStart trigger signals are received. When "SequencerMode" is set to “Off”, displays "Not Available".

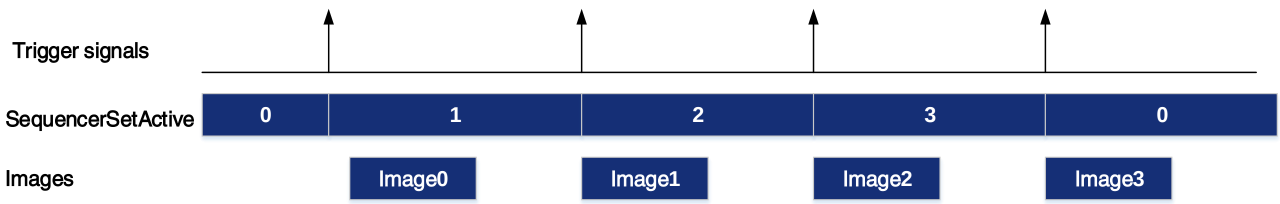


Figure 8-89 Timing diagram

[SequencerPathSelector] Not currently supported, the set value is fixed to 0.

[SequencerSetNext] The "SequencerSetSelector" sets number to which the next sequence set jumps. For example, if "SequencerSetSelector" is set to 1 and "SequencerSetNext" is set to 2, then after the camera uses the parameters to acquire an image, the sequence set will be switched to sequence set 2. Only sequential jump is supported, "SequencerSetSelector" is set to N, and then "SequencerSetNext" can only be set to N+1 or 0, and the maximum value of N+1 is "the maximum number of sequence sets supported-1". If the maximum number of sequences of cameras is 16, the maximum value of N+1 is 15.

[SequencerTriggerSource] The condition for the sequencer to start running, FrameStart only supported. Each time an image is acquired, the sequence switches to the next sequence set.

8.6.2. User Guide

- Set sequence parameters

1) Set the "SequencerMode" to "Off" and the "SequencerConfigurationMode" to "On".
2) Set the "SequencerSetSelector" parameter.
3) Click "SequencerSetLoad", the values of sequence set parameters are overwritten and replaced by the values stored in the selected sequence set.
4) Set the sequence set parameters: ExposureTime, Gain, FFC coefficient number, etc.
5) Click "SequencerSetSave".

- Change the number of sequence sets used

By default, sequence set are set as 0->1->2->3...->N–1, but in some cases we may want the sequence set to run in the order 0->1->2->3->0->1->2->3, in which case this order can be achieved by "SequencerSetNext".

For example, we want the sequence sets to run in the order 0->1->2->0->1->2, the setting is as follows:

1) Set the "SequencerSetSelector" to 2.
2) Set the "SequencerSetNext" to 0.

⚠

1) Before "SequencerMode" set to "On", the auto gain, auto exposure and auto white balance functions must be set to "Off".
2) Sequencer parameters can't be saved in user set.

8.7. Fan and TEC Control

The fan and TEC cooling system are the active cooling systems of the CXP camera. Thermoelectric Cooling (TEC) refrigerates the camera image sensor to prevent the temperature of the image sensor from being too high during work and ensure that the image sensor works at the optimal imaging temperature. A fan is installed on the rear panel of the camera and combined with the cooling fin to radiate heat.

8.7.1. GUI

The GUI layout and function descriptions are as follows:

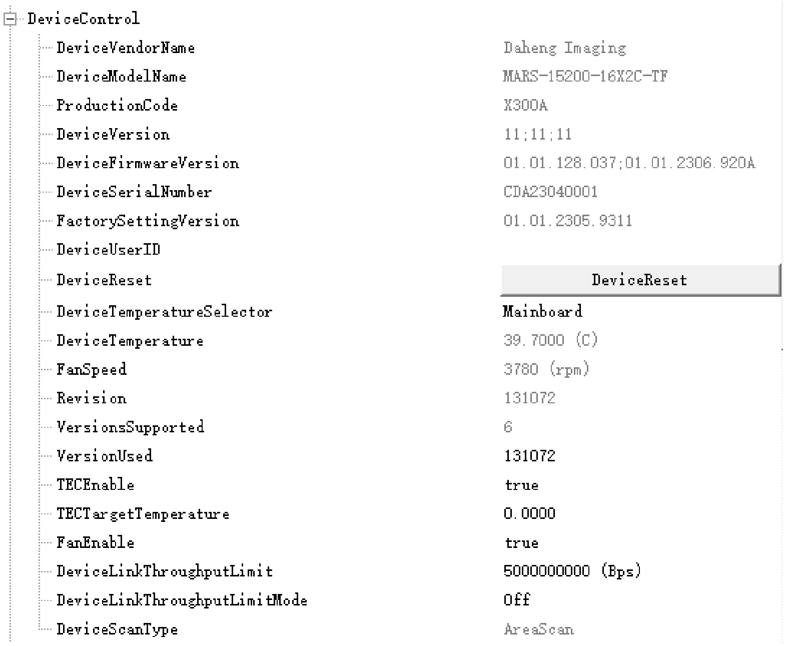


Figure 8-90 GUI

[TECEnable] Set the parameter to "true", enable the TEC. Set the parameter to "false", disable the TEC. When enabled, the camera image sensor temperature will be reduced to 15 degrees below ambient temperature within 5 minutes.

[TECTargetTemperature] Sets the target temperature. Range: -10°C ~ +60°C (Default: 0°C). Change the value to adjust the target temperature, and the camera will accurately adjust the temperature according to the current temperature and the target temperature adjustment algorithm.

[FanEnable] Set the parameter to "true", turn on the fan. Set the parameter to "false", turn off the fan. Turn on the fan will reduce the temperature of the camera.

[FanSpeed] The current fan speed after enable the fan (Unit: rpm).

[DeviceTemperatureSelector, DeviceTemperature] The DeviceTemperatureSelector can be set as "Sensor" or "Mainboard". Set the DeviceTemperatureSelector to "Sensor", DeviceTemperature displays the real-time temperature of the image sensor. Set the DeviceTemperatureSelector to "Mainboard", DeviceTemperature displays the real-time temperature of the mainboard.

8.7.2. Precautions

1) The camera image sensor's temperature will rise during image acquisition. In order to ensure image quality and sensor hardware safety, it is recommended to turn on TEC to keep the image sensor at the best working temperature when the camera is under long time image acquisition

2) When the TEC is turned on, the TEC will generate a lot of heat, which will increase the temperature of the mainboard and camera. In order to ensure the operation of all devices, it is recommended to turn on the fan to actively dissipate the heat when the TEC is turned on.

3) When TEC abnormality occurs at the user enables TEC, the camera will enter the self-protection mechanism to limit the image acquisition and protect the image sensor. Please contact our technical support for assistance in resolving the problem.

9. Software Tool

9.1. LUT Create Tool

9.1.1. GUI

LUT Create Tool, which supports all series of DAHENG IMAGING cameras. This plugin is integrated into GalaxyView.exe. After opening the device that you want to operate through this software, you can open LUT Create Tool from the menu bar plugin list. With the plugin you can achieve the following functions:

1) Adjust the image Gamma, brightness, and contrast.

2) Read the saved LUT from device.

3) Write the adjusted LUT to device.

4) Read the saved LUT from LUT/CSV file.

5) Save the adjusted LUT to file.

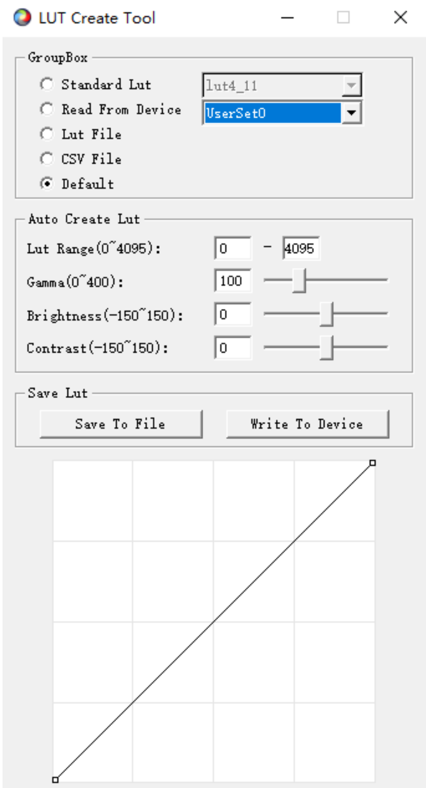


Figure 9-1 The GUI of LUT Create Tool

After opening the device and LUT Create Tool through GalaxyView.exe, the initial GUI is shown in Figure 9-1. The layout and function description of widgets are as follows:

[GroupBox] Select LUT from Standard LUT, Read From Device, LUT File, CSV File and Default. Among them, standard LUT is eight groups of factory standard LUTs. Read from file is the LUT that can be read from device. LUT/CSV file can read the saved values. The default mode is the camera default value.

[Auto Create LUT] Adjust the LUT range, Gamma, brightness, and contrast to add effects on base LUT.

[Save LUT] Write the currently generated LUT to device or save to LUT/CSV file.

[Polyline Drawing Area] Represent the currently generated LUT in a curve form.

9.1.2. User Guide

9.1.2.1. User Case

After you select GroupBox and adjust the LUT parameter to a satisfactory effect, if you want to save the currently set parameters and you want to restore the parameters after the camera is powered on again, you need to select "Write To Device". The LUT parameter will be written to the UserSet selected by the drop-down box. "Read From Device" is a check box. When switching UserSets in the drop-down box, the reading from device will not be operation. Users need to click "Read From Device" to trigger the reading from device.

Click "Read From Device" in the GroupBox. If the UserSet selected in the drop-down box is "Default", the pop-up window will prompt "Unable to load LUT operation! The user parameter group will be loaded internally". Click "Yes" or "No" to return to "Default" in the GroupBox. Click the "Write To Device". If the parameter group selected in the drop-down box is "Default", the same popup prompts "Unable to load LUT operation! The user parameter group will be loaded internally" as shown in Figure 9-3

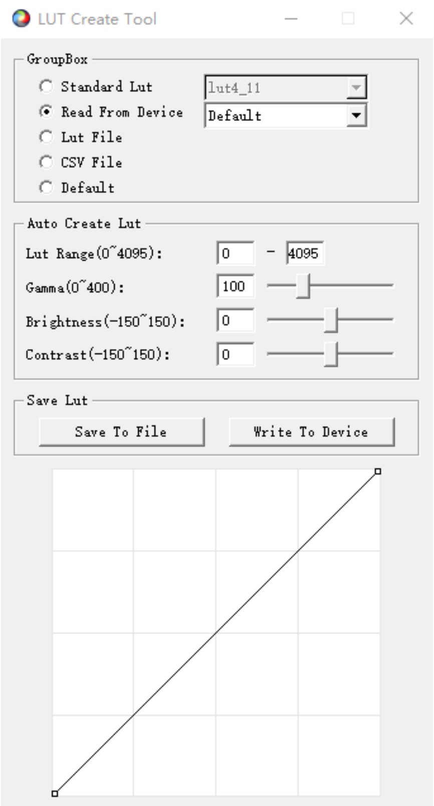


Figure 9-2 LUT create tool

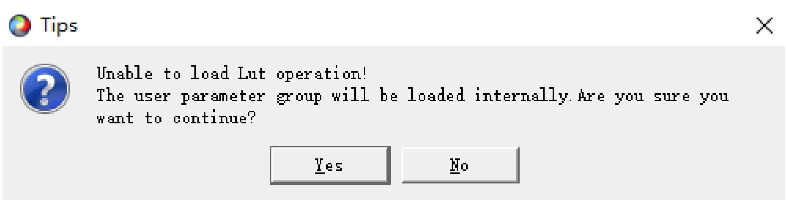


Figure 9-3 Tips

If the device does not support reading/writing LUT, or does not support LUT to be used on other terminal devices after adjusting LUT effect through this terminal, then you can use the "Save To File" function. After adjusting LUT, select "Save To File" and choose the save format as LUT. Then select the "LUT File" in GroupBox again and select the saved LUT file to restore the parameters. If you copy the file to another terminal and read it, you can still restore the parameters.

When reading/writing LUT and Auto Creat LUT, you need to rely on some files in the installation package directory, so do not arbitrarily change the installation package directory structure to avoid read/write failure.

9.1.2.2. GroupBox

1. Standard LUT

When selecting standard LUT in GroupBox, the drop-down list box is enabled, which contains eight sets of optional standard LUT, as shown in Figure 9-4. These eight sets of values are factory set, which can achieve the optimal image effect. When you choose different standard LUT, the polyline and image effects change. You can modify the LUT range, Gamma, brightness, contrast values to add image effects until you are most satisfied.

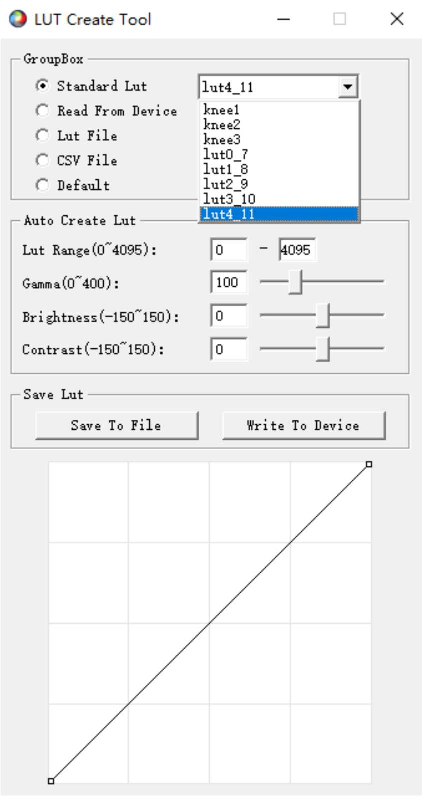


Figure 9-4 Standard LUT

2. Read From device

When you select read from device, the tool will automatically load the UserSet selected by the drop-down box, and then load the LUT saved by the device. If the device supports LUTEnable, it will automatically set LUTEnable to true to display the image effect in real time, the GUI is as shown in Figure 9-5.

The device do not supported LUT is shown in Figure 9-5. The widgets of Read From device, Read From device drop-down box and Write To Device are disabled. The device supported single parameter group LUT is shown in Figure 9-6. Read From device widget drop-down box is disabled.

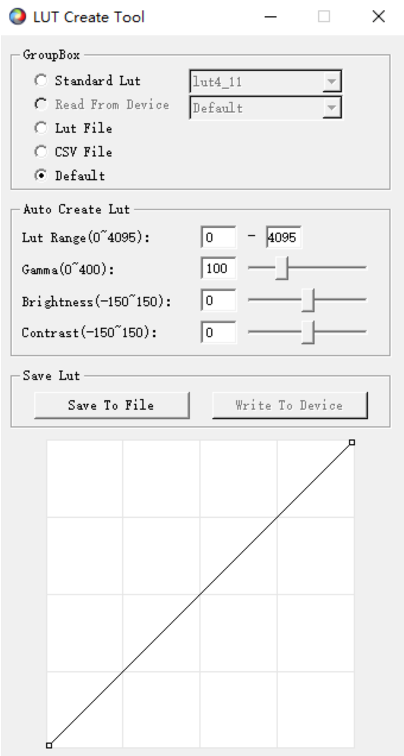


Figure 9-5 Do not support LUT

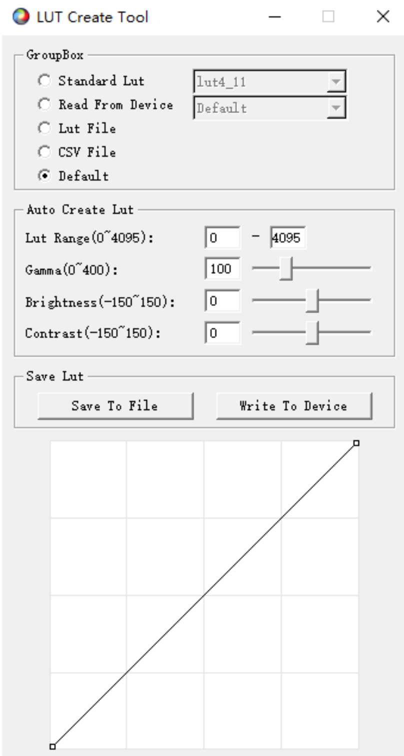


Figure 9-6 Single parameter group LUT

When selecting "Read From Device", the polyline graph and image effects are updated to the lookup table in the device. When selecting the standard LUT or default LUT and selecting "Write To Device", then when reading, the written parameters will be updated to the GUI. For example, standard LUT selects knee2, LUT range input 0-1023, Gamma input 110, brightness input 100, contrast input 100, and the GUI after selecting "Write To Device" is shown in Figure 9-6.

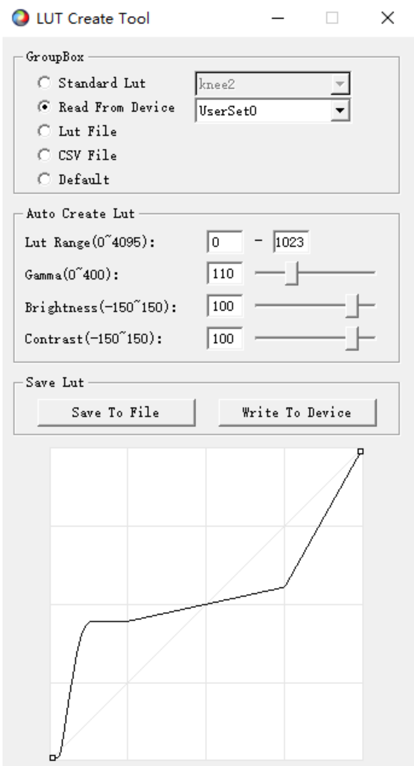


Figure 9-7 Select "Read From Device"

When reading from device, the currently selected parameter group in the drop-down box will be loaded, which will cause the previously modified device feature information to be lost. Therefore, the information should be saved in time before reading from device.

3. LUT file

After selecting the LUT file, a dialog box for selecting the file will pop up. You can select the file in the format of .lut, and update the polyline diagram and image acquisition effect of the device. If you select standard LUT or default LUT, and auto create LUT, the widget interface will update the parameters stored when saving LUT (the updated parameter values include LUT range, Gamma, brightness, contrast, and the values selected by the standard LUT drop-down box).

4. CSV file

After selecting CSV file, a dialog box for selecting the file will pop up. You can select the file in the format of .csv, and update the polyline diagram and image acquisition effect of the device. After selecting CSV file, all widgets of Auto Create LUT are disabled and unadjustable, as shown in Figure 9-8.

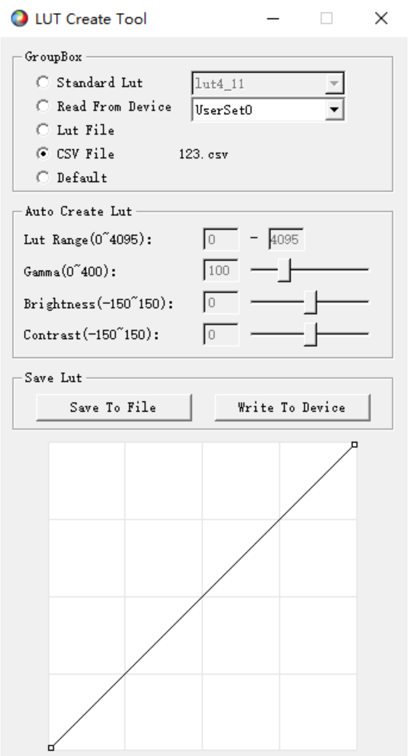


Figure 9-8 Select CSV file

CSV file can be manually modified by users. Currently, csv storage format saves decimal number of every four bytes to the first cell of each line in the file, and the maximum value of the number in each cell is 4095, a total of 4096 lines. The polyline graph of the GUI updates the curve according to the number of the first line of every 16 lines. Failure to follow the format when manually modifying will result in failure to read the file.

5. Default

The default option is the LUT data when the device is shipped from the factory, and is the initial value in each situation. If there is an error in other situation, it will automatically switch to the default. The default polyline graph is diagonal.

9.1.2.3. Auto Create LUT

There are five sets of parameters in Auto Create LUT, the maximum LUT range (default value 4095, range 0~4095), minimum value (default value 0, range 0~4032), Gamma (default value 100, range 0~400), brightness (default value 0, range -150~150), contrast (default value 0, range -150~150), where the difference between the maximum and minimum values of the LUT range needs to be greater than or equal to 63.

After selecting the GroupBox, when the above parameters are modified, the generated LUT will be written to the device Flash in real time. At this time, the "Write To Device" is not selected. After the device is powered off and restarted, the modified parameters will be lost. The generated LUT cannot be restored by "Read From Device".

If the GroupBox is selected as default or standard LUT, then adjusting the parameter values in the LUT group to generate LUT and saving the LUT file will save the parameter values together in the file. Reading the file again will restore the saved case.

9.1.2.4. Save LUT

The group contains two widgets: Save To File and Write To Device.

1. When selecting " Save To File ", the current LUT data can be saved to the file. The saved file contains two formats: lut and csv, as shown in Figure 9-9:

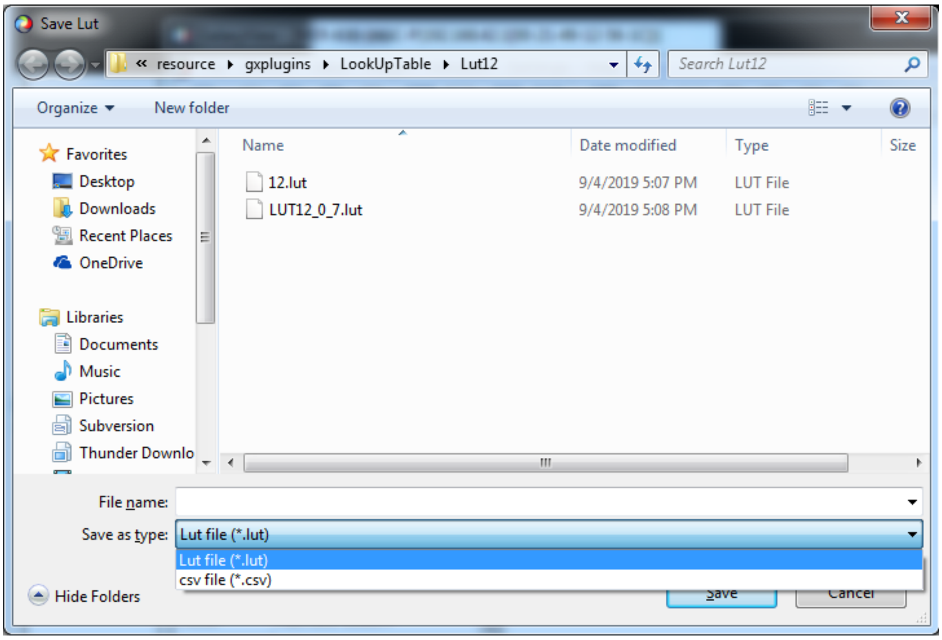


Figure 9-9 Save to file

The save type can be changed when saving the file. The default save path is ".\resource\gxplugins\LookUpTable\LUT12", which is the directory where the GalaxyView.exe is installed.

2. When "Write To Device" is selected, the current LUT data is written to UserSet (the currently selected parameter group in the drop-down box).

⚠ The "Default" parameter group cannot be the parameter group of the object being written to.

9.1.2.5. Read LUT

There are two ways to read the .lut file saved by the plugin and set it into the camera:

1. Using the plugin: After selecting the LUT file, a dialog box for selecting the file will pop up. You can select the lookup table file (xxx.lut). Clicking the "Write To Device" to set the LUT file data into the camera.

2. Using the API interface: Read the .lut file through the ReadLUTFile interface in the GxIAPI library and DxImageProc library and parse it into lookup table format that can be set to the appropriate camera. The specific steps are as follows:

    a) Get the length of the lookup table.

    b) Apply for the lookup table Buffer resource of the corresponding size according to the length of the lookup table.

    c) Read the lookup table file (xxx.lut), and get the lookup table Buffer data.

    d) Set the lookup table Buffer data into the camera. (Make sure the LUTEnable is true).

    e) Save the current lookup table data to UserSet (the currently selected parameter group in the drop-down box). When reading from the device again, the camera will load the lookup table data.

The API interface supports C/C++/C#. For specific about the interface and example programs, please refer to DxReadLutFile of "C SDK Programming Reference Manual", IGXImageSpecialFunction::ReadLutFile of "C++ SDK Programming Reference Manual" and IGXImageSpecialFunction::ReadLutFile of "DotNET SDK Programming Reference Manual".

⚠ This software tool is suitable for Euresys frame grabber and GalaxyView to operate the camera. If you use this tool with the Matrox frame grabber, please contact technical support to ask the use of the tool, see Section 2 of the Camera Tool Manual for details.

9.2. Frame Rate Calculation Tool

WidthMax	16544
HeightMax	9200
Width	16544
Height	9200
BinningHorizontal	1
BinningVertical	1
DecimationHorizontal	1
DecimationVertical	1
ExposureTime(us)	60000
ExposureDelay(us)	0
PixelFormat(8/12)	8
StreamPacketSizeMax	16384
TriggerMode	0
FramerateABS	16
FramerateAbsEn	0
Connection speed	12.5
Number of connections	4
DeviceLinkThroughputLimitMod	0
DeviceLinkThroughputLimit	5000
FPS	16.30

MARS-15200-16CX

Figure 9-10 Frame rate calculation tool

The frame rate calculation tool is currently provided in the form of Excel. When using it, firstly select the camera model in the table, and then achieve the expected frame rate by modifying the parameter of the camera. There are four major types of influencing factors, including image readout time (image width, image height, pixel format), exposure time, exposure delay, max stream packet size, trigger mode, connection speed, number of connections, acquisition frame rate control, and device link throughput limit.

Table parameter explanation:

1) The Width and Height are the set ROI size.

2) For more details about BinningHorizontal, BinningVertical, DecimationHorizontal and DecimationVertical, please refer to section 8.3.9 and section 8.3.10. These four parameters affect the transmission time of the image data.

3) The ExposureTime is the exposure time when the camera acquires one frame of image.

4) The PixelFormat is the pixel format corresponding to the camera output image, including 8 bits, 10 bits or 12 bits.

5) The DeviceLinkThroughputLimit represents the maximum bandwidth of the image transmitted by the camera. Whether the camera transmission bandwidth can reach the set bandwidth value is also affected by other acquisition parameters.

6) DeviceLinkThroughputLimitMode indicates whether bandwidth limit is enabled, On means bandwidth limit is enabled, and Off means bandwidth limit is disabled. When bandwidth limit is enabled, the camera acquires and transmits images at a bandwidth no higher than the DeviceLinkThroughputLimit. When bandwidth limit is disabled, the camera acquires images without being affected by the DeviceLinkThroughputLimit. However, the bandwidth of camera acquires and transmits images will not exceed the maximum bandwidth supported by the hardware.

7) The FramerateABS represents the maximum value of the frame rate control when the FramerateAbsEn is set to on, and whether the maximum value can be reached depends on whether the camera is affected by other acquisition parameters.

8) FramerateAbsEn indicates whether frame rate control is enabled, On means frame rate control is enabled, and Off means frame rate control is disabled. When frame rate control is enabled, the camera acquires images at a frame rate no higher than the FramerateABS. When frame rate control is disabled, the camera acquires images without being affected by the FramerateABS.

When using the frame rate calculation tool, please fill in the above information of the camera into the corresponding table. When the filled value exceeds the range or does not conform to the rules, the calculation tool will report an error. Please modify and fill in the value again according to the prompt information. When all parameters are correctly filled in, the FPS shown in the last column of the table is the theoretical frame rate currently acquired by the camera, and usually the error between this value and the actual frame rate acquired by the camera is no more than 1%.

9.3. Static Defect Correction Plugin

Static Defect Correction Plugin support all series of DAHENG IMAGING digital camera. The plugin is integrated into GalaxyView.exe. After opening the device through GalaxyView, open the Static Defect Correction plugin from the menu bar plugin list. Using the plugin, you can achieve the following functions:

1) Analyze the defect pixel in the current images of the device, including Bright dark scene and Actual scence.

2) Execute Static Defect Correction on the images.

3) Save the defect pixel information to the device.(The camera which support Static Defect Correction)

4) Save the defect pixel information to the file

9.3.1. GUI

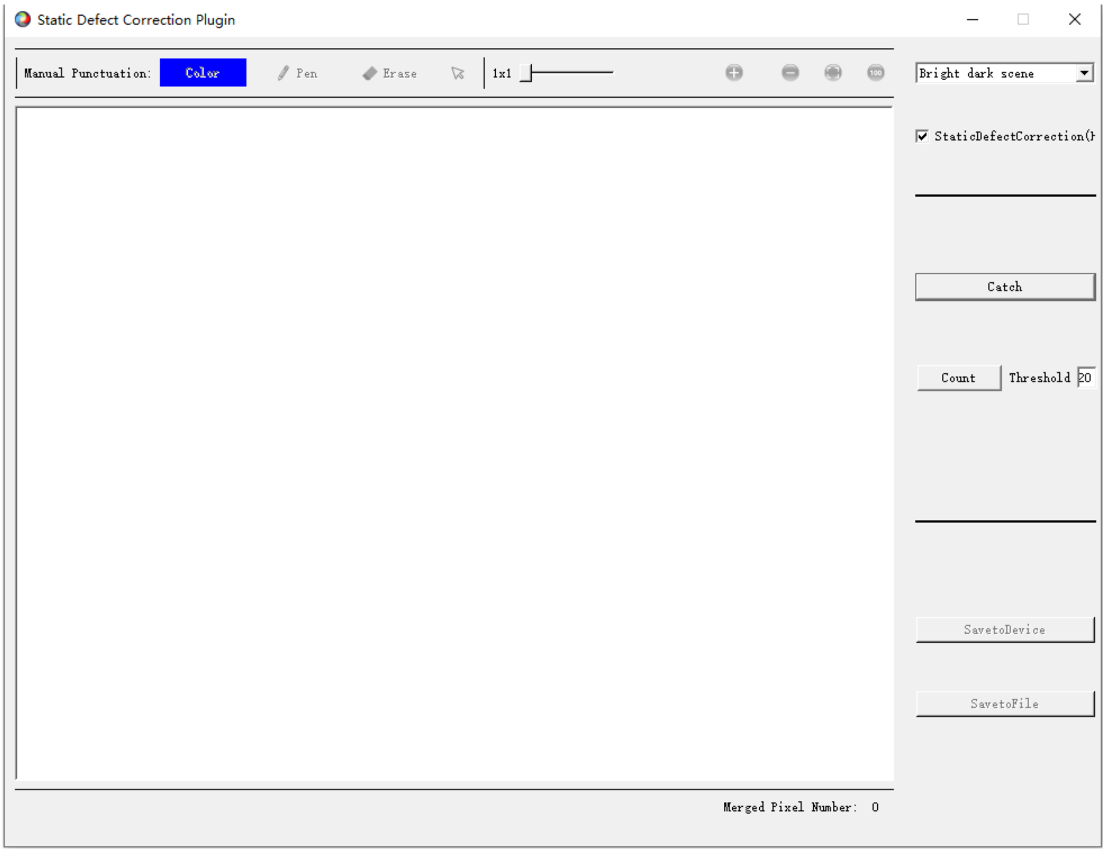


Figure 9-11 Static Defect Correction GUI

After opening the device through GalaxyView.exe and opening the Static Defect Correction plugin, the initial state of the GUI is shown in Figure 9-11. The plugin layout and function description are as follows:

No.	Widget	Function
1	Catch	Acquisition an image to analyze the location of the defect pixels and noise points
2	Threshold	Set the threshold for defect pixels and noise points judgment
3	Bright dark scene	Count the defect pixels
4	Actual scene	Count the noise points
5	Count	Count the location of the defect pixels and noise points

6	StaticDefectCorrection (hardware)	Choose whether to perform Static Defect Correction
7	SavetoDevice	Save the defects information to the device
8	SavetoFile	Save the defects information to a file
9	Image display area	Display the image. After counting the defect pixels and noise points, the location of the defect/noise pixels will be marked on the displayed image
10	Merged pixel number	Display the number of defects
11	Color	Change the color of merged pixels
12	Pen	Manually mark the defects on the image
13	Erase	Erase the original merged pixels on the image
14		Set mouse gestures as arrow
15		Change the size of merged pixels
16		Zoom in
17		Zoom out
18		Adaptive present image
19		Present image 100%

Table 9-1 Function description of the Static Defect Correction plugin

[Image] Capture an image through the catch button and display it in the white area in the middle of the plugin. The captured image is used to analyze the location of the defect pixels /noise points.

[Defect pixel analysis] User determines the range of defect pixels to be processed by setting the threshold and select the type of defect pixels. After clicking the "Count" button, the plugin will analyze the location of the defect pixels /noise points in the current image, and mark the location of the defect pixels on the image as red. The merged pixel number are display in the status bar.

If the current device supports the function of static defect pixel correction, and the merged pixel number is less than the number 8192 that the device supports. The defect pixel information will be written into the FLASH of the device.

[Operation] The Static Defect Correction can be performed by hardware or software. If the current device supports Static Defect Correction and the merged pixel number is less than 8192, hardware is preferred to perform Static Defect Correction, otherwise it can be executed through software. After the user check the Static Defect Correction box, the image displayed on GalaxyView is the image after performing the Static Defect Correction.

"SavetoDevice" button can save the defect pixel information to the FLASH of the device.

"SavetoFile" button can save the defect pixel information to .dp or .csv file.

[Image display area] Display the image and the location of the defect pixels /noise points.

[Status bar] Show the defect pixels number/noise points number/merged pixel number.

9.3.2. User Guide

9.3.2.1. Static Defect Correction Steps

1) Click the "Catch" to capture an image. For details, please see section 9.3.2.2
2) Set threshold to determine the range of defect pixels
3) Check "Bright dark scene" or "Actual scene" to select the type of defect pixels
4) Click "Count" to complete the defect pixel analysis. The location of the defect pixels on the image will be marked and displayed in the status bar
5) Check "StaticDefectCorrection" to execute Static Defect Correction
6) When the device supports Static Defect Correction and the merged number is less than 8192, the user can through the "Save to Device" to write the statistics of the defect pixel information into the device, and it will still be valid after power off and restart
7) The user can click the "Save to File" to save the statistics of defect pixel information to a file. For details, please see section 9.3.2.4

9.3.2.2. Acquisition Images

1) When the device is in the stop acquisition mode, click "Catch", the image will be displayed in the GalaxyView acquisition GUI.
2) When the device is in the acquisition mode, click "Catch" to complete the image acquisition.
3) When counting defect pixels, it is required to acquisition images with uniform gray scale. For example, use bright field images when detecting dark defect pixels, and use dark field images when detecting bright defect pixels.
4) When the threshold is fixed, the number of defect pixels will be affected by the exposure time and gain. The greater the value of exposure time and gain, the greater the number of defect pixels.
5) The counted defect pixels by the device under the maximum resolution are applicable to any ROI image. The counted defect pixels by the device in the ROI are only applicable to the image in the ROI.
6) Click "Color" to select the manual mark color.
7) Click "Pen", set the mouse gestures as pencil to mark the defects on the image.
8) Click "Erase" to erase the original merged pixels on the image.
9) Click " ⊕ " to zoom in the image.

10) Click "" to zoom out the image.

11) Click "" to adaptive present image.

12) Click "" to present image 100%.

13) When performing image scaling operation, the current image scaling ratio will be displayed.

14) The current image width and height, pixel coordinates of mouse position and RGB value of mouse position are displayed in the status bar.

9.3.2.3. Static Defect Correction

1) "StaticDefectCorrection" is divided into "StaticDefectCorrection (software)" and "StaticDefectCorrection (hardware)"

2) When the device perform Static Defect Correction, the plugin will give priority to hardware to implement Static Defect Correction, which will be displayed as "StaticDefectCorrection (hardware)", otherwise it will be displayed as "StaticDefectCorrection (software)"

3) The condition for the device to perform Static Defect Correction is that the device supports the Static Defect Correction function and the number of defects is less than 8192.

4) When the device is in the acquisition mode, the user can check or uncheck "Static Defect Correction" to check the correction result.

When the device performs Static Dead Pixel Correction, it is temporarily unable to remove the dead pixels at the left and right boundaries. The monochrome camera is 3 pixels from the boundary, and the color camera is 6 pixels from the boundary.

9.3.2.4. How to Use Defect Pixel Data File

1) The format of the defect pixel data file is ".dp" and ".csv", and the default save path is under the installation package directory:
*\Daheng Imaging\GalaxySDK\Demo\Win64\resource\gxplugins\DefectPixelCorrection;

2) When you need to use the SDK to implement the Static Defect Correction function, you can read the saved defect pixel data file and call the function of the image processing library: DxStaticDefectPixelCorrection to realize the Static Defect Correction of the image.

This software tool is suitable for Euresys frame grabber and GalaxyView to operate the camera. If you use this tool with the Matrox frame grabber, please contact technical support to ask the use of the tool, see Section 3 of the Camera Tool Manual for details.

10. FAQ

No.	General Question	Answer
1	Use Matrox frame grabber and GalaxyView to read-write property of the camera. The blue screen appeared after opening the device.	1) Please connect the frame grabber to the camera in the following sequence. Card CH0 <<==>> Cam CH1 Card CH1 <<==>> Cam CH2 Card CH2 <<==>> Cam CH3 Card CH3 <<==>> Cam CH4 2) Use the Matrox 2022 installation package.
2	Use Euresys frame grabber and GalaxyView to read-write property of the camera. If the camera information shows "unknown device", open the camera and report the error "A given address is out of range or invalid".	Please wait for about 10 seconds and enumerate the camera again. Open the camera after enumerated the camera's ModelName (SN).
3	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. Set the camera pixel format to GB8, image acquisition normally. Set the pixel format to GB12, no images after acquisition start.	Please turn off the camera and turn it back on before image acquisition after switching the pixel format.
4	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. Set the camera pixel format to Mono12, the frame rate can not reach the maximum.	Please modify "Set the number of acquisition Buffers" to be greater than or equal to 4 manually.
5	Use Euresys frame grabber and eGrabber Studio to operate the camera to acquire. When the ROI width is 32, the camera acquires only one frame of image.	The camera ROI width needs to be greater than or equal to 64.
6	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. If the ROI is less than 18K, the demo will hang and unresponsive.	Please modify "Set the number of acquisition Buffers" to be less than 100 manually.
7	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. When the pixel format is GB8/Mono8, image acquisition failed, and when the pixel format is GB12/Mono12, image acquisition normally.	1) Use the Matrox 2021 installation package. 2) Use the API interface provided by the Matrox frame grabber to control the camera.
8	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. Fail to acquire image in pixel format GB12 and shows that Announced Buffer is insufficient.	Use 32G memory. Set the non-paged memory in MILConfig to be greater than 16G, and check the box to check "Enable Large Non-Paged MIL Buffers".

No.	General Question	Answer
9	Use Matrox frame grabber and GalaxyView to operate the camera to acquire. After clicking the close button directly in the upper right corner, GalaxyView crashes.	Stop acquisition and turn off the camera before turning off GalaxyView.
10	Use Euresys frame grabber and GalaxyView to operate the camera to acquire. Sporadically, GalaxyView crashed and the camera could not stop acquiring image.	Please open the camera with eGrabber Studio and click stop acquisition in camera property list.
11	Use Matrox frame grabber, GalaxyView or Matrox Intellicam to perform enumerate camera. Power off/on the camera during enumeration and find that the camera can no longer be enumerated.	Please re-open the software and perform the enumeration to enumerate the camera.
12	Use Matrox frame grabber to trigger the camera to acquire via the frame grabber's Timer to stimulate CXPTrigger, the trigger may fail.	The Timer of the Matrox frame grabber is sometimes occupied, which causes the frame grabber not to send out the CXP Trigger packet, and thus no image is acquired. This problem can be avoided by replacing the Timer of the frame grabber.
13	Use Matrox frame grabber to set a device user ID to a character that is not an alpha or numeric character, the camera may fail to open.	Letters and numbers are recommended for device user ID.
14	Use Matrox frame grabber to set the ROI width to 32, the image display may flicker and the capture frame rate may be abnormal.	The camera ROI width needs to be greater than or equal to 64.

11. Revision History

No.	Version	Changes	Date
1	V1.0.0	1. Initial release	2023-09-25

12. Contact Us

12.1. Contact Sales

If you need to order products or inquire product information, please contact our sales:

Tel: +86 10 8282 8878-8081

Email: isales@deheng-imaging.com

12.2. Contact Support

If you have any questions in using DAHENG IMAGING products, please contact the experts on our support team:

Tel: +86 10 8282 8878

Email: isupport@daheng-imaging.com