vieworks

VZ Series User Manual

VZ-2MU-M41H00 / VZ-2MU-C41H00 / VZ-2MU-M168H00 / VZ-2MU-C168H00

VZ-3MU-M56H00 / VZ-3MU-C56H00 / VZ-3MU-M125H00 / VZ-3MU-C125H00

VZ-5MU-M79H00 / VZ-5MU-C79H00 / VZ-5MU-M79H00-POL

VZ-5MU-M36H00 / VZ-5MU-C36H00 / VZ-5MU-M36H00-POL

VZ-6MU-M60H00 / VZ-6MU-C60H00 / VZ-12MU-M32H00 / VZ-12MU-C32H00

VZ-12MU-M32H10 / VZ-12MU-C32H10 / VZ-12MU-M23H00 / VZ-12MU-C23H00

VZ-20MU-M19H00 / VZ-20MU-C19H00

VZ-400U-M528H00 / VZ-400U-C528H00 / VZ-1600U-M227H00 / VZ-1600U-C227H00

USB3 VISION

GEN<i>CAM

© 2024 Vieworks. All rights reserved.

The copyright of this document belongs to Vieworks Co., Ltd., and in accordance with copyright law, all or part of this document may not be copied, reprinted, or extracted without the permission of Vieworks Co., Ltd. Specifications and related information in this document may change without notice. Please refer to the latest version of the manual on the download website provided by our company. (http://vision.vieworks.com)

Before Using Our Products

Thank you for purchasing the VZ-2MU-M/C41H00™, VZ-2MU-M/C168H00™, VZ-3MU-M/C56H00™, VZ-3MU-M/C125H00™, VZ-5MU-M/C79H00™, VZ-5MU-M79H00-POL™, VZ-5MU-M/C36H00™, VZ-5MU-M36H00-POL™, VZ-6MU-M/C60H00™, VZ-12MU-M/C32H00™, VZ-12MU-M/C32H10™, VZ-12MU-M/C23H00™, VZ-20MU-M/C19H00™, VZ-400U-M/C528H00™, VZ-1600U-M/C227H00™ (hereinafter referred to as 'VZ USB Series') cameras.

- Be sure to read the manual before using the product.

- Be sure to have a professional engineer install and optimize the product.

- Keep the manual in a place where it can be easily accessed while using the product.

- This manual is written on the assumption that the user has expert knowledge about the camera.

Contents

Tables

Figures

51camera 志强视觉科技

Chapter 1. About This Manual

This manual is intended for the users of VZ USB Series camera models.

- With this manual, it is recommended to refer to your network card's user manual.
- This manual may contain links to websites of other companies that are not under the control of Vieworks Co., Ltd., and we are not responsible for any linked sites.
- The copyright for quoted materials whose source has not yet been disclosed belongs to the original author.
- Vieworks Co., Ltd. is not responsible for any errors or omissions that may occur within the manual.
- Depending on the product version or execution form, the product and screen images included in the manual may differ.

1.1 The Series

This manual is intended for users of the following products:

- VZ-2MU-M41H™
- VZ-2MU-C41H™
- VZ-3MU-M56H™
- VZ-3MU-C56H™
- VZ-5MU-M79H™
- VZ-5MU-C79H™
- VZ-5MU-M36H™
- VZ-5MU-C36H™
- VZ-6MU-M60H™
- VZ-6MU-C60H™
- VZ-12MU-M32H™
- VZ-12MU-C32H™
- VZ-12MU-M32H(01)
- VZ-12MU-C32H(01)™
- VZ-12MU-M23H™
- VZ-12MU-C23H™
- VZ-20MU-M19H™
- VZ-20MU-C19H™
- VZ-1600U-M227H™
- VZ-1600U-C227H™

1.2 Convention in This Manual

For better understanding, the following conventions are used throughout the manual.

Names and Fonts

The names and fonts of user interfaces are used as follows:

- The menu and icon names in this manual are used as displayed in the product.
- Command and parameter names are marked in *this font*.

Warning, Caution, and Note

This manual shows warnings, cautions, and notes with the following figures:

Warning!
A message with this icon indicates that you need to follow the message for your safety and to prevent the product from damage.

Caution!
A message with this icon indicates that you need to follow the message to prevent data from being lost or corrupted.

Note:
A message with this icon indicates that it provides additional information.

1.3 Revision History

This document has the revision history as follows:

Ver.	Date	Description
1.0	2024-01-30	Initial release
1.1	2024-02-23	Added chapters for adding the following models: - VZ-2MU-M/C41H, VZ-6MU-M/C60H, VZ-1600U-M/C227H
1.2	2024-04-16	Added chapters for adding the following models: - VZ-3MU-M/C56H, VZ-12MU-M/C32H, VZ-12MU-M/C23H, VZ-20MU-M/C19

51camera

Chapter 2. Introduction

2.1 Series Introduction

The VZ USB Series cameras from Vieworks Co., Ltd. is an industrial digital camera specialized for area scanning, with excellent performance for the price and ease of use due to its small size.

Features

- VZ USB Series cameras offer a variety of resolutions and frame rates and can be used with CMOS sensors from leading chip manufacturers.
- VZ USB Series cameras transmit image data through the UBS 3.0 data interface.
- VZ USB Series cameras use a locking screw connector, ensuring camera reliability even in harsh industrial environments.
- VZ USB Series cameras have high reliability and excellent price-performance ratio, making it especially suitable for industrial inspection and machine vision applications such as medical, scientific research, education, security, etc.

2.2 Standards

The camera follows the USB3 Vision 3.0 standard, and its development interface is implemented based on the GEN<i>CAM standard.

2.3 Document, CAD/Technical Drawing and Software Downloads

Product related document, CAD/Technical drawing and software can be downloaded from the Downloads of Vieworks website, http://vision.vieworks.com.

Chapter 3. Precautions

3.1 Safety Instructions

Before installing and using Vieworks' camera 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. Vieworks will not bear any legal responsibility for any damage or injury caused by improper use of this product and disregard of safety instructions.

Product Usage

Warning!

- 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.
- Do not aim at the product with high intensity light sources directly, as it may damage the sensor.
- 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.
- Unauthorized disassembly, repair, or modification of products is prohibited as it may damage the camera or cause a risk of electric shock.
- In the use of the device, you must be in strict compliance with the electrical safety regulations of the nation and region.
- Please use the power supply provided by reputable manufacturers that meets the camera power limit requirements, otherwise, it will damage the camera.

Caution!

- Check whether the device's package is in good condition, whether there is damage, deformation, etc. before unpacking.
- After unpacking, please carefully inspect the quantity and appearance of the product and accessories for any abnormalities.
- Please store and transport the product according to the specified storage and transportation conditions, ensure that the storage temperature and humidity meet the requirements.

51camera

Personal Safety

Warning!

- 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.
- It is prohibited to touch the camera directly during using, otherwise there may be a risk of burns.
- Please install and use the camera in accordance with regulations, otherwise there may be a risk of falling and get injured.
- The edges of the lens mount and fan are relatively sharp, so pay attention to the risk of scratches during installation or use.

3.2 Guidelines for Avoiding EMI and ESD

- USB cables certificated by USB IF with lock screw are recommended.
- 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.
- Keep your cameras away from equipment with high voltage, or high current (as motor, inverter, relay, etc.). If necessary, use additional shielding.
- 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.

3.3 Environmental Requirements

- Housing temperature during operation: 0 ℃ ~ 45 ℃, humidity during operation: 10% ~ 80%.
- Storage temperature: -20 ℃ ~ 70 ℃.
- To avoid collecting dust in the optical filter, always keep the plastic cap on cameras when no lens is mounted.
- PC requirement: Intel Core 2 Duo, 2.4 ㎓ or above, and 2GB memory or above.
- USB3.0 host controller requirement: Intel controller integrated in mainboard is recommend. Select Renesas controller if external frame grabber is needed.
- The cable must have a locking screw at the end of the device.
- Make sure that cameras are transported in the original factory packages.

3.4 Camera Mechanical Installation Precautions

Camera installation requirements

- The M3 screw and the camera should have a screw length between 2.5 and 2.7mm, and the M2 screw and the camera should have a screw length between 3 and 3.3mm.
- The M3 screw assembly torque ≤ 1N·M, and the M2 screw assembly torque ≤ 0.5N·M. If the screw assembly torque is too large, it may cause the camera thread stripping.

3.5 Certification and Declaration

CE, RoHS

We declare that the product has 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

Caution!

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

FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Caution!

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment can generate, uses, and radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Chapter 4. Installation Guidelines

4.1 Host Preparation

4.1.1 Software Package

The software package of Vieworks is used to control the VZ USB Series cameras to provide stable, real-time image transmission, and provides multiple samples and easy-to-integrate SDKs for various programming tools. The package is composed of the following modules:

- Driver Package (Driver): This package provides the driver program of VZ USB Series cameras, such as: the USB 3.0 cameras' driver program.
- Interface Library (API): This package provides the camera control interface library and the image processing interface library, supports the user for secondary development.
- Demonstration Program (VZViewer.exe): This demonstration program is used to display the camera control, image acquisition and image processing functions, the user can control the camera directly by the demonstration program, and the user can develop their own control program based on the camera interface library.
- Sample: These samples demonstrate cameras' functions; the user can easily use these samples to control cameras or refer to the samples to develop their own control programs.
- Programmer's Manual: This manual is the users programming guide that instructs the users how to configure the programming environment and how to control cameras and acquisition images through the camera interface library.

You can download the latest software package from the website: http://vision.vieworks.com.

4.1.2 User Software Interface

After installing the software package of VZ USB Series cameras, the user can use the demonstration program and the samples to control the camera, also the user can control the camera by the program which is written by the user themselves. The software package provides three kinds of program interface, the user can select the suitable one for use according to their own requirements:

API Interface

In order to simplify the users' programming complexity, the package provides the general C programming interface GxIAPI.dll and image processing algorithm interface DxImageProc.dll for the user to control the camera and provides the samples and software development manual which are based on these interfaces. The API interface supports C/C++/C#/Python, etc.

GenTL Interface

This interface is developed according to the standard of general transport layer in Gen<i>Cam standard, Vieworks 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. The definition and usage of GenTL interfaces can be downloaded from the website of EMVA.

USB3 Vision interface

The VZ USB Series cameras are compatible with the USB3 Vision protocol, which allows the user to control the camera directly through the USB3 Vision protocol. In addition, the user can use some third- party software that supports the USB3 Vision protocol to control the camera, such as HALCON.

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.

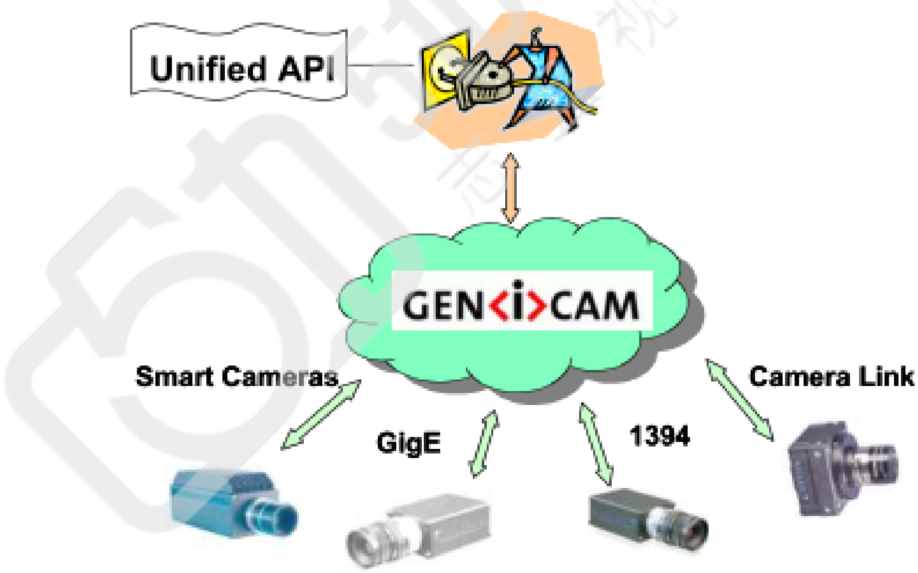


Figure 4-1 GEN<i>CAM standard schematic diagram

4.2 Camera Power

The VZ USB Series cameras are powered by the USB 3.0 interface.

Caution!

- Cameras that require an external power supply will only work if the USB3.0 cable and the external power supply are properly connected to the camera at the same time.

4.3 Camera Driver Installation

4.3.1 System Requirements

The VZseries SDK contains various operating systems such as Windows, Android and Linux. The requirements for the operating system and version of the installation package are as follows:

Operating Systems	Applicable Version
Windows	Windows 7 (32bit, 64bit) Windows 10 (32bit, 64bit) Windows 11 (64bit)
Linux	Ubuntu 12.04 or above, kernel version 3.5.0.23 or above
Android	Android 6 or above

Table 4-1 System Requirements

4.3.2 Driver Installation

The steps to install the VZseries SDK under Windows are as follows:

1 Download the corresponding version of the installation package from http://vision.vieworks.com.

2 Run the installer.

3 Follow the instructions of the installation wizard to complete the installation process.

4 During the installation process, you can choose the camera interface you need. (USB2.0, USB3 Vision, GigE Vision, etc.).

Caution!

- During the installation process, especially when installing the *.sys file, you must always pay attention to the anti-virus software to intercept the driver. If intercepted, it may cause the driver installation to fail.

4.4 Open Device and Start Acquisition

After powering the device, connecting the device to the USB 3.0 interface of host. Double-click the VZViewer software to acquire images. The steps are as follows:

1. Click the  icon on the Toolbar in the VZViewer to refresh device list.
2. After the device is enumerated, double-click the device enumerated in the device list.
3. Click the  icon on the Toolbar to perform the Start Acquisition operation on the current device.

51camera 志强视觉科技

Chapter 5. General Specifications

5.1 Specifications

5.1.1 VZ-2MU-M/C41H00

Specifications	VZ-2MU-C41H00	VZ-5MU-M41H00
Resolution	1920 × 1200	
Sensor Type	Sony IMX249 global shutter CMOS	
Max. Image Circle	1/1.2 inch	
Pixel Size	5.86 ㎛ × 5.86 ㎛	
Frame Rate	41 fps @ 1920 × 1200	
ADC Bit Depth	12 bit	
Pixel Bit Depth	8 bit, 10 bit, 12 bit	
Exposure Time	Standard: 20μs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB Default: 0dB, Steps: 0.1dB	
Binning	1×1, 1×2, 2×1, 2×2	
Decimation	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10 Bayer RG12	Mono8 Mono10 Mono12
Signal Noise Ratio	45.33 dB	45.33 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0°C ~ 45 °C	
Storage Temp.	-20°C ~ 70°C	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB 3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam	

Table 5-1 VZ-2MU-M/C41H00 specification

5.1.2 VZ-2MU-M/C168H00

Specifications	VZ-2MU-C168H00	VZ-5MU-M168H00
Resolution	1920 × 1200	
Sensor Type	Sony IMX174 global shutter CMOS	
Max. Image Circle	1/1.2 inch	
Pixel Size	5.86 ㎛ × 5.86 ㎛	
Frame Rate	168 fps	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	Standard: 20μs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	45.32 dB	45.32 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB 3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-2 VZ-2MU-M/C168H00 specification

5.1.3 VZ-3MU-M/C56H00

Specifications	VZ-3MU-C56H00	VZ-3MU-M56H00
Resolution	2048 × 1536	
Sensor Type	Sony IMX265 global shutter CMOS	
Max. Image Circle	1/1.8 inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	56 fps @ 2048 × 1536	
ADC Bit Depth	12 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 20μs~1s, Actual Steps: 1 row period	
Gain	0 ㏈ ~ 24 ㏈ 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	Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	40.09 ㏈	40.76 ㏈
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB 3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Data Interface	USB3.0	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-3 VZ-3MU-M/C56H00 specification

5.1.4 VZ-3MU-M/C125H00

Specifications	VZ-3MU-C125H00	VZ-3MU-M125H00
Resolution	2048 × 1536	
Sensor Type	Sony IMX252 global shutter CMOS	
Max. Image Circle	1/1.8" inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	79.1 fps @ 2048 × 1536	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	UltraShort: 1µs~100µs, Actual Steps: 1µs Standard: 20µs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	40.63 dB	40.55 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB 3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam	

Table 5-4 VZ-3MU-M/C125H00 specification

5.1.5 VZ-5MU-M/C79H00

Specifications	VZ-5MU-C79H00	VZ-5MU-M79H00
Resolution	2448 × 2048	
Sensor Type	Sony IMX250 global shutter CMOS	
Max. Image Circle	2/3 inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	79.1 fps @ 2448 × 2048	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	UltraShort: 1µs~100µs, Actual Steps: 1µs Standard: 20µs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4 Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	40.58 dB	40.65 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB 3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Data Interface	USB3.0	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-5 VZ-5MU-M/C79H00 specification

5.1.6 VZ-5MU-M79H00-POL

Specifications	VZ-5MU-M79H00-POL
Resolution	2448 × 2048
Sensor Type	Sony IMX250 MZR global shutter CMOS
Max. Image Circle	2/3 inch
Pixel Size	3.45 ㎛ × 3.45 ㎛
Frame Rate	79.1 fps @ 2448 × 2048
ADC Bit Depth	10 bit
Pixel Bit Depth	8 bit, 10 bit
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 20μs~1s, Actual Steps: 1 row period
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4 Sensor: 1×1, 2×2
Pixel Formats	Mono8, Mono10
Signal Noise Ratio	40.65 dB
Synchronization	Hardware trigger, Software trigger
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs
Operating Temp.	0℃ ~ 45 ℃
Storage Temp.	-20℃ ~ 70℃
Operating Humidity	10% ~ 80%
Power Consumption	< 2.7W @ 5V
Lens Mount	C
Data Interface	USB 3.0
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)
Weight	65 g
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam

Table 5-6 VZ-5MU-M79H00-POL specification

5.1.7 VZ-5MU-M/C36H00

Specifications	VZ-5MU-C36H00	VZ-5MU-M36H00
Resolution	2448 × 2048	
Sensor Type	Sony IMX264 global shutter CMOS	
Max. Image Circle	2/3 inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	36 fps @ 2448 × 2048	
ADC Bit Depth	12 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 20μs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4 Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	40.5 dB	40.4 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-7 VZ-5MU-M/C36H00 specification

5.1.8 VZ-5MU-M/C36H00-POL

Specifications	VZ-5MU-M36H00-POL
Resolution	2448 × 2048
Sensor Type	Sony IMX264 MZR global shutter CMOS
Max. Image Circle	2/3 inch
Pixel Size	3.45 ㎛ × 3.45 ㎛
Frame Rate	36 fps @ 2448 × 2048
ADC Bit Depth	10 bit
Pixel Bit Depth	8 bit, 10 bit
Exposure Time	20μs~1s, Actual Steps: 1 row period
Pixel Formats	Mono8, Mono10
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs
Operating Temp.	0℃ ~ 45 ℃
Storage Temp.	-20℃ ~ 70℃
Operating Humidity	10% ~ 80%
Power Consumption	< 2.7W @ 5V
Lens Mount	C
Data Interface	USB 3.0
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)
Weight	65 g
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam

Table 5-8 VZ-5MU-M36H00-POL specification

5.1.9 VZ-6MU-M/C60H00

Specifications	VZ-6MU-C60H00	VZ-6MU-M60H00
Resolution	3088 × 2064	
Sensor Type	Sony IMX178 rolling shutter CMOS	
Max. Image Circle	2/3 inch	
Pixel Size	2.4 ㎛ × 2.4 ㎛	
Frame Rate	60 fps @ 3088 × 2064	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	Standard: 8μs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	40.19 dB	40.18 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-9 VZ-6MU-M/C60H00 specification

5.1.10 VZ-12MU-M/C32H00

Specifications	VZ-12MU-C32H00	VZ-12U-M32H00
Resolution	4024 × 3036	
Sensor Type	Sony IMX226 rolling shutter CMOS	
Max. Image Circle	1/1.7 inch	
Pixel Size	1.85 ㎛ × 1.85 ㎛	
Frame Rate	32.3fps@4024 × 3036	
ADC Bit Depth	12bit	
Pixel Bit Depth	8bit, 12bit	
Exposure Time	Standard: 10μs~1s, Actual Steps: 1 row period	
Gain	0dB~24dB, 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG12	Mono8 Mono12
Signal Noise Ratio	40.61 ㏈	40.77 ㏈
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-10 VZ-12MU-M/C32H00 specification

5.1.11 VZ-12MU-M/C32H10

Specifications	VZ-12MU-C32H10	VZ-12MU-M32H10
Resolution	4096 × 3000	
Sensor Type	Sony IMX253 global shutter CMOS	
Max. Image Circle	1/1 inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	32.1fps@4096 × 3000	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit, 12bit	
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 24μs~1s, Actual Steps: 1 row period	
Gain	0 ㏈ ~ 24 ㏈ Default: 0dB, Steps: 0.1dB	
Binning	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4 Sensor: 1×1, 1×2 (Mono model only)	
Decimation	Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10 Bayer RG12	Mono8 Mono10 Mono12
Signal Noise Ratio	40.79 ㏈	40.63 ㏈
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 3.5W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	36 ㎜ × 31 ㎜ × 38.8 ㎜ (without lens adapter or connectors)	
Weight	66 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	

Table 5-11 VZ-12MU-M/C32H10 specification

5.1.12 VZ-12MU-M/C23H00

Specifications	VZ-12MU-C23H00	VZ-12MU-M23H00
Resolution	4096 × 3000	
Sensor Type	Sony IMX304 LQR global shutter CMOS	
Max. Image Circle	1.1 inch	
Pixel Size	3.45μm × 3.45μm	
Frame Rate	23.5fps@4096 × 3000	
ADC Bit Depth	12bit	
Pixel Bit Depth	8bit, 12bit	
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 28μs~1s, Actual Steps: 1 row period	
Gain	0dB~24dB, 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	Sensor: 1×1, 2×2	
Mono/Color	Color	Color
Pixel Formats	Bayer RG8 Bayer RG12	Bayer RG8 Bayer RG12
Signal Noise Ratio	40.59 dB	40.59 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 3W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	36 ㎜ × 31 ㎜ × 38.8 ㎜ (without lens adapter or connectors)	
Weight	66 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	

Table 5-12 VZ-12MU-M/C23H00 specification

5.1.13 VZ-20MU-M/C19H00

Specifications	VZ-20MU-C19H00	VZ-20MU-M19H00
Resolution	5496 × 3672	
Sensor Type	Sony IMX183 rolling shutter CMOS	
Max. Image Circle	1 inch	
Pixel Size	2.4μm × 2.4μm	
Frame Rate	19.6fps@5496 × 3672	
ADC Bit Depth	12bit	
Pixel Bit Depth	8 bit, 12 bit	
Exposure Time	Standard: 12μs~1s, Actual Steps: 1 row period	
Gain	0 dB ~ 24 dB 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG12	Mono8 Mono12
Signal Noise Ratio	41.56 dB	42.08 dB
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 mm × 29 mm × 58.8 mm (without lens adapter or connectors)	
Weight	78 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-13 VZ-20MU-M/C19H00 specification

5.1.14 VZ-400U-M/C528H00

Specifications	VZ-400U-C528H00	VZ-400U-M528H00
Resolution	720 × 540	
Sensor Type	Sony IMX287 global shutter CMOS	
Max. Image Circle	1/2.9 inch	
Pixel Size	6.9 ㎛ × 6.9 ㎛	
Frame Rate	528.5 fps @ 720 × 540	
ADC Bit Depth	8 bit, 10 bit, 12bit	
Pixel Bit Depth	8 bit, 10 bit, 12bit	
Exposure Time	UltraShort: 1μs~100μs, Actual Steps: 1μs Standard: 20μs~1s, Actual Steps: 1 row period	
Gain	0 ㏈ ~ 24 ㏈ 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	FPGA: 1×1, 1×2, 1×4, 2×1, 2×2, 2×4, 4×1, 4×2, 4×4	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10 Bayer RG12	Mono8 Mono10 Mono12
Signal Noise Ratio	44 ㏈	43.46 ㏈
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam	

Table 5-14 VZ-400U-M/C528H00 specification

5.1.15 VZ-1600U-M/C227H00

Specifications	VZ-1600U-C227H00	VZ-1600U-M227H00
Resolution	1440 × 1080	
Sensor Type	Sony IMX273 global shutter CMOS	
Max. Image Circle	1/2.9 inch	
Pixel Size	3.45 ㎛ × 3.45 ㎛	
Frame Rate	227 fps @ 1440 × 1080	
ADC Bit Depth	10 bit	
Pixel Bit Depth	8 bit, 10 bit	
Exposure Time	UltraShort: 1µs~100µs, Actual Steps: 1µs Standard: 20µs~1s, Actual Steps: 1 row period	
Gain	0 ㏈ ~ 24 ㏈ 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	Sensor: 1×1, 2×2	
Mono/Color	Color	Mono
Pixel Formats	Bayer RG8 Bayer RG10	Mono8 Mono10
Signal Noise Ratio	41 ㏈	41 ㏈
Synchronization	Hardware trigger, Software trigger	
I/O	1 input and 1 output with opto-isolated, 2 programmable GPIOs	
Operating Temp.	0℃ ~ 45 ℃	
Storage Temp.	-20℃ ~ 70℃	
Operating Humidity	10% ~ 80%	
Power Consumption	< 2.7W @ 5V	
Lens Mount	C	
Data Interface	USB3.0	
Dimensions	29 ㎜ × 29 ㎜ × 29 ㎜ (without lens adapter or connectors)	
Weight	65 g	
Operating System	Windows 7/10/11 32/64bit, Linux, Android, ARMv7, ARMv8	
Programmable Control	Image size, gain, exposure time, trigger polarity, flash polarity	
Conformity	CE, RoHS, FCC, USB3 Vision, GenICam, KC	

Table 5-15 VZ-1600U-M/C227H00 specification

5.2 Spectral Response

5.2.1 About Spectral Response

- QE: 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.

VZ-2MU-M/C41H00

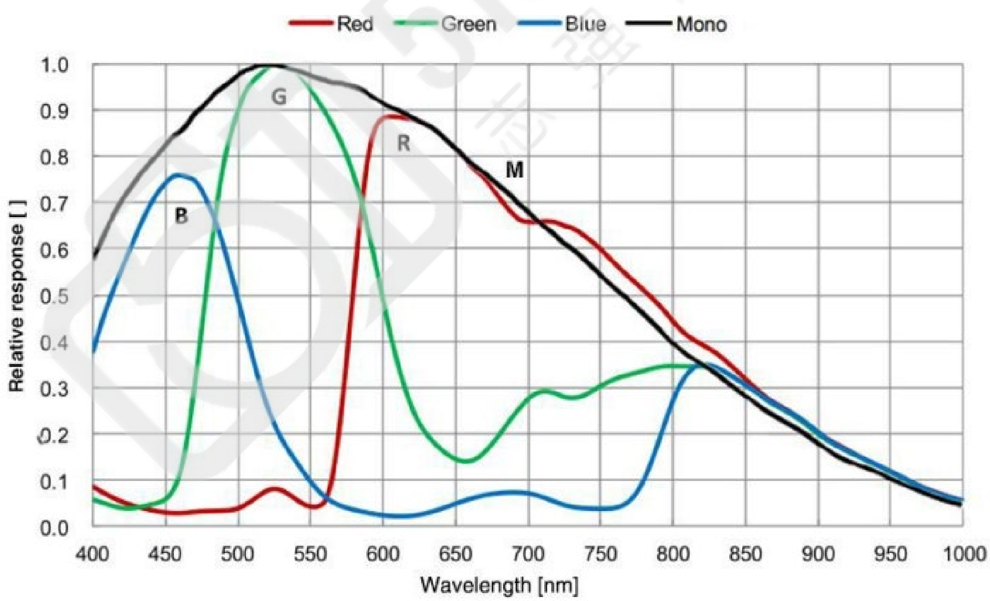


Figure 5-1 VZ-2MU-M/C41H00 Sensor spectral response (mono/color)

VZ-2MU-M/C168H00

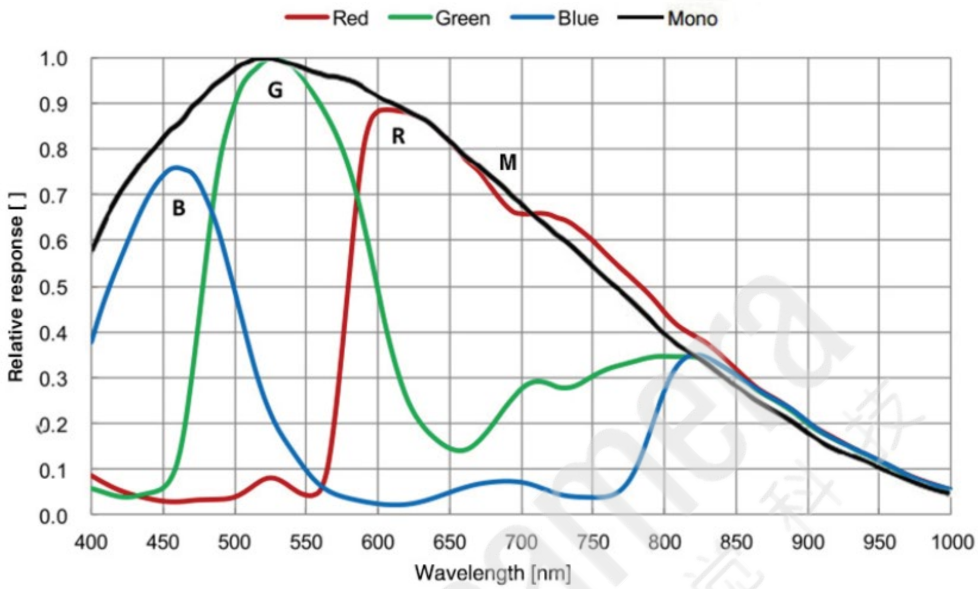


Figure 5-2 VZ-2MU-M/C168H00 Sensor spectral response (mono/color)

VZ-3MU-M/C56H00

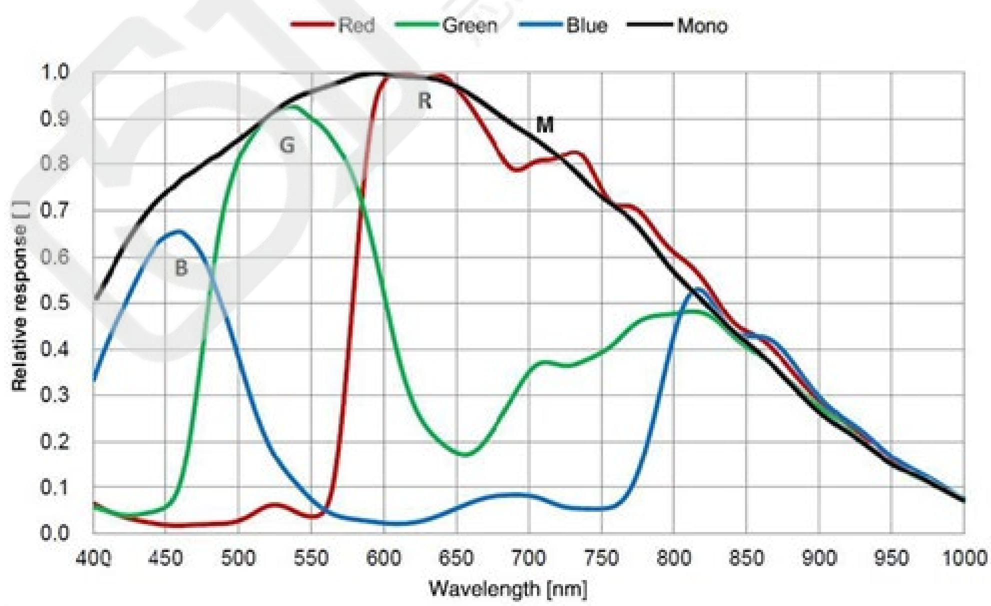


Figure 5-3 VZ-3MU-M/C56H00 Sensor spectral response (mono/color)

VZ-3MU-M/C125H00

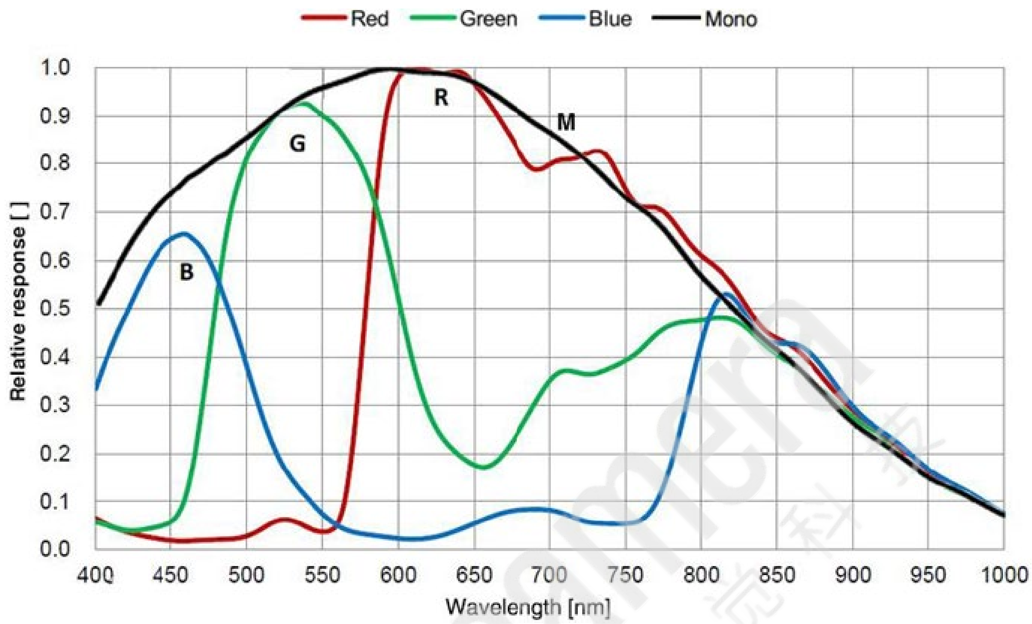


Figure 5-4 VZ-3MU-M/C125H00 Sensor spectral response (mono/color)

VZ-5MU-M/C79H00

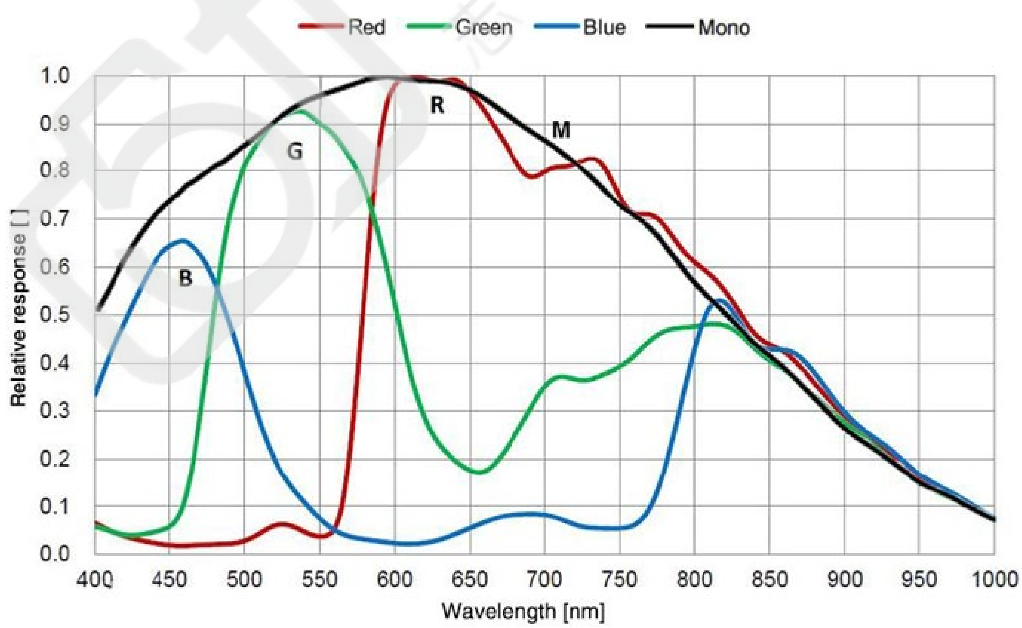


Figure 5-5 VZ-5MU-M/C79H00 Sensor spectral response (mono/color)

VZ-5MU-M/C79H00-POL

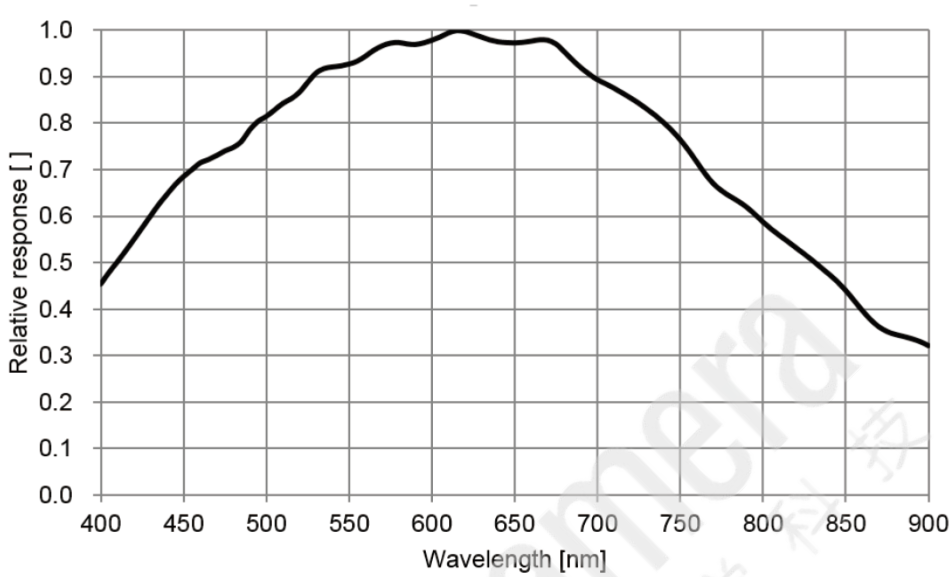


Figure 5-6 VZ-5MU-M79H00-POL Sensor spectral response (mono)

VZ-5MU-M/C36H00

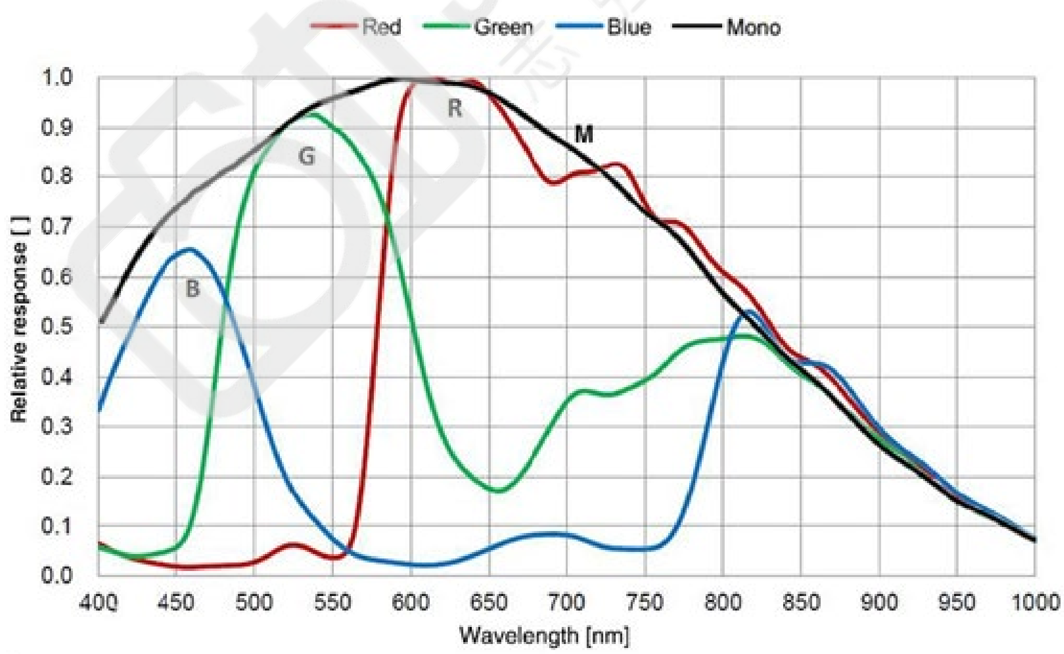


Figure 5-7 VZ-5MU-M/C36H00 Sensor spectral response (mono/color)

VZ-5MU-M/C36H00-POL

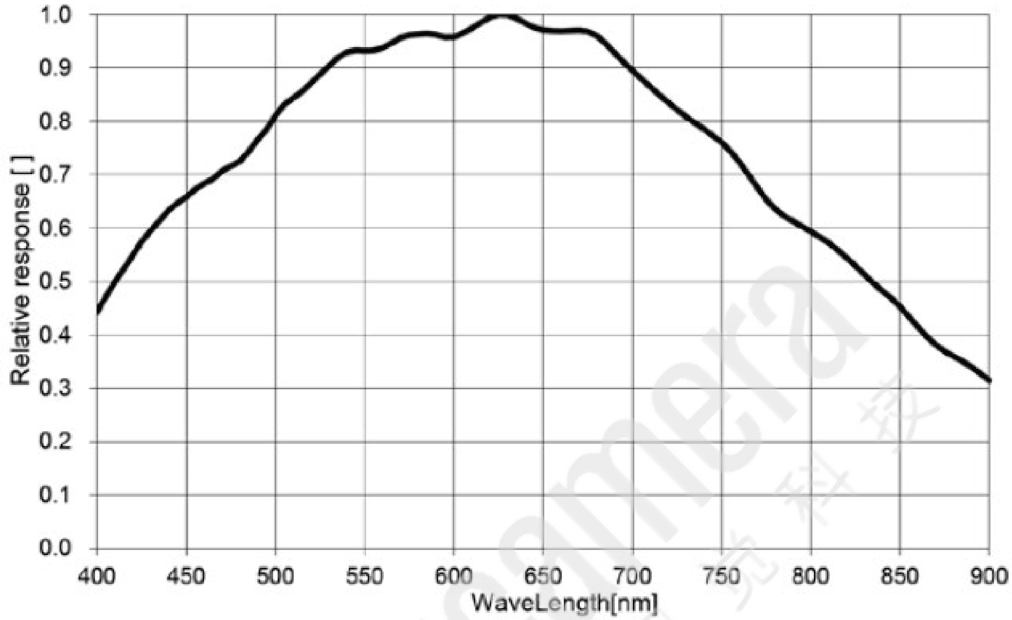


Figure 5-8 VZ-5MU-M/C36H00-POL Sensor spectral response (mono)

VZ-6MU-M/C60H00

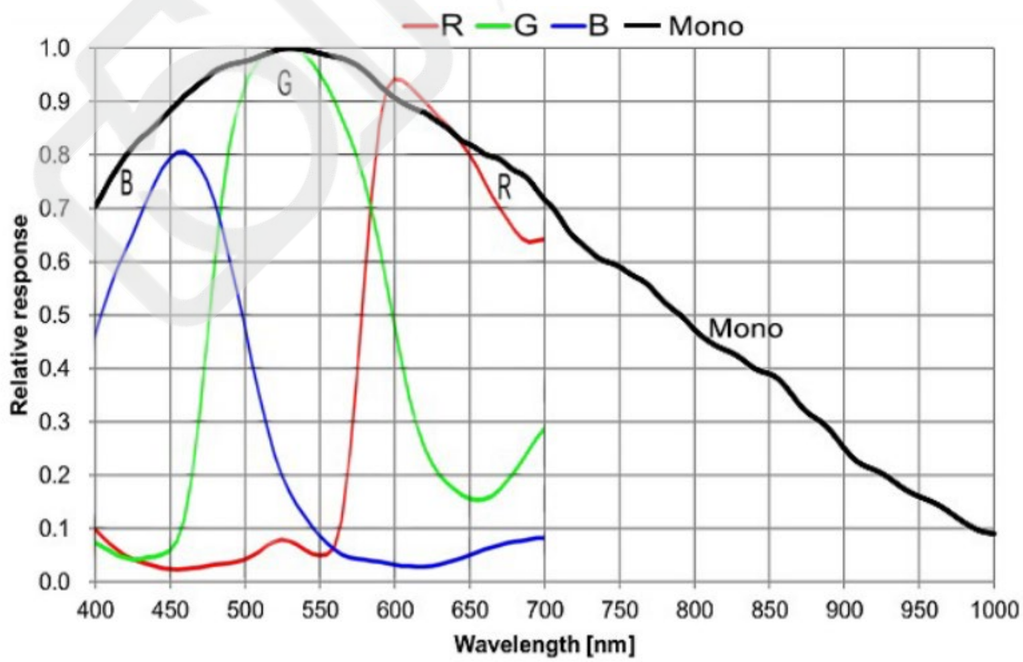


Figure 5-9 VZ-6MU-M/C60H00 Sensor spectral response (mono/color)

VZ-12MU-M/C32H00

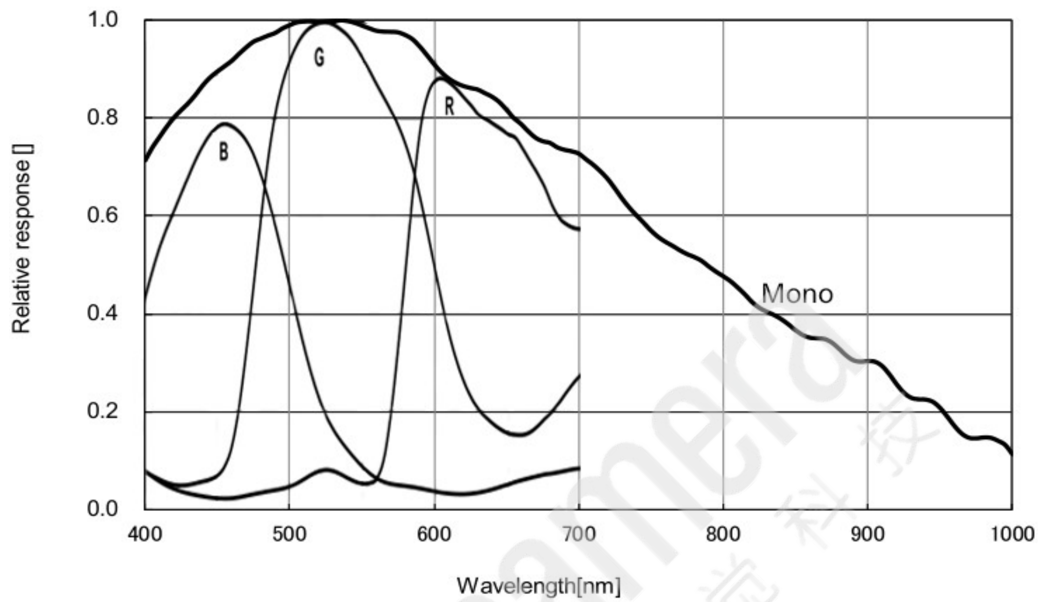


Figure 5-10 VZ-12MU-M/C32H00 Sensor spectral response (mono/color)

VZ-12MU-M/C23H00

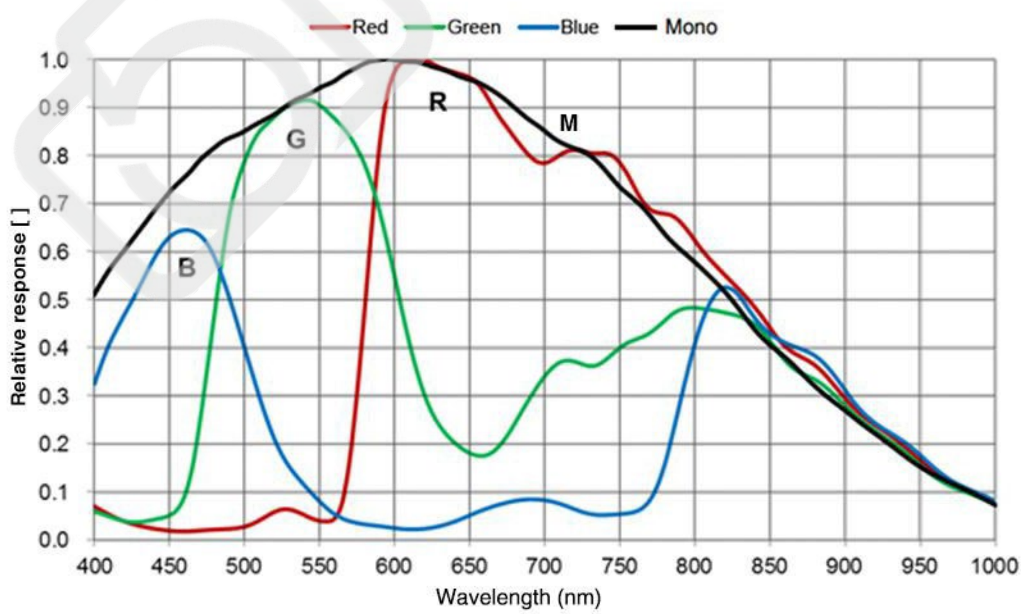


Figure 5-11 VZ-12MU-M/C23H00 Sensor spectral response (mono/color)

VZ-12MU-M/C32H10

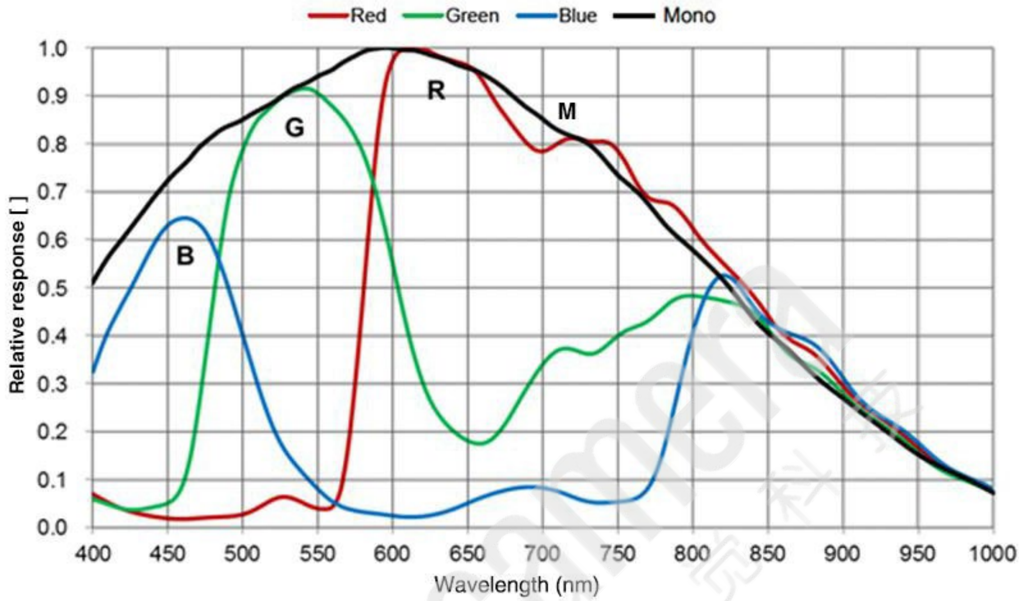


Figure 5-12 VZ-12MU-M/C32H10 Sensor spectral response (mono/color)

VZ-20MU-M/C19H00

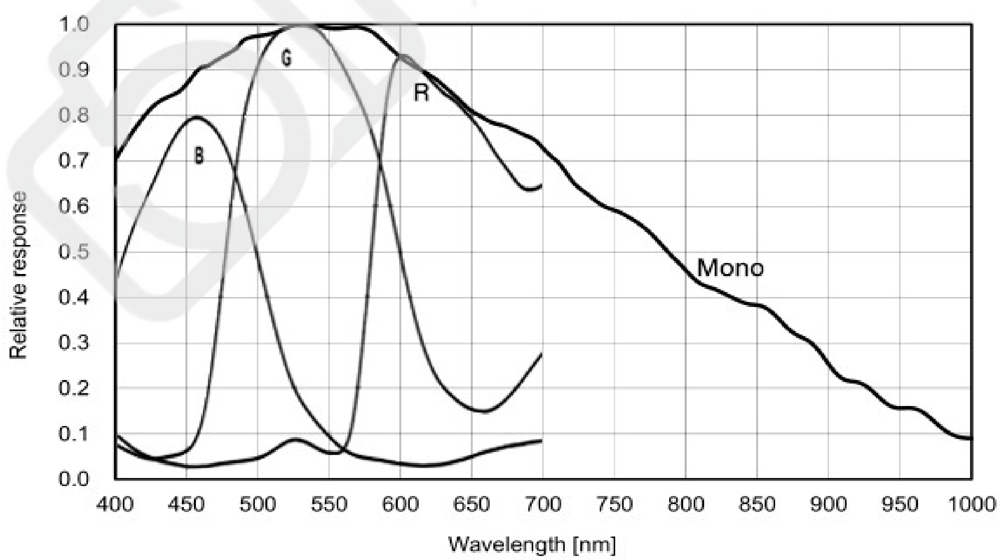


Figure 5-13 VZ-20MU-M/C19H00 Sensor spectral response (mono/color)

VZ-400U-M/C528H00

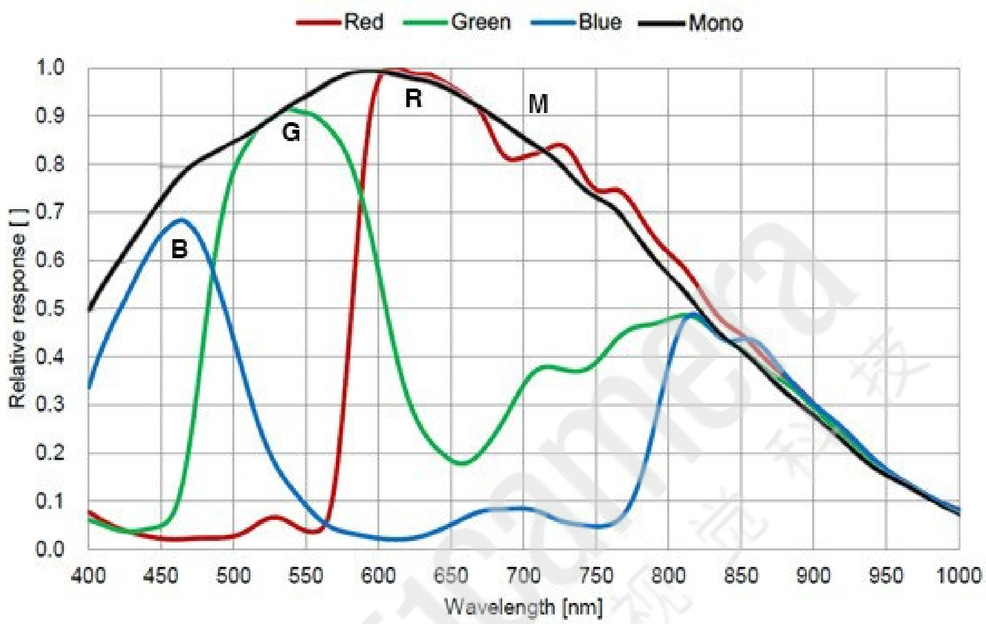


Figure 5-14 VZ-400U-M/C528H00 Sensor spectral response (mono/color)

VZ-1600U-M/C227H00

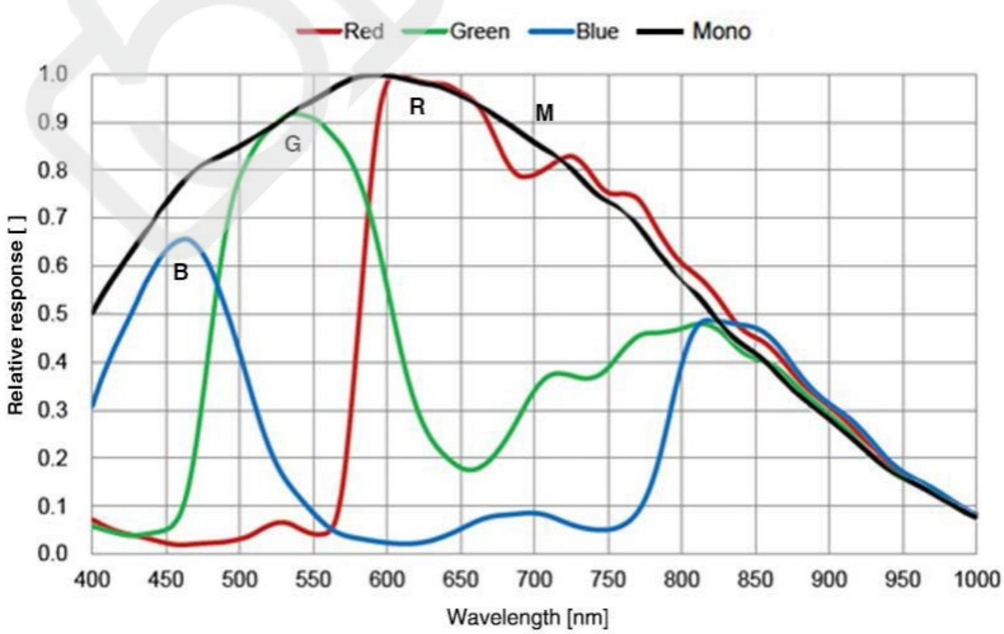


Figure 5-15 VZ-1600U-M/C227H00 Sensor spectral response (mono/color)

Chapter 6. Dimension

6.1 Camera Dimensions

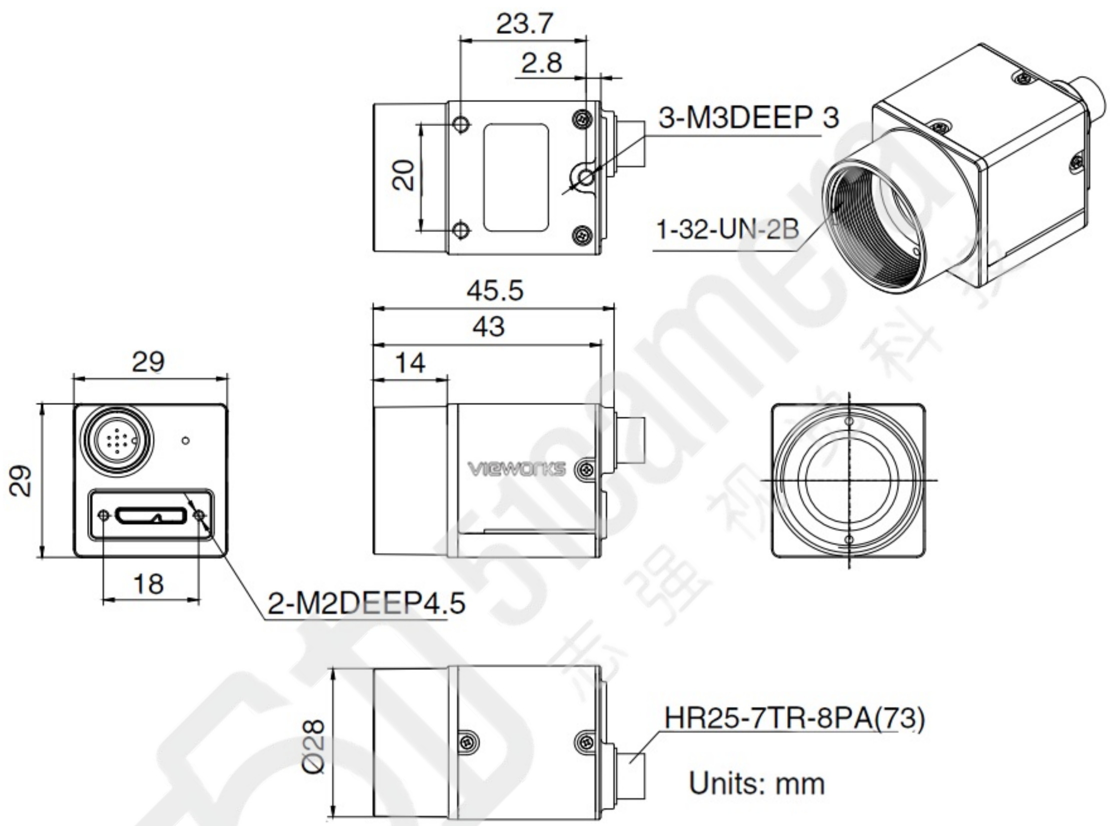


Figure 6-1 Mechanical Dimension (VZ-2MU, VZ-3MU, VZ-5MU, VZ-6MU, VZ-1600U, VZ-12MU-M/C32H00)

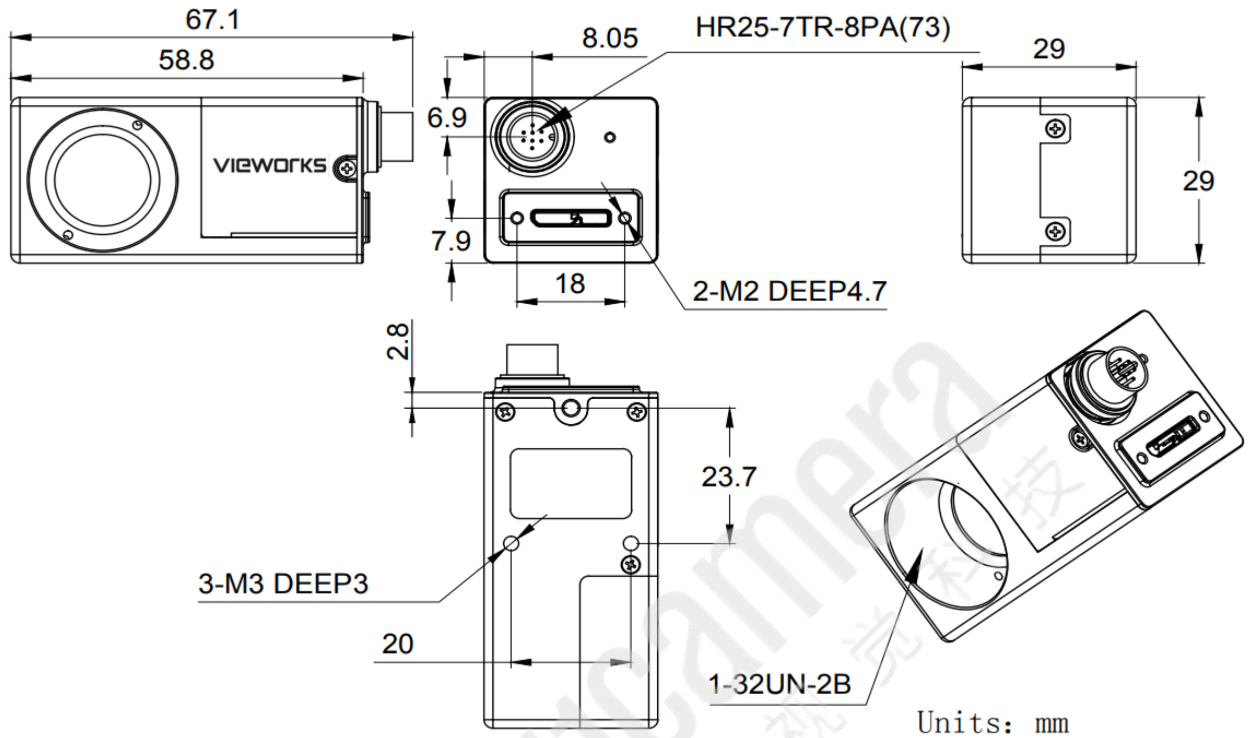


Figure 6-2 Mechanical Dimension (VZ-20MU-M/C19H00)

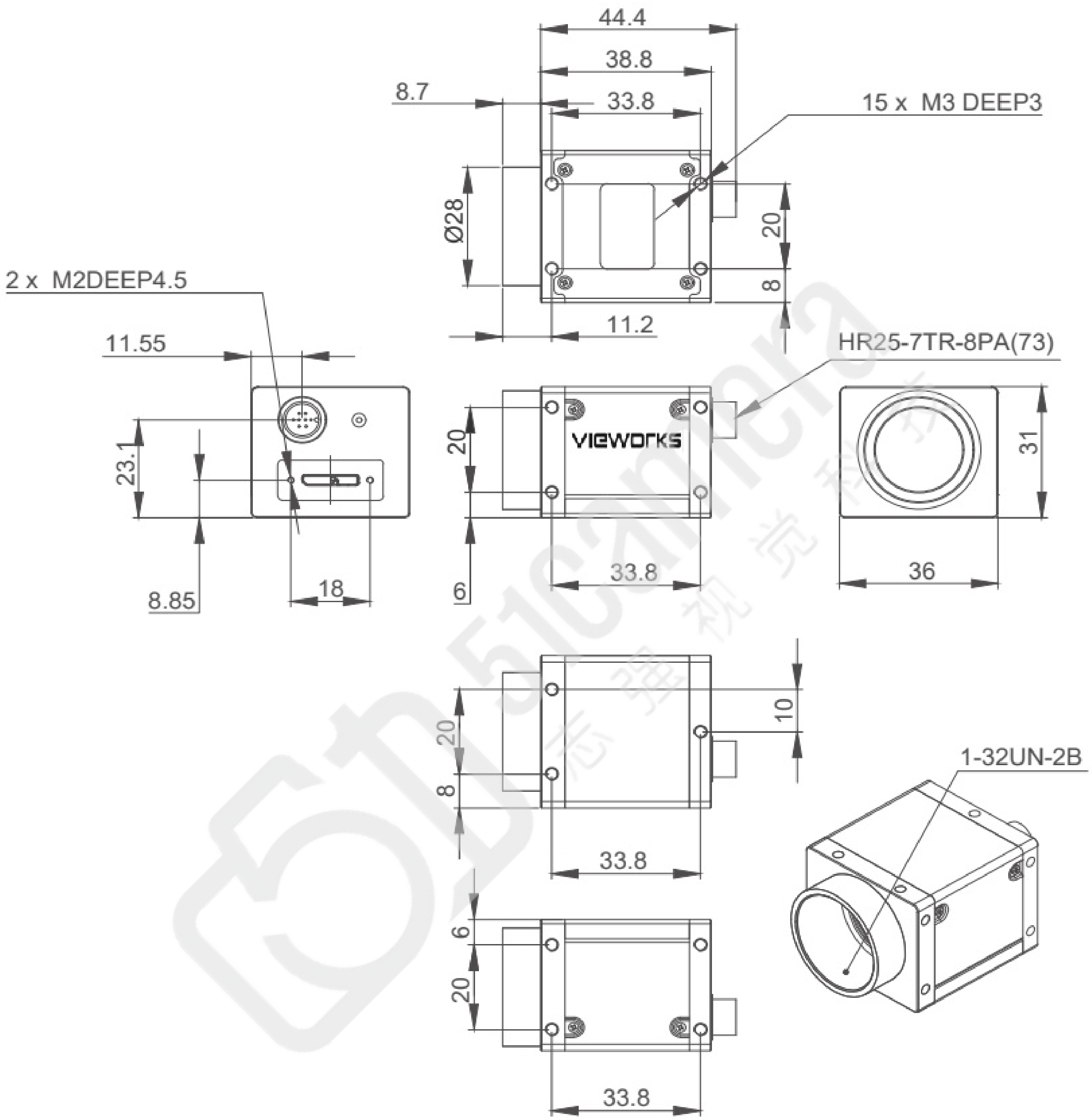


Figure 6-3 Mechanical Dimension (VZ-12MU-M/C23H00, VZ-12MU-M/C32H10)

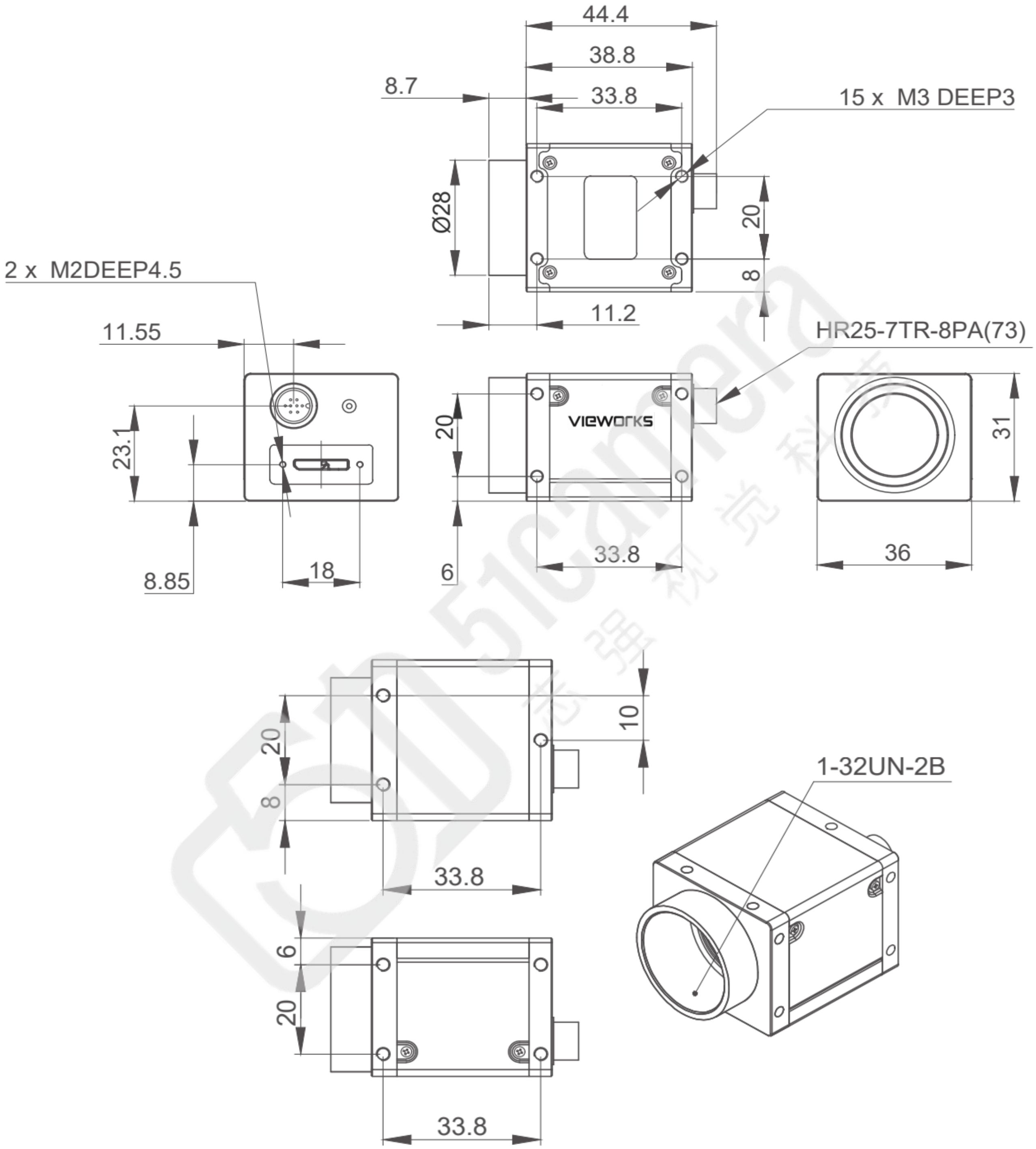


Figure 6-4 Mechanical Dimension (VZ-12MU-M/C23H00)

6.2 Optical Interface

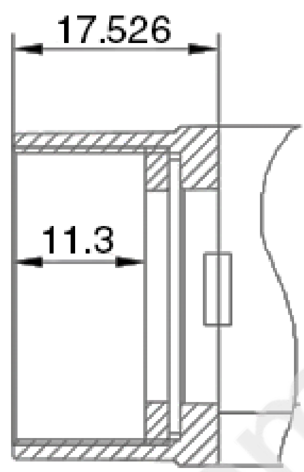


Figure 6-5 Optical interface of C-mount

The cameras are equipped with C-mount lens adapters. The back-flange distance is 17.526 ㎜ (in the air). The maximum allowed thread length of lens should be less than 11.3 ㎜, as shown in Figure 6-5.

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

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

6.3 Tripod Adapter Dimensions

When customizing the tripod adapter, you need to consider the relationship between tripod adapter, screw length and step thickness of tripod adapter.

- Screw length = tripod adapter step thickness + spring washer thickness + Screwing length of camera screw thread.

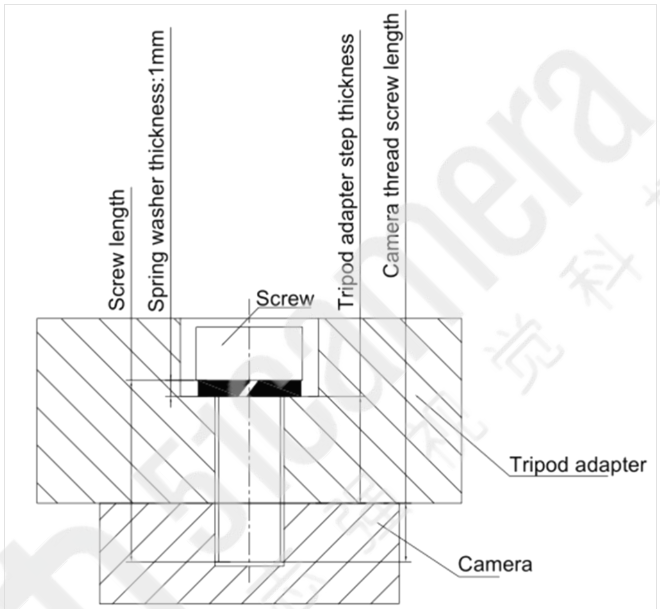


Figure 6-6 Screw specification, tripod adapter step thickness and spring washer thickness

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

Screw specification (Haxagon socket head cap screw)	Tripod adapter step thickness (mm)	Spring washer thickness (mm)	Screwing length of camera screw thread (mm)
M3×6 screw	2.5	0.8	2.7
M3×8 screw	4.5	0.8	2.7
M3×10 screw	6.5	0.8	2.7
M2×4 screw	1.1	0.6	2.3
M2×5 screw	2.1	0.6	2.3
M2×6 screw	3.1	0.6	2.3

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

Chapter 7. Electrical Interface

7.1 LED Light

An LED light is 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.
Solid red	The camera is not boot-loaded.
Flashing red	The camera is in low power consumption mode.
Solid green	The camera has been boot-loaded, but no data is being transmitted.
Flashing green	Data is being transmitted.
Flashing yellow	The camera's initialization failed.

Table 7-1 Camera status

7.2 USB Port

Recommend using the cables officially recognized by USB IF.

7.3 I/O Port

7.3.1 I/O Connector Pin

The camera's I/O port is implemented by 8-pin Hirose connector (No. HR25-7TR-8PA(73)), and the corresponding plug is HR25-7TP-8S.

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	NC	Purple	NC
	5	Line2	Orange	GPIO input/output
	6	Line3	Pink	GPIO input/output
	7	Line1-	White Green	Opto-isolated output -
	8	Line1+	White Blue	Opto-isolated output +

Table 7-2 Pin definition of 8-pin connector (back sight of camera)

51camera 志强视觉科技

Caution!

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

7.3.2 I/O Electrical Features

Line0 (Opto-isolated Input) Circuit

Hardware schematics of opto-isolated input circuit as shown below.

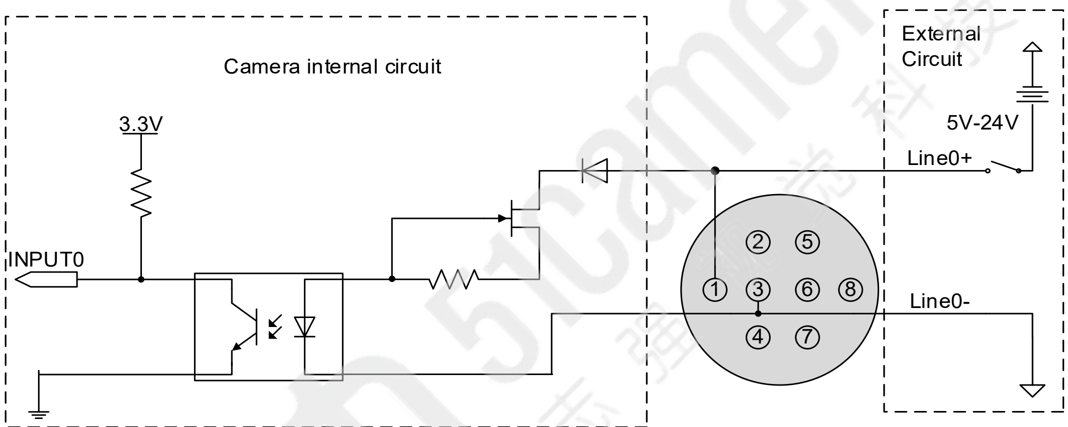


Figure 7-1 Opto-isolated input circuit

- Logic 0 input voltage: 0 V ~ +2.5 V (Line0+ voltage)
- Logic 1 input voltage: +5 V ~ +24 V (Line0+ voltage)
- Minimum input current: 7 mA
- 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, ensure the value is less than 90Ω.
  To protect the Line0+ while the external input voltage is higher than 9 V, 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
5 V	Non or < 90 Ω	About 5 V
9 V	680 Ω	About 5.5 V
12 V	1 kΩ	About 6 V
24 V	2 kΩ	About 10 V

Table 7-3 Circuit-limiting resistor value

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

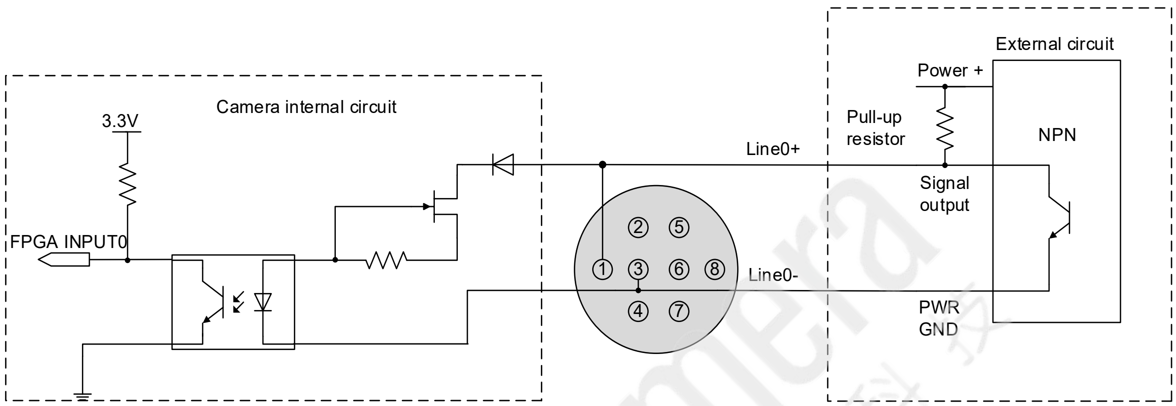


Figure 7-2 NPN photosensor connected to opto-isolated input circuit

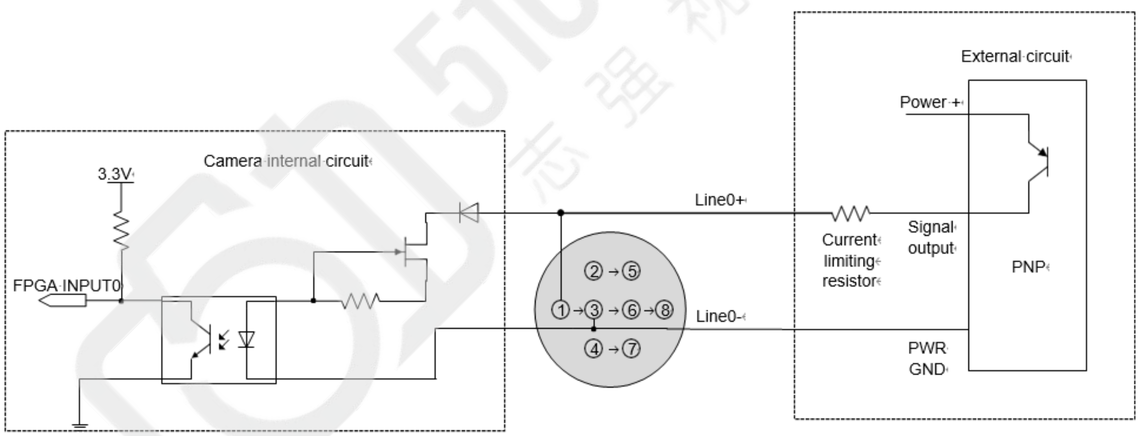


Figure 7-3 PNP photosensor connected to opto-isolated input circuit

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

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

Table 7-4 Delay time of opto-isolated input circuit

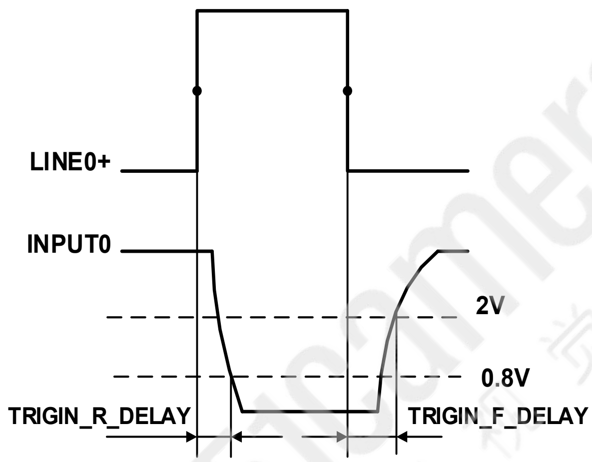


Figure 7-4 Parameter of opto-isolated input circuit

- 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+.

Line1 (Opto-isolated Output) Circuit

Hardware schematics of opto-isolated output circuit as shown below.

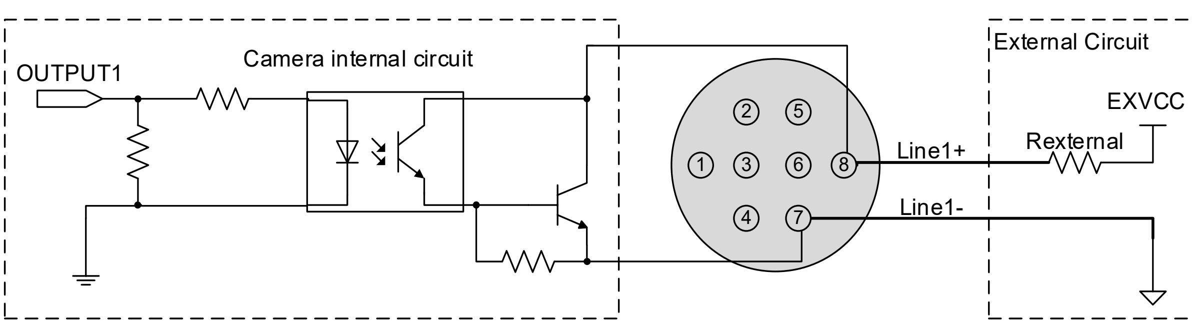


Figure 7-5 Opto-isolated output circuit

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

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

Table 7-5 Transistor voltage drop and output current of opto-isolated output circuit

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

Parameter	Test Condition	Value (μs)		
Storage time (ts)	External power is 5 V, pull-up resistor is 1 kΩ	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

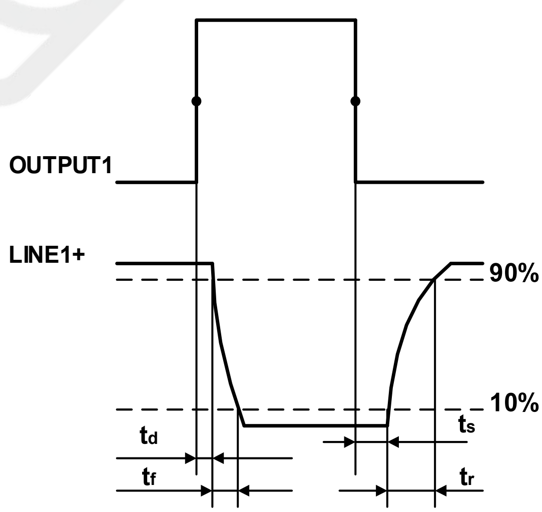


Figure 7-6 Parameter of opto-isolated output circuit

- 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.

Line 2/3 (Bidirectional) Circuit

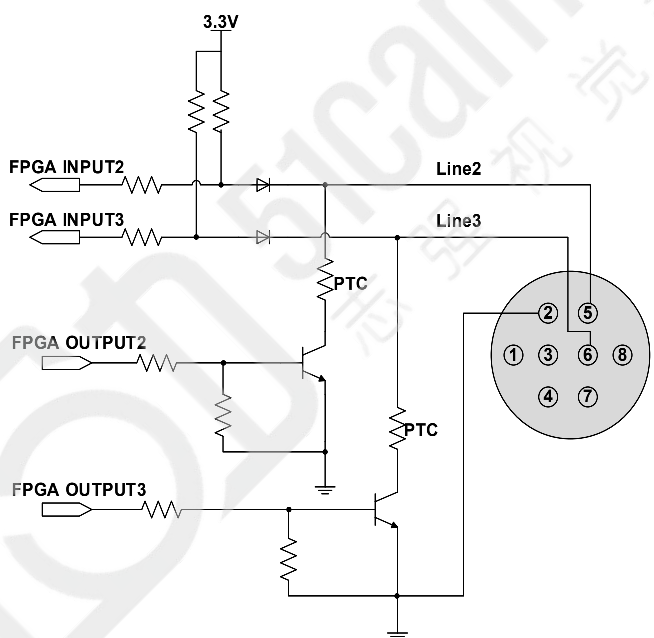


Figure 7-7 Line2/3 (bidirectional) circuit

Line2/3 is Configured as Input:

When Line2/3 is configured as input, the internal equivalent circuit of camera as shown below, taking Line2 as an example:

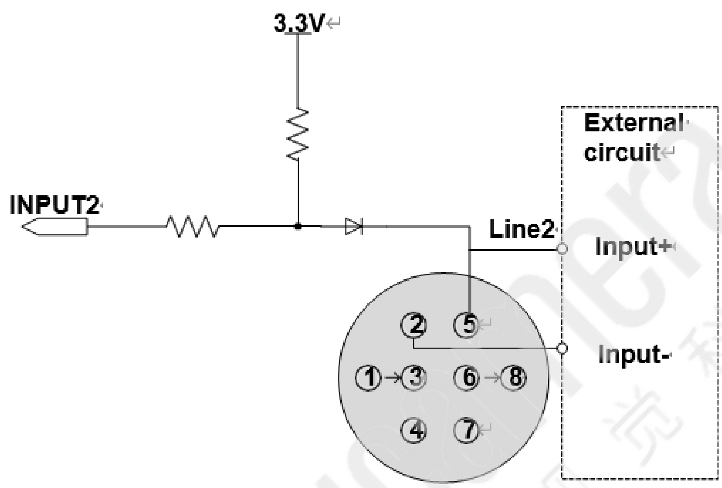


Figure 7-8 Internal equivalent circuit of camera when Line2 is configured as input

Caution!

To avoid the damage of GPIO pins, please connect GND pin before supplying power to Line2/3.

- Logic 0 input voltage: 0 V ~ +0.6 V (Line2/3 voltage)
- Logic 1 input voltage: +1.9 V ~ +24 V (Line2/3 voltage)
- The status is unstable when input voltage is between 0.6 V and 1.9 V, which should be avoided.
- When input of Line2/3 is high, input current is lower than 100 μA.
- When input of Line2/3 is low, input current is lower than -1 mA.
- When Line2/3 is configured as input, the connection method between NPN and PNP photoelectric sensors is shown below.

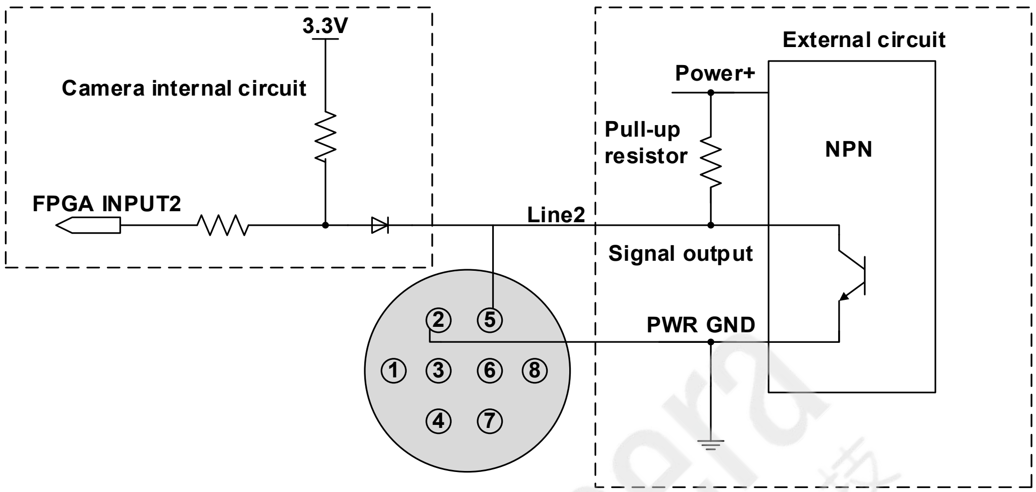


Figure 7-9 NPN photoelectric sensor connected to Line2 input circuit

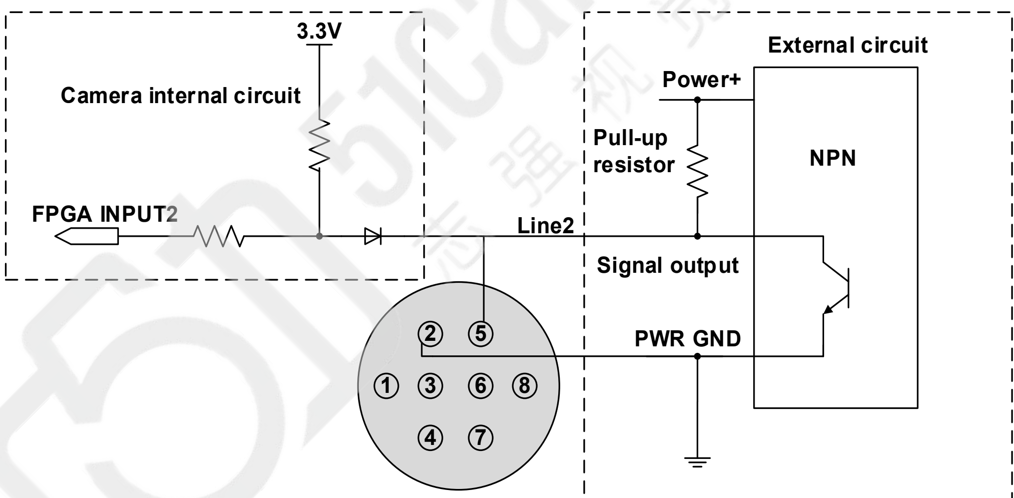


Figure 7-10 PNP photoelectric sensor connected to Line2 input circuit

- When Line2/3 is configured as input, pull-down resistor over 1K should not be used, otherwise the input voltage of Line2/3 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 7-11.
- Input falling time delay: <2μs (0°C~45°C), parameter description as shown in Figure 7-11.

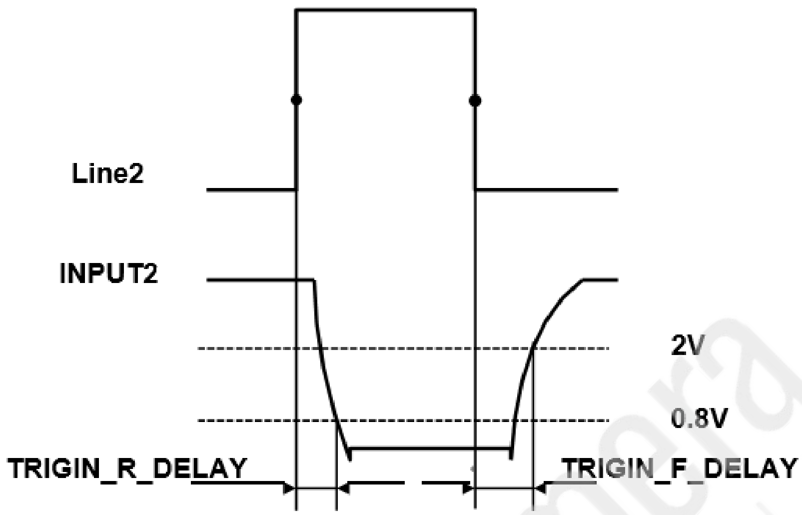


Figure 7-11 Parameter of Line2 input circuit

Line2/3 is Configured as Output:

- Range of external voltage (EXVCC) is 5 ~ 24 V
- Maximum output current of Line2/3 is 25 mA, output impedance is 40 Ω

Transistor voltage drop and output current in typical application conditions (temperature is 25 ℃) are shown in Table 7-7.

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

Table 7-7 Transistor voltage drop and output current of Line2/3 in typical conditions

- Rising time delay = tr+td: < 20 μs (0 ℃ ~ 45 ℃) (parameter description as shown in Figure 7-12)
- Falling time delay = ts+tf: < 20 μs (0 ℃ ~ 45 ℃) (parameter description as shown in Figure 7-12)

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

Parameter	Test Conditions	Value (μs)		
Storage time (ts)	External power is 5 V, pull-up resistor is 1 kΩ	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

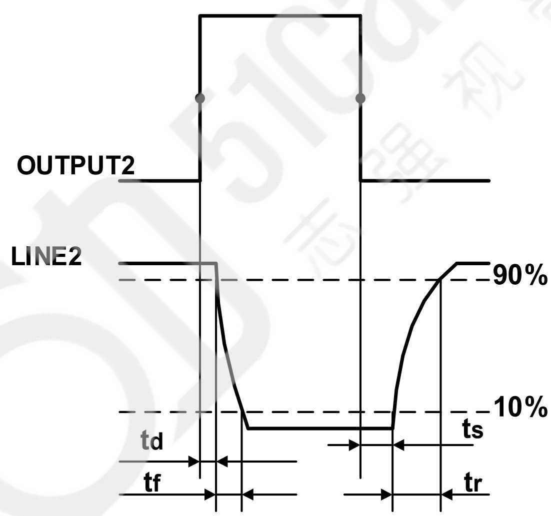


Figure 7-12 Parameter of Line2 output circuit

- Delay time (td): the time required from 50% rising of OUTPUT2 to the decrease to 90% of the maximum value of LINE2.

- Falling time (tf): the time taken for the amplitude of LINE2 to decrease from 90% to 10% of the maximum value.

- Storage time (ts): the time required from 50% falling of OUTPUT2 to the rise to 10% of the maximum value of LINE2.

- Rising time (tr): the time for the response of LINE2 to rise from 10% to 90% of its final value.

- When Line2/3 is configured as output, the internal equivalent circuit of camera as shown below.

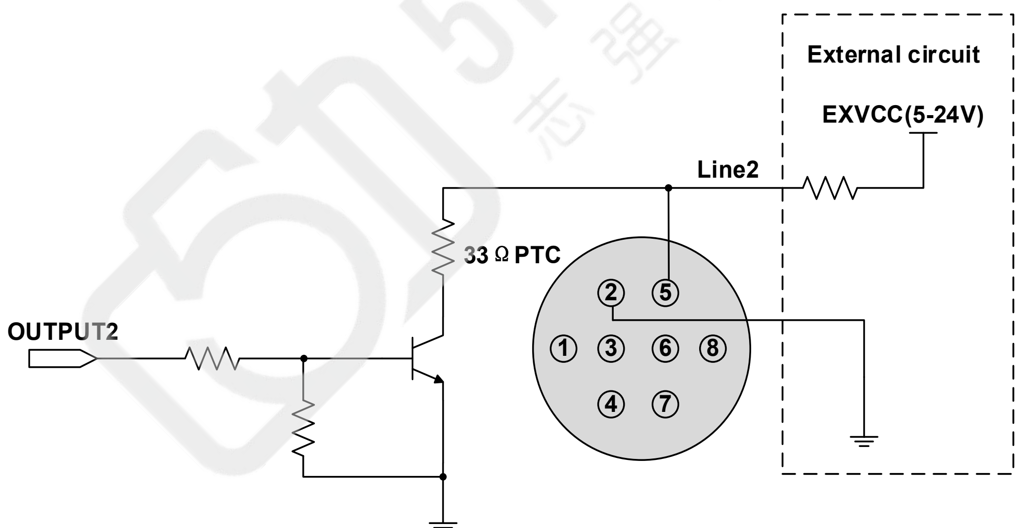


Figure 7-13 Internal equivalent circuit of camera when Line2 is configured as output

Chapter 8. Features

8.1 I/O Control

8.1.1 Input Mode Operation

Configuring Line as input

The camera's Line0 is uni-directional opto-isolated input, Line2 and Line3 are 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 and Line3 are input by default, which can be configured to be input or output by Linemodes.

Input Debouncer

To suppress the interference signals from hardware trigger, the VZ USB Series cameras have 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: 1 μs.

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

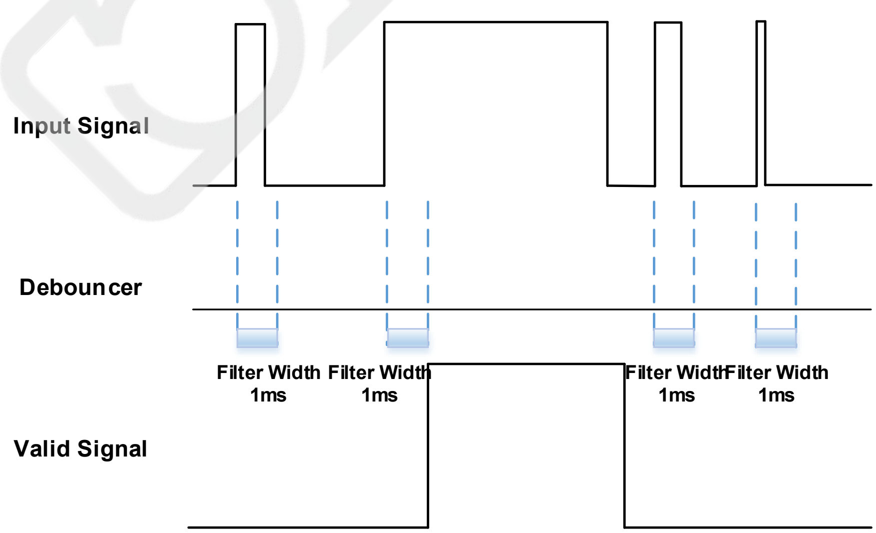


Figure 8-1 Input debouncer schematic diagram

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: 1 μs.

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

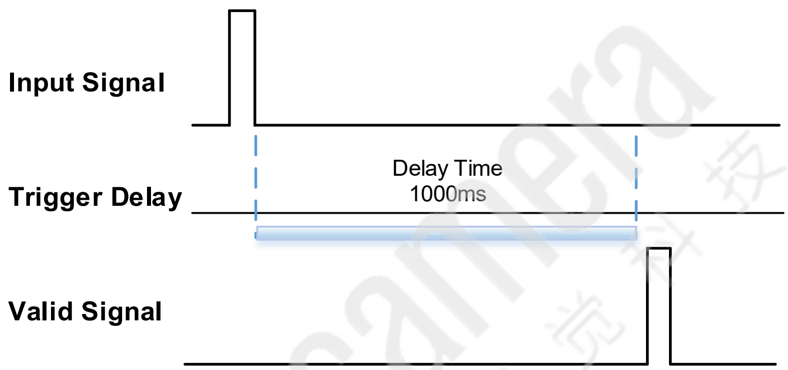


Figure 8-2 Trigger delay schematic diagram

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".

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, indicate that the input line level is reversed. As shown in the Figure 8-3:

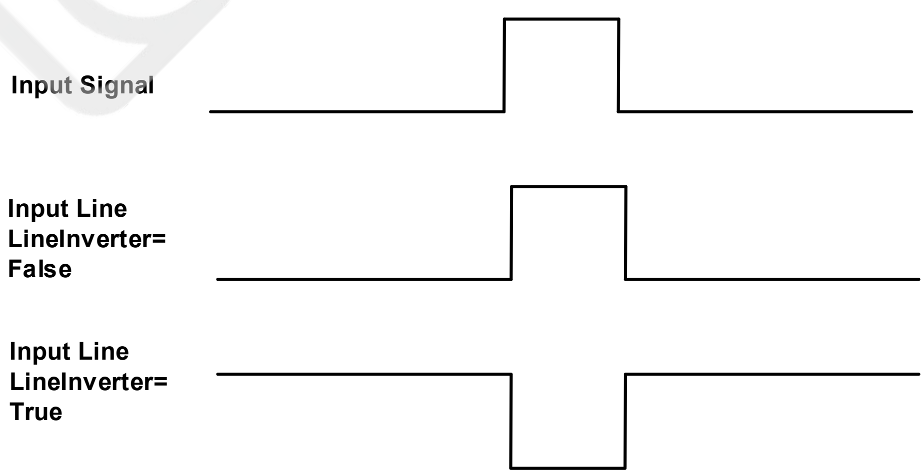


Figure 8-3 Setting input line reverse

8.1.2 Output Mode Operation

Configuring Line as output

- The camera's Line1 is a uni-directional opto-isolated output I/O, Line2 and Line3 are bi-direction configurable I/Os.
- The Line 1 is camera's default (Line2 is the default if the camera does not support Line1) output when the camera is powered on. Line2 and Line3 can be configured to be output by changing the "LineMode" of this line.
- Each output source of the three output lines can be configurable, and the output source includes: Strobe, UserOutput0, UserOutput1, UserOutput2, ExposureActive, FrameTriggerWait, AcquisitionTriggerWait, Timer1Active.

▫ ExposureActive, FrameTriggerWait, AcquisitionTriggerWait and Timer1Active are supported by partial models only.

- 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 > (image height - 1) x row period".

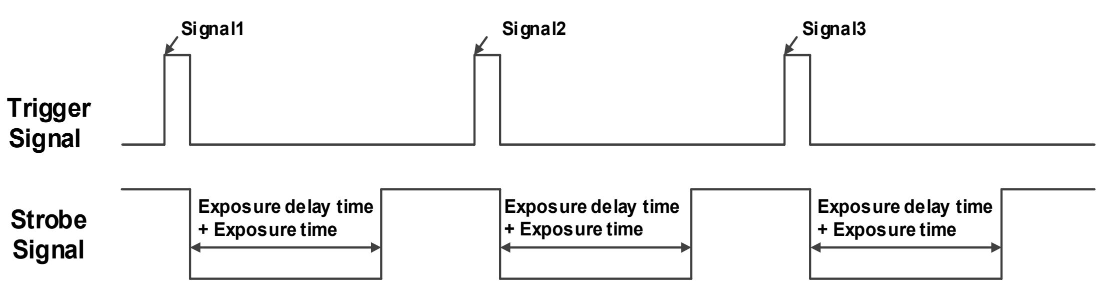


Figure 8-4 Strobe signal schematic diagram

- 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. For electronic rolling shutter cameras, the signal goes low when the exposure of the last line ends.

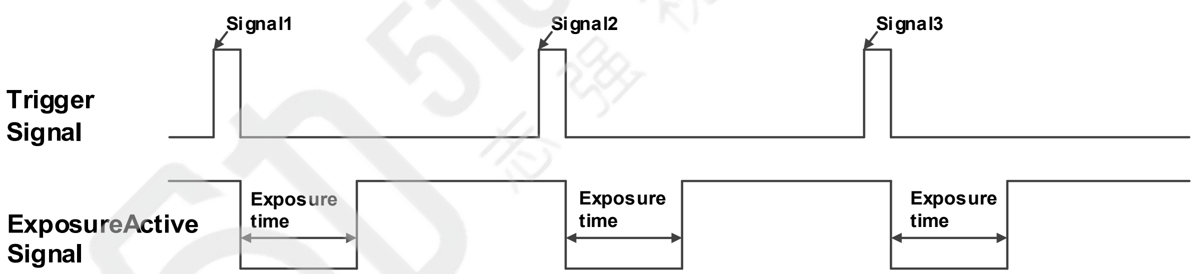


Figure 8-5 Global shutter "ExposureActive" signal schematic diagram

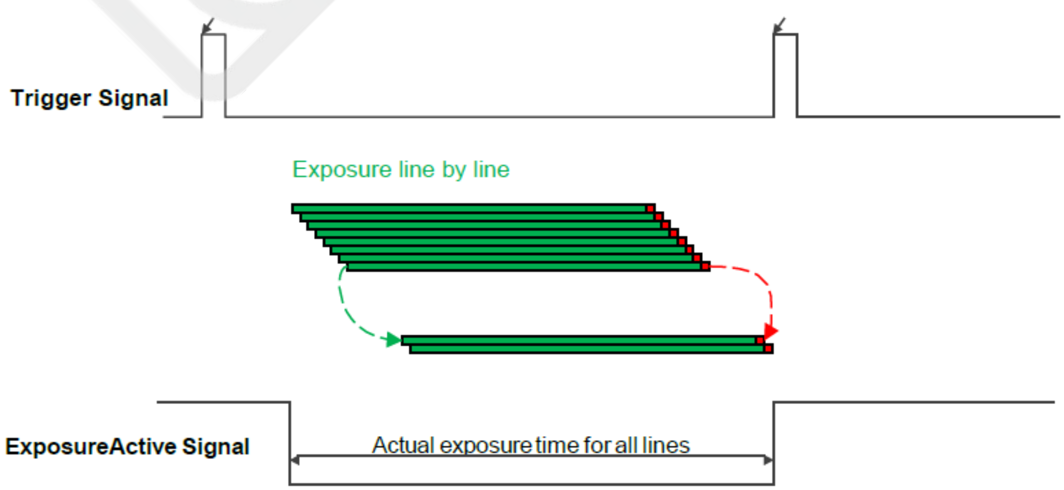


Figure 8-6 Electronic rolling shutter "ExposureActive" signal schematic diagram

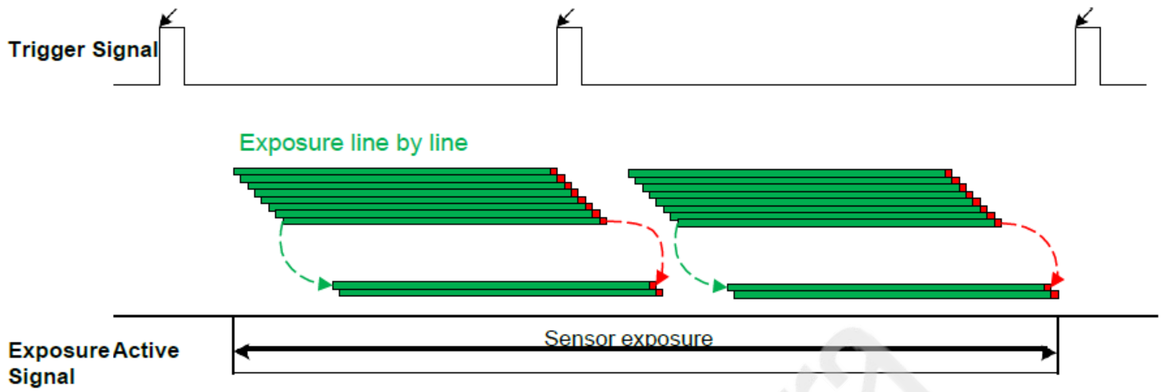


Figure 8-7 Electronic rolling shutter mode (overlapping exposure) "ExposureActive" signal schematic diagram

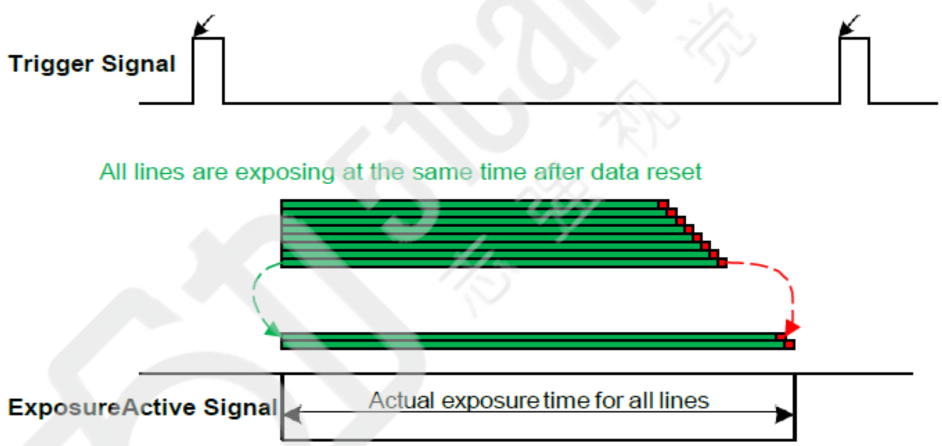


Figure 8-8 Global reset release shutter mode “ExposureActive” signal schematic diagram

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 a different position. Generally, it is not desirable for the camera to move during 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" ("FrameBurstStart" mode is off), 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.

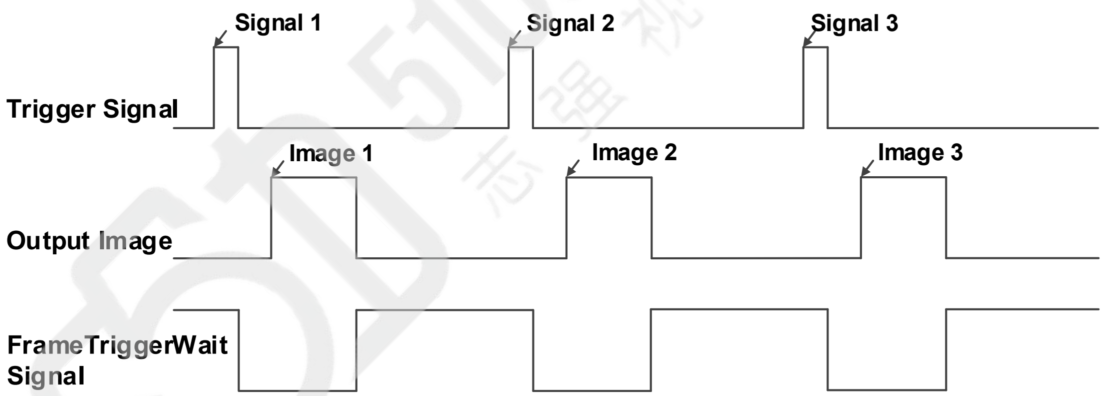


Figure 8-9 "FrameTriggerWait" signal schematic diagram

▫ 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.

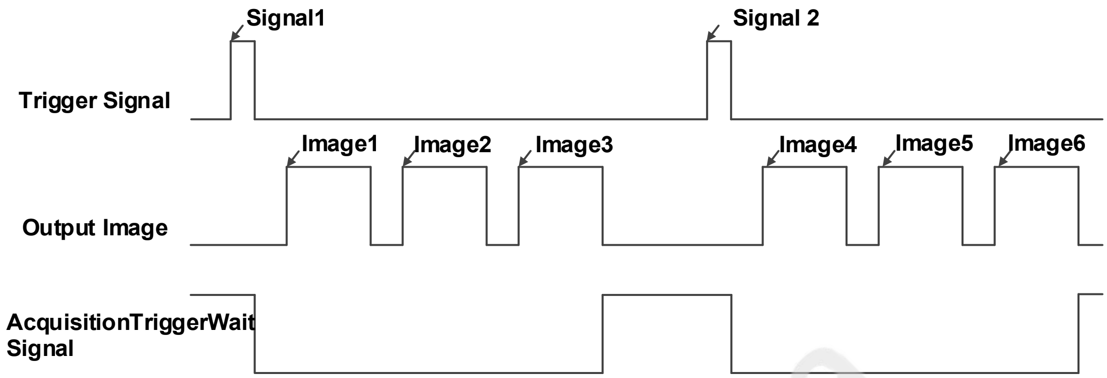


Figure 8-10 "AcquisitionTriggerWait" signal schematic diagram

- When the trigger mode is "FrameBurstStart" ("FrameStart" mode is on), if the high-speed burst frames is set to 3, the camera will first send a "FrameBurstStart" trigger signal.
- After receiving the trigger signal, the "AcquisitionTriggerWait" signal is pulled low. Then three "FrameStart" trigger signals need to be sent continuously. Each time the camera receives a trigger signal; it transmits one frame image.
- After receiving the trigger signal, the "FrameTriggerWait" signal is pulled low, and the camera will start exposure transmission.
- The "FrameTriggerWait" signal will be pulled high after the transmission is completed. Only the first 3 FrameStart trigger signals are valid.
- When the transmission is completed, the "AcquisitionTriggerWait" signal will be pulled high.

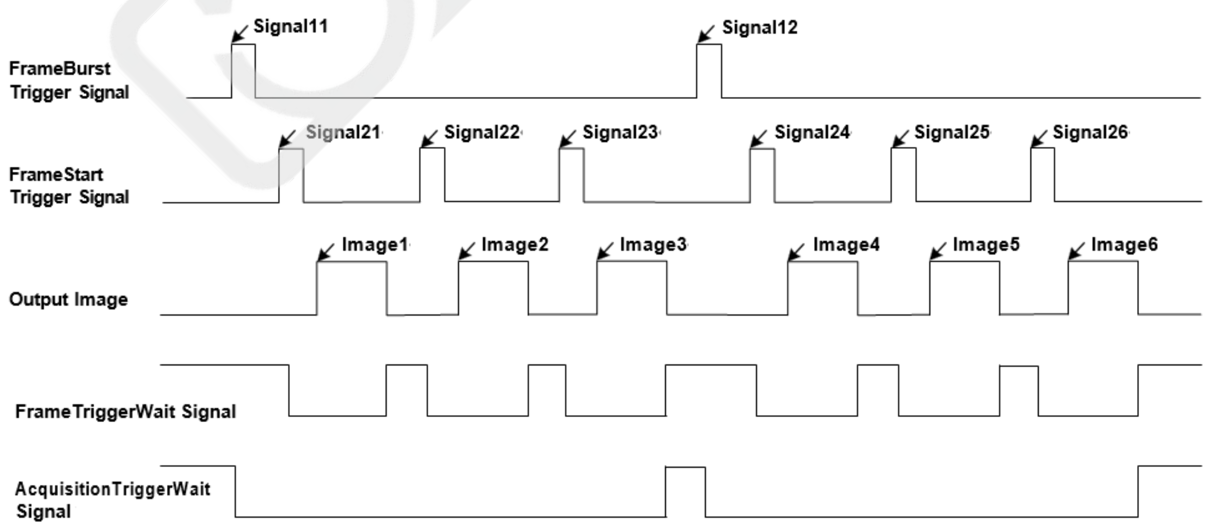


Figure 8-11 "TriggerWait" signal schematic diagram when "FrameBurstStart" and "FrameStart" enabled simultaneously

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.

Output Inverter

In order to facilitate the camera I/O configuration and connection, the camera can configure output signal level. The user can select whether the output level is reversed 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 8-12.

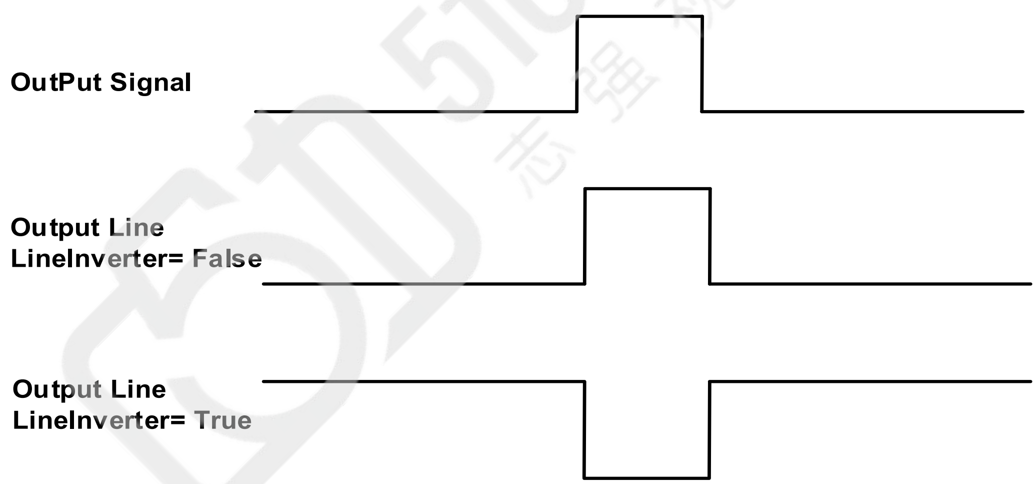


Figure 8-12 Set output line reversion

8.1.3 Read the LineStatus

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 and Line1 is False, and the default status of Line2 and Line3 is True.

Read all the lines level

The camera can get the 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 VZ-5MU-M/C79H and VZ-5MU-M/C 36H cameras are shown as follows:

Default value: 0xE.

Line3	Line2	Line1	Line0
1	1	0	0

8.2 Image Acquisition Control

8.2.1 Acquisition Start and Stop

Acquisition Start

It can send *Acquisition Start* command immediately after opening the camera. The acquisition process in continuous mode is illustrated in Figure 8-12, and the acquisition process in trigger mode is illustrated in Figure 8-13.

- Continuous Acquisition:
  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.

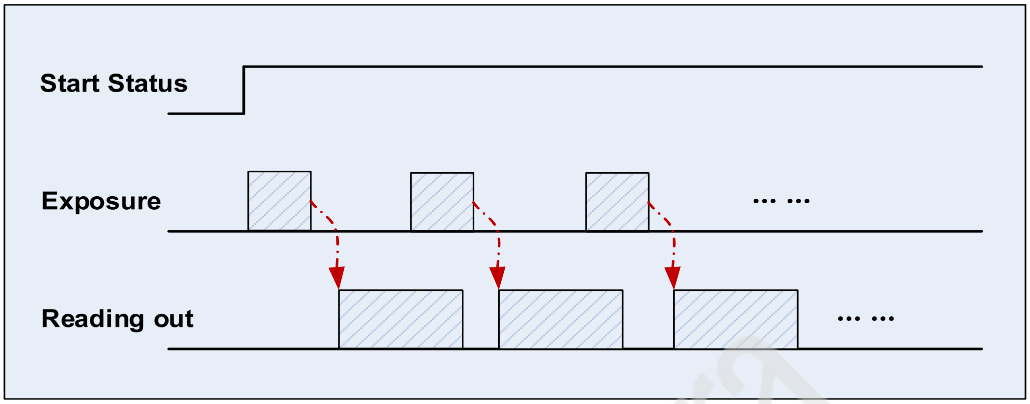


Figure 8-13 Continuous acquisition process

- Trigger Acquisition:
  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.

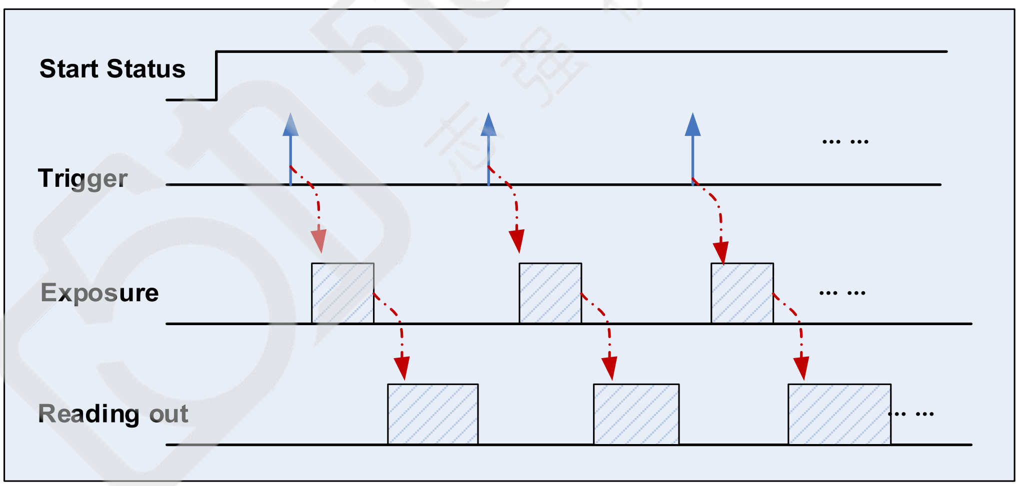


Figure 8-14 Trigger acquisition process

Acquisition Stop

It can send *AcquisitionStop* command to the 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 8-15 and Figure 8-16.

- Acquisition stops during reading out:
  As shown in Figure 8-15, when the camera receives an acquisition stop command during reading out, it stops transferring frame data immediately. The currently transferred frame data is regarded as incomplete frame and will be discarded.

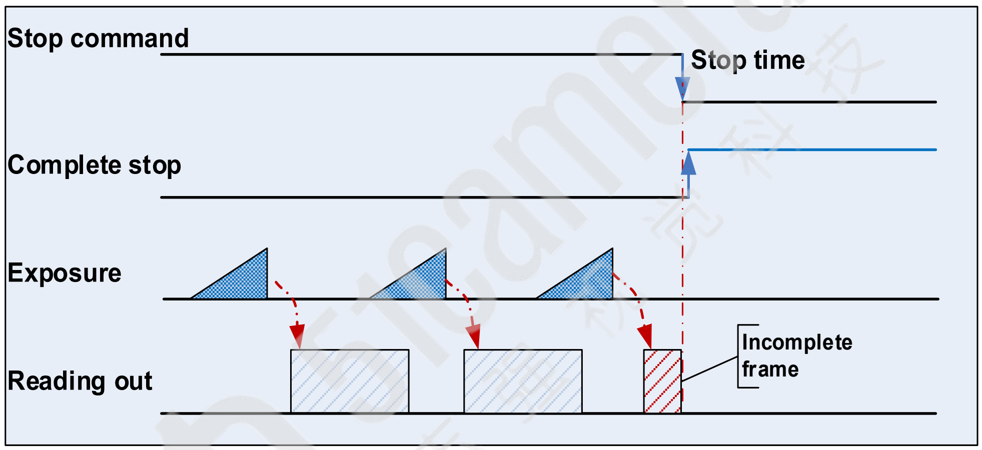


Figure 8-15 Acquisition stop during reading out

- Acquisition stops during blanking:
  After the camera transferred a whole frame, the camera goes into wait state. When the user sends *AcquisitionStop* command in wait state, the camera will return to stop-finished state. The camera will not send any frames even if it is just going to start the next exposing.

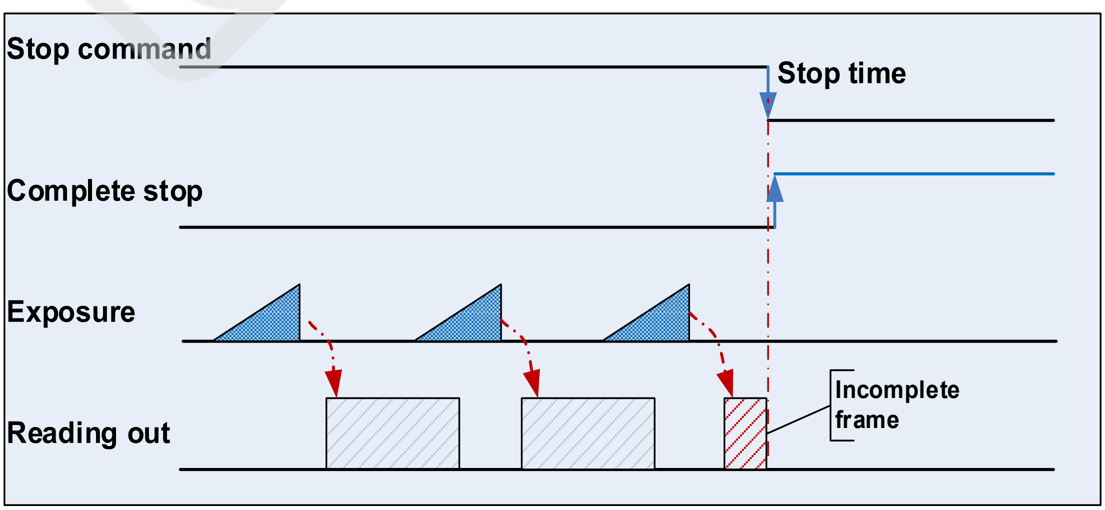


Figure 8-16 Acquisition stop during blanking

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.

> Note:
> 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, package 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', and 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, and 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.

Note:
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.

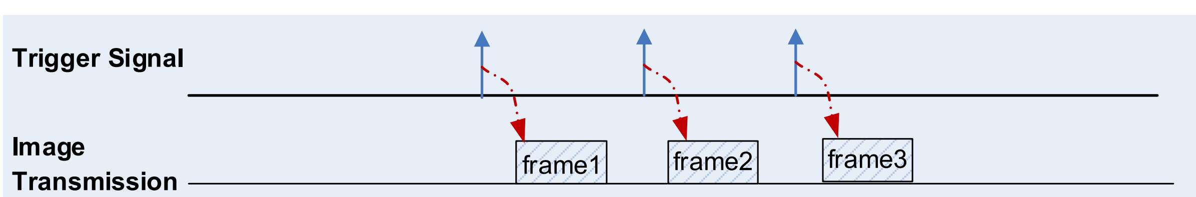


Figure 8-17 FrameStart trigger

5framera 志强视觉科技

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 1~255, 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.

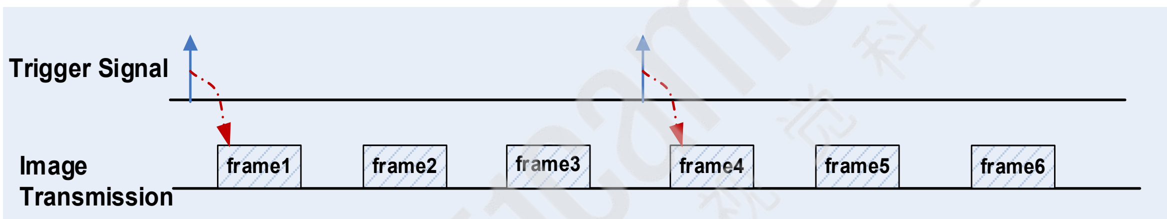


Figure 8-18 FrameBurstStart trigger

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 acquire 1 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.

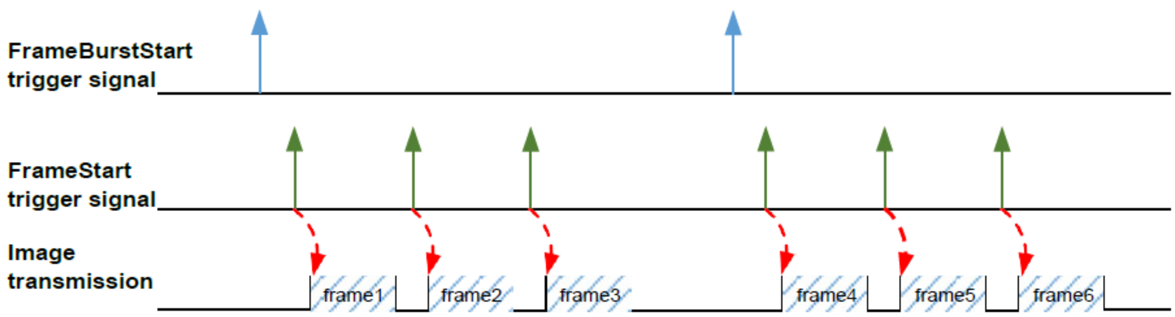


Figure 8-19 Two trigger modes are selected at the same time

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

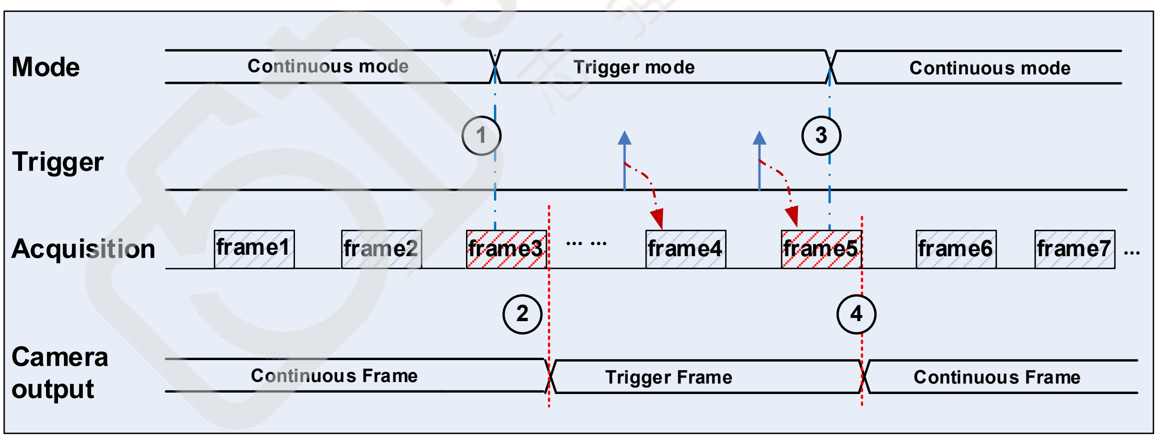


Figure 8-20 Switch trigger mode during frame reading out

As shown in Figure 8-20, 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 (or exposure)

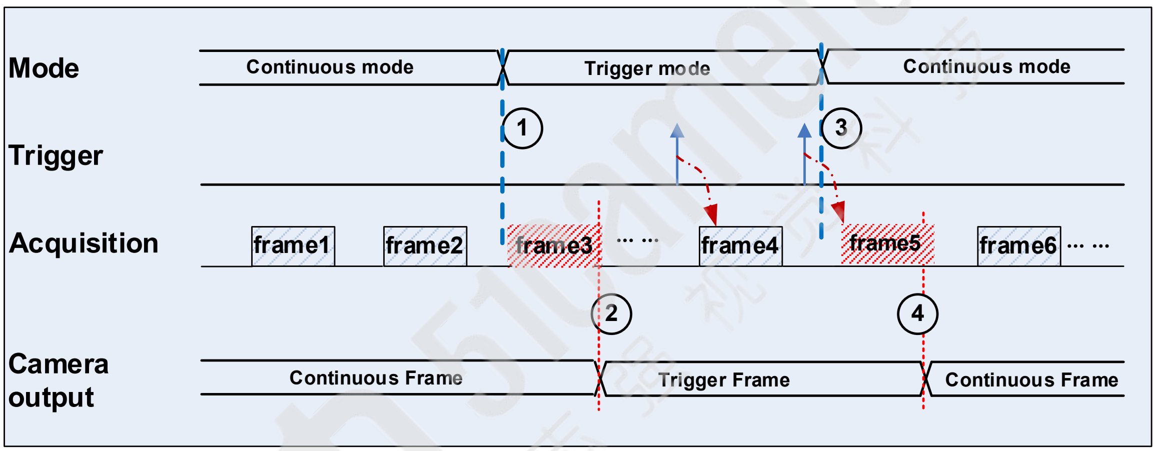


Figure 8-21 Switch trigger mode during blanking (or exposure)

As shown in Figure 8-21, 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 (including exposure and reading out), 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 for 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

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 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 transfers images according to camera parameter set.

Note:
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 should be ensured.

1. Set the Trigger Mode to ON.
2. Set the Trigger Source to Software.
3. Send *TriggerSoftware* command.

All the software trigger commands are sent by the host through the USB3.0 bus, 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 described below:

- 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 triggering 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.
- 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, Line2 or Line3.
3. Connect hardware trigger signal to Line0.

If the Trigger Source is set by Line2 or Line3, it should be ensured that the corresponding Line is set as Input.

Please refer to section 8.1.1 for more information of the programmable GPIO interfaces.

Hardware trigger acquisition features

The relative features about the camera's trigger signal process are described 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 range is from 0 to 5000 ㎲. The default configuration is not using trigger filter.

3. The time interval between trigger and exposure can be through the trigger delay feature. The range of time interval covers from 0 to 3000000 μs. The default value of trigger delay time is zero.

The features, like trigger polarity, trigger delay and trigger filter, can be selected in the VZViewer.

Note:
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 20 μs – 40 μs) and the negative pulse signal's negative width will be narrower (about 20 μs – 40 μs). You can adjust filter parameter to accurately filter trigger signal.

8.2.8 Overlapping Exposure and Non-overlapping Exposure

There are two stages in image acquisition of the VZ USB Series cameras: 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 VZ USB Series cameras support 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 modes are described 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 8-22, the Nth frame is read out, after a period, the N+1st frame to be exposed.

The formula of non-overlapping exposure frame period:

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

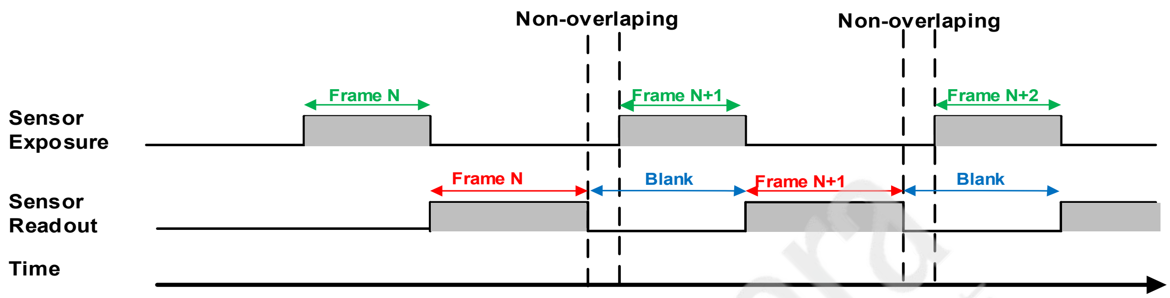


Figure 8-22 The exposure sequence in non-overlapping exposure mode

Trigger acquisition mode

If the interval between two triggers is greater than the sum of the exposure time and readout time, it will not occur overlapping exposure, as shown in Figure 8-23.

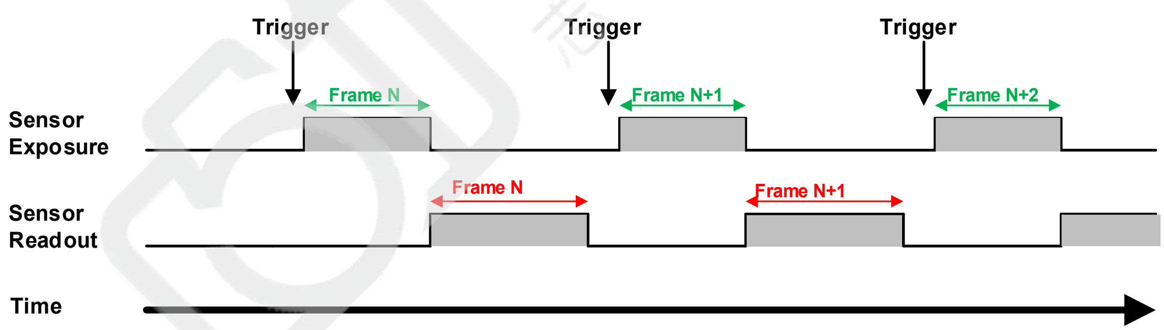


Figure 8-23 The trigger acquisition exposure sequence in non-overlapping exposure mode

Overlapping exposure

In overlapping exposure mode, the current frame image exposure process overlaps 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 Figure 8-24, when the Nth frame image is reading out, the N+1st frame image has been started exposure.

The formula of overlapping exposure frame period:

Overlapping exposure frame period ≤ exposure time + readout time

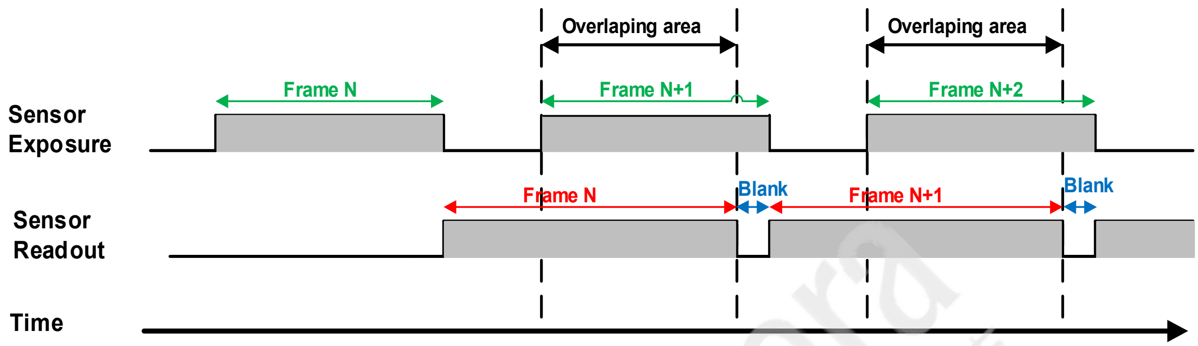


Figure 8-24 The exposure sequence in overlapping exposure mode

Continuous acquisition mode

If the exposure time is greater than the frame blanking time, the exposure time and the readout time will overlap.

Trigger acquisition mode

When the interval between two triggers is less than the sum of exposure time and the readout time, it will occur overlapping exposure, as shown in Figure 8-25.

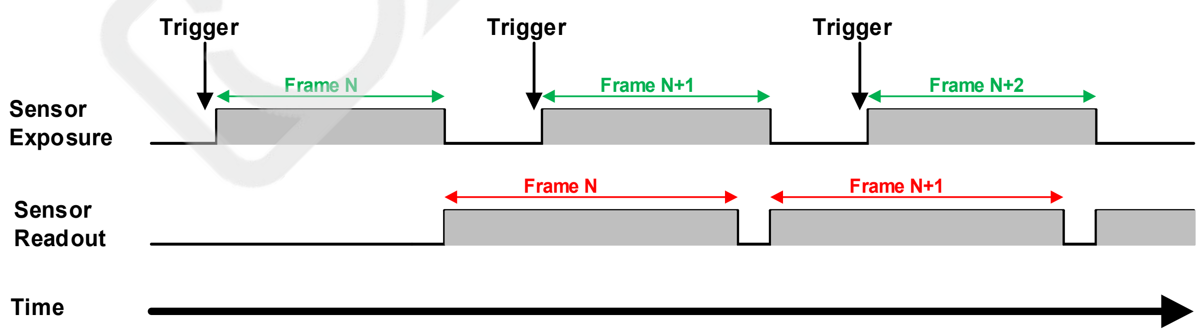


Figure 8-25 The trigger acquisition exposure sequence in overlapping exposure mode

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

8.2.9 Set Exposure

Set Exposure Mode

Two exposure modes 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) 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 8-26.

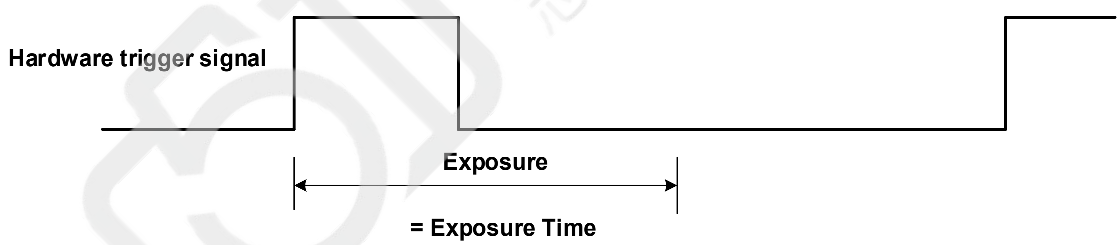


Figure 8-26 The sequence diagram in rising edge trigger of Timed exposure mode

▫ 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 8-27.

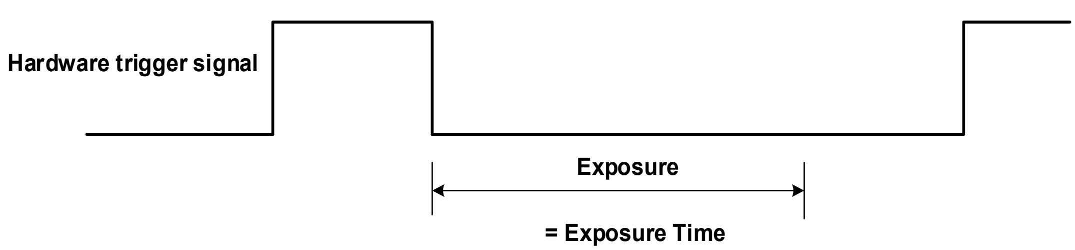


Figure 8-27 The sequence diagram in falling edge trigger of Timed exposure mode

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.

2) 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 contiue until the trigger signal falls, as shown in Figure 8-28.

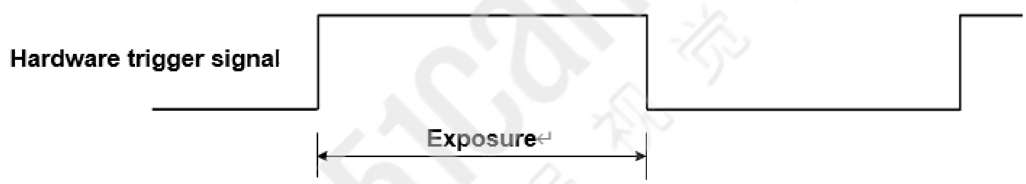


Figure 8-28 The sequence diagram in rising edge trigger of TriggerWidth exposure mode

- If rising edge triggering is enabled, exposure starts when the trigger signal rises and contiue until the trigger signal falls, as shown in Figure 8-29.

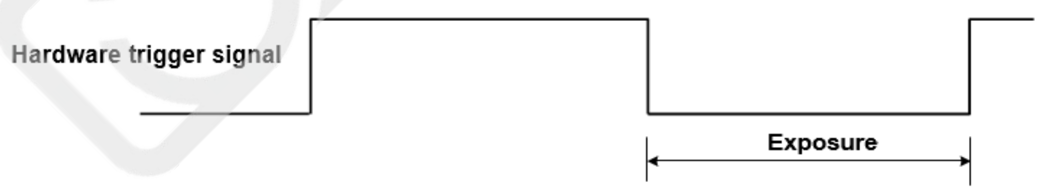


Figure 8-29 The sequence diagram in falling edge trigger of TriggerWidth exposure mode

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.

Caution!

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

1. Set the TriggerMode parameter to On.
2. Set the TriggerSource parameter to one of the available hardware trigger source, e.g., Line0.
3. 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 ExposureOverlap TimeMax

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).

Ex) 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.

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

Set Exposure Value

Global Shutter:

The implementation process of global shutter is as shown in Figure 8-30, 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:

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

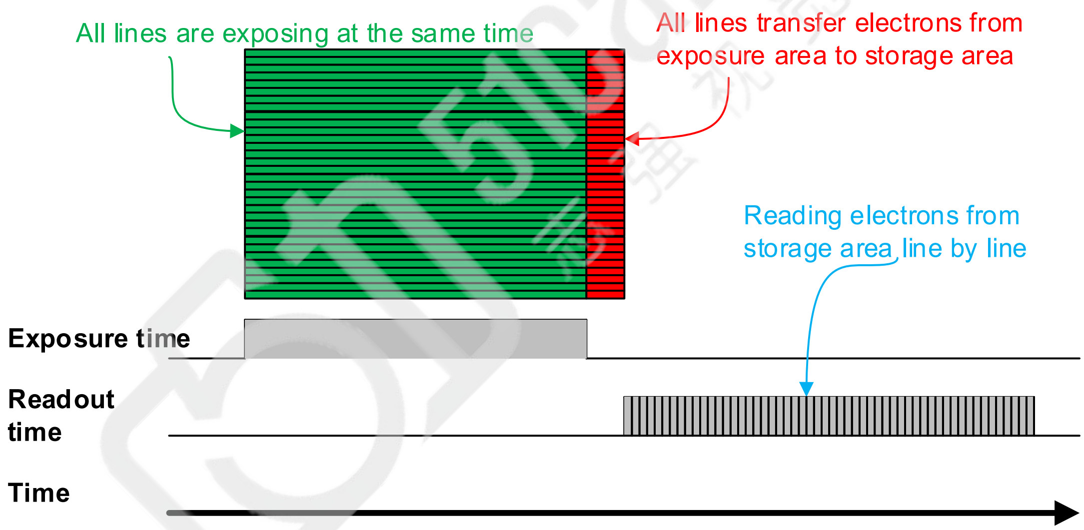


Figure 8-30 Global Shutter

Electronic Rolling Shutter:

The implementation process of electronic rolling shutter is as shown in Figure 8-31, different from the global shutter, electronic rolling shutter exposures from the first line, and starts the second line exposure after a row period. 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 images acquisition.
The time width of the flash signal can be got by the following formula:

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

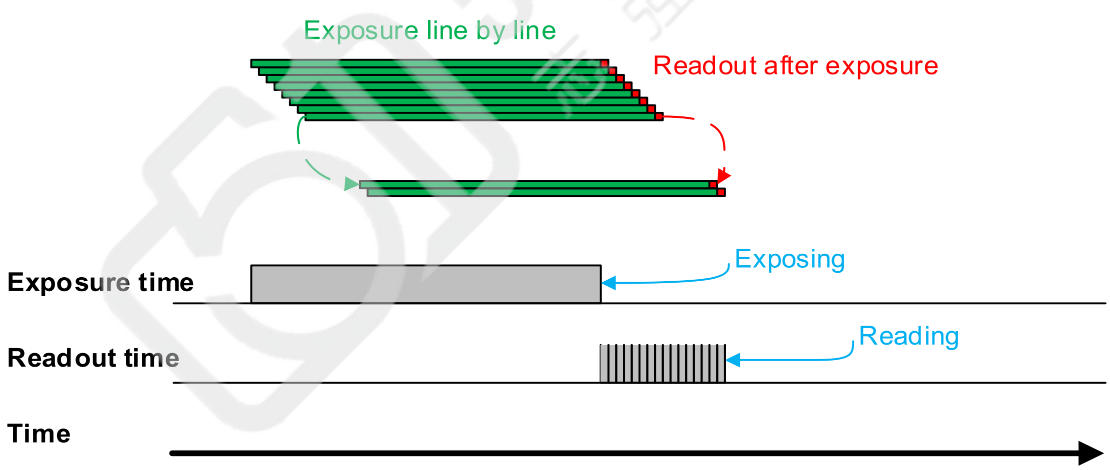


Figure 8-31 Electronic rolling shutter

Global Reset Release Shutter

As the sensor starts exposure line by line, all 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.

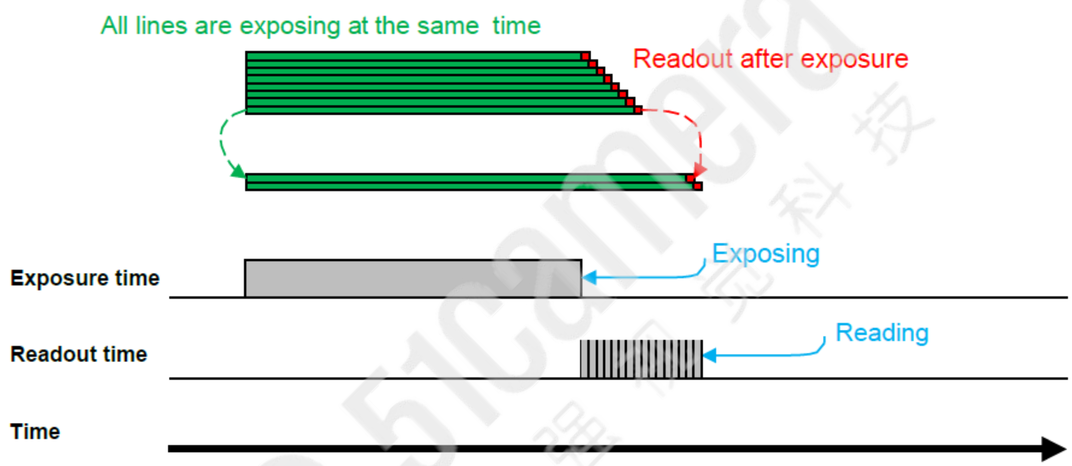


Figure 8-32 Global Reset Release shutter

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 8-32, 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.

Exposure Time Mode

According to the length of the exposure time, two exposure time modes of the VZ USB Series cameras are available: Standard exposure time mode and UltraShort exposure time mode.

1) Standard 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 "Auto Exposure" in section 8.3.4.

2) UltraShort Exposure Time Mode

In UltraShort exposure time mode, the VZ USB Series cameras only support 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.

> **Note:**
> In UltraShort exposure time mode, the VZ USB Series cameras do not support automatic adjustment of the exposure time, only support manual adjustment of the exposure time.

Setting the exposure time

The exposure precision of the camera is limited by the sensor, when the steps in the user's interface and the demo display as 1 μs, actually the steps is 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 36 μs, setting 80 μs exposure time, 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 50 ㎐ light source, the exposure time must be a multiple of 1/100s, under 60 ㎐ light source, the exposure time must be a multiple of 1/120s), to ensure better image quality.

The VZ USB Series cameras support Auto Exposure feature. If the Auto Exposure feature is enabled, the camera can adjust the exposure time automatically according to the environment's brightness. See section 8.3.4 for more details.

8.2.10 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 ~ 5000 μs, and the minimum value is 0.

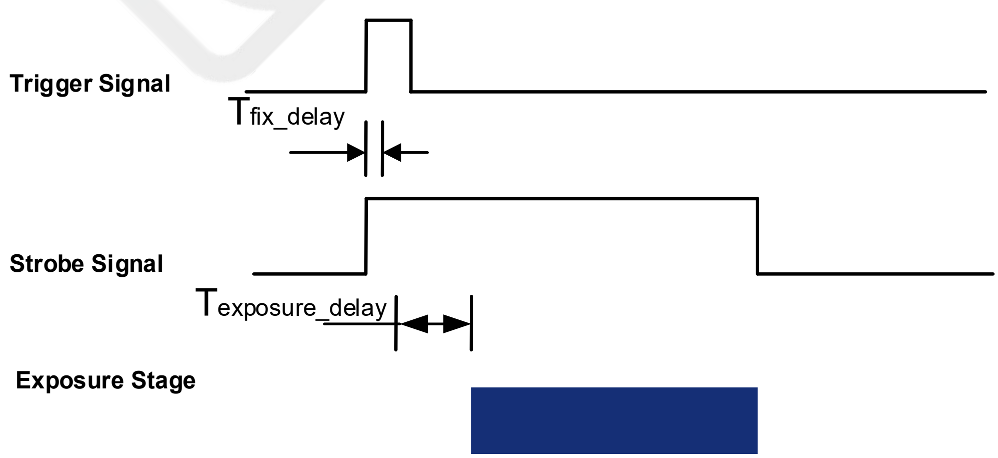


Figure 8-33 The exposure delay sequence diagram in overlaping exposure mode

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

Exposure Delay	Description
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.
T3	Trigger delay (trigger_delay) The camera supports trigger delay feature. If the trigger delay is set to 200μs, T3 is 200μs.
T4	The sensor timing sequence delay The internal exposure of the sensor is aligned with the row timing sequence, so T4 has a maximum row cycle jitter. The value of each sensor is different. Some products with large delay time (several hundred μs or more) have additional configuration time counted in T4.

Table 8-1 Exposure delay (T1 ~ T4)

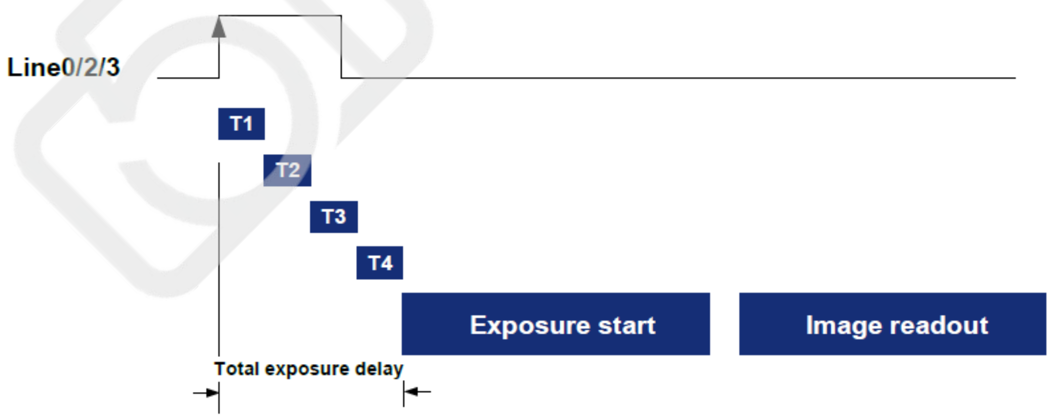


Figure 8-34 Exposure delay

- T1 is calculated according to the typical delay (5μs) of Line0. If it is Line2/3, T1 can be ignored.
- T2 and T3 are calculated as 0μs.
- T4 is calculated according to the ROI settings and features of each sensor.

Model	Exposure Delay (μs)
VZ-2MU-M/C41H00	44.8 ~ 64.7
VZ-2MU-M/C168H00	Mono8 / BayerRG8: 14.6 Mono10 / BayerRG10: 24.2
VZ-3MU-M/C56H00	33.8 ~ 45.1
VZ-3MU-M/C125H00	Mono8 / BayerRG8: 15.15 Mono10 / BayerRG10: 25.3
VZ-5MU-M/C79H00	Mono8 / Bayer RG8: 17 ~ 23 Mono10 / Bayer RG10: 29.2 ~ 36.3
VZ-5MU-M79H00-POL	Mono8: 17 Mono10: 29
VZ-5MU-M/C36H00	31.6 ~ 44.9
VZ-5MU-M36H00-POL	31.6
VZ-6MU-M/C60H00	BayerRG8 / Mono8: 2357 BayerRG10 / Mono10: 2707
VZ-12MU-M/C23H00	33 ~ 89
VZ-12MU-M/C32H00	BayerRG8 / Mono8: 650 BayerRG12 / Mono12: 1260
VZ-12MU-M/C32H10	24 ~ 62
VZ-20MU-M19H00	BayerRG8 / Mono8: 800 BayerRG12 / Mono12: 1550
VZ-400U-M/C528H00	BPP8: 11.5 BPP10: 12.85 BPP12: 15.7
VZ-1600U-M/C227H00	Mono8 / BayerRG8: 13~17 Mono10 / BayerRG10: 20.6~28.5

Table 8-2 Exposure delay data for each model

8.3 Basic Features

8.3.1 Gain

The VZ USB Series cameras can adjust the analog gain. Refer to <5.1 Specifications> for the range of analog gain.

- When the analog gain changes, the response curve of the camera changes, as shown in Figure 8-35. 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 6 dB increases of the gain, the gray value of the image will double. For example, when the camera has a gain of 0 dB, the image gray value is 126, and if the gain is increased to 6 dB, 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 <8.4.4 Lookup Table>.

Note:
Increasing the analog gain or digital will amplify the image noise.

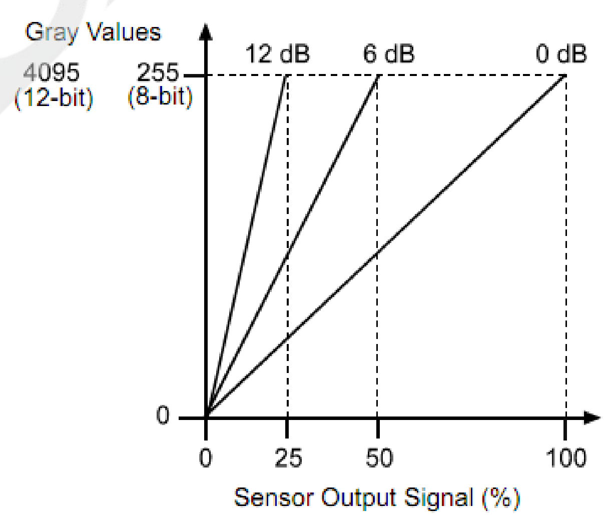


Figure 8-35 The cameras response curve

8.3.2 Pixel Format

By setting the pixel format, the user can select the format of the output image. The available pixel formats depend on the camera model and whether the camera is monochrome or color. 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

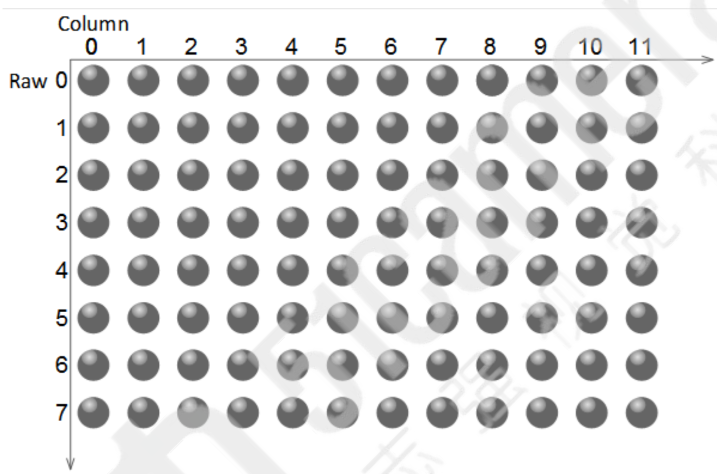


Figure 8-36 Mono8 pixel format

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

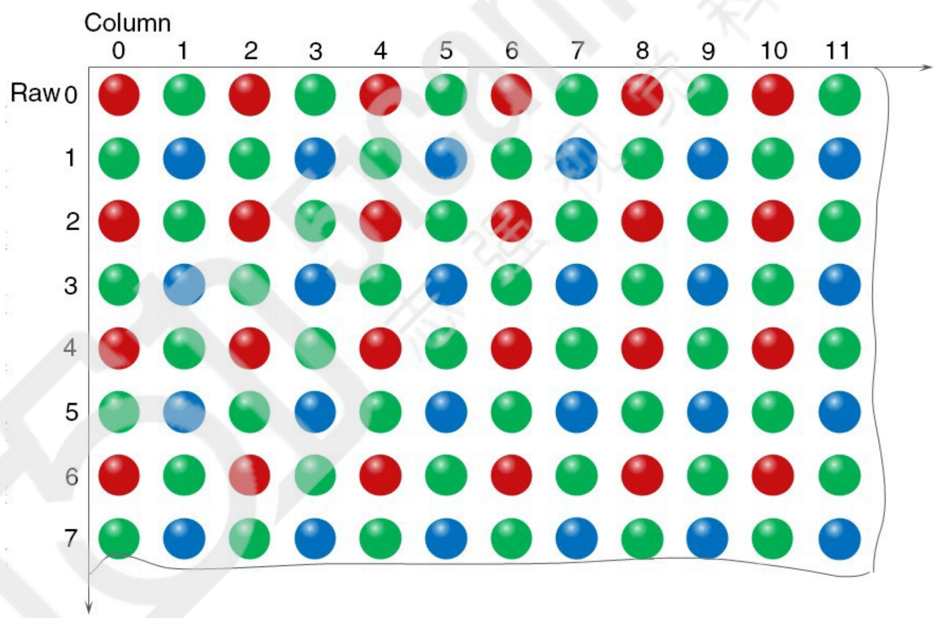


Figure 8-37 Bayer RG8 pixel format

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

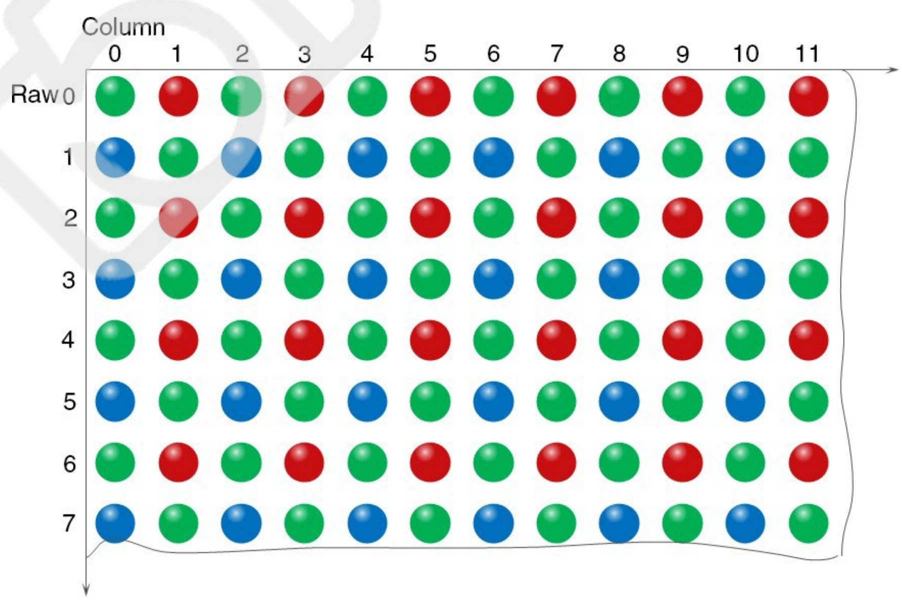


Figure 8-38 Bayer GR8 pixel format

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), B01 represents the second pixel value (for the red 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 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.

Bayer GR10 / Bayer GR12

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

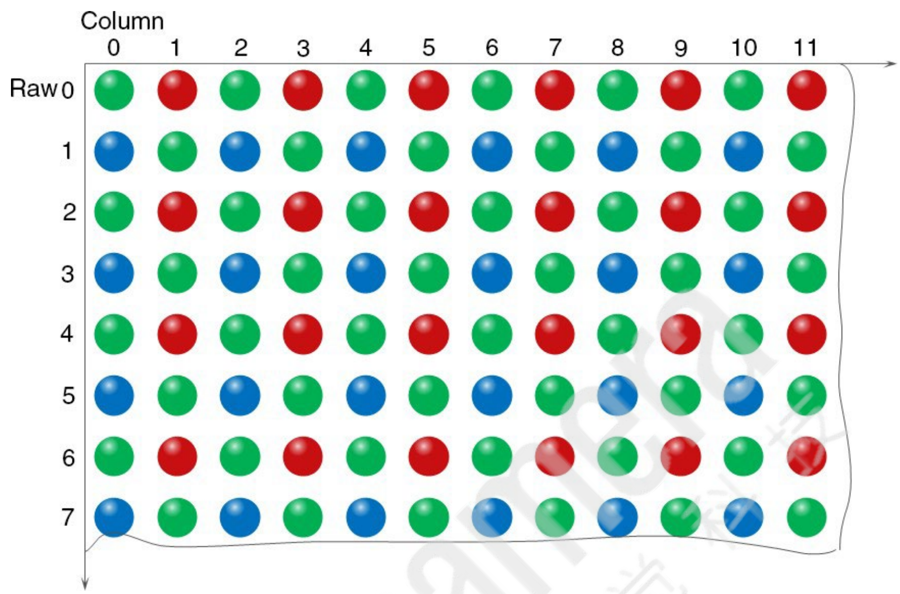


Figure 8-39 Bayer GB8 pixel format

When the pixel format is set to BayerGB8, 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.

8.3.3 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 transfers 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 as the 0th line and 0th columns 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.

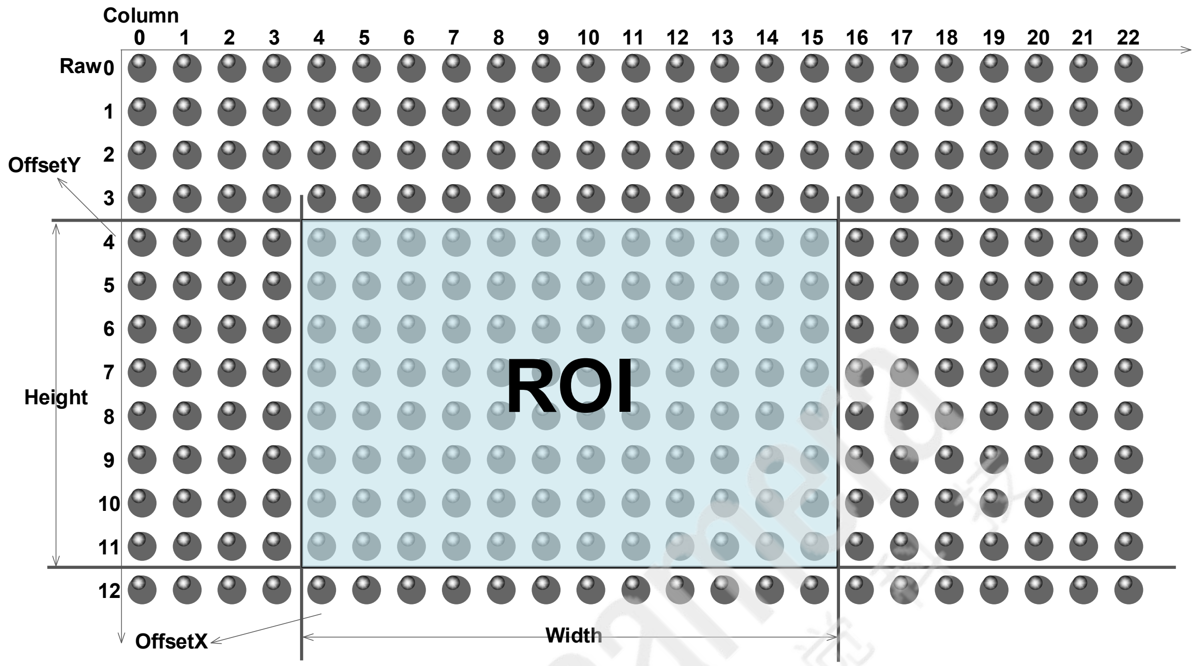


Figure 8-40 Mono8

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

8.3.4 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 step of AAROIOffsetX and AAROIWidth is 4. The step of AAROIOffsetY and AAROIHeight is 2. The setting of the AAROI depends on the size of the current image and cannot exceed the range of the current image. Assuming the Width and Height are parameters for users captured image, then the AAROI setting need to meet the condition 1:

- AAROIWidth+ AAROIOffsetX≤Width
- AAROIHeight+ AAROIOffsetY≤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 can be set to 16, and the maximum value is equal to the current image width. The minimum value of AAROIHeight can be set to 16, and the maximum value is equal to the current image height, they are all needed 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 8-41.

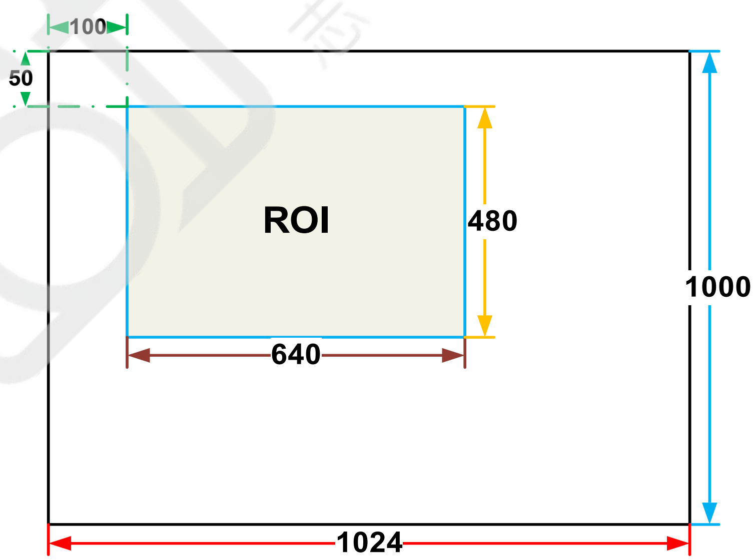


Figure 8-41 An example for the relative position between the ROI and the current image

Auto Gain

The auto gain can adjust the camera's gain automatically, so that the average gray value in AAROI is achieved to the expected gray value. The auto gain 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 turn off the auto gain feature. When using the "Continuous" mode, the camera will continuously adjust the gain value 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 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.

Auto Exposure

The auto exposure can adjust the camera's exposure time automatically, so that the average gray value in AAROI can achieve the expected gray value. The auto exposure 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 exposure feature. When using the "Continuous" mode, the camera will continuously be adjusting the 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, and for 12bit pixel data, the expected gray value range is 0-4095.

The camera adjusts the exposure time in the range [minimum exposure time, maximum exposure time] which is set by the user.

The auto exposure feature can be used with the auto gain 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.

8.3.5 Auto White Balance

VZ USB Series cameras support auto white balance function and support "Once" mode and "Continuous" mode.

Auto White Balance ROI

Auto White Balance feature uses the image data from AWBROI to calculate the white balance ratio, and then 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. Where the step of AWBROIOffsetX and AWBROIWidth is 4, the step of AWBROIOffsetY and AWBROIHeight is 2.

The ROI setting depends on the current image size and cannot exceed the current image range. Assuming the current image width is Width, the image height is Height, then the ROI setting need to meet the following condition 2:

- AWBROIWidth+ AWBROIOffsetX≤Width
- AWBROIHeight+ AWBROIOffsetY≤Height

If condition 2 is not met, the user cannot set the ROI.

The default value of ROI is the entire image, you can set the "white dot" area (ROI) according to your need. Where the minimum value of AWBROIWidth can be set is 16, the maximum value is equal to the current image width. The minimum value of AWBROIHeight can be set is 16, the maximum value is equal to the current image height, they are all need to meet the condition 2. Assuming the current image width is 1024, the height is 1000, and then the "white dot" area ROI setting is:

- AWBROIOffsetX = 100
- AWBROIOffsetY = 50
- AWBROIWidth = 640
- AWBROIHeight = 480

The relative position of the ROI and the image is shown in Figure 8-42.

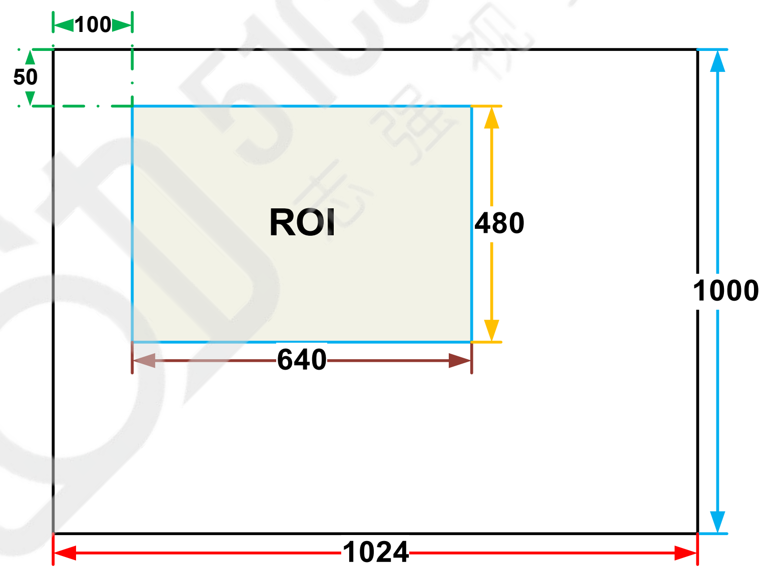


Figure 8-42 An example for the relative position between the ROI and the current image

Auto White Balance Adjustment

Auto White Balance function calculates the white balance coefficient based on the data in ROI and then use the coefficient to adjust the components of the image, in order to make the R/G/B component the same in the ROI. The Auto White Balance feature is only available on color sensors.

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 only 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 can also select the color temperature. When the color temperature of the selection is "Adaptive", the data in ROI always adjusting the red, green and blue to the same. When selecting the specific color temperature, the camera adjusts the factor according to the light source, so that the hue of the ROI is the same as the hue of the light source. That is: high temperature is cold, low color temperature is warm.

8.3.6 Test Pattern

The VZ USB Series cameras support 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 RAW10 mode, the gray value of test image is: the pixel gray value in RAW8 mode multiplies by 4, as the output of pixel gray value in RAW10 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, to 255, and then the next frame gray value returns to 0, and so on. A print screen of a single frame is shown in Figure 8-43:

Figure 8-43 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 8-44:

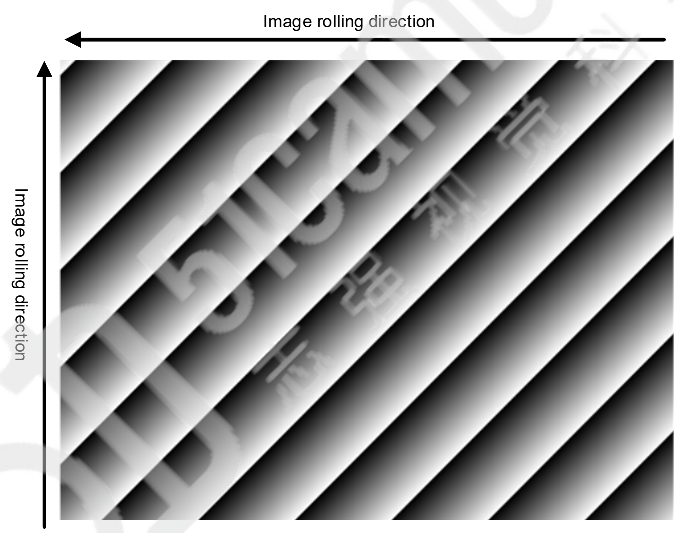


Figure 8-44 Moving diagonal gray gradient test image

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 print screen of the static diagonal gray gradient test image is shown in Figure 8-45.

Figure 8-45 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.

To save the specific parameters of the users, avoiding setting the parameters every time when you open the camera, the VZ USB Series cameras provide 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. Three types of configuration parameters are available: the currently effective configuration parameters, the vendor default configuration parameters (Default), and the user configuration parameters (UserSet).

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 manufacturer's default configuration parameters are the camera configuration parameters optimized by the manufacture 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 (UserSet): 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 VZ USB Series cameras can store a set 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:

- Gain
- ExposureTime
- PixelFormat
- OffsetX, OffsetY, ImageWidth, ImageHeight
- EventNotification
- TriggerMode, TriggerSource, TriggerPolarity, TriggerDelay
- TriggerFilterRaisingEdge, TriggerFilterFallingEdge
- LineMode, LineInverter, LineSource, UserOutputValue
- ChunkModeActive
- TestPattern
- ExpectedGrayValue
- ExposureAuto, AutoExposureTimeMax, AutoExposureTimeMin
- GainAuto, AutoGainMax, AutoGainMin
- AAROIOffsetX, AAROIOffsetY, AAROIWidth, AAROIHeight
- BalanceWhiteAuto, AWBLampHouse
- AWBROIOffsetX, AWBROIOffsetY, AWBROIWidth, AWBROIHeight
- BalanceRatio(R/G/B)
- LUT

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 UserSet0.
2. Execute *UserSetLoad* command to load the User Set specified by *UserSetSelector* to the device and makes it active.

Change startup parameter set (UserSetDefault):

The user can use *UserSetDefault* to select Default or UserSet0 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 VZ USB Series cameras provide 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 viewer program (VZViewer).
2. Set by calling the software interface, for details please see the Programmer's Guide.

> **Note:**
> 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 Timestamp

The timestamp feature counts the number of ticks generated by the camera's internal device clock. As soon as the camera is powered on, it starts generating and counting clock ticks. The counter is reset to 0 whenever the camera is powered off and on again. Some of the camera's features use timestamp values, such as event, and timestamps can be used to test the time spent on some of the camera's operations.

The unit of timestamp is 'ns'.

8.3.10 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:

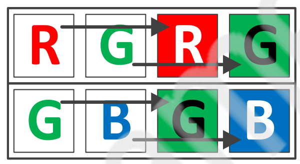


Figure 8-46 Horizontal color Binning by 2

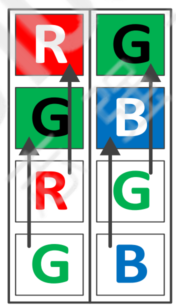


Figure 8-47 Vertical color Binning by 2

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.

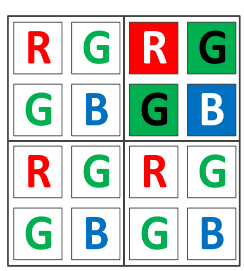


Figure 8-48 Horizontal and vertical color Binning by 2×2

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

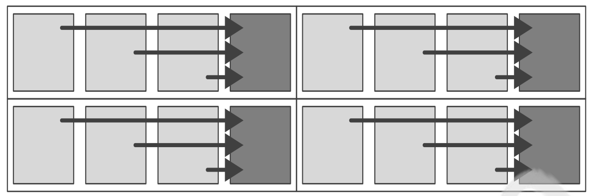


Figure 8-49 Horizontal mono Binning by 4

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 x 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.

8.3.11 Decimation

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 transferred 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 n^{th} 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.

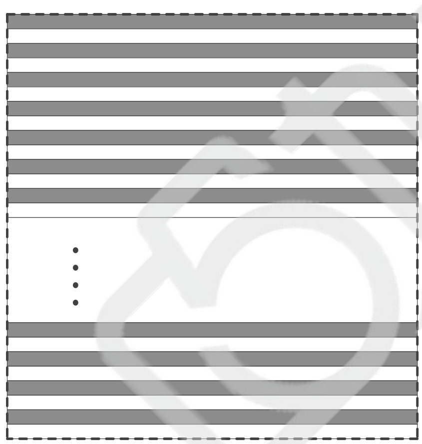


Figure 8-50 Mono camera vertical Decimation

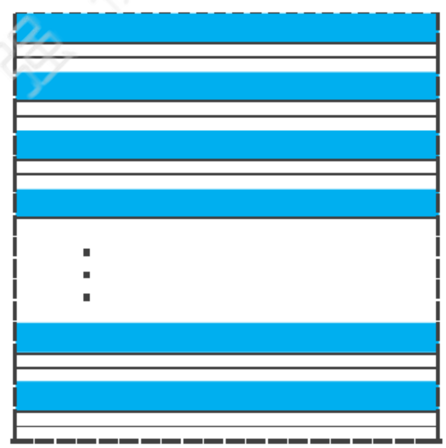


Figure 8-51 Color camera vertical Decimation

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 refer to <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 n[th] column. For example, if specify 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 n[th] 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.

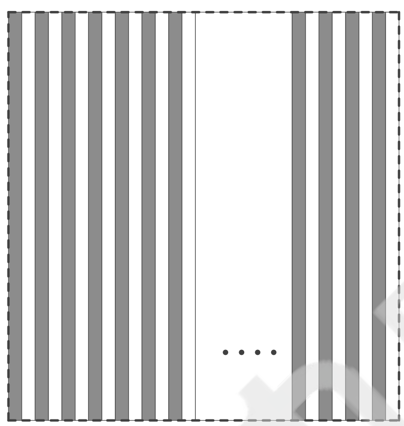


Figure 8-52 Mono camera horizontal Decimation

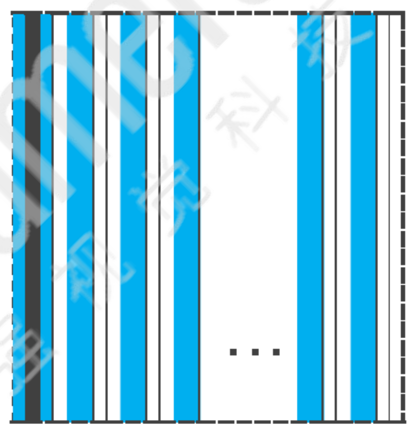


Figure 8-53 Color camera horizontal Decimation

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 the VZ-5MU-M/C79H camera as an example, the default resolution is 2448 x 2048. When horizontal Decimation by 4 and vertical Decimation by 4 are enabled, the maximum ROI width would be 612 and the maximum ROI height would be 512.

2) Reduced resolution

Using Decimation effectively reduces the resolution of the camera's imaging sensor. Taking the VZ-5MU-M/C79H camera as an example, the default resolution is 2448 x 2048. When horizontal Decimation by 4 and vertical Decimation by 4 are enabled, the effective resolution of the sensor is reduced to 612 × 512.

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.

8.3.12 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.

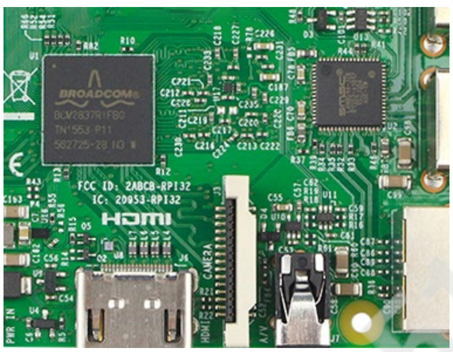


Figure 8-54 The original image

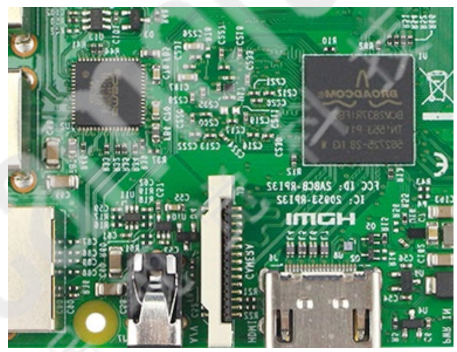


Figure 8-55 Reverse X enabled

Enabling Reverse Y

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

Figure 8-56 The original image

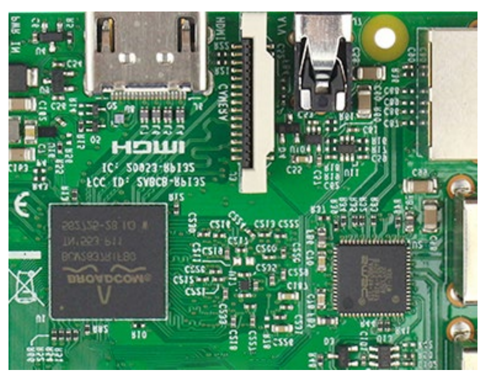


Figure 8-57 Reverse Y enabled

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 8-58 The original image

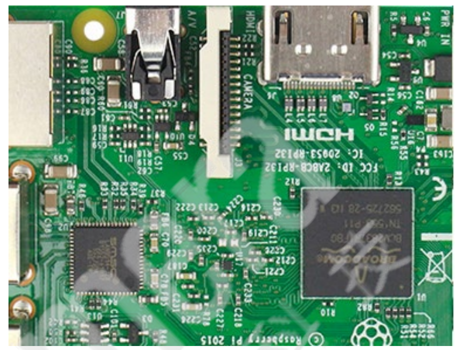


Figure 8-59 Reverse X and Y enabled

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 8-60 The original image

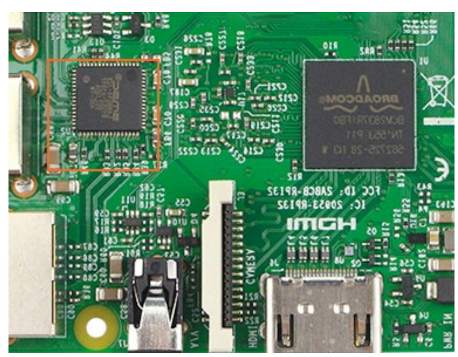


Figure 8-61 Reverse X enabled

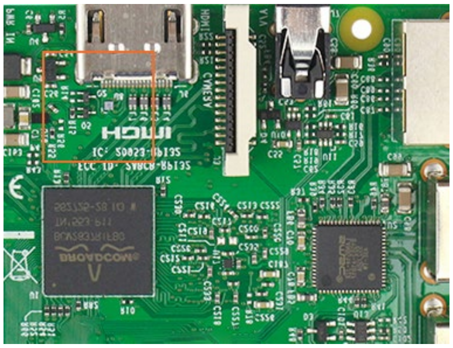


Figure 8-62 Reverse Y enabled

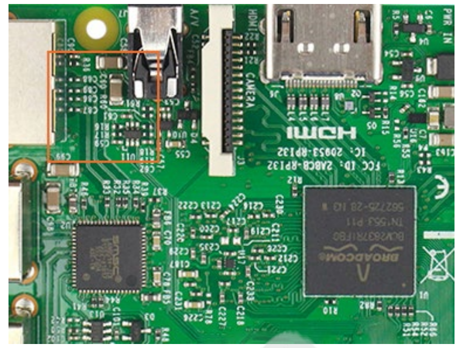


Figure 8-63 Reverse X and Y enabled

8.3.13 Digital Shift

The Digital Shift can multiply the pixel values by 2^n of the images.

This increases the brightness of the image. If your camera doesn't support the digital shift feature, you can use the Gain feature to achieve a similar effect.

How Digital Shift Works

Configuring a digital shift factor of n results in a logical left shift by n on all pixel values. This has the effect of multiplying all pixel values by 2^n.

If the resulting pixel value is greater than the maximum value possible for the current pixel format (e.g., 255 for an 8-bit pixel format, 1023 for a 10-bit pixel format, and 4095 for a 12-bit pixel format), the value is set to the maximum value.

Configuring Digital Shift

To configure the digital shift factor, enter the expected value for the *DigitalShift* parameter.
By default, the parameter is set to 0, i.e., digital shift is disabled.

- When the *DigitalShift* parameter is set to 1, the camera will shift the pixel value to the left by 1 bit.
- When the *DigitalShift* parameter is set to 2, the camera will shift the pixel value to the left by 2 bits.

Considerations When Using Digital Shift

Example 1: Digital Shift by 1, 12-bit Image Data

MSB (bit 11) … LSB (bit 0)

	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	
Binary	0	0	0	0	0	0	0	1	0	1	1	0	Raw pixel value: 22

	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	
Binary	0	0	0	0	0	0	1	0	1	1	0	0	Shift pixel value: 44

The least significant bit in each 12-bit image data is set to 0.

Example 2: Digital Shift by 2, 8-bit Image Data

MSB (bit 11) … LSB (bit 0)

	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	
Binary	0	0	1	0	1	1	0	1	0	1	1	0	Raw pixel value(8bit): 45 Raw pixel value(12bit): 726

	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	
Binary	1	0	1	1	0	1	0	1	-	-	-	-	Shift pixel value(8bit): 181

Assume that your camera has a maximum pixel bit depth of 12-bit but is currently using an 8-bit pixel format. In this case, the camera first performs the digital shift calculation on the 12-bit image data. Then, the camera transmits the 8 most significant bits.

Example 3: Digital Shift by 1, 12-bit Image Data, High Value

Assume that your camera is using a 12-bit pixel format. Also assume that one of your original pixel values is 2839.

	MSB bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	LSB bit 0	
Binary	1	0	1	1	0	0	0	1	0	1	1	1	Raw pixel value: 2839

	MSB bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	LSB bit 0	
Binary	1	1	1	1	1	1	1	1	1	1	1	1	Shift pixel value: 4095

If you apply digital shift by 1 to this pixel value, the resulting value is greater than the maximum possible value for 12-bit pixel formats. In this case, the value is set to the maximum value, i.e., all bits are set to 1.

8.3.14 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.

8.3.15 Black Level and Auto Black Level

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.

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

Auto Black Level

The dark current is greatly affected by the ambient temperature and individual differences are greater for high resolution camera models. The auto black level function ensures that the average gray value of the 12bit image is 0 when the camera is in the dark field.

The default mode is "Continuous" and the black level automatically adjusts. 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.

8.3.16 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 8-3.

Model	Features	Set the switch to off	Set the switch to on
VZ-2MU-M/C41H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~4095	0~4095
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-2MU-M/C168H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000

	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~511	0~511
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-3MU-M/C56H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~4084	0~4084
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-3MU-M/C125H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~1023	0~1023
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-5MU-M/C79H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~1023	0~1023
	Sharpness	0~3	0~63
	White Balance component factor	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-5MU-M79H00-POL	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~1023	0~1023
	Sharpness	0~3	0~63
VZ-5MU-M/C36H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~4095	0~4095
	Sharpness	0~3	0~63
	White Balance component factor	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-5MU-M36H00-POL	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000

	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~4095	0~4095
	Sharpness	0~3	0~63
VZ-6MU-M/C60H00	Exposure	8~1000000	8~15000000
	Auto Exposure	8~1000000	8~15000000
	Gain	0~24	0~27
	Auto Gain	0~24	0~27
	Black Level	0~1023	0~1023
	Sharpness	0~3	0~63
	White Balance component factor	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-12MU-M/C32H00	Exposure	10~1000000	10~15000000
	Auto Exposure	10~1000000	10~15000000
	Gain	0~24	0~27
	Auto Gain	0~24	0~27
	Black Level	0~255	0~255
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-12MU-M/C23H00	Exposure	28~1000000	28~15000000
	Auto Exposure	28~1000000	28~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~4095	0~4095
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~31.996
	Auto White Balance	1~15.996	1~31.996
VZ-12MU-M/C32H10	Exposure	24~1000000	24~15000000
	Auto Exposure	24~1000000	24~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~1023	0~1023
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~31.996
	Auto White Balance	0~15.996	0~31.996
VZ-20MU-M/C19H00	Exposure	12~1000000	12~15000000
	Auto Exposure	12~1000000	12~15000000
	Gain	0~24	0~27
	Auto Gain	0~24	0~27
	Black Level	0~255	0~255
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-400U-M/C528H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48

	Auto Gain	0~24	0~48
	Black Level	0~255 (BPP8) 0~1023 (BPP10) 0~4095 (BPP12)	0~255 (BPP8) 0~1023 (BPP10) 0~4095 (BPP12)
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996
VZ-1600U-M/C227H00	Exposure	20~1000000	20~15000000
	Auto Exposure	20~1000000	20~15000000
	Gain	0~24	0~48
	Auto Gain	0~24	0~48
	Black Level	0~255	0~255
	Sharpness	0~3	0~63
	White Balance component	0~15.996	0~63.996
	Auto White Balance	0~15.996	0~63.996

Table 8-3 Range of features supported before and after Remove Parameter Limits

8.3.17 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.

8.3.18 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:

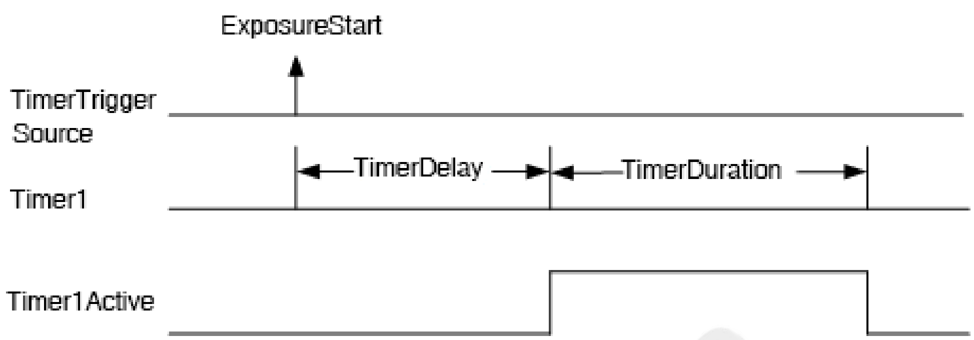


Figure 8-64 The schematic diagram of Timer1Active

The timer configuration process is as follows:

1. Set TimerSelector, currently only Timer1 is 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.

- 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 Figure 8-65, the red *ExposureStart* signals are ignored.
- After the acquisition is stopped, the timer is immediately cleared and the Timer1Active signal goes low immediately.

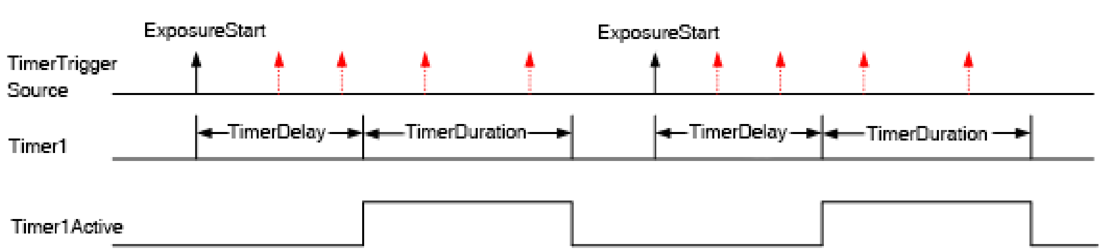


Figure 8-65 The relationship between Timer1Active and the ExposureStart signal

8.3.19 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, and Line3. Among them, Off means no reset, SoftWare means software reset, Line0, Line2 or Line3 means reset through IO interface input signal. 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 is 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, Line3.
4. Set *CounterResetActivation*, currently only *RisingEdge* is supported.

Note:

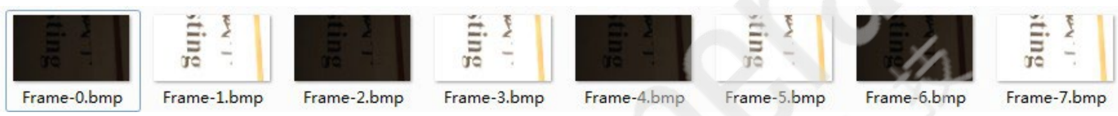
1. After the acquisition is stopped, the Counter continues to work, will not be cleared, and it will be cleared when the camera is powered off.
2. CounterReset is used to software reset the counter.

8.3.20 Multi Gray Control

The gray value of different frames can be set by the parameters setting, which can realize HDR and other functional applications. Configurable parameters include MGCExposureTime and MGCGain. Multi-gray Control supports Off mode, 2Frame mode and 4Frame mode.

- Off mode: That is Normal mode, the same MGCExposureTime and MGCGain parameters are in effect for each frame.

- 2Frame mode: Two frames of different MGCExposureTime and MGCGain can be set. For example, you can set the MGCExposureTime and MGCGain of frame 0 to (1000μs, 0); and the parameters of frame 1 to (10000μs, 6.0); acquire 8 frames of images, and the effect is as follows:



- 4Frame mode: Four frames of different MGCExposureTime and MGCGain can be set. For example, you can set the MGCExposureTime and MGCGain of frame 0 to (1000μs, 0); the parameters of frame 1 to (5000μs, 1.0); the parameters of frame 2 to (10000μs, 2.0); the parameters of frame 3 to (150000μs, 3.0); acquire 16 frames of images, and the effect is as follows:

Notes for Trigger mode

1) Multi frames acquisition in one trigger command

- In 2Frame mode, 2 images will be acquired after sending one trigger command.
- In 4Frame mode, 4 images will be acquired after sending one trigger command.

2) Serial Software Trigger is not supported (When Multi Gray Control mode is on)

- Serial Software Trigger: Send the next trigger immediately after receiving the last frame of image that acquired in this trigger.
- When the Multi Gray Control mode is set to 2Frame or 4Frame mode, the software will send a trigger command immediately after receiving the last frame of image, and the

camera will **not** respond to this trigger command, that is, **the trigger will be lost**. It is necessary to delay more than 20ms before sending the next software trigger command. Therefore, sending Software Trigger command in timer is recommended.

3) In send trigger command in timer mode, the trigger frequency determined method is as follows:

- Use the demo program to open the device, configure the Multi Gray Control parameters and set it to the required mode (2Frame or 4Frame).
- Set <TriggerMode> to "ON".
- View camera properties <CurrentAcquisitionFrameRate>.
- When the Multi Gray Control is set to 2Frame mode, if the value of <CurrentAcquisitionFrameRate> is 31.0Hz, then the maximum trigger frequency is 31.0 / 2 = 15.5 Hz.
- When the Multi Gray Control is set to 4Frame mode, if the value of <CurrentAcquisitionFrameRate> is 44.0Hz, then the maximum trigger frequency is 44.0 / 4 = 11 Hz.

8.4 Image Processing

8.4.1 Light Source Preset

VZ USB Series cameras support light source preset function, and provide Off mode, Custom mode, and four specified common color temperature light source modes. The camera provides the corresponding white balance coefficient and color transformation coefficient in the four specified color temperature light source modes. The function support of different models varies slightly.

Off Mode

The camera does not perform white balance and color conversion processing on the image by default.

Custom Mode

The camera does not perform white balance and color conversion processing on the image by default.

Users can perform automatic white balance, or manually input white balance coefficients, and it supports color conversion enable control and 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. 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 are not supported).

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

8.4.2 Color Transformation Control

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 8-66 Color template

51camera 志强视觉科技

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.

Prerequisites

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

Configuring color transformation

There are two modes for configuring color transformation: default mode (RGBtoRGB), user-defined mode (User).

1) RGBtoRGB: Default color transformation parameters provided to the camera when it leaves the factory.
2) User

- Set the *ColorTransformationValueSelector* parameter to the expected position in the matrix, e.g., Gain00.
- Enter the expected value for the *ColorTransformationValue* parameter to adjust the value at the selected position. The parameter's value range is -4.0 to +4.0.

In user mode, the user can input the color transformation value according to the actual situation to achieve the color transformation effect.

How it works

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

The transformation is performed by pre-multiplying a 3 x 1 matrix containing R, G, and B pixel values by a 3 x 3 matrix containing the color transformation values:

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

Effect images

Figure 8-67 Before color transformation

Figure 8-68 After color transformation

8.4.3 Gamma

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

Prerequisites

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

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, 1023 for 10-bit pixel formats or 4095 for 12-bit pixel formats.

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.

Caution!

If you enable Gamma correction and the pixel format is set to a 10-bit or 12-bit pixel format, some image information will be lost. Pixel data output will still be 10-bit or 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 10-bit or 12-bit pixel format.

51camera 志强视觉科技

Additional parameters

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

1. *GammaEnable*: Enables or disables Gamma correction.
2. *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.

8.4.4 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, 10 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.

How it works

1. LUT is short for "lookup table", which is basically an indexed list of numbers.
2. 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 1023 (= maximum gray value for 10-bit pixel formats). This changes all completely black pixels in your images to completely white pixels.
3. 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 tables do not affect image luminance.

Creating the user-defined LUT

To create a lookup table, you need to determine the range of *LUTIndex* and *LUTValue* parameters by the maximum pixel format supported by the currently used camera.

a) On cameras with a maximum pixel bit depth of 12 bits:
   The *LUTIndex* selectable item is 0-4095, each *LUTIndex* corresponds to a *LUTValue*, and the *LUTValue* range is [0,4095].
b) On cameras with a maximum pixel bit depth of 10 bits:
   The *LUTIndex* selectable item is 0-1023, each *LUTIndex* corresponds to a *LUTValue*, and the *LUTValue* range is [0,1023].

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

1. 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.
2. Set the *LUTIndex* parameter to the pixel value that you want to replace with a new value.
3. Set the *LUTValue* parameter to the new pixel value.
4. 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.
5. Set the *LutEnable* parameter to 'true' means that the lookup table feature is enabled. The default is disabled.

> Note:
> 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.

8.4.5 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 includes sharpness and sharpness with noise suppression.

- Enable sharpness: 'ON' means that the sharpness feature is enabled.

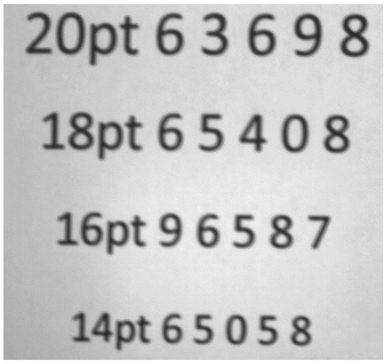


Figure 8-69 Before sharpness adjustment

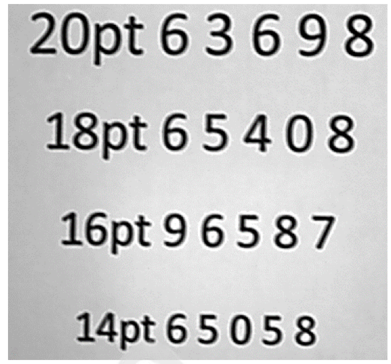


Figure 8-70 After sharpness adjustment

- Sharpness adjustment: Adjust the sharpness value to adjust the camera's sharpness to the image. The adjustment range is 0-3.0. The larger the value, the higher the sharpness.

Sharpness with Noise Suppression

- Enable sharpness

'ON' means that the sharpness feature is enabled.

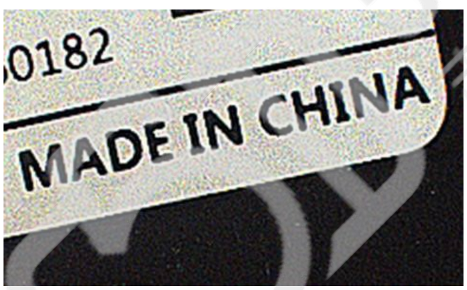


Figure 8-71 Before sharpness adjustment

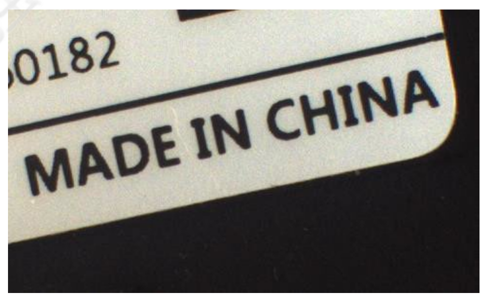


Figure 8-72 After sharpness adjustment

- Sharpness adjustment

Adjusting 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

Adjusting 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.

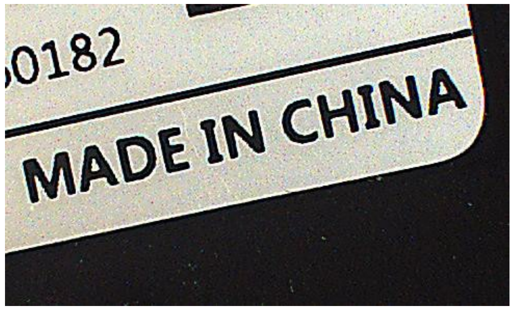


Figure 8-73 After sharpness noise suppression

8.4.6 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 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 8-74 Before FFC

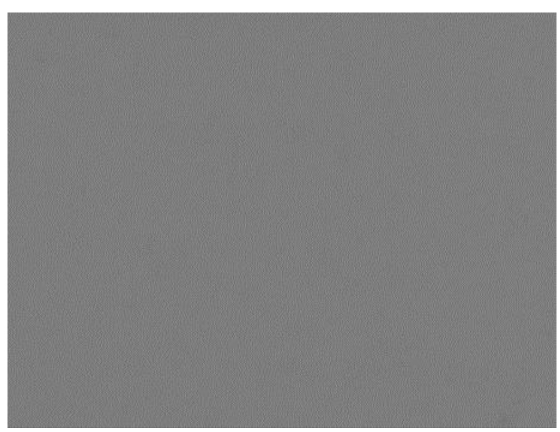


Figure 8-75 After FFC

The FFC Plugin can be used to obtain, save and preview the FFC coefficient. The plugin interface is shown in Figure 8-76.

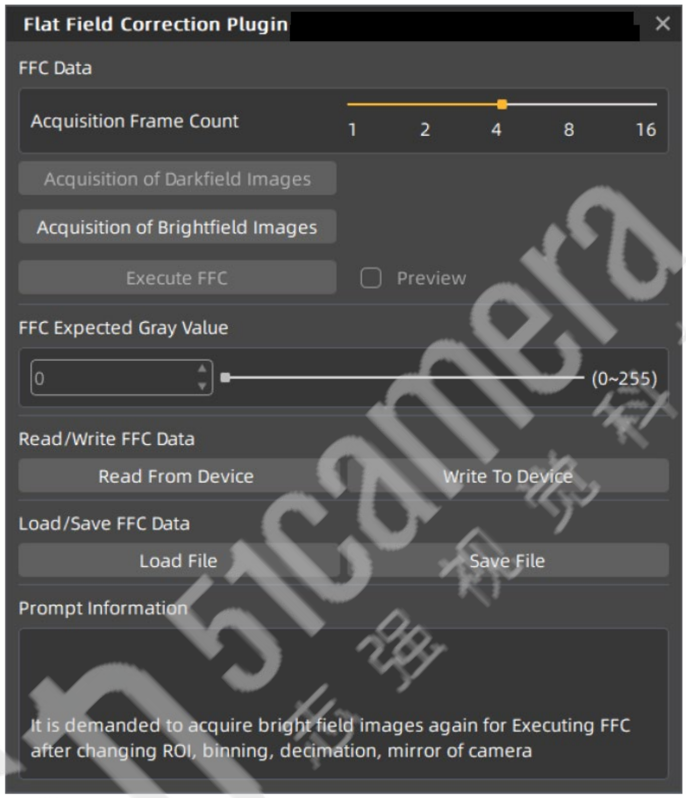


Figure 8-76 FFC Plugin Interface

Caution!

It is demanded to acquire bright field images again for executing FFC after changing ROI, Binning, Decimation, Reverse X/Y of the cameras that support FFC. The previous factor will no longer apply.

There are three ways to obtain the FFC coefficient:

1. According to the current environment
2. Read from device (available for part of the camera).
3. Load file.

There are two ways to save the FFC coefficient:

1. Write to device (available for part of the camera).
2. Save file.

Caution!

For cameras that support FFC, in addition to the plugin, FFC can be set to on/off in the camera feature. When set to on, FFC coefficients stored in the camera can be used to calibrate the image.

FFC Coefficient Calculation and Preview

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.

According to the FFC plugin, the process of obtaining FFC coefficient is shown in the figure below, and the yellow part is optional steps. For details of the FFC plugin, refer to <8.4.6 Flat Field Correction>.

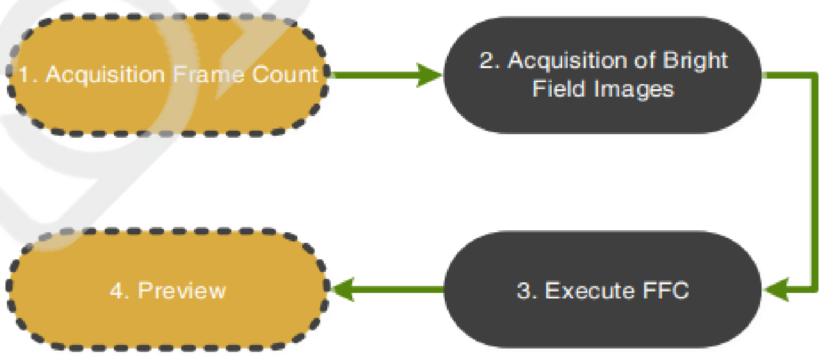


Figure 8-77 The process of obtaining FFC coefficient

1 **Acquisition frame count**: acquisition frame count for the bright field image to obtain the average image.

> Caution!
> - It is not a necessary step, generally the default value is used.
> - If the image noise is high, it is recommended to increase the acquisition frame count.

2 **Acquisition of bright field images**: perform this function to complete the bright field image acquisition.

> Caution!
> - It is recommended to aim at the white paper or the flat fluorescent lamp (to ensure the same amount of light in different areas of the sensor) and adjust the distance between the camera and the white paper/flat fluorescent lamp to fill the entire field of view.
> - 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 bright field is recommended to be greater than 20.
> - It is recommended to control the bright field gray value by adjusting the exposure time or light source, and do not adjust the aperture.

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

4 **Preview**: Preview the effect of the current FFC.

Read/Save Coefficient

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

> Caution!
> Available for part of the camera models: models that implement FFC in the camera. Other models are grayed out.

Load/Save File

1) Load from file: Load the saved FFC coefficient file (format: .ffc) from the file.
2) Save to file: Save the current coefficient to the FFC coefficient file (format: .ffc).

Precautions

The FFC coefficient is associated with the camera's features such as ROI, Binning, Decimation and Reverse X/Y. When the relevant parameters change, users need to perform FCC again to obtain the FFC coefficient. Otherwise, the correction data may be inconsistent with the current FFC coefficient, resulting in invalid FFC or unusual image.

For example: If FCC has been performed at a certain resolution and FFC coefficient has been written to the device, if you need to adjust ROI or set Binning (Decimation), Reverse X/Y and other parameters, you can follow the following steps.

1) Switch the FFC switch from on to off.
2) Stop the acquisition, modify the ROI to the expected value or set Binning (Decimation), Reverse X/Y and other parameters.
3) Start the acquisition, open the FFC plugin, and execute FFC coefficient calculation and save in order.

At this point, the FFC can be used normally under the new FFC coefficient.

8.4.7 Noise Reduction

During the digitization and transmission of an image, it is often disturbed by the noise of the imaging device and the external environment, which will cause the image to be made with noise. The process of reducing or suppressing the noise in the image is called image noise reduction.

Adjusting the noise reduction value can adjust the noise reduction intensity of the camera on the image. The adjustment range is 0-4.0. The larger the value, the higher the degree of noise reduction.

Noise reduction feature: determine whether to enable noise reduction. 'ON' means that the noise reduction feature is enabled. And 'OFF' means that the noise reduction feature is disabled.

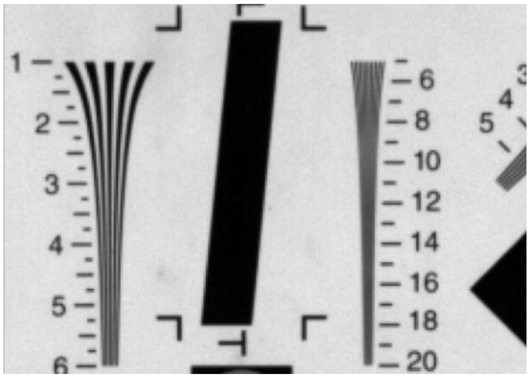


Figure 8-78 Before noise reduction

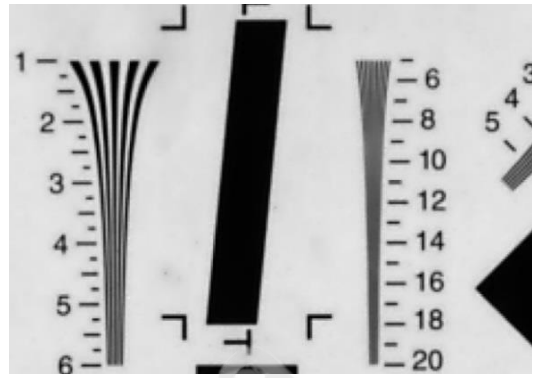


Figure 8-79 After noise reduction

8.5 Image Transmission

8.5.1 Calculate Frame Rate

Frame Period

You can calculate the frame period of the VZ USB Series cameras by the following formula:

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

Among them:

ImageSize = Width × Height × PixelSize + 84

Item	Description
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 1. In 10bit/12bit mode, the value is 2.
$BandWidth_{USB}$	The bandwidth of the USB 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)

Table 8-4 Items for calculating frame period

Frame rate (Unit: fps)

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

Note:
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 USB Interface Bandwidth

The theoretical bandwidth of the USB3.0 interface is 400MBps, but the value will decrease with the type of the USB3.0 host controller, the version of the host controller driver, the wastage of the HUB and the host performance. The user can refer to the test result of the interface bandwidth in <TN-USB3.0 host controller bandwidth and CPU utilization> document.

8.5.3 DeviceLinkThroughputLimit

The VZ USB Series cameras provide bandwidth limit function, 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, the current device acquisition bandwidth can be read from the camera. When the camera is working in trigger mode, the bandwidth limit will restrict the maximum trigger frequency.

- Ex 1) The VZ-5MU-M/C79H00 camera is working in continuous mode, the DeviceLinkCurrentThroughput is 35000000Bps, the DeviceLinkThroughputLimit is 40000000Bps, and then the DeviceLinkCurrentThroughput is still 35000000Bps. If the DeviceLinkCurrentThroughput is 70000000Bps, the DeviceLinkThroughputLimit is 40000000Bps, and then the DeviceLinkCurrentThroughput will be 40000000Bps.

- Ex 2) The VZ-5MU-M/C79H00 camera is working in trigger mode,
  the DeviceLinkCurrentThroughput is 300000000Bps, the maximum trigger frequency is 59.8Hz @ full resolution (8bit), when the DeviceLinkCurrentThroughput is 35000000Bps, the maximum trigger frequency is 6.9Hz @ full resolution (8bit).

Model	Min. of DeviceLinkThroughputLimit	Max. of DeviceLinkThroughputLimit	Step of DeviceLinkThroughputLimit
T_f	35000000Bps (8bit)	400000000Bps	1000000Bps
Width	70000000Bps (10bit)		
Height	70000000Bps (12bit)		

Table 8-5 Items of DeviceLinkThroughputLimit

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:

VZ-2MU-M/C41H00

The row period (unit: μs):

$$T_{row} = \frac{796}{40} = 19.9$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 38) \times T_{row}$$

VZ-2MU-M/C168H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{192}{40} = 4.8$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{192 \times 2}{40} = 9.6$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 38) \times T_{row}$$

VZ-3MU-M/C56H00

The row period (unit: μs):

$$T_{row} = \frac{452}{40} = 11.3$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 32) \times T_{row}$$

VZ-3MU-M/C125H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{203}{40} = 5.075$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{406}{40} = 10.15$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 38) \times T_{row}$$

VZ-5MU-M/C79H00, VZ-5MU-M/C79H00-POL

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{240}{40} = 6$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{240 \times 2}{40} = 12$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 38) \times T_{row}$$

51camera 志强视觉科技

VZ-5MU-M/C36H00, VZ-5MU-M/C36H00-POL

The row period (unit: μs):

$$T_{row} = \frac{532}{40} = 13.3$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 32) \times T_{row}$$

VZ-6MU-M/C60H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{420}{54} = 7.78$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{420 \times 2}{54} = 15.56$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 78) \times T_{row}$$

VZ-12MU-M/C32H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{720}{72} = 10$$

When the pixel format is Mono12 or BayerRG12, the row period (unit: μs):

$$T_{row} = \frac{720 \times 2}{72} = 20$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 38) \times T_{row}$$

VZ-12MU-M/C23H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{560}{40} = 14$$

When the pixel format is Mono12 or BayerRG12, the row period (unit: μs):

$$T_{row} = \frac{560 \times 2}{40} = 28$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 34) \times T_{row}$$

VZ-12MU-M/C32H10

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{376}{40} = 9.4$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{376 \times 2}{40} = 18.8$$

The camera acquisition time (unit: μs):

$$T_{acq} = (\mathit{Height} + 54) \times T_{row}$$

VZ-20MU-M/C19H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{900}{72} = 12.5$$

When the pixel format is Mono12 or BayerRG12, the row period (unit: μs):

$$T_{row} = \frac{900 \times 2}{72} = 25$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 38) \times T_{row}$$

VZ-400MU-M/C528H00

When the sensor bit depth is BPP8, the row period (unit: μs):

$$T_{row} = \frac{130}{40} = 3.25$$

When the sensor bit depth is BPP10, the row period (unit: μs):

$$T_{row} = \frac{157}{40} = 3.925$$

When the sensor bit depth is BPP12, the row period (unit: μs):

$$T_{row} = \frac{214}{40} = 5.35$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 42) \times T_{row}$$

VZ-1600U-M/C227H00

When the pixel format is Mono8 or BayerRG8, the row period (unit: μs):

$$T_{row} = \frac{157}{40} = 3.925$$

When the pixel format is Mono10 or BayerRG10, the row period (unit: μs):

$$T_{row} = \frac{157 \times 2}{40} = 7.85$$

The camera acquisition time (unit: μs):

$$T_{acq} = (Height + 42) \times T_{row}$$

8.6 Events

When event notification is set to "on", the camera can generate an "event" and transmit a related event message to the host whenever a specific situation has occurred.

For VZ USB Series cameras, they can generate and transmit events for the following situations:

- The camera has ended exposure (ExposureEnd)
- An image block is discarded (BlockDiscard)
- The trigger signal overflow (FrameStartOvertrigger)
- The image frame block is not empty (BlockNotEmpty)
- The burst trigger signal overflow (FrameBurstStartOvertrigger)
- The trigger signal wait (FrameStartWait)
- The burst trigger signal wait (FrameBurstStartWait)

Every event has a corresponding enable status, and in default all the events' enable status are disable. When using the event feature, you need to enable the corresponding event. The effective information contained in each event is shown in table 8-6.

No.	Event Type	Information
1	ExposureEnd Event	Event ID
		Frame ID
		Timestamp
2	BlockDiscard Event	Event ID
		Frame ID
		Timestamp
3	FrameStartOvertrigger Event	Event ID
		Frame ID
		Timestamp
4	BlockNotEmpty Event	Event ID
		Frame ID
		Timestamp
5	FrameBurstStartOvertrigger Event	Event ID
		Frame ID
		Timestamp
6	FrameStartWait Event	Event ID
		Frame ID
		Timestamp
7	FrameBurstStartWait Event	Event ID
		Frame ID
		Timestamp

Table 8-6 The effective information of each event

Among them: the timestamp is the time when the event occurs, and the timer starts when the camera is powered on or reset. The bit width of the timestamp is 64bits, and the unit is ns.

8.6.1 ExposureEnd Event

If the ExposureEnd Event is enabled, when the camera's sensor has been exposed, the camera sends out an ExposureEnd Event to the host, indicating that the exposure has been completed.

8.6.2 BlockDiscard Event

When the average bandwidth of the write-in data is greater than the average bandwidth of the read-out data, the frame buffer may overflow. If the frame buffer is full and the camera continues to write image data to it, then the new data will overwrite the previous image data which has been in the frame buffer. At this moment, the camera sends a BlockDiscard event to the host, indicating that once image discard event has occurred. So, when you read the next frame of image, the image is not continuous.

8.6.3 BlockNotEmpty Event

When the average bandwidth of the read-in data is greater than the average bandwidth of the readout data, if the frame buffer is not full, and there has image frame data in the frame buffer which has not been send out completely, then before the new image frame is written to the frame buffer, the camera will send a BlockNotEmpty event to the host, indicating that the previous image has not been send out completely when the new image is written in the frame buffer.

8.6.4 FrameStartOvertrigger Event

When the camera receives the FrameTrigger hardware trigger signal or software trigger signal, if the front-end sensor is exposing, it will not be able to respond to the new FrameTrigger signal, then the camera will send a FrameStartOvertrigger event to the host. Note that if multiple FrameTrigger signals are received within one frame acquisition period, the camera will send the corresponding number of FrameStartOvertrigger events.

8.6.5 FrameBurstStartOvertrigger Event

When the camera is in FrameBurstStart trigger mode, when it receives an AcquisitionTrigger hardware trigger or software trigger signal, if the front-end sensor is exposing, it will not be able to respond to the new AcquisitionTrigger signal, and the camera will send a FrameBurstStartOvertrigger event to the host. Note that the camera will send the corresponding number of FrameBurstStartOvertrigger events if it receives multiple AcquisitionTrigger signals during the acquisition period of one frame of image.

8.6.6 FrameStartWait Event

When the camera is in FrameTrigger mode, the camera starts acquiring images, and if it does not receive the FrameTrigger signal, the camera will send a FrameStartWait event to the host.

8.6.7 FrameBurstStartWait Event

When the camera is in AcquisitionTrigger mode, the camera starts acquiring images. If the camera does not receive the AcquisitionTrigger signal, the camera sends a FrameBurstStartWait event to the host. Note that if the FrameTrigger mode is set to on simultaneously with the AcquisitionTrigger mode, the FrameBurstStartWait event will be sent first. When the camera receives an AcquisitionTrigger signal, it will send a FrameBurstStartWait event.

8.7 UART Port

The camera supports the TTL serial port function, and the Tx/Rx and GPIO pins are multiplexed. Through the software API interface, it can be configured as either the GPIO or the serial port. After being configured as a serial port, the serial port commands can be transmitted to the GPIO pin of the camera through the API interface to control other serial port devices.

The baud rate supported by the serial port is 9600, 19200, 38400, 76800, 115200, and the data bit width is 8bit, the maximum length for a single transmission or reception is 1004 bytes. For more details or the sample code, please contact our technical support.

The wiring diagram of the camera and external serial port device is shown below. Line3 can be configured as Tx or Rx, the same as Line2. When Line3 is configured as Tx, it should be connected to the Rx of the UART module; At this time, Line2 should be configured as Rx and connected to the Tx of the UART module.

Due to the open drain output of Line2/Line3, it is necessary to supply power to the UART module at +3.3V/+5V for normal communication.

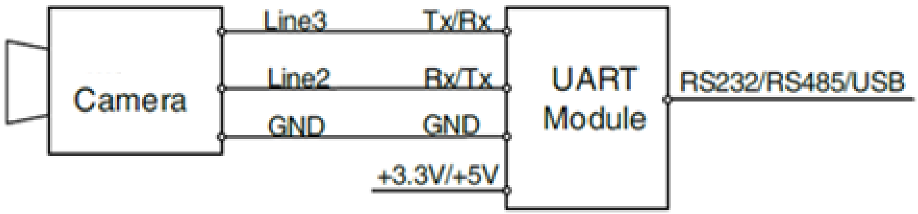


Figure 8-80 The wiring diagram of the camera and external serial port device

8.8 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 in Figure 8-81.

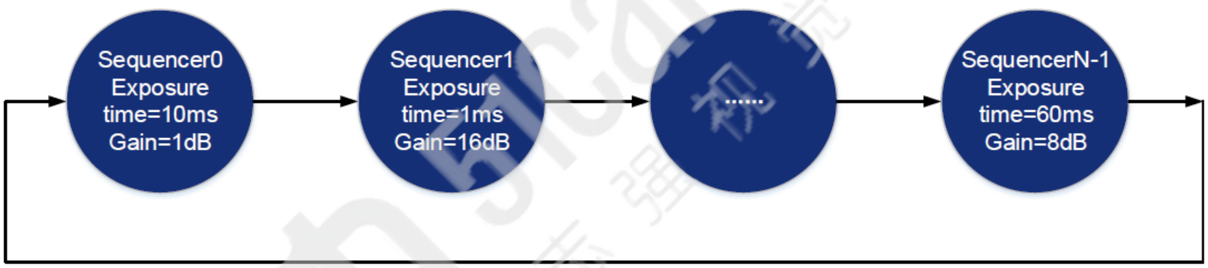


Figure 8-81 Sequencer feature schematic diagram

8.8.1 Relevant Parameters

[SequencerMode] Set the parameter to "On", enable the sequencer. Set the parameter to "Off", disable the sequencer. When enabled, the sequencer controls image acquisitions, switches to the 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 supports sequence, like ExposureTime, Gain.

[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".

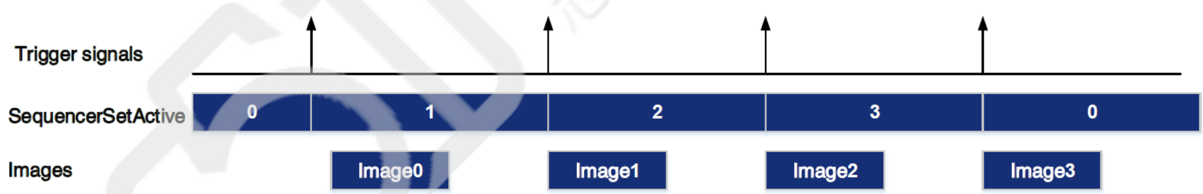


Figure 8-82 Timing Diagram

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

[SequencerSetNext] the "SequencerSetSelector" sets the 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 4, the maximum value of N+1 is 3.

[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.

8.8.2 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, Gamma, FFC coefficient number, etc.
5) Click "SequencerSetSave.

Change the number of Set sequence sets used

By default, sequence sets 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.

- When acquisition is stopped, the sequence set number is cleared to 0, and when acquisition is restarted, the sequence set number starts from 0 to perform the sequencer.
- Before "SequencerMode" is set to "On", the auto gain, auto exposure and auto white balance functions must be set to "Off".
- Sequencer Gain only supports digital gain, not analog gain.

1) When "SequencerConfigurationMode" is switched from "Off" to "On", the current value of "GainSelector" is automatically changed to digital gain.
2) When "SequencerMode" is switched from "Off" to "On", the current value of "GainSelector" is automatically changed to digital gain.

3) When both the "SequencerMode" and "SequencerConfigurationMode" are "Off", the "GainSelector" function will be restored to be settable, AnalogAll and DigtalAll are selectable. During auto gain adjustment, only analog gain is adjusted, digital gain is not adjusted but the setting value is valid.

- Sequencer parameters can be saved in the user set.
- Sequencer parameters do not support remove parameter limits.

8.8.3 Sequence Support

Model	Sequence support function	Max. sequence sets number
VZ-400U-M/C528H00 VZ-1600U-M/C227H00 VZ-2MU-M/C168H00 VZ-3MU-M/C125H00 VZ-5MU-M/C79H00 VZ-5MU-M79H00-POL VZ-12MU-M/C32H00 VZ-12MG-M/C9H10	ExposureTime, Gain	8

Table 8-7 Camera model sequence supported items

Chapter 9. Software Tools

9.1 LUT Create Tool

9.1.1 GUI

LUT Create Tool, which supports all series of Vieworks cameras. This plugin is integrated into VZViewer.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:

a) Adjust the image Gamma, brightness, and contrast.
b) Read the saved LUT from device.
c) Write the adjusted LUT to device.
d) Read the saved LUT from LUT/CSV file.
e) Save the adjusted LUT to file.

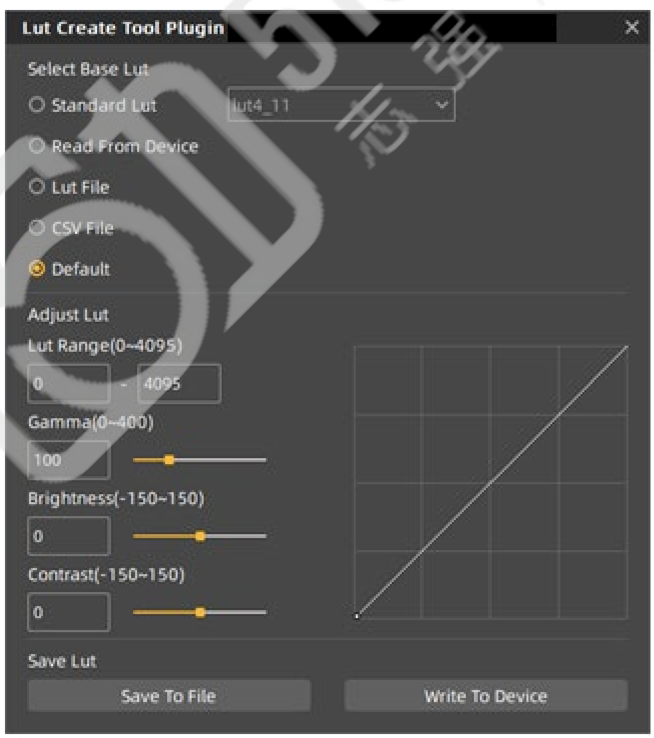


Figure 9-1 The GUI of LUT Create Tool

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

GUI	Description
Select Base LUT	Includes Standard LUT, Read from Device, LUT File, CSV File and Default. • Standard LUT : eight groups of factory standard LUTs. • Read from Device : LUT that can be read from device. • LUT/CSV file : Available to read the saved values. • Default : the camera default value.
Adjust 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	Display the currently generated LUT in a curve form.

Table 9-1 Function description of LUT Create Tool

9.1.2 User Guide

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 UserSet0. After the device is powered on again, select the "Read From Device" in the GroupBox to load the UserSet0 and restore the parameter value.

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.

Select Base LUT

1. Standard LUT:

When selecting standard Lut in Select Base LUT, the drop-down list box is enabled, which contains eight sets of optional standard Lut, as shown in Figure 9.2. These eight sets of values are factory sets, which can achieve the optimal image effect. When you choose a 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.

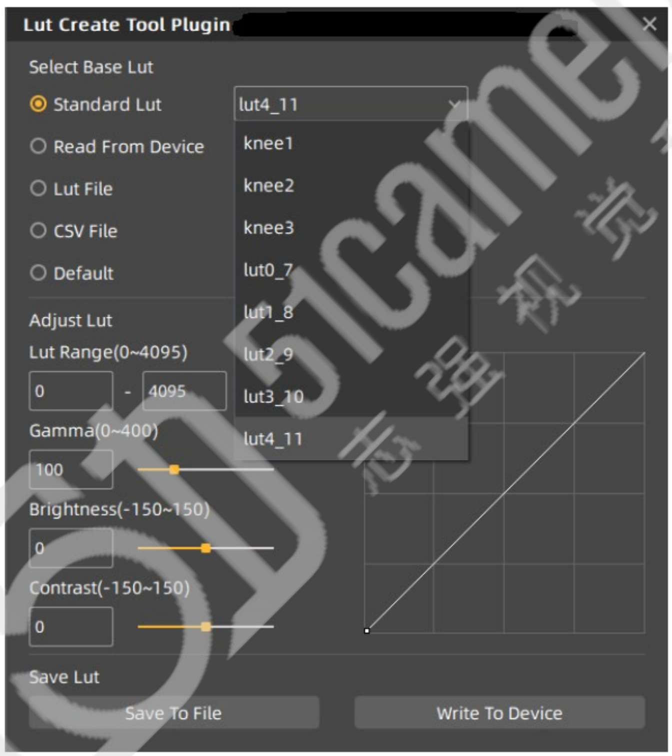


Figure 9-2 Standard Lut

2. Read From device:

When you select read from device, the tool will automatically load UserSet0 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 9-3.

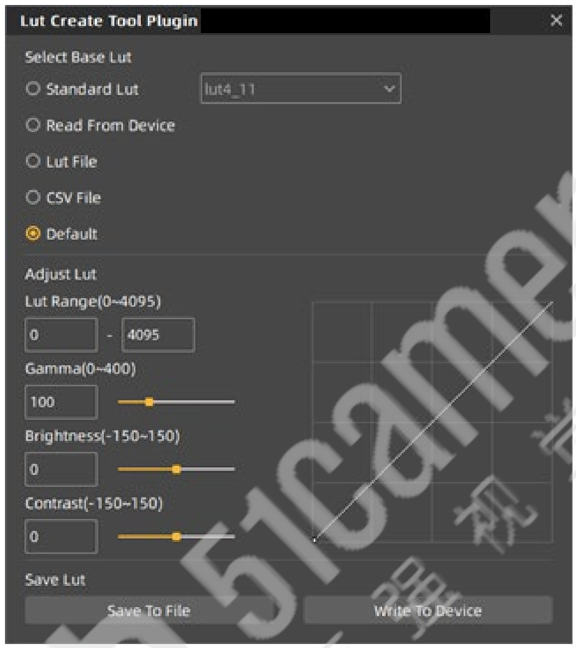


Figure 9-3 "Read From Device" disabled

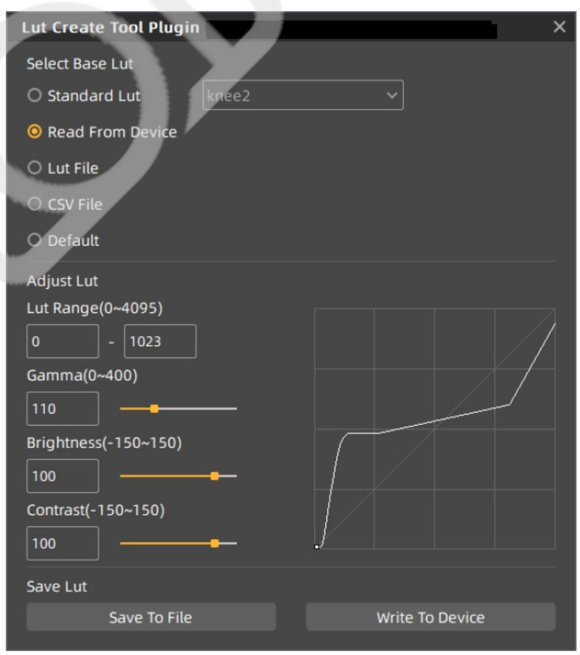


Figure 9-4 Select "Read From Device"

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 9-4.

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 9-5.

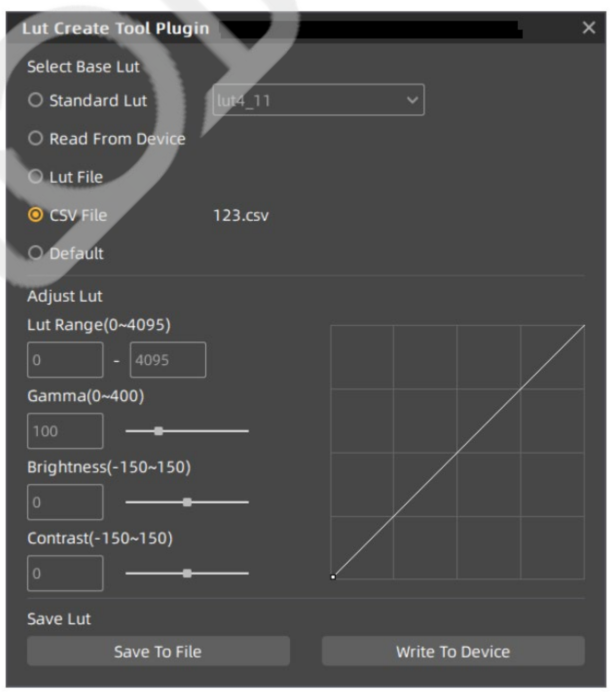


Figure 9-5 Select CSV file

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 another situation, it will automatically switch to the default. The default polyline graph is diagonal.

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, if 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. If written to the device, the cameras will save and restore the parameter.

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.

- You can change the save type when saving the file. The default save path is ".\resource\gxplugins\LookUpTable\Lut12" in the directory where VZViewer.exe is installed.

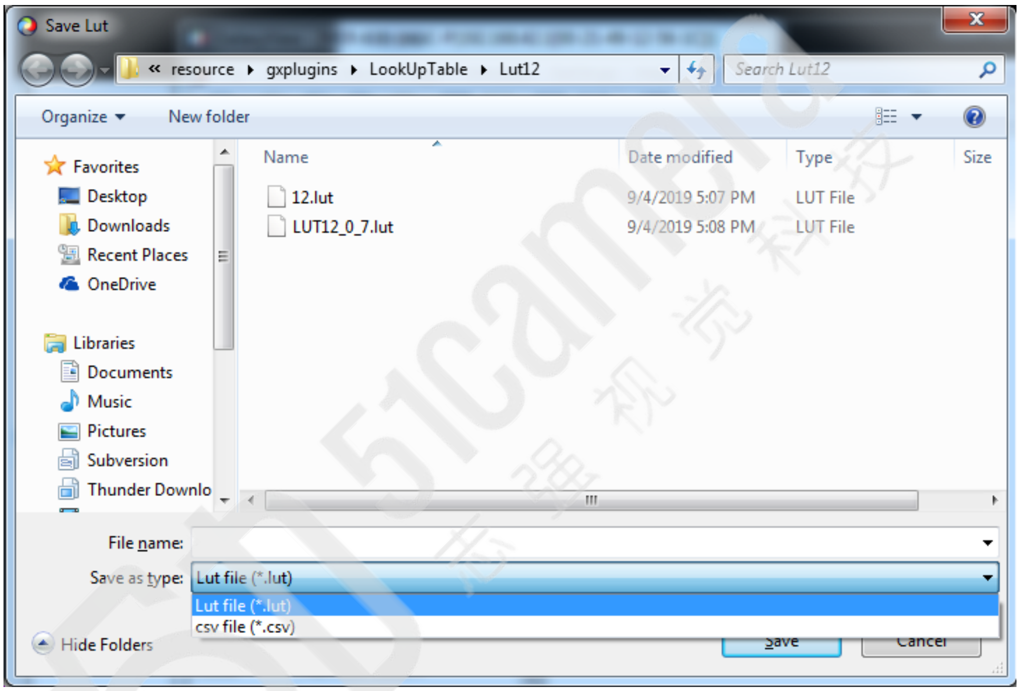


Figure 9-6 Save to file

2. When "Write To Device" is selected, the current Lut data is written to UserSet0, and UserSetDefault is modified to UserSet0. UserSet0 will be loaded when reading from the device again.

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 *UserSet0* and synchronously set the *UserSetDefault* to *UserSet0*. When reading from the device again, the camera will load the lookup table data.

> Note:
> The API interface supports C/C++/C#. For specific about the interface and example programs, please refer to "C SDK Programming Reference Manual", "C++ SDK Programming Reference Manual" or "DotNET SDK Programming Reference Manual".

9.1.3 Precautions

Read From Device

When reading from device, *UserSet0* 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.

Write To Device

To ensure that the device will restore the effect before power off after the device is power-on again. When writing to device, it will set the parameter set to *UserSet0* and set the *UserSetDefault* to *UserSet0*. If you do not want to restore the case and the Lut in the flash after powering off and restarting the device, please use the "Write To Device" function with caution.

Directory Structure

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.

9.2 Flat Field Correction Plugin

ShadingCorrectionTool.plx is the companion software for Vieworks' digital camera. The plugin is integrated into VZViewer.exe. After opening the device through this software, open the FFC plugin from the menu bar plugin list. Using the plugin, you can achieve the following functions.

1) Execute FFC on the current device.
2) Obtain the FFC factor that has been validated from the device.
3) Write the prepared FFC factor to the device to prevent the factor from being lost after the device is powered off.
4) Load the saved FFC factor from the file.
5) Save the prepared FFC factor to the file.

9.2.1 GUI

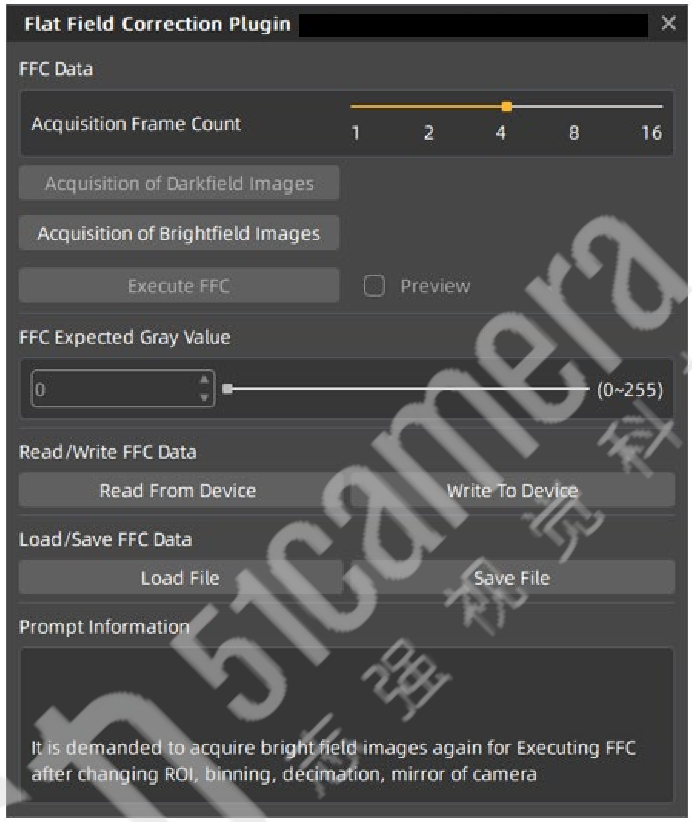


Figure 9-7 Flat field plugin GUI

After opening the device through VZViewer.exe and opening the FFC plugin, the initial state of the GUI is shown in Figure 9-7. The widgets layout and function description are as follows:

No.	Widget	Description
1	Acquisition Frame Count	The number of images acquired for the acquisition of bright field images.
2	Acquisition of Bright Field Images	Acquire a certain number of bright field images. Necessary operation.
3	Execute FFC	Calculate the FFC factor and make it Immediate effect.
4	Preview	Check the effects before and after the FFC
		Enable or disable FFC preview
5	Read from Device	If the device had executed FFC and the correction factor have been written to the device, the next time the camera is powered on, the FFC factor can be read directly from the device and take effect in real time.
6	Write to Device	Write the calculated FFC factor to the device to prevent factors loss when the device is powered off.
7	Load File	Load the FFC factor from the file and make it immediate effect.

51camera

8	Save File	Save the calculated FFC factor to a file. When the factor is subsequent used, it can be loaded directly from the file.
9	Prompt Information	Prompt the execution status and error message when executing FFC.
10	Default prompt message	It is demanded to acquire bright field images again for executing FFC after changing ROI, Binning, Decimation, Mirror of the camera. The prompt message will always be displayed on the GUI.

Table 9-2 Function description of the FFC widgets

9.2.2 User Guide

FCC Execution Steps

1. Set the acquisition frame count. Not necessary operation. You can skip to step 2 directly. For details, refer to Read/Save Coefficient in section 8.4.6.

2. Before acquiring bright field images, you need to align the lens to white paper or the flat fluorescent lamp.

3. Start acquiring bright field images. For details on acquiring bright field images, refer to Read/Save Coefficient in section 8.4.6.

4. Click "Execute FFC" to complete the correction

5. You can view the effect before and after FFC through the preview function.

6. You can choose to write the correction factor (including the Acquisition Frame Count) to the device or save it to a file for subsequent use.

Acquisition of Bright Field Images

1. When the device is in the stop acquisition mode, when you click "Acquisition of Brightfield Images", the image will be displayed in the VZViewer acquisition GUI.

2. When the device is in the acquisition mode, click "Acquisition of Brightfield image" to complete the bright field image acquisition.

3. The number of bright field images acquired is related to the Acquisition Frame Count. For example, if the number of Acquisition Frame Count is set to 4, when you click "Acquiring of Brightfield Image", images will be acquired for FFC calculation.

4. If the brightness of the acquired bright field image is less than 20, the prompt box will show "The bright field image is too dark, it will affect the flat field correction effect, it is recommended to adjust the brightness of the image in the range of 20-250" and then re-acquiring the bright field image.

5. If the brightness of the acquired bright field image is greater than 250, the prompt box will show "The bright field image is too bright, it will affect the flat field correction effect, it is recommended to adjust the brightness of the image in the range of 20-250" and then re-acquiring the bright field image.

Caution!

The larger the "Acquisition Frame Count" is set, the longer it will take to acquire the bright field images.
When the color camera is acquiring bright field images, if white balance has not been done, the image after FFC is an image with white balance effect.

Execute FFC

1. Click "Execute FFC" to calculate the FFC factor and set it to the device to take effect in real time. If the factor is not written to the device, it will be lost when the device is powered down. And the FFC needs to be redone.

2. Click "Execute FFC" to calculate the FFC factor and set it to the device to take effect in real time. If the factor is not written to the device, it will be lost when the device is powered down. And the FFC needs to be redone.

3. When the FFC is completed, the preview widget takes effect. The preview function can be used to check the effects before and after the FFC.

Read FCC Data from Device / Write FFC Data to Device

1. When reading FFC data from the device or writing FFC data to the device, the FFC is enabled by default. After the read from the device is successful, the FFC takes effect in real time.

2. When writing to the device, the user set will be saved, and the startup user set will be set to userset0.

Load FFC Data from File / Save FFC Data to File

1. When loading FFC data from a file or saving FFC data to file, the FFC is enabled by default. After the read from the device is successful, the FFC takes effect in real time.

2. When loading FFC data from a file or saving FFC data to file, the default file path is: under the installation path (\Vieworks\VZseriesSDK\Demo\Win64\resource\gxplugins\FlatFieldCorrection).

> **Caution!**
> When loading from a file, only files with a format of .ffc can be opened.

9.2.3 Precautions

FFC is not Supported

When the device does not support FFC, all widgets of the FFC plugin are disabled. The prompt box indicates that the device does not support FFC. Therefore, the FFC cannot be used for this device.

Preview

The preview widget is grayed out when acquiring bright field images and cannot be previewed.

9.3 Static Defect Correction Plugin

Static Defect Correction Plugin support all the cameras of Vieworks. The plugin is integrated into VZViewer.exe. After opening the device through VZViewer, open the Static Defect Correction plugin from the menu bar plugin list. Using the plugin, you can achieve the following functions:

a) Analyze the defect pixel in the current images of the device, including Bright dark scene and Actual scene.
b) Execute Static Defect Correction on the images.
c) Save the defect pixel information to the device. (The camera which support Static Defect Correction)
d) Save the defect pixel information to the file.

Screen image (example)

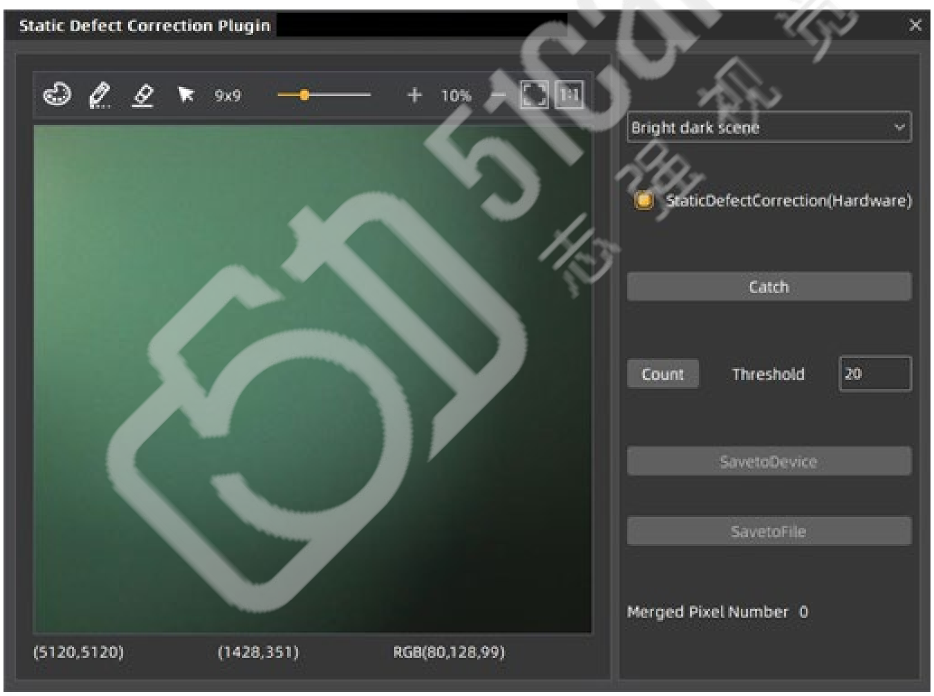


Figure 9-8 Static Defect Correction GUI

After opening the device through VZViewer.exe and opening the Static Defect Correction plugin, the initial state of the GUI is shown in Figure 9-8. The plugin layout and function description are as follows:

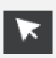
GUI	Description
Catch	Acquisition an image to analyze the location of the defect pixels and noise points.
Threshold	Set the threshold for defect pixels and judging noise points.
Bright dark scene	Count the defect pixels
Actual scene	Count the noise points
Count	Count the location of the defect pixels and noise points
StaticDefectCorrection (Hardware)	Choose whether to perform Static Defect Correction.
SavetoDevice	Save the defects information to the device.
SavetoFile	Save the defects information to a file.
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.
Merged pixel number	Display the number of defects
	Change the color of merged pixels
	Manually mark the defects on the image
	Erase the original merged pixels on the image
	Set mouse gestures as arrow
	Change the size of merged pixels
	Zoom in
	Zoom out
	Adaptive present image
	Present image 100%

Table 9-3 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 selecting 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 is displayed 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 checks the Static Defect Correction box, the image displayed on VZViewer 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.

9.3.1 Static Defect Correction Steps

1. Click the "Catch" to capture an image. For details, refer to “Acquisition Images”.
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 write the statistics of the defect pixel information into the device through "Save to Device", and it will still be valid after power off and restart the program.
7. The user can click the "Save to File" to save the statistics of defect pixel information to a file. For details, refer to “How to use defect pixel data file”.

9.3.2 Acquisition Images

- When the device is in the stop acquisition mode, click "Catch", the image will be displayed in the VZViewer acquisition GUI.
- When the device is in the acquisition mode, click "Catch" to complete the image acquisition.
- When counting defective pixels, it is required to acquire 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.
- 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.
- 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.
- When performing image scaling operation, the current image scaling ratio will be displayed.
- The current image width and height, pixel coordinates of mouse position and RGB value of mouse position are displayed in the status bar.
- Click "  " to select the manual mark color.
- Click "  ", set the mouse gestures as pencil to mark the defects on the image.
- Click "  " to erase the original merged pixels on the image.
- Click "  " to zoom in the image.
- Click "  " to zoom out the image.
- Click "  " to adapt present image.
- Click "  " to present image 100%.

- When performing image scaling operation, the current image scaling ratio will be displayed.
- The current image width and height, pixel coordinates of mouse position and RGB value of mouse position are displayed in the status.

9.3.3 Static Defect Correction

- "StaticDefectCorrection" is divided into "StaticDefectCorrection (software)" and "StaticDefectCorrection (hardware)"
- When the device performs 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)"
- The condition for the device to perform Static Defect Correction is that the device supports the Static Defect Correction function, and the number of defect pixels is less than 8192.
- When the device is in the acquisition mode, the user can check or uncheck "Static Defect Correction" to check the correction result.

Note:
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.

9.3.4 How to use defect pixel data file

a) The format of the defect pixel data file is ".dp" and ".csv", and the default save path is under the installation package directory: \Vieworks\VZseriesSDK\Demo\Win64\resource\gxplugins\DefectPixelCorrection;
b) 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.

9.4 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, acquisition frame rate control, and device link throughput limit.

Width	2448
Height	2048
BinningHorizontal	1
BinningVertical	1
DecimationHorizontal	1
DecimationVertical	1
ExposureTime(us)	10000
PixelFormat(8/10)	8
DeviceLinkThroughputLimit(Bps)	300000000
MaxUSBControllerThroughput(Bps)	380000000
AcquisitionFrameRateMode	off
AcquisitionFrameRate	79.1
FPS	59.83

Figure 9-9 Frame Rate Calculation Tool

9.4.1 Table Parameters

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

2) For more details about BinningHorizontal, BinningVertical, DecimationHorizontal and DecimationVertical, please refer to section <8.3.10 Binning> and section <8.3.11 Decimation>. 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.

6) The MaxUSBControllerThroughputLimit represents the recommended maximum transmission bandwidth of the camera. If this value is exceeded, frame losing may occur.

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

8) AcquisitionFrameRateMode 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 AcquisitionFrameRate. When frame rate control is disabled, the camera acquires images without being affected by the AcquisitionFrameRate.

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%.

Chapter 10. FAQ

No.	General Question	Answer
1	On the unactivated Windows7 64bit system, the installation of VZseries SDK has been successfully, but open the demo program failed.	Activate Windows7 64bit system, uninstall the package. Then, reinstall the package after restarting the system, and reopen the demo program.
2	The cameras cannot be enumerated.	1. Check if the network is connected. 2. Enumerate repeatedly. 3. Modify the host IP address and enumerate once again. 4. Make sure that the host IP address is not the same as the camera.
3	Fail to open device, it shows "Load XML failed".	Contact with the technical support to obtain upgrade program and then upgrade your cameras.
4	Fail to open device, it shows that "The device has been opened".	Confirm the data block timeout settings in the configuration page and adjust the timeout settings until the image data is received.
5	Fail to open device, it shows that "This device can only be operated on an USB3.0 Port".	Please check whether the camera is connected to USB2.0 port or USB2.0 HUB. Be sure to connect the camera to USB3.0 port.
6	No images after acquisition start.	1. Please load the default parameter set, reopen the demo, execute the command AcquisitionStart again, and then check the frame rate. 2. Open the demo, switch to stream features page, and decrease the number of StreamTransferNumberUrb to 10. Then try to execute the command AcquisitionStart again and check the frame rate. 3. Open the demo, switch to stream features page, check the statistic information, and check if any packet has been received. If there are some incomplete frames, please refer to section 2.4.
7	The frame rate is not up to the nominal value.	1. Change another PC with high performance. 2. It's recommended to use Intel host controller. 3. Be sure the main board support PCI-E2.0 or above. 4. If you have any other questions, please contact us.
8	Lose frames seriously in a multiple cameras' application	1. The bandwidth of the camera is more than the bandwidth of the host controller. You can decrease the bandwidth through the DeviceLinkThroughputLimit function. 2. Connect the camera to the host controller separately.
9	Camera crashes on Advantech AIIS- 1440 IPC.	Be sure the driver version of AMD USB controller is later than 2.20.

51camera 志强视觉科技

Vieworks Co., Ltd.

Headquarter

14055

Burim-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14055 Republic of Korea

Telephone: +82-70-7011-6161

Fax: +82-31-386-8631

Homepage: http://www.vision.vieworks.com

E-mail: vision@vieworks.com

Hwaseong Site

25-7, Jeongnamsandan 2-gil, Jeongnam-myeon, Hwaseong-si,

Gyeonggi-do, 18514 Republic of Korea

Telephone: +82-70-7011-6161