User Manual

English

Vieworks GigE CCD Cameras

VH-310G2
VH-2MG2
VH-4MG2
VH-5MG2
VH-11MG2
VH-16MG2

GigE VISION

vieworks

Revision History

Version	Date	Description
1.0	2013-01-24	Draft
1.1	2013-06-14	• Added description of M5 set screws for tilt adjustment • Revised spectral response to be separated by mono and color
1.2	2014-07-25	• Added the Exposure Auto and Gain Auto features • Added lwIP (lightweight IP) TCP/IP implementation

Contents

1 Precautions

General

- Do not drop, disassemble, repair or alter the device. Doing so may damage the camera electronics and cause an electric shock.
- Do not let children touch the device without supervision.
- Stop using the device and contact the nearest dealer or manufacturer for technical assistance if liquid such as water, drinks or chemicals gets into the device.
- Do not touch the device with wet hands. Doing so may cause an electric shock.
- Do not store the device at a higher temperature. In addition, maintain the temperature of the camera housing in a range of -5℃ to 40℃ during operation. Otherwise the device may be damaged by excessively high temperatures.

Installation and Maintenance

- Do not install in dusty or dirty areas - or near an air conditioner or heater to reduce the risk of damage to the device.
- Avoid installing and operating in an extreme environment where vibration, heat, humidity, dust, strong magnetic fields, explosive/corrosive mists or gases are present.
- Do not apply excessive vibration and shock to the device. This may damage the device.
- Avoid direct exposure to a high intensity light source. This may damage the image sensor.
- Do not install the device under unstable lighting conditions. Severe lighting change will affect the quality of the image produced by the device.
- Do not use solvents or thinners to clean the surface of the device. This can damage the surface finish.

Power Supply

- Applying incorrect power can damage the camera. If the voltage applied to the camera is greater or less than the camera's nominal voltage, the camera may be damaged or operate erratically. Please refer to 5.2 Specifications for the camera's nominal voltage.
  ※ Vieworks Co., Ltd. does NOT provide power supplies with the devices.
- Make sure the power is turned off before connecting the power cord to the camera. Otherwise, damage to the camera may result.

2 Warranty

Do not open the housing of the camera. The warranty becomes void if the housing is opened.
For information about the warranty, please contact your local dealer or factory representative.

3 Compliance & Certifications

3.1 FCC Compliance

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 generates, uses, and can 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 expenses.

3.2 CE : DoC

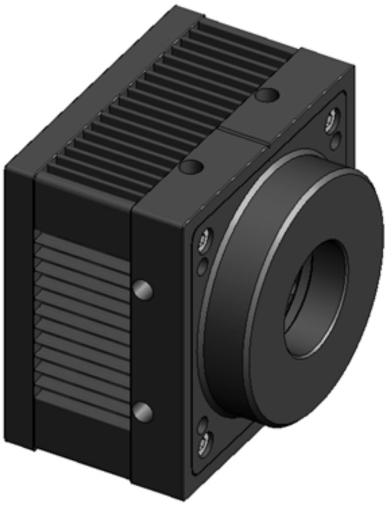
EMC Directive 2004/108/EC.
Testing Standard EN 55022:2006+A1:2007, EN 55024:1998+A1:2001+A2:2003
Class A

3.3 KC

KCC Statement

Type	Description
Class A (Broadcasting Communication Device for Office Use)	This device obtained EMC registration for office use (Class A), and may be used in places other than home. Sellers and/or users need to take note of this.

4 Package Components

Package Components	
	
VH Camera with C mount,	VH Camera with F mount or
	
VH-310G2 Camera with C mount	
	
Mount Plate (Optional)	

Package Components

M5 Set Screws for Tilt Adjustment (Provided only with F-mount camera)

CAUTION	• You can adjust the tilt using the M5 set screws, however it is not recommended since it is adjusted as factory default settings. • If the tilt settings need to be adjusted inevitably, please contact your local dealer or factory representative for technical support.

5 Product Specifications

5.1 Model

VH GigE series is a progressive scan high performance industrial digital camera. All features of the camera can be easily updated in the field through Gigabit Ethernet interface. The camera uses the latest CCD technology from Truesense Imaging, Inc. (formerly Kodak Imaging Solution) and Sony which provides superior low noise performance resulting in high dynamic range. The camera is developed based on GenICam standard. The image processing and controls of VH GigE series are based on embedded FPGA with a 32 bit microprocessor.

Main Features

- Normal and High Speed Operation Modes
- ×1, ×2, ×3, ×4, ×8 Horizontal and Vertical Binning
- Real Exposure
- Stream Hold
- Inter-Packet Delay
- Camera Image Memory: 128 MB
- Field Upgradable Firmware
- Pixel Defect Correction (Binning Mode: 2×2, 4×4)
- Excellent Dynamic Range and Noise Performance
- Auto Exposure, Auto Gain Controls

5.2 Specifications

VH GigE series technical specifications are as follows.

VH GigE Series		VH-310G2	VH-2MG2	VH-4MG2
Active Image (H × V)		640 × 480	1600 × 1200	2048 × 2048
Sensor Type		Truesense Imaging KAI-0340	Truesense Imaging KAI-2020	Truesense Imaging KAI-0421
Pixel Size		7.4 ㎛ × 7.4 ㎛		
Sensor Output		1 or 2 Tap		
Video Output		8/10/12 bits		
Dynamic Range		> 60 ㏈	> 62 ㏈	
Output Format	Mono	Mono8, Mono10, Mono10 packed, Mono12, Mono12 packed		
	Color	Bayer8, Bayer10, Bayer10 packed, Bayer12, Bayer12 packed		
Camera Interface		Gigabit Ethernet		
Electronic Shutter		Global Shutter		
Max. Frame Rate at Full Resolution		140 / 264 fps	23 / 42 fps	11 / 20 fps
Pixel Clock		40 / 50 ㎒		
Shutter Speed (10 ㎲ step)		16 ㎲ ~ 7s	37 ㎲ ~ 7s	55 ㎲ ~ 7s
Partial Scan (Max. Speed)		1396 fps at 60 Lines	159 fps at 150 Lines	86 fps at 256 Lines
Binning		×1, ×2, ×3, ×4, ×8 (Horizontal and Vertical Independent)		
Lookup Table		G=1.0, User Defined Lookup Table (LUT)		
Black Level		Adjustable (0 ~ 127 LSB at 12 bit, 256 steps)		
Analog Gain		×1 ~ ×40 (0 ~ 32 ㏈)		
Exposure Mode		Timed Exposure, Trigger Width Exposure, Double Exposure		
External Trigger		3.3 V ~ 24.0 V, 10 ㎃, Asynchronous, optically isolated		
Software Trigger		Asynchronous, Programmable via Camera API		
Camera Image Memory		128 MB		
Lens Mount		C-mount	C-mount or F-mount	
Power		10~15 V DC, Max. 6W		
Environmental		Operating: -5℃ ~ 40℃, Storage: -40℃ ~ 70℃		
Mechanical		49 ㎜ × 49 ㎜ × 62 ㎜, 220g (VH-310G2) 68 ㎜ × 68 ㎜ × 54 ㎜, 395 g (with C-mount) 68 ㎜ × 68 ㎜ × 83 ㎜, 430 g (with F-mount)		

Table 5.1 Specifications of VH GigE Series (VH-310/2/4MG2)

VH GigE Series		VH-5MG2	VH-11MG2	VH-16MG2
Active Image (H × V)		2448 × 2056	4008 × 2672	4872 × 3248
Sensor Type		Sony ICX625	Truesense Imaging KAI-11002	Truesense Imaging KAI-16000
Pixel size		3.45 ㎛ × 3.45 ㎛	9.0 ㎛ × 9.0 ㎛	7.4 ㎛ × 7.4 ㎛
Sensor Output		2 Tap	1 or 2 Tap	
Video Output		8/10/12 bits		
Dynamic Range		> 52 ㏈	> 64 ㏈	
Output Format	Mono	Mono8, Mono10, Mono10 packed, Mono12, Mono12 packed		
	Color	Bayer8, Bayer10, Bayer10 packed, Bayer12, Bayer12 packed		
Camera Interface		Gigabit Ethernet		
Electronic Shutter		Global Shutter		
Max. Frame Rate at Full Resolution		16 fps	3.4 / 6.4 fps	2.2 / 4.2 fps
Pixel Clock		60 ㎒	30/40 ㎒	
Shutter Speed (10 ㎲ step)		29 ㎲ ~ 7s	131 ㎲ ~ 7s	209 ㎲ ~ 7s
Partial Scan (Max. Speed)		41 fps at 256 Lines	27 fps at 334 Lines	15 fps at 406 Lines
Binning		×1, ×2, ×3, ×4, ×8 (Horizontal and Vertical Independent)		
Lookup Table		G=1.0, User Defined Lookup Table (LUT)		
Black Level		Adjustable (0 ~ 127 LSB at 12 bit, 256 steps)		
Analog Gain		×1 ~ ×40 (0 ~ 32 ㏈)		
Exposure Mode		Timed Exposure, Trigger Width Exposure, Double Exposure		
Auto Control (Only available on VH-5MG2)		Auto Exposure, Auto Gain Control		
External Trigger		3.3 V ~ 24.0 V, 10 ㎃, Asynchronous, optically isolated		
Software Trigger		Asynchronous, Programmable via Camera API		
Camera Image Memory		128 MB		
Lens Mount		C-mount or F-mount	F-mount	
Power		10~15 V DC, Max. 6W	10~15 V DC, Max. 10W	
Environmental		Operating: -5℃ ~ 40℃, Storage: -40℃ ~ 70℃		
Mechanical		68 ㎜ × 68 ㎜ × 54 ㎜, 395 g (with C-mount) 68 ㎜ × 68 ㎜ × 83 ㎜, 430 g (with F-mount)		

Table 5.2 Specifications of VH GigE Series (VH-5/11/16MG2)

5.3 Camera Block Diagram

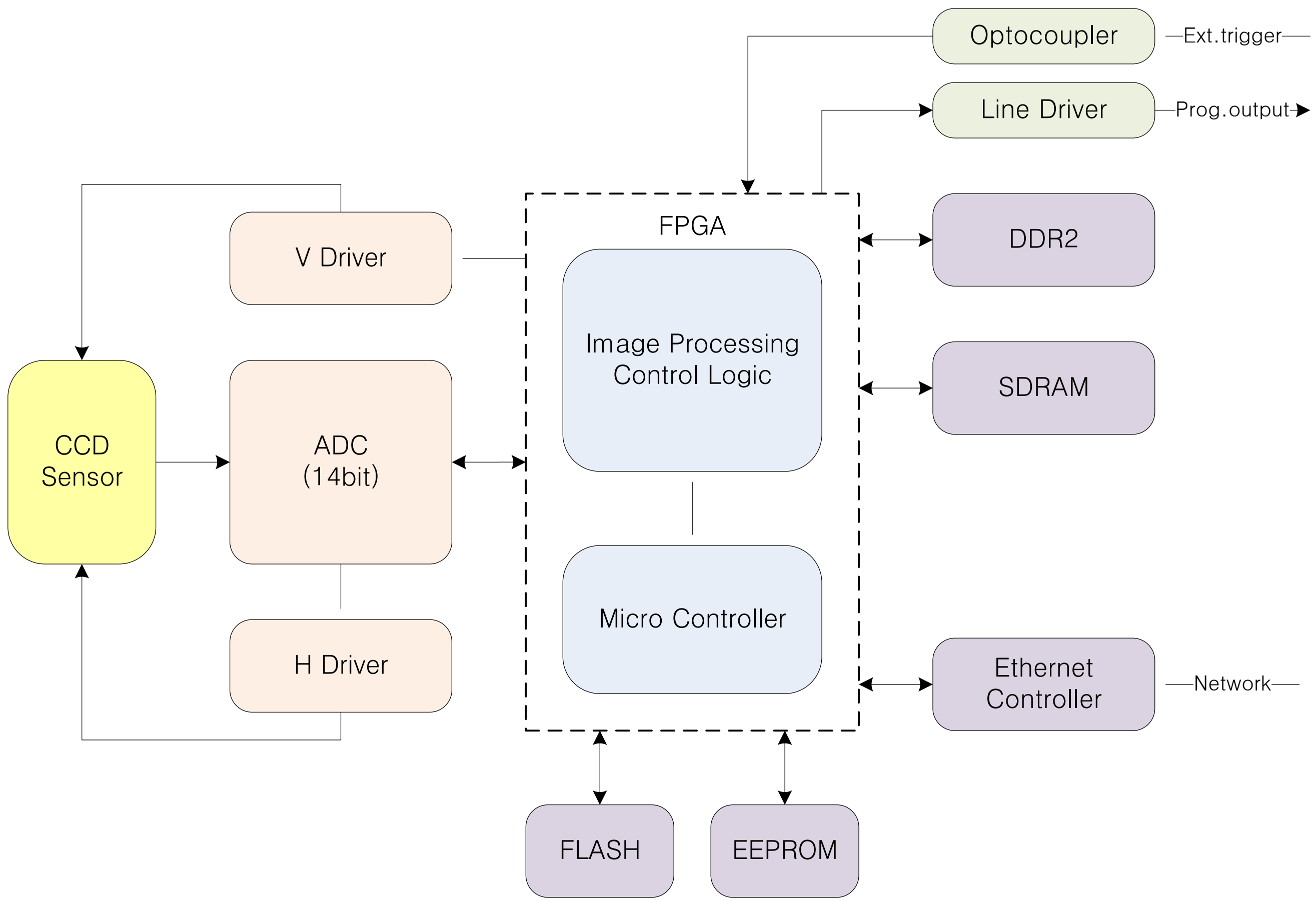


Figure 5.1 Camera Block Diagram

All controls and data processing of VH GigE cameras are carried out in one FPGA chip. The FPGA generally consists of a 32 bit RICS Micro-Controller and Processing & Control Logic. The Micro-Controller receives commands from the user through the Gigabit Ethernet interface and then processes them. The FPGA controls the Timing Generators (TGs) and the Analog Front End (AFE) chips where the TGs generate CCD control signals and AFE chips convert analog CCD output to digital values to be accepted by the Processing & Control Logic. The Processing & Control Logic processes the image data received from AFE and then transmits data through the Gigabit Ethernet interface. And also, the Processing & Control Logic controls the trigger input and output signal which are sensitive to time. Furthermore, DDR2 for operating Micro-Controller and for used as Gigabit Ethernet frame buffer, SDRAM for used as a frame buffer to process images, Gigabit Ethernet Controller and Flash memory for saving system codes and defect coordinates are installed outside FPGA.

5.4 Spectral Response

5.4.1 Mono Camera Spectral Response

The following graphs show the spectral response for VH GigE series monochrome cameras.

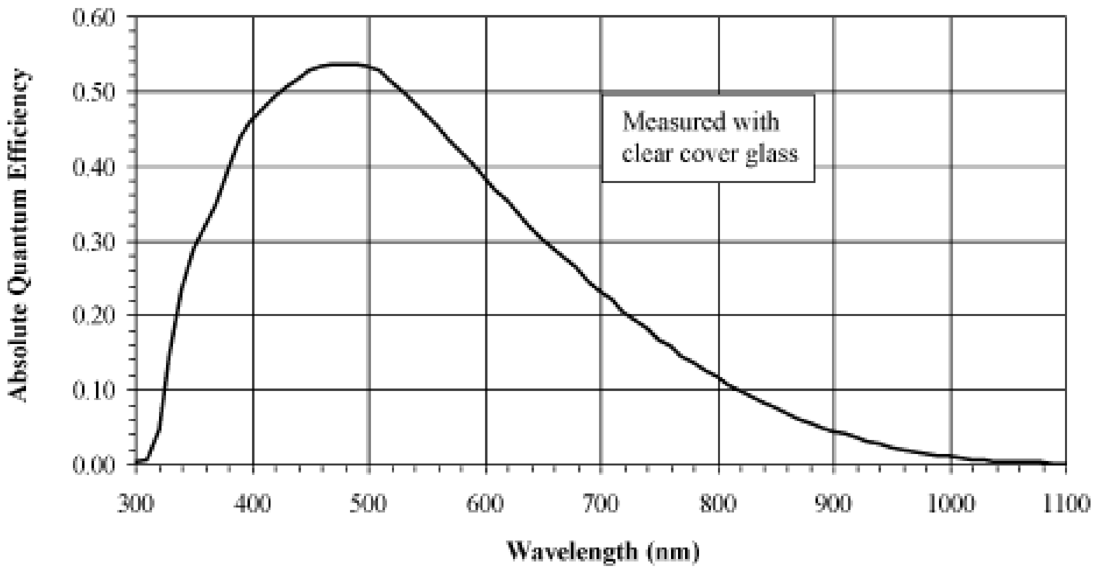


Figure 5.2 VH-310G2-M264 Spectral Response

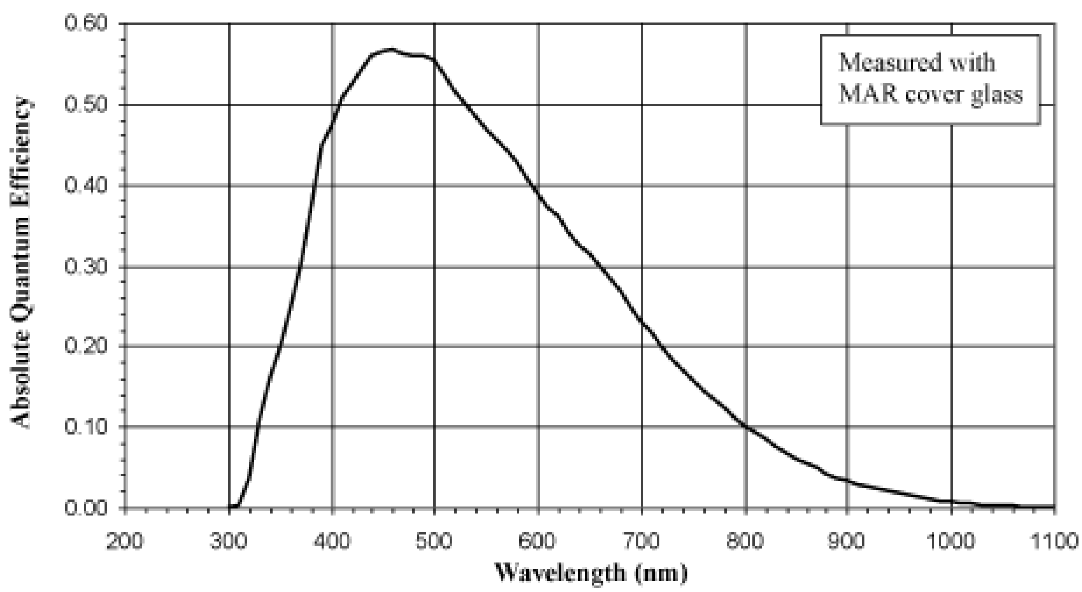


Figure 5.3 VH-2MG2-M42 Spectral Response

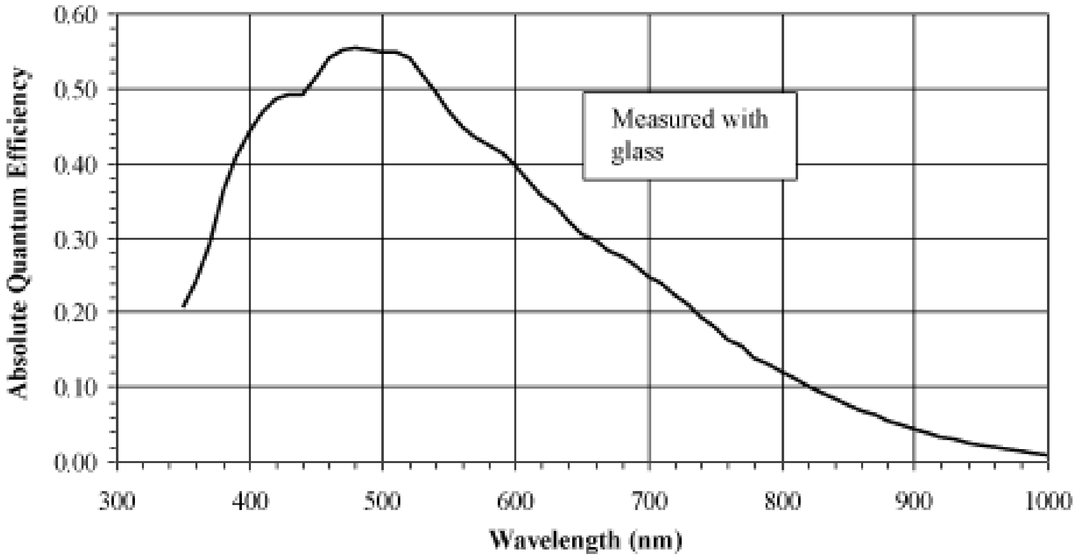


Figure 5.4 VH-4MG2-M20 Spectral Response

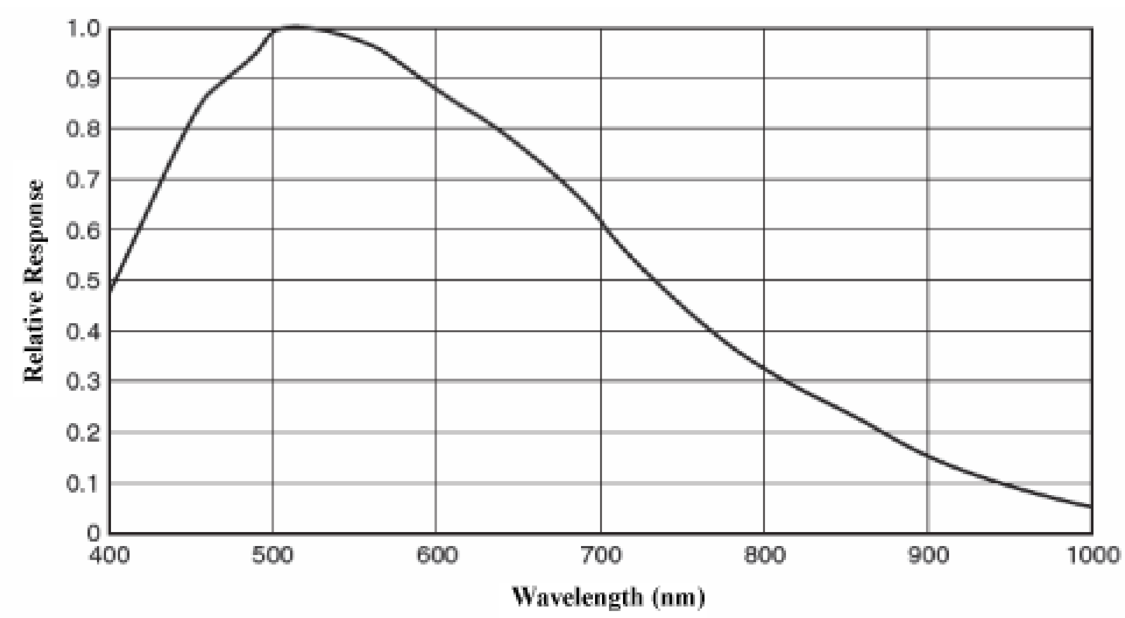


Figure 5.5 VH-5MG2-M16 Spectral Response

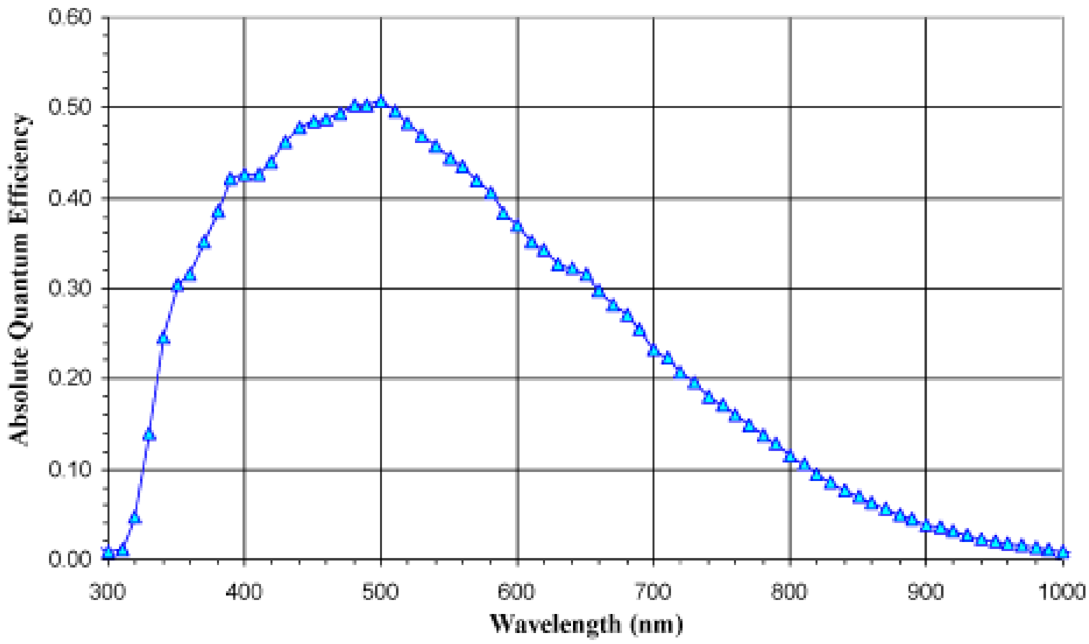


Figure 5.6 VH-11MG2-M6 Spectral Response

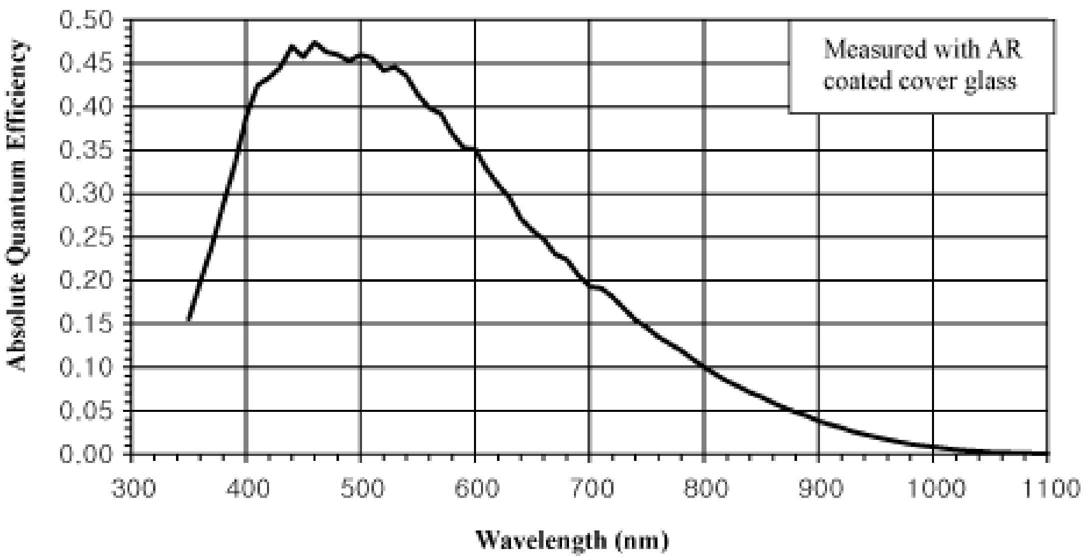


Figure 5.7 VH-16MG2-M4 Spectral Response

5.4.2 Color Camera Spectral Response

The following graphs show the spectral response for VH GigE series color cameras.

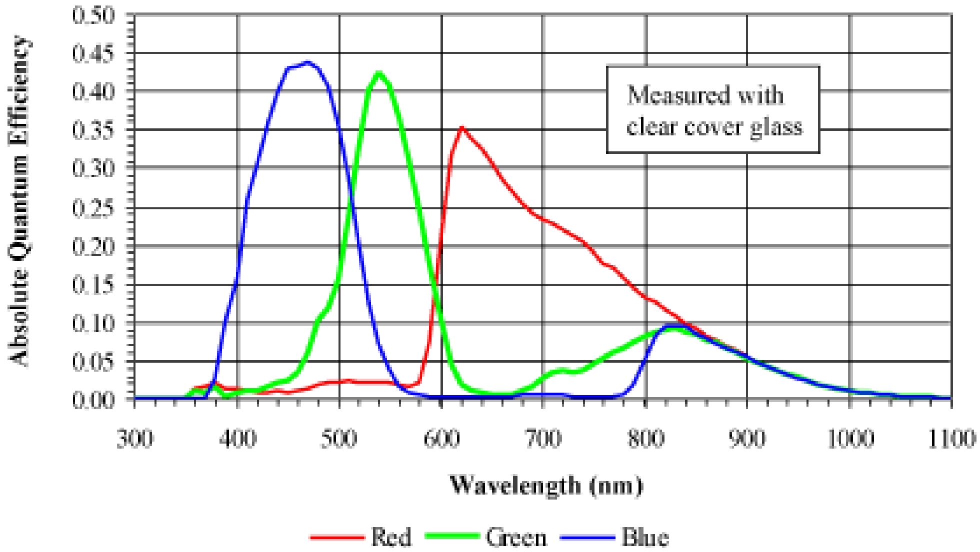


Figure 5.8 VH-310G2-C264 Spectral Response

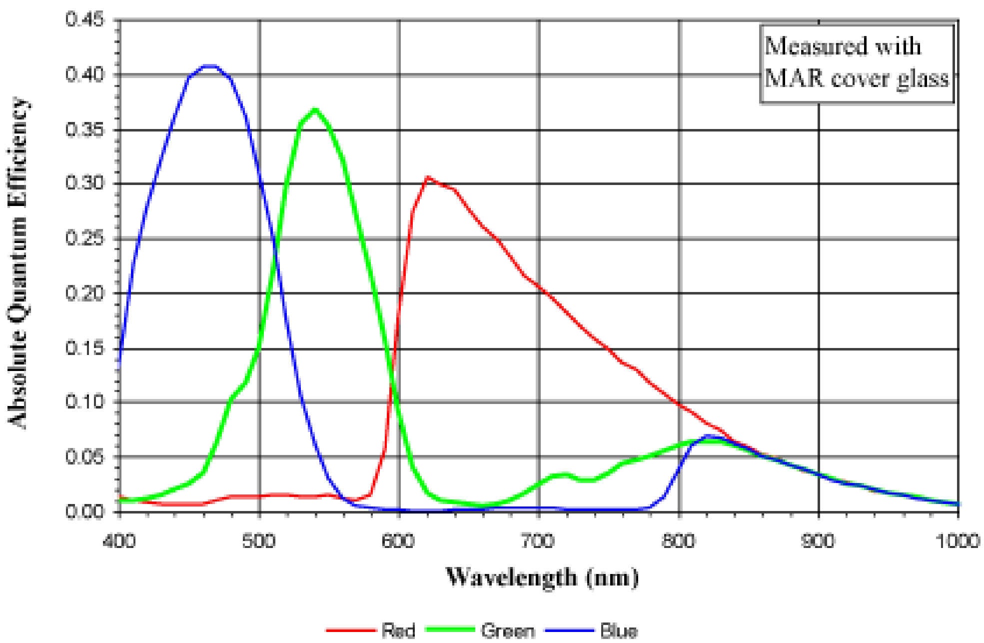


Figure 5.9 VH-2MG2-C42 Spectral Response

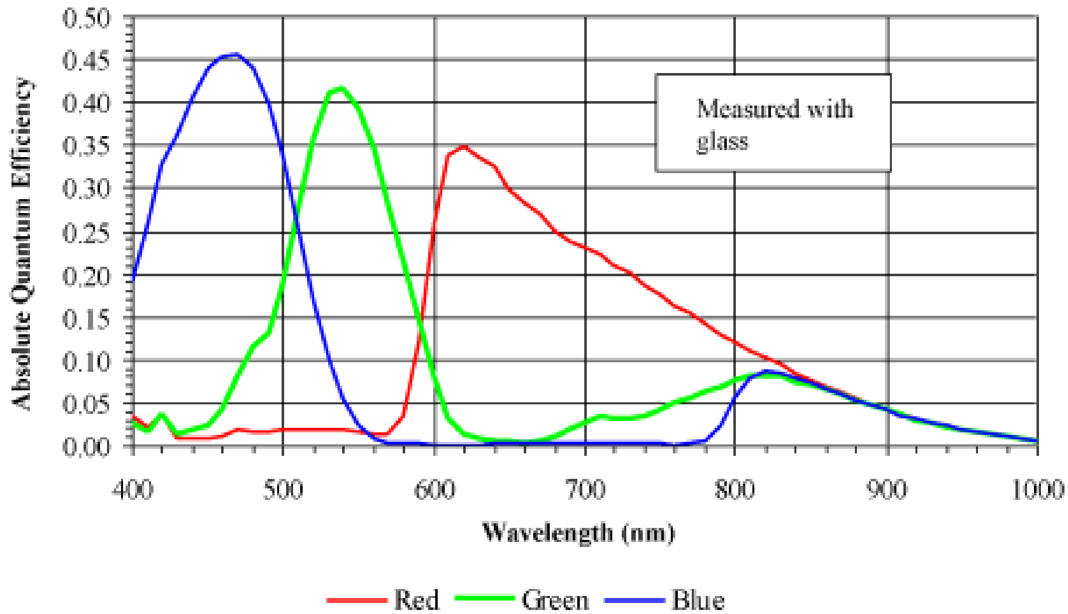


Figure 5.10 VH-4MG2-C20 Spectral Response

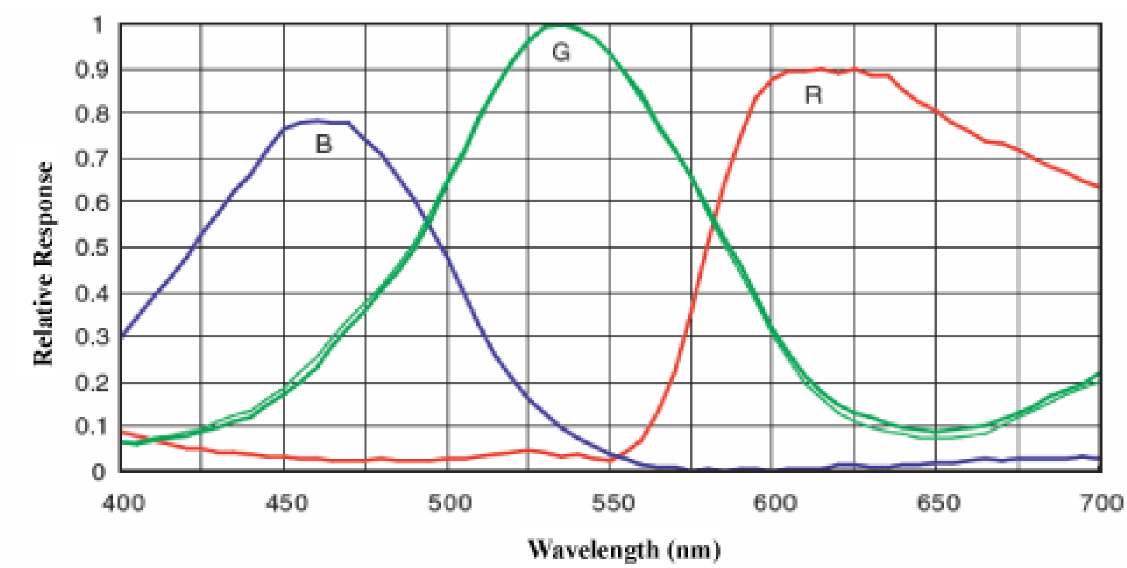


Figure 5.11 VH-5MG2-C16 Spectral Response

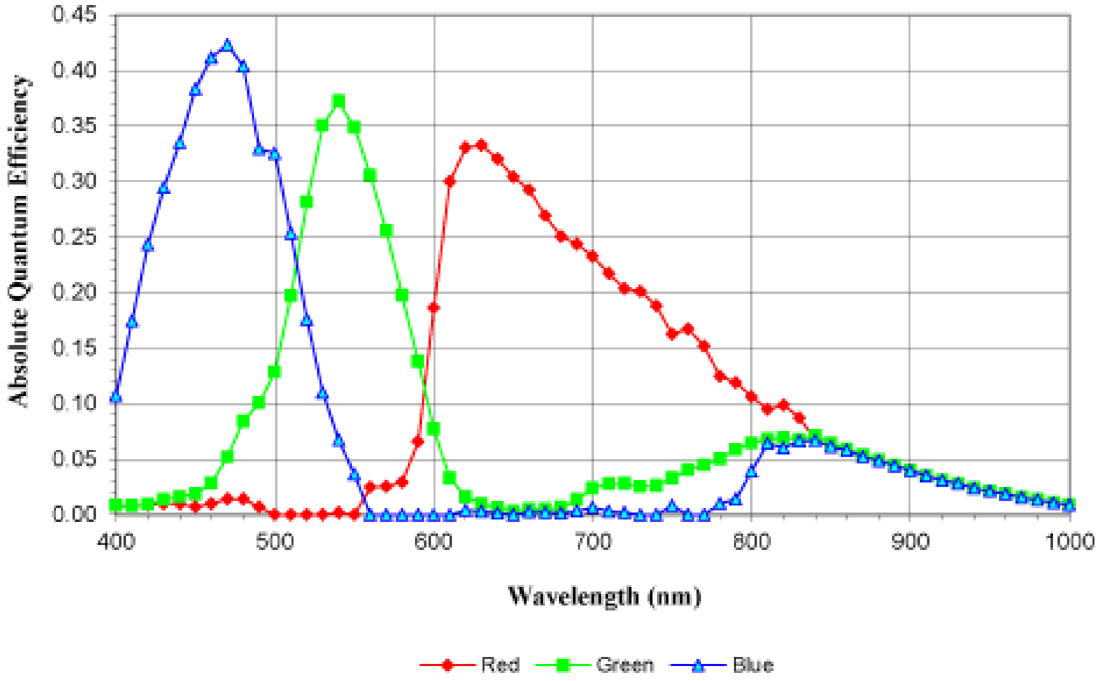


Figure 5.12 VH-11MG2-C6 Spectral Response

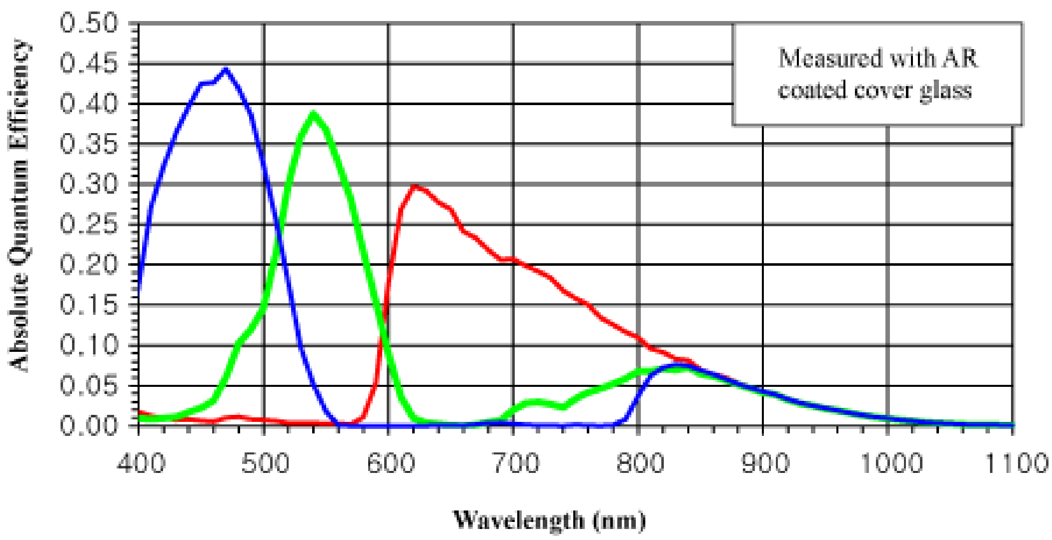


Figure 5.13 VH-16MG2-C4 Spectral Response

5.5 Mechanical Specification

The camera dimensions in millimeters are as shown in the following figure.

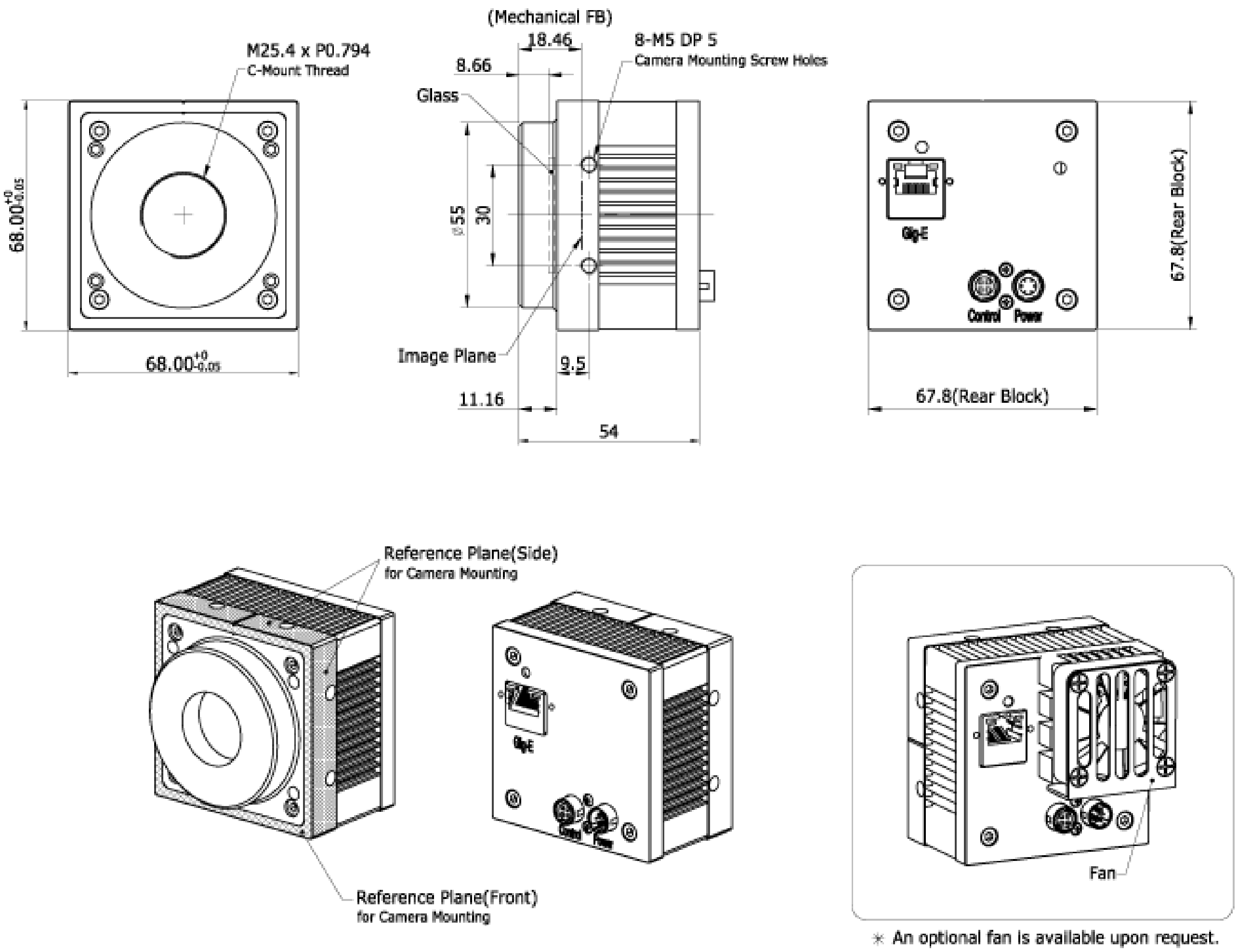


Figure 5.14 VH GigE Series C-mount Mechanical Dimension

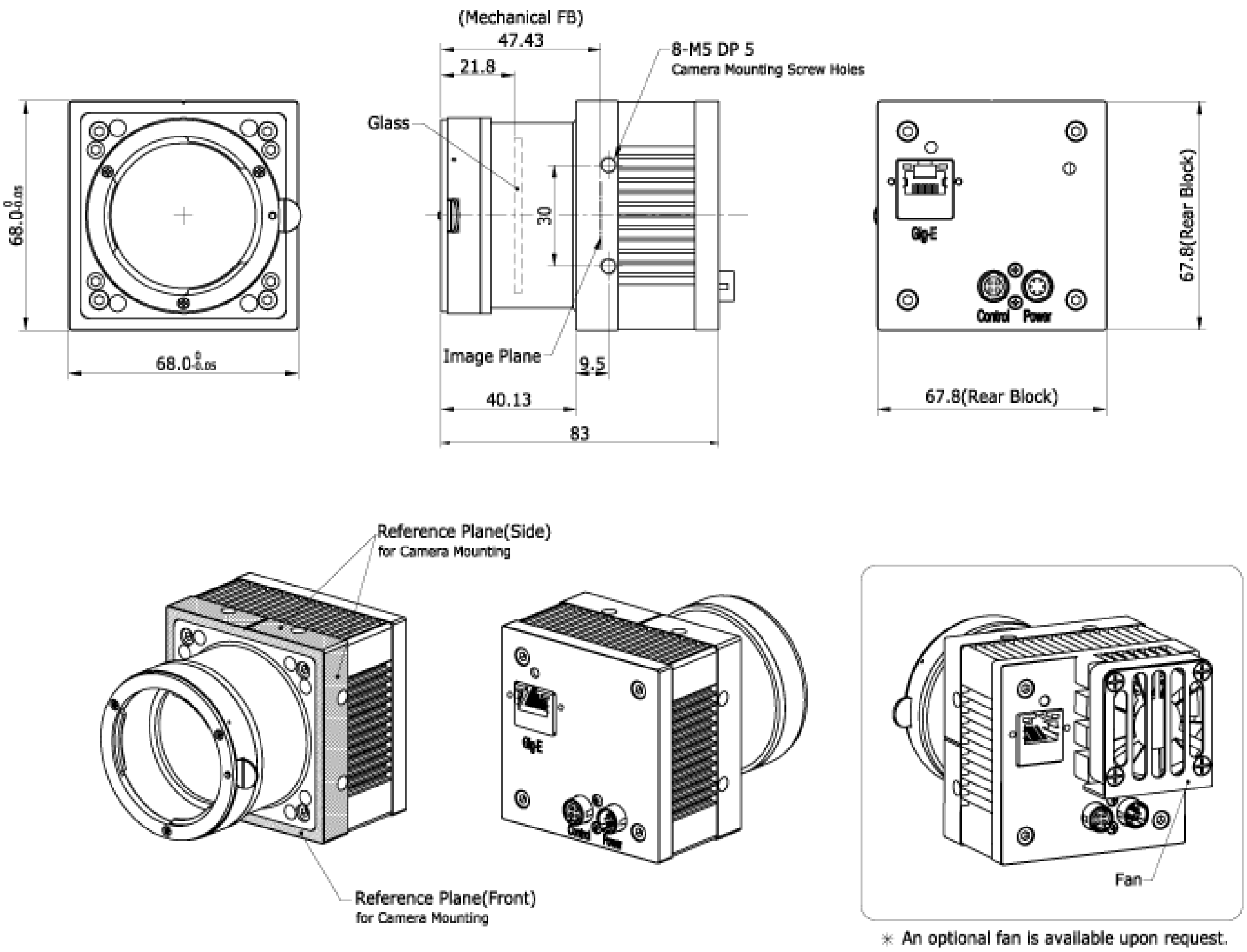


Figure 5.15 VH GigE Series F-mount Mechanical Dimension

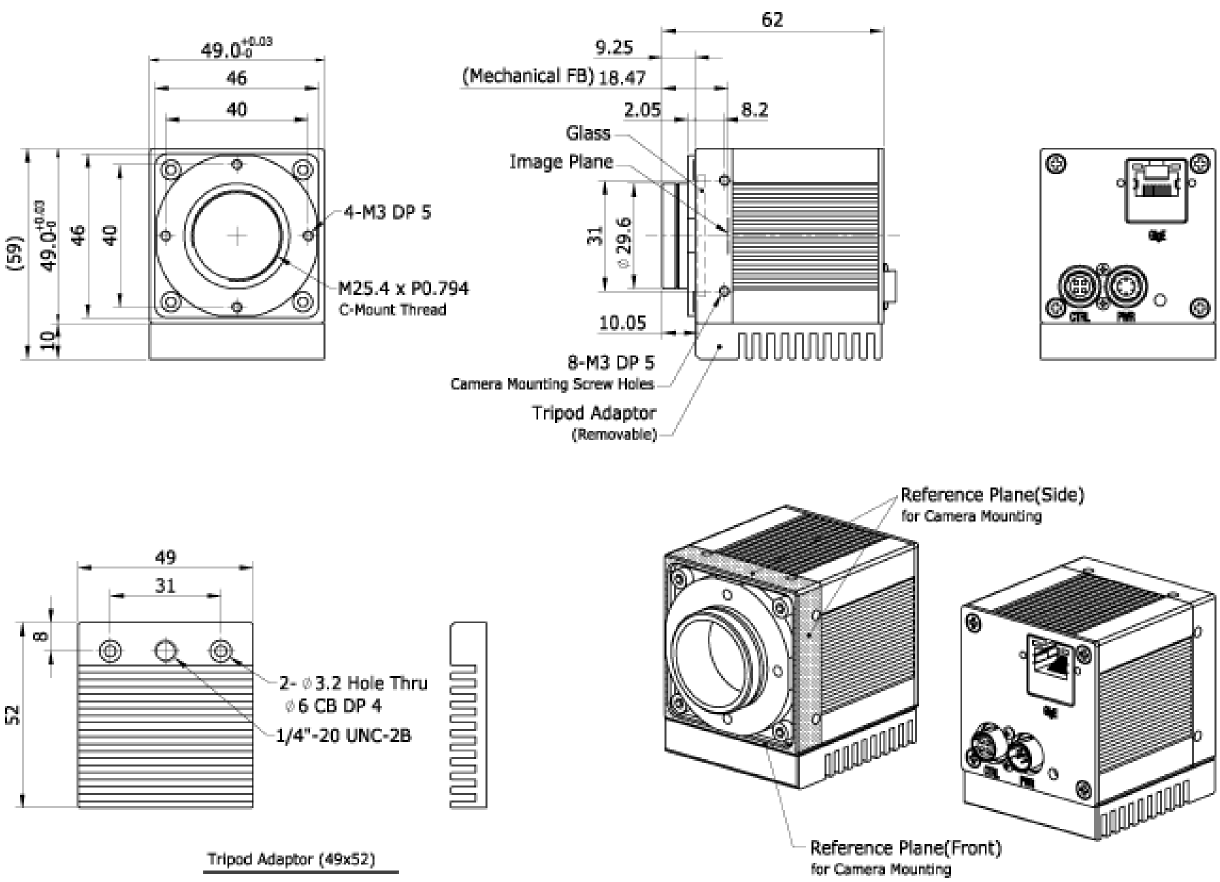


Figure 5.16 VH-310G2 C-mount Mechanical Dimension

6 Software Licensing Information

The software in VH GigE series includes the lightweight IP (lwIP) TCP/IP implementation. The software licensing information for this implementation is as follows.

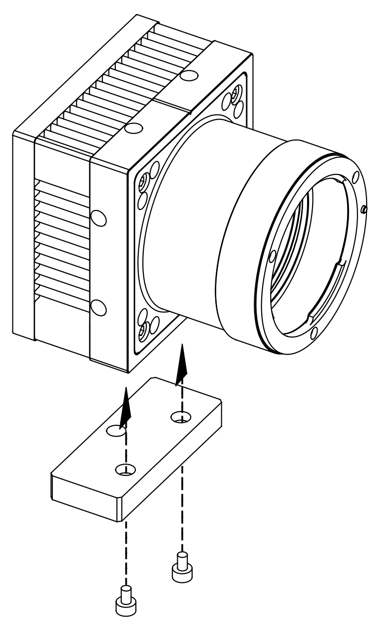
7 Connecting the Camera

The following instructions assume that you have installed an Ethernet Card including related software and **Vieworks Imaging Solution** in your PC. For more information, refer to your Vieworks Imaging Solution Installation Manual.

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

1. Make sure that the power supply is not connected to the camera and your PC is turned off.
2. Plug one end of an Ethernet cable into the RJ45 jack on the camera and the other end of the Ethernet cable into the Ethernet Card in your PC.
3. Connect the plug of the power adaptor to the power input receptacle on the camera.
4. Plug the power adaptor into a working electrical outlet.
5. Verify all the cable connections are secure.

7.1 Mount Plate



- The Mount Plate is provided as an optional item.
- The camera can be fixed without using this Mount Plate.
- The mount plate is integrated for VH-310G2 model.

7.2 Precaution to Center the Image Sensor

- Users do not need to center the image sensor as it is adjusted as factory default settings.
- When you need to adjust the center of the image sensor, please contact your local dealer or the manufacturer for technical assistance.

7.3 Precaution about Blurring Compared to Center

- Users do not need to adjust the tilt as it is adjusted as factory default settings.
- If the tilt settings need to be adjusted inevitably, please contact your local dealer or factory representative for technical support.

7.4 Installing Vieworks Imaging Solution

You can download the Vieworks Imaging Solution at machinevision.vieworks.com.
You should perform the software installation first and then the hardware installation.

8 Camera Interface

8.1 General Description

As shown in the following figure, 3 types of connectors and status indicator LED are located on the back of the camera and have the functions as follows:

- ① Status LED: displays power status and operation mode.
- ② RJ-45 Jack: controls video data and the camera.
- ③ 4 pin Control Receptacle: inputs external trigger signal and outputs strobe.
- ④ 6 pin Power Input Receptacle: supplies power to the camera.

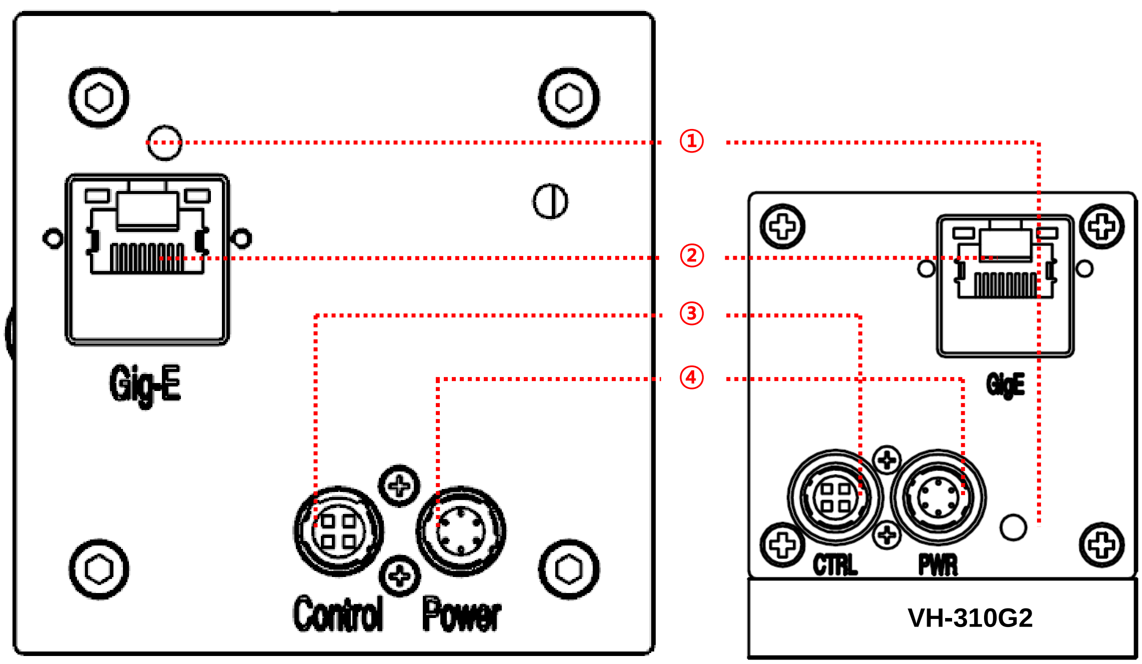


Figure 8.1 VH GigE Series Back Panel

8.2 RJ-45 Jack

The 8-pin RJ-45 jack provides Ethernet access to the camera. Pin assignments for the RJ-45 jack adhere to the Ethernet standard.

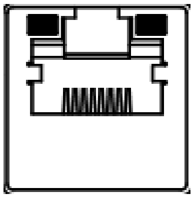


Figure 8.2 RJ-45 Jack

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	+TXA	Differential	Gigabit Ethernet Transceiver
	2	-TXA	Differential	Gigabit Ethernet Transceiver
PAIR 1	3	+TXB	Differential	Gigabit Ethernet Transceiver
	6	-TXB	Differential	Gigabit Ethernet Transceiver
PAIR 2	4	+TXC	Differential	Gigabit Ethernet Transceiver
	5	-TXC	Differential	Gigabit Ethernet Transceiver
PAIR 3	7	+TXD	Differential	Gigabit Ethernet Transceiver
	8	-TXD	Differential	Gigabit Ethernet Transceiver

Table 8.1 Pin Assignments for the RJ-45 Jack

8.3 Control Receptacle

The control receptacle is a Hirose 4 pin connector (part # HR10A-7R-4S) and consists of an external trigger signal input and strobe output port. The pin assignments and configurations are as follows:

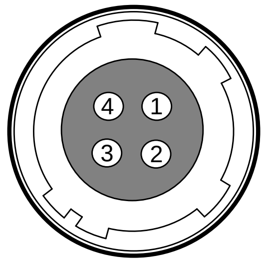


Figure 8.3 Pin Assignments for 4 Pin Control Receptacle

Pin Number	Signal	Type	Description
1	Trigger Input +	Input	Voltage difference of 3.3 V ~ 24 V, 10 ㎃, optically isolated
2	Trigger Input -	Input	
3	DC Ground	-	DC Ground
4	Programmable Output (Default: Strobe Out)	Output	3.3 V TTL Output Output resistance : 47 Ω

Table 8.2 Pin Arrangement of Control Receptacle

The mating connector is a Hirose 4 pin plug (part # HR10A-7P-4P) or the equivalent connectors.

8.4 Power Input Receptacle

The power input receptacle is a Hirose 6 pin connector (part # HR10A-7R-6PB). The pin assignments and configurations are as follows:

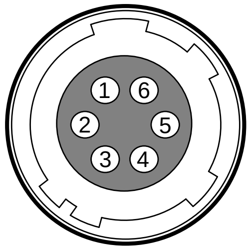


Figure 8.4 Pin Assignments for Power Input Receptacle

Pin Number	Signal	Type	Description
1, 2 , 3	+ 12V DC	Input	DC Power Input
4 , 5 , 6	DC Ground	Input	DC Ground

Table 8.3 Pin Configurations for Power Input Receptacle

Connecting the power cable to the camera can be made by using the Hirose 6 pin plug (part # HR10A-7P-6S) or the equivalent. The power adaptor is recommended to have at least 1A current output at 12 V DC ±10% voltage output (Users need to purchase the power adaptor separately).

Precaution for Power Input

CAUTION	• Make sure the power is turned off before connecting the power cord to the camera. Otherwise, damage to the camera may result. • If the camera input voltage is greater than 16 V, damage to the camera may result.

8.5 Trigger Input Circuit

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

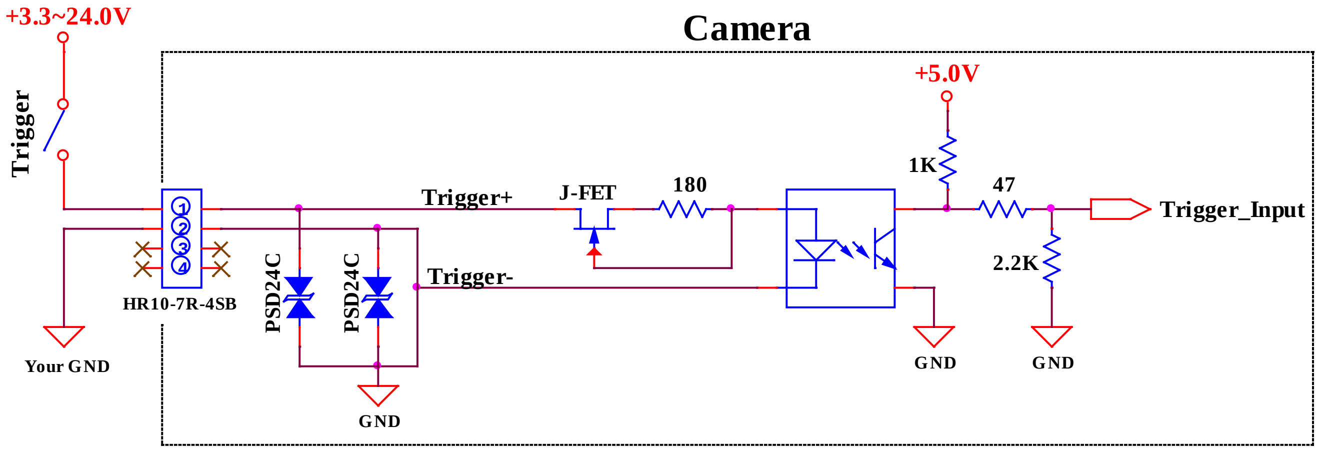


Figure 8.5 Trigger Input Schematic

8.6 Strobe Output Circuit

The strobe output signal comes out through a 3.3 V output level of Line Driver IC. You can change the strobe output by setting the Digital IO Control (Refer to chapter 10.19 Digital IO Control).

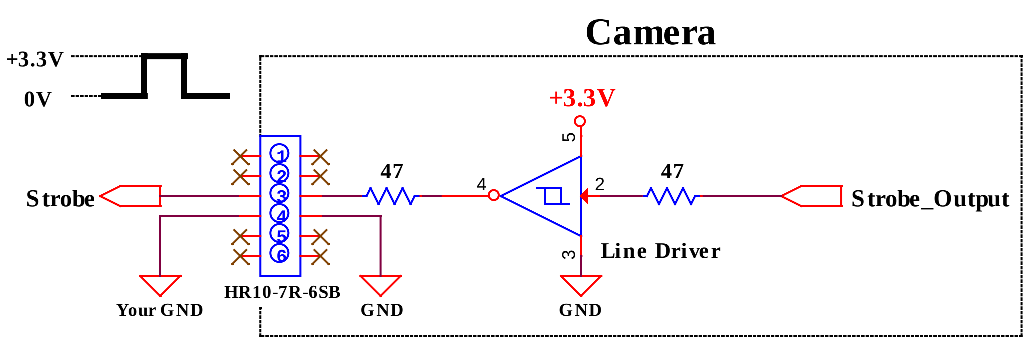


Figure 8.6 Strobe Output Schematic

9 Acquisition Control

This chapter provides detailed information about controlling image acquisition.

- Triggering image acquisition
- Setting the exposure time
- Controlling the camera's image acquisition rate
- Variation of the camera's maximum allowed image acquisition rate according to the camera settings

9.1 Overview

This section presents an overview of the elements involved with controlling the acquisition of images.

Three major elements are involved in controlling the acquisition of images:

- **Acquisition Start** and **Acquisition Stop** commands and the **Acquisition Mode** parameter
- The exposure start trigger
- Exposure time control

When reading the explanations in the overview and in this entire chapter, keep in mind that the term **frame** is typically used to mean a single acquired image.

Acquisition Start and Stop Commands and the Acquisition Mode

The **Acquisition Start** command prepares the camera to acquire frames. The camera cannot acquire frames unless an **Acquisition Start** command has first been executed.

A parameter called the **Acquisition Mode** has a direct bearing on how the **Acquisition Start** command operates.

If the **Acquisition Mode** parameter is set to **Single Frame**, you can only acquire one frame after executing an **Acquisition Start** command. When one frame has been acquired, the **Acquisition Start** command will expire. Before attempting to acquire another frame, you must execute a new **Acquisition Start** command.

If the **Acquisition Mode** parameter is set to **Continuous**, an **Acquisition Start** command does not expire after a single frame is captured. Once an **Acquisition Start** command has been executed, you can acquire as many frames as you like. The **Acquisition Start** command will remain in effect until you execute an **Acquisition Stop** command. Once an **Acquisition Stop** command has been executed, the camera will not be able to acquire frames until a new **Acquisition Start** command is executed.

Exposure Start Trigger

Applying an exposure start trigger signal to the camera will exit the camera from the *waiting for exposure start trigger* acquisition status and will begin the process of exposing and reading out a frame (see Figure 9.1). As soon as the camera is ready to accept another exposure start trigger signal, it will return to the *waiting for exposure start trigger* acquisition status. A new exposure start trigger signal can then be applied to the camera to begin another frame exposure.

The exposure start trigger has two modes: off and on.

If the **Trigger Mode** parameter is set to **Off**, the camera will generate all required exposure start trigger signals internally, and you do not need to apply exposure start trigger signals to the camera. The rate at which the camera will generate the signals and acquire frames will be determined by the way that you set several frame rate related parameters.

If the **Trigger Mode** parameter is set to **On**, you must trigger exposure start by applying exposure start trigger signals to the camera. Each time a trigger signal is applied, the camera will begin a frame exposure. When exposure start is being triggered in this manner, it is important that you do not attempt to trigger frames at a rate that is greater than the maximum allowed (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.). Exposure start trigger signals applied to the camera when it is not in a *waiting for exposure start trigger* acquisition status will be ignored.

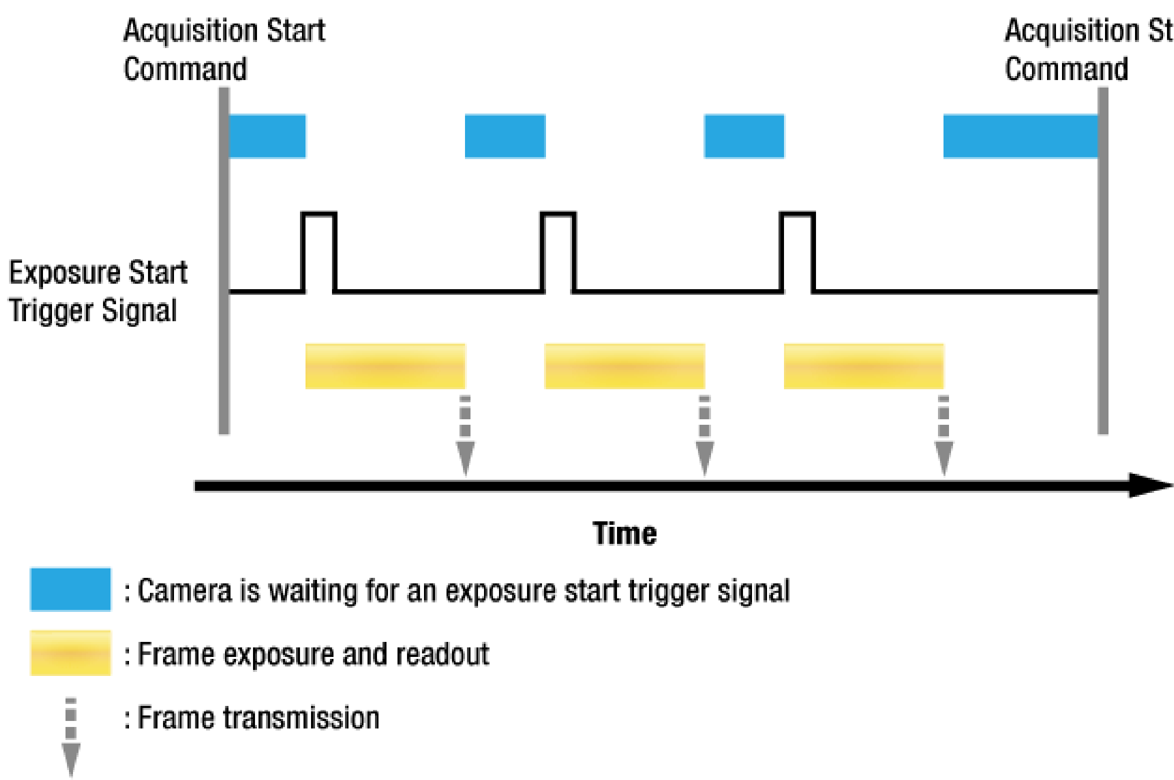


Figure 9.1 Exposure Start Triggering

Applying Trigger Signals

The paragraphs above mention "applying a trigger signal". There are two ways to apply an exposure start trigger signal to the camera: via software or via external (commonly referred to as hardware).

To apply trigger signals via **Software**, you must set the **Trigger Source** parameter to **Software**. At that point, each time a **Trigger Software** command is executed, the exposure start trigger signal will be applied to the camera.

To apply trigger signals via **External**, you must set the **Trigger Source** parameter to **External**. At that point, each time a proper electrical signal is applied to the camera, an occurrence of the exposure start trigger signal will be recognized by the camera.

Exposure Time Control

When an exposure start trigger signal is applied to the camera, the camera will begin to acquire a frame.

A critical aspect of frame acquisition is how long the pixels in the camera's sensor will be exposed to light during the frame acquisition.

If the **Trigger Source** parameter is set to **Software**, a parameter called the **Exposure Time** will determine the exposure time for each frame. At this point, you must set the **Exposure Mode** parameter to **Timed**.

If the **Trigger Source** parameter is set to **External**, there are two modes of operation: **Timed** and **Trigger Width**.

With the **Timed** mode, the **Exposure Time** parameter will determine the exposure time for each frame.

With the **Trigger Width** mode, the way that you manipulate the rise and fall of the external signal will determine the exposure time. The **Trigger Width** mode is especially useful if you want to change the exposure time from frame to frame.

9.2 Acquisition Start/Stop Commands and Acquisition Mode

Executing an **Acquisition Start** command prepares the camera to acquire frames. You must execute an **Acquisition Start** command before you can begin acquiring frames. Executing an **Acquisition Stop** command terminates the camera's ability to acquire frames. When the camera receives an **Acquisition Stop** command:

- If the camera is not in the process of acquiring a frame, its ability to acquire frames will be terminated immediately.
- If the camera is in the process of acquiring a frame, the frame acquisition process will be allowed to finish and the camera's ability to acquire new frames will be terminated.

The camera's **Acquisition Mode** parameter has three settings: **Single Frame**, **Multi-Frame** and **Continuous**. The use of **Acquisition Start** and **Acquisition Stop** commands and the camera's **Acquisition Mode** parameter setting are related.

If the camera's **Acquisition Mode** parameter is set to **Single Frame**, after an **Acquisition Start** command has been executed, a single frame can be acquired. When acquisition of one frame is complete, the camera will execute an **Acquisition Stop** command internally and will no longer be able to acquire frames. To acquire another frame, you must execute a new **Acquisition Start** command.

If the camera's **Acquisition Mode** parameter is set to **Multi-Frame**, after an **Acquisition Start** command has been executed, exposure start can be triggered as many as specified by the **Acquisition Frame Count** parameter. The camera will continue to react to exposure start trigger signals until the number of exposure start trigger signals it has received is equal to the current **Acquisition Frame Count** parameter setting. At that point, the **Acquisition Start** command will expire. Before attempting to acquire another frame, you must execute a new **Acquisition Start** command.

CAUTION	With **Single Frame** or **Multi-Frame Acquisition Mode**, if you execute another **Acquisition Start** command while the camera is in the process of acquiring a frame, an error may occur.

If the camera's **Acquisition Mode** parameter is set to **Continuous**, after an **Acquisition Start** command has been executed, exposure start can be triggered as desired. Each time an exposure start trigger is applied while the camera is in a waiting for *exposure start trigger* acquisition status, the camera will acquire and transmit a frame. The camera will retain the ability to acquire frames until an **Acquisition Stop** command is executed. Once the **Acquisition Stop** command is received, the camera will no longer be able to acquire frames.

When the camera's **Acquisition Mode** is set to **Single Frame**, the maximum possible acquisition frame rate for a given ROI cannot be achieved. This is true because the camera performs a complete internal setup cycle for each single frame and because it cannot be operated with **Trigger Overlap**. To achieve the maximum possible acquisition frame rate, set the **Acquisition Mode** to **Continuous** and **Trigger Overlap** to **Readout**.

9.3 Exposure Start Trigger

The exposure start trigger is used to begin frame acquisition. Exposure start trigger signals can be generated within the camera or may be applied externally as **Software** or **External** exposure start trigger signals. If an exposure start trigger signal is applied to the camera, the camera will begin to expose a frame.

9.3.1 Trigger Mode

The main parameter associated with the exposure start trigger is the **Trigger Mode** parameter. The **Trigger Mode** parameter for the exposure start trigger has two available settings: **Off** and **On**.

9.3.1.1 Trigger Mode = Off

When the **Trigger Mode** parameter is set to **Off**, the camera will generate all required exposure start trigger signals internally, and you do not need to apply exposure start trigger signals to the camera.

With the **Trigger Mode** set to **Off**, the way that the camera will operate the exposure start trigger depends on the setting of the camera's **Acquisition Mode** parameter:

- **Single Frame**: The camera will automatically generate a single exposure start trigger signal whenever it receives an **Acquisition Start** command.
- **Multi-Frame**: The camera will automatically begin generating exposure start trigger signals as many as specified by the **Acquisition Frame Count** parameter when it receives an **Acquisition Start** command. The camera will continue to generate exposure start trigger signals until the number of exposure start trigger signals it has received is equal to the current **Acquisition Frame Count** parameter setting or until it receives an **Acquisition Stop** command.

CAUTION	With **Single Frame** or **Multi-Frame Acquisition Mode**, if you execute another **Acquisition Start** command while the camera is in the process of acquiring a frame, an error may occur.

i	When the **Acquisition Mode** parameter is set to **Multi-Frame**, you must set the value of the camera's **Acquisition Frame Count** parameter. The value of the **Acquisition Frame Count** can range from 1 to 255.

- **Continuous**: The camera will automatically begin generating exposure start trigger signals when it receives an **Acquisition Start** command. The camera will continue to generate exposure start trigger signals until it receives an **Acquisition Stop** command.

Free Run

- When you set the **Trigger Mode** parameter to **Off** and the **Acquisition Mode** parameter to **Continuous**, the camera will generate all required trigger signals internally. When the camera is set this way, it will constantly acquire images without any need for triggering by the user. This use case is commonly referred as “free run”.
- When you operate the camera in free run, you must set the **Trigger Overlap** parameter to **Readout** to achieve optimal camera performance.

The rate at which the exposure start trigger signals are generated may be determined by the camera’s **Acquisition Frame Rate** parameter:

- If the parameter is set to a value less than the maximum allowed frame rate with the current camera settings, the camera will generate exposure start trigger signals at the rate specified by the parameter setting.
- If the parameter is set to a value greater than the maximum allowed frame rate with the current camera settings, the camera will generate exposure start trigger signals at the maximum allowed frame rate.

Exposure Time Control with Trigger Mode = Off

When the Trigger Mode parameter is set to **Off**, the exposure time for each frame acquisition is determined by the value of the camera’s **Exposure Time** parameter. For more information about the **Exposure Time** parameter, see 9.4 Setting the Exposure Time.

9.3.1.2 Trigger Mode = On

When the **Trigger Mode** parameter is set to **On**, you must apply an exposure start trigger signal to the camera each time you want to begin a frame acquisition. The **Trigger Source** parameter specifies the source signal that will act as the exposure start trigger signal.

The available settings for the **Trigger Source** parameter are:

- **Software**: You can apply an exposure start trigger signal to the camera by executing a **Trigger Software** command for the exposure start trigger on your computer.
- **External**: You can apply an exposure start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware trigger signal) into the Control Receptacle pin 1 on the camera.

If the **Trigger Source** parameter is set to **External**, you must also set the **Trigger Activation** parameter.

The available settings for the **Trigger Activation** parameter are:

- **Rising Edge**: Specifies that a rising edge of the electrical signal will act as the exposure start trigger.
- **Falling Edge**: Specifies that a falling edge of the electrical signal will act as the exposure start trigger.

Exposure Time Control with Trigger Mode = On

When the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **Software**, the exposure time for each frame acquisition is determined by the value of the camera's **Exposure Time** parameter.

When the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **External**, the exposure time for each frame acquisition can be controlled with the **Exposure Time** parameter or it can be controlled by manipulating the external trigger signal.

9.3.2 Using a Software Trigger Signal

If the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **Software**, you must apply a software trigger signal (exposure start) to the camera to begin each frame acquisition. Assuming that the camera is in a *waiting for exposure start trigger* acquisition status, frame exposure will start when the software trigger signal is received by the camera. Figure 9.2 illustrates frame acquisition with a software trigger signal.
When the camera receives a software trigger signal and begins exposure, it will exit the *waiting for exposure start trigger* acquisition status because at that point, it cannot react to a new exposure start trigger signal.
As soon as the camera is capable of reacting to a new exposure start trigger signal, it will automatically return to the *waiting for exposure start trigger* acquisition status.
When you are using a software trigger signal to start each frame acquisition, the camera's **Exposure Mode** parameter must be set to **Timed**. The exposure time for each acquired frame will be determined by the value of the camera's **Exposure Time** parameter.

When you use a software trigger signal to acquire frames, be aware that there is a Trigger Latency due to the characteristics of the Gigabit Ethernet. Use an external trigger signal to precisely synchronize the trigger signal with the exposure timing.

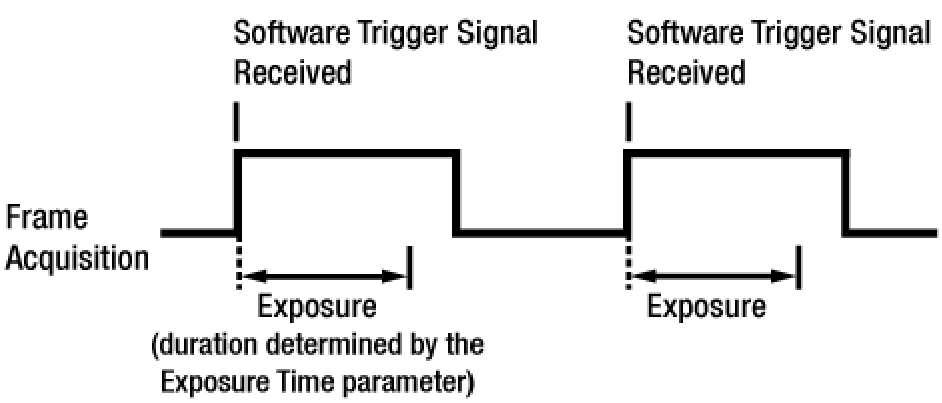


Figure 9.2 Frame Acquisition with Software Trigger Signal

When you are using a software trigger signal to start each frame acquisition, the frame rate will be determined by how often you apply a software trigger signal to the camera, and you should not attempt to trigger frame acquisition at a rate that exceeds the maximum allowed for the current camera settings. (There is a detailed explanation about the maximum allowed frame rate at the end of this chapter.)
Software trigger signals that are applied to the camera when it is not ready to receive them will be ignored.

9.3.3 Using an External Trigger Signal

If the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **External**, an externally generated electrical signal injected into the Control Receptacle pin 1 will act as the exposure start trigger signal for the camera. This type of trigger signal is generally referred to as a hardware trigger signal.

A rising edge or a falling edge of the external signal can be used to trigger frame acquisition. The **Trigger Activation** parameter is used to select rising edge or falling edge triggering.

Assuming that the camera is in a *waiting for exposure start trigger* acquisition status, frame acquisition will start whenever the appropriate edge transition is received by the camera.

When the camera receives an external trigger signal and begins exposure, it will exit the *waiting for exposure start trigger* acquisition status because at that point, it cannot react to a new exposure start trigger signal. As soon as the camera is capable of reacting to a new exposure start trigger signal, it will automatically return to the *waiting for exposure start trigger* acquisition status.

When the camera is operating under control of an external signal, the period of the external trigger signal will determine the rate at which the camera is acquiring frames:

$$\frac{1}{\text{External signal period in seconds}} = \text{Frame Rate}$$

For example, if you are operating a camera with an External trigger signal period of 500 ㎳ (0.5 s):

So in this case, the frame rate is 2 fps.

9.3.3.1 Exposure Modes

If you are triggering the start of frame acquisition with an externally generated trigger signal, two exposure modes are available: **Timed** and **Trigger Width**.

Timed Exposure Mode

When the **Timed** mode is selected, the exposure time for each frame acquisition is determined by the value of the camera's **Exposure Time** parameter. If the camera is set for rising edge triggering, the exposure time starts when the external trigger signal rises. If the camera is set for falling edge triggering, the exposure time starts when the external trigger signal falls. Figure 9.3 illustrates timed exposure with the camera set for rising edge triggering.

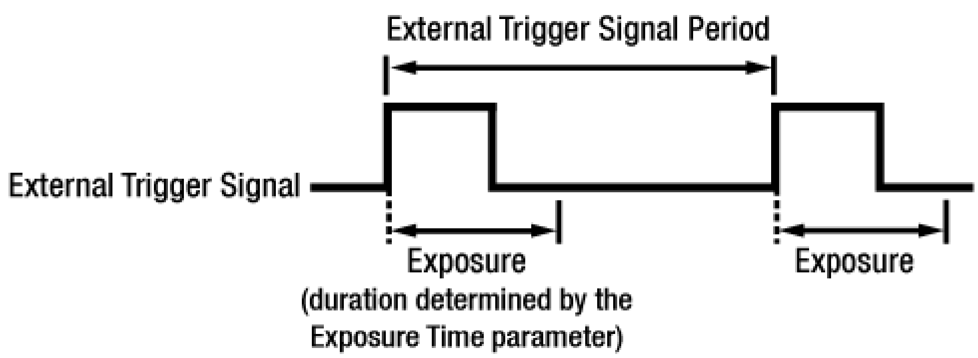


Figure 9.3 Timed Exposure Mode

Note that if you attempt to trigger a new exposure start while the previous exposure is still in progress, the trigger signal will be ignored, and an Over-trigger event will be generated.

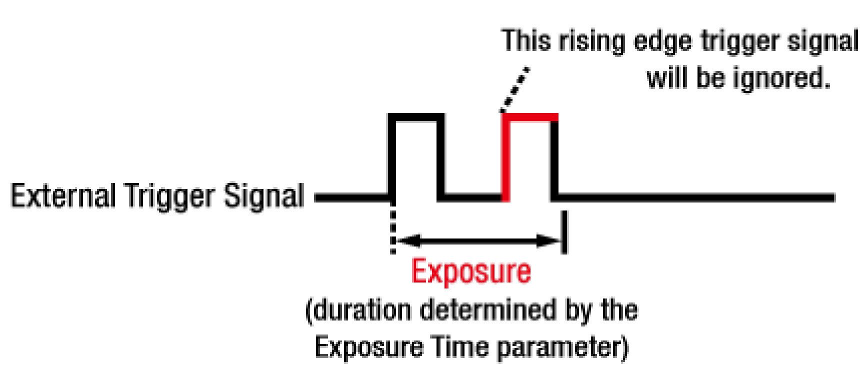


Figure 9.4 Trigger Overlapped with Timed Exposure Mode

Trigger Width Exposure Mode

When the **Trigger Width** exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the external trigger signal. If the camera is set for rising edge triggering, the exposure time begins when the external trigger signal rises and continues until the external trigger signal falls. If the camera is set for falling edge triggering, the exposure time begins when the external trigger signal falls and continues until the external trigger signal rises. Figure 9.5 illustrates **Trigger Width** exposure with the camera set for rising edge triggering.

Trigger Width exposure is especially useful if you intend to vary the length of the exposure time for each frame.

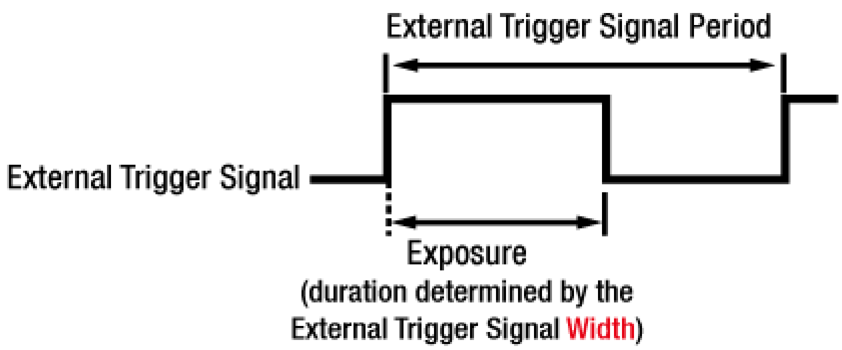


Figure 9.5 Trigger Width Exposure Mode

9.3.3.2 Double Exposure

When the **Double Exposure** mode is selected, two frames can be acquired in rapid succession using a single trigger signal. The exposure time for the first frame begins according to the current camera settings when the trigger signal is applied to the camera. Once the exposure for the first frame is complete, the camera reads out the sensor data. At this point, the exposure time for the second frame begins. Then, the camera reads out the sensor data for the second frame after reading out the sensor data for the previous frame.

In the **Double Exposure** mode, the exposure time for the second frame equals to the readout time of the first frame. There is a just few microseconds (or dozen of microseconds) between the point where the exposure time for the first frame ends and the point where the exposure time for the second frame begins. This is because the camera cannot react to the exposure start trigger signal while reading out the sensor data for the first frame. At this point, the camera outputs a strobe out signal reflected the exposure time for the first frame.

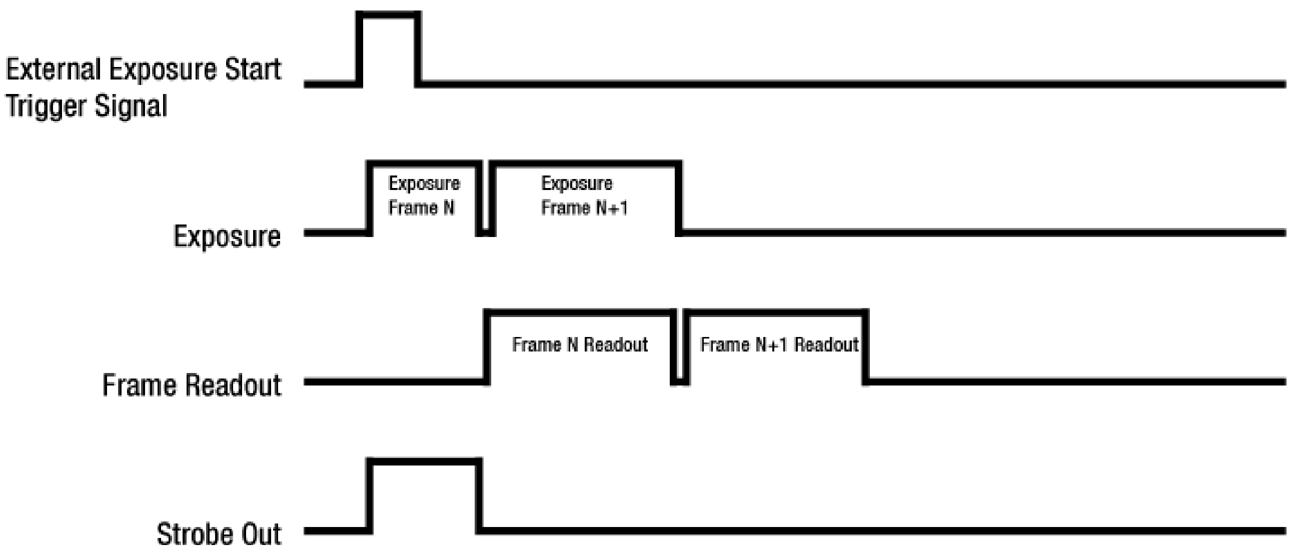


Figure 9.6 Double Exposure

9.3.4 Trigger Delay

The Trigger Delay feature specifies a delay (in microseconds) that will be applied between the receipt of a trigger signal (software or external) and when the trigger will become effective.

The Trigger Delay can be specified in the range from 0 to 10,000,000 μs (equivalent to 10 s).

	The **Trigger Delay** will not operate if the **Trigger Mode** parameter is set to **Off**.

9.4 Setting the Exposure Time

This section describes how the exposure time can be adjusted manually by setting the value of the exposure time parameter.

Manual adjustment of the exposure time parameter will only work correctly if the **Exposure Auto** feature is disabled.

If you are operating the camera in any one of the following ways, you must specify an exposure time by setting the camera's **Exposure Time** parameter:

- the **Trigger Mode** is set to off
- the **Trigger Mode** is set to **On** and the **Trigger Source** is set to **Software** (In this case, you must set the **Exposure Mode** parameter to **Timed**.)
- the **Trigger Mode** is set to **On**, the **Trigger Source** is set to **External**, and the **Exposure Mode** is set to **Timed**.

The **Exposure Time** parameter must not be set below a minimum specified value. The **Exposure Time** parameter sets the exposure time in μs. The minimum and maximum exposure time settings for each camera model are shown in the following table.

Camera Model	Minimum Allowed Exposure Time	Maximum Possible Exposure Time†
VH-310G2	16 μs	7,000,000 μs
VH-2MG2	37 μs	
VH-4MG2	55 μs	
VH-5MG2	29 μs	
VH-11MG2	131 μs	
VH16MG2	209 μs	

†: When the **Exposure Mode** is set to **Trigger Width**, the exposure time is controlled by the external trigger signal and has no maximum limit.

Table 9.1 Minimum and Maximum Exposure Time Setting

9.4.1 Exposure Auto

The **Exposure Auto** feature automatically adjusts the **Exposure Time** parameter within set limits until an average gray value for the pixel data from the AE Data ROI reaches an **Exposure Auto Target Level** setting value.

The **Exposure Auto** feature can be operated in the **Once** or **Continuous** modes of operation.

If the Data ROI does not overlap the Image ROI, the pixel data from the Data ROI will not be used to control the exposure time.

The **Exposure Auto** feature and the **Gain Auto** feature can be used at the same time.

When the **Trigger Width** parameter is selected for **Exposure Mode**, the **Exposure Auto** feature is not available.

For more information, refer to 10.9 Exposure Auto and Gain Auto.

9.5 Overlapping Exposure with Sensor Readout

The frame acquisition process on the camera includes two distinct parts. The first part is the exposure of the pixels in the imaging sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place. In regard to this frame acquisition process, there are two common ways for the camera to operate: with **Trigger Overlap** – **Off** and with **Trigger Overlap** - **Readout**.

In the **Trigger Overlap** – **Off** mode of operation, each time a frame is acquired the camera completes the entire exposure/readout process before acquisition of the next frame is started. The exposure for a new frame does not overlap the sensor readout for the previous frame. Figure 9.7 illustrates the **Trigger Overlap** parameter set to **Off** and the **Exposure Mode** parameter set to **Trigger Width**.

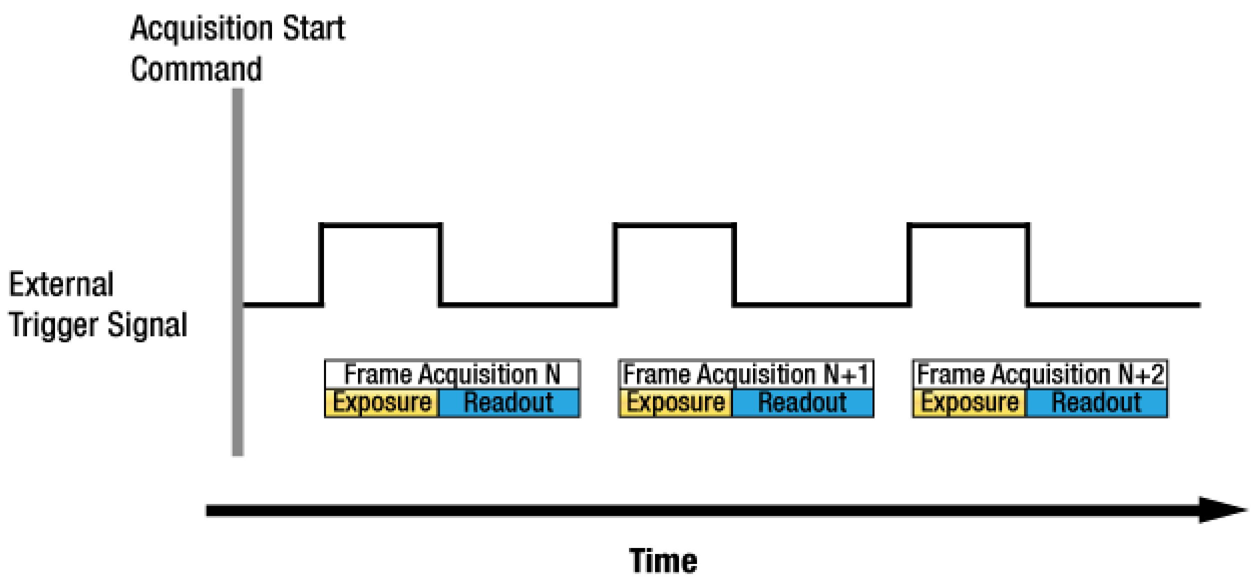


Figure 9.7 Trigger Overlap - Off

In the **Trigger Overlap** – **Readout** mode of operation, the exposure of a new frame begins while the camera is still reading out the sensor data for the previously acquired frame. Figure 9.8 illustrates the **Trigger Overlap** parameter set to **Readout** and the **Exposure Mode** parameter set to **Trigger Width**.

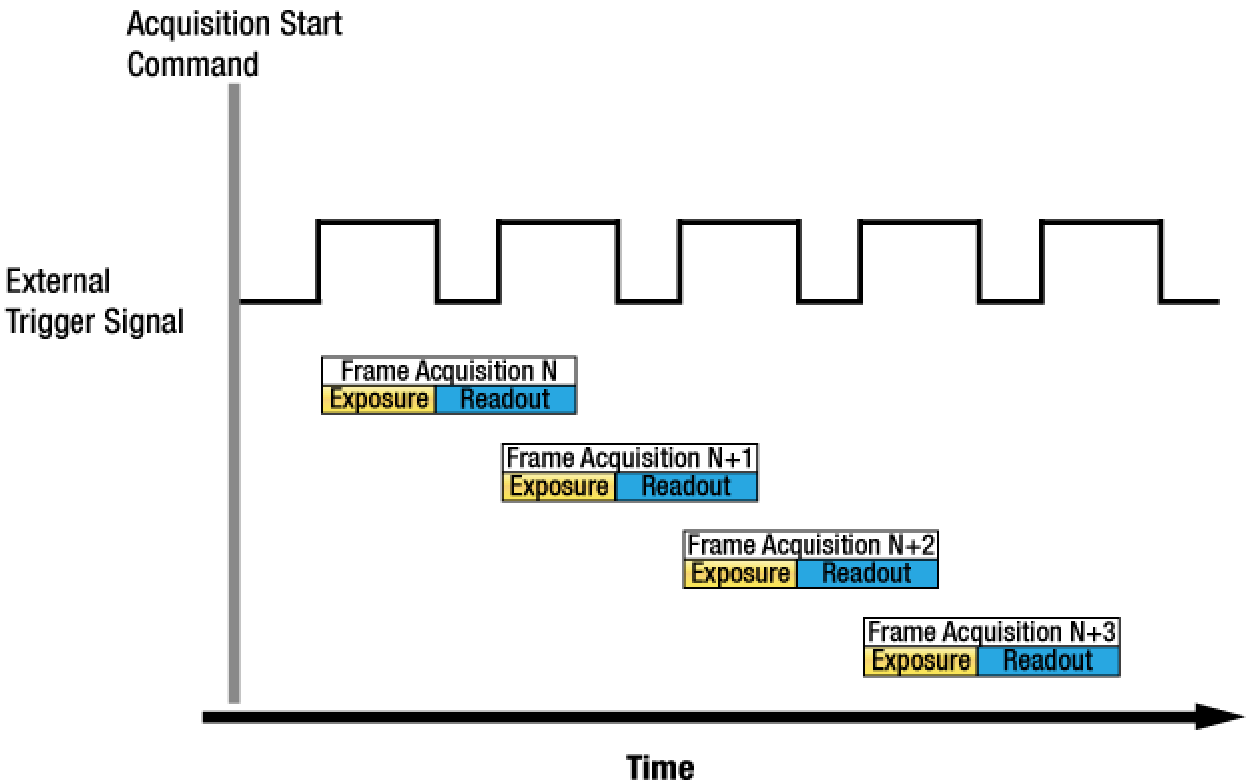


Figure 9.8 Trigger Overlap - Readout

Determining whether your camera is operating with overlapped or non-overlapped exposure and readout is not a matter of issuing a command or switching a setting on or off. Rather the way that you operate the camera will determine whether the exposures and readouts are overlapped or not.

If we define the "Frame Period" as the time from the start of exposure for one frame acquisition to the start of exposure for the next frame acquisition, then:

- Non-overlapped: Frame Period $\geq$ Exposure Time + Readout Time
- Overlapped: Frame Period $\leq$ Exposure Time + Readout Time

Guidelines for Overlapped Exposure

If you will be operating the camera with overlapped exposure, there are two important guidelines to keep in mind:

- You must not begin the exposure time for a new image acquisition while the exposure time of the previous acquisition is in progress.
- You must not end the exposure time of the current image acquisition until readout of the previously acquired image is complete.

When you are operating a camera with overlapped exposure and using an external trigger signal to trigger image acquisition, you could use the camera's Exposure time parameter settings and timing formulas to calculate when it is safe to begin each new acquisition.

ℹ	The exposure must always begin on an interline boundary of the CCD sensor. For this reason, if a trigger signal is applied during the readout process, there might be an Exposure Start Delay up to 1 horizontal line time.

9.6 Real Exposure

9.6.1 Timed Exposure Mode

When the **Timed** mode is selected, the exposure time is determined by the time interval between the point where an external trigger signal is applied and the point where the t_{pd} (Photodiode Transfer) signal falls.
The camera generates a shutter signal to clear pixels when an external trigger signal is applied. The exposure time begins when the shutter signal falls and continues until the t_{pd} (Photodiode Transfer) signal falls. As Figure 9.9 shows, there is an Exposure Start Delay (refer to Table 9.3) between the rise of the external trigger signal and the point where exposure actually begins. The setting value on the **Exposure Time** parameter is equal to the exposure time, because the t_{sub} value of the shutter signal and Transfer Pulse Offset value (t_{pd}, t_{3p}) are compensated on the exposure time by the camera's logic internally. Therefore, there is no difference between the setting value on the **Exposure Time** parameter and the exposure time. The t_{sub} value and Transfer Pulse Offset value are determined by the CCD sensor used in the camera.

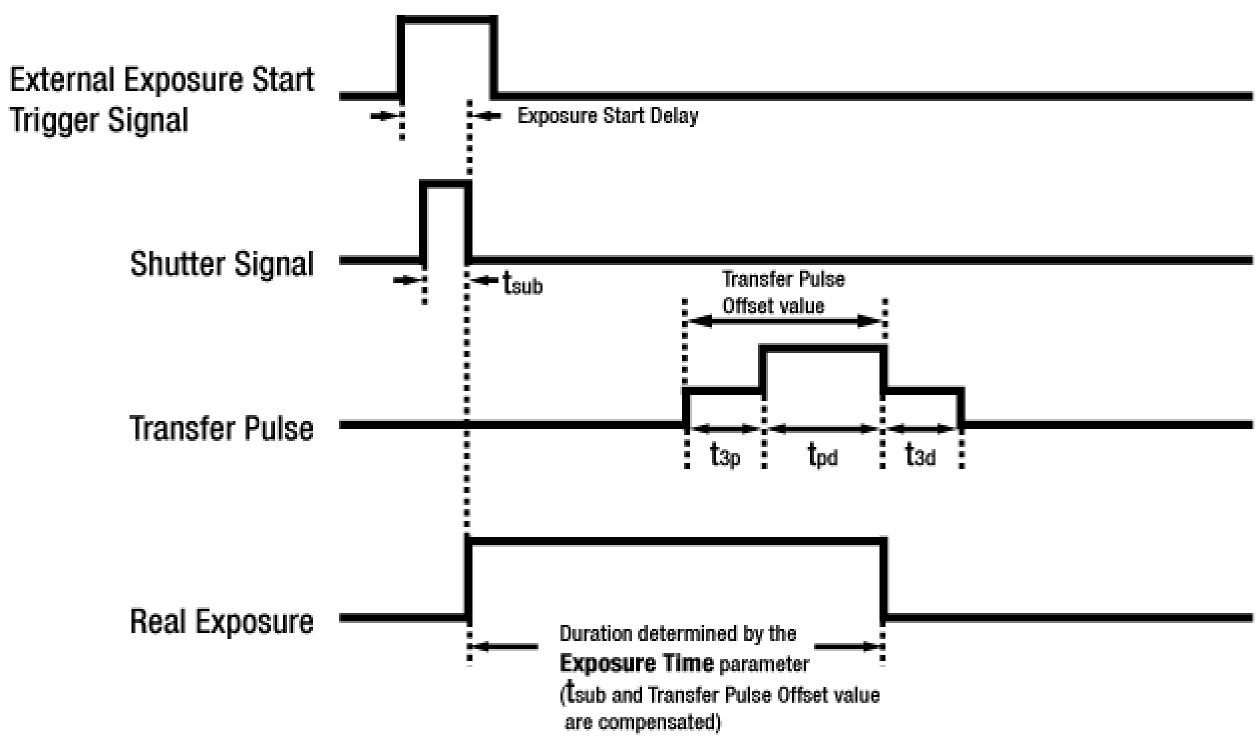


Figure 9.9 Real Exposure with Timed Exposure Mode

9.6.2 Trigger Width Exposure Mode

When the **Trigger Width** mode is selected, the exposure time is controlled by the external trigger signal.
The camera generates a shutter signal to clear pixels when an external trigger signal is applied. The exposure time begins when the shutter signal falls and continues until the tpd (Photodiode Transfer) signal falls. As Figure 9.10 shows, there is an Exposure Start Delay (refer to Table 9.3) between the rise of the external trigger signal and the rise of the shutter signal. There is difference between the width of the external trigger signal and the exposure time as much as the t_{sub} value of the shutter signal and Transfer Pulse Offset value (t_{pd}, t_{3p}).
You can calculate an actual exposure time by using the following formula:

- Exposure Time = Trigger Width + t_{3p} + t_{pd} - t_{sub}

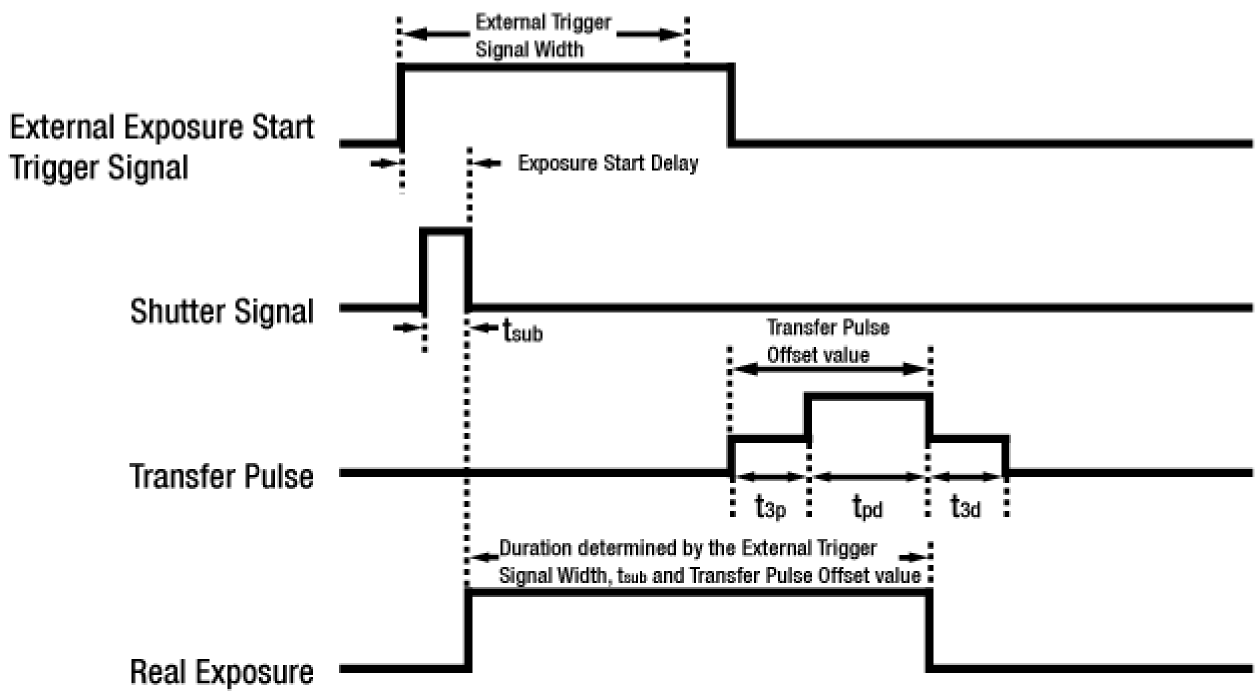


Figure 9.10 Real Exposure with Trigger Width Exposure Mode

The t_{sub} and Transfer Pulse Offset value are determined by the CCD sensor used in the camera.

The following table shows the t_{sub} and Transfer Pulse Offset values for VH GigE series.

Model	Real Exposure Parameters					Remarks
	t_{sub}	t_{3p}	t_{pd}	t_{3d}	Exposure Start Delay	
VH-310G2	0.7 ㎲	15 ㎲	0.4 ㎲	–	Refer to Table 9.3	• t_{sub}: Shutter Transfer • t_{3p}: VCCD leading pedestal signal • t_{pd}: Photodiode transfer signal • t_{3d}: VCCD trailing pedestal signal • Exposure Start Delay: Trigger Latency + Trigger Jitter
VH-2MG2	3 ㎲	24 ㎲	12 ㎲	–		
VH-4MG2	3 ㎲	49 ㎲	5 ㎲	–		
VH-5MG2	1 ㎲	20 ㎲	8.4 ㎲	–		
VH-11MG2	3 ㎲	109 ㎲	20 ㎲	–		
VH-16MG2	4 ㎲	196 ㎲	12 ㎲	–		

Table 9.2 Real Exposure Parameters

9.7 Acquisition Timing Chart

Figure 9.11 shows a timing chart for frame acquisition and transmission. The chart assumes that exposure is triggered by an externally generated exposure start trigger signal, that the **Trigger Activation** parameter is set to **Rising Edge** and that the **Exposure Mode** parameter is set to **Timed**.

As shown in the figure below, there is a slight delay between the rise of the exposure start trigger signal and the start of exposure. After the exposure time for a frame acquisition is complete, the camera begins reading out the acquired frame data from the imaging sensor into a frame buffer in the camera. When a sufficient amount of frame data has accumulated in the frame buffer, the camera will begin transmitting the data to your computer. This buffering technique avoids the need to exactly synchronize the clock used for sensor readout with the data transmission. The camera will begin transmitting data when it has determined that it can safely do so without over-running or under-running the buffer.

- **Exposure Start Delay**: the amount of time (including trigger jitter and latency) between the point where the trigger signal rises and the point where exposure actually begins
- **Frame Readout time**: the amount of time it takes to read out the frame data from the imaging sensor into the frame buffer
- **Frame Transmission time**: the amount of time it takes to transmit an acquired frame data from the frame buffer in the camera to your computer
- **Transmission Start Delay**: the amount of time between the point where the camera begins reading out the acquired frame data from the sensor and the point where it begins transmitting the acquired frame data from the buffer to your computer

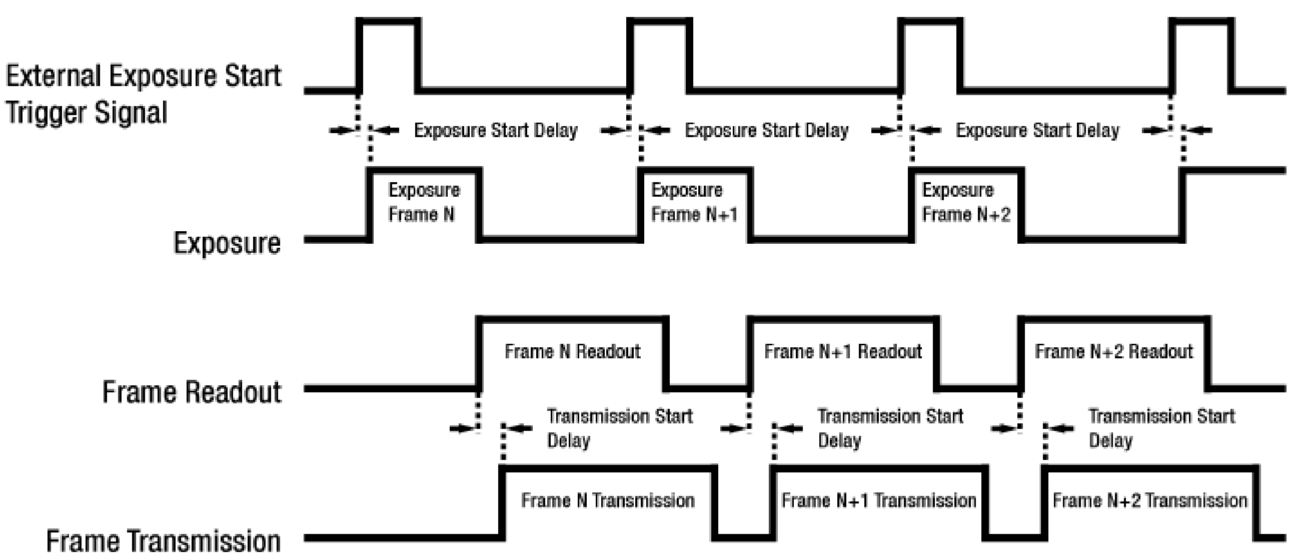


Figure 9.11 Timing Chart (not drawn to scale)

The following table shows Exposure Start Delay for VH GigE series.

Model	Exposure Start Delay	
	Triggering during the Idle State	**Triggering during the Readout State**
VH-310G2	2.2 µs ± 0.02 µs	3.7 µs ≤ Delay ≤ 19.1 µs (1 Tap) 3.7 µs ≤ Delay ≤ 12.2 µs (2 Tap)
VH-2MG2	4.5 µs ± 0.02 µs	8.5 µs ≤ Delay ≤ 40.4 µs (1 Tap) 8.5 µs ≤ Delay ≤ 24.0 µs (2 Tap)
VH-4MG2	4.5 µs ± 0.02 µs	8.3 µs ≤ Delay ≤ 49.8 µs (1 Tap) 8.3 µs ≤ Delay ≤ 28.7 µs (2 Tap)
VH-5MG2	2.5 µs ± 0.02 µs	12.5 µs ≤ Delay ≤ 55.8 µs (1 Tap) 12.5 µs ≤ Delay ≤ 34.7 µs (2 Tap)
VH-11MG2	4.5 µs ± 0.02 µs	12.5 µs ≤ Delay ≤ 113.4 µs (1 Tap) 12.5 µs ≤ Delay ≤ 62.5 µs (2 Tap)
VH-16MG2	5.5 µs ± 0.02 µs	18.5 µs ≤ Delay ≤ 141.1 µs (1 Tap) 18.5 µs ≤ Delay ≤ 78.8 µs (2 Tap)
Based on the High Speed Pixel Clock (**PclkSelector**: **PCLK1**) except VH-5MG2 model (Normal Speed)		

Table 9.3 Exposure Start Delay

The exposure must always begin on an interline boundary of the CCD sensor. For this reason, if a trigger signal is applied during the readout process, there might be an Exposure Start Delay up to 1 horizontal line time.

The transmission time can vary due to the characteristics of the Ethernet network.

And also, the transmission start delay can vary from frame to frame; however, it is very low significance when compared to the transmission time.

9.8 Maximum Allowed Frame Rate

In general, the maximum allowed acquisition frame rate on the camera may be limited by several factors:

- The amount of time that it takes to transmit an acquired frame from the camera to your computer. The amount of time needed to transmit a frame depends on the bandwidth assigned to the camera.
- The setting for the **Sensor Digitization Taps** parameter. If this parameter is set for **Two** taps, you will be able to acquire frames at a higher rate than if it is set to **One** tap.
- The **Binning** feature. If binning is enabled, the maximum allowed frame rate will increase.
- The amount of time it takes to read an acquired frame out of the imaging sensor and into the camera's frame buffer. This time varies depending on the setting for the **Height** parameter. Frames with a smaller height take less time to read out of the sensor. The frame height is determined by the camera's **Height** settings (Image Format Control).
- The exposure time for acquired frames. If you use very long exposure times, you can acquire fewer frames per second.

ℹ	Decreasing the **Height** parameter can increase the maximum allowed frame rate; however the **Width** parameter does not affect the frame rate.

ℹ	When the camera's **Acquisition Mode** is set to **Single Frame**, the maximum possible acquisition frame rate for a given ROI cannot be achieved. This is true because the camera performs a complete internal setup cycle for each single frame and because it cannot be operated with Trigger Overlap – Readout mode. To achieve the maximum possible acquisition frame rate, set the **Acquisition Mode** parameter to **Continuous** and the **Trigger Overlap** parameter to **Readout**.

9.8.1 Increasing the Maximum Allowed Frame Rate

You may find that you would like to acquire frames at a rate higher than the maximum allowed with the camera's current settings. In this case, you must adjust one or more of the factors that can influence the maximum allowed frame rate and then check to see if the maximum allowed frame rate has increased:

- The time that it takes to transmit a frame out of the camera is the main limiting factor on the frame rate. You can decrease the frame transmission time (and thus increase the maximum allowed frame rate) by doing one or more of the following:
  - Use an 8 bit pixel data format rather than a 12 bit pixel format. Images with fewer bits per pixel will take less time to transmit.
  - Use a smaller ROI. Decreasing the ROI means that the camera has less data to transmit and therefore the transmission time will decrease.
  - Use binning. When pixels are binned, there is less data to transmit and therefore the transmission time will decrease.
  - Make sure that the Packet Size (GevSCPSPacketSize) parameter is set as high as possible for your system and that the Inter-Packet delay (GevSCPD) parameter is set as low as possible.
- If you have the **Sensor Digitization Taps** parameter set to **One**, consider changing the value to **Two**. This will usually increase the maximum allowed frame rate.
- If you are using normal exposure times and you are using the camera at its maximum resolution, your exposure time will not normally restrict the frame rate. However, if you are using long exposure times or small region of interest, it is possible that your exposure time is limiting the maximum allowed frame rate. If you are using a long exposure time or a small ROI, try using a shorter exposure time and see if the maximum allowed frame rate increases. (You may need to compensate for a lower exposure time by using a brighter light source or increasing the opening of your lens aperture.)

An important thing to keep in mind is a common mistake new camera users frequently make when they are working with exposure time. They will often use a very long exposure time without realizing that this can severely limit the camera's maximum allowed frame rate. As an example, assume that your camera is set to use a 1 second exposure time. In this case, because each frame acquisition will take at least 1 second to be completed, the camera will only be able to acquire a maximum of one frame per second. Even if the nominal maximum frame rate of VH-16MG2 model is, for example, 4.2 frames per second, it will only be able to acquire one frame per second because the exposure time is set much higher than normal.

10 Camera Features

10.1 Image Region of Interest

The Image Region of Interest (ROI) feature allows you to specify a portion of the sensor array. You can acquire only the frame data from the specified portion of the sensor array while preserving the same quality as you acquire a frame from the entire sensor array. With the ROI feature, you can achieve increased frame rates by decreasing the height of the ROI; however, decreasing the width of the ROI does not affect the frame rate.
The ROI is referenced to the top left corner [origin (0, 0)] of the sensor array as follows.

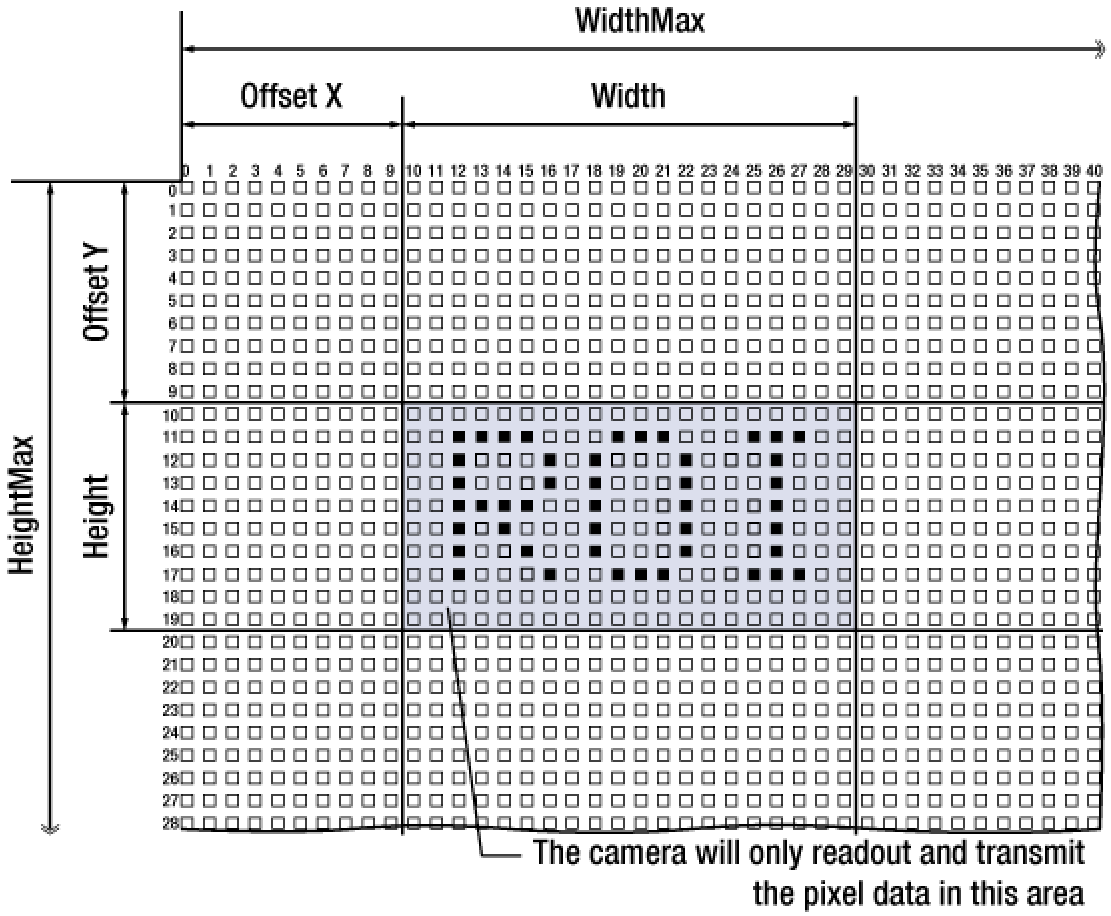


Figure 10.1 Image Region of Interest

The XML parameters related to ROI settings are as follows.

XML Parameters		Value	Description
ImageFormatControl	SensorWidth[a]	-	Effective width of the sensor
	SensorHeight[a]	-	Effective height of the sensor
	WidthMax[b]	-	Maximum allowed width of the image with the current camera settings
	HeightMax[b]	-	Maximum allowed height of the image with the current camera settings
	Width[c]	-	Current width of the image
	Height[c]	-	Current height of the image
	OffsetX[b, d]	-	Horizontal offset from the origin to the Image ROI
	OffsetY[b, d]	-	Vertical offset from the origin to the Image ROI

The unit for all parameters in this table is pixel
a: Read only. User cannot change the value
b: Changes and updates according to the Binning settings
c: User configurable parameters for settings ROI
d: User configurable parameters for setting the origin of the ROI

Table 10.1 XML parameters related to ROI

You can change the size of ROI by setting the **Width** and **Height** parameters. And also, you can change the position of the ROI origin by setting the **Offset X** and **Offset Y** parameters.
Make sure that the **Width + Offset X** value is less than the **Width Max** value, and the **Height + Offset Y** value is less than the **Height Max** value. You must set the size of the ROI first, and then set the Offset values since the **Width** and **Height** parameters are set to its maximum value by default.
The **Width** parameter must be set to a multiple of 4, and the Height parameter must be set to a value greater than the minimum Vertical ROI size shown in the Table 10.2. The **Width Max** and **Height Max** parameters will be changed and updated depending on the **Binning Horizontal** and **Binning Vertical** parameter settings respectively. And also, the **Width**, **Height**, **Offset X** and **Offset Y** parameters will be updated depending on the **Binning Horizontal** and **Binning Vertical** parameter settings respectively.

ROI Size updated according to the Binning settings may not be restored to its original value. For example, if you set the **Binning Horizontal** parameter to **×3** with **500 Width**, the **Width** parameter will be updated to **166** automatically. Then, if you set the **Width** parameter to **166** and the **Binning Horizontal** parameter to **×1**, the **Width** parameter will be **498** (166 × 3). If you want to restore the **Width** to its original value, you can set the **Width** to **500** manually.

The approximate maximum frame rate depending on the change of Vertical ROI can be obtained as shown in the following expression.

```
1 or 2 Channel Mode:
Frame Rate (fps) = 1000000 / [T_VCCD + T_RF × {V_SIZE – (V_ROI + 12)} + (V_ROI + 12) × T_L]
```

$$\text{Frame Rate (fps)} = 1000000 / [T_{VCCD} + T_{RF} \times \{V_{SIZE} - (V_{ROI} + 12)\} + (V_{ROI} + 12) \times T_L]$$

T_{VCCD}	: the amount of time required to transmit electric charges accumulated on the pixels to Vertical Register
T_{RF}	: the amount of time required for 1 row flush
V_{SIZE}	: the number of Vertical Line of CCD
T_L	: the amount of time required for transmission of one line
V_{ROI}	: size of the Vertical ROI

The available minimum value of T_{VCCD}, T_{RF}, V_{SIZE}, T_L and V_{ROI} may vary depending on the camera model.
The value of T_L may vary depending on the **Sensor Digitization Taps** and **Pclk Selector** parameter settings.
The values of each item are shown below.

VH GigE Series	VH-310G2	VH-2MG2	VH-4MG2	VH-5MG2	VH11MG2	VH-16MG2
T_{VCCD}	30.4 ㎲	97 ㎲	11.6 ㎲	29.6 ㎲	210 ㎲	292 ㎲
T_L (1 channel)	14.6 ㎲	35.9 ㎲	45.3 ㎲	-	108.9 ㎲	136.6 ㎲
T_L (2 channel)	7.7 ㎲	19.5 ㎲	24.2 ㎲	30.6 ㎲	58.0 ㎲	74.3 ㎲
T_{RF}	0.46 ㎲	3.0 ㎲	2.8 ㎲	9.0 ㎲	7.0 ㎲	12.0 ㎲
V_{SIZE}	492 Lines	1216 Lines	2072 Lines	2068 Lines	2721 Lines	3324 Lines
Minimum Vertical ROI	60 Lines	150 Lines	256 Lines	256 Lines	334 Lines	406 Lines
Based on the High Speed Pixel Clock (**PclkSelector**: **PCLK1**) except VH-5MG2 model (Normal Speed)						

Table 10.2 Timing Value for VH GigE Series

The following figure shows frame rate for each camera model depending on Vertical ROI changes with 1 Tap and 2 Tap settings.

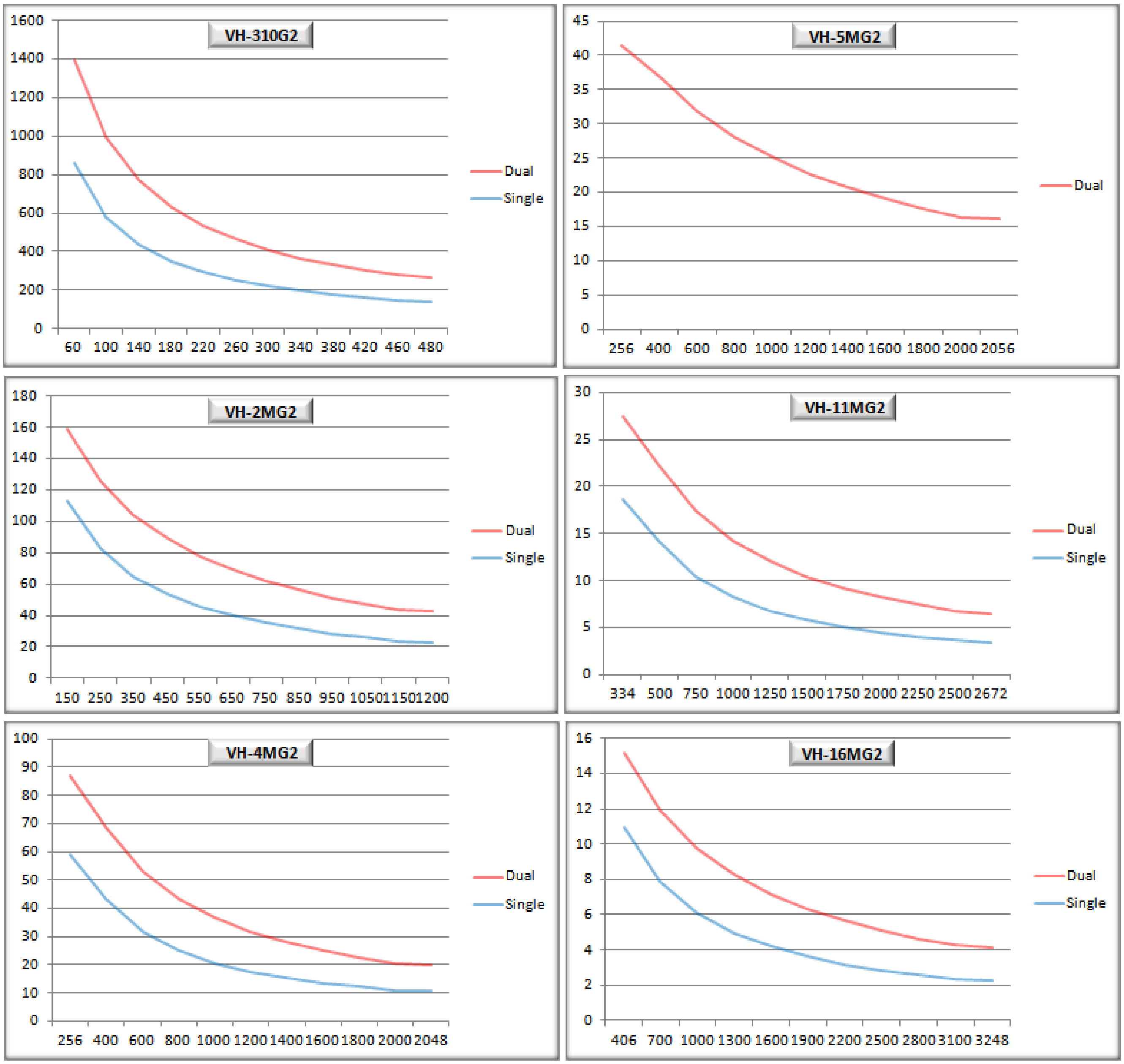


Figure 10.2 Frame Rate by Vertical ROI changes

10.2 Binning

Binning has the effects of increasing the level value and decreasing resolution by summing the values of the adjacent pixels and sending them as one pixel.
The XML parameters related to Binning are as follows.

XML Parameters		Value	Description
ImageFormatControl	BinningHorizontal	×1, ×2, ×3, ×4, ×8	Number of horizontal pixels to combine together
	BinningVertical	×1, ×2, ×3, ×4, ×8	Number of vertical pixels to combine together

Table 10.3 XML Parameters related to Binning

For example, if you set 2 × 2 binning as shown in the figure below, four pixels will be summed into one pixel. Then, the effective maximum resolution of the sensor is reduced to 1/2. The **Width Max** and **Height Max** parameters, indicating the maximum allowed resolution of the image with the current camera settings, will be updated depending on the binning settings. And also, the **Width**, **Height**, **Offset X** and **Offset Y** parameters will be updated depending on the binning settings. You can verify the current resolution through the **Width** and **Height** parameters.
Since vertical binning is processed in the internal register of CCD, the frame rate will be increased and SNR will be improved because the number of the readout process is reduced. However, the horizontal binning does not affect the frame rate and SNR because it is processed in the FPGA. The brightness will be increased about four times because four pixels are summed as one.

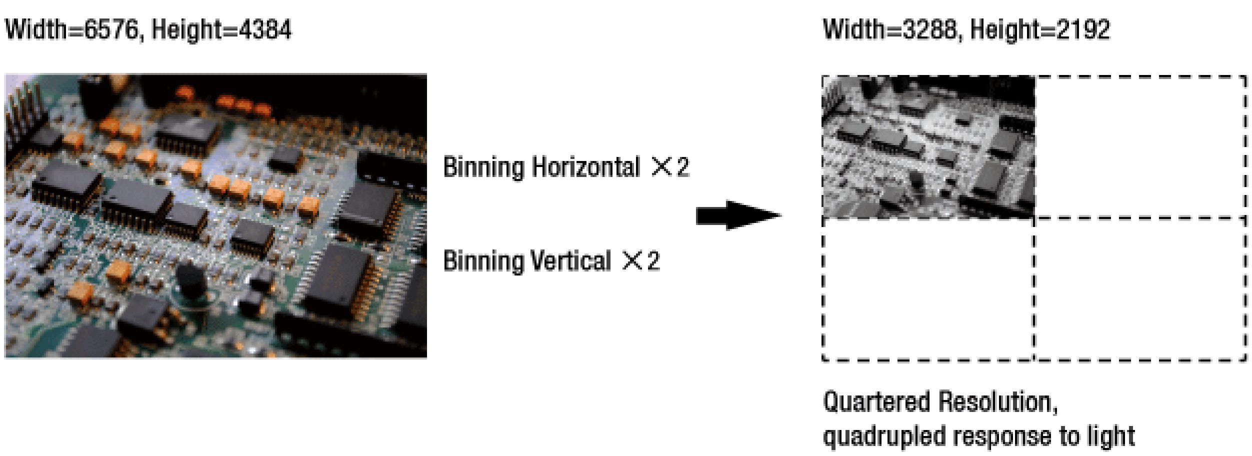


Figure 10.3 Binning

VH GigE series supports ×1, ×2, ×3, ×4, ×8 binning factors for both vertical and horizontal direction independently.

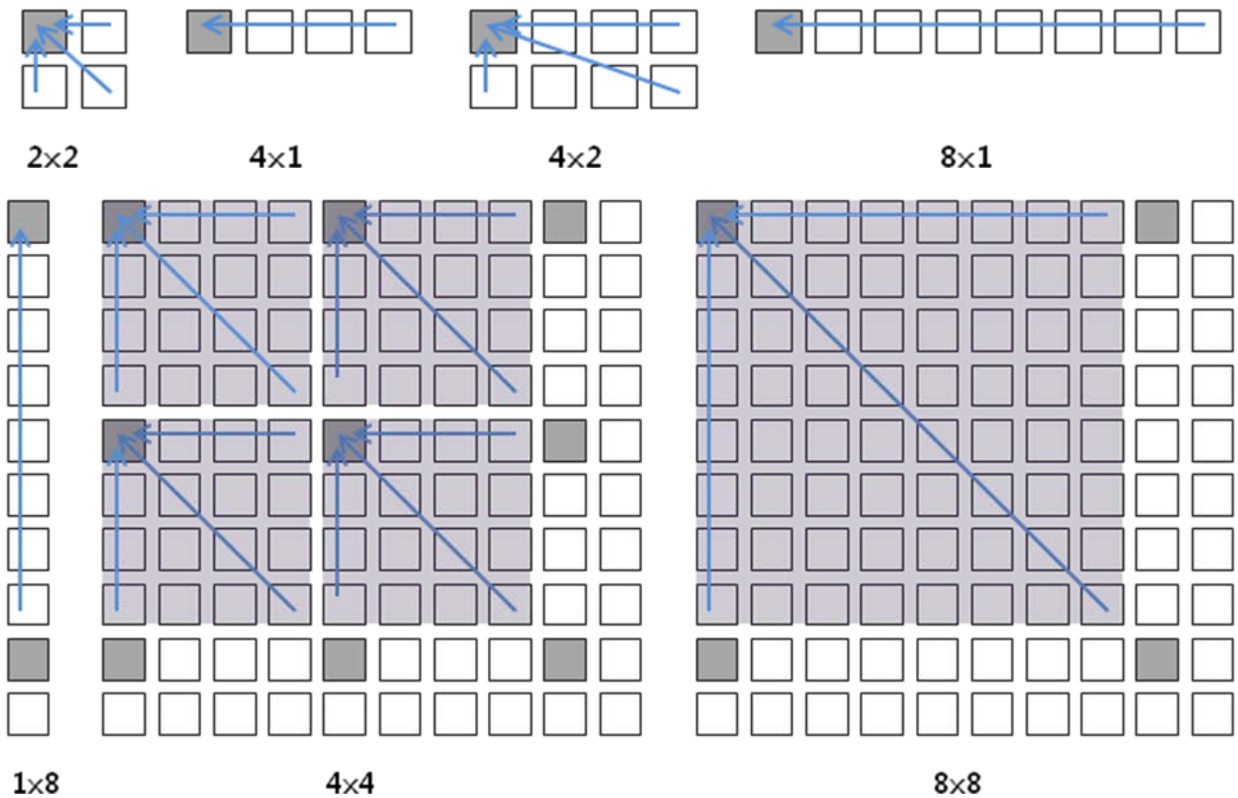


Figure 10.4 Binning factors

CAUTION	• Even if the binning is performed on the color camera, the resulting image will be monochrome. • The odd number of binning factor (×3) does not supported on the color camera due to the characteristics of Bayer pattern.

10.3 Sensor Tap Settings

With two taps sensor digitization, two (left and right) video amplifiers are used to output the charges moved to the horizontal register during reading out the accumulated charges. Charges from the left half of the sensor are shifted towards the Video L and charges from the right half of the sensor are shifted towards Video R.

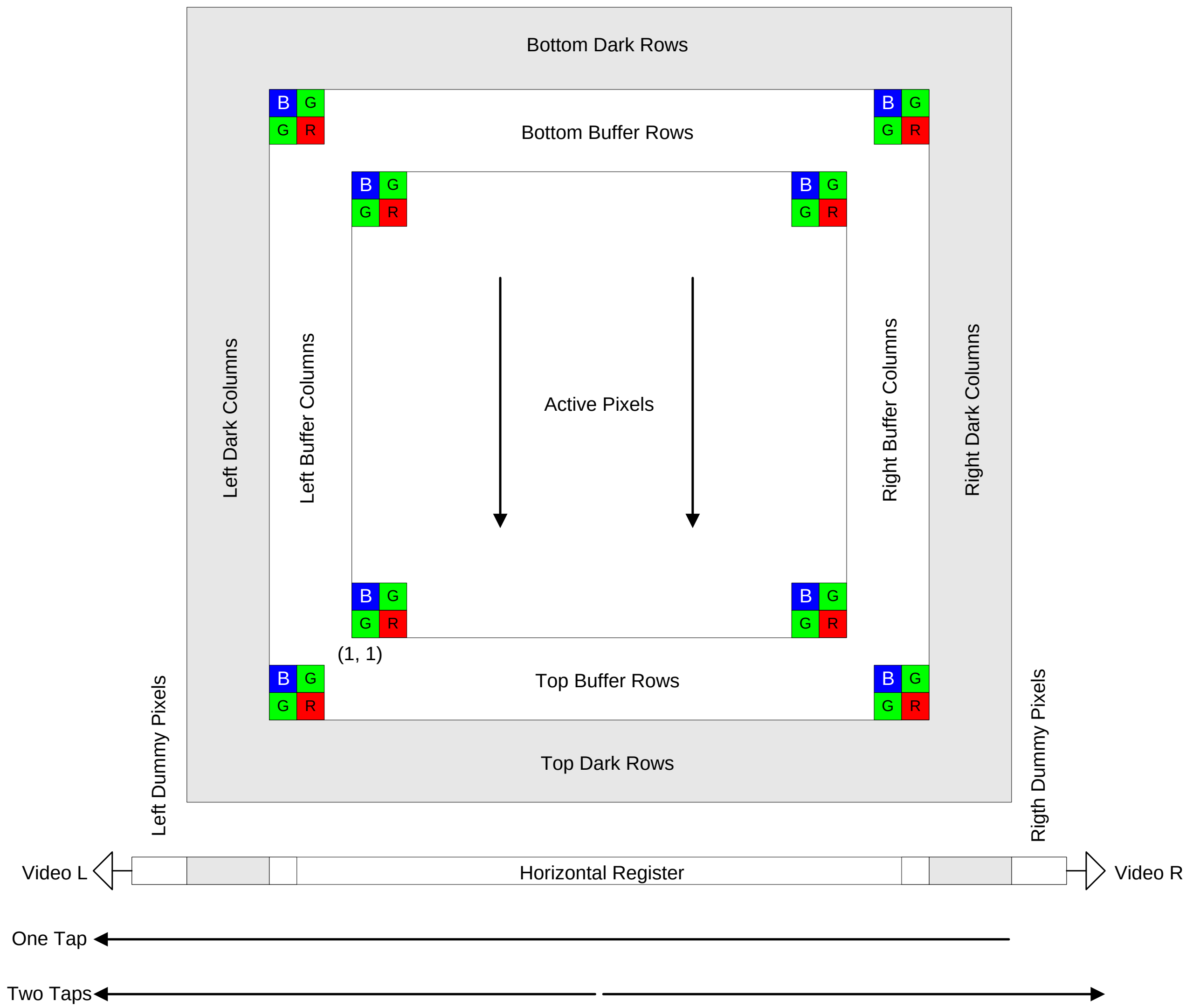


Figure 10.5 Two Taps Sensor Digitization

XML parameters related to Sensor Tap Settings are as follows.

XML Parameters		Value	Description
ImageFormatControl	SensorDigitizationTaps	One	Set the Sensor Readout mode to 1 tap
		Two	Set the Sensor Readout mode to 2 tap

Table 10.4 XML Parameter related to Sensor Tap Settings

When you set the **Sensor Digitization Taps** parameter to **One**, only the left video amplifier (Video L) will be used to output the video data as shown in the Figure 10.8. And when you set the **Sensor Digitization Taps** parameter to **Two**, both Video L and Video R will be used to output the video data as shown in the Figure 10.9. When LVDS signals converted from the video data through ADC are transmitted to FPGA, the signal data will be stored in the line buffer of FPGA until the transmission of one horizontal line is completed. Figure 10.10 and 10.11 show the structure which reorders and stores one line video data in the line buffer of FPGA according to the one tap and two taps settings. After completing one line transmission, the data goes through image processing. Then, the data will be reordered according to the **Pixel Format** parameter setting value and stored in the frame buffer.

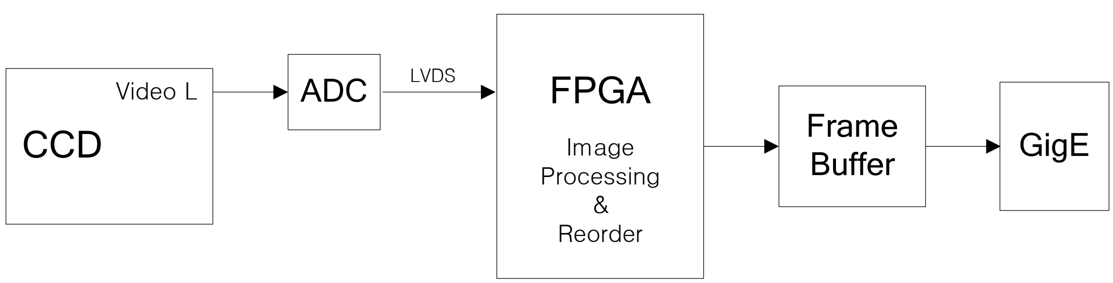


Figure 10.6 1Tap Image Data Flow

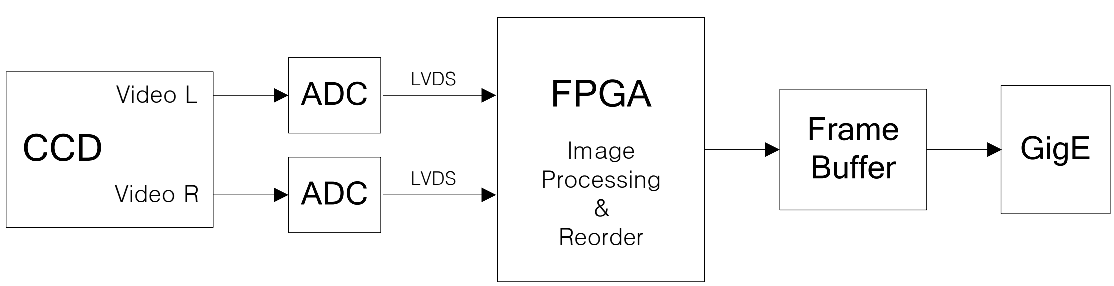


Figure 10.7 2Taps Image Data Flow

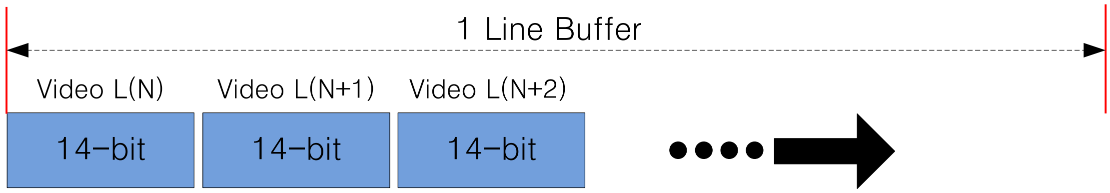


Figure 10.8 1 Tap Reorder

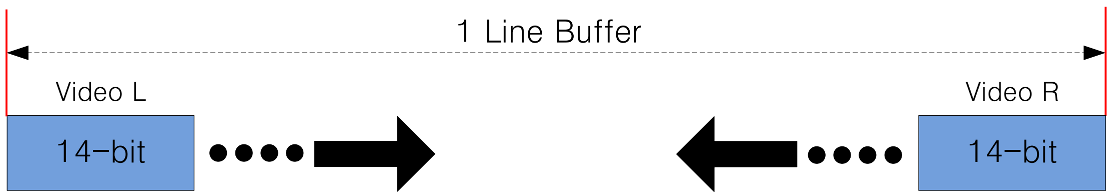


Figure 10.9 2 Tap Reorder

The LVDS video data converted in ADC are 14 bits, however the camera outputs 12 bits video data. The noise performance will be improved on the output image by removing the 2 least significant bits.

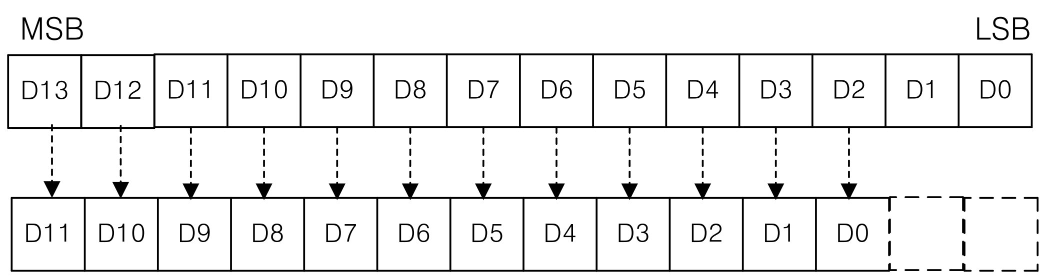


Figure 10.10 12bit Conversion

10.4 Pixel Format

The internal processing of image data is performed in 12 bits. Then, the camera can output the data in 8, 10 or 12 bits. When the camera outputs the image data in 8 bits or 10 bits, the 4 or 2 least significant bits will be truncated accordingly.

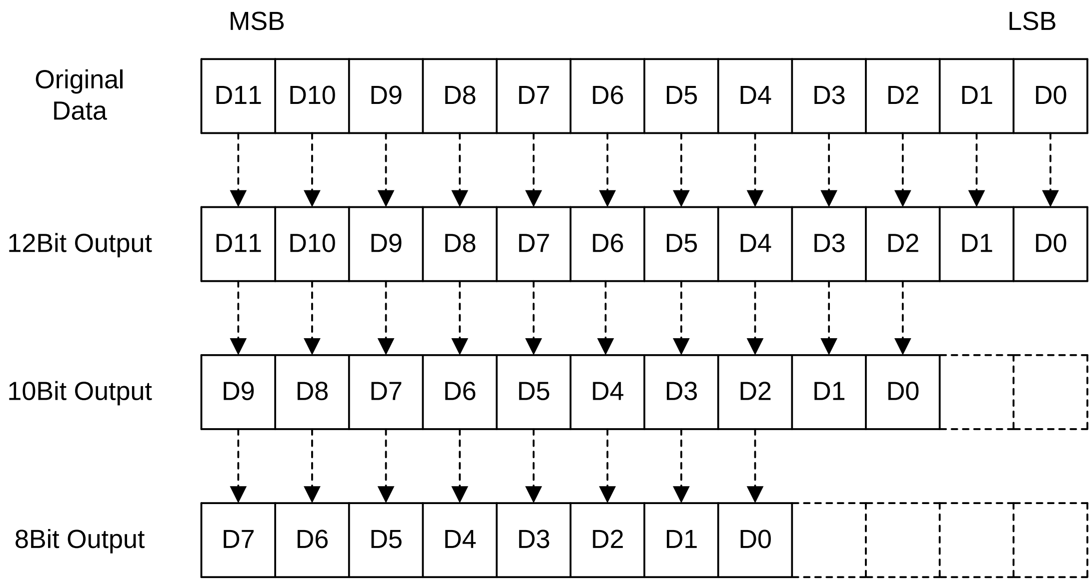


Figure 10.11 Pixel Format

The image data converted to 8, 10 or 12 bits support various pixel data format depending on the camera model. The pixel data will be reordered in FPGA according to the **Pixel Format** setting value. Then, it will be stored in the frame buffer before output. XML parameter related to the Pixel Format is as follows.

XML Parameters		Description
ImageFormatControl	PixelFormat	Set the pixel format supported by the device

Table 10.5 XML Parameter related to Pixel Format

The supported pixel formats for monochrome and color cameras are as follows.

Mono Sensor	Color Sensor
• Mono 8 • Mono 10 • Mono 10 Packed • Mono 12 • Mono 12 Packed	• Mono 8 • Mono 10 • Mono 10 Packed • Mono 12 • Mono 12 Packed • Bayer GR (or RG) 8 • Bayer GR (or RG) 10 • Bayer GR (or RG) 12 • Bayer GR (or RG) 10 Packed • Bayer GR (or RG) 12 Packed

Table 10.6 Pixel Data Format Value

The structures for supported pixel formats are as follows.

Mono 8

With the camera set to **Mono 8**, the pixel data output is 8 bit monochrome, unsigned char and unpacked type. This type is stored in a byte unit when 8 bit pixel data are stored in the frame buffer.

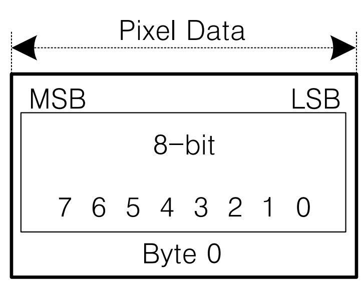


Figure 10.12 Mono 8 Format

Mono 10

With the camera set to **Mono 10**, the pixel data output is 10 bit monochrome, unsigned char and unpacked type. This type is divided into two bytes when 10 bit pixel data are stored in the frame buffer. 8 bits of pixel data will be stored in Byte 0, 2 bits of pixel data will be stored in Byte 1, and the rest 6 bits will not be used.

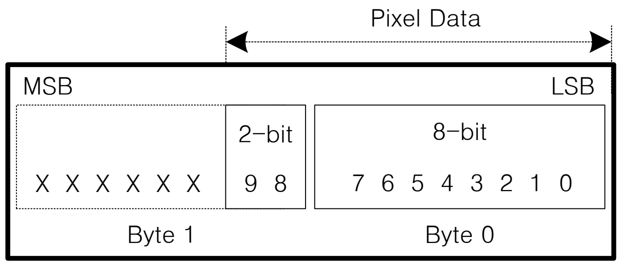


Figure 10.13 Mono 10 Format

Mono 10 Packed

With the camera set to **Mono 10 Packed**, the pixel data output is 10 bit monochrome, unsigned char and GigE Vision-specific packed type.

This type is divided into three bytes when 20 bit pixel data are stored in the frame buffer. 8 bits of pixel data 0 will be stored in Byte 0 and the rest 2 bits will be stored in Byte 1. Pixel Data 1 will be stored in Byte 2 and the rest 2 bits will be stored in Byte 1.

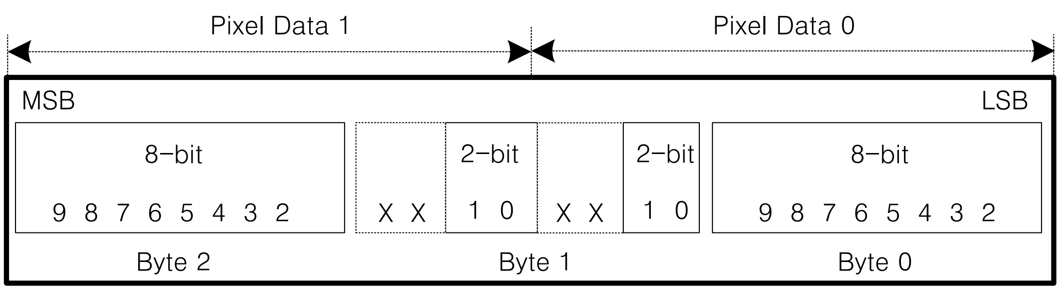


Figure 10.14 Mono 10 Packed Format

Mono 12

With the camera set to **Mono 12**, the pixel data output is 12 bit monochrome, unsigned and unpacked type. This type is divided into two bytes when 12 bit pixel data are stored in the frame buffer. 8 bits of pixel data will be stored in Byte 0 and the rest 4 bits will be stored in Byte 1. The rest 4 bits of Byte 1 will not be used.

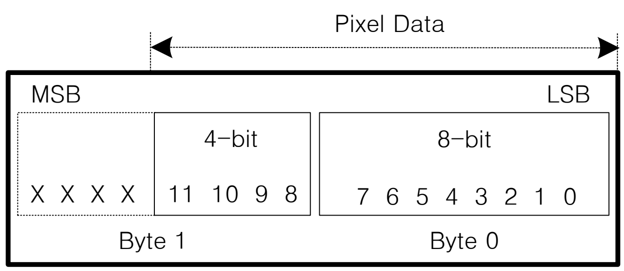


Figure 10.15 Mono 12 Format

Mono 12 Packed

With the camera set to **Mono 12 Packed**, the pixel data output is 12 bit monochrome, unsigned and GigE Vision-specific packed type.

This type will be divided into three bytes when 24 bit pixel data are stored in the frame buffer.

8 bits of pixel data 0 will be stored in Byte 0 and the rest 4 bits will be stored in Byte 1. 8 bits of pixel data 1 will be stored in Byte 2 and the rest 4 bits will be stored in Byte 1.

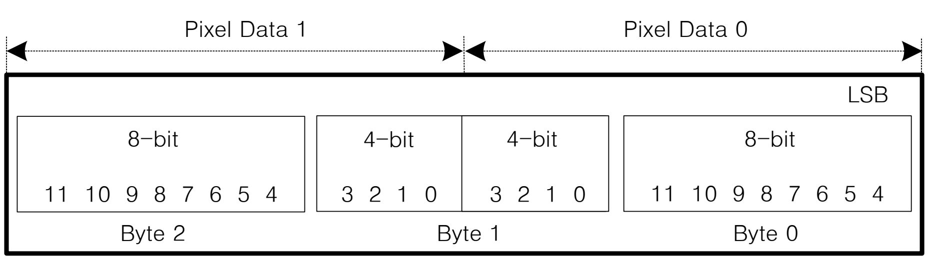


Figure 10.16 Mono 12 Packed Format

Bayer Format

When you set the **Pixel Format** parameter to any **Bayer Format** in the color camera, the bits of pixel data will be reordered to bytes, and then will be stored in the frame buffer in the same way as Mono Format.

For example, if you set the **Pixel Format** parameter to **Bayer GR 10 Packed**, the pixel data will be reordered and stored in the frame buffer as shown in the Figure 10.17. 10 least significant bits of green data will be stored in Byte 0 and Byte 1, and 10 most significant bits of red data will be stored in Byte 2 and Byte 1. The bit order is shown in the first figure below. After saving 1 - horizontal line of G-R pattern pixel data, 2 – horizontal line of B-G pattern pixel data will be stored as shown in the second figure below. G-R pattern (Horizontal Direction) and B-G pattern (Horizontal Direction) pixel data will be stored repeatedly as a line (Vertical Direction).

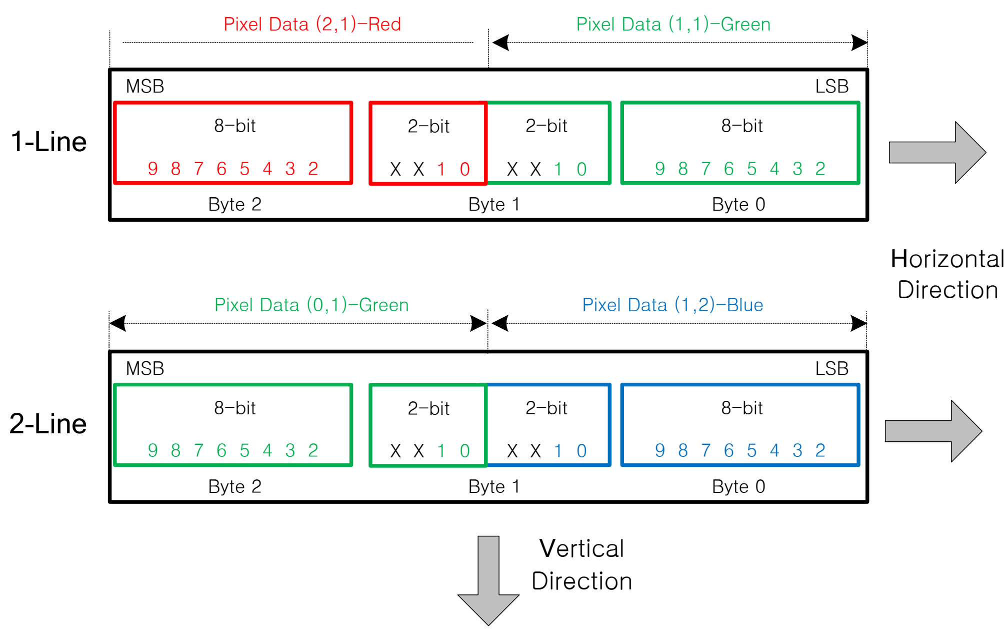


Figure 10.17 Bayer Format

The alignment of the Bayer filter used in color cameras depends on the camera model. The filter alignment for each available camera model is as follows.

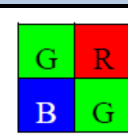
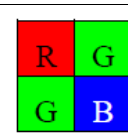
Color Camera Model	Filter Alignment
VH-310G2, VH-2MG2, VH-4MG2, VH-11MG2, VH-16MG2	GR 
VH-5MG2	RG 

Table 10.7 Bayer Filter Alignment

10.5 Pixel Clock

VH GigE camera provides a unique way to control the camera speed and frame rate. You can select the pixel clock to operate the camera either in Normal or High-speed (over-clocked) mode. With Normal mode, the camera's frame rate is determined by the CCD sensor manufacturer.

VH GigE camera internal design is optimized for High-speed mode. With High-speed mode, it is possible to over-clock the camera which will result in higher frame rate. However, the camera signal to noise ratio (SNR) may be reduced compared to Normal mode.

XML parameters related to pixel clock are as follows.

XML Parameters		Value	Description
DeviceControl	PclkSelector	PCLK0	Set pixel clock to Normal mode • VH-11M/16MG2 – 30 ㎒ • VH-310/2M/4MG2 – 40 ㎒ • VH-5MG2 – 60 ㎒ (Only operate in Normal mode)
		PCLK1	Set pixel clock to High-speed mode • VH-11M/16MG2 – 40 ㎒ • VH-310/2M/4MG2 – 50 ㎒
	CurrentPclkFreq	−	Display the current camera pixel clock in ㎒

Table 10.8 XML Parameters related to Pixel Clock

10.6 Stream Hold

VH GigE camera provides **Stream Hold** feature for controlling the transmission of data.
Normally, the camera transmits frame data to the host computer immediately after completing the exposure. Enabling the **Stream Hold** feature delays the transmission of data, storing it in the camera's volatile memory until the **Stream Hold** feature is disabled.
This feature is especially useful to prevent flooding in Gigabit Ethernet network where multiple cameras are connected to a single host computer and capture a single event. Using the **Stream Hold** feature, each camera will hold the image data until the camera's **Stream Hold** feature is disabled. VH GigE camera provides 128 MB on-board memory for the **Stream Hold** feature. The **Stream Hold** feature does not allow you to select which frame will be released to the host computer. When the **Stream Hold** feature is disabled, the stored frame data will be released to the host computer. For more information, refer to the application note about stream hold.

<table>
<tr><th colspan="2">XML Parameters</th><th>Value</th><th>Description</th></tr>
<tr><td rowspan="3">TransportLayerControl</td><td rowspan="2">StreamHold</td><td>On</td><td>Delay the transmission of frame data and store them in the frame buffer.</td></tr>
<tr><td>Off</td><td>Release the stored frame data to the host computer.</td></tr>
<tr><td>FrameCapacity</td><td>–</td><td>• Display the maximum number of frames that you can store in the frame buffer
• The maximum number of frames will vary depending on the Image ROI and pixel format settings.
• With the Stream Hold feature set to On, the newly acquired frame will be ignored after saving the maximum number of frames.</td></tr>
</table>

Table 10.9 XML Parameters related to Stream Hold feature

10.7 Inter-Packet Delay

VH GigE camera provides the Inter-packet delay feature to set the delay in ticks between the packets transmitted by the camera.

Packet Size

The **Gev SCPS Packet Size** parameter sets the size of the packets that the camera will use when it sends the data via the selected stream channel. This parameter should always be set to the maximum size that your network components (Ethernet Adapter) can handle.

Setting the delay between packets

The **Gev SCPD** parameter sets the delay in ticks between the packets transmitted from the camera. Increasing the delay will decrease the camera's effective data transmission rate and will thus decrease the network bandwidth used by the camera.

In the VH GigE camera, one tick is 8 ㎱. To check the tick frequency, read the **Gev Time stamp Tick Frequency** parameter value.

In case of multiple cameras or other devices working on the same physical network, it might be desirable to send the packets of a camera's streaming channel with a certain inter-packet delay in order to allow multiple cameras or devices to share a given network bandwidth.

XML Parameters		Value	Description
TransportLayerControl	GevSCPSPacketSize	576~16,000 Bytes	Set the packet size (The maximum value may vary depending on the Ethernet Adapter.).
	GevSCPD	0~ **TBD**	Set the delay between packets.

Table 10.10 XML Parameters related to Inter-Packet Delay

10.8 Data ROI

The **Exposure Auto** and **Balance White Auto** features use the pixel data from a Data Region of Interest (ROI) to adjust the related parameters. XML parameters related to data ROI are as follows.

XML Parameters		Value	Description
DataRoiControl	RoiSelector	AE	Select a Data ROI used for Exposure Auto
		AWB	• Select a Data ROI used for Balance White Auto • Only available on the color camera
	RoiOffsetX	−	X coordinate of start point ROI
	RoiOffsetY	−	Y coordinate of start point ROI
	RoiWidth	−	Width of ROI
	RoiHeight	−	Height of ROI

Table 10.11 XML Parameters related to Data ROI

Only the pixel data from the area of overlap between the data ROI by your settings and the Image ROI will be effective if you use Image ROI and Data ROI at the same time. The effective ROI is determined as shown in the figure below.

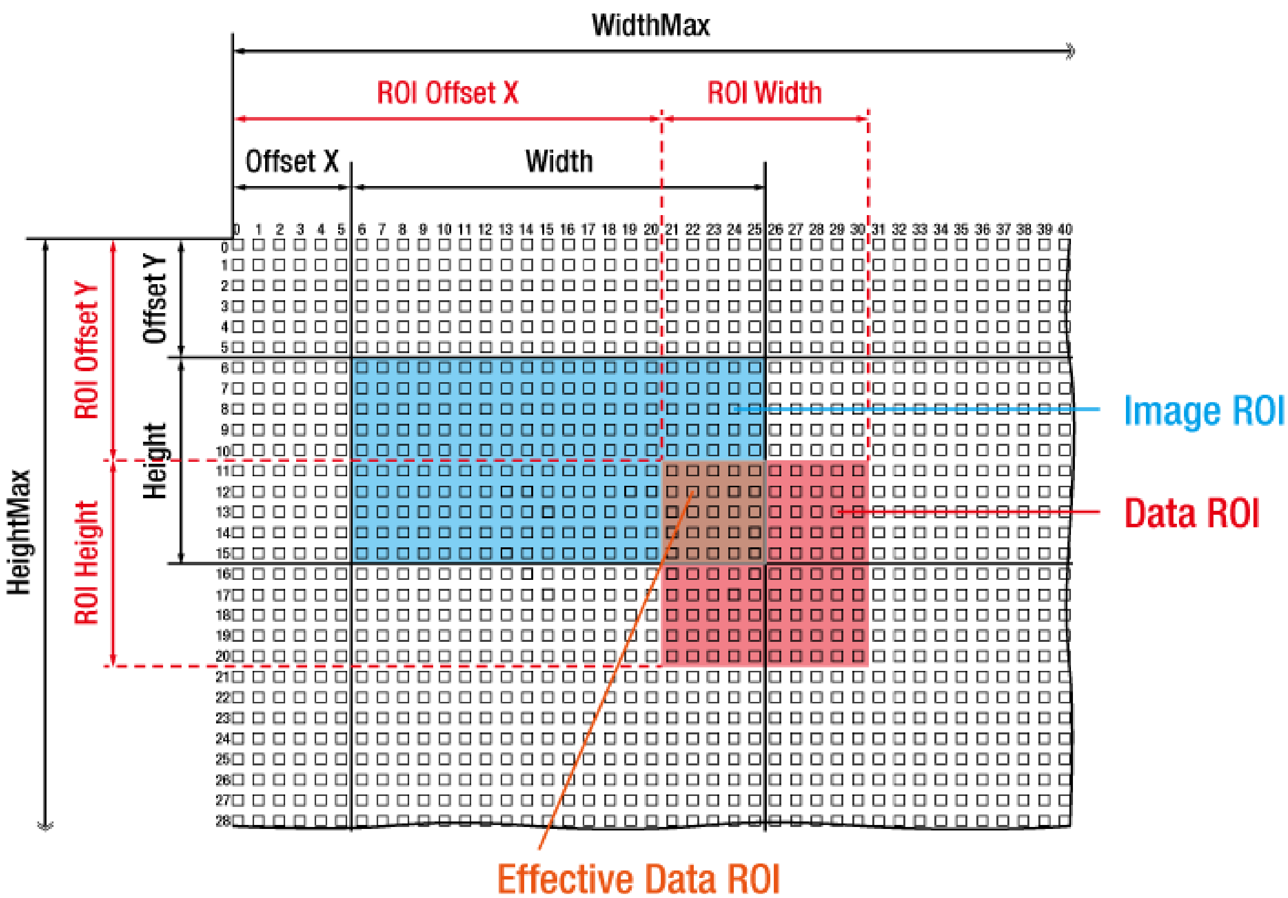


Figure 10.18 Effective Data ROI

10.9 Exposure Auto and Gain Auto

The **Exposure Auto** feature automatically adjusts the **Exposure Time** parameter until the grey level for the pixels in the given Data ROI reaches an **Exposure Auto Target Level** value set by the user.
The **Exposure Auto** feature in VH GigE series uses iterative algorithm which repeatedly calculates the previous exposure values until it gets new exposure value. Note that the camera needs up to 30 frames to complete the Exposure Auto feature.

The **Exposure Auto** feature is not available if the **Exposure Mode** parameter is set to **Trigger Width**.

The **Exposure Auto** and **Gain Auto** features can be used at the same time and operated in the **Off**, **Once** and **Continuous** modes of operation. If you use two features at the same time, the camera will adjust the value of Exposure Time followed by Digital Gain.
When the **Exposure Auto** or **Gain Auto** feature is set to **Once**, the parameter values are automatically adjusted until the related parameter value reaches the target value. After the automatic parameter value adjustment is complete, the feature will be set to **Off**. When the auto feature is set to **Continuous**, the camera adjusts Exposure Time or Digital Gain parameter to reach the target value every time the lighting conditions change. You can set the **Exposure Auto Tolerance** parameter to adjust the sensitivity of the Exposure Auto feature.

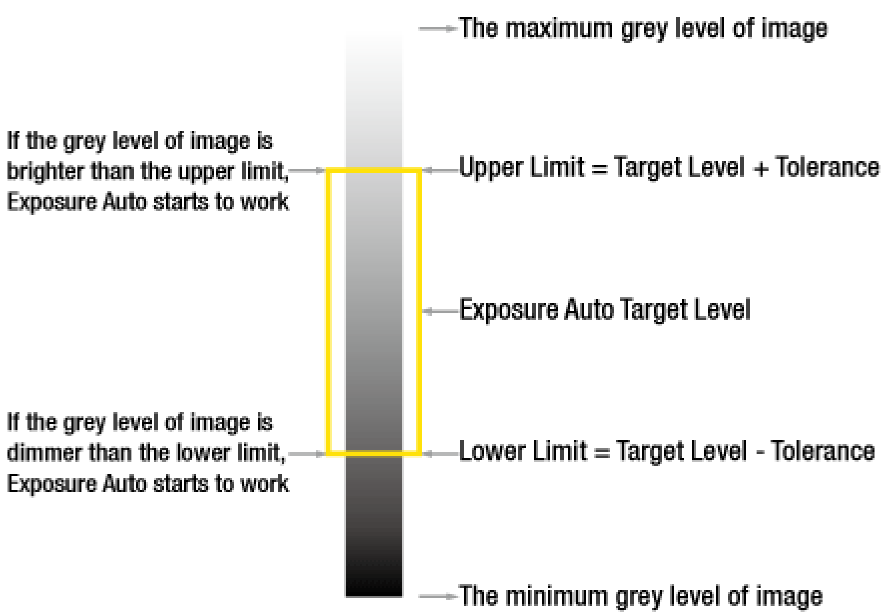


Figure 10.19 Exposure Auto Target Level and Exposure Auto Tolerance

Each auto feature has the following operating ranges depending on the object brightness level. You can set the operating range by adjusting the minimum and maximum value for each feature.

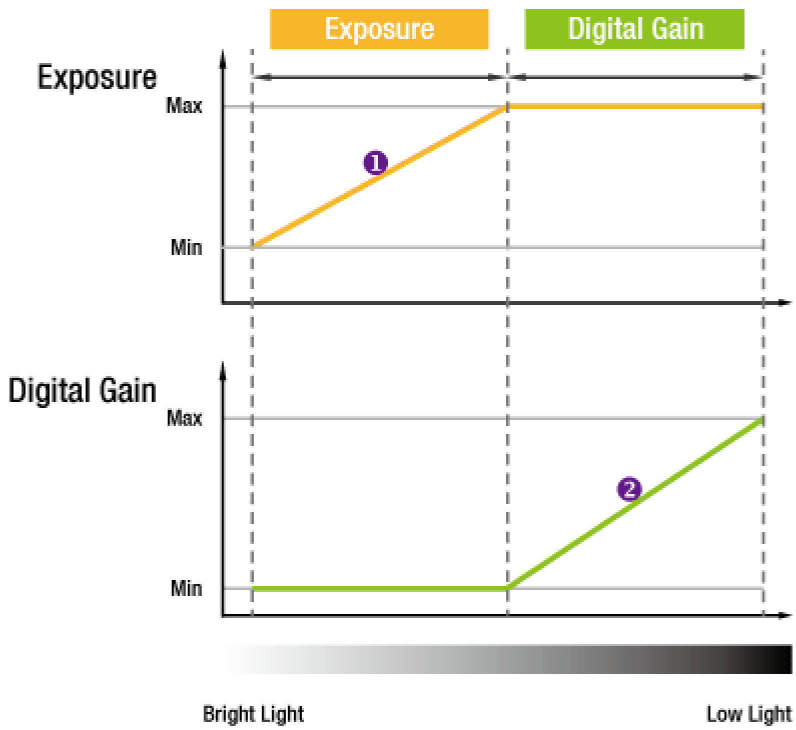


Figure 10.20 Image Level Adjustment

When the **Exposure Auto** or **Gain Auto** parameter is set to **Off**, the operating procedures are as follow.

Auto Features		Operating Procedures	Remarks
Exposure	Gain		
On	On	Exposure → Gain	Both the Exposure and Gain are adjusted automatically
On	Off	Exposure	Manually adjustable the Gain
Off	On	Gain	Manually adjustable the Exposure
Off	Off	-	Manually adjustable both the Exposure and Gain

Table 10.12 Operating Procedures for Auto Features

XML parameters related to AEC (Auto Exposure Control) are as follows.

XML Parameters		Value	Description
AcquisitionControl	ExposureAuto	Off	Exposure Auto Off
		Once	Target Level is adapted once and then Off
		Continuous	Target Level is constantly adapted
	ExposureAutoMin	Refer to Table 9.1	Lower limits of Exposure duration (The lower the value, the more smear)
	ExposureAutoMax	~7,000,000 ㎲	Upper limits of Exposure duration (The higher the value, the more motion blur)
	ExposureAutoTargetLevel	100~3995	Target average grey value (12bit†)
	ExposureAutoTolerance	100~2047	Tolerance of the target average grey value - 12 bit (If the current grey level is out of the tolerance, AEC starts to work.)
AnalogControl	GainAuto	Off	Gain Auto Off
		Once	Gain is adjusted once and then Off
		Continuous	Gain is constantly adjusted
	GainAutoMin	×1~×64	Lower limits of Gain
	GainAutoMax		Upper limits of Gain

Table 10.13 XML Parameters related to AEC

- You can set the Exposure Auto and Gain Auto feature in any order. However, we strongly recommend setting the one feature first while turning off the other features for the smooth operation.
- †: The maximum allowed **Exposure Auto Target Level** value may vary depending on the **Exposure Auto Tolerance** setting value.
  Exposure Auto Target Level = (0+Tolerance) ~ (4,095 –Tolerance)

10.10 Balance White Auto (Color Cameras)

The **Balance White Auto** feature is implemented on color cameras. It will control the white balance of the image acquired from the color camera according to the GreyWorld algorithm. Before using the **Balance White Auto** feature, you need to set the Data ROI for Balance White Auto. If you do not set the related Data ROI, the pixel data from the Image ROI will be used to control the white balance. As soon as the **Balance White Auto** parameter is set to **Once**, the Digital Red, Digital Green and Digital Blue will be set to 1. Then, Digital Red and Digital Blue will be adjusted to control the white balance.

XML parameters related to the Balance White Auto and RGB Gain settings are as follows.

XML Parameters		Value	Description
AnalogControl	GainSelector	AnalogAll	Apply gain to all analog taps
		AnalogTap1	Apply analog gain to Tap1
		AnalogTap2	Apply analog gain to Tap2
		DigitalAll	Apply gain to all digital channel
		DigitalRed	Apply gain to red digital channel
		DigitalGreen	Apply gain to green digital channel
		DigitalBlue	Apply gain to blue digital channel
	Gain	×0.5 ~ ×2.0	Set an absolute physical gain value when Digital Red, Green or Blue is selected
	BalanceWhiteAuto	Off	Balance White Auto Off
		Once	White Balance is adjusted once and then Off

Table 10.14 XML Parameters related to Balance White Auto

10.11 Gain and Black Level

You can set the analog (VGA) and digital gain factor to adjust the gain. The black level is adjusted by removing the optical black offset from the CCD so that the effect of dark current will be minimized.

10.11.1 Analog Domain

The VH GigE camera has one Analog Signal Processor (or Analog Front End (AFE)) for each channel. This AFE consists of Correlated Double Sampler (CDS), Variable Gain Amplifier (VGA), Black Level Clamp and 14-bit A/D converter.

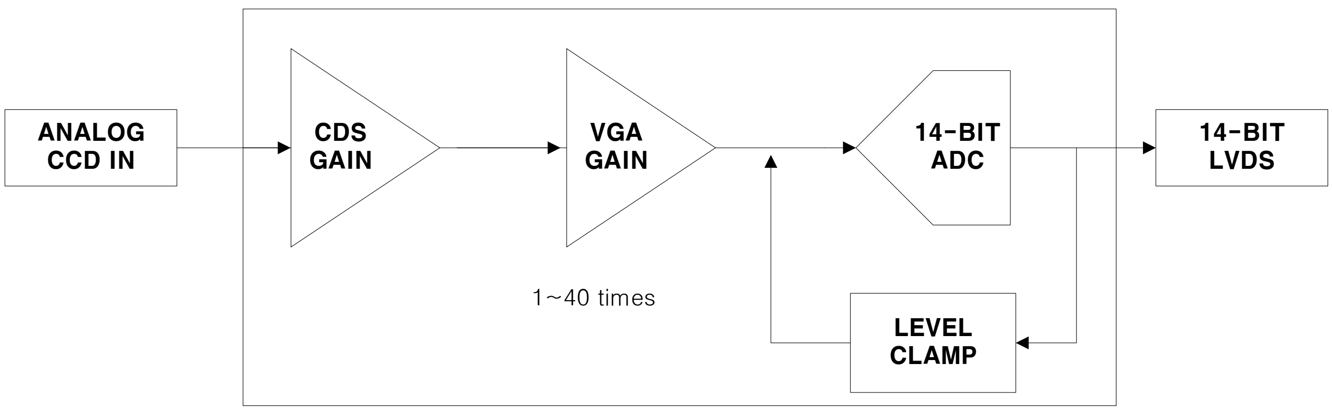


Figure 10.21 AFE Block Diagram

You can change the gain and black level value by inputting proper value into the registers for gain and black level adjustments inside the AFE. The CDS gain value is set in the factory during the manufacturing process, therefore you cannot change the value. The VGA gain is the same as the analog gain. You can set the analog gain for all analog taps or each tap. You can determine whether to control the gain balance between each tap manually or automatically by setting the **Gain Auto Balance** parameter to **Off** or **Once**. To balance the black level between each tap, use the **Black Level** parameter.

10.11.2 Digital Domain

Digital gain is adjustable from 1 to ×64 with almost 1/1024 step. If the **Gain Auto** parameter is set to **Once** or **Continuous**, the digital gain value will be automatically adjusted according to the **Exposure Auto Target Level** parameter settings. XML parameters related to Gain and Black Level are as follows.

<table>
<tr><th colspan="2">XML Parameters</th><th>Value</th><th>Description</th></tr>
<tr><td rowspan="21">AnalogControl</td><td rowspan="7">GainSelector</td><td>AnalogAll</td><td>Apply gain to all analog taps</td></tr>
<tr><td>AnalogTap1</td><td>Apply analog gain to Tap1</td></tr>
<tr><td>AnalogTap2</td><td>Apply analog gain to Tap2</td></tr>
<tr><td>DigitalAll</td><td>Apply gain to all digital channel</td></tr>
<tr><td>DigitalRed</td><td>Apply gain to red digital channel</td></tr>
<tr><td>DigitalGreen</td><td>Apply gain to green digital channel</td></tr>
<tr><td>DigitalBlue</td><td>Apply gain to blue digital channel</td></tr>
<tr><td>Gain</td><td>-</td><td>Set an absolute physical gain value.
• Analog All: ×1.0 ~ ×40
• Analog Tap1, 2†</td></tr>
<tr><td rowspan="3">GainAuto</td><td>Off</td><td>Gain Auto Off</td></tr>
<tr><td>Once</td><td>Gain value is adjusted once and then Off</td></tr>
<tr><td>Continuous</td><td>Gain value is constantly adjusted</td></tr>
<tr><td rowspan="2">GainAutoBalance</td><td>Off</td><td>Gain Auto Balance Off</td></tr>
<tr><td>Once</td><td>Gain Balance for each tap is adjusted once‡ and then Off</td></tr>
<tr><td rowspan="3">BlackLevelSelector</td><td>All</td><td>Apply black level to all taps</td></tr>
<tr><td>Tap1</td><td>Apply black level to Tap1</td></tr>
<tr><td>Tap2</td><td>Apply black level to Tap2</td></tr>
<tr><td>BlackLevel</td><td>0~255</td><td>Set an absolute physical black level value.
(0 ~ 127 LSB @ 12bit)</td></tr>
</table>

†: Adjustable value range may vary depending on the camera set and camera model.

‡: The illumination must be of uniform intensity throughout the sensor when performing Gain Auto Balance.

Table 10.15 XML Parameters related to Gain and Black Level

10.12 LUT

LUT (Lookup Table) converts original image values to certain level values.

Luminance

Since it is mapped one to one for each level value, 12-bit output can be connected to 12-bit input. LUT is in the form of table that has 4096 entries between 0~4095 and VH GigE camera provides a non-volatile space for LUT data storage. You can determine whether to apply LUT and which LUT to use. For more information about how to download LUT to the camera, refer to Appendix B.

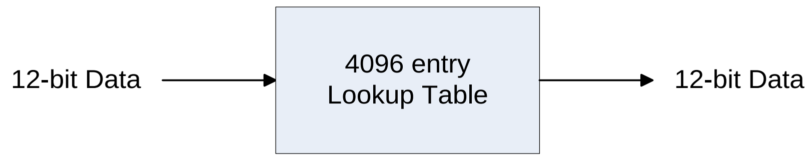


Figure 10.22 LUT Block

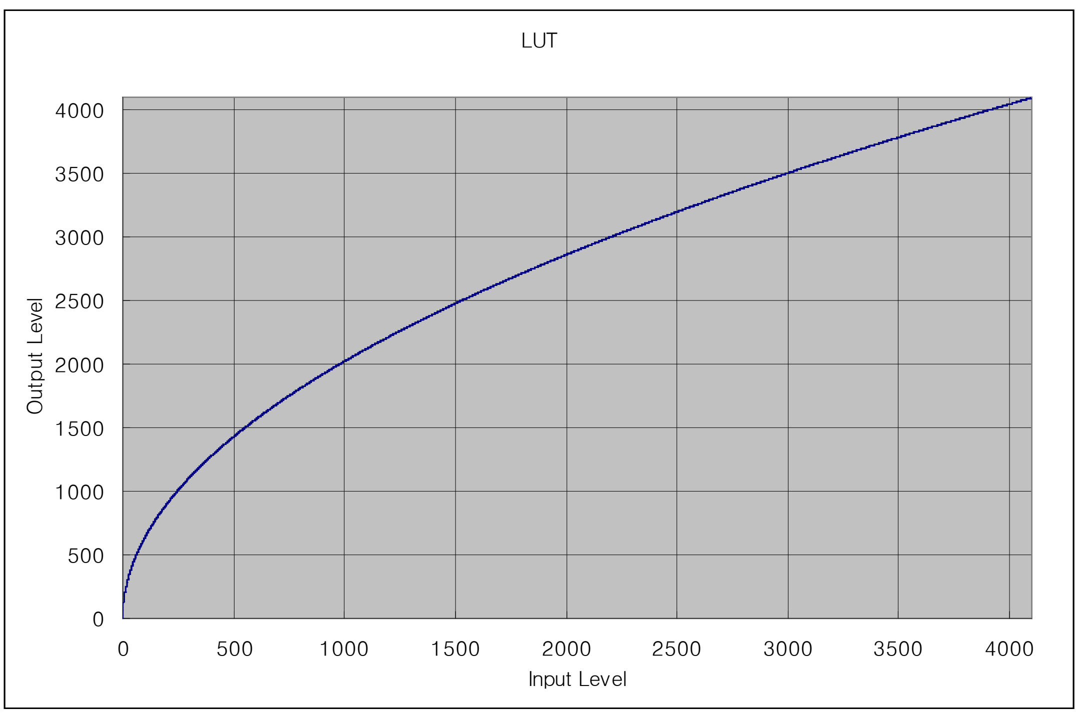


Figure 10.23 LUT at Gamma 0.5

XML parameters related to LUT are as follows.

XML Parameters		Value	Description
LUTControl	LUTSelector	Luminance	Luminance LUT
	LUTEnable	On	Activate the selected LUT
		Off	Deactivate the selected LUT
	LUTIndex	-	Index of coefficient for verifying the LUT Value • Luminance: 0 ~ 4095
	LUTValue	-	Output value of the current LUT corresponding to the input value of LUT Index

Table 10.16 XML Parameters related to LUT

10.13 Defective Pixel Correction

The CCD may have Defective Pixels which cannot properly react to the light. Correction is required since it may deteriorate the quality of output image. Defective Pixel information of CCD used for each camera is entered into the camera during the manufacturing process in the factory. If you want to add Defective Pixel information, it is required to enter coordinate of new Defective Pixel into the camera.

10.13.1 Correction Method

Correction value for a defective pixel is calculated based on valid pixel value adjacent in the same line.

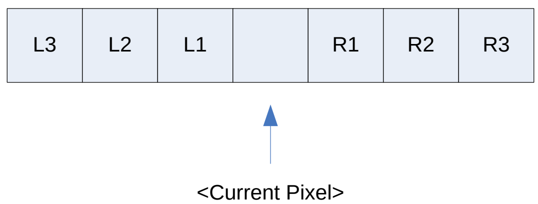


Figure 10.24 Location of Defective Pixel to be corrected

If current pixel is a defective pixel as shown in the above figure, correction value for this pixel is obtained as shown in the following table depending on whether surrounding pixel is defective pixel or not.

Adjacent Defective Pixel(s)	Correction value of Current Pixel
None	(L1 + R1) / 2
L1	R1
R1	L1
L1, R1	(L2 + R2) / 2
L1, R1, R2	L2
L2, L1, R1	R2
L2, L1, R1, R2	(L3 + R3) / 2
L2, L1, R1, R2, R3	L3
L3, L2, L1, R1, R2	R3

Table 10.17 Calculation of Defective Pixel Correction Value

10.13.2 Correction Method in Binning Mode

The **Defective Pixel Correction** feature is also available even when 2×2 or 4×4 binning is enabled. The correction value will be averaged based on four neighboring pixels during 2×2 binning and sixteen neighboring pixels during 4×4 binning.

XML parameter related to Defective Pixel Correction is as follows.

XML Parameters		Value	Description
ImageFormatControl	DefectivePixelCorrection	On	Apply a downloaded defective pixel map to the camera
		Off	Disable the application of the defective pixel map

Table 10.18 XML Parameter related to Defective Pixel Correction

To apply the **Defective Pixel Correction** feature, you must download a Defective Pixel Map to the camera. For more information about how to download a Defective Pixel Map to the camera, refer to Appendix A.

10.14 Flat Field Correction

The Flat Field Correction feature improves the image uniformity when you acquire a non-uniformity image due to external conditions. The Flat Field Correction feature can be summarized by the following equation:

```
IC = {(IR – IB) × M} / (IF – IB)
Where,
IC : Level value of corrected image;
IR : Level value of original image;
IB : Black offset value;
M : Average value of image after correction;
IF : Level value of Flat Field data.
```

In actual use conditions, generate a Flat Field data (IF) and perform the Flat Field Correction feature according to the following procedures.

1. Set the binning mode as desired.
2. Set the number of frames to be acquired for generating the Flat Field data into the **Ffc Frames** parameter.
3. Execute the **Ffc Generate** parameter. The series of frames will be averaged and scaled down to 1/16 pixel. Then, the camera will generate the Flat Field data.
4. Execute the **Ffc Save** parameter to save the generated Flat Field data in the non-volatile memory. When the Flat Field data are applied for correction, the Flat Field data which were scaled down will be enlarged via Bilinear Interpolation as shown in the Figure 10.26.
5. Set the average value in the **Ffc Target Level** parameter and the **Ffc Mode** parameter to **On**. Then, the Flat Field data will be applied to the camera.

CAUTION

- Executing the **Ffc Generate** parameter will ignore the current camera settings and will temporarily change the camera settings to operate under the following default conditions. When the generation of the Flat Field data is completed, the original settings of the camera will be restored. If the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **Software**, you must provide the number of trigger signals equal to the current **Acquisition Frame Count** parameter setting.
  - OffsetX, Y: 0
  - Width, Height: Maximum possible values
  - SensorDigitizationTaps: Maximum possible taps
- Every time you change the binning mode, you must generate the Flat Field data again.
- FFC feature may not work correctly in VH-310G2 due to small sensor size.

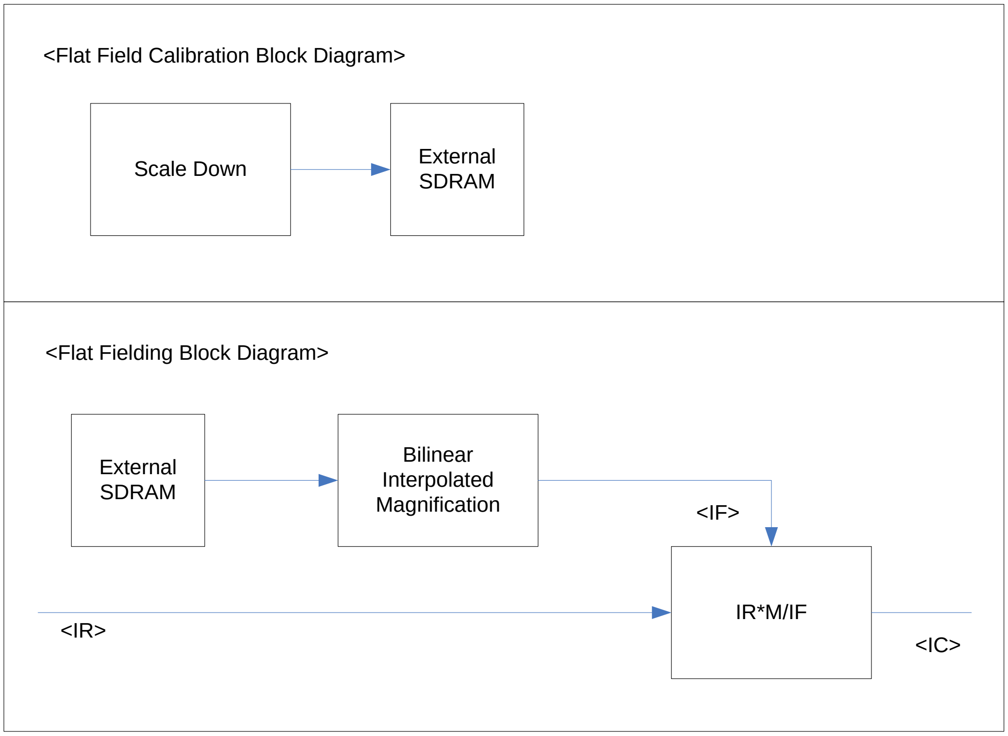


Figure 10.25 Generation and Application of Flat Field Data

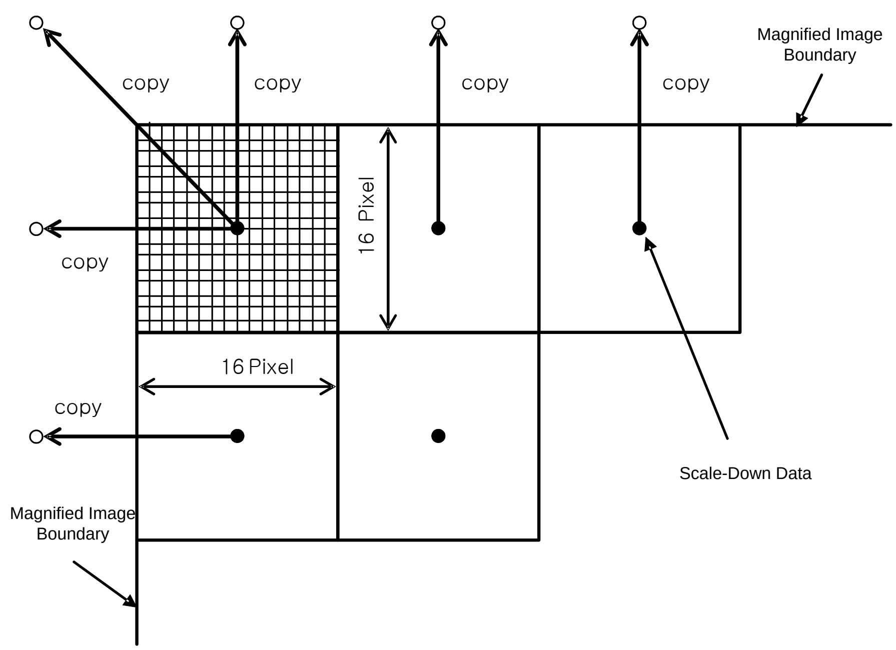


Figure 10.26 Bilinear Interpolated Magnification

XML parameters related to Flat Field Correction are as follows.

XML Parameters		Value	Description
FlatFieldCorrection	FfcMode	Off	Flat Field Correction Off
		On†	Enable the Flat Field Correction feature
	FfcTargetLevel	0~4095	Set the average grey level for image background
	FfcFrames	1,2,4,8,16	Set the number of frames to be acquired when generating the Flat Field data. The more frames result in the better data; however it takes more time to generate the data.
	FfcGenerate	–	Generate the Flat Field data
	FfcSave	–	Save the generated Flat Field data in the non-volatile memory. The generated data by executing the **FfcGenerate** parameter are saved in the volatile memory and the data are lost if the camera is reset or if power is turned off. To use the data after the camera is powered on or reset, save them in the non-volatile memory.
	FfcLoad	–	Load the Flat Field data from the non-volatile memory into volatile memory

†: If the current setting values for the Binning Horizontal and Binning Vertical parameters are different from the setting values at the time when you generate the Flat Field data, the Flat Field Correction feature is not available even if you set the **Ffc Mode** parameter to **On**.

Table 10.19 XML Parameters related to Flat Field Correction

10.15 Temperature Monitor

A sensor chip is embedded in the camera to monitor the internal temperature.

XML parameter related to Device Temperature is as follows.

XML Parameters		Description
DeviceControl	DeviceTemperature	Display device temperature in Celsius

Table 10.20 XML Parameter related to Device Temperature

10.16 Status LED

A green LED is installed on the back panel of the camera to inform the operation status of the camera. LED status and corresponding camera status are as follows:

- Continuous ON: operates in Trigger Off Mode.
- Repeat ON for 0.5 seconds, OFF for 0.5 seconds: operates in Trigger Mode.
- Repeat ON for 1 second, OFF for 1 second: outputs Test Image.
- Repeat ON for 0.25 second, OFF for 0.25 second: operates in Trigger Mode and outputs Test Image.

10.17 Test Image

To check whether the camera operates normally or not, it can be set to output test images generated in the camera, instead of the image data from the CCD. Three types of test images are available; image with different value in horizontal direction (Grey Horizontal Ramp), image with different value in diagonal direction (Grey Diagonal Ramp), and moving image with different value in diagonal direction (Grey Diagonal Ramp Moving). XML parameters related to Test Image are as follows.

XML Parameters		Value	Description
ImageFormatControl	TestImageSelector	Off	Test Image Off
		GreyHorizontalRamp	Set to Grey Horizontal Ramp
		GreyDiagonalRamp	Set to Grey Diagonal Ramp
		GreyDiagonalRampMoving	Set to Grey Diagonal Ramp Moving

Table 10.21 XML Parameter related to Test Image

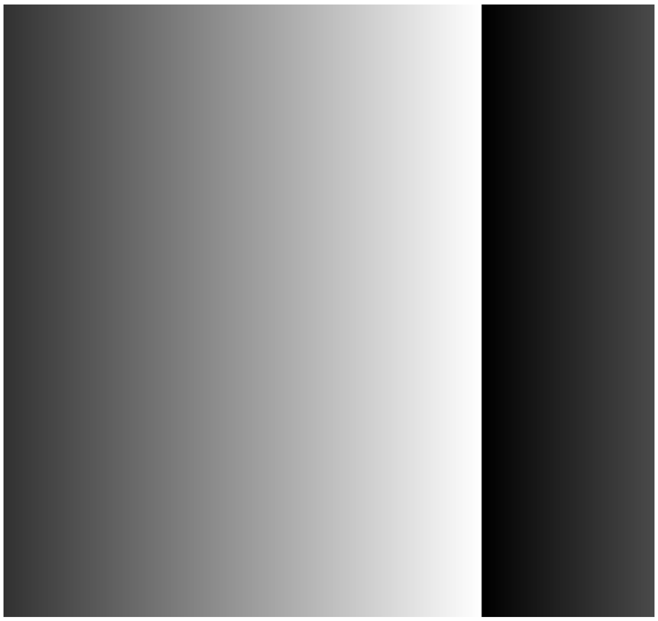


Figure 10.27 Grey Horizontal Ramp

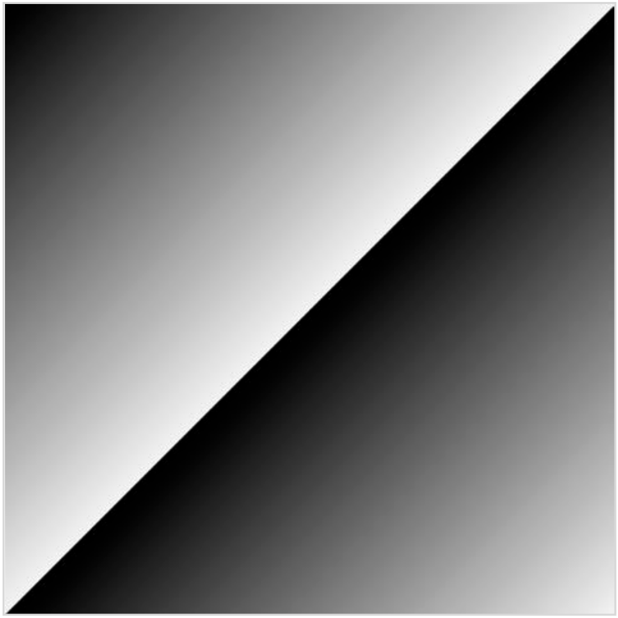


Figure 10.28 Grey Diagonal Ramp

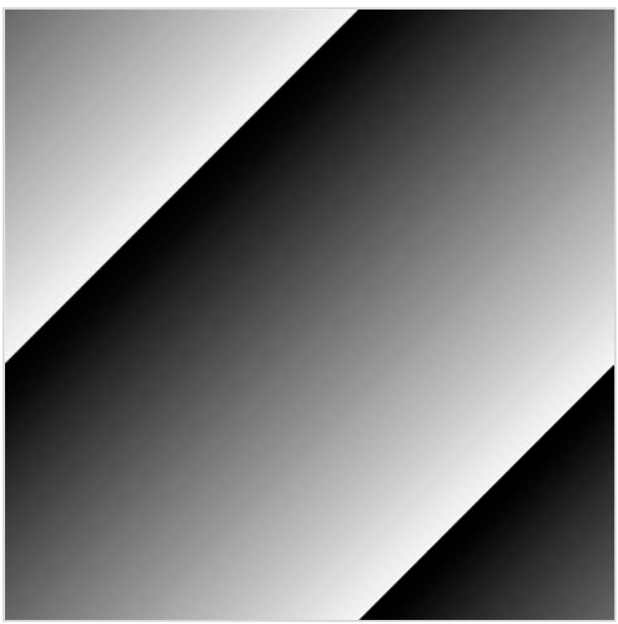


Figure 10.29 Grey Diagonal Ramp Moving

CAUTION	The test image may look different because the region of the test image may vary depending on the camera's resolution.

10.18 Reverse X

The Reverse X feature let you flip the image horizontally. This feature is available in all operation modes.

Figure 10.30 Original Image

Figure 10.31 Reverse X Image

On color models of the camera, when the **Pixel Format** parameter is set to **Bayer** and the **Reverse X** feature is used, the alignment of the color filter will be changed.

10.19 Digital IO Control

The pin number 3 of the control receptacle is designated as programmable output and can be operated in various modes.

XML parameters related to Digital IO Control are as follows.

XML Parameters		Value	Description
DigitalIO Control	LineInverter	On	Invert the output signal of the line
		Off	Do not invert the output signal of the line
	LineSource	Off	Disable the line output
		ExposureActive	Output pulse signals indicating the current exposure time
		FrameActive	Output pulse signals indicating a frame readout time
		StrobeOut	Output Exposure Active signals with Strobe Out Delay
		PulseGenerator	Output user defined pulse signals
		UserOutput	Output User Output signal set by User Output Value
	UserOutputValue	On	Set the bit state of the line to High
		Off	Set the bit state of the line to Low
	PulsePeriod	1~60,000,000	Set a pulse period in microseconds when the Line Source is set to Pulse Generator
	PulseWidth	0~60,000,000	Set a pulse width in microseconds when the Line Source is set to Pulse Generator
	StrobeOutDelay	0~65535	Set a delay in microseconds when the Line Source is set to Strobe Out

Table 10.22 Digital IO Control

The camera can provide a **Strobe Out** output signal. The signal goes high when the exposure time for each frame acquisition begins and goes low when the exposure time ends as shown in Figure 10.32. This signal can be used as a flash trigger and is also useful when you are operating a system where either the camera or the object being imaged is movable. Typically, you do not want the camera to move during exposure. You can monitor the **Strobe Out** signal to know when exposure is taking place and thus know when to avoid moving the camera.

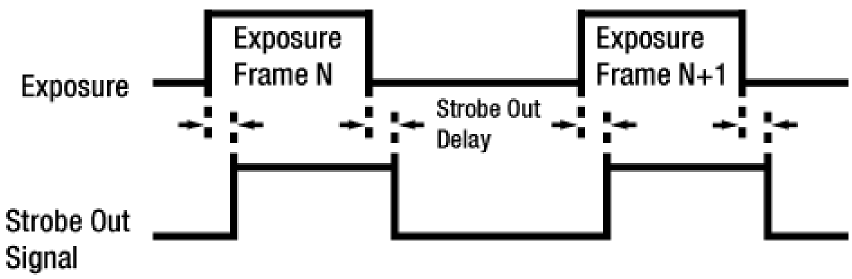


Figure 10.32 Strobe Out Signal (not drawn to scale)

10.20 Event Control

VH GigE camera provides an Event Notification feature. With the Event Notification feature, the camera can generate an event and transmit a related event message to the PC whenever a specific situation has occurred. The camera can generate and transmit events for the following type of situation:

- The end of an exposure has occurred (Exposure End)

XML parameters related to Event Control are as follows.

XML Parameters		Value	Description
EventControl	EventSelector	ExposureEnd†	Select which particular event to control • Exposure End event is only available
	Event Notification	On	Enable the selected event notification
		Off	Disable the selected event notification
TransportLayer Control	GevTimestampControlLatch	–	Latch the current time stamp counter into GevTimestampValue.
	GevTimestampControlReset	–	Reset the time stamp counter to 0.

†: The event notification may be delayed depending on your network latency or network circumstances.

Table 10.23 XML Parameters related to Event Control

10.21 Device User ID

You can input user defined information up to 16 bytes.

XML parameter related to Device User ID is as follow.

XML Parameters		Description
DeviceControl	DeviceUserID	Input user defined information (16 bytes)

Table 10.24 XML Parameter related to Device User ID

10.22 Device Reset

Reset the camera physically to power off and on. You must connect to the network because the camera will be released from the network after reset. XML parameter related to Device Reset is as follows.

XML Parameters		Description
DeviceControl	DeviceReset	Reset the camera physically

Table 10.25 XML Parameter related to Device Reset

10.23 User Set Control

You can save the current camera settings to the camera's internal ROM. You can also load the camera settings from the camera's internal ROM. The camera provides two setups to save and three setups to load settings. XML parameters related to User Set Control are as follows.

XML Parameters		Value	Description
UserSetControl	UserSetSelector	Default	Select the Factory Default settings
		UserSet1	Select the User Set1 settings
		UserSet2	Select the User Set2 settings
	UserSetLoad	-	Load the User Set specified by User Set Selector to the camera
	UserSetSave	-	Save the current settings to the User Set specified by User Set Selector Default is allowed to load only.
	UserSetDefaultSelector	Default	Apply the Factory Default settings when reset
		UserSet1	Apply the User Set1 settings when reset
		UserSet2	Apply the User Set2 settings when reset

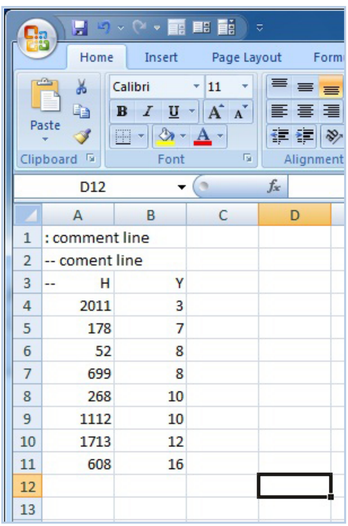
Table 10.26 XML Parameters related to User Set Control

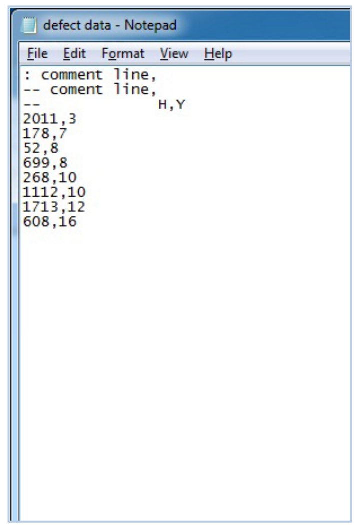
10.24 Field Upgrade

The camera provides a feature to upgrade Firmware and FGPA logic through Gigabit Ethernet interface rather than disassemble the camera in the field. Refer to Appendix C for more details on how to upgrade.

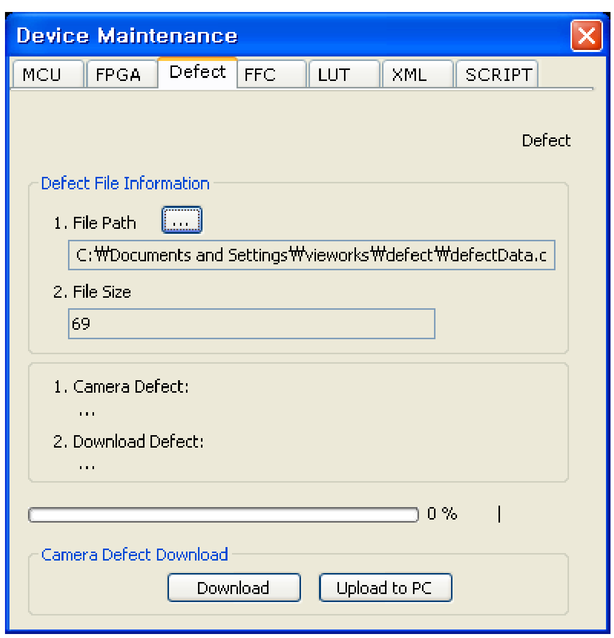
Appendix A Defective Pixel Map Download

1. Create the Defective Pixel Map data in Microsoft Excel format as shown in the left picture below and save as a CSV file (*.csv). The picture in the right shows the created Excel file opened in Notepad. The following rules need to be applied when creating the file.
   - Lines beginning with ':' or '—' are treated as notes.
   - Each row is produced in the order of the horizontal and vertical coordinate values.
   - The input sequence of pixel is irrelevant.

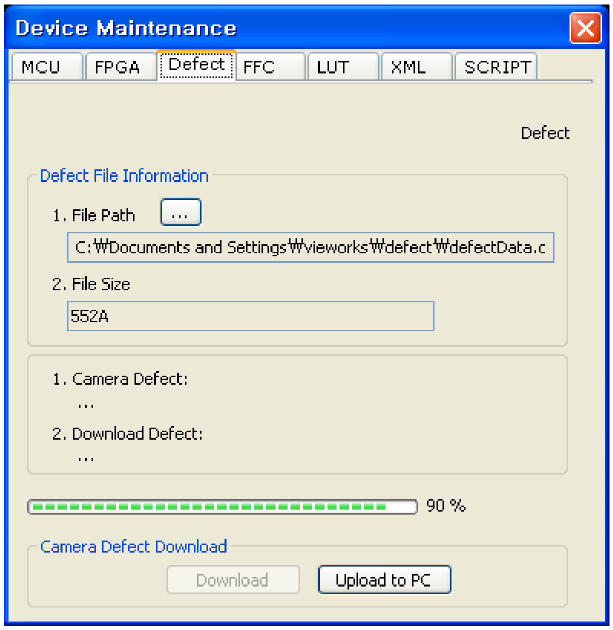




2. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below. Select the **Defect** tab, click the File Path button, search and select the defective pixel map file (*.csv), and then click the **Download** button.



3. Once the download is complete, the saving process will begin. During the saving process, make sure not to disconnect the power cord.



4. After completing the download, click the **OK** button to close the confirmation.

Appendix B LUT Download

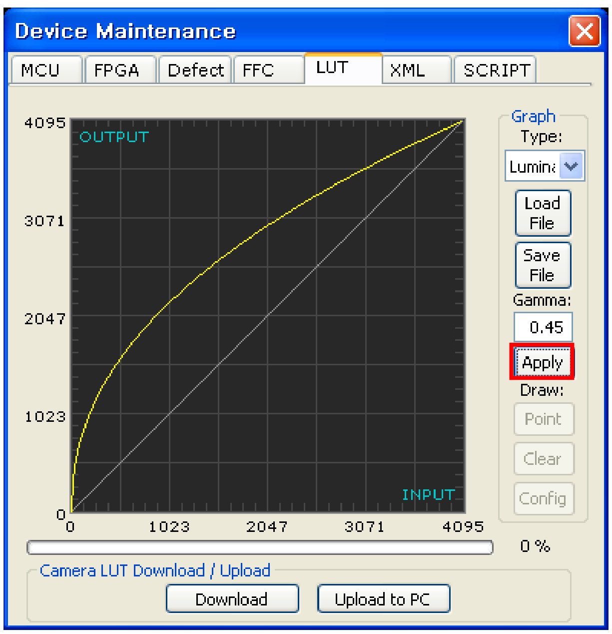
LUT data can be created in two ways; by adjusting the gamma values on the gamma graph provided in the program and then downloading the data or by opening a CSV file (*.csv) and then downloading the data.

B.1 Luminance LUT

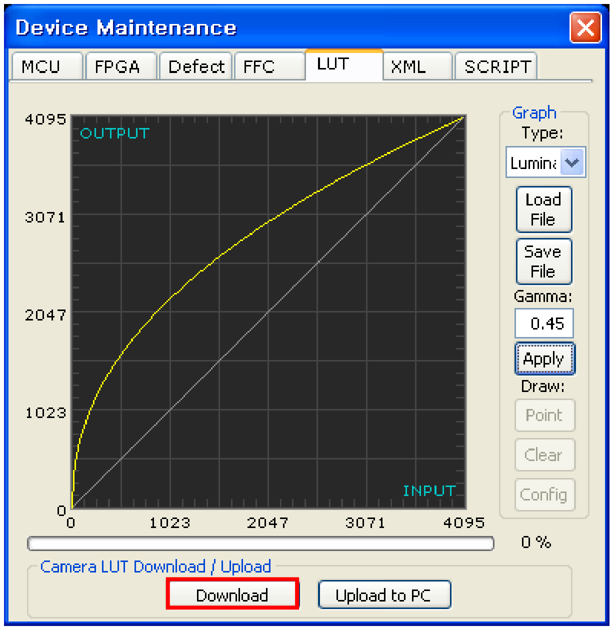
B.1.1 Gamma Graph Download

1. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below. Select the **LUT** tab, and then select **Luminance** from the **Type** dropdown list.

2. Set a desired value in the **Gamma** input field and click the **Apply** button.



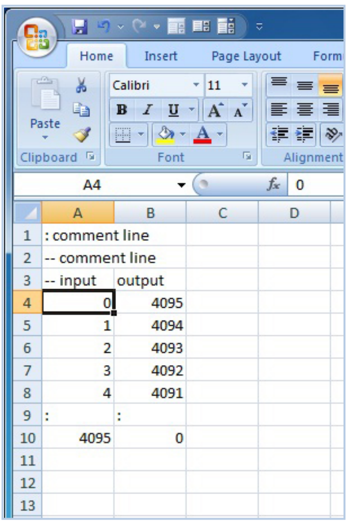
3. Click the **Download** button to download the gamma set to the camera.

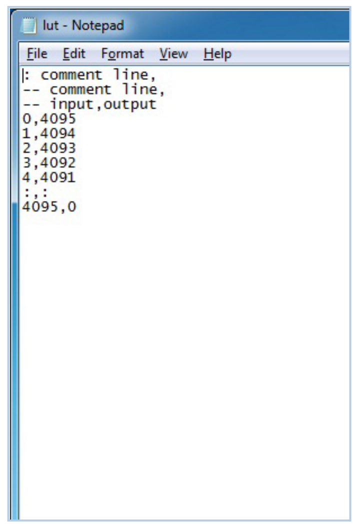


4. After completing the download, click the **OK** button to close the confirmation.

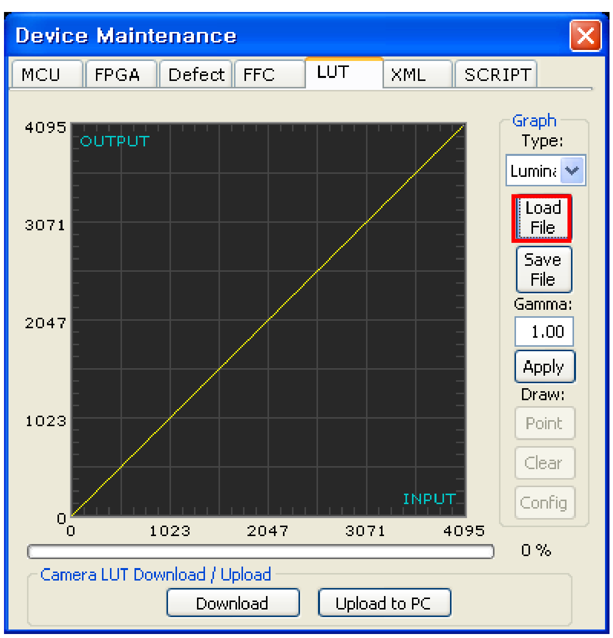
B.1.2 CSV File Download

1. Create the LUT table in Microsoft Excel format as shown in the left picture below and save as a CSV file (*.csv). The picture in the right shows the created file opened in Notepad. Once the file has been created completely, change the .csv file extension to .lut. The following rules need to be applied when creating the file.
   - Lines beginning with ‘:’ or ‘—‘ are treated as notes.
   - Based on the input values, make sure to record from 0 to 4095.

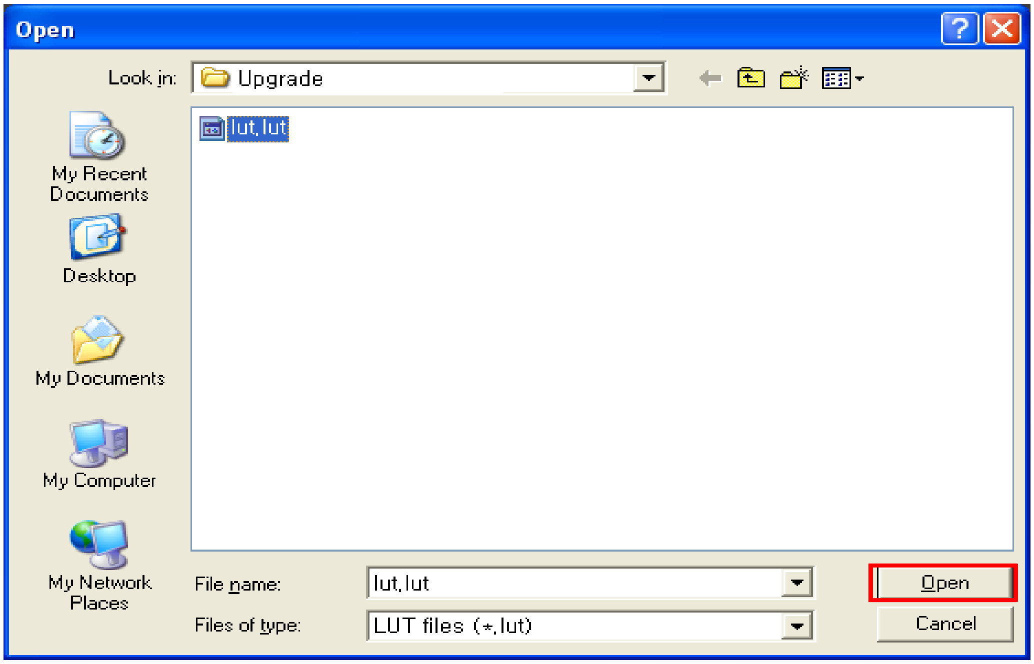




2. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below. Select the **LUT** tab, select **Luminance** from the **Type** dropdown list, and then click the **Load File** button.



3. Search and select the created LUT file and click the **Open** button.

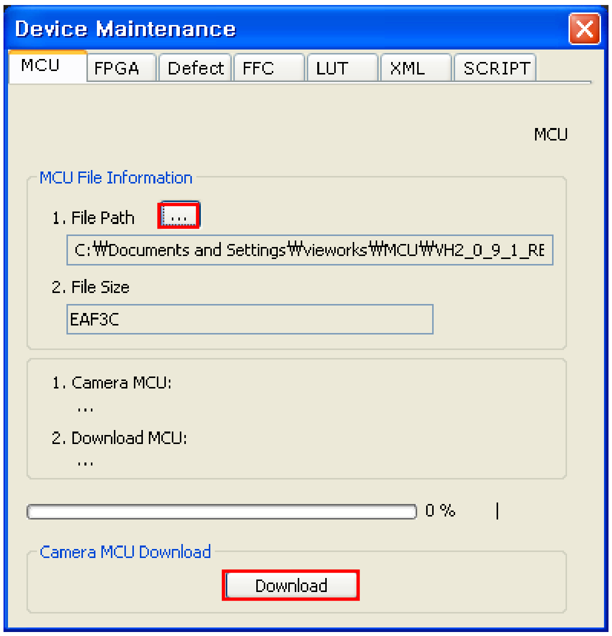


4. Click the **Download** button. After completing the download, click the **OK** button to close the confirmation.

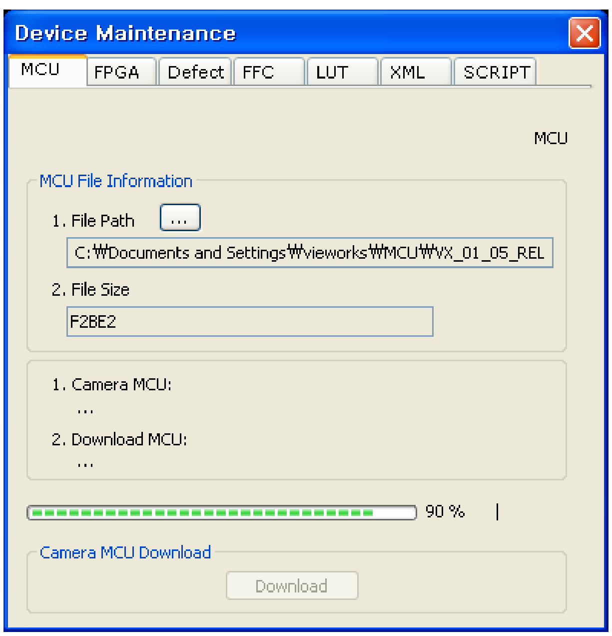
Appendix C Field Upgrade

C.1 MCU

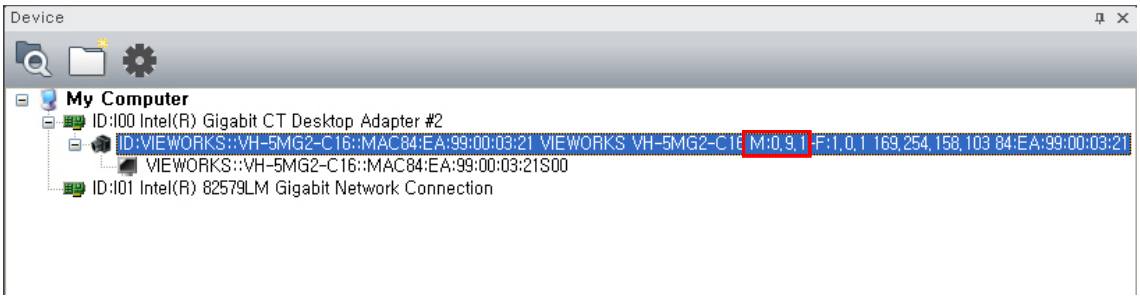
1. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below.
2. Select the **MCU** tab, click the File Path button, search and select the MCU upgrade file (*.srec), and then click the **Download** button.



3. MCU upgrade file download starts and the downloading status is displayed at the bottom of the window.

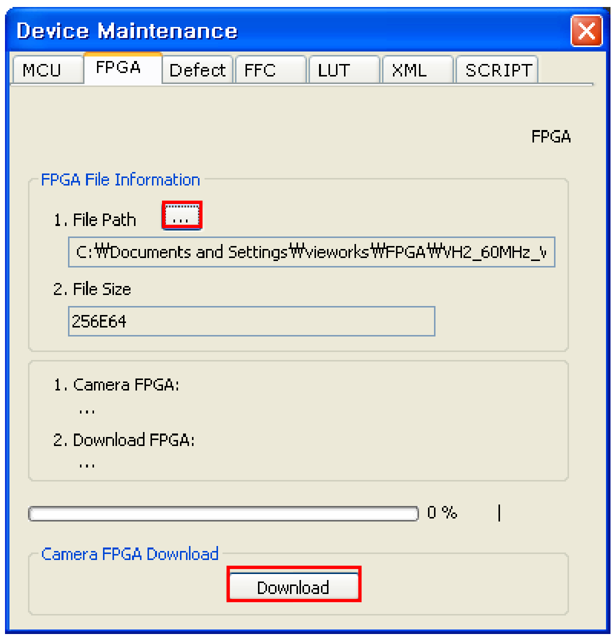


4. Once all the processes have been completed, turn the power off and turn it back on again. Check the DeviceVersion parameter value to confirm the version. Or, check under the My Computer to verify the upgraded version.



C.2 FPGA

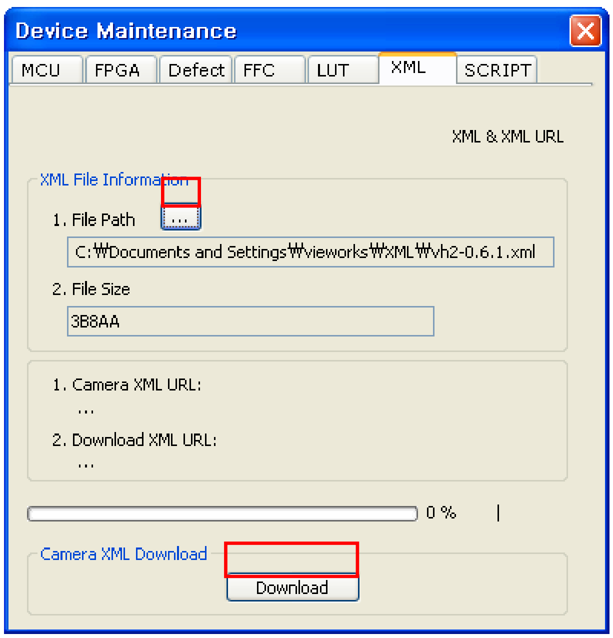
1. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below.
2. Select the **FPGA** tab, click the File Path button, search and select the FPGA upgrade file (*.bin), and then click the **Download** button.



3. The subsequent processes are identical to those of MCU upgrade.

C.3 XML

1. Run Vieworks Imaging Solution 6.X and click the **Configure** button to display the window as shown below.
2. Select the **XML** tab, click the File Path button, search and select the XML upgrade file (*.xml), and then click the Download button.



3. The subsequent processes are identical to those of MCU upgrade.

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