VNP Series User Manual

VNP-576MX2-M15K, VNP-864MX2-M/C15K, VNP-1152MX2-M15K

Preface

Before Using This Product

Thank you for choosing VNP-576/864/1125MX2™.

- Make sure to read this manual before using the product.
- Make sure to check whatever a professional engineer has finished installation and configuration.
- Make sure to keep this manual at hand as a reference while using the product.
- This manual assumes that you have expertise in how to use an industrial camera.

The Series

This manual is intended for users of the following products:

- VNP-576MX2-M15K™
- VNP-864MX2-M/C15K™
- VNP-1152MX2-M15K™

About This Manual

This manual is intended for the user of VNP-576/864/1152MX2 cameras. In addition to this manual, we recommend that you also refer to the manual for your frame grabber.

Convention in This Manual

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

Names and Fonts

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

- The menu and icon names in this manual are used as displayed in the product.

Warning, Caution, and Note

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

Warning!

This indicates that you need to follow this message for your safety and to prevent the product from damage.

Caution!

This indicates that you need to follow this message to prevent data from being lost or corrupted.

Note:

This indicates that this message provides additional information.

Definition of Terms

For clarity, this manual defines some terms as follows:

Term	Definition
Preface	The introductory part preceding the Table of Contents in this manual
Vieworks Imaging Solution (VIS)	Indicates the control software provided with the product together by Vieworks

Revision History

This document has the revision history as follows:

Version	Date	Description
1.0	2024-09-23	Initial release
1.1	2024-10-30	*Added model information : VNP-864Mx2-M/C15k *Chapter added 9.9 Data ROI (Color Camera) 9.10 White Balance (Color Camera)
1.2	2025-09-02	Added) 9.16 Pixel Shifting Added) Appendix C Position Settings according to Sequence Mode

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Chapter 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 or companion animals 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.
- Make sure that the temperature of the camera does not exceed the temperature range specified in 5.2 Specifications. Otherwise, the device may be damaged by extreme temperature.

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. (manufacturer) does NOT provide power supplies with devices.
- Make sure the power is turned off before connecting the power cord to the camera. Otherwise, damage to the camera may result.

Cleaning the Sensor Surface

Avoid cleaning the surface of the camera's sensor if possible. If you have dust or foreign matter on the sensor surface that will not blow off, use a soft lint free cotton bud dampened with a small quantity of high quality lens cleaner. Because electrostatic discharge (ESD) can damage the sensor, you must use a cloth (e.g. cotton) that will not generate static during cleaning.

Avoid dust or foreign matter on the sensor surface.

The camera is shipped with a protective plastic seal on the camera front. To prevent collecting dust or foreign matter on the camera sensor, make sure that you always put the protective seal in place when there is no lens mounted on the camera. In addition, make sure to always point the camera downward when there is no protective seal on the camera front or no lens mounted.

Procedures for Cleaning the Sensor

If you have dust or foreign matter on the sensor surface, follow the procedures below to wipe it off.

1. Remove contaminants by using an ionizing air gun.

   If this step does not remove the contaminant, proceed to the next step.

2. Clean the contaminant on the sensor using one drop of lens cleaner on a non-fluffy cotton bud.
3. Wipe the cotton bud gently in only one direction (either left to right or right to left). Avoid wiping back and forth with the same cotton bud to ensure that the contaminants are removed and not simply transferred to a new location on the sensor surface.
4. Mount a lens, set the lens at a smaller aperture (e.g. F8), and then acquire images under bright lighting conditions. Check the images on the monitor for dark spots or stripes caused by the contaminant. Repeat the steps above until there is no contaminant present.

Caution!

If the sensor is damaged due to electrostatic discharge or the sensor surface is scratched during cleaning, the warranty is void.

Chapter 2. Warranty

The following cases are excluded from warranty coverage:

- The manufacturer is not responsible for equipment failure due to service or modification by unauthorized manufacturers, agents, or technicians.
  - The manufacturer is not responsible for loss or damage to data due to operator negligence.
  - If the user uses the product for purposes other than its intended use, damage or malfunction occurs due to excessive use or negligence.
  - When using incorrect power or not using under the usage conditions specified in the user manual.
- Natural disasters caused by lightning, earthquakes, fires, floods, etc.
- If a problem occurs due to replacement or modification of equipment parts and software without permission

If you have any product-related inquiries or require service, please contact the sales office or manufacturer. The warranty period is the period specified in the warranty when the product is sold and applies from the time the product is shipped.

Chapter 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 expense.

3.2 CE : DoC

EMC Directive 2014/30/EU

EN 55032:2012 (Class A), EN 55024:2010

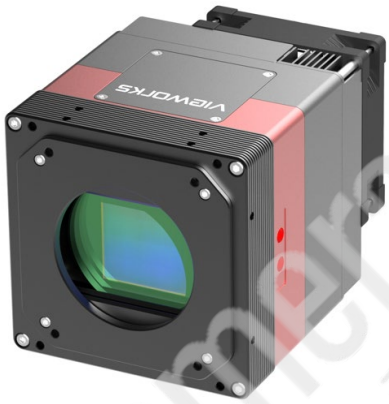
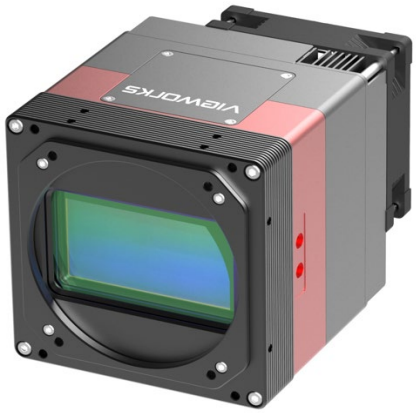
Class A

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.

Chapter 4. Package Components

Model	Image
VNP-576MX2-M15K	
VNP-864MX2-M/C15K	
VNP-1152MX2-M15K	

Chapter 5. Product Specifications

5.1 Overview

Featuring Thermoelectric Peltier (TEC) cooling technology in a pixel shift camera, the VNP-576/864/1152MX2 cameras are designed for applications that require high image quality while maximizing resolution. TEC cools the temperature of the image sensor by 10±2°C below ambient temperature, which significantly reduces noise (based on the VNP-576MX2).

With pixel shift technology based on a precise piezoelectric stage, the VNP-576/864/1152MX2 cameras can realize resolutions of up to 576/864/1152 Mega Pixels at a rate of 3.75 fps, and the CoaXPress2.0 interface allows data transfer at up to 50 Gbps via four Coax cables.

The VNP-576/864/1152MX2 cameras are ideal for demanding applications such as FPD, PCB and semiconductor inspection.

Main Features

- Nano Stage Pixel Shifting Mechanism
- Thermoelectric Peltier Cooled (10±2℃ (VNP-576MX2, VNP-864MX2), 7±1℃ (VNP-1152MX2))
- CoaXPress 2.0 Interface up to 15 fps at 50 Gbps using 4 Channels
- Minimizing the number of hot pixels with TEC (Thermoelectric Peltier)
- Global Shutter CMOS Technology
- DSNU Correction
- Pixel by Pixel PRNU Correction
- Flat Field Correction with Sequencer Control
- Defective Pixel Correction

5.2 Specifications

Technical specifications for VNP-576/864/1152MX2 are as follows.

Specifications		VNP-576MX2-M15K	VNP-864MX2-M/C15K	VNP-1152MX2-M15K
Resolution (H×V)	1x (1 Shot)	12000 × 12000	17984 × 12000	24000 × 12000
	4x (4 Shot)	24000 × 24000	35968 × 24000	48000 × 24000
Sensor		Vieworks Sensor (SCG144M)	Vieworks Sensor (SCG216M-M/C)	Vieworks Sensor (SCG288M)
Sensor Size (Diagonal)		42.0㎜ × 42.0㎜ (59.39㎜)	63.0㎜ × 42.0㎜ (75.71㎜)	84.0㎜ × 42.0㎜ (93.91㎜)
Sensor Type		High Speed CMOS Image Sensor		
Pixel size		3.5 ㎛ × 3.5 ㎛		
Interface		CoaXPress 2.0 (CXP-6/10/12)		
Device Tap Geometry		1X_1Y, 1X_2YE		
Max. Frame Rate (8 bit)		15 fps at 8bit		
Exposure Time		100 ㎲ ~ 7 s (1 ㎲ step)		
Pixel Data Format		Mono 8/10/12 bit	Mono: 8/10/12 bit Color: RG Bayer 8/10/12bit	Mono 8/10/12 bit
Electronic Shutter		Global Shutter		
Gain Control	Analog	1× ~ 4×		
	Digital	1× ~ 32×		
Digital Black Level		0~255 LSB in 12 bit		
Exposure Mode		Timed, TriggerWidth		
Trigger Synchronization		Free-Run, Hardware Trigger, Software Trigger, UserOutput0, CXP, Timer		
External Trigger		3.3 ~ 24.0 V, 10 ㎃, Logical Level Input Optically Isolated CoaXPress Control Port(CXP only)		
Software Trigger		Asynchronous, Programmable via Camera API(CXP only)		
Digital I/O		TTL Level Exposure Active, Frame Active, User Output, Timer, Strobe Output		
Dynamic Range		62 ㏈ at 12 bit		
Cooling Method (Standard cooling with fan)		10±2℃ below ambient temperature		7±1℃ below ambient temperature
Mechanical (W×H×L)		125 ㎜ × 125 ㎜ × 157 ㎜, 3.3 ㎏		
Environmental		Operating: 0℃ ~ 40℃, Storage: -40℃ ~ 70℃		
Lens Mount		M72-mount	M95-mount	M102-mount
Power	External	12 ~ 24V DC		
	Dissipation	Typical 41 W	Typical 43 W	Typical 46 W
Compliance		CE, FCC, KC		
API SDK		Vieworks Imaging Solution 7.3x		

Table 5-1 Specifications of VNP-576/864/1152MX2

Power:
24 VDC is recommended because the Pelitier Cooling performance may deteriorate if power is supplied below 14 VDC.

Device Tap Geometry:
For 1X_2YE, it is only possible when using CXP12_X4 and select CXP12_X4 and Geometry_1X_2YE first, after that, turn the camera power off to work the function properly.

5.3 Camera Block Diagram

The block diagram of the VNP-576/864/1152MX2 cameras are shown below.

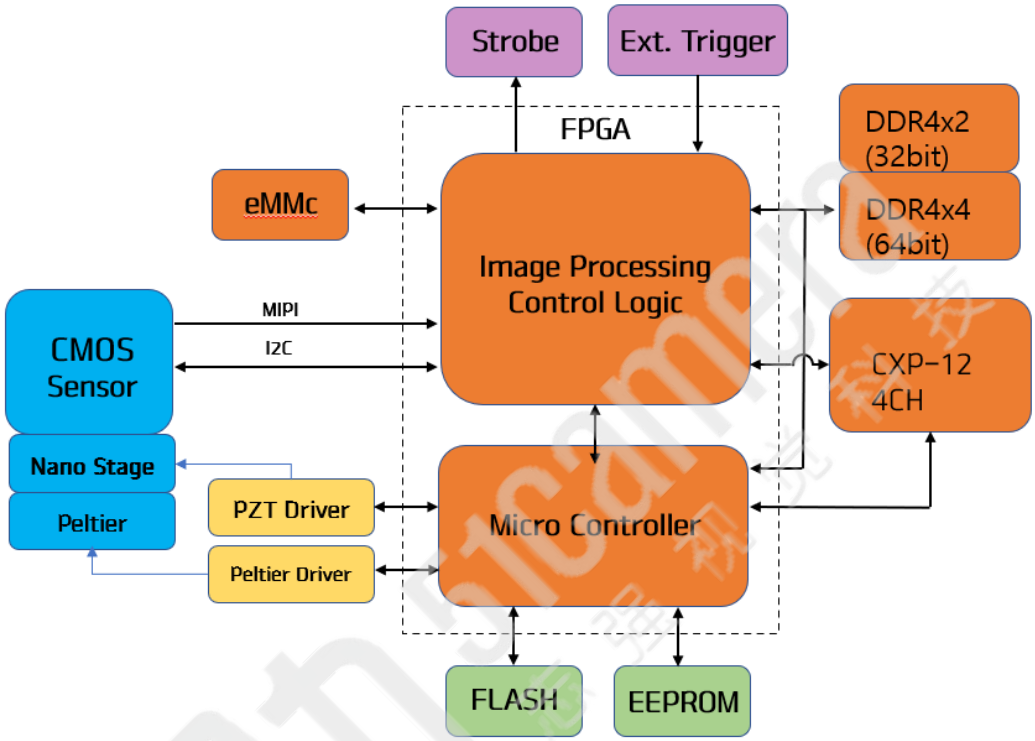


Figure 5-1 Camera Block Diagram

All controls and data processing of the camera are carried out in one FPGA chip. The FPGA generally consists of a 32-bit RISC Micro-Controller and Processing & Control logic. The Micro-Controller receives commands from the user through the CoaXPress 2.0 interface and then processes them.

The Processing & Control logic processes the image data received from the CMOS image sensor and then transmits data through the CoaXPress 2.0 interface. The Processing & Control logic also controls time-sensitive trigger inputs and output signals. Furthermore, Flash and DDR4 are installed outside FPGA. The DDR4 is used to process images, and Flash stores the firmware to operate the Micro-Controller.

5.4 Spectral Response

The following graphs show the spectral response for the VNP-576/864/1152MX2.

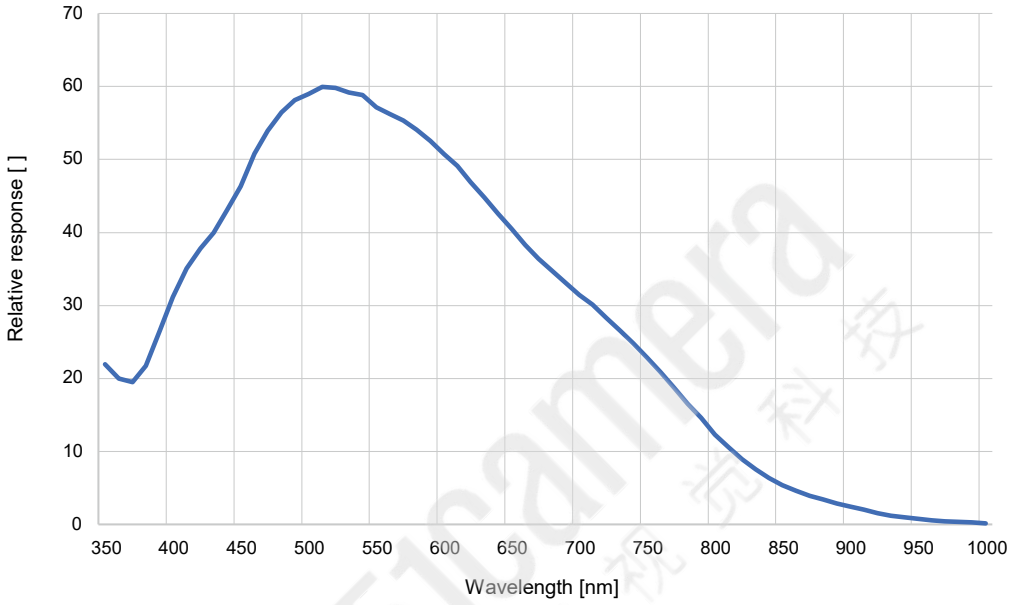


Figure 5-2 Spectral Response - Monochrome

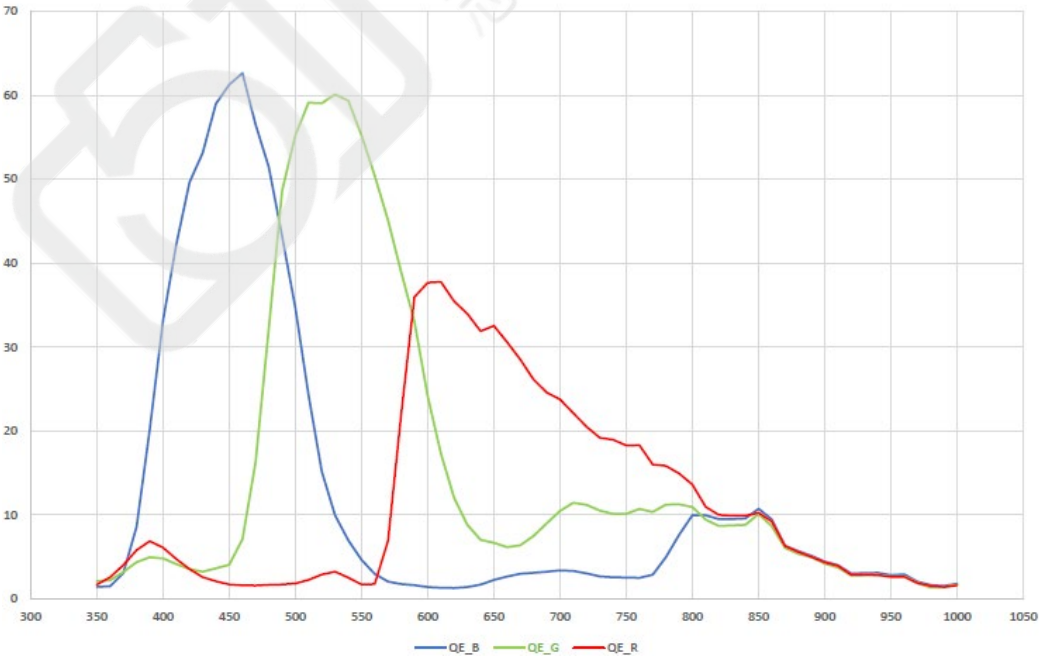


Figure 5-3 Spectral Response - Color (VNP-864MX2-C15K only)

5.5 Mechanical Specification

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

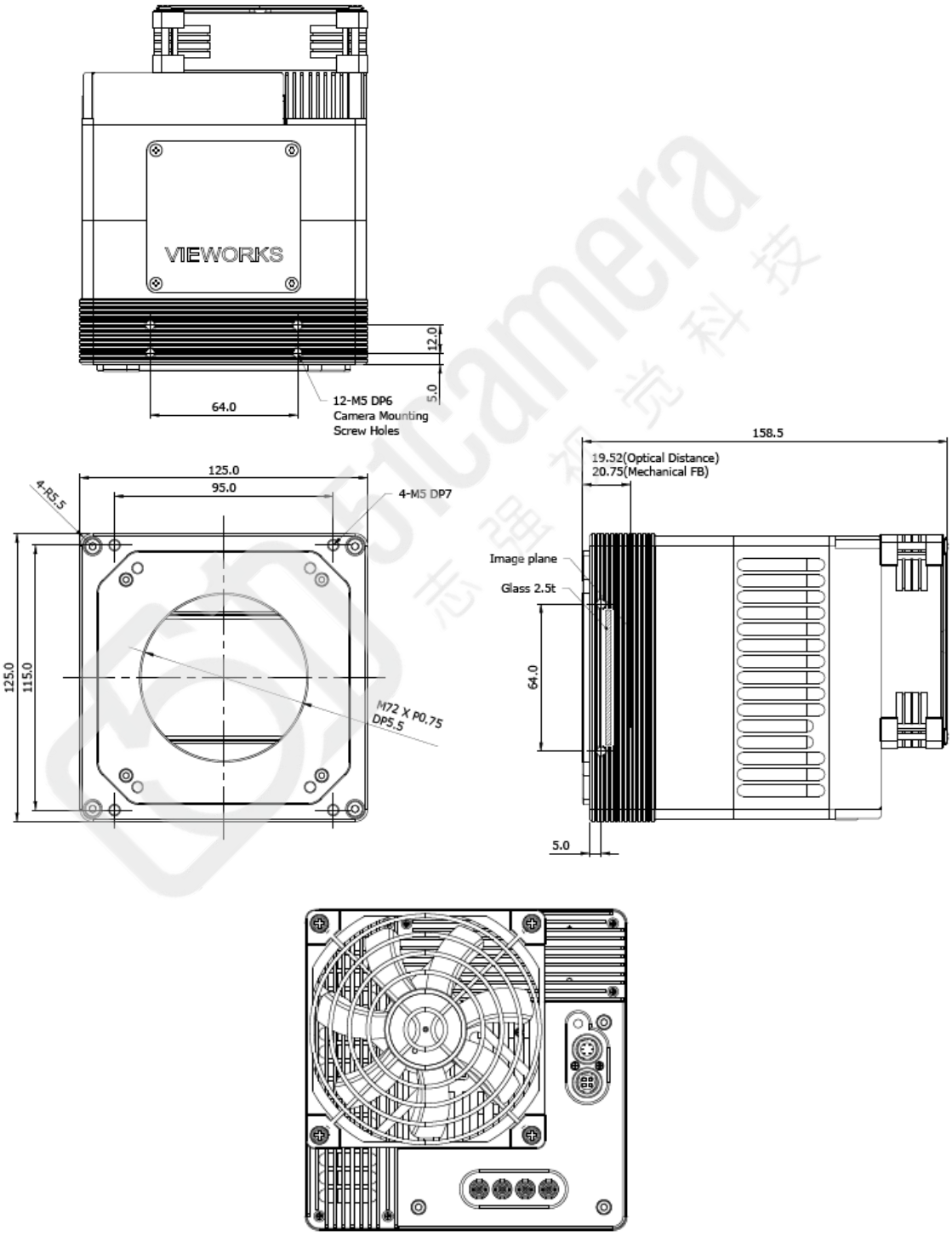


Figure 5-4 VNP-576MX2 Mechanical Dimension

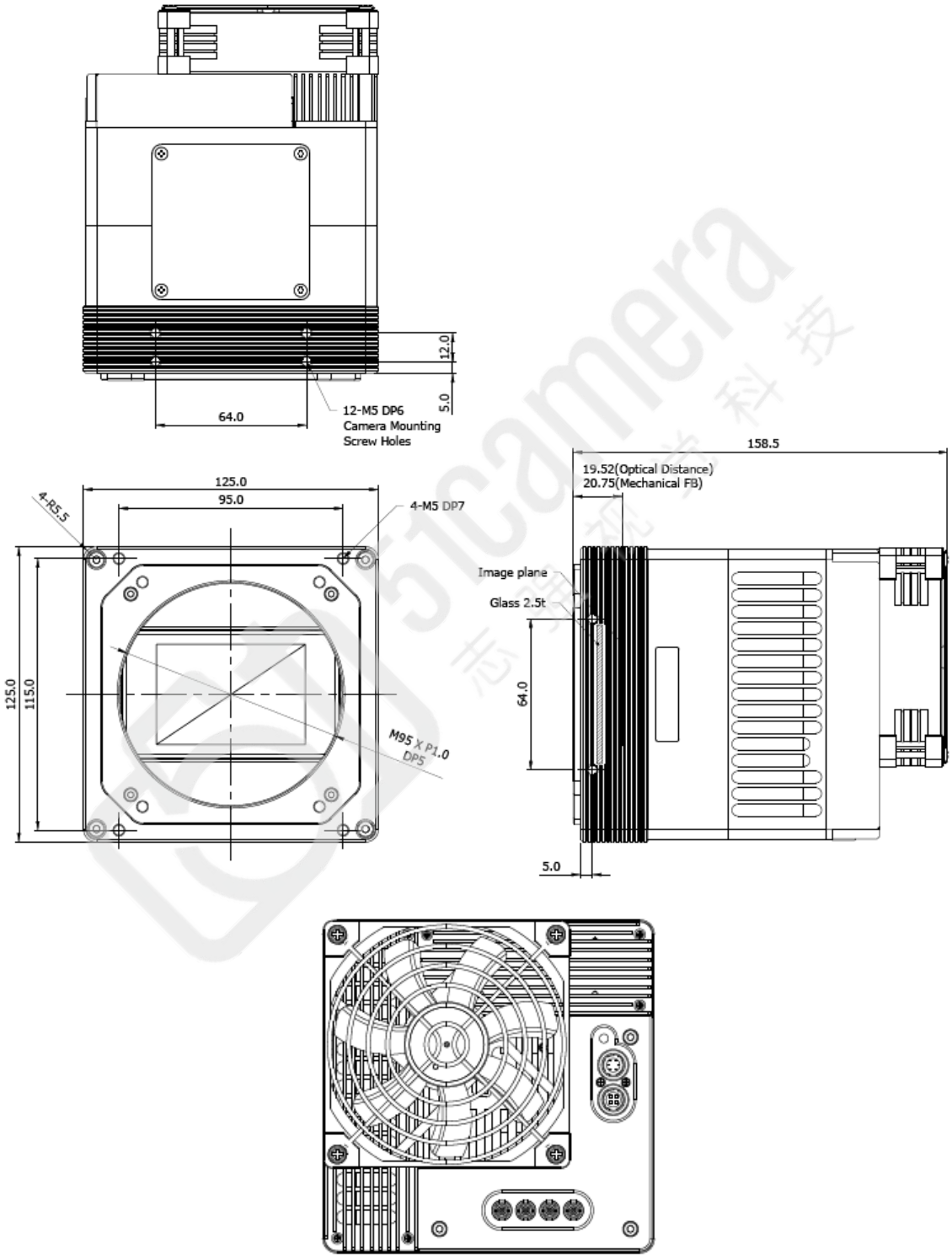


Figure 5-5 VNP-864MX2 Mechanical Dimension

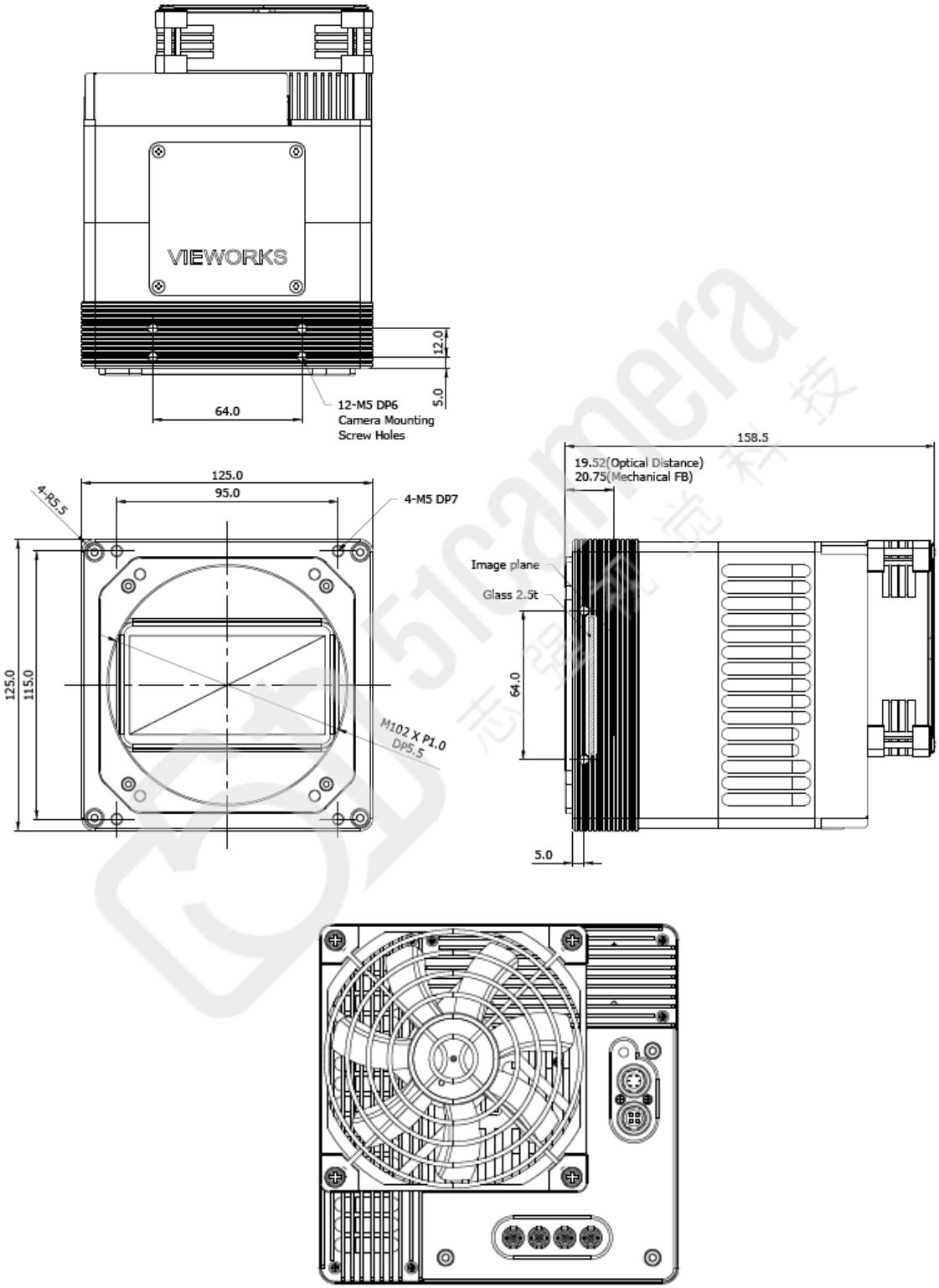


Figure 5-6 VNP-1152MX2 Mechanical Dimension

5.5.1 Camera Mounting and Heat Dissipation

Camera Mounting Recommendations for Antivibration

When you mount a camera in a poor condition, the fan equipped on the camera may amplify vibrations which can lead to blurry images. Follow the instructions below to prevent and/or reduce vibrations caused by the fan.

- Fix the camera's front or side surface by using at least four screws.
- Prevent ingress of foreign objects between the camera and system surfaces.
- Keep the camera's center of gravity as near as possible to the system's center of gravity.
- If your lens' weight or size is greater than the camera's, make and use proper mounting brackets to support the lens.
- Prevent foreign matters from falling into the fan. This may cause damage to the fan blades.

Camera Mounting Recommendations for Effective Heat Dissipation

- Do not obstruct the air inlets and outlets of the fan.
- If the fan is not available, leave enough space around the heat sink so that heat can be easily dissipated through the heat sink by natural convection.
- If the fan is not available, mount the camera to a metal structure made of high thermal conductive materials (e.g. Aluminum) to properly dissipate the heat generated by the camera.
- The contact surface of the camera must be at least 30% of the camera's Front-Block.

Chapter 6. Connecting the Camera

The following instructions assume that you have installed a CoaXPress 2.0 Frame Grabber (hereinafter 'CXP-12 Frame Grabber') in your computer including related software. The procedure below also assumes that you may attempt to configure a link between a camera and CXP-12 Frame Grabber by using four coax cables. For more detailed information, refer to your CXP-12 Frame Grabber User 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 computer is turned off.
2. Plug one end of a coax cable into the CH1 of the CXP connector on the camera and the other end of the coax cable into the CH1 of the CXP-12 Frame Grabber in your computer. Then, connect the CH2, CH3 and CH4 of the CXP connector on the camera to the CH2, CH3 and CH4 of the CXP-12 Frame Grabber respectively using the other three coax cables.
   - Connect the plug of the power adapter to the power input receptacle on the camera.
   - Plug the power adapter into a working electrical outlet.
3. Verify all the cable connections are secure.

6.1 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.

6.2 Precaution about Blurring Compared to the 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.

6.3 Installing Vieworks Imaging Solution

You can download the Vieworks Imaging Solution at http://vision.vieworks.com. You should perform the software installation first and then the hardware installation.

Chapter 7. Camera Interface

7.1 General Description

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

① Status LED: Displays power status and operation mode.
② 6 pin Power Input Receptacle: Supplies power to the camera.
③ 4 pin Control I/O Receptacle: Provides access to the camera's I/O lines.
④ CoaXPress Connector: Transmits data and controls the camera.

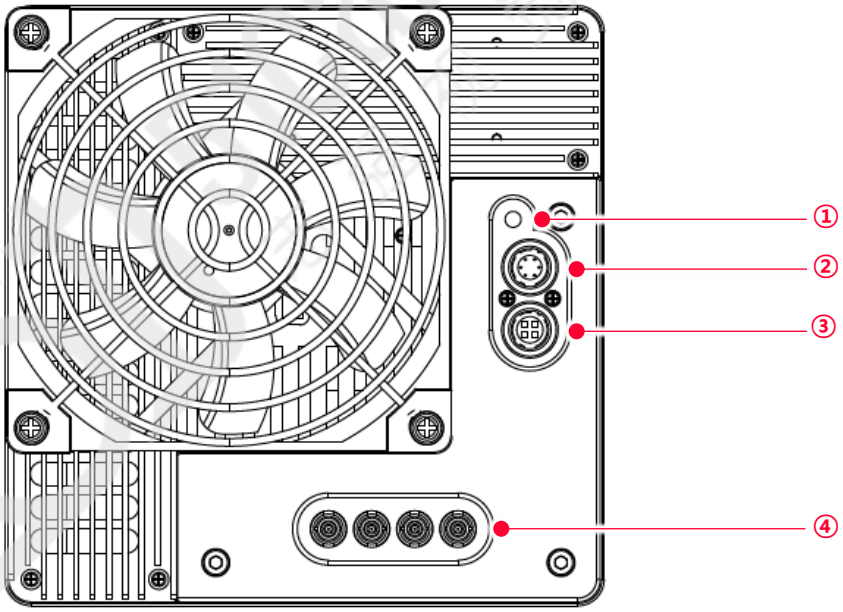


Figure 7-1 VNP-576/864/1152MX2 Back Panel

7.2 CoaXPress Connector

CoaXPress protocol includes an automatic link detection mechanism (Plug and Play) to correctly detect the camera to the CXP-12 Frame Grabber connection. The connection between the camera and CXP-12 Frame Grabber uses a coax (also known as 'coaxial') cable and provides up to 12.5 Gbps bit rate per cable.

7.2.1 Micro-BNC Connector

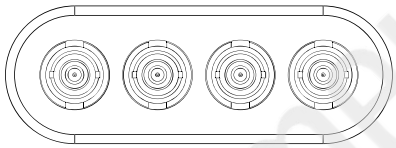


Figure 7-2 Micro-BNC Connector

The CoaXPress connectors on the VNP-576/864/1152MX2 cameras comply with the CoaXPress 2.0 standard, and the following table shows the channel assignments.

Channel	Max. Bit Rate per Coax	Type
CH1	12.5 Gbps	Master Connection
CH2	12.5 Gbps	Extension Connection
CH3	12.5 Gbps	Extension Connection
CH4	12.5 Gbps	Extension Connection

Table 7-1 Channel Assignments for Micro-BNC Connector

Note:

When you connect a camera to a CXP-12 Frame Grabber using coax cables, make sure to connect the cables to their correct channels. If you connect the CH1 of the CXP connector on the camera to a channel other than CH1 of the CXP-12 Frame Grabber, the camera may not transmit images properly or the communication between the computer and camera may fail.

7.3 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:

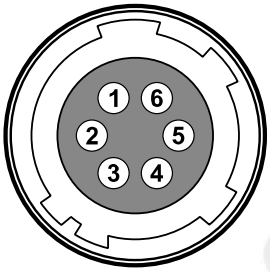


Figure 7-3 Pin Assignments for Power Input Receptacle

Pin Number	Signal	Type	Description
1, 2, 3	+ 24 VDC	Input	DC Power Input
4, 5, 6	DC Ground	Input	DC Ground

Table 7-2 Pin Configurations for Power Input Receptacle

Note:

- A recommended mating connector for the Hirose 6-pin connector is the Hirose 6-pin plug (part # HR10A-7P-6S) or the equivalent.
- It is recommended that you use the power adapter, which has at least 2A current output at 24 VDC ±10% voltage output (You need to purchase a power adapter 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 voltage applied to the camera is greater than specified in the specifications, damage to the camera may result.

7.4 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 ports. The pin assignments and configurations are as follows:

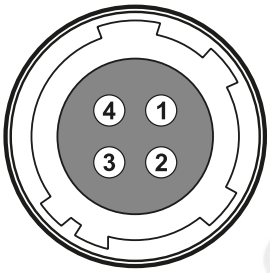


Figure 7-4 Pin Assignments for Control Receptacle

Pin Number	Signal	Type	Description
1	Trigger Input	Input	3.3 V — 24.0 V TTL Input Input Resistance: 1 kΩ
2	Trigger Input	Input	-
3	Strobe Out-	Output	GND
4	Strobe Out-+	Output	HR10A-7R-4S

Table 7-3 Pin Configurations for Control Receptacle

Note:

A recommended mating connector for the Hirose 4-pin connector is the Hirose 4-pin plug (part # HR10A-7P-4P) or the equivalent.

7.5 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. With the Debounce feature, you can specify the width of input signal to be considered as a valid input signal. An external trigger circuit example is shown below.

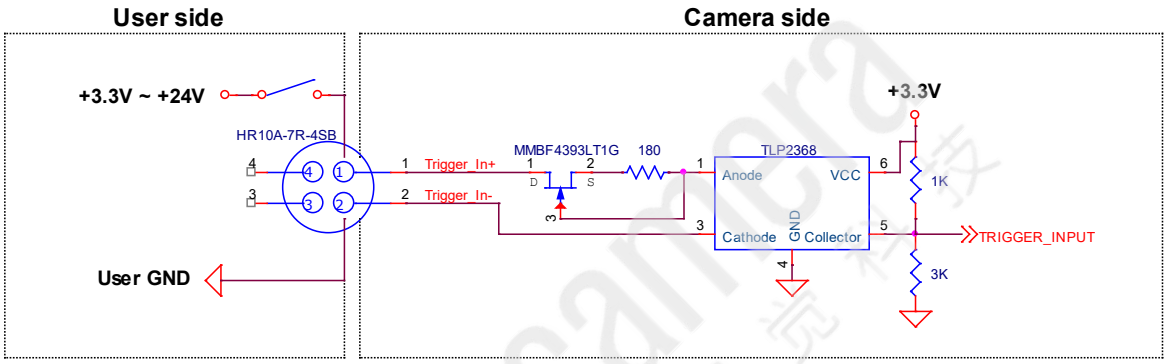


Figure 7-5 Trigger Input Schematic

7.6 Strobe Output Circuit

The strobe output signal comes out through a 3.3 V output level of TTL Driver IC. A pulse width of signal is synchronized with an exposure (shutter) signal of the camera.

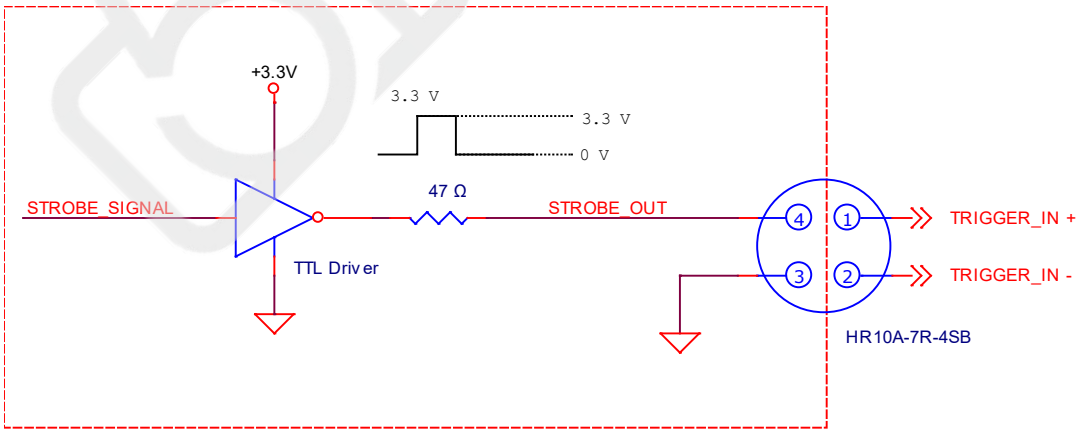


Figure 7-6 Strobe Output Schematic

Chapter 8. Acquisition Control

This chapter provides detailed information about controlling image acquisition.

- How to trigger image acquisition
- Set the exposure time
- Controlling the speed (Frame Rate)
- Maximum Frame Rate variation based on camera settings

8.1 Overview

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

The followings are involved in controlling the acquisition of images.

- Acquisition Start and Acquisition Stop commands and the Acquisition Mode parameter
- Exposure start trigger
- Exposure time control
- Frame acquisition process on the camera
- Global shutter
- Maximum Allowed Frame Rate

Note:
In this chapter, a "Frame" typically refers to a single acquired image.

8.2 Acquisition Start/Stop Commands and Acquisition Mode

This section describes function available to use via the followings:

- Acquisition Start/Stop commands
- Acquisition Mode

The details about each item above is described in the order from the following section.

8.2.1 Acquisition Start/Stop Commands

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

Executing an **Acquisition Stop** command terminates the camera's ability to acquire images.

8.2.2 Acquisition Mode

The **Acquisition Mode** parameter affects directly how the **Acquisition Start** command works. There are three of types available to select in this parameter as follows:

- Continuous:
  Acquires frames continuously once the Acquisition Start command is called until the Acquisition Stop command is called.
- SingleFrame:
  Acquires one single frame after the Acquisition Start command is called, and then, finishes acquiring images with calling the Acquisition Stop command automatically.
- MultiFrame:
  Acquires frames as many as the numbers designated on the AcqusitionFrameCount parameter after the Acquisition Start command is called, and then, finishes acquiring images with calling the Acquisition Stop command automatically.

Note:

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. If a user calls an Acquisition Stop command on the way of image acquisition, the work will finish after finishing the ongoing acquisition all.

8.2.3 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 8-1). 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.

Mode	Description
On	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.
Off	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.

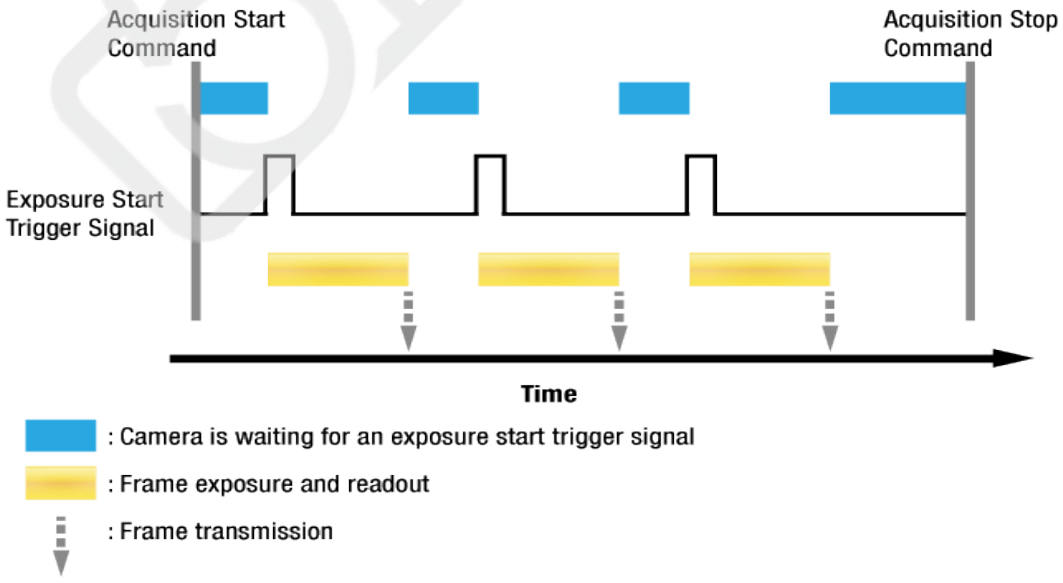


Figure 8-1 Exposure Start Triggering

8.2.4 Applying Trigger Signals

The paragraphs above mention "applying a trigger signal". There are five ways to apply an exposure start trigger signal to the camera: Software, UserOutput0, LinkTrigger0, Timer0Active, Line0

- 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 UserOutput0, you must set the Trigger Source parameter to UserOutput0. At that point, you can apply an exposure start trigger signal to the camera by switching the User Output Value parameter between On (rise) and Off (fall).
- To apply trigger signals via CH1 of the CXP-12 Frame Grabber, you must set the Trigger Source parameter to LinkTrigger0. At that point, each time a proper CoaXPress trigger signal is applied to the camera by using the APIs provided by a CXP-12 Frame Grabber manufacturer, the exposure start trigger signal will be applied to the camera. For more information, refer to your CXP-12 Frame Grabber User Manual.
- To apply trigger signals via the user-defined Timer feature, you must set the Trigger Source parameter to Timer0Active. When you set the Timer Trigger Source parameter to Line0 in the Counter And Timer Control category, you can apply an exposure start trigger signal to the camera by using a Timer that uses the Line0 signal as the source signal.
- To apply trigger signals via hardware (external), you must set the Trigger Source parameter to Line0. 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.

8.2.5 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**, the **Exposure Time** parameter will determine the exposure time for each frame.

If the **Trigger Source** parameter is set to **UserOutput0**, **LinkTrigger0**, **Timer0Active** or **Line0**, there are two modes of operation: **Timed** and **TriggerWidth**.

- With the Timed mode, the Exposure Time parameter will determine the exposure time for each frame.
- With the TriggerWidth mode, the way that you manipulate the rise and fall of the User Output, CoaXPress, Timer or hardware (external) signal will determine the exposure time. The TriggerWidth mode is especially useful if you want to change the exposure time from frame to frame.

8.3 Exposure Start Trigger

The **Trigger Selector** parameter is used to select a type of trigger and only the **Exposure Start** trigger is available on the VNP-576/864/1152MX2 cameras. 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 by setting the **Trigger Source** parameter to **Software**, **UserOutput0**, **LinkTrigger0**, **Timer0Active** or **Line0**. If an exposure start trigger signal is applied to the camera, the camera will begin to expose a frame.

8.3.1 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**.

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.

If the **Trigger Mode** parameter is set to **Off**, 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, 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 commonly referred as "Free-Run".

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.

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
- UserOutput0
- LinkTrigger0: For more information, refer to your CXP-12 Frame Grabber User Manual.
- Timer0Active: For more information, refer to 9.18 Timer Control.
- Line0: Refer to 7.5 Trigger Input Circuit for more information.

You must also set the **Trigger Activation** parameter after setting the **Trigger Source** parameter.

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

- Falling Edge: Specifies that a falling edge of the electrical signal will act as the exposure start trigger.
- Rising Edge: Specifies that a rising 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 **LinkTrigger0** or **Line0**, the exposure time for each frame acquisition will be determined by the **Exposure Mode** parameter settings as follows:

- Exposure Mode = Timed: Exposure time can be controlled with the Exposure Time parameter.
- Exposure Mode = TriggerWidth: Exposure time can be controlled by manipulating the external trigger signal.

When the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **TimerOActive**, the exposure time for each frame acquisition will be determined by the **Exposure Mode** parameter settings as follows:

- Exposure Mode = Timed: Exposure time can be controlled with the Exposure Time parameter.
- Exposure Mode = TriggerWidth: When you set the Timer Trigger Activation parameter to Rising/Falling Edge, the exposure time is controlled with the Timer Duration parameter. When you set the Timer Trigger Activation parameter to Level High/Low, the exposure time can be controlled by manipulating the external trigger signal.

When the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **UserOutput0**, the exposure time for each frame acquisition will be determined by the **Exposure Mode** parameter settings as follows:

- Exposure Mode = Timed: Exposure time can be controlled with the Exposure Time parameter.
- Exposure Mode = TriggerWidth: Exposure time can be controlled by switching the User Output Value parameter between On and Off.

8.3.2 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 '**waiting for exposure start trigger**' acquisition status, frame exposure will start when the software trigger signal is received by the camera. The following figure describes 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 can react to a new exposure start trigger signal, it will automatically return to the **waiting for exposure start trigger** acquisition status.

The exposure time for each acquired frame will be determined by the value of the camera's **Exposure Time** parameter.

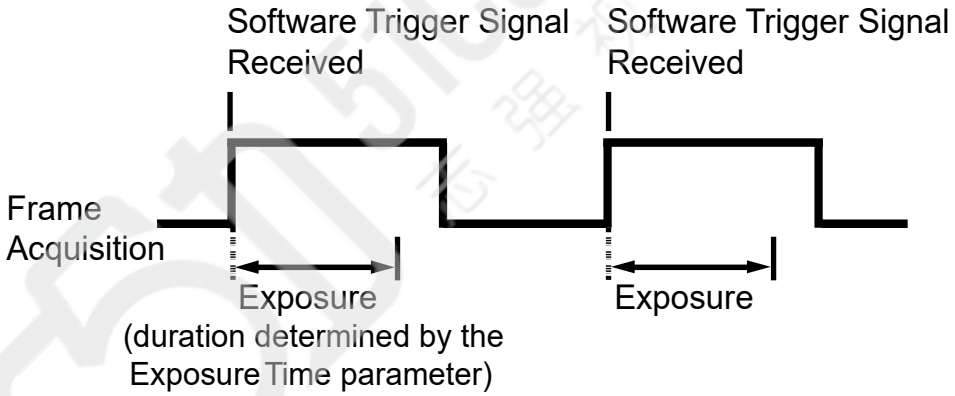


Figure 8-2 Frame Acquisition with Software Trigger Signal

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.

8.3.3 Using a CoaXPress Trigger Signal

If the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **LinkTrigger0**, you must apply a CoaXPress trigger signal to the camera to begin each frame acquisition. A CoaXPress trigger signal will act as the exposure start trigger signal for the camera. For more information, refer to your CXP-12 Frame Grabber User Manual.

A rising edge or a falling edge of the CoaXPress 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 *'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 a CoaXPress 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 can react 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 a CoaXPress signal, the period of the CoaXPress trigger signal will determine the rate at which the camera is acquiring frames:

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

For example, if you are operating a camera with a CoaXPress trigger signal period of 50 ㎳(0.05 s): So in this case, the frame rate is 20 fps.

8.3.4 Using an External Trigger Signal

If the **Trigger Mode** parameter is set to **On** and the **Trigger Source** parameter is set to **Line0**, an externally generated electrical signal injected into the Control I/O receptacle 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 *'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 can react 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 50 ㎳ (0.05 s): So in this case, the frame rate is 20 fps.

External Trigger Delay

When you set the **Trigger Source** parameter to **TimerOActive**, you can specify a delay between the receipt of a hardware trigger signal and when the trigger becomes effective.

1. Set the **Timer Trigger Source** parameter in the **Counter And Timer Control** category to **Line0**.
2. Set the **Timer Delay** parameter to the desired Timer delay in microseconds.
3. Set the **Trigger Source** parameter in the **Acquisition Control** category to **TimerOActive**.
4. Execute the **Acquisition Start** command and inject an externally generated electrical signal into the Control I/O receptacle. Then, the delay set by the **Timer Delay** parameter expires and the exposure for image acquisition begins.

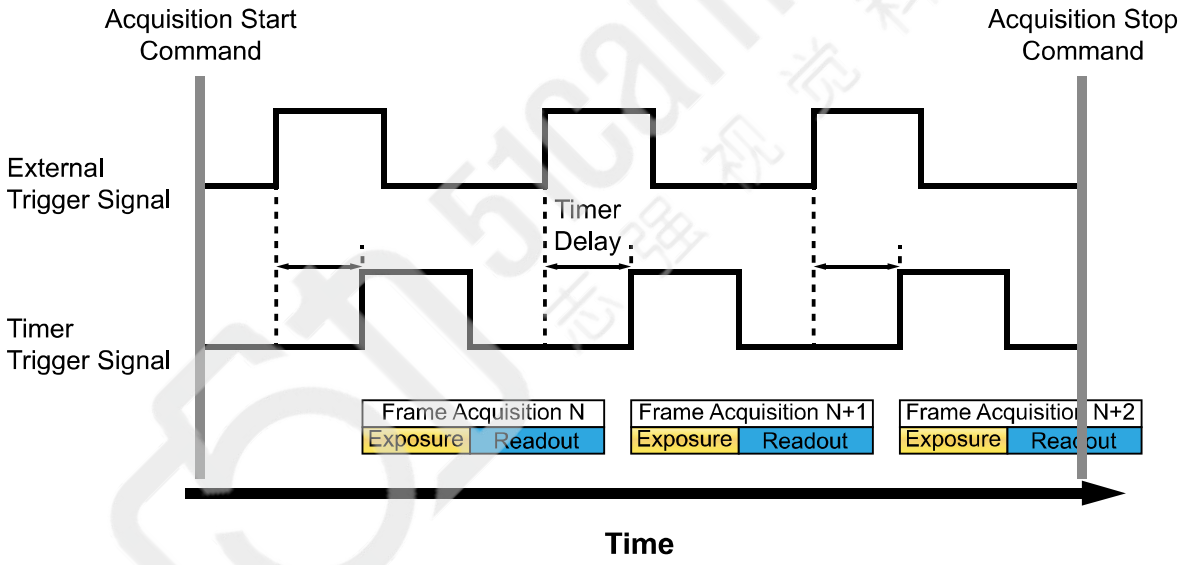


Figure 8-3 External Trigger Delay

8.3.5 Exposure Mode

If you are triggering the start of frame acquisition with an externally (CoaXPress or External) generated trigger signal, two exposure modes are available: **Timed** and **TriggerWidth**.

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. The following figure illustrates **Timed** exposure with the camera set for rising edge triggering.

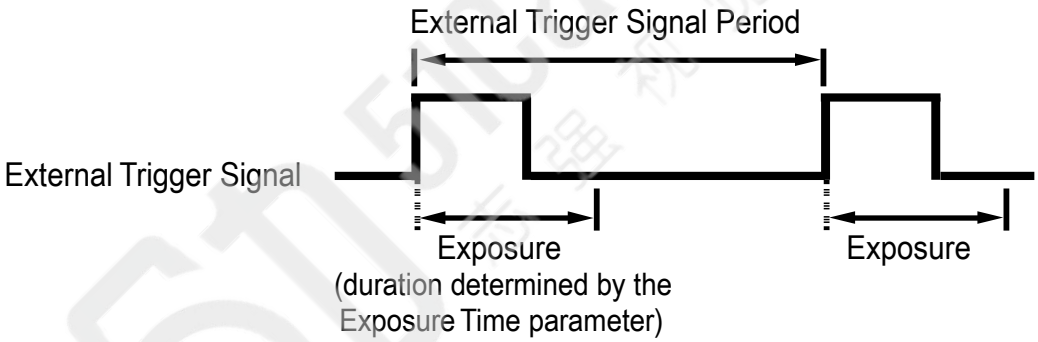


Figure 8-4 Timed Exposure Mode

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.

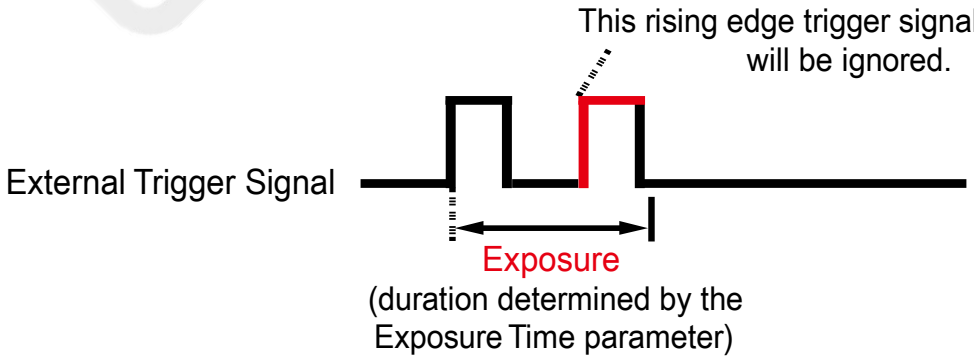


Figure 8-5 Trigger Overlapped with Timed Exposure Mode

TriggerWidth Exposure Mode

When the **TriggerWidth** exposure mode is selected, the length of the exposure for each frame acquisition will be directly controlled by the external trigger signal (CoaXPress or External). 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. The following figure illustrates **TriggerWidth** exposure with the camera set for rising edge triggering.

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

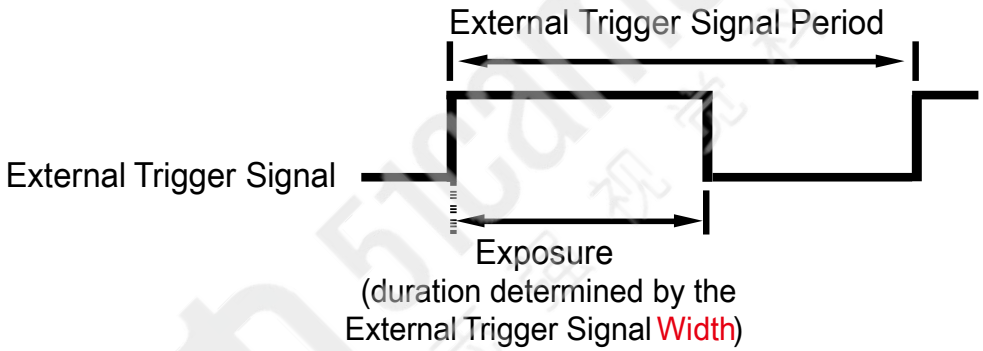


Figure 8-6 TriggerWidth Exposure Mode

8.4 Overlapping Exposure with Sensor Readout

The frame acquisition process on the camera includes three distinct parts. The first part is the exposure of the pixels in the image sensor. Once exposure is complete, the second part of the process – readout of the pixel values from the sensor – takes place, and after that, it proceeds the third part of the process that transfers these values. Regarding this frame acquisition process, the VNP-576/864/1152MX2 cameras basically operate with 'overlapped' exposure so that the exposure for a new frame can be overlapped with 'readout' and 'transfer' for the previous frame. When a new trigger signal is applied to the camera while reading out and transferring the previous frame, the camera begins the process of exposing a new frame. Note that the time to transfer varies depending on the speed setting.

This situation is illustrated in the following figure with the **Trigger Mode** set to **On**, the **Trigger Source** set to **Line0** and the **Exposure Mode** set to **TriggerWidth**.

The VNP-576/864/1152MX2 cameras support two tap geometries: 1X_1Y and 1X_2YE.

1X_1Y

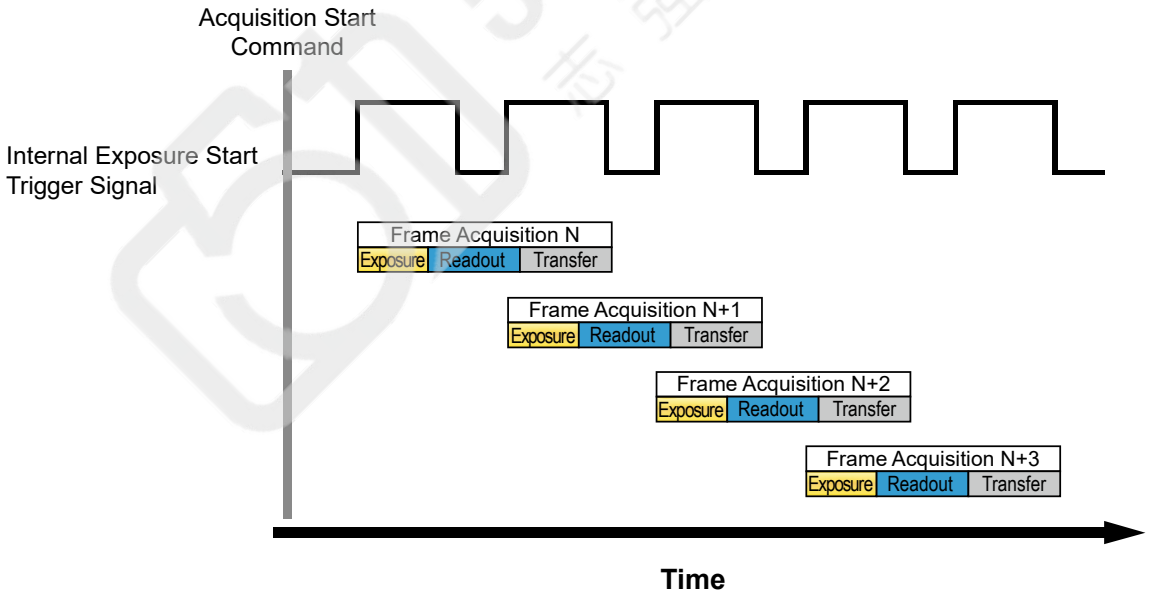


Figure 8-7 Overlapped Exposure and Readout (1X_1Y)

1X_2YE

Readout and transfer are performed simultaneously. If you select 1X_2YE to acquire the image, the overlapped process of readout and transfer is performed simultaneously, as shown below, resulting in a shorter tact time.

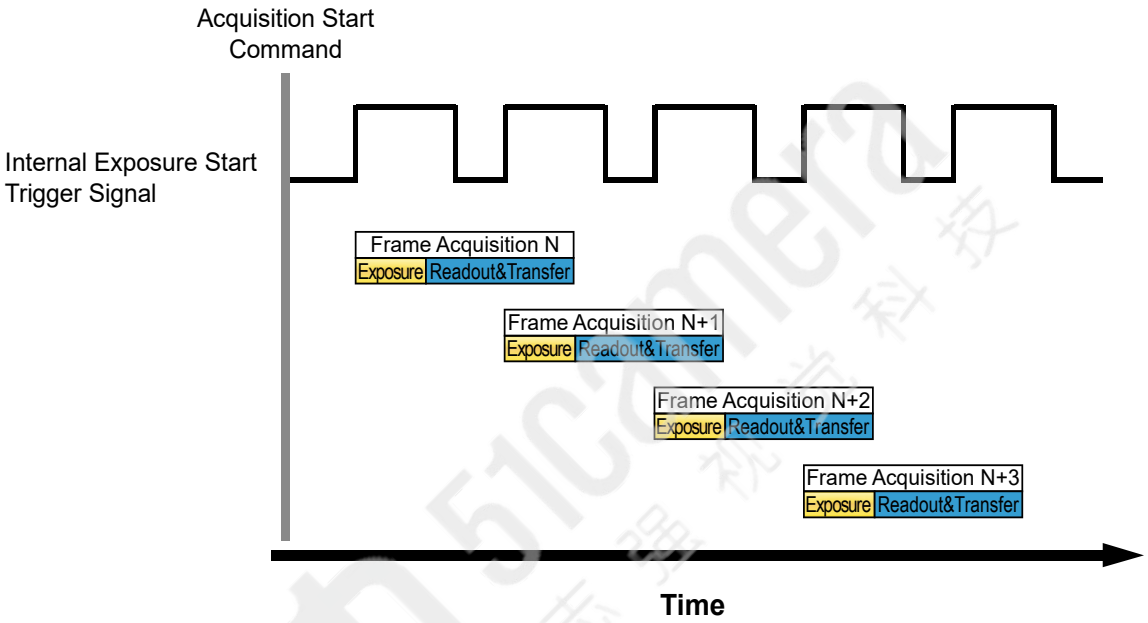


Figure 8-8 Overlapped Exposure and Readout (1X_2YE)

Determining whether your camera is operating with overlapped exposure and readout is not a matter of issuing a command or changing a setting. Rather a 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:

- Overlapped: Frame Period ≤ Exposure Time + Readout Time (+ Transfer Time)

8.5 Global Shutter

The VNP-576/864/1152MX2 cameras are equipped with an image sensor that has an electronic global shutter. When an exposure start trigger signal is applied to the camera equipped with a global shutter, exposure begins for all lines in the sensor as shown in the figure below. Exposure continues for all lines in the sensor until the programmed exposure time ends or when the exposure start trigger signal ends the exposure time if the camera is using the TriggerWidth exposure mode. At the end of the exposure time, exposure ends for all lines in the sensor. Immediately after the end of exposure, pixel data readout begins and proceeds line by line until all pixel data is read out of the sensor. A main characteristic of a global shutter is that for each frame acquisition, all the pixels in the sensor start exposing at the same time and all end exposing at the same time. This means that image brightness tends to be more uniform over the entire area of each acquired image, and it helps to minimize problems with acquiring images of object in motion.

The camera can provide an **Exposure Active** output signal that will go high when the exposure time for a frame acquisition begins and will go low when the exposure time ends.

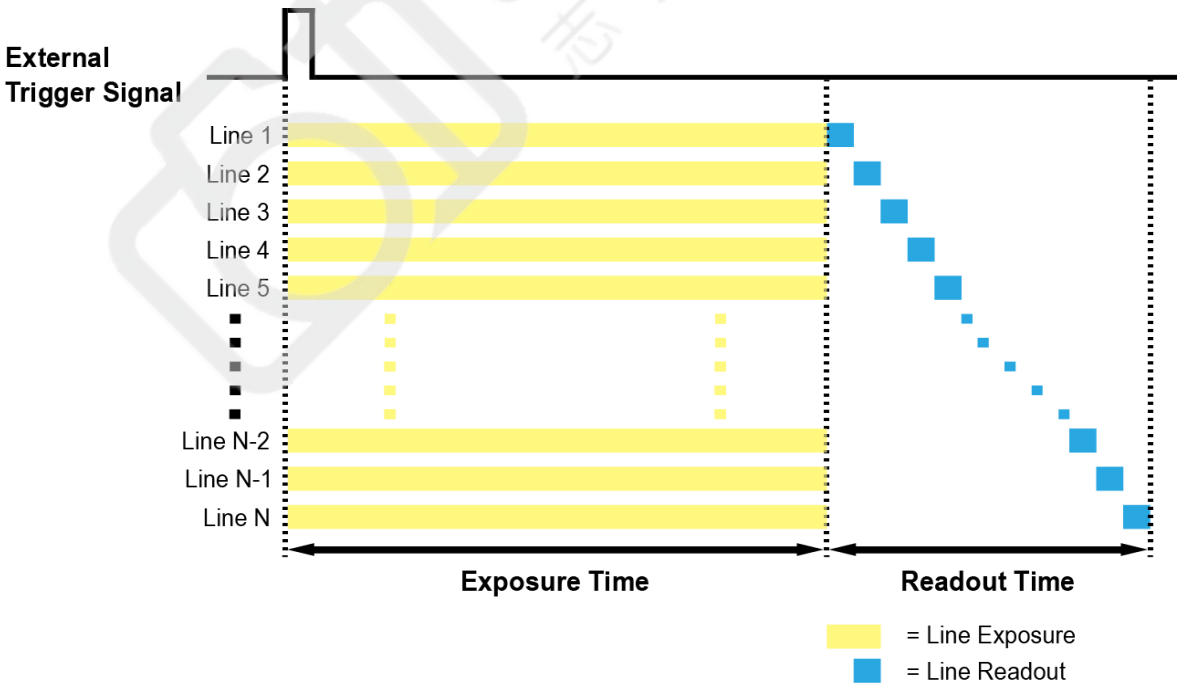


Figure 8-9 Global Shutter

8.6 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 amount of time it takes to read an acquired frame out of the image sensor and into the camera's frame buffer. This time varies depending on the setting for ROI. Frames with a smaller height and/or width take less time to read out of the sensor. The frame height and width are determined by the camera's Height and Width settings in the Image Format Control category.
- The CXP Link Configuration. When the camera is set for a CXP Link Configuration that uses more channels, it can typically transfer data out of the camera faster than when it is set for a CXP Link Configuration that uses less channels.
- The exposure time for acquired frames. If you use very long exposure time, you can acquire fewer frames per second.

8.6.1 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 using the ROI feature. Decreasing the size of the Image ROI may increase the maximum allowed frame rate. If possible, decrease the height and/or width of the Image ROI.
- If you are using a CXP Link Configuration with a low number of channels, consider using a CXP Link Configuration with a high number of channels. 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 time, it is possible that your exposure time is limiting the maximum allowed frame rate. If you are using a long exposure time, 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.).

Note:

A very long exposure time severely limits 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.

Chapter 9. Camera Features

9.1 Sequence of Signal Processing

To acquire the best-quality images, the VNP-576/864/1152MX2 cameras handle signals in the following sequence:

DSNU correction -> Tab Linearity correction -> PRNU correction (pixel by pixel) ->
Pixel Defect correction -> FFC correction -> White Balance correction -> Digital Gain/Offset ->
Reverse X

After finishing the current job, doing all the prior jobs to the current work again is recommended. It may affect the other jobs that have been done before the current job.

9.2 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 increase the maximum allowed frame rate by decreasing the **Width** and/or **Height** parameters. The ROI is referenced to the top left corner [origin (0, 0)] of the sensor array as shown below.

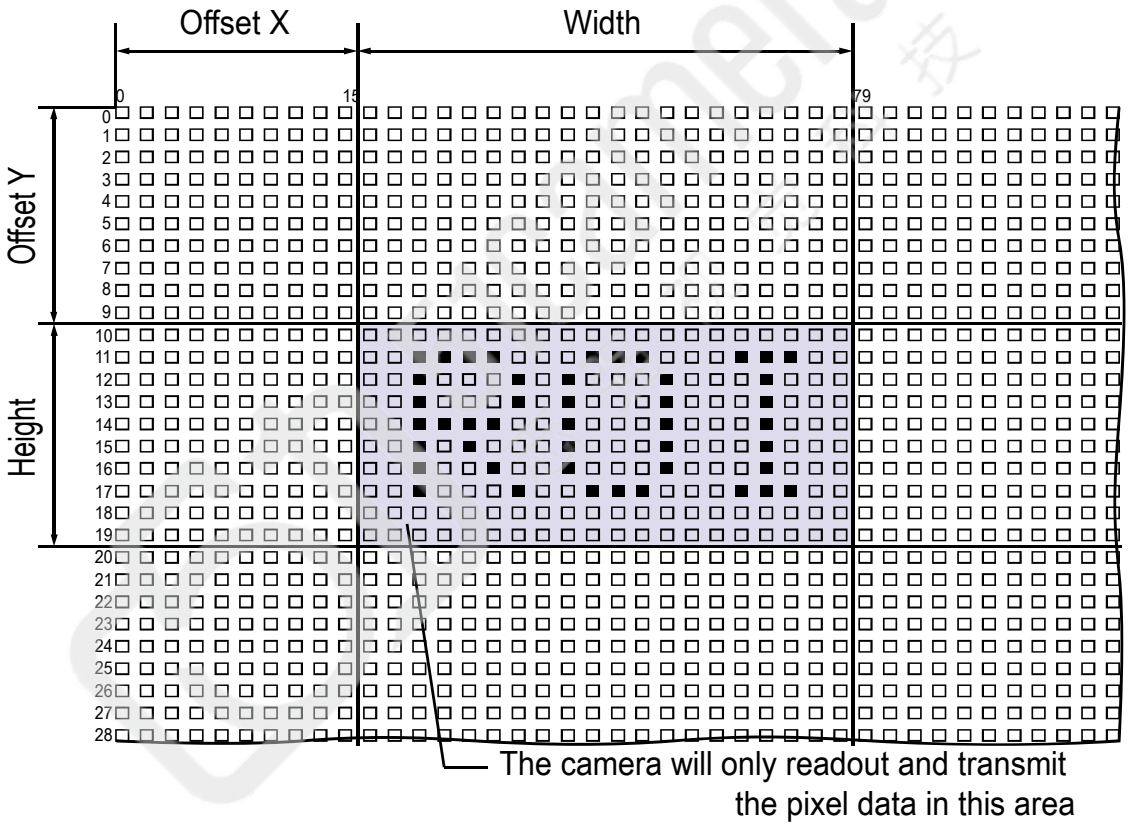


Figure 9-1 Region of Interest

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	-	Maximum allowed width of the image with the current camera settings
	HeightMax	-	Maximum allowed height of the image with the current camera settings
	Width[b]	-	Sets the Width of the Image ROI.
	Height[b]	-	Sets the Height of the Image ROI.
	OffsetX[c]	-	Sets the horizontal offset from the origin to the Image ROI.
	OffsetY[c]	-	Sets the 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: User configurable parameters for setting ROI
c: User configurable parameters for setting the origin of the ROI

Table 9-1 XML Parameters related to ROI

You can change the size of ROI by setting the **Width** and **Height** parameters in the **Image Format Control** category. You can also 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 Offset Y value is automatically changed to be centered.
- On the VNP-576/864/1152MX2 cameras, the Width parameter must be set to a multiple of 32, and the Height parameter must be set to a multiple of 8.

The minimum allowed setting values for the ROI Width and Height are shown below.

Camera Model	Minimum Width Settings	Minimum Height Settings
VNP-576/864/1152MX2	64	16

Table 9-2 Minimum ROI Width and Height Settings

On the VNP-576/864/1152MX2 camera, the maximum allowed frame rates depending on Horizontal and Vertical ROI changes are shown below. The maximum allowed frame rates shown below are based on 8 bit Pixel Format, the frame rates get about 20% faster usually when the Pixel Format changes from 10 bit to 8 bit. However, the frame rate doesn't get faster if it already reaches the maximum frame rate of the sensor output (Note up to Width '12000' for VNP-576MX2 and up to Width '17984' for VNP-864MX2).

ROI Size (H × V)	1 Channel	2 Channels	4 Channels
24000 × 8	355.6 fps	711.1 fps	1422.3 fps
24000 × 1000	24.07 fps	48.1 fps	96.2 fps
24000 × 3000	8.3 fps	16.7 fps	33.4 fps
24000 × 5000	5.0 fps	10.1 fps	20.2 fps
24000 × 7000	3.6 fps	7.2 fps	14.5 fps
24000 × 10000	2.5 fps	5.0 fps	10.1 fps
24000 × 12000	2.1 fps	4.2 fps	8.4 fps
64 × 12000	15.1 fps	15.1 fps	15.1 fps
2976 × 12000	15.1 fps	15.1 fps	15.1 fps
6016 × 12000	8.4 fps	15.1 fps	15.1 fps
9024 × 12000	5.6 fps	11.2 fps	15.1 fps
12032 × 12000	4.2 fps	8.4 fps	15.1 fps
17024 × 12000	2.9 fps	5.9 fps	11.9 fps
20000 × 12000	2.5 fps	5.0 fps	10.1 fps

Table 9-3 Maximum Frame Rates by VNP-576/865/1152MX2 ROI Changes_CXP-6

ROI Size (H × V)	1 Channel	2 Channels	4 Channels
24000 × 8	568.9 fps	1137.9 fps	2275.0 fps
24000 × 1000	38.5 fps	77.0 fps	154.0 fps
24000 × 3000	13.3 fps	26.7 fps	53.5 fps
24000 × 5000	8.0 fps	16.1 fps	32.3 fps
24000 × 7000	5.8 fps	11.6 fps	23.2 fps
24000 × 10000	4.0 fps	8.1 fps	16.2 fps
24000 × 12000	3.3 fps	6.7 fps	13.5 fps
64 × 12000	15.1 fps	15.1 fps	15.1 fps
2976 × 12000	15.1 fps	15.1 fps	15.1 fps
6016 × 12000	13.5 fps	15.1 fps	15.1 fps
9024 × 12000	9.0 fps	15.1 fps	15.1 fps
12032 × 12000	6.7 fps	13.5 fps	15.1 fps
17024 × 12000	4.7 fps	9.5 fps	15.1 fps
20000 × 12000	4.0 fps	8.1 fps	15.1 fps

Table 9-4 Maximum Frame Rates by VNP-576/865/1152MX2 ROI Changes_CXP-10

ROI Size (H × V)	1 Channel	2 Channels	4 Channels
24000 × 8	711.1 fps	1422.3 fps	2539.1 fps
24000 × 1000	48.1 fps	96.2 fps	171.8 fps
24000 × 3000	16.7 fps	33.4 fps	59.6 fps
24000 × 5000	10.1 fps	20.2 fps	36.1 fps
24000 × 7000	7.2 fps	14.5 fps	25.8 fps
24000 × 10000	5.0 fps	10.1 fps	18.1 fps
24000 × 12000	4.2 fps	8.4 fps	15.1 fps
64 × 12000	15.1 fps	15.1 fps	15.1 fps
2976 × 12000	15.1 fps	15.1 fps	15.1 fps
6016 × 12000	15.1 fps	15.1 fps	15.1 fps
9024 × 12000	11.2 fps	15.1 fps	15.1 fps
12032 × 12000	8.4 fps	15.1 fps	15.1 fps
17024 × 12000	5.9 fps	11.9 fps	15.1 fps
20000 × 12000	5.0 fps	10.1 fps	15.1 fps

Table 9-5 Maximum Frame Rates by VNP-576/865/1152MX2 ROI Changes_CXP-12

Caution!

Your CXP-12 Frame Grabber may place additional restrictions on how the ROI location and size must be set. Refer to your CXP-12 Frame Grabber user manual for more information.

9.3 Multi-ROI

The VNP-576/864/1152MX2 cameras provide the Multi-ROI feature which allows you to define up to 16 regions of the sensor array. When an image is acquired, only the pixel information from the defined regions will be readout of the sensor. The pixel data read out of the regions will then be combined and will be transmitted from the camera as a single image.

The XML parameters related to Multi-ROI are as follows.

XML Parameters		Value†	Description
MultiROIControl	MultiROISelector	Region0 – Rigion15	Selects the ROI to set.
	MultiROIMode	On/Off	Enables / Disables the selected ROI.
	MultiROIWidth	-	Width setting for the selected ROI
	MultiROIHeight	-	Height setting for the selected ROI
	MultiROIOffsetX	-	Horizontal offset from the origin to the selected ROI
	MultiROIOffsetY	-	Vertical offset from the origin to the selected ROI
	MultiROIValid[a]	-	Verifies the validation of the Multi-ROI setting values.
	MultiROIStatus	Active/Inactive	Displays the status of the Multi ROI feature. Active: The Multi-ROI feature is in use. Inactive: The Multi-ROI feature is not in use.

†The unit for all parameters in this table is pixel.
a: If the setting values for the Multi-ROI feature are valid, 'True' will be returned or the check box will be selected.

Table 9-6 XML parameters related to Multi-ROI

It is recommended that you first set the **MultiROIWidth** parameter, since all the regions must be the same width.

The sum of the Multi ROI Heights of the top and bottom regions must be the same to be set (MultiROIValid must be 'True' to output images).

The next step in the setup process is to define each individual region as desired. Up to 16 regions can be set up ranging from 0 through 15. Use the **MultiROISelector** parameter to select which ROI to set and then set the ROI to On/Off by using the **MultiROIMode** parameter. Then, set the **MultiROIOffsetX**, **MultiROIOffsetY** and **MultiROIHeight** parameters to define each region.

In the figure below, for example, three regions have been set. With these settings, the camera would output an image as follows:

- MultiROI Width × the total height of the three regions (Region0 Height + Region1 Height + Region2 Height)

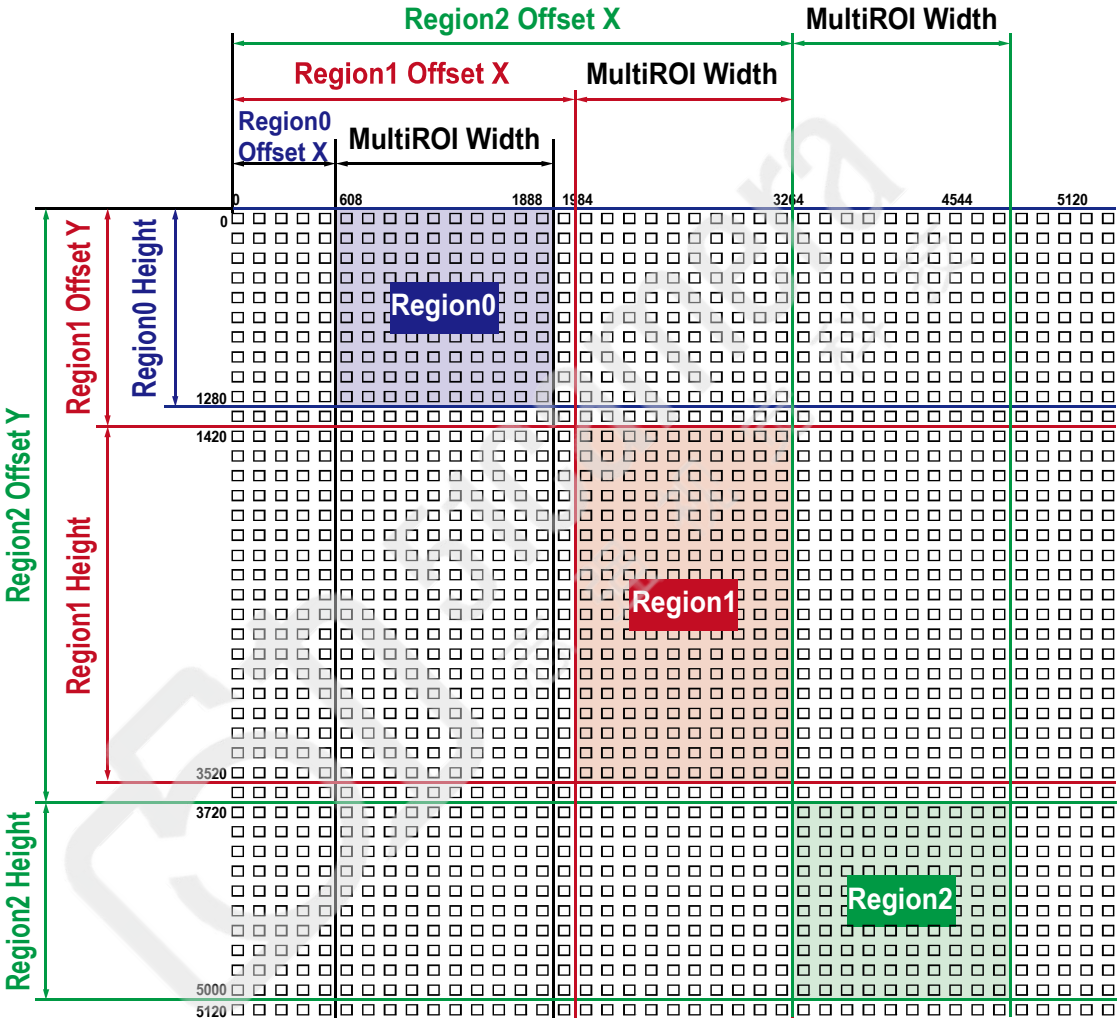


Figure 9-2 Multi-ROI

There are several things to keep in mind when setting the Multi-ROI feature on the VNP-576/864/1152MX2 cameras:

- The sum of the Multi-ROI Offset X value plus the Multi-ROI Width value must not exceed the Width value of the camera's sensor.
- The sum of the Multi-ROI Offset Y value plus the Multi-ROI Height value must not exceed the Height value of the camera's sensor.
- The Multi-ROI Offset X and Multi-ROI Width value must be a multiple of 32.
- The Multi-ROI Offset Y and Multi-ROI Height value must be a multiple of 4.
- The MultiROI Width values are equal, so the widths of the Region 0, Region 1, and Region 2 are the same in the figure above.
- You can save the Multi-ROI setting values as a User Set and then load the values to the camera when desired. For more information, refer to 9.28 User Set Control.

9.4 Binning

The 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
ImageFormat Control	BinningSelector	Sensor	Supports 1x1 only.
		Logic	Applies the Binning in digital by the logic.
	BinningHorizontalMode	Sum	Adds pixel values from the adjacent pixels as specified in the Binning Horizontal, and then sends them as one pixel.
		Average	Adds pixel values from the adjacent pixels as specified in the Binning Horizontal and divides them by the number of combined pixels, and then sends them as one pixel.
	BinningHorizontal	1×, 2×	The number of horizontal pixels to combine.
	BinningVerticalMode	Sum	Adds pixel values from the adjacent pixels as specified in the Binning Vertical, and then sends them as one pixel.
		Average	Adds pixel values from the adjacent pixels as specified in the Binning Vertical and divides them by the number of combined pixels, and then sends them as one pixel.
	BinningVertical	1×, 2×	The number of vertical pixels to combine.

Table 9-7 XML Parameters related to Binning

For example, if you set 2 × 2 binning, the camera's resolution is reduced to 1/4. If you set the **Binning Mode** to **Sum**, the maximum allowed resolution of the image is reduced 1/2 and the responsivity of the camera is quadrupled. If you set the **Binning Mode** to **Average**, the maximum allowed resolution of the image is reduced to 1/2, but there is no difference in responsivity between a binned image and an original image. The **Width Max** and **Height Max** parameter, indicating the maximum allowed resolution of the image with the current camera settings, will be updated depending on the binning settings. And, 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.

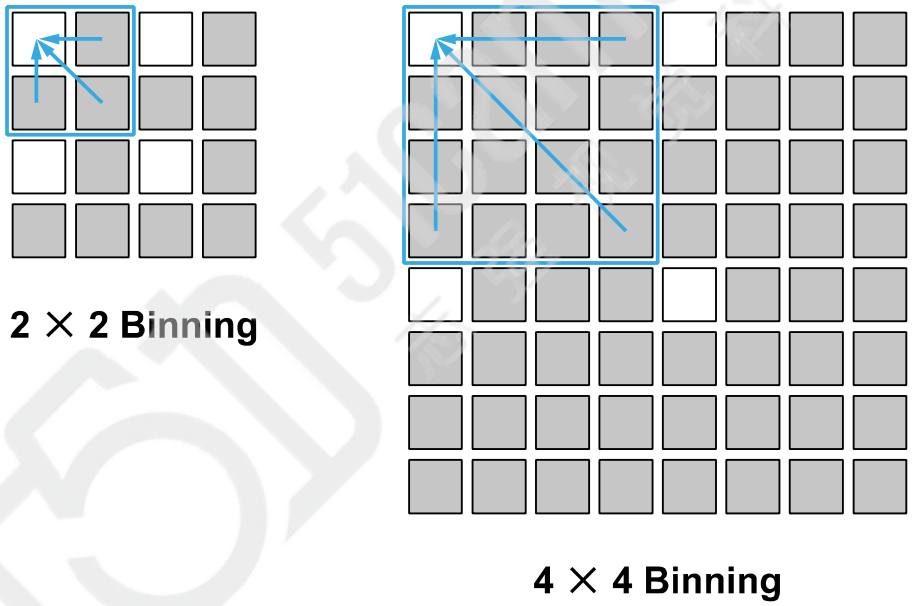


Figure 9-3 2 × 2 Binning and 4 × 4 Binning

9.5 CXP Link Configuration

The VNP-576/864/1152MX2 cameras must be connected to a CXP-12 Frame Grabber of CXP 2.0 interface. CoaXPress 2.0 interface allows you to connect a camera to a Frame Grabber supporting CXP 2.0 by using simple coax cabling and allows up to 12.5 Gbps data rate per cable. The VNP-576/864/1152MX2 cameras support one master connection and up to three extension connections to configure a link. In compliance with the CoaXPress standard, the camera includes an automatic link detection mechanism (Plug and Play) to correctly detect the camera to CXP-12 Frame Grabber connections.

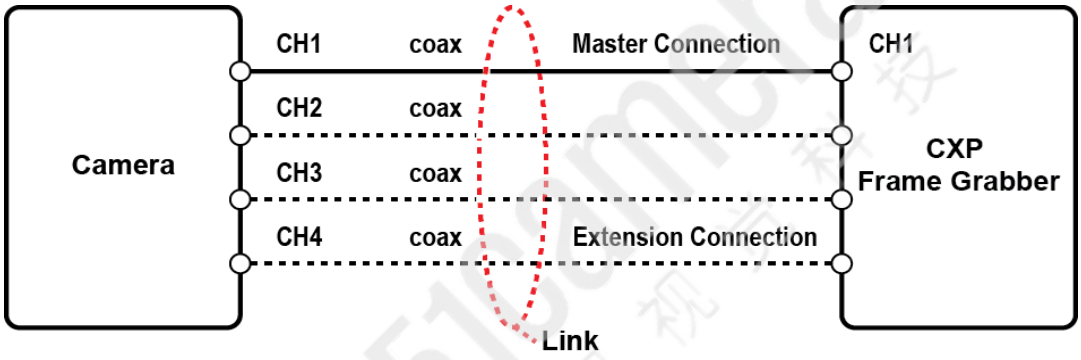


Figure 9-4 CXP Link Configuration

The XML parameters related to the link configuration between the camera and CXP-12 Frame Grabber are as follows.

XML Parameters		Value	Description
	CxpLinkConfiguration Preferred	Read Only	Displays bit rate and the number of connections to be set for the link configuration between the camera and Host (Frame Grabber) while discovering devices. Saves the current CxpLinkConfiguration values as the CxpLinkConfigurationPreferred value when you execute the User Set Save parameter.
CoaXPress	CxpLinkConfiguration	CXP6_X1 CXP6_X2 CXP6_X4 CXP10_X1 CXP10_X2 CXP10_X4 CXP12_X1 CXP12_X2 CXP12_X4	Sets bit rate and the number of connections for the link configuration. e.g. CXP12_X4: Four connections running at a maximum of CXP12 speed (12.5 Gbps)

Table 9-8 XML Parameters related to CXP Link Configuration

9.6 Pixel Format

You can determine the pixel format (8 bits, 10 bits or 12 bits) of these image data transmitted from the camera by selecting the **Pixel Format** parameter. The XML parameter related to Pixel Format is as follows.

XML Parameter		Description
ImageFormatControl	PixelFormat	Sets the pixel format supported by the device.

Table 9-9 XML Parameter related to Pixel Format

The available pixel formats on the monochrome and color cameras are as follows.

Mono Sensor	Color Sensor (VNP-864MX2-C15K only)
Mono 8 Mono 10 Mono 12	Mono 8 Mono 10 Mono 12 Bayer RG 8 Bayer RG 10 Bayer RG 12

Table 9-10 Pixel Format Values

9.7 Device Tap Geometry

The VNP-576/864/1152MX2 cameras support two of the Device Tap Geometry type. The tact time differs depending on the type, for more information on the tact time, see **8.4**:

- Geometry_1X_1Y
- Geometry_1X_2YE

Consider the following properties related to the feature and choose the method that works best:

- W: Width, H: Height
- X Start: X-coordinate of the first pixel column
- Y Start: Y-coordinate if the first pixel row
- X End: X-coordinate of the last pixel column
- Y End: Y-coordinate of the last pixel row
- X Step: Difference of X-coordinates between consecutive pixel columns;
  X-step is positive when X-coordinates are increasing along a row; it is negative otherwise.
- Y Step: Difference of Y-coordinates between consecutive pixel rows;
  Y-step is positive when Y-coordinates is increasing at the end of a line; it is negative otherwise.

Geometry Name		X Start	X End	Step X	Y Start	Y End	Step Y
1X_1Y		1	W	1	1	H	1
1X_2YE	Tap 1	1	W	1	1	H/2	1
	Tap 2	1	W	1	H	H/2+1	-1

Table 9-11 Tap Geometry Properties

Caution!

After changing the Device Tap Geometry, power cycle or reset the product before using it.

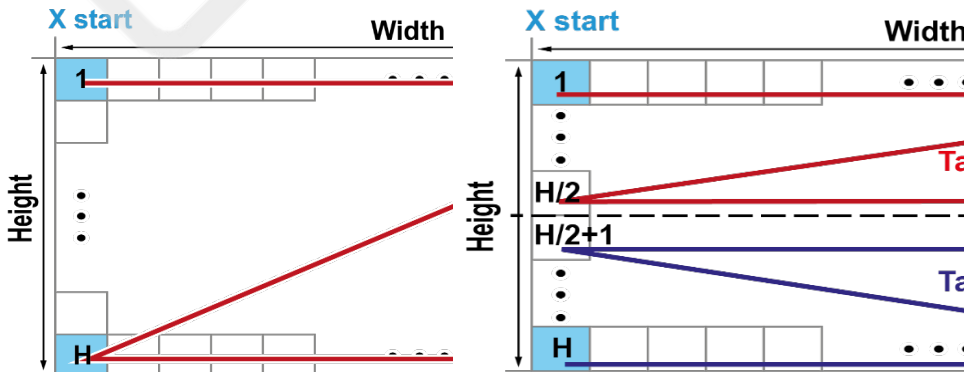


Figure 9-5 Operation of 1X_1Y (left) and 1X_2YE (right)

The XML parameters related to Device Tap Geometry are as follows.

XML Parameters		Value	Description
TransportLayer Control	DeviceTap Geometry	Geometry_1X_1Y	Proceeds in the direction of top-down
		Geometry_1X_2YE	By 2 taps, proceeds in the direction of top-down and bottom-up, respectively

Table 9-12 XML Parameters related to CXP Link Configuration

9.8 Data ROI

The FlatField feature uses the pixel data from a Data Region of Interest (ROI) to adjust the related parameters. Data ROI can also be applied to PRNU and DSNU correction.

The XML parameters related to Data ROI are as follows. (FFC is applied only to the setting area)

XML Parameters		Value	Description
DataRoiControl	RoiSelector	FlatField	Corrects the selected ROI only
	RoiOffsetX	-	X coordinate of start point Data ROI
	RoiOffsetY	-	Y coordinate of start point Data ROI
	RoiWidth	16 - 12000	Width of Data ROI
	RoiHeight	16 – 6000	Height of Data ROI

Table 9-13 XML Parameters related to Data ROI

Only the pixel data from the area of overlap between the Data ROI and the Image ROI by your settings will be effective if you use the Image ROI and Data ROI at the same time.

9.9 Data ROI (Color Camera)

The Balance White Auto feature provided by color cameras uses pixel data from a data region of interest (ROI) to adjust parameter values. Data ROI can also be applied to PRNU and DSNU correction.

The XML parameters related to Data ROI are as follows.

XML Parameters		Value	Description
DataRoiControl	DataRoiSelector	WhiteBalanceAuto	Selecting the Data ROI to use for Balance White Auto. Supported for color cameras only.
	DataRoiOffsetX	-	X coordinate of start point ROI
	DataRoiOffsetY	-	Y coordinate of start point ROI
	DataRoiWidth	32 - 13376	Width of ROI
	DataRoiHeight	2 - 9528	Height of ROI

Table 9-14 XML Parameters related to Data ROI (Color Camera)

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

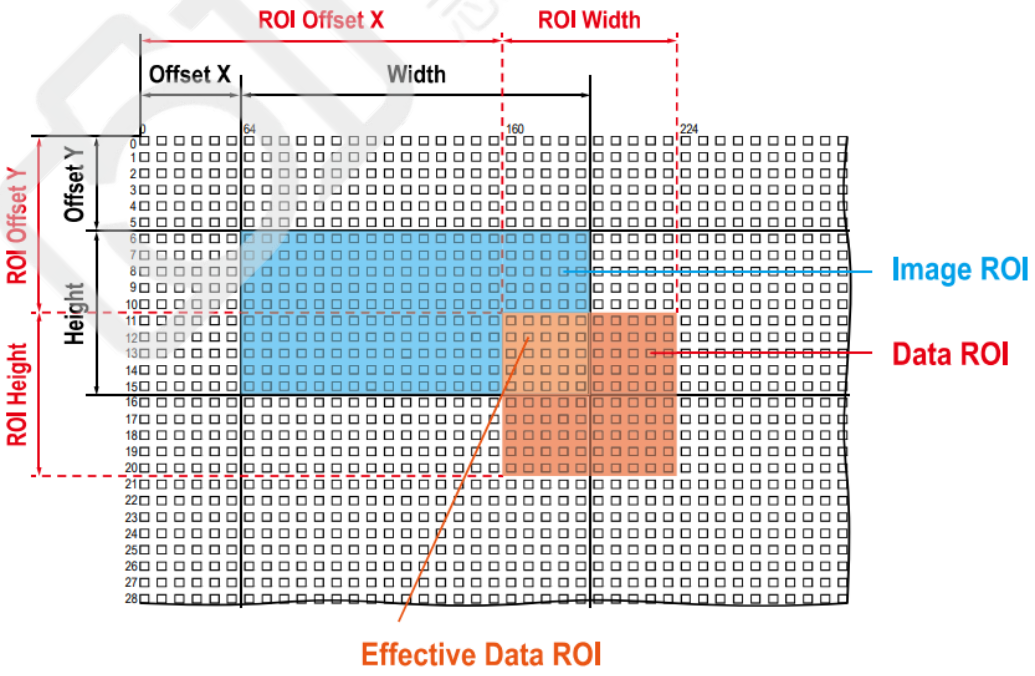


Figure 9-6 Effective Data ROI

9.10 White Balance (Color Camera)

The color camera includes the white balance capability to adjust the color balance of the images acquired from the image sensor. With the white balancing scheme used on the VNP-864MX2-C15K camera, the Red, Green and Blue intensities can be adjusted individually. You can set the intensity of each color by using the **Balance Ratio** parameter. The **Balance Ratio** value can range from 1.0 to 4.0. If the **Balance Ratio** parameter is set to 1.0 for a color, the intensity of the color will be unaffected by the white balance mechanism. If the **Balance Ratio** parameter is set to greater than 1.0, the intensity of the color will be proportionally increased to the ratio. For example, if the Balance Ratio is set to 1.5, the intensity of that color will be increased by 50%.

The XML parameters related to White Balance are as follows.

XML Parameters		Value	Description
Analog Control	BalanceRatio Selector	Red	A Balance Ratio value will be applied to red pixels.
		Green	A Balance Ratio value will be applied to green pixels.
		Blue	A Balance Ratio value will be applied to blue pixels.
	BalanceRatio	1.0× - 4.0×	Adjusts the ratio of the selected color.

Table 9-15 XML Parameters related to White Balance

9.10.1 Balance White Auto

The Balance White Auto feature is implemented on the color camera. 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. If you do not set the 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 Balance Ratio values for Red and Blue will be automatically adjusted to adjust the white balance by referring to Green.

XML Parameter		Value	Description
AnalogControl	BalanceWhiteAuto	Off	Balance White Auto Off
		Once	White Balance is adjusted once and then Off.

Table 9-16 XML Parameter related to Balance White Auto

9.11 Gain and Black Level

Increasing the **Gain** parameter increases all pixel values of the image. This results in a higher grey value output from the camera for a given amount of output from the image sensor.

1. Selects the **Gain Control** (**Digital All**) to be adjusted by using the **Gain Selector** parameter.
2. Sets the **Gain** parameter to the desired value.

Adjusting the **Black Level** parameter will result in an offset to the pixel values output from the camera.

1. Selects the **Black Level Control** (**Digital All**) to be adjusted by using the **Black Level Selector** parameter.
2. Sets the **Black Level** parameter to the desired value. The available setting range varies depending on the **Pixel Format** settings.

The XML parameters related to **Gain** and **Black Level** are as follows.

XML Parameters		Value	Description
Analog Control	GainSelector	Digital All	Applies the Gain value to all digital channels.
	Gain	1.0× - 32.0×	Sets a digital gain value.
	BlackLevelSelector	DigitalAll	Applies the Black Level value to all digital channels.
	BlackLevel	8 bit: 0 - 15.93 10 bit: 0 - 63.75 12 bit: 0 - 255.00	Sets a black level value.

Table 9-17 XML Parameters related to Gain and Black Level

9.12 Defective Pixel Correction

The CMOS sensor may have defective pixels which cannot properly react to the light. Correction is required since it may deteriorate the quality of output image. Defect pixel information of CMOS used for each camera is entered into the camera during the manufacturing process. If you want to add defect pixel information, it is required to enter coordinate of new defect pixel into the camera. For more information, refer to Appendix A.

Correction Method

A correction value for a defect pixel is calculated based on the valid pixel value adjacent in the same line.

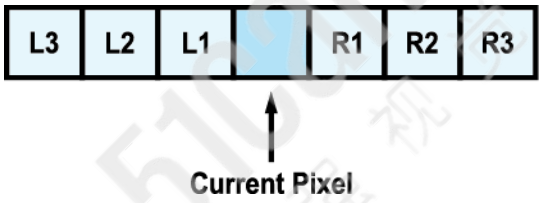


Figure 9-7 Location of Defect Pixel to be corrected

If the Current Pixel is a defect pixel as shown in the figure above, the correction value for this pixel is obtained as shown in the following table depending on whether surrounding pixels are defect pixels or not.

Adjacent Defect Pixel	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 9-18 Calculation of Defect Pixel Correction Value

9.13 Dark Signal Non-Uniformity Correction

In theory, when an area scan camera acquires images in complete darkness, all the pixel values in the image should be near zero and they should be equal. In practice, however, slight variations in the performance of the pixels in the sensor will cause some variations in the pixel values output from the camera when the camera is acquiring in darkness. This variation is known as Dark Signal Non-uniformity (DSNU). The VNP-576/864/1152MX2 cameras provide the DSNU Correction feature.

Note:

For the VNP-576/864/1152MX2, there is no need to adjust for users because the DSNU Correction feature is built in the camera.

9.14 Photo Response Non-Uniformity Correction

In theory, when an area scan camera acquires images with the camera viewing a uniform light-colored target in bright light, all the pixel values in the image should be near the maximum grey value or all of them should be equal. In practice, however, slight variations in the performance of the pixels in the sensor will cause some variations in the pixel values output from the camera. This variation is known as Photo Response Non-uniformity (PRNU), and the VNP-576/864/1152MX2 cameras provide the PRNU Correction feature.

The PRNU correction feature applied to the VNP-576/864/1152MX2 cameras acquire multiple images under non-saturated brightness conditions and average the gray level of the images on a pixel-by-pixel basis. It then generates a PRNU coefficient on a pixel-by-pixel basis based on the average gray level value. These correction values will be generated and applied to the VNP-576/864/1152MX2 cameras during the manufacturing process.

Note:

For the VNP-576/864/1152MX2, there is no need to adjust for users because the PRNU Correction feature is built in the camera.

9.15 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 of the VNP-576/864/1152MX2 cameras can be summarized by the following equation.

```
IC = IR / IF

IC:     Level value of corrected image
IR:     Level value of original image
IF:     Level value of Flat Field data
```

In actual use conditions, generate Flat Field correction data and then save the data into the non-volatile memory of the camera by following the procedure below.

1. Execute the **Flat Field Data Generate** parameter.

   After executing the **Flat Field Data Generate** parameter, you must acquire one image to generate the scaled down Flat Field correction data.

2. Use the **Flat Field Data Selector** parameter to specify a location to save the generated Flat Field correction data.
3. Execute the **Flat Field Data Save** parameter to save the generated Flat Field data into the non-volatile memory. When the scaled down Flat Field data are used for correction, they are expanded and applied with a Bilinear Interpolation as shown in the **Figure 9-10**.

   To disregard the generated Flat Field correction data and load the existing Flat Field correction data, execute the **Flat Field Data Load** parameter before executing the **Flat Field Data Save** parameter.

4. Set the **Flat Field Correction** parameter to **On** to apply the Flat Field data to the camera.

Caution!

- It is recommended that you enable the Defective Pixel Correction feature before executing the Flat Field Data Generate parameter.
- Before executing the Flat Field Data Generate parameter, you must set the camera as follows:
  OffsetX, Y: 0
  Width, Height: Maximum values
- After executing the Acquisition Start command, you need to operate the camera with the free-run mode or apply a trigger signal to acquire an image.

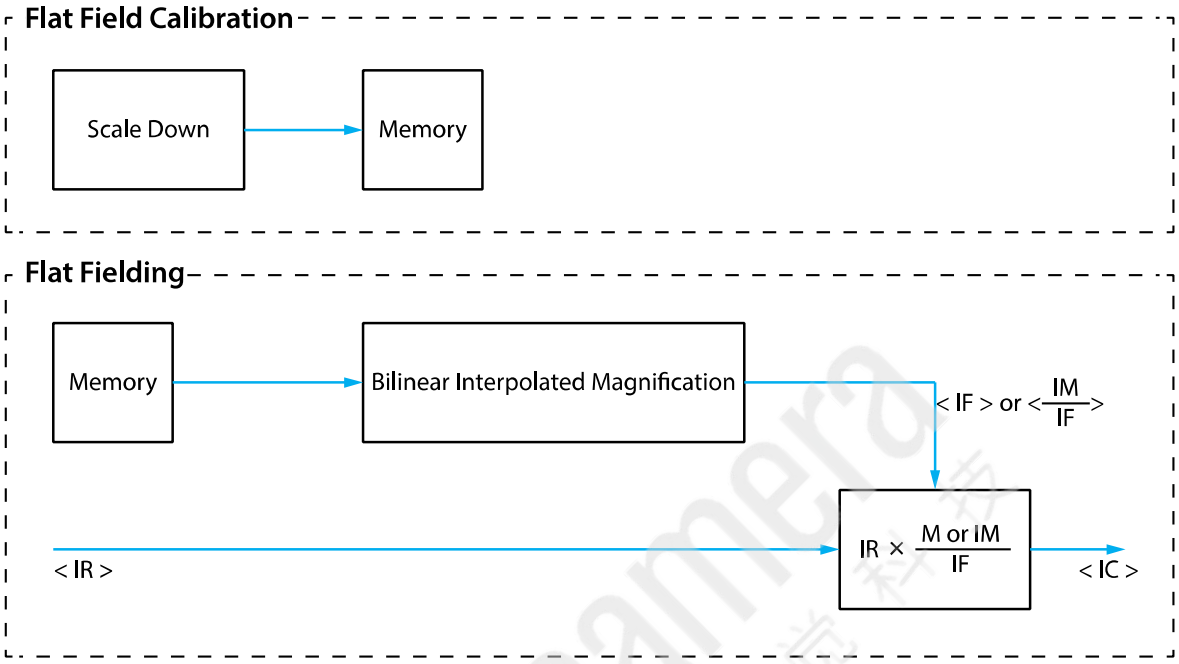


Figure 9-8 Generation and Application of Flat Field Data

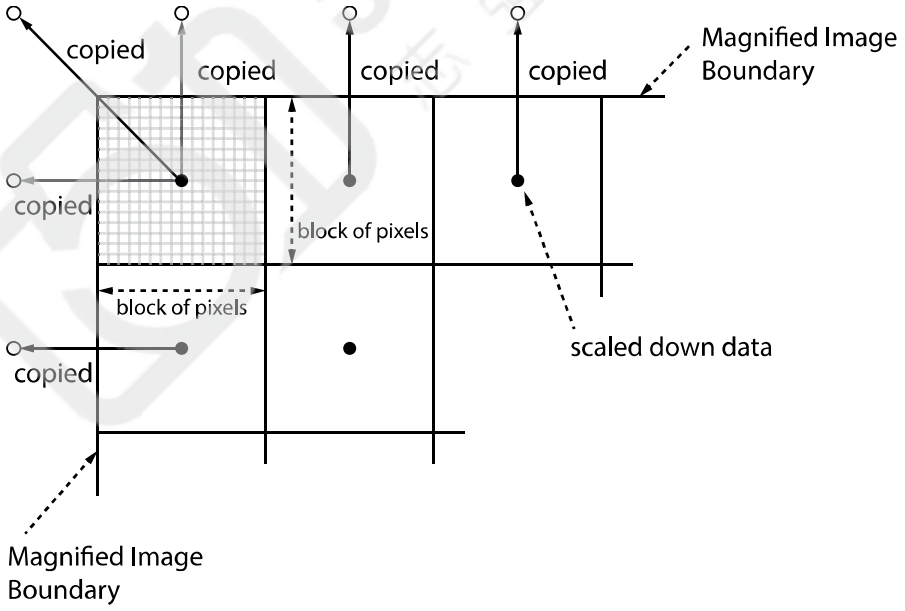


Figure 9-9 Bilinear Interpolated Magnification

The XML parameters related to Flat Field Correction are as follows.

XML Parameters		Value	Description
FlatFieldControl	FlatFieldCorrection	Off	Disables the Flat Field Correction feature.
		On	Enables the Flat Field Correction feature.
	FlatFieldData Selector	Space0 ~ Space15	Selects a location to save Flat Field data to or load Flat Field data from. Space0~Space15:User defined location
	FlatFieldDataGenerate	-	Generates the Flat Field data.
	FlatFieldDataSave	-	Saves the generated Flat Field correction data in the non-volatile memory. The data generated by executing the Flat Field Data Generate parameter are saved in the volatile memory so that 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.
	FlatFieldDataLoad	-	Loads the Flat Field data from the non-volatile memory into volatile memory.

Table 9-19 XML Parameters related to Flat Field Correction

9.15.1 Flat Field Data Selector

As mentioned above, the generated Flat Field correction data is stored in the camera's volatile memory and the data are lost if the camera is reset or powered off. To use the generated Flat Field correction data after the camera is powered on or reset, you need to save them in the camera's non-volatile memory. The VNP-576/864/1152MX2 cameras provide sixteen reserved locations in the camera's non-volatile memory available for saving and loading the Flat Field correction data. You can use the **Flat Field Data Selector** parameter to select a location as desired.

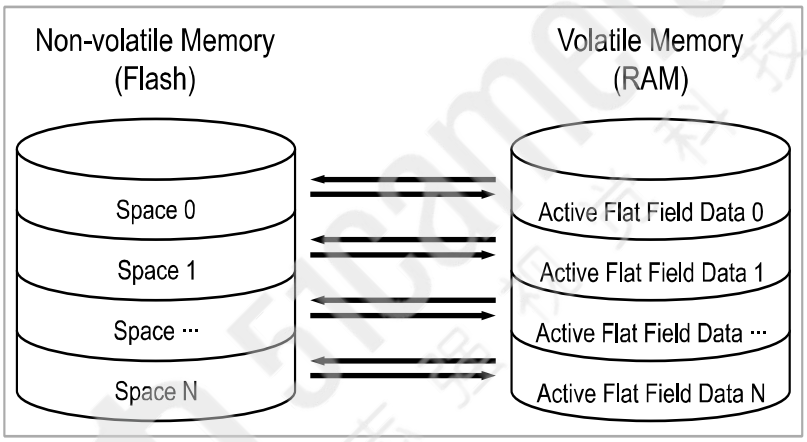


Figure 9-10 Flat Field Data Selector

Saving Flat Field Data

To save the active Flat Field data into a reserved location in the camera's Flash memory, follow the procedure below.

1. Use the **Flat Field Data Selector** parameter to specify a location to save the active Flat Field data.
2. Execute the **Flat Field Data Save** parameter to save the active Flat Field data to the selected location.

Loading Flat Field Data

If you saved Flat Field correction data into the camera's non-volatile memory, you could load the saved Flat Field correction data from the camera's non-volatile memory into the camera's

active Flat Field data location.

1. Use the **Flat Field Data Selector** parameter to specify a reserved location whose Flat Field correction data will be loaded into the camera's active Flat Field data location.
2. Execute the **Flat Field Data Load** parameter to load the selected Flat Field correction data into the active Flat Field data location.

9.16 Pixel Shifting

The VNP-576/864/1152MX2 cameras have a feature to shift the image sensor to X and Y direction precisely using the 2D-Stage. The resulting image can be combined of 4 individual images captured by shifting the image sensor to X and Y direction as shown in the figure below. Thus, the output image offers improved resolution (4 Shot Result Image) in comparison with standard output image (1 Shot Result Image). Combining the images should be done on the PC side with software processing. Contact the local dealer or factory representative for the details on the sample software combining the image.

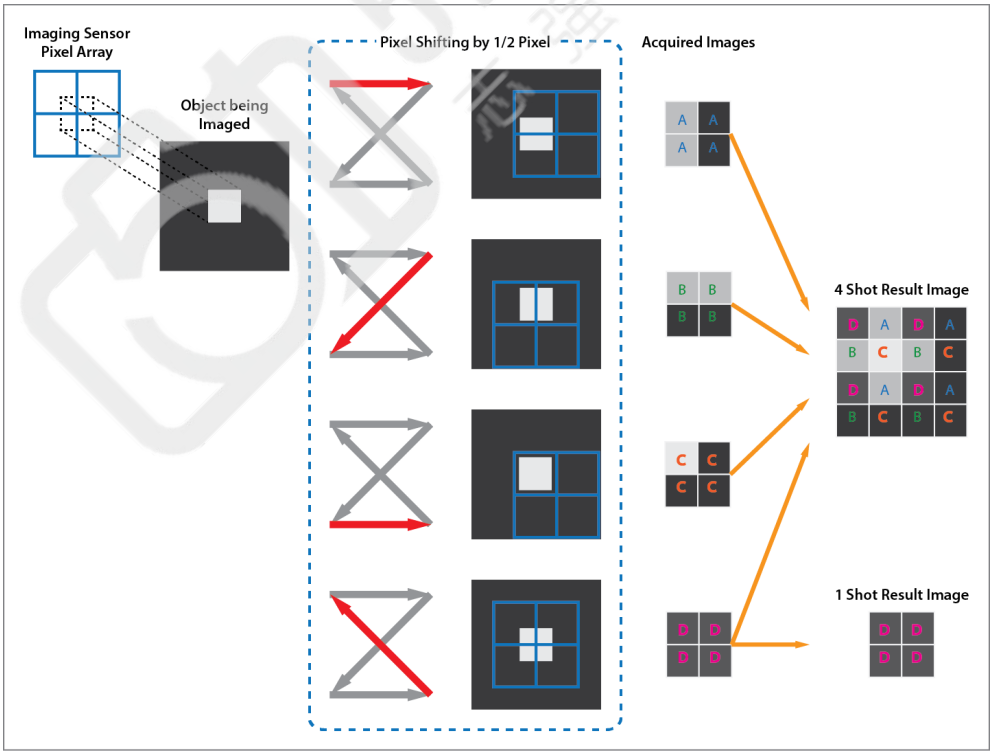


Figure 9-11 Comparison of a Pixel Shifting Image with Standard Image

Caution!

- The camera contains components sensitive to heat, shock, or vibration. Handle this camera with the maximum care. Operate the camera at temperature between 0℃ and 40℃.
- The Pixel Shifting feature is only available when the **Trigger Mode** parameter is set to **On**.

9.16.1 True Color Image at Enhanced Resolution

One benefit of pixel shift technology in comparison to fixed sensor camera is its ability to acquire more than four times higher resolution than the fixed one. The figures below show a standard output image and 9× shifting output image. For VNP-576/864/1152MX2 cameras, If Pixel Shifting is not applied, the image is acquired at 1× resolution (single shot). When Pixel Shifting is applied, the image is acquired at 4× resolution (four shots). Refer to <5.2 Specifications> for specific resolution.

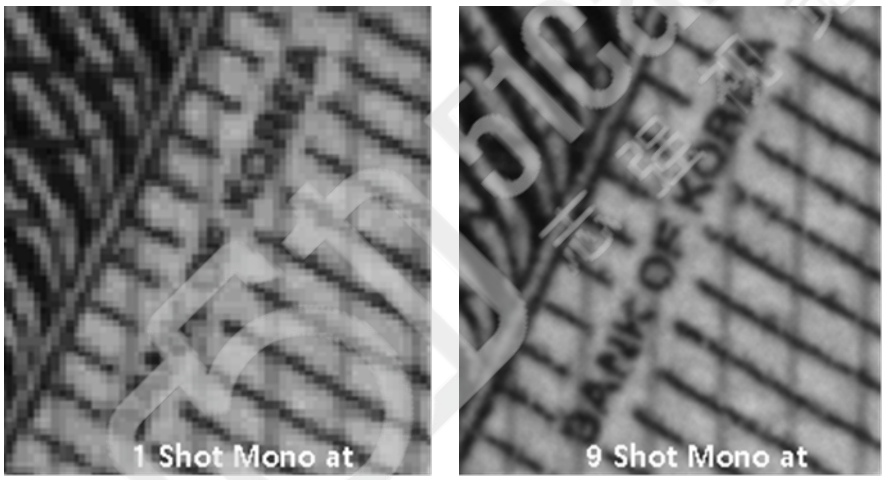


Figure 9-12 Standard (left) vs 9 Shot Pixel Shifting (right)

Another benefit of pixel shifting technology over a fixed image sensor is the ability to acquire a True Color image. If a camera uses Bayer Interpolation to produce a color image, unwanted artifacts, such as color moiré or false color pixels, may occur. Using pixel shifting, no color artifacts or aliasing will occur, and the color resolution is optimized.

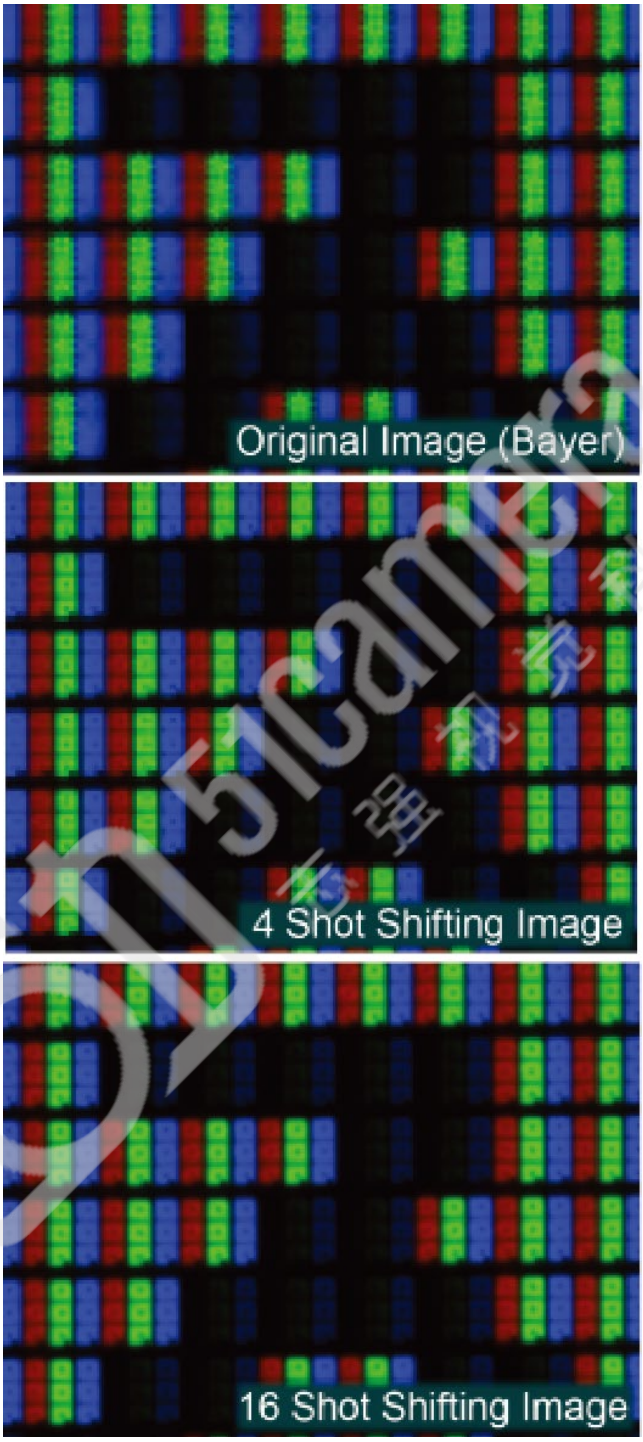


Figure 9-13 Standard Image Color vs Pixel Shifting Image Color

9.16.2 Sequence Mode

Pixel Shifting Sequence Mode

The available sequence modes of pixel shifting are as follows:

- Mono 4 Frame (Doubled vertical and horizontal resolution)
- Mono 9 Frame (Tripled vertical and horizontal resolution)
- Mono 2 Frame H (Doubled horizontal resolution)
- Mono 2 Frame V (Doubled vertical resolution)
- Bayer 4 Frame (Full color resolution, no increase in resolution)
- Bayer 16 Frame (Full color resolution, doubled vertical and horizontal resolution)

Operation of Sequence Mode

In the Sequence Mode, the position of the stage has been predefined and thus you can operate the sequence just by applying a trigger signal to the camera. The default position of the stage is (0, 0) and the following position will vary depending on the sequence mode. Once one cycle of operation has completed, the stage position returns to (0, 0). When the camera is running in the Free-Run mode, the sequence mode will be deactivated because the sequence mode is synchronized only with Software Trigger, External Trigger or CoaXPress Trigger. Refer to <Appendix C Position Settings according to Sequence Mode> for the position configurations according to the sequence modes.

The minimum trigger period can be obtained as shown in the following expression:

- When sum of exposure time and stage setup time is shorter than frame transfer time: (Frame Transfer Time > Exposure Time + Stage Setup Time)
  - Minimum Trigger Period = Frame Transfer Time
- When sum of exposure time and stage setup is longer than frame transfer time: (Frame Transfer Time < Exposure Time + Stage Setup Time)
  - Minimum Trigger Period = Exposure Time + Stage Setup Time

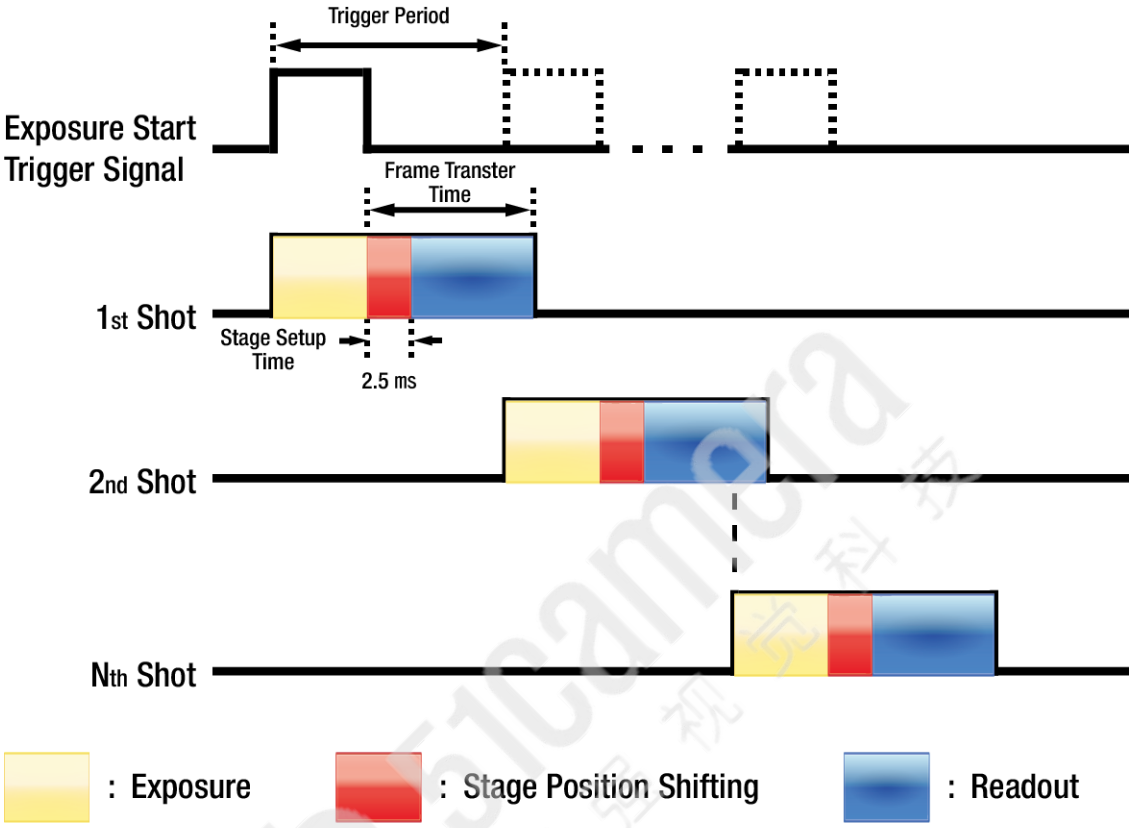


Figure 9-14 Sequence Mode Timing Diagram

The XML parameter related to Sequence Mode is as follows:

XML Parameters	Value	Description
DeviceControl StageMode	Off	Sequence Off
	Mono4Frame	4 shot Mono
	Mono9Frame	9 shot Mono
	Mono2FrameH	2 shot Mono in horizontal direction
	Mono2FrameV	2 shot Mono in vertical direction
	Bayer4Frame	4 shot Color (Color Camera Only)
	Bayer16Frame	16 shot Color (Color Camera Only)

Table 9-20 XML Parameter related to Sequence Mode

Multi Shot

When Multi Shot is enabled, the sequence operation that is followed by the first trigger input will be performed automatically by internal trigger. Internal trigger is generated by calculating the optimized timing reflecting trigger delay and stage setup time. Trigger input from the external ports will be ignored until completing the readout of the last image.

```
Multi Shot Enable: 1 trigger N snap
Sequence is performed in sequence with one trigger input.
```

```
Multi Shot Disable: 1 trigger 1 snap
Exposure synchronizes with trigger input and N times trigger input is
required to acquire N images.
```

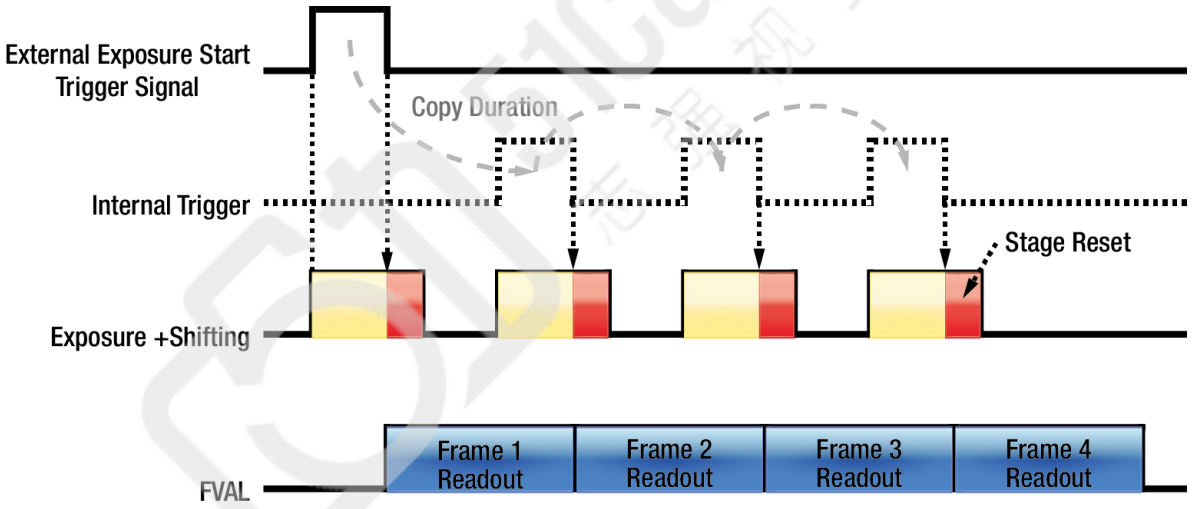


Figure 9-15 Timing Diagram when Multi Shot is enabled on Sequence 4 Shot Mode

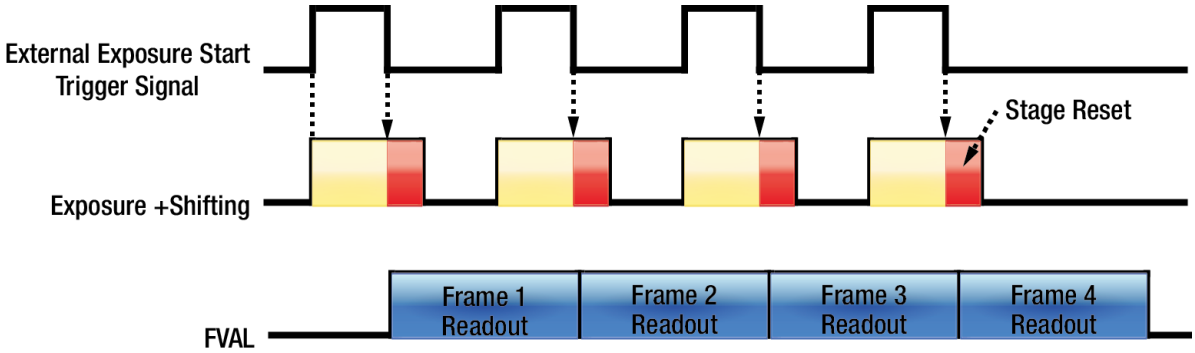


Figure 9-16 Timing Diagram when Multi Shot is disabled on Sequence 4 Shot Mode

The XML parameter related to Multi Shot is as follows:

XML Parameters	Value	Description
StageControl MultishotEnable	Off	Multi Shot feature Off
	On	Enables the Multi Shot feature.

Table 9-21 XML Parameter related to Multi Shot

Stage Reset

Stage Reset command resets the stage. Stage reset performs the following two features depending on the current status of the stage.

- Sequence Mode reset
  - When the **Stage Reset** command is executed while running the stage, the camera stops and resets the sequence, and then returns to the waiting for the trigger input status.
- Stage Position Sensor Calibration
  - Zero points can be changed according to temperature changes since the displacement sensor of the stage is sensitive to temperature. This feature adjusts zero point of the displacement sensor so that the sensor can be maintained within the operating range.

Caution!

Zero point drift (the displacement sensor strays from the stage's operating range) may occur due to changes to mechanical parts of the camera or to the temperature on the installation environment. In this case, executing the **Stage Reset** command will compensate zero point drift to operate the stage normally.

Calibration Auto

This feature is only available when the Sequence Mode is enabled. If the Calibration Auto feature is set to On, the displacement sensor of the stage will be reset (zero point adjustment) whenever one cycle of sequence is completed.

Stage Status

In the Sequence Mode, you can determine whether the stage normally operates or not by counting the number of images acquired. When you set the Sequence Mode to Mono4Frame, for example, the camera will acquire and transfer four images. However, if the camera unexpectedly stops the sequence, the camera cannot acquire and transfer four images in this

abnormal operation status. In this case, read the StageStatus parameter value in the StageControl category and then send it to local dealer or factory representative. Vieworks can diagnose the camera with the error code.

Caution!

An impact of 5G or more would distort the operation range of the stage or alignment of the sensor and cause permanent damage to the stage since it is mechanically sensitive to shocks. Please handle the camera with care.

The XML parameters related to Stage Reset and Stage Status are as follows:

XML Parameters		Value	Description
StageControl	StageReset	-	Resets the stage.
	CalibrationAuto	Off	Not to execute the Stage Reset after completing one cycle of sequence.
		On	Executes the Stage Reset automatically after completing one cycle of sequence.
	StageStatus	-	Returns an error code if the stage operates abnormally.

Table 9-22 XML Parameters related to Stage Reset and Stage Status

Stage Position

The Stage Position command allows you to move the stage in X and Y directions within the operating range of the stage. The XML parameters related to Stage Position are as follows:

XML Parameters		Value	Description
StageControl	StagePositionX	-	Moves the stage in X direction (0 to 12,000 ㎚).
	StagePositionY	-	Moves the stage in Y direction (0 to 12,000 ㎚).

Table 9-23 XML Parameters related to Stage Position

Stage Index Display

When the Stage Index Display feature is enabled in the Sequence Mode, you can output images with the specified grey level for the (0, 0) coordinates. Thus, you can verify the order of images acquired.

For example, if the Sequence Mode parameter is set to Mono4Frame, the grey level for the (0,

0) coordinate of the first image is '0', the grey level for the (0, 0) coordinate of the second image is '1', the grey level for the (0, 0) coordinate of the third image is '2', and the grey level for the (0, 0) coordinate of the fourth image is '3'.

The XML parameter related to Stage Index Display is as follows:

XML Parameters		Value	Description
StageControl	StageIndexDisplay	Off	Disables the Index Display when acquiring images in the Sequence Mode.
		On	Enables the Index Display when acquiring images in the Sequence Mode.

Table 9-24 XML Parameter related to Stage Index Display

9.17 Timestamp

VNP-576/864/1152MX2 cameras provide a Timestamp feature.

XML parameters related to Timestamp are as follows.

XML Parameters		Description
DeviceControl	Timestamp	Indicates the current Timestamp value of the connected device.
	TimestampIncrement	Indicates the increment of Timestamp.
	TimestampReset	Changes the current Timestamp value into 0 and restarts counting.
	TimestampResetValue	Designates time to reset Timestamp as 0, by the form in the numeric value.
	TimestampLatch	Latches the current value of Timestamp.
	TimestampLatchValue	Indicates prior value before resetting the Timestamp value.

Table 9-25 XML Parameters related to Timestamp

9.18 Event Control

VNP-576/864/1152MX2 cameras provide 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 VNP-576/864/1152MX2 cameras can generate and transmit events for the following type of situation:

- When the TestEventGenerate parameter is executed (Test)

XML parameters related to Event Control are as follows.

XML Parameters		Value	Description
EventControl	EventSelector	Test	Transfers the Test event generated from the execution of the TestEventGenerate parameter.
	Event Notification	On	Enables the selected event notification.
		Off	Disables the selected event notification.
TestControl	TestPendingAck	-	Sets time to wait before writing the device's pending acknowledge feature.
	TestEventGenerate	-	Generates a Test event.

Table 9-26 XML Parameters related to Event Control

9.19 Digital I/O Control

The Control I/O receptacle of the camera can be operated in various modes.

The XML parameters related to Digital I/O Control are as follows.

XML Parameters		Value	Description
DigitalIOControl	LineSelector	Line0	Set for items related to pin 1 of the camera's control 4-pin terminal.
		Line1	Set for items related to pin 4 of the camera's control 4-pin terminal.
	LineMode	Input	Sets the Line Mode of the selected input/output terminal (1) to Input.
		Output	Sets the Line Mode of the selected input/output terminal (4) to Output.
	LineInverter	FALSE	Line output signal not inverted.
		TRUE	Line output signal inverted.
	LineSource	Off	Disables the line output.
		ExposureActive	Outputs pulse signals indicating the current exposure time.
		FrameActive	Outputs pulse signals indicating a frame readout time.
		UserOutput0	Outputs pulse signals set by UserOutputValue.
		Timer0 Active	Outputs user-defined Timer signals as pulse signals.
	UserOutput Selector	UserOutput0	Outputs pulse signals set by UserOutputValue.
	UserOutput Value	FALSE	Sets the bit state of the line to Low.
		TRUE	Sets the bit state of the line to High.
	Debounce Time	0 ~ 1,000,000	Sets a Debounce Time in microseconds (Default: 0.5 μs).

Table 9-27 XML Parameters related to Digital I/O Control

When you set the **Line Source** to **UserOutput0**, you can use the user setting values as output signals.

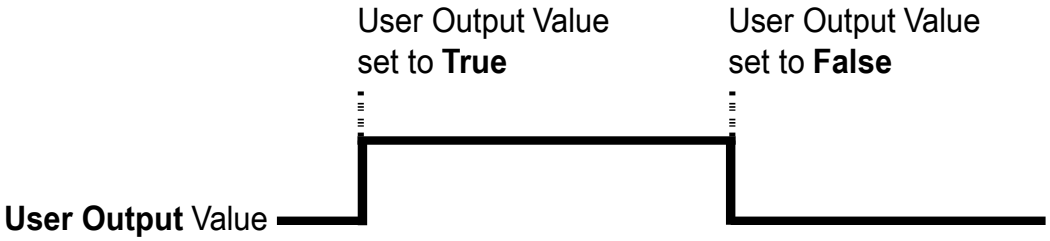


Figure 9-17 User Output

The camera can provide an Exposure Active 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 the figure below. 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 Exposure Active signal to know when exposure is taking place and thus know when to avoid moving the camera.

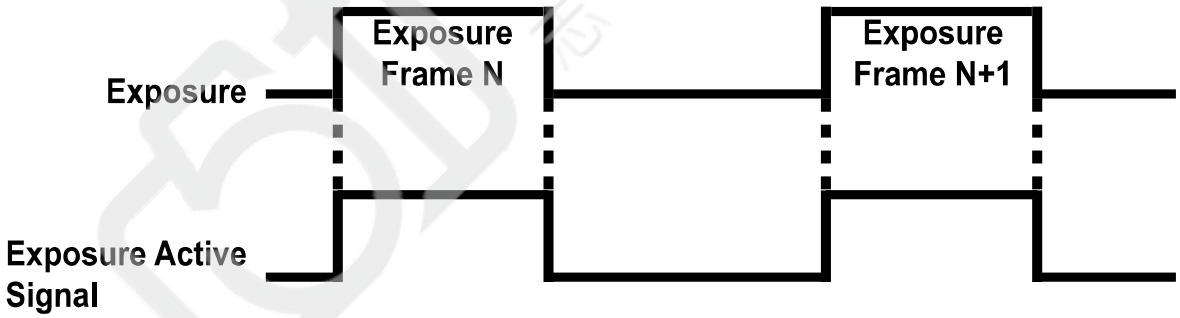


Figure 9-18 Exposure Active Signal

9.20 Debounce

The Debounce feature of the VNP-576/864/1152MX2 cameras allow to supply only valid signals to the camera by discriminating between valid and invalid input signals. The Debounce Time parameter specifies the minimum time that an input signal must remain High or Low to be considered as a valid input signal. When you use the Debounce feature, be aware that there is a delay between the point where the valid input signal arrives and the point where the signal becomes effective. The duration of the delay is determined by the Debounce Time parameter setting value.

When you set the Debounce Time parameter, High and Low signals shorter than the setting value are considered invalid and ignored as shown in the figure below.

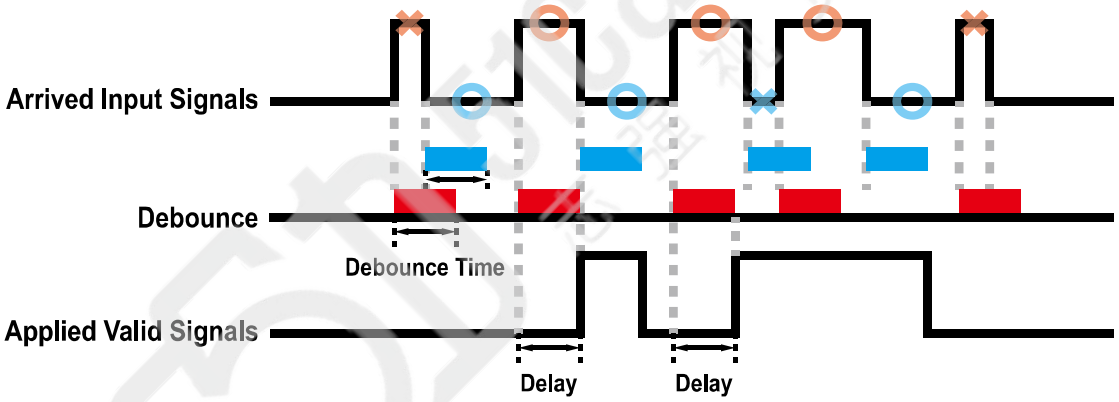


Figure 9-19 Debounce

The XML parameter related to Debounce Time is as follows.

XML Parameters		Value	Description
DigitalIOControl	Debounce Time	0 – 1,000,000 μs	Sets a Debounce Time in microseconds (Default: 0.5 μs).

Table 9-28 XML Parameter related to Debounce Time

9.21 Timer Control

When the **Line Source** parameter is set to **Timer0Active**, the camera can provide output signals by using the Timer. On the VNP-576/864/1152MX2 cameras, the Frame Active, Exposure Active event or external trigger signal is available as Timer source signal.

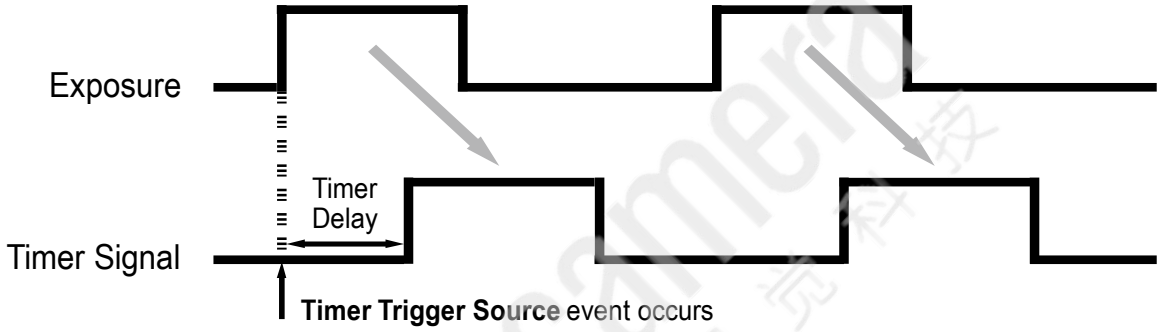
The XML parameters related to Timer are as follows.

XML Parameters		Value	Description
CounterAnd TimerControl	TimerSelector	Timer0	Select the timer to set
	TimerDuration	1 ~ 60,000,000 μs	Sets the duration of the Timer output signal to be used when Timer Trigger Activation is set to Rising/Falling Edge.
	TimerDelay	0 ~ 60,000,000 μs	Sets the delay time to be applied before starting the Timer.
	TimerReset	-	Resets the Timer and starts it again.
	TimerValue	-	Displays the current value of a selected Timer.
	TimerStatus	TimerIdle	Indicates that the Timer is in a standby state.
		TimerTriggerWait	Indicates that the timer is waiting for a trigger signal.
		TimerActive	Indicates that the timer is active.
	TimerTrigger Source	Off	Disables the Timer trigger.
		ExposureActive	Sets the Timer to use the current exposure time as the source signal.
		FrameActive	Sets the Timer to use a frame readout time as the source signal.
		Line0	Sets the Timer to use the external trigger signal as the source signal.
	TimerTrigger Activation	RisingEdge	Specifies that a rising edge of the selected trigger signal will act as the Timer trigger.
		FallingEdge	Specifies that a falling edge of the selected trigger signal will act as the Timer trigger.
		LevelHigh	Specifies that the Timer output signal will be valid as long as the selected trigger signal is High.
		LevelLow	Specifies that the Timer output signal will be valid as long as the selected trigger signal is Low.

Table 9-29 XML Parameters related to Timer Control

For example, when the **Timer Trigger Source** is set to **Exposure Active** and the **Timer Trigger Activation** is set to **Level High**, the Timer will act as follows.

1. When the source signals set by the **Timer Trigger Source** parameter are applied, the Timer will start operations.
2. The delay set by the **Timer Delay** parameter begins to expire.
3. When the delay expires, the Timer signal goes high as long as the source signal is high.



* **Timer Trigger Activation** is set to **Level High**.

Figure 9-20 Timer Signal

9.22 Cooling Control

A fan is installed on the rear panel of the camera and Thermoelectric Peltier is installed inside the camera to control the image sensor temperature. You can set the fan and Peltier to turn on or off. You can also set the Peltier to turn on when a specified internal temperature is reached.

Power:

24 VDC is recommended because the Pelitier Cooling performance may deteriorate if power is supplied below 14 VDC.

The XML parameters related to Cooling Control are as follows.

XML Parameters		Value	Description
CoolingControl	TargetTemperature	-10℃ ~ 80℃	Sets the temperature to operate the Thermoelectric Peltier when the Peltier Operation Mode parameter is set to On.
	FanOperationMode	Off	Turns off the fan.
		On	Turns on the fan.
	FanSpeed	-	Displays the current Fan RPM.
	PeltierOperationMode	Off	Turns off the Thermoelectric Peltier.
		On	Turns on the Thermoelectric Peltier when the internal temperature exceeds the value set in the Target Temperature parameter.

Table 9-30 XML Parameters related to Cooling Control

9.23 Temperature Monitor

The camera has an embedded sensor chip to monitor the internal temperature.

The XML parameters related to Device Temperature are as follows.

XML Parameters		Value	Description
DeviceControl	DeviceTemperature Selector	Sensor	Sets a temperature measuring spot to the image sensor.
		Mainboard	Sets a temperature measuring spot to the mainboard.
	DeviceTemperature	-	Displays device temperature in Celsius.

Table 9-31 XML Parameters related to Device Temperature

9.24 Status LED

An LED is installed on the rear panel of the camera to inform the operation status of the camera.

LED status and corresponding camera status are as follows:

Status LED	Description
Steady Red	The camera is not initialized.
Slow Flashing Red	A CXP Link is not configured.
Fast Flashing Orange	The camera is checking a CXP Link configuration.
Steady Green	A CXP Link is configured.
Fast Flashing Green	The camera is transmitting image data.

Table 9-32 Status LED

9.25 Test Pattern

To check whether the camera operates normally or not, it can be set to output test patterns generated in the camera, instead of image data from the image sensor. Four types of test patterns are available: images with different values in horizontal direction (Grey Horizontal Ramp), images with different values in diagonal direction (Grey Diagonal Ramp), moving images with different values in diagonal direction (Grey Diagonal Ramp Moving) and images with different values in horizontal direction output from the image sensor (Sensor Specific).

The XML parameter related to Test Pattern is as follows.

XML Parameter		Value	Description
ImageFormat Control	TestPattern	Off	Disables the Test Pattern feature.
		GreyHorizontalRamp	Sets to Grey Horizontal Ramp.
		GreyDiagonalRamp	Sets to Grey Diagonal Ramp.
		GreyDiagonalRampMoving	Sets to Grey Diagonal Ramp Moving.
		SensorSpecific	Sets to the Test Pattern generated by the image sensor.

Table 9-33 XML Parameter related to Test Pattern

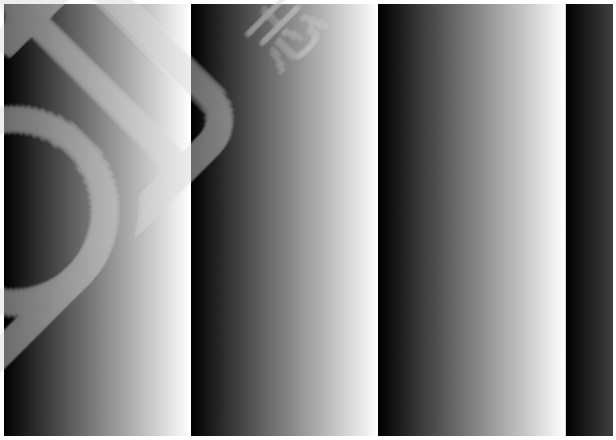


Figure 9-21 Grey Horizontal Ramp

Figure 9-22 Grey Diagonal Ramp

Figure 9-23 Grey Diagonal Ramp Moving

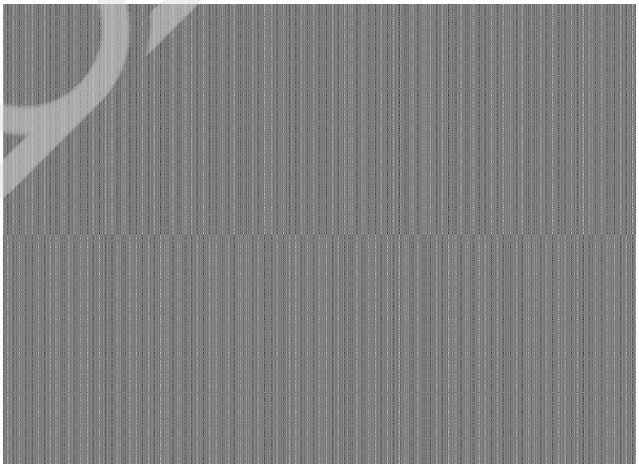


Figure 9-24 Sensor Specific

Caution!

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

9.26 Reverse X

The Reverse X feature lets you flip images horizontally. This feature is available in almost all of the operation modes of the camera, except for the **Test Image** mode.

XML Parameter		Value	Description
ImageFormatControl	ReverseX	FALSE	Disables the Reverse X feature.
		TRUE	Flips images horizontally.

Table 9-34 XML Parameter related to Reverse X

Figure 9-25 Original Image

Figure 9-26 Reverse X Image

9.27 Device Link Throughput Limit

The **Device Link Throughput Limit** feature allows you to limit the maximum available bandwidth for data transmission to your computer.

The XML parameter related to Device Link Throughput Limit is as follows.

XML Parameters		Description
DeviceControl	DeviceLinkThroughputLimit	Limits the maximum available bandwidth (Bps).

Table 9-35 XML Parameter related to Device Link Throughput Limit

Caution!

To ensure good image quality, we recommend that you set the Device Link Throughput Limit parameter to the maximum value. Otherwise, the image quality can decrease. In case of the VNP-576/864/1152MX2, the maximum value is 8000.

9.28 Device User ID

You can input user-defined information up to 16 bytes.

The XML parameter related to Device User ID is as follows.

XML Parameter		Description
DeviceControl	DeviceUserID	Input user-defined information (16 bytes).

Table 9-36 XML Parameter related to Device User ID

9.29 Device Reset

Resets the camera physically to power off and on.

The XML parameter related to Device Reset is as follows.

XML Parameter		Description
DeviceControl	Device Reset	Resets the camera physically.

Table 9-37 XML Parameter related to Device Reset

9.30 Field Upgrade

The camera provides a feature to upgrade the Firmware and FPGA logic through the Camera Link interface without disassembling the camera in the field. Refer to **Appendix A** for more details

about how to upgrade.

9.31 User Set Control

You can save or reload camera settings to the flash area inside the camera. It supports a total of two save areas and three load areas.

The XML parameters related to User Set Control are as follows.

XML Parameters		Value	Description
UserSetControl	UserSetSelector	Default	Selects the Factory Default settings.
		UserSet1	Selects the UserSet1 settings.
		UserSet2	Selects the UserSet2 settings.
	UserSetLoad	-	Loads the User Set specified by User Set Selector to the camera.
	UserSetSave	-	Saves the current settings to the User Set specified by User Set Selector. The Default is a Factory Default Settings and allowed to load only.
	UserSetDefault	Default	Applies the Factory Default settings when reset.
		UserSet1	Applies the UserSet1 when reset.
		UserSet2	Applies the UserSet2 when reset.

Table 9-38 XML Parameters related to User Set Control

The camera settings stored in the Default can be loaded into the camera's workspace but cannot be changed. The settings set in the workspace will be lost if the camera is reset or powered off. To use the current setting values in the workspace after a reset, you must save the settings to one of the user spaces.

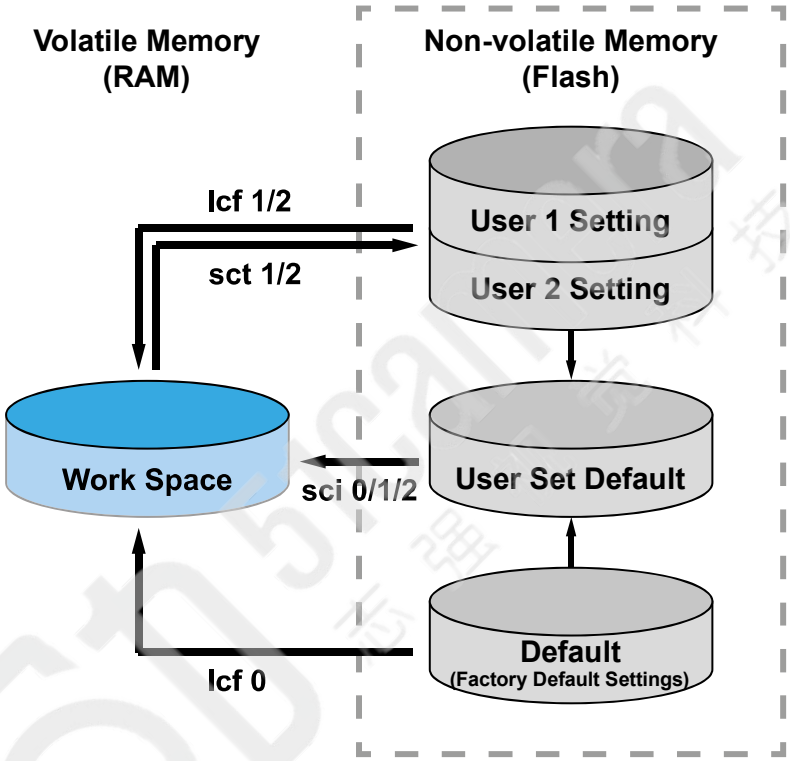


Figure 9-27 User Set Control

9.32 Sequencer Control

The Sequencer Control provided by the VNP-576/864/1152MX2 cameras allow you to apply different sets of parameter settings, called 'Sequencer Set', to a sequence of image acquisitions. As the camera acquires images, it applies one Sequencer Set after the other. This allows the camera to respond quickly to changing imaging requirements. For example, changes in illumination conditions influence the imaging requirements.

With the User Set Control feature, you can save user defined Sequencer Sets in the camera's non-volatile memory. Then after the camera is powered on or reset, the Sequencer Sets are available according to the **User Set Default** parameter. Each Sequencer Set is identified by an index number ranging from 0 to 31. Accordingly, you can define up to 32 different Sequencer Sets. On the VNP-576/864/1152MX2 cameras, only the Flat Field correction data can be configured for Sequencer Sets.

The XML parameters related to Sequencer Sets are as follows.

XML Parameters		Value	Description
Sequencer Control	SequencerMode	Off	Disables the Sequencer.
		On	Enables the Sequencer.
	Sequencer ConfigurationMode	Off	Disables the Sequencer Configuration Mode.
		On	Enables the Sequencer Configuration Mode.
	Sequencer FeatureSelector	FlatFieldData Selector	Selects a feature to be applied to Sequencer Sets.
	Sequencer FeatureEnable	False	Disables the selected feature for the application of Sequencer Sets.
		True	Enables the selected feature for the application of Sequencer Sets.
	Sequencer SetSelector	0 – 7	Selects an index number of a Sequencer Set to be configured.
	SequencerSetActive	-	Displays the index number (0 – 31) of the Sequencer Set that is currently active.
	SequencerSetCount	1 – 8	Sets the number of Sequencer Sets to be applied.
	SequencerReset	-	Returns to Sequencer Set 0.

Table 9-39 XML Parameters related to Sequencer Control

Caution!

To apply Sequencer Sets, you must set the Trigger Mode parameter to On.

Use Case –4 sets of Flat Field Correction Data as Sequencer Set

For example, four Flat Field calibration data optimized for white, green, red, and blue pixels could be applied with different Sequencer Sets to inspect an LCD panel, as follows.

1. Set the **Sequencer Mode** parameter to **Off**.
2. Set the Sequencer Configuration Mode parameter to On.
3. Set the Sequencer Set Selector parameter to 0, and the Flat Field Data Selector parameter to 0. Then, select the Sequencer Set Selector parameter to 1, 2, or 3, and set the Flat Field Data Selector parameters to 1, 2, or 3, respectively.
4. Set the **Sequencer Set Count** parameter to **4**.
5. Set the **Sequencer Configuration Mode** parameter to **Off**, and then set the **Sequencer Mode** parameter to **On**.

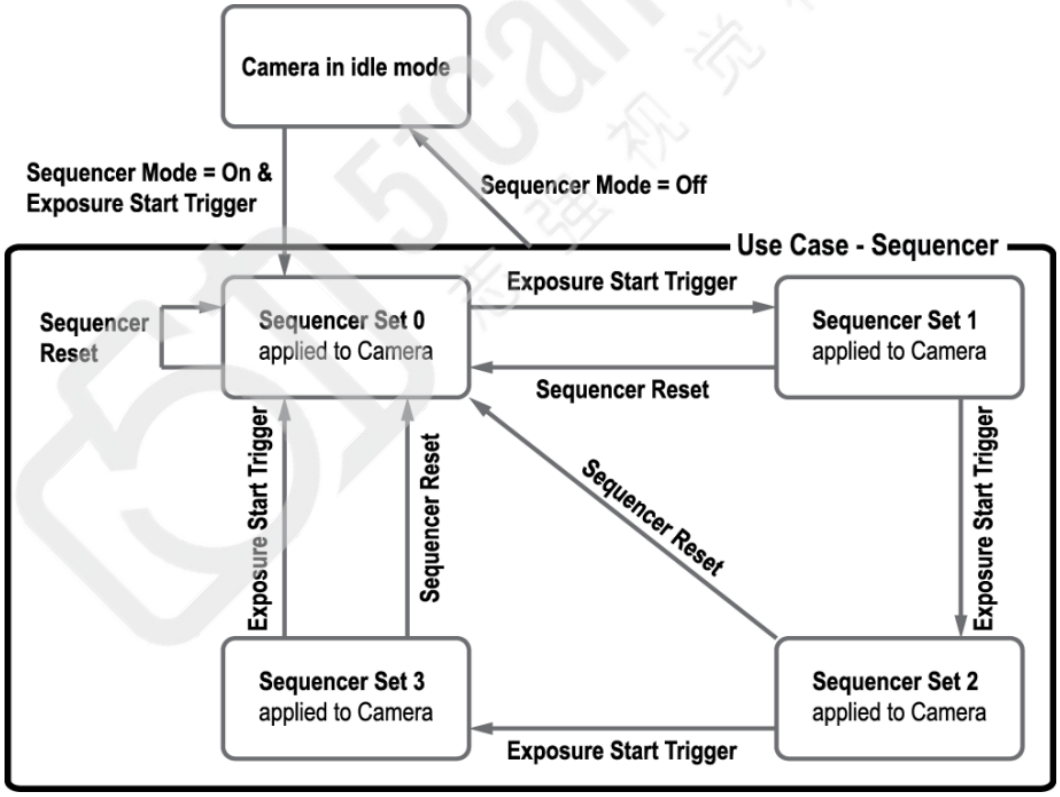


Figure 9-28 Sequencer Diagram (Use Case)

Note:

- You can save the user defined Sequencer Sets in the camera's non-volatile memory by using the User Set Control feature. For more information, refer to 9.28 User Set Control.
- Executing the Sequencer Reset parameter allows to return to the Sequencer Set 0 status at any time while cycling through the Sequencer.

9.33 Stitch Control

Using the Stitch Control provided by the VNP-576/864/1152MX2 cameras, it is available to correct any offsets occur in the edges at the joints of the sensors.

VNP-576MX2 has four tabs, VNP-864MX2 has six tabs, and VNP-1152MX2 has eight tabs.

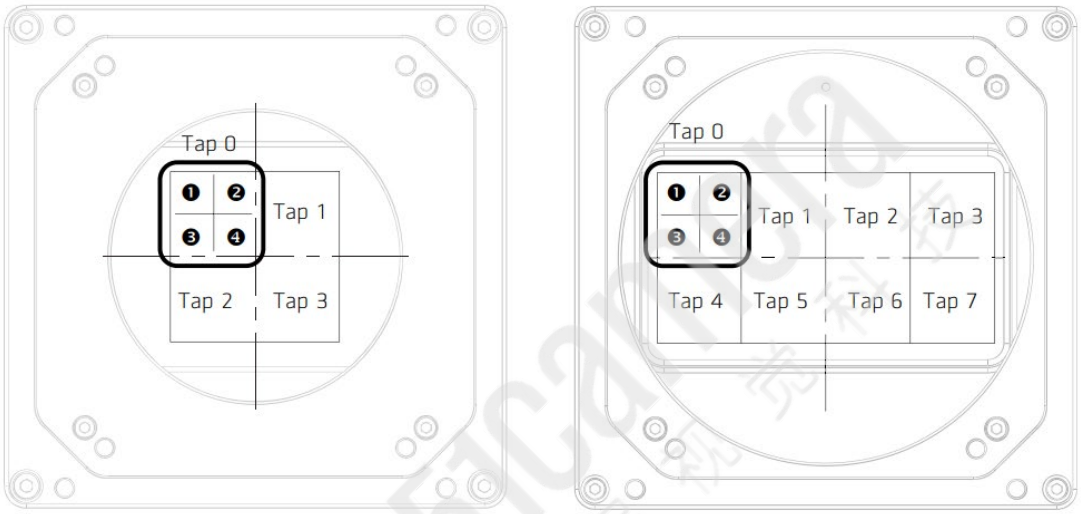


Figure 9-29 Structure of Sensors (VNP-576MX2 (left), VNP-1152MX2 (right))

The XML parameters related to Stitch Control are as follows.

XML Parameters	Value	Description
StitchGainCtrl	Off	Disables the gain-related setting function for stitches
	On	Activates the gain-related setting function for stitches
StitchOffsetCtrl	Off	Disables the offset-related setting function for stitches
	On	Activates the offset-related setting function for stitches
StitchDataSelector	-	Selects the stitch data
StitchTap	Tap0 ~Tap3	[VNP-576MX2] Selects which part of the stitch to use or set
	Tap0 ~Tap5	[VNP-864MX2] Selects which part of the stitch to use or set
	Tap0 ~Tap7	[VMP-1152MX2] Selects which part of the stitch to use or set
StitchIndex	TopLeft	Selects the upper left corner of the selected stitch tab (❶)
	TopRight	Selects the upper right corner of the selected stitch tab (❷)
	BottomLeft	Selects the lower left part of the selected stitch tab (❸)
	BottomRight	Selects the lower right part of the selected stitch tab (❹)
StitchGain	0.5 ~ 1.5	Sets the gain value of the selected stitch
StitchOffset	-128 ~ 127	Sets the offset value for the selected stitch
StitchDataSave	Execute	Saves current stitch-related settings
StitchDataLoad	Execute	Recalls the settings of the current stitch-related

Table 9-40 XML Parameters in Sequencer Control

Chapter 10. Troubleshooting

When you have a problem with a Vieworks camera, please check the followings:

- If no image is displayed on your computer,
  - Ensure that all cable connections are secure.
  - Ensure that the power supply is properly connected.
  - Ensure that trigger signals are applied correctly when you operate the camera with trigger signals.
- If images are not clear,
  - Ensure the camera lens or glass is clean.
  - Check the lens aperture is adjusted properly.
- If images are dark,
  - Ensure the camera lens is not blocked.
  - Check the exposure time is set properly.
- If you identify abnormal operation or overheating sign,
  - Ensure the power supply is properly connected.
  - Stop using the camera when you notice smoke or abnormal overheating.
- If you have a problem using the Trigger Mode,
  - Ensure that the Software trigger related parameters are configured correctly.
  - Ensure that the trigger related parameters on your CXP-12 Frame Grabber are configured correctly when you set the Trigger Source parameter to LinkTrigger0.
  - Ensure that cable connections are secure when you set the Trigger Source parameter to Line 0.
- If there is communication failure between the camera and computer,
  - Ensure coax cables are connected properly.
  - Ensure that you have configured a CXP-12 Frame Grabber in your computer correctly and the camera is connected properly to the CXP-12 Frame Grabber.

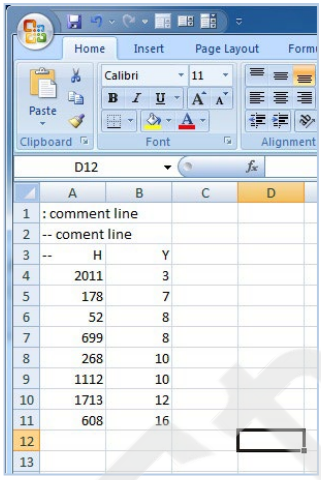
Appendix A. Defective Pixel Map Download

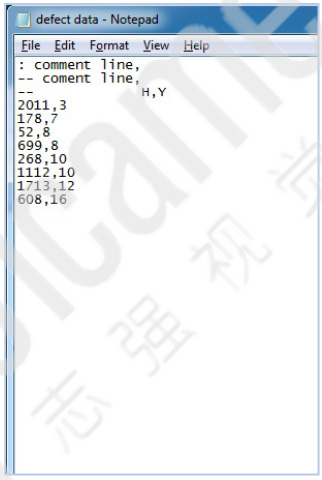
1. Create the Defective Pixel Map data in Microsoft Excel format as shown in the left picture below and save as a CSV file (*.csv). The picture in the right shows the created Excel file opened in Notepad. The following rules need to be applied when creating the file.

   • Lines beginning with ':' or '—' are treated as notes.

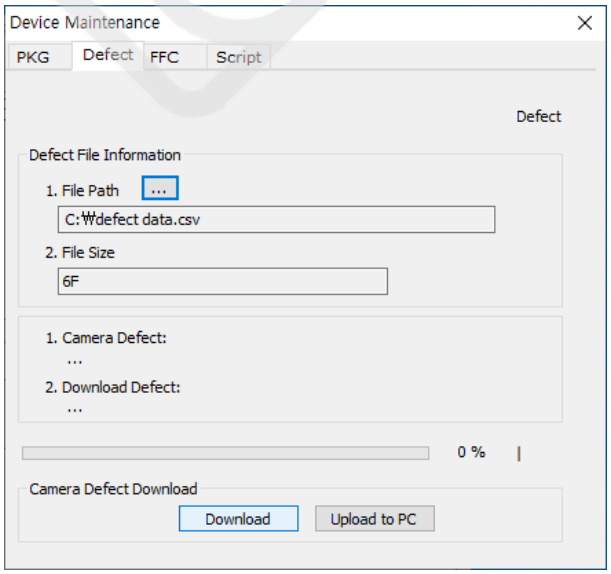
   • You must enter the horizontal value first and then the vertical value for coordinates of each defect pixel.

   • Coordinate values for each pixel can be placed in any order.





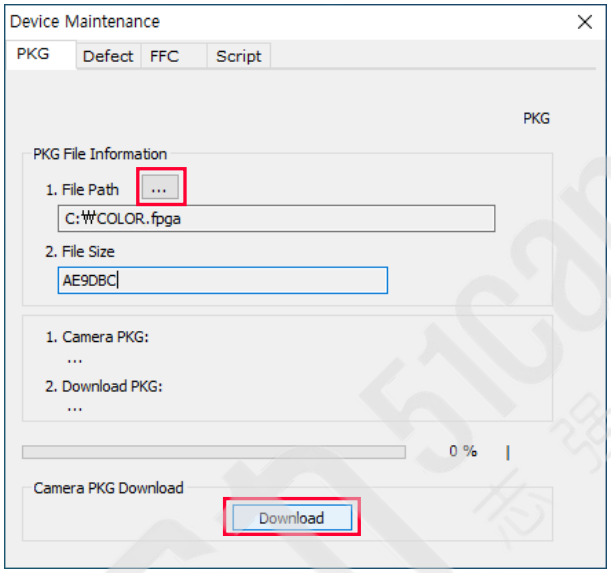
2. Run Vieworks Imaging Solution 7.X and click the Configure button to display the window as shown below. Select the **Defect** tab, click the **File Path** item, search and select the defective pixel map (*.csv), and then click the Download button.



Appendix B. Field Upgrade

You can upgrade the MCU, FPGA and XML file of the camera by following the procedure below.

1. Run Vieworks Imaging Solution 7.X and click the Configure button to display the window as shown below.
2. Select the **PKG** tab, click the button next to **File Path**, search and select the MCU, FPGA or XML upgrade file, and then click the Download button.



3. The camera begins downloading the upgrade file and the downloading status is displayed at the bottom of the window.

Appendix C. Position Settings according to Sequence Mode

Ratio for 1-pixel

Order	Mono4Frame		Mono9Frame		Mono2FrameH		Mono2FrameV		Bayer4Frame		Bayer16Frame	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
1	0	0	0	0	0	0	0	0	0	0	0	0
2	1/2	0	1/3	0	1/2	0	0	1/2	1	0	1	0
3	0	1/2	2/3	0	-	-	-	-	0	1	0	1
4	1/2	1/2	0	1/3	-	-	-	-	1	1	1	1
5	-	-	1/3	1/3	-	-	-	-	-	-	1/2	0
6	-	-	2/3	1/3	-	-	-	-	-	-	3/2	0
7	-	-	0	2/3	-	-	-	-	-	-	1/2	1
8	-	-	1/3	2/3	-	-	-	-	-	-	3/2	1
9	-	-	2/3	2/3	-	-	-	-	-	-	0	1/2
10	-	-	-	-	-	-	-	-	-	-	1	1/2
11	-	-	-	-	-	-	-	-	-	-	0	3/2
12	-	-	-	-	-	-	-	-	-	-	1	3/2
13	-	-	-	-	-	-	-	-	-	-	1/2	1/2
14	-	-	-	-	-	-	-	-	-	-	3/2	1/2
15	-	-	-	-	-	-	-	-	-	-	1/2	3/2
16	-	-	-	-	-	-	-	-	-	-	3/2	3/2

Appendix D. Glossary

Term	Description
Binning	The process of combining the signal values of two or more neighboring pixels to create a single "virtual" pixel with a higher signal level.
CMOS (Complementary Metal-Oxide Semiconductor)	Used in scanners and digital cameras based on semiconductor processes, or for the purpose of designing image sensors.
CXP (CoaXPress)	Asymmetric high-speed serial communication standard using coaxial cable.
Color Image	RBG (Red, Green, Blue = 3-Band) imaging, the three primary colors of light.
DSNU (Dark Signal Non-Uniformity)	Differences in individual pixel behavior that can be seen or measured even in the absence of light.
Dynamic Range	The maximum-to-minimum ratio of measurable light, with higher values indicating a wider range of expression (unit: dB (decibels))
FPN (Fixed Pattern Noise)	FPN has a fixed noise value and can be used to reduce level deviations between pixels, resulting in a cleaner image. Correcting FPN in the absence of light is called DSNU, and correcting FPN in the presence of light is called PRNU.
Frame Grabber	A device that converts an analog video signal from an image medium, such as a camera, into a signal that can be processed by a personal computer (PC) by digitizing it with a defined number of bits per sample (digital image signal).
Gain	The degree of brightness of light in a camera. Adjusting the strength of the signal to control the brightness of the shadows in an image.
GenICam	A universal configuration interface that supports a wide range of standard interfaces such as GigE Vision, Camera Link, and IEEE 1394-IIDC, regardless of camera type and image format. It allows users to easily identify the type of camera, the features and functions supported by a particular camera, and the range of parameters associated with each function. The main point of the GenICam standard is a Descriptor File (in XML format) on board the camera that maps the camera's internal registers to a standardized list of features.
Global Shutter	A global shutter reads all the pixels of the entire image sensor at once, simultaneously. Global shutter sensors are effective for imaging fast-moving objects and can capture distortion-free images.
Interface	A standardized protocol (means of data transfer) for connecting the

	camera to the Frame Grabber. Ex) Camera Link, Giga-E, USB 2.0 / 3.0, etc. (The transmission specification is determined by the interface)
Lens Mount	The part of the camera that holds the lens. (Classified as C-mount, F-mount, etc. depending on the mounting method)
Line Rate	The number of lines transmitted per second.
Line Scan Camera	A camera that uses a sensor consisting of a single row of photodetectors, collecting images line by line. Unlike Area Scan cameras, the sensor is organized in straight lines.
LUT (Lookup Table)	A user-programmable method of modifying the relationship between the value recorded by each pixel and the value output to the image for viewing or processing. In case of LUT, the user can define and use custom mappings between input values and output values. In this case, the mapping is done by selecting "index" and assigning "value".
Mono Image	Black and white or monochrome image. Based on 8-bit data, the closer to 0, the darker, and the closer to 255, the lighter.
Resolution	Number of horizontal x vertical pixels Ex) Black and white image (capacity calculation) : 640 * 480 * 8(bit) = 2,457,600 bit = 307,200 byte
Offset	Adjusting the intensity of the signal to adjust the darker parts of the image (luminance).
Parameter	An intrinsic variable used to describe or organize a particular function or model.
PCB Inspection	Automated imaging of PCB (printed circuit board) or electronics subsystem to determine proper component placement, identify defects, and assess overall quality.
Pixel	The smallest unit that makes up imaging data Ex) Pixel value = 8 Bit = 2^8 = 256 level
Pixel Size	The actual size of each pixel in a camera sensor. (Unit: ㎛ (micrometer))
PRNU (Photo Response Non-Uniformity)	The pixel-by-pixel variation in the response of an image sensor to the same amount of light falling on all pixels.
Q.E (Quantum Efficiency)	Quantum efficiency (Q.E.) is a quantity defined in photosensitive devices, such as photographic film or charge-coupled devices (CCDs), that refers to the percentage of photons that strike a photoreactive surface and create electron-hole pairs. It is a key factor in measuring the electrical sensitivity of a device to light.
Sensitivity	A term that refers to how easily a camera responds to small amounts of light, whether visible or invisible wavelengths. There are many factors that affect sensitivity, including the size of the pixel, its ability to collect light, its ability to convert light into electrical signals, and the

	amount of "noise" it produces in the process.
Shutter	For digital sensors, an electronic shutter transfers the digital charge collected by the pixels at the end of a specified exposure time to a shaded buffer area (transfer register), called a "global shutter" if all pixels are transferred simultaneously. ('rolling shutter' if pixels are transferred sequentially)
TDI (Time Delay and Integration)	A method of taking multiple shots of an area and superimposing the image data into a single image.
Vieworks Imaging Solution (VIS)	Indicates the control application provided with the product together by Vieworks
White Balance	Refers to the process of making pixels with multiple color filters respond to a light source with the correct color ratio.

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