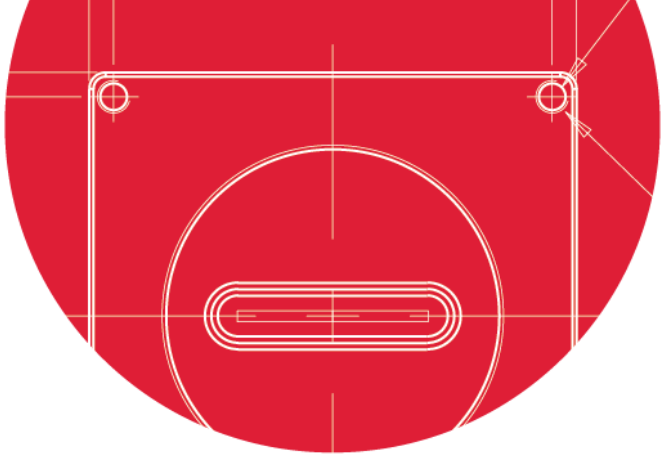
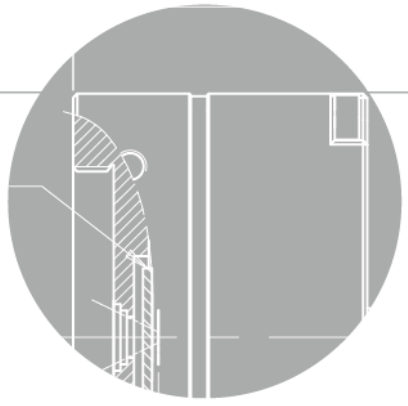


VTC 2k Color

User Manual

English

VTC-2K10.5C-C100A-80



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Revision History

Version	Date	Description
1.0	2018-09-05	Initial Release
1.1	2021-01-21	• Revised the Quantum Efficiency graph • Revised the model name • Revised camera mechanical dimensions
1.2	2021-05-12	Corrected the orientation of the 4-pin connector in the user manual
	2021-09-24	Deleted the “Exposure Control” text in the “Main Features”

Contents

1 Precautions

General

- Do not drop, disassemble, repair or alter the device. Doing so may damage the camera electronics and cause an electric shock.
- Do not let children touch the device without supervision.
- Stop using the device and contact the nearest dealer or manufacturer for technical assistance if liquid such as water, drinks or chemicals gets into the device.
- Do not touch the device with wet hands. Doing so may cause an electric shock.
- 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 temperatures.

Installation and Maintenance

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

Power Supply

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

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, 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 off.

1. Remove a contaminant 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 in order 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.

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

2 Warranty

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

3 Compliance & Certifications

3.1 FCC Compliance

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

3.2 CE: DoC

EMC Directive 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.

4 Package Components

Package Components

VTC-2K10.5C-C100A-80 Camera with M42 mount

5 Product Specifications

5.1 Overview

The VTC-2K10.5C camera, a hybrid Time Delayed Integration (TDI) color line scan camera, provides faster line rates and higher sensitivity than existing line scan cameras. With hybrid TDI line scan technology combining the strengths of both CCD and CMOS image sensors, the M42 mount based VTC-2K10.5C-C100A-80 camera can acquire True Color images at faster line rates of up to 100 ㎑ with up to 80× higher sensitivity.
Featured with high speed and high sensitivity, the VTC-2K10.5C camera is ideal for demanding applications such as flat panel display inspection, wafer inspection, printed circuit board inspection, and high performance document scanning.

Main Features

- Hybrid TDI Color Line Scan
- True Color Imaging
- 2160 × 80 Pixel Resolution
- Bidirectional Operations with up to 80 TDI Stages
- Anti-blooming
- Trigger Rescaler and Strobe Output Control
- Camera Link Full Interface up to 100 ㎑
- Advanced PRNU and DSNU Correction
- Area Scan Mode for Camera Alignment

Applications

- Flat Panel Display Inspection
- Printed Circuit Board Inspection
- Wafer Inspection
- High Performance Document Scanning

5.2 Specifications

Technical specifications for the VTC-2K10.5C camera are as follows:

Specification		VTC-2K10.5C-C100A-80
Active Image(H × V)		2160 × 80
Sensor Type		Hybrid TDI Color Line Scan
Pixel Size		10.5 ㎛ × 10.5 ㎛
Interface		Camera Link (Base/Medium/Full)
Pixel Data Format		8 bit (2/3/4/8/10 Tap) /10 bit (2/4 Tap) / 12 bit (2/4 Tap)
TDI Stage		20 / 40 / 60 / 80
TDI Direction		External Control Port or Programmable
Trigger Synchronization		Free-Run, External Trigger Signal, Camera Link CC1 Programmable Line Rate
Max. Line Rate		100 ㎑
Min. Line Rate		1 ㎑
Camera Link Pixel Clock		40 / 60 / 80 / 85 ㎒
Video Output		2, 3, 4, 8 or 10 Tap
Throughput		0.22 Gpix/s
Gamma Correction		User Defined LUT (Look Up Table)
Black Level		-255 ~ 255 at 8 bits
Gain Control		Analog Gain: 1×, 2×, 3×, 4× / Digital Gain: 1.0× ~ 8.0×
External Trigger		External, 3.3 V – 5.0 V
Power	External	10 ~ 30 V DC
	Dissipation	Typ. 5.0 W
Environmental		Ambient Operating: 0℃ ~ 50℃ (Housing: 10℃ ~ 50℃), Storage: -40℃ ~ 70℃
Mechanical / Weight		60 ㎜ × 60 ㎜ × 36 ㎜, 223 g
Configuration Software		Configurator
Optical Interface		
Lens Mount		M42 × 1 ㎜
Sensor to Camera Front		10.10 ㎜ (Optical Distance)
Sensor Alignment		
Flatness x y z		±25 ㎛ ±0.15 ㎜ ±0.15 ㎜ ±0.1 ㎜

Table 5.1 Specifications of the VTC-2K10.5C camera

5.3 Camera Block Diagram

The VTC-2K10.5C camera consists of three printed circuit boards (PCB), and its block diagram is shown below.

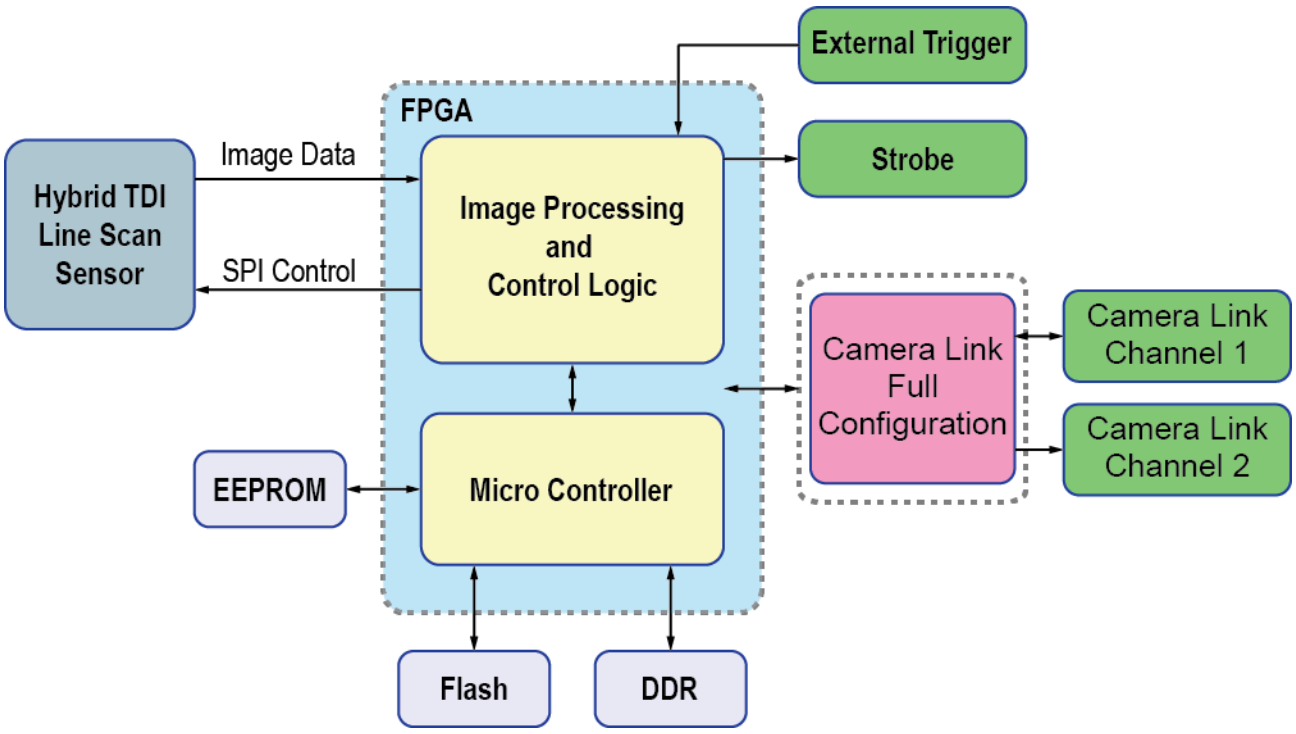


Figure 5.1 VTC-2K10.5C-C100A-80 Camera Block Diagram

5.4 Spectral Response

The following graphs show the spectral response for the VTC-2K10.5C camera.

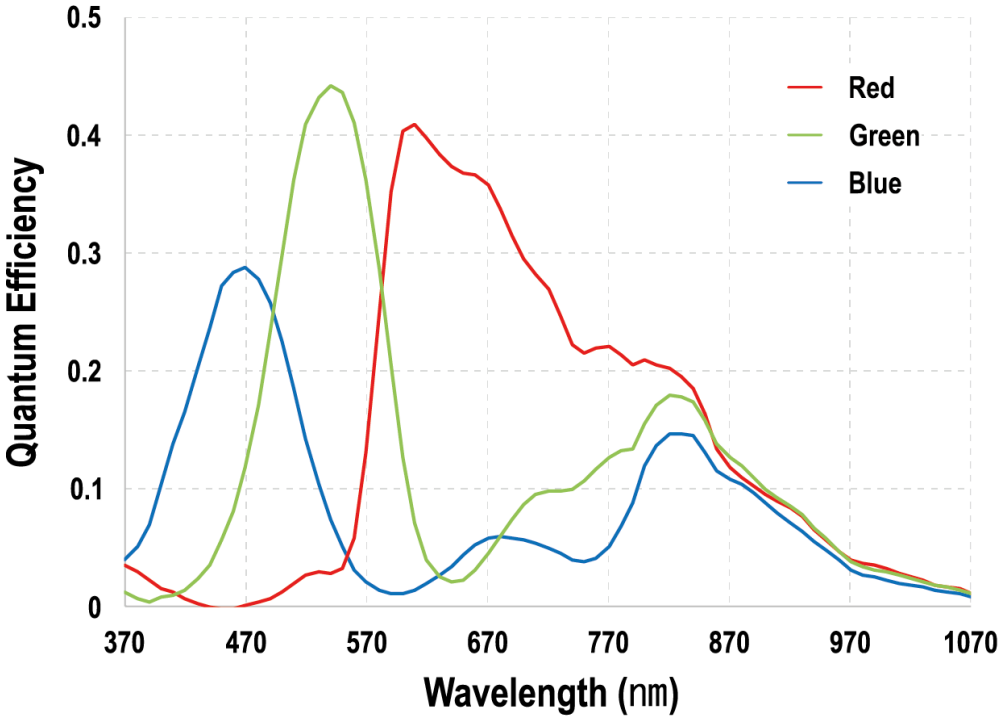


Figure 5.2 Quantum Efficiency

5.5 Mechanical Specification

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

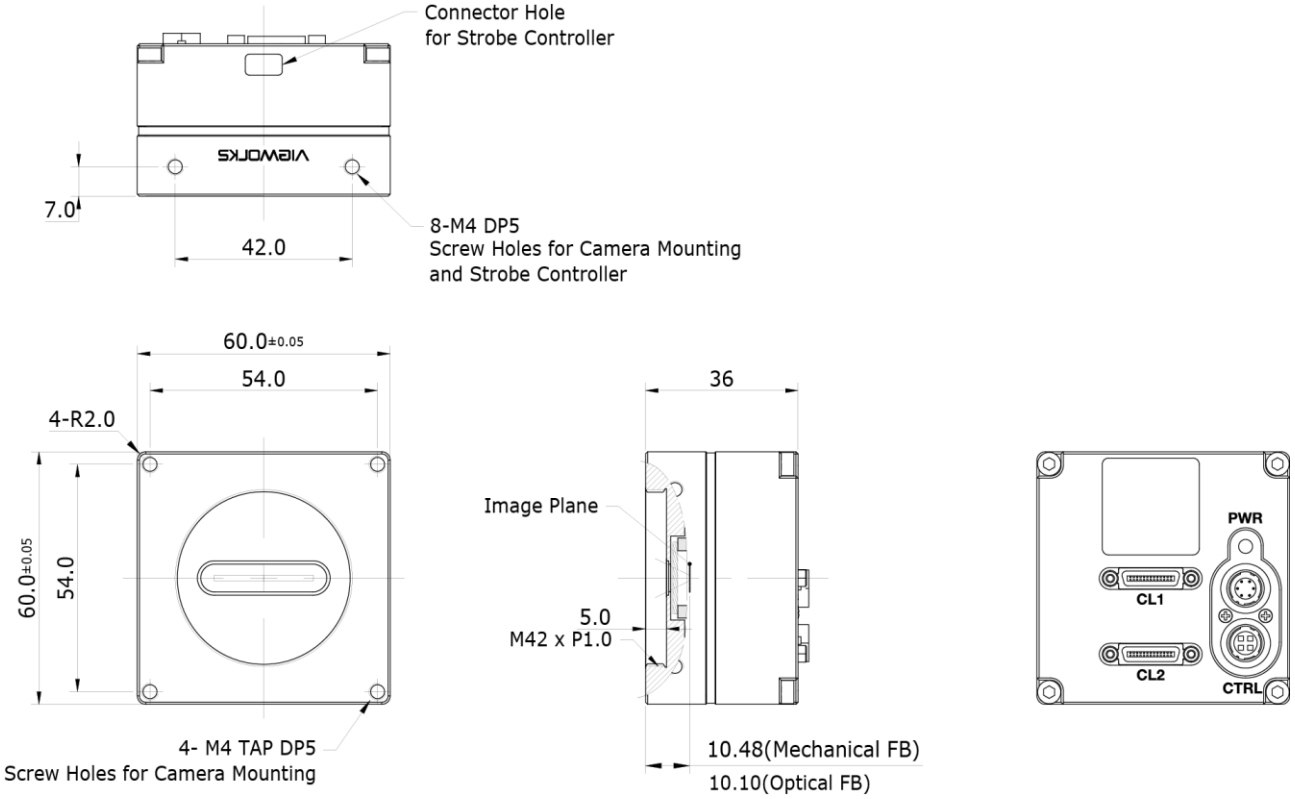


Figure 5.3 VTC-2K10.5C Mechanical Dimension

5.5.1 Camera Mounting and Heat Dissipation

You must mount the camera on a heat dissipation structure to maintain the temperature of the camera housing at 50℃ or less. Given the low power consumption of the VTC camera, its housing temperature during operation will generally stay within the specified limits. However, overheating can occur if heat dissipation is restricted or if the camera is mounted on a severe environment. We strongly recommend that you follow the general guidelines below when you mount the camera.

- In all cases, you should monitor the temperature of the camera housing and make sure that the temperature does not exceed 50℃. You can monitor the internal temperature of the camera by using the **Device Temperature** parameter.
- If your camera is mounted on a metal component in your system, this may provide sufficient heat dissipation.

6 Connecting the Camera

The following instructions assume that you have installed a Camera Link frame grabber in your computer including related software. For more information, refer to your Camera Link frame grabber user manual.
To connect the camera to your computer, 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 Camera Link cable into the Camera Link1 connector on the camera and the other end of the Camera Link cable into the Base connector on the Camera Link frame grabber.
3. Plug one end of a Camera Link cable into the Camera Link2 connector on the camera and the other end of the Camera Link cable into the Medium/Full connector on the Camera Link frame grabber.
4. Connect the plug of the power adapter to the power input receptacle on the camera.
5. Plug the power adapter into a working electrical outlet.
6. Verify all the cable connections are secure.

Precautions for using Camera Link Medium/Full Configuration

	The VTC-2K10.5C camera supports Camera Link Base, Medium and Full configurations. To operate the camera in the medium or full Camera Link configuration, you must connect the camera to the Camera Link frame grabber using two Camera Link cables. Make sure that you connect both Camera Link1 (Base) and Camera Link2 (Medium/Full) connectors on the camera to their respective connectors on the Camera Link frame grabber.

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 Controlling the Camera

- You can control the camera by using Configurator.
- You can download the latest Configurator at http://www.vieworks.com.
- Please refer to your Camera Link frame grabber user manual.

7 Camera Interface

7.1 General Description

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

- ① 26 pin SDR Connector 1 (Camera Link Base): transmits video data and controls the camera.
- ② 26 pin SDR Connector 2 (Camera Link Medium/Full): transmits video data.
- ③ Status LED: displays power status and operation mode.
- ④ 6 pin Power Input Receptacle: supplies power to the camera.
- ⑤ 4 pin Control I/O Receptacle: provides access to the camera's I/O lines.

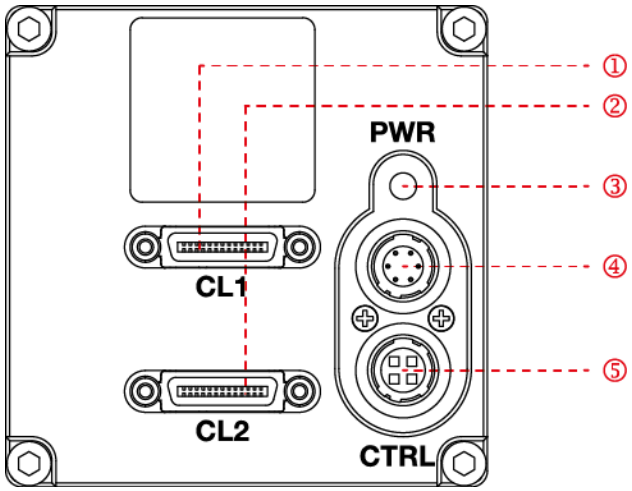


Figure 7.1 VTC-2K10.5C Back Panel

7.2 Camera Link SDR Connector

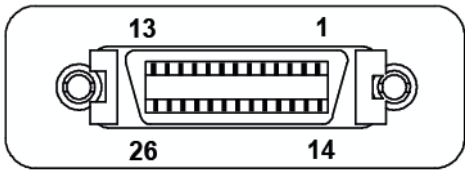


Figure 7.2 Camera Link SDR Connector

Camera Link connectors comply with Camera Link Standard and the following list shows the pin assignments of the connector.

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	-X0	LVDS - Out	Camera Link Transmitter
	15	+X0	LVDS - Out	Camera Link Transmitter
PAIR 2	3	-X1	LVDS - Out	Camera Link Transmitter
	16	+X1	LVDS - Out	Camera Link Transmitter
PAIR 3	4	-X2	LVDS - Out	Camera Link Transmitter
	17	+X2	LVDS - Out	Camera Link Transmitter
PAIR 4	5	-XCLK	LVDS - Out	Camera Link Transmitter
	18	+XCLK	LVDS - Out	Camera Link Transmitter
PAIR 5	6	-X3	LVDS - Out	Camera Link Transmitter
	19	+X3	LVDS - Out	Camera Link Transmitter
PAIR 6	7	+ SerTC	LVDS - In	Serial Data Receiver
	20	- SerTC	LVDS - In	Serial Data Receiver
PAIR 7	8	- SerTFG	LVDS - Out	Serial Data Transmitter
	21	+ SerTFG	LVDS - Out	Serial Data Transmitter
PAIR 8	9	- CC 1	LVDS - In	Software External Trigger
	22	+ CC 1	LVDS - In	Software External Trigger
PAIR 9	10	N/C	N/C	N/C
	23	N/C	N/C	N/C
PAIR 10	11	N/C	N/C	N/C
	24	N/C	N/C	N/C
PAIR 11	12	N/C	N/C	N/C
	25	N/C	N/C	N/C
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

Table 7.1 Pin Assignments for Camera Link Connector 1

PAIR List	Pin	Signal Name	Type	Description
PAIR 0	1	Ground	Ground	Cable Shield
	14	Ground	Ground	Cable Shield
PAIR 1	2	-Y0	LVDS - Out	Camera Link Transmitter
	15	+Y0	LVDS - Out	Camera Link Transmitter
PAIR 2	3	-Y1	LVDS - Out	Camera Link Transmitter
	16	+Y1	LVDS - Out	Camera Link Transmitter
PAIR 3	4	-Y2	LVDS - Out	Camera Link Transmitter
	17	+Y2	LVDS - Out	Camera Link Transmitter
PAIR 4	5	-YCLK	LVDS - Out	Camera Link Transmitter
	18	+YCLK	LVDS - Out	Camera Link Clock Tx
PAIR 5	6	-Y3	LVDS - Out	Camera Link Channel Tx
	19	+Y3	LVDS - Out	Camera Link Channel Tx
PAIR 6	7	-	Not Used	Connected with 100 ohm
	20	-	Not Used	
PAIR 7	8	-Z0	LVDS - Out	Camera Link Transmitter
	21	+Z0	LVDS - Out	Camera Link Transmitter
PAIR 8	9	-Z1	LVDS - Out	Camera Link Transmitter
	22	+Z1	LVDS - Out	Camera Link Transmitter
PAIR 9	10	-Z2	LVDS - Out	Camera Link Transmitter
	23	+Z2	LVDS - Out	Camera Link Transmitter
PAIR 10	11	-ZCLK	LVDS - Out	Camera Link Transmitter
	24	+ZCLK	LVDS - Out	Camera Link Clock Tx
PAIR 11	12	-Z3	LVDS - Out	Camera Link Channel Tx
	25	+Z3	LVDS - Out	Camera Link Channel Tx
PAIR 12	13	Ground	Ground	Cable Shield
	26	Ground	Ground	Cable Shield

Table 7.2 Pin Assignments for Camera Link Connector 2

Model	Tap Mode	CL Configuration	CL1 Connector	CL2 Connector
VTC-2K10.5C-C100A-80	2 Tap	BASE	O	X
	3 Tap	BASE	O	X
	4 Tap	MEDIUM	O	O
	8 Tap	FULL	O	O
	10 Tap	FULL	O	O

Table 7.3 Connector Arrangement for the Camera Link Output Modes

When you connect a frame grabber to Camera Link connectors on the camera using Camera Link cables, make sure that you connect to the correct Camera Link connectors. Incorrect connection of CL1 connector and CL2 connector may cause malfunction of the camera or communication problems between your computer and the camera.

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:

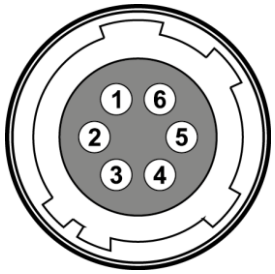


Figure 7.3 Pin Assignments for 6-pin Power Input Receptacle

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

Table 7.4 Pin Arrangements for Power Input Receptacle

- 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 3 A current output at 10 ~ 30 V 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 I/O Receptacle

The control I/O 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:

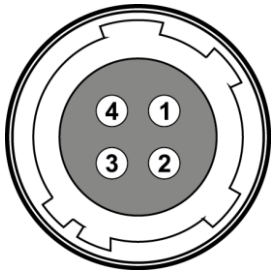


Figure 7.4 Pin Assignments for 4-pin Control I/O Receptacle

Pin Number	Signal	Type	Description
1	Trigger Input	Input	3.3 V ~ 5.0 V TTL input
2	Scan Direction Input	Input	3.3 V ~ 5.0 V TTL input
3	DC Ground	-	DC Ground
4	Strobe Out	Output	3.3 V TTL Output Output resistance: 47 Ω

Table 7.5 Pin Arrangements for Control I/O Receptacle

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 / Direction Input Circuit

The following figure shows trigger signal input and TDI direction signal input circuit of the 4-pin connector. Transmitted trigger signal and TDI direction signal is applied to the internal circuit through a CMOS butter with a good noise margin. The minimum trigger width that can be recognized by the camera is 1 μs. If transmitted trigger signal is less than 1 μs, the camera will ignore the trigger signal. An external trigger and TDI direction circuit example is shown below.

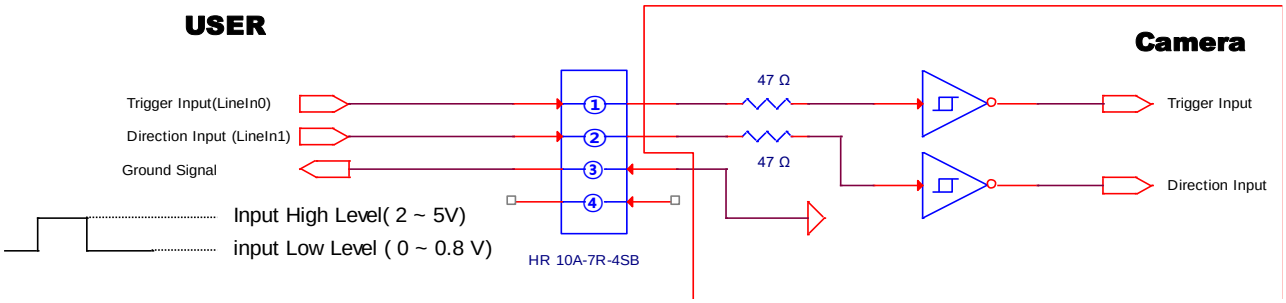


Figure 7.5 Trigger / Direction Input Schematic

7.6 Strobe Output Circuit

The strobe output signal comes out through a 3.3 V output level of Line Driver IC. A pulse width of the signal is synchronized with a Line Start trigger (shutter) signal of the camera (refer to 9.14 Strobe Mode).

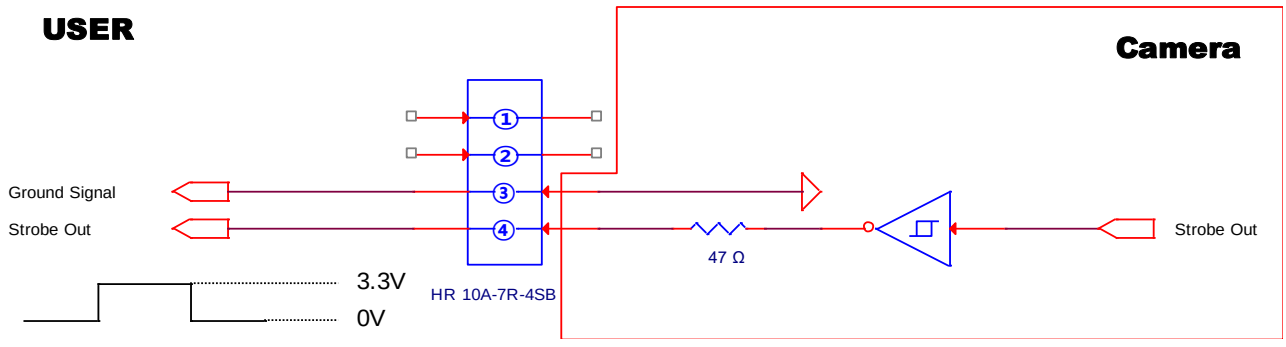


Figure 7.6 Strobe Output Schematic

8 Acquisition Control

This chapter provides detailed information about the following elements involved with the image acquisition.

- Line Start trigger – Trigger Mode
- Line Rate control

8.1 Line Start Trigger

The Line Start trigger is used to begin line acquisition. Line Start trigger signals can be generated within the camera or may be applied externally by setting the **Source** parameter to **CC1** or **External**. If a line start trigger signal is applied to the camera, the camera will begin to acquire line images.

8.1.1 Trigger Mode

The main parameter associated with the line start trigger is the **Trigger Mode** parameter. The **Trigger Mode** parameter for the line start trigger has two available settings: **OFF** and **ON**.

8.1.1.1 Trigger Mode = OFF

When the **Trigger Mode** parameter is set to **OFF**, the camera will generate all required line start trigger signals internally, and you do not need to apply line start trigger signals to the camera.
If the **Trigger Mode** parameter is set to **OFF**, the camera will automatically begin generating line start trigger signals.

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 is commonly known as “free run”.

The rate at which the line start trigger signals are generated may be determined by the camera's **Line Rate** parameter.

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

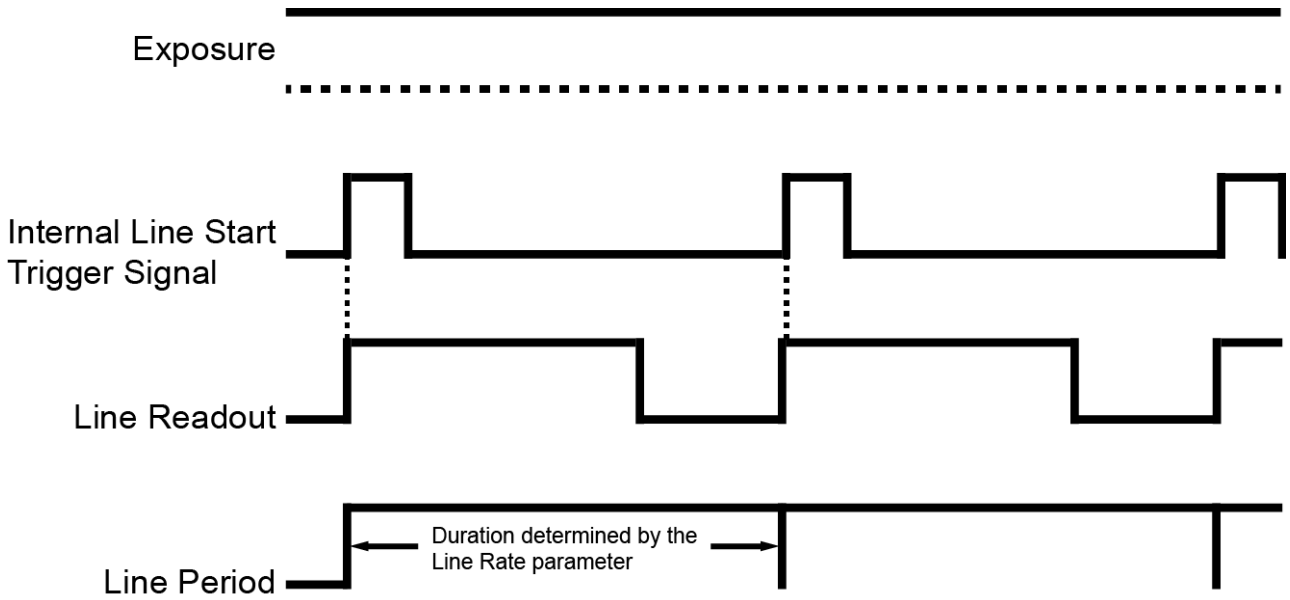


Figure 8.1 Trigger Mode = OFF

8.1.1.2 Trigger Mode = ON

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

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

- **External**: You can apply a line start trigger signal to the camera by injecting an externally generated electrical signal (commonly referred to as a hardware or external trigger signal) into the Control I/O receptacle on the camera. Refer to 7.5 Trigger / Direction Input Circuit for more information.
- **CC1**: You can apply a line start trigger signal via CC1 port of the Camera Link frame grabber. For more information, refer to your Camera Link frame grabber user manual.

After setting the **Source** parameter, you must also set the **Activation** parameter.

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

- **Rising**: Specifies that a rising edge of the electrical signal will act as the line start trigger.
- **Falling**: Specifies that a falling edge of the electrical signal will act as the line start trigger.
- **Both**: Specifies that both rising and falling edges of the electrical signal will act as the line start trigger.

When the **Trigger Mode** parameter is set to **ON**, the camera's line rate can be controlled by manipulating the external trigger signal. At this point, it is important that you do not attempt to trigger images at a rate that is greater than the maximum allowed.

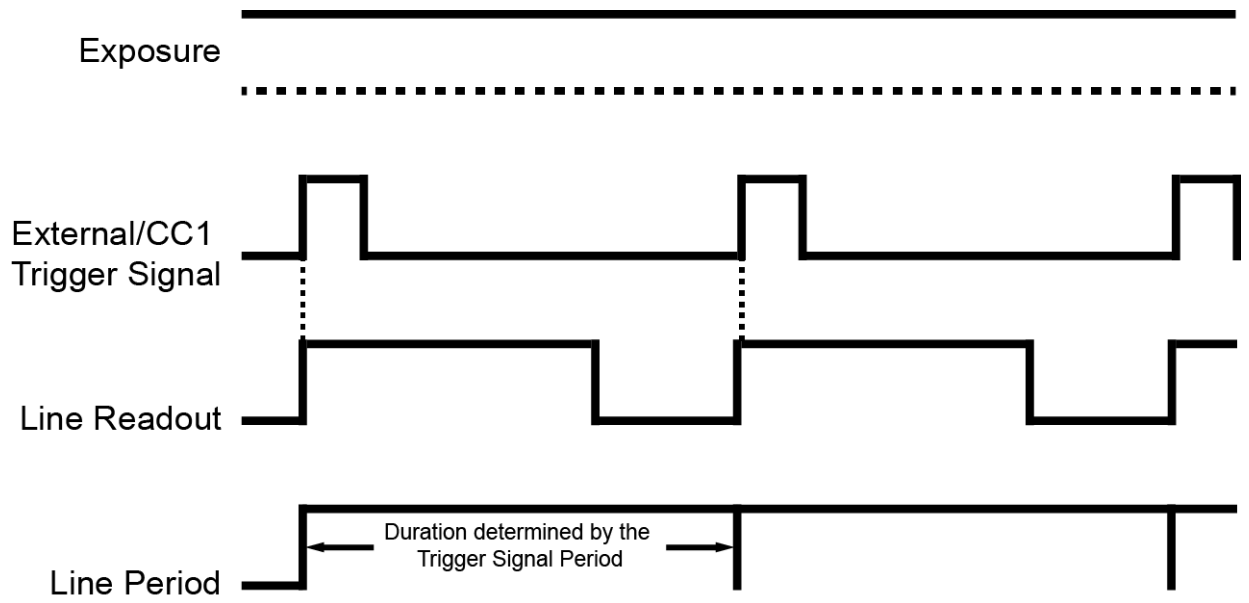


Figure 8.2 Trigger Mode = ON

8.1.2 Using an External / CC1 Trigger Signal

If the **Trigger Mode** parameter is set to **ON**, and the **Source** parameter is set to **External** or **CC1**, you must apply an external or CC1 trigger signal (line start) to the camera to begin image acquisition.
To apply trigger signals via CC1 port of the Camera Link frame grabber, you must set the **Source** parameter to **CC1**. At that point, each time a proper CC1 trigger signal is applied to the camera by using the APIs provided by a Camera Link frame grabber manufacturer, the line start trigger signal will be applied to the camera.
For more information, refer to your Camera Link frame grabber user manual.

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

A rising edge and/or a falling edge of the external or CC1 signal can be used to trigger image acquisition.
The **Activation** parameter is used to select rising edge and/or falling edge triggering.
When the camera is operating under control of an external or CC1 signal, the period of trigger signal will determine the rate at which the camera is acquiring images:

$$\text{Line Rate (Hz)} = \frac{1}{\text{External/CC1 signal period in seconds}}$$

For example, if you are operating a camera with an external trigger signal period of 20 μs (0.00002 s):
So in this case, the line rate is 50 ㎑.

8.1.3 Rescaler Mode

With the **Rescaler Mode**, you can modulate the period of the external trigger signal as desired.

For example, if you supply external trigger signals into the camera's I/O receptacle using the conveyor's encoder, the number of output pulses per revolution of the encoder is fixed. In this situation, you can modulate the period of the trigger signal received from the camera in the following manner to match the pitch of the image in vertical direction.

```
Line Rate (Hz) = External Trigger Line Rate × Rescaler Rate
```

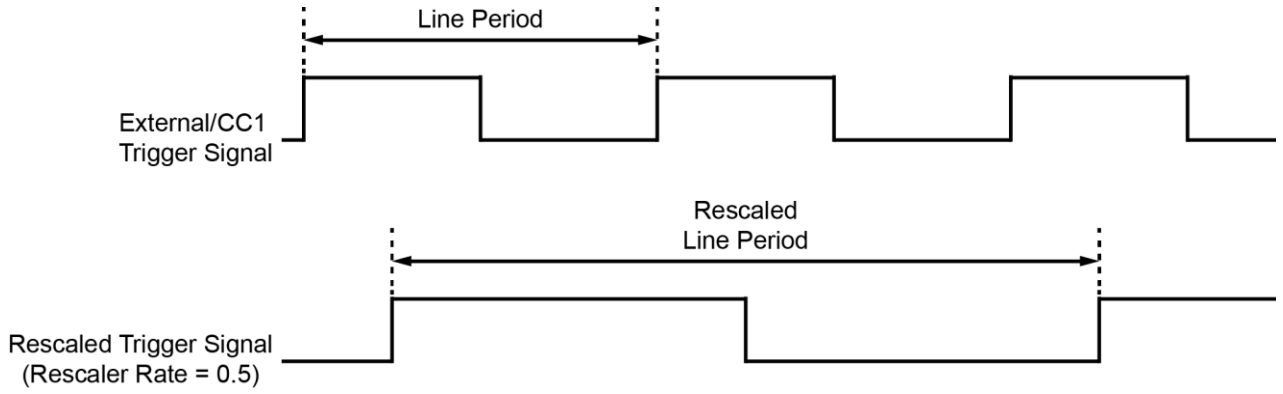


Figure 8.3 Rescaler Rate = 0.5

The commands related to Rescaler Mode are as follows.

Configurator Parameters	Command	Value	Description
Rescaler Mode	srm	0: Off	Disables Rescaler Mode.
		1: On	Enables Rescaler Mode.
Rescaler Rate	srr	f: 0.010000 ~ 100.000000	Sets the trigger rescaler rate for converting trigger signals. f: Float, 0.010000 ~ 100.000000
Rescaler Filter	srf	0: 16	Sets the rescaler filter factor to decrease the jitter of the external trigger signals.
		1: 32	
		2: 64	
		3: 128	
		4: 256	
		5: 512	

Table 8.1 Commands related to Rescaler Mode

8.1.4 Trigger Statistics

The Trigger Statistics feature allows you to determine the trigger signals applied to the camera and then converted by the Trigger Rescaler.

The table below shows the parameters for the Trigger Statistics provided in the Configurator.

Configurator Parameters		Value	Description
Trigger Statistics	InputTriggerRate	-	Displays the rate at which the input trigger signals are applied to the camera in Hz.
	InputTriggerRateHighest	-	Displays the highest rate at which the input trigger signals are applied to the camera in Hz.
	InputTriggerJitter	-	Displays the jitter of the input trigger signals in %.
	InputTriggerDuration	-	Displays the pulse duration of the input trigger signals in μs.
	RescaledTriggerRate	-	Displays the rate of the trigger signals converted by the Trigger Rescaler in Hz.
	RescaledTrigger Jitter	-	Displays the jitter of the input trigger signals converted by the Trigger Rescaler in %.

Table 8.2 Trigger Statistics Parameters

8.2 Maximum Allowed Line Rate

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

- Camera Link Tap Configuration (Tap Mode) Settings.
  When the camera is set for a Tap Mode that uses more taps, it will take less time to transfer acquired images from the camera to the Camera Link frame grabber in your computer. For example, if the camera is set to 8 Tap (Camera Link Full Configuration), it can typically transfer data out of the camera two times faster than when the camera is set to 4 Tap (Camera Link Medium).
- The amount of time it takes to read acquired line images out of the image sensor and into the camera's line buffer. This time varies depending on the length of image ROI. Images with a smaller length take less time to read out of the sensor. The image length is determined by the camera's **Width** settings.

The maximum allowed line rates of the VTC-2K10.5C camera depending on the Tap Mode settings are as follows.

Tap Mode	VTC-2K10.5C
2 Tap	25.8 ㎑
3 Tap	37.8 ㎑
4 Tap	51.5 ㎑
8 Tap	100.0 ㎑
10 Tap	100.0 ㎑

When the camera is set for 4 Tap (CL Medium), 8 Tap (CL Full) or 10 Tap (CL Full), you must connect the camera to the Camera Link frame grabber using two Camera Link cables.

Table 8.3 Maximum Allowed Line Rates depending on the Tap Mode settings

9 Camera Features

9.1 Operation Mode

The VTC-2K10.5C camera has two different operation modes: **Area** and **TDI** (Time Delayed Integration).

If the **Operation Mode** parameter is set to **Area**, the camera will operate as an area scan camera using two dimensional array of pixels. This mode is useful for aligning the camera to your target object.

If the **Operation Mode** parameter is set to **TDI**, the camera will operate as a high sensitivity line scan camera and provide up to 80× higher sensitivity than existing line scan cameras.

The command related to Operation Mode is as follows.

Configurator Parameter	Command	Value	Description
Operation Mode	som	0: TDI	Operates the camera in the TDI mode.
		1: Area	Operates the camera in the Area mode.

Table 9.1 Command related to Operation Mode

9.2 TDI Stages

In the **TDI** mode, the **TDI Stages** parameter is used to determine the number of integration stages used by the camera. For example, if the **TDI Stages** parameter is set to **80**, the camera will acquire images with 80× higher sensitivity.

In the **Area** mode, the **TDI Stages** parameter is used to determine the height of the image sensor. For example, if the **Operation Mode** parameter is set to **Area** and the **TDI Stages** parameter is set to **80** on the VTC-2K10.5C camera, the camera will acquire 2160 × 80 area images.

The command related to TDI Stages is as follows.

Configurator Parameter	Command	Value	Description
TDI Stages	std	1: 20	Sets the number of TDI Stages to 20.
		2: 40	Sets the number of TDI Stages to 40.
		3: 60	Sets the number of TDI Stages to 60.
		4: 80	Sets the number of TDI Stages to 80.

Table 9.2 Command related to TDI Stages

9.3 Direction

In the **TDI** mode, the **Direction** parameter is used to select the image sensor's scan direction. You need to set the **Direction** parameter to **Forward** if the object being imaged will pass the bottom of the camera, and then pass the top of the camera. On the contrary, you need to set the **Direction** parameter to **Reverse** if the object being imaged will pass the top of the camera, and then pass the bottom of the camera.

When you set the **Direction** parameter to **Line 1**, you can also select the scan direction by injecting an externally generated electrical signal (Low = Forward, High = Reverse) into the Control I/O receptacle on the camera.

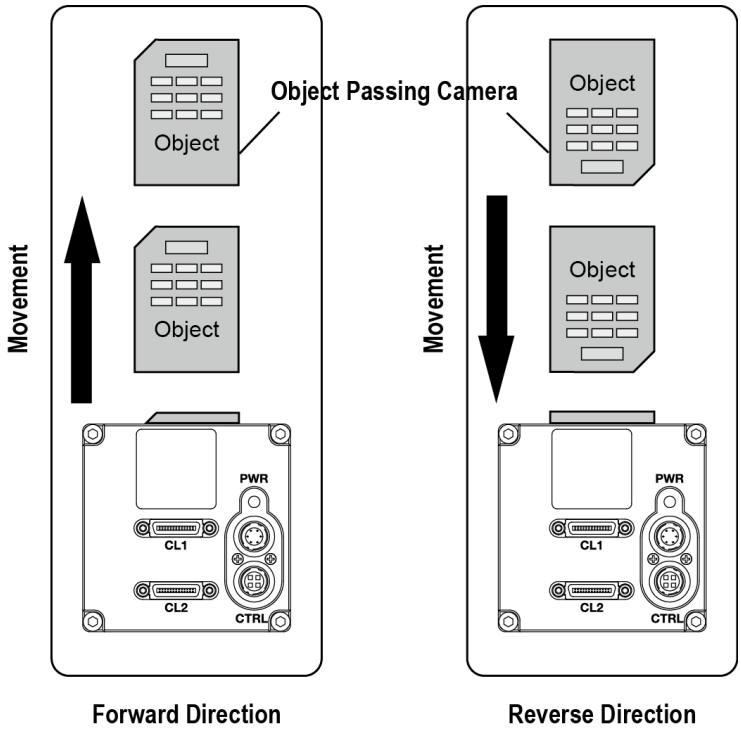


Figure 9.1 Direction

Configurator Parameter	Command	Value	Description
Direction	ssd	0: Forward	Scans images in the forward direction.
		1: Reverse	Scans images in the Reverse direction.
		2: Line 1	Selects the scan direction using an external signal.

Table 9.3 Command related to Scan Direction

When you set the **Direction** parameter to **Reverse** in the **Area** mode, you can acquire vertically flipped images.

9.4 Region of Interest

The Region of Interest (ROI) feature allows you to specify a portion of the sensor lines. During operation, only the pixel information from the specified portion of the lines is read out of the sensor and transmitted from the camera to your computer.

The ROI is referenced to the left end of the sensor array. The location and size of the ROI is defined by declaring the **Offset X** and **Width** settings. For example, suppose that you set the Offset X parameter to 48 and the Width parameter to 288 as shown in the figure below. With these settings, the camera will read out and transmit pixel values for pixels 48 through 335.

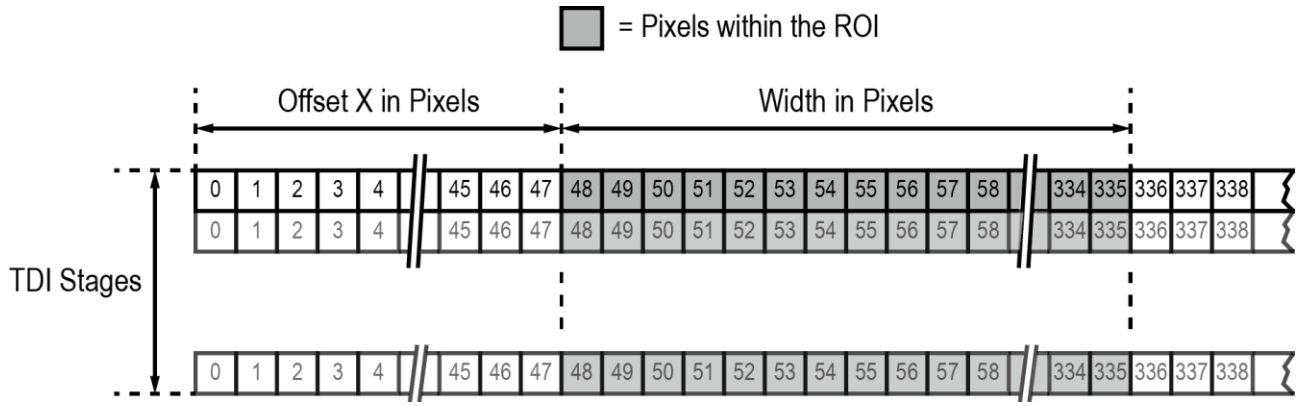


Figure 9.2 Region of Interest

9.4.1 Setting the ROI

By default, the ROI is set to use the full resolution of the camera's image sensor. You can change the size and location of the ROI by changing the Offset X and Width parameter values.

When you are setting the camera's region of interest, you must consider the following guidelines:

- The sum of the Offset X and Width setting values must not exceed the width of the camera's image sensor. For example, on the VTC-2K10.5C camera, the sum of the Offset X and Width setting values must not exceed 2160.
- The Offset X setting value can be set to 0 and can be increased in increments of 48. The Width setting values must be a minimum of 48 and can be set to a multiple of 48.

Your Camera Link frame grabber may place additional restrictions on how the ROI location and size must be set. Refer to your Camera Link frame grabber user manual for more information.

The maximum allowed line rates of the VTC-2K10.5C camera depending on the ROI settings are as follows.

Width	2 Tap	3 Tap	4 Tap	8 Tap / 10 Tap
384	100.0 kHz	100.0 kHz	100.0 kHz	100.0 kHz
528	100.0 kHz	100.0 kHz	100.0 kHz	100.0 kHz
720	78.1 kHz	100.0 kHz	100.0 kHz	100.0 kHz
1056	53.4 kHz	79.8 kHz	100.0 kHz	100.0 kHz
1536	36.7 kHz	55.1 kHz	73.2 kHz	100.0 kHz
2160	25.8 kHz	37.8 kHz	51.5 kHz	100.0 kHz

Table 9.4 Maximum Allowed Line Rates by ROI Changes (RGB8 Pixel Format)

To acquire images at the maximum allowed line rate, you need to set the camera's Tap Mode to 8 Tap / 10 Tap (Camera Link Full Configuration). In this case, you must connect the camera to the Camera Link frame grabber using two Camera Link cables.

9.5 Pixel Format

The camera processes image data in the unit of 12 bit internally. You can determine the format of these image data transmitted from the camera by using the **Pixel Format** parameter.

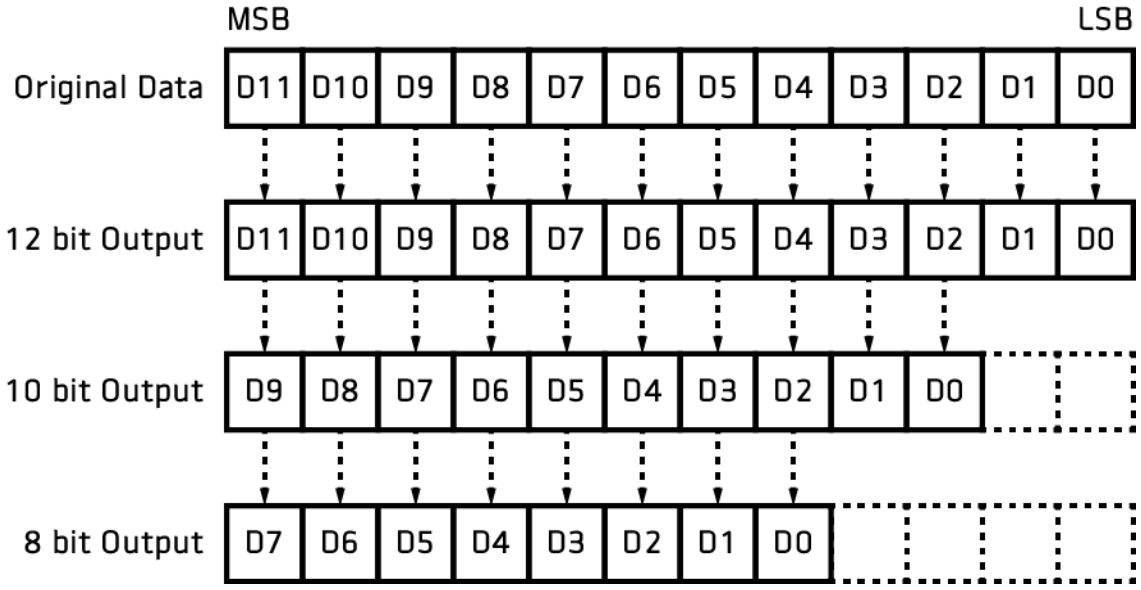


Figure 9.3 Data Format

The command related to Pixel Format is as follows.

Configurator Parameter	Command	Value	Description
Pixel Format	sdb	8: RGB8	Sets the pixel format to RGB 8 bit.
		10: RGB10	Sets the pixel format to RGB 10 bit.
		12: RGB12	Sets the pixel format to RGB 12 bit.
		108: BGR8	Sets the pixel format to BGR 8 bit.
		110: BGR10	Sets the pixel format to BGR 10 bit.
		112: BGR12	Sets the pixel format to BGR 12 bit.

Table 9.5 Command related to Pixel Format

9.6 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. Select a Gain Control parameter as desired.
2. Set 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. Set the Black Level parameter to the desired value.
2. The available setting range varies depending on the Pixel Format settings.

The commands related to Gain and Black Level are as follows.

Configurator Parameters	Command	Value	Description
Analog Gain	sag	1×, 2×, 3×, 4×	Sets an absolute analog gain value.
Digital Gain	sdg	f: 1.0× ~ 8.0×	Sets an absolute digital gain value. f: Float, 0 ~ 18 dB
Black Level	sdbl	n: -255 ~ 255	Sets a physical black level value (@ 8 bits) n: Integer

Table 9.6 Commands related to Gain and Black Level

9.7 White Balance

The VTC-2K10.5C camera allows you to adjust the white balance manually or automatically by setting the gain values for the Red, Green and Blue channels. To adjust the white balance manually, use the ‘srg’ command to set the intensity of each color. If you set the intensity of a color to a value greater than 1.0, the intensity of the color will be proportionally increased to the setting value. For example, if you execute the ‘srg b 1.5’ command, the blue intensity will be increased by 50%.

The commands related to White Balance are as follows.

Command		Value	Description
RGB Gain	srg r	1.0× ~ 3.9×	Sets the intensity of the red pixels.
	srg g	1.0× ~ 3.9×	Sets the intensity of the green pixels.
	srg b	1.0× ~ 3.9×	Sets the intensity of the blue pixels.

Table 9.7 Commands related to White Balance

To adjust the white balance automatically, execute the ‘arg’ command. The intensity values for the Red and Blue will be automatically adjusted by referring to the Green.

Command		Value	Description
Auto White Balance	arg	-	White Balance is adjusted once and then Off.

Table 9.8 Command related to Auto White Balance

9.8 Color Correction Matrix

The VTC-2K10.5C camera provides the Color Transformation feature. After adjusting the white balance, you can adjust colors to your light source by using the Color Transformation feature. The Color Transformation feature converts the RGB triplet from the camera color space to the RGB triplet of the final color space when you enter nine Gain factors in the 3 × 3 matrix as shown below.

$$\begin{pmatrix} R' \\ G' \\ B' \end{pmatrix} = \begin{pmatrix} Gain\ 00 & Gain\ 01 & Gain\ 02 \\ Gain\ 10 & Gain\ 11 & Gain\ 12 \\ Gain\ 20 & Gain\ 21 & Gain\ 22 \end{pmatrix} \times \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

$$\text{Equivalent: } \begin{pmatrix} R_{out} \\ G_{out} \\ B_{out} \end{pmatrix} = \begin{pmatrix} RR & RG & RB \\ GR & GG & GB \\ BR & BG & BB \end{pmatrix} \times \begin{pmatrix} R_{in} \\ G_{in} \\ B_{in} \end{pmatrix}$$

The commands related to Color Correction Matrix are as follows.

Command		Value	Description
Color Correction Matrix	sccm 0	-4.0× ~ 4.0×	Gain00: Sets red contribution to the red pixels.
	sccm 1		Gain01: Sets green contribution to the red pixels.
	sccm 2		Gain02: Sets blue contribution to the red pixels.
	sccm 3		Gain10: Sets red contribution to the green pixels.
	sccm 4		Gain11: Sets green contribution to the green pixels.
	sccm 5		Gain12: Sets blue contribution to the green pixels.
	sccm 6		Gain20: Sets red contribution to the blue pixels.
	sccm 7		Gain21: Sets green contribution to the blue pixels.
	sccm 8		Gain22: Sets blue contribution to the blue pixels.

Table 9.9 Commands related to Color Correction Matrix

9.9 LUT

The Lookup Table (LUT) feature allows you to convert original image values to certain level values.

Luminance

Since it is mapped one to one for each level value, 12 bit output can be connected to 12 bit input. The LUT is in the form of table that has 4096 entries between 0~4095 and the VTC-2K10.5C camera provides a non-volatile space for LUT data storage. You can determine whether to apply LUT. For more information about how to download LUT to the camera, refer to Appendix B.

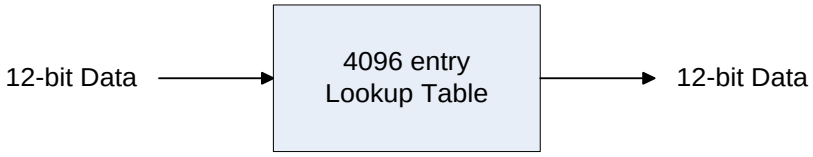


Figure 9.4 LUT Block

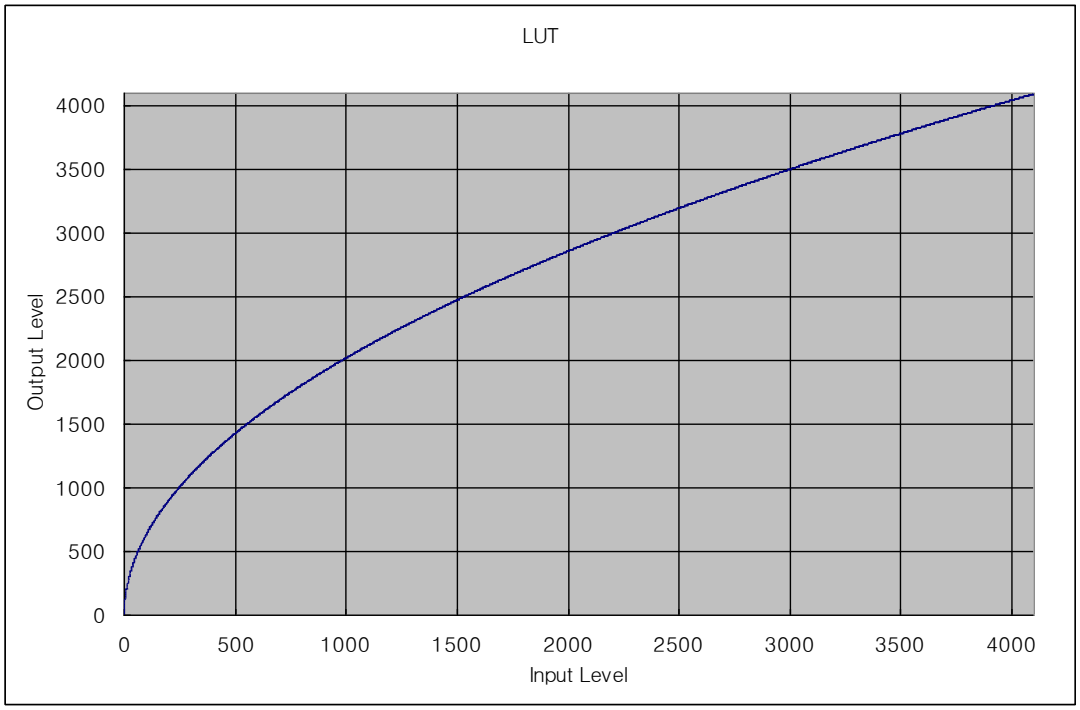


Figure 9.5 LUT at Gamma 0.5

The command related to LUT is as follows.

Configurator Parameters	Command	Value	Description
LUT	sls	0: Off	Disables the LUT feature.
		1: On	Enables the LUT feature.

Table 9.10 Command related to LUT

9.10 Dark Signal Non-uniformity Correction

In theory, when a digital camera acquires images in complete darkness, all of 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 VTC-2K10.5C camera provides the DSNU Correction feature.

The commands related to DSNU are as follows.

Configurator Parameters	Command	Value	Description
Generate All	gdda	–	Generates and saves the DSNU data for each Analog Gain setting value (1×, 2×, 3×, 4×).
Generate	gdd	–	Generates the DSNU data.
Save to Flash	sdd	–	Saves the generated DSNU data in the non-volatile memory. • The data generated by executing the Generate command 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.
Load from Flash	ldd	–	Loads the DSNU data from the non-volatile memory into the volatile memory.

Table 9.11 Commands related to DSNU

9.10.1 Generating and Saving User DSNU Correction Values

To generate and save user DSNU correction values, use the following procedure.

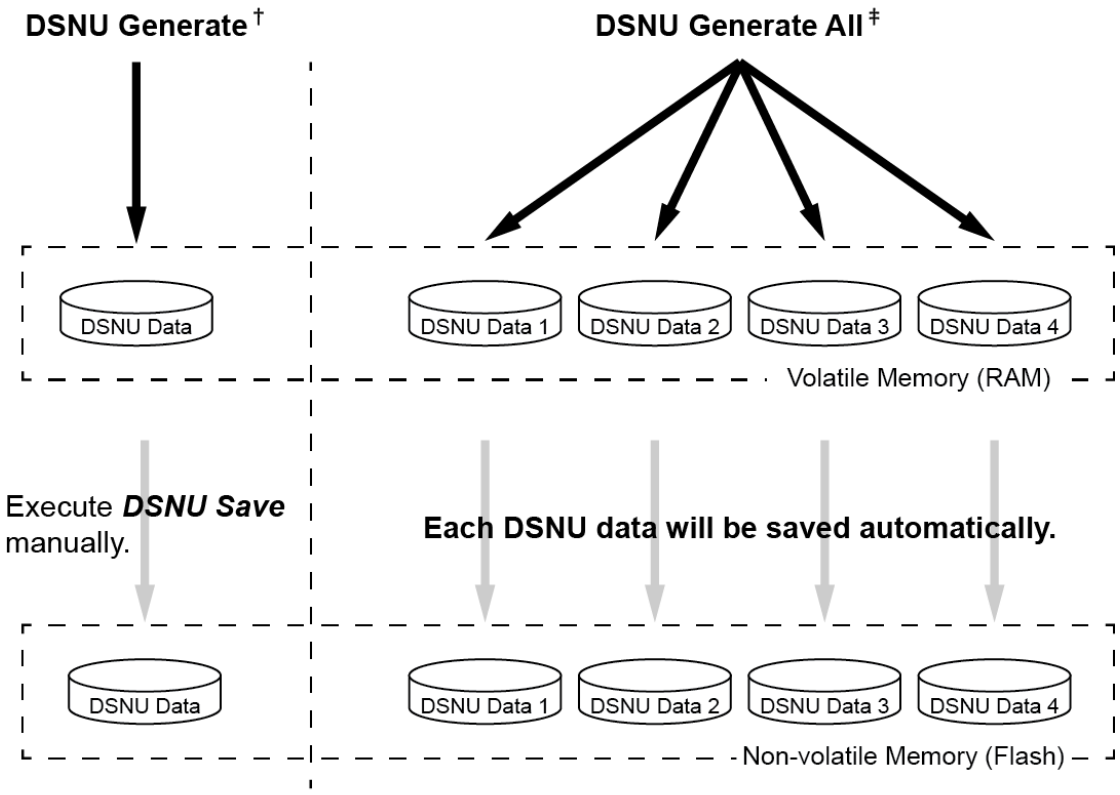
For optimum DSNU correction results, we recommend that you generate DSNU data after the temperature of the camera housing has been stabilized.

1. The camera will use the entire sensor when generating DSNU correction values. Therefore, we recommend that you set the ROI setting to use the entire width of the sensor.
2. Ensure that the camera will be acquiring line images in complete darkness by covering the camera lens, closing the iris in the lens, or darkening the room.
3. Begin acquiring line images either by setting the camera for the Free-Run mode or by supplying external trigger signals to trigger line acquisitions.
4. Generate DSNU correction values.
   - Go to step 5 if you execute the **Generate** command to generate DSNU data.
   - Go to step 6 if you execute the **Generate All** command to generate DSNU data.

5. If you execute the **Generate** command,
   a. The camera generates DSNU data according to the current Analog Gain setting value. The camera must acquire at least 4096 line images to create a set of DSNU correction values.
   b. After completing 4096 line acquisitions, the generated DSNU correction values will be activated and saved in the camera's volatile memory.
   c. To save the generated DSNU correction values in the camera's Flash (non-volatile) memory, execute the **Save to Flash** command. The previous DSNU values for the current Analog Gain setting value saved in the memory will be overwritten.

6. If you execute the **Generate All** command,
   a. The camera generates the DSNU data for each Analog Gain setting value (1×, 2×, 3×, 4×) and then executes the **Save to Flash** command automatically. The camera must acquire at least 4096 line images to create sets of DSNU correction values.
   b. After completing 4096 line acquisitions, the generated DSNU correction values according to the current Analog Gain setting values will be activated.

7. If you change the Analog Gain setting values or want to load the existing values in the Flash memory, execute the **Load from Flash** command.



† . The camera generates **DSNU data** according to **the current Analog Gain setting**.

‡ . The camera generates **four different DSNU data** according to **the Analog Gain setting values**.

Figure 9.6 Generating and Saving DSNU Correction Values

9.11 Photo Response Non-uniformity Correction

In theory, when a line scan camera acquires images with the camera viewing a uniform light-colored target in bright light, all of the pixel values in the image should be near the maximum grey value and they should be equal. In practice, however, slight variations in the performance of the pixels in the sensor, variations in the optics, and variations in the lighting will cause some variations in the pixel values output from the camera. This variation is known as Photo Response Non-uniformity (PRNU). The VTC-2K10.5C camera provides the PRNU Correction feature and five storage locations for PRNU correction values.

The commands related to PRNU are as follows.

Configurator Parameters	Command	Value	Description
PRNU Correction	sprnu	0: Off	Disables the PRNU Correction feature.
		1: On	Enables the PRNU Correction feature.
PRNU Selector	spi	0/1/2/3/4	Selects a location to save PRNU data to or load PRNU data from.
Auto	gpd	0	Select to set the PRNU Target Level automatically.
Target	-	1 ~ 255	Sets the PRNU Target Level(@8 bit pixel format).
Generate	gpd	n: 0 ~ 255	Generates the PRNU data. 0: Auto, 1 ~ 255: Sets the PRNU Target Level.
Save to Flash	spd	-	Saves the generated PRNU data in the non-volatile memory. • The data generated by executing the **Generate** command 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.
Load from Flash	lpd	-	Loads the PRNU data from the non-volatile memory into the volatile memory.

Table 9.12 Commands related to PRNU

9.11.1 Generating and Saving User PRNU Correction Values

To generate and save user PRNU correction values, use the following procedure.

- We strongly recommend that you generate new PRNU correction values whenever you make a change to the optics or lighting or if you change the camera's line rate.
- For optimum PRNU correction results, we recommend that you generate DSNU correction values first before generating PRNU correction values.

1. The camera will use the entire sensor when generating PRNU correction values. Therefore, we recommend that you set the ROI settings to use the entire width of the sensor.
2. Place a uniform white target in the field of view of the camera. Adjust the optics, lighting and line rate as you would for normal operation. We recommend that you make adjustments to achieve the digital output level in a range from 100 to 200 (Gain: 1.00 at 8 bit).
3. Begin acquiring line images either by setting the camera for the Free-Run mode or by supplying external trigger signals to trigger line acquisition.
4. Set the Target Level.
   - To set the Target Level automatically, select the **Auto** check box.
   - To set the Target Level manually, deselect the **Auto** check box and input the target level in a range from 0 to 255.
5. Execute the **Generate** command to generate PRNU correction values.
6. The camera must acquire at least 4096 line images to create a set of PRNU correction values.
7. After completing 4096 line acquisitions, the generated PRNU correction values will be activated and saved in the camera's volatile memory.
8. To save the generated PRNU correction values in the camera's Flash (non-volatile) memory, specify a location to save by using the **PRNU Selector** parameter and execute the **Save to Flash** command.
   The existing values in the memory will be overwritten.
   To ignore the generated PRNU correction values and load the existing values in the Flash memory, specify a location to load from by using the **PRNU Selector** parameter and execute the **Load from Flash** command.

9.12 Reverse X

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

Figure 9.7 Original Image

Figure 9.8 Reverse X Image

The command related to Reverse X is as follows.

Configurator Parameters	Command	Value	Description
Reverse X	shf	0	Disables the Reverse X feature.
		1	Enables the Reverse X feature.

Table 9.13 Command related to Reverse X

9.13 Camera Link Output

The VTC-2K10.5C camera supports 2 Tap, 3 Tap, 4 Tap, 8 Tap and 10 Tap Camera Link output modes. The number of taps represents the number of pixel data that will be output on each cycle of the Camera Link pixel clock. The maximum allowed line rate will be changed according to the Tap Mode settings. The line image data is transmitted in the interleaved order as shown in the figure below.

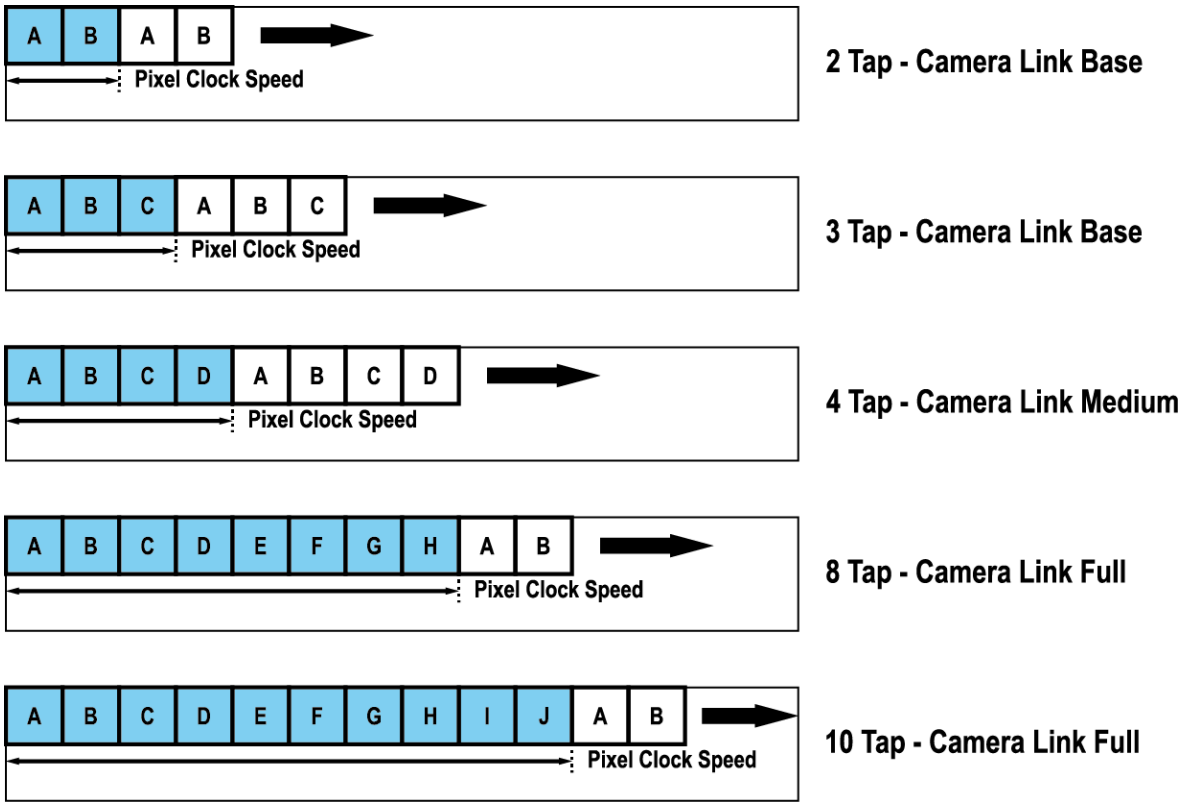


Figure 9.9 Camera Link Output Mode

The command related to Camera Link Output Mode is as follows.

Configurator Parameters	Command	Value	Description
Tap Mode	scl	0: 2 Tap	Sets the Camera Link Output Mode to 2 Tap.
		1: 4 Tap	Sets the Camera Link Output Mode to 4 Tap.
		2: 8 Tap	Sets the Camera Link Output Mode to 8 Tap.
		3: 10 Tap	Sets the Camera Link Output Mode to 10 Tap.
		4: 3 Tap	Sets the Camera Link Output Mode to 3 Tap.

Table 9.14 Command related to Camera Link Output Mode

9.14 Strobe Mode

The VTC-2K10.5C camera can output pulse signals through the control I/O receptacle. You can set a width of the pulse signal by using the **Strobe Mode** feature. This feature is useful when you need to supply source signal to the other device such as a Strobe Controller.

The commands related to Strobe Mode are as follows.

Configurator Parameters	Command	Value	Description
Strobe Mode	ssm	0: Off	Disables the Strobe Mode feature.
		1: Timed	Outputs pulse signals according to the Strobe Duration setting value.
		2: Pulse Width	Outputs pulse signals of which the period is equal to the trigger signals applied to the camera.
		3: On	Outputs continuous High signals.
Strobe Inverter	ssp	0	Deselect not to invert the output signal.
		1	Select to invert the output signal.
Strobe Duration	ssr	f: 1.00 ~ 1000.00	Sets a duration of pulse signal in microseconds when the Strobe Mode is set to Timed.
Strobe Out Delay	sto	f: 0.00 ~ 1000.00	Sets a delay to the current output signal in microseconds.

Table 9.15 Commands related to Strobe Mode

9.15 Temperature Monitor

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

The command related to the device temperature is as follows.

Command	Description
gct	Displays device temperature in Celsius.

Table 9.16 Command related to Device Temperature

9.16 Status LED

A red/green LED is installed on the back panel of the camera to inform the operation status of the camera.

LED status and corresponding camera status are as follows.

Status LED	Descriptions
Steady Red	Camera is not initialized.
Steady Green	Camera is waiting for transmitting images.
Fast Flashing Green	Camera is acquiring images.

Table 9.17 Status LED

9.17 Device Reset

Resets the camera physically to power off and on. The command related to Device Reset is as follows.

Command	Description
rst	Resets the camera physically.

Table 9.18 Command related to Device Reset

9.18 Test Image

To check normal operation of the camera, it can be set to output test images created inside, instead of image data from the image sensor. There are three types of test images; image with different value in horizontal direction (Test #1), image with different value in diagonal direction (Test #2), and moving image with different value in diagonal direction (Test #3).

The command related to Test Image is as follows.

Configurator Parameters	Command	Value	Description
Test Image	sti	0: Off	Disables the Test Image feature.
		1: Test #1	Sets the Test Image to Test #1.
		2: Test #2	Sets the Test Image to Test #2.
		3: Test #3	Sets the Test Image to Test #3.

Table 9.19 Command related to Test Image

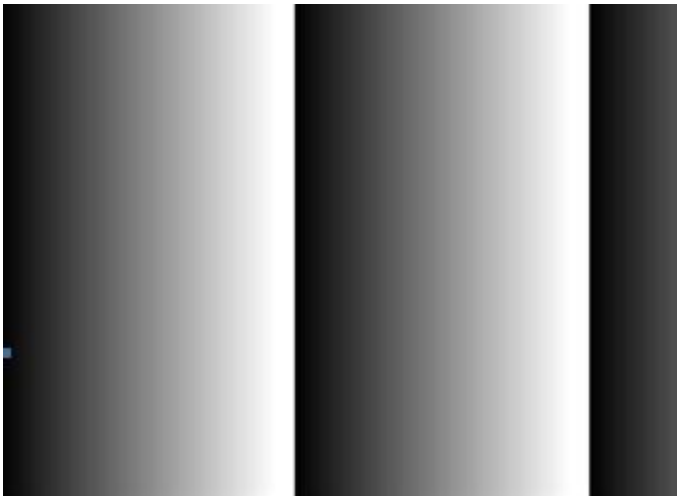


Figure 9.10 Test #1

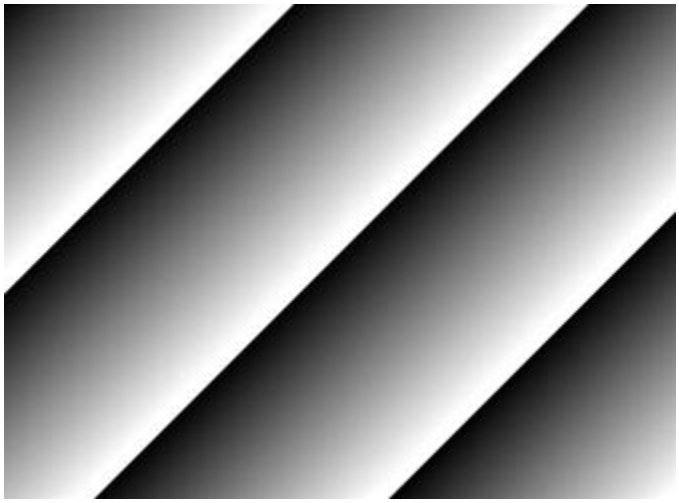


Figure 9.11 Test #2

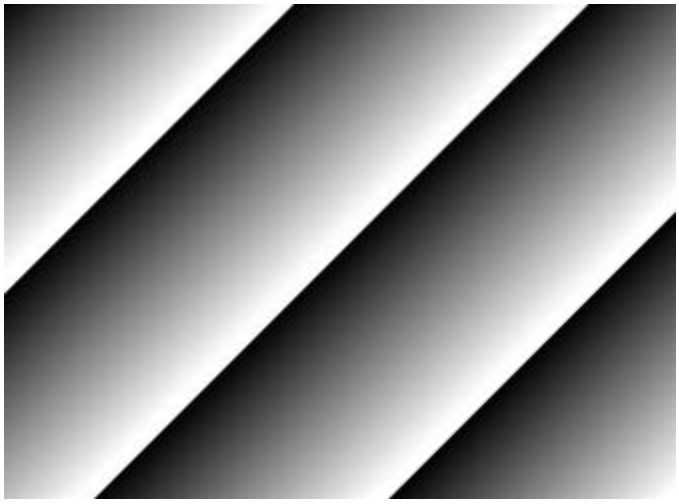


Figure 9.12 Test #3

CAUTION

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

9.19 Camera Link Pixel Clock

The Pixel Clock feature provided by the VTC-2K10.5C camera allows you to select a Camera Link pixel clock so that you can increase the available Camera Link cable length or extend the Camera Link bandwidth. Typically, you can extend the Camera Link cable length up to 15 meters with the Camera Link pixel clock of 40 ㎒.
The command related to Pixel Clock is as follows.

Configurator Parameters	Command	Value	Description
Pixel Clock	sccs	0: 40 ㎒	Sets the Camera Link Pixel Clock to 40 ㎒.
		1: 60 ㎒	Sets the Camera Link Pixel Clock to 60 ㎒.
		2: 80 ㎒	Sets the Camera Link Pixel Clock to 80 ㎒.
		3: 85 ㎒	Sets the Camera Link Pixel Clock to 85 ㎒.

Table 9.20 Command related to Pixel Clock

9.20 Field Upgrade

The camera provides a feature to upgrade the camera's firmware and FPGA logic through the Camera Link interface rather than disassemble the camera in the field. Refer to Appendix A for more details about how to upgrade.

10 Camera Configuration

10.1 Setting Commands

You can configure all camera settings via RS-644 serial interface of the Camera Link. When you want to control the camera using a terminal or to access directly to the camera at your application, you need to set your network as follows.

- Baud Rate: 115200 bps
- Data Bit: 8 bit
- Parity Bit: No Parity
- Stop Bit: 1 stop bit
- Flow Control: None

All camera setting commands are transmitted in the ASCII command type except a command for transmitting a large file such as firmware download. All camera setting commands are transmitted from the user application and then the camera returns a response (“OK”, “Error” or information) for a command. When you execute a write command, the camera returns a response to inform whether the command has been successfully executed. When you execute a read command, the camera returns an error or information.

```
Command Format:
<command> <parameter1> <parameter2> <cr>
0 – 2 parameters follow the command.
Response:
If a write command is successfully executed
OK <cr> <lf>
```

ex) Write Command

```
In response to a “set 100” command the camera will return (in hex value)
Command:    73 65 74 20 31 30 30 0D
            set 100<cr>
Response:   73 65 74 20 31 30 30 0D 0A  4F 4B 0D 0A   3E
            set 100<cr><lf>             OK<cr><lf>    >
            Echo                        result        prompt
```

```
If a read command is successfully executed
<parameter1> <cr> <lf>
```

ex) Read Command

```
In response to a "get" command the camera will return (in hex value)
Command:    67 65 74 0D
            get <cr>
Response:   67 65 74 0D 0A 31 30 30 0D 0A 3E
            get<cr><lf>    100<cr><lf>    >
            Echo           response       prompt
```

```
If a command is not executed successfully
Error: <Error Code> <cr> <lf>
```

```
Prompt:
A prompt always follows after the response. '>' is used as prompt.

Types of Error Code
0x80000481: value of parameter is not valid
0x80000482: the number of parameters is not matched
0x80000484: command does not exist
0x80000486: no permission to execute
```

10.2 User Set Control

You can save the current camera settings to the camera's internal Flash memory. You can also load the camera settings from the camera's internal Flash memory. The camera provides two setups to save and three setups to load settings.

The commands related to User Set Control are as follows.

Configurator Menus	Command	Value	Description
Load Setting	lcf	0: Factory Space	Loads the Factory Default Settings to the camera.
		1: User 1 Space	Loads the User 1 Settings to the camera.
		2: User 2 Space	Loads the User 2 Settings to the camera.
Save Setting	sct	1: User 1 Space	Saves the current settings to User 1 Setting.
		2: User 2 Space	Saves the current settings to User 2 Setting.
Start-Up	sci	0: Factory Setting	Applies the Factory Default Settings when reset.
		1: User 1 Setting	Applies the User 1 Settings when reset.
		2: User 2 Setting	Applies the User 2 Settings when reset.

Table 10.1 Commands 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.

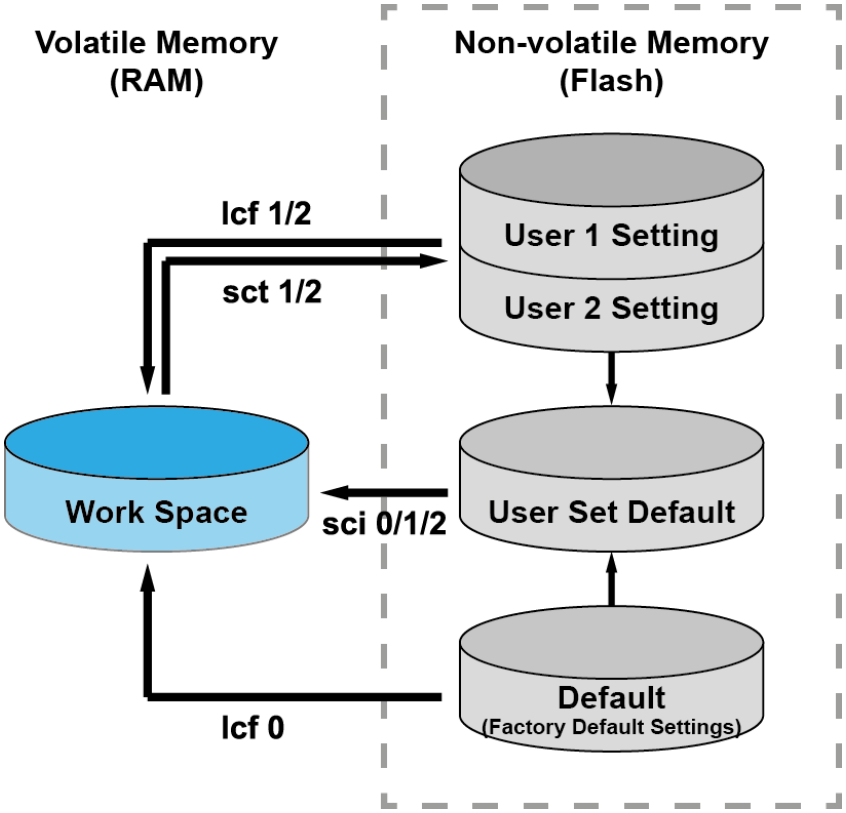


Figure 10.1 User Set Control

10.2.1 Factory Default Setting Values

When you power the camera for the first time on, the factory default setting values will be loaded into the camera and the factory default setting values are as follows:

Configurator Parameters	Value
Operation Mode	TDI
Scan Direction	Forward
TDI Stages	Maximum Integration Stages
Trigger Mode	Off
Test Image	Off
Pixel Format	RGB 8
PRNU Mode	On
DSNU Mode	On
Analog Gain	1×
Digital Gain	1×
Line Rate	35 kHz

Table 10.2 Factory Default Setting Values

10.3 Command List

You can set all features provided by the VTC-2K10.5C camera by using the following commands.

Command Syntax		Return Value	Description
Help	help	String	Displays a list of all commands.
Set Offset X Get Offset X	sox n gox	OK n	X coordinate of start point ROI n: X axis offset
Set Image Width Get Image Width	siw n giw	OK n	Width of ROI, n: Width value • 48 ~ 2160
Set Test Image Get Test Image	sti 0|1|2|3 gti	OK 0|1|2|3	Sets the Test Image. 0: Test Image Off 1, 2: Fixed pattern image 3: Moving pattern image
Set Scan Direction Get Scan Direction	ssd 0|1|2 gsd	OK 0|1|2	Sets the camera's scan direction. 0: Forward 1: Reverse 2: Line 1 (External Port)
Set Data Bit Get Data Bit	sdb 8|10|12|XX gdb	OK 8|10|12	Sets the Pixel Format. 8: RGB 8 bit 10: RGB 10 bit 12: RGB 12 bit 108: BGR 8 bit 110: BGR 10 bit 112: BGR 12 bit
Set TDI Stage Get TDI Stage	std 1|2|3|4 gtd	OK 1|2|3|4	Sets the number of TDI Stages. 1: 20 Stage 2: 40 Stage 3: 60 Stage 4: 80 Stage
Set Line Rate Get Line Rate	slr f glr	OK f	Sets the camera's line rate. f: Line period (μs) <Float>

Table 10.3 Command List #1

Command Syntax		Return Value	Description
Set Exposure Time Get Exposure Time	set n get	OK n	Sets an exposure time (When the Operation Mode is set to Area) n: exposure time in microseconds (μs)
Set Trigger Mode Get Trigger Mode	stm 0|1 gtm	OK 0|1	Sets the Trigger Mode. 0: Free-Run mode 1: Activates the Trigger Mode.
Set Horizontal Flip Get Horizontal Flip	shf 0|1 ghf	OK 0|1	Enables the Reverse X feature. 0: Disables the Reverse X feature. 1: Enables the Reverse X feature.
Set Trigger Source Get Trigger Source	sts 1|5 gts	OK 1|5	Specifies a source signal when the Trigger Mode is set to On. 1: CC1 port (Camera Link) 5: External port (LineIn0)
Set Trigger Activation Get Trigger Activation	sta 0|1|2 gta	OK 0|1|2	Specifies a polarity of trigger when the Trigger Mode is set to On. 0: Falling 1: Rising 2: Both
Set Trigger Rescaler Mode Get Trigger Rescaler Mode	srm 0|1 grm	OK 0|1	Sets the Trigger Rescaler feature. 0: Disables the Trigger Rescaler feature. 1: Enables the Trigger Rescaler feature.
Set Trigger Rescaler Rate Get Trigger Rescaler Rate	srr f grr	OK F	Sets the Trigger Rescale Rate. f: Rescaler rate <Float> (Setting range: 0.010 ~ 100.000)
Set Trigger Rescaler Filter Get Trigger Rescaler Filter	srf 0|1|2|3|4|5 grf	OK 0|1|2|3|4|5	Sets the Trigger Rescaler Noise Filter. 0: 16 1: 32 2: 64 3: 128 4: 256 5: 512
Set Operation Mode Get Operation Mode	som 0|1 gom	OK 0|1	Sets the camera's operation mode. 0: TDI mode 1: Area mode

Table 10.4 Command List #2

Command Syntax		Return Value	Description
Set Strobe Mode Get Strobe Mode	ssm 0|1|2|3 gsm	OK 0|1|2|3	Sets whether to output strobe signals. 0: Off 1: Outputs strobe signals according to the Strobe Duration setting value. 2: Outputs signals of which the width is equal to the trigger signals applied to the camera. 3: Outputs continuous High signals.
Set Strobe Inverter Get Strobe Inverter	ssp 0|1 gsp	OK 0|1	Sets whether to invert strobe signals. 0: Disables the inversion of strobe signals. 1: Enables the inversion of strobe signals.
Set Strobe Delay Get Strobe Delay	sto f gto	OK f	Sets a delay to the strobe signal. f: Strobe out delay (μs) <Float> (Setting range: 0.00 ~ 1000.00 μs)
Set Strobe Duration Get Strobe Duration	ssr f gsr	OK f	Sets a width of the strobe signal in microseconds when the Strobe Mode is set with the ssm 1 command. f: Strobe duration (μs) <Float> (Setting range: 1.00 ~ 1000.00 μs)
Set Analog Gain Get Analog Gain	sag 1|2|3|4 gag	OK 1|2|3|4	Sets the Analog Gain. 1/2/3/4: Analog gain (1×, 2×, 3×, 4×)
Set Digital Gain Get Digital Gain	sdg f gdg	OK f	Sets the Digital Gain. f: Digital gain <Float> (Setting Range: 1.000 ~ 8.000)
Set Black Level Get Black Level	sdbl n gdbl	OK n	Sets the Black Level. n: Black level (Setting Range: -255 ~ 255)
Set RGB Gain Get RGB Gain	srg r|g|b g grg r|g|b	OK g	Sets the intensity of color pixels. r|g|b: Red / Green / Blue pixels g: Gain value (1.0× ~ 3.9×)
Auto White Balance	arg	OK	Automatically adjusts the white balance once.
Set Color Correction Matrix Get Color Correction Matrix	sccm 0 ~ 8 gccm	OK 0 ~ 8	Sets gain factors in the Color Correction matrix. (Setting range: -4.0× ~ 4.0×)

Table 10.5 Command List #3

Command Syntax		Return Value	Description
Generate DSNU Data All	gdda	OK	Generates and saves the DSNU data for each Analog Gain setting values.
Generate DSNU Data	gdd	OK	Generates the DSNU data for the current Analog Gain setting value.
Save DSNU Data	sdd	OK	Saves the generated DSNU data in the non-volatile memory.
Load DSNU Data	ldd	OK	Loads the DSNU data from the non-volatile memory into the volatile memory.
Set DSNU Transform	sdt n1 (n2) v1	OK	Performs additional correction to the PRNU correction values. n1: X coordinate of a start pixel n2: X coordinate of an end pixel v1: Black level value to be added to the specified region (-255 ~ 255)
Set DSNU Coefficient Get DSNU Coefficient	sdc n f1 sdc n1 n2 f1 gdc n1 (n2)	OK f1	Sets or retrieves the DSNU Correction Coefficient. n: X coordinate of a pixel to set n1: X coordinate of a start pixel n2: X coordinate of an end pixel f1: DSNU correction coefficient (Black Level = 0.1 ~ 4095)
Set LUT Select Get LUT Select	sls 0|1 gls	OK 0|1	Sets the LUT feature. 0: Disables the LUT feature. 1: Enables the LUT feature.
Set Camera Link mode Get Camera Link mode	scl 0|1|2|3|4 gcl	OK 0|1|2|3|4	Sets the Camera Link Output mode. 0: 2 Tap 1: 4 Tap 2: 8 Tap 3: 10 Tap 4: 3 Tap

Table 10.6 Command List #4

Command Syntax		Return Value	Description
Set Camera Link Clock Speed Get Camera Link Clock Speed	sccs 0|1|2|3 gccs	OK 0|1|2|3	Sets the Camera Link Pixel Clock. 0: 40 ㎒ 1: 60 ㎒ 2: 80 ㎒ 3: 85 ㎒
Generate PRNU Data	gpd n	OK	Generates the PRNU data. n: Target level (Setting Range: 1 ~ 255, 0: Auto)
Set PRNU Mode Get PRNU Mode	sprnu 0|1 gprnu	OK 0|1	Sets the PRNU Correction feature. 0: Disables the PRNU Correction feature. 1: Enables the PRNU Correction feature.
Save PRNU Data	spd	OK	Saves the PRNU data in the non-volatile memory.
Load PRNU Data	lpd	OK	Loads the PRNU data from the non-volatile memory into the volatile memory.
PRNU Selector	spi 0|1|2|3|4 gpi	OK 0|1|2|3|4	Selects a location to save PRNU data to or load PRNU data from. 0/1/2/3/4: PRNU data storage area
Set PRNU Transform	spt n1 (n2) f1	OK	Performs additional correction to the PRNU correction values. n1: X coordinate of a start pixel n2: X coordinate of an end pixel f1: Gain value to be multiplied to the specified region (0.1 ~10.0)
Set PRNU Coefficient Get PRNU Coefficient	spc n f1 spc n1 n2 f1 gpc n1 (n2)	OK f1	Sets or retrieves the PRNU Correction Coefficient. n: X coordinate of a pixel to set n1: X coordinate of a start pixel n2: X coordinate of an end pixel f1: PRNU correction coefficient (Gain = 0.1 ~10.0)

Table 10.7 Command List #5

Command Syntax		Return Value	Description
Load Config From	lcf 0|1|2	OK	Loads camera setting values to the camera's work space. 0: Loads from Factory space. 1: Loads from User 1 space. 2: Loads from User 2 space.
Save Config To	sct 1|2	OK	Saves the current camera setting values. 1: Saves to User 1 space. 2: Saves to User 2 space.
Set Config Initialization Get Config Initialization	sci 0|1|2 gci	OK 0|1|2	Specifies setting values to be loaded when reset. 0: Applies Factory default settings when reset. 1: Applies User 1 settings when reset. 2: Applies User 2 settings when reset.
Get MCU Version	gmv	String	Displays the version of camera MCU.
Get Model Number	gmn	String	Displays camera model name.
Get FPGA Version	gfv	String	Displays the version of camera FPGA.
Get Serial Number	gsn piece	String	Displays the serial number of the camera.
Get Current Temperature	gct	String	Displays device temperature in Celsius.
Reset	rst	-	Resets the camera.

Table 10.8 Command List #6

11 Configurator GUI

Configurator, a sample application, is provided to control the VTC-2K10.5C camera. Configurator provides easy-to-use Graphic User Interface (GUI) that allows users to view and change the camera's settings mentioned in the previous chapters.

11.1 Camera Scan

When you execute the Configurator.exe file while the camera is powered on, the **Camera Scan** window appears as shown in the figure below. At this time, the Configurator checks serial ports of your computer and DLL provided by the Camera Link to scan whether a camera is connected. If the Configurator finds a connected camera, it displays the model name of the camera on the Camera Scan window. If the camera is not displayed on the window, check the cable connections and power of the camera, and then press the **refresh** button. Double-clicking the model name of the camera displayed on the window will launch the Configurator and display the current parameter settings of the camera connected.

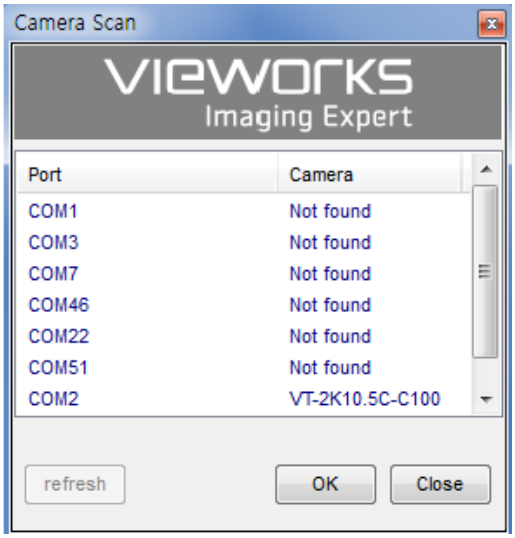


Figure 11.1 Configurator Loading Window

11.2 Menu

The menu bar of the Configurator provides the File, Start-Up, Tool and About menus.

11.2.1 File

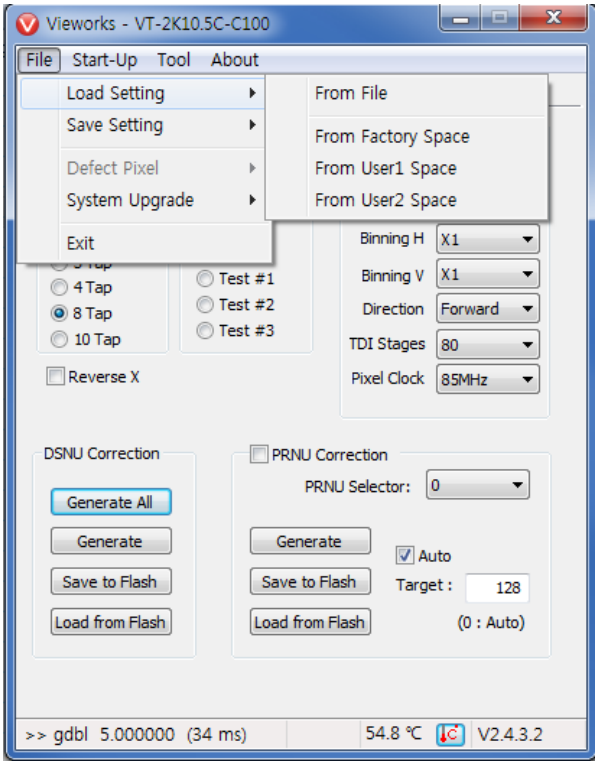


Figure 11.2 File Menu

- **Load Setting:** Loads the camera setting values from the camera memory (Factory, User1 or User2) or user's computer (File).
- **Save Setting:** Saves the camera setting values to the camera memory (User1 or User2) or user's computer (File).
- **System Upgrade:** Upgrades the MCU or FPGA logic.
- **Exit**: Exits the Configurator.

11.2.2 Start-Up

The Start-Up menu allows you to select the camera setting values to be loaded when the camera is powered on.

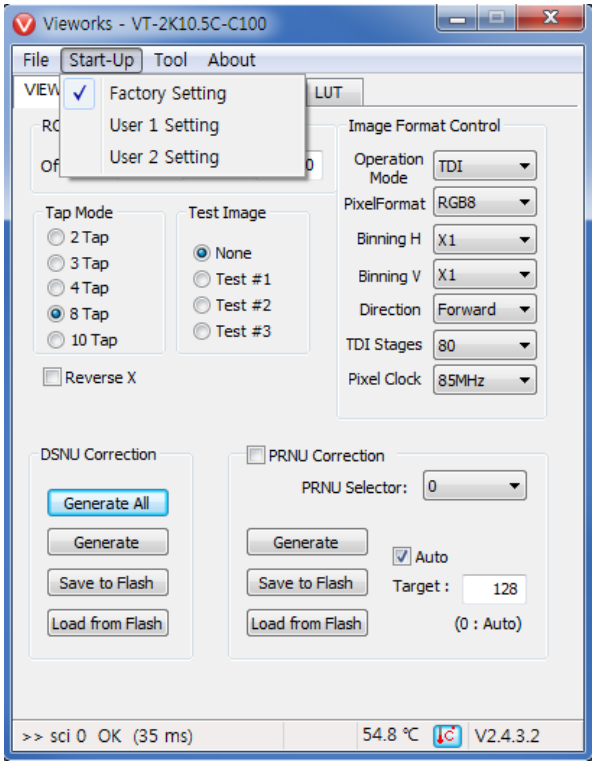


Figure 11.3 Start-Up Menu

- **Factory Setting:** Loads the camera setting values from the Factory space when the camera is powered on.
- **User 1 Setting:** Loads the camera setting values from the User1 space when the camera is powered on.
- **User 2 Setting:** Loads the camera setting values from the User2 space when the camera is powered on.

11.2.3 Tool

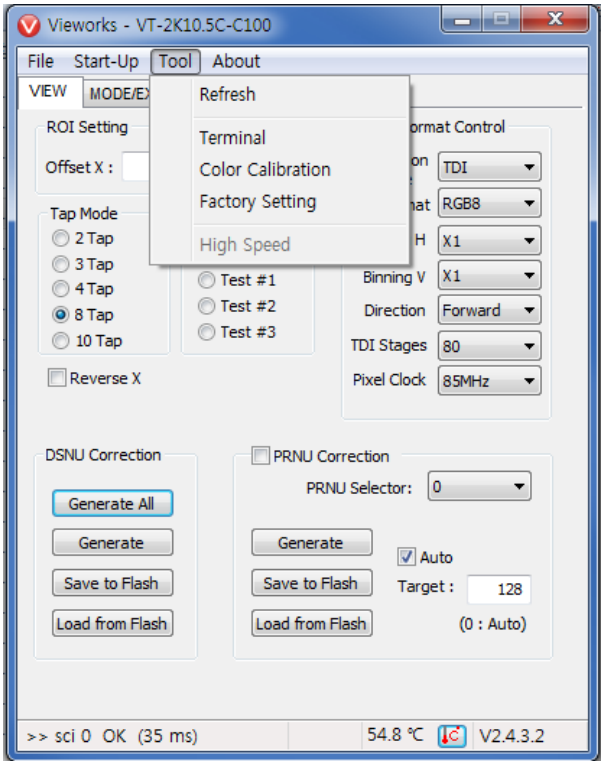


Figure 11.4 Tool Menu

- **Refresh:** Loads and displays the current camera setting values on the Configurator.
- **Terminal:** Displays the Terminal window. The Terminal window displays a user command for the feature that you have set on the Configurator. To hide the Terminal window, uncheck Terminal by clicking it again.
- **Color Calibration:** Displays the window for adjusting the white balance. When you click the **Auto White Balance** button, the white balance is adjusted once and then Off.

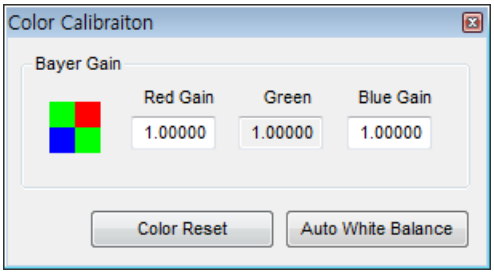


Figure 11.5 Color Calibration

- **Factory Setting:** Not supported for users.
- **High Speed:** Not supported in the Configurator.

11.2.4 About

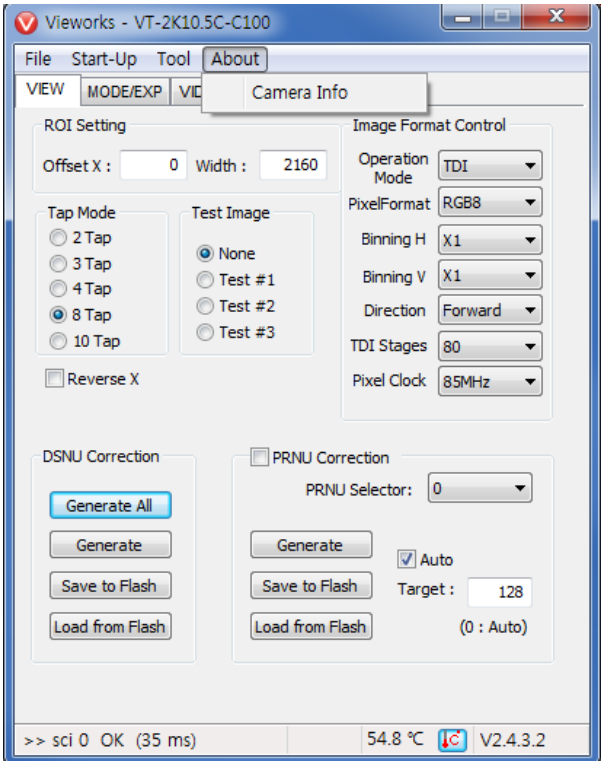


Figure 11.6 About Menu

- **Camera Info:** Displays camera information (model name, serial number, version, etc.).

11.3 Tab

11.3.1 VIEW Tab

The VIEW tab allows you to set the camera's region of interest (ROI), Camera Link output mode, test image mode, operation mode, pixel format, scan direction, TDI stage, DSNU, PRNU features, etc.

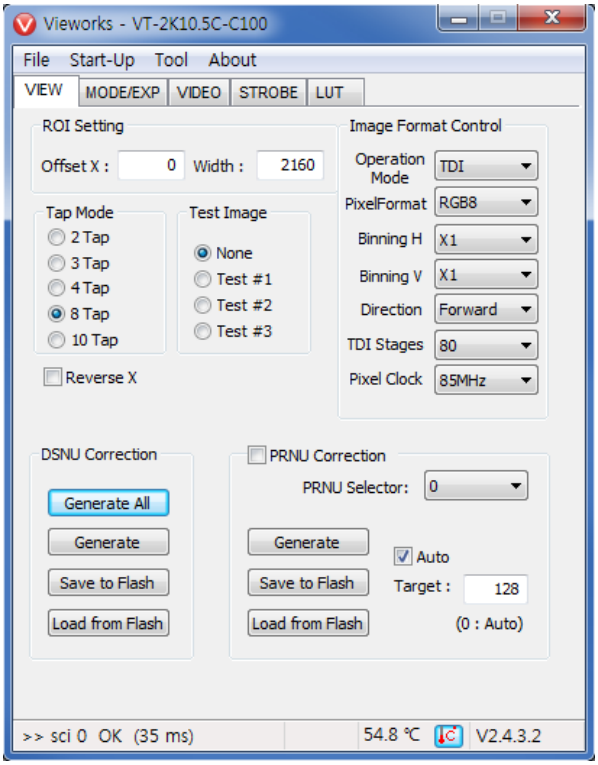


Figure 11.7 VIEW Tab

- **ROI Setting**: Sets the camera's ROI by using the Offset X and Width input boxes.
- **Tap Mode**: Selects a Camera Link output mode.
- **Test Image**: Selects whether to apply test image and a type of test images.
- **Reverse X**: Sets the Reverse X feature to On or Off.
- **Image Format Control**: Sets the Operation Mode, Pixel Format, Scan Direction, TDI Stages and Camera Link Pixel Clock.
- **DSNU Correction**: Sets the DSNU Correction feature.
- **PRNU Correction**: Sets the PRNU Correction feature.

11.3.2 MODE/EXP Tab

The MODE/EXP tab allows you to configure the camera's trigger mode, line rate, exposure time, trigger rescaler and trigger statistics.

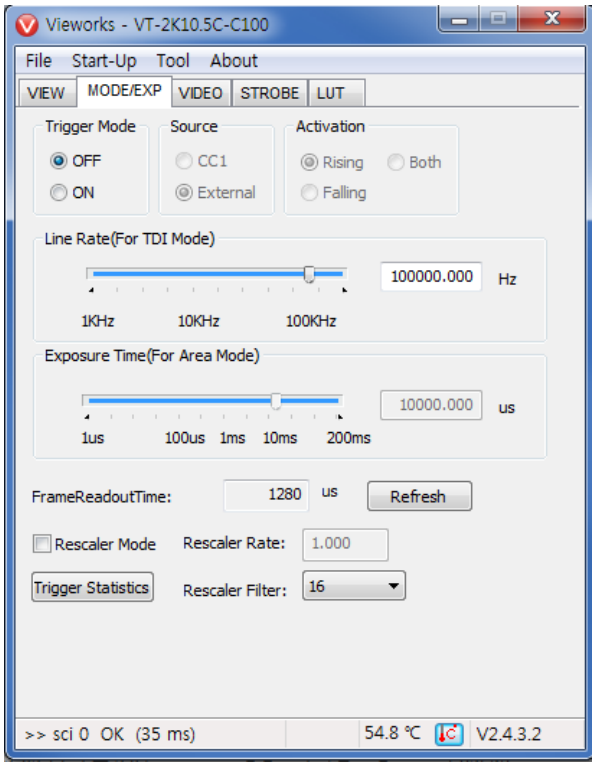


Figure 11.8 MODE/EXP Tab

- **Trigger Mode**: Sets the trigger mode.
- **Source**: Selects a source signal for triggering.
- **Activation**: Selects a polarity of trigger signals.
- **Line Rate**: Sets the camera's line rate when the Operation Mode is set to TDI and the Trigger Mode is set to Off.
- **Exposure Time**: Sets the camera's exposure time when the Operation Mode is set to Area and the Trigger Mode is set to Off.
- **Rescaler Mode**: Sets the Trigger Rescaler mode.
- **Trigger Statistics**: Determines the trigger signals applied to the camera and then converted by the Trigger Rescaler.

11.3.3 VIDEO Tab

The VIDEO tab allows you to adjust the camera's gain and black level settings.

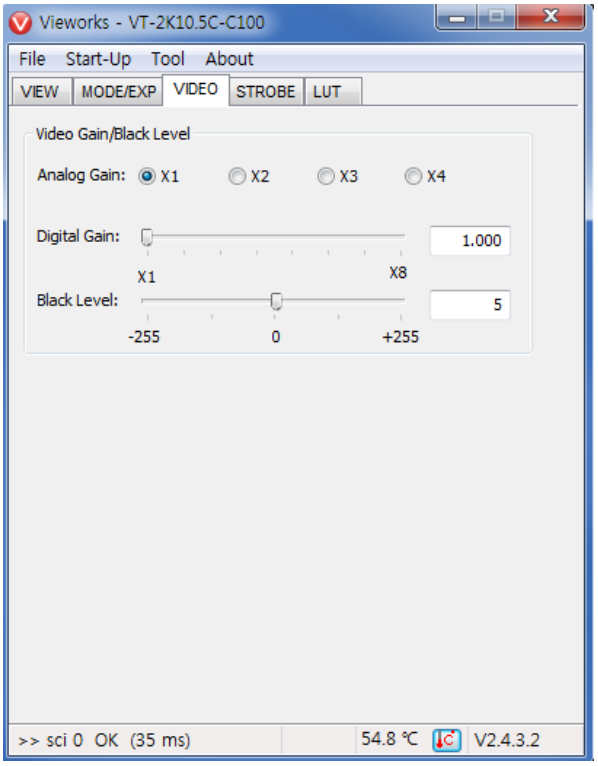


Figure 11.9 VIDEO Tab

- **Analog Gain**: Sets an analog gain value.
- **Digital Gain**: Sets a digital gain value.
- **Black Level**: Sets a black level value.

11.3.4 STROBE Tab

The STROBE tab allows you to set the camera's strobe output signals or dedicated strobe controller (The Strobe Controller category will be activated when a dedicated strobe controller is connected.).

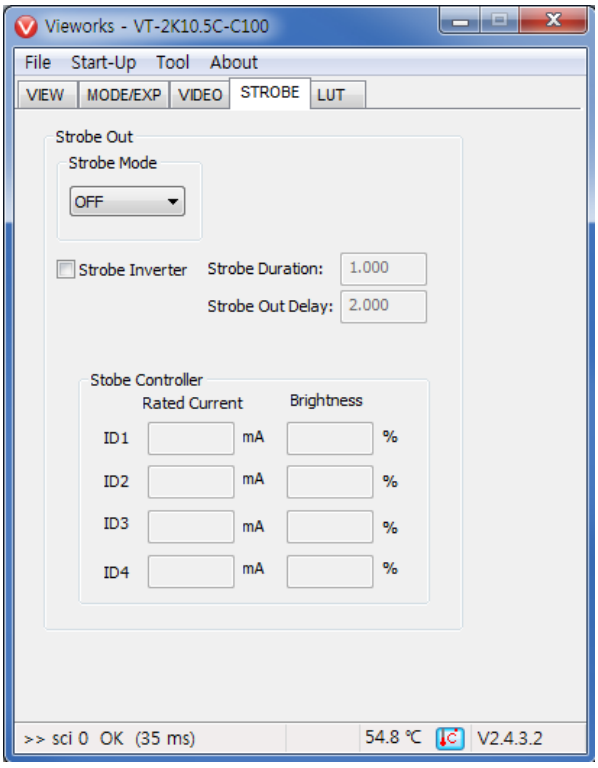


Figure 11.10 STROBE Tab

- **Strobe Mode:** Sets the Strobe Mode.
- **Strobe Inverter:** Inverts the output signal.
- **Strobe Duration:** Sets a duration of the pulse signal in microseconds when the Strobe Mode is set to Timed.
- **Strobe Out Delay:** Sets a delay to the current output signal in microseconds.
- **Rated Current:** Sets a rated current of the LED light when a dedicated strobe controller is connected.
- **Brightness:** Sets the brightness of the LED light when a dedicated strobe controller is connected.

11.3.5 LUT Tab

The LUT tab allows you to download LUT data. For more information about LUT download, refer to Appendix B.

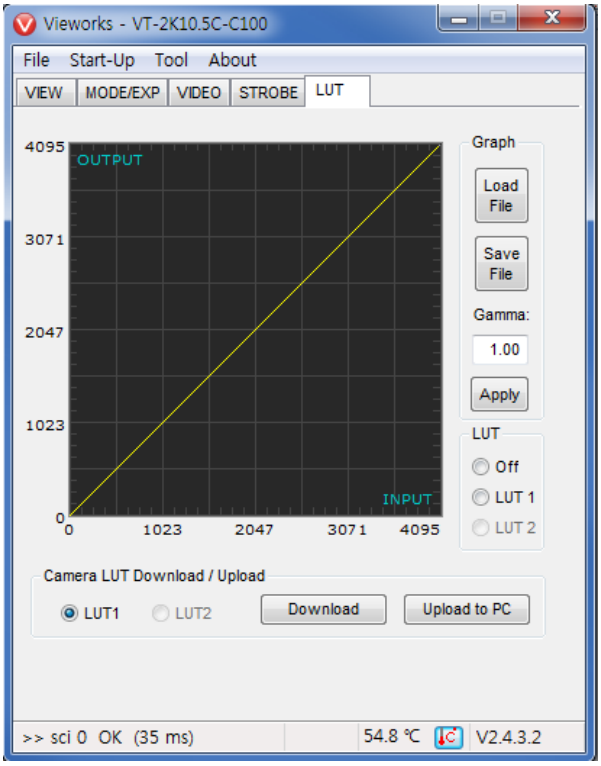


Figure 11.11 LUT Tab

- **Graph:** Loads LUT data from user's computer or sets a Gamma value to be applied when using a Gamma curve.
- **Camera LUT Download / Upload:** Downloads LUT data stored in user's computer to the camera (Download) or uploads LUT data stored in the camera to user's computer (Upload to PC).

12 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 line rate is set properly.
  - Check the aperture is opened properly.
  - Check the digital gain value is not set to small.

- 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.

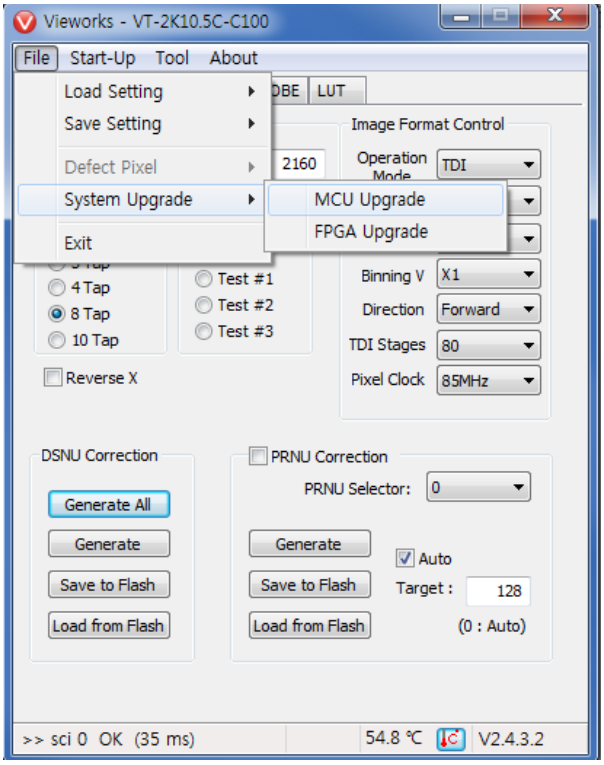
- If you have a problem using the Trigger Mode,
  - Ensure that parameter settings on your Frame Grabber are configured correctly when you operate the camera with CC1 trigger signals.
  - Ensure that cable connections are secure when you operate the camera with external trigger signals.

- If there is a communication failure between the camera and user's computer,
  - Ensure that the Camera Link cable connections are secure.
  - Ensure that you have configured a frame grabber in your computer and the camera is connected to the frame grabber correctly.

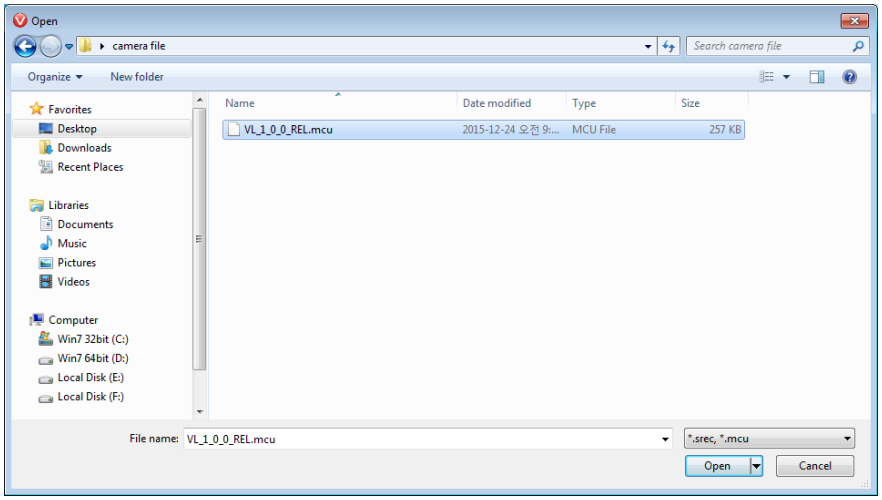
Appendix A Field Upgrade

A.1 MCU

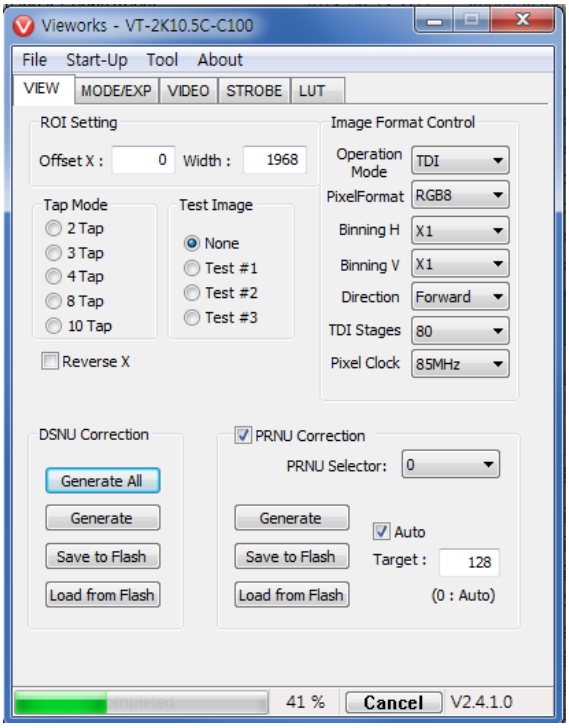
1. Select **File** > **System Upgrade** > **MCU Upgrade** in the Configurator.



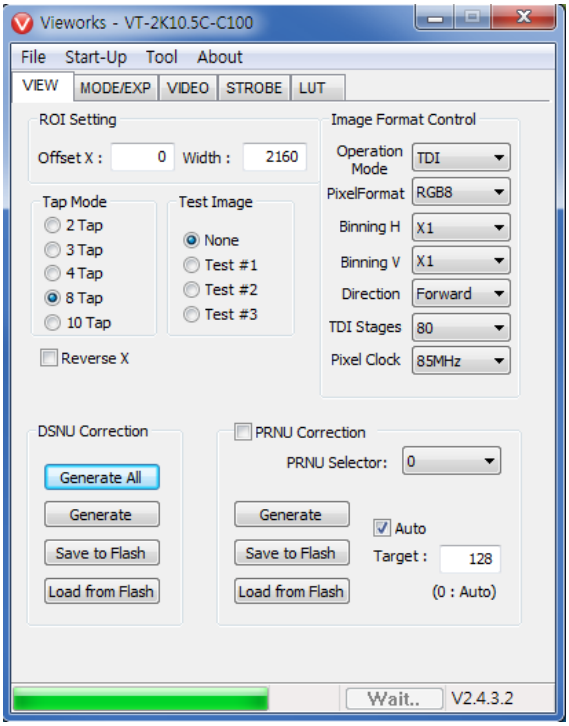
2. Search and select the provided MCU upgrade file and click **Open**.



3. The Configurator starts downloading MCU upgrade file to the camera and downloading status is displayed at the bottom of the window. This process may require several minutes to complete. If you want to cancel the upgrade process, click **Cancel**.



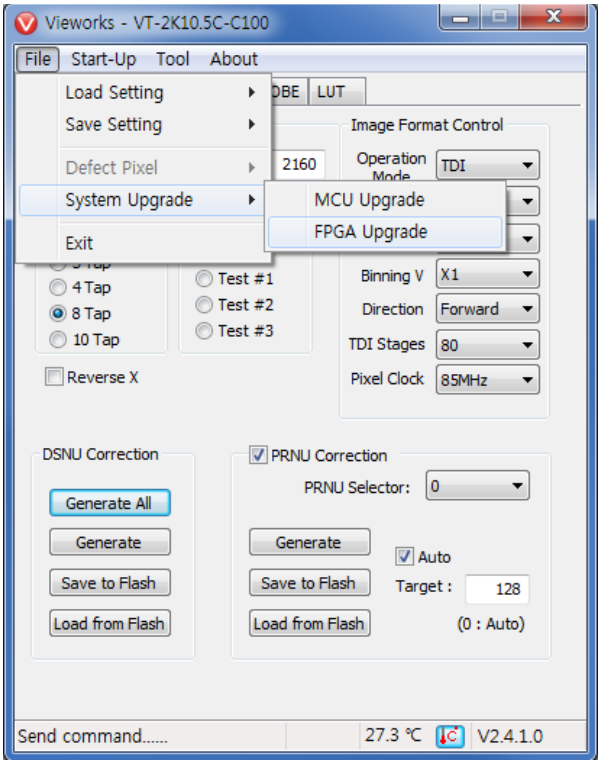
4. Once the download is complete, the saving process will begin. If a power failure occurs during the saving process, the camera cannot be restored. Make sure that the power connection is secure.



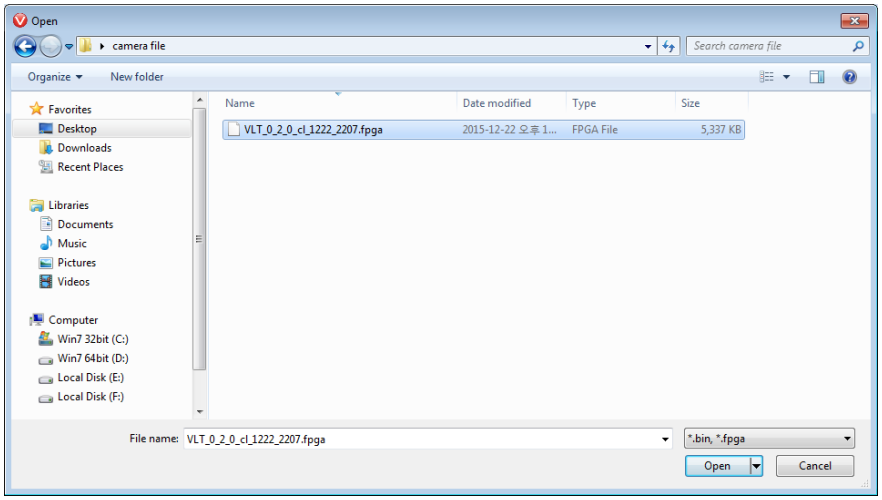
5. Once all the processes are complete, turn the camera power off and turn it back on again. Select **Tool** > **Terminal** and enter the ‘gmv' command to confirm the version. Or select **About** > **Camera Info** to confirm the MCU version.

A.2 FPGA

1. Select **File** > **System Upgrade** > **FPGA Upgrade** in the Configurator.



2. Search and select the provided FPGA upgrade file and click **Open**.



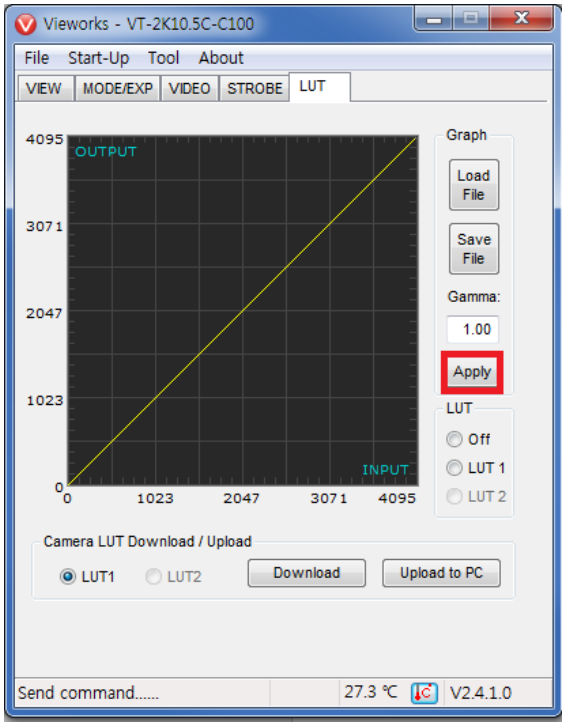
3. The subsequent processes are identical to those of MCU upgrade.

Appendix B LUT Download

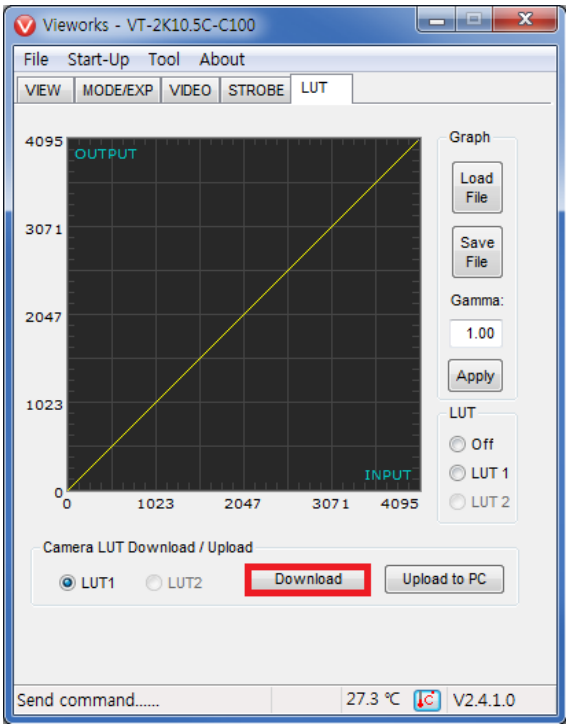
You can create LUT data in two different ways; by adjusting the gamma values on the gamma graph provided in the program and then downloading the data or by opening a CSV file (*.csv) and then downloading the data.

B.1 Gamma Graph Download

1. Set a gamma value in the LUT tab and click the **Apply** button.



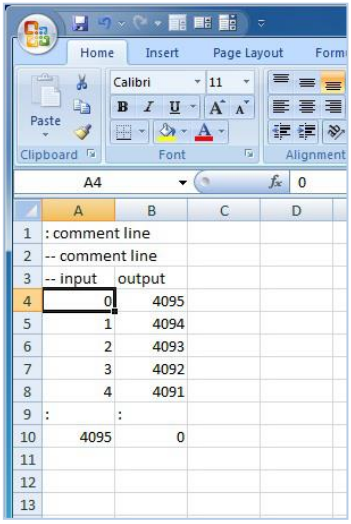
2. Click the **Download** button to download the gamma values to the camera.

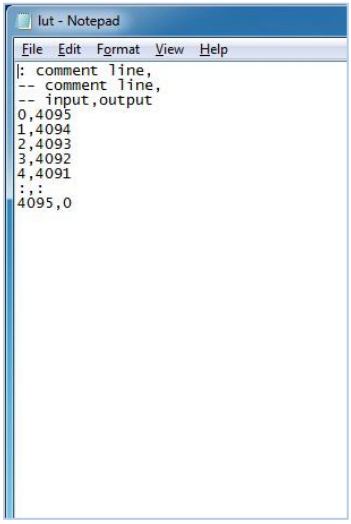


3. Once the download is complete, the **Download completed** message will appear at the bottom of the window.

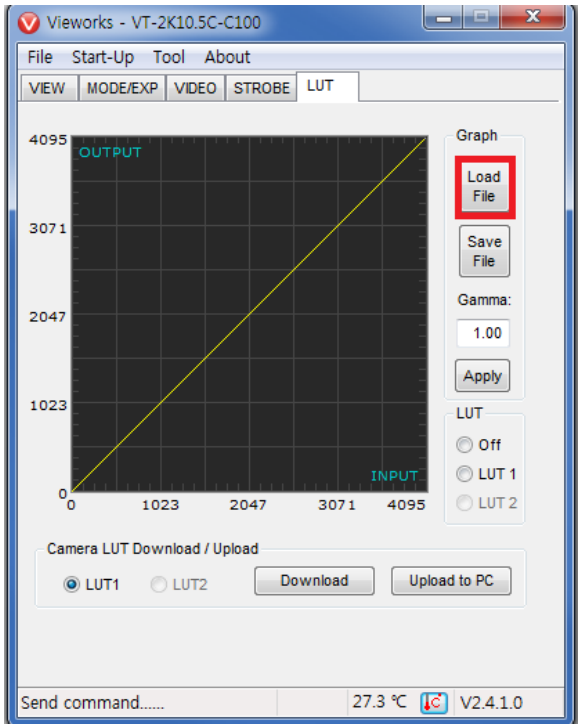
B.2 CSV File Download

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

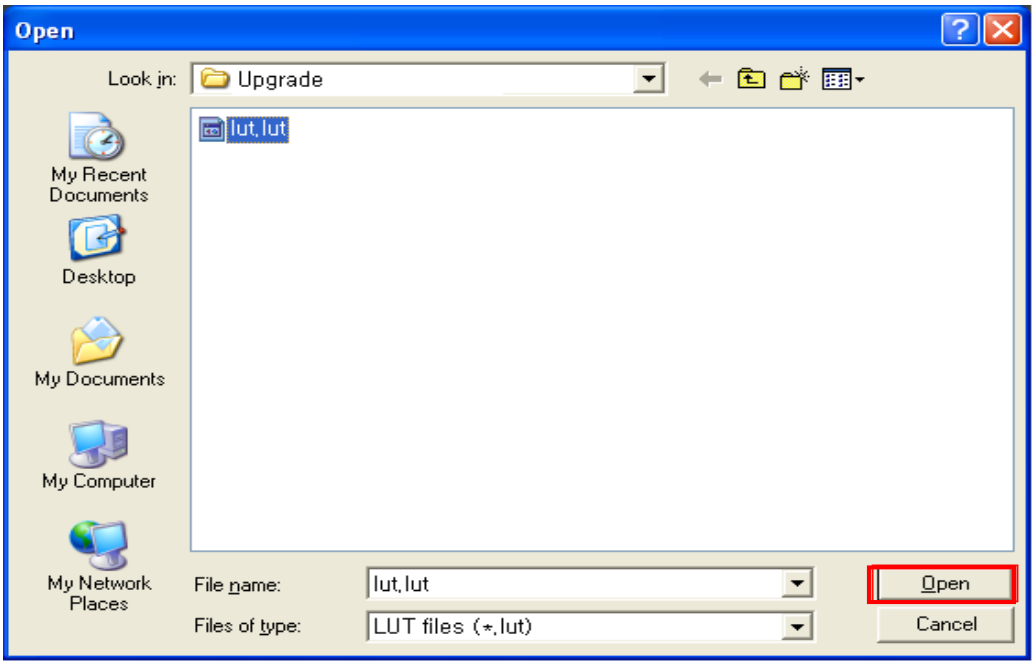




2. In the **LUT** tab, select **Luminance** from the **Type** dropdown list, and then click the **Load File** button.



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



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

Appendix C Correction Control

The VTC-2K10.5C camera provides an additional feature to adjust DSNU or PRNU correction values after the DSNU or PRNU Correction feature is enabled. You can specify a pixel or region of the sensor and the pixel information from the specified portion will be adjusted according to the DSNU or PRNU coefficient value.

The commands related to the additional DSNU Correction are as follows.

sdt Xstart Xend Black Level ex. sdt 100 109 -2

Command Syntax	Description
sdt	Applies the additional DSNU correction value to the specified region of the sensor.
Xstart	X coordinate of a start pixel
Xend	X coordinate of an end pixel (If you specify a pixel, you can leave this value blank.)
Black Level	Sets an additional DSNU coefficient value [Black Level value to be added to the specified region (DN, digital number)]

Table C.1 Command related to Additional DSNU Correction

For more details on how to save or load DSNU correction values, refer to 9.10 Dark Signal Non-uniformity Correction.

The commands related to the additional PRNU Correction are as follows.

spt Xstart Xend Gain ex. spt 100 109 1.1

Command Syntax	Description
spt	Applies the additional PRNU correction value to the specified region of the sensor.
Xstart	X coordinate of a start pixel
Xend	X coordinate of an end pixel (If you specify a pixel, you can leave this value blank.)
Gain	Sets an additional PRNU coefficient value (Gain value to be multiplied to the specified region)

Table C.2 Commands related to Additional PRNU Correction

For more details on how to save or load PRNU correction values, refer to 9.11 Photo Response Non-uniformity Correction.

C.1 Adjusting and Saving Additional DSNU Correction Value

For example, if you want to apply -2 black level from the 100th pixel to the 109th pixel, follow the procedures below.

1. Click **Tool** > **Terminal** in the Configurator.
2. Input the **sdt 99 108 -2** command into the Terminal input box.
3. Execute the **sdd** command to save the additional DSNU correction values in the camera's Flash (non-volatile) memory. In this case, the previous DSNU values for the current Analog Gain setting value saved in the memory will be overwritten.
   To ignore the adjusted DSNU correction values and load the existing values in the Flash memory, execute the **ldd** command.

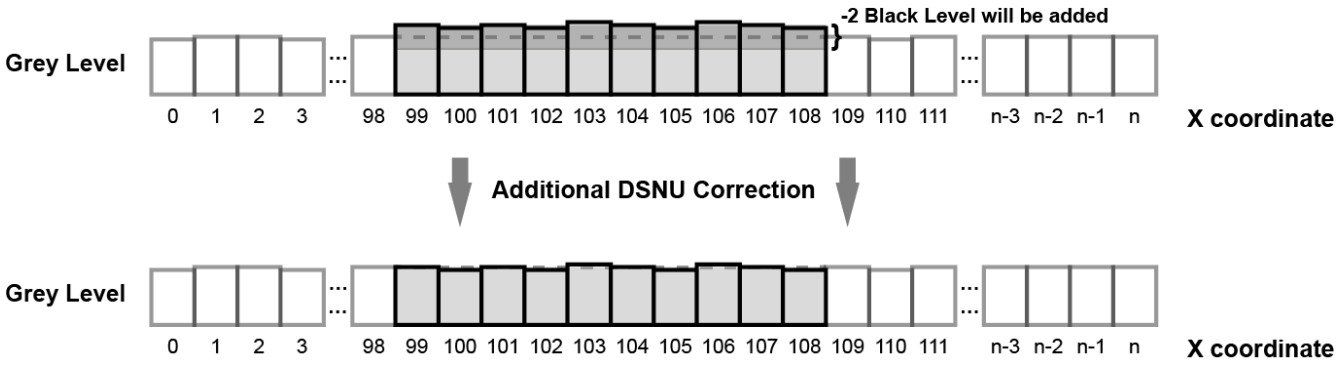


Figure C.1 Additional DSNU Correction

C.2 Adjusting and Saving Additional PRNU Correction Value

For example, if you want to apply 1.1× gain from the 100th pixel to the 109th pixel, follow the procedures below.

1. Click **Tool** > **Terminal** in the Configurator.
2. Input the **spt 99 108 1.1** command into the Terminal input box.
3. Specify a location to save by using the **spi *0/1/2/3/4*** command and execute the **spd** command to save the additional PRNU correction values in the camera's Flash (non-volatile) memory. The existing values in the Flash memory will be overwritten.
   To ignore the adjusted PRNU correction values and load the existing values in the Flash memory, specify a location to load from by using the **spi *0/1/2/3/4*** command and execute the **lpd** command.

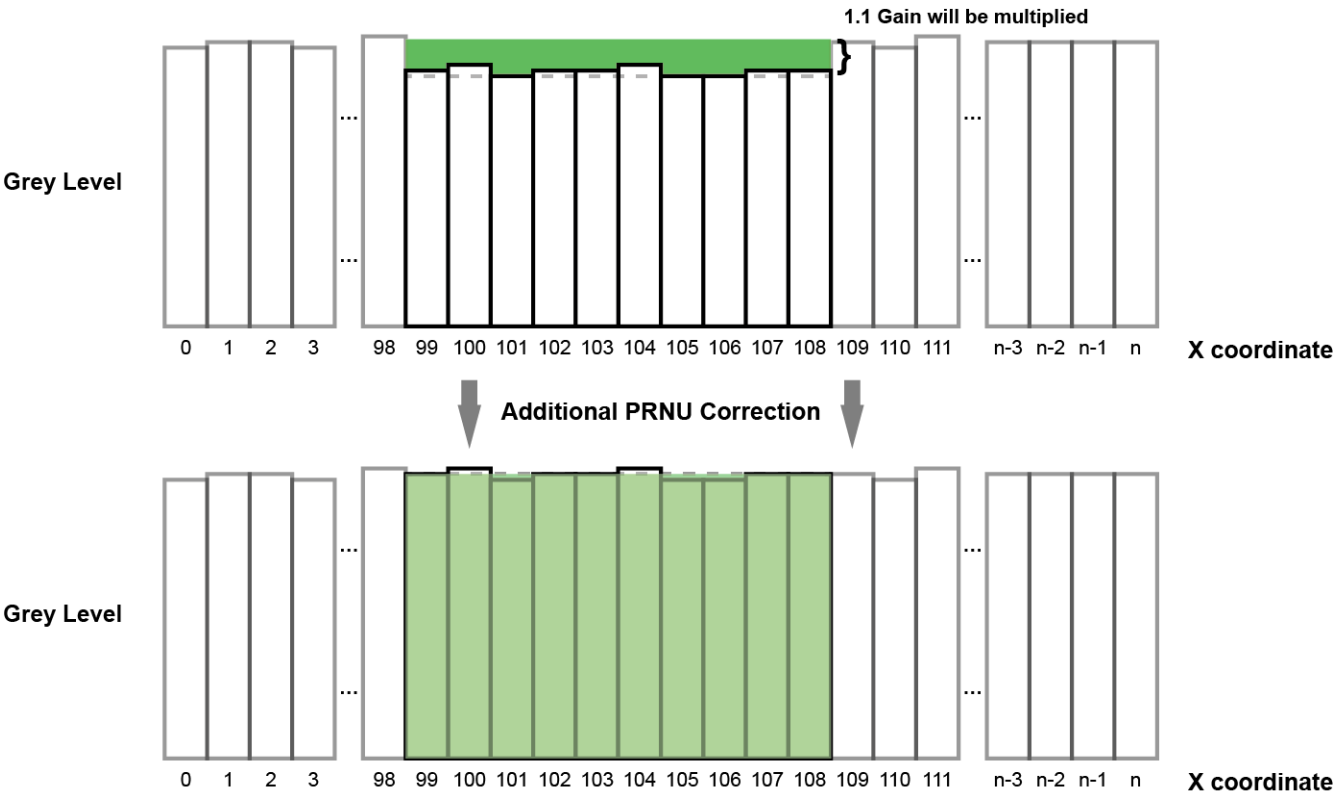
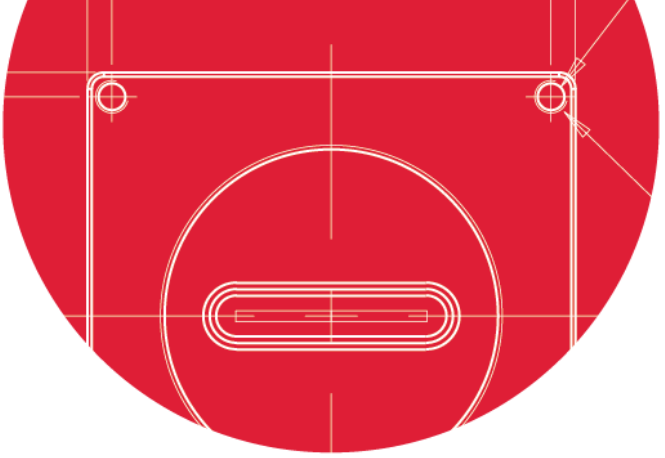
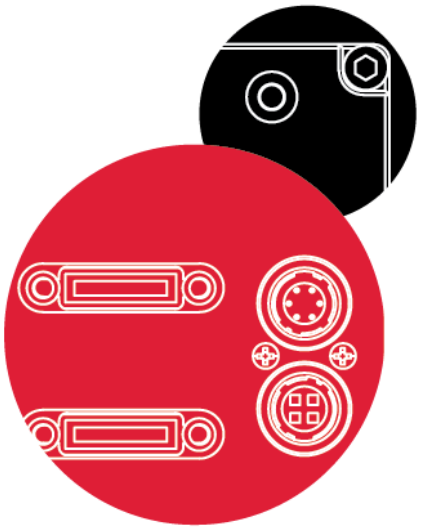
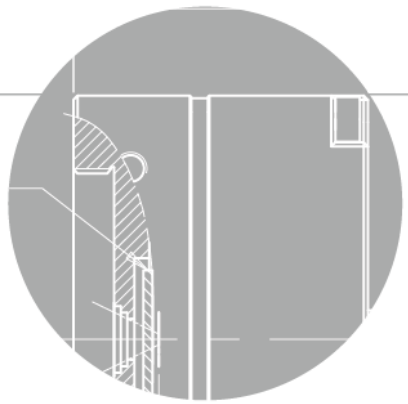


Figure C.2 Additional PRNU Correction

Before executing the **spt** command, if you set the **PRNU Mode** to **On** by using the **sprnu** command, you can determine the adjusted PRNU correction values in the acquired line images.







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