

# BU Series CCD Camera

---

## Instruction Manual

Model

B/W Camera : BU030 / BU031 / BU080 / BU130

Color Camera : BU030C / BU030CF / BU130C / BU130CF

Thank you for purchasing our product.

Before using this CCD camera, please read through this instruction manual carefully in order to use this product correctly and safely.

After reading, keep this instruction manual handy so that you can refer to, whenever you need it.

# Toshiba Teli Corporation

Information contained in this document is subject to change without prior notice.

D4213050K

# Contents

Safety Precautions.....	1
General Handling.....	2
CASES FOR INDEMNITY (LIMITED WARRANTY).....	4
RESTRICTION FOR USE .....	5
Notes on using this product .....	6
Installation .....	10
Specifications.....	11
Overview .....	11
Features.....	11
Configuration .....	14
Connection.....	15
Connector Pin Assignment .....	16
Outline Drawing .....	17
General Specifications .....	18
LED status .....	21
I/O Specification.....	22
Timing Specification.....	24
Typical Spectral Response .....	26
Operating Ambient Conditions.....	30
Functions .....	32
Bootstrap Registers .....	34
DeviceControl .....	35
ImageFormatControl.....	36
Scalable .....	37
Binning .....	39
PixelFormat.....	41
TestPattern.....	42
AcquisitionControl.....	44
TriggerControl .....	46
ExposureTime.....	50
DigitalIOControl.....	51
TimerControl .....	54
Gain .....	56
BlackLevel.....	57
Gamma .....	58
BalanceRatio .....	59
BalanceWhiteAuto .....	61
ColorCorrectionMatrix.....	62
LUTControl.....	64
UserSetControl .....	65
EventControl .....	67
FrameSynchronization.....	70
LEDIndicatorLuminance .....	71
AntiGlitch / AntiChattering.....	72
Appendix.....	74
MultiFrame and Bulk function difference .....	74
Warranty rules .....	77
Repair .....	78

# Safety Precautions

Before using this product, read these safety precautions carefully. Important information is shown in this Instruction Manual to protect users from bodily injuries and property damages, and to enable them to use the product safely and correctly.

Please be sure to thoroughly understand the meanings of the following signs and symbols before reading the main text that follow, and observe the instructions given herein.

[Definition of Safety Signs]

Safety Signs	Description
 WARNING	Indicates a potentially hazardous situation that may result in death or serious injury (*1) in the event of improper handling.
 CAUTION	Indicates a potentially hazardous situation that may result in light to moderate injuries (*2) or only in property damage (*3) in the event of improper handling.

Notes \*1: "Serious injury" refers to cases of loss of eyesight, wounds, burns (high or low temperature), electric shock, broken bones, poisoning, etc., which leave after-effects or which require hospitalization or a long period of outpatient treatment of cure.

\*2: "Light to moderate injuries" refers to injuries, burns, electric shock etc. that do not require hospitalization or long-term treatment.

\*3: "Property damage" refers to cases of extensive damage involving damage to buildings, equipment, farm animals, pet animals and other belongings.

[Explanation of Safety Symbols]

Safety Symbols	Description
 PROHIBITED	This sign indicates <b>PROHIBITION</b> (Do not). The content of prohibition is shown by a picture or words beside the symbol.
 MANDATORY	This sign indicates <b>MANDATORY ACTION</b> (You are required to do). The content of action is shown by a picture or words beside the symbol.

# General Handling

## **WARNING**



Unplug

- **Stop operation immediately when any abnormality or defect occurs.**

If abnormal conditions are present, such as smoke, a burning smell, ingress of water or foreign matter, or if the equipment is dropped or malfunctions, fire or electric shock may result.

Be always sure to disconnect the power cable from the wall socket at once and contact your dealer.



Do not get wet

- **Do not use the equipment in locations subject to water splashes.**

Otherwise, fire or electric shock may result.



Never pull apart

- **Do not disassemble, repair, or modify the equipment.**

Otherwise, fire or electric shock may result.

For internal repair, inspection, or cleaning, contact your sales representative.



Avoid

- **Do not place anything on the equipment.**

If metallic objects, liquid, or other foreign matter enters the equipment, fire or electric shock may result.



Avoid

- **Do not install the equipment in an unstable or inclined location or locations subject to vibration or impact.**

Otherwise, the equipment may topple over and cause personal injury.



Do not touch

- **During an electrical storm, do not touch the power cable and the connection cable.**

Otherwise, an electric shock may result.



Instruction

- **Use the specified voltage.**

Use of an unspecified voltage may result in fire or electric shock.



Avoid

- **Do not be handled roughly, damaged, fabricated, bent forcefully, pulled, twisted, bundled, placed under heavy objects or heated the power cable and the connection cable.**

Otherwise, fire or electric shock may result.

---

# CAUTION

---



Instruction

- **Observe the following when installing the equipment:**

- Do not cover the equipment with a cloth, etc.
- Do not place the equipment in a narrow location where heat is likely to accumulate. Otherwise, heat will accumulate inside the equipment, possibly resulting in a fire.



Avoid

- **Do not place the equipment in locations subject to high moisture, oil fumes, steam, or dust.**

Otherwise, fire or electric shock may result.



Avoid

- **Do not install the equipment in locations exposed to direct sunlight or humidity.**

Otherwise, the internal temperature of the equipment will rise, which may cause a fire.



Instruction

- **Use only specified the power cable and the connection cables.**

Otherwise, fire or electric shock may result.



Avoid

- **Do not give strong impact against the equipment.**

It may cause the trouble.



Instruction

- **When performing connection, turn off power.**

When connecting the power cable and the connection cable, turn off the equipment power. Otherwise, fire or electric shock may result.



Avoid

- **Do not expose its camera head to any intensive light (such as direct sunlight).**

Otherwise, its inner image pickup device might get damaged.



Avoid

- **Avoid short-circuiting signal output.**

Otherwise, a malfunction may occur.



Avoid

- **Avoid giving a strong shock against the camera body.**

It might cause a breakdown or damage. If your camera is used in a system where its camera connector is subjected to strong repetitive shocks, its camera connector is possible to break down. If you intend to use your camera in such a situation, if possible, bundle and fix a camera cable in the place near the camera, and do not transmit a shock to the camera connector.



Instruction

- **Contact your sales representative to request periodic inspection and cleaning (every approx five years).**

Accumulation of dust inside the equipment may result in fire or electric shock. For inspection and cleaning costs, contact your sales representative.

# CASES FOR INDEMNITY (LIMITED WARRANTY)

We shall be exempted from taking responsibility and held harmless for damage or losses incurred by the user in the following cases.

- In the case damage or losses are caused by natural disasters, such as an earthquake and thunder, fire, or other acts of God, acts by a third party, deliberate or accidental misuse by the user, or use under extreme operating conditions.
- In the case of indirect, additional, consequential damages (loss of business interests, suspension of business activities) are incurred as result of malfunction or non-function of the equipment, we shall be exempted from responsibility for such damages.
- In the case damage or losses are caused by failure to observe the information contained in the instructions in this instruction manual and specifications.
- In the case damage or losses are caused by use contrary to the instructions in this instruction manual and specifications.
- In the case damage or losses are caused by malfunction or other problems resulting from unintended use of equipment or software etc. that are not specified.
- In the case damage or losses are caused by repair or modification conducted by the customer or any unauthorized third party (such as an unauthorized service representative).
- Expenses we bear on this product shall be limited to the individual price of the product.
- The item that is not described in specifications of this product is out of the guarantee.
- The case of damages or losses which are caused by incorrect connection of the cable is out of the guarantee.

# RESTRICTION FOR USE

- Should the equipment be used in the following conditions or environments, give consideration to safety measures and inform us of such usage:
  1. Use of the equipment in the conditions or environment contrary to those specified, or use outdoors.
  2. Use of the equipment in applications expected to cause potential hazard to people or property, which require special safety measures to be adopted.
  
- This product can be used under diverse operating conditions. Determination of applicability of equipment or devices concerned shall be determined after analysis or testing as necessary by the designer of such equipment or devices, or personnel related to the specifications. Such designer or personnel shall assure the performance and safety of the equipment or devices.
  
- This product is not designed or manufactured to be used for control of equipment directly concerned with human life (\*1) or equipment relating to maintenance of public services/functions involving factors of safety (\*2). Therefore, the product shall not be used for such applications.
  - (\*1): Equipment directly concerned with human life refers to.
    - Medical equipment such as life-support systems, equipment for operating theaters.
    - Exhaust control equipment for exhaust gases such as toxic fumes or smoke.
    - Equipment mandatory to be installed by various laws and regulations such as the Fire Act or Building Standard Law
    - Equipment related to the above
  - (\*2): Equipment relating to maintenance of public services/functions involving factors of safety refers to.
    - Traffic control systems for air transportation, railways, roads, or marine transportation
    - Equipment for nuclear power generation
    - Equipment related to the above

# Notes on using this product

- Handle carefully

Do not drop the equipment or allow it to be subject to strong impact or vibration, as such action may cause malfunctions. Further, do not damage the connection cable, since this may cause wire breakage.

- Environmental operating conditions

Do not use the product in locations where the ambient temperature or humidity exceeds the specifications.

Otherwise, image quality may be degraded or internal components may be adversely affected. In particular, do not use the product in areas exposed to direct sunlight. Moreover, during shooting under high temperatures, vertical stripes or white spots (noise) may be produced, depending on the subject or camera conditions (such as increased gain). However, such phenomena are not malfunctions.

- Check a combination with the lens

Depending on the lens and lighting you use, an image is reflected as a ghost in the imaging area. However, this is not because of a fault of the camera.

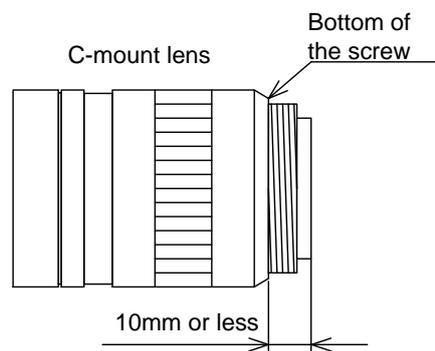
In addition, depending on the lens you use, the performance of the camera may not be brought out fully due to deterioration in resolution and brightness in the peripheral area, aberration and others.

Be sure to check a combination with the camera by using the lens and lightning you actually use.

When installing a lens in the camera, make sure carefully that it is not tilted.

In addition, use a mounting screw free from defects and dirt. Otherwise, the camera may be unable to be removed.

Install a next lens; its dimension of protrusion from bottom of the screw is equal to or less than 10 mm. If a lens does not stand to this condition, it might not be installed to this camera.



- Mounting to pedestal

When mounting this product to a pedestal, make sure carefully that lens doesn't touch with the pedestal.

- Do not shoot under intense light

Avoid intense light such as spot lights on part of the screen because it may cause blooming or smears. If intense light falls on the screen, vertical stripes may appear on the screen, but this is not a malfunction.

- Do not expose the camera's image-pickup-plane to sunlight or other intense light directly  
Its inner CCD (charge-coupled device) might be damaged.
- Occurrence of moiré  
If you shoot thin stripe patterns, moiré patterns (interference fringes) may appear. This is not a malfunction.
- Occurrence of noise on the screen  
If an intense magnetic or electromagnetic field is generated near the camera or connection cable, noise may be generated on the screen. If this occurs, move the camera or the cable.
- Handling of the protective cap  
If the camera is not in use, attach the lens cap to the camera to protect the image pickup surface.
- If the equipment is not to be used for a long duration  
Turn off power to the camera for safety.
- Maintenance  
Turn off power to the equipment and wipe it with a dry cloth.  
If it becomes severely contaminated, gently wipe the affected areas with a soft cloth dampened with diluted neutral detergent. Never use alcohol, benzene, thinner, or other chemicals because such chemicals may damage or discolor the paint and indications.  
If the image pickup surface becomes dusty, contaminated, or scratched, consult your sales representative.

- Disposal

When disposing of the camera, it may be necessary to disassemble it into separate parts, in accordance with the laws and regulations of your country and/or municipality concerning environmental contamination.

**Following information is only for EU-member states:**

The use of the symbol indicates that this product may not be treated as household waste. By ensuring this product is disposed of correctly, you will help prevent potential negative consequences for the environment and human health, which could otherwise be caused by inappropriate waste handling of this product. For more detailed information about the take-back and recycling of this product, please contact your supplier where you purchased the product.



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 communication.

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.



中华人民共和国  
环保使用期限

环保使用期限标识，是根据电子信息产品污染控制管理办法以及，电子信息产品污染控制标识要求(SJ/T11364-2014)、电子信息产品环保使用期限通则，制定的适用于中国境内销售的电子信息产品的标识。

电子信息产品只要按照安全及使用说明内容，正常使用情况下，从生产月期算起，在此期限内，产品中含有的有毒有害物质不致发生外泄或突变，不致对环境造成严重污染或对其人身、财产造成严重损害。

产品正常使用后，要废弃在环保使用年限内或者刚到年限的产品时，请根据国家标准采取适当的方法进行处置。

另外，此期限不同于质量/功能的保证期限。

The Mark and Information are applicable for People's Republic of China only.

<产品中有毒有害物质或元素的名称及含量>

部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr (VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
相机本体	×	○	○	○	○	○

「本表格依据SJ/T 11364的规定编制」

○：表示该有毒有害物质在该部件所有均质材料中的含量均在电子信息产品中有毒有害物质的限量要求标准规定的限量要求(GB/T26572)以下

×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出电子信息产品中有毒有害物质的限量要求标准规定的限量要求(GB/T26572)

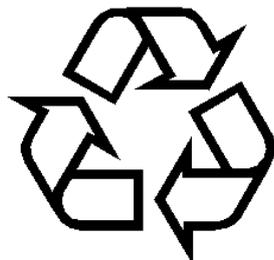
This information is applicable for People's Republic of China only.

リサイクルに関する情報（包装物）

有关再利用的信息(包装物)

Information on recycling of wrapping composition

箱 / 箱子 / Box



ペーパーボード  
纸板  
Paper board

内部緩衝材料・袋

内部缓冲材料・袋

Internal buffer materials・Bag



PE-LD

# Installation

Before using this product, you shall install application software to display image and control registers of camera, and IP configuration tool for network setting.

You can download the SDK for our USB camera products (TeliCamSDK) from the Service & Support section of our website.

User registration is necessary to use downloading service. Please make a user registration, or contact your sales representative.

- TOSHIBA TELI CORPORATION Top Page  
<http://www.toshiba-teli.co.jp/en/>
- Service & Support  
<https://www.toshiba-teli.co.jp/cgi/ss/en/service.cgi>

Please refer to the TeliCamSDK startup guide, about Operation environment, Installation, and Setup.

# Specifications

## Overview

This camera series is an integrated-(one-body)-type camera that adopts all pixel data readout inter line CCD. There are BU030 (VGA: 1/3 type), BU031 (VGA: 1/2 type), BU080 (XGA: 1/3 type), and BU130 (SXGA: 1/3 type). Suffix [C] is attached to the color models. For video output and camera control, the USB 3.0 interface standard is adopted for high transfer rate, and it is easy to integrate into industrial equipment.

## Features

- High frame rate and high resolution

Supporting high frame rate, BU030 VGA 125fps, BU031 VGA 125fps, BU080 XGA 40fps, BU130 SXGA 30fps.

- All pixel readout

All pixel signals (in the effective area) are output in one frame processing.

- Full frame shutter

Since all pixels are output even in Random Trigger Shutter operation, high resolution can be achieved, without deteriorating the vertical resolution.

- Square grids

The CCD pixels arrayed in square grids facilitates computation for image processing.

- USB\*3 interface

Video output and camera control are performed via the USB 3.0 standard interface. Data transfer is up to 5Gbps (Maximum) that enables to output uncompressed video data at high frame rate.

- USB3 Vision\*

This product is based on USB3 Vision Ver.1.0.

- GenICam\* Ver 2.3

This product is based on GenICam Generic Interface for Cameras Ver 2.3.

- IIDC2 Digital Camera Control Specification Ver.1.0.0

This product is based on IIDC2 Digital Camera Control Specification Ver.1.0.0.

- e-CON\* Connector adoption

The e-CON connector adoption enables to assemble the cable easily without using special tools.

- Random Trigger Shutter

The Random Trigger Shutter function provides images in any timing by input of an external trigger signal. Trigger control from PC is available as well.

- Scalable

Selectable video output area. This mode achieves higher frame rate by reducing vertical output area. And reduces occupied data rate of USB bus by reducing horizontal output area.

- Binning mode

B/W models have binning mode. In this mode, pixel data is combined by vertical and horizontal. Vertical binning mode achieves high frame rate

- Color processing

Color models have built in color processing. There are RGB, BGR, YUV 4:2:2, YUV 4:1:1, Bayer and Mono output modes.

- IR-cut filter

Build-in IR-cut filter models are optional for color models.

Suffix [F] is attached to the model name of built-in IR-cut filter model. (e.g. BU030CF, BU130CF)

\* Suffix [F] is not shown in the common part of specifications.

- Compact and lightweight

This camera is compact and lightweight; it is easy to integrate into industrial equipment.

- EU RoHS & Chinese ROHS

- \* USB is a unified standard established by USB-IF(USB Implementers Forum).
- \* USB3 Vision is a unified standard established by AIA (Automated Imaging Association).
- \*GenICam is a registered trademark of EMVA (European Machine Vision Association).
- \* IIDC2 is a unified standard established by JIIA (Japan Industrial Association).
- \*e-CON (Easy & Economy connector) is a sensor connector that is normalized by the manufacturer of the sensor, FA equipment and connector.

# Configuration

The system configuration of this camera series is as follows;

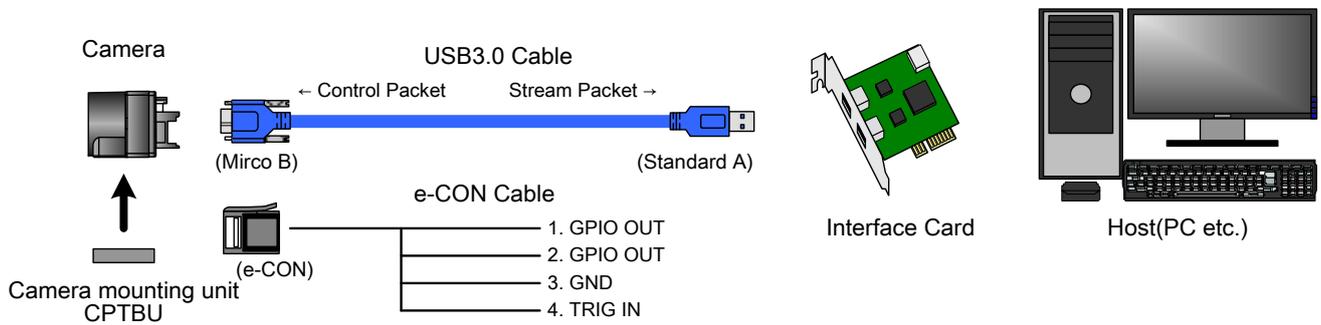
This camera has no accessories, please prepare other equipments separately.

- Camera: This product. (BU)
- Camera mounting kit CPTBU (\*1): To fix a camera to a tripod; attach this to the bottom of the camera.
- USB3.0 Cable (\*2): This cable is used to connect the camera to host PC. Please use a USB3.0 cable of Standard A - Micro B. This product is able to connect a USB cable equipped with screw lock mechanism. Please use it as needed.
- USB3.0 Interface Card (\*2): This is the interface card to connect to the camera. Usually this card is installed to expansion slot of PC etc.
- e-CON Cable. (\*2): This cable is used to input external trigger signal and output GPIO signal.  
We recommend using shielded cable, because there is likely to be affected by the noise depending on the operating environment of the camera.

\*1: Optional part. Contact your sales representative for details of option units.

\*2: Commercial items.

# Connection

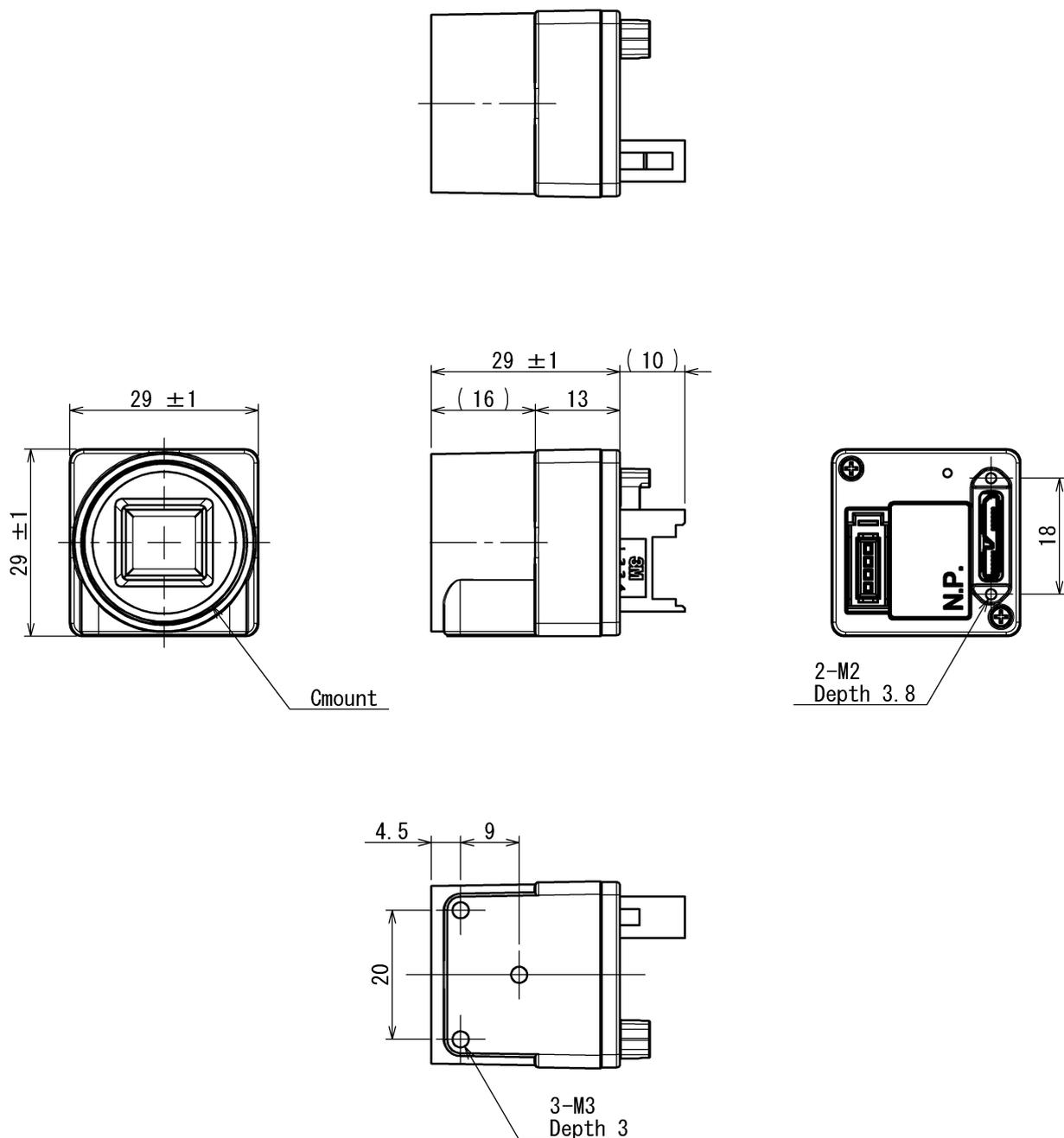


## **Notes on Connection:**

- Please confirm the power supply of the camera off when plugging in or pulling out the I/O Connector. It causes the breakdown.
- If your camera is used in a system where its connectors are subjected to strong repetitive shocks, its connectors are possible to break down. If you use your camera in such a situation, use an USB3.0 cable with a lock screw, and secure the camera cable as close as possible to the camera body for avoid physical shock to the camera connector.
- About e-CON cable: In the case that electric-wire is long or thin, input and output voltage may not satisfy specifications of the camera or your system by voltage drop. Please confirm wires' specifications before use them.
- Lost packets may occur by an electrical characteristic of the transmission line of USB3.0. (USB3.0 Interface Card, USB3.0 Cable, and USB3.0 HUB).



# Outline Drawing



## Specification

Main material : Aluminum die-cast metal  
Processing : Cation coating (black)

# General Specifications

- B/W model

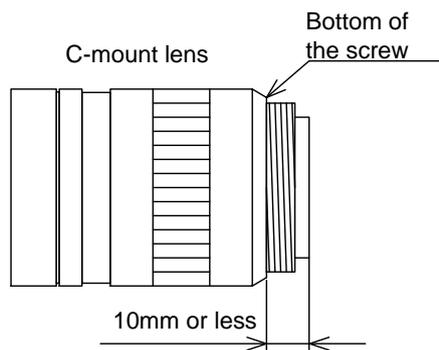
Model Name	BU030	BU031	BU080	BU130
Imager	All-pixel-data-readout interline transfer CCD			
Number of total pixels (H) × (V)	692 × 504	692 × 504	1077 × 788	1348 × 976
Number of effective pixels (H) × (V)	659 × 494	659 × 494	1034 × 779	1296 × 966
Optical Size	1/3 type	1/2 type	1/3 type	1/3 type
Scanning area (H) × (V)[mm]	4.88 × 3.66	6.52 × 4.89	4.81 × 3.62	4.86 × 3.62
Pixel size (H) × (V)[μm]	7.4 × 7.4	9.9 × 9.9	4.65 × 4.65	3.75 × 3.75
Scan method	Non-interlace			
Electronic shutter method	Global shutter			
Aspect ratio	4: 3			
Standard subject illuminance	1700lx (F5.6, 1/125s)	1700lx (F5.6, 1/125s)	1700lx (F5.6, 1/40s)	1300lx (F8, 1/30s)
Minimum subject illuminance	F1.4, Gain: Maximum (+18dB), video level: 50%			
	7lx	7lx	7lx	3lx
Power supply	DC +5V±5% (from USB connector)			
Power consumption (at the all pixel readout)	2.6W (maximum)			
Base clock frequency	50.000MHz ±100ppm	50.000MHz ±100ppm	45.000MHz ±100ppm	50.000MHz ±100ppm
Interface	USB 3.0 (Only SuperSpeed is supported)			
Transmission speed	5Gbps (Maximum)			
Protocol	USB3 Vision			
Image format	Mono 8 bit, Mono 10bit			
Number of Video out pixels (H) × (V)	640 × 480	640 × 480	1024 × 768	1280 × 960
Maximum Frame rate (at the all pixel readout)	125 fps	125 fps	40 fps	30 fps
Dimensions	29 mm(W) × 29 mm (H) × 13 mm (D) (Not including protrusion)			
Mass	Approximately 27g			
Lens mount	C-mount			
Flange back	17.526mm			
Camera body grounding: insulation status	No conductive between circuit GND and camera body			

● Color model

Model Name		
Without IR-cut filter	BU030C	BU130C
With IR-cut filter	BU030CF	BU130CF
Imager	All-pixel-data-readout interline transfer CCD	
Number of total pixels (H) × (V)	692 × 504	1348 × 976
Number of effective pixels (H) × (V)	659 × 494	1296 × 966
Optical Size	1/3 type	1/3 type
Scanning area (H) × (V)[mm]	4.88 × 3.66	4.86 × 3.62
Pixel size (H) × (V)[μm]	7.4 × 7.4	3.75 × 3.75
Scan method	Non-interlace	
Electronic shutter method	Global shutter	
Aspect ratio	4: 3	
Standard subject illuminance		
Without IR-cut filter	3500lx, F5.6, 1/125s	1250lx, F5.6, 1/30s
With IR-cut filter	4200lx, F5.6, 1/125s	1500lx, F5.6, 1/30s
Minimum subject illuminance	F1.4, Gain +18dB, Video level 50%	
Without IR-cut filter	14lx	5lx
With IR-cut filter	17lx	6lx
Power supply	DC +5V±5% (from USB connector)	
Power consumption (at the all pixel readout)	2.7W (maximum)	
Base clock frequency	50.000MHz ±100ppm	50.000MHz ±100ppm
Interface	USB 3.0 (Only SuperSpeed is supported)	
Transmission speed	5Gbps (Maximum)	
Protocol	USB3 Vision	
Image format	RGB 8, BGR 8, YUV411, YUV422, Bayer 8, Bayer 10, Mono 8	
Number of Video out pixels (H) × (V)	640 × 480	1280 × 960
Maximum Frame rate (at the all pixel readout)	125 fps	30 fps
Dimensions	29 mm(W) × 29 mm (H) × 13 mm (D) (Not including protrusion)	
Mass	Approximately 27g	
Lens mount	C-mount	
Flange back	17.526mm	
Camera body grounding: insulation status	No conductive between circuit GND and camera body	

### **Notes on combination of C-mount lens:**

- Depending on the lens you use, the performance of the camera may not be brought out fully due to the deterioration in resolution and brightness in the peripheral area, occurrence of a ghost, aberration and others. When you check the combination between the lens and camera, be sure to use the lens you actually use.
- In addition, use a mounting screw free from defects and dirt. Otherwise, the camera may be unable to be removed.
- As for the C-mount lens used combining this camera, the projection distance from bottom of the screw should use 10mm or less.



### **Notes on Dropping Frames:**

Depends on your PC and USB3.0 interface card configurations, images may not be captured properly (e.g. dropping frames). In this case, change frame rate setting lower.

# LED status

Camera state	Lamp indication
No power	Off
Link detection in progress	Fast flash green (ON:20ms, OFF:60ms)
Connection Error	Flash alternate red / green
SuperSpeed connected, but no data being transferred	Flash green (ON: 200ms, OFF: 800ms)
SuperSpeed connected, waiting for trigger	Flash orange (ON: 200ms, OFF: 800ms)
HighSpeed connected, but no data being transferred	Slow flash green (ON: 400ms, OFF: 1600ms)
HighSpeed connected, waiting for trigger	Slow flash orange (ON: 400ms, OFF: 1600ms)
Data being transferred	Solid Green
Error during data transfer	Solid Red (Time period: 500ms)
Stand-by	Super slow flash orange (ON:200ms, OFF: 2800ms)

# I/O Specification

- Signal Specification

- Trigger Input

Input Circuit : LVTTTL  
Level : Low 0 ~ 0.5V, High 2.0 ~ 24.0V  
Polarity : High active / Low active (initial factory setting: Low active)  
Pulse Width : Minimum 50µs

**Notes of external trigger signal:**

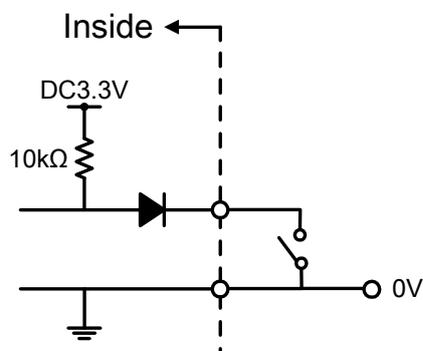
Depending on cable length, cable kinds and input current of trigger input line, Random Trigger Shutter operation may not satisfy timing specification or camera

- GPIO Output

Output Circuit : 5V CMOS  
Maximum Current: +/-32mA  
Polarity : High active / Low active (initial factory setting: Low active)  
Signal Source : TIMER0 ACTIVE  
USER OUTPUT  
EXPOSURE ACTIVE  
FRAME ACTIVE  
FRAME TRANSFER  
FRAME TRIGGER WAIT

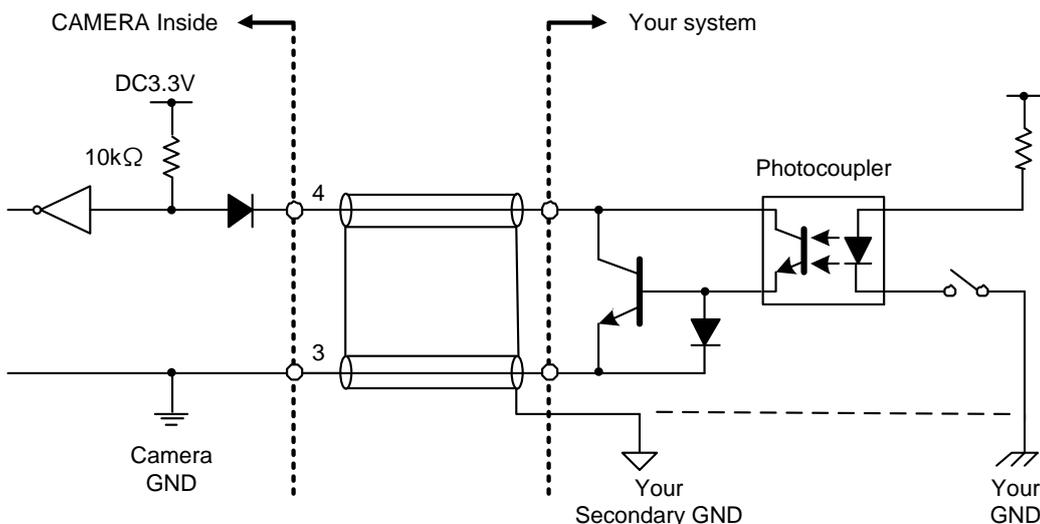
- Circuit diagram

- Trigger Input

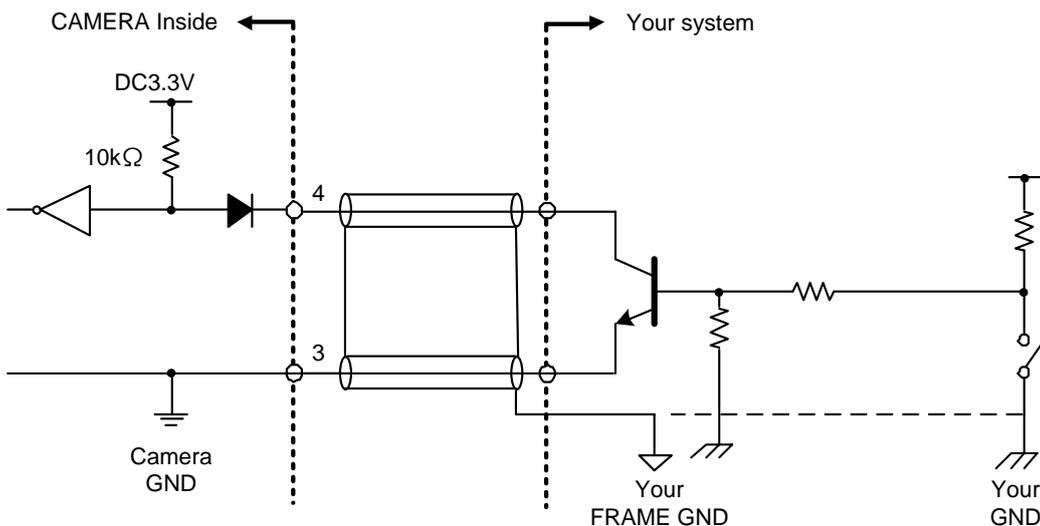


• External trigger input recommended circuit

- Isolated I/F



- Non-Isolated I/F



**Notes of trigger input cable:**

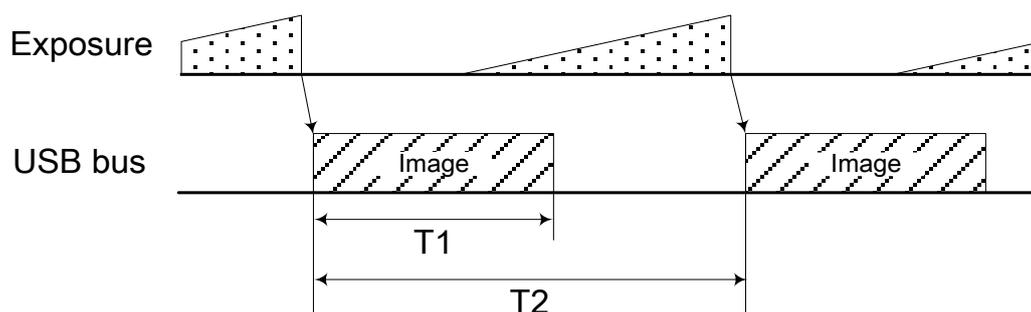
- The recognition of the trigger signal depends on the length, characteristic or driving current of the cable. Therefore please confirm your system about those conditions.
- Pin 3 is signal ground. It isn't conducted with camera frame.  
Using shield cable, terminal processing of the shield is referred as above.
- Please confirm the EMC adaptability in whole of your system.

# Timing Specification

Image data outputs are transferred with USB bulk transfer. Timing numerical value below is described by absolute prerequisite that camera can use transmission band without restriction of other device. When there is other device on the same bus, the value described below is not guaranteed.

- In normal shutter mode

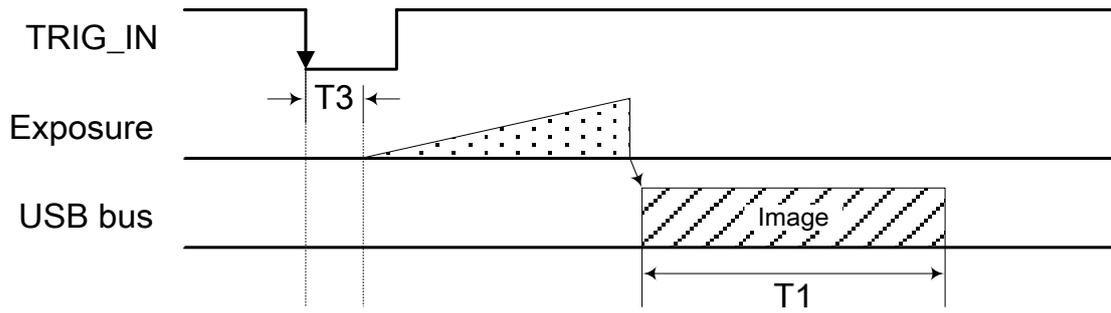
Video format Mono 8, all pixel readout



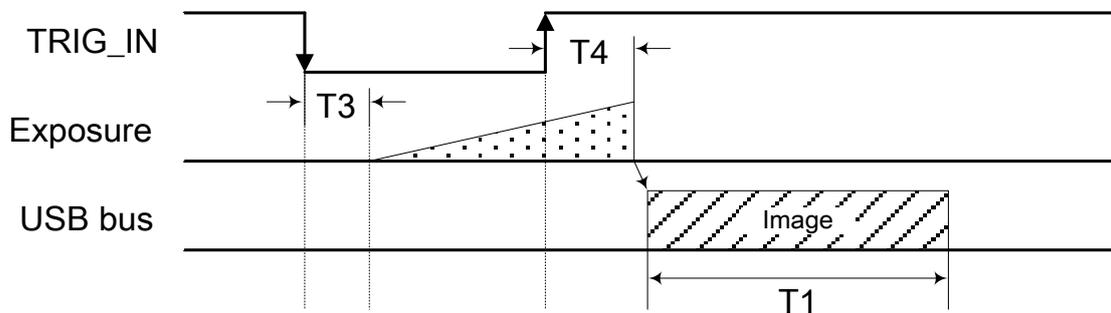
Model	T1 [ms]	T2 [ms]	Default Framerate [ms]
BU030	7.8	Frame Rate setting by the application.	8.0
BU031	7.8		8.0
BU080	25.0		25.0
BU130	33.3		33.3
BU030C	7.8		8.0
BU130C	33.3		33.3

\* If the value of T2 is not set by the application, it will be the same as T1.

• In Random Trigger Shutter mode



Edge mode (Image format: Mono 8, all pixel readout)



Level mode (Image format: Mono 8, all pixel readout)

Model	T3 [ $\mu$ s]	T4 [ $\mu$ s]
BU030	1.0	2.5
BU031	1.0	2.5
BU080	2.2	34.0
BU130	1.2	7.1
BU030C	1.0	2.5
BU130C	1.2	7.1

\* T1 is the same value as the normal shutter mode.

\* T3 and T4 are typical value.

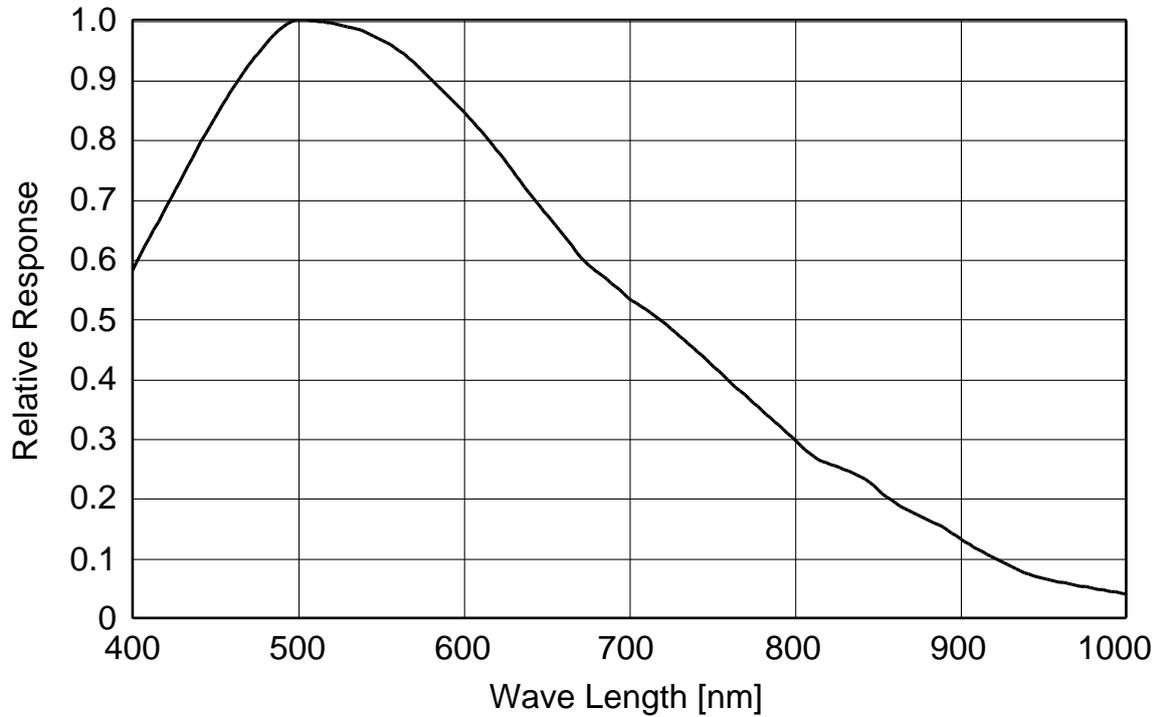
**Notes of random trigger shutter mode:**

- In the period when FRAME\_TRIGGER\_WAIT (GPIO signal) is inactive, user must not input external trigger signal to this camera.
- When the interval of the input trigger signal is extremely short, or when the trigger signal is noisy, there is a possibility of causing the malfunction. In this case, please input a proper trigger signal.

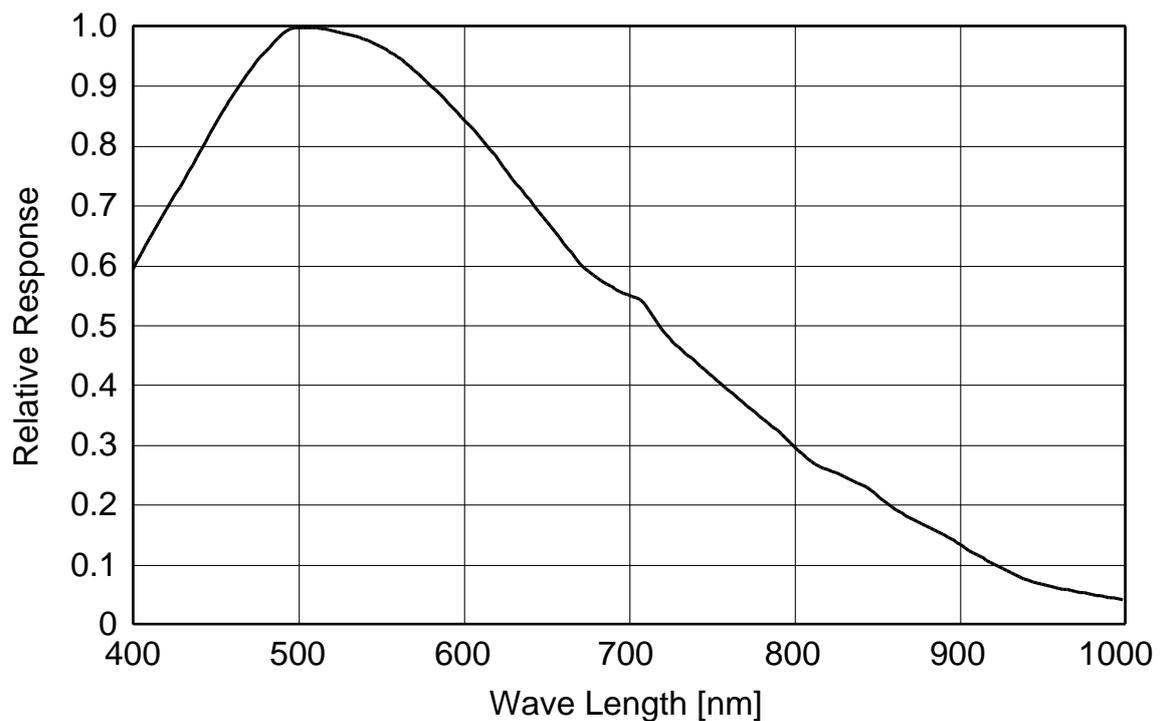
# Typical Spectral Response

\* The lens characteristics and light source characteristics is not reflected in table.

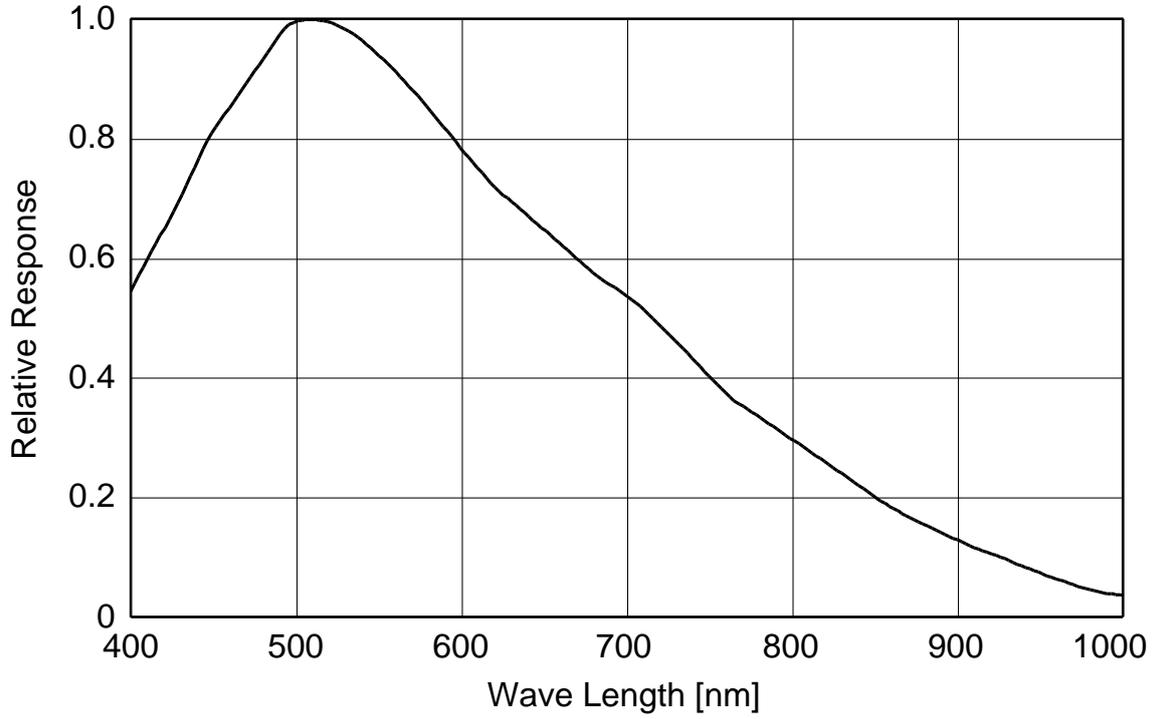
- BU030



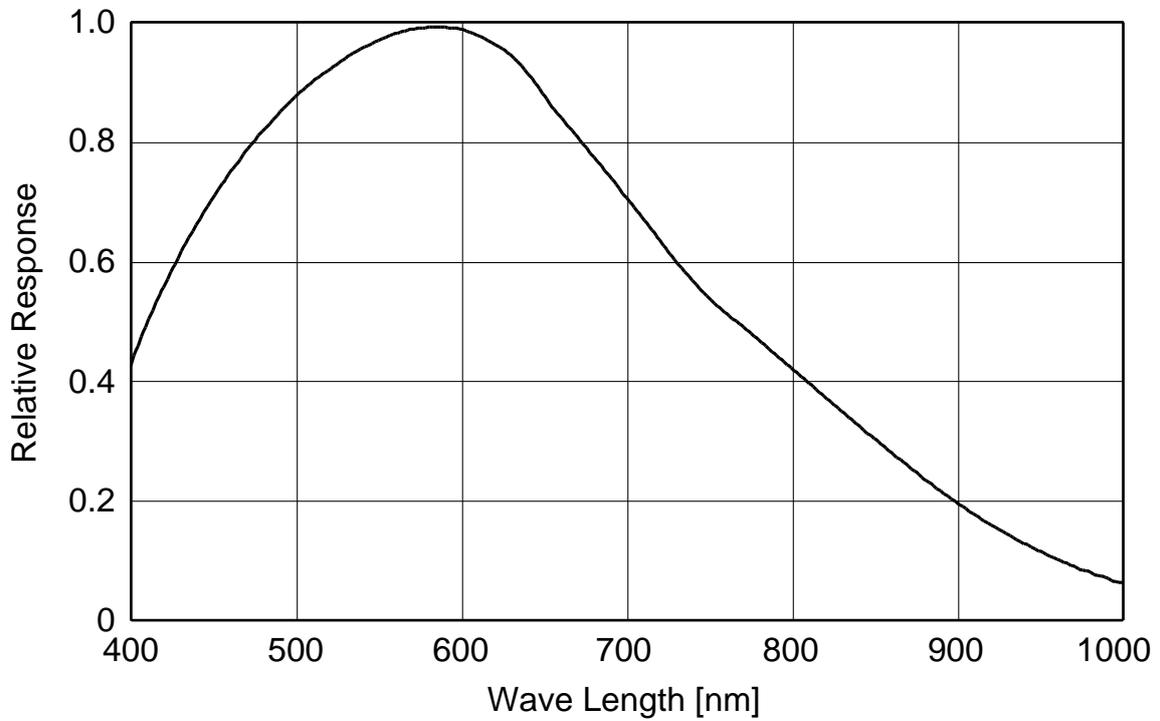
- BU031



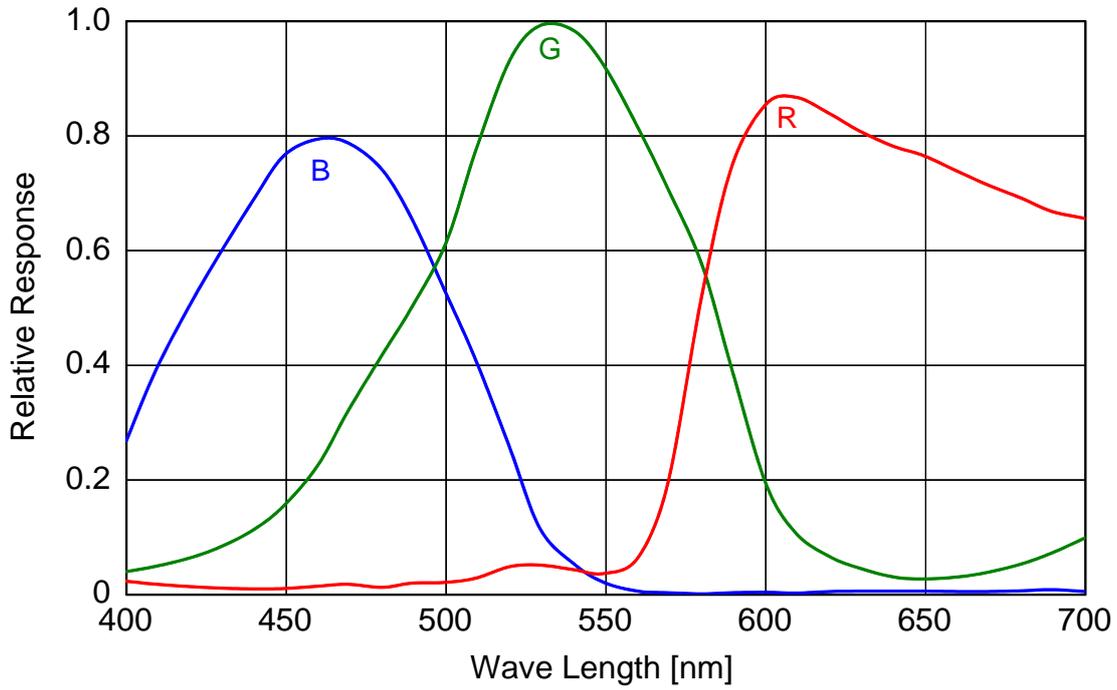
• BU080



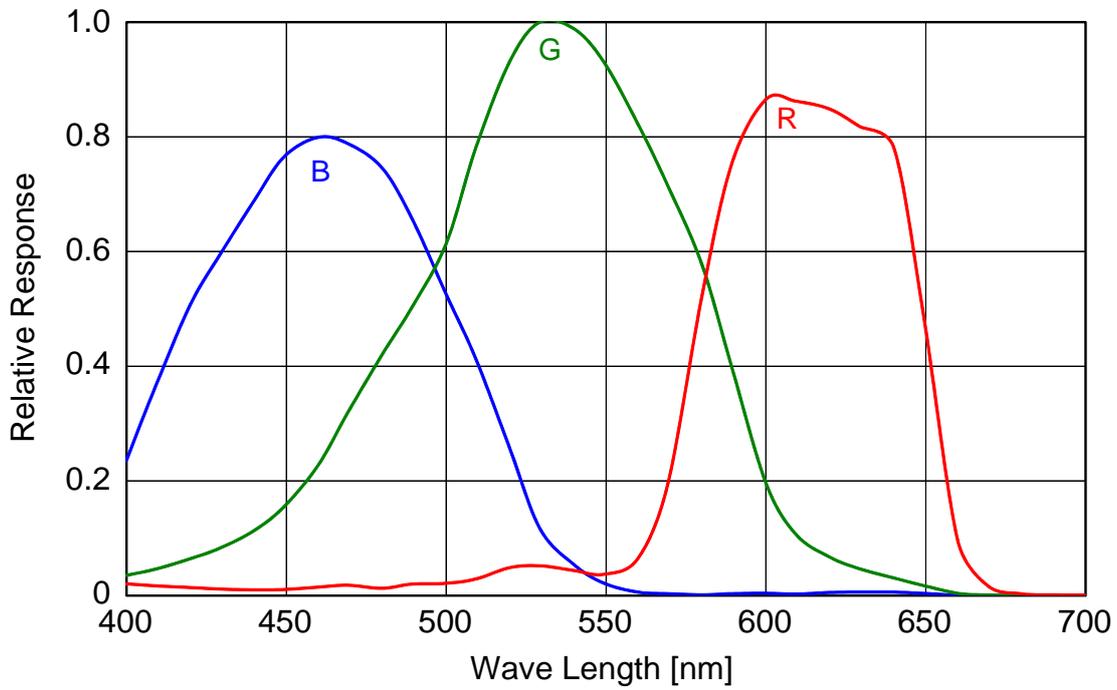
• BU130



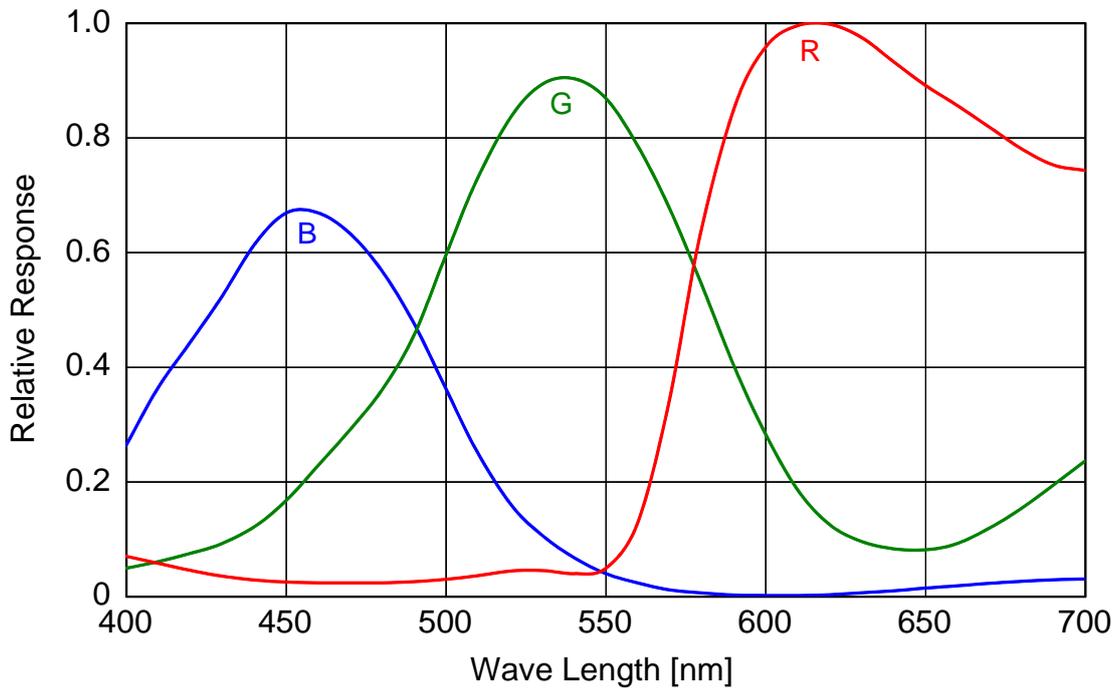
• BU030C



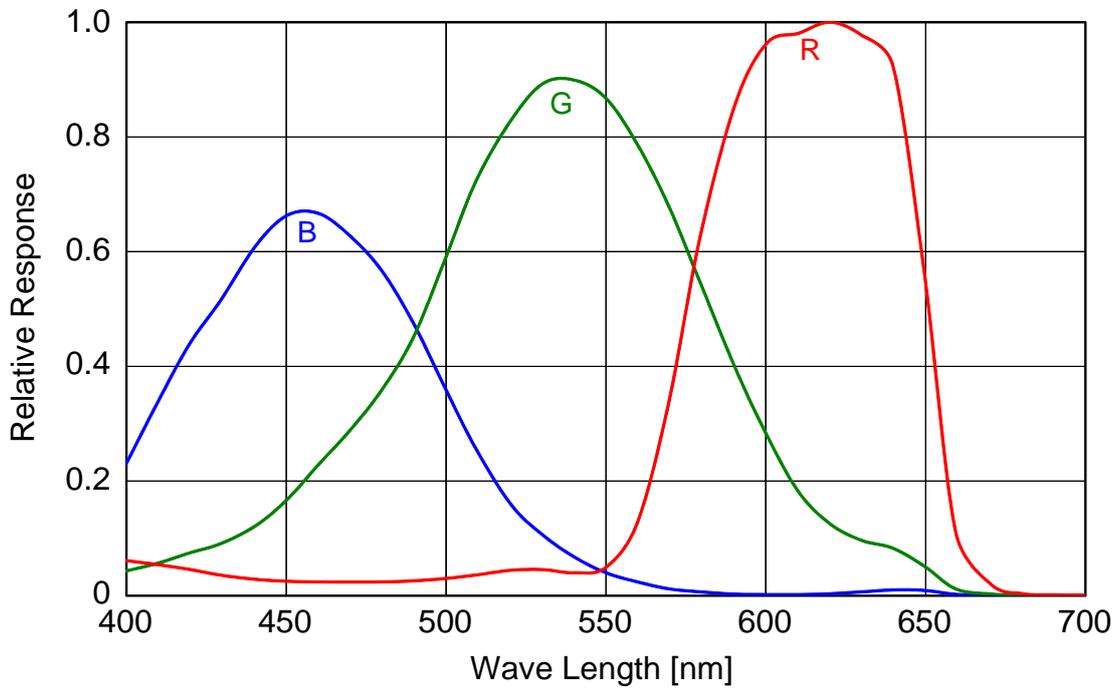
• BU030CF



• BU130C



• BU130CF



# Operating Ambient Conditions

- Ambient conditions

- Operating Assurance

Temperature: 0°C ~ 40°C, Camera housing temperature: less than 50°C

Humidity: 10% ~ 90% (no condensation)

- Storage Assurance

Temperature: -20°C ~ 60°C

Humidity: 90% or less (no condensation)

## **Notes on Heat Radiation:**

The top surface temperature of camera housing must be kept less than 50 °C in principle.

However, about the upper limit of top surface temperature of camera housing and the allowed ambient temperature of each model, please refer to the "Thermal design manual" on our HP.

- EMC Conditions

- EMI (Electro-Magnetic Interference): EN61000-6-4  
FCC Part 15 Subpart B Class A

- EMS (Electro-Magnetic Susceptibility): EN61000-6-2

### Notes on Conformity of the EMC:

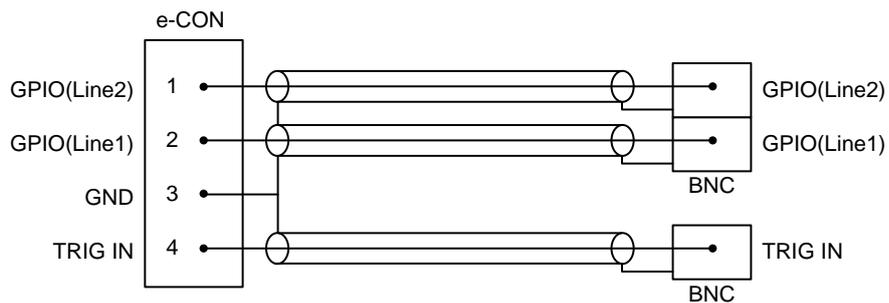
The adaptability of the safety standard of this camera is assured in the condition of combination with the following parts:

- USB Cable                    USB3C-A/1-CS/1-C-0                    (COMOSS Electronic Co., Ltd.)
- e-CON Cable                3.0m, Shield cable                    (Fabricated parts)

#### Parts:

- e-CON connector        XN2A-1470                    (OMRON Corporation)
- Shielded wire            UL1533 (AWG28)                (Hitachi cable, Ltd.)

#### Connection:



Please confirm the EMC adaptability when it combines with parts other than them.

# Functions

This section introduces standard functions of BU series. This camera series provides following functions.

Category	Function	
USB3 Vision	Bootstrap Registers	USB3 Vision standard registers
DeviceControl	DeviceControl	Device information
ImageFormatControl	ImageFormatSelector	Image format selection
	Scalable	Scalable control
	Binning	Binning control
	PixelFormat	Pixel format selection
	TestPattern	Test pattern control
AcquisitionControl	AcquisitionControl	Image stream start / stop
	TriggerControl	Trigger control
	ExposureControl	Exposure time control
DigitalIOControl	DigitalIOControl	GPIO signal control
CounterAndTimerControl	TimerControl	Timer0Active signal control
AnalogControl	Gain	Gain control
	BlackLevel	Black level control
	Gamma	Gamma correction
	BalanceRatio	Color gain (R,B)
	BalanceWhiteAuto	Execute auto white balance once
	ColorCorrectionMatrix	Color matrix correction
LUTControl	LUTControl	LUT control
UserSetControl	UserSetControl	Load / Save user setting
EventControl	EventControl	Event packet control
VenderUniqueControl	FrameSynchronization	Frame synchronization control
	LEDIndicatorLuminance	LED luminance control
	AntiGlitch	AntiGlitch control
	AntiChattering	AntiChattering control

Features supported by each model are as follows.

Function	BU030	BU031	BU080	BU130	BU030C	BU130C
Bootstrap Registers	○	○	○	○	○	○
DeviceControl	○	○	○	○	○	○
ImageFormatSelector	○	○	○	○	-	-
Scalable	○	○	○	○	○	○
Binning	○	○	○	○	-	-
PixelFormat	○	○	○	○	○	○
TestPattern	○	○	○	○	○	○
AcquisitionControl	○	○	○	○	○	○
TriggerControl	○	○	○	○	○	○
ExposureControl	○	○	○	○	○	○
DigitalIOControl	○	○	○	○	○	○
TimerControl	○	○	○	○	○	○
Gain	○	○	○	○	○	○
BlackLevel	○	○	○	○	○	○
BalanceRatio	-	-	-	-	○	○
BalanceWhiteAuto	-	-	-	-	○	○
Gamma	○	○	○	○	○	○
ColorCorrectionMatrix	-	-	-	-	○	○
LUTControl	○	○	○	○	○	○
UserSetControl	○	○	○	○	○	○
EventControl	○	○	○	○	○	○
FrameSynchronization	○	○	○	○	○	○
LEDIndicatorLuminance	○	○	○	○	○	○
AntiGlitch	○	○	○	○	-	-
AntiChattering	○	○	○	○	-	-

Details of each feature are described in following pages.

# Bootstrap Registers

This camera is in conformity with USB3 Vision.

Please refer to USB3 Vision specification for details about Bootstrap Registers defined in USB3 Vision.

AIA (Automated Imaging Association) USB3 Vision Homepage.

<http://www.visiononline.org/vision-standards-details.cfm?type=11>

Followings are commonly used registers.

## ● Registers

USB3 Vision ABRM			
Register	Visibility	Access	Description
UserDefinedName	Expert	R/W	Store user's arbitrary string in non-volatile memory.

USB3 Vision SIRM			
Register	Visibility	Access	Description
StreamEnable	Expert	R/W	Open and close the stream channel.

USB3 Vision EIRM			
Register	Visibility	Access	Description
EventEnable	Expert	R/W	Activate event notification function. Please refer to EventControl section as well.
TriggerEventTest	Expert	W	Issue test event packet.

## ● Note

When opening and closing the stream channel, it is required to control StreamEnable plus SDK setups on your application. Please refer to the TeliCamSDK for details.

# DeviceControl

Registers of this category provide various information of the camera. And you can set the free user ID to the camera.

## ● Registers

Register	Visibility	Access	Description
DeviceReset	Expert	W	Resets the device.
DeviceVendorName	Beginner	R	Returns the vendor name.
DeviceModelName	Beginner	R	Returns the model name.
DeviceManufacturerInfo	Beginner	R	Returns the manufacturer information.
DeviceVersion	Beginner	R	Returns the device version.
DeviceID	Beginner	R	Returns the device ID (serial number).

# ImageFormatControl

Registers of this category are related to image format control.

## ● Registers

Register	Visibility	Access	Description
ImageFormatSelector	Beginner	R/W	Selects an image format.

## ● Setting

- Select an image format.

Set a following value to “ImageFormatSelector” register. Setting value is Enumeration type.

ImageFormatSelector	Function
Format0 (*)	Scalable Mode
Format1	Binning Mode

\* initial factory setting

## ● Note

Changing “ImageFormatSelector” register value is invalid during image stream data output.

Binning function is disabled when the camera is running in Scalable mode.

Scalable function is disabled when the camera is running in Binning mode.

Binning mode is available only in B/W models.

# Scalable

BU series provide the scalable mode that can read out defined area of the screen.

In the scalable mode, camera reads out only necessary area at the normal speed and reads out other area at high speed. The frame rate can be faster when the vertical height size is small. However, the frame rate cannot be faster only when the horizontal width size is small, due to the operation mechanism of the CCD sensor.

Only single rectangle is selectable. Concave or convex shape is not selectable.

- Window size:  $\{A + 2 \times m (H)\} \times \{B + 2 \times n (V)\}$   
 A, B = minimum unit size  
 m, n = integer  
 The window size is equal or less than maximum image size.
- Start address:  $\{2 \times i (H)\} \times \{2 \times j (V)\}$   
 i, j = integer  
 The window size is equal or less than maximum image size.

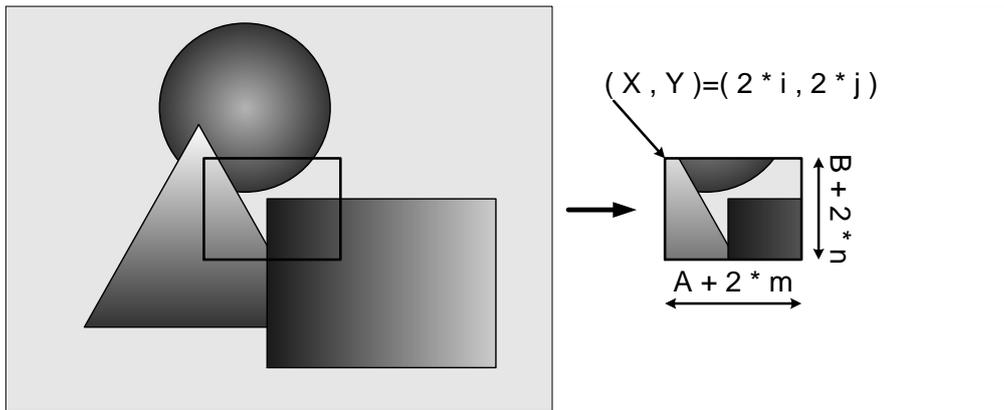


Fig. Scalable

## • Registers

Register	Visibility	Access	Description
Width	Beginner	R/W	Sets width (in pixels) of the image data.
Height	Beginner	R/W	Sets Height (in pixels) of the image data.
OffsetX	Beginner	R/W	Sets horizontal offset (in pixels) from the origin to the region of interest.
OffsetY	Beginner	R/W	Sets vertical offset (in pixels) from the origin to the region of interest.

● **Setting**

- Select an image format.

Select "Format0" of "ImageFormatSelector" register.

- Set image size and image start position

Set the following value to "Width", "Height", "OffsetX", "OffsetY" registers. Setting value is Integer type. "Width", "Height" registers are image size setting. "OffsetX", "OffsetY" registers are image start position setting.

Model	BU030	BU031	BU080	BU130
Width/OffsetX unit size	2x2	2x2	2x2	2x2
Height/OffsetY unit size	2x2	2x2	2x2	2x2
Minimum unit size	160x120	160x120	256x192	160x120
Maximum unit size (*)	640x480	640x480	1024x768	1280x960

Model	BU030C	BU130C
Width/OffsetX unit size	2x2	2x2
Height/OffsetY unit size	2x2	2x2
Minimum unit size	160x120	160x120
Maximum unit size (*)	640x480	1280x960

\* initial factory setting

● **Note**

Changing "Width", "Height", "OffsetX", "OffsetY" register value is invalid during image stream data output.

**Notes on scalable mode:**

White lines may occur in the upper portions of the screen when strong light exists in a wide area during the scalable mode. This is not a malfunction. If white lines occur, adjust the amount of incident light using the lens.

# Binning

In the binning mode, a pixel is added with the neighboring pixel(s). This increases the sensitivity of the image. It's alike scalable mode, the frame rate can be faster and USB bandwidth occupation decrease. This function is available only in B/W models.

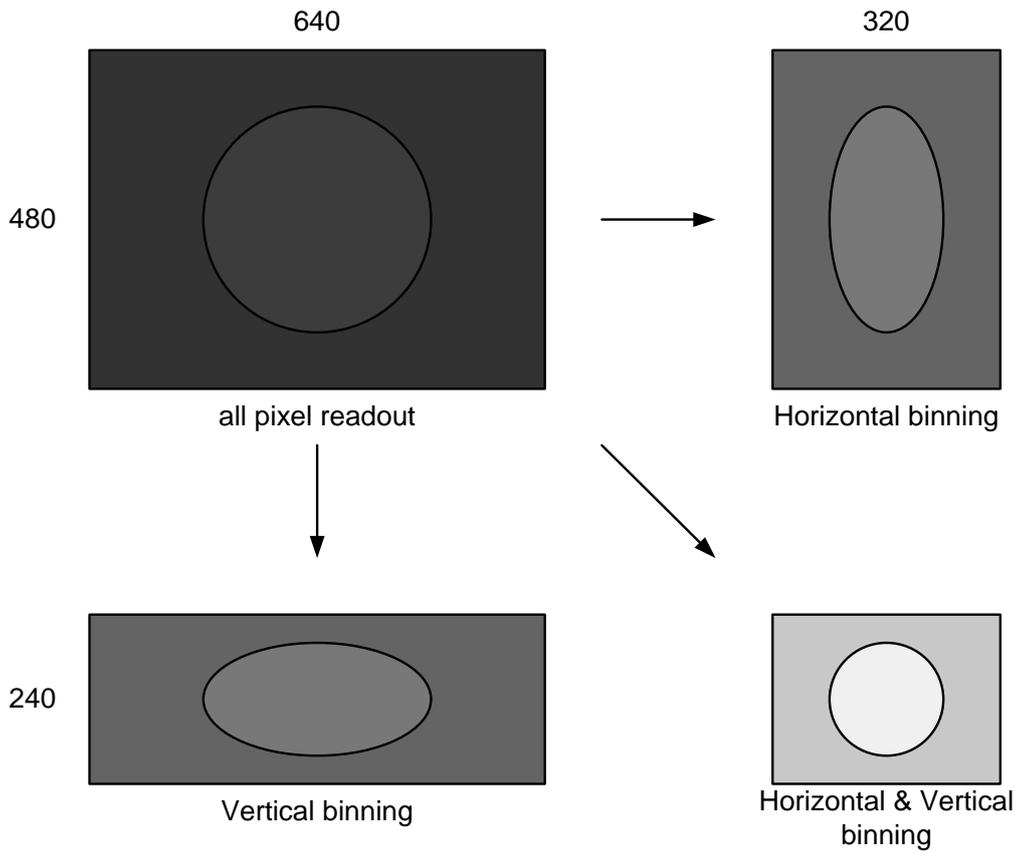


Fig. Binning operation (e.g. VGA)

## • Registers

Register	Visibility	Access	Description
BinningHorizontal	Beginner	R/W	Set horizontal binning.
BinningVertical	Beginner	R/W	Set vertical binning.

● **Setting**

- Select an image format.

Select "Fomat1" of "ImageFormatSelector" register.

- Set binning operation

Set the following value to "BinningHorizontal", "BinningVertical" registers. Setting value is Integer type.

"BinningHorizontal" is the number of horizontal pixel(s) to add. And "BinningVertical" is the number of vertical pixel(s) to add.

Model	BU030	BU031	BU080	BU130
Minimum (*)	1(H)×1(V)	1(H)×1(V)	1(H)×1(V)	1(H)×1(V)
Maximum	2(H)×2(V)	2(H)×2(V)	2(H)×2(V)	2(H)×2(V)

\* initial factory setting

● **Note**

The range of register setting depends on camera model.

Binning function is disabled when the camera is running in Scalable mode.

Scalable function is disabled when the camera is running in Binning mode.

Changing "BinningHorizontal", "BinningVertical" register value is invalid during image stream data output.

# PixelFormat

Select a pixel format of image stream data.

## ● Registers

Register	Visibility	Access	Description
PixelCoding	Beginner	R/W	Selects a pixel coding.
PixelSize	Beginner	R/W	Selects a bit size of image pixel.
PixelEndian	Beginner	R/W	Selects a pixel endian. (B/W model only)
PixelFormat	Beginner	R	Returns a selected pixel format. PixelFormat is conformed to AIA Pixel Format Naming Convention.

## ● Setting

- Set PixelFormat

PixelFormat is determined by combination of “PixelCoding” and “PixelSize” register. Select a following combination to “PixelCoding” and “PixelSize” register. Setting values are Enumeration type.

### B/W model

PixelCoding \ PixelSize	Bpp8	Bpp10
Mono	Mono8 (*)	Mono10
PixelFormat ID	0x01080001	0x01100003

### Color model

PixelCoding \ PixelSize	Bpp8	Bpp10	Bpp12	Bpp16	Bpp24
Mono	Mono8	-	-	-	-
PixelFormat ID	0x01080001	-	-	-	-
Bayer**	Bayer**8	Bayer**10	-	-	-
PixelFormat ID	0x0108000*	0x0110000*	-	-	-
YUV411	-	-	YUV411Packed	-	-
PixelFormat ID	-	-	0x020C001E	-	-
YUV422	-	-	-	YUV422Packed	-
PixelFormat ID	-	-	-	0x0210001F	-
RGB	-	-	-	-	RGB8 (*)
PixelFormat ID	-	-	-	-	0x02180014
BGR	-	-	-	-	BGR8
PixelFormat ID	-	-	-	-	0x02180015

\* initial factory setting

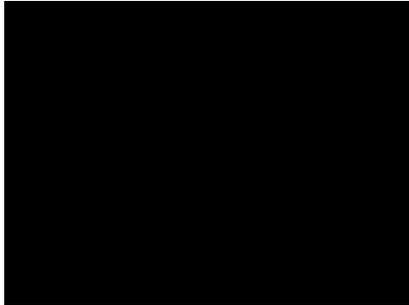
## ● Note

Bayer alignment of color models is dependent on its model.

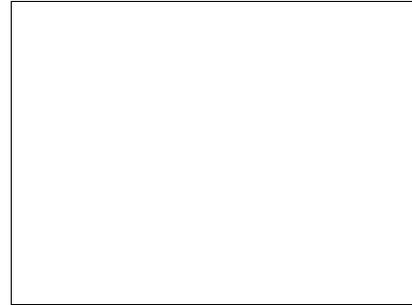
Changing “PixelSize” register value is invalid during image stream data output.

# TestPattern

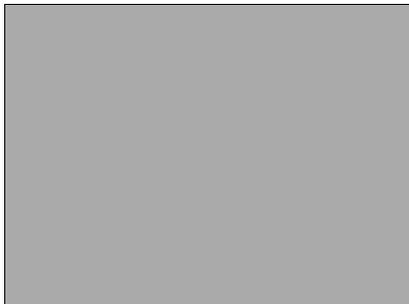
BU series support test pattern data output. Camera provides following Test patterns;



Black



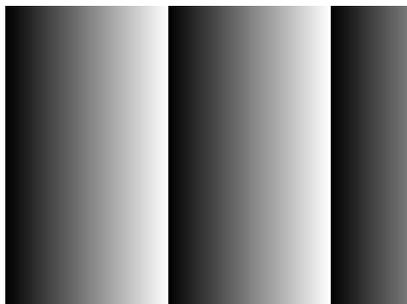
White



GreyA



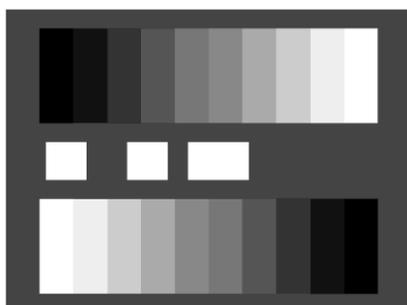
GreyB



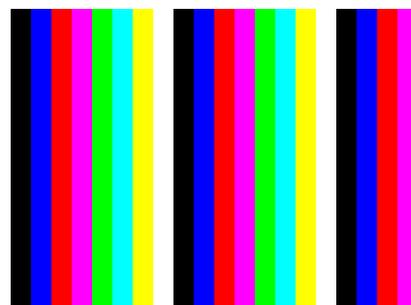
GreyHorizontalRamp



GreyVerticalRamp



GreyScale  
(B/W model only)



ColorBar  
(Color model only)

Fig. Test pattern (e.x. BU030 / BU030C)

## ● Registers

Register	Visibility	Access	Description
TestPattern	Beginner	R/W	Selects a test pattern.

## ● Setting

- Select a test pattern output

Set the following value to “TestPattern” register. Setting value is Enumeration type.

The camera generates a test pattern.

TestPattern	function
Off (*)	Test pattern disable(Normal data output)
Black	All pixel = 0 LSB
White	All pixel = 255 @Mono8
GreyA	All pixel = 170 @Mono8
GreyB	All pixel = 85 @Mono8
GreyHorizontalRamp	Horizontal Ramp
GreyVerticalRamp	Vertical Ramp
GreyScale	Grey scale (B/W model only)
ColorBar	Color bars (Color model only)

\* initial factory setting

## ● Note

# AcquisitionControl

Make a setting of image stream and control image stream output.

Camera starts image stream output by receiving AcquisitionStart command. And there are some registers that require camera to stop image stream output to change values.

Acquisition frame rate is variable. Maximum acquisition frame rate depends on camera operation mode (scalable, binning, draft, etc.)

## ● Registers

Register	Visibility	Access	Description
AcquisitionMode	Beginner	R/W	Selects an acquisition mode.
AcquisitionStart	Beginner	W	Executes the image stream output start.
AcquisitionStop	Beginner	W	Executes the image stream output stop.
AcquisitionAbort	Beginner	W	Executes the image stream output abort.
AcquisitionFrameCount	Beginner	R/W	Sets the number of frames to transfer in MultiFrame mode.
AcquisitionFrameRateControl	Beginner	R/W	Activates frame rate setting.
AcquisitionFrameRate	Beginner	R/W	Sets frame rate of image stream.
AcquisitionFrameIntervalControl	Beginner	R/W	Activates frame interval setting.
AcquisitionFrameInterval	Beginner	R/W	Sets frame interval of image stream.

## ● Setting

- Select an acquisition mode

Set the following value to “AcquisitionMode” register. Setting value is Enumeration type.

AcquisitionMode	Function
Continuous (*)	Continuous image transfer
MultiFrame	Multi frame image transfer

\* initial factory setting

- Set the number of frames to transfer (In MultiFrame mode)

Set the number of frames to transfer to “AcquisitionFrameCount”. Setting value is Integer type.

- Open/Close stream channel (to be ready to receive stream data)
  - Set "1" to "StreamEnable" in Bootstrap Registers before "AcquisitionStart".
  - Set "0" to "StreamEnable" in Bootstrap Registers before "AcquisitionStop" or "AcquisitionAbort".
  
- Start image stream output
  - The camera starts image stream output by executing "AcquisitionStart" register command.
  
- Stop image stream output
  - The camera stops image stream output by executing "AcquisitionStop" register command.
  - The camera aborts image stream output by executing "AcquisitionAbort" register command.
  
- Set frame rate
  - Set the "AcquisitionFrameRateControl" register to "Manual".
  - And set the following value to "AcquisitionFrameRate" register. Setting value is Float type.
  - The range of register setting depends on camera model, and camera operation mode.
  - "AcquisitionFrameInterval" register is a reciprocal of "AcquisitionFrameRate".

AcquisitionFrameRateControl	Function
NoSpecify (*)	The frame rate is determined by giving priority to ExposureTime setting value.
Manual	The frame rate is determined by giving priority to AcquisitionFrameRate setting value.

\* initial factory setting

AcquisitionFrameRate	Value
Minimum	0.5[Hz]
Maximum (*)	Depend on register setting of "Height", and "Binning".

\* initial factory setting

### ● Note

Changing "AcquisitionFrameRateControl", "AcquisitionFrameRate", "AcquisitionFrameIntervalControl", "AcquisitionFrameInterval" register value is invalid during image stream data output.

When exposure time setting is longer than frame rate setting, camera operation gives priority to exposure time setting.

When opening and closing the stream channel, it is required to control StreamEnable plus SDK setups on your application. Please refer to the TeliCamSDK for details.

#### **Notes on Frame Drops of Image:**

Depends on your PC or USB3.0 interface card configurations, images may not be captured normally (e.g. frame drops may occur). In this case, change to frame rate setting lower.

# TriggerControl

This section describes trigger control of TriggerControl category for the BU series.

This camera series provides two kinds of exposure synchronization.

1. Normal Shutter mode : Free run operation (internal synchronization)
2. Random Trigger Shutter mode : Synchronized with external trigger input

In Random Trigger Shutter mode, two kinds of trigger input are available.

1. Trigger signal via the I/O connector (HardwareTrigger)
2. Trigger command via the USB interface (SoftwareTrigger)

The following table shows the combination of operation mode of this camera series.

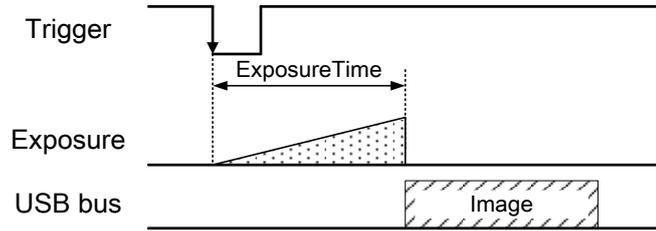
Table. Operation Mode

Trigger Mode	Synchronization	Exposure Control
Normal Shutter mode	Free run	“ExposureTime” register control
Random Trigger Shutter mode	HardwareTrigger	-Edge mode:TriggerSequence0 -Bulk mode:TriggerSequence6 “ExposureTime” register control
	SoftwareTrigger	-Level mode:TriggerSequence1 Trigger pulse width control -Edge mode:TriggerSequence0 -Bulk mode:TriggerSequence6 “ExposureTime” register control

\* The camera operation not mentioned above is not guaranteed.

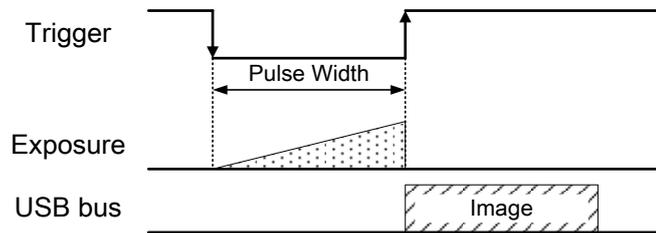
**- Edge mode (TriggerSequence0)**

The exposure time is determined by Exposure Time setting.



**- Level mode (TriggerSequence1)**

The exposure time is determined by the pulse width of the trigger signal.



**- Bulk mode (TriggerSequence6)**

Camera exposes and transfers multiple frames by a single trigger.

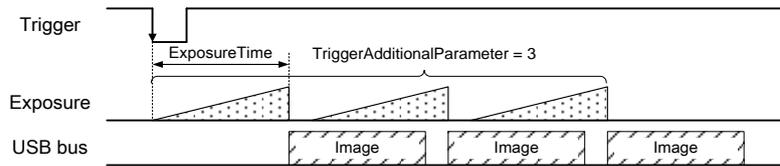


Fig. Trigger sequence

Operation point of HardwareTrigger is at the edge of trigger signal, and active edge polarity is able to change by register setting. And you can add delay time from trigger edge to exposure start by register setting.

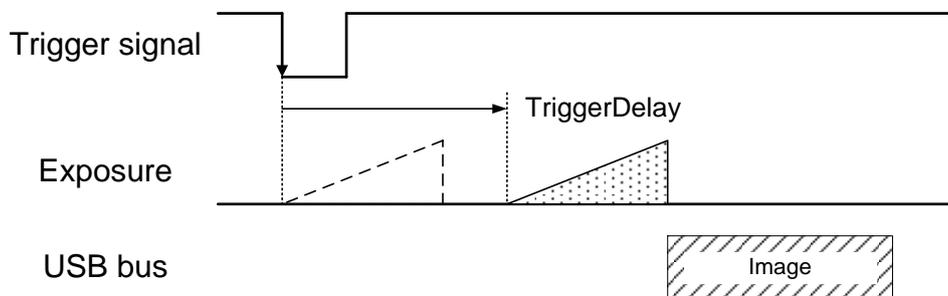


Fig. Trigger Delay

Details of Random Trigger Shutter operation, refer to "Timing" of "Specification".

## ● Registers

Register	Visibility	Access	Description
TriggerMode	Beginner	R/W	Selects Random Trigger Shutter mode.
TriggerSequence	Beginner	R/W	Selects trigger sequence.
TriggerSource	Beginner	R/W	Selects trigger source of Random Trigger Shutter.
TriggerAdditionalParameter	Expert	R/W	Sets the number of frames to exposure in Bulk mode.
TriggerDelay	Beginner	R/W	Sets trigger delay.
TriggerSoftware	Beginner	W	Executes software trigger.

## ● Setting

- Select trigger mode

Set the following value to “TriggerMode” register. Setting value is Enumeration type.

TriggerMode	Function
Off (*)	Normal Shutter Mode
On	Random Trigger Shutter mode

\* initial factory setting

- Select trigger sequence

Set the following value to “TriggerSequence” register. Setting value is Enumeration type.

TriggerSequence	Function
TriggerSequence0 (*)	Edge mode
TriggerSequence1	Level mode
TriggerSequence6	Bulk mode

\* initial factory setting

In Normal Shutter mode, the exposure time is determined by “ExposureTime” register value regardless of “TriggerSequence” register setting.

- Select trigger source

Set the following value to “TriggerSource” register. Setting value is Enumeration type.

TriggerSource	Function
Line0 (*)	Hardware trigger
Software	Software trigger

\* initial factory setting

- Set the number of frames to exposure (In Bulk mode)

Set the number of frames to exposure to "TriggerAdditionalParameter". Setting value is Integer type.

TriggerAdditionalParameter	Value
Minimum (*)	0 [frame]
Maximum	255 [frames]

\* initial factory setting

- Set trigger delay (HardwareTrigger operation only)

Set the following value to "TriggerDelay" register. Setting value is Float type.

Adds delay time from trigger edge to exposure start.

TriggerDelay	Value
Minimum (*)	0.00[ $\mu$ s]
Maximum	2000000.00[ $\mu$ s]

\* initial factory setting

- Grabs image stream by software trigger

When executes "TriggerSoftware" register command, software trigger command is generated. Camera starts exposure by receiving software trigger command.

#### ● Note

In SoftwareTrigger operation, the delay time from "TriggerSoftware" to exposure is not guaranteed.

# ExposureTime

BU series are able to adjust exposure time by using electric shutter control.

BU series provide two kinds of exposure time control mode.

- Manual : The exposure time is determined by “ExposureTime” register setting value.
- NoSpecify : The exposure time is determined by “AcquisitionFrameRate” register setting value

## ● Registers

Register	Visibility	Access	Description
ExposureTimeControl	Beginner	R/W	Selects exposure time control mode.
ExposureTime	Beginner	R/W	Sets absolute exposure time.

## ● Setting

- Select exposure time control mode

Set the “ExposureTimeControl” register to “Manual”.

Set the following value to “ExposureTime” register. Setting value is Float type.

AcquisitionFrameRateControl	Function
NoSpecify	The frame rate is determined by giving priority to AcquisitionFrameRate setting value.
Manual (*)	The frame rate is determined by giving priority to ExposureTime setting value.

\* initial factory setting

Register	BU030	BU031	BU080	BU130
ExposureTime (*)	8000 [μs]	8000 [μs]	25000 [μs]	33333 [μs]
ExposureTimeMin	10 [μs]	10 [μs]	30 [μs]	30 [μs]
ExposureTimeMax	16000000 [μs]			

Register	BU030C	BU130C
ExposureTime (*)	8000 [μs]	33333 [μs]
ExposureTimeMin	10 [μs]	30 [μs]
ExposureTimeMax	16000000 [μs]	

\* initial factory setting

## ● Note

# DigitalIOControl

This section describes DigitalIOControl category for the BU series.

This camera provides GPIO output selected by the register setting. And the polarity of the signal is able to switch by the register setting. The following chart shows the specifications of the selectable signals.

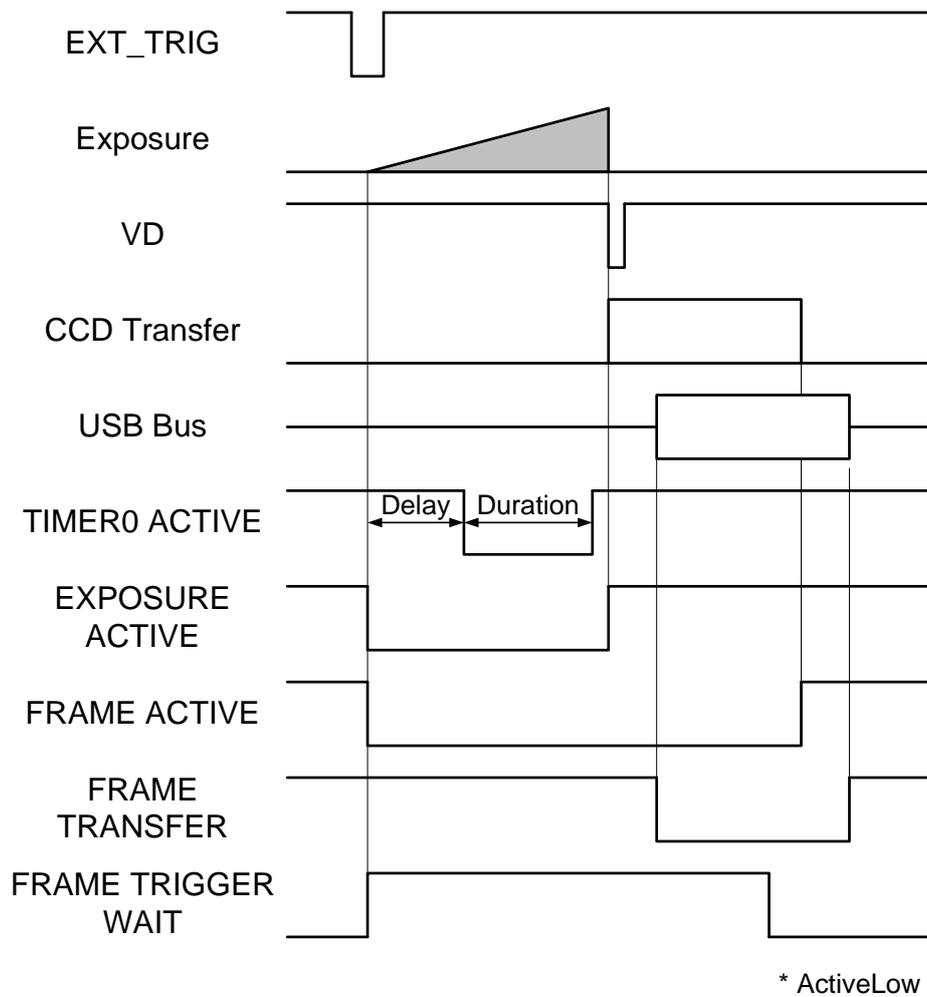


Fig. Selectable signals

## ● Registers

Register	Visibility	Access	Description
LineModeAll	Beginner	R	Returns the direction of each Line signal.
LineInverterAll	Beginner	R/W	Selects the polarity of each Line signal.
LineStatusAll	Beginner	R	Returns the status of each Line signal.
UserOutputValueAll	Beginner	R/W	Sets the user output value.
LineSelector	Beginner	R/W	Selects the Line of I/O connector.
LineSource	Beginner	R/W	Selects the source of the output signal.

## ● Setting

- Select the Line of the I/O connector

Set the following value to “LineSelector” register. Select the line to output “LineSource” signal.

Setting value is Enumeration type.

LineSelector	I/O connector pin assignment	LineMode	Output circuit
Line1 (*)	2 pin: GPIO Output	Output	5V CMOS
Line2	1 pin: GPIO Output	Output	5V CMOS

\* initial factory setting

- Select the source of GPIO output signal

Set the following value to “LineSource” register to change GPIO output signal selected by “LineSelector”.

Setting value is Enumeration type.

LineSource	Signal description
Off (*)	No output.
FrameTriggerWait	Indicating waiting a Random Trigger Shutter. An External trigger is input during this period, exposure starts immediately.
FrameActive	Period from exposure start to CCD transfer completion.
FrameTransfer	Period of transferring image data on USB bus.
ExposureActive	Period from exposure start to exposure end.
UserOutput	Outputs the value set in “UserOutputValueAll”.
Timer0Active	This signal can be used as strobe control signal. The delay time and pulse width of this signal are configurable.

\* initial factory setting

- Set the UserOutput signal

Set the following value to “UserOutputValueAll” register. Setting value is Integer type.

Each bit corresponds to each Line (bit0=Line0, bit1=Line1).

Line1 and Line2 are available. Line0 is dedicated trigger input.

UserOutputValueAll	Function
0 (*)	Low level output
1	High level output

\* initial factory setting

- Select the polarity of each signal

Set the following value to "LineInverterAll" register. The setting value is Integer type.

Each bit corresponds to each Line. Both Line0 and Line1 are settable.

Inverter is also inserted to UserOutputValue.

LineInverterAll	Function
0 (*)	non inverted
1	inverted

\* initial factory setting

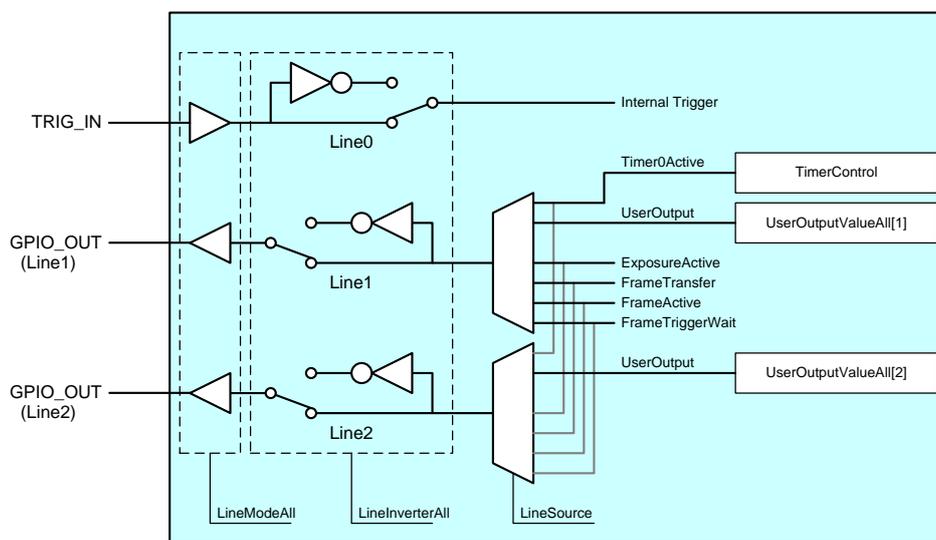


Fig. GPIO internal circuit diagram

● **Note**

About the details of Timer0Active signal, refer to "TimerControl" of "Functions".

# TimerControl

This section describes TimerControl category for the BU series.

This camera series is able to generate Timer0Active signal, derived from exposure start, by register setting.

This signal can be used as strobe control signal.

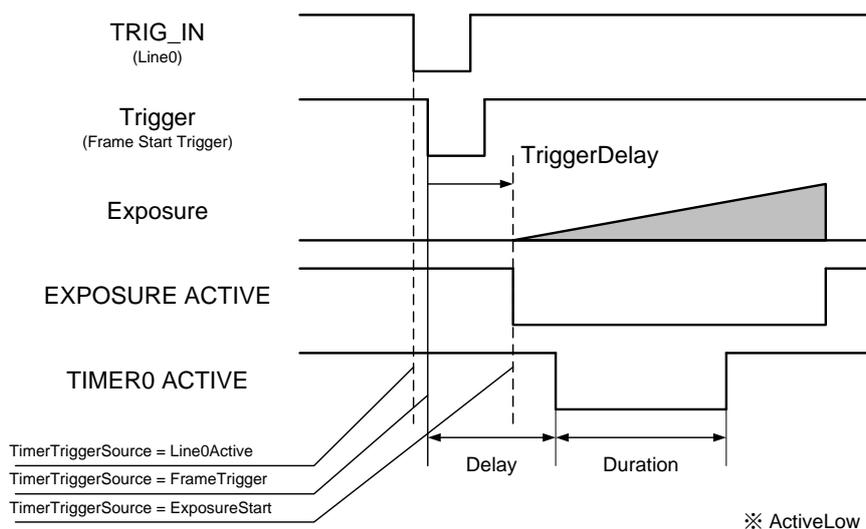


Fig. Timer0Active

## ● Registers

Register	Visibility	Access	Description
TimerSelector	Beginner	R	Returns the selected timer name.
TimerDuration	Beginner	R/W	Sets the width of Timer0Active signal.
TimerDelay	Beginner	R/W	Sets the delay of Timer0Active signal.
TimerTriggerSource	Beginner	R/W	Selects the source of Timer0Active pulse to start.

## ● Setting

- Set the width of Timer0Active pulse

Set the following value to “TimerDuration” register. Setting value is Float type.

TimerDuration	Pulse width
Minimum (*)	0.00[μs]
Maximum	2000000.00[μs]

\* initial factory setting

- Set the delay of Timer0Active pulse

Set the following value to “TimerDelay” register. Setting value is Float type.

TimerDelay	Delay value
Minimum (*)	0.00[μs]
Maximum	2000000.00[μs]

\* initial factory setting

- Select the source of Timer0Active pulse to start

Select the following value to “TimerTriggerSource” register. Setting value is Enumeration type.

TimerTriggerSource	Description
Off	Disables the timer trigger.
Line0Active	Starts when TRIG_IN (Line0) is active.
ExposureStart (*)	Starts with the reception of the Exposure Start
FrameTrigger	Starts with the reception of the Frame Start Trigger.

\* initial factory setting

## ● Note

“TimerTriggerSource” operation is as follows,

Line0Active is available in HardwareTrigger mode, and to be responded at FrameTriggerError.

FrameTrigger is available in both HardwareTrigger and Software Trigger mode, and not to be responded at FrameTriggerError.

ExposureStart is available in both HardwareTrigger and Software Trigger mode, and not to be responded at FrameTriggerError. Timer0Active pulse delays TiggerDelay+TimerDelay[us].

# Gain

This section describes Gain control of LuminanceControl category of the BU series.  
 This control adjusts the gain of the image.

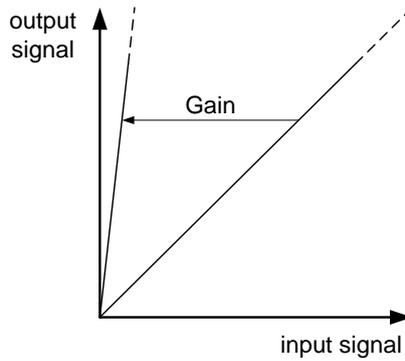


Fig. Gain

## • Registers

Register	Visibility	Access	Description
Gain	Beginner	R/W	Sets the absolute Gain.

## • Setting

- Set Manual Gain

Set the following value to “Gain” register. Setting value is Float type. This setting value is valid only at Manual Gain mode setting.

Gain	Value
Minimum (*)	0.00 [dB]
Maximum	18.00 [dB]

\* initial factory setting

The formula of Gain value is as follows;

$$\text{output signal} = \text{input signal} \times 10^{\frac{\text{Gain}}{20}}$$

## • Note

### Notes on gain setting:

Setting the gain value too high increases noises. When you adjust the brightness of the image, I ask you to have final image quality checked with your environment.

# BlackLevel

This section describes BlackLevel control of LuminanceControl category of the BU series.

This control adjusts the black level of the image. It is adjustable from -5% to +25% as white saturation level is 100%. However, when BlackLevel is lower than 0[%], the image level may not be saturated.

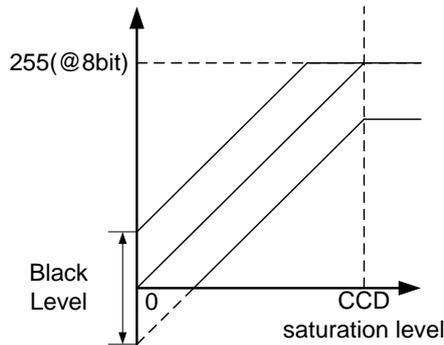


Fig. Black Level

## ● Registers

Register	Visibility	Access	Description
BlackLevel	Beginner	R/W	Sets the absolute Black Level.

## ● Setting

- Set Black Level

Set the following value to “BlackLevel” register. Setting value is Float type.

BlackLevel	Value
Minimum	-5.00[%]
Maximum	+25.00[%]

\* initial factory setting = 0.00[%]

## ● Note

# Gamma

This section describes Gamma correction of AnalogControl category for the BU series.  
This function allows you to apply a gamma correction to the output images.

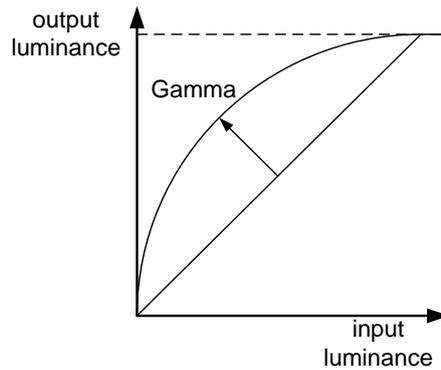


Fig. Gamma correction

## • Registers

Register	Visibility	Access	Description
Gamma	Beginner	R/W	Sets the Gamma correction.

## • Setting

- Set Gamma correction

Set the following value to “Gamma” register. Setting value is Float type.

Gamma	Value
Minimum	0.45
Maximum (*)	1.00

\* initial factory setting

## • Note

# BalanceRatio

This section describes BalanceRatio control of AnalogControl category for the BU series.

This control adjusts the white balance gain of the image.

This function is available only in Color models.

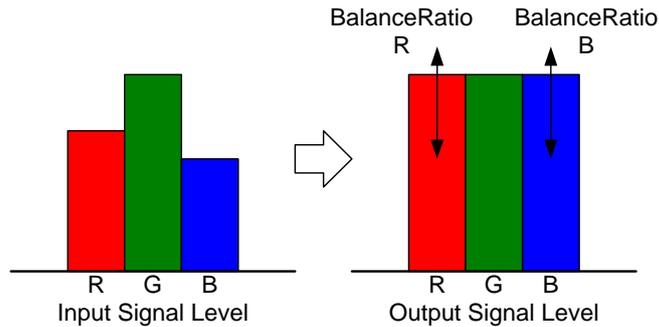


Fig. BalanceRatio

## • Registers

Register	Visibility	Access	Description
BalanceRatioSelector	Beginner	R/W	Selects a color component of white balance gain to control.
BalanceRatio	Beginner	R/W	Sets a white balance gain.

## • Setting

- Select BalanceRatio

Select the color component of white balance gain to control in “BalanceRatioSelector” register.

Setting value is Enumeration type.

BalanceRatioSelector	Function
None (*)	None of component is selected.
Red	BalanceRatio = Red Gain
Blue	BalanceRatio = Blue Gain

\* initial factory setting

- Set BalanceRatio

Set the following value to “BalanceRatio” register. The value is to be applied to selected color component. Setting value is Float type.

BalanceRatio	Value
Minimum	x 1.0
Maximum	x 8.0

\* initial factory setting value is device-specific

**Notes on white balance gain setting:**

Too high white balance gain increases noises. After adjusting the white balance of the image, I ask you to have final image quality checked with your environment.

# BalanceWhiteAuto

Adjust white balance gain automatically.

This function is available only in Color models.

## ● Registers

Register	Visibility	Access	Description
BalanceWhiteAuto	Beginner	R/W	Adjust white balance gain automatically.

## ● Setting

- Set BalanceWhiteAuto

Set the following value to “BalanceWhiteAuto” register.

After setting “Once”, camera executes auto white balance once. If execution of auto white balance is successful, both R and B gain are applied to BalanceRatio respectively.

BalanceWhiteAuto	Function
Offl (*)	No operation
Once	Execute auto white balance once.

\* initial factory setting

## ● Note

BalanceRatio and BalanceWhiteAuto controls are available in following PixelFormat modes.

RGB8, BGR8, YUV411\_8, YUV422\_8, Bayer\*8, Bayer\*10

# ColorCorrectionMatrix

This section describes ColorCorrectionMatrix control of AnalogControl category for the BU series.

This control corrects RGB data by using color correction matrix.

This function is available only in Color models.

The relationship between original data (R, G, and B) and corrected data (R', G', and B') are represented in the following formula.

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} 1 & -mask\_rg & -mask\_rb \\ -mask\_gr & 1 & -mask\_gb \\ -mask\_br & -mask\_bg & 1 \end{bmatrix} \begin{bmatrix} R & (G-R) & (B-R) \\ (R-G) & G & (B-G) \\ (R-B) & (G-B) & B \end{bmatrix}$$

$$R' = (1 - mask\_rg - mask\_rb) \cdot R + mask\_rg \cdot G + mask\_rb \cdot B$$

$$G' = mask\_gr \cdot R + (1 - mask\_gr - mask\_gb) \cdot G + mask\_gb \cdot B$$

$$B' = mask\_br \cdot R + mask\_bg \cdot G + (1 - mask\_br - mask\_bg) \cdot B$$

The correspondence of “SelectorI” and “SelectorJ” to color correction matrix element is as follows.

	SelectorJ=R	SelectorJ=G	SelectorJ=B
SelectorI=R		mask_rg	mask_rb
SelectorI=G	mask_gr		mask_gb
SelectorI=B	mask_br	mask_bg	

Fig. Corresponding elements of color correction matrix

## • Registers

Register	Visibility	Access	Description
ColorCorrectionMatrixSelectorI	Beginner	R/W	Selects a row element of color correction matrix.
ColorCorrectionMatrixSelectorJ	Beginner	R/W	Selects a column element of color correction matrix.
ColorCorrectionMatrix	Beginner	R/W	Sets a coefficient of color correction matrix.

● **Setting**

- Select ColorCorrectionMatrix

Select row and column elements of color correction matrix in “ColorCorrectionMatrixSelectorI” and “ColorCorrectionMatrixSelectorJ” register.

ColorCorrectionMatrixSelector	Value
I	R / G / B
J	R / G / B

\* initial factory setting = R

- Set ColorCorrectionMatrix

Set a color correction matrix coefficient to the element selected by “SelectorI” and “SelectorJ”.

Setting value is Float type. Coefficients of (SelectorI, SelectorJ)=(R,R),(G,G),(B,B) are internally fixed to 1.0 and read out data is always 1.0.

ColorCorrectionMatrix	Value
Minimum	-1.0
Maximum	+0.99

\* initial factory setting = 0.0

● **Note**

ColorCorrectionMatrix control is available in following PixelFormat modes.

RGB8, BGR8, YUV411\_8, YUV422\_8

# LUTControl

This function allows you to apply the arbitrary LUT(input: 10bit, output: 10bit) to the output images.

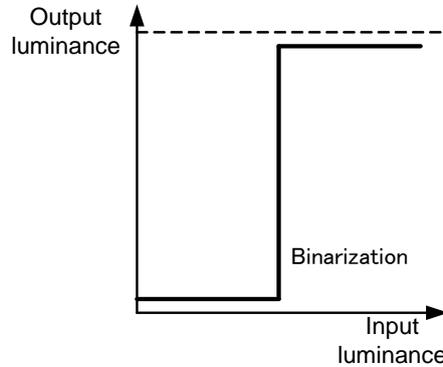


Fig. example of LUT setting

## ● Registers

Register	Visibility	Access	Description
LUTEnable	Beginner	R/W	Sets the activation of LUT function.
LUTIndex	Beginner	R/W	Sets the input level of LUT.
LUTValue	Beginner	R/W	Sets the output level of LUT.

## ● Setting

- Set the activation of LUT

Set the following value to “LUTEnable” register. The setting value is Enumeration type.

setting value	function
OFF (*)	Inactive
ON	Active

\* initial factory setting

- Set the input/output value of LUT

Set the following value to “LUTIndex”, “LUTValue” registers. These setting values are Integer type.

“LUTIndex” register value is input level of LUT, and “LUTValue” register value is output level of LUT.

LUTIndex / LUTValue	setting value
Minimum (*)	0
Maximum	1023

\* initial factory setting

## ● Note

# UserSetControl

You are able to save a user setting to the non-volatile memory of the camera. There is 15 user memory channels for user setting.

By using user memory, you are able to restore frequent used settings at the time of next start-up.

The following table is the list of registers applied by “UserSetLoad”/“UserSetSave”.

Table: List of registers to be applied in UserSet

Category	Register	Category	Register
ImageFormatControl	ImageFormatSelector	AnalogControl	Gain
	Width		BlackLevel
	Height		Gamma
	OffsetX		BalanceRatio
	OffsetY		ColorCorrectionMatrix
	Binning	LUT Control	LUTEnable
	PixelFormat	EventControl	EventNotification
	TestPattern	VendorUniqueControl	FrameSynchronization
AcquisitionControl	AcquisitionFrameRateControl		LEDIndicatorLuminance
	AcquisitionFrameRate		AntiGlitch
	AcquisitionFrameIntervalControl		AntiChattering
	AcquisitionFrameInterval		
TriggerControl	TriggerMode		
	TriggerSequence		
	TriggerSource		
	TriggerAdditionalParameter		
	TriggerDelay		
ExposureControl	ExposureTimeControl		
	ExposureTime		
DigitalIOControl	LineInverterAll		
	UserOutputValueAll		
	LineSelector		
	LineSource		
CounterAndTimerControl	TimerTriggerSource		
	TimerDuration		
	TimerDelay		

## ● Registers

Register	Visibility	Access	Description
UserSetSelector	Beginner	R/W	Selects a channel of user setting.
UserSetLoad	Beginner	W	Executes load a user setting.
UserSetSave	Beginner	W	Executes to save a user setting.
UserSetDefault	Beginner	R/W	Selects a channel of user setting when camera powers up.

## ● Setting

- Select a channel of a user setting

Set the following value to “UserSetSelector” register. The setting value is Enumeration type.

Select the channel of user setting for “UserSetLoad” and “UserSetSave”.

setting value	Description	Save	Load
Default	Initial factory setting data.	-	○
UserSet1 (*)~15	Select memory channel 1 to 15 for user setting.	○	○

\* initial factory setting

- Load/Save a user setting

When execute “UserSetLoad”, the camera loads user setting from the channel selected in “UserSetSelector” register and applies them.

When execute “UserSetSave”, the camera saves user setting to the channel selected in “UserSetSelector” register.

- Load a user setting at the time of start-up

Set the following value to “UserSetDefault” register. The setting value is Enumeration type.

The camera loads user setting from the channel selected in “UserSetDefault” register and applies them at the time of next start-up.

setting value	Description
Default (*)	Memory channel to read initial factory setting data.
UserSet1~15	Memory channel 1 to 15 for user setting.

\* initial factory setting

## ● Note

“UserSetDefault” register value is stored to non-volatile memory when “UserSetSave” is executed.

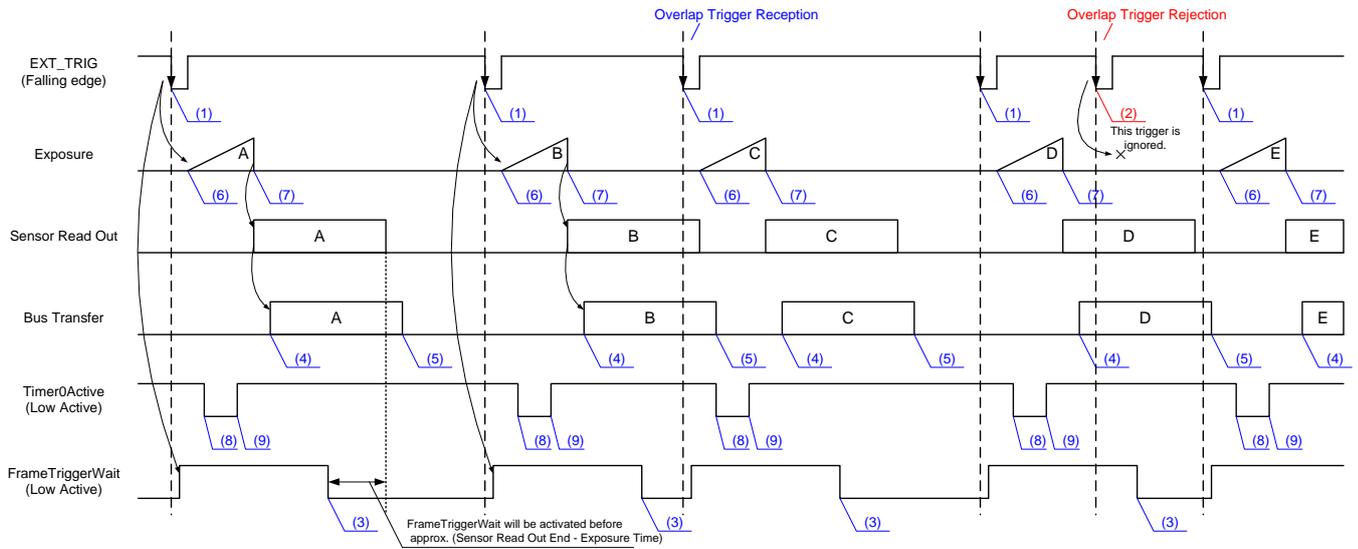
Thus, “UserSetSelector” shall be set other than “Default” in advance.

# EventControl

Camera notifies FrameTrigger status and other information by USB3 Vision Event Packet.

- FrameTrigger : Reception of Frame Start Trigger
- FrameTriggerError : Rejection of Frame Start Trigger
- FrameTriggerWait : Start of waiting for Frame Start Trigger
- FrameTransferStart : Start of transferring streaming data
- FrameTransferEnd : End of transferring streaming data
- ExposureStart : Start of Exposure
- ExposureEnd : End of Exposure
- Timer0Start : Start of Timer0
- Timer0End : End of Timer0

Events timing are as following chart.



**Event Name**

- (1) FrameTrigger : Reception of Frame Start Trigger.
- (2) FrameTriggerError : Rejection of Frame Start Trigger.
- (3) FrameTriggerWait : Start of waiting for Frame Start Trigger.
- (4) FrameTransferStart : Start of transferring streaming data.
- (5) FrameTransferEnd : End of transferring streaming data.
- (6) ExposureStart : Start of Exposure.
- (7) ExposureEnd : End of Exposure.
- (8) Timer0Start : Start of Timer0.
- (9) Timer0End : End of Timer0.

## ● Registers

Register	Visibility	Access	Description
<b>EventControl</b>			
EventSelector	Beginner	R/W	Selects the type of Event notifications.
EventNotification	Beginner	R/W	Sets the activation of Event notifications.
<b>EventFrameTriggerData</b>			
EventFrameTriggerTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventFrameTriggerErrorData</b>			
EventFrameTriggerErrorTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventFrameTriggerWaitData</b>			
EventFrameTriggerWaitTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventFrameTransferStartData</b>			
EventFrameTransferStartTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventFrameTransferEndData</b>			
EventFrameTransferEndTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventExposureStartData</b>			
EventExposureStartTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventExposureEndData</b>			
EventExposureEndTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventTimer0StartData</b>			
EventTimer0StartTimestamp	Expert	R	Returns the timestamp at the time of Event.
<b>EventTimer0EndData</b>			
EventTimer0EndTimestamp	Expert	R	Returns the timestamp at the time of Event.

## ● Setting

- Select the type of Event notifications

Set the following value to “EventSelector” register. The setting value is Enumeration type.

setting value	Event ID	Timing of Event notification
FrameTrigger (*)	0x8020	Reception of Frame Start Trigger
FrameTriggerError	0x8021	Rejection of Frame Start Trigger
FrameTriggerWait	0x8022	Start of waiting for Frame Start Trigger
FrameTransferStart	0x8030	Start of transferring streaming data
FrameTransferEnd	0x8031	End of transferring streaming data
ExposureStart	0x8040	Start of Exposure
ExposureEnd	0x8041	End of Exposure
Timer0Start	0x9000	Start of Timer0
Timer0End	0x9100	End of Timer0

\* initial factory setting

- Set the activation of Event notifications

Set the following value to “EventNotification” register. The setting value is Enumeration type.

setting value	Event notification
Off (*)	Inactive
On	Active

\* initial factory setting

## ● Note

# FrameSynchronization

Selects the camera frame synchronization method.

## ● Registers

Register	Visibility	Access	Description
FrameSynchronization	Beginner	R/W	Selects the camera frame synchronization method.

## ● Setting

- Selects the camera frame synchronization method.

Set the following value to “FrameSynchronization” register. Setting value is Enumeration type.

setting value	function
Off(*)	Internal synchronization
Bus	Bus synchronization

\* initial factory setting

## ● Note

# LEDIndicatorLuminance

Adjusts LED indicator luminance.

## ● Registers

Register	Visibility	Access	Description
LEDIndicatorLuminance	Expert	R/W	Sets LED indicator luminance.

## ● Setting

- Set LED indicator luminance

Set the following value to “LEDIndicatorLuminance” register. Setting value is Float type.

LEDIndicatorLuminance	Value
Minimum	0.00(%)
Maximum (*)	100.00(%)

\* initial factory setting

## ● Note

# AntiGlitch / AntiChattering

AntiGlitch and AntiChattering functions filter noise and unstable state of the digital input (trigger signal).

AntiGlitch circuit performs the digital integration of the trigger signal.

It is effective to remove impulsive noise.

AntiChattering circuit sets the edge insensible time to avoid trigger malfunction.

It is effective to remove unstable logic state and switch-chattering.

This function is available only in B/W models.

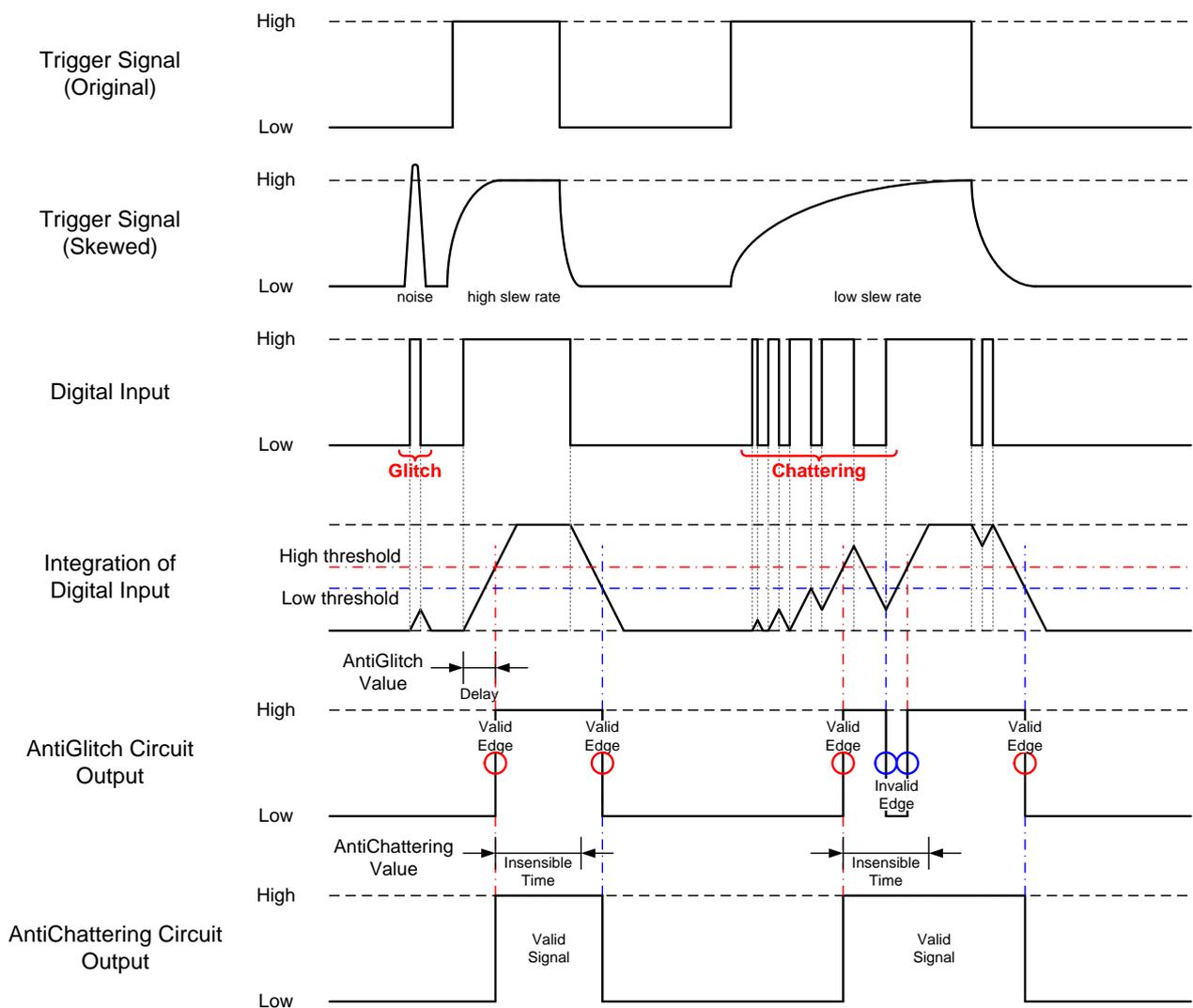


Fig. AntiGlitch and AntiChattering

## ● Registers

Name	Visibility	Access	Description
AntiGlitch	Expert	R/W	Integration time of digital input signal. (Absolute value)
AntiChattering	Expert	R/W	Insensible time of digital input signal. (Absolute value)

## ● Setting

- Set the integration time for AntiGlitch.

Set the integration time to “AntiGlitch Value” register.

Trigger signal is delayed by AntiGlitch setting.

The setting is applied to the GPIO Input of Line0 and Line2.

AntiGlitch	Integration time [sec]
Minimum (*)	0.000 000 090
Maximum	0.002

\* initial factory setting

- Set the insensible time for AntiChattering.

Set the insensible time to “AntiChattering Value” register.

The setting is applied to the GPIO Input of Line0 and Line2.

AntiChattering	Insensitive time [sec]
Minimum (*)	0.000 001 992
Maximum	0.001 999 992

\* initial factory setting

## ● Note

# Appendix

## MultiFrame and Bulk function difference

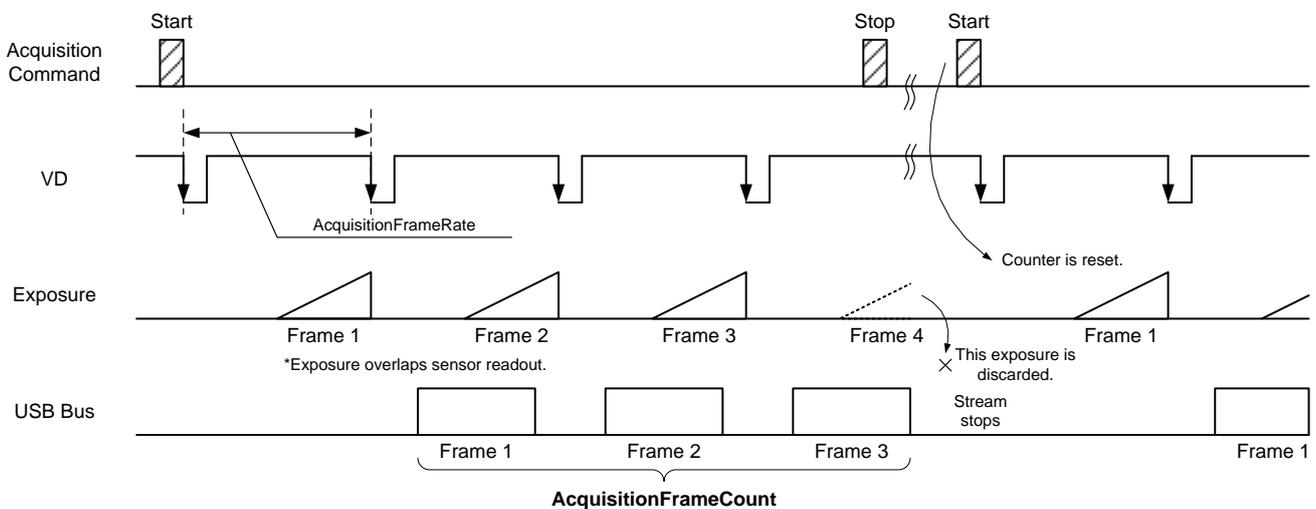
This section describes the difference between MultiFrame function of AcquisitionMode and Bulk function of TriggerSequence.

- MultiFrame function sets limits to the number of frames to transfer with AcquisitionFrameCount register.
- Bulk function sets limits to the number of frames to exposure with TriggerAdditionalParameter register.

### - MultiFrame function in Normal Shutter mode (TriggerMode = Off)

Camera transfers "AcquisitionFrameCount" frame(s).

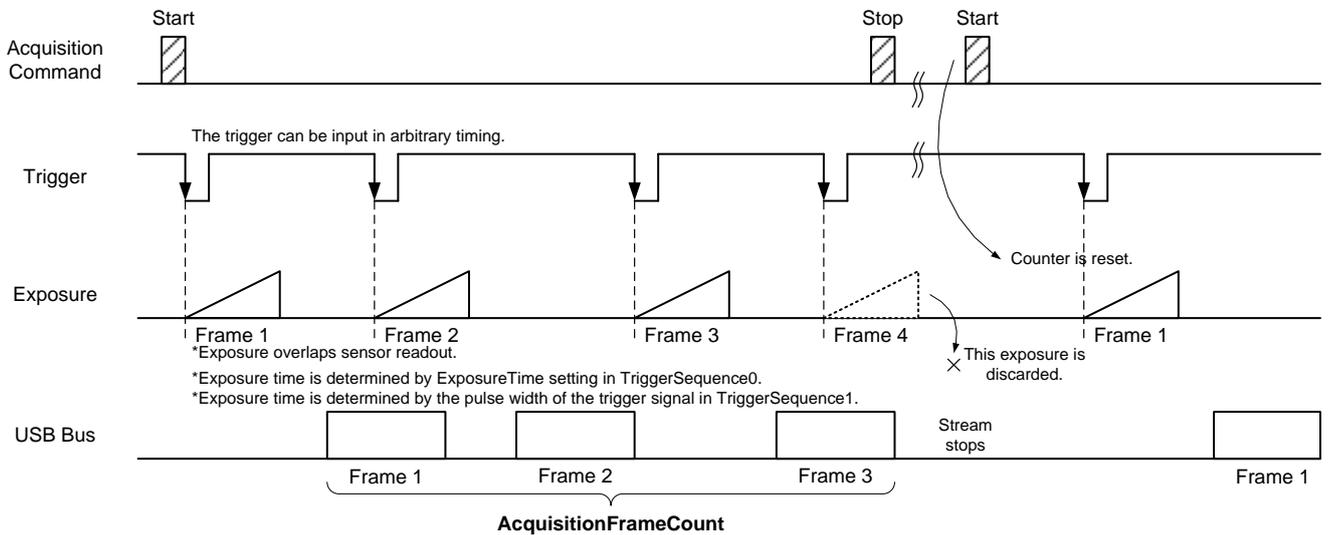
**AcquisitionMode = MultiFrame**  
**AcquisitionFrameCount = 3**  
**TriggerMode = Off**



**- MultiFrame function in Random Trigger Shutter mode (TriggerMode = On, TriggerSequence = 0 or 1)**

Camera transfers "AcquisitionFrameCount" frame(s). It requires "AcquisitionFrameCount" time(s) of trigger.

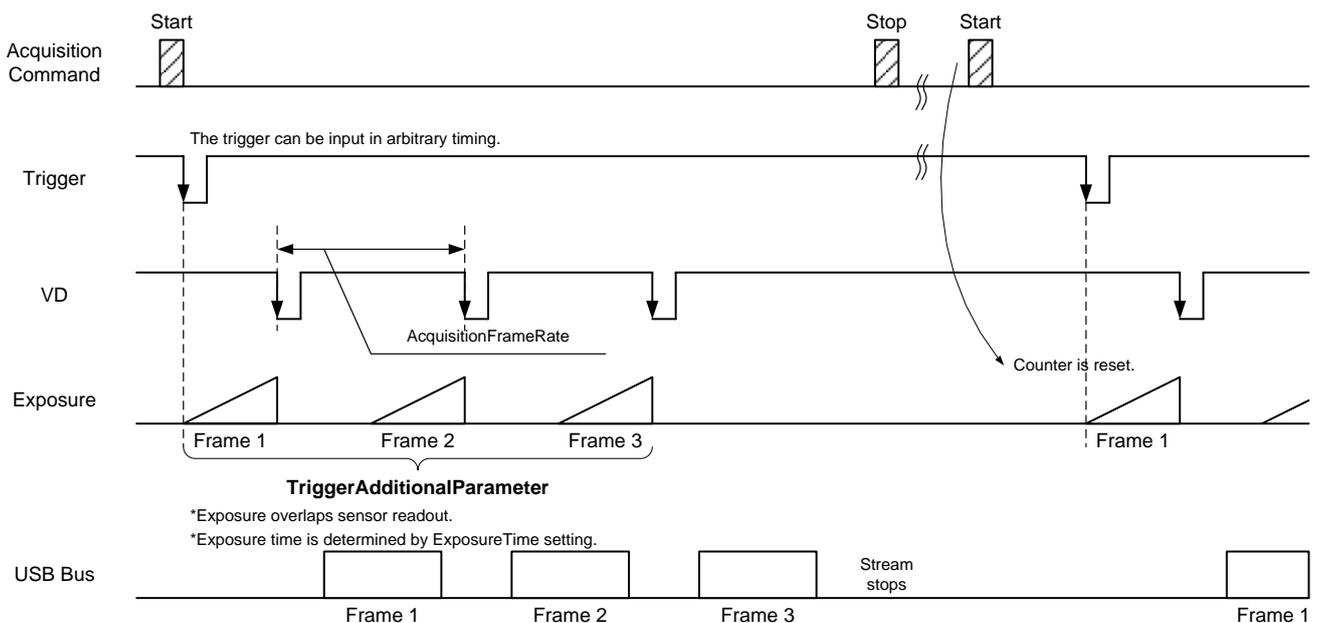
**AcquisitionMode = MultiFrame**  
**AcquisitionFrameCount = 3**  
**TriggerMode = On**  
**TriggerSequence = 0 or 1**



**- Bulk function (TriggerMode = On, TriggerSequence = 6)**

Camera transfers "TriggerAdditionalParameter" frame(s) by a single trigger.

**AcquisitionMode = Continuous**  
**TriggerMode = On**  
**TriggerSequence = 6**  
**TriggerAdditionalParameter = 3**

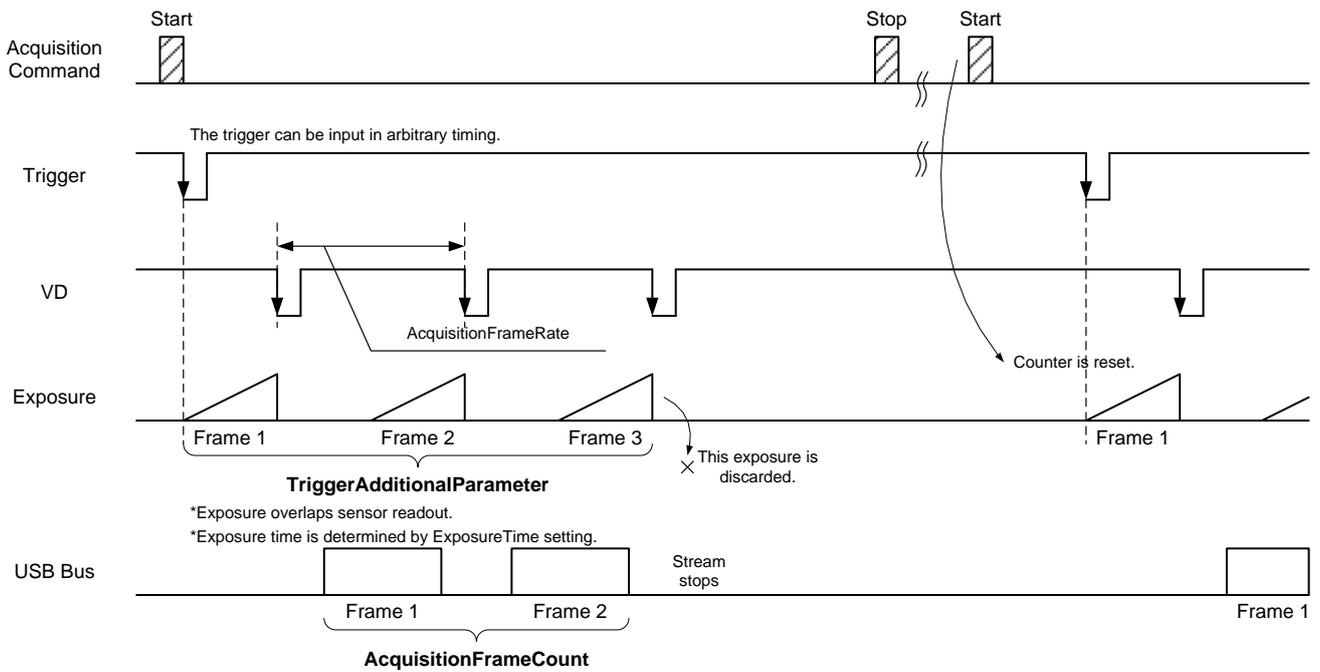


● **Note**

In Bulk function, you may want to set “Continuous” to “AcquisitionMode” register.

You can set “MultiFrame”, but acquisition frame number is limited by “AcquisitionFrameCount”.

**AcquisitionMode = MultiFrame**  
**AcquisitionFrameCount = 2**  
**TriggerMode = On**  
**TriggerSequence = 6**  
**TriggerAdditionalParameter = 3**



# Warranty rules

- **Warranty term**

Warranty term is 36 months after your purchase. We may assume the date of the purchase from our shipping date when the date is unidentified.

- **Limited Warranty**

Free warranty is not applicable for the troubles, damages or losses caused by the cases of the followings, even if it is during the warranty term.

1. Natural exhaust, wear or degradation of a component parts
2. Handling against the instructions and conditions described in the instruction manual
3. Remodeling, adjustment and the part exchange. (including the opening of the enclosure box and the alteration)
4. Using the accessories not included with the product or our non-designated optional articles
5. Damages caused during the transportation or deficiency of the handling such as drop or fall of the products after the products having been transferred to customers, leaving the products to corrosive environment such as sunlight, fire, sand, soil, heat, moisture, or an inappropriate storing method
6. A fire, an earthquake, a flood, a lightning, or other natural disasters, pollution and a short circuit, abnormal voltage, excessive physical pressure, theft, other accident
7. When connected to a product which is not recommended
8. When connected to the power supply which is not suitable
9. Forgery product, products which does not have proper serial number, products of which serial number is forged, damaged or deleted
10. All defects that happened after the expiration for a warranty term

# Repair

- **Repair methods**

Exchange to a replacement or an equal function product.

- **Repair request methods**

On the occasion of a repair request, please download the "Failure situation report sheet" from our website, fill in the necessary items and return it together with the defective product.

Repair Request Methods

[http://www.toshiba-teli.co.jp/en/support/contact/failure\\_situation.htm](http://www.toshiba-teli.co.jp/en/support/contact/failure_situation.htm)

Please read the following instructions carefully.

1. Please return our product alone, taking out of your equipment in case that our product is installed to an equipment
2. We are unable to return the information such as your own serial numbers, control number, the identification seal, if it is attached to the returned products. Please keep record before you return the product.
3. As the data saved in the camera will not be kept after the repair, please take out data before return.
4. We are unable to accept the cancellation after the repair request by the customer's reason.
5. About the repair product shipping expenses, please bear the charges when you return the product to us. We bear the charges to you from us only for a warranty period.
6. We are unable to accept your request of a delivery date and time of the product return, or the delivery method.
7. We are unable to accept a trouble factor investigation, the request of the repair report.
8. We accept a repair of out of warranty product, if it is reparable.
9. The proprietary rights of the repair request products after the exchange repair belong to us.
10. The immunity from responsibility of the product is applied in the repair completion products.

\* Please refer for the inquiry about the software to our homepage or sales personnel.