See the possibilities

User's Manual

BM-500GE, OP22-5-1
BB-500GE, OP22-5-1

5-Megapixel Monochrome / Color
Progressive Scan GigE Vision Camera
With Extended Temperature Operation

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Warranty

For information about the warranty, please contact your factory representative.

Certifications

CE compliance

As defined by the Directive 2004/108/EC of the European Parliament and of the Council, EMC (Electromagnetic compatibility), JAI Inc. declares that BM-500GE and BB-500GE comply with the following provisions applying to its standards.
EN 61000-6-3 (Generic emission standard part 1)
EN 61000-6-2 (Generic immunity standard part 1)

FCC

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into a outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Warning

Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

BM-500GE

Supplement

The following statement is related to the regulation on " Measures for the Administration of the control of Pollution by Electronic Information Products " , known as " China RoHS ". The table shows contained Hazardous Substances in this camera.

(15) mark shows that the environment-friendly use period of contained Hazardous Substances is 15 years.

重要注意事项

有毒，有害物质或元素名称及含量表

根据中华人民共和国信息产业部『电子信息产品污染控制管理办法』，本产品《 有毒，有害物质或元素名称及含量表 》如下.

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（PPB）	多溴二苯醚（PBDE）
螺丝固定座	×	○	○	○	○	○
连接插头	×	○	○	○	○	○
电路板	×	○	○	○	○	○
.....	.....	.....	.....	.....	.....	.....

○：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SJ/T11363-2006规定的限量要求以下。
×：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SJ/T11363-2006规定的限量要求。
（企业可在此处、根据实际情况对上表中打 " × " 的技术原因进行进一步说明。）

环保使用期限
电子信息产品中含有的有毒有害物质或元素在正常使用的条件下不会发生外泄或突变、电子信息产品用户使用该电子信息产品不会对环境造成严重污染或对基人身、财产造成严重损害的期限。
数字「15」为期限15年。

BB-500GE

Supplement

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(15) mark shows that the environment-friendly use period of contained Hazardous Substances is 15 years.

重要注意事项

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根据中华人民共和国信息产业部『电子信息产品污染控制管理办法』，本产品《 有毒，有害物质或元素名称及含量表 》如下.

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（PPB）	多溴二苯醚（PBDE）
螺丝固定座	×	○	○	○	○	○
光学滤色镜	×	○	×	○	○	○
连接插头	×	○	○	○	○	○
电路板	×	○	○	○	○	○
.....	.....	.....	.....	.....	.....	.....

○：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SJ/T11363-2006规定的限量要求以下。
×：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SJ/T11363-2006规定的限量要求。
（企业可在此处、根据实际情况对上表中打"×"的技术原因进行进一步说明。）

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数字「15」为期限15年。

Table of Contents

1. General

This manual covers the digital monochrome progressive scan camera BM-500GE, OP22-5-1 and color progressive scan camera BB-500GE, OP22-5-1

The BM-500GE, OP22-5-1 and BB-500GE, OP22-5-1 are GigE Vision compliant cameras offering 5 megapixel resolution and a "B Series" 55 mm cubic form factor. The OP22-5-1 designations indicate that the cameras have been certified for operation across an extended temperature range of -40ºC to +65ºC, making them capable of withstanding harsh field environments. For simplicity, the remainder of this manual will typically refer to the cameras without the OP22-5-1 suffixes.

Both the monochrome version (BM-500GE) and the color version (BB-500GE) provide a frame rate of 15 frames/second at full resolution. Using vertical binning (BM-500GE only), draft mode (BB-500GE only), or partial scan, the cameras can achieve faster frame rates.
The 2/3" CCD (ICX625) with square pixels offers superb image quality. The high-speed shutter function and asynchronous random trigger mode allows the camera to capture high quality images of fast moving objects.

The color version BB-500GE incorporates a primary RGB Bayer mosaic filter on the CCD to output raw Bayer images. Host-based color interpolation, using the JAI GigE Vision SDK and Control Tool or other GigE Vision compliant software, provides color interpolation to display or save color images. The camera features built-in white balance and dual-tap channel balancing, eliminating the need for performing these functions on the host-PC.

The BM-500GE/BB-500GE also complies with the GenICam standard, including the Standard Feature Naming Convention (SFNC) as it has an internal XML file that is used to describe the functions/features of the camera. For further information on GenICam and SFNC, please go to www.emva.org

As an application programming interface, JAI provides an SDK (Software Development Kit). This SDK includes a GigE Vision Filter Driver, JAI control tool, software documentation and code examples.

The JAI SDK and the latest version of this manual can be downloaded from www.jai.com. For camera revision history, please contact your local JAI distributor.

2. Camera nomenclature

The standard camera composition consists of the camera main body and C-mount protection cap. The camera is available in the following versions:

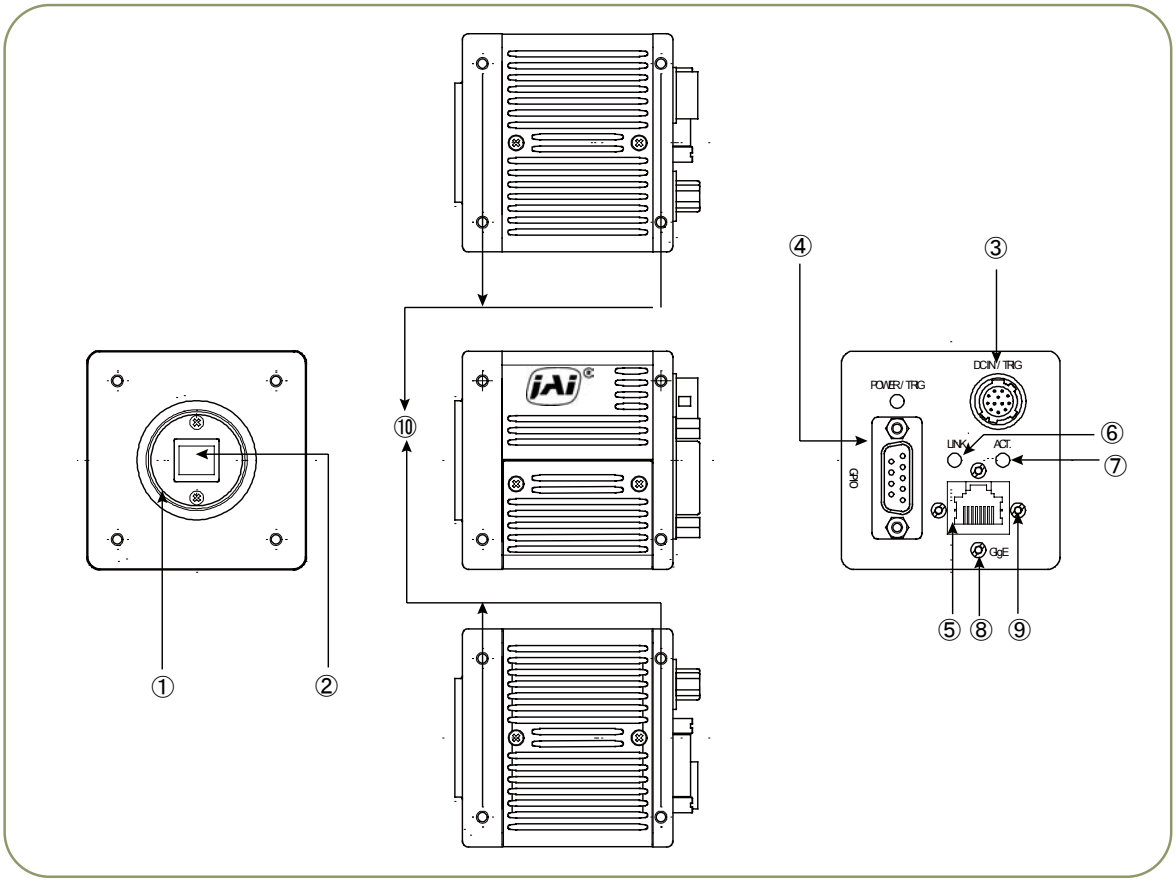
BM-500GE, OP22-5-1
Where **B** stands for "B-series" form factor, **M** stands for monochrome, **500** represents the resolution "5 million pixels", **GE** stands for "GigE Vision" interface, and **OP22-5-1** indicates extended temperature operation.

BB-500GE, OP22-5-1
Where **B** stands for "B-series" form factor, **B** stands for Bayer color output, **500** represents the resolution "5 million pixels", **GE** stands for "GigE Vision" interface, and **OP22-5-1** indicates extended temperature operation.

3. Main Features

- 5-megapixel digital video camera
- Certified for extended temperature operation (-40ºC to +65ºC)
- GigE vision and GenICam SFNC compliant
- 2456 (h) x 2058 (v) resolution
- 3.45 µm square pixels
- 2/3 inch progressive scan CCD – Monochrome and Bayer mosaic color versions
- 15 fps (dual-tap) with full resolution in continuous or triggered operation
- Increased frame rate with vertical binning (BM-500GE only), draft mode(BB-500GE only), and fixed or variable partial scan
- Preset and auto shutter modes provided
- Exposure time from 64µs to 2 sec. using pulse width trigger mode
- Programmable exposure from 64µs to 66 ms in full frame scan
- GPIO in combination with pulse width trigger for more precise exposure time
- Sequencer trigger mode for on-the –fly change of gain, exposure and ROI
- Edge pre-select, pulse width control and modes
- One-push or preset white balance for BB-500GE
- Manual and automatic gain control
- Look Up Table (LUT) for gamma and knee settings
- Blemish compensation circuit built in
- LVAL-synchronous/-asynchronous operation (auto-detect)
- Auto iris lens video output (can be selected by DIP switch)
- GigE Vision interface with 12, 10 or 8-bit output
- Programmable GPIO with opto-isolated inputs and outputs
- Comprehensive software tools and SDK for Windows XP/Vista/Windows 7 - 32-bit (x86) and 64-bit (x64)

4. Locations and Functions



①	Lens mount	C-mount (Note *1)
②	CCD sensor	2/3 inch CCD sensor
③	12-pin connector	DC +12V power and GPIO interface
④	D-sub 9 pin connector	Auxiliary GPIO interface (LVDS IN and TTL IN/OUT)
⑤	RJ-45	GigE Vision I/F. Accepts connector w thumbscrews.
⑥	LED	GigE Network condition: LINK
⑦	LED	GigE Network condition: ACT
⑧	Holes for RJ-45 thumbscrews	Vertical type (above and below RJ-45).
⑨	Holes for RJ-45 thumbscrews	Horizontal type (left and right of RJ-45) (Note *2)
⑩	Mounting holes	M3 depth 5 mm for tripod mount plate (Note *3)

*1) Note: Rear protrusion on C-mount lens must be less than 10.0mm.

*2) Note: When an RJ-45 cable with thumbscrews is connected to the camera, please do not excessively tighten screws by using a screwdriver. The RJ-45 receptacle on the camera might be damaged.
For security, the strength to tighten screws is less than 0.291 Newton meter (Nm). Tightening by hand is sufficient in order to achieve this.

*3) Note: The tripod adapter plate MP-41 can be used with BM/BB-500GE

Fig. 1. Locations

5. Pin Assignment

5.1 12-pin Multi-connector (DC-in/GPIO/Iris Video)

Type: HR10A-10R-12PB
(Hirose) male.
(Seen from the rear of camera)

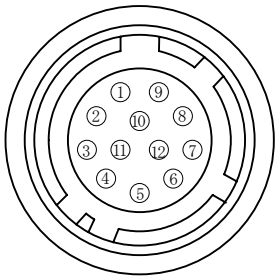


Fig. 2. 12-pin connector.

Pin no.	Signal	Remarks
1	GND	
2	+12 V DC input	
3	Opt IN 2 (-) / GND (*1)	GPIO IN / OUT
4	Opt IN 2 (+)/Iris Video out (*1)	
5	Opt IN 1 (-)	
6	Opt IN 1 (+)	
7	Opt Out 1 (-)	
8	Opt Out 1 (+)	
9	Opt Out 2 (-)	
10	Opt Out 2 (+)	
11	+ 12 V DC input	
12	GND	

*1: Iris Video output function can be set by the internal DIP switch (SW601).

5.2 Digital Output Connector for Gigabit Ethernet

Type: RJ-45 : HFJ11-1G02E-L21RL or equivalent

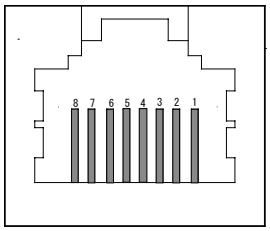
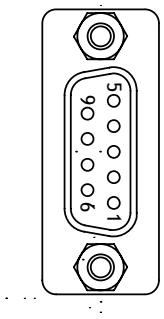


Fig. 3. Gigabit Ethernet connector

The digital output signals follow the Gigabit Ethernet interface using RJ-45 conforming connector. The following is pin assignment for Gigabit Ethernet connector.

Pin No	In/Out	Name
1	In/Out	MX1+ (DA+)
2	In/Out	MX1- (DA-)
3	In/Out	MX2+ (DB+)
4	In/Out	MX3+ (DC+)
5	In/Out	MX3- (DC-)
6	In/Out	MX2- (DB-)
7	In/Out	MX4+ (DD+)
8	In/Out	MX4- (DD-)

5.3 D-sub 9 pin connector for GPIO (Auxiliary)



Type: DD-09SSG

Fig. 4 D-sub 9 pin connector

No	I/O	Name	Note
1	I	LVDS In1-	
2	I	LVDS In1+	
3	I	TTL IN 1	75ohm Terminator *
4	O	TTL Out 1	
5		GND	
6		NC	
7		NC	
8	O	TTL Out 2	
9		GND	

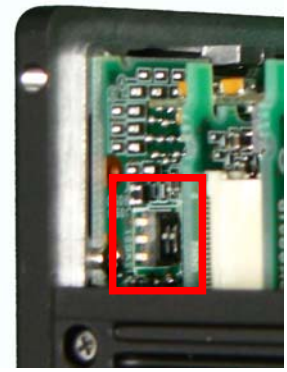
*Can be changed by internal DIP switch (SW600)

5.4 Internal DIP switch

In order to change, the top cover must be removed.

SW601 For selection of OPT IN and Iris Video OUT

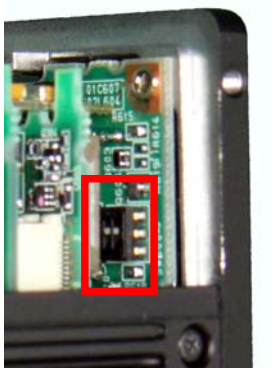
Factory default is UP position (OPT IN). To select an Iris video, these two switches should be set at DOWN.



Left side, as seen from the lens side

SW600 For selection of TTL IN 1 75 ohm ON or OFF

Factory default is UP position (75 ohm OFF). To set 75 ohm ON, these two switches must be DOWN.

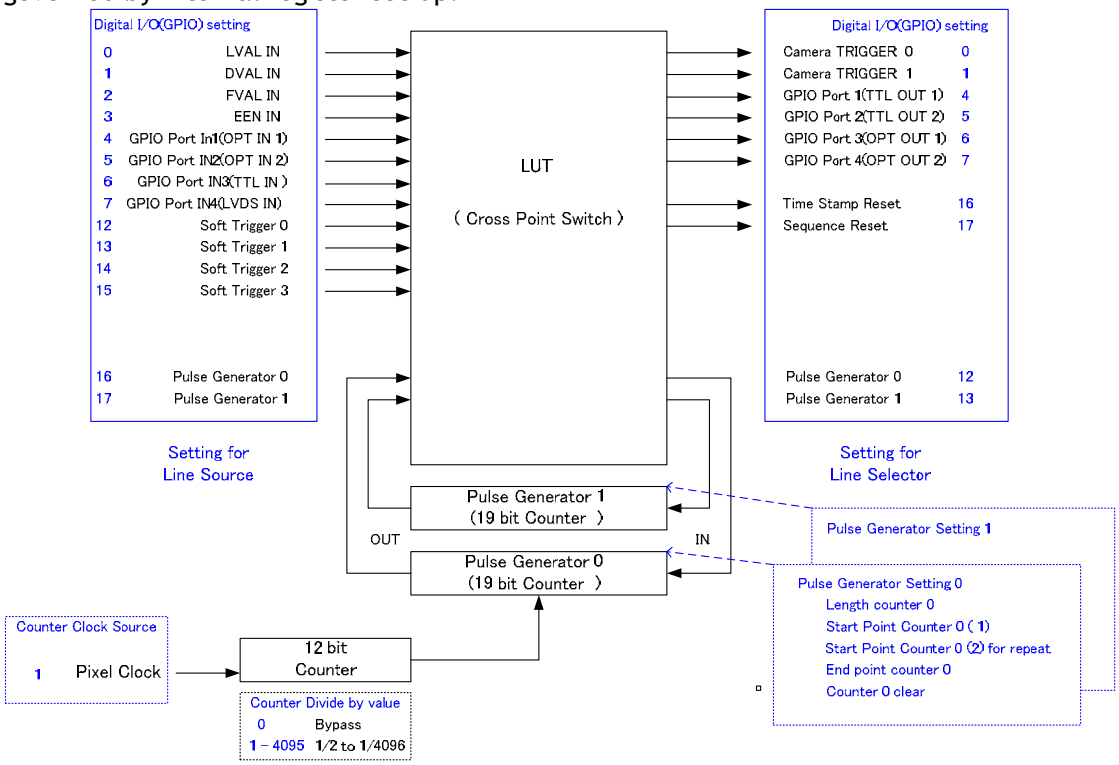


Right side, as seen from the lens side

6. GPIO (Inputs and outputs)

6.1. Overview

All input and output signals pass through the GPIO (General Purpose Input and Output) module. The GPIO module consists of a Look-Up Table (LUT – Cross-Point Switch), 2 Pulse Generators and a 12-bit counter. In the LUT, the relationship between inputs, counters and outputs is governed by internal register set-up.



On the above block diagram, Trigger 0 is used for Exposure and Trigger 1 is used for Delayed Readout. The Time Stamp Reset can reset the time stamp compliant with GigE Vision standard. This is used for ensuring the same time stamp if multiple cameras are used.

The blocks shown in the above diagram have the following functionality:

6.1.1 LUT (Cross Point Switch)

The LUT works as a cross-point switch which allows connecting inputs and outputs freely. The signals LVAL_IN, DVAL_IN, FVAL_IN and EEN_IN all originate from the camera timing circuit. On this diagram, Trigger 0 is used for exposure and Trigger 1 is used for Delayed Readout. The Time Stamp Reset signal can reset the time stamp specified in GigE Vision Format. This signal can be used when time stamps from several cameras connected are coincident with each other.
Outputs from the LUT described in the blue line block show GPIO settings for LINE SELECTOR on JAI Camera Control tool and inputs for the LUT on the left side show GPIO settings for LINE SOURCE on JAI Camera Control tool. Refer to Chapter 6.3 GPIO inputs/Outputs table.

6.1.2 12-bit Counter

The camera pixel clock can be used as a source. The counter has a “Divide by N”, where N has the range 1 through 4096, allowing a wide range of clock frequencies to be programmed. Setting Value 0 is bypass, setting value 1 is 1/2 dividing and setting value 4095 is 1/4096 dividing. The pixel clock for BM-500GE/BB-500GE is 60 MHz.

6.1.3 Pulse Generators (0 to 1)

Each pulse generator consists of a 19-bit counter. The behavior of these signals is defined by their pulse width, start point and end point.
The pulse generator signals can be set in either triggered or periodic mode.
In triggered mode, the pulse is triggered by the rising edge/falling edge/high level or low level of the input signal. In periodic mode, the trigger continuously generates a signal that is based on the configured pulse width, starting point and end point.
Each pulse generator operates at the frequency created in the 12-bit counter. As the pixel clock (60 MHz) is used as the main frequency, the frequency of pulse generator is 60MHz to 14.648 KHz.

6.2 Opto-isolated Inputs/Outputs

The control interface of the C3 GigE Vision camera series has opto-isolated inputs and outputs, providing galvanic separation between the camera's inputs/outputs and peripheral equipment. In addition to galvanic separation, the opto-isolated inputs and outputs can cope with a wide range of voltages; the voltage range for inputs is +3.3V to +24V DC whereas outputs will handle +5V to +24V DC.

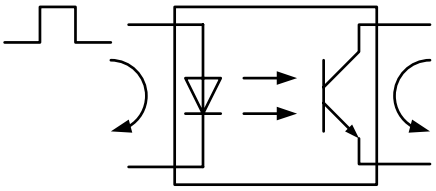


Fig.5. Photo coupler

6.2.1 Recommended External Input circuit diagram for customer

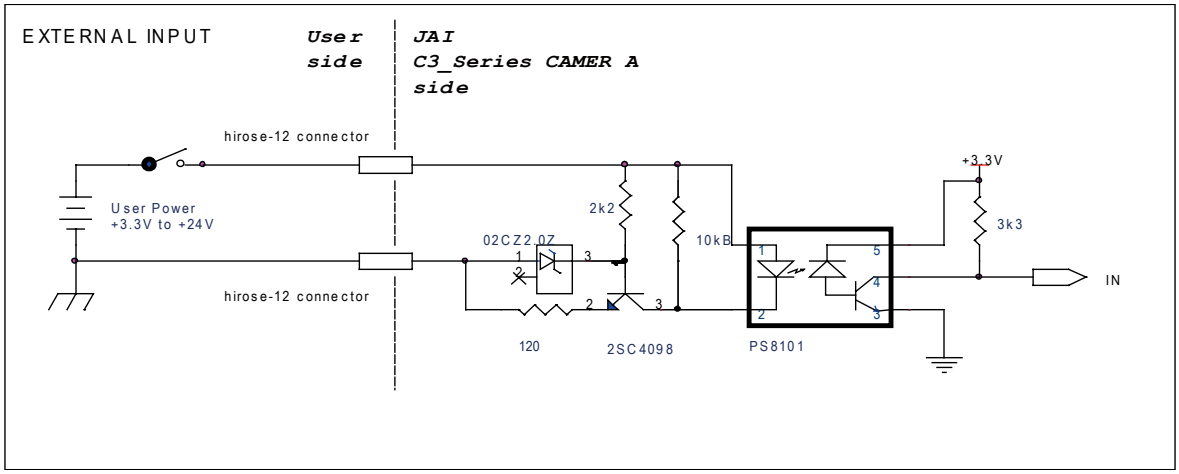


Fig.6. External Input Circuit、OPT IN 1 and 2

6.2.2 Recommended External Output circuit diagram for customer

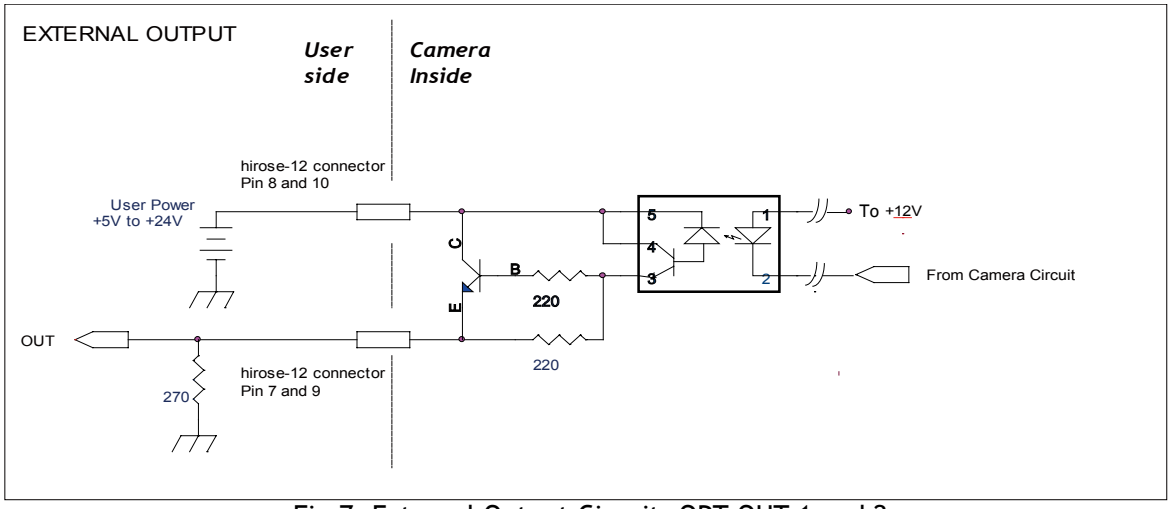
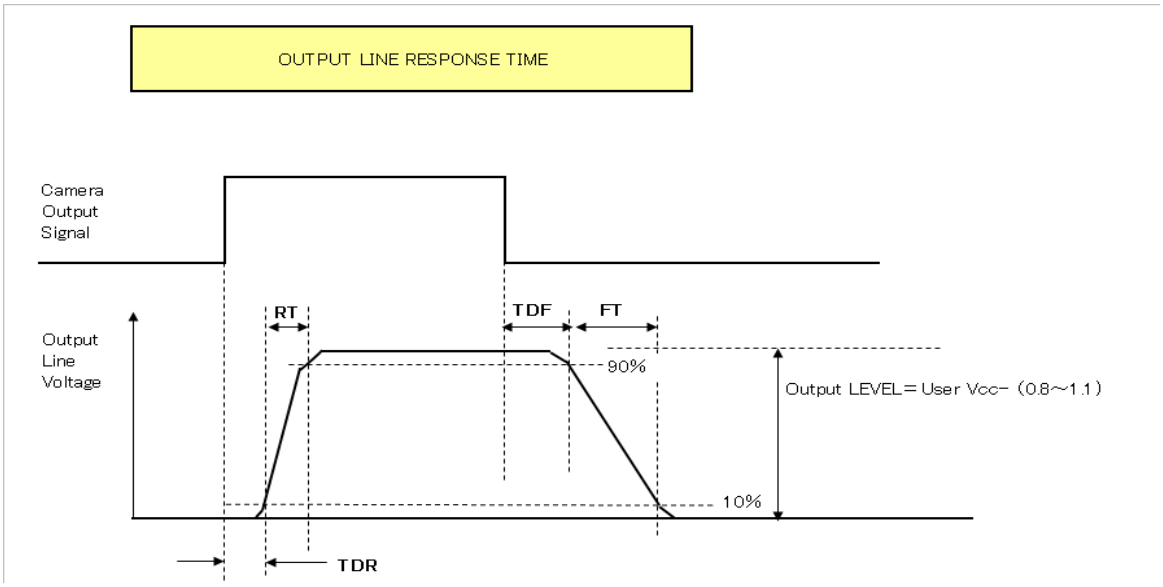


Fig.7. External Output Circuit, OPT OUT 1 and 2

6.2.3 Optical Interface Specifications

The relation of the input signal and the output signal through the optical interface is as follows.



Conditions for Input	
Input Line Voltage Range	+3.3V ~ +24V
Input Current	6mA ~ 30mA
Minimum Input Pulse Width to Turn ON	0.5µs

Output Specifications	
Output Load(Maximum Current)	100mA
Minimum Output Pulse Width	20µs
Time Delay Rise TDR	0.5µs ~ 0.7µs
Rise Time RT	1.2µs ~ 3.0µs
Time Delay Fall TDF	1.5µs ~ 3.0µs
Fall Time FT	4.0µs ~ 7.0µs

Fig.8 Optical Interface Performance

6.3 Inputs and outputs table

		Output Ports									
		Trigger 0	Trigger 1	OPT OUT1	OPT OUT2	TTL OUT1	TTL OUT2	Time Stamp Reset	Sequence Reset	Pulse Generator 0	Pulse Generator 1
Input Ports	LVAL IN	×	×	×	×	○	○	×	×	○	○
	DVAL IN	×	×	×	×	○	○	×	×	○	○
	FVAL IN	×	×	×	×	○	○	×	×	○	○
	EEN IN	×	×	○	○	○	○	×	×	○	○
	OPT IN 1	○	○	○	○	○	○	○	○	○	○
	OPT IN 2	○	○	○	○	○	○	○	○	○	○
	TTL IN	○	○	○	○	○	○	○	○	○	○
	LVDS IN	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 0	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 1	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 2	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 3	○	○	○	○	○	○	○	○	○	○
	Pulse Gen. 0	○	○	○	○	○	○	○	○	×	○
	Pulse Gen. 1	○	○	○	○	○	○	○	○	○	×

LEGEND: 0 = valid combination / x = Not valid (do not use this combination)
The shaded parts are for the interface to external equipment.

6.4 Configuring the GPIO module (register settings)

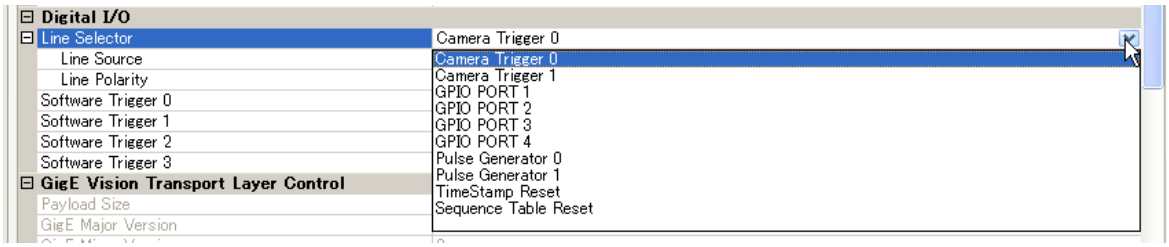
6.4.1 Input /Output Signal Selector

Address	Internal Name	GenICam Name	Access	Size	Value (Range)
0xB060	Selector CAMERA TRIGGER 0 (for Camera Trigger)	Camera Trigger 0	R/W	4	GPIO Selector: **Line Source (SDK)** 0x00:CAMERA LVAL IN 0x01:CAMERA DVAL IN 0x02:CAMERA FVAL IN 0x03:CAMERA EEN IN 0x04:OPT 1 IN 0x05:OPT 2 IN 0x06:TTL 1 IN 0x07:LVDS 1 IN 0x0C:SOFT TRIG 0 0x0D:SOFT TRIG 1 0x0E:SOFT TRIG 2 0x0F:SOFT TRIG 3 0x10:Pulse Generator 0 0x11: Pulse Generator 1 0x7F: No connect
0xB064	Selector CAMERA Trigger 1 (For Delayed Trigger)	Camera Trigger 1	R/W	4	
0xB070	Selector GPIO PORT 1	GPIO_Port1	R/W	4	
0xB074	Selector GPIO PORT 2	GPIO_Port2	R/W	4	
0xB090	Pulse Generator 0 Selector	PulseGenerator 0	R/W	4	
0xB094	Pulse Generator 1 Selector	PulseGenerator 1	R/W	4	
0xB0A0	Selector Time Stamp Reset	TimeStamp Reset	R/W	4	

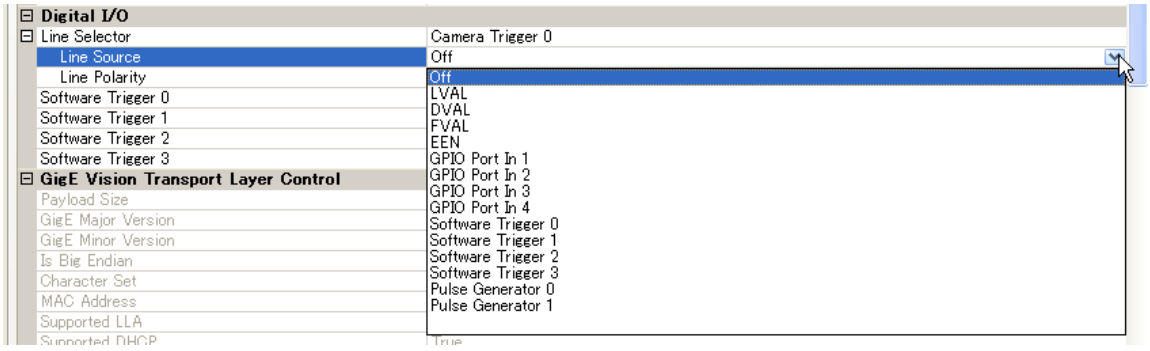
0xB0A4	Selector Sequence Table Reset	Sequence Table reset	R/W	4	**Line selector (SDK)** 0x00:CAMERA Trigger 0 0x01:CAMERA Trigger 1 0x04:TTL OUT 1 0x05:TTL OUT 2 0x06:OPT OUT 1 0x07:OPUOUT 2 0x0C:Pulse Generator 0 0x0D:Pulse Generator 1 0x10:Time stamp reset 0x11:Sequence table reset 0x7F: No connect Add 0x80 will result in low active output.

The following figures show how to set in the JAI SDK Camera Control Tool.

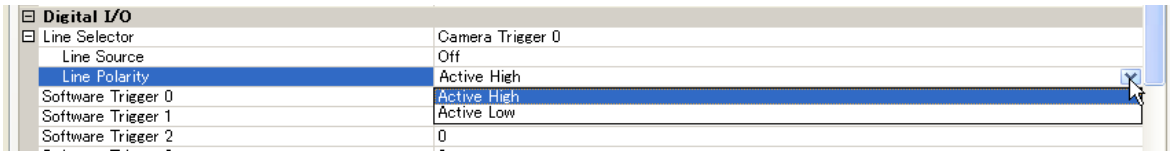
Line Selector



Line Source



Line Polarity

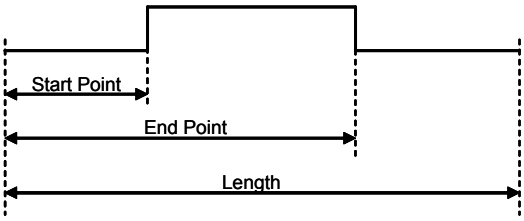


6.4.2 12-bit counter

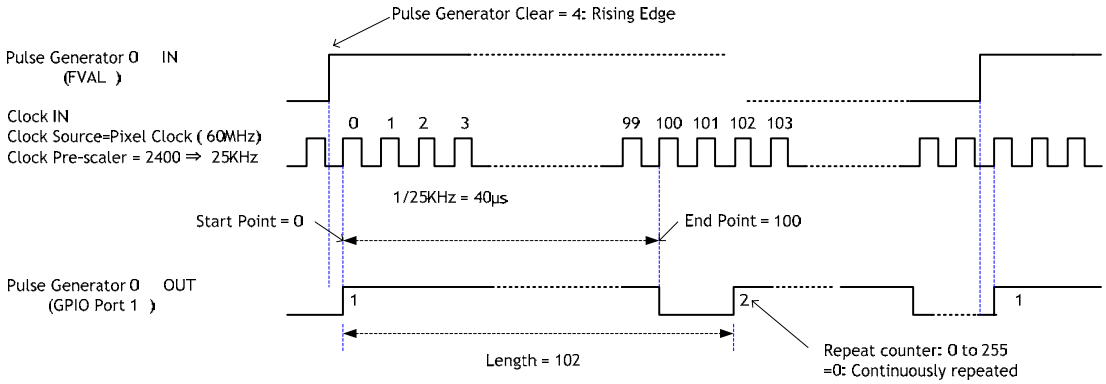
Address	Internal Name	GenICam Name	Access	Size	Value (Range)
0xB004	Counter Dividing Value	ClockPreScaler	R/W	4	0x000: Bypass 0x001: 1/2 Dividing 0x002: 1/3 Dividing | 0xFFF: 1/4096 Dividing

6.4.3 Pulse generators (19 bit x 2)

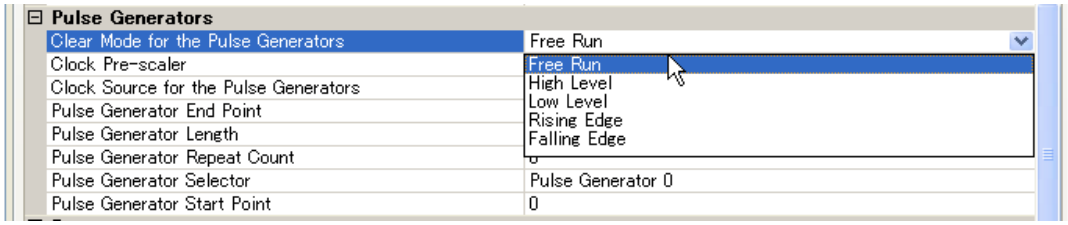
There are 2 pulse generators (designated 0 through 1) that can be used to create various timing scenarios by programming start point, endpoint, length and repeats.



The following drawing is an example of settings.
FVAL is used for the input of a pulse generator 0 and the clock after the rising edge of FVAL counts 100 clocks for the high period of the pulse and 102 clocks for the pulse length.
As 2400 is for Clock Pre-scaler, the output of 12 bit counter is 25 KHz, which is 40µs.
Thus, pulse generator 0 creates a 4 ms pulse.



The following shows how to set the pulse generators in the JAI SDK Camera Control Tool.



Address	Internal Name	GenICam name	Access	Size	Value (range)
0xB008	Length Counter 0	Pulse Generator Length	R/W	4	0x00001 to 0xFFFFF
0xB00C	Start point Counter 0(1)	PulseGenerator StartPoint	R/W	4	0x00000 to 0xFFFFF
0xB010	Start point Counter 0(2)	PulseGenerator RepeatCOunt	R/W	4	0x00: infinite 0x01: 1 time | 0xFF: 255 times
0xB014	End point Counter 0	PulseGenerator EndPoint	R/W	4	0x00001 to 0xFFFFF
0xB018	Counter Clear 0	PulseGenerator Clear	R/W	4	0x00: Free Run 0x01: High Level Clear 0x02: Low Level Clear 0x04: Rising Edge Clear 0x08: Falling Edge Clear
0xB01C	Length Counter 1	Pulse Generator Length	R/W	4	0x00001 to 0xFFFFF
0xB020	Start point Counter 1(1)	PulseGenerator StartPoint	R/W	4	0x00000 to 0xFFFFF
0xB024	Start point Counter 1(2)	PulseGenerator RepeatCount	R/W	4	0: Infinite 1: 1 time | 255: 255 times
0xB028	End point Counter 1	PulseGenerator EndPoint	R/W	4	0x00001 to 0xFFFFF
0xB02C	Counter 1 Clear	PulseGenerator Clear	R/W	4	0x00: Free Run 0x01: High Level Clear 0x02: Low Level Clear 0x04: Rising Edge Clear 0x08: Falling Edge Clear

6.5 GPIO programming examples

6.5.1 GPIO Plus PWC shutter

Example: 10µs unit pulse width exposure control (PWC).
Pixel clock is 60MHz. 600 clocks (700-100) equal 10µs.

	Address	*Register*	*Value*
	0xA040	Trigger Mode	2 = PWC (Pulse Width Control)
①	0xB090	Pulse Generator 0 Selector	4 =OPT IN 1
②	0xB000	Clock Choice	1 = Pixel Clock (60MHz)
	0xB004	Counter Dividing Value	0 = Pass through
	0xB008	Length Counter 0	1000 Clocks
	0xB00C	Start point Counter 0(1)	100 Clocks
	0xB010	Start point Counter 0(2)	1
	0xB014	End point Counter 0	700 Clocks
	0xB018	Counter Clear 0	4 = Rising Edge Clear
③	0xB060	CAMERA TRIGGER Selector	16 = pulse generator 0
①	0xB090	Pulse Generator 0 Selector	4 =OPT IN 1

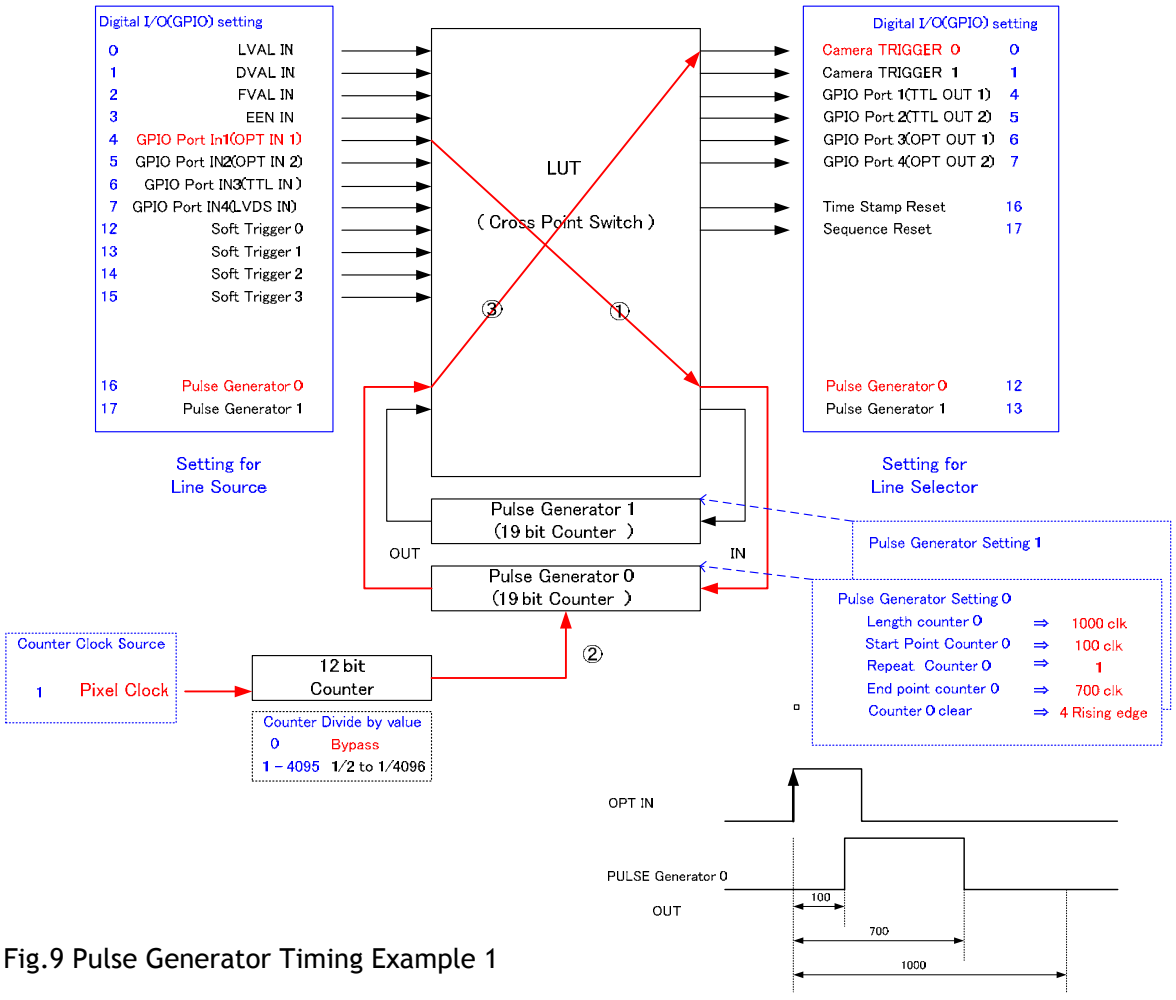
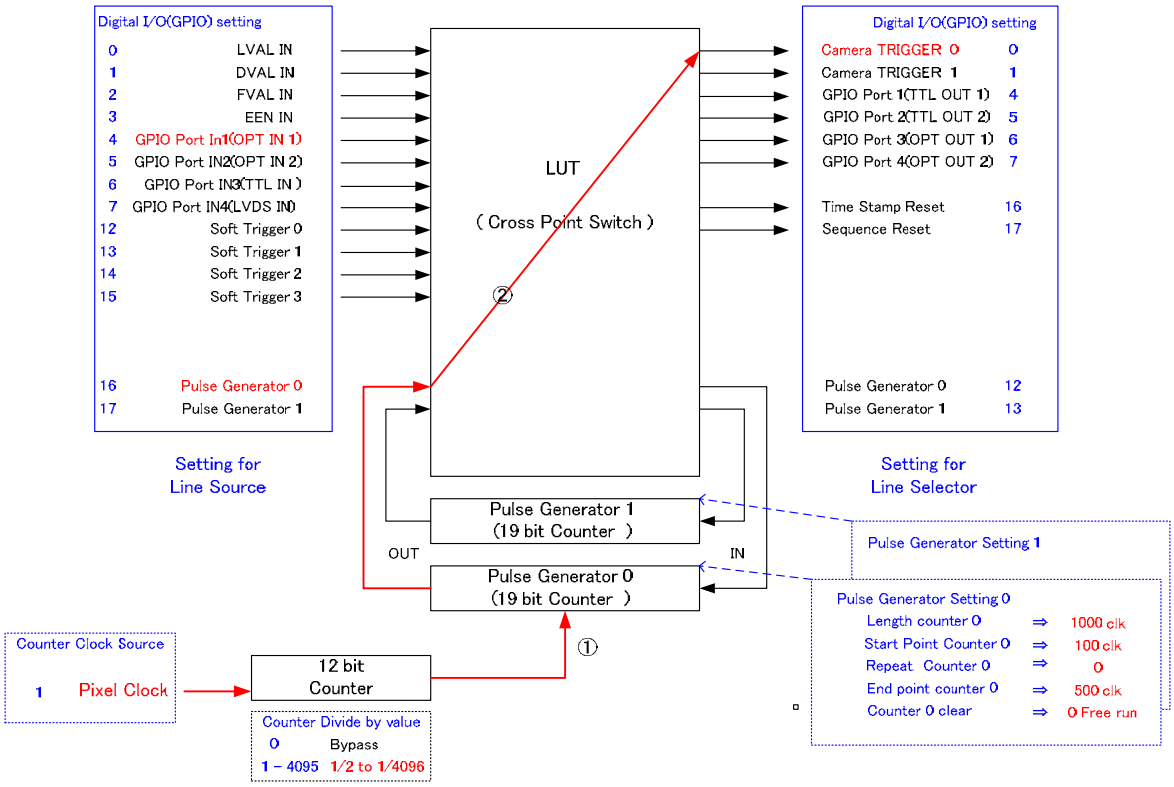


Fig.9 Pulse Generator Timing Example 1

6.5.2 Internal Trigger Generator

Example: Create a trigger signal and trigger the camera

	Address	Register	Value
	0xA040	Trigger Mode	1 = EPS
①	0xB000	Clock Choice	1 = Pixel Clock
	0xB004	Counter Dividing Value	2079= 1/2080(Line Rate)
	0xB008	Length Counter 0	1000 Clocks
	0xB00C	Start point Counter 0 (1)	100 Clocks
	0xB010	Start point Counter 0 (2)	0 = Infinite
	0xB014	End point Counter 0	500 Clocks
	0xB018	Counter Clear 0	0 = Free Run
②	0xB060	CAMERA TRIGGER Selector	16 = pulse generator 0



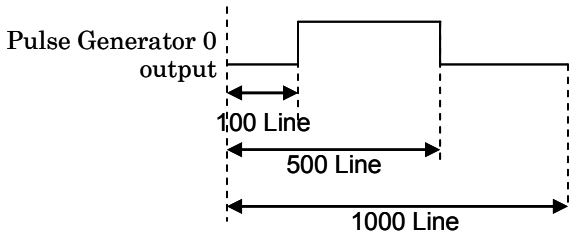


Fig.10 Pulse Generator 0 timing Example 2

7. GigE Vision Streaming Protocol (GVSP)

7.1. Digital Video Output (Bit Allocation)

Although the BM-500GE and BB-500GE are digital cameras, the image is generated by an analog component, the CCD sensor.
The table and diagram below show the relationship between the analog CCD output level and the digital output.

CCD out	Analog Signal *	Digital Out		
		8 bit	10 bit	12 bit
Black	Setup 3.6%, 25mV	8 LSB	32 LSB	128 LSB
200mV	700mV	222 LSB	890 LSB	3560 LSB
230mV	800mV	255 LSB	1023 LSB	4095 LSB

The standard setting for 10-bit video level is 890 LSB. 200 mV CCD output level equals 100% video output.

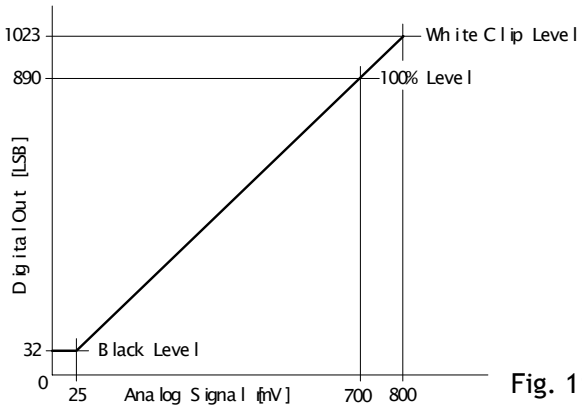


Fig. 11. Digital Output (10-bit output)

Important Note:
When gain is set at -4.5db to -6dB, the linearity of the video output may deteriorate around 100% video output level. Please confirm the output level characteristics when -4.5dB to -6dB gain is set.

7.2. Bit Allocation (Pixel Format / Pixel Type) – BM-500GE (monochrome)

In the GigE Vision Interface, GVSP (GigE Vision Streaming Protocol) is used for an application layer protocol relying on the UDP transport layer protocol. It allows an application to receive image data, image information and other information from a device. In the BM-500GE monochrome camera, the following pixel types supported by GVSP are available. With regard to the details of GVSP, please refer to the GigE Vision Specification available from AIA (www.machinevisiononline.org).

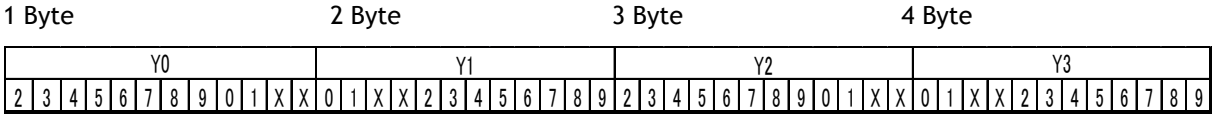
7.2.1 GVSP_PIX_MONO8 (8bit)

1 Byte								2 Byte								3 Byte							
Y0								Y1								Y2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

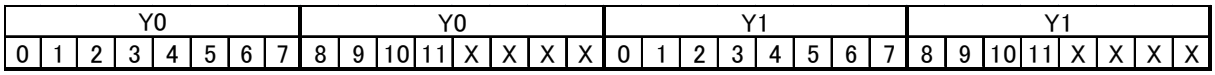
7.2.2 GVSP_PIX_MONO10 (10bit)

1 Byte								2 Byte								3 Byte								4 Byte							
Y0								Y0								Y1								Y1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

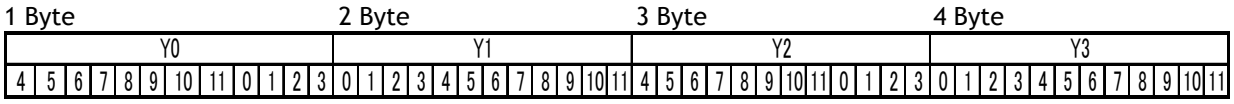
7.2.3 GVSP_PIX_MONO10_PACKED (10 bit)



7.2.4 GVSP_PIX_MONO12 (12 bit)



7.2.5 GVSP_PIX_MONO12_PACKED (12 bit)

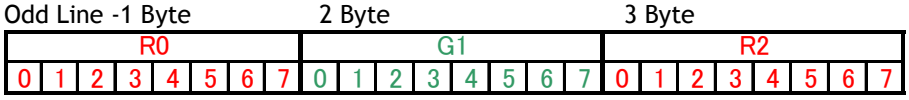


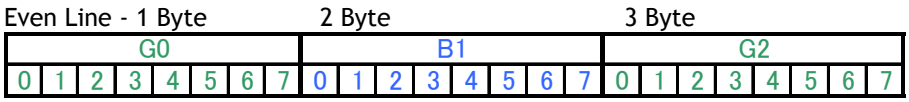
Address	Internal Name	Access	Size	Value
0xA410	Pixel Format type	R/W	4	0x01080001:Mono8 0x01100003:Mono10 0x010C0004:Mono10 Packed 0x01100005:Mono12 0x010C0006:Mono12 Packed

7.3 Bit Allocation (Pixel Format / Pixel Type) - BB-500GE (Bayer mosaic color)

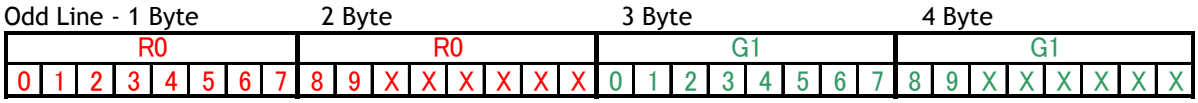
In the GigE Vision Interface, GVSP (GigE Vision Streaming Protocol) is used for an application layer protocol relying on the UDP transport layer protocol. It allows an application to receive image data, image information and other information from a device.
In the BB-500GE color camera, the following pixel types supported by GVSP are available.
With regard to the details of GVSP, please refer to the GigE Vision Specification available from AIA.

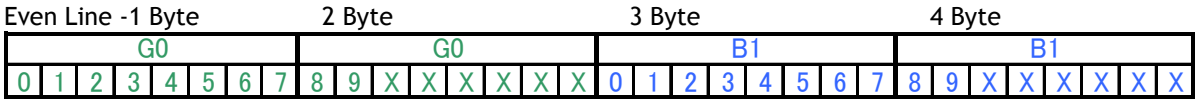
7.3.1 GVSP_PIX_BAYRG8 “BayerRG8”





7.3.2 GVSP_PIX_BAYRG10 “Bayer RG10”





7.3.3 GVSP_PIX_BAYRG12 "Bayer RG12"

Odd Line - 1 Byte

R0							
0	1	2	3	4	5	6	7

2 Byte

R0							
8	9	10	11	X	X	X	X

3 Byte

G1							
0	1	2	3	4	5	6	7

4 Byte

G1							
8	9	10	11	X	X	X	X

Even Line - 1 Byte

G0							
0	1	2	3	4	5	6	7

2 Byte

G0							
8	9	10	11	X	X	X	X

3 Byte

B1							
0	1	2	3	4	5	6	7

4 Byte

B1							
8	9	10	11	X	X	X	X

7.3.4 GVSP_PIX_BAYGB8 "Bayer GB8"

Odd Line - 1 Byte

G0							
0	1	2	3	4	5	6	7

2 Byte

B1							
0	1	2	3	4	5	6	7

3 Byte

G2							
0	1	2	3	4	5	6	7

Even Line - 1 Byte

R0							
0	1	2	3	4	5	6	7

2 Byte

G1							
0	1	2	3	4	5	6	7

3 Byte

R2							
0	1	2	3	4	5	6	7

7.3.5 GVSP_PIX_BAYGB10 "Bayer GB10"

Odd Line - 1 Byte

G0							
0	1	2	3	4	5	6	7

2 Byte

G0							
8	9	X	X	X	X	X	X

3 Byte

B1							
0	1	2	3	4	5	6	7

4 Byte

B1							
8	9	X	X	X	X	X	X

Even Line - 1 Byte

R0							
0	1	2	3	4	5	6	7

2 Byte

R0							
8	9	X	X	X	X	X	X

3 Byte

G1							
0	1	2	3	4	5	6	7

4 Byte

G1							
8	9	X	X	X	X	X	X

7.3.6 GVSP_PIX_BAYGB12 "Bayer GB12"

Odd Line - 1 Byte

G0							
0	1	2	3	4	5	6	7

2 Byte

G0							
8	9	10	11	X	X	X	X

3 Byte

B1							
0	1	2	3	4	5	6	7

4 Byte

B1							
8	9	10	11	X	X	X	X

Even Line - 1 Byte

R0							
0	1	2	3	4	5	6	7

2 Byte

R0							
8	9	10	11	X	X	X	X

3 Byte

G1							
0	1	2	3	4	5	6	7

4 Byte

G1							
8	9	10	11	X	X	X	X

Address	Internal Name	Access	Size	Value
0xA410	Pixel Format type	R/W	4	0x01080009:BAYRG8 0x0108000A:BAYGB8 0x0110000D:BAYRG10 0x0110000E:BAYGB10 0x01100011:BAYRG12 0x01100012:BAYGB12

Note: BB-500GE has the same Bayer sequence for full and any partial scanning as RG. Therefore, comparing full scanning and partial scanning, the center might be shifted. BB-500GE supports BAYER GB 8, BAYER GB10 and BAYER GB12. When this type is selected, the output starts from the 2nd line for all scanning.

8. Functions and Operations

8.1. GigE Vision Standard Interface

The BM-500GE and BB-500GE are designed in accordance with the GigE Vision standard. Digital images are transmitted over Cat5e or Cat6 Ethernet cables. All camera functions are also controlled via the GigE Vision interface.

The camera can operate in continuous mode, providing an endless stream of images. For capturing individual images related to a specific event, the camera can also be triggered. For precise triggering, it is recommended to use a hardware trigger applied to the Hirose 12-pin connector. It is also possible to initiate a software trigger through the GigE Vision interface. However, when using a software trigger, certain latency inherent to the GigE interface must be expected. This latency, which manifests itself as jitter, greatly depends on the general conditions and traffic on the GigE connection. The frame rate described in this manual is for the ideal case and may deteriorate depending on conditions.

When using multiple cameras (going through a switch and/or a single path) or when operating in a system with limited transmission bandwidth the Delayed Readout Mode and Inter-Packet Delay functions can be useful.

8.2. Recommended Network Configurations

Although the BM-500GE and BB-500GE conform to Gigabit Ethernet (IEEE 802.3) not all combinations of network interface cards (NICs) and Switches/Routers are suitable for use with the GigE Vision compliant camera. JAI will endeavor to continuously verify these combinations, in order to give users the widest choice of GigE components for their system design.

8.2.1 Verified Network Interface Cards (NICs)

At the time of publishing this document these combinations have been verified:

NIC manufacturer	Model	PCI Bus	PCI-X Bus	PCI-Express Bus
Intel	PRO/1000MT (PWLA8490MT)	√ (33MHz)	√(100MHz)	–
Intel	PRO/1000GT (PWLA8391GT)	√ (33MHz)	√ (33MHz)	–
Intel	PRO/1000PT (EXPI9300PT)	–	–	√ (x1)
Intel	Gigabit CT Desktop adaptor (EXPI9301CT)	–	–	√ (x1)
Intel	PRO/1000PT Quad port (EXPI9404PT)	–	–	√ (x4)
Intel	PRO/1000PT Dual port (EXPI9402PT)	–	–	√ (x4)

Minimum PC requirements are as follows in order to fulfill the above conditions:

- Intel Core 2 Duo , 2.4 GHz or better
- At least 2 GB memory
- Video Card with PCI Express Bus x 16, VRAM better than DDR2 with 256 MB or more, and display capability of 2560 x 1600
- Windows XP, SP2 (32bit)
- Functions such as screen saver and power save should not be used. Unnecessary applications such as Word, Excel or others should not be used.

Note: Pentium 4 type PC is not recommended due to dependency on chip set bus performance.

8.2.2 Video data rate (network bandwidth)

The video bit rates for BM-500GE and BB-500GE in continuous mode are (note: the data rate depends on the system and the OB transfer setting):

Model	Pixel Type	Frame Rate	Packet data volume (based on a packet size of 4036 or 4032)
BM-500GE	MONO8	15 fps	625 Mbit/s
	MONO10_PACKED MONO12_PACKED	14 fps	875 Mbit/s
	MONO10 MONO12	11 fps	917 Mbit/s
BB-500GE	BAYRG8,BAYGB8	15 fps	625 Mbit/s
	BAYRG10,BAYBG10 BAYRG12,BAYGB12	11 fps	917 Mbit/s

- In the case of using Jumbo Frames, the packet data will be improved by 2%.
- For BM-500GE and BB-500GE, the jumbo frame size can be a maximum of 4036 Bytes (factory setting is 1428 Bytes). The NIC must also be set to support Jumbo Frames (see section 8.2.4).
- Based on Pixel Type, the packet size may be automatically adjusted inside the camera to its most suitable value.

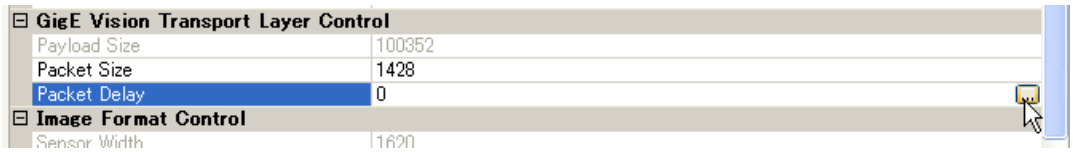
To ensure the integrity of packets transmitted from the camera, it is recommended that these simple guidelines be followed:

1. Whenever possible use a peer-to-peer network.
2. When connecting several cameras, going through a network switch, make sure it is capable of handling jumbo packets and that it has sufficient memory capacity.
3. Configure inter-packet delay to avoid congestion in networks switches.
4. Disable screen saver and power save functions on computers.
5. Use high performance computers with multi-CPU, hyper-thread and 64-bit CPU, etc.
6. Only use Gigabit Ethernet equipment and components together with the camera.
7. Use at least Cat5e and preferably Cat6 Ethernet cables.
8. Whenever possible, limit the camera output to 8-bit.

◆ **Note for setting packet size**

The packet size is set to 1428 as the factory default. Packet size can be modified in the GigE Vision Transport Layer Control section of the camera control tool (see below). For BM-500GE and BB-500GE, users may enter any value for the packet size and the value will be internally adjusted to an appropriate, legal value that complies with the GenICam standard. Thus, the actual packet size may be different than the value entered by the user.

Caution: do not set the packet size larger than the maximum setting available in the NIC or switch to which the camera is connected (see section 8.2.4). Doing so will cause output to be blocked.

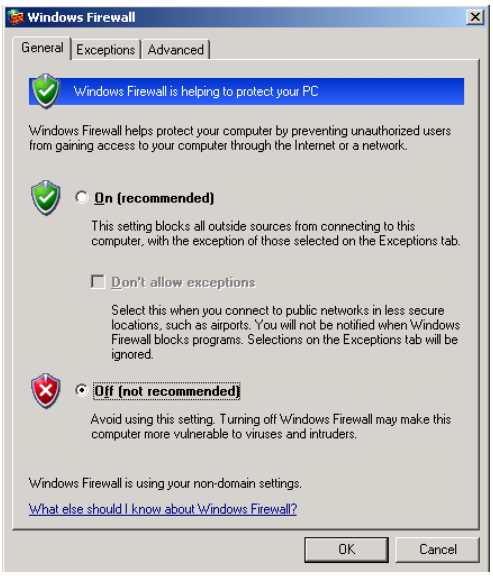


Regarding data transfer rate, a larger packet size produces a slightly lower data transfer rate. BM-500GE and BB-500GE can support a maximum of 4036 byte packets provided the NIC being used has a Jumbo Frames function with a setting of a 4036 bytes or larger.

8.2.3 Disable Firewalls

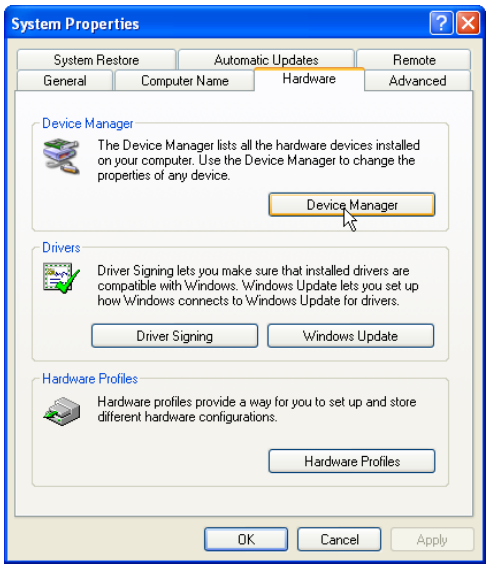
To ensure proper functions of the JAI SDK & Control Tool, all firewalls must be disabled. This also includes the Windows firewall.

Click [**Start**], [**Control Panel**] for accessing the Windows firewall configuration.

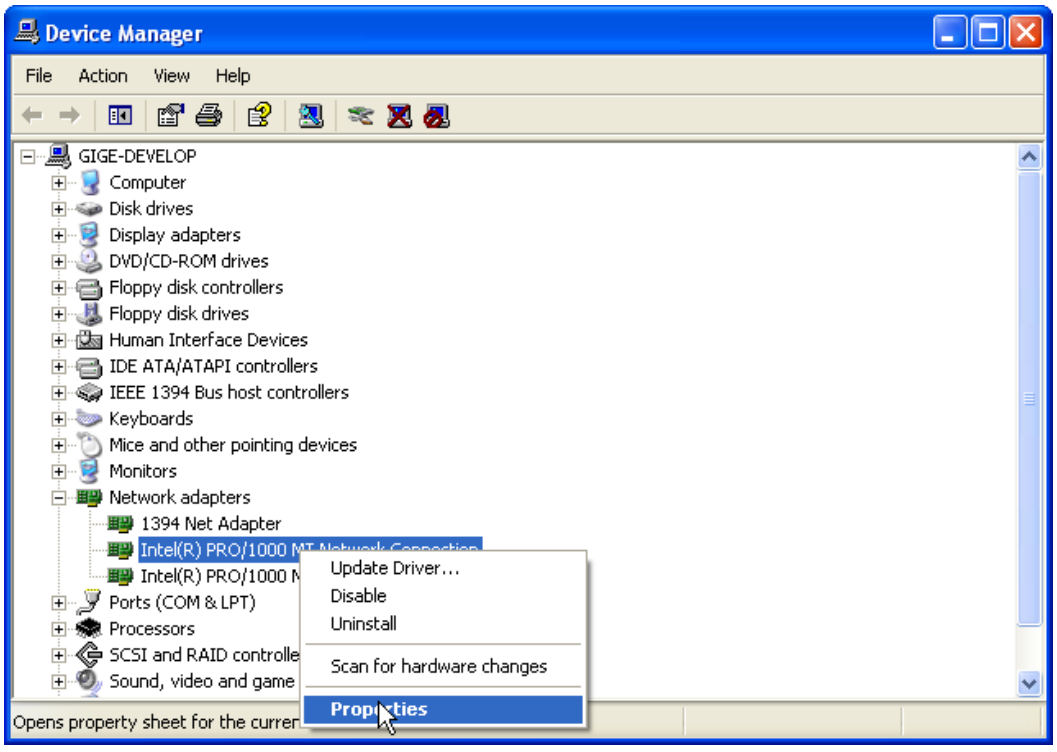


8.2.4 Enabling Jumbo Frames

(1) Click [**Start**] and click [**Control Panel**].
(2) Click [**Performance and Maintenance**].
(3) Click [**System**].
(4) Click [**Hardware**] tab.
(5) Click [**Device Manager**].



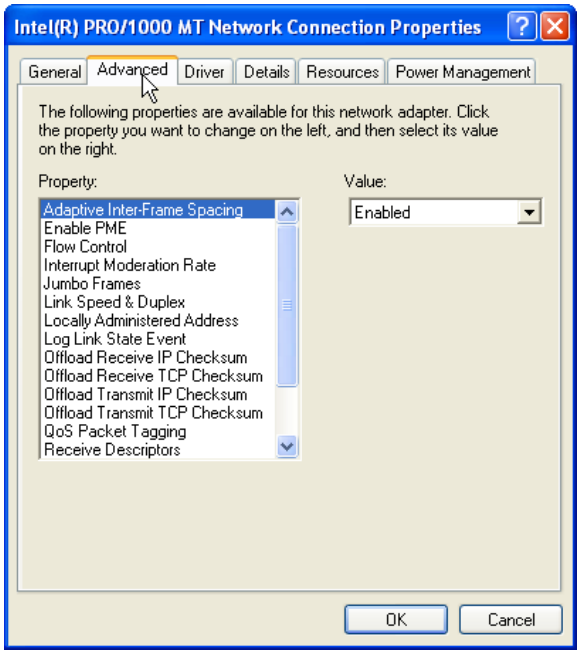
(6) Expand [**Network adapters**].
(7) Select target NIC, **right-click**, and click [**Properties**].



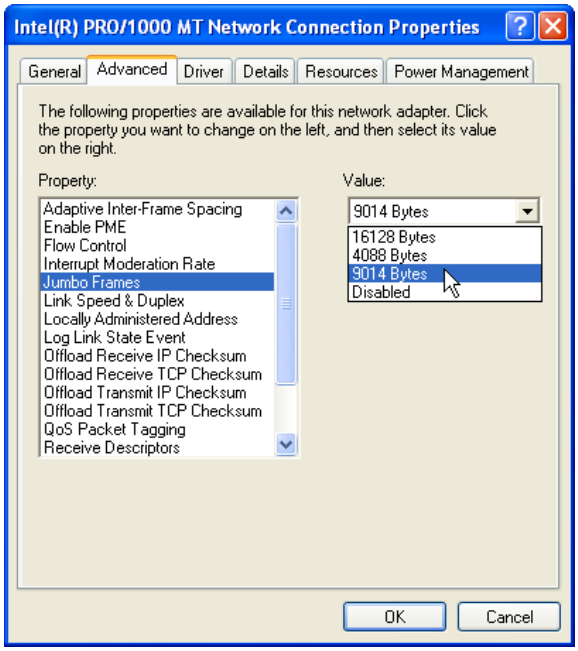
Note: Intel(R) 1000 is used in this example.

If different NICs are used, the following setup tabs will likely be different. Follow the tabs associated with the specific NIC used.

(8)Click [**Advanced**] tab.



(9) Select **Jumbo Frames** under Property, and select **4088 or 16128** under Value.

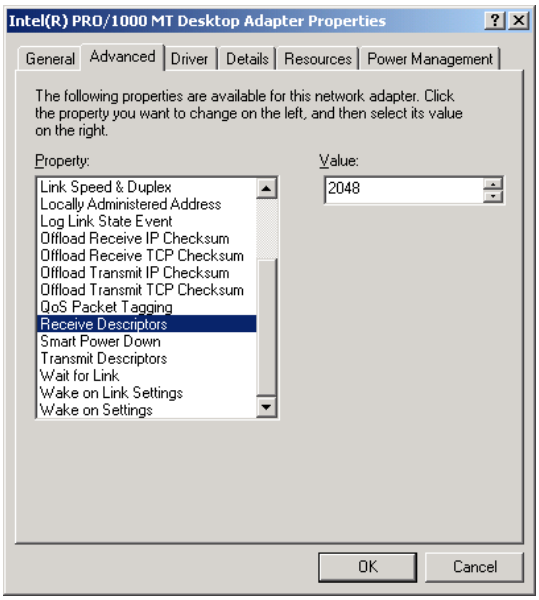


(10)Click [**OK**].
(11)Close [**Device Manager**].
(12)Close [**System Properties**] by clicking [**OK**].

8.2.5 Setting Receive Descriptors

If the Network Connection Properties list contains a property called Receive Descriptors, then change its property to the maximum value supported by the NIC installed in the computer.

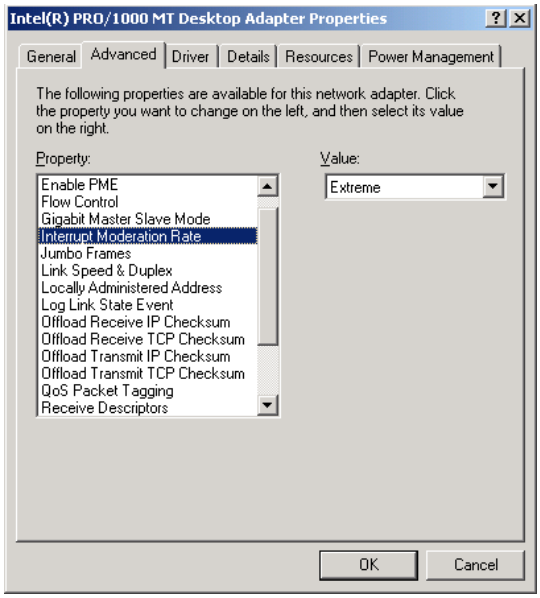
Click “OK” to save the property.



8.2.6 Interrupt Moderation rate

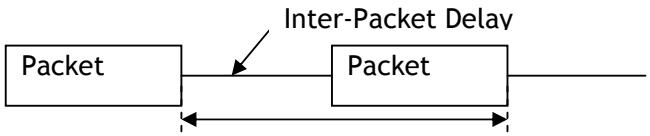
If the Network Connection Properties list contains a property called Interrupt Moderation Rate, then it is possible to set the preferred value. When it is changed from Minimal, to Medium, High and Extreme, the number of interrupts is decreased to get better performance. Set it to “Extreme”.

Click “OK” to save the property.



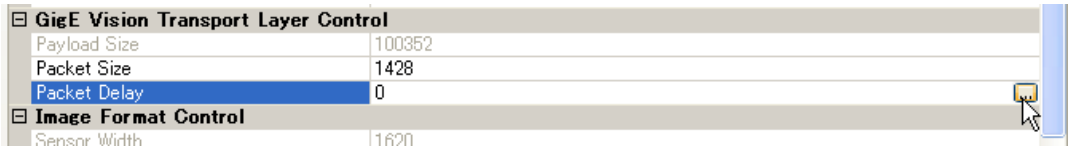
8.2.7 Calculating and setting Inter-Packet Delay

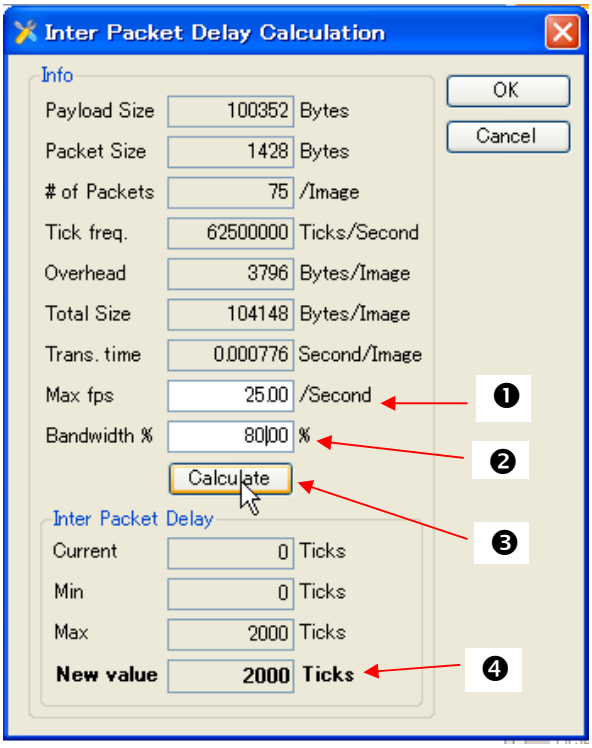
When connecting several cameras to one network interface card via a switching hub, it is important to optimize the Inter-Packet Delay of the cameras to avoid congestion in the switch. A sure sign of congestion is the loss of packets. Since increasing the inter-packet delay also adds overhead to the data transfer, it is important to calculate the optimal setting in order to make best use of the video bandwidth.



Duration of the entire packet, with delay

The JAI Control Tool has a built in wizard for calculating Inter-Packet Delay. When the Inter-Packet Delay function is activated, a button appears on the right hand side of the bar. Click the button to open the calculation wizard window.

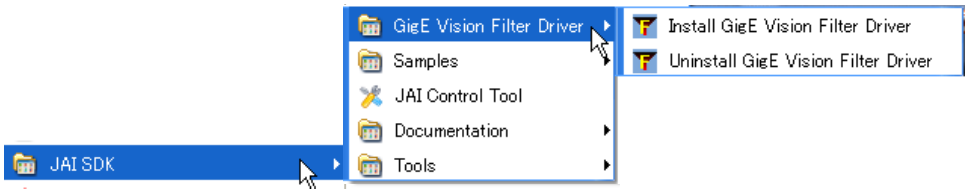




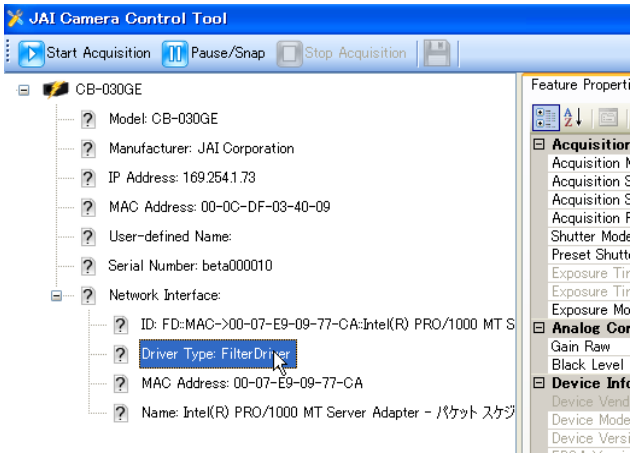
1. Type in the frame rate of the connected camera. BM-500GE and BB-500GE operate at 15 fps.
2. Set the bandwidth at 80%.
3. Click the calculation tab.
4. New value is calculated.
5. Click OK. This shown value is automatically transferred to the Packet Delay column of the Control Tool.

8.2.8 Confirm the Filter Driver is used

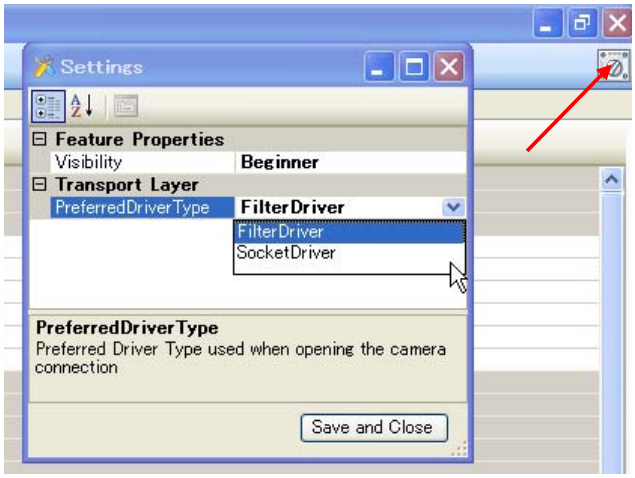
- The filter driver is installed as an optional function when JAI SDK is installed. If the filter driver is not installed at that time, it can be installed from All Programs ⇒ JAI SDK ⇒ GigE Vision Filter Driver ⇒ Install GigE Vision Filter Driver.
-



- If the Filter Driver is installed properly, the Camera Control Tool indicates "Driver Type Filter Driver" in the Network Interface.



- If it is not shown, confirm the setting by clicking the "Settings" icon as indicated by the red arrow below.



8.2.9 Others

- IF "Receive Descriptor" is set at its maximum value, picture disturbance may occur due to "Hyper Threading" mode. If that happens, check that "Hyper Threading" is set at OFF. This is set in BIOS.

- When the image is being captured, if the frame rate is decreased, change the packet size. Each packet contains header data and when the packet size is small, the total data including header information will increase. Depending on the performance of the computer used, the frame rate may be decreased. Confirm the packet size is increased. It can be set in the Camera Control Tool provided in JAI SDK.

8.2.10 Note for 100BASE-TX connection

- In order to use a 100Mbps network, 100BASE-TX and Full Duplex are available. Half Duplex cannot be used.
- When connecting on 100BASE-TX, the maximum packet size should be 1500 bytes.
- In the case of connecting on 100BASE-TX, specifications such as frame rate, trigger interval and so on described in this manual cannot be satisfied.

8.3. Basic functions

The BM-500GE and BB-500GE cameras are progressive scan cameras with 12, 10 or 8-bit video output in Gigabit Ethernet. The camera has 2/3, 1/2, 1/4 or 1/8 partial scanning for faster frame rates. Vertical binning (monochrome) and Draft (color) modes are also available.
The camera can operate in continuous mode as well as in 4 triggered modes:

- Edge Pre-Select Trigger (PS)
- Pulse Width Control Trigger (PW)
- Sequential EPS Trigger (PS)
- Delayed readout Trigger (PS, PW)

Depending on the timing of the trigger input in relationship to FVAL (camera internal frame valid clock), the start of exposure can be immediate (no-delay, LVAL asynchronous) or delayed until next LVAL (LVAL synchronous). In the following sections, the functions are described in detail.

8.3.1 Vertical Binning (BM-500GE only)

The binning function can be used to achieve a higher frame rate or higher sensitivity. The drawback is lower resolution. Vertical binning is done by adding the charge from pixels in adjacent lines in the horizontal CCD register. Figure 12 on the following page shows the vertical binning principle.

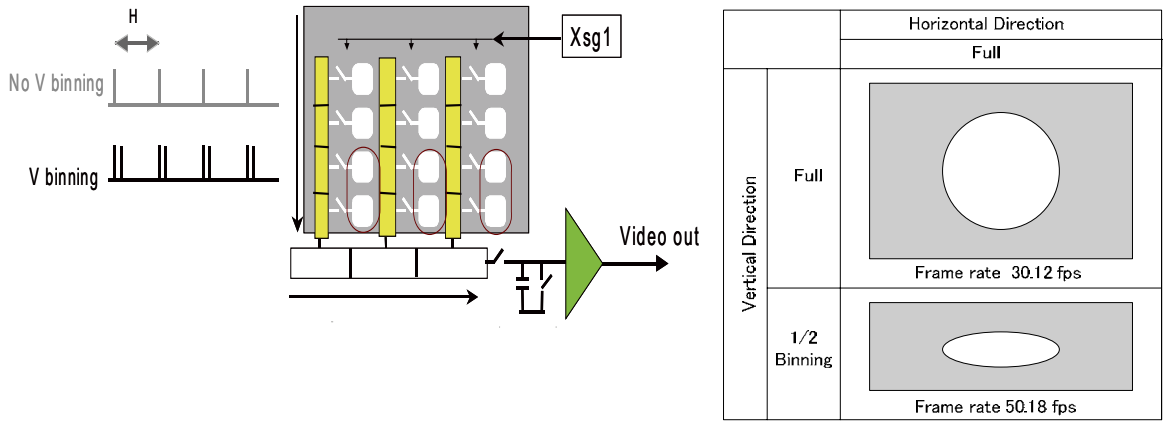


Fig.12. BM-500GE Vertical binning.

The BM-500GE has ON or OFF function for Vertical Binning:

Setting	Value for Register address 0xA084	Resolution	Frame rate
Off (no binning)	0x01	2456(h) x 2058(v) pixels	15.05 frames/sec.
2:1 binning	0x02	2456(h) x 1029(v) pixels	22.88 frames /sec.

8.3.2 BB-500GE. Bayer mosaic filter

BB-500GE is a color camera based on a CCD sensor with a Bayer RGB color mosaic.
The color image reconstruction is done in the host PC. The color sequence in the video signal is the same for all scanning formats.

The line readout follows LVAL.
The first valid pixel is the same timing as DVAL.

The Bayer color sequence starts with:

- RGR for odd line numbers.
- GBG for even line numbers.

Figure 13 shows the timing sequence for the Bayer mosaic read-out for the available scan modes.

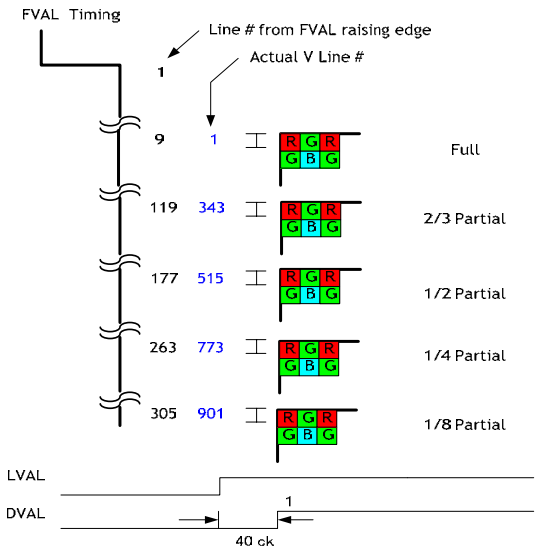
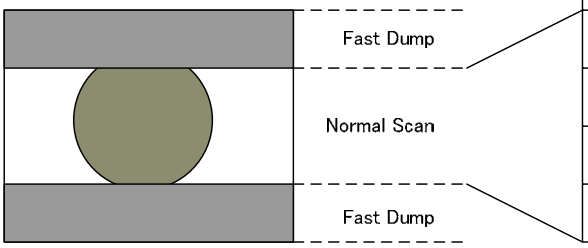


Fig.13. Bayer layout for each scanning

8.3.3 Partial Scanning (fixed and variable)

The partial scanning function uses the middle of the image vertically to achieve faster frame rates. This is very useful when capturing and inspecting an image which does not require the full image height. BM-500GE/BB-500GE has 4 fixed-size partial scan modes: 2/3, 1/2, 1/4 and 1/8.



Mode	Start line	End line	Frame Rate
2/3	343	1716	19.97 fps
1/2	515	1544	23.93 fps
1/4	773	1286	34.04 fps
1/8	901	1158	43.07 fps

In addition to the fixed partial scan modes, BM/BB-500GE has a variable partial scan mode. The start line can be set from the 1st line to the 1025th line and the scanned lines can be set from 8 lines to 1032 lines. Please note that if an odd line is selected as the start line, the Bayer color sequence is RGR, and if an even line is selected, it is GBG.

8.3.4 Decimation Readout (Draft) mode (BB-500GE only)

The BB-500GE color model is equipped with a draft mode instead of a vertical binning function. 4 lines of every 16 (2 GB lines and 2 RG lines) are combined before being read out. The field of view is not changed but the height of the image is reduced to 1/8 which is 261 lines. The frame rate is 37.54 frames per second.

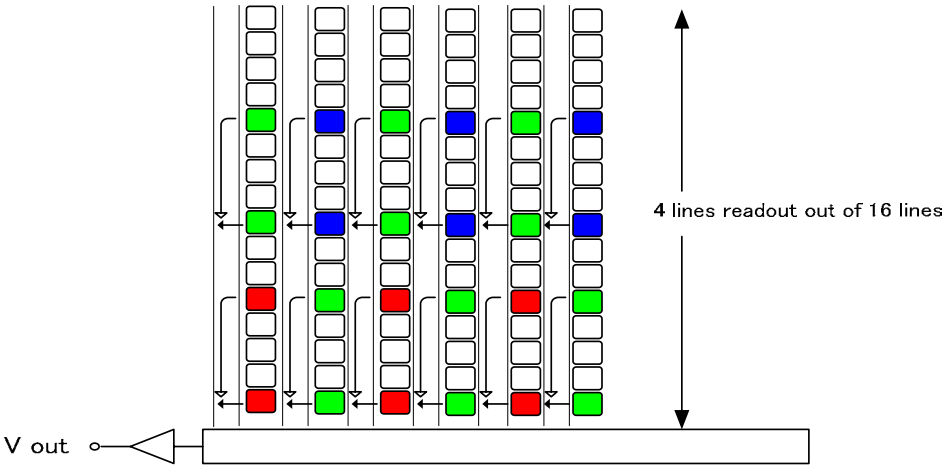


Fig.14 Draft mode

8.3.5 Electronic Shutter

BM-500GE / BB-500GE have conventional shutter functions as well as the GenICam standard “Exposure Time Abs” function.

Preset Shutter

11 preset shutter steps (including OFF) are available. They are: OFF (1/15), 1/30,

1/60,1/100,1/250,1/500,1/1,000,1/2,000, 1/4,000,1/8,000,1/10,000 sec. (See the register map in the SDK documentation for details on how to configure this register - 0xA004)

Programmable Shutter
It is possible to set the shutter speed in the range of 2L to 2072L by 1L increments using the programmable shutter. When 2072L is set, it is the equivalent of "OFF (1/15)" or 66.44ms in full frame operation. (See the register map included in the SDK documentation for details how to configure this register - 0xA008)

	Minimum Shutter Time 2L	Maximum Shutter Time
Normal	32.067 µs(1L) * 2L = 64.13 µs	32.067 µs * 2072 L≈ 66.44 ms
V Binning	42.067 µs * 2L = 84.13 µs	42.067 µs * 1039 L ≈ 43.71 ms
Draft	102.066 µs * 2L = 204.132 µs	102.066 µs * 261 L ≈ 26.64 ms

Pulse Width Control
When this mode is selected, the exposure time is controlled by the width of the trigger pulse. The minimum trigger pulse width is equal to 2L (64µs) and the maximum is 2 seconds.

Exposure Auto Continuous (Auto Shutter)
In this mode, the shutter continuously functions in the range of OFF to 1/250 sec.

Exposure Time Abs (GenICam Standard)
This is a function specified in the GenICam standard. The shutter speed can be entered as an absolute exposure time in microseconds (µs) in register address 0xA018. The entered absolute time (Time Abs) is then converted to a programmable exposure (PE) value inside the camera.

The formula below shows the relationship between the PE value used by the camera for the different readout modes and the value entered in register 0xA018.
Due to rounding, some discrepancies may occur.

The relation between PE value and Time Abs
Normal readout PE= 2 + INT (Exposure time -64) µs / (1924/60000000)
V Binning readout PE= 2 + INT (Exposure time -71.692) µs / (2524/60000000)
INT means round down.

The following table shows the minimum value and maximum value for each readout mode.

	Minimum value	Maximum Value
Normal Scan	64.13 µs	66.442 ms
2/3 Partial Scan	64.13 µs	49.736 ms
1/2 Partial Scan	64.13 µs	41.495 ms
1/4 Partial Scan	64.13 µs	29.117 ms
1/8 Partial Scan	64.13 µs	22.960 ms
V-Binning Scan	84.13 µs	43.708 ms

GPIO in combination with Pulse Width trigger
More precise exposure time can be obtained by using GPIO in combination with Pulse Width Control trigger mode. The clock generator and counter can be programmed in very fine increments. For an example, refer to section 6.5.1.

8.3.6 Auto-Iris Lens video output (12-pin Hirose connector)

This analog signal is not routed through the GPIO. This signal is available at pin 4 of the 12-pin Hirose connector. It can be used for lens iris control in Continuous mode only.
The signal is taken after the CCD sensor output passes through the gain circuit. The video output is without sync. The signal is 0.7 Vp-p.
To get this signal, the internal DIP switch (SW 601) must be set. Refer to section 5.4.

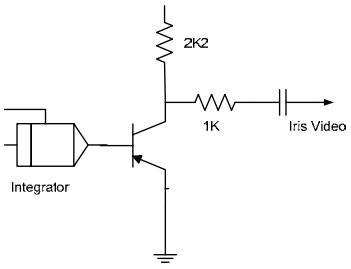


Fig. 15. Video output circuit.

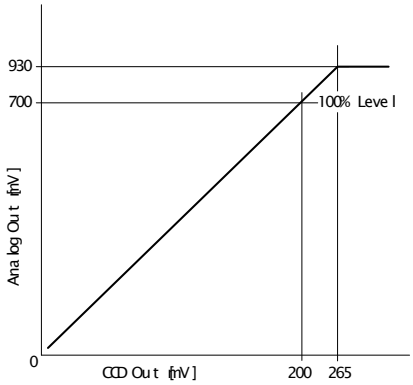
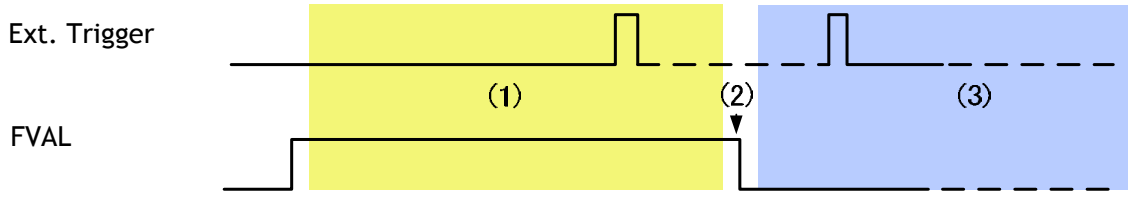


Fig. 16. Iris Video

8.3.7 Auto-detect LVAL-sync / async accumulation

This function replaces the manual setting found in older JAI cameras. Whether accumulation is synchronous or asynchronous in relationship to LVAL depends on the timing of the trigger input. When a trigger is received while FVAL is high (during readout), the camera works in LVAL-synchronous mode, preventing reset feed-through in the video signal. There is a maximum jitter of one LVAL period from issuing a trigger and accumulation start.
When a trigger is received while FVAL is low, the camera works in LVAL-asynchronous mode, (no delay) mode. This applies to both Edge Pre-Select (EPS) trigger mode and Pulse Width Control (PWC) trigger mode.



(1) In this period camera executes trigger at the next LVAL. (Prevents feed-through noise)
(2) Avoid trigger at FVAL transition (+/- 1 LVAL period), as the function may randomly switch between “next“ and “immediate“.
(3) In this period camera executes trigger immediately. (No delay)

Fig. 17. Auto-detect LVAL sync / async accumulation

8.3.8 Rear panel indicator.

The rear panel mounted LED provides the following information:

Power Trig LED
- Amber: Power connected – initiating
- Steady green: Camera is operating in Continuous mode
- Flashing green: Camera is receiving an external trigger

LINK LED
- Steady green: 1000 Base-T has been connected
- Flashing green: 100 Base-TX has been connected

ACT LED
- Flashing amber: Network active in communication

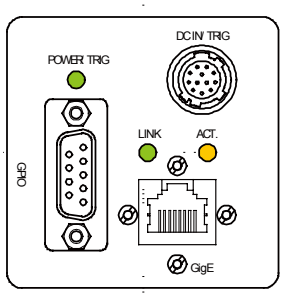


Fig.18 Rear Panel

Note: When flashing green, video is not streamed through Ethernet.

8.4 Pre-process functions

BM-500GE/BB-500GE is equipped with several pre-processing functions. The output from the camera is selectable to 8, 10 or 12 bits, but video is digitized to 14-bit quantization.
The pre-processing functions make use of the 14-bit video. Featured functions are: Bayer color white balance, R/L channel balance, blemish compensation, gain control and LUT (Look Up Table) for Gamma and Knee correction.

8.4.1 Bayer White Balance (BB-500GE only)

Normally, the raw Bayer color signals are sent to the host as they are. In the host, the signals are interpolated to generate an RGB image and perform white balance. In order to offload the host, the BB-500GE can adjust Gr, R, Gb and B levels individually to get the white balance for the Bayer output signal.
Note: Bayer white balance must be set in Normal mode.

8.4.2 R/L channel balance (Register 0xA0B8, 0xA0BC)

BM-500GE/BB-500GE has a dual-tap readout architecture, with a Left (L) and Right (R) channel. In order to achieve the same gain and black level for both channels, the BM-500GE/BB-500GE has built-in R/L channel balance function. The function is activated by a "one-push" software command.
Note: R/L channel balance must be set at Normal mode.

8.4.3 Automatic Gain Control

This function uses gain to maintain a constant output level in accordance with ambient brightness changes. It is also part of the integrated ALC capability described in section 8.3.7.
The range of AGC, as well as manual gain adjustment, is -3dB to +12 dB.
The AGC function can be set to ON or OFF.

Note: This is available only in Normal mode.

8.4.4 Programmable Look UP table (LUT)

The BM-500GE and BB-500GE have a programmable look-up table (LUT) that can be used to adjust the transfer function of the video output. The look-up table has 256 set points

representing coefficients which are multiplied across the full range of input values. At each point, the LUT values cause gain to be applied to produce the desired output characteristics (for knee and gamma). In the case of the BB-500GE, Gr, R, Gb and B signals all have the same characteristics.

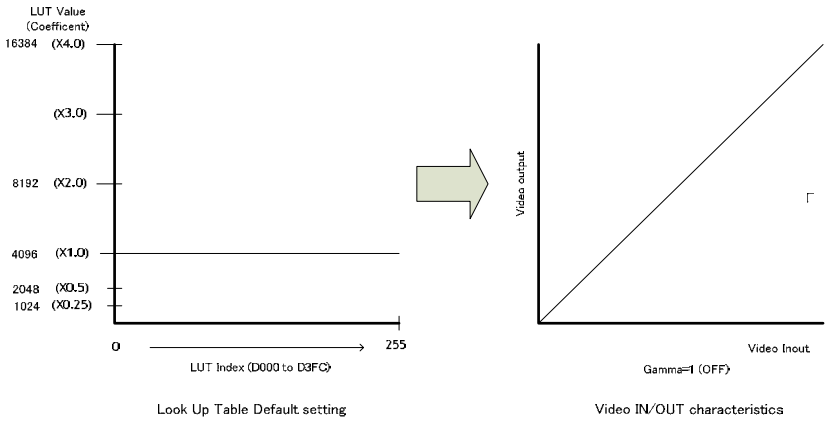


Fig.19 LUT default setting (Coefficient : x 1.0=4096)

The look-up table is handled in a 14-bit video processing circuit and the resulting signal is output as an 8-, 10- or 12-bit pixel format through the GigE interface.

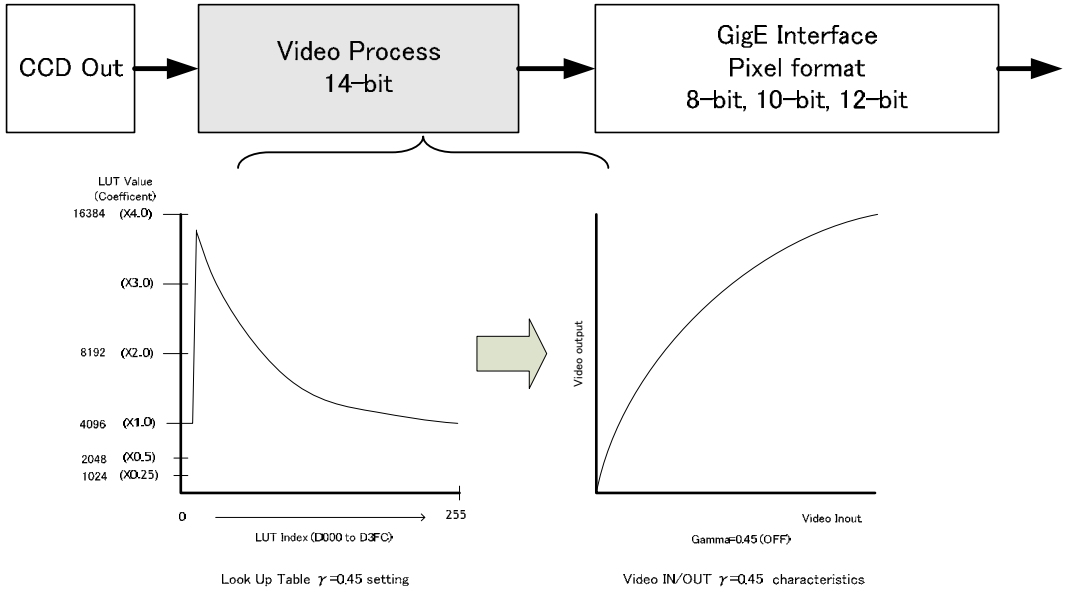
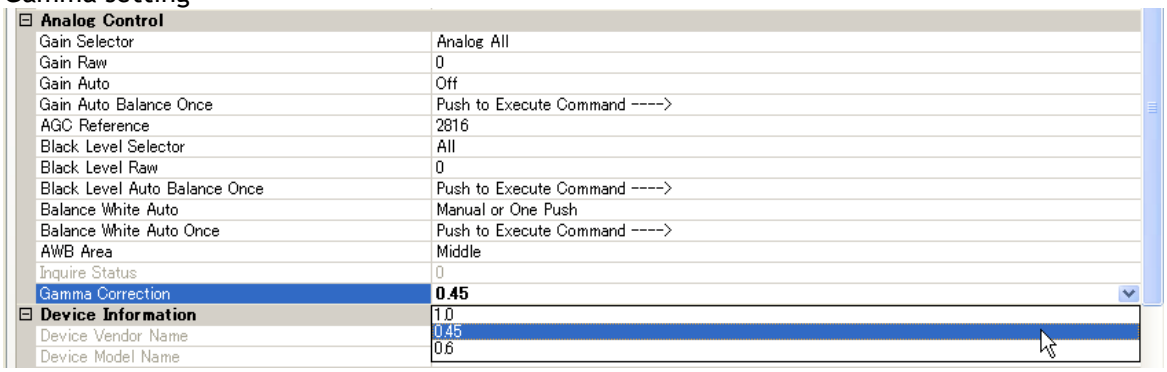
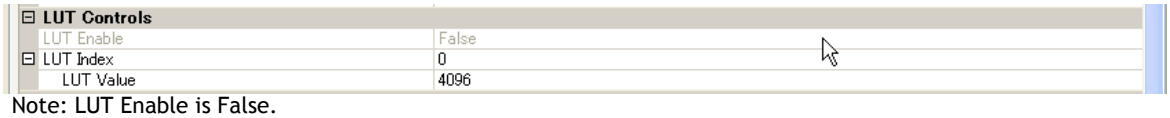


Fig.20 Setting example of Gamma=0.45

If set by the JAI SDK Camera Control Tool, the Gamma setting and LUT cannot be used at the same time. This is because the Gamma setting and LUT use the same data table (see the following diagram for an example).

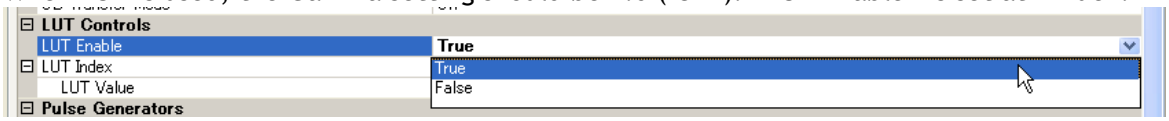
Gamma setting

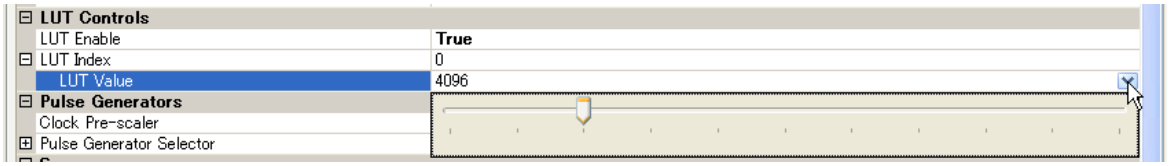




Note: LUT Enable is False.

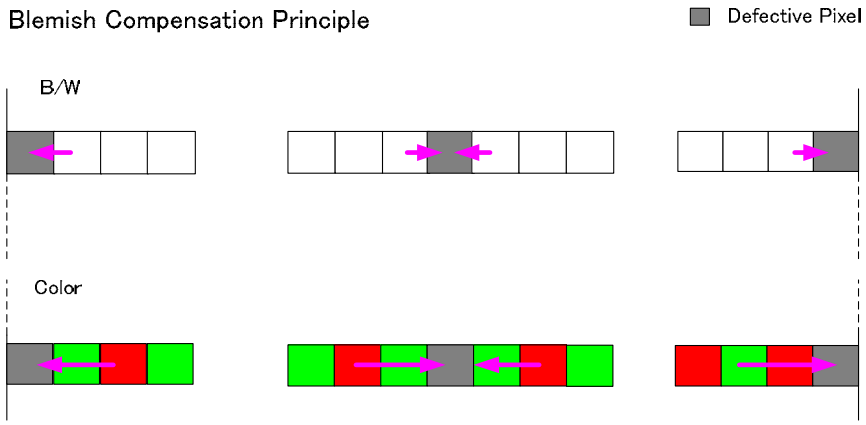
When LUT is used, the Gamma setting should be 1.0 (OFF). “LUT Enable” is set at “True”.





8.4.5 Blemish Compensation circuit

BM-500GE/BB-500GE has a blemish compensation circuit. This function compensates for blemishes on the CCD sensor (typically pixels with extremely high response or extremely low response). This applies to both monochrome and color versions. Pixels that fulfill the blemish criteria can be compensated by pixels in adjacent columns and, in the case of the BB-500GE, the defective pixels can be compensated by the nearest adjacent same Bayer color pixels. The number of compensations is up to 8 pixels on both L and R channels.
The circuit built into the BM-500GE/BB-500GE has an ON/OFF function for the compensation data derived in the factory. The default setting is OFF.



8.5 Extended temperature operation (-45 ºC to +65 ºC)

The OP22-5-1 model suffix indicates that the BM-500GE/BB-500GE are individually tested, validated and temperature cycled to certify their operating ability throughout an extended temperature range which is greater than the operating range of typical COTS (commercial off-the-shelf) cameras. Although units are guaranteed to operate throughout the temperature range, operating the camera beyond the standard range of -5 ºC to +45 ºC may result in some reduced performance characteristics, such as higher noise, reduced SNR, etc. Specifications shown in the camera data sheet and in the table at the back of this document are for when the camera is operating within normal temperature conditions and may be subject to variations when operating in extreme temperatures.

8.6 Sensor Layout and timing

8.6.1 CCD Sensor Layout

The CCD sensor layout with respect to pixels and lines used in the timing and video full frame read out is shown below.

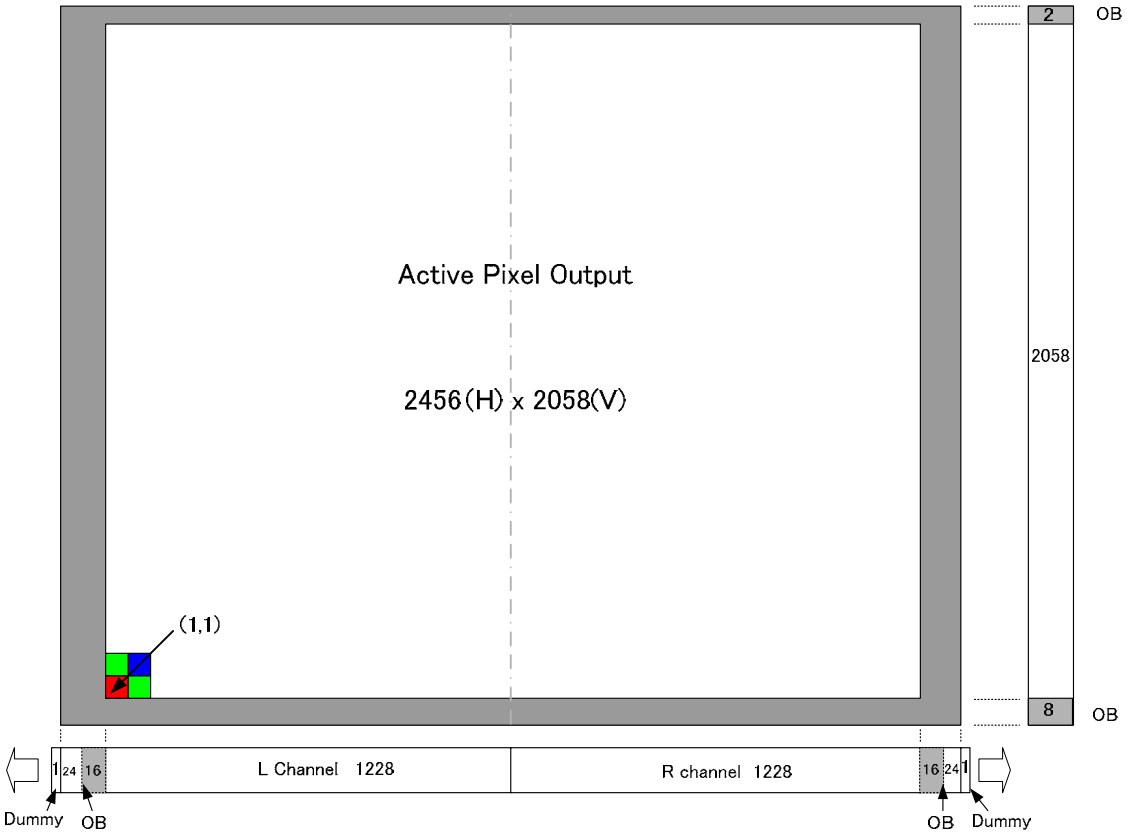


Fig. 21 CCD sensor layout

Important Note: By setting the Optical Black (OB) transfer mode, the user can select whether to include optical black pixels in the image stream. This is for horizontal OB only.

8.6.2 Horizontal timing

The LVAL period is shown for normal continuous mode.
FULL FRAME READ OUT / PATIAL READ OUT

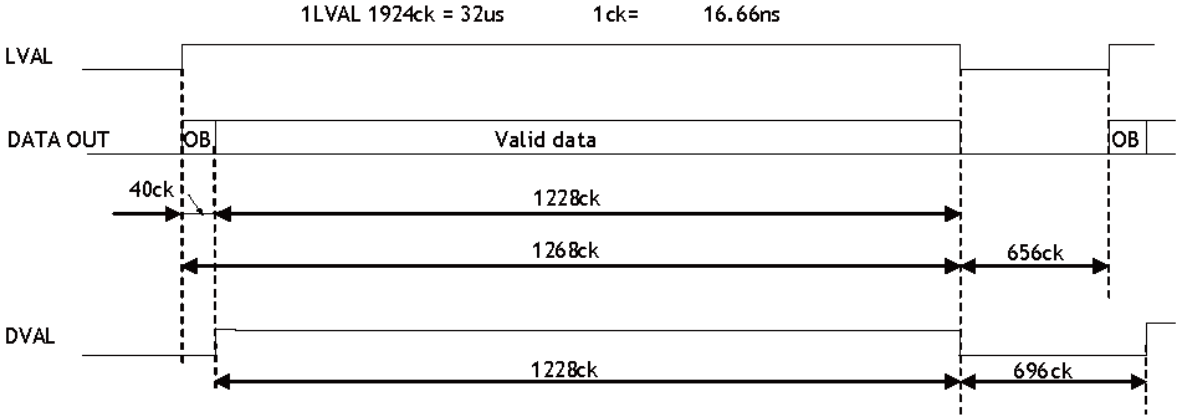


Fig. 22 Horizontal timing

8.6.3 Vertical timing

The FVAL period for normal continuous mode full scan is shown.

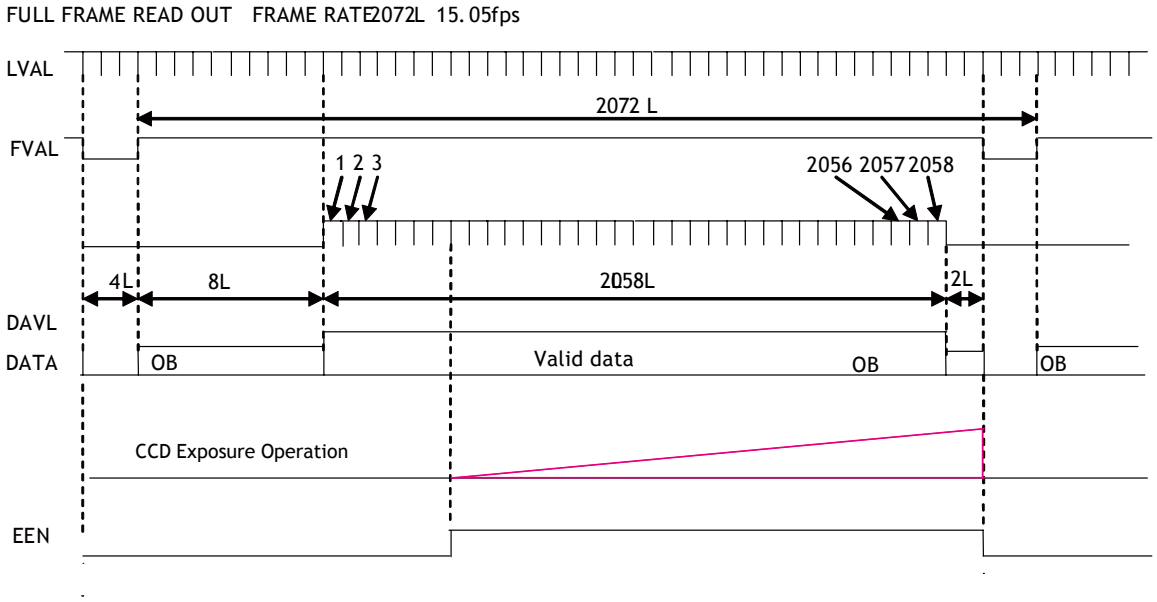


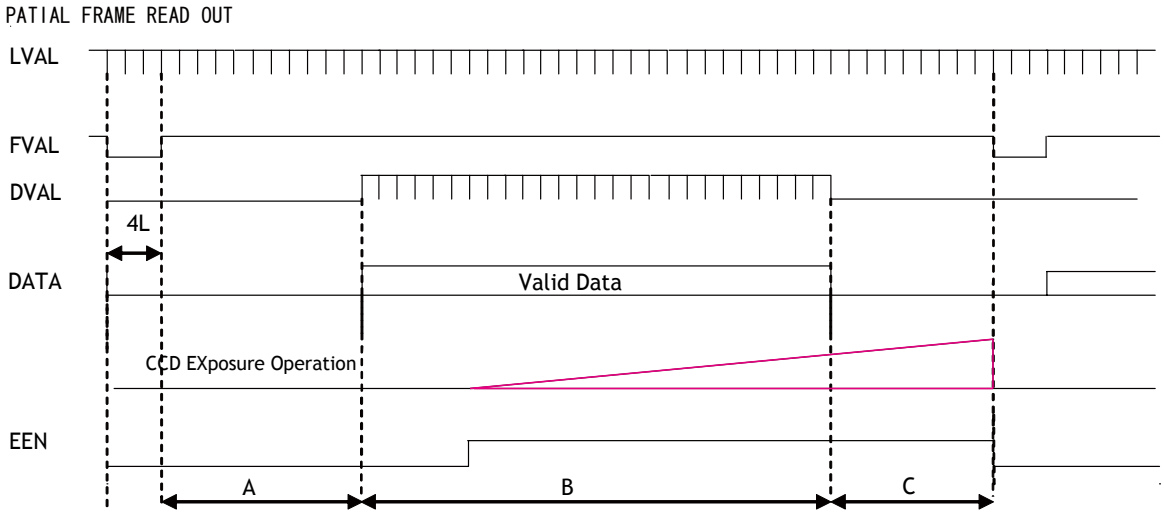
Fig. 23 Vertical timing for full scan

8.6.4 Partial Scanning

The FVAL period is shown for 1/2 partial scan in normal continuous mode.

Vertical Timing

The below diagram and table provide vertical timing information for the fixed partial scan settings 2/3, 1/2, 1/4 and 1/8.



Values for vertical timing in partial scan continuous mode.

AREA	FVAL Low (L)	A (L)	B (L)		C (L)	Total line	frame rate
			Start line	End line			
2/3	4	118	1374 343	1716	65 L	1561 L	19.97
1/2	4	176	1030 515	1544	93 L	1303 L	23.93
1/4	4	262	514 773	1286	136 L	918 L	34.04
1/8	4	304	258 901	1158	158 L	724 L	43.07

Fig. 24 Vertical timing for partial scanning

Horizontal Timing

The horizontal timing is the same as for full scanning.

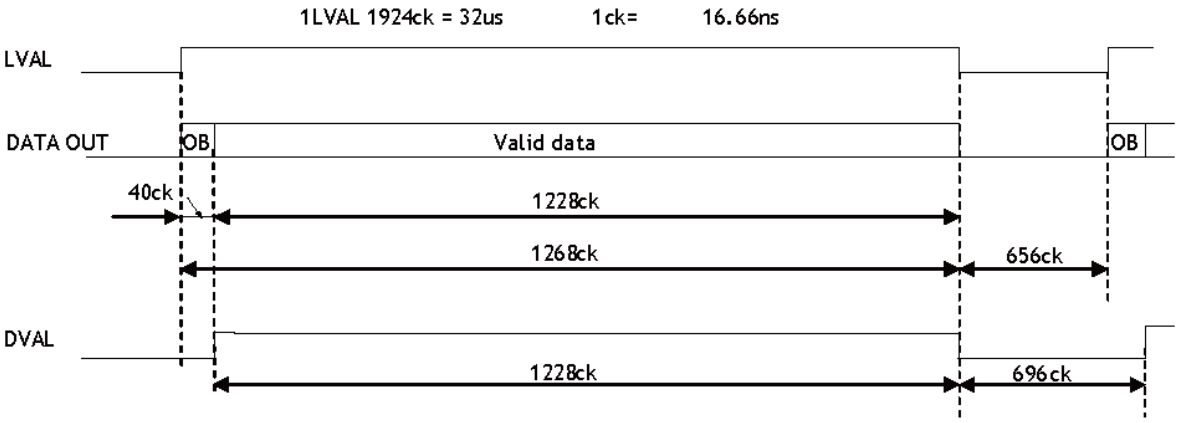


Fig.25 Horizontal Timing for Partial Scanning

8.6.5 Vertical binning

Vertical binning combines charge from two adjacent lines, reducing the vertical resolution to half and at the same time increasing frame rate and sensitivity. By activating this function, the frame rate is increased to 44.492 fps.
This function is available only on the BM-500GE.

Important Note
Vertical Binning can not be used together with Partial Scanning.

Horizontal Timing

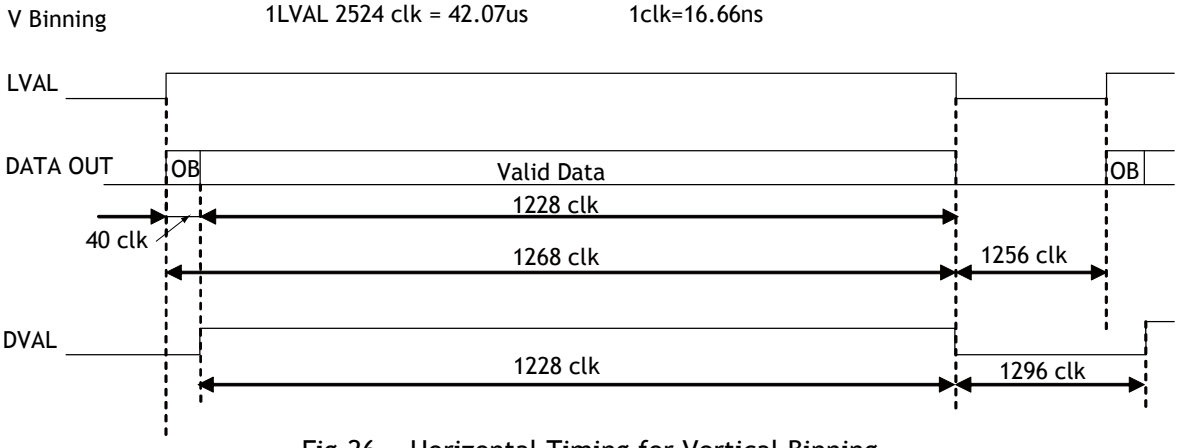


Fig.26 Horizontal Timing for Vertical Binning

Vertical timing

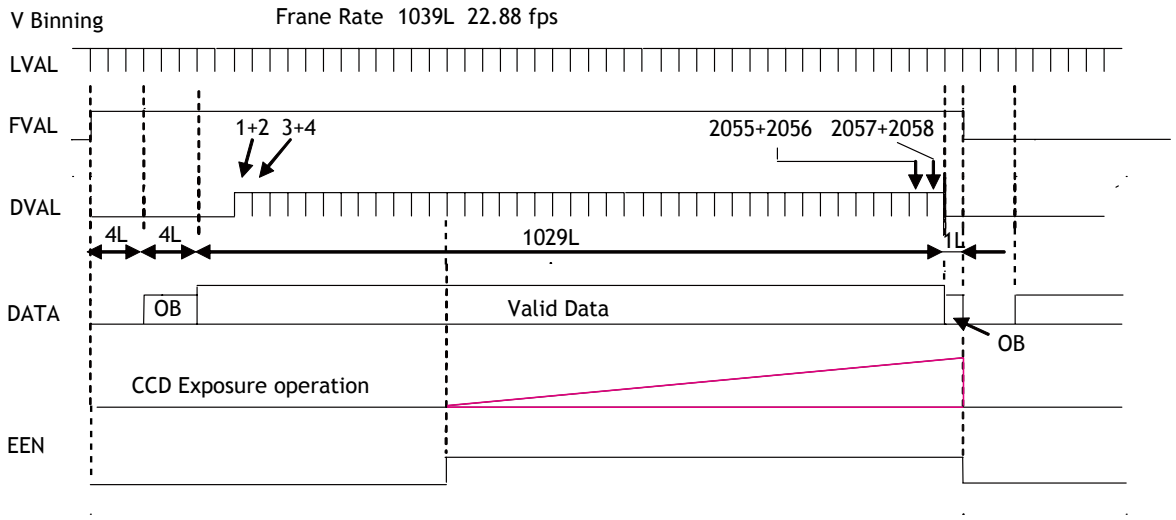


Fig.27 Vertical Timing for Vertical Binning

8.7. Operation Modes

This camera can operate in 5 primary modes.

1. ***Continuous Mode***	Pre-selected exposure.
2. ***Pre-select Mode (PS)***	Pre-selected exposure.
3. ***Pulse Width Mode (PW)***	Pulse width controlled exposure.
4. ***Sequential Trigger***	Pre-selected exposure (PS)
5. ***Delayed Readout Trigger***	Pre-selected exposure (PS,PW)

8.7.1 Continuous Mode

For applications not requiring asynchronous external triggering, this mode should be used.
In continuous mode it is possible to use a lens with video controlled iris.
For timing details, refer to fig. 20. through fig. 27.

To use this mode:

Set function:	Trigger mode	Continuous
	Scanning	Full, Partial scanning
	Draft mode	ON/OFF (BB-500GE only)
	Vertical binning	ON/OFF (BM-500GE only)
	Shutter mode	Preset, Programmable, Exposure Time Abs, Auto
	Shutter speed	1/30 to 1/10,000
	Programmable exposure	2L to 2072L

8.7.2 Pre-Select (PS) Trigger Mode

An external trigger pulse initiates the capture, and the exposure time (accumulation time) is the fixed shutter speed set by registers. The accumulation can be LVAL synchronous or LVAL asynchronous. The resulting video signal will start to be read out after the selected shutter time.
For timing details, refer to fig. 20. through fig. 29.

To use this mode:

Set function:	Trigger mode	PS
	Scanning	Full, Partial
	Vertical binning	ON / OFF (BM-500GE only)
	Draft Mode	ON / OFF (BB-500GE only)
	Shutter mode	Preset, Programmable, Exposure Time Abs
	Shutter speed	1/30 to 1/10,000
	Programmable exposure	2L to 2072L
	Accumulation (Auto)	LVAL sync / LVAL async
	Other functions and settings	
Input:	External trigger	GigE interface or 12-pin Hirose

Important notes on using this mode

- Trigger pulse >2 LVAL to <1 FVAL
- The following table shows minimum trigger interval in synchronous accumulation mode

Full scan	2072L
2/3 Partial	1551L
1/2 Partial	1294L
1/4 Partial	908 L
1/8 Partial	716 L
1/2 V Binning	1039 L

In the case of asynchronous mode, the exposure time should be added to the above table.

LVAL_sync timing

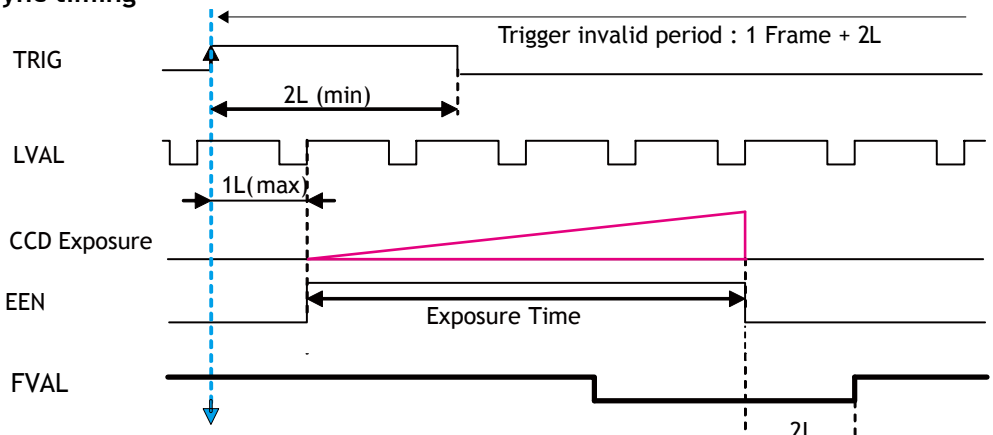


Fig. 28 Edge Pre-Select LVAL sync timing

LVAL_async timing

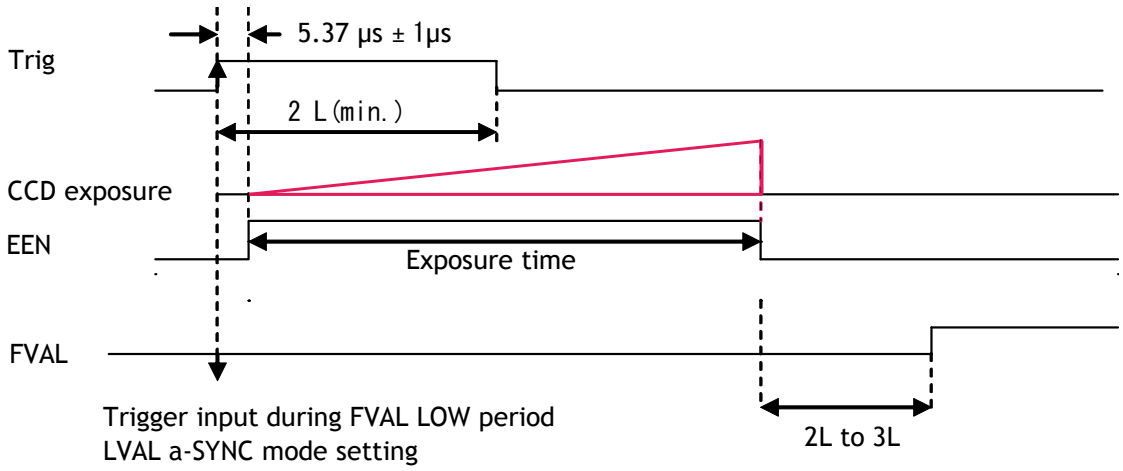


Fig.29 Edge Pre-Select LVAL async timing

Note: In case PE value is between 2 or more and 4 or less, LVAL a-sync mode is set.

8.7.3 Pulse Width Control (PWC) Trigger Mode

In this mode the accumulation time is equal to the trigger pulse width. Here it is possible to have long exposure times. For best image quality, the maximum recommended time is <2 seconds. Longer exposures may show signs of CCD noise. The accumulation can be LVAL synchronous or LVAL asynchronous. The resulting video signal will start to be read out after the trigger rising edge.
For timing details, refer to fig. 20. through fig. 27 and fig.30 and 31.

To use this mode:

Set function:	Trigger mode	PWC
	Scanning	Full, Partial
	Vertical binning	ON / OFF (BM-500GE only)
	Draft Mode	ON / OFF (BB-500GE only)
	Accumulation (Auto)	LVAL sync / LVAL async
	Other functions and settings	
Input:	External trigger	GigE interface or 12-pin Hirose

Important notes on using this mode

- Trigger pulse width >2LVAL to <2 seconds
- The following table shows minimum trigger interval in synchronous accumulation mode

Full scan	2073L
2/3 Partial	1563 L
1/2 Partial	1305L
1/4 Partial	918 L
1/8 Partial	726L
V Binning	1039 L

In the case of asynchronous mode, the exposure time should be added to the above table.

LVAL_sync timing

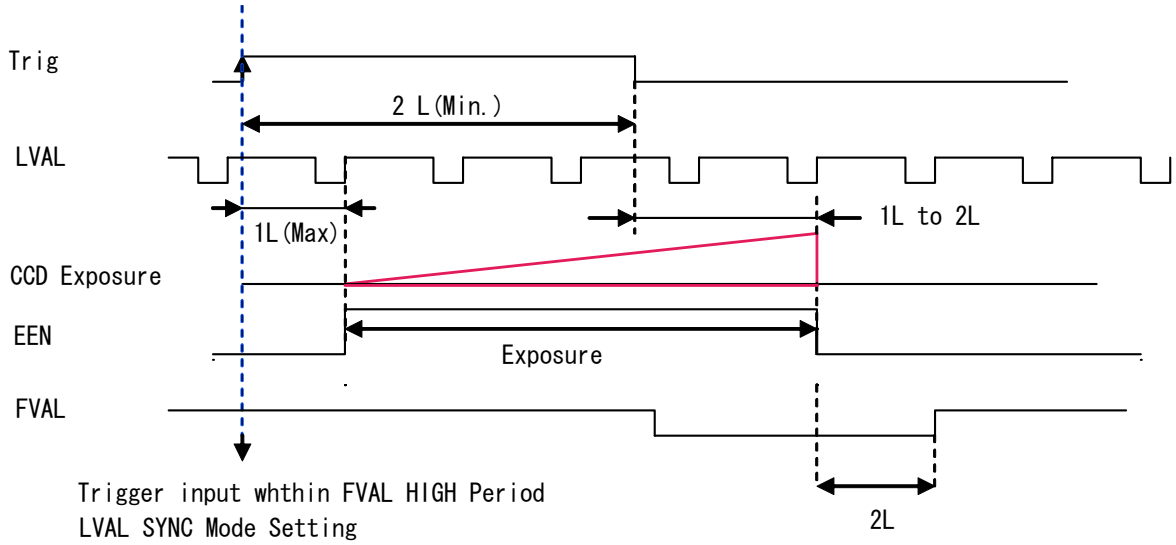


Fig. 30 Pulse Width Control LVAL sync.

LVAL_async timing

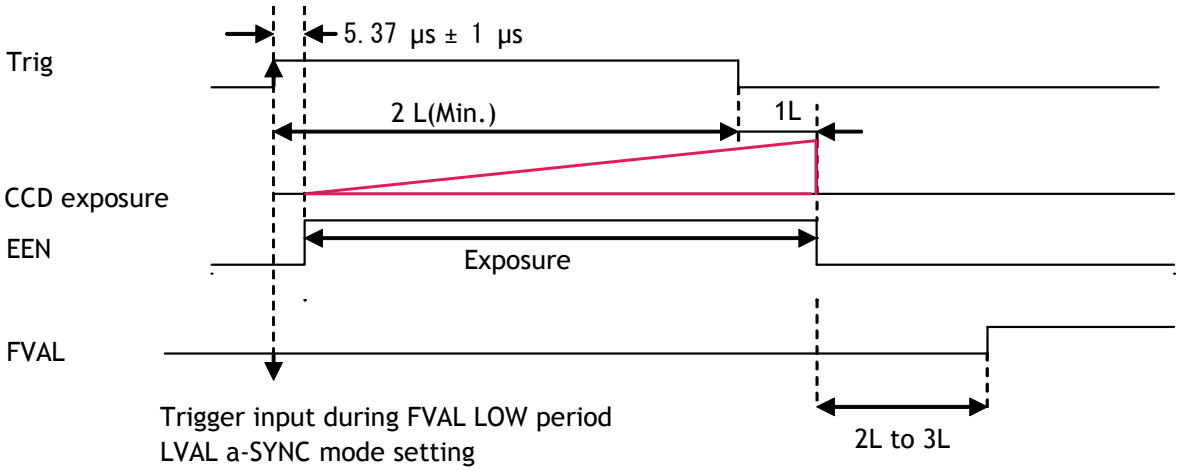


Fig.31 Pulse Width Control LVAL async

8.7.4 Sequential Trigger Mode (PS)

This mode allows the user to define a preset sequence of up to 10 images, each with its own ROI, Shutter and Gain values. As each trigger input is received, the image data within the preset sequence is output as described below.

Fig. 34 Sequential Trigger Mode

Signals added to a trigger can be selected by 0xB060 Camera Trigger Selector in the register map via GPIO. The camera will function on the rising edge of the trigger and Negative or Positive should be determined accordingly.

The following default settings can be modified by the user to define a sequence.

ID	ROI				Shutter	Gain
	Width	Height	Offset X	Offset Y		
1	2456	2058	0	0	2072	0
2	2456	2058	0	0	2072	0
3	2456	2058	0	0	2072	0
4	2456	2058	0	0	2072	0
5	2456	2058	0	0	2072	0
6	2456	2058	0	0	2072	0
7	2456	2058	0	0	2072	0
8	2456	2058	0	0	2072	0
9	2456	2058	0	0	2072	0
10	2456	2058	0	0	2072	0

The following registers are used to configure the sequence.

0xC0F4 Sequence Repetitions (Number of Repetitions)
0xC0F8 Sequence Ending Position (Ending Position)
0xA30C Sequence Reset Command (1 only)
0xB060 Selection for camera trigger 0
0xA040 Trigger mode selection and 0x09 for Sequential PS mode

Example of settings

Setting: Repeat 5 times from ID 1 through ID 8

0xC0F4 Set to 0x05
0xC0F8 Set to 0x08
0xB060 For instance, 12p #6 for Optical IN 1
0xA040 Sequential PS (9)
0xA3F0 Set this for start
0xA040 Set Normal Mode (0) for stop

Please refer to the detailed register description on Camera Register Map which is included in the SDK. The following table shows the minimum trigger interval in synchronous accumulation mode. In the case of asynchronous accumulation mode, the exposure time should be added to figures in this table.

Full Scan	2/3 Partial	1/2 Partial	1/4 Partial	1/8 Partial	1/2 V Binning
2077 L	1556 L	1299 L	913 L	722 L	2044 L

- This table assumes that shutter speed is set the same for all sequences. If the shutter speed is different, the difference of exposure time should be added.
- It is recommended to set the exposure time in order from the shortest to the longest one.
- The above table shows the interval at PE=2 (minimum). In case of longer exposures, the interval is (Value on the table – 2) + Exposure lines.
- Do not input the trigger just after the sequence is reset. It requires at least 500ms delay.
- ROI can be set by 8-pixel increments in horizontal direction. In vertical direction, ROI minimum increment is 1 line for BM-500GE and 2 lines for BB-500GE.

8.7.5 Delayed Readout Mode (PS and PW)

This mode can be used to delay the transmission of a captured image. When several cameras are triggered simultaneously and connected to the same GigE interface, it allows the cameras to be read out in sequence, preventing congestion.

The image data is not transmitted directly by the trigger 0 and is stored in the memory located at Ethernet Interface. By the falling edge of the soft trigger 1, the image data is output.

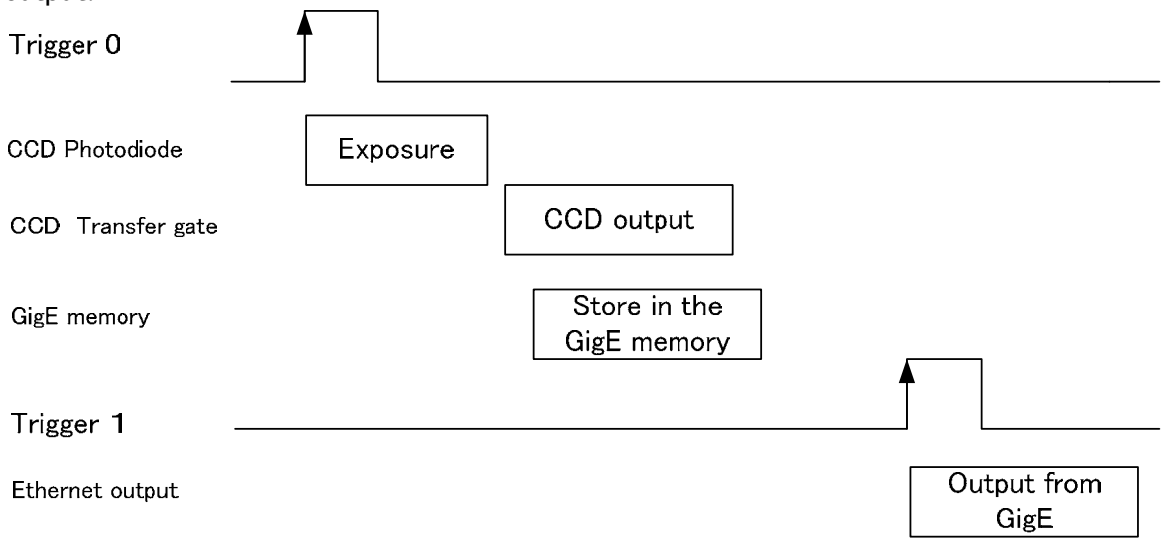


Fig.35 Delayed Readout Mode

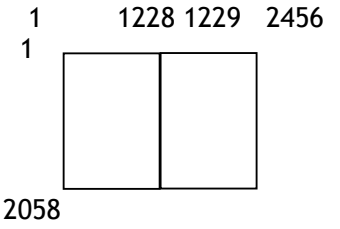
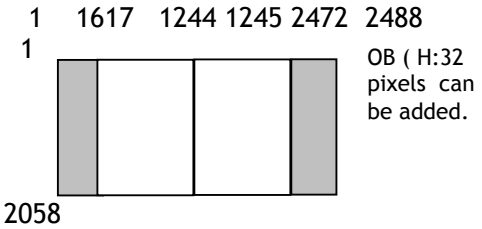
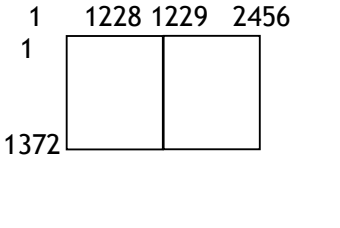
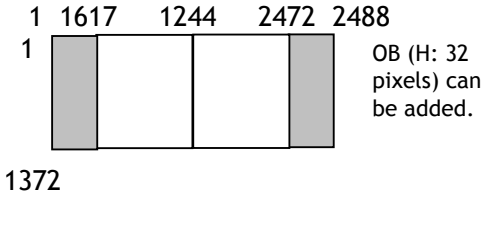
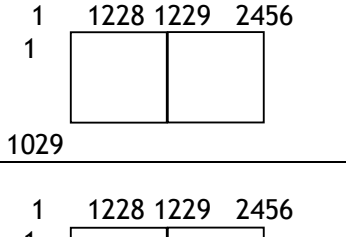
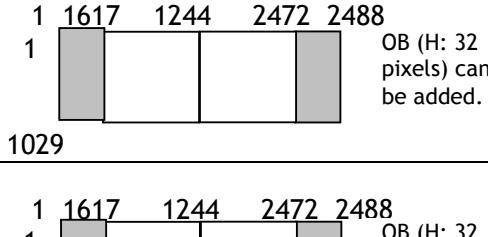
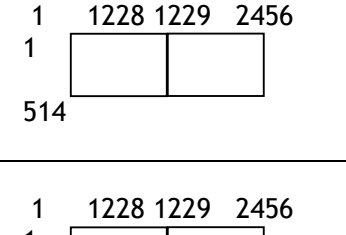
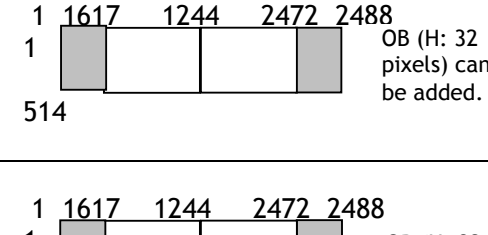
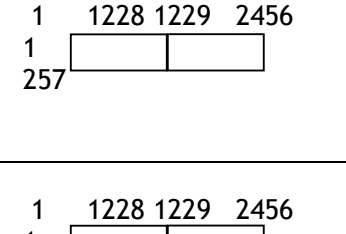
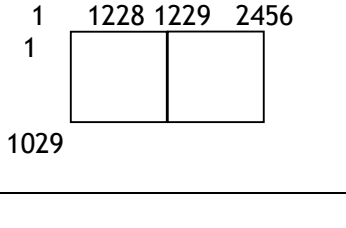
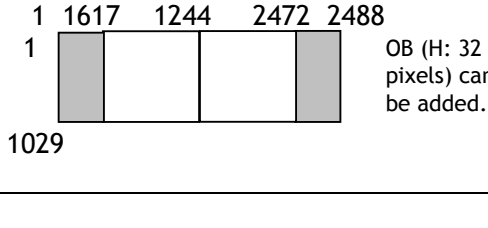
Example of setting

0xA040 PS Delayed Readout (0x17)
0xB060 Trigger 0 select, e.g. 0x04 OPT IN 1
0xB-064 Trigger 1 select, e.g. 0x05 OPT IN 2

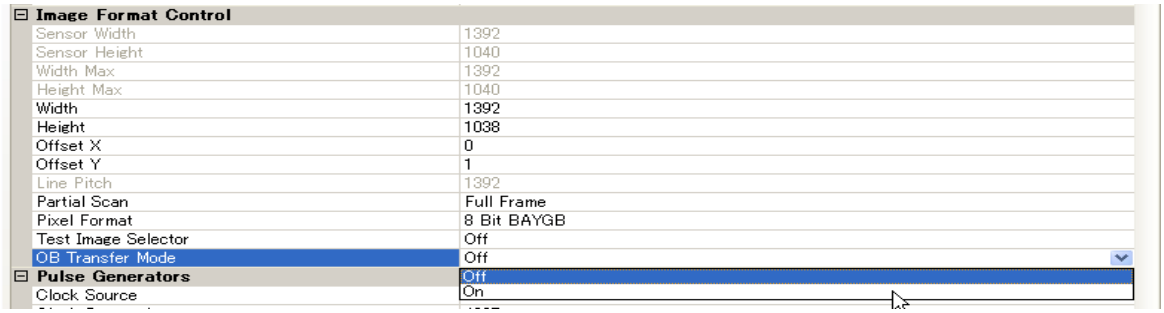
For the details of Registers, please refer to Camera Register Map which is included in the SDK.

8.7.6 Optical Black Transfer Mode

It is possible for the user to decide whether the optical black (OB) portion of the image will be transferred or not. The optical black part can be used for black reference in the application software. Setting register 0xA41C turns the optical black transfer ON or OFF. The default condition is OFF.

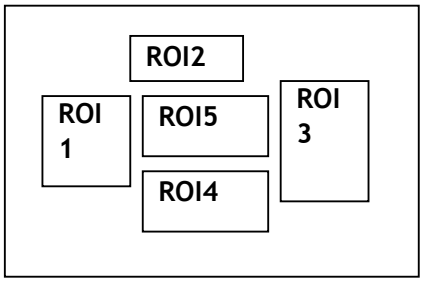
	Normal Mode	OB Transfer Mode
Normal Scan		
2/3 Partial Scan		
1/2 Partial Scan		
1/4 Partial Scan		
1/8 Partial Scan		
V Binning Scan		

Note: The menu for ON or OFF of OB transfer mode is found in the Image Format Control section of the JAI SDK Camera Control Tool.



8.7.7 Multi ROI Mode (Multi Region of Interest)

In the trigger mode, a maximum of 5 ROIs located on one image can be output by one trigger input. By using this mode, the data stream can be made smaller.
Each ROI can be overlapped.



8.8 Operation Mode and Functions matrix

ID (Value) Note 1	Mode	Shutter Preset / Program.	Vertical Binning (Note 2)	Partial Scanning	DRAFT (Note 3)	Multi ROI	LVAL Sync/ Async	Auto Iris output (Note 4)
0x00	Continuous	Yes	Yes	Yes	Yes	No	---	Yes
0x01	Pre-select (PS)	Yes	Yes	Yes	Yes	Yes	Auto	No
0x02	Pulse Width (PW)	Not applicable	Yes	Yes	Yes	Yes	Auto	No
0x09	Sequential Pre-select (PS)	Yes	Yes	Yes	Yes	No	Async	No
0x11	PS Delayed Readout	Yes	Yes	Yes	Yes	Yes	Auto	No

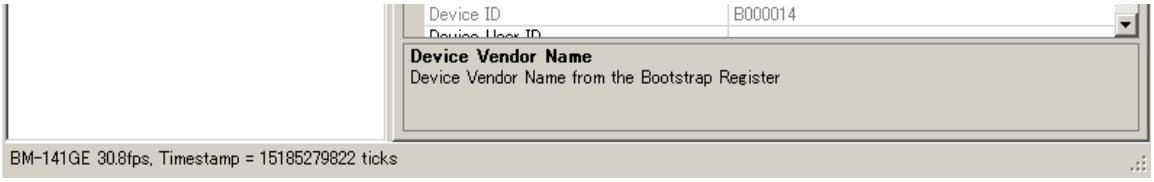
Note 1: Write ID in register address 0xA040 in order to set trigger mode.
Note 2: Vertical Binning is available for only BM-500GE.
Note 3: Draft mode is available only in BB-500GE.
Note 4: The Auto iris output is only effective on Normal scan and Vertical binning modes. It is not available on the partial scan mode and Draft mode.

8.8.1 When the image size is changed

If the image size needs to be changed while the image is being captured, stop the image capturing by pressing “Stop Acquisition”. Then change the value. It is possible to set shutter values and gain settings while watching the picture on the screen.

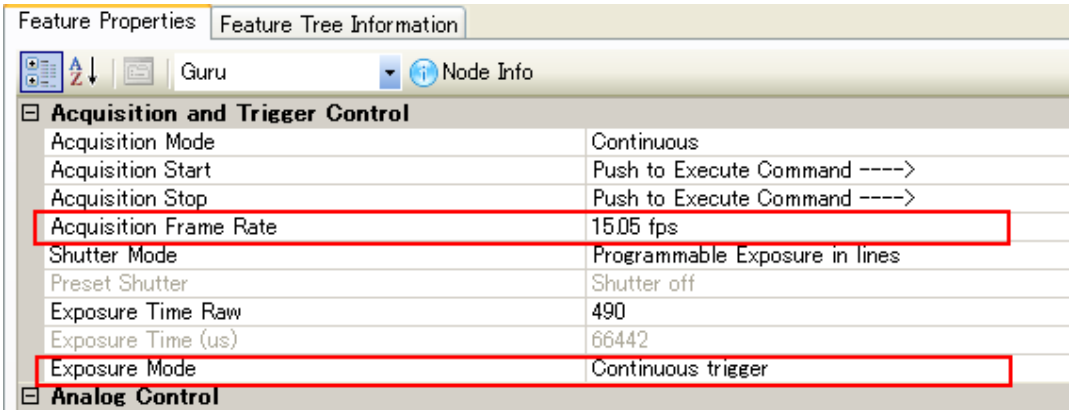
8.8.2 When the image is captured

While capturing image, if the frame rate is decreased, please check the packet size. Each packet includes header information. If the packet size is small, the percentage of header data vs. image data can become significant in the output rate. Accordingly, the frame rate may be slower than expected. In this case, it is recommended to set the packet size at a higher value. Please note that the packet size is not stored, and it is necessary to set it on every start up. The current frame rate is shown on the bottom of the camera control tool.



8.8.3 Acquisition frame rate

Acquisition frame rate is a function for controlling the rate of image capture in Continuous mode. The frame rate can be set at full speed, 1/2, 1/4 and 1/8. If a trigger mode is used, it is strongly recommended to use the full frame rate. Otherwise, the trigger frequency will also be divided according to the frame rate setting.



9 Register Map

The table below provides detailed information for the hardware registers used for controlling the camera and obtaining information on the status of the camera. The content of this register map is also found in the XML file, as stipulated by the GenICam standard.

Device Information

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0x0048	Device Vendor Name	DeviceVendorName	R	32		Manufacture of this device	
0x0068	Device Model Name	DeviceModelName	R	32		Model Name of this device	
0x0088	Device Version	DeviceVersion	R	32		Version of this device	
0x00A8	Device Manufacturer Info	DeviceManufacturerInfo	R	48		Provides extended manufacturer information about the device.	
0x00D8	Device ID	DeviceID	R	16		Camera serial number	
0x00E8	Device User ID	DeviceUserID	RW	16		User assignable string (16 Byte)	
0xA714	FPGA version	DeviceFPGAVersion	R	4			
0xA640	Device Reset	DeviceReset	W	4	Command=1		
0xA1FC	Temperature	Temperature	R	4	0.0625° step	-55 ℃ ～ 150 ℃	

Image Format Control

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA400	Width Max	WidthMax	R	4	2456	Width max	2456
0xA404	Height Max	HeightMax	R	4	2058	Height max	2058
0xA410	Pixel Format	PixelFormat	RW	4	Mono CCD(BM-500GE) 0x01080001 0x010C0004 0x01100003 0x01100005 0x010C0006 Bayer CCR(BB=500GE) 0x01080009 0x0108000A 0x0110000D 0x0110000E 0x01100011 0x011000112	 Mono8 Mono10Packed Mono0 Mono12 Mono12Packed BayerRG8 BayerGB8 BayerRG10 BayerGB10 BayerRG12 BayerGB12	Mono8 BayerRG8
0xA500	ROI Mode	ROIMode	RW	4	1 to 5	1:ROI disable 2 to 5: Enable	1
0xA504	ROI 1 Width	Width	RW	4	8 - 2456	Width	W.Max
0xA508	ROI 1 Height	Height	RW	4	8 – 2058	Height	H.Max
0xA50C	ROI 1 Offset X	OffsetX	RW	4	0 – 2448	Horizontal offset	0
0xA510	ROI 1 Offset Y	OffsetY	RW	4	0 – 2050	Vertical offset	0
0xA514	ROI 2 Width	Width2	RW	4	8 - 2456	Width 2	W.Max
0xA518	ROI 2 Height	Height2	RW	4	8 – 2058	Height 2	H.Max

0xA51C	ROI 2 Offset X	OffsetX2	RW	4	0 – 2448	Offset X2	0
0xA520	ROI 2 Offset Y	OffsetY2	RW	4	0 – 2050	Offset Y2	0
0xA524	ROI 3 Width	Width3	RW	4	8 - 2456	Width 3	W.Max
0xA528	ROI 3 Height	Height3	RW	4	8 – 2058	Height 3	H.Max
0xA52C	ROI 3 Offset X	OffsetX3	RW	4	0 – 2448	Offset X3	0
0xA530	ROI 3 Offset Y	OffsetY3	RW	4	0 – 2050	Offset Y3	0
0xA534	ROI 4 Width	Width4	RW	4	8 - 2456	Width 4	W.Max
0xA538	ROI 4 Height	Height4	RW	4	8 – 2058	Height 4	H.Max
0xA53C	ROI 4 Offset X	OffsetX4	RW	4	0 – 2448	Offset X4	0
0xA540	ROI 4 Offset Y	OffsetY4	RW	4	0 – 2050	Offset Y4	0
0xA544	ROI 5 Width	Width5	RW	4	8 - 2456	Width 5	W.Max
0xA548	ROI 5 Height	Height5	RW	4	8 – 2058	Height 2	H.Max
0xA54C	ROI 5 Offset X	OffsetX5	RW	4	0 – 2448	Offset X 5	0
0xA550	ROI 5 Offset Y	OffsetY5	RW	4	0 – 2050	Offset Y 5	0
0xA080	Partial scan	PartialScan	RW	4	0=Full frame 1=2/3 2=1/2 3=1/4 4=1/8 15=Variable		
0xA088	Variable Partial Scan Start Line	VariablePartialScanStartLine	RW	4	2 - 2050		
0xA08C	Variable Partial Scan Num. of Lines	VariablePartialScanNumOfLines	RW	4	8 - 2058		
0xA084	Binning Vertical	BinningVertical	RW	4	1=Binning OFF 2=1/2 V Binning	Only BM-500GE	1
0xA094	Draft Mode	DraftMode	RW	4	0= OFF 1= ON	Only BB-500GE	0
0xA13C	Test Image Selector	TestImageSeleector	RW	4	0=OFF 4=H Ramp Scale 5=V Ramp Scale 6= Moving Ramp Scale 8=Normal Color bar 9=Vertical Color Bar 10=Moving Color Bar	8,9,10 only for BB-500GE	0
0xA41C	OB Transfer Enable	OBTransferEnable	RW	4	0=OFF 1=ON		0

Acquisition and Trigger Control

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA604	Acquisition Mode	AcquisitionMode	RW	4	0=Stop 1=Start	Acquisition start and stop	0
0xA414	Acquisition frame rate	AcquisitionFrameRate	RW	4	0=Full speed 1=1/2 speed 2=1/4 speed 3=1/8 speed		0
0xA000	Shutter mode	ShutterMode	RW	4	1= Programmable exposure in line 2=Programmable exposure(us) 3=Auto Exposure Constantly	Sets exposure time for image capture.	1
0xA008	Exposure Time Raw	ExposureTimeRaw	RW	4	2 to2072 (OFF)	Flexible setting of exposure time ranging from 64 µs to 66.44 ms using the LVAL period (L) as increment. 1L is 32.07us.	2072
0xA018	Exposure Time (us)	ExposureTimeAbs	RW	4	64 to 66442 (OFF)	Actual exposure time in microseconds, µs. The camera will round value off to match LVAL increments.	66442
0xA030	Auto exposure value	AutoExposureValue	R	4		Exposure time on Auto exposure mode	
0xA040	Exposure Mode	ExposureMode	RW	4	00=Continuous trigger 01=Edge pre-select 02=Pulse-width control 04=RCT mode 09=Sequential EPS trigger 17=Delayed readout EPS trigger 18=Delayed readout PWC trigger		0

Analog Control

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA0A0	Digital Gr	DigitalGr	RW	4	0 ~ 16384		
0xA0A4	Digital Gb	DigitalGb	RW	4	0 ~ 16384		
0xA0A8	Digital Red	DigitalRed	RW	4	0 ~ 16384		
0xA0AC	Digital Blue	DigitalBlue	RW	4	0 ~ 16384		
0xA0B0	Gain Auto	GainAuto	RW	4	0=OFF 1=continuous		0
0xA0B4	AGC Reference	AGCReference	RW	4	0 to 8192	Reference value for AGC as well as Auto shutter	0
0xA0B8	Gain Auto Balance Once	GainAuotBalanceOnce	RW	4	Command=0		0
0xA0BC	Black Level Auto Balance Once	BlackLevelAuotBalanceOnce	RW	4	Command=0		0
0xA09C	Analog Fine Tap 2	AnalogFineTap2	RW	4	-64 to 63		0

0xA0C4	Analog All	AnalogAll	RW	4	-84 to 341		0
0xA0E0	Black Level Selector :All Black Level Raw	BlackLevelSelector All BlackLevelRaw	RW	4	-768 to 767		0
0xA0F8	Black Level Selector :Fine Tap 2 Black Level Raw	BlackLevelSelector FineTap2 BlackLevelRaw	RW	4	-64 to 63		0
0xA150	Black Level Selector :Tap1 Black Level Raw	BlackLevelSelector Tap1 BlackLevelRaw	RW	4	-256 to 255		0
0xA160	Black Level Selector :Tap2 Black Level Raw	BlackLevelSelector Tap2 BlackLevelRaw	RW	4	-256 to 255		0
0xA0C0	Balance White Auto	BalanceWhiteAuto	RW	4	0=Manual or one push 1=Continuous 2=3200K 3=4600K 4=5600K		
0xA0D0	Balance White Auto Once	BalanceWhiteAutoOnce	W	4	Command=0		0 only
0xA0D8	Status of video processing	StatusOfProcessing	R	4	0=Complete successfully 1=Busy 2=Too high level 3=Too low level 4=Time-out error 5=Reaching a limit of Feature's value 6=Inappropriate trigger mode	For auto white balance, Exposure Mode should be 0=Continuous.	
0xA0D4	AWB Area Enable	AWBAreaEnable	RW	4	0=Full area 1=Upper left 2=Upper middle 3=Upper right 4=Middle left 5=Middle middle 6=Middle right 7=Lower left 8=Lower middle 9=Lower right	Block 1～ Block 9 Image is divided in 9	
0xA0EC	Gamma Correction	GammaCorrection	RW	4	0=Gamma 1.0 1=Gamma 0.45 2=Gamma 0.6		

Image Processing

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA128	Blemish Reduction Enable	BlemishReductionEnable	RW	4	0=OFF 1=ON		0

Digital IO

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA600	Software Trigger 0	SoftwareTrigger0	RW	4	0 to 1		
0xA644	Software Trigger 1	SoftwareTrigger1	RW	4	0 to 1		
0xA648	Software Trigger 2	SoftwareTrigger2	RW	4	0 to 1		
0xA64C	Software Trigger 3	SoftwareTrigger3	RW	4	0 to 1		
0xB060	Line Selector Camera trigger 0	LineSelector CameraTrigger0	RW	4	Line Source Bit31 ~ Bit25 Bit24:Line Inverter 0=False (Active High) 1=True(Active Low)	Line Source 127:OFF 0:LVAL 1:DVAL 2:FVAL 3:EEN 4:GPIO_PortIn1(Opt In1) 5:GPIO_PortIn2(Opt In2) 6: GPIO_PortIn3(TTL In) 7: GPIO_PortIn4(LVDS In) 12:Software Trigger 0 13: Software Trigger 1 14: Software Trigger 2 15: Software Trigger 3 16:Pulse Generator 0 17:Pulse Generator 1	
0xB064	Liner Selector Camera Trigger 1	LineSelector CameraTrigger1	RW	4			
0xB070	Line Selector GPIO Port 1(TTL Out 1)	GPIO_Port1	RW	4			
0xB074	Line Selector GPIO Port 2(TTL Out 2)	GPIO_Port2	RW	4			
0xB078	Line Selector GPIO Port 3(Optical Out 1)	GPIO_Port3	RW	4			
0xB07C	Line Selector GPIO Port 4(Optical Out 2)	GPIO Port 4	RW	4			
0xB090	Line Selector Pulse Generator 0	PulseGenerator0	RW	4			
0xB094	Line Selector Pulse Generator 1	PulseGenerator1	RW	4			
0xB0A0	Line Selector TimeStamp Reset	TimeStampReset	RW	4			
0xB0A4	Line Selector Sequence Table Reset	SequenceTableReset	RW	4			

Pulse Generator

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xB004	Clock Pre-scaler	ClockPreScaler	RW	4	0x000 0x001 0x002 | 0xFFF	Bypass Divide by 2 Divide by 3 | Divide by 4096	0
0xB008	Pulse Generator Length 0	PulseGeneratorLength0	RW	4	1～1048575	Defines the length of the counter 0	1
0xB00C	Pulse Generator Start Point 0	PulseGeneratorStartPoint 0	RW	4	0～1048574	Defines the starting point of the counter 0	0
0xB010	Pulse Generator Repeat Count 0	PulseGeneratorRepeatCou nt0	RW	4	0 - 255	Defines the repeat count of the counter 0	0
0xB014	Pulse Generator End Point 0	PulseGeneratorEndPoint0	RW	4	1～1048575	Defines the end point of the counter 0	1
0xB018	Clear Mode for the Pulse Generator 0	PulseGeneratorClear0	RW	4	0 :Free Run 1:High Level 2: Low Level 4: Rising Edge 8: Falling Edge		0

0xB01C	Pulse Generator Length 1	PulseGeneratorLength1	RW	4	1～1048575	Defines the length of the counter 1	1
0xB020	Pulse Generator Start Point 1	PulseGeneratorStartPoint 1	RW	4	0～1048574	Defines the starting point of the counter 1	0
0xB024	Pulse Generator Repeat Count 1	PulseGeneratorRepeatCount1	RW	4	0 - 255	Defines the repeat count of the counter 1	0
0xB028	Pulse Generator End Point 1	PulseGeneratorEndPoint1	RW	4	1～1048575	Defines the end point of the counter 1	1
0xB02C	Clear Mode for the Pulse Generator 1	PulseGeneratorClear1	RW	4	0 :Free Run 1:High Level 2: Low Level 4: Rising Edge 8: Falling Edge		0
0xB030	Pulse Generator Length 2	PulseGeneratorLength2	RW	4	1～1048575	Defines the length of the counter 2	1
0xB034	Pulse Generator Start Point 2	PulseGeneratorStartPoint 2	RW	4	0～1048574	Defines the starting point of the counter 2	0
0xB038	Pulse Generator Repeat Count 2	PulseGeneratorRepeatCount2	RW	4	0 - 255	Defines the repeat count of the counter 2	0
0xB03C	Pulse Generator End Point 2	PulseGeneratorEndPoint2	RW	4	1～1048575	Defines the end point of the counter 2	1
0xB040	Clear Mode for the Pulse Generator 2	PulseGeneratorClear2	RW	4	0 :Free Run 1:High Level 2: Low Level 4: Rising Edge 8: Falling Edge		0

Sequence Acquisition Mode

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
	Sequence Selector	SequenceSelector			Sequence Selector Val 0=Sequence 1 1=Sequence 2 2=Sequence 3 3=Sequence 4 4=Sequence 5 5=Sequence 6 7=Sequence 8 8=Sequence 9 9=Sequence 10	Sequence Selector value is the INDEX for each sequence。	
0xC000	Sequence Exposure Time Raw	SequenceExposureTimeRaw	RW	4	2 - 2072	Shutter value Base Address INDEX=0 to 9 (Base Address + Index *4)	2072
0xC078	Sequence Master Gain Raw	SequenceMasterGain	RW	4	-84 to 588	Gain value Base Address INDEX=0 to 9 (Base Address + Index *4)	0
0xC0FC	Sequence ROI Size X	SequenceROISizeX	RW	4	8 - 2456	ROI width value Base Address INDEX=0 to 9 (Base Address + Index *4)	Width max
0xC124	Sequence ROI Size Y	SequenceROISizeY	RW	4	8 - 2058	ROI Height value Base Address INDEX=0 to 9 (Base Address + Index *4)	Height Max
0xC14C	Sequence ROI Offset X	SequenceROIOffsetX	RW	4	0 - 2448	ROI H Offset value Base Address INDEX=0 to 9 (Base Address + Index *4)	0
0xC174	Sequence ROI Offset Y	SequenceROIOffsetY	RW	4	0 - 2050	ROI V Offset value Base Address INDEX=0 to 9 (Base Address + Index *4)	0

0xC19C	Repeat Count in Each Step	SequenceRepeatCountInEachStep	RW	4	1 to 255	Sequence repeat count value Base Address INDEX=0 to 9 (Base Address + Index *4)	0
0xA30C	Save Sequence Settings	SequenceSaveCommand	RW	4	1 only	Save sequence	1
0xC0F0	Reset Sequence Settings	SequenceResetCommand	RW	4	1 only	Sequence reset	1
0xC0F4	Sequence Repetition Count	SequenceRepetitions	RW	4	0 to 255	Sequence repeat count	0
0xC0F8	Last Sequence	SequenceEndingPosition	RW	4	1 to 10	Last sequence number setting	1

GigE Transport Layer

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA418	Payload size	PayloadSize	R	4		Return image size of 1 frame	
0x0000	GigE Major Version	GevVersionMajor	R	4		Version of the GigE Standard to which the device is compliant.	0001
	GigE Minor Version	GevVersionMinor					0000
0x0004	Is Big Endian	GevDeviceModeIsBigEndian	R	4	0:Littel-endian 1:Big-endian	0:Little endian 1:Big endian 1:UTF-8	1
	Character set	GevDeviceModeCharacterSet			0:Unknown ,1:UTF-8		1
0x0008	MAC address	GevMacAddress	R	4		Upper 4 bytes of the MAC address	
0x000c	MAC address	GevMacAddress	R	4		Lower 4 bytes of the MAC address	
0x0010	Support LLA	GevSupportedIPConfigurationLLA	R	4	Bit 31: persistent Bit 30: DHCP Bit 29: LLA	Bits can be OR-ed. All other bits are reserved and set to 0. DHCP and LLA bits must be on.	All True
	Support DHCP	GevSupportedConfigurationDHCP					
	Support Persistent IP	GevSupportedConfigurationPersistentIP					
0x0014	Current IP configuration LLA	GevCurrentIPConfigurationLLA	RW	4	Bit 31: persistent Bit 30: DHCP Bit 29: LLA	Bits can be OR-ed. LLA is always activated and is read only.	LLA is always true
	Current IP configuration DHCP	GevCurrentIPConfigurationDHCP					
	Current IP configuration Persistent IP	GevCurrentIPConfigurationPersistentIP					
0x0024	Current IP address	GevCurrentIPAddress	R	4			
0x0034	Current Subnet Mask	GevCurrentSubnetAddress	R	4			
0x0044	Current Default Gteway	GevCurrentDefaultGateway	R	4			
0x0200	First URL	GevFirstURL	R	512		File extension .XML indicates uncompressed text file. File extension .ZIP indicates compressed using ZIP.	
0x0400	Second URL	GevSecondURL	R	512			
0x0600	Number Of Interfaces	GevNumberOfInterfaces	R	4		Indicates the number of physical network interfaces on this device.	
0x064C	Persistent IP Address	GevPersistentIPAddress	RW	4		Valid if Persistent IP is enabled	
0x065C	Persistent Subnet Mask	GevPersistentSubnetMask	RW	4		Valid if Persistent IP is enabled	
0x066C	Persistent Default Gateway	GevPersistentDefaultGateway	RW	4		Valid if Persistent IP is enabled	
0x0900	Message Channel Count	GevMessageChannelCount	R	4		number of available message channel	

0x0904	Stream Channel Count	GevStreamChannelCount	R	4		number of available stream channel	
0x0934	Supported Optional Commands EVENTDATA	GevSupportedOptionalCommandsEVENTDATA	R	4	Bit 31:multiple read Bit 30:WRITEMEM Bit29: PACKETRESEND Bit 28:EVENT Bit 27:EVENTDATA Bit 1:Serial No. Bit 0:User defined name 0=false 1=True	This is a capability register indicating which one of the non-mandatory GVCP commands are supported by this device.	
	Supported Optional Commands EVENT	GevSupportedOptionalCommandsEVENT					
	Supported Optional Commands PACKET RESEND	GevSupportedOptionalCommandsPACKETRESEND					
	Supported Optional Commands WRITEMEM	GevSupportedOptionalCommandsWRITEMEM					
	Supported Optional Commands Concatenation	GevSupportedOptionalCommandsConcatenation					
0x0938	Heartbeat Timeout	GevHeartbeatTimeout	RW	4	0 ～4294967295		0
0x093C	Timestamp Tick Frequency	GevTimestampTickFrequency	R	4	Timestamp tick frequency is 0 if timestamp is not supported.	In milliseconds. Internally, the heartbeat is rounded according to the clock used for heartbeat.	
0x0940		GevTimestampTickFrequency	R	4		64-bit value indicating the number of timestamp clock ticks in 1 second. This register holds the most significant bytes.	
0x0944	Timestamp control Latch	GevTimestampcontrolLatch	W	4	Command 2	This register holds the least significant bytes. Used to latch the current timestamp value. No need to clear to 0.	
	Timestamp control Reset	GevTimestampcontrolReset			Command 1		
0x0948	Timestamp Tick Value	GevTimeStampValue	R	4	High	Latched value of the timestamp (most significant bytes)	
0x094C		GevTimeStampValue	R	4	Low	Latched value of the timestamp (least significant bytes)	
0x0A00	Control Channel Privilege Feature	GevCCP	R	4	0:Open Access 1:Exclusive 2:Control 3:Exclusive Control	control channel privilege register	0
0x0B00	Message Channel Port	GevMCPHostPort	R	4		message channel port register	0
0x0B10	Message Channel Destination Address	GevMCDA	R	4		message channel destination address register	
0x0B14	Message Channel Transmission Timeout	GevMCTT	R	4		message channel transfer timeout: ms	300
0x0B18	Message Channel Retry Count	GevMCRC	R	4		message channel retry count	2
0x0D00	Stream Channel Port	GevSCPHostPort	R	4		primary stream port register	
0xD04	Fire Test Packet	GevSCPSFireTestPacket	RW	4	1	The device will fire one test packet of size specified by the packet size. The don't fragment bit of IP header must be set for this test packet.	
0x0D04	Packet Size	GevSCPSPacketSize	RW	4	1476 ～4036	primary stream channel packet size register/ packet size includes IP, UDP&GVSP Header	1476

0x0D04 (cont.)	Do Not Fragment	GevSCPSDoNotFragment			0=False 1=True	This bit is copied into the "don't fragment" Ebit of IP header of each stream packet. It can be used by the application to prevent IP fragmentation of packets on the stream channel.	1
0x0D08	Packet Delay	GevSCPD	RW	4	0 ～ 125000	Set the delay in between packets	0
0x0D18	Strem Channel Destination Address	GevSCDA	R	4		primary stream channel destination address register	
0xA610	Event GEV_EVENT_TRIGGER Enabled	GevEventTrigger	RW	4	Bit31:Gev Event Trigger Bit30:Gev Event Start Of Exposure Bit29:Gev Event End Of Exposure Bit28:Gev Event Start Of Transfer Bit27:Gev Event End Of Transfer Bit26:Gev Event Trigger Error	Indicate event message on message channel if it is enable	
	Event GEV_EVENT_START_OF_Expsoure enabled	GevEventStartOfExposure	RW	4			
	Event GEV_EVENT_END_OF_EXPOSURE Enabled	GevEventEndOfExposure	RW	4			
	Event GEV_START_OF_TRANSFER Enabled	GevEventStartOfTransfer	RW	4			
	Event GEV_END_OF_TRANSFER Enabled	GevEventEndOfTransfer	RW	4			

LUT Controls

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA200	LUT Enable	LUTEnable	R W	4			
0xD000 | 0xD3FC	LUT Value	LUTValue[Red]	R W	4	1024 ～ 16384	D000 to D3FC is LUT Index(0 to 255)	4096

User Sets

Address	Display Name (JAI Control Tool)	GenICam name	Read / Write	Size	Value / Range of value	Description	Default value
0xA300	UserSet Save	UserSetSave	W	4	1=User area1	Allows use to save all camera settings. Last used area number becomes new default.	1
0xA304	UserSet Load	UserSetLoad	W	4	0=Factory area 1=User area1	Allow the user to recall all camera settings.	0
0xA308	UserSet Selector	UserSetSelector	RW	4	When receiving following commands, store the parameters 0xA300 0xA304	Check the used data, 0=Factory or1=User	0

10 External Appearance and Dimensions

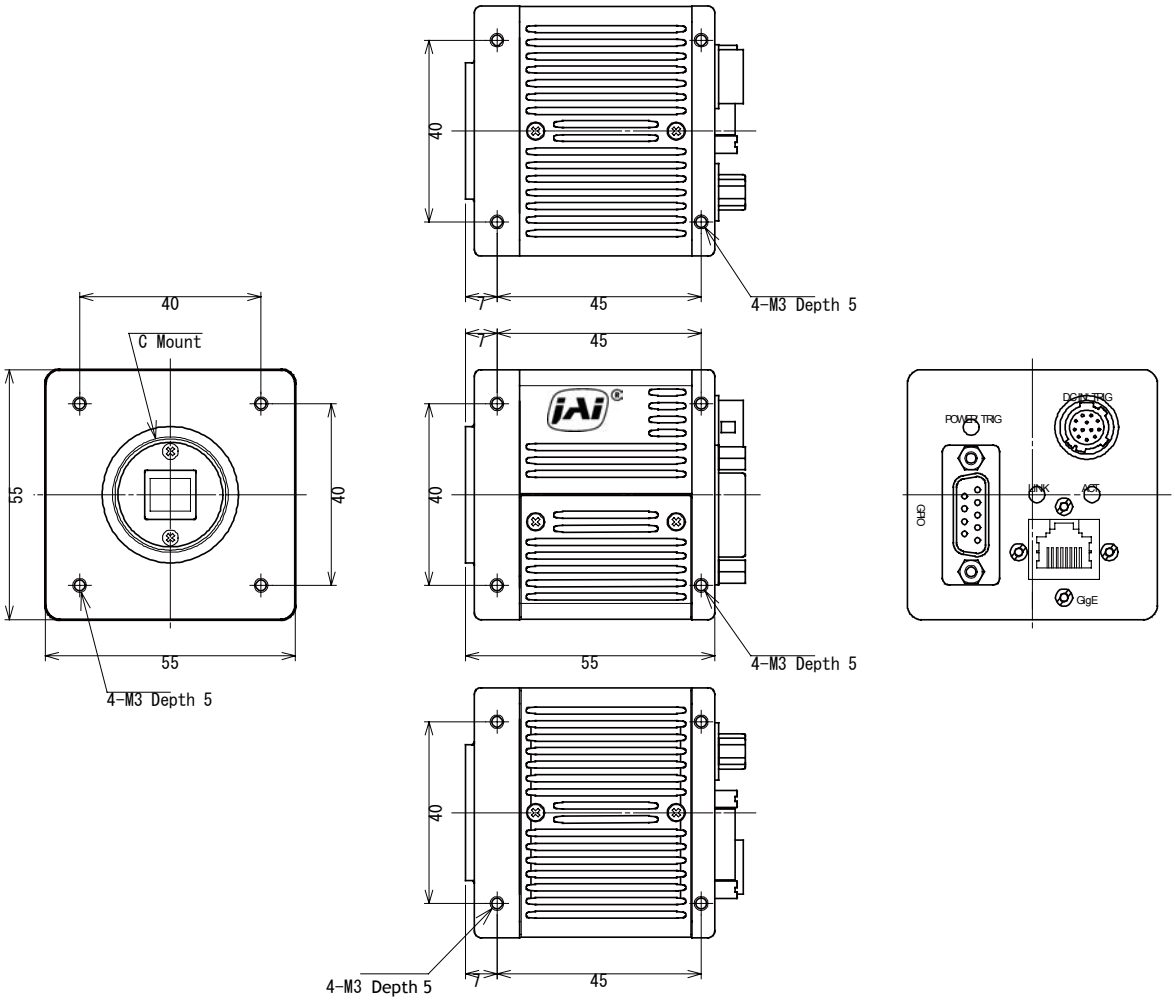


Fig. 36 Outline.

11 Specifications

11.1 Spectral response

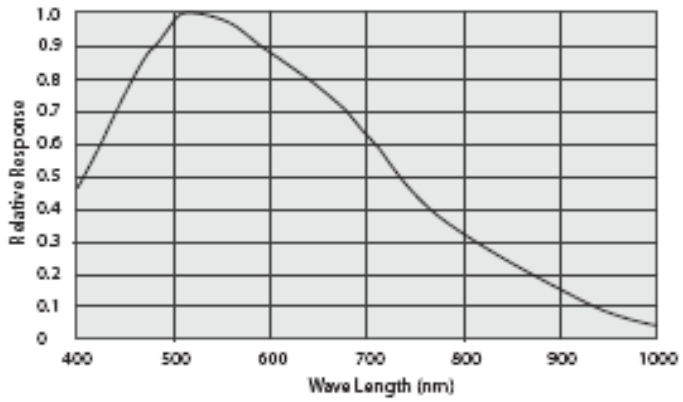


Fig.37 Spectral response for BM-500GE

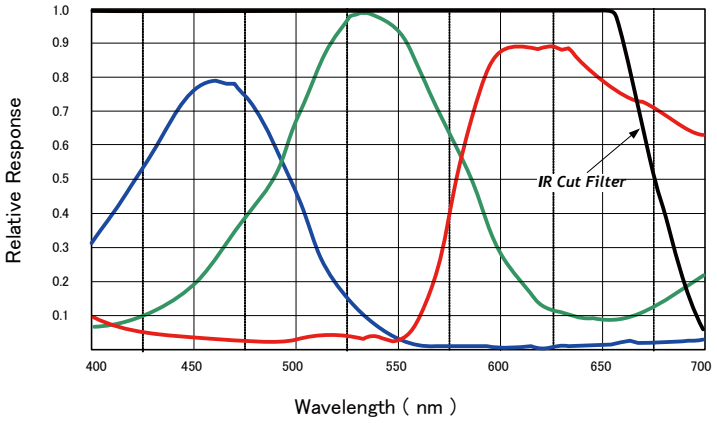


Fig.38 Spectral response for BB-500GE

11.2 Specification table

Specifications	BM-500GE	BB-500GE
Scanning system	Progressive scan	
Frame rate full frame	15.05 frames/sec. Progressive (2072 lines/frame)	
Pixel clock	60 MHz	
Line frequency	31.19 kHz (1H = 32 µs) (1924 pixel clock/line L ch and 1924 pixel clock / line R ch)	
CCD sensor	2/3" Monochrome ICX625ALA	2/3" Bayer Color ICX625AQA
Sensing area	8.47 (h) x 7.10 (v) mm 2/3 inch diagonal	
Cell size	3.45 µm (h) x 3.45 µm (v)	
Active pixels	2456 (h) x2058 (v)	
Pixels in video output. Full Scan 2/3 partial scan 1/2 partial scan 1/4 partial scan 1/8 partial scan Variable partial scan Vertical binning Draft Region-of-interest (ROI)	2456 (h) x 2058 (v) 15.05 fps. H = 31.19 kHz 2456(h) x 1372 (v) 19.97 fps H= 31.19 kHz 2456 (h) x 1028 (v) 23.93 fps. H = 31.19 kHz 2456(h) x 514 (v) 34.04fps. H = 31.19 kHz 2456 (h) x 258 (v) 43.07 fps. H = 31.19 kHz Start line from 2 to 2050, height(lines) from 8 to 2058 2456 (h) x 1029 (v) 22.88 fps. H = 23.77 kHz (*Note1) 2456 (h) x 261 (v) 37.54 fps. H = 9.79 kHz (*Note2) User Definable. Memory read-out *Note1: Vertical binning is for BM-500GE only *Note2: Draft mode is for BB-500GE only	
Sensitivity on sensor (minimum)	0.34 Lux (Max. gain, Shutter OFF, 50% video)	1.0 Lux (Max. gain, Shutter OFF,50% Green, w/IR cut filter)
S/N ratio	More than 50 dB (0dB gain, standard temp.)	
Digital Video output.	GigE Vision Compliant Mono8,Mono10,Mono10_Packed Mono 12, Mono12_Packed	GigE Vision Compliant BAYRG8,BAYGB8,BAYRG10,BAYGB10 BAYRG12, BAYGB12
White Balance	n/a	Manual/One push Continuous Preset (3200K,4600K,5600K)
Iris video output Analog	0.7 V p-p , enabled by internal switch	
Gain	Manual / AGC : -3 to +12 dB	
Blemish Correction	ON / OFF	
Synchronization	Internal/external hardware trigger via GPIO. SW trigger via GigE Vision.	
GPIO Module Input/output switch Clock Generator (One) Pulse Generators (Two)	Configurable 16-in / 12-out switch 12-bit counter based on Pixel clock 19-bit counter programmable for length, start point, stop point, repeat	
Hardware Trigger modes	Edge Pre-Select , Pulse Width Control, Frame Delay and Sequence	
OB area transfer mode	ON / OFF	
Event message	SYNC / ASYNC mode (Trigger mode status when exposure starts) Exposure start, Exposure end, Trigger IN, Video start, Video end	
Electronic Shutter Preset Shutter speed Programmable exposure Exposure Time (Abs) Exposure Auto continuous GPIO plus Pulse Width	OFF(1/15) and 1/30 to 1/10,000 in 10 steps 2L(64µs) to 2072 L (66.44ms) in 1L steps µsec – user definable. Same range as PE OFF to 1/250s max. 2 sec (Can be set by 100µs unit or Pixel Clock unit)	
Control interface	Register based. GigE Vision / GenIcam compliant	
Functions controlled via GigE Vision Interface	Shutter, Gain, Black Level, Trigger mode, Read out mode, GPIO setup ,ROI (GenIcam mandatory functions)	

GigE Vision Streaming Control	Packet size, Delayed (Frame) read-out, inter-packet delay Jumbo frame can be set at max. 4K (4036) , Default packet size is 1428 Byte.	
Indicators on rear panel	Power, Hardware trigger, GigE Link, GigE activity	
Operating temperature	-40°C to +65°C (Some reduced performance may occur when operating outside the standard -5ºC to +45ºC range)	
Humidity	20 – 80% non-condensing	
Storage temp/humidity	-50°C to +70°C/20% to80 % non-condensing	
Vibration	10G (20Hz to 200Hz, XYZ)	
Shock	70G	
Regulatory	CE (EN61000-6-2 and EN61000-6-3), FCC part 15 class B, RoHS, WEEE	
Power	12V DC ± 10%. 5.9W	
Lens mount	C-mount Rear protrusion on C-mount lens must be less than 10.0mm	
Optical Low Pass Filter	Built in (Only for BB-500GE, OP22-5-1)	
Dimensions	55 x 55 x 55 mm (HxWxD)	
Weight	226 g	226 g

In order to get specified performance, approx. 30 minutes of pre-heating is required.

Note: Above specifications are subject to change without notice

12 Appendix

12.1 Precautions

Personnel not trained in dealing with similar electronic devices should not service this camera.
The camera contains components sensitive to electrostatic discharge. The handling of these devices should follow the requirements of electrostatic sensitive components.
Do not attempt to disassemble this camera.
Do not expose this camera to rain or moisture.
Do not face this camera towards the sun, extreme bright light or light reflecting objects, including laser sources.
When this camera is not in use, put the supplied lens cap on the lens mount.
Handle this camera with the maximum care.
Operate this camera only from the type of power source indicated on the camera.
Remove power from the camera during any modification work, such as changes of jumper and switch settings.

12.2 Typical Sensor Characteristics

The following effects may be observed on the video monitor screen. They do not indicate any fault of the camera, but are associated with typical sensor characteristics.

V. Aliasing
When the camera captures stripes, straight lines or similar sharp patterns, a jagged image on the monitor may appear.

Blemishes
All cameras are shipped without visible image sensor blemishes.
Over time some pixel defects can occur. This does not have a practical effect on the operation of the camera. These will show up as white spots (blemishes).
Exposure to cosmic rays can cause blemishes to appear on the image sensor. Please take care to avoid exposure to cosmic rays during transportation and storage. It is recommended to use sea shipment instead of air transportation in order to limit the influence of cosmic rays on the camera.
Pixel defects/blemishes may also emerge due to prolonged operation at elevated ambient temperature, due to high gain setting or during long time exposure. It is therefore recommended to operate the camera within its specifications.

Patterned Noise
When the sensor captures a dark object at high temperature or is used for long time integration, fixed pattern noise may appear in the image.

12.3 Caution when mounting a lens on the camera

When mounting a lens on the camera dust particles in the air may settle on the surface of the lens or the image sensor of the camera. It is therefore important to keep the protective caps on the lens and on the camera until the lens is mounted. Point the lens mount of the camera downward to prevent dust particles from landing on the optical surfaces of the camera. This work should be done in a dust free environment. Do not touch any of the optical surfaces of the camera or the lens.

12.4 Exportation

When exporting this product, please follow the export regulation of your own country.

12.5 References

1. This manual for BM-500GE, OP22-5-1 / BB-500GE, OP-22-5-1 can be downloaded from www.jai.com
2. Datasheet for BM-500GE, OP22-5-1 / BB-500GE, OP22-5-1 can be downloaded from www.jai.com
3. Camera control software can be downloaded from www.jai.com

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Change History

Month/Year	Revision	Changes
	1.0	New issue

User's Record

Camera type:	**BM-500GE, OP22-5-1 / BB-500GE, OP22-5-1**
Revision:	……..
Serial No.	……..
Firmware version.	……..

For camera revision history, please contact your local JAI distributor.

User's Mode Settings.

User's Modifications.

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