See the possibilities

Spark Series

User Manual

SP-20000M-CXP2
SP-20000C-CXP2

20 MP CMOS Digital Progressive Scan Monochrome and Color Camera

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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 Ltd., Japan declares that SP-20000M-CXP2 and SP-20000C-CXP2 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 an 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.

- Contents -

Introduction

EMVA 1288

With regard to signal to noise ratio in this manual, specifications measured by EMVA 1288 are used together with specifications by a traditional measurement method.

EMVA 1288 is a more complete measurement that considers multiple noise sources, including random noise, pattern noise, and shading. Additionally, EMVA 1288 incorporates temporal variances in pixel output by capturing 100 frames of data and computing the RMS variations over the captured frames. Because of the comprehensive nature of the noise analysis and the additional consideration for RMS variances over time, EMVA 1288 SNR measurements are inherently lower than the traditional SNR measurements given by manufacturers. However, the comprehensive nature combined with rigid test parameters, means that all manufacturers' are measuring their products equally and EMVA 1288 tested parameters can be compared among different manufacturers' products.

In order to learn more about EMVA 1288, please visit http://www.emva.org

Interface

The SP-20000-CXP2 employs CoaXPress as an interface system. In order to connect the camera to a PC, it requires the use of a Frame Graber board and the appropriate coaxial cable(s). The maximum video transfer rate per coaxial cable is 6.25 Gbps. In addition to video information, power and control signals can be transferred to the camera over this interface. For detailed specifications, please refer to "JIIA-NTF-001-2010" published by Japan Industrial Imaging Association, http://www.jiia.org.

Computer used for SP-20000 series

In order to get proper performance from this camera, it is necessary to use a PC equipped with a PCIe 2.0 slot with a size and capacity of 16 lanes or higher (x16 or x32).

Frame grabber boards used with SP-20000 series

As the SP-20000-CXP2 employ CoaXPress as an interface system, a CoaXPress-compliant frame grabber board is required. Both cameras have two CoaXPress interface connectors and it is recommended that a frame grabber board with more than two interface connectors be used in order to maximize camera performance.

Cables used with SP-20000 series

For the CoaXPress interface, coaxial cables are used. In the SP-20000-CXP2, they use 75Ω 1.0/2.3 DIN receptacles (Amphenol ACX1785-ND or equivalent). The coaxial cable used to connect the camera must have a 75Ω 1.0/2.3 DIN-type plug at the camera side. An ordinary BNC cable cannot be used.

1. General

The SP-20000-CXP2 cameras are members of JAI's new "Spark Series." They provide both high resolution and a high frame rate with excellent image quality for machine vision applications. The SP-20000M-CXP2 is a monochrome progressive scan COMS camera and the SP-20000C-CXP2 is the equivalent Bayer mosaic progressive scan CMOS camera. Both are equipped with CMOS sensors offering a 35mm full size image format, a resolution of 20 million pixels, and a 4:3 aspect ratio. They provide 30 frames per second for continuous scanning with 5120 x 3840 full pixel resolution for both monochrome and raw Bayer output.

8-bit, 10-bit or 12-bit output can be selected for both monochrome and raw Bayer formats. 24-bit (3 x 8-bit) in-camera color interpolation is also selectable in the color model. The new cameras feature a CoaXPress interface with two coaxial cables which is capable of supporting a "Power over Coaxial Cable" capability. A full pixel readout or partial scan readout mode can be selected depending on applications. The readout format is available as an 8-tap output.

The SP-20000-CXP2 have various comprehensive functions needed for automated optical inspection applications, such as solid state device inspection or material surface inspection. They incorporate video processing functions such as a look-up table, flat field shading compensation and blemish compensation in addition to fundamental functions such as trigger, exposure setting and video level control.

The latest version of this manual can be downloaded from: www.jai.com
The latest version of the JAI SDK for the SP-20000-CXP2 can be downloaded from: www.jai.com

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

2. Camera composition

The standard camera composition is as follows.

Camera body	1
Sensor protection cap	1
Dear Customer (sheet)	1

The following optional accessories are available.

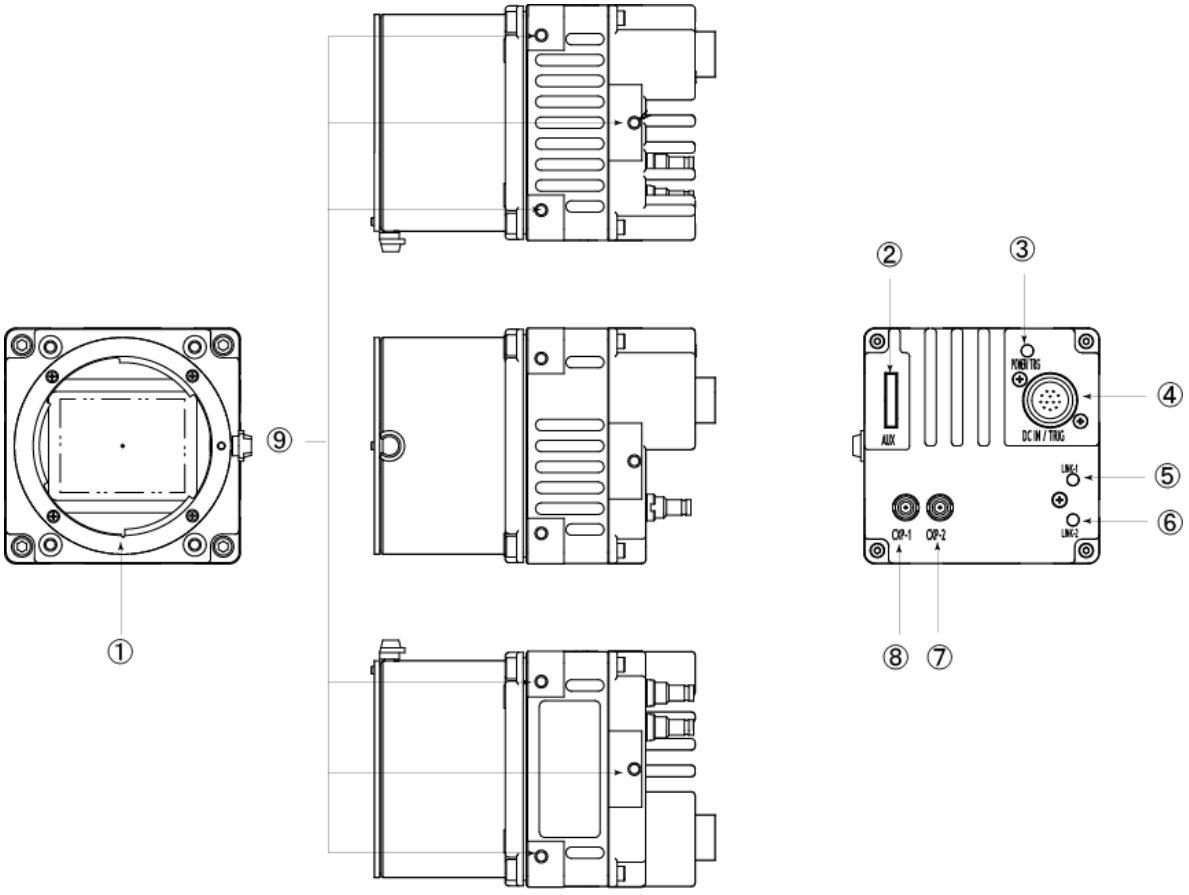
Tripod base	MP-42
Power supply unit	PD-12 series

3. Key features

- New Spark Series, 35mm full size, CMOS 20-megapixel progressive scan camera with global shutter
- Utilizes CoaXPress interface with two cables configuration
- Aspect ratio 4:3, 5120(H) x 3840(V) - 20 million effective pixels
- 6.4 µm square pixels
- S/N 53 dB for monochrome and 51 dB for color
- 8-bit, 10-bit or 12-bit output for monochrome and Bayer color, plus 3 x 8-bit RGB for color with in-camera color interpolation
- 30 frames/second with full resolution in continuous operation for CXP6_X2 Link Configuration
- Supports ROI (Region Of Interest) modes for faster frame rate
- 0 dB to +24 dB gain control for both SP-20000-CXP2 models
- 299µs (1/100,000) to 8 seconds exposure control in 1 µs step
- Auto exposure control
- Timed and trigger width exposure control
- PIV and sequential trigger modes for specific applications
- ALC control with combined function of AGC and auto exposure
- Various pre-processing circuits are provided
  Programmable LUT
  Gamma correction from 0.45 to 1.0
  Flat field correction
  Bayer white balance with manual or one-push auto (SP-20000C-CXP2 only)
  Blemish compensation
  Color interpolation
- New Hirose 10P connector for TTL IN and OUT and LVDS IN interface
- F-mount for lens mount
- Accepts power over Coaxial cable
- Setup by Windows XP/Vista/7 via serial communication

4. Parts locations and their functions

4.1 Parts locations and their functions



①	Lens mount	F-mount (Note *1)
②	AUX 10-pin connector	AUX Connector for TTL IN/OUT and LVDS IN
③	LED	Indication for power and trigger input
④	12-pin connector	DC and trigger input
⑤	LINK 1	LINK Status indication for CXP#1
⑥	LINK 2	LINK Status indication for CXP#2
⑦	CXP#2	CoaXPress No.2 connector
⑧	CXP#1	CoaXPress No.1 connector (Note*2)
⑨	Mounting holes	Holes for mounting tripod base or direct installation. Depth 5 mm (Note*3)

*1) Note1: Rear protrusion on F-mount lens must be less than 14.0 mm.
*2) Note2: When one coaxial cable is used, CXP#1 must be used.
*3) Note3: The part number for the tripod adapter plate (with 1/4"-20 thread) is MP-42 (option).

Fig. 1 Locations

4.2 Rear Panel

The rear panel mounted LED provides the following information:

- Amber: Power connected – initiating
  This light goes OFF after initiating.
  In the process of changing Link Configuration
- Steady green: Camera is operating in Continuous mode
- Flashing green: The camera is receiving external triggering

Note: The interval of flashing does not correspond with external trigger duration.

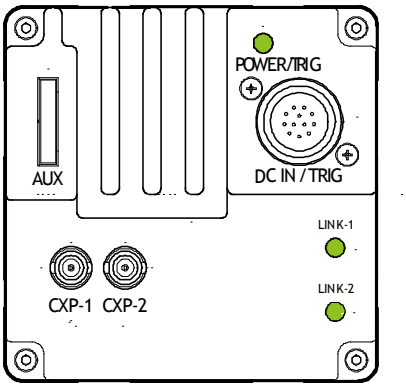


Fig. 2 Rear panel

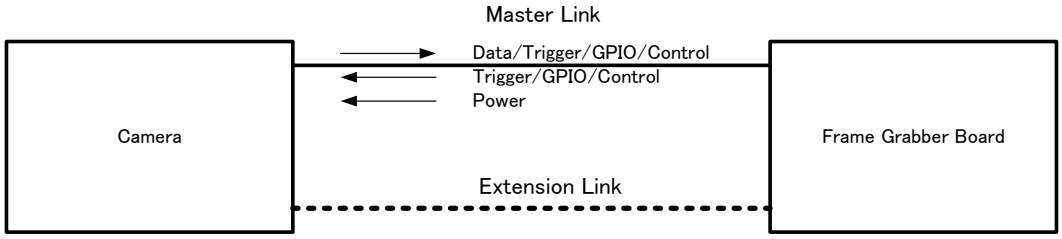
LINK1, LINK 2

- Steady green: Acquisition Active, Outputting video
- Flashing green: Acquisition Wait

5. Input and output

5.1 CoaXPress interface standard

The SP-20000-CXP2 use CoaXPress as their interface. CoaXPress is a PLUG-AND-PLAY interface and connects the camera and the frame grabber board by coaxial cable(s). Its maximum transfer rate is 6.25 Gbps per one coaxial cable. Additionally, CoaXPress interface supports power supplied through the coaxial cable as well as communication signals. In the CoaXPress interface, multiple coaxial cables can be used in order to achieve a faster transfer rate or a reduced transfer rate can be used to extend the cable length.
In the SP-20000-CXP2, a 2 coaxial cable system is used.



The distance between camera and frame grabber board depends on the bit rate of the video and the cable used. Among the unique features of CoaXPress is its ability to supply DC power and provide trigger timing accuracy.
The maximum power supply per one cable is 13W with DC+24V voltage. If the system uses 2 cables, it will be 26W. The accuracy of the trigger is ±2 ns at 3.125 Gbps.
The CoaXPress compliance labeling is assigned to the following five cable types and the maximum bit rate and transmission length is indicated in the table below.

Compliance Labeling	Maximum Operational Bit Rate per coax (Gbps) and transmission length
CXP-1	1.250 (up to 212 m)
CXP-2	2.500 (up to 185 m)
CXP-3	3.125 (up to 169 m)
CXP-5	5.000 (up to 102 m)
CXP-6	6.250 (up to 68 m)

In the SP-20000-CXP2, the maximum bit rate is 6.25 Gbps per one cable and the power supply is available on the CXP#1 connector only.

The following link configurations with the reference to pixel format are use in SP-20000-CXP2.

Table – 1 SP-20000-CXP2 Link Configuration

Model	Pixel format	Link configuration	Bit rate / cable	Used BNC cable
SP-20000M-CXP2	Mono 8/10/12	CXP6_X2	6.250 Gps	2
	Mono 8/10/12	CXP6_X1	6.250 Gps	1
	Mono 8/10/12	CXP3_X2	3.125 Gps	2
	Mono 8/10/12	CXP3_X1	3.125 Gps	1
SP-20000C-CXP2	Bayer 8/10/12/RGB	CXP6_X2	6.250 Gps	2
	Bayer 8/10/12/RGB	CXP6_X1	6.250 Gps	1
	Bayer 8/10/12/RGB	CXP3_X2	3.125 Gps	2
	Bayer 8/10/12/RGB	CXP3_X1	3.125 Gps	1

For the details of the specifications, please refer to “JIIA-NTF-001-2010” published by Japan Industrial Imaging Association, http://www.jiia.org.

5.2 Connectors and pin assignment

5.2.1 Digital Video Output (75Ω 1.0・2.3 DIN Receptacle)

Type: CoaXPress Connector (ACX1785-ND Amphenol Connector or equivalent)

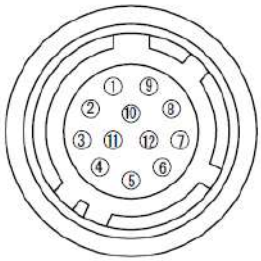
CXP#1	PoCXP compliant
CXP#2	

Maximum Bit Rate per one coax: 6.25 Gbps
Maximum Bit Rate per two coax: 12.5 Gbps

Note: If one coaxial cable is used, CXP#1 must be used.

5.2.2 12-Pin connector

5.2.2.1 Figure



Type: HR-10A-10R-12PB (72) Hirose male or equivalent.

Fig.3 Hirose 12-pin connector

5.2.2.2 Pin configuration

Table – 2 12-pin configuration

Pin no.	Signal	Remarks
1	GND	
2	DC input	+12V ～ +24V (note 3)
3	GND	
4	NC	
5	OPTO IN-	Line 5
6	OPTO IN+	
7	OPTO OUT -	Line 2
8	OPTO OUT+	
9	TTL out 1	Line1 (note 1)
10	TTL In 1	Line4 (note 2)
11	DC input	+12V ～ +24V (note 3)
12	GND	

Note 1) Factory default setting is Exposure Active and negative
Note 2) Factory default setting is trigger input.
Note 3) See page 6 for notes about power options for these cameras

Note: If power is supplied from both the 12-pin connector and CoaXPress, the power from the 12-pin is active. If power from the 12-pin is interrupted, the operation depends on how power was initially connected. Please refer to the following:

The order of power supply connections	If the power supply from 12-pin is interrupted
First 12-pin, then CoaXPress	The power is supplied from CoaXPress
First CoaXPress, then 12-pin	The power is supplied from CoaXPress but the camera is not restarted.

5.2.3 AUX Connector Hirose 10-Pin connector

Type: HIROSE 10-Pin Connector 3260-10S3 (55)

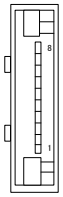


Fig. 4 Hirose 10p connector

Table-3 Pin configuration for Hirose 10P

No	I/O	Name	Note
1	O	TTL OUT2	Line8
2	O	TTL OUT3	Line9
3	I	TTL IN2	Line10
4		NC	
5		GND	
6	I	LVDS IN1+	Line11
7	I	LVDS IN1-	
8		NC	
9		GND	
10		GND	

5.3 Digital In and out interface

In the SP-20000-CXP2, the software control tool can assign the necessary signals used in the system to digital inputs and outputs.

5.3.1 Line Selector

In the Line Selector, the following input and output signals can be assigned.

Table – 4 Line Selectors

Line Selector item	Description
Line 1 TTL OUT 1	TTL output from #9 pin of DC In/Trigger HIROSE 12-Pin on the rear
Line 2 OPTO OUT 1	Optical output from #7 and 8 pins of DC In/Trigger HIROSE 12-Pin on the rear
Line 8 TTL OUT 2	TTL output from #1 pin “AUX” HIROSE 10-Pin on the rear
Line 10 TTL OUT 3 t	TTL output from #2 pin “AUX” HIROSE 10-Pin on the rear
NAND 0 In 1	First input at first NAND gate in GPIO
NAND 0 In 2	Second input at first NAND gate in GPIO
NAND 1 In 1	First input at second NAND gate in GPIO
NAND 1 in 2	Second input at second NAND gate in GPIO
Note: In the line source, input interfaces besides those mentioned above will be shown but the line source setting is not available. The input interface can be configured in the trigger source and the pulse generator source.	

5.3.2 Line Source

Line source signal can be selected from the following table to connect it to the line item which is selected in the line selector.

Table-5 Line Source

Line Source item	Description
Low	Connect Low Level signal to line item selected in Line Selector, **Default setting**
High	Connect High Level signal to line item selected in Line Selector
Acquisition Trigger Wait	Connect Acquisition Trigger Wait signal to line item selected in Line Selector
Acquisition Active	Connect Acquisition Active signal to line item selected in Line Selector
Frame Trigger Wait	Connect Frame Trigger Wait signal to line item selected in Line Selector
Frame Active	Connect Frame Active signal to line item selected in Line Selector
Exposure Active	Connect Exposure Active signal to line item selected in Line Selector
FVAL	Connect FVAL signal to line item selected in Line Selector
LVAL	Connect LVAL signal to line item selected in Line Selector
PulseGenerator0 Out	Connect Pulse Generator 0 signal to line item selected in Line Selector
PulseGenerator1 Out	Connect Pulse Generator 1 signal to line item selected in Line Selector
PulseGenerator2 Out	Connect Pulse Generator 2 signal to line item selected in Line Selector
PulseGenerator3 Out	Connect Pulse Generator 3 signal to line item selected in Line Selector
Line 7 - CXP IN (Trigger Packet)	Connect CXP IN signal to line item selected in Line Selector
Line 4 – TTL IN 1	Connect TTL IN 1 signal to line item selected in Line Selector
Line 5 – OPTO IN 1	Connect OPTO IN 1 signal to line item selected in Line Selector
User output 0	Connect User output 0 signal to line item selected in Line Selector
User output 1	Connect User output 1 signal to line item selected in Line Selector
User output 2	Connect User output 2 signal to line item selected in Line Selector
User output 3	Connect User output 3 signal to line item selected in Line Selector
Nand0 Out	Connect NAND 0 signal to line item selected in Line Selector
Nand1 Out	Connect NAND 1 signal to line item selected in Line Selector
Line 10 TTL IN 2	Connect TTL IN 2 signal to Line 10
Line 11 LVDS IN	Connect LVDS IN signal to Line 11

Note: (1) The user output is the trigger signal generated by software in PC for the camera.
(2) As for LVAL, some line items cannot be connected. Refer to “5.3.6.2 GPIO matrix table”

5.3.3 Line Mode

Indicates the status of the item selected in Line Selector. (INPUT or OUTPUT)

Table – 6 Associated GenICam register information

GenICam Name	Access	Values	Category
Line Selector	R/W	Line1,2,4,5,7～11 NAND 0 In1 to 2 NAND 1 In1 to 2	Digital I/O Control
Line Mode	RO	Output Input	Digital I/O Control
Line Inverter	R/W	False True	Digital I/O Control
Line Status	RO	False True	Digital I/O Control
Line Source	R/W	Low High Acquisition Trigger Wait Acquisition Active Frame Trigger Wait Frame Active Exposure Active FVAL PG0 to 3 User out0 to 3 TTL In1 Opt In CXP In (Trigger Packet) Nand0 to 1 TTL In2 LVDS In1	Digital I/O Control
Line Format	RO	TTL LVDS Opto CXP	Digital I/O Control

5.3.4 Line Inverter

Inverts the signal polarity for the item selected in Line Selector. False=Positive, True=Negative）

5.3.5 Line Status

Indicates the status of the selected signal (input or output) （True=High, False=Low）

5.3.6 Line Format

Indicates the interface category of input and output for the selected signal.

Category: No connect, TTL, LVDS and OPTO coupled

5.3.7 GPIO

GPIO is a general interface for input and output and controls the I/O for trigger signals and other valid signals and pulse generators. By using this interface you can control an external light source, make a delay function for an external trigger signal, or make a precise exposure setting together with a PWC trigger.

5.3.7.1 Basic block diagram

The basic block diagram is as follows.
In the SP-20000-CXP2, the pixel clock is fixed at 40 MHz, even though the sensor clock is selectable in Link Configuration setting.

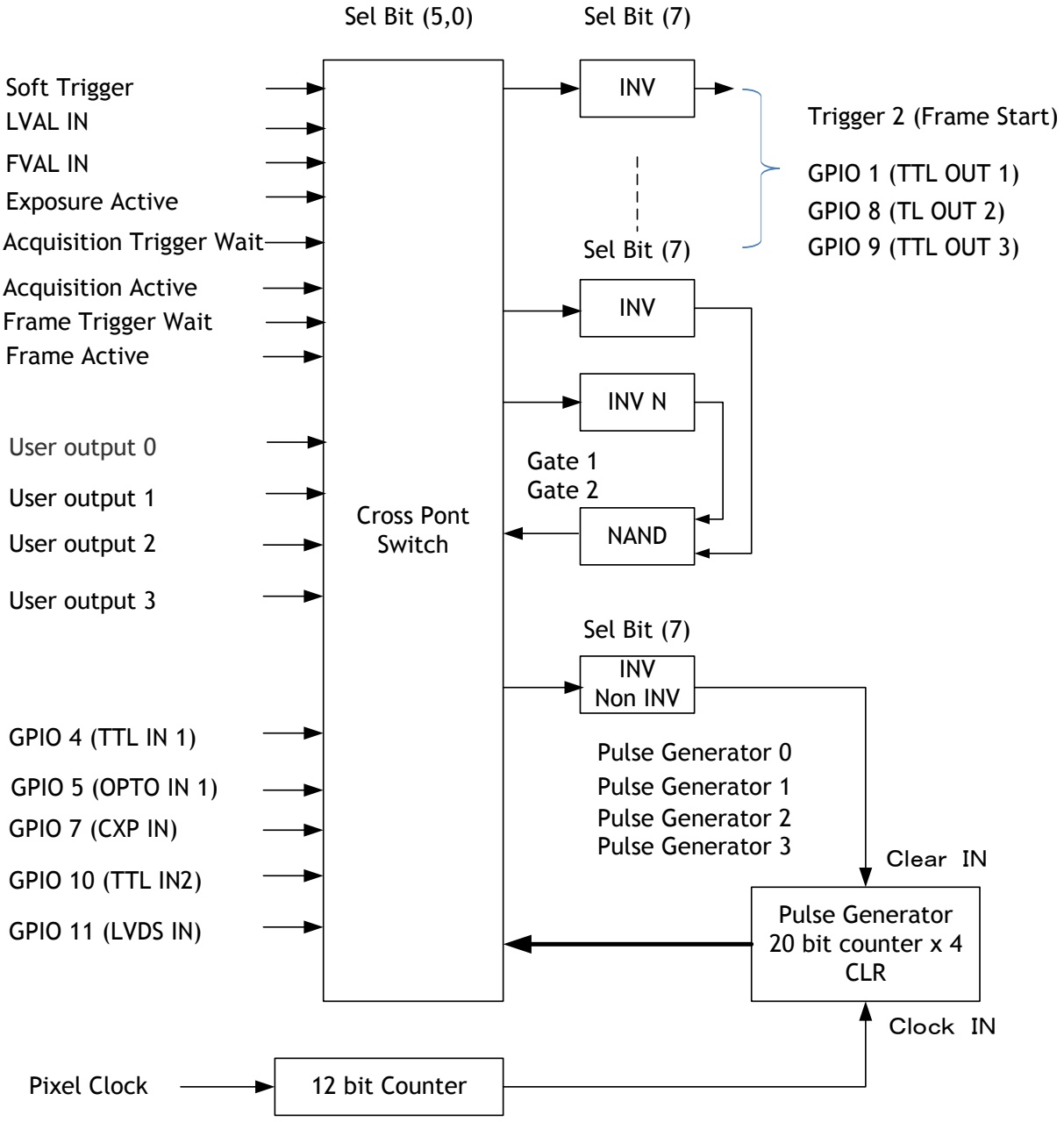


Fig.5 GPIO interface

5.3.7.2 Input and output matrix table

The relation between input and output is as follows.

Table - 7 GPIO matrix table

Selector (Cross point switch output) / Source signal (Cross point switch input)	Trigger Selector			Line Selector								Pulse Generator Selector			
	Frame Start	Acquisition Start	Acquisition End	Line 1 - TTL OUT 1	Line 2 OPTO OUT 1	Line 8 - TTL OUT 2	Line 9 - TTL OUT 3	NAND 1 In 1	NAND 1 In 2	NAND 2 In 1	NAND 2 In 2	Pulse Generator 0	Pulse Generator 1	Pulse Generator 2	Pulse Generator 3
Low	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
High	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Soft Trigger	O	O	O	×	×	×	×	×	×	×	×	×	×	×	×
Acqusition Trigger Wait	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
Acqusition Active	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
Exposure Active	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
Frame Trigger Wait	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
Frame Active	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
FVAL	×	×	×	O	O	O	O	O	O	O	O	O	O	O	O
LVAL	×	×	×	×	×	×	×	×	×	×	×	O	O	O	O
Pulse Generator 0	O	O	O	O	O	O	O	O	O	O	O	×	O	O	O
Pulse Generator 1	O	O	O	O	O	O	O	O	O	O	O	O	×	O	O
Pulse Generator 2	O	O	O	O	O	O	O	O	O	O	O	O	O	×	O
Pulse Generator 3	O	O	O	O	O	O	O	O	O	O	O	O	O	O	×
Line 4 - TTL In1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Line 5 - OPTO IN 1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Line 7 - CXP IN Trigger Packet	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
NAND 0 Out	O	O	O	O	O	O	O	×	×	O	O	O	O	O	O
NAND 1 Out 1	O	O	O	O	O	O	O	O	O	×	×	O	O	O	O
User Output 0	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
User Output 1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
User Output 2	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
User Output 3	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Line 10 - TTL IN 2	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Line 11 - LVDS IN	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
	Trigger Source			Line Source								Pulse Generator Clear Source			

5.4 Optical Interface

SP-20000-CXP2 is equipped with 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.
The following drawing is the concept of photo coupler

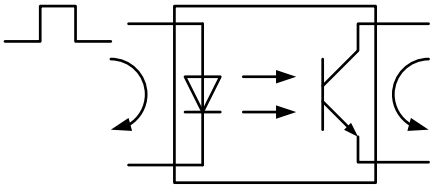


Fig.6 Photo coupler

5.4.1 Recommended External Input circuit diagram for customer

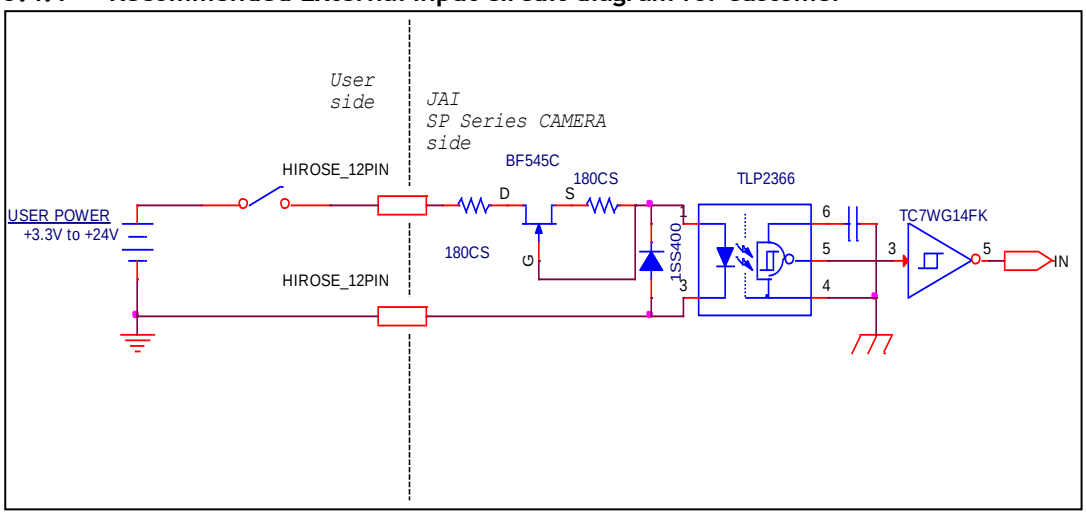


Fig.7 Example of external input circuit

5.4.2 Recommended External Output circuit diagram for customer

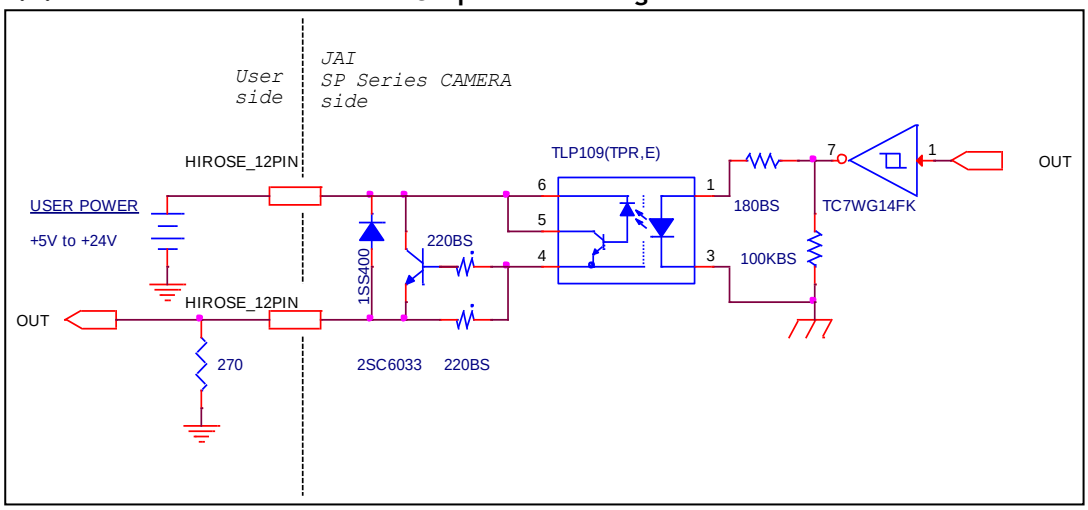
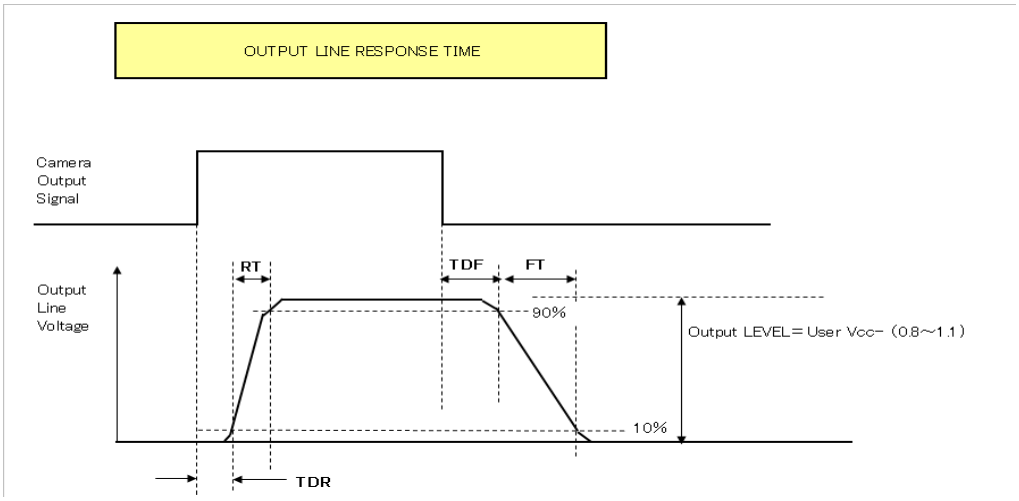


Fig.8 Example of external output circuit

5.4.3 Characteristics of optical interface

The relationship of the input signal to the output signal through the optical interface is as follows.



270Ω	User Power (VCC)			
	3.3V	5V	12V	24V
Time Delay Rise TDR (us)	0.54	0.54	0.62	0.68
Rise Time RT (us)	1.2	1.2	2	3
Time Delay Fall TDF (us)	1.5	1.5	2.4	2.1
Fall Time FT (us)	3.6	3.4	4.5	6.8

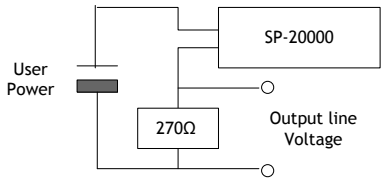


Fig.9 Optical interface characteristics

5.5 Pulse Generator

The SP-20000-CXP2 has a frequency divider using the sensor clock as the basic clock and four pulse generators. In each Pulse Generator, various Clear settings are connected to GPIO.
The following shows Pulse Generator default settings.

Table - 8 Pulse Generator default settings

Display Name	Value							
Clock Pre-scalar	1							
	Pulse Generator							
Pulse Generator Selector	Length	Start Point	End Point	Repeat Count	Clear Source	Clear Inverter	Clear Activation	Clear Sync Mode
- Pulse Generator 0	1	0	1	0	Off	True	Off	Async Mode
- Pulse Generator 1	1	0	1	0	Off	True	Off	Async Mode
- Pulse Generator 2	1	0	1	0	Off	True	Off	Async Mode
- Pulse Generator 3	1	0	1	0	Off	True	Off	Async Mode

Note: When Pulse Generator Repeat Count is set to "0", the camera is operating in free-running mode.
However, based on the above default settings, Length=1, Start Point=0 and End Point=1, Pulse Generator stops at High output. Therefore, if Start Point =0 and End Point=1 are configured, Length should be "2" as the minimum active width.

5.5.1 Clock Pre-scaler

Clock pre-scaler (Divide Value) can set the dividing value of the frequency divider (12-bit length) and the sensor clock are used for this. Four built-in pulse generators work by the same clock. In the SP-20000-PMCL, the sensor pixel clock is 40 MHz .

5.5.2 Pulse Generator Selector

This is where you select one of the 4 pulse generators in order to set or modify its parameters.

Table - 9 Pulse Generator setting

Trigger Selector item	Description
Pulse Generator 0	If Pulse Generator 0 is selected, Length, Start Point, End Point, Repeat Count, Clear Source, Clear Inverter, Clear Activation and Clear Sync Mode of Pulse Generator 0 are displayed under the selector.
Pulse Generator 1	If Pulse Generator 1 is selected, Length, Start Point, End Point, Repeat Count, Clear Source, Clear Inverter, Clear Activation and Clear Sync Mode of Pulse Generator 1 are displayed under the selector.
Pulse Generator 2	If Pulse Generator 2 is selected, Length, Start Point, End Point, Repeat Count, Clear Source, Clear Inverter, Clear Activation and Clear Sync Mode of Pulse Generator 2 are displayed under the selector.
Pulse Generator 3	If Pulse Generator 3 is selected, Length, Start Point, End Point, Repeat Count, Clear Source, Clear Inverter, Clear Activation and Clear Sync Mode of Pulse Generator 3 are displayed under the selector.

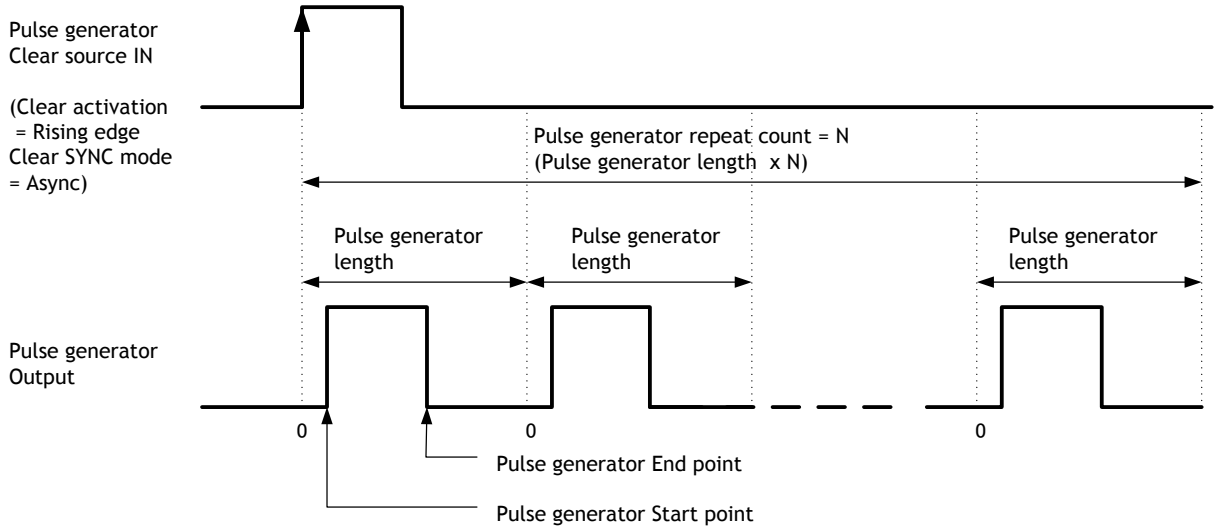


Fig.10 Pulse Generator pulse construction

5.5.3 Pulse Generator Length

Set the counter up value (number of clocks, refer to Table 12) for the selected pulse generator. If Repeat Count value is “0”, and if Pulse Generator Clear signal is not input, the pulse generator generates the pulse repeatedly until reaching this counter up value.

5.5.4 Pulse Generator Start Point

Set the active output start count value for the selected pulse generator.
However, please note that a maximum 1 clock jitter for the clock which is divided in the clock pre-scaler can occur.

5.5.5 Pulse Generator End Point

Set the active output ending count value for the selected pulse generator.

5.5.6 Pulse Generator Repeat Count

Set the repeating number of the pulse for the selected pulse generator. After Trigger Clear signal is input, the pulse generator starts the count set in Repeat Count. Accordingly, an active pulse which has a start point and end point can be output repeatedly.
However, if Repeat Count is set to “0”, it works as free-running counter.

5.5.7 Pulse Generator Clear Activation

Set the clear conditions of clear count pulse for the selected pulse generator.

5.5.8 Pulse Generator Clear Sync Mode

Set the count clear method for the selected pulse generator.
In case of Async Mode, if the clear signal is input during the length setting value, the counter will stop counting according to the clear signal input.
In case of Sync Mode, if the clear signal is input during the length setting value, the counter will continue to count until the end of the length setting value and then clear the count.
Both modes clear the repeat count when the counter is cleared.

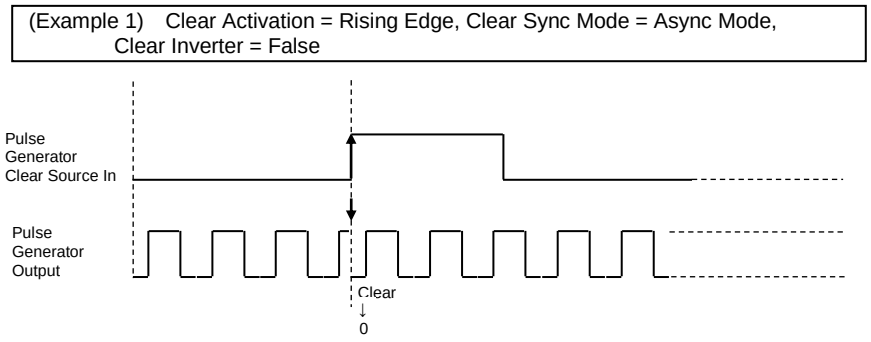


Fig.11 Counter clear in Async mode

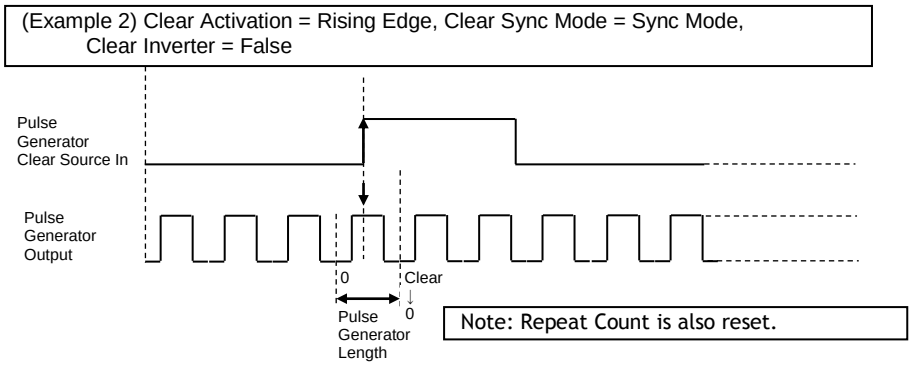


Fig.12 Counter clear in Sync mode

5.5.9 Pulse Generator Clear Source

The following clear source can be selected as the pulse generator clear signal.

Table - 10 Pulse generator clear source

Pulse Generator Clear Source item	Description
Low	Connect Low level signal to Clear Source for the selected pulse generator. **Default setting**
High	Connect High level signal to Clear Source for the selected pulse generator.
Acquisition Trigger Wait	Connect Acquisition Trigger Wait signal to Clear Source for the selected pulse generator.
Acquisition Active	Connect Acquisition Active signal to Clear Source for the selected pulse generator.
Frame Trigger Wait	Connect Frame Trigger Wait signal to Clear Source for the selected pulse generator.
Frame Active	Connect Frame Active signal to Clear Source for the selected pulse generator.
Exposure Active	Connect Exposure Active signal to Clear Source for the selected pulse generator.
FVAL	Connect FVAL signal to Clear Source for the selected pulse generator.
LVAL	Connect LVAL signal to Clear Source for the selected pulse generator.
PulseGenerator0 Out	Connect Pulse Generator 0 output to Clear Source for the selected pulse generator.
PulseGenerator1 Out	Connect Pulse Generator 1 output to Clear Source for the selected pulse generator.
PulseGenerator2 Out	Connect Pulse Generator 2 output to Clear Source for the selected pulse generator.
PulseGenerator3 Out	Connect Pulse Generator 3 output to Clear Source for the selected pulse generator.
Line 7 – CXP IN (Trigger Packet)	Connect CXP IN signal to Clear Source for the selected pulse generator.
Line 4 - TTL IN 1	Connect TTL IN 1 signal to Clear Source for the selected pulse generator.
Line 5 – OPTO IN1	Connect OPTO IN 1 signal to Clear Source for the selected pulse generator.
Nand0 Out	Connect NAND 0 output signal to Clear Source for the selected pulse generator.
Nand1 Out	Connect NAND 1 output signal to Clear Source for the selected pulse generator.
User Output 0	Connect User Output 0 signal to Clear Source for the selected pulse generator.
User Output 1	Connect User Output 1 signal to Clear Source for the selected pulse generator.
User Output 2	Connect User Output 2 signal to Clear Source for the selected pulse generator.
User Output 3	Connect User Output 3 signal to Clear Source for the selected pulse generator.
Line 10 TTL IN 2	Connect TTL 2 IN signal to LINE 10.
Line 11 LVDS IN	Connect LVDS 1 IN signal to Line 11

Note: The pulse generator output cannot be used as the clear input to the same pulse generator. Refer to “5.4.7.2.GPIO matrix table”.

5.5.10 Pulse Generator Inverter

Clear Source Signal can have polarity inverted.

5.5.11 Pulse Generator setting parameters

Table - 11 Pulse Generator setting parameters

Display Name	Value
Clock Pre-scaler	1 to 4096
Pulse Generator Clock (MHz)	[Pixel Clock: 40 MHz]÷[Clock Pre-scaler]
Pulse Generator Selector	- Pulse Generator 0
	- Pulse Generator 1
	- Pulse Generator 2
	- Pulse Generator 3
- Pulse Generator Length	1 to 1048575
- Pulse Generator Length (ms)	([Clock Source]÷[Clock Pre-scaler]) $^{-1}$ x [Pulse Generator Length]
- Pulse Generator Frequency (Hz)	[Pulse Generator Length (ms)] $^{-1}$
- Pulse Generator Start Point	0 to 1048574
- Pulse Generator Start Point (ms)	([Clock Source]÷[Clock Pre-scaler]) $^{-1}$ x [Pulse Generator Start Point]
- Pulse Generator End Point	1 to 1048575
- Pulse Generator End Point (ms)	([Clock Source]÷[Clock Pre-scaler]) $^{-1}$ x [Pulse Generator End Point]
- Pulse Generator pulse-width (ms)	[Pulse Generator End Point (ms)]－[Pulse Generator Start Point (ms)]
- Pulse Generator Repeat Count	0 to 255
- Pulse Generator Clear Activation Clear Mode for the Pulse Generators	- Off
	- High Level
	- Low level
	- Rising Edge
	- Falling Edge
- Pulse Generator Clear Sync Mode	- Async mode
	- Sync mode
- Pulse Generator Clear Source	- Low
	- High
	- Acquisition Trigger Wait
	- Acquisition Active
	- Frame Trigger Wait
	- Frame Active
	- Exposure Active
	- FVAL
	- LVAL
	- PulseGenerator0
	- PulseGenerator1
	- PulseGenerator2
	- PulseGenerator3
	- Line 7 – CXP IN (Trigger Packet)
	- Line 4 – TTL IN 1
	- Line 5 – OPTO IN 1
	- Nand0 Out
	- Nand1 Out
	- User Output 0
	- User Output 1
	- User Output 2
	- User Output 3
	- Line 10 - TTL 2 In
	- Line 11 - LVDS 1 In
- Pulse Generator Inverter(Polarity) Pulse Generator Clear Inverter	- False
	- True

Note: 1. If Pulse Generator Repeat Count is set to “0”, the pulse generator works in free-running mode.
2. The output of the same pulse generator cannot be connected to Clear input.

5.5.12 Associated GenICam register information

Table – 12 Associated GenICam register information

GenICam Name	Access	Values	Category
Pre-scaler	R/W	1 to 4096	Pulse Generators
Pulse Generator Selector	R/W	PG0 to PG3	Pulse Generators
Pulse Generator Length	R/W	0 to 1048575	Pulse Generators
Pulse Generator Start Point	R/W	0 to 1048575	Pulse Generators
Pulse Generator End Point	R/W	0 to 1048575	Pulse Generators
Pulse Generator Repeat Count	R/W	0 to 255	Pulse Generators
Pulse Generator Clear Activation	R/W	Free Run High Level Low Level Rising Edge Falling Edge	Pulse Generators
Pulse Generator Clear Source	R/W	Low High Soft Acquisition Trigger Wait Acquisition Active Frame Trigger Wait Frame Active Exposure Active FVAL PG0 to 3 User out0 to 3 TTL in Opto1 in CXP in (Trigger Packet) Nand0 to 1	Pulse Generators
Pulse Generator Invertor	R/W	True False	Pulse Generators
Pulse Generator Sync Mode	R/W	Async Mode Sync Mode	Pulse Generators

6. Sensor layout, output format and timing

6.1 Sensor layout

The CMOS sensors used in the SP-20000-CXP2 have the following pixel layout.

6.1.1 Monochrome sensor

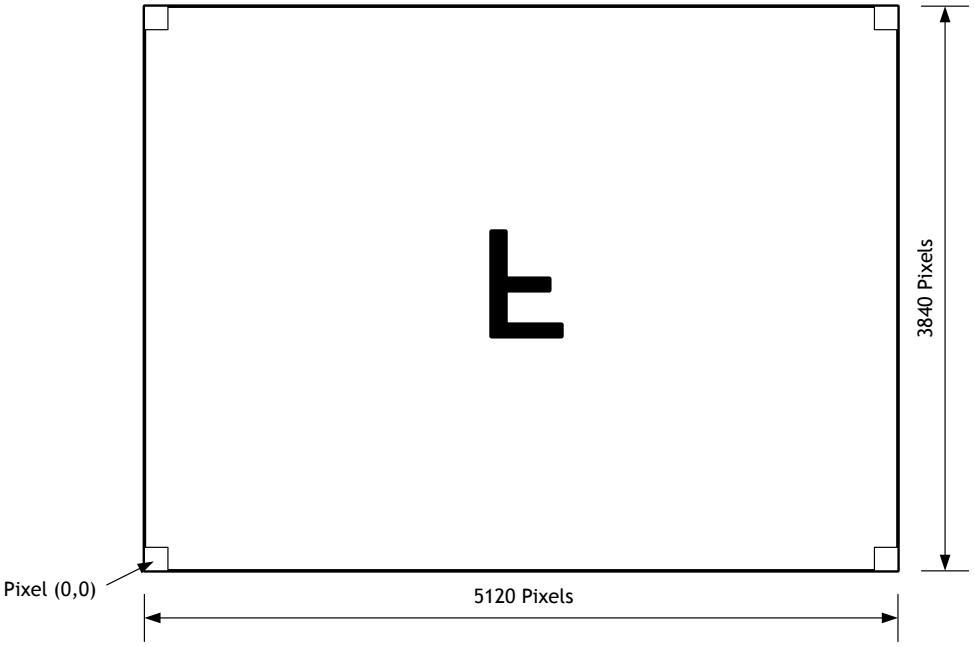


Fig. 13 Monochrome sensor layout

6.1.2 Bayer sensor

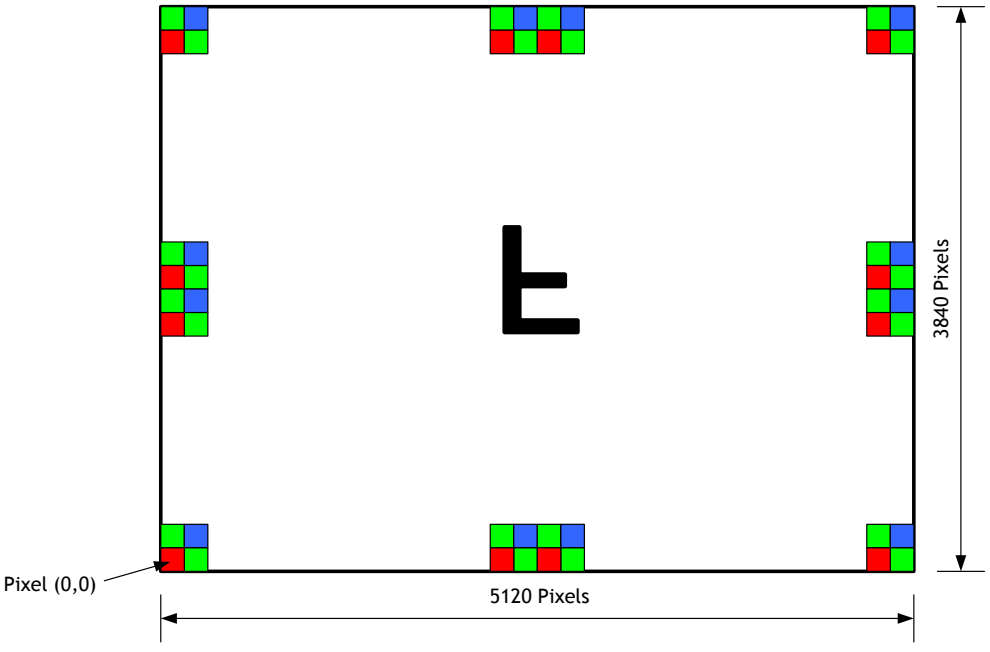


Fig. 14 Color sensor layout

6.2 Camera output format (Tap Geometry)

Table - 13 Output format

Camera output format	Pixel format	Refer to drawing
1X-1Y	8-bit, 10-bit, 12-bit, RGB 8-bit	6.2.1

Note: The camera output description is based on GenICam SFNC Ver.1.5.1.

6.2.1 1X-1Y

1X-1Y is 1-tap readout system specified in GenICam Tap Geometry and it outputs as the following.

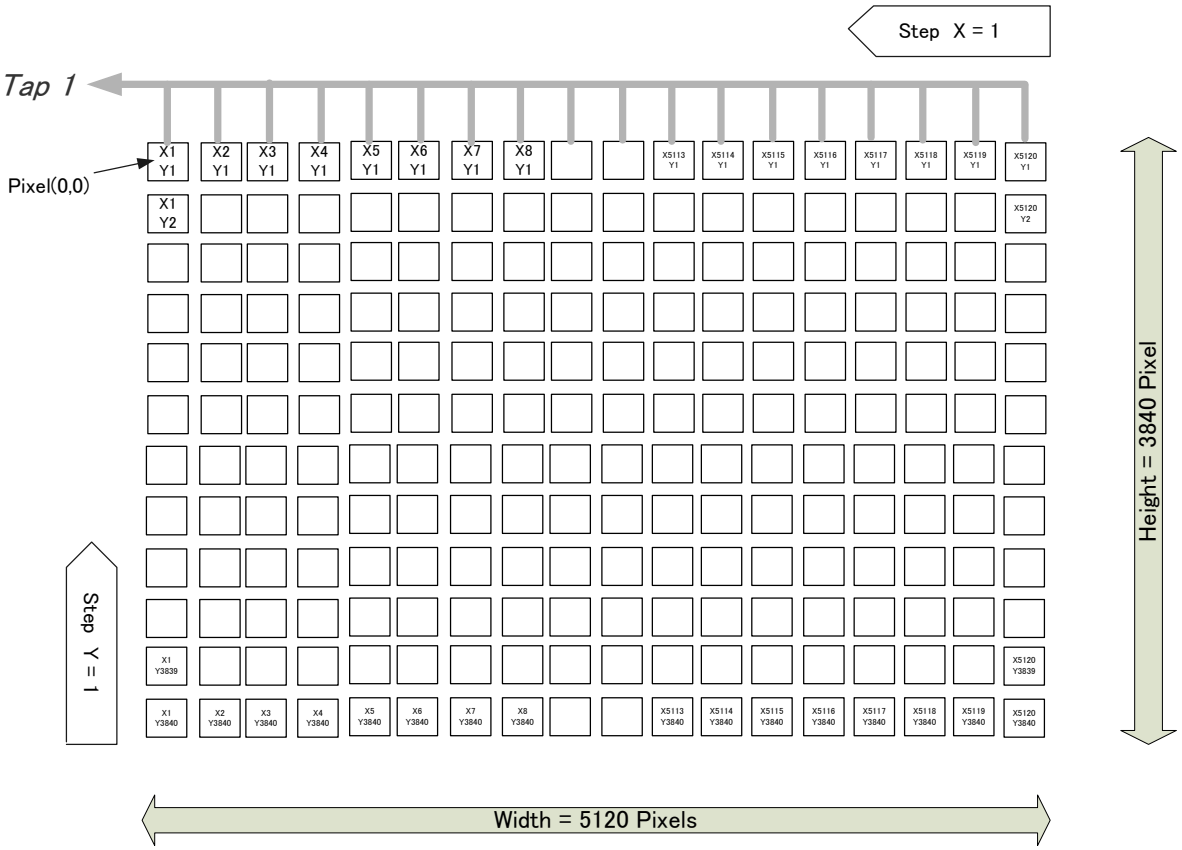


Fig. 15 1X-1Y output system

6.3 Output timing and output image

6.3.1 Horizontal timing

The horizontal frequency depends on the link configuration. The following chart and tables explains the details.
In the SP-20000M-CXP2, the horizontal frequency does not change when horizontal binning is effective, and therefore, the frame rate is not increased.

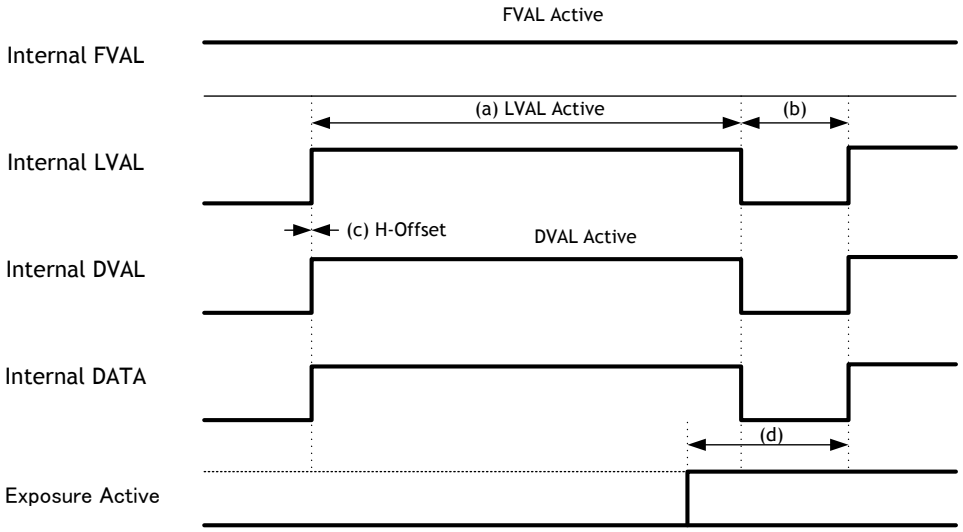


Fig.16 Horizontal timing

Table – 14 Horizontal formats in continuous trigger (1/2)

Camera Settings								(a)	(b)	(c)	(d)	Step (Typ.)
Link Configuration	Tap Geometry	ROI				Binning		LVAL Active	LVAL Non-Active	H-Offset	Exposure Active Start to LVAL Active Start	
		Width	Offset X	Height	Offset Y	Horizontal	Vertical	[Unit: Clock]	[Unit: Clock]	[Unit: Clock]	[Unit: us]	LSB
CXP6 _X2	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	320	0.5	0	0.512	8
		5120	0	1920	0	1 (Off)	2 (On)	320	321	0	0.512 or 8.523	8
		2560	0	3840	0	2 (On)	1 (Off)	160	160.5	0	0.512	8
		2560	0	1920	0	2 (On)	2 (On)	160	481	0	0.512 or 8.523	8
CXP6 _X1 or CXP3 _X2	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	640	1	0	7.815	16
		5120	0	1920	0	1 (Off)	2 (On)	640	642	0	7.815 or 23.838	16
		2560	0	3840	0	2 (On)	1 (Off)	320	321	0	7.815	16
		2560	0	1920	0	2 (On)	2 (On)	320	962	0	7.815 or 23.838	16
CXP3 _X1	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	640	1	0	15.630	16
		5120	0	1920	0	1 (Off)	2 (On)	640	642	0	15.630 or 47.676	16
		2560	0	3840	0	2 (On)	1 (Off)	320	321	0	15.630	16
		2560	0	1920	0	2 (On)	2 (On)	320	962	0	15.630 or 47.676	16

Note: (1) The horizontal frequency is not doubled if horizontal binning is ON.
(2) If vertical binning is ON, the horizontal frequency becomes half.
(3) H-Offset: The period from the LVAL Active start to DATA Active start
(4) If the next frame is exposed while the image is read out in the vertical binning mode, the exposure control is controlled by 0.5 line.
(5) "(d) Exposure Active Start to LVAL Active Start "has 1 clock difference due to the jitter in LVAL Non Active period.

Table – 15 Horizontal formats in continuous trigger (2/2)

Camera Settings								1Line Total Clock [Unit: Clock]	Horizontal Frequency [Unit: kHz]	Horizontal Period [Unit: us]
Link Configuration	Tap Geometry	ROI				Binning				
		Width	Offset X	Height	Offset Y	Horizontal	Vertical			
CXP6_X2	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	320.5	124.805	8.013
		5120	0	1920	0	1 (Off)	2 (On)	641	62.402	16.025
		2560	0	3840	0	2 (On)	1 (Off)	320.5	124.805	8.013
		2560	0	1920	0	2 (On)	2 (On)	641	62.402	16.025
CXP6_X1 or CXP3_X2	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	641	62.402	16.025
		5120	0	1920	0	1 (Off)	2 (On)	1282	31.201	32.050
		2560	0	3840	0	2 (On)	1 (Off)	641	62.402	16.025
		2560	0	1920	0	2 (On)	2 (On)	1282	31.201	32.050
CXP3_X1	1X_1Y	5120	0	3840	0	1 (Off)	1 (Off)	641.	31.201	32.050
		5120	0	1920	0	1 (Off)	2 (On)	1282	15.601	64.100
		2560	0	3840	0	2 (On)	1 (Off)	641	31.201	32.050
		2560	0	1920	0	2 (On)	2 (On)	1282	15.601	64.100

6.3.2 Vertical timing

In Continuous Trigger operation, the output timing relation is as follows.
The SP-20000M-CXP2 supports H-Binning and V-Binning functions, but the frame rate is not increased.

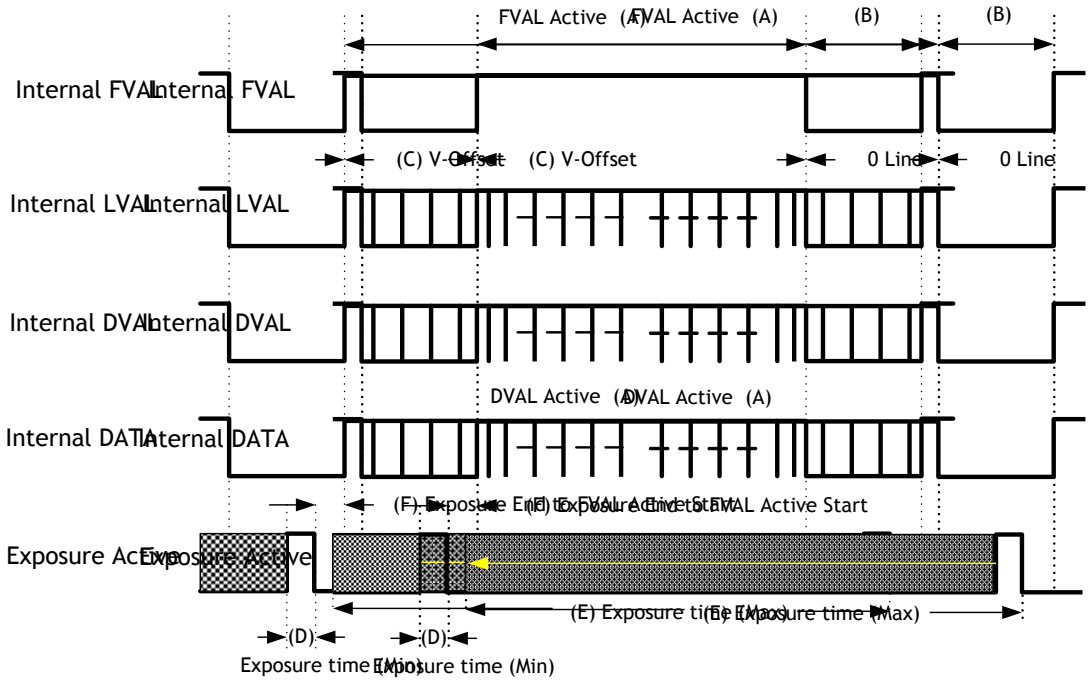


Fig. 17 Vertical timing relation

Table – 16 Vertical formats in Continuous Trigger (1/2)

Camera Settings										(A)	(B)	(C)	(D)
Link Configuration	Tap Geometry	Acquisition Frame Rate	ROI				Binning 1:OFF, 2:ON			FVAL Active [Unit: Line]	FVAL Non -Active [Unit: Line]	V -Offset [Unit: Line]	Exposure Time (Min) [Unit: us]
			Width	Offset X	Height	Offset Y	Horizontal	Vertical					
CXP6 _X2	1X_1Y	30.0	5120	0	3840	0	1	1		3840	321.1	0	10.0
			5120	0	1920	0	1	2		1920	160.6		
			2560	0	3840	0	2	1		3840	321.1		
			2560	0	1920	0	2	2		1920	160.6		
CXP6 _X1 or CXP3 _X2	1X_1Y	15.0	5120	0	3840	0	1	1		3840	320.6	0	10.0
			5120	0	1920	0	1	2		1920	160.3		
			2560	0	3840	0	2	1		3840	320.6		
			2560	0	1920	0	2	2		1920	160.3		
CXP3 _X1	1X_1Y	7.5	5120	0	3840	0	1	1		3840	320.6	0	10.0
			5120	0	1920	0	1	2		1920	160.3		
			2560	0	3840	0	2	1		3840	320.6		
			2560	0	1920	0	2	2		1920	160.3		

Table – 17 Vertical formats in Continuous Trigger (2/2)

Camera Settings									Frame Rate	(E) Exposure Time (Max.)	(F) Exposure End to FVAL Active Start	
Link Configuration	Tap Geometry	Acquisition Frame Rate	ROI				Binning 1:OFF, 2:ON					
			Width	Offset X	Height	Offset Y	Horizontal	Vertical	[Unit: Hz]	[Unit: us]	[Unit: Line]	[Unit: us]
CXP6 _X2	1X_1Y	30.0	5120	0	3840	0	1	1	30.000	[Acquisition Frame Rate Raw] - 250us = 33333-250 =33083	38.1	305.225
			5120	0	1920	0	1	2			19.0	305.225
			2560	0	3840	0	2	1			38.1	305.225
			2560	0	1920	0	2	2			19.0	305.225
CXP6 _X1 or CXP3 _X2	1X_1Y	15.0	5120	0	3840	0	1	1	15.000	ROUNDDOWN([Acquisition Frame Rate Raw] - 250us = 66667-250 =66417	19.0	305.225
			5120	0	1920	0	1	2			9.5	305.225
			2560	0	3840	0	2	1			19.0	305.225
			2560	0	1920	0	2	2			9.5	305.225
CXP3 _X1	1X_1Y	7.5	5120	0	3840	0	1	1	7.500	[Acquisition Frame Rate Raw] - 500us = 133333-500 =132833	19.0	610.424
			5120	0	1920	0	1	2			9.5	610.424
			2560	0	3840	0	2	1			19.0	610.424
			2560	0	1920	0	2	2			9.5	610.424

Note: (1) In the SP-20000-CXP2, the frame rate control is done in steps of 1 µs unit. Therefore, FVAL Non Active conversion has tolerance.
(2) Even if the horizontal binning is ON, the horizontal frequency is not doubled. Therefore, the vertical frequency is not increased.
(3) If the vertical binning is ON, the horizontal frequency becomes half. Therefore, if the height is half, the vertical frequency is not doubled.
(4) In the SP-20000-CXP2, the frame rate can be varied in steps of 1 µs. "(B) FVAL NON Active in the table XX will be varied.
(5) V-Offset: The period from FVAL Active Start to 1st LVAL Active Start

6.3.3 ROI (Region of Interest)

In the SP-20000-CXP2, a subset of the image can be output by setting Width, Height, Offset-X, and Offset-Y. If the height is decreased, the number of lines read out is decreased and as the result, the frame rate is increased. However, in the horizontal direction, the horizontal frequency is not changed if the width is decreased. In the SP-20000-CXP2, the minimum width is "8" and minimum height is "2".

Setting example (1)
Binning Horizontal = 1
Binning Vertical = 1
Mirroring = Off

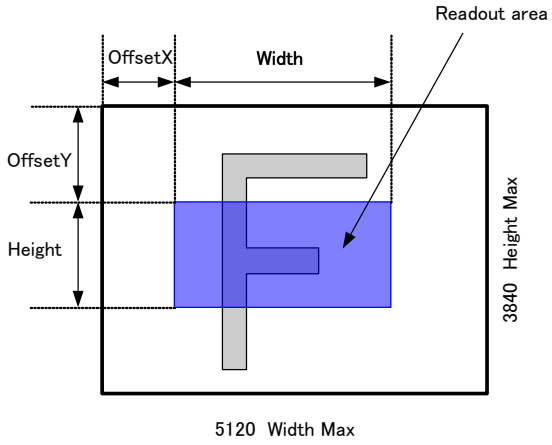
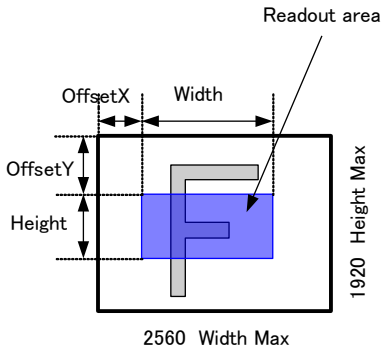


Fig. 18 setting example (No binning)

Setting example (2)
Binning Horizontal = 2
Binning Vertical = 2
Mirroring = Off



Note: Binning is available only for SP-20000M-CXP2.
Binning can be used in horizontal, vertical, or both directions.

Fig.19 Setting example (Binning)

Table – 18 Trigger / ROI setting examples (1/2)

設定参考	Camera Settings						Width Max	Height Max	Max Offset X Value	Width and Offset X Step			Max Offset Y Value	Height Step	Offset Y Step
	ROI				Binning										
	Width	Offset X	Height	Offset Y	Horizontal	Vertical				CXP6_X2	CXP6_X1 or CXP3_X2	CXP3_X2			
Full Line	5120	0	3840	0	1 (Off)	1 (Off)	5120	3840	0	8	8	8	0	2	1
2/3 Screen - Center	3408	856	2560	640	1 (Off)	1 (Off)	5120	3840	1712	8	8	8	1280	2	1
1/2 Screen - Center	2560	1280	1920	960	1 (Off)	1 (Off)	5120	3840	2560	8	8	8	1920	2	1
1/4 Screen - Center	1280	1920	960	1440	1 (Off)	1 (Off)	5120	3840	3840	8	8	8	2880	2	1
1/8 Screen - Center	640	2240	480	1680	1 (Off)	1 (Off)	5120	3840	4480	8	8	8	3360	2	1
Full Line	2560	0	1920	0	2 (On)	2 (On)	2560	1920	0	8	8	8	0	1	1
2/3 Screen - Center	1704	428	1280	320	2 (On)	2 (On)	2560	1920	856	8	8	8	640	1	1
1/2 Screen - Center	1280	640	960	480	2 (On)	2 (On)	2560	1920	1280	8	8	8	960	1	1
1/4 Screen - Center	640	960	480	720	2 (On)	2 (On)	2560	1920	1920	8	8	8	1440	1	1
1/8 Screen - Center	320	1120	240	840	2 (On)	2 (On)	2560	1920	2240	8	8	8	1680	1	1

Note: Setting restrictions
1. [Width Max] = 5120, [Height Max] = 3840 (H and V Binning Off) (If it is On, the value is 1/2)
2. [Max Offset X Value] = [Width Max] - [Width] : Maximum value which Offset X can be set
3. [Max Offset Y Value] = [Height Max] - [Height] : Maximum value which Offset Y can be set
4. [Width and Offset X Step] : The step number which Width and horizontal offset can be shifted
5. [Height and Offset Y Step] : The step number which Height and vertical offset can be shifted 。

6.3.4 Mirroring function

SP-20000-CXP2 has the ability to reverse the image vertically, horizontally, or both vertically and horizontally. If ROI readout is used, ROI image can be read out after the image is reversed.
The following drawings are setting examples of mirror image.

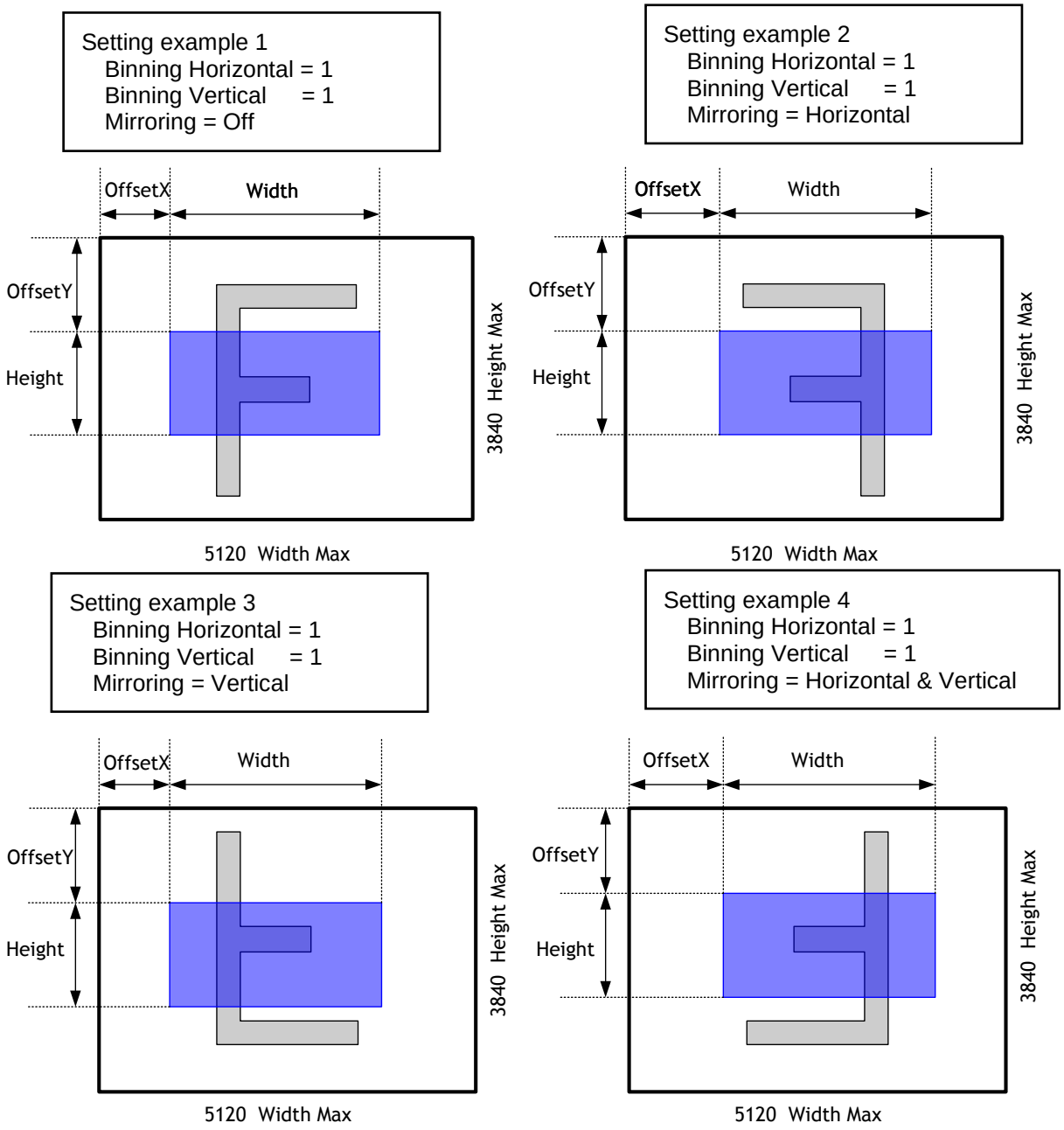


Fig 20 Mirror setting examples

Table – 19 The start pixel and line for SP-20000C-CXP2

	Start Line	Start Pixel
OFF	R & G	R
Horizontal	R & G	G
Vertical	B & G	G
Horizontal & Vertical	B & G	B

6.3.5 Multi ROI function

This function divides one frame image into a maximum of 8 images vertically and reads out all areas in one frame. In this function, width is the same for all 8 images. The multi ROI function is enabled if [Video Sending Mode] is set to “Multi ROI”.

Table – 20 Multi ROI Index table default values

Multi ROI Index Max	1		
Multi ROI Width	5120		
Multi ROI Index Selector	Multi ROI		
	Height	Offset	
		X	Y
- Index 0	1	0	0
- Index 1	1	0	0
- Index 2	1	0	0
- Index 3	1	0	0
- Index 4	1	0	0
- Index 5	1	0	0
- Index 6	1	0	0
- Index 7	1	0	0

6.3.5.1 Multi ROI setting parameters

(1) Multi ROI Index Max : Setting value 0 ~ 7

Maximum 8 ROI settings are possible in a frame. Set Index 1 through 8 in Multi ROI Index table as an application requires.

(2) Multi ROI Width

The setting range and Step number are the same as the normal ROI setting in which [Width] plus [Offset X] should be equal to [Width Max]. In Multi ROI operation, the maximum offset value in index 1 to index 8 is the object in this calculation.

(3) Multi ROI Index Selector :

Index 0 to 7 can be selected. [Height], [Offset X], and [Offset Y] of the selected Multi ROI Index are displayed and can be set.

(4) Multi ROI Offset X :

Offset X can be set for each ROI area of Multi ROI Index 0 to 7.

The restriction for setting Step and other factors are the same as the normal ROI setting. As described before, in Multi ROI operation, Multi ROI Width is a common width setting for Multi ROI Index 0 to 7.

(5) Multi ROI Height :

Height can be set for each ROI area of Multi ROI Index 0 to 7.

The restriction for setting Step and other factors are the same as the normal ROI setting.

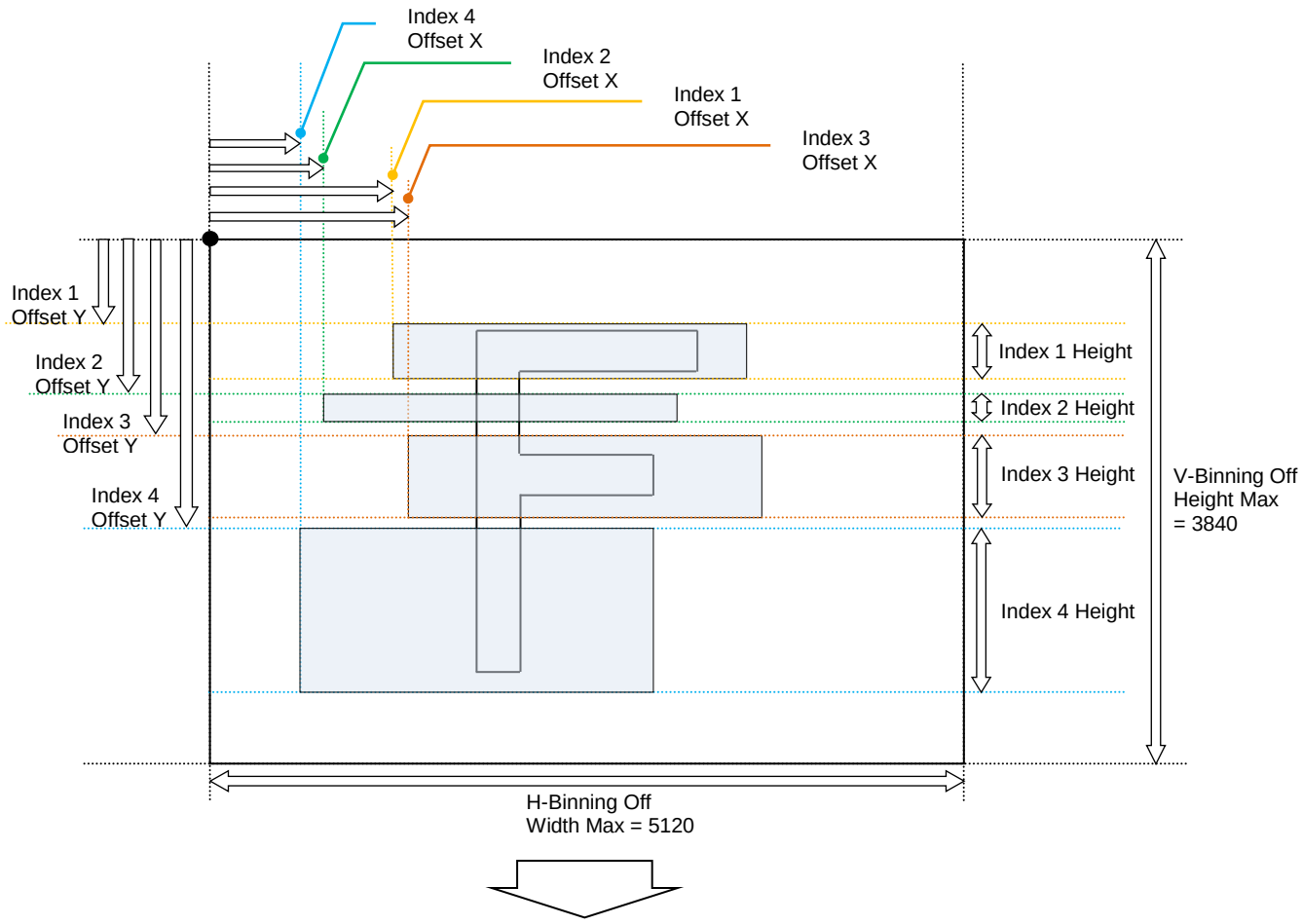
(6) Multi ROI Offset Y :

Offset Y can be set for each ROI area of Multi ROI Index 0 to 7.

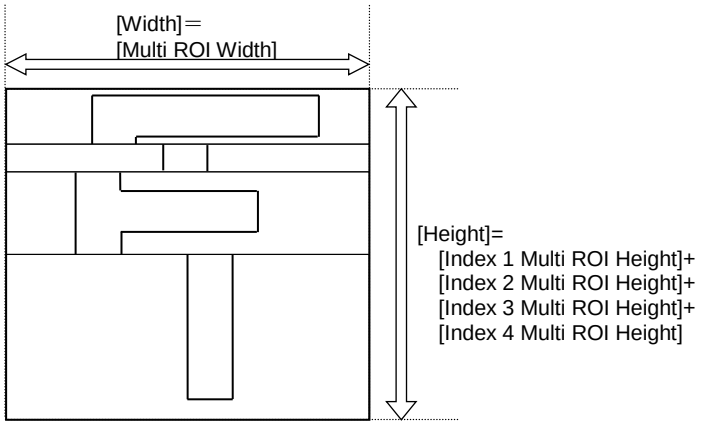
The restriction for setting Step and other factors is the same as the normal ROI setting.

The summary of Multi ROI Height value of index 1 to 8 should be less than Height Max.

ROI setting explanation if Multi ROI Index Max is set to 4



Video output of Multi ROI



Note:
If Multi ROI function is used, the frame grabber board that is used should be set as follows.
Horizontal pixel number is [Multi ROI Width]. Vertical pixel number is the aggregate of [Multi ROI Height] as configured.

Fig. 21 Multi ROI output image

6.3.5.2 Associated GenICam register information

Table – 21 Associated GenICam register information

GenICam Name	Access	Values	Category
Video Send Mode Selector	R/W	Normal Mode Trigger Sequence Command Sequence Multi Mode	JAI-Custom
Multi ROI Index	R/W	Index 0 to Index 7	JAI-Custom
Multi ROI Width	R/W	8 to 5120	JAI-Custom
Multi ROI Offset X	R/W	0 to 5120 – Multi ROI Width	JAI-Custom
Multi ROI Height	R/W	2 to 3840	JAI-Custom
Multi ROI Offset Y	R/W	0 to 3840 – Multi ROI Height	JAI-Custom
Multi ROI Index Max	R/W	1 to 8	JAI-Custom

6.4 Digital output bit allocation

Table – 22 Digital output video level

CCD out		Digital Out		
		8-bit	10-bit	12-bit
Black	0%	8LSB	32LSB	128LSB
Monochrome	100%	222LSB	890LSB	3560LSB
Color				
Monochrome	115%	255LSB	1023LSB	4095LSB
Color				

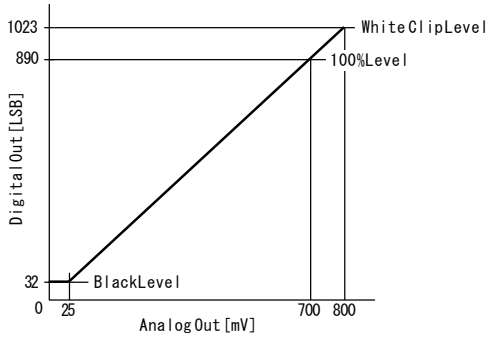


Fig. 22 Bit allocation (10-bit)

7. Operating modes

7.1. Acquisition control (change the frame rate)

7.1.1 Acquisition control

With Trigger OFF and in free-running mode, the default frame rate of the camera is based on the specified ROI. The smaller the ROI, the faster the default frame rate. However, it is possible to specify a free-running frame rate that is slower than the default rate. This can be useful when a longer exposure time is needed for a specific ROI.
Modification of the frame rate is done by entering a value in the AcquisitionFrameRate control corresponding to the frequency to be allocated to each frame period. Allowed values range from the frequency required for the default frame rate to a maximum of 0.125Hz (8 seconds).

The setting range is:

The shortest	to	The longest
Inverse number of time required to drive all pixels in the area set by ROI command or inverse number of time required to transmit one frame data	to	0.125 Hz = 8 seconds

Note:
1. If the trigger is set to ON, this function is not available.
2. The value for setting is the frequency (Hz).
3. The minimum interval of a frame depends on reading out time. If the setting value is less than time required for the minimum period, this setting is ignored and camera automatically operates at the minimum period (frequency).

Self-running (Trigger OFF) works under the following conditions.
Exposure Mode: OFF
Exposure Mode: Timed and Frame start OFF
Exposure mode: Trigger width and Frame start OFF.

7.1.2 The relationship between Link Configuration and Acquisition Frame Rate

Table – 23 The relationship between Link Configuration and Acquisition Frame Rate

Type	Image Size	Tap Geometry	Pixel Format	Link Configuration	Acquisition Frame Rate (Max. Value)
SP-20000M-CXP2	5210(H) x 3840(V)	1X_1Y	Mono 8/10/12	CXP6_X2	30
			Mono 8/10/12	CXP6_X1	15
			Mono 8/10/12	CXP3_X2	15
			Mono 8/10/12	CXP3_X1	7.5
SP-20000C-CXP2	5210(H) x 3840(V)	1X_1Y	BayerRG 8/10/12	CXP6_X2	30
			RGB8		15
			BayerRG 8/10/12	CXP6_X1	15
			RGB8		7.5
			BayerRG 8/10/12	CXP3_X2	15
			RGB8		7.5
			BayerRG 8/10/12	CXP3_X1	7.5

Note: When the link configuration is changed, it will take a maximum of 10 seconds. While changing the link configuration, the camera LED lights in amber and after changed, it will turn to green.

7.1.3 Calculation of frame rate（In Continuous Trigger mode）

Table – 24 Calculation of frame rate

Camera Settings			Acquisiton Frame Rate Minimum Value setting formula [Unit : us]
Link Configuration	Sensor Clock	Binning Vertical	
CXP6_X2	40MHz	1 (Off)	ROUNDDOWN((([Height] x 320.5) + 102600) ÷ 40MHz x 10^6)
		2 (On)	ROUNDDOWN((([Height] x 641) + (102600÷2)) ÷ 40MHz x 10^6)
CXP3_X2 or CXP6_X1	40MHz	1 (Off)	ROUNDDOWN((([Height] x 641) + 205240) ÷ 40MHz x 10^6)
		2 (On)	ROUNDDOWN((([Height] x 1282) + (205240÷2)) ÷ 40MHz x 10^6)
CXP3_X1	20MHz	1 (Off)	ROUNDDOWN((([Height] x 641) + 205220) ÷ 20MHz x 10^6)
		2 (On)	ROUNDDOWN((([Height] x 1282) + (205220÷2)) ÷ 20MHz x 10^6)

Note: (1) As the horizontal frequency is doubled with Binning Vertical ON, even though the height becomes 1/2, the frame rate is not changed.
(2) If Binning Horizontal is set to ON, the horizontal frequency is not changed and therefore, the frame rate is not changed.

7.1.4 Associated GenICam register information

Table - 25 Associated GenICam register information

GenICam Name	Access	Values	Category
Acquisition Frame Rate	R/W	0.125 to 30	Acquisition Control
Acquisition Frame Rate Raw	R/W	33333 to 8000000	Acquisition Control

Note: faster frame rates than described in the above table cannot be set.

7.2. Exposure control

This function sets how to expose the object.

7.2.1 Exposure Mode

The exposure mode can be selected from the following three ways.

Table – 26

Exposure Mode setting	Exposure operation
OFF	No exposure control (free-running operation)
Timed	Exposure operation at the value set in Exposure Time. Setting value is usec unit. ・If Trigger Mode setting is OFF, the camera is in free-running operation. ・If Trigger Mode setting is ON, the exposure operation depends on the setting of Trigger Option.
Trigger Width	The exposure is controlled by the pulse width of the external trigger. ・Trigger Mode is forced to ON.

For trigger operation, Exposure Mode must be set to something other than OFF and Trigger Mode of Frame Start must be ON.
If Exposure Mode is set at Timed, the exposure operation can be selected as follows by setting Trigger Option

Table – 27 Trigger option

Trigger Option setting	Exposure operation
OFF	Timed (EPS) mode
PIV	PIV (Particle Image Velocimetry) mode

The effect of the combination of Exposure Mode, Trigger Option and Trigger Mode is as follows.

Table – 28 The combination of Exposure Mode, Trigger Option and Trigger Mode

Exposure Mode	Trigger Option	Trigger Mode (Frame Start)	Operation
OFF	invalidity	Invalidity	Self-running operation Exposure control by Exposure Time is not possible
Timed	OFF	OFF	Self-running operation Exposure control by Exposure Time is not possible
		ON	Timed (EPS) Operation Exposure can be controlled by Exposure Time
	PIV	Forced to ON	PIV Operation Exposure can be controlled by Exposure Time
Trigger Width	invalidity	Forced to ON	Exposure is controlled by the pulse width of the external trigger

Table – 29 Associated GenICam register information

GenICam Name	Access	Values	Category
Exposure Mode	R/W	Off Timed Trigger Width	Acquisition Control
Trigger Mode	R/W	Off On	Acquisition Control
Trigger Option	R/W	Off PIV	JAI-Custom

7.2.2 Exposure Time

This command is effective only when Exposure Mode is set to Timed. It is for setting exposure time. The setting step for exposure time is 1 μsec per step.

Minimum: 10 μsec (Note: The actual exposure time is 299μ
Maximum: 8 seconds (When Frame Start Trigger Mode is ON)

Note: The actual exposure time is added the values listed in the following table against the setting exposure time due to the sensor characteristics. However, Exposure Active signal is not the actual exposure time, but the setting exposure time.

Link Configuration	Sensor actual exposure time
CXP6_X2 CXP6_X1 CXP3_X2	Exposure Time + 289us
CXP3_X1	Exposure Time + 577us

Note:
In free-running mode with the frame start trigger set to OFF, the maximum setting value of the exposure time is limited by the frame rate setting.
Although 8 seconds is the maximum frame rate setting, the upper limit of the exposure time setting value (for all configurations except CXP3_X1) is 7,999,750 μsec., which is 250 μsec. shorter than the maximum. In the case of CXP_X3, it is 500 μsec. shorter.
In EPS trigger operation, where Exposure Time is not influenced by the frame rate setting, the upper limit is 8 seconds.
However, please note the following:
As a characteristic of the senso used in SP-20000-CXP2, the black level tends to increase depending on the exposure time and the tenmperature of the sensor. SP-20000-CXP2 compensates black shift inside the camera but the following are the maximum ambient temperatures at which camera performance can be guaranteed for 8 secs of exposure time.
SP-20000M-CXP2: Up to 15 ºC of ambient temperature
SP-20000C-CXP2: Up to 5ºC of ambient temperature

Table – 30 Associated GenICam register information

GenICam Name	Access	Values	Category
Exposure Mode	R/W	Off Timed Trigger Width	Acquisition Control
Exposure Time	R/W	10 to 8000000 [us]	Acquisition Control
Exposure Time Raw	R/W	10 to 8000000 [us]	Acquisition Control

7.2.3 Behaviour if Trigger Overlap is set to Readout

In the SP-20000-PMCL, if the accumulation of the next frame starts while the current image is read out, the varied value of accumulation time is changed to 1 Line period inside the camera. This is done so that the accumulation start signal will not affect the output signal while it is overlapped.

However, the shutter noise at the exposure start period will appear on images. It is approximately 70LSB/10-bit as the maximum.

Table – 31 Modes where the exposure control becomes 1L if overlap occurs

JAI Custom Naming	Trigger Mode	Trigger Overlap
Continuous Trigger	Off	(don't care)
EPS Trigger / LVAL SYNC Reset	On	Readout

Table – 32 Formula of the exposure time maximum value at the continuous trigger

Camera Settings			At the continuous trigger operation, [Exposure Time Max] setting formula [Unit : us]
Link Configuration	Sensor Clock	Binning Vertical	
CXP6_X2	40MHz	1 (Off)	= [Acquisition Frame Rate Raw] - 250
		2 (On)	= [Acquisition Frame Rate Raw] - 250
CXP6_X1 or CXP3_X2	40MHz	1 (Off)	= [Acquisition Frame Rate Raw] - 250
		2 (On)	= [Acquisition Frame Rate Raw] - 250
CXP3_X1	20MHz	1 (Off)	= [Acquisition Frame Rate Raw] - 500
		2 (On)	= [Acquisition Frame Rate Raw] - 500
Note: [Acquisition Frame Rate Raw] is the frame interval [Unit: us].			

As an example, the following is for the continuous trigger operation.

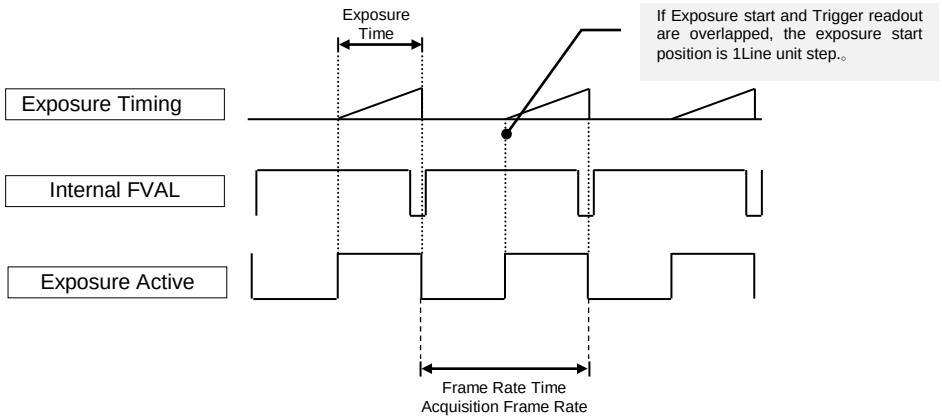


Fig. 23 Behaviour in the continuous trigger operation

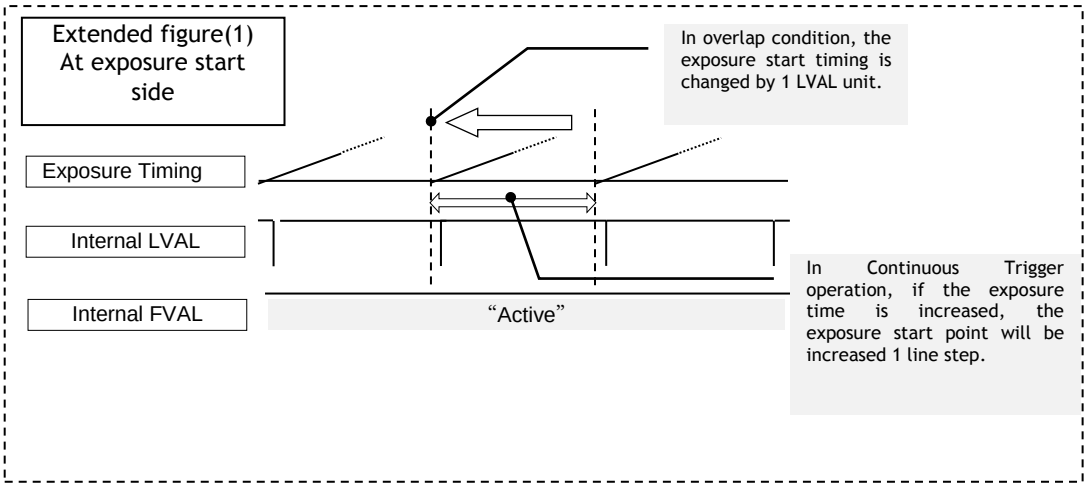


Fig.24 Extended figure at the exposure start side

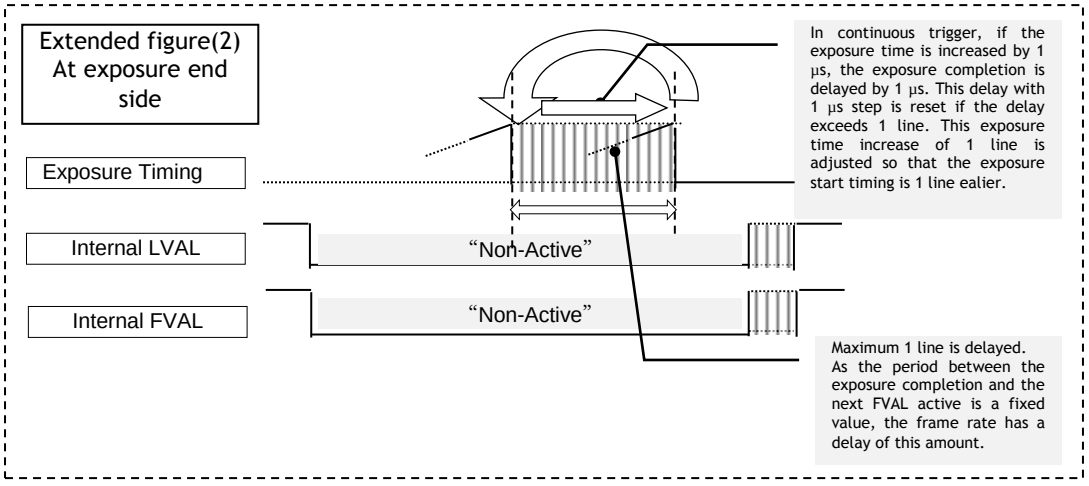


Fig.25 Extended view for the exposure end side

7.2.4 Exposure Auto

This is a function to control the exposure automatically. It is effective only for Timed.
ALC Reference controls the brightness.

There are three modes: OFF, Once and Continuous.

OFF:	No exposure control
Once:	Exposure adjusts when the function is set, then remains at that setting
Continuous:	Exposure continues to be adjusted automatically

In this mode, the following settings are available.

ALC Speed:	Rate of adjustment can be set (common with Gain Auto)
ASC Max:	The maximum value for the exposure time to be controlled can be set
ASC Min:	The minimum value for the exposure time to be controlled can be set
ALC Reference:	The reference level of the exposure control can be set (common with Gain Auto)
ALC Channel area:	The measurement area of the exposure control can be set

Table – 33 Associated GenICam register information

GenICam Name	Access	Values	Category
Exposure Auto	R/W	Off Continuous Once	Acquisition Control
Exposure Auto Max	R/W	100 to 8000000	JAI-Custom
Exposure Auto Min	R/W	100 to 8000000	JAI-Custom

7.3. Trigger operation

Trigger Source can be selected in Trigger Selector.
In the SP-20000-CXP2, the trigger source can be selected from Frame Start, Acquisition Start and Acquisition End.

Table - 34 Trigger operation settings

Camera Settings				JAI Custom Trigger Mode Name	Description
Trigger Selector	Trigger Mode	Exposure Mode	Trigger Option		
Frame Start	Off	Off	Off	Continuous Trigger	Self-running operation with the maximum exposure time per the frame rate
	Off	Timed	Off	Continuous Trigger	Self-running operation with a user-set exposure time.
	On	Timed	Off	EPS Trigger	Externally triggerred operation with a user-set exposure time
	On	Timed	PIV	PIV Trigger	Externally triggerred operation for PIV
	On	Trigger Width	Off	PWC Trigger	Externally triggerred operation with a pulse width exposure time

7.3.1 Trigger Selector

Selects the trigger operation. In the SP-20000-CXP2, the following trigger operation can be selected as the trigger.

Table – 35 Trigger selector

Trigger Selector Item	Description
Frame Start	Frame Start Trigger operation
Acquisition Start	Acquisition Start Trigger operation
Acquisition End	Acquisition End Trigger operation

7.3.2 Trigger Mode

Select either free-running operation or external trigger operation.

OFF: Free-running operation
ON: External trigger operation

7.3.3 Trigger Source

Select the trigger source to be used for trigger operation from the following table.

Table – 36 Trigger Source

Trigger Source Item	Description
Low	Connect LOW level signal to the selected trigger operation **Default setting**
High	Connect HIGH level signal to the selected trigger operation
Soft Trigger	Connect Soft Trigger signal to the selected trigger operation Trigger can be input manually by the execution of the software trigger Trigger software is available on each trigger source.
PulseGenerator0 Out	Connect Pulse generator 0 signal to the selected trigger operation
PulseGenerator1 Out	Connect Pulse generator 1 signal to the selected trigger operation
PulseGenerator2 Out	Connect Pulse generator 2 signal to the selected trigger operation
PulseGenerator3 Out	Connect Pulse generator 3 signal to the selected trigger operation
Line 7 – CXP IN	Connect the trigger up-linked from the frame grabber board to the selected trigger operation
Line 4 - TTL 1 In	Connect TTL 1 IN signal to the selected trigger operation
Line -5 – OPTO IN 1	Connect OPTO IN 1 signal to the selected trigger operation
Nand 0 Out	Connect NAND 0 OUT signal to the selected trigger operation
Nand1 Out	Connect NAND 1 OUT signal to the selected trigger operation
User Output 0	Connect User Output 0 signal to the selected trigger operation. 0 or 1 status can be sent by User 0 command from PC (Host side).
User Output 1	Connect User Output 1 signal to the selected trigger operation. 0 or 1 status can be sent by User 0 command from PC (Host side).
User Output 2	Connect User Output 2 signal to the selected trigger operation. 0 or 1 status can be sent by User 0 command from PC (Host side).
User Output 3	Connect User Output 3 signal to the selected trigger operation. 0 or 1 status can be sent by User 0 command from PC (Host side).
Line 10 TTL IN 2	Connect TTL 2 IN signal to Line 10
Line 11 LVDS IN	Connect LVDS 1 IN signal to Line 11
Note: In the SP-20000-CXP2, GPIO port is located on the AUX interface (Hirose 10P). In this GPIO. Line 10 and Line 11 are available.	

7.3.4 Trigger Activation

This command can select how to activate the trigger.

Rising edge: At the rising edge of the pulse, the trigger is activated.
Falling edge: At the falling edge of the pulse, the trigger is activated.
Level High: During the high level of trigger, the accumulation is activated
Level Low: During the low level of trigger, the accumulation is activated

If Exposure Mode is set to Trigger Width, Level High or Level Low must be used.

Table - 37 Trigger Activation

Camera Settings				JAI Custom Trigger Mode Name	Trigger Activation Setting			
Trigger Selector	Trigger Mode	Exposure Mode	Trigger Option		Rising Edge	Falling Edge	Level High	Level Low
Frame Start	On	Timed	Off	EPS Trigger	○	○	×	×
	On	Timed	PIV	PIV Trigger	○	○	×	×
	On	Trigger Width	Off	PWC Trigger	×	×	○	○

7.3.5 Trigger overlap

This function defines whether or not a trigger pulse can be accepted while data is being read out.

OFF : The trigger pulse is not accepted during CMOS readout.
Read Out : The trigger pulse can be accepted during CMOS readout.

7.3.6 Associated GenICam register information

Table – 38 Associated GenICam register information

GenICam Name	Access	Values	Category
Trigger Selector	R/W	Acquisition Start Acquisition End Frame Start	Acquisition Control
Trigger Mode	R/W	On Off	Acquisition Control
Trigger Software	W	Command	Acquisition Control
Trigger Source	R/W	Low High Soft Frame Trigger Wait Frame Active Exposure Active FVAL PG0 to PG3 User out0 to 3 TTL In1 Optp In CXP In (Trigger Packet) TTL In2 LVDS In1 Nand0 to 1	Acquisition Control
Trigger Activation	R/W	Rising Edge Falling Edge Level High Level Low	Acquisition Control
Trigger Over Lap	R/W	Off Read out	Acquisition Control

7.4. Normal continuous operation (Timed Exposure Mode/Trigger Mode OFF)

This is used for applications which do not require triggering.
For the video timing, refer to chapter 6.3.

Table – 39 Typical Minimum interval (Pixel format: 8-bit)

Trigger Mode	Readout Mode	Time (Min. Trigger Period)		
		CXP6_X2	CXP6_X1, CXP3_X2	CXP3_X1
Timed Exposure Mode Trigger Mode OFF (Note 1)	Full	33.333 ms	66.666 ms	133.333 ms
	AOI Center 2/3	22.222 ms	44.444 ms	88.889 ms
	AOI Center 1/2	16.667 ms	22.222 ms	66.667 ms
	AOI Center 1/4	8.428 ms	16.826 ms	33.713 ms
	AOI Center 1/8	4.500 ms	9.001 ms	18.002 ms
	V Binning ON (Full) (Note2)	33.333 ms	66.666 ms	133.333 ms

Note 1 : Readout setting in Trigger Overlap is not available
Note 2: SP-20000M-CXP2 only

7.5. Timed mode (EPS)

This mode allows a single image frame to be captured with a preset exposure time by using the external trigger. An additional setting determines if the trigger pulse can be accepted during the exposure period.

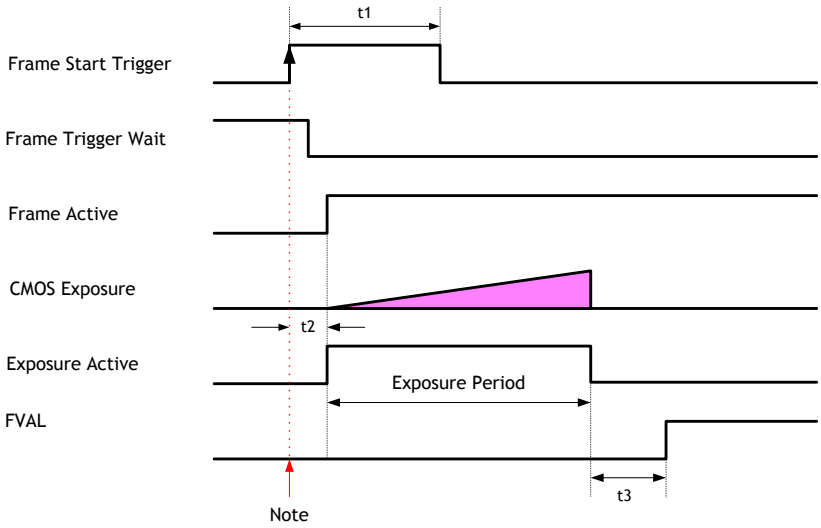
Basic settings to use this mode
Trigger Mode = ON
Exposure Mode = Timed
Trigger Option = Off
Trigger Overlap = Off

Table - 40 Typical Trigger minimum interval (Pixel format: 8-bit)

Trigger Mode	Readout Mode	Time (Min. Trigger Period)		
		CXP6_X2	CXP6_X1, CXP3_X2	CXP3_X1
Timed Exposure Mode Trigger Mode On	Full	≧31.761 ms	≧63.200 ms	≧126.389 ms
	AOI Center 2/3	≧21.287 ms	≧42.252 ms	≧84.492 ms
	AOI Center 1/2	≧16.050 ms	≧31.777 ms	≧63.544 ms
	AOI Center 1/4	≧8.195 ms	≧16.066 ms	≧32.121 ms
	AOI Center 1/8	≧4.267 ms	≧8.211 ms	≧16.410 ms
	V Binning ON (Full) (Note1)	≧31.770 ms	≧63.216 ms	≧126.423 ms

Note1 : SP-20000M-CXP2 only
Note2 : The above table is if Trigger Overlap is set to Readout.

7.5.1 If Overlap setting is OFF



Note: The trigger pulse is accepted during Frame Trigger Wait being active if the trigger overlap is OFF. When the trigger is accepted, the trigger wait is inactive until the readout is completed.

Fig. 26 Timed Overlap = OFF

Table – 41 Timing values

	Camera Settings					
	Tap Geometry	Vertical Binning	Exposure Active Signal source	Link Configuration		
				CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1
t1	1X - 1Y	—		2L(mini)	2L(mini)	2L(mini)
t2	1X - 1Y	—	TTL Out	2.120 us	2.120 us	2.370 us
			Inside Camera	450 ns ～480 ns	450 ns ～480 ns	700 ns ～750 ns
t3	1X -1Y	1 (Off)	TTL Out	304.980 us	304.980 us	610.170 us
			Inside Camera	305.240 us	305.240 us	610.400 us
		2 (On)	TTL Out	305.240 us	305.240 us	610.170 us
			Inside Camera	304.980 us	304.980 us	610.400 us

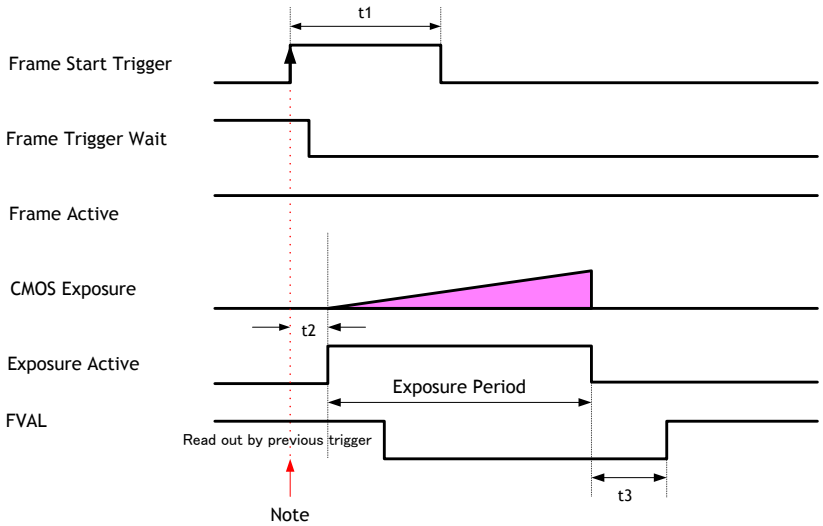
Note: (1) Because jitter occurs during triggering, t2 has tolerance in time.
(2) If the exposure signal is used as TTL OUT, the timing is delayed against the timing inside camera. Especially, the phase delay is large at the rising edge.

Table – 42 Minimum trigger interval calculation formula (Trigger Overlap: OFF)

Camera Settings			Settings: Trigger Mode="On"、Exposure Mode="Timed"、Trigger Overlap="Off" [Unit : us]
Link Configuration	Tap Geometry	Binning Vertical	
CXP6_X2	1X - 1Y	1 (Off)	ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + 10us
		2 (On)	ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10us
CXP6_X1 CXP3_X2	1X - 1Y	1 (Off)	ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10 us
		2 (On)	ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) + 10us
CXP3_X1	1X - 1Y	1 (Off)	ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + 10us
		2 (On)	ROUNDDOWN(((([Height]+1) x 1282) +12205) ÷ 20MHz x 10^6) + 10us

Note: If Trigger Overlap is set at OFF and the trigger period is less than value described in the above table, the trigger mask becomes effective and the trigger might be ignored.

7.5.2 If Overlap setting is Readout



Note: If the trigger overlap is Readout mode, Frame Trigger Wait is active on FVAL period of the previous trigger. In this period, the next trigger can be accepted. After receiving this trigger pulse, Frame Trigger Wait becomes inactive.

Fig. 27 Overlap Readout

Table – 43 Timing values

	Camera Settings					
	Tap Geometry	Vertical Binning	Exposure Active Signal source	Link Configuration		
				CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1
t1	1X - 1Y	—		2L(min)	2L(min)	2L(min)
t2	1X - 1Y	—	TTL Out	1.680 us ～ 1.680 us + 1 Line	1.680 us ～ 1.680 us + 1 Line	2.330 us ～ 2.330 us + 1 Line
			Inside Camera	460 ns ～ 460 ns + 1 Line	460 ns ～ 460 ns + 1 Line	710 ns ～ 710 ns + 1 Line
t3	1X -1Y	1 (Off)	TTL Out	305.240 us	305.240 us	610.170 us
			Inside Camera	307.990 us	307.990 us	610.400 us
		2 (On)	TTL Out	305.240 us	305.240 us	610.170 us
			Inside Camera	307.990 us	307.990 us	610.400 us

Table – 44 Minimum trigger interval calculation formula (Trigger Overlap: Readout)

Camera Settings			Conditions: Trigger Mode="On",Exposure Mode="Timed",Trigger Overlap="Readout" [Unit : us]
Link Configuration	Tap Geometry	Binning Vertical	
CXP6_X2	1X - 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + 10 - 260 ≧ [Exposure Time] Result= ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + 10 us
			If ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + 10 - 260 < [Exposure Time] Result = [Exposure Time] + 260 us
		2 (On)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10 - 260 ≧ [Exposure Time] Result =ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10us
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10 - 260 < [Exposure Time] Result = [Exposure Time] + 260 us
CXP6_X1 CXP3_X2	1X - 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10 - 260 ≧ [Exposure Time] Result =ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) +10us
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + 10 - 260 < [Exposure Time] Result = [Exposure Time] + 260 us
		2 (On)	If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) + 10 - 260 ≧ [Exposure Time] Result =ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) + 10us
			If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) + 10 - 260 < [Exposure Time] Result = [Exposure Time] + 260 us
CXP3_X1	1X - 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + 10 - 510 ≧ [Exposure Time] Result =ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + 10us
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + 10 - 510 < [Exposure Time] Result = [Exposure Time] + 510 us
		2 (On)	If ROUNDDOWN(((([Height]+1) x 1282) +12205) ÷ 20MHz x 10^6)+ 10 - 510 ≧ [Exposure Time] Result = ROUNDDOWN(((([Height]+1) x 1282) +12205) ÷ 20MHz x 10^6) + 10us
			If ROUNDDOWN(((([Height]+1) x 1282) +12205) ÷ 20MHz x 10^6) + 10 - 510 < [Exposure Time] Result = [Exposure Time] + 510 us

Note: (1) If Trigger Overlap is set at Readout and the trigger interval is set more than the value described in the above table, The exposure might not work properly and the proper image might not be output.

(2) If the trigger overlap is set at "Readout" and the trigger period is set such that (the trigger period (μs) - 260μs) is shorter than the exposure time, the exposure operation does not work properly and as a result, the proper image is not displayed. In this case, it is required either to shorten the exposure time or to prolong the **trigger period.**

If the link configuration CXP3_X1 is used, the figure 520μs must be used instead of 260μs.

7.5.3 GPIO TTL output timing if Trigger Overlap is OFF

Frame Start -Trigger Mode = "On"
Exposure Mode = "Timed"
Trigger Overlap =OFF

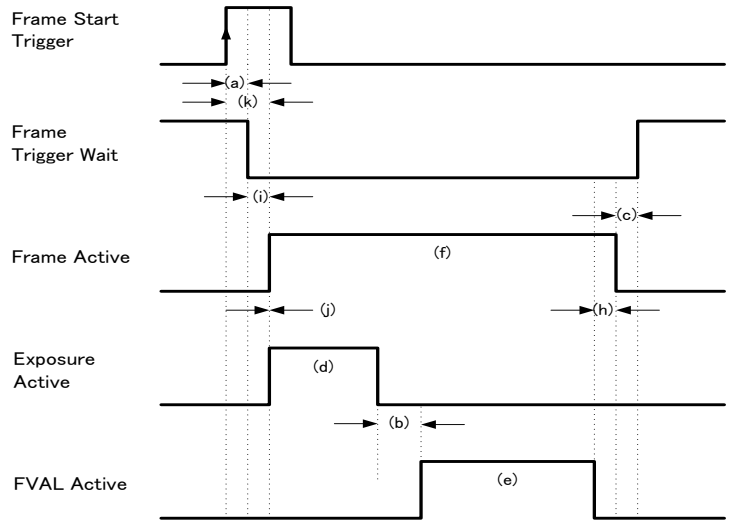


Fig. 28 GPIO TTL OUT timing

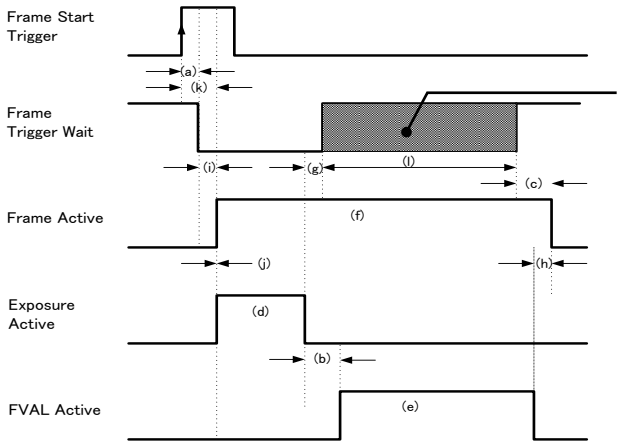
Table - 45 GPIO Out timing (Reference) (Trigger Overlap= OFF)

	Description	Tap Geometry : Geometry_1X_1Y Link Configuration Setting			Note
		CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1	
(a)	Frame Start Trigger to Frame Trigger Wait Falling Edge	860 ns	860 ns	1.06 us	If Frame Start Trigger is input from TTL IN 1
(b)	Exposure Active Falling Edge to FVAL Rising Edge	304.97 us (305.22 us)	304.97 us (305.22 us)	610.19 us (610.24 us)	( ) is the phase relation between the exposure time and FVAL inside camera
(c)	Frame Active Falling Edge to Frame Trigger Wait Rising Edge	990 ns	990 ns	1.83 us	
(d)	Exposure Active	8.61 us (10.03 us)	8.61 us (10.03 us)	8.68 us (10.05 us)	If Exposure Time = 10. ( ) is the exposure time inside camera
(e)	FVAL Active	30.74 ms (Internal : 30.77 ms)	61.53 ms (Internal : 61.54 ms)	123.07 ms (Internal : 123.07 ms)	If Binning off and Height=3840 (Varies by the vertical ROI)
(f)	Frame Active	31.08 ms	61.85 ms	123.69 ms	If Exposure Mode = Timed
(h)	FVAL Falling Edge to Frame Active Falling Edge	1.02 us	1.02 us	0.80 us	This may vary by binning setting and ROI setting. The phase of Frame Active End Edge may vary by 1us against FVAL Active End.
(i)	Frame Trigger wait Falling Edge to Frame Active Rising Edge	1.28 us	1.28 us	1.27 us	
(j)	Frame Active Rising Edge to Exposure Active Rising Edge	0.00 us	0.00 us	0.00 us	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.13 us ~ 2.16 us (450 ns~ 480 ns)	2.129 us~ 2.156 us (450 ns~ 480 ns)	2.312 us~ 2.360 us (704.00 ns~ 754.00 ns)	Exposure Active at TTL I/F output ( ) is the exposure phase relation inside camera
-	Exposure Active Start Edge : Internal / TTL Out Phase	1.67 us	1.67 us	1.61 us	If the polarity is Active High
-	Exposure Active End Edge : Internal / TTL Out Phase	260 ns	260 ns	230 ns	If the polarity is Active High

Note: The figure in ( ) is the comparison between the exposure time inside camera and Exposure Active

7.5.4 GPIO TTL output timing if Trigger Overlap is Readout

Frame Start -Trigger Mode = "On"
Exposure Mode = "Timed"
Trigger Overlap = "Readout"



Starting position of Frame Trigger Active at EPS Trigger / [Trigger Overlap] = "Readout" setting.

The starting position will vary until [Exposure Time] value exceeds ([FVAL]+[Exposure Active End Edge ~ FVAL Active Start Edge]-158).

[FVAL]+[Exposure Active End Edge ~ FVAL Active Start Edge] is a constant value. If [Exposure Time] is smaller than this constant value, the overlap period is shorter and if [Exposure Time] is larger than this constant value, the overlap period is longer.

Fig. 29 GPIO timing (Overlap = Readout)

Table - 46 GPIO output timing(Reference) (Trigger Overlap = Readout)

	Description	Tap Geometry : Geometry_1X_1Y Link Configuration Setting			Note
		CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1	
(a)	Frame Start Trigger to Frame Trigger Wait Falling Edge	860 ns	840.00 ns	1.063 us (±25ns)	
(b)	Exposure Active Falling Edge to FVAL Raising Edge	304.97 us (305.22 us)	304.97 us (305.21 us)	610.19 us (610.42 us)	This is changed by Link Configuration setting.
(c)	Frame Trigger Wait Rising Edge to Frame Active Falling Edge	6.98 us	6.97 us	6.97 us	Is Exposure Time=10 us
(d)	Exposure Active	8.61 us (10.03 us)	8.56 us (10.03 us)	8.68 us (10.05 us)	If Exposure Time=10 us ( ) is the exposure time inside camera
(e)	FVAL Active	30.77 ms (Internal : 30.77 ms)	61.53 ms (Internal : 61.54 ms)	123.07 ms (Internal : 123.07 ms)	If Binning off and Height = 3840 (Varies by the vertical ROI setting)
(f)	Frame Active	31.08 ms	61.85 ms	123.69 ms	If Exposure Mode = Timed
(g)	Exposure Active Falling Edge to Frame Trigger Wait Rising Edge	4.05 us	5.05 us	5.03 us	
(h)	FVAL Falling Edge to Frame Active Falling Edge	1.02 us	1.03 us	270 ns	This may vary by binning setting and ROI setting. The phase of Frame Active End Edge may vary by 1us against FVAL Active End.
(i)	Frame Trigger Wait Falling Edge to Frame Active Rising Edge	1.32 us	1.33 us	1.29 us	
(j)	Frame Active Rising Edge to Exposure Active Rising Edge	0.00 us	0.00 us	0.00us	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.15 us ~ 2.17 us (450 ns~ 480 ns)	2.16 ~ 2.17 us (450 ~ 480 ns)	2.33 ~ 2.38 us (700 ~ 750 ns)	Exposure Active at TTL I/F output ( ) is the exposure phase relation inside camera
(l)	Frame Trigger Wait Rising Edge Variableness	31.06 ms	61.83 ms	123.67 ms	Varies by Exposure Time setting
-	Exposure Active Start Edge : Internal / TTL Out Phase	1.70 us	1.71 us	1.62 us	
-	Exposure Active End Edge : Internal /TTL Out Phase	250 ns	250 ns	230 ns	

Note: (1) In order to explain the phase relation of Frame Trigger Wait and Frame Active, the timing in this table reflects the condition that the trigger input is not overlapped in the previous video readout.
(2) Figures in ( ) are the comparison between the exposure time inside camera and Exposure Active.

7.6 Trigger width mode (PWC)

In this mode, the exposure time is equal to the trigger pulse width. Accordingly, longer exposure times are supported. Additional settings determine if the trigger pulse can be accepted during the exposure period.

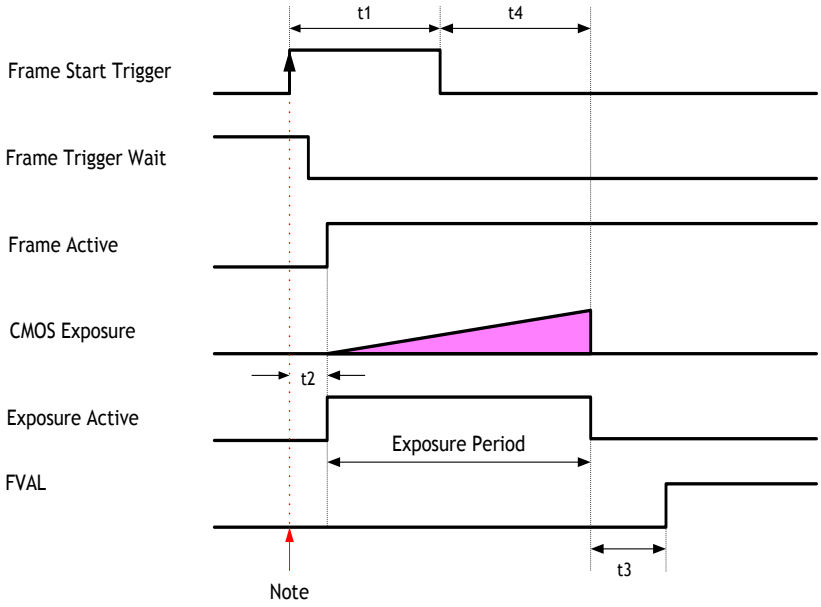
Basic settings to use this mode
Trigger Mode = ON
Exposure Mode = Trigger Width

Table - 47 Typical Minimum trigger interval (Pixel Format : 8-bit)

Trigger Mode	Readout Mode	Time (Min. Trigger Period)		
		CXP6_X2	CXP6_X1, CXP3_X2	CXP3_X1
Trigger Width Exposure Mode	Full	≧31.761 ms	≧63.200 ms	≧126.389 ms
	AOI Center 2/3	≧21.287 ms	≧42.252 ms	≧84.492 ms
	AOI Center 1/2	≧16.050 ms	≧31.777 ms	≧63.544 ms
	AOI Center 1/4	≧8.195 ms	≧16.066 ms	≧32.121 ms
	AOI Center 1/8	≧4.267 ms	≧8.211 ms	≧16.410 ms
	V Binning ON (Full) (Note1)	≧31.770 ms	≧63.216 ms	≧126.423 ms

Note1 : SP-20000M-CXP2 only
Note2 : The above table is if Trigger Overlap is Readout.

7.6.1 If Overlap setting is OFF



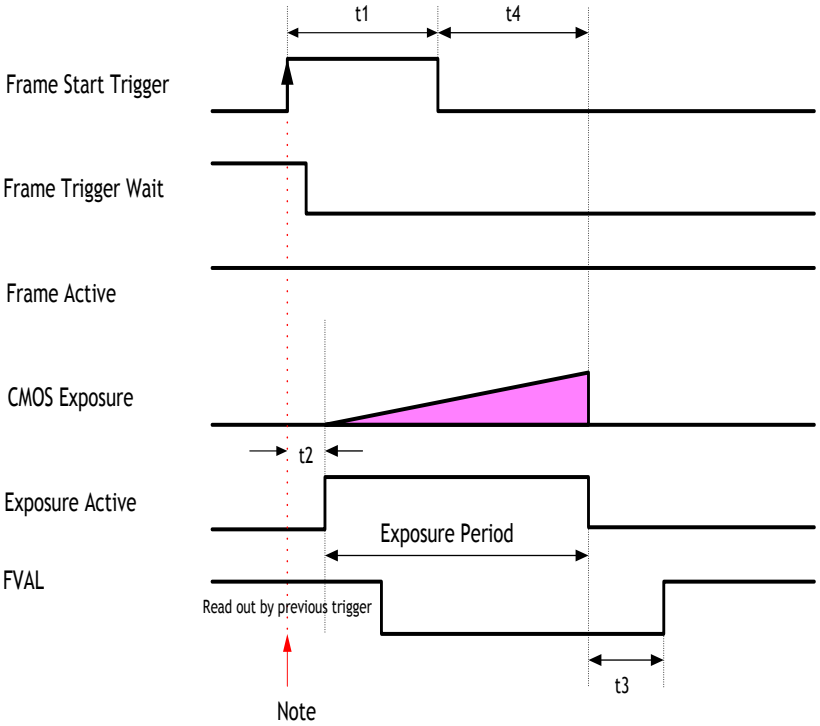
Note: The trigger pulse is accepted during Frame Trigger Wait being active if the trigger overlap is OFF. When the trigger is accepted, the trigger wait is inactive until the readout is completed.

	Camera Settings					
	Tap Geometry	Vertical Binning	Exposure Active Signal source	Link Configuration		
				CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1
t1				10µs (min)	10µs (min)	10µs (min)
t2	1X - 1Y	-	TTL Out	2.050 us ~ 2.080 us	2.070 us ~ 2.090 us	2.120 us ~ 2.320 us
			Inside camera	380 ns ~ 410 ns	380 ns ~ 400 ns	550 ns ~ 600 ns
t3	1X - 1Y	1 (Off)	TTL Out	304.990 us	304.990 us	610.170 us
			Inside camera	305.240 us	305.240 us	610.400 us
		2 (On)	TTL Out	304.990 us	304.990 us	610.170 us
			Inside camera	305.240 us	305.240 us	610.400 us
t4	1X - 1Y	-	TTL Out	2.860 us ~ 2.880 us	2.840 us ~ 2.870 us	3.060 us ~ 3.010 us
			Inside camera	2.600 us ~ 2.630 us	2.560 us ~ 2.620 us	2.840 us ~ 2.790 us
Real Exposure time difference	1X - 1Y	-	TTL Out	0.780 us ~ 0.830 us	0.750 us ~ 0.800 us	0.740 us ~ 0.800 us
			Inside camera	2.190 us ~ 2.250 us	2.160 us ~ 2.240 us	2.240 us ~ 2.260 us

Note: 1. The jitter from the trigger occurs at both the exposure start edge and exposure end edge.
2. The real exposure time difference is an additional period of exposure time against TTL trigger input.
(t4) - (t2) ≒ The real exposure time difference

Fig. 30 Overlap = OFF

7.6.2 If Overlap setting is Readout



Note: If the trigger overlap is Readout mode, Frame Trigger Wait is active during FVAL period of the previous trigger. In this period, the next trigger can be accepted. After receiving this trigger pulse, Frame Trigger Wait becomes inactive.

	Camera Settings					
	Tap Geometry	Vertical Binning	Exposure Active Signal source	Link Configuration		
				CXP6_X2	CXP6_X1 CXP3_X2	CXP3_X1
t1				10μs (min)	10μs (min)	10μs (min)
t2	Geometry _1X_1Y	-	TTL Out	2.090 us ~ 2.090 us + 1Line	1.690 us ~ 1.690 us + 1Line	2.230 us ~ 2.230 us + 1Line
			Inside camera	380 ns ~ 380 ns + 1Line	390 ns ~ 390 ns + 1Line	550 ns ~ 550 ns + 1Line
t3	Geometry _1X_1Y	1 (Off)	TTL Out	304.990 us	304.990 us	610.200 us
			Inside camera	305.240 us	305.240 us	610.420 us
		2 (On)	TTL Out	304.990 us	304.990 us	610.200 us
			Inside camera	305.240 us	305.240 us	610.420 us
t4	Geometry _1X_1Y	-	TTL Out	2.900 us ~ 2.920 us	2.880 us ~ 2.910 us	3.050 us ~ 3.100 us
			Inside camera	2.650 us ~ 2.670 us	2.630 us ~ 2.660 us	2.820 us ~ 2.870 us
(t4)-(t2) : Exposure Difference	Geometry _1X_1Y	-	TTL Out	-7.180 us ~ 0.840 us	-15.210 us ~ 1.220 us	-31.240 us ~ 0.870 us
			Inside camera	-5.730 us ~ 2.290 us	-13.770 us ~ 2.270 us	-29.780 us ~ 2.320 us

Note: .1. The jitter from the trigger occurs at both the exposure start edge and exposure end edge.
2. The exposure start edge has 1 line jitter at receiving trigger in order not to influence the video signal.

Fig. 31 Overlap: Readout

7.6.3 Minimum trigger interval calculation formula (Trigger Overlap = OFF)

Table – 48 Minimum trigger interval calculation formula (Trigger Overlap = OFF)

Camera Settings			Conditions: PWC Trigger / Trigger Overlap = OFF [Unit : us]
Link Configuration	Tap Geometry	Binning Vertical	
CXP6_X2	1X - 1Y	1 (Off)	ROUNDDOWN ((((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
		2 (On)	ROUNDDOWN ((((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
CXP6_X1 CXP3_X2	1X - 1Y	1 (Off)	ROUNDDOWN ((((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
		2 (On)	ROUNDDOWN ((((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
CXP3_X1	1X - 1Y	1 (Off)	ROUNDDOWN ((((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + [Trigger Pulse Width : 10us~])
		2 (On)	ROUNDDOWN ((((([Height]+1) x 1282) +12205) ÷ 20MHz x 10^6) + [Trigger Pulse Width : 10us~])
Note: If Trigger Overlap is set to OFF and the trigger period is less than value described in the above table, the trigger mask becomes effective and the trigger might be ignored.			

7.6.4 Minimum trigger interval calculation formula (Trigger Overlap = Readout)

Table – 49 Minimum trigger interval calculation formula (Trigger Overlap = Readout)

Camera Settings			Conditions: PWC Trigger / Trigger Overlap = Readout [Unit : us]
Link Configuration	Tap Geometry	Binning Vertical	
CXP6_X2	1X - 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) +10 - 260 ≧ [Trigger Pulse Width] Result= ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) +10 - 260 < [Trigger Pulse Width] Result=260us+[Trigger Pulse Width]
		2 (On)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) +10 - 260 ≧ [Trigger Pulse Width] Result= ROUNDDOWN((((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) +10 - 260 < [Trigger Pulse Width] Result= 260us+[Trigger Pulse Width]
CXP6_X1 CXP3_X2	1X - 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) +10 - 260 ≧ [Trigger Pulse Width] Result= ROUNDDOWN((((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 40MHz x 10^6) +10 - 260 < [Trigger Pulse Width] Result=260us+[Trigger Pulse Width]
		2 (On)	If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6) +10 - 260 ≧ [Trigger Pulse Width] Result=ROUNDDOWN((((([Height]+1) x 320.5) + 12205) ÷ 40MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 40MHz x 10^6)+10 - 260 < [Trigger Pulse Width] Result=260us+[Trigger Pulse Width]
CXP3_X1	1X 1Y	1 (Off)	If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) +10 - 520 ≧ [Trigger Pulse Width] Result= ROUNDDOWN((((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 641) + 12205) ÷ 20MHz x 10^6) +10 - 520 < [Trigger Pulse Width] Result= 520us+[Trigger Pulse Width]
		2 (On)	If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 20MHz x 10^6) +10 - 520 ≧ [Trigger Pulse Width] Result=ROUNDDOWN((((([Height]+1) x 1282) + 12205) ÷ 20MHz x 10^6) + [Trigger Pulse Width : 10us~])
			If ROUNDDOWN(((([Height]+1) x 1282) + 12205) ÷ 20MHz x 10^6) +10 - 520 < [Trigger Pulse Width] Result=520us+[Trigger Pulse Width]

Note: For [Trigger Overlap]=Readout setting, if the trigger interval is set longer than the interval described in this table or the same as the trigger width, the exposure operation might not work properly and as a result, the normal image might not be output.

7.7 PIV (Particle Image Velocimetry)

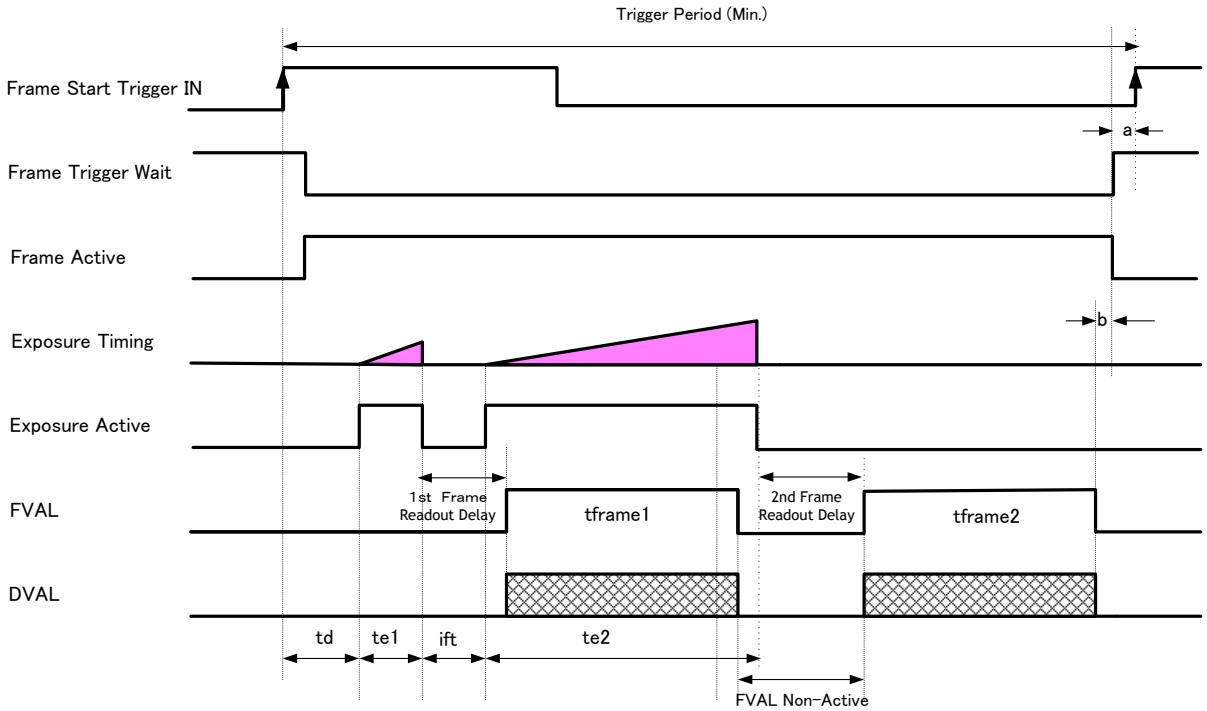
The Particle Image Velocimetry mode can be used in applications where 2 images need to be taken with a very short time interval. It can only be used with strobe flash as illumination. The first accumulation time is 10 μsec to 33 msec. Then, the second exposure will be taken. The first strobe is activated during the first exposure duration and the second strobe are pulsed while the first frame is being read out. In this way, two strobe flashes generate two video outputs.

Basic settings to use this mode
Trigger Mode = ON
Exposure Mode = Timed
Trigger Option = PIV

Table – 50 Typical Minimum trigger intervals (Pixel Format: 8-bit)

Trigger Mode	Readout Mode	Time (Min. Trigger Period)		
		CXP6_X2	CXP6_X1, CXP3_X2	CXP3_X1
PIV mode (Note1)	Full	≧63.625 ms	≧126.489 ms	≧252.834 ms
	AOI Center 2/3	≧42.677 ms	≧84.592 ms	≧169.041 ms
	AOI Center 1/2	≧32.203 ms	≧63.644 ms	≧127.144 ms
	AOI Center 1/4	≧16.492 ms	≧32.221 ms	≧64.299 ms
	AOI Center 1/8	≧8.636 ms	≧16.510 ms	≧32.877 ms
	V Binning ON (Full) (Note2)	≧63.635 ms	≧126.504 ms	≧252.868 ms

Note 1. This is Trigger Overlap=OFF. Trigger Overlap mode=Readout is not available
Note 2. SP-20000M-CXP2 only



Note 1. The exposure time for the first frame (te1) can be set by [Exposure Time].
Note 2. The second exposure time (te2) varies by ROI setting and Binning setting, but is not affected by [Exposure Time] setting.

Fig. 32 PIV mode timing

Table – 51 PIV trigger mode specifications (CXP-6_X2)

time name	Description	Exposure Active Signal Source	Time Geometry_1X_1Y CXP6_X2
td	Exposure Beginning delay	TTL Out	2.11 us
		Internal	400 ns~ 430 ns
te1	First exposure time period	-	10us ~ ≒1 Frame ([Height]=3840 : 33083us Max) = [Exposure Time Settings]
		TTL Out	8.62 us ~ 33.08 ms
		Internal	10.05 us ~ 33.08 ms
itf	Inter framing time	TTL Out	307.01 us
		Internal	305.58 us
te2	Second exposure time	TTL Out	≒1 frame (1) V-Binning Off =((([Height]×320.5) - 0.5) ÷ 40MHz) - 2.05 us + 128.77 us
		Intenal	=((([Height]×320.5) - 0.5) ÷ 40MHz) - 0.35 us + 128.78 us
		TTL Out	(2) V-Binning On =((([Height]×641) - 1) ÷ 40MHz) - 2.05 us + 128.77 us
		Intenal	=((([Height]×641) - 1) ÷ 40MHz) - 0.350 us + 128.78 us
tframe1	First Frame read out	-	(1) V-Binning Off [FVAL Active] =((([Height]×320.5) - 0.5) ÷ 40MHz
		-	(2) V-Binning On [FVAL Active] =((([Height]×641) - 1) ÷ 40MHz
tframe2	Second Frame read out	Internal	[FVAL Active] (same as tframe1)
-	1st Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 304.97 us
		Internal	Both V-Binning Off / V-Binning On = 305.22 us
-	2nd Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 304.97 us
		Internal	Both V-Binning Off / V-Binning On = 305.224 us
-	FVAL Non-Active	-	Both V-Binning Off / V-Binning On = 434.00 us (1) V-Binning Off = 54.2 Line (2) V-Binning On = 27.1 Line
-	Trigger Period (Min.)	-	(1) V-Binning Off =((((([Height]+0.5)×320.5)-0.5) x 2Frame ÷ 40MHz) +[Exposure Time] + 305.22 us + 434.00 us
		-	(2) V-Binning On =((((([Height]+0.5)×641)-0.5) x 2Frame ÷ 40MHz) +[Exposure Time] + 305.22 us + 434.00 us
-	2nd FVAL Active End ~ Frame Active End	-	0 Line

Table - 52 PIV trigger mode specifications (CXP-6_X1, CXP3_X2)

time name	Description	Exposure Active Signal Source	Time Geometry_1X_1Y CXP-6_X1 CXP-3_X2
td	Exposure Beginning delay	TTL Out	2.11 us
		Internal	400 ns~ 430 ns
te1	First exposure time period	-	10us ～ ≒1 Frame ([Height]=3840 : 66417us Max) ＝ [Exposure Time Settings]
		TTL Out	8.62 us ~ 66.42 ms
		Internal	10.05 us ~ 66.42 ms
itf	Inter framing time	TTL Out	307.01 us
		Internal	305.58 us
te2	Second exposure time	TTL Out	≒1 frame (1) V-Binning Off ＝((([Height]×641) - 1) ÷ 40MHz) - 2.05 us + 128.77 us
		Internal	＝((([Height]×641) - 1) ÷ 40MHz) - 0.35 us + 128.78 us
		TTL Out	(2) V-Binning On ＝((([Height]×1282) - 2) ÷ 40MHz) - 2.05 us + 128.77 us
		Internal	＝((([Height]×1282) - 2) ÷ 40MHz) - 0.35 us + 128.78 us
tframe1	First Frame read out	-	(1) V-Binning Off [FVAL Active] ＝((([Height]×641) - 1) ÷ 40MHz
		-	(2) V-Binning On [FVAL Active] ＝((([Height]×1281) - 2) ÷ 40MHz
tframe2	Second Frame read out	Internal	[FVAL Active] (same as tframe1)
-	1st Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 304.97 us
		Internal	Both V-Binning Off / V-Binning On = 305.22 us
-	2nd Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 304.97 us
		Internal	Both V-Binning Off / V-Binning On = 305.22 us
-	FVAL Non-Active	-	Both V-Binning Off / V-Binning On = 434.00 us (1) V-Binning Off = 27.1 Line (2) V-Binning On = 13.5 Line
-	Trigger Period (Min.)	-	(1) V-Binning Off ＝(((([Height]+0.5)×641)-0.5) x 2Frame ÷ 40MHz) +[Exposure Time] + 305.22 us + 434.00 us
		-	(2) V-Binning On ＝(((([Height]+0.5)×1282)-0.5) x 2Frame ÷ 40MHz) +[Exposure Time] + 305.22 us + 434.00 us
-	2nd FVAL Active End ~ Frame Active End	-	0 Line

Table - 53 PIV trigger mode specifications (CXP3_X1)

time name	Description	Exposure Active Signal Source	Time Geometry_1X_1Y CXP3_X1
td	Exposure Beginning delay	TTL Out	2.29 us
		Internal	600 ns~ 650 ns
te1	First exposure time period	-	10us ～ ≒1 Frame ([Height]=3840 : 132833us Max) ＝ [Exposure Time Settings]
		TTL Out	8.67 us ~ 123.68 ms
		Internal	10.10 us ~ 123.68 ms
itf	Inter framing time	TTL Out	612.53 us
		Internal	611.10 us
te2	Second exposure time	TTL Out	≒1 frame (1) V-Binning Off ＝((([Height]×641) - 1) ÷ 20MHz) - 2.35 us + 128.80 us
		Internal	＝((([Height]×641) - 1) ÷ 20MHz) - 680 ns + 128.57 us
		TTL Out	(2) V-Binning On ＝((([Height]×1282) - 2) ÷ 20MHz) - 2.35 us + 128.80 us
		Internal	＝((([Height]×1282) - 2) ÷ 20MHz) - 680 ns + 128.57 us
tframe1	First Frame read out	-	(1) V-Binning Off [FVAL Active] ＝((([Height]×641) - 1) ÷ 20MHz
		-	(2) V-Binning On [FVAL Active] ＝((([Height]×1282) - 2) ÷ 20MHz
tframe2	Second Frame read out	Internal	[FVAL Active] (same as tframe1)
-	1st Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 610.19 us
		Internal	Both V-Binning Off / V-Binning On = 610.43 us
-	2nd Frame Readout Delay	TTL Out	Both V-Binning Off / V-Binning On = 610.19 us
		Internal	Both V-Binning Off / V-Binning On = 610.43 us
-	FVAL Non-Active	-	Both V-Binning Off / V-Binning On = 739.00 us (1) V-Binning Off 時 = 23.1 Line (2) V-Binning On 時 = 11.5 Line
-	Trigger Period (Min.)	-	(1) V-Binning Off ＝(((([Height]+0.5)×641) -1) x 2Frame ÷ 20MHz) +[Exposure Time] + 610.43 us + 739.00 us
		-	(2) V-Binning On ＝(((([Height]+0.5)×1282) -2) x 2Frame ÷ 20MHz) +[Exposure Time] + 610.43 us + 739.00 us
-	2nd FVAL Active End ~ Frame Active End	-	0 Line

7.8 Sequence ROI Trigger

This is a function to capture images in sequence based on preset ROI, Exposure Time, Gain and other parameters in the sequence index table.

Basic settings to use this mode
Acquisition mode: Continuous
Trigger selector: Frame Start
Trigger mode: ON
Exposure mode: Timed
Video send mode selector: Trigger Sequence or Command Sequence

7.8.1 Trigger Sequence

In this mode, while the previous trigger operation (Index table) is activating, the next trigger cannot be overlapped. Sequence index table must complete index 0 and after index 0 is performed, the next index can be operated.

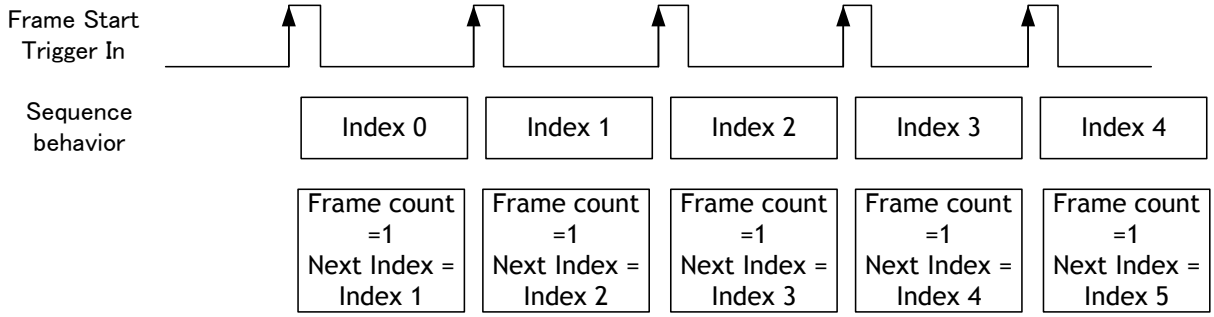


Fig. 33 Behavior of Sequence Mode 1

7.8.2 Command Sequence

In this mode, after the acquisition starts, the index table is executed by the external trigger which sets the index according to the Next Sequence Index Command. In this case, Sequence ROI Frame Count and Sequence ROI Next Index commands in the index table are ignored.

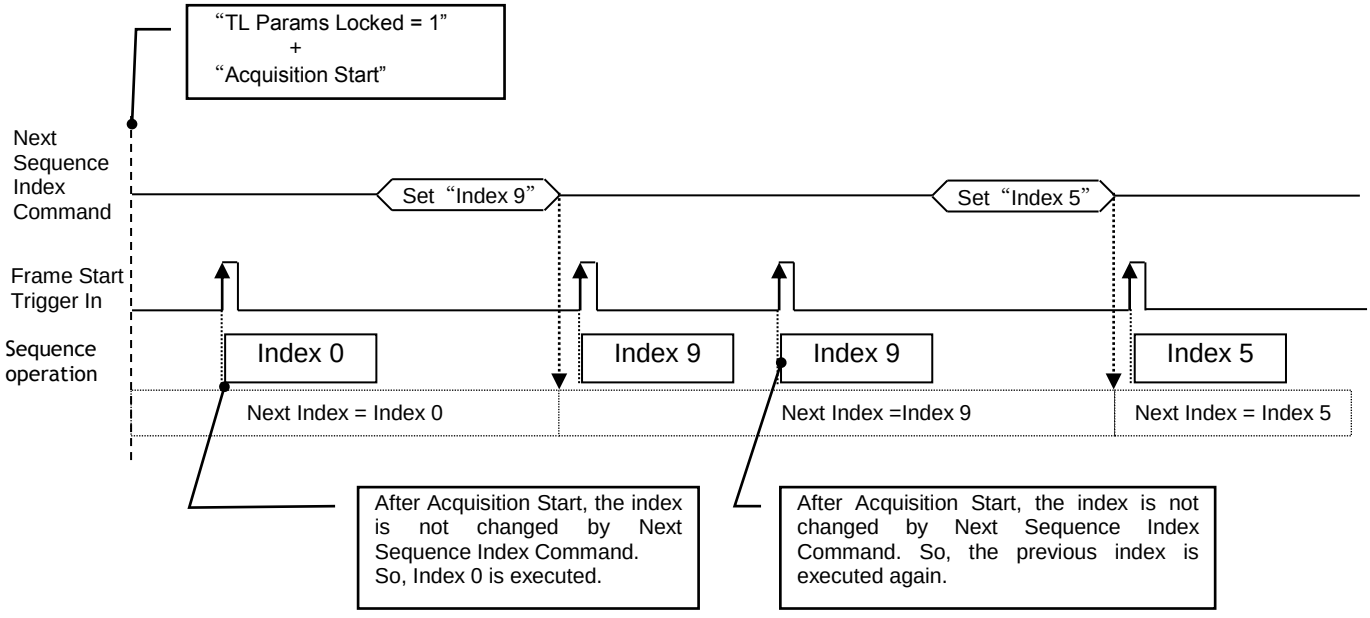


Fig. 34 Behaviour of Sequence Mode 2

7.8.3 Typical minimum trigger interval of Sequence ROI Trigger

Table - 54 Typical Minimum trigger interval (Pixel Format: 8-bit)

Trigger Mode	Readout Mode	Time (Min. Trigger Period)		
		CXP6_X2	CXP6_X1, CXP3_X2	CXP3_X1
Sequential Timed Exposure Mode (Note1)	Full	≧31.761 ms	≧63.200 ms	≧126.389 ms
	AOI Center 2/3	≧21.287 ms	≧42.252 ms	≧84.492 ms
	AOI Center 1/2	≧16.050 ms	≧31.777 ms	≧63.544 ms
	AOI Center 1/4	≧8.195 ms	≧16.066 ms	≧32.121 ms
	AOI Center 1/8	≧4.267 ms	≧8.211 ms	≧16.410 ms
	V Binning ON (Full) (Note2)	≧31.770 ms	≧63.216 ms	≧126.423 ms

Note 1. Overlap mode=Readout is not available. Please set the exposure time not to be Readout mode.
Note 2. SP-20000M-CXP2 only
Note 3. The minimum interval calculation assumes that the exposure time for all sequences is equal. If there are differences, it is necessary to add the difference to the calculation. If the exposure times are different, it is recommended to organize the exposure times from the shortest exposure to the longest one in order to operate faster.
Note 4. The above interval is if the exposure time is set to 10 μs.

7.8.4 Default Sequence Index Table

Table – 55 Sequence Index table (Default)

Sequence AOI Index \ Trigger Sequence	Width	Height	Offset		Gain Selector			Exposure Time	Black Level	Binning		LUT Enable	Frame Count	Next Index
			X	Y	Gain (ALL)	Red	Blue			Horizontal	Vertical			
- Index 0	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 1	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 2	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 3	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 4	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 5	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 6	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 7	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 8	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 9	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0

7.8.5 Sequence ROI setting parameters

Setting parameters for Sequence ROI are as follows.

(1) Sequence ROI Index Selector
In Sequence ROI Index Selector, Index 0 to 9 can be selected.
Sequence ROI – Width, Height, Offset X, Offset Y, Gain Selector - Gain/Red/Blue, Exposure Time, Black Level, Binning Horizontal, Binning Vertical, LUT Enable, Frame Count, Next Index for the selected index are displayed.

(2) Sequence ROI Width
Set the width of sequence ROI. The setting range is 8 to 5120 Pixels.
Rules for setting area and step number are the same as the normal ROI mode set by [Video Send Mode] =“Normal”.

(3) Sequence ROI Height
Set the height of sequence ROI. The setting range is 2 to 3840 lines.
Rules for setting area and step number are the same as the normal ROI mode set by [Video Send Mode] =“Normal”.

(4) Sequence ROI Offset X

Set Offset X of sequence ROI.
Sequence ROI Binning Horizontal =1 (Off):
Setting range is 0 to (5120 - [Sequence ROI Width])
Sequence ROI Binning Horizontal =2 (On):
Setting range is 0 to (2560 - [Sequence ROI Width])
The limitations of step number and other factors are the same as the normal ROI mode set by [Video Send Mode] =“Normal”.

(5) Sequence ROI Offset Y
Set Offset Y of sequence ROI.
Sequence ROI Binning Vertical =1 (Off):
Setting range is 0 to (3840 - [Sequence ROI Height])
Sequence ROI Binning Vertical =2 (On):
Setting range is 0 to (1920 - [Sequence ROI Height])
The limitations of step number and other factors are the same as the normal ROI mode set by [Video Send Mode] =“Normal”.

(6) Sequence ROI Gain Selector
In Sequence ROI Gain Selector, the gain settings for each index are available.
SP-20000C-CXP2: Gain (ALL), Red, and Blue can be set.
SP-20000M-CXP2: Only Gain is displayed and can be set.

(7) Sequence ROI Black Level
Black Level setting is available for each index.

(8) Sequence ROI Exposure Time
Exposure Time setting is available for each index.

(9) Sequence ROI Binning Horizontal
ON or OFF of Horizontal Binning for each index can be set.

(10) Sequence ROI Binning Vertical
ON or OFF of Vertical Binning for each index can be set.

(11) Sequence ROI LUT Enable
Enable or disable of LUT function for each index 0 to 9 can be set.

(12) Sequence ROI Frame Count
This can set how many times the selected index is repeated. This is applied to each index. Triggers are input according to numbers set in Frame Count and index is repeated and moves to the next index. Therefore, the same number of triggers as Frame Count must be input.

(13) Sequence ROI Next Index
Only when Trigger Sequence is configured, it is possible to set the next index to the currently executing index. In this case, after the acquisition starts and the external trigger is input, the index table always starts from index 0. Accordingly, after the repeated cycle of index 0 set by Frame Count is completed, the next index can be set as required. However, if Sequence ROI Next Index is set to OFF, it refers to the setting of Sequence Repetition.

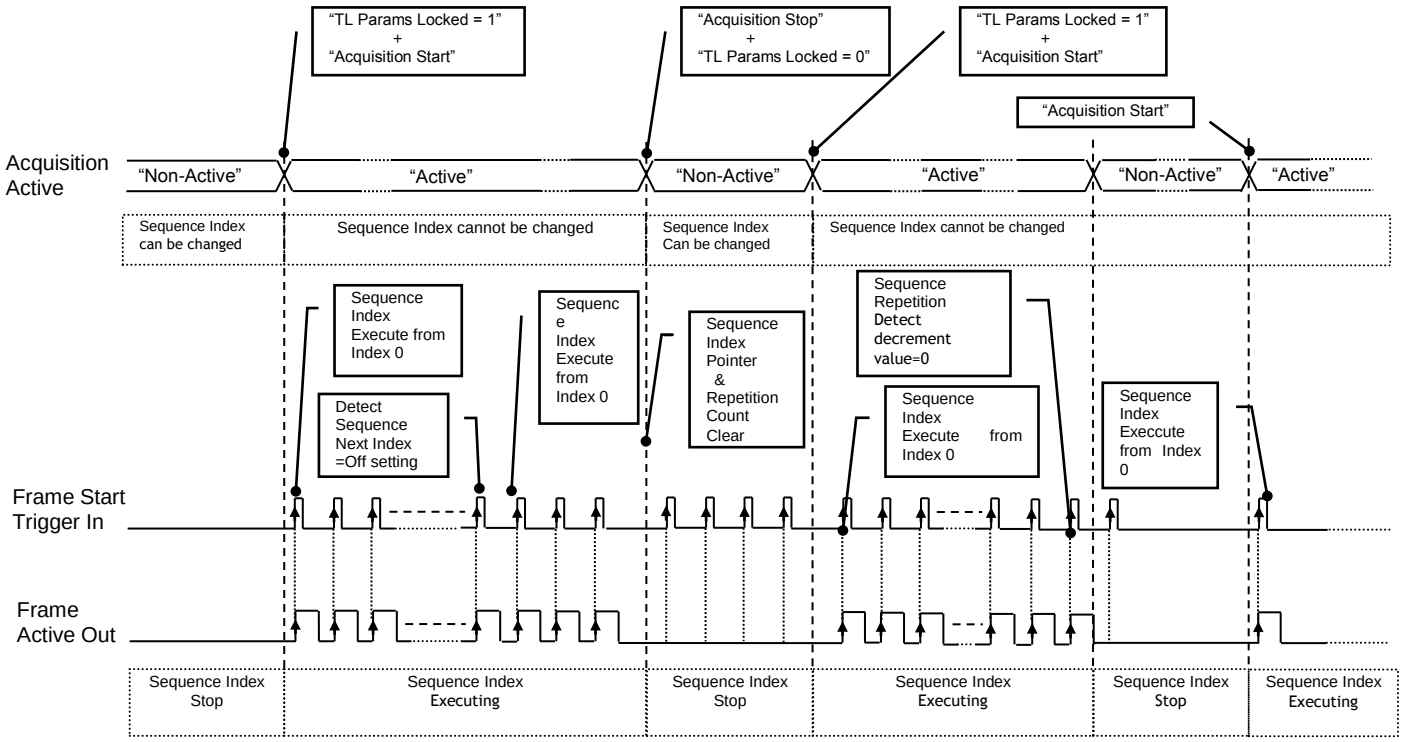


Fig.35 Sequence ROI trigger timing chart

(14) Sequence Repetition

If Trigger Sequence is selected, and if there is an entry in the Index Table whose Sequence ROI Next Index is set to OFF, the value of Sequence Repetition is valid. Then, it becomes possible to repeat the Index Table as set in Sequence Repetition.

After the acquisition starts, the index table is executed from Index 0 by the external trigger. And when the index table whose Sequence ROI Next Index is set to OFF is finished, the value of Sequence Repetition is decremented internally. In this case, if the result of decrement is not "0", the index table starts from Index 0 again. If the result of decrement is 0, the status changes to Acquisition Stop and cannot accept the external trigger.

The following chart shows the flow chart.

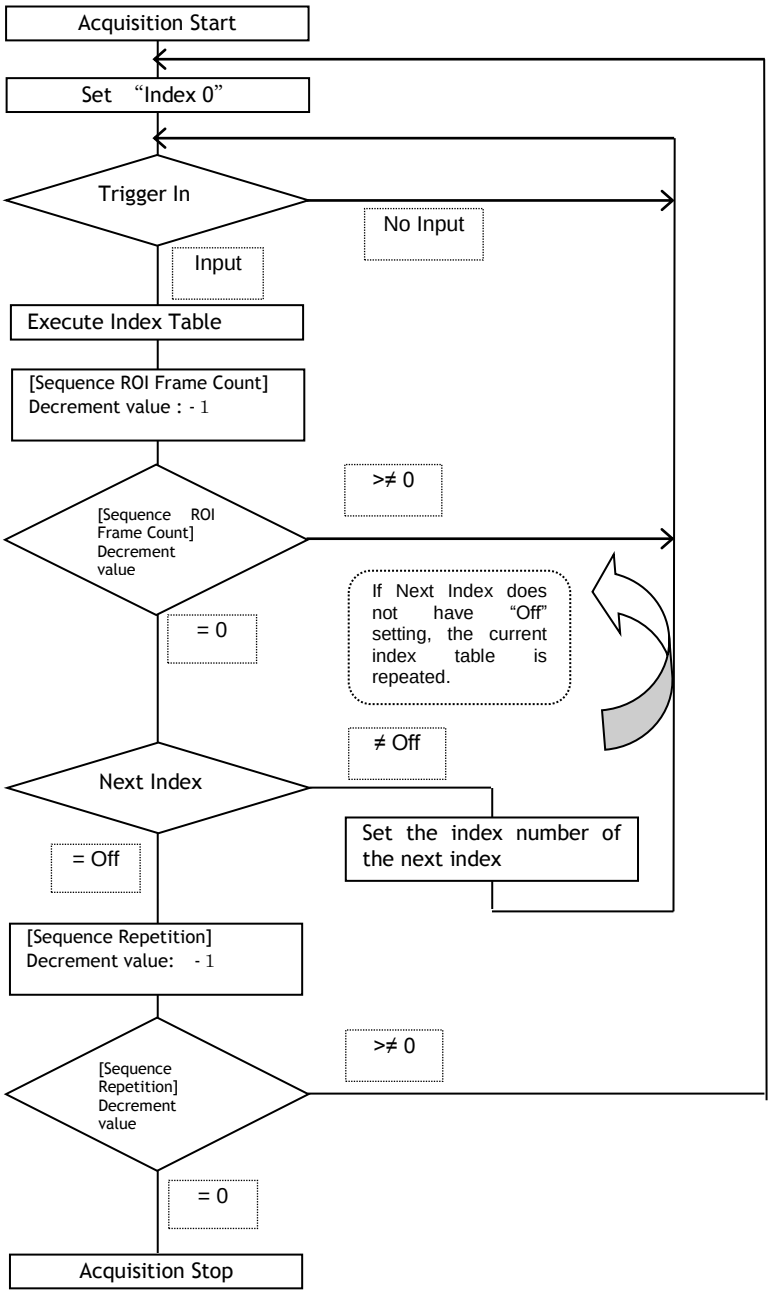


Fig.36 Flow chart of Trigger Sequence

(15) Next Sequence Index

If Command Sequence is selected, Next Sequence Index can be used. When the index is changed in the Next Sequence Index selector, a Next Sequence Index command is sent to the camera manually. The index table which is indicated by the Next Sequence Index command is executed by the next trigger input.

However, when Command Sequence is used, Sequence ROI Frame Count and Sequence ROI Next Index are disabled and ignored.

In the case of Command Sequence, as Next Sequence Index command is not sent after the acquisition starts, Index 0 is executed if the external trigger is input.
The index table indicated by the Next Sequence Index command executed by the external trigger. But, if the following Next Sequence Index command is not sent, and then the external trigger is input, the same index table is executed again.

7.8.6 Associated GenICam register information

Table – 56 Associated GenICam register information

GenICam Name	Access	Values	Category
Video Send Mode Selector	R/W	Normal Mode Trigger Sequence Command Sequence Multi Mode	JAI-Custom
Sequence ROI Index	R/W	Index 0 to Index 9	JAI-Custom
Sequence Repetition	R/W	1 to 255	JAI-Custom
Sequence ROI Frame Count	R/W	1 to 255	JAI-Custom
Sequence ROI Next Index	R/W	Index 0 to Index 9 Off	JAI-Custom
Sequence ROI Width	R/W	8 to 5120	JAI-Custom
Sequence ROI Height	R/W	2 to 3840	JAI-Custom
Sequence ROI OffsetX	R/W	0 to (5120 – Sequence ROI Width)	JAI-Custom
Sequence ROI OffsetY	R/W	0 to (3840 – Sequence ROI Height)	JAI-Custom
Sequence ROI Gain	R/W	100 to 1600	JAI-Custom
Sequence Exposure Time	R/W	10 to Acquisition Frame rate Raw	JAI-Custom
Sequence ROI H Binning	R/W	1 or 2	JAI-Custom
Sequence ROI V Binning	R/W	1 or 2	JAI-Custom
Sequence ROI LUT Enable	R/W	0 or 1	JAI-Custom
Sequence ROI Black Level	R/W	-256 to 255	JAI-Custom
Sequence ROI Gain Red (for Color Model)	R/W	-4533 to 17713	JAI-Custom
Sequence ROI Gain Blue (for Color Model)	R/W	-4533 to 17713	JAI-Custom
Next Sequence Index	R/W	Index 0 to Index 9	JAI-Custom

7.9. Operation and function matrix

Table - 46 Operation and function matrix

Exposure Mode	Trigger mode	Trigger Option	V-Binning (Note1)	H-Binning (Note1)	Exposure control	ROI	Auto White Balance (Note2)	Auto Gain	Auto Exposure	Trigger Overlap	Video Send Mode	
											Multi ROI	Sequence ROI
OFF (Note3)	OFF	OFF	1	1	×	○	○	○	×	×	○	×
			2	2	×	○	○	○	×	×	○	×
Timed (Note 3)	OFF	OFF	1	1	○	○	○	○	○	×	○	×
			2	2	○	○	○	○	○	×	○	×
Timed (Note 4)	ON	OFF	1	1	○	○	○	○	○	○	○	○
			2	2	○	○	○	○	○	○	○	○
Trigger Width (Note4)	ON	OFF	1	1	×	○	×	×	×	○	○	×
			2	2	×	○	×	×	×	○	○	×
Timed (Note4)	ON	PIV	1	1	○	○	×	×	×	×	○	×
			2	2	○	○	×	×	×	×	○	×

(Note1) SP-20000M-CXP2 only
(Note2) SP-20000C-CXP2 only
(Note3) Continuous trigger operation
(Note4) External trigger operation

8. Other functions

8.1 Black level control

This function adjusts the setup level.
Variable range: -256 to 255 LSB (at 10-bit output)

8.1.1 Black Level Selector

The following items can be adjusted.

Monochrome:	Black Level All
Color:	Black Level All/ Black Level Red/ Black Level Blue

8.1.2 Black Level

The black level can be adjusted in the following range.

Monochrome:	Black Level All : -256 ～+255
Color:	Black Level All : -256 ～+255
	Black Level Red: -128 ～+127
	Black Level Red: -128 ～+127

8.1.3 Auto black control

The auto black control function is used to automatically adjust the black level of the sensor, which may vary due to temperature changes and/or the exposure time.
It can adjust up to 30% of the video output level.

It has three modes which have different compensation values and the user can choose an appropriate mode depending on the application.
As the dynamic range of the sensor depends on the compensation value of the black level, for best results it is recommended that the camera be used under low temperature conditions, i.e., less than 30°C and with exposure times of less than 1 frame, in order to maintain an appropriate dynamic range.

Auto: The compensation value can be automatically varied up to 30%. In this mode, the dynamic range is the smallest.

Limit: In this mode, the limit of the black level compensation value can be set in the range of 0% to 30% by 1% steps. If the camera is used in an environment with little temperature change or short exposure time, this mode can automatically provide an appropriate balance between black level compensation and dynamic range by setting the upper limit of the black level compensation.

Fix: In this mode, the camera automatically saves the temperature and the status of the exposure time just before this mode is set. Then, it sets the appropriate black level compensation value and the maximum dynamic range in accordance with the saved conditions. After this automatic adjustment, the compensation value, which is indicated by percentage, can be read out.
In this mode, the black level compensation value is fixed. It is recommended to use this mode if the temperature and exposure time are stable. If the black level varies due to temperature change and/or exposure time variation, it is necessary to set this mode again in order to learn the new environmental conditions. If the environmental conditions are expected to be varied, it is recommended to use Auto or limit mode.

8.1.4 Associated GenICam register information

Table – 57 Associated GenICam register information

GenICam Name	Access	Values	Category
Black Level Selector	R/W	Digital All	Analog Control
Black Level Raw	R/W	-256 to 255	Analog Control

8.2 Gain control

The SP-20000M-CXP2 can adjust the master gain level (DigitalGainAll) from x1 (0dB) to 16 times (+24dB) using x1 (0dB) as the reference (Factory default).
In the SP-20000C-CXP2, the master gain level (DigitalGainAll) can be adjusted from x1 (0dB) to 16 times (+24dB) and R and B gains can be adjusted in the range of 0.45 times (-7dB) to 3.16 times (+ 10dB) using the master gain as the reference.

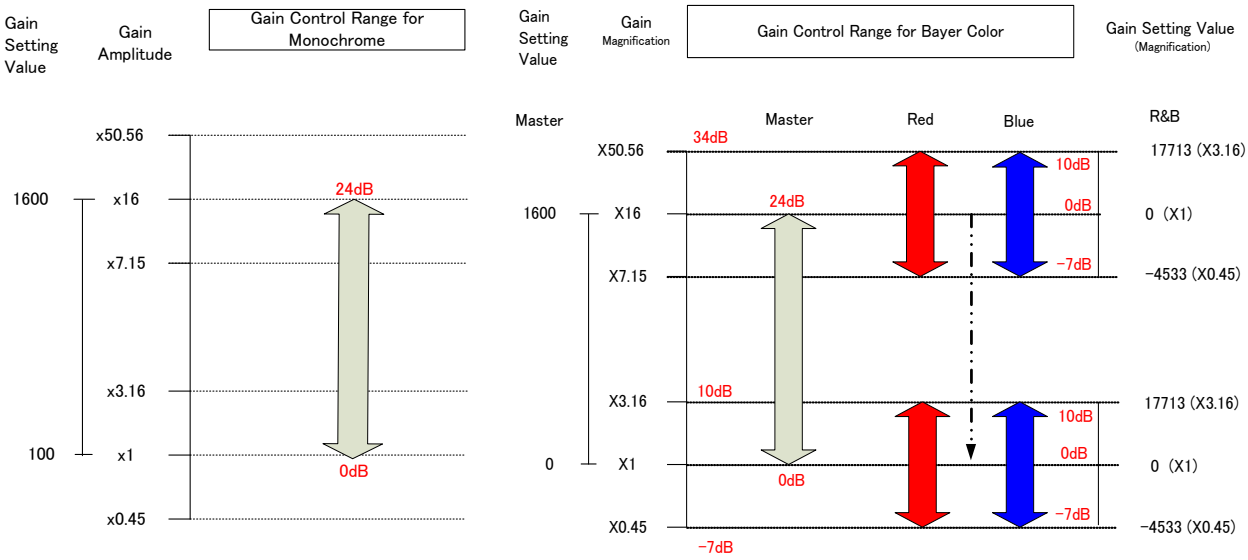
Resolution: Master Gain: x0.01 /Step
Blue/Red Gain: x0.00017 /Step

In the SP-20000-CXP2, the digital gain is entirely used for adjusting the gain. Therefore, if a high gain setting is used, breaks in the histogram may occur.

In the SP-20000C-CXP2, the color temperature adjusting range is specified in order to maintain the maximum dynamic range of the sensor. Therefore, if the white balance is adjusted out of the specified color temperature adjusting range and if the gain setting is less than the following conditions, the sensor output may clip before it is saturated.

The guideline for settings at which the sensor output is clipped
At Master Gain 0 dB: R/B Gain = -2995 (approx. x 0.6)
The guideline for R and B gain

Color temperature	R Gain setting	B Gain setting
3000K	-2110(approx. x 0.74)	16828(approx.. x 3)
9000K	18057(approx. x 3.2)	-2993(approx.. x 0.6)



The above drawing shows the relation among gain setting value (command), gain amplitude and dB indication. For example, the gain amplitude “x 3.16” equals 10dB.

Fig.37 Gain control

8.2.1 Gain Selector

The following parameters can be set.

Monochrome: Digital All
Color: Digital All / Digital Red/ Digital Blue

8.2.2 Gain

The range for adjustment is as follows.

Monochrome: Digital All : 100 ～ 1600 (0dB ～24dB)
Color: Digital All : 100 ～ 1600 (0dB ～24dB)
Digital Red: -4533 ～ +17713 (-7dB ～ +10dB)
Digital Blue: -4533 ～ +17713 (-7dB ～ +10dB)

8.2.3 Gain Auto

This provides automatic control of the gain level.
This is controlled by the command ALC Reference.
There are three modes.

OFF: Adjust manually.
Once: Operate only one time when this command is set
Continuous: Operate the auto gain continuously

The following detailed settings are also available.

ALC Speed: The rate of adjustment of Gain Auto can be set. (Common with Exposure Auto)
Gain Auto Max: The maximum value of Gain Auto control range can be set
Gain Auto Min: The minimum value of Gain Auto control range can be set
ALC Reference: The reference level of Gain Auto control can be set (Common with Exposure Auto)
ALC channel area: The measurement area of Gain Auto control can be set, either entire area or individual section (Common with Exposure Auto)

High Left	High Mid-left	High Mid-right	High Right
Mid-High Left	Mid-High Mid-left	Mid-High Mid-right	Mid-High Right
Mid-Low Left	Mid-Low Mid-left	Mid-Low Mid-right	Mid-Low Right
Low Left	Low Mid-left	Low Mid-right	Low Right

Fig.38 Detection area

8.2.4 Balance White Auto

This is a function to adjust white balance by controlling red and blue gain automatically.
The operation can be selected from the following methods.

OFF: Manual adjustment
Once: Performs auto white balancing once when this function is called.
Continuous: Continuously adjusts white balance.

The controlled area can be set in AWB Channel Area. This is the same as ALC channel area.

8.2.5 Associated GenICam register information

Table – 58 Associated GenICam register information

GenICam Name	Access	Values	Category
Gain Auto	R/W	Off Continuous Once	Analog Control
ALC Speed	R/W	1 to 8	JAI-Custom
ALC Reference	R/W	1 to 100	JAI-Custom
Gain Auto Max	R/W	100 to 1600	JAI-Custom
Gain Auto Min	R/W	100 to 1599	JAI-Custom
ALC Channel Area ALL	R/W	Off On	JAI-Custom
ALC Channel Area Low Right	R/W	Off On	JAI-Custom
ALC Channel Area Low Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Low Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Low Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Left	R/W	Off On	JAI-Custom
ALC Channel Area High Right	R/W	Off On	JAI-Custom
ALC Channel Area High Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area High Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area High Left	R/W	Off On	JAI-Custom

8.3. LUT

This function can be used to convert the input to the desired output characteristics.
The Look-Up Table (LUT) has 256 points for setup. The output level can be created by multiplying the

gain data by the input level.

8.3.1 LUT Enable

Can be selected from OFF, Gamma or LUT Table.

8.3.2 LUT Index

This represents the “starting” or “input” pixel value to be modified by the Lookup Table. The SP-20000-CXP2 has a 256-point Lookup Table, meaning the index points is treated like an 8bit image with 0 representing a full black pixel and 255 representing a full white pixel. The index points are automatically scaled to fit the internal pixel format of the camera. This is common for all output configuration.

8.3.3 LUT Value

This is the “adjusted” or “output” pixel value for a given LUT index. It has a range of 0 to 4095 (12-bit) and is automatically scaled to the bit depth of the current operating mode (8-bit or 10-bit).
Note: linear interpolation is used if needed to calculate LUT values between index points. In the color mode, the LUT function works the same regardless of the color of the pixel.

Output Data = Video IN x LUT data

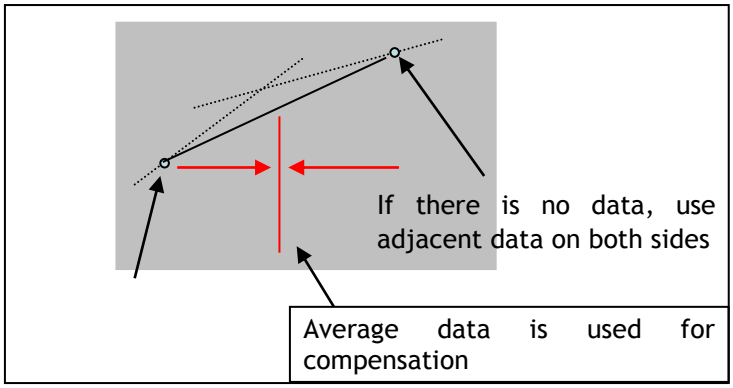


Fig.39 LUT data processing method

8.3.4 Associated GenICam register information

Table – 59 Associated GenICam register information

GenICam Name	Access	Values	Category
Gamma	R/W	0 to 15	Analog Control
JAI LUT Mode	R/W	Off Gamma LUT	Analog Control
LUT Selector	R/W	Mono (for mono) Red/Green/Blue (for Color)	LUT Control
LUT Index	R/W	0 to 255	LUT Control
LUT Value	R/W	0 to 4095	LUT Control

8.4 Gamma

This command is used set gamma between gamma 0.45 and gamma 1.0(OFF).
16 steps are provided. The gamma value is an approximate value.

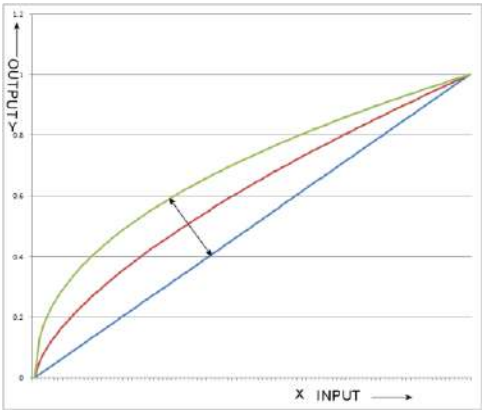


Fig.40 Gamma correction

8.5 Shading Correction

This function compensates for shading (non-uniformity) caused by the lens or the light source used. This compensation can be performed even if shading issues are not symmetrical in horizontal and/or vertical directions.

There are two methods of correction.

Flat shading correction:
The method to compensate the shading is to measure the highest luminance level in the image and use that data as the reference. Luminance levels of other areas are then adjusted so that the level of the entire area is equal. Compensation is performed using a grid of 20 blocks (H) x 15 blocks (V). Each block has 256 pixels x 256 pixels. The complementary process is applied to produce the compensation data with less error.

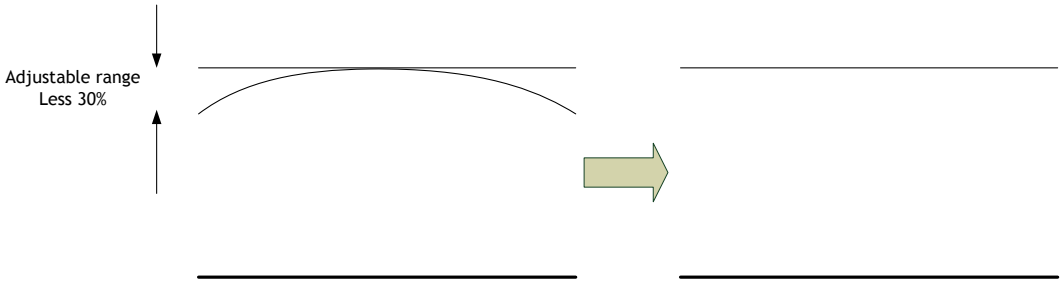
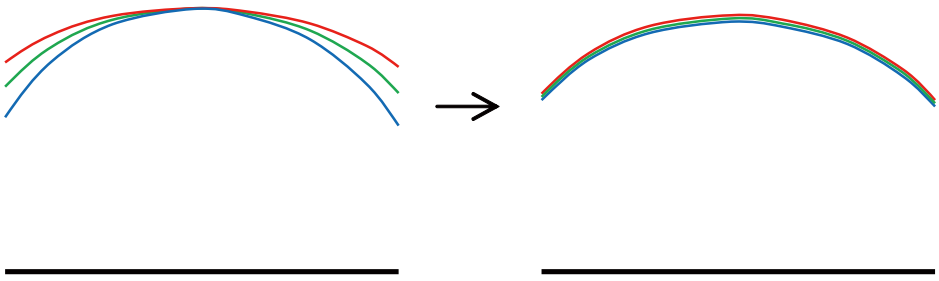


Fig.41 Concept drawing of Flat shading correction

Color shading correction (For SP-20000C-CXP2 only):
In this case, R channel and B channel are adjusted to match with G channel characteristics. The block grid for compensation is 20 blocks (H) x 15 blocks (V) and each block contains 256 x 256 pixels. The complementary process is applied to produce the compensation data with less error.



Before adjustment After adjustment

Fig. 42 Concept drawing of Color shading correction

Note: Under the following conditions, the shading correction circuit may not work properly.

- If there is some area in the image with a video level less than 70%
- If part of the image or the entire image is saturated
- If the highest video level in the image is less than 300LSB (at 10-bit output)

Table – 60 Associated GenICam register information

GenICam Name	Access	Values	Category
Shading Mode (Color Model Only)	R/W	Flat Shading Color Shading	JAI-Custom
Perform Shading Correct	WO	True	JAI-Custom
Shading Mode	R/W	Off User1 User2 User3	JAI-Custom

8.6 Blemish compensation

The SP-20000-CXP2 has a blemish compensation circuit. This function compensates blemishes on the CMOS 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 averaging the data from pixels in both adjacent columns and, in the case of the SP-20000C-CXP2, the defective pixels can be compensated by averaging the data from the same Bayer color pixels in adjacent columns. The number of pixels that can be compensated is up to 1000 pixels.

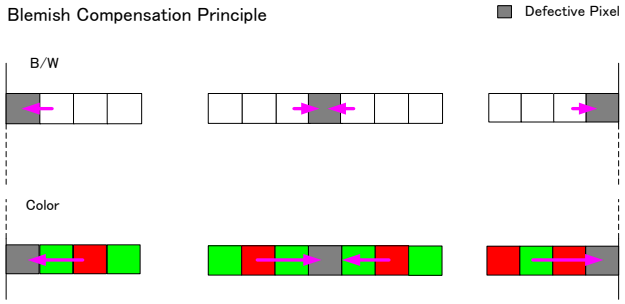


Fig. 43 Blemish compensation

If several defective pixels occur in series, 3 pixels in monochrome and 2 same color pixels in color can be compensated.

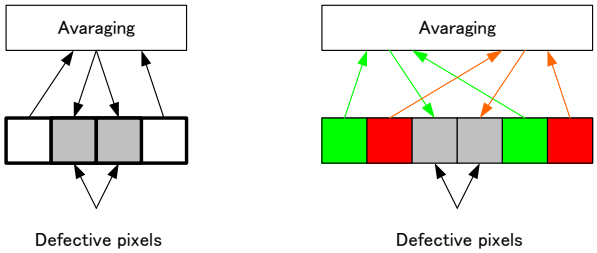


Fig. 44 Compensation if defective pixels are in series

Table – 61 Associated GenICam register information

GenICam Name	Access	Values	Category
Blemish Reduction Enable	R/W	False True	JAI-Custom
Blemish Reduction Calibration	WO	True	JAI-Custom
Blemish Detect Threshold	R/W	0 to 100	JAI-Custom
Blemish Detect Position Index	R/W	0 to 1000	JAI-Custom
Blemish Detect Position X	R/W	0 to 5119	JAI-Custom
Blemish Detect Position Y	R/W	0 to 3839	JAI-Custom

8.7 ALC

In the SP-20000-CXP2, auto gain and auto exposure can be combined to provide a wide ranging automatic exposure control from dark to bright or vice versa.
The functions are applied in the sequence shown below and if one function is disabled, the remaining function will work independently.

If the lighting condition is changed from bright to dark ASC — AGC
If the lighting condition is changed from dark to bright AGC — ASC

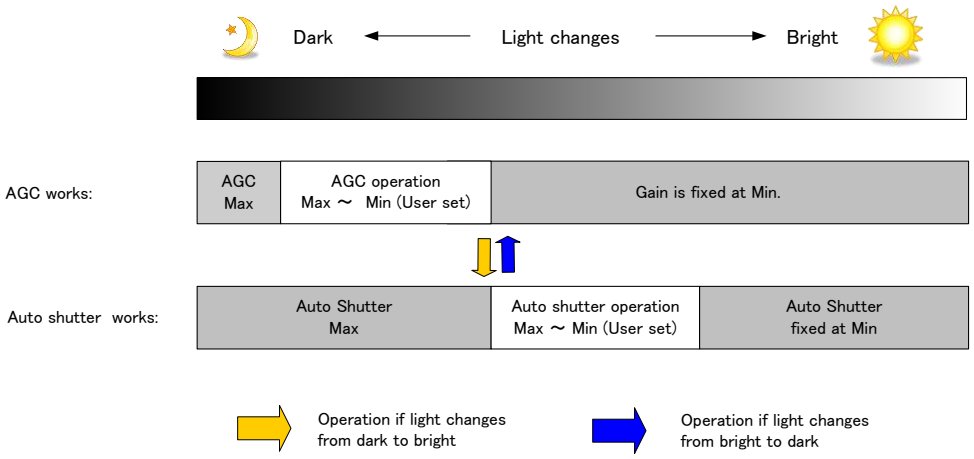


Fig.45 ALC function

ALCReference will determine the target video level for AGC and Auto Exposure. For instance, if ALCReference is set to 100% video level, AGC and/or Auto Exposure will function to maintain 100% video level.

Table - -62 Associated GenICam register information

GenICamName	Access	Values	Category
Exposure Auto	R/W	Off Continuous Once	Acquisition Control
Gain Auto	R/W	Off Continuous Once	Analog Control
ALC Speed	R/W	1 to 8	JAI-Custom
ALC Reference	R/W	1 to 100	JAI-Custom

ASC Max	R/W	101 to 8000000	JAI-Custom
ASC Min	R/W	100 to 999999	JAI-Custom
AGC Max	R/W	100 to 1600	JAI-Custom
AGC Min	R/W	100 to 1599	JAI-Custom
ALC Area Enable ALL	R/W	Off On	JAI-Custom
ALC Channel Area Low Right	R/W	Off On	JAI-Custom
ALC Channel Area Low Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Low Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Low Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle Low Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area Middle High Left	R/W	Off On	JAI-Custom
ALC Channel Area High Right	R/W	Off On	JAI-Custom
ALC Channel Area High Middle Right	R/W	Off On	JAI-Custom
ALC Channel Area High Middle Left	R/W	Off On	JAI-Custom
ALC Channel Area High Left	R/W	Off On	JAI-Custom

9. Camera Settings

9.1 Camera Control Tool

In the SP-20000-CXP2, control of all camera functions is done by the JAI SDK and Control Tool software. All controllable camera functions are stored in an XML file inside of the camera. The JAI SDK and Control Tool software can be downloaded from www.jai.com.

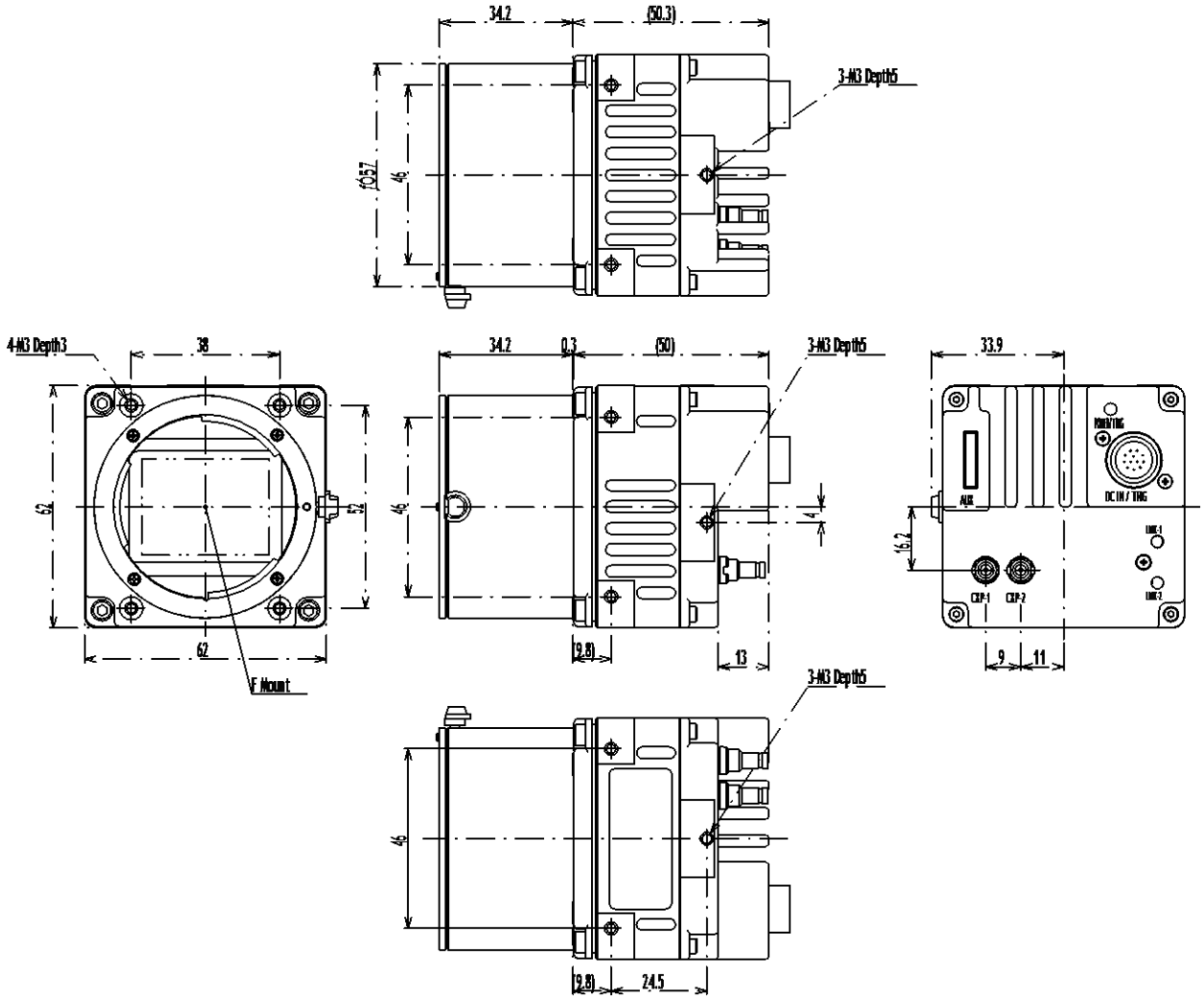
9.2 Camera Default Settings

When the camera is connected to PC and start up JAI_SDK, camera setting data (XML file) is downloaded to the camera.

The following table shows default settings of basic functions.

Image Format	Bit allocation	8-bit
	Width	5120
	Height	3840
	Binning Horizontal	1(OFF)
	Binning Vertical	1(OFF)
Link Configuration		CXP3_X2 (Dual)
Acquisition Control	Acqusition Mode	Continuous
	Acquisition Frame Rate	15Hz
Trigger Selector		Acqusition Start
	Trigger Mode	OFF
	Trigger Activation	Rising Edge
	Trigger Source	Low
Trigger Overlap		OFF
Exposure Control	Exposure Mode	Timed
Gain	Gain	1
	Gain Auto	OFF
Gamma		0.45
Video Send Mode		Normal

10. External appearance and dimensions



Dimensions tolerance : ±0.3mm
Unit : mm

Fig. 47 Appearance and Dimensions

11. Specifications

11.1. Camera spectral response

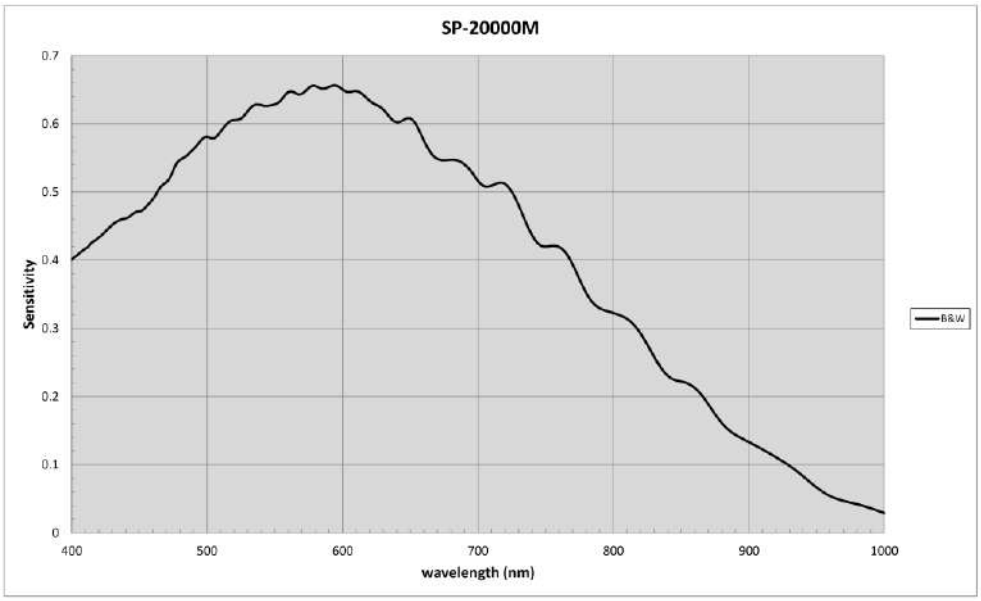


Fig.48 SP-20000M-CXP2 Spectral response

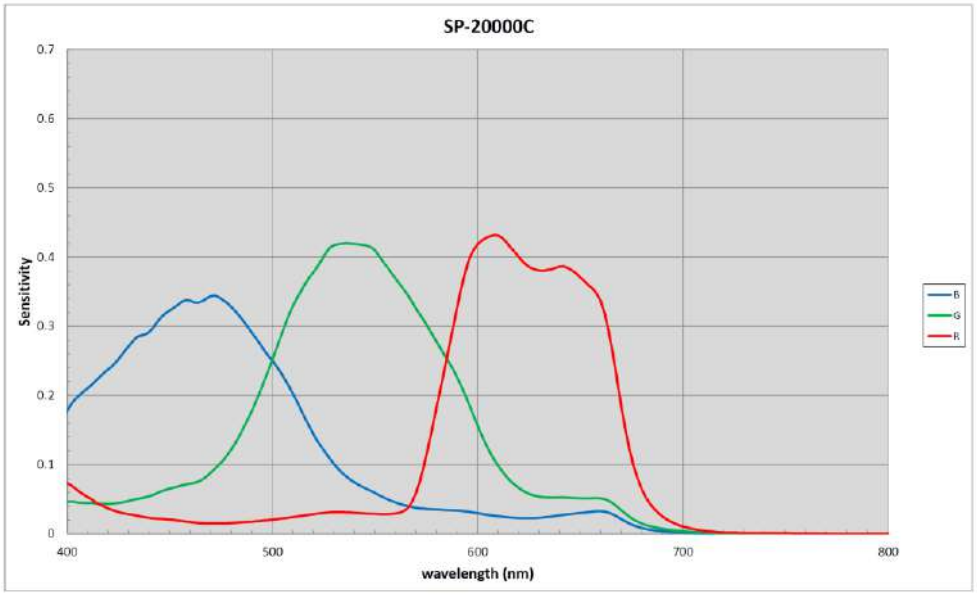


Fig.49 SP-20000C-CXP2 Spectral response (With IR Cut Filter)

11.2. Specification table

Specifications			SP-20000M-CXP2	SP-20000C-CXP2
Scanning system			Progressive scan, 1-tap output	
Synchronization			Internal	
Interface			CoaXPress (JIIA NIF-011-2010 CoaXPress Standard first edition) 6.25 Gbps, 2 Link PoCXP compliance	
Image sensor (CMV-20000)			35mm Monochrome CMOS	35mm Bayer color CMOS
Aspect ratio			4:3	
Effective image size			32.77 (h) x 24.58 (v) mm 41mm diagonal	
Cell size			6.4 (h) x 6.4 (v) μm	
Effective Image output pixel			5120 (h) x 3840 (v)	5120 (h) x 3840 (v)
Pixel clock			40 MHz (CXP6_X2,CXP6_X1,CXP3_X2) and 20 MHz (CXP3_X1)	
Link Configuration			CXP6_X2 Dual 6.25 Gbps CXP6_X1 Single 6.25 Gbps CXP3_X2 Dual 3.125 Gbps CXP3_X1 Singal 3.125 Gbps	
Tap Geometry			1X-1Y	
Acquisition Frame rate	CXP6_X2		30 fps (Max) to 8 sec (Min) : 12-bit	30 fps (Max) to 8 sec (Min) : 12-bit
			–	15 fps (Max) to 8 sec (Min) : RGB 8-bit
	CXP6_X1		15 fps (Max) to 8 sec (Min) : 12-bit	15 fps (Max) to 8 sec (Min) : 12-bit
			–	7.5 fps (Max) to 8 sec (Min) : RGB 8-bit
	CXP3_X2		15 fps (Max) to 8 sec (Min) : 12-bit	15 fps (Max) to 8 sec (Min) : 12-bit
			–	7.5 fps (Max) to 8 sec (Min) : RGB 8-bit
	CXP3_X1		7.5 fps (Max) to 8 sec (Min) : 12-bit	7.5 fps (Max) to 8 sec (Min) : 12-bit
EMVA 1288 Parameters Absolute sensitivity Maximum SNR			10-bit output format 16.05 p (λ = 525 nm) 40.24dB	10-bit output format 18.14 p (λ = 530 nm) 38.32dB
SN ratio (Traditional Method)			53 dB (Typical) (0dB gain, Black))	51 dB (Typical) (0dB gain, Green Pixel Black)
Image Output Format Digital	Full image		5120 (h) x 3840 (v)	Bayer 5120 (h) x 3840 (v)
	ROI	Height	2 ～3840 lines, 2 line / step	2 ～3840 lines, 2 lines / step
		OFFSET Y	0 ～3838 lines, 2 line / step	0 ～3838 lines , 2 lines / step
		Width	8 ～ 5120 pixels, 8 pixel/step	8 ～ 5120 pixels, 8 pixel/step
		OFFSET X	0 ～ 5112 pixels, 8 pixel/step	0 ～ 5112 pixels, 8 pixel/step
	Binning	H-1	5120 pixels (H)	5120 pixels (H)
		H-2	2560 pixels (H) * Frame rate is not changed	–
		V-1	3840 lines (V)	3840 lines (V)
		V-2	1920 lines (V) * Frame rate is not changed	–
	Pixel format		8-bit , 10-bit ,12-bit	Bayer 8-bit , 10-bit ,12-bit, RGB 8-bit(Only for CXP6_X2/X1 & CXP3_X2)
Video Send Mode			Normal mode,Trigger Sequence, Command Sequence, Multi ROI	
Acquisition Mode			Continuous / Single frame / Multi frame	
Trigger selector	Acquisition		Acqusition Start / Acquisition End	
	Exposure		Frame Start	
Trigger option			OFF (Timed), PIV(Timed PIV)	
Trigger Overlap			OFF , Overlap ON (Only for Frame Start),	

Trigger input signal		Line4(TTL 1), Line 5 (Opt In 1), Line 7 (CXP IN), Pulse Generator 0/1/2/3 Soft Trigger, Line 10 (TTL 2), Line 11 (LVDS)	
Exposure Mode	Timed	299 µs (Min) ～ 8 sec. (Max), Step: 1 µs	
	Trigger Width	299 µs (Min) ～ ∞ (Max)	
Auto exposure		OFF / Once / Continuous - 100 µs (Min) ～ 8 sec. (Max)	
Exposure Auto response speed		1 ～ 8	
Digital I/O		Line Selector (12-Pin and AUX 10-Pin): GPIO IN / GPIO OUT	
Black level adjust	Reference	33.5LSB 10-bit (Average of 100*100)	
	Adj. range	-256 ～ 255LSB 10bit	
	Resolution	1 STEP = 1LSB	
Auto Black Control	Mode	Auto, Limit, Fix	
	Limit	0% to 30%	
Gain Adjust	Manual adj. range	0dB ～+24dB, 0.01dB/step	0dB ～+24dB、0.01dB/step
	WB gain	—	R / B : -7dB to +10dB, 0.01dB/ step
	WB area	—	4 x 4
	Preset xcolor temp.	—	4600K, 5600K, 6500K
	WB range	—	3000K ～ 9000K
	White balance	—	OFF, Once, continuous
Blemish comp.	Detection	Detect white blemish above the threshold value (Black blemish is detected only by factory)	
	Compensation	Complement by adjacent pixels	
	Correct Numbers	Up to 1000 pixels	
ALC		AGC and Auto Exposure can be combined and automatically controlled	
Gamma		0.45 ～ 1.0 (8 steps are available)	
LUT		OFF: γ=1.0, ON= 256 points can be set	
Shading compensation		Flat field Block based （256 x 256 pixels）	Flat field, Color shading Block based （256 x 256 pixels）
Color interpolation			3 x 3 matrix, Linear compensation
Power supply	Power input	DC+12V to +24V ± 10% (at the input terminal)	
	Current	660mA ± 10% (12V input, Normal operation at CXP6_X2, 30 fps)	
	Power consumption	7.9W ± 10% (12V input, Normal operation at CXP6_X2, 30 fps)	
Lens mount		F mount, Rear protrusion of the lens is less than 40mm.	
Flange back		F mount : 46.5 mm, Tolerance 0 to -0.05 mm	
Optical filter		Protection glass : Not provided	Optical Low Pass filter ＋ IR cut filter (Half value is 670nm)
Operating temperature / Humidity (Performance guaranteed)		-5°C to +45°C / 20 – 80% (no-condensing)	
Operating temperature / Humidity		-45°C to +70°C / 20 – 80% (no-condensing)	
Storage Temp. / Humidity		-45°C to +70°C / 20% - 80 % (no-condensing)	
Regulation		CE (EN61000-6-2 and EN61000-6-3), FCC part 15 class B, RoHS, WEEE	
Housing Dimensions		62 x 62 x 84.5 mm (W x H x D) (excluding protrusion)	
Weight		350 g	

Note 1) Approximately 5 minutes pre-heating is required to achieve these specifications.
Note 2) The above specifications are subject to change without notice.

Appendix

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.
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.
Power off the camera during any modification such as changes of jumper and switch setting.

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 CMOS camera captures stripes, straight lines or similar sharp patterns, jagged edges may appear on the monitor.

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 using sea shipment instead of air flight in order to limit the influence of cosmic rays on the camera. Pixel defects/blemishes also may 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 on the video monitor screen.

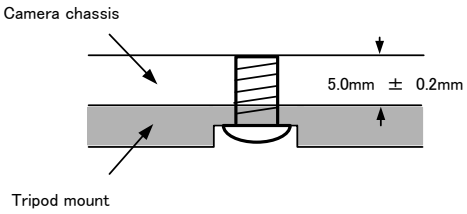
3. Caution when mounting a lens on the camera

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.

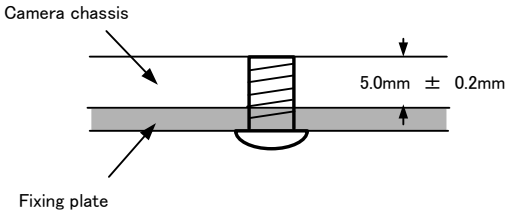
4. Caution when mounting the camera

When you mount the camera on your system, please make sure to use screws of the recommended length described in the following drawing. Longer screws may cause serious damage to the PCB inside the camera.

If you mount the tripod mounting plate, please use the provided screws.



Attaching the tripod mount



Mounting the camera to fixing plate

5. Exportation

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

6. References

1. This manual and a datasheet for SP-20000M-CXP2 / SP-20000C-CXP2 can be downloaded from www.jai.com
2. Camera control software can be downloaded from www.jai.com

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.

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GB/T 26572-2011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GB/T 26572-2011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。

Supplement

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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GB/T 26572-2011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GB/T 26572-2011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。

Manual change history

Date	Revision	Changes
Nov. 2013	1.0	New release
Jan. 2014	1.1	Correct weight and power consumption in the specifications table, Change the description in Sequence ROI trigger mode, Add GenICam register information to relative chapter, Addcautions to sections, 5.2.2.2, 7.1.2 and 8.2, Correct typo
June 2014	1.2	Review totaly
Sept. 2014	1.3	Revise Spectral Response, Correct Typo
Oct. 2014	1.4	Revise spectral response with wider wave length range
Mar. 2015	1.5	Add 12-bit function, HDR is an optional function
May 2015	1.6	Add the description of the optical inteface
June 2016	1.7	Remove HDR indication. HDR function is not avlilalbe.
Jan 2021	1.8	China RoHS

User's Record

Camera type: **SP-20000M-CXP2 / SP-20000C-CXP2**

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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