See the possibilities

Spark Series

User Manual

SP-5000M-USB
SP-5000C-USB

5M Digital Progressive Scan
Monochrome and Color Camera

Document Version: Ver.1.7
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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-5000M-USB and SP-5000C-USB 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.

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.

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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	×	○	○	○	○	○
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。
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数字「15」为期限15年。

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	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。
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数字「15」为期限15年。

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Before using this camera

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-5000-USB employs a USB 3.0 interface and is in the process of being certified for compliance with the USB3 Vision standard. USB3 Vision is a new standard interface for machine vision applications being developed and managed by the AIA (Automated Imaging Association). USB3 Vision uses USB 3.0 ports that will soon be standard on most PCs (with Windows 7 service pack and Windows 8 native support expected soon). Components from different manufacturers will easily communicate with each other.

USB3 Vision also supports the GenICam™ standard which is managed by the EMVA (European Machine Vision Association). The purpose of the GenICam standard is to provide a common program interface for various machine vision cameras. By using GenICam, cameras from different manufacturers can seamlessly connect in one platform.

The maximum transfer speed of USB 3.0 is specified at 5.0 Gbps, however effective bandwidth is reduced by a number of factors including pixel format conversions and the physical interface components used. The USB3 Vision standard specifies a bandwidth of 2.8 Gbps or greater. Maximum cable length for passive cables is five meters, but this can be made longer using active cables.

As for the USB connector, SP-5000-USB uses a Micro B connector which complies with USB 3.0. This connector has an additional 5-pin plug "stacked" on the side of a standard USB 2.0 Micro B connector. However, USB 2.0 cannot be used with the SP-5000-USB.

Power supply

Although the USB 3.0 interface is capable of supporting both data and power, the power supplied through the interface is not sufficient to operate the camera. A separate power supply unit must be connected to the 12-pin connector.
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Computer used for SP-5000-USB series

It is necessary to use a PC equipped with a USB 3.0 interface. It is also recommended to use a PC equipped with slots of better than PC Express 2.0 x 8. Please note that the SP-5000-USB may not work properly depending on the chipset used in the PC.

1. General

The SP-5000M-USB and SP-5000C-USB are new Spark Series high performance cameras with high resolution and a fast frame rate suitable for high speed machine vision applications. The SP-5000M-USB is a monochrome progressive scan CMOS camera and the SP-5000C-USB is the equivalent Bayer mosaic progressive scan CMOS camera. Both are equipped with a CMOS sensor offering a 1-inch optical format, a resolution of 5.24 million pixels, and a 5:4 aspect ratio. They provide up to 61.98 frames per second for continuous scanning with 2560 x 2048 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. The new cameras feature a USB3 Vision interface. A full pixel readout or partial scan readout mode can be selected depending on applications.

The SP-5000M-USB and SP-5000C-USB 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, shading compensation and blemish compensation in addition to fundamental functions such as trigger, exposure setting and video level control.

As a common Spark Series feature, a new connector for lens control is employed. SP-5000M-USB and SP-5000C-USB support P-iris and motor-driven lenses as standard lens control capabilities. Factory options are available to configure this connector to support DC iris systems, as well as provide a video iris output signal, or to provide additional TTL IN and OUT lines.

The latest version of this manual can be downloaded from: www.jai.com
The latest version of the Camera Control Tool for the SP-5000M-USB and SP-5000C-USB 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.

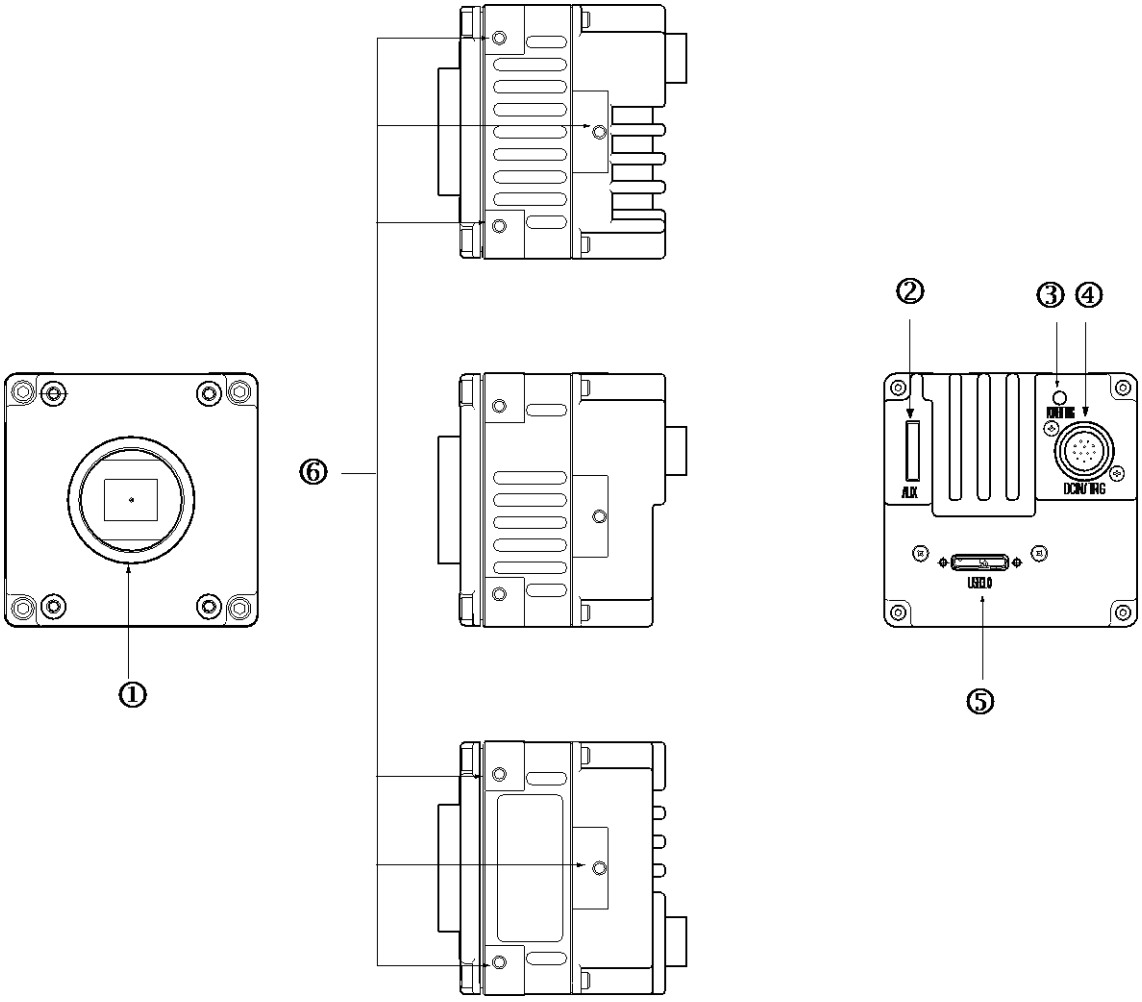
Tripod base	MP-42
Power supply unit	PD-12 series

3. Main features

- New Spark Series, 1” progressive scan camera
- Intelligent body design for easy and flexible installation
- Utilizes new USB 3.0 interface
- Aspect ratio 5:4, 2560(H) x 2048(V) - 5.2 million effective pixels
- 5 µm square pixels
- S/N 55 dB for monochrome and 50 dB for color
- 8-bit, 10-bit or 12-bit output for monochrome and Bayer
- 61.98 frames/second with full resolution in continuous operation (8-bit)
- Various readout modes, including horizontal and vertical binning (SP-5000M-USB only) and ROI (Region Of Interest) for faster frame rates
- 0 dB to +24 dB gain control for both SP-5000M-USB and SP-5000C-USB
- 10 µs (1/100,000) to 8 seconds exposure control in 1 µs step
- Auto exposure control
- Timed and trigger width exposure control
- RCT and PIV trigger modes for specific applications
- ALC control with combined function of AGC, auto exposure, and auto iris
- HDR (High Dynamic Range) function is available (SP-5000M-USB only)
- Various pre-processing circuits are provided
  - Programmable LUT
  - Gamma correction from 0.45 to 1.0
  - Shading correction
  - Bayer white balance with manual or one-push auto (SP-5000C-USB only)
  - Blemish compensation
- New Hirose 10P connector for lens interface including P-Iris lens control
- C-mount for lens mount
- Setup by Windows XP/Vista/7/8 via serial communication

4. Locations and functions

4.1 Locations and functions



①	Lens mount	C-mount (Note *1)
②	AUX 10-pin connector	AUX Connector for lens control
③	LED	Indicator for power and trigger input
④	12-pin connector	DC and trigger input
⑤	USB 3.0 connector	Connector for interfacing via USB 3.0
⑥	Mounting holes	Holes for mounting tripod base or direct installation. Depth 5 mm (Note*2)

Note1: Rear protrusion on C-mount lens must be less than 10.0 mm.
Note2: The part number for the tripod adapter plate (with 1/4"-20 thread) is MP-42 (option). When the camera is mounted directly using mounting holes, the length of screws must be less than 5mm. If they are longer than 5mm, they may not fasten securely due to the 5mm hole depth.

Fig. 1 Locations

4.2 Rear panel

The rear panel mounted LEDs provide the following information:

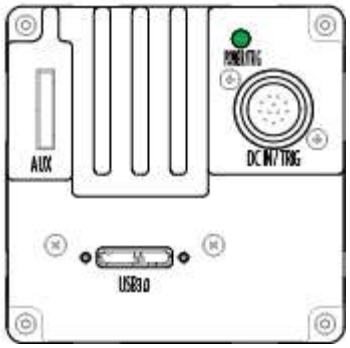


Fig. 2 Rear panel

POWER/TRIG

- Amber: Power connected – initiating
  This light goes OFF after initiating.
- 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.

5. Input and output

5.1 USB 3.0 Interface specifications

The SP-5000-USB employs a USB 3.0 interface for video and data transfer. USB 3.0 is an upgraded version of USB 2.0 widely used in the industry. Its transfer rate is 5 Gbps, which is 10 times faster than the 480 Mbps rate of USB 2.0. USB 3.0 employs a full-duplex system which executes both transmitting and receiving at the same time. USB 3.0 has downward compatibility to USB 2.0 but in the SP-5000-USB, USB 2.0 cannot be used because the performance is not guaranteed.
The connector used for USB 3.0 in the SP-5000-USB is a Micro B Type connector with a USB 3.0 form factor.

5.2 Connectors and pin assignment

5.2.1 Output connector for Digital Video Output (USB 3.0 Micro B connector)

Type : ZX3600-B-10p or equivalent

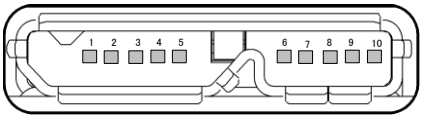


Fig.3 USB 3.0 Micro B Connector

No	I/O	Name	Note
1	I	Power(VBUS)	+5V
2	I/O	USB2.0 Differential pair(D-)	Differential pair
3	I/O	USB2.0 Differential pair(D+)	
4	I	USB OTG ID for identifying lines	Line identification ID
5		GND	
6	O	USB 3.0 Signal Transmission line (-)	Signal transmission line
7	O	USB 3.0 Signal Transmission line (+)	
8		GND	
9	I	USB 3.0 Signal Receiving line (-)	Signal Receiving line
10	I	USB 3.0 Signal Receiving line (+)	

5.2.2 12-Pin connector

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

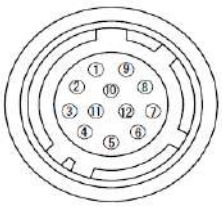


Fig.4 12-pin connector

Table 5. Hirose 12P pin assignment

Pin no.	I/O	Signal	Remarks
1		GND	
2	I	DC in	+12V ~ +24V
3		GND	
4		NC	
5	I	Opto in1-	Line5
6	I	Opto in1+	
7	O	Opto out1-	Line2
8	O	Opto out1+	
9	O	TTL out1	Line1 (Note1)
10	I	TTL In1	Line4 (Note2)
11	I	DC in	+12V ~ +24V
12		GND	

Note1: Factory default is Exposure Active, Negative
Exposure Active is positive polarity inside camera operation but it is converted to Negative by using the signal polarity function of TTL OUT 1 and output.
Note2: Factory default is Trigger In

5.2.3 AUX Standard Hirose 10-Pin connector

5.2.3.1 Figure and pin configuration

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

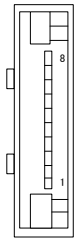


Fig.5 Hirose 10-pin connector

Table 6. Hirose 10P pin assignment (Standard)

No	I/O	Name	Note
1	O	DRIVE IRIS+	Motorized Lens
2	O	DRIVE FOCUS+	Motorized Lens
3	O	DRIVE ZOOM+	Motorized Lens
4	O	COMMON	Motorized Lens
5		GND	
6	O	P-IRIS OUT A+	P-Iris Lens
7	O	P-IRIS OUT A-	P-Iris Lens
8	O	P-IRIS OUT B+	P-Iris Lens
9	O	P-IRIS OUT B-	P-Iris Lens
10	O	GND	

5.2.4 AUX Type 2 HIROSE 10-Pin connector (factory option)

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

Table 7. Hirose 10P pin assignment (Option 1)

No	I/O	Name	Note
1	O	Video Signal	Video Iris Lens
2	O	Power DC+12V	Video Iris Lens
3		NC	
4		NC	
5		GND	
6	O	DC IRIS DAMP-	DC Iris
7	O	DC IRIS DAMP+	DC Iris
8	O	DC IRIS DRIVE+	DC Iris
9	O	DC IRIS DRIVE-	DC Iris
10		GND	

5.2.5 AUX Type 3 HIROSE 10-Pin connector (factory option)

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

Table 8. HIROSE 10P pin assignment

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/OUT interface

In the SP-5000M-USB and SP-5000C-USB, the digital IN/OUT capability in the software control tool can assign the necessary signals needed for the system.

5.3.1 Line Selector

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

Table 9. Line selector

Line Selector item	Description
Line 1 TTL 1 Out	TTL 1 output from #9 pin of DC In/Trigger 12-Pin on the rear
Line 2 Opt Out	Opt output from #7 & 8 pins of DC In/Trigger 12-Pin on the rear
Line 8 TTL 2 Out	TTL 2 output from #1pin “AUX” HIROSE 10-Pin on the rear (Factory option)
Line 9 TTL 3 Out	TTL 3 output from #2pin “AUX” HIROSE 10-Pin on the rear (Factory option)
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: Select and connect the line source signal against the item selected in the line selector.

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 10. 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
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
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
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
Line 4 TTL 1 In	Connect TTL 1 In signal to line 4 in Line Selector
Line 5 Opt In	Connect Opt In signal to line 5 in Line Selector
NAND 0 Out	Connect NAND 0 signal to line item selected in Line Selector
NAND 1 Out	Connect NAND 1 signal to line item selected in Line Selector
Line 10 TTL 2 In	Connect TTL 2 In signal to Line 10
Line 11 LVDS 1 In	Connect LVDS 1 In signal to Line 11

Note] As for LVAL, some line items cannot be connected. Refer to "5.3.7.2 GPIO matrix table"

5.3.3 Line Mode

Indicates the status of the interface, input or output.

5.3.4 Line Inverter

Sets the polarity of the selected input or output.

5.3.5 Line Status

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

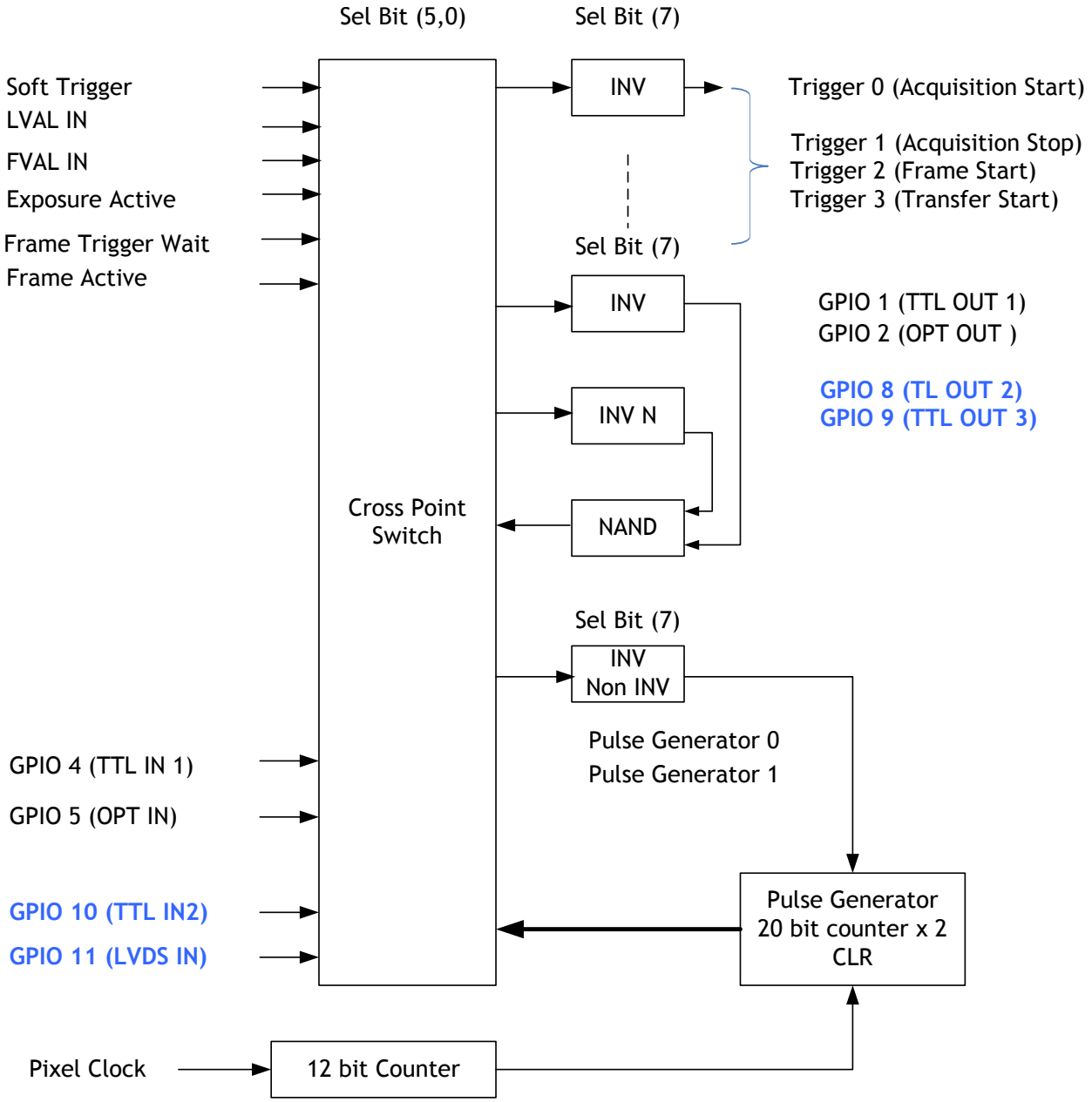
5.3.6 Line Format

Controls the format of the line item selected in Line Selector.
(No Connect, TTL, LVDS, Opto Coupled)

5.3.7 GPIO

This is a general interface for input and output and controls input and output for trigger signals or valid signals and pulse generator. By using this interface, you can control an external light source, make a delayed function to input a trigger signal or make a precise exposure control with PWC trigger.

5.3.7.1 Basic block diagram



Note: Items written in blue are available only if Type 3 is selected for AUX connector.

Fig. 6 GPIO

5.3.7.2 IN and OUT matrix table

The following table shows the input and output matrix table.

Table 11. GPIO IN and OUT matrix table

Selector (Cross point switch output) / Source signal (Cross point switch input)	Trigger Selector				Line Selector								Pulse Generator		
	Acquisition Start	Acquisition Stop	Frame Start	Acquisition Transfer Start	Line 1 - 12P TTL Out 1	Line 2 - 12P Opt Out 1	Line 8 - TTL 2 Out	Line 9 - TTL 3 Out	NAND 1 In 1	NAND 1 In 2	NAND 2 In 1	NAND 2 In 2	Pulse Generator 0	Pulse Generator 1	
LOW	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	
Software Trigger	O	O	O	O	×	×	×	×	O	O	O	O	×	×	
Exposure Active	×	×	×	×	O	O	O	O	O	O	O	O	O	O	
Frame Trigger Wait	×	×	×	×	O	O	O	O	O	O	O	O	O	O	
Frame Active	×	×	×	×	O	O	O	O	O	O	O	O	O	O	
FVAL	×	×	×	×	O	O	O	O	O	O	O	O	O	O	
LVAL	×	×	×	×	O	O	O	O	O	O	O	O	O	O	
Pulse Generator 0	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	×	
Line 4 - 12P TTL 1 In	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
Line 5 - 12P OPT In	O	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	O	
NAND 2 Out 1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
Line 10 - TTL 2 In	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Extension GPIO Connection
Line 11 - LVDS 1 In	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
	Trigger Source				Line Source								Pulse Generator Clear Source		

Note: Line 8, Line 9, Line 10, and Line 11 are only available if AUX Type 3 is used for AUX connector configuration.

5.4 Optical Interface

SP-5000-USB 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

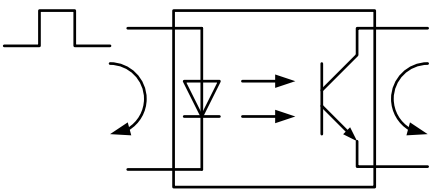


Fig.7 Photo coupler

5.4.1 Recommended External Input circuit diagram for customer

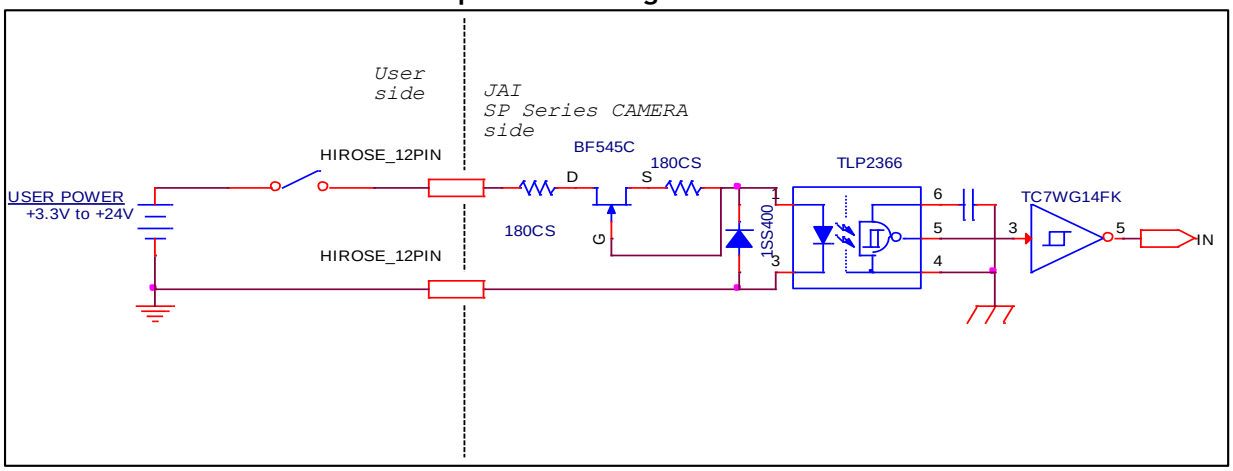


Fig.8 Example of external input circuit

5.4.2 Recommended External Output circuit diagram for customer

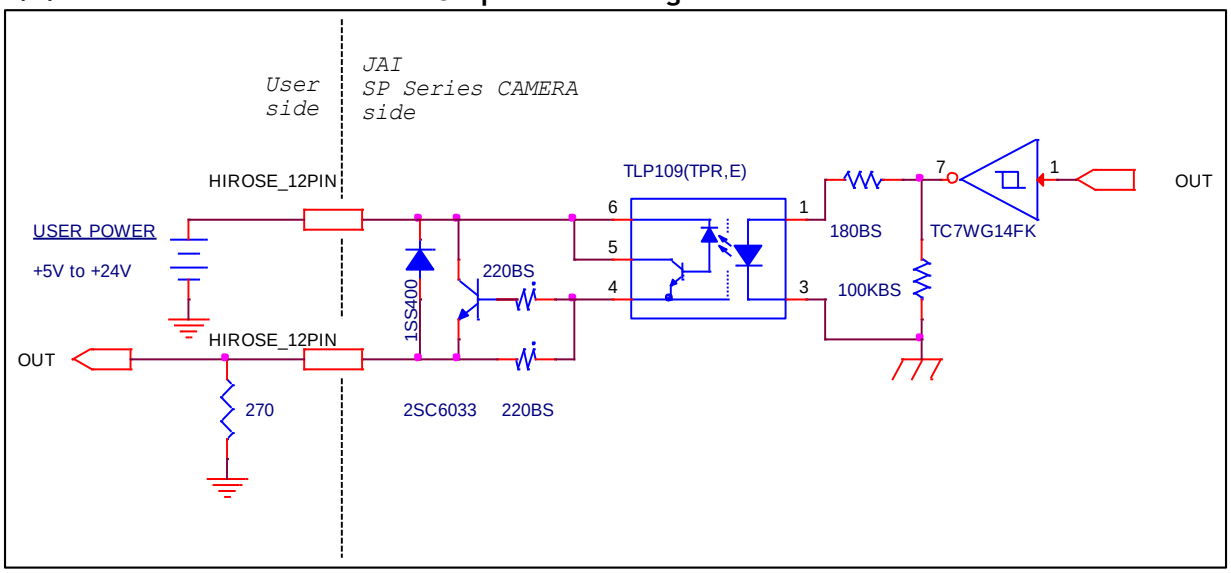
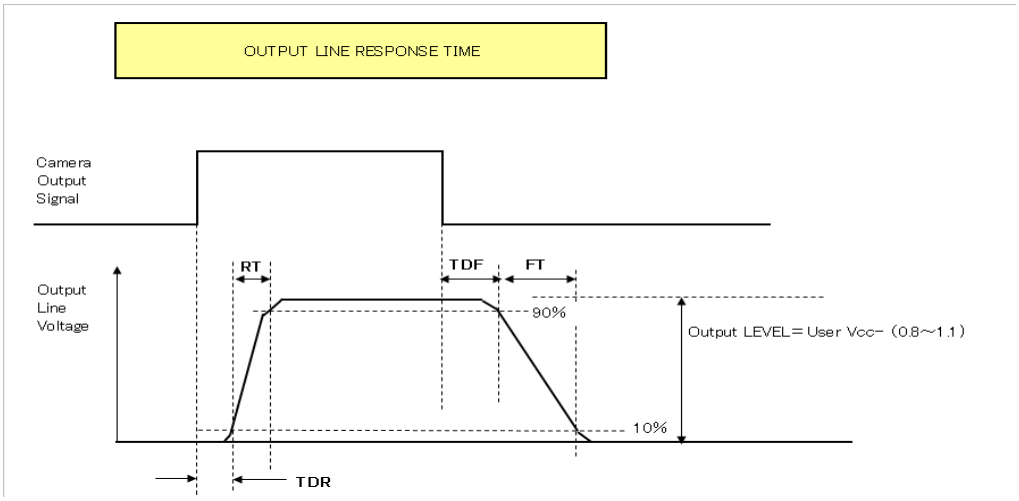


Fig.9 Example of external output circuit

5.4.3 Characteristics of optical interface

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

Input Line Voltage Range	3.3V ～ 24V
Input Current	6mA ～ 30mA
Output Load(Maximum Current)	100mA
Minimum Input Pulse Width to turn ON	0.5μs
Minimum Output Pulse Width	20μs



270Ω Termination	User Power (VCC)
	3.3V ～ 24V
Time Delay Rise TDR (us)	0.5V ～ 0.7V
Rise Time RT (us)	1.2V ～ 3.0V
Time Delay Fall TDF (us)	1.5V ～ 3.0V
Fall Time FT (us)	4V ～ 7V

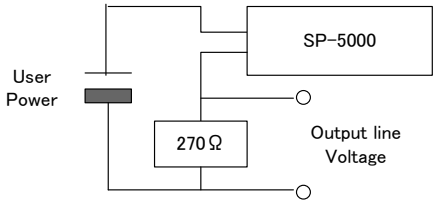


Fig.10 Optical interface characteristics

5.5 Pulse Generator

The SP-5000-USB has a frequency divider using the pixel clock as the basic clock and two pulse generators. In each Pulse Generator, various Clear settings are connected to GPIO.
The following shows Pulse Generator default settings.

Table12. Pulse Generator default settings

Display Name	Value							
Clock Pre-scaler	1							
Pulse Generator Selector	Pulse Generator							
	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

Note: When Pulse Generator Repeat Count is set to “0”, the camera is operating in Free Running mode.
However, based on the above default setting, 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 pixel clock is used for this. Two built-in pulse generators work by the same clock. In the SP-5000-USB, the pixel clock is 48 MHz.

5.5.2 Pulse Generator Selector

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

Table13. 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.

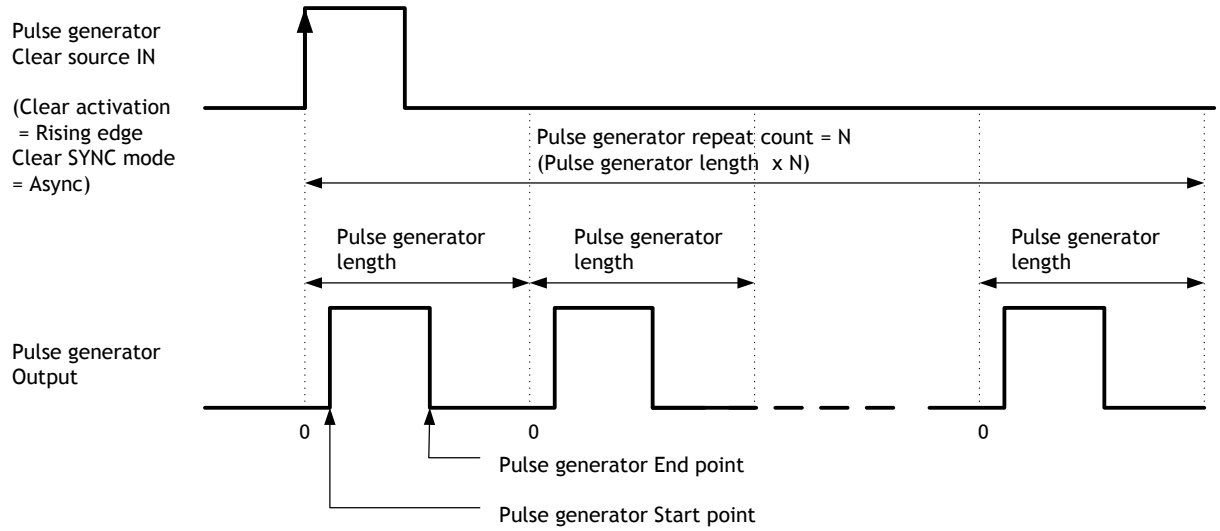


Fig.11 Pulse Generator Pulse construction

5.5.3 Pulse Generator Length

Set the counter up value (number of clocks, refer to Table 14) 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 can occur for the clock which is divided in the clock pre-scaler.

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 a Free-Running counter.

5.5.7 Pulse Generator Clear Activation

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

5.5.8 Pulse Generator Clear Sync Mode

Set the clear count method for the selected pulse generator. In the 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 the 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.

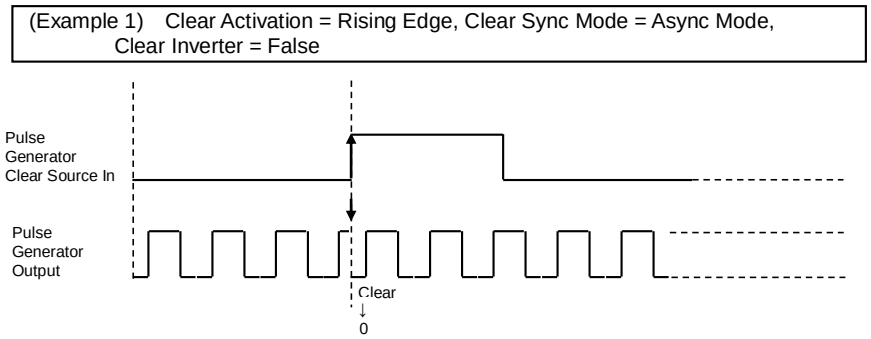


Fig.12 Counter clear in Async mode

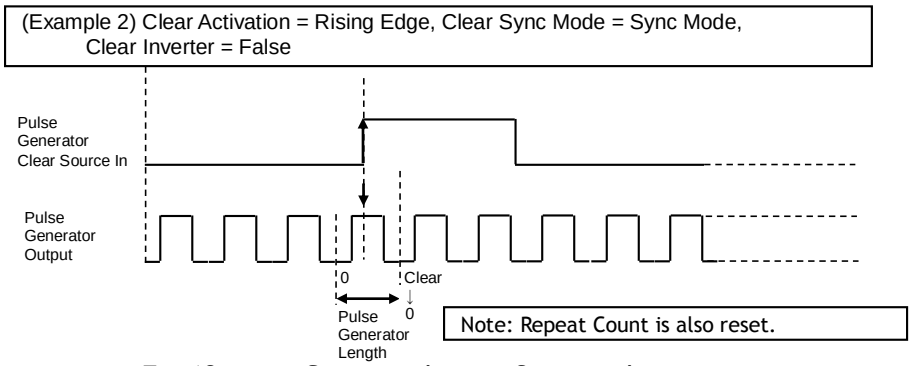


Fig.13 Counter clear in Sync mode

5.5.9 Pulse Generator Clear Source

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

Table14. 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.
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.
Line 4 TTL 1 In	Connect TTL 1 In signal to Clear Source for the selected pulse generator.
Line 5 OPT in	Connect Opt In signal to Clear Source for the selected pulse generator.
NAND 0 Out	Connect NAND 0 output signal to Clear Source for the selected pulse generator.
NAND 1 Out	Connect NAND 1 output signal to Clear Source for the selected pulse generator.
Line 10 TTL 2 In	Connect TTL 2 In signal to LINE 10.
Line 11 LVDS 1 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 “5.3.7.2. Table 10”.

5.5.10 Pulse Generator Inverter

Clear Source Signal can have polarity inverted.

5.5.11 Pulse Generator Setting Parameters

Table15. Pulse Generator setting parameters

Display Name	Value
Clock Pre-scaler	1 to 4096
Pulse Generator Clock (MHz)	[Pixel Generator Tick Frequency: 72MHz]÷[Clock Pre-scaler]
Pulse Generator Selector	- Pulse Generator 0
	- Pulse Generator 1
- 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
	- Frame Trigger Wait
	- Frame Active
	- Exposure Active
	- Fval
	- Lval
	- PulseGenerator0
	- PulseGenerator1
	- TTL_In1
	- OPT In
	- NAND0 Out
	- NAND1 Out
	- 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.

6. Sensor layout, output format and timing

6.1 Sensor layout

CMOS sensors used in the SP-5000M-USB and SP-5000C-USB have the following tap and pixel layout.

6.1.1 Monochrome sensor

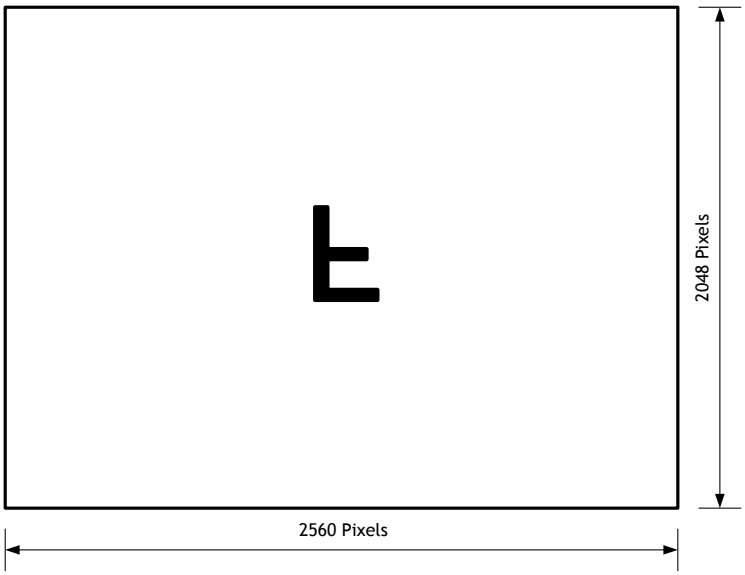


Fig.14 Monochrome sensor layout

6.1.2 Bayer color sensor

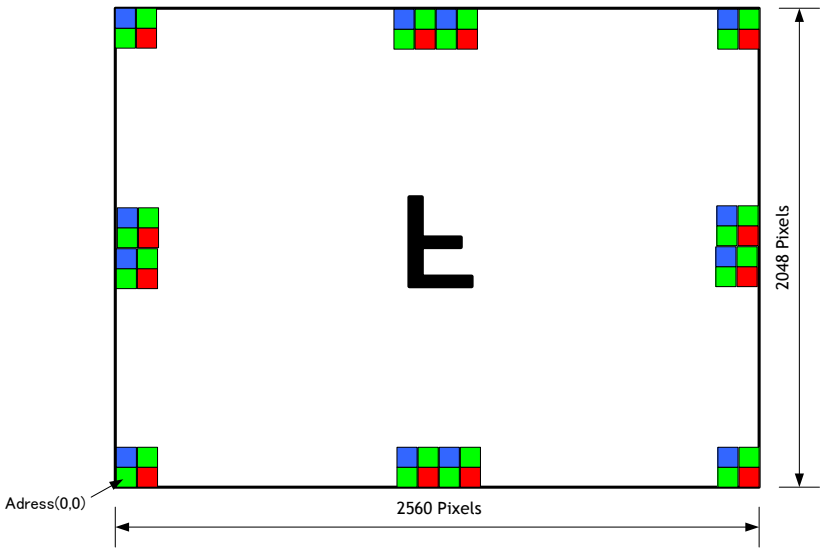


Fig.15 Bayer color sensor layout

6.2. Camera output format

The following table shows the relationship between camera output and sensor readout system.

Camera output format	Sensor readout system	Reference figure
1X-1Y	1-tap readout	6.2.1

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

6.2.1 1X-1Y

1X-1Y is defined in GenICam SFNC Ver.1.5.1 for 1-tap readout and the readout system is the following.

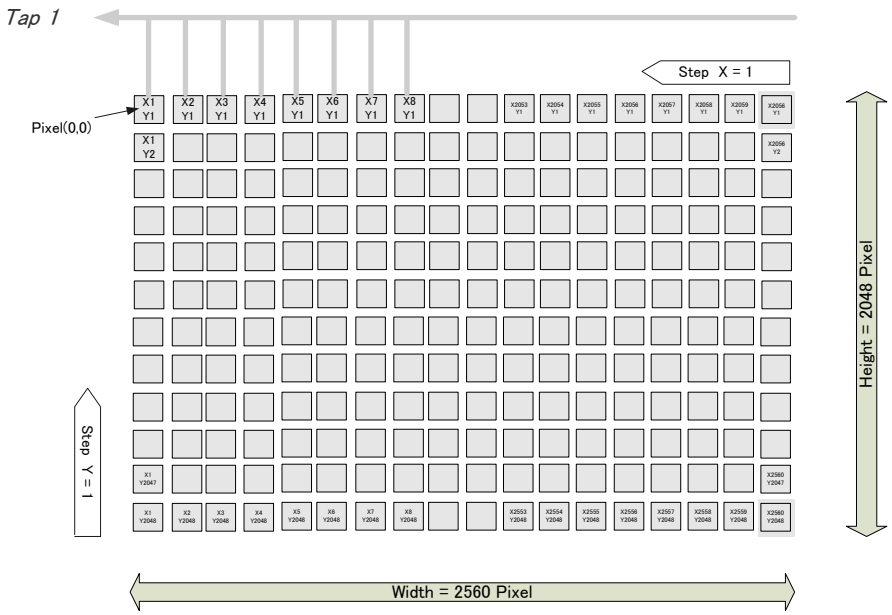


Fig.16 1X – 1Y readout

6.3 Pixel Format

6.3.1 Pixel Format

Model	Supported Pixel Formats
SP-5000M-USB	Mono8, Mono10, Mono10_Packed, Mono 12, Mono12_Packed
SP-5000C-USB	BayGR8, BayGR10, BayGR12, BayGR10_Packed, BayGR12_Packed

6.3.2 SP-5000M-USB Pixel Type

6.3.2.1 GVSP_PIX_MONO8 8-bit output

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

6.3.2.2 GVSP_PIX_MONO10 10-bit output

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

6.3.2.3 GVSP_PIX_MONO10_PACKED 10-bit output

Y0								Y0		Y1					Y1					Y2				Y2					Y3							Y3						
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9

6.2.2.4 GVSP_PIX_MONO12 12-bit output

Y0								Y0								Y1								Y1							
0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X	0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X

6.2.2.5 GVSP_PIX_MONO12PACKED 12-bit output

Y0												Y1												Y2												Y3											
4	5	6	7	8	9	10	11	0	1	2	3	0	1	2	3	4	5	6	7	8	9	10	11	4	5	6	7	8	9	10	11	0	1	2	3	0	1	2	3	4	5	6	7	8	9	10	11

6.3.3 SP-5000C-USB Pixel Type

6.3.3.1 GVSP_PIX_BAYGR8 8-bit output

odd Line

G0								R1								G2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

Even Line

B0								G1								B2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

6.3.3.2 GVSP_PIX_BAYGR10 10-bit output

Odd Line

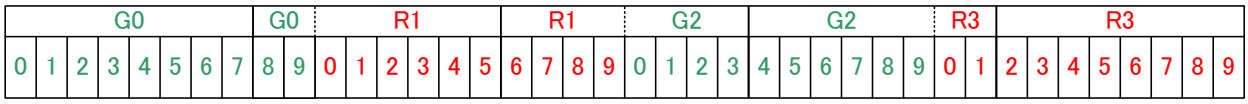
G0								G0								R1								R1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

Even Line

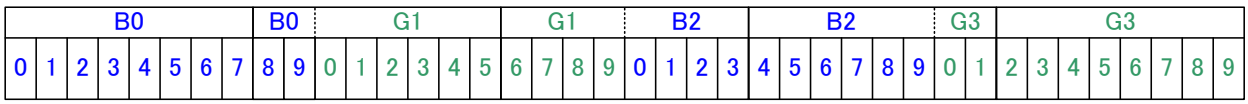
B0								B0								G1								G1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

6.3.3.3 GVSP_PIX_BAYGR10_PACKED 10-bit output

Odd Line

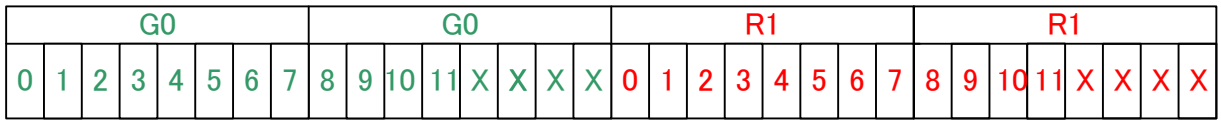


Even Line

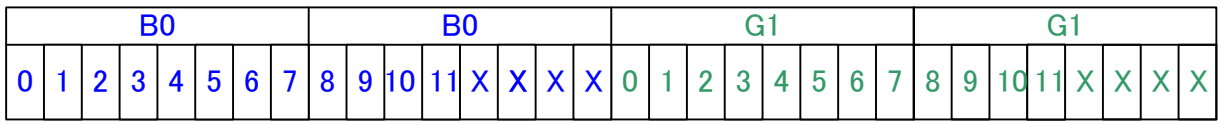


6.2.3.4 GVSP_PIX_BAYERBG12 12-bit output

Odd Line

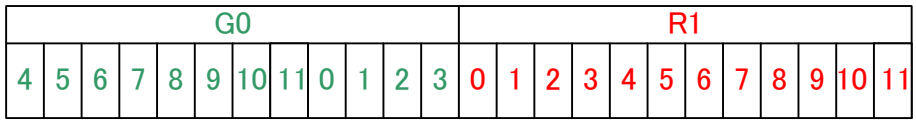


Even Line

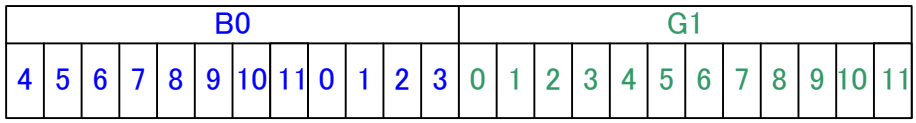


6.2.3.5 GVSP_PIX_BAYERBG12PACKED 12-bit output

Odd Line



Even Line



6.3.4 PixelSize

Table16. Pixel size

Pixel size	Pixel Format	
	SP-5000M-USB2	SP-5000C-USB2
Bpp8	Mono8	BayerBG8
Bpp10	Mono10Packed	BayerBG10Packed
Bpp12	Mono12Packed	BayerBG12Packed
Bpp16	Mono10 Mono12	BayerBG10 BayerBG12

6.4 Output timing

6.4.1 Horizontal timing

The horizontal timing of the SP-5000-USB is described below. Although the SP-5000-USB has a horizontal binning function, its horizontal frequency does not change if it is ON. So, the frame rate is not increased.

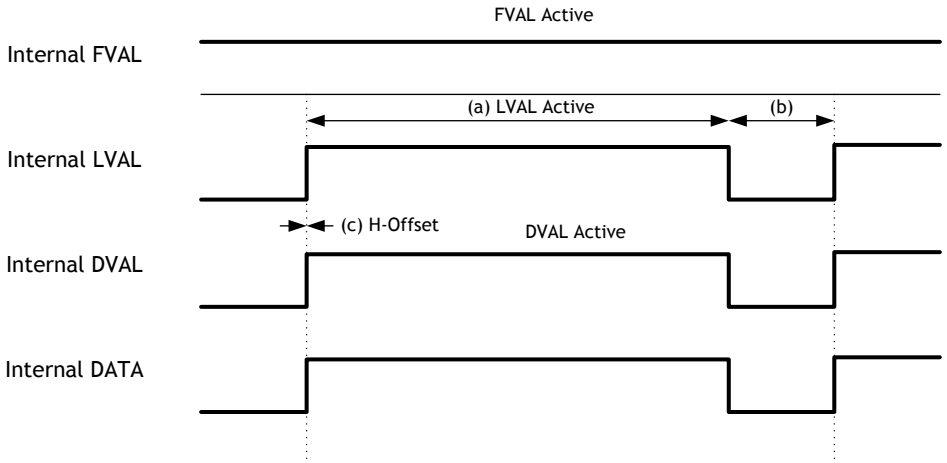


Fig.17 Horizontal Timing (Vertical timing OFF)

Table - 17 Timing parameters in Continuous Trigger mode

Camera Settings								(a) LVAL Active	(b) LVAL Non-Active	(c) H-Offset
Tap Geometry	Pixel Clock	ROI				Binning				
		Width	Offset X	Height	Offset Y	Horizontal	Vertical	[Unit: Clock]	[Unit: Clock]	[Unit: Clock]
8-Bit	48 MHz	2560	0	2048	0	1 (Off)	1 (Off)	320	14	0
		1280	0	2048	0	2 (On)	1 (Off)	160	174	0
		2560	0	1024	0	1 (Off)	2 (On)	320	14	0
		1280	0	1024	0	2 (On)	2 (On)	160	174	0
10-Bit	48 MHz	2560	0	2048	0	1 (Off)	1 (Off)	320	82	0
		1280	0	2048	0	2 (On)	1 (Off)	160	242	0
		2560	0	1024	0	1 (Off)	2 (On)	320	82	0
		1280	0	1024	0	2 (On)	2 (On)	160	242	0
12Bit	48 MHz	2560	0	2048	0	1 (Off)	1 (Off)	320	166	0
		1280	0	2048	0	2 (On)	1 (Off)	160	326	0
		2560	0	1024	0	1 (Off)	2 (On)	320	166	0
		1280	0	1024	0	2 (On)	2 (On)	160	326	0

6.4.2 Vertical timing

The vertical timing of the SP-5000-USB is described below.

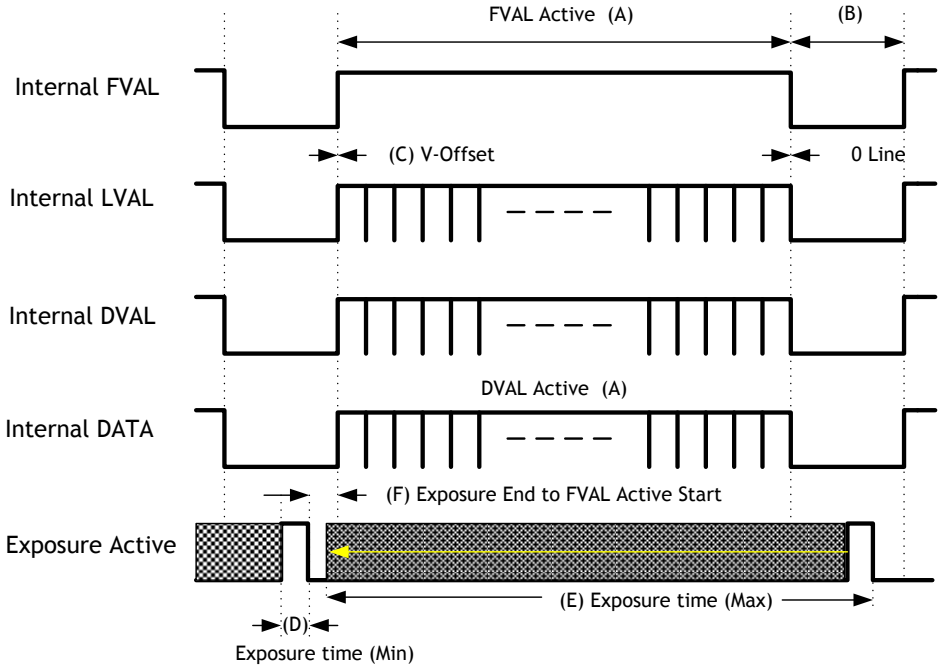


Fig.19 Vertical Timing (Vertical binning OFF)

Table - 18 Timing parameters in Continuous Trigger mode

Camera Settings									(A)	(B)	(C)	(D)
Tap Geometry	Pixel Clock	Frame Period (Typ.)	ROI				Binning		FVAL & DVAL 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				
8-Bit	48 MHz		2560	0	2048	0	1 (Off)	1 (Off)	2048	5	0	10
			2560	0	1024	0	1 (Off)	2 (On)	1024	5		
			1280	0	2048	0	2 (On)	1 (Off)	2048	5		
			1280	0	1024	0	2 (On)	2 (On)	1024	5		
10-Bit	48 MHz		2560	0	2048	0	1 (Off)	1 (Off)	2048	5	0	10
			2560	0	1024	0	1 (Off)	2 (On)	1024	5		
			1280	0	2048	0	2 (On)	1 (Off)	2048	5		
			1280	0	1024	0	2 (On)	2 (On)	1024	5		
12Bit	48 MHz		2560	0	2048	0	1 (Off)	1 (Off)	2048	5	0	10
			2560	0	1024	0	1 (Off)	2 (On)	1024	5		
			1280	0	2048	0	2 (On)	1 (Off)	2048	5		
			1280	0	1024	0	2 (On)	2 (On)	1024	5		

6.4.3 ROI (Region Of Interest) setting

In the SP-5000-USB, 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-5000-USB, the minimum width is “16” and minimum height for SP-5000M-USB is “1” and that for SP-5000C-USB is “2”..

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

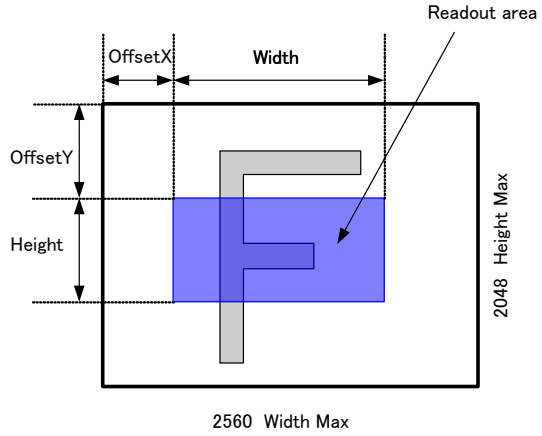


Fig.21 Setting example (No binning)

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

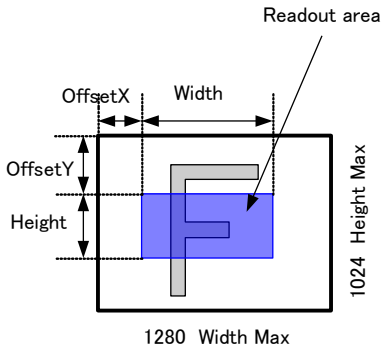


Fig.22 Setting example (Binning)

6.5 Digital output Bit allocation

Table19. Digital output

	CMOS out	Offset -100(12bit)	Setup +133(12bit)	Digital Out		
				8bit	10bit	12bit
Black	0%	0LSB	133LSB	8LSB	33.5LSB	133LSB
100%	3527	3427LSB	3560LSB	222LSB	890LSB	3560LSB
Full(115%)	4062	3962LSB	4095LSB	255LSB	1023LSB	4095LSB

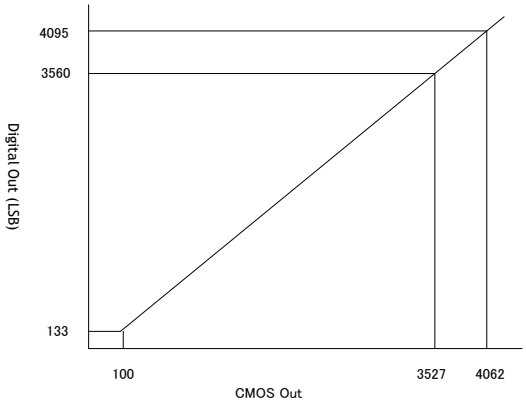


Fig.23 Bit allocation (12-bit)

7. Operating modes

7.1. Acquisition control

7.1.1 Acquisition Mode

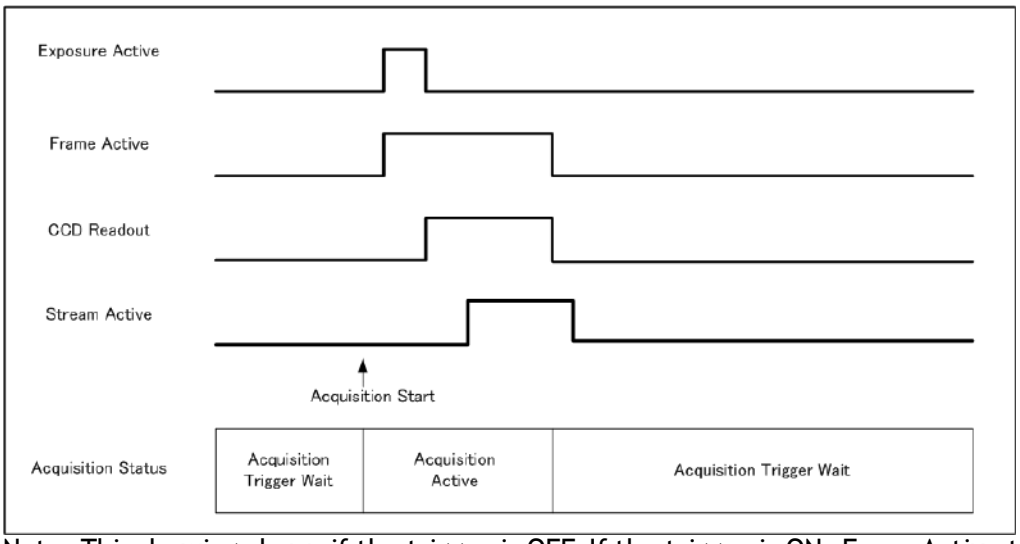
In the SP-5000-USB, the following three acquisition modes are available.

Single frame :	One frame can be output by AcqusitionStart command
Multi frames :	The number of frames which is specified in Acquistion Frame Count, are output by AcquisitionStart command
Continuous :	Images are continuously output by AcquisitionStart command until AcqusitionStop command is input.

7.1.1.1 Single Frame operation

In single frame mode, executing the AcquisitionStart command causes one frame to be captured. After one frame is captured, this operation is automatically stopped.
In order to restart the capture, it is necessary to input the AcquisitionStart command again. BlockID is not reset until AcquisitionStop is input and is incremented when the AcquisitionStart command is called.
In the case of PIV operation, 2 frames are captured.

◆ Normal single frame operation
1) AcquisitionStart command is input
2) AcquisitionActive becomes “TRUE” (accepts capture)
3) 1 frame is output
4) AcquisitionActive becomes “FALSE” (stop capturing)



Note: This drawing shows if the trigger is OFF. If the trigger is ON, FrameActive turns to True at a different AcquisitionActive timing.

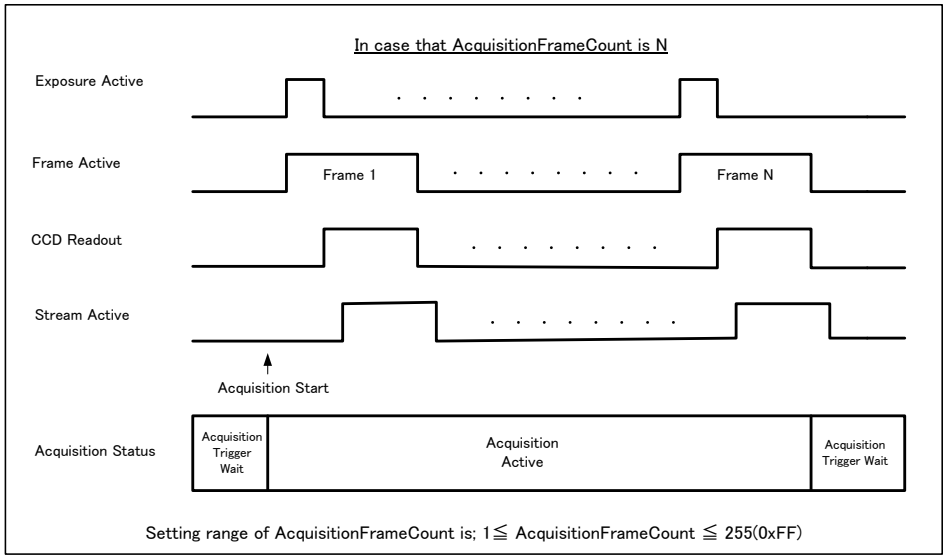
◆ Forcing acquisition to stop
While AcquisitionActive is “TRUE”, if AcquisitionStop or AcquisitionAbort is initiated, AcquisitionActive becomes “FALSE” (stop capturing).
However, if AcqusitionStop command is initiated during image output period, AcqusitionActive becomes “FALSE” (stop capturing) after image output is completed.

Associated commands : Acqusition Start, Acqusition Stop

7.1.1.2 Multi Frame operation

In this mode, the AcquisitionStart command captures the number of frames which are specified by AcquisitionFrameCount. If PIV mode is used, the number of frames must be set in multiples of 2.

◆ Normal multi-frame operation
1) AcquisitionStart command is input
2) AcquisitionTriggerWait becomes effective
3) AcquisitionActive becomes "TRUE" (accepts capture)
4) Output N frames as specified by AcquisitionFrameCount
5) AcquisitionActive becomes "FALSE". Then the output stops. (See the following diagram)



Note: This drawing shows if the trigger is OFF. If the trigger is ON, FrameActive turns to True at a different AcquisitionActive timing.

◆ Forcing acquisition to stop
While AcquisitionActive is "TRUE", if AcquisitionStop or AcquisitionAbort is initiated, AcquisitionActive becomes "FALSE" (stop capturing).
Once the operation is set to "FALSE", the internal FrameCount is reset.
However, if AcqusitionStop command is initiated during image output period, AcqusitionActive becomes "FALSE" (stop capturing) after image output is completed.
Once, AcqusitionActive becomes "FALSE", the internal count is reset.

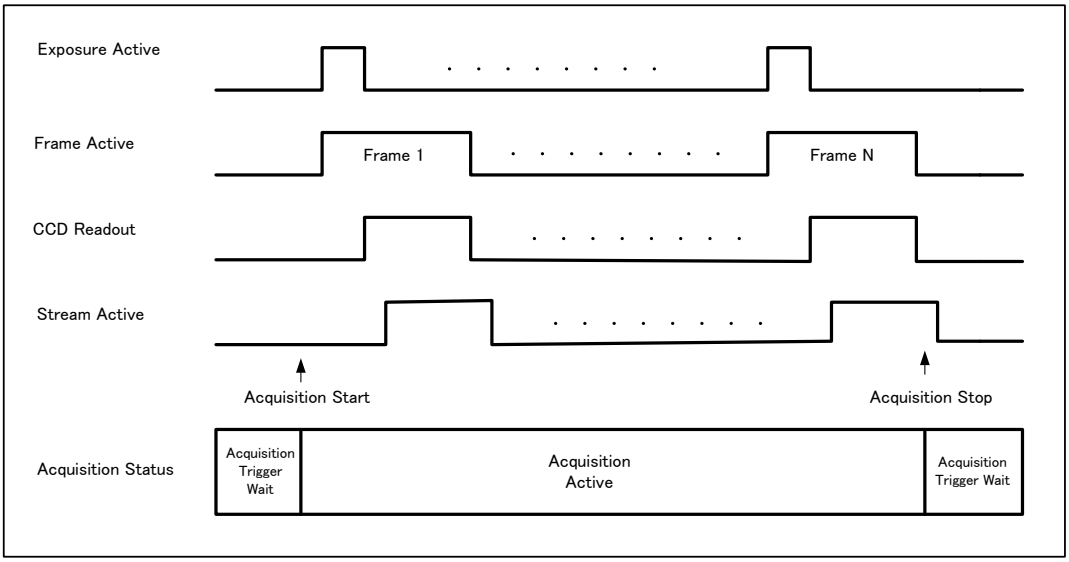
Associated commands: Acqusition Start, Acqusition Frame Count, Acquisition Stop

7.1.1.3 Continuous

In this mode, when the AcquisitionStart command is set, the image is continuously output at the current frame rate. This is the default setting for the SP-5000M-USB and SP-5000C-USB.

1) AcquisitionStart command is input
2) AcquisitionTriggerWait becomes effective
3) AcquisitionActive becomes "TRUE"
4) Images begin outputting continuously
5) AcquisitionStop command is sent
6) AcquisitionActive becomes "FALSE". At this moment, the output stops.

However, if AcqusitionStop command is initiated during image output period, AcqusitionActive becomes "FALSE" (stop capturing) after image output is completed.



Note: This drawing shows if the trigger is OFF. If the trigger is ON, FrameActive turns to True at a different AcquisitionActive timing.

Associated commands : Acqusition Start, Acqusition Stop

7.1.2 AcquisitionStart

This is the command to start Acquisition.

7.1.3 AcquisitionStop

This is the command to stop Acquisition.

7.1.4 Acquisition frame rate

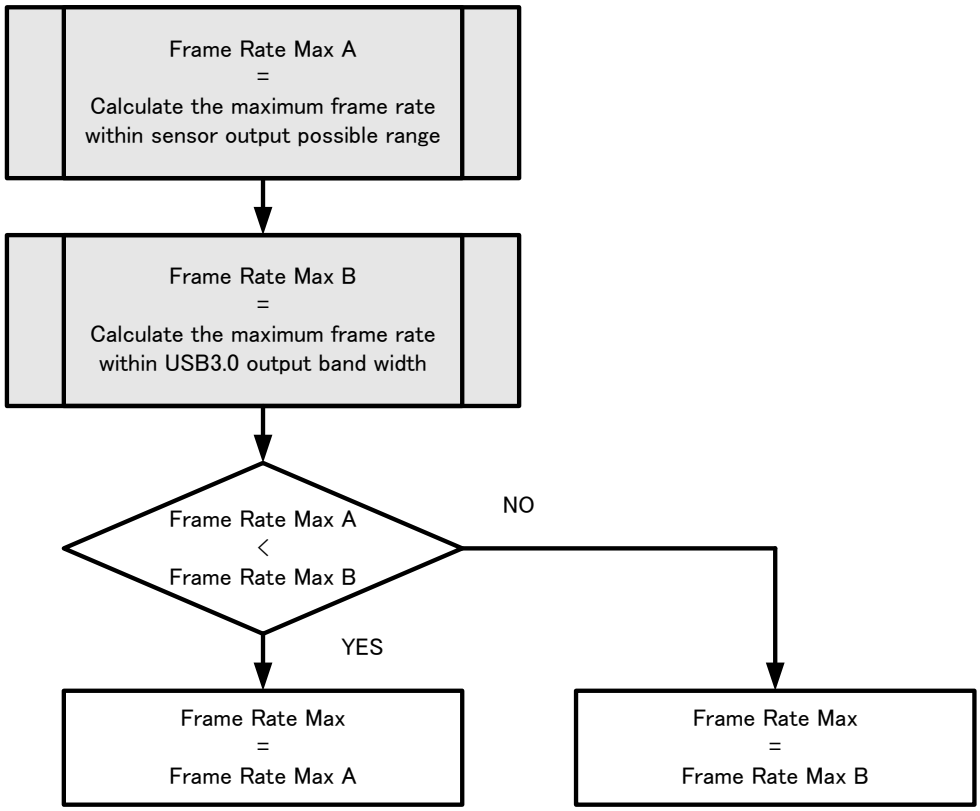
With Trigger OFF (free running mode – see section 7.2.1), the default frame rate of the camera is based on the specified ROI. The smaller the ROI, the faster the default frame rate. However, it is possible to specify a free-running frame rate (i.e., no trigger needed) that is slower than the default 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 frame frequency. Allowed values range from 126953 Hz to 0.125 Hz for SP-5000-USB. However, if the value entered is less than the time required for the default frame rate of the specified format, the setting is ignored and the default frame rate is used. For example, the minimum frame period for the smallest possible ROI (1 line) requires 126953 Hz (fps), so any entry more than 126953 Hz (fps) will always be ignored.

The setting range in Acquisition Frame Rate is:

Shortest	to	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 (fps) = 8 seconds

For the above setting, Acquisition Frame Rate is used and its unit is Hz (fps).
Acquisition Frame Rate range: 126953 Hz (fps) to 0.125 Hz (fps)
Note: The acquisition frame rate may be limited to the maximum value which will fit within the USB 3.0 bandwidth.



7.1.5 Calculation of the sensor maximum frame rate

$$t_{readout}[\text{sec}] = t_{row} \times (\text{Nrows} + K + 2) + \frac{1}{f_{sys}} + (t_{row} \times 2) + t_{expF}$$

$$\text{Frame rate Max [fps]} = \frac{1}{t\_readout}$$

f_{sys}	
Sensor 12-bit	48MHz

$$t_{row} = \frac{165 + HBlanking\_cycle}{f\_sys}$$

$$HBlankingCycle = HBlankingCycleTmp - 164$$

$$HBlankingCycleTmp = SemsorHBlanking \times \frac{SensorWidth}{2560}$$

Note: If HBlanking_cycle_Tmp < 165, HBlanking_cycle_Tmp is 165.

$$SensorWidth = \text{Rounddown}\left(\frac{Width}{64}\right) \times 64 + 64$$

SensorHBlanking	
Mono/bayer	330

Nrows = Height : 1∼2048

$$K = \text{Roundup}\left(\frac{t_{expB}}{t_{row}}\right) + 1$$

t_{exp_B} = 2.333 us
t_{exp_F} = 10.2083 us

7.1.6 Maximum frame rate in USB 3.0 bandwidth

The maximum bandwidth of the SP-5000-USB is capped at 2.6 Gbps, which is approximately 80% of the typical 3.2 Gbps maximum value listed for the USB3 Vision standard.

Frame rate Max[fps] = 2.6 Gbps / (Width x Height x Bit)

Bit	
Mono8/BayerGR8	8
Mono10/BayerGR10	16
Mono10/BayerGR10_Packed	10
Mono12/BayerGR12	16
Mono12/BayerGR12_Packed	12

7.2. Exposure settings

This section describes how to set the exposure settings.

7.2.1 Exposure Mode

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

Table -20 Exposure mode

Exposure Mode setting	Exposure operation
OFF	No exposure control (free-running operation)
Timed	Exposure operates 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 21 Trigger option

Trigger Option setting	Exposure operation
OFF	Timed (EPS) mode
RCT	RCT mode, Refer to Chapter 7.7 for the details
PIV	PIV mode. Refer to Chapter 7.8 for the details

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

Table – 22 The combination of Exposure Mode, Trigger Option and Trigger Mode

Exposure Mode	Trigger Option	Trigger Mode (Frame Start)	Operation
OFF	N/A	N/A	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
	RCT	Forced to ON	RCT Operation Exposure can be controlled by Exposure Time
	PIV	Forced to ON	PIV Operation Exposure can be controlled by Exposure Time
Trigger Width	N/A	Forced to ON	Exposure is controlled by the pulse width of the external trigger

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
Maximum: 8 seconds (Note – noise may make image unusable after 1 second)

7.2.3 Exposure Auto

This is a function to control the exposure automatically. It is effective only for Timed.
JAI 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 GainAuto)
Exposure Auto Max: The maximum value for the exposure time can be set.
Exposure Auto Min: The minimum value for the exposure time can be set.
ALC Reference: The reference level of the exposure control can be Set (Common with GainAuto)
ALC Channel Area : ExpsoureAuto control reference area can be set from 16 (4x4) Choices (Common with GainAuto)

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.32 ALC Channel Area

7.3. Trigger Control

The following 6 types of Trigger Control are available by the combination of Trigger Selector, Trigger Mode, Exposure Mode and Trigger Option.

Table23 Trigger control

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

7.3.1 Trigger Selector

Selects the trigger operation. In the SP-5000-USB, the following trigger operation can be selected as the trigger.

Table24. Trigger selector

Trigger Selector Item	Description
Acquisition Start	Set to start Acquisition or not
Acquisition End	Set to end Acquisition or not
Frame Start	Set to start Frame control or not
Acquisition Transfer Start	Set to start the stream or not

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

The following signals can be used as the trigger source signal.

In the following table, Line 10 and Line 11 are effective if optional AUX type 3 is used.

Table25. 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
Line 4 - TTL IN 1	Connect TTL 1 IN signal to the selected trigger operation
Line 5 - OPT IN	Connect OPTO IN 1 signal to the selected trigger operation
NAND 0 Out	Connect NAND 0 OUT signal to the selected trigger operation
NAND 1 Out	Connect NAND 1 OUT signal to the selected trigger operation
Line 10 - TLL IN 2	Connect TTL 2 IN signal to Line 10
Line 11 - LVDS IN	Connect LVDS 1 IN signal to Line 11

Note: Line 10 and Line 11 are effective if AUX Type 3 is selected as the configuration.

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 the trigger, the accumulation is activated.
Level Low : During the Low level of the trigger, the accumulation is activated.

Table 26. Trigger Activation

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

Note: When Trigger Width mode is used, the level High or level Low must be used.

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 the sensor readout.
Read Out : The trigger pulse can be accepted during the sensor readout.

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

This is used for applications which do not require triggering. In this mode, the video signal for the auto-iris lens is available if AUX connector is configured with option Type 2.
For the video timing, refer to chapter 6.3.

Primary settings to use this mode

Trigger Mode: Off

Table -27 Minimum frame interval of the video (at 8-bit)

Readout Mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum frame interval (ms)	16.14	13.44	8.07	4.04	2.02	8.07 (Note)

Note: Only for SP-5000M-USB

7.5. Timed mode

This mode allows a single image frame to be captured with a preset exposure time by using the external trigger. Additional settings determine if the trigger pulse can be accepted during the exposure period.

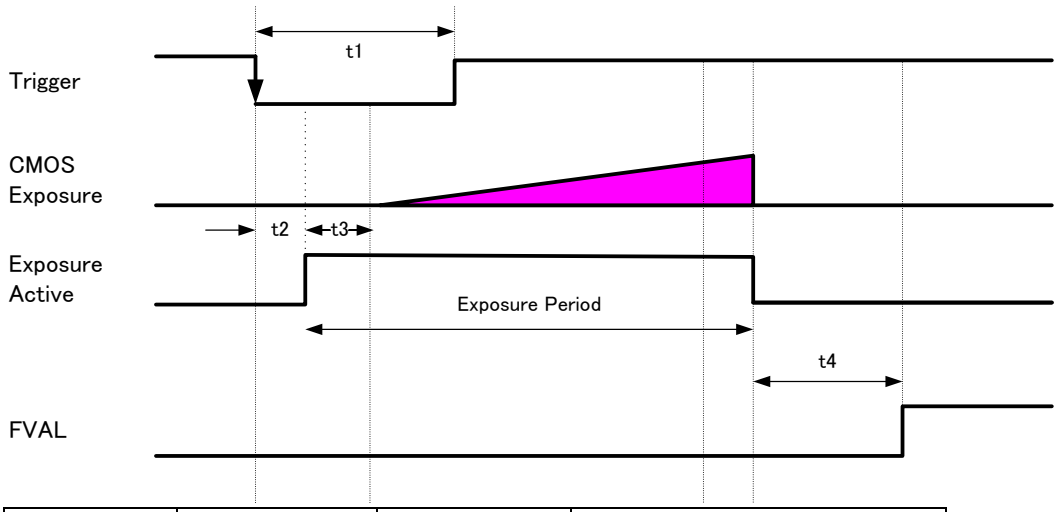
Primary settings to use this mode
Exposure Mode: Timed
Trigger Mode: ON
Trigger Option: OFF

Table – 28 Minimum Trigger Interval (at 8-bit)

Readout mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum Interval (ms)	16.14ms +8.01µs	13.44ms +8.01µs	8.07ms +8.01µs	4.04ms +8.01µs	2.02ms +8.01µs	8.07ms+8.01µs (Note1)

Note1: Only SP-50000M-USB
Note2: The above applies if the trigger Overlap is set to READOUT. If it is set to OFF, the value is longer than this table.

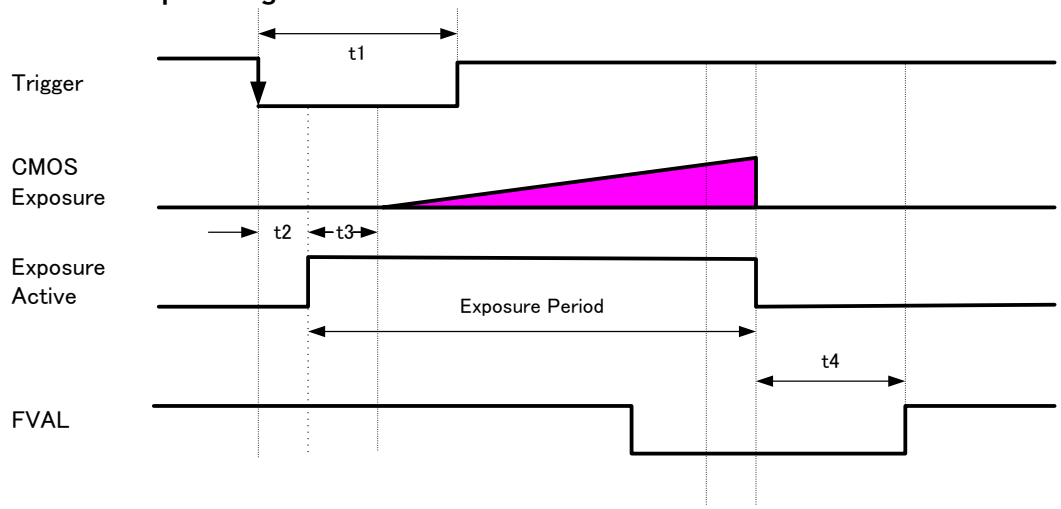
7.5.1 If the overlap setting is “OFF”



t1	t2	t3	t4
2L (Min)	218 clk	10.13 µs	8L ～9L (18.142 µs)

Fig.34 Overlap OFF

7.5.2 If the overlap setting is “Readout”



t1	t2	t3	t4
2L (Min)	218 clk	10.13 µs	8L ～9L (18.142 µs)

Fig.35 Readout

7.6. Trigger width mode

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.

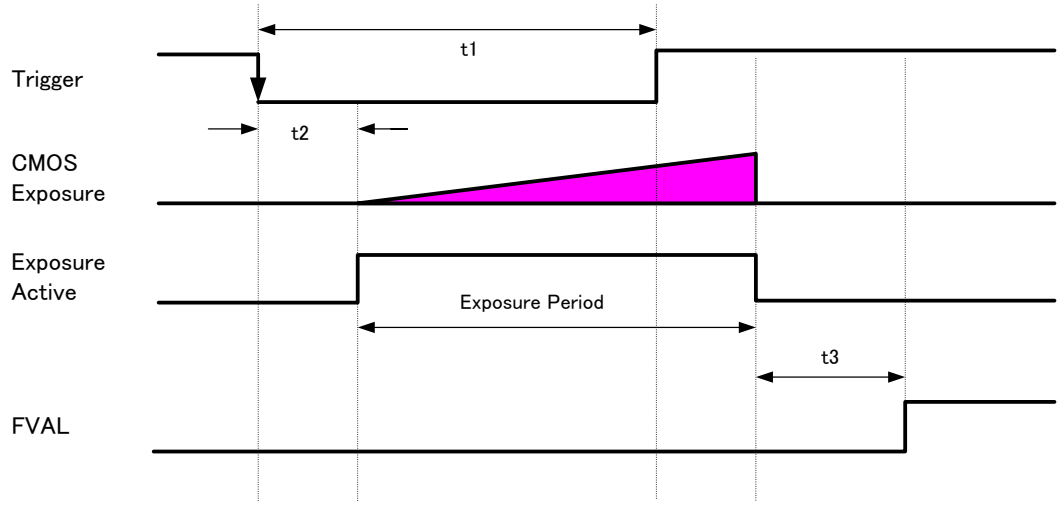
Primary settings to use this mode
Exposure Mode: Trigger Width
Trigger Mode: ON
Trigger Option: OFF

Table - 29 Minimum Trigger Interval (at 8-bit)

Read out mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum Interval (ms)	16.14ms +8.01µs	13.44ms +8.01µs	8.07ms +8.01µs	4.04ms +8.01µs	2.02ms +8.01µs	8.07ms+8.01µs (Note1)

Note1: Only SP-50000M-USB
Note2: The above applies if the trigger Overlap is set to READOUT. If it is set to OFF, the value is longer than this table.

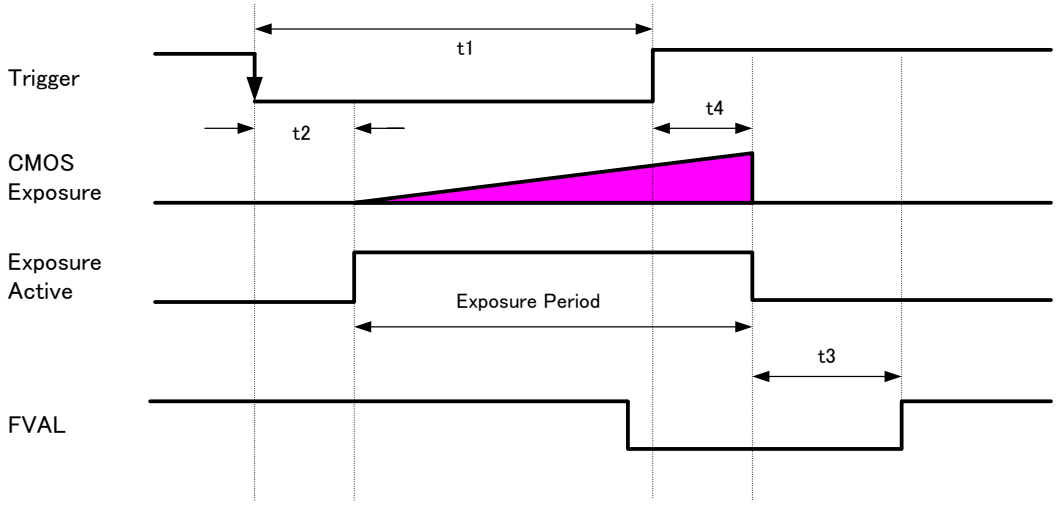
7.6.1 If the overlap setting is “OFF”



t1	t2	t3
2L (Min)	208 clk	7L ～8L

Fig.36 Overlap = OFF

7.6.2 If the overlap setting is “Readout”



t1	t2	t3	t4
2L (Min)	208 clk	7L ～8L	1L

Fig.37 Readout

7.7. RCT mode

Until the trigger is input, the camera operates continuously and the video signal for the auto-iris lens is output, provided the AUX connector has been ordered with a Type 2 configuration option. At this moment, the video signal, FVAL and LVAL are output but DVAL is not output. When the trigger is input, the fast dump is activated to read out the electronic charge very quickly, after which the accumulation and the readout are performed. When the accumulated signal against the trigger is read out, FVAL, LVAL and DVAL are output too.

Primary settings to use this mode

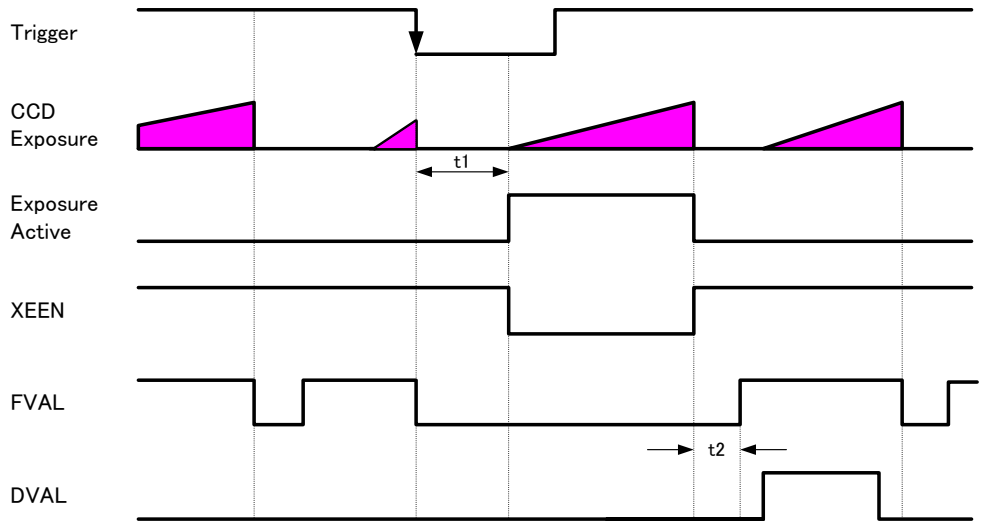
Exposure Mode: Timed
Trigger Mode: ON
Trigger Option: RCT

In this mode, the setting of Trigger Overlap is invalid.

Table - 30 Minimum Trigger Interval (at 8-bit)

Read out mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum Interval (ms)	16.14 ms+ Exposure time +1.562 ms	13.44 ms+ Exposure time +1.562 ms	8.07 ms+ Expsoure time +1.562 ms	4.04 ms+ Exposure time +1.562 ms	2.02 ms+ Exposure time +1.562 ms	8.07ms+ Exposure time +1.562 ms (Note1)

Note1: Only SP-50000M-USB



t1	t2
100 μs	8L ～9L

Fig.39 RCT mode timing

7.8. 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 2 sec. Then, the second exposure will be taken. The accumulation is LVAL asynchronous. The first strobe is activated during the first exposure period and the second strobe is pulsed while the first frame is being read out. In this way, two strobe flashes generate two video outputs.

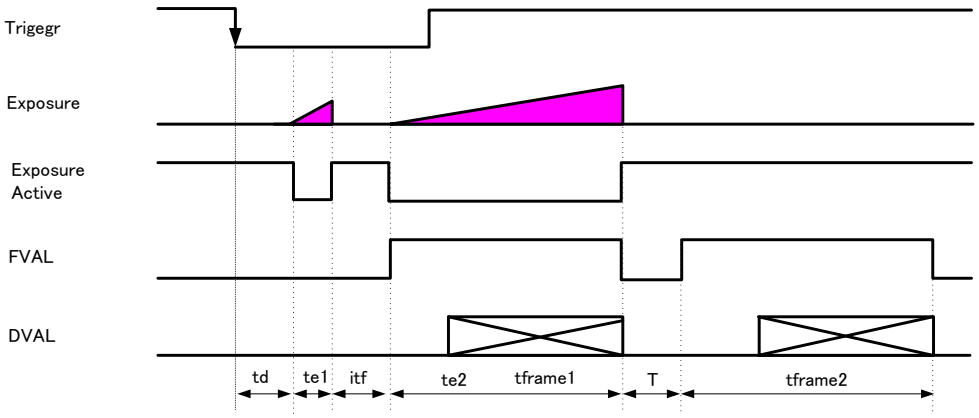
Primary Settings
Exposure Mode: Timed
Trigger Mode: ON
Trigger Option: PIV

In this mode, the setting of Trigger Overlap is invalid.

Table - 31 Minimum Trigger Interval (at 8-bit)

Readout Mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum Interval (ms)	32.28 ms+ Exposure time +8.01 μs	26.88ms+ Exposure time +8.01 μs	16.14ms+ Exposure time +8.01 μs	8.08 ms+ Exposure time +8.01 μs	4.04 ms+ Exposure time +8.01 μs	16.14ms+ Exposure time+ 8.01 μs (Note1)

Note1: Only SP-50000M-USB



time name	description	time
td	Exposure beginning delay	10.486 μs
te1	First exposure time period	10 μs ～ 2s
te2	Second exposure time	2515L
itf	Inter framing time	10.34μs
T	FVAL non active	10LVAL
tframe1	First Frame read out	1 frame
tframe2	Second Frame read out	1 frame

Fig.40 PIV mode

7.9. Sequence ROI Trigger

This mode allows the user to define a preset sequence of up to 10 images, each with its own ROI, exposure time and gain values.

Primary settings to use this mode
Exposure Mode: Timed
Trigger Mode: ON
Video Send Mode: Trigger Sequence or Command Sequence

Table - 32 Minimum Trigger Interval (at 8-bit)

Readout Mode	FULL	2/3 ROI	1/2 ROI	1/4 ROI	1/8 ROI	1/2V Binning
Minimum Interval (ms)	16.14 ms+ Exposure time +8.01 μs	13.44 ms+ Exposure time +8.01 μs	8.07 ms+ Exposure time +8.01 μs	4.04 ms+ Exposure time +8.01 μs	2.02 ms+ Exposure tieme +8.01 μs	8.07ms+ Exposure time+ 8.01 μs (Note1)

Note1: Only SP-5000-USB

7.9.1 Video send mode

The sequential trigger mode is selected via the Video Send Mode command and has the following options.

Table – 33 Video send mode

Mode selected	Index selection method
Trigger Sequence	Select the index by using the Frame Start trigger signal. (The setting index can be determined by the Next Index setting.)
Command Sequence	Select the index number to assign directly by using the Command Sequence Index command.

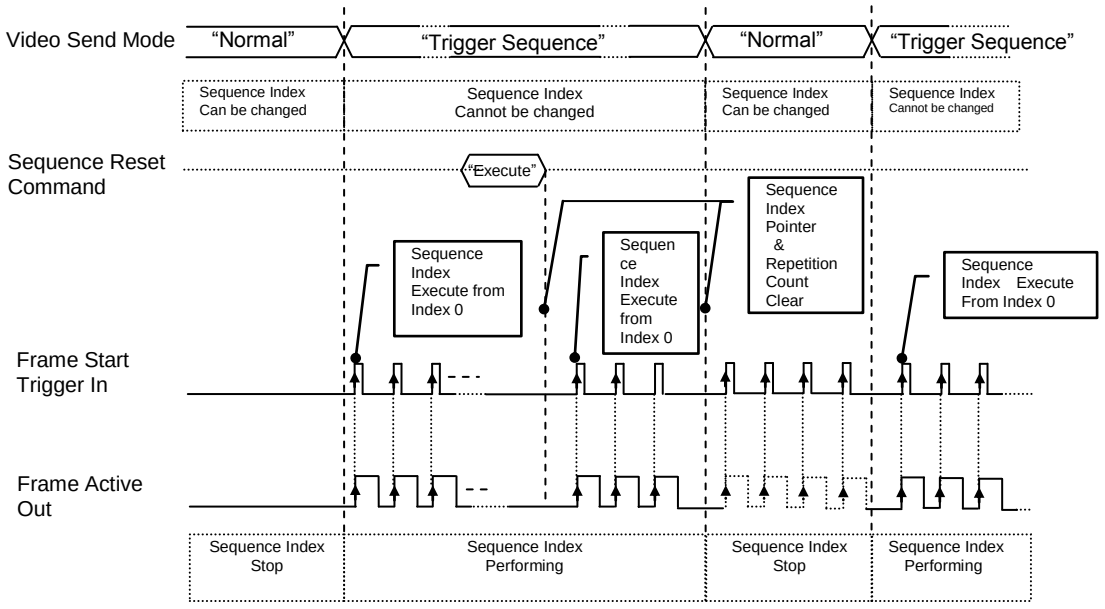


Fig. 41 Behavior if Video Send Mode is set to Trigger Sequence

7.9.2 Trigger Sequence mode basic timing

In this mode, as each trigger input is received, the image data associated with the next index within the preset sequence is output.

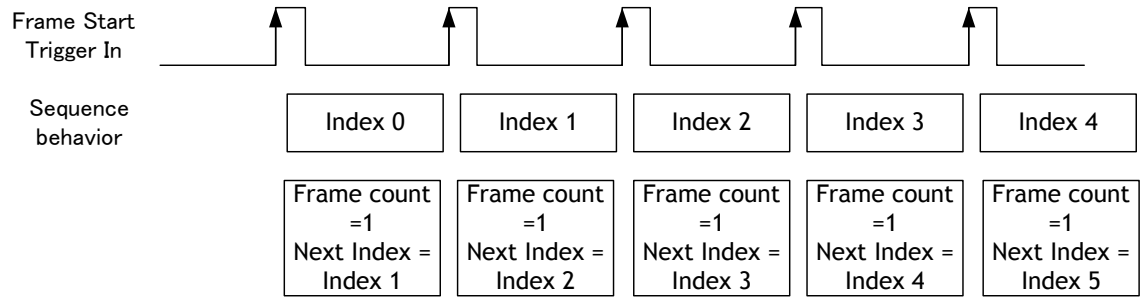


Fig. 42 Behavior of Sequence trigger

7.9.3 Sequence ROI setting parameters

7.9.3.1 Sequence index table (Default)

The following table shows the default settings.

Table – 34 Sequence Index table (Default)

Sequence ROI Index	Sequence ROI													
	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 1	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 2	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 3	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 4	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 5	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 6	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 7	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 8	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 9	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1
- Index 10	2560	2048	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 1

7.9.3.2 Descriptions of index table parameters

(1) Sequence ROI Index Selector
In Sequence ROI Index Selector, Index 1 to 10 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 16 to 2560 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 1 to 2048 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 (2560 - [Sequence ROI Width])

Sequence ROI Binning Horizontal = 2 (On):
Setting range is 0 to (1280 - [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 (2048 - [Sequence ROI Height])
Sequence ROI Binning Vertical = 2 (On):
Setting range is 0 to (1024 - [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-5000C-USB: Gain (ALL), Red and Blue can be set.
SP-5000M-USB: 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 1 to 10 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
The number of the index that will follow the current index can be set.
If [Video Send Mode] is set to “Trigger Sequence” and the trigger pulse is input in EPS trigger, the sequence is executed from index 1.

(14) Sequence ROI Reset Command
This command resets the current index pointer and reverts to index 1 in the table. Frame Count is also re-initialized.

7.10 Multi ROI function

This function can define a maximum of 8 images to be extracted from one frame image. Each image can have its width and height set individually as required. And each ROI can also be overlapped. Each ROI image can be read out as a frame in accordance with its index number.
The multi ROI function is enabled if [Video Sending Mode] is set to “Multi ROI”.

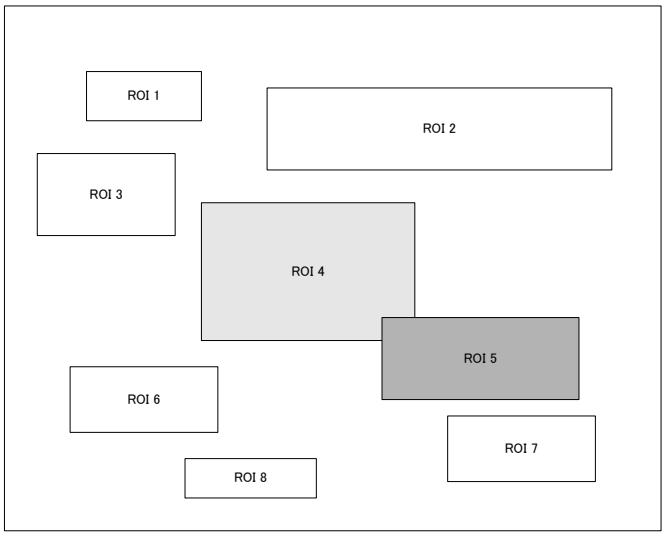


Fig.27 Multi ROI image

Table – 35 Multi ROI Index table default values

Multi ROI Index Max	1			
Multi ROI Index Selector	Multi ROI			
	Width	Offset X	Height	Offset Y
- Index 1	16	0	1	0
- Index 2	16	0	1	0
- Index 3	16	0	1	0
- Index 4	16	0	1	0
- Index 5	16	0	1	0
- Index 6	16	0	1	0
- Index 7	16	0	1	0
- Index 8	16	0	1	0

7.10.1 Multi ROI setting parameters

(1) Multi ROI Index Max : Setting value = 1 ～ 8
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 Index Selector :
Index 1 to 8 can be selected. [Width],[Height], [Offset X], and [Offset Y] of the selected Multi ROI Index are displayed and can be set.

(3) Multi ROI next index
This defines the index to display after the current ROI index being displayed.

(4) Multi ROI Width
The setting range and Step number are the same as the normal ROI setting in which "Video Send Mode" is set to "Normal". The restrictions for setting Step and other factors are the same as the normal ROI setting.

(5) Multi ROI Offset X :
Offset X can be set for each ROI area of Multi ROI Index 1 to 8.
The restrictions for setting Step and other factors are the same as the normal ROI setting.

(6) Multi ROI Height :
Height can be set for each ROI area of Multi ROI Index 1 to 8.
The restrictions for setting Step and other factors are the same as the normal ROI setting.

(8) Multi ROI Offset Y :
Offset Y can be set for each ROI area of Multi ROI Index 1 to 8.
The restrictions for setting Step and other factors is the same as the normal ROI setting.

7.11. Operation and function matrix

Table – 36 Operation and function matrix

Exposure Operation	Trigger mode	Trigger Option	V-BinningNote1	H-BinningNote1	Exposure Time	ROI	AWB Note2	Auto Iris Output	Auto Gain	Auto Exposure	Trigger Overlap	Video Send Mode		HDR Note1
												Multi ROI	Sequence ROI	
OFF	OFF	OFF	1	1	×	○	○	○	○	×	×	○	×	×
			2	2	×	○	×	○	○	×	×	○	×	×
Timed	OFF	OFF	1	1	○	○	○	○	○	○	×	○	×	○
			2	2	○	○	×	○	○	○	×	○	×	○
Timed (EPS)	ON	OFF	1	1	○	○	○	○ Note4	○	○	○	○	○	○ Note3
			2	2	○	○	×	○ Note4	○	○	○	○	○	○ Note3
Trigger Width	ON	OFF	1	1	×	○	○	○ Note4	○	×	○	○	×	×
			2	2	×	○	×	○ Note4	○	×	○	○	×	×
Timed (RCT)	ON	RCT	1	1	○	○	○	○	○	○	×	○	×	×
			2	2	×	×	×	×	×	×	×	○	×	×
Timed (PIV)	ON	PIV	1	1	○	○	○	×	×	×	×	×	×	×
			2	2	○	×	×	×	×	×	×	×	×	×

Note 1. Only SP-5000M-USB
Note 2: Only SP-5000C-USB
Note3: Trigger Overlap is OFF
Note4: If the trigger interval is long, the auto iris will exhibit a hunting phenomenon.

8. Other functions

8.1 Black level control

This function adjusts the setup level.
The adjusting level is 0 to +100LSB at 10-bit output.

8.1.1 Black Level Selector

The following factors can be set.

SP-5000M-USB: DigitalAll
SP-5000C-USB: DigitalAll/DigitalRed/ DigitalBlue

8.1.2 Black Level

The black level can be set in the following range.

SP-5000M-USB: DigitalAll : -256～ +255
SP-5000C-USB: DigitalAll : -256～ +255
DigitalRed/DigitalBlue : -512～ +511

8.2 Gain control

In the SP-5000-USB, the gain control uses Analog Base Gain and Digital Gain.
Analog Base Gain can be set at 0dB, +6dB or +12dB for both SP-5000M-USB and SP-5000C-USB. The digital gain is used for the master gain setting.

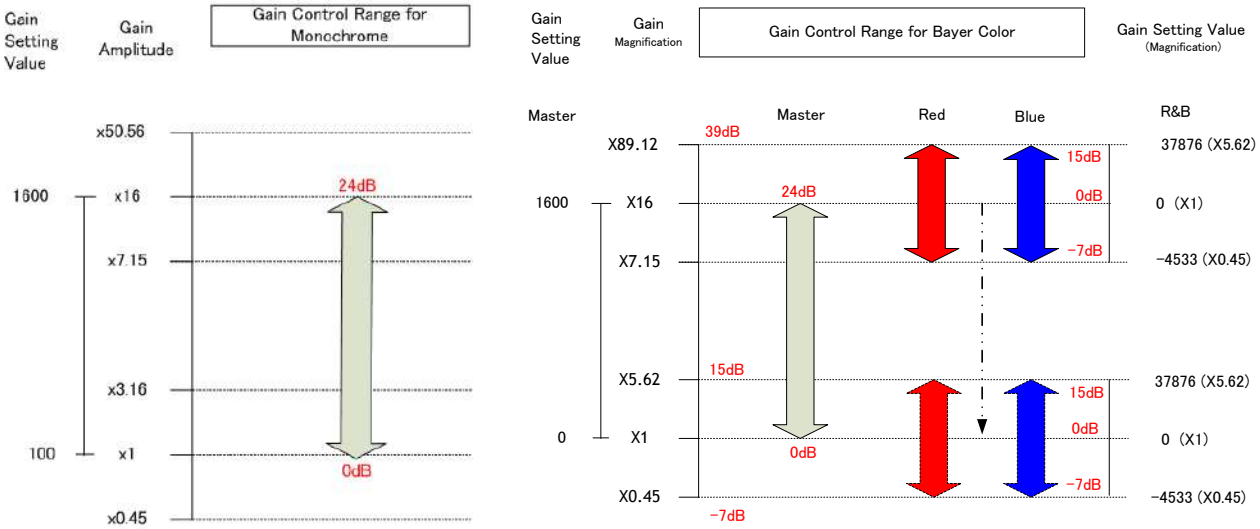
For setting the gain,

1. Set analog base gain (Select from 0dB, +6dB and +12dB)
2. Set digital gain
   The master gain (DigitalAll) for both monochrome and color can be set x1 (0dB) to x16 (+24dB) against the analog base gain. The resolution for gain setting is x0.01/step which is 0.05dB to 0.08dB, depending on the setting value.
3. In the SP-5000C-USB, blue and red digital gain can be set from x0.45 to x5.62 against the Master gain setting and its resolution is x0.01/step.
4. In the SP-5000C-USB, analog base gain can be applied to R, G and B channel respectively in order to cover wider range of color temperature.

Note1: If the gain up function is used, it is recommended to use the analog base gain as the master gain setting. For instance, if +12dB gain up is required, the analog base gain is set at +12dB and no digital gain is added. This is because the signal-to-noise performance is better with analog gain. However, the AGC function works only with digital gain.
Additionally, the analog base gain is effective in order to minimize missing counts in the histogram at higher gain settings. Please note that the analog base gain has less accuracy due to its variability.

Note2: If the analog base gain is set at 0dB and Digital Gain is used at a high gain setting, the video level may be unstable and fluctuate approx. 5%. In this case, it is suggested to set the analog base gain at +6dB or +12dB.

The master gain control uses Digital Gain. All digital gain can be set by x0.01/step. If the digital gain is set too high, breaks (missing counts) in the histogram may occur.



The above drawing shows the relationship between gain setting value (command), gain amplitude, and dB indication. For example, the gain amplitude “x 5.62” equals 15dB.

Fig.43 Gain control

8.2.1 Gain Selector

The following parameters can be set.

SP-5000M-USB: DigitalAll
SP-5000C-USB: DigitalAll/Digital Red All/Digital Blue All

8.2.2 Gain

This is the reference value upon which gain adjustments are based. The operational adjustment is done in Gain Raw.

SP-5000M-USB: DigitalAll : 1～16 (0dB to +24dB)
SP-5000C-USB: DigitalAll : 1～16 (0dB to +24dB)
Digital Red All : 0.4467～5.6235 (0dB to +15dB)
Digital Blue All : 0.4467～5.6235 (0dB to +15dB)

8.2.3 Gain Raw

The gain raw can be adjusted in the following range.

SP-5000M-USB: DigitalAll : 100～1600
SP-5000C-USB: DigitalAll : 100～1600
Digital Red All/Digital Blue All : -4533～37876

Note: Gain calculation

$$\text{Gain} = \frac{8192 + Setting\ Value}{8192}$$

Example: If setting value is -4533, Gain = (8192-4533)/8192 = 0.4467 (-7dB)

8.2.4 Gain Auto

This function automatically controls the gain level.
This is controlled by the command JAI 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 GainAuto can be set (Common with ExposureAuto).
Gain Auto Max:	The maximum value of GainAuto control range can be set
Gain Auto Min:	The minimum value of GainAuto control range can be set
ALC Reference:	The reference level of Gain Auto control can be set (Common with ExposureAuto)
ALC Channel Area :	Gain Auto control reference area can be set from 16 (4x4) choices（Common with ExposureAuto）

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.45 ALC Channel Area

8.2.5 Balance White Auto

This is a function to achieve auto white balance by using R and B gain.
There are three methods which can be selected.

OFF:	Manual operation
Once:	The auto white balance is executed one time when this command is set.
Continuous:	The auto white balance is continuously executed.

AWB Channel Area: AWB reference areas can be selected form 16 (4x4) choices.

Note: The figure for AWB Channel Area is the same as Fig.45.

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 Mode

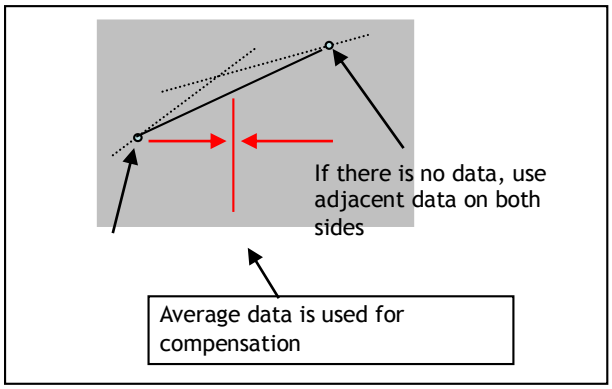
Can be set to OFF, gamma (see section 8.4), or Lookup Table.

8.3.2 LUT Index

This represents the “starting” or “input” pixel value to be modified by the Lookup Table. The SP-5000-GE2 has a 256-point Lookup Table, meaning the index points are treated like an 8-bit 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 configurations.

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. 46 LUT value

8.4. Gamma

This command is used set gamma between gamma 0.45 and gamma 1.0 (OFF) in 8 steps.
The gamma value is an approximate value.
The gamma is adjusted based on the dark compression curve described in 8.4.1.

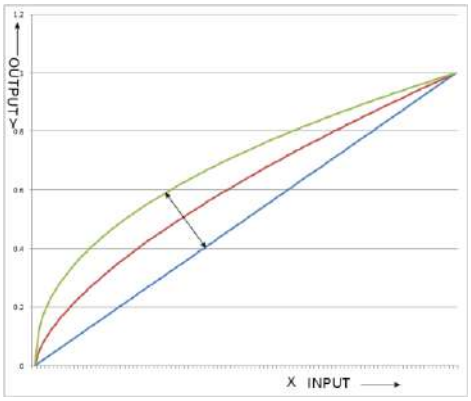


Fig. 47 Gamma compensation

8.4.1 Linear and Dark Compression

SP-5000-USB has a dark compression circuit to improve the signal to noise ratio in the dark portions of an image.

Dark Compression: 0: Dark Compression
1: Linear (Default)

Dark Compression	Function
Linear(Factory default)	No compression, Gamma=1.0
Dark Compression	Compress the signal level in the dark portion. It can improve the signal to noise ratio, but on the other hand, the linearity will be deteriorated.

The following drawing shows the characteristics of linear and dark compression.

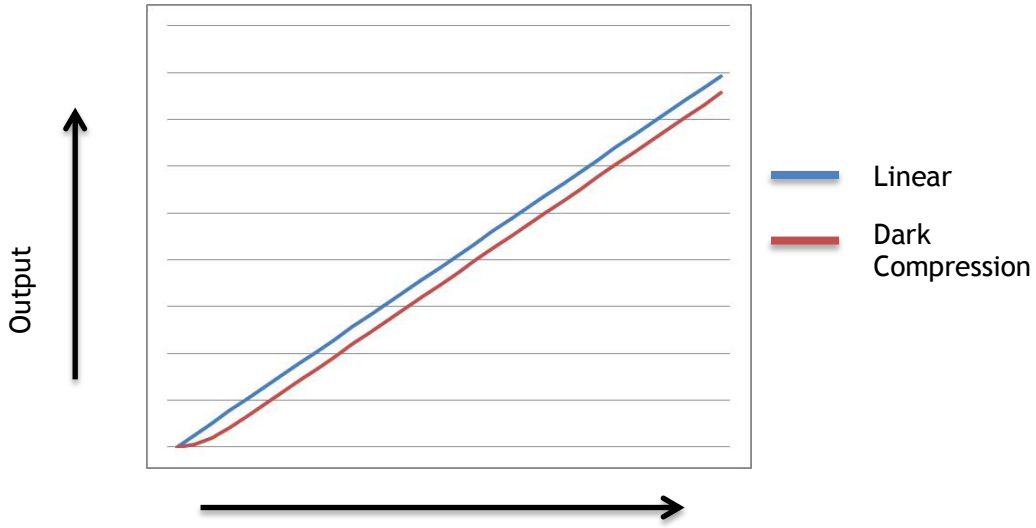


Fig.48 Characteristics

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 block grid of 20 blocks (H) x 16 blocks (V). Each block contains 128 x 128 pixels. The complementary process is applied to produce the compensation data with less error.

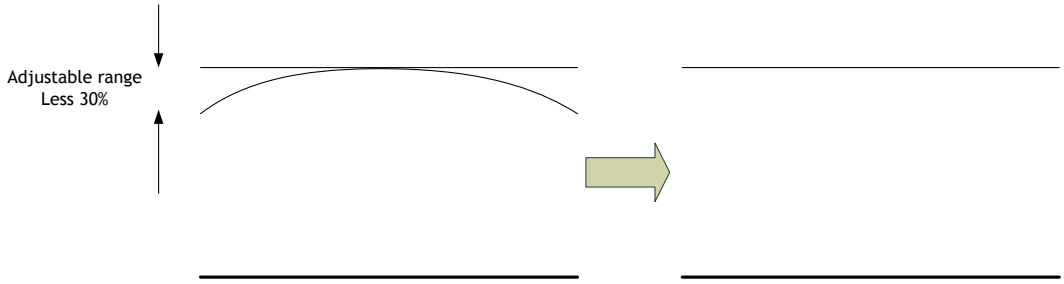


Fig. 48 Flat shading correction concept drawing

Color shading correction (For SP-5000C-USB 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 16 blocks (V). Each block contains 128 x 128 pixels and the complementary process is applied to produce the compensation data with less error.

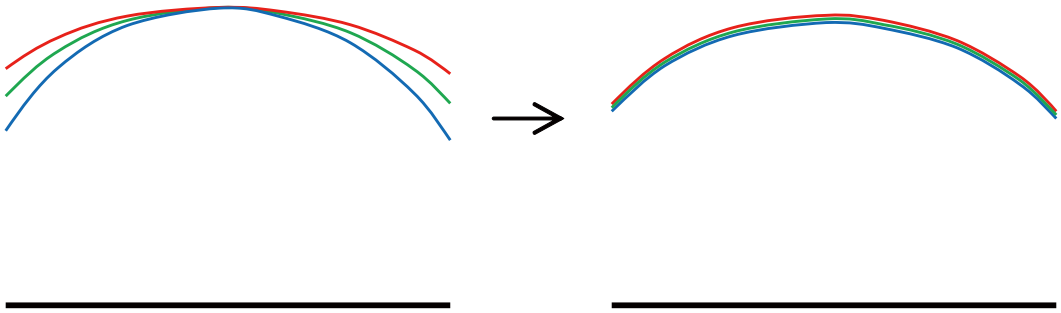


Fig.49 Color shading correction concept drawing

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)

8.6. Blemish compensation

The SP-5000M-USB and SP-5000C-USB have 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 adjacent pixel in left column and, in the case of the SP-5000C-USB, the defective pixel can be compensated by the same Bayer color pixel in left adjacent column. Please refer to the following drawing. As for white blemishes, the automatic detection function is available and after its execution, the data is stored in memory. The customer can use the data by setting the blemish compensation ON. For black blemishes, only compensation that has been done in the factory is available. The number of pixels that can be compensated is up to 512 pixels.

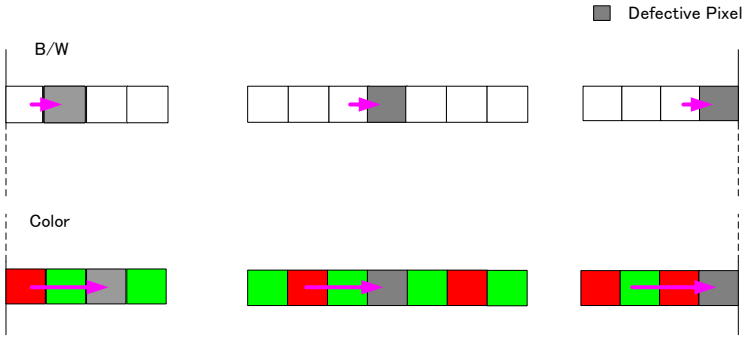


Fig.50 Blemish compensation

Note: If defective pixels are found consecutively in the horizontal direction, the blemish compensation circuit does not work.

8.7 Lens control

The SP-5000M-USB and SP-5000C-USB can be used with 4 different types of auto iris lenses, in addition to standard lenses with manual iris control. If an auto iris function is to be utilized, the lens type used must be selected in Lens Select.

Table - 37 Lens selector

Lens Select	Description (Control with camera)	Note
P-Iris Lens	1) Iris position can be remotely controlled manually 2) Auto iris control is also available	If P-iris lens is used, the specific model name should be selected in Lens Select.
Motor controlled lens	1) Iris position can be remotely controlled manually 2) Auto iris control is also available	
Video iris lens	Only auto iris control is available	Factory Option
DC iris lens	Only auto iris control is available	Factory Option

8.7.1 About P-Iris

New Spark Series SP-5000M-USB and SP-5000C-USB come equipped with P-Iris control as part of the standard lens control function. The P-Iris system is a newly developed lens control method designed to control the iris more precisely. Especially for video cameras in surveillance applications utilizing megapixel CCD or CMOS imagers, it becomes a very important factor to control an iris in order to achieve the maximum camera performance. In surveillance applications, depending on shooting conditions, resolution and depth of field are important factors. The iris is deeply related with these factors. If the iris diaphragm is smaller, but not too small, resolution gets better and the depth of field is also deeper. The P-Iris system controls the iris diaphragm precisely and maintains the best image with the highest resolution and depth of field. P-Iris can also combine with gain and electronic shutter to keep the appropriate iris position under changing lighting conditions (ALC function).

8.7.2 Setting for P-iris lens being used

P-iris lenses use an absolute setting value control system and therefore, if the following parameters are input, precise iris position control is possible.

8.7.2.1 P-Iris lens select

Select the lens used from the P-iris select list. At this moment, there are no 1-inch P-Iris lenses available in the list. When P-Iris Lens Select is opened, the following lenses are indicated but they are 2/3 inch format. If they are used, the corners of the image may be vignetted.

Table – 29 P-iris lens select

P-Iris lens select	Description	Control step number	Open F value
LM16JC5MM	Kowa 16mm 2/3”	74	F1.4
LM35JC5MM	Kowa 35mm 2/3”	73	F2.0

8.7.2.2 Step max.

Iris control step depends on lens. The setting value uses the value stored in the camera.

8.7.2.3 Position

The iris position can be set between 0 to Step Max. 0 means to open the iris and Step Max means to close the iris.
In the following conditions, the camera initializes P-iris control and acquires iris position.

1) When the camera is powered
2) When the lens is selected in P-Iris Lens Select
3) If the lens is changed in P-iris Lens Select

8.7.2.4 Current F value

The current F value is indicated by using iris position information. This can be indicated during auto iris operation. The relation between iris position and F value depends on the lens used.

8.7.2.5 P-Iris Auto min. / P-Iris Auto max.

This function can set the control range when the iris is operated automatically. Auto max. sets the limit when the iris goes open and Auto min. sets the limit when the iris goes closed. Auto max. can be set to fully open but Auto min. is stopped at F5.6 as lens performance typically degrades if the iris is closed beyond this point.

8.7.3 Motorized lenses

The SP-5000C-USB and SP-5000C-USB can use the 3-axis motorized lens control for zoom, focus and iris. The following functions are available via the motorized lens commands.

8.7.3.1 Iris

Open: While this command is supplied, the iris will continue to open.
Close: While this command is supplied, the iris will continue to close.
Stop: When this command is supplied, the iris operation stops.

8.7.3.2 Zoom

Wide: While this command is supplied, the zoom will continue to move towards wide angle.
Tele: While this command is supplied, the zoom will continue to move towards telephoto.
Stop: When this command is supplied, the zoom operation stops.

8.7.3.3 Focus

Near: While this command is supplied, the focus will continue to shift closer to the camera.
Far: While this command is supplied, the focus will continue to move towards infinity.
Stop: When this command is supplied, the focus operation stops.

8.8 ALC

In the SP-5000M-USB and SP-5000C-USB, auto gain, auto shutter and auto iris functions 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 linkage between the other two is maintained.

In order to make the ALC function effective, set the Auto Iris Lens Control Signal Output to “ON”. The auto iris function (AIC) works together with AGC and Exposure Auto (ASC).

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

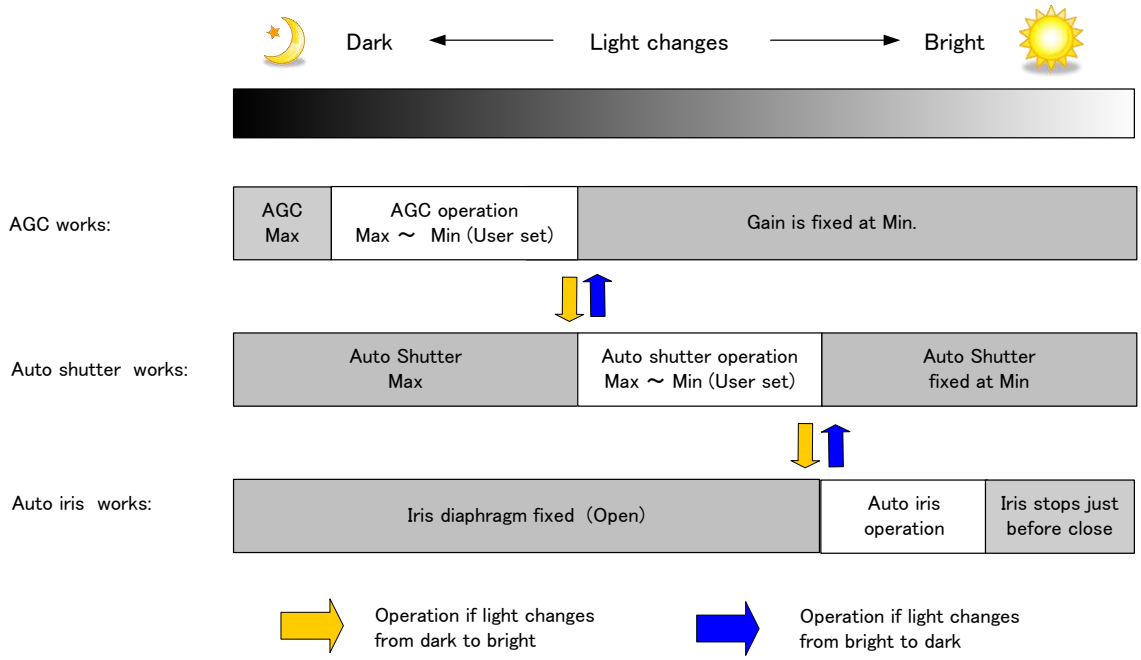


Fig.53 ALC function concept

ALC Reference will determine the target video level for AGC, Auto Shutter and/or Auto iris. For instance, if ALC Reference is set to 100% video level, AGC, Auto Shutter and/or Auto Iris will function to maintain 100% video level.

■ Please note that ALC function is available only in continuous mode, as well as RCT mode.

8.9 HDR (High Dynamic Range) (SP-5000M-USB only)

HDR sensing mode can be set when HDR Mode is set to ON while Exposure Mode is Timed.
The parameters to configure dynamic range are HDR_SLOPE Level 1, Level 2, Level 3 and Level 4.
The user can select any one of those parameters as required for their application.
In this mode, the timed exposure is used as the reference and the value selected in HDR_SLOPE will compensate to get an appropriate dynamic range by changing the exposure time.

Notes:

1. If the exposure mode is OFF and the HDR mode is set to ON, the exposure mode is automatically changed to Timed.
2. If horizontal binning and/or vertical binning are set to ON, the HDR mode cannot be set. In this case, the HDR mode must be set first before H-Binning and/or V-Binning are set.
3. In this mode, exposure overlapped behavior is not available and the frame rate is slower than the normal operation.
4. The exposure time value is fixed at the value when HDR Mode is activated. When the exposure time is changed, HDR Mode should be off. Once the exposure time is changed, the HDR Mode can be set to ON again.
5. In this mode, Exposure Auto function is disabled.

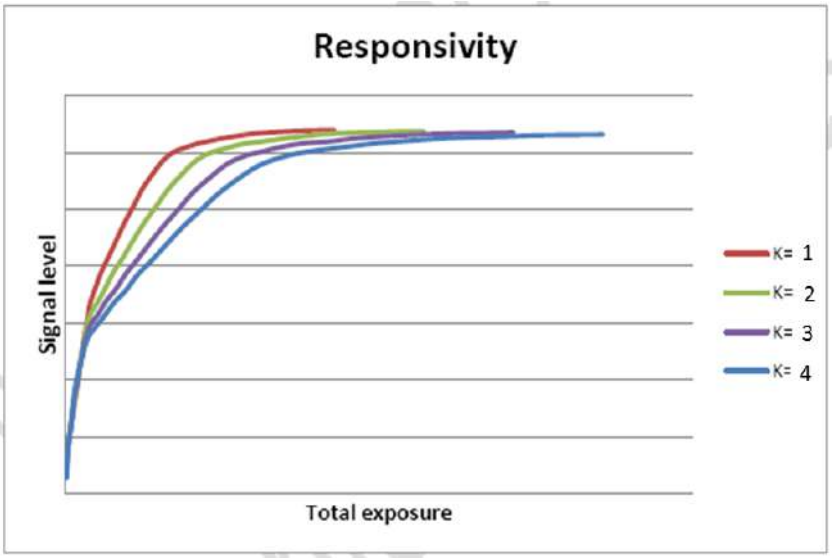


Fig.54 HDR characteristics

Knee Slope	Dynamic Range [%]
1	(200)
2	(400)
3	(800)
4	(1600)

9. Camera setting

9.1 Camera Control Tool

In the SP-5000M-USB and SP-5000C-USB, 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.

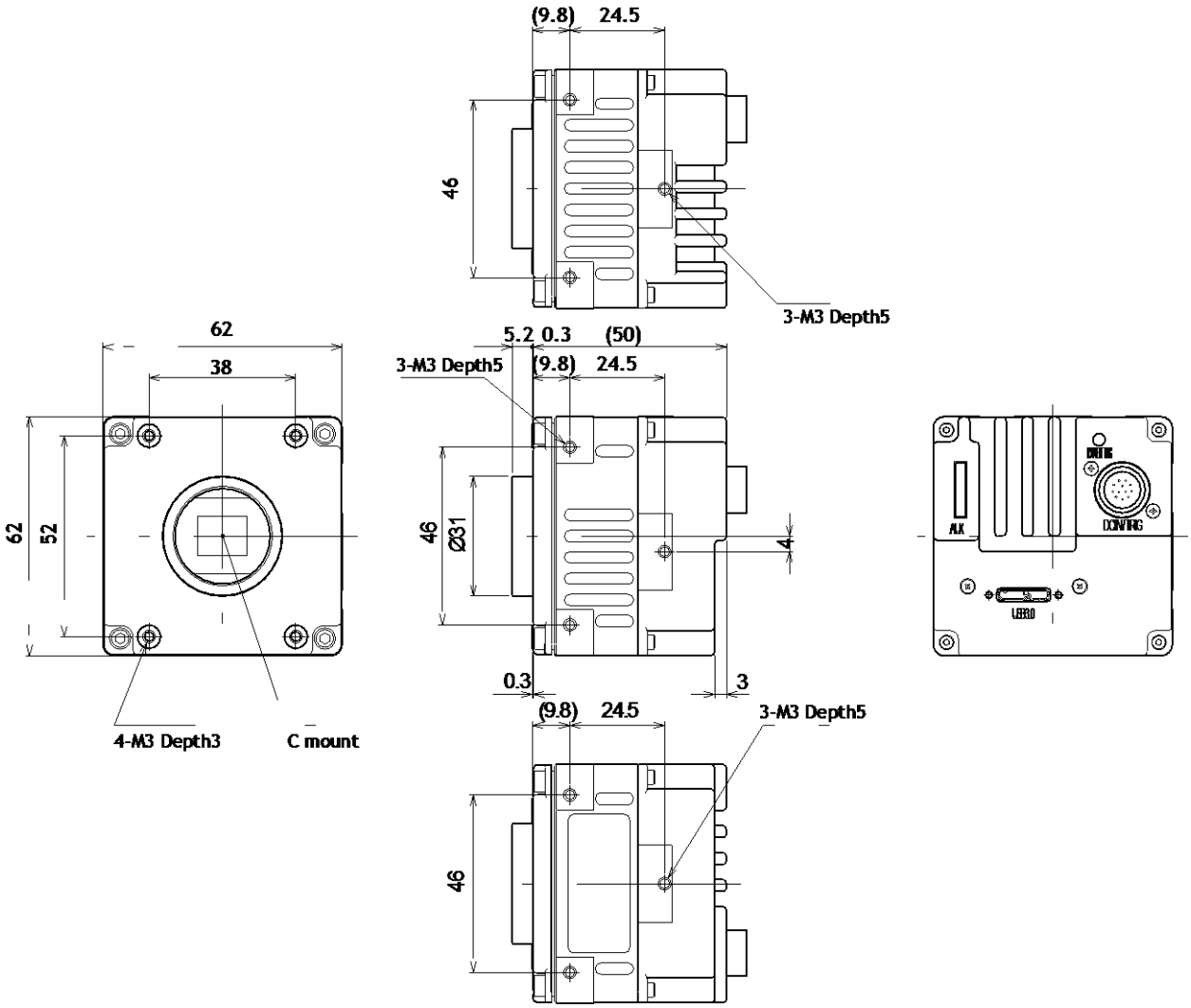
9.2 Camera Default Settings

When the camera is connected to the PC and JAI SDK 2.0 is started up, an XML file which stores default settings of the camera is downloaded to the JAI_SDK camera control tool.

The default settings of the SP-5000-USB are as follows.

Image Format	Bit allocation	8-bit
	Width	2560
	Height	2048
	Binning Horizontal	1(OFF)
	Binning Vertical	1(OFF)
Acquisition Control	Acquisition mode	Continuous
	Acquisition Frame Rate	61.9
Trigger Selector	Trigger Mode	OFF
	Trigger Activation	Rising Edge
	Trigger Source	Low
Trigger Overlap		OFF
Exposure Control	Exposure Mode	OFF
Gain	Gain	1
	Gain Auto	OFF
Analog Base gain		0dB
Gamma		0.45
Video Send Mode		Normal

10. External appearance and dimensions



Dimensions tolerance: ± 0.3mm
Unit: mm

Fig.55 Outside dimensions

11. Specifications

11.1 Spectral response

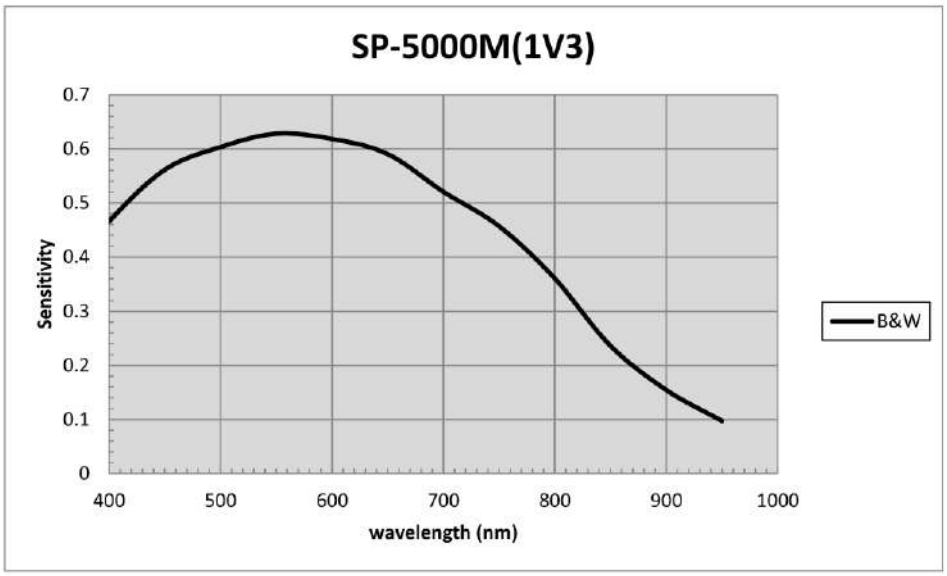


Fig.56 Spectral response (SP-5000M-USB)

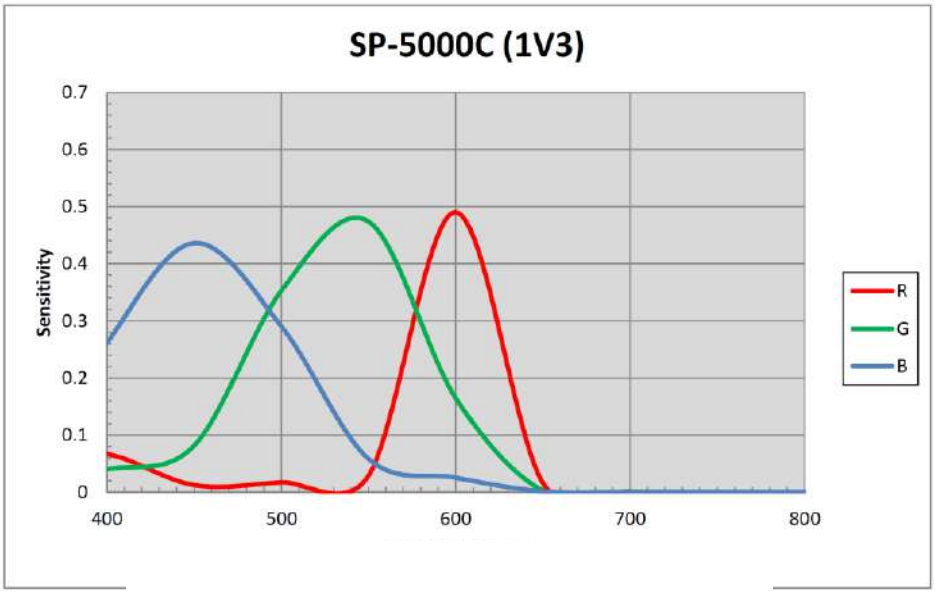


Fig.57 Spectral response (SP-5000C-USB) (With IR Cut Filter)

11.2 Specifications table

Specifications				SP-5000M-USB	SP-5000C-USB
Scanning system				Progressive scan, 1-tap	
Synchronization				Internal	
Interface				USB3 Vision (Specification V1.0 RC4.12)	
Image sensor				1 inch Monochrome CMOS	1 inch Bayer color CMOS
Aspect Ratio				5:4	
Image size(Effective Image)				12.8 (h) x 10.24 (v) mm, 16.39 mm diagonal	
Pixel size				5 (h) x 5 (v) μm	
Effective Image output Pixels				2560 (h) x 2048 (v)	2560 (h) x 2048 (v)
Pixel Clock				48 MHz	
Acquisition Frame Rate (Maximum rate shown. Minimum is 0,125fps in all instances)	Mono 8 Bayer GR8	H1, V1		61.98fps (Max)	61.98fps (Max)
		Binning H1, V2		123.97fps(Max)	—
		Binning H2, V1		61.98fps(Max)	—
		Binning H2,V2		123.97fps(Max)	—
	Mono 10 BayerGR10	H1, V1		30.99fps(Max)	30.99fps(Max)
		Binning H1, V2		61.98fps(Max)	—
		Binning H2, V1		30.99fps(Max)	—
		Binning H2,V2		61.98fps(Max)	—
	Mono10P Bayer GR10P	H1, V1		49.59fps(Max)	49.59fps(Max)
		Binning H1, V2		99.18fps(Max)	—
		Binning H2, V1		49.49fps(Max)	—
		Binning H2,V2		99.18fps(Max)	—
	Mono12 Bayer12	H1, V1		30.99fps(Max)	30.99fps(Max)
		Binning H1, V2		61.98fps(Max)	—
		Binning H2, V1		30.99fps(Max)	—
		Binning H2,V2		61.98fps(Max)	—
	Mono12P BayerGR12 P	H1, V1		41.32fps(Max)	41.32fps(Max)
		Binning H1, V2		82.65fps(Max)	—
		Binning H2, V1		41,32fps(Max)	—
		Binning H2,V2		82.65fps(Max)	—
EMVA 1288 Parameters Absolute sensitivity Maximum SNR				At 10-bit output 23.50 p (λ = 525 nm) 41.48 dB	At 10-bit output 36.08 p (λ = 525 nm) 38.00 dB
SN ratio (traditional method)				49dB (Typical)(at Linear) 55dB(Typical)(at Dark Compression) (0dB gain, Black)	44dB (Typical) (at Linear) 50dB(Typical)(at Dark Compression) (0dB gain, Green Black)
Image Output format Digital	Full pixels			2560 (h) x 2048 (v)	Bayer 2560 (h) x 2048 (v)
	ROI	Width		16 ～2560, 16 pixel/step	16 ～2560, 16 pixels/step
		OFFSET X		0 ～2544, 16 pixel/step	0 ～2544, 16 pixels/step
		Height		1 ～2048 lines,1 line/step	2 ～2048 lines,2 line/step
		OFFSET Y		0 ～2047 lines, 1 line/step	0 ～2046 lines, 2 line/step
	Binning	H	1	2560 (H)	2560 (H)

			2	1280 (H)	–
		V	1	2048 (V)	2048 (V)
			2	1024 (V)	–
	Bit assignment			Mono8, Mono10, Mono10 Packed, Mono12, Mono12 Packed	BayerGR, BayerGR10, BayerGR10 Packed, BayerGR12, BayerGR12 Packed,
Acquisition mode				Continuous / Single Frame / Multi Frame (1 ～255)	
Trigger Selector	Acquisition			Acquisition Start/ Acquisition Stop	
	Exposure			Frame Start	
	Transfer			Acquisition Transfer Start	
Exposure Mode				OFF, Continuous, Timed (EPS), Trigger Width	
Trigger Option				OFF / PIV / RCT (with ALC function)	
Trigger Overlap				OFF / Readout	
Trigger Input Signal				Software, PG0/1, Line4(TTL In), Line5(OPT In), NAND 0, NAND 1, Line10 (Option TTL In 2), Line11 (Option LVDS In)	
Exposure Mode	Timed			Exposure Auto: OFF, 10 μs (Min.) ～ 8 second (Max. Note1), Variable unit: 1 μs Exposure Auto: ON, 100 μs (Min.) ～ 8 second (Max. Note1), Variable unit: 1 μs	
	Trigger Width			10 μs (Min.) ～ ∞ (Max.Note 1))	
Auto Exposure				OFF / Once / Continuous	
Auto Exposure Response Speed				1 ～ 8	
Digital I/O				Line Selector (12P): GPIO IN / GPIO OUT	
Black Level Adjust.	Ref. level			33.5LSB 10-bit (Average value of 100*100)	
	Adj. range			-256 ～ +255LSB 10-bit	
	Resolution			1 STEP = 0.25LSB	
Sensor Base Gain				0dB, 6dB, 12dB	0dB, 6dB, 12dB (RGB respectively)
Gain Control	Manual Adj. range			-0dB ～+24dB (Note2) 1 step=0.01% (0.005dB to 0.08dB) Varies by setting value	-0dB ～+24dB (Note2) 1 step=0.01% (0.005dB to 0.08dB) Varies by setting value
	WB Gain			–	R / B : -7dB to +15dB, 1 step = 0.01dB
	WB Area			–	4 x 4
	Color Temp. Range (Preset)			–	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 (Continuous blemishes are not compensated)	
	Numbers			512 pixels	
ALC				AGC, auto exposure, iris control 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	
HDR Correction				4 settings Level 1, 2, 3 and 4	–
Shading Compensation				Flat Field Block Comp. (20 x 16 blocks) Block size:128 x 128 pixels	Flat Field, Color shading Block comp. (20 x 16 blocks) Block size: 128 x 128 pixels

Power	Input range	DC+12V to +24V ± 10% (At the input terminal)	
	Current consumption	DC IN(12P): 360mA (At 12V input, Full pixels) USB VBUS: 160mA ± 10% (At 5V input)	
	Power consumption	6.24W (At 12V + 5V input, Full pixels)	
Lens mount		C mount Rear protrusion of the lens is less than 10 mm	
Flange back		17.526 mm, Tolerance: 0 to -0.05 mm	
Optical filter		Protection glass: Not provided	IR cut filter (Half value is 670 nm)
Operating temperature/Humidity Performance guaranteed		-10°C to +50°C / 20 – 80% (No-condensing)	
Operating Temperature / Humidity		-45°C to +70°C/20% to 80% (No-condensing)	
Storage Temp. / Humidity		-45°C to +70°C/20% to 80 % (no-condensing)	
Regulation		CE (EN61000-6-2 and EN61000-6-3), FCC part 15 class B, RoHS,	
Housing Dimensions		62 x 62 x 55.5 mm (W x H x D) (excluding protrusion)	
Weight		255 g	

Note1): Usable performance will be up to 1 seconds.

Note2): Histogram integrity is guaranteed with up to +12dB gain applied.

Note3): Approximately 5 minutes pre-heating is required to achieve these specifications.

Note4): 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.

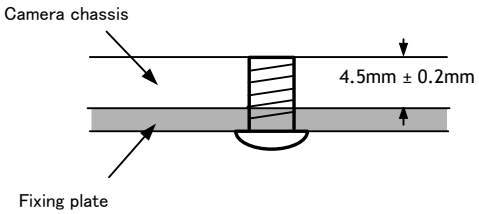
Patterned Noise
When the sensor captures a dark object at high temperature or is used for long time integration, fixed pattern noise may appear on the video monitor screen.

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.

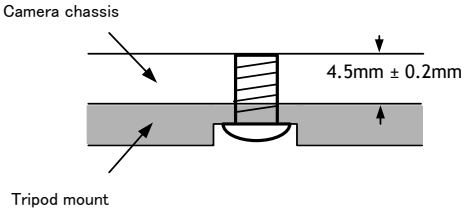
4. Caution when mounting the camera

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.



Mounting the camera to fixing plate

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



Attaching the tripod mount

5. Exportation

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

6. References

1. This manual can and datasheet for SP-5000M-USB / SP-5000C-USB can be downloaded from www.jai.com
2. Camera control software can be downloaded from www.jai.com

Manual change history

Date	Revision	Changes
May 2014	Preliminary	New Release
June 2014	Ver.1.0	Release
Aug. 2014	Ver.1.1	Correct pixel type Mono 10Paked and Bayer10Packed
Sept. 2014	Ver.1.2	Revise Spectral Response
Oct. 2014	Ver. 1.3	Revise B/E spectral response with wider wave length range
Feb. 2015	Ver. 1.4	12-bit specifications added
Mar. 2015	Ver. 1.5	Correct the value of itf in PIV
May 2015	Ver. 1.6	Revised an optical interface recommended circuit
Jan 2021	Ver. 1.7	China RoHS

User's Record

Camera type: **SP-5000M-USB / SP-5000C-USB**

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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