See the possibilities

Spark Series

User Manual

SP-20000M-PMCL
SP-20000C-PMCL

20M CMOS Digital Progressive Scan Monochrome and Color Camera

Document Version: Ver.2.2
SP-20000-PMCL_Ver.2.2_Jan2021

1045J-1304

Notice

The material contained in this manual consists of information that is proprietary to JAI Ltd., Japan and may only be used by the purchasers of the product. JAI Ltd., Japan makes no warranty for the use of its product and assumes no responsibility for any errors which may appear or for damages resulting from the use of the information contained herein. JAI Ltd., Japan reserves the right to make changes without notice.

Company and product names mentioned in this manual are trademarks or registered trademarks of their respective owners.

Warranty

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

Certifications

CE compliance

As defined by the Directive 2004/108/EC of the European Parliament and of the Council, EMC (Electromagnetic compatibility), JAI Ltd., Japan declares that SP-20000M-PMCL and SP-20000C-PMCL 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.

KC

상 호 : JAI Ltd.,Japan
기자재 명칭 : Industrial camera
모 델 명 : SP-20000M-PMCL
제조자 및 제조국가: JAI Ltd.,Japan / JAPAN
MSIP-REM-JAi-SP-20000M-PMCL

상 호 : JAI Ltd.,Japan
기자재 명칭 : Industrial camera
모 델 명 : SP-20000C-PMCL
제조자 및 제조국가: JAI Ltd.,Japan / JAPAN
MSIP-REM-JAi-SP-20000M-PMCL

제조년월은 제품상자의 라벨을 참조하십시요

Supplement

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

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

重要注意事项

有毒，有害物质或元素名称及含量表

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

部件名称	有毒有害物质或元素					
	铅（Pb）	汞（Hg）	镉（Cd）	六价铬（Cr(VI)）	多溴联苯（PPB）	多溴二苯醚（PBDE）
螺丝固定座	×	○	○	○	○	○
连接插头	×	○	○	○	○	○
电路板	×	○	○	○	○	○
.....	.....	.....	.....	.....	.....	.....

○: 表示该有毒有害物质在该部件所有均质材料中的含量均在GB/T 26572-2011规定的限量要求以下。
×: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572-2011规定的限量要求。
（企业可在此处,根据实际情况对上表中打"×"的技术原因进行进一步说明。）

环保使用期限

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

数字「15」为期限15年。

Supplement

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

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

重要注意事项

有毒，有害物质或元素名称及含量表

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

部件名称	有毒有害物质或元素					
	铅（Pb）	汞（Hg）	镉（Cd）	六价铬（Cr(VI)）	多溴联苯（PPB）	多溴二苯醚（PBDE）
螺丝固定座	×	○	○	○	○	○
光学滤色镜	×	○	×	○	○	○
连接插头	×	○	○	○	○	○
电路板	×	○	○	○	○	○
…….	…….	…….	…….	…….	…….	…….

○: 表示该有毒有害物质在该部件所有均质材料中的含量均在GB/T 26572-2011规定的限量要求以下。
×: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572-2011规定的限量要求。
（企业可在此处,根据实际情况对上表中打"×"的技术原因进行进一步说明。）

环保使用期限

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

数字「15」为期限15年。

- Contents -

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

Frame grabber board

The SP-20000M-PMCL and SP-20000C-PMCL comply with "Power over Camera Link" which enables power to be supplied to the camera through the Camera Link cable(s). Because the power requirements of the camera exceed the amount of power which can be provided over a single PoCL connection, power must be supplied via both Camera Link cables in order to utilize the PoCL capabilities. If you plan to use this function, please be sure that the frame grabber board you are using also complies with this specification. Alternatively, the camera can be powered via a separate power supply connected to the 12-pin Hirose connector.

The SP-20000M-PMCL and SP-20000C-PMCL employ output formats which comply with the GenICam® standard. They are 1X8-1Y (8-Tap output), 1X4–1Y (4-Tap output) and 1X2–1Y (2-Tap output). 1X8–1Y, 1X4-1Y and 1X2–1Y are available for 8-bit and 10-bit. Please check if the frame grabber used in the system complies with the mentioned formats.

Computer used for SP-20000 series

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

Camera control tool

The SP-20000M-PMCL and SP-20000C-PMCL are designed to use the JAI SDK and Control Tool software to control camera functions. All controllable functions are stored in the camera's XML file. The JAI SDK can be downloaded from www.jai.com .

A camera control tool for using the Short ASCII command protocol is not available on the JAI website. Please contact your local JAI representative if this is required.

1. General

The SP-20000M-PMCL and SP-20000C-PMCL are among the first new "Spark Series" cameras to be introduced. They provide both high resolution and a high frame rate with excellent image quality for machine vision applications. The SP-20000M-PMCL is a monochrome progressive scan CMOS camera and the SP-20000C-PMCL is the equivalent Bayer mosaic progressive scan CMOS camera. Both are equipped with CMOS sensors offering a 35 mm full size image format, a resolution of 20 million pixels, and a 4:3 aspect ratio. They provide 30 frames per second for 1X8–1Y output format continuous scanning with 5120 x 3480 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 Mini Camera Link interface which is capable of supporting a "Power over Camera Link" capability. A full pixel readout or partial scan readout mode can be selected depending on applications. The readout format is available from 8-tap, 4-tap or 2-tap output.

The SP-20000M-PMCL and SP-20000C-PMCL have various comprehensive functions needed for automated optical inspection applications, such as solid state device inspection or material surface inspection. They incorporate video processing functions such as a look-up table, flat field shading compensation and blemish compensation in addition to fundamental functions such as trigger, exposure setting and video level control. They also provide a new HDR (High Dynamic Range) function.

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

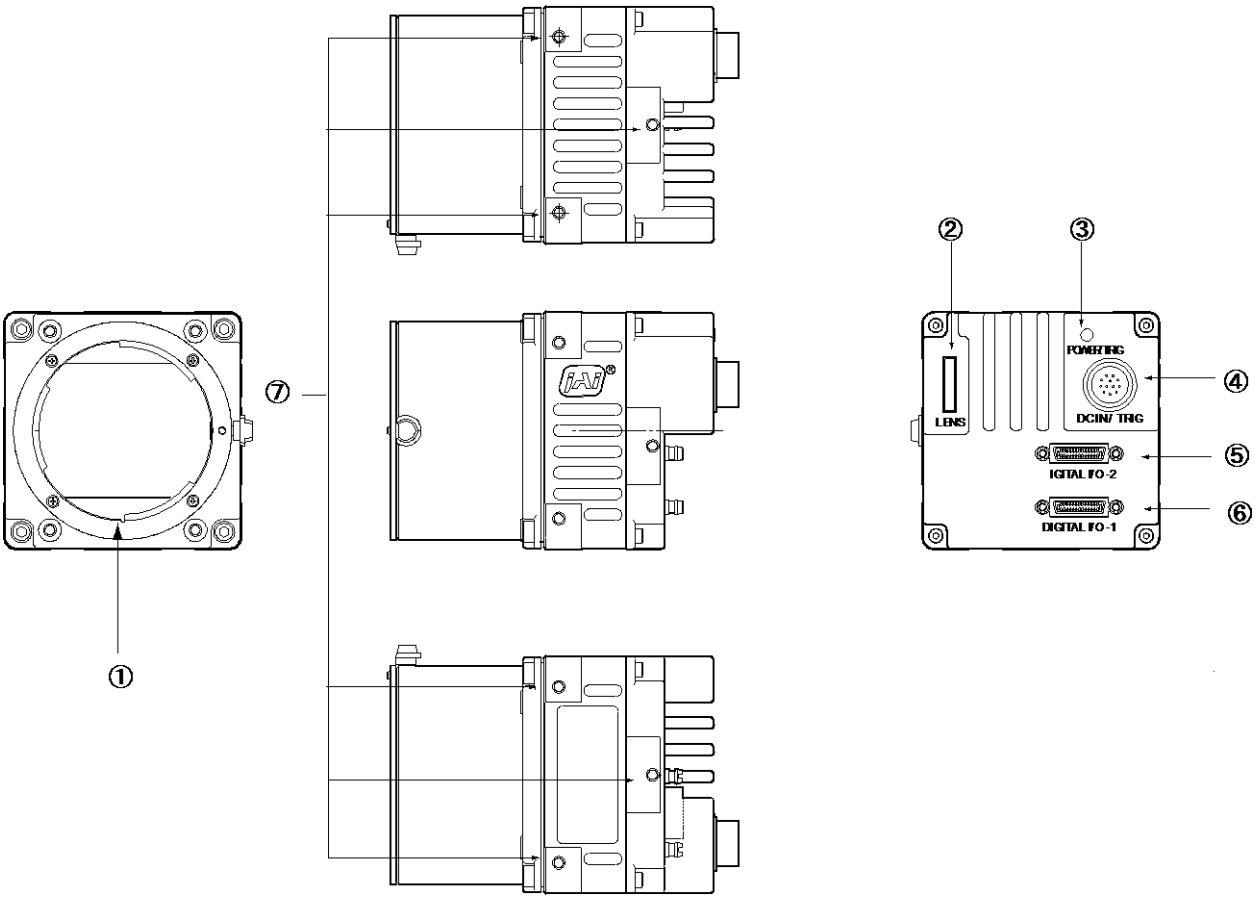
- New Spark Series, 35mm full size, CMOS 20-megapixel progressive scan camera with global shutter
- Utilizes Mini Camera Link interface in Medium or Full configurations
- Aspect ratio 4:3, 5120(H) x 3480(V) - 20 million effective pixels
- 6.4 µm square pixels
- S/N 53dB for monochrome and 51dB for color
- 8-bit, 10-bit or 12-bit output for monochrome and Bayer
- 30 frames/second with full resolution in continuous operation for 8-tap output,
  15 frames/second for 4-tap output and 7.5 fps for 2-tap output for both monochrome and Bayer
- Vertical and horizontal binning on monochrome model
- Supports ROI (Region Of Interest) modes for faster frame rate
- 0dB to +24dB gain control for both SP-20000M-PMCL and SP-20000C-PMCL
- 304 µs (1/3290) to 8 seconds exposure control in 1 µs step
- Auto exposure control
- Timed and trigger width exposure control
- PIV and sequential trigger modes for specific applications
- ALC control with combined function of AGC and auto exposure
- Various pre-processing circuits are provided

  Programmable LUT
  Gamma correction from 0.45 to 1.0
  Shading correction
  Bayer white balance with manual or one-push auto (SP-20000C-PMCL only)
  Blemish compensation

- Auto iris lens video output with H-sync
- New Hirose 10P connector for TTL IN and OUT and LVDS IN interface
- F-mount for lens mount
- Accepts power over Mini Camera Link or via 12-pin connector
- Setup by Windows XP/Vista/7/8 via serial communication

4. Locations and functions

4.1 Locations and functions



①	Lens mount	F-mount (Note *1)
②	10-pin connector	AUX connector for TTL IN/OUT and LVDS IN
③	LED	Indication for power and Trigger input
④	12-pin connector	DC+12V and Trigger input
⑤	Camera Link Connector 2	Digital video output (Medium and Full configuration) (Note *2)
⑥	Camera Link Connector 1	Digital video output (Base, Medium and Full config.) (Note *2)
⑦	Mounting holes	M3 depth 5 mm for fixing the camera to the tripod base or direct installation (Note *3)

*1) Note: Rear protrusion on F-mount lens must be less than 40.0 mm.
*2) Note: When a Camera Link cable is connected to the camera, please do not excessively tighten screws by using a driver. The Camera Link receptacle on the camera might be damaged. For security, the strength to tighten screws is less than 0.147 Newton meter (Nm). Tightening by hand is sufficient in order to achieve this.
*3) Note: The part number for the tripod adapter plate (with 1/4"-20 thread) is MP-42 (option).

Fig. 1 Locations

4.2 Rear Panel

The rear panel mounted LED provides the following information:

- Amber: Power connected – initiating
  This light goes OFF after initiating.
- Steady green: Camera is operating in Continuous mode
- Flashing green: The camera is receiving external triggering

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

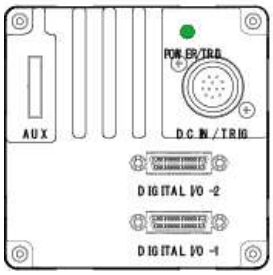


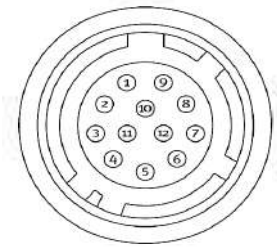
Fig. 2 Rear panel

5. Input and output

5.1 Connectors and pin assignment

5.1.1 12-Pin connector

5.1.1.1 Figure



Type: HR-10A-10R-12PB(72) Hirose male or equivalent
Use the part number HR10A-10P-12S or equivalent for the cable side.

Fig.3 Hirose 12-pin connector

5.1.1.2 Pin Assignment

Table 1 12-pin configuration

Pin no.	Signal	Remarks
1	GND	
2	DC input	+12V ～ +24V (note 3)
3	GND	
4	Video Iris	For lens auto iris
5	NC	
6	NC	
7	NC	
8	NC	
9	TTL Out 1	Line1 (note 1)
10	TTL In 1	Line4 (note 2)
11	DC input	+12V ～ +24V (note 3)
12	GND	

Note 1) Factory default setting is Exposure Active and negative
Although Exposure Active is positive in the inside of the camea, it is output from TTL Out 1 after being inverted to negative.
Note 2) Factory default setting is trigger input.
Note 3) See page 6 for notes about power options for these cameras

5.1.2 Camera Link Connector

5.1.2.1 Figure

Type: 26-pin Mini Camera Link connector (Honda HDR-EC26FYTG2-SL+)
See page 6 for notes about Power over Camera Link (PoCL) options for this camera.

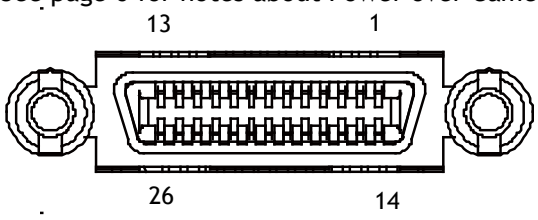


Fig.4 Camera Link connector

5.1.2.2 Pin assignment

Table-2 Camera link pin configuration – connector 1

Pin No	In/Out	Name	Note
1,26		Power	Power
2(-),15(+)	O	X_OUT0	Data output
3(-),16(+)	O	X_OUT1	
4(-),17(+)	O	X_OUT2	
5(-),18(+)	O	X_Clk	Clock for CL
6(-),19(+)	O	X_OUT3	Data output
7(+),20(-)	I	SerTC (RxD)	LVDS serial control
8(-),21(+)	O	SerTFG (TxD)	
9(-),22(+)	I	CC1 (Trigger)	Trigger input
10(+),23(-)		CC1 (Reserved)	
11,24		N.C	
12,25		N.C	
13,14		Shield	Power Return

Camera Link connector 2

Pin No	In/Out	Name	Note
1,26		Power	Power
2(-),15(+)	O	Y_OUT0	Data output
3(-),16(+)	O	Y_OUT1	
4(-),17(+)	O	Y_OUT2	
5(-),18(+)	O	Y_Clk	Clock for CL
6(-),19(+)	O	Y_OUT3	Data output
7(+),20(-)	I	N.C	
8(-),21(+)	O	Z_OUT0	Data output
9(-),22(+)	I	Z_OUT1	
10(-),23(+)		Z_OUT2	
11(-),24(+)		Z_Clk	Clock for CL
12(-),25(+)		Z_OUT3	Data output
13,14		Shield	Power Return

5.1.3 AUX connector HIROSE 10-Pin connector

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

Fig. 5 Hirose 10p connector

Table-3 Pin configuration for Hirose 10P AUX connector

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	

5.2 Camera Link interface

5.2.1 Camera Link Interface

Table-4 Camera Link interface

	SP-20000M/C-PMCL					
Port	Camera Link Configuration		Base	Medium	Full	80bit
	Camera Link port/bit		2Tap / 12bit	4Tap / 12bit	8 Tap / 8bit	8 Tap / 10bit
	GenICam Tap Geometry		1X2 - 1Y	1X4 - 1Y	1x8 - 1Y	1X8 - 1Y
Digital I/O-1	Port A0	TxIN 0	Tap 1 D0	Tap 1 D0	Tap 1 D0	Tap 1 D2
	Port A1	TxIN 1	Tap 1 D1	Tap 1 D1	Tap 1 D1	Tap 1 D3
	Port A2	TxIN 2	Tap 1 D2	Tap 1 D2	Tap 1 D2	Tap 1 D4
	Port A3	TxIN 3	Tap 1 D3	Tap 1 D3	Tap 1 D3	Tap 1 D5
	Port A4	TxIN 4	Tap 1 D4	Tap 1 D4	Tap 1 D4	Tap 1 D6
	Port A5	TxIN 6	Tap 1 D5	Tap 1 D5	Tap 1 D5	Tap 1 D7
	Port A6	TxIN 27	Tap 1 D6	Tap 1 D6	Tap 1 D6	Tap 1 D8
	Port A7	TxIN 5	Tap 1 D7	Tap 1 D7	Tap 1 D7	Tap 1 D9
	Port B0	TxIN 7	Tap 1 D8	Tap 1 D8	Tap 2 D0	Tap 2 D2
	Port B1	TxIN 8	Tap 1 D9	Tap 1 D9	Tap 2 D1	Tap 2 D3
	Port B2	TxIN 9	Tap 1 D10	Tap 1 D10	Tap 2 D2	Tap 2 D4
	Port B3	TxIN 12	Tap 1 D11	Tap 1 D11	Tap 2 D3	Tap 2 D5
	Port B4	TxIN 13	Tap 2 D8	Tap 2 D8	Tap 2 D4	Tap 2 D6
	Port B5	TxIN 14	Tap 2 D9	Tap 2 D9	Tap 2 D5	Tap 2 D7
	Port B6	TxIN 10	Tap 2 D10	Tap 2 D10	Tap 2 D6	Tap 2 D8
	Port B7	TxIN 11	Tap 2 D11	Tap 2 D11	Tap 2 D7	Tap 2 D9
	Port C0	TxIN 15	Tap 2 D0	Tap 2 D0	Tap 3 D0	Tap 3 D2
	Port C1	TxIN 18	Tap 2 D1	Tap 2 D1	Tap 3 D1	Tap 3 D3
	Port C2	TxIN 19	Tap 2 D2	Tap 2 D2	Tap 3 D2	Tap 3 D4
	Port C3	TxIN 20	Tap 2 D3	Tap 2 D3	Tap 3 D3	Tap 3 D5
	Port C4	TxIN 21	Tap 2 D4	Tap 2 D4	Tap 3 D4	Tap 3 D6
	Port C5	TxIN 22	Tap 2 D5	Tap 2 D5	Tap 3 D5	Tap 3 D7
	Port C6	TxIN 16	Tap 2 D6	Tap 2 D6	Tap 3 D6	Tap 3 D8
	Port C7	TxIN 17	Tap 2 D7	Tap 2 D7	Tap 3 D7	Tap 3 D9
	-	TxIN 24	LVAL	LVAL	LVAL	LVAL
	-	TxIN 25	FVAL	FVAL	FVAL	FVAL
	(Port I0)	TxIN 26	DVAL	DVAL	DVAL	Tap 1 D0
	(Port I1)	TxIN 23	Exposure Active	Exposure Active	Exposure Active	Tap 1 D1

	SP-20000M/C-PMCL					
Port	Camera Link Configuration		Base	Medium	Full	80bit
	Camera Link port/bit		2Tap / 12bit	4Tap / 12bit	8 Tap / 8bit	8 Tap / 10bit
	GenICam Tap Geometry		1X2 - 1Y	1X4 - 1Y	1x8 - 1Y	1X8 - 1Y
Digital I/O-2 (1/2)	Port D0	TxIN 0	–	Tap 4 D0	Tap 4 D0	Tap 4 D2
	Port D1	TxIN 1	–	Tap 4 D1	Tap 4 D1	Tap 4 D3
	Port D2	TxIN 2	–	Tap 4 D2	Tap 4 D2	Tap 4 D4
	Port D3	TxIN 3	–	Tap 4 D3	Tap 4 D3	Tap 4 D5
	Port D4	TxIN 4	–	Tap 4 D4	Tap 4 D4	Tap 4 D6
	Port D5	TxIN 6	–	Tap 4 D5	Tap 4 D5	Tap 4 D7
	Port D6	TxIN 27	–	Tap 4 D6	Tap 4 D6	Tap 4 D8
	Port D7	TxIN 5	–	Tap 4 D7	Tap 4 D7	Tap 4 D9
	Port E0	TxIN 7	–	Tap 3 D0	Tap 5 D0	Tap 5 D2
	Port E1	TxIN 8	–	Tap 3 D1	Tap 5 D1	Tap 5 D3
	Port E2	TxIN 9	–	Tap 3 D2	Tap 5 D2	Tap 5 D4
	Port E3	TxIN 12	–	Tap 3 D3	Tap 5 D3	Tap 5 D5
	Port E4	TxIN 13	–	Tap 3 D4	Tap 5 D4	Tap 5 D6
	Port E5	TxIN 14	–	Tap 3 D5	Tap 5 D5	Tap 5 D7
	Port E6	TxIN 10	–	Tap 3 D6	Tap 5 D6	Tap 5 D8
	Port E7	TxIN 11	–	Tap 3 D7	Tap 5 D7	Tap 5 D9
	Port F0	TxIN 15	–	Tap 3 D8	Tap6 D0	Tap 6 D2
	Port F1	TxIN 18	–	Tap 3 D9	Tap6 D1	Tap 6 D3
	Port F2	TxIN 19	–	Tap 3 D10	Tap6 D2	Tap 6 D4
	Port F3	TxIN 20	–	Tap 3 D11	Tap6 D3	Tap 6 D5
	Port F4	TxIN 21	–	Tap 4 D8	Tap6 D4	Tap 6 D6
	Port F5	TxIN 22	–	Tap 4 D9	Tap6 D5	Tap 6 D7
	Port F6	TxIN 16	–	Tap 4 D10	Tap6 D6	Tap 6 D8
	Port F7	TxIN 17	–	Tap 4 D11	Tap6 D7	Tap 6 D9
	-	TxIN 24	–	LVAL	LVAL	LVAL
	(Port I2)	TxIN 25	–	FVAL	FVAL	Tap 2 D0
	(Port I3)	TxIN 26	–	DVAL	DVAL	Tap 2 D1
	(Port I4)	TxIN 23	–	Exposure Active	Exposure Active	Tap 3 D0

SP-20000M/C-PMCL						
Port	Camera Link Configuration		Base	Medium	Full	80bit
	Camera Link port/bit		2Tap / 12bit	4Tap / 12bit	8 Tap / 8bit	8 Tap / 10bit
	GenICam Tap Geometry		1X2 - 1Y	1X4 - 1Y	1x8 - 1Y	1X8 - 1Y
Digital I/O-2 (2/2)	Port G0	TxIN 0	–	–	Tap 7 D0	Tap 7 D2
	Port G1	TxIN 1	–	–	Tap 7 D1	Tap 7 D3
	Port G2	TxIN 2	–	–	Tap 7 D2	Tap 7 D4
	Port G3	TxIN 3	–	–	Tap 7 D3	Tap 7 D5
	Port G4	TxIN 4	–	–	Tap 7 D4	Tap 7 D6
	Port G5	TxIN 6	–	–	Tap 7 D5	Tap 7 D7
	Port G6	TxIN 27	–	–	Tap 7 D6	Tap 7 D8
	Port G7	TxIN 5	–	–	Tap 7 D7	Tap 7 D9
	Port H0	TxIN 7	–	–	Tap 8 D0	Tap 8 D2
	Port H1	TxIN 8	–	–	Tap 8 D1	Tap 8 D3
	Port H2	TxIN 9	–	–	Tap 8 D2	Tap 8 D4
	Port H3	TxIN 12	–	–	Tap 8 D3	Tap 8 D5
	Port H4	TxIN 13	–	–	Tap 8 D4	Tap 8 D6
	Port H5	TxIN 14	–	–	Tap 8 D5	Tap 8 D7
	Port H6	TxIN 10	–	–	Tap 8 D6	Tap 8 D8
	Port H7	TxIN 11	–	–	Tap 8 D7	Tap 8 D9
	(Port I5)	TxIN 15	–	–	–	Tap 3 D1
	(Port I6)	TxIN 18	–	–	–	Tap 4 D0
	(Port I7)	TxIN 19	–	–	–	Tap 4 D1
	(Port K0)	TxIN 20	–	–	–	Tap 5 D0
	(Port K1)	TxIN 21	–	–	–	Tap 5 D1
	(Port K2)	TxIN 22	–	–	–	Tap 6 D0
	(Port K3)	TxIN 16	–	–	–	Tap 6 D1
	(Port K4)	TxIN 17	–	–	–	Tap 7 D0
	-	TxIN 24	–	–	LVAL	LVAL
	(Port K5)	TxIN 25	–	–	FVAL	Tap 7 D1
	(Port K6)	TxIN 26	–	–	DVAL	Tap 8 D0
	(Port K7)	TxIN 23	–	–	Exposure Active	Tap 8 D1

Note

1. In this table, all Tap Geometry items are not described. For instance, 1X2–1Y and 1X4–1Y show only 12-bit. In case of 10-bit, upper 2 bits (D10 and D11) are not used and in case of 8-bit, upper 4 bits (D8 through D11) are not used.
2. Please check whether the frame grabber complies with those formats if you use 80-bit (8Tap/10-bit) camera configuration.
3. If you use 80-bit (8Tap/10-bit) camera configuration, DVAL and Exposure Active (JAI custom) are not output through the Camera Link interface. FVAL is only output via Digital I/O-1 connector.

5.2.2 Camera Link Pixel clock

The SP-20000M-PMCL and SP-20000C-PMCL use the Camera Link pixel clock of 80 MHz as the default setting. It can be changed.

Table – 5 Camera Link pixel clock

Camera Link Pixel Clock	Tap Geometry	Camera Link Configuration	Note
80 MHz	1X8-1Y	80-bit, Full	Defaut setting
	1X4-1Y	Medium	
	1X2-1Y	Base	
60 MHz	1X8-1Y	80-bit, Full	
	1X4-1Y	Medium	
	1X2-1Y	Base	

[Note]
If the Camera Link pixel clock is changed, the output is immediately changed but it may take a few seconds for the output signal to be stable.

5.3 Digital IN/OUT Inteface

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

5.3.1 Line Selector

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

Table-6 Line selector

Line Selector item	Description
Line 1 TTL 1 Out	TTL output from # 9 pin of DC In/Trigger 12-Pin on the rear
Line 8 TTL 2 Out	TTL output from #1pin “AUX” HIROSE 10-Pin on the rear
Line 9 TTL 3 Out	TTL output from #2pin “AUX” HIROSE 10-Pin on the rear
NAND 0 In 1	First input at NAND first gate in GPIO
NAND 0 In 2	Second input at NAND first gate in GPIO
NAND 1 In 1	First input at NAND second gate in GPIO
NAND 1 in 2	Second input at NAND second gate in GPIO

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-7 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
Exposure Active	Connect Exposure Active signal to line item selected in Line Selector
FVAL	Connect FVAL signal to line item selected in Line Selector
LVAL	Connect LVAL signal to line item selected in Line Selector
PulseGenerator0 Out	Connect Pulse Generator 0 signal to line item selected in Line Selector
PulseGenerator1 Out	Connect Pulse Generator 1 signal to line item selected in Line Selector
PulseGenerator2 Out	Connect Pulse Generator 2 signal to line item selected in Line Selector
PulseGenerator3 Out	Connect Pulse Generator 3 signal to line item selected in Line Selector
TTL 1 In	Connect TTL 1 IN signal to line item selected in Line Selector
CL CC1 In	Connect CL CC1 IN signal to line item selected in Line Selector
Nand0 Out	Connect NAND 0 signal to line item selected in Line Selector
Nand1 Out	Connect NAND 1 signal to line item selected in Line Selector
Line 10 TTL 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 can not be connected. Refer to “5.4.6.2 GPIO matrix table”

5.3.3 Line Mode

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

5.3.4 Line Inverter

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

5.3.5 Line Status

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

5.3.6 Line Format

Controls the format of the line item selected in Line Selector.
(No Connect, TTL, LVDS, Opt Coupled)
Note: The SP-20000-PMCL does not have “Opto Coupled” in and out interface.

5.3.7 GPIO

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

5.3.7.1 Basic block diagram

The basic block diagram is as follows.

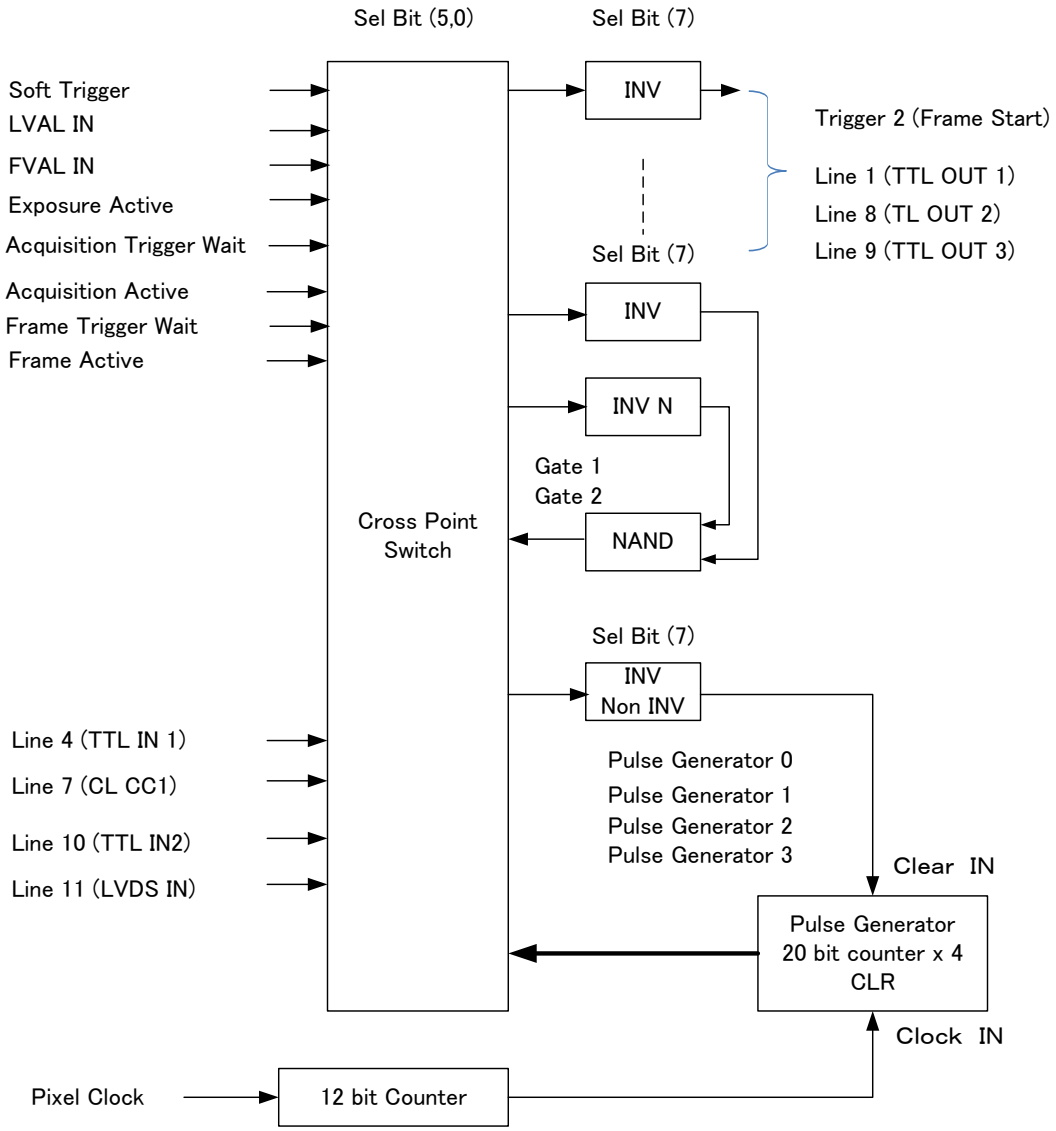


Fig.6 GPIO interface

5.3.7.2 Input and output matrix table

The relation between input and output is as follows.

Table-8 GPIO matrix table

Selector (Cross point switch output) / Source signal (Cross point switch input)	Trigger Selector	Line Selector							Pulse Generator Selector			
	Trigger Source (Frame Start)	Line 1 - 12P TTL Out	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	Pulse Generator 2	Pulse Generator 3
Low	○	○	○	○	○	○	○	○	○	○	○	○
High	○	○	○	○	○	○	○	○	○	○	○	○
Soft Trigger	○	×	×	×	×	×	×	×	×	×	×	×
Exposure Active	×	○	○	○	○	○	○	○	○	○	○	○
Frame Trigger Wait	×	○	○	○	○	○	○	○	○	○	○	○
Frame Active	×	○	○	○	○	○	○	○	○	○	○	○
FVAL	×	○	○	○	○	○	○	○	○	○	○	○
LVAL	×	○	○	○	○	○	○	○	○	○	○	○
Pulse Generator 0	○	○	○	○	○	○	○	○	×	○	○	○
Pulse Generator 1	○	○	○	○	○	○	○	○	○	×	○	○
Pulse Generator 2	○	○	○	○	○	○	○	○	○	○	×	○
Pulse Generator 3	○	○	○	○	○	○	○	○	○	○	○	×
Line 4 - TTL In1	○	○	○	○	○	○	○	○	○	×	○	○
Line 7 - CL CC1 in	○	○	○	○	○	○	○	○	○	×	○	○
NAND 0 Out	○	○	○	○	×	×	○	○	○	○	○	○
NAND 1 Out 1	○	○	○	○	○	○	×	×	○	○	○	○
Line 10 - TTL 2 In	○	○	○	○	○	○	○	○	○	○	○	○
Line 11 - LVDS 1 In	○	○	○	○	○	○	○	○	○	○	○	○
	Trigger Source	Line Source							Pulse Generator Clear Source			

5.4 Pulse Generator

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

Table - 9 Pulse Generator default settings

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

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

5.4.1 Clock Pre-scaler

Clock pre-scaler (Divide Value) can set the dividing value of the frequency divider (12-bit length) and the sensor clock is used for this. Four built-in pulse generators work by the same clock. In the SP-20000-PMCL, the sensor pixel clock is 39.16 MHz.

5.4.2 Pulse Generator Selector

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

Table - 10 Pulse Generator setting

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

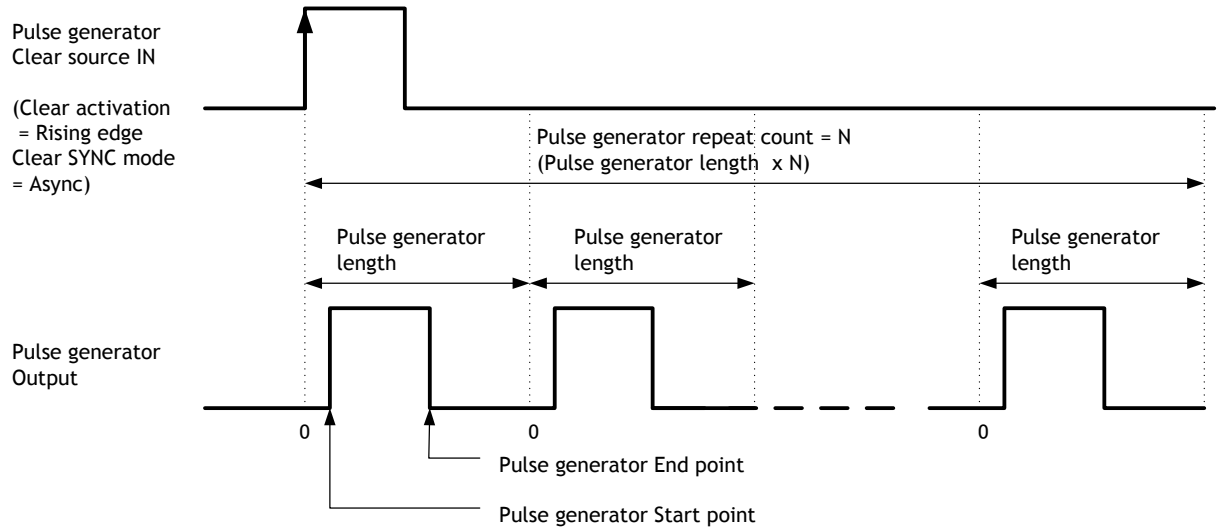


Fig.7 Pulse Generator pulse construction

5.4.3 Pulse Generator Length

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

5.4.4 Pulse Generator Start Point

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

5.4.5 Pulse Generator End Point

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

5.4.6 Pulse Generator Repeat Count

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

5.4.7 Pulse Generator Clear Activation

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

5.4.8 Pulse Generator Clear Sync Mode

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

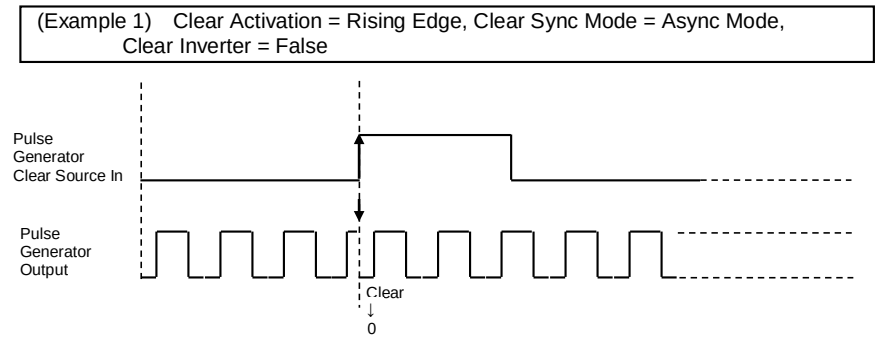


Fig.8 Counter clear in Async mode

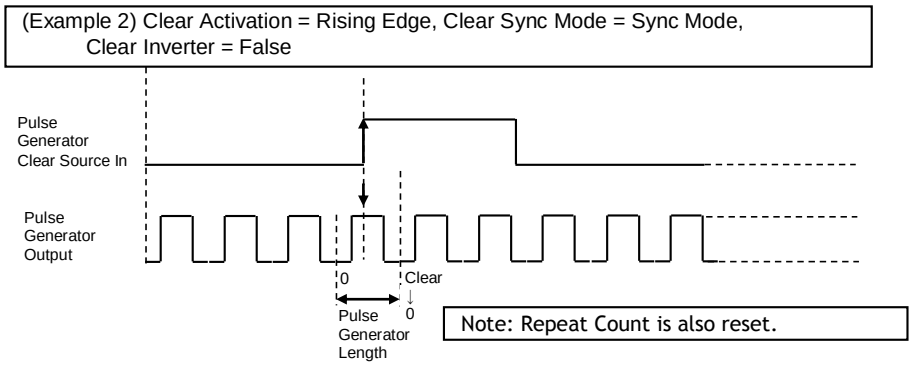


Fig.9 Counter clear in Sync mode

5.4.9 Pulse Generator Clear Source

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

Tabel - 11 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.
PulseGenerator2 Out	Connect Pulse Generator 2 output to Clear Source for the selected pulse generator.
PulseGenerator3 Out	Connect Pulse Generator 3 output to Clear Source for the selected pulse generator.
TTL 1 In	Connect TTL 1 IN signal to Clear Source for the selected pulse generator.
CL CC1 In	Connect CL CC1 IN signal to Clear Source for the selected pulse generator.
Nand0 Out	Connect NAND 0 output signal to Clear Source for the selected pulse generator.
Nand1 Out	Connect NAND 1 output signal to Clear Source for the selected pulse generator.
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 “5.4.6.2.GPIO matrix table”.

5.4.10 Pulse Generator Inverter

Clear Source Signal can be have polarity inverted.

5.4.11 Pulse Generator setting parameters

Table - 12 Pulse Generator setting parameters

Display Name	Value
Clock Pre-scaler	1 to 4096
Pulse Generator Clock (MHzMHz)	[Pixel Clock:39.16 MHz]÷[Clock Pre-scaler]
Pulse Generator Selector	- Pulse Generator 0
	- Pulse Generator 1
	- Pulse Generator 2
	- Pulse Generator 3
- Pulse Generator Length	1 to 1048575
- Pulse Generator Length (ms)	([Clock Source]÷[Clock Pre-scaler])$^{-1}$ x [Pulse Generator Length]
- Pulse Generator Frequency (Hz)	[Pulse Generator Length (ms)]$^{-1}$
- Pulse Generator Start Point	0 to 1048574
- Pulse Generator Start Point (ms)	([Clock Source]÷[Clock Pre-scaler])$^{-1}$ x [Pulse Generator Start Point]
- Pulse Generator End Point	1 to 1048575
- Pulse Generator End Point (ms)	([Clock Source]÷[Clock Pre-scaler])$^{-1}$ x [Pulse Generator End Point]
- Pulse Generator pulse-width (ms)	[Pulse Generator End Point (ms)]－[Pulse Generator Start Point (ms)]
- Pulse Generator Repeat Count	0 to 255
- Pulse Generator Clear Activation Clear Mode for the Pulse Generators	- Off
	- High Level
	- Low level
	- Rising Edge
	- Falling Edge
- Pulse Generator Clear Sync Mode	- Async mode
	- Sync mode
- Pulse Generator Clear Source	- Low
	- High
	- Frame Trigger Wait
	- Frame Active
	- Exposure Active
	- Fval
	- Lval
	- PulseGenerator0
	- PulseGenerator1
	- PulseGenerator2
	- PulseGenerator3
	- TTL_In1
	- CL_CC1_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.
2. The output of the same pulse generator cannot be connected to Clear input.
3. If the Camera Link pixel clock is changed, the pixel clock of the pulse generator remains 39.16 MHz.

6. Sensor layout, output format and timing

6.1 Sensor layout

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

6.1.1 Monochrome sensor

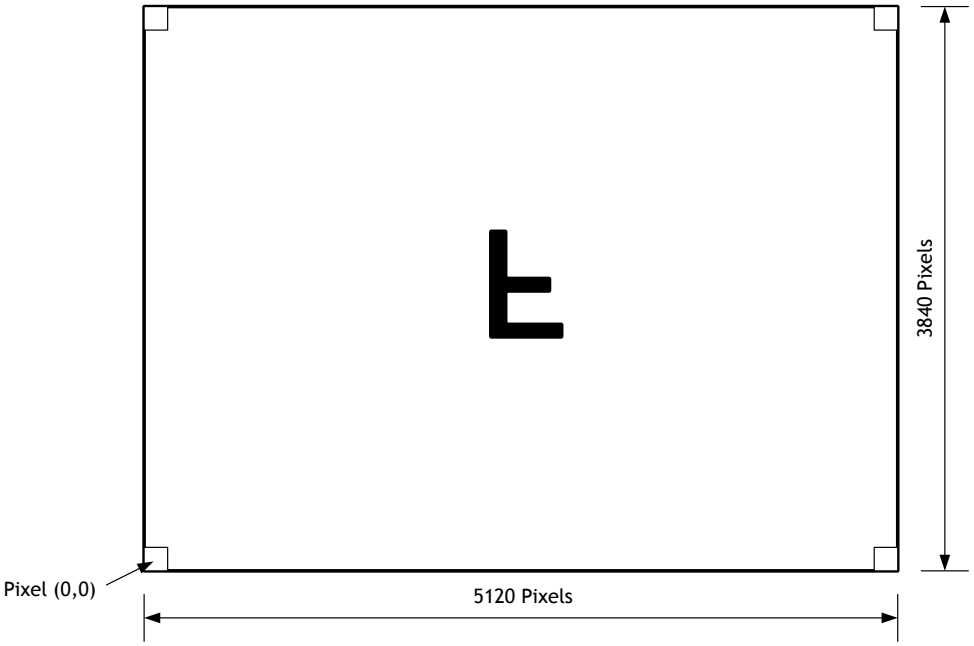


Fig. 10 Monochrome sensor layout

6.1.2 Bayer sensor

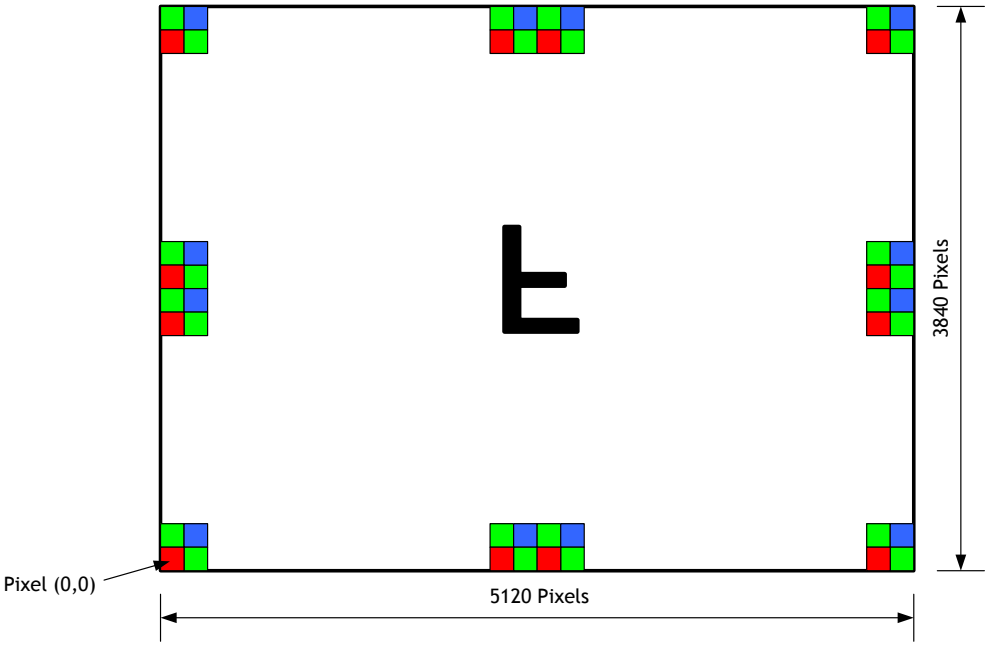


Fig. 11 Color sensor layout

6.2 Camera output format

Table - 13 Output format

Camera output format	Pixel format	Refer to drawing
1X2-1Y	8-bit, 10-bit, 12-bit	6.2.1
1X4-1Y	8-bit, 10-bit, 12-bit	6.2.2
1X8-1Y	8-bit, 10-bit	6.2.3

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

6.2.1 1X2-1Y

1X2-1Y is a 2-tap readout system specified in GenICam Tap Geometry and it outputs as follows.

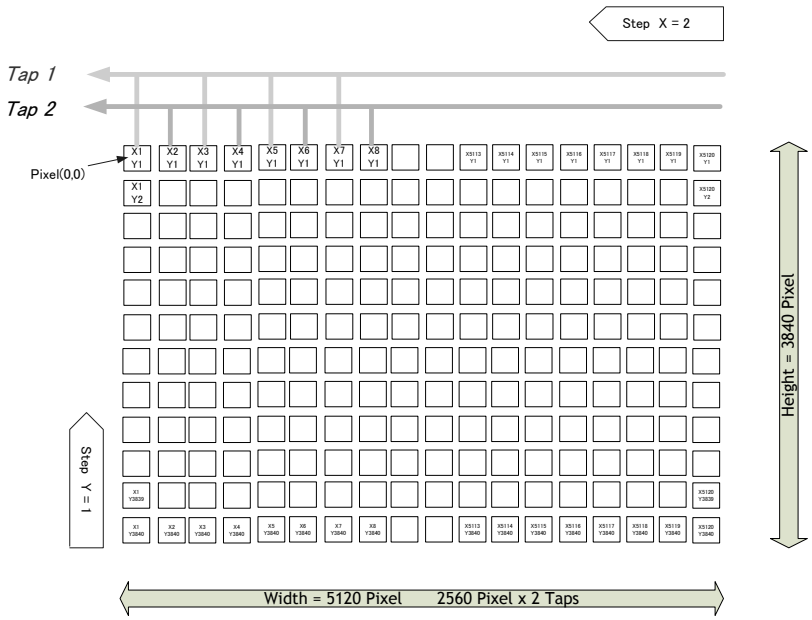


Fig. 12 1X2-1Y camera output format

6.2.2 1X4-1Y

1X4-1Y is a 4-tap readout system specified in GenICam Tap Geometry and it outputs as follows.

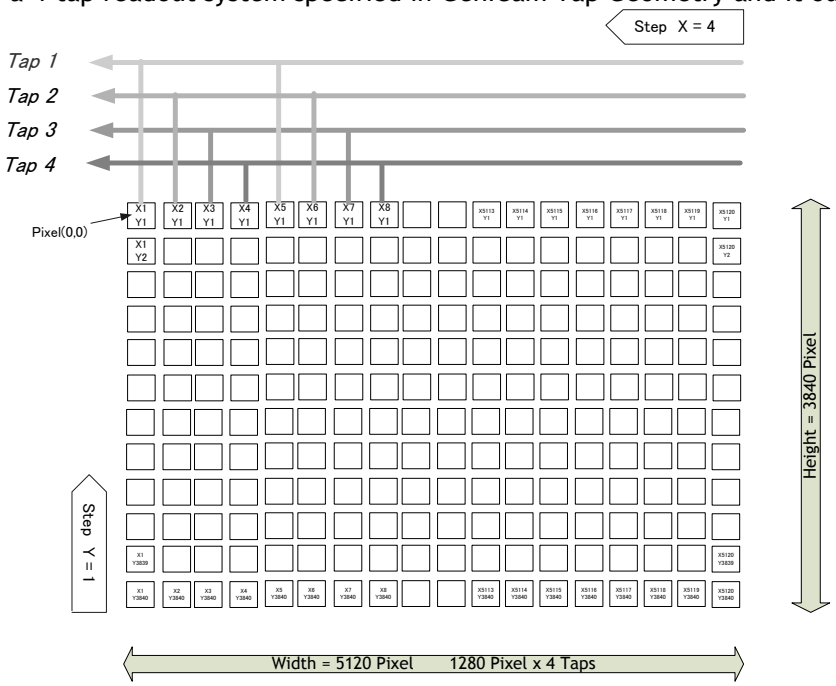


Fig. 13 1X4-1Y output system

6.2.3 1X8-1Y

1X 8-1Y is an 8-tap readout system and outputs as follows.

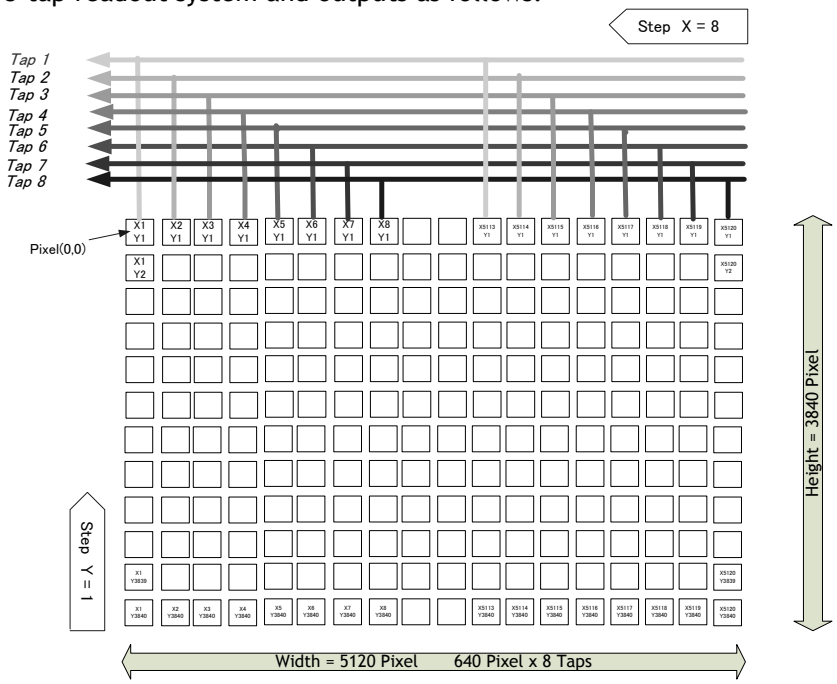


Fig. 14. 1X8-1Y output sysytem

6.3 Output timing

6.3.1 Horizontal timing

This timing is for the continuous trigger. The horizontal frequency is changed by the setting of Tap Geometry. The SP-20000M-PMCL (monochrome) supports horizontal and vertical binning. However, the horizontal frequency does not change when horizontal binning is effective, and therefore, the frame rate is not increased.

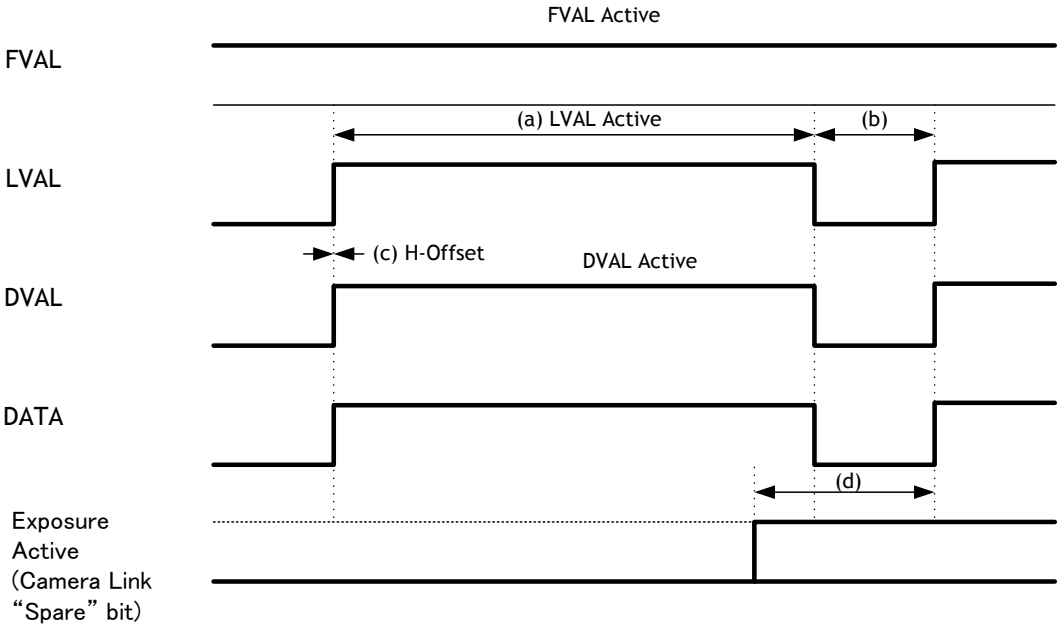


Fig. 15 Horizontal timing per 1 tap

Table – 14 Continuous trigger horizontal timing

Camera Settings								(a)	(b)	(c)	(d)			Step
Tap Geometry	Camera Link Pixel Clock	ROI				Binning		LVAL Active	LVAL Non-Active	H-Offset	Exposure Active Start to LVAL Active Start			(Typ.)
		Width	Offset X	Height	Offset Y	Horizontal	Vertical	[Unit: Clock]	[Unit: Clock]	[Unit: Clock]	[Unit: Camera Link Clock]			
1X8-1Y	80MHz	5120	0	3840	0	1 (Off)	1 (Off)	640	14～15	0	53			8
		5120	0	1920	0	1 (Off)	2 (On)	640	669～670	0	53	or	707	8
		2560	0	3840	0	2 (On)	1 (Off)	320	334～335	0	53			8
		2560	0	1920	0	2 (On)	2 (On)	320	989～990	0	53	or	707	8
	60MHz	5120	0	3840	0	1 (Off)	1 (Off)	640	19～20	0	53			10
		5120	0	1920	0	1 (Off)	2 (On)	640	678～679	0	53	or	713	10
		2560	0	3840	0	2 (On)	1 (Off)	320	339～340	0	53			10
		2560	0	1920	0	2 (On)	2 (On)	320	998～999	0	53	or	713	10
1X4-1Y	80MHz	5120	0	3840	0	1 (Off)	1 (Off)	1280	29～30	0	650			16
		5120	0	1920	0	1 (Off)	2 (On)	1280	1339～1340	0	650	or	1959	16
		2560	0	3840	0	2 (On)	1 (Off)	640	669～670	0	650			16
		2560	0	1920	0	2 (On)	2 (On)	640	1979～1980	0	650	or	1959	16
	60MHz	5120	0	3840	0	1 (Off)	1 (Off)	1280	38～39	0	653			22
		5120	0	1920	0	1 (Off)	2 (On)	1280	1357～1358	0	653	or	1972	22
		2560	0	3840	0	2 (On)	1 (Off)	640	678～679	0	653			22
		2560	0	1920	0	2 (On)	2 (On)	640	1997～1998	0	653	or	1972	22
1X2-1Y	80MHz	5120	0	3840	0	1 (Off)	1 (Off)	2560	58～59	0	1290			33
		5120	0	1920	0	1 (Off)	2 (On)	2560	2677～2678	0	1290	or	3909	33
		2560	0	3840	0	2 (On)	1 (Off)	1280	1339～1340	0	1290			33
		2560	0	1920	0	2 (On)	2 (On)	1280	3957～3958	0	1290	or	3909	33
	60MHz	5120	0	3840	0	1 (Off)	1 (Off)	2560	77～78	0	1301			44
		5120	0	1920	0	1 (Off)	2 (On)	2560	2714～2715	0	1301	or	3939	44
		2560	0	3840	0	2 (On)	1 (Off)	1280	1357～1358	0	1301			44
		2560	0	1920	0	2 (On)	2 (On)	1280	3994～3995	0	1301	or	3939	44

Note:
1. In 1X8-1Y, 10-bit setting (80-bit Configuration), DVAL output port is used for data output and therefore, DVAL is not output through Camera Link interface.
2. In the SP-20000-PMCL, the horizontal frequency is not doubled even if horizontal binning is ON.
3. In the SP-20000-PMCL, the horizontal frequency is 1/2 if vertical binning is ON. And if vertical binning is ON, the invalid data is output in non-active range (H-offset range) of DVAL during LVAL being active.
4. H-Offset : Duration between LVAL Active Start and DVAL Active Start.
5. The phase of Exposure Active is described based on using the output at Camera Link Spare bit as the reference.
6. If the next exposure is done while the image of V-Binnig On is read out, the exposure control is increased or decreased by 0.5 line unit.
7. “d” ExposureActive Start to LVALActiveStart may have 1 clock difference due to the jitter in LVALNonActive period.

Table – 15 Continuous trigger horizontal frequency (1X8-1Y, 1X4-1Y)
In the following table, values in "Actual operation" are real operating values. However, "1 Line Total Clock" values in "Calculation" are used to calculate the frame rate and other. This is because jitter occurs in "LVAL Non Active" period.

Camera Settings									1Line Total Clock [Unit: Clock]	Horizontal Frequency [Unit: kHz]	Horizontal Period [Unit: us]
Tap Geometry	Camera Link Pixel Clock	ROI				Binning					
		Width	Offset X	Height	Offset Y	Horizontal	Vertical				
1X8-1Y	80 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	654 or 655	122.324 or 122.137	8.175 or 8.188
								Calculation	654.63	122.206	8.183
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	1309 or 1310	61.115 or 61.068	16.363 or 16.375
								Calculation	1309.27	61.103	16.366
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	654 or 655	122.324 or 122.137	8.175 or 8.188
								Calculation	654.63	122.206	8.183
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	1309 or 1310	61.115 or 61.068	16.363 or 16.375
								Calculation	1309.27	61.103	16.366
	60 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	659 or 660	91.047 or 90.909	10.983 or 11.000
								Calculation	659.31	91.004	10.989
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	1318 or 1319	45.523 or 45.489	21.967 or 21.983
								Calculation	1318.61	45.502	21.977
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	659 or 660	91.047 or 90.909	10.983 or 11.000
								Calculation	659.31	91.004	10.989
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	1318 or 1319	45.523 or 45.489	21.967 or 21.983
								Calculation	1318.61	45.502	21.977
1X4-1Y	80 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	1309 or 1310	61.115 or 61.069	16.363 or 16.375
								Calculation	1309.27	61.103	16.366
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	2618 or 2619	30.558 or 30.546	32.725 or 32.738
								Calculation	2618.53	30.551	32.732
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	1309 or 1310	61.115 or 61.069	16.363 or 16.375
								Calculation	1309.27	61.103	16.366
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	2618 or 2619	30.558 or 30.546	32.725 or 32.738
								Calculation	2618.53	30.551	32.732
	60 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	1318 or 1319	45.524 or 45.489	21.967 or 21.983
								Calculation	1318.61	45.502	21.977
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	2637 or 2638	22.753 or 22.745	43.950 or 43.967
								Calculation	2637.23		
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	1318 or 1319	45.524 or 45.489	21.967 or 21.983
								Calculation	1318.61	45.502	21.977
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	2637 or 2638	22.753 or 22.745	43.950 or 43.967
								Calculation	2637.23	22.751	43.954

Table – 16 Continuous trigger horizontal frequency (1X2-1Y)

In the following table, values in "Actual operation" are real operating values. However, "1 Line Total Clock" values in "Calculation" are used to calculate the frame rate and other. This is because jitter occurs in "LVAL Non Active" period.

Camera Settings									1Line Total Clock [Unit: Clock]	Horizontal Frequency [Unit: kHz]	Horizontal Period [Unit: us]
Tap Geometry	Camera Link Pixel Clock	ROI				Binning					
		Width	Offset X	Height	Offset Y	Horizontal	Vertical				
1X2-1Y	80 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	2618 or 2619	30.558 or 30.546	32.725 or 32.738
								Calculation	2618.54	30.551	32.732
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	5237 or 5238	15.276 or 15.273	65.463 or 65.475
								Calculation	5237.09	15.276	65.464
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	2618 or 2619	30.558 or 30.546	32.725 or 32.738
								Calculation	2618.54	30.551	32.732
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	5237 or 5238	15.276 or 15.273	65.463 or 65.475
								Calculation	5237.09	15.276	65.464
	60 MHz	5120	0	3840	0	1 (Off)	1 (Off)	Actual operation	2637 or 2638	25.349 or 22.745	39.450 or 43.967
								Calculation	2637.25	22.751	43.954
		5120	0	1920	0	1 (Off)	2 (On)	Actual operation	5274 or 5275	11.377 or 11.374	87.900 or 87.917
								Calculation	5274.49	11.376	87.908
		2560	0	3840	0	2 (On)	1 (Off)	Actual operation	2637 or 2638	25.349 or 22.745	39.450 or 43.967
								Calculation	2637.25	22.751	43.954
		2560	0	1920	0	2 (On)	2 (On)	Actual operation	5274 or 5275	11.377 or 11.374	87.900 or 87.917
								Calculation	5274.49	11.376	87.908

[Note]
"Actual operation" shows the real operating values that can be expected. However, in order to calculate the frame rate and so on, the value of 1 Line Total Clock in the calculation is used. This is because jitter occurs in the LVAL Non Active period.

6.3.2 Vertical timing

In Continuous Trigger operation, the output through the Camera Link interface is as follows. However, if 80-bit (1X8-1Y, 10-bits) configuration is set, DVAL and Exposure Active (JAI CUSTOM) are not output through Camera Link "Spare" bit because this port is used for data output.
The SP-20000-PMCL can support H-Binning and V-Binning functions, but the frame rate is not increased.

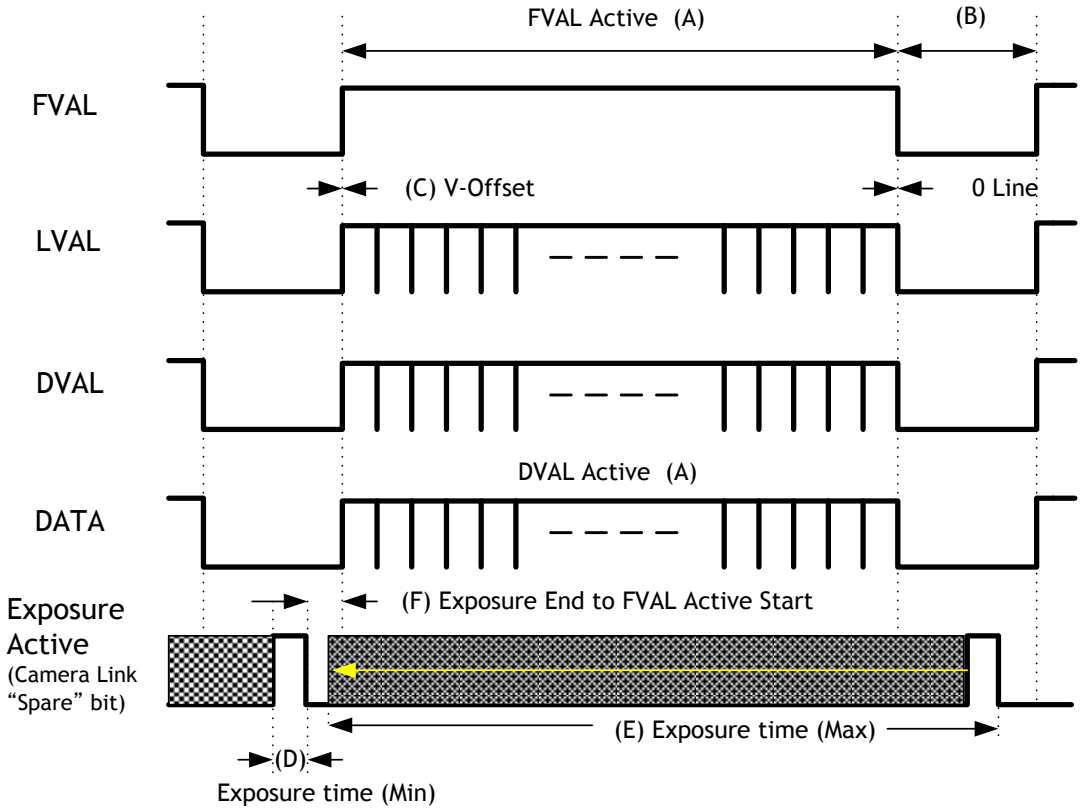


Fig. 16 Vertical timing

Table – 17 Continuous trigger vertical timing (1/2)

Camera Settings									(A)	(B)	(C)	(D)
Tap Geometry	Camera Link Pixel Clock	Frame Rate (Typ.) / Time	ROI Width	ROI Offset X	ROI Height	ROI Offset Y	Binning Horizontal	Binning Vertical	FVAL & DVAL Active [Unit: Line]	FVAL Non -Active [Unit: Line]	V -Offset [Unit: Line]	Exposure Time (Min) [Unit: us]
1X8 -1Y	80 MHz	33333	5120	0	3840	0	1 (Off)	1 (Off)	3840	233.53	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	117.27		
			2560	0	3840	0	2 (On)	1 (Off)	3840	234.02		
			2560	0	1920	0	2 (On)	2 (On)	1920	117.51		
	60 MHz	44444	5120	0	3840	0	1 (Off)	1 (Off)	3840	204.65	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	102.82		
			2560	0	3840	0	2 (On)	1 (Off)	3840	205.13		
			2560	0	1920	0	2 (On)	2 (On)	1920	103.07		
1X4 -1Y	80 MHz	66666	5120	0	3840	0	1 (Off)	1 (Off)	3840	233.53	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	117.27		
			2560	0	3840	0	2 (On)	1 (Off)	3840	234.02		
			2560	0	1920	0	2 (On)	2 (On)	1920	117.51		
	60 MHz	88888	5120	0	3840	0	1 (Off)	1 (Off)	3840	204.60	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	102.80		
			2560	0	3840	0	2 (On)	1 (Off)	3840	205.09		
			2560	0	1920	0	2 (On)	2 (On)	1920	103.04		
1X2 -1Y	80 MHz	133333	5120	0	3840	0	1 (Off)	1 (Off)	3840	233.53	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	117.27		
			2560	0	3840	0	2 (On)	1 (Off)	3840	234.02		
			2560	0	1920	0	2 (On)	2 (On)	1920	117.51		
	60 MHz	177777	5120	0	3840	0	1 (Off)	1 (Off)	3840	204.62	0	10.0
			5120	0	1920	0	1 (Off)	2 (On)	1920	102.81		
			2560	0	3840	0	2 (On)	1 (Off)	3840	205.11		
			2560	0	1920	0	2 (On)	2 (On)	1920	103.05		

Table – 18 Continuous trigger vertical timing (2/2)

Camera Settings									Frame Rate	(E) Exposure Time (Max.)	(F) Exposure End to FVAL Active Start	
Tap Geometry	Camera Link Pixel Clock	Frame Rate (Typ.)	ROI				Binning					
			Width	Offset X	Height	Offset Y	Horizontal	Vertical				
		Time							[Unit: Hz]	[Unit: us]	[Unit: Line]	[Unit: us]
1X8-1Y	80 MHz	33333	5120	0	3840	0	1 (Off)	1 (Off)	30.000	ROUNDDOWN([Frame Rate (Time)] - (20600clk ÷ 80)) = 33075	39.10	319.96
			5120	0	1920	0	1 (Off)	2 (On)			20.05	328.15
			2560	0	3840	0	2 (On)	1 (Off)			39.10	319.96
			2560	0	1920	0	2 (On)	2 (On)			20.05	328.15
	60 MHz	44444	5120	0	3840	0	1 (Off)	1 (Off)	22.500	ROUNDDOWN([Frame Rate (Time)] - (20600clk ÷ 60)) = 44100	39.10	429.68
			5120	0	1920	0	1 (Off)	2 (On)			20.05	440.68
			2560	0	3840	0	2 (On)	1 (Off)			39.10	429.68
			2560	0	1920	0	2 (On)	2 (On)			20.05	440.68
1X4-1Y	80 MHz	66666	5120	0	3840	0	1 (Off)	1 (Off)	15.000	ROUNDDOWN([Frame Rate (Time)] - (20600clk ÷ 80)) = 66408	20.05	328.15
			5120	0	1920	0	1 (Off)	2 (On)			10.53	344.51
			2560	0	3840	0	2 (On)	1 (Off)			20.05	328.15
			2560	0	1920	0	2 (On)	2 (On)			10.53	344.51
	60 MHz	88888	5120	0	3840	0	1 (Off)	1 (Off)	11.250	ROUNDDOWN([Frame Rate (Time)] - (20600clk ÷ 60)) = 88544	20.05	440.67
			5120	0	1920	0	1 (Off)	2 (On)			10.53	462.63
			2560	0	3840	0	2 (On)	1 (Off)			20.05	440.67
			2560	0	1920	0	2 (On)	2 (On)			10.53	462.63
1X2-1Y	80 M Hz	133333	5120	0	3840	0	1 (Off)	1 (Off)	7.500	ROUNDDOWN([Frame Rate (Time)] - (41200clk ÷ 80)) = 132818	20.05	656.20
			5120	0	1920	0	1 (Off)	2 (On)			10.52	688.93
			2560	0	3840	0	2 (On)	1 (Off)			20.05	656.20
			2560	0	1920	0	2 (On)	2 (On)			10.52	688.93
	60 MHz	177777	5120	0	3840	0	1 (Off)	1 (Off)	5.625	ROUNDDOWN([Frame Rate (Time)] - (41200clk ÷ 60)) = 177090	20.05	881.22
			5120	0	1920	0	1 (Off)	2 (On)			10.52	925.17
			2560	0	3840	0	2 (On)	1 (Off)			20.05	881.22
			2560	0	1920	0	2 (On)	2 (On)			10.52	925.17

Note:
1. As the frame rate of the SP-20000-PMCL is 1 µs duration per 1 step, the above FVAL Non-Active conversion may have certain tolerance.
2. In the SP-20000-PMCL, the horizontal frequency is not doubled even if horizontal binning is used. The frame rate is not increased.
3. In the SP-20000-PMCL, the horizontal frequency is 1/2 if vertical binning is used. Therefore, if the height is 1/2, the vertical frequency is not doubled.
4. In the SP-20000-PMCL, the frame rate can be changed by 1 µs unit. In the above table, “B” FVAL Non-Active duration is varied.
5. V-Offset : The duration between FVAL Active Start and 1st LVAL Active Start

6.3.3 ROI (Region Of Interest)

In the SP-20000-PMCL, 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 directon, the horizontal frequency is not changed if the width is decreased. In the SP-20000-PMCL, the minimum width is “8” and minimum height is “2”.

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

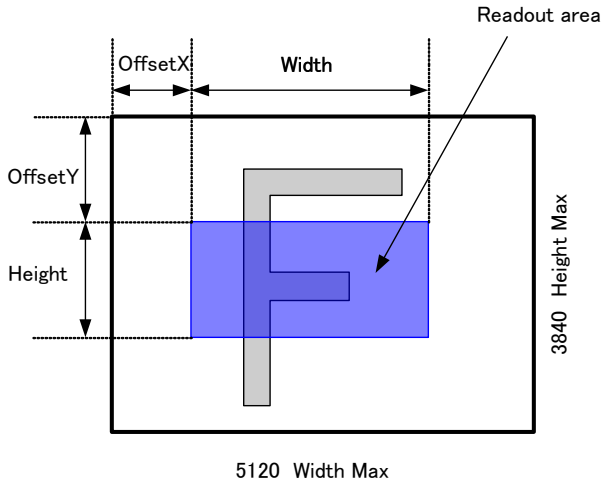
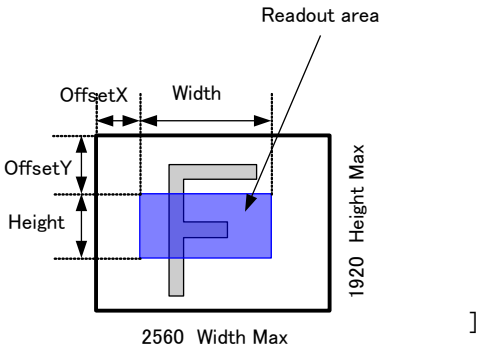


Fig. 17 Setting example (No binning)

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



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

Fig.18 Setting example (Binning)

Table - 19 ROI setting examples (1/2)

ROI	Camera Settings						Width Max	Height Max	Max Offset X Value	Width and Offset X Step			Max Offset Y Value	Height Step	Offset Y Step
	ROI				Binning										
	Width	Offset X	Height	Offset Y	Horizontal	Vertical				1X8 -1Y	1X4 -1Y	1X2 -1Y			
Full Line	5120	0	3840	0	1 (Off)	1 (Off)	5120	3840	0	8	8	8	0	2	1
2/3 Screen - Center	3408	856	2560	640	1 (Off)	1 (Off)	5120	3840	1712	8	8	8	1280	2	1
1/2 Screen - Center	2560	1280	1920	960	1 (Off)	1 (Off)	5120	3840	2560	8	8	8	1920	2	1
1/4 Screen - Center	1280	1920	960	1440	1 (Off)	1 (Off)	5120	3840	3840	8	8	8	2880	2	1
1/8 Screen - Center	640	2240	480	1680	1 (Off)	1 (Off)	5120	3840	4480	8	8	8	3360	2	1
Full Line	2560	0	1920	0	2 (On)	2 (On)	2560	1920	0	8	8	8	0	1	1
2/3 Screen - Center	1704	428	1280	320	2 (On)	2 (On)	2560	1920	856	8	8	8	640	1	1
1/2 Screen - Center	1280	640	960	480	2 (On)	2 (On)	2560	1920	1280	8	8	8	960	1	1
1/4 Screen - Center	640	960	480	720	2 (On)	2 (On)	2560	1920	1920	8	8	8	1440	1	1
1/8 Screen - Center	320	1120	240	840	2 (On)	2 (On)	2560	1920	2240	8	8	8	1680	1	1

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

Table - 20 ROI setting examples (Frame rate)

ROI 考	Camera Settings							Frame Rate (Typ.)					
	ROI				Binning			Tap Geometry					
	Width	Offset X	Height	Offset Y	Horizontal	Vertical		1X8-1Y		1X4-1Y		1X2-1Y	
								Camera Link Pixel Clock		Camera Link Pixel Clock		Camera Link Pixel Clock	
								80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full Line	5120	0	3840	0	1 (Off)	1 (Off)	Setting value [Unit: us]	33333	44444	66666	88888	133333	177777
							Output [Unit: Hz]	30.000	22.500	15.000	11.250	7.500	5.625
2/3 Screen - Center	3408	856	2560	640	1 (Off)	1 (Off)	Setting value [Unit: us]	22222	29629	44444	59259	88889	118518
							Output [Unit: Hz]	44.998	33.751	22.500	16.875	11.250	8.4375
1/2 Screen - Center	2560	1280	1920	960	1 (Off)	1 (Off)	Setting value [Unit: us]	16667	22222	33333	44444	66667	88889
							Output [Unit: Hz]	59.998	45.000	30.000	22.500	15.000	11.250
1/4 Screen - Center	1280	1920	960	1440	1 (Off)	1 (Off)	Setting value [Unit: us]	8428	11318	16856	22636	33713	45272
							Output [Unit: Hz]	118.64	88.352	59.325	44.176	29.662	22.088
1/8 Screen - Center	640	2240	480	1680	1 (Off)	1 (Off)	Setting value [Unit: us]	4500	6043	9001	12087	18002	24174
							Output [Unit: Hz]	222.18	165.46	111.09	82.728	55.549	41.366
Full Line	2560	0	1920	0	2 (On)	2 (On)	Setting value [Unit: us]	33333	44444	66666	88888	133333	177777
							Output [Unit: Hz]	30.000	22.500	15.000	11.250	7.500	5.625
2/3 Screen - Center	1704	428	1280	320	2 (On)	2 (On)	Setting value [Unit: us]	22222	29629	44444	59258	88889	118518
							Output [Unit: Hz]	44.998	33.751	22.500	16.875	11.250	8.4375
1/2 Screen - Center	1280	640	960	480	2 (On)	2 (On)	Setting value [Unit: us]	16667	22222	33333	44444	66667	88889
							Output [Unit: Hz]	59.998	45.000	30.000	22.500	15.000	11.250
1/4 Screen - Center	640	960	480	720	2 (On)	2 (On)	Setting value [Unit: us]	8412	11296	16824	22592	33648	45184
							Output [Unit: Hz]	118.87	88.521	59.437	44.262	29.719	22.132
1/8 Screen - Center	320	1120	240	840	2 (On)	2 (On)	Setting value [Unit: us]	4484	6021	8968	12043	17937	24086
							Output [Unit: Hz]	222.99	166.08	111.50	83.032	55.748	41.518

[Note]
(1) This example is based on 1X8-1Y, Camera Link Pixel Clock =80MHz and 30 fps output.
(2) In case of 1/4 Partial and lower height, the maximum frame rate is described

6.3.4 Mirroring function

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

Setting example 1: No binning, no mirror
Setting example 2: No binning, horizontal mirror
Setting example 3: No binning, vertical mirror
Setting example 4: No binning, horizontal and vertical mirror

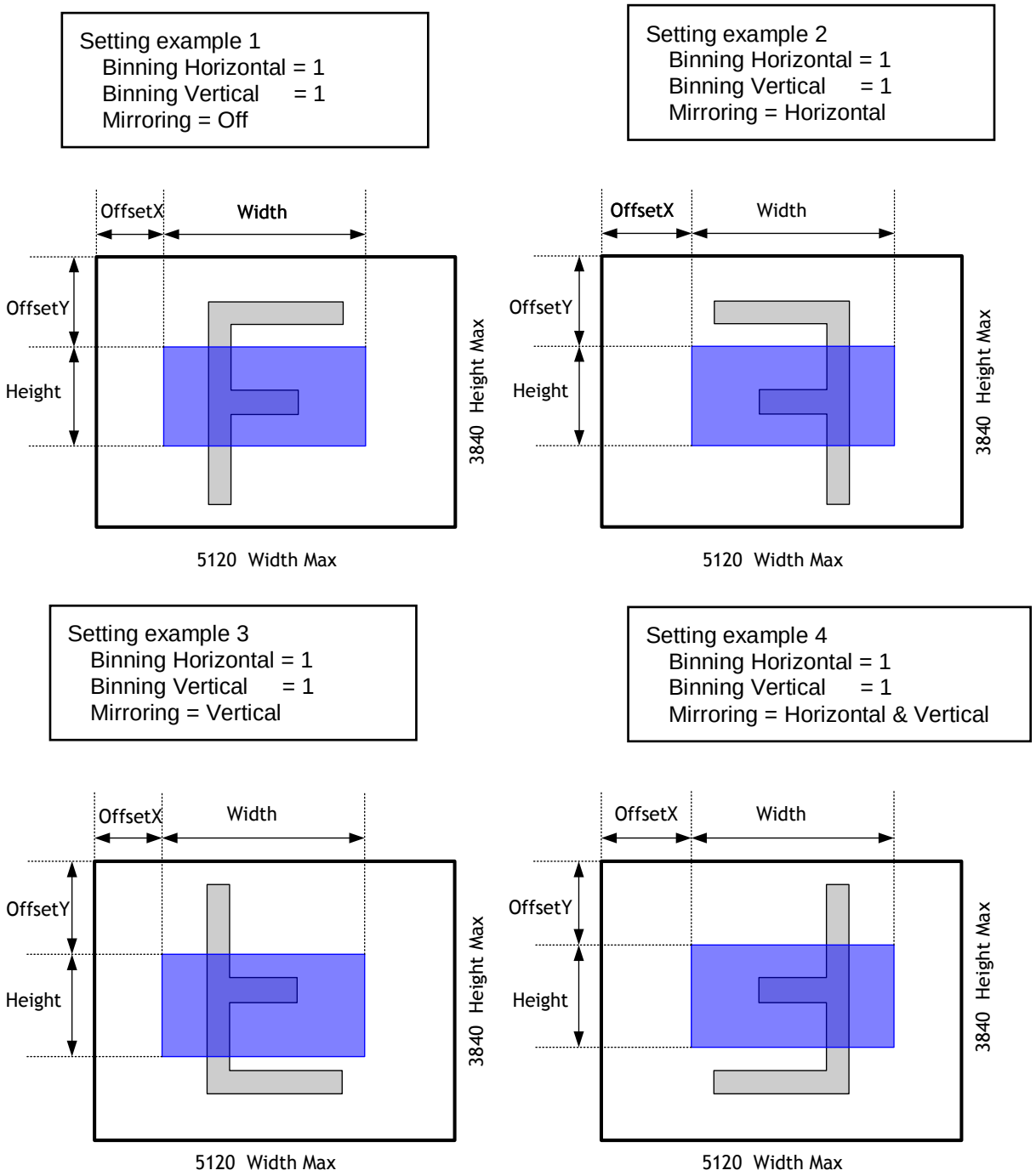


Fig 19. Mirror setting examples

6.3.5 Multi ROI function

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

Table - 21 Multi ROI Index table default values

Multi ROI Index Max	1		
Multi ROI Width	5120		
Multi ROI Index Selector	Multi ROI		
	Height	Offset	
		X	Y
- Index 1	1	0	0
- Index 2	1	0	0
- Index 3	1	0	0
- Index 4	1	0	0
- Index 5	1	0	0
- Index 6	1	0	0
- Index 7	1	0	0
- Index 8	1	0	0

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

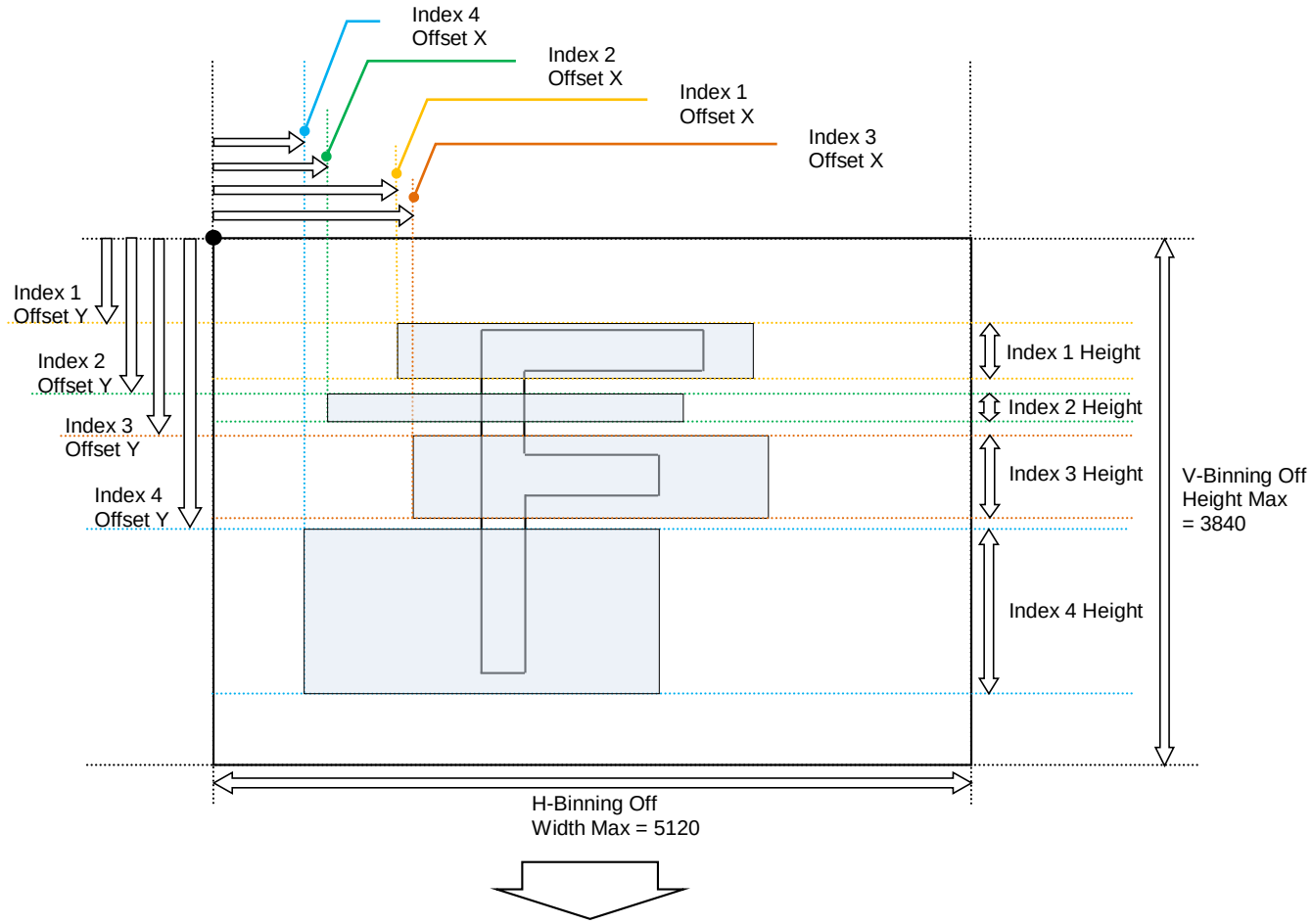
(3) Multi ROI Index Selector :
Index 1 to 8 can be selected. [Height], [Offset X], and [Offset Y] of the selected Multi ROI Index are displayed and can be set.

(4) Multi ROI Offset X :
Offset X can be set for each ROI area of Multi ROI Index 1 to 8.
The restriction for setting Step and other factors are the same as the normal ROI setting.
As described before, in Multi ROI operation, Multi ROI Width is a common width setting for Multi ROI Index 1 to 8.

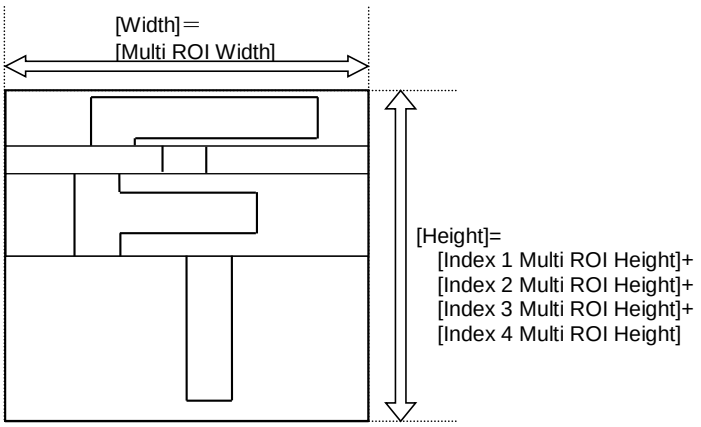
(5) Multi ROI Height :
Height can be set for each ROI area of Multi ROI Index 1 to 8.
The restriction for setting Step and other factors are the same as the normal ROI setting.

(6) Multi ROI Offset Y :
Offset Y can be set for each ROI area of Multi ROI Index 1 to 8.
The restriction for setting Step and other factors is the same as the normal ROI setting.
The summary of Muliti ROI Height value of index 1 to 8 should be less than Height Max.

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



Video output of Multi ROI



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

Fig. 20 Multi ROI output image

6.4 Digital output bit allocation

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

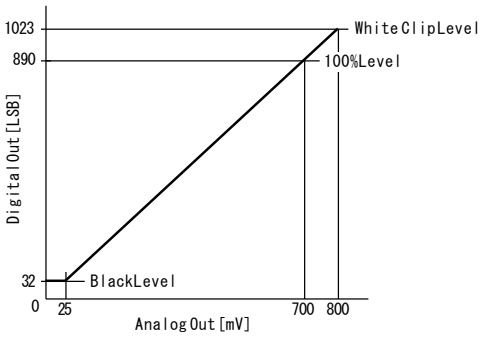


Fig. 21 Bit allocation (10-bit)

7. Operating modes

7.1. Acquisition control (change the frame rate)

7.1.1 Acquisition control

With Trigger OFF (free-running mode), it is possible to specify a free-running frame rate (i.e., no trigger needed) that is slower than the default rate.

Modification of the frame rate is done by entering a value in the AcquisitionFrameRate control corresponding to the frequency to be allocated to each frame period. Allowed values range from 1697Hz to 0.125Hz depending on the ROI and the tap geometry specified. However if the value entered is less than the time required for the default frame rate, the setting is ignored and the default frame rate is used. For example, in 1X2 if the value entered is less than the time required at 80MHz Camera Link pixel clock, the minimum frame period for the smallest possible ROI (2 lines) requires 424Hz, so any entry less than 424Hz will always be ignored in this configuration.

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 = 8 seconds

For additional details, refer to table 23.

Note: In the table 23, it is possible to set, for instance 7.8136 fps for 1X2–1Y, full frame and 80 MHzMHz of Camera Link pixel clock, but 7.8136 fps is the setting limit value. This value will vary depending on shutter settings which will cause 1 H delay in conditions. 7.5 fps is the performance guaranteed value.

How to set:
ROI should be set first.
The available number shown in Acquisition Frame Rate will correspond to the maximum frame period for the specified ROI.
The value can be decreased up to 0.125Hz (fps).
If ROI is changed from a smaller size to a larger size, the default frame rate of the ROI is automatically recalculated inside the camera and changed to the slower frame rate of the larger ROI.

ROI setting:
Height: 2 lines to 3840 lines for SP-20000M-PMCL
2 lines to 3840 lines for SP-20000C-PMCL

As for the details of ROI settings, refer to section 6.3.3.

7.1.2 Interval calculation of frame rate（In Continuous Trigger mode）

Table 22 Frame rate interval calculation formula

Camera Settings			ART Command Minimum Value Setting Calculation Formula [Unit : us]
Tap Geometry	Binning Vertical	Camera Link Pixel Clock	
1X8-1Y	1 (Off)	80 MHz	ROUND(([Height] + 70 Line) x 654.63÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 70 Line) x 659.31÷ [Camera Link pixel clock:60MHz] x 10^6)
	2 (On)	80 MHz	ROUND(([Height] + 34 Line) x 1309.27÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 34 Line) x 1318.61÷ [Camera Link pixel clock:60MHz] x 10^6)
1X4-1Y	1 (Off)	80 MHz	ROUND(([Height] + 70 Line) x 1309.50÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 70 Line) x 1318.93÷ [Camera Link pixel clock:60MHz] x 10^6)
	2 (On)	80 MHz	ROUND(([Height] + 34 Line) x 2618.53÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 34 Line) x 2637.23÷ [Camera Link pixel clock:60MHz] x 10^6)
1X2-1Y	1 (Off)	80 MHz	ROUND(([Height] + 70 Line) x 2618.54÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 70 Line) x 2637.25÷ [Camera Link pixel clock:60MHz] x 10^6)
	2 (On)	80 MHz	ROUND(([Height] + 34 Line) x 5237.09÷ [Camera Link pixel clock:80MHz] x 10^6)
		60 MHz	ROUND(([Height] + 34 Line) x 5274.49 ÷ [Camera Link pixel clock:60MHz] x 10^6)

Note:
1. If Tap Geometry is changed, the minimum value of the frame rate interval is limited automatically. Please refer to Table 17.
2. If Exposure Mode is set at Timed, the maximum value of Exposure Time is varied automatically by the setting value of the frame rate. Refer to Table 14 Continuous trigger vertical timing (2/2).
3. The Camera Link pixel clock is 80 MHz as the default setting.

Table 23 Frame rate interval setting range (typical value) in Continuous Trigger mode

Camera Settings				ART Command value (limited standard value)			
Tap Geometry	Camera Link Pixel Clock	Binning Vertical	Height	Min.		Max.	
				Setting value	Actual operating time/Actual operating interval	Setting value	Actual operating time/Actual operating interval
1X8-1Y	80 MHz	1 (Off)	3840	31995	31.996 ms / 31.254 Hz	8 000 000	8 sec / 0.125 Hz
		2 (On)	1920	31978	31.979 ms / 31.271 Hz		
	60 MHz	1 (Off)	3840	42965	42.966 ms / 23.274 Hz		
		2 (On)	1920	42942	42.942 ms / 23.287 Hz		
1X4-1Y	80 MHz	1 (Off)	3840	63990	63.992 ms / 15.627 Hz		
		2 (On)	1920	63957	63.959 ms / 15.635 Hz		
	60 MHz	1 (Off)	3840	85929	11.637 Hz 85.933 ms		
		2 (On)	1920	85885	85.889 ms / 11.643 Hz		
1X2-1Y	80 MHz	1 (Off)	3840	127981	127.982 ms / 7.8136 Hz		
		2 (On)	1920	127915	127.916 ms / 7.8176 Hz		
	60 MHz	1 (Off)	3840	171860	171.860 ms / 5.8187 Hz		
		2 (On)	1920	171772	171.771 ms / 5.8217 Hz		

Note:]

1. The above reference value is the setting range to which frame interval is automatically changed if Height is set at Height Max. In vertical ROI operation, if Height is set at less than Height Max, the minimum setting value will be smaller. Use Table 17 to calculate the minimum Frame Rate interval in vertical ROI operation.
2. In the SP-20000-PMCL, the frame rate in 1X8-1Y and Full Line setting can be set at a maximum of 31.250 fps. However, it is only guaranteed up to 30 fps in terms of performance.
3. In the SP-20000M-PMCL and SP-20000C-PMCL, the frame rate has maximum 1 line longer or shorter depending on the exposure time. This happens, when the exposure executes for the next frame while the previous video is reading out, the increment or of 1 µs for the exposure time is completed at the exposure completion side. Refer to 7.2.3.

^

7.2. Exposure control

7.2.1 Exposure Mode

Exposure mode sets which exposure mode is to be used.
If the trigger is used, Frame Start must also be used.
When Exposure mode is set to Timed or Trigger Width, the combination of Exposure Mode and Frame Start can set various operations.

The following table shows the operation depending on the combination.

Table 24 Exposure mode and trigger control matrix table

Exposure Mode	Trigger Control	Trigger mode OFF	Trigger mode ON
	Frame Start	Behavior	
OFF	OFF or ON	Free running No exposure control	–
Timed (EPS) Timed(RCT) Timed (PIV)	OFF	Free running Exposure control available	–
	ON	–	Operate in EPS, RCT or PIV
Trigger width	OFF	Free running No exposure control	–
	ON	–	Exposure control by trigger width

Trigger Control select

Frame Start trigger: Sets whether the start of the frame is controlled externally or not.
Trigger mode ON: If Acquisition Active is active and Exposure Mode chooses Timed or Trigger width, the exposure will be started by using the signal set in Frame Trigger as the trigger.
Trigger mode OFF: If Acquisition Active is active, the camera operates in free-running mode.

Exposure mode can be selected from the following.

OFF: No shutter control

Timed: The exposure will be done in the preset period. The setting can be done in µsec units.
Frame Start OFF: Free-running mode and exposure control is available.
Frame Start ON: EPS operation mode

In this status, if JAI_PIV is selected as the Trigger option, the camera will operate in PIV mode.

Trigger width: The exposure will be controlled by the width of the trigger pulse.
Frame Start OFF: Not active. No exposure control
Frame Start ON: PWC operation mode

7.2.2 ExposureTime

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

Minimum: 10 μsec (Note: The real exposure rtime is 304μs)
Maximum: 8 seconds (When Frame Start Trigger Mode is ON)

Note: The real exposure time is shown in the following table due to the sensor characteristics. But the exposure active signal is same as the exposure time.

TapGeometry	CmaeraLink Clock	Sensor real exposure time
1X8-1Y 1X4-1Y	80MHz	Exposure Time + 294us
1X8-1Y 1X4-1Y	60MHz	Exposure Time + 395us
1X2-1Y	80MHz	Exposure Time + 589us
1X2-1Y	60MHz	Exposure Time + 791us

Note:
In Continuous Trigger operation with Frame Start Trigger Mode OFF, the maximum Exposure Time is limited by the frame rate setting. In 1X8-1Y camera output format and 80 MHz Camera Link pixel clock, the maximum setting value is 7.999742 sec which is 258 μs smaller than 8 seconds, the maximum value of frame rate setting.
In EPS Trigger operation (Frame Start Trigger Mode set to On), the maximum exposure time is not influenced and therefore it is 8 seconds as the maximum.

Due to the characteristics of the camera's sensor, the black level may rise if a long time exposure is used, or if the sensor temperature increases. Although this black level variance is compensated in the camera, the performance needed to maintain the dynamic range for a maximum exposure of 8 seconds is guaranteed only under the following conditions.
SP-20000M-PMCL : The ambient temperature is up to 25℃.
SP-20000C-PMCL : The ambient temperature is up to 15℃.

7.2.3 Behavior if Trigger Overlap is set to Readout

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

Table - 25 Modes where the exposure control becomes 1L if overlap occurs

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

As an example, the following is for Continuous Trigger.

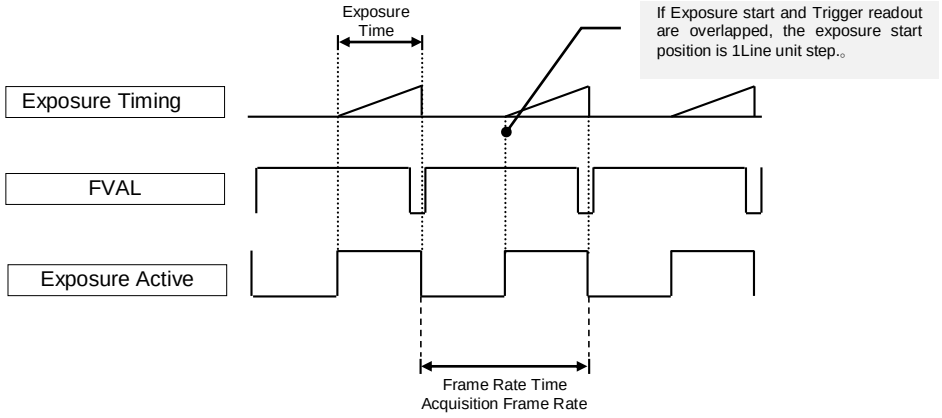


Fig. 22 Behavior in the continuous trigger operation

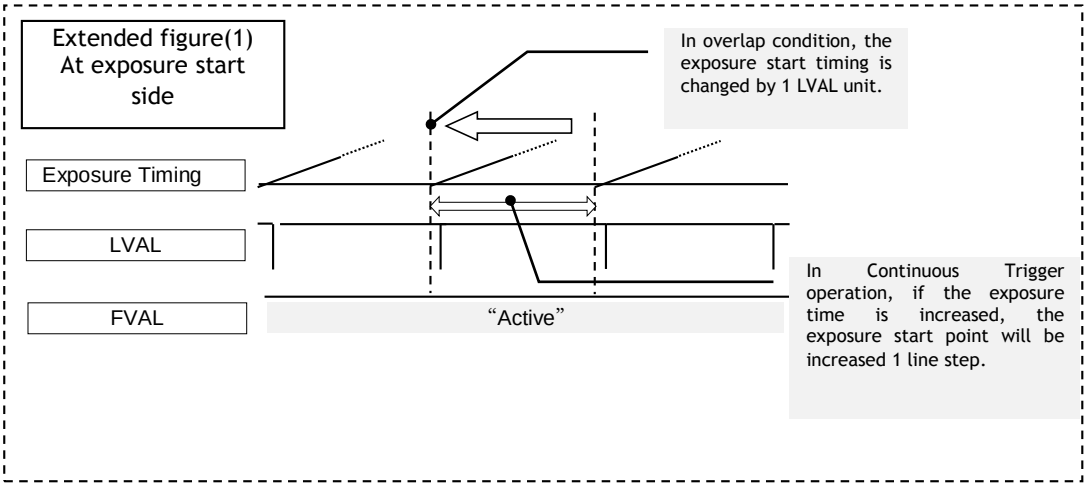


Fig.23 Extended figure at the exposure start side

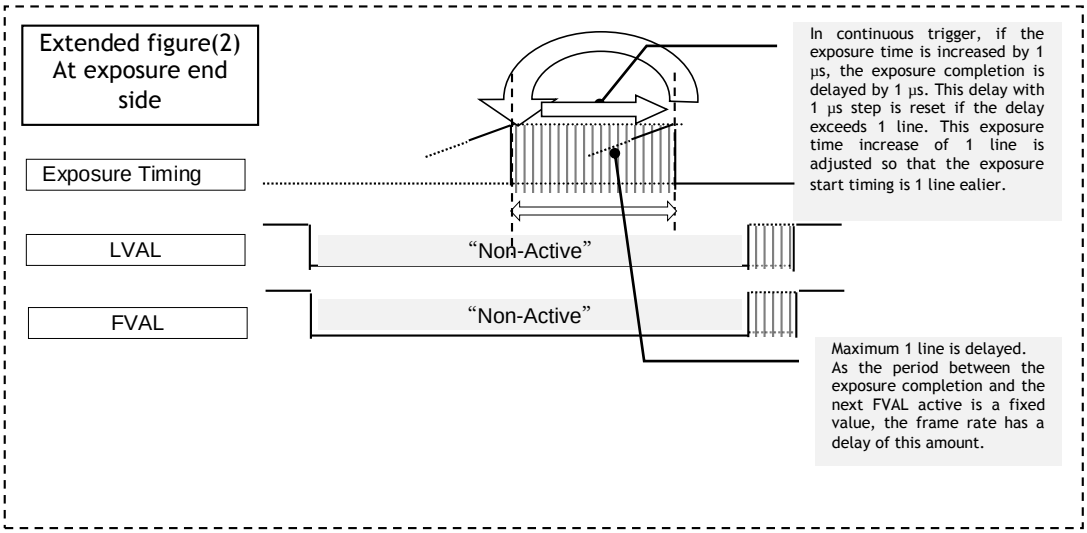


Fig.24 Extended view for the exposure end side

Table - 26 Calculation for the period which the exposure time is overlapped with previous trigger in Continuous Trigger mode (1/3)

Tap Geometry	Item	Binning Vertical	Camera Link Pixel Clock	Continuous trigger readout / exposure overlapped period Exposure Time value calculation formula
1X8-1Y	1Line Control Start Exposure Time value [Unit : us]	1 (Off)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×654.63)+24901 -654.63+([Width]÷8)) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×659.31)+25109 -654.63+([Width]÷8)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
		2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×1309.27)+24901 -640+([Width]÷8)) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×1318.61)+25109 -640+([Width]÷8)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
	1Line Contrl End Exposure Time value [Unit : us]	1 (Off) , 2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ (24901÷[Camera Link pixel clock:80MHz]×(10^6))
			60 MHz	ROUND([Frame Rate (Time)]－ (25109÷[Camera Link pixel clock:60MHz]×(10^6))
	When overlapped, Exposure Time effective step value [Unit : us/step]	1 (Off)	80 MHz	ROUNDDOWN(654.63÷[Camera Link pixel clock:80MHz]×10^6)
			60 MHz	ROUNDDOWN(659.31÷[Camera Link pixel clock:60MHz]×10^6)
		2 (On)	80 MHz	ROUNDDOWN(1309.27÷[Camera Link pixel clock:80MHz]×10^6÷2)
			60 MMz	ROUNDDOWN(1318.61÷[Camera Link pixel clock:60MHz]×10^6÷2)
	Exposure Start Position [Unit : Line]	1 (Off)	80 MHz	ROUND([Height]－1－(ROUNDOWN(([Exposure Time] －[1Line Control Start Exposure Time value])×(10^-6)×[Camera Link pixel clock:80MHz]÷654.63)))
			60 MHz	[Height] － 1 － (ROUNDDOWN(([Exposure Time] － [1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷659.31))
		2 (On)	80MHz	[Height]－0.5－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Time Value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷1309.27)÷2)
			60 MHz	[Height]－0.5－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:60MHz]÷1318.61)÷2)
	Exposure Time Max value	1 (Off) , 2 (On)	80 MHz	ROUNDDOWN([Frame Rate (Time)] － (20600÷[Camera Link pixel clock:80MHz]×10^6))
			60 MHz	ROUNDDOUWN([Frame Rate (Time)] － (20600÷[Camera Link pixel clock:60MHz]×10^6))

Note:

1. If V-Binning is set to On, the horizontal frequency is 1/2. However, as the effective image period is not changed, the exposure time setting step is approx. 8 steps for 1X8 –1Y and approx. 16 steps for 1X4 –1Y.
2. The default setting for Camera Link Pixel Clock is 80 MHz.
3. The exposure start position calculate numbers of line which Exposure Active Start Edge passes , if the upper part of the previous video is 1 line. However, it the frame rate is overlapped with Exposure Start, maximum 1 line delay is occurred and differences may be happened.
4. The result of calculation and actual camera operation may differ by 1 to 2 μs.
5. Exposure Time Effective Step value when overlapped is basic figure. It may be increased or decreased due to ROUND figures..
6. In overlapped operation, shutter noise occuring at the start of the exposure period will appear in the video (Approx. 70LSB/10bit/24dB as the maximum)

Table - 27 Calculation for the period which the exposure time is overlapped with previous trigger in Continuous Trigger mode (2/3)

Tap Geometry	Item	Binning Vertical	Camera Link Pixel Clock	Continuous trigger readout / exposure overlapped period Exposure Time value calculation formula
1X4-1Y	1Line Control Start Exposure Time value [Unit : us]	1 (Off)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×1309.27)＋24931－1309.27＋([Width]÷4) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×1318.61)＋25111－1318.61+([Width]÷4)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
		2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×2618.53)＋24931－1280＋([Width]÷4)) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×2637.23)＋25111−1280＋([Width]÷4)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
	1Line Contrl End Exposure Time value [Unit : us]	1 (Off) , 2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ (24931÷[Camera Link pixel clock:80MHz]×(10^6))
			60 MHz	ROUND([Frame Rate (Time)]－ (25111÷[Camera Link pixel clock:60MHz]×(10^6))
	When overlapped, Exposure Time effective step value [Unit : us/step]	1 (Off)	80 MHz	ROUNDDOWN(1309.27÷[Camera Link pixel clock]×10^6)
			60 MHz	ROUNDDOWN(1318.61÷[Camera Link pixel clock]×10^6)
		2 (On)	80 MHz	ROUNDDOWN(2618.53÷[Camera Link pixel clock])×10^6÷2)
			60 MHz	ROUNDDOWN(2637.23÷[Camera Link pixel clock])×10^6÷2)
	Exposure Start Position [Unit : Line]	1 (Off)	80 MHz	[Height]－1－(ROUNDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷1309.27))
			60 MHz	[Height]－1－(ROUNDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷1318.61))
		2 (On)	80 MHz	[Height]－0.5－(ROUNDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷2618.53)÷2)
			60 MMz	[Height]－0.5－(ROUNDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:60MHz]÷2637.23)÷2)
	Exposure Time Max value	1 (Off) , 2 (On)	80 MHz	ROUNDDOWN([Frame Rate (Time)]－(20600÷[Camera Link pixel clock:80MHz]×10^6))
			60 MHz	ROUNDDOWN([Frame Rate (Time)]－(20600÷[Camera Link pixel clock:60MHz]×10^6))

Table - 28 Calculation for the period which the exposure time is overlapped with previous trigger in Continuous Trigger mode (3/3)

Tap Geometry	Item	Binning Vertical	Camera Link Pixel Clock	Continuous trigger readout / exposure overlapped period Exposure Time value calculation formula
1X2-1Y	1Line Control Start Exposure Time value [Unit : us]	1 (Off)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×2618.54)＋49865－2618.54＋([Width]÷2)) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×2637.25)＋50223－2637.25＋([Width]÷2)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
		2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×5237.09)＋49865－2560＋([Width]÷2)) ÷[Camera Link pixel clock:80MHz]×(10^6)))
			60 MHz	ROUND([Frame Rate (Time)]－ ((([Height]×5274.49)＋50223－2560＋([Width]÷2)) ÷[Camera Link pixel clock:60MHz]×(10^6)))
	1Line Contrl End Exposure Time value [Unit : us]	1 (Off) , 2 (On)	80 MHz	ROUND([Frame Rate (Time)]－ (49865÷[Camera Link pixel clock:80MHz]×(10^6))
			60 MHz	ROUND([Frame Rate (Time)]－ (50223÷[Camera Link pixel clock:60MHz]×(10^6))
	When overlapped, Exposure Time effective step value [Unit : us/step]	1 (Off)	80 MHz	ROUNDDOWN(2618.54÷[Camera Link pixel clock]×10^6)
			60 MHz	ROUNDDOWN(2637.25÷[Camera Link pixel clock]×10^6)
		2 (On)	80 MHz	ROUNDDOWN(5237.09÷[Camera Link pixel clock])×10^6÷2)
			60 MHz	ROUNDDOWN(5274.49÷[Camera Link pixel clock])×10^6÷2)
	Exposure Start Position [Unit : Line]	1 (Off)	80 MHz	[Height]－1－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Timevalue]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷2618.54))
			60 MHz	[Height]－1－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷2637.25))
		2 (On)	80 MHzz	[Height]－0.5－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:80MHz]÷5237.09)÷2)
			60 MHz	[Height]－0.5－(ROUNDDOWN(([Exposure Time]－[1Line Control Start Exposure Time value]) ×(10^-6)×[Camera Link pixel clock:60MHz]÷5274.49)÷2)
	Exposure Time Max value	1 (Off) , 2 (On)	80 MHz	ROUNDDOWN([Frame Rate (Time)]－(41200÷[Camera Link pixel clock:80MHz]×10^6))
			60 MHz	ROUNDDOWN([Frame Rate (Time)]－(41200÷[Camera Link pixel clock:60MHz]×10^6))

7.2.4 ExposureAuto

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

7.3. Trigger Mode

Trigger Mode can be selected in Trigger Selector.
In the SP-20000-PMCL, the trigger mode is limited to Frame Start. However, it is possible to operate as shown in Table-29 with the trigger option (JAI Custom).

Table - 29 Trigger operation settings

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

7.3.1 Trigger Selector

Selects the trigger operation. In the SP-20000-PMCL, only Frame Start is available.

Table - 30 Trigger selector

Trigger Selector Item	Description
Frame Start	Frame Start Trigger

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 TriggerSource

Select the trigger source to be used for trigger operation (Frame Start for the SP-20000-PMCL) from the following table.

Table - 31 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
PulseGenerator0 Out	Connect Pulse generator 0 signal to the selected trigger operation
PulseGenerator1 Out	Connect Pulse generator 1 signal to the selected trigger operation
PulseGenerator2 Out	Connect Pulse generator 2 signal to the selected trigger operation
PulseGenerator3 Out	Connect Pulse generator 3 signal to the selected trigger operation
TTL 1 In	Connect TTL 1 IN signal to the selected trigger operation
CL CC1 In	Connect CL CC1 IN signal to the selected trigger operation
Nand0 Out	Connect NAND 0 OUT signal to the selected trigger operation
Nand1 Out	Connect NAND 1 OUT signal to the selected trigger operation
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: In the SP-20000-PMCL, GPIO port is located on the AUX interface (Hirose 10P). In this GPIO. Line 10 and Line 11 are available.	

7.3.4 TriggerActivation

This command can select how to activate the trigger.

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

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

Table - 32 Trigger Activation

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

7.3.5 Trigger overlap

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

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

7.4. 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.

Table – 33 Minimum interval

Readout Mode	Time (Min. Trigger Period)					
	1x8 – 1Y		1x4 – 1Y		1X2 – 1Y	
	80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full	33.333 ms	44.444 ms	66.666 ms	88.888 ms	133.333 ms	177.777 ms
ROI Center 2/3	22.222 ms	29.629 ms	44.444 ms	59.259 ms	88.889 ms	118.518 ms
ROI Center 1/2	16.667 ms	22.222 ms	22.222 ms	44.444 ms	66.667 ms	88.889 ms
ROI Center 1/4	8.428 ms	11.318 ms	16.826 ms	22.636 ms	33.713 ms	45.272 ms
ROI Center 1/8	4.500 ms	6.043 ms	9.001 ms	12.087 ms	18.002 ms	24.174 ms
V Binning ON (Full) (Note 1)	33.333 ms	44.444 ms	66.666 ms	88.888 ms	133.333 ms	177.777 ms

Note 1: SP-20000M-PMCL only

7.5. Timed (EPS) mode

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

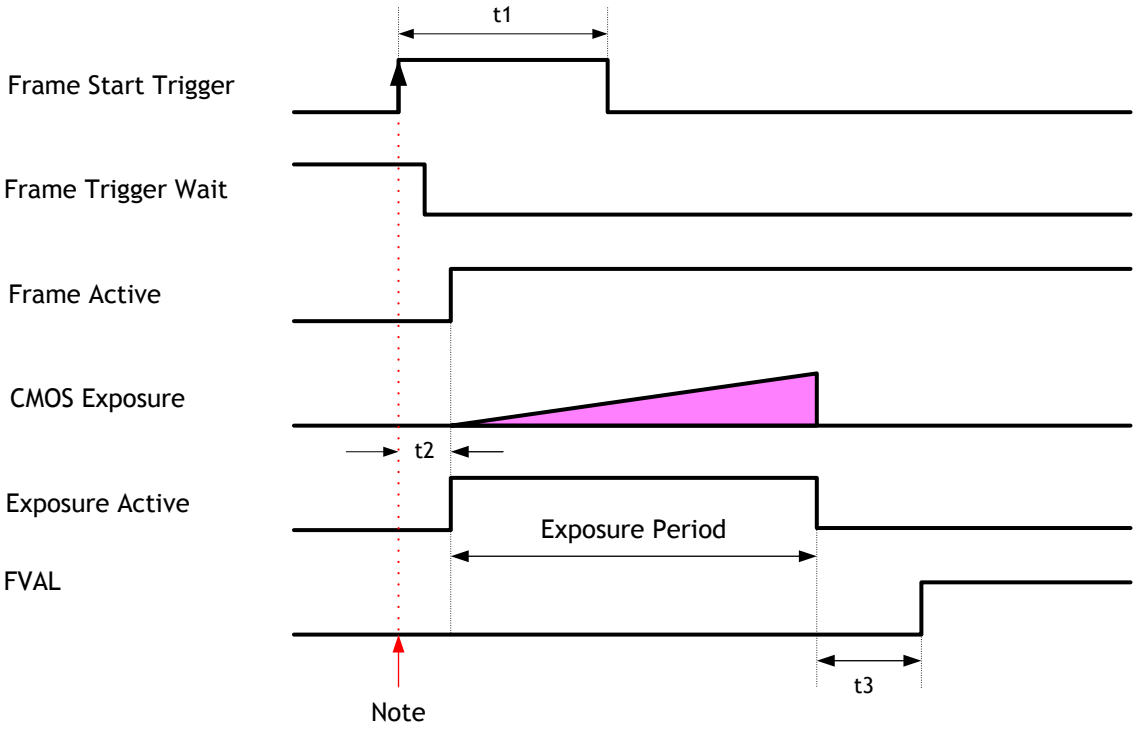
Basic settings to use this mode
Trigger Mode = ON
Exposure Mode = Timed
Trigger Option: OFF

Table - 34 Trigger minimum interval (Trigger Overlap = Readout)

Readout Mode	Time (Min. Trigger Period)					
	1x8 – 1Y		1x4 – 1Y		1X2 – 1Y	
	80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full	≧31.761 ms	≧42.648 ms	≧63.200 ms	≧84.864 ms	≧126.389 ms	≧169.719 ms
ROI Center 2/3	≧21.287 ms	≧28.582 ms	≧42.252 ms	≧56.734 ms	≧84.492 ms	≧113.457 ms
ROI Center 1/2	≧16.050 ms	≧21.550 ms	≧31.777 ms	≧42.669 ms	≧63.544 ms	≧85.327 ms
ROI Center 1/4	≧8.195 ms	≧11.001 ms	≧16.066 ms	≧21.571 ms	≧32.121 ms	≧43.131 ms
ROI Center 1/8	≧4.267 ms	≧5.726 ms	≧8.211 ms	≧11.022 ms	≧16.410 ms	≧22.033 ms
V Binning ON (Full) (Note 1)	≧31.770 ms	≧42.658 ms	≧63.216 ms	≧84.887 ms	≧126.423 ms	≧169.764 ms

Note1 : SP-20000M-PMCL only
Note2 : If Trigger Overlap is OFF, the accumulation time is added to the above table.

7.5.1 If Overlap setting is" OFF"



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

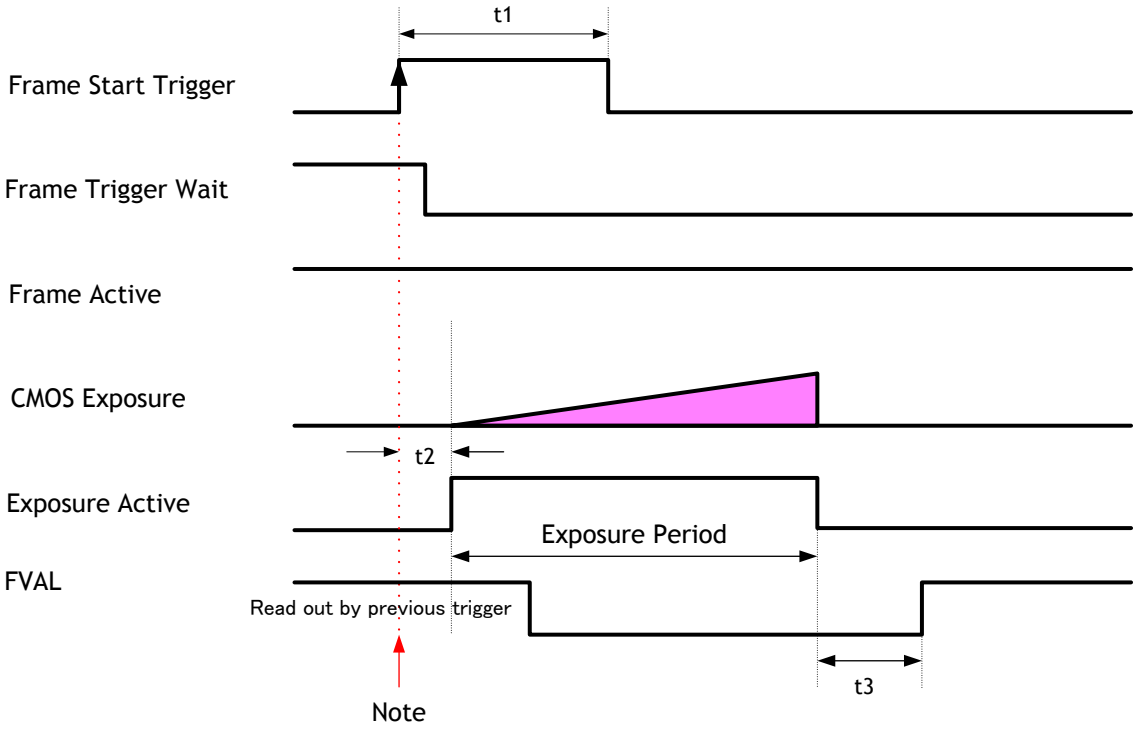
EPS Trigger Mode、If Trigger Overt Lap = Off

	Camara Settings				
	Camera Link Pixel Clock	Vertical Binning	Tap Geometry Setting		
			1X8-1Y	1X4-1Y	1X2-1Y
t1	80/60 MHz	-	2L (min)	2L (min)	2L (min)
t2	80 MHz	-	450 ns ～ 490 ns	460 ns ～ 490 ns	630 ns ～ 690 ns
	60 MHz	-	530 ns ～ 580 ns	530 ns ～ 580 ns	770 ns ～ 860 ns
t3	80 MHz	1 (Off)	320 us	328 us	656 us
		2 (On)	328 us	345 us	689 us
	60 MHz	1 (Off)	430 us	441 us	881 us
		2 (On)	441 us	463 us	925 us

Note: Because jitter occurs during triggering, t2 has tolerance in time.

Fig. 25 Overlap OFF

7.5.2 If Overlap setting is “Readout”



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

EPS Trigger Mode、If Trigger Overt Lap = Readout

	Camara Settings				
	Camera Link Pixel Clock	Vertical Binning	Tap Geometry Setting		
			1X8-1Y	1X4-1Y	1X2-1Y
t1	80/60 MHz	-	2L (min)	2L (min)	2L (min)
t2	80 MHz	-	460 ns ～ 460ns + 1 Line	470 ns ～ 471 ns + 1 Line	655 ns ～ 655 ns + 1 Line
	60 MHz	-	540 ns ～ 540 ns + 1 Line	540 ns 540 ns +1 Line	780 ns ～ 780 ns + 1 Line
t3	80 MHz	1 (Off)	320 us	328 us	656 us
		2 (On)	328 us	345 us	689 us
	60 MHz	1 (Off)	430 us	441 us	881 us
		2 (On)	441 us	463 us	925 us

Fig. 26 Overlap Readout

7.5.3 Calculation formula for the minimum trigger interval if Trigger Overlap is OFF

Table - 35 Minimum Trigger Interval Calculation (If EPS Trigger/ Trigger Overlap is OFF)

Camera Settings			EPS Trigger / Trigger Overlap = Off Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry	Camera Link Pixel Clock	Binning Vertical	
1X8-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×654.63) – 654.63 + ([Width]÷8)) ÷ 80MHz x 10^6) +321+ [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×1309.27) – 640 + ([Width]÷8)) ÷ 80MHz x 10^6) + 321 + [Exposure Time]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×659.31) – 659.31 + ([Width]÷8)) ÷ 60MHz x 10^6) + 431 + [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×1318.61) – 640 + ([Width]÷8)) ÷ 60MHz x 10^6) + 431 + [Exposure Time]
1X4-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×1309.27) – 1309.27 + ([Width]÷4)) ÷ 80MHz x 10^6) + 329 + [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×2618.53) – 1280 + ([Width]÷4)) ÷ 80MHz x 10^6) + 329 + [Exposure Time]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×1318.61) – 1318.61 + ([Width]÷4)) ÷ 60MHz x 10^6) + 442 + [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×2637.23) – 1280 + ([Width]÷4)) ÷ 60MHz x 10^6) + 442 + [Exposure Time]
1X2-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×2618.54) – 2618.54 + ([Width]÷2)) ÷ 80MHz x 10^6) + 657 + [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×5237.09) – 2560 + ([Width]÷2)) ÷ 80MHz x 10^6) + 657 + [Exposure Time]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×2637.25) – 2637.25 + ([Width]÷2)) ÷ 60MHz x 10^6) + 882 + [Exposure Time]
		2 (On)	=ROUND((([Height]+1)×5274.49) – 2560 + ([Width]÷2)) ÷ 60MHz x 10^6) + 882 + [Exposure Time]
Note: When Trigger Overlap is set to OFF, if the trigger pulse is input in shorter period than the period listed in the above trigger interval, this trigger input may be ignored by the trigger mask.			

7.5.4 Calculation formula for the minimum trigger interval if Trigger Overlap is Readout

Table - 36 Minimum Trigger Interval Calculation (If EPS Trigger/ Trigger Overlap is Readout)

Camera Settings			EPS Trigger / Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry	Camera Link Clock	Binning Vertical	
1X8-1Y	80 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－266 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)× 654.63)－654.63＋([Width]÷8))÷80MHz×10^6)+331 (2) If [Exposure Time] value is more than 1Frame ＝266＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－266 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)×1309.27)－640＋([Width]÷8))÷80MHz×10^6)+331 (2) If [Exposure Time] valueis more than 1Frame ＝266＋[Exposure Time]
	60 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－353 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)× 659.31)－659.31＋([Width]÷8))÷60MHz×10^6)+441 (2) If [Exposure Time] value is more than 1Frame ＝353＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－353 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)×1318.61)－1318.61＋([Width]÷8))÷60MHz×10^6)+441 (2) If [Exposure Time] value is more than 1Frame ＝353＋[Exposure Time]

Note: When Trigger Overlap is set to Readout, if the trigger interval is set more than the period seecified in the above table, the exposure operation may not be activated and the video may be disturbed.

Camera Settings			EPS Trigger / Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry	Camera Link Clock	Binning Vertical	
1X4-1Y	80 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－266 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)×1309.27)－1309.27＋([Width]÷4))÷80MHz×10^6)+339 (2) If [Exposure Time] value is more than 1Frame ＝266＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－266 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)×2618.53)－1280＋([Width]÷4))÷80MHz×10^6)+339 (2) If [Exposure Time] value is more than 1Frame ＝266＋[Exposure Time]
	60 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－353 (1) If [Exposure Time]value is less than 1Frame ＝ROUND(((([Height]＋1)×1318.61)－1318.61＋([Width]÷4))÷60MHz×10^6)+452 (2) If [Exposure Time] value is more than 1Frame ＝353＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－353 (1) If [Exposure Time] value is less than 1Frame ＝ROUND(((([Height]＋1)×2637.23)－1280＋([Width]÷4))÷60MHz×10^6)+452 (2) If [Exposure Time] value is more than 1Frame ＝353＋[Exposure Time]

Camera Settings			EPS Trigger / Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry		Binning Vertical	
1X2-1Y	80 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－521 (1) If [Exposure Time] value is less than 1Frame ＝ROUND((([Height]＋1)×2618.54)－2618.54＋([Width]÷2))÷80MHz×10^6)+667
			(2) If [Exposure Time] value is more than 1Frame ＝521＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－521 (1) If [Exposure Time] value is less than 1Frame ＝ROUND((([Height]＋1)×5237.09)－2560＋([Width]÷2))÷80MHz×10^6)+667
			(2) If [Exposure Time] valueis more than 1Frame ＝521＋[Exposure Time]
	60 MHz	1 (Off)	At the condition of [Expousre Time Max]≦[Trigger Period]－696 (1) If [Exposure Time] value is less than 1Frame ＝ROUND((([Height]＋1)×2637.25)－2637.25＋([Width]÷2))÷60MHz×10^6)+892
			(2) If [Exposure Time] valueis more than 1Frame ＝696＋[Exposure Time]
		2 (On)	At the condition of [Expousre Time Max]≦[Trigger Period]－696 (1) If [Exposure Time] value is less than 1Frame ＝ROUND((([Height]＋1)×5274.49)－2560＋([Width]÷2))÷60MHz×10^6)+892
			(2) If [Exposure Time] value is more than 1Frame ＝696＋[Exposure Time]

7.5.5 GPIO TTL output timing if Trigger Overlap is OFF

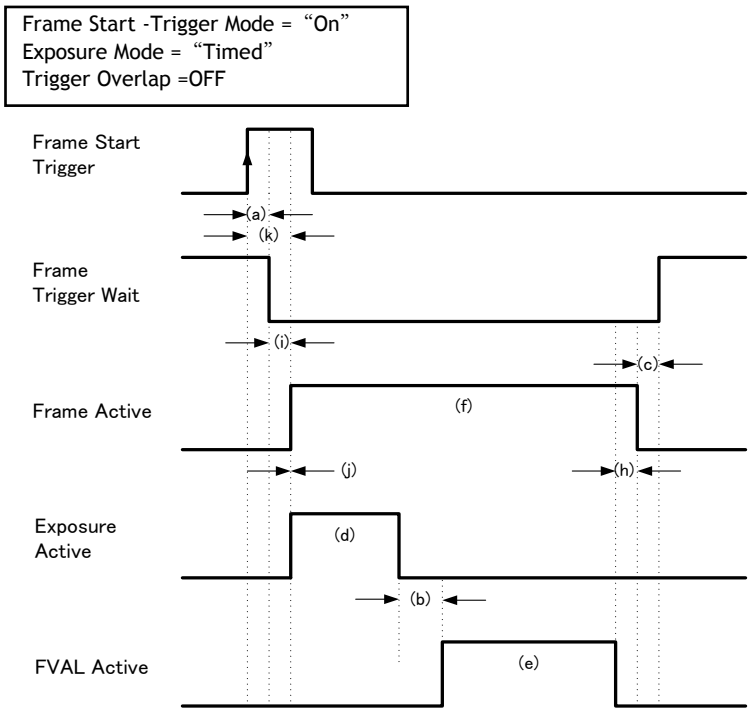


Fig. 27 GPIO TTL OUT timing

Table - 37 GPIO Out timing (Reference) (80 MHz, EPS Trigger, Trigger Overlap= OFF)

	Description	1X8-1Y	1X4-1Y	1X2 – 1Y	Note
(a)	Frame Start Trigger to Frame Trigger Waite Falling Edge	820 ns	820 ns	1.010 us	Frame Start Trigger is input through TTL IN 1
(b)	Exposure Active Falling Edge to FVAL Rising Edge	320 us (320 us)	328 us (328 us)	656 us (656 us)	Varies by Tap Geometry setting. ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(c)	Frame Active Falling Edge to Frame Trigger Wait Rising Edge	1.00 us	1.00 us	1.00 us	
(d)	Exposure Active	8.91 us (10.26 us)	8.91 us (10.26 us)	8.98 us (10.31 us)	If Exposure Time is 10, ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(e)	FVAL Active	31.42 ms	62.84 ms	125.69 ms	If Binning off and [Height]=3840, (Will be changed by Height setting)
(f)	Frame Active	31.75 ms	63.18 ms	126.36 ms	If [Exposure Mode] is Timed
(h)	FVAL Falling Edge to Frame Active Falling Edge	1.110 us	1.110 us	410 ns	This will be different by Binning or ROI setting. Frame Active End Edge against FVAL Active End is shifted by approx. 1us.
(i)	Frame Trigger wait Falling Edge to Frame Active Rising Edge	1.19 us	1.19 us	1.19 us	
(j)	Frame Active Raising Edge to Exposure Active Rising Edge	0 ns	0 ns	0 ns	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.05 us (470 ns)	2.05 us (470 ns)	2.23 us (660 ns)	Exposure Active at TTL I/F ( ) is if comparing with Exposure Active which is assigned to Camera Link Spare Bit
	Exposure Active Start Edge: CL/TTL out phase difference	1.60 us	1.60 us	1.60 us	If the polarity is Active High
	Exposure Active End Edge: CL/TTL out phase difference	240 ns	240 ns	240 ns	If the polarity is Active High

Table - 38 GPIO Out timing (Reference) (60 MHz, EPS Trigger, Trigger Overlap= OFF)

	Description	1X8-1Y	1X4-1Y	1X2 – 1Y	Note
(a)	Frame Start Trigger to Frame Trigger Waite Falling Edge	890 ns	890 ns	810 ns	Frame Start Trigger is input through TTL IN 1
(b)	Exposure Active Falling Edge to FVAL Rising Edge	429 us (430 us)	440 us (441 us)	881 us (881 us)	Varies by Tap Geometry setting. ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(c)	Frame Active Falling Edge to Frame Trigger Wait Rising Edge	975 ns	975 ns	1.028us	
(d)	Exposure Active	9.04 us (10.37 us)	9.04 us (10.37 us)	9.09 us (10.43 us)	If Exposure Time is 10, ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(e)	FVAL Active	42.20 ms	84.39 ms	168.78 ms	If Binning off and [Height]=3840, (Will be changed by Height setting)
(f)	Frame Active	42.64 ms	84.84 ms	169.67 ms	If [Exposure Mode] is Timed
(h)	FVAL Falling Edge to Frame Active Falling Edge	780 ns	390 ns	760 ns	This will be different by Binning or ROI setting. Frame Active End Edge against FVAL Active End is shifted by approx. 1us.
(i)	Frame Trigger wait Falling Edge to Frame Active Rising Edge	1.19 us	1.19 us	1.19 us	
(j)	Frame Active Raising Edge to Exposure Active Rising Edge	0 ns	0 ns	0 ns	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.08 us (560 ns)	2.08 us (560 ns)	2.35 us (800 ns)	Exposure Active at TTL I/F ( ) is if comparing with Exposure Active which is assigned to Camera Link Spare Bit
	Exposure Active Start Edge: CL/TTL out phase difference	1.53 us	1.53 us	1.53 us	If the polarity is Active High
	Exposure Active End Edge: CL/TTL out phase difference	220 ns	220 ns	220 ns	If the polarity is Active High

7.5.6 GPIO TTL output timing if Trigger Overlap is Readout

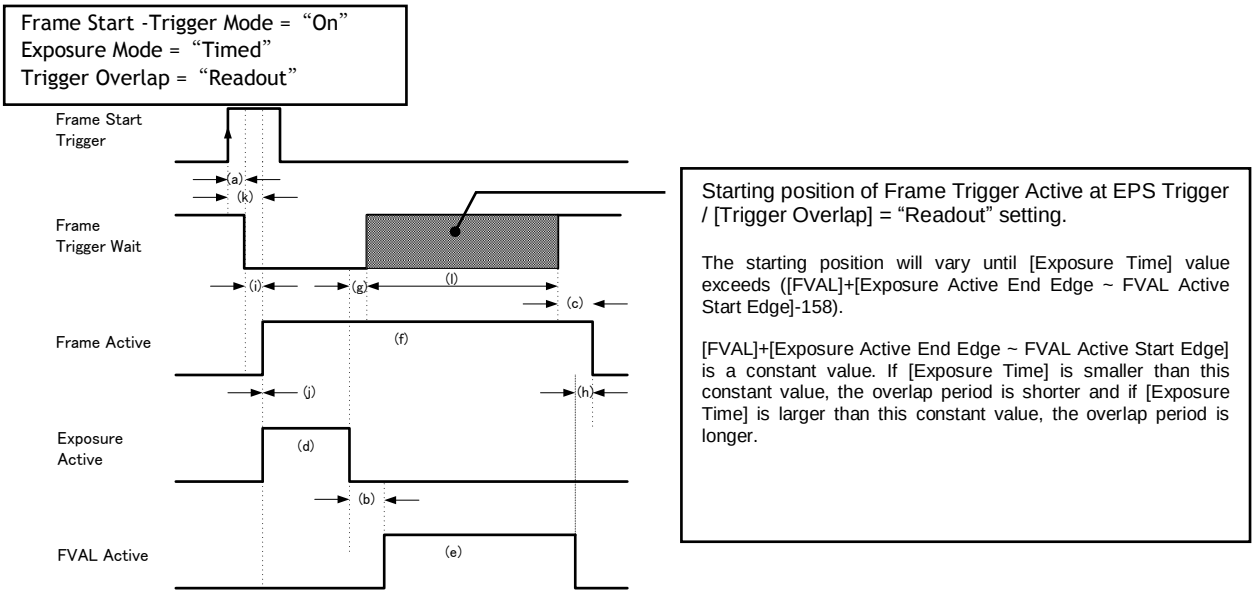


Fig. 28 GPIO timing (Overlap = Readout)

Table - 39 GPIO output timing(Reference) (80 MHz, EPS Trigger, Trigger Overlap = Readout)

	Description	1X8-1Y	1X4-1Y	1X2 – 1Y	Note
(a)	Frame Start Trigger to Frame Trigger Waite Falling Edge	810 ns	810 ns	1.010 us	
(b)	Exposure Active Falling Edge to FVAL Rising Edge	320 us (320 us)	328 us (328 us)	656 us (656 us)	Varies by Tap Geometry setting.
(c)	Frame Active Falling Edge to Frame Trigger Wait Rising Edge	7.15 us	7.15 us	7.15 us	Phase if [Exposure Time] is set to 10us
(d)	Exposure Active	8.93 us (10.28 us)	8.93 us (10.28 us)	9.00 us (10.33 us)	If [Exposure Time] is 10, ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(e)	FVAL Active	31.42 ms	62.84 ms	125.69 ms	If Binning off and [Height]=3840, (Will be changed by Height setting)
(f)	Frame Active	31.75 ms	63.18 ms	126.36 ms	If [Exposure Mode] is Timed
(g)	Exposure Active Falling Edge to Frame Trigger Wait Rising Edge	241.03 us	231.84 us	470.81 us	
(h)	Frame Active Falling Edge to FVAL Falling Edge	1.10 us	1.27 us	370 ns	This will be different by Binning or ROI setting. Frame Active End Edge against FVAL Active End is shifted by approx. 2us.
(i)	Frame Trigger wait Falling Edge to Frame Active Rising Edge	1.22 us	1.22 us	1.22 us	
(j)	Frame Active Rising Edge to Exposure Active Rising Edge	0 ns	0 ns	0 ns	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.04 us (470 ns)	2.04 us (470 ns)	1.01 us (660 ns)	Exposure Active at TTL I/F ( ) is if comparing with Exposure Active which is assigned to Camera Link Spare Bit
(l)	Exposure Active Rising Edge Variableness	31.50 ms	62.93 ms	125.87 ms	Varies by [Exposure Time] setting
	Exposure Active Start Edge: CL/TTL out phase difference	1.58 us	1.58 us	1.58 us	
	Exposure Active End Edge: CL/TTL out phase difference	230 ns	230 ns	230 ns	

Note: The timing in this table is in the condition that the trigger pulse is not input during the video readout from the previous trigger. This is for the explanation of the phase relation between Frame Trigger Wait and Frame Active.

Table - 40 GPIO output timing(Reference) (60 MHz, EPS Trigger, Trigger Overlap = Readout)

	Description	1X8-1Y	1X4-1Y	1X2 – 1Y	Note
(a)	Frame Start Trigger to Frame Trigger Waite Falling Edge	890 ns	890 ns	1.160 us	
(b)	Exposure Active Falling Edge to FVAL Rising Edge	429 us (430 us)	440 us (441 us)	881 us (882 us)	Varies by Tap Geometry setting.
(c)	Frame Active Falling Edge to Frame Trigger Wait Rising Edge	7.21 us	7.21 us	7.21 us	Phase if [Exposure Time] is set to 10us
(d)	Exposure Active	9.04 us (10.37 us)	9.04 us (10.37 us)	9.09 us (10.44 us)	If [Exposure Time] is 10, ( ) is Exposure Active which is assigned to Camera Link Spare Bit
(e)	FVAL Active	42.20 ms	84.39 ms	125.69 ms	If Binning off and [Height]=3840, (Will be changed by Height setting)
(f)	Frame Active	42.64 ms	84.84 ms	168.78 ms	If [Exposure Mode] is Timed
(g)	Exposure Active Falling Edge to Frame Trigger Wait Rising Edge	323.97 us	314.73 us	634.65 us	
(h)	Frame Active Falling Edge to FVAL Falling Edge	790 ns	410 ns	730 ns	This will be different by Binning or ROI setting. Frame Active End Edge against FVAL Active End is shifted by approx. 2us.
(i)	Frame Trigger wait Falling Edge to Frame Active Rising Edge	1.20 us	1.20 us	1.20 us	
(j)	Frame Active Rising Edge to Exposure Active Rising Edge	0 ns	0 ns	0 ns	
(k)	Frame Start Trigger to Exposure Active Rising Edge	2.11 us (560 ns)	2.11 us (560 ns)	2.38 us (810 ns)	Exposure Active at TTL I/F ( ) is if comparing with Exposure Active which is assigned to Camera Link Spare Bit
(l)	Exposure Active Rising Edge Variableness	42.29 ms	84.51 ms	169.02 ms	Varies by [Exposure Time] setting
	Exposure Active Start Edge: CL/TTL out phase difference	1.53 us	1.53 us	1.53 us	
	Exposure Active End Edge: CL/TTL out phase difference	220 ns	220 ns	220 ns	

Note: The timing in this table is in the condition that the trigger pulse is not input during the video readout from the previous trigger. This is for the explanation of the phase relation between Frame Trigger Wait and Frame Active.

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.

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

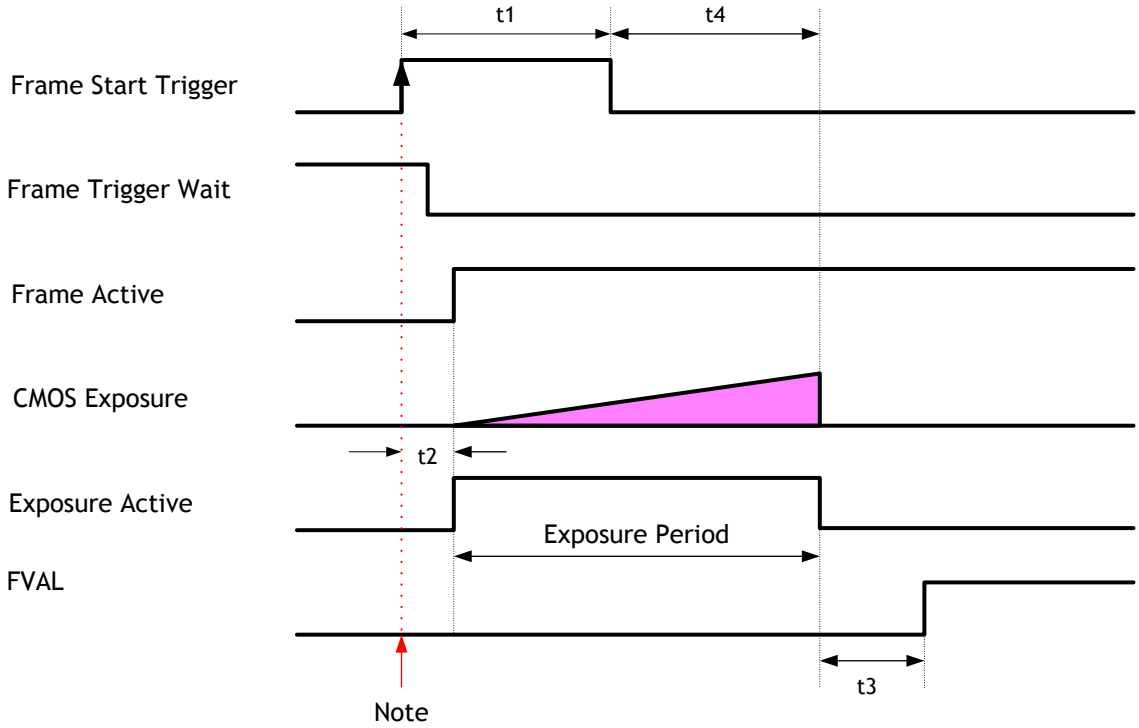
Table - 41 Minimum trigger interval (Trigger Overlap = Readout)

Readout Mode	Time (Min. Trigger Period)					
	1x8 – 1Y		1x4 – 1Y		1X2 – 1Y	
	80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full	≧31.761 ms	≧42.648 ms	≧63.200 ms	≧84.864 ms	≧126.389 ms	≧169.719 ms
ROI Center 2/3	≧21.287 ms	≧28.582 ms	≧42.252 ms	≧56.734 ms	≧84.492 ms	≧113.457 ms
ROI Center 1/2	≧16.050 ms	≧21.550 ms	≧31.777 ms	≧42.669 ms	≧63.544 ms	≧85.327 ms
ROI Center 1/4	≧8.195 ms	≧11.001 ms	≧16.066 ms	≧21.571 ms	≧32.121 ms	≧43.131 ms
ROI Center 1/8	≧4.267 ms	≧5.726 ms	≧8.211 ms	≧11.022 ms	≧16.410 ms	≧22.033 ms
V Binning ON (Full) (Note1)	≧31.770 ms	≧42.658 ms	≧63.216 ms	≧84.887 ms	≧126.423 ms	≧169.764 ms

Note1 : SP-20000M-PMCL only

Note2 : If Trigger Overlap is OFF, the accumulation time is added to the above table.

7.6.1 If Overlap setting is “OFF”



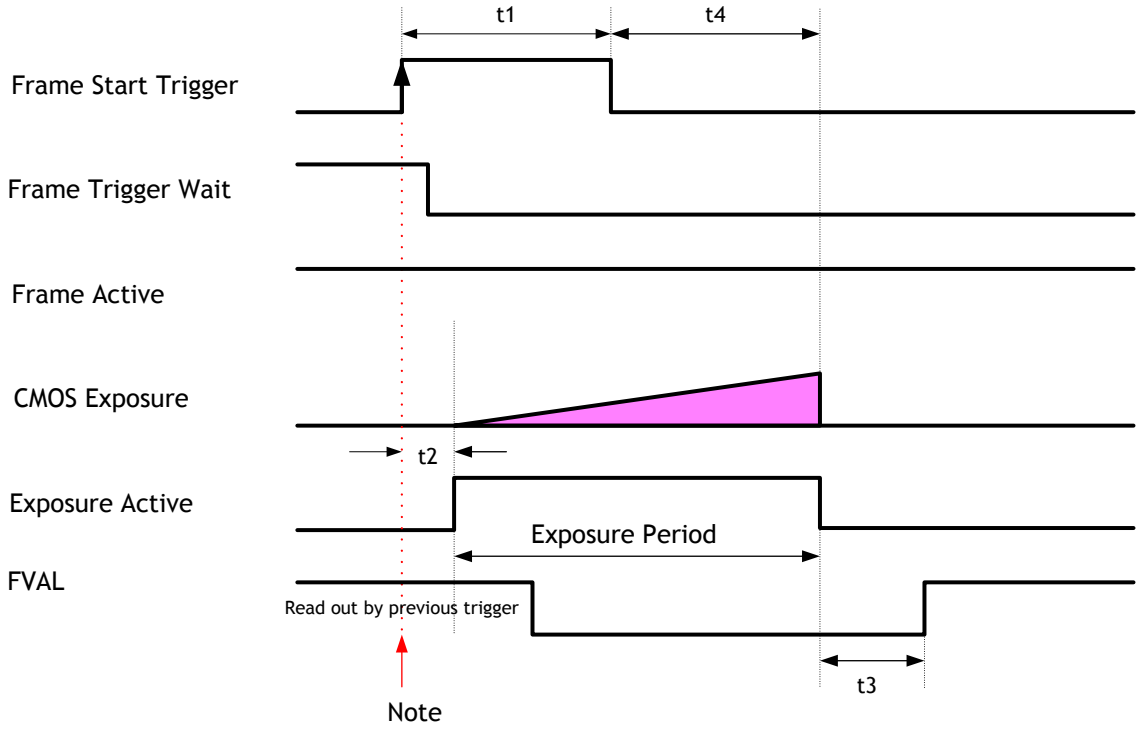
Note: The trigger pulse is accepted during Frame Trigger Wait being active if the trigger overlap is OFF. When the trigger is accepted, the trigger wait is inactive until the readout is completed.

Fig. 29 Overlap = OFF

	Camera Settings				
	Camera Link Pixel Clock	Vertical Binning	Tap Geometry Setting		
			1X8-1Y	1X4-1Y	1X2-1Y
t1	80/60 MHz	—	10 µs (Min)	10 µs (Min)	10 µs (Min)
t2	80 MHz	-	400 ns ~ 440 ns	400 ns ~ 440 ns	520 ns ~ 590 ns
	60 MHz	-	460 ns ~ 510 ns	460 ns ~ 510 ns	630 ns ~ 720 ns
t3	80 MHz	1 (Off)	320 us	328 us	656 us
		2 (On)	328 us	345 us	689 us
	60 MHz	1 (Off)	430 us	441 us	881 us
		2 (On)	441 us	643 us	925 us
t4	80 MHz	-	2.42 us ~ 2.45 us	2.42 us ~ 2.46 us	2.55 us ~ 2.62 us
	60 MHz	-	2.48 us ~ 2.53 us	2.48 us ~ 2.53 us	2.67us ~ 2.75 us
Real Exposure time differen ce	80 MHz	-	2.00 us ~ 2.06 us	2.00 us ~ 2.04 us	12.00us ~ 12.63 us
	60 MHz	-	2.00 us ~ 2.05 us	2.00 us ~ 2.52 us	12.00us ~ 12.08 us

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

7.6.2 If Overlap setting is “Readout”



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

Fig. 30 Overlap: Readout

	Camera Settings				
	Camera Link Pixel Clock	Vertical Binning	Tap Geometry Setting		
			1X8-1Y	1X4-1Y	1X2-1Y
t1	80/60 MHz	–	10 µs (Min)	10 µs (Min)	10 µs (Min)
t2	80 MHz	-	440 ns ～440 ns + 1Line	420 ns ～420 ns + 1Line	550 ns ～550 ns + 1Line
	60 MHz	-	490 ns ～490 ns + 1Line	500 ns ～500 ns + 1Line	700 ns ～700 ns + 1Line
t3	80 MHz	1 (Off)	320 us	328 us	656 us
		2 (On)	328 us	345 us	689 us
	60 MHz	1 (Off)	430 us	441 us	881 us
		2 (On)	441 us	463 us	925 us
t4	80 MHz	-	2.46 us～2.50 us	2.49 us～2.53 us	2.61 us～2.67 us
	60 MHz	-	2.53 us～2.58 us	2.53 us～2.59 us	2.70 us～2.78 us
(t4)-(t2) : Exposure time difference	80 MHz	-	-6.16us～+2.01us	-13.46us～+2.11us	-35.26 us～+2.12 us
	60 MHz	-	-7.97us～+2.09us	-18.95us～+2.09us	-41.95us～+2.08us

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

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

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

Camera Settings			Trigger Width / Trigger Overlap = Off Minimum Trigger interval calculation formula [Unit : us]
Tap Geometry	Camera Link Pixel Clock	Binning Vertical	
1X8-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×654.63) – 654.63 + ([Width]÷8)) ÷ 80MHz x 10^6) +321+ [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×1309.27) – 640 + ([Width]÷8)) ÷ 80MHz x 10^6) + 321 + [Trigger Pulse Width:10us～]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×659.31) – 659.31 + ([Width]÷8)) ÷ 60MHz x 10^6) + 431 + [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×1318.61) – 640 + ([Width]÷8)) ÷ 60MHz x 10^6) + 431 + [Trigger Pulse Width:10us～]
1X4-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×1309.27) – 1309.27 + ([Width]÷4)) ÷ 80MHz x 10^6) + 329 + [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×2618.53) – 1280 + ([Width]÷4)) ÷ 80MHz x 10^6) + 329 + [Trigger Pulse Width:10us～]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×1318.61) – 1318.61 + ([Width]÷4)) ÷ 60MHz x 10^6) + 442 + [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×2637.23) – 1280 + ([Width]÷4)) ÷ 60MHz x 10^6) + 442 + [Trigger Pulse Width:10us～]
1X2-1Y	80 MHz	1 (Off)	=ROUND((([Height]+1)×2618.54) – 2618.54 + ([Width]÷2)) ÷ 80MHz x 10^6) + 657 + [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×5237.09) – 2560 + ([Width]÷2)) ÷ 80MHz x 10^6) + 657 + [Trigger Pulse Width:10us～]
	60 MHz	1 (Off)	=ROUND((([Height]+1)×2637.25) – 2637.25 + ([Width]÷2)) ÷ 60MHz x 10^6) + 882 + [Trigger Pulse Width:10us～]
		2 (On)	=ROUND((([Height]+1)×5274.49) – 2560 + ([Width]÷2)) ÷ 60MHz x 10^6) + 882 + [Trigger Pulse Width:10us～]
Note: When Trigger Overlap is set to OFF, if the trigger pulse is input in shorter period than the period listed in the above trigger interval, this trigger input may be ignored by the trigger mask.			

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

Table – 43 Minimum trigger interval calculation formula (Trigger Overlap = Readout) (1X8-1Y)

Camera Settings			Trigger Width/ Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry	Camera Link Clock	Binning Vertical	
1X8-1Y	80 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us] - 266us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)× 654.63)−654.63+([Width]÷8))÷80MHz×10^6)+331 (2) If [Trigger Pulse Width] is more than 1Frame =266+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us] - 266us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)×1309.27)−640+([Width]÷8))÷80MHz×10^6)+331 (2) If [Trigger Pulse Width] is more than 1Frame =266+[Trigger Pulse Width]
	60 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us] - 353us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)× 659.31)−659.31+([Width]÷8))÷60MHz×10^6)+441 (2) If [Trigger Pulse Width] is more than 1Frame =353+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us] - 353us (1) If [Trigger Pulse Width] is less trhan 1Frame =ROUND(((([Height]+1)×1318.61)−1318.61+([Width]÷8))÷60MHz×10^6)+441 (2) If [Trigger Pulse Width] is more than 1Frame =353+[Trigger Pulse Width]

Note: When Trigger Overlap is set to Readout, if the trigger interval is set at more than the period specified in the above table or Trigger Pulse width, the exposure operation may not work properly and the video image may be deteriorated.

Table – 44 Minimum trigger interval calculation formula (Trigger Overlap = Readout) (1X4-1Y)

Camera Settings			Trigger Width/ Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry	Camera Link Clock	Binning Vertical	
1X4-1Y	80 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−266us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)×1309.27)−1309.27+([Width]÷4))÷80MHz×10^6)+339 (2) If [Trigger Pulse Width] is more than 1Frame =266+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−266us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)×2618.53)−1280+([Width]÷4))÷80MHz×10^6)+339 (2) If [Trigger Pulse Width] is more than 1Frame =266+[Trigger Pulse Width]
	60 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−353us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)×1318.61)−1318.61+([Width]÷4))÷60MHz×10^6)+452 (2) If [Trigger Pulse Width] is more than 1Frame =353+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−353us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND(((([Height]+1)×2637.23)−1280+([Width]÷4))÷60MHz×10^6)+452 (2) If [Trigger Pulse Width] is more than 1Frame =353+[Trigger Pulse Width]

Table – 45 Minimum trigger interval calculation formula (Trigger Overlap = Readout) (1x2-1Y)

Camera Settings			Trigger Width/ Trigger Overlap = Readout Minimum Trigger Interval calculation formula [Unit : us]
Tap Geometry		Binning Vertical	
1X2-1Y	80 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−521us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND((((([Height]+1)×2618.54)−2618.54+([Width]÷2))÷80MHz×10^6)+667
			(2) If [Trigger Pulse Width] is more than 1Frame =521+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−521us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND((((([Height]+1)×5237.09)−2560+([Width]÷2))÷80MHz×10^6)+667
			(2) If [Exposure Time] is more than 1Frame =521+[Trigger Pulse Width]
	60 MHz	1 (Off)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−696us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND((((([Height]+1)×2637.25)−2637.25+([Width]÷2))÷60MHz×10^6)+892
			(2) If [Exposure Time] is more than 1Frame =696+[Trigger Pulse Width]
		2 (On)	At the condition of [Trigger Pulse Width] ≦ [Trigger Period :us]−696us (1) If [Trigger Pulse Width] is less than 1Frame =ROUND((((([Height]+1)×5274.49)−2560+([Width]÷2))÷60MHz×10^6)+892
			(2) If [Exposure Time] is more than 1Frame =696+[Trigger Pulse Width]

7.7 PIV (Particle Image Velocimetry)

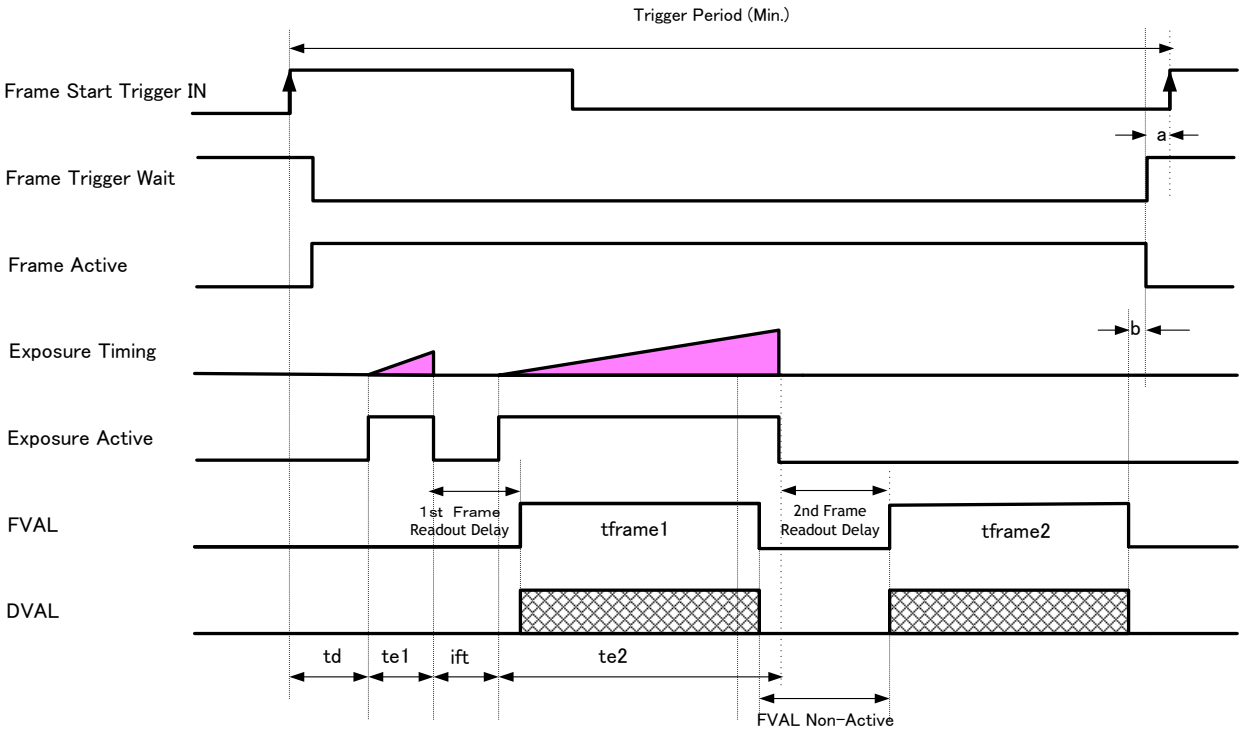
The Particle Image Velocimetry mode can be used in applications where 2 images need to be taken with a very short time interval. It can only be used with strobe flash as illumination. The first accumulation time is 10 μsec to 2 sec. Then, the second exposure will be taken. The first strobe is activated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

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

Table – 46 Minimum trigger interval (Trigger overlap = Off)

Readout Mode	Time (Min. Trigger Period)					
	1x8-1Y		1x4-1Y		1X2-1Y	
	80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full	≧63.625 ms	≧85.394 ms	≧126.489 ms	≧169.807 ms	≧252.834 ms	≧339.472 ms
ROI Center 2/3	≧42.677 ms	≧57.263 ms	≧84.592 ms	≧113.546 ms	≧169.041 ms	≧226.950 ms
ROI Center 1/2	≧32.203 ms	≧43.198 ms	≧63.644 ms	≧85.416 ms	≧127.144 ms	≧170.688 ms
ROI Center 1/4	≧16.492 ms	≧22.100 ms	≧32.221 ms	≧43.220 ms	≧64.299 ms	≧88.055 ms
ROI Center 1/8	≧8.636 ms	≧11.551 ms	≧16.510 ms	≧22.122 ms	≧32.877 ms	≧44.110 ms
V Binning ON (Full) (Note1)	≧63.635 ms	≧85.404 ms	≧126.504 ms	≧169.831 ms	≧252.868 ms	≧339.518 ms

Note 1. SP-20000M-PMCL only
Note 2. Overlap mode=Readout is not available



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

Fig. 31 PIV mode

Table - 47 PIV trigger mode specifications (1X8-1Y)

time name	Description	Time	
		1X8-1Y	
		Camera Link Pixel Clock = 80 MHz	Camera Link Pixel Clock = 60 MHz
td	Exposure Beginning delay	430 ns~470 ns	500 ns ~ 540 ns
te1	First exposure time period	10us ～ ≒ at 1 Frame ([Height]=3840 : 31737us Max) ＝ [Exposure Time Settings]	10us ～≒ at 1 Frame ([Height]=3840 : 42619us Max) ＝ [Exposure Time Settings]
itf	Inter framing time	312 us	419 us
te2	Second exposure time	≒1 frame (1) V-Binning Off ＝([Height]×654.63÷80MHz)＋131 us	≒1 frame (1) V-Binning Off ＝([Height]×659.31÷60MHz)＋132 us
		(2) V-Binning On ＝([Height]×1309.27÷80MHz)＋131 us	(2) V-Binning On ＝([Height]×1318.61÷60MHz)＋132 us
tframe 1	First Frame read out	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝ (([Height]×654.63)-654.63+([Width]÷8))÷80MHz	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝(([Height]×659.31)-659.31+([Width]÷8))÷60MHz
		(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×1309.27)-640+([Width] ÷ 8))÷80MHz	(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×1318.61)-640+([Width] ÷ 8))÷60MHz
tframe 2	Second Frame read out	[FVAL Active] (the same as tframe1)	[FVAL Active] (the same as tframe1)
-	1st Frame Readout Delay	(1) V-Binning Off ＝320 us (2) V-Binning On ＝328 us	(1) V-Binning Off ＝430 us (2) V-Binning On ＝441 us
-	2nd Frame Readout Delay	(1) V-Binning Off ＝320 us (2) V-Binning Off ＝328 us	(1) V-Binning Off ＝551 us (2) V-Binning On ＝562 us
-	FVAL Non-Active	(1) V-Binning Off , H-Binning Off ＝443 us (2) V-Binning On , H-Binning Off ＝452 us (3) V-Binning Off , H-Binning On ＝447 us (4) V-Binning On , H-Binning On ＝456 us	(1) V-Binning Off , H-Binning Off ＝551 us (2) V-Binning On , H-Binning Off ＝562 us (3) V-Binning Off , H-Binning On ＝556 us (4) V-Binning On , H-Binning On ＝567 us
-	Trigger Period (Min.)	(1) V-Binning Off ＝(((([Height]+0.5)×654.63)-654.63+([Width]÷8)) x 2Frame÷80MHz) +[Expousre Time] +763us	(1) V-Binning Off ＝(((([Height]+0.5)×659.31)-659.31+([Width]÷8)) x 2Frame÷60MHz) +[Expousre Time] + 982us
		(2) V-Binning On ＝((([Height]×1309.27)-640+([Width÷8]))x 2Frame÷80MHz) +[Expousre Time] +780us	(2) V-Binning On ＝((([Height]×1318.61)-640+([Width÷8]))x 2Frame ÷60MHz) +[Expousre Time] +1003us
-	2nd FrameActive End ~ Frame Actiev End	0us	1.8us
a		More than 1 Line	More than 1 Line
b		Less than 1 Line	Less than 1 Line

Table - 48 PIV trigger mode specifications (1X4-1Y)

time name	Description	Time	
		1X4-1Y	
		Camera Link Pixel Clock = 80 MHz	Camera Link Pixel Clock = 60 MHz
td	Exposure Beginning delay	430 ns~470 ns	490 ns ~540 ns
te1	First exposure time period	10us ～ ≒at 1 Frame ([Height]=3840 : 63164us Max) ＝ [Exposure Time Settings]	10us ～≒ at 1 Frame ([Height]=3840 : 84819us Max) ＝ [Exposure Time Settings]
itf	Inter framing time	312 us	419 us
te2	Second exposure time	≒1 frame (1) V-Binning Off ＝([Height]×1309.27÷80MHz)＋132 us	≒1 frame (1) V-Binning Off ＝([Height]×1318.61÷60MHz)＋133 us
		(2) V-Binning On ＝([Height]×2618.53÷80MHz)＋132 us	(2) V-Binning On ＝([Height]×2637.23÷60MHz)＋133 us
tframe 1	First Frame read out	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝ (([Height]×1309.27)-1309.27+([Width]÷4))÷80MHz	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝(([Height]×1318.61)-1318.61+([Width]÷4))÷60MHz
		(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×2618.53)-1280+([Width]÷4))÷80MHz	(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×2637.23)-1280+([Width]÷4))÷60MHz
tframe 2	Second Frame read out	[FVAL Active] (the same as tframe1)	[FVAL Active] (the same as tframe1)
-	1st Frame Readout Delay	(1) V-Binning Off ＝328 us (2) V-Binning On ＝345 us	(1) V-Binning Off ＝441 us (2) V-Binning On ＝463 us
-	2nd Frame Readout Delay	(1) V-Binning Off ＝328 us (2) V-Binning Off ＝345 us	(1) V-Binning Off ＝441 us (2) V-Binning On ＝463 us
-	FVAL Non-Active	(1) V-Binning Off , H-Binning Off ＝444 us (2) V-Binning On , H-Binning Off ＝460 us (3) V-Binning Off , H-Binning On ＝452 us (4) V-Binning On , H-Binning On ＝468 us	(1) V-Binning Off , H-Binning Off ＝552 us (2) V-Binning On , H-Binning Off ＝574 us (3) V-Binning Off , H-Binning On ＝563 us (4) V-Binning On , H-Binning On ＝585 us
-	Trigger Period (Min.)	(1) V-Binning Off ＝(((([Height]+0.5)×1309.27)-1309.27+([Width]÷4)) x 2Frame÷80MHz) +[Expousre Time] + 773 us	(1) V-Binning Off ＝(((([Height]+0.5)×1318.61)-1318.61+([Width]÷4)) x 2Frame÷60MHz) +[Expousre Time] + 994 us
		(2) V-Binning On ＝((([Height]×2618.53)-1280+([Width÷4]))x 2Frame÷80MHz) +[Expousre Time] + 805 us	(2) V-Binning On ＝((([Height]×2637.23)-1280+([Width÷4]))x 2Frame ÷60MHz) +[Expousre Time] + 1038 us
-	2nd FrameActive End ~ Frame Actiev End	8.2 us	11.8us
a		More than 1 Line	More than 1 Line
b		Less than 1 Line	Less than 1 Line

Table - 49 PIV trigger mode specifications (1X2-1Y)

time name	Description	Time	
		1X2-1Y	
		Camera Link Pixel Clock = 80 MHz	Camera Link Pixel Clock = 60 MHz
td	Exposure Beginning delay	580 ns~640 ns	700 ns ~780 ns
te1	First exposure time period	10us ～ ≒at 1 Frame ([Height]=3840 : 126328us Max) ＝ [Exposure Time Settings]	10us ～≒at 1 Frame ([Height]=3840 : 169641us Max) ＝ [Exposure Time Settings]
itf	Inter framing time	624 us	838 us
te2	Second exposure time	≒1 frame (1) V-Binning Off ＝([Height]×2618.54÷80MHz)＋131us	≒1 frame (1) V-Binning Off ＝([Height]×2637.25÷60MHz)＋133us = 168.9165000 ms
		(2) V-Binning On ＝([Height]×5237.09÷80MHz)＋131us	(2) V-Binning On ＝([Height]×5274.49÷60MHz)＋133us
tframe 1	First Frame read out	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝ (([Height]×2618.54)-2618.54+([Width]÷2))÷80MHz	[FVAL Active] (1) V-Binning Off [FVAL Active] ＝(([Height]×2637.25)-2637.25+([Width]÷2))÷60MHz
		(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×5237.09)-2560+([Width]÷2))÷80MHz	(2) V-Binning On [FVAL Active] ＝ ((([Height]-0.5)×5274.49)-2560+([Width]÷2))÷60MHz
tframe 2	Second Frame read out	[FVAL Active] (the same as tframe1)	[FVAL Active] (the same as tframe1)
-	1st Frame Readout Delay	(1) V-Binning Off ＝656 us (2) V-Binning On ＝689 us	(1) V-Binning Off ＝881 us (2) V-Binning On ＝925 us
-	2nd Frame Readout Delay	(1) V-Binning Off ＝656 us (2) V-Binning Off ＝656 us	(1) V-Binning Off ＝881 us (2) V-Binning On ＝925 us
-	FVAL Non-Active	(1) V-Binning Off , H-Binning Off ＝755 us (2) V-Binning On , H-Binning Off ＝788 us (3) V-Binning Off , H-Binning On ＝771 us (4) V-Binning On , H-Binning On ＝804 us	(1) V-Binning Off , H-Binning Off ＝971 us (2) V-Binning On , H-Binning Off ＝1.015 ms (3) V-Binning Off , H-Binning On ＝993 us (4) V-Binning On , H-Binning On ＝1.037 ms
-	Trigger Period (Min.)	(1) V-Binning Off ＝(((([Height]+0.5)×2618.54)-2618.54+([Width]÷2)) x 2Frame÷80MHz) +[Expousre Time] + 1413 us	(1) V-Binning Off ＝(((([Height]+0.5)×2637.25)-2637.25+([Width]÷2)) x 2Frame÷60MHz) +[Expousre Time] + 1853 us
		(2) V-Binning On ＝((([Height]×5237.09)-2560+([Width÷2]))x 2Frame÷80MHz) +[Expousre Time] + 1478 us	(2) V-Binning On ＝((([Height]×5274.49)-2560+([Width÷2]))x 2Frame ÷60MHz) +[Expousre Time] + 1941 us
-	2nd FrameActive End ~ Frame Actiev End	22.9 us	33.7us
a		More than 1 Line	More than 1 Line
b		Less than 1 Line	Less than 1 Line

7.8 Sequential Timed Exposure mode

This is a function to capture images in sequence based preset ROI, Exposure Time, Gain and other parameters in the sequence index table.
In order activate this function, Video Send Mode should be set at Trigger Sequence.

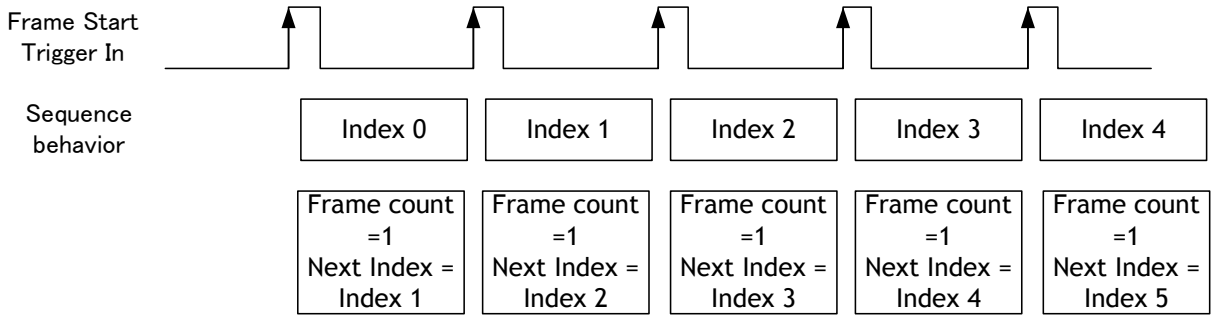


Fig. 32 Behavior of Sequence trigger

Table - 50 Minimum trigger interval (Trigger overlap = Off)

Readout Mode	Time (Min. Trigger Period)					
	1x8-1Y		1x4-1Y		1X2-1Y	
	80 MHz	60 MHz	80 MHz	60 MHz	80 MHz	60 MHz
Full	≧31.761 ms	≧42.648 ms	≧63.200 ms	≧84.864 ms	≧126.389 ms	≧169.719 ms
ROI Center 2/3	≧21.287 ms	≧28.582 ms	≧42.252 ms	≧56.734 ms	≧84.492 ms	≧113.457 ms
ROI Center 1/2	≧16.050 ms	≧21.550 ms	≧31.777 ms	≧42.669 ms	≧63.544 ms	≧85.327 ms
ROI Center 1/4	≧8.195 ms	≧11.001 ms	≧16.066 ms	≧21.571 ms	≧32.121 ms	≧43.131 ms
ROI Center 1/8	≧4.267 ms	≧5.726 ms	≧8.211 ms	≧11.022 ms	≧16.410 ms	≧22.033 ms
V Binning ON (Full) (Note 1)	≧31.770 ms	≧42.658 ms	≧63.216 ms	≧84.887 ms	≧126.423 ms	≧169.764 ms

Note 1. Overlap mode=Readout is not available
Note 2. The minimum interval calculation assumes that the exposure time for all sequences are equal. If there are differences, it is necessary to add the diference to the calculation. If the exposure times are different, it is recommended to organize the exposure times from the shortest exposure to the longest one.
Note 3. The sequence must start with Index 0. After Index 0 is executed, the sequence proceeds to the next setting index.

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

Table – 51 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 0	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 1	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 2	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 3	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 4	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 5	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 6	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 7	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 8	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0
- Index 9	5120	3840	0	0	100	0	0	180000	0	1 (Off)	1 (Off)	Off	1	Index 0

7.8.1 Sequence ROI setting parameters

Setting parameters for Sequence ROI are as follows.

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

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

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

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

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

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

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

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

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

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

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

(12) Sequence ROI Frame Count
This can set how many times the seleted 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 excuted from index 0.

(14) Sequence ROI Reset Command
This command resets the current index pointer and reverts to index 0 in the table. Frame Count is also re-initialized.

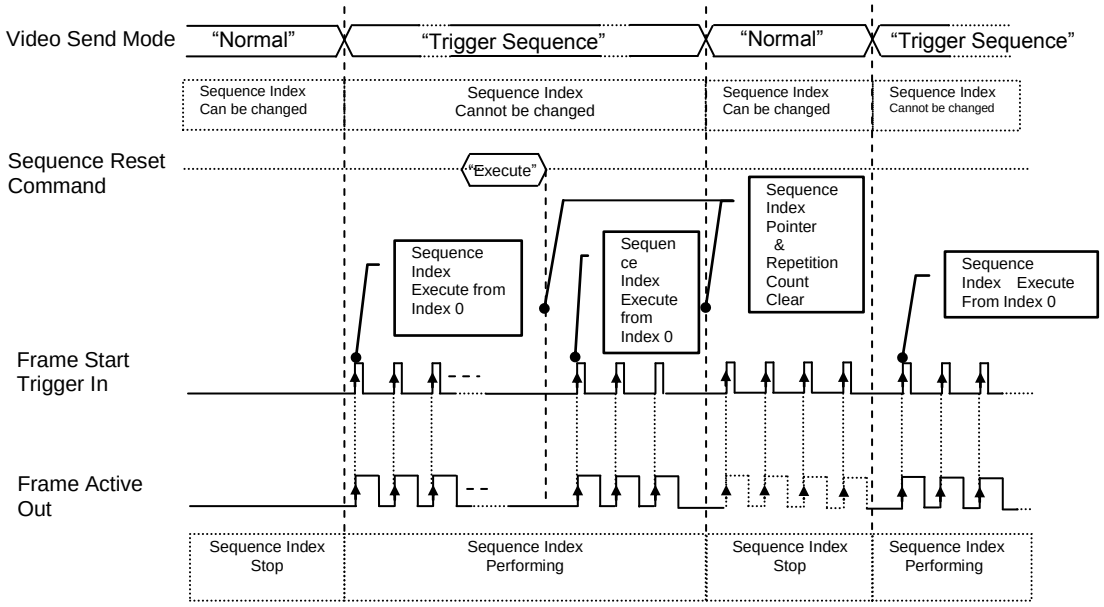


Fig. 33 Sequence trigger timing

7.9. Operation and function matrix

Table - 52 Operation and function matrix

Exposure Mode	Trigger Mode	V-Binning (Note1)	H-Binning (Note1)	Exposure control	ROI	Auto White Balance (Note2)	Auto Gain	Auto Expsoure	Trigger Overlap	Video Sending Mode		HDR (Note 3)
										Multi ROI	Sequence ROI	
OFF	OFF	1	1	×	○	○	○	×	×	○	×	×
		2	2	×	○	○	○	×	×	○	×	×
Timed	OFF	1	1	○	○	○	○	○	×	○	×	○
		2	2	○	○	○	○	○	×	○	×	○
Timed	ON	1	1	○	○	○	○	○	○	○	○	○
		2	2	○	○	○	○	○	○	○	○	○
Trigger Width	ON	1	1	×	○	×	×	×	○	○	×	×
		2	2	×	○	×	×	×	○	○	×	×
PIV	ON	1	1	×	○	×	×	×	×	○	×	×
		2	2	×	○	×	×	×	×	○	×	×

(Note1) SP-20000M-PMCL only
(Note2) SP-20000C-PMCL only
(Note3) HDR is optional function

8. Other functions

8.1 Black level control

This function adjusts the setup level.
Variable range: -256 to 255 LSB (at 12-bit output)

8.1.1 Black Level Selector

The following items can be adjusted.

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

8.1.2 Black Level

The black level can be adjusted in the following range.

Monochrome:	Black Level All: -256 ～+255
Color:	Black Level All: -256 ～+255
	Black Level Red: -512 ～+511
	Black Level Blue: -512 ～+511

8.1.3 Auto black control

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

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

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

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

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

8.2 Gain control

The SP-20000M-PMCL can adjust the gain level from x1 (0dB) to 16 times (+24dB) using x1 (0dB) as the reference (Factory default). In the SP-20000C-PMCL, the master gain can be adjusted from x1 (0dB) to 16 times (+24dB) and R and B gains can be adjusted in the range of 0.45 times (-7dB) to 7.15 times (+10dB) using the master gain as the reference.

Resolution:
Master Gain: x0.01 (0.035dB)/Step
Blue/Red Gain: x0.00017 /Step

The master gain uses digital gain. All digital gain has the resolution of x0.01 /Step and provides more precise gain setting. However, as it uses only digital gain, please note that if high gain is set, breaks in the histogram may occur.

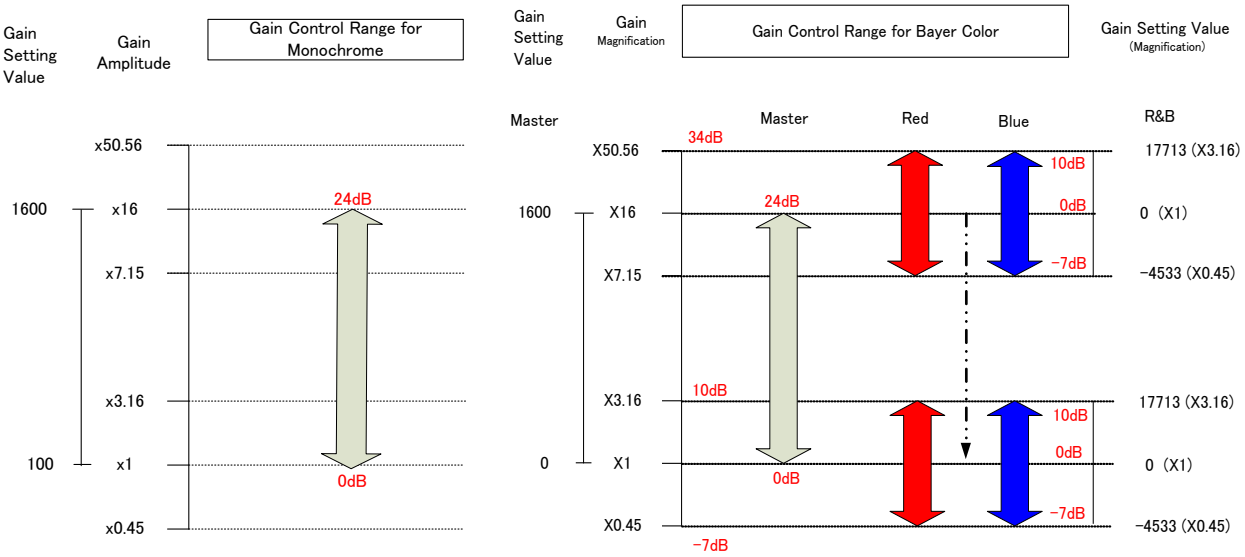


Fig.35 Gain control

8.2.1 Gain Selector

The following parameters can be set.

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

8.2.2 Gain

The range for adjustment is as follows.

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

8.2.3 Gain Auto

This provides automatic control of the gain level.
This is controlled by the command 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 Exposure Auto)
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 Exposure Auto)
ALC channel area:	The measurement area of GainAuto control can be set, either entire area or individual section

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.36 Detection area

8.2.4 Balance White Auto

This is a function to enable the auto white balance by using R and B gain controls.
It contains the following methods.

OFF :	Set the white balance manually
Once :	Control the auto white balance only one time when it is set
Continuous :	Continuing control of the auto white balance

AWB Channel area: Can set the area to control the auto white balance.
The detection area is the same as the figure 36.

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 selected from OFF, Gamma or LUT Table.

8.3.2 LUT Index

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

8.3.3 LUT Value

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

Output Data = Video IN x LUT data

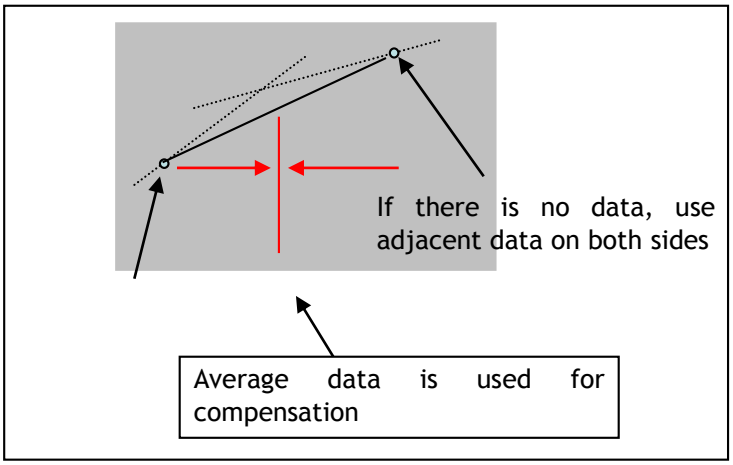


Fig.37 LUT data processing method

8.4 Gamma

This command is used to set gamma between gamma 0.45 and gamma 1.0 (OFF). 8 steps are provided. The gamma value is an approximate value.

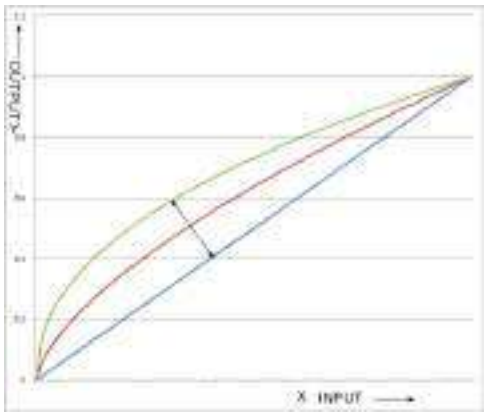


Fig.35 Gamma correction

8.5 Shading Correction

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

There are two methods of correction.

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

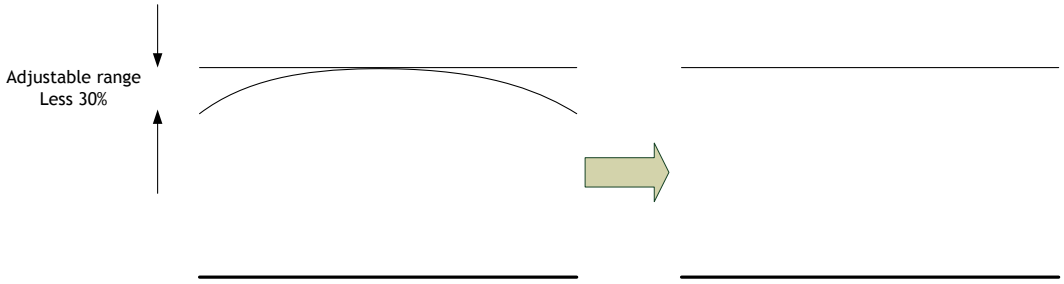


Fig.38 Concept drawing of Flat shadingcorrection

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

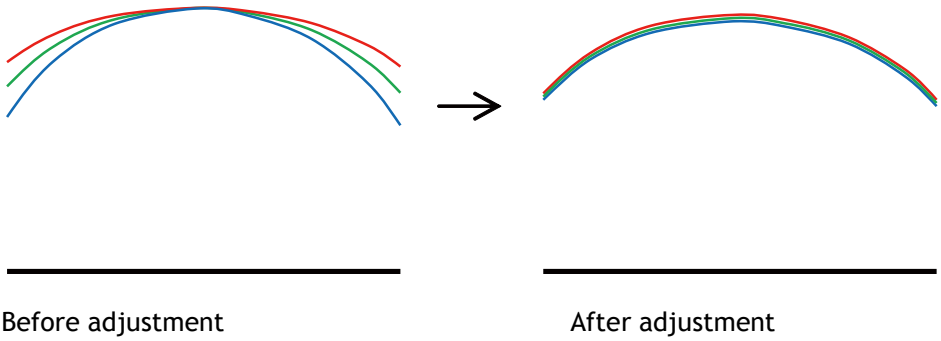


Fig. 39 Concept drawing of color shading correction

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

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

8.6 Blemish compensation

The SP-20000-PMCL has a blemish compensation circuit. This function compensates blemishes on the CMOS sensor (typically pixels with extremely high response or extremely low response). This applies to both monochrome and color versions. Pixels that fulfill the blemish criteria can be compensated by averaging the data from pixels in both adjacent columns and, in the case of the SP-20000C-PMCL, the defective pixels can be compensated by averaging the data from the same Bayer color pixels in adjacent columns. The number of pixels that can be compensated is up to 1000 pixels.

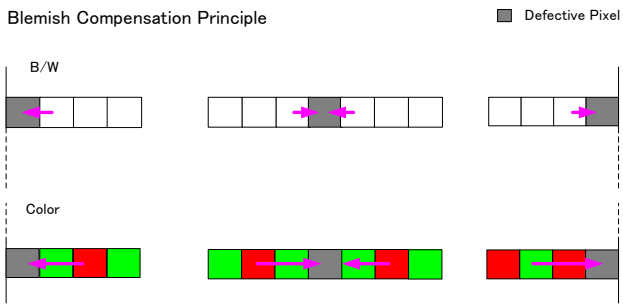


Fig. 40 Blemish compensation

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

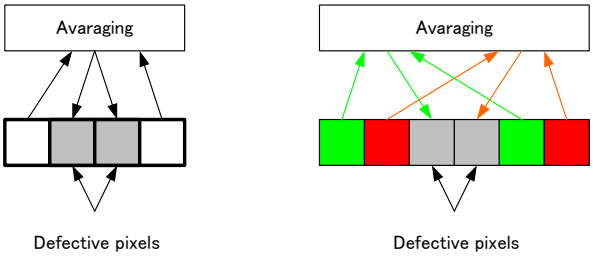


Fig. 41 Compensation if defective pixels are in series

8.7 ALC

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

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

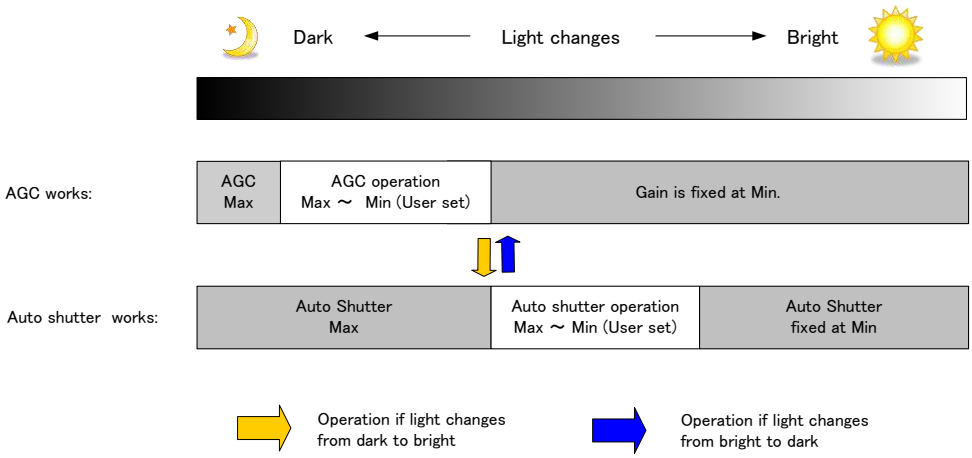


Fig.42 ALC function

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

9. Camera Settings

9.1 Camera Control Tool

In the SP-20000-PMCL, 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.

If you need to use the Short ASCII communication protocol and associated control tool, please contact your local JAI representative.

Specific notes regarding Control Tool use:

1. For SP-20000-PMCL, the JAI SDK and Control Tool 2.0 can be used to control the camera, provided the PC on which the JAI software is installed is connected to the camera via a GenCP-compliant Camera Link frame grabber. Many frame grabber vendors also provide their own GenICam control tool software, as do a number of third-party software companies. Software conflicts can occur between these GenICam tools and the JAI SDK and Control Tool causing one or both tools to function improperly. Therefore, if you intend to use the JAI SDK and Control Tool you should A) not install any other GenICam software on your host PC, or B) install the JAI SDK and Control Tool last, after installing any other software. This will, in most cases, ensure that the JAI SDK and Control Tool functions properly. If not, please contact the frame grabber manufacturer or JAI to determine other ways to eliminate any software conflict.

2. The frame grabber used must be compliant with Camera Link Specification v1.1 or greater in order to communicate with the JAI SDK and Control Tool. If it is not, the JAI SDK and Control Tool cannot be used, and the Short ASCII communication protocol and associated control tool should be used instead.

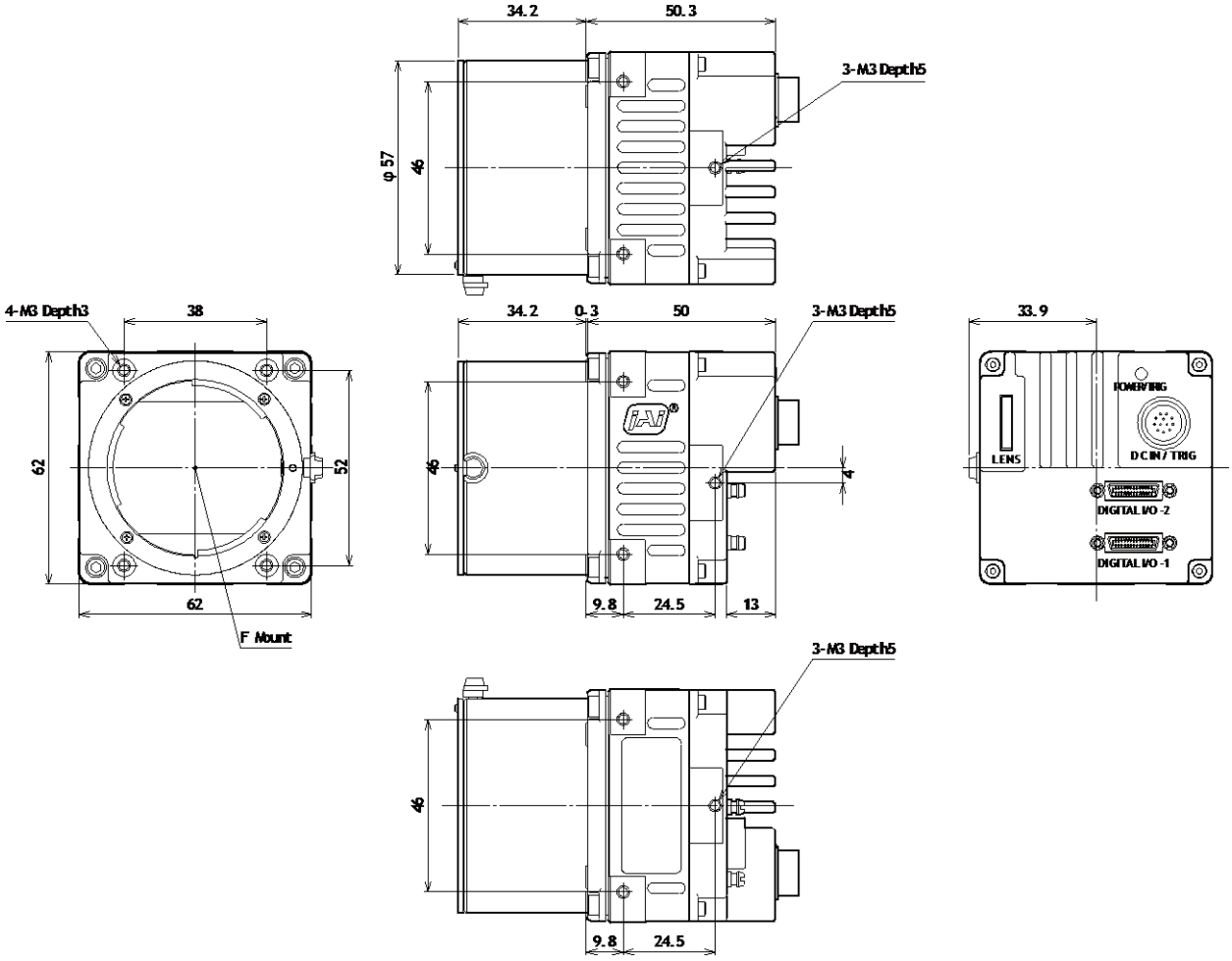
9.2 Camera Default Settings

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

The following table shows default settings of basic functions.

Image Format	Bit allocation	8-bit
	Width	5120
	Height	3840
	Binning Horizontal	1(OFF)
	Binning Vertical	1(OFF)
Acquisition Control	Acquisition Frame Rate	30Hz
Trigger Selector		Frame Start
	Trigger Mode	OFF
	Trigger Activation	Rising Edge
	Trigger Source	Low
Trigger Overlap		OFF
Exposure Control	Exposure Mode	Timed
Gain	Gain	1
	Gain Auto	OFF
Gamma		0.45
Video Send Mode		Normal

10. External appearance and dimensions



Dimensions tolerance: ±0.3mm
Unit: mm

Fig. 44 Appearance and Dimensions

11. Specifications

11.1. Camera spectral response

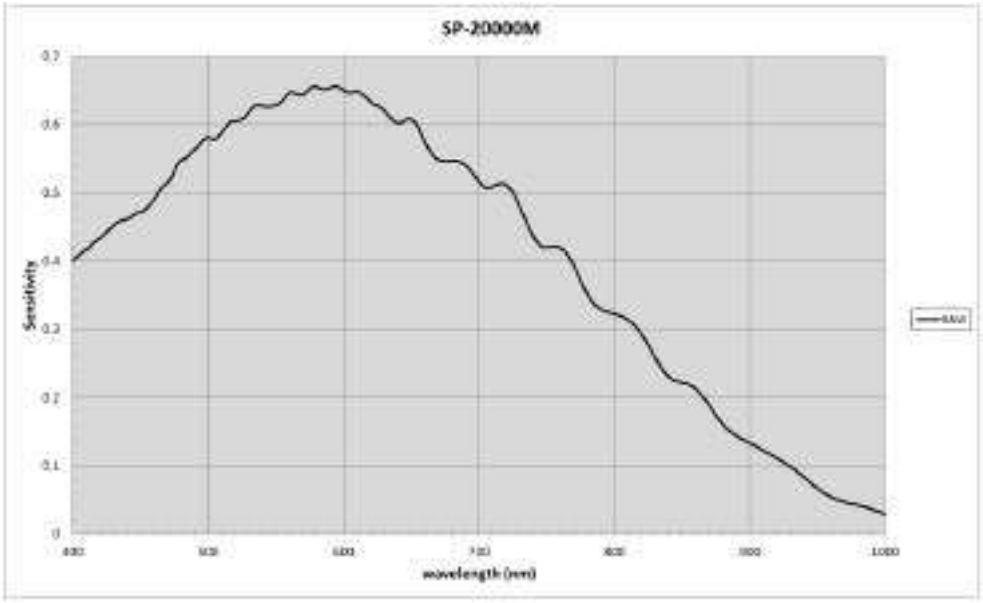


Fig.45 SP-20000M-PMCL Spectral response

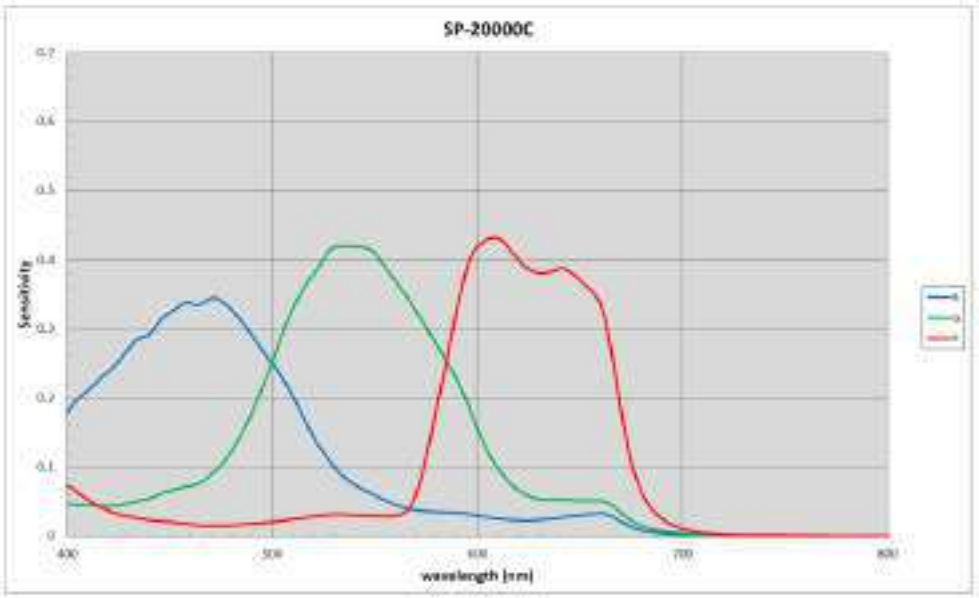


Fig.46 SP-20000C-PMCL Spectral response (With IR Cut Filter)

11.2. Specification table

Specifications			**SP-20000M-PMCL**		**SP-20000C-PMCL**	
Scanning system			Progressive scan, 4-Tap or 8-Tap output			
Synchronization			Internal			
Interface			Camera Link Specfications （V.2.0 RC2）, Conforming with PoCL specifications			
			Pixel clock: 80 MHz (Standard) or 60 MHz can be selected in conjunction with sensor clock			
Image sensor (CMV-20000)			35 mm Monochrome CMOS		35 mm Bayer color CMOS	
Aspect ratio			4:3			
Effective image size			32.77 (h) x 24.58 (v) mm 41 mm diagonal			
Cell size			6.4 (h) x 6.4 (v) μm			
Effective Image output pixel			5120 (h) x 3840 (v)		5120 (h) x 3840 (v)	
Sensor Pixel Clock			39.16 MHzMHz (1X8-1Y Standard operation)			
Acquisition Frame rate	1X8-1Y		30 fps (Max) to 8 sec Maximum on 80-bit Configuration		30 fps (Max) to 8 sec Maximum on 80-bit Configuration	
	1X4-1Y		15 fps (Max) to 8 sec Maximum on Medium Configuration		15 fps (Max) to 8 sec Maximum on Medium Configuration	
	1X2-1Y		7.5 fps (Max) to 8 sec Maximum on Base Configuration		7.5 fps (Max) to 8 sec Maximum on Base Configuration	
EMVA 1288 Parameters Absolute sensitivity Maximum SNR			10-bit output format 16.05 p (λ = 525 nm) 40.24dB		10-bit output format 18.14 p (λ = 530 nm) 38.32dB	
SNR (traditional method)			53dB (Typical) (0dB gain, Black)		51dB (Typical) (0dB gain, Green Pixel Black)	
Image Output Format Digital	Full image		5120 (h) x 3840 (v)		Bayer 5120 (h) x 3840 (v)	
	Binning Horizontal		1: 5120(h), 2: 2560(h) (frame rate does not change)		—	
	Binning Vertical		1: 3840(v), 2: 1920(v) (frame rate does not change)		—	
	ROI	Height	2 ～3840 lines, 2 lines / step		2 ～3840 lines, 2 lines / step	
		OFFSET Y	0 ～3838 lines、2 lines / step		0 ～3838 lines , 2 lines / step	
		Width	8 ～ 5120 pixels		8 ～ 5120 Pixels	
			1X 8-1Y	8 pixels/step	1X 8-1Y	8 pixels/step
			1X4-1Y	8 pixels/step	1X4-1Y	8 pixels/step
			1X2-1Y	8 pixels/step	1X2-1Y	8 pixels/step
		OFFSET X	0 ～ 5112 pixels		0 ～ 5112 pixels	
			1X8-1Y	8 pixels/step	1X8-1Y	8 pixels/step
			1X4-1Y	8 pixels/step	1X4-1Y	8 pixels/step
			1X2-1Y	8 pixels/step	1X2-1Y	8 pixels/step
	Bit assignment		8-bit , 10-bit, 12-bit		8-bit , 10-bit , 12-bit	
Video send mode	Sequence ROI		ROI, Gain and Exposure time can be set for 10 indexes in sequence output by trigger			
	Multi ROI		Maximum 8 ROIs can be set in one frame and are output as one video			
Acquisition Mode			Continuous/Single Fraem/Multi Frame			
Trigger mode			Acqusition: Acquistion Start/ Acquistion End Exposure: Frame Start			
Trigger option			Trigger Overlap (Only Frame Start), PIV			
Trigger input signal			Line 4 (TTL 1),Line7(Camera Link) ,Pulse Generator 0/1/2/3, Soft Trigger Line 10(TTL2), Line 11(LVDS)			

Exposure Mode	Timed	304 μs (Min) ～ 8 sec. (Max), Step: 1 μs	
	Trigger Width	304 μs (Min) ～ ∞ (Max)	
Auto exposure		OFF / Once / Continuous	
Exposure Auto response speed		1 ～ 8	
Digital I/O		Line Selector (12P): GPIO IN / GPIO OUT	
Black level adjust	Reference	33.5LSB 10-bit (Average of 100*100)	
	Adj. range	-256 ～ 255LSB 12-bit	
	Resolution	1 STEP = 1LSB	
Gain Adjust	Manual adj. range	0dB ～+24dB, 0.01dB/step	0dB ～+24dB, 0.01dB/step
	WB gain	—	R / B : -7dB to +10dB, 0.01dB/step
	WB area	—	4 x 4
	Preset xcolor temp.	—	4600K, 5600K, 6500K
	WB range	—	3000K ～ 9000K
	White balance	—	OFF, Once, continuous
Auto Black	Mode	Auto, Limit, Fix	
	Limit	0 to 30%	
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)	
	Correct Numbers	Up to 1000 pixels	
ALC		AGC and Auto Exposure can be combined and automatically controlled	
Gamma		0.45 ～ 1.0 (8 steps are available)	
LUT		OFF: γ=1.0, ON= 256 points can be set	
Shading compensation		Flat field Block based (20 x 15 blocks) Each block: 256 x 256 pixels	Flat field, Color shading Block based (20 x 15 blocks) Each block: 256 x 256 pixels
Power supply	Power input	DC+12V to +24V ± 10% (at the input terminal)	
	Current	450mA ± 10% (12V input, full image), 480mA ± 10% (12V input, 8 lines ROI)	
	Power consumption	5.4W ± 10% (12V input, full image), 5.6W ± 10% (12V input, 8 lines ROI)	
Lens mount		F mount, Rear protrusion of the lens is less than 40 mm.	
Flange back		F mount : 46.5 mm, Tolerance 0 to -0.05 mm	
Optical filter		Protection glass : Not provided	Optical Low Pass filter ＋ IR cut filter (Half value is 670 nm)
Operating temperature / Humidity (Performance guaranteed)		-5°C to +45°C / 20 – 80% (non-condensing)	
Operating temperature / Humidity		-45°C to +70°C / 20 – 80% (non-condensing)	
Storage Temp. / Humidity		-45°C to +70°C / 20% - 80 % (non-condensing)	
Regulation		CE (EN61000-6-2 and EN61000-6-3), FCC part 15 class B, RoHS, WEEE	
Housing Dimensions		62 x 62 x 84.5 mm (W x H x D) (excluding protrusion)	
Weight		320 g	

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

Appendix 1 Short ASCII Command Communication Protocol

This chapter described the communication control protocol based on the short ASCII command as the reference.

1 Communication setting

Baud Rate	9600
Data Length	8bit
Start Bit	1bit
Stop Bit	1bit
Parity	Non
Xon/Xoff Control	Non

2 Protocol（Short ASCII Command）

2.1 Transmit the setting command to camera

NN is any kind of command.
NN=[Param.]<CR><LF>
e.g.
Send to camera: GA=0 <CR><LF>
Camera response: COMPLETE<CR><LF>

When camera receives a valid command, camera will return 'COMPLETE'.
If camera receives an improper command, camera will return one of the following:
e.g.
Send to camera: GAX=0 <CR><LF>
Camera response: 01 Unknown Command!!<CR><LF>
e.g.
Send to camera: GA=1000 <CR><LF>
Camera response: 02 Bad Parameters!!<CR><LF>

2.2 Transmit the request command to camera

The status of camera's settings can be queried by transmitting NN?<CR><LF>, where NN is any valid command.
The camera will return the current setting data.
e.g.
Send to camera: GA? <CR><LF>
Camera response: GA=0<CR><LF>

2.3 Switching baud rate between PC and camera

Camera always starts up with 9600 bps. This can be switched to higher baud rates after communication has been established. When switching to other baud rates the procedure is as follows.
e.g. Change baud rate to 115200 bps
1. Confirm baud rates camera supported
Send to camera: SBDRT? <CR><LF>
Camera response: SBDRT=31(0x1F)<CR><LF>

2. Request new baud rate
   Send to camera: CBDRT=16(0x10) <CR><LF>
   Camera response: COMPLETE<CR><LF>
   (Change baud rate to 115200 bps)
3. Rewrite new baud rate again with new baud rate (Confirmation command)
   Send to camera: CBDRT=16(0x10) <CR><LF>
   Camera response: COMPLETE<CR><LF>
   In case the camera does not receive the confirming command with new baud rate within 250 ms after sending the acknowledgement it falls back to the original baud rate (9600 bps).

2.4 Command list (Short ASCII command)

2.4.1 GenCP Bootstrap Register

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
DeviceVendorName	I String	R/O	DVN	"JAI Ltd., Japan"	—	—	—	**DVN**?<CR><LF>
DeviceModelName	I String	R/O	MD		—	—	—	**MD**?<CR><LF>
DeviceVersion	I String	R/O	DV	Indicate device version (e.g. "0.1.0.0")	—	—	—	**DV**?<CR><LF>
DeviceID	I String	R/O	ID	Serial Number	—	—	—	**ID**?<CR><LF>
DeviceUserID	I String	R/W	UD	User can save and load free text.(12 or less characters)				**UD**=[Param.]<CR><LF> UD?<CR><LF>

2.4.2 Tecnology Specific Bootstrap Register

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
SupportedBaudrates	I Integer	R/O	SBDRT	Indicate Support/Non-support status for each baud rate bit0: 9600bps bit1: 19200bps bit2: 38400bps bit3: 57600bps bit4: 115200bps	0x01	0x1F	0x1F	**SBDRT**?<CR><LF>
CurrentBaudrate	I Integer	R/W	CBDRT	READ: Indicate current baud rate WRITE: Set any bit of baud rate bit0: 9600bps bit1: 19200bps bit2: 38400bps bit3: 57600bps bit4: 115200bps	0x01	0x10	1 (9600bps)	**CBDRT**=[Param.]<CR><LF> CBDRT?<CR><LF> In case of WRITE execution (change baud rate), it needs to control in the proper sequence between Host and Camera. (Refer to the section 3.3)

2.4.3 Device Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
DeviceFirmwareVersion	I String	R/O	VN	Firm Ver. No.	—	—	—	**VN**?<CR><LF>
DeviceReset	I Command	W/O	CRS00	1	—	—	—	**CRS00=1**<CR><LF>

2.4.4 Image Format Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
Width	I Integer	R/W	WTC	Min～(Max - OffsetX)	8	5120	5120	**WTC**=[Param.]<CR><LF> WTC?<CR><LF>
Height	I Integer	R/W	HTL	Min～(Max - OffsetY)	1	3840	3840	**HTL**=[Param.]<CR><LF> HTL?<CR><LF>
Offset X	I Integer	R/W	OFC	Min ～ Max(Width + OffsetX)	0	5112	0	**OFC**=[Param.]<CR><LF> OFC?<CR><LF>
Offset Y	I Integer	R/W	OFL	Min ～ Max(Height + OffsetY)	0	3839	0	**OFL**=[Param.]<CR><LF> OFL?<CR><LF>
BinningHorizontal	I Integer	R/W	HB	1: Normal / 2: Binning mode	1	2	1	**HB**=[Param.]<CR><LF> HB?<CR><LF> only Mono
BinningVertical	I Integer	R/W	VB	1: Normal / 2: Binning mode	1	2	1	**VB**=[Param.]<CR><LF> VB?<CR><LF> only Mono
PixelFormat	I Enumeration	R/W	BA	Mono model: 0: Mono8 1: Mono10 2: Mono12 Bayer model: 0: BayerRG8 1: BayerRG10 2: BayerRG12	0	2	0	**BA**=[Param.]<CR><LF> BA?<CR><LF> Mono12(Geometry_1X4_1Y Only)
TestImageSelector	I Enumeration	R/W	TPN	0: Off 1: GreyHorizontalRamp 2: GreyVerticalRamp 3: GreyHorizontalRampMoving 4: Horizontal Colorbar* 5: Vertical Colorbar* 6: Moving Colorbar* (* Bayer model only)	0	7	0	**TPN**=[Param.]<CR><LF> TPN?<CR><LF>

2.4.5 Acquistion Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
FrameStartTrigMode	I Enumeration	R/W	TM	Off/On	0	1	0	**TM**=[Param.]<CR><LF> TM?<CR><LF>
TrigSoftware	I Command	W/O	STRG	0	—	—	—	**STRG**=0<CR><LF>
FrameStartTrigSource	I Enumeration	R/W	TI	0: Low 1: High 2: SoftTrigger 8: PulseGenerator0 9: PulseGenerator1 10: PulseGenerator2 11: PulseGenerator3 12: TTL_In1 13: CL_CC1_In 14: Nand0 15: Nand1 16:TTL_In2 17:LVDS_In	0	17	0	**TI**=[Param.]<CR><LF> TI?<CR><LF>
FrameStartTrigActivation	I Enumeration	R/W	TA	0: RisingEdge 1: FallingEdge 2: LevelHigh 3: LevelLow	0	3	0	**TA**=[Param.]<CR><LF> TA?<CR><LF>
FrameStartTrigOver Lap	I Enumeration	R/W	TO	0: Off / 1: ReadOut	0	1	0	**TO**=[Param.]<CR><LF> TO?<CR><LF>
ExposureMode	I Enumeration	R/W	EM	0: Off 1: Timed 2: TriggerWidth	0	2	0	**EM**=[Param.]<CR><LF> EM?<CR><LF>
ExposureTimeRaw	I Integer	R/W	PE	Min～Max[us]	10	8000000	18000	**PE**=[Param.]<CR><LF> PE?<CR><LF>
ExposureAuto	I Enumeration	R/W	ASC	0: Off 2: Once 1: Continuous	0	2	2	**ASC**=[Param.]<CR><LF> ASC?<CR><LF>

2.4.6 Digital I/O Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
LineInverter_0	I Boolean	R/W	LI0	False/True	0	1	0	**LI0**=[Param.]<CR><LF> LI0?<CR><LF>
LineInverter_1	I Boolean	R/W	LI1	False/True	0	1	0	**LI1**=[Param.]<CR><LF> LI1?<CR><LF>
LineInverter_2	I Boolean	R/W	LI2	False/True	0	1	0	**LI2**=[Param.]<CR><LF> LI1?<CR><LF>
GpioNand0InputInvert1	I Enumeration	R/W	ND0INV1	0: Non-Inv 1: Inv	0	1	0	**ND0INV1**=[Param.]<CR><LF> ND0INV1?<CR><LF>
GpioNand0InputInvert2	I Enumeration	R/W	ND0INV2	Same as above.	0	1	0	**ND0INV2**=[Param.]<CR><LF> ND0INV2?<CR><LF>
GpioNand1InputInvert1	I Enumeration	R/W	ND1INV1	Same as above.	0	1	0	**ND1INV1**=[Param.]<CR><LF> ND1INV1?<CR><LF>
GpioNand1InputInvert2	I Enumeration	R/W	ND1INV2	Same as above.	0	1	0	**ND1INV2**=[Param.]<CR><LF> ND1INV2?<CR><LF>
GpioNand0InputInvert1	I Enumeration	R/W	ND0INV1	0: Non-Inv 1: Inv	0	1	0	**ND0INV1**=[Param.]<CR><LF> ND0INV1?<CR><LF>
LineSource_0	I Enumeration	R/W	LS0	0: Low 1: High 3: FrameTriggerWait 4: FrameActive 5: ExposureActive 6: Fval 8:Pulse Generator0 9:Pulse Generator1 10:Pulse Generator2 11:Pulse Generator3 12: TTL_In 13: CL_CC1_In 14: Nand0 15: Nand1 16:TTL_In2 17:LVDS_In	0	17	0	**LS0**=[Param.]<CR><LF> LS0?<CR><LF> For TTL1

LineSource_1	I Enumeration	R/W	LS1	0: Low 1: High 3:FrameTrigger Wait 4: FrameActive 5: ExposureActive 6: Fval 8: PulseGenerator 0 9: PulseGenerator 1 10: ulseGenerator2 11:PulseGenerator3 12: TTL_In 13: CL_CC1_In 14: Nand0 15: Nand1 16:TTL_In2 17:LVDS_In	0	17	0	**LS1**=[Param.]<CR><LF> LS1?<CR><LF> TTL2
LineSource_2	I Enumeration	R/W	LS2	0: Low 1: High 3:FrameTrigger Wait 4: FrameActive 5: ExposureActive 6: Fval 8: PulseGenerator 0 9: PulseGenerator 1 10: PulseGenerator 2 11: PulseGenerator 3 12: TTL_In 13: CL_CC1_In 14: Nand0 15: Nand1 16:TTL_In2 17:LVDS_In	0	17	0	**LS3**=[Param.]<CR><LF> LS3?<CR><LF> TTL3

GpioNand0InputSource1	I Enumeration	R/W	ND0IN1	0: Low 1: High 3: FrameTriggerWait 4: FrameActive 5: ExposureActive 6: Fval 8: PulseGenerator0 9: PulseGenerator1 10: PulseGenerator2 11: PulseGenerator3 12: TTL_In1 13: CL_CC1_In 15: NAND1 16: TTL_In2 17: LVDS_In	0	17	0	**ND0N1**=[Param.]<CR><LF> ND0IN1?<CR><LF>
GpioNand0InputSource2	I Enumeration	R/W	ND0IN2	Same as above.	0	17	0	**ND0N2**=[Param.]<CR><LF> ND0IN2?<CR><LF>
GpioNand1InputSource1	I Enumeration	R/W	ND1IN1	0: Low 1: High 3:Frame TriggerWait 4: FrameActive 5:Exposure Active 6: Fval 8:Pulse Generator0 9:Pulse Generator1 10:Pulse Generator2 11:Pulse Generator3 12: TTL_In1 13: CL_CC1_In 14:NAND0 16:TTL_In2 17:LVDS_In	0	17	0	**ND1N1**=[Param.]<CR><LF> ND1IN1?<CR><LF>
GpioNand1InputSource2	I Enumeration	R/W	ND1IN2	Same as above.	0	17	0	**ND1N2**=[Param.]<CR><LF> ND1IN2?<CR><LF>

2.4.7 Analog Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
GainRawDigitalAll	I Integer	R/W	FGA	min～max	100	1600	100	**FGA**=[Param.]<CR><LF> FGA?<CR><LF>
GainRawDigitalRedAll	I Integer	R/W	PGR	min～max	-4533	17713	0	**PGR**=[Param.]<CR><LF> PGR?<CR><LF> (Bayer model only)
GainRawDigitalBlueAll	I Integer	R/W	PGB	min～max	-4533	17713	0	**PGB**=[Param.]<CR><LF> PGB?<CR><LF> (Bayer model only)
GainAuto	I Enumeration	R/W	AGC	0: Off 1: Continuous 2: Once	0	2	0	**AGC**=[Param.]<CR><LF> AGC?<CR><LF>
BlackLevelRawAll	I Integer	R/W	BL	min～0～max	-256	255	0	**BL**=[Param.]<CR><LF> BL?<CR><LF>
BlackLevelRawTap1All	I Integer	R/W	BL1	min～0～max	-512	511	0	**BL1**=[Param.]<CR><LF> BL1?<CR><LF>
BlackLevelRawTap1 Red	I Integer	R/W	BLR1	min～0～max	-512	511	0	**BLR1**=[Param.]<CR><LF> BLR1?<CR><LF> (Bayer model only)
BlackLevelRawTap1 Blue	I Integer	R/W	BLB1	min～0～max	-512	511	0	**BLB1**=[Param.]<CR><LF> BLB1?<CR><LF> (Bayer model only)
BalanceWhiteAuto	I Enumeration	R/W	AWB	0: Off 2: Once 1: Continuous	0	2	0	**AWB**=[Param.]<CR><LF> AWB?<CR><LF> (Bayer model only)

2.4.8 LUT Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
LUTValueRed	I Integer	R/W	LUTR	Param 1: LUT index Param 2:LUTdata(Min～Max) (Bayer model only)	0 0	255 4095	γ=1 equivalent	**LUT*=[Param1],[Param2]<CR><LF>** LUT*?[Param1]<CR><LF>
LUTValueGreen	I Integer	R/W	LUTG	Param 1: LUT index Param 2:LUTdata(Min～Max)	0 0	255 4095		
LUTValueBlue	I Integer	R/W	LUTB	Param 1: LUT index Param 2:LUTdata(Min～Max) (Bayer model only)	0 0	255 4095		

2.4.9 Transport Layer Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
DeviceTapGeometry	I Enumeration	R/W	TAGM	1: Geometry_1X2_1Y 3: Geometry_1X4_1Y 5: Geometry_1X8_1Y	1	5	5	**TAGM**=[Param.]<CR><LF> TAGM?<CR><LF>

2.4.10 User Set Control

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
UserSetLoad	I Command	W/O	LD	0: Default 1: UserSet1 2: UserSet2 3: UserSet3	0	3	0	**LD**=[Param.]<CR><LF> LD?<CR><LF>
UserSetSave	I Command	W/O	SA	1: UserSet1 2: UserSet2 3: UserSet3	1	3	1	**SA**=[Param.]<CR><LF> SA?<CR><LF>

2.4.11 JAI Custom

Name	Interface	Access	Short ASCII	Values	MIN	MAX	DEFAULT	Description
BlemishWhiteEnable	I Boolean	R/W	BMW	0: False 1: True	0	1	0	**BMW**=[Param.]<CR><LF> BMW?<CR><LF>
BlemishWhiteDetect	I Command	W/O	BMRCW	0	0	0	0	**BMRCW**=0<CR><LF>
BlemishWhiteDetect Threshold	I Integer	R/W	BMTHW	0	0	100	10	**BMTHW**=[Param.]<CR><LF> BMTHW?<CR><LF>
BlemishWhiteDetect PositionX	I Integer	R/W	BMPXW	Min～Max	0	1919	0	**BMPXW**=[Param.]<CR><LF> BMPXW?<CR><LF>
BlemishWhiteDetect PositionY	I Integer	R/W	BMPYW	Min～Max	0	1439	0	**BMPYW**=[Param.]<CR><LF> BMPYW?<CR><LF>
ShadingCorrection Mode	I Enumeration	R/W	SDCM	0: Flat Shading 1: Color Shading* (*Bayer model only)	0	1	0	**SDCM**=[Param.]<CR><LF> SDCM?<CR><LF>
ShadingCorrect	I Command	W/O	RS		0	0	0	**BMRCW**=0<CR><LF>
RequestShadingDetectResult	I Enumeration	R/O	SDRS	0=Complete. 1=Too Bright. 2=Too dark. 3=Timeout Error. 4=Busy. 5=Limit. 6= Trig is not set as Normal.	0	6	0	**SDRS**?<CR><LF>

ShadingMode	I Enumeration	R/W	SDM	0: OFF 1: User 1 2: User 2 3: User 3	0	3	0	**SDM**=[Param.]<CR><LF> SDM?<CR><LF>
VideoSendMode	I Enumeration	R/W	VSM	0: Normal 1: Trigger Sequence 2:Command Sequence 3: Multi AOI	0	2	0	**VSM**=[Param.]<CR><LF> VSM?<CR><LF>
SequenceRoiFrameCount1	I Integer	R/W	SQF1	Min～Max	1	255	1	**SQF1**=[Param.]<CR><LF> SQF1?<CR><LF>
SequenceRoiFrameCount2	I Integer	R/W	SQF2	Min～Max	1	255	1	**SQF2**=[Param.]<CR><LF> SQF2?<CR><LF>
SequenceRoiFrameCount3	I Integer	R/W	SQF3	Min～Max	1	255	1	**SQF3**=[Param.]<CR><LF> SQF3?<CR><LF>
SequenceRoiFrameCount4	I Integer	R/W	SQF4	Min～Max	1	255	1	**SQF4**=[Param.]<CR><LF> SQF4?<CR><LF>
SequenceRoiFrameCount5	I Integer	R/W	SQF5	Min～Max	1	255	1	**SQF5**=[Param.]<CR><LF> SQF5?<CR><LF>
SequenceRoiFrameCount6	I Integer	R/W	SQF6	Min～Max	1	255	1	**SQF6**=[Param.]<CR><LF> SQF6?<CR><LF>
SequenceRoiFrameCount7	I Integer	R/W	SQF7	Min～Max	1	255	1	**SQF7**=[Param.]<CR><LF> SQF7?<CR><LF>
SequenceRoiFrameCount8	I Integer	R/W	SQF8	Min～Max	1	255	1	**SQF8**=[Param.]<CR><LF> SQF8?<CR><LF>
SequenceRoiFrameCount9	I Integer	R/W	SQF9	Min～Max	1	255	1	**SQF9**=[Param.]<CR><LF> SQF9?<CR><LF>
SequenceRoiFrameCount10	I Integer	R/W	SQF10	Min～Max	1	255	1	**SQF10**=[Param.]<CR><LF> SQF10?<CR><LF>
SequenceRoiNextIndex1	I Enumeration	R/W	SQNI1	0: Index1 1: Index2 2: Index3 3: Index4 4: Index5 5: Index6 6: Index7 7: Index8 8: Index9 9: Index10	0	9	0	**SQNI1**=[Param.]<CR><LF> SQNI1?<CR><LF>
SequenceRoiNextIndex2	I Enumeration	R/W	SQNI2	Same as above.	0	9	0	**SQNI2**=[Param.]<CR><LF> SQNI2?<CR><LF>
SequenceRoiNextIndex3	I Enumeration	R/W	SQNI3	Same as above.	0	9	0	**SQNI3**=[Param.]<CR><LF> SQNI3?<CR><LF>
SequenceRoiNextIndex4	I Enumeration	R/W	SQNI4	Same as above.	0	9	0	**SQNI4**=[Param.]<CR><LF> SQNI4?<CR><LF>
SequenceRoiNextIndex5	I Enumeration	R/W	SQNI5	Same as above.	0	9	0	**SQNI5**=[Param.]<CR><LF> SQNI5?<CR><LF>

SequenceRoiNextIndex6	I Enumeration	R/W	SQNI6	Same as above.	0	9	0	**SQNI6**=[Param.]<CR><LF> SQNI6?<CR><LF>
SequenceRoiNextIndex7	I Enumeration	R/W	SQNI7	Same as above.	0	9	0	**SQNI7**=[Param.]<CR><LF> SQNI7?<CR><LF>
SequenceRoiNextIndex8	I Enumeration	R/W	SQNI8	Same as above.	0	9	0	**SQNI8**=[Param.]<CR><LF> SQNI8?<CR><LF>
SequenceRoiNextIndex9	I Enumeration	R/W	SQNI9	Same as above.	0	9	0	**SQNI9**=[Param.]<CR><LF> SQNI9?<CR><LF>
SequenceRoiNextIndex10	I Enumeration	R/W	SQNI10	Same as above.	0	9	0	**SQNI10**=[Param.]<CR><LF> SQNI10?<CR><LF>
SequenceRoiWidth1	I Integer	R/W	SQW1	Min ~ Max(Width + OffsetX)	8	5120	5120	**SQW1**=[Param.]<CR><LF> SQW1?<CR><LF>
SequenceRoiWidth2	I Integer	R/W	SQW2	Same as above.	8	5120	5120	**SQW2**=[Param.]<CR><LF> SQW2?<CR><LF>
SequenceRoiWidth3	I Integer	R/W	SQW3	Same as above.	8	5120	5120	**SQW3**=[Param.]<CR><LF> SQW3?<CR><LF>
SequenceRoiWidth4	I Integer	R/W	SQW4	Same as above.	8	5120	5120	**SQW4**=[Param.]<CR><LF> SQW4?<CR><LF>
SequenceRoiWidth5	I Integer	R/W	SQW5	Same as above.	8	5120	5120	**SQW5**=[Param.]<CR><LF> SQW5?<CR><LF>
SequenceRoiWidth6	I Integer	R/W	SQW6	Same as above.	8	5120	5120	**SQW6**=[Param.]<CR><LF> SQW6?<CR><LF>
SequenceRoiWidth7	I Integer	R/W	SQW7	Same as above.	8	5120	5120	**SQW7**=[Param.]<CR><LF> SQW7?<CR><LF>
SequenceRoiWidth8	I Integer	R/W	SQW8	Same as above.	8	5120	5120	**SQW8**=[Param.]<CR><LF> SQW8?<CR><LF>
SequenceRoiWidth9	I Integer	R/W	SQW9	Same as above.	8	5120	5120	**SQW9**=[Param.]<CR><LF> SQW9?<CR><LF>
SequenceRoiWidth10	I Integer	R/W	SQW10	Same as above.	8	5120	5120	**SQW10**=[Param.]<CR><LF> SQW10?<CR><LF>
SequenceRoiHeight1	I Integer	R/W	SQH1	Min ~ Max(Hight + OffsetY)	1	3840	3840	**SQH1**=[Param.]<CR><LF> SQH1?<CR><LF>
SequenceRoiHeight2	I Integer	R/W	SQH2	Same as above.	1	3840	3840	**SQH2**=[Param.]<CR><LF> SQH2?<CR><LF>
SequenceRoiHeight3	I Integer	R/W	SQH3	Same as above.	1	3840	3840	**SQH3**=[Param.]<CR><LF> SQH3?<CR><LF>
SequenceRoiHeight4	I Integer	R/W	SQH4	Same as above.	1	3840	3840	**SQH4**=[Param.]<CR><LF> SQH4?<CR><LF>
SequenceRoiHeight5	I Integer	R/W	SQH5	Same as above.	1	3840	3840	**SQH5**=[Param.]<CR><LF>

								SQH5?<CR><LF>
SequenceRoiHeight6	I Integer	R/W	SQH6	Same as above.	1	3840	3840	**SQH6**=[Param.]<CR><LF> SQH6?<CR><LF>
SequenceRoiHeight7	I Integer	R/W	SQH7	Same as above.	1	3840	3840	**SQH7**=[Param.]<CR><LF> SQH7?<CR><LF>
SequenceRoiHeight8	I Integer	R/W	SQH8	Same as above.	1	3840	3840	**SQH8**=[Param.]<CR><LF> SQH8?<CR><LF>
SequenceRoiHeight9	I Integer	R/W	SQH9	Same as above.	1	3840	3840	**SQH9**=[Param.]<CR><LF> SQH9?<CR><LF>
SequenceRoiHeight10	I Integer	R/W	SQH10	Same as above.	1	3840	3840	**SQH10**=[Param.]<CR><LF> SQH10?<CR><LF>
SequenceRoiOffsetX1	I Integer	R/W	SQOX1	Min ~ Max(Width + OffsetX)	0	5112	0	**SQOX1**=[Param.]<CR><LF> SQOX1?<CR><LF>
SequenceRoiOffsetX2	I Integer	R/W	SQOX2	Same as above.	0	5112	0	**SQOX2**=[Param.]<CR><LF> SQOX2?<CR><LF>
SequenceRoiOffsetX3	I Integer	R/W	SQOX3	Same as above.	0	5112	0	**SQOX3**=[Param.]<CR><LF> SQOX3?<CR><LF>
SequenceRoiOffsetX4	I Integer	R/W	SQOX4	Same as above.	0	5112	0	**SQOX4**=[Param.]<CR><LF> SQOX4?<CR><LF>
SequenceRoiOffsetX5	I Integer	R/W	SQOX5	Same as above.	0	5112	0	**SQOX5**=[Param.]<CR><LF> SQOX5?<CR><LF>
SequenceRoiOffsetX6	I Integer	R/W	SQOX6	Same as above.	0	5112	0	**SQOX6**=[Param.]<CR><LF> SQOX6?<CR><LF>
SequenceRoiOffsetX7	I Integer	R/W	SQOX7	Same as above.	0	5112	0	**SQOX7**=[Param.]<CR><LF> SQOX7?<CR><LF>
SequenceRoiOffsetX8	I Integer	R/W	SQOX8	Same as above.	0	5112	0	**SQOX8**=[Param.]<CR><LF> SQOX8?<CR><LF>
SequenceRoiOffsetX9	I Integer	R/W	SQOX9	Same as above.	0	5112	0	**SQOX9**=[Param.]<CR><LF> SQOX9?<CR><LF>
SequenceRoiOffsetX10	I Integer	R/W	SQOX10	Same as above.	0	5112	0	**SQOX10**=[Param.]<CR><LF> SQOX10?<CR><LF>
SequenceRoiOffsetY1	I Integer	R/W	SQOY1	Min ~ Max(Hight + OffsetY)	0	3839	0	**SQOY1**=[Param.]<CR><LF> SQOY1?<CR><LF>
SequenceRoiOffsetY2	I Integer	R/W	SQOY2	Same as above.	0	3839	0	**SQOY2**=[Param.]<CR><LF> SQOY2?<CR><LF>
SequenceRoiOffsetY3	I Integer	R/W	SQOY3	Same as above.	0	3839	0	**SQOY3**=[Param.]<CR><LF> SQOY3?<CR><LF>
SequenceRoiOffsetY4	I Integer	R/W	SQOY4	Same as above.	0	3839	0	**SQOY4**=[Param.]<CR><LF> SQOY4?<CR><LF>
SequenceRoiOff	I Integer	R/W	SQOY5	Same as above.	0	3839	0	**SQOY5**=[Param.]<CR

setY5								><LF> SQOY5?<CR><LF>
SequenceRoiOffsetY6	I Integer	R/W	SQOY6	Same as above.	0	3839	0	**SQOY6**=[Param.]<CR><LF> SQOY6?<CR><LF>
SequenceRoiOffsetY7	I Integer	R/W	SQOY7	Same as above.	0	3839	0	**SQOY7**=[Param.]<CR><LF> SQOY7?<CR><LF>
SequenceRoiOffsetY8	I Integer	R/W	SQOY8	Same as above.	0	3839	0	**SQOY8**=[Param.]<CR><LF> SQOY8?<CR><LF>
SequenceRoiOffsetY9	I Integer	R/W	SQOY9	Same as above.	0	3839	0	**SQOY9**=[Param.]<CR><LF> SQOY9?<CR><LF>
SequenceRoiOffsetY10	I Integer	R/W	SQOY10	Same as above.	0	3839	0	**SQOY10**=[Param.]<CR><LF> SQOY10?<CR><LF>
SequenceRoiGain1	I Integer	R/W	SQGA1	Min～Max	100	1600	100	**SQGA1**=[Param.]<CR><LF> SQGA1?<CR><LF>
SequenceRoiGain2	I Integer	R/W	SQGA2	Same as above.	100	1600	100	**SQGA2**=[Param.]<CR><LF> SQGA2?<CR><LF>
SequenceRoiGain3	I Integer	R/W	SQGA3	Same as above.	100	1600	100	**SQGA3**=[Param.]<CR><LF> SQGA3?<CR><LF>
SequenceRoiGain4	I Integer	R/W	SQGA4	Same as above.	100	1600	100	**SQGA4**=[Param.]<CR><LF> SQGA4?<CR><LF>
SequenceRoiGain5	I Integer	R/W	SQGA5	Same as above.	100	1600	100	**SQGA5**=[Param.]<CR><LF> SQGA5?<CR><LF>
SequenceRoiGain6	I Integer	R/W	SQGA6	Same as above.	100	1600	100	**SQGA6**=[Param.]<CR><LF> SQGA6?<CR><LF>
SequenceRoiGain7	I Integer	R/W	SQGA7	Same as above.	100	1600	100	**SQGA7**=[Param.]<CR><LF> SQGA7?<CR><LF>
SequenceRoiGain8	I Integer	R/W	SQGA8	Same as above.	100	1600	100	**SQGA8**=[Param.]<CR><LF> SQGA8?<CR><LF>
SequenceRoiGain9	I Integer	R/W	SQGA9	Same as above.	100	1600	100	**SQGA9**=[Param.]<CR><LF> SQGA9?<CR><LF>
SequenceRoiGain10	I Integer	R/W	SQGA10	Same as above.	100	1600	100	**SQGA10**=[Param.]<CR><LF> SQGA10?<CR><LF>
SequenceRoiHbinning1	I Enumeration	R/W	SQHB1	1: Off 2: On	1	2	1	**SQHB1**=[Param.]<CR><LF> SQHB1?<CR><LF>
SequenceRoiHbinning2	I Enumeration	R/W	SQHB2	Same as above.	1	2	1	**SQHB2**=[Param.]<CR><LF> SQHB2?<CR><LF>
SequenceRoiHbinning3	I Enumeration	R/W	SQHB3	Same as above.	1	2	1	**SQHB3**=[Param.]<CR><LF> SQHB3?<CR><LF>
SequenceRoiHbinning4	I Enumeration	R/W	SQHB4	Same as above.	1	2	1	**SQHB4**=[Param.]<CR><LF> SQHB4?<CR><LF>
SequenceRoiHbi	I	R/W	SQHB5	Same as above.	1	2	1	**SQHB5**=[Param.]<CR

nning5	Enumeration							><LF> SQHB5?<CR><LF>
SequenceRoiHbinning6	I Enumeration	R/W	SQHB6	Same as above.	1	2	1	**SQHB6**=[Param.]<CR><LF> SQHB6?<CR><LF>
SequenceRoiHbinning7	I Enumeration	R/W	SQHB7	Same as above.	1	2	1	**SQHB7**=[Param.]<CR><LF> SQHB7?<CR><LF>
SequenceRoiHbinning8	I Enumeration	R/W	SQHB8	Same as above.	1	2	1	**SQHB8**=[Param.]<CR><LF> SQHB8?<CR><LF>
SequenceRoiHbinning9	I Enumeration	R/W	SQHB9	Same as above.	1	2	1	**SQHB9**=[Param.]<CR><LF> SQHB9?<CR><LF>
SequenceRoiHbinning10	I Enumeration	R/W	SQHB10	Same as above.	1	2	1	**SQHB10**=[Param.]<CR><LF> SQHB10?<CR><LF>
SequenceRoiVbinning1	I Enumeration	R/W	SQVB1	1: Off 2: On	1	2	1	**SQVB1**=[Param.]<CR><LF> SQVB1?<CR><LF>
SequenceRoiVbinning2	I Enumeration	R/W	SQVB2	Same as above.	1	2	1	**SQVB2**=[Param.]<CR><LF> SQVB2?<CR><LF>
SequenceRoiVbinning3	I Enumeration	R/W	SQVB3	Same as above.	1	2	1	**SQVB3**=[Param.]<CR><LF> SQVB3?<CR><LF>
SequenceRoiVbinning4	I Enumeration	R/W	SQVB4	Same as above.	1	2	1	**SQVB4**=[Param.]<CR><LF> SQVB4?<CR><LF>
SequenceRoiVbinning5	I Enumeration	R/W	SQVB5	Same as above.	1	2	1	**SQVB5**=[Param.]<CR><LF> SQVB5?<CR><LF>
SequenceRoiVbinning6	I Enumeration	R/W	SQVB6	Same as above.	1	2	1	**SQVB6**=[Param.]<CR><LF> SQVB6?<CR><LF>
SequenceRoiVbinning7	I Enumeration	R/W	SQVB7	Same as above.	1	2	1	**SQVB7**=[Param.]<CR><LF> SQVB7?<CR><LF>
SequenceRoiVbinning8	I Enumeration	R/W	SQVB8	Same as above.	1	2	1	**SQVB8**=[Param.]<CR><LF> SQVB8?<CR><LF>
SequenceRoiVbinning9	I Enumeration	R/W	SQVB9	Same as above.	1	2	1	**SQVB9**=[Param.]<CR><LF> SQVB9?<CR><LF>
SequenceRoiVbinning10	I Enumeration	R/W	SQVB10	Same as above.	1	2	1	**SQVB10**=[Param.]<CR><LF> SQVB10?<CR><LF>
SequenceRoiLutEnable1	I Enumeration	R/W	SQLUT1	0: Off 1: On	0	1	0	**SQLUT1**=[Param.]<CR><LF> SQLUT1?<CR><LF>
SequenceRoiLutEnable2	I Enumeration	R/W	SQLUT2	Same as above.	0	1	0	**SQLUT2**=[Param.]<CR><LF> SQLUT2?<CR><LF>
SequenceRoiLutEnable3	I Enumeration	R/W	SQLUT3	Same as above.	0	1	0	**SQLUT3**=[Param.]<CR><LF> SQLUT3?<CR><LF>
SequenceRoiLutEnable4	I Enumeration	R/W	SQLUT4	Same as above.	0	1	0	**SQLUT4**=[Param.]<CR><LF> SQLUT4?<CR><LF>
SequenceRoiLut	I	R/W	SQLUT	Same as above.	0	1	0	**SQLUT5**=[Param.]<C

Enable5	Enumeration		5					R><LF> SQLUT5?<CR><LF>
SequenceRoiLutEnable6	I Enumeration	R/W	SQLUT6	Same as above.	0	1	0	**SQLUT6**=[Param.]<CR><LF> SQLUT6?<CR><LF>
SequenceRoiLutEnable7	I Enumeration	R/W	SQLUT7	Same as above.	0	1	0	**SQLUT7**=[Param.]<CR><LF> SQLUT7?<CR><LF>
SequenceRoiLutEnable8	I Enumeration	R/W	SQLUT8	Same as above.	0	1	0	**SQLUT8**=[Param.]<CR><LF> SQLUT8?<CR><LF>
SequenceRoiLutEnable9	I Enumeration	R/W	SQLUT9	Same as above.	0	1	0	**SQLUT9**=[Param.]<CR><LF> SQLUT9?<CR><LF>
SequenceRoiLutEnable10	I Enumeration	R/W	SQLUT10	Same as above.	0	1	0	**SQLUT10**=[Param.]<CR><LF> SQLUT10?<CR><LF>
SequenceRoiBlackLevel1	I Integer	R/W	SQBL1	Min～Max	-256	255	0	**SQBL1**=[Param.]<CR><LF> SQBL1?<CR><LF>
SequenceRoiBlackLevel2	I Integer	R/W	SQBL2	Same as above.	-256	255	0	**SQBL2**=[Param.]<CR><LF> SQBL2?<CR><LF>
SequenceRoiBlackLevel3	I Integer	R/W	SQBL3	Same as above.	-256	255	0	**SQBL3**=[Param.]<CR><LF> SQBL3?<CR><LF>
SequenceRoiBlackLevel4	I Integer	R/W	SQBL4	Same as above.	-256	255	0	**SQBL4**=[Param.]<CR><LF> SQBL4?<CR><LF>
SequenceRoiBlackLevel5	I Integer	R/W	SQBL5	Same as above.	-256	255	0	**SQBL5**=[Param.]<CR><LF> SQBL5?<CR><LF>
SequenceRoiBlackLevel6	I Integer	R/W	SQBL6	Same as above.	-256	255	0	**SQBL6**=[Param.]<CR><LF> SQBL6?<CR><LF>
SequenceRoiBlackLevel7	I Integer	R/W	SQBL7	Same as above.	-256	255	0	**SQBL7**=[Param.]<CR><LF> SQBL7?<CR><LF>
SequenceRoiBlackLevel8	I Integer	R/W	SQBL8	Same as above.	-256	255	0	**SQBL8**=[Param.]<CR><LF> SQBL8?<CR><LF>
SequenceRoiBlackLevel9	I Integer	R/W	SQBL9	Same as above.	-256	255	0	**SQBL9**=[Param.]<CR><LF> SQBL9?<CR><LF>
SequenceRoiBlackLevel10	I Integer	R/W	SQBL10	Same as above.	-256	255	0	**SQBL10**=[Param.]<CR><LF> SQBL10?<CR><LF>
SequenceRoiGainRed1	I Integer	R/W	SQPGR1	Min～Max	-4533	17713	0	**SQPGR1**=[Param.]<CR><LF> SQPGR1?<CR><LF>
SequenceRoiGainRed2	I Integer	R/W	SQPGR2	Same as above.	-4533	17713	0	**SQPGR2**=[Param.]<CR><LF> SQPGR2?<CR><LF>
SequenceRoiGainRed3	I Integer	R/W	SQPGR3	Same as above.	-4533	17713	0	**SQPGR3**=[Param.]<CR><LF> SQPGR3?<CR><LF>
SequenceRoiGainRed4	I Integer	R/W	SQPGR4	Same as above.	-4533	17713	0	**SQPGR4**=[Param.]<CR><LF> SQPGR4?<CR><LF>
SequenceRoiGai	I Integer	R/W	SQPGR	Same as above.	-4533	17713	0	**SQPGR5**=[Param.]<C

nRed5			5					R><LF> SQPGR5?<CR><LF>
SequenceRoiGainRed6	I Integer	R/W	SQPGR6	Same as above.	-4533	17713	0	**SQPGR6**=[Param.]<CR><LF> SQPGR6?<CR><LF>
SequenceRoiGainRed7	I Integer	R/W	SQPGR7	Same as above.	-4533	17713	0	**SQPGR7**=[Param.]<CR><LF> SQPGR7?<CR><LF>
SequenceRoiGainRed8	I Integer	R/W	SQPGR8	Same as above.	-4533	17713	0	**SQPGR8**=[Param.]<CR><LF> SQPGR8?<CR><LF>
SequenceRoiGainRed9	I Integer	R/W	SQPGR9	Same as above.	-4533	17713	0	**SQPGR9**=[Param.]<CR><LF> SQPGR9?<CR><LF>
SequenceRoiGainRed10	I Integer	R/W	SQPGR10	Same as above.	-4533	17713	0	**SQPGR10**=[Param.]<CR><LF> SQPGR10?<CR><LF>
SequenceRoiGainBlue1	I Integer	R/W	SQPGB1	Min～Max	-4533	17713	0	**SQPGB1**=[Param.]<CR><LF> SQPGB1?<CR><LF>
SequenceRoiGainBlue2	I Integer	R/W	SQPGB2	Same as above.	-4533	17713	0	**SQPGB2**=[Param.]<CR><LF> SQPGB2?<CR><LF>
SequenceRoiGainBlue3	I Integer	R/W	SQPGB3	Same as above.	-4533	17713	0	**SQPGB3**=[Param.]<CR><LF> SQPGB3?<CR><LF>
SequenceRoiGainBlue4	I Integer	R/W	SQPGB4	Same as above.	-4533	17713	0	**SQPGB4**=[Param.]<CR><LF> SQPGB4?<CR><LF>
SequenceRoiGainBlue5	I Integer	R/W	SQPGB5	Same as above.	-4533	17713	0	**SQPGB5**=[Param.]<CR><LF> SQPGB5?<CR><LF>
SequenceRoiGainBlue6	I Integer	R/W	SQPGB6	Same as above.	-4533	17713	0	**SQPGB6**=[Param.]<CR><LF> SQPGB6?<CR><LF>
SequenceRoiGainBlue7	I Integer	R/W	SQPGB7	Same as above.	-4533	17713	0	**SQPGB7**=[Param.]<CR><LF> SQPGB7?<CR><LF>
SequenceRoiGainBlue8	I Integer	R/W	SQPGB8	Same as above.	-4533	17713	0	**SQPGB8**=[Param.]<CR><LF> SQPGB8?<CR><LF>
SequenceRoiGainBlue9	I Integer	R/W	SQPGB9	Same as above.	-4533	17713	0	**SQPGB9**=[Param.]<CR><LF> SQPGB9?<CR><LF>
SequenceRoiGainBlue10	I Integer	R/W	SQPGB10	Same as above.	-4533	17713	0	**SQPGB10**=[Param.]<CR><LF> SQPGB10?<CR><LF>
SequenceRoiIndexread	I Enumeration	RO	SQIDX	0: Index0 1: Index1 2: Index2 3: Index3 4: Index4 5: Index5 6: Index6 7: Index7 8: Index8 9: Index9				SQIDX? <CR><LF>
SequenceRoiReset	I Integer	WO	SQRST		0	0	0	**SQRST**=0<CR><LF>

CommandSequenceIndex	I Enumeration	R/W	CSQI	0: Index0 1: Index1 2: Index2 3: Index3 4: Index4 5: Index5 6: Index6 7: Index7 8: Index8 9: Index9	0	9	0	**CSQI**=[Param.]<CR><LF> CSQI?<CR><LF>
MultiRoiIndexMax	I Integer	R/W	MRIM	Min～Max	1	8	1	**MRIM=[Param.]<CR><LF>** **MRIM?<CR><LF>**
MultiRoiWidth	I Integer	R/W	MRW	Min～Max	8	5120	8	**MRW**=[Param.]<CR><LF> MRW?<CR><LF>
MultiRoiHeight1	I Integer	R/W	MRH1	Min～Max	0	3840	1	**MRH1**=[Param.]<CR><LF> MRH1?<CR><LF>
MultiRoiHeight2	I Integer	R/W	MRH2	Min～Max	0	3840	1	**MRH2**=[Param.]<CR><LF> MRH2?<CR><LF>
MultiRoiHeight3	I Integer	R/W	MRH3	Min～Max	0	3840	1	**MRH3**=[Param.]<CR><LF> MRH3?<CR><LF>
MultiRoiHeight4	I Integer	R/W	MRH4	Min～Max	0	3840	1	**MRH4**=[Param.]<CR><LF> MRH4?<CR><LF>
MultiRoiHeight5	I Integer	R/W	MRH5	Min～Max	0	3840	1	**MRH5**=[Param.]<CR><LF> MRH5?<CR><LF>
MultiRoiHeight6	I Integer	R/W	MRH6	Min～Max	0	3840	1	**MRH6**=[Param.]<CR><LF> MRH6?<CR><LF>
MultiRoiHeight7	I Integer	R/W	MRH7	Min～Max	0	3840	1	**MRH7**=[Param.]<CR><LF> MRH7?<CR><LF>
MultiRoiHeight8	I Integer	R/W	MRH8	Min～Max	0	3840	1	**MRH8**=[Param.]<CR><LF> MRH8?<CR><LF>
MultiRoiOffsetX1	I Integer	R/W	MROX1	Min～Max	0	5118	0	**MROX1**=[Param.]<CR><LF> MROX1?<CR><LF>
MultiRoiOffsetX2	I Integer	R/W	MROX2	Min～Max	0	5118	0	**MROX2**=[Param.]<CR><LF> MROX2?<CR><LF>
MultiRoiOffsetX3	I Integer	R/W	MROX3	Min～Max	0	5118	0	**MROX3**=[Param.]<CR><LF> MROX3?<CR><LF>
MultiRoiOffsetX4	I Integer	R/W	MROX4	Min～Max	0	5118	0	**MROX4**=[Param.]<CR><LF> MROX4?<CR><LF>
MultiRoiOffsetX5	I Integer	R/W	MROX5	Min～Max	0	5118	0	**MROX5**=[Param.]<CR><LF> MROX5?<CR><LF>
MultiRoiOffsetX6	I Integer	R/W	MROX6	Min～Max	0	5118	0	**MROX6**=[Param.]<CR><LF> MROX6?<CR><LF>
MultiRoiOffsetX7	I Integer	R/W	MROX7	Min～Max	0	5118	0	**MROX7**=[Param.]<CR><LF> MROX7?<CR><LF>
MultiRoiOffsetX	I Integer	R/W	MROX8	Min～Max	0	5118	0	**MROX8**=[Param.]<CR

8								><LF> MROX8?<CR><LF>
MultiRoiOffsetY 1	I Integer	R/W	MROY1	Min～Max	0	3839	0	**MROY1**=[Param.]<CR ><LF> MROY1?<CR><LF>
MultiRoiOffsetY 2	I Integer	R/W	MROY2	Min～Max	0	3839	0	**MROY2**=[Param.]<CR ><LF> MROY2?<CR><LF>
MultiRoiOffsetY 3	I Integer	R/W	MROY3	Min～Max	0	3839	0	**MROY3**=[Param.]<CR ><LF> MROY3?<CR><LF>
MultiRoiOffsetY 4	I Integer	R/W	MROY4	Min～Max	0	3839	0	**MROY4**=[Param.]<CR ><LF> MROY4?<CR><LF>
MultiRoiOffsetY 5	I Integer	R/W	MROY5	Min～Max	0	3839	0	**MROY5**=[Param.]<CR ><LF> MROY5?<CR><LF>
MultiRoiOffsetY 6	I Integer	R/W	MROY6	Min～Max	0	3839	0	**MROY6**=[Param.]<CR ><LF> MROY6?<CR><LF>
MultiRoiOffsetY 7	I Integer	R/W	MROY7	Min～Max	0	3839	0	**MROY7**=[Param.]<CR ><LF> MROY7?<CR><LF>
MultiRoiOffsetY 8	I Integer	R/W	MROY8	Min～Max	0	3839	0	**MROY8**=[Param.]<CR ><LF> MROY8?<CR><LF>
LUTMode	I Enumera tion	R/W	LUTC	0: Off 1: Gamma 2: LUT	0	2	0	**LUTC**=[Param.]<CR> <LF> LUTC?<CR><LF>
ColorMatrixMod e	I Enumera tion	R/W	MTX	0: Off 1: On	0	1	0	**MTX**=[Param.]<CR><< LF> MTX?<CR><LF> (Bayer model only)
AlcSpeed	I Integer	R/W	AGCS	Min～Max	1	8	4	**ALCS**=[Param.]<CR> <LF> ALCS?<CR><LF> for AGC and ASC
ExposureAutoM ax	I Integer	R/W	ASCEA	Min～Max[us]	11	80000 00	18000	**ASCEA**=[Param.]<CR ><LF> ASCEA?<CR><LF> Maximum value is varied depending on frame rate.
ExposureAutoMi n	I Integer	R/W	ASCEI	Min～Max	10	79999 99	100	**ASCEI**=[Param.]<CR ><LF> ASCEI?<CR><LF> Maximum value is varied depending on frame rate.
RequestExposur eAuto Result	I Enumera tion	R/O	ASRS	0=Complete. 1=Too Bright. 2=Too dark. 3=Timeout Error. 4=Busy. 5=Limit. 6= Trig is not set as Normal.	0	6	0	**ASRS?<CR><LF>**

TriggerOption	I Enumeration	R/W	TRGOP	0: Off 1: PreDump 2: PIV 3: Smear-less	0	3	0	**TRGOP**=[Param.]<CR><LF> TRGOP?<CR><LF>
AlcReference	I Integer	R/W	AGCF	Min～Max[%]	1	100	50	**AGCF**=[Param.]<CR><LF> AGCF?<CR><LF>
GainAutoMax	I Integer	R/W	AGCGA	Min～Max	200	1600	1600	**AGCGA**=[Param.]<CR><LF> AGCGA?<CR><LF>
GainAutoMin	I Integer	R/W	AGCGI	Min～Max	100	1500	100	**AGCGI**=[Param.]<CR><LF> AGCGI?<CR><LF>
RequestGainAuto Result	I Enumeration	R/O	AGRS	0=Complete. 1=Too Bright. 2=Too dark. 3=Timeout Error. 4=Busy. 5=Limit. 6= Trig is not set as Normal.	0	6	0	**AGRS?<CR><LF>**
ALCChannelAreaAll	I Enumeration	R/W	ALCA	0: Off / 1: On	0	1	0	**ALCA**=[Param.]<CR><LF> ALCA?<CR><LF>
ALCChannelArea LowRight	I Enumeration	R/W	ALCLR	0: Off / 1: On	0	1	1	**ALC****=[Param.]<CR><LF> ALC**?<CR><LF>
ALCChannelArea LowMidRight	I Enumeration	R/W	ALCLMR	0: Off / 1: On	0	1	1	
ALCChannelArea LowMidLeft	I Enumeration	R/W	ALCLML	0: Off / 1: On	0	1	1	
ALCChannelArea LowLeft	I Enumeration	R/W	ALCLL	0: Off / 1: On	0	1	1	
ALCChannelArea MidLowRight	I Enumeration	R/W	ALCMLR	0: Off / 1: On	0	1	1	
ALCChannelArea MidLowMidRight	I Enumeration	R/W	ALCMLMR	0: Off / 1: On	0	1	1	
ALCChannelArea MidLowMidLeft	I Enumeration	R/W	ALCMLML	0: Off / 1: On	0	1	1	
ALCChannelArea MidLowLeft	I Enumeration	R/W	ALCMLL	0: Off / 1: On	0	1	1	
ALCChannelArea MidHighRight	I Enumeration	R/W	ALCMHR	0: Off / 1: On	0	1	1	
ALCChannelArea MidHighMidRight	I Enumeration	R/W	ALCMHMR	0: Off / 1: On	0	1	1	
ALCChannelArea MidHighMidLeft	I Enumeration	R/W	ALCMHML	0: Off / 1: On	0	1	1	
ALCChannelArea MidHighLeft	I Enumeration	R/W	ALCMHL	0: Off / 1: On	0	1	1	

ALCChannelArea HighRight	I Enumeration	R/W	ALCHR	0: Off / 1: On	0	1	1	
ALCChannelArea HighMidRight	I Enumeration	R/W	ALCHMR	0: Off / 1: On	0	1	1	
ALCChannelArea HighMidLeft	I Enumeration	R/W	ALCHML	0: Off / 1: On	0	1	1	
ALCChannelArea HighLeft	I Enumeration	R/W	ALCHL	0: Off / 1: On	0	1	1	
AWBChannelAreaAll	I Enumeration	R/W	AWBA	0: Off / 1: On	0	1	0	**AWB****=[Param.]<CR><LF> AWB**?<CR><LF> (Bayer model only)
AWBChannelArea LowRight	I Enumeration	R/W	AWBLR	0: Off / 1: On	0	1	1	
AWBChannelArea LowMidRight	I Enumeration	R/W	AWBLMR	0: Off / 1: On	0	1	1	
AWBChannelArea LowMidLeft	I Enumeration	R/W	AWBLML	0: Off / 1: On	0	1	1	
AWBChannelArea LowLeft	I Enumeration	R/W	AWBLL	0: Off / 1: On	0	1	1	
AWBChannelArea MidLowRight	I Enumeration	R/W	AWBMLR	0: Off / 1: On	0	1	1	
AWBChannelArea MidLowMidRight	I Enumeration	R/W	AWBMLMR	0: Off / 1: On	0	1	1	
AWBChannelArea MidLowMidLeft	I Enumeration	R/W	AWBMLML	0: Off / 1: On	0	1	1	
AWBChannelArea MidLowLeft	I Enumeration	R/W	AWBMLL	0: Off / 1: On	0	1	1	
AWBChannelArea MidHighRight	I Enumeration	R/W	AWBMHR	0: Off / 1: On	0	1	1	
AWBChannelArea MidHighMidRight	I Enumeration	R/W	AWBMHMR	0: Off / 1: On	0	1	1	
AWBChannelArea MidHighMidLeft	I Enumeration	R/W	AWBMHML	0: Off / 1: On	0	1	1	
AWBChannelArea MidHighLeft	I Enumeration	R/W	AWBMHL	0: Off / 1: On	0	1	1	
AWBChannelArea HighRight	I Enumeration	R/W	AWBHR	0: Off / 1: On	0	1	1	
AWBChannelArea HighMidRight	I Enumeration	R/W	AWBHMR	0: Off / 1: On	0	1	1	

AWBChannelArea HighMidLeft	I Enumeration	R/W	AWBHML	0: Off / 1: On	0	1	1	
AWBChannelArea HighLeft	I Enumeration	R/W	AWBHL	0: Off / 1: On	0	1	1	
RequestBalanceWhite AutoResult	I Enumeration	R/O	AWRS	0=Complete. 1=Too Bright. 2=Too dark. 3=Timeout Error. 4=Busy. 5=Limit. 6= Trig is not set as Normal.	0	6	0	**AWRS**?<CR><LF> (Bayer model only)
CurrentAreaNo Request	I Integer	R/O	EA	0: Factory area 1: User 1 area 2: User 2 area 3: User 3 area	0	3	0	**EA**?<CR><LF> The camera return the latest used DATA AREA.
AcquisitionFrameTime	I Integer	R/W	ART	Min～Max	1	8000000	32000	**ART**=[Param.]<CR><LF> ART?<CR><LF> Maximum value is calculated depending on Height and Offset Y settings
GammaSelector	I Integer	R/W	GMA	0(γ=1)～8(γ=0.45)～15(γ=TBD)	0	15	8	**GMA**=[Param.]<CR><LF> GMA?<CR><LF>
Temperature	I Integer	R/O	TMP0	value	—	—	—	**TMP0**?<CR><LF> Value = Temperature[℃]
GpioPulseGenDivide Value	I Integer	R/W	PGDEV	Min～Max	1	4095	1	**PGDEV**=[Param.]<CR><LF> PGDEV?<CR><LF>
GpioPulseGenLength0	I Integer	R/W	PGL0	Min～Max	1	1048575	1	**PGL0**=[Param.]<CR><LF> PGL0?<CR><LF>
GpioPulseGenLength1	I Integer	R/W	PGL1	Min～Max	1	1048575	1	**PGL1**=[Param.]<CR><LF> PGL1?<CR><LF>
GpioPulseGenLength2	I Integer	R/W	PGL2	Min～Max	1	1048575	1	**PGL2**=[Param.]<CR><LF> PGL2?<CR><LF>
GpioPulseGenLength3	I Integer	R/W	PGL3	Min～Max	1	1048575	1	**PGL3**=[Param.]<CR><LF> PGL3?<CR><LF>
GpioPulseGenStart Point0	I Integer	R/W	PGST0	Min～Max	0	1048574	0	**PGST0**=[Param.]<CR><LF> PGST0?<CR><LF>
GpioPulseGenStart Point1	I Integer	R/W	PGST1	Min～Max	0	1048574	0	**PGST1**=[Param.]<CR><LF> PGST1?<CR><LF>
GpioPulseGenStart Point2	I Integer	R/W	PGST2	Min～Max	0	1048574	0	**PGST2**=[Param.]<CR><LF> PGST2?<CR><LF>
GpioPulseGenStart Point3	I Integer	R/W	PGST3	Min～Max	0	1048574	0	**PGST3**=[Param.]<CR><LF> PGST3?<CR><LF>
GpioPulseGenEnd Point0	I Integer	R/W	PGEN0	Min～Max	1	1048575	1	**PGEN0**=[Param.]<CR><LF>

								PGEN0?<CR><LF>
GpioPulseGenEnd Point1	I Integer	R/W	PGEN1	Min～Max	1	1048575	1	**PGEN1**=[Param.]<CR><LF> PGEN1?<CR><LF>
GpioPulseGenEnd Point2	I Integer	R/W	PGEN2	Min～Max	1	1048575	1	**PGEN2**=[Param.]<CR><LF> PGEN2?<CR><LF>
GpioPulseGenEnd Point3	I Integer	R/W	PGEN3	Min～Max	1	1048575	1	**PGEN3**=[Param.]<CR><LF> PGEN3?<CR><LF>
GpioPulseGenRepeat Count0	I Integer	R/W	PGRPT0	Min～Max	0	255	0	**PGRPT0**=[Param.]<CR><LF> PGRPT0?<CR><LF>
GpioPulseGenRepeat Count1	I Integer	R/W	PGRPT1	Min～Max	0	255	0	**PGRPT1**=[Param.]<CR><LF> PGRPT1?<CR><LF>
GpioPulseGenRepeat Count2	I Integer	R/W	PGRPT2	Min～Max	0	255	0	**PGRPT2**=[Param.]<CR><LF> PGRPT2?<CR><LF>
GpioPulseGenRepeat Count3	I Integer	R/W	PGRPT3	Min～Max	0	255	0	**PGRPT3**=[Param.]<CR><LF> PGRPT3?<CR><LF>
GpioPulseGenClear Mode0	I Enumeration	R/W	PGCM0	0: Free Run 1: Level High 2: Level Low 3: Rising Edge 4: Falling Edge	0	4	0	**PGCM0**=[Param.]<CR><LF> PGCM0?<CR><LF>
GpioPulseGenClear Mode1	I Enumeration	R/W	PGCM1	Same as above.	0	4	0	**PGCM1**=[Param.]<CR><LF> PGCM1?<CR><LF>
GpioPulseGenClear Mode2	I Enumeration	R/W	PGCM2	Same as above.	0	4	0	**PGCM2**=[Param.]<CR><LF> PGCM2?<CR><LF>
GpioPulseGenClear Mode3	I Enumeration	R/W	PGCM3	Same as above.	0	4	0	**PGCM3**=[Param.]<CR><LF> PGCM3?<CR><LF>
GpioPulseGenSync Mode0	I Enumeration	R/W	PGSM0	0: Async Mode 1: Sync Mode	0	1	0	**PGSM0**=[Param.]<CR><LF> PGSM0?<CR><LF>
GpioPulseGenSync Mode1	I Enumeration	R/W	PGSM1	Same as above.	0	1	0	**PGSM1**=[Param.]<CR><LF> PGSM1?<CR><LF>
GpioPulseGenSync Mode2	I Enumeration	R/W	PGSM2	Same as above.	0	1	0	**PGSM2**=[Param.]<CR><LF> PGSM2?<CR><LF>
GpioPulseGenSync Mode3	I Enumeration	R/W	PGSM3	Same as above.	0	1	0	**PGSM3**=[Param.]<CR><LF> PGSM3?<CR><LF>

GpioPulseGenInput0	I Enumeration	R/W	PGIN0	0:Low 1:High 3:AcquisitionTriggerWait 4:FrameActive 5:ExposureActive 6:FVAL 7:LVAL 9:PG1 10:PG2 11:PG3 12: TTL in 13:CL CC1 in 14:nand0 15:nand1 16: OPTTL in2 17: OPLVDS in	0	17	0	**PGIN0**=[Param.]<CR><LF> PGIN0?<CR><LF>
GpioPulseGenInput1	I Enumeration	R/W	PGIN1	0:Low 1:High 3:AcquisitionTriggerWait 4:FrameActive 5:ExposureActive 6:FVAL 7:LVAL 8:PG0 10:PG2 11:PG3 12: TTL in 13:CL CC1 in 14:nand0 15:nand1 16: OPTTL in2 17: OPLVDS in	0	17	0	**PGIN1**=[Param.]<CR><LF> PGIN1?<CR><LF>
GpioPulseGenInput2	I Enumeration	R/W	PGIN2	0:Low 1:High 3:AcquisitionTriggerWait 4:FrameActive 5:ExposureActive 6:FVAL 7:LVAL 8:PG0 9:PG1 11:PG3 12: TTL in 13:CL CC1 in 14:nand0 15:nand1 16: OPTTL in2 17: OPLVDS in	0	17	0	**PGIN2**=[Param.]<CR><LF> PGIN2?<CR><LF>
GpioPulseGenInput3	I Enumeration	R/W	PGIN3	0:Low 1:High 3:AcquisitionTriggerWait 4:FrameActive 5:ExposureActive 6:FVAL 7:LVAL 8:PG0 9:PG1 10:PG2 12: TTL in	0	17	0	**PGIN3**=[Param.]<CR><LF> PGIN3?<CR><LF>

				13:CL CC1 in 14:nand0 15:nand1 16: OPTTL in2 17: OPLVDS in				
GpioPulseGenInvert0	I Enumeration	R/W	PGINV0	0:Non-Inv 1:Inv	0	1	0	**PGIN0**=[Param.]<CR><LF> PGIN0?<CR><LF>
GpioPulseGenInvert1	I Enumeration	R/W	PGINV1	Same as above.	0	1	0	**PGIN1**=[Param.]<CR><LF> PGIN1?<CR><LF>
GpioPulseGenInvert2	I Enumeration	R/W	PGINV2	Same as above.	0	1	0	**PGIN2**=[Param.]<CR><LF> PGIN2?<CR><LF>
GpioPulseGenInvert3	I Enumeration	R/W	PGINV3	Same as above.	0	1	0	**PGIN3**=[Param.]<CR><LF> PGIN3?<CR><LF>
GpioNand0InputSource1	I Enumeration	R/W	ND0IN1	0: Low 1: High 3: FrameTriggerWait 4: FrameActive 5: ExposureActive 6: Fval 8: PulseGenerator0 9: PulseGenerator1 10: PulseGenerator2 11: PulseGenerator3 12: TTL_In1 13: CL_CC1_In 15: NAND1 16: TTL_In2 17: LVDS_In	0	17	0	**ND0N1**=[Param.]<CR><LF> ND0IN1?<CR><LF>
GpioNand0InputSource2	I Enumeration	R/W	ND0IN2	Same as above.	0	17	0	**ND0N2**=[Param.]<CR><LF> ND0IN2?<CR><LF>
GpioNand1InputSource1	I Enumeration	R/W	ND1IN1	0: Low 1: High 3: FrameTriggerWait 4: FramActive 5: ExposureActive 6: Fval 8: PulseGenerator0 9: PulseGenerator1 10: PulseGenerator2 11: PulseGenerator3 12: TTL_In1 13: CL_CC1_In 14:NAND0 16:TTL_In2 17:LVDS_In	0	17	0	**ND1N1**=[Param.]<CR><LF> ND1IN1?<CR><LF>
GpioNand1InputSource2	I Enumeration	R/W	ND1IN2	Same as above.	0	17	0	**ND1N2**=[Param.]<CR><LF> ND1IN2?<CR><LF>

GpioNand0InputInvert1	I Enumeration	R/W	ND0INV1	0: Non-Inv 1: Inv	0	1	0	**ND0INV1**=[Param.]<CR><LF> ND0INV1?<CR><LF>
GpioNand1InputInvert1	I Enumeration	R/W	ND1INV1	Same as above.	0	1	0	**ND1INV1**=[Param.]<CR><LF> ND1INV1?<CR><LF>
GpioNand0InputInvert2	I Enumeration	R/W	ND0INV2	Same as above.	0	1	0	**ND0INV2**=[Param.]<CR><LF> ND0INV2?<CR><LF>
GpioNand1InputInvert2	I Enumeration	R/W	ND1INV2	Same as above.	0	1	0	**ND1INV2**=[Param.]<CR><LF> ND1INV2?<CR><LF>
HDRExposureSwitch	I Integer	R/W	“HES”	Min～Max	0	2	0	**HES**=[Param.]<CR><LF> HES?<CR><LF>
HDRKneeSlope2	I Integer	R/W	“HKS2”	Min～Max	2	16	2	**HKS2**=[Param.]<CR><LF> HKS2?<CR><LF>
HDRKneeSlope3	I Integer	R/W	“HKS3”	Min～Max	2	16	2	**HKS3**=[Param.]<CR><LF> HKS3?<CR><LF>
HDRKneePoint1	I Integer	R/W	“HKP1”	Min～Max	10	120	100	**HKP1**=[Param.]<CR><LF> HKP1?<CR><LF>
HDRKneePoint2	I Integer	R/W	“HKP2”	Min～Max	10	120	100	**HKP2**=[Param.]<CR><LF> HKP2?<CR><LF>
HDRKneeSlopeNumber	I Integer	R/O	“HKSN”					HKSN?<CR><LF>
ImageFlipping	I Enumeration	R/W	“FLIP”	0:Off 1:Horizontal 2:Vertical 3:Horizontal & Vertical	0	3	0	FLIP=[Param.]<CR><LF> FLIP?<CR><LF>
SensorClockFrequency	I Enumeration	R/W	“SCF”	0:80MHz 1:60MHz	0	2	0	SCF=[Param.]<CR><LF> SCF?<CR><LF>
DsnuDetect	I Integer	R/W	“DSNUD”		0	0	0	DSNUD=[Param.]<CR><LF> DSNUD?<CR><LF>
DsnuCorrect	I Enumeration	R/W	"DSNUC"	0: Off / 1: On	0	1	0	DSNUC=[Param.]<CR><LF> DSNUC?<CR><LF>
BlackTempMode	I Enumeration	R/W	“BTM”	0:Auto 1:Limit 2:Fix	0	2	0	BTM=[Param.]<CR><LF> BTM?<CR><LF>
BlackTempLimit	I Integer	R/W	“BTL”	Min～Max	0	30	30	BTL=[Param.]<CR><LF> BTL?<CR><LF>
BlackTempFix	I Integer	R/O	“BTF”	Min～Max	0	30	30	BTF?<CR><LF>

Appendix 2

1. Precautions

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

2. Typical Sensor Characteristics

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

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

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

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

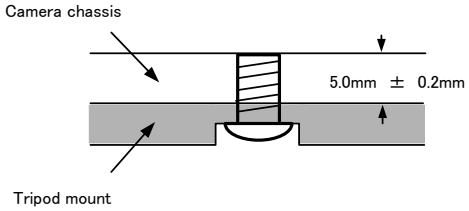
3. Caution when mounting a lens on the camera

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

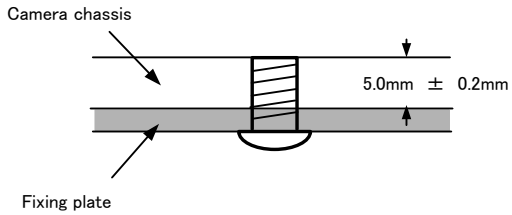
4. Caution when mounting the camera

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

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



Attaching the tripod mount



Mounting the camera to fixing plate

5. Exportation

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

6. References

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

Manual change history

Date	Revision	Changes
June 2013	1.0	New release
Aug. 2013	1.1	Add information for 1X2 – 1Y, Review all functionality
Sept. 2013	1.2	Add ASCII command list as Appendix 1
Sept. 2013	1.3	Revised EMVA1288 parameter, Add auto black control(8.1.3), Add the caution for Exposure tim(7.2.2), Correct typo
Oct. 2013	1.4	Add EMVA spec. for SP-20000C-PMCL
Oct. 2013	1.5	Correct the timing chart of PIV, ADD Sequential Timer Trigger Mode to Table – 52.
June 2014	1.6	Review totally
Sept. 2014	1.7	Revise Spectral Response
Oct. 2014	1.8	Revise B/W spectral response with wider wave length range
Mar. 2015	1.9	Adde 12-bit function, HDR function is an optional function
Nov. 2018	2.0	Add KC
Feb. 2018	2.1	Revised Variable range of Black Level
Jan. 2021	2.2	China RoHS

User's Record

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

Revision: **……..**

Serial No. **……..**

Firmware version. **……..**

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

User's Mode Settings.

User's Modifications.

Europe, Middle East & Africa	*Asia Pacific*	*Americas*
Phone +45 4457 8888 *Fax +45 4491 3252*	*Phone +81 45 440 0154* *Fax +81 45 440 0166*	*Phone (toll-free) +1 800 445 5444* *Phone +1 408 383 0300*

Visit our web site at www.jai.com

See the possibilities