OMRON

CameraLink
SWIR CMOS Camera

STC-LBS132CL-SWIR (1.3M / SWIR)

Product Specifications and User’s Guide

Table of Contents

Precautions for safety

Please read carefully this “Precautions for safety” before use the camera. Then the camera uses correctly with agreeing with below notes.

In this “Precautions for safety”, notes divides into “Warning” and “Caution” to use the camera safety and prevent to harm and damage.

⚠ Warning	This shows, assumption for possibility of serious accident leading death or serious injury if ignore this note and camera uses incorrectly.
⚠ Caution	This shows, assumption for possibility of bear the damage or physical damage if ignore this note and camera uses incorrectly.

About Graphic symbols

This symbol shows general prohibition.

This symbol shows completion or instruction.

[Environment / condition]

⚠ Warning	
Do not use flammable or explosiveness atmospheres. This will cause of personal injury or fire.	Do not use for “safety for human body” related usage. This camera is designed for use “do not harm human body immediately” if by any chance the camera has malfunction.
⚠ Caution	
Use and store under specified environmental conditions (Vibration, shock, temperature, humidity) in the specifications for this camera. This will cause of fire or damage the camera.	

[Installation and cable wiring]

⚠ Warning	
Do not use with out of power voltage range that is specified in the specifications for this camera. This will cause of fire, electrification or malfunction.	Do not wrong wiring. This will cause of fire or malfunction.

⚠ Caution	
Do not grounding DC power (+) of all devices that are connect to the camera. The camera housing is connecting to 0 V line of camera inside circuit. There is a risk of short circuit between camera inside ciurcuit and frame ground. This will cause of malfunction.	It is necessary to wiring and mounting that is specified in the specifications for this camera. This will cause of fire or malfunction.
It is necessary to wiring with turn off the camera. This will cause of electrification or malfunction.	It is necessary to mounting the camera without stress for the cable. This will case of electrification or fire.
Do not use Camera Link un-supported cable and board. There is a risk of malfunction if the camera connects with wrong environment and turn on the camera.	

[Usage instruction]

⚠ Warning	
Do not touch the terminal and PCB board While turn on the camera. This will cause of electrification or accident caused by malfunction.	Do not put combustibles near the camera. This will cause of fire.
Do not use without usage that is specified in the specifications for this camera. This will cause of personal injury or malfunction.	Do not push metals including screw driver into radiation holes. This will cause of electrification or malfunction.
⚠ Caution	
Do not push contamination into opening of the camera. This will cause of electrification or malfunction.	Do not block the radiation holes. This will cause of fire due to increase the camera inside temperature.

[Maintenance]

⚠ Caution	
Do not disassemble or repair the camera. This will cause of fire, electrification or malfunction.	It is turn off the camera when maintaining or inspecting the camera. This will cause of electrification.

[Disposal]

⚠ Caution	
It is necessary to dispose as industrial waste. In EU, it is necessary to dispose of accordance with WEEE directive.	

[Security Measures, Anti-virus protection]

⚠ Warning	
Install the latest commercial-quality antivirus software on the computer connected to the control system and maintain to keep the software up-to-date.	

1 Product Precautions

Do not give shock to the camera.
Do not haul or damage the camera cable.
Do not wrap the camera with any material while using the camera. This will cause the internal camera temperature to increase.
When the camera moving or using the place that temperature difference is extreme, countermeasure for dew condensation (heat removal / cold removal) is necessary.
While the camera is not using, keep the lens cap on the camera to prevent dust or contamination from getting in the sensor or filter and scratching or damaging it.
Do not keep the camera under the following conditions.

- In wet, moist, high humidity or dusty place
- Under direct sunlight
- In extreme high or low temperature place
- Near an object that releases a strong magnetic or electric filed
- Place with strong vibrations

Apply the power that satisfies the specified in specifications for the camera.
The defective pixels may appear due to the sensor characteristics.
Use below recommend materials (or equivalent materials) to clean the surface of glass.

- Air dust: Non Freon air duster (NAKABAYASHI Co., LTD.)
- Alcohol: Propan-2-ol (SAN'EI KAKO Co., LTD.)
- Non-woven: nikowipe clean room (NKB)

Use a soft cloth to clean the camera.

2 Product conformity / compliance

Please confirm regulation in each country by responsibility of exporter and importer when exporting this product from Japan.

3 Export and Trade Control Laws

This product is classed as a commodity (or technology) requiring acquisition of export permission in accordance with foreign exchange and overseas trade control laws.
When this product is to be taken outside of Japan, adopt the required procedures such as application for export permission by the Japanese government.
When this product is to be taken outside of countries after imported from Japan, please confirm export and trade control laws of country and adopt the required procedures.

4 Warranty

■Warranty period

One year after delivery (However, the camera had malfunction with camera uses correctly)
In below case for a fee even within warranty period.

- The malfunction caused by incorrect usage, incorrect modify or repair.
- The malfunction caused by external shock including the camera dropping after delivery the camera.
- The malfunction caused by fire, earthquake, flood disaster, thunderbolt struck, other natural disaster or wrong voltage.

■Warranty coverage

Exchange or repair the malfunction camera if the malfunction is occurred by our responsibility.
"Warranty" mean is warranty for the delivered camera itself. Please accept the induction damage by the camera malfunction is not included.

5 Specifications

5.1 Electronic specifications

Model Number			**STC-LBS132CL-SWIR**
Image Sensor			1/2” 1.3M Progressive SWIR CMOS (SONY: IMX990)
Shutter Type			Global Shutter
Effective Picture Resolution			1,280 (H) x 1,024 (V)
Cell Size			5.0 (H) x 5.0 (V) µm
Scanning Mode			**Full Scanning** / ROI
Maximum Frame Rate (at full resolution) (*1)	**3TAP Output**		**125 fps (8bits, 84.857 MHz)** / 125 fps (8bits, 66 MHz) 134 fps (8bits, 84.857 MHz, High rate) / 134 fps (8bits, 66 MHz, High rate)
	2TAP Output		120 fps (8bits, 84.857 MHz) / 120 fps (10bits, 84.857 MHz) / 71 fps (12bits, 84.857 MHz) 93 fps (8bits, 66 MHz) / 93 fps (10bits, 66 MHz) / 71 fps (12bits, 66 MHz)
	1TAP Output		61 fps (8bits, 84.857 MHz) / 61 fps (10bits, 84.857 MHz) / 61 fps (12bits, 84.857 MHz) 47 fps (8bits, 66 MHz) / 47 fps (10bits, 66 MHz) / 47 fps (12bits, 66 MHz)
ADC Bits (*1)			**8bits** / 10bits / 12bits
Image Output			**8bits** / 10bits / 12bits
Camera Link Data Output (*2)			Base Configuration
Camera Link TAP Configuration			**3TAP** / 2TAP / 1TAP
Camera Link Clock Speed (*3)			**84.857** / 66 MHz
Noise Level (Gain 0 dB) (*4)	8bits Output		Less than 1 digit
	8bits High-Rate Output		Less than 4 digits
	10bits Output		Less than 4 digits
	12bits Output		Less than 16 digits
Spectral Sensitivity Range			400 to 1,700 nm
Exposure Time (1TAP / 2TAP / 3TAP common)			8 µsecond to 16.777 seconds (**Default: 1 µsecond**)
Gain	Analog Gain		0 dB to 25.5 dB (**Default: 0 dB**)
	Digital Gain		x1 to x2 (**Default: x1**)
Black Level (*4)	8bits Output		0 to 63 digits
	10bits Output		0 to 255 digits
	12bits Output		0 to 1,020 digits
White Balance Gain			N/A
ROI	Size	Horizontal	8 to 1,280 pixels (adjustable unit: 8 pixels) (**Default: 1,280**)
		Vertical	8 to 1,024 lines (adjustable unit: 8 lines) (**Default: 1,024**)
	Position	Horizontal	0 to 1,272 pixels (adjustable unit: 8 pixels) (**Default: 0**)
		Vertical	0 to 1,016 lines (adjustable unit: 8 lines) (**Default: 0**)
Multi ROI			N/A
Gamma			Gamma 0.4 to 1.0 **(Default: 0.45)**
Binning			Horizontal and Vertical decimation (2x2) summing / **Off**
Decimation			Horizontal and Vertical decimation (2x2) / **Off**
Mirror Image			Horizontal / Vertical / Horizontal and Vertical / **Off**
Defective Pixel Correction			Up to 8,192 points
Pre-processing filter			Brightness inverse, Banalization, Spatial filter, Median filter

Default setting: **Bold**

Model Number		STC-LBS132CL-SWIR
Blooming Reduction Mode		Support
Shading Correction Function		Support
Auto Image Control	Auto Exposure	N/A
	Auto Gain	N/A
	Auto White Balance	N/A
Operating Mode		**Edge preset trigger** / Pulse width trigger / Free-run (continuous)
Save User Mode		Support
I/O Ports		4 I/Os
Power	Input Voltage	+12 Vdc +/- 10 %
	Consumption	Maximum: 8.0 W, Typical: 4.5 W

Default setting: **Bold**

Precautions

(*1) The selected image output bit does not make any influence for maximum frame rate.

(*2) Camera Link data output formats (TAP configuration and output bits) are in below table:

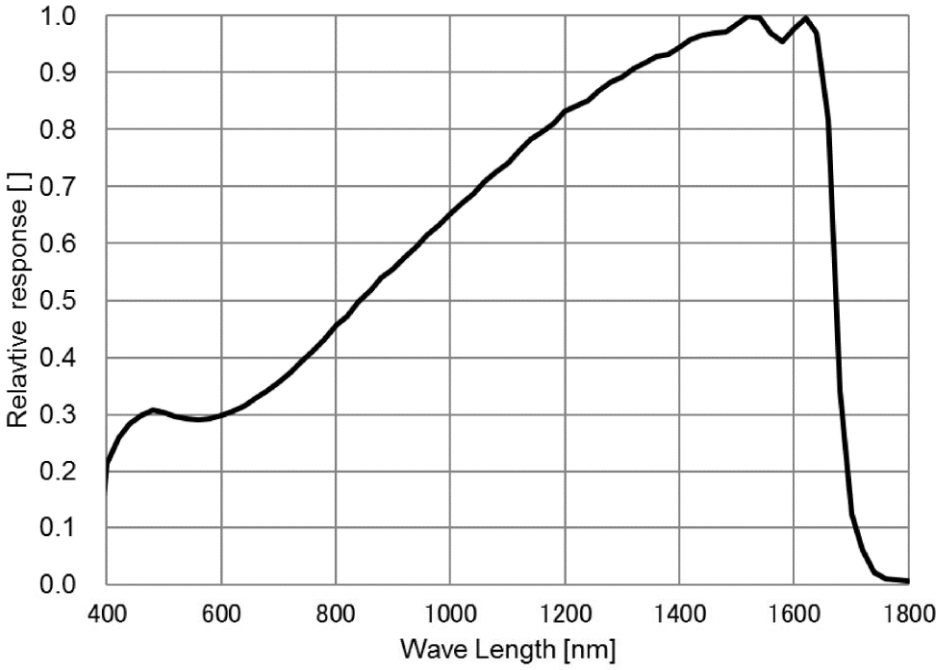
	3TAP	2TAP	1TAP
8bits	Base configuration	Base configuration	Base configuration
10bits	N/A	Base configuration	Base configuration
12bits	N/A	Base configuration	Base configuration

(*3) Please select the optimum Camera Link clock speed if long length Camera Link cable is required.
Please refer “The image data transferring speed” for more details.

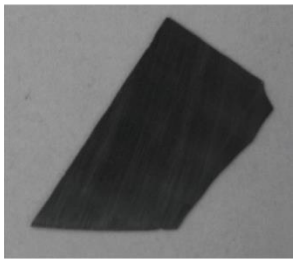
(*4) The selected TAP configuration does not make any influence for noise level and black level.

* When the strong light is incident on extensive area of the image sensor of camera, the image could be become dark due to characteristics of image sensor on this camera.
Please adjust incident light with adjusting lens iris or other way to avoid strong light is not incident on the image sensor of camera.

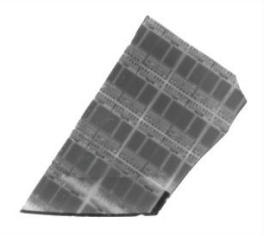
5.2 Spectral Sensitivity Characteristics



5.3 Acquisition image samples



With visible light



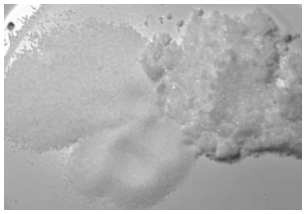
with 1450nm light

White pin Blue pin

Red pin

with visible light

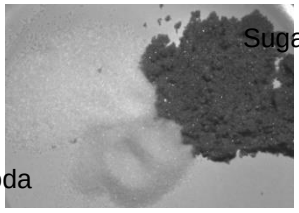
with 1450nm light



with visible light

Salt Sugar

Baking soda



with 1450nm light

5.4 Mechanical specifications

Model Number	STC-LBS132CL-SWIR
Dimensions	58 (W) x 58 (H) x 85 (D) mm (*1)
Optical Filter	No Optical Filter
Optical Center Accuracy	Positional accuracy in Horizontal and Vertical directions: +/- 0.4 mm Rotational accuracy in Horizontal and Vertical directions: +/- 1.5 deg.
Material	Aluminum alloy
Lens Mount	C Mount
Interface Connectors	Camera Link connector: SDR connector (3M) or equivalent x 1 Power/IO connector: HR10A-7R-6PB (Hirose) or equivalent x 1
Camera Mounting	Sixteen M3 screw holes (Four on front, bottom and both side plates) Four 1/4” Tripod screw holes (One on top, bottom and both side plates)
Weight	Approximately 425 g

(*1) Excluding the connectors

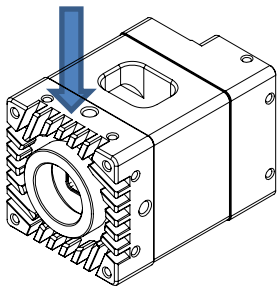
5.5 Environmental specifications

Model Number	STC-LBS132CL-SWIR
Operational Temperature / Humidity	Environmental temperature: 0 to +60 deg. C (camera housing temperature (top plate): less than +69 deg. C (*1)) Environmental humidity: 20 to 85 %RH (No condensation)
Storage Temperature / Humidity	Environmental temperature: -25 to +75 deg. C Environmental humidity: 20 to 85 %RH (No condensation)
Vibration	20 Hz to 200 Hz to 20 Hz (5 min. / cycle), acceleration 10 G, XYZ 3 directions 30 min. each
Shock	Acceleration 38 G, half amplitude 6 msec. XYZ 3 directions 3 times each
Standard Compliancy	EMS: EN61000-6-2, EMI: EN61000-6-4
RoHS	RoHS compliance

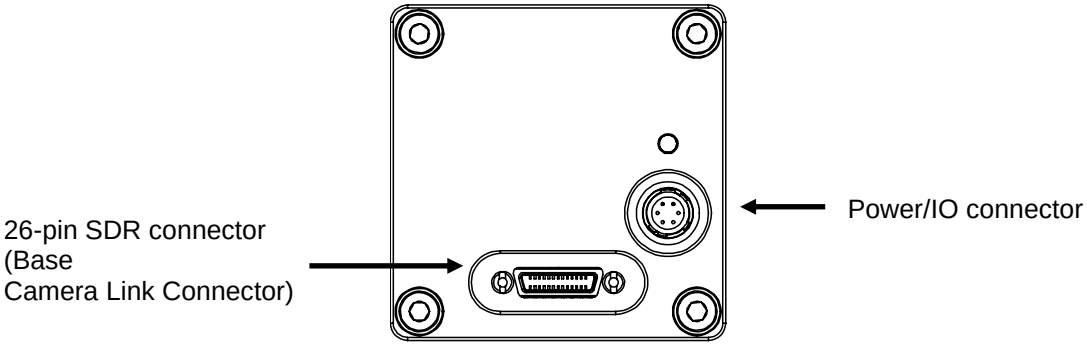
(*1) When the internal temperature sensor on camera (value of 2BH command) exceeding +15 deg. C, defective pixels and noise are appearing increasingly on image. We recommend using this camera under +37 deg. C environmental temperature or housing temperature at temperature measuring point of camera is not exceeded +47 deg. C condition.
Please insure the camera is installed with appropriate heat dissipation to keep camera housing temperature (top plate) is less than 69 deg. C when camera using ambient temperature is exceeded 60 deg. C.
If the camera has a mounted lens and a tripod with an aluminum plate, this could decrease camera housing temperature for heat dissipation.
When attaching camera to lens and aluminum fixture/frame/plate, dissipating camera housing heat efficiently then camera can be used without increase housing temperature.
When the internal temperature sensor on camera (value of 2BH command) shows less than 36 deg. C, camera housing temperature (top plate) will be less than 69 deg. C.

Taking these steps will maintain the heat rating of the electronic components of the camera.

Temperature measuring point



5.6 Connector specifications



5.6.1 Camera Link connector

SDR (3M) or equivalent connector x 1

This camera is None PoCL Camera Link camera.
It is necessary to supply camera power through Power/IO connector.

Camera Link connector pin assignment

Base Camera Link Connector

Pin No.	Signal Name	Pin No.	Signal Name
1	N/A	14	GND
2	X0-	15	X0+
3	X1-	16	X1+
4	X2-	17	X2+
5	Xclk-	18	Xclk+
6	X3-	19	X3+
7	SerTC+	20	SerTC-
8	SerTFG-	21	SerTFG+
9	CC1- (TRG)	22	CC1+ (TRG)
10	CC2+	23	CC2-
11	CC3-	24	CC3+
12	CC4+	25	CC4-
13	GND	26	N/A

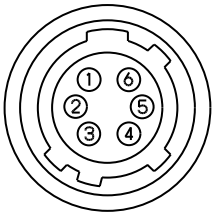
5.6.2 Power/IO connector

HR10A-7R-6PB (Hirose) or equivalent connector x 1

This connector is for DC12V power input and input and output signals.
Please use HR10A-7P-6S (Hirose) or equivalent connector for connecting cable.

Power/IO connector pin assignment

Pin No.	Signal Name	IN / OUT	Voltage		Consumption
			Low voltage	High voltage	
1	GND	IN	0 V		
2	Trigger	IN	0 to +0.99 V	+2.3 to +3.6V	5 μA (typ.) (*1)
	FVAL	OUT	0 V	+3.3 V	10 mA (Max.) (*2)
3	LVAL	OUT	0 V	+3.3 V	10 mA (Max.) (*2)
4	Exposure	OUT	0 V	+3.3 V	10 mA (Max.) (*2)
5	Trigger Filter	OUT	0 V	+3.3 V	10 mA (Max.) (*2)
6	12 Vdc	IN	+12 V		

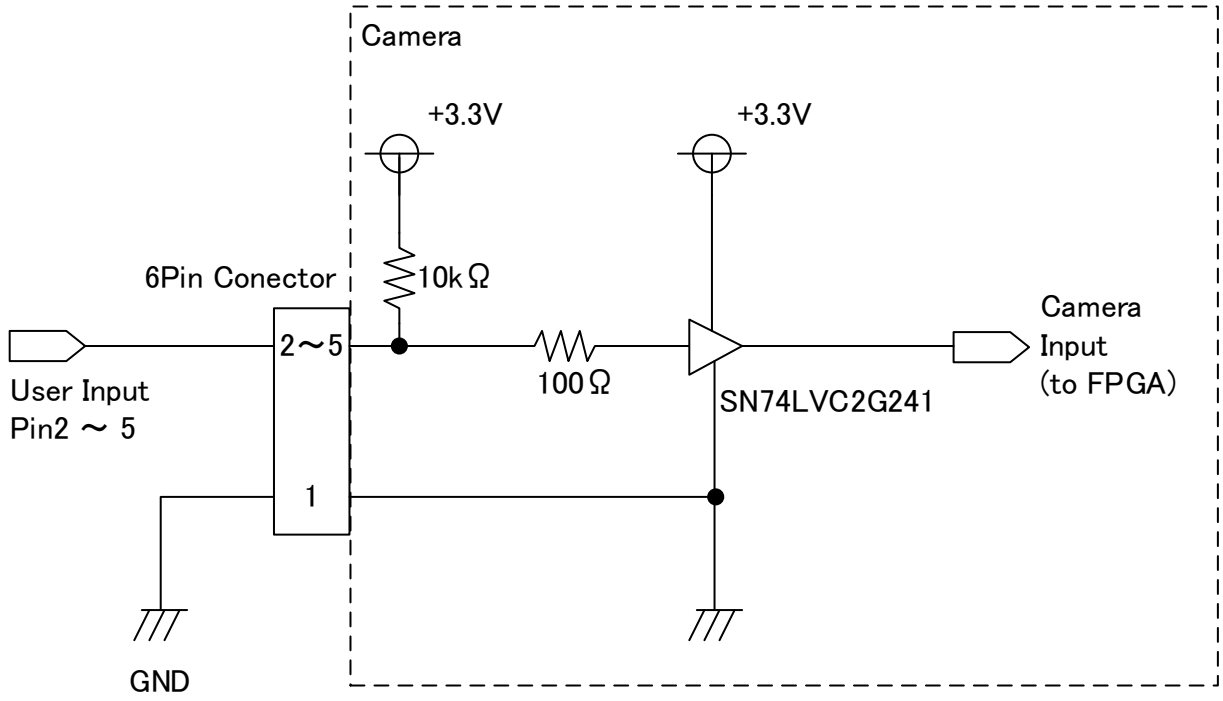


The trigger signal input connector is selectable from below two connectors by camera control command (12H).

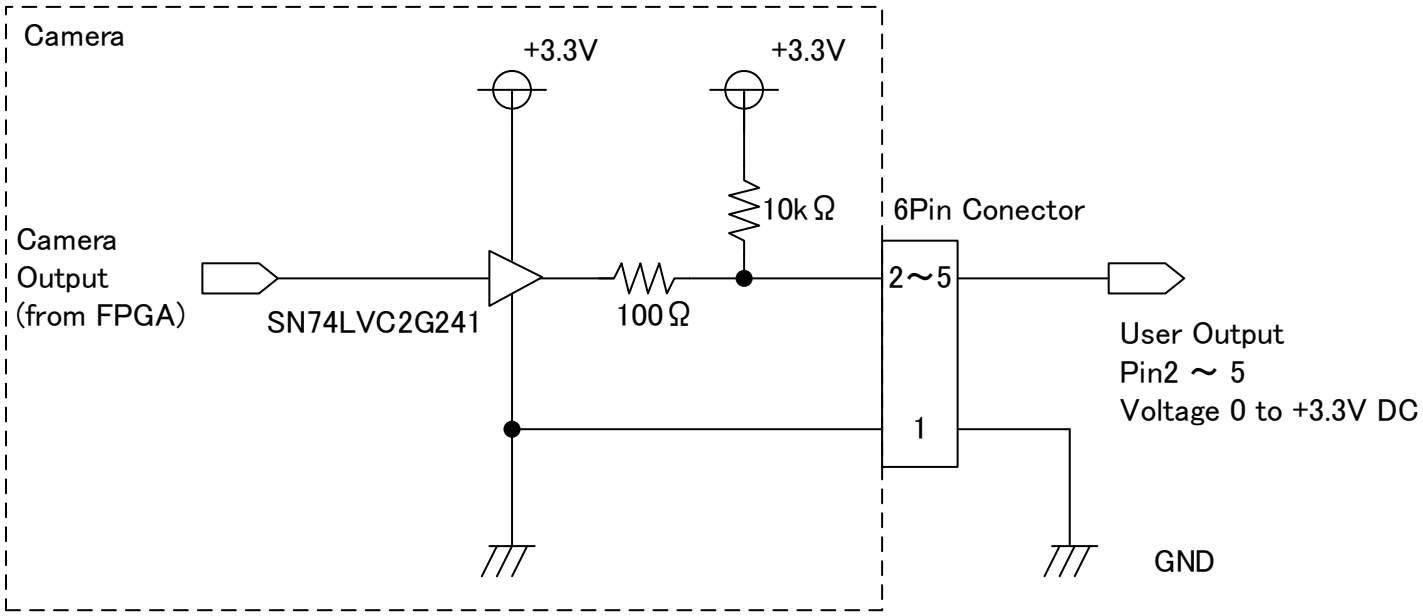
Camera Link connector: CC1
Power/IO connector: Pin No. 2

(*1) The power consumption when high voltage trigger signal input to input port.
(*2) The power consumption for output port has to be managed less than 10 mA.

5.6.3 Input signal circuit

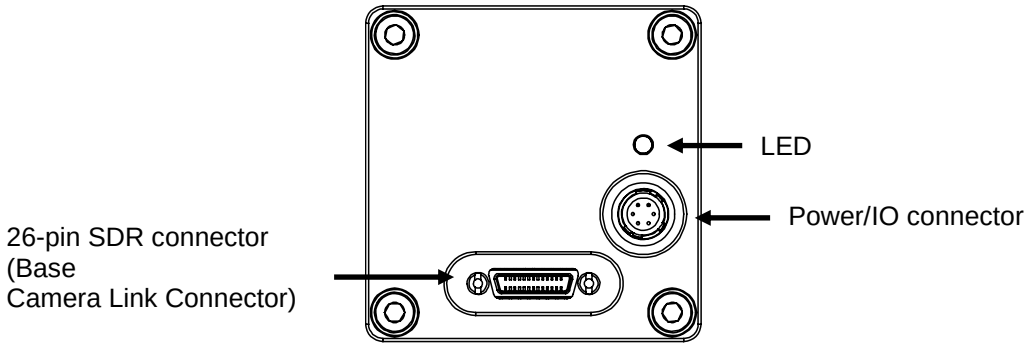


5.6.4 Output signal circuit



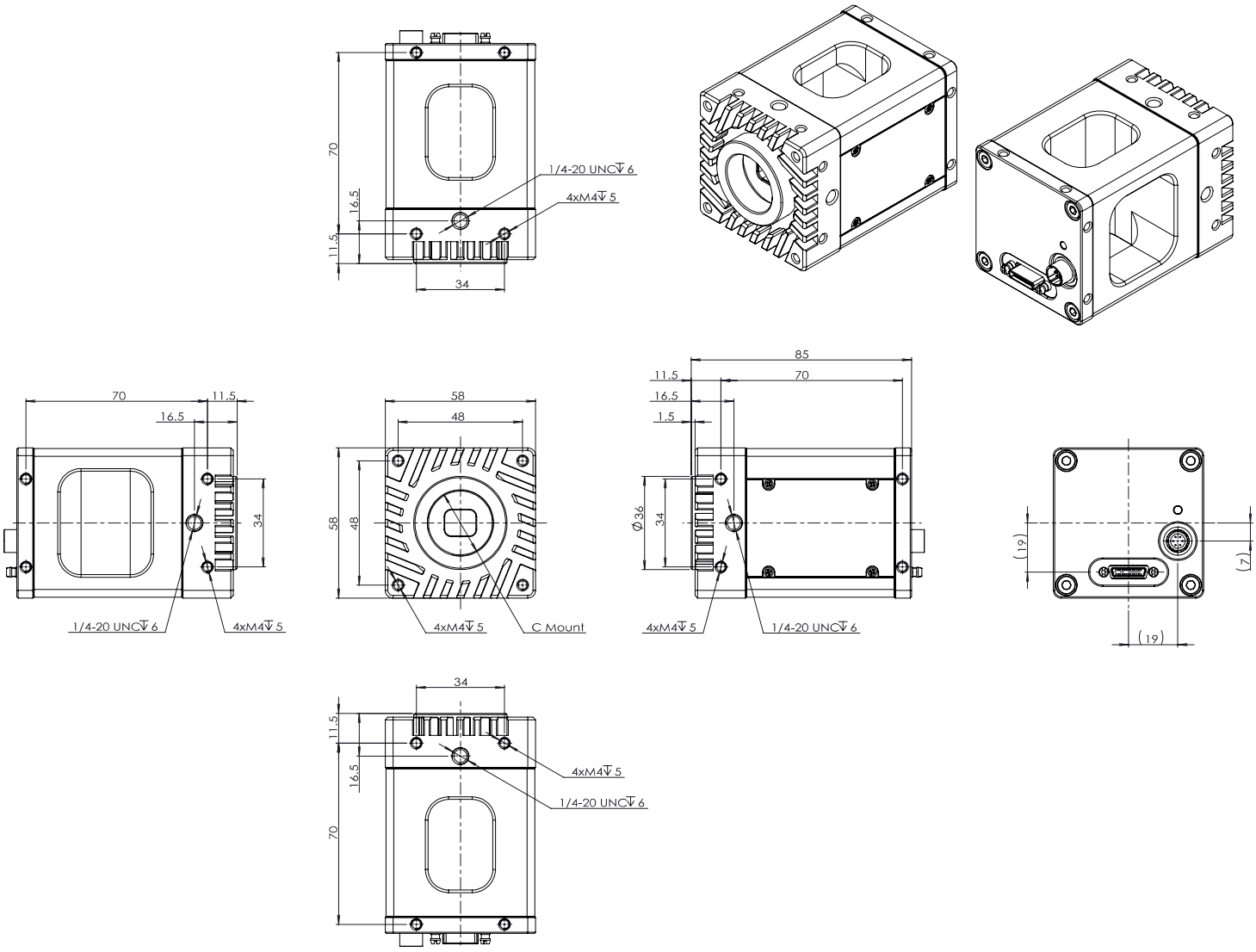
5.7 Indicator lamp

LED indicator lamp is located on above of Power/IO connector.
This LED indicates condition of temperature of CMOS image sensor.



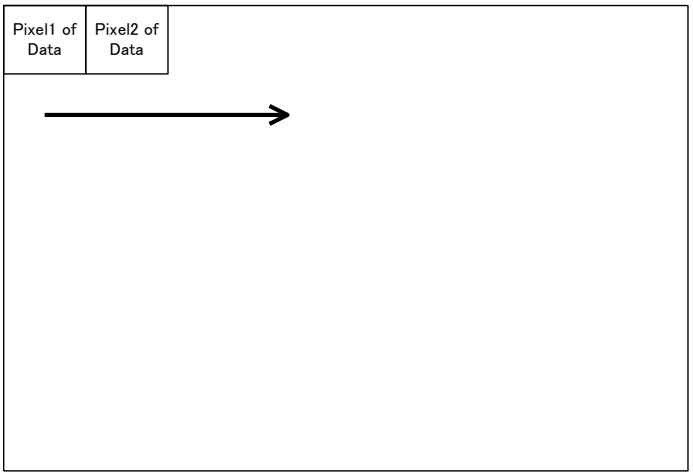
Condition	LED pattern
Camera power is off	OFF
Temperature sensor of CMOS (value 2BH command) is 15 deg. C.	ON
Temperature sensor of CMOS (value 2BH command) is NOT 15 deg. C.	Flashing

6 Dimensions



Unit: mm

7 Sensor Information



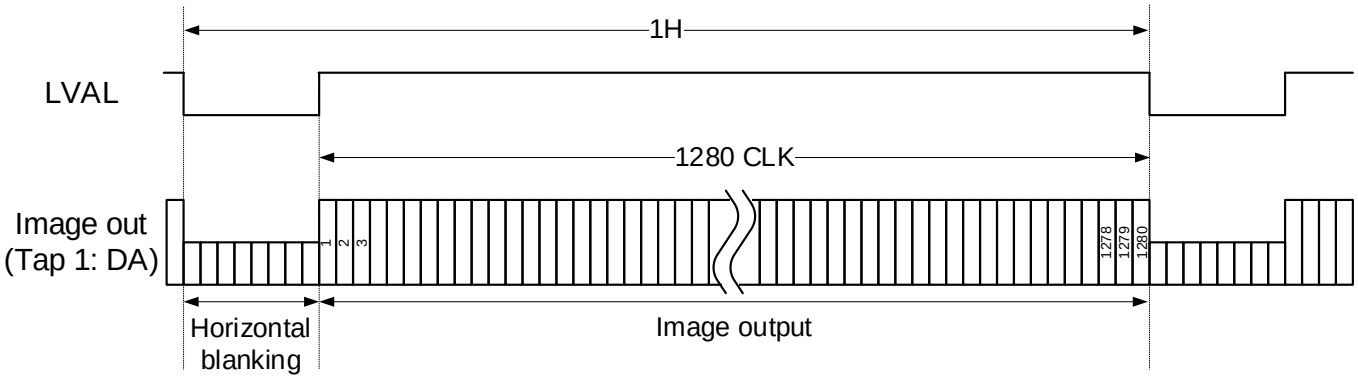
Pixel (n) of Data: nth pixel being transferred

8 Camera Output Timing Charts

8.1 Horizontal timing: Full scanning

8.1.1 1TAP (1X1-1Y) / Horizontal: 1,280 pixels

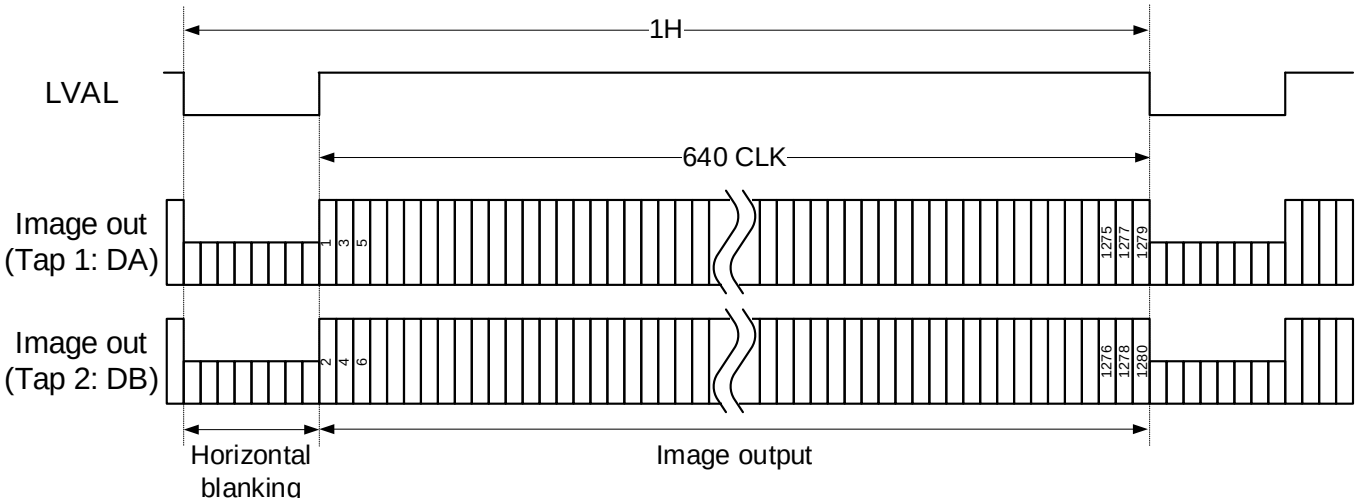
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	15.3	16
	12	15.3	16
66	8 / 10	19.7	16
	12	19.7	16

8.1.2 2TAP (1X2-1Y) / Horizontal: 1,280 pixels

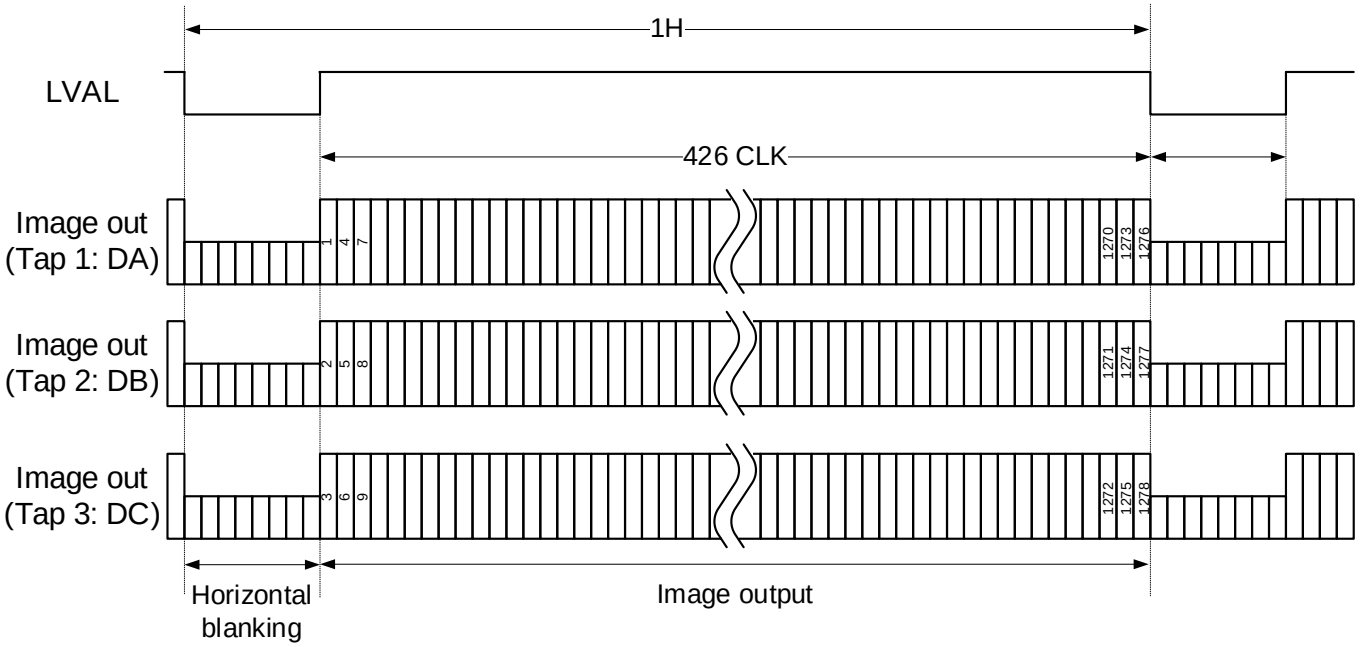
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	7.8	17
	12	13.1	471
66	8 / 10	10.0	18
	12	13.1	224

8.1.3 3TAP (1X3-1Y) / Horizontal: 1,278 pixels

When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds

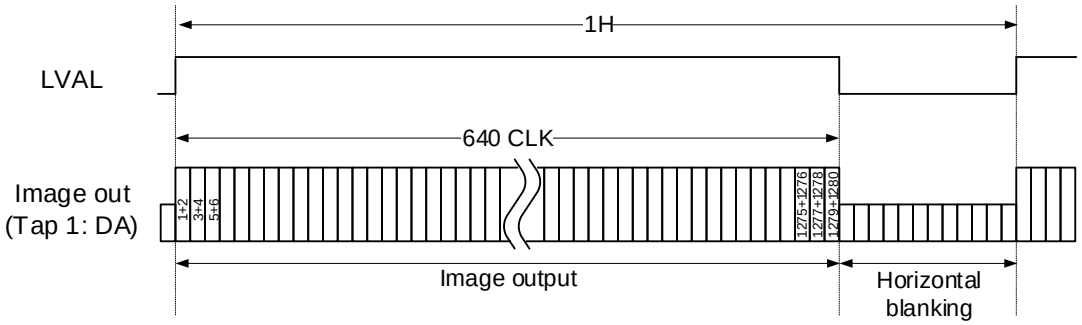


Camera settings			Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format	High rate mode		
84.857	8	OFF	7.5	208
		ON	7.0	164
66	8	OFF	7.5	67
		ON	7.0	32

8.2 Horizontal timings: Binning operation

8.2.1 1TAP (1X1-1Y)

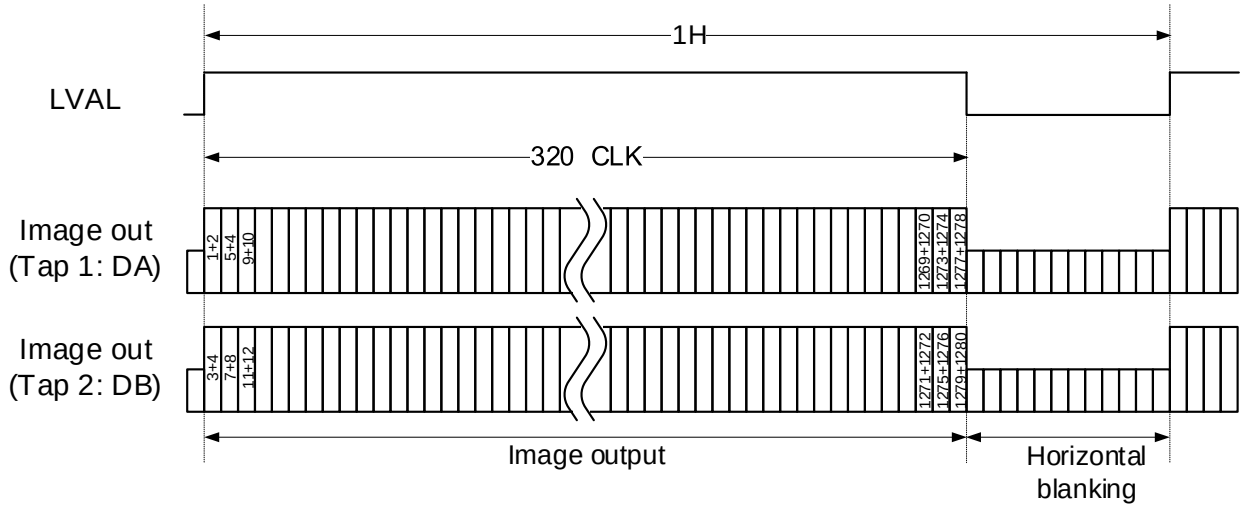
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	30.5	1,952
	12	30.5	1,952
66	8 / 10	39.2	1,952
	12	39.2	1,952

8.2.2 2TAP (1X2-1Y)

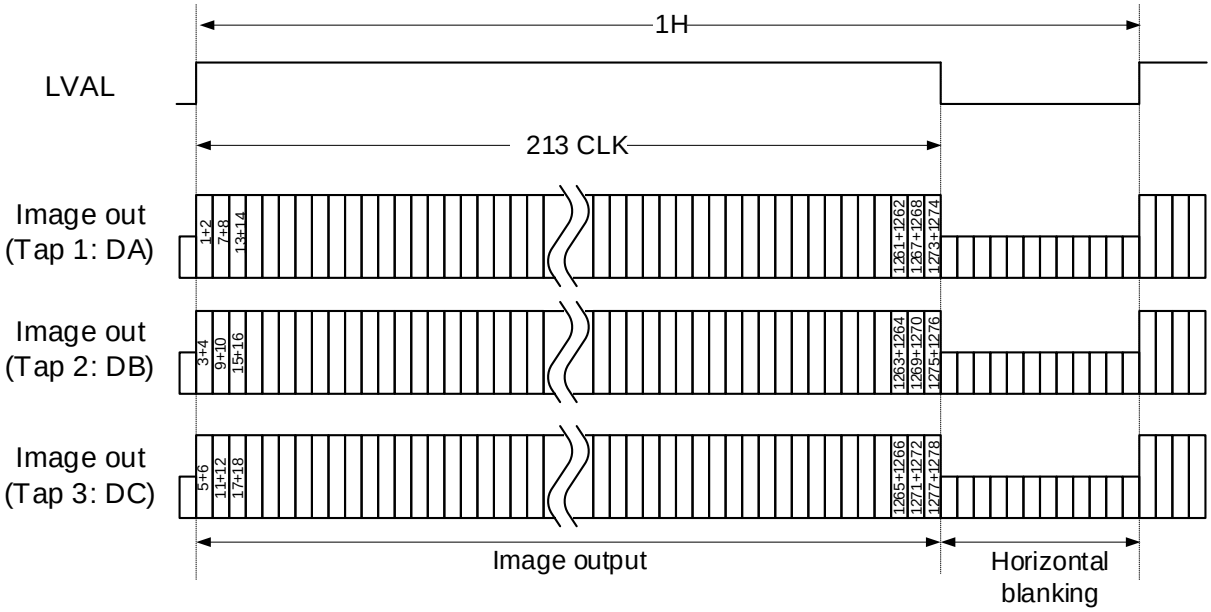
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	15.5	994
	12	26.2	1,902
66	8 / 10	19.9	995
	12	26.2	1,408

8.2.3 3TAP (1X3-1Y)

When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds

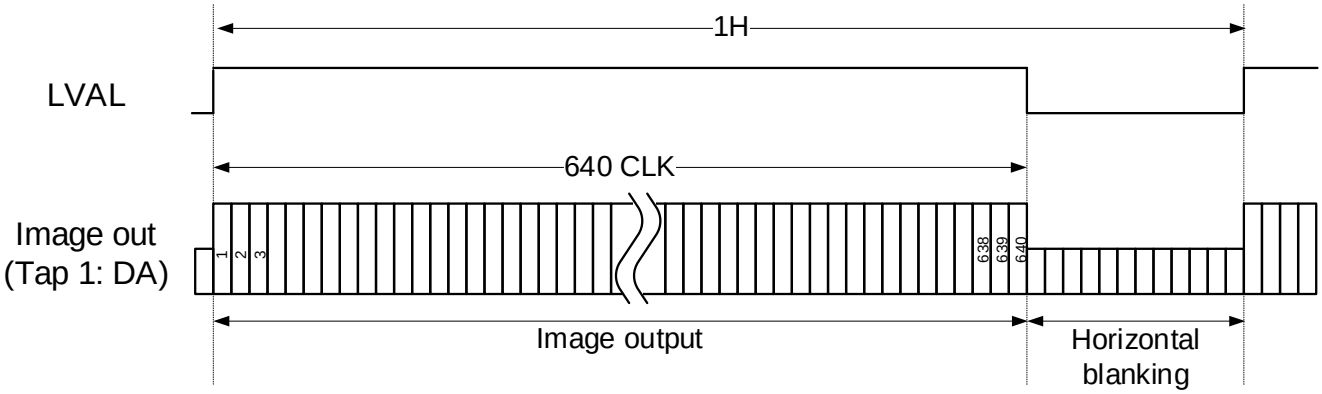


Camera settings			Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format	High rate mode		
84.857	8	OFF	14.9	1,055
		ON	13.9	965
66	8	OFF	14.9	773
		ON	13.9	704

8.3 Horizontal timings: Decimation operation

8.3.1 1TAP (1X1-1Y)

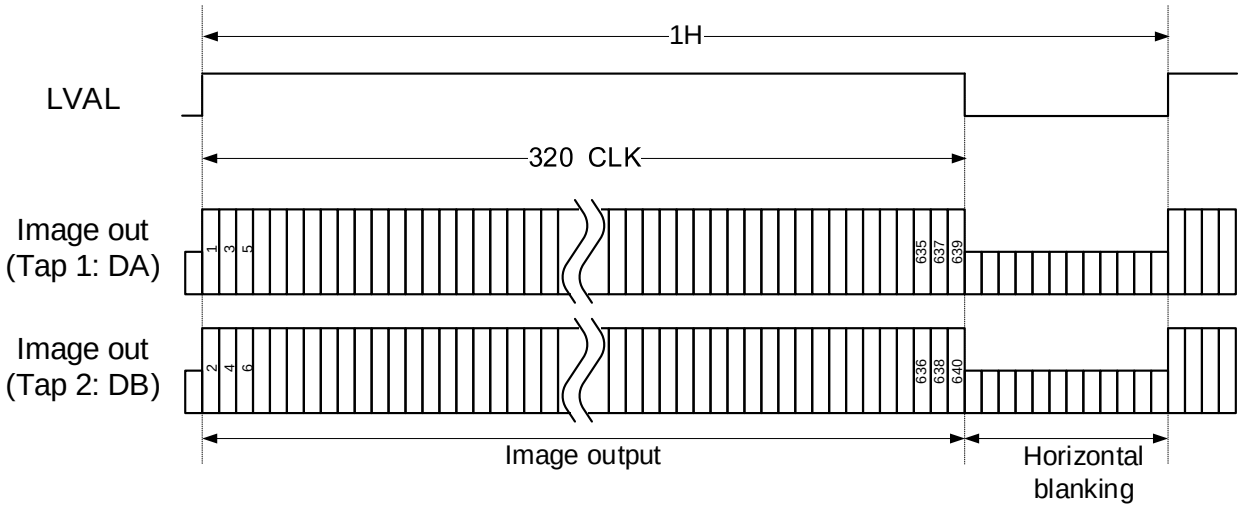
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	15.3	656
	12	15.3	656
66	8 / 10	19.7	656
	12	19.7	656

8.3.2 2TAP (1X2-1Y)

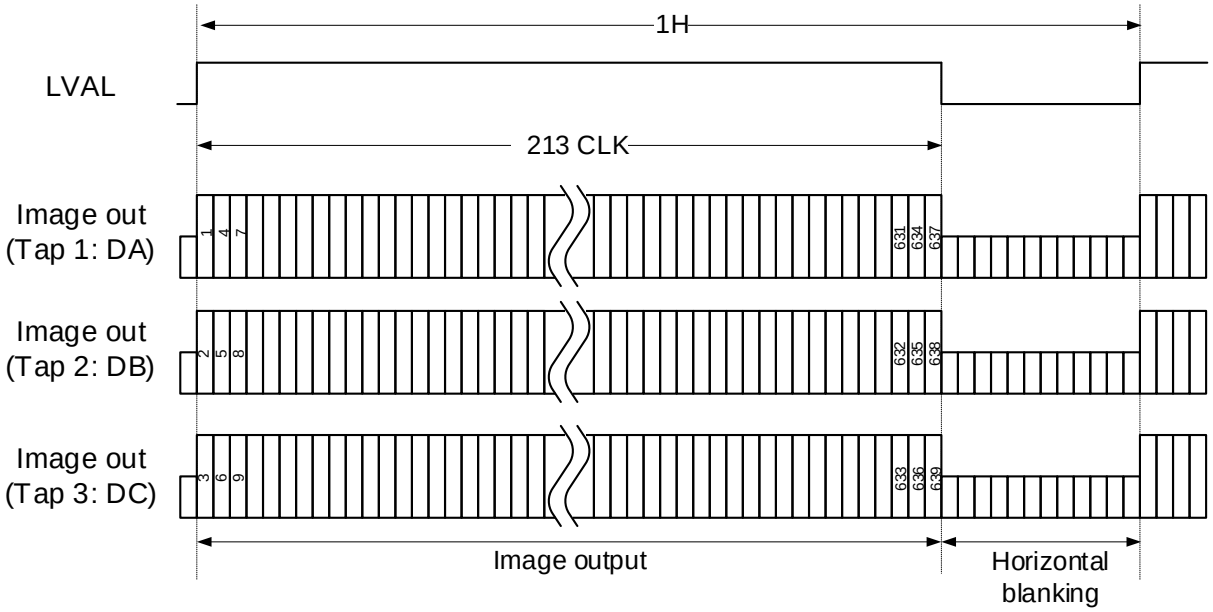
When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings		Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format		
84.857	8 / 10	7.8	337
	12	13.1	791
66	8 / 10	10.0	338
	12	13.1	544

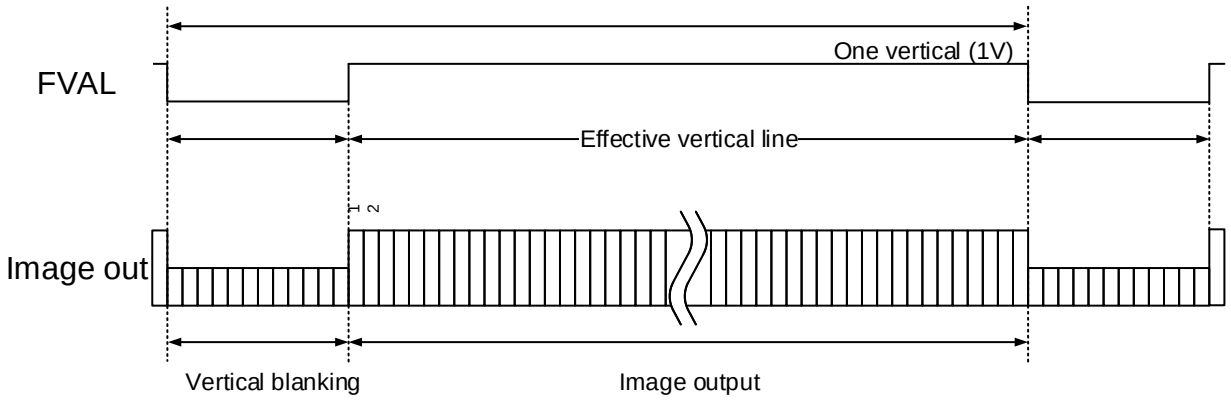
8.3.3 3TAP (1X3-1Y)

When selecting 84.857 MHz, 1 CLK = 11.785 nseconds
When selecting 66 MHz, 1 CLK = 15.15 nseconds



Camera settings			Horizontal interval (µs)	Number of clock of Blanking
Camera Link Clock speed (MHz)	Camera Link output format	High rate mode		
84.857	8	OFF	7.5	422
		ON	7.0	377
66	8	OFF	7.5	281
		ON	7.0	246

8.4 Vertical timings



The table of vertical effective lines and vertical blanking (Free-run / continuous operation)

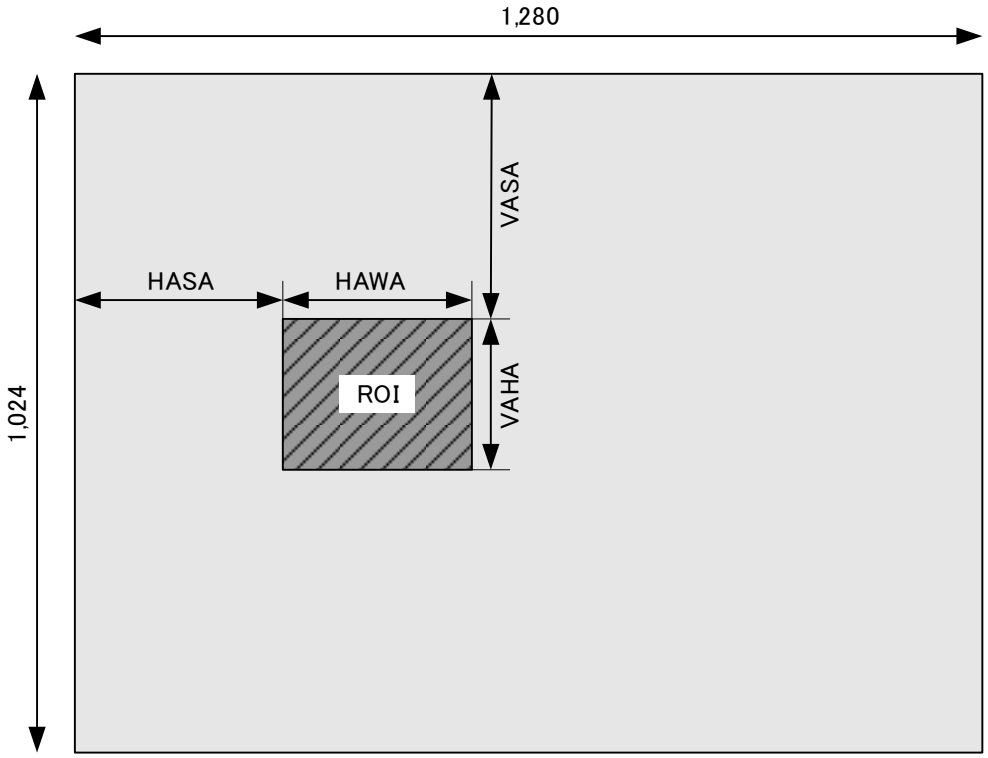
Camera Link output TAP configuration	Bit	CLK	High Rate	Full scanning			Binning		
				Vertical blanking (H)	Vertical effective lines (H)	Frame rate (fps)	Vertical blanking (H)	Vertical effective lines (H)	Frame rate (fps)
3	8bits	84.857	ON	44	1,024	134.7	22	512	134.7
			OFF			125.2			125.2
		66	ON			134.7			134.7
			OFF			125.2			125.2
2	8bits / 10bits	84.857	-			120.9			120.9
		66	-			93.9			93.9
	12bits	84.857	-			71.5			71.5
		66	-			71.5			71.5
1	8bits / 10bits	84.857	-			61.3			61.3
		66	-			47.6			47.6
	12bits	84.857	-			61.3			61.3
		66	-			47.6			47.6

Camera Link output TAP configuration	Bit	CLK	High Rate	Decimation		
				Vertical blanking (H)	Vertical effective lines (H)	Frame rate (fps)
3	8bits	84.857	ON	36	256	486.1
			OFF			451.9
		66	ON			486.1
			OFF			451.9
2	8bits / 10bits	84.857	-			451.9
		66	-			451.9
	12bits	84.857	-			258.0
		66	-			258.0
1	8bits / 10bits	84.857	-			451.9
		66	-			451.9
	12bits	84.857	-			258.0
		66	-			258.0

9 Scanning Modes

9.1 ROI output timing

The size and position for ROI region (one region) are adjustable.
Please refers ROI setting parameters in below drawing.



The frame rate on ROI

The maximum frame rate can be increase by adjusting vertical effective lines for ROI.
The frame rate calculation formula is as following:

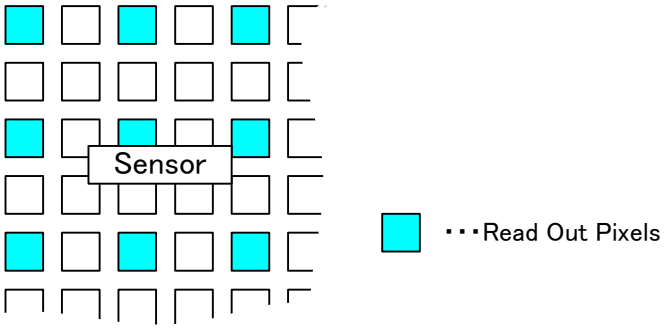
Frame rate = Horizontal frequency / (Vertical effective lines + Vertical blanking)

The horizontal effective pixels for ROI do not make any influence for maximum frame rate.
Please refer “The image data transferring speed” for details of horizontal frequency.

9.2 Decimation

The horizontal and vertical thinning image is output.
By using decimation function, half resolution (2x2 sub-sampling) without change view angle, and twice faster frame rate image can be obtained.

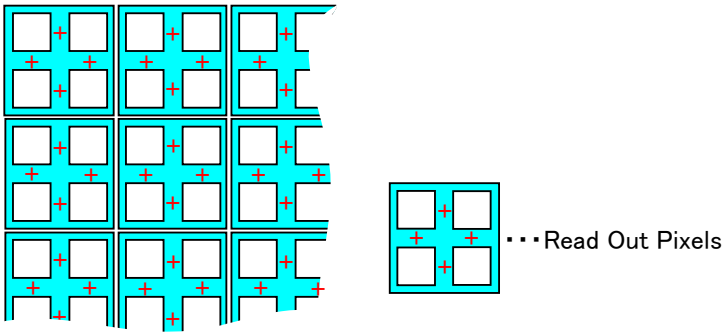
* Decimation function cannot use with binning function.
* Decimation function cannot use with ROI function.



9.3 Binning

The brightness of two vertical pixels are summing into one pixel. (No horizontal brightness summing)
By using binning function, twice brighter, half resolution and twice faster frame rate image can be obtained.

* Binning function cannot use with decimation function.



10 Image Data Transferring Speed

10.1 Change transferring clock

The Camera Link clock speed is selectable from 84.857 MHz or 66 MHz.

Please select the optimum Camera Link clock speed if long length Camera Link cable is required.

The table of Camera Link clock speed and camera operation

Camera settings				Camera operation		
Register [EEH] Camera Link TAP Configuration	Register [11H[D6~D5]] Camera Link Clock speed	Register [11H[D7]] High Rate	Register [12H[D7~D6]] Output Format	Camera Link Clock speed (MHz)	Horizontal frequency (KHz)	Frame rate (fps)
3	00	1	00 (8bits)	84.857	144.0	134.7
		0	00 (8bits)	84.857	133.8	125.2
	01	1	00 (8bits)	66	144.0	134.7
		0	00 (8bits)	66	133.8	125.2
2	00	-	00 (8bits)	84.857	129.1	120.9
		-	01 (10bits)	84.857	129.1	120.9
		-	10 (12bits)	84.857	76.3	71.5
	01	-	00 (8bits)	66	100.3	93.9
		-	01 (10bits)	66	100.3	93.9
		-	10 (12bits)	66	76.3	71.5
1	00	-	00 (8bits)	84.857	65.4	61.3
		-	01 (10bits)	84.857	65.4	61.3
		-	10 (12bits)	84.857	65.4	61.3
	01	-	00 (8bits)	66	50.9	47.6
		-	01 (10bits)	66	50.9	47.6
		-	10 (12bits)	66	50.9	47.6

11 Camera Function Modes

The overlap mode or fast trigger mode can be selectable for each camera function mode.

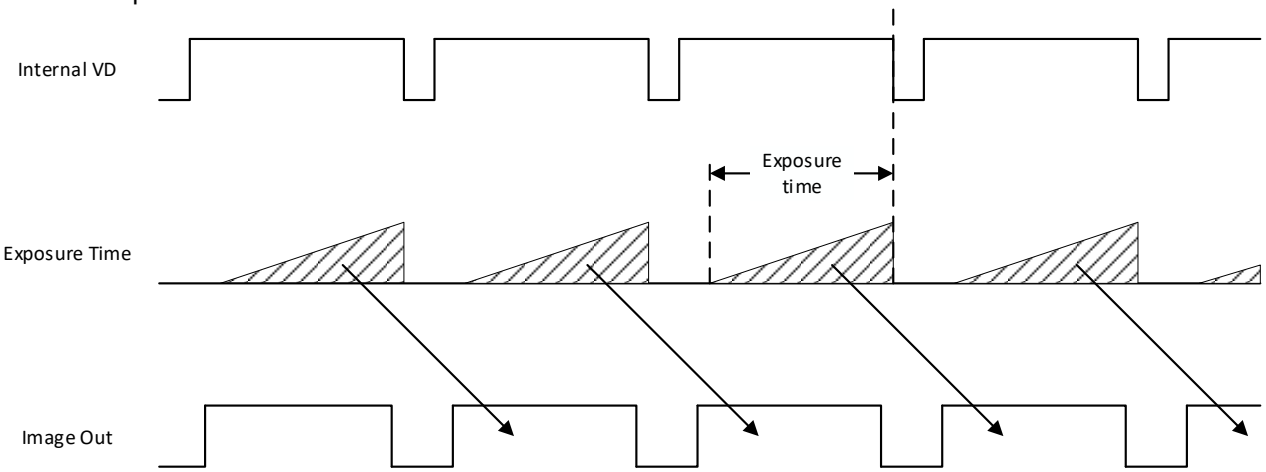
- Overlap mode: The trigger signal is valid when input trigger signal during image output period.
- Fast trigger mode: The trigger signal is invalid when input trigger signal during image output period.

11.1 Free-run / Continuous mode

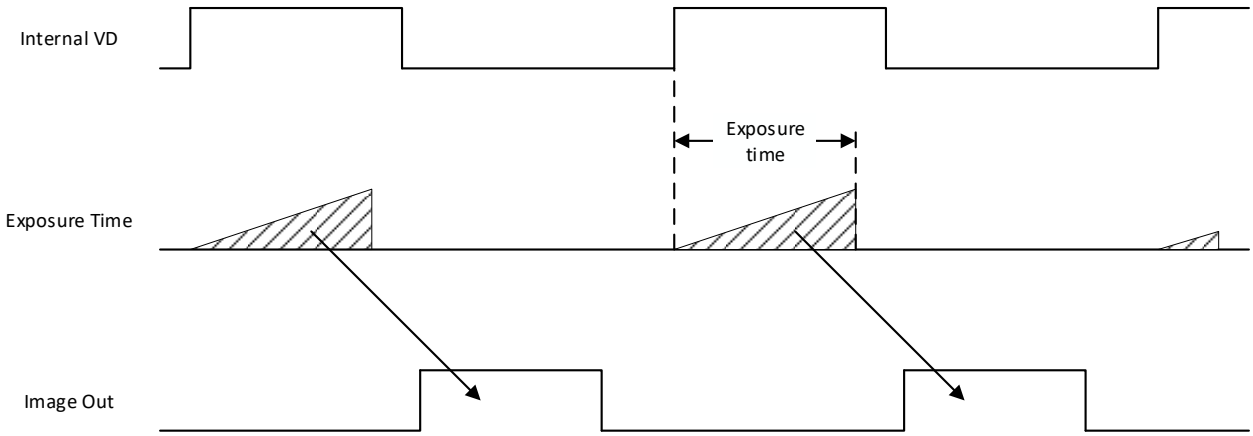
This mode can be outputted camera image signal continuously.

11.1.1 Full frame exposure

- Overlap mode



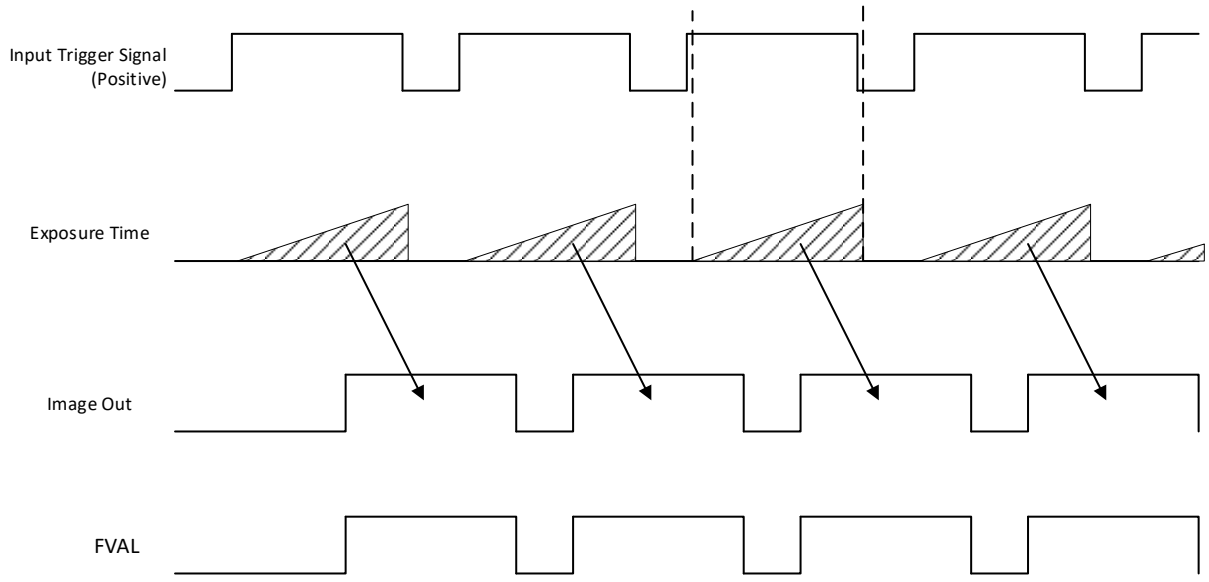
- Fast trigger mode



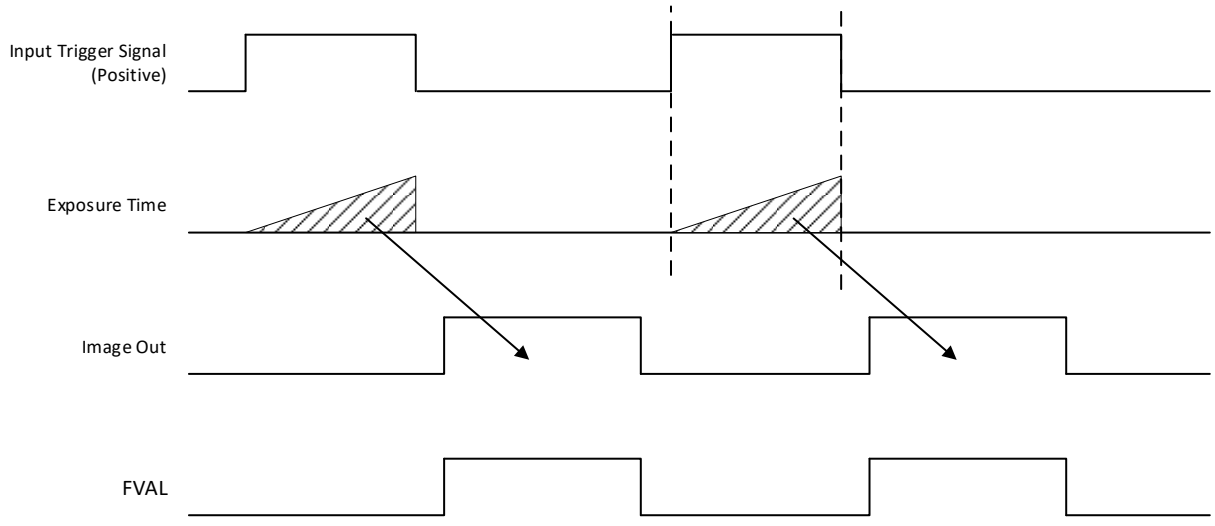
11.2 Pulse width trigger mode

The camera exposure starts by trigger signal.
In this trigger mode with positive trigger polarity, camera exposure starts at rising edge of trigger signal and stops at falling edge of trigger signal.
Therefore, In case of exposure positive polarity is selected, the exposure periods (exposure time) are high states of trigger signal.

- Overlap mode



- Fast trigger mode

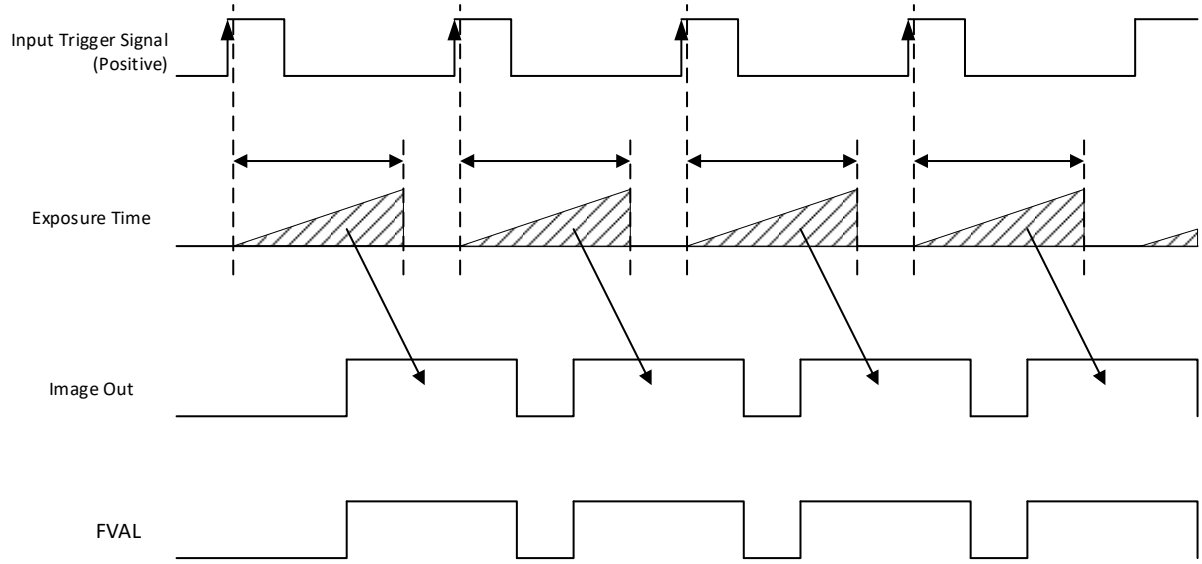


Note.1: The exposure time sets by active pulse width of trigger signal.
No FVAL output without any trigger signal.

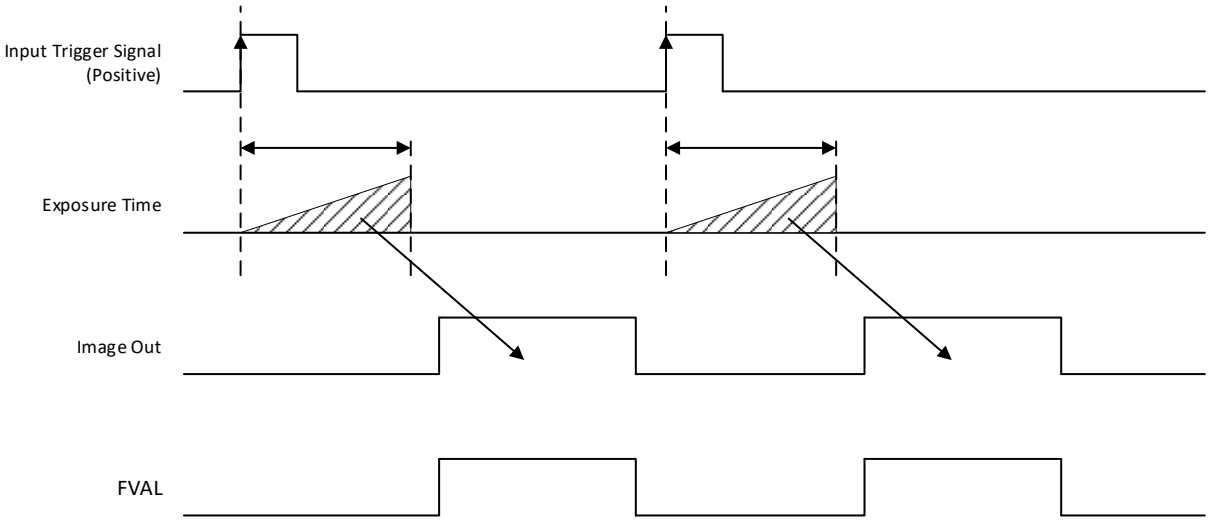
11.3 Edge Preset Trigger mode

The camera exposure starts by trigger signal.
In this trigger mode with positive trigger polarity, camera exposure starts at rising edge of trigger signal.
The exposure time is preset by “Electrical Shutter” settings.

- Overlap mode



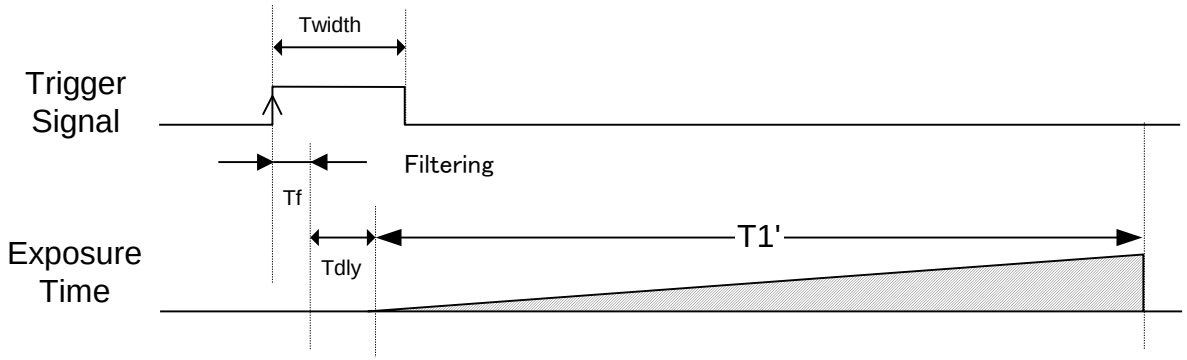
- Fast trigger mode



Note.1: The exposure time sets by preset electronic shutter speed.

11.4 Exposure Timing Details

11.4.1 Exposure timing for each mode



Toffset = 7.37 μseconds

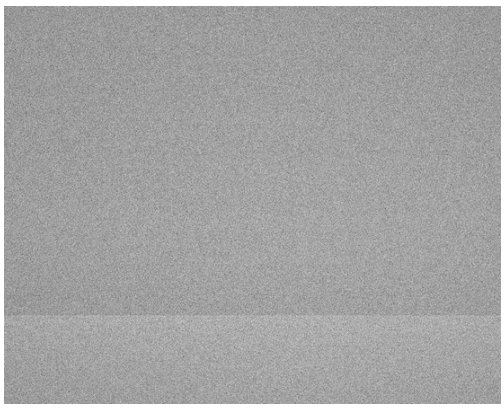
Exposure start mode	Trigger mode	(Tf)	Delay for trigger signal input to start exposure (Tdly)		Adjustment unit for exposure time	Exposure time (T1)	Minimum Exposure time (T1min)
			Without trigger overlap	With trigger over lap			
Fast trigger	Pulse width	0.8 μs.	No delay	No delay to 1H	40.4 ns (24.75MHz)	Twidth + Toffset	Toffset
	Edge preset				1 μs	Preset exposure time	8 μs
Trigger Overlap	Pulse width	0.8 μs.	2 to 3H	2 to 3H	1H	Twidth + Toffset	1H + Toffset
	Edge preset					Preset exposure time	

12 Camera Function

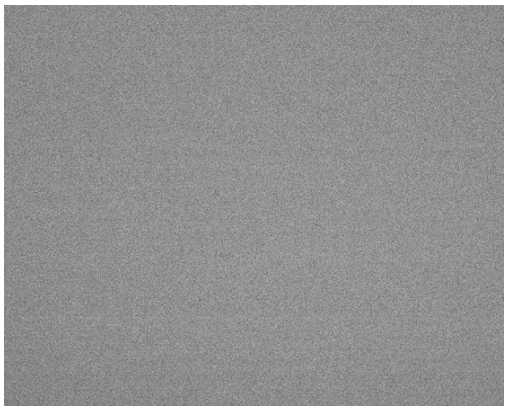
12.1 Black Level Correction

When the exposure is starting while image is output, below left image, which is different offset image may acquire due to the characteristics of CMOS image sensor of this camera.

This issue can be avoided with adjusting timing of exposure start. But adjusting timing of exposure start influences frame rate.
Also, this issue can be improving when using Black Level Correction function without influences frame rate.



When “HOB_CLAMP” is Off



When “HOB_CLAMP” is On

Command No.	Descriptions
39H: HOB_CLAMP[0]	[HOB clamp] Default data: HOB_CLAMP[0] = 0 Sets black level correction when releasing shutter while image output. HOB_CLAMP[0] = 0 : Black level correction is Off HOB_CLAMP[0] = 1 : Black level correction is On

12.2 Gamma Correction

When selecting “ON” at Gamma function, selected gamma coefficient of gamma processed image is output.

Command No.	Descriptions
37H: GAM_SEL[3..0]	[Selection of Gamma coefficient] Default: GAM_SEL[3..0] = 12, Data range: 0 to 15 Sets gamma correction value for Gamma function. (This setting valid when setting “On” at Gamma function) Gamma = 1 / (1 + 0.1 x GAM_SEL[3..0])

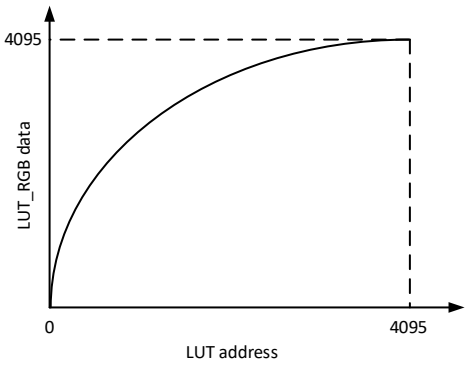
12.3 LUT Function

Output signal can be convert with LUT (Look Up Table) function.

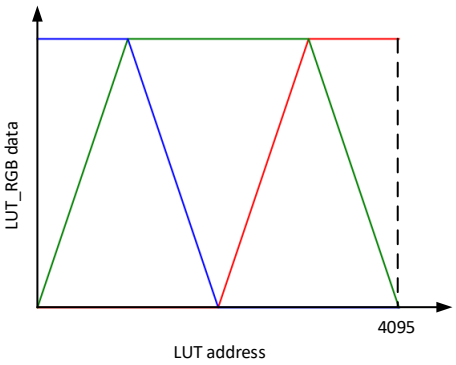
<table>
<tr><th>Command No.</th><th>Descriptions</th></tr>
<tr><td>24H:
LUA_GDA[7..0]
25H:
LUT_GDA[15..8]</td><td>[LUT_G data] Default data: LUT_GDA[15..0] = 0, Data range: 0 to 4,095
Sets data for selected LUT_G address.</td></tr>
<tr><td>26H:
LUA_BDA[7..0]
27H:
LUT_BDA[15..8]</td><td>[LUT_B data] Default data: LUT_BDA[15..0] = 0, Data range: 0 to 4,095
Sets data for selected LUT_B address.</td></tr>
<tr><td>3AH:
LUA_ADD[7..0]
3BH:
LUA_ADD[15..8]</td><td>[LUT address] Default data: LUT_ADD[15..0] = 0, Data range: 0 to 4,095
Sets LUT address.</td></tr>
<tr><td>3CH:
LUA_RDA[7..0]
3DH:
LUT_RDA[15..8]</td><td>[LUT_R data] Default data: LUT_DA[15..0] = 0, Data range: 0 to 4,095
Sets data for selected LUT_R address.</td></tr>
<tr><td>3EH:
LUT_SET[7..0]</td><td>[LUT setting] Default data: LUT_SET[7..0] = 00H
Sets LUT setting for LUT save and load.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7</td><td>No Function</td><td colspan="2">Always sets as "0"</td></tr>
<tr><td>D6</td><td>LUT save</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D5</td><td>LUT load</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D4</td><td>LUT enable</td><td>0: OFF</td><td>1: ON</td></tr>
<tr><td>D3 to D0</td><td>LUT select</td><td colspan="2">0 to 15</td></tr>
</table>
*1: This bit is cleared to “0” automatically after LUT process.</td></tr>
</table>

Example of LUT

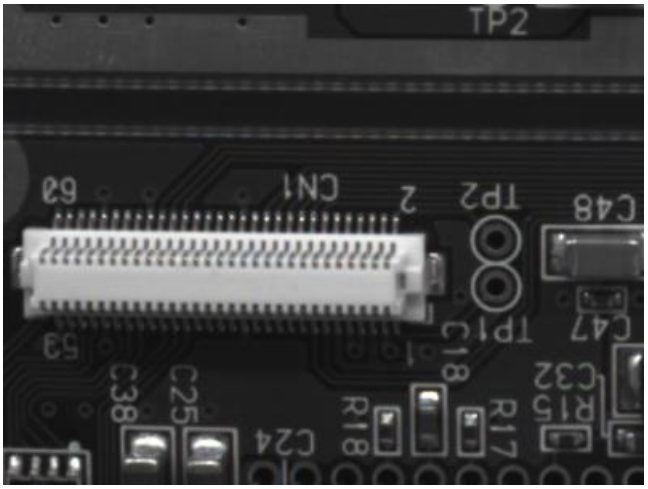


<Low light enhancement>

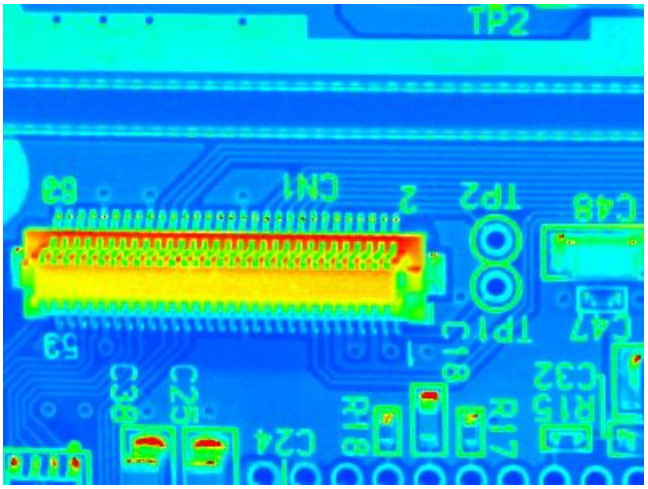


<Pseudo color displaying: Coloring with brightness level >

Pseudo color displaying: Output image that coloring with brightness level



When disable LUT



When pseudo color displaying

*Note: When displaying pseudo color image, it is necessary to use color image supported camera file.

12.4 Shading correction

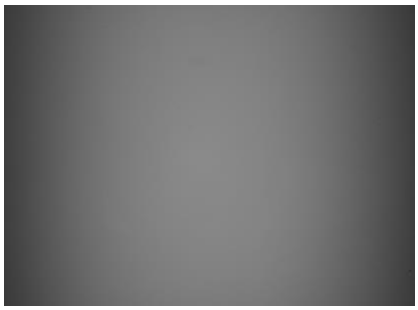
Shading correction function is correcting shading on image that caused by characteristics of lens (amount of through light difference at center and edge of lens) and characteristics of light (uneven brightness level).
When using this function, please take about 50% brightness level image with even white target then generates coefficient of shading correction. (Camera condition: Free-run, full resolution image and flip image off)

Command No.	Descriptions
16H: SHD [7..0]	[Shading Correction] Default data: SHD[7..0] = 00H Sets the shading correction.

D7	D6	D5	D4	D3	D2	D1	D0

D7 ～ D4	No Function	Always sets as “0000”	
D3	Load	0: OFF	1: ON (*1)
D2	Save	0: OFF	1: ON (*1)
D1	Generates Coefficient of Correction	0: OFF	1: ON (*1)
D0	Shading Correction Function	0: OFF	1: ON

Note: This bit is cleared to “0” automatically after proceed selected operation.



Shading correction: Off

Shading correction: On

12.5 Blooming reduction mode

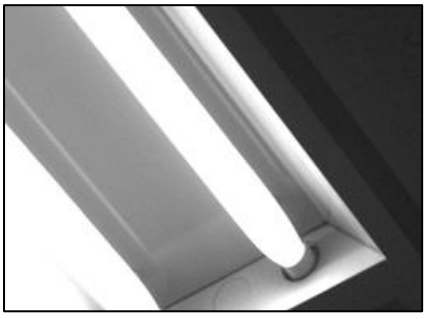
The blooming reduction among pixels while image is saturating.
When selecting “On” this function, range of Gain becomes from 6dB.
When selecting “On”, Gain becomes 6 dB automatically while setting 0 to 5.9 dB.

Command No.	Descriptions
12H: MOD3 [7..0]	[Camera function mode 3] Default data: MOD3[7..0] = 50H Sets the camera function mode.

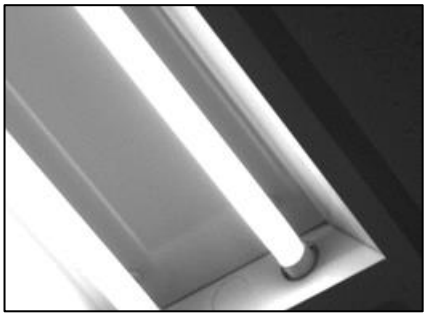
D7	D6	D5	D4	D3	D2	D1	D0

D3	Blooming Reduction Mode	0: OFF	1: ON

Example: Acquiring florescent light



Blooming reduction mode: Off



Blooming reduction mode: On

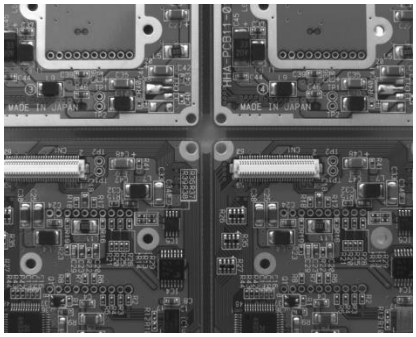
12.6 Pre-processing filters

When using pre-processing filter function, noise reduction image, specific information extract image or other image can be output.

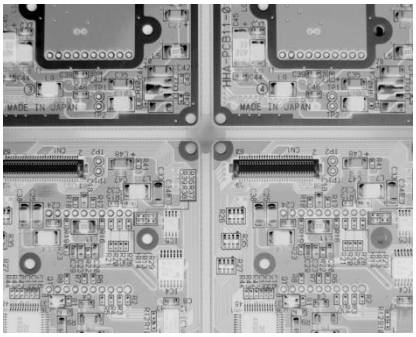
Command No.	Descriptions
15H: FIL [7..0]	[Filtering] Default data: FIL[7..0] = 00H Sets image filtering. D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 D7 to D4: No Function — Always sets as "0000" D3: Brightness invert — 0: OFF / 1: ON D2: Binarization filtering — 0: OFF / 1: ON D1: Spatial filtering — 0: OFF / 1: ON D0: Median filtering — 0: OFF / 1: ON

12.6.1 Brightness Inverse function (Nega/Posi inverse)

The inversed brightness image is outt.



Brightness invert: Off

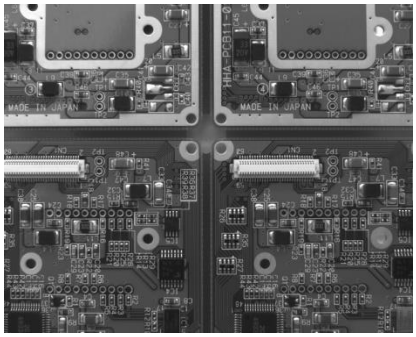


Brightness invert: On

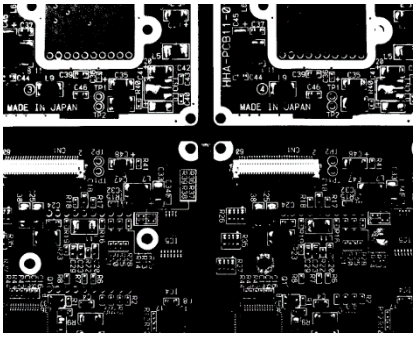
12.6.2 Binarization function

The binarized image is out.

Command No.	Descriptions
35H: FIL_TH[7..0]	[Threshold for binarization] Default data: FIL_TH[7..0] = 128, Data range: 0 to 255 Sets threshold for binarization.



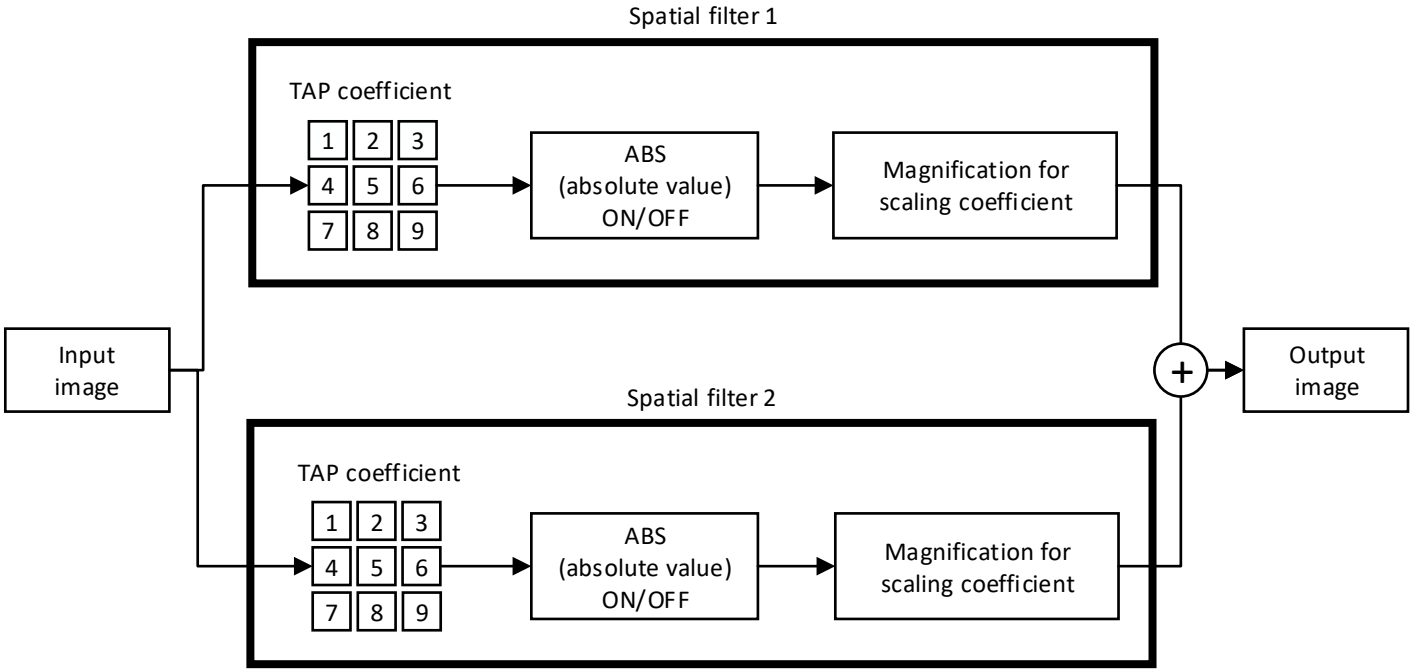
Binarization: Off



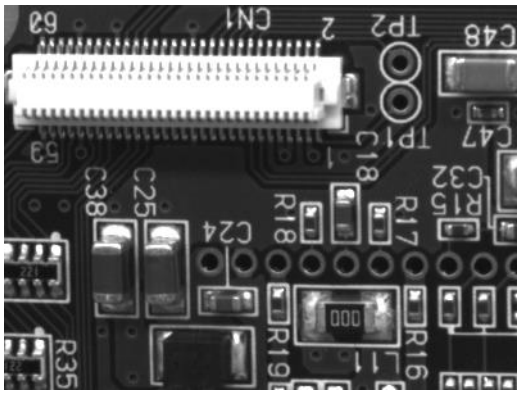
Binarization: On

12.6.3 Spatial filtering function

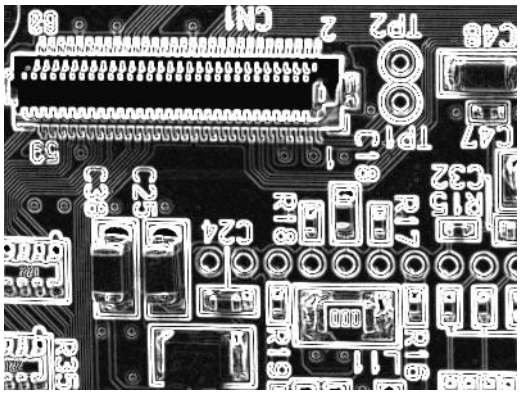
This camera has spatial filtering function, that converts image data.
The edge extract image, smooth image or other image can be output with this function.



* Please refers “The Description of camera control commands” (40H to 56H commands) for details.



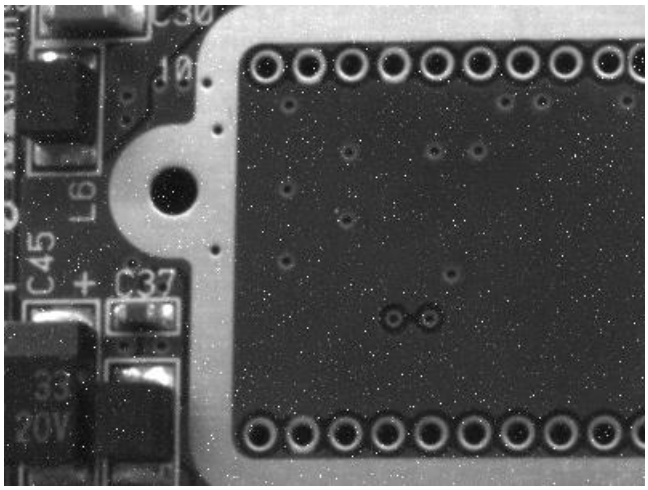
Spatial filtering function: Off



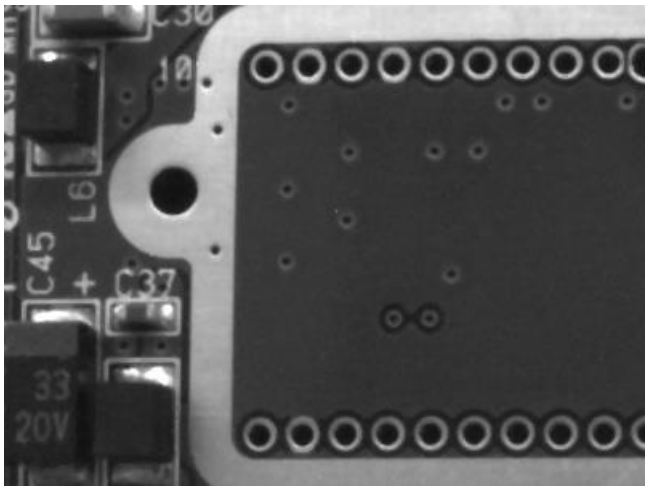
Spatial filtering function: On
(Default: Sobel filtering)

12.6.4 Median filter function

When acquiring dark object image, it is necessary to increase gain or exposure time to increase sensitivity. However, also noise and defective pixels on image may increasing.
The noise and defective pixels can be reducing with Median filter. (The resolution of image also reducing)



Median filter: Off



Median filter: On

13 Communication Protocol specifications

This camera has a communication function that enables external devises such as a PC, to change camera settings. Please use “CLCtrl2 (ver. 1.18 or later)” communication software or use following communication protocol to communicate to camera.

13.1 Communication method

UART (RS232C standard compliant), Binary communication

13.2 Communication settings

Baud rate	**9,600bps** / 38,400bps / 57,600bps / 115,200bps / 230,400bps
Data bit	8bits
Parity	None
Stop bit	1bit
Flow control	None

13.3 Communication format

A. The sending data format from PC to camera is as follows:

SOF (8bits)	Device code (6bits)	Read / write (1bit)	Page selection (1bit)	Command code (8bits)	Data length (8bits)	Data (Write: Data length) (Read: 1byte)	EOF (8bits)

B. The receiving data format from camera is as follows:

a. After sent the read command

SOF (8bits)	Data length (8bits)	Data (Data length byte)	EOF (8bits)

b. After sent the write command

SOF (8bits)	Data length (00H) (8bits)	Receiving code (8bits)	EOF (8bits)

C. Descriptions of format

SOF	Start of the frame. Sets (or obtains) the value is as “02H” always.
Device code	Sets the device code of camera. Sets the value is as “000000” always.
Read / Write	Sets “0” when sending read command. Sets “1” when sending write command.
Page selection	Sets “0” when accessing to register of camera. Obtains the current data from register when sending read command. Replaces the data in register by sending data when sending write command. **The data in EEPROM does not replace.** Sets “1” when accessing to EEPROM of camera. Obtains the data from EEPROM when sending read command. Replaces the data in EEPROM by sending data when sending write command. The camera uses data in EEPROM when power on camera. The camera sends receiving code as “01H” to PC after data in EEPROM is replaced. The camera rejects any commands while data in EEPROM is replacing. (Approximately 5 mseconds / byte)
Command code	Sets the command code. Please refer “The camera control commands” for more details.
Data length	Sets (or obtains) the data length. (unit: byte) For receiving data: The data length is based on command after sent read command. The data length is “00H” after sent write command. For sending data: The data length is 1 byte when sending read command. The data length is based on command when sending write command.
Data	Sets (or obtains) the data based on command.
EOF	End of the frame Sets (or obtains) the value is as “03H” always.
Receiving code	Obtains the result of sending command. 01H: The command proceeded correctly (ACK) 10H: The command could not process correctly (NAC) 11H: The communication issue

D. Command example

Send the read command to read 00H address data of register

02, 00, 00, 01, 00, 03

SOF, (Device code / Read / Register), Command code, Data length, Data, EOF

The return command

02, 01, 00, 03

13.4 Camera control commands

13.4.1 Camera control commands list

Note. 1: The data unit of each command is 1 byte (8bits).
Note. 2: The data can be saved to EEPROM if “X” in “EEPROM” column in list.
Note. 3: The camera is operating with data of EEPROM when power on camera.

Command No.	R/W	EEPROM	Function	Default Data	Data Range
00 - 0FH			Reserved	-	-
10H	R/W	X	Camera function mode 1 (8bits: D[7..0])	00H	
11H	R/W	X	Camera function mode 2 (8bits: D[7..0])	08H	
12H	R/W	X	Camera function mode 3 (8bits: D[7..0])	50H	
13H			Reserved	-	-
14H	R/W	X	Communication mode (8bits: D[7..0])	01H	
15H	R/W	X	Filtering (8bits: D[7..0])	00H	
16H	R/W	X	Shading Correction (8bits: D[7..0])	00H	
17 - 1FH			Reserved	-	-
20H	R/W	X	Exposure time of electronic shutter (24bits: D[7..0])	0	0 to 16,777,215
21H	R/W	X	Exposure time of electronic shutter (24bits: D[15..8])		
22H	R/W	X	Exposure time of electronic shutter (24bits: D[23..16])		
23H			Reserved	-	-
24H	R/W	X	LUT_G data (16bits: D[7..0])	0	0 to 4,095
25H	R/W	X	LUT_G data (16bits: D[15..8])		
26H	R/W	X	LUT_B data (16bits: D[7..0])	0	0 to 4,095
27H	R/W	X	LUT_B data (16bits: D[15..8])		
28H	R/W	X	Delay time for trigger signal (8bits: D[7..0])	0	0 to 255
29H	R		Temperature of camera		
2AH			Reserved		
2BH	R		Temperature of camera		
2C - 2FH			Reserved		
30H	R/W	X	Gain (8bits: D[7..0])	0	0 to 255
31H			Reserved		
32H	R/W	X	Offset gain for factory adjustment (8bits: D[7..0])	Factory adjusted value	0 to 60
33 - 35H			Reserved	-	-
36H	R/W	X	Gamma coefficient selection (4bits: D[3..0])	12	0 to 15
37H			Reserved		
38H	R/W	X	Black level (8bits: D[7..0])	40	0 to 255
39H			HOB clamp (8bits: D[7..0])	0	0 to 1
3AH	R/W	X	LUT Address (16bits: D[7..0])	0	0 to 4,095
3BH	R/W	X	LUT Address (16bits: D[15..8])		
3CH	R/W	X	LUT_R data (16bits: D[7..0])	0	0 to 4,095
3DH	R/W	X	LUT_R data (16bits: D[15..8])		
3EH	R/W	X	LUT_R setting (8bits: D[7..0])	00H	
3FH			Reserved	-	-

Command No.	R/W	EEPROM	Function	Default Data	Data Range
40H	R/W	X	Spatial filter 1 - Tap1 coefficient (8bits: D[7..0])	FFH	-128 to 127
41H	R/W	X	Spatial filter 1 - Tap2 coefficient (8bits: D[7..0])	00H	-128 to 127
42H	R/W	X	Spatial filter 1 - Tap3 coefficient (8bits: D[7..0])	01H	-128 to 127
43H	R/W	X	Spatial filter 1 - Tap4 coefficient (8bits: D[7..0])	FEH	-128 to 127
44H	R/W	X	Spatial filter 1 - Tap5 coefficient (8bits: D[7..0])	00H	-128 to 127
45H	R/W	X	Spatial filter 1 - Tap6 coefficient (8bits: D[7..0])	02H	-128 to 127
46H	R/W	X	Spatial filter 1 - Tap7 coefficient (8bits: D[7..0])	FFH	-128 to 127
47H	R/W	X	Spatial filter 1 - Tap8 coefficient (8bits: D[7..0])	00H	-128 to 127
48H	R/W	X	Spatial filter 1 - Tap9 coefficient (8bits: D[7..0])	01H	-128 to 127
49H	R/W	X	Spatial filter 1 - Absolute value (1bits: D[0])	0	0 to 1
4AH	R/W	X	Spatial filter 1 - Scaling coefficient (16bits: D[7..0])	4,096	0 to 65,535
4BH	R/W	X	Spatial filter 1 - Scaling coefficient (16bits: D[15..8])		
4CH	R/W	X	Spatial filter 2 - Tap1 coefficient (8bits: D[7..0])	FFH	-128 to 127
4DH	R/W	X	Spatial filter 2 - Tap2 coefficient (8bits: D[7..0])	FEH	-128 to 127
4EH	R/W	X	Spatial filter 2 - Tap3 coefficient (8bits: D[7..0])	FFH	-128 to 127
4FH	R/W	X	Spatial filter 2 - Tap4 coefficient (8bits: D[7..0])	00H	-128 to 127
50H	R/W	X	Spatial filter 2 - Tap5 coefficient (8bits: D[7..0])	00H	-128 to 127
51H	R/W	X	Spatial filter 2 - Tap6 coefficient (8bits: D[7..0])	00H	-128 to 127
52H	R/W	X	Spatial filter 2 - Tap7 coefficient (8bits: D[7..0])	01H	-128 to 127
53H	R/W	X	Spatial filter 2 - Tap8 coefficient (8bits: D[7..0])	02H	-128 to 127
54H	R/W	X	Spatial filter 2 - Tap9 coefficient (8bits: D[7..0])	01H	-128 to 127
55H	R/W	X	Spatial filter 2 - Absolute value (1bits: D[0])	1	0 to 1
56H	R/W	X	Spatial filter 2 - Scaling coefficient (16bits: D[7..0])	4,096	0 to 65,535
57H	R/W	X	Spatial filter 2 - Scaling coefficient (16bits: D[15..8])		
58 - 77H			Reserved	-	-
78H	R/W	X	Test Pattern (3bits: D[2..0])	00H	0 to 15
79 - 7FH			Reserved	-	-
80H	R/W	X	EEPROM control (8bits: D[7..0])	00H	
81 - 8FH			Reserved	-	-
90H	R/W	X	Vertical ROI_1 Start line (16bits: D[7..0])	0	0 to 1,016
91H	R/W	X	Vertical ROI_1 Start line (16bits: D[15..8])		
92 - 9FH			Reserved	-	-
A0H	R/W	X	Vertical ROI_1 Effective lines (16bits: D[7..0])	1,024	8 to 1,024
A1H	R/W	X	Vertical ROI_1 Effective lines (16bits: D[15..8])		
A2 - AFH			Reserved	-	-
B0H	R/W	X	Horizontal ROI_1 Start pixel (16bits: D[7..0])	0	0 to 1,272
B1H	R/W	X	Horizontal ROI_1 Start pixel (16bits: D[15..8])		
B2 - BFH			Reserved	-	-
C0H	R/W	X	Horizontal ROI_1 Effective pixels (16bits: D[7..0])	1,280	8 to 1,280
C1H	R/W	X	Horizontal ROI_1 Effective pixels (16bits: D[15..8])		
C2 - CFH			Reserved	-	-

Command No.	R/W	EEPROM	Function	Default Data	Data Range
D0H	R/W	X	Defective pixel correction control (8bits: D[7..0])	00H	
D1H	R/W	X	Defective pixel correction coordinate number (16bits: D[7..0])	0	0 to 255
D2H	R/W	X	Defective pixel X position (Set) (16bits: D[7..0])	0	0 to 1,279
D3H	R/W	X	Defective pixel X position (Set) (16bits: D[15..8])		
D4H	R/W	X	Defective pixel Y position (Set) (16bits: D[7..0])	0	0 to 1,023
D5H	R/W	X	Defective pixel Y position (Set) (16bits: D[15..8])		
D6H	R/W	X	Defective pixel X position (Read) (16bits: D[7..0])	0	-
D7H	R/W	X	Defective pixel X position (Read) (16bits: D[15..8])		
D8H	R/W	X	Defective pixel Y position (Read) (16bits: D[7..0])	0	-
D9H	R/W	X	Defective pixel Y position (Read) (16bits: D[15..8])		
DAH	R/W	X	Defective pixel correction coordinate number (16bits: D[15..8])	0	0 to 255
DB - DDH			Reserved	-	-
DEH	R/W	X	Defective pixel correction mode (8bits: D[7..0])	01H	
DF - EDH			Reserved	-	-
EEH	R/W	X	Camera function mode 6 (8bits: D[7..0])	02H	
EF - FFH			Reserved	-	-

13.4.2 The Description of camera control commands
The underline settings are factory default settings.

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>10H:
MOD1 [7..0]</td><td>[Camera function mode 1] Default data: MOD1 [7..0] = 00H
Sets the camera function mode.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7</td><td>No Function</td><td colspan="2">Always sets as “0”</td></tr>
<tr><td>D6</td><td>Trigger Polarity</td><td>0: Positive</td><td>1: Negative</td></tr>
<tr><td>D5</td><td>Trigger Mode</td><td>0: Edge Preset</td><td>1: Pulse Width</td></tr>
<tr><td>D4</td><td>Binning Mode</td><td>0: Off</td><td>1: On</td></tr>
<tr><td>D3</td><td>Decimation Mode</td><td>0: Off</td><td>1: On</td></tr>
<tr><td>D2 to D0</td><td>No Function</td><td colspan="2">Always sets as “000”</td></tr>
</table></td></tr>
<tr><td>11H:
MOD2 [7..0]</td><td>[Camera function mode 2] Default data: MOD2 [7..0] = 08H
Sets the camera function mode.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7</td><td>High Rate</td><td>0: Off</td><td>1: On</td></tr>
<tr><td>D6 to D5</td><td>Clock Speed</td><td>00: 84.857 MHz</td><td>01: 66 MHz</td></tr>
<tr><td></td><td></td><td colspan="2">10 - 11: No function</td></tr>
<tr><td>D4</td><td>No Function</td><td colspan="2">Always sets as “0”</td></tr>
<tr><td>D3</td><td>Operation Mode</td><td>0: Trigger</td><td>1: Free-run / Continuous</td></tr>
<tr><td>D2 to D0</td><td>No Function</td><td colspan="2">Always sets as “000”</td></tr>
</table>
* Note: While the camera is in trigger mode, image will not output without trigger signal input.</td></tr>
<tr><td>12H:
MOD3 [7..0]</td><td>[Camera function mode 3] Default data: MOD3 [7..0] = 50H
Sets the camera function mode.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7 to D6</td><td>Output Format</td><td>00: 10bits</td><td>01: 8bits</td></tr>
<tr><td></td><td></td><td>10: 12bits</td><td>11: No Function</td></tr>
<tr><td>D5</td><td>Trigger Input Selection</td><td>0: CC1 on Camera Link</td><td>1: 2pin on Power/IO</td></tr>
<tr><td>D4</td><td>Exposure Start Mode</td><td>0: Fast Trigger</td><td>1: Trigger Overlap</td></tr>
<tr><td>D3</td><td>No Function</td><td colspan="2">Always sets as "0"</td></tr>
<tr><td>D2</td><td>Vertical Image Flip</td><td>0: Off</td><td>1: Vertical Flip</td></tr>
<tr><td>D1</td><td>Horizontal Image Flip</td><td>0: Off</td><td>1: Horizontal Flip</td></tr>
<tr><td>D0</td><td>Gamma Mode</td><td>0: Off</td><td>1: On</td></tr>
</table>
* Note: Please refer “The details of exposure timing” for more details of exposure start mode.</td></tr>
<tr><td>14H:
UART [7..0]</td><td>[Communication mode] Default data: UART [7..0] = 01H
Sets the communication mode.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7 to D5</td><td>No Function</td><td colspan="2">Always sets as "000000"</td></tr>
<tr><td>D4 to D0</td><td>Communication Mode</td><td>0000: 38,400 bps</td><td>0001: 9,600 bps</td></tr>
<tr><td></td><td></td><td>0010: 57,600 bps</td><td>0011: 115,200 bps</td></tr>
<tr><td></td><td></td><td>10000: 230,400 bps</td><td>Others: No function</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>15H:
FIL [7..0]</td><td>[Filtering] Default data: FIL[7..0] = 00H
Sets image filtering.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D4</td><td>No Function</td><td colspan="2">Always sets as "0000"</td></tr>
<tr><td>D3</td><td>Brightness invert</td><td>0: OFF</td><td>1: ON</td></tr>
<tr><td>D2</td><td>Binarization filtering</td><td>0: OFF</td><td>1: ON</td></tr>
<tr><td>D1</td><td>Spatial filtering</td><td>0: OFF</td><td>1: ON</td></tr>
<tr><td>D0</td><td>Median filtering</td><td>0: OFF</td><td>1: ON</td></tr>
</table></td></tr>
<tr><td>16H:
SHD [7..0]</td><td>[Shading Correction] Default data: SHD[7..0] = 00H
Sets the shading correction.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D4</td><td>No Function</td><td colspan="2">Always sets as “0000”</td></tr>
<tr><td>D3</td><td>Load</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D2</td><td>Save</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D1</td><td>Generates Coefficient of Correction</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D0</td><td>Shading Correction Function</td><td>0: OFF</td><td>1: ON</td></tr>
</table>
Note: This bit is cleared to “0” automatically after proceed selected operation.</td></tr>
<tr><td>20H: SVR [7:0]
21H: SVR [15:8]
22H: SVR [23:16]</td><td>[Exposure time of electronic shutter] Default data: SVR [23..0] = 0, Data range: 0 to 16,777,215
Sets the preset shutter speed (exposure time) for electronic shutter.
Exposure time (shutter speed) = 1 * SVR (µseconds)</td></tr>
<tr><td>24H:
LUA_GDA[7..0]
25H:
LUT_GDA[15..8]</td><td>[LUT_G data] Default data: LUT_GDA[15..0] = 0, Data range: 0 to 4,095
Sets data for selected LUT_G address.</td></tr>
<tr><td>26H:
LUA_BDA[7..0]
27H:
LUT_BDA[15..8]</td><td>[LUT_B data] Default data: LUT_BDA[15..0] = 0, Data range: 0 to 4,095
Sets data for selected LUT_B address.</td></tr>
<tr><td>28H:
DLY [7:0]</td><td>[Delay time for trigger signal] Default data: DLY [7..0] = 0, data range: 0 to 255
Sets the delay time from trigger signal input to start exposure.
Delay time = 2 * DLY [7..0] (µseconds)</td></tr>
<tr><td>28H:
DLY [7:0]</td><td>[Delay time for trigger signal] Default data: DLY [7..0] = 0, data range: 0 to 255
Sets the delay time from trigger signal input to start exposure.
Delay time = 2 * DLY [7..0] (µseconds)</td></tr>
<tr><td>29H:
BORD_TMP[7..0]</td><td>[Camera inside temperature] Default: BORD_TMP[7..0] = Variable
Obtains the temperature of inside of camera (temperature sensor on FPGA board)
(-128 to 127 deg. C)

Examples:
<table>
<tr><td>Temperature [deg. C]</td><td>Value (Binary)</td><td>Value (Decimal)</td></tr>
<tr><td>100</td><td>0110 0100</td><td>100</td></tr>
<tr><td>15</td><td>0000 1111</td><td>15</td></tr>
<tr><td>0</td><td>0000 0000</td><td>0</td></tr>
<tr><td>-1</td><td>1111 11111</td><td>255</td></tr>
<tr><td>-5</td><td>1111 11011</td><td>251</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>2BH:
CIS_TMP[7..0]</td><td>[Camera inside temperature] Default: CIS_TMP[7..0] = Variable
Obtains the temperature of inside of camera (temperature sensor on CMOS image sensor board)
(-128 to 127 deg. C)

Examples:
<table>
<tr><th>Temperature [deg. C]</th><th>Value (Binary)</th><th>Value (Decimal)</th></tr>
<tr><td>100</td><td>0110 0100</td><td>100</td></tr>
<tr><td>15</td><td>0000 1111</td><td>15</td></tr>
<tr><td>0</td><td>0000 0000</td><td>0</td></tr>
<tr><td>-1</td><td>1111 11111</td><td>255</td></tr>
<tr><td>-5</td><td>1111 11011</td><td>251</td></tr>
</table></td></tr>
<tr><td>30H: GAIN [7:0]</td><td>[Gain] Default data: GAIN [7:0] = 0, Data range: 0 to 255
Sets the analog gain and digital gain.

GAIN = GAIN[7..0] / 10 [dB]</td></tr>
<tr><td>35H:
FIL_TH[7..0]</td><td>[Threshold for binarization] Default data: FIL_TH[7..0] = 128, Data range: 0 to 255
Sets threshold for binarization.</td></tr>
<tr><td>37H:
GAM_SEL[3..0]</td><td>[Selection of Gamma coefficient] Default: GAM_SEL[3..0] = 12, Data range: 0 to 15
Sets gamma correction value for Gamma function.
(This setting valid when setting “On” at Gamma function)

Gamma = 1 / (1 + 0.1 x GAM_SEL[3..0])</td></tr>
<tr><td>38H:
CLAMP [7:0]</td><td>[Clamp level] Default data: CLAMP [7..0] = 40, Data range: 0 to 255
Sets the 10bits clamp level of black signal.</td></tr>
<tr><td>39H:
HOB_CLAMP[0]</td><td>[HOB clamp] Default data: HOB_CLAMP[0] = 0
Sets black level correction when releasing shutter while image output.

HOB_CLAMP[0] = 0 : Black level correction is Off
HOB_CLAMP[0] = 1 : Black level correction is On</td></tr>
<tr><td>3AH:
LUA_ADD[7..0]
3BH:
LUA_ADD[15..8]</td><td>[LUT address] Default data: LUT_ADD[15..0]=0, Data range: 0 to 4,095
Sets LUT_R address.</td></tr>
<tr><td>3CH:
LUA_RDA[7..0]
3DH:
LUT_RDA[15..8]</td><td>[LUT_R data] Default data: LUT_RDA[15..0]=0, Data range: 0 to 4,095
Sets data for selected LUT_R address.</td></tr>
<tr><td>3EH:
LUT_SET[7..0]</td><td>[LUT setting] Default data: LUT_SET[7..0] = 00H
Sets LUT setting for LUT save and load.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>
<table>
<tr><td>D7</td><td>No Function</td><td colspan="2">Always sets as "0"</td></tr>
<tr><td>D6</td><td>LUT save</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D5</td><td>LUT load</td><td>0: OFF</td><td>1: ON (*1)</td></tr>
<tr><td>D4</td><td>LUT enable</td><td>0: OFF</td><td>1: ON</td></tr>
<tr><td>D3 to D0</td><td>LUT select</td><td colspan="2">0 ～ 15</td></tr>
</table>
*1: This bit is cleared to “0” automatically after LUT process.</td></tr>
</table>

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>40H:
FIL1_TAP1[7..0]</td><td>[Spatial filter 1_TAP1 coefficient] Default data: FIL1_TAP1 [7..0] = 0xFF, Data range: -128 to 127
Sets TAP1 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>41H:
FIL1_TAP2[7..0]</td><td>[Spatial filter 1_TAP2 coefficient] Default data: FIL1_TAP2[7..0] = 0x00, Data range: -128 to 127
Sets TAP2 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>42H:
FIL1_TAP3[7..0]</td><td>[Spatial filter 1_TAP3 coefficient] Default data: FIL1_TAP3[7..0] = 0x01, Data range: -128 to 127
Sets TAP3 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>43H:
FIL1_TAP4[7..0]</td><td>[Spatial filter 1_TAP4 coefficient] Default data: FIL1_TAP4[7..0] = 0xFE, Data range: -128 to 127
Sets TAP4 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>44H:
FIL1_TAP5[7..0]</td><td>[Spatial filter 1_TAP5 coefficient] Default data: FIL1_TAP5[7..0] = 0x00, Data range: -128 to 127
Sets TAP5 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>45H:
FIL1_TAP6[7..0]</td><td>[Spatial filter 1_TAP6 coefficient] Default data: FIL1_TAP6[7..0] = 0x02, Data range: -128 to 127
Sets TAP6 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>46H:
FIL1_TAP7[7..0]</td><td>[Spatial filter 1_TAP7 coefficient] Default data: FIL1_TAP7[7..0] = 0xFF, Data range: -128 to 127
Sets TAP7 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>47H:
FIL1_TAP8[7..0]</td><td>[Spatial filter 1_TAP8 coefficient] Default data: FIL1_TAP8[7..0] = 0x00, Data range: -128 to 127
Sets TAP8 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>48H:
FIL1_TAP9[7..0]</td><td>[Spatial filter 1_TAP9 coefficient] Default data: FIL1_TAP9[7..0] = 0x01, Data range: -128 to 127
Sets TAP9 coefficient for Spatial filter 1.

Magnification = Set value (two’s compliment)
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>49H:
FIL1_ABS[0]</td><td>[Spatial filter 1_Absolute value] Default data: FIL1_ABS[0] = 1
Controls Spatial filter1.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D1</td><td>No Function</td><td colspan="2">Always sets as "0000000"</td></tr>
<tr><td>D0</td><td>Spatial filter 1 control</td><td>0: OFF</td><td>1: ON</td></tr>
</table>
</td></tr>
</table>

Command No.	Command Description
4AH: FIL1_SCA[7..0] 4BH: FIL1_SCA[15..8]	[Spatial filter 1_scaling coefficient] Default data: FIL1_SCA [15..0] = 4,096, Data range: 0 to 65,535 Sets scaling coefficient for Spatial filter 1. Magnification = Set value / 4,096 * Please refers "Spatial filtering" for more details.
4CH: FIL2_TAP1[7..0]	[Spatial filter 2_TAP1 coefficient] Default data: FIL2_TAP1 [7..0] = 0xFF, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
4DH: FIL2_TAP2[7..0]	[Spatial filter 2_TAP2 coefficient] Default data: FIL2_TAP2[7..0] = 0x00, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
4EH: FIL2_TAP3[7..0]	[Spatial filter 2_TAP3 coefficient] Default data: FIL2_TAP3[7..0] = 0x01, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
4FH: FIL2_TAP4[7..0]	[Spatial filter 2_TAP4 coefficient] Default data: FIL2_TAP4[7..0] = 0xFE, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
50H: FIL2_TAP5[7..0]	[Spatial filter 2_TAP5 coefficient] Default data: FIL2_TAP5[7..0] = 0x00, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
51H: FIL2_TAP6[7..0]	[Spatial filter 2_TAP6 coefficient] Default data: FIL2_TAP6[7..0] = 0x02, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
52H: FIL2_TAP7[7..0]	[Spatial filter 2_TAP7 coefficient] Default data: FIL2_TAP7[7..0] = 0xFF, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
53H: FIL2_TAP8[7..0]	[Spatial filter 2_TAP8 coefficient] Default data: FIL2_TAP8[7..0] = 0x00, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.
54H: FIL2_TAP9[7..0]	[Spatial filter 2_TAP9 coefficient] Default data: FIL2_TAP9[7..0] = 0x01, Data range: -128 to 127 Sets TAP1 coefficient for Spatial filter 2. Magnification = Set value (two's compliment) * Please refers "Spatial filtering" for more details.

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>55H:
FIL2_ABS[0]</td><td>[Spatial filter 2_Absolute value] Default data: FIL2_ABS[0] = 1
Controls Spatial filter 2.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D1</td><td>No Function</td><td colspan="2">Always sets as "0000000"</td></tr>
<tr><td>D0</td><td>Spatial filtering 2 control</td><td>0: OFF</td><td>D0</td></tr>
</table>
</td></tr>
<tr><td>56H:
FIL2_SCA[7..0]
57H:
FIL2_SCA[15..8]</td><td>[Spatial filter 2_scaling coefficient] Default data: FIL2_SCA [15..0] = 4,096, Data range: 0 to 65,535
Sets scaling coefficient for Spatial filter 2.

Magnification = Set value / 4,096
* Please refers “Spatial filtering” for more details.</td></tr>
<tr><td>78H:
TESTP [7:0]</td><td>[Test Pattern] Default data: TESTP [7..0] = 00H
Sets the output test pattern.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D4</td><td>No Function</td><td colspan="2">Always sets as “00000”</td></tr>
<tr><td rowspan="6">D3 to D0</td><td rowspan="6">Test Pattern</td><td>0: Off (Image output)</td><td>1: Gray scale image</td></tr>
<tr><td>2: Lamp image</td><td>3: 100% white image</td></tr>
<tr><td>4: 50% white image</td><td>5: Horizontal color bar image</td></tr>
<tr><td>6: Vertical color bar image</td><td>7: Gradation image</td></tr>
<tr><td>8: Sequence image1</td><td>9: Sequence image2</td></tr>
<tr><td>10 Gray scale image2</td><td>Others: Black image</td></tr>
</table>
</td></tr>
<tr><td>80H:
E2P [7..0]</td><td>[EEPROM control] Default data: E2P[7:0] = 00H
Controls the data writing to EEPROM.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D1</td><td>No Function</td><td colspan="2">Always sets as “0000000”</td></tr>
<tr><td>D0</td><td>Data writes to EEPROM</td><td>0: Prohibited</td><td>1: Accept</td></tr>
</table>
Note: This bit is cleared to “0” automatically after data writes into EEPROM.</td></tr>
<tr><td>90H:VASA [7..0]
91H:VASA [15..8]</td><td>[Vertical ROI_1 Start line] Default data: VASA [15..0] = 0, Data range: 0 to 1,016, Data adjustable unit: 8 lines
Sets the start line (vertical) of ROI.
The actual start line of ROI = this value (VASA) + 1</td></tr>
<tr><td>A0H:VAHA [7..0]
A1H:VAHA [15..8]</td><td>[Vertical ROI_1 Effective lines] Default data: VAHA [15..0] = 1,024, Data range: 8 to 1,024,
Data adjustable unit: 8 lines
Sets the effective lines (image height) of ROI.</td></tr>
<tr><td>B0H:HASA [7..0]
B1H:HASA [15..8]</td><td>[Horizontal ROI_1 Start pixel] Default data: HASA [15..0] = 0, Data range: 0 to 1,272,
Data adjustable unit: 8 pixels
Sets the start pixel (horizontal) of ROI.
The actual start pixel of ROI = this value (HASA) + 1</td></tr>
<tr><td>C0H:HAWA [7..0]
C1H:HAWA [15..8]</td><td>[Horizontal ROI_1 Effective pixels] Default data: HAWA [15..0] = 1,280,
Data range: 1TAP/2TAP: 8 to 1,280, 3TAP: 8 to 1,278,
Data adjustable unit: 8 pixels
Sets the effective pixels (image width, DVAL, LVAL) of ROI.</td></tr>
</table>

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>D0H:
DEF_M[7..0]</td><td>[Defective pixel correction control] Default data: PDC0 [7..0] = 00H

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7</td><td>Set coordinate of defective pixel position</td><td>0 to 1: Set the coordinate of defective pixel position
Sets the correspond positions in D2H to D5H registers to defective pixel coordinate number is assigned in D1H register.
(This bit is cleared to “0” automatically after sets coordinate of defective pixel position)</td></tr>
<tr><td>D6</td><td>Load coordinate of defective pixel position</td><td>0 to 1: Read the coordinate of defective pixel position
Reads the defective pixel coordinate number is assigned in D1H register corresponding position to D6H to D9H registers.
(This bit is cleared to “0” automatically after reads coordinate of defective pixel position)</td></tr>
<tr><td>D5</td><td>Save coordinate of defective pixel position into EEPROM</td><td>0 to 1: Save the coordinate of defective pixel positions into EEPROM
All 512 coordinate numbers of defective pixel position information are saved into EEPROM.
(This bit is cleared to “0” automatically after saves coordinate of defective pixel positions)</td></tr>
<tr><td>D4 toD0</td><td>No Function</td><td>Always sets as "00000"</td></tr>
</table>
</td></tr>
<tr><td>D1H:
PDC1[7..0]</td><td>[Defective pixel correction coordinate number] Default data: PDC1 [7..0] = 0
Sets the coordinate number of defective pixel correction.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D0</td><td>Defective pixel correction coordinate number</td><td>0 to 255</td></tr>
</table>
* PDC1[15..8]: DAH</td></tr>
<tr><td>D2H:
PDC_WX [7..0]
D3H:
PDC_WX [15..8]</td><td>[Defective pixel X position (Set)] Default data: PDC_WX [15..0] = 0, Data range: 0 to 639
Sets the X (horizontal) coordinate position of defective pixel for set position.</td></tr>
<tr><td>D4H:
PDC_WY [7..0]
D5H:
PDC_WY [15..8]</td><td>[Defective pixel Y position (Set)] Default data: PDC_WY [15..0] = 0, Data range: 0 to 511
Sets the Y (vertical) coordinate position of defective pixel for set position.</td></tr>
<tr><td>D6H:
PDC_RX [7..0]
D7H:
PDC_RX [15..8]</td><td>[Defective pixel X position (Read)] Default data: PDC_RX [15..0] = 0
Sets the X (horizontal) coordinate position of defective pixel for read position.</td></tr>
<tr><td>D8H:
PDC_RY [7..0]
D9H:
PDC_RY [15..8]</td><td>[Defective pixel Y position (Read)] Default data: PDC_RY [15..0] = 0
Sets the Y (vertical) coordinate position of defective pixel for read position.</td></tr>
<tr><td>DAH:
PDC1[15..0]</td><td>[Defective pixel correction coordinate number] Default data: PDC1 [15..0] = 0
Sets the coordinate number of defective pixel correction.

<table>
<tr><td>D15</td><td>D14</td><td>D13</td><td>D12</td><td>D11</td><td>D10</td><td>D9</td><td>D8</td></tr>
</table>

<table>
<tr><td>D15 to D7</td><td>Defective pixel correction coordinate number</td><td>0 to 255</td></tr>
</table>
* PDC1[7..0]: D1H</td></tr>
</table>

<table>
<tr><th>Command No.</th><th>Command Description</th></tr>
<tr><td>DEH:
DEF_M [7..0]</td><td>[Defective pixel correction mode] Default data: DEF_M [7..0] = 01H

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D2</td><td>No Function</td><td colspan="2">Always sets as “000000”</td></tr>
<tr><td>D1</td><td>Highlight corrected pixel</td><td>0: Disable</td><td>1: Enable</td></tr>
<tr><td>D0</td><td>Defective pixel correction</td><td>0: Disable</td><td>1: Enable</td></tr>
</table>
The corrected pixel is appeared with highlight when “Highlight corrected pixel” is enabled.</td></tr>
<tr><td>EEH:
MOD6 [7..0]</td><td>[The camera function mode] Default data: MOD6 [7..0] = 02H
Sets the camera TAP number for each setting.

<table>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>D3</td><td>D2</td><td>D1</td><td>D0</td></tr>
</table>

<table>
<tr><td>D7 to D3</td><td>No Function</td><td colspan="2">Always sets as “00000”</td></tr>
<tr><td rowspan="2">D2 to D0</td><td rowspan="2">TAP Configuration</td><td>0: 1TAP</td><td>1: 2TAP</td></tr>
<tr><td>2: 3TAP</td><td>Others: No Function</td></tr>
</table></td></tr>
</table>

13.4.3 Command sequence for data saves to EEPROM

Please follow the command sequence in below for data saves to EEPROM.

1) Sets “1” to command 80H.0 to accept “write control to EEPROM”.

2) Sends the EEPROM write command with data, which sets “1” for page selection.

3) The camera sends back one of below receiving code after EEPROM write command is proceeding.
   01H: Data saves to EEPROM correctly
   10H: EEPROM write error

4) Command 80H.0 is changed to “0” automatically after EEPROM write command is proceeding.

Note.1) The data does not save into EEPROM when command 80H.0 is “0”.

Note.2) The data of multiple continuous commands can save to EEPROM by one sets of above sequence (1) to 4)).
   e.g. Multiple continuous command: “10H, 11H, 12H and 13H” or “22H, 23H and 24H”.

Note.3) When save the data of multiple commands, which is not continuous commands, to EEPROM, it is necessary to operate multiple sets of above sequence (1) to 4)).
   e.g. Multiple commands: “10H, 13H, 19H and 1BH” or “20H, 23H and 25H”.

14 Revision History

Rev	Date	Changes	Note
00	2022/12/19	● New Document	

Note: Product specifications would be changed without notification.

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