ORCA-Lightning
Digital CMOS Camera
C14120-20P
Instruction manual

Thank you for your purchase

⚠CAUTION	• Follow the safety precautions in Chapter 1 in order to avoid personal injury and damage to property when using this camera. The manual describes the correct handling method of the camera and provides instructions that should be followed to avoid accidents. **Read this manual carefully** before using this camera. After reading this manual, store it in a location where you can refer to it at any time.

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HAMAMATSU PHOTONICS K.K.

A6540313-07

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1. SAFETY PRECAUTIONS

1-1 SYMBOLS

The symbols shown below are used for this camera.

⎓	Direct current
~	Alternating current

1-2 CLASSIFICATION OF WARNINGS

We have classified the warnings symbols that appear in this instruction manual and on the camera as follows for your convenience. Make sure that you fully understand them and follow the instructions they contain.

⚠WARNING	Improper handling of the camera without observing these warnings could lead to serious injury to the user and even death.
⚠CAUTION	Improper handling of the camera without observing these cautions could lead to personal injury to the user or damage to property.

	This symbol indicates a cautionary item that should be followed when handling the camera. Read the contents carefully to ensure correct and safe use.
	This symbol indicates an action that is forbidden. Read and follow the instructions carefully.
	This symbol indicates a compulsory action or instruction. Read and follow the instructions carefully.
Note	This symbol indicates a note to help you get the best performance from the camera. Read the contents of the note carefully to ensure correct and safe use. Failure to observe one of these notes might impair the performance of the camera.

1-3 BASIC PERCAUTIONS

⚠WARNING	
	**Power supply** Use the camera with the indicated voltage on the rating sticker. Using a different voltage can damage the camera and lead to fire or electric shock.
	**Cables** Do not place heavy objects on cables or bend them excessively. Doing so can damage the cables and lead to fire or electric shock.
	**Power supply cord** Use the accessory power supply cord when using this camera.
	**AC adapter** Use the accessory AC adapter when using this camera.
	Do not touch the plug with wet hands. Doing so can lead to electric shock.
	**Do not attempt to dismantle or modify the camera** Doing so can also lead to damage and even injury, as some internal components become very hot or high voltage. Do not touch parts that are not indicated in this manual.
	**Do not allow foreign objects** Such as combustible substances, metal objects or water to get inside the camera. These can damage the camera and lead to fire or electric shock.
	**In the event of an anomaly** Such as the image suddenly disappearing or the occurrence of a strange noise, a strange smell or smoke coming from the camera, immediately turn off the power switch and unplug the power supply cord and contact a Hamamatsu subsidiary or your local distributor. Do not attempt to repair the camera yourself.

⚠CAUTION	
	**AC adapter** When unplugging the power supply cord, do not pull on the cord. Remove the plug from the outlet to avoid causing electric shock or fire.
	When unplugging the power supply cord, do not pull on the cord, but remove the plug from the camera to avoid breakdown of the AC adapter or the camera.
	**Connecting and disconnecting cables** Always turn off the power supply of the peripheral device before connecting and disconnecting cables.
	**Mounting the camera** When mounting the camera to a tripod or other fixture, use the optional base plate. Be careful that the mounting screw does not enter more than 8 mm from the surface of the base plate. Screwing it in further can impair normal operation.
	**Screwing a C-mount lens (when using a C-mount)** Do not screw the lens more than 7 mm from the surface of the C-mount adapter on the camera. Doing so can scratch the protective glass. (Some wide-angle lenses in particular can have a thread of 7 mm or more.)
	**Shipping precautions** When transporting the camera by truck, ship, airplane, etc., wrap it securely in packaging material or something similar.
	**Strong impact** Do not subject the camera to strong shocks (such as dropping it). Doing so can damage the camera.
	**Operating environment** This camera is designed and tested for use in an industrial environment. If this camera is used in residential areas, EMI (electro-magnetic interference) may occur. This camera must not be used in residential areas.
	**Disposal** When disposing of the camera, take appropriate measures in compliance with applicable regulations regarding waste disposal and correctly dispose of it yourself, or entrust disposal to a licensed industrial waste disposal company. In any case, be sure to comply with the regulations in your country, state, region or province to ensure the camera is disposed of legally and correctly.

2. CHECK THE CONTENTS OF PACKAGE

When opening the package, check that the following items are included before use.
If the contents are incorrect, insufficient or damaged in any way, contact a Hamamatsu subsidiary or your local distributor before attempting to operate the camera.

[Standard configuration]

Camera: C14120-20P	1
AC adapter	1
Power supply cord for AC adapter	1
F-mount lens cap (attached to the camera)	1
C-mount adapter	1
C-mount lens cap (attached to the C-mount adapter)	1
Hexagonal wrench	1
C14120-20P Before Use (Booklet)	1
C14120-20P Instruction manual (CD-ROM)	1

[Options]

SMA-BNC cable	A12106-05
SMA-SMA cable	A12107-05
CoaXPress interface board	M9982-30
CoaXPress interface cable (4 cables)	A14590-03-40 (3 m)
Circulating water cooler	C3142-11
Cooling water hose (2 hoses)	A10788-04
Adjustable pole for C14120-20P	A14490-01
Base plate for C14120-20P	A14491-01

- Use the above options for the CoaXPress interface board (M9982-30) and the CoaXPress interface cables (A14590-03-40). If a board and cables other than the options are used, the camera cannot acquire images properly.

Note

- The cable listed in option is highly recommended for use with the camera. The camera system may not confirm to CE marking regulation if other type of cable is used with.

Note

- If you use the above options, please refer to the each installation manual.

Note

- Store the unused contents. Do not lose them.

3. INSTALLATION

Avoid using or storing this camera in the following places

- Places where the temperature is not the operating temperature indicated in the specifications
- Places where the temperature is not the storage temperature indicated in the specifications
- Places where the temperature varies greatly
- In direct sunlight or near a heater
- Places where the humidity levels are not the operating humidity levels indicated in the specifications and where the camera may be exposed to liquid
- Places where the humidity levels are not the storage humidity levels indicated in the specifications and where the camera may be exposed to liquid
- Close to a strong source of magnetism or ratio waves
- Places where there are vibrations
- Places where the camera may come into contact with corrosive gases (such as chlorine or fluorine)
- Places where there is a lot of dust

Do not allow the ventilation ports to become blocked

To prevent the camera from overheating, do not wrap the camera in cloth or any other material, or in any way allow the camera's ventilation ports to become blocked. If the camera is being operated in a closed environment, ensure clearance of at least 10 cm from both the intake (Fan) and the exhaust (Air outlet) vents when setting up the camera.

Weight of the camera

Be careful not to drop the camera when carrying it as it is approx. 3.6 kg.

Accessories installation

When the mount adapter, the adjuster pole or the base plate is installed, always secure a space where you can work stably and do it without risks.
The C14120-20P instruction manual and each installation manual should be followed.

Contents

4. OVERVIEW

C14120-20P is equipped with the new scientific image sensor, an advanced CMOS device that realizes the multiple benefits of high resolution, high readout speed, and low noise all at once.
The setting and the control of the camera are operated by the application software.

5. FEATURES

(1) Pixel size and pixel number

The CMOS image sensor mounted on the camera has a smaller pixel size compared to the conventional ORCA-Flash4.0 series (such as C13440-20CU), but since it has a large number of pixels, it achieves about twice the field of view than the conventional.

Sensor specification	C14120-20P (H × V)	Other camera (H × V) (example for C13440-20CU)
Cell size	5.5 µm × 5.5 µm	6.5 µm × 6.5 µm
Effective number of pixels	4608 × 2592	2048 × 2048
Effective area	25.344 mm × 14.256 mm	13.312 mm × 13.312 mm

(2) Cooling structure

Cooling of this equipment is done using a Peltier element. With a Peltier element, when current is supplied, one surface is cooled, and the other surface is heated. CMOS image sensor is positioned on the cooled side, and cooling is done by discharging the heat from the heated surface.

(3) Protection circuit

This camera's thermoelectric cooling device is protected by a thermal protection circuit. If the internal temperature of the camera becomes abnormally hot, the protection circuit operates to inform the user by a buzzer alarm (beep tone) and switch the STATUS lamp in red while simultaneously cutting the current supply to the Peltier element.

(4) Readout noise

The readout noise of the camera achieves a low noise performance or more than the conventional cooled CCD image sensor.
In the camera, the pixel amplifier is optimized: it has high gain from optimizing the semiconductor process, and the difference among pixel amplifiers is greatly minimized. In addition, there is on-chip CDS (correlated double sampling) circuit, which plays an important role in achieving low noise.

(5) Readout method of CMOS image sensor

The exposure and the readout method of CMOS image sensor which this camera adopts is rolling shutter. In the rolling shutter, the exposure and readout are done four lines and the data of each horizontal line is read by four lines of column amplifier and A/D simultaneously. As a result, it achieves very fast readout speed while keeping very good low-noise performance.
Therefore, the exposure timing is different on one screen. However, even if the object moves during the exposure, the affect of rolling shutter is very small.

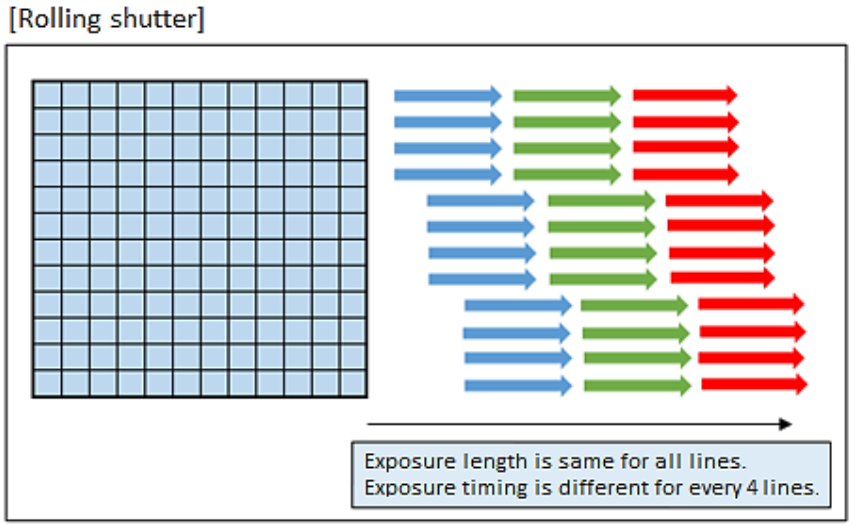


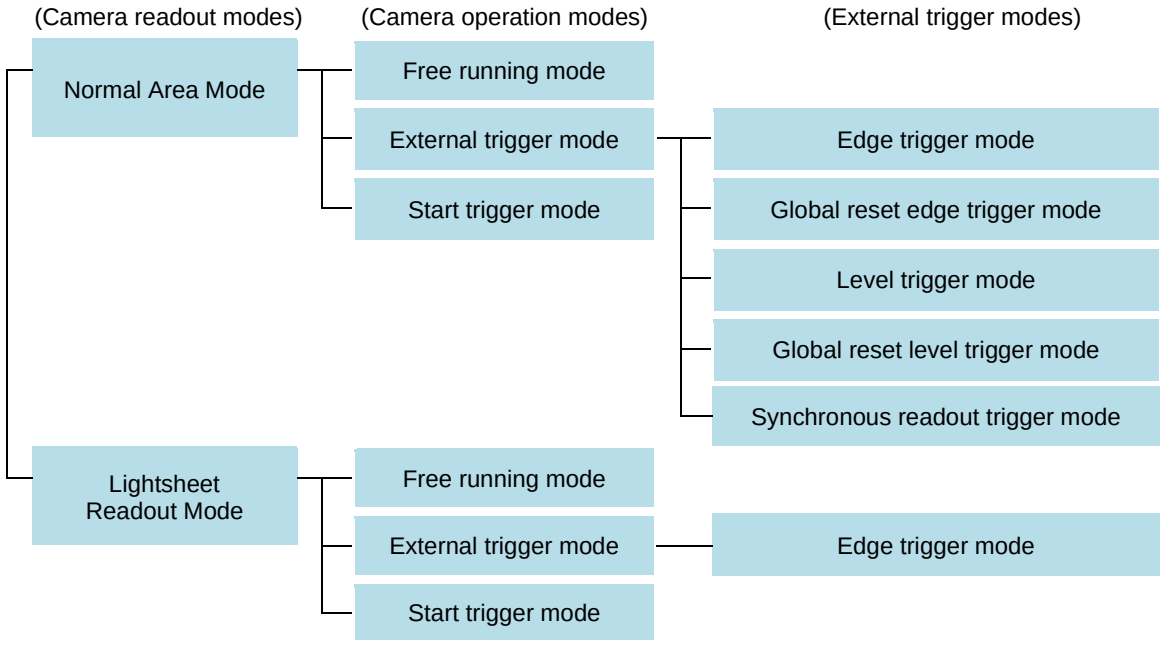
Figure 5-1

(6) Modes for the image acquisition: Camera readout modes, Camera operation modes, Readout methods

This camera has various modes for the image acquisition. The modes are set in the following functions. (Refer to 10 “CAMERA SETTINGS AND FUNCTIONS”)

- Camera readout modes : How to the readout of image
- Camera operation modes : How to the image acquiring of the camera
- Readout methods : Units for reading out images

[Relationship diagram]



[Readout methods]

Readout methods	Readout unit	Readout area
Normal readout	1×1 step (1 pixel)	Whole area
Binning readout (Digital binning)	2×2 step (2 pixel (H) × 2 pixel (V))	Whole area
	4×4 step (4 pixel (H) × 4 pixel (V))	
Sub-array readout	1×1 step (1 pixel)	Designated area

(7) Trigger outputs (Controlling external equipment)

This camera has “Trigger output function” to be able to control external equipment from the camera. (Refer to 10-7 “TRIGGER OUTPUTS”)

(8) Real-time defect pixel correction

This camera is correcting the dispersion of the readout noise between pixels during the image acquisition. There is no effect to a frame rate by this. (Refer to10-8 “REAL-TIME DEFECT PIXEL CORRECTION”)

(9) Full well capacity mode (FWC mode)

In this camera, High FWC mode which is suitable for high dynamic range imaging is selectable in addition to Standard FWC mode which is suitable for both high speed and low readout noise imaging. (Refer to 10-9 “HIGH FULL WELL CAPACITY MODE”)

6. NAME AND FUNCTION PARTS

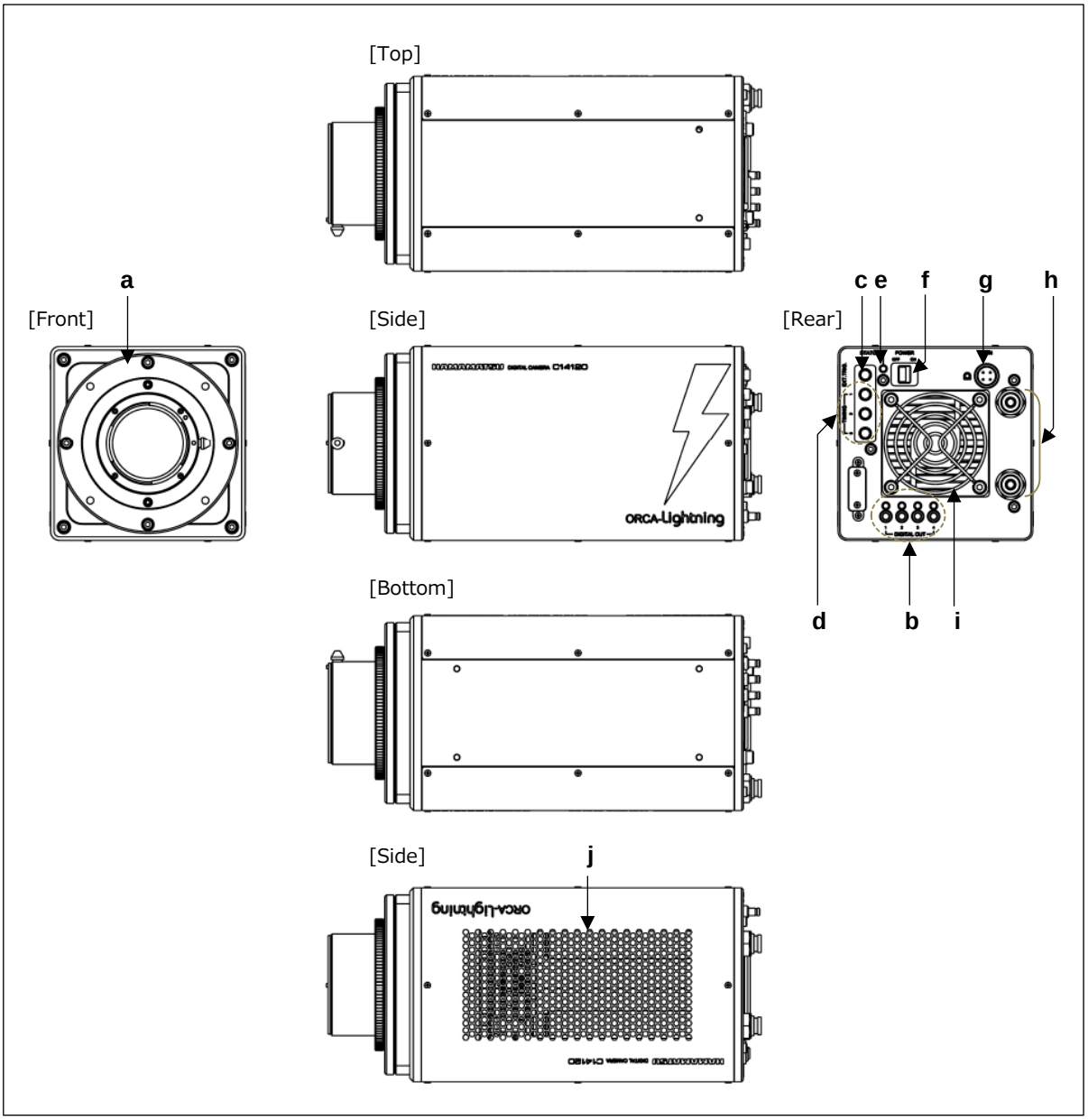


Figure 6-1

a. Lens mount
b. CoaXPress interface connector 1, 2, 3, 4
c. Trigger input connector
d. Timing out connector 1, 2, 3
e. STATUS lamp
f. Power switch
g. DC power input connector
h. WATER connector
i. Fan
j. Air outlet

⚠CAUTION	• Do not connect anything to a connector not to use.
⚠CAUTION	• When the camera heats up (STATUS lamp stays on red), stop operation and unplug the AC adapter immediately.

• Refer to 7. “CABLE CONNECTIONS” for the cabling of connectors.

a. Lens mount

This attaches an optical lens or an optical system with an optical lens.
It can attach the type of F-mount, C-mount or TFL-II-mount either.
It is attached F-mount adapter by default. When used C-mount type, it need to change to the C-mount adapter. When used TFL-II-mount, it need to remove the mount adapter from the camera. Refer to 8-4 "EXCHANGING / DETACHING OF MOUNT ADAPTER".

- Do not to screw the lens more than 7 mm from the surface of the C-mount adapter on the camera. Doing so can scratch the protective glass.

b. CoaXPress interface connector 1,2,3,4

This is the cable to connect the CoaXPress interface connector of the camera and the CoaXPress interface connector on the computer.
Each connector on the CoaXPress interface board and the camera has a number. When they are connected, connect the same number of connectors to each other with CoaXPress interface cables.
In addition, each connector on the camera has a LED lamp. All the lamps stay on green when the interface is ready to communicate after turning on the camera.

- Launch the application software after all the lamps stay on green. Because the computer does not recognize the camera.

Note

- All the lamps do not stay on green when the computer (CoaXPress interface board) is not turned on.

c. Trigger input connector [EXT.TRIG]

This is used when the camera is being operated using external synchronization.
Input is 3.3 V LVCMOS level, and input impedance is 10 kΩ.
When an external trigger is input, the trigger is activated at the falling or rising edge of the signal. (You can choose external trigger polarity between Negative and Positive.)

Note

- Please refer to 10-3 “CAMERA OPERATION MODES” for the details of External trigger mode and Start trigger mode.

d. Timing out connector 1, 2, 3 [TIMING 1, 2, 3]

This is used when peripheral device(s) require synchronization with the camera.
There are 3 connectors that can output 3 types of signals. There is no specified connection order for the connector.
Output is 3.3 V LVCMOS level, and it is output though BUS TRANSCEIVER IC SN74LVC541.
Output impedance is 33 Ω.

Note

- Please refer to 10-7 “TRIGGER OUTPUTS” for the details of the trigger outputs function.

e. STATUS lamp [STATUS]

The LED indicates status of the camera.

Status of power distribution	Lighting color
Power off	Turn off
Power on - initialization	Orange (Flashing)
Ready to operate	Green
Date transfer	Orange
Heat up	Red

f. Power switch [POWER]

The power is turned on/off.
When the camera is turned on, the camera starts to initialize and after the initialization is complete, the camera can be operated.

g. DC power input connector [DC IN]

This is the power supply terminal. Use the accessory AC adapter.

h. WATER connector for Water-cooling [WATER]

They connect to the water connectors on the circulating water cooler with the cooling water hoses. The connector position of WATER IN/OUT is not specified. If Water-cooling is used, refer to 11. “WHEN USING WATER-COOLING METHOD”.

i. Fan for Air-cooling

This is a fan for heat ventilation that blown air inside the camera.
The fan does not work in Water-cooling.

- If the camera is being operated in an enclosed environment, ensure to keep clearance at least 10 cm from both intake and exhaust vents when setting up.

- To prevent overheating inside the camera, do not wrap the camera in cloth or other material, or block the camera’s ventilation.

j. Air outlet

This is the outlet for heat ventilation.

- If the camera is being operated in an enclosed environment, ensure to keep clearance at least 10 cm from both intake and exhaust vents when setting up.

- To prevent overheating inside the camera, do not wrap the camera in cloth or other material, or block the camera’s ventilation.

7. CABLE CONNECTIONS

Refer to the figure when connecting the various cables.

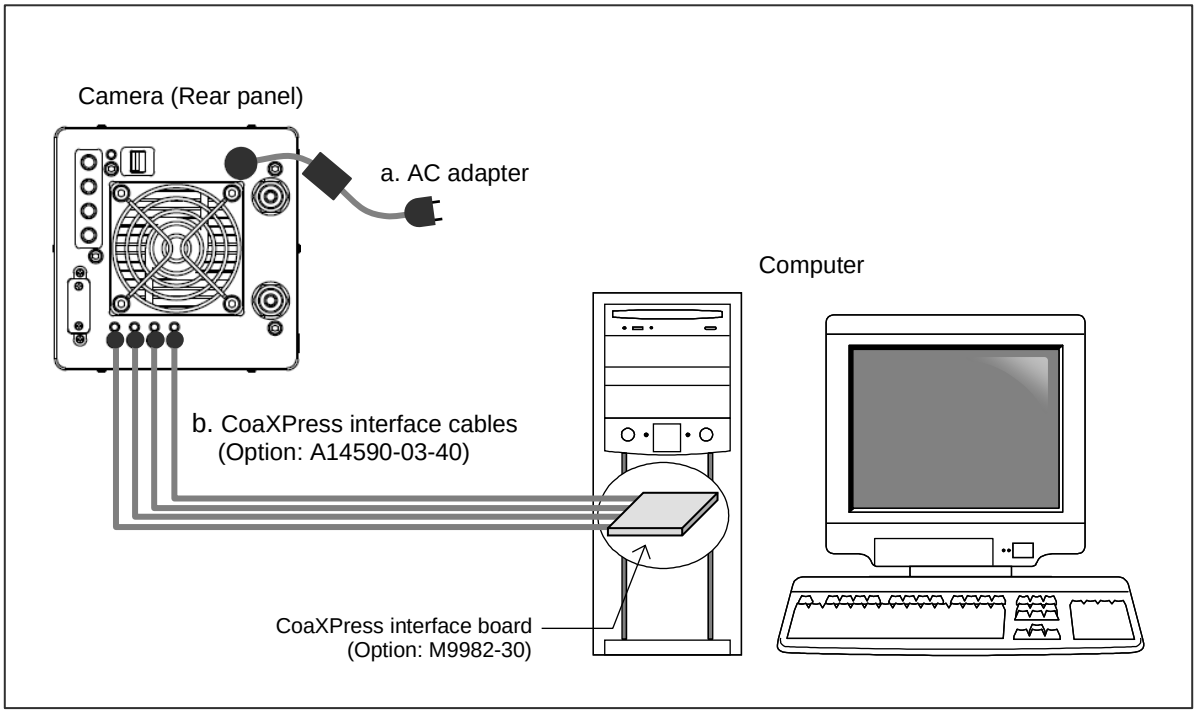


Figure 7-1

a. AC adapter

This is the cord to supply a power supply. Use the accessory AC adapter.

b. CoaXPress interface cables (Option)

These are four cables to connect the CoaXPress interface connector of the camera and the CoaXPress interface connector on the computer.
Each connector on the CoaXPress interface board and the camera has a number. When they are connected, connect the same number of connectors to each other with CoaXPress interface cables.

⚠CAUTION	• When cables are connected, turn off the power supply of the camera and peripheral devices.

!	• Use the above options for the CoaXPress interface board (M9982-30) and the CoaXPress interface cables (A14590-03-40). If a board and cables other than the options are used, the camera cannot acquire images properly.
Note	• Hamamatsu recommends A14590-03-40 optional CoaXPress interface cable for this camera. The camera complies with EMC direction with using A14590-03-40 CoaXPress interface cable. Be careful that the camera with other interface cable may not fulfill the EMC directive requirements.
Note	• If options are used, handle those according to the instructions of each installation manual.

8. OPERATIONS

This camera can be started after setup.
The setting and the control of the camera are operated by the application software.

8-1 PRECAUTION FOR IMAGING

(1) Ambient temperature

The recommended ambient temperature for camera operation is 25 °C.
The maximum temperatures to which the CMOS image sensor can be cooled, and the stability of the cooled temperature, are affected by the ambient temperature. The ambient temperature should be maintained at a constant temperature for camera operation is 25 °C.

(2) Protection circuit

This camera's thermoelectric cooling device is protected by a thermal protection circuit.
If the internal temperature of the camera becomes abnormally hot, the protection circuit operates to inform the user by a buzzer alarm (beep tone) and switch the STATUS lamp in red while simultaneously cutting the current supply to the Peltier element. As soon as this protection is implemented, turn off the power switch, unplug the AC supply. Then remove the cause of the overheating when it is cooled down.

(3) Cooling methods

The camera has two cooling methods, Air-cooling method and Water-cooling method. The default of cooling method is Air-cooling.
The cooling mode can be changed by software which is called, "DCAM Configurator". Refer to 11-5 "SWITCHING THE COOLING METHOD OF "DCAM CONFIGURATOR"".

Cooling method	Detail
Air-cooling (Default)	The heated side of a peltier element is cooled by a fan inside the camera. When the camera is turned on, the fan starts rotating and cooling is started.
Water-cooling	Circulating water cooler (Option) is used for cooling the heated side of a peltier element. Cooling does not start just turning on the camera. Cooling water circulation must be started before start operating the camera in water-cooling. A fan inside the camera does not rotate. Refer to 12-2 "WHEN USING AT WATER-COOLING" for the details.

When the setting is changed, restart the camera. By restarting, the setting is reflected on the camera. After cooling method was switched, the camera memorizes the last setting as the default setting for cooling.
The setting of DCAM Configurator is maintained, even if the power supply of the camera is turned off.

8-2 SET UP

First, set up the following before operating the camera.

(1) Setup of the computer and installation of an application software

Set up a computer to use beforehand, such as installing interface or application software. Perform these procedures according to the each instruction manual.

(2) Preparing the mount adapter for attaching the lens

When using the F-mount, the lens can be attached to the camera in state of the product shipment. The F-mount adapter is already attached at the product shipment.

- When using the F-mount lens, it is just attached.
- When using the C-mount, change to the dedicated adapter for the C-mount. (Refer to 8-4-1)
- When using the TFL-II-mount, detach the adapter attached to the camera. (Refer to 8-4-2)

When the mount part is ready, attach the same type of a lens or an optical system.

⚠CAUTION	• When using the C-mount, do not to screw the lens more than 7 mm from the surface of the C-mount adapter on the camera. Doing so can scratch the protective glass. (Some wide-angle lenses in particular can have a thread of 7 mm or more.)

(3) Connecting to peripherals and outlets

Perform these connections according to 7. “CABLE CONNECTIONS”.

About CoaXPress interface connectors;
Each connector on the CoaXPress interface board and the camera has a number. When they are connected, connect the same number of connectors to each other with CoaXPress interface cables.

⚠CAUTION	• When cables are connected, turn off the power supply of the camera and peripheral devices.

(4) When the camera is fixed by options

When the options such as Adjuster pole or Base plate are used and the camera is fixed, attach according to procedure of each installation manual.

8-3 OPERATING PROCEDURE

After setup, operate Air-cooling according to the following.
Handle the application software and peripherals according to each instruction.

SET UP (Section 8-2)

↓

Turn on the camera

↓

Make sure the cooling fan is turning

↓

Turn on the computer and peripherals

↓

Make sure “STATUS lamp” and “CoaXPress interface connector lamps” stay on green

↓

Launch the application software

↓

Camera setting *****

(* Set the camera setting when there is necessary for using application software. Refer to Chapter 10.)

↓

Image acquisition

↓

End of imaging

End of image acquisition and software → Turn off all the power

⚠CAUTION	• The operating procedure for Water-cooling method is different from the above. Refer to 11-4. “WHEN USING WATER-COOLING METHOD” for the details.

8-4 EXCHANGING / DETACHING OF MOUNT ADAPTER

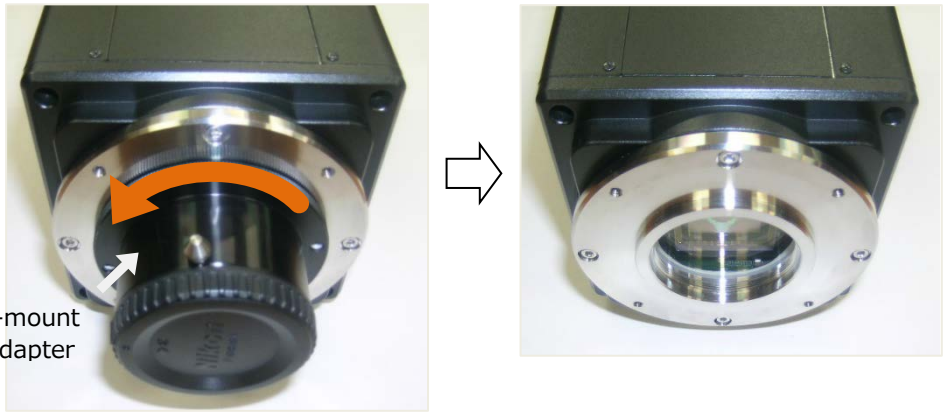
When using the C-mount lens or the TFL-II-mount lens, exchanging or detaching a mount adapter according to the following.

⚠CAUTION	• When the mount adapter is installed, always secure a space where you can work stably and do it without risks.
⚠CAUTION	• When the mount adapter is attached or detached, be careful not to make a scratch and not to put dust on the window glass in front of the camera.

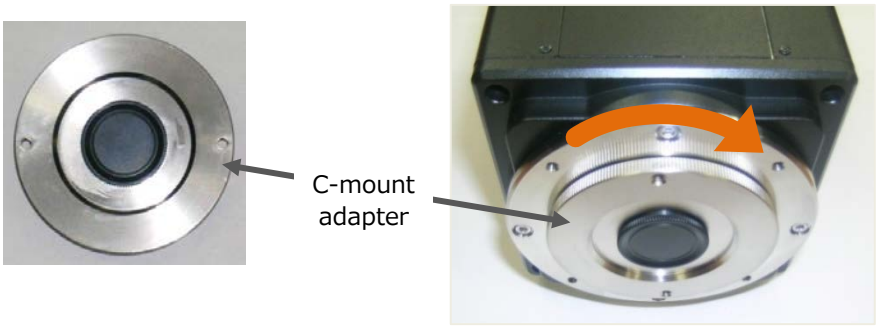
8-4-1 When using C-mount lens: Exchange from F-mount adapter to C-mount adapter

1. Loosen the 2 screws of the F-mount adapter by using the hexagonal wrench included as a camera accessory.

2. Turn counterclockwise and detach the F-mount adapter from the lens mount of the camera.



3. Fit the C-mount adapter which is accessory of the camera into the center of the lens mount. Turn it clockwise and tighten the screw surely.



4. Tighten the 2 screws of the C-mount by using the hexagonal wrench.

5. Attach the C-mount lens on the adapter.

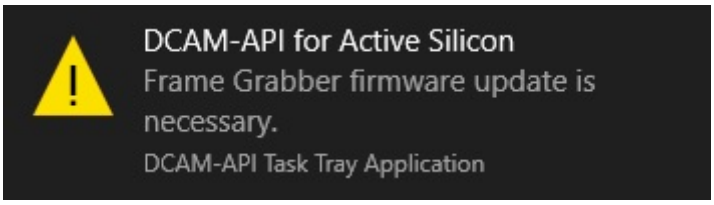
- Use a lens with the screw part of less than 7 mm.

8-4-2 When using TFL-II-mount: Detach F-mount adapter

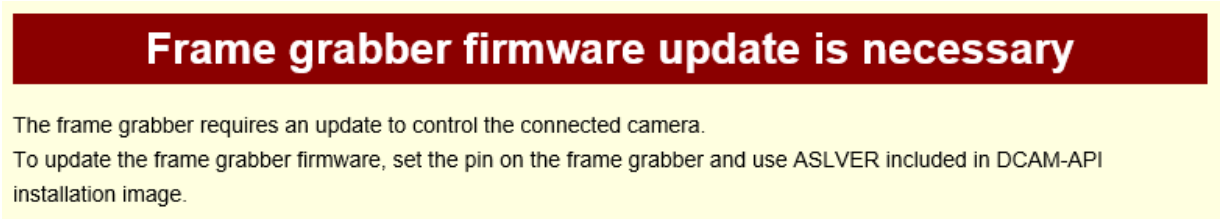
1. As in the preceding paragraph, turn counterclockwise and detach the F-mount adapter from the lens mount of the camera.
2. Attach the TFL-II-mount lens on the lens mount.

8-5 UPDATE PROCEDURE OF COAXPRESS INTERFACE BOARD

If you use an optional CoaXPress interface board, when the driver included in DCAM-API does not match the firmware version of the interface board, the following message prompting update of the interface board may be displayed.



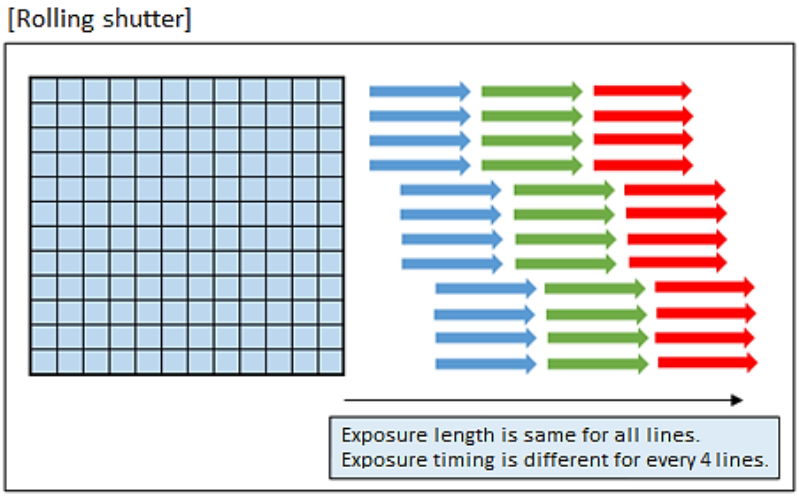
When this message is displayed, you need to update the firmware of the interface board to use the connected camera. In this case, an update procedure manual will be displayed when you click on the message. Please update the interface board according to the procedure manual.



9. ABOUT IMAGE ACQUISITION

9-1 READOUT METHOD OF THE IMAGE

This camera uses scientific CMOS image sensor. The exposure and the readout method of CMOS image sensor which this camera adopts is rolling shutter. In the rolling shutter, the exposure and readout are done four lines simultaneously. Therefore, the exposure timing is different on one screen. However, even if the object moves during the exposure, the affect of rolling shutter is very small.



9-2 PRECAUTIONS WHEN USING THE SENSOR

Careful attention must be paid to the following points when using CMOS image sensor.

(1) White spot

Subjecting CMOS image sensor to extended exposures may cause failure in part of the silicon wafer, resulting in white spots. Currently this phenomenon is not preventable. If CMOS image sensor is at a fixed temperature, recurrence of the white spot increases proportionally with the exposure time, so this can be rectified with dark subtraction*. Cosmic ray may generate white spot.

* Dark subtraction: After acquiring an image using a certain exposure time is loaded, CMOS image sensor is exposed to darkness for the same amount of time, and another image is obtained. After this, the difference between the images is determined, and the data for the dark portion of the original image is nullified.

(2) Folding distortion

A rough-edged flicker may be visible when imaging striped patterns, lines, and similar subject matter.

(3) Excessive light

⚠CAUTION	• Be careful not to input too strong light such as high-energy laser into CMOS image sensor because CMOS image sensor may be damaged by excessive light.

10. CAMERA SETTINGS AND FUNCTIONS

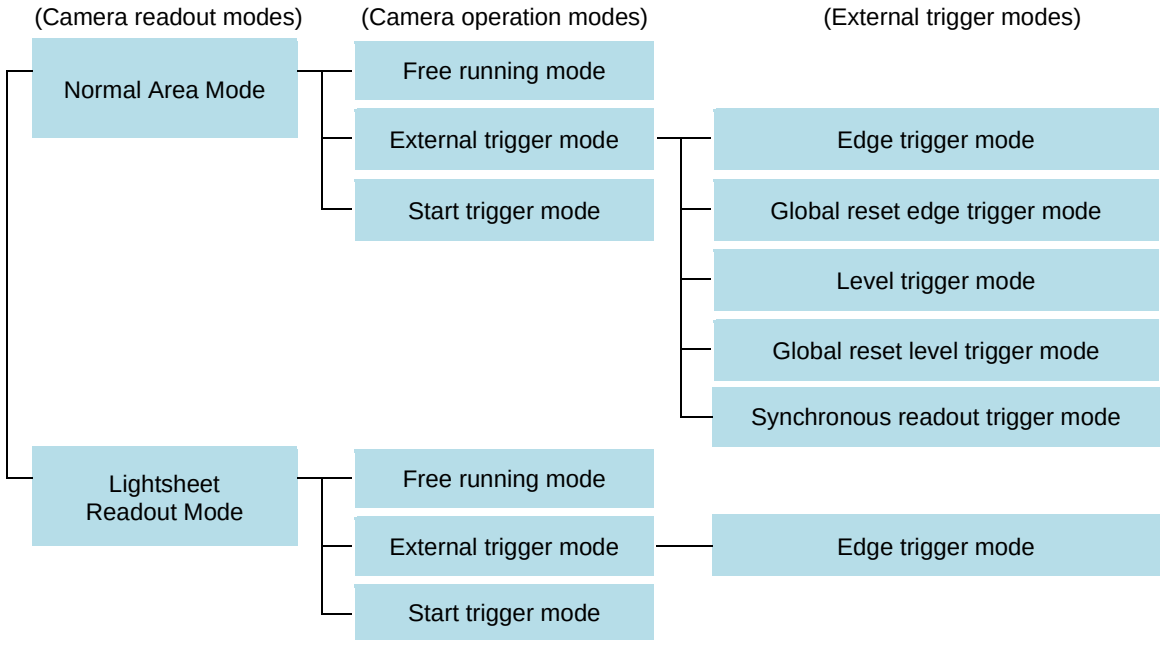
The camera setting and operating is controlled by the connected computer (the application software).

10-1 SETTINGS AND FUNCTIONS

The following are the camera's settings and functions.

Items	Outlines [Default]	Refer to
Camera readout modes	Choose the readout method of image. [Norma Area Mode]	10-2
Camera operation modes	Choose the synchronization control system of the camera among an internal synchronization (Free running mode) or an external synchronization (External trigger mode, Start trigger mode). [Free running mode]	10-3
Readout methods	Choose the unit of readout pixel. When Sub-array readout is chosen, the readout area is specified. [Full resolution readout]	10-4
Exposure time setting	Set the exposure time when the following modes; Free running mode, Edge trigger mode, Global reset edge trigger mode [8.2 ms at Free running mode and 12 bit digital output]	10-6
Trigger outputs	The camera controls an external device. [OFF]	10-7
Real-time defect pixel correction	The unevenness of the noise of the pixel is leveled in real time. [ON]	10-8
High Full Well Capacity mode	The full well capacity is increased, and enable 16 bit digital output. [OFF]	10-9

[Relationship diagram]



[Setting parameters]

The setting parameters are different by the camera readout modes.

(✓: enabled, –: disabled)

Functions			Normal Area Mode	Lightsheet Readout Mode
Camera operation modes	Free running mode		✓	✓
	External triggermode	Edge trigger mode	✓	✓
		Global reset Edge trigger mode	✓	–
		Level trigger mode	✓	–
		Global reset Level trigger mode	✓	–
		Synchronous readout trigger mode	✓	–
	Start trigger mode		✓	✓
Readout methods	Normal readout: 1x1		✓	✓
	Binning readout: 2x2, 4x4		✓	–
	Sub-array readout		✓	✓
Exposure time settings	It depends on each calculating formula.		✓	✓
Trigger outputs	Global exposure timing output		✓	–
	Programmable timing output 1,2,3		✓	✓
	Trigger ready output		✓	✓
	Continuous High output (Positive)		✓	✓
	Continuous Low output (Negative)		✓	✓
Real-time defect pixel correction			✓	✓
High Full Well Capacity mode			✓	✓

10-2 CAMERA READOUT MODES

This mode is for acquiring the image. There are two following modes. The default is “Normal Area Mode”. The “Lightsheet Readout Mode” is chosen if the lightsheet microscope is used.

10-2-1 Normal Area Mode

Images are readout with the timing depending on the horizontal pixel numbers and the vertical line numbers. The high frame rate will be maintained because 4 horizontal lines are readout simultaneously.

Note

- Please refer to 10-10 “REFERENCE: FRAME RATE CALCULATION METHOD” about the frame rate.

10-2-2 Lightsheet Readout Mode

Lightsheet Readout Mode is a unique feature of CMOS image sensor which provides improved control over the rolling shutter mechanism.
By finely synchronizing the camera readout with the illumination scan, scattered light is rejected allowing images of higher signal to noise ratios to be acquired.

The detail information of Lightsheet Readout Mode is published on our website.

Website http://www.hamamatsu.com/jp/ja/technology/innovation/lightsheetreadout/index.html

10-3 CAMERA OPERATION MODES

This mode is for controlling the timing of readout and exposure.
This mode can use; Free running mode, Edge trigger mode (External trigger mode), and Start trigger mode.

Note

- Please contact a Hamamatsu subsidiary or your local distributor for the detail of the timing information.

10-3-1 Free running mode

The camera has Free running mode which the exposure and readout timing can be set and controlled by an internal microprocessor. The exposure time is set by application software.

(1) In Normal Area Mode

This mode has “Normal readout operation” (in which the exposure time is longer than the one frame readout time) and “electrical shutter operation” (in which the exposure time is shorter than the one frame readout time). These operations are automatically switched depending on the exposure time setting.

a. Normal readout operation or action

The operation is suitable for observation, monitoring, field of view and focus adjustment, and animation because it can operate with full resolution, which is faster than the video rate.
In addition, the exposure time can be extended to collect more signals and increase the signal to noise ratio if the object is dark. In this operation, the exposure time is the same or longer than the 1 frame readout time. In this mode, the frame rate depends on the exposure time, and it becomes frame rate = 1/exposure time. The maximum exposure time is 1 s.

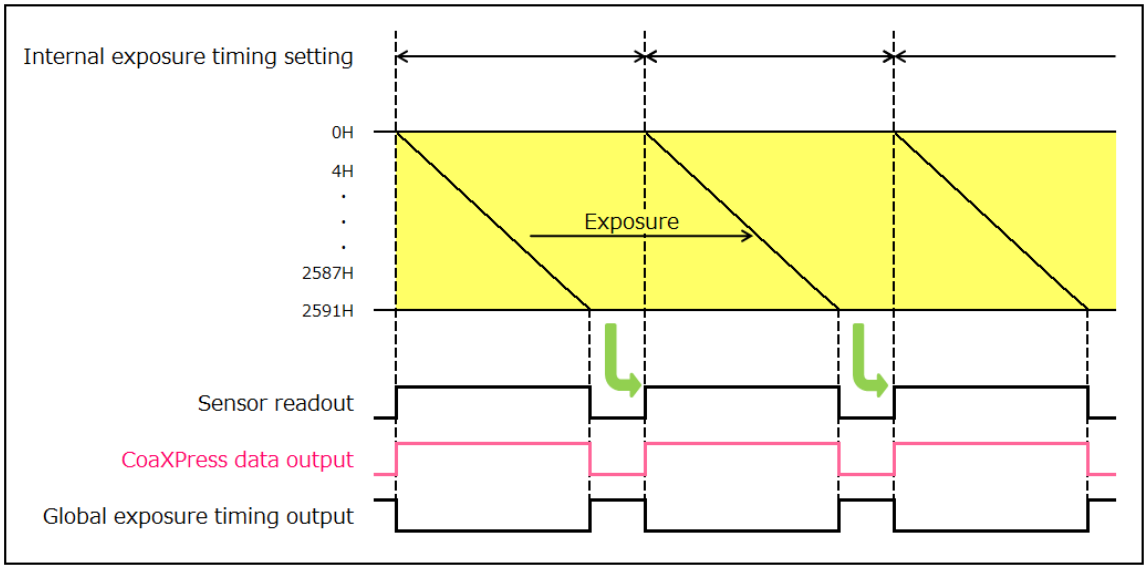


Figure 10-1

b. Electrical shutter operation or action

The electrical shutter operation is used to get a proper signal level when signal overflow happens due to too much input photons in the normal readout operation. In this operation, the fastest frame rate is operated at full resolution even when the exposure time is short.

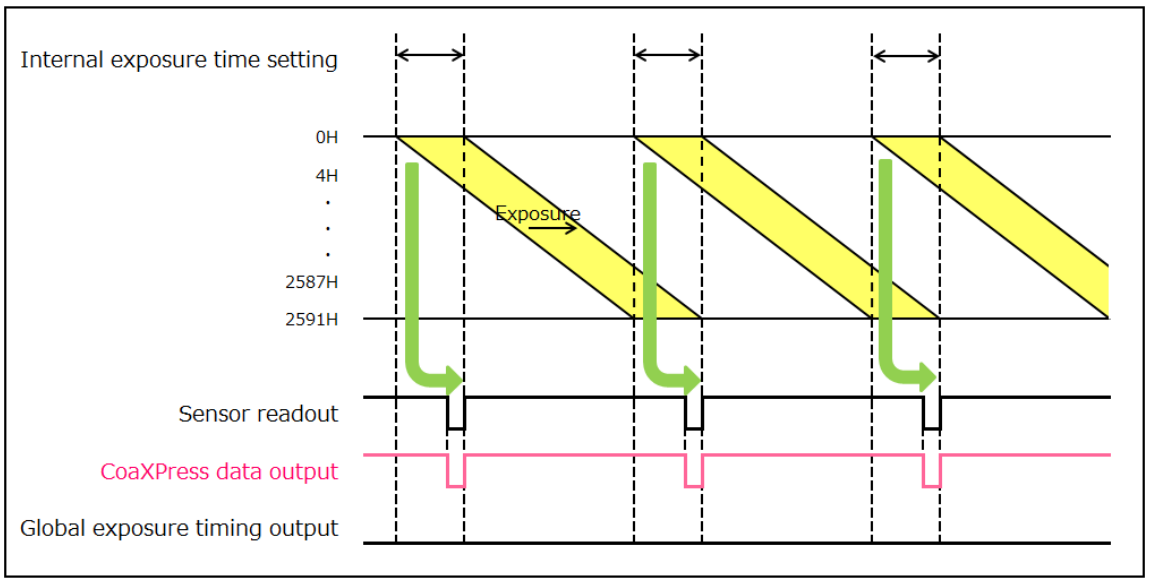


Figure 10-2

(2) In Lightsheet Readout Mode

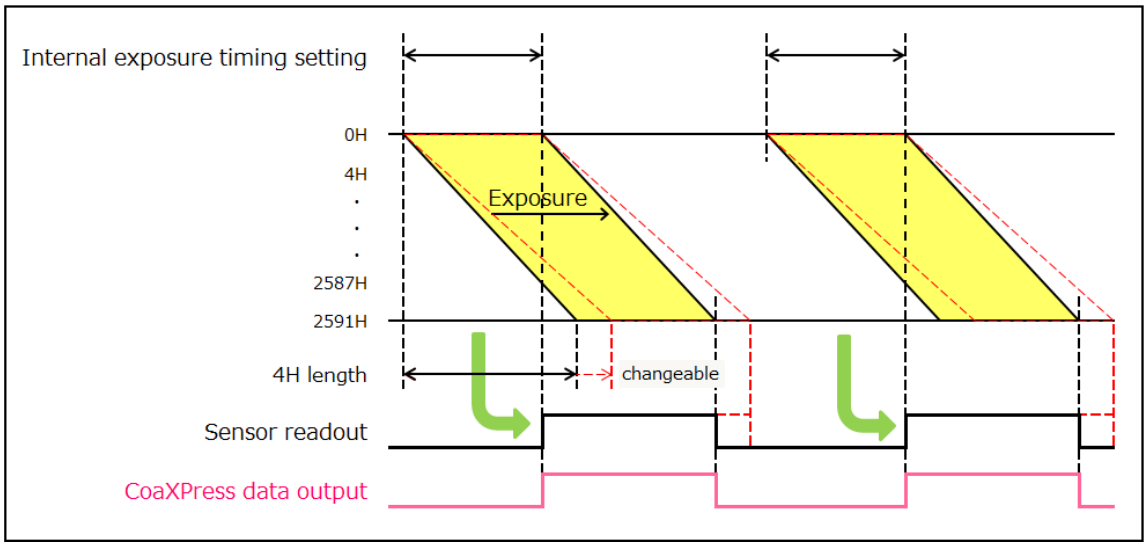


Figure 10-3

10-3-2 External trigger mode

The camera has various external trigger functions to synchronize the camera with the external equipment. In this mode, the external equipment becomes a master and the camera becomes a slave. The mode has the following kinds.

(✓: enabled, –: disabled)

Functions		Normal Area Mode	Lightsheet Readout Mode
External trigger mode	Edge trigger mode	✓	✓
	Global reset Edge trigger mode	✓	–
	Level trigger mode	✓	–
	Global reset Level trigger mode	✓	–
	Synchronous readout trigger mode	✓	–

Incidentally, External trigger mode has “External trigger delay function”.
In most cases when a delay between the laser pulse emission and the exposure start is needed, a delay unit is set between the laser and camera to control trigger timing. In each external trigger mode of the camera, the delay can be set to the trigger signal input to the camera by command. With this setting, a range of trigger can be arranged without a delay unit. The range for delay time is 0 µs to 10 s (1 µs steps).

Note

- Please contact a Hamamatsu subsidiary or your local distributor for the detail of the timing information.

(1) Edge trigger mode

Edge trigger mode is used so that the exposure starts according to an external signal. The exposure time is set by application software. In this mode, the exposure of the first four lines (the following figure: 0H to 3H) are begun on the rising edge timing or falling edge timing of the input trigger signal into the camera. After the readout time of four lines passes, the exposure of the second lines (the following figure: 4H to 7H) are begun, and subsequent lines are exposed similarly.

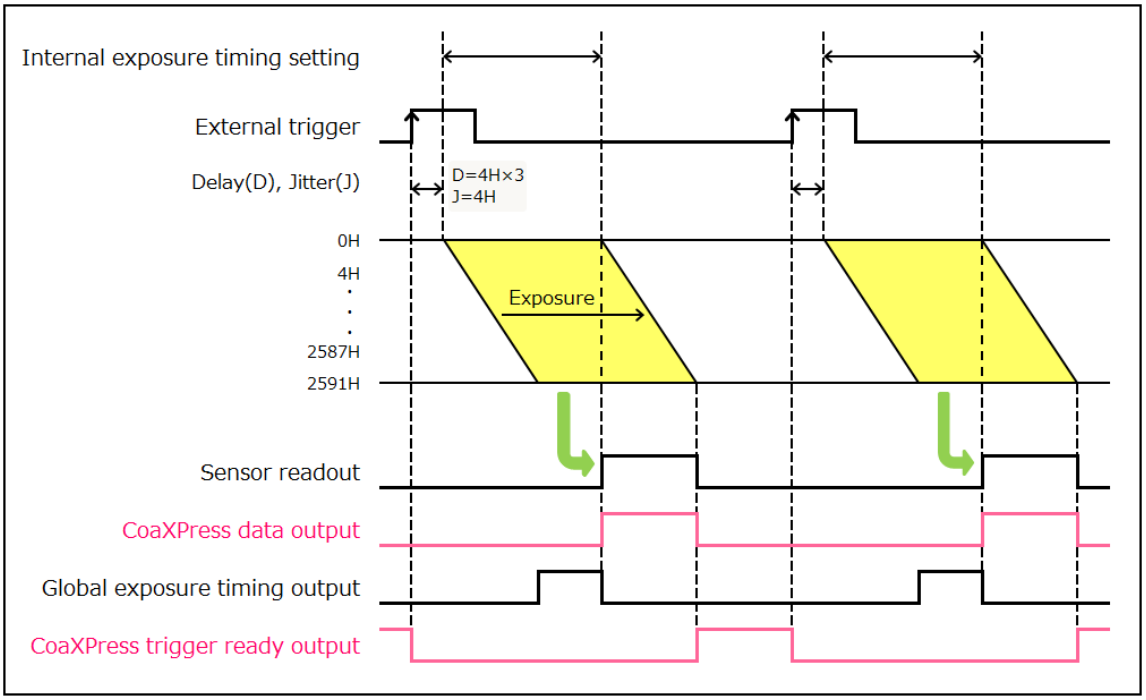


Figure 10-4 (Example for rising edge in Normal Area Mode)

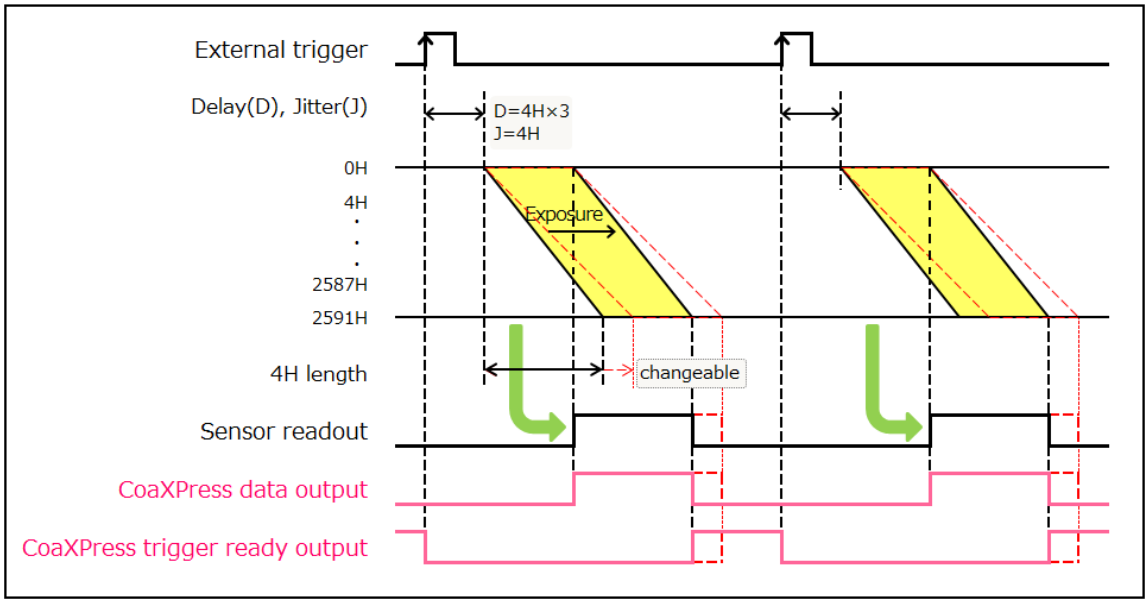


Figure 10-5 (Example for rising edge in Lightsheet Readout Mode)

(2) Global reset Edge trigger mode

Global reset function enables to reset the electric charge of all pixels at the same time. Then all pixels can start exposure at the same time. The exposure time is set by application software. With this Global reset Edge trigger mode, the exposure of all pixels begins on the edge (rising / falling) timing of the input trigger signal into the camera.

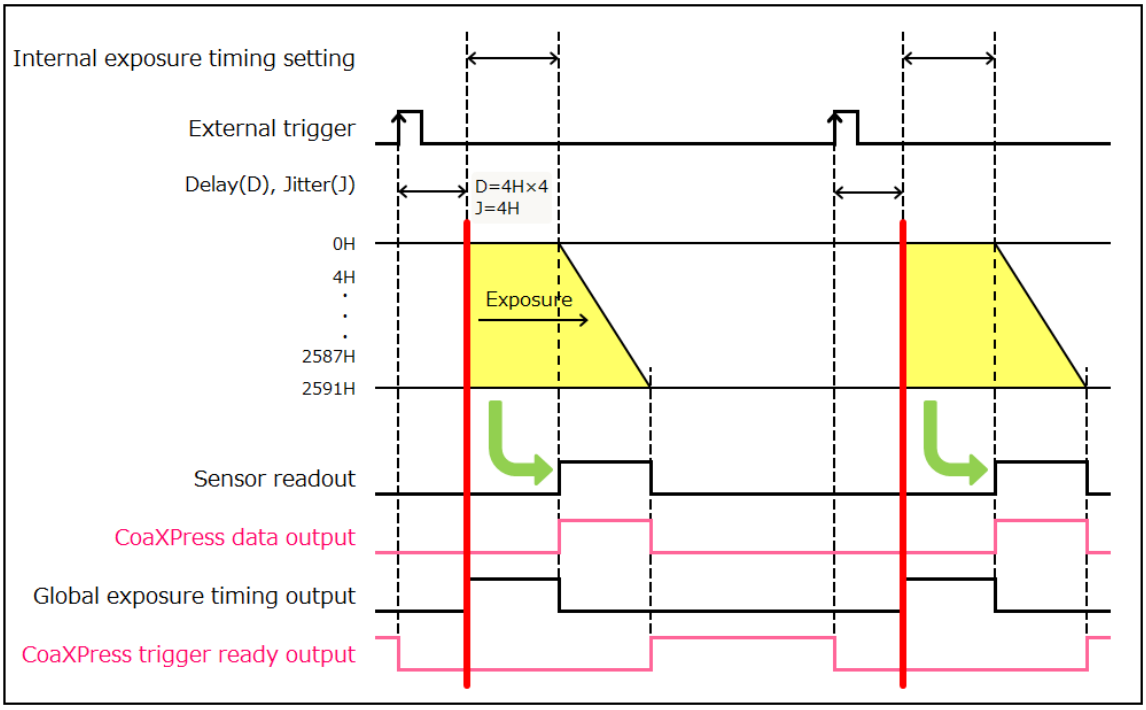


Figure 10-6 (Example for rising edge)

(3) Level trigger mode

The Level trigger mode is used to control both exposure start timing and exposure time length by inputting external trigger pulses. In this mode, the camera starts exposure at the start of high or low period of the input trigger pulse and stops exposure at the end of high or low period of the input trigger pulse.
The example below is for the trigger level High. The exposure of the first four lines (0H - 3H) begins when the trigger signal becomes High, and the exposure of the second four lines (4H - 7H) begins after the readout time of line one passes. Each exposure begins one by one for each four lines. The exposure of the first lines is finished when the trigger signal becomes low, and signal readout is begun. The exposure time of each four lines is defined by the time that the input trigger is high.

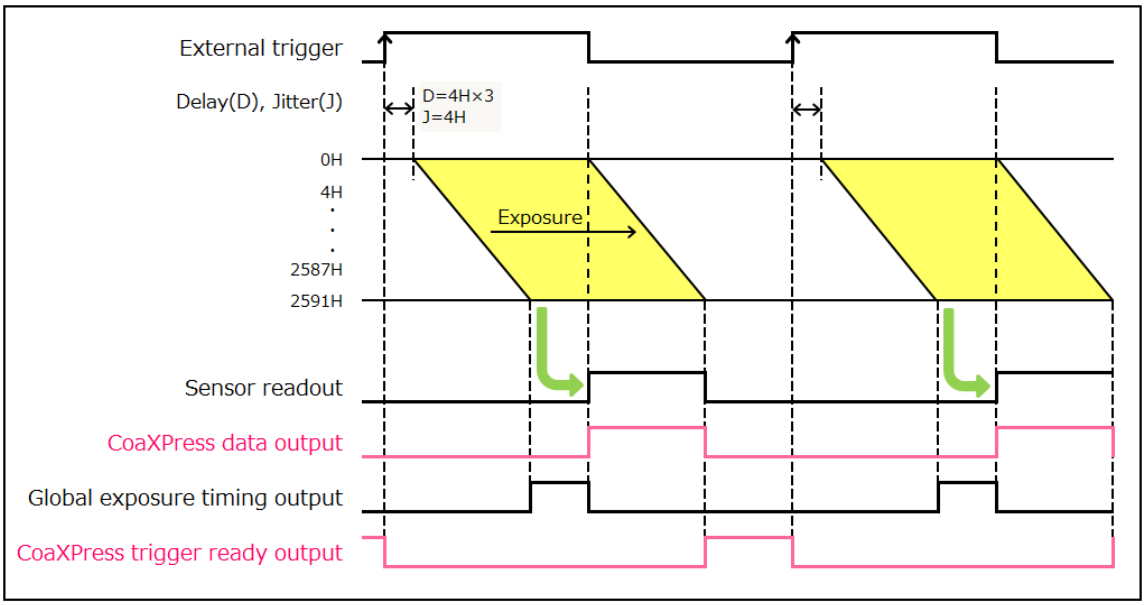


Figure 10-7 (Example for level High)

(4) Global reset Level trigger mode

The Global reset function enables to reset the electric charge of all pixels at the same time. Then all pixels can start exposure at the same time.
The example below is for the trigger level High. With this Global reset Level trigger mode, the exposure of all pixels begins when the trigger signal becomes “High”.

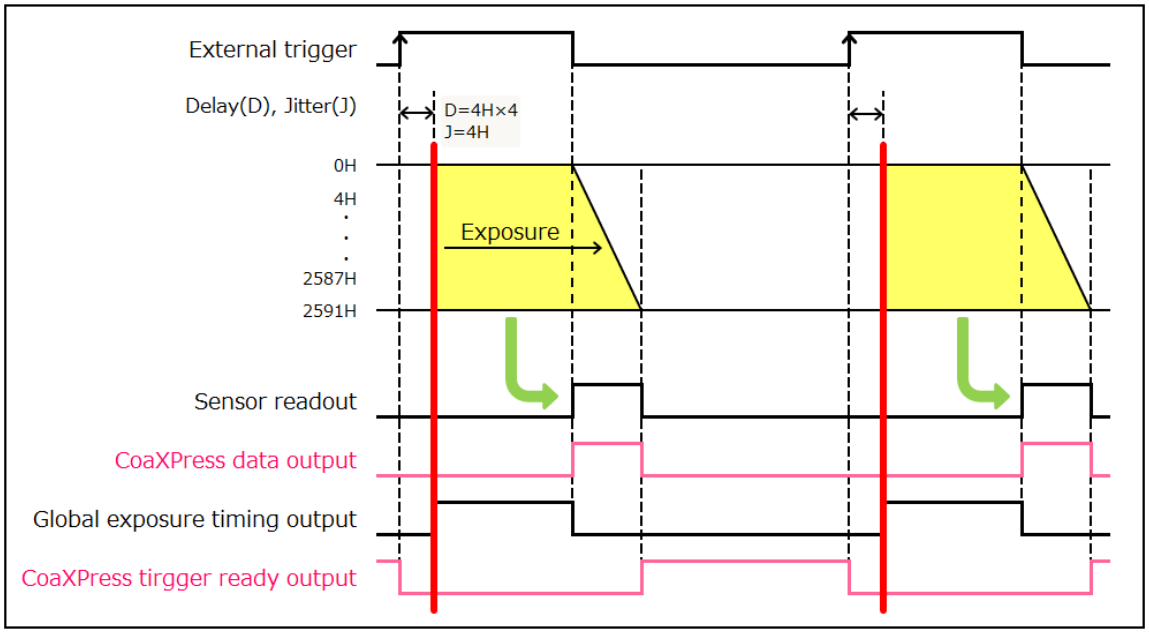


Figure 10-8 (Example for level High)

(5) Synchronous readout trigger mode

The Synchronous readout trigger mode is used for continuous imaging when it is necessary to control the exposure start timing of each frame from an external source. It is useful for confocal microscopy. For example, when the camera is used with a spinning disk confocal microscope and the camera exposure time is synchronized to the spinning disk's rotation speed, it is possible to eliminate uneven illumination (called banding noise) caused by variation of the spinning disk rotation speed. Also, it is useful for securing as long exposure time as possible while controlling the exposure start timings by external trigger signals.

a. Normal operation

The Synchronous readout trigger mode is used for continuous imaging when it is necessary to control the exposure start timing of each frame from an outside source and also when it is necessary to secure as long exposure time as possible. In the Synchronous readout trigger mode, the camera ends each exposure, starts the readout and also, at the same time, starts the next exposure at the edge of the input trigger signal (rising edge / falling edge). That is, the interval between the same edges of the input trigger becomes the exposure time.

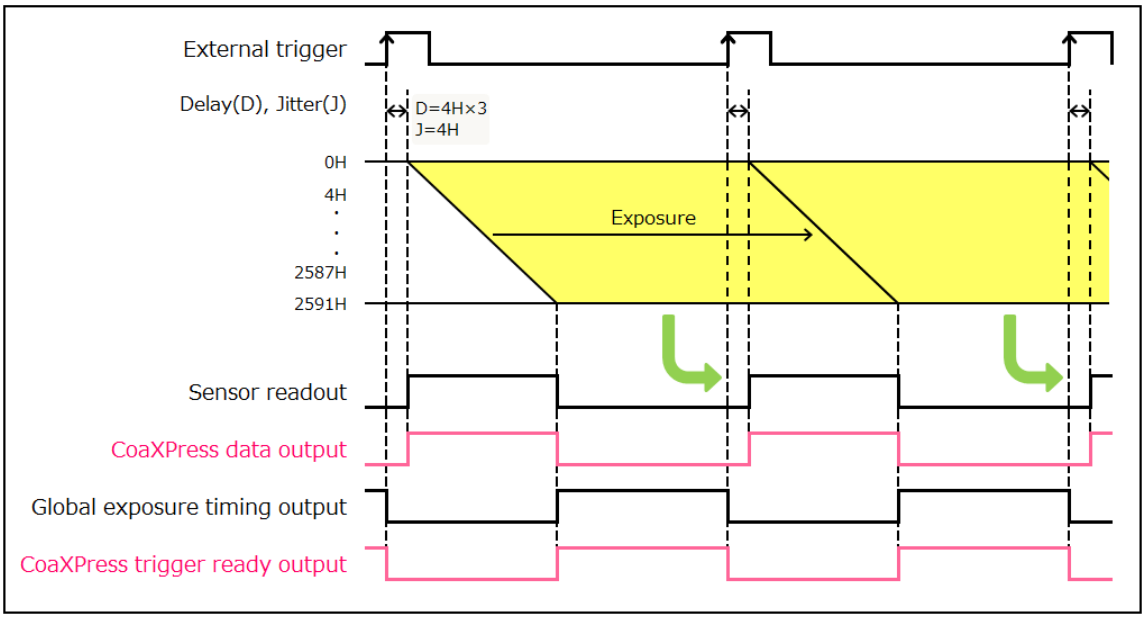


Figure 10-9 (Example for rising edge)

b. Trigger times

Also in the Synchronous readout trigger mode, synchronous readout can be controlled by specifying, the number of timing pulses to determine the exposure time.
The following figure shows the exposure timing when the Trigger times is set as 3.

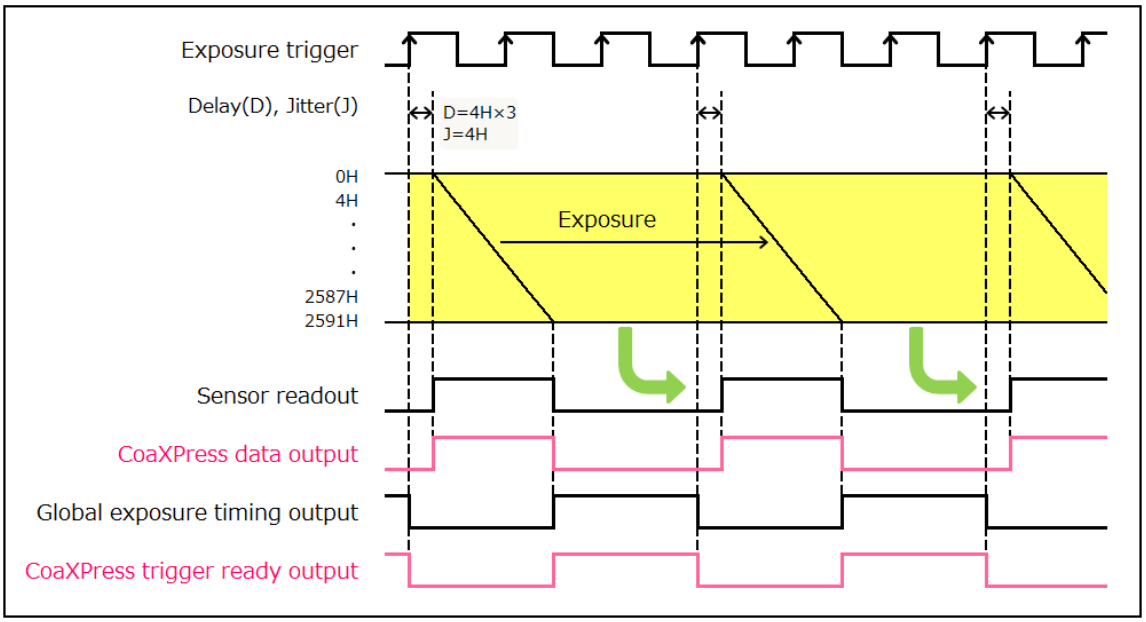


Figure 10-10 (Example for trigger times)

10-3-3 Start trigger mode

The Start trigger mode is to start operating the camera by a trigger input for a continuous imaging. It is useful to secure the frame rate as fast as possible when continuous image acquisition and not to sacrifice the exposure time. For example, when it is necessary to measure the phenomenon after stimulation, it is possible to start continuous image acquisition at the stimulation timing.
Start trigger mode is to start operating the camera by a trigger input for continuous imaging, and it works at the highest frame rate because it is operated in internal trigger mode. In Start trigger mode, the camera starts exposure and switches to internal trigger mode by the edge of an external trigger signal (rising edge / falling edge).

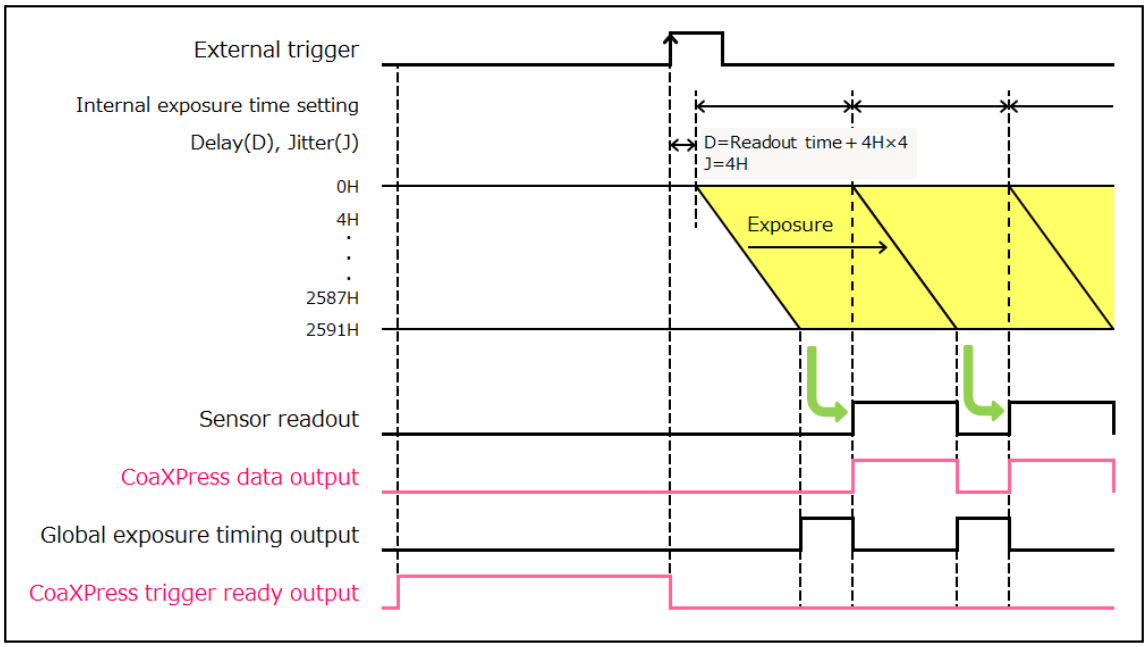


Figure 10-11 (Example for rising edge in Normal Area Mode)

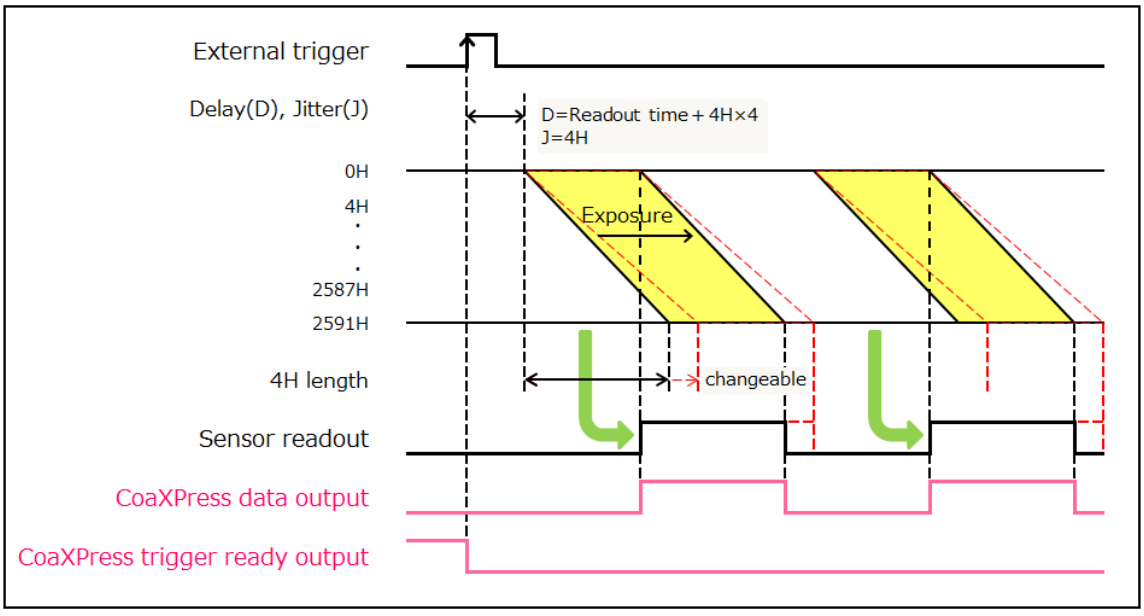


Figure 10-12 (Example for rising edge in Lightsheet Readout Mode)

10-4 READOUT METHODS

The readout methods can set units for reading out images. In the Sub-array readout, the readout area is also set. The methods have the below.

(✓: enable, –: disable)

Readout methods	Unit of readout pixel (Horizontal×Vertical)	Readout area (Horizontal×Vertical)	Normal Area Mode	Lightsheet Readout Mode
Normal readout	1×1 (1 pixel)	Whole area: 4608 × 2592	✓	✓
Binning readout	2×2	Whole area: 2304 × 1296	✓	–
	4×4	Whole area: 1152 × 648		
Sub-array readout	1×1 (1 pixel)	Designated area	✓	✓

(1) Normal readout (Full resolution readout)

Perform charge readout from camera individually for all pixels.

(2) Binning readout

With this camera, 2×2 binning and 4×4 binning readout are available by adding the signal of adjacent pixels in the digital domain. Binning readout is a method for achieving high sensitivity in exchange for losing resolution. The mode is not supported at Lightsheet Readout Mode.

(3) Sub-array readout

The Sub-array readout is a procedure only a region of interest is scanned. It is possible to increase the frame rate by reducing the number of vertical lines scanned. In the readout, binning configuration is enabled.

Camera readout modes	Specified	Unit of setting	
		Horizontal	Vertical
Normal Area Mode	Position (Start position)	by 128 pixels	by 4 lines
	Area size	by 128 pixels	by 4 lines
Lightsheet Readout Mode	Position (Start position)	by 128 pixels	by 4 lines
	Area size	by 128 pixels	by 4 lines

10-5 READOUT TIME OF HORIZONTAL LINE

Readout time of the horizontal line is varied depending on the horizontal pixel number set in the Sub-array readout mode.

Readout time = (Vn+2) × 4H

Vn = number of vertical lines
4H = readout time of one line

The readout time per one line (4H) can be calculated by the following formula:

(1) In Normal Area Mode

Standard Full Well Capacity mode	**4H = MAX（Number of horizontal pixel / 365.25, 6.304）**[µs]
High Full Well Capacity mode	**4H = 50.432** [µs]

(2) In Light Sheet Readout Mode

The readout time in the lightsheet mode is adjustable from the calculated value in the normal area mode as the minimum value upto 200 µs.

10-6 EXPOSURE TIME SETTING

The exposure time setting can be done by the units of seconds.
The actual exposure time setting is defined by the following formula, and the camera automatically calculates a longer and closest value from the specified exposure time setting.

(1) In Normal Area Mode

4H × roundup (Exp1 / 4H)

Exp1 = 4H to 1 s (input in units of seconds)
roundup () = round up to integer

(2) In Light Sheet Readout Mode

4H × roundup (Exp1 / 4H)

Vn = number of vertical line
Exp1 = 4H to Vn / 4 × 4H (input in units of seconds)
roundup () = round up to integer

10-7 TRIGGER OUTPUTS

The camera provides a range of trigger output signals to synchronize with an external instrument and the camera becomes the master and the external instrument becomes the slave.

There are three different trigger output functions as follows.

- Global exposure timing output
- Programmable timing output
- Trigger ready output

Also, it can output continuous High output (High output fixed) or continuous Low output (Low output fixed). They are output from Timing out connector.

(✓: enable, –: disable)

	Normal Area Mode	Lightsheet Readout Mode
Global exposure timing output	✓	– *
Programmable timing output	✓	✓
Trigger ready output	✓	✓
Continuous High output (positive output)	✓	✓
Continuous Low output (negative output)	✓	✓

* The global exposure timing output is not provided, however, because there is no timing where all lines expose at the same time with Lightsheet Readout Mode.

(1) Global exposure timing output

It shows the global exposure timing where all lines expose at the same time. There is a case that one event is divided into two frames because the timing of the exposure in each line is different for the rolling shutter. However, by using the Global exposure timing output the global exposure becomes possible for the phenomenon that happens for this period. Global exposure timing output shows the period where all lines expose at the same time. There is no output signal when the exposure time is less than the frame rate.

(2) Programmable timing output

a. In Normal Area Mode

By using the programmable timing output, synchronizing external equipment is simple. A system that needs simple timing signal does not require a delay unit or pulse generator. It is possible to program and output a pulse that has an optional pulse width and an optional delay time to Read End (the end of readout timing) or Vsync. The setting range for delay time is 0 µs to 10 s, and the setting range for pulse width is 1 µs to 10 s.
The relation between the parameter which can be set with each reference signal and an output signal becomes below.

Reference signal	Output signal
Read End	The signal with the preset pulsewidth is output after the preset delay from the end of the sensor readout.
Vsync	The signal with the preset pulsewidth is output after the preset delay from the start of the sensor readout.

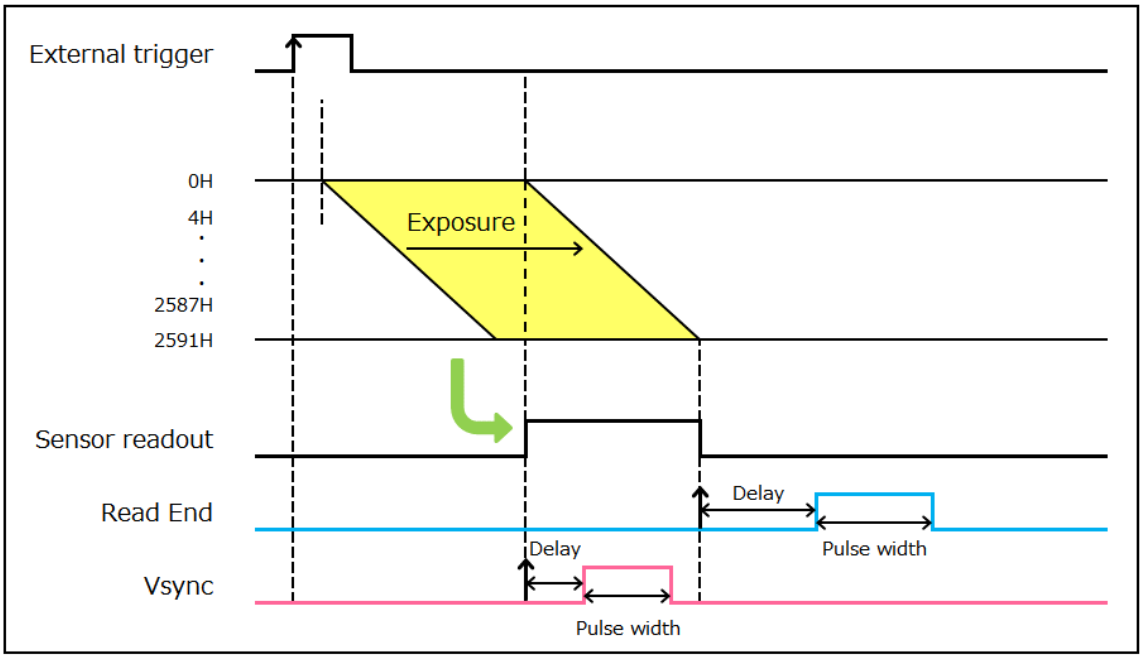


Figure 10-13 (Example for Programmable timing output in Normal Area Mode)

b. In Lightsheet Readout Mode

By using the programmable timing output, synchronizing with external devices is simple. A system which needs simple timing signal does not require a delay unit or pulse generator. It is possible to program and output a pulse that has an optional pulse width and an optional delay time to Read End (the end of readout timing), Vsync or Hsync. The range of delay is 0 µs to 10 s, and the range of pulse width is 1 µs to 10 s.
The relation between the parameter which can be set with each reference signal, and an output signal becomes as shown below.

Reference signal	Output signal
Read End	The signal with the preset pulsewidth is output after the preset delay from the end of the sensor readout.
Vsync	The signal with the preset pulsewidth is output after the preset delay from the start of the sensor readout.
Hsync	The signal with the preset pulsewidth is output after the preset delay from the horizontal synchronized signal in the camera. (Figure 10-15)

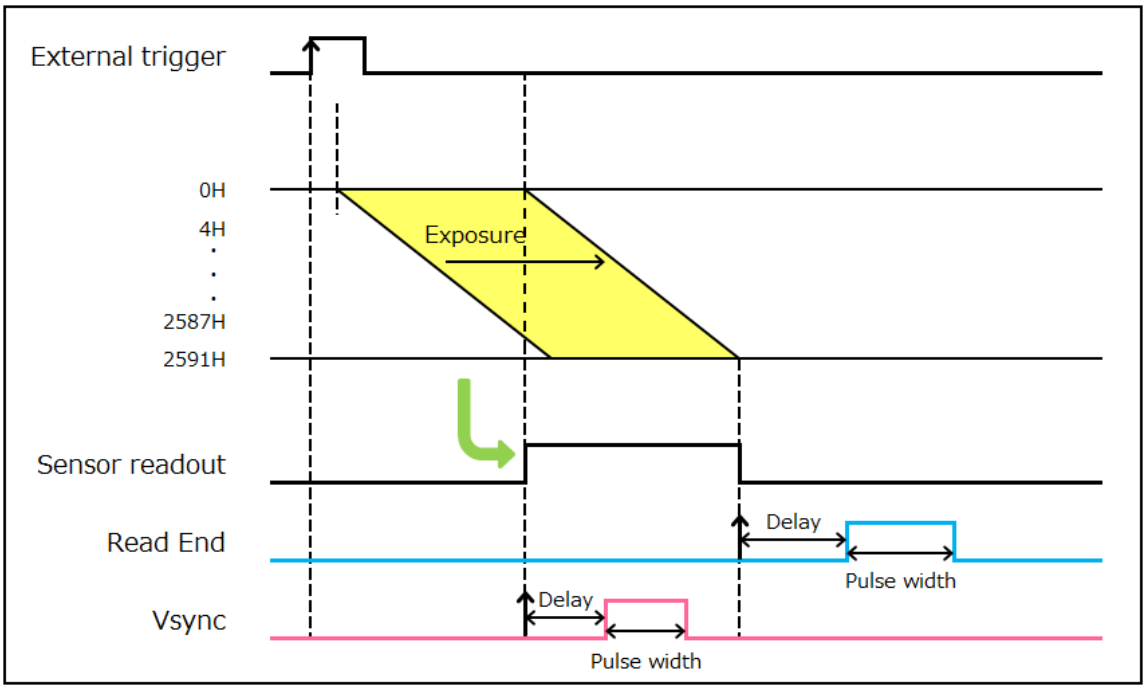


Figure 10-14 (Example for Programmable timing output in Lightsheet Readout Mode, forward direction readout)

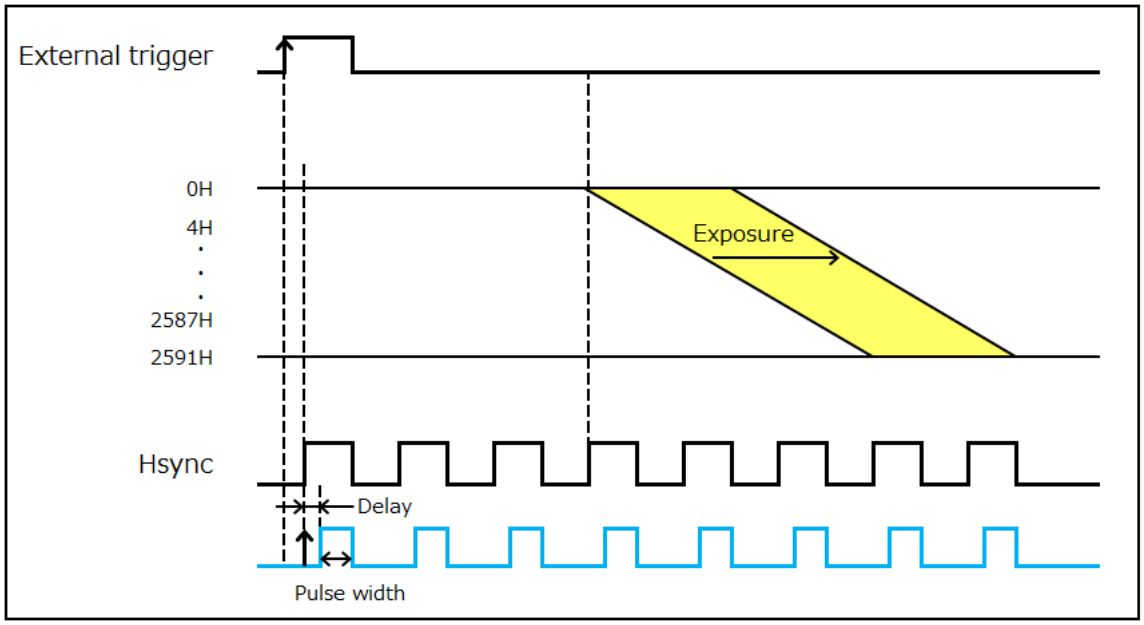


Figure 10-15 (Example for Programmable timing output with Hsync in Lightsheet Readout Mode, forward direction readout)

When you choose Hsync for the reference of programmable timing output, camera can output some pulses before start the exposure. It is called as Pre-Hsync. You can set the number of Pre-Hsync.

(3) Trigger ready output

The trigger ready output is useful to make the frame intervals as short as possible in external trigger mode. For example, when the camera is working in the Edge trigger mode, the next frame can start after the previous frame exposure is done. Thus, the camera cannot accept a trigger for the next frame during the exposure period. To reduce useless time to be as short as possible, it is necessary to know the period when the camera can accept a trigger for the next frame. The trigger ready output shows the trigger ready period when the camera can accept an external trigger in External trigger mode.

10-8 REAL-TIME DEFECT PIXEL CORRECTION

There are a few pixels in CMOS image sensor that have slightly higher readout noise performance compared to surrounding pixels. And the extended exposures may cause a few white spots which is caused by failure in part of the silicon wafer in CMOS image sensor. The camera has real-time variant pixel correction features to improve image quality.
The correction is performed in real-time without sacrificing the readout speed at all. This function can be turned ON and OFF. (Default is ON)
User can choose the correction level for white spots depend on the exposure time.

10-9 FULL WELL CAPACITY MODE

In this camera, High FWC mode which is suitable for high dynamic range imaging is selectable in addition to Standard FWC mode which is suitable for both high speed and low readout noise imaging. As Standard FWC mode has 12-bit digital output, high speed, and low readout noise, it is suitable for high frame imaging. On the other hand, as High FWC mode has 16-bit digital output, it is suitable for high dynamic range imaging.

With the exposure time exceeding hundreds of milliseconds in Standard FWC mode, the pixels saturated in intensity may appear. (See next Note) In this case, using in High FWC mode is recommended.

Note

- The saturated pixels which have high dark current, called “White spots” are appeared by long exposure time and low FWC, however they are not bad sensor.

Note

- Switching Standard Full Well Capacity mode / High Full Well Capacity mode is done by HighDynamicRange Mode Off/On in DCAM property.

10-10 REFERENCE: FRAME RATE CALCULATION METHOD

The following is a calculation formula and an example for calculating the frame rate value.

Camera operation modes		Calculating formula
Free running mode	Exp > Vn/4+2	**1/((Exp+2)x4H)**
	Exp ≤ Vn/4+2	**1/((Vn/4+4)x4H)**
External trigger mode	Edge trigger mode	**1/((Exp+Vn/4+6)x4H)**
	Level trigger mode	
	Synchronous readout trigger mode	**1/((Exp+Vn/4+3)x4H)**
	Global reset Edge trigger mode	**1/((Exp+Vn/4+7)x4H)**
	Global reset Level trigger mode	
Lightsheet Readout Mode		**1/((Exp+Vn/4+6)x4H)**
Start trigger mode		Same as the Free running mode

Hn : Number of horizontal pixel (128 to 4608, multiples of 128)
Vn : Number of vertical line (4 to 2592, multiples of 4)

4H : [Standard Full Well Capacity mode] MAX(Hn / 365.25, 6.304) [µs]
[High Full Well Capacity mode] 50.432 [µs]

MAX(A,B) = the larger value in A and B
In Lightsheet Readout Mode, it can changed up to maximum 200 µs

Exp : roundup(Exposure time setting / 4H) [µs] roundup( ) = round up to integer

[Calculation example]

	Hn	Vn	Frame rate (fps)			
			Free running mode	Edge trigger mode	Synchronous readout trigger mode	Global reset
Standard Full Well Capacity mode	4608	2592	121	121	121	120
	2688	2592	208	207	208	207
	2560	2560	221	220	221	220
	2048	2048	307	305	308	305
	1024	1024	610	603	612	600
	512	512	1201	1175	1210	1166
	256	256	2332	2234	2367	2203
	128	4	31 725	19 828	39 657	17 625
High Full Well Capacity mode	4608	2592	30	30	30	30
	2688	2592	30	30	30	30
	2560	2560	30	30	30	30
	2048	2048	38	38	38	38
	1024	1024	76	75	76	75
	512	512	150	146	151	145
	256	256	291	279	295	275
	128	4	3965	2478	4957	2203

Note

- The frame rate in binning mode will be same as no-binning setting.
- The frame rates in the table above are the output frame rates from the camera.
- Since the frame rates of image acquisition by software depend on the PC performance and the application software, they may be slower than the frame rates in the table above without sufficient PC performance and application software. The slower frame rates mean the lost frames.
- The lost frames will be reduced by using Frame bundle function of DCAM-API software that transfers multiple frames at once.

11. WHEN USING WATER-COOLING METHOD

Water-cooling method is used when the camera is used in a place where the air conditioning is unstable.

⚠CAUTION	• When using Water-cooling method, follow this chapter and chapter 8.

11-1 BEFORE USING THE CAMERA AT WATER-COOLING

(1) Change the cooling method by “DCAM Configurator”

The default setting of cooling method is Air-cooling. The setting is changed by the “DCAM Configurator” software. When the setting is changed, restart the camera. By restarting, the setting is reflected on the camera. Refer to 11-5 “SWITCHING THE COOLING METHOD OF “DCAM CONFIGURATOR” for the setting procedure.

(2) Cooling water

a. Requirement

Hamamatsu recommends using soft water (except pure water) for cooling water.
If you plan on using water other than soft water as recommended for example antifreeze etc, choose the water which followed notices of 12-2. “WHEN USING AT WATER-COOLING” or contact a Hamamatsu subsidiary or your local distributor.

b. Recommendation temperature

Hamamatsu recommends 25 °C for Circulating water temperature.
For the appropriate temperature range of the cooling water, confirm with the instruction manual of your circulating water cooler.

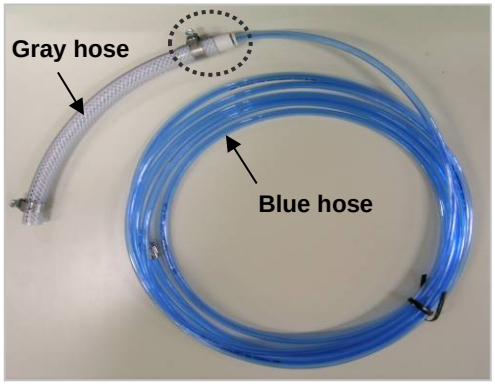
(3) Circulating water cooler

Handle the circulating water cooler and the cooling water according to an instruction manual of the circulating water cooler. Proper performance may not be achievable if a non-recommended circulating water cooler is used.

(4) Cooling water hose

a. Configurations

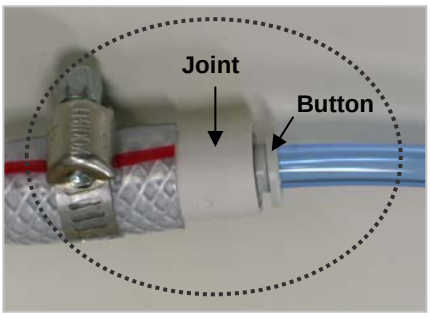
The hose has a blue hose and a gray hose.



[Diameter of hoses]

	Internal	External
Blue hose	4 mm	6 mm
Gray hose	8 mm	13.5 mm

If the hose size on circulating water cooler is the same as blue hose, remove gray hose from the joint part. The gray hose can be removed when blue hose is pulled with pushing the button of the joint on gray hose.



b. Connections to connectors of the circulating water cooler

When connecting the hoses to each connector of the camera and the circulating water cooler, handle according to 11-3 "CONNECTIONS".
The hoses do not have to be removed from the connector every time. If disconnecting the hoses from connectors, handle according to 11-6 "DISCONNECTION OF WATER COOLING HOSES".

- Stop water circulation when connecting / disconnecting the hose, and turn off the power of the camera and the circulating water cooler.
- Confirm that cooling water stops.
- Prepare water absorption sheet (such as Waste, Towel or so) and catch pan in order to avoid water drop or water splash.

c. Deterioration of hoses

Replace the water hose with a new one whenever it cannot keep 0.45 L/min flow rate for water circulation due to the hose deterioration.

(5) Cautions during Water-cooling

Be always careful about the following during Water-cooling.

- Keep 0.45 L/min flow rate for water circulation.
- Check cooling water is circulating properly and the camera is cooled properly.
- Do not stop the cooling while the power supply is supplied to the camera.
- Be careful not to be scattered water drop or water splash around peripherals. Prepare water absorption sheet (such as Waste, Towel or so) and catch pan in order to avoid them.

11-2 PREPARING

preparation	Hamamatsu option
Circulating water cooler	C3142-11
Cooling water hose (2 hoses)	A10788-04
Cooling water	—

- When you need our option the circulating water cooler and the cooling water hoses , please contact a Hamamatsu subsidiary or your local distributor.

Note

- Handle the circulating water cooler and the cooling water according to this manual and the instruction manual of the circulating water cooler.

11-3 CONNECTIONS

Connect the cooling water hoses to the connectors of the circulating water cooler.

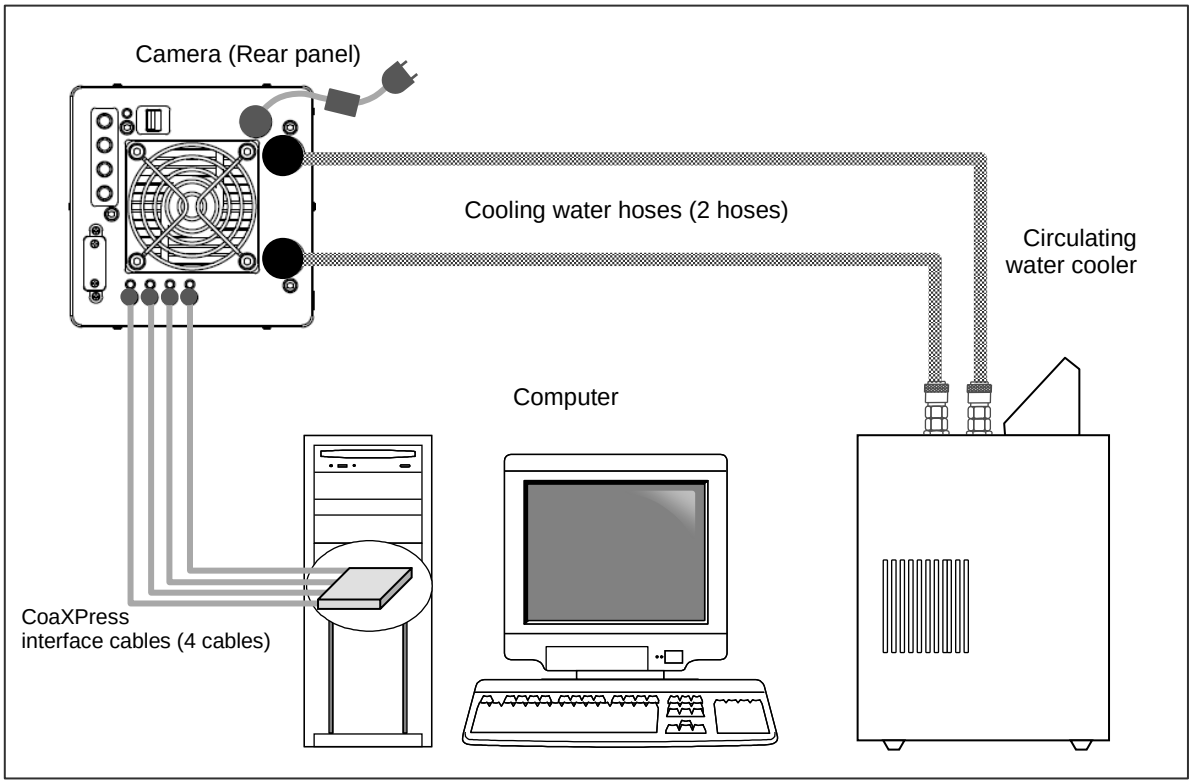


Figure 11-1

- When cables are connected, turn off the power supply of the camera and peripheral devices.

[Connection of water cooling hoses]

1. Place the camera on the stable table.
2. Connect water cooling hose into the WATER connector on the camera. (as shown in Figure 11-2) Confirm the hose stops at it.
3. Set the camera onto a microscope (If the camera is used on the microscope).
   If it is easy to connect the hose onto the camera after the camera is set onto the microscope then it is OK to connect the hose after the camera is set on the microscope.

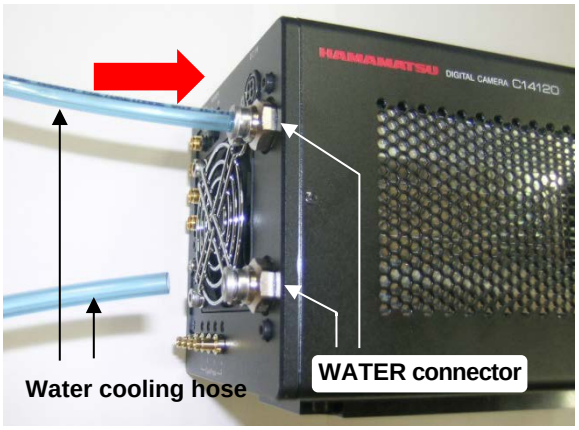


Figure 11-2

4. Connect the hose onto the circulating water cooler.
   Follow the instruction on the circulating water cooler when you connect the hose onto the circulating water cooler.
5. Turn on the circulating water cooler and confirm the cooling water is flowing normally.

CAUTION	• Stop the circulating water cooler when the water flow is abnormal or water drop or splash is found.

11-4 OPERATIONS

After setup, operate Water-cooling according to the following.
Handle the application software and peripherals according to each instruction.

SET UP (Section 8-2, 11-2, 11-3)

↓

Switch on the cooling method by DCAM Configurator

Turn on the camera and the computer

↓

Switch the cooling method

↓

Turn off the camera

↓

Turn on the circulating water cooler

↓

Turn on the computer and peripherals

↓

Make sure “STATUS lamp” and “CoaXPress interface connector lamps” stays on green

↓

Launch the application software

↓

Start Water-cooling by the application software

↓

Camera setting *****

(* Set the camera setting when there is necessary for using application software. Refer to Chapter 10.)

↓

Image acquisition

↓

End of imaging

End of image acquisition and software , Turn off all the power

↓

Turn off the cooler

11-5 SWITCHING THE COOLING METHOD OF "DCAM CONFIGURATOR"

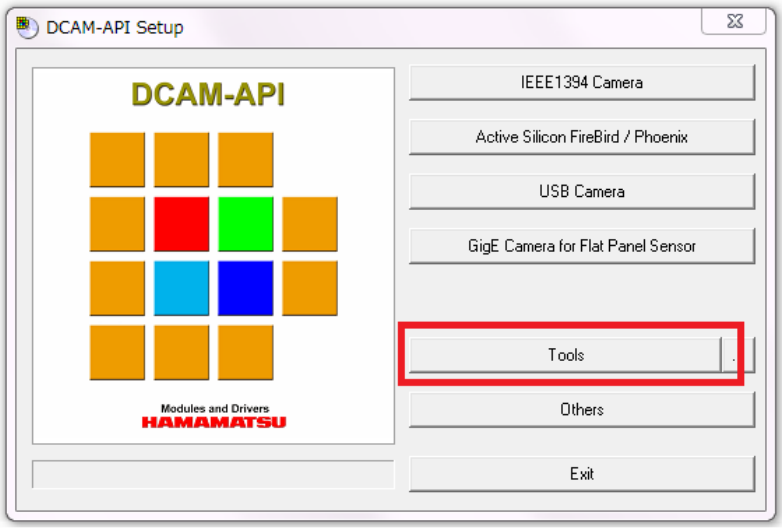
(1) Notices

- When the camera is shipped, the cooling method for the camera is set for "Air-cooling". (It is unnecessary to exchange it when the camera is just used at "Air-cooling".)
- The setting is not changed even if the power supply of the camera is turned off. Because it is unnecessary to set the "DCAM Configurator" whenever the camera is started.
- When the setting is changed, restart the camera. By restarting, the setting is reflected on the camera. After cooling method was switched, the camera memorizes the last setting as the default setting for cooling.

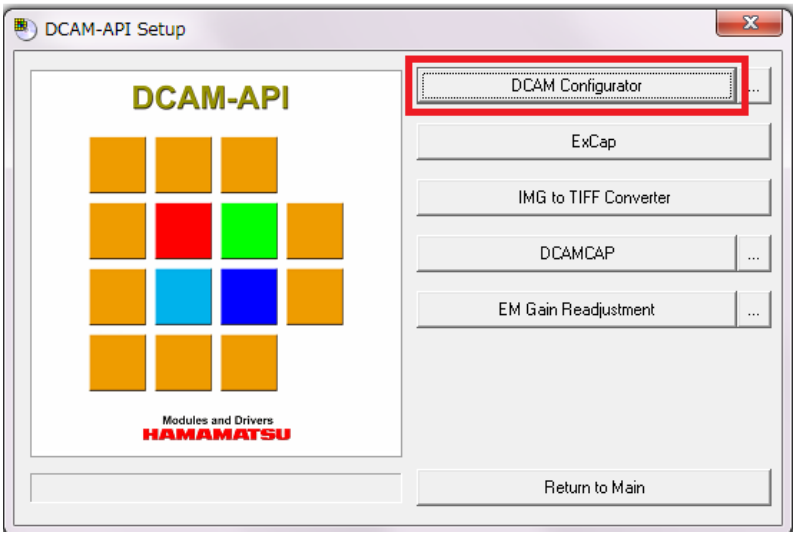
(2) Starting "DCAM Configurator", Setting to "Water-cooling"

1. Start the "Setup.exe" in the DCAM-API software holder in the computer.
   If the software is not installed to the computer, set the CD/DVD of the DCAM-API into the CD/DVD driver in the computer.

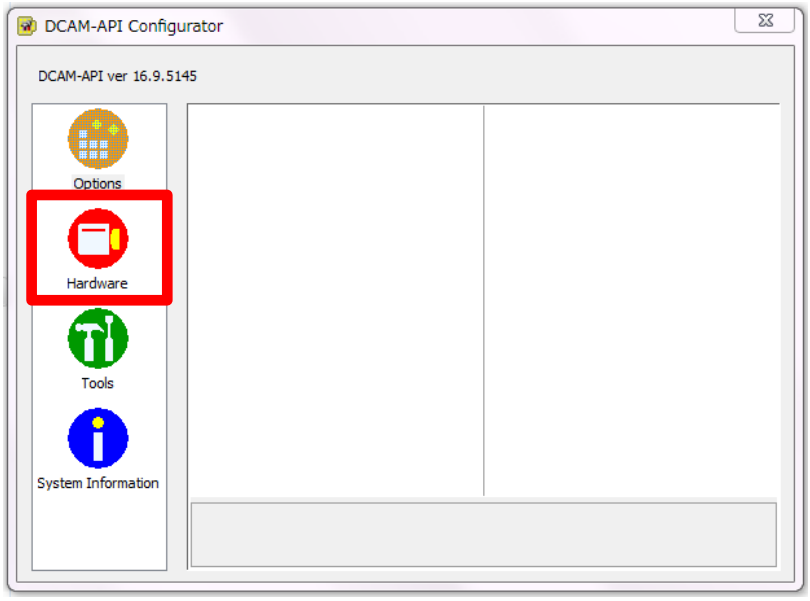
2. "DCAM-API Setup" window is displayed on the screen. Click the "Tools".



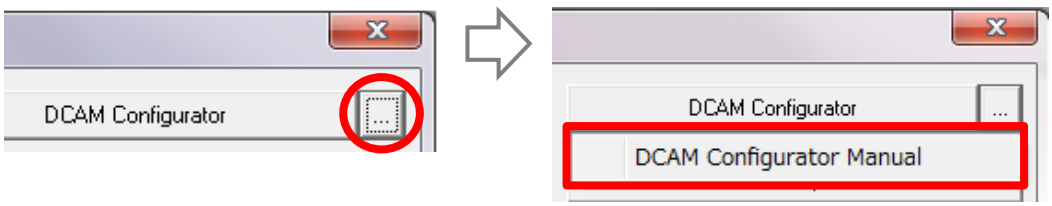
3. The items of window are changed as follows. Click the “DCAM Configurator”.



4. “DCAM Configurator” is started. “DCAM-API Configurator” window is displayed. Click the “Hardware” icon, and set the cooling method to Water-cooling.



Refer to the instruction manual of DCAM Configurator about how to operate the “DCAM Configurator” window. The manual is stored in the “DCAM-API Setup” window. Click the “…” button, and then click “DCAM Configurator Manual”. The PDF file of the manual is displayed.



5. After the setting was switched, turn off the power of the camera. Then turn on it again.

11-6 DISCONNECTION OF WATER COOLING HOSES

Remove the water cooling hoses only when it is necessary to remove.

⚠CAUTION	• Cooling water may be left inside the camera even after hoses are removed. In such case, remove water inside by blowing air from connectors. Be careful not to splash water onto the camera.

1. Turn off the camera power and all peripheral devices including circulating water cooler.

2. Remove the hose on circulating water cooler side.
   Follow the instruction on the circulating water cooler when you disconnect the hose from the circulating water cooler.

3. Remove water or water drop inside the hose and the camera by air.
   Blow air from one side of hose. Prepare water absorption sheet (such as Waste, Towel or so) and catch pan on another side of hose in order to avoid water drop or water splash.
   Blow Air until no water drop come out.

4. Remove the camera from the microscope (if the camera is used on the microscope).
   It is not necessary to remove the camera from the microscope if it is possible to remove the hoses from the camera as it is.

5. Place the camera on the stable table.
   Put the lens cap on to protect the sensor.

6. Change the WATER connector direction to be downward.
   Prepare water absorption sheet (such as Waste, Towel or so) and catch pan.

7. Remove hoses one by one, and wipe water.
   Disconnect hoses with pushing button while being careful not to splash water.

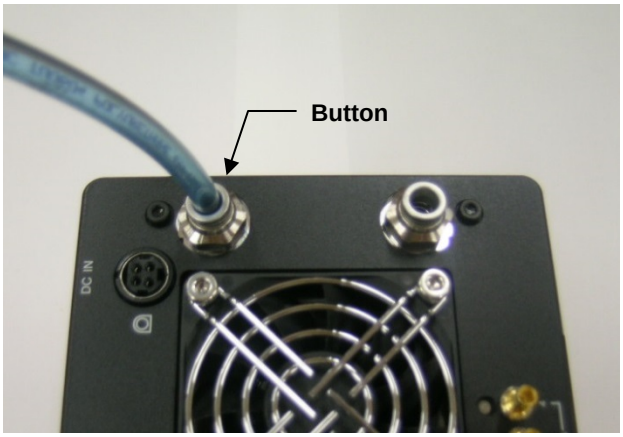


Figure 11-3

12. MAINTENANCE

12-1 CARE

(1) Camera body

Perform cleaning of this equipment with the dry soft cloth.

- Do not wipe with a damp cloth or unclean cloth.

(2) Glass window on the image sensor

1. Blow the dust from the glass window with an air duster.
2. Moisten a lens cleaning paper with a little ethanol, and wipe over center area of the window, gently.
3. Confirm whether dust is not left.

   Attach the camera to an optics, and check if there is dust or not under the uniform light condition. If there is dust on the image, please clean the glass window again.

- Do not use anything other than a lens cleaning paper for cleaning of glass window in front of the image sensor.

- Do not touch the surrounding parts of image area when wiping the glass window.

- Use a plastic tweezers and take extra care not to scratch the glass window with the tweezers. Even with plastic tweezers, there is possibility to make scratch on the glass window in case tweezers touch it.

12-2 WHEN USING AT WATER-COOLING

(1) Circulating water cooler

- Regarding handling cooling water and circulating water cooler, refer to instruction manual attached to the circulating water cooler.

(2) Cooling water

- It is recommended to use soft water (except pure water) for cooling water.

- Do not use hard water for cooling. It cause inside of cooling water circulating path to be calcified or corroded and it result lower flow rate or water flow stop.

- When using hard water, conduct a process to soften water before use it.

When using cooling water other than recommended;

[Pure water]

- Pure water is not appropriate for cooling water. There is possibility that pure water absorb component of cooling water path and it may cause corrosion. In addition pure water is easy to be polluted and cause impurity, sliminess or forming foreign substances. It cause lower flow rate or water flow stop.

[Distilled water / Deionized water]

- When using the camera inside clean room, it is possible to use distilled water or deionized water by conducting periodical check. However please notice it increases possibility of corrosion inside cooling water path, lowering flow rate or water flow stop.
- Monthly check: Check water impurity, non-existence of sliminess, foreign particle is not mixed with water or not adhered inside water path and no unusual odor. If you find any of the issues, please exchange cooling water and clean cooling water path.

[Soft water from tap]

- It is possible to use soft water from tap with conducting periodical change of cooling water and checkup. However please notice it increases possibility of corrosion inside cooling water path, lowering flow rate or water flow stop.
- Monthly check: Check water impurity, non-existence of sliminess, foreign particle is not mixed with water or not adhered inside water path and no unusual odor. If you find any of the issues, please exchange cooling water and clean cooling water path.
- Exchange cooling water every 3 months.
- Clean cooling water path every 6 months.

[Bottled water]

One example of soft water which is commonly available is mineral water (Hardness less than 70). Please check hardness of water by referring product information of bottled water manufacturer.

13. TROUBLSHOOTING

If an abnormality occurs, look up the possible causes in the following tables and, if necessary, report the details to Hamamatsu subsidiary or your local distributor.

⚠CAUTION	• When the following measures are taken, turn off the camera and peripherals and secure a space where you can work stably and do it without risks.
⚠CAUTION	• Do not attempt to dismantle or modify the camera. Do not touch parts that are not indicated in this manual.

13-1 TURNING ON THE POWER

Symptom	Cause	Measures	Chapter
Image is not transferred	AC adapter is unconnected to an electrical outlet	Connect the AC adapter surely	7
	AC adapter or other cable is loose	Reconnect the cable and tighten the fixing screws of the connector surely	7
	AC adapter or other cable is broken	Exchange it for a new cable	
The fan inside the camera does not rotate (at Air-cooling)	The cooling method of DCAM Configurator is set to “Water-cooling”	Change the setting to “Air-cooling”	11-5

13-2 ALTHOUGH IMAGES ARE TRANSFERRED

Symptom	Cause	Measures	Chapter
Scratches or discoloration visible on the screen	Lens is dirty	Wipe the lens.	12-1
Image is blurred	Lens is not focused	Contact a Hamamatsu subsidiary or your local distributor.	17
Only shadowed images are output	Lens mount cap has been left on	Remove the cap.	
	Amount of light is too much or too low	Adjust amount of light.	
All screens overflow	Too much amount of light	Reduce amount of light.	
Noise appears on the screen	Ambient temperature is high	Lower the temperature to 25 °C.	
		Change the cooling method to Water-cooling.	11
	Exogenous noise	Find and remove cause.	
	Poor connection of internal connector	Contact a Hamamatsu subsidiary or your local distributor.	17
	Defective circuit system		
Ring a buzzer (beep tone) The STATUS lamp is lit in red	The temperature inside the camera rises abnormality	As soon as turn off the power switch, unplug the AC supply. Wait till the temperature falls, and then remove the cause of the overheating. After that turn on the power supply of the camera again. If the symptom is unimproved, and the cause is unidentifiable, contact a Hamamatsu.	17

13-3 AT WATER-COOLING

Symptom	Cause	Measures	Chapter
Cooling or circulation does not start	The power supply of circulating water cooler is not turning on	Turn on the power supply of the circulating water cooler.	
	The cooling method of DCAM Configurator is set to “Air-cooling”	Change the setting to “Water-cooling”.	11-5
	Quantity of water is insufficient	Supply sufficient quantity of water (Refer to the instruction manual of the circulating water cooler).	
Noise appears on the screen	The temperature of cooling water is high (more than 25 °C)	Lower the temperature to 25 °C.	
The flow of cooling water is unnatural	The inside of the hose is clogged up or is dirty	Wash dirt away by water current or water pressure. If the symptom is unimproved, exchange it for a new hose.	
Water leak	The connection of the hose is loose	Reconnect the hose.	11-3
	The diameter of the hose does not fit the connector of the circulating water cooler	Exchange it for the hose in accord with the diameter of the connector.	11-1(4)
	The hose is damaged	Exchange it for a new hose.	

14. SPECIFICATIONS

(1) Performances

Imaging device	Scientific CMOS image sensor	
Effective number of pixels	4608 (H) × 2592 (V)	
Cell size	5.5 µm (H) × 5.5 µm (V)	
Effective area	25.344 mm (H) × 14.256 mm (V)	
Cooling method	Peltier device + Forced air-cooling, Water-cooling	
Cooling temperature	at Forced air-cooling	+20 °C (Ambient temperature: +25 ºC)
	at Water-cooling	+20 °C (Water temperature: +25 ºC)
Dark current *1	15 electrons/pixel/s	
Dark Signal Non-Uniformity (DSNU) *1	0.5 electrons r.m.s.	
Photo Response Non-Uniformity (PRNU) *1	3 % or less (20 000 electrons signal)	
Linearity error *1	EMVA 1288 standard	1 % or less
	< 500 electrons signal	1 % or less
Dark offset	200 counts (at Normal (1×1) readout)	
Exposure time	6.304 µs to 1 s (in step of 6.304 µs)	

		Standard Full Well Capacity mode	High Full Well Capacity mode
Full well capacity *1		1000 electrons	38 000 electrons
Dynamic range *2		650:1	17 000:1
Readout noise *1		2.0 electrons (r.m.s.) 1.5 electrons (median)	2.7 electrons (r.m.s.) 2.2 electrons (median)
Conversion factor *1		0.26 electrons/count	0.58 electrons/count
Digital output		12 bit	16 bit
Maximum pixel rate		1445 Mpixels/s	358 Mpixels/s
Frame rate	4608 × 2592	121 fps	30 fps
	2048 × 2048	307 fps	38 fps
	1024 × 1024	610 fps	76 fps
	512 × 512	1201 fps	150 fps
	128 × 128	4406 fps	550 fps

* 1 Typical value
* 2 Calculated from the ratio of the full well capacity and the readout noise.

Note

- The frame rates in the table above are the output frame rates from the camera.
- Since the frame rates of image acquisition by software depend on the PC performance and the application software, they may be slower than the frame rates in the table above without sufficient PC performance and application software. The slower frame rates mean the lost frames.
- The lost frames will be reduced by using Frame bundle function of DCAM-API software that transfers multiple frames at once.

Note

- With the exposure time exceeding hundreds of milliseconds in Standard FWC mode, the pixels saturated in intensity may appear. (See next Note) In this case, using in High FWC mode is recommended. The saturated pixels which have high dark current, called “White spots” are appeared by long exposure time and low FWC, however they are not bad sensor.

(2) Functions

[Correspondence table by camera readout modes]

Functions		Camera readout modes (✓: enabled, –: disabled) Normal Area Mode	Lightsheet Readout Mode
Camera operation modes	Free running mode	✓	✓
	External trigger mode	✓	✓
	Start trigger mode	✓	✓
External trigger mode	Edge trigger mode	✓	✓
	Global reset Edge trigger mode	✓	–
	Level trigger mode	✓	–
	Global reset Level trigger mode	✓	–
	Synchronous readout trigger mode	✓	–
Readout methods	Normal readout: 1x1	✓	✓
	Binning readout: 2x2, 4x4	✓	–
	Sub-array readout	✓	✓
Trigger outputs	Global exposure timing output	✓	–
	Programmable timing output 1,2,3	✓	✓
	Trigger ready output	✓	✓
	Continuous High output (Positive)	✓	✓
	Continuous Low output (Negative)	✓	✓

a. Camera readout mode (Light sheet readout mode)

	Standard Full Well Capacity Mode	High Full Well Capacity Mode
Row interval time (4 H *3)	12.608 µs to 200 µs	50.432 µs to 200 µs
Readout time (at Full resolution)	8.2 ms to 129.6 ms	32.7 ms to 129.6 ms
Readout direction	Forward direction	

* 3 Four horizontal lines (4 H) are readout simultaneously in one line interval.

b. Readout methods

Normal readout (Full resolution readout)	Readout pixel	1×1 (1 pixel step)	
	Number of readout pixel	4608 (H) × 2592 (V)	
Binning readout (Digital binning) *4	Readout pixel	2×2 (2 pixels (H) × 2 pixels (V) step)	
		4×4 (4 pixels (H) × 4 pixels (V) step)	
	Number of readout pixel	2×2	2304 (H) × 1296 (V)
		4×4	1152 (H) × 648 (V)
Sub-array readout	Readout pixel	1×1	
	Number of readout pixel	It depends on the following setting.	
	Unit of setting for the number of readout pixel	1×1	Horizontal: 128 pixels Vertical: 4 pixels
		2×2	Horizontal: 64 pixels Vertical: 2 pixels
		4×4	Horizontal: 32 pixels Vertical: 1 pixel

* 4 Digital binning processing in the camera.

c. External trigger mode

External signal input	External input (SMA connector)
External trigger input level	3.3 V LVCMOS level
External trigger input impedance	10 kΩ
External trigger delay function	0 µs to 10 s (in steps of 1 µs)

d. Trigger outputs

External signal output	Global exposure timing output
	Programmable timing output 1
	Programmable timing output 2
	Programmable timing output 3
	Trigger ready output
	Continuous High output
	Continuous Low output
External trigger output level	3.3 V LVCMOS level
Output impedance	33 Ω

e. Other

Image processing function	Real-time defect pixel correction
Interface	CoaXPress (Quad CXP-6)
Lens mount	C-mount
	F-mount
	TFL-II-mount

(3) Power supply specifications

Camera	Input power supply	DC 19 V
	Power consumption	Max. 80 W
AC adapter	Input power supply	AC 100 V to AC 240 V
	Frequency	50 Hz / 60 Hz
	Typical output	DC 18.62 V to DC 19.95 V Max. 7.9 A
	Power consumption	Max. 200 VA

Note

- Fluctuations of input power supply voltages are not to exceed ±10 % of the nominal voltage.

(4) Operating environment

Ambient operating temperature	0 ºC to +40 ºC
Ambient storage temperature	-10 ºC to +50 ºC
Ambient operating humidity	30 % to 80 %, no condensation
Ambient storage humidity	Less than 90 %, no condensation
Place of operating	Indoor, altitude 2000 m No corrosive gasses, dust, dirt, vibration, or unnecessary radiation

(5) Dimensional outline and weight

Dimensional outline	110 mm (W) × 110 mm (H) × 235 mm (D)
Weight	Approx. 3.6 kg (Camera only)

- Be careful not to drop off the camera or not drop underfoot when making it move because it is approx. 3.6 kg.

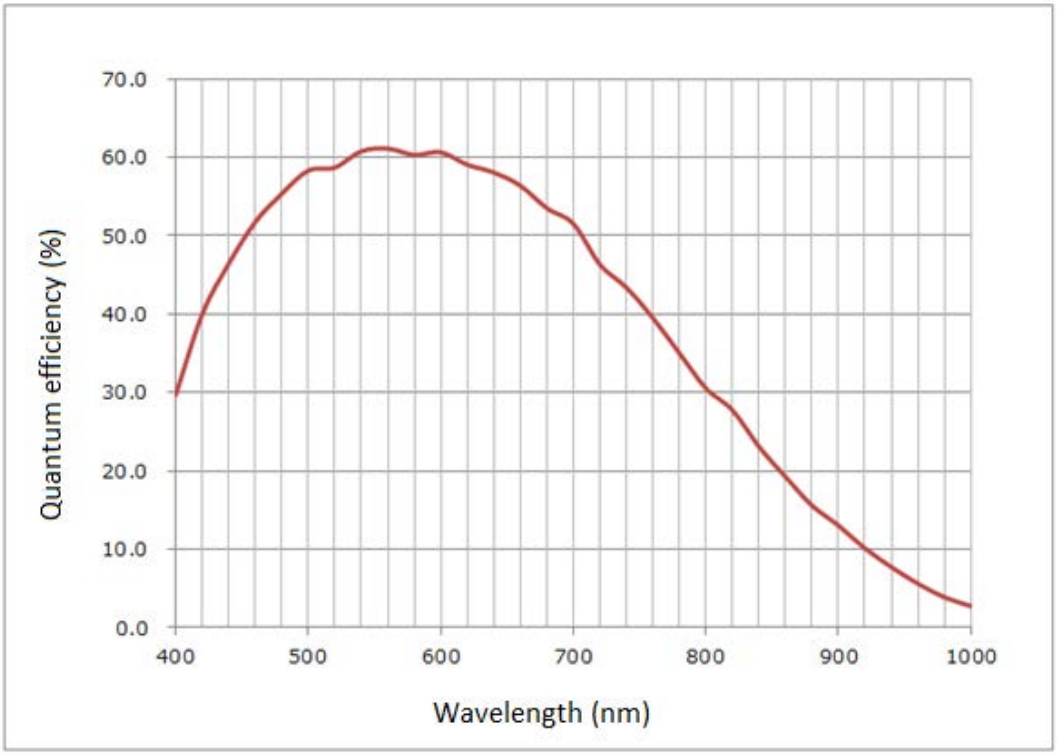
Note

- Please refer to 15 “DIMENSIONAL OUTLINES” for detail of dimensions.

(6) Applicable standards

EMC	EN61326-1: 2013 Class A

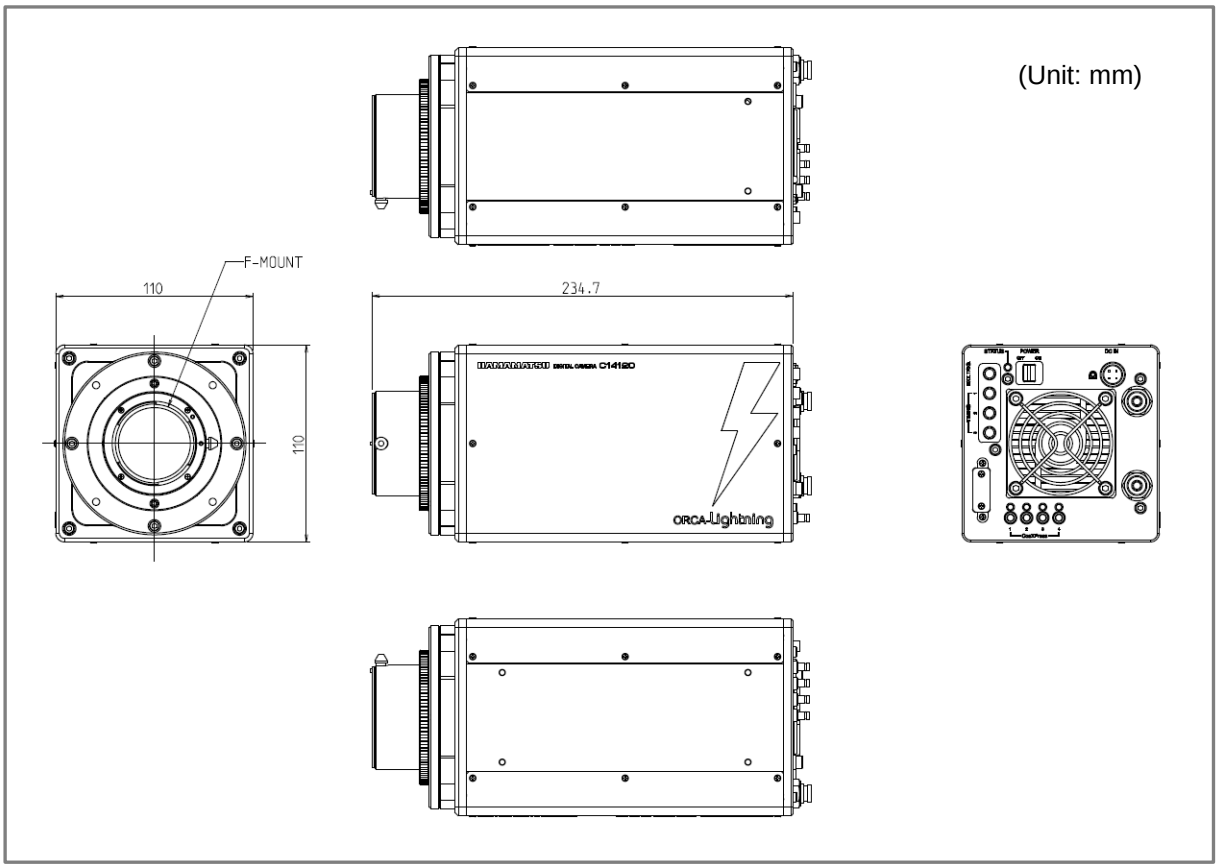
(7) Spectral response characteristics (Typical)



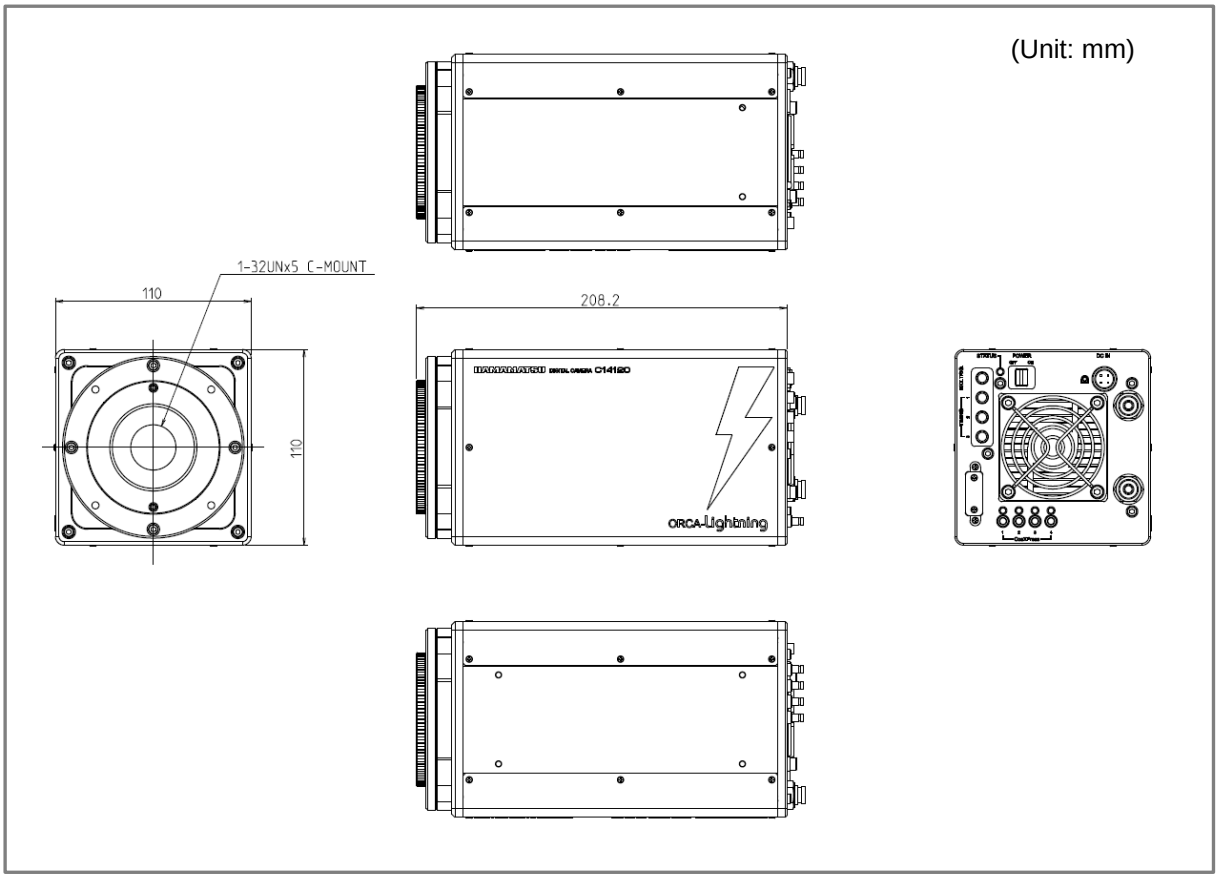
Graph 14-1

15. DIMENSIONAL OUTLINES

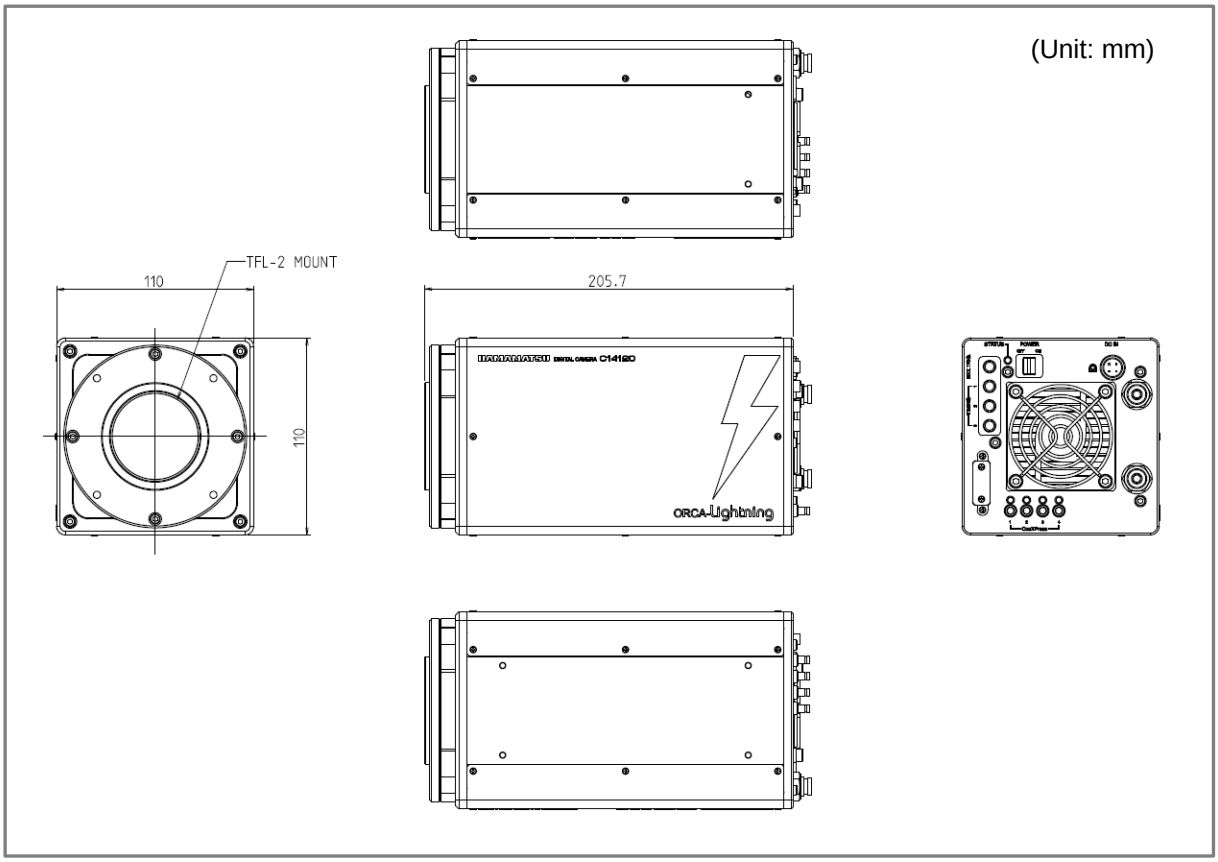
15-1 F-MOUNT TYPE



15-2 C-MOUNT TYPE



15-3 TFL-II-MOUNT TYPE



16. WARRANTY

Hamamatsu Photonics have fully inspected this camera and checked that its performance conforms to specifications. In the unlikely event of a breakdown or other malfunction, contact a Hamamatsu subsidiary or your local distributor.

16-1 BASIC WARRANTY

1. Unless otherwise stated by Hamamatsu subsidiary or your local distributor, this camera is under warranty for 24 months from the delivery date.
   - Consumable parts, such as a fan, a mechanical shutter, and a fuse, are excepted.
   - Degradation with cosmic rays and the radiation (X-rays, gamma rays, UV light, etc.) of CMOS image sensor is excepted.

2. The warranty only covers defects in the materials and manufacturing of the camera. You may be liable for repairs during the warranty period in the event of a natural disaster or if you handle the camera contrary to the instructions in this manual, use it without due caution, or try to modify it.

3. We will repair the camera or replace it, subject to availability, free of charge within the terms of the warranty.

16-2 REPAIRS

1. If you notice anything wrong with the camera, confirm whether or not it is malfunctioning by referring to the TROUBLESHOOTING in this instruction manual. You must first clarify the symptoms in order to avoid any misunderstanding or error.

2. If you have any trouble or are unclear about anything, contact a Hamamatsu subsidiary or your local distributor giving the product name, serial number and details of the problem. If Hamamatsu Photonics consider the problem to be a malfunction, we will decide whether dispatch an engineer or have the camera returned to us for repairs.

17. CONTACT INFORMATION

Manufacturer

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