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Digital CCD Camera
C10600-10B
Instruction Manual

ORCA-R²

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. Be sure to read this Instruction manual beforehand in order to use the digital CCD camera correctly. The manual describes the correct method of handing the camera and provides cautions in order to avoid accidents. After reading, keep the manual where it can be referred to at any time.

Ver. 1.4
May 2009

HAMAMATSU PHOTONICS K.K.

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1. SAFETY PRECAUTIONS

1-1 INDICATION OF THE SYMBOLS

The following symbols can be found on this camera:

	Protective conductor terminal
	Alternating current
	ON (Supply)
	OFF (Supply)
	Read cautions in the instruction manual regarding this caution label on the camera head.

1-2 CLASSIFICATION OF WARNING

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 obey 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.

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.
	This symbol indicates a cautionary item that should be obeyed when handling the camera. Read the contents carefully to ensure correct and safe use.
	This symbol indicates an action that is forbidden. Read the contents carefully and be sure to obey them.
	This symbol indicates a compulsory action or instruction. Read the contents carefully and be sure to obey them.

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⚠ WARNING

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Power supply

Use the camera with the voltage indicated on the rating sticker. Using a different voltage can damage the camera and lead to fire or electric shock.

Cables

Be careful not to place heavy objects on cables or bend it excessively. Doing so can damage the cable and lead to fire or electric shock.

Power supply cord

This equipment must be connected to protective earth for operating the equipment.
Use the accessory of the power supply cord when this camera is used.
In addition, the main power supply plug must be connected to a power outlet with a protective earth terminal. Notice if the protective earth terminal is not used, it may be a cause of electrical shock.

Do not touch the plug with wet hand. 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. Only touch parts as indicated in this manual.

Do not insert a foreign substance into the camera

Do not allow foreign objects such as combustible substances, metal objects or water to get inside the camera. They can damage the camera and lead to fire or electric shock.

If an abnormality occurs

Such as the image suddenly disappearing or a strange noise, smell or see smoke coming from the camera, stop the power supply immediately and contact Hamamatsu subsidiary or local distributor. Never attempt to repair the camera yourself.

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⚠ CAUTION



Power supply cord

When unplugging the power supply cord, always pull by the plug, not the cord. Doing so can lead to fire or electric shock.



Remove the power supply cord from the outlet when not using the camera for long periods of time. Doing so can damage the cable and lead to fire or electric shock.



Connecting and disconnecting cables

Always turn off the power before connecting and disconnecting cables.



Lenses

Be careful not to screw the lens more than 6.5 mm onto the C-mount of the camera head. Doing so can scratch the protective glass. (Some wide-angle lenses in particular can have a thread of 6.5 mm or more.)



Fixing the camera head

When fitting the camera head to a tripod or other fixture, use the When fitting the camera head to a tripod, for example, use the screw (1/4-20UNC) in the center of a camera mount. Be careful that the fitting screw does not enter more than 8 mm from the surface of the mount. Screwing it in excessively can impair normal operation.



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 by dropping it, for example. Doing so can damage the camera.



At the water cooling

Be careful water does not splash on the camera. Cut off the power supply of the circulating water cooler and the camera when you remove and install the cooling water hoses.



Disposal

When disposing of the system, 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 system is disposed of legally and correctly.



Operating environment

This equipment is designed and tested for use in an industrial environment. If this equipment is used in residential areas, EMI (electro-magnetic interference) may occur. In that case, the user should take appropriate measures to reduce EMI problems.

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2. CHECK THE CONTENTS OF PACKAGE

When you open the package, check that the following items are included before use. If the contents are incorrect, insufficient or damaged in any way, contact your local dealer without attempting to operate the camera.

C10600-10B Camera head	1
C10600-10B Camera control unit	1
Camera cable: 5 m	1
Power supply cord	1
Lens mount cap * attached to the camera	1
IEEE1394b interface cable for industrial type	1
C10600-10B Instruction manual * this booklet	1
DCAM-API Installation manual for C10600-10B	1

[Option]

Water cooling hoses (2 hoses: 2 m)	A10788-04

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.

3. INSTALLATION



Avoid using or storing this camera in the following places

- Where the ambient temperature might fall below 0 °C or rise above 40 °C
- Where the temperature varies extremely
- In direct sunlight or near a heater
- Where the humidity is 70 % or more or where there is dripping water
- Close to a strong source of magnetism or radio waves
- Where there is vibration
- Where it might come into contact with corrosive gases (such as chlorine or fluorine)
- Where there is a lot of dust



Do not block ventilation openings

To prevent the internal temperature from rising excessively, do not wrap cloth around the equipment while it is operating, and make sure the fan on the back panel of the CCD and the slits on the sides are not blocked. Both the air blown for air outlet and the air inlet must be at least 10 cm from the wall.



Attaching the camera head to tripod

Follow instruction in "ANNEX: ATTACHING THE CAMERA HEAD TO TRIPOD" when attaching the camera head to tripod.

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4. OVERVIEW

C10600-10B is a compact and high-performance 12 bit/16 bit* digital output CCD camera with the IEEE1394b interface. C10600-10B is developed to meet the demands of high-precision and high-quality imaging for the industrial / scientific image capturing. This camera is capable of transferring images directly to computer using the IEEE1394b interface in either conventional readout mode or an additional feature of high-speed readout mode. Furthermore, this camera has water-cooled heat release feature to cool down the CCD cooling temperature and also to stabilize the performance.

Note

* Default setting is 12 bit.

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5. FEATURES

(1) High resolution

Equipped with a high-resolution solid-state imaging device having 1344 (Horizontal) × 1024 (Vertical) pixels. Pixels are square, facilitating image processing for measurement purposes.

(2) High-speed readout

High-speed readout (which is called fast scan) of 28 MHz/pixel is added as a new feature, in addition to the conventional readout. (14 MHz/pixel)

(3) No need for Mechanical shutter

The use of a progressive-scan interline CCD image sensor (below, give a brief "CCD" in some part) obviates the need for a mechanical shutter.

(4) Use of IEEE1394b interface

Image signals undergo A/D conversion inside the camera control unit, and are transmitted externally via the IEEE1394 bus interface as 12 bit digital data. The camera can also be controlled via this bus.

(5) Employment of common camera control standard

Uses the industry-standard "IIDC 1394-based Digital Camera Control Specification Ver.1.31" for this control. This ensures compatibility with other cameras and controls, which support this standard.

(6) Low distortion

The CCD's pixels are laid out geometrically, ensuring nearly zero distortion.

(7) No burn-in

(8) C-Lens mount

(9) Small head

Small, lightweight camera head allows for a construction that is extremely easy to use in such applications as microscopic measurement and spectrometry.

(10) Water and Air cooling

Lower the cooling temperature or stabilize the performance.
The camera can be used in both water and forced air cooling mode.

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6. NAME AND FUNCTION OF THE PARTS

6-1 CAMERA HEAD

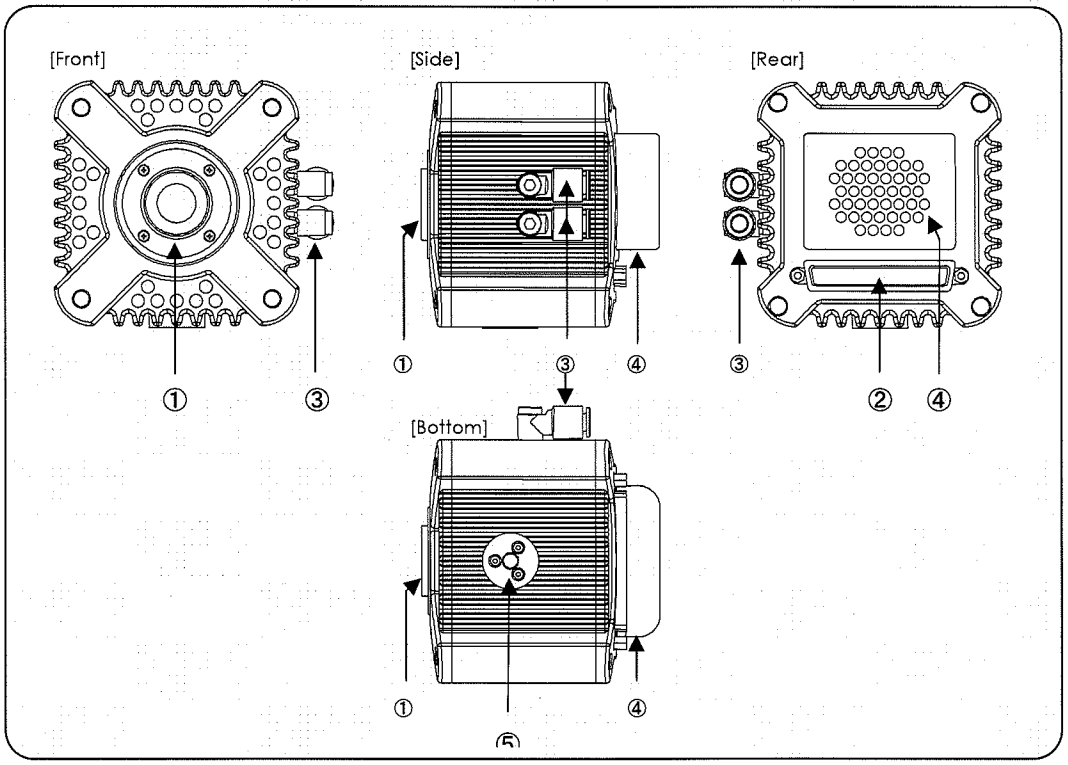


Fig. 6-1

① Lens mount

C-mount lens or an optics system with C-mount can be attached.

Note

- The depth of the C-mount is 6.5 mm. Screwing in the mount too far can scratch the glass surface.

② Camera connector

This is used to connect the camera head to the camera control unit.

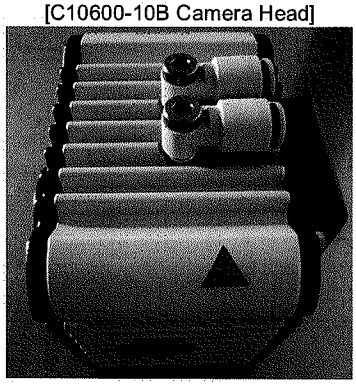
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③ Water connector (WATER IN/OUT)

This is for coolant. It connects the camera head and the cooler for circulating water with the cooling water hoses. "WATER IN" is on the inflow side and "WATER OUT" is on the outflow side.

⚠ CAUTION

[C10600-10B Camera Head]



- Follow the instruction in 7-2 [CONNECTION OF WATER-COOLING HOSES (WATER-COOLING ONLY)] to connect / disconnect the hose.
- Use distilled water or deionized water for water cooling.
- When the cooling water temperature is lower than the ambient temperature, condensation can appear on the surface of the hose and the inside of the camera. Condensation inside the camera will cause trouble. When using cooling water that is cooler than the ambient temperature, ensure that the ambient humidity is low and use the camera in an environment where condensation never happens inside the camera.
- Hamamatsu recommends 20 °C for Circulating water temperature.
- Confirm that water comes in when you start cooling it.
- Do not stop coolant in the system working.
- Keep 0.3 L/min flow rate or 0.3 MPa water pressure for water circulation.
- Replace the water hose with a new one whenever it can't keep the Keep 0.3 L/min flow rate or 0.3 MPa water pressure for water circulation due to the hose deterioration.
- Be careful of not to spill water on the camera or other peripheral equipments when connecting / disconnecting the hose. When water circulation is stopped, water may remain in the hose. Remove water or water drop inside the hose by air or other appropriate methods.
- Stop water circulation when connecting / disconnecting the hose, and turn off the power of the camera and other peripheral equipments.

Note

- As for how to use the circulating water cooler, please refer to the manual of the circulating water cooler.

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④ Air outlet / Cooling fan

This is the outlet for the heat ventilation.



- To prevent overheating in the camera's interior, do not wrap the device in cloth or other material, or in any way allow the power supply unit's ventilation ports to become blocked.



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

⑤ Camera attachment stand

This is used to secure the camera head in place when using a tripod.

Note

- Be careful not to allow the fitting screw to enter more than 8 mm from the surface of the mount. Screwing this in excessively may impair normal operation.



- Follow instruction in "ANNEX: ATTACHING THE CAMERA HEAD TO TRIPOD" when attaching the camera head to tripod. Hamamatsu is not responsible for defect or damage that occurs as a result of your failure to follow the instructions and notices written in the Annex. Contact Hamamatsu subsidiary or distributor for installation condition which is not listed in the Annex.

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6-2 CAMERA CONTROL UNIT (FRONT PANEL)

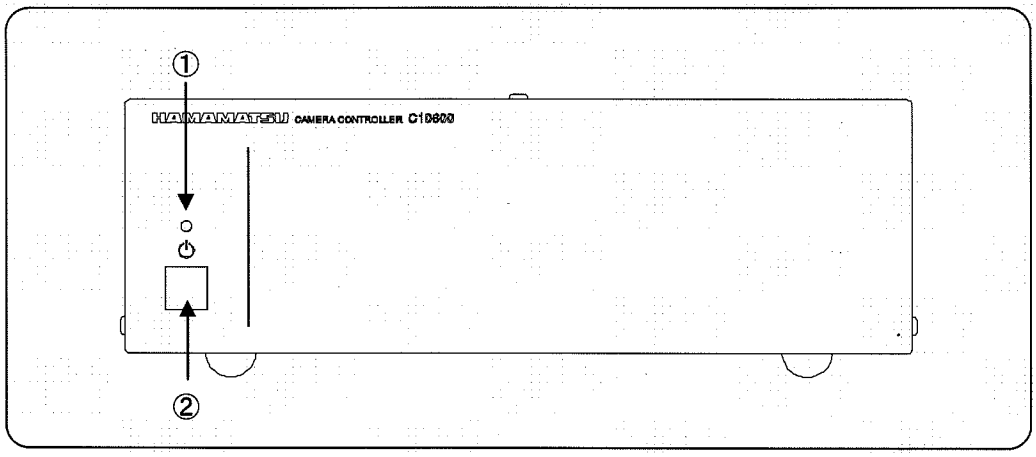


Fig. 6-2

① Power LED

The LED indicates status of power. The indicator lights in the following colors.

Status of power distribution	Lighting color
Stand by	orange
Power is on	green
Power failure	red

- When power failure occurred, stop operation immediately and unplug the power code immediately.

② Power switch

Before pressing the power button, the camera status is stand by. When the power button is pressed for a couple of seconds, camera turns on and the LED lights up in green. To change the status to stand by, press the button for a couple seconds again. The LED lights up in orange when the status is back to stand by.

- Unplug the power code to stop power supply completely.

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6-3 CAMERA CONTROL UNIT (REAR PANEL)

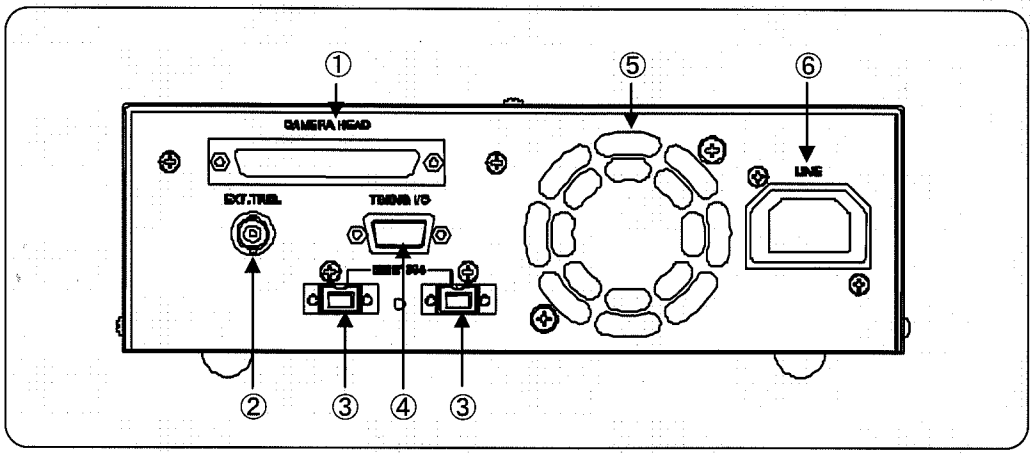


Fig. 6-3

① Camera connector [CAMERA HEAD]

This is used to connect the camera head to camera control unit. Use the special cable provided for that purpose.

② Trigger input connector [EXT.TRIG.]

This is used when the camera is being operated using external synchronization. Input is TTL level (EXT.TRIG circuit is terminated by 1 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.)

③ IEEE1394b interface connector [IEEE1394b]

This connector is used to connect the camera controller to a host computer. Connect to the host computer's IEEE1394b interface connector using the cable.

④ Timing I/O connector [TIMING I/O]

The connector is used to output various signals.

Note

- Please see 9-9 [TIMING OUTPUT SETTING] for details.

⑤ Air outlet

This is the outlet for heat ventilation.

- Make sure a space of at least 10 cm is available at the back of the unit for ventilation.

⑥ AC inlet [LINE]

This is the power supply terminal. Using the accessory power supply cord.

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7. CONNECTING CABLES

Refer to the figure when connecting the various cables.

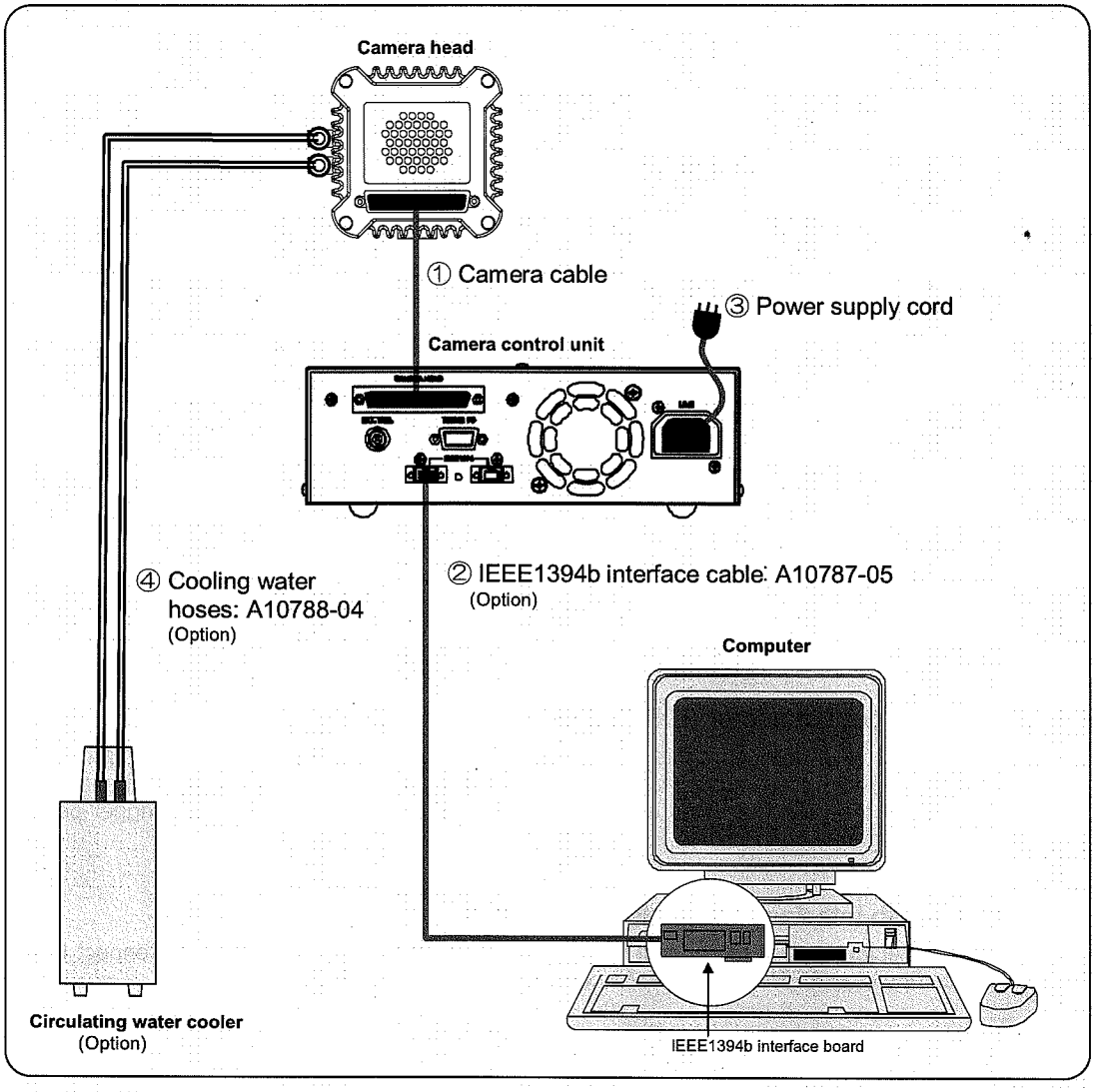


Fig. 7-1

- Connect camera cable and IEEE1394b interface cable first, and then connect the power supply cord.

- IEEE1394a board can also be used. However, in that case, data transfer speed may become 1/2 of IEEE1394b. For example, at the setting of fast readout mode, 1x1 full frame readout, frame rate is 16.2 Hz with using IEEE1394b, but it is 11.8 Hz with using IEEE1394a.

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① Camera cable

This connects the camera control unit to the camera head using the dedicated camera connector. The cable has no particular polarity.

② IEEE1394b interface cable

This cable is to connect IEEE1394b interface on the camera head and the interface on the computer. After the cable is connected, fix the connectors using screws.

Note

- Hamamatsu recommends A10787-05 optional IEEE1394b interface cable for this camera. The camera complies with EMC direction with using A10787-05 IEEE1394b interface cable. Be careful that the camera with other IEEE1394b interface cable may not fulfill the EMC directive requirements. Hamamatsu does not ensure the camera performance when the camera is used with other IEEE1394b interface cable.

③ Power supply cord

This is the cord to supply a power supply.

- Check AC power voltage is within the spec below before connecting the power supply cord.
  - Power voltage spec: AC 100 V to AC 240 V
  - Input voltage range: AC 90 V to AC 264 V

Note

- At shipment, the voltage is set for the customer. Use the camera with the voltage indicated on the rating sticker.

④ Cooling water hoses (Option)

They are used for connecting "WATER IN" of the camera head and the outflow mouthpiece of the water cooler, and "WATER OUT" and the inflow one respectively.

⚠ CAUTION

- Be careful water does not splash on the camera. Cut off the power supply of the circulating water cooler and the camera when you remove and install the cooling water hoses.

Note

- As for detail of the circulating water cooler, please refer to the manual of the circulation water cooler.

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7-2 CONNECTION OF WATER-COOLING HOSES (WATER-COOLING ONLY)

(1) Camera head

Connect the cooling water circulation hose as shown in the Fig. 7-2. Insert the hose in the direction indicated as 1. Push the button indicated as 2 to remove the hose.

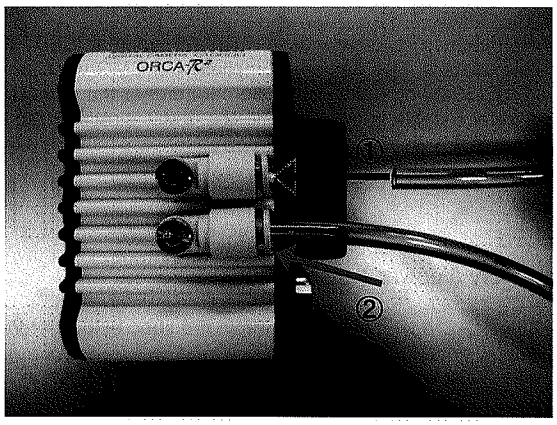


Fig. 7-2

⚠ CAUTION	• Stop water circulation when connecting / disconnecting the hose, and turn off the power of the camera and other peripheral equipments. • Be careful of not to spill water on the camera or other peripheral equipments when connecting / disconnecting the hose. When water circulation is stopped, water may remain in the hose. Remove water or water drop inside the hose by air or other appropriate methods.

(2) Circulating water cooler

The hose has ③ (Internal diameter: 4 mm / External diameter: 6 mm) and ④ (Internal diameter: 8 mm / External diameter: 13.5 mm). (Refer to Fig.7-3)
When the hose is used in ③, the hose of ④ can be removed when the hose of ③ is pulled with pushing the part (Refer to Fig.7-4) of ⑤ into ④ side.

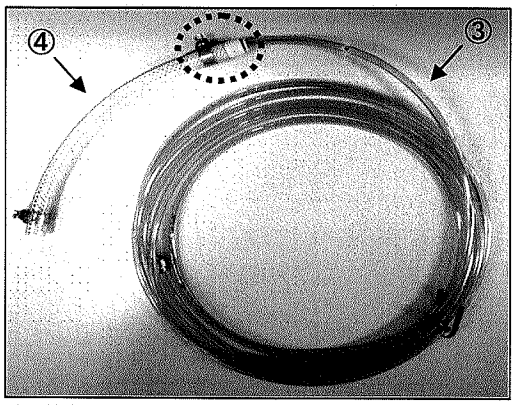


Fig. 7-3

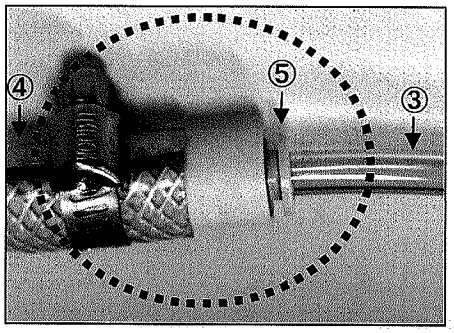


Fig. 7-4

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⚠ CAUTION	• Follow the instruction in 7-2 [CONNECTION OF WATER-COOLING HOSES (WATER-COOLING ONLY)] to connect / disconnect the hose. • Use distilled water or deionized water for water cooling. • When the cooling water temperature is lower than the ambient temperature, condensation can appear on the surface of the hose and the inside of the camera. Condensation inside the camera will cause trouble. When using cooling water that is cooler than the ambient temperature, ensure that the ambient humidity is low and use the camera in an environment where condensation never happens inside the camera. • Hamamatsu recommends 20 °C for Circulating water temperature. • Confirm that water comes in when you start cooling it. • Do not stop coolant in the system working. • Keep 0.3 L/min flow rate or 0.3 MPa water pressure for water circulation. • Replace the water hose with a new one whenever it can't keep the Keep 0.3 L/min flow rate or 0.3 MPa water pressure for water circulation due to the hose deterioration. • Be careful of not to spill water on the camera or other peripheral equipments when connecting / disconnecting the hose. When water circulation is stopped, water may remain in the hose. Remove water or water drop inside the hose by air or other appropriate methods. • Stop water circulation when connecting / disconnecting the hose, and turn off the power of the camera and other peripheral equipments.

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8. OPERATION

8-1 PRECAUTIONS

When cables are connected, confirming the power switch is in the OFF position.

(1) Ambient temperature

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. The CCD chip is positioned on the cooling side, and cooling is done by discharging the heat from the heated surface. Thus, the maximum temperatures to which the CCD 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 in order for cooling to be effective. The recommended ambient temperature for camera operation is 20 °C.
Both water-cooling or air-cooling are available as cooling method, CCD cooling temperature is more stable under water cooling operation.

(2) Protection circuit

A double protection circuit protects this camera's thermoelectric cooling device. Once the protection circuit is activated, fan at the back of the camera head stops forcibly, warning buzzer beeps and also power supply to the peltier stops. When the protection circuit is activated, turn off the power immediately and remove cause of heat radiation defect.

(3) Control specifications

This camera conforms to the "IIDC 1394-based Digital Camera Specification, Ver.1.31" control specifications (below, "controller specification"). It is possible to modify camera operation from a host computer by configuring each of the camera parameters, via the IEEE1394 interface.

Note

- Please see the "IIDC 1394-based Digital Camera Specification, Ver. 1.31," and the supplementary section of this User's guide for camera parameter definitions and configuration.

(4) Starting up the control software

The control software should be run several seconds after the power supply to the camera has been turned on. If commands are received through the serial interface when the power supply to the camera is turned on, the camera may not start up properly. If this happens, immediately stop the camera and the control software, and restart both, waiting the appropriate interval before running the software.

Note

- The control software is not attached to this camera.

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8-2 PREPARATION FOR IMAGING

Use the following procedure when starting operating of the camera.

(1) Connect the equipment as shown in Fig.7-1 before operating of the camera.

- When the cables are connected, confirming the power switch is in the OFF position.

(2) Switch the camera's power switch to ON.

(3) At the time of the air-cooling, check that the cooling fan is turning properly and that air is circulating. At the time of the water-cooling, check that cooling water always circulates suitably.

Note

- The cooling temperature becomes stable about 10 minutes after cooling begins.

8-3 CAMERA DRIVER INSTALLATION

Install DCAM API.

After connecting the camera to computer and the camera is turned on, two icons “Generic 1394 Desktop Camera” and “HAMAMATSU C10600-10B” are added and the drivers are applied for each icon.

(1) Generic 1394 Desktop Camera

This equipment is compliant to the IIDC standard. Any special driver does not have to be installed since Windows already contains the IIDC standard driver.

(2) Hamamatsu C10600-10B

In order to use all available camera features, Hamamatsu’s camera driver, DCAM-API is required. After installing DCAM-API of June 2008 version or after, this icon becomes available.

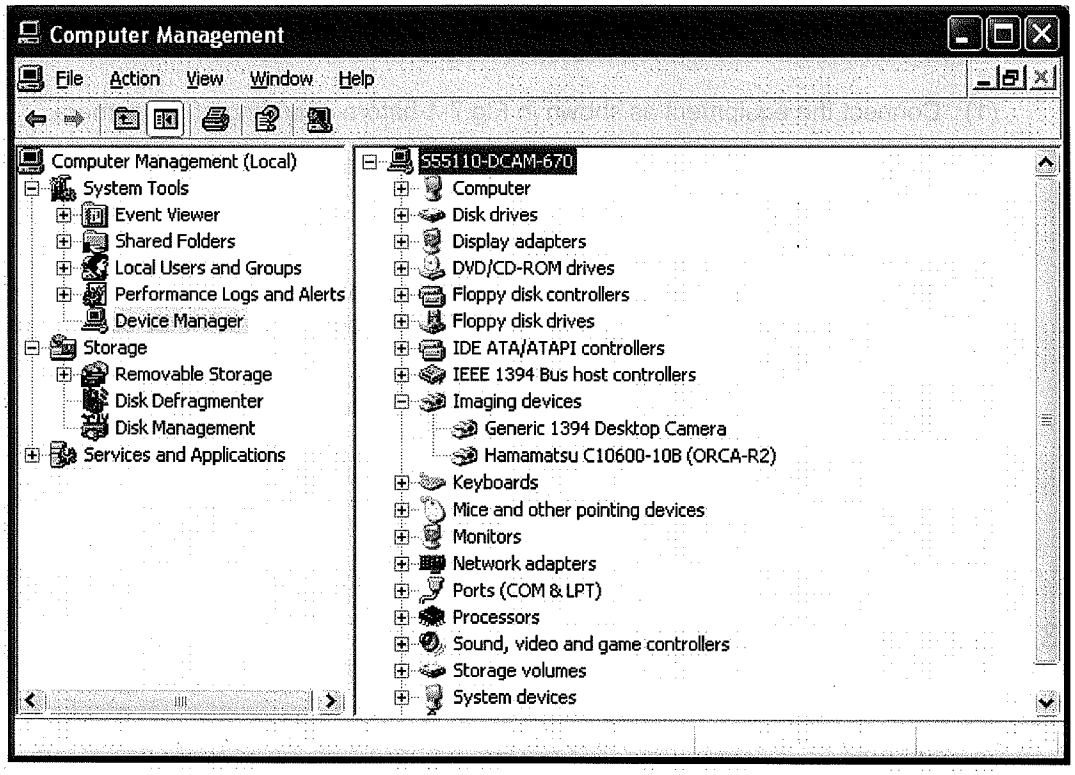
Note

- Contact Hamamatsu subsidiary or local distributor for the DCAM-API.

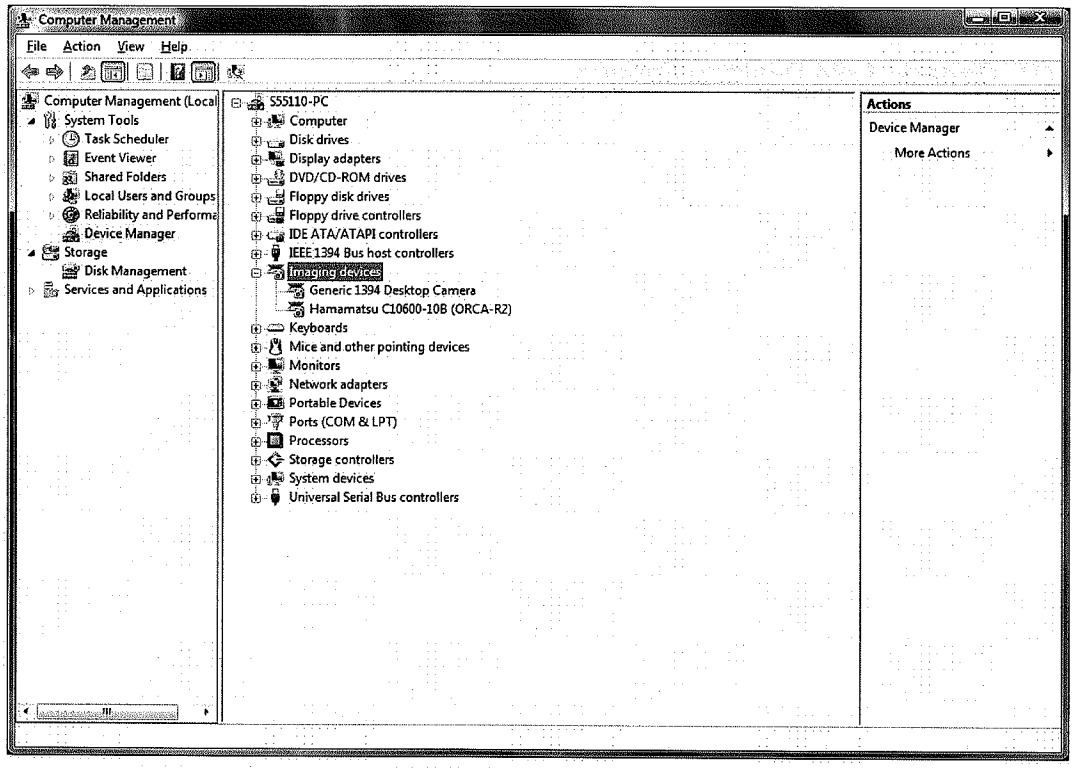
Note

- Refer to the "DCAMP-API Installation manual" for installation directions.

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After installation of DCAM (Win XP)



After installation of DCAM (Win Vista)

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8-4 IMAGING

When control software starts, the system start to take images and to send image data.

Readout mode	Normal scan
Scan mode	1×1 Normal readout
Exposure time	100 ms
Contrast enhancement gain	0
Contrast enhancement offset	255
A/D converter	12 bit



- Carefully check that the cooling fan is operating properly during measurement and that CCD temperature is stable.

8-5 END OF IMAGING

Carry out the procedure below when imaging is finished.

(1) End imaging or transmission of image data with the control software.

(2) Turn off the power to the camera and peripheral equipment*.

* When the controller is turned off, the status becomes stand by. Unplug AC power code to terminate power supply completely.

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9. IMAGE ACQUISITION

9-1 THEORY OF CCD

The camera uses the new progressive-scan inter-line CCD, its structure is as shown in Fig.9-1. Incident photon generates an electron on the photo-diode. Generated electrons are transferred from photo-diode through the masked vertical CCD (VCCD) and horizontal CCD (HCCD), to an on-chip amplifier, which converts the electron to voltage.
Readout signal opens the sensor gate and transfer generated charges from all the photo-diode without mixed with the VCCD. After all these processes, exposure end. This CCD has also a function of electrical shutter. By using this function, all charges integrated in the photo-diode are dumped to the silicon base instantaneously.

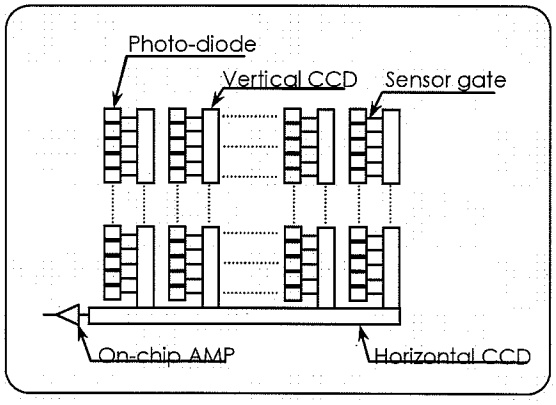


Fig. 9-1

- Binning:
  Accumulated charges for a specified number of pixels in the vertical and horizontal directions on the CCD are calculated and combined (binned), then readout from the CCD. With this camera, binning can be set to 2×2, which two pixels in the vertical and horizontal directions are combined, 4×4, which four vertical and horizontal pixels are combined, or 8×8, which eight vertical and horizontal pixels are combined.
- Exposure time:
  When the camera is set to the normal CCD scanning mode, its operation is as shown in Fig.9-2. Exposure time is the elapsed time between one readout signal and the next. This interval should be longer than the necessary time for all charges from the CCD to be readout.

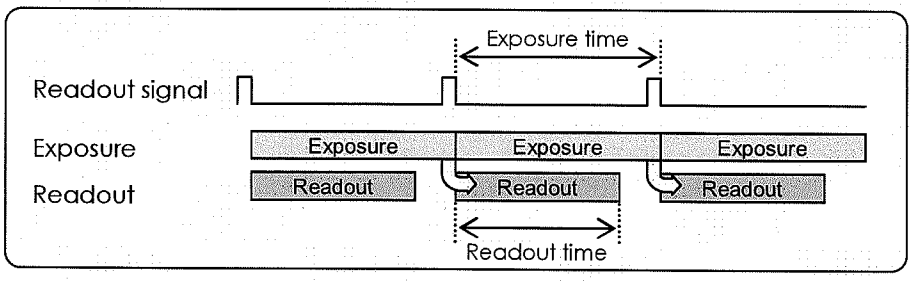


Fig. 9-2

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9-2 CAMERA CONTROL SPECIFCATIONS

This digital camera has an IEEE1394-compliant interface. It operates under Format 7 of the "IIDC 1394-based Digital Camera specification, Ver 1.31." See the specification documents listed below for details about camera control:

- IEEE 1394b-2002, Standard for a High Performance Serial Bus s
- 1394-TA 2003017, IIDC 1394-based Digital Camera Specification Version 1.31

Format 7 operation modes on this camera are as follows:

Format7	Mode 0	Normal scan	1×1 Normal readout
	Mode 1	Normal scan	2×2 Binning readout
	Mode 2	Normal scan	4×4 Binning readout
	Mode 3	Normal scan	8×8 Binning readout
	Mode 4	Fast scan	1×1 Normal readout
	Mode 5	Fast scan	2×2 Binning readout
	Mode 6	Fast scan	4×4 Binning readout
	Mode 7	Fast scan	8×8 Binning readout

Note

- In order to operate the camera with Microsoft standard driver, Format0_mode3 {640x480 YUV(4:2:2)} is supported. When the camera is operated with Format 0, the camera setting would be normal scan, 1x1, 640 x 480 from center and sub-array output.

9-2-1 CCD SCAN SPEED SETTING

This camera has a selectable clock speed (scan speed) feature for various applications.

(1) Normal scan

When performing a charge readout operation of CCD at 14 MHz pixel clock, its frame rate will be 8.5 Hz at 1×1 normal readout. At that time, readout noise is 6 electrons r.m.s. (typ.). This setting is suitable for an application, which requires low noise.

(2) Fast scan

When performing a charge readout operation of CCD at 28 MHz pixel clock, its frame rate will be 16.2 Hz at 1×1 normal readout. At that time, readout noise is 10 electrons r.m.s. (typ.). This setting is suitable for an application, which requires faster readout.

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9-2-2 DYNAMIC RANGE SETTING

This camera provides the high-dynamic range mode at 2x2, 4x4 and 8x8 binning readout with normal scan setting. Normally the full-well capacity is set to be approximately 18 000 electrons, however when the high-dynamic range mode is selected, its full-well capacity will be increased to approximately 36 000 electrons. Note the high-dynamic range mode is not a default setting.

Note

- This feature is enabled when this digital camera is operated with driver software called DCAM-API, which supports HAMAMATSU digital cameras.

9-2-3 CCD READOUT METHOD (SCAN MODE)

(1) 1x1 Normal Readout

Perform charge readout from CCD uniformly for all pixels.
The frame rate of all pixel readout is 8.5 Hz at normal scan and 16.2 Hz at fast scan.

(2) 2x2 Binning Readout

Perform charge readout from CCD by 2x2 binning.
The frame rate of all pixel readout is 15.6 Hz at normal scan and 28.4 Hz at fast scan.

(3) 4x4 Binning Readout

Perform charge readout from CCD by 4x4 binning.
The frame rate of all pixel readout is 26.7 Hz at normal scan and 45.7 Hz at fast scan.

(4) 8x8 Binning Readout

Perform charge readout from CCD by 8x8 binning.
The frame rate of all pixel readout is 40.6 Hz at normal scan and 64.3 Hz at fast scan.

(5) Partial scan (Sub-array scan)

This camera supports partial-scanning operation in each mode. Partial scanning is a procedure in which only a portion of the image is scanned. See the IIDC camera control specification for instructions on configuring partial scanning. It is possible to increase the frame rate by reducing the number of vertical lines scanned.

Note

- See 9-3 "Configuring exposure time" to figure out fastest frame rate.

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9-3 CONFIGURING EXPOSURE TIME

Exposure time is configured in the "shutter" feature of camera feature. The "shutter" parameter can be configured in either relative or absolute settings. However, there is range limitation on relative register settings. Available setting range of absolute register is 10 µs to 4200 s. When this feature is turned off, exposure time will be set to equivalent time of single frame.
The time of a single frame (Tf) is calculated using the following formulas:

Readout setting		Tf (µs)
Normal scan	1×1 Normal readout	***Vn × 104 µs + 0.01084 s***
	2×2 Binning readout	***Vn × 52 µs + 0.01084 s***
	4×4 Binning readout	***Vn × 26 µs + 0.01084 s***
	8×8 Binning readout	***Vn × 13.375 µs + 0.010909 s***
Fast scan	1×1 Normal readout	***Vn × 52 µs + 8.588 ms***
	2×2 Binning readout	***Vn × 26 µs + 8.588 ms***
	4×4 Binning readout	***Vn × 13 µs + 8.588 ms***
	8×8 Binning readout	***Vn × 6.75 µs + 8.634 ms***

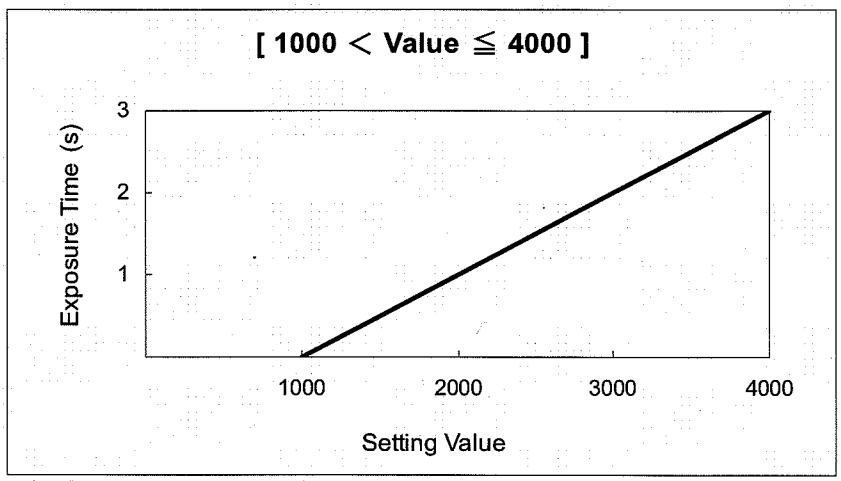
Vn: Number of vertical readout lines

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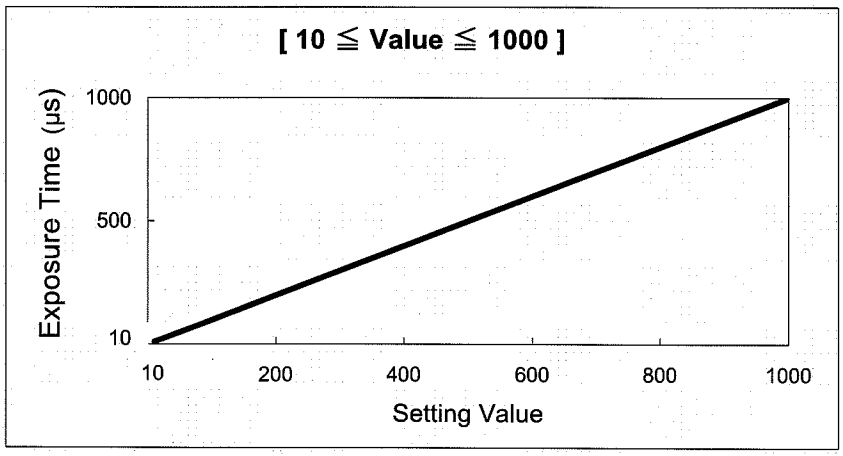
9-3-1 RELATIVE VALUE SETTING

Set relative parameter in +81Ch of camera CSR using 12 bit values. Following Fig. 9-3 shows rough relation between relative parameter and exposure time. Setting parameter range is between 10 µs to 3 s.

【Relative parameter and exposure time】



Exposure Time ≒ Setting value × 1 (ms) - 1000 (ms)



Exposure Time ≒ Setting value × 1 (µs)

Fig. 9-3

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9-3-2 ABSOLUTE VALUE SETTING

To configure an absolute value, set an absolute value in the shutter's absolute value register (its location is mentioned later) in seconds, then set bit 1 (Abs_Control) in the Shutter register of +81Ch.

Note

- If the bit 1 (Abs_Control) is already set in the shutter register, it is sufficient to write an absolute value to the shutter absolute value register only.

To figure out the address of absolute register of "Shutter", use the Quadlet offset from the base address (0xF000_0000) is written at "ABS_CSR_HI_INQ_7" of +71Ch. Setting parameter range is between 10 µs to 4200 s.
When absolute setting is used, an actual parameter inside the camera is set as a returned value in the set value register. The actual readout time can be recognized from this value.

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9-4 EXTERNAL TRIGGER SETTING

External trigger is set at "Trigger" in the "Camera feature". The following trigger modes are available on this camera.

Trigger	Mode 0	Edge trigger
	Mode 1	Level trigger
	Mode 14	Synchronous readout trigger
	Mode 15	Start trigger

9-4-1 EDGE TRIGGER

Edge trigger mode is a mode which the camera starts exposure at the rising or falling edges of input trigger signal. At that time, exposure time is set at "Shutter" in the "Camera feature" (See 9-3). When another trigger signal is input while exposure time, the camera disregards the trigger automatically until exposure time end. Valid input time of trigger signal is generated to outside through the timing I/O connector. Following Fig. 9-4 shows an example of timing chart in the case of rising edge.

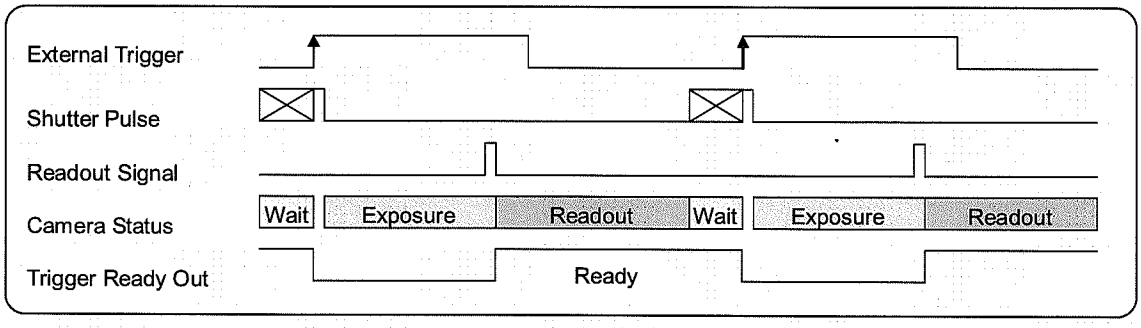


Fig. 9-4

9-4-2 LEVEL TRIGGER

Level trigger mode is a mode the camera keeps exposure during input trigger signal is either High or Low level. Charge accumulation (exposure) lasts during input trigger signal at either High or Low level, at the timing when signal level is shifted to opposite level (when High became Low or Low became High), exposure ends and the camera starts to readout signal. Following Fig. 9-5 shows an example of timing chart.

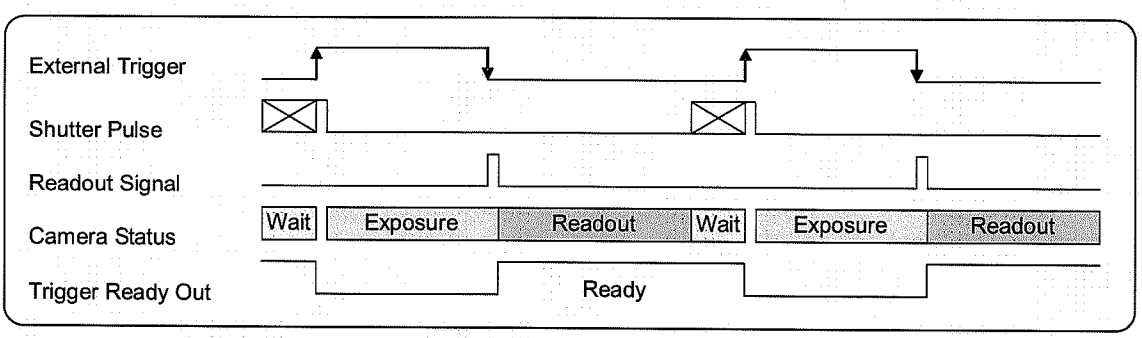


Fig. 9-5

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9-4-3 SYNCHORONOUS READOUT TRIGGER

Synchronous readout trigger is a mode the camera starts readout at the rising or falling edge of input trigger signal. In this mode, exposure time is the time between triggers. Following Fig. 9-6 shows the timing chart.

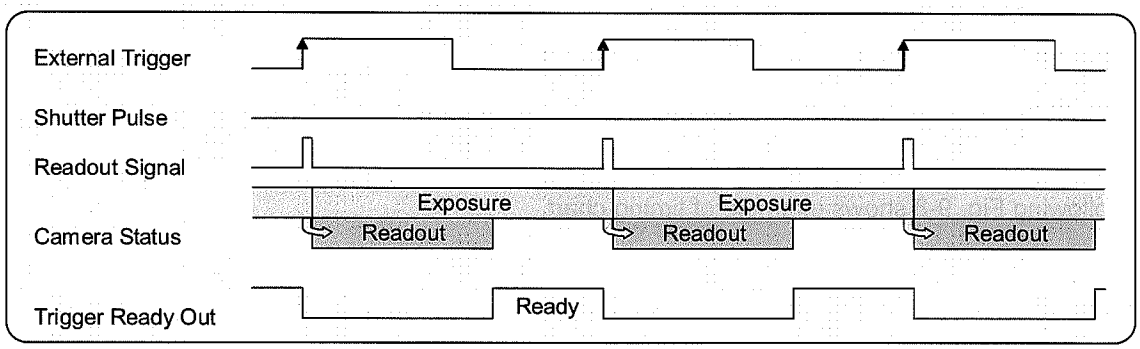


Fig. 9-6

In addition, this mode enables to set exposure time by input pulse number. This feature counts number of input pulses inside the camera. When the number of count is reached to previously specified number, the camera starts readout. Default time is 1 (max. 4095 times).

Note

- This feature can be controlled when this camera is operated with driver software called DCAM-API, which supports HAMAMATSU digital cameras.

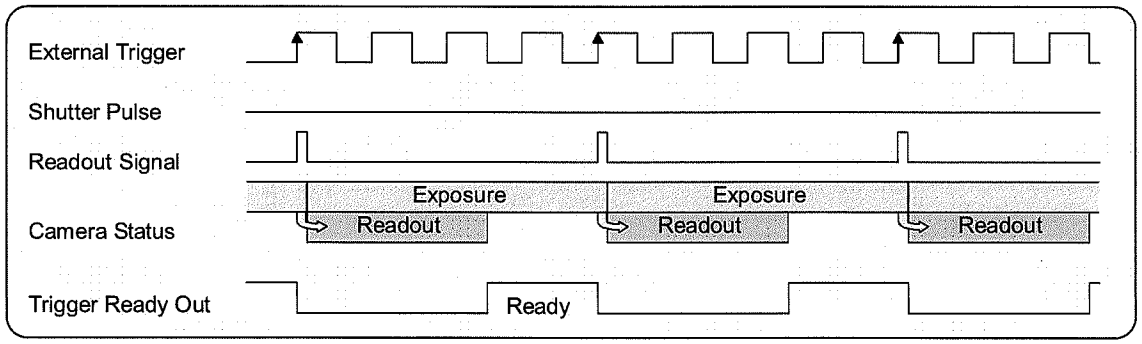


Fig. 9-7

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9-4-4 START TRIGGER

Start trigger mode enables to operate the camera as internal mode by rising or falling edge of input trigger signal. This feature is appropriate to acquire consecutive images by only one trigger pulse.

Note

- This feature can be controlled when this camera is operated with driver software called DCAM-API, which supports HAMAMATSU digital cameras.

Note

- If exposure time is shorter than 1 frame readout time, the camera does not start exposure with the timing of input trigger pulse edge but starts exposure with some delay.

Following Fig. 9-8 shows example of timing chart.

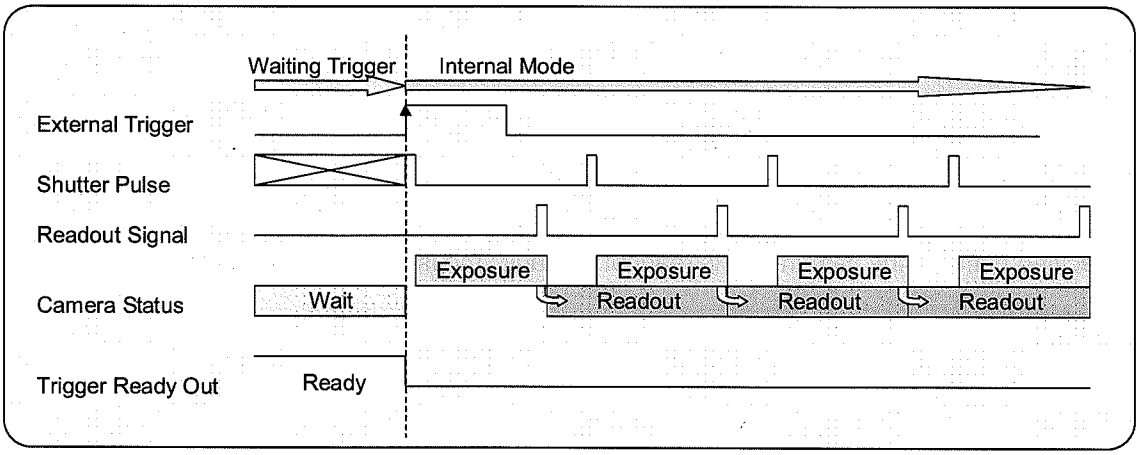


Fig. 9-8

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9-5 GAIN LEVEL CONFIGURATION

Camera gain is configured at the "Gain" in the "Camera feature". The gain can be configured in the relative register. The setting range for the relative value register is 0 to 255. Parameter 0 is equivalent to 0 dB and 255 is equivalent to 20 dB.

9-6 OFFSET LEVEL CONFIGURATION

Camera offset is configured in the "Brightness" in the "Camera feature". Brightness can be configured in the relative register. The setting range for the relative value register is 0 to 255. Parameter 0 is equivalent to -100 %, 255 is equivalent to 0 %.

9-7 LIGHT MODE SPECIFICATIONS

Switching the camera between Low light mode and High light mode can be done in "Gamma" in the "Camera feature". Set this value to 0 for low light mode, and 1 for high light mode. At low light mode, the camera becomes high sensitivity mode operation, therefore when the camera is operated under circumstance of short exposure and high intensity, specific phenomena of low light mode might occur, however it is not a trouble of the camera. At high light mode, anti-blooming feature will become effective, however sensitivity becomes slightly lower.

9-8 A/D BIT SETTING

Digital output can be selected between 12 bit and 16 bit on this camera. Default is 12 bit output.

Note

- This feature can be controlled when this camera is operated with driver software called DCAM-API, which supports HAMAMATSU digital cameras.

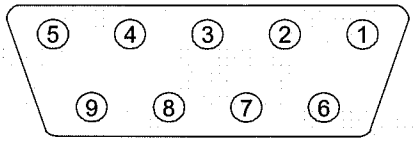
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9-9 TIMIMG OUTPUT SETTING

This camera provides a function to output the timing signal from the timing I/O connector on the back of the camera control unit, which synchronized with the camera operation. Output signal from the timing I/O connector is shown as below.

Pin No.	Signal
1	Option
2	Option
3	**Integ out**
4	**Programmable Timing out**
5	**Trigger Ready out**
6	GND
7	GND
8	GND
9	GND

Pin connection



- 1pin, 2pin are option. Do not connect anything.

(1) Integ out

This outputs the timing of CCD exposure time. Polarity is High during exposure.

Note

- Please see Fig. 9-9 for details.

(2) Programmable Timing out

This output enables to output pulse with discretional delay time and pulse range based on the start of CCD exposure timing. Output polarity can also be selected.

Note

- This feature can be controlled when this camera is operated with driver software called DCAM-API, which supports HAMAMATSU digital cameras.

Fig. 9-9 shows the example of timing chart.
Default is set as follows; 0 µs delay time, 100 µs pulse range and negative polarity (polarity indicated in Fig. 9-9).

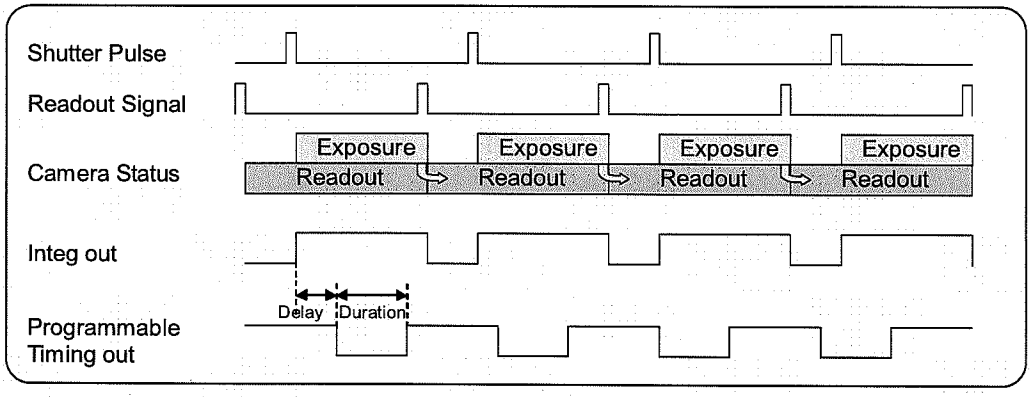


Fig. 9-9

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(3) Trigger Ready out

This outputs the time when trigger is acceptable in external trigger mode. Polarity is High during acceptable time. The camera disregards a trigger, which has been input other than the acceptable timing.

Note

- Please see the timing charts example of each external trigger case, which are shown in 9-4 [EXTERNAL TRIGGER SETTING] for details.

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10. PRECAUTIONS WHEN USING THE CCD

This camera uses a CCD. Careful attention must be paid to the following points when using a CCD:

(1) White Spot

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

* After an image made using a certain exposure time is loaded, the CCD 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) Smear

When imaging very bright objects, bright vertical stripes (vertical smear) may be visible in the images being taken. This is due to leakage of current to the vertical CCD's from the photosensors. The amount of leakage is proportional to the readout time and exposure time. Smear presents no problem when the camera is in Normal frame blanking mode. However, when using the electronic shutter of the external exposure time settings, this sometimes becomes a problem when the exposure time is shortened.

(3) Folding distortion

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

(4) Interference fringes pattern

Coherent light such as LASER light may generate interference fringes pattern on image.

(5) Over light

⚠ CAUTION	• Be careful not to input too strong light such as high-energy laser into CCD chip because CCD chip may be damaged by over light.

11. MAINTENANCE

11-1 CARE

Clean the exterior with a soft, dry cloth.



- Do not use a wet cloth, dirty cloth.

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12. TROUBLESHOOTING CHECKLIST

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

12-1 TURNING ON THE POWER

(1) The power LED doe not light

Cause	Measures	Chapter
Loose AC inlet	Reconnect AC inlet	7
Short in power supply cord	Contact Hamamatsu subsidiary or distributor	16
Damaged LED circuit		
Damaged power switch		

(2) Image is not transferred

Cause	Measures	Chapter
Camera cable not fully connected	Reconnect	7
IEEE1394 interface cable not fully connected		
Short in camera cable	Replace the cable	
Short in IEEE1394 interface cable		

12-2 ALTHOUGH IMAGES ARE TRANSFFERED

(1) Scratches or discoloration visible on the screen

Cause	Measures	Chapter
The glass on the front of the camera head is dirty	Wipe the glass with a piece of gauze dipped lightly in alcohol	

(2) Image is blurred

Cause	Measures	Chapter
The lens is not focused	Focus the lens	16
The CCD chip is dirty	Contact Hamamatsu subsidiary or distributor	

(3) Only dark shaded Image output

Cause	Measures	Chapter
The lens mount cap has been left in place	Take off the cap	

(4) All Image overflowing

Cause	Measures	Chapter
The volume of light is too high	Tighten the lens aperture	
The amp gain is too high	Reduce the amp gain	

(5) Noise in Image

Cause	Measures	Chapter
There is external noise coming in	Find the source and eliminate it	
Internal connectors are loose	Contact Hamamatsu subsidiary or distributor	16
Circuitry is defective.		

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13. SPECIFICATIONS

13-1 CAMERA SPECIFICATIONS

(1) Electrical specifications

Imaging device		Progressive-scan interline CCD with micro-lens	
Effective number of pixels		1344 (H) × 1024 (V)	
Cell size		6.45 µm × 6.45 µm (Square format)	
Effective area		8.66 mm × 6.60 mm (2/3" size)	
Scan mode		Normal scan	14 MHz/pixel
		Fast scan	28 MHz/pixel
Frame rate	Normal readout	Normal scan	8.5 Hz
		Fast scan	16.2 Hz
	2×2 binning readout	Normal scan	15.6 Hz
		Fast scan	28.4 Hz
	4×4 binning readout	Normal scan	26.7 Hz
		Fast scan	45.7 Hz
	8×8 binning readout	Normal scan	40.6 Hz
		Fast scan	64.3 Hz
Readout noise (r.m.s.)		Normal scan	6 electrons (typ.)*1
		Fast scan	10 electrons (typ.)*1
A/D converter		12 bit (default) / 16 bit (In both scan modes)	
Cooling methods		Electronic cooling + Air cooling or Water cooling	
Cooling temperature		- 35 °C at Air cooling / - 40 °C at Water cooling	
Lens mount		C mount	
Amp gain conversion coefficient*2		12 bit: 4.4 electrons / ADcounts 16 bit: 0.275 electrons/ADcounts (18 000 electrons)	
Contrast enhancement gain		Gain: 1 to Approx. 10 times (256 steps) Offset: 256 steps	
Exposure time		10 µs to 4200 s	
Partial scan		Arbitrary area of 64×64 pixel units (Mode 0) Arbitrary area of 84×64 pixel units (Mode 1 to 3)	
External trigger mode		Edge trigger, Level trigger, Start trigger, Synchronous readout trigger, Cyclic trigger	
External trigger function		Trigger readout delay, Thin out of encoder pulses	
Image data format		Uncompressed B&W (Mono8, Mono16)	
Host interface standard		IEEE1394b	
Connector specification		6-pin IEEE1394 connector (Industrial type)	
Camera control specification		IIDC 1394-based Digital Camera specification Ver1.31	

*1 This value is the measured value in normal readout mode. To find this value, the CCD was placed in darkened conditions and the exposure time set to the minimum level. Two images were then read under these conditions and subtraction carried out between the images. The standard deviation of the results was measured and that value was multiplied by the conversion coefficient divided by the square root.

*2 The amp gain conversion coefficient is the coefficient used to convert the count value for the measured image to electrons. When the conversion is carried out, dark subtraction must always be done first. The value noted in parentheses below the conversion coefficient indicates the amount of load placed on the CCD if the A/D converter overflows.

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(2) Power supply specifications

Input power supply	AC 100 V to AC 240 V
Frequency	50 Hz / 60 Hz
Power consumption	Approx. 60 V·A

Note

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

Note

- UL compliance is valid only with the camera line voltage of AC 100 V or AC 117 V originally set by the factory of Hamamatsu Photonics K.K

(3) Ambient operating environment

Ambient operating temperature	0 °C to + 40 °C
Ambient storage temperature	-10 °C to + 50 °C
Ambient operating humidity	70 % max. (with no condensation)
Ambient use place	Indoors, maximum elevation 2000 m

(4) Dimensional outlines and weight

Camera head	Approx. 1.1 kg
Camera control unit	Approx. 2.8 kg (not including cables and accessories)

Note

- Please see Chapter 14 for dimensional outlines.

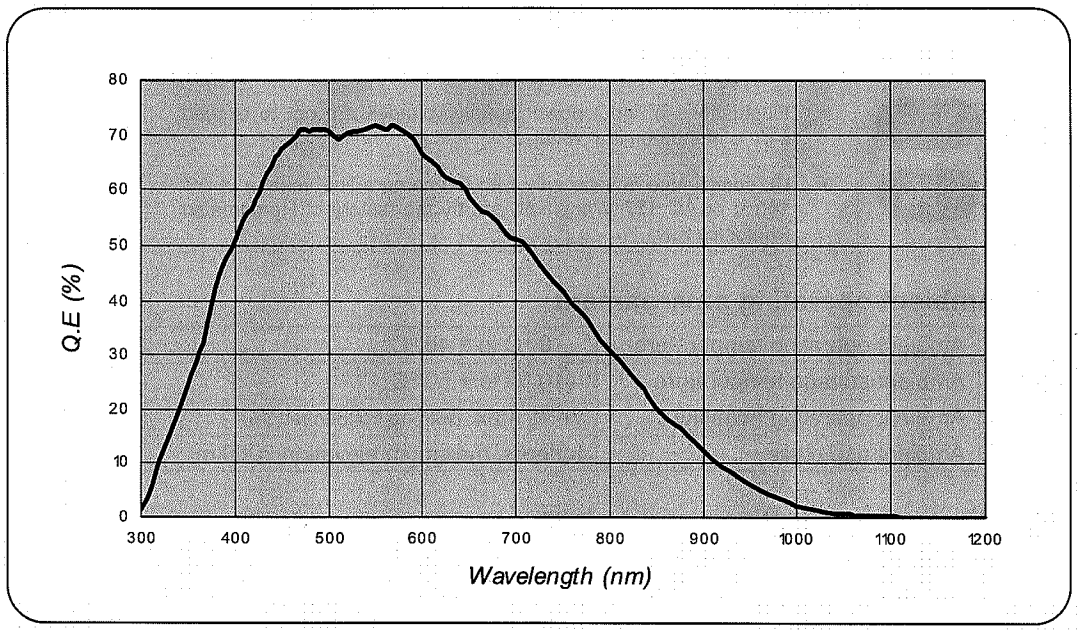
(5) Applicable standards

Safety	EN61010-1: 2001
	Overvoltage category: II
	Pollution degree: 2
EMC	EN61326-01: 2006 Class A

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13-2 SPECTRAL CHARACTERISTICS

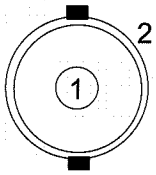
Following is the typical spectral characteristics of the CCD. (Using Low-light mode)



13-3 INTERFACE SPECIFICATIONS

(1) Trigger input connector pin assignments [EXT.TRIG.]

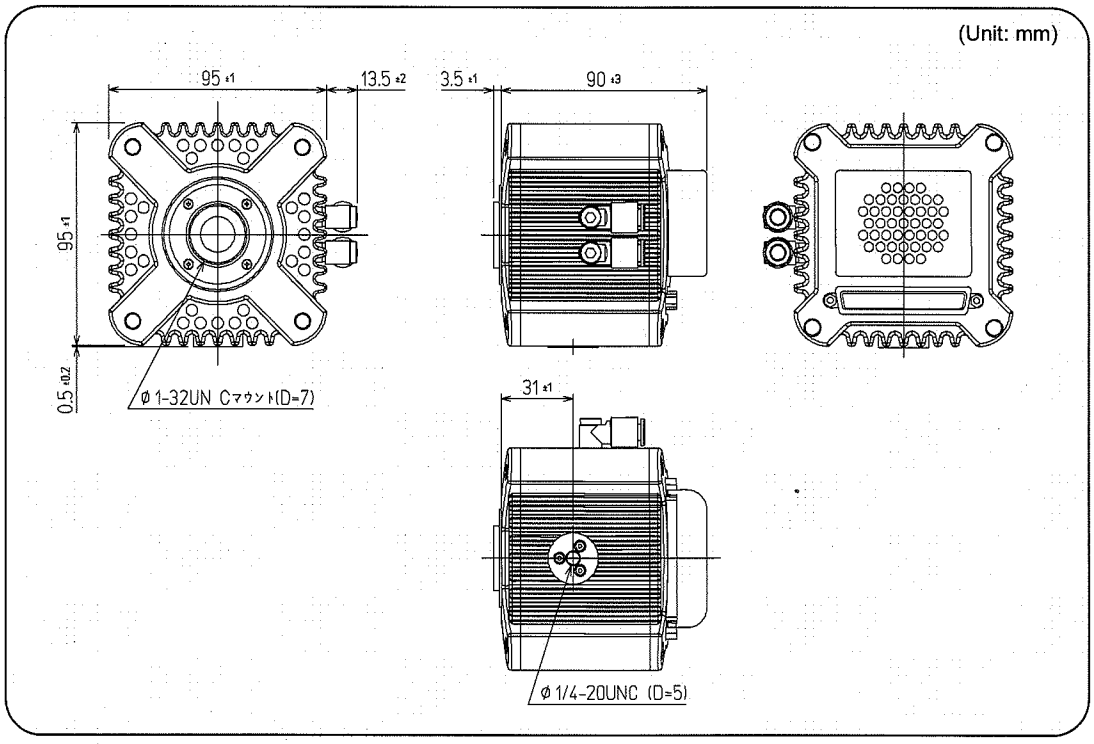
This is the external trigger input terminal used when the camera is being operated externally, in External control mode. The input level is TTL level (EXT.TRIG. circuit is terminated by 1 kΩ.), and the trigger polarity is programmable.

No.	Signal	Pin connection
1	TRIG IN	
2	GND	

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14. DIMENSIONAL OUTLINES

14-1 CAMERA HEAD

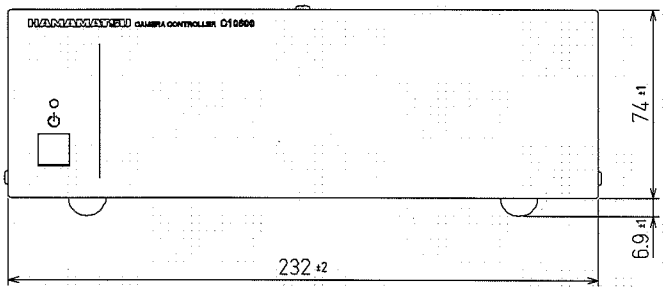


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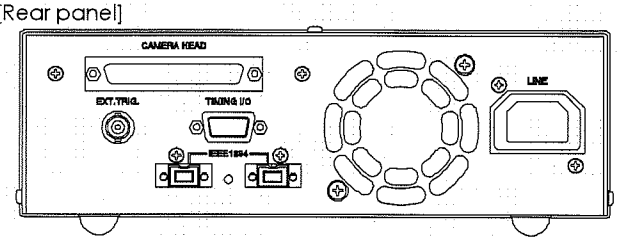
14-2 CAMERA CONTROL UNIT

(Unit: mm)

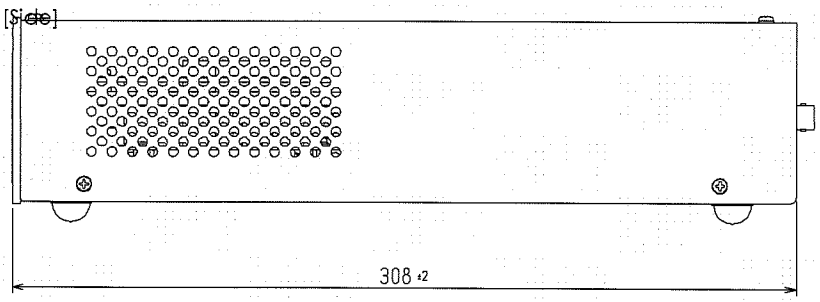
[Front panel]



[Rear panel]



[Side]



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15. WARRANTY

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

(1) Unless otherwise stated by Hamamatsu subsidiary or local distributor, this system 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 atomic rays, the radiation (X-rays, gamma rays, UV light, etc.) of CCD is excepted.

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

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

(4) We offer LIFETIME WARRANTY for the hermetically vacuum-shield head regarding vacuum leakage. However, following cases are exceptional to the LIFETIME WARRANTY.
- Outgassing is under warranty for 12 months from the delivery date.
- Peltier element deterioration is under warranty for 24 months from the delivery date.

REPAIRS

(1) If you notice anything wrong with the camera, confirm whether or not it is malfunctioning by referring to the troubleshooting checklist 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 Hamamatsu subsidiary or 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.

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16. CONTACT INFORMATION

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- *The contents of this manual are subject to change without notice.*
- *The unauthorized reproduction or distribution of parts or all of this manual is prohibited.*
- *If one of the following problems occurs, please contact Hamamatsu Photonics. (See the CONTACT INFORMATION.) We will deal with the problem immediately.*
  - *Some contents of the manual are dubious, incorrect or missing.*
  - *Some pages of the manual are missing or in the wrong order.*
  - *The manual is missing or dirty.*

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ANNEX: ATTACHING THE CAMERA HEAD TO TRIPOD

Follow instructions below when attaching the C10600-10B camera head to tripod.

⚠CAUTION	• Follow instructions and notices written in this Annex. • Hamamatsu is not responsible for defect or damage that occurs as a result of your failure to follow the instructions and notices written in the Annex.

- Contact Hamamatsu subsidiary or distributor for installation condition which is not listed in this Annex.

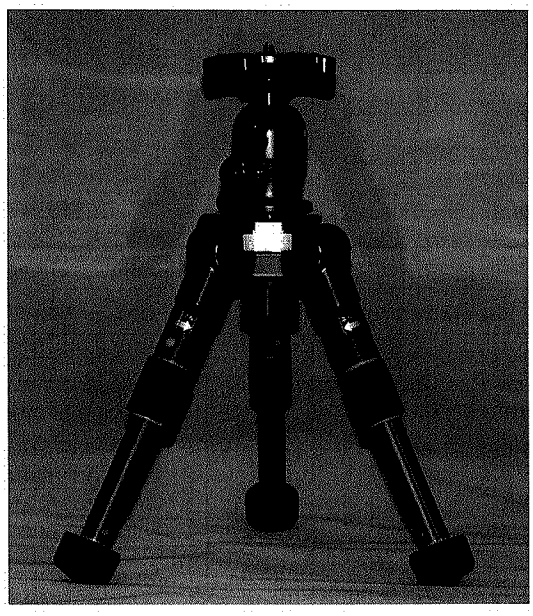
A-1 PREPARING TRIPOD

A-1-1 SELECTING TRIPOD

Select a tripod which has sufficient capability to hold the camera head.

Note

- Weight (mass) of the camera head is approximately 1.1 kg.



[Sample image of tripod]

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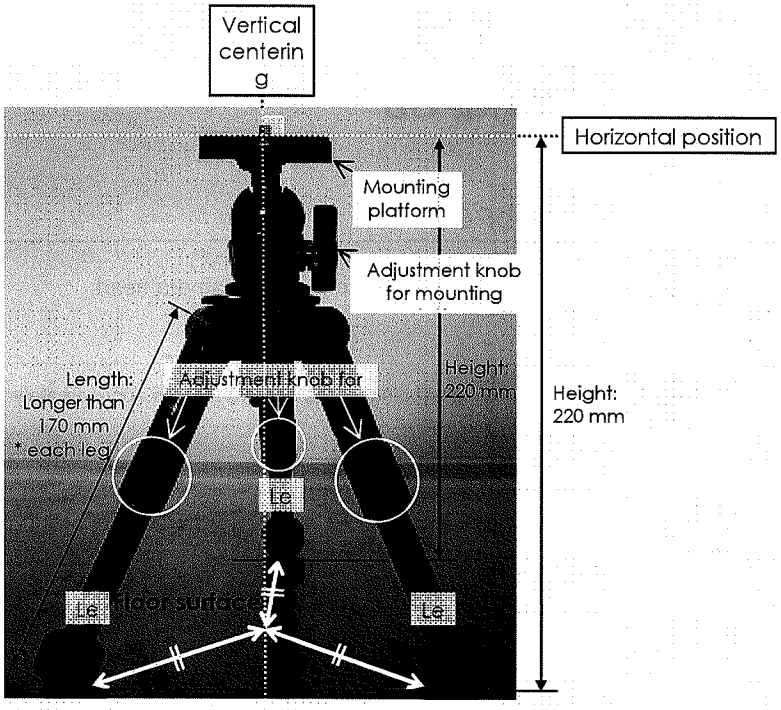
A-1-2 PLACING TRIPOD

Place tripod on firm and level floor where the tripod can be placed stably.

- Do not place tripod where the tripod become unstable when the camera head is attached to the tripod.
- With regard to placing tripod, follow instructions written in section 3. "INSTALLATION" as well.

A-1-3 ADJUSTING TRIPOD

(1) Adjust each leg of tripod.



[Tripod]

Adjustment of leg spreading position	Adjusting of leg height
1. Spread each leg completely. Check distance between each leg is apart more than 150 mm from each other. 2. Adjust length of tripod legs to be longer than 170 mm. 3. With the condition mentioned in #1, adjust each leg position to be the even distance from the intersection point of perpendicular line of vertical centering position and floor surface.	1. Extend legs and open legs in same leg spread angle. Adjust height from floor surface to mounting platform to be 220 mm. 2. After adjustment, tighten and lock adjustment knob for leg (Do not loosen the knob after the knob is tighten).

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- After all adjustment is done, make sure to check the tripod is placed on floor stably without wobbling.

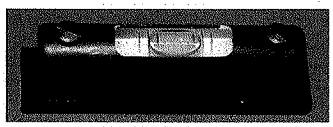
- Do not use tripod in a place where it becomes unstable.

(2) Adjust mounting platform to be horizontal position.

Take a level to check the mounting plat form is horizontal.

Note

- Level tool is not attached with camera. Prepare level tool on your own.

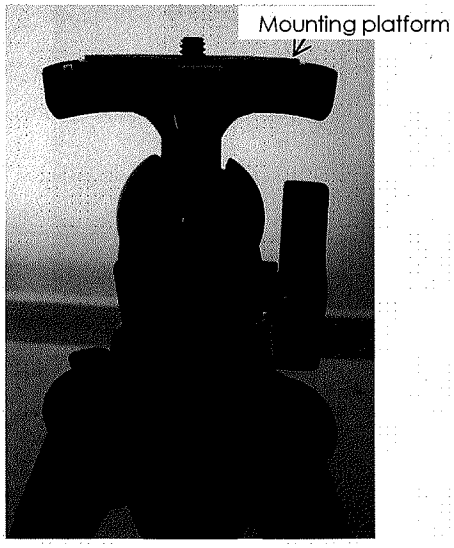


[Sample image of level tool]

A-2 ATTACHING THE CAEMRA HEAD

A-2-1 HOW TO ATTACH THE CAMERA HEAD

Mount the camera head on tripod which is adjusted as instructed in A-1-3.



[The platform where the camera head is mounted tripod: Mounting platform]

(1) Attach the camera head.

Match screw opening for mounting platform on the camera head side and thread of mounting platform. Tighten platform screw for more than 3 threads. After the platform screw is tightened, check the camera head and mounting platform is firmly fixed without wobbling.

Note

- Refer to section 6. "NAME AND FUNCTION OF THE PARTS" for detail of the camera head.

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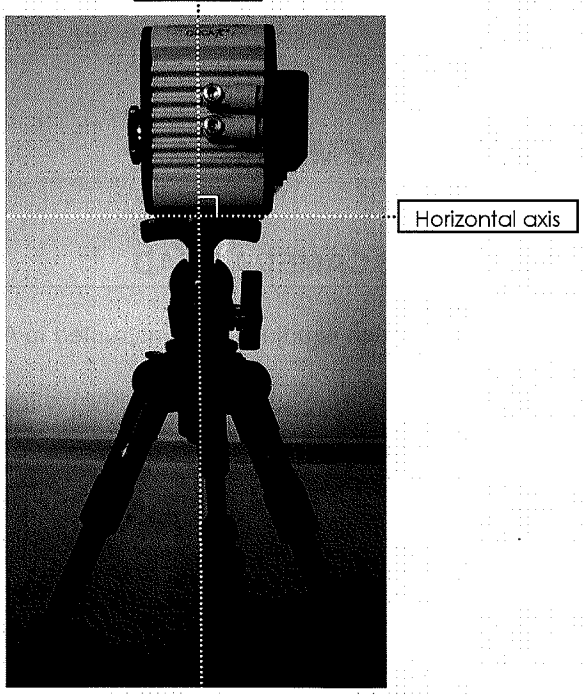
A-3 CONFIRMING SAFE CONDITIONS

Check the following points with the camera head is attached to tripod.

(1) Tripod is placed stably on floor without wobbling.

- If the tripod wobbles, redo attaching the camera head.

(2) When the camera head is viewed from any angle on horizontal axis, camera head has to be placed on vertical perpendicular line of centering position.



[The image of attached the camera head on tripod]

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