Digital CMOS Camera
C11440-36U
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. Be sure to read this Instruction manual beforehand in order to use the digital 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.1.1
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HAMAMATSU PHOTONICS K.K.

A1210300-01

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1. SAFETY PRECAUTIONS

1-1 INDICATION OF THE SYMBOLS

The following symbols can be found on this camera:

⎓	Direct current
~	Alternating current

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.

⚠WARNING

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

Use the accessory of the AC adapter when this camera is used.

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.

⚠CAUTION

AC adapter

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

Remove the AC adapter 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 supply of the peripheral device before connecting and disconnecting cables.

Fixed the camera

When fitting the camera to a tripod or other fixture, use the screw hole in the camera bottom. Be careful that the fitting screw does not enter more than 8 mm. Screwing it in excessively can damage the camera.

Lenses

Be careful not to screw the lens more than 5 mm onto the C-mount of the camera. Screwing it in excessively can damage the camera.

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.

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 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 Hamamatsu subsidiary or local distributor without attempting to operate the camera.

C11440-36U camera	1
AC adapter	1
Power supply cord for AC adapter	1
Lens mount cap (attached to the camera)	1
C11440-36U Before Use (Booklet)	1
C11440-36U Instruction manual (CD-ROM)	1

[Option]

SMA-BNC cable	A12106-05
SMA-SMA cable	A12107-05
USB 3.0 interface board*	M9982-26
USB 3.0 MicroB interface cable (3 m)	A12046-03

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

* A12046-03 (USB 3.0 MicroB interface cable) is included, when M9982-26 (USB 3.0 interface board) is ordered.

3. INSTALLATION

Avoid using or storing this camera in the following places

- Where the ambient temperature for using this system might fall below 0 °C or rise above +40 °C
- Where the ambient temperature for storing this system might fall below -10 °C or rise above +50 °C
- Where the temperature varies extremely
- In direct sunlight or near a heater
- Where the humidity is 30 % or less or 80 % or more or where there is dripping water
- Where the dew condensation might generate
- 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 allow the ventilation ports to become blocked

Do not allow the ventilation ports to become blocked

To prevent overheating in the camera's interior, do not wrap the unit 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 the camera.

Contents

4. OVERVIEW

C11440-36U is a USB 3.0 Output and non-cooling digital camera, which is equipped with Global Shutter CMOS image sensor. C11440-36U realizes the multiple benefits of high resolution, high readout speed, and low noise all at once.
C11440-36U provides 2.3 megapixels resolution at 64.9 fps (and up to 2008.9 fps by sub-array readout) while achieving 6.6 electrons (r.m.s.) readout noise performance. Moreover, the camera delivers high sensitivity through its on-chip micro lens, 5000:1 high dynamic range, on-chip analog gain and correction feature that make the camera suitable for almost any scientific application from bright field imaging to low-light fluorescence imaging across a wide spectral range. Various external trigger functions and timing output functions ensure proper timing control with peripheral equipment to cover a wide range of applications.
C11440-36U is the new scientific digital camera for life science microscopy, semiconductor inspection, x-ray scintillator readout or industrial imaging.

5. FEATURES

(1) Readout noise

With the CMOS 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 the on-chip CDS (correlated double sampling) circuit, which plays an important role in achieving low noise. Moreover, the data of one horizontal line is read by the on-chip column amplifier and A/D in parallel and simultaneously. As a result, it achieves very fast readout speed while keeping very good low-noise performance.
The camera has lower readout noise (6.6 electrons) than the conventional CCD camera. Moreover, high-speed readout (64.9 fps with 2.3 megapixels) with very low readout noise can now be achieved.

(2) Global shutter

In general, rolling shutter method is commonly used as the exposure and the readout mode of the CMOS image sensor. In this method, the exposure timing is varied by each line. This variation can cause distortion when capturing a moving subject.
On the other hand, a global shutter method is applied in this camera. Thereby the exposure timing is same at the all lines.

(3) Pixel number and pixel size

The CMOS image sensor has 5.86 µm x 5.86 µm pixel sizes that is equivalent to conventional CCD image sensor (2/3 inch, 1.3 megapixels). Also, the camera can observe a wider field of view because the pixel number, 1.3 megapixels, is about 1.7 times that of the conventional CCD image sensor (2/3 inch, 1.3 megapixels).

(4) Readout method

The camera has a variety of readout modes. In addition to full resolution readout mode, sub-array readout and binning readout are supported.

(5) Frame rate (readout speed)

The sensor of this camera realizes both low noise (6.6 electrons) and high speed readout (64.9 fps with all pixels) simultaneously, owing to 1 line parallel simultaneous readout using column A/D.

(6) Real-time correction functions

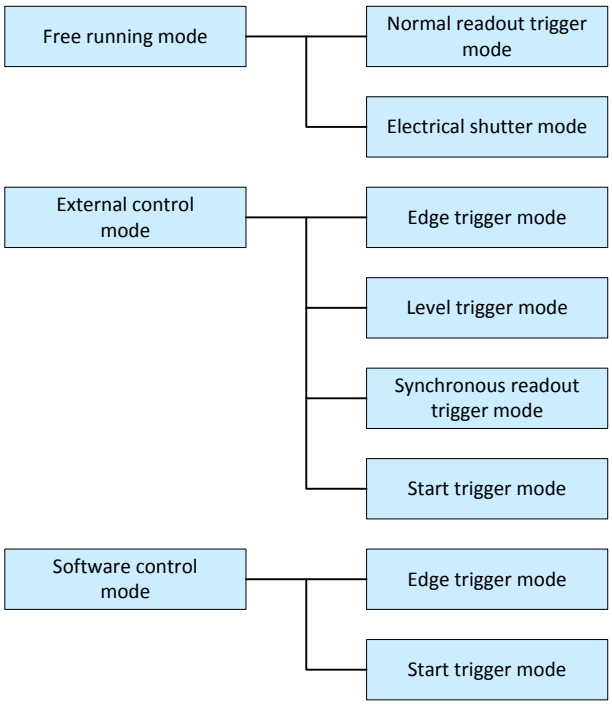
There are a few pixels in the CMOS image sensor of this camera that have slightly higher readout noise performance compared with surrounding pixels. When using the camera, there is a chance that the data from variant pixels caused by uneven illumination and optics is not negligible in the image. Therefore, the camera has variant pixel correction feature to further improve image quality. The correction is performed in real-time without scarifying the readout speed at all.

(7) USB 3.0 bus Interface

Image signals undergo A/D conversion inside the camera, and are transmitted externally via the USB 3.0 bus interface as 12 bit digital data. The camera can also be controlled via this bus.

(8) Camera operation modes

The camera has three operation modes: 1) Free running mode, in which the exposure and readout timing are controlled by the internal microprocessor, 2) External trigger mode, in which the exposure and readout timing are decided by External trigger and 3) Software trigger mode, in which the exposure and readout timing are decided by application software.



6. NAME AND FUNCTION OF THE PARTS

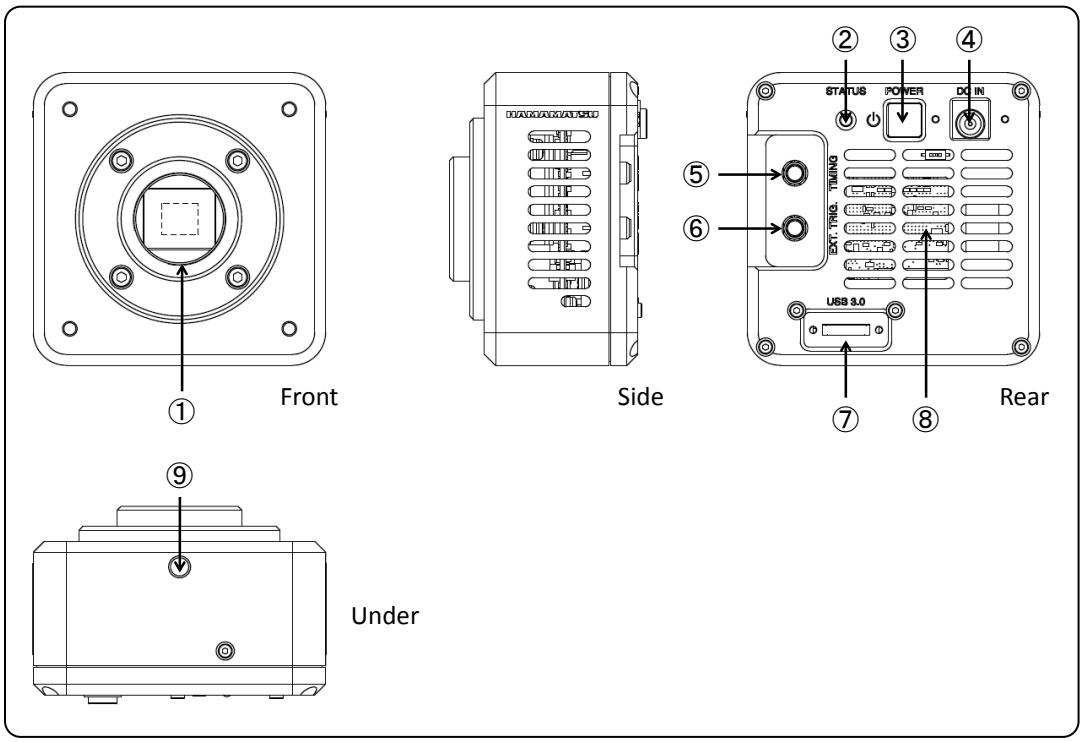


Figure 6-1 Name and function of the parts

① Lens mount

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

Note

- Be careful not to screw the lens more than 5 mm onto the C-mount of the camera. Screwing it in excessively can damage the camera.

② STATUS lamp [STATUS]

The LED indicates status of camera.

Lighting color	Status of power distribution
Turn off (no color)	Power off
Green (lighting)	Power on
Orange (lighting)	Data transfer
Red (lighting)	Heat up

⚠CAUTION

- When the camera heats up, stop operation and unplug the AC adapter immediately.

③ Power switch [POWER]

The power is turned on/off.

When the power switch is pressed once, the camera is powered on and the lamp color stays in green.
When the camera transfers data and the lamp color is orange.
When the power switch is pressed once again, the camera returns to the power off state and the lamp turns off.

④ DC power input connector [DC IN]

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

⑤ Timing out connector [TIMING]

This is used when peripheral device(s) require synchronization with the camera.
Output is 3.3 V LVCMOS level, and it is output though BUS TRANSCEIVER IC "SN74LVC541APW". Output impedance is 33 Ω.

⑥ 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 External trigger is input, the trigger is activated at the falling or rising edge of the signal.
(External trigger polarity is selectable between Negative and Positive.)

⑦ USB 3.0 interface connector [USB 3.0]

This is connected to the USB 3.0 interface connector on the computer.

- When the USB 3.0 cable is connected, the application software must be closed and the camera must be turned off.

⑧ Air outlet

This is the outlet for the heat ventilation.

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

⑨ Mounting screw hole

This is the screw hole for fixing the camera to a tripod or other fixture.

Note

- When fitting the camera to a tripod or other fixture, be careful that the fitting screw does not enter more than 8 mm. Screwing it in excessively can be damaged the camera.

7. CONNECTING CABLE

7-1 CONNECTING CABLE

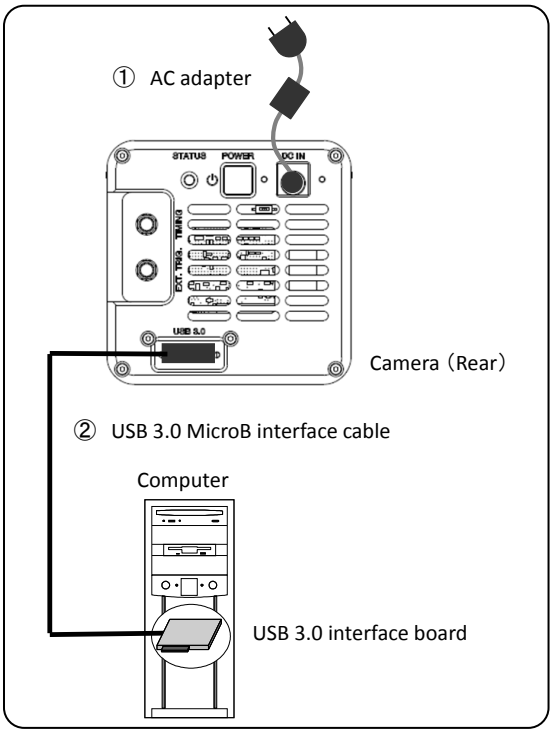


Figure 7-1 Connecting cable

① AC adapter

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

② USB 3.0 MicroB interface cable (Option)

This is the cable to connect the camera and the computer.

- Connect the cable to the connector of the computer corresponding to USB 3.0.

- When the USB 3.0 cable is connected, the application software must be closed and the camera must be turned off.

Note

- Hamamatsu recommends A12046-03 optional USB 3.0 MicroB interface cable for this camera. The camera complies with EMC direction with using A12046-03 USB 3.0 MicroB interface cable. Be careful that the camera with other interface cable may not fulfill the EMC directive requirements.

8. OPERATION

8-1 PREPARATION FOR IMAGING

Use the following procedure when start operating the camera.

(1) Connect the cable as shown in Figure 7-1 before you start operation.
(2) Turn on the power of computer.

8-2 END OF IMAGING

Follow the procedure as below when imaging is finished.

(1) End the imaging and transmission of image data.
(2) Close the application software.
(3) Turn off the peripheral devices.

9. DESCRIPTION OF VARIOUS FUNCTIONS

9-1 THEORY OF CMOS IMAGE SENSOR

The pixel of a CMOS image sensor is composed of the photodiode and the amplifier that converts the charge into voltage. Entered light is converted to charge and converted to voltage in the pixel. The voltage of each pixel is output by switching the switch one by one. (Figure 9-1)
The CMOS image sensor used in this camera has an on-chip CDS (correlated double sampling) circuit, which plays an important role in achieving low noise. In addition, the data of one horizontal line is read by the on-chip column amplifier and A/D in parallel and simultaneously. Therefore, the CMOS image sensor realizes both low noise and high speed readout simultaneously.

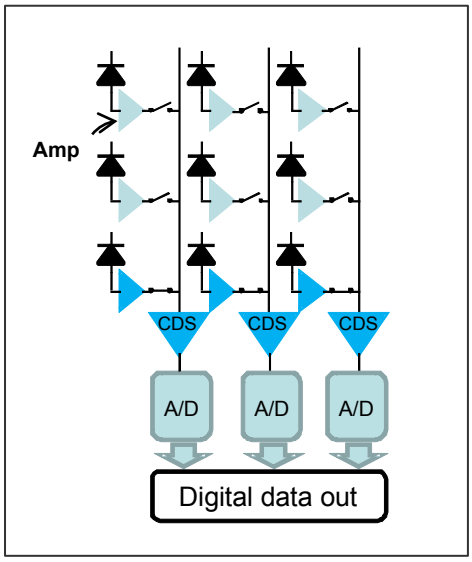


Figure 9-1 Structure of the CMOS image sensor

In general, rolling shutter method is commonly used as the exposure and the readout mode of the CMOS image sensor. In this method, the exposure timing is varied by each line. This variation can cause distortion when capturing a moving subject.
On the other hand, a global shutter method is applied in this camera. Thereby the exposure timing is same at the all lines.

9-2 READOUT METHOD

(1) Full resolution readout

Perform charge readout from the CMOS image sensor individually for all pixels.
The frame rate of all pixels readout is 64.9 fps at maximum.

(2) 2×2 Digital binning readout

With this camera, 2×2 digital binning readout are available by adding the signal of adjacent pixels in the digital domain. The flame rate of all pixel readout is same as 1x1 Normal readout.

(3) Sub-array readout

This camera supports sub-array-scanning operation in each mode.
Sub-array scanning is a procedure in which only a portion of the image is scanned. It is possible to increase the frame rate by reducing the number of lines scanned. The frame rate is determined only by vertical width, the horizontal width does not affect to the frame rate.
The Sub-array scan setting is specified by the offset from 1st pixel on upper-left and width, and the selectable range is as follows.

		Settable range			
		Minimum value	Maximum value	Minimum step	Unit
Full resolution readout	Horizontal offset	0	1918	2	pixel
	Horizontal width	2	1920	2	
	Horizontal offset＋Horizontal width	2	1920	-	
	Vertical offset	0	1118	2	line
	Vertical width	2	1200	2	
	Vertical offset＋Vertical width	2	1200	-	
2x2 Digital binning readout	Horizontal offset	0	959	1	pixel
	Horizontal width	1	960	1	
	Horizontal offset＋Horizontal width	1	960	-	
	Vertical offset	0	559	1	line
	Vertical width	1	600	1	
	Vertical offset＋Vertical width	1	600	-	

9-3 FREE RUNNING MODE

The camera has Free running mode which the exposure and readout timing can be set by software command and controlled by an internal microprocessor. Free running mode has Normal readout mode (in which the exposure time is longer than the 1 frame readout time) and Electrical shutter mode (in which the exposure time is shorter than the 1 frame readout time). These readout modes are automatically switched depending on the exposure time setting.

Note

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

9-3-1 NORMAL READOUT MODE

Normal readout mode is used so that the exposure time can be extended to collect more signals and increase the signal-to-noise ratio if the object is dark.

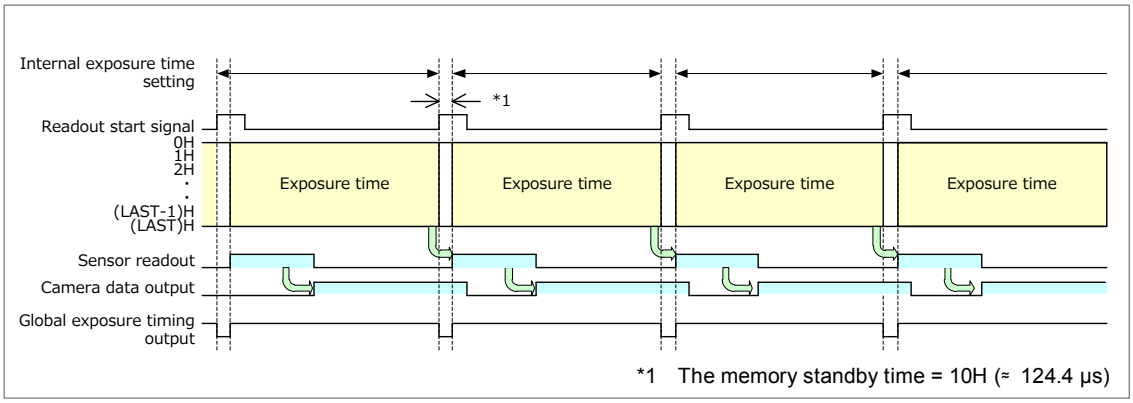


Figure 9-2 Normal readout mode

9-3-2 ELECTRICAL SHUTTER MODE

Electrical shutter mode is used to get a proper signal level when signal overflow happens due to too much input photons in Normal readout mode.

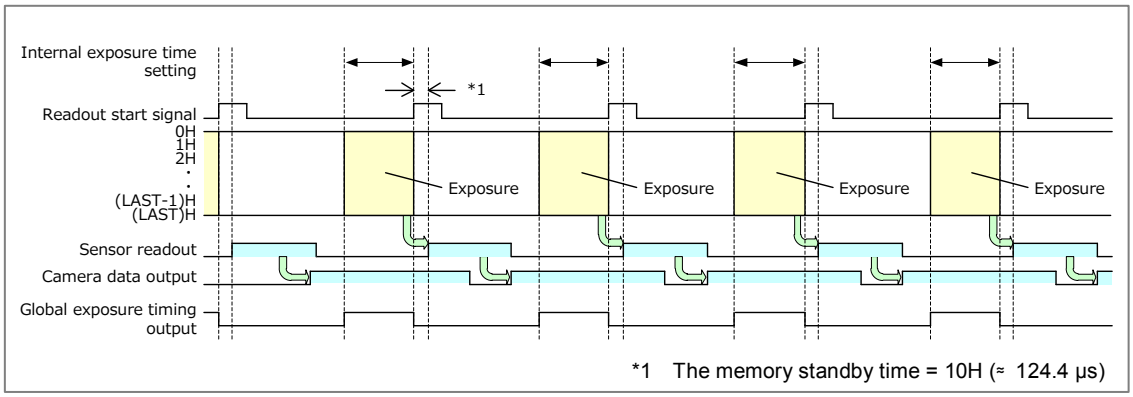


Figure 9-3 Electrical shutter mode

9-4 EXTERNAL TRIGGER MODE

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

Note

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

9-4-1 EDGE TRIGGER MODE

Edge trigger mode is used so that the exposure starts according to an external signal. Exposure time is set by software command. In this mode, the exposure begins on the edge (rising / falling edge) timing of the input trigger signal into the camera. The sample of timing chart for the rising edge is shown in figure 9-4.

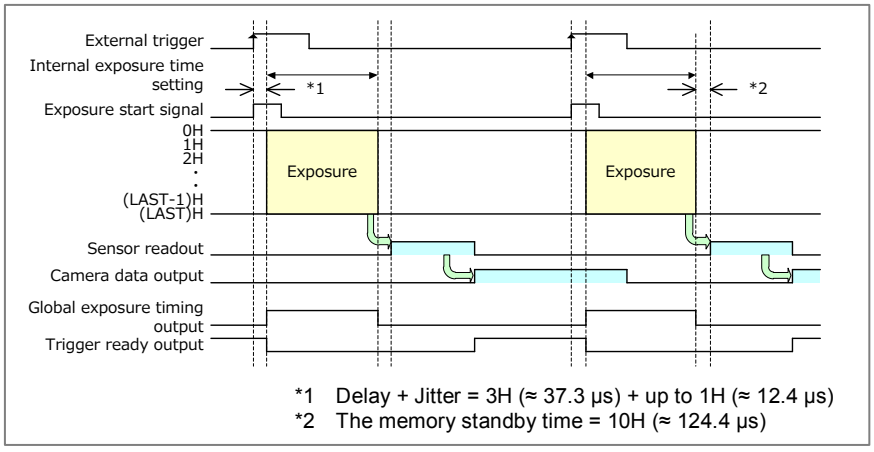


Figure 9-4 Edge trigger mode (Rising edge)

9-4-2 LEVEL TRIGGER MODE

Level trigger mode is used to control both exposure start timing and exposure time length by inputting external trigger pulses. In the 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 begins when the trigger signal becomes High. The exposure is finished when the trigger signal becomes Low, and signal readout is begun. The exposure time of each line is defined by the time that the level of input trigger becomes High to Low.

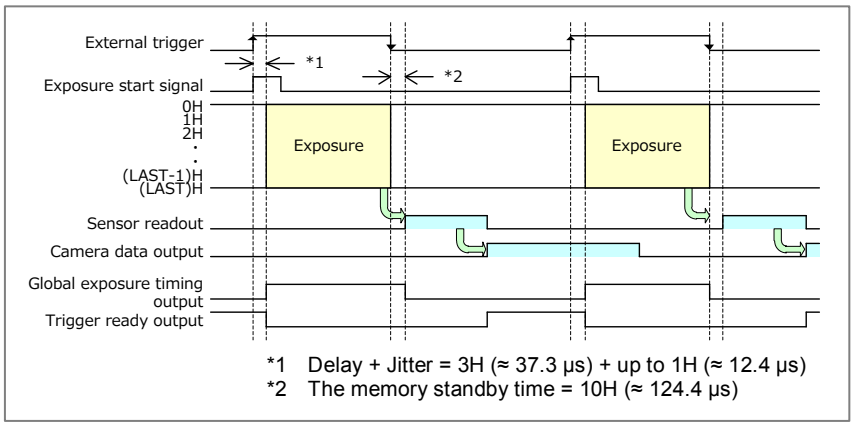


Figure 9-5 Level trigger mode (Rising edge)

Note

- Input pulse width should be subtracted 13.73 µs from the desired exposure time.

Note

- Jitter which is up to ±1H (≈ 12.4 µs) might be included in exposure time.

9-4-3 SYNCHRONOUS READOUT TRIGGER MODE

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.

Note

- Input pulse width should be subtracted 13.73 µs from the desired Exposure time

Note

- Jitter which is up to ±1H (≈ 12.4 µs) might be included in exposure time

(1) Normal operation (when the pulse count is set as 1.)

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 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 / falling edge). That is, the interval between the same edges of the input trigger becomes the exposure time.

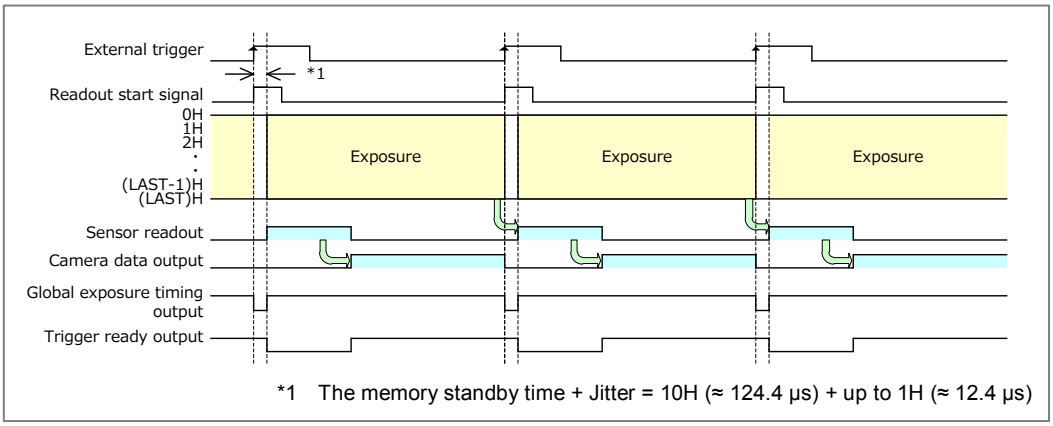


Figure 9-6 Synchronous readout trigger mode (Rising edge)

(2) Pulse count

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

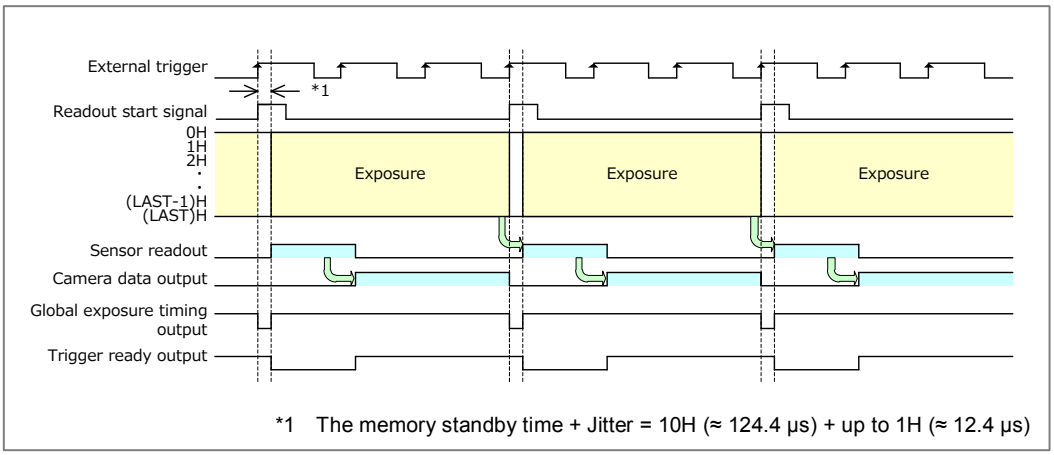


Figure 9-7 Synchronous readout trigger mode (Rising edge, Pulse count is set as 3)

9-4-4 START TRIGGER MODE

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 / falling edge).

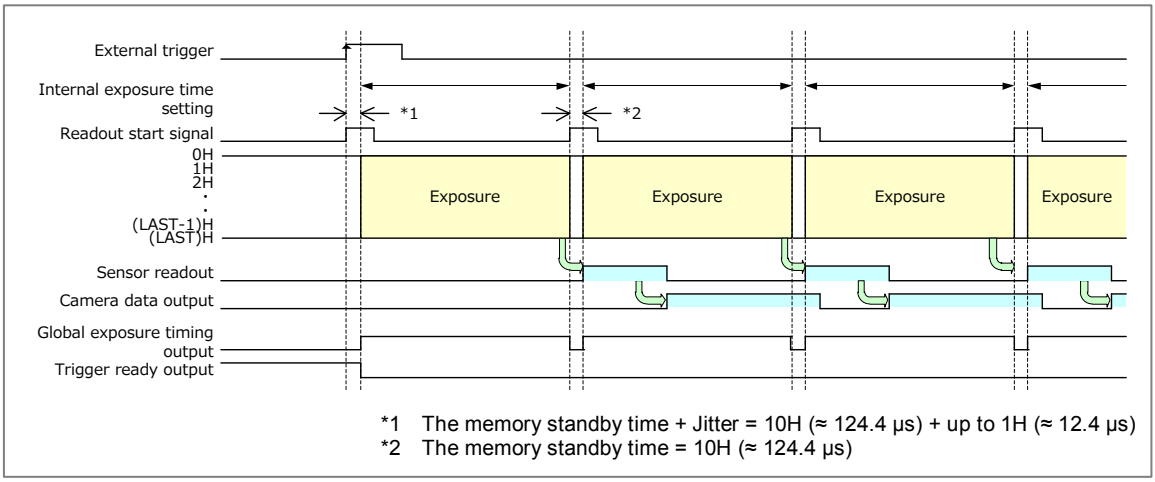


Figure 9-8 Start trigger mode

9-4-5 TRIGGER DELAY FUNCTION

In most cases when a delay is needed 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 and the minimum setting steps is 1 µs.

9-5 SOFTWARE TRIGGER MODE

The camera has two software trigger functions, Edge trigger mode and Start trigger mode. Each software trigger function is basically same as External trigger mode. The software trigger modes enable to control the exposure start timing of the camera as well as External trigger mode, but through application software. Therefore software trigger mode cannot precisely control the exposure start timing of the camera than External trigger mode. It depends on the performance of host system. Also, trigger delay function is available.

Note

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

9-6 CONFIGURING EXPOSURE TIME

The exposure time can be set with the absolute value by the command in Free running mode, Edge trigger or Start trigger mode. The actual exposure time setting is defined by the following formula, and the camera automatically calculates a larger and closest value from the specified exposure time setting. And the exposure times in Level trigger mode and Synchronous readout trigger mode are determined by a trigger signal from the outside.
Available setting range of the exposure time is 26.17 µs to 10 s in Free running mode, Edge trigger mode, and Start trigger mode, and 1 ms to 1 s in Level trigger mode and Synchronous readout trigger mode.

$$\textit{Exposure time} = N \times 1H + 13.73\ \mu s$$

N: Integer number (1 to 803 572)
1H = (1 / 37.125 MHz) × 462 clk ≈ 12.4 µs

Note

- In the case of Level trigger and Synchronous readout trigger mode, jitter which is up to 1H (≈ 12.4 µs) might be included in exposure time

9-7 FRAME RATE CALCULATION

The frame rate is calculated as below.

In Free running mode, in External trigger mode (Synchronous readout trigger and Start trigger) and Software trigger mode (Start trigger mode);

$N > (Vn + 28)$	***1 / Exposure time***
$N \leqq (Vn + 28)$	***1/((Vn + 38) × 1H)***

In External trigger mode (Edge trigger mode, Level trigger mode) and Software trigger mode (Edge trigger mode);

$$\textit{1/(((Vn + 38) × 1H) + Exposure time)}$$

N = ROUNDUP((Exposure time – 13.75 µs) / 1 H)
Vn: Width of vertical line (2 to 1200)
1H = (1 / 37.125 MHz × 462 clk ≈ 12.4 µs

Note

- In the case of Edge trigger mode, Level trigger and Synchronous readout trigger mode, there are some jitters and delays between a trigger input timing and an exposure start timing. Therefore, it has possibility not to reach frame rate which is calculated by using above formula in some case.

9-8 TRIGGER OUTPUT

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).
These trigger output functions can be selected by software command, and they are output from Timing out connector. And the polarity can be changed by software command.

9-8-1 GLOBAL EXPOSURE TIMING OUTPUT

Global exposure timing output shows the period of all pixels exposing.

Note

- For more detail, please refer to the timing charts of Figure 9-1 to 9-8.

9-8-2 PROGRAMMABLE TIMING OUTPUT

By using the programmable timing output, synchronizing external devices is simple. A system that needs simple timing signal does not require a delay unit nor pulse generator. It is possible to program and output a pulse that has an optional pulse width and an optional delay time to the exposure start timing of the camera by command.
The setting range for delay time is 0 µs to 10 s, the setting range for pulse width is 1 µs to 10 s, and the minimum setting step is respectably 1 µs.

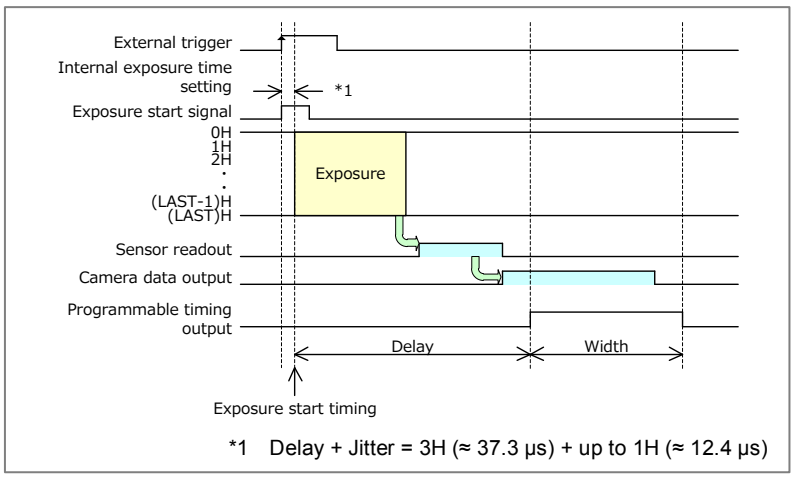


Figure 9-9 Programmable timing output (Edge trigger mode, Rising edge)

9-8-3 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 Edge trigger mode, the next frame can start after the previous frame exposure and sensor readout are done. Thus, the camera cannot accept a trigger for the next frame during the exposure and readout 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.

Note

- For more detail, please refer to the timing charts of Figure 9-1 to 9-4.

9-9 ANALOG GAIN FUNCTION

The camera features an on-chip gain control capability that can multiply the analog signal in CMOS sensor prior to converting it into a digital signal. The setting range for analog gain is 0 dB to 24 dB and the minimum setting step is 0.1 dB.

9-10 REAL-TIME CORRECTION FUNCTIONS

There is a chance that the data from variant pixels caused by illumination and optics cannot be negligible in the imaging with camera. The camera has the variant pixel correction feature for a further image quality improvement. The correction can be effective in real-time without scarifying the readout speed at all.

10. PRECAUTION USING CMOS IMAGE SENSOR

This camera uses CMOS image 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. This phenomenon is not currently 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.

* After an image made using a certain exposure time is loaded, the 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) Over 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 over light.

(4) Brighter phenomenon

Over extended exposure may cause the brighter phenomenon on the right and bottom of image especially in Level trigger mode and Synchronous readout trigger mode.

11. MAINTENANCE

11-1 CARE

Perform cleaning of this equipment with the dry soft cloth.

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

Then, the glass window on the image sensor should be cleaned according to the following.

(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.

- Use Lens Cleaning Paper for cleaning of glass window in front of the image sensor.

- Please 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.

- Please avoid touching the surrounding parts of image area when wiping the glass window.

(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.

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 IMAGE IS NOT TRANSFERRED

Cause	Measures	Chapter
USB 3.0 MicroB interface cable not fully connected	Reconnect	7
USB 3.0 MicroB interface cable is broken	Replace cable	

12-2 ALTHOUGH IMAGES ARE TRANSFFERED

(1) Scratches or discoloration visible on the screen

Cause	Measures	Chapter
Lens is dirty	Wipe the lens	

(2) Image is blurred

Cause	Measures	Chapter
Lens is not focused	Contact Hamamatsu subsidiary or local distributor	16
CMOS image sensor is dirty		

(3) Only shaded images are output

Cause	Measures	Chapter
Lens mount cap has been left	Remove the cap	
Amount of light is too much or too low	Reduce amount of light	

(4) All screens overflow

Cause	Measures	Chapter
Too much amount of light	Reduce amount of light	
Gain is too high	Reduce gain	

(5) Noise appears on the screen

Cause	Measures	Chapter
Exogenous noise	Find and remove cause	
Poor connection of internal connector	Contact Hamamatsu subsidiary or local distributor	16
Defective circuit system		

13. SPECIFICATIONS

13-1 CAMERA SPECIFICATIONS

(1) Image sensor specifications

Imaging device	CMOS image sensor
Effective number of pixels	1920 (H) × 1200 (V)
Cell size	5.86 µm (H) × 5.86 µm (V)
Effective area	11.25 mm (H) × 7.03 mm (V)
Full well capacity (typ.)	33 000 electrons
Readout noise (typ.)	6.6 electrons r.m.s. (gain 1 x)
Dynamic range *1	5000 : 1 (gain 1x)
Analog gain	0 dB to 24 dB (0.1 dB step)
A/D converter	12 bit

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

(2) Camera functions specifications

a. Image readout

Readout mode		Full resolution
		Digital binning *2
		Sub-array
Full resolution	Number of pixel	1920 (H) × 1200 (V)
	Maximum frame rate	64.9 fps
Digital binning	Binning mode	2 × 2
	Number of pixel	960 (H) × 600 (V)
	Maximum frame rate	64.9 fps
Sub-array	Number of pixel	{2 to 1920 (H)} × {2 to 1200 (V)} (In Digital binning mode OFF)
		{1 to 960 (H)} × {1 to 600 (V)} (In Digital binning mode ON)
	Offset, Width (Horizontal and Vertical)	2 steps (In Digital binning mode OFF)
		1 steps (In Digital binning mode ON)
	Maximum frame rate	2008.9 fps (In Digital binning mode OFF and 2 lines sub-array read out mode)

* 2 Digital binning processing in digital domain.

b. Exposure and readout timing control

Control mode			Free running
			External trigger
			Software trigger
Free running	Exposure time		26.17 µs to 10 s
External trigger	Trigger input mode		Edge
			Level
			Synchronous readout
			Start
	Exposure time	Edge	26.17 µs to 10 s
		Start	
		Level	1 ms to 1 s
		Synchronous readout	
	Input signal	Connector	SMA × 1
		Polarity	Positive or Negative
		Input level	3.3 V LVCMOS
	Pulse count function (Only in Synchronous readout)		0 to 4095 times
	Trigger delay function		0 µs to 10 s (1 µs step)
Software trigger	Trigger input mode		Edge
			Start
	Exposure time		26.17 µs to 10 s
	Trigger delay function		0 µs to 10 s (1 µs step)

c. Trigger output

Output mode		Programmable timing output
		Global exposure timing output
		Trigger ready output
		High or Low fixed output
Output signal	Connector	SMA × 1
	Polarity	Positive or Negative
	Input level	3.3 V LVCMOS
Programmable timing output (From exposure start timing)	Delay	0 µs to 10 s (1 µs step)
	Width	1 µs to 10 s (1 µs step)

d. Others

Real time correction function	Variant pixel correction
Lens mount	C-mount
Interface standard	USB 3.0
Connector	USB 3.0 MicroB

(3) Power supply specification

AC adapter	Input power supply	AC 100 V to AC 240 V
	Frequency	50 Hz / 60 Hz
Camera	Input power supply	DC 12 V
	Power consumption	Approx. 5 VA

Note

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

(4) Operating environment

Ambient operating temperature	0 °C to + 40 °C
Ambient storage temperature	-10 °C to + 50 °C
Ambient operating humidity	30 % to 80 %, no condensation
Ambient storage humidity	90 %, no condensation

(5) Dimensional outline and weight

Dimensional outline	80 mm (W) × 80 mm (H) × 51.5 mm (D)
Weight of the camera	Approx. 0.5 kg
Weight of the AC adapter	Approx. 0.8 kg
Weight of the power supply code	Approx. 0.2 kg

Note

- Please see Chapter 14 [DIMENSIONAL OUTLINES] for detail of dimensions.

(6) Applicable standards

EMC	EN61326-1: 2013 Class A

(7) Spectral response characteristics

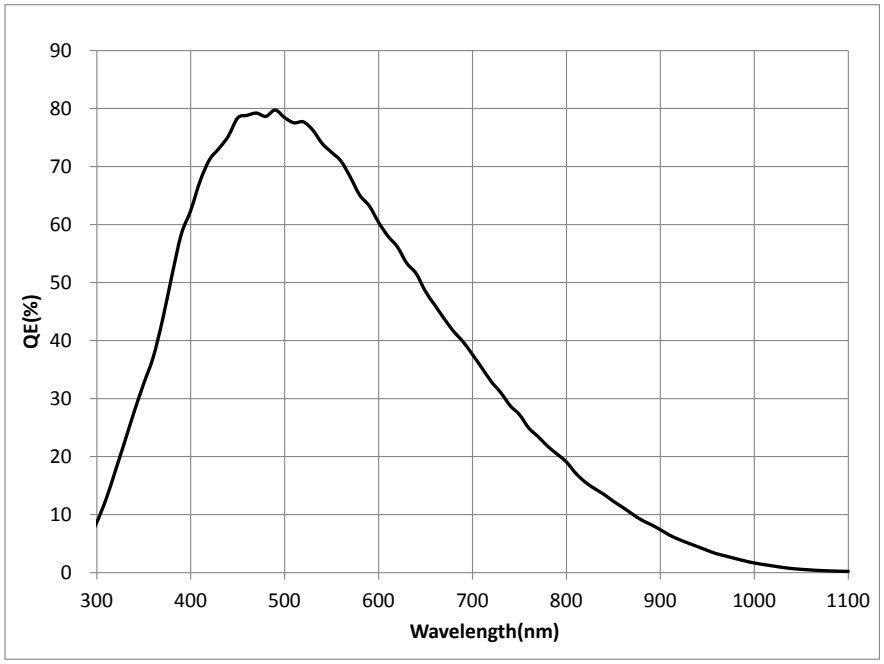


Figure 13-1 Spectral response characteristics

14. DIMENSIONAL OUTLINES

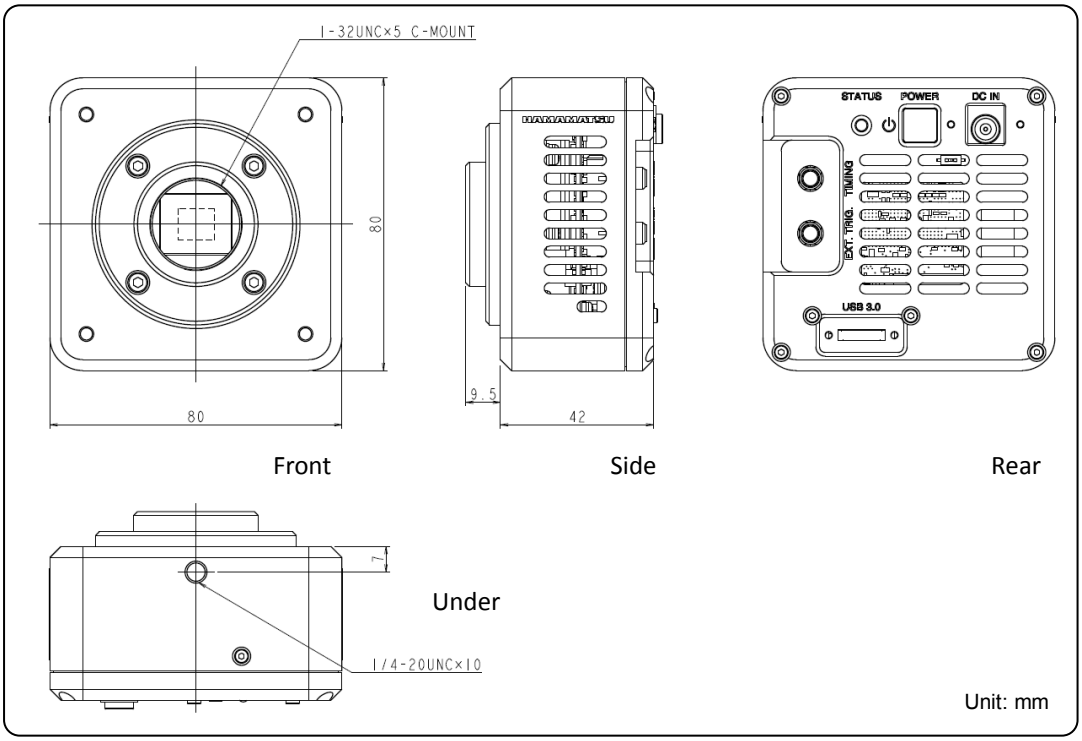


Figure 14-1 Dimensional outlines

15. WARRANTY

Hamamatsu Photonics have fully inspected this system 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.
- Degradation with cosmic rays, the radiation (X-rays, gamma rays, UV light, etc.) of the CMOS image sensor 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.

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.

16. CONTACT INFORMATION

Manufacturer

HAMAMATSU PHOTONICS K. K., Systems Division

812 Joko-cho, Higashi-ku, Hamamatsu City, 431-3196, Japan
Telephone (81) 53-431-0124, Fax: (81) 53-435-1574
E-mail: export@sys.hpk.co.jp

Local contact information worldwide could be found under:
www.hamamatsu.com

- *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.*