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Digital CCD Camera
C8484-16C
Instruction Manual

Thank you for your purchase

⚠CAUTION	• Follow the safety precautions in Chapter 1 in order to avoid personal injury and damage to property when using this camera. The manual describes the correct handling method of C8484-16C camera and provides cautions in order to avoid accidents. **Read this manual carefully** beforehand use the camera correctly. • After reading the manual, store it in a location where you can refer to it at any time.

Ver. 1.5
March 2012

HAMAMATSU PHOTONICS K.K.

75100301-01

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1. SAFETY PRECAUTIONS

1-1 CLASSIFICATION OF WARNINGS

We have classified the warning symbols that appear in this operating manual and on the camera as follows for better comprehension of their meaning. 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



Power supply

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



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.



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 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 strange noises, smell or see smoke coming from the camera, contact Hamamatsu subsidiary or local distributor quickly.

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⚠CAUTION

Connecting and Disconnecting cables
Always turn off the power before connecting and disconnecting cables.

Fixing the camera head
When fitting the camera head to a tripod or other fixture, use the screw (1/4-20UNC) in the center of a camera mount or the threaded sleeve (M3) about the mount's perimeter. Be careful not to allow the fitting screw to enter more than 5 mm from the surface of the mount. Screwing this in excessively may impair normal operation.

Lenses
Be careful not to screw the lens more than 7 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 7 mm or more.)

Shipping precautions
When transporting the camera by truck, ship, airplane, etc., wrap it securely in packaging material or something similar.

Strong impact
Do not subject the camera to strong shocks by dropping it, for example. Doing so can damage the camera.

Operating environment
This system is designed and tested for use in an industrial environment. If this system is used in residential areas, EMI (electro-magnetic interference) may occur. This system must not be used in residential areas.

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.

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

C8484-16C Camera head	1
C8484-16C Camera control unit	1
Camera head extension cable	1
Lens mount cap * attached to the camera	1
C8484-16C Instruction manual * this booklet	1

<Option>

AC adaptor	Recommendation article of Hamamatsu
Camera cable (5 m)	A3194-01
CameraLink interface cable	A9262-05

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

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4. OVERVIEW

C8484-16C is a small CCD camera which provides 12 bit digital output and high resolution for industrial/ scientific measurement, in which high accuracy and quality imaging are required. This camera employs “CameraLink” which is used as standard interface for industrial application.

5. FEATURES

(1) High Resolution

The camera is equipped with a high-resolution CCD Sensor featuring an effective pixel count of 1344×1023 (horizontal × vertical) pixels. The pixels are square, thus simplifying image processing for measurement purposes.

(2) No Mechanical Shutter Used

The all-pixel-readout interline CCD image sensor included in this camera (hereafter referred to as CCD or all-pixel-readout CCD), eliminates the need for a mechanical shutter.

(3) Digital Output

Image signals are converted from analog to digital in the camera control unit and maximum signal cable length is 10 m.

(4) Low Distortion

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

(5) Compact Head

The camera head has been made lighter and more compact that makes the camera easy to use in microscopic measurements, spectrophotometry, and other applications.

(6) No Burn-in

(7) Lens mount

The lens mount uses C-mount.

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6. NAME AND FUNCTION OF THE PARTS

6-1 CAMERA HEAD

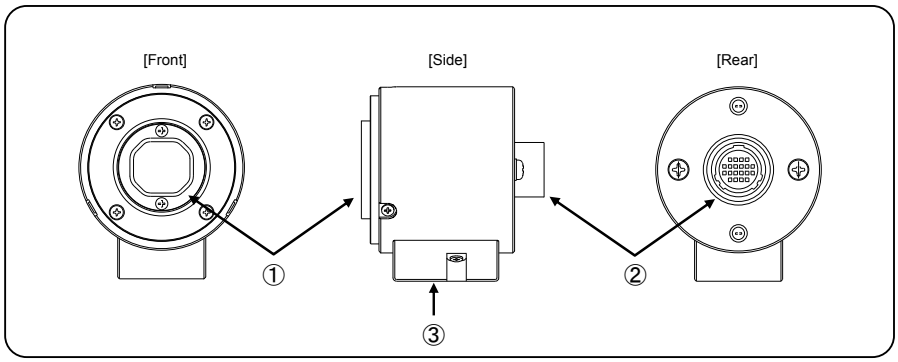


Figure 6-1

① Lens mount

C-mount lens or optical system with C-mount can be attached.

Note

- C-mount has a depth of 7 mm. Screwing the lens too far into the camera head may scratch the glass surface.

② Camera head extension connector

Connector used for connecting the camera head to the camera control unit.

③ Camera mount

Jig for fixing the camera head. Used when mounting the head on a tripod or other fixture.

- When fitting the camera head to a tripod or other fixture, use the screw (1/4-20UNC) in the center of a camera mount or the threaded sleeve (M3) about the mount's perimeter. Be careful not to allow the fitting screw to enter more than 5 mm from the surface of the mount. Screwing this in excessively may impair normal operation.

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6-2 CAMERA CONTROL UNIT

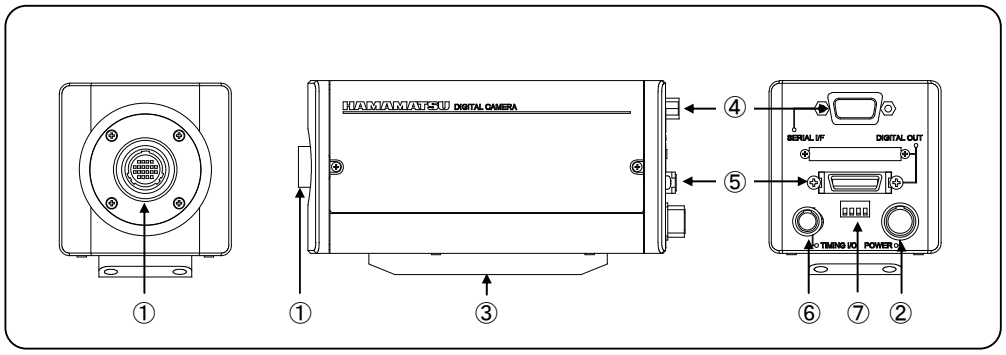


Figure 6-2

① Camera head extension connector

Connector used for connecting the camera head to the camera control unit.

② Camera connector [POWER]

Connector used for connecting the camera head to the AC adaptor.

Note

- The AC adaptor in an option. Use the recommendation article of Hamamatsu.

③ Camera mount

Jig for fixing the camera head. Used when mounting the camera control unit on a tripod or other fixture.

④ Serial interface connector [SERIAL I/F]

- Do not connect it. Because this is a connector for the camera maintenance.

⑤ CameraLink interface connector [DIGITAL OUT]

Connector used for connecting the camera control unit to the CameraLink interface board.

⑥ Timing I/O connector [TIMING I/O]

This connector is used for input and output of timing signals when synchronizing with external equipment.

⑦ Mode switching switch

- Do not change this. All positions are set to “OFF”.

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7. CONNECTING CABLES

Refer to the figure below when connecting the various cables.

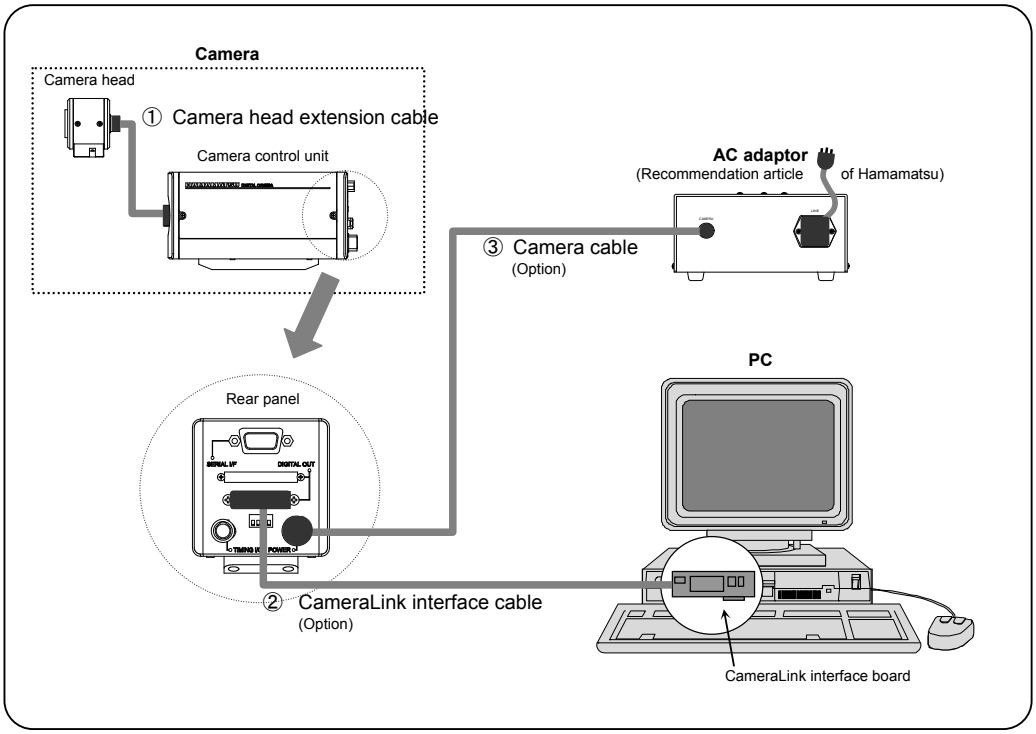


Figure 7-1

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

① Camera head extension cable

Cable used for connecting the camera head to the camera control unit.

② CameraLink interface cable (Option)

Cable used for connecting the CameraLink interface connector to the CameraLink interface board mounted on the host computer.

③ Camera cable (Option)

Cable used for connecting the camera head to the AC adaptor.

Note

- Hamamatsu recommends optional interface for the camera.
  - AC adaptor: Recommendation article of Hamamatsu
  - Camera cable: A3194-01
  - CameraLink interface cable: A9262-05

  Depending on type of interface cables, the camera may not keep CE marking compliance in terms of EMC directive.

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8. OPERATION

8-1 PREPARATION FOR IMAGING

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



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

(2) After turning the power switch on, wait approximately 10 minutes for the temperature to stabilize; this completes preparation for imaging.

8-2 IMAGING

The camera works with following setting after power is switched ON.

Digital data output pixel count	1024
Operation mode	Normal readout
Exposure time setting	Normal setting
Contrast enhancement gain	0
Digital data output bit count	12 bit

The camera mode and parameters can be changed by command from the host computer, which transmitted via the CameraLink interface.

8-3 END OF IMAGING

Carry out the procedure below when imaging is finished.

(1) End imaging or transmission of image data.
(2) Turn off the power to the camera and peripheral equipment.

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9. IMAGE ACQUISITION

9-1 DESCRIPTION OF HOW THE CCD FUNCTIONS

The all-pixel-readout interline transfer CCD used in this camera is arranged as shown in Figure 9-1. Incident light at the CCD is converted by photosensors to electrical charges which are transmitted through a shielded vertical transfer CCD (VCCD) and a horizontal transfer CCD (HCCD) to a final output charge-voltage conversion amp. The sensor gate is opened by the readout signal, and the charges generated by all of the photosensors are transmitted unmixed to the VCCD, completing the exposure.
In addition, an electronic shutter signal is applied to the CCD, allowing any accumulated charge in the photosensors to be discharged.

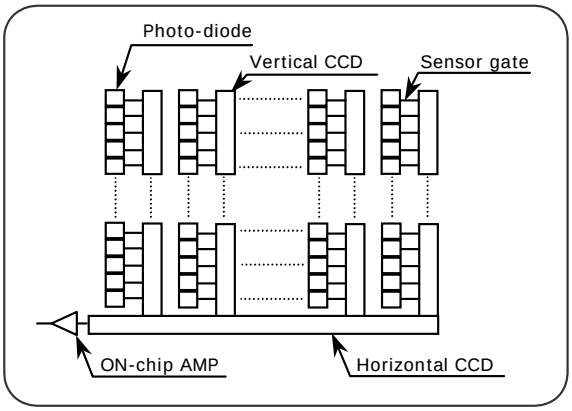


Figure 9-1

- Binning: Accumulated charges for a specified number of pixels in the vertical and horizontal directions on the CCD are calculated and combined (binned), then read out from the CCD. With this camera, binning can be set to 2×2, where two pixels in the vertical and horizontal directions are combined, 4×4, where four vertical and horizontal pixels are combined.

- Exposure time:
  When set to the normal CCD scanning mode, this is as shown in Figure 9-2. Exposure time is the elapsed time between one readout signal and the next; this interval is at least as long as the time necessary for all of the charges from the CCD to be read out.

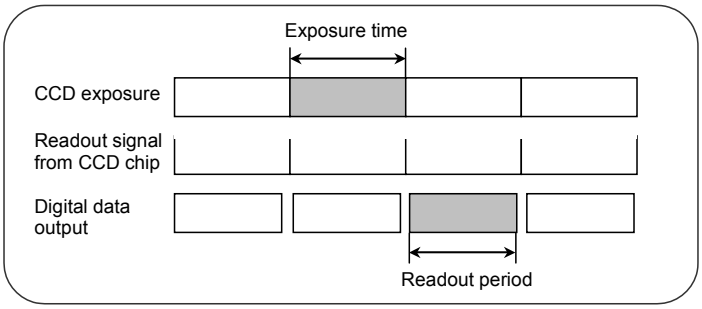


Figure 9-2

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9-2 OVERVIEW OF THE CAMERA MODES

This camera features many different operational modes. Furthermore, all modes involve the CameraLink interface's built-in microprocessor, providing control and setting for all modes. Of the numerous different modes, the modes used for obtaining images are broadly classified into the two categories below.

(1) Free running mode

Exposure and readout is performed repeatedly, controlled by the internal microprocessor. Some operations for which the commands can be used are shown below.

Digital output data count	1024 / 1280 / 1344
Scan mode	Normal / Binning / Sub-array
Exposure time setting	Normal / Electronic shutter / Frame blanking
Digital output bit count	12 bit / 10 bit / 8 bit

(2) External control mode

An external control (trigger) pulse input the internal microprocessor and the repeating exposure and readout.
Exposure start timing and length of exposure can be controlled with the external trigger pulse. In addition, commands can be used the following.

Digital output data count	1024 / 1280 / 1344
Scan mode	Normal / Binning / Sub-array
Exposure time setting	Internal setting / External setting
Digital output bit count	12 bit / 10 bit / 8 bit
External control pulse polarity	Negative / Positive

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9-3 DETAILS OF CAMERA MODE

9-3-1 DIGITAL OUTPUT PIXEL COUNT

Select one of the numbers of effective horizontal pixel settings (1024/1280/1344) for the camera's digital data output in accordance with the specifications of the digital input frame grabber board being used.

Horizontal × Vertical	Command
1024 × 1024	SHA K
1280 × 1024	SHA F
1344 × 1024	SHA M

9-3-2 DIGITAL OUTPUT BIT COUNT

Select the output bit count for the digital data output by the camera.

12 bit digital data, output at DB 0 to DB 11.	ADS 12
The ten most significant bits of the 12 bit digital data are output to DB 0 to DB 9.	ADS 10
The eight most significant bits of the 12 bit digital data are output to DB 0 to DB 7.	ADS 8

9-3-3 BINNING READOUT AND BINNING SETTINGS VALUES

In addition to the normal readout, <1×1>, in which the digital output pixel count is read out as is, the following readouts are available.

2×2 binning: 2 horizontal pixels combined with 2 vertical pixels	SMD S, SPX 2
4×4 binning: 4 horizontal pixels combined with 4 vertical pixels	SMD S, SPX 4

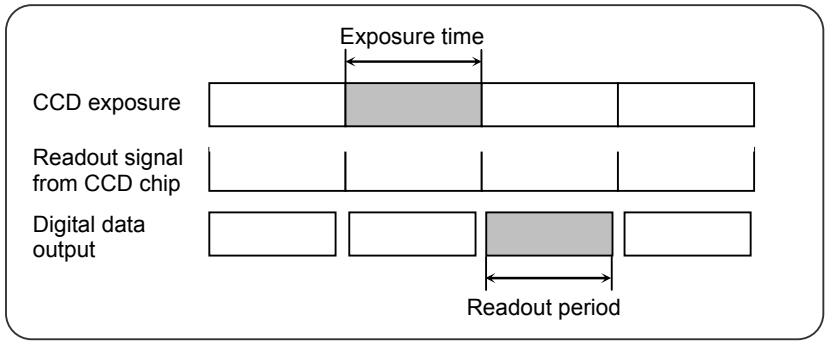
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9-3-4 CCD READOUT METHODS (SCAN MODE)

Select either normal readout or binning readout.

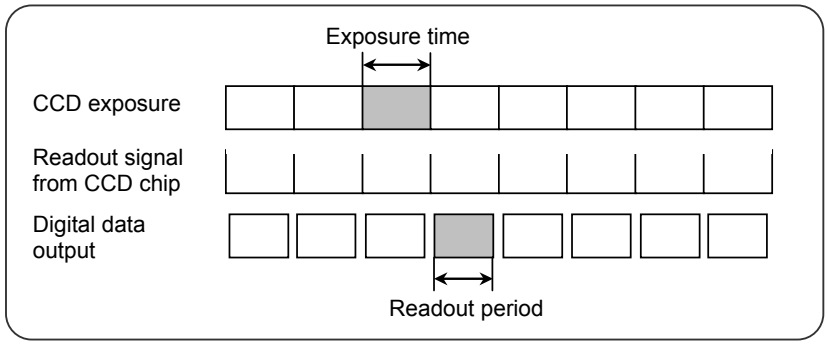
(1) Normal readout ..... SMD N

Electrical charges from the CCD are read out in the normal, standard manner. The time required for CCD readout of all of the CCD's pixels is approximately 1/11.9 s.



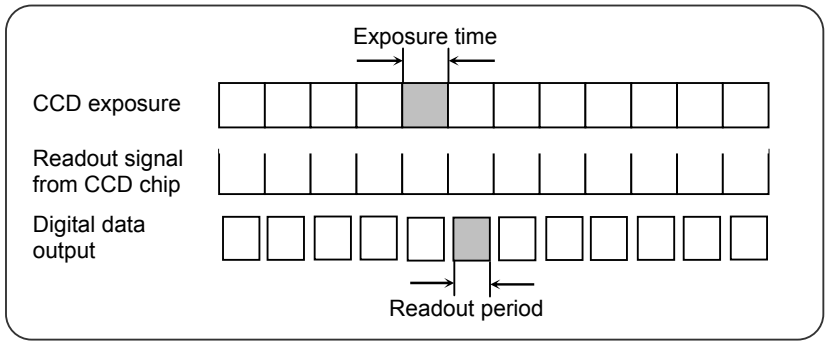
(2) 2×2 binning readout ..... SMD S, SPX 2

Electrical charges from the CCD are read out in 2×2 binning readout. Time for total readout of the CCD's pixels is approximately 1/21.3 s.



(3) 4×4 binning readout ..... SMD S, SPX 4

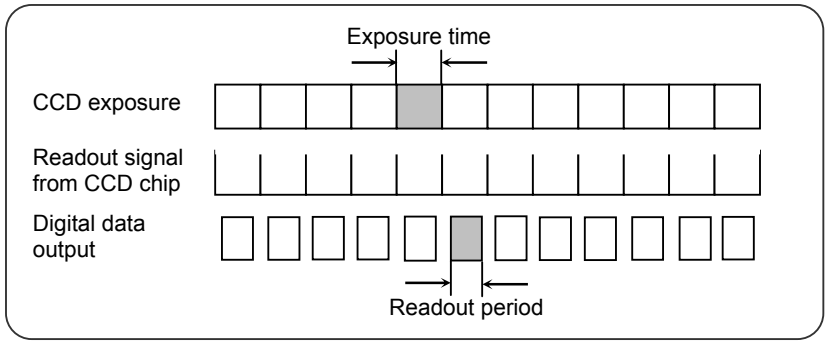
Electrical charges from the CCD are read out in 4×4 binning readout. Time for total readout of the CCD's pixels is approximately 1/35.7 s.



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(4) Sub-array readout ..... SMD A

In this mode, only a required area is read out at the normal speed while the remaining areas are rapidly cleared. This operation allows the frame rate to be increased.



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9-4 EXPOSURE TIME SETTINGS

The exposure time and the methods used for making the exposure time settings are different for Free running mode and External control mode. The following explains more about each mode.

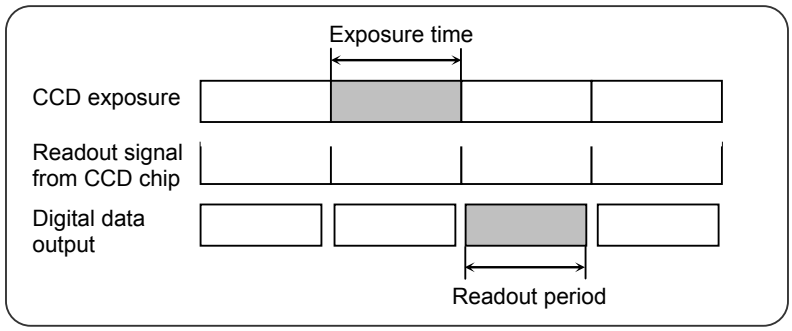
9-4-1 FREE RUNNING MODE

9-4-1-1 Exposure time setting: Normal

(1) Normal readout

Exposure and normal readout repeat according to the sequence set internally.

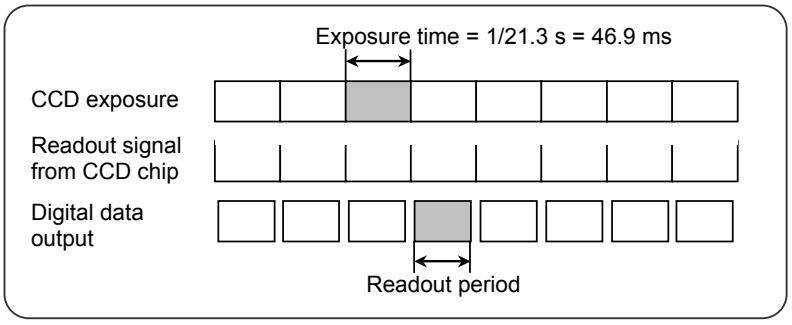
Command : AMD N (Free running mode)
Scan mode : SMD N (Normal)
Exposure time : NMD N (Normal)
Exposure time : 1/11.9 s (83.8 ms)
Repeat cycle : 11.9 Hz



(2) 2×2 binning readout

Exposure and 2×2 binning readout repeat according to the sequence set internally.

Command : AMD N (Free running mode)
Scan mode : SMD S (Binning)
Exposure time : NMD N (Normal)
Binning : SPX 2 (2×2 binning)
Exposure time : 1/21.3 s (46.9 ms)
Repeat cycle : 21.3 Hz

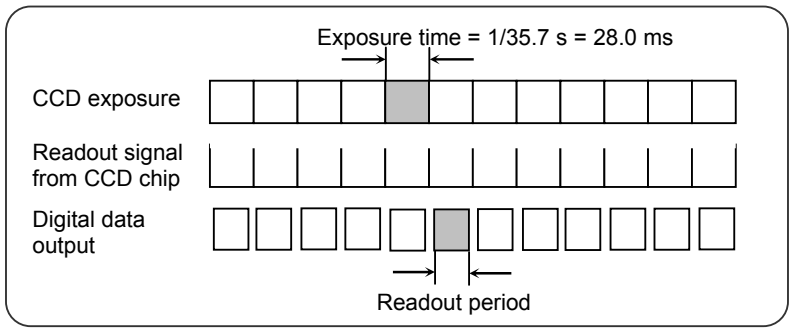


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(3) 4×4 binning readout

Exposure and 4×4 binning readout repeat according to the sequence set internally.

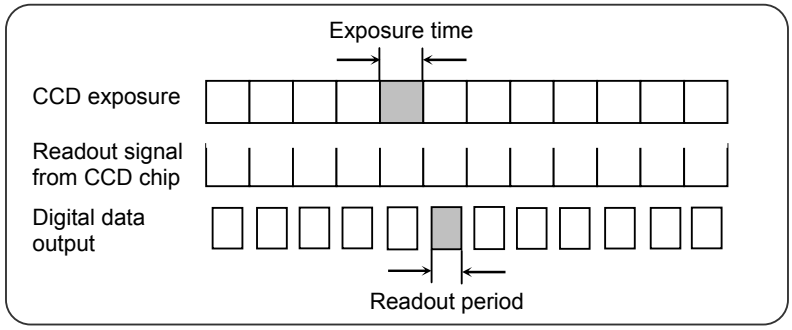
Command	:	AMD N	(Free running mode)
Scan mode	:	SMD S	(Binning)
Exposure time	:	NMD N	(Normal)
Binning	:	SPX 4	(4×4 binning)
Exposure time	:	1/35.7 s	(28.0 ms)
Repeat cycle	:	35.7 Hz	



(4) Sub-array readout

Readout of the sub-array repeats according to the sequence set internally with the selection of <SVO n/SVW m/SPX e>.

Command	:	AMD N (Free running mode)
Scan mode	:	SMD A (Sub-array)
Exposure time	:	NMD N (Normal)
Sub-array	:	SVO n/SVW m/SPX e



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9-4-1-2 Exposure time setting: Electronic shutter

Exposure and readout repeat along with the operation of the electronic shutter according to the sequence set internally. The exposure time (electronic shutter time) is set with the SHT n command. This setting is made in units of one horizontal scan cycle.

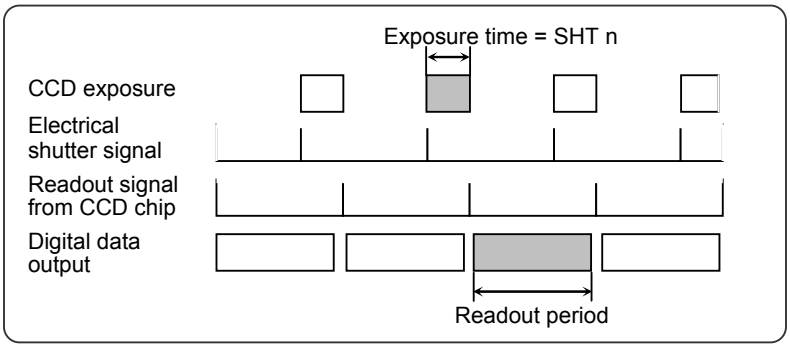
(1) Normal readout

Exposure and normal readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD N	(Normal)
Exposure time	:	NMD S, SHT n	(Shutter)
1H (horizontal)	:	79.3 µs	
Setting count	:	1H to 1055H	
Repeat cycle	:	11.9 Hz	

Exposure time cane be calculated using the formula below.

Exposure time = 12.4 µs + (n-1) × 79.3 µs (n=1 to1055)



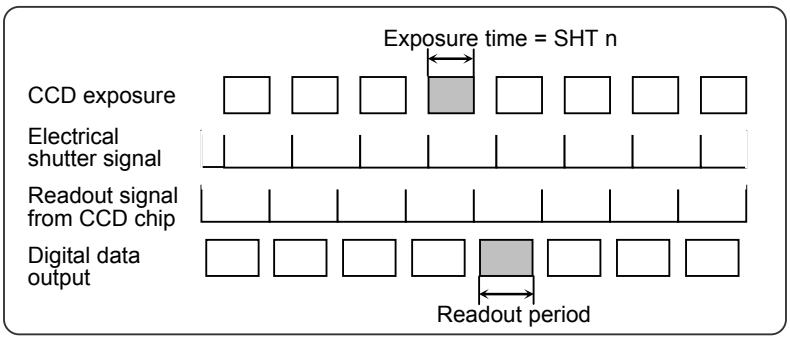
(2) 2×2 binning readout

Exposure and 2×2 binning readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD S	(Binning)
Exposure time	:	NMD S, SHT n	(Shutter)
Binning	:	SPX 2	(2×2 binning)
1H (horizontal)	:	87.4 µs	
Setting count	:	1H to 535H	
Repeat cycle	:	21.3 Hz	

Exposure time can be calculated using the formula below.

Exposure time = 20.5 µs + (n-1) × 87.4 µs (n = 1 to 535)



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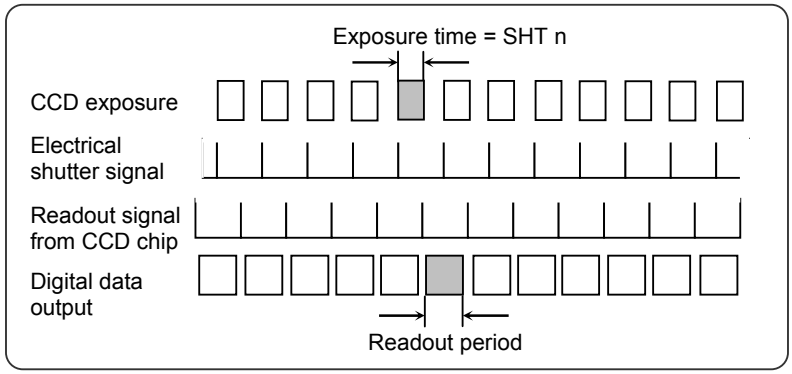
(3) 4×4 binning readout

Exposure and 4×4 binning readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD S	(Binning)
Exposure time	:	NMD S, SHT n	(Shutter)
Binning	:	SPX 4	(4×4 binning)
1H (horizontal)	:	103.6 µs	
Setting count	:	1H to 269H	
Repeat cycle	:	35.7 Hz	

Exposure time can be calculated using the formula below.

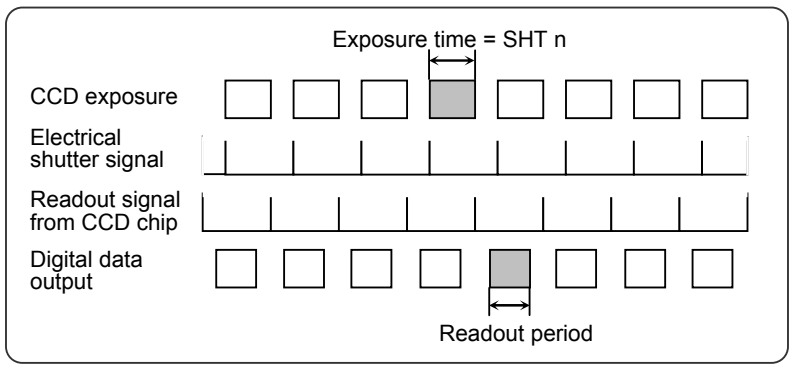
Exposure time = 36.7 µs + (n-1) × 103.6 µs (n=1 to 269)



(4) Sub-array readout

Readout of the sub-array repeats according to the sequence set internally with the selection of <SVO n/SVW m/SPX e>.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD A	(Sub-array)
Exposure time	:	NMD S, SHT n	(Shutter)
Sub-array	:	SVO n/SVW m/SPX e	



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9-4-1-3 Exposure time setting: Frame blanking*

Exposure and readout repeat along with the operation of the electronic shutter according to the sequence set internally. The exposure time (Frame blanking*) is set with the FBL n command. This setting is made in units of one vertical scan cycle.

* Frame blanking: Photosensors are exposed for a specified number of frames; however the accumulated charge to the VCCD from the photosensors are not read out every frame.

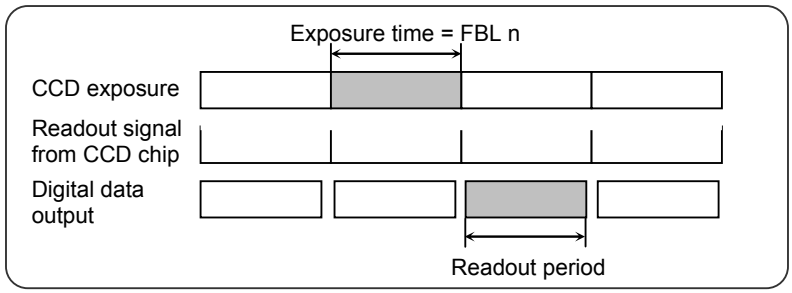
(1) Normal readout

Exposure and normal readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD N	(Normal)
Exposure time	:	NMD F, FBL n	(Frame blanking)
1V (vertical)	:	83.8 ms	
Setting count	:	1V to 12V	(83.8 ms to 1.00 s)
Repeat cycle	:	11.9 Hz/n	

Exposure time can be calculated using the formula below.

Exposure time = n × 83.8 ms (n=1 to 12)



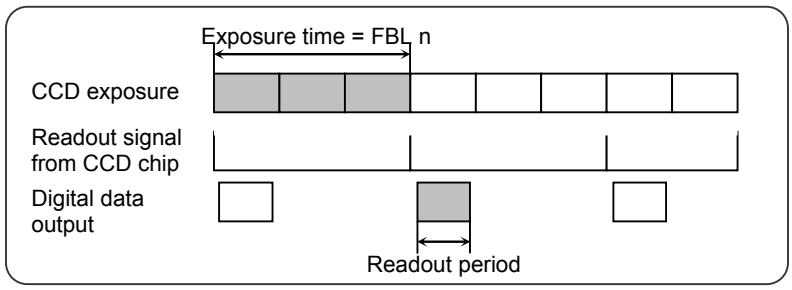
(2) 2×2 binning readout

Exposure and 2×2 binning readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD S	(Binning)
Exposure time	:	NMD F, FBL n	(Frame blanking)
Binning	:	SPX 2	(2×2 binning)
1V (vertical)	:	46.9 ms	
Setting count	:	1V to 22V	(46.9 ms to 1.03 s)
Repeat cycle	:	21.3 Hz/n	

Exposure time can be calculated using the formula below.

Exposure time = n × 46.9 ms (n=1 to 22)



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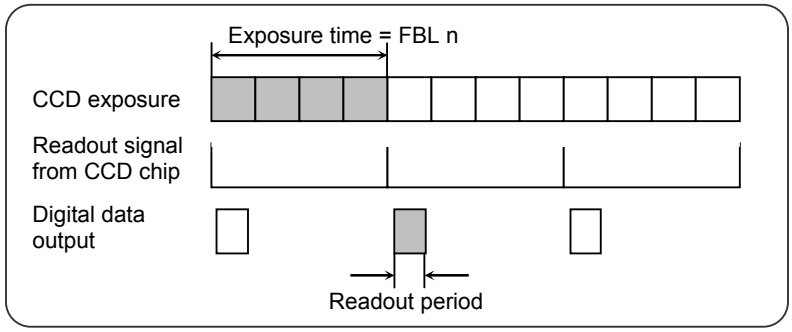
(3) 4×4 binning readout

Exposure and 4×4 binning readout repeat according to the sequence set internally.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD S	(Binning)
Exposure time	:	NMD F, FBL n	(Frame blanking)
Binning	:	SPX 4	(4×4 binning)
1V (vertical)	:	28.0 ms	
Setting count	:	1V to 36V	(28.0 ms to 1.00 s)
Repeat cycle	:	35.7 Hz/n	

Exposure time can be calculated using the formula below.

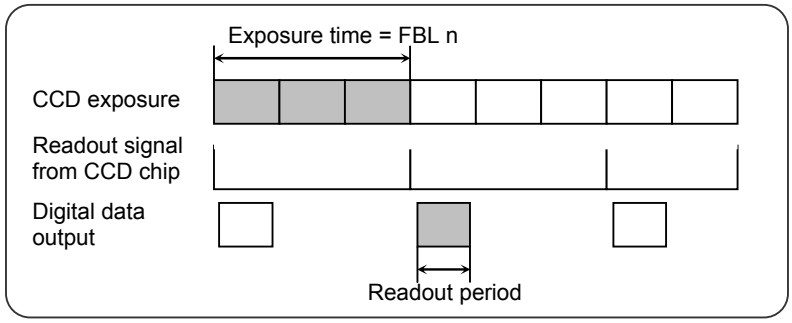
Exposure time = n × 28.0 ms (n=1 to 36)



(4) Sub-array readout

Readout of the sub-array repeats along with frame blanking according to the sequence set internally with the selection of <SVO n/SVW m/SPX e>. The exposure time (electronic shutter time) is set with the FBL n command.

Command	:	AMD N	(Free running mode)
Scan mode	:	SMD A	(Sub-array)
Exposure time	:	NMD F, FBL n	(Frame blanking)
Sub-array	:	SVO n / SVW m / SPX e	



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9-4-2 EXTERNAL CONTROL MODE

The external trigger pulse polarity is selected from <N (Negative) low-level active/P (Positive) high-level active> and is input via the timing I/O connector (TIMING I/O) on the rear panel.
The external trigger pulse is at TTL level (Termination is 680 Ω).
The cycle is active for a minimum of 1 µs, and the repeat must match the selected mode.

Note

- Images are not output correctly if the pulse input is shorter than 1 µs.

The following text describes the External Control mode with the external trigger pulse polarity set to N (Negative). If P (Positive) is selected, the rise and fall of each pulse is reversed (inverted), with the LO interval becoming the HI interval.
Descriptions enclosed in brackets ({ }) indicate cases where P (Positive) is selected.

9-4-2-1 Exposure time setting: Internal setting

Exposure begins within 2.2 µs from the fall {rise} of the external trigger pulse, the exposure is made using the time set with the EST n command, and readout follows. After readout, the system waits for the external trigger pulse to fall {rise} again. The exposure time (electronic shutter time) is set with the EST n command. This setting is made in units of one horizontal scan cycle. The repeat cycle is controlled by the external control pulse's repeat cycle.

Note

- Set the external control pulse's repeat cycle so that it is longer than the minimum cycle.

(1) Normal readout

Exposure and normal readout repeat according to the sequence set internally.

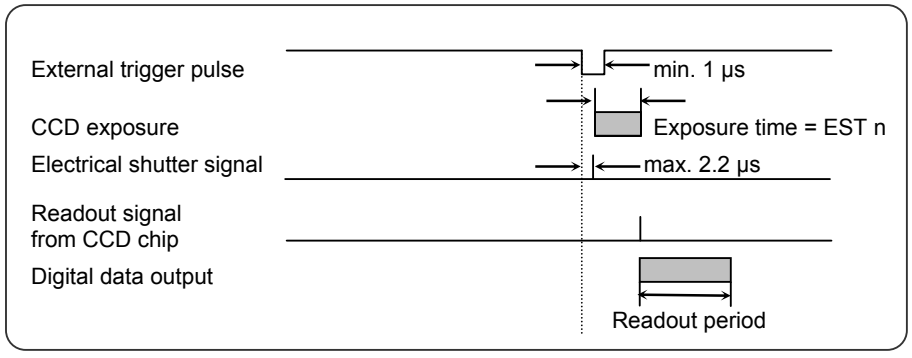
Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD N (Normal)
Exposure time	:	EMD E, EST n (Internal setting)
1V (vertical)	:	79.3 µs
Setting count	:	1H to 12 930H (14.5 µs to 1.025 s)

Minimum Repeat cycle can be calculated using the formula below.

Minimum repeat cycle = 83.8 ms (readout time) + set exposure time

Exposure time can be calculated using the formula below.

Exposure time = 14.5 µs + (n-1) × 79.3 µs (n = 1 to 12 930)



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(2) 2×2 binning readout

Exposure and 2×2 binning readout repeat according to the sequence set internally.

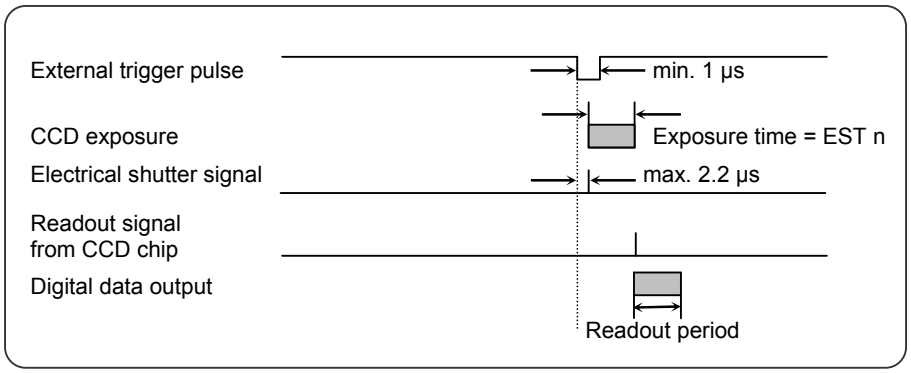
Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD S (Binning)
Exposure time	:	EMD E,EST n (Internal setting)
Binning	:	SPX 2 (2×2)
1V (vertical)	:	87.4 µs
Setting count	:	1H to 12 930H (22.65 µs to 1.129 s)

Minimum Repeat cycle can be calculated using the formula below.

Minimum repeat cycle = 46.9 ms (readout time) + set exposure time

Exposure time can be calculated using the formula below.

Exposure time = 22.65 µs + (n-1) × 87.4 µs (n = 1 to 12 930)



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(3) 4×4 binning readout

Exposure and 4×4 binning readout repeat according to the sequence set internally.

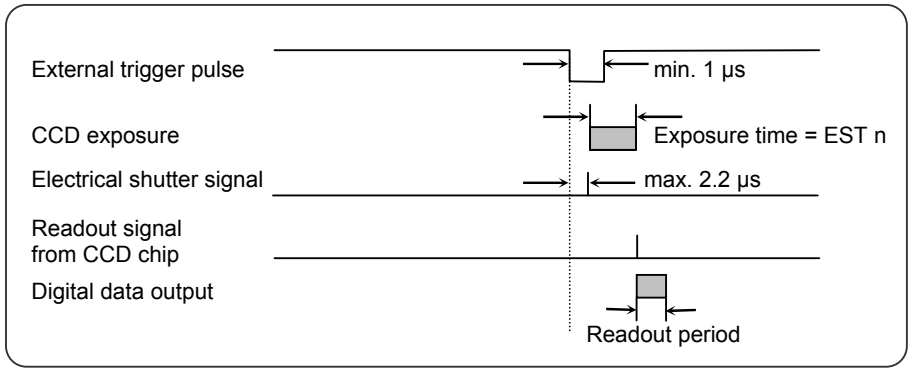
Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD S (Binning)
Exposure time	:	EMD E,EST n (Internal setting)
Binning	:	SPX 4 (4×4)
1V (vertical)	:	103.6 µs
Setting count	:	1H to 12 930H (38.45 µs to 1.339 s)

Minimum Repeat cycle can be calculated using the formula below.

Minimum repeat cycle = 28.0 ms (readout time) + set exposure time

Exposure time can be calculated using the formula below.

Exposure time = 38.45 µs + (n-1) × 103.6 µs (n = 1 to 12 930)



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9-4-2-2 Exposure time setting: External setting

Exposure begins within 2.2 µs from the fall {rise} of the external trigger pulse. After this, when external trigger pulse rises {falls} again, the exposure is stopped within the designated time, and the data is read out. After readout, the system waits for the external trigger pulse to fall {rise} again. The exposure time (electronic shutter time) is controlled according to the external control pulse's LO interval {HI interval}. The repeat cycle is controlled by the external control pulse's repeat cycle.

Note

- Set the external control pulse's repeat cycle so that it is longer than the minimum cycle.

Note

- The external control pulse's LO interval {HI interval} must be at least 10 µs.

Maximum exposure time is 1 s.
When the external control pulse's LO interval {HI interval} exceeds 1 s, the exposure is stopped and the data is read out (exposure cannot exceed 1 s).

(1) Normal readout

Exposure and normal readout repeat according to the sequence set internally.

Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD N (Normal)
Exposure time	:	EMD L (External setting)
Designated time	:	within 152 µs

Minimum repeat cycle can be calculated using the formula below.

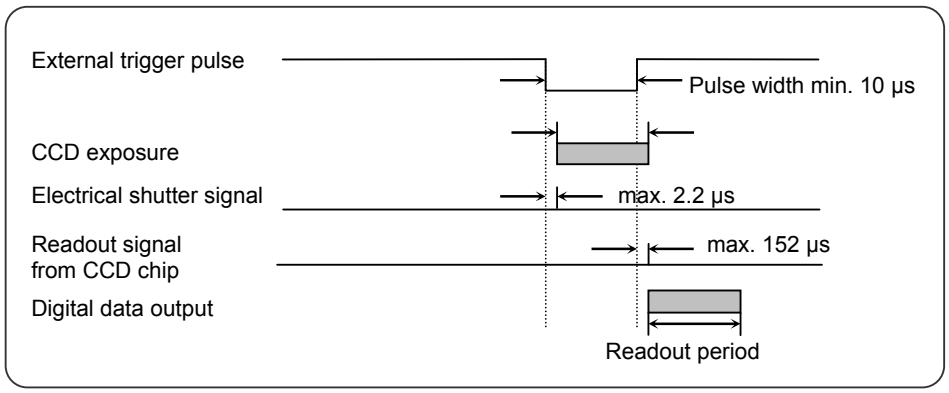
Minimum repeat cycle = 83.8 ms (readout time) + external control pulse's LO interval {HI interval} (exposure time)

Exposure time can be calculated using the formula below.

Exposure time = external trigger pulse LO interval {HI interval} - 2.2 µs (MAX) (exposure lock-in time) + 152 µs (MAX) (readout lock-in time)

Ex) When the external control pulse's LO interval {HI interval} is 40,

Exposure time = 40 µs - 2.2 µs (MAX) + 152 µs (MAX) = 189.8 µs (MAX)



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(2) 2×2 binning readout

Exposure and 2×2 binning readout repeat according to the sequence set internally.

Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD S (Binning)
Exposure time	:	EMD L (External setting)
Binning	:	SPX 2 (2×2 binning)
Designated time	:	within 152 µs

Minimum repeat cycle can be calculated using the formula below.

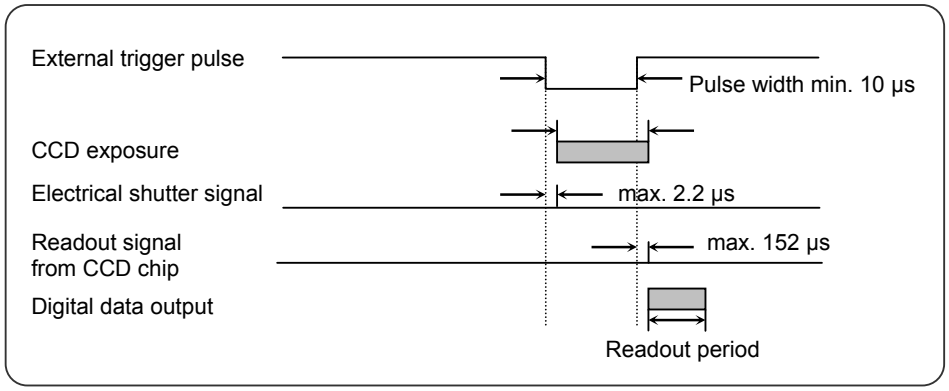
Minimum repeat cycle = 46.9 ms (readout time) + external control pulse's LO interval {HI interval} (exposure time)

Exposure time can be calculated using the formula below.

Exposure time = external trigger pulse LO interval {HI interval} - 2.2 µs (MAX) (exposure lock-in time) + 152 µs (MAX) (readout lock-in time)

Ex) When the external control pulse's LO interval {HI interval} is 40,

Exposure time = 40 µs - 2.2 µs (MAX) + 152 µs (MAX) = 189.8 µs (MAX)



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(3) 4×4 binning readout

Exposure and 4×4 binning readout repeat according to the sequence set internally.

Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD S (Binning)
Exposure time	:	EMD L (External setting)
Binning	:	SPX 4 (4×4 binning)
Designated time	:	within 182 µs

Minimum repeat cycle can be calculated using the formula below.

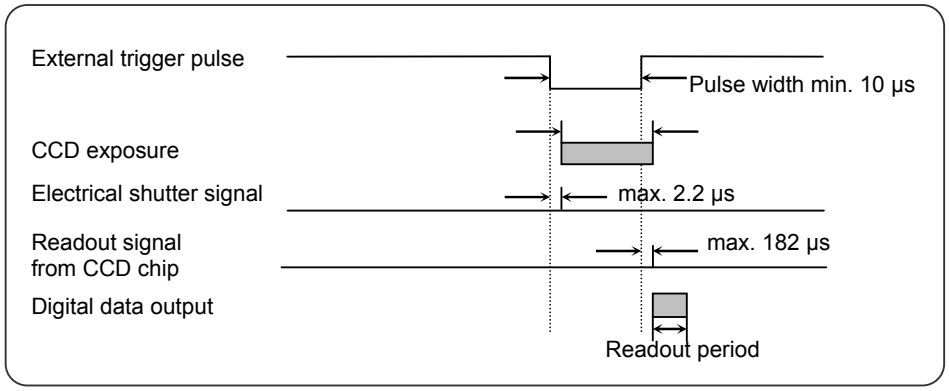
Minimum repeat cycle = 28.0 ms (readout time) + external control pulse's LO interval {HI interval} (exposure time)

Exposure time can be calculated using the formula below.

Exposure time = external trigger pulse LO interval {HI interval} - 2.2 µs (MAX) (exposure lock-in time) + 182 µs (MAX) (readout lock-in time)

Ex) When the external control pulse's LO interval {HI interval} is 40,

Exposure time = 40 µs - 2.2 µs (MAX) + 182 µs (MAX) = 219.8 µs (MAX)



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(4) Sub-array readout

Readout of the sub-array repeats according to the sequence set internally.

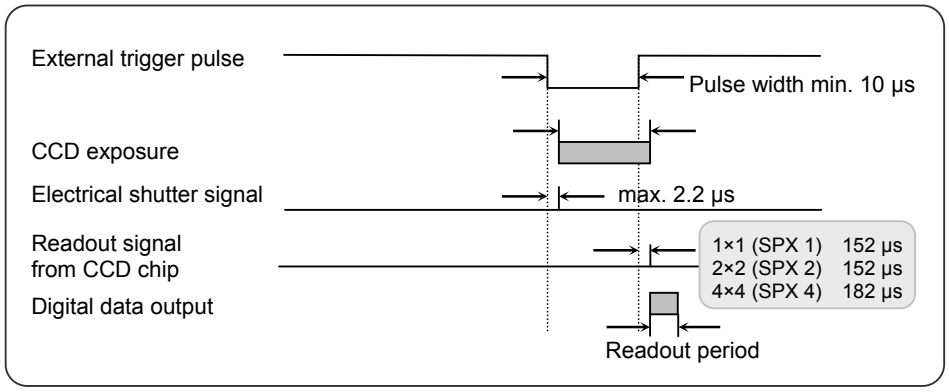
Command	:	AMD E (External control mode)
External control pulse	:	ATP N {ATP P}
Scan mode	:	SMD A (Sub-array)
Exposure time	:	EMD L (External setting)
Sub-array	:	SVO n / SVW m / SPX e
Designated time	:	within 40 µs

Minimum repeat cycle can be calculated using the formula below.

Minimum repeat cycle = readout time + external control pulse's LO interval {HI interval} (exposure time)

Exposure time can be calculated using the formula below.
Ex) When the external control pulse's LO interval {HI interval} is 40,

Exposure time = external trigger pulse LO interval {HI interval} - 2.2 µs (MAX) (exposure lock-in time) + 152 µs (MAX) (readout lock-in time)



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10. COMMAND SPECIFICATION

10-1 TRANSMISSION INTERFACE

The camera is controlled from the host computer through the serial interface.
Specifications for the serial interface are shown below.

Baud rate	9600
Bit length	8
Parity check	None
Stop bit	1

10-2 COMMAND FORMAT

(1) Basic system

External control commands for the camera are output by the computer in the following format.

Command_Parameter	CR

CR: Carriage Return

<CR> appended to a command being output indicates the end of the data.
Spaces (_) are used to separate commands from parameters in commands requiring the inclusion of parameters.

10-3 CAMERA RESPONSE TO COMMANDS

The camera responds to commands transmitted from the host computer.
The camera can be set so that a response is either sent or withheld when the RESponse command is received.
However, responses to status commands from the camera cannot be refused.

RES	(RESponse)		
	Function	Setting allows or prevents responses when commands are sent from the host computer.	
	Parameter	RES Y	Response is transmitted for each separate command (default).
		RES N	Response is not transmitted for each separate command.

The following describes cases in which the camera responds to the RES command. Responses indicate the completion of actions the camera performs when the corresponding commands are received; responses differ according to the type of command received by the camera.

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(1) Responses to operating commands and setting commands

When execution of a command proceeds normally, a reply with the executed command (with parameter) is sent back to the host computer.

XXX_PP	CR

XXX: Executed command
PP : Parameter

If the command sent by the computer contains an error (undefined command, parameter error), the character string below is sent as an error message.

E3	CR

(2) Responses to status commands

This is always output; regardless of the RES command setting.
When the camera interprets a command as being proper, the response to the command's execution is to send back to the host computer the required status. Accordingly, the status command is executed normally, and the response is the transmission of the status to the host computer.

XXX_PP	CR

XXX : Command Name (Three characters, omitting "?")
PP : Status Response to the Command

Just as described above, when the command sent by the computer contains an error (undefined command, parameter error), the character string below is sent as an error message.

E3	CR

(3) Reply when error occurs on reception

There are two things to be considered when an error occurs during reception. One is framing, parity, or overrun errors; the other is the possible overloading of the input buffer. The fact that one of these errors has occurred is transmitted in the character string below.

En	CR

Here, n indicates an error, with the type of error indicated by the following.

n = 1: Framing, parity, or overrun error
n = 2: Input buffer overload

Moreover, when either of the two errors above occurs, the command generating the error is cancelled from the camera's input buffer.

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10-4 OVERVIEW OF COMMANDS

The external control commands are categorized into the five following groups.

- Mode setting commands
- Parameter setting commands
- Correctional commands
- Other setting commands
- Status commands

(1) Mode setting commands

This group contains commands that switch the modes used in obtaining images.

AMD	Selects internal control or external control for the exposure trigger timing.
NMD	Switches the method used to set the exposure time when the exposure trigger timing is controlled internally.
EMD	Switches the method used to set the exposure time when the exposure trigger timing is controlled externally.
SMD	Switches the scanning mode.
ADS	Switches the digital data output bit count.

(2) Parameter setting commands

This group contains commands for setting parameters such as exposure time and digital output pixel count.

SHT	Sets the exposure time (sets the electronic shutter speed) when the exposure trigger timing is controlled internally.
FBL	Sets the exposure time (sets the frame blanking count) when the exposure trigger timing is controlled internally.
EST	Sets the exposure time when the exposure trigger timing is controlled externally (sets the electronic shutter speed when the exposure time is set internally).
SHA	Selects the pixel number of digital output horizontal.
ATP	Sets the external trigger pulse polarity to N (Negative) or P (Positive).
SPX	Sets the number of binning when binning is selected.
SHO	Selects the sub-array's horizontal start address.
SHW	Selects the sub-array's horizontal line width.
SVO	Selects the sub-array's vertical start address.
SVW	Selects the sub-array's vertical line width.
ESC	Selects input connector for external trigger.

(3) Correctional commands

This group contains commands for setting the contrast enhancement function and other picture-correction settings.

CEG	Sets the contrast enhancement gain.

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(4) Other Setting Commands

This group contains commands for initializing the camera and for other settings.

INI	Sets the various settings that determine the camera's overall operation to the initial values.
RES	Selects whether responses are made to commands.

(5) Status commands

When the host computer outputs a status command, a response is then returned by the camera. All status commands are preceded by a question mark ("?"); if the status command is contained within a setting command, the question mark is added at the beginning of the command.

?AMD	Returns the setting for the exposure trigger timing.
?NMD	Returns the setting for the method used to set the exposure time when the exposure trigger timing is controlled internally.
?EMD	Returns the setting for the method used to set the exposure time when the exposure trigger timing is controlled externally.
?SMD	Returns the setting switching the scan mode.
?ADS	Returns the bit number of digital data output.
?SHT	Returns the exposure time (sets the electronic shutter speed) when the exposure trigger timing is controlled internally.
?FBL	Returns the exposure time (sets the frame blanking count) when the exposure trigger timing is controlled internally.
?EST	Returns the exposure time when the exposure trigger timing is controlled externally (sets the electronic shutter speed when the exposure time is set internally).
?SHA	Returns the pixel number of digital output horizontal pixel.
?ATP	Returns the external trigger pulse polarity.
?SPX	Returns the setting value when binning is selected as the readout mode.
?SHO	Returns the setting value for the horizontal start address.
?SHW	Returns the setting value for the horizontal line width.
?SVO	Returns the setting value for the vertical start address.
?SVW	Returns the setting value for the vertical line width.
?ESC	Returns the setting input connector for external trigger.
?CEG	Returns the contrast enhancement gain setting value.
?RES	Returns the setting for the command response.
?VER	Returns the version of camera's internal components.
?CAI	Returns information about the camera hardware.

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10-5 COMMAND INITIAL SETTING

Settings commands are set as shown below with the power is turned on.
These settings are initialized, regardless of the "INI" command.

Category	Initial command	Detail	
Mode setting commands	AMD N	Exposure start timing	Free running mode
	NMD N	Exposure time setting (in the free running mode)	Normal
	EMD E	Exposure time setting (in the external control mode)	Edge
	SMD N	Scan mode	Norma readout
	ADS 12	Digital data output bit count	12 bit
Parameter setting commands	SHT 160	Electronic shutter speed (in the free running mode)	160
	FBL 9	Frame blanking count (in the free running mode)	9
	EST 160	Electronic shutter speed (in the internal setting at the time of External control mode)	160
	SHA K	Digital output horizontal pixel count	1024
	ATP N	External trigger pulse polarity	Negative
	SPX 2	Super pixel readout	2×2 binning
	SHO 160	Horizontal offset (in the sub-array readout)	160
	SHW 1024	Horizontal line width (in the sub-array readout)	1024
	SVO 0	Vertical offset (in the sub-array readout)	0
	SVW 1024	Vertical line width (in the sub-array readout)	1024
	ESC I	Input connector (for external trigger)	Digital interface connector
Correctional commands	CEG L	Contrast enhancement gain	Low
Other setting commands	RES Y	Responses are made to commands.	

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10-6 DETAIL OF COMMANDS

(1) Mode setting commands

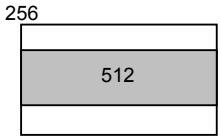
AMD	(Acquire MoDe)		
	Parameter	**N** (Normal) / E (External)	
	Function	Selects internal control or external control for the exposure trigger timing.	
	Example	AMD N	The command setting the mode is executed, and then internally controlled imaging begins.
		AMD E	The command setting the mode is executed, exposure according to external control pulses begins, and the images are output.
NMD	(Normal MoDe)		
	Parameter	N (Normal) / S (Shutter) / F (Frame blanking)	
	Function	Selects mode used to set the exposure time when the exposure trigger timing is controlled internally: Normal, in which exposure is set by exposure time, electronic shutter, or frame blanking.	
	Example	NMD N	The command setting the mode is executed, and exposure using normal exposure times goes into effect.
		NMD S	The command setting the mode is executed, and exposure using the electronic shutter goes into effect.
		NMD F	The command setting the mode is executed, and exposure using frame blanking goes into effect.
EMD	(External MoDe)		
	Parameter	E (Edge) / L (Level)	
	Function	Selects either internal or external settings are used in setting the exposure time when the exposure trigger timing is controlled externally.	
	Example	EMD E	The command setting the mode is executed, and exposure with exposure times with the internal settings goes into effect.
		EMD L	The command setting the mode is executed, and exposure with exposure times with the external settings goes into effect.
SMD	(Scan MoDe)		
	Parameter	N (Normal) / S (Super pixel)	
	Function	Selects either normal readout or binning readout (Super Pixel).	
	Example	SMD N	The command setting the mode is executed, and the data is read out using N/normal readout.
		SMD S	The command setting the mode is executed, and the data is read out using binning readout.
ADS	(A/D Select)		
	Parameter	12 (12 bit output) / 10 (10 bit output) / 8 (8 bit output)	
	Function	Selects 8 bit output, 10 bit output, or 12 bit output.	
	Example	ADS 12	12 bit digital data is output to DB0 to DB11.
		ADS 10	Of the 12 bit digital data, the 10 most significant bits are output to DB 0 to DB 9.
		ADS 8	Of the 12 bit digital data, the 8 most significant bits are output to DB 0 to DB 7.

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(2) Parameter setting commands

SHT	(SHutter Time)		
	Parameter	n (n: Number of Horizontal line) Normal readout : 1 to 1055 2×2 binning readout : 1 to 535 4×4 binning readout : 1 to 269	
	Function	Sets the exposure time (electronic shutter time) in units of 1 H when the exposure trigger timing is controlled internally and the electronic shutter is selected as the method for setting the exposure time.	
FBL	(Frame BLanking)		
	Parameter	n (n: Number of Frame) Normal readout : 1 to 12 2×2 binning readout : 1 to 22 4×4 binning readout : 1 to 36 --- [Sub-array readout] 1×1 (Normal) : 1 to (1 000 000/((W+10)×79.3+(1046-W)×6.6) 2×2 : 1 to (1 000 000/((W/2+9)×87.4+(527-W/2)×14.7) 4×4 : 1 to (1 000 000/((W/4+8)×103.6+(262-W/4)×30.9)	
	Function	Sets the exposure frame count when the exposure trigger timing is controlled internally and frame blanking is selected as the method for setting the exposure time.	
EST	(External Shutter Time)		
	Parameter	n (n: number of horizontal line) 1 to 12 930	
	Function	Sets the exposure time (electronic shutter time) in units of 1H when the exposure trigger timing is controlled externally and the internal settings for exposure time are used.	
SHA	(Scan Horizontal Area)		
	Parameter	K(Kilo) / F(Full) / M(Max)	
	Function	Selects 1024 (K), 1280 (F), or 1344 (M) for the pixel number of digital output horizontal.	
ATP	(Active Trigger Polarity)		
	Parameter	N(Negative) / P(Positive)	
	Function	Sets the external trigger pulse polarity.	
	Example	ATP N	Sets the external trigger pulse polarity to Negative.
		ATP P	Sets the external trigger pulse polarity to Positive.
SPX	(Super Pixel X)		
	Parameter	1(1×1) / 2(2×2) / 4(4×4)	
	Function	Sets 2×2 or 4×4 super pixel readout when binning readout is selected as the scan mode.	
	Example	SPX 2	The mode-setting command is executed, and the readout is set to 2×2 binning.
		SPX 4	The mode-setting command is executed, and the readout is set to 4×4 binning.

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SHO	(Scan H-Offset)		
	Parameter	n (0≤n≤1336, n = multiples of 8)	
	Function	Selects the sub-array's horizontal start address.	
	Example	When the n value is set to a number that is not a multiple of 8, the command returns an error (E3) in response. Furthermore, the SHA setting is enabled when the SHO command is processed.	
SHW	(Scan H-Width)		
	Parameter	m (8≦m≦1344, m=multiples of 8)	
	Function	Selects the sub-array's horizontal line width.	
	Example	When the n value is set to a number that is not a multiple of 8, the command elicits an error (E3) in response. Furthermore, the SHA setting is enabled when the SHW command is processed.	
SVO	(Scan V-Offset)		
	Parameter	n (0≦n≦1016, n=multiples of 8)	
	Function	Sets the vertical start address for the sub-array readout.	
	Example	When the n value is set to a number that is not a multiple of 8, the command elicits an error (E3) in response.	
SVW	(Scan V-Width)		
	Parameter	m (8≦m≦1024, m=multiples of 8)	
	Function	Selects the vertical line width for readout in sub-array or binning mode.	
	Example	Offset 256 (start address 256) Width 512 SVO 256 SVW 512 SHA F SMD A 	
ESC	(External trigger Source Connector)		
	Parameter	I (Digital Interface connector) / M (Digital 6-pin Multi connector)	
	Function	Selects input connector for external trigger.	
	Example	ESC I	Receives external trigger from Digital interface connector of the camera control unit.
		ESC M	Receives external trigger from Digital 6-pin multi connector of the camera control unit.

(3) Correctional commands

CEG	(Contrast Enhance Gain)		
	Parameter	L (Low) / H (High)	
	Function	Sets the gain for the Contrast Enhance function.	
	Example	CEG L	Gain is set to Low (0 dB).
		CEG H	Gain is set to High (14 dB).

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(4) Other setting commands

INI	(INItialize)		
	Parameter	None	
	Function	Initializes the contents of the camera control unit's internal parameter RAM.	
RES	(RESponse)		
	Parameter	Y (Yes) / N (No)	
	Function	Determines whether or not responses are returned when commands are executed.	
	Example	RES Y	Responses are returned when command are executed.
		RES N	Responses are not returned when command are executed.

(5) Status commands

Status commands return the current settings values.

Commands	Return value
?AMD (read Acquire MoDe)	N/E
?NMD (read Normal MoDe)	N/S/F
?EMD (read External MoDe)	E/L
?SMD (read Scan MoDe)	N/S
?ADS (read A/D Select)	8/10/12
?SHT (read SHutter Time)	n ・Normal readout : 1 to 1055 ・2×2 binning readout : 1 to 535 ・4×4 binning readout : 1 to 269
?FBL (read Frame BLanking)	n ・Normal readout : 1 to 12 ・2×2 binning readout : 1 to 22 ・4×4 binning readout : 1 to 36
?EST (read External Shutter Time)	n (1 to 12 930)
?SHA (read Scan Horizontal Area)	F/K/M
?ATP (read Acquire Trigger Polarity)	N/P
?SPX (read Super Pixel X)	1/2/4
?SHO (read Scan H-Offset)	n (0 to 1336)
?SHW (read Scan H-Width)	m (8 to 1344)
?SVO (read Scan V-Offset)	n (0 to 1016)
?SVW (read Scan V-Width)	m (8 to 1024)
?ESC (read External trigger Source Connector)	I/M
?CEG (read Contrast Enhancement Gain)	L/H
?RES (read RESponse)	Y/N

The following command is a special status command not in the group of settings commands.

?VER	(read rom VERsion)	
	Function	Returns the version of the camera's internal ROM.
	Return value	x.xx

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(6) Obtaining camera hardware information commands

This command returns information about the camera hardware. This command differs from other status commands, in that it includes parameters.

?CAI	(CAmera Information)	
	Parameter	T: Camera type name A: Bit number of output H: Pixel number of CCD effective horizontal V: Pixel number of CCD effective vertical U: Pixel number of CCD upper OPB W: Pixel number of CCD lower OPB L: Pixel number of CCD left OPB R: Pixel number of CCD right OPB I: Bit number of A/D converter S: Bit number of A/D converter O: Camera options B: Binning number
	Example	?CAI H → CAI H 1024

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11. 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) Damage (drop in sensitivity) to CCD by ultraviolet light exposure

Ultraviolet light has higher energy than visible light, so it can easily damage the sensors forming the CCD, causing a drop in sensitivity and rise dark current according to the total incident light energy. (Example: When the CCD is exposed to ultraviolet light having a wavelength of 196 nm and total radiation energy of 15 J/cm^2 for 625 minutes with an irradiance of 0.4 mW/cm^2, sensitivity will drop by approximately 15 % and dark current will increase by approximately 10 %.)
When using in the ultra violet range, take steps not to apply excessive ultraviolet light. (If a part of the effective area of the CCD is exposed to excessive ultravio let light, such as by direct incidence of the ultraviolet light laser, then sensitivity may drop accordingly.)
In addition, extended exposure may cause a drop in sensitivity, even if the intensity is not excessive. When not shot, take care to protect the CCD from ultraviolet light.

(3) 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.

(4) Folding distortion

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

(5) Interference fringes pattern

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

(6) 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.

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12. MAINTENANCE

12-1 CARE

Clean the exterior with a soft, dry cloth.



- Do not use a wet cloth, dirty cloth.

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13. 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.

13-1 IMAGES NOT TRANSFERRED

Cause	Measure	Chapter
Cables not fully connected	Reconnect	7
Camera control register not correctly configured	Recheck register settings	10
Short in cables	Replace cables	

13-2 ALTHOUGH IMAGES ARE TRANSFERRED (OTHER PROBLEMS)

(1) Scratches or discoloration visible on the screen

Cause	Measure	Chapter
Front glass of camera head dirty	Wipe with gauze dampened with alcohol	

(2) Image is blurred

Cause	Measure	Chapter
Incorrect back focus	Contact Hamamatsu subsidiary or distributor	17
Dirty CCD chip		

(3) Only dark, shaded images output

Cause	Measure	Chapter
Lens mount cap left on	Remove the cap	

(4) All images overflowing

Cause	Measure	Chapter
Too much light	Reduce amount of light Reduce exposure time	
Contrast enhancement set too high	Lower gain	

(5) Noise in image

Cause	Measure	Chapter
Noise introduced from exterior	Find and remedy problem	
Poor connection of internal components	Contact Hamamatsu subsidiary or distributor	17
Bad circuitry		

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14. SPECIFICATION

14-1 CAMERA SPECIFICATION

(1) Electrical specification

Imaging device	Progressive scan inline CCD solid-state imaging device	
Effective number of pixels	1344 (H) × 1024 (V)	
Cell size	4.65 µm × 4.65 µm	(Square format)
Effective area	6.25 mm × 4.76 mm	(1/2-inch size)
Frame rate	Normal readout	11.9 Hz
	2×2 binning readout	21.3 Hz
	4×4 binning readout	35.7 Hz
Readout noise	14 electrons (typ.) *1	
A/D converter	12 bit	
Lens mount	C-mount	
Amp gain conversion factor *2	2.8 electrons/ADcounts	
Full well capacity	10 900 electrons	
Contrast enhancement gain	0 dB/14 dB	
Exposure time setting	12.4 µs to 1 s	

* 1 This value is the measurement in free running and scan modes normal readout. The value was measured with the CCD in dark state. In this state, two images are acquired, image subtraction performed, the standard deviation taken from the results, and this value was then divided by squire root of 2 and plugged into a transformation coefficient.

* 2 When running an amp-gain transformation coefficient to convert measured image count values into electrons be sure to conduct dark subtraction first.

(2) Operating environment

Ambient storage temperature	0 ºC to + 40 ºC
Ambient operation temperature	-10 ºC to + 50 ºC
Ambient operating humidity	70 % or less (no condensation)
Operating space	Indoor, altitude up to 2000 m

(3) Dimensional outline and weight

Camera head	Approx. 160 g
Camera control unit	Approx. 610 g

Note

- Please refer to 15 Dimensional outline.

(4) Applicable standards

EMC	EN61326-1:2006	Class A

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14-2 SPECTRAL RESPONSE CHARACTERISTICS

Following is the typical spectral characteristics of the CCD.

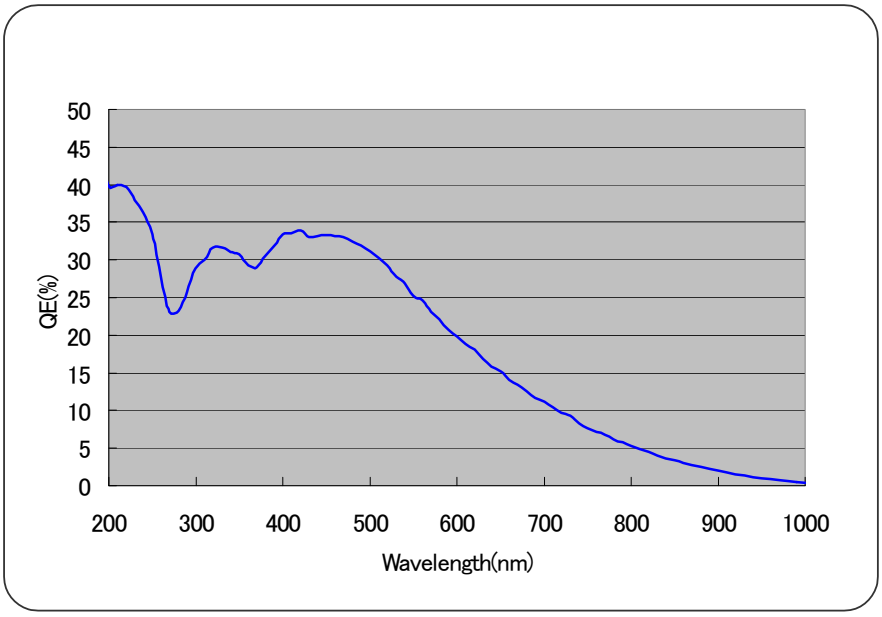


Figure 14-1

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14-3 INTERFACE SPESIFICATION

14-3-1 CAMERALINK INTERFACE

CameraLink interface is a standard of a digital interface for industrial application standardized by digital camera manufactures and frame grabber board manufactures. 28 bits digital data (TX0 to TX27) can be transferred as being changed into 5 signals (X0 to X3 and XCLK) by parallel serial transformation.
This camera is based on CameraLink interface and Base Configuration 12 bit digital camera standard.

(1) CameraLink connector pin assignments (MDR-26)

Camera Connector	Frame Grabber Connector	Channel Link Signal
1	1	Inner Shield
2	25	X0-
3	24	X1-
4	23	X2-
5	22	Xclk-
6	21	X3-
7	20	SerTC+ *2
8	19	SerTFG- *2
9	18	CC1- *1
10	17	CC2+ *1
11	16	CC3- *1
12	15	CC4+ *1
13	13	Inner Shield
14	14	Inner Shield
15	12	X0+
16	11	X1+
17	10	X2+
18	9	Xclk+
19	8	X3+
20	7	SerTC- *2
21	6	SerTFG+ *2
22	5	CC1+ *1
23	4	CC2- *1
24	3	CC3+ *1
25	2	CC4- *1
26	26	Inner Shield

* 1 CC1 to CC4 are options. It is possible to use an external trigger. So when it is needed, please feel free to contact our sales group.

* 2 SerTC and SerTFG are available when the second of DIPSW on the back panel of the camera is off.

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(2) CameraLink bit assignments

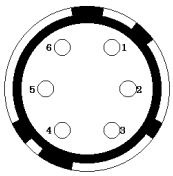
28 bit Solution Pin Name	Input Signal Name	28 bit Solution Pin Name	Input Signal Name
TX0	DB0	TX14	NC
TX1	DB1	TX15	NC
TX2	DB2	TX16	NC
TX3	DB3	TX17	NC
TX4	DB4	TX18	NC
TX5	DB7	TX19	NC
TX6	DB5	TX20	NC
TX7	DB8	TX21	NC
TX8	DB9	TX22	NC
TX9	DB10	TX23	Spare
TX10	NC	TX24	LVAL
TX11	NC	TX25	FVAL
TX12	DB11	TX26	DVAL
TX13	NC	TX27	DB6

- **DVAL** (Data valid signal)
  This signal synchronizes in the image data from CCD, and it is outputted. Each digital data is effective with the period of “On” of the signal.
- **LVAL** (Line valid signal)
  This signal shows the period during which the line part of the image data from the CCD is in effect. This is “ON” when during the period the line is active.
- **FVAL** (Frame valid signal)
  This signal shows the period during which the vertical part of the image data from the CCD is in effect. This is “ON” during the period the frame is active.
- **DB0 to DB11** (Digital image data)
  This is the image signal data from the CCD converted A/D. DB0 is the LSB (least significant bit) and DB11 is the MSB (most significant bit).

14-3-2 TIMING I/O INTERFACE

(1) Timing I/O pin assignments [TIMING I/O]

The camera uses Hirose model HR10A-7R-6S connector for inputting the external trigger pulse when the camera is operated in External Control mode. Input is TTL level (termination is 680 Ω), and the external trigger pulse polarity can be set either to negative or positive.

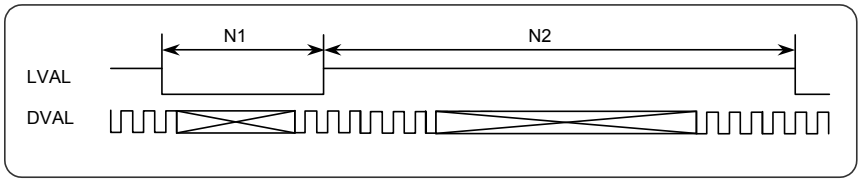
No.	Signal	Pin connections
1	Ext.Trigger	
2	Digital GND	
3	NC	
4	Digital GND	
5	NC	
6	Digital GND	HR10A-7R-6S

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14-4 IMAGE DATA OUTPUT TIMING SPECIFICATION

(1) Line timing (LVAL)

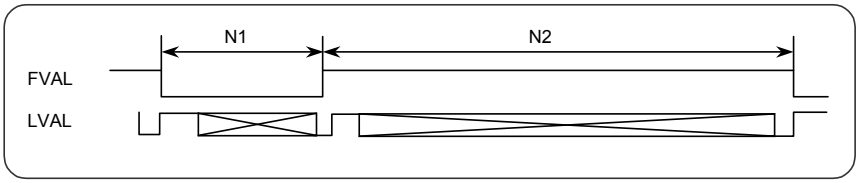
The following is the relationship the line valid timing signal (LVAL) and the data valid signal (DVAL).



Digital data output pixel number	Scan mode	N1 Pixel number	N2 Pixel number
1024	Normal readout	562	1024
	2×2 binning readout	362	512
	4×4 binning readout	262	256
1280	Normal readout	306	1280
	2×2 binning readout	234	640
	4×4 binning readout	198	320
1344	Normal readout	242	1344
	2×2 binning readout	202	672
	4×4 binning readout	182	336

(2) Frame timing (FVAL)

The following is the relationship the frame valid timing signal (FVAL) and the line valid timing signal (LVAL).

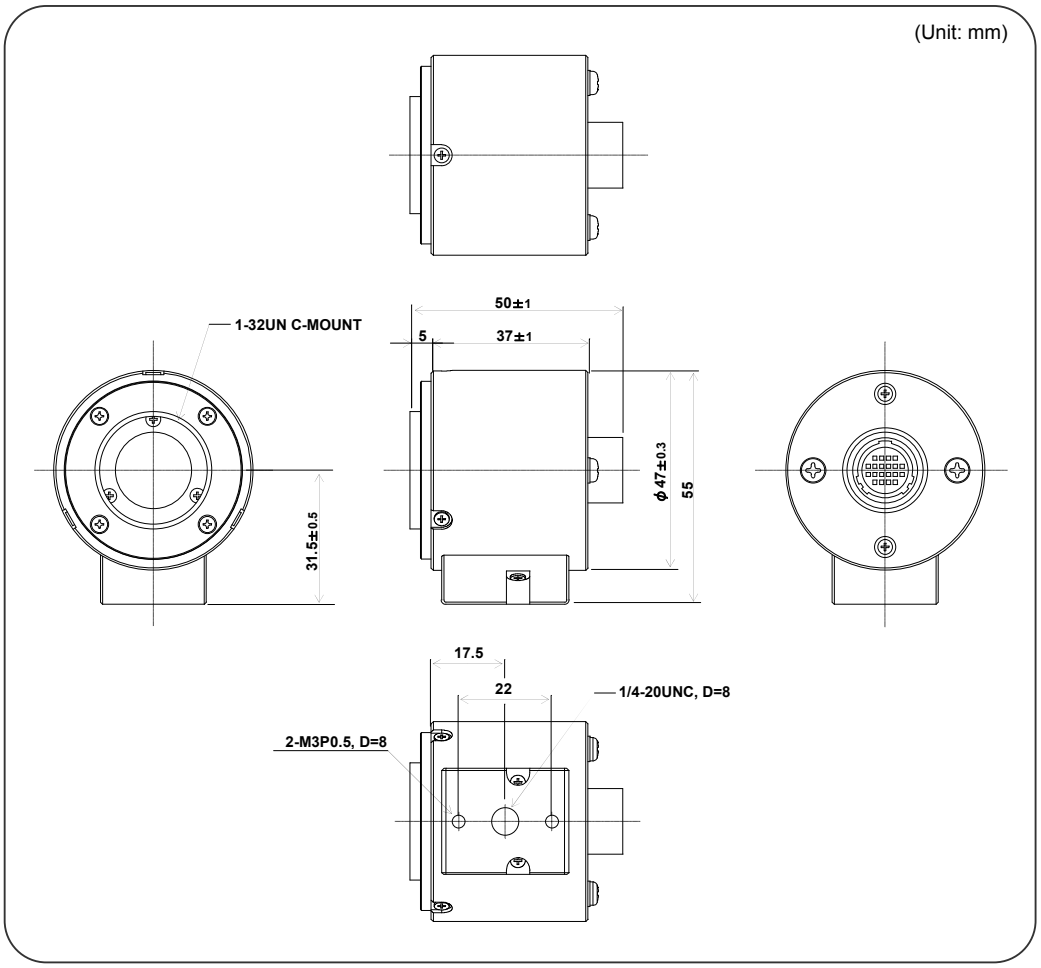


Digital data output pixel number	Scan mode	N1 Pixel number	N2 Pixel number
1024/1280/1344	Normal readout	32	1024
	2×2 binning readout	24	512
	4×4 binning readout	14	256

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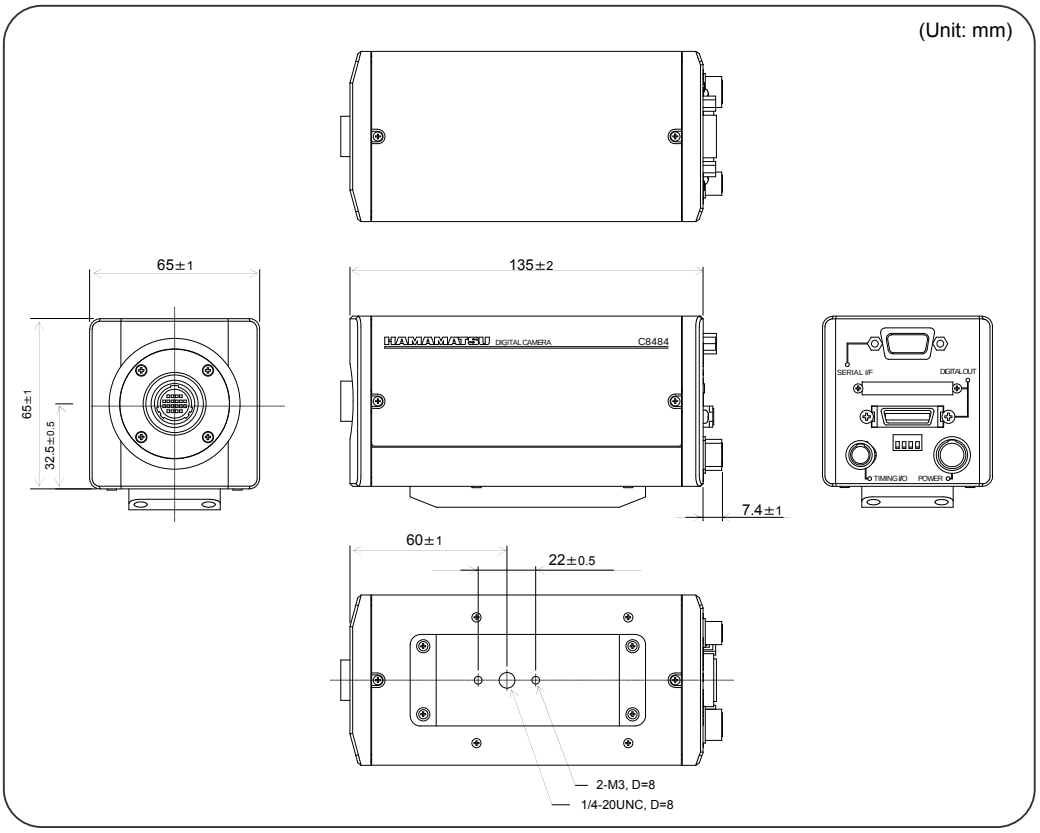
15. DIMENSIONAL OUTLINE

15-1 CAMERA HEAD



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15-2 CAMERA CONTROL UNIT



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16. 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.

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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17. CONTACT INFORMATION

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