Digital Camera
C11440-10C
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.

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HAMAMATSU PHOTONICS K.K.

90090301-02

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1. SAFETY PRECAUTIONS

1-1 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 adaptor 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 adaptor

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

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

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.

Disposal

When disposing of the system, take appropriate measures in compliance with applicable regulations regarding waste disposal and correctly dispose of it yourself, or entrust disposal to a licensed industrial waste disposal company. In any case, be sure to comply with the regulations in your country, state, region or province to ensure the system is disposed of legally and correctly.

Operating environment

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

2. CHECK THE CONTENTS OF PACKAGE

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

C11440-10C camera	1
AC adaptor	1
Power supply cord for AC adaptor	1
Lens mount cap *attached to the camera	1
C11440-10C Before Use	1
C11440-10C Instruction manual CD	1

[Option]

CameraLink interface cable	A10514-05

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

Do not block ventilation openings

- To prevent overheating in the camera's interior, do not wrap the device in cloth or other material, or in any way allow the camera'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.

Contents

4. OVERVIEW

At its core, C11440-10C is equipped with the new scientific image sensor FL-280, an advanced CMOS device that finally realizes the multiple benefits of high resolution, high readout speed, and low noise all at once.
C11440-10C provides 2.8 megapixel resolution at 45 frames/s (and up to 1273 frames/s by sub-array readout) while achieving 3 electrons r.m.s. readout noise performance. Moreover, the camera delivers high sensitivity through its on-chip micro lens, 4500:1 high dynamic range, on-chip analog gain and various correction features 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.
C11440-10C is the new scientific digital camera for life science microscopy, semiconductor inspection, x-ray scintillator readout or industrial imaging.

5. FEATURES

(1) Readout noise

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 (3 electrons r.m.s.) than the conventional cooled CCD camera. Moreover, high-speed readout (45 frame/s with 1920 pixels × 1440 pixels) with very low readout noise, which was impossible, can now be achieved.

(2) Cooling structure

In the camera, the FL-280 is cooled down by the peltier element to suppress the dark current. If FL-280 is exposed to the atmosphere, condensation of the moisture from the air might occur. The camera has a special hermetic chamber structure to isolate the sensor from the atmosphere, and the chamber is filled with nitrogen gas.

(3) Pixel number and pixel size

The FL-280 equipped in the camera has 3.63 µm x 3.63 µm pixel size that is about half of the conventional CCD image sensor (2/3 inch, 1.3 megapixels). When using the camera with a microscope, the number of photons coming to one pixel can be made equal to the conventional CCD image sensor (2/3 inch, 1.3 megapixels) if 0.5x relay lens is used. Also, the camera can observe a wider field of view because the pixel number is about 2 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 FL-280 realizes both low noise (3 electrons r.m.s.) and high speed readout (45 frame/s with 1920 pixels x 1440 pixels) simultaneously, owing to 1 line parallel simultaneous readout using column A/D.

(6) Real-time correction functions

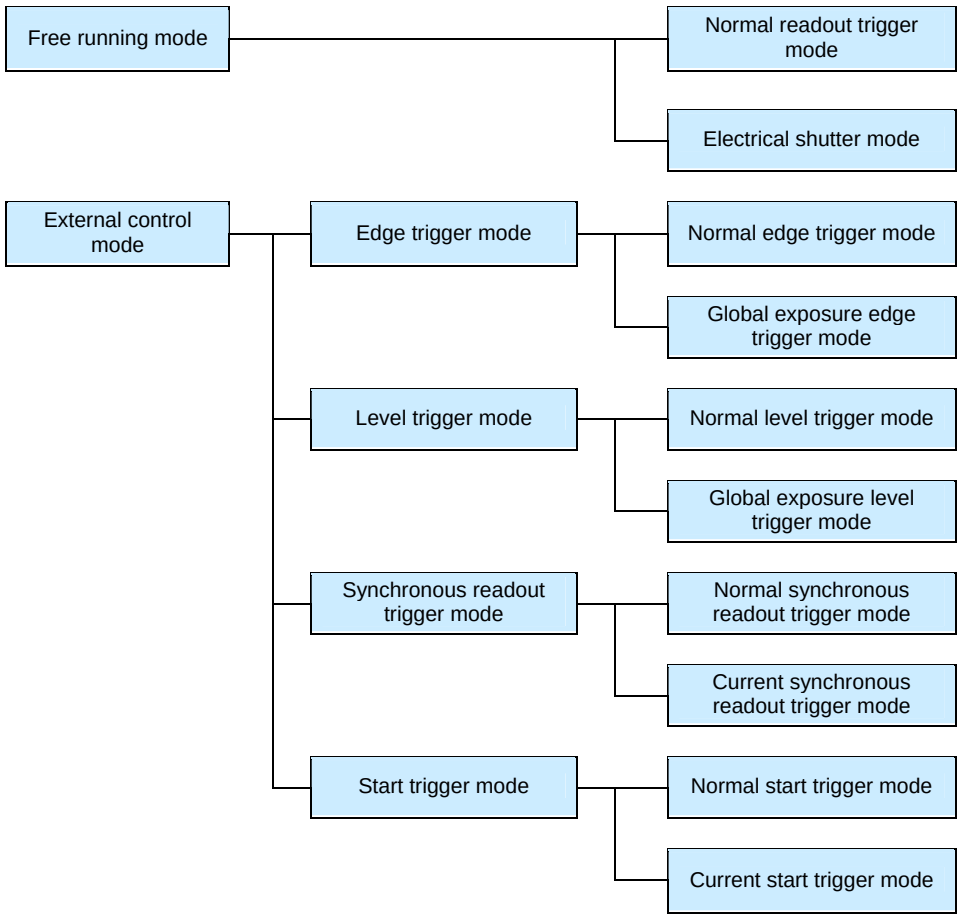
When using the camera, there is a chance that shading caused by uneven illumination and optics is not negligible in the image. Also, there are a few pixels in FL-280 that have slightly higher readout noise performance compared with surrounding pixels. Therefore, the camera has real-time offset level, shading and defective pixel correction features to further improve image quality. The correction is performed in real-time without scarifying the readout speed at all.

(7) CameraLink interface

The camera realizes 45 frames/s high-speed data transfer for 2.8 megapixels by using the CameraLink interface. Data is output with 75 MHz x 2 tap (12 bits) that follows the Base Configuration standard of CameraLink interface, and images can be transferred into a personal computer by using a CameraLink interface board available in the market.

(8) Camera operation modes

The camera has two operation modes: 1) the free running mode, in which the exposure and readout timing are controlled by the internal microprocessor, and 2) the external control mode, in which the exposure and readout timing are decided by an external trigger.



6. NAME AND FUNCTION OF THE PARTS

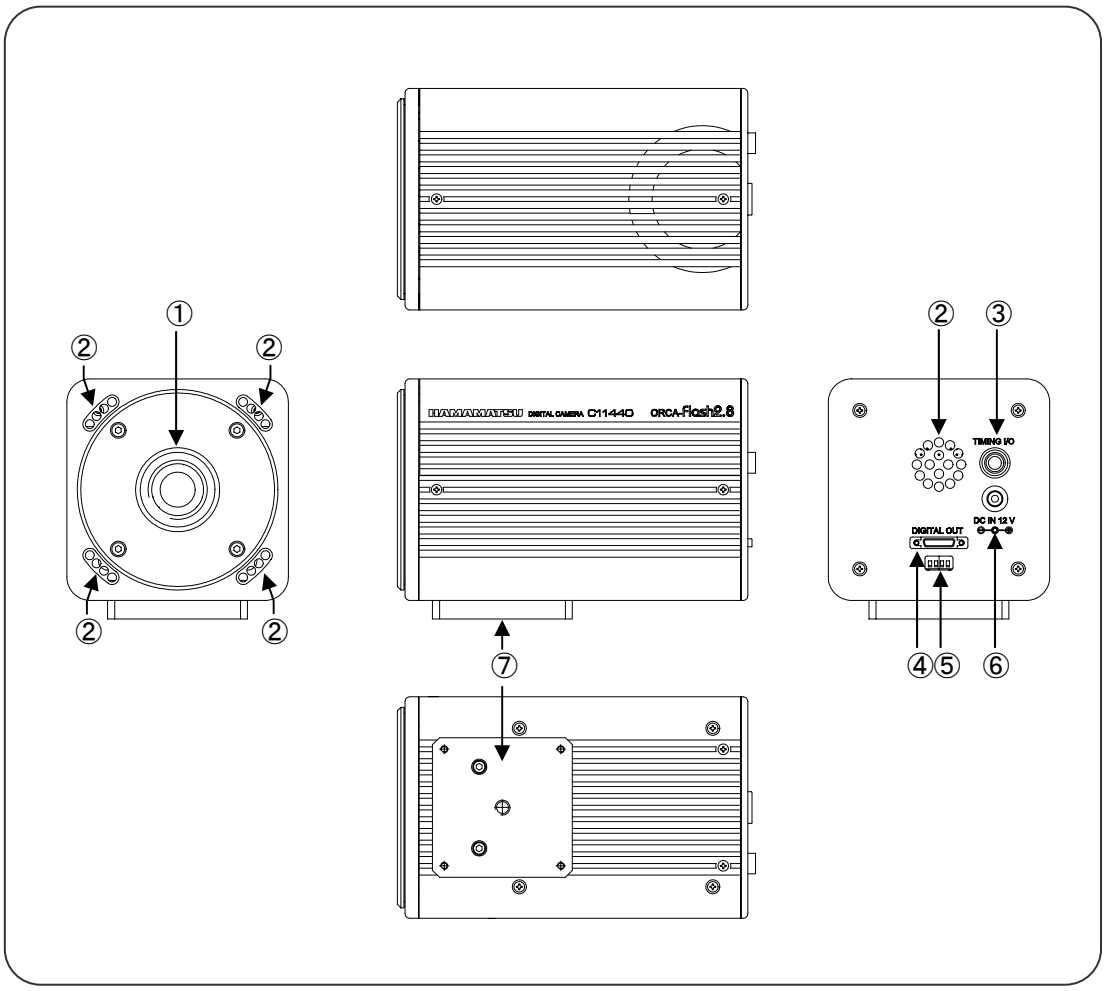


Figure 6-1

① Lens mount

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

Note

- The depth of the C-mount is 7 mm. Screwing in the mount too far can scratch the glass surface.

② Air outlet

This is the outlet for the heat ventilation.

- To prevent overheating in the camera's interior, do not wrap the device in cloth or other material, or in any way allow the camera'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.

③ Timing I/O connector [TIMING I/O]

The connector is used to output various signals.

Note

- Please see 12-2 [TIMING OUTPUT SETTING] for details.

④ Camera connector [DIGITAL OUT]

This is used to connect the camera to the computer.

⑤ DIP switch

- Do not change the setup of the switch.

⑥ DC power input connector

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

⑦ Camera attachment stand

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

Note

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

7. CONNECTION

7-1 CONNECTING OF CABLES

Refer to the figure when connecting the various cables.

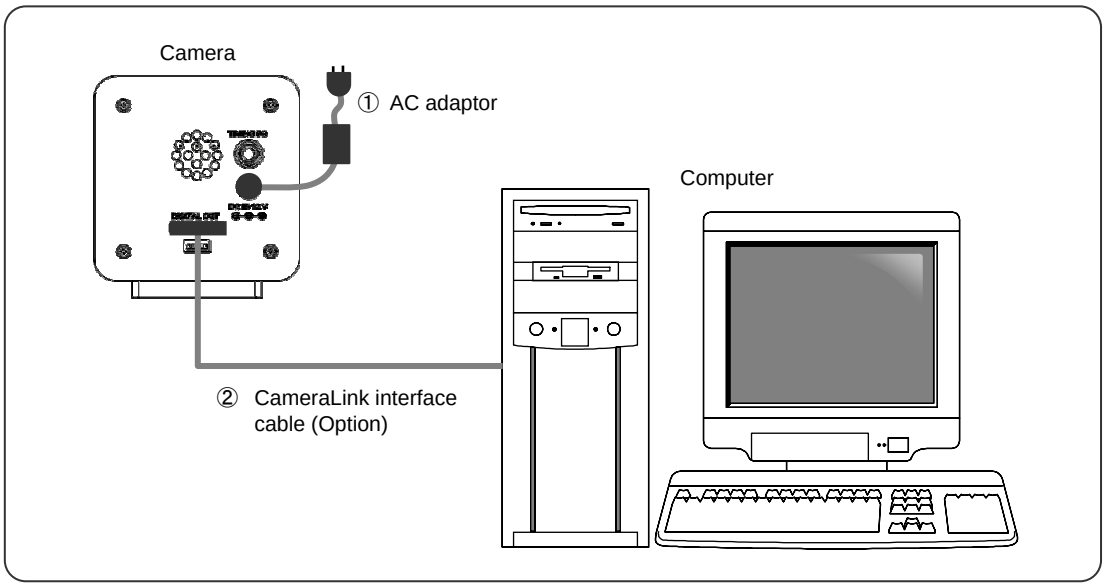


Figure 7-1

- When the cables are connected, confirm the power switch of peripheral device is in the OFF position.

① AC adaptor

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

② CameraLink interface cable (Option)

This is the cable to connect the camera and the CameraLink interface board on the computer.

Note

- Hamamatsu recommends A10514-05 optional CameraLink interface cable for this camera. The camera complies with EMC direction with using A10514-05 CameraLink interface cable. Be careful that the camera with other interface cable may not fulfill the EMC directive requirements.

7-2 WHEN THE CAMERA HEAD IS FIXED

The camera head is fixed by using the fitting screw at the bottom of the camera head.
Fix the camera head with a tool such as a laboratory jack so that a load may not be imposed to the part of C-mount when the camera is fixed by C-mount.

Note

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

8. OPERATION

8-1 PRECAUTIONS

Be careful of the following when you operate the camera.

(1) Cooling method

Cooling of this equipment is done using a Peltier element. With a Peltier element, when current is supplied, one surface is cooled, and the other surface is heated. The FL-280 is positioned on the cooling side, and cooling is done by discharging the heat from the heated surface. This cooling method is passive air-cooling.

(2) Ambient temperature

The recommended ambient temperature for camera operation is 20 °C. Thus, the maximum temperatures to which the FL-280 can be cooled, and the stability of the cooled temperature, are affected by the ambient temperature. The ambient temperature should be maintained at a constant temperature in order for cooling to be effective.

(3) Protection circuit

A double protection circuit protects this camera's thermoelectric cooling device. If the heat dissipater becomes abnormally hot, the protection circuit sets off a buzzer alarm from the camera while simultaneously cutting the current supply to the peltier element. When the protection circuit operates like this, immediately turn off the power switch. Then locate and remove the cause of the overheating and restart.

8-2 PREPARATION FOR IMAGING

Use the following procedure when starting operating of the camera.

(1) Connect devices as shown in Figure 7-1 before you start operation.
(2) Turn on the computer's power switch.
The cooling temperature becomes stable about 15 minutes after cooling begins.

- When the cables are connected, confirm the power switch of peripheral device is in the OFF position.

8-3 END OF IMAGING

Carry out the procedure below when imaging is finished.

(1) End the imaging or transmission of image data with the application software.
(2) Turn off the power to the peripheral device.

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. The entering light is converted into charge and converted into voltage in the pixel. The voltage of each pixel is output by switching the switch one by one. (Figure 9-1)

FL-280 that the scientific 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, FL-280 realizes both low noise and high speed readout simultaneously, owing to 1 line parallel simultaneous readout using column A/D.

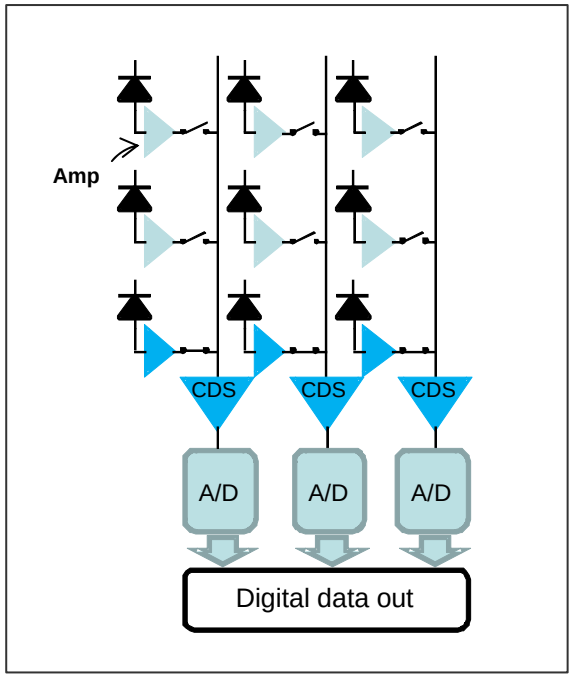


Figure 9-1 Structure of the FL-280

The exposure and the readout method of FL-280 adopt the rolling shutter.
In the rolling shutter, the exposure and readout are done line by line. Therefore, the exposure timing is different on one screen. (Figure 9-2) But even if the object moves during the exposure, the affect of rolling shutter shows very little afterglow or smear in many cases.

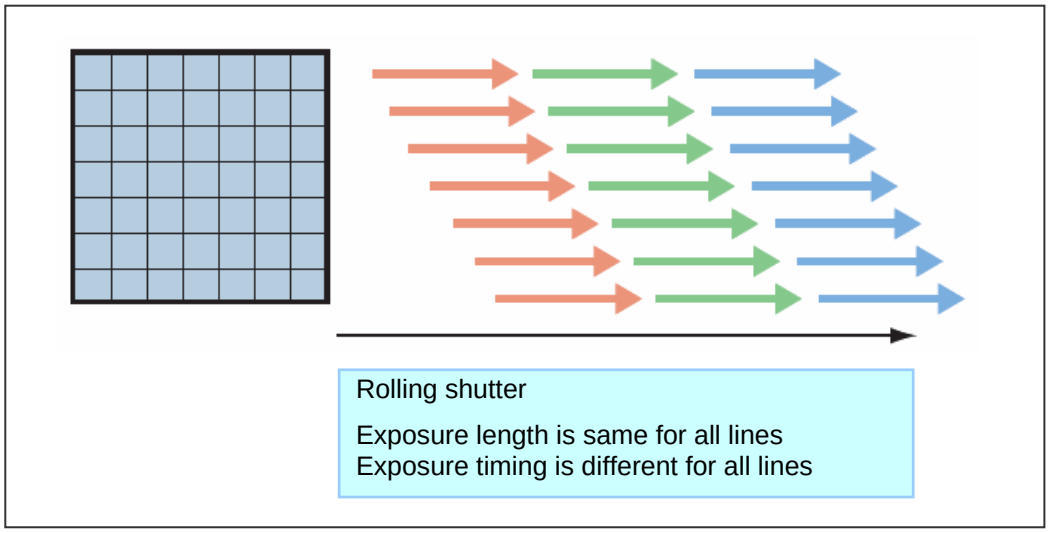


Figure 9-2 Readout timing of rolling shutter

9-2 READOUT METHOD (SCAN MODE)

(1) 1×1 Normal readout

Perform charge readout from camera individually for all pixels.
The frame rate of all pixel readout is 45 Hz.

(2) 2×2 binning readout

With this camera, 2x2 binning readout is available by adding the signal of adjacent pixels in the digital domain, and is a method of achieving high sensitivity as a tradeoff for resolution. The frame rate of all pixel readout is 45 Hz same as 1x1 normal readout. The digital output can be selected 14bit or 12bit when the 2x2 binning readout is selected.

(3) Sub-array readout

Sub-array readout is a function to select an vertical area from among an effective all pixel, and to read only the signal in the selection part from the FL-280. The readout time of one frame can be shortened by using this function, and the frame rate can be increased.

Typical examples of vertical area width and frame rate are shown in the following.

Vertical width	Frame rate
1080	60.0 Hz
768	83.0 Hz
600	104.7 Hz
480	128.6 Hz
240	236.8 Hz
80	540.0 Hz
8	1273.6 Hz

The Sub-array setting is specified by the vertical offset from 1st line and width, and the selectable range is as follows.

	Minimum	Maximum	Step
Vertical offset	8	1336	8
Vertical width	8	1336	8
Vertical offset + Vertical width	16	1344	

9-3 CONFIGURING EXPOSURE TIME

The exposure time setting can be done by absolute value. The actual exposure time setting is defined by the following formula, and the camera automatically calculate a larger and closest value from the specified exposure time setting.

$$Vn \times 14.81\ \mu s + 20.94\ \mu s$$

Vn: integer number (0 to 675)

Available setting range of the exposure time is 20.94 µs to 10 s.

9-4 FREE RUNNING MODE

The camera has the free running mode in which the exposure and readout timing can be set by software command and controlled by the internal microprocessor. The 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.

9-4-1 NORMAL READOUT MODE

The normal readout mode is suitable for observation, monitoring, field of view and focus adjustment, and animation because it can operate at 45 fps with full resolution, which is faster than the video rate. In addition, the exposure time can be extended to collect more signals and increase the signal-to-noise ratio if the object is dark. In the normal readout mode, the exposure time is the same or longer than the 1 frame readout time. In this mode, the frame rate depends on the exposure time, and it becomes frame rate = 1/exposure time. The maximum exposure time is 10 s.

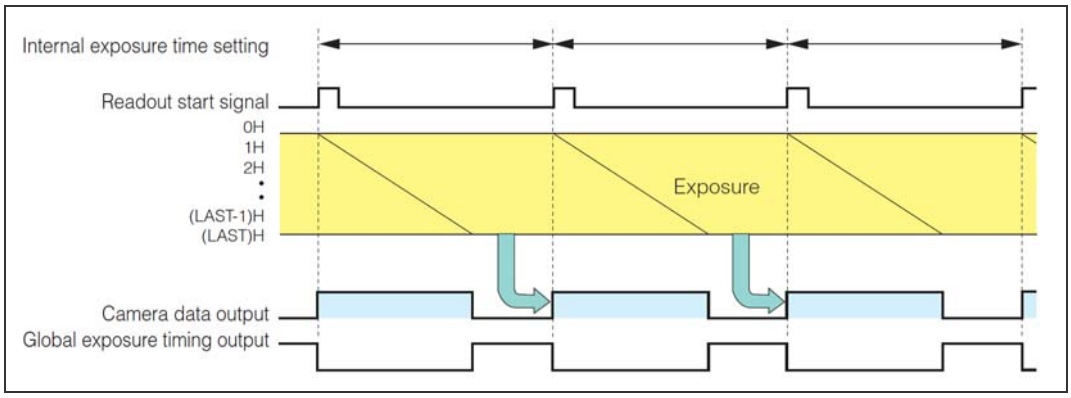


Figure 9-3

9-4-2 ELECTRICAL SHUTTER MODE

The 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. In this mode, the frame rate is 45 Hz at full resolution even when the exposure time is short.

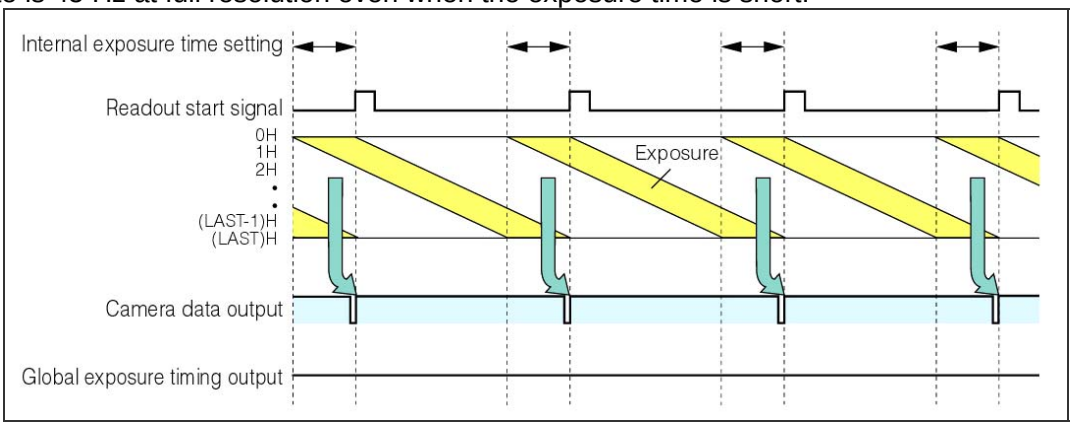


Figure 9-4

9-5 EXTERNAL CONTROL MODE

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

9-5-1 EDGE TRIGGER MODE

The edge trigger mode is used so that the exposure is synchronized with an external signal.

9-5-1-1 Normal edge trigger mode

The normal edge trigger mode is used so that the exposure starts according to an external signal. Exposure time is set by software commend. In this mode, the exposure of the first line begins on the edge (rising/falling) timing of the input trigger signal into the camera. (0H in Figure 9-5) The exposure of the second line is begun after the readout time of one line passes (1H in Figure 9-5), and the exposure is begun one by one for each line. The example timing chart below shows a rising edge trigger.

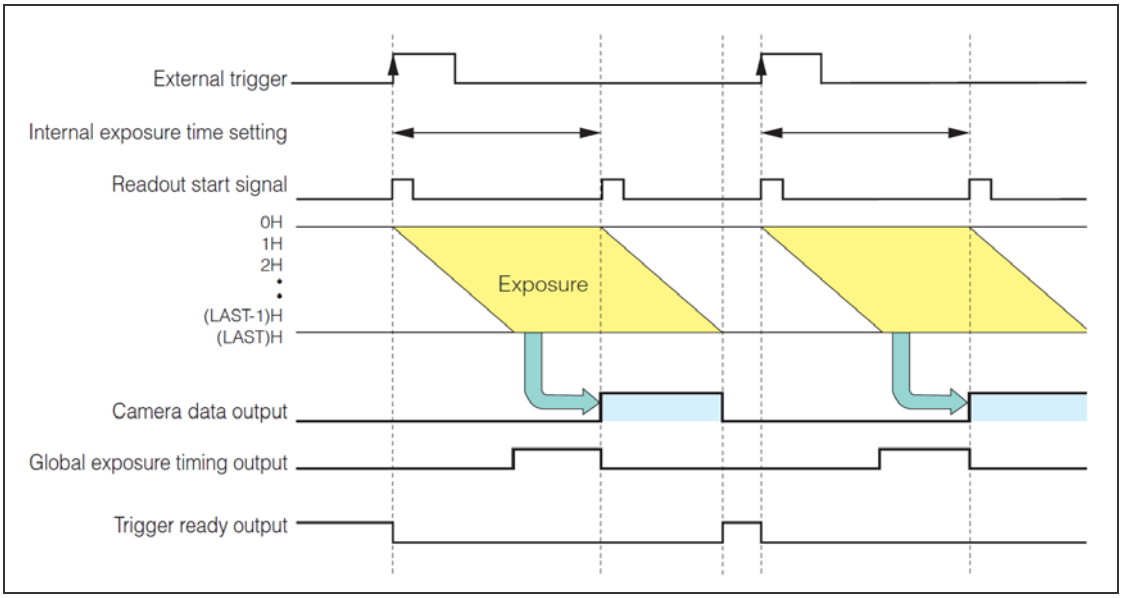


Figure 9-5

9-5-1-2 Global exposure edge trigger mode

The global exposure edge trigger mode is used when imaging with a pulsed light source such as pulsed laser or flash lamp. The exposure time can be set by software command. In this mode, the camera combines the frames right before and after the global exposure trigger signal (falling/rising edge) into one frame and output them as one frame of data. The exposure time of this second frame can be set by software command. Minimum value of exposure time setting is about 22 ms (1 frame readout time).

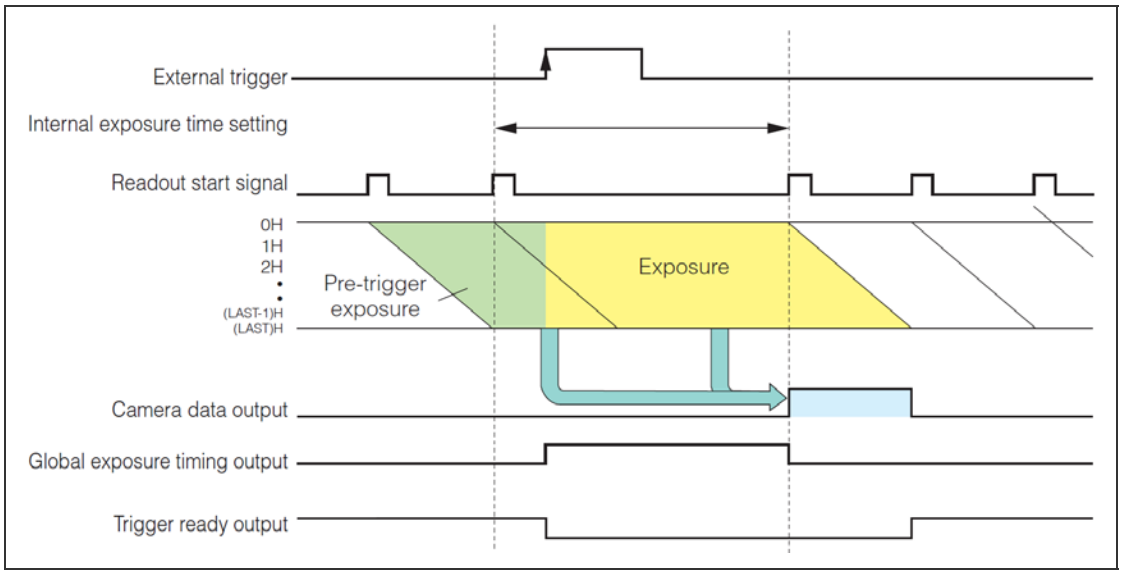


Figure 9-6

9-5-2 LEVEL TRIGGER MODE

The level trigger mode is used to control both exposure start timing and exposure time length by inputting external trigger pulses.

9-5-2-1 Normal level trigger mode

The normal 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 the exposure at the start of high or low period of the input trigger pulse and stops the exposure at the end of high or low period of the input trigger pulse. The example below is for the trigger level High. The exposure of the first line begins when the trigger signal becomes High, and the exposure of the second line begins after the readout time of line one passes. Each exposure begins one by one for each line. The exposure of the first line 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 input trigger is high.

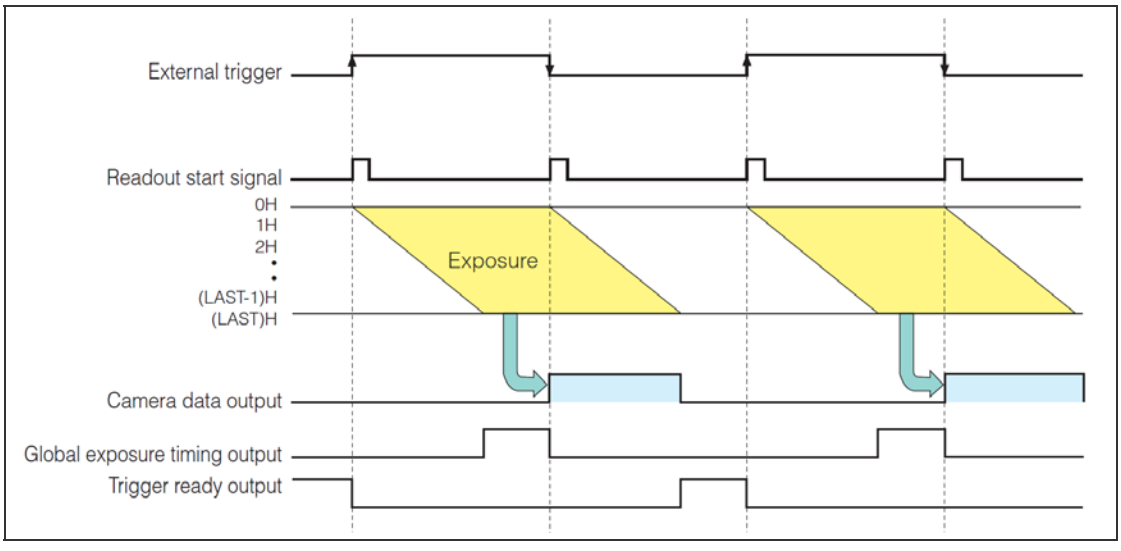


Figure 9-7

9-5-2-2 Global exposure level trigger mode

The global exposure level trigger mode is used to take a snapshot of a moving object with a pulsed light source or get a momentarily illuminated event. The exposure time can be set by software command. In this mode, the camera combines the frames right before and after the global exposure trigger signal (falling/rising edge) into one frame and output them as one frame of data. The exposure is finished when the trigger signal becomes inactive (falling/rising edge). Minimum value of exposure time setting is about 22 ms (1 frame readout time).

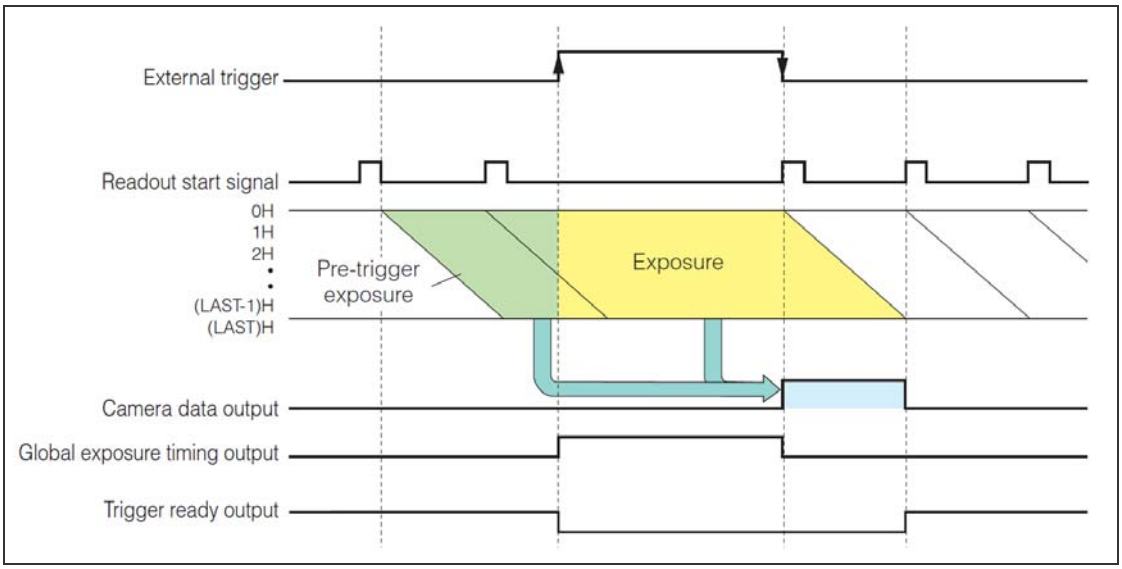


Figure 9-8

9-5-3 SYNCHRONOUS READOUT TRIGGER MODE

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

9-5-3-1 Normal synchronous readout trigger mode

The normal 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 an exposure time as possible. In the synchronous readout trigger mode, the camera ends each exposure, starts the readout and also, at the same time, starts the next exposure at the edge of the input trigger signal (rising /falling edge). That is, the interval between the same edges of the input trigger becomes the exposure time.

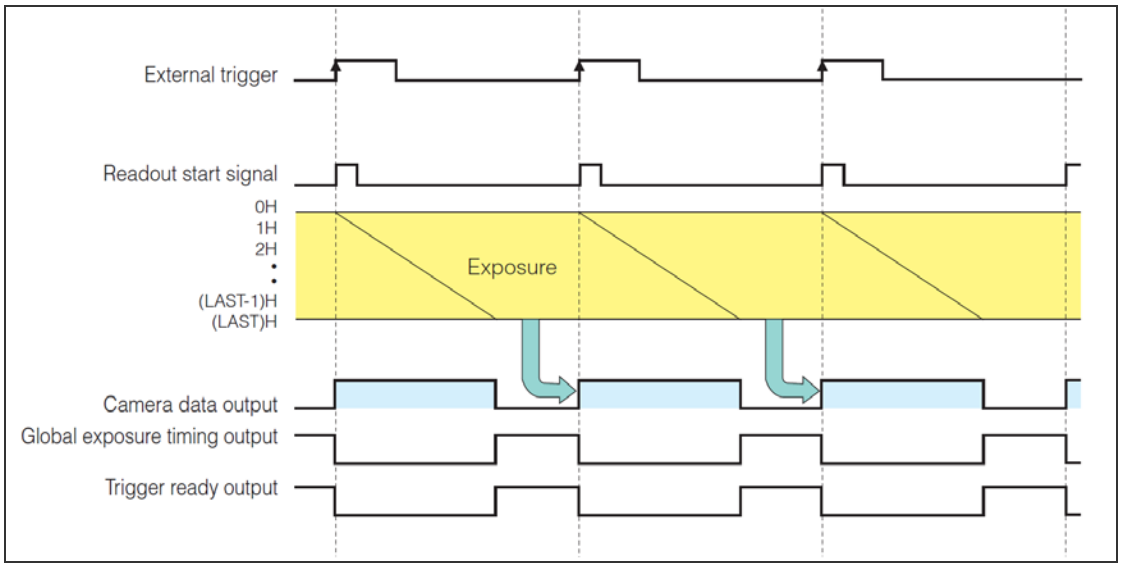


Figure 9-9 (rising edge)

9-5-3-2 Normal synchronous readout trigger mode (Pulse count)

Also in the normal synchronous readout trigger mode, synchronous readout can be controlled by specifying, set by command, the number of timing pulses to use to determine the exposure time. Figure 9-10 shows the exposure timing when the pulse count is set as 3.

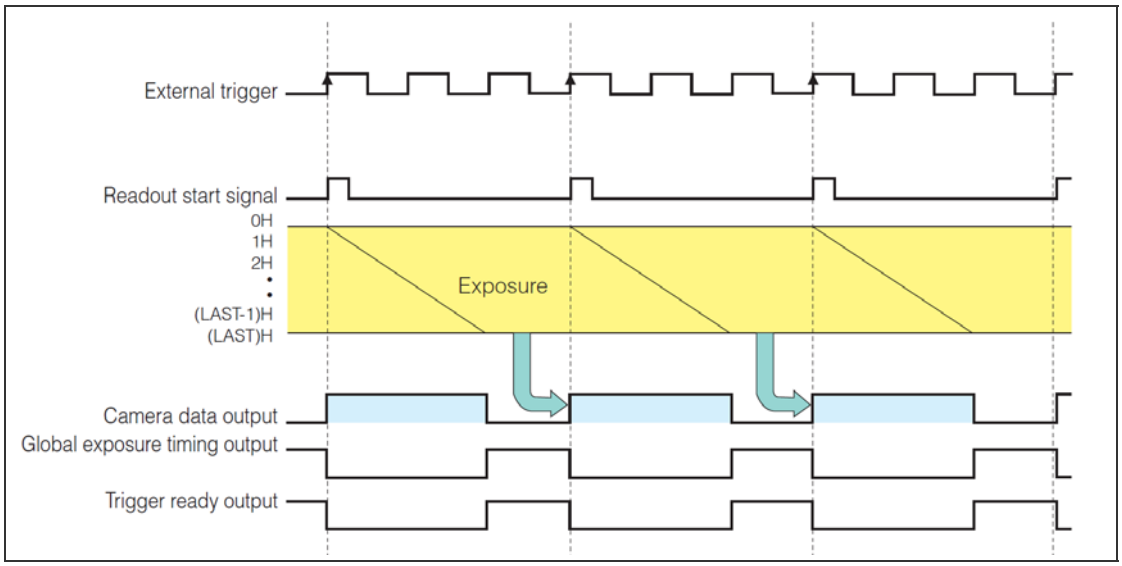


Figure 9-10 (Pulse count)

9-5-3-3 Current synchronous readout trigger mode

In the current synchronous readout trigger mode it is possible to control the exposure start timing by using ACT command from application software. First, the camera is set to be idle condition by ACT S command input. In idle condition, the camera does not start exposure even by a trigger signal in yet. Then, the camera start an exposure by ACT I command and then start to readout by input external trigger.
(In the normal synchronous readout trigger mode, the camera does not readout by the first trigger pulse after ACT I command.)

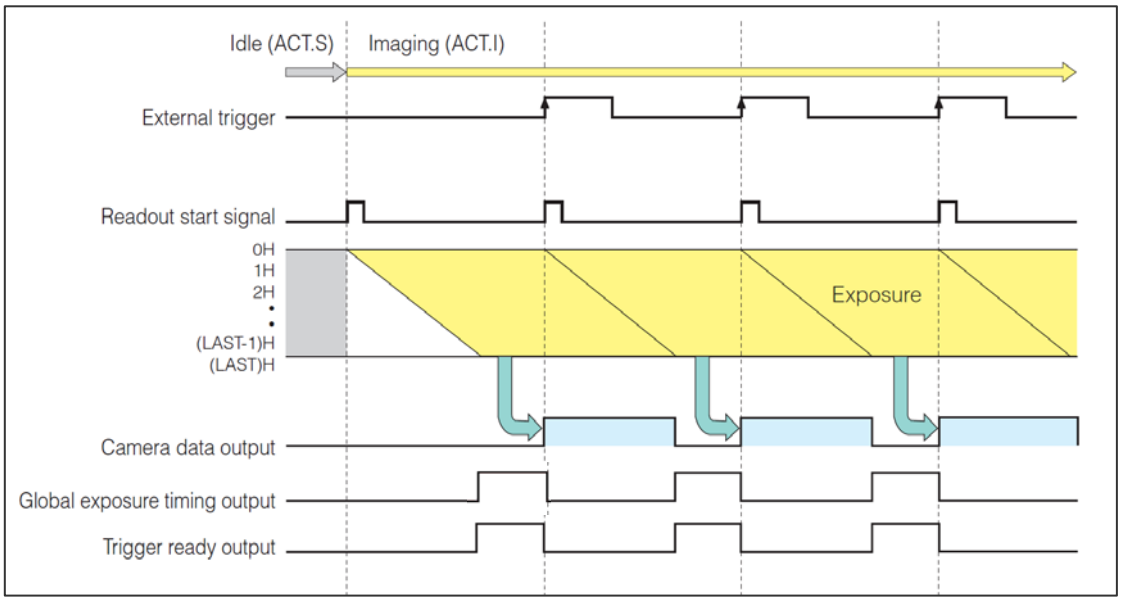


Figure 9-11

9-5-4 START TRIGGER MODE

The start trigger mode is used to start operating the camera by a trigger input for a continuous imaging. It is useful to secure the frame rate as fast as possible when continuous image acquisition and not to sacrifice the exposure time. Example, when it is necessary to measure the phenomenon after stimulation, it is possible to start continuous image acquisition at the stimulation timing.

9-5-4-1 Normal start trigger mode

The start trigger mode is used 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 the start trigger mode, the camera starts exposure and switches to internal trigger mode by the edge of an external trigger signal (rising / falling edge).

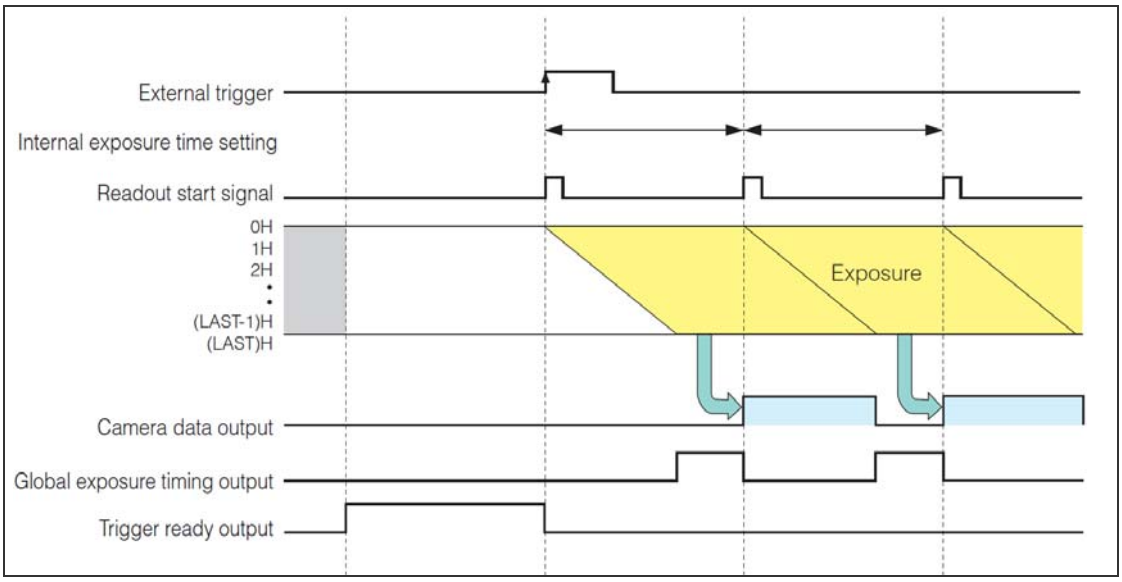


Figure 9-12 (rising edge)

9-5-4-2 Current start trigger mode

In the current start trigger mode it is possible to control the exposure start timing by using a command from application software and external trigger pulses. The fastest frame rate is possible because the camera works in the internal trigger mode. It is possible to control the exposure start timing from application software by using ACT commands. First, the camera is set to be idle condition by ACT S command input. In idle condition, the camera does not start exposure even by a trigger signal in yet. Then, the camera starts an exposure by ACT I command, and then the camera starts 2nd frame exposure by input external trigger and switches to internal trigger mode.
(In the normal start trigger mode, the camera does not readout by the first trigger pulse after ACT I command.)
Minimum value of exposure time setting is about 22 ms (1 frame readout time).

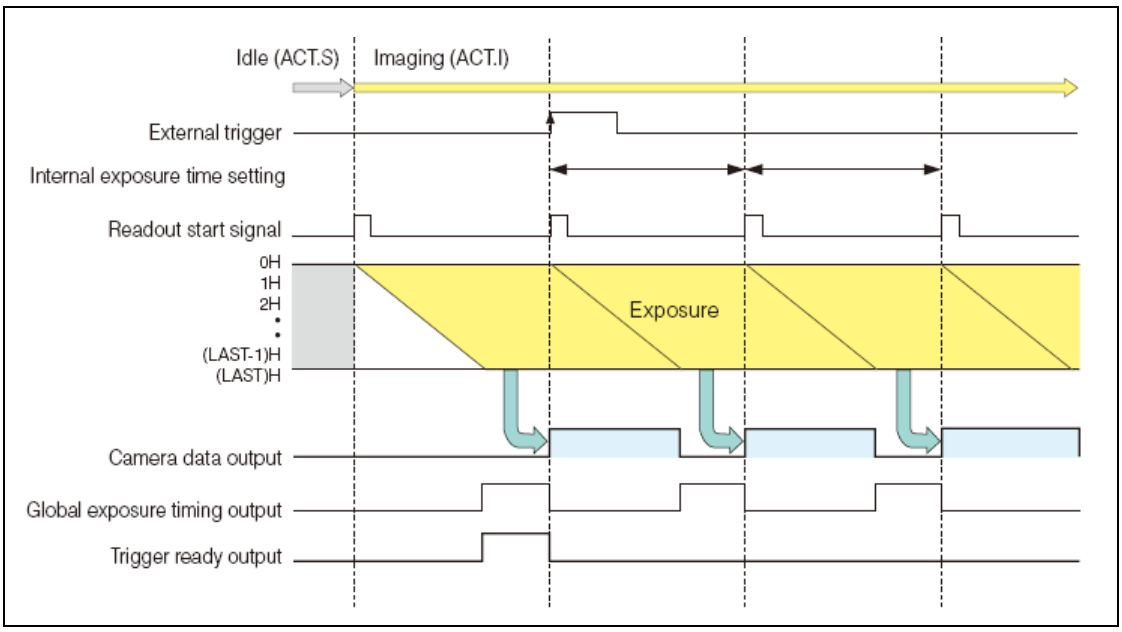


Figure 9-13

9-5-5 EXTERNAL TRIGGER DELAY FUNCTION

In most case when a delay between the laser pulse emission and the exposure start is needed, a delay unit is set between the laser and camera to control trigger timing. In each external trigger mode of the camera, the delay time can be set to the trigger signal input to the camera by commands. Therefore, a range of trigger can be arranged without a delay unit.

9-6 TRRIGER 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 the slave. There are three different trigger output functions as follows. Please refer to Figure 9-3 to Figure 9-13.

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

These three different trigger output functions can be selected by software command, and they are output from PIN5 of timing I/O connector (Refer to Figure 13-2)

9-6-1 GLOBAL EXPOSURE TIMING OUTPUT

It shows the global exposure timing where all lines expose at the same time. There is a case that one event is divided into two frames because the timing of the exposure in each line is different for the rolling shutter. However, by using the Global exposure timing output the global exposure becomes possible for the phenomenon that happens for this period. Global exposure timing output shows the period where all lines expose at the same time.

9-6-2 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, and the setting range for pulse width is 20 µs to 10 s.

9-6-3 TRIGGER READY OUTPUT

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

9-7 ANALOG GAIN FUNCTION

The camera features an on-chip gain control capability that can multiply the analog signal in sensor prior to converting it into a digital signal. This has the effect of reducing the quantization error in the A/D converter, and the readout noise can be lowered to 3 electrons (r.m.s) at analog gain 8x.
When low-light sample imaging in a short time is necessary and the output signal level is only a few to a few dozen ADU out of 12 bits (4096 ADU), the image quality can be improved by increasing the analog gain. It is necessary to note that the conversion coefficient* of the camera changes when the analog gain is increased.
The setting range for the relative value register is 0 to 255. Parameter 0 is correspond to 1x, 255 is correspond to 8x.

9-8 REAL-TIME CORRECTION FUNCTIONS

There is a chance that Shading caused by illumination and optics can't be negligible in the imaging with camera. The camera has the real-time offset level, shading and defective pixel correction features for a further image quality improvement. The correction can be effective in real-time without scarifying the readout speed at all.

10. PRECAUTION WHEN USING FL-280

This camera uses FL-280 (scientific CMOS image sensor). Careful attention must be paid to the following points when using FL-280:

(1) White spot

Subjecting FL-280 to extended exposures may cause failure in part of the silicon wafer, resulting in white spots. This phenomenon is not currently preventable. If FL-280 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 FL-280 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 FL-280 because FL-280 may be damaged by over light.

11. MAINTENANCE

11-1 CARE

Clean the exterior with a soft, dry cloth.

🚫	• Do not use a wet cloth, dirty cloth.

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
AC adaptor or other cable is loose	Reconnect the cable	7
AC adaptor or other cable is broken	Replace the cable	7
The correct command has not been sent to the camera	Recheck command	

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
FL-280 is dirty		

(3) Only shadowed 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	
Contrast enhancement is too high	Reduce gain	

(4) All screens overflow

Cause	Measures	Chapter
Too much amount of light	Reduce amount of light	
Contrast enhancement 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) Electric specifications

Imaging device	Scientific CMOS image sensor FL-280	
Effective number op pixels	1920 (H) × 1440 (V)	
Cell size	3.63 µm (H) × 3.63 µm (V)	
Effective area	6.97 mm (H) × 5.23 mm (V)	
Readout mode/speed	Full resolution	45.4 frames/s (1920 (H) × 1440 (V))
	Sub-array (typical examples)	60.0 frames/s (1920 (H) × 1080 (V))
		104.6 frames/s (1920 (H) × 600 (V))
		236.8 frames/s (1920 (H) × 240 (V))
		540.0 frames/s (1920 (H) × 80 (V))
		1273.6 frames/s (1920 (H) × 8 (V))
Binning *1	2×2	
Readout noise (typ.)	3 electrons r.m.s. (gain 8x)	
Full well capacity (typ.)	18 000 electrons	
Analog gain	1x to 8x (256 steps)	
Dynamic range *2	4500 : 1 (gain 1x)	
Cooling method	Peltier device + Passive air-cooled	
Cooling temperature	+ 5 ºC (Ambient temperature + 20 ºC)	
A/D converter	12 bit	
Exposure time	20 µs to 10 s (at internal trigger/external trigger)	
External trigger mode	・ Edge trigger ・ Level trigger ・ Global exposure timing output ・ Synchronous readout trigger ・ Start trigger	
Trigger delay function	0 µs to 10 s (10 µs steps)	
Trigger output	・ Programmable timing output ・ Global exposure timing output ・ Trigger ready output	
Lens mount	C-mount	
Interface	Camera Link Base configuration	
Connector	Mini-Camera Link	

* 1 Digital binning processing in the camera.
* 2 Calculated from the ratio of the full well capacity and the readout noise.

(2) Power supply specifications

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

Note

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

(3) Operating environment

Ambient operating temperature	0 ºC to + 40 ºC
Ambient storage temperature	-10 ºC to +50 ºC
Ambient operating humidity	70 %, no condensation
Ambient storage humidity	90 %, no condensation

(4) Dimensional outline and weight

Dimensional outline	95 mm (W) × 95 mm (H) × 150.3 mm (D)
Weight	Approx. 1.5 kg

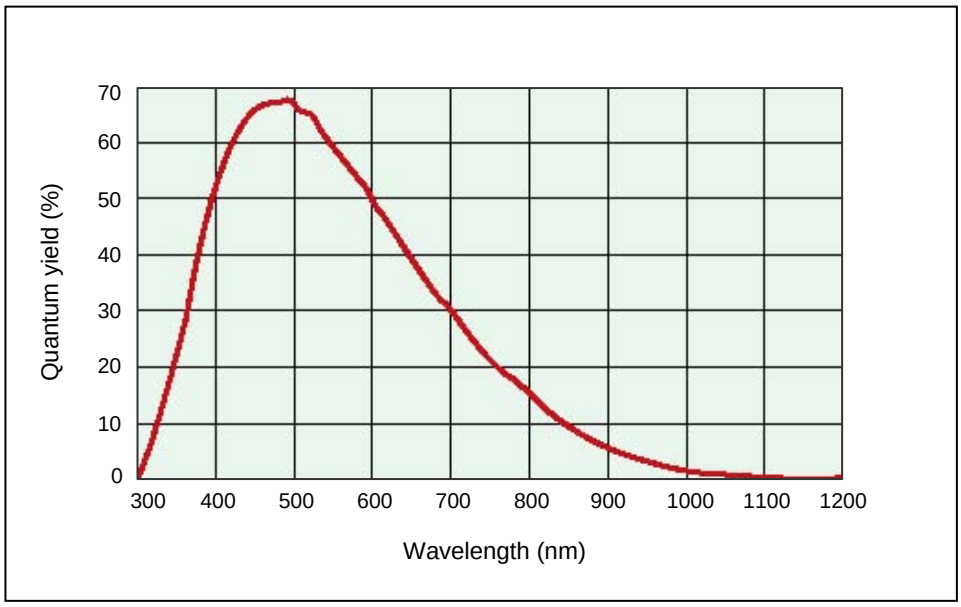
Note

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

(5) Applicable standards

EMC	EN61326-1: 2006 Class A

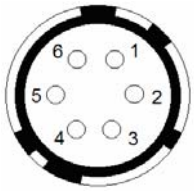
(6) Spectral response characteristics



13-2 INTERFACE SPECIFICATIONS

13-2-1 TIMING I/O CONNECTOR PIN ASSIGNMENTS [TIMING I/O]

The camera uses Hirose model HR10A-7R-6S connector for input and output signals.

No.	Signal	Pin connections
1	Ext. Trigger In	 HR10A-7R-6S
2	GND	
3	NC	
4	GND	
5	Global Exposure Timing Out / Programmable Timing Out / Trigger Ready Out	
6	GND	

Note

- Please see 9-6 [Trigger output] for detail of 5 pin.

13-2-2 CAMERALINK INTERFACE

Camera Link interface is a standard of digital interface for industrial digital cameras. It transfers 28bit digital data (TX0 to TX27) by converting parallel data to only 5 signals (X0, X1, X2, X3, XCLK) of serial data. This camera is compatible to CameraLink interface / Base configuration 12 bit 2TAP digital camera standards at 1x1 normal readout mode, and 14 bit digital camera standards at 2x2 binning readout mode.

(1) CameraLink connector pin assignments (SDR-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+
8	19	SerTFG-
9	18	CC1-
10	17	CC2+
11	16	CC3-
12	15	CC4+
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-
21	6	SerTFG+
22	5	CC1+
23	4	CC2-
24	3	CC3+
25	2	CC4-
26	26	Inner Shield

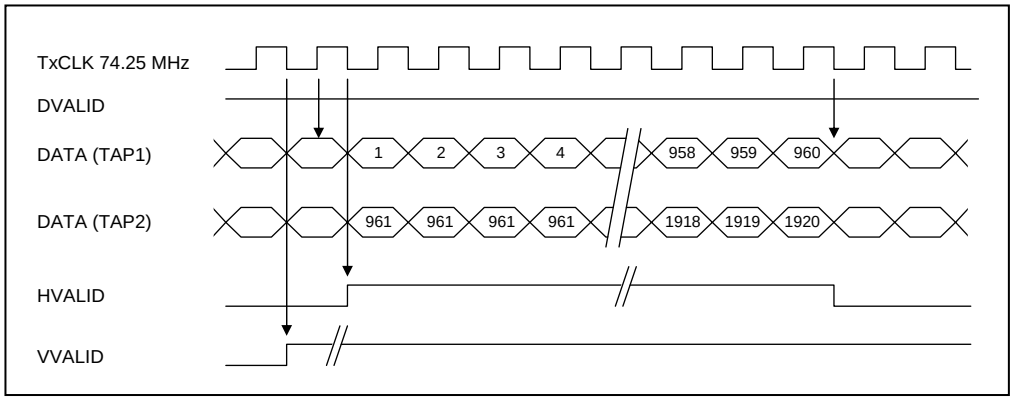
(2) CameraLink bit assignments

28 bit solution pin name	Input signal name (12 bit)	Input Signal Name (16 bit)
TX0	DB0 TAP1	DB0
TX1	DB1 TAP1	DB1
TX2	DB2 TAP1	DB2
TX3	DB3 TAP1	DB3
TX4	DB4 TAP1	DB4
TX5	DB7 TAP1	DB7
TX6	DB5 TAP1	DB5
TX7	DB8 TAP1	DB8
TX8	DB9 TAP1	DB9
TX9	DB10 TAP1	DB10
TX10	DB10 TAP2	NC
TX11	DB11 TAP2	NC
TX12	DB11 TAP1	DB11
TX13	DB8 TAP2	DB12 (NC when 12bit output is selected)
TX14	DB9 TAP2	DB13 (NC when 12bit output is selected)
TX15	DB0 TAP2	NC
TX16	DB6 TAP2	NC
TX17	DB7 TAP2	NC
TX18	DB1 TAP2	NC
TX19	DB2 TAP2	NC
TX20	DB3 TAP2	NC
TX21	DB4 TAP2	NC
TX22	DB5 TAP2	NC
TX23	Spare	Spare
TX24	LVAL	LVAL
TX25	FVAL	FVAL
TX26	DVAL	DVAL
TX27	DB6 TAP1	DB6

- **DVAL** (Data Valid signal)
  This signal synchronizes in the image data from FL-280, and it is outputted.
  Each digital data is effective with the period of “ON” of this signal.
- **LVAL** (Line Valid signal)
  This signal show the period during which the line part of the image data from FL-280 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 FL-280 is in effect. This is “ON” during the period the frame is active.
- **DB0 to DB13** (Digital image data)
  This is the image signal data from FL-280 converted A/D. DB0 is the LSB（least significant bit）,
  DB13 is the MSB (most significant bit).

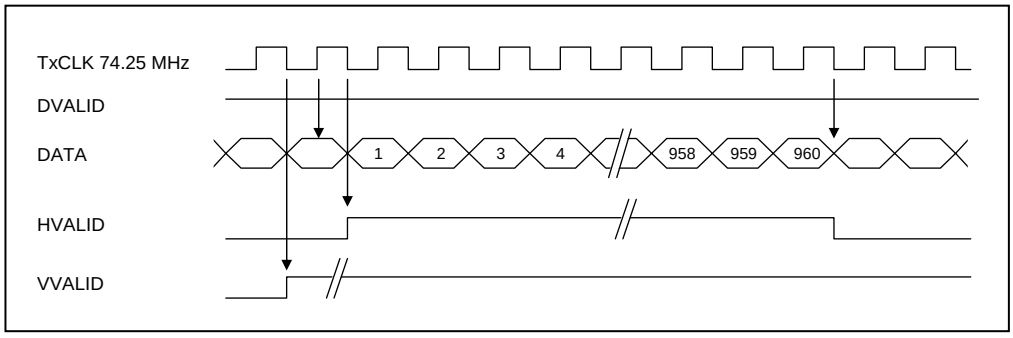
13-2-3 OUTPUT TIMING SPECIFICATIONS

① Pixel Timing at 1x1 (12 bit 2TAP output)



1) DVALID output is high all the time
2) HVALID changes synchronizing with falling edge of TxCLK
3) VVALID changes synchronizing with falling edge of TxCLK
4) DATA will be valid with rising edge of TxCLK

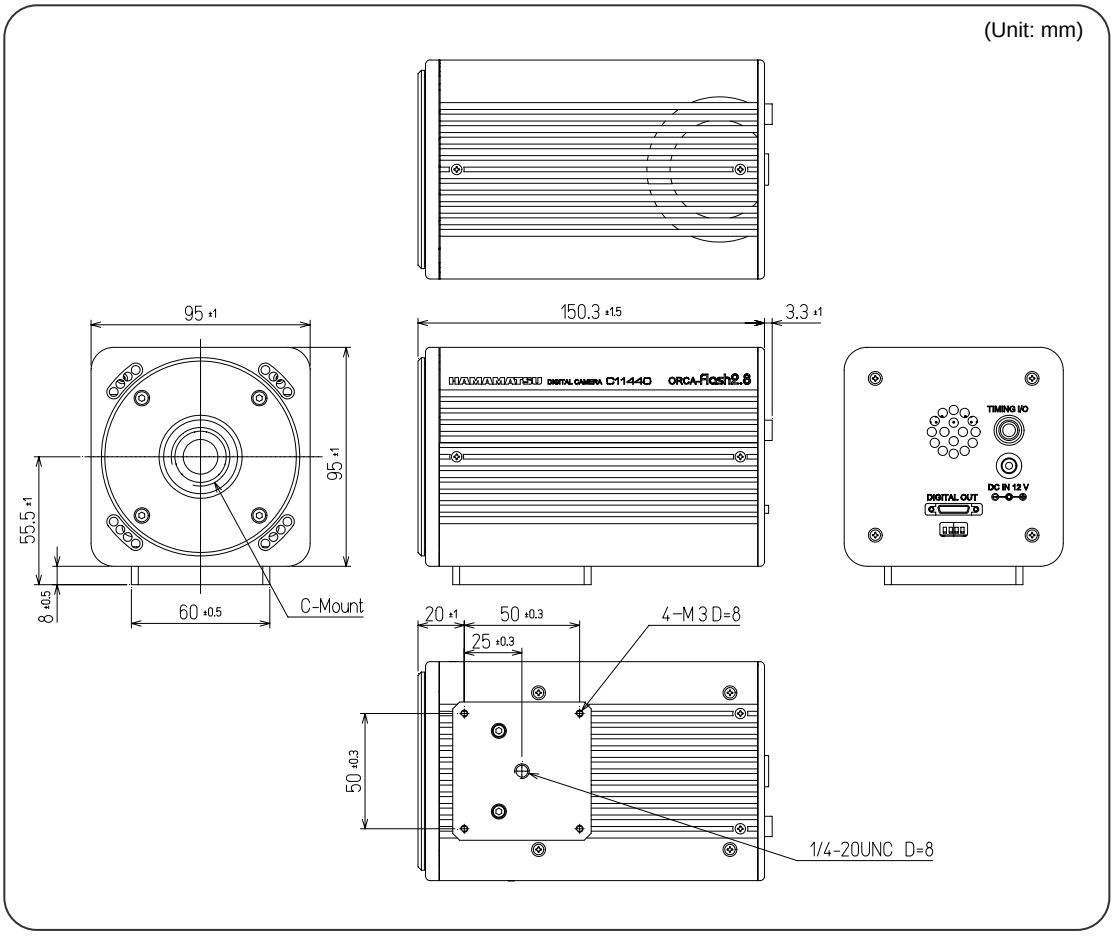
② Pixel Timing at 2x2 (14 bit output)



1) DVALID is valid at High
2) HVALID changes synchronizing with falling edge of TxCLK
3) VVALID changes synchronizing with falling edge of TxCLK
4) DATA will be valid with rising edge of TxCLK when DVALID is H.

14. DIMENSIONAL OUTLINES

(Unit: mm)



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 atomic rays, the radiation (X-rays, gamma rays, UV light, etc.) of FL-280 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

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