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Digital CCD Camera
C4742-95-12ER
Instruction Manual

Ver. 1.2

Oct. 2000

HAMAMATSU

55110-467

7010112

1 Precautions

Please read and observe the following precautions in order to use your equipment safely.

◎ If the equipment is damaged in any way when unpacked, please contact HAMAMATSU immediately, without operating the unit first.

◎ Connect the power supply plug of this unit to a 3-pin power outlet that has a protective grounding contact. If such an outlet is not available, always use the accessory grounding line to ground the unit.

2 Using Your Equipment Safely

Safety Precautions

Power Supply

- Use only the voltage noted on the rating seal.
- Do not set heavy objects on the power cable, bend it sharply, or scratch or damage the cable in any way. It can be extremely dangerous to use a damaged power cable.
- When unplugging the power cable, grasp it by the plug. Never tug on the cable to unplug it.
- If the equipment is not to be used for a long period of time, unplug the power cable from the outlet.

Don't Disassemble the Equipment

Internal components of this equipment become extremely hot and touching them can be dangerous. Disassembling the equipment can lead to breakdowns and accidents. Never touch any parts of the equipment other than those described in this instruction manual.

Don't Insert Objects Into the Equipment

Never insert any burnable materials, metallic objects, water, or other foreign substances into the equipment, as this can cause breakdowns and accidents.

If a Problem Occurs

If the unit suddenly stops producing images, if you notice any unusual noise or odor, or if there is smoke coming from the unit, immediately unplug the power cable from the outlet and contact HAMAMATSU or a sales agent of HAMAMATSU.

3 Handling Precautions

Don't Use or Store the Unit in These Locations:

- Where the ambient temperature may fall below 0°C or rise above 40°C
- Where the temperature fluctuates sharply
- In direct sunlight, or near a source of heat
- Where the humidity exceeds 70%, or where it is exposed to water
- Near sources generating strong magnetic or electrical fields
- Where there is vibration
- Where it comes in contact with corrosive gases (chlorine, fluorine, etc.)
- Dusty locations

Don't Block Ventilation Openings

To prevent the internal temperature from rising excessively, don't wrap cloth around the equipment while it is operating, and make sure the fan on the back panel of the CCD and the slits on the sides are not blocked.

Avoid Strong Impact

Dropping the equipment, or subjecting it to strong impact, can cause it to break down.

Plugging In and Detaching Cables

Always turn off the power supply before plugging in or unplugging cables.

Securing the Camera Head

If the camera head is being attached to a tripod, use the screw (1/4-20UNC) in the center of the camera attachment stand, or the screws (M3) in the periphery to attach it. When doing this, be careful not to screw the attachment screws into the camera attachment stand by more than 8 mm. Screwing the screws too far in can cause malfunctioning.

Lens

If the lens in the camera head C mount is screwed in more than 6.5 mm, it may scratch the protective glass. (Some wide-angle lenses have a screw length of 6.5 mm or more, so be particularly careful with these.)

Precautions Concerning Transport

If the camera is being shipped as cargo by truck, ship, airplane, etc., use the original packing material or equivalent material, and pack the camera very securely.

4 Configuration

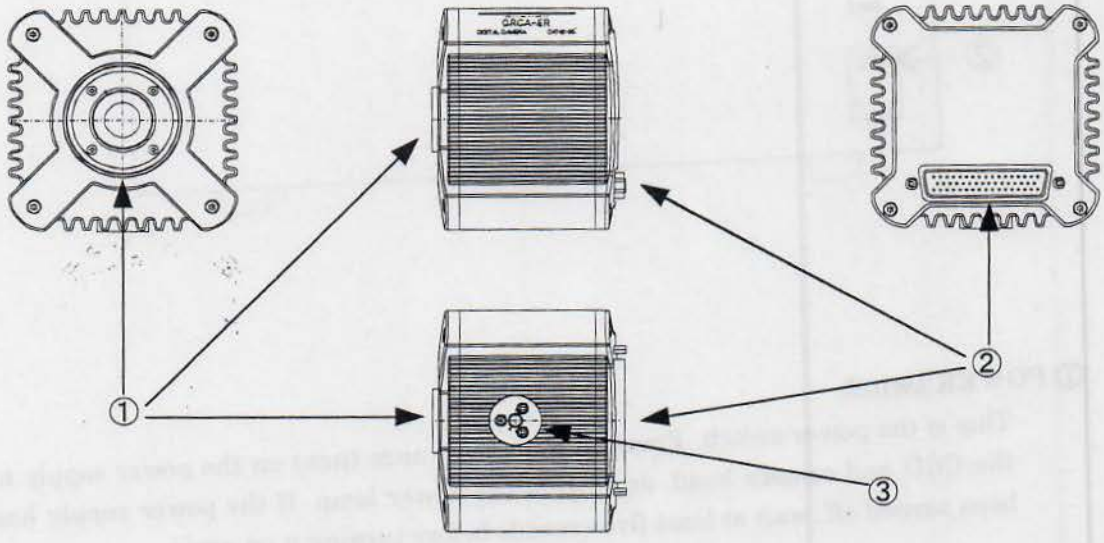
The C4742-95 is configured as follows:

(1) C4742-95 camera head (1)
(2) C4742-95 camera control unit (1)
(3) Instruction manual (1)
(4) Cables
  4-1. Camera cable (5 m) (1)
  4-2. Power cable (1)

(5) Accessories
  5-1. Spare fuse (1)

5 Names and Functions of Parts

5 - 1 Camera Head



① Lens mount

A C-mount lens or an optics system with a C-mount can be attached. Thus, by using an F/C mount, K/C mount, or P/C mount adaptor, various lenses can be attached.

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

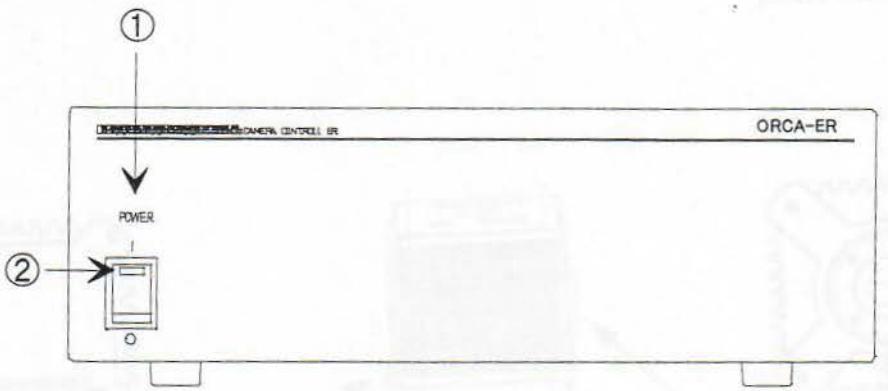
② Camera connector

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

③ Camera attachment stand

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

5 - 2 Camera control unit (Front panel)



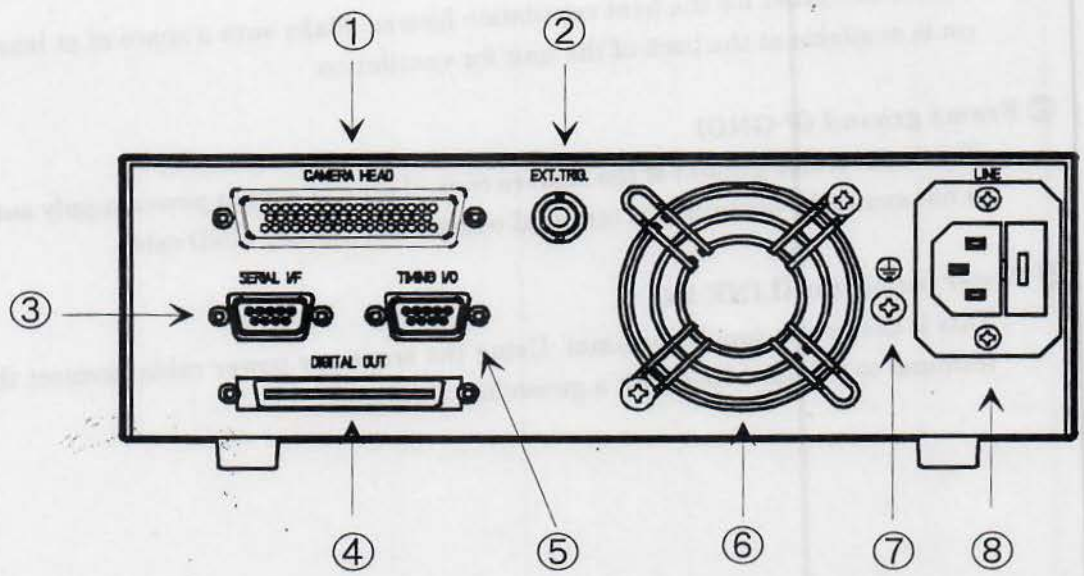
① POWER switch

This is the power switch. Pressing the switch once turns on the power supply to the CCD and camera head, and lights the power lamp. If the power supply has been turned off, wait at least five seconds before turning it on again.

② POWER LED

This green LED lights to indicate that the power is on.

5 - 3 Camera control unit (back panel)



① Camera connector (CAMERA HEAD)

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

② Trigger In connector (TRIGGER IN)

This is used when the C4742-95 is being operated using external synchronization. Input is TTL level (EXT. TRIG circuit is terminated by 680Ω resister.) . When an external trigger is input, the trigger is activated at the falling or rising edge of the signal. (You can choose external trigger polarity between Negative and Positive.) For signal names, signal timings, and pin layouts, please refer to pages 11-3-(3).

③ Serial interface connector (SERIAL I/F)

This is used to transmit various commands sent from the host computer to operate the C4742-95. For signal names, signal timings, and pin layouts, please refer to pages 11-3-(3).

④ Digital output connector (DIGITAL OUT)

This is used to connect the camera control unit and the frame grabber. For signal names, signal timings, and pin layouts, please refer to pages 11-3-(3).

⑤ Options

⑥ Air outlet

This is the outlet for the heat ventilation blower. Make sure a space of at least 10 cm is available at the back of the unit for ventilation.

⑦ Frame ground (F-GND)

This is the frame ground of the camera control unit. If a 3-pin power supply outlet is not available, connect this terminal using the accessory GND cable.

⑧ Power connector (LINE IN)

This is the power supply terminal. Using the accessory power cable, connect this terminal to a 3-pin outlet with a grounding terminal.

6 Cable Connections

Connect the various cables as shown in Fig. 6-1.

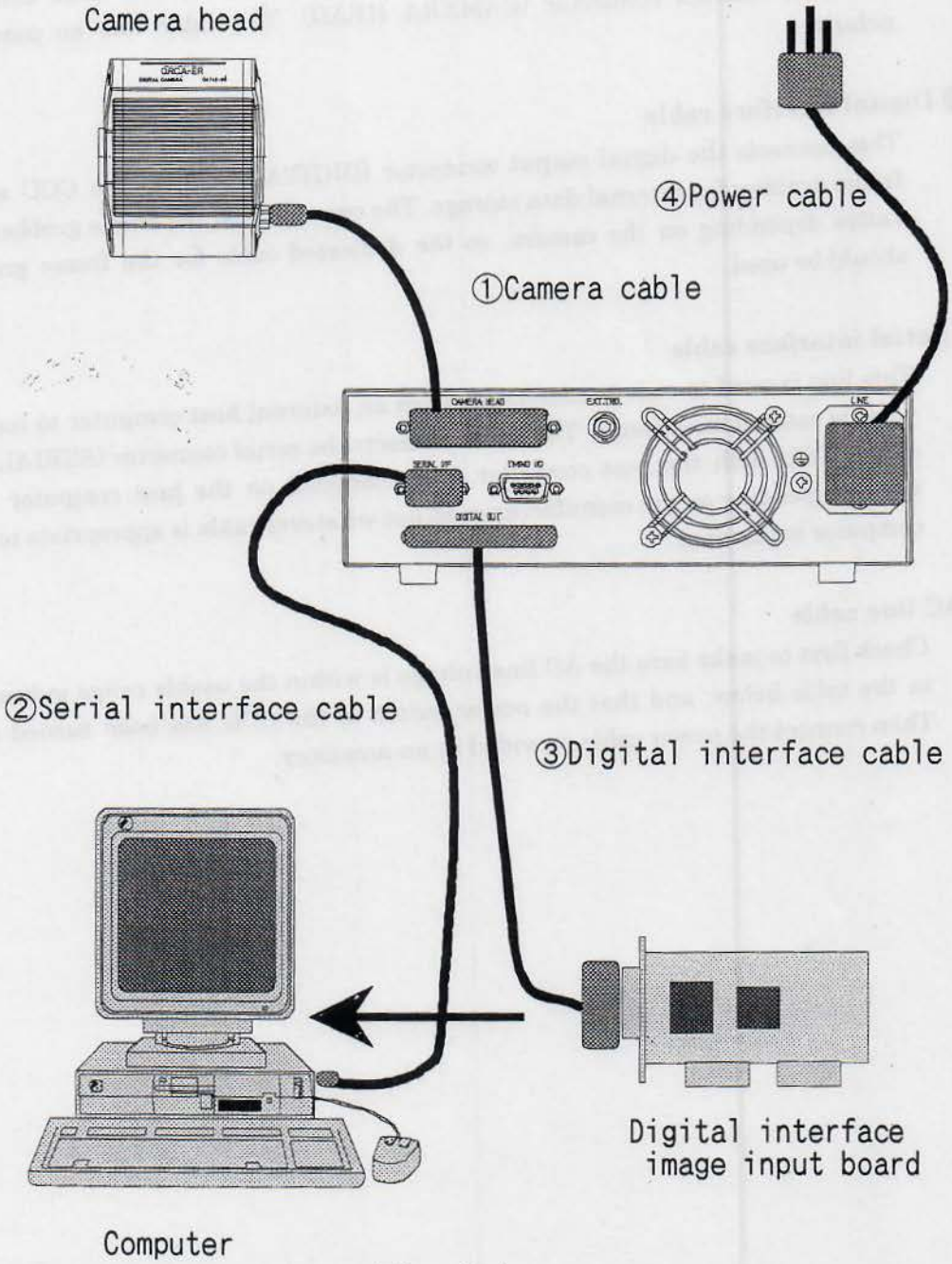


Fig. 6-1

① Camera cable

This connects the camera control unit (CCU) to the camera head using the dedicated camera connector (CAMERA HEAD). The cable has no particular polarity.

② Digital interface cable

This connects the digital output connector (DIGITAL OUT) of the CCU with a frame grabber for external data storage. The connector on the frame grabber side varies depending on the camera, so the dedicated cable for the frame grabber should be used.

③ Serial interface cable

This line is used to convey commands from an external host computer to control various camera movements. The cable connects the serial connector (SERIAL I/F) of the CCU with the host computer. The connector on the host computer side varies depending on the manufacturer, so use whatever cable is appropriate to the computer being used.

④ AC line cable

Check first to make sure the AC line voltage is within the usable range indicated in the table below, and that the power switch of the CCU has been turned off. Then connect the power cable provided as an accessory.

7 Operation

7 - 1 Precautions

Make sure the power supply switch has been turned off before making the connections shown below.

(1) Ambient temperature

Cooling of this equipment is done using a Peltier element. With a Peltier element, when current is supplied, one surface is cooled, and the other surface is heated. The CCD chip is positioned on the cooling side, and cooling is done by discharging the heat from the heated surface. Thus, the maximum temperature to which the CCD can be cooled, and the stability of the cooled temperature, are affected by the ambient temperature. The ambient temperature should be maintained at a constant temperature in order for cooling to be effective.

The recommended ambient temperature for camera operation is 20 °C. At this temperature, the CCD will be cooled to approximately –20°C.

(2) Control software

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

7 - 2 Preparing for measurement

The initial procedures should be carried out in the sequence listed below.

(1) Turn on the power supply switch on the C4742-95.

(2) The cooling temperature stabilizes about 10 minutes after cooling has begun, and the equipment is ready for operation.

7 - 3 Concluding measurement

Follow the procedure outlined below to terminate measurement.

Turn off the power supplies to the cooled CCD camera and peripheral equipment.

8 Image acquisition

8 - 1 Theory of CCD

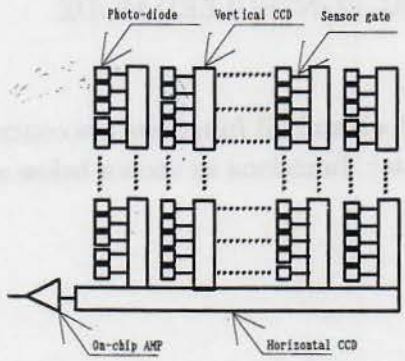
C4742-95 CCD camera uses the new progressive scan inter-line CCD whose structure is shown as below. Incident photon generates an electron on the photo-diode and generated electrons are transferred from photo-diode to on-chip amplifier ,which converts the electron to voltage, by using the vertical CCD and horizontal CCD. By supplying the readout signal to the sensor gate, all generated charges are transferred to vertical CCD and, next, stored charges are transferred line by line in the vertical CCD and finally charges are shifted pixel by pixel in the horizontal CCD. Finally all charges reach to the on-chip amplifier.

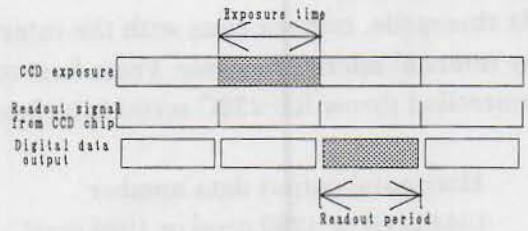
This CCD has also a function of electrical shutter. By using this function, all charges integrated in the photo-diode are dumped to the silicon base instantaneously.

Furthermore, C4742-95 has a binning function for getting better signal to noise ratio and high sensitivity in exchange for resolution. Because at the binning mode, charges of adjacent pixels (2 by 2 matrix or 4 by 4 matrix or 8 by 8 matrix and be called "Super Pixel") are added in the CCD chip to achieving high sensitivity. With 2 by 2 binning, charges of four pixels are added in the CCD chip. Thus the signal increases fourfold, although total pixel number decreases to quarter and frame readout speed becomes double. With 4 by 4 binning, charges of sixteen pixels are added in the CCD chip. Thus the signal increases sixteen times, although total pixel number decreases to 1/16 and frame readout speed becomes four times. With 8 by 8 binning , charges of 64 pixels are added in the CCD chip. Thus the signal increases 64 times, although total pixel number decreases to 1/64 and frame readout speed becomes eight times. At the normal inter-line transfer CCD, exposure time is defined as the period between readout signal and next readout signal shown below. And this exposure time is equals to the readout time of all charges in the CCD chip.

A sub-array scan is a method of picking out from the charges accumulated on the CCD the necessary data of a line area as efficiently and in as short a time as possible. With this method, only the line area deemed necessary is read out at the normal speed, and all remaining line areas are read out at high speed, thus boosting the frame rate considerably. In this process, horizontal transmission is not carried out at all; instead, only vertical transmission is carried out at high speed, until the bottom of the specified line area has arrived in the bottom section of the CCD image area, and electrical charges are discarded during this time. Next, after the bottom of the specified area has been sent to the horizontal transmission register, all pixels in the

line other than those specified will simply be transferred without being read, and only the necessary data will be read out as effective data. Consequently, when one screen is read, using this mode shortens readout time considerably in comparison with full-frame reading, enabling image input to be speeded up. This is effective in reducing measurement time and is also extremely useful in compressing data and other functions.





8 - 2 Image acquisition

The C4742-95 CCD camera can be controlled externally, through RS-232C serial interface, from host computer. So, all function ,e.g. camera' gain and offset, exposure time, etc., should be set from host computer by using commands. If camera does not recognize any commands, it works by initial setting mode.

8-2-1.Explanation of MODE

This camera's MODE are divided broadly into two categories. One is FREE RUNNING MODE and the other is EXTERNAL CONTROLLED MODE.

(1) Free running mode

At this mode, camera runs with the internal clock and all functions are controlled by internal micro-processor. From host computer, functions as shown below are controlled throw RS-232C serial interface.

- Horizontal output data number
  1344 pixel or 1280 pixel or 1024 pixel
- Scan mode
  Normal readout or Super pixel readout or Sub-array readout
- Exposure time setting
  Normal Setting, Electrical Shutter or Frame Blanking
- Contrast enhancement
  Gain and Offset of Signal are set from 0 to 255 at the 256 steps.
- Bit number of digital output
  8 bit, 10 bit, 12 bit

(2) External controlled mode

At this mode, camera runs by the external trigger pulse. Integration period and start timing of data readout from camera are controlled by this pulse. Even at this external controlled mode, function as shown below are controlled throw RS-232C serial interface.

- Horizontal output data number
  1344 pixel or 1280 pixel or 1024 pixel
- Scanning mode
  Normal readout or Super pixel readout or Sub-array readout
- Exposure time setting
  Internal Setting or External Setting
- Contrast enhancement
  Gain and Offset of Signal are set from 0 to 255 at the 256 steps.
- Bit number of digital output
  8 bit, 10 bit, 12 bit
- External trigger polarity
  N (Negative) Low active and P (positive) High active

8 - 3 Detailed information of camera mode

8-3-1. Set up of Digital data output number

According to the specification of frame grabber board, total pixel number should be set to the correct number. It is possible to select the horizontal pixel number between 1024 and 1280 and 1344 pixels. And it is possible to add the 8 dummy pixels in front of horizontal data output.

Dummy	H	V	Command
0	1344	1024	SHA M, SFD F
0	1280	1024	SHA F, SFD F
0	1024	1024	SHA K, SFD F
8	1344	1024	SHA M, SFD O
8	1280	1024	SHA F, SFD O
8	1024	1024	SHA K, SFD O

8-3-2. Set up of digital output bit number

It is possible to select the bit number of digital output from 8/10/12.

Camera outputs 12 bit digital data through DB0~DB11. : ADS 12

Camera outputs high rank 10 bit digital data from 12 bit digital data through DB0~DB9. : ADS 10

Camera outputs high rank 8 bit digital data from 12 bit digital data through DB0~DB7. : ADS 8

8-3-3. Super pixel readout mode・Matrix number of binning

C4742-95 has 2x2 binning and 4x4 binning and 8x8 binning function.

Frame readout speed is as follows.

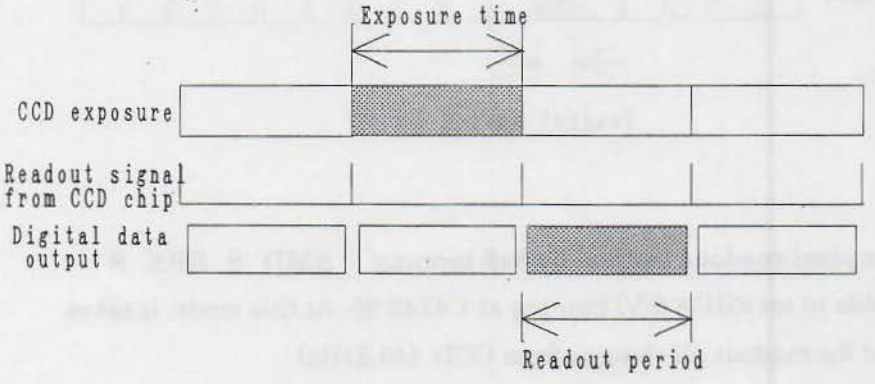
2x2 binning	1/16.45sec	SMD S ・ SPX 2
4x4 binning	1/29.05sec	SMD S ・ SPX 4
8x8 binning	1/45.31sec	SMD S ・ SPX 8

8-3-4. Selection of readout from CCD

There are three methods of reading out data from the CCD chip. The SMD command changes the readout method of electrical charges in the CCD chip. One mode is the standard readout method in conformity with technical theory, another is called Super pixel readout and the third is called Sub-Array readout.

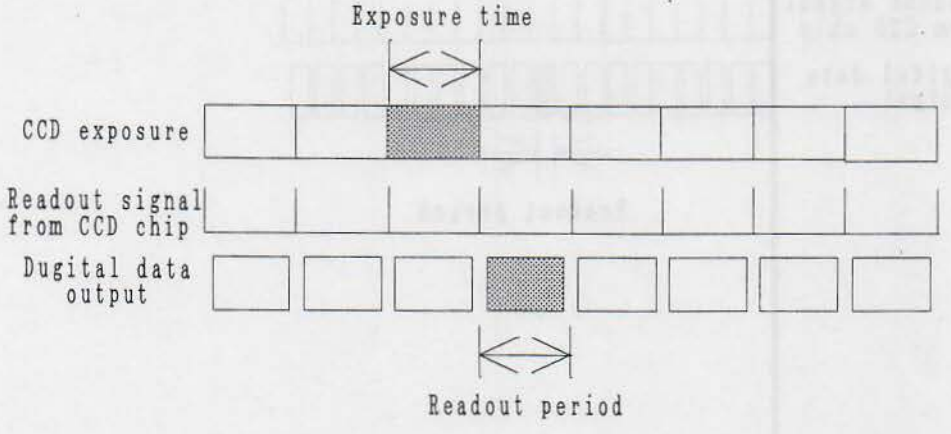
8-3-4-1. Normal readout method from CCD : SMD N

At this mode, it takes 119.7msec for readout all charges from CCD. (8.3542Hz)



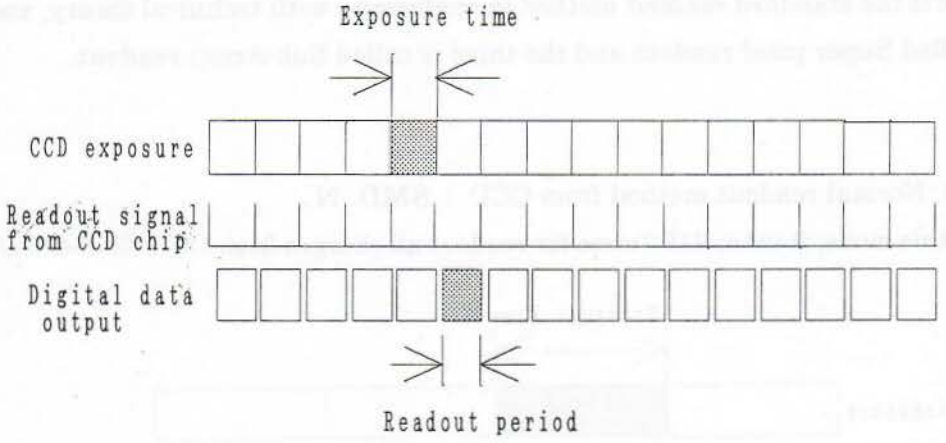
8-3-4-2. Super pixel readout method by 2x2 binning : SMD S SPX 2

It is possible to set 2(H) x2 (V) binning at C4742-95. At this mode, it takes 60.77msec for readout all charges from CCD. (16.45Hz).



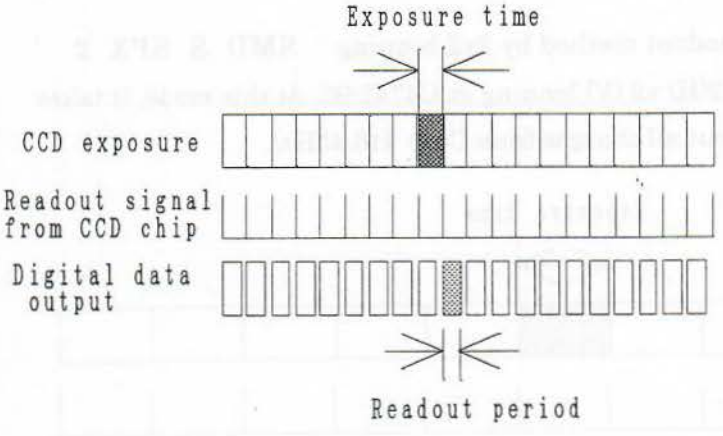
8-3-4-3. Super pixel readout method by 4x4 binning : SMD S SPX 4

It is possible to set 4(H)x4(V) binning at C4742-95. At this mode, it takes 34.42msec for readout all charges from CCD. (29.05Hz).



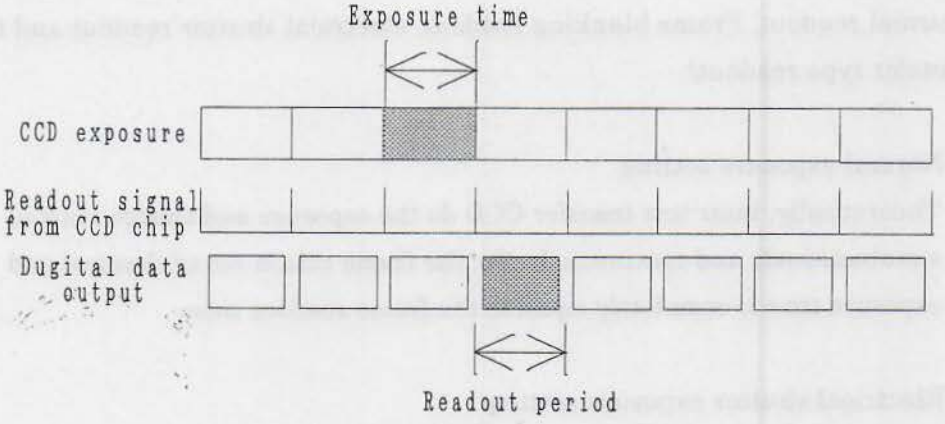
8-3-4-4. Super pixel readout method by 8x8 binning : SMD S SPX 8

It is possible to set 8(H)×8(V) binning at C4742-95. At this mode, it takes 22.07msec for readout all charges from CCD. (45.31Hz).



8-3-4-5. Sub-array readout method : SMD A

It is possible to readout selected lines of the CCD using the C4742-95. In this mode, the CCD exposure time and frame rate depends on the selected sub-array area.



8-3-5Exposure Time Setting Control Command

There are two modes in exposure time setting command. One is for free running mode and NMD command is used. The other is for external controlled mode and EMD command is used. Basically there are four kinds of exposure method. (Normal readout, Frame blanking readout, electrical shutter readout and frame transfer type readout)

(a)Normal exposure setting

Theoretically, inter-line transfer CCD do the exposure and charge readout simultaneously and continuously. So, the frame rate is never changed and exposure time is completely equal to the frame readout time.

(b)Electrical shutter exposure setting

When shorter exposure time than one is needed, this mode is used. ER-150 CCD chip has a function of electrical shutter. Generated electrical charges in the pixel are dumped to the silicon base instantaneously. Normally exposure time is equal to the frame readout time, but electrical shutter mode can control the exposure time by step of approx.

(c) Frame blanking exposure setting

When longer exposure time than one frame is needed, this mode is used. Exposure time is defined by the step of frame number.

(d)Full frame transfer type exposure setting.

At this mode, CCD behave just like full frame transfer CCD. This means that exposure period and readout period are separated and one cycle becomes longer than normal inter-line transfer CCD readout time. And this mode is only available in the External exposure controlled mode.

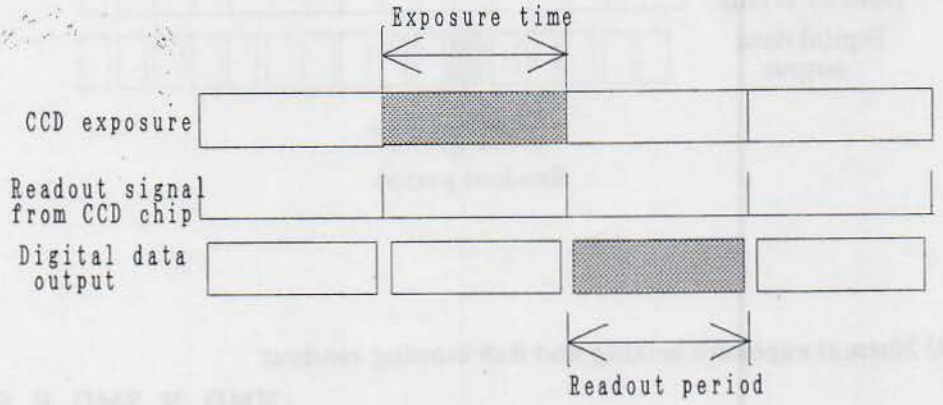
8-3-5-1. At free running mode : AMD N.

There are three kinds of command for exposure setting. (NMD N / NMD S / NMD F). At this mode, frame readout time depends on the selection of SMD command.

8-3-5-1-1. Normal exposure setting NMD N

(1) Normal exposure setting and Normal readout : NMD N SMD N

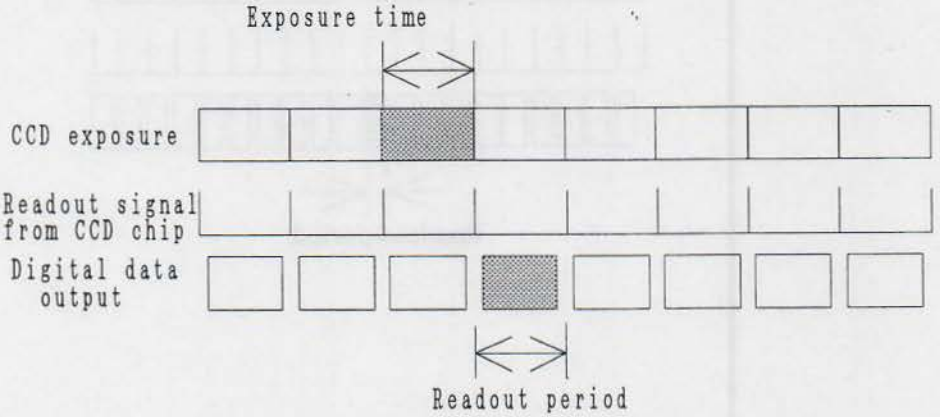
When NMD N and SMD N are selected, camera works at 8.3542Hz (119.7msec exposure time) continuously.



(2) Normal exposure setting and 2x2 binning readout

: NMD N SMD B SPX 2

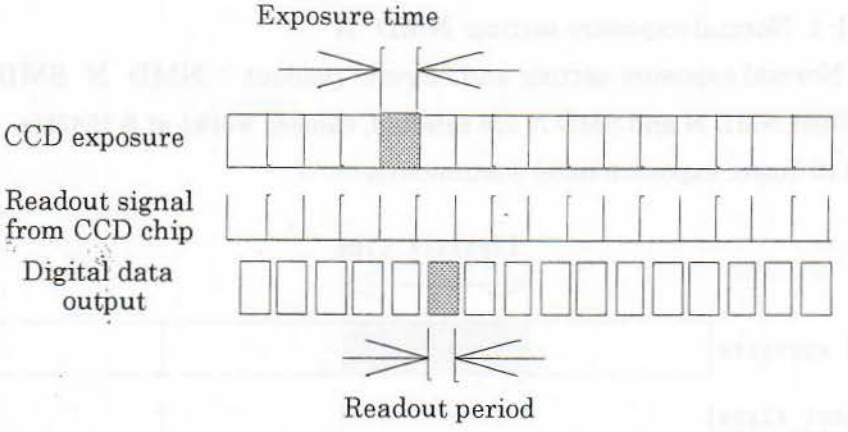
When NMD N, SMD B and SPX 2 are selected, camera works at 16.45Hz (60.77msec exposure time) continuously.



(3) Normal exposure setting and 4x4 binning readout

: NMD N SMD B SPX 4

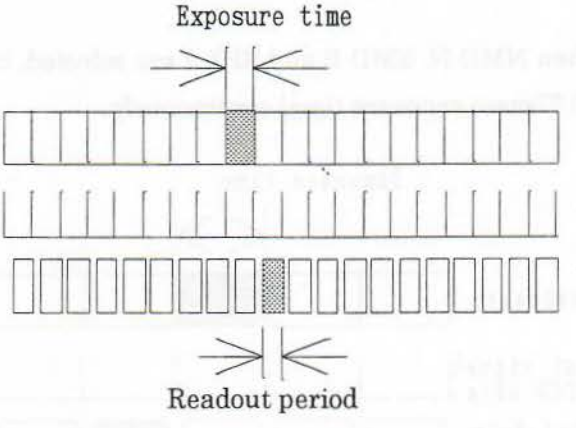
When NMD N, SMD B and SPX 4 are selected, camera works at 29.05Hz (34.42msec exposure time) continuously.



(4) Normal exposure setting and 8x8 binning readout

: NMD N SMD B SPX 8

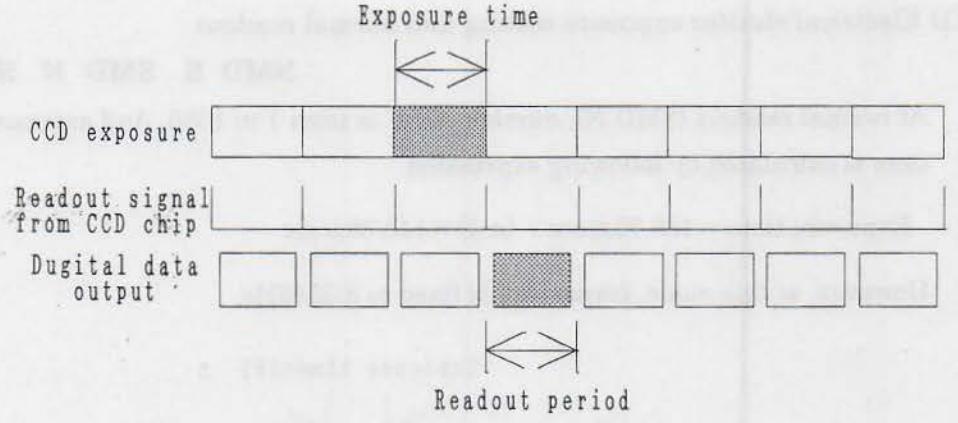
When NMD N, SMD B and SPX 8 are selected, camera works at 45.31Hz (22.07msec exposure time) continuously.



(5) Normal exposure setting and sub-array readout :

NMD N SMD A (SVO n, SVW m)

When NMD N and SMD A are selected, the camera works at faster frame rate than the standard frame rate . In this mode, the CCD exposure time and frame rate depends on the selected sub-array area.



8-3-5-1-2. Electrical shutter exposure setting : NMD S

At this mode, exposure time is set by step of line number "n". Exposure time is defined as the number of "n" in the command of "SHT n". Depending on the selection of SMD the range of number "n" is different.

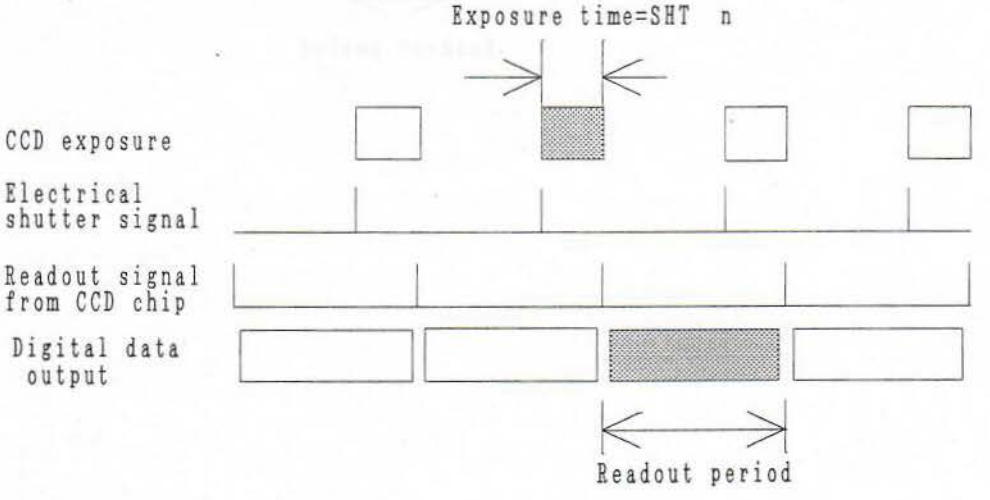
(1) Electrical shutter exposure setting and normal readout

: NMD S SMD N SHT n

At normal readout (SMD N), number of "n" is from 1 to 1055. And exposure time is calculated by following expression.

Exposure time = 138.75μsec + (n-1)×113.38μsec

However, at this mode, frame rate is fixed to 8.3542Hz.



(2) Electrical shutter exposure setting and 2x2 binning readout

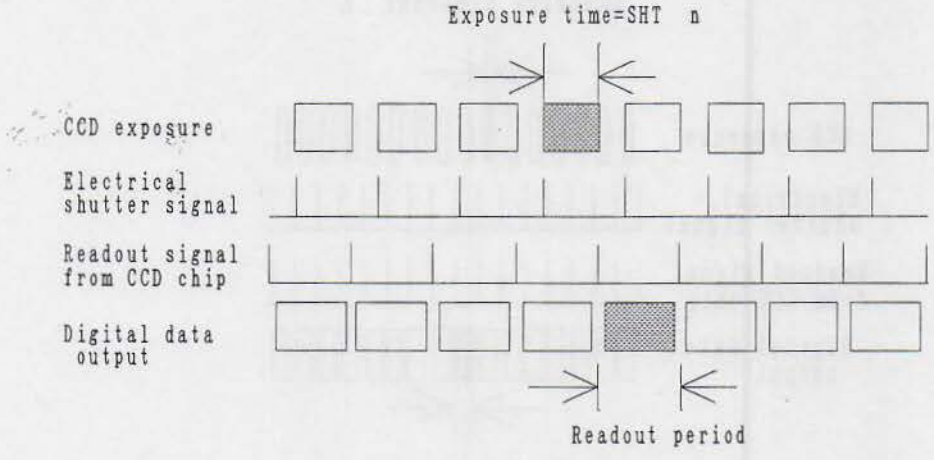
: NMD S SMD S SPX 2 SHT n

At 2x2 binning readout (SMD S and SPX 2), number of "n" is set from 1 to 535.

And exposure time is calculated by following expression.

Exposure time = 138.75μsec + (n-1)×113.38μsec

However, at this mode, frame rate is fixed to 16.45Hz.



(3) Electrical shutter exposure setting and 4x4 binning readout

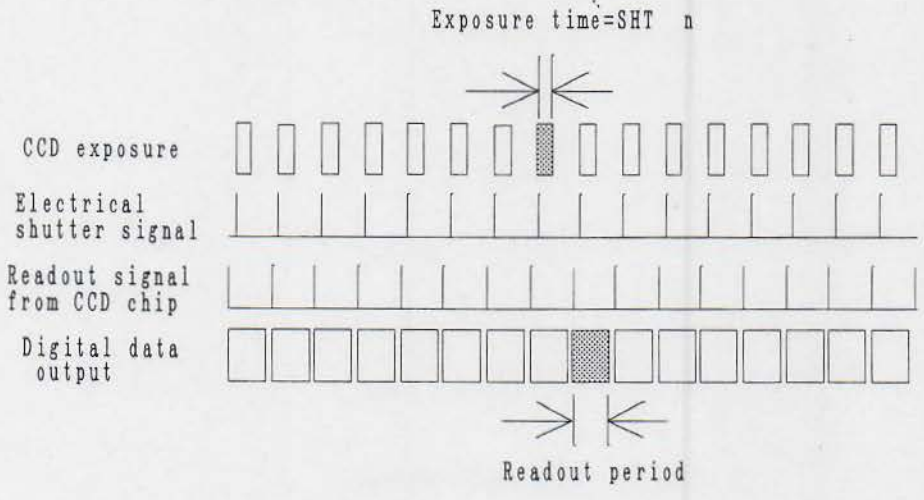
: NMD S SMD S SPX 4 SHT n

At 4x4 binning readout (SMD S and SPX 4), number of "n" is set from 1 to 266.

And exposure time is calculated by following expression.

Exposure time = 138.75μsec + (n-1)×128.58μsec

However, at this mode, frame rate is fixed to 29.05Hz.



(4) Electrical shutter exposure setting and 8x8 binning readout

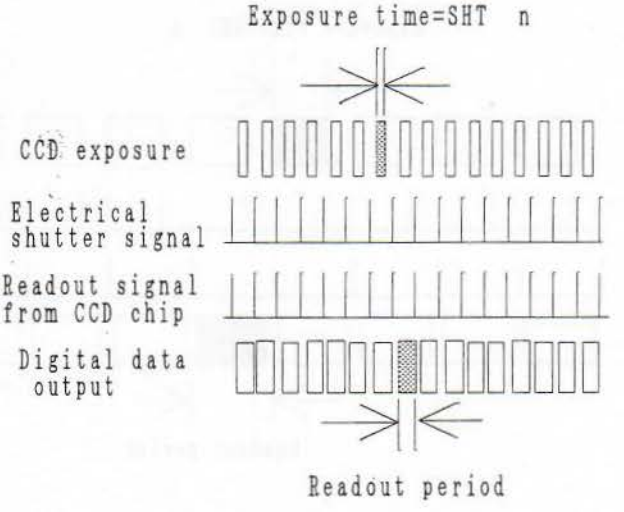
: NMD S SMD S SPX 8 SHT n

At 8x8 binning readout (SMD S and SPX 8), number of "n" is set from 1 to 137.

And exposure time is calculated by following expression.

Exposure time = 138.75μsec + (n-1) × 159.50μsec

However, at this mode, frame rate is fixed to 45.31Hz.

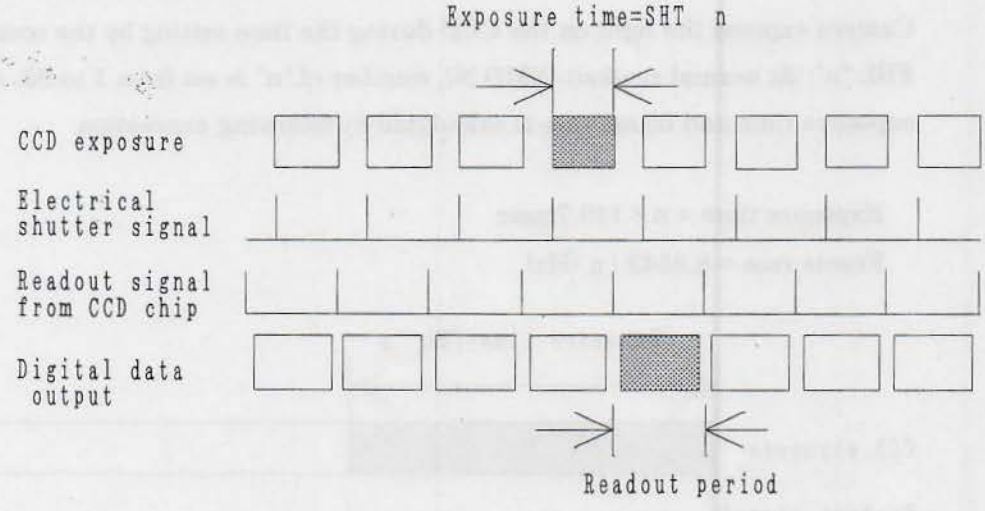


(5) Electrical shutter exposure setting and sub-array readout :

NMD S SMD A SHT n (SVO o, SVW m)

In sub-array readout, SMD A, number of "n". And exposure time is changeable by SHT n. The minimum exposure time is SHT 1 is selected. The maximum exposure time depends on combination of SVO o and SVW m selected. In this mode, frame rate also depends on combination of SVO o and SVW m selected.

Please refer to 44 pages about the exposure time.



8-3-5-1-3. Frame blanking exposure setting : NMD F

At this mode, exposure time is set by step of frame number "n". One frame readout time equal to 119.7msec. Exposure time is defined as the number of "n" in the command of "SHT n". Depending on the selection of SMD the range of number "n" is different.

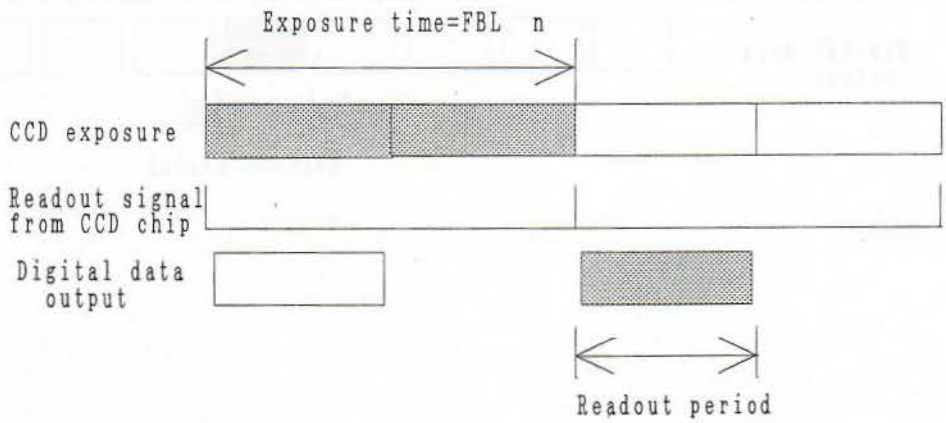
(1) Frame blanking exposure setting and normal readout.:

NMD F SMD N FBL n

Camera exposes the light on the CCD during the time setting by the command of FBL "n". At normal readout (SMD N), number of "n" is set from 1 to 90. And exposure time and frame rate is calculated by following expression.

Exposure time = n × 119.7msec

Frame rate = 8.3542 / n (Hz)



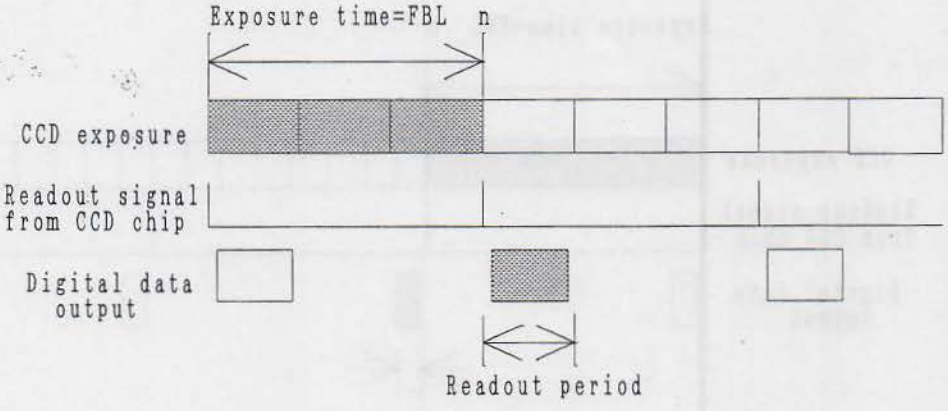
(2) Frame blanking exposure setting and 2x2 binning readout.

: NMD F SMD S SPX 2 FBL n

Camera exposes the light on the CCD during the time setting by the command of FBL "n". At 2x2 super pixel readout (SMD S), number of "n" is set from 1 to 180. And exposure time and frame rate is calculated by following expression.

Exposure time = n × 60.77msec

Frame rate = 16.45 / n (Hz)



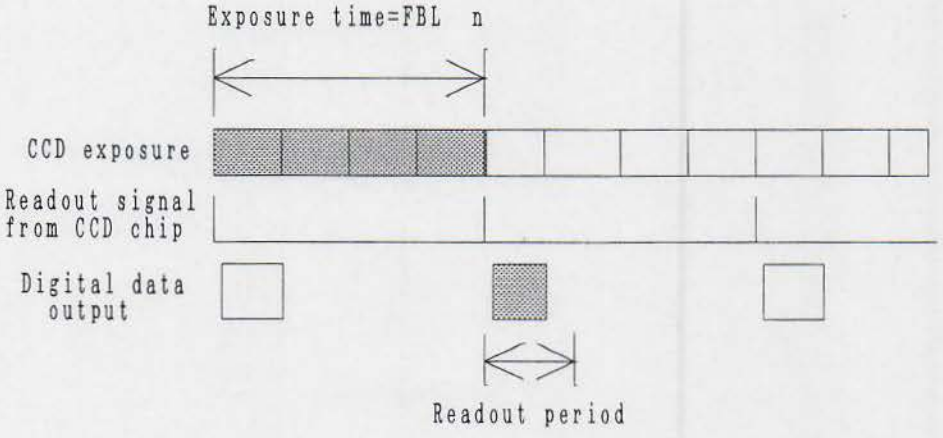
(3) Frame blanking exposure setting and 4x4 binning readout.

: NMD F SMD S SPX 4 FBL n

Camera exposes the light on the CCD during the time setting by the command of FBL "n". At 4x4 super pixel readout (SMD S and SPX 4), number of "n" is set from 1 to 325. And exposure time and frame rate is calculated by following expression.

Exposure time = n × 34.42msec

Frame rate = 29.05 / n (Hz)



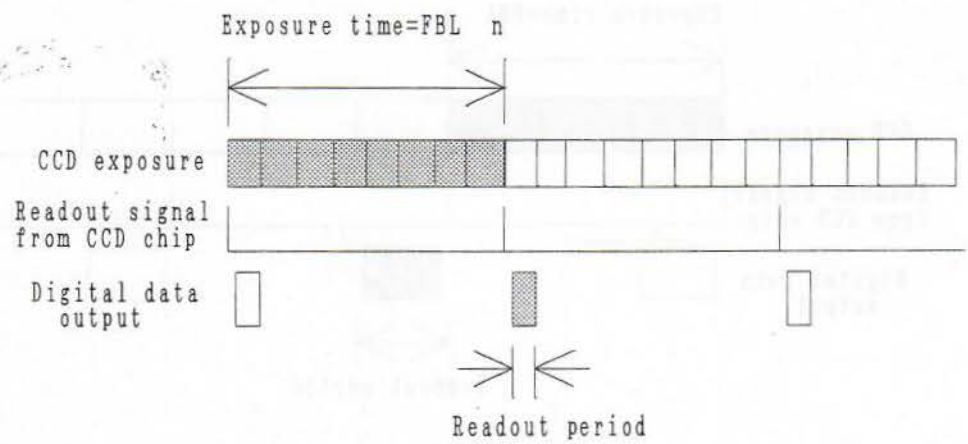
(4) Frame blanking exposure setting and 8x8 binning readout.

: NMD F SMD S SPX 8 FBL n

Camera exposes the light on the CCD during the time setting by the command of FBL "n". At 8x8 super pixel readout (SMD S and SPX 8), number of "n" is set from 1 to 534. And exposure time and frame rate is calculated by following expression.

Exposure time = n × 22.07msec

Frame rate = 45.31 / n (Hz)



8-3-5-2 At external control mode : AMD E ATP N or P.

There are two modes in exposure setting command.
(EMD E / EMD L)

At external control mode, exposure timing and readout timing are controlled by external trigger pulse. It is possible to select external trigger polarity between N(Negative true) and P(Positive true) .(ATP N or P)

Input external trigger pulse(TTL level) into BNC connector on CCU rear panel.
(EXT.TRIG circuit is terminated by 680Ω resister.)

Minimum active period of external trigger pulse is 40μsec.

If an external trigger pulse shorter than 40μsec is input to camera, camera does not recognize it therefore output no signal.

Note) Following explanations are for the case of choosing N(Negative true).
In case choosing P(Positive true), read with replacing High with [Low] and falling edge with [rising edge].

8-3-5-2-1 External edge trigger : EMD E

(1) External edge trigger and normal readout :

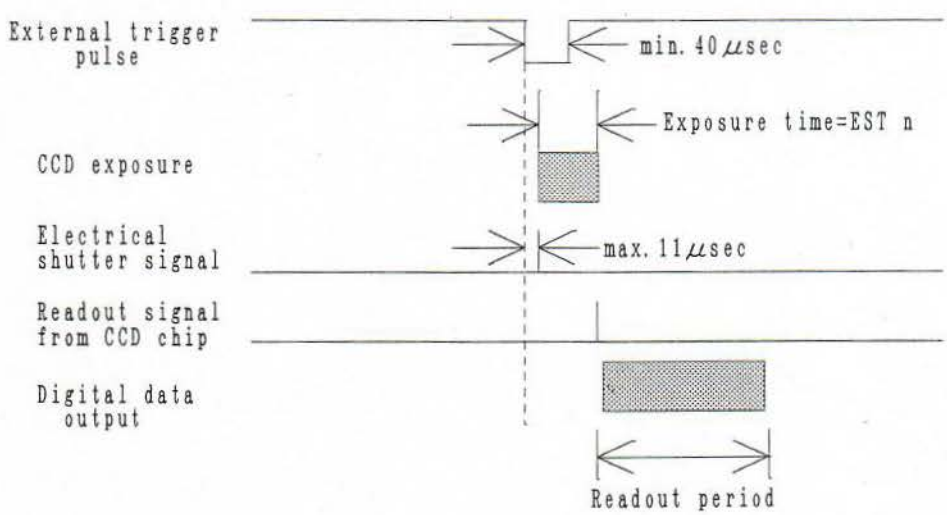
SMD N EMD E EST n

At this mode, camera behaves like a full frame transfer CCD camera. This means that exposure and data readout don't work at the same time, so, firstly camera starts the exposure and after exposure, camera starts the data readout. When external trigger pulse changes from high to low(falling edge)[low to high(raising edge)], camera starts the exposure within 10μsec. Exposure time is defined as the number of "n" from 1 to 95040 in the command of "EST n". Minimum repetition time of external trigger pulse needs 119.7 msec + exposure time. So during the period of exposure and readout, if another trigger comes to camera, camera ignore this second pulse.

And exposure time and repetition time is calculated by following expression.

Exposure time = 138.75μsec + (n-1)$\times$ 113.38μsec

Repetition time = 119.7msec + exposure time



(2) External edge trigger and 2x2 super pixel readout

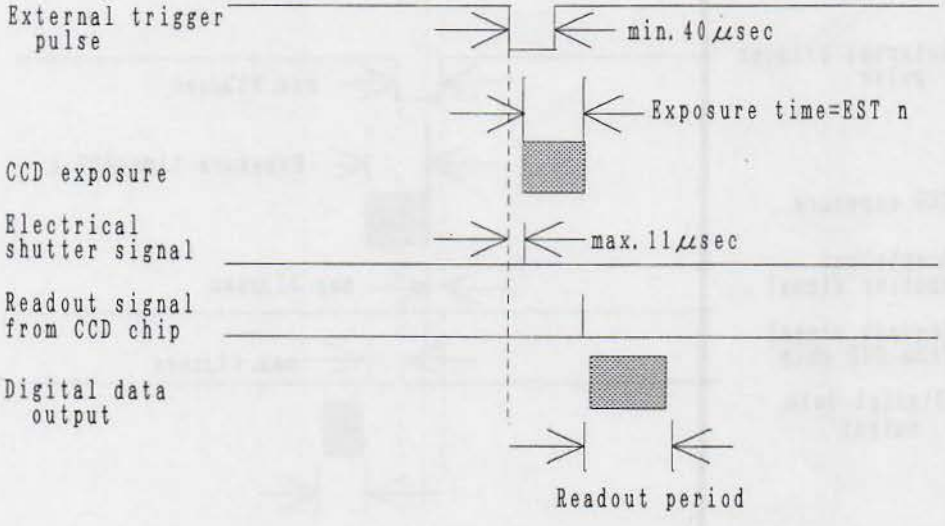
: SMD S SPX 2 EMD E EST n

When external trigger pulse changes from high to low(falling edge)[low to high(raising edge)], camera starts the exposure within 11μsec. Exposure time is defined as the number of "n" from 1 to 95040 in the command of "EST n". (138.75 μsec ~ 10sec) Minimum repetition time of external trigger pulse needs 60.77msec + exposure time. So during the period of exposure and readout, if another trigger comes to camera, camera ignores this second pulse.

And exposure time and repetition time is calculated by following expression.

Exposure time = 138.75μsec + (n-1) × 113.38μsec

Repetition time = 60.77msec + exposure time



(3) External edge trigger and 4x4 super pixel readout

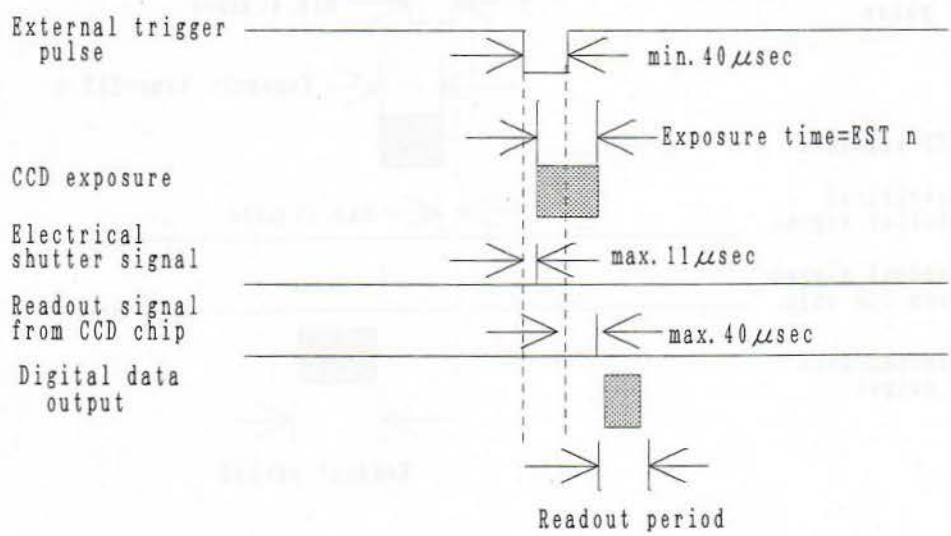
: SMD S SPX 4 EMD E EST n

When external trigger pulse changes from high to low(falling edge)[low to high(raising edge)], camera starts the exposure within 11μsec. Exposure time is defined as the number of "n" from 1 to 95040 in the command of "EST n". (138.75 μsec ~10sec) Minimum repetition time of external trigger pulse needs 34.42 msec + exposure time. So during the period of exposure and readout, if another trigger comes to camera, camera ignores this second pulse.

And exposure time and repetition time is calculated by following expression.

Exposure time = 138.75μsec + (n-1) × 113.38μsec

Repetition time = 34.42 msec + exposure time



(4) External edge trigger and 8x8 super pixel readout

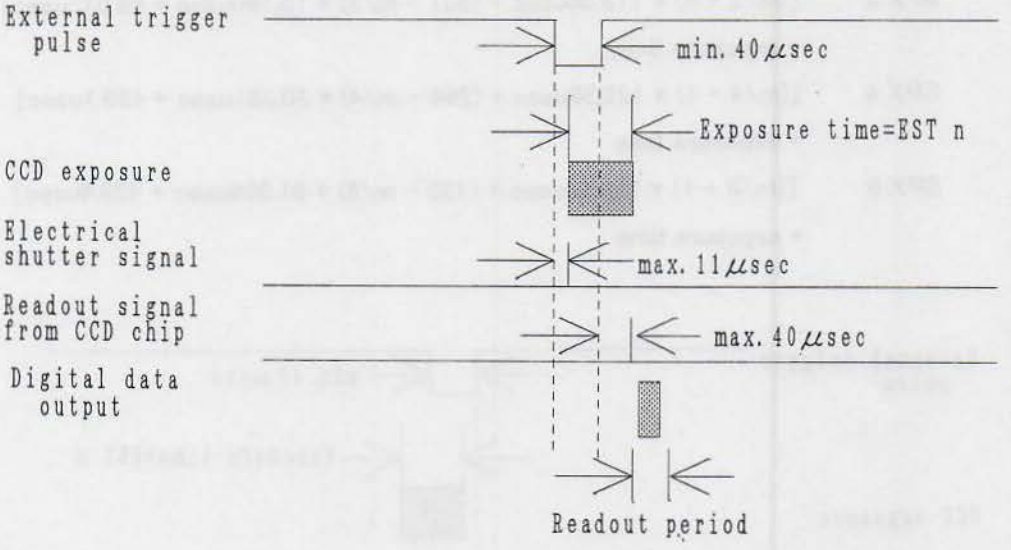
: SMD S SPX 8 EMD E EST n

When external trigger pulse changes from high to low(falling edge)[low to high(raising edge)], camera starts the exposure within 11μsec. Exposure time is defined as the number of "n" from 1 to 95040 in the command of "EST n". (138.75 μsec ~10sec) Minimum repetition time of external trigger pulse needs 22.07 msec + exposure time. So during the period of exposure and readout, if another trigger comes to camera, camera ignore this second pulse.

And exposure time and repetition time is calculated by following expression.

Exposure time = 138.75μsec + (n-1) × 113.38μsec

Repetition time = 22.07 msec + exposure time



(5) External edge trigger and sub-array readout

: SMD A SVO n SPX x SVW m EMD E EST n

When the external trigger pulse changes from high to low (falling edge), the camera starts the exposure within 11μsec. Exposure time is defined as the number of "n" from 1 to 95040 in the command of "EST n". The minimum repetition time for an external edge trigger pulse in sub-array readout mode is CCD readout period, which depends on combination of SVO n and SVW m selected, + exposure time. If another trigger comes to camera during this exposure and readout time period, this second pulse is ignored.

Exposure time is calculated by following expressions.

Exposure time = 138.75μsec + (n-1) x 113.38μsec

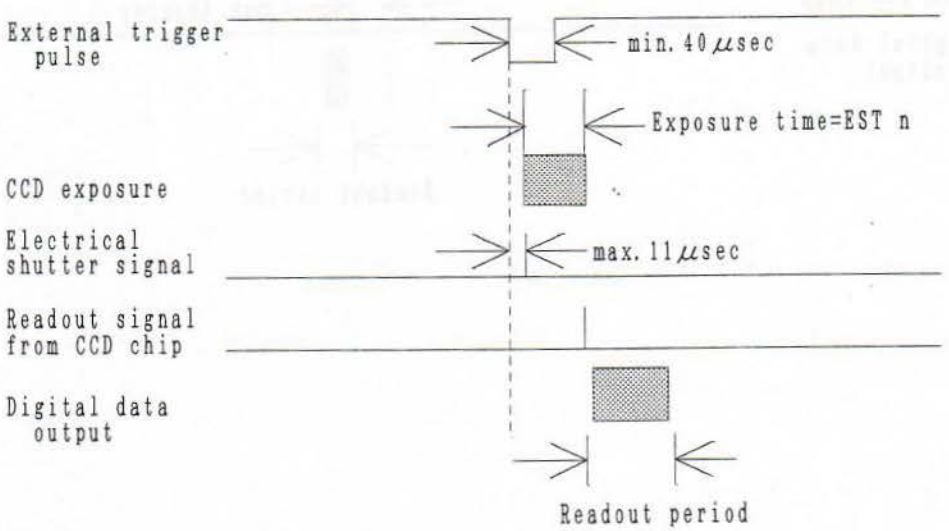
Repetition rate is:

SPX 1 [(m + 5) * 113.38usec + (1051 − m) * 7.0529usec] + exposure time

SPX 2 [(m/2 + 4) * 113.38usec + (531 − m/2) * 15.190usec + 99.012usec] + exposure time

SPX 4 [(m/4 + 1) * 128.58usec + (264 − m/4) * 30.381usec + 439.1usec] + exposure time

SPX 8 [(m/8 + 1) * 159.50usec + (135 − m/8) * 61.306usec + 439.4usec] + exposure time



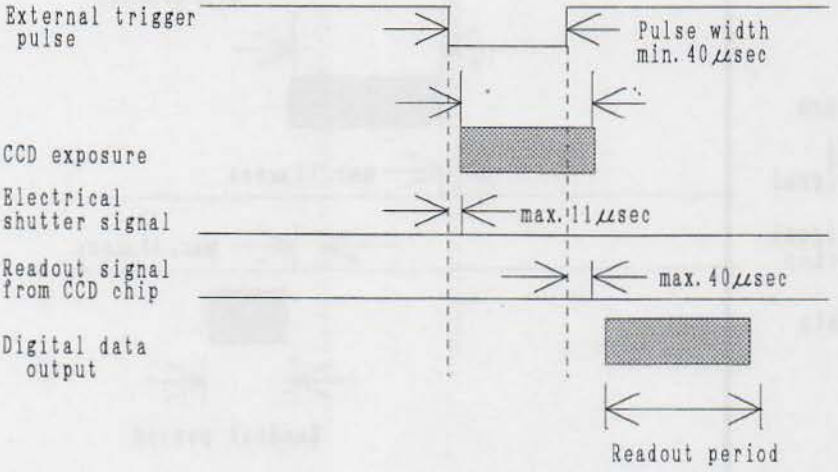
8-3-5-2-2 External level trigger

(1) External level trigger and normal readout : SMD N EMD L

Exposure time is controlled by the external pulse. At this mode, exposure time is fully controlled by the level of external trigger pulse. After changing the pulse from high to low (falling edge)[low to high(raising edge)] camera starts the exposure within 11μsec. During the external pulse is low [high], camera continues to expose. And when pulse changes from low to high[high to low], camera stops the exposure and starts the data readout within 40μsec. Repetition cycle is also fully controlled by external pulse and camera needs the repetition time at least 119.7 msec +low[high] level time of external pulse. During readout period, if pulse changes to low[high], camera keeps to the readout and end of readout, camera wait until next low[high] level coming from external trigger in.

Note) External trigger pulse needs at least 40μsec low [high] level period. Maximum exposure time is 10 sec. If low[high] level period of external trigger excesses 10 sec, camera stops the exposure and starts the data readout.

Exposure time and repetition time is calculated by following expression.
Repetition time = 119.7msec + low[high] period of external trigger pulse
Exposure time = low[high] period of external trigger pulse +29μsec

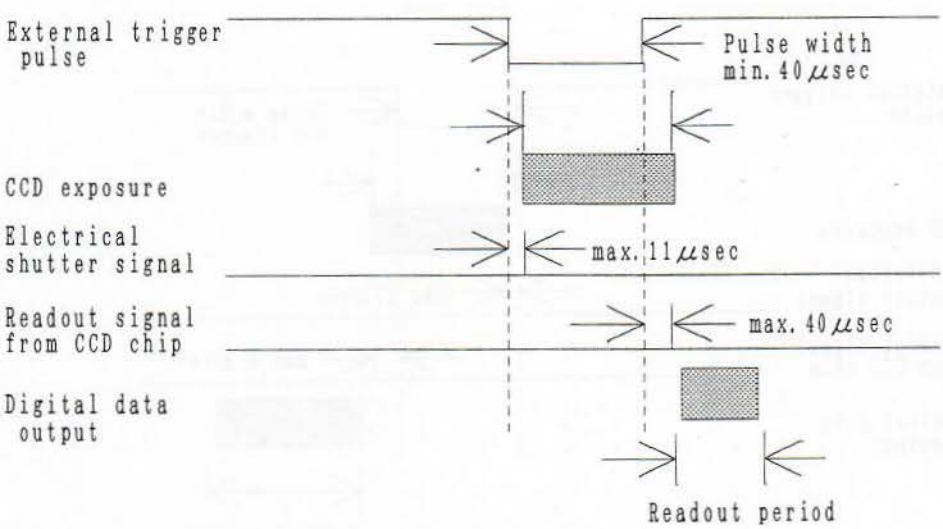


(2) External level trigger and 2x2 binning readout : SMD S SPX 2 EMD L

Exposure time is controlled by the external pulse. At this mode, exposure time is fully controlled by the level of external trigger pulse. After changing the pulse from high to low [low and high] camera starts the exposure within 11μsec. During the external pulse is low[high], camera continues to expose. And when pulse changes from low to high [high and low], camera stops the exposure and starts the data readout within 40μsec. Repetition cycle is also fully controlled by external pulse and camera needs the repetition time at least 60.77msec +low[high] level time of external pulse. During readout period, if pulse changes to low[high], camera keeps to readout and end of readout, camera wait until next low[high] level coming from external trigger in.

Note) External trigger pulse needs at least 40μsec low [high] level period. Maximum exposure time is 10 sec. If low[high] level period of external trigger excesses 10 sec, camera stops the exposure and starts the data readout.

Exposure time and repetition time is calculated by following expression.
Repetition time = 60.77msec + low [high] period of external trigger pulse
Exposure time = low[high] period of external trigger pulse +29μsec

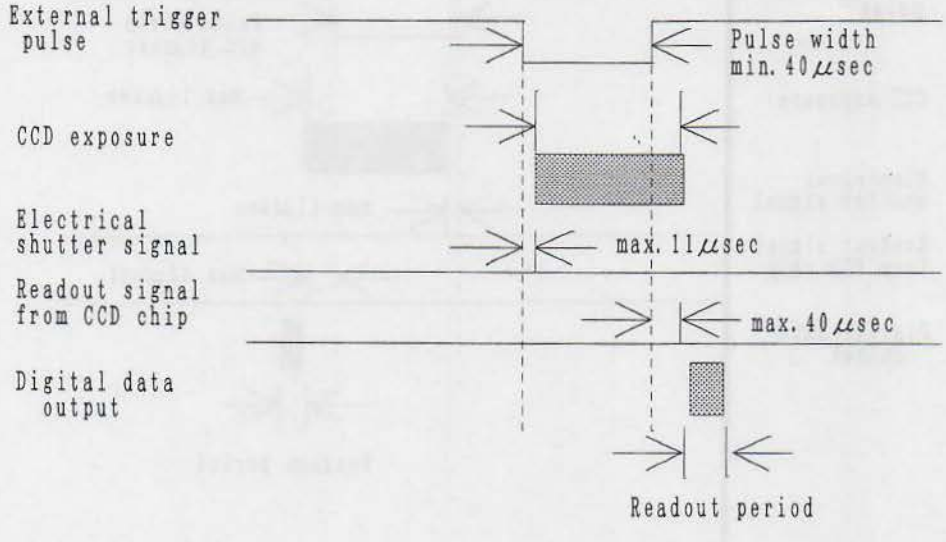


(3) External level trigger and 4x4 binning readout : SMD S SPX 4 EMD L

Exposure time is controlled by the external pulse. At this mode, exposure time is fully controlled by the level of external trigger pulse. After changing the pulse from high to low [low and high] camera starts the exposure within 11μsec. During the external pulse is low[high], camera continues to expose. And when pulse changes from low to high [high and low], camera stops the exposure and starts the data readout within 40μsec. Repetition cycle is also fully controlled by external pulse and camera needs the repetition time at least 34.42msec +low[high] level time of external pulse. During readout period, if pulse changes to low[high], camera keeps to readout and end of readout, camera wait until next low[high] level coming from external trigger in.

Note) External trigger pulse needs at least 40μsec low [high] level period. Maximum exposure time is 10 sec. If low[high] level period of external trigger excesses 10 sec, camera stops the exposure and starts the data readout.

Exposure time and repetition time is calculated by following expression.
Repetition time = 34.42 msec + low [high] period of external trigger pulse
Exposure time = low[high] period of external trigger pulse +29μsec

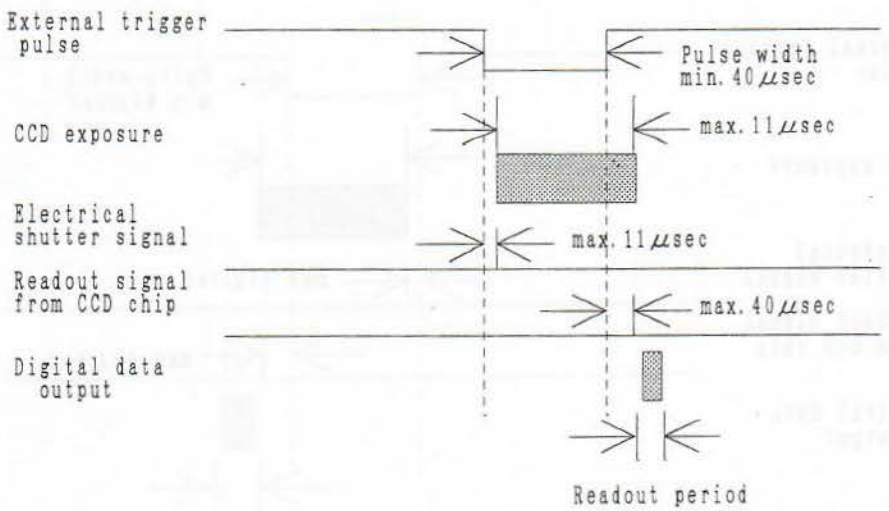


(4) External level trigger and 8x8 binning readout : SMD S SPX 8 EMD L

Exposure time is controlled by the external pulse. At this mode, exposure time is fully controlled by the level of external trigger pulse. After changing the pulse from high to low [low and high] camera starts the exposure within 11μsec. During the external pulse is low[high], camera continues to expose. And when pulse changes from low to high [high and low], camera stops the exposure and starts the data readout within 40μsec. Repetition cycle is also fully controlled by external pulse and camera needs the repetition time at least 22.07msec +low[high] level time of external pulse. During readout period, if pulse changes to low[high], camera keeps to readout and end of readout, camera wait until next low[high] level coming from external trigger in.

Note) External trigger pulse needs at least 40μsec low [high] level period. Maximum exposure time is 10 sec. If low[high] level period of external trigger excesses 10 sec, camera stops the exposure and starts the data readout.

Exposure time and repetition time is calculated by following expression.
Repetition time = 22.07 msec + low [high] period of external trigger pulse
Exposure time = low[high] period of external trigger pulse +29μsec



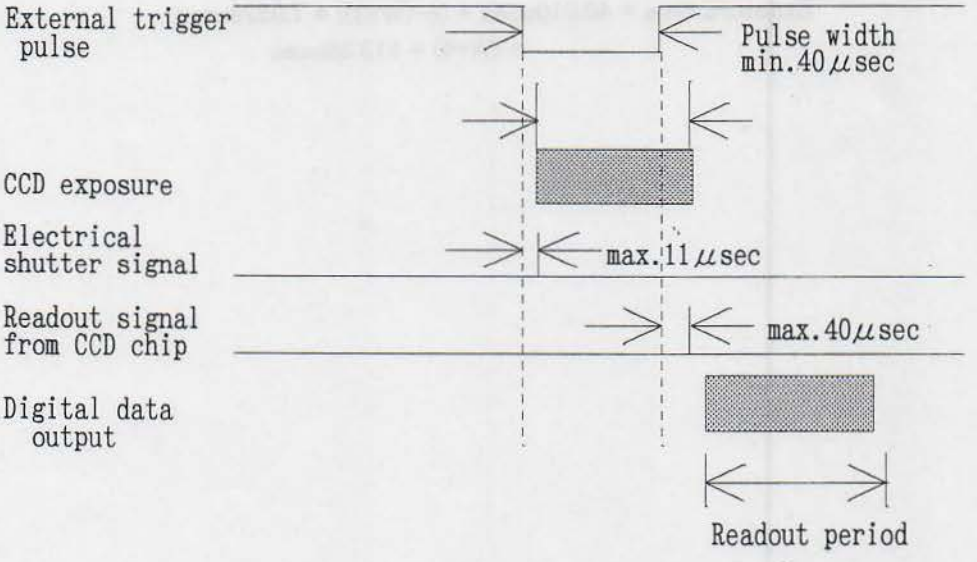
(5) External level trigger and sub-array readout :

SMD A EMD L (SVO n, SVW m)

In this mode, exposure time is fully controlled by the level of external trigger pulse. After changing the pulse from high to low (falling edge), the camera starts the exposure within 11μsec. While the external pulse level is low, the camera continues the exposure. When the pulse changes from low to high, the camera stops the exposure and starts the data readout within 40μsec. The minimum repetition time for an external level trigger pulse acquisition in sub-array readout mode is CCD readout period, which depends on the combination of SVO n and SVW m selected, + low level time of external pulse. During readout period, if the pulse changes to low, the camera continues to readout. At the end of readout, the camera waits until next high to low transition pulse coming from external trigger in.

Note) External trigger pulse needs at least a 40μsec low level period. Maximum exposure time is 1 sec. If the low level period of external trigger excesses 1 sec, the camera stops exposing and starts the data readout.

Exposure time and repetition time are calculated by following expression.
Exposure time > or = low period of external trigger pulse + 29μsec
Repetition time = readout time + low period of external trigger pulse



8 - 4 Sub-Array Scan Mode Exposure time

Sub-array Exposure time is calculated by the formula below.

(1) Note SMD_A / SPX_1
SVW_W
SVO_O

For Flame blanking mode(NMD_F) in Sub-array mode (SMD_A)
FBL_F
Exposure Time=Et

Et = [(W + 5) * 113.38usec + (1051 − W) * 7.0529usec]* F

For Shutter mode(NMD_S) in Sub-array mode (SMD_A)
SHT_n
Exposure Time=Et

(n=1)
Exposure time = 138.75usec

(1<n<=(1036−(W+O)))
Exposure time = 153.39usec + (n−2) * 7.0529usec

((1036−(W+O))<n<=(1037−O))
Exposure time = 138.75usec + (n−(1036−(O+W))) * 113.38usec
+ (1035−(O+W)) * 7.0529usec

((1037−O)<n<=1055)
Exposure time = 40.010usec + (n−(W+3)) * 7.0529usec
+ (W+4) * 113.38usec

(2) SMD_A / SPX_2

For Flame blanking mode(NMD_F) in Sub-array mode (SMD_A)

FBL_F

Exposure Time=Et

Et = [(W/2 + 4) * 113.38usec + (531 - W/2) * 15.190usec + 99.012usec]* F

For Shutter mode (NMD_S) in Sub-array mode (SMD_A)

SHT_n

Exposure Time=Et

(n=1)

Exposure time = 138.75usec

(1<n<=(525-(O+W)/2))

Exposure time = 153.39usec + (n-2) * 15.190usec

((525-(O+W)/2)<n<=(526-(O/2)))

Exposure time = 138.75usec + (n-(525-(O+W)/2)) * 113.38usec
+ (524-(O+W)/2) * 15.190usec

((526-(O/2))<n<=535)

Exposure time = 139.6usec + (n-(W/2 + 3)) * 15.190usec
+ (W/2 + 3) * 113.38usec

(3) SMD_A / SPX_4

For Flame blanking mode(NMD_F) in Sub-array mode (SMD_A)
FBL_F
Exposure Time=Et

Et = [(W/4 + 1) * 128.58usec + (264 − W/4) * 30.381usec + 439.1usec]* F

For Shutter mode (NMD_S) in Sub-array mode (SMD_A)
SHT_n
Exposure Time=Et

(n=1)
Exposure time = 138.75usec

(1<n<=(262−(W+O)/4))
Exposure time = 169.20usec + (n−2) * 30.381usec

((262−(W+O)/4)<n<=(263−(O/4)))
Exposure time = 138.75usec + (n−(262−(O+W)/4)) * 128.58usec
+ (261−(O+W)/4) * 30.381usec

((263−(O/4))<n<=265)
Exposure time = 381.5usec + (n−(W/4+3)) * 30.381usec
+ (W/4 + 1) * 128.58usec

(4) SMD_A / SPX_8

For Flame blanking mode (NMD_F) in Sub-array mode (SMD_A)

FBL_F

Exposure Time=Et

Et = [(W/8 + 1) * 159.50usec + (135 − W/8) * 61.306usec + 439.4usec]* F

For Shutter mode (NMD_S) in Sub-array mode (SMD_A)

SHT_n

Exposure Time=Et

(n=1)

Exposure time = 138.75usec

(1<n<=(135−(O+W)/8))

Exposure time = 200.121usec + (n−2) * 61.306usec

((135−(O+W)/8)<n<=(136−(O/8)))

Exposure time = 138.75usec + (n−(135−(O+W)/8)) * 159.50usec
+ (134−(O+W)/8) * 61.306usec

((136−O/8)<n<=137)

Exposure time = 412.7usec + (n−(W/8 + 3)) * 61.306usec
+ (W/8 + 1) * 159.50usec

9 Command specification

9-1 Communications interface

The C4742-95 CCD camera can be controlled externally, through a serial interface, using a host computer.

The serial interface parameters are as shown below.

Baud rate	:	9600
Bit length	:	8
Parity check	:	None
Stop bits	:	1

9-2 Command formats

(1) Basic system

External control commands used with the C4742-95 are output from the host computer in the format shown below.

Command	Parameter	CR

CR : Carriage Return

Commands are output with the <CR> code added at the end, as the final data element.

When using commands where parameters are required, a space is used to separate the command from the parameter.

9 - 3 Camera responses to commands

(1) Presence/absence of response

The camera responds to commands sent from the host computer.
The RESponse command can be used to specify whether or not responses from the camera are enabled.
With status commands, however, the user may not specify that no response is to be made.

Command : RES (RESponse)
Function : Specifies whether or not the camera is to respond to commands output from the host computer.

Parameter : Y/N
RES Y : A response will be sent for each command as it is issued. (default value)
RES N : Responses will not be made to each command issued.

If the parameter is set so that a response will be issued by the camera when a command is received, the following type of response will be made.

When a command is received from the host computer and the camera executes the command, the response indicates to the computer that the command has been executed. Therefore, the response differs depending on the type of command.

(2) Responses to executed commands and to specified commands

If the command has been executed properly, a response is sent to the computer, indicating that the command (with parameters) has been executed.

XXX_PP	CR

XXX : Executed command
PP : Parameter

If there is an error in the command sent from the host computer (an undefined command or an error in a parameter), the following character string is returned to signify that an error has occurred.

E3	CR

(3) Responses to status commands

(These are always output, regardless of the setting of the RES command.)

If the camera interprets the command to be correct, the camera returns the necessary status information to the host computer. Consequently, the status command is executed normally, and the sending of the status data to the computer serves as the response.

XXX_PP	CR

XXX : Command name
(3 characters, not including the ?)

PP : Status pertaining to command

If there is an error in the command sent from the computer (an undefined command or another problem), a character string is returned identifying the error, in the same way as described above.

E3	CR

(4) Response when an error occurs during reception

If there are any problems with receiving a command, there are two possible causes.

One is that there is a framing, parity, or overrun error, and the other is that there is an overflow in the reception buffer. If these errors occur, the following character string will be sent back to the computer the next time the error occurs.

En	CR

Here, "n" indicates the error, and the subsequent number indicates the situation of the error.

n=1: Framing, parity, or overrun error

n=2: Reception buffer overflow

If the errors described above occur, all commands in the reception buffer which have not yet been executed, including that in which the error occurred, will be canceled.

9 - 4 An overview of commands

External control commands are divided into the following five groups:

- Mode setting commands
- Parameter setting commands
- Correction commands
- Other setting commands
- Status commands

With status commands, after the command has been output on the host computer side, a response is sent back from the camera side. All commands begin with a question mark (?) and all specification commands should have this question mark attached as a prefix.

(1) Mode setting commands

These commands are used to change the mode relating to acquire the image.

AMD : This selects the timing of exposure starting trigger, internally or externally.

NMD : This selects the exposure time setting method when internal exposure starting trigger is selected.

EMD : This selects the exposure time setting method when external exposure starting trigger is selected.

SMD : This changes the readout method from CCD.

ADS : This changes the bit number of output digital data .(8/10/12bit)

(2) Parameter setting commands

These commands are used to set parameters relating to exposure time setting and output data number.

SHT : This sets the exposure time using electrical shutter at internal exposure starting trigger mode.

FBL : This sets the exposure time using frame blanking at internal exposure starting trigger mode.

EST : This sets the exposure time using electrical shutter at external exposure starting trigger mode.

SHA : This selects the output data number from camera. (1024×1024 or 1280×1024 or 1344×1024).

ESC : This selects the external trigger connector.
SVO : This selects the vertical start address of sub-array.
SVW : This selects the vertical line width of sub-array.
SHO : Returns the set value for horizontal start address.
SHW : Returns the set value for horizontal width.
SFD : This selects the front dummy pixel in the horizontally. (0 or 8 pixels)
SPX : This selects the matrix number of binning at super pixel readout mode.
(1x1 binning or 2x2 binning or 4x4 binning or 8x8 binning)
ATP : This chooses the external trigger polarity between N(Negative) and P(Positive).
ADS : This selects the bits of digitization.

(3) Correction commands

These are commands relating to correction, such as settings for the contrast enhancement function and the shading correction function.

CEG : This specifies the video signal gain for the contrast enhancement function.
CEO : This specifies the video signal offset for the contrast enhancement function.

(4) Other specification commands

This group contains specification commands used to initialize the C4742-95.

INI : This initializes the settings for the values of the various conditions relating to the camera.
RES : This selects parameters regarding responses to commands.

(5) Status commands

?AMD : Returns the set values for exposure starting trigger mode.

?NMD : Returns the set values for exposure time setting method when internal exposure starting trigger is selected.

?EMD : Returns the set values for exposure time setting method when external exposure starting trigger is selected.

?SMD : Returns the set values for readout method from CCD.

?ADS : Returns the set values for the bit number of output digital data.

?SHT : Returns the set values for the exposure time using electrical shutter at internal exposure starting trigger mode.

?FBL : Returns the set values for the exposure time using frame blanking at internal exposure starting trigger mode.

?EST : Returns the set values for the exposure time using electrical shutter at external exposure starting trigger mode.

?SHA : Returns the set value for digital output data .

?SFD : Returns the set value for dummy out put data.

?ESC : Returns the set source connector for external trigger.

?SVO : Returns the set value for vertical start address.

?SVW : Returns the set value for vertical line width.

?SVO : Returns the set value for vertical start address.

?SHW : Returns the set value for horizontal width.

?ATP : Returns the set external trigger polarity.

?SPX : Returns the set number of binning when binning mode is selected.

?CEG : Returns the set values for the gain.

?CEO : Returns the set values for the offset .

?RES : Returns the set values for the parameters regarding responses to commands.

?VER : Returns the version for the ROM inside the camera.

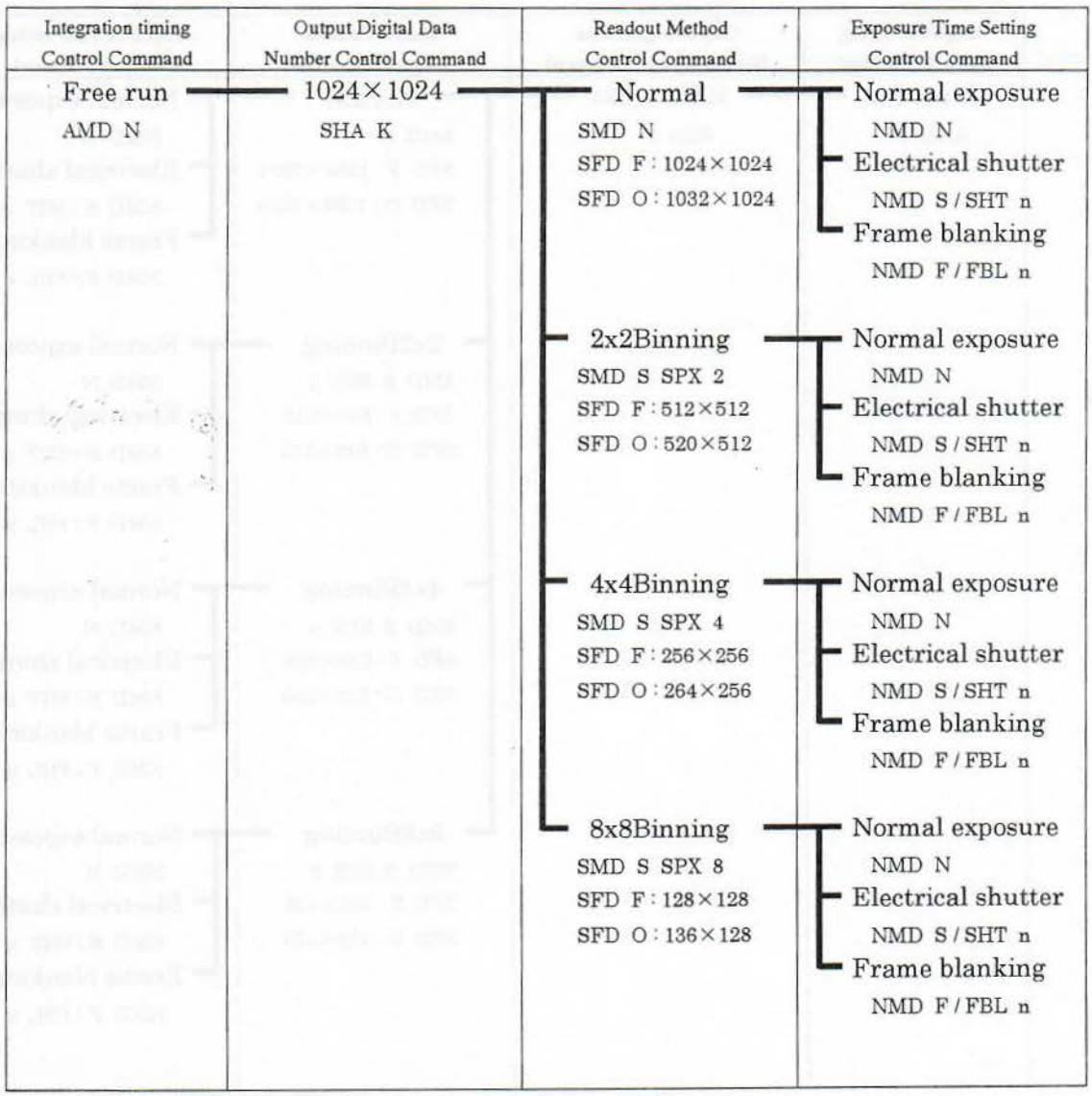
?CAI : Returns information concerning the camera hardware.

9 - 5 Commands relation in the mode setting and parameter setting.

Free running mode

Integration timing Control Command	Output Digital Data Number Control Command	Readout Method Control Command	Exposure Time Setting Control Command
Free run AMD N	1344×1024 SHA M	Normal SMD N SFD F : 1344×1024 SFD O : 1352×1024	Normal exposure NMD N
			Electrical shutter NMD S / SHT n
			Frame blanking NMD F / FBL n
		2x2Binning SMD S SPX 2 SFD F : 672×512 SFD O : 680×512	Normal exposure NMD N
			Electrical shutter NMD S / SHT n
			Frame blanking NMD F / FBL n
		4x4Binning SMD S SPX 4 SFD F : 336×256 SFD O : 344×256	Normal exposure NMD N
			Electrical shutter NMD S / SHT n
			Frame blanking NMD F / FBL n
		8x8Binning SMD S SPX 8 SFD F : 168×128 SFD O : 176×128	Normal exposure NMD N
			Electrical shutter NMD S / SHT n
			Frame blanking NMD F / FBL n

Integration timing Control Command	Output Digital Data Number Control Command	Readout Method Control Command	Exposure Time Setting Control Command
Free run AMD N	1280×1024 SHA F	Normal SMD N SFD F : 1280×1024 SFD O : 1288×1024	Normal exposure NMD N Electrical shutter NMD S / SHT n Frame blanking NMD F / FBL n
		2x2Binning SMD S SPX 2 SFD F : 640×512 SFD O : 648×512	Normal exposure NMD N Electrical shutter NMD S / SHT n Frame blanking NMD F / FBL n
		4x4Binning SMD S SPX 4 SFD F : 320×256 SFD O : 328×256	Normal exposure NMD N Electrical shutter NMD S / SHT n Frame blanking NMD F / FBL n
		8x8Binning SMD S SPX 8 SFD F : 160×128 SFD O : 168×128	Normal exposure NMD N Electrical shutter NMD S / SHT n Frame blanking NMD F / FBL n



External controlled mode

Integration timing Control Command	Output Digital Data Number Control Command	Readout Method Control Command	Exposure Time Setting Control Command
External AMD E	1344×1024 SHA M	Normal SMD N SFD F : 1344×1024 SFD O : 1352×1024	External edge EMD E / EST n
			External level EMD L
		2x2Binning SMD S SPX 2 SFD F : 672×512 SFD O : 680×512	External edge EMD E / EST n
			External level EMD L
		4x4Binning SMD S SPX 4 SFD F : 336×256 SFD O : 344×256	External edge EMD E / EST n
			External level EMD L
		8x8Binning SMD S SPX 8 SFD F : 168×128 SFD O : 176×128	External edge EMD E / EST n
			External level EMD L

Integration timing Control Command	Output Digital Data Number Control Command	Readout Method Control Command	Exposure Time Setting Control Command
External AMD E	1280×1024 SHA F	Normal SMD N SFD F : 1280×1024 SFD O : 1288×1024	External edge EMD E / EST n
			External level EMD L
		2x2Binning SMD S SPX 2 SFD F : 640×512 SFD O : 648×512	External edge EMD E / EST n
			External level EMD L
		4x4Binning SMD S SPX 4 SFD F : 320×256 SFD O : 328×256	External edge EMD E / EST n
			External level EMD L
		8x8Binning SMD S SPX 8 SFD F : 160×128 SFD O : 168×128	External edge EMD E / EST n
			External level EMD L

Integration timing Control Command	Output Digital Data Number Control Command	Readout Method Control Command	Exposure Time Setting Control Command
External AMD E	1024×1024 SHA K	Normal SMD N SFD F : 1024×1024 SFD O : 1032×1024	External edge EMD E / EST n
			External level EMD L
		2x2Binning SMD S SPX 2 SFD F : 640×512 SFD O : 648×512	External edge EMD E / EST n
			External level EMD L
		4x4Binning SMD S SPX 4 SFD F : 320×256 SFD O : 328×256	External edge EMD E / EST n
			External level EMD L
		8x8Binning SMD S SPX 8 SFD F : 160×128 SFD O : 168×128	External edge EMD E / EST n
			External level EMD L

9 - 6 Detailed format of command

(1)Mode setting command

# Command	:	AMD (Acquire MoDe)
Parameter	:	N or E (Normal or External)
Function	:	This selects the timing of exposure by internally or externally.
Example	:	AMD N Camera runs by the internal clock and all function are controlled by internal micro-processor and host computer, throw RS-232C serial interface.
	:	AMD E Camera runs by the external trigger pulse. Integration period and start timing of data readout from camera are synchronized or controlled by this external pulse.

#Command	:	NMD (Normal exposure time setting MoDe)
Parameter	:	N or S or F (Normal or electrical Shutter or Frame blanking)
Function	:	This sets the exposure time setting method when AMD N command is selected.
Example	:	NMD N Exposure is set the normal setting. NMD S Exposure is set by using electrical shutter. NMD F Exposure is set by frame blanking.

#Command	:	EMD (External exposure time setting MoDe)
Parameter	:	E or L (Edge trigger or level trigger)
Function	:	This sets the exposure time setting method by external trigger pulse, when AMD E command is selected.
Example	:	EMD E Exposure timing is set by edge of external trigger pulse . EMD L Exposure timing is set by the level of external trigger pulse..

#Command : SMD (Scan MoDe)

Parameter : N or S or A
(Normal readout mode or Super pixel readout mode)

Function : This selects the readout method form CCD.

Example : SMD N Normal readout mode.
SMD S This selects the super pixel readout mode.
SMD A This selects the sub array readout mode.

#Command : ADS (AD Select)

Parameter : 8 or 10 or 12
(8bits or 10bits or 12bits)

Function : This selects the number of output data bits.

Example : ADS 8 The number of output data bits is 8bits.
ADS 10 The number of output data bits is 10bits.
ADS 12 The number of output data bits is 12bits.

(2) Parameter setting commands

#Command : SHT (electrical SHutter Time)

Parameter : n (Horizontal line number)

Normal readout (SMD N) is selected, n = 1 to 1055

2x2 super pixel readout (SMD S SPX 2) is selected, n = 1 to 535

4x4 super pixel readout (SMD S SPX 4) is selected, n = 1 to 266

8x8 super pixel readout (SMD S SPX 8) is selected, n = 1 to 137

Function : When internal exposure timing(AMD N) and electrical shutter exposure(NMD S) is selected, exposure time is set by using the horizontal line number of "n" .

Example : SMD N & SHT 1 Exposure time is set to 138.75usec.

SMD N & SHT 10 Exposure time is set to 1.159msec

#Command : FBL (Frame BLanking)

Parameter : n (Frame number)

Normal readout (SMD N) is selected, n = 1 to 90

1x1 super pixel readout (SMD S SPX 1) is selected, n = 1 to 90

2x2 super pixel readout (SMD S SPX 2) is selected, n = 1 to 180

4x4 super pixel readout (SMD S SPX 4) is selected, n = 1 to 325

8x8 super pixel readout (SMD S SPX 8) is selected, n = 1 to 534

1x1 sub array readout (SMD S SPX 1) is selected,
n = 1 to (10000000 / ((W × 113)+(1024-W) × 7+650))

2x2 sub array readout (SMD S SPX 2) is selected,
n = 1 to (10000000 / ((W × 113)/2)+((1024-W) × 15 / 2 +757))

4x4 sub array readout (SMD S SPX 4) is selected,
n = 1 to (10000000 / ((W × 128) / 4 + (1024-W) × 30 / 4 + 836))

8x8 sub array readout (SMD S SPX 8) is selected,
n = 1 to (10000000 / ((W × 159) / 8 + (1024-W) × 61 / 8 + 975))

Function : When internal exposure timing(AMD N) and frame blanking exposure (NMD F) is selected, exposure time is set by using the frame number of "n" .

Example : FBL 1 Set the exposure frame 1

FBL 10 Set the exposure frame 10

#Command : EST (External Shutter Time)
Parameter : n (n=1 to 95040) (Horizontal line number)
Function : When External exposure timing(AMD E) and external edge trigger exposure (EMD F) is selected, exposure time is set by using horizontal line number of "n" .
Example : EST 1 Set the exposure time 134.0msec
EST 10 Set the exposure time 1.157msec

#Command : SHA (Scan Horizontal Area)
Parameter : F or K or M (Full or kilo)
Function : This select the horizontal output digital data number 1024 pixels or 1280 pixels, or 1344 pixels.
Example : SHA F Set the digital data number to 1280 pixels
SHA K Set the digital data number to 1024 pixels
SHA M Set the digital data number to 1344 pixels

#Command : SFD (Set Front Dummy)
Parameter : O or F (On or oFf)
Function : This sets the horizontal 8 pixels dummy in front of digital valid data.
Example : SFD O Set the front dummy
SFD F Doesn't set the front dummy

#Command : ATP (Active Trigger Polarity)
Parameter : N or P (Negative or Positive)
Function : This sets the external trigger polarity.
Example : ATP N The external trigger polarity is Negative.
ATP P The external trigger polarity is Positive.

#Command : SPX (Super PiXel)
Parameter : 1 or 2 or 4 or 8
(1x1 binning 2x2 binning or 4x4 binning or 8x8 binning)
Function : This sets matrix number of binning at super pixel readout mode.
Example : SPX 2 Set the 2x2 binning
SPX 4 Set the 4x4 binning
SPX 8 Set the 8x8 binning

#Command : ESC (External trigger Source Connector)

Parameter : B or D or I (BNC connector or D-sub I/O connector or digital I/F connector)

Function : This selects the connector used for External trigger input.

Example : ESC B External trigger signals should be input through the BNC connector.

ESC D External trigger signals should be input through the D-sub I/O connector (PIN 1).

ESC I External trigger signals should be input through the Digital I/F connector (PIN 58).

#Command : SVO (Sub array Vertical Offset number)

Parameter : n (0 – 1016)

Function : This selects the vertical start address of sub-array. The SVO should be set by 8lines step.

An error code of E3 is returned when the parameter is not acceptable against the area set by SVW.

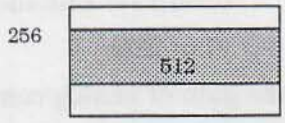
#Command : SVW (Sub array Vertical Width number)

Parameter : n (8 – 1024)

Function : This selects the vertical line width of sub-array. The SVW should be set by 8 lines steps.

An error code of E3 is returned when the parameter is not acceptable with the area set by SVO.

Example : Offset 256 (start address 256)
Width 512



SVO 256
SVW 512
SMD A

#Command : SHO (Scan H-Offset)
Parameter : n (0≦n≦1336, n= multiple of 8)
Function : This selects the horizontal start address of sub-array.
Comment : If the number of "n" is not the multiple of 8, command responses the error [E3]. And when SHO command is processed, the setting of SHA becomes invalid.

#Command : SHW (Scan H-Width)
Parameter : n (8≦n≦1344, n= multiple of 8)
Function : This selects the horizontal width of sub-array.
Comment : If the number of "n" is not the multiple of 8, command responses the error [E3]. And when SHW command is processed, the setting of SHA becomes invalid.

(3) Correction commands

#Command	:	CEG	(Contrast Enhance Gain)
Parameter	:	n	(0 to 255)
Function	:	This sets the gain of analog contrast enhancement function.	
Example	:	CEG 100	Set the gain to 100
		CEG 255	Set the maximum gain

#Command	:	CEO	(Contrast Enhance Offset)
Parameter	:	n	(0 to 255)
Function	:	This sets the offset of analog contrast enhancement function.	
Example	:	CEO 100	Set the offset to -100
		CEO 255	Set the maximum offset

#Command:	LMD (Light MoDe)
Parameter:	L or H (Low or High)
Function:	This controls the anti-blooming function.
Example:	LMD L Camera works with the highest sensitivity. In this mode Anti-blooming function is not effective as this mode gives priority to sensitivity.
	LMD H Camera works with Anti-blooming function with a little decrease to sensitivity.

(4) Other specification commands

#Command : INI (INItialize)

Parameter : doesn't use

Function : This initials the parameter RAM in the CCU to the initial setting.
It takes minimum 6 seconds for initialization.

Initial setting is

AMD	N	NMD	N	ESC	B
EMD	E	SMD	N	SVO	0
ADS	12	SHT	160	SVW	1024
FBL	9	EST	160	SHO	160
SHA	K	SFD	F	SHW	1024
ATP	N	CEG	0	LMD	L
CEO	0	RES	Y		
ATP	N	SPX	2		

#Command : RES (RESponse)

Parameter : Y/N (Yes or No)

Function : This specifies whether or not a response is to be returned each time when a command is executed.

Example : RES Y
A response is returned each time a command is executed.
RES N
No response is returned when a command is executed.

(5)Status commands

Status commands return the currently specified values.

#Command : ?AMD (read Acquire MoDe)
Returned value : N or E

#Command : ?NMD (read Normal exposure time setting MoDe)
Returned value : N or S or F

#Command : ?EMD (read External exposure time setting MoDe)
Returned value : E or L

#Command : ?SMD (read Scan MoDe)
Returned value : N or S or A

#Command : ?SMD (read Scan MoDe)
Returned value : N or S

#Command : ?ADS (real AD Select)
Returned value : 8 or 10 or 12

#Command : ?FBL (read Frame BLanking)
Returned value : n

#Command : ?EST (read External Shutter Time)
Returned value : n

#Command : ?SHA (read Scan Horizontal Area)
Returned value : F or K or M

#Command : ?SFD (read Set Front Dummy)
Returned value : O or F

#Command : ?ATP (read Active Trigger Polarity)
Returned value : N or P

#Command : ?ESC (read External trigger Source Connector)
Returned value : B or D or I

#Command : ?SVO (read Scan V-Offset)
Returned value : n (0 to 1016)

#Command : ?SVW (read Scan V-Width)
Returned value : n (8 to 1024)

#Command : ?SHO (read Scan H-Offset)
Returned value : n (0 to 1336)

#Command : ?SHW (read Scan H-Width)
Returned value : n (8 to 1344)

#Command : ?SPX (Super PiXel)
Returned value : 1 or 2 or 4 or 8

#Command : ?CEG (read Contrast Enhance Gain)
Returned value : n

#Command : ?CEO (read Contrast Enhance Offset)
Returned value : n

#Command : ?LMD (LightMoDe)
Returned value : L or H

#Command : ?RES (read RESponse)
Returned value : Y or N

The commands described below are special status commands which do not existamong the specification commands.

#Command : ?VER (read rom VERsion)
Function : This returns the version number of the ROM inside the camera.
Returned value : x.xx

(6) Camera hardware information command: ?CAI (CAmera Information)

This command obtains information concerning the camera hardware. Unlike other status commands, parameters need to be specified for this command.

Parameters:

C	:	CCD name
T	:	Camera type name
H	:	Number of effective CCD pixels in the horizontal direction
V	:	Number of effective CCD pixels in the vertical direction
A	:	Digital data output number
U	:	Number of Optical Black pixels on the CCD
W	:	Number of Optical Black pixels under the CCD
L	:	Number of Optical Black pixels to the left of the CCD
R	:	Number of Optical Black pixels to the right of the CCD
I	:	Number of A/D converter bits
S	:	Number of A/D converter bits
O	:	Camera options
B	:	Number of binning

Example : ?CAI H --> CAI H 1024

10 Checklist of Unusual Phenomena

If anything unusual occurs, check the symptoms and their causes noted below, and describe the symptoms in detail to HAMAMATSU.
In some cases, although there may appear to be symptoms of something unusual, the cause may lie in a misunderstanding or erroneous operation on the part of theuser.
(Repair of items marked with an asterisk should be left to HAMAMATSU.)

10-1 The POWER LED does not light when the power is turned on.

(Cause)	(Corrective Action)
(1) A fuse is blown.	Replace the fuse.
(2) The AC plug is loose.	Tighten the connection.
(3) The AC cord is cut or damaged.	*
(4) The LED circuit is has broken down.	*
(5) The power switch is broken.	*

10-2 No image is transferred.

(Cause)	(Corrective Action)
(1) The camera cable is not tightly connected.	Tighten the connection.
(2) The digital I/F cable is not tightly connected.	Tighten the connection.
(3) The correct command has not been sent to the camera side.	Check the command.
(4) The serial I/F cable is not tightly connected.	Tighten the connection.
(5) The monitor I/F cable is not tightly connected.	Tighten the connection.
(6) The camera cable is cut or disconnected.	*
(7) The digital I/F cable is cut or disconnected.	*
(8) The serial I/F cable is cut or disconnected.	*
(9) The monitor I/F cable is cut or disconnected.	*

10-3 The image is transferred, but the following problem occurs:

10-3-1. The image is scratchy and smudged.

(Cause)	(Corrective Action)
(1) The lens is dirty.	Wipe the lens clean.
(2) The glass on the front of the camera head is dirty.	Wipe the glass with a piece of gauze dipped lightly in alcohol.

10-3-2. The image is fuzzy.

(Cause)	(Corrective Action)
(1) The lens is not focused.	Focus the lens.
(2) The monitor contrast is too high.	Reduce the contrast.
(3) The background focus is not adjusted correctly.	*
(4) The CCD chip is dirty.	*

10-3-3. Images can only be produced under darkened conditions.

(Cause)	(Corrective Action)
(1) The lens cap has been left in place.	Take off the cap.

10-3-4. The full screen overflows.

(Cause)	(Corrective Action)
(1) The volume of light is too high.	Tighten the lens aperture.
(2) The amp gain is too high.	Reduce the amp gain.

10-3-5. Noise appears on the screen.

(Cause)	(Corrective Action)
(1) Contact between the lens and the camera head is not tight.	Tighten the contact.
(2) The monitor cable and connector are not in complete contact.	Re-connect them.
(3) There is external noise coming in.	Find the source and eliminate it.
(4) Internal connectors are loose.	*
(5) Circuitry is defective.	*

1 1 Specifications and Other Data

1 1 - 1 Camera specifications

(1) Electrical specifications

Imaging element	
	Progressive-scan interline CCD fixed imaging element
Effective no. of pixels	1344 (H) x 1024(V)
Pixel size	6.45um x 6.45μm square pixels
Sensitive area	8.66 mm x 6.60 mm (2/3-inch size)
Frame rate	
Normal mode	8.3 Hz
2x2 Binning mode	16 Hz
4x4 Binning mode	29 Hz
8x8 Binning mode	45 Hz
Mean readout noise	8 electron r.m.s (Note 1)
A/D converter resolution	12 bits
Cooling method	Electronic cooling + air cooling
Lens mount	C-mount
Amp gain conversion coefficient (Note 2)	
	4.6 electrons/AD count 12 bits
	(18000 electrons)
Contrast enhancement gain	1～10

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

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

(2) Power supply specifications

Input power supply	110/117 VAC +/- 10% 220/240 VAC +/- 10% 50/60 Hz
Power consumption	90 VA

(3) Ambient operating conditions

Ambient storage temperature	-10°C to +50°C
Ambient operating temperature	0°C to +40°C
Ambient operating humidity	70% max.
(with no condensation)	

(4) External dimensions and weight

Camera head	Approx. 1.25 kg
Camera control unit	Approx. 6.2 kg

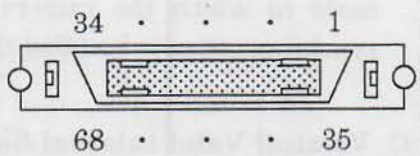
For external dimensions, please see the accompanying diagram.

1 1 -2 Digital interface specifications

The pin connections for the various digital connectors are shown below.

(1) Digital data connector pin arrangement (DIGITAL OUT)

Pin No.	Signal	Pin No.	Signal	Pin connection
1	PIXCLK-	35	PIXCLK+	
2	HVALID-	36	HVALID+	
3	VVALID-	37	VVALID+	
4	DB0-	38	DB0+	
5	DB1-	39	DB1+	
6	DB2-	40	DB2+	
7	DB3-	41	DB3+	
8	DB4-	42	DB4+	
9	DB5-	43	DB5+	
10	DB6-	44	DB6+	
11	DB7-	45	DB7+	
12	DB8-	46	DB8+	
13	DB9-	47	DB9+	
14	DB10-	48	DB10+	
15	DB11-	49	DB11+	
16	reserved	50	reserved	
17	reserved	51	reserved	
18	reserved	52	reserved	
19	reserved	53	reserved	
20	A/D OVF-	54	A/D OVF+	
21	GND	55	GND	
22	×reserved	56	reserved	
23	reserved	57	reserved	
24	reserved	58	reserved	
25	reserved	59	reserved	
26	reserved	60	reserved	
27	reserved	61	reserved	
28	reserved	62	reserved	
29	reserved	63	reserved	
30	reserved	64	reserved	
31	RXD-	65	RXD+	
32	TXD-	66	TXD+	
33	DTR-	67	DTR+	
34	DSR-	68	DSR+	



* Reserved pins are signals set aside to be used for expanded functions in the future, so they should be left open. Do not connect anything to these pins.

The input and output signals pass through a balanced digital voltage interface which conforms to RS-422A specifications. The "1" and "0" settings for the data correspond to the voltages for the + and - terminals. If the voltage at the + terminal is negative in comparison to that at the - terminal, a value of "1" is set (mark or OFF). If the voltage at the + terminal is positive in comparison to that at the - terminal, a value of "0" is set (space or ON). The signal level for output signals is -5 V to +5 V for TXD and DTR, and 0 V to +5 V for all others.

A. Pixel Clock (PIXCLK)

This signal is synchronized to the image data from the CCD and output. The digital data of the various pixels is synchronized to the timing at which the signal changes from "OFF" to the rising edge of "ON" before being output.

B. Horizontal Valid Interval Signals (HVALID)

This signal indicates the interval during which image data from the CCD is valid in the horizontal direction. The signal is "ON" during the interval when horizontal data is valid. The invalid and valid intervals differ depending on the mode in which the camera is operating. On the frame grabber side, line synchronization is handled through this signal.

C. Vertical Valid Interval Signals (VVALID)

This signal indicates the interval during which image data from the CCD is valid in the vertical direction. The signal is "ON" during the interval when vertical data is valid. The invalid and valid intervals differ depending on the mode in which the camera is operating. On the frame grabber side, frame synchronization is handled through this signal.

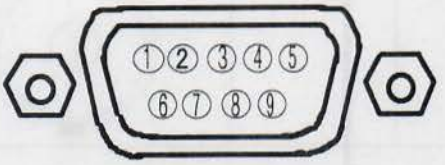
D. Digital Image Data (DB0 to DB11)

This is digital data consisting of image signals from the CCD which have undergone A/D conversion. The data is synchronized to the pixel clock and output. DB0 is the LSB (least significant bit) and DB11 is the MSB (most significant bit). For the output formats for the various modes, please refer to the section on "Digital Image Data Output Formats" (15-5).

(2) Serial interface pin assignments (SERIAL I/F)

No	Signal
1	N.C.
2	TXD
3	RXD
4	DSR
5	GND
6	DTR
7	N.C.
8	D+5V
9	N.C.

Pin connection



These signals make up the serial control line which is used to control camera movements from the host computer. The host computer sends commands out over this line and receives status reports back through it. Asynchronous communication is used, and the transmission protocol conforms to CCITT V.24 and RS-232C. The transmission speed can be selected from among five speeds available in a range of 1200 bps to 19,200 bps. These signals can be input and output in a voltage range between -5 V and +5 V, so an RS-232C interface can be connected using the - terminal. These signals are output in both directions between the digital data connector and the serial interface connector, so either can be used. Both connectors are connected internally, so be careful not to connect both at the same time.

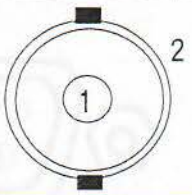
A. Transmit Data (TXD) [Output signal]
This is transmission data sent from the camera to the host computer. The signal is "OFF" if there is no data being transmitted.

B. Receive Data (RXD) [Input signal]
This is reception data sent from the host computer to the camera. The signal is "OFF" if there is no data being transmitted.

C. Terminal Ready (DTR) [Output signal]
This informs the host computer that the camera side is ready to send and receive data. The signal is "ON" when the camera side is not yet ready for transmission and reception.

D. Data Set Ready (DSR) [Input signal]
When the host computer is able to send and receive data, "ON" is output to the camera side. The C4742-95 does not support this signal, however, so transmission control cannot be implemented on the host computer side.

(3) Trigger input connector pin assignments (TRIGGER IN)

No.	Signal	Pin connection
1	TRIG IN	
2	GND	

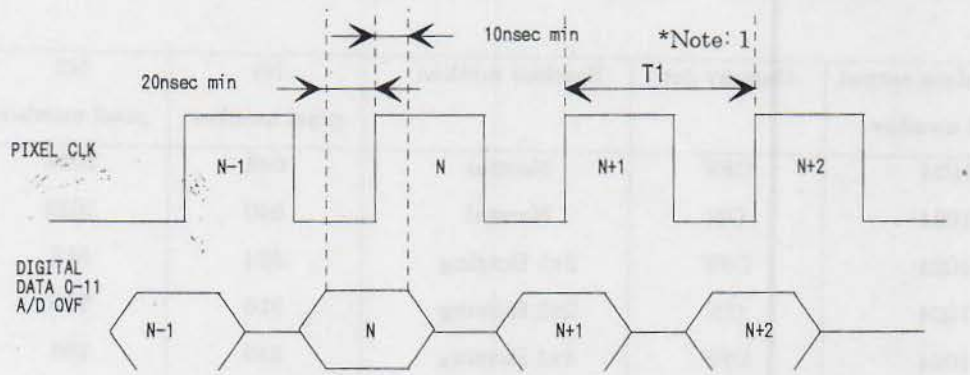
This is the external trigger input terminal used when the camera is being operated externally, in External Trigger Mode.
The input level is TTL level (EXT.TRIG circuit is terminated by 680Ω resister.), and the trigger polarity is programmable. For more detailed information on External Trigger Mode, please see Section 7-3.

1 1 -3 Image data output timing specifications

The specifications for the output timing of the digital data are illustrated below.

(1) Digital video signal timing

The relationship between the digital image data (DB0 to DB11) and between the A/D converter overflow (A/D OVF) signal and pixel clock (PIXCLK) signal is shown below.

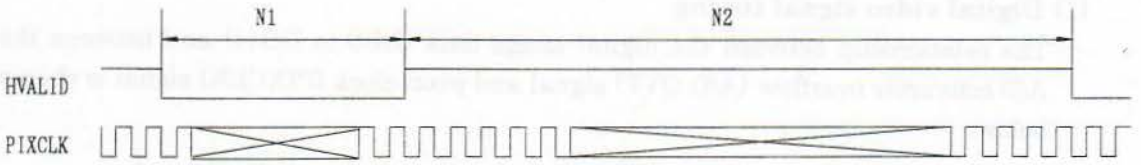


*Note: 1) Synchronization to the pixel clock under normal readout is as follows:

Normal readout mode	:	T1 = 68 nsec
2x2 Binning readout mode	:	T1 = 136 nsec
4x4 Binning readout mode	:	T1 = 272 nsec
8x8 Binning readout mode	:	T1 = 544 nsec

(2) Line timing (HVALID)

The relationship between the horizontal valid signal (HVALID) and the pixel clock (PIXCLK) is shown below.

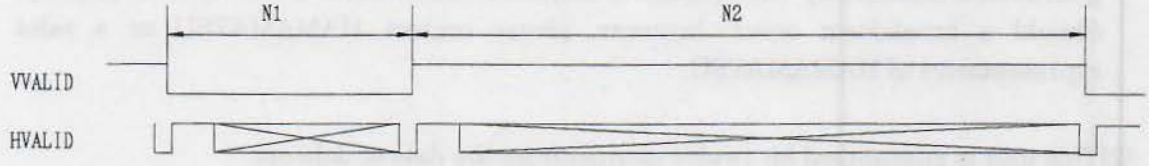


Digital data output pixel number	Dummy out	Readout method	N1 pixel number	N2 pixel number
1024	OFF	Normal	648	1024
1024	ON	Normal	640	1032
1024	OFF	2x2 Binning	324	512
1024	ON	2x2 Binning	316	520
1024	OFF	4x4 Binning	219	256
1024	ON	4x4 Binning	211	264
1024	OFF	8x8 Binning	166	128
1024	ON	8x8 Binning	158	136
1280	OFF	Normal	392	1280
1280	ON	Normal	384	1288
1280	OFF	2x2 Binning	196	640
1280	ON	2x2 Binning	188	648
1280	OFF	4x4 Binning	155	320
1280	ON	4x4 Binning	147	328
1280	OFF	8x8 Binning	134	160
1280	ON	8x8 Binning	126	168
1344	OFF	Normal	328	1344
1344	ON	Normal	320	1352
1344	OFF	2x2 Binning	164	672
1344	ON	2x2 Binning	156	680
1344	OFF	4x4 Binning	139	336
1344	ON	4x4 Binning	131	344
1344	OFF	8x8 Binning	127	168
1344	ON	8x8 Binning	119	176

Caution 1) Each edge of HVALID signal synchronizes with fall edge of PIXCLK.

(3) Frame timing

The relationship between the horizontal valid signal (HVALID) and vertical valid signal (VVALID) is shown below.



Digital data output pixel number	Dummy out	Readout method	N1 HVLID signal	N2 HVLID signal
1024	OFF	Normal	32	1024
1024	ON	Normal	32	1024
1024	OFF	2x2Binning	24	512
1024	ON	2x2Binning	24	512
1024	OFF	4x4Binning	11	256
1024	ON	4x4Binning	11	256
1024	OFF	8x8Binning	10	128
1024	ON	8x8Binning	10	128
1280	OFF	Normal	32	1024
1280	ON	Normal	32	1024
1280	OFF	2x2Binning	24	512
1280	ON	2x2Binning	24	512
1280	OFF	4x4Binning	11	256
1280	ON	4x4Binning	11	256
1280	OFF	8x8Binning	10	128
1280	ON	8x8Binning	10	128
1344	OFF	Normal	32	1024
1344	ON	Normal	32	1024
1344	OFF	2x2 Binning	24	512
1344	ON	2x2 Binning	24	512
1344	OFF	4x4 Binning	11	256
1344	ON	4x4 Binning	11	256
1344	OFF	8x8 Binning	10	128
1344	ON	8x8 Binning	10	128

Caution 1) Each edge of VVALID signal changes during inactive period of HVALID.

Caution 2) Each edge of VVALID signal never synchronizes with rise edge of PIXCLK.

Caution 3) Active and inactive period of HVALID change with running mode.

1 2 Warranty

(1)This device has been thoroughly tested by HAMAMATSU and its performance is guaranteed satisfactory with regard to standard rated values at the time of delivery. Should a breakdown occur, however, please contact HAMAMATSU or a sales representative of HAMAMATSU.

(2)This unit is guaranteed for twelve months from the date of delivery.

(3)This warranty is limited to defects in the materials and workmanship of the equipment. The warranty does not cover cases involving natural disaster, improper operation (including problems caused by renovations in the construction on the part of the user), and usage exceeding the specified ratings, even if these occur within the warranty period.

(4)The range covered by this warranty is limited to repair or replacement of the product or parts at no cost to the customer.

Handling Breakdowns

(5)In the event something unusual occurs, please consult the Checklist of Unusual Phenomena in this manual, and verify the cause of the breakdown. This is necessary both to avoid erroneous operation and misconceptions, and to clarify the symptoms of the problem.

(6)If the unit has broken down, or if you have any questions, please contact HAMAMATSU or a sales representative of HAMAMATSU and report the model name, serial number, and detailed symptoms of the problem. If HAMAMATSU determines that a breakdown has indeed occurred, a service technician will be dispatched to the site, or HAMAMATSU will request that the product be sent in for repair.

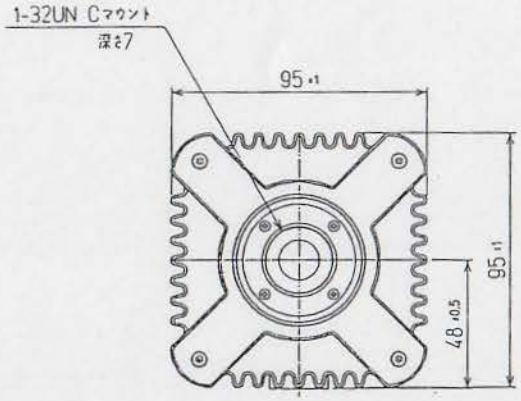
(7)Within the warranty period, all transportation, delivery and repair costs will be absorbed by HAMAMATSU.

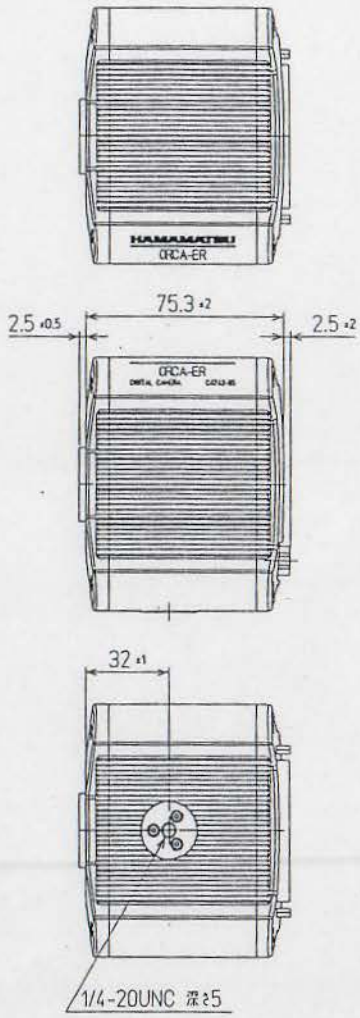
(8)Service and repairs will be carried out as rapidly as possible. However, in the cases listed below, repair service may not be provided in the event that a long period of time and high repair costs would be required.

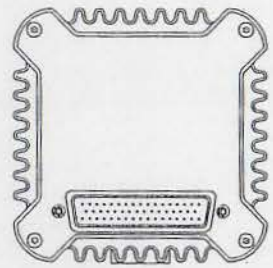
- A long period of time has passed since the initial purchase
- Replacement parts are no longer in production
- The degree of damage is extremely severe
- The equipment has been renovated
- The problem cannot be reproduced by HAMAMATSU
- The problem is caused by other equipment being used at the same time
- Other applicable instances

様式：A3図面用B(51-518 40-008-01)

No.	品　名	図面番号,型名	数量
1			







塗装：ライトグレー/ダークグレー
質量：約1.25Kg

ALT.	MARK	DESCRIPTION	SIGN	DATE

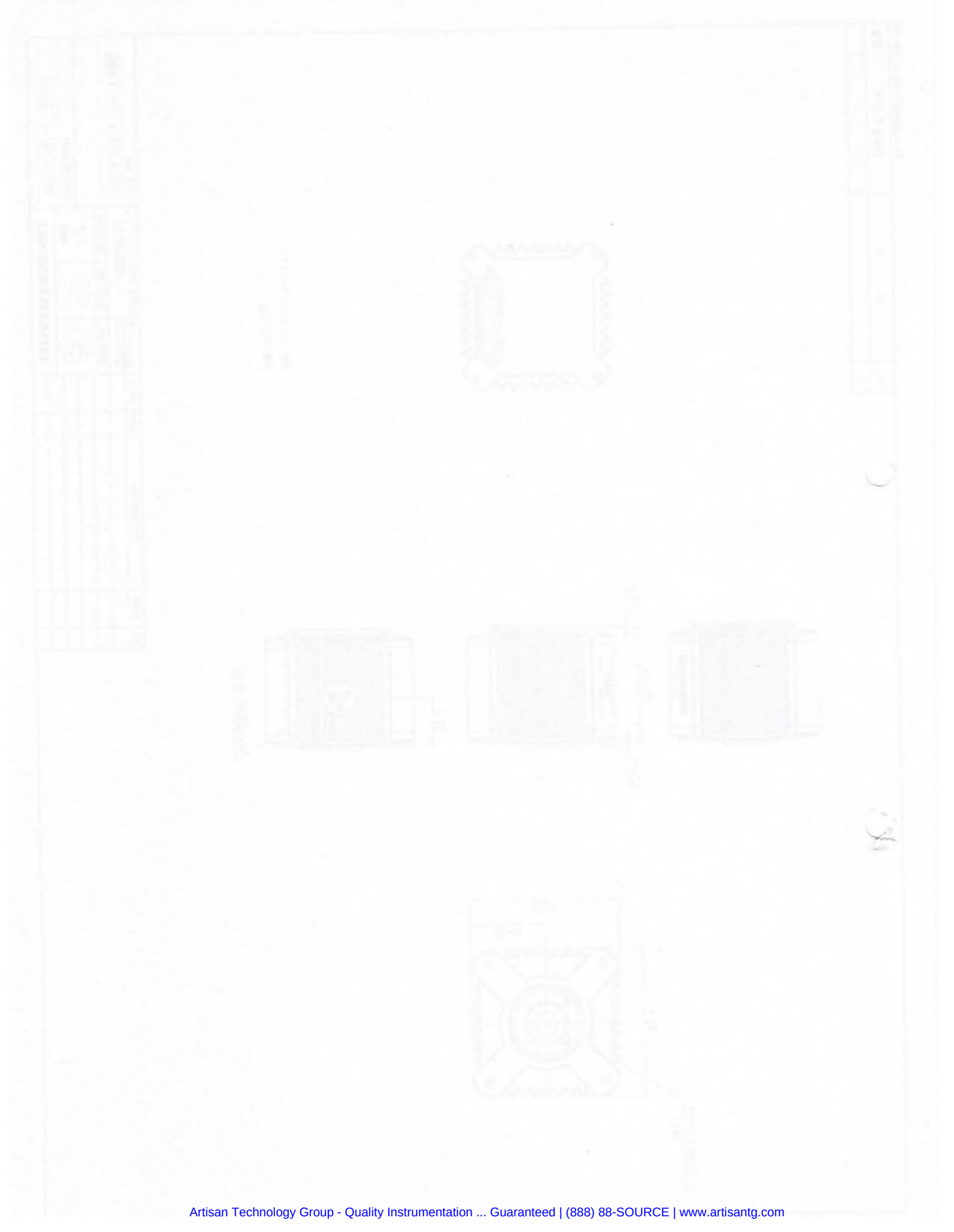
DATE 作成日 2000.06.27

APPD. 承認	CHCK. 審査	DESN. 作成
		小池 視技G

HAMAMATSU

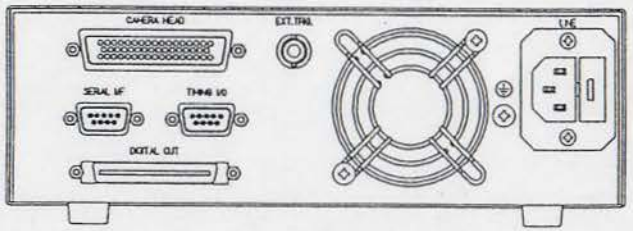
TITLE 名称 ORCA-ER カメラヘッド外観図

DRAW.NO. 図面番号 MB1-060-3T4002

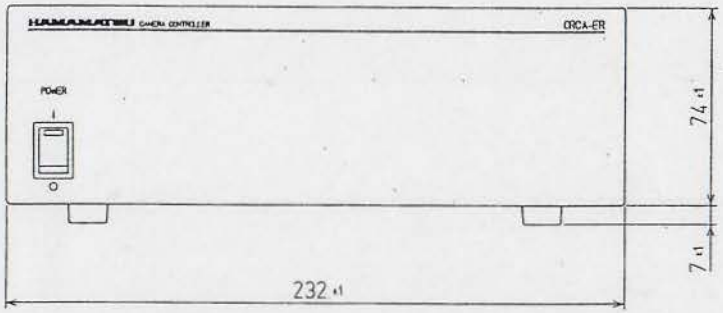


様式：A3図面枠B(51-51840-008-01)

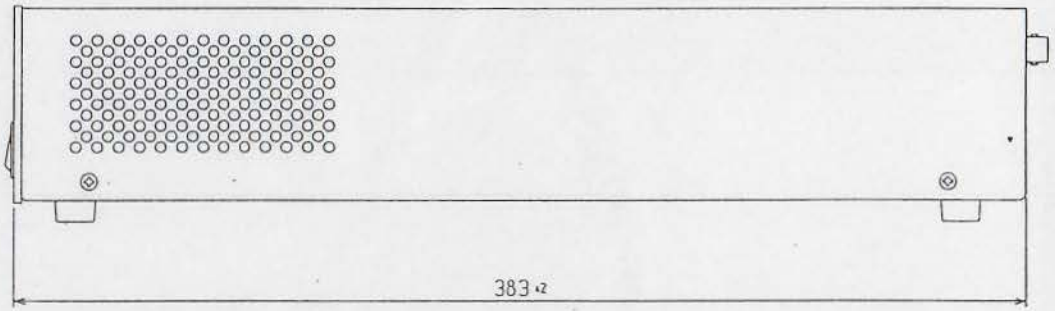
No.	品　名	図面番号,型名	数量
1			



背面



正面



側面

塗装色

正面パネル	ライトグレー
カバー	ダークグレー

質量　約6.3kg

ALT.	MARK	DESCRIPTION	SIGN	DATE

DATE 作成日 2000.07.10

APPD. 承認 | CHCK. 審査 | DESN. 作成

渡瀬 機構G

HAMAMATSU

TITLE 品名 ORCA-ER CCU外観図

DRAW.NO. 図面番号 MB2-049-3T1001