

CCD Video Camera Instruction Manual



5 Mega pixel Progressive Scan Color Camera

FS5000HECL

- We greatly appreciate your confidence choosing our TAKEX CCD Video Camera.
- Please read this manual and the attached guarantee certificate carefully and manage the camera properly. Keep this manual at hand and reread it whenever you are uncertain about the operation.

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[Revision history]

	Version	Revised contents	Articles	Date	Document No.	Remarks
1	1 st version	--	Initial version	2005-12-16	M05C16	
2	2 nd version	Error correction	Correction of frame rate	2006-03-01	M06301	
3	3 rd version	Correction of terminology	Add Draft scan on table(5-2)	2006-05-24	M06524	
4	4 th version	Error correction	Correction of low speed shutter time (table 6-1).	2006-05-30	M06530	
5	5 th version	The modification associated with the design change of the front-end	Change of the number of fixing holes at front-end.	2007-03-15	M07315	
6	6 th version	Error correction	Correction of serial communication stop bit length (section 7)	2007-06-18	M07618A	
7	7 th version	Error correction	Correction of outside dimensions	2008-04-17	M08417A	
8	8 th version	Error correction	Correction of Pin layout table(3-2)	2008-06-27	M08627	

Description of special remarks used in this manual

(Note)..... Particulars which require the user's attention are explained.

(!)..... Particulars which require the user's close attention in terms of comparison with the conventional products are explained.

[Terminology]..... Terms specifically defined for the purpose of describing the operation of this camera are explained.

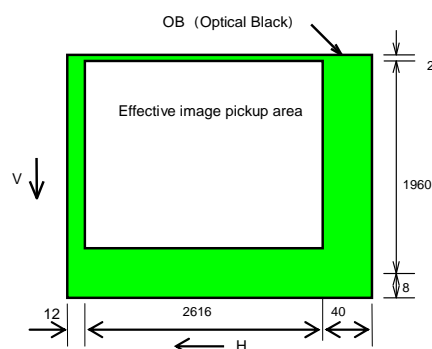
[Explanation]..... Particulars for which details may be needed for user's understanding of the operation of this camera are explained.

1. Features

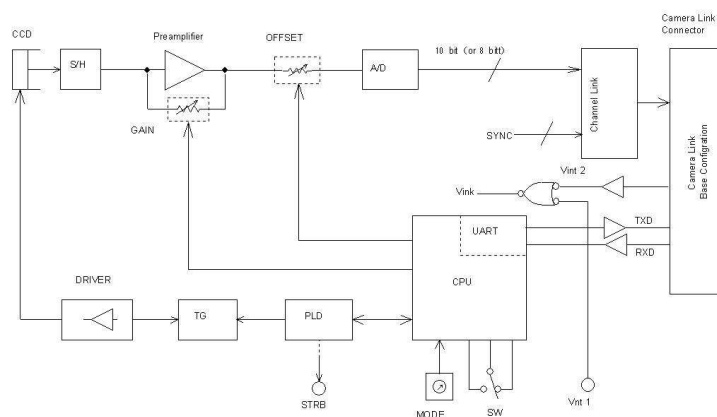
- FS5000HECL is a full frame shutter camera incorporated with 5 megapixel, 2/3"-size CCD image sensor.
- High resolution full frame color image can be obtained when used in combination with the capture board which has color conversion function (Bayer to RGB).
- A full frame shutter image can be obtained at a rate of 5 frames per second.
- 10 bit (or 8bit/selectable) digital image signal output complying with Camera Link (Base Configuration).
- The internally set values of the camera can be externally controlled with serial communication via Camera Link.
- The character information of the current setting status of the camera can be superimposed over the captured image on the screen. (On Screen Display function)
- The monitoring function for measuring the internal temperature of the camera.
- The asynchronous shutter is applicable in the existing preset shutter mode and the pulse width control mode and additionally in the double pulse mode.
- The camera is designed so that the strobe signal can be output even in the continuous shutter mode, and this contributes to the power saving for LED lighting and others as well as the reduction of smear.
- The ID information set by the user for each camera can be saved and read out whenever necessary (via serial communication link).

2. Outline

Image sensor		Progressive scanning, interline	
		2/3 inch	
Number of effective pixels		5 megapixels	
Read out scanning	Horizontal	10.30	KHz
	Vertical	5	Hz
	Clock	32.50	MHz
Electronic shutter		1/10000 ~ 1/5 second (Continuous shutter / Asynchronous shutter)	
Video output signal		Digital 10bit Complied with Camera Link (Base Configuration)	
Scanning mode		Normal scanning for all pixels (5 fps)	
		Partial scanning for central part (10 fps)	
		Draft scanning (35.7 fps)	

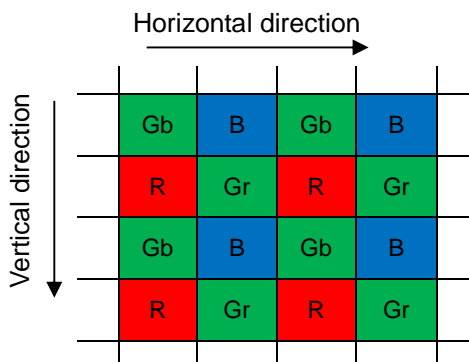


Block chart of this equipment



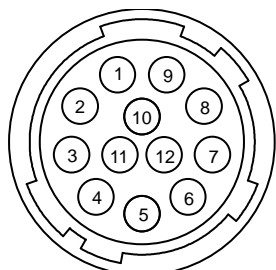
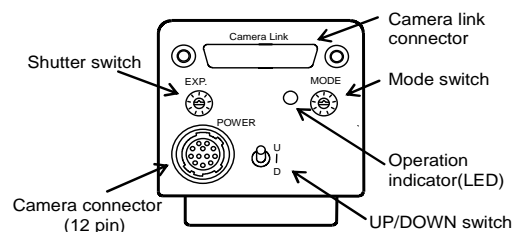
Color coding

The Bayer color filter array is adopted for a RGB primary color filter arrangement.(See right figure.) Gb or Gr in the right figure represents Green filter on the same line as Blue filter or Red filter respectively.



3. Description of Each Component

- (3-1) Description of rear panel of camera
Panel to set up operation mode, electronic shutter speed and other parameters and to connect each output connector
- (3-2) Camera connector (HRS HR10A-10R-12PB)
The pin arrangement of the camera cable connector (12 pins) and the signals assigned to those pins are shown in the following table:



(Pin arrangement viewed from the outside of the camera)

Pin No.	Signal name	Description	I/O
1	GND (0V)	Power ground	
2	+12VDC	DC power input	(In)
3	(AGND) *1	Analog signal ground	
4	NC *2	No contact	
5	GND	Signal ground	
6	Vinit1	Input for external trigger	In
7	Ext-VD	Input for external VD	In
8	GND	Signal ground	
9	Ext-HD	Input for external HD	In
10	GND	Signal ground	
11	STRB	Strobe signal output	Out
12	GND	Signal ground	

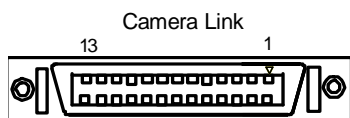
*1 (AGND) is Analog signal ground. Do not assign any signals for this camera.

*2 Normally, Do not assign any signals to the NC pins .

- (3-3) Camera Link connector (3M / MDR-26 FEMALE)
The pin arrangement and the signals assigned to those pins are shown in the following table:

[Pin arrangement of Camera Link connector (MDR-26 Connector)]

Pin No.	Signal name	Twin-ax cable assignment	Pin No.	Signal name	Twin-ax cable assignment
1	inner shield	shield	14	inner shield	shield
2	X0-	PAIR1-	15	X0+	PAIR1+
3	X1-	PAIR2-	16	X1+	PAIR2+
4	X2-	PAIR3-	17	X2+	PAIR3+
5	Xclk-	PAIR4-	18	Xclk+	PAIR4+
6	X3-	PAIR5-	19	X3+	PAIR5+
7	SerTC+	PAIR6+	20	SerTC-	PAIR6-
8	SerTFG-	PAIR7-	21	SerTFG+	PAIR7+
9	CC1-	PAIR8-	22	CC1+	PAIR8+
10	CC2+	PAIR9+	23	CC2-	PAIR9-
11	CC3-	PAIR10-	24	CC3+	PAIR10+
12	CC4+	PAIR11+	25	CC4-	PAIR11-
13	inner shield	shield	26	inner shield	shield



External view of Camera Link connector
(Viewed from the outside of the camera)

(Note) The pins of Camera Link connector are differently laid out for the camera (upper table) and for the capture board.

Note that the connection numbers of the cable for the capture board are opposite to those for the camera as described below:

1 = inner shield,	14 = inner shield
2 = CC4-,	15 = CC4+
3 = CC3+,	16 = CC3-
....
12 = X0+,	25 = X0-
13 = inner shield,	26 = inner shield

(Pin layout on frame grabber board side)

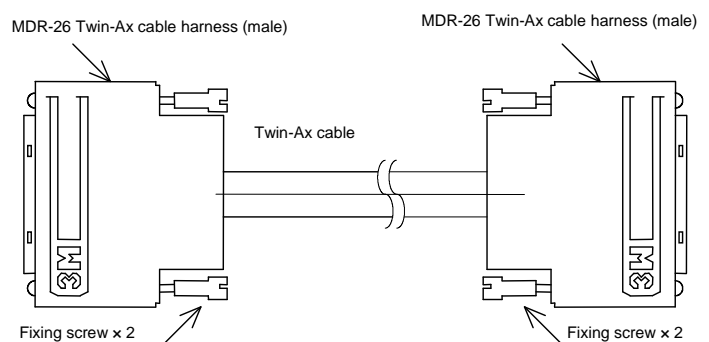
[Table of Camera Link bit assignment] (showing correspondence relation between before and after encoding)

Camera Link port (Node name)	Camera signal name	I/O	Remark
Strobe	CLK	O	Pixel clock
LVAL	LDV	O	Horizontal synchronous timing
FVAL	FDV	O	Vertical synchronous timing
DVAL	-	O	(Fixed to H level)
Spare	-	O	(Fixed to H level)
PORTA0	D0 / (D2)	O	Lowermost data
PORTA1	D1 / (D3)	O	
PORTA2	D2 / (D4)	O	
PORTA3	D3 / (D5)	O	
PORTA4	D4 / (D6)	O	
PORTA5	D5 / (D7)	O	
PORTA6	D6 / (D8)	O	
PORTA7	D7 / (D9)	O	
PORTB0	D8 / (L)	O	
PORTB1	D9 / (L)	O	Uppermost data
PORTB2, 3, 6, 7	L	O	(Fixed to L level)
PORTC0 ~ 7	L	O	(Fixed to L level)
CC1	Vinit2	I	Asynchronous shutter trigger
CC2	(reserved)	I	(Reserved for future products)
CC3	(reserved)	I	(Reserved for future products)
CC4	(reserved)	I	(Reserved for future products)
SerTFG	TXD	O	URAT transmission data (Same timing as conventional RS-232C)
SerTC	RXD	I	URAT reception data (Same timing as conventional RS-232C)

* The port assignment is in conformity to “**Base Configuration**”, the standard of Camera Link.

* 8 or 10 bit digital image signal output complying with Camera Link STD (Base Configuration) can be obtained.

* Indicators in parenthesis corresponding to camera signal name PORTA(0) to PORTA(7), PORTB(0) to PORTB(1) are bit assignment for 8 bit output. The factory default is 10 bit format (10 bit×1) for image signal data.



External view of Camera Link cable assembly

4. How to Operate

(4-1) Connection method

- Connection

Refer to the connection example between the camera and peripheral devices (Fig. 4-1).

- (1) Remove the cover of the lens attachment section and attach a lens (option).
- (2) Connect the camera head to a power supply unit (option) with a camera cable (option).
The maximum allowable length of a camera cable is 25 m.
- (3) Set the camera operation modes in accordance with the setting instructions for the operation modes and the shutter speed that are described in another section.
- (4) Connect the digital output connectors on the rear panel of the camera to the input terminals of the image processing units (frame grabber board, computer, etc.) with digital cables (option) conforming to Camera Link STD. The maximum allowable length between the digital output connector of the camera and the input terminal of said image processing unit is 10m.

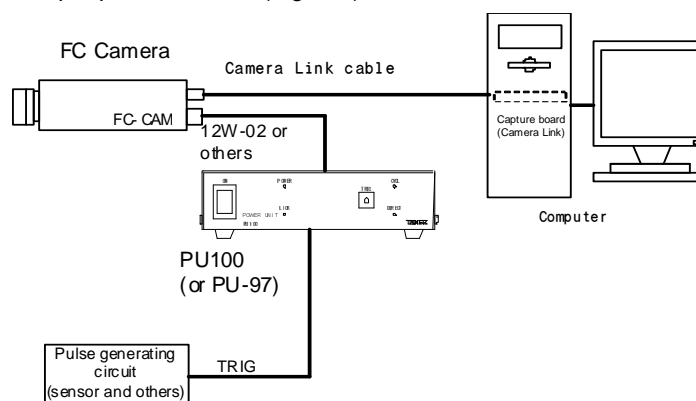


Fig. 4-1 Connection example between camera and peripheral devices

- (5) Confirm the connecting condition before turning on the power switch of the camera.
In 1 or 2 seconds after the power is turned on, the LED operation indicator on the rear panel of the camera changes from orange to green to show that the camera is in operation.

- (Note) It is required that the capture board should have the color conversion function (Bayer to RGB conversion) to obtain color images by this camera.
- (Note) The maximum allowable lengths of the camera cable and the digital cable aforementioned are not for the purpose of guaranteeing the operation of the camera. Proper image signals may not be obtained even when the cables are within the allowable ranges, depending on the installation conditions of the camera, cables in use and others.

[Important]

- (Note) Make sure to turn off the power switch of the camera before connecting or disconnecting the camera cable. If the cable is connected or disconnected while the power is supplied, troubles may be caused.
- (Note) Make sure to turn off the camera and connected devices in advance when the camera is connected.
- (Note) When a power supply unit other than Takenaka's product that are separately sold is used, make sure that it complies with the following rated specifications:
- Power supply voltage: DC12V±10%
 - Current capacity: 500mA or over
 - Take into consideration the fact that inrush current of about 1A flows in when power is applied.
 - Ripple voltage: 50mVp-p or less (recommended value)
 - Connector: 12 pin connector 1 pin (GND), 2 pins (+12VDC)
- (Note) ~~Some power supply units other than TAKENAKA's products have different layout of power connection pins. Make sure to check the compatibility of the power supply unit and the camera connection pins in advance.~~
Carefully note that any failure associated with power application to out-of-specification pins and others is subject to charged repair.

(4-2) Input of Vinit signal (asynchronous trigger signal)

- How to input Vinit signal

If the camera is used in the asynchronous shutter mode, the Vinit signal (asynchronous trigger signal) must be input from the user side unit.

The Vinit signal is input from Pin (6) of the "POWER" connector (12 pin connector) on the rear of the camera, or is input as the CC1 signal from the "Camera Link" connector.

If the camera is connected to the power supply unit, PU100 (or PU-97), with a cable of Takenaka's 12W series, connect the Vinit signal (asynchronous trigger signal) to the trigger input terminal ("EXT" BNC for PU-97) of the power supply unit (PU100).

(Note) OR operation (negative OR) is implemented inside the camera between Vinit1 input signal from Pin (6) of "POWER" connector and Vinit2 input signal as CC1 signal of "Camera Link" connector (see the figure below).

(Note) If either one of those are fixed to the L level (active state), the Vinit signal (logical sum) is also fixed to the L level and the trailing edge signal cannot be obtained. This would result in failure in starting up the asynchronous shutter operation. Make sure to fix the input signal on the unused side to the H level, to keep it at high impedance level or open state (no connection).

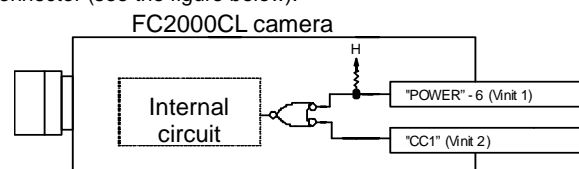


Fig. 4-2 Internal connection of Vinit signals

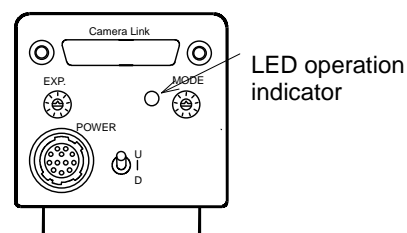
- LED Vinit signal monitor indicator

When this camera is set in the asynchronous shutter mode, the LED indicator on the rear panel of the camera lights up in red for one shot in response to the input of the external trigger signal (Vinit signal).

This allows the user to confirm the state of signal input.

The red LED lights up for a certain period of time (about 100 ms) on each trailing edge of the trigger input pulse. If a next trigger signal is input within this period, the lighting time of the LED will be retriggered and extended.

Since the lighting of the LED responses only to the trailing edge of the trigger input, it lights up only once for 100 ms even if the trigger input pulse duration is longer than the one shot time of period.



Red LED lights up in response to trigger signal input (Vinit).

- Setting of various asynchronous shutter modes

Set the parameters and others in accordance with the following table:

Table 4-1 Setting of various asynchronous shutter modes

Asynchronous shutter mode	2 TRIG	PWC	Shutter switch	Remark
Preset shutter (PWC=DISABLED)	DISABLED	DISABLED	1 to 9	
Preset shutter (PWC=ENABLED)		ENABLED	1 to 8	
Pulse width control	ENABLED	ENABLED	9	Shutter switch = 1 to 8: same as preset shutter
2 TRIG (Double pulse)		ENABLED	9	Shutter switch = 1 to 8: same as preset shutter (NOTE !)

(Note) When shutter switch is 0, "Continuous image output(without shutter)" is applied for the all.

(Note) For setting methods for the respective parameters of "PWC" and others → See "(6-3) How to set operation mode".

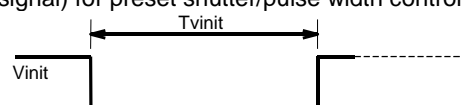
(Note) When it is set to "2 TRIG=ENABLED" and "PWC=ENABLED" and the shutter switch is positioned from 2 to 8, only if the trigger pulse is input in the order of "TRIG-A"→"TRIG-B" at a time lag longer than 1 horizontal synchronous interval, preset shutter operation starting at trailing edge of "TRIG-A" is initiated.

- Recommended timing of asynchronous shutter trigger signal (Vinit signal) for preset shutter/pulse width control

For the case of preset shutter mode, the negative logic pulse is applied within the width range from 1 H (1 horizontal synchronous interval) to 1 msec as described below.

For this case, the exposure operation starts in synchronization with the HD(horizontal synchronous signal) trailing edge inside the camera after and closest to the trailing edge timing of the applied pulse.

For the case of the pulse width control exposure mode, numeric value of the L level interval of the input Vinit pulse (shown as T_{vinit} in the figure) is retrieved in synchronization with the HD trailing edge inside the camera, and the integer multiple number of H (1 horizontal synchronous interval) that is closest to the retrieved Vinit pulse duration is transmitted as nH to the inside of the camera. Then the shutter speed is determined in response to the time nH .



[For the case of preset shutter mode]

$$1H(100\mu s) \leq T_{vinit} \leq 1ms$$

(The shutter speed is independent of the Vinit width.)

[For the case of pulse width control mode]

(Where PWC=ENABLED, shutter switch = 9)

$$nH \leq T_{vinit} < (n+1)H \quad (n \text{ is } 1 \text{ or larger integer.})$$

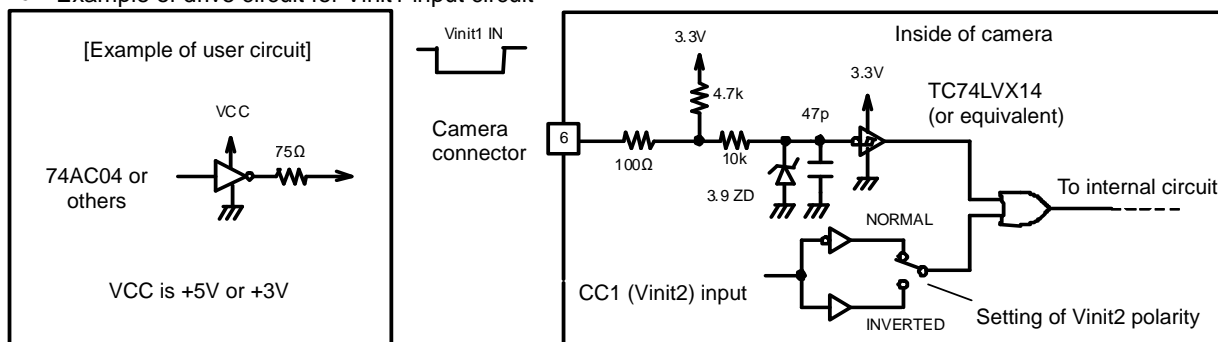
(This is the pulse width where shutter exposure time = nH)

Fig. 4-3 Recommended Vinit signal timing waveform

(Note) In the pulse width control, the shutter exposure time is almost equal to the integral multiple number of the horizontal synchronous time (H) that is closest to the Vinit pulse duration. More specifically, however, the shutter exposure time is indefinite for the time period corresponding to 1H width in the case of normal external trigger input (or the case where the Vinit signal is not in synchronization with the horizontal synchronous timing of the camera) → Refer to the timing chart described in another section for the details.

(Note) When the shutter exposure time is too long in the pulse width control mode, the S/N ratio of the image will be degraded due to the reduction of dynamic range of CCD, accumulation of thermal noise components of CCD image sensor in proportion to the shutter speed and other factors. Therefore, if a long exposure time is employed, it is recommended to conduct experiments using realistic exposure times in actual conditions to check for the appropriateness.

- Example of drive circuit for Vinit1 input circuit



* The Vinit signal should not include unnecessary noise components such as chattering.

- Polarity reversal of Vinit2 input

The input polarity of the trigger signal (Vinit2) to be applied via CC1 of Camera Link can be inverted.

Some capture boards may have the polarity of the trigger signal input from CC1 that is fixed to positive logic (L level at normal/H level at active), which is not compatible with the trigger signal of negative logic input (factory preset polarity of this equipment). In this case, the input polarity of the trigger signal (Vinit2) via CC1 can be inverted to change from negative to positive logic by the setting of the camera.

→ Refer to “(6-3) How to set operation mode” for the specific setting method.

(Note) The setting of the polarity reversal is valid only for Vinit2. The input polarity of Vinit1 is always negative logic regardless of this setting.

(4-3) Asynchronous shutter / Double pulse mode

The camera can operate in double pulse mode (2-trigger mode) which controls shutter exposure time by the time interval of two input pulses, applying independent dual negative logic pulses as trigger signals.

- Trigger input pins

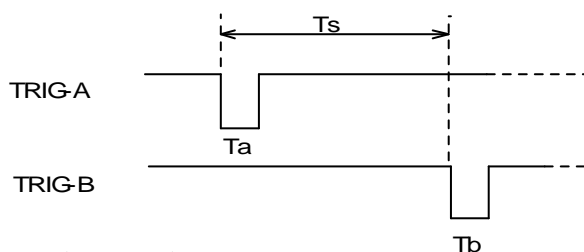
The pin arrangement of trigger input pins (in Camera connector) are shown in the table below.

(Camera connector) Double pulse mode input pins

Pin No.	Signal name	Description	I/o
7	TRIG-A	Trigger input A	In
9	TRIG-B	Trigger input B	In

(Note) Normal trigger inputs (Vinit1, Vinit2) for asynchronous shutter operation are not used. Keep it open state or H level.

- External sync operation by HD/VD.
External sync operation by HD/VD signal is not available in double pulse mode, as each input pins used for Ext-VD and Ext-HD at normal setting are used for trigger signal input.
- Setting for double pulse mode
Set it in accordance with the table 4-1” Setting of various asynchronous shutter modes”.
- Recommending timing for double pulse trigger signal
The negative logic pulse is applied to TRIG-A, TRIG-B input pins within the width range from 1 H (1 horizontal synchronous interval) to 1ms, as shown in right figure.
- Level of input signal
Sync input signal level is 2 to 5 V p-p (within the level range from -0.5V to 5V), in contact state to TRIG-A, TRIG-B input pins.



$$1H \leq T_a, T_b \leq 1ms \quad [T_a, T_b]$$

(Shutter exposure time is independent of these pulse duration.)

[Shutter exposure time in Double pulse mode]

$$nH \leq T_s < (n+1)H \quad (n \text{ is } 1 \text{ or larger integer})$$

(This is the time difference where shutter exposure time = nH)

(4-4) Input of external synchronous trigger signal(Ext-HD/VD)

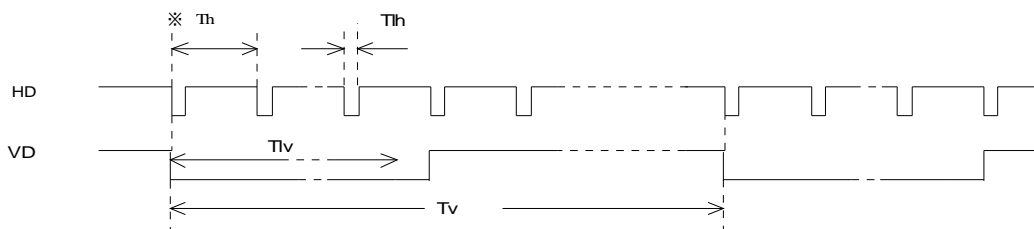
- How to input external synchronous trigger signal

When more than one cameras are used in synchronization state, it is necessary to input external synchronous signal (Ext-HD/VD signal) from user side equipment. When it is needed to synchronize horizontal timing, input HD signal. Input HD and VD signals to synchronize both horizontal and vertical timings.

(Note) Note that the delay jitter may occur between externally supplied HD signal and HD signal within the camera, when horizontal operation timing is synchronized by external synchronous signal,

(Note) When in asynchronous mode, only the HD signal is effective as an external sync signal. In that case, VD signal is neglected. Normally, do not apply VD external sync signal in asynchronous shutter mode.

- Recommended external sync signal



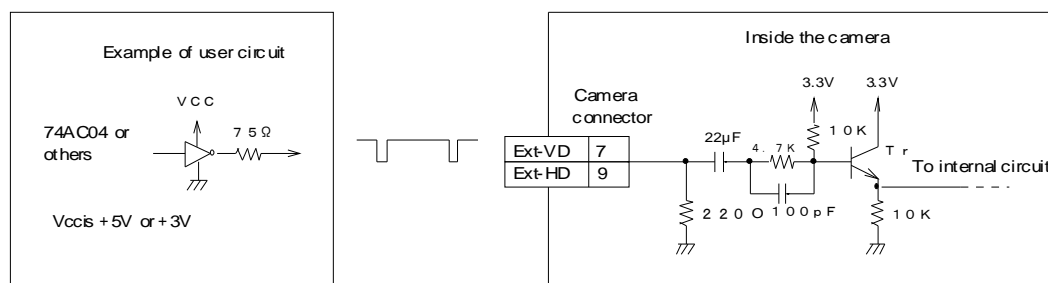
Scan mode	Parameter				
	Th	Tv	Tlh	Tlv	VD↓ / HD↓ phase error
Normal scan mode	97.11 μ s \pm 1 %	2056 \times Th	0.1 \times Th \pm 10 %	9 \times Th	0 \pm 1.0 μ s
Partial scan mode	↑	1028 \times Th	↑	↑	↑
Draft scan mode	112.37 μ s \pm 1 %	249 \times Th	↑	↑	↑

[Important]

(Note) Make sure to follow the conditions of "Recommended external sinc signal". If the signals of incorrect timing or incorrect level are input, troubles may be caused.

(Note) When the camera is used in the asynchronous shutter mode / double pulse mode, set the camera operation mode to double pulse mode ("2 TRIG-ENABLED") before the trigger signal is input to TRIG-A, TRIG-B. If the trigger signal is input before the camera is set to double pulse mode, the camera may malfunction as if external sync signal is applied at abnormal timing.

- Example of external sync input circuit and drive circuit

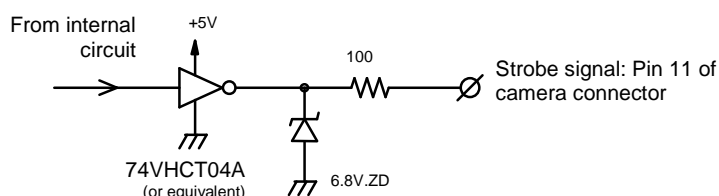


※ The Vint signal should not include unnecessary noise components such as chattering.

(4-5) Other input/output circuit

- Strobe signal output circuit

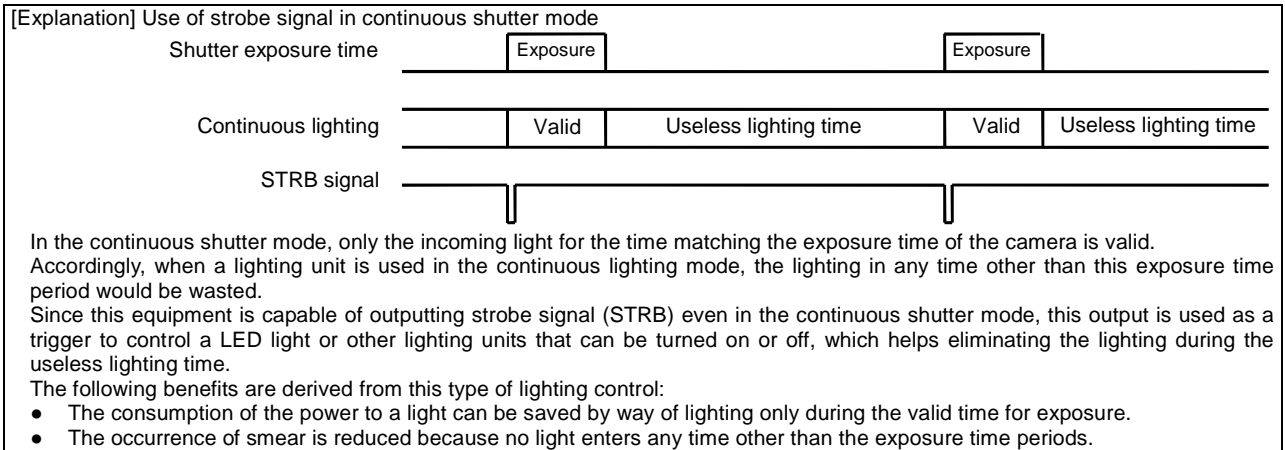
The internal output circuit is shown in the right figure.



(4-6) Strobe signal in continuous shutter mode

Although conventional cameras output the strobe signal (STRB) only in the asynchronous shutter mode, this equipment is capable of outputting the strobe signal even in the continuous shutter mode by changing the settings.

The default setting is OFF (no strobe signal in continuous shutter mode). This setting can be changed on the configuration menu (Operation Mode Setting Group C) or by way of rewriting the configuration register with serial communication commands.



(Note) When the strobe signal is used in the continuous shutter mode to make ON/OFF control on a lighting source unit, the following must be taken into consideration:

Wherever possible, use a strobe lighting unit or others that are equipped with a power source separated from that of the camera (electrically isolated power source) and a trigger input terminal (photo coupler input, etc.). If a lighting unit that shares a power source or a ground circuit with the camera is turned on or off by the strobe signal, the image output from the camera may have noise due to the influence of the fluctuation of the power supply voltage or change in the electric potential that occurs at the ON/OFF timing.

Even when the insulation aforementioned is applied, the electromagnetic induction may lead to the occurrence of noise on the image signal if the electric current of the lighting unit to be control is large. In this case, a measure must be introduced to reduce electromagnetic induction noise arising from the lighting unit.

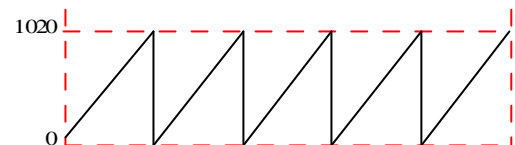
(4-7) Test pattern display function

When initially connecting this camera to an image capture board, the use of the test pattern display function of the equipment makes it easier to confirm that the output timing of the camera and the details of the signal connection match the particulars of the capture board.

When the test pattern function is set to be ON, the image sensor outputs not pictures but the test pattern as shown on the right.

As for this pattern, a numerical value of 4 is simply added in an incremental manner for every horizontal pixel, and a saw-tooth profile is shown in the range of numerical value of 0 to 1020.

(when set at 10bit gray scale) (Lower part of the right figure)



(Note) In this camera, Bayer array RGB signal is normally output, but output signal is of B/W when this test pattern function is used.

(Note) In the higher-order 8 bits out of 10 bits data, a numerical value of 1 is incrementally added for every horizontal pixel in the range of 0 to 255 for the case of 8 bits output.

And it's in the range of 0 to 1020 for the case of 10bits output, as lower-order 2 bits of 10 bits data are fixed to zero.

(Note) The value does not start with 0 at the edge of the effective image area.

(Note) The output values of the test pattern are not affected by the values of the gain setting or offset setting of the camera.

The default setting is OFF. This setting can be changed on the configuration menu (Operation Mode Setting Group D) or by way of rewriting the configuration register with serial communication commands.

(4-8) Monitoring function for internal temperature of camera

This camera is equipped with an internal temperature sensor to monitor the temperature inside the body. This function makes it possible to use the camera in a safer way even in a harsh environment in terms of temperature, for example use in the open air. With the use of serial communication commands, this function also works to control the forced air-cooling fan of the camera and peripheral devices and others.

• How to monitor internal temperature of camera

The following two methods are available for monitoring the internal temperature of the camera:

- Turn on the MENU display and confirm it by the OSD over the image. (Temperature to be displayed in Celsius)
- Confirm it by temperature data to be returned in response to the RS-232C command ("RTMP" command). (Numerical conversion required separately)

(Note) Carefully note that the temperature data obtained by this monitoring function is not for the ambient temperature but the internal temperature of the camera. As a general rule, the internal temperature of the camera is higher than the ambient temperature because of the heat generation associated with the consumed electric power inside the camera.

Even when the temperature monitored by this function exceeds the value of the "Operation ambient temperature" shown in the specifications of the camera, no operational trouble will be caused as long as the ambient temperature is equal to the one of the specifications or lower, and sufficient countermeasures against temperature are taken.

- Detection performance for temperature data

Temperature resolution :	0.5°
Update interval of data :	0.4 sec.
Temperature detection accuracy:	±2°C (-40°C to +85° C), +3 to -2°C (55°C to 125°C)
Effective data range :	-55°C to 125°C (as long as the operation ambient temperature of the camera is within the range defined by the specifications.)
- Temperature data by RS-232C communication

The temperature data to be returned in response to the "RTMP" command of RS-232C is generated in the following format:

[Data format]

The lower 10 bits out of the 16 bits of the returned data are valid.

XXXXXD9D8...D0 (invalid upper 6 bits/valid lower 10 bits as the data)

Db=B'D9D8...D0 in the binary system shows a signed integer value in two's complement form.

However, the effective range of the temperature data is limited to the following due to the operational restriction of the temperature sensor:

Effective range of temperature data: -110 (-55°C) to +250 (125°C)

(Note) The accuracy of the values of the temperature data is not guaranteed when the operation ambient temperature is not within the range defined by the specifications.

[Conversion method from returned data to temperature in Celsius]

The temperature in Celsius is computed as T_c from the following formula where D_t is the signed integer number converted from the above described 10 bit binary value of "Db=B'D9D8...D0":

Internal temperature of camera: $T_c = D_t \times 0.5^\circ\text{C}$

(Example 1) Where T_d , the returned value of the temperature data, is "H'0032" in the hexadecimal system, it is expressed in the binary system as follows:

$T_d = \text{H}'0032 = \text{B}'0000.0000.0011.0010$

$\therefore \text{Db} = \text{B}'00.0011.0010 = +50$ (Only upper 10 digits of T_d are valid.)

Then, T_c is calculated from the following formula: $T_c = +50 \times 0.5^\circ\text{C} = +25^\circ\text{C}$

(Example 2) Where T_d , the returned value of the temperature data, is "H'03FA" in the hexadecimal system, it is expressed in the binary system as follows:

$T_d = \text{H}'03FA = \text{B}'0000.0011.1111.1010$

$\therefore \text{Db} = \text{B}'11.1111.1010$ (Only upper 10 digits of T_d are valid.) $\rightarrow D_t = -6$ (↓ Refer to [Explanation])

Then, T_c is calculated from the following formula: $T_c = D_t \times 0.5^\circ\text{C} = -6 \times 0.5^\circ\text{C} = -3^\circ\text{C}$

[Explanation] Example of conversion algorithm from data in the complement number system to signed data

The following example shows how to convert 10 digit data in the complement number system into ordinary signed data:

- (1) Whether the value is positive or negative is determined by checking the uppermost bit (MSB) out of the 10 digit number. When the MSB is 0, "+" is added, and when it is "1", "-" is added to the number (absolute value) to be obtained in accordance with the below described (2).
- (2) The absolute value is obtained from a binary number expressed in the remaining 9 digits including the lowermost bit (LSB) as follows:
Simply convert into an integer number if the MSB is 0 ("+" sign) in accordance with (1).
Reverse each of all the 9 digits and add 1 to the result if the MSB is 1 ("-" sign) in accordance with (1).
- (3) The signed number is obtained from (1) for the sign and (2) for the absolute value.

* In the case of the (Example 2) as above, its sign is "-" because the MSB is 1 in accordance with (1). The absolute value is "6" because of $(\text{invert}(\text{B}'11111010) + 1 = \text{B}'00000101 + 1 = 5 + 1 = 6)$ in accordance with (2). Therefore, this value (D_t) is expressed as "-6" in the ordinary signed number system.

(4-9) Operation confirmation buzzer

This equipment is designed to sound the confirmation buzzer of “pip” when a stroke is applied to the UP/DOWN switch on the rear panel, or at the time of other manipulation including the start-up after power application.

The factory default setting is ON. This setting can be changed to cancel the buzzer.

[Procedure for switching buzzer between ON/OFF]

- Start up in the Setting Group C. (Set the mode switch to the position “C” while the power is turned off. Then apply the power while the UP/DOWN switch is positioned to either side.)
- Change the mode switch to the position 2” after confirming that the orange LED is flashing.
- When an upward stroke is applied to the UP/DOWN switch, the buzzer is set to be ON. When a downward stroke is applied, it is set to be OFF.
- Simply turn off the power after the setting is complete. (The setting is saved.)

(4-10) Camera ID saving function

The ID code and other information set by the user for each camera can be stored in the camera and read out wherever necessary.

The saved identification data for each camera including installation location in the case of using more than one camera

(e.g., “CAMERA-RIGHT” and “CAMERA-LEFT”) allows the user to easily control and identify the camera (s).

The setting is executed through the serial communication. The settable maximum number of characters are 15, and alphanumeric characters (both uppercase and lowercase characters) and some special symbols such as “+” and “-” excluding the control codes can be used.

(→ Refer to the section of “Serial Communication Control” for the details.)

5. Various Settings

(5-1) Operation mode

Operation mode is classified into two groups as follows.

- Electronic shutter operation mode
Shutter mode
No shutter / continuous / asynchronous
Shutter speed category
High speed/low speed/pulse width control
(See the right schematic diagram)
- Scanning system Normal scan / partial scan
→ Refer to the following page (Section 6) for the specific setting method.
- (!) This camera does not support the asynchronous shutter mode for the low speed shutter operation.
- Fast dump Fast-dump / No fast-dump

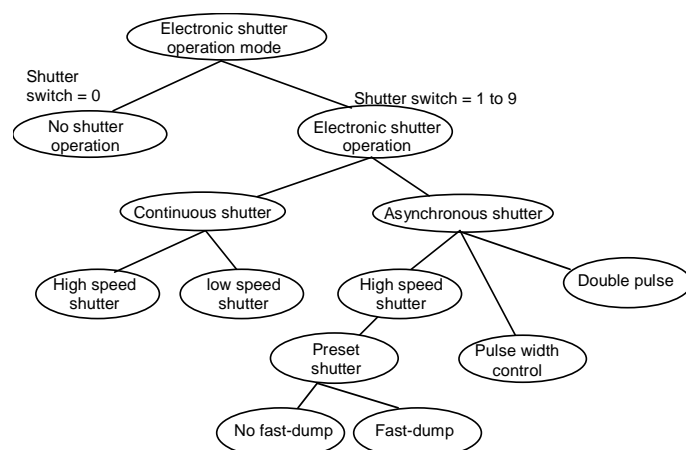


Fig. 5-1 Electronic shutter operation modes

Table 5-1. Description of electronic shutter operation modes

Shutter mode	No shutter	Electronic shutter is not used. Exposure time of image sensor is equivalent to one frame duration. Exposure is continuously performed for each frame.
	Continuous shutter	Repeats exposure regardless of external trigger input (Vinit). Repetition pitch is per frame.
	Asynchronous shutter	Electronic shutter is released each time the external trigger is input (Vinit). The permissible shortest repetition pitch is [exposure time + 1 frame duration].
Type of shutter speed	Normal shutter (High speed shutter)	Shutter, the exposure time of which is less than one frame, is used. The shutter speed can be set as a preset shutter speed at 9 different levels both for the continuous shutter/asynchronous shutter mode. (!) As for the shutter speed of the conventional FC series cameras, 8 different levels for the asynchronous shutter mode.
	Low speed shutter	The shutter, the exposure time of which is two frames or over, is used. (Only for continuous shutter mode) The shutter speed can be set as a preset shutter speed at 9 different levels. (Note) This camera allows this setting only for the continuous shutter mode.
	Pulse width control	In case of the asynchronous shutter setting only, the shutter, shutter speed of which corresponds to the pulse width (during an effective level) of the external trigger input (Vinit), is released. Shutter speed can be set as nH (n = 1 or larger integer number) in H (horizontal synchronous time) unit.
	Double pulse (2 Triggers)	In case of the asynchronous shutter setting only, the shutter, shutter speed of which corresponds to the time difference between two external trigger inputs (Trig-A, Trig-B), is released. Shutter speed can be set as nH (n = 1 or larger integer number) in H (horizontal synchronous time) unit.

Table 5-2 Description of other operation modes

Scanning system	Normal scan	The read out for each frame is conducted by the all pixel readout scanning (5Hz).
	Partial scan	The read out for each frame is conducted by the partial readout scanning (10Hz). The vertical width of the longitudinal picture area corresponds to approx. one-half of the central portion of the image pickup area.
	Draft scan	The read out for each frame is conducted by the draft readout scanning (35.7Hz). 4 lines out of every 16 lines are read out for all pixels.
	Fast-dump scan	Fast-dump scan is conducted in the asynchronous shutter mode. Smear which comes up in the high speed shutter mode is reduced only in the upper part of the image area

[Terminology] Preset shutter..... This refers to the shutter speed setting other than those specified by the pulse width control. More specifically, the shutter speed is preliminarily set by the shutter switch positions from "1" to "9" for the continuous shutter operation, or the shutter switch positions from "1" to "9" (PWC (where pulse width operation mode setting)=DISABLED) or from "1" to "8" (PWC (where pulse width operation mode setting)=ENABLE) for the asynchronous shutter operation. The shutter speed is defined in the Table 6-1.

[Terminology] Pulse width control This is the way of setting or controlling the shutter speed by the width of the Vinit signal that is externally input in the asynchronous shutter mode. With this camera, this is selected by setting as "PWC=ENABLED", "2 TRIG=DISABLED" in the asynchronous shutter mode together with the shutter switch position of "9".

(!) With the conventional products, the pulse width operation mode is always enabled when “9” is selected for the shutter switch in the asynchrony shutter mode. Carefully note that this camera, however, will be in the preset shutter mode when “PWC=DISABLED (prohibited)” is set, even if the shutter switch is positioned at “9”.

[Terminology] Double Pulse This is the way of setting or controlling the shutter speed by the time difference between two types of external trigger inputs (TRIG-A, TRIG-B) in the asynchronous shutter mode. With this camera, this is selected by setting as “PWC=ENABLED”, “2 TRIG=ENABLED” in the asynchronous shutter mode together with the shutter switch position of “9”.

[Terminology] High speed shutter This means the shutter of which shutter speed is shorter than 1 frame duration(=1 vertical synchronous time). The shutter speed is set as a preset fixed length of the 9 different levels that are determined by the position of the shutter switch (continuous shutter and asynchronous shutter).

[Terminology] Low speed shutter This means the shutter of which shutter speed is longer than 1 frame duration. The shutter speed is set as a preset fixed length of the 9 different levels that are determined by the position of the shutter switch (continuous shutter).

(!) This camera does not support the functions of “low speed/asynchronous shutter”.

[Terminology] Fast dump... It is able to reduce an effect of the smear in capturing images of high-intensity object only in the upper part of the image area, by rapidly dumping (sweeping out) charges of the transfer channel in CCD image sensor immediately after trigger signal is input in the asynchronous shutter mode.

[Explanation]

Fast-dump operation is effective in pre-set high speed asynchronous shutter mode.

When high-intensity subject including infra-red radiation is in the visual field, the phenomenon arises that even the low-intensity part is displayed whitely like a vertical streak, as the generated charges leak into the transfer channel for read-out even in the period out of the normal exposure duration.

This phenomenon is called “smear”, and it poses impediment for image processing when the shorter shutter speed is adopted as the relative contrast ratio gets higher than that of normal image part.

This camera is normally equipped with “Fast dump” function, and it is effective to reduce the smear (especially for the smear extending upward)

(See right figure)

When the fast dump operation is selected, the exposure starting time gets delayed as long as it takes to dump charges.



No fast dump

Fast dump

(5-2) Setting of shutter speed

The shutter speed is determined mainly by the shutter switch position from “0” to “9”.

When a shutter speed is specified using a communication command, the communication command is prioritized.

The shutter speed to be displayed is the one that is corresponding to the currently selected shutter switch position. When “7” is selected for the mode switch, the current shutter speed can be changed.

(Note) The change of the shutter speed is enabled only when the shutter switch is set to any positions other than “0”.

As long as the shutter switch is positioned at “0”, shutter speed cannot be changed even if “7” is selected for the mode switch and the UP/DOWN switch is manipulated. (The shutter is always OFF where the shutter switch = “0”)

→ Refer to the next section (Section 6) for the specific setting method.

(5-3) Level setting

The level setting is mostly divided into the following two groups:

- **Gain setting**
This is to set the gain (amplification ratio) of the preamplifier between the CCD image sensor inside the camera to A/D converter.
- **Offset setting**
This is to set the offset of the preamplifier between the CCD image sensor inside the camera to A/D converter.

→ Refer to the next section (Section 6) for the specific setting method.

(Note) As for the offset setting, it is recommended to use the factory default setting except for a special case.

(Note) Follow the procedure (gain setting → offset setting) if fine tuning of the offset value is required.

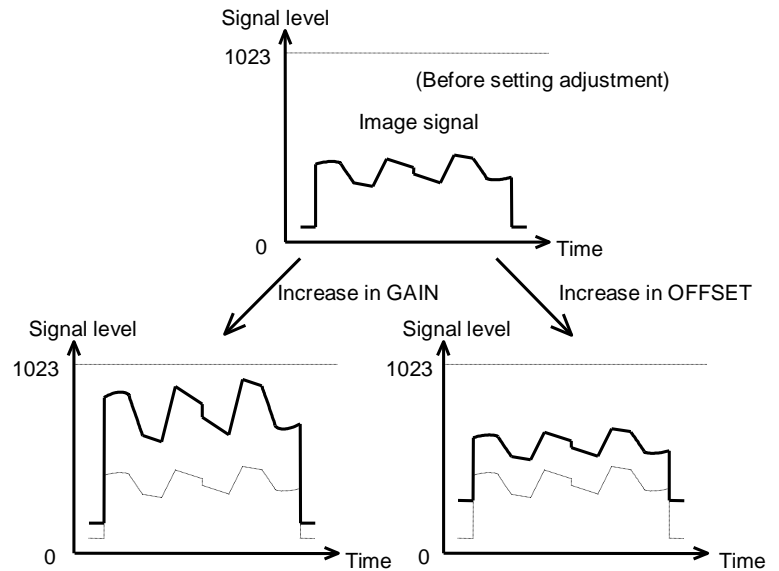
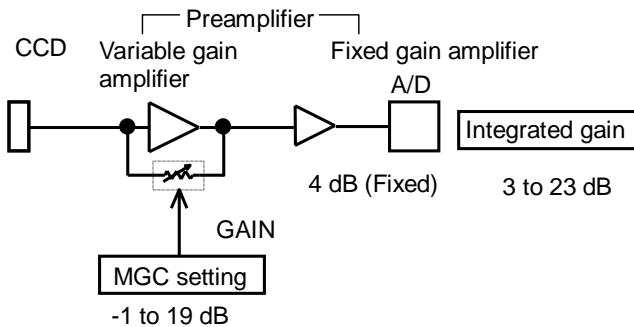


Fig. 5-2 Conceptual diagram of gain and offset levels

(5-4) MGC gain setting value



- **Gain variable amplifier and integrated gain**
The image signal output from CCD is amplified inside the camera through the following variable gain amplifier and then through the fixed gain amplifier before being input into the A/D converter.
The left block chart shows this flow.

(Note) The gain value (dB) described here is the one based on the CCD output (0 dB) as the baseline.

- **Correlation between MGC gain setting value and MGC gain**

The MGC setting value of this equipment is controlled by giving 0 to 255.

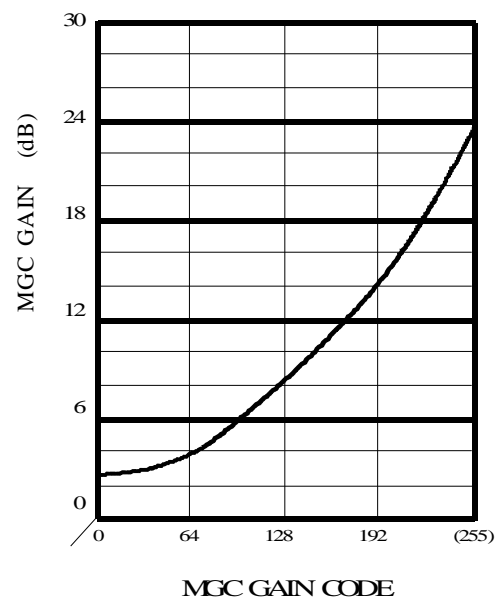
The correlation between this setting value and the MGC gain (integrated gain including the gain of the variable gain amplifier and that of the fixed gain amplifier) is shown in the right graph.

(Note) When the CCD element receives excessive light with a low gain value of the amplifier, the signals of the nonlinear area of the CCD element and the preamplifier are output at the high brightness area due to the restriction of the dynamic range of the CCD light receiving element.

In this state, unnatural image (Note below) may appear in the neighborhood of the saturating signal area of the image due to the characteristic of the nonlinear area. This phenomenon, which is associated with the saturation characteristic of the CCD element, is not a failure arising from the camera.

To eliminate this phenomenon, reduce the amount of light by stopping down the lens and newly set a higher gain value. Then, the output signal from the CCD element at the saturating area will be appropriately saturated into a white level for the output.

(Note) The above described unnatural image



represents the following states:

- Black and white look inverted at the saturating area.
- The outline of the saturating area is blurred.
- The saturating area slightly shifts upward or downward.
- The brightness value of the saturating area does not reach 1023.

(5-5) Output data gray scale setting

It is selectable any of the following as the output data format in Camera Link STD

- 10 bit gray scale (default)
- 8 bit gray scale

In 10 bit gray scale format, 10 bit image data are output using PORTB(1), PORTB(0), PORTA(7) to PORTA(0).

Meanwhile, in 8 bit gray scale format, only the higher-order 8 bits are output via Camera Link port of PORT(7) to PORT(0) omitting the lower-order 2 bits. (Refer to right table).

The setting is performed according to the input format of the capture board. The setting is changed by rewriting the configuration items or "CR" using serial communication command.

(5-6) Program page setting

The FC series cameras incorporate nonvolatile memories and various operation mode settings and level settings can be stored in them.

The setting items are stored in the virtual pages (hereinafter referred to as "program pages") inside the camera.

This camera has 6 program pages of "A", "B", "C", "D", "E" and "F" (right figure).

The camera starts operating according to the various settings stored in the relevant page when the mode switch is at any one of the positions from "A" to "F" at the time of power-on.

The camera starts operating according to the settings stored in the page "A" when the mode switch is at any position other than those from "A" to "F" at the time of power-on.

(Note) The memory area has the independent configuration area aside from the storage area of program pages. Common setting items(configuration items) are stored in this area.

Assignment of output data bit

Image data	Output port assignment	
	10bit × 1	8bit × 1
D9	PORTB(1)	PORTA(7)
D8	PORTB(0)	PORTA(6)
D7	PORTA(7)	PORTA(5)
D6	PORTA(6)	PORTA(4)
D5	PORTA(5)	PORTA(3)
D4	PORTA(4)	PORTA(2)
D3	PORTA(3)	PORTA(1)
D2	PORTA(2)	PORTA(0)
D1	PORTA(1)	
D0	PORTA(0)	

↑
(Default)

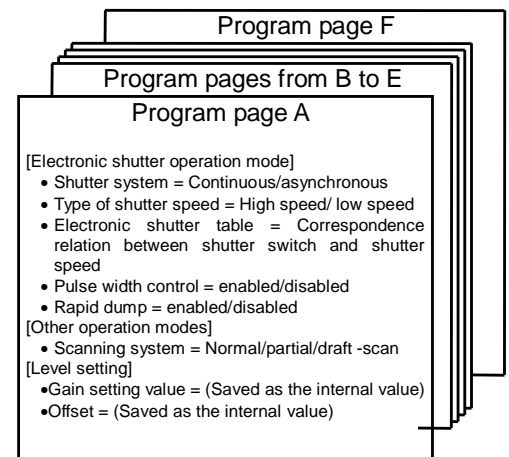


Fig. 5-2 Conceptual diagram of program page

6. How to Change Setting

(6-1) How to set shutter speed

The shutter speed is determined mainly by the setting positions of the shutter switch from “0” to “9”.

Table 6-1 Setting value of shutter speed

Position of shutter switch	High speed shutter (continuous/asynchronous)		Low speed shutter (continuous)	
0	No shutter (continuous)		1/5.0 second	(1V)
1	1/10000 second	(1H)	1/2.50 second	(2V)
2	1/3000 second	(3H)	1/1.67 second	(3V)
3	1/1200 second	(9H)	1/1.25 second	(4V)
4	1/600 second	(17H)	1/1.00 second	(5V)
5	1/240 second	(43H)	1/0.83 second	(6V)
6	1/120 second	(86H)	1/0.71 second	(7V)
7	1/60 second	(172H)	1/0.63 second	(8V)
8	1/30 second	(343H)	1/0.56 second	(9V)
9	1/10 second (1026H)	Pulse width control / asynchronous (!)	1/0.50 second	(10V)

(Note) (H) and (V) in the table represent the horizontal time unit and the vertical time (frame duration) unit respectively.

(Note) “No shutter” in the table means the continuous shutter mode with exposure time = 1 frame duration.

(Note) The value of each shutter speed is the factory default value. The shutter speed of each position (excluding shutter position = 0) is possible to change by the user in the operation mode [Group 1].

(Note) The expression on the second time scale in this table is not applicable on draft mode setting. →Refer to (6-7) for 1H time at Draft mode.

(!) As for this camera, it must be set to be “Pulse width control (PWC) = ENABLED” for implementing “Pulse width control /asynchronous” shutter operation .

When it is set to be “Pulse width control (PWC) = DISABLED” (default), the selection can be made out of the 9 levels not only for the continuous shutter operation but also for the asynchronous shutter operation.

(6-2) Start-up option

This equipment is operated after turning on the power in the normal manner (Terminology below) for the regular usage. The camera will be ready for special settings or specific modes when the mode switch is set to a specific position and a stroke is given to the UP/DOWN switch before the power is turned on. The start-up options are summarized in the following table:

[Terminology] Turning on the power in the normal manner

This means turning on the power while the UP/DOWN switch is kept at the neutral position. Unless otherwise instructed, “turning on the power” or “at the time of power-on” in this document refers to this type of action for turning on the camera.

Table 6-2 Start-up option

Start-up condition (at the time of power-on)		Start-up option	Operation state of camera at start-up
Position of mode switch	UP/DOWN switch		
Positions from 0 to A	Neutral position (no manipulation)	Regular operation (Setting Group 1)	Settings of program page A
Positions from B to F			Settings of program pages from B to F
9	Retention of UP or DOWN position	Read out of factory default	Settings of program page A
A		Setting Group 2	
C		Setting Group C	
D		Setting Group D	

(6-3) How to set operation mode

The setting items of the operation modes are divided into 4 groups of Group 1, Group 2, Group C and Group D as follows:

Group 1 This is for the operation mode to be changed when turning on the power in the normal manner. After start-up, set the mode switch to the position corresponding to the item to be changed and then manipulate UP/DOWN switch to change the setting.

Group 2 This is for the operation mode to be changed when setting the mode switch to the position “A”, pushing up (or pushing down) the UP/DOWN switch lever and holding it in the position before turning on the power. After starting up as above, change the position of the mode switch from said position “A” to the position corresponding to the item to be changed and then manipulate UP/DOWN switch to change the setting.

Group C and D These are mainly used for setting the configuration items (Terminology below).

The operation modes can be changed when setting the mode switch to the “C” (or “D”) position, pushing up (or pushing down) the UP/DOWN switch lever and holding it in the position before turning on the power. After starting up as above, change the position of the mode switch from said “C” (or “D”) to the position corresponding to the item to be changed and then manipulate the UP/DOWN switch to change the setting.

(Note) When any setting item is changed, it must be saved in one of the program pages from “A” to “F” before turning off the power to store the data in the memory of the camera. Carefully note that the new setting is not automatically saved and that the prior setting will be effective at the next time of power-on if the power is turned off before storing it. The configuration items, however, are automatically saved whenever they are changed.

[Terminology] Configuration items They are the common setting items that are independent of the program pages. These items are automatically saved in the internal EEPROM at the same time as they are changed by manipulating the switches on the rear panel.

Table 6-3 Start-up condition for each setting Group

Start-up condition (at time of power-on)		The groups of Operation Mode Setting	Operation state of camera at start-up
Position of mode switch	UP/DOWN switch		
Arbitrary position from 0 to F	Neutral position (no switch manipulation)	Group 1	By normal automatic loading (→ Table 6-2)
A	Retention of UP or DOWN position	Group 2	Start-up with the settings stored in program page A
C		Group C	
D		Group D	

Table 6-4 Set contents for Operation Mode Setting [Group 1]

Position of mode switch	Item to be changed	UP/DOWN switch	
		UP position	DOWN position
0	Change of gain	Increase in gain	Decrease in gain
1	Menu display (MENU) <* C>	ON	OFF
2	(Not used)		
3	Gain mode (GAIN)	MGC (MGC)	AGC (AGC)
4	Draft scan mode (SCAN)	OFF (NORMAL)	ON (DRAFT)
5	Shutter – continuous/asynchronous (S.FORM)	Continuous (NORMAL)	Asynchronous (ASYNC)
6	Shutter – high speed/low speed (S.TIME)	High speed (HIGH)	Low speed (LOW)
7	Change of shutter speed (S.TIME)	Longer	Shorter
8	Digital offset (OFFSET)	Increase in offset	Decrease in offset
9	Switch between normal scan/partial scan (SCAN)	All pixels (NORMAL)	Partial (PARTIAL)
A to F	Program pages from A to F	Write	Read

(Note) “Draft scan mode=ON” is put ahead of “Switch between normal scan/partial scan”. For example, When Partial (PARTIAL) at “Switch between normal scan/partial scan” and ON (DRAFT) at “Draft scan mode” are selected, scanning mode of the camera gets Draft mode.

(Note) The shutter speed can be changed only when the shutter switch is currently set at any other positions than “0”. When the shutter switch is positioned at “0”, the shutter speed cannot be changed even if the mode switch is set to the position “7” and the UP/DOWN switch is manipulated. (The shutter is always OFF where shutter switch = “0”).

Table 6-5 Set contents for Operation Mode Setting [Group 2]

Position of mode switch	Item to be changed	UP/DOWN switch	
		UP position	DOWN position
1	Menu display (MENU) <* C>	ON	OFF
2	(Not used)	-	-
3	(Not used)	-	-
4	Enabled/disabled for pulse width control (PWC)	ENABLED	DISABLED
5	Enabled/disabled for rapid dump (DUMP)	ENABLED	DISABLED
A to F	Program pages from A to F	Write	Read

(!) When the setting of “Enabled/disabled for pulse width control” is not set to be “ENABLED”, the pulse width control is not effective even if the shutter switch is set to the position “9” for the asynchronous shutter operation. In this case, the preset shutter in asynchronous shutter mode is effective.

(!) The rapid dump is able to use only in all pixels readout mode, preset asynchronous shutter operation.

Table 6-6 Set contents for Operation Mode Setting [Group C]

Position of mode switch	Item to be changed	UP/DOWN switch	
		UP position	DOWN position
1	Menu display (MENU) <* C>	ON	OFF
2	Operation confirmation buzzer (BZ) <* C>	ON	OFF
3	Serial communication baud rate (BAUDP) <* C>	19200 bps	9600 bps
4	(Not used) (-)	-	-
5	Double pulse mode (2 TRIG) <* C>	ENABLED	DISABLED
6	Polarity setting for Vinit2 (Vinit2) <* C>	Positive logic (INVERTED)	Negative logic (NORMAL)
7	Continuous shutter strobe signal (STRB-C) <* C>	ON	OFF

(!) This camera does not have the Clock phase setting item (CLOCK).

Table 6-7 Set contents for Operation Mode Setting [Group D]

Position of mode switch	Item to be changed	UP/DOWN switch	
		UP position	DOWN position
1	Menu display (MENU) <* C>	ON	OFF
2	Test pattern (PATTERN) <* C>	ON	OFF
3	Output bit (BIT) <* C>	10bit	8bit

* Notes in common with all setting groups

(Note) The standard factory mode (default) is underlined.

(Note) The items marked with <* C> in the table (configuration items) are automatically stored in EEPROM whenever they are changed.

(Note) The new settings of the other items than the configuration items are lost at the time of power-off unless they are manually saved in the program pages after changing them.

(6-4) Setting of program page

The setting operations for the program pages are roughly divided into 2 groups: save (writing the current setting into the program page) and load (reading out the setting that was previously saved in the program page as the current setting). More specifically, "save" means overwriting the new setting that was changed from the current one onto one of the program pages after turning on the power while "load" means the opposite operation that is reading out the setting saved one of the program pages as the current setting.

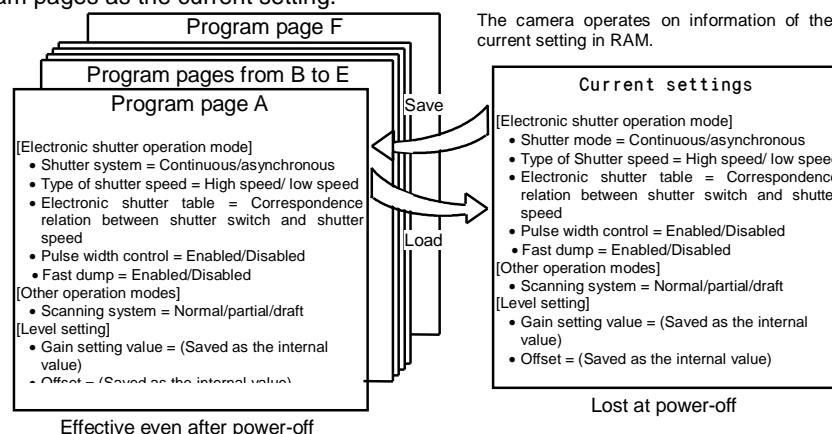


Fig. 6-3 Conceptual diagram of saving and loading operations

[Explanation] Correlation between current setting and program page

The setting information saved in the program page is automatically read out to RAM (volatile memory) when the camera is turned on, and that determines the operation of the camera as the current setting.

When the setting of a mode is changed, the older one is overwritten, and the new setting is temporarily effective as the operation setting for the camera until the power is turned off. The new setting in the program page on RAM, however, is lost when the power is turned off, and the old setting before power-on will be effective for the operation of the camera.

Accordingly, it is absolutely necessary to write the new setting in one of the program pages from "A" to "F" to save it.

The setting saved in the program page can be read out for use by the loading operation (including automatic load at power-on) as described later.

- Automatic load at power-on

When the power is turned on, the camera automatically loads the setting stored in one of the program page from "A" to "F", which determines the operation of the camera.

The program page of which setting is automatically loaded is determined by the position of the mode switch at the time of power-on.

(Note) Note that the setting of the program page "A" is automatically loaded when the switch is at any position other than "B" to "F".

- Manual load/save

Manual load/save of the setting from/to the program page can be enabled when setting the mode switch to one of the positions from "A" to "F" and manipulate the UP/DOWN switch after the power is turned on.

(Note) This saving operation must be performed to keep the new setting effective for later use after changing it.

Table 6-6 Automatically loaded program page

Position of mode switch	Automatically loaded program page
0 to A	Program page A
B	Program page B
C	Program page C
D	Program page D
E	Program page E
F	Program page F

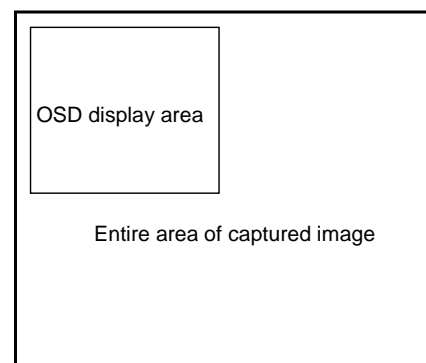
Table 6-7 Setting operation for program page (manual operation)

Position of mode switch	Item to be changed	UP/DOWN switch	
		UP position	DOWN position
A	Program page A	Save	Load
B	Program page B		
C	Program page C		
D	Program page D		
E	Program page E		
F	Program page F		

(6-5) Description of menu display by OSD (On Screen Display)

This camera is equipped with the OSD function of superimposing a character information on the output digital image signal. Using this function, the current setting status of the camera can be displayed over the image of the capture board in menu-driven form.

(Note) This camera is basically designed so that all settings can be done without this menu display by OSD just like the conventional cameras of FC series. However the menu display allows the user to quickly understand the current settings at a glance. Furthermore, if the contents of the menu display are captured and saved before collecting data using the camera, they serve as useful information to be referred when comparing data or setting additionally introduced cameras.



Display position by OSD

[Requirement for menu display]

The menu display requires a system that is capable of updating the captured image constantly responding to the timing of FDV/LDV to be output from the camera on the side of the user's capture board.

When the asynchronous shutter mode is set for the camera, the repetitive asynchronous shutter operations are automatically made at certain intervals to automatically refresh the image so that the menu display is updated. During this process, the externally input trigger signals are ignored.

The display area of OSD is located on the upper left on the entire area of the captured image, and therefore this system must be additionally capable of displaying this menu on the screen.

[ON/OFF operation of menu display]

If the OSD menu display does not appear on the capture image, perform the following procedure to display it:

Turn on the power in the normal manner → Set the mode switch to "1" → Apply an upward stroke to the UP/DOWN switch
To disable the output of the menu display, perform the same procedure except for applying a downward stroke to the switch.

(Note) Since the ON/OFF setting of the menu display is a configuration item, it is automatically saved in the internal EEPROM.

(Note) If the menu display is set to be ON in the asynchronous shutter mode, the repetitive trigger (cyclic trigger) that is generated inside the camera is automatically input. Make sure to set the menu display OFF when the camera is used in the normal state (online state).

(Note) Note that the difference between the pulse width generated by the camera with the menu display turned on and that provided by the user unit results in the difference in the brightness of image between those when the asynchronous shutter operation in the pulse width control mode is set (S.FORM=ASYNC/HIGH, PWC=ENABLED).

[Description of display content]

MENU 1, 2, C or D: Current setting is displayed.

The following is displayed:

"1": Set content of Setting Group 1

"2": Set content of Setting Group 2

"C": Set content of Setting Group C

"D": Set content of Setting Group D

MENU: Current menu status is displayed.
When the menu is being displayed, "ON" is kept displayed.
When "(CYCLIC)" is displayed on the right, the camera is cyclically outputting the asynchronous shutter image using the internal trigger to refresh the image.
When the asynchronous shutter mode is set and the menu is set to ON, the cyclic trigger input is automatically selected. When the menu is set to OFF, the cyclic trigger input is automatically cancelled and external trigger is ready to be received.

GAIN: The left number is the gain setting value expressed in the decimal system. (Range: 0 to 255).
The right part shows the effective one among AGC and MGC.

OFFSET: The set value of the digital signal offset is displayed in the decimal system. (Range: 0 to 255)

S.TIME: The current shutter speed is displayed. The left number is H number (horizontal synchronous time unit, in the case of high speed shutter – range: 1 to 1200 <normal scan> or range: 1 to 620 <partial scan> in decimal system) or V number (vertical synchronous time unit, in the case of low speed shutter – range: 1 to 255 in decimal system). The right number in parentheses shows the actual time.
The actual time is displayed after being converted in accordance with the settings of the scan mode (all pixels/partial/draft) and shutter mode (HIGH/LOW).

(Note) When the pulse width control mode or double pulse mode is set for the asynchronous shutter operation or when a shutter setting value is out of the predetermined range in the draft scan mode, the actual time is displayed as "--.-".

MENU1	
MENU	: *ON (CYCLIC)
GAIN	: 160 / MGC
OFFSET	: 140
S.TIME	: 257 h (33.38)ms
S.FORM	: ASYNC / HIGH
SCAN	: NORMAL / NORMAL
EXT=HD Tc= 45 deg	
MS=1 SS=7	MF=0000.0001
FS5000HECL [VX.XX]	

Menu display of Setting Group 1

- S.FORM:** The current shutter operation mode is displayed. The left is either continuous (NORMAL) or asynchronous (ASYNC), and the right is either high speed (HIGH) or low speed (LOW).
- SCAN:** The current scanning system is displayed on the left. It is either all pixel readout scan (NORMAL) or partial readout scan (PARTIAL), and the right is to select (DRAFT) or not to select (NORMAL) of Draft scan mode.
Actual scan mode is decided by these two setting items. Among two setting items, selection of Draft scan mode prevails.
- PWC:** Whether the position "9" of the shutter switch for the asynchronous shutter operation is used (ENABLED) or not used (DISABLED) is selected.
- DUMP:** Whether the fast dump operation for the (preset) asynchronous operation is used (ENABLED) or not used (DISABLED) is selected.
- BZ:** This is to switch between (ON) and (OFF) for the confirmation sound to be activated when switch manipulation is made.
- BAUD:** The baud rate used for RS-232C communication is displayed.
- 2 TRIG** Whether the double pulse(2 trig) mode for the asynchronous shutter operation is used (ENABLED) or not used (DISABLED) is selected.
- Vinit2:** The polarity of the trigger signal via CC1 of Camera Link is set. The factory default is negative logic (NORMAL). When (INVERTED) is selected, positive logic input is used.
- STRB-C:** ON/OFF is set for the strobe signal (STRB) output for the continuous shutter operation. When (ON) is selected, the strobe signal is output even in the continuous shutter mode.

(Note) The strobe signal is always output in the asynchronous shutter mode regardless of this setting.

- PATTERN:** This is to switch between (ON) and (OFF) for the test pattern output.
- bit:** This is to set for the bit format (gray scale) of the output data complying with Camera Link STD. The settable data format in this camera is 10 bits or 8 bits format. Default is 10 bits.
(Both are single line output format.)

* The following items are for display only; they cannot be directly changed on the menu. These are automatically updated when a corresponding change is made using the switches:

- MS=** The current position of the mode switch is displayed.
- SS=** The current position of the shutter setting switch (EXP.) is displayed.
- MF=** The information (16 bits x 2 sets) of the internal mode flags of the camera (internal flags to determine operation) is displayed in the hexadecimal system. The details of the internal flags are described later.
- Tc=** The current internal temperature of the camera is displayed in Celsius. The temperature data are refreshed every 0.4 seconds.

[ID information display]

The ID code and other information set by the user for each camera can be saved in the camera (with the use of the serial communication).

The settable maximum number of characters are 15, and alphanumeric characters (both upper and lower cases) and some special symbols such as "+" and "." excluding the control codes are used.

(→ Refer to the section of "Serial Communication Control" for the details.)

The ID code set by the user is displayed on the lower left of the "Menu Display of Setting Group 1" by the OSD function; this allows the user to confirm the setting content (ID: onward).

(If the ID code is not set, the camera model name is displayed instead.)

The bottommost and right figure shows an example where "CAMERA-1" is set as the ID information.

MENU2

MENU : ON
 - : (Reserved)
 - : (Reserved)
 PWC : DISABLED
 DUMP : DISABLED

MS=A SS=7 MF=0000.0000

FS5000HECL [V.X.XX]

MENU C

MENU : ON
 BZ : ON
 BAUD : 9600bps
 - : (Reserved)
 2 TRIG : DISABLED
 Vinit 2 : NORMAL
 STRB-C : OFF

MS=C SS=7 MF=0000.0000

FS5000HECL [V.X.XX]

Menu display of Setting Group C

MENU D

MENU : ON
 PATTERN : OFF
 bit : 8bit

MS=C SS=7 MF=0000.0000

FS5000HECL [V.X.XX]

Menu display of Setting Group D

<div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 5px;"> MS=1 SS=7 </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;"> FS5000HECL </div> <div style="text-align: center;">ID not specified</div>	<div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 5px;"> MS=1 SS=7 </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;"> ID: CAMERA-1 </div> <div style="text-align: center;">ID specified</div>
---	---

[Change of setting]

Perform the procedure described in another section: “(6-3) How to set operation mode” when changing the current setting while referring to the information displayed by the OSD function.

When the position of the mode switch is changed, a flashing “*” mark appears on the left of the numeric value or the parameter of the item corresponding to the switch position to indicate that the setting can be changed using the UP/DOWN switch.

When a stroke is applied to the UP/DOWN switch, the value of gain or others increases or decreases by 1. When a stroke is applied and kept for about 2 seconds, the number continuously increases or decreases at fast speed after the response sound of “pip-pip”.

[Save of setting after change]

The settings changed on the menu are divided into 2 groups; one is for those that are automatically saved in the nonvolatile ROM area whenever a change is made (configuration items) and the other is for those that are saved in the program pages only when manually stored (See the following table).

Automatic save and manual save	Item	Remark
Items automatically saved when changed on menu	“MENU”	Reflected in (CR)
	“BZ”	Reflected in (CR)
	“BAUD”	Reflected in (CR)
	“FORMAT”	Reflected in (CR)
	“2 TRIG”	Reflected in (CR)
	“Vinit2”	Reflected in (CR)
	“STRB-C”	Reflected in (CR)
	“PATTERN”	Reflected in (CR)
Items requiring manual save into program pages after changed on menu	“GAIN”	Saved as numerical value
	“OFFSET”	Saved as numerical value
	“S.TIME”	Saved as numerical value
	“S.FORM”	Reflected in (FR)
	“SCAN”	Reflected in (FR)
	“PWC”	Reflected in (FR)
	“DUMP”	Reflected in (FR)

(6-6) Internal flag register (FR) and configuration register (CR)

The camera internally has RAM areas for the flag register (FR) (2 bytes) and the configuration register (CR) (2 bytes).

If the user checks the contents of these registers, he or she can get the information on the current operational status. In addition, it is possible to change more than one operation mode at a time by way of rewriting the contents of the registers. In this section, the functions of the flag register and the configuration register are described.

- **Flag register (FR) and configuration register (CF)**
Both FR and CR are 2 bite (16 bit) memory areas in RAM. When the camera is turned on, the data stored in the internal EEPROM (nonvolatile storage) are read out and copied into these areas. The current operation mode of the camera is determined by the data in FR and CR.
Each set of FR data is saved in each of the program pages (A to F), and the data are copied to the flag register by the automatic loading at the time of power-on or manual loading onto one of the program pages to determine the operation of the camera. On the contrary, the memory area for CR in EEPROM is only one and the data are read out separate from the program pages to determine the operation mode.
- The data of those registers can be changed by manipulating the switches on the rear panel of the camera (regardless of ON/OFF state on the menu display) or using serial communication commands.
- When the menu display is set to “ON”, the contents of (FR) and (CR) are displayed as 8 numbers like “MF=0000.0000” to show the current states of the registers. The numbers are expressed in the hexadecimal system. The first (upper) 2 bytes show the setting data of the configuration register (CR) and the bottom (lower) 2 bytes show the setting data of the flag register (FR).

[Description of CR data]

Bit	Abbrev.	Content	Logic	Remark
0	MNI	Disabled display of menu screen	1: Disabled (OFF)	
1	BZI	Disabled buzzer output	1: Disabled (OFF)	
2	TPEN	ON/OFF selection for test pattern	1: Test pattern ON	
3	DFRM	Selection of output data format	1: 8bit format	0: 10bit format(Default)
4	-	(Not used)		
5	TWEN	Double pulse · asynchronous shutter	1: Enabled	
6	STRBC	Enabled STRB signal output for continuous shutter	1: Enabled	
7	CC1P	Selection of trigger signal (Vinit2) polarity via CC1	1: Positive polarity	
8	-	(Not used)		No change can be executed by a communication command. (Readout is possible.)
9	BAUD	9600bps/19200bps selection for serial communication baud rate	1=19200bps	
10	-	(Not used)		
11	-	(Not used)		
12	-	(Not used)		
13	-	(Not used)		
14	-	(Not used)		
15	DEFR	Request for reading out default value at next start-up	1: Request	

(Note) All the items of the CR data are "0" as factory default.

[Description of FR data]

Bit	Abbrev.	Content	Logic	Remark
0	ASYE	Selection of continuous/asynchronous shutter	1: Asynchronous (ASYNC)	
1	PWCE	Selection of enabled/disabled for pulse width control	1: Enabled pulse width control	
2	LEXE	Selection of high speed/low speed shutter	1: Low speed shutter	
3	PSCE	Selection of normal scan/partial scan	1: Partial scan	Selection of DRFT is put ahead of PSCE
4	DRFT	Selection of draft scan ON/OFF	1: Draft scan ON	
5	FDUMP	Selection of fast dump ON/OFF	1:Fast dump ON	
6	-	(Not used)		
7	-	(Not used)		
8	ESP(0)	Externally designated shutter speed position	H'0 to H'9 or H'F	Where ESPE=1, externally designated number from 0 to 9 (designated position) is reflected. In case of H'F, external shutter speed in H unit is selected.
9	ESP(1)			
10	ESP(2)			
11	ESP(3)			
12	ESPE	Effectiveness of externally designated shutter speed	1: Effective	
13	-	(Not used)		
14	-	(Not used)		
15	AGCE	Selection of MGC/AGC operation	1: AGC	

(Note) All the items of the FR data are "0" as factory default.

(Example) If "MF=H'0080.0003" is displayed on the menu screen, the camera is in the following state (converting the numbers to ones in binary system):

H'00=B'00000000, H'10=B'10000000 and H'03=00000011 are substituted to the above numbers.
CR=B'0000000010000000, FR=B'0000000000000011

..... CR(7)=FR(1)=FR(0)=1, All other bits = 0

(Where CR(n) and FR(m) represent the nth bit of CR and mth bit of FR respectively)

Based on 1 or 0 of these bits and the information in the above table, the user can know that the camera is in the state of "Vint2= Positive polarity", "ASYNC" and "Enabled pulse width control".

[Explanation]

The setting values (1 or 0 of respective bits) of (CR) and (FR) vary according to the change to be made using the switches on the rear panel of the camera. The operation modes that cannot be changed by the RS-232C commands can be changed by altering the bits of (CR) and (FR).

(Example 1) When a change is made from the continuous shutter mode → asynchronous shutter mode, "MF=0000.0000" is replaced by "MF=0000.0001" (ASYE bit = 1).

(Example 2) When CR (0) is changed from 0 → 1 using a serial communication command, "ON" on the menu display is replaced by "OFF" (MIND=1).

(Example 3) When FR (3) is changed from 0 → 1 using a serial communication command, the scan mode changes from Normal scan mode to Draft scan mode,

(6-7) Description of scan mode and functional limitation

[Scan mode]

- Description of scan mode

This camera has the following 3 scan modes which are selectable by setting:

Scan mode	Operation	Frame duration H/V	Frame rate
Normal scan mode (NORMAL)	Readout of all 5.0 megapixels	97.1μs/199.7ms	5.0fps
Partial scan mode (PARTIAL)	Read out of approx. 2.40megapixels (920 lines) at the central area	97.1μs/99.8ms	10.0fps
Draft scan mode (DRAFT)	4 lines out of each 16 lines are read out for all pixels.	112.4μs/27.98ms	35.7fps

- Normal scan mode The image of all effective pixels is read out at a frame rate of 5.0 Hz.
- Partial scan mode..... The image of the central area of 920 lines in vertical width is read out at a frame rate of 10 Hz. This mode is suitable for capturing the image only of the central area at a high speed.
- Partial scan mode The image of 4 lines out of each 16 lines are read out. The image signals of 12 lines out of 16 lines are cut, and is not output. Frame rate is 35.7 fps.

- Functional limitation by scan mode

Usable functions vary by the scan mode that is currently selected.

The functions marked with O in the following table are usable and those marked with ✕ are not usable.

Current scan mode	No shutter	Continuous shutter	Asynchronous shutter	Prolonged exposure
Normal scan mode (NORMAL)	O	O	O	O
Partial scan mode (PARTIAL)	O	O	O	X
Draft scan mode (DRAFT)	O	O	X	X

(Note) Carefully note that the operation is not guaranteed if an unusable function is selected.

(Note) Caution is required especially when control is executed using the write commands for the flag register among the serial communication commands because the incompatibility between the selected scan mode and the selected function is not warned. Setting of an inappropriate parameter results in operation failure.

- Priority order of scan mode setting items

“Selection of draft scan ON/OFF(=ON)” is put ahead of “ Selection of normal scan/partial scan”. For example, when Partial scan mode(PARTIAL) is selected at “Selection of normal scan/partial scan” and Draft scan mode(DRAFT) is selected at “ Selection of draft scan ON/OFF”, the scan mode of the camera gets Draft scan mode.(Refer to the table below)

Even if set contents of “Selection of normal scan/partial scan” is changed when draft scan is ON at “Selection of draft scan ON/OFF”, the operating conditions of the camera do not reflect the changes immediately. When it is followed by the selection of normal scan , “Selection of normal scan/partial scan” gets effective.

Scan mode setting		Actual scan mode
Selection of draft scan ON/OFF DRAFT/NORMAL	Selection of normal scan/partial scan PARTIAL/NORMAL	
NORMAL	NORMAL	Normal scan (NORMAL)
	PARTIAL	Partial scan (PARTIAL)
DRAFT	NORMAL	Draft scan (DRAFT)
	PARTIAL	

[Dump mode]

- The fast dump mode which is effective to reduce the smear of the upper part of the image area is selectable in the asynchronous shutter operation. See (5-1)

- Functional limitation by dump mode

Current dump mode (DUMP)	No shutter	Continuous shutter	Asynchronous shutter (preset shutter)	Asynchronous shutter (pulse width control)	Prolonged exposure
No Fast dump (DISABLED)	O	O	O	O	O
Fast dump (ENABLED)	X	X	O	X	X

(Note) “Fast dump” setting is invalid except for preset asynchronous shutter operation.

(Note) Carefully note that the operation is not guaranteed if an unusable function is selected.

[Shutter mode]

- Functional limitation by shutter mode

Current shutter mode	AGC operation	Draft scan	Prolonged exposure
No shutter	O	O	O
Continuous shutter	O	O	O
Asynchronous shutter	X	X	X

(6-8) Typical setting procedure

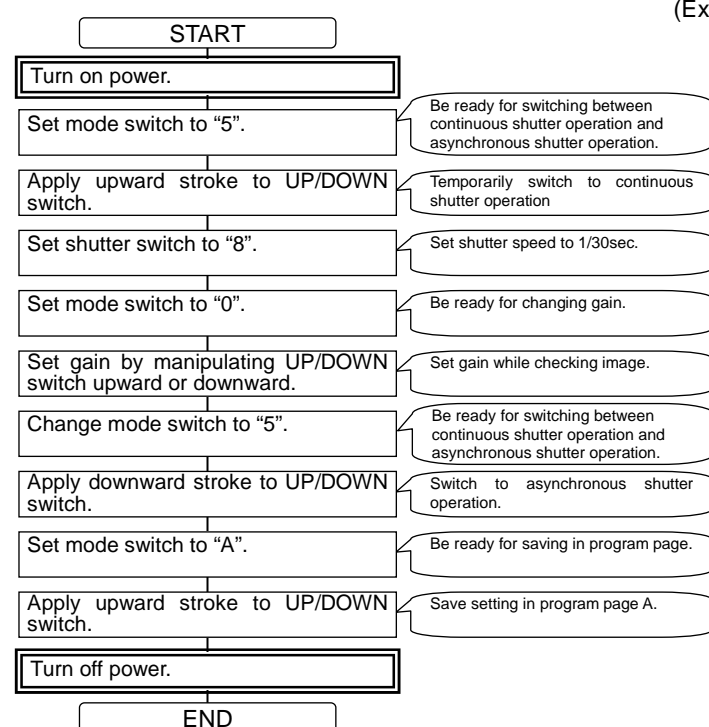


Fig. 6-4 Example of procedure for gain setting for random shutter

(Example 1) This is the procedure for setting the gain for the asynchronous shutter operation (1/30 sec.).

[Explanation]

The left example of the setting procedure is for using the camera in the asynchronous shutter operation. In the left example, the operation mode is temporarily set to be the continuous shutter operation because this makes it easier to set the gain and others. In the case where the image output state can be easily checked by way of repeatedly inputting external trigger signal (Vinit) from a user device, the operation mode should be set to be "Asynchronous Shutter" from the beginning before setting the gain and others.

(Note) When the pulse width control mode is set for the asynchronous shutter operation, the above described method in which the continuous shutter mode is temporarily set cannot be used (because the shutter speed at the position "9" for the asynchronous shutter mode is different from that for the continuous shutter mode). If the camera is used in the pulse width control mode, it is necessary to set the asynchronous shutter operation and then set the gain and others while actually inputting the trigger signal (Vinit) from a user device.

(!) This equipment is designed so that the pulse width control mode can be set to OFF even when it is in the asynchronous shutter mode and the mode switch is at the position "9". (Default condition)

(Note) This equipment is put into the condition where the cyclic asynchronous shutter trigger is internally generated (in the cyclic trigger state) when the menu is displayed.

When the menu is displayed in accordance with the procedure for setting the gain for the asynchronous shutter operation as described in Fig. 6-4, it is not necessary to temporarily switch to the continuous shutter operation as shown above.

(Example 2) This is the procedure for use in continuous/ low speed shutter operation (1.2 sec.).

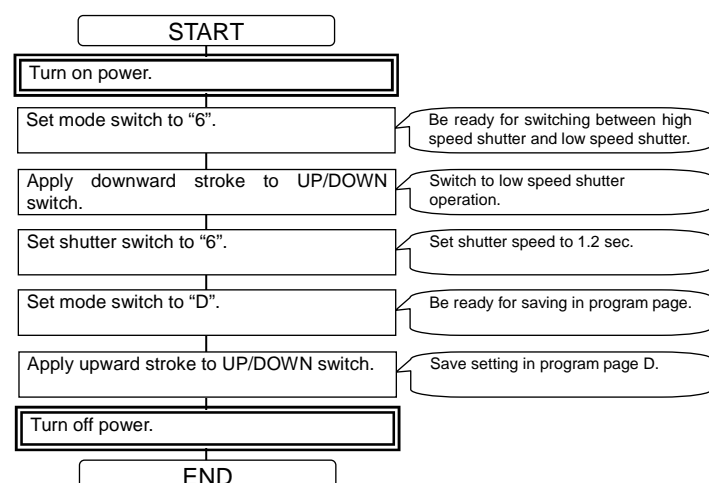


Fig. 6-5 Example of procedure for use in continuous/low speed shutter operation

[Explanation]

The above example is for saving the setting in the program page D.

(6-9) Read out of factory default

Setting items to be read out to RAM

[Electronic shutter operation mode]

- Shutter mode = Continuous
- Type of shutter speed = High speed
- Electronic shutter table = Content of (Table 6-1)
- Pulse width control = DISABLED
- Fast dump = DISABLED

[Other operation modes]

- Scanning system = Normal scan

[Level setting]

- Gain setting value = (Factory default)
- Offset setting value = (Factory default)

[Configuration]

- Manu display = ON
- BZ = ON
- Baud rate = 9600bps
- Output bit format = 10 bit
- Double pulse = DISABLED
- Vinit2 polarity = NORMAL (negative logic)
- Test pattern = OFF
- Continuous strobe signal = OFF

This procedure is for reading out the factory default (initial setting before shipment) in order to initialize the setting that was changed by the user after purchase.

With this equipment, the following 2 different procedures are selectable for the readout:

- a. The factory default is read out to the internal RAM of the camera.
- b. The factory default is read out to the internal RAM of the camera and written in the all program pages.

(Note) When the procedure a. is selected, the "storage page for factory default" that is located separately from the memory for automatic loading at the time of power-on (program pages from "A" to "F") is loaded and the camera is started up. In this case, the data is temporarily read out to the internal RAM of the camera. If it is necessary to use the camera with the factory default values after the power is turned off, those must be saved in the program pages from "A" to "F".

When the procedure b. is selected, the parameters that were read out are automatically saved in the program pages from "A" to "F". Carefully note that the earlier setting data that were saved by the user are all overwritten and lost.

Fig. 6-7 Setting contents immediately after reading out factory default

[Procedure a. (read out of default to RAM)]

- <Step 1> Set the mode switch to the position "9", and manipulate the UP/DOWN switch either upward or downward. Then, turn on the power and keep the position of the UP/DOWN switch for several seconds.
 - <Step 2> Return the UP/DOWN switch to the neutral position when the response sound of "pip-pip" is heard and LED flashes in orange.
 - <Step 3> For execution, apply an upward or downward stroke to the UP/DOWN switch again. For cancellation, turn off the power to the camera.
 - <Step 4> The camera automatically restarts and the operation mode is set to be Group 1.
- (Note) To save the read data, set the mode switch to "A" (or other page corresponding to the data to be saved) and apply an upward stroke to the UP/DOWN switch (save to the program page).

[Procedure b. (read out of default to RAM and save in all program pages)]

- <Step 1> Set the mode switch to the position "9", and manipulate the UP/DOWN switch either upward or downward. Then, turn on the power and keep the position of the UP/DOWN switch for several seconds.
- <Step 2> Return the UP/DOWN switch to the neutral position when the response sound of "pip-pip" is heard and LED flashes in orange.
- <Step 3> Then, change the position of the mode switch to "0". LED will flash in red.
- <Step 4> For execution, apply an upward or downward stroke to the UP/DOWN switch again. For cancellation, turn off the power to the camera.
- <Step 5> The camera restarts and the operation mode is set to be Group 1.

7. Serial Communication Control

FS5000HECL can be externally controlled by the serial interface via Camera Link cable.

(Note) When the operation modes of the camera are changed by the communication functions, it takes some time to switch the modes. Carefully note that normal image may not be obtained from the signal for each one frame before and after transmitting a command.

(Note) The settings and timings of the serial communication commands are the same as those of the products that have the conventional RS-232C communication functions.

- The setting of the serial communication is as follows:
 Baud rate : 9600bps or 19200bps (Specified by Setting Group 2, default: 9600bps)
 Data : 8bit/character
 Start bit : 1start bit
 Stop bit : 1stop bit
 Parity : none
 XON/XOFF : no control
- Serial communication commands
 The command packet starts with STX(02h), followed by command code(s) and command option parameter(s) and ends with ETX(03h). All those are of 8 bit ASCII codes.
 When the camera receives 1 packet (by detecting ETX:03h) and judges it is a normal packet, it returns a transaction completion signal (ACK: 06h) or others corresponding to the commands received. When the camera judges it is an abnormal packet, it returns the abnormal signal (NAK: 15h).
- Operation mode "Group 1/2" and reception of serial communication commands
 Serial communication commands are received only for the period when the camera is in the operation mode of "Group 1" (= "normal power-on state").
 However, only the command "ARESET" (returning to power-on state) is received even during the periods when the camera is in the operation modes of Group 2 to D.
- Description of commands

(1) Command "e"

Function: Initialization of page memory

Transmission from host: STX: "e": ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

* CPU initializes each of the page memories when the power is turned on next time. "Initialization" here means returning the parameter values stored in the internal EEPROM of the camera to the factory default values. (→ corresponding to the procedure b. under the section (6-9))

(2) Command "R"

Function: Command for reporting camera operation and setting status

The contents of the report can be selected by adding the following option code after the command code "R".

G: Gain report

S: Shutter report

T: Shutter SW set report

V: Camera version report

1) Analog report

Transmission from host: STX: "R": "A": ETX

Return by camera: STX: ACK: "R": (SETUP setting value): (WC setting value): "1": ETX

(!) FS5000HECL does not use the values in parentheses. This camera returns the fixed values instead.

(Note) FS5000HECL does not use the setting values corresponding to this command, but it does not cause an error even when it is input.

2) Gain report

Transmission from host: STX: "R": "G": ETX

Return by camera: STX: ACK: "R": MGC setting value: AGC setting value: (VRT setting value): (VRB setting value): OFFSET setting value: ETX

(!) FS5000HECL does not use the values in parentheses. This camera returns the fixed values instead.

3) Camera version report

Transmission from host: STX: "R": "V": ETX

Return by camera: STX: ACK: "R":
"Takenaka SYS.FS5000HECL V1.00 Txxxxx": ETX

* The underlined values show the control program version number of the camera and a file name. These values and

the number of characters vary by program version. Use when confirming the communication mode of the camera and obtaining internal information of the camera.

The maximum number of the characters to be inserted between ACK and ETX is 48.

4) Shutter SW report

Transmission from host: STX: "R": "T": "H": ETX

Return by camera: STX: ACK: "R": "H":

SW0: SW1: SW2: SW3: SW4: SW5: SW6: SW7: SW8: SW9: ETX

5) Shutter mode report

Transmission from host: STX: "R": "S": ETX

Return by camera: STX: ACK: "R": "A" or "M"*¹: "H" or "L" *²: "N" or "F" *³: Exposure time*⁴: ETX

*¹ A : Asynchronous shutter

M : Continuous shutter

*² H : High speed shutter

L : Low speed shutter

*³ N : Normal scan

F : Partial scan

*⁴ : Exposure time

4 characters are returned as the electronic shutter exposure time.

- In the case where the electronic shutter exposure time is externally set:

When the exposure time is set in the unit of H (horizontal scan time), the exposure setting count value of the time in H is returned.

Example) If the shutter exposure time is 8Hs (1/2300): "0008"

If the shutter exposure time is 1208Hs (1/160): "00A0"

- In the case where the electronic shutter exposure time is set using the shutter switch number on the connector panel:

Example) If the shutter switch is set to "4": "I4.."

- In the case where the electronic shutter exposure time is set by the shutter switch number via a RS-232C command:

Example) If "3" is specified for the shutter switch, : "S3.."

(Note) When directly specifying the exposure time, only the following range of values is acceptable. The operation with other values than these is not guaranteed.

Normal scan: H' 0000 to H' 04B0 (D' 0 to 1200) ("0" is used only when the external specification is cancelled.)

Partial scan: H' 0000 to H' 026C (D' 0 to 620) ("0" is used only when the external specification is cancelled.)

(3) Command "G"

Function: Command for setting gain

Transmission from host: STX: "G": MGC setting value: AGC setting value: (VRT setting value): (VRB setting value): OFFSET setting value: ETX

Return by camera: STX: ACK: ETX (transaction completion) or STX: NAK: ETX (transaction rejection)

(!) This camera does not use the values in parentheses ". " must be transmitted to the camera.

2 digit ASCII codes in the hexadecimal system are used for the data setting values of MGC, AGC and OFFSET.

Example) If level 128 (decimal) is set: "80"

If level 200 (decimal) is set: "C8"

The setting value that does not require a change should be represented by "." (a full stop) so that the setting value before the command transmission is retained.

Example) if only MGC is changed to Level 90 (decimal):

STX: "G": "5A": ".": ".": ".": ".": ETX

(4) Command "S"

Function: Command for setting shutter mode and shutter exposure time

Transmission from host: STX: "S": "A" or "M": "H" or "L": "N" or "F": exposure time: ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The transmitting command has the following meanings:

STX: "S": "A" or "M": "H" or "L": "N" or "F": Exposure time: ETX

*¹ *² *³ *⁴

*¹ A: Asynchronous shutter

M: Continuous shutter

*² H: High speed shutter

L: Low speed shutter

*³ N: Normal scan

F: Partial scan

*⁴: Exposure time

The format of "Exposure time" complies with one of the followings:

a. 4 characters representing 2-byte number and corresponding to the hexadecimal system

b. 4 characters of "S" "0 to 9" ".." for externally specifying a shutter position (2 full stops of "." in the last are mandatory.)

- In the case where the electronic shutter exposure time is externally set:
When the exposure time is set in the unit of H (horizontal scan time), the exposure setting count value of the time in H is set.
Example) If the shutter exposure time is 17Hs (1/ 600):
STX: "S": " ": " ": " ": "0011": ETX
- In the case where the exposure time is set using the shutter SW number on the connector panel:
Example) If the shutter SW is set to "4":
STX: "S": " ": " ": " ": "S4..": ETX
- In the case where the exposure time is set to 3Hs in the asynchronous/high speed shutter mode:
STX: "S": "A": "H": " ": "0003": ETX
- In the case where the control is returned to the one using the rear panel of the camera:
STX: "S": " ": " ": " ": " ": "0000": ETX

(Note) When the exposure time is externally set with the command "S", the exposure time of the camera will finally be locked to the position specified by the command or to the value directly specified. This locked state is released when the exposure time is set to "0000" by RS-232C again as described above.
To release this locked state without using RS-232C after specifying the exposure time using RS-232C, perform the procedure of "Read out of factory default" as described in the Section (6-8).

(5) Command "A"

Function: Command for setting analog image signal

Transmission from host: STX: "A": (SETUP setting value): (WC setting value): " ": ETX

Return by camera: STX: NAK: ETX (transaction rejection) , or STX: NAK: ETX (transaction rejection)

(!) FS5000HECL does not use the values in parentheses.

(Note) FS5000HECL does not use the setting values corresponding to this command, but it is not regarded as error even when it is input.

(6) Command "E"

Function: Command for editing shutter menu

Transmission from host: STX: "E": "H": SW0: SW1: SW2: SW3: SW4: SW5: SW6: SW7: SW8: SW9: ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

* The exposure time (H) to be allocated to the shutter SW number is expressed in 4 digits in the hexadecimal system for SW0 to SW9.

* The exposure time of SW0 cannot be changed.

Example) If only the exposure time of SW5 for the high speed shutter operation is changed to 88 (decimal):

STX: "E": "H": " ": " ": " ": " ": " ": " ": " ": " ": "0058": " ": " ": " ": " ": ETX

(7) Command "W"

Function: Command for saving operation mode (Write into page memory)

Transmission from host: STX: "W": memory page ("A" to "F"): ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The current setting is written and saved in the EEPROM of the specified page number.

(8) Command "L"

Function: Command for reading out operation mode (Load)

Transmission from host: STX: "L": reading page ("A" to "H"): ETX

Return by camera : STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

* The factory default is stored in the Page H, which will be used when resetting to the default setting.

<The following commands are exclusively for FC2000 and FS5000HECL, and not common with other FC cameras.>

(9) Command "WMC"

Function: Command for writing in configuration flag register (CR) (Write Mode Configuration)

Transmission from host: STX: "WMC": flag setting value: ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The content of "flag setting value" (2 bytes/4 characters) is written in the configuration register.

(Note) This command does not execute the writing in EEPROM, and the setting by this command is lost when the power is turned off. To save the setting value in EEPROM, use another command, "SMC".

(10) Command "WMF"

Function: Command for writing in mode flag register (FR) (Write Mode Flag)

Transmission from host: STX: "WMF": flag setting value: ETX

Return by camera : STX: ACK: ETX (transaction completion) or STX: NAK: ETX (transaction rejection)

The content of "flag setting value" (2 bytes/4 characters) is written in the flag register.

(Note) This command does not execute the writing in EEPROM, and the setting by this command is lost when the power is turned off. To save the setting value in EEPROM, use other commands, "WA to WF", to save in the specified pages.

(11) Command "RMC"

Function: Command for reading configuration flag register (CR) (Read Mode Configuration)

Transmission from host: STX: "RMC": ETX

Return by camera: STX: ACK: "RMC": flag setting value: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The current content of the common mode flag register (2 bytes/4 characters) is returned in the hexadecimal system.

(12) Command "RMF"

Function: Command for reading mode flag register (FR) (Read Mode Flag)

Transmission from host: STX: "RMF": ETX

Return by camera: STX: ACK: "RMF": flag setting value: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The current content of the mode flag register (2 bytes/4 characters) is returned in the hexadecimal system.

(13) Command "SMC"

Function: Command for saving configuration flag register (CR) (Save Mode Configuration)

Transmission from host: STX: "SMC": ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The current content of the common mode flag register is saved in EEPROM.

(14) Command "RTMP"

Function: Command for reading data of internal temperature of camera (Read TeMPerature)

Transmission from host: STX: "RTMP": ETX

Return by camera: STX: ACK: "RTMP": internal temperature data: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The current content of the internal temperature data of the camera is returned in the hexadecimal system.

The effective data is the lower 10 bits out of the returned 16 bits. This 10 bit value presents a signed integer value in two's complement form -511 to 511. Actual temperature in Celsius is calculated by multiplying the value by a certain factor.

→ Refer to "(4-6) Monitoring function for internal temperature of camera" for the conversion method from the returned data to temperature value.

(15) Command "X"

Function: Command for asynchronous shutter trigger (eXecute trigger)

Transmission from host: STX: "X": ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

When the camera is set to be in the asynchronous shutter mode (excluding the time when the menu is being displayed), this command enables the camera to update the image by internally generating the asynchronous trigger signal.

The internally generated trigger signal is of negative logic at 1ms±5%. The minimum repetition pitch is approx. 300ms.

Only when the trigger signal is input by this command, the internal buzzer of the camera sounds for one shot time (approx. 50 ms) in response to the input. If this buzzer should not be activated, set "operation confirmation buzzer = OFF" either by changing the setting of the configuration menu or the configuration flag by the serial communication command.

(Note) When the command "X" is received, "ACK"(transaction completion) is returned even if the asynchronous shutter mode is not selected or the menu is displayed (in the setting condition where the asynchronous shutter operation is disabled by the command "X").

(Note) Since the command is executed through the serial communication, it does not quickly act unlike a normal trigger signal. Therefore, it is recommended to use the commands only when no immediacy is required, for example, in the case where the operation of the camera is checked for setting, or the moving velocity of an object to be shot is extraordinary slow.

(16) Command "ARESET"

Function: Command for operation reset (All RESET)

Transmission from host: STX: "ARESET": ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

This command is used to reset the camera to the initial power-on state.

(Note) This command responds to the operation when the camera is restarted after the power is turned off. The data stored in EEPROM are not lost.

(Note) Only this command is received in the operation modes of "Group 2", "Group C" and "Group D".

<The following commands are exclusively for FS5000HECL/ FC2000CL/FC2000FCL, and not common with other FC cameras.>

(17) Command "WID"

Function: Command for writing camera ID (set by user) (Write ID)

Transmission from host: STX: "WID": character string with 0 up to 15 characters: ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The acceptable characters are English 1 byte characters (both upper and lower cases) and some special symbols as shown below:

Usable special symbols..... SP(H'20), !(H'21), '(H'27), +(H'2B), comma (H'2C), -(H'2D), .(a full stop mark)(H'2E), /(H'2F), : (H'3A), ;(H'3B), <(H'3C), =(H'3D), >(H'3E), ?(H'3F), [(H'5B)], (H'5D), _ (H'5F)

(Note) When the number of the characters exceeds 15, (transaction rejection) is returned.

(Note) When the number of the characters is 0, the ID code is deleted.

(Note) Carefully note that ID is not correctly written when the character string to be sent includes an unusable character(s). This case, however, is not regarded as error ((transaction rejection) is not returned).

(Note) This command does not execute the writing into EEPROM and therefore, the setting by this command is lost when the power is turned off. If it is necessary to store the setting in EEPROM, transmit another command of "SID".

(18) Command "SID"

Function: Command for saving camera ID (set by user) (Save ID)

Transmission from host: STX: "SID": ETX

Return by camera: STX: ACK: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

The data of the current ID code is saved in EEPROM.

(Note) The ID code (character string) is saved in a separate area from the program pages, and this common value (one numerical number) is applied when the camera is turned on with any one of the program pages.

(Note) No ID code is stored before shipment.

(19) Command "RID"

Function: Command for reading out camera ID (set by user) (Read ID)

Transmission from host: STX: "RID": ETX

Return by camera: STX: ACK: "RID": character string with 0 up to 15 characters: ETX (transaction completion), or STX: NAK: ETX (transaction rejection)

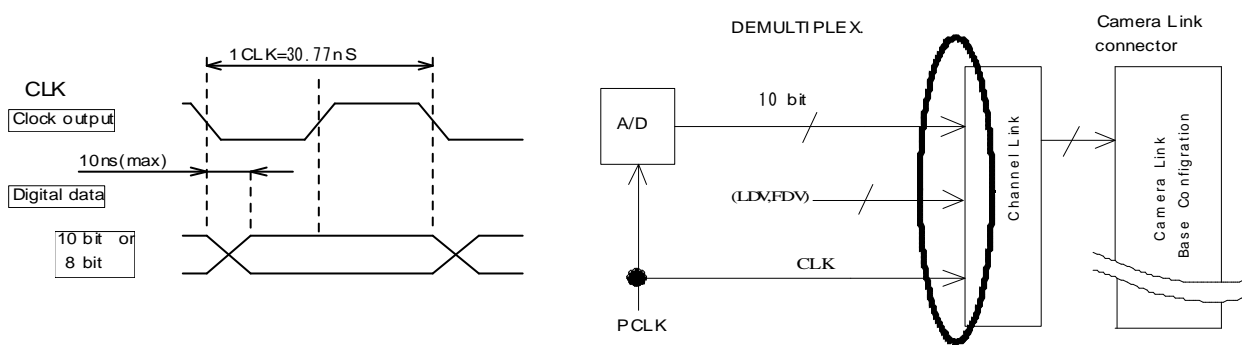
The data (0 up to 15 characters) of the ID code (character string) is read out. When an ID code is not set, the number of the characters to be returned is 0.

- Note in use of commands

- The internal nonvolatile ROM (EEPROM) guarantees the rewritable times up to 1 million based on the specifications of the device. Accordingly, it is highly recommended to avoid such usage as the commands accompanied by writing in EEPROM including "WA to WF", "SMC" and "e" are repeated endlessly (or almost endlessly) in the program loop on the user side.

8. Timing Chart

- Pixel clock timing (common in various operation modes)
[Phase relationship between clock output and data]

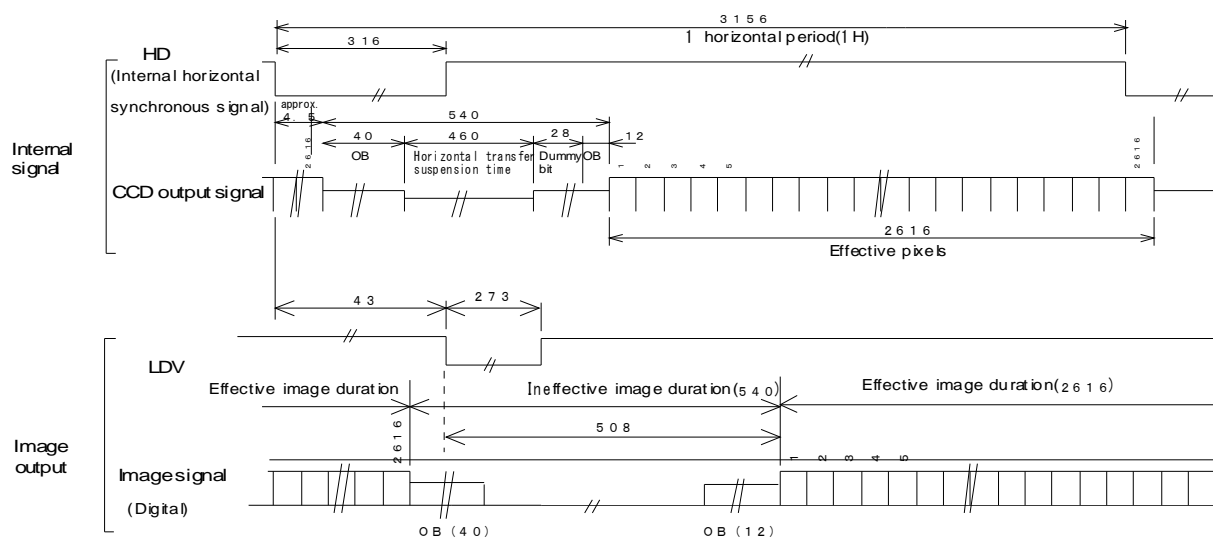


(Note) The above timing represents the signal timing before being encoded to serial data by the channel link device on the side of the sending end (the part circled in the above right figure). If signal conversion from serial to parallel is made by a channel link device in accordance with the Camera Link standard on the side of the receiving end, the phase relationship between the clock and the data after decoding will be different from that of the above timing due to the structural nature of a channel link device. (In the case of the output from a channel link device, the data are aligned with the trailing edge of the clock signal.)

(!) FS5000HECL does not have the timing signal "BUSY" that LVDS type FC cameras normally have.

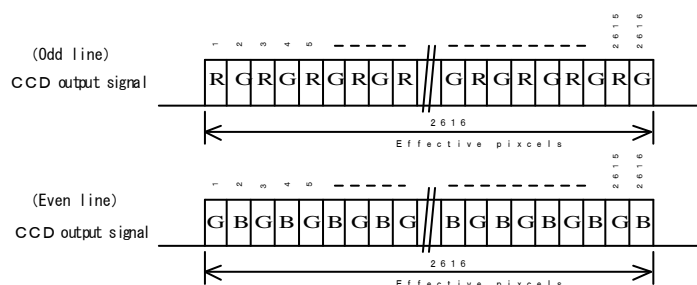
(Note) When a channel link device is mounted directly to the capture interface on the user side, instead of using a commercially available capture board that supports Camera Link, it is necessary to pay close attention to the descriptions of the data sheet of the channel link device including the phase relationship between data and clock prior to the use.

- Horizontal timing

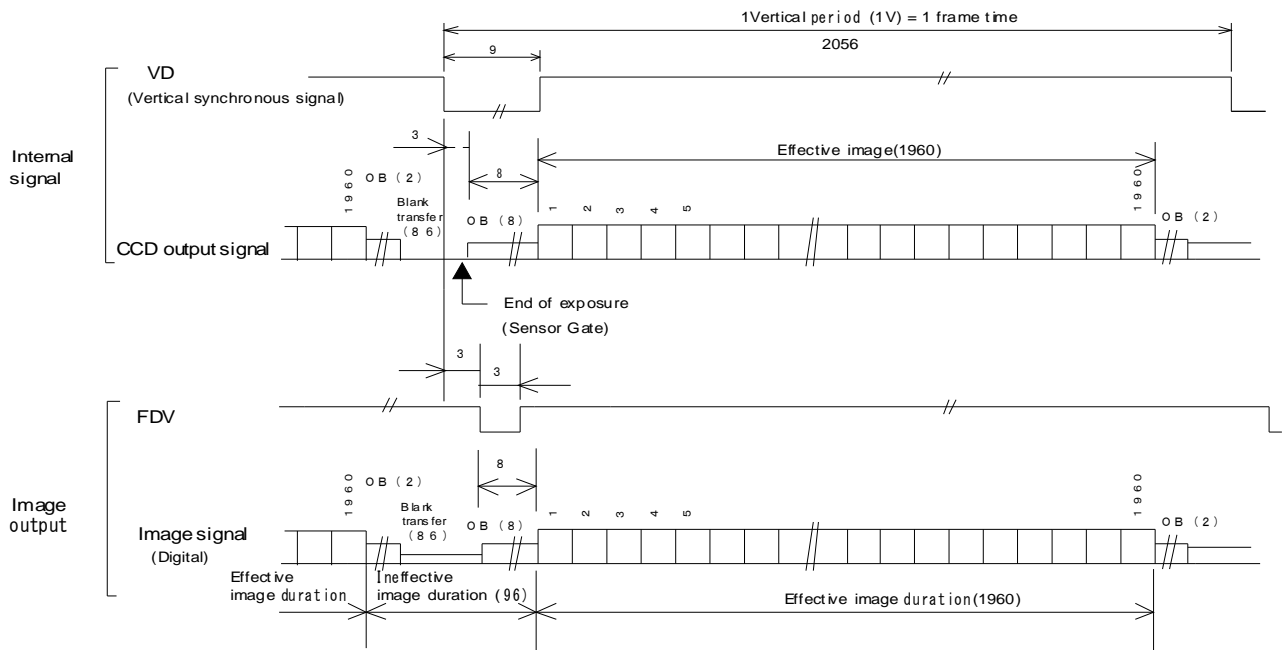


* Unless otherwise specified, the time unit of the numbers in the horizontal timing chart is CLK (= 1/32.5MHz = 30.77nS).

Color coding (Horizontal output timing)

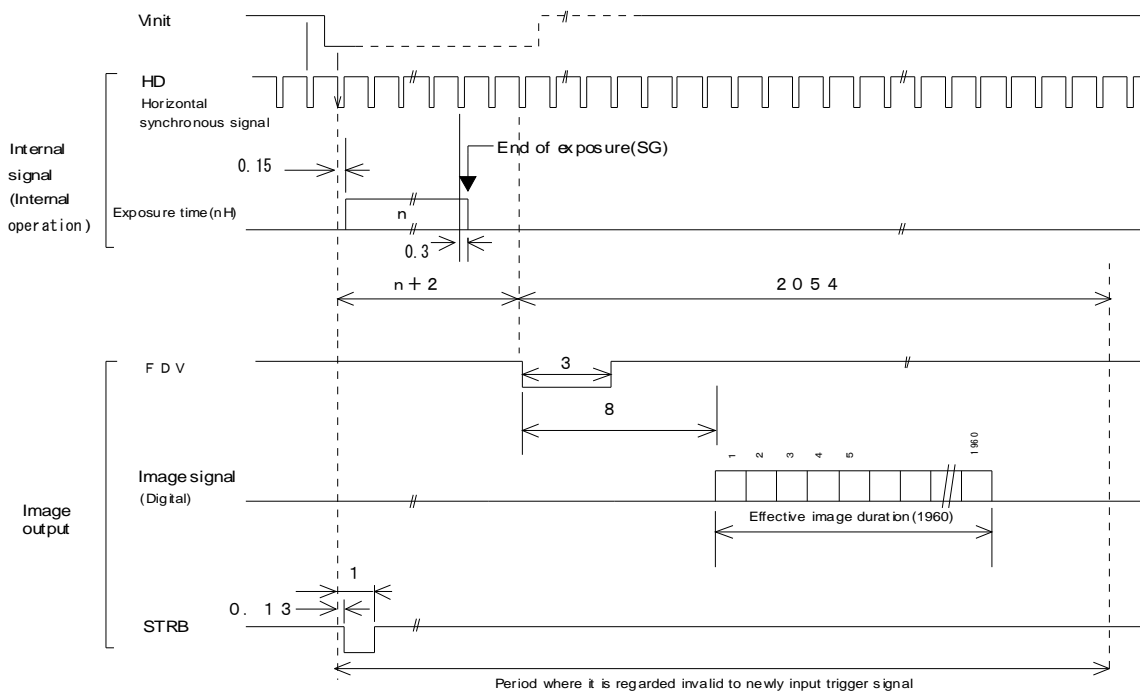


- Vertical timing: Continuous shutter, No shutter/Normal scan/No fast dump



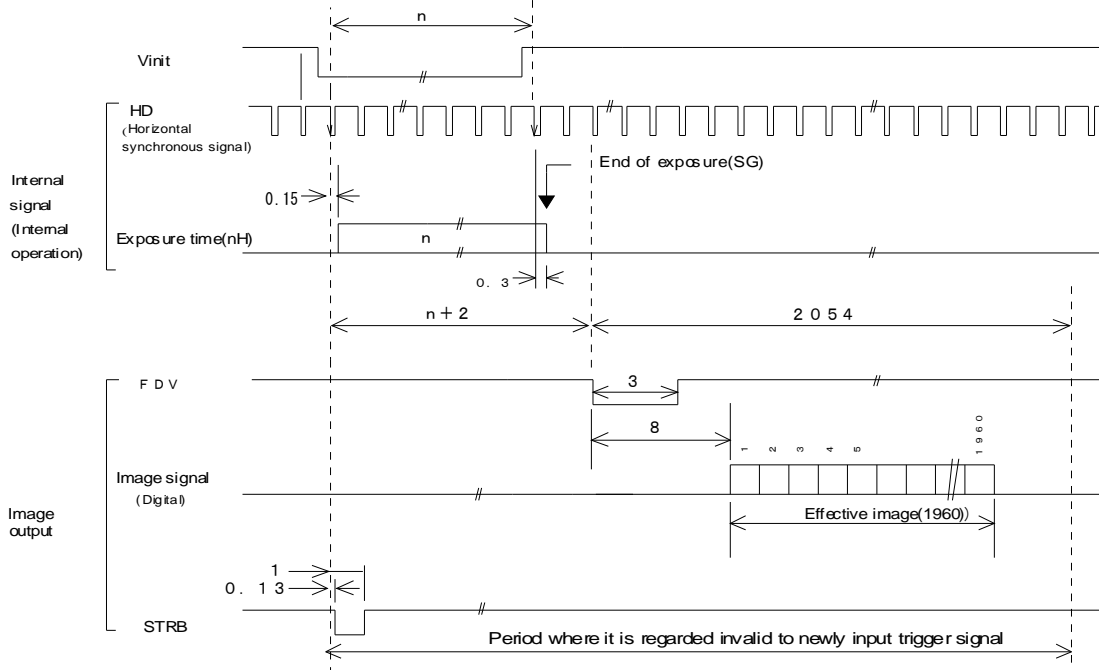
* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{S})$.

- Vertical timing: High speed/preset shutter/asynchronous shutter/normal scan/No fast dump



* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{S})$.

- Vertical timing: High speed/pulse width control/asynchronous shutter/normal scan/No fast dump

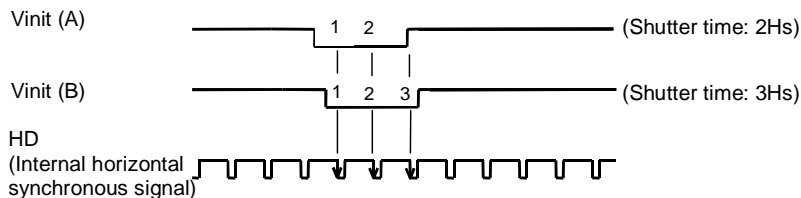


* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is H(= 3156 PCLK = 1920 x 1/32.50MHz = 97.11μS)

(Note) Strictly speaking, even if the same pulse width of Vinit is applied, the shutter speed differs for the period corresponding to 1H width when the asynchronous shutter operation is executed in the pulse width control mode (indefinite for 1H width).

Although an equal pulse width (value between 2Hs and 3Hs) is applied both for (A) and (B) in the figure below, the phase relationship with the internal horizontal synchronous timing makes their shutter speeds different from each other: (A) shutter speed = 2Hs and (B) shutter speed = 3Hs.

Example of 1H difference with same Vinit signal

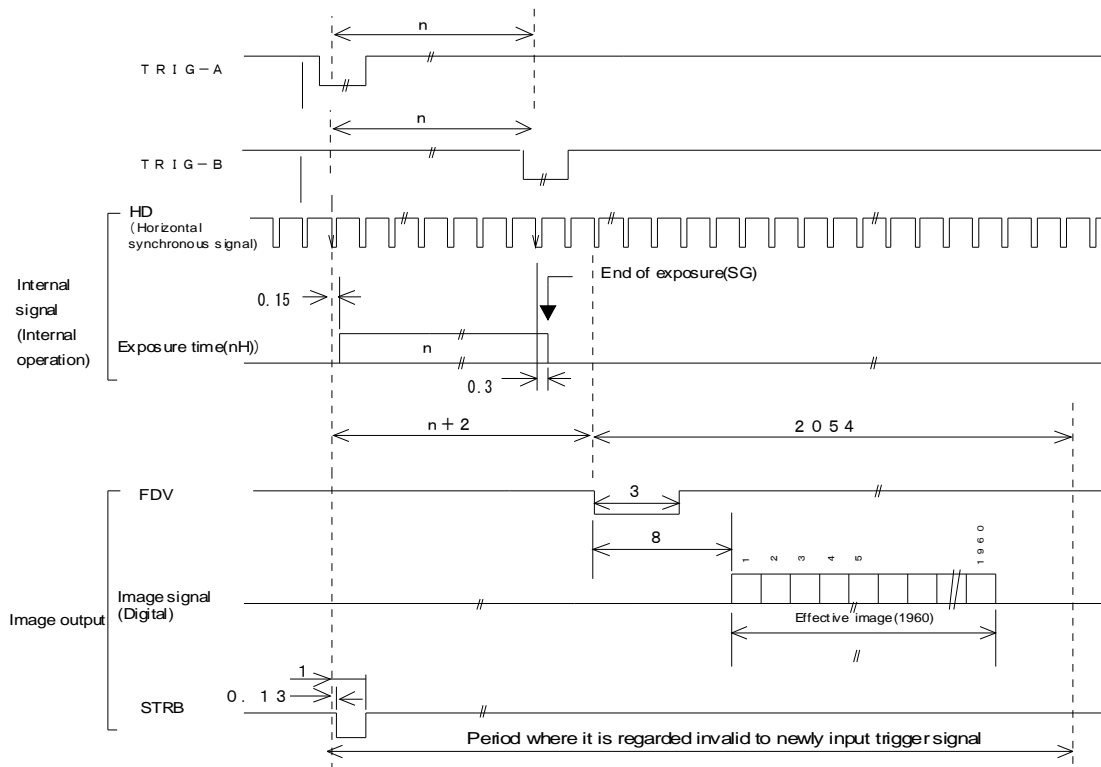


Because of the above reason, consideration must be given to the fact that the exposure time becomes indefinite for the period of 1H shutter speed when a Vinit signal that is not in synchronization with the internal horizontal synchronous signal (HD) is input from the user side. Some of the countermeasures to be taken are as follows:

- (1) Use only with the shutter speed that do not have serious impact even if the shutter speed is indefinite for a period of 1H.
 - No practical problem may be caused when the shutter speed is fairly long, say 100H width or longer because the impact of 1H difference in exposure time over the signal level is relatively small.
- (2) Synchronize the external trigger signal with the use of the LDV signal of the camera to keep the Vinit phase relationship constant.
 - Control can be made in the absence of the infinite time of 1H by stabilizing the generation phase of Vinit against the internal HD.

(Note) Since n does not have an upper limit, the exposure time can be prolonged to be more than one frame time. The maximum exposure time to be employed, however, should be determined after implementing experiments based on the conditions of the actual operation because a longer exposure time is accompanied by the degradation of S/N ratio due to the accumulation of CCD thermal noises.

- Vertical timing: High speed/double pulse/asynchronous shutter/normal scan/No fast dump



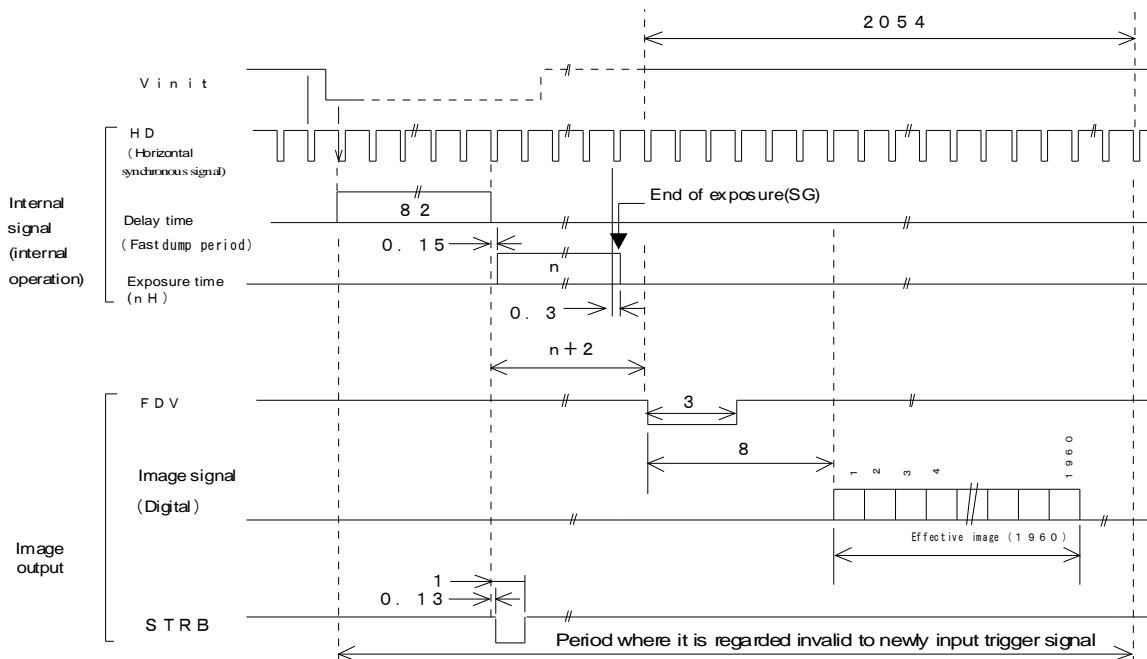
* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{S})$

(Note) When Double pulse mode is set ("2 TRIG"=ON and asynchronous shutter operation is selected), the shutter switch is effective only at the position "9".

(Note) When double pulse mode is set ("2-TRIG"=ON), the external synchronous function by EXT-HD/VD get disabled, as two types of trigger input pins overlap with the external synchronous input pins for normal use.

(Note) Even if two pulses TRIG-A, TRIG-B having the same time difference are applied, the shutter speed might differ for the period corresponding to 1H width in the double pulse mode as well as in the pulse width control mode/asynchronous shutter. Therefore it is required to synchronize the two trigger signals which is input to the camera with the horizontal synchronous timing signal (LDV) which is output from the camera to control the exposure time with the exact shutter speed.

- Vertical timing: High speed/preset/asynchronous shutter/normal scan/fast dump



* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{S})$

(Note) When in asynchronous operation with fast dump, the exposure starting time gets delayed as long as it takes to dump charges, compared to no fast dump operation.

- Vertical timing: High speed/pulse width control/asynchronous shutter/normal scan/fast dump

Timing is the same as “no fast dump” case, except that starting time of exposure, FDV, image signal, STRB is delayed by 82H(approx.8.1ms)

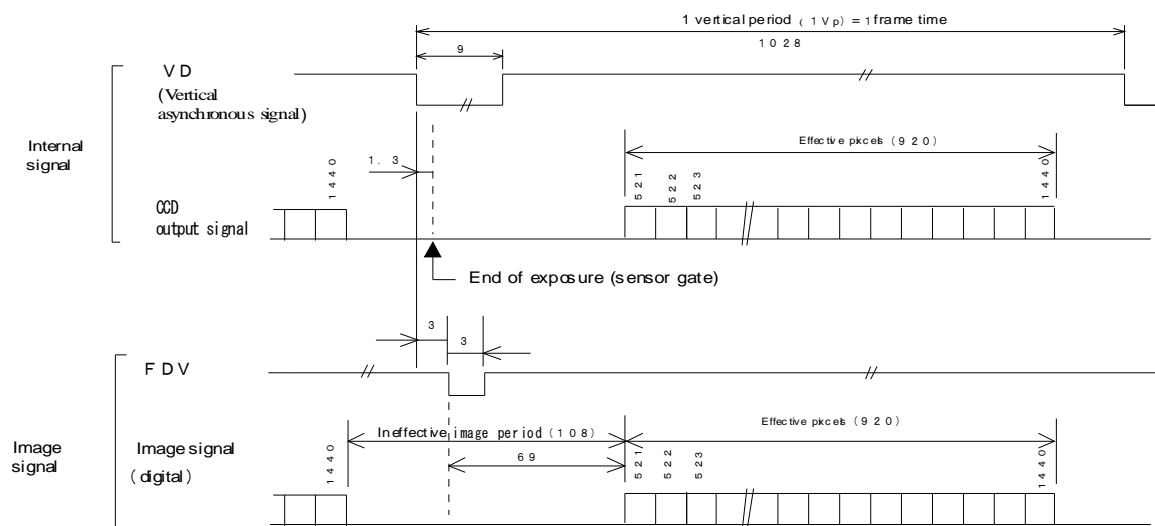
(Timing chart is omitted)

- Vertical timing: High speed/double pulse/asynchronous shutter/normal scan/fast dump

Timing is the same as “no fast dump” case, except that starting time of exposure, FDV, image signal, STRB is delayed by 82H(approx.8.1ms)

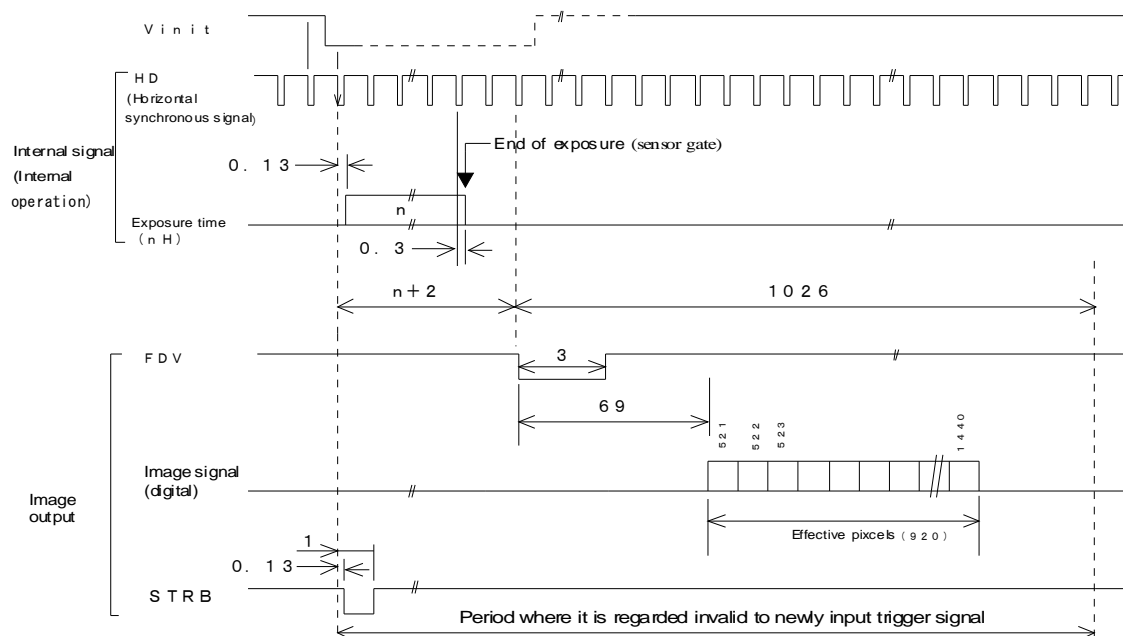
(Timing chart is omitted)

- Vertical timing: Continuous shutter, no shutter/partial scan



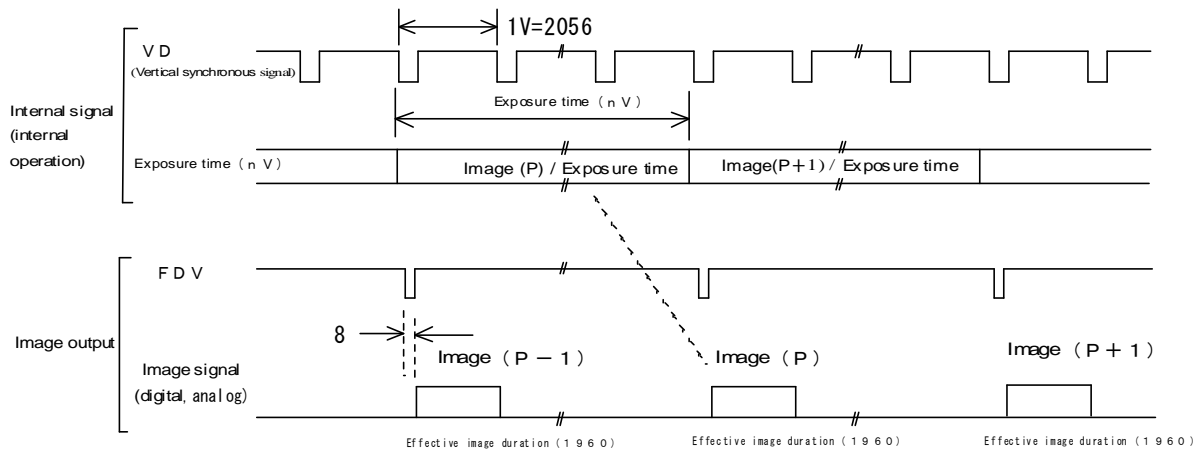
* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{s})$

- Vertical timing: High speed/preset/asynchronous shutter/partial scan



* Unless otherwise specified, the time unit of the numbers in the vertical timing chart is $H (= 3156 \text{ PCLK} = 1920 \times 1/32.50\text{MHz} = 97.11\mu\text{s})$

- Vertical timing: Low speed(prolonged exposure)/preset /continuous/normal scan

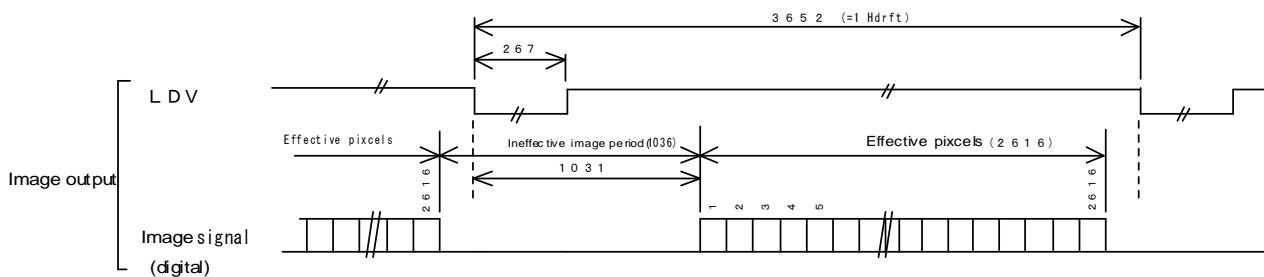


- * Unless otherwise specified, the time unit of the numbers in the vertical timing chart is H(= 3156 PCLK = 1920 x 1/32.50MHz = 97.11μS)
- * The detailed vertical timing of each effective image duration is the same as "vertical timing/continuous shutter, no shutter" case.

(Note) Prolonged exposure mode is not able to go with partial scan, draft scan mode.

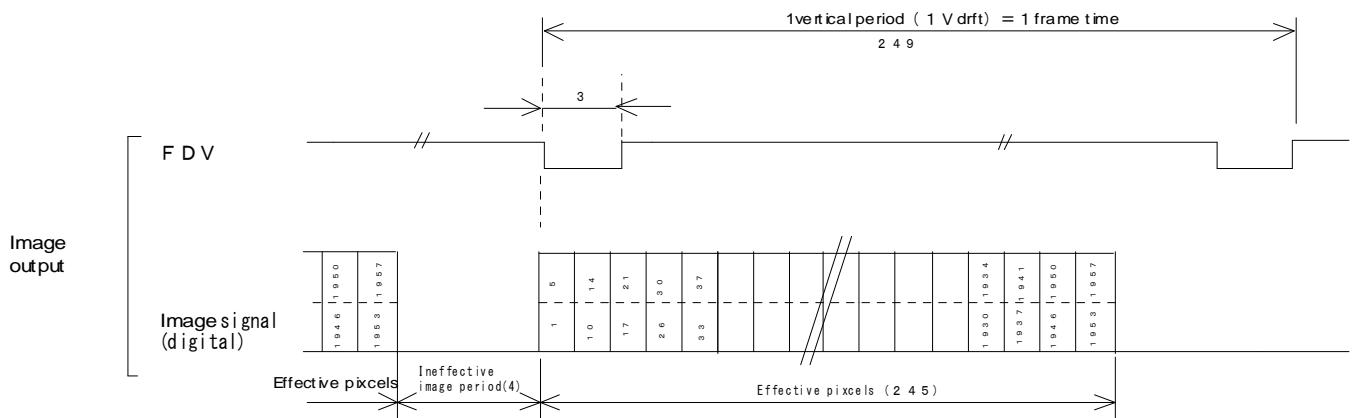
(Note) Asynchronous shutter operation in prolonged exposure mode is not supported.

- Horizontal timing: Continuous shutter, no shutter/draft scan



- * Unless otherwise specified, the time unit of the numbers in the horizontal timing chart is CLK (=1/32.5MHz = 30.77nS)

- Vertical timing: Continuous shutter, no shutter/draft scan



- * Unless otherwise specified, the time unit of the numbers in the vertical timing chart is Hdrft(= 3652 CLK x 1/32.5MHz = 112.37μS)

(Note) In the draft scan mode, 4 pixel lines out of every 16 pixel lines are read out for all pixels. And image data equivalent of 2 pixel lines as (1 + 5), (10 + 1) are read out, adding up 2 pixel lines together.

(Note) In the draft scan mode, whole image field is read out in 35.7fps frame rate by cutting numbers of scanning lines..

9. Notes

[Usage environment]

[Important]

On the usage of this equipment, please note the following to prevent the problem of time degradation of CCD image sensor (Increase of pixel defects etc.).

- Do not use this equipment in an environment subject to high temperatures and high humidity.
Especially in a high-temperature environment, degradation of CCD imager device is accelerated, and pixel defects such as sunspot may be caused. It is recommended that the equipment is used in an ambient temperature around normal room temperature (below 30°C degrees) as far as possible. If there is any concern that ambient temperature of the camera may be heated up when embedded in the apparatus, please consider to use a cooling equipment such as a cooling fan.
- Be careful not to get the light receiving surface be exposed to high intensity light over a long periods of time.
If a light receiving surface is exposed to high intensity light over a long time (regardless of the on/off state of the camera), the color filter on a surface of CCD image sensor may get discolored or get burnt in and normal image could not be output. Please reduce the amount of incoming light by using dark filter or by stopping down the aperture of the lens if the high intensity light like sunlight enters over a long periods of time.
The amount of light falling on the light receiving surface does not decrease with an adjustment of output level by getting electronic shutter speed higher, therefore note that discoloration or burn-in of image sensor can not be prevented that way.

[General precautions]

- This equipment is not allowed to be used for medical purposes, detection of hazardous materials or any other operations of which performance may exert influence on human lives or safety.
- Do not disassemble this equipment or alter the internal circuits. A fire accident may be caused by the heat generation associated with system failure.
- Refrain from connecting or disconnecting cables and connectors while power is being supplied, otherwise troubles may be caused.
- Connect this equipment to a high quality power source unit that does not contain noise components.
- Take appropriate measures to control the generation of noise if a power machine or other installations in the close neighborhood of this equipment radiates noise, which might adversely affect this equipment.● Fix a lens or implement other measures when using with a large or heavy lens, so that no extraordinarily large force is applied to the camera.
- Do not use this equipment in an environment subject to any temperatures other than that of the specifications or condensation, or a place subject to considerable dust or constant vibration/impact.
- When this equipment is not used for a long time, isolate the power from the equipment and remove the power cable and external connection cables.
- When an abnormal or failure condition is detected, immediately stop using this equipment, cut off the power supply, remove the external connection cables and contact the dealer for inspection/repair.
- The specifications and operational details described in the catalogues, manuals and others are subject to change for performance improvement or other reasons without notice.

10. Specifications

[Specifications]

Image sensor	Progressive scanning, interline transfer CCD 2/3 inch size RGB Primary color filter / Bayer arrangement Unit cell size: 3.4μm(H) × 3.4μm(V)
Number of effective pixels	2616 (H)×1960(V) square grid pattern
Read out scanning	Horizontal scanning frequency: $f_H = 10.3\text{KHz}$ Vertical scanning frequency: $f_V = 5.0\text{ Hz}$ Pixel clock frequency: $f_{CLK} = 32.50\text{ MHz}$
Standard sensitivity	400Lx at F8 * (* at 1/30sec exposure time and 512/1024 gray scale)
Minimum illuminance	4 Lx at F1.4
S/N	Approx. 50dB
Video output signal	Progressive scanning: 5 frames / sec Digital output / Camera Link (Base Configuration) 10 bit (32.5MHz×1×10 bit) / 8 bit (32.5MHz×1×8 bit) switchable
Synchronous input	HD/VD (2 to 5 Vp-p / 220Ω terminating) Automatic change Horizontal : $f_H=10.30\text{ kHz}$ Vertical : $f_V=f_H/2056$ (Approx.5.0Hz)
Electronic shutter	1/10000 sec.~1/ 5 sec. (No shutter) ~ 10 sec.
Asynchronous shutter	Preset fixed shutter/pulse width control/double pulse
Scan mode	Normal scan (all pixels)/Partial scan(central area)/Draft scan(4 lines out of every 16 lines)
Lens mount	C mount (flange back fixed) * movable type: option
Optical filter	IR cut filter ※Optical low-pass filter is optional
External control	Serial interface via Camera Link
Special functions	Function of superimposing setting information over output image Function of monitoring internal temperature of camera Function of storing camera ID information
Power supply	DC12V±10%, 500mA (max)
Operation ambient temperature	0°C to 40°C (Shall be free from dew condensation and frost.)
Storage temperature range	-30°C to 60°C (Shall be free from dew condensation and frost.)
Anti-shock	70G
Anti-vibration	7G
External dimension	46(W) × 42(H) × 128(L) mm (excluding tripod attachment)
Weight	Approx. 200g

11. External Dimensions

[External dimensions]

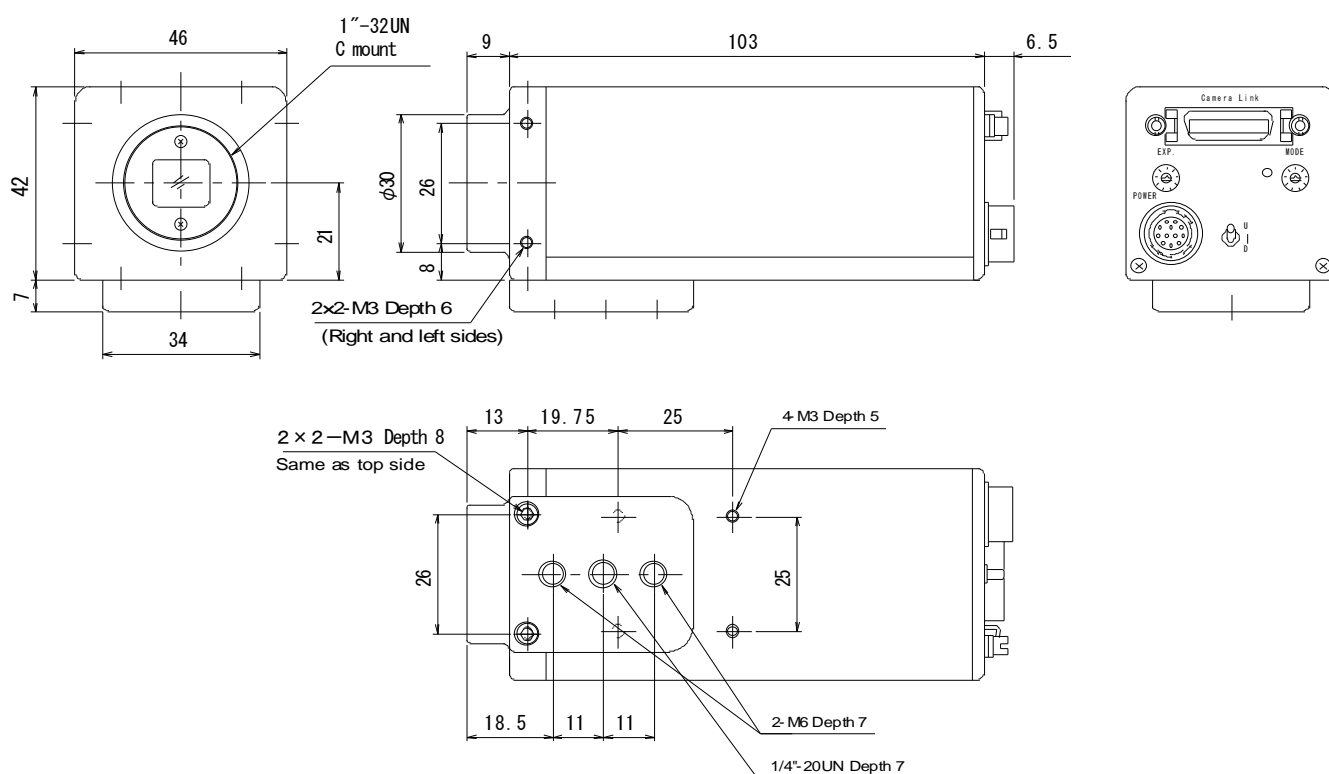


Fig.11-1 FS5000HCL external views