TDI Camera C10000-801 Instruction Manual

Thank you for your purchase.



- Follow the safety precautions in Chapter 1 in order to avoid personal injury and damage to property when using this camera. The manual describes the correct method of handling the C10000 camera and provides cautions in order to avoid accidents. Read this manual carefully beforehand, and use the camera correctly.
- After reading the manual, store it in a location where you can refer to it at any time.

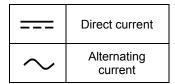
Ver. 1.1 Mar. 2013

HAMAMATSU PHOTONICS K.K.

1. SAFETY PRECAUTIONS

1-1 SYMBOL MARKING

The following symbols marks are used on the camera.



1-2 CLASSIFICATION OF WARNINGS

We have classified the warning symbols that appear in this operating manual and on the camera as follows for better comprehension of their meaning. Make sure that you fully understand them and obey the instructions they correspond to.

⚠ WARNING	Improper handling of the camera without observing these warnings could lead to serious injury to the user and even death.
⚠ CAUTION	Improper handling of the camera without observing these cautions could lead to personal injury to the user or damage to property.

Note	This symbol indicates a note to help you get the best performance from the camera. Read the contents of the note carefully to ensure correct and safe use. Failure to observe the note might impair the performance of the camera.	
	This symbol indicates a cautionary item that should be obeyed when handling the camera. Read the contents carefully to ensure correct and safe use.	
	This symbol indicates an action that is forbidden. Read the contents carefully and be sure to obey them.	
	This symbol indicates a compulsory action or instruction. Read the contents carefully and be sure to obey them.	

MARNING



Observe the power supply rating

Use this camera with the voltage indicated in the specifications of this manual. Using a different voltage can damage the camera and lead to fire or electric shock.



Do not damage cables

Do not allow cables to be damaged such as by placing heavy objects on top of it or by bending it with force. Using damaged cables can lead to fire or electric shock.



Do not insert a foreign substance into the camera

Do not allow foreign objects such as combustible substances, metal objects, or water to get inside the device. They can damage the camera and lead to fire or electric shock.



Do not attempt to dismantle or modify the camera

Touching high voltage parts in the camera can damage the camera and lead to accidents. Only touch parts as indicated in this manual.



Use the supplied power cord

Always use the AC adapter supplied with the camera when using the camera.



Do not connect or disconnect the power plug with wet hands. Such acts can lead to electric shock.



If an abnormality occurs

If the camera suddenly fails to display images or emits strange noise, odor, or smoke; turn off the camera immediately, disconnect the power plug, and contact a Hamamatsu subsidiary or local distributor. Never attempt to repair the camera yourself.

CAUTION



Handle the AC adapter correctly

When unplugging the AC adapter, do not pull on the cord; pull the plug.



If you are not going to use the camera for an extended period of time, unplu the AC adapter from the outlet.



Connecting and disconnecting cables

Always turn off the power before connecting and disconnecting cables.



Fixing the camera

When attaching the camera to some other equipment, use the four screws (M4) on the front panel. Do not insert the screws more than 10 mm from the front plate surface. If you do, the camera may not perform properly.



Shipping precautions

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



Do not subject the camera to strong shocks

Dropping the camera or applying shock to it can damage the camera.



Dispose the camera properly

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



Operating environment

This system is designed and tested for use in an industrial environment. If this system is used in residential areas, EMI (electro-magnetic interference) may occur.

This system must not be used in residential areas.

2. CHECK THE CONTENTS OF THE PACKAGE

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

C10000-801 TDI camera		1
Lens mount cap *attached to the camera		1
AC adapter		1
Power supply code for AC adapter		1
C10000-801 Before Use (Booklet)		1
C10000-801 instruction manual CD-ROM		1

[Option]

Camera Link interface cable	A10514-05
SMA-BNC cable	A12106-05
SMA-SMA cable	A12107-05



 We recommend that you use the options listed above. If you use other items, the camera may not meet the EMC directive requirements.

3. INSTALLATION



Avoid using or storing this camera in the following places

- Where the ambient temperature might fall below 0 °C or rise above 40 °C
- Where the temperature varies extremely
- In direct sunlight or near a heater
- Where the humidity is 70 % or more or where there is dripping water
- Close to a strong source of magnetism or radio waves
- · Where there is vibration
- Where it might come into contact with corrosive gases (such as chlorine or fluorine)
- · Where there is a lot of dust



Do not block ventilation opening

To prevent increase of temperature inside the equipment, do not block the ventilation opening when operating the equipment. For example, wrapping the camera with cloth blocks the ventilation opening. If the installation conditions require that the camera be covered, leave at least 10 cm of clearance around the ventilation opening.

Contents

1.	SAFETY PRECAUTIONS	1
	1-1 SYMBOL MARKING	
	1-2 CLASSIFICATION OF WARNINGS	1
2.	CHECK THE CONTENTS OF THE PACKAGE	4
3.	INSTALLATION	4
4.	OVERVIEW	7
5.	FEATURES	7
6.	NAMES AND FUNCTIONS OF PARTS	8
7.	CABLE CONNECTION	10
8.	OPERATION	11
	8-1 PRECAUTIONS	
	8-2 PREPARATION FOR IMAGING	
	8-3 IMAGING	
	8-4 END OF IMAGING	
9.	IMAGE ACQUISITION	12
	9-1 OVERVIEW	
	9-2 EXPOSURE AND READOUT CONTROL	
	9-3 EXTERNAL CONTROL SIGNAL POLARITY SETTING	
	9-4 EXTERNAL CONTROL SIGNAL TYPE SETTING	
	9-5 DIGITAL OUTPUT SETTING	
	9-6 EXPOSURE TIME	
	9-6-1 AREA IMAGING MODE [AMD N]	
	9-6-2 TDI MODE [AMD T]	14
	9-7 MODE RELATIONSHIP	15
10.	. COMMAND SPECIFICATIONS	16
	10-1 COMMUNICATION INTERFACE	16
	10-2 COMMAND FORMAT	
	10-3 CAMERA RESPONSES TO COMMANDS	17
	10-4 OVERVIEW OF COMMANDS	
	10-5 INITIAL COMMAND SETTINGS	
	10-6 DETAILS OF COMMANDS	21
11.	. PRECAUTIONS WHEN USING THE CCD	28
12.	. TROUBLESHOOTING CHECKLIST	29
	12-1 NO IMAGES	
	12-2 ALTHOUGH IMAGES APPEAR	29
13.	. SPECIFICATIONS	30
	13-1 CAMERA SPECIFICATIONS	30
	13-2 INTERFACE SPECIFICATIONS	32

	13-2-1 CAMERA LINK INTERFACE	32
	13-2-2 TIMING I/O CONNECTOR PIN ASSIGNMENT [TIMING I/O]	36
	13-3 OUTPUT TIMING SPECIFICATIONS	37
	13-4 CAMERA LINK OUTPUT SPECIFICATIONS	41
	13-5 CAMERA LINK SIGNAL TIMING SPECIFICATIONS	42
	13-6 FULL-WELL CAPACITY AND AMP GAIN CONVERSION COEFFICIENT SPECIFICATIONS	
14.	DIMENSIONAL OUTLINES	44
	14-1 CAMERA	44
15.	WARRANTY	45
16.	CONTACT INFORMATION	46

4. OVERVIEW

The C10000-801 utilizes TDI (Time Delay Integration) technology, enabling high sensitivity and large field imaging with high resolution at high speeds. It is equipped with a bidirectional TDI readout CCD. The camera has 2 tap output modes (1024 pixels for each).

5. FEATURES

(1) High resolution

Equipped with a high-resolution 2048 (horizontal) × 128 (vertical) pixel CCD.

(2) High sensitivity

The signal from 128 lines is integrated in TDI operation, realizing high sensitivity.

(3) Operation mode control

The numerous operation modes available in this camera can be controlled with commands via the serial line in the Camera Link.

(4) Digital output

Image signals are converted from analog to digital in the camera and output as 12 bit or 8 bit data. This camera complies with the base configuration 12 bit and 8 bit digital camera standard of the Camera Link interface.

(5) Real-time shading correction

In conventional camera output, the inconsistency in background and sensitivity inherent to CCD sensors caused shading, which

appeared in images. However, the TDI function of this camera is internally equipped with an image processing feature for background subtraction and shading correction, which used to be processed by software. This has made real-time processing and high-quality image output possible. As a result, the load on software has been reduced, improving the processing performance of the camera and software as a whole.

(6) Low graphic distortion

There is almost no graphical distortion, as pixels are lined geometrically.

(7) Lens mount

F-mount is standard.

6. NAMES AND FUNCTIONS OF PARTS

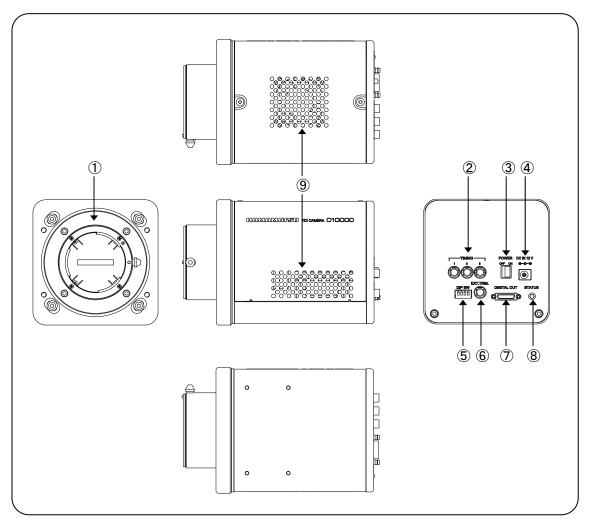


Figure 6-1

(1) Lens mount

F-mount lens or optics can be attached to the camera.

2 Timing I/O connectors 1, 2, 3 [TIMING 1, 2, 3]

Transmit or receive trigger signals for synchronizing with external devices. The I/O signal level is 3.3 V LVCMOS. Signals passes through an SN74LVC541 bus transceiver chip.



 Take termination into consideration depending on the cable length and other factors.

3 Power switch [POWER]

Turns the power on and off.

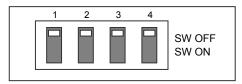
Flipping the switch to the ON. The STATUS LED is lights in green and starts the camera. Flipping the switch to the OFF. The camera will be standby mode and turns off the STATUS LED.

4 DC inlet [DC IN 12 V]

Power inlet. Connect the supplied AC adapter here.

5 Dip switch [DIP SW]

The factory default dip switch settings are shown below.



Use SW4 to switch the fan operation. By factory default, the fan is enabled (SW4 = OFF). To disable the fan, switch SW4 to ON.



· Never change the other switches.



• Turn off the camera before you change the switch.



To change the switch, use a thin flat-head screwdriver that matches the size
of the switch.

6 Trigger input connector [EXT.TRIG]

Use this connector to apply an external control signal to synchronize the camera's TDI line shift timing with this signal. The input level is 3.3 V LVCMOS. The input impedance is 1 k Ω .

⑦ Camera Link interface connector [DIGITAL OUT]

Connect a Camera Link interface cable to this connector. Digital image data is transmitted through this connector. In addition, you can send commands on the serial line of this connector to switch the camera operation mode. The camera's TDI line shift timing can be synchronized with an external control signal that is provided through CC1 of this connector.

8 STATUS LED [STATUS]

Indicates the power status. Different colors indicate different states.

State	Color
Standby	Off
On	Green
Abnormal temperature	Red



If abnormal temperature is indicated, stop using the camera immediately.

9 Ventilation opening

Exhaust opening for heat dissipation.



 Leave at least 10 cm of clearance around the ventilation opening.

7. CABLE CONNECTION

Refer to the following diagram to connect the cables.

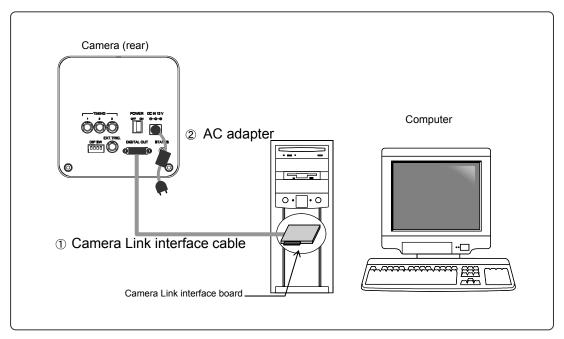


Figure 7-1



Turn off all devices before connecting or disconnecting cables.

1 Camera Link interface cable (Option)

Connect the Camera Link interface connector on the camera and the Camera Link interface board on the Computer using this cable.



 This camera conforms to the EMC directive when the following recommended items are used with the camera.

Note that if you do not use these items, the camera may not meet the EMC directive requirements.

Camera Link interface cable A10514-05

2 AC adapter

Supplies power to the camera.

8. OPERATION

8-1 PRECAUTIONS

(1) Starting the control software

Start the control software a few seconds after turning on the camera's power switch. The camera may not operate properly if it receives a command immediately after it starts. If the camera does not operate properly, close the control software immediately, and restart the camera.

(2) Protection circuit

The camera is protected from overheating with a protection circuit. Even when the fan is disabled, if the temperature rises abnormally, the protection circuit will drive the fan. If the protection circuit is activated, turn off the power immediately, eliminate the root cause of the heating problem, and then turn the power back on.

8-2 PREPARATION FOR IMAGING

Follow the procedure below to prepare the camera.



- Turn off all relevant devices before connecting cables.
- (1) Connect the cables in accordance with Figure 7-1.
- (2) Turn on the camera. (Flip the POWER switch on the rear of the camera to ON.)

8-3 **IMAGING**

The camera starts operating after the control software is started.



• For details on commands, see chapter 10, "COMMAND SPECIFICATIONS."

8-4 END OF IMAGING

After imaging is finished, follow the procedure below.

- (1) Stop imaging and any image data transmission, and close the control software.
- (2) Turn off the camera and peripherals.(Flip the POWER switch on the rear of the camera to OFF.)

9. IMAGE ACQUISITION

9-1 OVERVIEW

This camera acquires images by the TDI imaging method. The movement of the object has to be synchronized with the CCD charge transfer speed. This CCD can also operate as a normal full-frame transfer CCD (area imaging mode). We recommend that you use this mode to adjust the position and focus before switching to the TDI mode. You can use commands to switch the operation mode.



 For details on commands, see chapter 10, "EXTERNAL CONTROL COMMANDS."

9-2 EXPOSURE AND READOUT CONTROL

(1) Area imaging mode [AMD N]

Exposure and readout are repeated through internal microprocessor control. You can set the following parameters using commands.

Exposure time	Integer multiple of the exposure time of one line (256 to 50 200)
Digital output bits	12 bits or 8 bits

The exposure time of one line is 20 µs.



 Smear may be visible when the camera is operated in the area imaging mode since the camera is equipped with a full-frame transfer TDI CCD chip. Shorter the exposure time, the stronger the smear. This camera is specially designed for high speed TDI imaging; image quality in area imaging mode is not guaranteed.

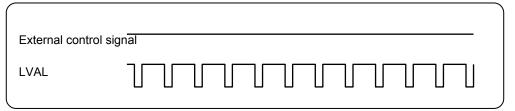
(2) TDI mode [AMD T]

The TDI line is shifted in sync with the internal signal or external control signal. The TDI line data is transmitted in sync with the LVAL signal of Camera Link. You can set the following parameters using commands.

TDI line shift signal	Internal signal or external control signal		
External control signal polarity	Negative or positive		
External control signal type	EXT.TRIG., Camera Link CC1		
Digital output bits	12 bits or 8 bits		

Use the TMD command to switch the TDI line shift control signal between internal signals and external control signal. The following are the timing diagrams of each TMD mode.

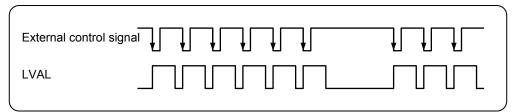
(1) **TMD I**



The camera outputs LVAL on the basis of its own internal signal, independent of the external control signal.

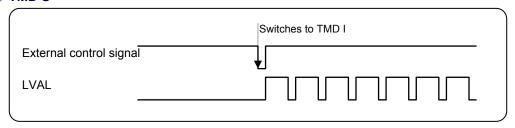
Use the HLN command to set the internally generated signal's TDI line shift frequency.

② TMD E



The camera outputs LVAL in sync with the external control signal.

③ TMD S



TMD I mode starts after an external control signal is received.

9-3 EXTERNAL CONTROL SIGNAL POLARITY SETTING

You can use a command to set the external control signal polarity to N (negative; falling edge) or P (positive; rising edge).

ATP (Active Trigger Polarity)	ATP N	Negative (falling edge)
	ATP P	Positive (rising edge)

9-4 EXTERNAL CONTROL SIGNAL TYPE SETTING

You can set the external control signal type to the SMA connector EXT.TRIG or Camera Link CC1.

ESC (External Trigger Source)	ESC M	EXT.TRIG.
	ESC I	Camera Link CC1

The minimum external control signal cycle is 50 kHz. The minimum pulse width is 500 ns.

9-5 DIGITAL OUTPUT SETTING

You can select the camera's digital output format.

9-5-1 DIGITAL OUTPUT BITS SETTING

You can set the number of bits that the camera transmits for digital data.

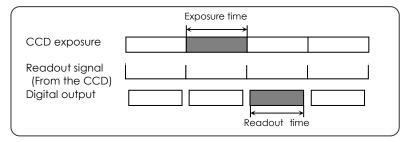
ADS (A/D Select)	ADS 12	12 bit data output
	ADS 8	8 bit data output

9-6 EXPOSURE TIME

The definition of exposure time is different in TDI mode from area imaging mode.

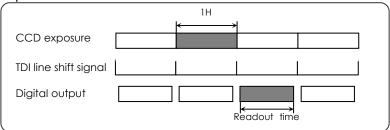
9-6-1 AREA IMAGING MODE [AMD N]

The camera alternates between exposure and readout according to the internal setting. Because the CCD is a full-frame transfer type, the readout time is contained in the exposure time. The exposure time can vary anywhere from 5.12~ms to 1004~ms in units of $20~\mu\text{s}$.

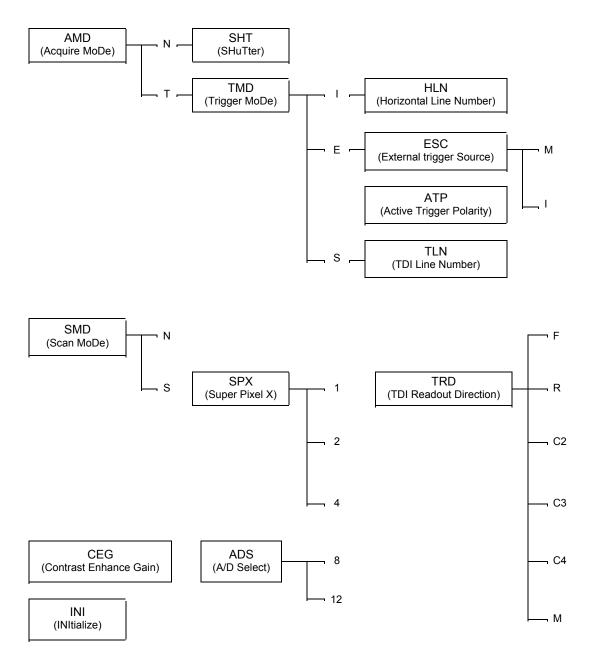


9-6-2 TDI MODE [AMD T]

The exposure time is determined by the TDI line shift signal interval. The minimum interval that you can set is $20 \mu s$.



9-7 MODE RELATIONSHIP



10. COMMAND SPECIFICATIONS

10-1 COMMUNICATION INTERFACE

The camera can be controlled from a computer through the serial interface in the Camera Link. The serial interface parameters are as shown below.

Baud rate	38 400 bps
Bit length	8 bits
Parity bit	None
Stop bits	1 bit

10-2 COMMAND FORMAT

Use either of the following formats to send external control commands from the computer to the camera.

External control commands are made up of ASCII codes.

Command	CR	CR: Carriage return		
Command SP parameter		neter	CR	SP: Space CR: Carriage return

<Command examples>

AMD T

	Α	М	D	<sp></sp>	T	<cr></cr>
ASCII code	0x41	0x4D	0x44	0x20	0x54	0x0D

Attach <CR> to the end of every command.

For commands that require parameters, insert a space as a separator between the command parameters (spaces will be represented by underscores hereafter).

10-3 CAMERA RESPONSES TO COMMANDS

The camera responds to commands received from the computer. A response indicates that the camera has finished processing the command it has received. How long the camera takes to make a response and the character string that the camera returns vary depending on the type of command.

(1) Responses to mode setting commands, parameter setting commands, and correction commands

If a command has been executed properly, the camera returns the command string (with parameters) to the camera.

XXX_PP	CR
--------	----

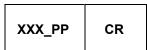
XXX: Executed command

PP: Parameter

If there is an error in the command received from the host computer (an undefined command or parameter error), the camera returns the following character string as an error.

(2) Responses to status commands

The camera returns the current operation mode to the computer.



XXX: Command name (three characters without the question mark) PP: Status gueried by the command

If there is an error in the command received from the host computer (an undefined command or another problem), the camera returns the following character string as an error.

10-4 OVERVIEW OF COMMANDS

External control commands are divided into the following five groups.

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

(1) Mode setting commands

These commands change the image acquisition mode.

AMD	Sets the exposure start timing.		
TMD	Switches between internal trigger and external control signal.		
SMD	Sets the scanning mode (normal or binning).		
ADS	Sets the number of digital data output bits.		

(2) Parameter setting commands

These commands set parameters, such as the length of exposure and the number of digital output pixels.

SHT	Sets the exposure time in area imaging mode.
HLN	Sets the exposure time of one line in TDI mode.
ESC	Sets the external control signal type.
ATP	Sets the polarity of external control signal pulses.
TDN	Sets external control signal skipping.
TRD	Sets the camera's readout direction.
TLN	Sets the number of frame valid lines to output.
SPX	Sets the binning number.
CEG	Sets the contrast enhancement gain.
FAN	Turns on or off the fan rotation.

(3) Correction commands

These commands deal with correction.

BGC	Sets the DSP subtraction image display to on or off.
BGS	Retrieves the subtraction image.
BGO	Sets the offset.
SHC	Sets shading correction to on or off.
SHS	Retrieves shading corrected data.
SHM	Saves retrieved corrected data.
BGX	Copies the dark table from the host computer to the Flash memory.
SHX	Copies the shading table from the host computer to the Flash memory.
BGD	Saves the dark table to the Flash memory through the host computer.
SHD	Saves the shading table to the Flash memory through the host computer.
BGP	Loads the dark table from the Flash memory into the DSP.
SHP	Loads the shading table from the Flash memory into the DSP.

(4) Other setting commands

These commands deal with initialization and other settings.

INI	Initializes the camera settings.
-----	----------------------------------

(5) Status commands

These commands query the camera status. All commands start with a question mark.

?AMD	Returns the exposure start timing setting.
?TMD	Returns the external control signal input setting.
?SMD	Returns the scanning mode setting.
?ADS	Returns the number of digital data output bits.
?SHT	Returns the exposure time in area imaging mode.
?HLN	Returns the exposure time of one line in TDI mode.
?ESC	Returns the external control signal type setting.
?ATP	Returns the external control signal polarity setting.
?TDN	Returns the external control signal skipping setting.
?TRD	Returns the camera's readout direction.
?TLN	Returns the number of lines to output.
?SPX	Returns the binning number.
?CEG	Returns the gain setting.
?FAN	Returns the fan setting.
?BGC	Returns the DSP subtraction image display on/off state.
?BGO	Returns the offset setting.
?SHC	Returns the shading correction on/off state.
?BGX	Returns the dark table value saved in the Flash memory.
?SHX	Returns the shading table value saved in the Flash memory.
?VER	Returns the camera ROM version.
?CAI	Returns the camera hardware information.
?TNS	Returns the number of Camera Link taps.

10-5 INITIAL COMMAND SETTINGS

Setting commands are set as follows when the power is turned on. You can also initialize the commands to the these values by using the INI command. However, the FAN command depends on the DIPSW setting.

Initial values		
Mode setting commands	AMD	Т
	TMD	E
	SMD	N
	ADS	12
Parameter setting commands	SHT	256
	HLN	600
	ESC	М
	ATP	N
	TDN	1
	TRD	F
	TLN	0
	SPX	2
	CEG	0
Correction commands	BGC	F
	BGS	(no initial value)
	BGO	0
	SHC	F
	SHS	(no initial value)
	SHM	(no initial value)
	BGX	(no initial value)
	SHX	(no initial value)
	BGD	(no initial value)
	SHD	(no initial value)
	BGP	(no initial value)
	SHP	(no initial value)

10-6 DETAILS OF COMMANDS

(1) Mode setting commands

AMD	(Acquire MoDe)			
	Function	Sets the	Sets the exposure start timing to area imaging mode or TDI mode.	
	Format	AMD <a>		
	Parameter <a>	T (TDI) / N	T (TDI) / N (Normal)	
	Example	AMD T	Switches to TDI mode.	
	Lxample	AMD N	Switches to area imaging mode.	
TMD	(Trigger MoDe)			
	Function		TDI line shift signal to the internally generated signal, control signal, or TDI start trigger.	
	Format	TMD <a>		
	Parameter <a>	I (Internal) / E (External) / S (TDI start trigger)	
		TMD I	Sets the TDI mode's line shift signal to the internally generated signal.	
	Example	TMD E	Sets the TDI mode's line shift signal to the external control signal.	
		TMD S	Starts the TDI mode's line shift on the basis of a TDI start trigger. After receiving the start trigger, the camera operates in internal control (TMD I) mode.	
SMD	(Scan MoDe)			
	Function	exposure	TDI mode's scanning mode to normal or binning. If the start timing is set to area imaging mode, the camera peration is set to normal readout.	
	Format	SMD <a>		
	Parameter <a>	N (Normal) / S (Super pixel)	
	Example	SMD N	Reads in normal mode (maximum resolution).	
	Example	SMD S	Reads in binning mode.	
ADS	(A/D Select)			
	Function	Sets the n	number of digital data output bits to 12 bits or 8 bits.	
	Parameter	12 (12 bit	output)/8 (8 bit output)	
	Example	ADS 12	Outputs 12-bit digital image data.	
		ADS 8	Outputs the 8 most significant bits of the 12-bit digital image data.	

(2) Parameter setting commands

SHT	SHT (SHuTter)			
	Function	Sets the e	xposure time in area imaging mode.	
	Format	SHT <a>		
		n* (256≤ * n: Integr	n≤50 200) ation frame number (initial value = 256)	
	Parameter <a>	the result.	exposure for the specified number of lines and reads. The exposure time of one line is 20 μ s, and the total time is an integer multiple of 20 μ s.	
	Example	SHT 256	Integrates 256 lines and reads the result. The exposure time is calculated as 20 μ s × 256 = 5.12 ms.	
HLN	(Horizontal Line N	Number)		
	Sets the exposure time when the TDI line shift is being with the internally generated signal. This setting is the of one TDI line shift. Function Function			
			$f(Hz) = 30 \times 10^6 \div n$	
	Format	HLN <a>		
	Parameter <a>	n* (600≤n≤65 646) * n: Line shift interval (initial value = 600)		
	Example	HLN 600	Performs TDI line shift at 50 kHz.	
ESC	(External Trigger	Source)		
	Function		external control signal type to SMA connector 3) or Camera Link CC1.	
	Function Format			
		(EXT.TRIC		
	Format Parameter <a>	(EXT.TRIC	S) or Camera Link CC1.	
	Format	(EXT.TRICE ESC <a> M (Timing I/	O) / I (Camera Link CC1) Sets the external control signal type to SMA connector	
АТР	Format Parameter <a>	(EXT.TRIC ESC <a> M (Timing I/ ESC M	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link	
АТР	Format Parameter <a> Example	(EXT.TRIC ESC <a> M (Timing I/ ESC M ESC I	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link	
АТР	Format Parameter <a> Example (Active Trigger Po	(EXT.TRIC ESC <a> M (Timing I/ ESC M ESC I	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1.	
АТР	Format Parameter <a> Example (Active Trigger Pounction	(EXT.TRICE ESC <a> M (Timing I/ ESC M ESC I Clarity) Sets the e ATP <a> N (Negative	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. Sets the external control signal type to Camera Link CC1.	
АТР	Format Parameter <a> Example (Active Trigger Pounction Format	ESC <a> M (Timing I/ ESC M ESC I Diarity) Sets the e ATP <a> ATP N	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. External control signal polarity to negative or positive. External control signal polarity to negative or positive.	
	Format Parameter <a> Example (Active Trigger Pounction Format Parameter <a> Example	(EXT.TRICE ESC <a> M (Timing I/ ESC M ESC I Clarity) Sets the e ATP <a> N (Negative ATP N ATP P	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. Sets the external control signal type to Camera Link CC1.	
ATP	Format Parameter <a> Example (Active Trigger Pounction Format Parameter <a> Example (Trigger Divide N	(EXT.TRICE ESC <a> M (Timing I/ ESC M ESC I Distrity) Sets the ear ATP <a> N (Negative ATP N ATP P umber)	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. External control signal polarity to negative or positive. External control signal polarity to negative or positive. External control signal polarity to negative or positive. External control signal polarity to negative. Sets the external control signal polarity to positive.	
	Format Parameter <a> Example (Active Trigger Pounction Format Parameter <a> Example (Trigger Divide Normat)	ESC <a> M (Timing I/ ESC M ESC I Diarity) Sets the e ATP <a> ATP N ATP P umber) Sets exter	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. External control signal polarity to negative or positive. Sets the external control signal polarity to negative or positive.	
	Format Parameter <a> Example (Active Trigger Pounction Format Parameter <a> Example (Trigger Divide Normat Function Format	(EXT.TRICE ESC <a> M (Timing I/ ESC M ESC I Diarity) Sets the ear ATP <a> N (Negative ATP N ATP P umber) Sets exter TDN <a> TDN <a> ATDN <a> ATDN	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. External control signal polarity to negative or positive. External control signal polarity to negative or positive. External control signal polarity to negative to negative. Sets the external control signal polarity to negative. Sets the external control signal polarity to positive.	
	Format Parameter <a> Example (Active Trigger Pounction Format Parameter <a> Example (Trigger Divide Normat)	(EXT.TRICE ESC <a> M (Timing I/ ESC M ESC I Diarity) Sets the ear ATP <a> N (Negative ATP N ATP P umber) Sets exter TDN <a> TDN <a> ATDN <a> ATDN	Sets the external control signal type to SMA connector (EXT.TRIG.). Sets the external control signal type to Camera Link CC1. External control signal polarity to negative or positive. External control signal polarity to negative or positive. External control signal polarity to negative or positive. External control signal polarity to negative. Sets the external control signal polarity to positive.	

1	(TBTTCaacat B				
	Function	Sets the	Sets the TDI transfer direction.		
	Format	TRD <a>			
	Parameter <a>		d) / R (Reverse) / C2 (Camera Link CC2) / C3 (Camera Link (Camera Link CC4) / M (Timing I/O)		
		TRD F	Reads in the forward direction.		
		TRD R	Reads in the backward direction.		
		TRD C2	Sets the transfer direction on the basis of the Camera Link CC2 signal. Low is forward direction; high is backward direction.		
	Example	TRD C3	Sets the transfer direction on the basis of the Camera Link CC3 signal. Low is forward direction; high is backward direction.		
		TRD C4	Sets the transfer direction on the basis of the Camera Link CC4 signal. Low is forward direction; high is backward direction.		
		TRD M	Sets the transfer direction on the basis of the SMA connector (TIMING 1) signal. Low is forward direction; high is backward direction.		
TLN	(Trigger Line N	umber)	<u> </u>		
	Function	Sets the trigger is	number of frame valid lines to output when a TDI start received.		
	Format	TLN <a>			
	Parameter <a>		16, ···65 512)		
	Example	TLN 8	Outputs frame valid for 8 TDI lines.		
SPX	(Super Pixel X)	Ta			
	Function		binning number for when the scan mode is set to binning ×2, or 4×4.		
	Format	SPX <a>			
	Parameter <a>	n (1, 2,	4)		
		SPX 1	Reads using 1×1 binning.		
	Example	SPX 2	Reads using 2×2 binning.		
	<u> </u>	SPX 4	Reads using 4×4 binning.		
CEG	(Contrast Enhar	1			
	Function		contrast enhance gain to one of 16 levels in the range of The amount of gain increase is linear between levels.		
	Format	CEG <a>			
	Parameter <a>	n (0≤n≤	15)		
	Example	CEG 15	Sets the camera gain to 5x.		
FAN	(FAN control)				
	Function	Turns on	or off the fan.		
	Format	FAN <a>			
	Parameter <a>	0 (On) / F	(oFf)		
1	1		1		
	Example	FAN O	Turns on the fan.		

TRD

(TDI Readout Direction)

(3) Correction commands

Note

• Image processing does not work in area imaging mode.

BGC	(Back Ground s	ubtraction Control)		
	Function	Sets the image subtraction processing to on or off.		
	Format	BGC <a>		
	Parameter <a>	O (On) / F (oFf)		
		BGC 0 Enables image subtraction processing.		
	Example	BGC F Disables image subtraction processing.		
BGS	(Back Ground s	ubtraction Saving)		
	Function	Retrieves the image to subtract in the camera's internal memory.		
	Format	BGS		
BGO	(Back Ground C	Offset)		
	Function	Sets the offset for image subtraction processing.		
	Format	BGO <a>		
	Parameter <a>	n (0≤n≤1000)		
	Example	BGO 1000 Sets the offset to the maximum.		
SHC	(SHading Corre	ction)		
	Function	Sets the shading correction feature of image processing to on or off.		
	Format	SHC <a>		
	Parameter <a>	O (On) / F (oFf)		
		SHC 0 Sets the shading correction feature to on.		
	Example	SHC F Sets the shading correction feature to off.		
SHS	(SHading image	Saving)		
	Function	Retrieves the shading correction data for image processing into the camera's internal memory.		
	Format	SHS		
SHM	(SHading image	Making)		
	Function	Saves the shading corrected data after image processing to the camera's internal memory.		
	Format	SHM		
BGX	(Back Ground s	ubtraction Xfer)		
	Function	Copies the dark table from the host computer to the Flash memory.		
	Format	BGX <a>, 		
	Parameter <a>	n (0,16,32,2032)		
	Parameter 	0000000100020003000400050006000700080009000A000B000 C000D000E000Fxxxx		
	Example	One command transfers 16 pixels × 2 bytes (four hexadecimal characters) to the Flash memory. xxxx is the check sum obtained through 2-byte summation ignoring overflow (0078 in this example). You can set the offset to an integer multiple of 16 between 0 and 2032. You cannot specify the page; the data is always saved to page 0. Binning data and TDI transfer direction data are saved to page 0 of their corresponding storage areas, which are automatically determined by the camera.		

SHX	(SHading image Xfer)		
	Function	Copies the shading table from the host computer to the Flash memory.	
	Format	SHX <a>, 	
	Parameter <a>	n (0,16,32,2032)	
	Parameter 	0000000100020003000400050006000700080009000A000B000 C000D000E000Fxxxx	
	Example	One command transfers 16 pixels × 2 bytes (four hexadecimal characters) to the Flash memory. xxxx is the check sum obtained through 2-byte summation ignoring overflow (0078 in this example). You can set the offset to an integer multiple of 16 between 0 and 2032. You cannot specify the page; the data is always saved to page 0. Binning data and TDI transfer direction data are saved to page 0 of their corresponding storage areas, which are automatically determined by the camera.	
BGD	(Back Ground D	ata)	
	Function	Saves the dark table to the Flash memory through the host computer.	
	Format	BGD <a>	
	Parameter <a>	n (1,2,8)	
	Example	Saves the dark table stored in the IRAM area of the DSP to the Flash memory through the host computer. Six types (12 sector each) of data—1×1, 2×2, and 4×4 in the forward direction and 1×1, 2×2, and 4×4 in the backward direction—can be saved to the Flash memory. The type is automatically designated depending on the setting conditions of the host computer. Only the page can be designated.	
SHD	(SHading Data)		
	Function	Saves the shading table to the Flash memory through the host computer.	
	Format	SHD <a>	
	Parameter <a>	n (1,2,8)	
	Example	Saves the shading table stored in the IRAM area of the DSP to the Flash memory through the host computer. Six types (12 sector each) of data—1×1, 2×2, and 4×4 in the forward direction and 1×1, 2×2, and 4×4 in the backward direction—can be saved to the Flash memory. The type is automatically designated depending on the setting conditions of the host computer. Only the page can be designated.	
BGP	(Back GroundPa	age)	
	Function	Loads the dark table from the Flash memory into the DSP.	
	Format	BGP <a>	
	Parameter <a>	n (1,2,8)	
	Example	Loads a dark table from the Flash memory into the IRAM area of the DSP through the host computer. Six types (12 sector each) of data—1×1, 2×2, and 4×4 in the forward direction and 1×1, 2×2, and 4×4 in the backward direction—are available. The type is automatically designated depending on the setting conditions of the host computer. Only the page can be designated.	

SHP	(SHading Page)	
	Function	Loads the shading table from the Flash memory into the DSP.
	Format	SHP <a>
	Parameter <a>	n (1,2,8)
	Example	Loads a shading table from the Flash memory into the IRAM area of the DSP through the host computer. Six types (12 sector each) of data—1×1, 2×2, and 4×4 in the forward direction and 1×1, 2×2, and 4×4 in the backward direction—are available. The type is automatically designated depending on the setting conditions of the host computer. Only the page can be designated.

(4) Other setting commands

INI	(INItialize)		
	Function	Initializes the camera command settings. The settings are set to the same values as when the camera is powered on.	
	Format	INI	

Status commands
These commands query the current settings.

	Command	Return value
?AMD	(read Acquire MoDe)	T/N
?TMD	(read Trigger MoDe)	I/E/S
?SMD	(read Scan MoDe)	N/S
?ADS	(read A/D Select)	12/8
?SHT	(read SHuTter)	n (256≤n≤50 200)
?HLN	(read Horizontal Line Number)	n (600≤n≤65 646)
?ESC	(read External trigger SourCe)	M/I
?ATP	(read Active Trigger Polarity)	N/P
?TDN	(read Trigger Divide Number)	n (1≤n≤65 535)
?TRD	(read TDI Readout Direction)	F/R/C2/C3/C4/M
?TLN	(read Trigger Line Number)	n (0,8,16,•••65 512)
?SPX	(read Super Pixel X)	n (1,2,4)
?CEG	(read contrast Enhancement Gain)	n (0≦n≦15)
?FAN	(read FAN control)	0/F
?BGC	(read Back Ground subtraction Control)	O/F
?BGO	(read Back Ground subtraction Offset)	n (0≦n≦1000)
?SHC	(read SHading Correction)	0/F

?BGX	(read Back Ground Xfer)			
	Function	Returns the data of 16 pixels in page 0.		
	Format	?BGX <a>		
	Parameter <a>	n: 0,16,32,2032		
?SHX	(read SHading Xfe	(fer)		
	Function	Returns the data of 16 pixels in page 0.		
	Format	?SHX <a>		
	Parameter <a>	n: 0,16,32,2032		

The following commands are only for querying the status; they do not have corresponding setting commands.

?VER	(read ROM VERsion)			
	Function	Returns the camera firmware version.		
	Return value	x.xx		
?CAI	(CAmera Inform	ation)		
	Function	Returns the camera hardware information.		
	Format	CAI <a>		
	Parameter <a>	T: Camera type I: Number of A/D converter bits		
	Example	CAI T CAI T C10000-801		
?TNS	(read Tap Number Select)			
	Function	Returns the number of Camera Link taps.		
	Return value	2		

11. PRECAUTIONS WHEN USING THE CCD

The CCD used in the camera has the following characteristics. Take these characteristics into consideration when you use the camera.

(1) White spot

Subjecting the CCD to extended exposures may result in white spots due to a defect in the silicon wafer. This phenomenon is currently not preventable. Cosmic rays may also cause white spots.

(2) Smear

Smear is a group of vertical streaks that appears when a very bright subject is imaged. On this camera, the amount of smear increases as the exposure time is decreased in area imaging mode.

(3) Aliasing

Due to the inherent characteristics of the CCD, rough-edged flicker may be visible when stripe patterns, lines, and so forth are imaged.

(4) Interference fringes

Coherent light such as LASER light may generate interference fringes on images.

(5) Excessive light



 Be careful not to apply high-energy light, such as laser light, to the CCD, because the CCD may be damaged.

12. TROUBLESHOOTING CHECKLIST

If an abnormality occurs, look up the possible causes in the following tables, and if necessary, report the details to a Hamamatsu subsidiary or local distributor.

12-1 NO IMAGES

Cause	Measure	Chapter
Power is not being supplied.	Check the connections.	7
Cables are not connected properly.		
Cables are broken.	Replace broken cables.	
Commands that have been sent are invalid.	Check the commands.	

12-2 ALTHOUGH IMAGES APPEAR

(1) Images are blurred

Cause	Measure	Chapter
The back focus is not aligned.	Contact a Hamamatsu subsidiary or	16
The CCD chip is dirty.	distributor.	10

(2) Only shadowed images are output

Cause	Measure	Chapter
The lens mount cap is still on.	Remove the cap.	

(3) The entire screen overflows

Cause	Measure	Chapter
There is too much light.	Reduce the amount of light.	

(4) Noise appears on the screen

Cause	Measure	Chapter
External noise	Determine the cause and eliminate.	
Poor connection inside the camera.	Contact a Hamamatsu subsidiary or	16
Defective circuitry	distributor.	10

13. SPECIFICATIONS

13-1 CAMERA SPECIFICATIONS

(1) Electrical specifications

Imaging device	Full-Frame Transfer TDI-CCD: S10201-04-01	
Effective number of pixels	2048 (H) × 128 (V)	
Cell size	12 μm × 12 μm (square)	
Effective area	24.58 mm (H) × 1.536 mm (V)	
TDI line shift frequency	457 Hz to 50 kHz *1	
Readout noise (r.m.s.)	50 electron (typ.) *2	
Amp gain conversion coefficient *3,*4	19.5 electron / AD count (for 12-bit digital data output)	
coefficient *3,*4	312 electron / AD count (for 8-bit digital data output)	
Full well capacity (typ.) *4	80 000 electrons	
A/D converter	12 bit or 8 bit	
Lens mount	F-mount	
Exposure time	5.12 ms to 1004 ms (area imaging mode operation)	
Interface	Camera Link (Base Configuration)	

- * 1 When the TDI line shift signal is set to the internally generated signal. If it is set to the external control signal, a lower frequency can be specified, but the exposure time will be outside the specifications, and a large mount of noise will appear in the image.
- * 2 This value is the measured value in TDI mode. To find this value, the CCD was placed in a dark environment, and two images were taken in this condition. The two images were subtracted from each other, and the standard deviation of the difference was found. Then, the result was divided by the square root of 2 and multiplied by the conversion coefficient.
- * 3 The amp gain conversion coefficient is the coefficient used to convert the count value of the measured image to electrons. Before making this conversion, be sure to carry out dark subtraction.
- * 4 This is the value when the contrast enhancement gain is set to zero.

(2) Power specifications

Input power supply	AC 100 V to AC 240 V	
Frequency	50 Hz / 60 Hz	
Power Consumption	Approx. 14 VA	



• The tolerance of input power supply voltages is within ±10 %.

(3) Operating environment

Ambient storage temperature	-10 °C to + 50 °C
Ambient operation temperature	0 °C to + 40 °C
Ambient operation humidity	70 % or less (no condensation)
Operating location	Indoors, altitude up to 2000 m

(4) Dimensional outlines and weight

Camera	Approx. 1.4 kg
--------	----------------

Note

• See chapter 14 for full dimensional outlines.

(5) Applicable standards

EMC EN61326-1: 2006 Class A	
-----------------------------	--

13-2 INTERFACE SPECIFICATIONS

13-2-1 CAMERA LINK INTERFACE

The Camera Link interface is a digital interface standard that was developed by digital camera and frame grabber manufacturers in order to consolidate the numerous original standards that had been in use. The interface transfers 28-bit digital data (TX0 to TX27) that is converted into serial data over only five signal lines (X0, X1, X2, X3, and XCLK). This camera complies with the base configuration 12 bit and 8 bit digital camera standard of the Camera Link interface.

(1) Camera Link connector pin assignment (SDR-26)

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

(2) Camera Link connector bit assignment (SDR-26)

Camera Link port	PORT A		PORT B	\rightarrow
------------------	--------	---------	--------	---------------

Binning	PORT A	PORT B
1×1	1024 pixel	1024 pixel
2×2	512 pixel	512 pixel
4×4	256 pixel	256 pixel

28 bit solution pin name	8-bit	12-bit
Tx 00	PORT A0	PORT A0
Tx 01	PORT A1	PORT A1
Tx 02	PORT A2	PORT A2
Tx 03	PORT A3	PORT A3
Tx 04	PORT A4	PORT A4
Tx 05	PORT A7	PORT A7
Tx 06	PORT A5	PORT A5
Tx 07	PORT B0	PORT A8
Tx 08	PORT B1	PORT A9
Tx 09	PORT B2	PORT A10
Tx 10	PORT B6	PORT B10
Tx 11	PORT B7	PORT B11
Tx 12	PORT B3	PORT A11
Tx 13	PORT B4	PORT B8
Tx 14	PORT B5	PORT B9
Tx 15	nc	PORT B0
Tx 16	nc	PORT B6
Tx 17	nc	PORT B7
Tx 18	nc	PORT B1
Tx 19	nc	PORT B2
Tx 20	nc	PORT B3
Tx 21	nc	PORT B4
Tx 22	nc	PORT B5
Tx 23	Spare	Spare
Tx 24	LVAL	LVAL
Tx 25	FVAL	FVAL
Tx 26	DVAL	DVAL
Tx 27	PORT A6	PORT A6

(3) Camera Link bit and CCD tap assignment (in 12 bit mode; ADS 12)

Camera Link port	PORT A	\rightarrow	PORT B	
CCD tap	TAP1	TAP2	TAP3	TAP4

28 bit solution pin name	Input signal name		
TX0	DB0 TAP1,2		
TX1	DB1 TAP1,2		
TX2	DB2 TAP1,2		
TX3	DB3 TAP1,2		
TX4	DB4 TAP1,2		
TX5	DB7 TAP1,2		
TX6	DB5 TAP1,2		
TX7	DB8 TAP1,2		
TX8	DB9 TAP1,2		
TX9	DB10 TAP1,2		
TX10	DB10 TAP3,4		
TX11	DB11 TAP3,4		
TX12	DB11 TAP1,2		
TX13	DB8 TAP3,4		
TX14	DB9 TAP3,4		
TX15	DB0 TAP3,4		
TX16	DB6 TAP3,4		
TX17	DB7 TAP3,4		
TX18	DB1 TAP3,4		
TX19	DB2 TAP3,4		
TX20	DB3 TAP3,4		
TX21	DB4 TAP3,4		
TX22	DB5 TAP3,4		
TX23	Spare		
TX24	LVAL		
TX25	FVAL		
TX26	DVAL		
TX27	DB6 TAP1,2		

- **DVAL** (Data Valid signal)This signal is output in sync with the image data from the CCD. The digital data of each pixel is valid while this signal is ON.
- LVAL (Line Valid signal)This signal indicates the effective horizontal period of the image data from the CCD. The signal is ON during the effective horizontal period.
- **FVAL** (Frame Valid signal)This signal indicates the effective vertical period of the image data from the CCD. The signal is ON during the effective vertical period.
- DB0 to DB11 (Digital image data) These signals contain the digital image data obtained by converting
 the image signal from the CCD with the A/D converter. DB0 is the LSB (least significant bit); DB11 is
 the MSB (most significant bit).

(4) Camera Link bit and CCD tap assignment (in 8 bit mode; ADS 8)

Camera Link port	PORT A		PORT B	\
CCD tap	TAP1	TAP2	TAP3	TAP4

28 bit solution pin name	Input signal name
TX0	DB0 TAP1,2
TX1	DB1 TAP1,2
TX2	DB2 TAP1,2
TX3	DB3 TAP1,2
TX4	DB4 TAP1,2
TX5	DB7 TAP1,2
TX6	DB5 TAP1,2
TX7	DB0 TAP3,4
TX8	DB1 TAP3,4
TX9	DB2 TAP3,4
TX10	DB6 TAP3,4
TX11	DB7 TAP3,4
TX12	DB3 TAP3,4
TX13	DB4 TAP3,4
TX14	DB5 TAP3,4
TX15	nc
TX16	nc
TX17	nc
TX18	nc
TX19	nc
TX20	nc
TX21	nc
TX22	nc
TX23	Spare
TX24	LVAL
TX25	FVAL
TX26	DVAL
TX27	DB6 TAP1,2

- DVAL (Data Valid signal)This signal is output in sync with the image data from the CCD. The digital
 data of each pixel is valid while this signal is ON.
- LVAL (Line Valid signal)This signal indicates the effective horizontal period of the image data from the CCD. The signal is ON during the effective horizontal period.
- FVAL (Frame Valid signal)This signal indicates the effective vertical period of the image data from the CCD. The signal is ON during the effective vertical period.
- DB0 to DB7 (Digital image data)These signals contain the digital image data obtained by converting the image signal from the CCD with the A/D converter. DB0 is the LSB (least significant bit); DB7 is the MSB (most significant bit).

13-2-2 TIMING I/O CONNECTOR PIN ASSIGNMENT [TIMING I/O]

The camera uses an SMA connector for the timing I/O connector.

The camera transmits or receives timing signals for synchronizing with external devices. The I/O signal level is 3.3 V LVCMOS. Signals passes through an SN74LVC541 bus transceiver

	Signal		
EXT.TRIG.	Ext.Trigger input		

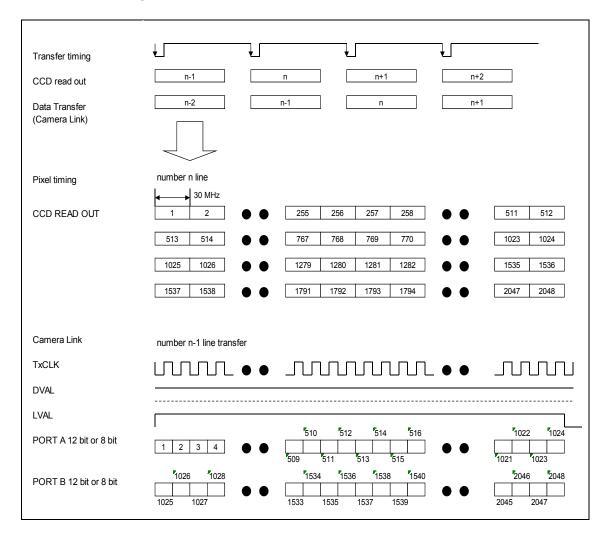
TIMING	Signal		
1	TDI transfer direction (LVCMOS low: forward direction; high: backward direction)		
2	NC		
3	NC		



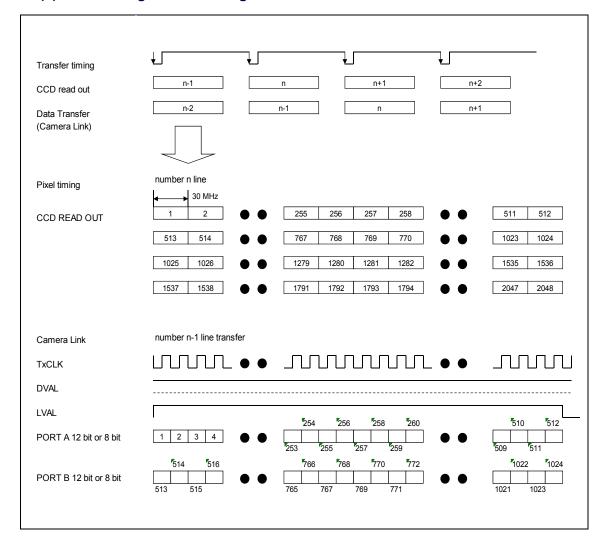
Do not connect anything to pins 2 or 3.

13-3 OUTPUT TIMING SPECIFICATIONS

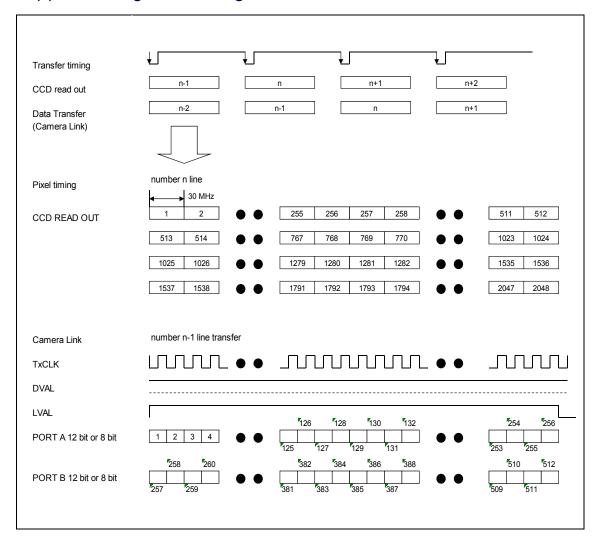
(1) Line timing: 1×1



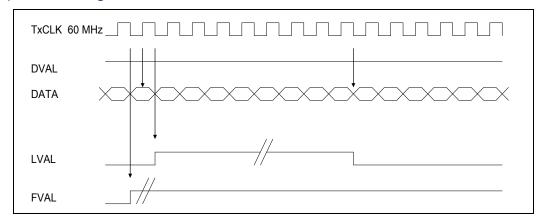
(2) Line timing: 2×2 binning



(3) Line timing: 4×4 binning

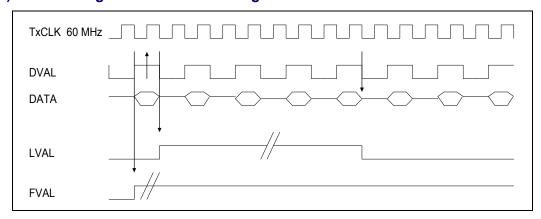


(4) Pixel timing 1×1



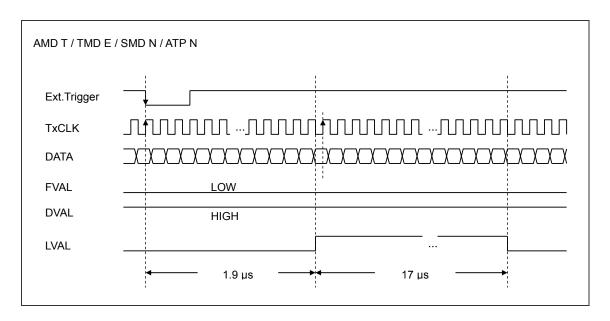
- 1) DVAL is high at all times.
- 2) LVAL changes in sync with the falling edge of TxCLK.
- 3) FVAL changes in sync with the falling edge of TxCLK.
- 4) DATA is valid on the rising edge of TxCLK.

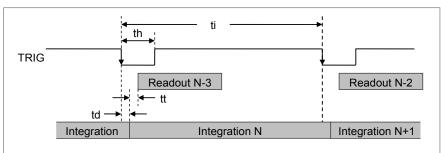
(5) Pixel timing 2×2 and 4×4 binning



- 1) DVAL is valid when it is high.
- 2) LVAL changes in sync with the falling edge of TxCLK.
- 3) FVAL changes in sync with the falling edge of TxCLK.
- 4) DATA is valid on the rising edge of TxCLK when DVAL is high.

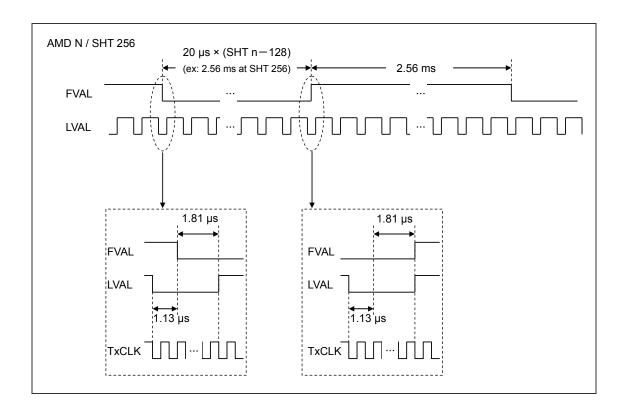
13-4 CAMERA LINK OUTPUT SPECIFICATIONS





Label	Min	Тур	Max
th	500 ns		
tt		1.6 µs	
td		17 ns	
ti	20 µs		

13-5 CAMERA LINK SIGNAL TIMING SPECIFICATIONS



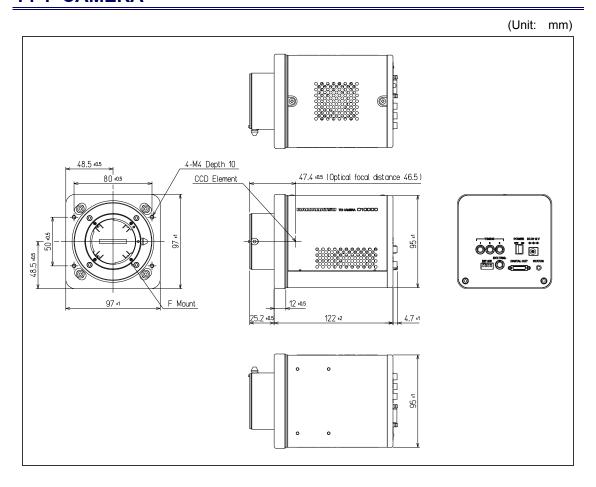
13-6 FULL-WELL CAPACITY AND AMP GAIN CONVERSION COEFFICIENT SPECIFICATIONS

The full-well capacity and amp gain conversion coefficient that the camera uses are shown below. They depend on the contrast enhancement gain setting and the number of digital data output bits.

	Full well	Amp gain conversion coefficient		
CEG	capacity	ADS 12	ADS 8	
	[electrons]	[electrons/AD count]	[electrons/AD count]	
0	80000	19.5	312	
1	63157	15.4	246	
2	52173	12.7	203	
3	44444	10.8	173	
4	38709	9.4	151	
5	34285	8.3	133	
6	30769	7.5	120	
7	27906	6.8	109	
8	25531	6.2	99	
9	23529	5.7	91	
10	21818	5.3	85	
11	20338	4.9	79	
12	19047	4.6	74	
13	17910	4.3	69	
14	16901	4.1	66	
15	16000	3.9	62	

14. DIMENSIONAL OUTLINES

14-1 CAMERA



15. WARRANTY

Hamamatsu Photonics has fully inspected this camera and checked that its performance conforms to specifications. In the unlikely event of breakdown or other malfunction, contact a Hamamatsu subsidiary or local distributor.

BASIC GUARANTEE

- (1) If the product malfunctions within 2 years from the delivery date under normal use, it will be repaired free of charge.
- (2) However, even during the warranty period, repairs will not be provided free of charge in the following circumstances.
 - · Malfunction or damage caused by not following the instructions in this manual.
 - Malfunction or damage caused by repairs, adjustments, parts replacement, modification, and so
 forth that are carried out by a party other than Hamamatsu Photonics.
 - · Malfunction or damage caused by acts of god such as fire, earthquake, floods, and so forth.
 - Malfunction or damage resulting from the customer transporting or dropping the product, or applying physical shock to the product.
 - · Malfunction or damage caused by effects of other devices that are used at the same time.
 - · Replacement of consumable parts.
- (3) We will repair the system or replace it, subject to availability, free of charge within the terms of the warranty. Hamamatsu Photonics will not be held responsible for any secondary malfunction, damage, or accidents to equipment, material, personnel, and so forth as a result of using the product.

SPECIAL NOTE

(1) Repairs and replacement of consumable parts, such as the fan and AC adapter, and repair and replacement of parts to deal with the degradation of the CCD due to cosmic rays and radiation (X-rays, gamma rays, ultraviolet rays, etc.) will not be provided free of charge even during the warranty period.

REPAIRS

- (1) If you notice anything wrong with the product, confirm whether or not it is malfunctioning by referring to the troubleshooting checklist in this instruction manual. This is necessary to clarify the symptoms and to avoid any misunderstanding or error.
- (2) If you have any problems or are unclear about anything, contact a Hamamatsu subsidiary or local distributor. Please provide your product name, serial number, and the details of the problem. If Hamamatsu Photonics determines that the product has malfunctioned, we will decide whether to dispatch a service engineer or have you send the product back to us.
- (3) During the warranty period, dispatch, repair, and return fees will be paid for by Hamamatsu Photonics.
- (4) Hamamatsu Photonics will work diligently to repair the product as soon as possible. In the following circumstances, however, repairs may take many days, repairs may not be free of charge, or repairs may not be provided.
 - · A long period of time has passed since the date of purchase.
 - Service parts have been discontinued.
 - Severe damage is found on the product.
 - · The product has been modified.
 - The problem cannot be reproduced at Hamamatsu Photonics.
 - Malfunction or damage caused by effects of other devices that are used at the same time.
 - · Other circumstances.

16. CONTACT INFORMATION

HAMAMATSU PHOTONICS K. K., Systems Division

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

U.S.A. and Canada

Hamamatsu Corporation

360 Foothill Road, Bridgewater, N.J. 08807-0910, U.S.A. Telephone: (1) 908-231-0960, Fax: (1) 908-231-0852 E-mail: usa@hamamatsu.com

Germany

Hamamatsu Photonics Deutschland GmbH

Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany Telephone: (49) 8152-375-0, Fax: (49) 8152-265-8 E-mail: info@hamamatsu.de

France

Hamamatsu Photonics France S.A.R.L.

19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France Telephone: (33) 1 69 53 71 00, Fax: (33) 1 69 53 71 10 E-mal: infos@hamamatsu.fr

United Kinadom

Hamamatsu Photonics UK Limited

2 Howard Court, 10 Tewin Road, Welwyn Garden City Hertfordshire AL7 1BW, United Kingdom Telephone: (44) 1707-294888, Fax: (44) 1707-325777 E-mail: info@hamamatsu.co.uk

North Europe

Hamamatsu Photonics Norden AB

Smidesvagän 12, SE-171 41 Solna, Sweden Telephone: (46) 8-509-031-00, Fax: (46)8-509-031-01 E-mail: info@hamamatsu.se

Italy

Hamamatsu Photonics Italia S.R.L.

Strada della Moia, 1/E 20020 Arese (Milano), Italy Telephone: (39) 02-935 81 733, Fax: (39) 02-935 81 741 E-mail: info@hamamatsu.it

China

Hamamatsu Photonics (China) Co., Ltd.

1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu, Chaoyang District, Beijing 100020, China Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866

E-mail: hpc@hamamatsu.com.cn

- The contents of this manual are subject to change without notice.
- The unauthorized reproduction or distribution of parts or all of this manual is prohibited.
- If one of the following problems occurs, please contact Hamamatsu Photonics. (See the CONTACT INFORMATION.) We will deal with the problem immediately.
 - Some contents of the manual are dubious, incorrect or missing.
 - Some pages of the manual are missing or in the wrong order.
 - The manual is missing or dirty.