High-Resolution CMOS Camera

CSC6M100BMP11

CSC6M100CMP11

INTERFACE SPECIFICATION

Ver. 1.0

TOSHIBA TELI CORPORATION

D4245297A

Changes on Delivery

REV.	Item	Revised Item	Revised Date
1.0	／	Release	19 May 2015

CONTENTS

1. OVERVIEW

This document explains the control interface specification of High-Resolution CMOS camera CSC6M100BMP11/CMP11. CSC6M100BMP11/CMP11 adopts the camera link interface, and uses the serial port on the camera link interface for the control of the camera.

2. INPUT-OUTPUT INTERFACE

2.1. VIDEO OUTPUT AND CONTROL INTERFACE

The input-output interface of this camera is in conformity with Camera Link version 1.2.

(1) Connector model
SDR 26-PIN connector HDR-EC26FDTG2+ (Manufactured by HTK）

(2) Pin assignment
Connector name : B (Base)

Pin No.	I/O	Signal name	Pin No.	I/O	Signal name
1	-	DC+12V (PoCL)	14	-	GND
2	O	X0-	15	O	X0+
3	O	X1-	16	O	X1+
4	O	X2-	17	O	X2+
5	O	X CLK -	18	O	X CLK+
6	O	X3-	19	O	X3+
7	I	Ser TC+	20	I	Ser TC-
8	O	Ser TFG-	21	O	Ser TFG+
9	I	CC1-	22	I	CC1+
10	I	CC2+	23	I	CC2-
11	I	CC3-	24	I	CC3+
12	I	CC4+	25	I	CC4-
13	-	GND	26	-	DC+12V (PoCL)

Connector name : M/F (Medium / Full)

Pin No.	I/O	Signal name	Pin No.	I/O	Signal name
1	-	10kΩ Pull-down (connected 26pin)	14	-	GND
2	O	Y0-	15	O	Y0+
3	O	Y1-	16	O	Y1+
4	O	Y2-	17	O	Y2+
5	O	Y CLK-	18	O	Y CLK+
6	O	Y3-	19	O	Y3+
7	-	100Ω terminated(20)	20	-	100Ω terminated(7)
8	O	Z0-	21	O	Z0+
9	I	Z1-	22	I	Z1+
10	I	Z2-	23	I	Z2+
11	I	Z CLK-	24	I	Z CLK+
12	I	Z3-	25	I	Z3+
13	-	GND	26	-	10kΩ Pull-down (connected 1pin)

2.2. SIGNAL INPUT-OUTPUT INTERFACE

(1) Connector model (Camera side)
HR10A-7R-6PB(73) (HIROSE ELECTRIC)

(2) Matching connector (Cable Side)
HR10A-7P-6S(73) (HIROSE ELECTRIC)

(3) Pin assignment
Connector name : I/O

Pin No.	I/O	Signal name
1	O	GPO
2	-	GND
3	-	GND
4	I	TRIG
5	-	N.C.
6	-	DC+12V

* Please connect in a state that has OFF the power of the power supply source when you connect the camera and cable.

3. CAMERA BIT ASSIGNMENT

Full Configuration

Camera Out	8 bit
DATA OUT1=	A[7:0]
DATA OUT2=	B[7:0]
DATA OUT3=	C[7:0]
DATA OUT4=	D[7:0]
DATA OUT5=	E[7:0]
DATA OUT6=	F[7:0]
DATA OUT7=	G[7:0]
DATA OUT8=	H[7:0]

Port/Bit	8 bit	Port/Bit	8 bit
Port A0	A[0]	Port E0	E[0]
Port A1	A[1]	Port E1	E[1]
Port A2	A[2]	Port E2	E[2]
Port A3	A[3]	Port E3	E[3]
Port A4	A[4]	Port E4	E[4]
Port A5	A[5]	Port E5	E[5]
Port A6	A[6]	Port E6	E[6]
Port A7	A[7]	Port E7	E[7]
Port B0	B[0]	Port F0	F[0]
Port B1	B[1]	Port F1	F[1]
Port B2	B[2]	Port F2	F[2]
Port B3	B[3]	Port F3	F[3]
Port B4	B[4]	Port F4	F[4]
Port B5	B[5]	Port F5	F[5]
Port B6	B[6]	Port F6	F[6]
Port B7	B[7]	Port F7	F[7]
Port C0	C[0]	Port G0	G[0]
Port C1	C[1]	Port G1	G[1]
Port C2	C[2]	Port G2	G[2]
Port C3	C[3]	Port G3	G[3]
Port C4	C[4]	Port G4	G[4]
Port C5	C[5]	Port G5	G[5]
Port C6	C[6]	Port G6	G[6]
Port C7	C[7]	Port G7	G[7]
Port D0	D[0]	Port H0	H[0]
Port D1	D[1]	Port H1	H[1]
Port D2	D[2]	Port H2	H[2]
Port D3	D[3]	Port H3	H[3]
Port D4	D[4]	Port H4	H[4]
Port D5	D[5]	Port H5	H[5]
Port D6	D[6]	Port H6	H[6]
Port D7	D[7]	Port H7	H[7]

Full Configuration(80bit Configuration)

Camera Out	10 bit
DATA OUT1=	A[9:0]
DATA OUT2=	B[9:0]
DATA OUT3=	C[9:0]
DATA OUT4=	D[9:0]
DATA OUT5=	E[9:0]
DATA OUT6=	F[9:0]
DATA OUT7=	G[9:0]
DATA OUT8=	H[9:0]

Port/Bit	10 bit	Port/Bit	10 bit
Port A0	A[2]	Port F0	F[2]
Port A1	A[3]	Port F1	F[3]
Port A2	A[4]	Port F2	F[4]
Port A3	A[5]	Port F3	F[5]
Port A4	A[6]	Port F4	F[6]
Port A5	A[7]	Port F5	F[7]
Port A6	A[8]	Port F6	F[8]
Port A7	A[9]	Port F7	F[9]
Port B0	B[2]	Port G0	G[2]
Port B1	B[3]	Port G1	G[3]
Port B2	B[4]	Port G2	G[4]
Port B3	B[5]	Port G3	G[5]
Port B4	B[6]	Port G4	G[6]
Port B5	B[7]	Port G5	G[7]
Port B6	B[8]	Port G6	G[8]
Port B7	B[9]	Port G7	G[9]
Port C0	C[2]	Port H0	H[2]
Port C1	C[3]	Port H1	H[3]
Port C2	C[4]	Port H2	H[4]
Port C3	C[5]	Port H3	H[5]
Port C4	C[6]	Port H4	H[6]
Port C5	C[7]	Port H5	H[7]
Port C6	C[8]	Port H6	H[8]
Port C7	C[9]	Port H7	H[9]
Port D0	D[2]	Port I0	A[0]
Port D1	D[3]	Port I1	A[1]
Port D2	D[4]	Port I2	B[0]
Port D3	D[5]	Port I3	B[1]
Port D4	D[6]	Port I4	C[0]
Port D5	D[7]	Port I5	C[1]
Port D6	D[8]	Port I6	D[0]
Port D7	D[9]	Port I7	D[1]
Port E0	E[2]	Port J0	E[0]
Port E1	E[3]	Port J1	E[1]
Port E2	E[4]	Port J2	F[0]
Port E3	E[5]	Port J3	F[1]
Port E4	E[6]	Port J4	G[0]
Port E5	E[7]	Port J5	G[1]
Port E6	E[8]	Port J6	H[0]
Port E7	E[9]	Port J7	H[1]

* Port assignments conform to the Camera Link standard.

Medium Configuration

Camera Out	8 bit	10 bit	12 bit
DATA OUT1=	A[7:0]	A[9:0]	A[11:0]
DATA OUT2=	B[7:0]	B[9:0]	B[11:0]
DATA OUT3=	C[7:0]	C[9:0]	C[11:1]
DATA OUT4=	D[7:0]	D[9:0]	D[11:1]
DATA OUT5=	(N/A)	(N/A)	(N/A)
DATA OUT6=	(N/A)	(N/A)	(N/A)
DATA OUT7=	(N/A)	(N/A)	(N/A)
DATA OUT8=	(N/A)	(N/A)	(N/A)

Base Configuration

Camera Out	8 bit	10 bit	12 bit
DATA OUT1=	A[7:0]	A[9:0]	A[11:0]
DATA OUT2=	B[7:0]	B[9:0]	B[11:0]
DATA OUT3=	(N/A)	(N/A)	(N/A)
DATA OUT4=	(N/A)	(N/A)	(N/A)
DATA OUT5=	(N/A)	(N/A)	(N/A)
DATA OUT6=	(N/A)	(N/A)	(N/A)
DATA OUT7=	(N/A)	(N/A)	(N/A)
DATA OUT8=	(N/A)	(N/A)	(N/A)

Port/Bit	8 bit	10 bit	12 bit	Port/Bit	8 bit	10 bit	12 bit
Port A0	A[0]	A[0]	A[0]	Port D0	D[0]	D[0]	D[0]
Port A1	A[1]	A[1]	A[1]	Port D1	D[1]	D[1]	D[1]
Port A2	A[2]	A[2]	A[2]	Port D2	D[2]	D[2]	D[2]
Port A3	A[3]	A[3]	A[3]	Port D3	D[3]	D[3]	D[3]
Port A4	A[4]	A[4]	A[4]	Port D4	D[4]	D[4]	D[4]
Port A5	A[5]	A[5]	A[5]	Port D5	D[5]	D[5]	D[5]
Port A6	A[6]	A[6]	A[6]	Port D6	D[6]	D[6]	D[6]
Port A7	A[7]	A[7]	A[7]	Port D7	D[7]	D[7]	D[7]
Port B0	B[0]	A[8]	A[8]	Port E0	n/a	C[0]	C[0]
Port B1	B[1]	A[9]	A[9]	Port E1	n/a	C[1]	C[1]
Port B2	B[2]	n/a	A[10]	Port E2	n/a	C[2]	C[2]
Port B3	B[3]	n/a	A[11]	Port E3	n/a	C[3]	C[3]
Port B4	B[4]	B[8]	B[8]	Port E4	n/a	C[4]	C[4]
Port B5	B[5]	B[9]	B[9]	Port E5	n/a	C[5]	C[5]
Port B6	B[6]	n/a	B[10]	Port E6	n/a	C[6]	C[6]
Port B7	B[7]	n/a	B[11]	Port E7	n/a	C[7]	C[7]
Port C0	C[0]	B[0]	B[0]	Port F0	n/a	C[8]	C[8]
Port C1	C[1]	B[1]	B[1]	Port F1	n/a	C[9]	C[9]
Port C2	C[2]	B[2]	B[2]	Port F2	n/a	n/a	C[10]
Port C3	C[3]	B[3]	B[3]	Port F3	n/a	n/a	C[11]
Port C4	C[4]	B[4]	B[4]	Port F4	n/a	D[8]	D[8]
Port C5	C[5]	B[5]	B[5]	Port F5	n/a	D[9]	D[9]
Port C6	C[6]	B[6]	B[6]	Port F6	n/a	n/a	D[10]
Port C7	C[7]	B[7]	B[7]	Port F7	n/a	n/a	D[11]

Port/Bit	8 bit	10 bit	12 bit
Port A0	A[0]	A[0]	A[0]
Port A1	A[1]	A[1]	A[1]
Port A2	A[2]	A[2]	A[2]
Port A3	A[3]	A[3]	A[3]
Port A4	A[4]	A[4]	A[4]
Port A5	A[5]	A[5]	A[5]
Port A6	A[6]	A[6]	A[6]
Port A7	A[7]	A[7]	A[7]
Port B0	B[0]	A[8]	A[8]
Port B1	B[1]	A[9]	A[9]
Port B2	B[2]	n/a	A[10]
Port B3	B[3]	n/a	A[11]
Port B4	B[4]	B[8]	B[8]
Port B5	B[5]	B[9]	B[9]
Port B6	B[6]	n/a	B[10]
Port B7	B[7]	n/a	B[11]
Port C0	n/a	B[0]	B[0]
Port C1	n/a	B[1]	B[1]
Port C2	n/a	B[2]	B[2]
Port C3	n/a	B[3]	B[3]
Port C4	n/a	B[4]	B[4]
Port C5	n/a	B[5]	B[5]
Port C6	n/a	B[6]	B[6]
Port C7	n/a	B[7]	B[7]

* Port assignments conform to the Camera Link standard.

4. COMMUNICATION PROTOCOL

4.1. SERIAL COMMUNICATION PROTOCOL

The serial communications between frame grabber board and the camera are done with SerTFG and the SerTC signal on the Camera Link interface. The communication protocol shall be in conformity with the camera link standard. (refer to the following)

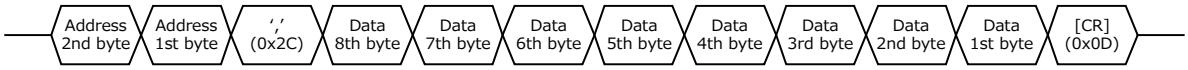
(1)	Communication speed	9600, 19200, 38400, 57600, 115200 bps
(2)	Start bit	1
(3)	Data bit	8
(4)	Stop bit	1
(5)	Parity	none
(6)	Handshake	none

4.2. COMMAND COMMUNICATION PROTOCOL

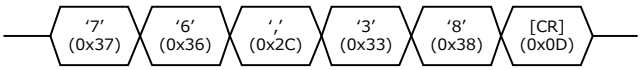
The command communication protocol is the TELI standard method (method in which parameters are set in the registers in the camera). In command send/receive operation, hexadecimal address and data are converted to ASCII data.

(1) Write to a register

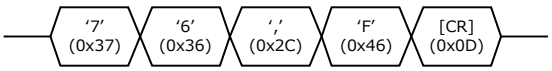
To write data in a register, send a command, as follows. (Address' max-length is 2 bytes, and Data's max-length is 8 bytes)



For example, to write data 0x38 to address 0x76, send a command, as follows:



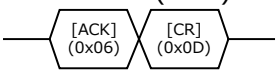
In addition, when writing in data of a single figure (less than 0x0F) to the register which can set up data of double or more (0x10 or more) figures by a hexadecimal number, "0" of a high-order digit can be omitted as follows.



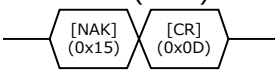
Moreover, because the data size of each address that can be set is decided, the transmission for the width of data to exceed the data size is not accepted.
For instance, five bytes or more cannot be received though it is possible to receive up to four bytes because the data size of address 0xA0 (shutter speed denominator register) is two bytes.
("A0,00001000" cannot be received though "A0,1000" can be received.)

The camera responds to the write command with No Error (ACK) or Error (NAK), as follows:

No Error (ACK):



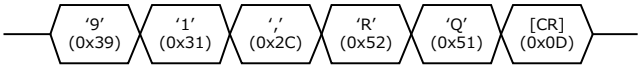
Error (NAK):



Because max five kinds of data is needed for the setting about a part of the register that relates to WOI, the setting is reflected by writing the register for "Set value application".

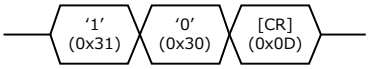
(2) Reading the register

To read data from a register, send ', (comma)', 'R', 'Q' and [CR] code following the address. For example, to read data in address 0x91, send a command, as follows:



The camera responds to the read request, as follows (Data's max-length is 8 bytes):

Actually, the camera responds to the read request as minimum data length: For example, to read data 0x10 to address 0x91, the camera responds as follows:



5. REGISTER MAP

Adderss	Access	Memory	Register Name
0x00 | 0x0F	R	–	Manufacture name ASCII format
0x10 | 0x2F	R	–	Model name ASCII format
0x30 | 0x3F	R	–	Serial number ASCII format
0x40 | 0x47	R	–	Firmware version ASCII format
0x48 | 0x4F	R	–	FPGA version ASCII format
0x50 | 0x5F	N.A.	–	Reserved
0x60 | 0x67	R	–	Register map version ASCII format
0x68	N.A.	–	Reserved
0x69	R	–	Status
0x6A	R	–	Extended status
0x6B	–	–	Reserved
0x6C	R	–	Check memory bank
0x6D	W	–	Save memory
0x6E	RW	–	Call memory
0x6F	W	–	Initialize memory
0x70	RW	○	Setup
0x72 | 0x75	N.A.	–	Reserved
0x76	RW	○	Gain
0x77 | 0x85	N.A.	–	Reserved
0x86	RW	–	Output control
0x87	RW	○	Number of output bits
0x88	RW	–	Test pattern
0x89	N.A.	–	Reserved
0x8A	RW	○	Gamma
0x8B	RW	○	Defective pixel correction
0x8C | 0x8F	N.A.	–	Reserved
0x90	RW	○	Scan mode
0x91	RW	○	Shutter mode
0x92	RW	○	Random trigger mode
0x93	RW	○	Trigger polarity
0x94	N.A.	–	Reserved
0x95	N.A.	–	Reserved
0x96	RW	○	Binning
0x97	N.A.	–	Reserved
0x98	RW	○	Reverse
0x99	RW	○	Number of frame for bulk trigger
0x9A	RW	○	Trigger delay
0x9C | 0x9F	N.A.	–	Reserved
0xA0	RW	○	Shutter speed denominator
0xA4	RW	○	Shutter speed numerator
0xA5 | 0xB1	N.A.	–	Reserved
0xB2	RW	○	MWB red gain
0xB3	RW	○	MWB green gain
0xB4	RW	○	MWB blue gain
0xB5	N.A.	–	Reserved
0xB6	W	–	OPWB execution
0xB7 | 0xBF	N.A.	–	Reserved
0xC0	W	–	WOI update
0xC1	RW	○	WOI area number
0xC2	RW	○	WOI horizontal start coordinate
0xC4	RW	○	WOI vertical start coordinate
0xC6	RW	○	WOI horizontal width
0xC8	RW	○	WOI vertical height
0xCA	RW	–	Control of WOI bank
0xCB	RW	–	Save/call WOI bank
0xCC	RW	○	WOI area effective
0xD0	RW	–	DP correction data/address
0xD2	N.A.	–	Reserved
0xD3	W	–	DP correction data/save/erase
0xD4	RW	–	DP correction data/data
0xD8	RW	–	User area/address
0xDA	RW	–	User area/data
0xDB	W	–	User area/erase
0xDC	RW	○	User area/number of bytes
0xDD	N.A.	–	Reserved
0xDE	N.A.	–	Reserved
0xDF	N.A.	–	Reserved
0xE0	W	–	Sequential command
0xE1	W	–	FPN correction calibration
0xE2	RW	○	Trigger source
0xE3	N.A.	–	Reserved
0xE4	W	–	LUT data write
0xE5	W	–	LUT data read
0xE6	RW	–	LUT bank select
0xE7	W	–	LUT data save/erase
0xE8	RW	△	Baudrate
0xE9	RW	△	Output format
0xEA	RW	○	GPO setting
0xEB	RW	○	GPO porality
0xEC	RW	○	strobe signal delay
0xEE	RW	○	strobe signal time
0xF0	RW	△	Pre-gain
0xF1	RW	△	Pixel clock
0xF2	N.A.	–	Reserved
0xF3 | 0xFF	N.A.	–	Reserved

－：Cannot be saved in memory
○：Can be saved in memory
△：Saved in a separate area from memory

6. CAMERA CONTROL

6.1. CAMERA INFORMATION

6.1.1. Function explanation

The information such as manufacturer name, the model name of the camera, and serial number, firmware, FPGA and the version of the register map can be read by the register access.

6.1.2. Register explanation

(1) Manufacturer name

Manufacturer name information of this camera can be read.

Manufacturer name information is stored as follows by one character at each address with ASCII code.

Table1. Manufacturer name

Register	R/W	Description	Default
0x00 - 0x0F : Manufacture name			
0x00	R.O	ASCII code : Character“T”	0x54
0x01	R.O	ASCII code : Character“O”	0x4F
0x02	R.O	ASCII code : Character“S”	0x53
0x03	R.O	ASCII code : Character“H”	0x48
0x04	R.O	ASCII code : Character“I”	0x49
0x05	R.O	ASCII code : Character“B”	0x42
0x06	R.O	ASCII code : Character“A”	0x41
0x07	R.O	ASCII code : Character“ ”	0x20
0x08	R.O	ASCII code : Character“T”	0x54
0x09	R.O	ASCII code : Character“E”	0x45
0x0A	R.O	ASCII code : Character“L”	0x4C
0x0B	R.O	ASCII code : Character“I”	0x49
0x0C	R.O	[NULL]	0x00
0x0D	R.O	[NULL]	0x00
0x0E	R.O	[NULL]	0x00
0x0F	R.O	[NULL]	0x00

(2) Model name

Model name information on this camera can be read.

Model name information is stored as follows by one character at each address with ASCII code.

(example: in case of CSC6M100BMP11)

Table2. Model name

Register	R/W	Description	Default
0x10 - 0x2F : Model name			
0x10	R.O	ASCII code : Character “C”	0x43
0x11	R.O	ASCII code : Character “S”	0x53
0x12	R.O	ASCII code : Character “C”	0x43
0x13	R.O	ASCII code : Character “6”	0x36
0x14	R.O	ASCII code : Character “M”	0x4D
0x15	R.O	ASCII code : Character “1”	0x31
0x16	R.O	ASCII code : Character “0”	0x30
0x17	R.O	ASCII code : Character “0”	0x30
0x18	R.O	ASCII code : Character “B”	0x42
0x19	R.O	ASCII code : Character “M”	0x4D
0x1A	R.O	ASCII code : Character “P”	0x50
0x1B	R.O	ASCII code : Character “1”	0x31
0x1C	R.O	ASCII code : Character “1”	0x31
0x1D	R.O	[NULL]	0x00
0x1E	R.O	[NULL]	0x00
0x1F	R.O	[NULL]	0x00
0x20	R.O	[NULL]	0x00
0x2F	R.O	[NULL]	0x00

(3) Serial number

Serial number information on this camera can be read.

Serial number information is stored as follows by one character at each address with ASCII code. (example: serial number "1234567")

Table3. Serial number

Register	R/W	Description	Default
0x30 - 0x3F : Serial number			
0x30	R.O	ASCII code : Character “1”	0x31
0x31	R.O	ASCII code : Character “2”	0x32
0x32	R.O	ASCII code : Character “3”	0x33
0x33	R.O	ASCII code : Character “4”	0x34
0x34	R.O	ASCII code : Character “5”	0x35
0x35	R.O	ASCII code : Character “6”	0x36
0x36	R.O	ASCII code : Character “7”	0x37
0x37	R.O	[NULL]	0x00
0x38	R.O	[NULL]	0x00
0x39	R.O	[NULL]	0x00
0x3A	R.O	[NULL]	0x00
0x3B	R.O	[NULL]	0x00
0x3C	R.O	[NULL]	0x00
0x3D	R.O	[NULL]	0x00
0x3E	R.O	[NULL]	0x00
0x3F	R.O	[NULL]	0x00

(4) Firmware version

Firmware version information on this camera can be read.

Firmware version information is stored as follows by one character at each address with ASCII code. (example: version "01.01.01")

Table4. Firmware version

Register	R/W	Description	Default
0x40 - 0x47 : Firmware version			
0x40	R.O	ASCII code : Character “0”	0x30
0x41	R.O	ASCII code : Character “1”	0x31
0x42	R.O	ASCII code : Character “.”	0x2E
0x43	R.O	ASCII code : Character “0”	0x30
0x44	R.O	ASCII code : Character “1”	0x31
0x45	R.O	ASCII code : Character “.”	0x2E
0x46	R.O	ASCII code : Character “0”	0x30
0x47	R.O	ASCII code : Character “1”	0x31

(5) FPGA version

FPGA version information on this camera can be read.

FPGA version information is stored as follows by one character at each address with ASCII code. (example: version "01.01.01")

Table5. FPGA version

Register	R/W	Description	Default
0x48 - 0x4F : FPGA version			
0x48	R.O	ASCII code : Character “0”	0x30
0x49	R.O	ASCII code : Character “1”	0x31
0x4A	R.O	ASCII code : Character “.”	0x2E
0x4B	R.O	ASCII code : Character “0”	0x30
0x4C	R.O	ASCII code : Character “1”	0x31
0x4D	R.O	ASCII code : Character “.”	0x2E
0x4E	R.O	ASCII code : Character “0”	0x30
0x4F	R.O	ASCII code : Character “1”	0x31

(6) Register map version

Register map version information on this camera can be read.

Register map version information is stored as follows by one character at each address with ASCII code. (example: version "01.01.01")

Table6. Register map version

Register	R/W	Description	Default
0x60 - 0x67 : Register map version			
0x60	R.O	ASCII code : Character “0”	0x30
0x61	R.O	ASCII code : Character “1”	0x31
0x62	R.O	ASCII code : Character “.”	0x2E
0x63	R.O	ASCII code : Character “0”	0x30
0x64	R.O	ASCII code : Character “1”	0x31
0x65	R.O	ASCII code : Character “.”	0x2E
0x66	R.O	ASCII code : Character “0”	0x30
0x67	R.O	ASCII code : Character “1”	0x31

6.2. ERROR STATUS

6.2.1. Function explanation

When NAK is sent back to the transmitted command, detailed information of the error can be acquired by accessing the status register.
Please inquire of our Sales Department when the error status not in the following table is acquired.

6.2.2. Register explanation

Table7. Error status

Register	R/W	Description	Default
0x69 : Error status			
0x69 [7:0]	R.O	Error classification is stored. *See the error status list.	0x00
0x6A : Extended status			
0x6A [7:0]	R.O	Error details is stored. *See the error status list.	0x00

6.2.3. Error status list

Table8. Error status list

Error classification	Error status (0x69)	Extended error status (0x6A)	Contents
No error	0x00	0X00	No error
Protocol	0x03	0x01	The command format is illegal
		0x04	Uncertain command
		0x05	No command
		0x06	There is no address setting
		0x07	There is no data setting
		0x08	The address is illegal
		0x09	The data is illegal
		0x0A	The small letter was input to the command (command is capital letter only)
		0x0B	The character and the sign were input to the address value (the address value is numerical value only (hexadecimal number))
		0x0C	Uncertain error
Register	0x04	0x01	The address is invalid
		0x02	The data is invalid
		0x03	The value of 0x100 or more was set to → 1 byte address (0xFF or less) where data had exceeded the register
		0x06	Reading is improper
		0x07	Writing is improper
		0x0C	Uncertain error
Memory bank	0x0A	0x01	No data
		0x02	Reading failure
		0x03	Initialization failure
		0x04	The bank number is outside the range
		0x05	Uncertain error
Degital prosess	0x0B	0x01	The setup is outside a setting range
		0x03	The gain is outside a setting range
		0x05	The output control is outside asetting range
		0x32	The test pattern output was set in modes other than the test pattern
		0x36	The test pattern mode was set in the partial reading mode
		0x37	Uncertain error
Scan mode	0x0C	0x01	Ther scan mode is outside a setting range
		0x04	Uncertain error

Error classification	Error status (0x69)	Extended error status (0x6A)	Contents
Shutter mode	0x0D	0x01	The shutter mode is outside a setting range
		0x02	The random trigger mode is outside a setting range
		0x03	The trigger polarity is outside a setting range
		0x04	The shutter speed denominator is outside a setting range
		0x05	The shutter speed numerator is outside a setting range
		0x06	The shutter speed is outside a setting range
		0x11	The shutter speed denominator were set ata shutter OFF
		0x12	The shutter speed numerator were set at shutter OFF
		0x17	Uncertain error
WOI	0x0F	0x01	Update failure
		0x02	The WOI area number is outside a setting range
		0x03	The WOI horizontal start coordinate is outside a setting range
		0x04	The WOI vertical start coordinate is outside a setting range
		0x05	The WOI horizontal width is outside a setting range
		0x06	The WOI vertical height is outside a setting range
		0x07	Only the WOI mode can be set (access)
		0x08	The WOI area effective is outside a setting range
		0x09	The WOI update is outside a setting range
		0x0A	The sum of start position and the size sticks out of a screen
		0x0E	The WOI bank is outside a setting range
		0x0F	Uncertain error
User area	0x12	0x01	The address is outside a setting range
		0x02	The data is outside a setting range
		0x04	The data size is outside a setting range
		0x05	Uncertain error
TG	0x13	0x1F	The test pattern was set in the WOI mode
		0x2D	Uncertain error
etc..	0x23	0x03	Uncertain error

6.3. MEMORY CONTROL

6.3.1. Function explanation

Each register value can be saved in EEPROM. After the camera power supply is turned off, the content of the memory is maintained. Retention Registers, refer to “5.REGISTER MAP”.

6.3.2. Register explanation

Table9. Memory control

Register	R/W	Description	Default
0x6C : Check memory bank			
0x6C [7:0]	R.O	(Memory bank number -1) which the setting would have been saved is set. <Example> 0x00 : User setting is not saved 0x01 : The user setting is saved in the bank "1". 0x80 : The user setting is saved in the bank "8". 0xFF : The user settings would have been saved in all banks ("8" from "1").	0x00
0x6D : Save memory			
0x6D [3:0]	W.O	Each register value is saved in memory area (EEPROM) corresponding to the memory bank number. <Example> 0x01 : A current setting is saved in the memory bank "1". 0x08 : A current setting is saved in the memory bank "8".	–
0x6E : Call memory			
0x6E [3:0]	R/W	The register setting value saved in the specified memory is called. Moreover, the memory bank number called at the end can be confirmed by reading the register. <Example> 0x00 : The memory bank "0" (factory shipment setting) is called. 0x01 : The memory bank "1" is called. 0x08 : The memory bank "8" is called.	0x00
0x6F : Initialize memory			
0x6F [3:0]	W.O	The user setting being saved in the specified memory bank is initialized (deleted). <Example> 0x01 : The saved content of the memory bank "1" is deleted. 0x08 : The saved content of the memory bank "8" is deleted.	–

6.4. OUTPUT FORMAT CHANGE

6.4.1. Function explanation

The change of an image output format (taps, data width and pixel clock) is possible.

Table10. Output format change

Configuration	Taps	Pixel clock	Data width	Frame rate
Full	8	84MHz	8 / 10 bit	Approx. 99 fps
		72MHz		Approx. 85 fps
		60MHz		Approx. 70 fps
Medium	4	84MHz	8 / 10 /12 bit	Approx. 49 fps
		72MHz		Approx. 42 fps
		60MHz		Approx. 35 fps
Base	2	84MHz		Approx. 24 fps
		72MHz		Approx. 21 fps
		60MHz		Approx. 17 fps

***** Frame rate is the shutter OFF, all pixel readout.

6.4.2. Register explanation

(1) Output format

The setup of Camera Link format. If the data width is set to 12 bit cannot be set to Full configuration 8tap.

Table11. Output format

Register	R/W	Description	Default
0xE9 : Output format			
0xE9 [7:0]	R/W	The setup of Camera Link format. 0x00 : Base configuration, 2tap 0x01 : Medium configuration, 4tap 0x02 : Full configuration, 8tap	0x02

* To enable the setting of this register will need to reboot the camera.
* Setting of this register will be reflected in all memory banks.

(2) Data width

The setup of data width. If the output format is set to Full configuration 8tap cannot be set to 12 bit.

Table12. Data width

Register	R/W	Description	Default
0x87 : Data width			
0x87 [7:0]	R/W	The setup of data width. 0x08 : 8 bit 0x0A : 10 bit 0x0C : 12 bit	0x08

(3) Pixel clock

The setup of pixel clock. Frame rate will change, depending on the set pixel clock.

Table13. Pixel clock

Register	R/W	Description	Default
0xF1 : Pixel clock			
0xF1 [7:0]	R/W	The setup of pixel clock. 0x00 : 60 MHz 0x01 : 72 MHz 0x02 : 84 MHz	0x01

* To enable the setting of this register will need to reboot the camera.
* Setting of this register will be reflected in all memory banks.

6.5. SCAN CONTROL

6.5.1. Function explanation

The image output mode can be selected at all pixels readout (normal scan), binning, binning-WOI, partial readout (WOI) and reverse output. The frame rate and the resolution of the output image that this camera corresponds are as follows. (Full configuration, 8tap, 8bit, Shutter OFF)

Table14. Scan control

Output mode	Frame rate			Output size
	@60MHz	@72MHz	@84MHz	
Normal scan	Approx.70fps	Approx.85fps	Approx.99fps	2560 (H) x 2560 (V)
WOI	Depends on the window setting			
Binning 2x2	Approx.141fps	Approx.169fps	Approx.197fps	1280 (H) x 1280 (V)
Binning 4x4	Approx.281fps	Approx.337fps	Approx.394fps	640 (H) x 640 (V)
Binning WOI	Depends on the window setting			

(1) Normal scan

The camera readouts all pixels (2560(H) × 2560(V) pixels).

(2) Binning

The camera readouts all effective areas in approx. 170 fps by binning (2x2) for all pixels (2560(H) × 2560(V) pixels). As it readouts adjacent 4 pixels as one pixel, the resolution reduces. However, as the pixel noise is averaged, it can output lower noise than that is produced when it reads all pixels.

(3) WOI

Only arbitrary area can be readout. It can be readout in high speed by skipping unwanted areas.

(4) Binning-WOI

It can be readout in higher speed by binning the WOI arbitrary area.

(5) Reverse

An image output is changed into a mirror, flip, or rotation (180-degree), and can be outputted.

6.5.2. Register explanation

(6) Scan mode

The readout method of the camera (scanning mode) is set.

Table15. Scan mode

Register	R/W	Description	Default
0x90 : Scan mode			
0x90 [7:0]	R/W	The readout method of the camera (scanning mode) is set. 0x00 : Normal scan 0x01 : WOI 0x02 : Binning 0x03 : Binning-WOI	0x00

(7) Binning

The number of Binning in Binning mode is set up.

In addition, only when scan mode is set as Binning, the number of Binning can be set up.

Table16. Binning mode

Register	R/W	Description	Default
0x96 : Binning			
0x96 [7:0]	R/W	The number of Binning in Binning mode is set up. 0x02 : 2x2 Binning 0x04 : 4x4 Binning	0x02

(8) Image mirroring and flipping

Setup of Image mirroring and flipping.

Table17. Image mirroring and flipping

Register	R/W	Description	Default
0x98 : Image mirroring and flipping			
0x98 [7:0]	R/W	Setup of Image mirroring and flipping. 0x00 : Normal 0x01 : Flip vertical 0x02 : Flip horizontal 0x03 : 180-degree rotation	0x00

6.6. WOI (Window Of Interest)

6.6.1. Function explanation

Only arbitrary areas can be readout by specifying an address in horizontal and vertical directions.

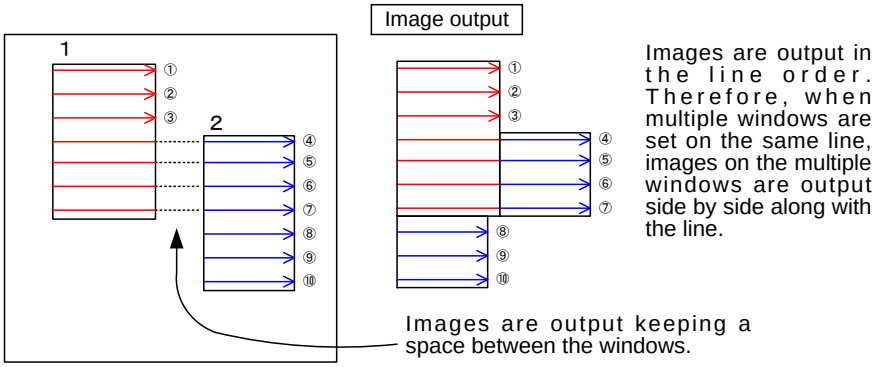
Area setting has the following conditions.

1) Number of windows	1 to 32
2) Setting position	H: Integral multiple of 16 columns. V: Integral multiple of 2 rows.
3) Window size	H: Integral multiple of 16 columns. (minimum size : 16) V: Integral multiple of 2 rows. (minimum size : 2)
4) Overlapping of windows	Possible
5) Others	
a. Frame rate	There is no proportional relation between the window area and the frame rate.
b. Set values of the coordinate and the size	Set the coordinate and the size to fit the effective pixel area. Values cannot set beyond the effective pixel area.
c. Memory	WOI setting can be saved in memory banks 1- 8.

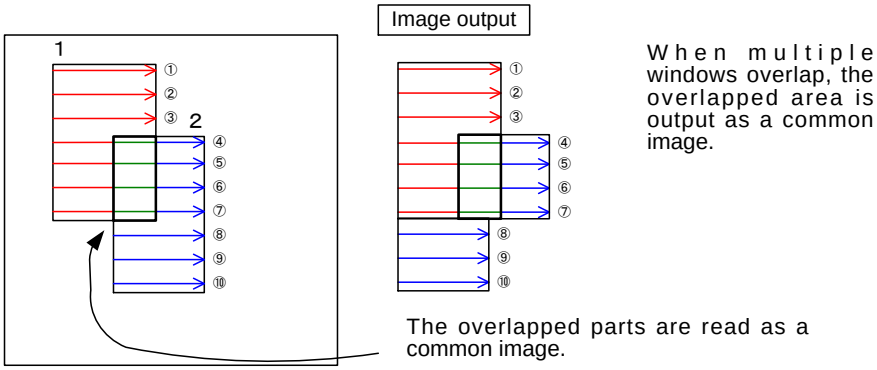
(1) Image output for WOI

Images are outputted per line. Therefore, when multiple windows are set on the same line, images of multiple windows are included in the image output of the line.

1) When multiple windows are set on the same line



2) When multiple windows overlap



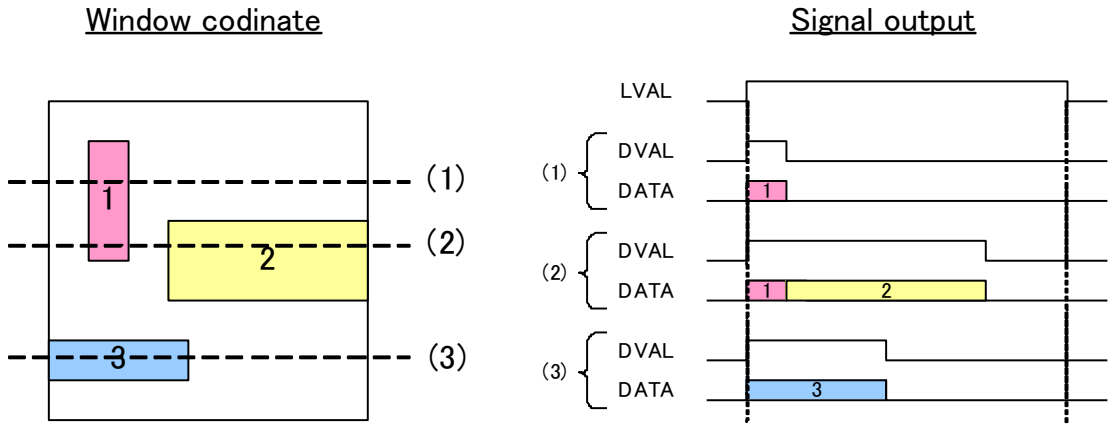
About the frame rate at the WOI

(2) About the frame rate at the WOI

Since output data becomes small by setup of a window, frame rate improves.
However, data volume (window size) is not proportional to a frame rate.
The influence on the frame rate by horizontal and vertical setup has the following features.

1) Horizontal direction

Horizontal rate is fixed by 2560 px (330 CLK). When two or more windows are arranged, the data volume outputted outputs the sum total of the data on the same line. DVAL becomes active only during the period when data is outputted. Even if changing window size, LVAL does not change.



2) Vertical direction

Vertical direction is output only set width.

(3) WOI bank

WOI setting value can be saved up to eight patterns at RAM (WOI bank) in a camera. The change of the WOI pattern which uses a WOI bank can be performed at high speed than the operation which calls separate setting and a memory bank.
However, the setting value saved on the WOI bank is lost with the power supply OFF.

(4) Binning WOI

Using both the WOI and the binning function can output the images in higher speed. Please notice the difference of restrictions for the position or size of window depending each modes.

Table18. Binning WOI

		WOI	Bining WOI	
			2×2	4×4
Position	H	16 px	32 px	64 px
	V	2 px	4 px	8 px
Size	H	16 px	32 px	64 px
	V	2 px	4 px	8 px
Number of window		1 to 32		
Overlapping of window		Possible		

6.6.2. Register explanation

Table19. WOI related register

Register	R/W	Description	Default
0xC0 : WOI update			
0xC0 [7:0]	W.O	Update of WOI setting value. 0x01 : WOI update execution	–
0xC1 : WOI area number			
0xC1 [7:0]	R/W	The area which makes setting reflected at the time of WOI update (address :0xC0) execution is set.	0x00
0xC2 : WOI horizontal start coordinate			
0xC2 [11:0]	R/W	The WOI horizontal start coordinates are set. The assignable value is in a configurable range and is a multiple of 16. <Example> 0x0000 : WOI horizontal start coordinate (0,xxxx) 0x09F0 : WOI horizontal start coordinate (2544,xxxx)	0x000
0xC4 : WOI vertical start coordinate			
0xC4 [11:0]	R/W	The WOI vertical start coordinates are set. The assignable value is in a configurable range and is a multiple of 2. <Example> 0x0000 : WOI vertical start coordinate (xxxx,0) 0x09FE : WOI vertical start coordinate (xxxx,2558)	0x000
0xC6 : WOI horizontal width			
0xC6 [11:0]	R/W	The horizontal width of WOI is set. The assignable value is in the configurable range and is a multiple of 16. <Example> 0x0010 : WOI horizontal width (16pix) 0x0A00 : WOI horizontal width (2560pix)	0x0A00
0xC8 : WOI vertical height			
0xC8 [11:0]	R/W	The vertical height of WOI is set. The assignable value is in the configurable range and is a multiple of 2. <Example> 0x0002 : WOI vertical height (2pix) 0x0A00 : WOI vertical height (2560pix)	0x0A00
0xCB : Save/call WOI bank			
0xCB [7:0]	R/W	The registers related to WOI is saved or called at one time. Moreover, by reading the register, the WOI bank number called at the end can be confirmed. The saved value is lost at the time of power supply interception, and returns to a default value. 0x00 : Call of default value 0x01～0x08 : Call of saved WOI bank "1"～"8" 0x81～0x88 : Save of WOI bank "1"～"8"	0x0A00
0xCC : WOI area effective			
0xCC [31:0]	R/W	Effective and invalidity in each WOI area are set. <Example> 0x00000001 : The WOI setting of area "1" is effective. 0x0000C000 : The WOI setting of area 15 and area 16 are effective. 0xFFFFFFFF : The WOI setting of all area is effective.	0x00000001

Although the following WOI related registers are common by WOI and Binning WOI, in Binning WOI, an output is set to one half to the preset value of a position and width. (x4 is 1/4).

(1) WOI update

At the time of executing updating, if each register value ("WOI horizontal beginning coordinates (The address: 0xC2)", "WOI vertical beginning coordinates (The address: 0xC4)", "Horizontal width of WOI (The address: 0xC6)", and "Vertical height of WOI (The address: 0xC8)") is judged as a setting which can be displayed, the setting of the area specified by "WOI area number (The address: 0xC1)" is updated according to each register value. When the updated area is effectively set by "WOI effective area (The address: 0xCC)", it is reflected in the image output with the trigger after the setting is completed.

* When WOI set to the register protrudes outputting effective pixel 2560(H)x2560(V)), NAK is sent back without reflecting the setting in the camera. And, the content set before the update is replaced to the content set to the specified WOI area number. Therefore, when the update is executed again, ACK is sent back. However, if the WOI area number is specified right after the NAK is sent back, the content which is further set to WOI area number is replaced.

(2) WOI area number

The area which makes setting reflected at the time of WOI update (address :0xC0) execution is set.

* When specifying the WOI area number, the value set to the WOI area number which is specified by the each register value of "The WOI horizontal beginning coordinates (Address: 0xC2)", "WOI vertical beginning coordinates (Address: 0xC4)", "Horizontal width of WOI (Address: 0xC6)" and "Vertical height of WOI (Address: 0xC8)" is updated.
  When the update is executed specifying WOI area number after setting the each register of "WOI horizontal beginning coordinates (Address: 0xC2)", "WOI vertical beginning coordinates (Address: 0xC4)", and "Horizontal width of WOI (Address: 0xC6)""Vertical height of WOI (Address: 0xC8)", the value which is set to the each register before specifying WOI area number is reflected to WOI area number. (Even if the WOI area number is set, the value set to the register is not cleared).

(3) WOI horizontal start coordinate

The WOI horizontal start coordinates are set.
The assignable value is in a configurable range and is a multiple of 16.

* Because a minimum, set value of "Horizontal width of WOI" is 0x10, a value (=0x09F0) which horizontal effective pixel (0x0A00) is subtracted by 0x0010 becomes the maximum value of "WOI horizontal start coordinates".
  The value set to the register is not reflected in the specified WOI area number until the update is executed. Besides it is not possible to be acquired.

* In the case of x2, please set to the multiple of 32 at the time of Binning-WOI.
  Please set up to become a multiple of 64 in the case of x4.

(4) WOI vertical start coordinate

The WOI vertical start coordinates are set.

* Because a minimum, set value of "Vertical width of WOI" is 0x0002, value (=0x09FE) in which vertical effective pixel (0x0A00) is subtracted by 0x0002 becomes the maximum value of "WOI horizontal start coordinates".
  The value set to the register is not reflected in the specified WOI area number until the update is executed. It is not possible to acquire it again.

* In the case of x2, please set to the multiple of 4 at the time of Binning-WOI.
  Please set up to become a multiple of 8 in the case of x4.

(5) WOI horizontal width

The horizontal width of WOI is set.

The assignable value is in the configurable range and is a multiple of 16.

* The value set to the register is not reflected in the specified WOI area number until the update is executed. Besides it is not possible to be acquired.

* In the case of x2, please set to the multiple of 32 at the time of Binning-WOI.
  Please set up to become a multiple of 64 in the case of x4.

(6) WOI vertical height

The vertical height of WOI is set.

The assignable value is in the configurable range and is a multiple of 2.

* The value set to the register is not reflected in the specified WOI area number until the update is executed. Besides it is not possible to be acquired.

* In the case of x2, please set to the multiple of 4 at the time of Binning-WOI.
  Please set up to become a multiple of 8 in the case of x4.

(7) Save/call WOI bank

The registers related to WOI "the WOI area number" "WOI horizontal start coordinate" "WOI vertical start coordinate" "the WOI horizontal width" "the WOI vertical height" "WOI area effective" and all area 1-32 of "WOI horizontal start coordinate" "WOI vertical start coordinate" "the WOI horizontal width" "the WOI vertical height" is saved or called at one time. Moreover, by reading the register, the WOI bank number called at the end can be confirmed.

* Higher speed processing is possible comparing memory preservation (The address: 0x6D) and the memory call (The address: 0x6E). However, calling or saving a register not related to WOI is not possible.
  The register "WOI horizontal beginning coordinates", "WOI vertical beginning coordinates", "Horizontal width of WOI", and "Vertical height of WOI" in area 1-32 of each WOI bank is not saved in the memory save. Therefore, all the contents of the WOI bank when the power supply are turned to default (The horizontal start coordinates: 0 and the vertical start coordinates: 0 and the horizontal width: 2560 and vertical height: 2560).

(8) WOI area effective

Effective and invalidity in each WOI area are set.

All WOI area cannot be invalidly set. The setting is immediately reflected.

Only the case the range is specified in an effective WOI area, the image data is output. Even if the range specified in two or more WOI areas comes in succession, it is output only once.

6.7. OUTPUT CONTROL

6.7.1. Function explanation

The camera output is possible to switch to the sensor image, OFF, or some test patterns.

(1) Output of sensor image
The image which entered into the sensor is outputted.

(2) Number of output bits
The black image of output level "0" is outputted.
In the case of a random trigger shutter, a trigger input is needed although various VALID signals are outputted as they are.

(3) Output of test pattern
Some test patterns can be output by cutting the output of the sensor.
It is output by the frame rate matched to each shutter mode and the scanning mode.
However, the test pattern cannot be output in the WOI mode and Binning-WOI mode. It is output for the random trigger shutter by the external trigger signal input.
The shutter speed, the setup, and the gain become invalid.
The FPN correction and pixel defect correction function, etc. become invalid.

The kind of the test pattern that can be output is as follows.
a. Black
b. White
c. Gray (25%) / Gray (75%)
d. Gray (50%)
e. Stripe
f. Grayscale
g. Ramp
h. Mix

The test pattern can reverse the brightness and change direction of the pattern (horizontal and vertical) (Part is excluded).

Moreover, it is possible to display it by superimposing the following enhancing patterns.
a. Line
b. Center marker
c. character

6.7.2. Register explanation

(1) Output control

The image output is set. The test pattern cannot be set at binning and binning-WOI.

Table20. Output control

Register	R/W	Description	Default
0x86 : Output control			
0x86 [7:0]	R/W	The image output is set. 0x00: Output OFF（Black image） 0x01: Output ON 0x02: Test pattern	0x01

(2) Output of test pattern

The type of the output test pattern is set. Only when test pattern output (0x02) has been selected at output control (0x86), it is possible to set it.

Table21. WOI related register

Register	R/W	Description	Default
0x88 : Test pattern output			
0x88 [2:0]	R/W	The type of the output test pattern is set. 0x00: Black 0x01: White 0x02: Gray(25%) 0x03: Gray(50%) 0x04: Stripe 0x05: Gray scale / Color bar 0x06: Ramp 0x07: Mix	0x07
0x88 [3]	R/W	Direction of pattern 0x00: Horizontal 0x01: Vertical	0x00
0x88 [4]	R/W	Line 0x00: OFF 0x01: ON	0x00
0x88 [5]	R/W	Center marker 0x00: OFF 0x01: ON	0x00
0x88 [6]	R/W	Character 0x00: OFF 0x01: ON	0x00
0x88 [7]	R/W	Brightness reversing 0x00: Normal 0x01: Reverse	0x00

6.8. SETUP LEVEL SETTING

6.8.1. Function explanation

The setup level (standard black level) of the camera can be adjusted only toward plus direction.

6.8.2. Register explanation

Table22. Setup

Register	R/W	Description	Default
0x70 : Setup level setting			
0x70 [15:0]	R/W	The setup is set. <Example> 0x0000 : 0DN 0x0108 : 264DN (@12bit) 0x0210 : 528DN (@12bit)	0x0000

6.9. GAIN SETTING

6.9.1. Function explanation

The gain of the photographic image can be adjusted.

6.9.2. Register explanation

(1) Pre-gain

The pre-gain (analog gain) of the camera can be adjusted.

Table23. Pre-gain

Register	R/W	Description	Default
0xF0 : Pre-gain			
0xF0 [7:0]	R/W	The pre-gain is set. <Example> 0x00 : 0dB 0x01 : +3dB 0x02 : +6dB 0x03 : +9dB	0x00

* To enable the setting of this register will need to reboot the camera.
* Setting of this register will be reflected in all memory banks.

(2) Gain

The gain (digital gain) of the camera can be adjusted. The variable range is 0 to +18dB (calculation value). The gain is set in about 0.1dB.

Table24. Gain

Register	R/W	Description	Default
0x76 : Gain			
0x76 [7:0]	R/W	The gain is set. <Example> 0x00 : 0dB 0xB4 : +18dB	0x00

6.10. WHITE BALANCE

6.10.1. Function explanation

It is possible to adjust the white balance according to objects or applications, because the color camera model has the manual white balance and the one-push white balance functions.
Some lacks of the gray level will be shown when the gain becomes larger, because of the fundamental for the digital-gain.

(1) Manual white balance (MWB)
It is possible to set the R/G/B gain separately.
Setting range: 0 dB to +12 dB

(2) One-push auto white balance (OPWB)
It is adjusted to be the equivalent luminance level between R/G/B pixels of the entire effective area (the entire output window when using WOI) by one-push. But there may be cases where the white balance is not adjusted correctly depending the photo objects or the light sources.

6.10.2. Register explanation

Table25. White balance

Register	R/W	Description	Default
0xB2 : MWB red gain			
0xB2 [7:0]	R/W	The red gain is set. <Example> 0x00 : 0dB 0x78 : +12dB	0x00
0xB3 : MWB green gain			
0xB3 [7:0]	R/W	The green gain is set. <Example> 0x00 : 0dB 0x78 : +12dB	0x00
0xB4 : MWB blue gain			
0xB4 [7:0]	R/W	The blue gain is set. <Example> 0x00 : 0dB 0x78 : +12dB	0x00
0xB6 : OPWB execution			
0xB6 [7:0]	W.O	OPWB execution. 0x01 : OPWB execution	–

6.11. GAMMA

6.11.1. Function explanation

The gamma of a image can be adjusted.
The variable range can be selected from OFF, 16types of curve and LUT.

6.11.2. Register explanation

Table26. Gamma

Register	R/W	Description	Default
0x8A : Gamma			
0x8A [7:0]	R/W	Gamma is setup. <Example> 0x00 : OFF 0x01 : Gamma is set as the 1st step. 0x10 : Gamma is set as the 16th step. 0xFF : LUT	0x00

6.12. LUT (Look-Up Table)

6.12.1. Function explanation

It is possible to set the values of gamma correction and perform image thresholding using the LUT consisting of 12 bit inputs/ 10bit outputs.

6.12.2. Register explanation

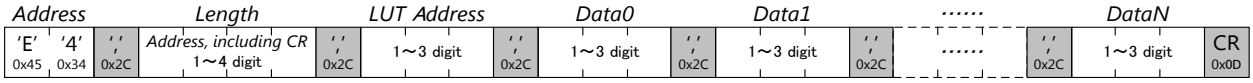
Table27. LUT

Register	R/W	Description	Default
0xE4 : LUT data write			
0xE4 [-:-]	W.O	The setup of LUT data. *See below.	–
0xE5 : LUT data read			
0xE5 [7:0]	W.O	The execution of LUT data readout. 0x01 : read	–
0xE6 : LUT bank select			
0xE6 [7:0]	R/W	The designation of LUT bank. <Example> 0x00 : bank0 0x04 : bank4	0x00
0xE7 : LUT data save/erase			
0xE7 [7:0]	W.O	The execution of LUT data save/erase. 0x01 : save 0x81 : erase	–

(1) LUT data write

Gamma correction data is written in the LUT. Up to 1024 maximum in a single transmission is writable. Therefore, in order to set data in all points (4096) , it requires a minimum of four transmissions.

* The transmitted data will be erased when the power is turned off if you do not save. If you want to keep the data inside the camera, please save data by specifying the LUT bank.

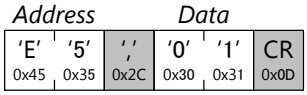


● Length	Set all packet length including from [Address] to [CR]. Packet length is change by the number or digit number of setting data. If you send up to 1024 data (3 digits) at once, packet length will be 4108Byte (100Ch).
● LUT Address	Specifies the start address for writing. In any position from 0x000 to 0xFFF can be set the starting point.
● Data	It is possible to write in up to 1024 (N = 0 to 1023). Since the video output is 10bit, one of the data can be set in the range of from 0h (1 digit) to 3FFh (3 digits). The set data will reflect in order from the starting point that you set in the LUT Address.

(2) LUT data read

Gamma correction data written in the LUT is read. Data of all points (4096) is read at once.

* Data to read will be the data that is saved in the specified LUT bank. Please read the data by specifying the LUT bank.



Response from the camera to the read command is as follows.

● Length	In order to read all data (4096) at once, packet length is 16389 byte fixed.
● LUT Address	4096 data is read. Always output by the 3 digit data.

(3) LUT data select

Specifies the Read / Save / Erase destination bank of LUT data.

* The specified bank information will be erased every time when the power supply is turned off. LUT bank will return to the default (0x00 : Bank0) in the power on. After camera start-up, please specified LUT bank

(4) LUT data save/erase

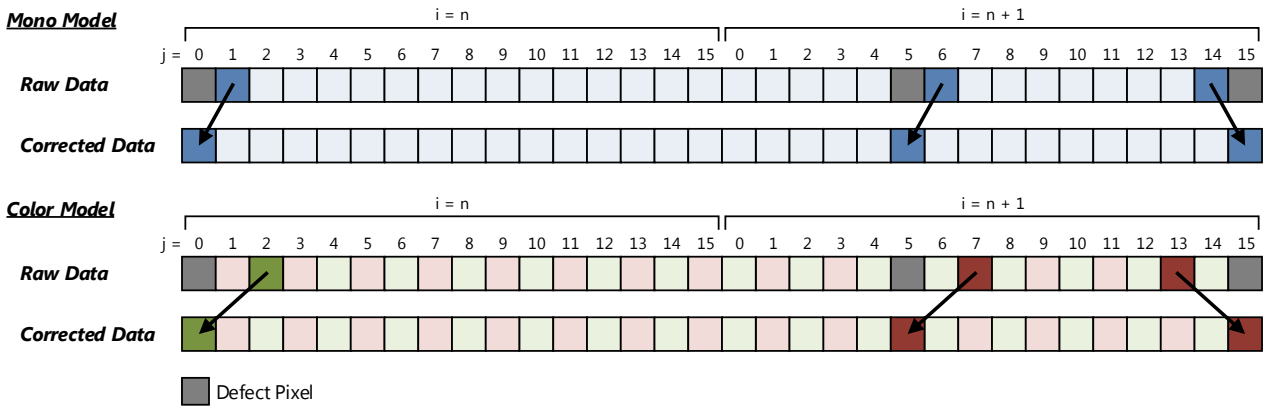
Save or erase of gamma correction data.

* Data to be saved or erased will be executed in the specified LUT bank. Specify the LUT bank, please save or erase.

6.13. DEFECTIVE PIXELS CORRECTION

6.13.1. Function explanation

The defective pixels of an arbitrary position up to 512 pixels by writing the corrected data of the defective pixels in the camera internal register can be corrected. Pixels set as the pixel defect is corrected by replacing the same color pixel data in the vicinity. There is no need to update the correction data of defective pixels in setting change of WOI, but you will need to update the correction data of defective pixels for an array of pixels are changed if you have changed the setting of binning.



The correction data setting of defective pixel correction has the following restrictions.

- Maximum 512 pixels
- Maximum 8 pixels per line
- From the upper left toward the lower right, and set from the address 0x000 in order
- Disable the defective pixel correction when you access to the correction data register

6.13.2. Register explanation

Table28. Defective pixels correction

Register	R/W	Description	Default
0x8B : Defective pixel correction			
0x8B [7:0]	R/W	ON/OFF settting of defective pixels correction. 0x00 : Defective pixel correction OFF 0x01 : Defective pixel correction ON	0x01
0xD0 : DP correction data/address			
0xD0 [9:0]	R/W	Specifies the address of the writing or reading of defective pixels correction data. <Example> 0x000 : Address 0x000 0x1FF : Address 0x1FF	0x000
0xD3 : DP correction data/save /erase			
0xD3 [7:0]	W.O	Save/erase of defect data. 0x00 : Save 0x01 : Erase	0x00
0xD4 : DP correction data/data			
0xD4 [25:24]	R/W	Set the coordinate information of the defective pixel. 00 : There are multiple defective pixels on the same line, and it is on the left extremity. 01 : There are multiple defective pixels on the same line, and it is not on the both ends. 10 : There are multiple defective pixels on the same line, and it is on the right extremity. 11 : There is only one defective pixel on the same line.	0x0
0xD4 [23:12]	R/W	Set the horizontal coordinate of the defective pixel. <Example> 0x000 : (0, xxx) 0x9FF : (2559, xxx)	0x000
0xD4 [11:0]	R/W	Set the vertical coordnate of the defective pixel. <Example> 0x000 : (xxx, 0) 0x9FF : (xxx, 2559)	0x000

(1) Defective pixels correction
ON/OFF setting of defective pixels correction. Reading/writing of correction data is defective pixels correction is valid only when the OFF.

(2) DP correction data/address
Specify the address of the writ or read of defective pixels correction data.

(3) DP correction data /save/erase
Save/erase of defect data.

(4) DP correction data/data
Writing or reading the correction data of the address that is set to “DP correction data/address”. Please set to order correction data is always in the direction from the coordinates of the upper left to the coordinates of lower right. Please refer to the pixel defect correction off if you want to write or read the correction data.
In addition, if you get the correction data from the register, “row information” necessary at the time of setup cannot be acquired.

6.14. FPN CORRECTION / CALIBRATION

6.14.1. Function explanation

FPN correction is a function to correct the sensor specific FPN (Fixed Pattern Noise). FPN correction value becomes the optimal state in the environment and setting by running the calibration.

6.14.2. Register explanation

Table29. FPN Correction / Calibration

Register	R/W	Description	Default
0xE1 : FPN Correction / Calibration			
0xE1 [7:0]	W.O	The correction value of FPN correction is updated. 0x01 : Calibration execution	–

6.15. SHUTTER CONTROL

6.15.1. Function explanation

(1) Shutter OFF

Shutter speed to match the frame rate is the mode to change. Shutter speed will be the same as the reading period.

(2) Normal shutter

This mode is used to determine the shutter speed by the register value.
Shutter speed can be set 1/100,000(sec) – 1/5(sec).
If the shutter speed is slower than readout period, the frame rate will vary depending on the shutter speed.

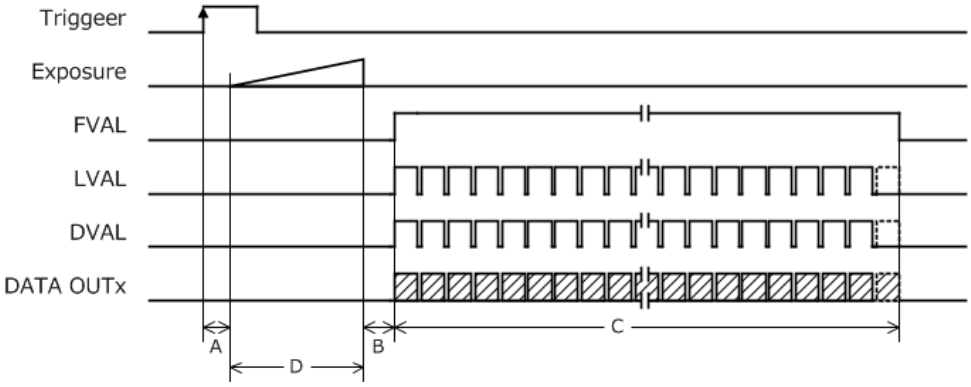
(3) Random trigger shutter

In the random trigger shutter mode can take an image at any time by external trigger signal input.

- The external trigger signal select to input from either the camera link I/F CC1 and I/O connector by the register. External trigger signal cannot be entered at the same time. Input that is not used please be fixed to LOW.
- If the polarity is set to positive polarity, it will start exposure on rising edge of trigger. If the polarity is set to negative polarity, it will start exposure on falling edge of trigger.
- Random trigger shutter of this camera, there are two types of fixed mode and pulse width mode. Determination of exposure time method is different depending on the mode.
- When random trigger shutter can be exposure during the read period of the video, but cannot terminate the exposure. Make sure that the exposure will end after image output of a camera ends when inputting a trigger continuously.

(1) Fixed mode

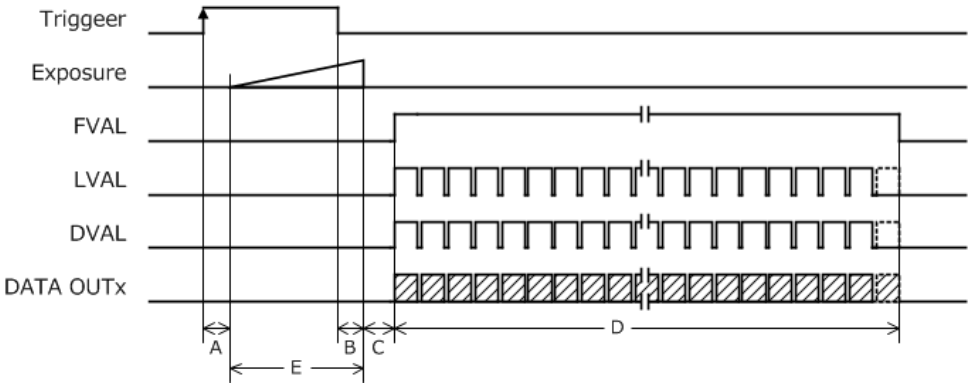
The exposure time is determined by the setting value for the shutter speed.
(Exposure time = Setting value)
* All pixel readout@72MHz



Configuration	A	B	C	D
Base	20.7 us	64.8 us	3,380,496 clk	Reg. value
Medium	11.1 us	33.0 us	1,690,248 clk	Reg. value
Full	6.3 us	17.1 us	845,124 clk	Reg. value

(2) Pulse width mode

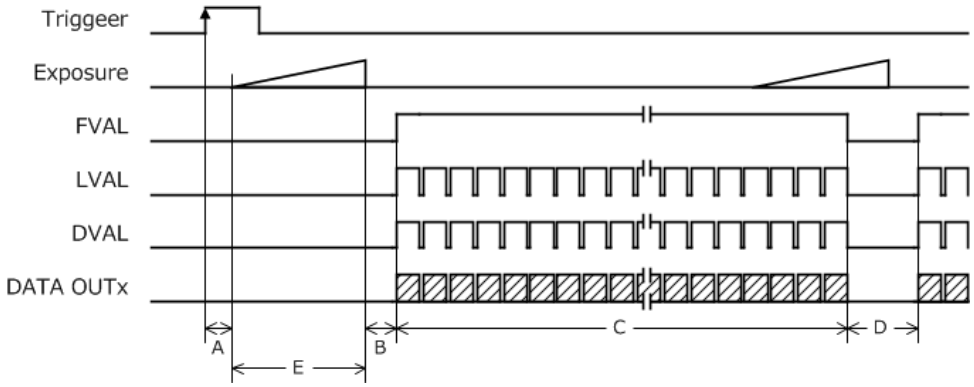
The exposure time is determined by pulse width. (Exposure time = Pulse width)
The pulse width should be more than 10 us.
* All pixel readout@72MHz



Configuration	A	B	C	D	E
Base	20.7 us	20.7 us	64.8 us	3,380,496 clk	Pulse width
Medium	11.1 us	11.1 us	33.0 us	1,690,248 clk	Pulse width
Full	6.3 us	6.3 us	17.1 us	845,124 clk	Pulse width

(3) Bulk trigger mode

The exposure time is determined by the setting value for the shutter speed.
(Exposure time = Setting value)
Outputs the specified multiple frames by one trigger input.
* All pixel readout@72MHz



Configuration	A	B	C	D	E
Base	20.7 us	64.8 us	3,380,496 clk	6,624 clk	Reg. value
Medium	11.1 us	33.0 us	1,690,248 clk	3,312 clk	Reg. value
Full	6.3 us	17.1 us	845,124 clk	1,656 clk	Reg. value

6.15.2. Register explanation

(1) Shutter mode

The shutter mode is set.

Table30. Shutter mode

Register	R/W	Description	Default
0x91 : Shutter mode			
0x91 [7:0]	R/W	The shutter mode is set. 0x00: Normal shutter OFF 0x01: Normal shutter 0x02: Random trigger shutter	0x00

(2) Random trigger shutter

The random trigger mode (exposure method) is set.
Only when the shutter mode is set to the random trigger shutter, this register can be set.

Table31. Random trigger shutter

Register	R/W	Description	Default
0x92 : Random trigger mode			
0x91 [7:0]	R/W	The random trigger mode (exposure method) is set. 0x00: Fixed mode 0x01: Pulse width mode 0x02: Bulk trigger mode	0x00

(3) Number of frame for bulk trigger

Number of frame for bulk trigger is set.

Table32. Number of frame for bulk trigger

Register	R/W	Description	Default
0x99 : Number of frame for bulk trigger			
0x99 [7:0]	R/W	Number of frame for bulk trigger is set. <Example> 0x01 : 1 frame 0xFF : 255 frame	0x01

(4) Trigger source

Input control of an external trigger is set.

Table33. Trigger source

Register	R/W	Description	Default
0xE2 : Trigger source			
0xE2 [7:0]	R/W	Input control of an external trigger is set. 0x00 : Only CC1 is effective. 0x01 : Only I/O connector is effective.	0x00

(5) Trigger polarity

The polarity of the trigger signal is set.

Only when the shutter mode is set to the random trigger shutter, the trigger polarity can be set.

Table34. Trigger polarity

Register	R/W	Description	Default
0x93 : Trigger polarity			
0x93 [7:0]	R/W	The polarity of the trigger signal is set. 0x00 : Negative 0x01 : Positive	0x00

◎ The state of the exposure might change according to the state of an external trigger if the switch of the trigger polarity is executed in the random trigger shutter mode.
When switching trigger polarity after setting to random trigger shutter mode, please set the trigger polarity after switching shutter mode. The setting should be done after making the external trigger be in the state of negative (In this state, High would mean the negative polarity, Low would mean the positive polarity) against the state which the trigger polarity has been switched.

(6) Trigger delay

Set the delay time from the external trigger input to the camera accept.

Table35. Trigger delay

Register	R/W	Description	Default
0x9A : Trigger delay			
0x9A [15:0]	R/W	Set the delay time of external trigger. <Example> 0x0000 : 0 sec 0xFFFF : 65,536 sec	0x0000

(7) Shutter speed denominator

Setting of The denominator (b) at the shutter speed (a/b[sec]).

Only when the shutter mode is set to a normal shutter and the random trigger shutter, the denominator of the shutter speed can be set.

Table36. Shutter speed denominator

Register	R/W	Description	Default
0xA0 : Shutter speed denominator			
0xA0 [31:0]	R/W	Setting of The denominator (b) at the shutter speed (a/b[sec]). <Example> 0x00001 : a/1 [sec] 0x186A0 : a/100,000 [sec]	0x3C

(8) Shutter speed numerator

Setting of the numerator (a) at the shutter speed (a/b[sec]).

Only when the shutter mode is set to a normal shutter and the random trigger shutter, the numerator of the shutter speed can be set.

Table37. Shutter speed numerator

Register	R/W	Description	Default
0xA4 : Shutter speed numerator			
0xA4 [7:0]	R/W	Setting of the numerator (a) at the shutter speed (a/b[sec]). <Example> 0x01 : 1/b [sec] 0xFF : 255/b [sec]	0x01

◎ Although shutter speed can finally be set up in the extent of 2/1[sec] to 1/100,000[sec], please use it within the limits of 1/5[sec] to 1/100,000[sec].

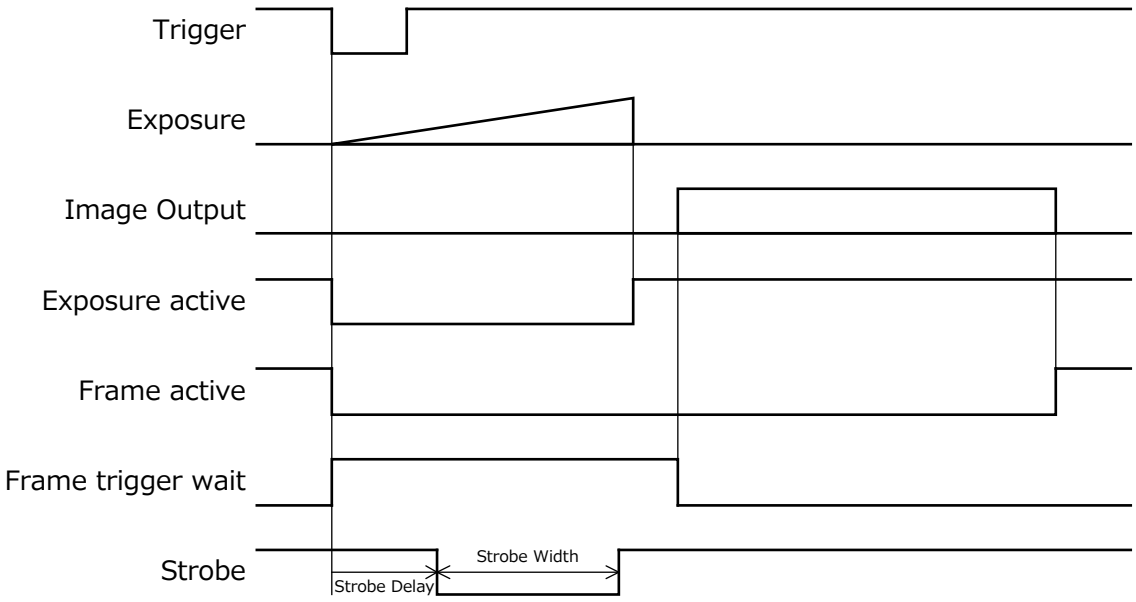
6.16. GPO

6.16.1. Function explanation

It is possible to output various control signals of the camera from the I/O connector on the back of the camera. Output channel number is one channel. Can be output signal are shown in the table below.

Table38. GPO signal

Singal name	Explanation
Exposure active	This signal is a period from an exposure start to the end of exposure.
Frame active	This signal is a period from an exposure start to the completion of image transmissiom.
Frame trigger wait	This signal is that it is a waiting period for a trigger at the time of a random trigger shutter. Exposure is started without restrictions of a previous frame when an external trigger is inputted in this period.
Strobe	This is a signal for strobe control. The delay time and strobe width from an exposure start can be set up.



6.16.2. Register explanation

(1) Select of GPO

The kind of output signal is chosen.

Table39. GPO setting

Register	R/W	Description	Default
0xEA : GPO setting			
0xEA [7:0]	R/W	It is a register which chooses the kind of output signal. 0x00 : OFF 0x01 : STROBE 0x02 : EXPOSURE ACTIVE 0x03 : FRAME ACTIVE 0x04 : FRAME TRIGGER WAIT	0x00

(2) Polarity

Positive/Negative switching (Factory default: Negative)

※The following figure becomes an output of each signal at the time of negative.

Table40. GPO polarity

Register	R/W	Description	Default
0xEB : GPO polarity			
0xEB [7:0]	R/W	It is a register which chooses the polarity of an output signal. 0x00 : Negative 0x01 : Positive	0x00

(3) Strobe signal delay

The strobe signal is controlled.

When 0x01 (STROBE) is chosen in address 0xEA, the time signal set up by this register with the exposure start timing of a camera as the starting point is delayed.

Table41. GPO setting

Register	R/W	Description	Default
0xEC : Strobe signal delay			
0xEC [11:0]	R/W	The deray of strobe signal is controlled. <Example> 0x0000 : 0μsec 0xFFFF : 65,535μsec	0x0000

(4) Strobe signal time

A strobe signal is controlled.

When 0x01 (STROBE) is chosen in address 0xEA, it can carry out variable of the signal width in this register.

Table42. GPO setting

Register	R/W	Description	Default
0xEE : Strobe signal time			
0xEE [11:0]	R/W	The pulse width of strobe signal is controlled. <Example> 0x0001 : 1μsec 0xFFFF : 65,535μsec	0x0001

6.17. DATA STORAGE TO USER AREA

6.17.1. Function explanation

Writing arbitrary data (environmental in surrounding information etc. on the camera) in the user area of EEPROM enables to manage additive information by communication.

6.17.2. Register explanation

Table43. User area related register

Register	R/W	Description	Default
0xD8 : Specify user area / address			
0xD8 [15:0]	R/W	The address is specified at the destination of the data writing. <Example> 0x0000 : Preparation for writing data at address of 0x0000. 0x07FF : Preparation for writing data at address of 0x07FF.	0x0000
0xDA : Specify user area / data			
0xDA [7:0]	R/W	One byte's worth of data is written in the house number specified by the addressing register (The address: 0xD8). <Example> 0x30 : 0x30 ("0" in ASCII code) is written. 0x41 : 0x41 ("A" in ASCII code) is written.	0x00
0xDB : Erase user area			
0xDB [7:0]	W.O	The content of the user's area writing is deleted in the lump (The value of all house numbers is NULL in "0x00" and ASCII code). 0x01 : Erase	–
0xDC : Number of bytes to read user area			
0xDC [7:0]	R/W	The number of house numbers which is continuously read at the time of reading the user's area is specified. The assignable value is a multiple of 4 in the configurable range or 0x01. <Example> 0x01 : A continuous reading of 1 byte (1 character in ASCII) is possible. 0x04 : A continuous reading of 4 byte (4 characters in ASCII) is possible. 0x80 : A continuous reading of 128 byte 128 characters in ASCII) is possible.	0x01

(1) Specify user area / address
The address is specified at the destination of the data writing.

(2) Specify user area / data
One byte's worth of data is written in the house number specified by the addressing register (The address: 0xD8). It reads, only the number of values specified by reading byte number register (The address: 0xDC) reads the house number from the house number of the addressing register at times, and data can be read continuously.

◎ When the address is set to the addressing register, data is called in the data specification register. Moreover, when data is set to the data specification register, the address of the addressing register is done and the increment is done automatically (If the increment is done in address value 0x07FF, it becomes 0x0000). When the increment is done, the incremented address is read out, therefore the value is set to the data specification register. Therefore, to acquire the data set to the data specification register, reading the data specification register after the address is set is required. (The data of the following address is read even if it reads out data following the data setting).
When reading out the data specification register, the data for the number of bytes specified at the number of read out byte register is read by two hexadecimal number digits per data(In case of 0x00～0x0F, "00"～"0F" is read out), the address of the addressing register is incremented automatically only by the number of reading byte.

Therefore, it is possible to read continuously without specifying the address.
However, when trying to read a data from the present address for the number of byte which specified at reading byte number register, NAK is sent. Then set again the address or the number of the read out byte. If read the data of address 0x07FF, the address becomes 0x0800 and not possible to set or read the data. Accordingly please set the address 0x07FF or less.

(3) Erase user area
The content of the user's area writing is deleted in the lump (The value of all house numbers is NULL in "0x00" and ASCII code).

(4) Number of bytes to read user area
The number of house numbers which is continuously read at the time of reading the user's area is specified. The assignable value is a multiple of 4 in the configurable range or 0x01.

6.18. SEQUENTIAL COMMAND

6.18.1. Function explanation

The time which communication takes can be shortened by transmitting two or more commands collectively and performing camera settings.

6.18.2. Register explanation

Only a maximum of 256 items of setting command is ability ready for sending.
When there is a command which can be executed by neither the case where a read-out command is contained, nor restriction, processing is ended at the time.

Table44. Sequential command

Register	R/W	Description	Default
0xE0 : Sequential command			
0xE0 [-:-]	R/W	Send a sequential command. *See below	–

Address		,	Packet length	,	Command 1		,	Command 2		,	…	,	Command N		CR
0x45	0x30	0x2C	Address and CR	0x2C	Address 1	Data 1	0x2C	Address2	Data 2	0x2C	…	0x2C	Address N	Data N	0x0D
E	0	1digit	1～3digit	1digit	2digit	1～8digit	1digit	2digit	1～8digit	1digit		1digit	2digit	1～8digit	1digit

Please make the address into the 2 fixed numbers of digits. ("0" to "F" are "00" to "0F")

6.19. COMMUNICATION SPEED

6.19.1. Function explanation

Communication speed with a camera can be set up arbitrarily.

6.19.2. Register explanation

Table45. Communication speed

Register	R/W	Description	Default
0xE8 : Communication speed			
0xE8 [7:0]	R/W	The setup of communication speed. 0x00 : 9600bps 0x01 : 19200bps 0x02 : 38400bps 0x03 : 57600bps 0x04 : 115200bps	0x00

* To enable the setting of this register will need to reboot the camera.
* Setting of this register will be reflected in all memory banks.

7. NOTE ON USE

- ●Always read the corresponding operating instruction manuals and precautions for any devices connected to this product before use.
- ●With regard to the data saved using a grabber board connected to the camera, neither TELI, the frame grabber board manufacturer, nor the peripheral device manufacturer will accept any liability for the loss of data or damage resulting from use of the camera, the frame grabber board, or other peripheral devices. Always back up important data if there is any possibility of loss of data.
- ●Data may be subject to copyright or other usage restrictions. Users are responsible for performing due diligence regarding the copying or distribution of such data. TELI rejects all liability for problems arising from improper use of data or printed matter.
- ●Use in conjunction with devices for which compatibility has not been confirmed by TELI may result in failure, damage, or malfunctions. Fees will be charged for all repairs made necessary by such failures. For more information on what devices can be connected, please check with your retailer, sales agent, or TELI customer service department.
- ●Do not expose the CMOS sensor to bright light for extended periods.
- ●Pixel drop-outs may occur suddenly or randomly on the CMOS sensor during transport or storage. This does not constitute a defect.
- ●Noise may appear on the screen if the camera or cables are located close to devices such as lighting cables or motors.
- ●Keep the camera and wiring away from noise sources.
- ●Do not use it in locations of ambient temperature or humidity that exceeds the specification. Doing so may affect image quality or internal components. Avoid use in locations subject to direct sunlight.
- ●Do not store in locations subject to direct sunlight. Doing so may degrade components.

8. EXEMPTION CLAUSES

●TELI assumes no responsibility or liability for damage arising from fire, earthquake, an act by a third party or other accidents, or intentional or careless error or misuse by the user, or use under abnormal conditions.

●TELI assumes no responsibility or liability for incidental damages (e.g., loss of business profits or interruption of business) arising from use of or inability to use the camera equipment.

●TELI assumes no responsibility or liability in the case damages or losses are caused by failure to observe the information contained in the operation manual and specifications and interface specifications.

●TELI assumes no responsibility or liability in the case damages or losses are caused by use contrary to the instructions in this operation manual and specifications and interface specifications.

●TELI assumes no responsibility or liability in the case damages or losses are caused by malfunction or other problems resulting from use of equipment or software that is not specified.

●TELI assumes no responsibility or liability in the case damages or losses are caused by repair or modification conducted by the customer or any unauthorized third party (such as an unauthorized service representative).

●Expenses we bear on this product shall be limited to the individual price of the product.

9. RESTRICTION FOR USE

●Should the equipment be used in the following conditions or environments, give consideration to safety measures and inform us of such usage:

1. Use of the equipment in the conditions or environment contrary to those specified, or use outdoors.
2. Use of the equipment in applications expected to cause potential hazard to people or property, which require special safety measures to be adopted.

●This product can be used under diverse operating conditions. Determination of applicability of equipment or devices concerned shall be determined after analysis or testing as necessary by the designer of such equipment or devices, or personal related to the specifications. Such designer or personal shall assure the performance and safety of the equipment or devices.

●This product is not designed or manufactured to be used for control of equipment directly concerned with human life (*1) or equipment relating to maintenance of public services/functions involving factors of safety (*2). Therefore, the product shall not be used for such applications.

(*1): Equipment directly concerned with human life refer to:

- Medical equipment such as life-support systems, equipment for operating theaters.
- Exhaust control equipment for exhaust gases such as toxic fumes or smoke.
- Equipment mandatory to be installed by various laws and regulations such as the Fire Act or Building Standard Law.
- Equipment related to the above.

(*2): Equipment relating to maintenance of public service/functions involving factors of safety refer to:

- Traffic control systems for air transportation, railways, roads, or marine transportation.
- Equipment for nuclear power generation.
- Equipment related to the above.

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Distributor

- This product must be classified for disposal according to the laws of each country and municipal laws.
- Information contained in this document is subject to change without prior notice.

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