Standard Specification【General Disclosure】

Product name	: TOF camera (Outdoor NIR Wide FOV type)
Part number	: CDM-GCHC4WZA
Ref#	: Ver.1.2(tentative)
Issue date	: 17.Dec. 2019
Company name	: Panasonic Photo & Lihgting Co., Ltd. 1-1, Saiwai-Cho, Takatsuki, Osaka, Japan

Panasonic Photo & Lighting Co., Ltd.		
Approve	Check	Made
DATE:	DATE:	DATE:

Rivision record

Date	Ver	Items	Contents	Remarks
2019/7/4	1.0		First edition	
2019/9/20	1.1	4.Command list	Revision coefficient of thermal feedback	
2019/12/17	1.2 (t)	4.Command list	(*11)Revision interferencesetting list	

Contents

1. Overview

1.1 Scope

These specifications are for VGA-NIR wide FOV TOF camera

1.1.1 Product Specification

■Image sensor

- Type : IR(near infrared) exclusive use CCD sensor MN34906BL@Panasonic
- Pixel number : VGA
- Size : 1/4"

■Lens Specification

- Focal Distance : 2.09mm ±3%
- F : 1.2 ±5%
- Distortion : min -17.4%、typ -14.4%、max -11.4% (horizontal end)
- Field of view : Diagonal 106. 6° 、Horizontal 90° 、Vertical 70.3° 各±3%
- Resolution : Center/Periphery(0.4H):160TV or more (@800mm)

■Camera focus position

- Focus adjustment rate : ~800mm (@IR)
- Recommended IR shooting range : ~400mm-5000mm

■Light source specification

- Semiconductors : Semiconductor Laser x 4 type
- Wave : 940nm(typ)
- Diffusion angle : Horizontal above 90° 、 Vertical above 70.3°
- Safety : Class 1 Laser product (Compliant IEC60825-1、JIS C 6802)
- Luminous Intensity : Rated 3200(register setting value)

■Distance specifications

- Distance measurement range
  - ・Computational power limit : 100mm～13200mm
    ※It's a settable distance performance, not guaranteed.
  - ・Recommended practical range : 100mm～3000mm
    ※depends on various conditio such as reflectance and required accuracy

- Distance accuracy : shooting range 1000mm、±50mm (center pixel)
- Distance repeatability : shooting range 1000mm、standard deviation under 26mm(center)
- Distanceresolution : 1mm(distance range ~2400mm)～2mm(distance range~13200mm)
- In-plane resolution : above 60TV (Nq/8)

■Output data format

- Data format
  1) Parallel 24bit (Depth/IR24bit data line separation)
  2) Parallel 16bit (Depth/IR16bit same data line)
  3) Parallel 14bit (Depth/IR14bit same data line+2bit synchronization)
  4) Parallel 8bit (Depth 8bit only)

  ※Refer to 「1.2.1 connection outline drawing」, 「2.2 data format」
- Image size
  Depth:640x480, IR:640x480
- Reference clock
  1) 45MHz@Parallel 24bit
  2) 90MHz@Parallel 16bit、Parallel 14bit、Parallel 8bit
- Signal level common with CMOS 3.3V

■Frame rate
- 30fps ±0.1

■External dimensions
- I2C (communicationspeed:100kHz)
- Signal level : 3.3V pulled up on camera board)
- Signal value absolute rating :-0.3V～ 3.6V

■External dimentions
- H66mm×W100mm×D28mm (excluding protrusions)
  ※Refer to 2.1.1

■Weight
- under 150g

■Consumption current(Ave.)
- Run (rated light intensity) : 1100mA
- Standby : 245mA

■Power supply
- Recommended 5V(Tolerance ±5%、ripple factor 100mVp-p under) 、4A power
- Absolute maximum range:+0～+5.5V
- Current capacitance rating:min 3A

※Please do not power supply from pwer jack on the camera side, if our Ethernet I/F board Is used. Camera might be broken.

■Guaranteed operation temperature(at rated light intensity)
- 0℃～+40℃(surrounding environment temperature)

・camera position uplight (Opening holes on the upper/lower surface are vertical)

・camera body (The camera is not in an enclosure)

※Refer to 2.1.4(2) , in case camera is enclosed and position is not uplight.

■Strage temperature range

- -40℃～+85℃

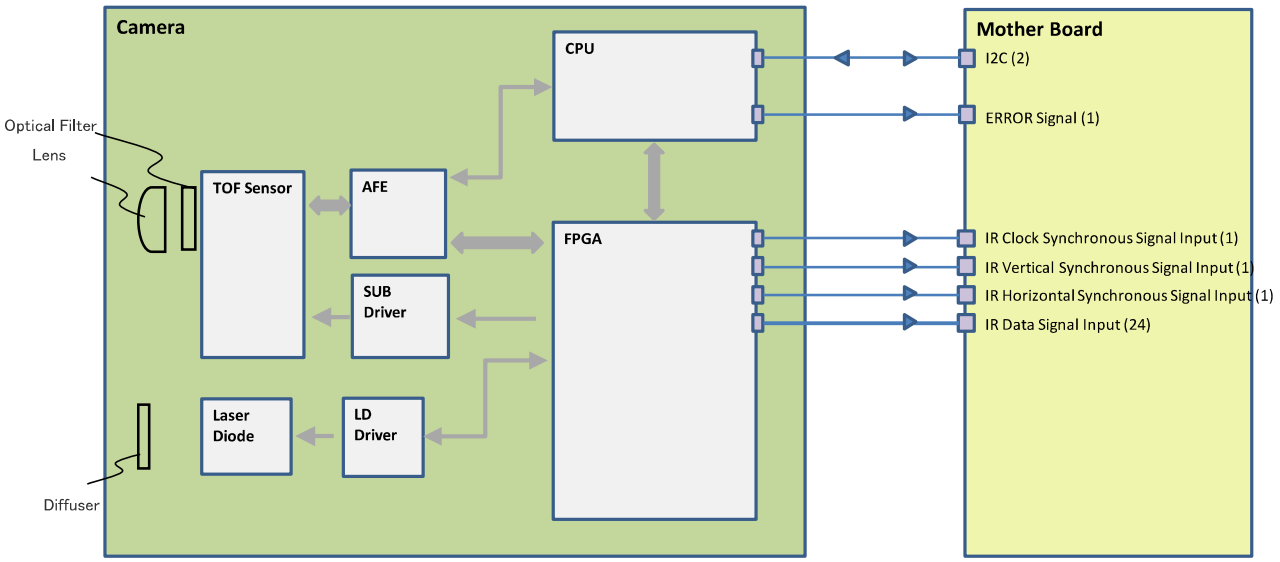
■Illuminance of surrounding environment

- Refer to 6.2 Cautions for use

1.2 Overall diagram and function list

1.2.1 Connection Schematics

The following drawing shows the cameraconnections schematics.



The FPGA outputs the IR data.

IMG data includes distance data (the below Depth data) and IR data.

The IR data outputs an IR synchronized signal for

IR/Depth clock synchronization signal (IMG_DAT_FCK)

IR/Depth VD vertical synchronization signal (IMG_DAT_VD_SYC)

IR/Depth HD horizontal synchronization signal (IMG_DAT_HD_SYC)

The communication with the TOF camera is done via I2C, In this case, the TOF camera operatesas a slave.

The ERROR signal terminal conveys malfunctions from the TOF camkera to the motherboard.

1.2.2 Function list

The TOF camera functions are as below.

① Imag data output

DepthMap data (distance image data)、IR image data are output as digital parallel signals to the mother board.
Clock,VD, HD are output as synchronization signals.

a) DepthMap data (16bit) 、IR image data(8bit)

② Abnormalituy detection

When the TOF camera fails, it informs the motherboard of abnormality by setting the ERROR terminal to Lo.
ERROR terminal normal :Hi、abnormal :Lo
Abnormality detection is performed in the following state.

-TOF camera device does not start (Deveice initialization error)
-Camera data is not output (No signal error)
-Camera temperature is abnormal (Temp over error)

③ Temperature feedback function

The function compensates for the deviation of the distance data with respect to the temperature change of the TOF camera.

④ Serial communication function

TOF camera communicates via I2C. The TOF camera operates as a slave.
The communication enables camera state change, setting/controls change, reading of the setting values, etc.

⑤ Para,eter hold function

This function holds the parameters set by the user and activates the parameters set at restart.
※The guaranteed number of rewriting parameters : 100,000 times

⑥ Noise resuction

IR data and distance image data are filtered to remove noise.

⑦ IR-AE(IR Automatic Exposure Control)

In order to optimize the brightness of the IR, the light emission intensity is changedon a frame by Frame basis.

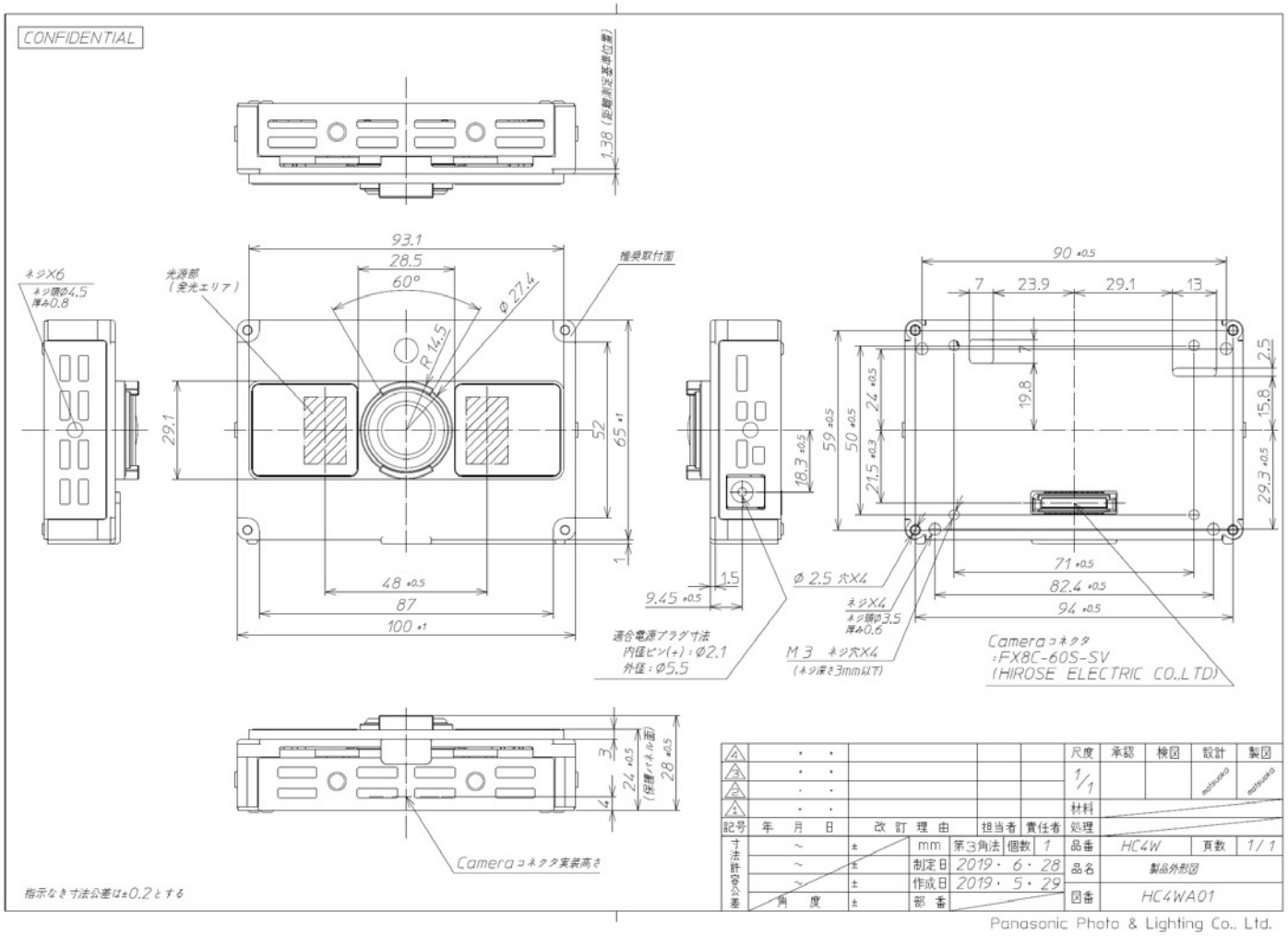
⑧ Interference Mitigation Function 干渉軽減機能

When several cameras are in oeration, the distance shift caused by the interference from other cameras is reduced.(maximum 27 units) ※default setting : OFF

2. Hardware specifications

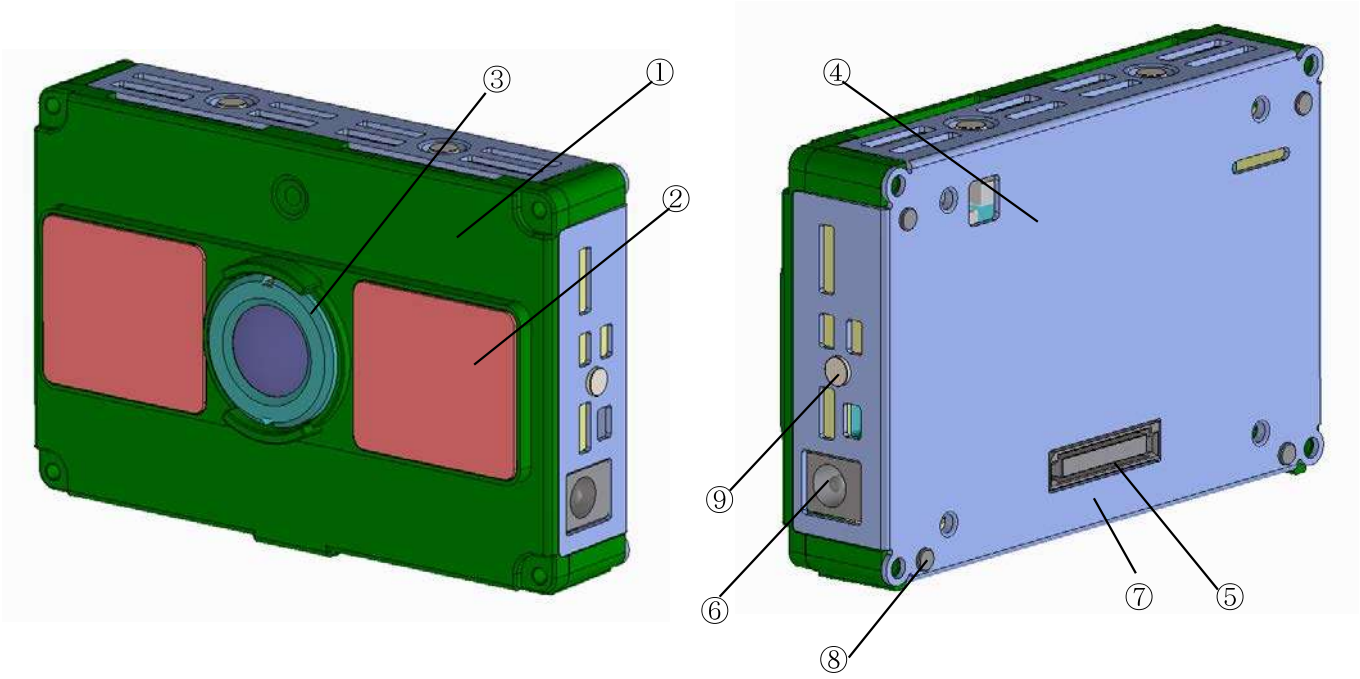
2.1 Overall diagram

2.1.1 External shape diagram



※The evaluation sample can have a tripod.

2.1.2 Parts name



No.	Parts name		
1	Body		
2	Protection panel		
3	Lens		
4	Shield		
5	Connector		
6	Power jack		
7	Label for lot#		
8	Screw		
9	Screw		

2.1.3 Function terminal

The table below shows the pin arrangement of the camera connectors.

Camera コネクタ (FX8C-60S-SV)		内容
Pin No.	Pin Name	
1	IMG_5V	+5V 出力 注:TOFカメラ電源入力時
3	IMG_5V	
5	IMG_5V	
7	IMG_5V	
9	IMG_5V	
11	IMG_5V	
13	TEST	INDEX信号出力
15	IMG_CDAT_HD_SYC	RGB HD水平同期信号出力
17	IMG_CDAT_VD_SYC	RGB VD垂直同期信号出力
19	IMG_CDAT_FCK	RGBクロック同期信号出力
21	IMG_CDAT_[11]	RGB画像データ信号出力
23	IMG_CDAT_[10]	RGB画像データ信号出力
25	IMG_CDAT_[9]	RGB画像データ信号出力
27	IMG_CDAT_[8]	RGB画像データ信号出力
29	IMG_CDAT_[7]	RGB画像データ信号出力
31	IMG_CDAT_[6]	RGB画像データ信号出力
33	IMG_CDAT_[5]	RGB画像データ信号出力
35	IMG_CDAT_[4]	RGB画像データ信号出力
37	IMG_CDAT_[3]	RGB画像データ信号出力
39	IMG_CDAT_[2]	RGB画像データ信号出力
41	IMG_CDAT_[1]	RGB画像データ信号出力
43	IMG_CDAT_[0]	RGB画像データ信号出力(※最下位bit)
45	ERROR	異常検知ERROR信号出力
47	SDA	I2Cデータ信号入出力
49	SCL	I2Cクロック信号入力
51	IMG_DAT_HD_SYC	IR/Depth HD水平同期信号出力
53	IMG_DAT_VD_SYC	IR/Depth VD垂直同期信号出力
55	IMG_DAT_FCK	IR/Depthクロック同期信号出力
57	UART16	UART TX信号用※未使用
59	UART14	UART RX信号用※未使用

Camera コネクタ (FX8C-60S-SV)		内容
Pin No.	Pin Name	
2	GND	GND
4	GND	
6	GND	
8	GND	
10	GND	
12	GND	
14	IMG_DAT[23]	IR/Depthデータ信号出力
16	IMG_DAT[22]	IR/Depthデータ信号出力
18	IMG_DAT[21]	IR/Depthデータ信号出力
20	IMG_DAT[20]	IR/Depthデータ信号出力
22	IMG_DAT[19]	IR/Depthデータ信号出力
24	IMG_DAT[18]	IR/Depthデータ信号出力
26	IMG_DAT[17]	IR/Depthデータ信号出力
28	IMG_DAT[16]	IR/Depthデータ信号出力
30	IMG_DAT[15]	IR/Depthデータ信号出力
32	IMG_DAT[14]	IR/Depthデータ信号出力
34	IMG_DAT[13]	IR/Depthデータ信号出力
36	IMG_DAT[12]	IR/Depthデータ信号出力
38	IMG_DAT[11]	IR/Depthデータ信号出力
40	IMG_DAT[10]	IR/Depthデータ信号出力
42	IMG_DAT[9]	IR/Depthデータ信号出力
44	IMG_DAT[8]	IR/Depthデータ信号出力
46	IMG_DAT[7]	IR/Depthデータ信号出力
48	IMG_DAT[6]	IR/Depthデータ信号出力
50	IMG_DAT[5]	IR/Depthデータ信号出力
52	IMG_DAT[4]	IR/Depthデータ信号出力
54	IMG_DAT[3]	IR/Depthデータ信号出力
56	IMG_DAT[2]	IR/Depthデータ信号出力
58	IMG_DAT[1]	IR/Depthデータ信号出力
60	IMG_DAT[0]	IR/Depthデータ信号出力(※最下位bit)

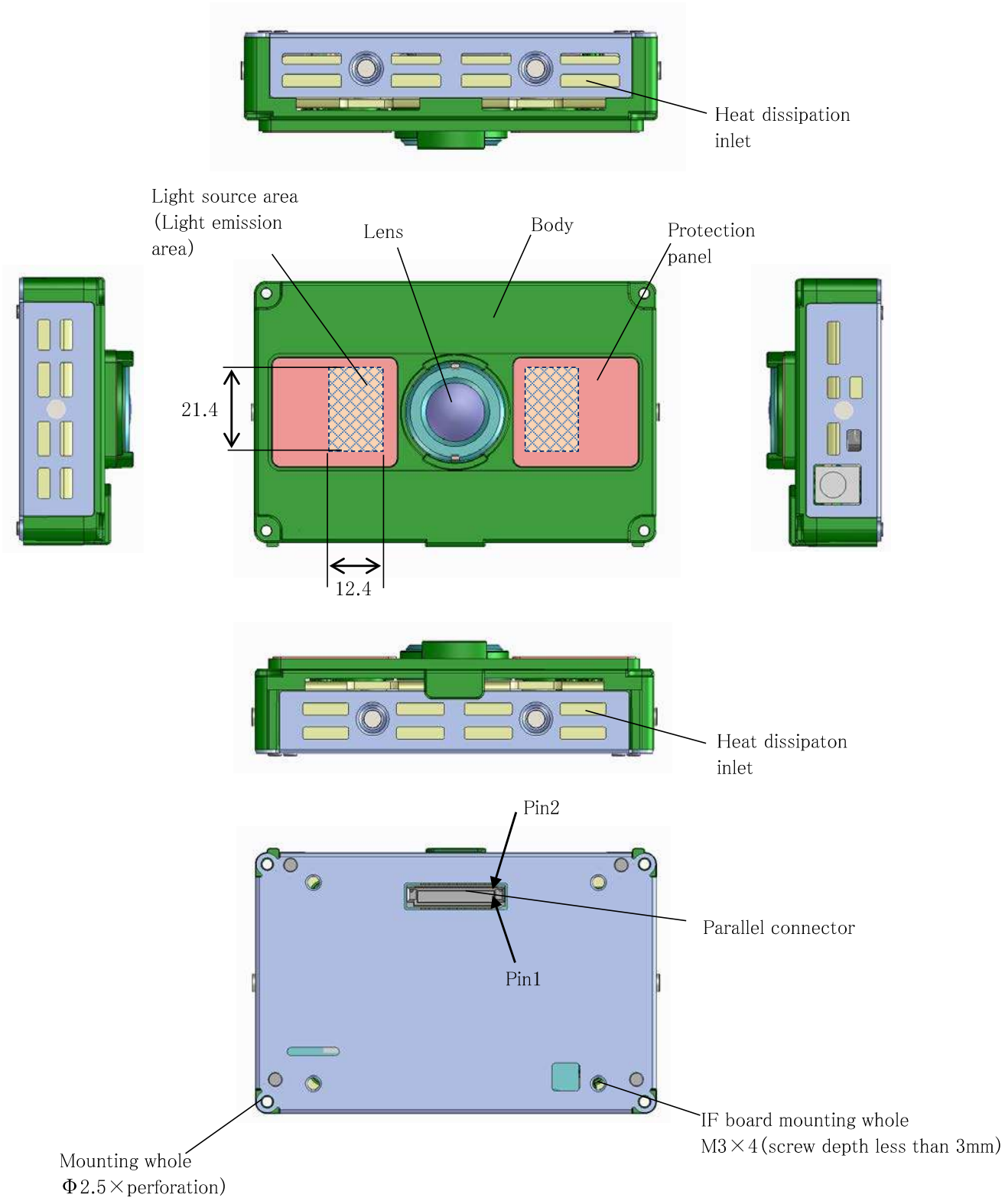
Connectors

The Camera connectors　FX8C-60S-SV　(HIROSE ELECTRIC CO.LTD)

Applicable connectors　FX8C-60P-SV*　(HIROSE ELECTRIC CO.LTD)

※The user has to use connectors compatible with the above connectors for the motherboard.

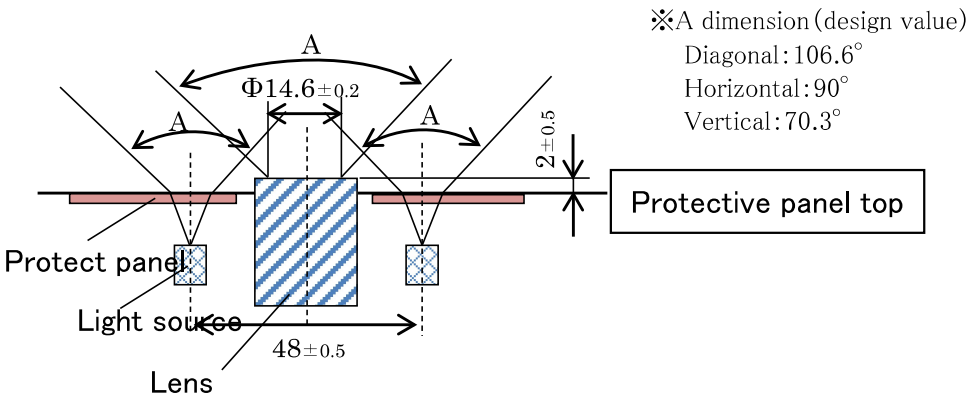
2.1.4　Exterior functional position



(1) Opening design

・The protective panel and the lens have the following dimensions

・Refer to theprevious section for the light emitting area of the protective panel



※Since the angle of view is based on these values, please allow for extra space when you install an additional panel.

※There is the risk of halation or light attenuation in case another panel is installed in fromt f the protective panel or in fromt of the lens.

※The irradiation light from the light source is diffusing slightly even outside the viewing angle in the figure above. Please check the performance in actual use conditions, since errors may occur in the measured distance when an opening is provided in fromt of the camera, irradiation light hits and halation occurs.

Please refer to the example below and design when setting up protective panel for the camera.

・Position	:	Keep it close to the front of the camera
・Materials and colors	:	black type materials, especially those which do not easily reflect near infrared light and desirable.
・Shape	:	make the cross section of the opening thin and edge shape.
・Surface condition	:	anti-reflection surface by matte treatment should be used.

(2) Heat radiation design

・When installing the camera sand covering it with another part, consideration should be given to ventilation, so that the heat does not stay inside. Please provide ventilation openings.

・Please do not block the openings on the upper and lower surfaces of the camera since they are intake andexhaust ports for heat radiation.

Also, if the left, right sides and the back side are blocked from outside air, the heat dissipation properties may decrease.

・While the camera is in operation, please take measure to dissipate heat so that the internal temperatureof the camera is 75 ℃ or less. (at ambient temperature of 25 ℃)

Please set heasink or cooling for the camera, if the internal temperature is more than 75 ℃.

(Refer to the value of「Local Address 494A」in 4.Command List for the camera internal temoerature..

・Error detection function (temp over error) may work and the camera state may shift to “error”, if the camera internal temperature is more than 100℃. Please refer to「3.4Error processing」.

(3) Recommended installation (reference)

＜Camera body installation＞

・The camera can be fixed using the through holes at the Four corners of the front and back of the body.

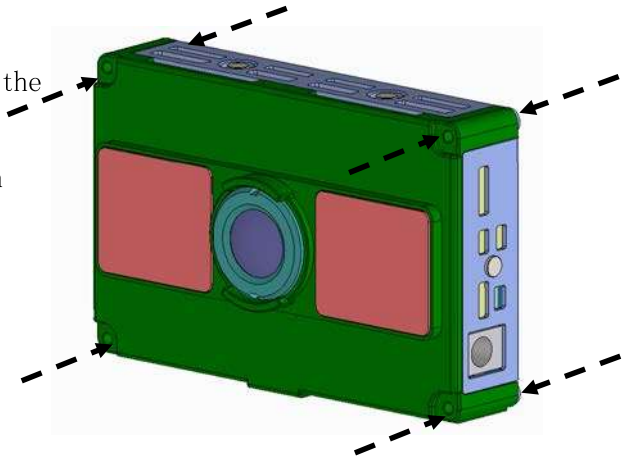
・Refer to the external drawing for fixing hole position

・Hole size　: Φ2.5

・Reference screw size

　-Tapping screw normal diameter　Φ3

　-M screw less than M2.5



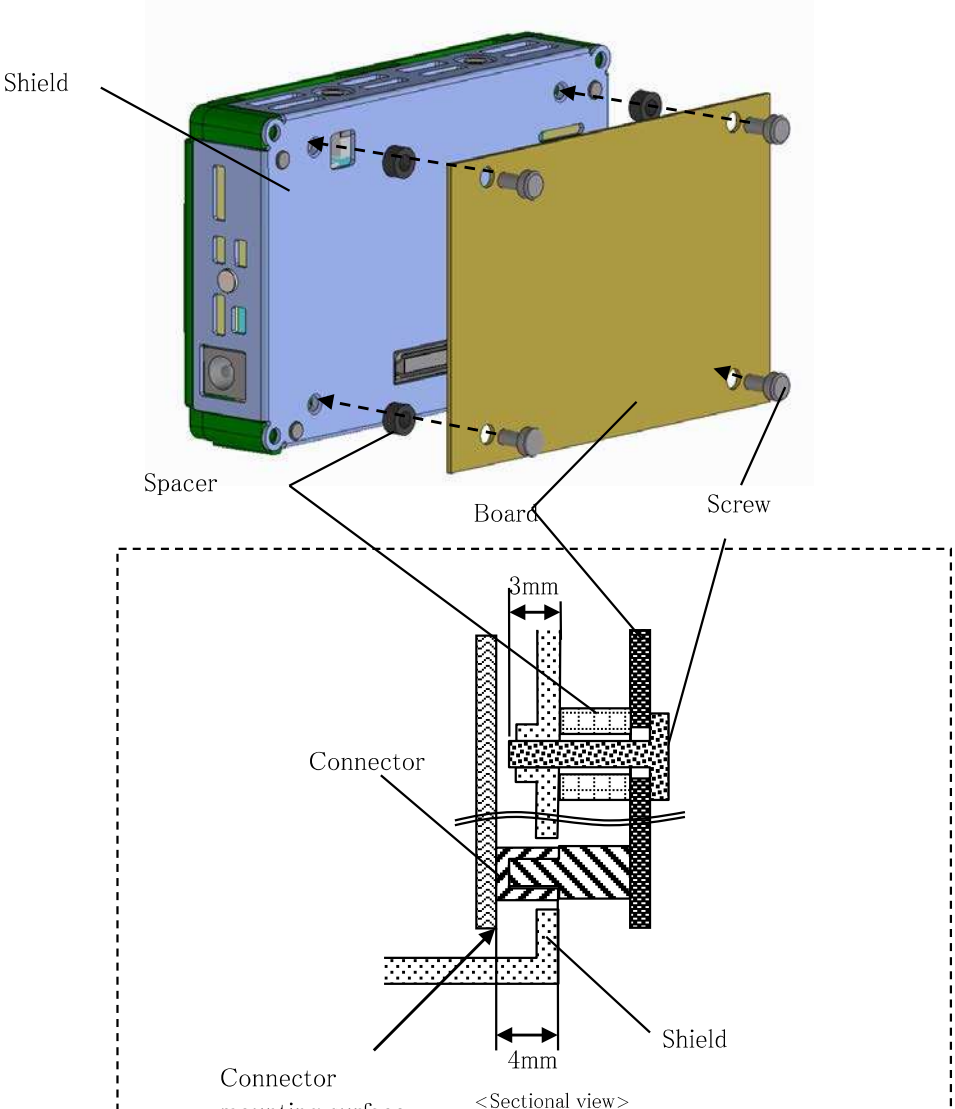
＜Board installation＞

・Please use a spacer, screw etc. that match the height of the connector in order to prevent unstable connections.

・Please refer to 2.1.1 for the fixed holes positions.

・Recommended screw size　: M3　(screw height : less than 3mm for the shield. Effective screw depth 2mm)

※Please do not use screw longer than the recommended length as it might in shorting with the internal board.



2.2 Data format

2.2.1 Parallel 24bit

Depth/IR is processed on a 24bit.

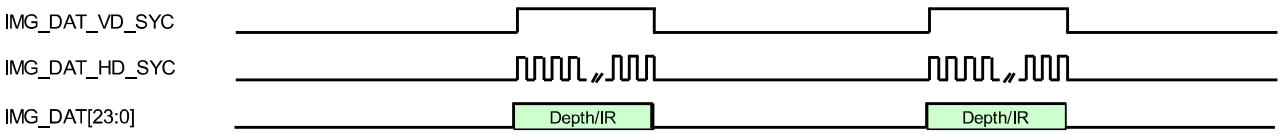
The sync signal (VD,HD) is common for the Depth/IR on the signal line.

The clock works at 45MHz.

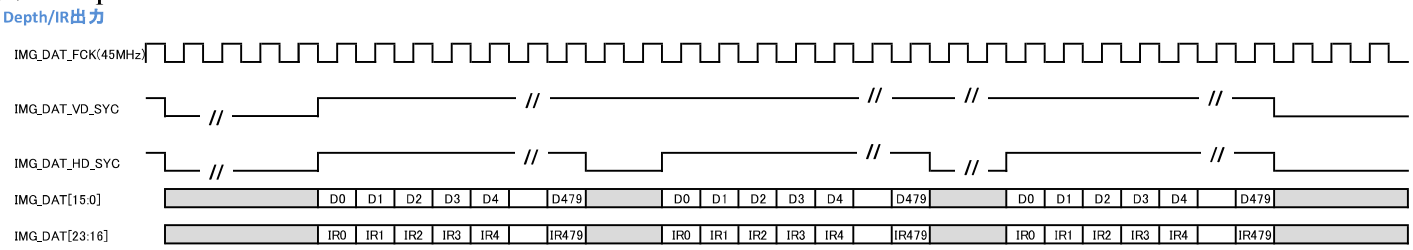
Depth output　:　IMG_DAT[15:0]　+ IMG_DAT_VD_SYNC　+ IMG_DAT_HD_SYNC

IR output　　:　IMG_DAT[23:16] + IMG_DAT_VD_SYNC　+ IMG_DAT_HD_SYNC

(1) Depth/IR output timing



(2) Output format

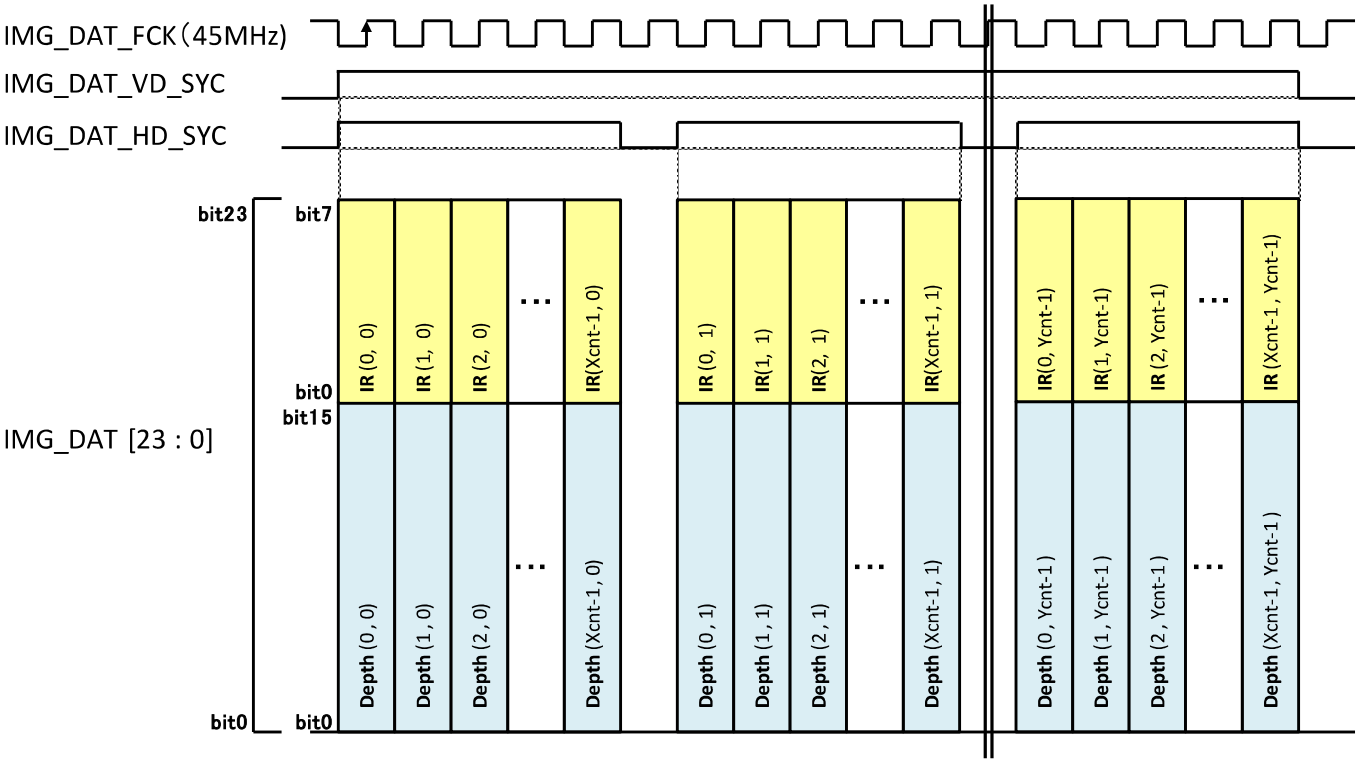


(3) Depth/IR image data output

・Depth data is represented on 16bit Depth(0,0)～Depth(Xcnt-1, Ycnt-1).

・IR data is represented on 8bit IR(0,0)～IR(Xcnt-1, Ycnt-1).

・Depth data and IR data have a simultaneous output on 24bit pixels with the target pixel position aligened.



(0,0)	(1,0)	(2,0)	···	···	(Xcnt-1,0)
(0,1)	(1,1)	(2,1)	···	···	(Xcnt-1,1)
(0,2)	(1,2)	(2,2)	···	···	(Xcnt-1,2)
⋮					
(0,Ycnt-1)	(1,Ycnt-1)	(2,Ycnt-1)			(Xcnt-1,Ycnt-1)

Pixel address Data image

2.2.2 Parallel 16bit

Depth/IR is processed on a 16 bit the same data line.

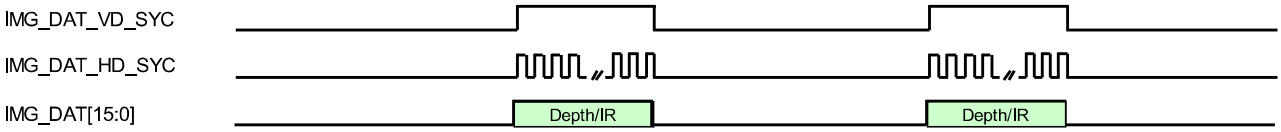
The sync signal (VD,HD) is common for Depth/IR.

The clock operates at 90MHz for Depth/IR.

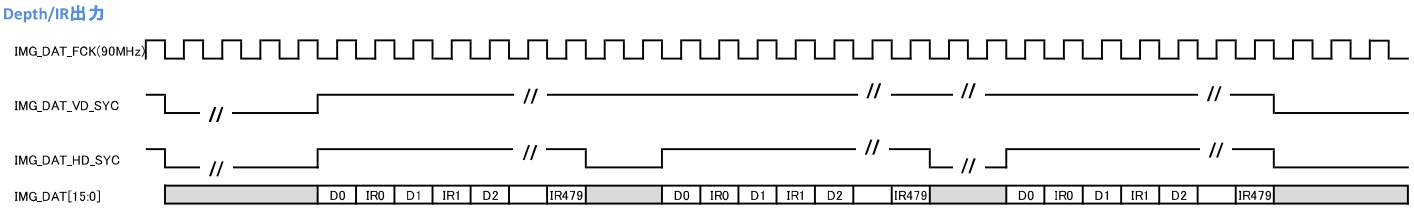
Depth output : IMG_DAT[15:0] + IMG_DAT_VD_SYNC + IMG_DAT_HD_SYNC

IR output : IMG_DAT[7:0] + IMG_DAT_VD_SYNC + IMG_DAT_HD_SYNC

(1) Depth/IR output timing



(2) Output format

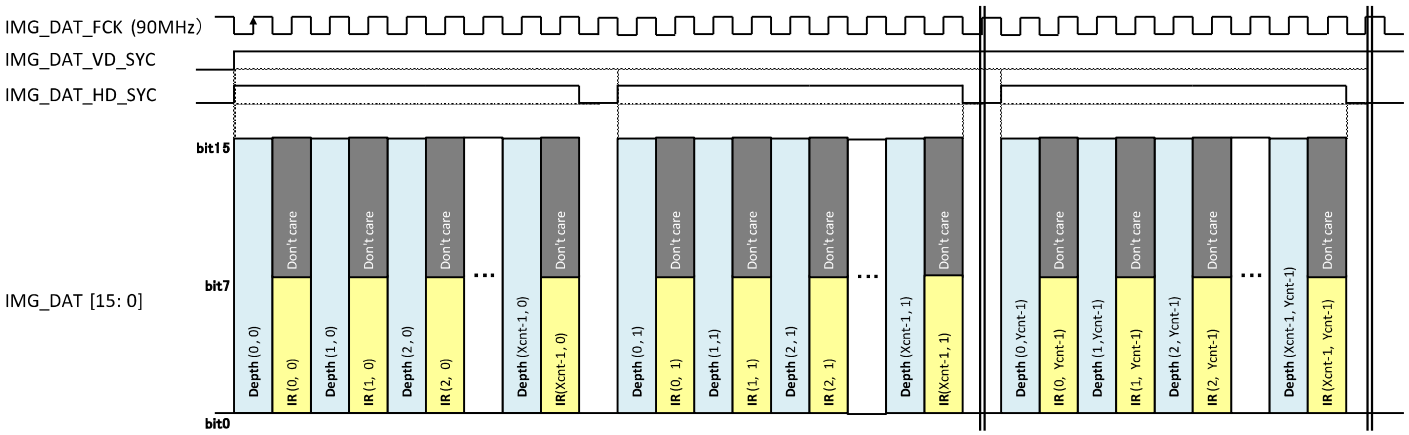


(3) Depth/IR image data output

・Depth data 16bit is represented Depth(0,0)～Depth(Xcnt-1, Ycnt-1)

・IR data is represented on 8bit 幅 IR(0,0)～IR(Xcnt-1, Ycnt-1).

・Depth data and IR data are represented on 16bit as an alternate output.



2.2.3 Parallel 14bit

Depth/IR＋VDSYC/HD_SYC have an embedded data format.

Depth/IR is processed on 16bit the same data line.

The upper 2 bits of the 16bits data output are VD、HD. 。

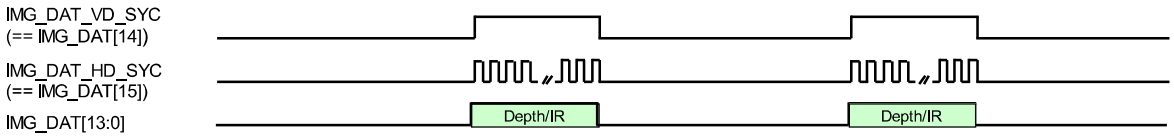
The embedded VD、HD are processed at the same line with the separately IMG_DAT_VD_SYNC、IMG_DAT_HD_SYNC.

The clock works at 90MHz for noth Depth/IR.

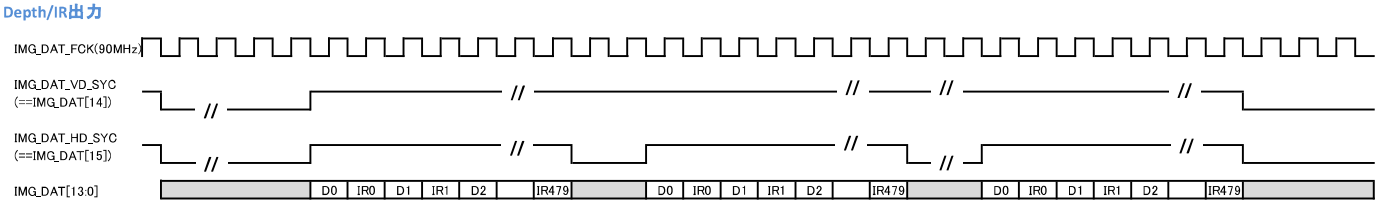
Depth output ： IMG_DAT[13:0](Data) + IMG_DAT[15:14](VD,HD)
+ IMG_DAT_VD_SYNC + IMG_DAT_HD_SYNC

IR output ： IMG_DAT[7:0] (Data) + IMG_DAT[15:14](VD,HD)
+ IMG_DAT_VD_SYNC + IMG_DAT_HD_SYNC

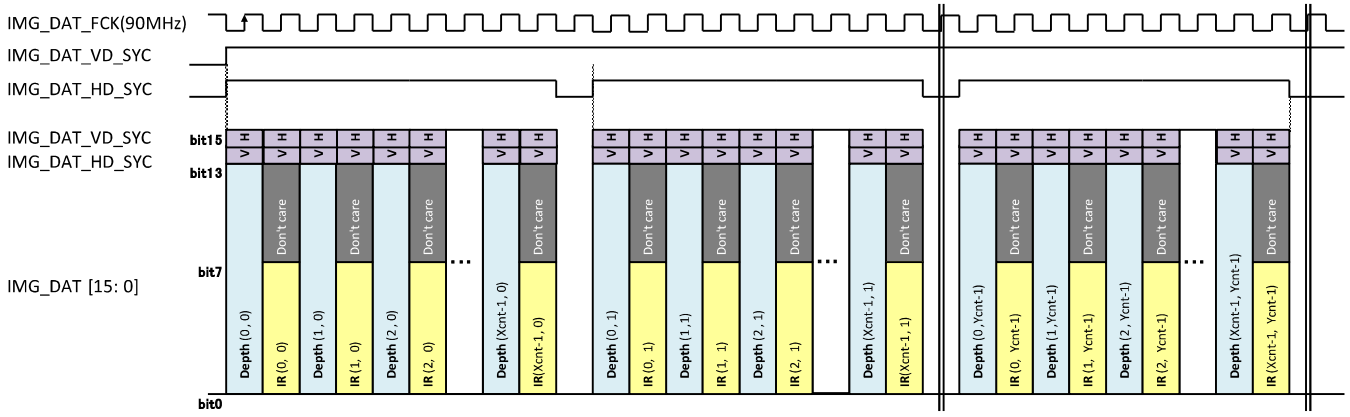
(1) Depth/IR output timing



(2) Output format



(3) Depth/IR data output



2.2.4　パラレル 8bit

Depth data is processed on 8bit.

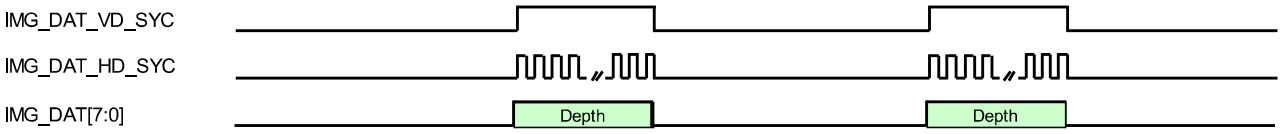
IR data is not processed.

Depth data is processed the upper 8 bit, lower 8 bit for 1 pixel, it should handled as 16bit.

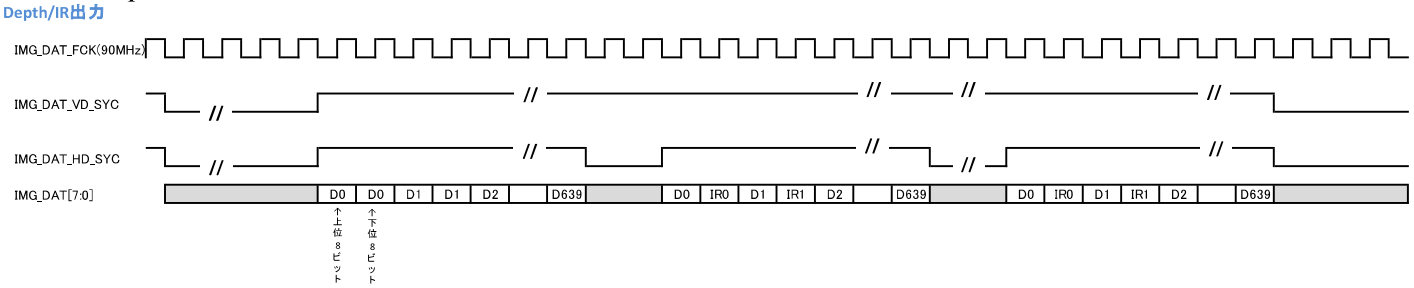
The clock works 90MHz.

Depth output　:　IMG_DAT[7:0]　+ IMG_DAT_VD_SYNC　+ IMG_DAT_HD_SYNC

(1)　Depth/IR output timing



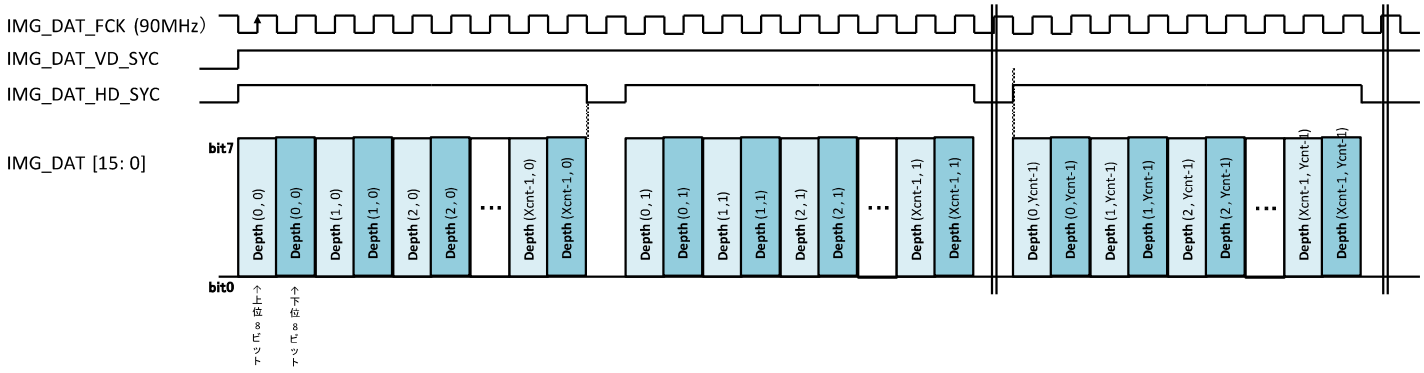
(2)　Output format



(3)　Depth/IR image data output

・Depth data is represented 8bit Depth(0,0)～Depth(Xcnt-1, Ycnt-1)

・Depth data is processed the upper 8 bit, lower 8 bit for 1 pixel, it should handled as 16bit.



2.3 Serial Communication

The TOF camera communicates via I2C.

2.3.1 I2C communication specification

The following represents the I2C communication. The TOF camera operats as a slave.

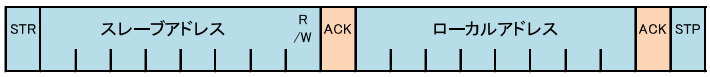
(1) Communication Spec

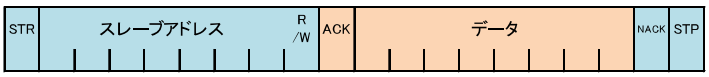
・ The TOF camera operats as a slave.

Item	Spec
Communication master	External device
Communication speed	Standard mode (100kHz)
Shift mode	MSB
Slave address	0xC2

a)Write

b)Read





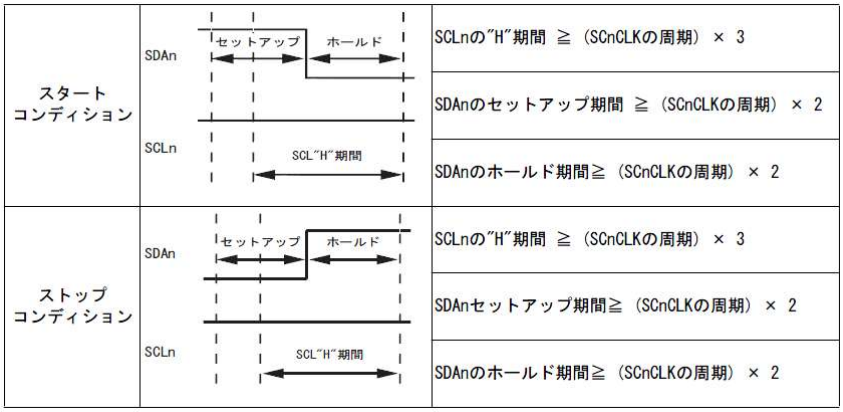
*SRT:Start condition、STP:Stop condition

* ▭ :Processing on the master side

(2) Communication control

1. Hard constrains

・Terminal is open-drain



2. Command transmission constrains

・Communication frequency 95kHz～105kHz　(corresponding clock stretch required)

・The camera can hold up to 10 commands at a time.

・In case the camera receives more than 10 commands, the local address NACK(the slave address becomes ACK)

・One commands per frame is processed.。

・The commands received first are processed first.

・The commands will be processed and an NACK will be issued if more than the specified number of signals are sent during one transmission.

2.4 Pin Processing

2.4.1 Pin prpcessing

The following indicate the terminal state after the camera activation.

Terminal name	Contents	Polarity	Remarks
UART16	UART　Write	Hi	Pulled up at the camera board(3.3V)
UART14	UART　Read	Hi	Pulled up at the camera board(3.3V)
SCL	I2C clock	Hi	Pulled up at the camera board(3.3V)
SDA	I2C data	Hi	Pulled up at the camera board(3.3V)
ERROR	Camera board error notification GPIO	Hi	Abnormal time low output

2.4.2 Unused pins processing

The following indicate the processing for unused pins

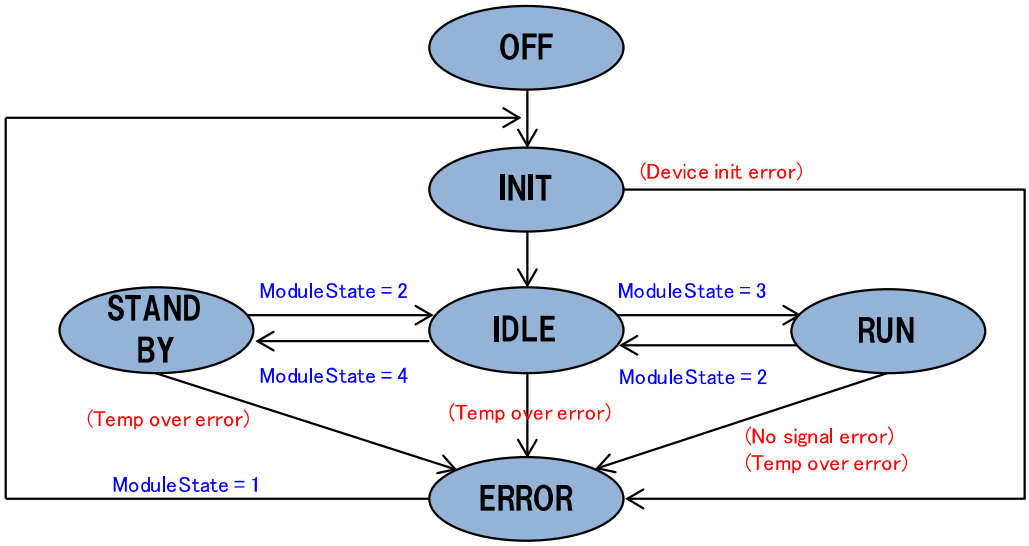
Terminal name	Contents	Polarity	Remarks
TEST	INDEX signal output	Not fixred	Open
IMG_CDAT_HD_SYC	RGB HD horizontal sync signal output	Not fixed	Open
IMG_CDAT_VD_SYC	RGB VD vertical sync signal output	Not fixed	Open
IMG_CDAT_FCK	RGB clock sync signaloutput	Not fixed	Open
IMG_CDAT_[11]	RGB data signal output	Not fixed	Open
IMG_CDAT_[10]	RGB data signal output	Not fixed	Open
IMG_CDAT_[9]	RGB data signal output	Not fixed	Open
IMG_CDAT_[8]	RGB data signal output	Not fixed	Open
IMG_CDAT_[7]	RGB data signal output	Not fixes	Open
IMG_CDAT_[6]	RGB data signal output	Not fixed	Open
IMG_CDAT_[5]	RGB data signal output	Not fixed	Open
IMG_CDAT_[4]	RGB data signal output	Not fixed	Open
IMG_CDAT_[3]	RGB data signal output	Not fixed	Open
IMG_CDAT_[2]	RGB data signal output	Not fixed	Open
IMG_CDAT_[1]	RGB data signal output	Not fixed	Open
IMG_CDAT_[0]	RGB data signal output	Not fixed	Open
UART16	Unused	High	Pulled up at the camera(3.3V)
UART14	Unused	High	Pulled up at the camera(3.3V)

3. Operation Sequence

3.1 State transition diagram

The following shows the state transition diagram. There are the following 6 states.

The transition to each state is done by the “SetModuleState” command.



State	Contents	I2C commands		Remarks
		Write	Read	
OFF	Power OFF	–	–	
INIT	Device initiakization (including FPGA configuration)	–	–	
IDLE	Waiting	All commands	All commands	No LD light、no data output
RUN	Normal operation	All commands	All commands	
STANDBY	Standby	Only for ModuleState	All commands	No LD light, no data output
ERROR	Error occured	Only for ModuleState	All commands	NO LD light, no data output

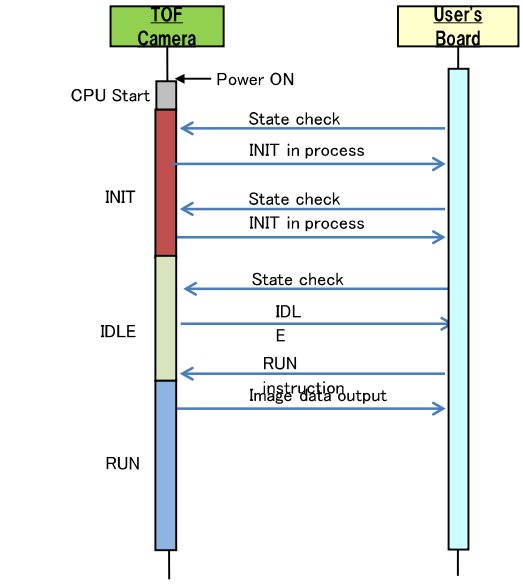
3.2 Startup sequence

The following is an example of the startup sequence of the camer.

The camera board starts the initialization of each devices after the TOF camera is powered ON. After the initialization is completed the camera transitions automatically into IDLE.

If necessary, a statecheck will be performed.

While the camera is in IDLE, if RUN instructions are issued the TOF camera starts the normal operation.



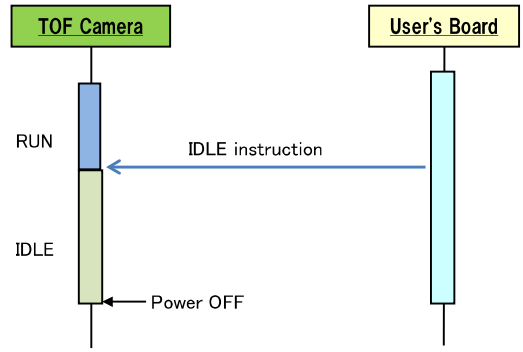
Item	Resister name	LocalAddress	Value
State check	ModuleState	0x02	-
RUN transfer instruction	ModuleState	0x02	0x03

3.3 Exit Sequence

All example of the exit sequence operation is shown.

While the TOF camera is in operation, the IDLE instruction need to be issued.

After the camera transitioned into IDLE, one can turn OFF the power.



Item	Resiste name	LocalAddress	Value

IDLE transfer instruction	ModuleState	0x02	0x02

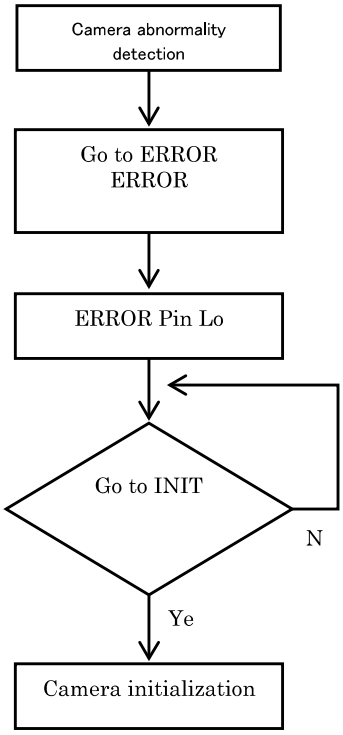
3.4 Error processing

If a malfunction is detected within the camera, the camera transitions into ERROR mode, the ERROR(PinNo45) Issues a Low signal.

On the motherboard ERROR output (ERRORPin->Lo), perform state restoration by I2C command.

For other kinds of undetected abnormalities, the camera is automatically initialized if the camera detects runaway throughthe watchdog timer.

Item	Resister nome	LocalAddress	Value
INIT transfer instruction	ModuleState	0x02	0x01



4. Command list

Local Address	Register name	Initial Value (HEX)	R/W	Outline of Register
0	Soft ver	0x50	R	Read Camera Version (*1) [b7:0] 0 to 255
1	ModuleType	0x12	R	Read Module Type [b7:0] 0 to 255
2	ModuleState	0x00	R/W	Setting / reading state transition Please refer to state transition diagram for details. [b7:0] 0:Reserved 1:INIT(RESET) 2:IDLE 3:RUN(Normal operating) 4:STANDBY 5:ERROR 6 to 255:Reserved
3	Param_Init	0xFF	W	Back parameters to shipping status (Note) The camera is reset, when the command is executed [b7:0] 0:Reserved 1:Initialize 2 to 255:Reserved
4	ModuleErrorState	0x00	R	Reading error state of camera [b7:0] 0:No error 1:Device operating error 2:Image output error 3:Camera temperature error 4 to 255:Reserved
5	Depth Range_near_H	0x03	R/W	Setting / reading minimum distance [mm] (*2) Min. ditection distance(16bit) = Depth Range_near_H<<8 + Depth Range_near_L [b15:0] 0 to 99 :Not used(Setting prohibited) 100 to 13230 :Setting value 13231 to 65535 :Reserved
6	Depth Range_near_L	0xE8	R/W	
7	Depth Range_far_H	0x0B	R/W	Setting / reading maximum distance [mm] (*2) Max. detection distance(16bit) = Depth Range_far_H<<8 + Depth Range_far_L [b15:0] 0 to 99 :Not used(Setting prohibited) 100 to 13330 :Setting value 13331 to 65535 :Reserved
8	Depth Range_far_L	0xB8	R/W	
9	OutputSel	0x01	R/W	Change Image output method [b7:0]0: Parallel 36bit 1: Parallel 14bit (USB3.0) 2: Not used(Setting prohibited) 3: Parallel 16bit 4 to 255: Not used(Setting prohibited)
A	FarLimit_H	0x00	R/W	Setting / reading threshold of far distance Replace the distance equal to or greater than the set value with 0xFFFF. [b15:0] 0 : Auto setting (Automatically set in conjunction with Depth Range_far_H,L) 1 to 9 : Not used 10 to 65535 : Manual setting
B	FarLimit_L	0x00	R/W	
C	Not Used	–	–	–
D	Not Used	–	–	–
E	Smoothing Filter	0x77	R/W	Setting / reading smoothing filter processing of depth image [b7:0] 0: Smoothing filter OFF 1 to 118: Not used(Setting prohibited) 119: Smoothing filter ON 120 to 255: Not used(Setting prohibited)
F	Out Of Depth Range	0x00	R/W	Setting / reading replacement method of out-of-range measurement data Image data of out-of-range data (error output) is replaced by appointed value. Threshold distance value of near is set by Depth Range_near_H,L(address: 0X05, 0X06), [b1:0] 0: to 0x0000 1: to 0xFFFF 2: to the value of Depth Range_near_H,L 3: Reserved [b2:7] Reserved
10	Not Used	–	–	–

11	Gradient_H	0x00	R/W	Setting / reading the gradient of Depth Correct slope of Depth linearity. Value big -> gradient big, Value small -> gradient small There are two types of operation auto setting and mnual one. The value of the inclination 3331 is 1 time, and the inclination to be set is the following. Setting value = Depth inclination correction value(16bit)/3331 Depth inclination correction value(16bit) = Gradient_H<<8 + Gradient_L [b15:0] 0 to 65535
12	Gradient_L	0x00	R/W	
13	Offset_H	0x00	R/W	Setting / reading Depth offset correction Set the correction value for the offset that is automatically set according to the value of Depth Range_near (address: 0x05, 0x06). The set value is a 2's complement, and the unit is [mm]. Offset value = Offset_H<<8 + Offset_L [b15:0]　0x0000～0xFFFF　(- 32768～ 32767)
14	Offset_L	0x00	R/W	
15	LuminescenceStrength_H	0x07	R/W	Setting / reading of emission intensity Emission intensity(16bit) = LuminescenceStrength_H<<8 + LuminescenceStrength_L This register is valid when IR AE ([b0]) of AE Setting (address: 0×25) is OFF. When IR AE is ON, the set value is ignored. [b15:0] 0 : Auto setting (Optimum value is set in conjunction with Depth Range_near_H,L) 1 to 9: Reserved 10 to 8000 : Manual setting (Min:10, Max:8000) 8001 to 65535: Reserved
16	LuminescenceStrength_L	0xD0	R/W	
17	Depth Coordinate Trans	0x01	R/W	On / Off　Depth Coordinate transformation (*3) [b7:0] 0: OFF 1: ON 2 to 255: Reserved
18	IR Selection	0x03	R/W	Setting / reading IR image type [b0] IR gamma correction setting [b1] Select the presence or absence of BG in the output value of the IR image [b0] 0: Not used 1: γ= 1 [b1] 0: with BG 1: without BG [b2:7]　Reserved
19	Not Used	–	–	–
1A	RGB Exposure	0x50	R/W	Setting / reading of RGB exposure time It is valid when RGB AE [b1] of AE Select (address: 0x25) is OFF [b7:0] 0 to 200(0:Minimum exposure, 200:Maximum exposure) 201 to 255　Reserved
1B	Not Used	–	–	–
1C	Not Used	–	–	–
1D	Not Used	–	–	–
1E	Not Used	–	–	–
1F	Not Used	–	–	–
20	Not Used	–	–	–
21	Not Used	–	–	–
22	EDGE_DEL	0x60	R/W	Setting / reading of edge removal A large setting value increases the effect of edge removal. [b7:0] 0　　: OFF 1 to 254 : Setting value of edge removal 255　　: Not used
23	CORING_H	0x00	R/W	Setting / reading　small signal removal A large setting value increases the effect of small signal removal. Setting value(16bit) = CORING_H<<8 + CORING_L [b15:0] 0　　: OFF 1 to 4095 : Setting value of small signal removal from 4096: Not used
24	CORING_L	0x30	R/W	
25	AE Select	0x01	R/W	Setting / reading of Auto Exposure (*4) [b0]　IR Auto Exposure 0: OFF, Operates with the value set by LuminescenceStrength_H,L (address: 0x15, 0x16) 1: ON,　AE operates so as to be the IR value set by IRAE_TargetVal (address 0x2A, 0x2B) [b1]　RGB Auto Exposure 0: OFF, Operates with the value set by RGB Exposure (address: 0x1A) 1: ON,　AE operates so as to be the RGB value set by RGBAE_TargetVal (address 0x39, 0x3A) [b7:2] Reserved
26	IRAE_StrX	0x00	R/W	Start position X of the IR-AE effective area (20 × 15 block) (*5) [b7:0] 0 to 19　: Start position X from 20 : Not used
27	IRAE_StrY	0x00	R/W	Start position Y of the IR-AE effective area (20 × 15 block) (*5) [b7:0] 0 to 14　: Start position Y from 15 : Not used
28	IRAE_SizeX	0x14	R/W	Width of IR-AE effective area (20 x 15 blocks) in X direction. (IRAE_StrX + IRAE_SizeX) is the effective width in the X direction. (*5) [b7:0] 0　　: NotUsed 1 to 20　: X effective width from 21 : Not used

2A	IRAE_TargetVal_H	0x0A	R/W	Target 12-bit IR value for IR-AE (*5) Target IR value(12bit) = IRAE_TargetVal_H<<8 + IRAE_TargetVal_L [b15:0] 0 to 3800 : Setting value from 3801 : Not used
2B	IRAE_TargetVal_L	0xF0	R/W	
2C	Not Used	–	–	–
2D	Not Used	–	–	–
2E	Not Used	–	–	–
2F	Not Used	–	–	–
30	Not Used	–	–	–
31	Not Used	–	–	–
32	Not Used	–	–	–
33	Not Used	–	–	–
34	Not Used	–	–	–
35	Not Used	–	–	–
36	Not Used	–	–	–
37	Not Used	–	–	–
38	Not Used	–	–	–
39	Not Used	–	–	–
3A	Not Used	–	–	
3B	Not Used	–	–	–
3C	Not Used	–	–	–
3D	Not Used	–	–	–
3E	Not Used	–	–	–
3F	Not Used	–	–	–
40	LuminescenceStrengthMax_H	0x0C	R/W	Setting / reading maximum emission strength Maximum emission strength(16bit) = LuminescenceStrengthMax_H<<8 + LuminescenceStrengthMax_L This register sets the maximum emission strength of IR-AE. [b15:0] 0 to 9 :Not used 10 to 8000 : Setting value 8001 to 65535 : Reserved
41	LuminescenceStrengthMax_L	0x80	R/W	
42	Not Used	–	–	–
43	Not Used	–	–	–
44	Not Used	–	–	–
45	Not Used	–	–	–
46	Not Used	–	–	–
47	Not Used	–	–	–
48	Not Used	–	–	–
49	ModuleTemp_H	0x00	R	Reading Module temperature [℃] The value is a 2's complement, and it is output with a value obtained by multiplying the actual temperature by 10 times. To return to the actual temperature, multiply by 0.1. Module temperature = (ModuleTemp_H<<8 + ModuleTemp_L) * 0.1 [b15:0] 0 to 65535 : Module temperature * 10
4A	ModuleTemp_L	0x00	R	
4B	InterferenceParam	0x00	R/W	Parameter for interference reduction (Total 27 pcs of camera can be used) [b7:0] 0 : OFF 1～13 : Interference reduction on 14～32 : NotUsed 33～45 : Interference reduction on 250～255 : NotUsed
4C	Not Used	–	–	–
4D	AxisShiftX	0x00	R	Optical axis misalignment volume X[pixel] Tere's a differences for each individual. [b7:0] -128～127
4E	AxisShiftY	0x00	R	Optical axis misalignment volume Y[pixel] Tere's a differences for each individual. [b7:0] -128～127
4F	StartState	0x02	R/W	Camera state when operation starts 2:IDLE 3:RUN
50	Not Used	–	–	–
51	TofMethod	0x03	R/W	Select ToF method 2:3W （Distance range prior method） 3:3WF（Accuracy prior method）
52	Not Used	–	–	–
53	Not Used	–	–	–
54	Not Used	–	–	–
55	Not Used	–	–	–
56	TestPattern	0x00	R/W	Output test pattern [b0] 0: OFF 1: test pattern output1 2: test pattern output2 3: test pattern output3 4: test pattern output4 5～255: NotUsed
				Select output polarity

59	TempCorParam0_H	0x93	R/W	Temp correction parameter for range 1 Temp correction value = (TempParam /10000) * ΔT *ΔT= (current temp - [42]ModuleTempRef)
5A	TempCorParam0_L	0xAB	R/W	
5B	TempCorParam1_H	0x8E	R/W	Temp correction parameter for range 2 Temp correction value = (TempParam /10000) * ΔT *ΔT= (current temp - [42]ModuleTempRef)
5C	TempCorParam1_L	0x00	R/W	
5D	TempCorParam2_H	0xD6	R/W	Temp correction parameter for range 3 Temp correction parameter = (TempParam /10000) * ΔT *ΔT= (current temp - [42]ModuleTempRef)
5E	TempCorParam2_L	0x79	R/W	
5F	Not Used	–	–	–
60	Not Used	–	–	
61	TempFB	0x01	R/W	Temp feedback function on/off 0 : OFF 1 : ON
62	WDR	0	R/W	Wide dynamic range function on/off (*9) 0 : OFF 1 : ON
D0	IP_frg	0xFF	R/W	Validate of IP address 1:Valid Except 1:Invalid
D1	IP1	0xFF	R/W	1st digit of IP address
D2	IP2	0xFF	R/W	2nd digit of IP address
D3	IP3	0xFF	R/W	3rd digit of IP address
D4	IP4	0xFF	R/W	4th digit of IP address
D5	Netmask1	0xFF	R/W	1st digit of Netmask
D6	Netmask2	0xFF	R/W	2nd digit of Netmask
D7	Netmask3	0xFF	R/W	3rd digit of Netmask
D8	Netmask4	0xFF	R/W	4th digit of Netmask
D9	MAC_frg	0x01	R/W	Validate of MAC address 1:Valid Except 1:Invalid
DA	MAC1	0xFF	R/W	1st digit of MAC address
DB	MAC2	0xFF	R/W	2nd digit of MAC address
DC	MAC3	0xFF	R/W	3rd digit of MAC address
DD	MAC4	0xFF	R/W	4th digit of MAC address
DE	MAC5	0xFF	R/W	5th digit of MAC address
DF	MAC6	0xFF	R/W	6th digit of MAC address
EC	User SoftReset	0xFF	W	Soft reset on camera required from user 0x01 : Perform soft reset
ED	ParamSaveSel	0x01	R/W	Parameter save settings for each communication [b7:0] 0: OFF : without save settings 1: ON : with save settings from 2 : Not used

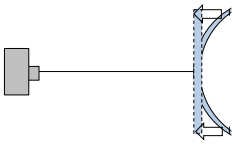
Note1 : Set the register setting in the order of the high order (H) low order (L).
Note2 : Operation is not guaranteed if you enter anything other than the setting value specified in this register map.
Note3 : If inputting to NotUsed, Reserved, operation is not guaranteed.

(*1)　Please contact us for Soft ver. of your camera.

(*2)　Please set the distance range to be used.
The optimum setting is done inside the camera according to the set distance range.

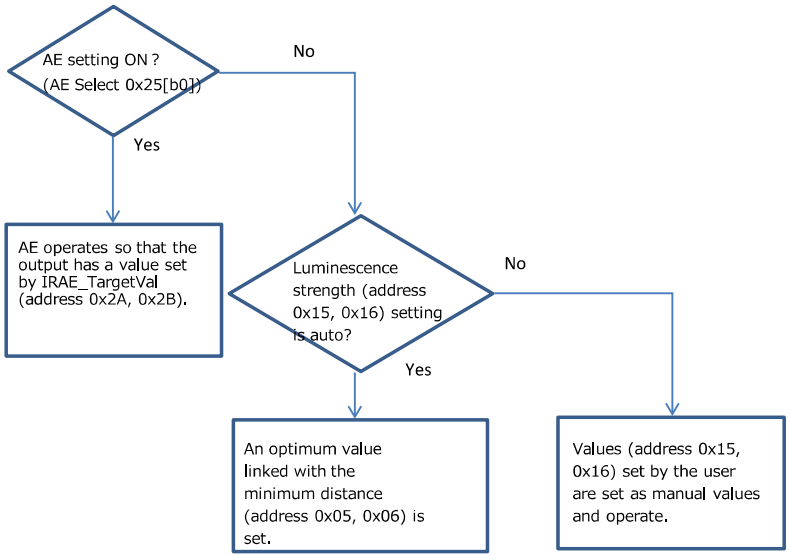
Please note that distance shorter than the minimum distance setting can not be used.
Please make a distance difference of 100 mm or more by setting the maximum distance and minimum distance.

(*3)　The distance value around the screen becomes farther from the center distance value.
For example, when imaging a plane, it curves as shown below.
Depth Coordinate Trans is a process to correct the distance difference between the center and the arround.



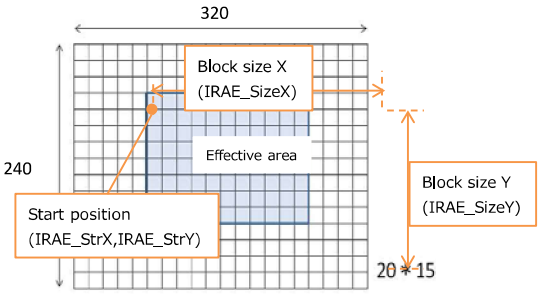
(*4)　When changing the register related to IR-AE, the setting operation is performed according to the following flow.

Flow of setting emission strength



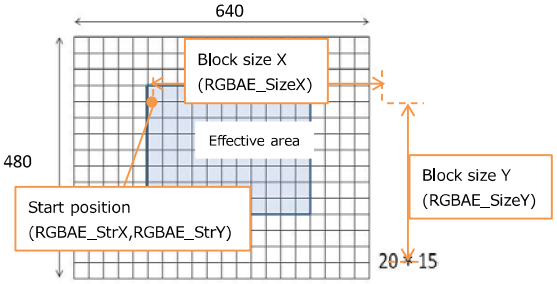
(*5)　About setting value of IR-AE

The effective area of the AE is divided into 20 x 15 (1 block 16 x 16) and the output image is divided into 20 x 15 (1 block 16 x 16),
and within the effective area determined by the start position (IRAE_StrX: 0x26, IRAE_StrY: 0x27)
and the block size (IRAE_SizeX: 0x28, IRAE_SizeY: 0x29) Blocks are used.
An average frame value is calculated for each block of the effective area,
and the maximum value among the average values is used as the IR acquisition value.
In the AE, the emission strength is automatically adjusted
so that the acquired value of IR becomes the target IR value (IRAE_TargetVal: 0x2A,0x2B) of IR-AE.
＊Calculation of IR is internally calculated with 12 bits. Therefore, IRAE_TargetVal: 0x2A, 0x2B should be set with 12 bits.



(*6)　About setting value of RGB-AE

The effective area of the AE is divided into 20 x 15 (1 block 32 x 32) and the output image is divided into 20 x 15 (1 block 32 x 32),
and within the effective area determined by the start position (RGBAE_StrX: 0x35, RGBAE_StrY: 0x36)
and the block size (RGBAE_SizeX: 0x37, RGBAE_SizeY: 0×38) Blocks are used.
An average frame value is calculated for each block of the effective area,
and the maximum value among the average values is used as the RGB acquisition value.
In the AE, the emission strength is automatically adjusted
so that the acquired value of RGB becomes the target RGB value (RGBAE_TargetVal: 0x39,0x3A) of RGB-AE.
＊To set the fixed exposure time, perform flicker countermeasure frequency setting (RGBAE_Frequency: 0x3B)
according to the environment to be used.
However, in the case of an environment that can not be fully adjusted by digital gain, processing is performed with shorter exposure time.



(*7)　About TOF method

Possible to choose 2 kinds of method shown as below.
① Accuracy prior mothod ： Detection accuracy is better relatively, but it's subject to maltipath.
② Distance range prior method ： Detection accuracy is not better relatively, but it's not subject to multipath so much.
Operation mode of each method is changed by setting detection distance range as below(Depth_Range_far - Depth_Range_near).

[mm]

Distance range / TOF method	Range1	Range2	Range3
Accuracy prior method	≦1000	1000< ≦2500	2500<
Distance range prior method	≦2600	2600< ≦5900	5900<

※Camera is set Accuracy prior method when it's delivery.
※Accuracy is going to be improved from range3＜range2＜range1.

(*8)　About function of stopping unused clock.

CLK is stopped (fixed as Lo) in invalid period of Syncronizing signal.

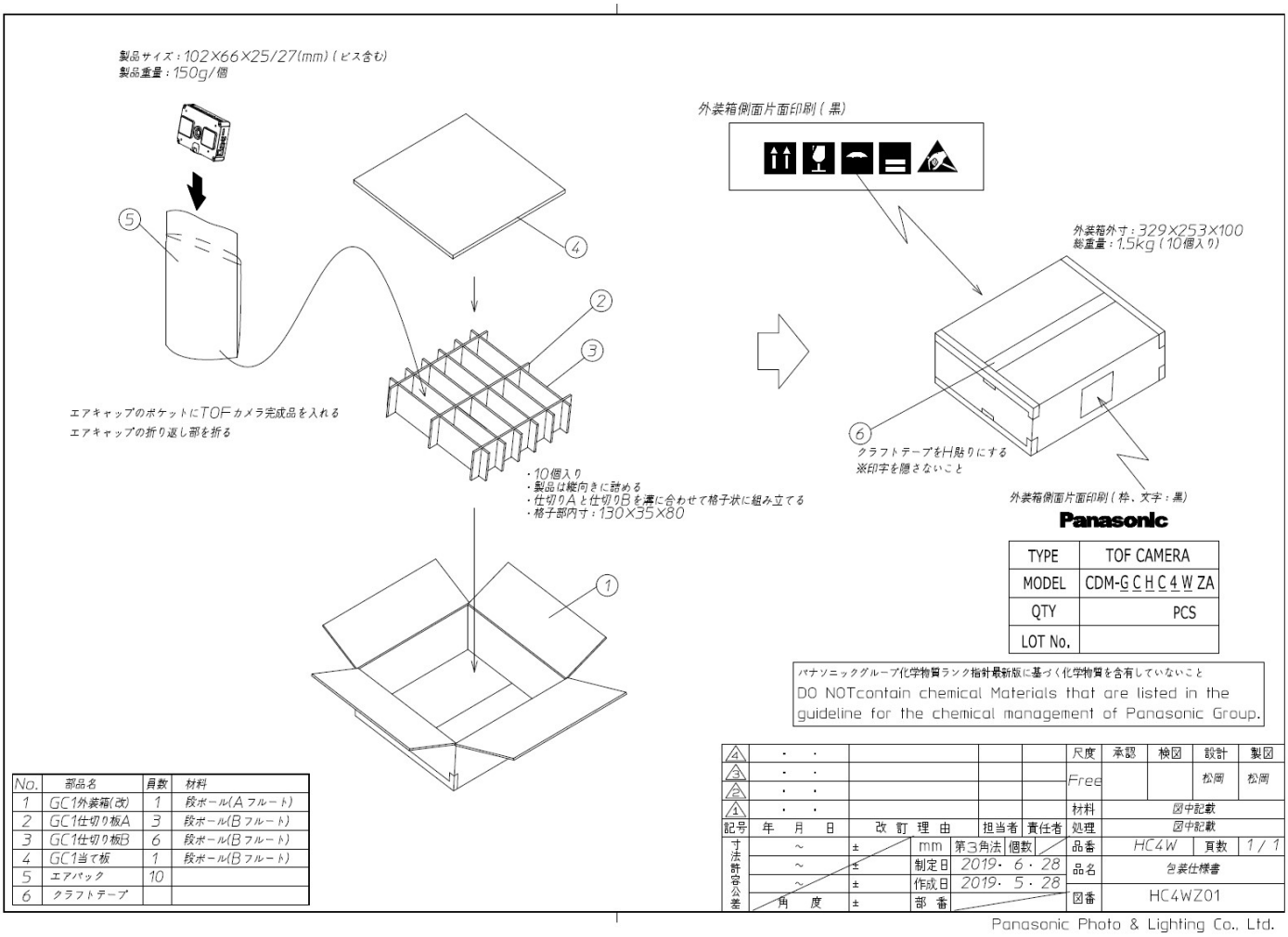
(*9)　When using WDR function, please stop AutoExposure Function.（address 0x25 =0）

5. others

5.1 Packing specification

・Min packing q'ty：10 pcs/box

・Outer carton size(External)：329×253×100mm



5.2 Lot number

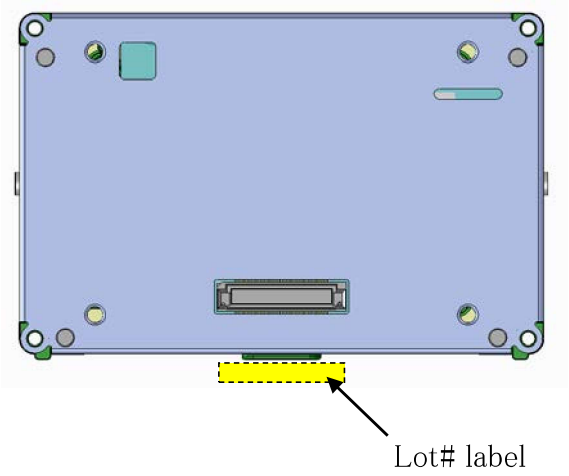
・The lot number is assigned in the following way

YYYYMMDD＊＊＊＊12

Indication	digit	Information
YYYYMMDD	8	Production YMD
＊＊＊＊	4	Ref#
12	2	Number for the model

・Display position

There will be a seal with the lot number attached at the bottom of the camera.



6. Cautions

6.1 Cautions for safty

・This product is meant for indoors. Please don't use at outside or in wet place.

・Please don't exceed the rated voltage range and and environmental conditions.

・Please pay attention not to enter dust, metallic things and water from an opening, since it will be a cause of trouble, electric shock and fire.

・Please use power supply which is suitable for the spec, and connect to camera correctly.

It will be in danger of fire and electric shock by trouble, overheating and smoke, if it connect to camera incorrectly.

・Please pay attention not to touch human body, since surface of camera bodyis to be high temperature.

・Please don't anlyze and modify this product. There is a possibility of causing laser exposure and the other unsafety trouble.

・Do not disassemble or modify this products. There is the danger of lasor exposure and other hazards.

6.2 Caution when using

6.2.1 Caution in principle

The sensor for distance image shooting is a sensor that measures the distance by reflection of near infrared rays. Please confirm the performance and reliability. Caution is generally necessary in the following cases:

① Strong reflection of the object
When receiving reflected light from a regularly reflecting object such as a mirror, the received light power becomes extremely strong, saturation of pixels happens and the measurement cannot be performed correctly.
In addition, errors may occur in distance measurement even at positions other than the object being measured.

② Strong ambient light
An error in distance measurement may occur when light with a near infrared wavelength component, e.g. sunlight, incandescent lamp, halogen light, heater, etc., is irradiated within the measurement area.
Furthermore, if the ambient light becomes strong, pixel saturation may occur, and normal measurement may not be possible.

③ Fast movement of the measured object
Miscalculation of the outline of the object can occur resulting in errors in the distance measurement.

④ Vicinity of floors, walls to the measured object
Multiple reflections e.g. light reflected by a wall, floor, etc. being reflected again by the object to be measured) may result in errors in measurement.

⑤ Other points to be aware of:

- There may be errors in the distance measurement depending on the distance and reflectance of the object to be measured and the position in the screen.
- Errors may occur in distance measurement immediately after starting up the product or when the

6.2.2 Handling of product

・Please don't touch and give pressureto the lens and protection panel by hand.

Optical property and metric property are affected by stain.

・Please pay attention not to make break at body, crack on circuit and open circuit by dropping

・Please don't remove the screw attached camera body. There is a possibility of malfunction.

・Please don't take any stress for power supply jack and connector.

・The condensation may occur inside the camera body, in case this prooducts will usein te sealed place. Please dry and remove humidity from this product,

6.2.3 Handling of static electricity

・There is a possibility of having damage on circuit and degradation in reliability caused by static electricity and surge voltage. Pleass refer to the following examples.

Removal of electric charge by wrist strap, electric conductive cloth, shows and floor.

Removal of electric charge by earthing on equipment and tools in work space.

Earthing of working tables and racks by using electric conductive material.

・Please take earthing for devices, tools, equipments and work space. And having countermeasure of Surge voltage is recommended.

・Pleqase refer to the following examples, if insulating materiallike glass and plastics are used for tools and Equipments.

To be conductive by conductive material

Privantion of static charge by humidify.

Neutralization of electric charge by static eliminator (Ionizor)

6.2.4 Cleaning

・Please remove stains by soft paper towel or wiper on protecti on the panel and lens.

・Please don't use chemicals. It caused crack, a change in color and in quality.

6.2.5 Strage

・Please keep under the environment that temperature and humidity is stable, and use the product within a year after delivery.

・Please pay attention to check atmosphere. It's in danger of prpperties degradation and a change in quality on the product surface.

6.3 Safety of Laser

・This product correspond to risk groupe "class 1" which is defined by「IECequipment in 60825-1、JIS-C-6802」(safty standard of laser products).

・It doesn't indicate laser explanation label on the product. Please put indication on the equipment which includes TOF camera according to「IEC60825-1、JIS-C-6802」.

・In case of handling and setting that is not according to specification, and damaged, it's in danger of injury on eyes.

6.4 EMI

・Noise level of thi product is as follows.

Please note that it's not applied to the following standards but just checking under environment in our

company.

・Correspond to VCCI class B

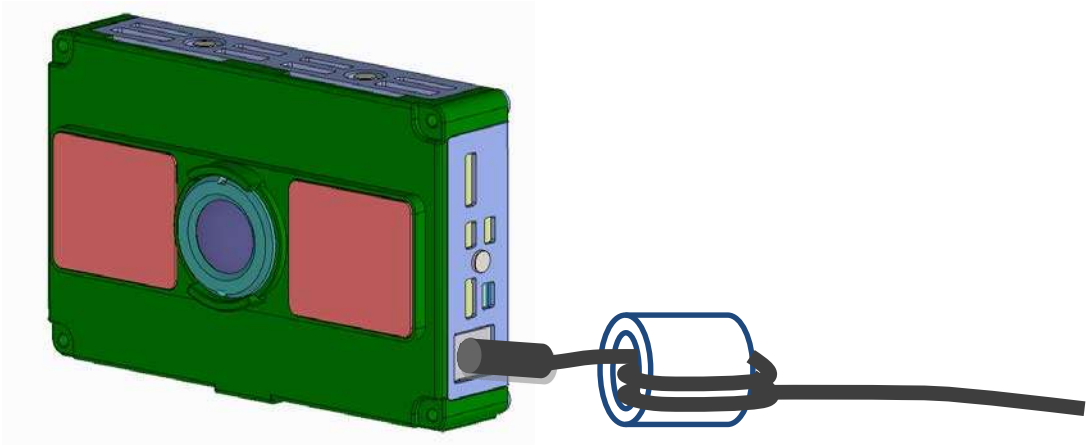
・Correspond to CISPR22 Class B

However, we use AC adaptor with ferrite core as follows when we check.

Ferrite core

・Part No.　　：　TDK　　HF70T31X13X19

・Winding number　：　More than 3 times



6.5 Special notes

・Please comply「Foreign Exchange and Foreigh Trade Act」and governmental and ministerial ordinance, and also some regulation of export control which is desided in United Nations Securuty Council. Then please make sure not to use and materiality (products, equipments, tools, parts etc…) and intangible (technology, how to, information, intellectual property right etc..) for military purpose、and also not to deal with hand over, rental, diversion and licensing.

・This document only shows caracteristics of product. Then it's not guarantee intellectual property right and another rght for us and for tird party, and also not license enforcement right.

・Please contact us in advance, if customer has an idea that failure and mulfunctioning may endanger human body and life.

・Please pay attention that the obtained image is not to be privacy invasion.

・Please contact to us if customer find out some failure.

・A gurantee of quality on this product is 1 year after purchasing, and a gurantee can cover items which are Indicated in this doument. We will repair or replace for product, if responsibility of fault is clearly on us. However, even though in guaranteed period, we don't have any responsibility for damegethat is caused by a natural disaster and a irrelevant use.

・Please don't take action of analysis and reverese engineering without our company's lisence.

・Please note and understand that specifications and appearanve will be changed without any notice.