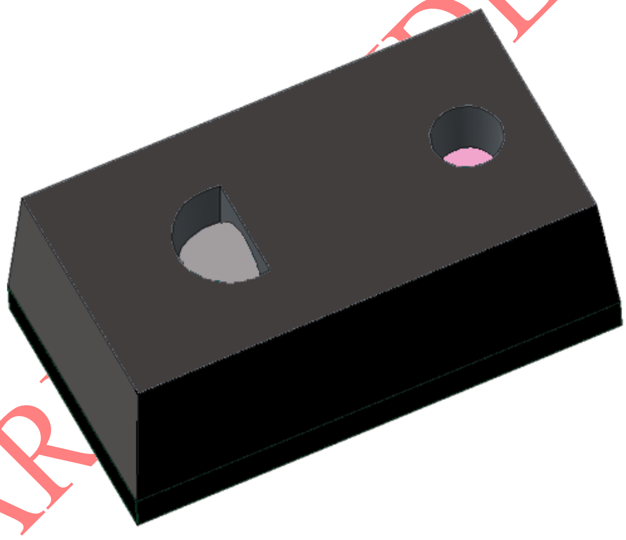
GP2AP03VT USER MANUAL

Time-of-Flight ranging Sensor



Contents

1. Abstract

GP2AP03VT is a ToF(Time of Flight) sensor that implemented a TDC(Time-to-Digital Conversion) circuit.

1.1. Features

- This product is composed of following two chips in one package, which is IC with a built-in single photon avalanche diode (SPAD) (Infrared photodiode by infrared light band pass filter) for range sensor, and infrared VCSEL.
- Maximum measurable distance:10cmMeasures absolute range from 2.5mm to above 10 cm (Measurement of 10 cm or more depends on the object to be detected)
- This sensor adopts TDC circuit system. The crosstalk characteristic from cover glass is good.
- This sensor automatically performs crosstalk calibration. The crosstalk characteristic is good when stains such as fingerprints and face oils are attached.
- I2C bus interface

This product has 7bit slave address adherence to I2C bus interface and can change register value for each function via I2C bus. This product can communicate at 1 MHz.

- This sensor has a function to reduce the influence of disturbance light.

1.2. Application

Proximity sensor, face detect, camera AF, robot, home appliances, toilet facility, personel computer

2. I^{2}C interface

2.1. I2C bus interface

Table 1 shows the description of the SDA and SCL terminals.

Table 1 SDA and SCL terminals.

Name	Description
SCL	Clock
SDA	Data bus

- Basic data format are as follows.

		SLAVE									DATA									DATA									
	START	MSB						LSB	R/W	ACK									ACK	MSB							LSB	ACK	STOP
SDA		A6	A5	A4	A3	A2	A1	A0			D7	D6	D5	D4	D3	D2	D1	D0		D7	D6	D5	D4	D3	D2	D1	D0		

DATA: Data which write into internal register/read from internal register.

Fig.1 I^{2}C Basic data format

- SLAVE ADDRESS : 0x29

Table 2 I^{2}C slave address

ADDRESS	A6	A5	A4	A3	A2	A1	A0	R/W
	0	1	0	1	0	0	1	X

2.2. Write format

Write value in register and enable to write the next address sequentially after writing data. Data writing will be end with inputting stop-condition.

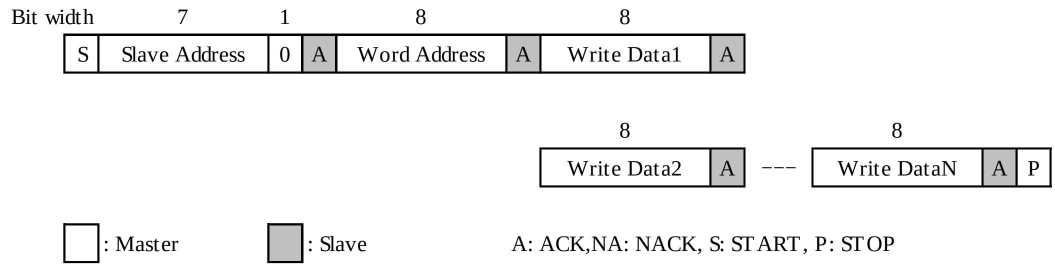


Fig.2 I2C write format

2.3. Read format

Enable to read data in register. Following address can be read sequentially by inputting ACK after reading data. Reading data will be stopped by inputting NACK.Stop-condition after setting Word address can be deleted since it corresponds to repeat-start-condition. Reading read data is done by not opening I2C bus interface.

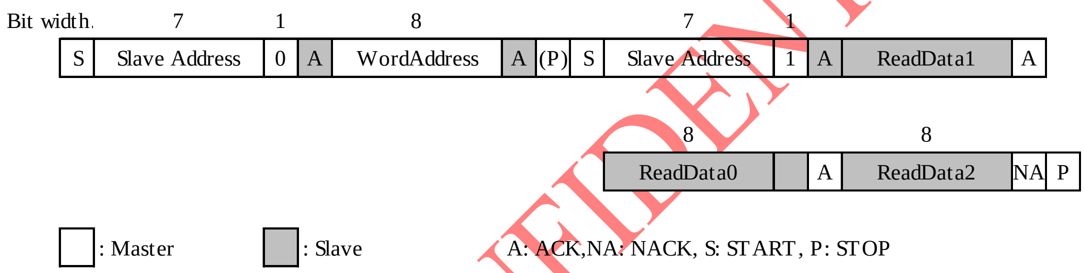


Fig.3 I2C read format

2.4. Others and Notes

This product doesn't support Clock-stretch function and General-call-address function.

3. Operation

3.1. Summary

Figure 4 shows the operation flow of the GP2AP03VT sensor.
(1) When a power supply voltage is applied to the sensor, the power-on reset circuit inside the IC circuit operates to initialize the sensor and enter the shutdown state.
(2) By executing the initialization function via I2C, set the value in the register of the sensor. Execute the initialization function with the GPIO pin voltage set to 0 voltage. The GPIO pin is pulled down internally, so it is in the 0 V state in the open state.
(3) Measurement is started by executing the measurement start function, and automatically returns to the shutdown state when the measurement is completed.
(4) The host can read the measurement result via i2c and calculate the distance value by carrying out calculation processing. Approximately 6 msec of data reading time is required at I2C communication speed 400 kHz.
(5) To continue measurement, execute the measurement start function again.

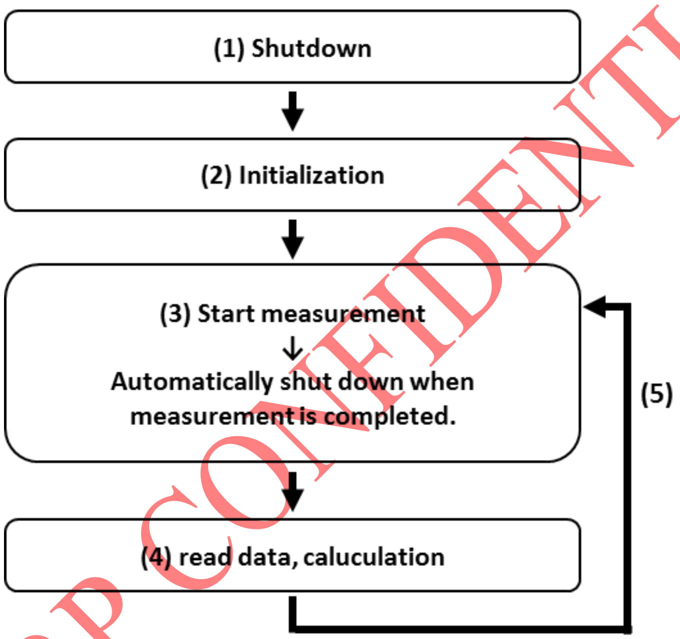


Fig.4 Operational flow

3.2. Measurement time

The time taken to acquire the distance value when I2C communication speed is 400 kHz is as follows.
Measurement time + data acquisition time (6 msec) within 33.3 msec

3.3. Distance

The distance value can be obtained by reading the measured value via i2c and calculating it. The distance value is output in mm for the sample code range1.
Status information is output to range1_status. An accurate distance value is output only when range1_status is 0x00. However, there is no distance accuracy that is shorter than 20 mm. The meaning of range1_status is shown in Table 3.

Table 3 Error status

Error Code	Error Status	Description
0x00	VALID_DATA	Valid data.
0x01	VCSEL_SHORT	When the VCSEL is short-circuited. If this error occurs, the VCSEL current will not flow inside the IC.
0x02	LOW_SIGNAL	The amount of reflected light obtained from the detected object is small
0x04	LOW_SN	The ratio of reflected light from the detected object and disturbance light is small.
0x08	TOO_MUCH_AMB	Disturbance light is large.
0x10	WAF	Wrap around error.
0x20	CAL_ERROR	Internal calculation error.
0x80	CROSSTALK_ERROR	Crosstalk from the panel is large.

3.4. Average consumption currnet

Table 4 shows the sum of the current values of VDD and VCSEL. The emission duty of the VCSEL is about 10%.

Table 4 Average consumption current

VDD=VDDV=3.3V	9.5mA

It represents a typical value.

4. Calibration at user factory

This sensor usually uses a cover glass mounted in front of the sensor. The distance value will be affected by the reflection from the cover panel. It is necessary to compensate for its influence at the user's factory. Figure 5 shows the calibration flow. There are two kinds of calibration. Please carry out in the order of Figure 5. It is necessary to save the calibration result in the nonvolatile memory of the user. For detailed calibration method please refer to Software manual.

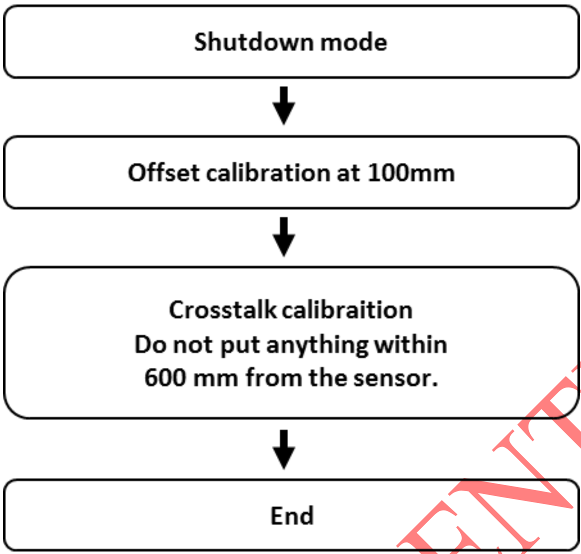


Fig.5 Calibration flow

4.1. Offset calibration

Figure 6 shows concept image of offset calibration at user's factory. The offset calibration of range minimizes the influence of a cover glass over a sensor and the output of range is able to be close to actual range to a target object. The calibration is done just once by user at factory.

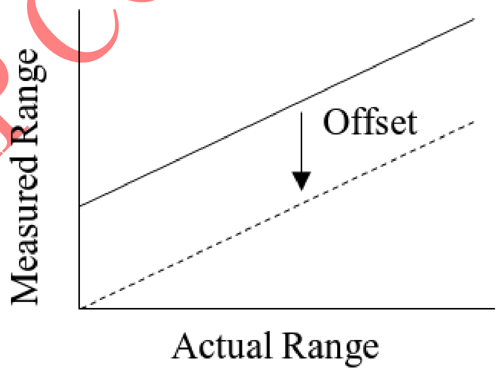


Fig.6 Offset calibration

4.2. Crosstalk calibration

This sensor adopts the TDC method, and it creates a histogram inside the IC and calculates the distance value from the histogram. Figure 7 shows the histogram when there is no cover glass. A histogram of only the detected objects is created. Figure 8 shows the histogram when cover glass is installed. A histogram of cover glass will be created next to the detected object. In this case, the cover glass overlaps the histogram of the detected object, and the sensor can not calculate the correct distance value. Therefore, it is necessary to perform crosstalk calibration for each terminal at customer's factory.

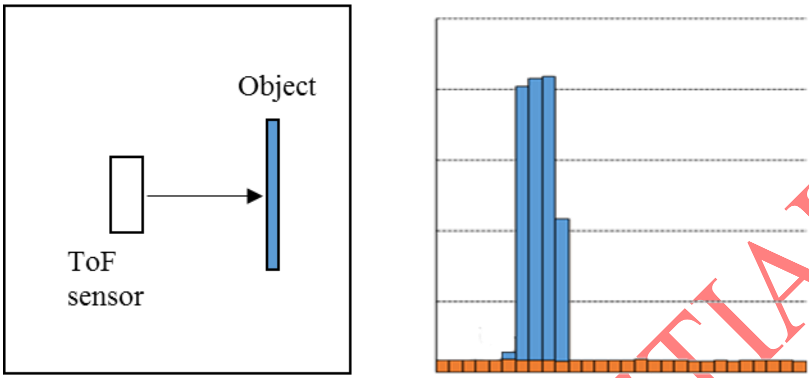


Fig.7 Histgram without cover glass

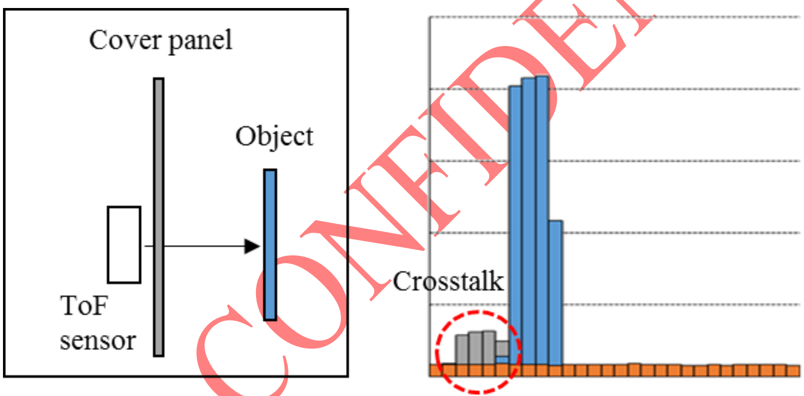


Fig.8 Histgram with cover glass

Figure 9 shows the distance characteristics before and after crosstalk calibration.

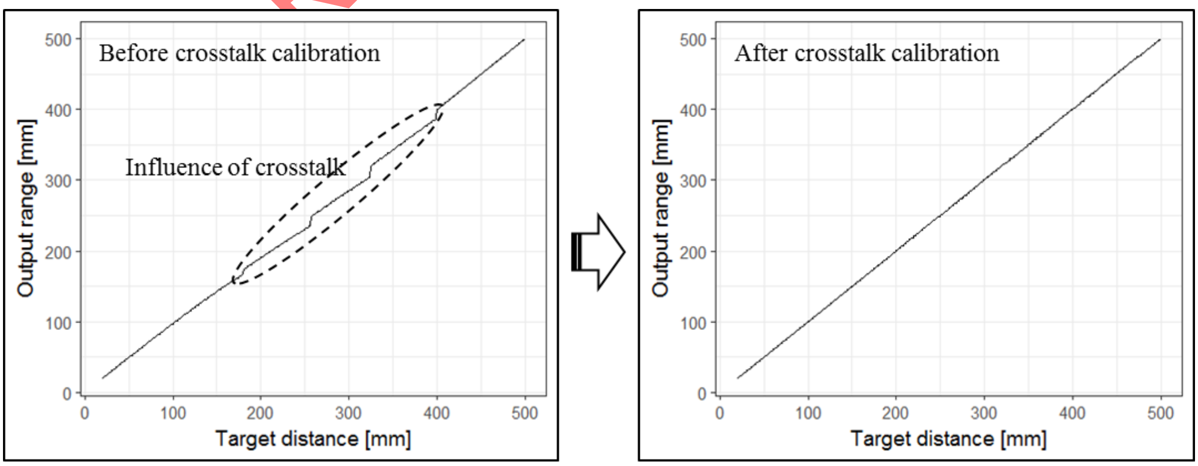


Fig.9 Crosstalk calibration

5. Functional description

5.1. Register map

Table 5 shows the register map.

Table 5 Register map

Address	NAME	BIT								Initial value
		7	6	5	4	3	2	1	0	
00h	COMMAND00H	OP3	-							0x00
01h	COMMAND01H	RESERVED						FLAG	FUSE	0x00
02h	COMMAND02H	0	0	PIN3	1	0	1	0	RST	0x00
04h	COMMAND04H	-				IDRV[3:0]				0x00
05h-0Eh	-	RESERVED								0x00
0Fh	OFFSET1	OFFSET CALIBRATION DATA1[7:0]								0x00
10h	OFFSET2	OFFSET CALIBRATION DATA2[7:0]								0x00
11h-15h	-	RESERVED								0x00
16h 17h	CROSSTALK	CROSSTALK CALIBRATION DATA[13:0]								0x00
18h-2Ah	-	RESERVED								0x00
2Bh	MEASUREMENT TIME	-						CONV[1:0]		0x00
32h-40h	-	RESERVED								0x00
41h	DEVICE ID	0	0	1	0	1	1	1	1	0x00
42h-54h	-	RESERVED								0x00

5.2. Registar setting

Table 6 shows recommended register setting values. Since register setting values are dynamically controlled according to sensor operating conditions, be sure to use the function of sample code.

Table 6 Register setting

Address	Setting value		Address	Setting value	
00h *1	0x80	R/W	41h	0x2F	R
01h	0x00	R/W	43h	0xC0	R/W
02h	0x34	R/W	44h	0x00	R/W
03h	0x00	R/W	45h	0x04	R/W
04h	0x07	R/W	46h	0x00	R/W
05h	0x0C	R/W	47h	0x20	R/W
06h	0x67	R/W	48h	0x00	R/W
07h	0xDF	R/W	49h	0x00	R/W
0Dh	0x82	R/W	4Ah	-	R
0Eh	0x02	R/W	4Bh	-	R
0Fh *2	offset1	R/W	4Ch	0x00	R/W
10h *2	offset2	R/W	4Dh	0x06	R/W
11h	0x98	R/W	4Eh	0x2B	R/W
12h	0x00	R/W	50h	Trimming value at Sharp' factory	R
13h	0x15	R/W	51h		R
14h	0x64	R/W	52h		R
15h	0x01	R/W	53h		R
16h *3	Depends on crosstalk from the panel	R/W			
17h *3	Depends on crosstalk from the panel				
18h	Depends on crosstalk from the panel	R			
19h	Depends on crosstalk from the panel				
1Ah	0x75	R/W			
1Bh	0x57	R/W			
1Ch	0x75	R/W			
1Dh	0x57	R/W			
1Eh	0xF4	R/W			
1Fh	0xF7	R/W			
28h	0x84	R/W			
29h	0x00	R/W			
2Ah	0x0B	R/W			
2Bh	0x03	R/W			
2Eh	-	R			
38h	-	R/W			
39h	-	R			
3Ah	-				
3Bh	-	R/W			
3Ch	-	R/W			
3Dh	-	R			

*1 Measurement starts when 0x80 is written.

*2 Offset value at user factory.

*3 Be sure to write the register using the function of the sample code.

5.3. Register functions

5.3.1. Operating mode

Note: Set 00h register after setting other registers.

Table 7 Register 00h operation mode setting

Address	NAME	7	6	5	4	3	2	1	0
00h	COMMAND00H	OP3	-						

The OP3 register sets measurement start and stop. When the measurement is completed, the OP3 register automatically returns to 0.

Table 8 Operation setting

OP3	Setting
0	Shutdown mode
1	Start measurement

5.3.2. INT terminal

This sensor can set the output signal of the INT terminal by setting the PIN3, PIN1, PIN0 registers. The interrupt type can be set with the INTTYPE register.

Table 9 Register 02h int terminal setting

Address	NAME	7	6	5	4	3	2	1	0
02h	COMMAND02H	0	0	**PIN3**	1	0	1	0	RST

- **Output of INT terminal**

The PIN3 register sets whether or not to output an interrupt signal to the INT terminal.

Table 10 INT terminal enable setting

PIN3	Setting
0	Don't output interrupt signal
1	Output interrupt signal

5.3.3. VCSEL drive current

Enable to select VCSEL drive peak current by setting IDRV[3:0] register (Address 04H).

Table 11 Register 04h VCSEL current setting

Address	NAME	7	6	5	4	3	2	1	0
04h	COMMAND04H	0				IDRV[3:0]			

Table 12 VCSEL current setting

IDRV	Vcsel curmet [mA]
0x07	31

5.3.4. Measurement time

The measurement time can be set with the following register. The total measurement time is the sum of Measurement time and Interval time.

Table 13 Register 2Bh measurement time

Address	NAME	7	6	5	4	3	2	1	0
2Bh	MEASUREMENT TIME	-						CONV[1:0]	

The CONV register sets 0x03.

Table 14 Mteasument time setting

CONV[1:0]	Measuerment time [msec]
0x03	24.4

5.3.5. Software reset

Initialize all registers by writing 1 in RST register. RST register is also initialized automatically and becomes 0.

Table 15 Register 02h software reset

Address	NAME	7	6	5	4	3	2	1	0
02h	COMMAND02H	0	0	PIN3	1	0	1	0	**RST**

5.3.6. Device ID

Device ID: 0x2F

Table 16 Register 41h Device ID

Address	NAME	7	6	5	4	3	2	1	0
41h	DEVICE ID	0	0	1	0	1	1	1	1

6. Power on/off sequence

The following figure 10 shows configuration sequence at Power-On and Power-Off

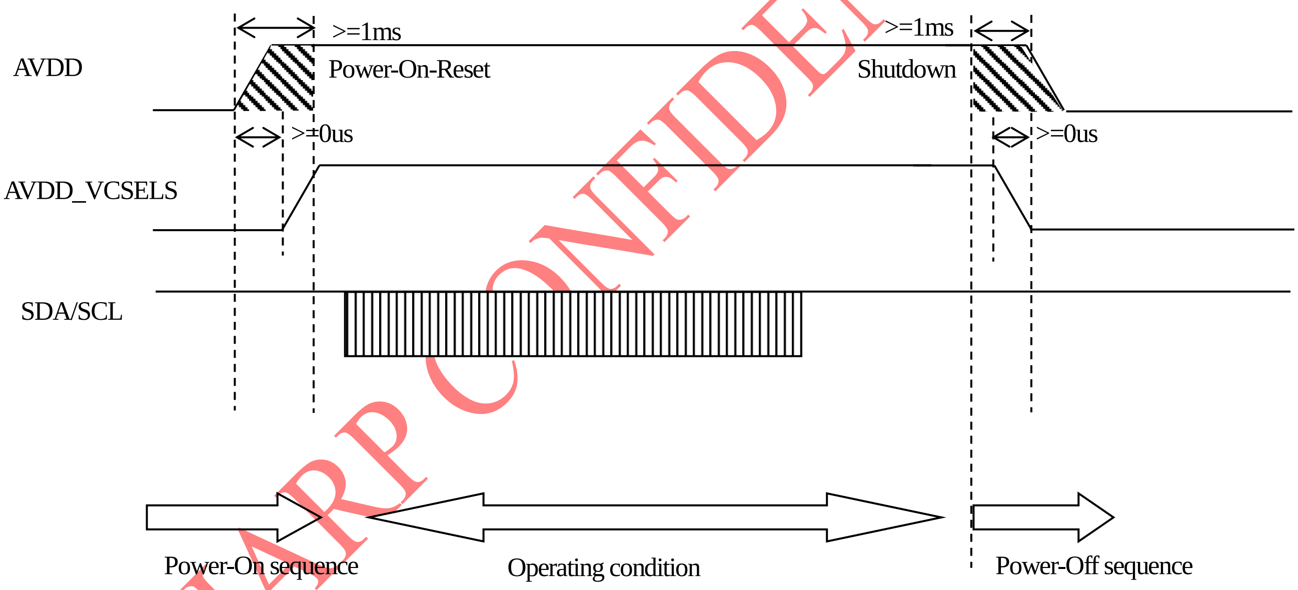


Fig.10 Power on/off sequence

7. Optical / mechanical design

7.1. FOV

Figure 11 shows the directional angle characteristics of the sensor.

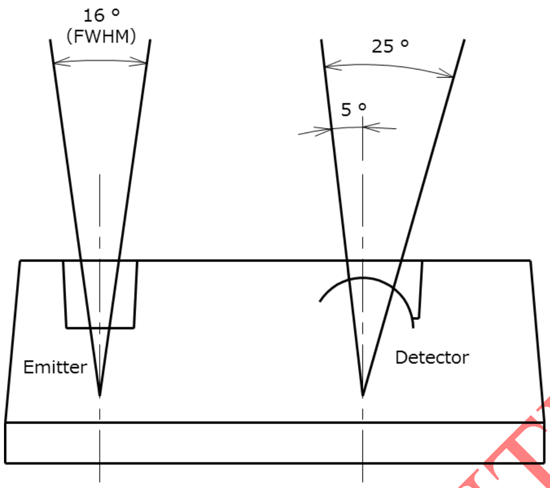


Fig.11

7.2. Recommended panel design rule

The recommended optical design is shown in Figure 12.

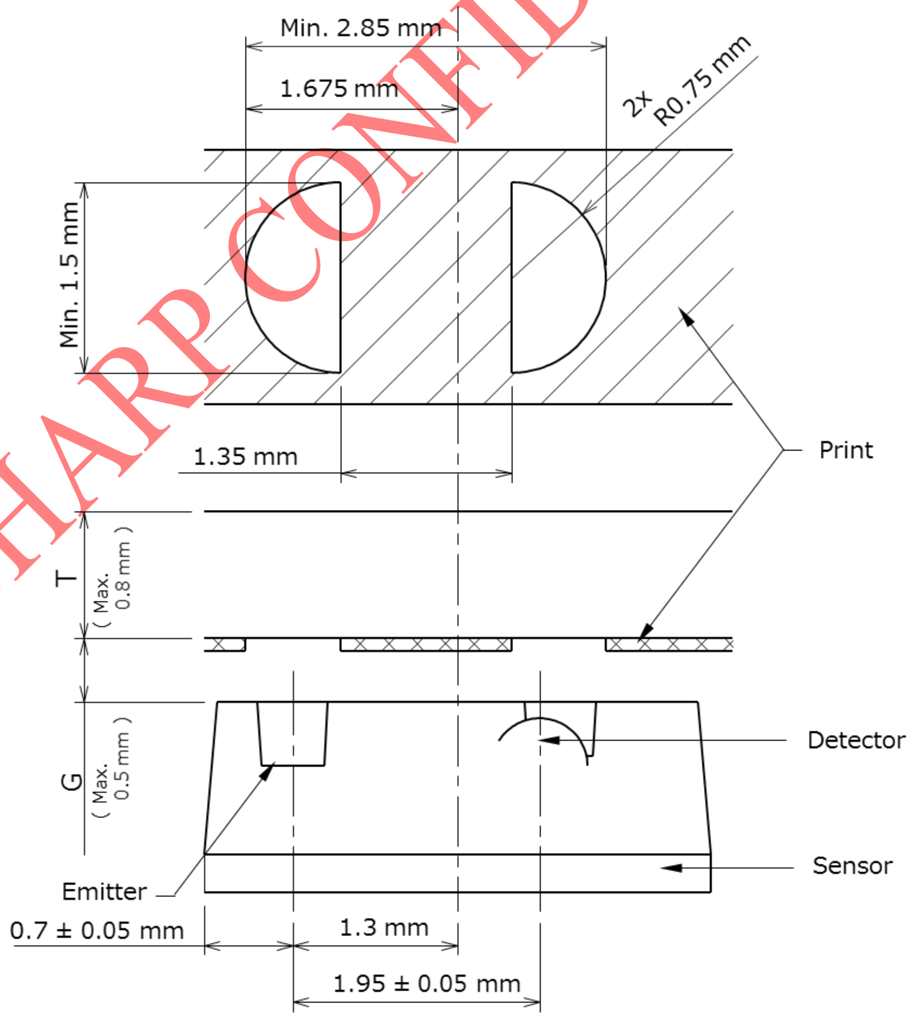


Fig.12 Optical design

8. Software

The following software is prepared. Please check the development kit.

- Windows evaluation application
- Source code for MCU

Please see the software manual for software implementation in your application.

9. Support

Please contact an agent/reseller from who you purchased this product
or contact our sales company in each region from the following URL.
http://www.sharp-world.com/products/device/support/call/index.html

10. Revision history

4/15/19	First edition