GestureR User Manual

June 5, 2014

Table of Contents

Figures

Tables

1. INTRODUCTION

GestureR is a single tiny module that includes Gesture Sensing, Proximity Sensing, and Ambient Light Sensing. This document introduces different variants of GestureR. It also describes the Arduino functions for the sample codes included, as well as operations to use the sensor directly with I2C.

2. VARIANTS OF GESTURER

2.1. GestureR SHIELD

- Size around 54 x 53 mm
- Pin Assignment is compatible with Arduino UNO.
- 1 Bright RGB LED and 12 Purple LEDs for you to use and demonstrate easily.
- 1 2-channel DIP Switch to use for mode changing or anything you want.
- 2 Bus Switches that can cut off the connections of LEDs on the GestureR when you use the I/O pin to do something else.

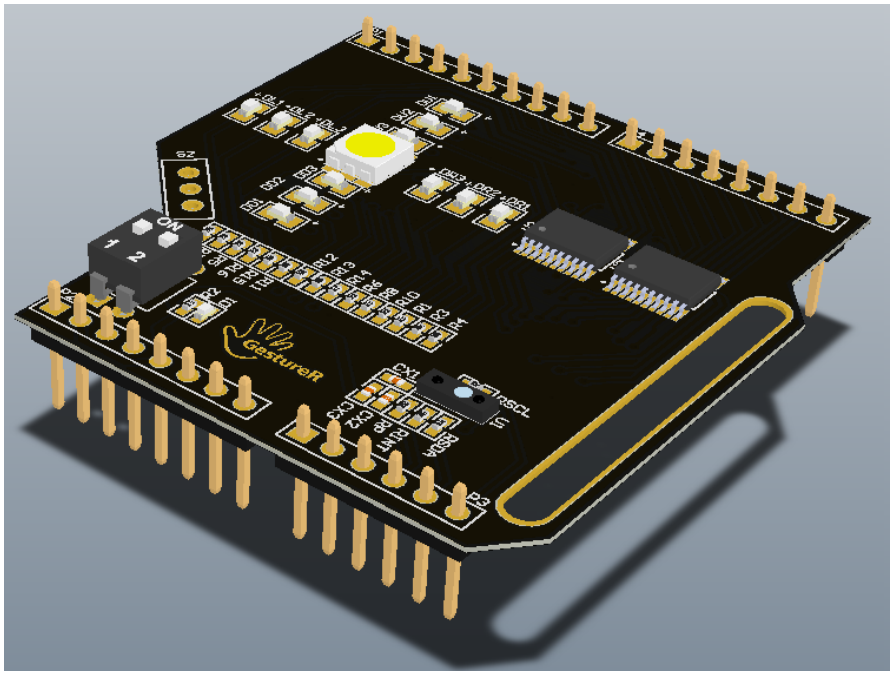

Figure 1. GestureR SHIELD

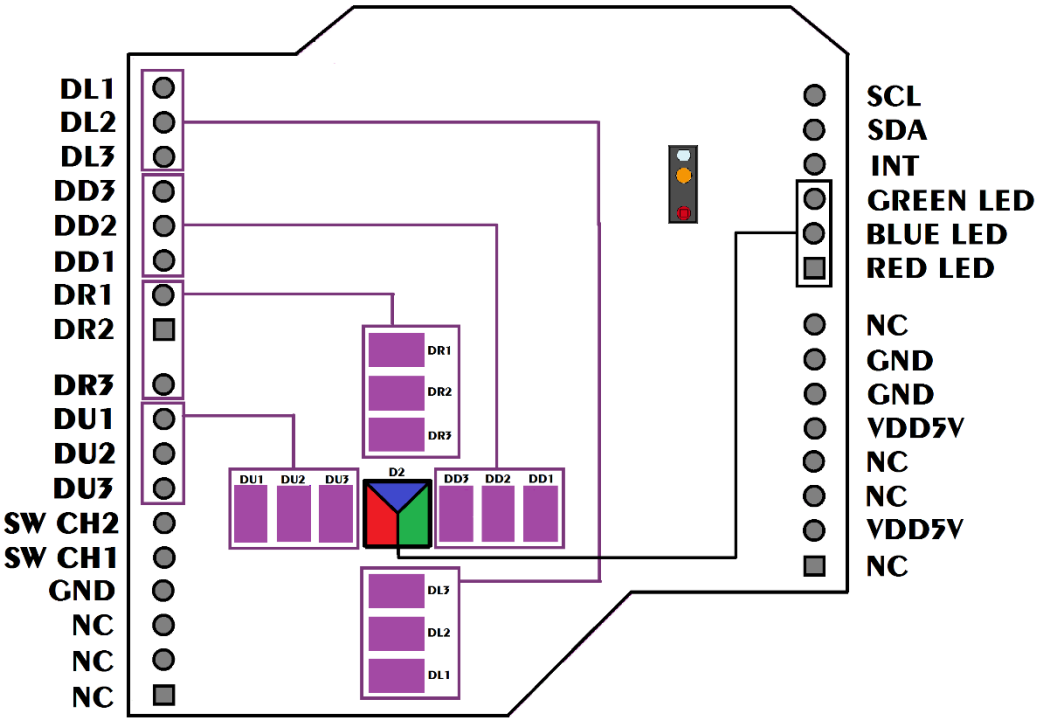

Figure 2. Pin Configurations of GestureR SHIELD

2.2. GestureR SHIELD ULTRA

- Pin Configuration also compatible to Arduino Leonardo
- SPDT mechanical switch and the bus switches on GestureR SHIELD are upgraded and replaced by PCA9685, an I2C PWM LED Driver.
- Free up the I/O on Arduino host originally connected to the LEDs.
- Allow you to make use of the LEDs on GestureR SHIELD ULTRA as well as the I/O on Arduino host at the same time.
- Other features will remain the same as the original GestureR SHIELD.

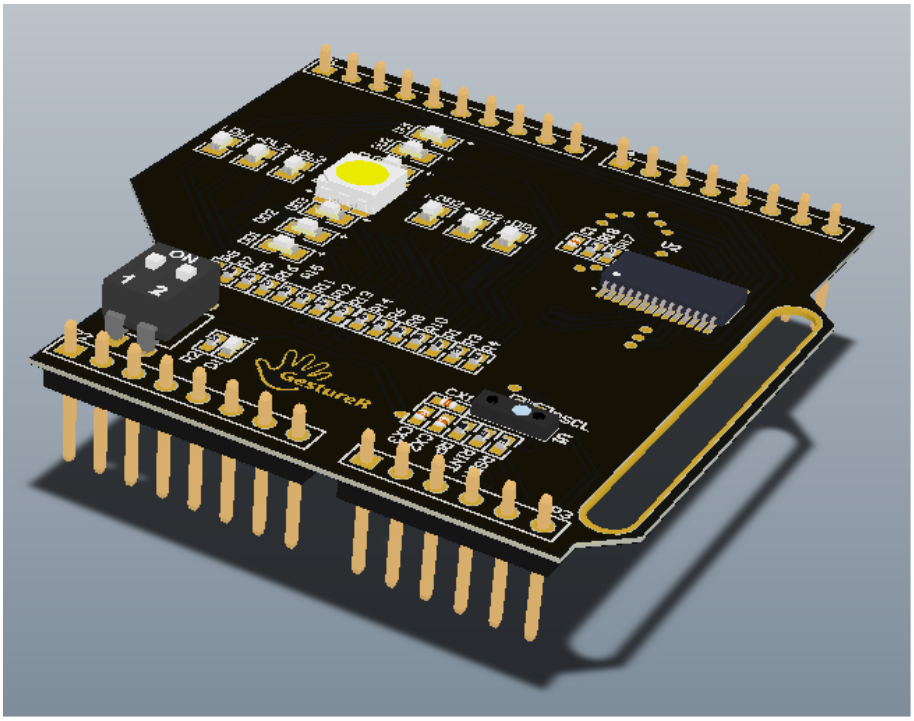

Figure 3. GestureR SHIELD ULTRA

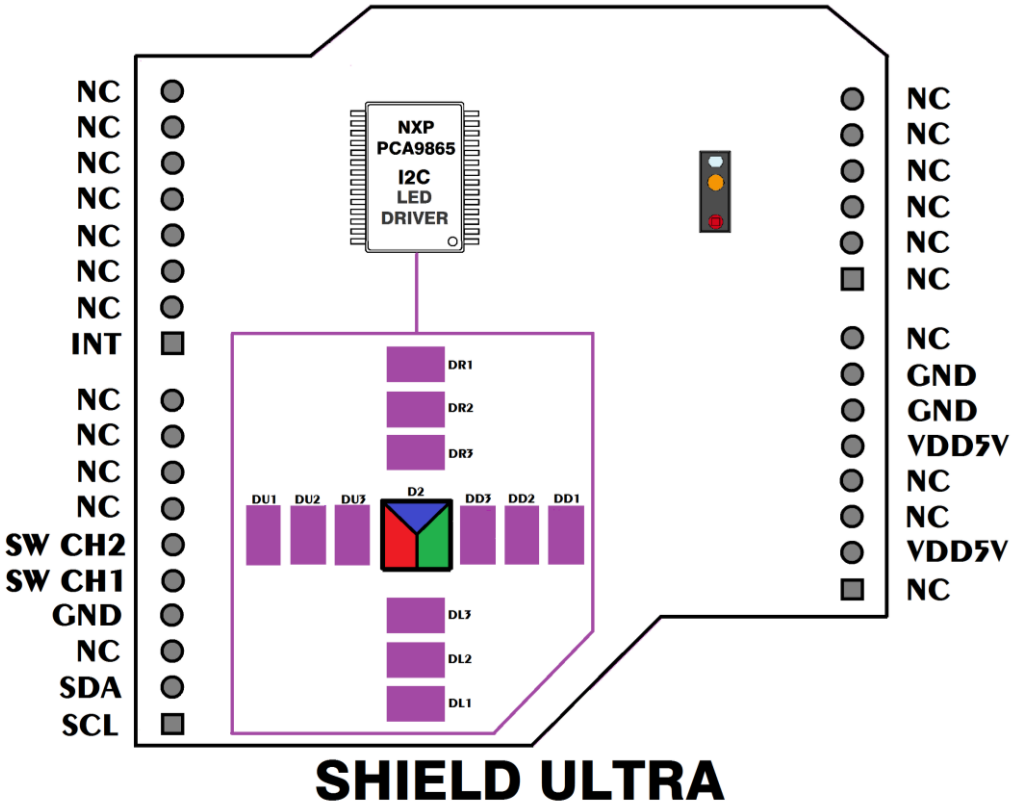

Figure 4. Pin Configurations of GestureR SHIELD ULTRA

2.3. GestureR BREAD

- Size around 21 x 11mm
- Pins pitch in DIP format.
- Compatible with breadboards.
- 1 Bright RGB LED for you to use.

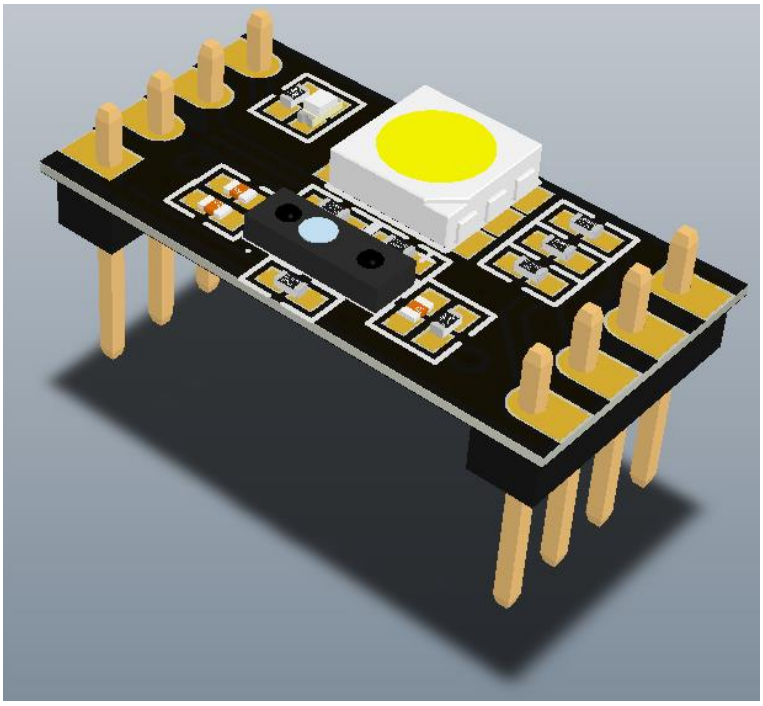

Figure 5. GestureR BREAD

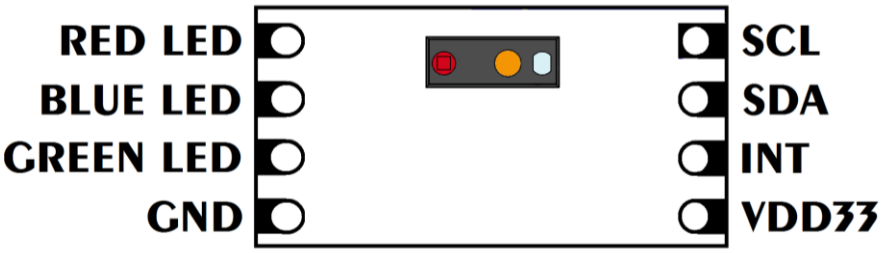

Figure 6. Pin Configurations of GestureR BREAD

2.4. GestureR TINY

- Size around 11 x 11mm
- Ultimately small size and thin.
- Best for making your own tiny DIY devices

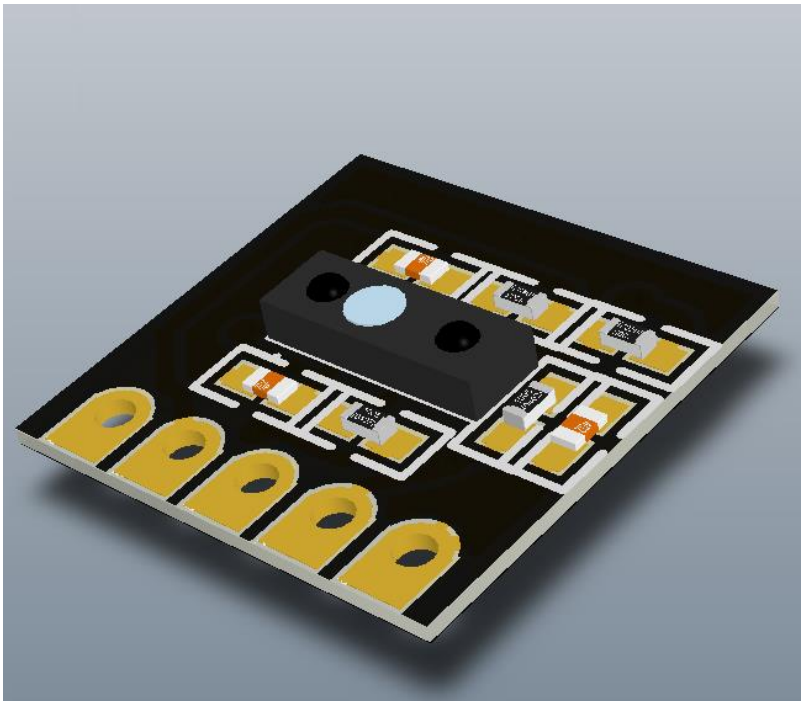

Figure 7. GestureR TINY

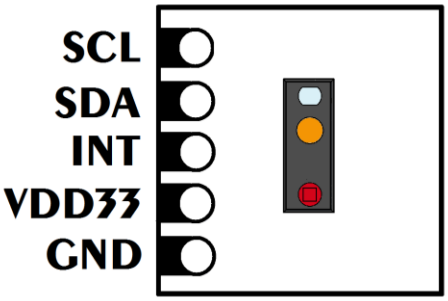

Figure 8. Pin Configuration of GestureR TINY

3. ARDUINO SAMPLE FUNCTIONS

There are sample codes for each model of GestureR. Please refer to readme.txt attached in GestureR_Sample_Code.zip. You can also find the descriptions of functions in the comments within the codes.

4. USING SENSOR DIRECTLY WITH I2C

The sensor is composed of following three chips in one package, which is IC1 with the four built-in PD(photodiode) for Gesture sensors and proximity sensors, IC2 with a built-in PD(clear and infrared photodiode) for ambient light sensors(ALS), and infrared LED.

The sensor has 7bit slave address adherence to I2C bus interface and can change register value for each function via I2C bus. Besides, judgment result for detection/non-detection status can be read via I2C bus.

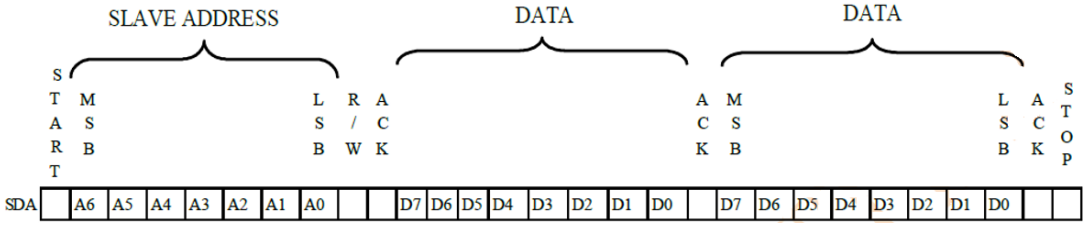

Figure 9. I2C Basic Data Format

4.1. Gesture and Proximity Sensing (GS) Part

4.1.1.I2C Slave Address for GS

SLAVE ADDRESS:

ADDR terminal setting	A6	A5	A4	A3	A2	A1	A0	R/W
Slave address	1	0	0	0	1	0	1	X

R/W：Read:X=1, Write:X=0

Table 1. I2C Slave Address for Gesture and Proximity Sensing

4.1.1.1. 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.

WordAddress: 00H　PROX, FLAG register in 00H are read only.

WordAddress:10H～19H　D0[13:0], D1[13:0], D2[13:0] ,D3[13:0] and D4[15:0] registers from 10H to 19H are read only.

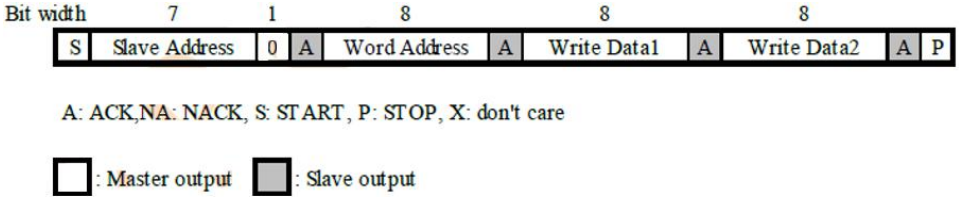

Figure 10. GS I2C Write Format

4.1.1.2. 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.

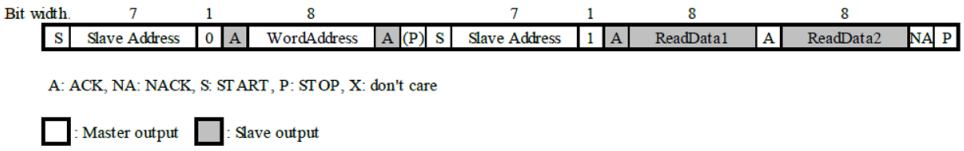

Figure 11. GS I2C Read Format

4.1.2.Basic Operation for Gesture Sensor and Proximity Sensor Mode

The device can detect proximity objects by which integrates incident light in IR(infrared) photodiode during the time without emission of LED (LED off) and the time with emission of LED (LED on) in order to eliminate the influence of ambient light. The way of detection is as follows:

[1]In LED on/off period, this device store a signal charge which is subtracted LEDoff period charge from LEDon period charge automatically. (Recommend setting for SUM[2:0] is 16times of LED pulses.)

[2]In Count period, this device convert from a signal charge to digital value. (Recommend setting for RES[1:0] is 14bit resolution.)

[3]Then, obtain detection result by subtracting the influence of ambient light. By using this value, proximity sensing judgment is done if reflective object is there or not.

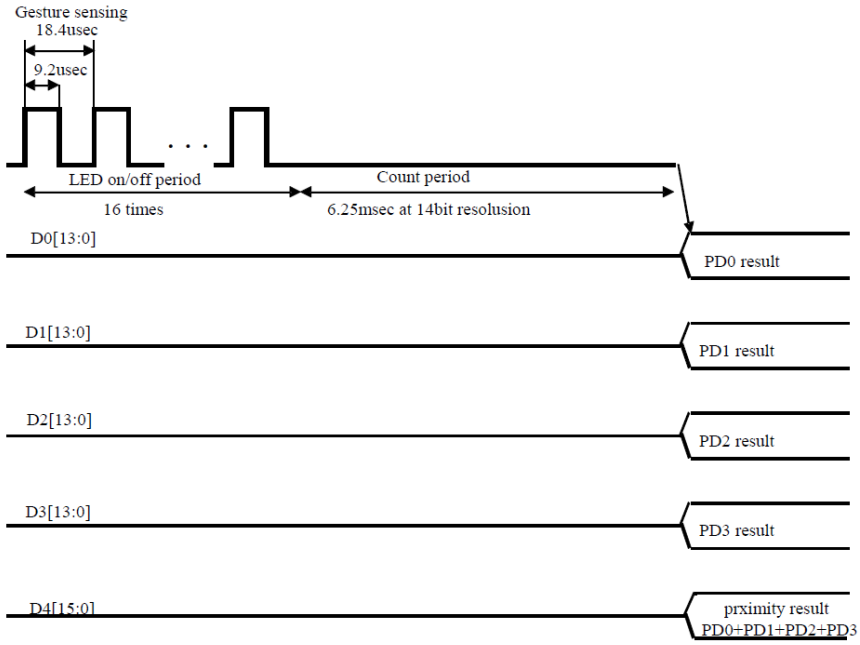

Figure 12. Output Results for GS Mode

4.1.3.Register Mapping

ADDRESS	REG NAME	DATA								Initial
		D7	D6	D5	D4	D3	D2	D1	D0	Value
00H	COMMAND I	OP3	OP2							H'00
						PROX	FLAG			
01H	COMMAND II	INTVAL1	INTVAL0	INTSEL2	INTSEL1	INTSEL0	PIN	INTTYPE	RST	H'00
02H	PS I	PRST2	PRST1	PRST0	RES1	RES0	RANGE2	RANGE1	RANGE0	H'00
03H	PS II	IS2	IS1	IS0	SUM2	SUM1	SUM0	PULSE1	PULSE0	H'00
04H	INT_LT_LSB	TL7	TL6	TL5	TL4	TL3	TL2	TL1	TL0	H'00
05H	INT_LT_MSB	TL15	TL14	TL13	TL12	TL11	TL10	TL9	TL8	H'00
06H	INT_HT_LSB	TH7	TH6	TH5	TH4	TH3	TH2	TH1	TH0	H'FF
07H	INT_HT_MSB	TH15	TH14	TH13	TH12	TH11	TH10	TH9	TH8	H'FF
08H	OS_DATA0_MSB	OS_D0_7	OS_D0_6	OS_D0_5	OS_D0_4	OS_D0_3	OS_D0_2	OS_D0_1	OS_D0_0	H'00
09H	OS_DATA0_MSB			OS_D0_13	OS_D0_12	OS_D0_11	OS_D0_10	OS_D0_9	OS_D0_8	H'00
0AH	OS_DATA1_MSB	OS_D1_7	OS_D1_6	OS_D1_5	OS_D1_4	OS_D1_3	OS_D1_2	OS_D1_1	OS_D1_0	H'00
0BH	OS_DATA1_MSB			OS_D1_13	OS_D1_12	OS_D1_11	OS_D1_10	OS_D1_9	OS_D1_8	H'00
0CH	OS_DATA2_MSB	OS_D2_7	OS_D2_6	OS_D2_5	OS_D2_4	OS_D2_3	OS_D2_2	OS_D2_1	OS_D2_0	H'00
0DH	OS_DATA2_MSB			OS_D2_13	OS_D2_12	OS_D2_11	OS_D2_10	OS_D2_9	OS_D2_8	H'00
0EH	OS_DATA3_MSB	OS_D3_7	OS_D3_6	OS_D3_5	OS_D3_4	OS_D3_3	OS_D3_2	OS_D3_1	OS_D3_0	H'00
0FH	OS_DATA3_MSB			OS_D3_13	OS_D3_12	OS_D3_11	OS_D3_10	OS_D3_9	OS_D3_8	H'00
10H	DATA0 LSB	D0_7	D0_6	D0_5	D0_4	D0_3	D0_2	D0_1	D0_0	H'00
11H	DATA0 MSB	SAT0		D0_13	D0_12	D0_11	D0_10	D0_9	D0_8	H'00
12H	DATA1 LSB	D1_7	D1_6	D1_5	D1_4	D1_3	D1_2	D1_1	D1_0	H'00
13H	DATA1 MSB	SAT1		D1_13	D1_12	D1_11	D1_10	D1_9	D1_8	H'00
14H	DATA2 LSB	D2_7	D2_6	D2_5	D2_4	D2_3	D2_2	D2_1	D2_0	H'00
15H	DATA2 MSB	SAT2		D2_13	D2_12	D2_11	D2_10	D2_9	D2_8	H'00
16H	DATA3 LSB	D3_7	D3_6	D3_5	D3_4	D3_3	D3_2	D3_1	D3_0	H'00
17H	DATA3 MSB	SAT3		D3_13	D3_12	D3_11	D3_10	D3_9	D3_8	H'00
18H	DATA4 LSB	D4_7	D4_6	D4_5	D4_4	D4_3	D4_2	D4_1	D4_0	H'00
19H	DATA4 MSB	D4_15	D4_14	D4_13	D4_12	D4_11	D4_10	D4_9	D4_8	H'00

Table 2. Register Mapping for GS

- Please start setting registers after power-supply voltage becomes stable up to 90% or more set value. Please wait for some 1msec before setting registers from power-on.

- PROX, FLAG registers are able to be cleared by writing 0 data in each register. (but these registers can't be written 1 data.)
- Please don't set the address 19H and the larger ones. (Test registers are assigned in those addresses)

4.1.4.Register Functions

ADDR	register	function	setting
00H	OP3	Software shutdown	0:shutdown, 1:operation
	OP2	Auto shutdown/Continuous operation	0:auto shutdown, 1:continuous operating function
	PROX	detection/non-detection	0:non-detection, 1:detection
	FLAG	interrupt result	0:non-interrupt, 1:interrupt
01H	INTVAL[1:0]	Intermittent operating	00: 0msec, 01: 1.56msec, 10: 6.25msec, 11: 25msec
	INTSEL[2:0]	The interrupt data setting	000:D0[13:0], 001:D1[13:0], 010:D2[13:0], 011:D3[13:0], 100:D4[15:0], 101~111:not allowed
	PIN	INT terminal setting	0:FLAG, 1:PS(Detection/Non-detection)
	INTTYPE	Interrupt type setting	0:level, 1:pulse
	RST	Software Reset	0:not reset, 1:reset
02H	PRST[2:0]	Number of measurement cycles	000 : once - 111 : 8cycles
	RES[1:0]	Resolution	00:14bits(6.25msec),01:12bits(1.56msec),10:10bits(0.39msec),11:8bits(0.1msec)
	RANGE[2:0]	Maximum measurable range	000:×1 - 111:×128
03H	IS[2:0]	LED drive peak current setting	000:17.5mA、001:35.0mA、010:70mA、011:140mA、111:193mA、
	SUM[2:0]	LED pulse setting	000:not allowed, 001:×2 to 111:×128
	PULSE[1:0]	LED pulse width setting	00:9.16us, 01:6.11us, 10:4.58us, 11:3.82us
04H.05H	TL	Low threshold setting(Loff)	16bits counts setting
06H,07H	TH	High threshold setting(Lon)	16bits counts setting
08H,09H	OS_DATA0	DATA0 offset count(Offset0)	14bits counts setting
0AH,0BH	OS_DATA1	DATA1 offset count(Offset1)	14bits counts setting
0CH,0DH	OS_DATA2	DATA2 offset count(Offset2)	14bits counts setting
0EH,0FH	OS_DATA3	DATA3 offset count(Offset3)	14bits counts setting
10H,11H	D0	DATA0 result	14bits output data of Photodiode0
12H,13H	D1	DATA1 result	14bits output data of Photodiode1
14H,15H	D2	DATA2 result	14bits output data of Photodiode2
16H,17H	D3	DATA3 result	14bits output data of Photodiode3
18H,19H	D4	DATA0-DATA3 sum	16bits output data of all Photodiode(D4=D0+D1+D2+D3)

Table 3. Description of Register Functions for GS

4.1.5.Register Settings for Gesture and Proximity Sensing

4.1.5.1. GS Detection Result:

Gesture sensing results can be read at D0[13:0],D1[13:0] ,D2[13:0],D3[13:0], and D4[15:0] register (Address 10H~19H) through I2C bus interface.

The device outputs raw data of the four IR photodiodes sensitive to only infrared spectrum gesture sensing. It is necessary for device host (user side) to get detection results with calculation of gesture values for each channel data at D0[13:0] ,D1[13:0],D2[13:0],D3[13:0] and total value of each channel data at D4[15:0].

Detection result is defined as follows,

Detection result (D0[13:0]) = Raw count(D0[13:0], include panel crosstalk) – Offset(OS_D0[13:0])

Detection result (D1[13:0]) = Raw count(D1[13:0], include panel crosstalk) – Offset(OS_D1[13:0])

Detection result (D2[13:0]) = Raw count(D2[13:0], include panel crosstalk) – Offset(OS_D2[13:0])

Detection result (D3[13:0]) = Raw count(D3[13:0], include panel crosstalk) – Offset(OS_D3[13:0])

Gesture detection:

- If the detected object on the right, D0[13:0]+D3[13:0] > D1[13:0]+D2[13:0].
- If the detected object on the left, D0[13:0] +D3[13:0] < D1[13:0]+D2[13:0].

- If the detected object on the top, D0[13:0]+D1[13:0] > D2[13:0]+D3[13:0].
- If the detected object on the bottom, D0[13:0]+D1[13:0] < D2[13:0]+D3[13:0].

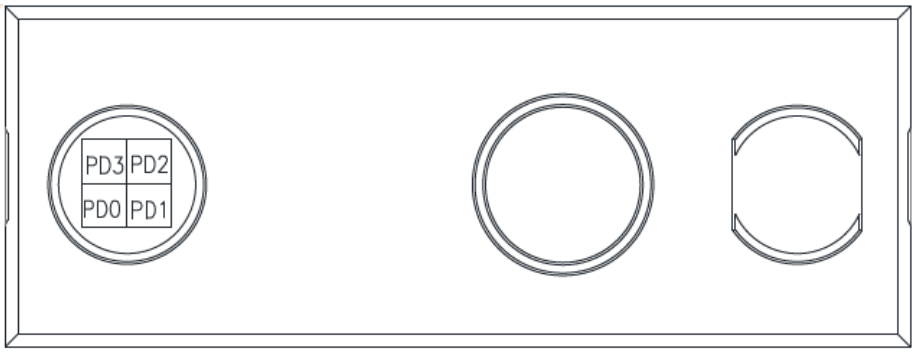

Figure 13. The Built-in Photodiodes Position (PD0, PD1, PD2, PD3)

- Photodiode0(PD0) count value is stored to the raw count of D0[13:0].
- Photodiode1(PD1) count value is stored to the raw count of D1[13:0].
- Photodiode2(PD2) count value is stored to the raw count of D2[13:0].
- Photodiode3(PD3) count value is stored to the raw count of D3[13:0].

4.1.5.2. Output Value of Sensing Result for Detection/non-detection

Sensing result for detection/non-detection is output. There is a function which clears data by writing 0 in PROX register. PROX register(Address 00H): 0: non-detection, 1: detection

4.1.5.3. Output Value of Interrupt Result

FLAG register is output interrupt result.

There is a function which clears by writing 0 in d FLAG register.

FLAG register (Address 00H) : 0: non-interrupt, 1: interrupt

4.1.5.4. Number of Measurement Cycles Setting

Select number of measurement cycles by setting PRST[2:0] register. Judgment result for detection/non-detection is over threshold continuously more than the set cycles in PRST[2:0] register.
This judgment result is done in using the detection result of distance (D4[15:0]).

PRST[2:0]	Persistence Cycle	Remarks
000	1 cycle	Recommended (Gesture)
001	2 cycles	
010	3 cycles	
011	4 cycles	
100	5 cycles	
101	6 cycles	
110	7 cycles	
111	8 cycles	

Table 4. Number of Measurement Cycles Setting

4.1.5.5. Resolution/Measuring Duration Setting

Select measuring resolution and measuring duration by setting RES[1:0] register (Address 02H).
If resolution is low, measuring tolerance becomes large. Please have an adjustment at your system.

RES[1:0]	Resolution	Measurement Duration	Remarks
00	14 bit	6.25 ms	Recommended
01	12 bit	1.56 ms	Recommended
10	10 bit	0.39 ms	Not Recommended
11	8 bit	0.098ms	Not Recommended

Table 5. Resolution/Measuring Duration Setting

4.1.5.6. Maximum Measurable Range

Select maximum measurable range by setting RANGE [2:0] register (Address 02H).
Detect with a set range. Maximum count value is outputted in case of incident light exceeding maximum measurable range.
Changing maximum measurable range, detection result count is also change. In case of considering 000: ×1 setting as ×1 time, count would be 1/2 times at 001: ×2 setting, 1/4 times at 010: ×4 setting. Adjusting

detecting distance by proximity low threshold TL[15:0] and TH[15:0]. It is necessary to set them considering the condition in the actual use and evaluating at your system.

RANGE[2:0]	Maximum Measurable Range	Remarks
000	x 1	Not Recommended
001	x 2	Recommended
010	x 4	Not Recommended
011	x 8	Not Recommended
100	x 16	Not Recommended
101	x 32	Not Recommended
110	x 64	Not Recommended
111	x 128	Not Recommended

Table 6. Maximum Measurable Range

4.1.5.7. LED Drive Peak Current Setting

Enable to select LED drive peak current by setting IS[2:0] register (Address 03H).
In case of changing this setting, the count will change correspond to the set LED drive peak current.
Please adjust detecting distance with proximity low threshold TL[15:0] and proximity high threshold TH[15:0].
LED drive peak current will depend on Vcc voltage. (Refer to 12.1. LED drive peak current data)

IS[2:0]	LED Drive Peak Current	Remarks
000	17.5mA	Not Recommended
001	35mA	Not Recommended
010	70mA	Not Recommended
011	140mA	Recommended
111	193mA	Recommended

Table 7. LED Drive Peak Current

4.1.5.8. LED Pulse Setting

Select LED pulse setting by setting SUM[2:0] register (Address 03H).
If LED pulse setting is low, measuring tolerance becomes large. Please have an adjustment at your system. Number of LED pulses can be changed from 2 times to 128 times.

SUM[2:0]	LED Pulse Setting	Remarks
000	NA	Not Recommended
001	x 2 times	Not Recommended
010	x 4 times	Not Recommended
011	x 8 times	Not Recommended
100	x 16 times	Recommended
101	x 32 times	Recommended
110	x 64 times	Not Recommended
111	x 128 times	Not Recommended

Table 8. LED Pulse Setting

4.1.5.9. LED Pulse Width Setting

Select LED pulse width setting by setting PULSE[1:0] register (Address 03H).

PULSE[1:0]	LED Pulse Width	Remarks
00	9.16 μs	Recommended
01	6.11 μs	Not Recommended
10	4.58 μs	Not Recommended
11	3.82 μs	Not Recommended

Table 9. LED pulse Width Setting

4.1.5.10. Gesture and Proximity Low Threshold (Loff)

Sets proximity low threshold in TL[15:0] register at PS mode.
Please set it with confirming at optical mounting condition in the actual use.

4.1.5.11. Gesture and Proximity High Threshold (Lon)

Sets proximity high threshold in TH[15:0] register at PS mode.
Please set it with confirming at optical mounting condition in the actual use.

4.1.5.12. Gesture Offset (Offset)

Sets proximity offset in PO[13:0] register at PS mode.
If there is Panel crosstalk, you will be able to subtract the Panel crosstalk count by using proximity offset.
Please set it with confirming at optical mounting condition in the actual use.

4.1.6.Register Setting for Basic Operation

4.1.6.1. Software-Shutdown

Control power supply to the circuit. LED drive circuit is always off in shutdown mode. After power on, start with shutdown mode.

OP [3] register (Address 00H)

0: shutdown mode

1: operating mode.

4.1.6.2. Auto-Shutdown/Continuous Operation

Select auto-shutdown mode or continuous operating mode. After shutdown, OP[3] register will be automatically cleared.

OP [2] register (Address 00H)

0: auto shutdown mode

1: continuous operating mode.

4.1.6.3. Intermittent Operating Function

Enable to change intermittent operating periods by setting INTVAL [1:0] register (Address 01H).

00: 0msec, 01: 1.56msec, 10: 6.25msec, 11: 25msec

Intermittent operating will be done during period set by INTVAL [1:0] register.

For GS mode, in case of INTVAL[1:0]=10(6.25msec), quiescent operation time will be after GS operation.

Although setting a longer intermittent operating period contributes to reduce average consumption current, it makes update period and response time for detection longer as a result.

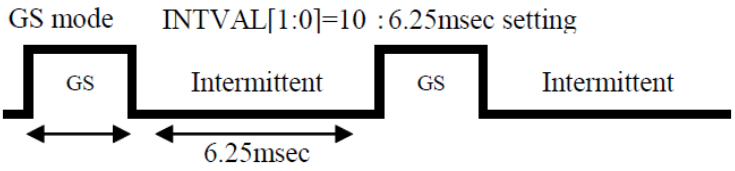

Figure 14. Intermittent Setting

4.1.6.4. Interrupt Data Setting

Select interrupt data source by setting INTSEL[2:0] register (Address 01H).

INTSEL[2:0]	The Interrupt Data	Remarks
000	D0[13:0]	Not Recommended
001	D1[13:0]	Not Recommended
010	D2[13:0]	Not Recommended
011	D4[13:0]	Not Recommended
100	D4[13:0]	Recommended (Proximity)
101	NA	Not Recommended
110	NA	Not Recommended
111	NA	Not Recommended

Table 10. Number of Measurement Cycles Setting

4.1.6.5. INT Terminal Setting

Select output mode in INT terminal by setting PIN register (Address 01H).
The outputs by FLAG, PROX can be selected.

PIN	Setting	Output Data
0	Interrupt Output	FLAG
1	Detection/Non-detection Judgment Output	PROX

Table 11. INT Terminal Setting

4.1.6.6. Interrupt Type Setting

Select level interrupt type or pulse interrupt type.
INTTYPE register (Address 01H)

0: level interrupt type

In this case, transition from H to L in INT terminal become occurring interrupt signal and INT terminal will hold L level until interrupt is cleared.

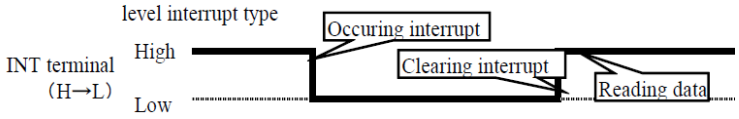

Table 12. Interrupt Output (Level Interrupt Type)

1: pulse interrupt type

In this case, L pulse output in INT terminal become occurring interrupt signal and INT terminal will not hold L level. Therefore we need not to clear interrupt flag(FLAG). FLAG are cleared automatically in 1 clock (about 0.39μs).

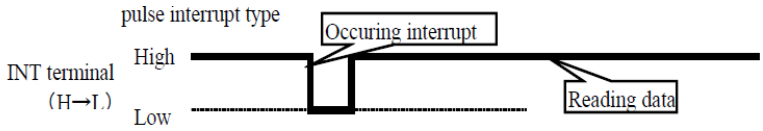

Table 13. Interrupt Output (Pulse Interrupt Type)

4.1.6.7. Software Reset

Initialize all registers by writing 1 in RST register (Address 01H). RST register is also initialized automatically and becomes 0.

4.1.7.INT Terminal Output Mode

4.1.7.1. Proximity Detection/non-detection Sensing Result Output Mode

INT terminal operates with sensing result output mode by setting PIN register (Address 01H)

11: detection/non-detection sensing result output mode.

Sensing result whether or not object is detected is able to be read out via I2C bus interface and output from INT terminal with negative logic.

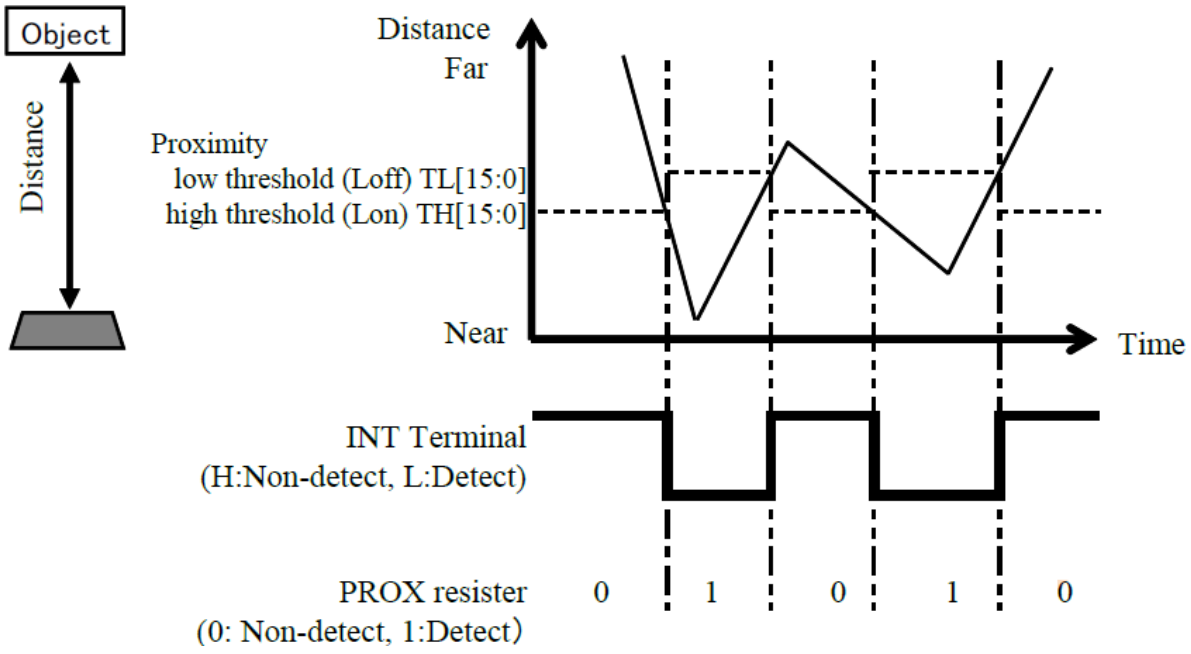

Figure 15. Detection Result Output Mode

4.1.7.2. Interrupt Output Mode

Operates as interrupt output mode by setting PIN register (Address 01H) 0,1: interrupt output mode.

There are two kinds of output mode (level interrupt & pulse interrupt, see **4.1.5.6 Interrupt Type Setting**).

Below is a description of the level interrupt type.

The result of interrupt judgment is written into FLAG register (Address 00H), and is read out from I2C bus interface. (0: Non-interrupt, 1: interrupt.)

In this case, transition from H to L in INT terminal become occurring interrupt signal and INT terminal will be hold L level until interrupt is cleared. Interrupt will be cleared in writing 0 data in FLAG register.

Detecting operation will continue while INT terminal is L level. Update proximity detection result D4[15:0] and sensing result of object detection/non-detection status. Therefore, host needs to read data after FLAG register clear.

For example, as shown in below diagram,

Interrupt occurs with FLAG=1: interrupt

Actual object moves “Detection” to “Non-detection” to “Detection” while interrupt is cleared.

In this case, while INT terminal (FLAG register) is hold, PROX value will be updated with result of judgment for detection/non-detection of object.

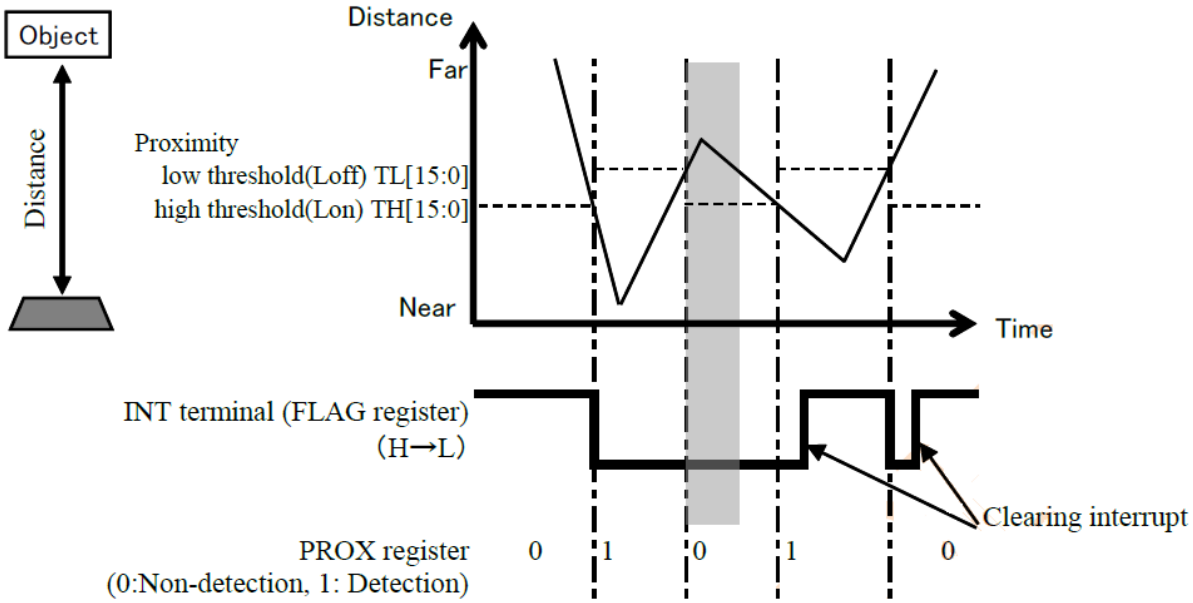

Figure 16. Interrupt Output Mode (Level Interrupt Type)

4.2. Ambient Light Sensing (ALS) Part

4.2.1.I2C Slave Address for ALS

SLAVE ADDRESS:

ADDR terminal setting	A6	A5	A4	A3	A2	A1	A0	R/W
Slave address	0	1	1	1	0	0	1	X

R/W ： Read:X=1, Write:X=0

Table 14. I2C Slave Address for Ambient Light Sensing

4.2.1.1. ALS 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.

WordAddress: 00H FLAG_A register in 00H are read only.

WordAddress: 0CH～11H D0[15:0], D1[15:0] and D2[15:0] registers from 0CH to 11H are read only.

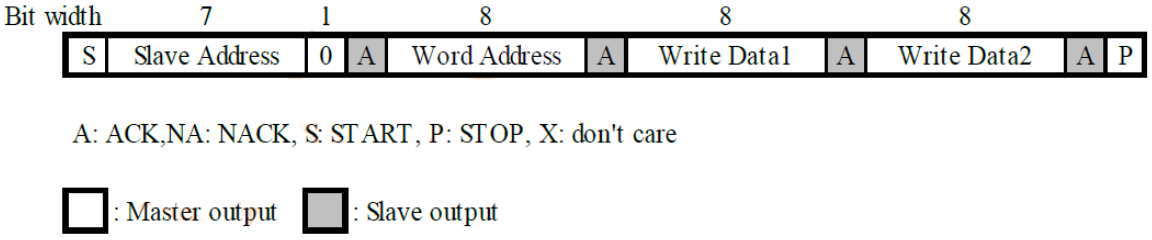

Figure 17. ALS I2C Write Format

4.2.1.2. ALS 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.

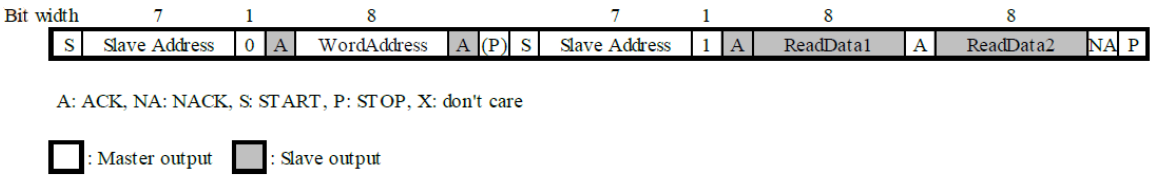

Figure 18. ALS I2C Read Format

4.2.2.Basic Operation for Ambient Light Sensor (ALS) Mode

There are 2 photodiodes, CLEAR (sensitive to visible and infrared spectrum) and IR photodiodes (sensitive to only infrared spectrum) in this sensor. Illuminance value can be obtained by calculation from CLEAR and IR data.

The device continues to execute integration operation until set measuring time(100msec, recommended) passes, and then outputs the results of CLEAR photodiode at D0[15:0] register and IR photodiode at D1[15:0] register. Illuminance value can be obtained by some calculation using D0[15:0] and D1[15:0].

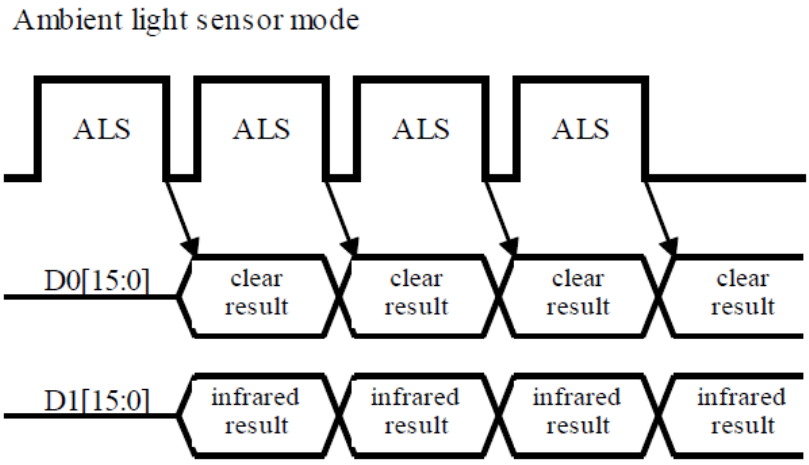

Figure 19. Output Results for ALS Mode

4.2.3.Register Mapping

ADDRESS	DATA								Initial Value	R/W
	D7	D6	D5	D4	D3	D2	D1	D0		
00H	OP3	OP2	OP1	OP0	0	0		0	H'00	R/W
							FLAG_A			R +clear
01H	PRST1	PRST0	RES_A2	RES_A1	RES_A0	RANGE_A2	RANGE_A1	RANGE_A0	H'00	R/W
02H	0	INTTYPE	0	0	0	0	0	0	H'00	R/W
03H	INTVAL1	INTVAL0	0	0	PIN1	PIN0	0	RST	H'00	R/W
04H	TL7	TL6	TL5	TL4	TL3	TL2	TL1	TL0	H'00	R/W
05H	TL15	TL14	TL13	TL12	TL11	TL10	TL9	TL8	H'00	R/W
06H	TH7	TH6	TH5	TH4	TH3	TH2	TH1	TH0	H'FF	R/W
07H	TH15	TH14	TH13	TH12	TH11	TH10	TH9	TH8	H'FF	R/W
08H	0	0	0	0	0	0	0	0	H'00	R/W
09H	0	0	0	0	0	0	0	0	H'00	R/W
0AH	1	1	1	1	1	1	1	1	H'FF	R/W
0BH	1	1	1	1	1	1	1	1	H'FF	R/W
0CH	D0_7	D0_6	D0_5	D0_4	D0_3	D0_2	D0_1	D0_0	H'00	R
0DH	D0_15	D0_14	D0_13	D0_12	D0_11	D0_10	D0_9	D0_8	H'00	R
0EH	D1_7	D1_6	D1_5	D1_4	D1_3	D1_2	D1_1	D1_0	H'00	R
0FH	D1_15	D1_14	D1_13	D1_12	D1_11	D1_10	D1_9	D1_8	H'00	R

Table 15. Register Mapping for ALS

- Please start setting registers after power-supply voltage becomes stable up to 90% or more set value.

Please wait for some 1msec before setting registers from power-on.

- FLAG_A registers are able to be cleared by writing 0 data in each register. (but these registers can't be written 1 data.)
- Please don't set the address 12H and the larger ones. (Test registers are assigned in those addresses)

4.2.4.Register Functions

ADDR	Register	Function	Setting
00H	OP3	Software shutdown	0:shutdown, 1:operation
	OP2	Auto shutdown/Continuous operation	0:auto shutdown, 1:continuous operating function
	OP[1:0]	Operating mode selection	01:ALS
	FLAG_A	ALS: interrupt result	0:non-interrupt, 1:interrupt
01H	PRST[1:0]	Number of measurement cycles	00 : once, 01 : 4 cycles, 10 : 8 cycles, 11 : 16 cycles
	RES_A[2:0]	ALS:Resolution	000:8bits(0.39msec) to 111:19bits(800msec)
	RANGE_A[2:0]	ALS:Maximum measurable range	000: x1 to 111: x128
02H	INTTYPE	Interrupt type setting	0level, 1:pulse
03H	INTVAL[1:0]	Intermittent operating	00:0, 01:4 times, 10:8 times, 11:16 times
	PIN[1:0]	INT terminal setting	00:ALS or PS, 01:ALS, 10:PS, 11:PS(Detection/Non-detection)
	RST	Software Reset	0:not reset, 1:reset
04H,05H	TL	ALS:low threshold setting	16bits counts setting
06H,07H	TH	ALS:High threshold setting	16bits counts setting
08H,09H			
0AH,0BH			
0CH,0DH	D0	ALS result:Clear	16bits output data from Clear PD
0EH,0FH	D1	ALS result :IR	16bits output data from IR PD
10H,11H			

Table 16. Description of Register Functions for GS

4.2.5.Register Settings for Ambient Light Sensing

4.2.5.1. ALS Detection result

Detection result of clear photodiode is output to D0[15:0] register (Address 0CH, 0DH).

Detection result of infrared photodiode is output to D1[15:0] register (Address 0EH, 0FH).

The results of without infrared light can be obtained by some calculation using D0[15:0] and D1[15:0].

The results of without infrared light = α*D0[15:0] – β*D1[15:0]

α and β factor are decided by ratio of D1 [15:0]/D0 [15:0].

These factors are shown below in the case of no panel.

These factors might be necessary to be adjusted according to the case panel in use.

Ratio of Data1[15:0]/ Data0[15:0]	α	β
Ratio ≦ 0.67	6.650	9.653
0.67 ＜ Ratio ≦0.90	1.805	1.977
0.90 ＜ Ratio	0.000	0.000

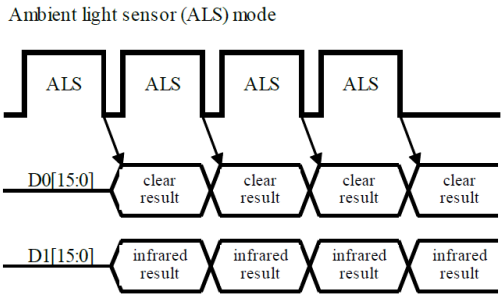

Figure 20. Sensing Results Output for ALS Mode

4.2.5.2. Output Value of ALS Interrupt Result

FLAG_A register is output interrupt result for ALS mode.

There is a function which clears by writing 0 in d FLAG_A register.

FLAG_A register (Address 00H): 0: non-interrupt, 1: interrupt

4.2.5.3. Resolution/Measuring Duration Setting for ALS Mode

Select measuring resolution and measuring duration for ALS mode by setting RES_A [2:0] register (Address 01H). If resolution is low, measuring tolerance becomes large. Please have an adjustment at your system.

RES_A[2:0]	Resolution	Measuring Time	Remarks
000	19bit	800ms	Not Recommended
001	18bit	400ms	Not Recommended
010	17bit	200ms	Not Recommended
011	16bit	100ms	Recommended
100	14bit	25ms	Recommended
101	12bit	6.25ms	Not Recommended
110	10bit	1.56ms	Not Recommended
111	8bit	0.39ms	Not Recommended

Table 17. Resolution/Measuring Duration Setting for ALS Mode

4.2.5.4. Maximum Measurable Range for ALS Mode

Select maximum measurable range for ALS mode by setting RANGE_A [2:0] register (Address 01H).
Detect with a set range in ALS mode. Maximum count value is outputted in case of incident light exceeding maximum measurable range.
It is possible to have countermeasure for external light by setting a large count value at maximum measurable range. It is necessary to set them considering the condition in the actual use and evaluating at your system.

RANGE_A[2:0]	Maximum Measurable Range	Remarks
000	x1	
001	x2	
010	x4	
011	x8	
100	x16	
101	x32	
110	x64	
111	x128	

Table 18. Maximum Measurable Range for ALS Mode

4.2.5.5. ALS interrupt Low Threshold

Sets interrupt low threshold in TL[15:0] register (Address 04H,05H) at ALS mode.
Please set it with confirming at optical mounting condition in the actual use.

4.2.5.6. ALS interrupt High Threshold

Sets interrupt high threshold in TH[15:0] register (Address 06H,07H) at ALS mode.
Please set it with confirming at optical mounting condition in the actual use.

4.2.6.Register Settings for Basic Operation

4.2.6.1. Software-Shutdown

Control power supply to the circuit. Circuit is always off in shutdown mode. After power on, start with shutdown mode.

OP [3] register (Address 00H)

0: shutdown mode

1: operating mode.

4.2.6.2. Auto-Shutdown/Continuous Operation

Select auto-shutdown mode or continuous operating mode. After shutdown, OP[3] register will be automatically cleared.

OP [2] register (Address 00H)

0: auto shutdown mode

1: continuous operating mode.

4.2.6.3. Operating Mode Selection

Select ALS mode.

OP [1:0] register (Address 00H)

01: ALS mode

Detection result of clear photodiode is output to D0[15:0] register (Address 0CH, 0DH).

Detection result of infrared photodiode is output to D1[15:0] register (Address 0EH, 0FH).

00, 10, 11: not allowed

Please always be set to 01 in this register.

4.2.6.4. Number of Measurement Cycles Setting

Select number of measurement cycles by setting PRST[1:0] register. Output interrupt result or judgment result for detection/non-detection in case detection result is over threshold continuously more than the set cycles in PRST[1:0] register (Address 01H):

00: 1cycle

01: 4cycles,

10: 8cycles

11: 16cycles

4.2.6.5. Interrupt Type Setting

Select level interrupt type or pulse interrupt type.

INTTYPE register (Address 02H)

0: level interrupt type

In this case, transition from H to L in INT terminal become occurring interrupt signal and INT terminal will hold L level until interrupt is cleared.

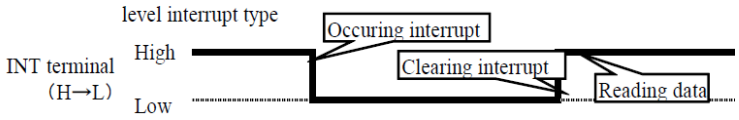

Table 19. Interrupt Output (Level Interrupt Type)

1: pulse interrupt type

In this case, L pulse output in INT terminal become occurring interrupt signal and INT terminal will not hold L level. Therefore we need not to clear interrupt flag(FLAG_P, FLAG_A). FLAG_P and FLAG_A are cleared automatically in 1 clock (about 1.5us).

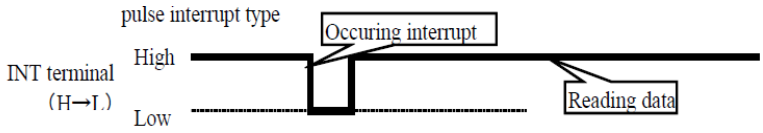

Table 20. Interrupt Output (Pulse Interrupt Type)

4.2.6.6. Intermittent Operating Function

Enable to change intermittent operating periods by setting INTVAL [1:0] register (Address 03H).

00: 0 time, 01: 4 times, 10: 8 times, 11: 16 times

Intermittent operating will be done during setting period in RES_A[2:0](Resolution/measuring time) by the number of times set by INTVAL [1:0] register.

For ALS mode, in case of RES_A [2:0]=011 16bit setting (measuring period 100ms) and INTVAL [1:0]=01(4 intermittent operating cycles), quiescent operation time will be 400ms (=100ms × 4 times).

Although setting a longer intermittent operating period contributes to reduce average consumption current, it makes update period and response time for detection longer as a result. Need to set it considering your actual conditions in use.

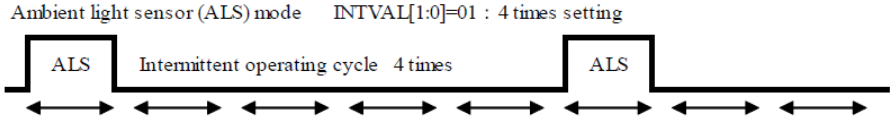

Table 21. Intermittent Operating for Each Mode

4.2.6.7. INT Terminal Setting

Select output mode in INT terminal by setting PIN register (Address 03H).
The outputs by INCLUSIVE-OR(FLAG_P, FLAG_A), FLAG_P, FLAG_A, PROX can be selected.

PIN[1:0]	Setting	Output Data
01	Interrupt output for ALS mode only	FLAG_A

Table 22. INT Terminal Setting

4.2.6.8. Software Reset

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

4.2.7.INT Terminal Output Mode

4.2.7.1. Interrupt Output Mode

Operates as interrupt output mode by setting PIN[1:0] register (Address 03H) 00,01,10: interrupt output mode.
There are two kinds of output mode (level interrupt & pulse interrupt, see **4.2.6.5. Interrupt Type Setting**). Below is a description of the level interrupt type.
The result of interrupt judgment for ALS mode is written into FLAG_A register (Address 00H), and is read out from I2C bus interface. (0: Non-interrupt, 1: interrupt.)
In this case, transition from H to L in INT terminal become occurring interrupt signal and INT terminal will be hold L level until interrupt is cleared. Interrupt will be cleared in writing 0 data in FLAG_A register.
Detecting operation will continue while INT terminal is L level. Update ALS detection result D0[15:0],D1[15:0].
Therefore, host needs to read data after FLAG_A register clear.