GP2Y8E01

3D Motion Sensor

■Description

GP2Y8E01 is 3D Motion detection Sensor.
IR-LED and Image sensor and DSP
(for coordinates calculation) is integrated
to one package and reduce the CPU load of the equipment.
Also, small size (7.9mmx3.9mmx3.4mm) is realized by becoming one package built-in to the mobile equipment.
Furthermore, I^2C interface compatible was to Easy to incorporate into the equipment.

■Features

1. IR-LED and Image sensor and DSP
   (for coordinates calculation) is integrated
   to one package.
2. Compact size (7.9 × 3.9 × 3.4mm)
3. Low current consumption : Typ.1.6mA
4. Detection distance : 5~20cm
5. Position accuracy : 2mm@10cm*
   (* : Target Object : 2cm□ White paper)

■Agency approvals/Compliance

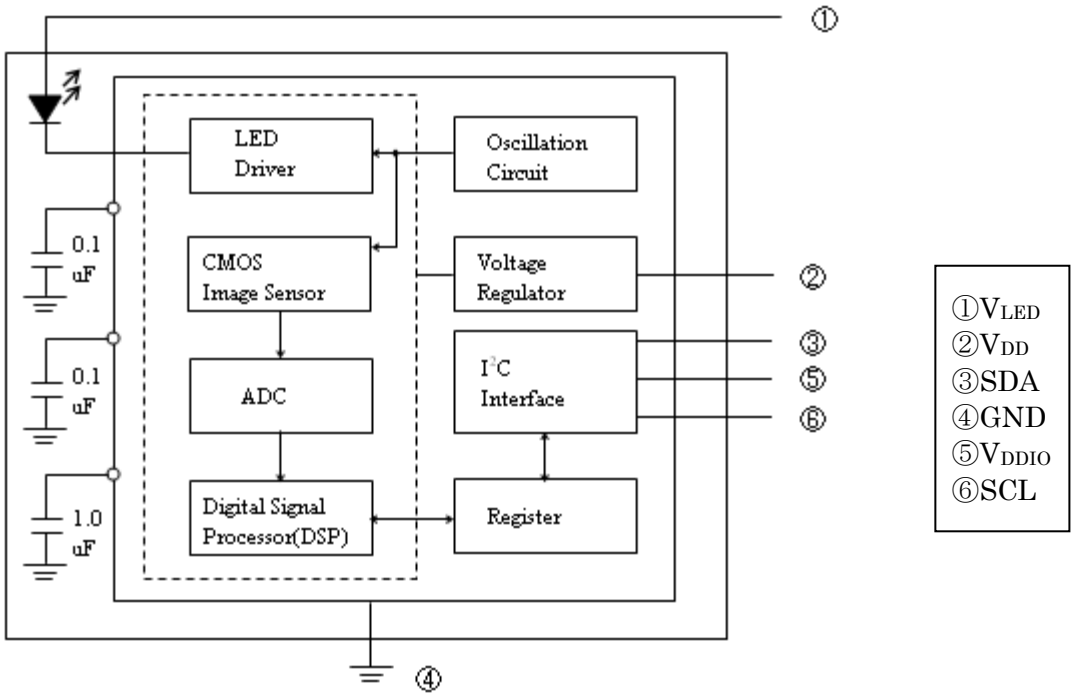
1. Compliant with RoHS directive (2002/95/EC)

■Applications

1. Smartphone, Tablet
2. Note PC
3. Car navigation
4. Game machine

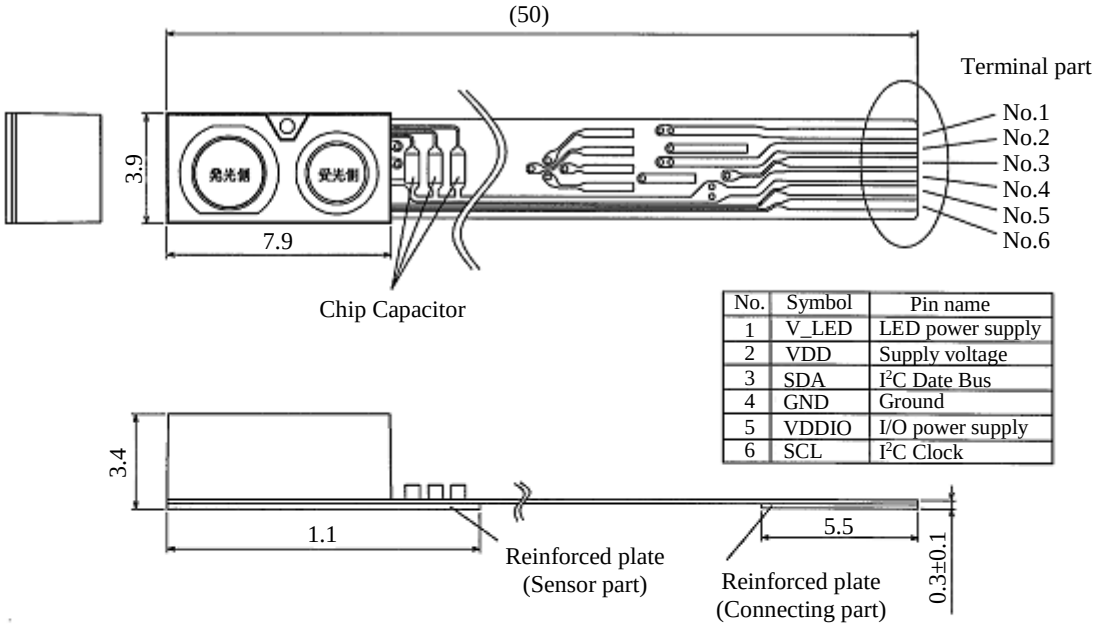
Sheet No.: OP13040EN

■ Schematic



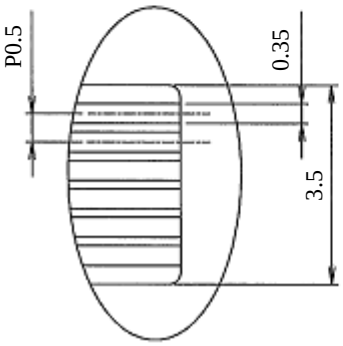
Please use an electric source with an output current of 150mA or more because there is the possibility that LED pulse current is more than 90mA in case that the register of this product is set to power on timing sequence and initial setting (standard operating condition) which is described in 1-4.

■ Outline capacitor



No.	Symbol	Pin name
1	V_LED	LED power supply
2	VDD	Supply voltage
3	SDA	I^2C Date Bus
4	GND	Ground
5	VDDIO	I/O power supply
6	SCL	I^2C Clock

Scale drawing of terminal part (10/1)



Unit : mm
Scale : 5/1

(Note 1) Unspecified tolerances shall be ±0.2mm
(Note 2) ( ): Reference value
(Note 3) I^2C voltage level is changed by VDDIO input voltage.
(Note 4) Terminal connector is matched by FPC connector (pin pitch: 0.5mm, thickness: 0.3mm)
(For example: 06FHSY-RSM1-GAN-TB, JST Mfg. Co., Ltd.)
(Note 5) There are many site of the opening on FPC. Please don't short circuit.

■Absolute Maximum Ratings

Ta=25°C (unless otherwise specified)

Parameter	Symbol	Rating	Unit	Remark
Supply voltage	V_{DD}	-0.3 to 3.9	V	-
LED supply voltage	V_{LED}	-0.3 to 3.9	V	-
I/O supply voltage	V_{DDIO}	-0.3 to V_{DD}+0.3 or 3.9	V	-
I^2C input terminal voltage	SCL	-0.3 to V_{DD}+0.3 or 3.9	V	-
I^2C I/O terminal voltage	SDA	-0.3 to V_{DD}+0.3 or 3.9	V	-
Operating temperature	Topr	(-20) to (+85)	°C	-
Storage temperature	Tstg	(-40) to (+85)	°C	-

■Recommended Operating Conditions

Parameter	Symbol	Rating	Unit	Remark
Supply voltage	V_{DD}	(2.7) to 3.6	V	
LED supply voltage	V_{LED}	(2.7) to 3.6	V	
I/O supply voltage	V_{DDIO}	(1.8) to 3.6	V	
I^2C High level input	V_{IH}	0.7×V_{DDIO} to V_{DDIO}+0.3	V	
I^2C Low level input	V_{IL}	-0.3 to 0.2 × V_{DDIO}	V	

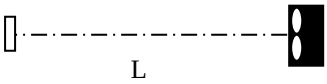
■Electro-optical Characteristics

(Ta=25°C, V_{DD}=3.3V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Distance Range	* L	(Note1, 3)	5	-	(20)	cm
Viewing Angle	θ	(Note2)	±15	-	(TBD)	degree
Detection Axis	θ_0	(Note2)	-	0	(TBD)	degree
Accuracy	⊿	L=10cm (Note1, 3)	-	2	(TBD)	mm
Average Supply Current	I_{DD}	Operation State (Note3)	-	1.6	(TBD)	mA
Suspend Current	I_{DD_SUS}	Suspend State	-	15	(TBD)	uA
Standby1 Current Consumption	I_{DD_ST1}	Standby 1 State (Note3)	-	0.9	(TBD)	mA
Standby2 Current Consumption	I_{DD_ST2}	Standby 2 State (Note3)	-	0.3	(TBD)	mA
Frame Rate	F_S	Operation State (Note3)	(TBD)	120	(TBD)	fps

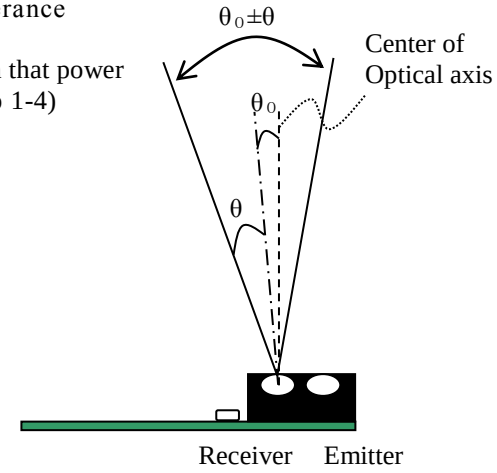
* L : Distance to reflective object

(Note 1) Using reflective object :
White paper 2cm×2cm (mat, reflective ratio : 90%)
The background of the reflective object is at infinity.



(Note2) Detection area angle is $\theta_0 \pm \theta$ because of mounting tolerance of optical parts. (Refer to right figure)

(Note3) Test condition is based on the standard operating condition that power on timing sequence and initial setting is executed. (refer to 1-4)



■I²C interface and register

1-1 I²C interface

This product has 7 bits slave address (0x73) which comply with I²C bus standard , so the space coordinates of the object can be read through I²C bus. Besides, this product can change register value for each function through I²C bus.

The below table shows I²C bus terminal.

Pin name	Description
SCL	I²C clock
SDA	I²C data bus

Besides the product can be changed the slave address from initial one (0x73)
If you need to change slave address, please contact to Sharp.

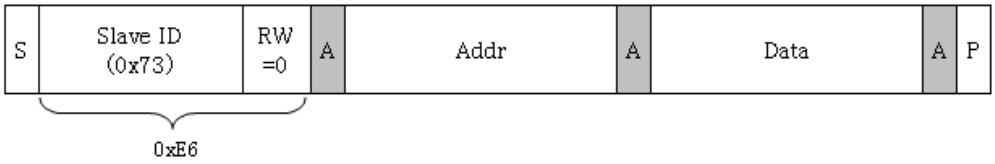
(1) I²C data transfer format

Symbols explaining read and write format of this product are shown in the following table.

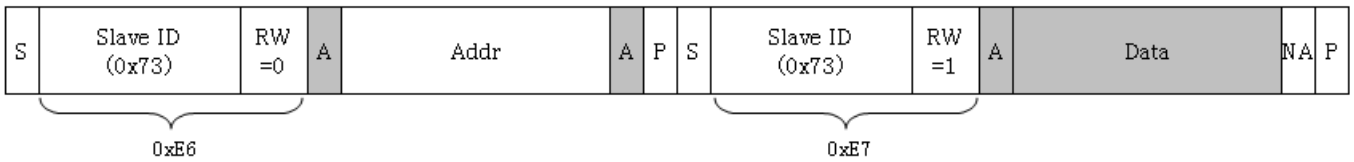
Symbol	Description	Note
S	Start	Master output
A	ACK	Master / Slave output
NA	NACK	Master / Slave output
P	Stop	Master output
Addr(Address)	Register address	Master output
Data	Data	Master / Slave output

(2) Wake up command format

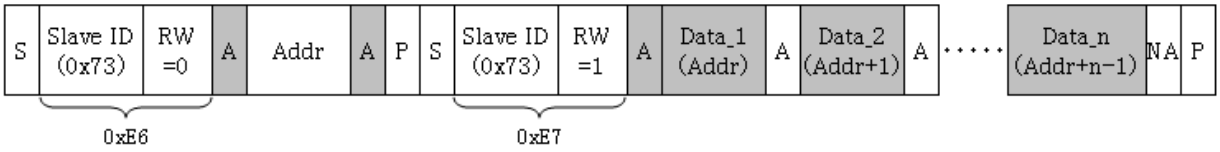
(3) Write format



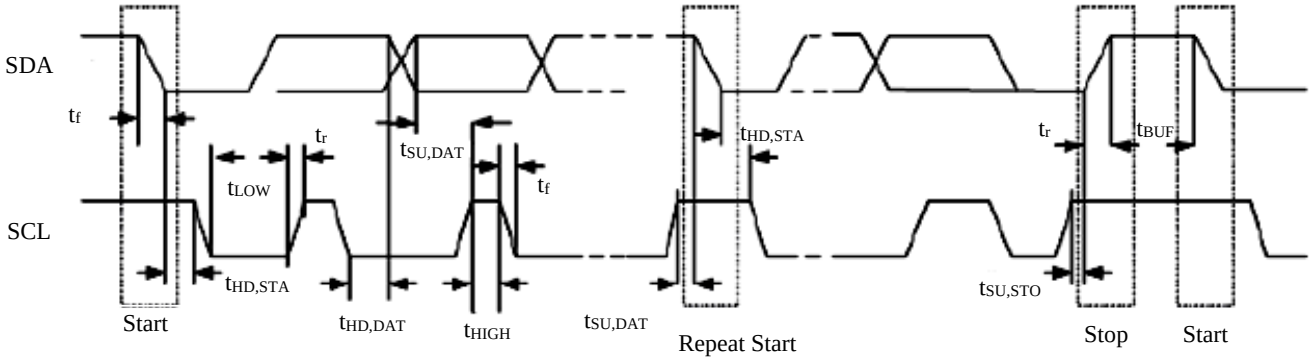
(4) Read format



(5) Burst read format



1-2 I²C bus timing



(Ta=25°C)

Parameter	Symbol	Min.	Max.	Unit
SCL clock frequency	f_{scl}	10	400	kHz
Hold time for Start / Repeat Start. After this period, the first clock pulse is generated.	$t_{HD:STA}$	0.6	-	us
Set-up time for a repeated start	$t_{SU:STA}$	0.6	-	us
Low period of SCL clock.	t_{LOW}	1.3	-	us
High period of SCL clock	t_{HIGH}	0.6	-	us
Data hold time. For I²C™-bus device	$t_{HD:DAT}$	0	-	us
Data set-up time	$t_{SU:DAT}$	100	-	ns
Rise time of both SDA and SCL signals	t_r	-	300	ns
Fall time of both SDA and SCL signals	t_f	-	300	ns
Set-up time for STOP condition	$t_{SU:STO}$	0.6	-	us
Bus free time between a STOP and START	t_{BUF}	1.3	-	us

1-3 Register map

GP2Y8E01 has two register banks (bank 0 and bank 1).
Accessed register bank can be selected by setting the register.

・Register bank 0 (Addr:0xEF = Data:0x00)

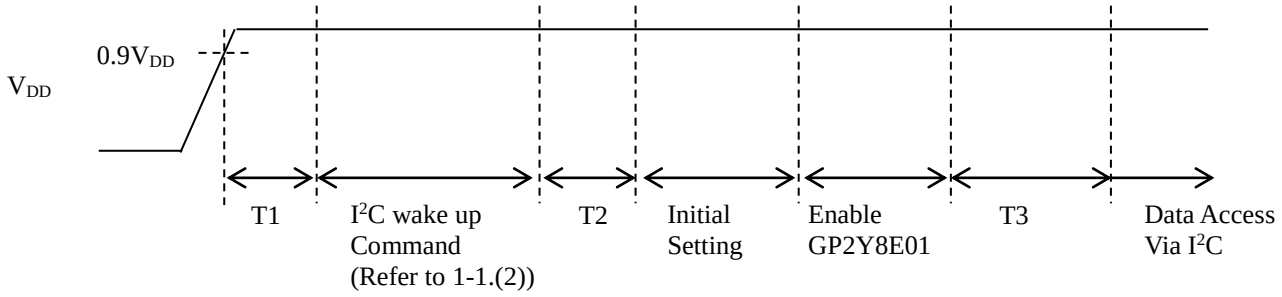
Addr (Hex)	Register Name	Access	Reg Field	Notes
0x03	I²C Suspend Command[0]	W	[0]	0x01:Suspend State
0x48	Emission Pulse Width UB[7:0]	R/W	[7:0]	Emission Pluse Width = UB[15:0]/4 [us] (20 < UB[15:0] < 1200)
0x49	Emission Pulse Width UB[15:8]	R/W	[7:0]	
0x4A	Emission Pulse Width LB[7:0]	R/W	[7:0]	Same Value with UB
0x4B	Emission Pulse Width LB[15:8]	R/W	[7:0]	
0xD9	Z_Data[9:8] ※	R	[1:0]	Spot Size ＝256*Z Data[9:8]+Z Data[7:0]
0xDA	X Data[7:0]	R	[7:0]	X Data＝256*X Data[11:8]+X Data[7:0]
0xDB	X Data[11:8]	R	[3:0]	
	Y Data[11:8]	R	[7:4]	Y Data＝256*Y Data[11:8]+Y Data[7:0]
0xDC	Y Data[7:0]	R	[7:0]	
0xDD	Z_Data[7:0]※	R	[7:0]	

※The distance output of GP2Y8E01 shall be the spot size of photo detector.
The spot size will be bigger in coming near, and the spot size will be smaller in going far.
This means that the distance output is relative value because spot size also changes by the size of reflective object.

・Register bank 1 (Addr:0xEF = Data:0x01)

Addr (Hex)	Register Name	Access	Reg Field	Notes
0x32	LED Current1[4:0]	R/W	[4:0]	LED Pulse Current = typ.30mA/count
0x33	LED Current2[4:0]	R/W	[4:0]	Same Value with LED Current1
0x65	Frame Rate[7:0]	R/W	[7:0]	Fs = EVEN(1000/(0.0323*α+3.55))
0x66	Frame Rate[15:8]	R/W	[7:0]	α = Frame Rate[15:0]
0x67	IDLE_S1[7:0]	R/W	[7:0]	IDLE_S1_time
0x68	IDLE_S1[15:8]	R/W	[7:0]	=(0.0323×IDLE_S1[15:0]+3.55)/1000 - 1/Fs
0x69	IDLE_S2[7:0]	R/W	[7:0]	IDLE_S2_time
0x6A	IDLE_S2[15:8]	R/W	[7:0]	=(0.0645*IDLE_S2[15:0]+3.55)/1000 - 1/Fs
0x6B	OP_to_S1[7:0]	R/W	[7:0]	OP to S1 Time = OP_to_S1[15:0]/Fs
0x6C	OP_to_S1[15:8]	R/W	[7:0]	
0x6D	S1_to_S2[7:0]	R/W	[7:0]	S1 to S2 Time = S1_to_S2[15:0]/(Fs/2*S1)
0x6E	S1_to_S2[15:8]	R/W	[7:0]	(S1 = 1000/Fs/(0.0323×IDLE_S1[15:0]+3.55))
0x72	Enable/Disable[0]	R/W	[0]	0x00:Disable 0x01:Enable

1-4 Power On Timing Sequence And Register Setting



T1>700us
T2>400us
T3>8.3ms (standard operating condition)

①Wait T1 after power supply on.
②Set the wake up command.
③Wait T2.
④Set the initial setting command (refer to next table).
Electro-optical characteristic is satisfied by setting register value of below table.
In case operating other condition, please refer to 1-7.
⑤Set the Enable command.
⑥Wait one cycle time of detecting (8.3ms in standard operating condition).
In case operating other condition, please refer to 1-7.
⑦Read the coordinates of the point.

・Initial Setting

This product in standard condition can be operated by setting register value according to below table.

No	Addr	Data	Notes	No	Addr	Data	Notes	No	Addr	Data	Notes
1	0xEF	0x01	Switch to Bank1*	23	0xA5	0x19	*	45	0x90	0x06	*
2	0x25	0x01	*	24	0xCD	0x0B	*	46	0x91	0x06	*
3	0x26	0x00	*	25	0xCF	0x64	*	47	0xA3	0x08	*
4	0x28	0x7F	*	26	0xD0	0x21	*	48	0xCE	0x13	*
5	0x29	0x09	*	27	0xD2	0x88	*	49	0xD2	0x88	*
6	0x5E	0x1D	*	28	0xEF	0x01	Switch to Bank1*	50	0xEF	0x01	Switch to Bank1*
7	0x73	0x35	*	29	0x41	0x48	*	51	0x01	0x3C	*
8	0xEF	0x00	Switch to Bank0*	30	0x43	0x30	*	52	0x02	0x00	*
9	0x82	0x06	*	31	0x74	0x00	*	53	0x03	0x00	*
10	0x41	0xFF	*	32	0xEF	0x00	Switch to Bank0*	54	0x04	0x9A	*
11	0x42	0x01	*	33	0x48	0x00	Emission Pulse Width Refer to 1-7.(2)	55	0x32	0x03	LED Current
12	0x46	0x2D	*	34	0x49	0x01		56	0x33	0x03	Refer to 1-7.(1)
13	0x47	0x0F	*	35	0x4A	0x00		57	0x65	0x96	Frame Rate
14	0x4C	0x20	*	36	0x4B	0x01		58	0x66	0x00	Refer to 1-7.(3)
15	0x4D	0x00	*	37	0x88	0x05	*	59	0x67	0x97	IDLE_S1 Time
16	0x51	0x10	*	38	0x89	0x18	*	60	0x68	0x01	Refer to 1-7.(4)
17	0x83	0x20	*	39	0x93	0x0D	*	61	0x69	0xCD	IDLE_S2 Time
18	0x91	0x05	*	40	0x94	0x0A	*	62	0x6A	0x01	Refer to 1-7.(5)
19	0x97	0x05	*	41	0x95	0x0A	*	63	0x6B	0xB0	OPtoS1 Time
20	0x9A	0x14	*	42	0x96	0x0C	*	64	0x6C	0x04	Refer to 1-7.(6)
21	0x9C	0x3F	*	43	0x9C	0x3F	*	65	0x6D	0x2C	S1toS2 Time
22	0x9F	0xF9	*	44	0xCC	0x19	*	66	0x6E	0x01	Refer to 1-7.(7)

It is prohibited to change the register value marked *.

・Enable command

①Addr = 0xEF, Date = 0x01

②Addr = 0x72, Date = 0x01

The product becomes enable mode by writing ① and ② in each register in order.

1-5 Read the Coordinates

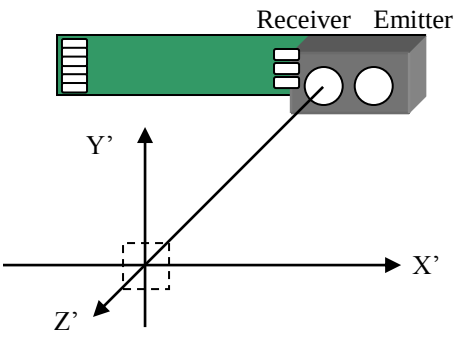
After the initial setting (1-4) and enable command and waiting T3,
Please set below value in the register.

・Addr = 0xEF, Data = 0x00

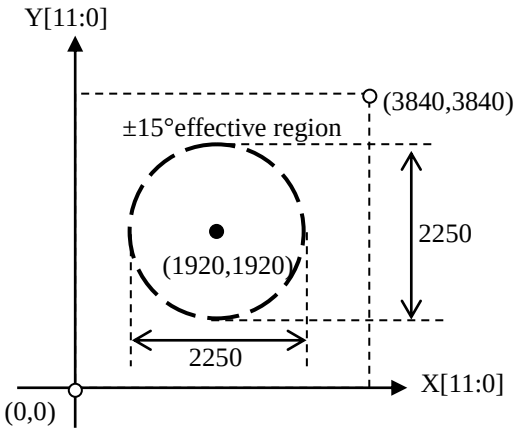
It is possible to read the coordinates of the point.
Register name (X Data, Y Data) has each 12bits. And Register name Z Data has 10bits.

Address (Hex)	Register Name	Reg Field	Notes
0xD9	Z Data[9:8]	[1:0]	Upper Bit of Spot Size
0xDA	X Data[7:0]	[7:0]	Lower bit of X Data
0xDB	X Data[11:8]	[3:0]	Upper bit of X Data
	Y Data[11:8]	[7:4]	Upper bit of Y Data
0xDC	Y Data[7:0]	[7:0]	Lower bit of Y Data
0xDD	Z Data[7:0]	[7:0]	Lower bit of Spot Size

In case that there is the vertically and horizontally symmetry object in the center line of Z-axis (refer to left below figure), the value of X, Y is (1920,1920). (refer to right below figure).
These X, Y, Z axis is the axis of coordinates of detection area. It is possible to read this coordinate value by the register. The effective region of the X and Y value is the circle of the 2250 diameter according to the detection angle ±15° (refer to right below figure). The center point of the effective region shifts θ_0 in each product.



Coordinate Axis of Detection Space



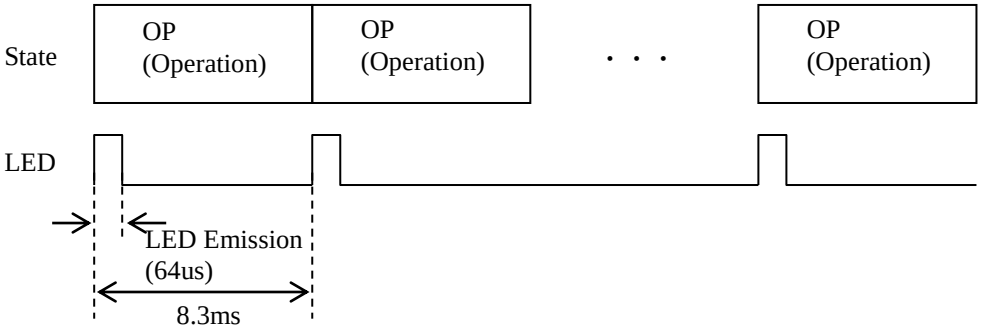
Coordinate Axis on Photo Detector

1-6 Each Operation State and State Machine Diagram

GP2Y8E01 has below four states ((1) ~ (4)) by detection condition of the object and setting the register value. Below specified value is based on standard operation condition (refer to 1-4). Specified value can be changed by setting register value. The specific changing method is written in 1-7. In addition, after changing register value, it is not specified with electro-optical characteristic written. So please confirm that there is no problem on the actual use condition.

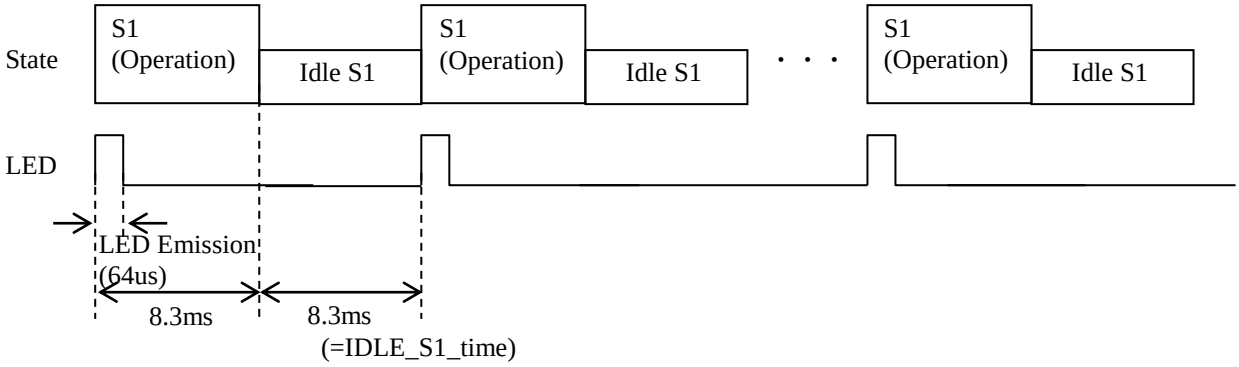
(1) Operation State (OP State)

Measured coordinate is output every 8.3ms (=120fps) in operation state.



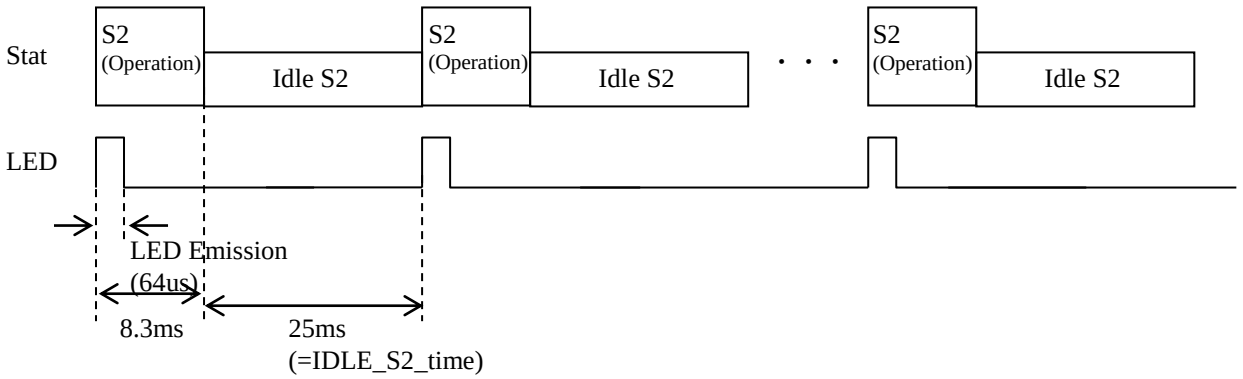
(2) Standby State1 (S1 State)

If there is no detection for 10 seconds in operation state, it will shift from operation state to standby state1. It reduces power consumption by this transition.



(3) Standby State2 (S2 State)

If there is no detection for 10 seconds in standby state1, it will shift from standby state1 to standby state2. Moreover, it reduces power consumption by this transition.



(4) Suspend State (SUS State)

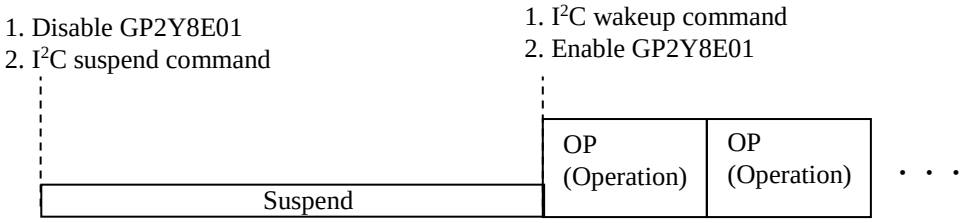
GP2Y8E01 can be the suspend state by setting the register value of disable command and suspend command in turn. And then, return to operation state from suspend state by setting register of wake up command and enable command in turn.

・Disable command
Addr = 0xEF, Data = 0x01
Addr = 0x72, Data = 0x00

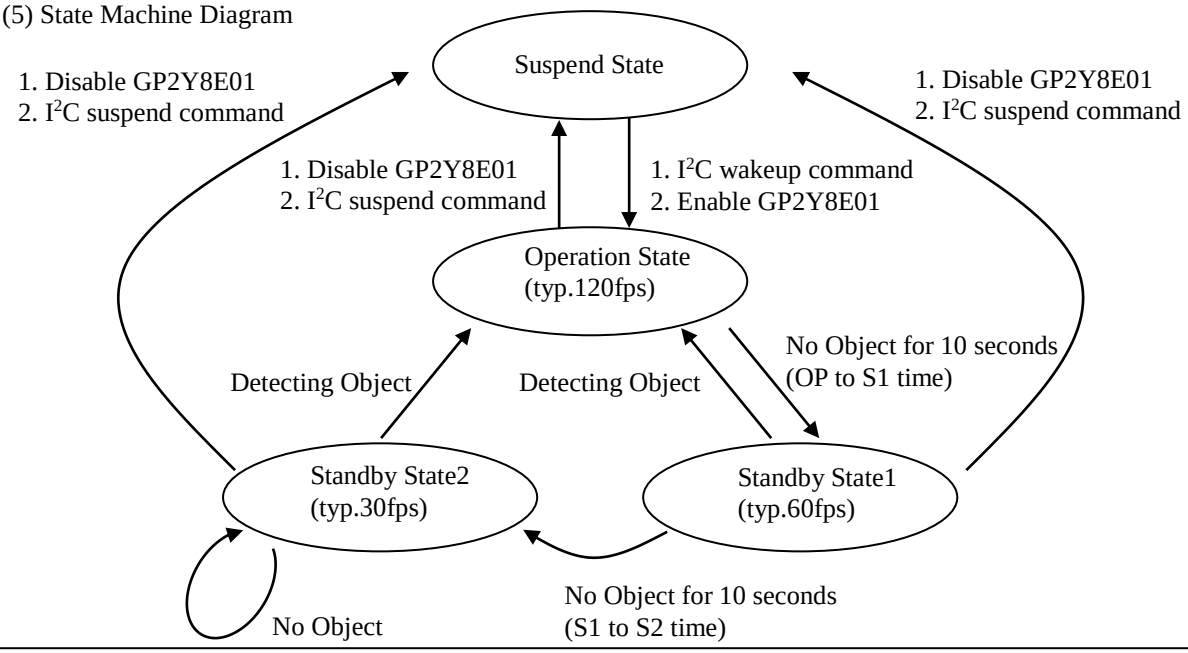
・Suspend command
Addr = 0xEF, Data = 0x00
Addr = 0x03, Data = 0x00

・Wakeup command
Refer to 1-1. (2)

・Enable command
Refer to 1-4.



(5) State Machine Diagram



1-7 Changeable Parameter

It is possible to change operation condition of below table (7 parameters) by that setting register.
Below table shows the changeable parameter and the characteristics affected by the one.

No	Items	Bank	Addr	Standard Condition	Affected Characteristic	Range	
						Min	Max
(1)	LED Current	1	0x32 0x33	typ.90mA	Distance Range:L Accuracy:⊿ Power Consumption:I_{DD},I_{DD_ST1},I_{DD_ST2}	30mA	(360mA)
(2)	Emission Pulse Width	0	0x48 0x49 0x4A 0x4B	typ.64us	Distance Range:L Accuracy:⊿ Power Consumption:I_{DD},I_{DD_ST1},I_{DD_ST2}	5us	300us
(3)	Frame Rate	1	0x65 0x66	typ.120fps	Power Consumption:I_{DD},I_{DD_ST1},I_{DD_ST2} Frame Rate:Fs	-	240fps
(4)	IDLE S1 Time	1	0x67 0x68	typ.8.3ms	Power Consumption:I_{DD_ST1}	TBD	TBD
(5)	IDLE S2 Time	1	0x69 0x6A	typ.25ms	Power Consumption:I_{DD_ST2}	TBD	TBD
(6)	OP to S1 Time	1	0x6B 0x6C	10s		TBD	TBD
(7)	S1 to S2 Time	1	0x6D 0x6E	10s		TBD	TBD

(1) LED current (Bank1 Addr = 0x32, 0x33)
It needs to be set same value in both 0x32 and 0x33 in register.
LED emits light more than 0x01 in both registers. And driving current becomes large, so that a register value is enlarged.
Driving current is about 30 mA per value 1.
Standard operation condition is typ.90mA.
It is possible to set up LED current between 30 and (360 mA).
When LED current is changed, please use the power supply that has enough in current capacity from setting current

(2) Emission pulse width (Bank0 Addr = 0x48, 0x49, 0x4A, 0x4B)
It needs to set same value both 0x48 and 0x4A in register.
Pulse width is about 0.25 μs per value 1.
Standard operation condition is typ.64μs.
It is possible to set up pulse width between 5 and 300 μs.

(3) Frame Rate (Bank1 Addr = 0x65, 0x66)
Please refer to the 1-3. register map for the calculation method of Frame Rate.
Standard operation condition is typ.120fps.
Please set up less than 240fps.

(4) IDLE S1 Time (Bank1 Addr = 0x67, 0x68)
IDLE S1 Time is the register for setting idle time under standby state1.
Frame rate of Standby state1 is set by IDLE S1 Time.
Please refer to 1-3 Register map with respect to calculation method.
Frame rate of Standby state1 is set to 60fps under standard operation condition.

(5) IDLE S2 Time (Bank1 Addr = 0x69, 0x6A)
IDLE S2 Time is the register for setting idle time under standby state2.
Frame rate of Standby state1 is set by IDLE S2 Time.
Please refer to 1-3 Register map with respect to calculation method.
Frame rate of Standby state2 is set to 30fps under standard operation condition.

(6) OP to S1 Time (Bank1 Addr = 0x6B, 0x6C)

When there is no object for certain time (below threshold of signal intensity), GP2Y8E01 is shift to standby state1 from operation state in order to decrease power consumption. OP to S1 Time is the register of setting time when there is no object. This is set to 10 seconds under standard operation condition. Please refer to 1-3. register map with respect to calculation method.

When object is detected under standby state1, it will shift to operation state. Please refer to 1-6. (5) State Machine Diagram with respect to the detail of state shift in each state.

(7) S1 to S2 Time (Bank1 Addr = 0x6D, 0x6E)

When there is no object for certain time (below threshold of signal intensity), GP2Y8E01 is shift to standby state2 from standby state1 in order to decrease power consumption. S1 to S2 Time is the register of setting time when there is no object. This is set to 10 seconds under standard operation condition.

Please refer to 1-3. register map with respect to calculation method.

When object is detected under standby state2, it will shift to operation state. Please refer to 1-6. (5) State Machine Diagram with respect to the detail of state shift in each state.

■Notes

[Advice for the optics]

- Lens of this device shall be kept cleanly. There are cases that the refractive material (for example, dust, water, oil or so on) deteriorate the characteristics of this device. Please consider the mounting state or housing structure in actual application according to the customer's environment.

- In case that protection cover is set in front of this sensor, the protection cover shall be recommended to use material which doesn't scatter light and be matt finish. And the protection cover shall be recommended to use over 90% transmittance at the emitting wavelength range of LED for this product (λ=950nm±70nm). Also, as there are cases that the characteristics may not be satisfied with according to the distance between the protection cover and this product, the thickness of the protection cover or the shape of the protection cover, please use this product after confirming the operation sufficiently in actual application.

[Advice for the characteristics]

- In case that there is an object near to light exits of the sensor between the sensor and the detected object, please use this device after confirming in actual application sufficiently whether the characteristics of this sensor do not change by the object, because there are cases that the characteristics may not be satisfied with.

- When the detector receive direct light from the sun, tungsten lamp and so on, there are cases of malfunction. Please consider the design that the detector does not receive direct light from such light source. It has the possibility to be able to avoid malfunction by means of register setting of decrease emission pulse width and increase of LED current. Please confirm the operation in actual application sufficiently because there are cases that the characteristic and ratings may not be satisfied with in case that register setting is changed.

- In case that there is the reflective object in the back of target object for coordinate measuring, there are cases of malfunction due to the reflection by it. Please use this device after confirming sufficiently.

- Output distance data between the object and this product is relative distance data and it is possible to detect the object approaching. Because of relative distance, output data is different by object size even if they are on same distance. Please consider output data is relative distance in case of using distance output data.

[Notes on handling]

- Please don't do washing. Washing may deteriorate the characteristics of optical system and so on. Please confirm resistance to chemicals under the actual usage since this product has not been designed against washing.

- If external pressure is brought on this product, there are possible that the characteristic is defected by changing position between case with lens and FPC, or FPC or chip capacitor is damaged. Please be careful.

■Important Notices

· The circuit application examples in this publication are provided to explain representative applications of SHARP devices and are not intended to guarantee any circuit design or license any intellectual property rights. SHARP takes no responsibility for any problems related to any intellectual property right of a third party resulting from the use of SHARP's devices.

· Contact SHARP in order to obtain the latest device specification sheets before using any SHARP device. SHARP reserves the right to make changes in the specifications, characteristics, data, materials, structure, and other contents described herein at any time without notice in order to improve design or reliability. Manufacturing locations are also subject to change without notice.

· Observe the following points when using any devices in this publication. SHARP takes no responsibility for damage caused by improper use of the devices which does not meet the conditions and absolute maximum ratings to be used specified in the relevant specification sheet nor meet the following conditions:
(i) The devices in this publication are designed for use in general electronic equipment designs such as:
--- Personal computers
--- Office automation equipment
--- Telecommunication equipment [terminal]
--- Test and measurement equipment
--- Industrial control
--- Audio visual equipment
--- Consumer electronics
(ii) Measures such as fail-safe function and redundant design should be taken to ensure reliability and safety when SHARP devices are used for or in connection with equipment that requires higher reliability such as:
--- Transportation control and safety equipment (i.e., aircraft, trains, automobiles, etc.)
--- Traffic signals
--- Gas leakage sensor breakers
--- Alarm equipment
--- Various safety devices, etc.
(iii) SHARP devices shall not be used for or in connection with equipment that requires an extremely high level of reliability and safety such as:
--- Space applications
--- Telecommunication equipment [trunk lines]
--- Nuclear power control equipment
--- Medical and other life support equipment (e.g., scuba).

· If the SHARP devices listed in this publication fall within the scope of strategic products described in the Foreign Exchange and Foreign Trade Law of Japan, it is necessary to obtain approval to export such SHARP devices.

· This publication is the proprietary product of SHARP and is copyrighted, with all rights reserved. Under the copyright laws, no part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, in whole or in part, without the express written permission of SHARP. Express written permission is also required before any use of this publication may be made by a third party.

· Contact and consult with a SHARP representative if there are any questions about the contents of this publication.