dToF Sensor

EDTOF 4424

DATASHEE**T (Preliminary)**

Edison EDToF Series delivers high-precision distance sensing powered by a 940nm VCSEL-based ToF sensor with advanced SPAD architecture. With a 24° FoV, multi-object detection and ranging capability up to 5,000mm, these sensors offer outstanding accuracy and low power consumption for various applications.

Features

- Size: 4.4 mm × 2.4 mm × 1.0 mm.
- Typical full FoV : 24°single zone detect with multi-objects detection (three objects).
- High accurate detection with long and short distance.
- Provide interrupt GPIO pin for frame ready event.
- Works with many types of cover glass materials and compensate for smudge on glass.
- Ultra-low power without firmware update.
- Class 1 Eye Safety.

Applications

- IoT (User and object detection).
- Presence detection for laptop.
- Collision avoidance for robots.
- Video focus tracking assistance.

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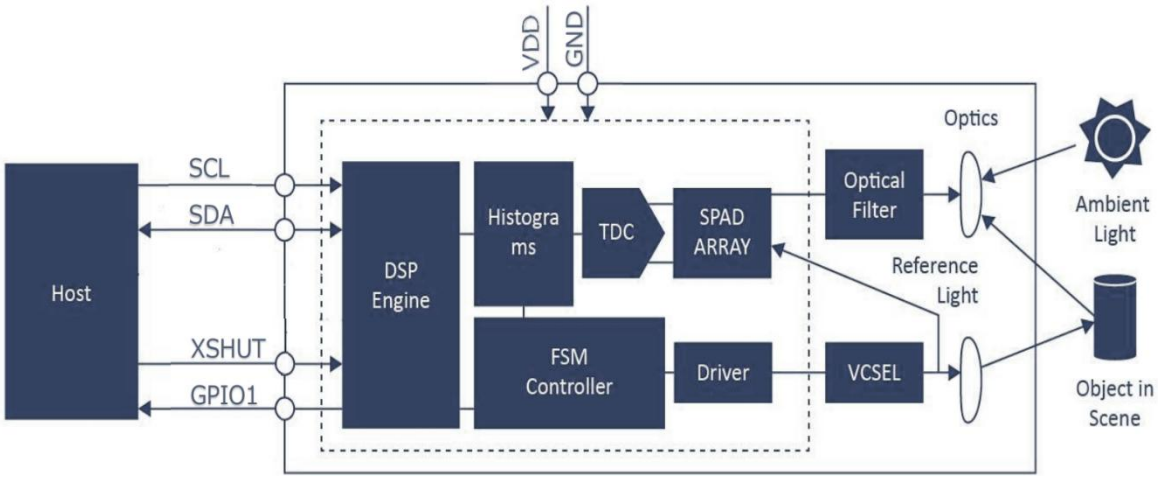
Product Code Information

Part No.	Description
RS28010123249001	1 zone_ LGA12 4424_940nm_FoV 24_module

Sensor Module Description

Block Diagram



Technical specification:

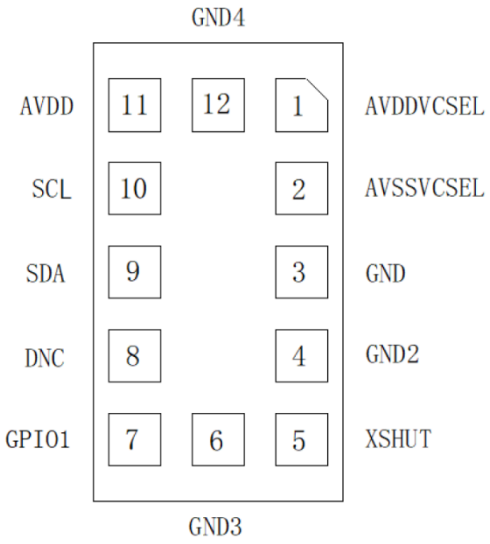
Pin Name	Detail
Package	Optical LGA12
Size	4.4 mm × 2.4 mm × 1.0 mm
Operating voltage	2.8 to 3.3V
Operating temperature	-20 to 85°C
Infrared emitter	940nm
I²C	Up to 1 MHz serial bus

Electrostatic discharge (ESD)

Parameter	Condition	Specification
Human body model	± 2,000V, 1,500 Ohms, 100pF	JS-001-2017
Charged device model	± 500 V	JESD22-C101-C

NOTE: This module complies with the electrostatic discharge (ESD) values shown in the table above.

Pin Diagram (TOP view)

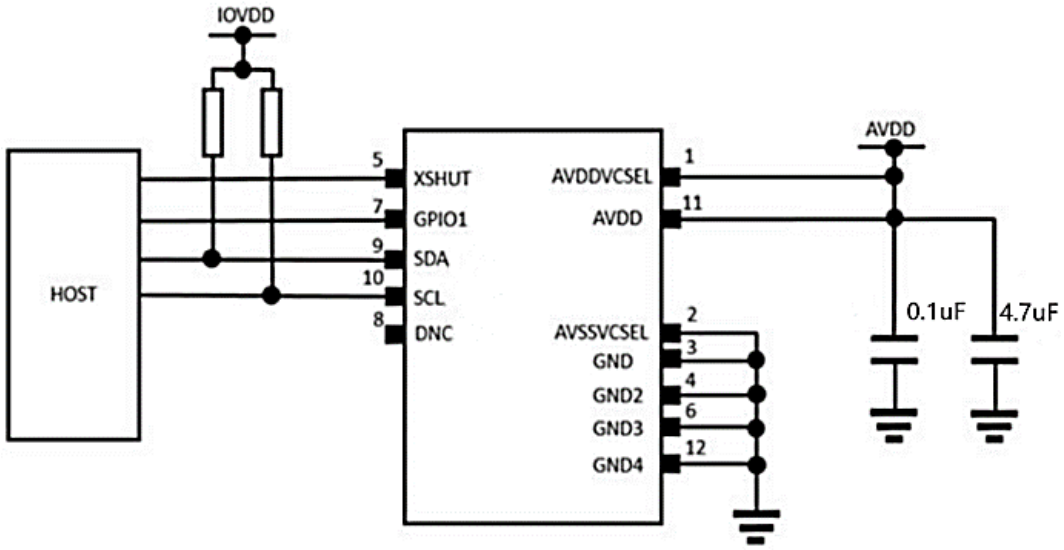


Pin Name	Number	Signal Type	Description
AVDDVCSEL	1	Power supply	VCSEL supply, to be connected to main supply
AVSSVCSEL	2	Ground	VCSEL ground, to be connected to main ground
GND	3	Ground	to be connected to main ground
GND2	4	Ground	to be connected to main ground
XSHUT	5	Digital input	Xshutdown pin, active low
GND3	6	Ground	to be connected to main ground
GPIO1	7	Digital output	Interrupt pin
DNC(*)	8	VCCIO	For 1.8V IO, do not connect to GND, must be floating
SDA	9	Digital IO	I²C data
SCL	10	Digital input	I²C clock input
AVDD	11	Power supply	Supply, to be connected to main supply
GND4	12	Ground	to be connected to main ground

NOTE: For 3.3V IO applications, DNC needs to connect external power supply, and bypass DNC to GND with a 1uF capacitor.

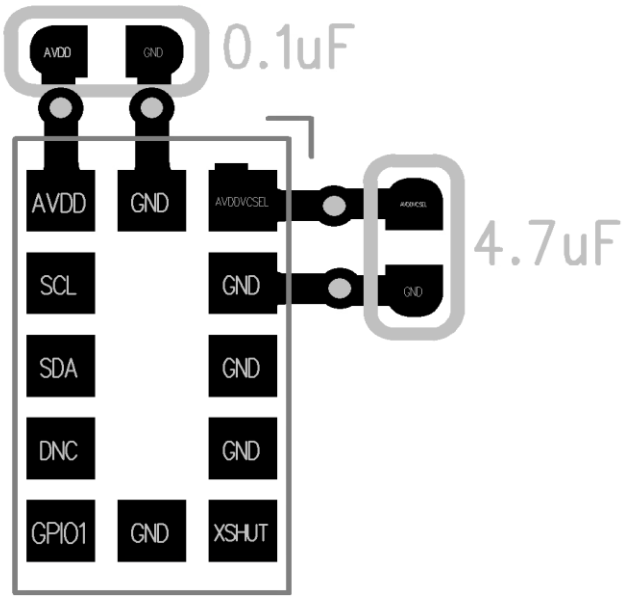
Application Information

Application Schematic:



NOTE: GPIO1 as interrupt pin, shouldn’ t be pulled up.

PCB Layout Recommendation



NOTE: Bypass capacitors should be placed as close as possible to the supply and ground pins.

Electrical Characteristic

Absolute Maximum Ratings

Parameter	Symbol	Value		Unit
		Min	Max	
Supply 3V Voltage to GND	AVDD, AVDDVSCEL	-0.3	3.6	V
Ground	GND, GND2, GND3, GND4, AVSSVCSEL	0	0	V
VCCIO	DNC	-0.3	3.6	V
Digital output	GPIO1	-0.3	3.6	V
Digital I/O	SDA	-0.3	3.6	V
Digital input	SCL	-0.3	3.6	V
Analog input	XSHUT	-0.3	3.6	V

Temperature-dependent Characteristics

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Storage Temperature Range	T_{STRG}	-40	-	85	°C
Package Body Temperature	T_{BODY}	-	-	260(*)	°C
Relative Humidity(non-condensing)	RH_{NC}	-	-	85	%

NOTE: IPC / JEDEC J-STD-020: The reflow peak soldering temperature (body temperature) is specified according to IPC / JEDEC J-STD-020 “Moisture / Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices.”

Digital input and output

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
GPIO Pin					
Low level input voltage	VIL	-0.3	-	0.3 * IOVCC	V
High level input voltage	VIH	0.7 * IOVCC	-	1.1 * IOVCC	V
Low level output voltage (I_{out} = 6mA)	VOL	-	-	0.4	V
High level output voltage (I_{out} = 6mA)	VOH	0.8 * IOVCC	-	-	V
Low level input leakage @ Vi = 0V	IIL	-0.15	-	0.15	uA
High level input leakage @ Vi=1.1*IOVCC	IIH	-10	-	10(*)	uA
RESET Pin					
Low level input voltage	VIL	-0.3	-	0.5	V
High level input voltage	VIH	1.17	-	1.1 * IOVCC	V
Low level input leakage @ Vi = 0V	IIL	-0.15	-	0.15	uA
High level input leakage @ Vi=1.1*VCCIO	IIH	-10	-	10	uA

NOTE: When IOVCC using external VCC,IIH < 30uA@Temp > 60°.

Typical Operating Conditions

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Supply 3.3V Voltage to GND	AVDD, AVDDVCSEL	2.8	3.3	3.6	V
Internal 1.8V, no need supply	DNC	1.68	1.8	2	V
External 3.3V, need supply		2.8	3.3	3.6	V
Digital I/O with internal VCCIO	VOL	1.68	1.8	2	V
Digital I/O with external VCCIO		2.8	3.3	3.6	V
Digital I/O with internal VCCIO	GPIO1	1.68	1.8	2	V
Digital I/O with external VCCIO		2.8	3.3	3.6	V
Digital input with internal VCCIO	SDA	1.68	1.8	2	V
Digital input with external VCCIO		2.8	3.3	3.6	V
Analog input with internal VCCIO	XSHUT	1.68	1.8	2	V
Analog input with external VCCIO		2.8	3.3	3.6	V
Free air temperature	Temperature Range	-20	25	85	°C

NOTE:

※ Device parameters are guaranteed at nominal conditions unless otherwise NOTEd. While the device is Operational across the temperature range, functionality will vary with temperature.

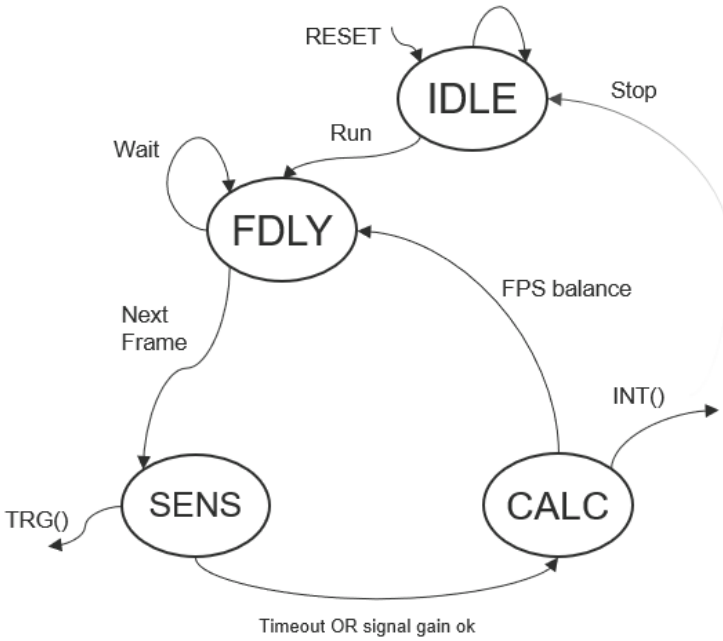
※ XSHUT: VIL650mV, VIH850mv.

Power Consumption

Mode	Duty Ration	Typ	Unit
Idle	Re-initialization required 2.8V power support.	10	uA
Active Ranging	Ranging 30 Hz, 33 ms, default settings, open power saving feature 2.8V power support.	25	mA
VCCIO	Ranging 5 Hz, default settings, open power saving feature 2.8V power support.	5.7	mA

Functional description

State Machine



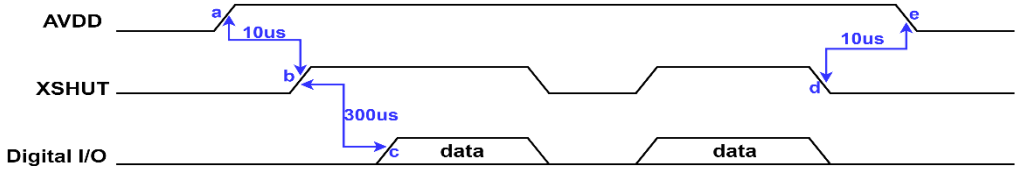
The FSM is in default IDLE state after power up. During this state, Driver will do housekeeping sequence to setup, and configure the chip to expected working mode.

Then the software driver will configure the chip to enter working mode. In working mode, chip will enter FDLY state first. As for each FRAME, this state will help balance the Frame period configured by registers.

After each frame delay cycle has finished, FSM will start sensing, this is SENS state. In this state, chip will trigger multiple configured laser pulses, and for each trigger, wait for configured times based on configured clock frequency. The time of SENS state can be configured by two aspects, 1st is highest signal value, when the max value in histogram reached configured value, SENS state will finish and FSM proceed to next state, 2nd is timeout, if maximum (timeout) flashes reached, before max histogram value reached its threshold, FSM will also move on to CALC state.

CALC state is for point distance calculation, during this state, histogram will be processed by internal DSP. After the DSP processing has finished, an interrupt request will be sent out to chip, generating an interrupt. FSM move on to FPS balance, and then start the next frame.

Operation Sequence



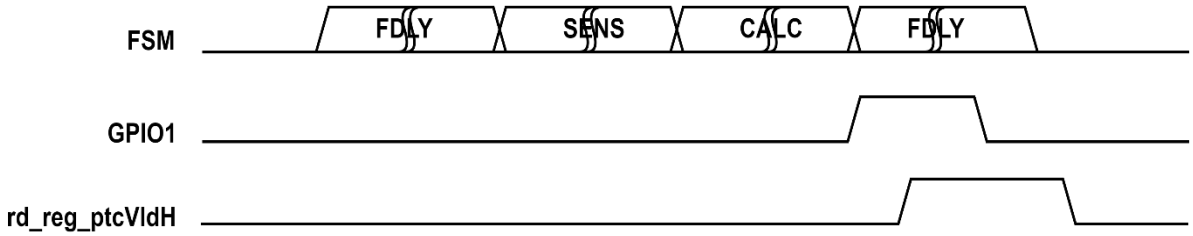
NOTE:

※ In Power up sequence, AVDD should be powered up. After power up, the XSHUT pin can be set to 1 after a 10 us delay. Digital I/O can be ready for operation after another 300us delay.

※ In Power down sequence, to avoid electricity leakage, XSHUT pin must be set to 0 before AVDD is powered down. This time delay is 10us.

※ Digital I/O include GPIO1, SDA, SCL.

Interrupt Behavior and Timing



NOTE:

※ The GPIO1 is level-sensitive interrupt pin which can be HIGH active.

※ The interrupt will be HIGH at the end of each frame and can be cleared by reading register ptcVldH.

Communication Interfaces

I²C Protocol

The device uses I2C serial communication protocol for communication. The device supports 7-bit chip addressing and both standard and full-speed clock frequency modes. Read and Write transactions comply with the standard set by Philips (now NXP). For a complete description of the I2C protocol, please review the NXP I2C design specification.

Internal to the device, an 8-bit buffer stores the register address location of the desired byte to read or write. This buffer auto-increments upon each byte transfer and is retained between transaction events (i.e. valid even after the master issues a STOP command and the I2C bus is released). During consecutive Read transactions, the future / repeated I2C Read transaction may omit the memory address byte normally following the chip address byte, the buffer retains the last register address +1.

All 16-bit fields have a latching scheme for reading and writing. In general, it is recommended to use I2C bursts whenever possible, especially in this case when accessing two bytes of one logical entity. When reading these fields, the high byte must be read first, and it triggers a 16-bit latch that stores the 16-bit field. The low byte must be read immediately afterwards. When writing to these fields, the high byte must be written first, immediately followed by the low byte. Reading or writing to these registers without following these requirements will cause errors.

A Write transaction consists of a START, CHIP-ADDRESSWRITE, REGISTER-ADDRESS WRITE. DATA BYTE (S), and STOP. Following each byte (9TH clock pulse) the slave places an ACKNOWLEDGE / NOT-ACKNOWLEDGE (ACK / NACK) on the bus. If NACK is transmitted by the slave, the master may issue a STOP.

A Read transaction consists of a START, CHIP-ADDRESSWRITE, REGISTER-ADDRESS, RESTART, CHIP-ADDRESSREAD, DATA BYTE (S), and STOP. Following all but the final byte, the master places an ACK on the bus (9TH clock pulse). Termination of the Read transaction is indicated by a NACK being placed on the bus by the master, followed by STOP.

The I²C Device Address

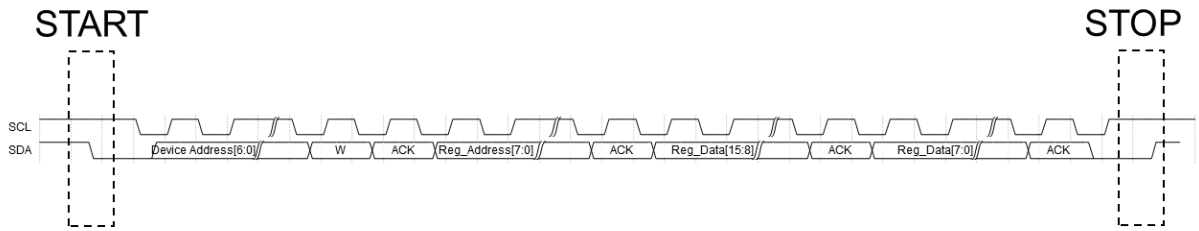
The Sensor contains eight-bit registers accessed via the I2C bus. All operations can be controlled by the command register. The simple command structure makes user easy to configure the operation setting and latch the output data from the Sensor.

The Sensor provides fixed I2C slave address of 0x10 or 0x01 (default) using 7 bit addressing protocol.

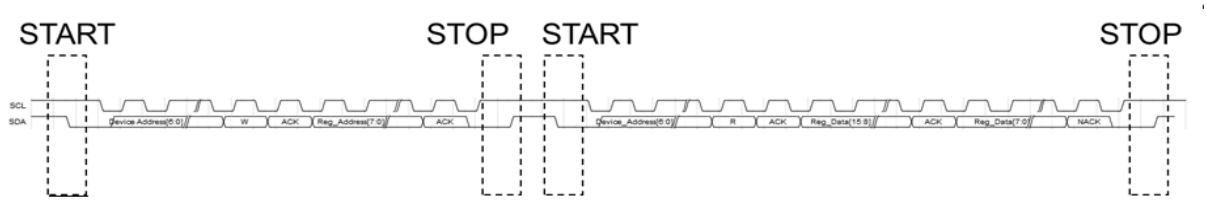
The address is record in the OTP during the CP testing process.

7-bit Slave Address	R/W Command Bit 0	Operation
0x10 or 0x01	0	Write Command to Sensor
	1	Read Data from Sensor

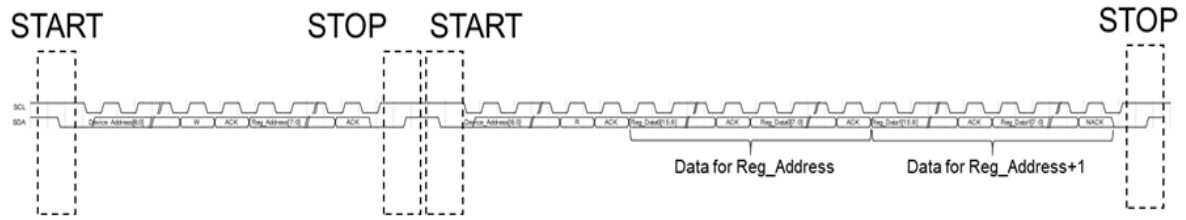
I²C Write



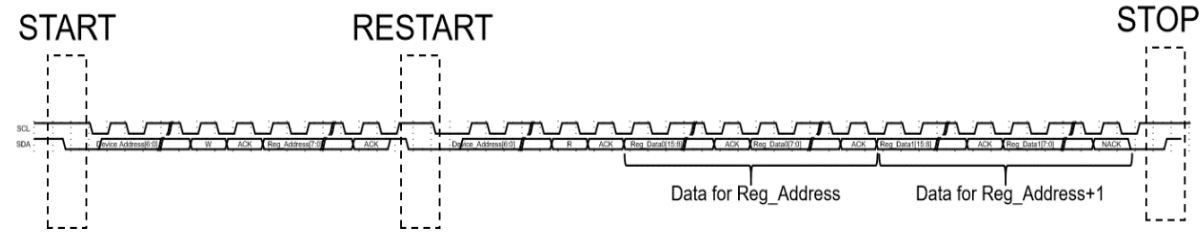
I²C Read



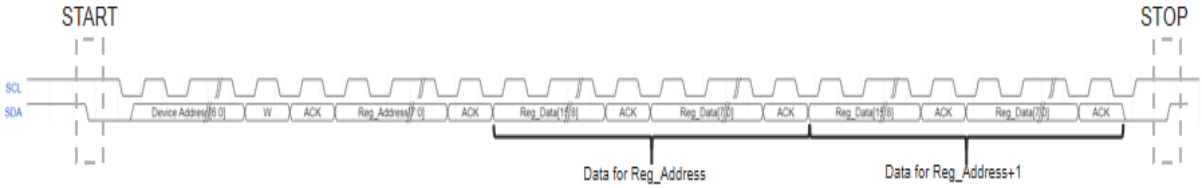
I²C Sequential Read with STOP / START



I²C Sequential Read with RESTART

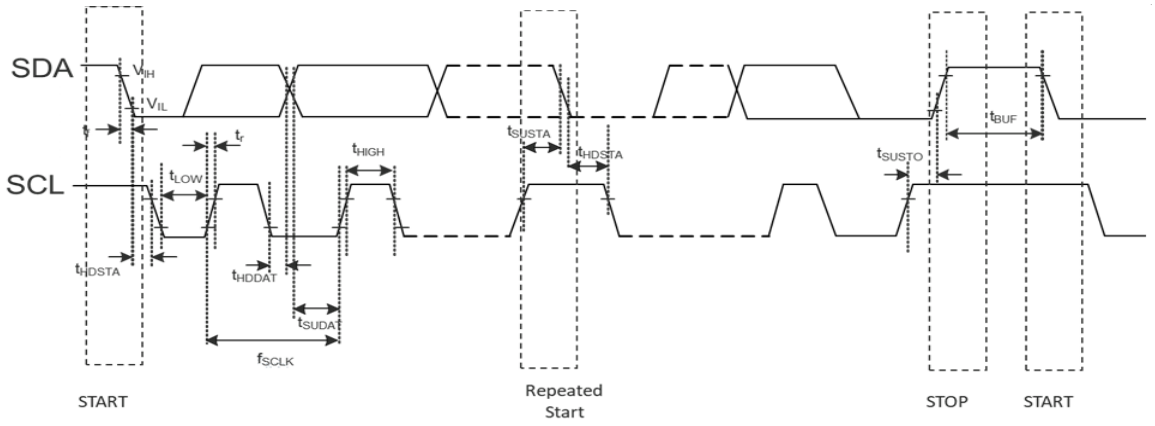


I²C Sequential Write



NOTE: with I²C sequential write mode, support Registers and RAM.

I²C Timing Specification



NOTE: The I²C Timing Specification is as shown.

Parameter	Symbol	Standard Mode		Fast Mode		Fast Plus Mode		Unit
		Min	Max	Min	Max	Min	Max	
SCL clock frequency	F_{SCL}	0	100	0	400	0	1,000	KHz
Hold time after (repeated) start condition. After this period, the first clock is generated.	$t_{HD.STA}$	4.0	-	0.6	-	0.26	-	us
Low period of the SCL clock	t_{LOW}	4.7	-	1.3	-	0.5	-	us
HIGH period of the SCL clock	t_{HIGH}	4.0	-	0.6	-	0.26	-	us
Set-up time for a repeated START condition	$t_{SU.STA}$	4.7	-	0.6	-	0.26	-	us
Data in hold time	$t_{HD.DAT}$	0.25	-	0.25	-	0.25	-	us
Data in setup time	$t_{SU.DAT}$	250	-	100	-	50	-	ns
Rise time of both SDA and SCL signals	t_R	-	1,000	-	300	-	120	ns
Fall time of both SDA and SCL signals	t_F	-	300	-	300	-	120	ns
Set-up time for STOP condition	$t_{SU.STO}$	4.0	-	0.6	-	0.26	-	us
Bus free time between STOP and START condition	t_{BUF}	4.7	-	1.3	-	0.5	-	us

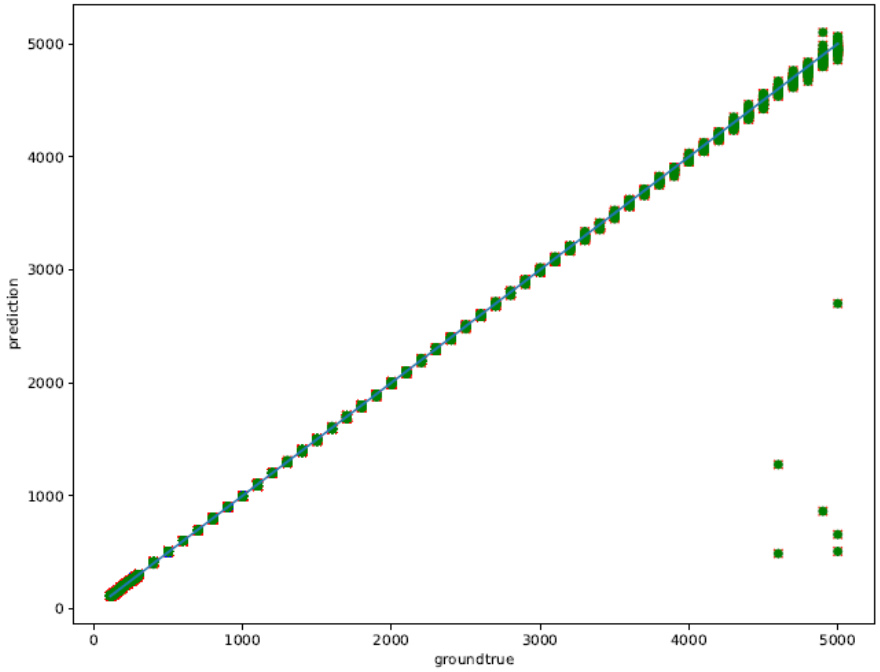
Ranging Accuracy

Measurement conditions

- The full of FoV (Field of View) is covered by 24 degrees.
- Targets used are grey (10 % reflectance) and white (80 % reflectance).
- Normal voltage supply (2.8V) and temperature (23 °C).
- Indoor: No external light within the wavelength band 940nm, +/- 30nm..
- All tests are performed without cover glass.
- Range 200 mm~5,000 mm.
- Typical samples used.

Target reflectance	Performance		Dark
White 88 %	Max distance		5,000 mm
	Accuracy	20 ~ 90 mm	±8 mm
		90 ~ 200 mm	±5 %
		200 ~ 5,000 mm	±3 %
Grey 17 %	Max distance		2,900 mm
	Accuracy	20 ~ 90 mm	±7 mm
		90 ~ 200 mm	±5 %
		200 ~ 2,900 mm	±3 %

88 % White Card, ranging distance 200 mm to 5,000 mm



Measurement conditions for ambient light:

- The full of FoV (Field of View) is covered by 24°.
- Targets used are grey (17 % reflectance) and white (88 % reflectance).
- Normal voltage supply (2.8V or 3.3V) and temperature (23 °C).
- Tests are performed with 1,950 lux Halogen Lamp on (is equivalent to 10kLux sunlight).
- All tests are performed without cover glass.
- Up to 800mm detection distance with white targets with 88% reflectance.

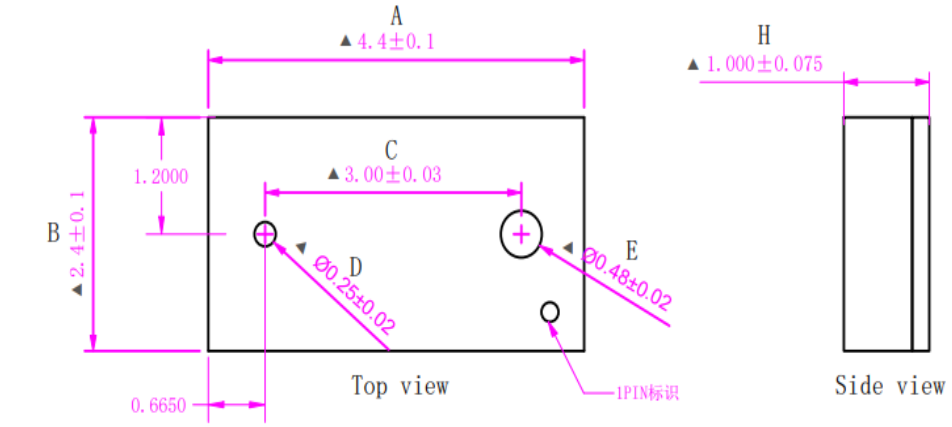
  Up to 1,100mm detection distance with grey targets with 17% reflectance.

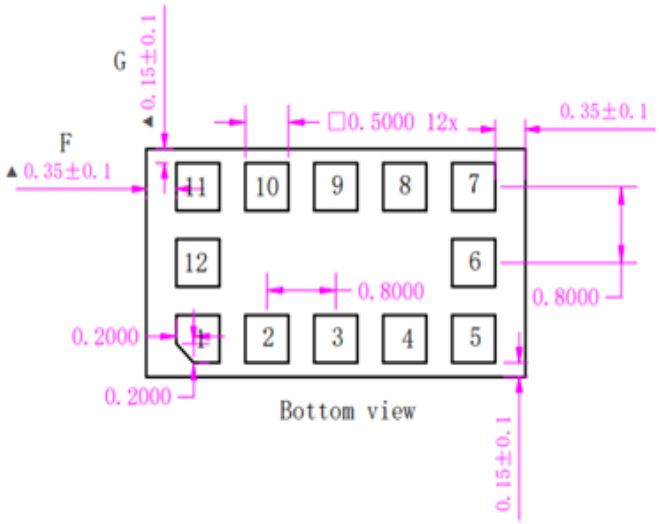
Target reflectance	Performance		Ambient (IR Light)
White 88 %	Max distance		800 mm
	Accuracy	200 ~ 800 mm	±3 %
Grey 17 %	Max distance		1,100 mm
	Accuracy	200 ~ 1,100 mm	±3 %

NOTE: IR light represents 10k sunlight equivalence, light on object only.

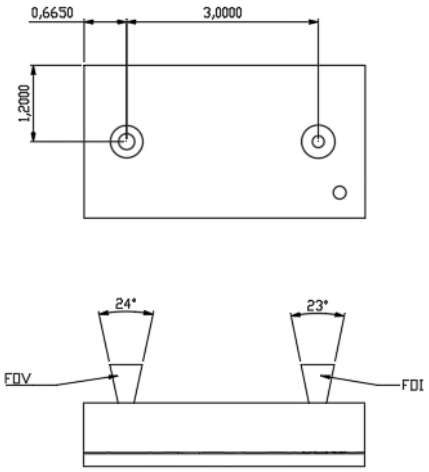
Outline drawings

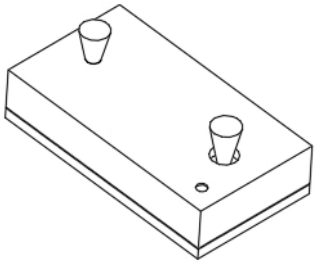
Mechanical Dimensions & FoI/FoV drawing





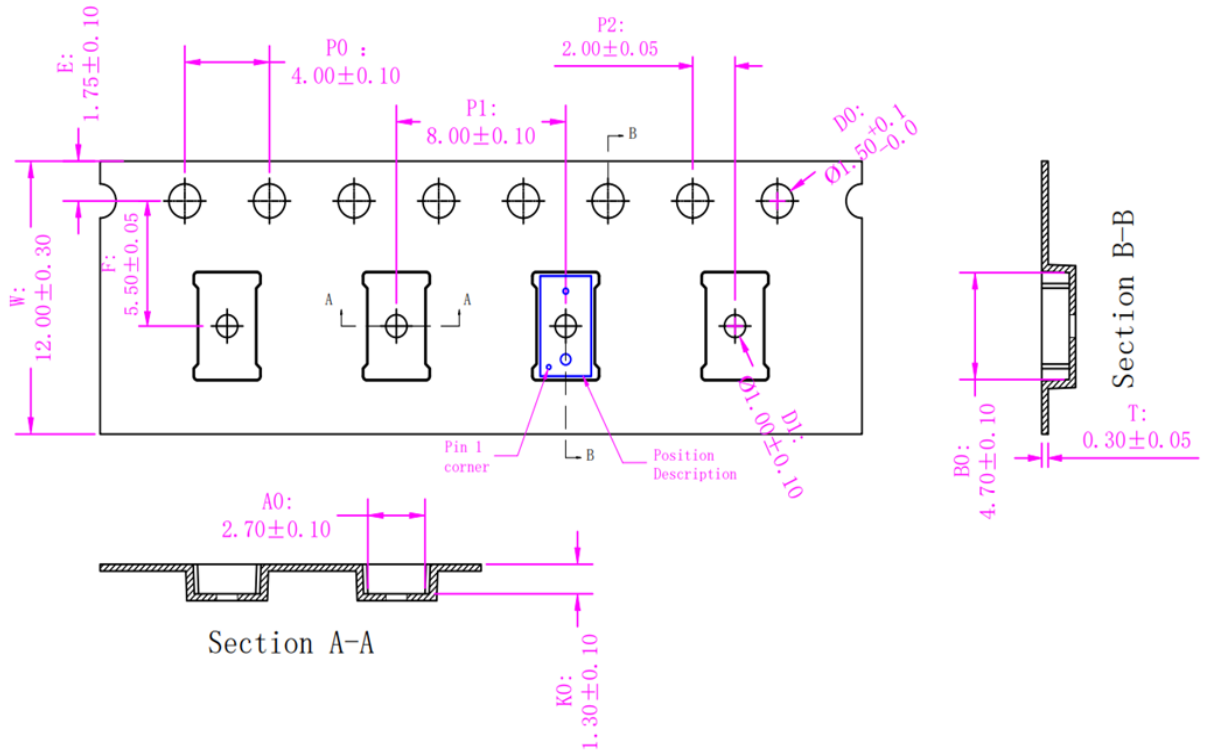
Pin Define	
1	AVDDVCSEL
2	AVSSVCSEL
3	GND
4	GND2
5	XSHUT
6	GND3
7	GPIO1
8	DNC
9	SDA
10	SCL
11	AVDD
12	GND4





NOTE: All dimension unit in mm

Product Packaging Information



Symbol	Ao	Bo	Ko	P0	P1	P2
Spec	2.70±0.10	4.70±0.10	1.30±0.10	4.00±0.10	8.00±0.10	2.00±0.05

Symbol	E	D0		D1	W	T
Spec	1.75±0.10	Ø1.50+0.10/-0.0	Ø1.00±0.10	12.0±0.30	0.30±0.05	

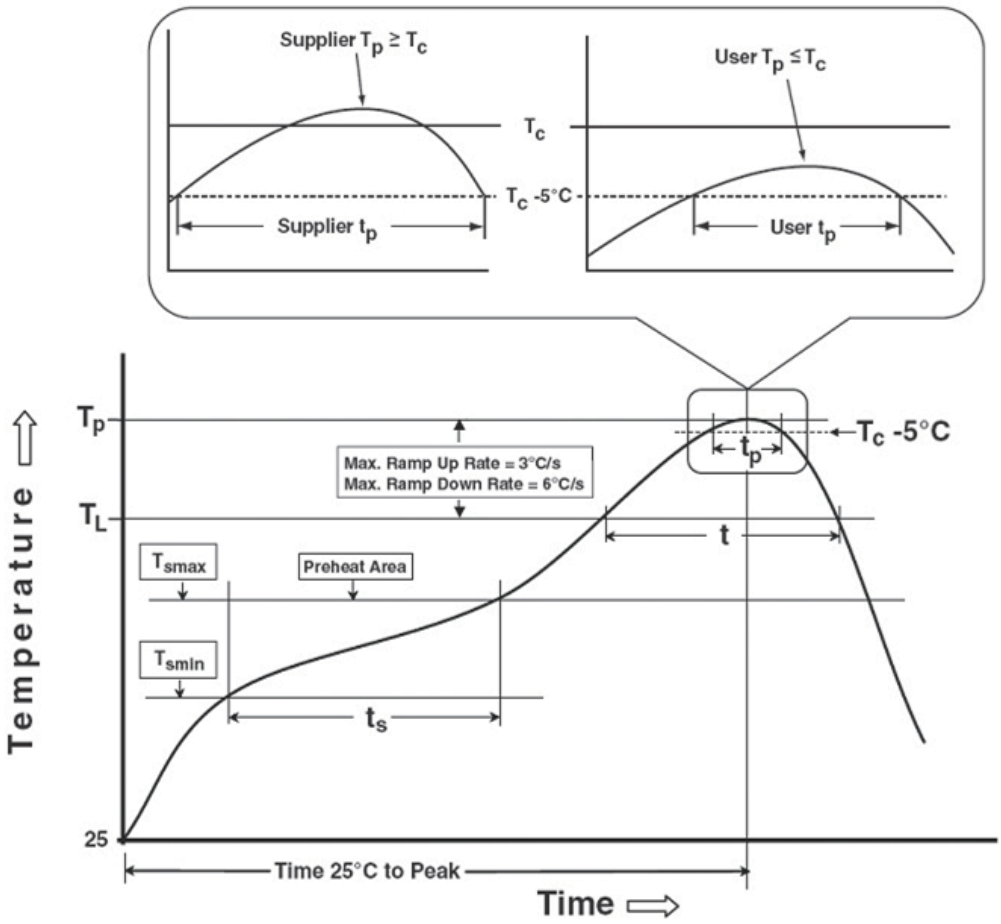
Item	Quantity	Total	Dimensions(mm)
Reel	5,000pcs	5,000pcs	D-330

NOTE:

※ All dimension unit in mm
※ sprocket hole pitch cumulative tolerance ±0.2
※ Camber in compliance with EIA 481
※ Carrier camber is within 1mm in 250mm.
※ Material: black conductive polystyrene alloy.
※ Moisture sensitivity level (MSL) is level 3 as described in IPC/JEDEC JSTD-020-C

Reflow Profile

The following reflow profile is from IPC/JEDEC J-STD-020D which provided here for reference.



Profile Feature	Pb-Free Assembly
Preheat & Soak	150 °C
Temperature min (Tsmin) Temperature max	200 °C
(Tsmax) Time (Tsmin to Tsmax) (ts)	60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3 °C/second max.
Liquidous temperature (TL)	217 °C
Time at liquidous (tL)	35-60 seconds
Peak package body temperature (Tp)	255 °C ~260 °C
Classification temperature (Tc)	250 °C
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25oC to peak temperature	8 minutes max.

Precaution for Use

1. Specifications and technical data may be modified without notice. Performance graphs are illustrative; actual results require validation.
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Datasheet History

Versions	Description	Release Date
1	Establish order code information	2024 / 11 / 07
2	Add Technical specification	2024 / 12 / 31

About EDISON OPTO

Edison Opto provides comprehensive LED and solid-state lighting products from LED Component, Light Module, UV / IR LED, LED sensing, Horticulture and Automotive Lighting. With a view to improve R&D process, Edison Opto develops the vertical platform on TEMOTM (Thermal．Electrical．Mechanical．Optical) to ensure the quality of products and services; Furthermore, Edison Opto creates LDMSTM (LED Design Manufacturing Service) from light source to luminaire manufacturing, to serve our customers a quality experience of customized solutions.

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