Digital Output Type Ambient Light Sensor with I2C Interface

General Description

The uS5151 is an integrated ambient light sensor for I2C BUS interface with a 9-bit SAR type ADC. It is easily operated via a simple I2C command by digital output interface.

It is possible to detect wide range from darkness to direct sunlight environment. The best spectral sensitivity is used to closely capture real human eye responses.

These ICs are the most suitable to obtain the ambient light data for adjusting LCD and Keypad backlight power of Mobile phone.

The uS5151 is a digital output ambient light sensor available in ODFN2x2-6L and ODFN2.35x1.8-6L packages.

Applications

- **Mobile Phones, Smart Phones**
- **LCD TVs, PDP TVs**
- **Laptop PCs, LCD Displays**
- **Portable Game Consoles**
- **Digital Cameras, Digital Video Cameras**
- **Car Navigations, PDAs**

Features

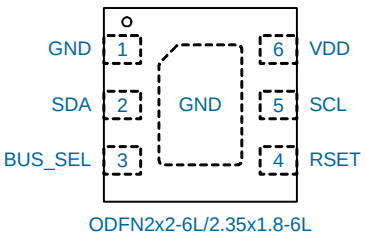
- **Supply Voltage Range from 2.8V to 5.5V**
- **Spectral Sensitivity Close to Human Eyes Sensitivity**
- **Output Current in Proportion to Brightness**
- **Built-in Shutdown Function**
- **9-bit Resolution**
- **IR + UV Rejection**
- **Integrated 50/60Hz Noise Rejection**
- **Low Supply Current**
- **Space Saving ODFN Packages**

Ordering Information

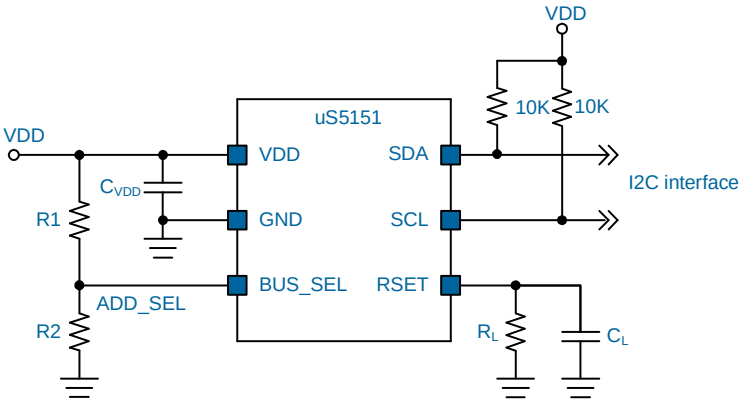
Order Number	Package	Remark
uS5151ADQ6	ODFN2x2-6L	
uS5151ADT6	ODFN2.35x1.8-6L	

Note: uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and suitable for use in Pb-free soldering processes.

Pin Configuration & Typical Application Circuit



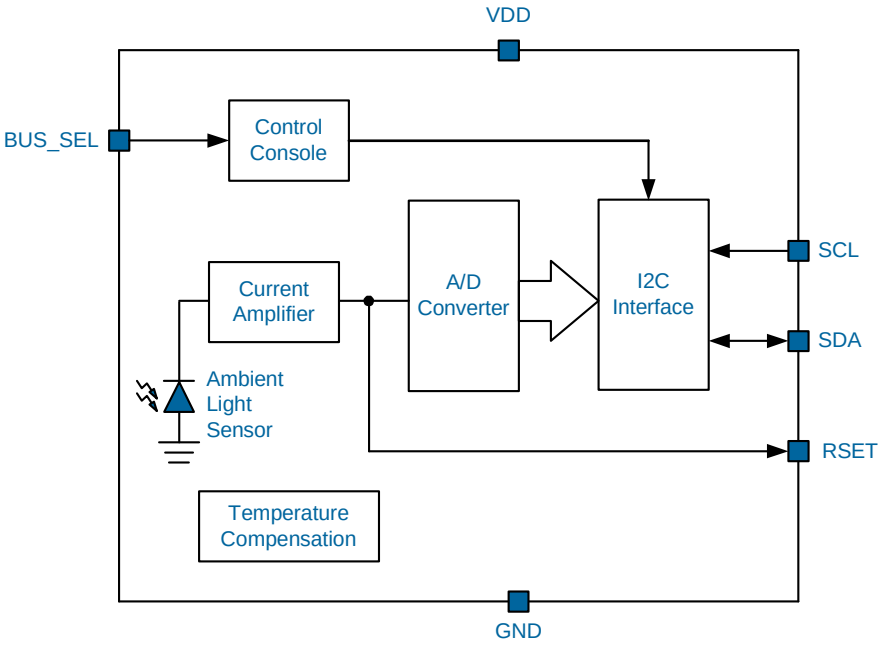
ODFN2x2-6L/2.35x1.8-6L



Functional Pin Description

Pin	Pin Name	Description
1	GND	**Ground.**
2	SDA	**Serial Data Input.** This pin is input or output of serial bus data signal.
3	BUS_SEL	**Bus Address Selection.** Connect a voltage divider to program the bus address of the uS5151.
4	RSET	The pin sourcing current at this pin is proportional to the illumination level. RSET pin connect external resistor to GND will output voltage for internal ADC converter.
5	SCL	**Serial Clock Input.** This pin receives serial bus clock signal.
6	VDD	**Supply Voltage Input.**
Exposed Pad		**Ground.**

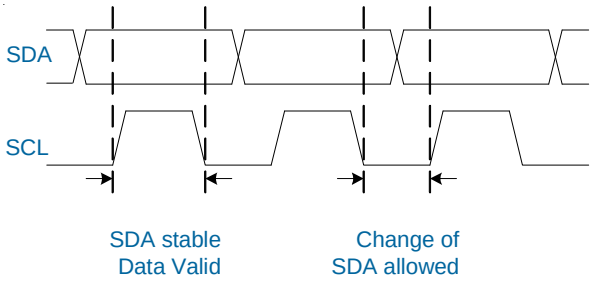
Functional Block Diagram



Functional Description

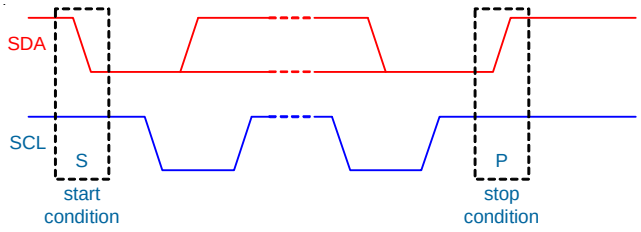
I2C Interface Data Validity

The data on the SDA line must be stable during the HIGH period of the SCL, unless generating a START or STOP condition. The HIGH or LOW state of the data line can only change when the clock signal on the SCL line is LOW. Refer to the figure below.



I2C Start and Stop Conditions

A START (S) condition is a HIGH to LOW transition of SDA while SCL is HIGH. The STOP (P) condition is a LOW to HIGH transition of SDA while SCL is HIGH. A STOP condition must be sent before each START condition.



I2C Acknowledge

Each address and data transmission uses 9 clock pulses. The ninth pulse is the acknowledge bit (A). After the start condition, the master sends 7 slave address bits and a R/W bit during the next 8 clock pulses. During the ninth clock pulse, the device that recognizes its own address pulls SDA low to acknowledge. The acknowledge bit is also used by both the master and the slave to acknowledge receipt of register addresses and data.

Read and Write Protocol

Write to a Single Register

S	slave_addr+W [A7 : A0]	AS	reg_addr (index) [I7 : I0]	AS	reg_data [D7 : D0]	AS	P

Read from a Single Register

S	slave_addr+W [A7 : A0]	AS	reg_addr (index) [I7 : I0]	AS	RS	slave_addr + R [A7 : A0]	AS	reg_data [D7 : D0]	NA	P

S = Start, P = Stop, AS = ACK from slave, AM = ACK from master, NA = No ACK, RS = Repeat Start

I2C Write Timing Diagram Sample

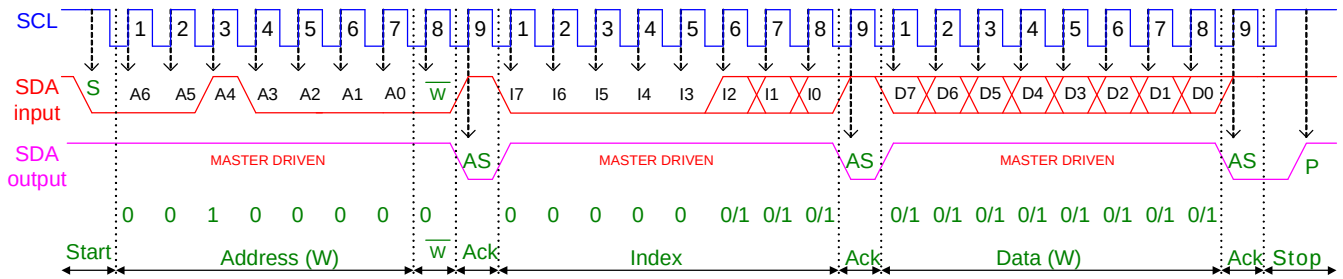


Figure 1. WRITE example

I2C Read Timing Diagram Sample

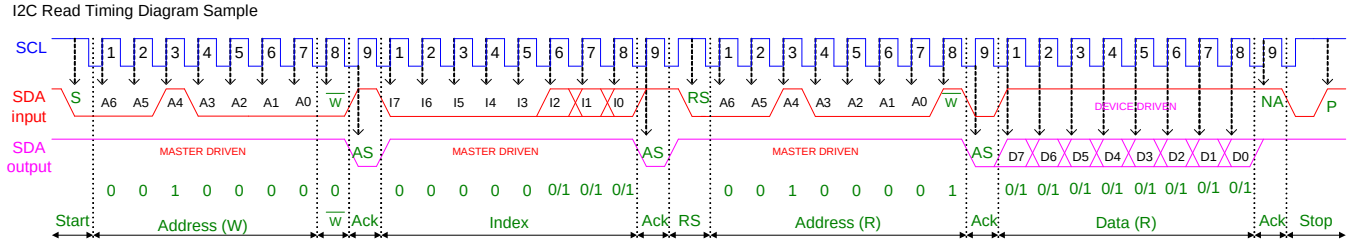
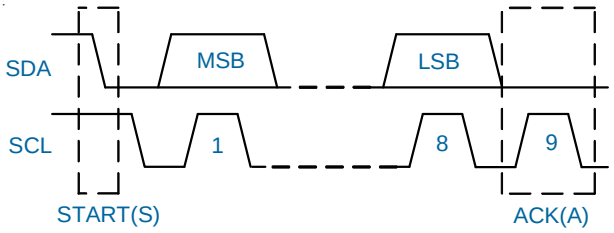


Figure 2. READ example



I2C Address Programming

The uS5151 features user programmable address by a voltage divider from VCC-to-BUS_SEL-to-GND as shown in the *Typical Application Circuit*. BUS_SEL pin voltage is compared with internal reference voltage for address programming. There are total 3 addresses available. Table 1 illustrates recommended external voltage divider for address programming.

Table 1. Recommended Address Programming

8bit Address Format (Write/Read)	0111_000X (70h/71h)	0010_000X (20h/21h)	1001_000X (90h/91h)
7bit Address Format	0111_000 38h	0010_000 10h	1001_000 48h
R1(kohm)	open	open	10
R2(kohm)	10	open	open
BUS_SEL Input Voltage(% of VCC)	0	Input floating	100

I2C Programming Interface

The uS5151 owns a 9-bits A/D converter that it can provide a high resolution on light intensity sensing that are programmed by Reg0x01, Reg0x02 and Reg0x03 respectively.

Enable(Reg0x01)

Reg0x01[7] = 0: disable the chip

Reg0x01[7] = 1: enable the chip

Reg0x02[7:0], Reg0x03[7] : Ambient Light Sensor (ALS) A/D Converter Data Output Byte

The RSET pin voltages are directly digitalizzed by A/D converters and interfaced with microprocessors by I2C bus. The A/D converters have resolutiom of 4mV and full scale of to 2.048V. The A/D converter outputs are stored in Reg0x03[7] and Reg0x02[0:7] respectively.

Reg0x02[7] → ALS_Bit8

Reg0x02[6] → ALS_Bit7

Reg0x02[5] → ALS_Bit6

Reg0x02[4] → ALS_Bit5

Reg0x02[3] → ALS_Bit4

Reg0x02[2] → ALS_Bit3

Reg0x02[1] → ALS_Bit2

Reg0x02[0] → ALS_Bit1

Reg0x03[7] → ALS_Bit0

Table 2. I2C Registers Summary

Reg_addr	**Data**							
Reg	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Reg0x01	Chip-EN	Reserved						
Reg0x02	ALS_Bit8	ALS_Bit7	ALS_Bit6	ALS_Bit5	ALS_Bit4	ALS_Bit3	ALS_Bit2	ALS_Bit1
Reg0x03	ALS_Bit0	Reserved						

Absolute Maximum Rating

(Note 1)

Supply Voltage, V_{DD} ---------- 0V to 6.0V
I2C Bus Pin Voltage (SCL, SDA) ---------- 0V to 6.0V
I2C Bus Pin Current (SCL, SDA) ---------- < 10mA
Other Pins ---------- -0.2V to V_{DD}
Storage Temperature Range, T_{STG} ---------- -40°C to +85°C
Operating Temperature Range, T_{OPR} ---------- -40°C to +85°C
Lead Temperature (Soldering, 10 sec) ---------- 260°C
ESD Rating (Note 2)
HBM (Human Body Mode) ---------- 2kV
MM (Machine Mode) ---------- 200V

Recommended Operation Conditions

Supply Voltage, V_{DD} (Note 3) ---------- 2.8V to 5.5V
Operating Temperatur Range ---------- -40°C to +85°C

Electrical Characteristics

(V_{DD} = 3.3V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Input						
Supply Input Voltage	V_{DD}		2.8	--	5.5	V
Supply Current	I_{DD1}	Ambient light = 100 Lux	--	140	--	uA
	I_{DD2}	Ambient light = 0 Lux	--	122	--	uA
Shutdown Current	I_{DD_SD}	I2C software disable	--	15	--	uA
I2C Clock Rate Range	f_{I2C}		1	--	400	kHz
Data Output When Dark	DATA_0	Ambient light = 0Lux, RSET = 4kΩ	0	--	2	Counts
A/D Full Scale Range	DATA_FS		--	--	511	Counts
Data Output Variation		ΔDATA/DATA	--	+/- 15	--	%
Detectable Intensity			--	0~4096	--	Lux
SCL and SDA Input Low Voltage	V_{IL}		--	--	0.5	V
SCL and SDA Input High Voltage	V_{IH}		1.5	--	--	V
Peak Wave Length	λ_P		--	550	--	nm
Address Selection						
Address 1 Voltage Range		Address = 0x70	--	--	23	%VCC
Address 2 Voltage Range		Address = 0x20	28	--	60	%VCC
Address 3 Voltage Range		Address = 0x90	65	--	--	%VCC

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

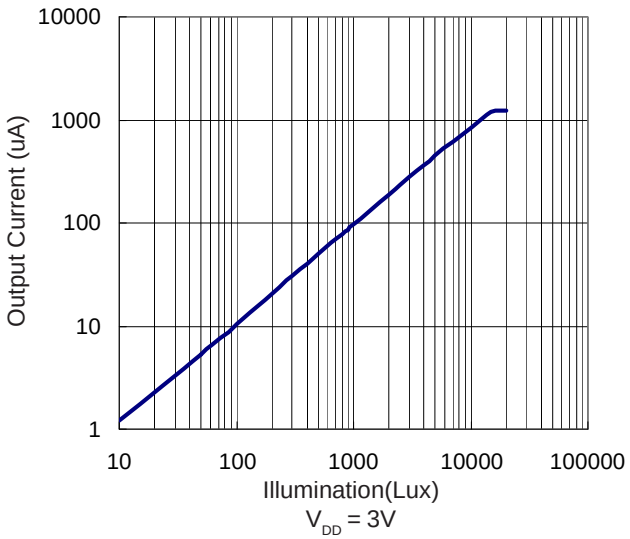
Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. The device is not guaranteed to function outside its operating conditions.

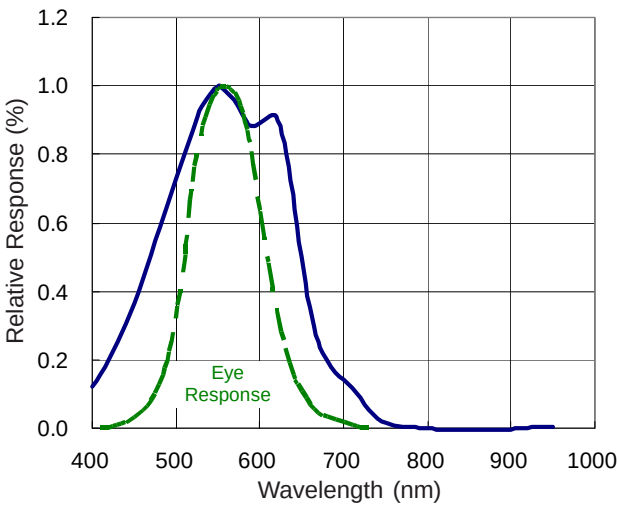
Note 4. White LED is used as optical source

Typical Operation Characteristics

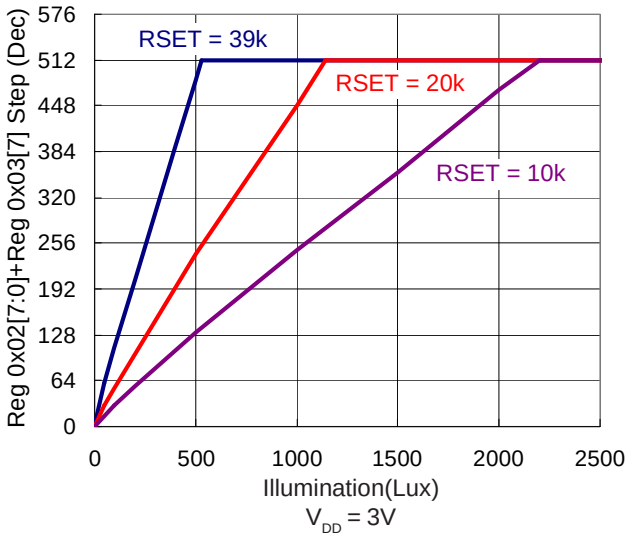
Output Current vs. Illumination



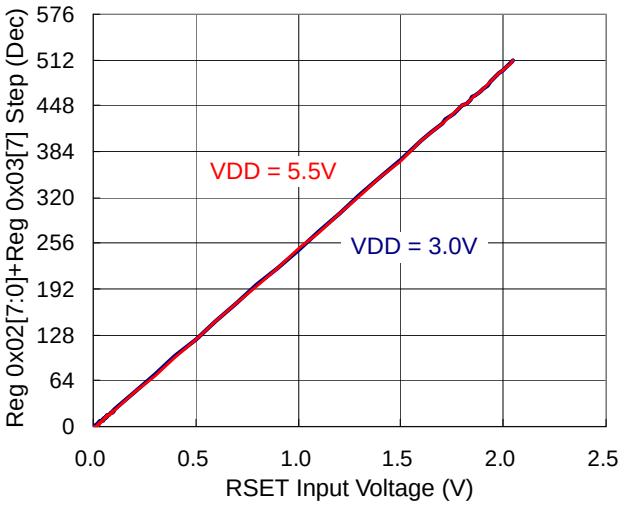
Spectral Response



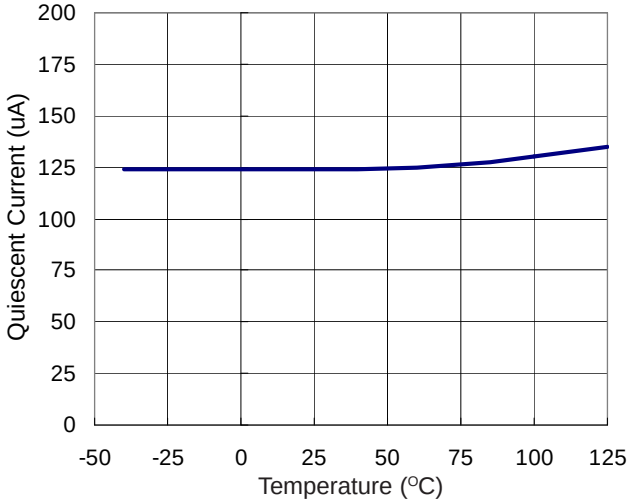
A/D Converter Data Output vs. Illumination



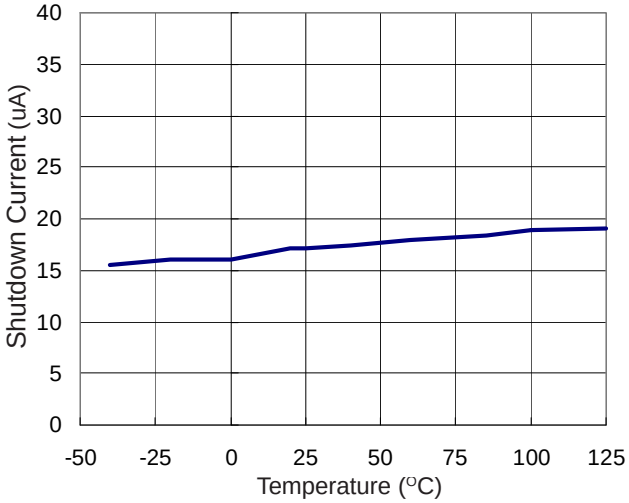
A/D Converter Data Output vs. RSET V_{IN}



Quiescent Current vs. Temperature

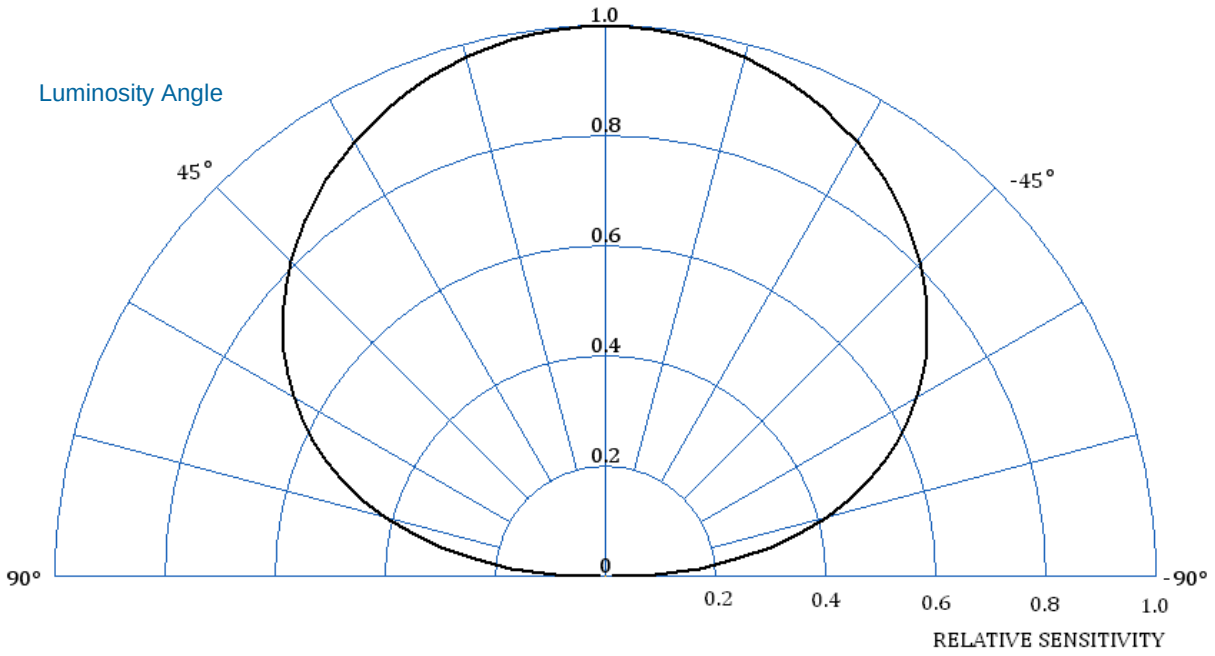


Shutdown Current vs. Temperature



Typical Operation Characteristics

Radiation Pattern



Input Capacitor (C_{VDD})

A 0.1uF ceramic capacitor physically near the VDD pin is used for power supply noise rejection.

RSET Output Resistance (R_L) Selection

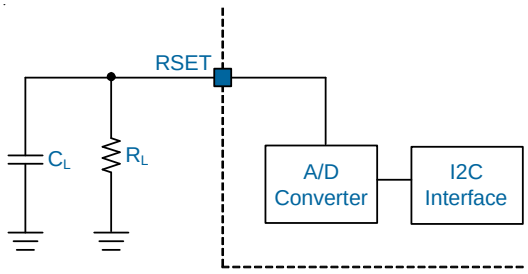


Figure 1. ALS A/D Converter

For the 200Lux~4096Lux high resolution the RL resistance is calculated by uS5151 maximum A/D full scale voltage RSET=2.048V and a given maximum Lux as the following equation.

$$R_L = \frac{VRSET}{(0.1\times Lux + 2)\times 10^{-6}}$$

Example1:

If you want to convert the illuminace value up to 500 Lux of the ALS surface by ADC. Output resistance value will be as below .

$$R_L = \frac{2.048}{(0.1\times 500 + 2)\times 10^{-6}} = 39.38k\Omega \Rightarrow 39k\Omega$$

Example2:

If you want to convert the illuminace value up to 1000 Lux of the ALS surface by ADC. Output resistance value will be as below .

$$R_L = \frac{2.048}{(0.1\times 1000 + 2)\times 10^{-6}} = 20.1k\Omega \Rightarrow 20k\Omega$$

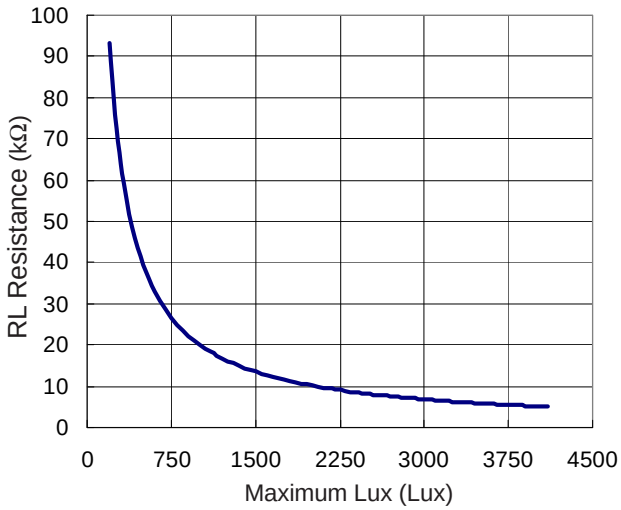


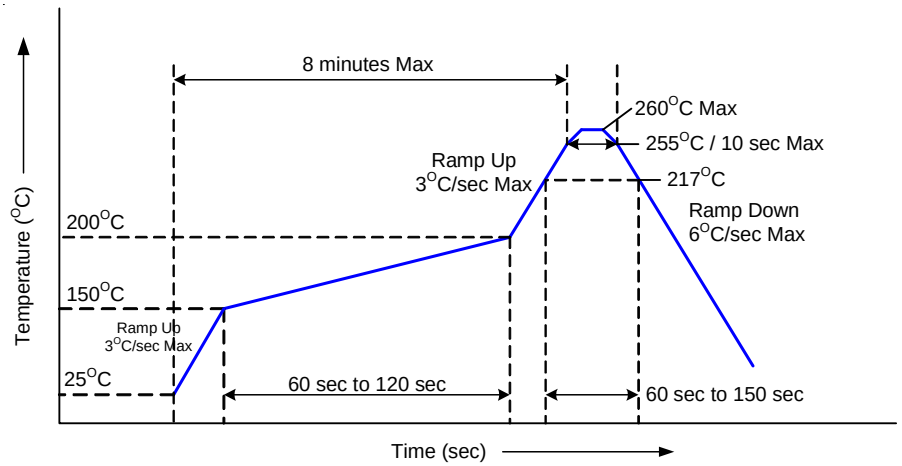
Figure 2. RL Resistance vs. Maximum Lux

Please set output resistance R_L within the range of 1kΩ~ 1MΩ which needs to be smaller than the input impedance of the next circuit. In actual design the device will be mounted under the optical window. There is a possibility that the illuminace to the ambient light sensor through the optical window will be less than the illuminance on the final product surface.

RSET Output Capacitor (C_L) Selection

In this case, please set it to C_L x R_L = about 1~10 as a time constant. C_L is effective to control backlight smoothly for a rapid changing of the illuminance.

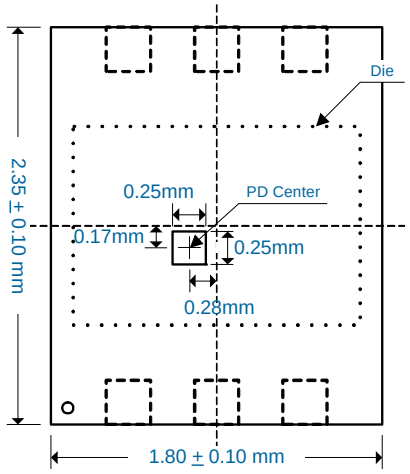
Recommended Infrared Reflow



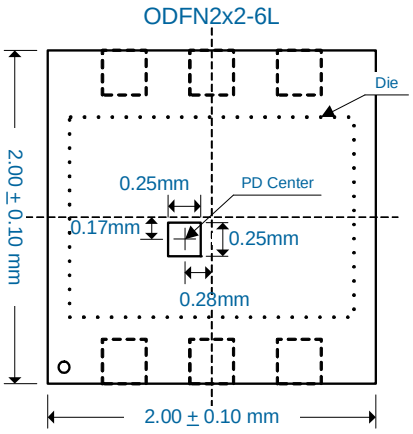
Parameter	Pb-Free Assembly
Average Ramp-up Rate	3°C/second max.
Preheat -Temperature(Min)/Temperature(Max)/Time	150°C/200°C/60~120 seconds
Time Maintained Above - Temperature/Time	217°C/60-150 seconds
Time within 5°C of Actual Peak Temperature	10 seconds max
Ramp-Down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

Sensor Location Drawing

ODFN2.35x1.8-6L

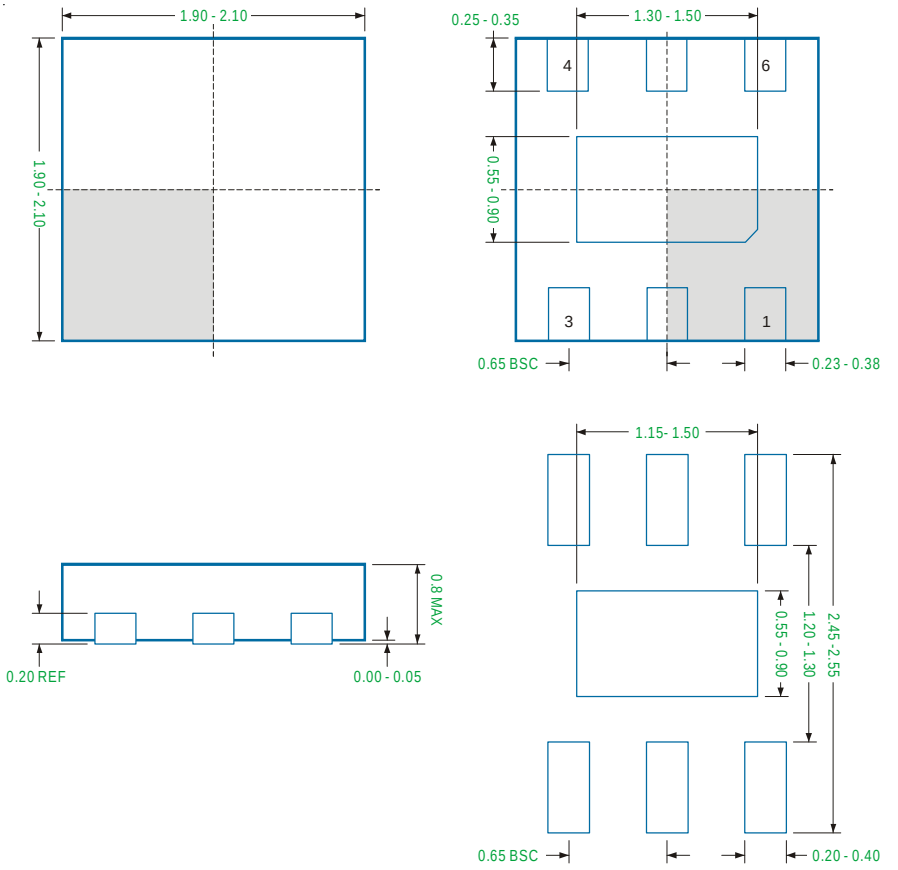


ODFN2x2-6L



Package Information

ODFN2x2-6L



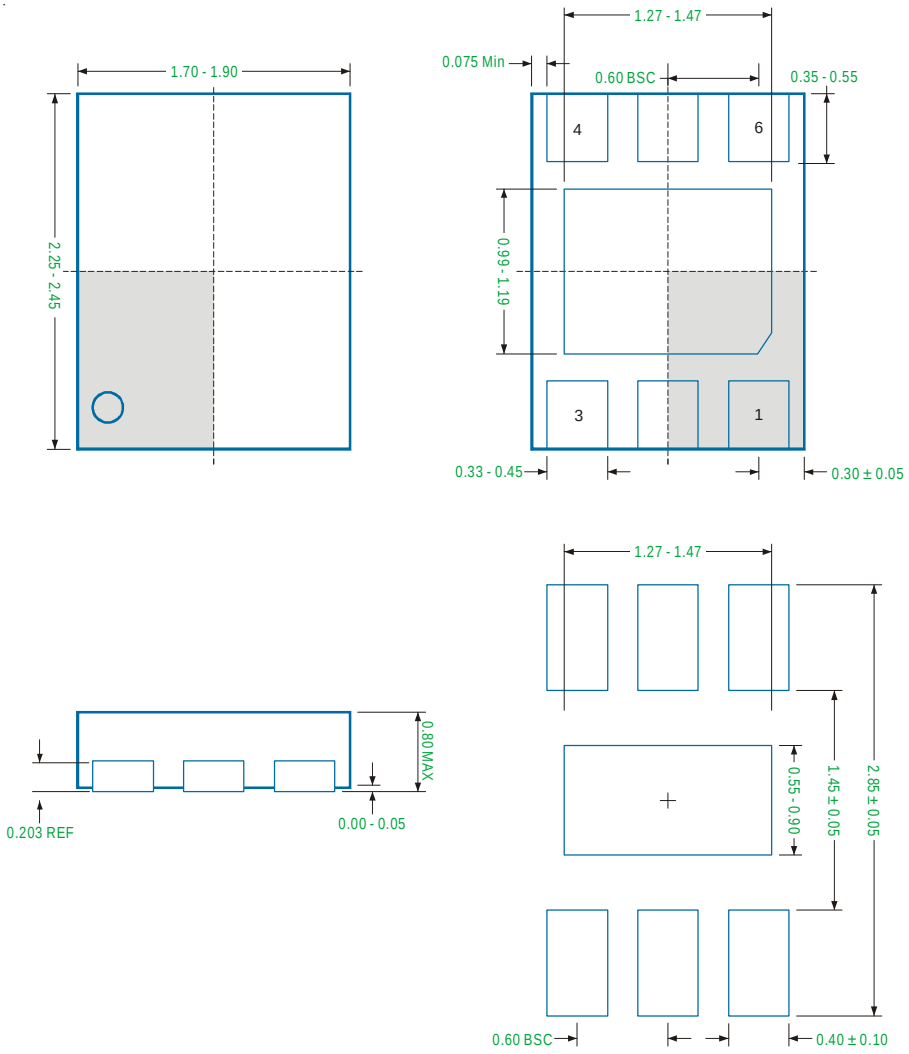
Recommended Solder Pitch and Dimensions

Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.
5. Sensor Location refers to Page 10.

Package Information

ODFN2.35x1.8-6L



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