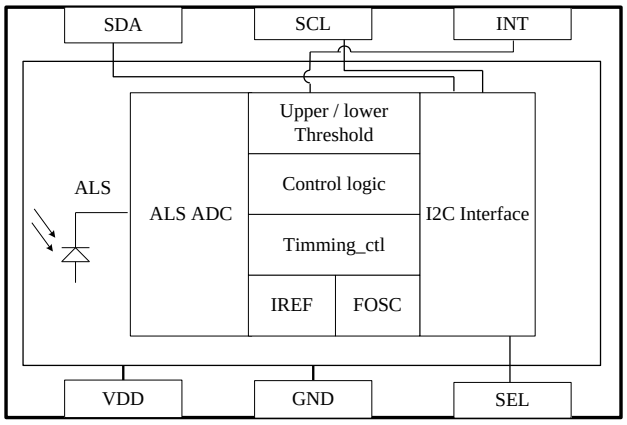
Descriptions

The AL3010 is a 16-bit digital ambient light sensor [ALS] in a chipLed RoHS package. This device provides a multiple gain function with linear response over a dynamic range 1216/ 4863/ 19452/ 77806 and is well suited to applications under clear glass or darkened glass.

Features

- I2C interface (up to 400k Hz, contact factory for 3.4M Hz option)
- 3 selectable I2C address
- Mode Select : Power Up/Down, ALS Once, Reset
- Built-in temperature compensation circuit
- Wide supply voltage from +2.3V ~ +3.6V
- Wide operating temperature range (-30°C to +80°C)
- Ambient Light Photo Sensor
  - 16-bit effective linear output (0~65535)
  - 4 user selectable dynamic range.
  - Anti-flicker rejection (reject 50/60 Hz)
  - High sensitivity @ darkened glass
- Small form factor 2.0 mm x 2.0 mm x 0.7 mm
- RoHS compliant

Function Block Diagram



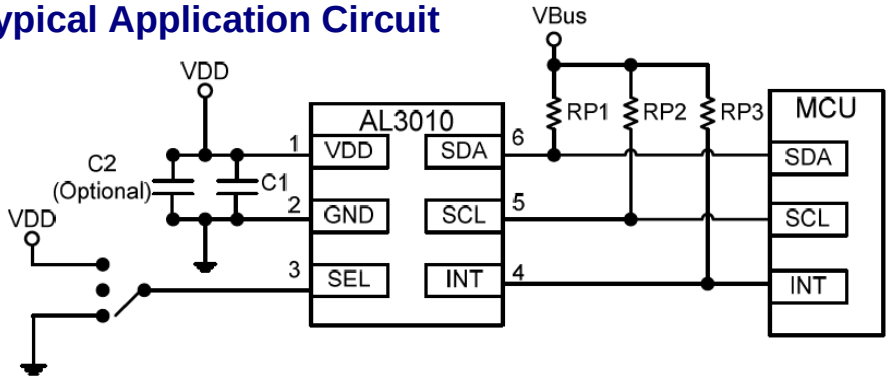
Applications

- Mobile handsets
- Personal Navigation Device
- Tablet PCs
- LCD/PDP TV backlight systems

Ordering Information

Part No.	Packing Type	Package	Quantity
AL3010	Tape and Reel	6Ld Chipled 2.0 x 2.0 x 0.7mm	2,500

Typical Application Circuit



Please be aware that an **Important Notice** concerning availability, disclaimers, and use in critical applications of DI products is at the end of this document.

Recommended Application Circuit Components

Component	Recommended Value	Condition / Range
R_{p1}, R_{p2}	Depends on system design**(*1)**	
R_{p3}	Depends on system design	
C_1	0.1μF, ±20%	
C_2	1 μF, ±20%	Optional

Note 1: I²C Pull up resistor for standard protocol format. For the complete description of maximum pull up resistor and minimum pull up resistor, please refer to: http://www.semiconductors.philips.com.

Pin Descriptions

Pin Number	I/O Type	Pin Name	Description
1		VDD	Digital/Analog Power Supply
2		GND	Ground
3	I	SEL	Connect to GND
4	O	INT	Interrupt pin
5	I	SCL	I²C serial clock line
6	I/O	SDA	I²C serial data line

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	VDD	4.5	V
I²C Address Pin Voltage	SEL	-0.2 to 4.5	V
I²C Bus Pin Voltage	SCL, SDA	-0.2 to 4.5	V
I²C Bus Pin Current	SCL, SDA	10	mA
ESD Rating, HBM	HBM	2k	V
Operating Temperature	T_{ope}	-40 to +85	℃
Storage Temperature	T_{stg}	-40 to +100	℃

Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.

Recommended Operation Conditions

Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage	V_{DD}	2.3	3.3	3.63	V	
Operating Temperature	T_{ope}	-30		80	℃	
I^2C Bus Input Pin High Voltage	V_{IH_SCL}, V_{IH_SDA}	1.62			V	
I^2C Bus Input Pin Low Voltage	V_{IL_SCL}, V_{IL_SDA}			0.4	V	
SDA Output Low Voltage	V_{OL_SDA},	0		0.4	V	3mA sinking current
		0		0.6	V	6mA sinking current
INT Output Low Voltage	V_{OL_INT}	0		0.4	V	3mA sinking current

Note : The specs are defined under VDD=2.8V, T=25°C

Electrical & Optical Specifications

All specifications are at VDD=3.3V, Tope=25°C, white light LED, unless otherwise noted.

Parameter		Symbol	MIN	TYP	MAX	Notes	UNIT
Supply Voltage		VDD	2.3	3.3	3.63		V
I^2C Bus Pin Voltage		VBus	1.7		3.63		V
Operating Temperature			-30		80		℃
Active Supply Current		Idd		175	250	Ev=0 , Range 1	μA
Shutdown Current		Ipd		1	2.5	Ev=0 , I^2C inactive	μA
Linearity Response	Range 1				77806	1.1872 lux/count **(Default)**	lux
	Range 2				19452	0.2968 lux/count	lux
	Range 3				4863	0.0742 lux/count	lux
	Range 4				1216	0.0186 lux/count	lux
Ambient Light Sensor							
ADC count	Range 1			108		Ev=128lux	count
	Range 2			431		Ev=128lux	count
	Range 3			1725		Ev=128lux	count
	Range 4		5865	6900	7935	Ev=128lux	count
Dark count					10	Ev=0	count
Conversion Time				50	60		ms
Response Time (First Stable Data)				210	250	Sychronous Test	ms
Persist Function 1 unit = 1 conversion time				1		Default	unit
				4			unit
				8			unit
				16			unit

Note1: Considering VDD rising time, please make sure a VDD slew rate at least 0.6V/ms. If users want to use the hardware reset method, please set VDD = GND for more than one second and then power back up at the requirement slew rate.

Typical Performance Charts

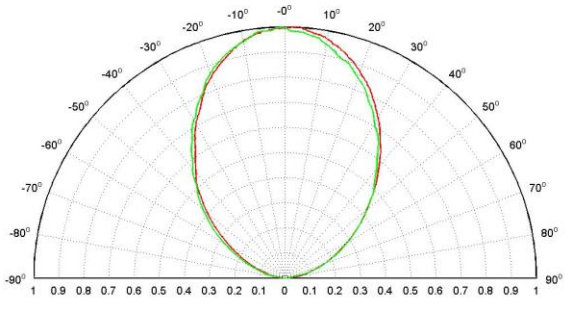


Fig1. Angular Response of ALS

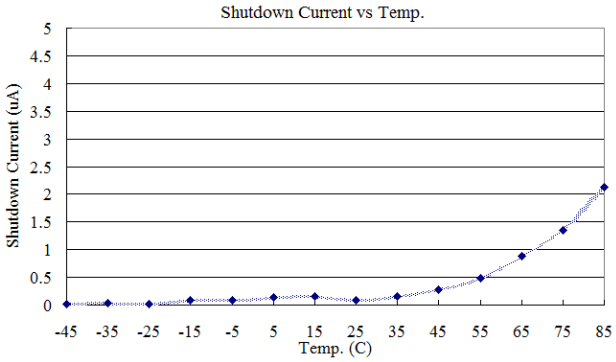


Fig2. Shutdown Current vs Temp

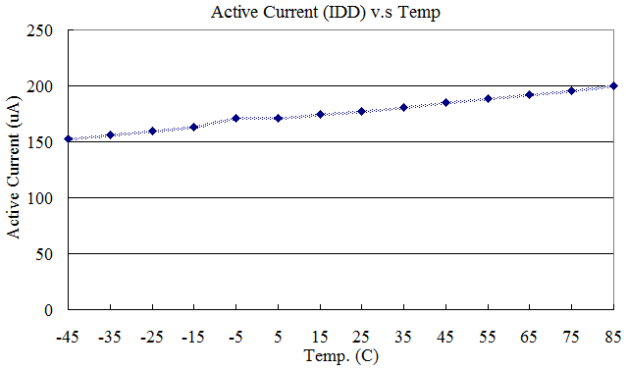


Fig3. Active Current vs Temp

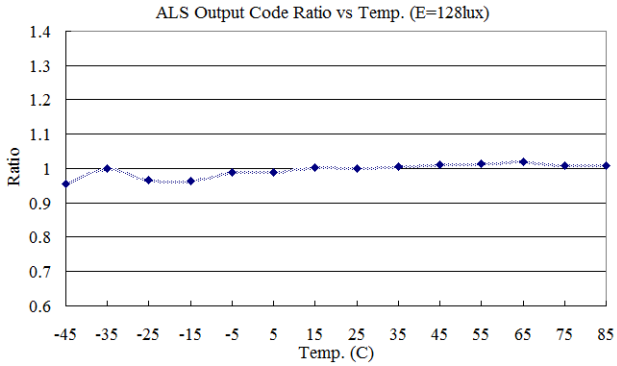


Fig4. ALS Output Code Ratio vs Temp

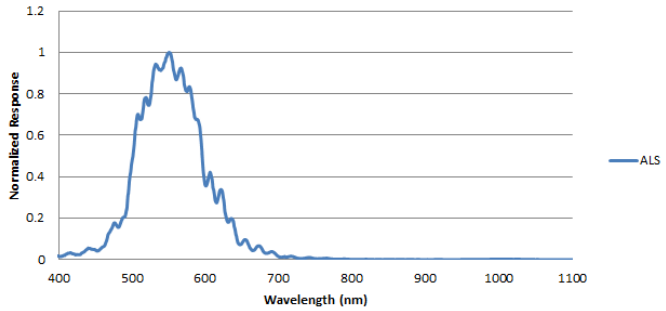
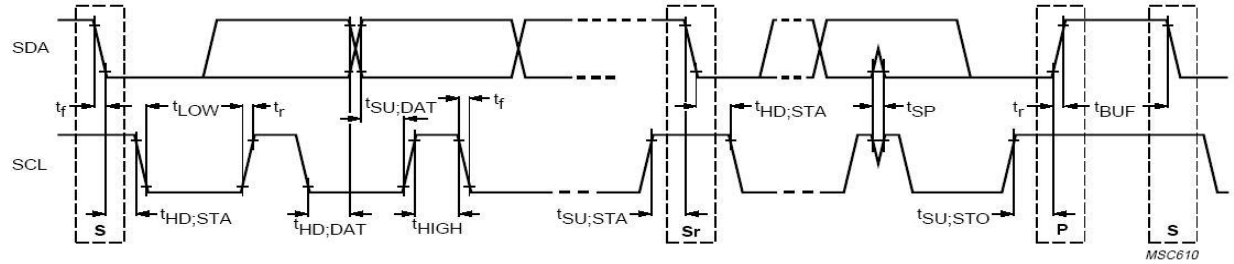


Fig5. Spectrum Response of ALS

Definition of timing for I²C devices

This section will describe the main protocol of the I²C bus. For more details and timing diagrams, please refer to the I²C specification.



The Device can operate at the standard mode I²C bus line or the fast mode I²C bus line. The characteristics of the I²C bus for difference modes are as below.

Characteristics of the SDA and SCL bus lines for I²C bus devices

(All specifications are at Tope=25℃, unless otherwise noted.)

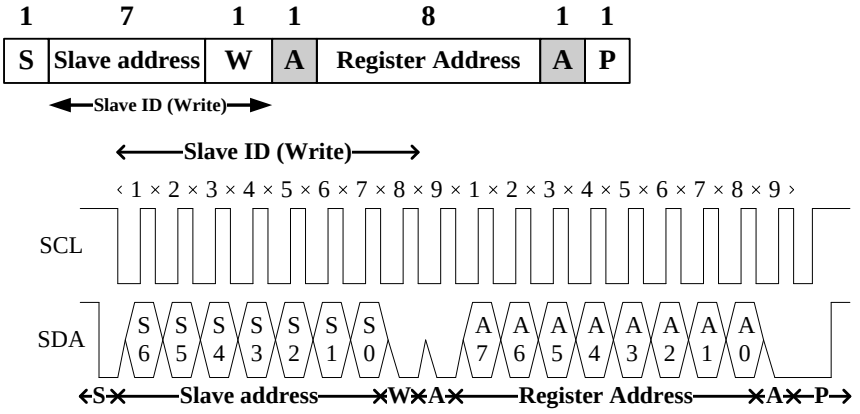
Parameter (*)	Symbol	Fast mode		Unit
		Min	Max	
SCL clock frequency	f_{SCL}	**1**	**400**	**kHz**
Bus free time between a STOP and START condition	t_{BUF}	**1.3**	**--**	**µs**
Hold time (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	**0.6**	**--**	**µs**
LOW period of the SCL clock	t_{LOW}	**1.3**	**--**	**µs**
HIGH period of the SCL clock	t_{HIGH}	**0.6**	**--**	**µs**
Set-up time for a repeated START condition	$t_{SU;STA}$	**0.6**	**--**	**µs**
Set-up time for STOP condition	$t_{SU;STO}$	**0.6**	**--**	**µs**
Rise time of both SDA and SCL signals	t_r	**--**	**300**	**ns**
Fall time of both SDA and SCL signals	t_f	**--**	**300**	**ns**
Data hold time	$t_{HD;DAT}$	**50**	**--**	**ns**
Data setup time	$t_{SU;DAT}$	**100**	**--**	**ns**
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	**0**	**50**	**ns**

Note1: C_b (capacitance of one bus line) = 10~400(pF)

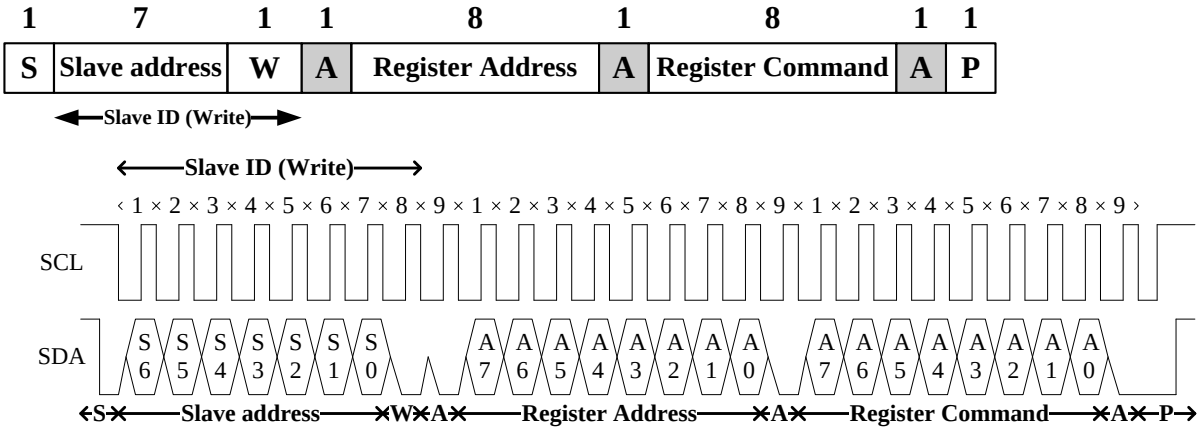
(*) Specified by design and characterization; not production tested.

I²C Protocols

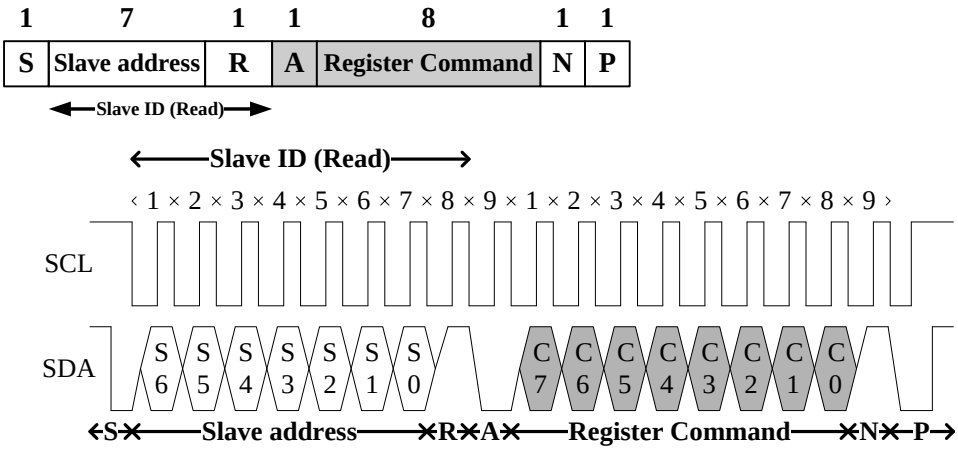
- I²C Write Protocol (type 1):



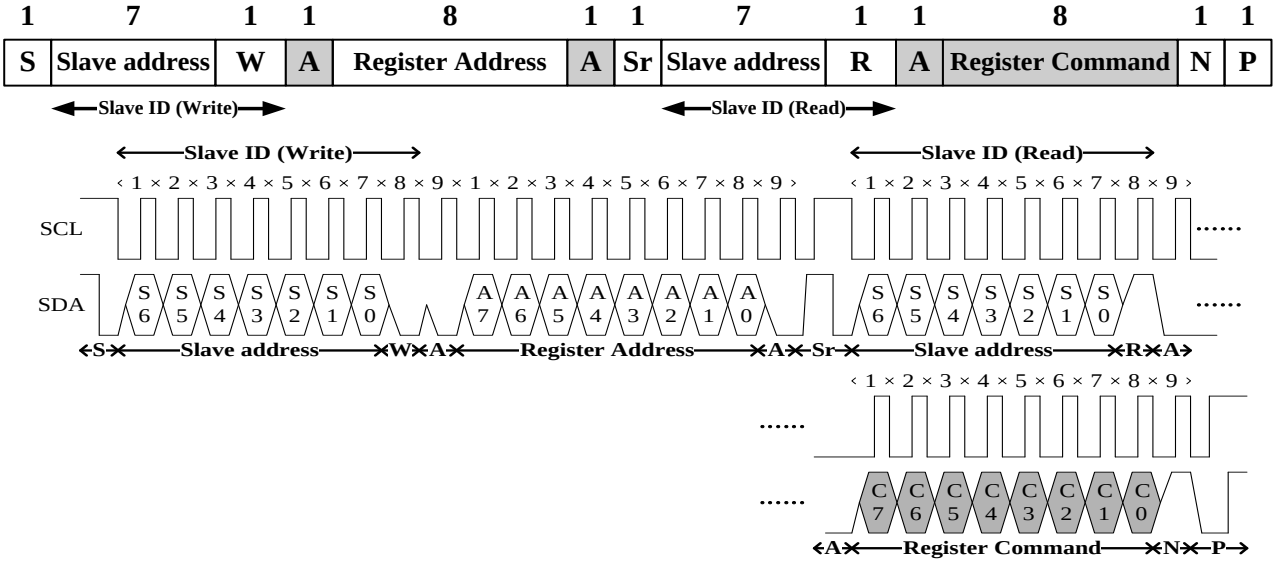
- I²C Write Protocol (type 2):



- I²C Read Protocol:



- I²C Read (Combined format) Protocol:



A	Acknowledge (0 for an ACK)	**N**	Non-Acknowledge(1 for an NACK)
S	Start condition	**Sr**	Repeated Start condition
P	Stop condition		
W	Write (0 for writing)	**R**	Read (1 for read)
■	Slave-to-master	□	Master-to-Slave

I²C Slave Address

The device offers three slave addresses that are selectable via SEL pin. The slave addresses are 7 bits. A read/write bit should be appended to the slave address by the master device to properly communicate with the device.

ADDR SEL TERMINAL LEVEL SLAVE	ADDRESS
GND	0x1C
VDD	0x1D
Float	0x1E

Register Table list

System Register set

ADDR (HEX)	REGISTER NAME	DESCRIPTION
0x00	SYSTEM CONFIGURATION	Power Down, Enable ALS, Reset & execute ALS once
0x01	INTERRUPT STATUS	Interrupt status output
0x0C	ALS DATA LOW	ALS ADC data low byte
0x0D	ALS DATA HIGH	ALS ADC data high byte

ADDR (Hex)	REGISTER NAME	Bits	REGISTER COMMAND	FUNCTIONS/DESCRIPTION
0x00	System Configuration (Default :0x00)	2:0	Sysm Mode (Default :000)	000: Power down **(Default)**
				001: Enable ALS
				100: Reset (Note 1)
				101: Execute ALS function once.
0x01	INT Status	0	ALS Int (Read only) **(Default=0)**	0: Interrupt is cleared or not triggered yet 1: Interrupt is triggered (Note 2)
0x02	Reserved	7:0	(Read only) (Default :0x00)	
0x03	Reserved	7:0	(Read only) (Default :0x00)	
0x04	Reserved	7:0	(Read only) (Default :0x00)	
0x0C	ALS DATA LOW	7:0	(Read only)	ALS ADC data low byte
0x0D	ALS DATA HIGH	7:0	(Read only)	ALS ADC data high byte

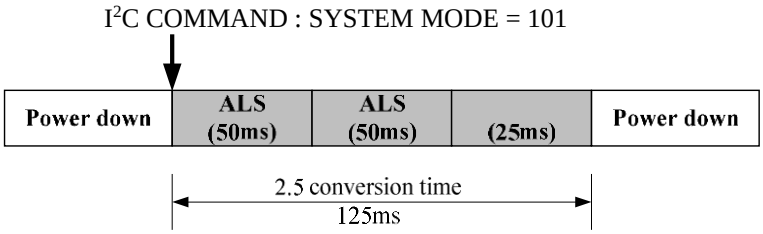
Note1. It takes 10 ms to complete Reset function. To avoid abnormal operation, don't issue any command during this period.

Note2. Clear interrupt status bit automatically by reading the ALS DATA HIGH register 0x0D.

SYSTEM CONFIGURATION Register (Read/Write)

0x00	SYSTEM CONFIGURATION (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved					*System Mode*		

The SYSTEM CONFIGURATION register is used to power up/down the device and to select ALS once/Reset function.

Field	BITS	Description
Reserved	7:3	Write as 0
System mode	2:0	000: Power down (Default) 001: Enable ALS 100: Reset ALS and all registers in default settings. 101: Get one ALS data and then power down. 

INT STATUS Register (Read Only)

0x01	ALS Interrupt Status Register (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved							*ALS INT*

The ALS interrupt status register is used to indicate the ALS interrupt status. It will be set after interrupt occur and cleared automatically after reading **ALS DATA HIGH** register 0x0D.

ALS DATA LOW/HIGH Register (Read only)

0x0C	ALS DATA LOW (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Data Low byte							

0x0D	ALS DATA HIGH (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Data High byte							

The ALS ADC data are expressed as 16-bit data spread across two registers, ALS Data Low and ALS Data High.

The upper byte data register must be read after a read to the lower byte register. After reading the lower byte register, the upper byte register is stored in a temporary register, which should be read by a subsequent read to the upper byte.

ALS Register set

ADDR (HEX)	REGISTER NAME	DESCRIPTION
0x10	CONFIGURATION	Gain control, ALS conversion time & interrupt filter Settings
0x1A	ALS LOW THRESHOLD(7:0)	ALS low threshold low byte
0x1B	ALS LOW THRESHOLD(15:8)	ALS low threshold high byte
0x1C	ALS HIGH THRESHOLD(7:0)	ALS high threshold low byte
0x1D	ALS HIGH THRESHOLD(15:8)	ALS high threshold high byte

ADDR (Hex)	REGISTER NAME	Bit	REGISTER COMMAND	FUNCTIONS/DESCRIPTION
0x10	ALS Configuration (Default :0x00)	6:4	Gain (Default=00)	Ambient light detectable range 000: 0 ~ 77806 lux **(Default)** 001: 0 ~ 19452 lux 010: 0 ~ 4863 lux 011: 0 ~ 1216 lux
		1:0	Interrupt Filter (Default=00)	ALS Interrupt is triggered after (integrated cycle) 00 : 1 conversion time **(Default)** 01 : 4 conversion time 10 : 8 conversion time 11 : 16 conversion time
0x1A	ALS Threshold low L **(Default :0x00)**	7:0		ALS low threshold low byte
0x1B	ALS Threshold low H **(Default :0x00)**	7:0		ALS low threshold high byte
0x1C	ALS Threshold High L **(Default :0xFF)**	7:0		ALS high threshold low byte
0x1D	ALS Threshold High H **(Default :0xFF)**	7:0		ALS high threshold high byte

ALS CONFIGURATION Register (Read/Write)

0x10	ALS CONFIGURATION (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved	*ALS Gain*			*Reserved*		*ALS Interrupt Filter*	

The ALS CONFIGURATION register is used to control the following ALS features.

1. ALS Gain (Ambient light detectable range). There are 4 ranges for AL3010.
   A. Range 1: 0 ~ 77806 Lux. Resolution = 1.1872 lux/count.
   B. Range 2: 0 ~ 19452 Lux. Resolution = 0.2968 lux/count.
   C. Range 3: 0 ~ 4863 Lux. Resolution = 0.0742 lux/count.
   D. Range 4: 0 ~ 1216 Lux. Resolution = 0.0186 lux/count

   ADC data to Lux conversion formula as below

   Ambient Light (lux) = 16 bit ADC data * Resolution
2. ALS Interrupt Filter: Configurable filtering is provided to allow hardware interrupt to be generated after interrupts trigger for N consecutive numbers of conversion time. The ALS Interrupt Filter bits determine N.

ALS LOW THRESHOLD Register (Read/Write)

0x1A	ALS LOW THRESHOLD (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Low Threshold Low byte							

0x1B	ALS LOW THRESHOLD (default = 0x00)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Low Threshold High byte							

The ALS LOW THRESHOLD registers store the values of the low threshold data for comparison against ALS DATA (Registers 0CH and 0DH). If the ALS DATA crosses below or is equal to the ALS Low Threshold, an interrupt is asserted.

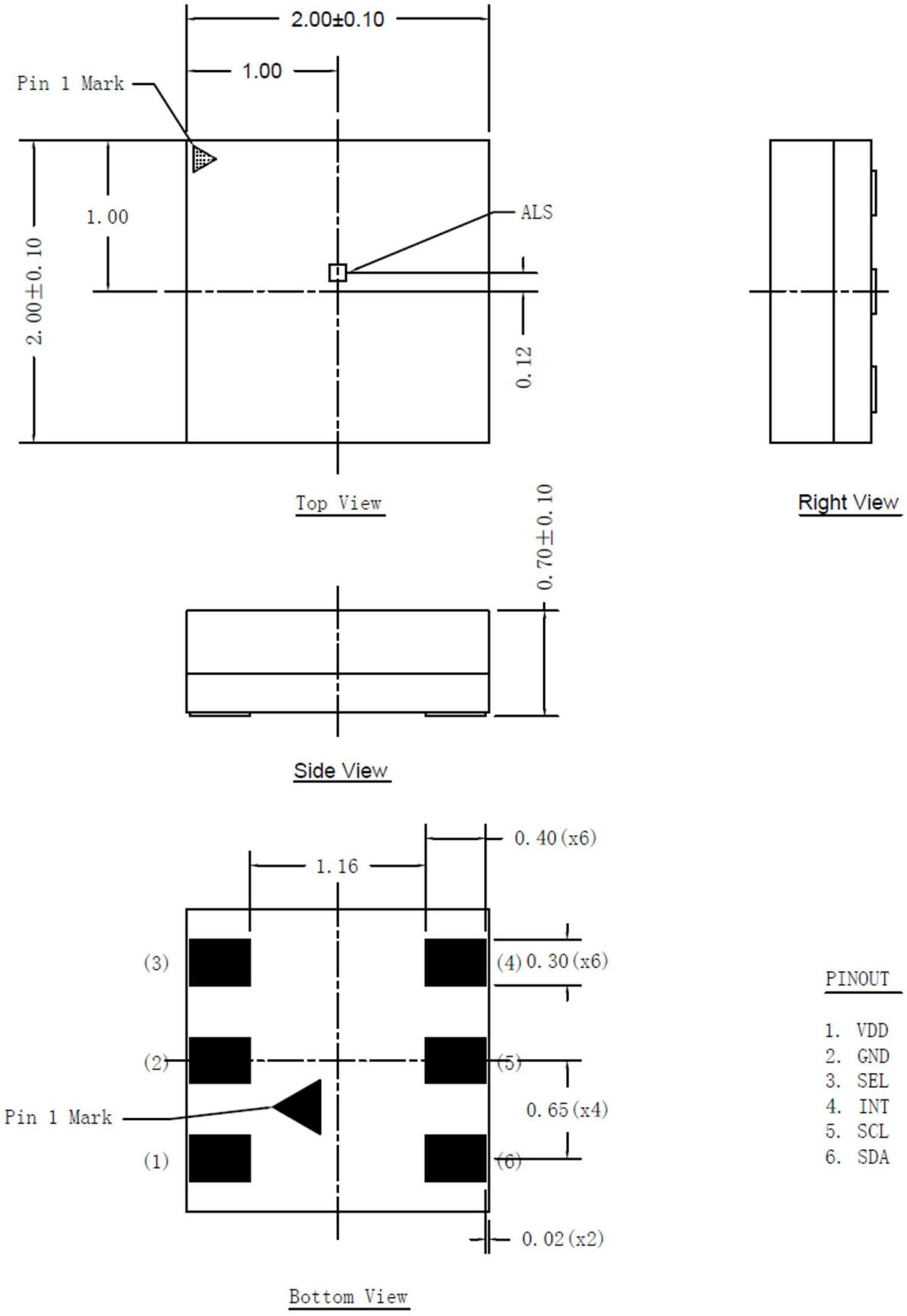
ALS HIGH THRESHOLD Register (Read/Write)

0x1C	ALS HIGH THRESHOLD (default = 0xFF)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS High Threshold Low byte							

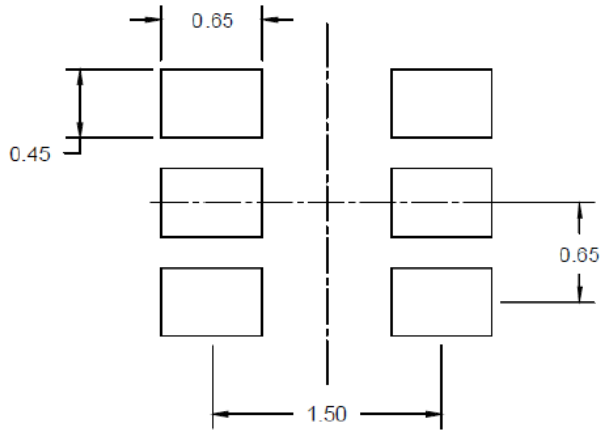
0x1D	ALS HIGH THRESHOLD (default = 0xFF)							
BIT	B7	B6	B5	B4	B3	B2	B1	B0
	ALS High Threshold High byte							

The ALS HIGH THRESHOLD registers store the values of the high threshold for comparison against ALS DATA (Registers 0CH and 0DH). If ALS DATA crosses above or is equal to the ALS High Threshold, an interrupt is asserted.

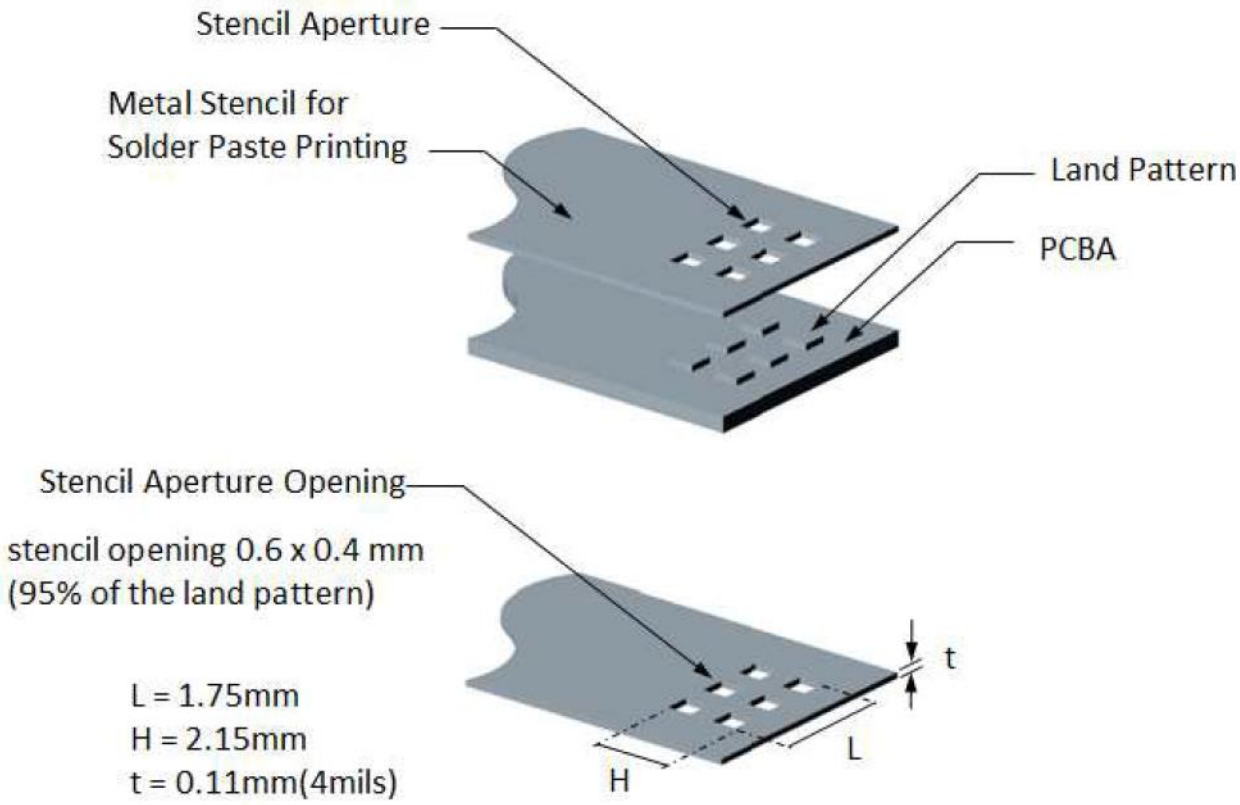
Package Outline Dimensions



Recommended Land Pattern

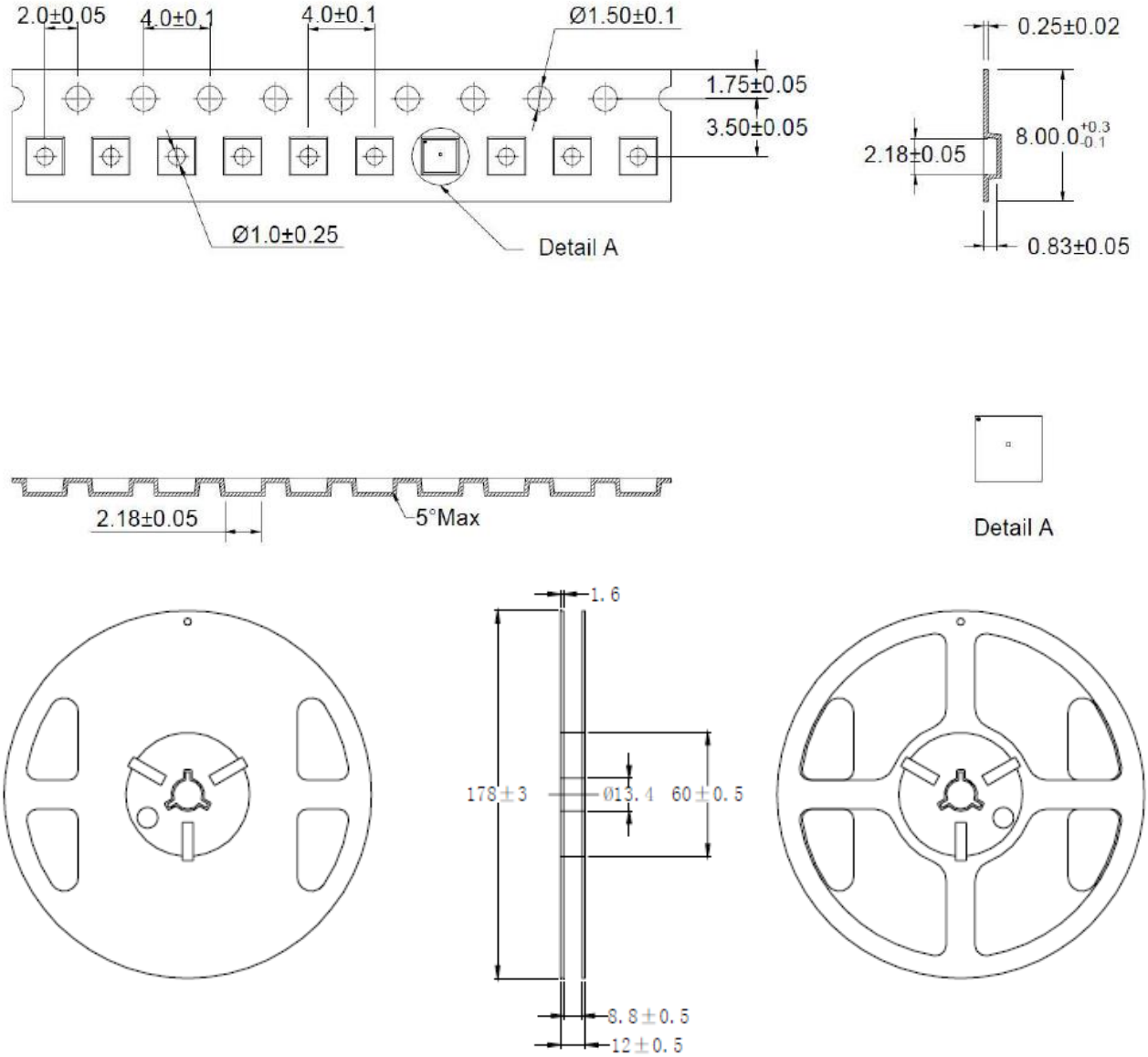


PCB Stencil

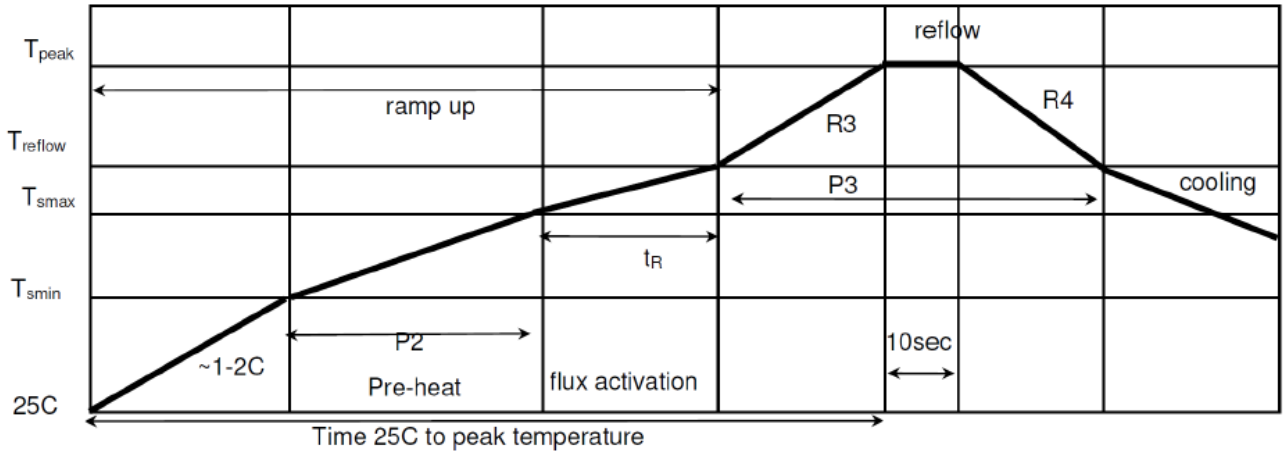


Note : The dimensions of stencil are designed base on the SMT process tolerance (less than +/-3° rotation and +/- 0.05mm offset).

Package Dimension of Tape and Reel



Recommended Reflow Profile



	Peak temperature (Tpeak)	255-260C (max) ; 10sec
Pre-Heat	Temperature min (Tsmin) Temperature max (Tsmax) P2: (Ts min to Ts max)	150C 2C/sec 150C-217C 100s to 180s 90-110s
Time maintain above	Temperature (T_{reflow}) Time (P3) R3 slope (from 217C -> peak) R4 slope (from peak -> 217C)	217C 60-90sec 2C/sec [typ] -> 2.5C/sec (max) -1.5C/sec [typ]-> -4C/sec (max)
	Time to peak temperature	480s max
	Cooling down slope (peak to 217C)	2-4C/ sec

Note : The actual profile may need to be adjusted base on the actual layout. When parts are placed upside down, proper protection/support is recommended. Max reflow should not exceed 2x max.