Descriptions

The AL3006 is an integrated low voltage I²C digital ambient light sensor [ALS] and proximity sensor [PS] with built-in IR LED packaged in a single miniature lead-free package. This device provides logarithmic response over a wide dynamic range from 2 lux to 100k lux and is well suited to applications under high ambient brightness. With built-in proximity sensor and IR LED, AL3006 can detect object at a distance that is user configurable through register. This added configuration features offer flexibility in both design and usage as compared to the on/off type of proximity sensors currently in the field. As for the IR LED, AL3006 is optimized to use 850nm which is more efficient from power consumption point of view as compared to the typical 940nm used in the market today. The device supports an interrupt feature to improve system efficiency. The device also supports several features that help to minimize the occurrence of false triggering. This CMOS design and factory-set one time trimming capability ensure minimal device-to-device variations for ease of manufacturability to the end customers.

Features

- I²C interface (Fast Mode @ 400kbit/s)
- Modulized ALS, PS and IR LED
- Configurable PS detection distance
- Low power long detection distance 850nm PS
- High ambient light suppression PS
- Built-in light loss compensation
- Wide dynamic range from 2 lux to 100k lux
- Built-in temperature compensation circuit
- Low active power consumption
- Wide Supply voltage range
  - ALS&PS sensor: +1.8V to +3.3V
  - VLED: +2.5V to +3.3V
- Close to human eye spectral response
- 6-bit effective ADC resolution
- Logarithmic output code
- Automatically rejects 50 / 60 Hz light ripple
- Wide operating temperature: -20℃ to +70℃
- Package 4.6 mm x 2.9 mm x 1.5 mm
- RoHS compliant

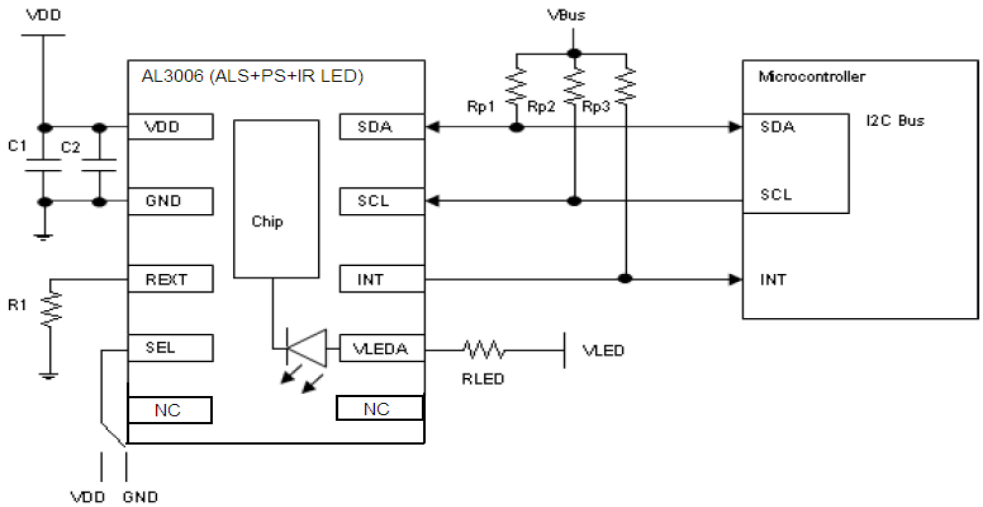
Applications

- Mobile phone, PDA
- Personal Navigation Device
- Notebook, LCD Monitor
- LCD/PDP TV backlight systems
- Digital Photo Frame
- Applications with Capacitive Touch Panel

Ordering Information

Part No.	Packaging Type	Package	Quantity
AL3006	Tape and Reel	Chipled Package	1000

Typical Application Circuit



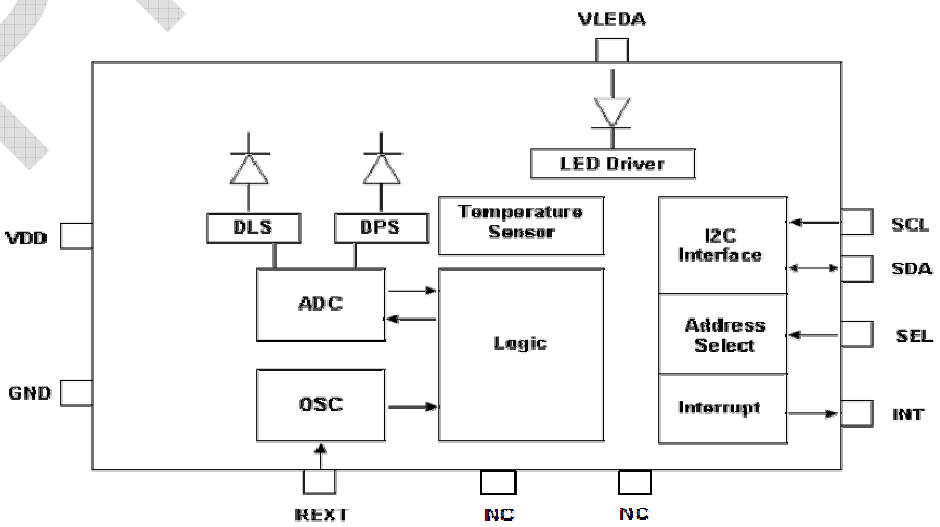
Recommended Application Circuit Components

Component	Recommended Value	Condition / Range
R1	680 kΩ, ± 5%	1.8V≦VDD≦1.9V
	750 kΩ, ± 5%	1.9V≦VDD≦2.1V
	820 kΩ, ± 5%	2.1V≦VDD≦2.9V
	910 kΩ, ± 5%	2.9V≦VDD≦3.3V
VLED	+3.3V	+2.8V to +3.3V
RLED	10 Ω	0 Ω to 100 Ω, ±5%
Rp1, Rp2,Rp3	Depends on system design	10 kΩ to 100 kΩ
C1	0.1uF, ±20%	
C2	2.2 uF, ±20%	1~4.7 uF

Pin Descriptions

Pin	I/O	Symbol	Description
1		VDD	Supply Voltage.
2		GND	Ground.
3	I	REXT	Tied through external resistor, R1, to Ground. Refer to the table above for recommended resistor value.
4	I	SEL	I^2C address selection. Connect to VDD or GND directly.
5		NC	Not connected. Leave this pin open.
6		NC	Not connected. Leave this pin open.
7	I	VLEDA	IR LED Anode pin. Connect to VLED through a resistor.
8	O	INT	Interrupt pin, open drain. Active LOW.
9	I	SCL	I^2C serial clock.
10	I/O	SDA	I^2C serial data.

Function Block Diagram



Absolute Maximum Ratings at Ta = 25℃

Parameter	Symbol	Value	Unit
Supply Voltage	VDD	3.6	V
I^2C Address Pin Voltage	SEL	-0.2 to 3.6	V
I^2C Bus Pin Voltage	SCL, SDA	-0.2 to 3.6	V
I^2C Bus Pin Current	SCL, SDA	10	mA
REXT Pin Voltage	REXT	-0.2 to 3.6	V
Operating Temperature	Tope	-40 to +85	℃
Storage Temperature	Tstg	-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 Operating Conditions

Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage	VDD	1.8		3.3	V	
Operating Temperature	Tope	-20		70	℃	
I^2C Bus Input Pin High Voltage	Vih_SCL, Vih_SDA	0.65*VDD			V	
I^2C Bus Input Pin Low Voltage	Vil_SCL, Vil_SDA			0.35*VDD	V	
I^2C Bus Output Pin Low Voltage	Vol_SDA,	0		0.4	V	3mA sinking current
	Vol_INT	0		0.6	V	5mA sinking current

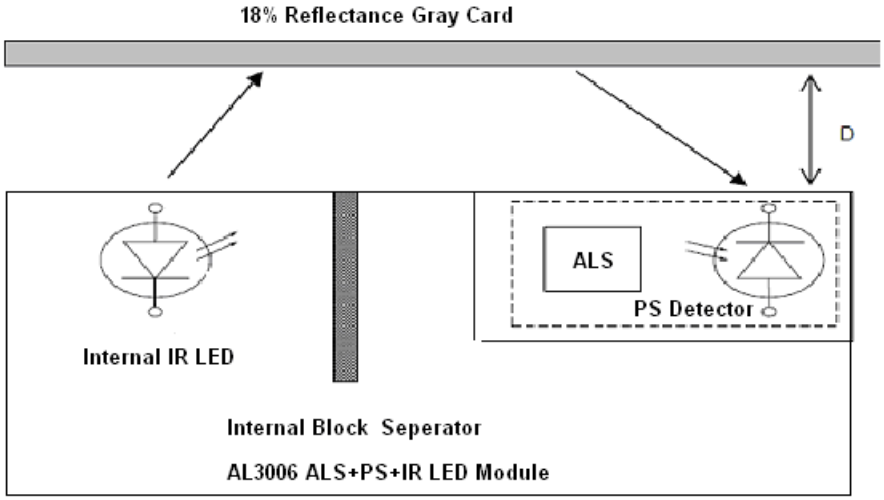
Electrical & Optical Specifications

All specifications are at VDD=3.3V, Tope=25℃, R1=910kΩ, ±5%, unless otherwise noted.

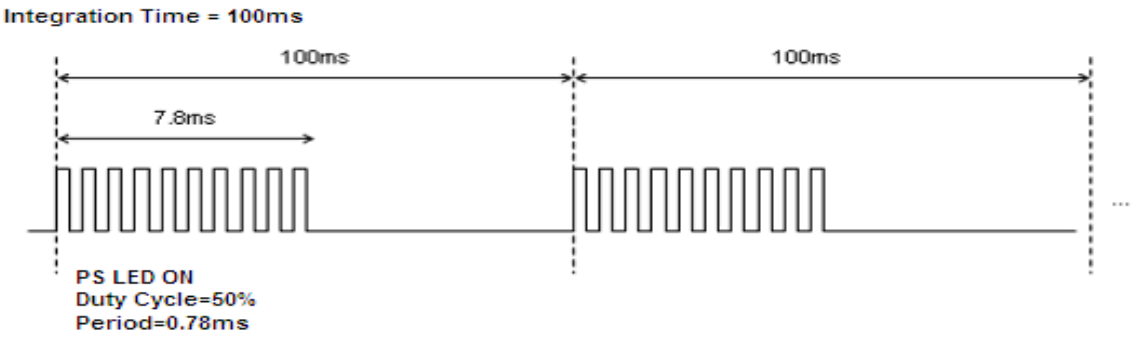
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Active Supply Current	IDD1	(Note 1)		300	400	uA
Shutdown Current	IDD2	SDA, SCL≧Vih; VLED=0V; Lux=1		0.1	1.5	uA
Light Sensor	**Symbol**	**Test Conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
Peak Sensitivity	λpeak	Figure 1		550		nm
Full Scale ADC Count	DATA0				63	count
Dark ADC Count	DATA1	Lux=1 (Note 1)			3	count
ADC Count	DATA3	Lux=1000 (Note 1)	35	38	41	count
Light Ratio	L1	Lux=1000 (Note 2)	0.8	1	1.25	
Proximity Sensor	**Symbol**	**Test Conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
Peak Sensitivity of Detector	λDetector	Figure 3		830		nm
Detection Distance	D	Register 04H=0x4A RLED=10Ω (Note 3)		60		mm
Peak LED Current	ILEDPEAK			110		mA
Ambient Light Suppression		(Note 1)			5000	lux

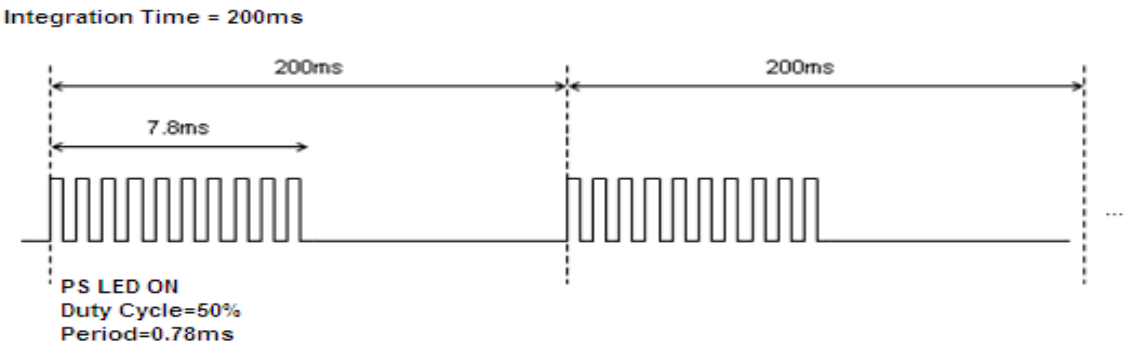
Notes:

1. White LED is used as light source.
2. L1 = Y(Incandescent) / Y(Fluorescent)
   Y(Incandescent) = output signal under incandescent light
   Y(Fluorescent) = output signal under fluorescent light
3. Test Condition for Detection Distance



PS LED PWM Waveform





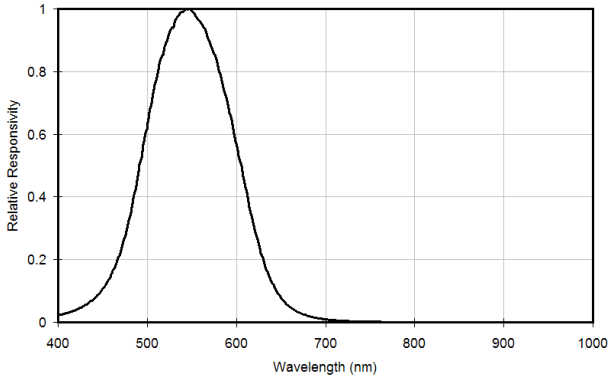


Figure1. Spectral Response of ALS

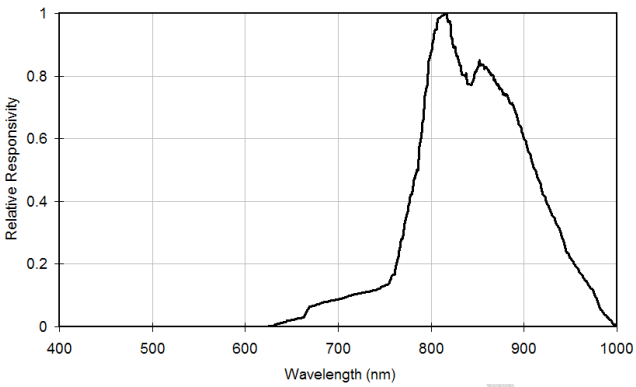


Figure2. Spectral Response of PS Detector

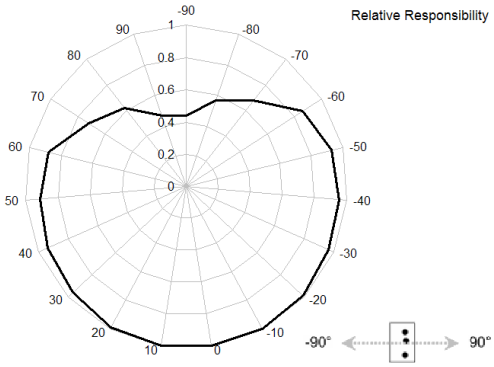


Figure3. Radiation Pattern for ALS (horizontal)

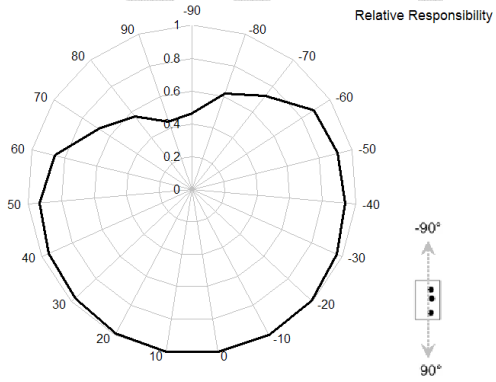


Figure4. Radiation Pattern for ALS (vertical)

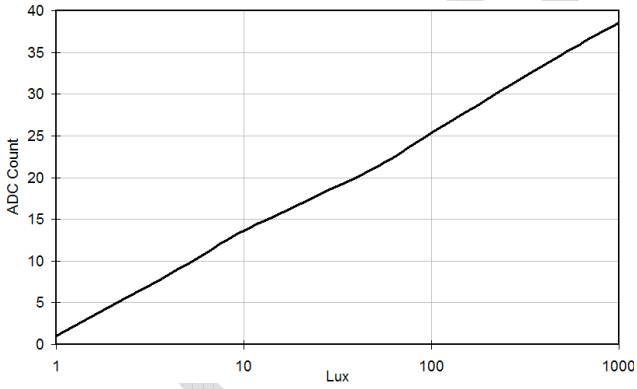


Figure5. Logarithmic Output Response for ALS

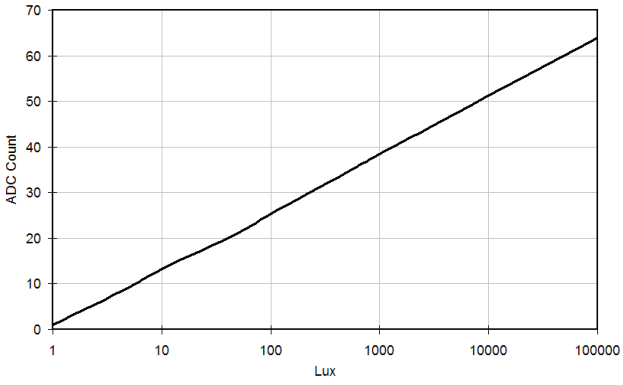


Figure6. Logarithmic Output Response for ALS

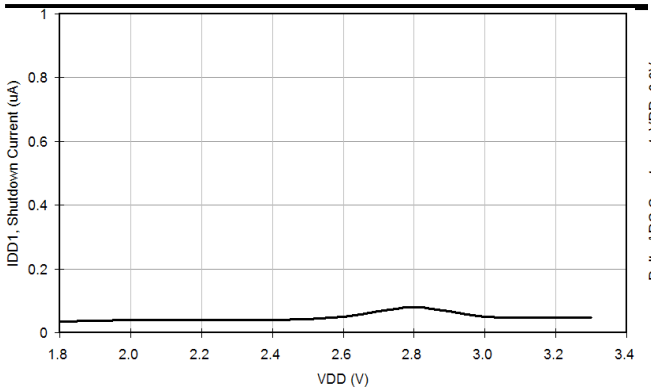


Figure7. Shutdown Current vs VDD

(T^{ope} = 25℃, Lux=1000)

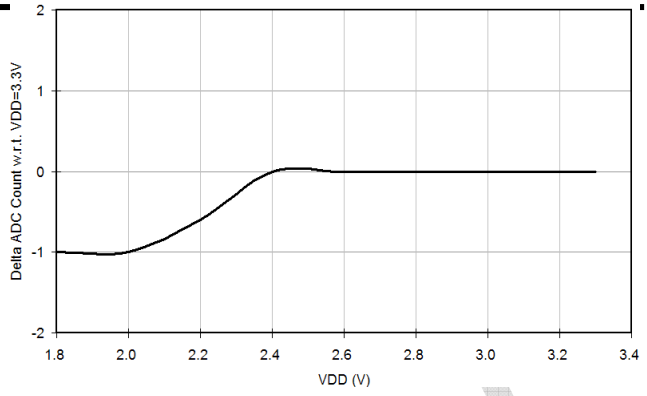


Figure8. Delta ADC Count vs VDD

(T^{ope} = 25℃, Lux=1000)

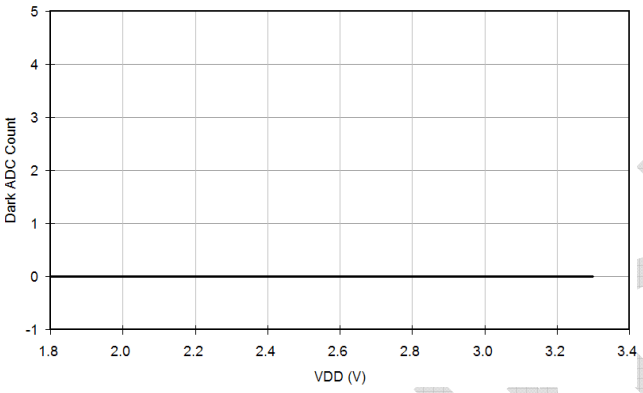


Figure9. Dark ADC Count vs VDD

(T^{ope} = 25℃, Lux=1)

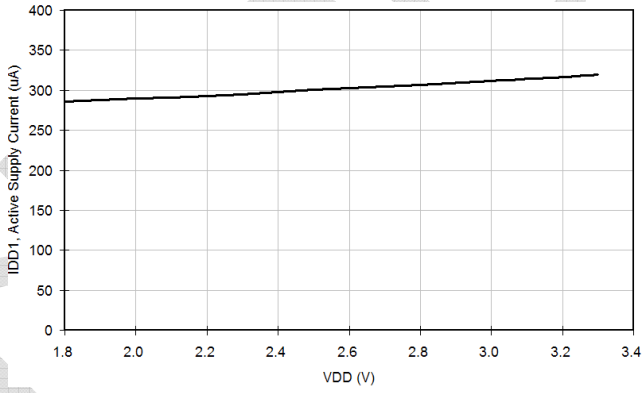
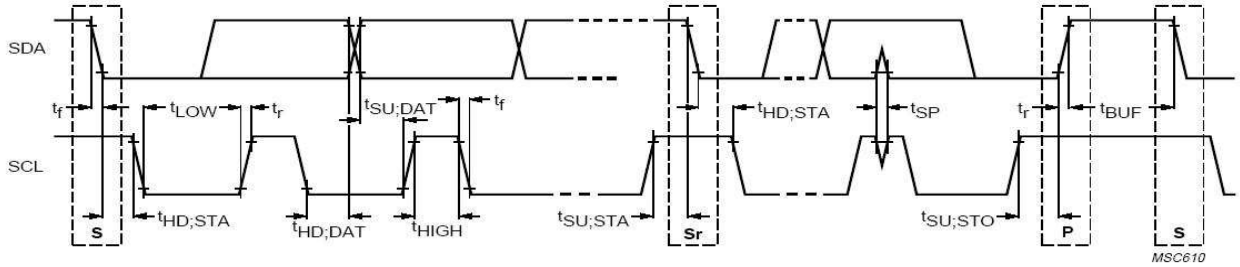


Figure10. Active Supply Current vs VDD

(T^{ope} = 25℃, Lux=1000)

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 bellow.

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

Parameter (*)	Symbol	Standard-mode		Fast-mode		Unit
		Min	Max	Min	Max	
SCL clock frequency	f_{SCL}	1	100	1	400	kHz
Bus free time between a STOP and START condition	t_{BUF}	4.7	--	1.3	--	us
Hold time (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	4.0	--	0.6	--	us
LOW period of the SCL clock	t_{LOW}	4.7	--	1.3	--	us
HIGH period of the SCL clock	t_{HIGH}	4.0	--	0.6	--	us
Set-up time for a repeated START condition	$t_{SU;STA}$	4.7	--	0.6	--	us
Set-up time for STOP condition	$t_{SU;STO}$	4.0	--	0.6	--	us
Rise time of both SDA and SCL signals	t_r	--	1000	20 + 0.1Cb (note1)	300	ns
Fall time of both SDA and SCL signals	t_f	--	300	20 + 0.1Cb (note1)	300	ns
Data hold time	$t_{HD;DAT}$	0.1	3.45 (note 2)	0.1	0.9 (note2)	us
Data setup time	$t_{SU;DAT}$	250	--	100	--	ns
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	n/a	n/a	0	50	ns

note1: Cb (capacitance of one bus line) = 10~400(pF)

note2 : The maximum tHD;DAT has only to be met if the device does not stretch the LOW period (tLOW) of the SCL signal.

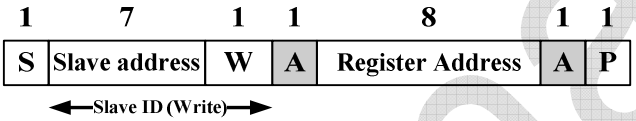
(*) Specified by design and characterization; not production tested.

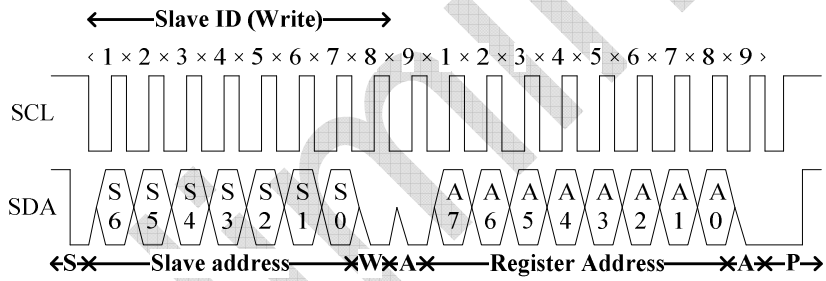
(**) All specifications are at VBus = 3.3V, Tope=25℃, unless otherwise noted.

I²C Protocols

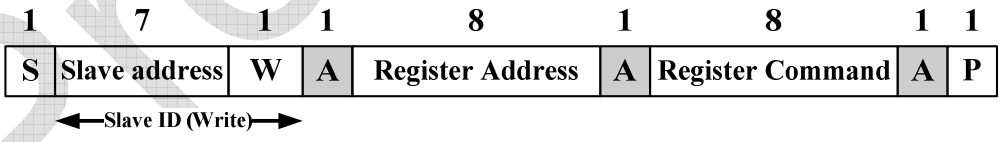
The AL3006 supports a bidirectional 2-wire bus and data transmission protocol as below.

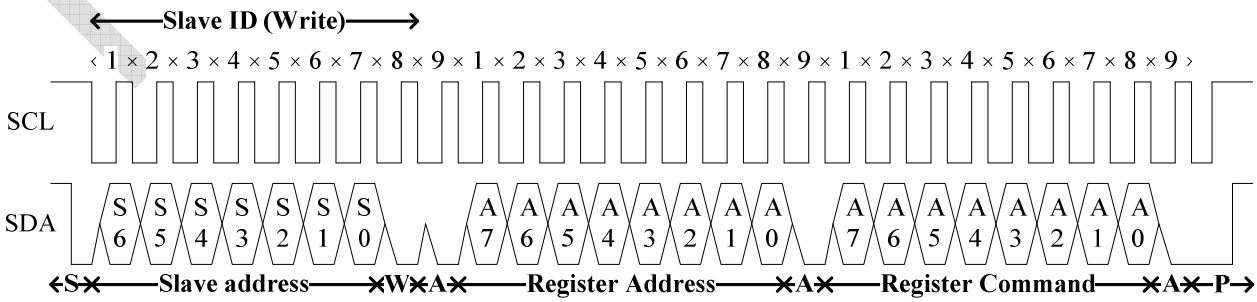
I²C Write Protocol (type 1):



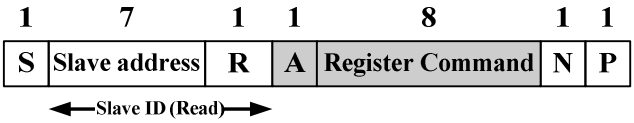


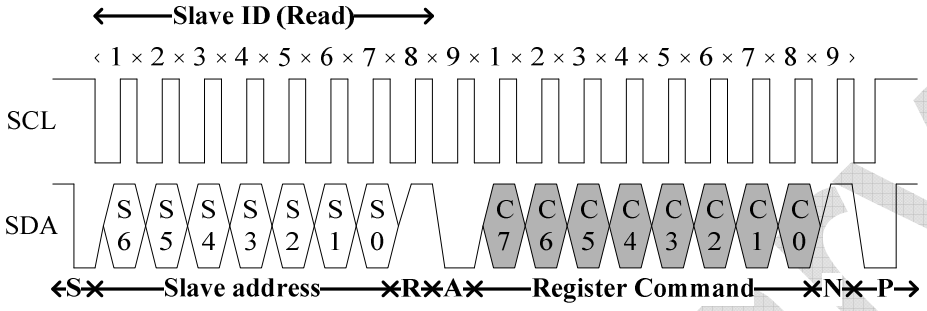
I²C Write Protocol (type 2):



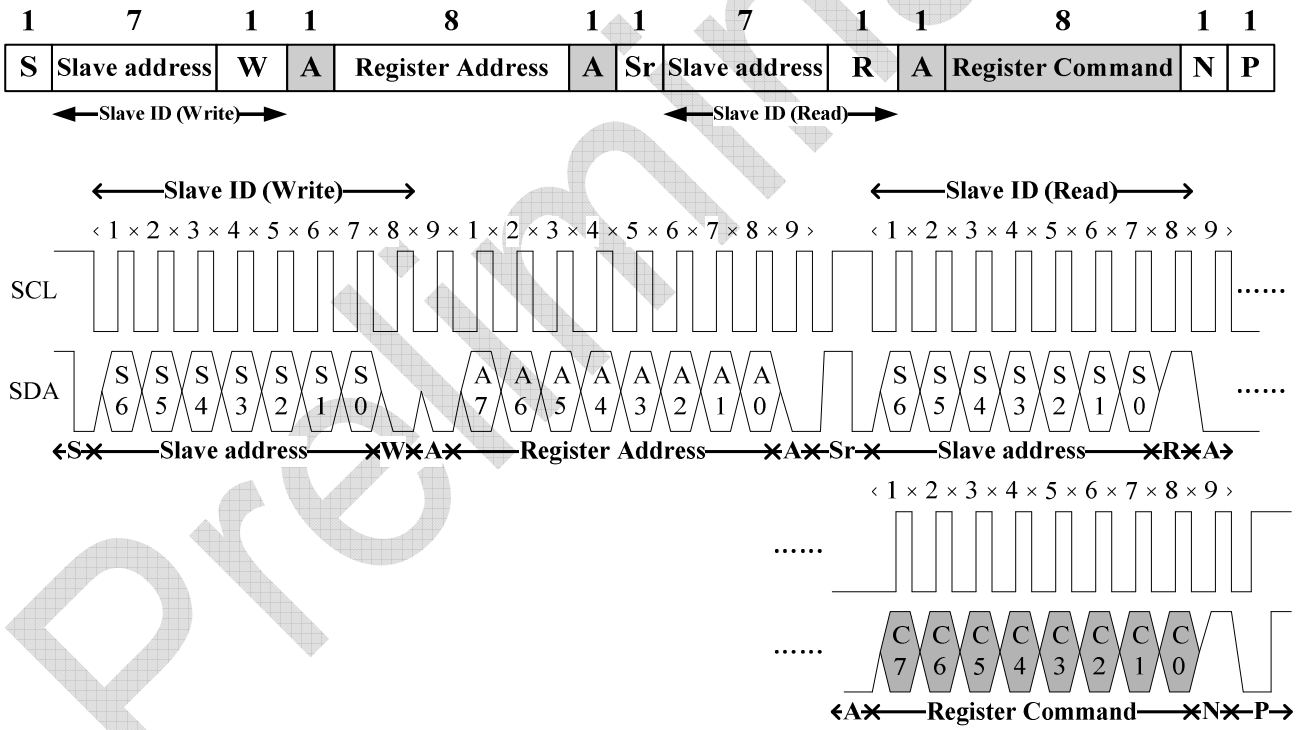


I²C Read Protocol:





(3) **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 AL3006 is equipped with a 7-bit address as a slave device on the I²C bus interface and offers two slave addresses that are selectable via pin 4 (SEL). The slave addresses are 7 bits and the LSB is defined by the SEL pin. The SEL pin must connect to either VDD or GND.

(1) SEL pin connect to GND (I²C Slave address = 0x1CH):

Command type	Slave Address							W/R	value
	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1(SEL)	Bit0	
Writing type	0	0	1	1	1	0	0	0	0x38H
Read type	0	0	1	1	1	0	0	1	0x39H

(2) SEL pin connect to VDD (I²C Slave address = 0x1DH):

Command type	Slave Address							W/R	value
	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1(SEL)	Bit0	
Writing type	0	0	1	1	1	0	1	0	0x3AH
Read type	0	0	1	1	1	0	1	1	0x3BH

Register Address for ALS and Proximity Sensor

Address	Register Name	Default	Register Function
00h	Configuration	0x03	Switch to shutdown or active mode.
01h	Timing Control	0x11	PS/ALS Interrupt Filter and integration time.
02h	ALS Control	0xA0	ALS Level and Low Lux threshold.
03h	Interrupt Status (Read Only)	0x00	PS/ALS interrupt.
04h	PS Control	0x4A	PS accuracy and PS threshold level control.
05h	Data (Read Only)	0x00	PS/ALS Data.
08h	ALS Window	0x00	ALS Window Loss.

Register Set (**bold: default**)

Address	Register Name	Default	Bit(s)	Function	Description
00h	Configuration	0x03	7:4	Reserved	Write as 0
			3:2	Mode Select	**00: Power up mode** 01: Reserved 10: Power down mode 11: Reset mode
			1:0	Operation Select	00: ALS active mode 01: PS active mode 10: ALS and PS active mode **11: Idle mode**
01h	Timing Control	0x11	7:6	Reserved	Write as 0
			5:4	PS Interrupt Filter	PS interrupt is triggered after 00: 1 integration cycle **01: 4 integration cycles** 10: 6 integration cycles 11: 8 integration cycles
			3	Reserved	Write as 0
			2	Integration Time	Integration time **0: 100 ms** 1: 200 ms
			1:0	ALS Interrupt Filter	ALS interrupt is triggered after 00: 1 integration cycle **01: 4 integration cycles** 10: 8 integration cycles 11: 16 integration cycles
02h	ALS Control	0xA0	7:5	ALS Level	The ADC effective resolution 000: 3 levels 001: 5 levels 010: 9 levels 011: 17 levels 100: 33 levels **101: 64 levels** Others: Reserved
			4:0	Low Lux	Low lux threshold level

				Threshold	

Address	Register Name	Default	Bit(s)	Function	Description
03h	Interrupt Status (Read Only)	0x00	7:2	Reserved	
			1	PS_Int	**0: Interrupt is cleared or not yet triggered** 1: Interrupt is triggered
			0	ALS_Int	**0: Interrupt is cleared or not yet triggered** 1: Interrupt is triggered
04h	PS Control	0x4A	7:6	PS Accuracy	Sets the accuracy of the PS data 00: 6 PS counts **01: 7 PS counts** 10: 8 PS counts 11: 9 PS counts
			5	Reserved	Write as 0
			4:0	PS Threshold Level Control	Sets the PS threshold level
05h	Data (Read Only)	0x00	7	PS Data	**0: Object is not detected** 1: Object is detected
			6	Reserved	
			5:0	ALS Data	6-bit ADC data
08h	ALS Window	0x00	7:4	Reserved	Write as 0
			3:0	ALS Window Loss	ALS window loss compensation

Configuration Register (00H)

00H	Configuration **(default = 0x03)**							
	B7	B6	B5	B4	B3	B2	B1	B0
	Write as 0				Mode Select		Operation Select	

Mode Select (BITS 3:2)

This function selects the device operation mode.

BITS 3:2	Description
00	**Power up the device. Internal IR LED driver can be enabled or disabled. (default)**
01	Reserved.
10	Power down the device. Disable internal IR LED driver. All registers are accessible under this mode.
11	Soft reset the device and all the registers will be reset to the default value.

Operation Select (BITS 1:0)

This function selects ALS or/and PS to be in operational mode.

BITS 1:0	Description
00	Enable ALS to be in active mode and disable internal IR LED driver.
01	Enable PS to be in active mode and enable internal IR LED driver.
10	Enable both ALS and PS to be in active mode. Enable internal IR LED driver.
11	**The device is in idle mode and will not generate any interrupt. All device registers can be modified at this mode. (default)**

Timing Control Register (01H)

01H	Timing Control **(default = 0x11)**							
	B7	B6	B5	B4	B3	B2	B1	B0
	Write as 0		PS Interrupt Filter		Write as 0	Integration Time	ALS Interrupt Filter	

PS Interrupt Filter (BITS 5:4)

This PS Interrupt Filter controls the filtering interrupt capabilities of the PS. Configurable filtering is provided to allow interrupts to be generated when there is a change in PS Data from ‘object detected’ to ‘object not detected’ for N consecutive numbers of integration cycles (100ms or 200ms, set by Integration Time) or vice versa. The PS Interrupt Filter bits determine N.

BITS 5:4	N, Number of Integration Cycles
00	1 integration cycle (PS interrupt is triggered after 1 integration cycle)
01	**4 integration cycles (PS interrupt is triggered after 4 integration cycles) (default)**
10	6 integration cycles (PS interrupt is triggered after 6 integration cycles)
11	8 integration cycles (PS interrupt is triggered after 8 integration cycles)

Integration Time (BIT 2)

This function controls the internal integration time of the ADC channels for PS and ALS. This is the period at which the device's ADC will sample the photodiode current signal for a measurement. Integration time affects the measurement resolution. The device will respond faster when the integration time is shorter. However, this will result in a decrease in time-to-time accuracy of the PS and ALS readings.

BIT 2	Integration Time
0	**100ms (default)**
1	200ms

ALS Interrupt Filter (BITS 1:0)

This ALS Interrupt Filter controls the filtering interrupt capabilities of the ALS. Configurable filtering is provided to allow interrupts to be generated when there is a change in ALS Data and get same ALS data for N consecutive numbers of integration cycles (100ms or 200ms, set by Integration Time). The ALS Interrupt Filter bits determine N.

BITS 1:0	N, Number of Integration Cycles
00	1 integration cycle (ALS interrupt is triggered after 1 integration cycle)
01	**4 integration cycles (ALS interrupt is triggered after 4 integration cycles) (default)**
10	8 integration cycles (ALS interrupt is triggered after 8 integration cycles)
11	16 integration cycles (ALS interrupt is triggered after 16 integration cycles)

ALS Control Register (02H)

02H	ALS Control (**default = 0xA0**)							
	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Level			Low Lux Threshold				

ALS Level (BITS 7:5)

This function selects the ADC effective resolution of the device.

BITS 7:5	ALS Level, ADC Effective Resolution
000	3 levels
001	5 levels
010	9 levels
011	17 levels
100	33 levels
101	**64 levels (default)**
Other	Reserved

Low Lux Threshold (BITS 4:0)

This function sets the low lux threshold level and is default to 00000. For example, when the Low Lux Threshold is set to 00101 (ADC count = 5), the device will output the ALS data as '0' for any light level that translates to ADC count ≤ 5.

Interrupt Status Register (03H) (Read Only)

03H	Interrupt Status (**default = 0x00**)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Write as 0						PS_Int	ALS_Int

PS_Int (BIT 1)

This bit shows the status of the PS interrupt. Read Data Register (0x05) to clear PS_Int.

BIT 1	PS_Int
0	**Interrupt is cleared or not yet triggered (default)**
1	Interrupt is triggered

ALS_Int (BIT 0)

This bit shows the status of the ALS interrupt. Read Data Register (0x05) to clear ALS_Int.

BIT 1	ALS_Int
0	**Interrupt is cleared or not yet triggered (default)**
1	Interrupt is triggered

PS Control Register (04H)

04H	**PS Control (default = 0x4A)**							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Accuracy		Write as 0	PS Threshold Level Control				

PS Accuracy (BITS 7:6)

This function controls the accuracy of the PS data. In each integration cycle, the PS device transmits 10 pulses and checks for how many pulses, M, reflected by object and detected by the PS sensor. The PS Data output as 'object detected' when M >= PS Accuracy setting.

BITS 7:6	PS Accuracy
00	6 PS counts
01	**7 PS counts (default)**
10	8 PS counts
11	9 PS counts

PS Threshold Level Control (BITS 4:0)

This function sets the DPS threshold level and is default to 01010 (0x0A). There are 31 threshold levels to select except 0x00 which must not be used. Refer to Figure14 for the typical detection distance at different threshold level control. Larger value is recommended for operating in sunlight environment. The PS Threshold Level adjustment by software provides designer more flexibility and forgiveness against design and assembly tolerance against environment. Such tolerance comes from parts tolerance, IR LED bin2bin variation, etc as resulted from mass production.

Data Register (05H) (Read only)

05H	**Data (default = 0x00)**							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Data	Reserved	ALS Data					

PS Data (BIT 7)

BIT 7	PS Data
0	**Object is not detected (default)**
1	Object is detected

ALS Data (BITS 5:0)

The ADC channel data for ALS.

ALS Window Register (08H)

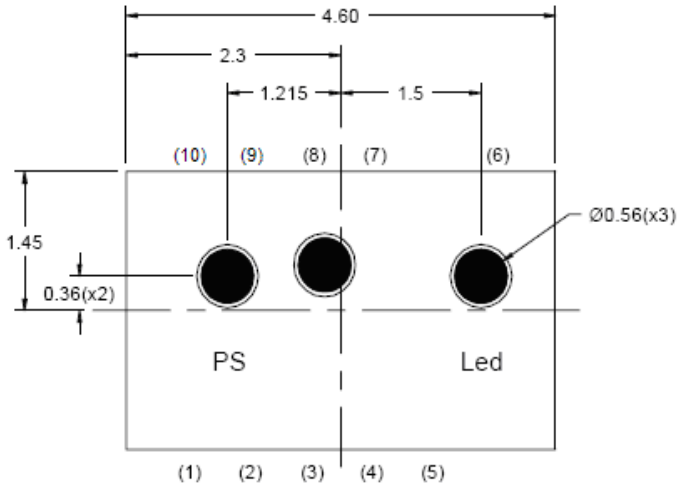
08H	**ALS Window (default = 0x00)**							
	B7	B6	B5	B4	B3	B2	B1	B0
	Write as 0				ALS Window Loss			

ALS Window Loss (BITS 3:0)

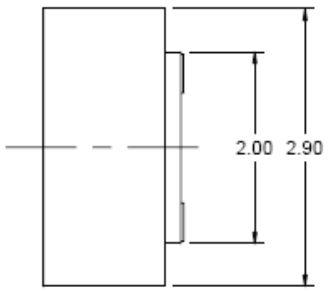
This function compensates the window transmission loss observed by ALS and it must be used in conjunction with Register 02H, Low Lux Threshold parameter. It is default to 0000 and this function affects the low illuminance detection sensitivity. For example, at default setting when there is no window transmission loss compensation, the minimum detection illuminance level is 2 lux. The minimum detection illuminance level will be higher with higher compensation for window transmission loss.

BITS 3:0	ALS Window Loss	Low Lux Threshold (Register 02H)
0000	**No Window Transmission Loss Compensation (default)**	**00000**
0001	Compensate for 17% Window Transmission Loss	00001
0010	Compensate for 31% Window Transmission Loss	00010
0011	Compensate for 42% Window Transmission Loss	00011
0100	Compensate for 52% Window Transmission Loss	00100
0101	Compensate for 60% Window Transmission Loss	00101
0110	Compensate for 65.6% Window Transmission Loss	00110
0111	Compensate for 67% Window Transmission Loss	00111
1000	Compensate for 72.2% Window Transmission Loss	01000
1001	Compensate for 80.7% Window Transmission Loss	01001
1010	Compensate for 84% Window Transmission Loss	01010
1011	Compensate for 86.7% Window Transmission Loss	01011
1100	Compensate for 89% Window Transmission Loss	01100
1101	Compensate for 90.75% Window Transmission Loss	01101
1110	Compensate for 92.3% Window Transmission Loss	01110
1111	Compensate for 93.5% Window Transmission Loss	01111

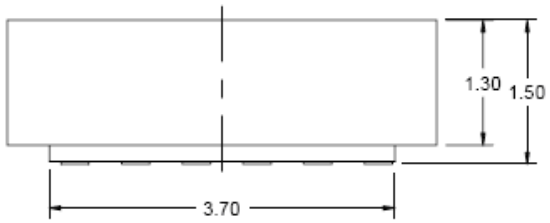
Outline Dimensions



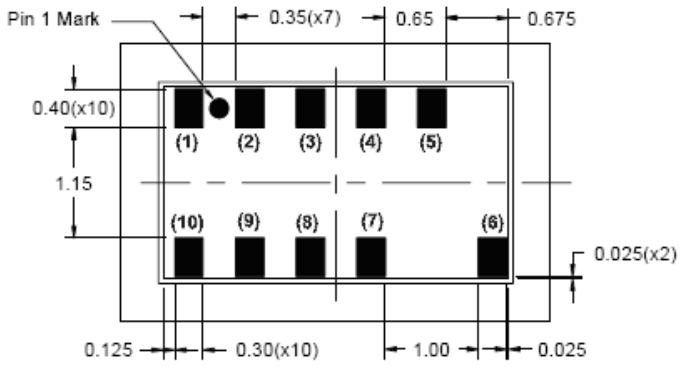
Top View



Right Side View



Front View



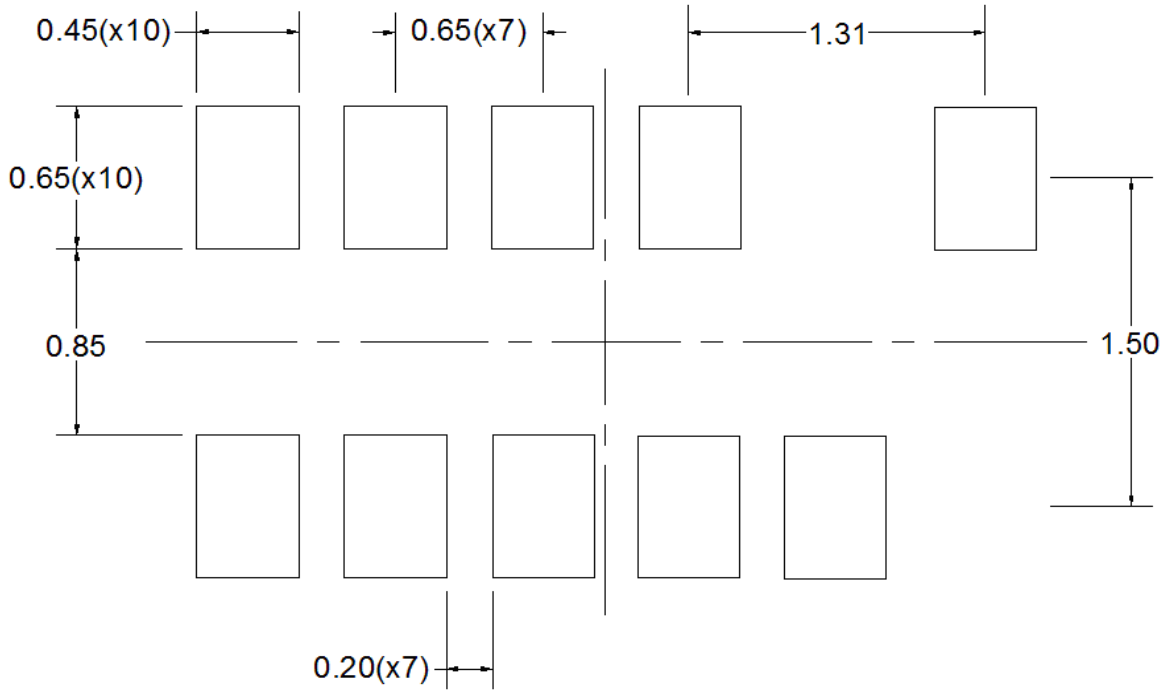
Bottom View

1. VDD
2. GND
3. REXT
4. SEL
5. NC
6. NC
7. VLEDA
8. INT
9. SCL
10. SDA

"*"Pads are option but recommend.
To better secure the package(one or both)

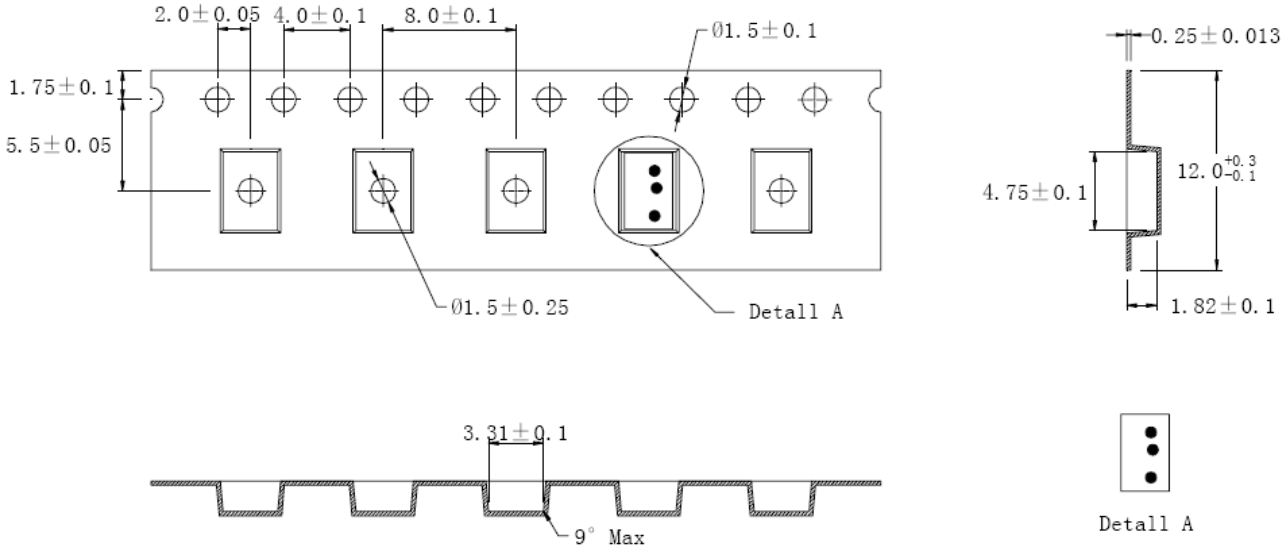
Notes:
All dimensions are in milimeters.
Tolerances: ±0.2mm

Recommended Land Pattern



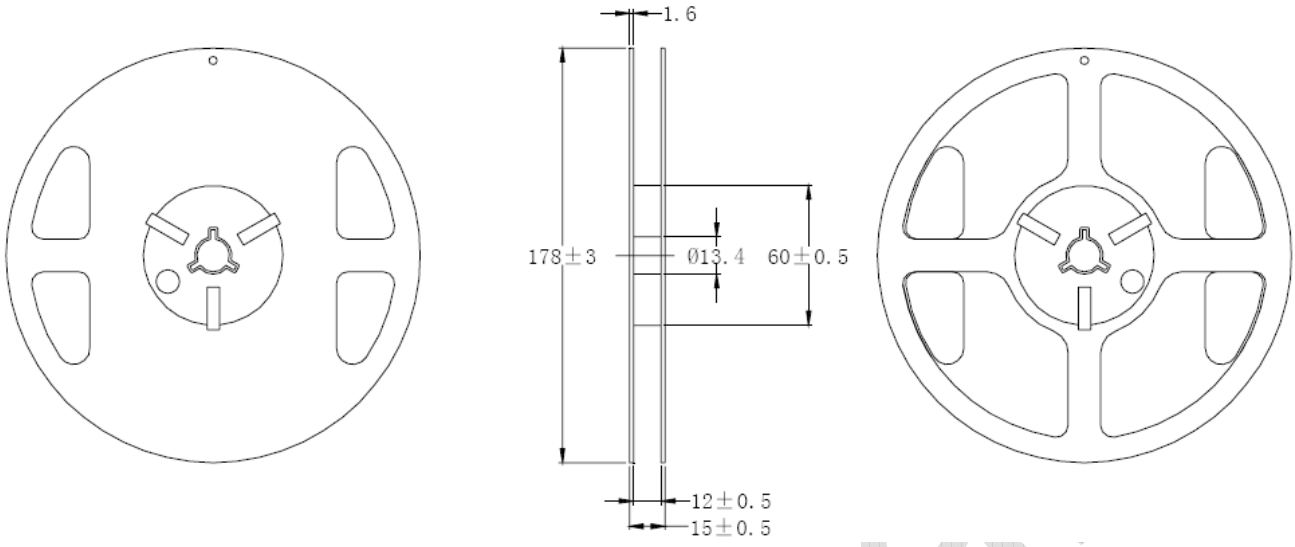
Note:
All dimensions are in millimeters

Package Dimension for Tape and Reel



Note:
All dimensions are in millimeters

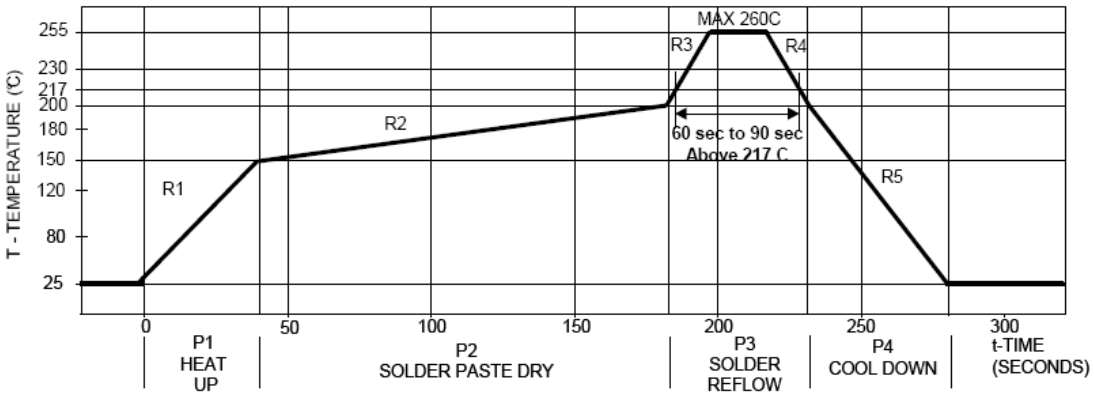
Package Dimension of Reel



Notes:

1. All dimensions are in millimeters.

Recommend Leadfree Reflow Profile



Process Zone	Symbol	ΔT	Maximum ΔT/Δtime or Duration
Heat Up	P1, R1	25°C to 150°C	3°C/s
Solder Paste Dry	P2, R2	150°C to 200°C	100s to 180s
Solder Reflow	P3, R3	200°C to 260°C	3°C/s
	P3, R4	260°C to 200°C	-6°C/s
Cool Down	P4, R5	200°C to 25°C	-6°C/s
Time maintained above liquidus point , 217°C		> 217°C	60s to 90s
Peak Temperature		260°C	-
Time within 5°C of actual Peak Temperature		> 255°C	20s
Time 25°C to Peak Temperature		25°C to 260°C	8mins