LITEON OPTOELECTRONICS

Optical Sensor

Product Data Sheet

LTR-558ALS-01

Spec No.: DS86-2011-0006

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Revision: C

LITE-ON DCC

RELEASE

BNS-OD-FC001/A4

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1. Description

The LTR-558ALS-01 is an integrated low voltage I2C digital light sensor [ALS] and proximity sensor [PS] with built-in emitter, in a single miniature chipled lead-free surface mount package. This sensor converts light intensity to a digital output signal capable of direct I^2C interface. It provides a linear response over a wide dynamic range from 0.01 lux to 64k lux and is well suited to applications under high ambient brightness. With built-in proximity sensor (emitter and detector), LTR-558ALS-01 offers the feature to detect object at a user configurable distance.

The sensor supports an interrupt feature that removes the need to poll the sensor for a reading which improves system efficiency. The sensor 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 sensor-to-sensor variations for ease of manufacturability to the end customers.

2. Features

- I^2C interface (Fast Mode @ 400kbit/s)
- Ultra-small ChipLED package
- Built-in temperature compensation circuit
- Low active power consumption with standby mode
- Supply voltage range from 2.4V to 3.6V capable of 1.7V logic voltage
- Operating temperature range from -30°C to +70°C
- RoHS and Halogen free compliant
- Light Sensor
  - Close to human eye spectral response
  - Immunity to IR / UV Light Source
  - Automatically rejects 50 / 60 Hz lightings flicker
  - Full dynamic range from 2 lux to 64k lux
  - High resolution range from 0.01 lux to 320 lux
  - 16-bit effective resolution
- Proximity Sensor
  - Built-in LED driver, emitter and detector
  - Programmable LED drive settings
  - 11-bit effective resolution
  - High ambient light suppression

3. Applications

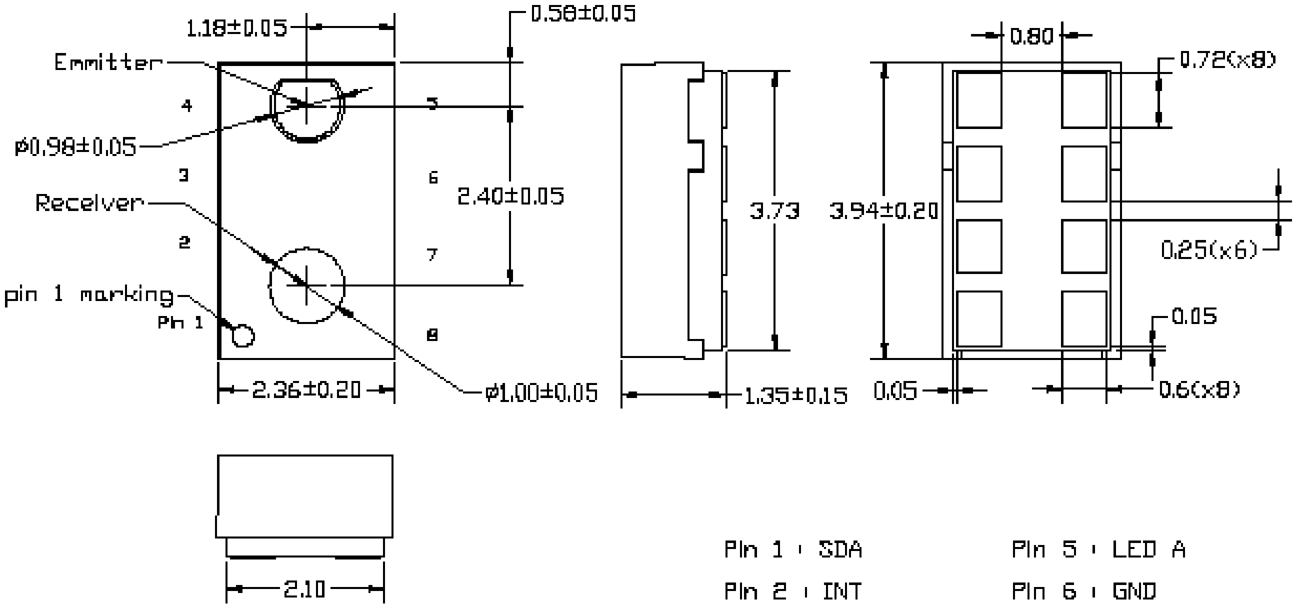
To control display backlight in

- Mobile Devices: Mobile phone, PDA
- Computing Devices: Notebook PC, Desktop Monitor
- Consumer Devices: LCD/PDP TV backlight systems, Cameras, Personal Navigation Device, Digital Photo Frame
- Dashboard

4. Ordering Information

Part Number	Packaging Type	Package	Quantity
LTR-558ALS-01	Tape and Reel	8-pins chipled package	8000

5. Outline Dimensions

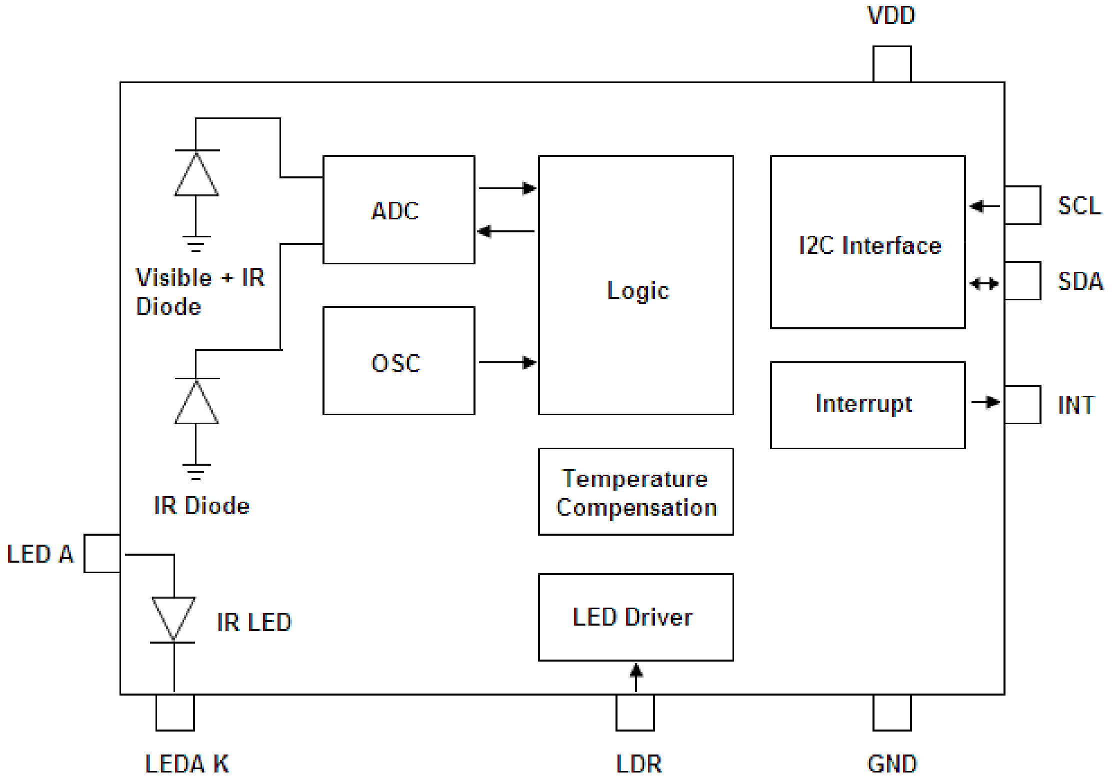


Pin 1 : SDA
Pin 2 : INT
Pin 3 : LDR
Pin 4 : LED K
Pin 5 : LED A
Pin 6 : GND
Pin 7 : SCL
Pin 8 : VDD

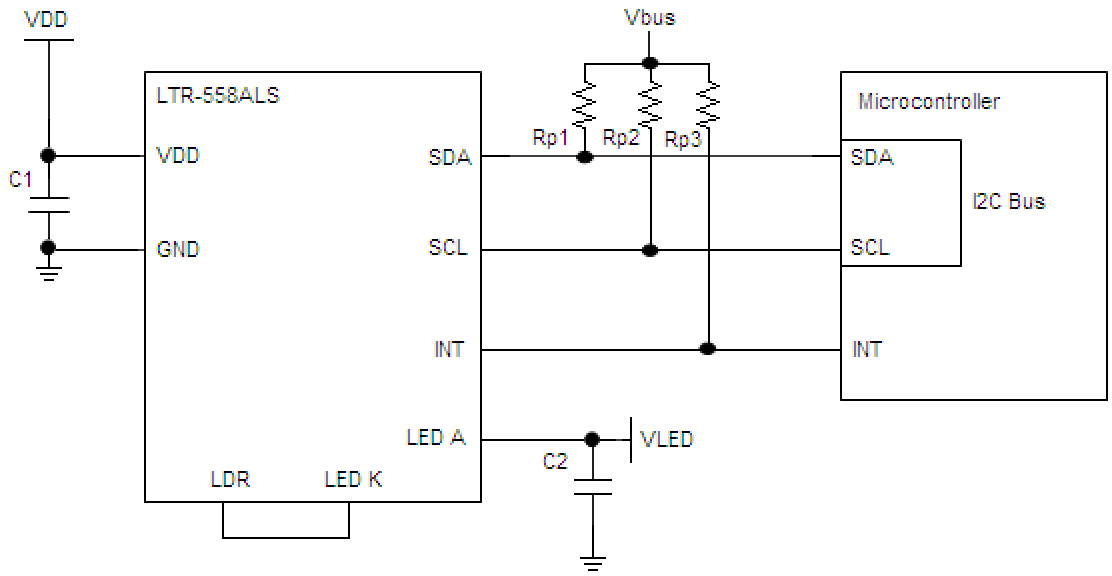
Notes:

1. All dimensions are in millimeters

6. Functional Block Diagram



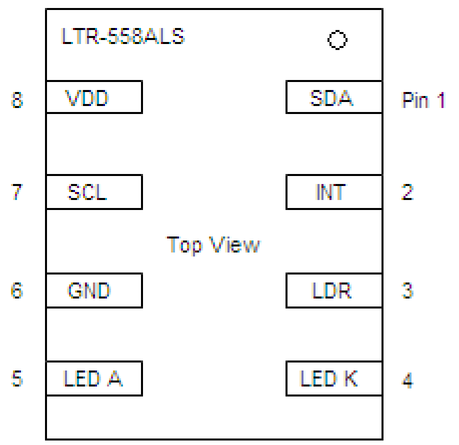
7. Application Circuit



I/O Pins Configuration Table

Pin	I/O Type	Symbol	Description
1	I/O	SDA*	I^{2}C serial data. This pin is an open drain input / output.
2	O	INT*	Level Interrupt Pin. This pin is an open drain output.
3	I	LDR	LED Driver for proximity emitter. This pin is an open drain input.
4	O	LED K	LED Cathode. Connect to LDR pin if internal LED driver circuit is in use.
5	I	LED A	LED Anode. Connect to VDD or VBAT on PCB
6		GND	Ground
7	I	SCL*	I^{2}C serial clock. This pin is an open drain input.
8		VDD	Power Supply Voltage

** Note: For noisy environment, add 10pF capacitor from signal to GND for additional noise filtering.*



Recommended Application Circuit Components

Component	Recommended Value	Condition
Rp1, Rp2, Rp3 [1]	1 kΩ to 10 kΩ	
C1, C2	1uF ± 20%, X7R / X5R Ceramic	

[1] Selection of pull-up resistors value is dependent on bus capacitance values. For more details, please refer to I2C Specifications: http://www.nxp.com/documents/user_manual/UM10204.pdf

8. Rating and Specification

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Rating	Unit
Supply Voltage	VDD	3.8	V
Digital Voltage Range	SCL, SDA, INT	-0.5 to 3.8	V
Digital Output Current	SCL, SDA, INT	-1 to 20	mA
Storage Temperature	T_{stg}	-40 to 85	°C

Note: Exceeding these ratings could cause damage to the sensor. 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	2.4		3.6	V	
LED Supply Voltage	VLED	2.5		4.35	V	
Interface Bus Power Supply Voltage	V_{IO}	1.7		3.6	V	
I^{2}C Bus Input Pin High Voltage	V_{IH} SCL, V_{IH} SDA	1.2			V	
I^{2}C Bus Input Pin Low Voltage	V_{IL} SCL, V_{IL} SDA			0.6	V	
Operating Temperature	T_{ope}	-30		70	°C	

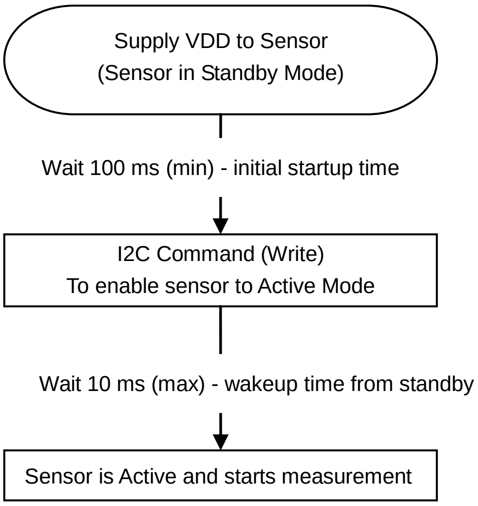
Electrical & Optical Specifications

All specifications are at VDD = 3.0V, T_{ope} = 25°C, unless otherwise noted.

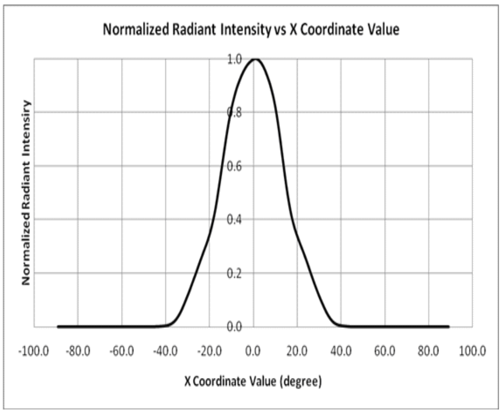
Parameter	Min.	Typ.	Max.	Unit	Condition
Active Supply Current		200	300	uA	Active Mode, T_{ope} = 25°C
Standby Current			5	uA	Standby / Sleep Mode
Initial Startup Time	100			ms	(Note 1)
Wakeup Time from Standby			10	ms	(Note 1)
Light Sensor					
Parameter	**Min.**	**Typ.**	**Max.**	**Unit**	**Condition**
Full Scale ADC Count			65535	count	
Dark ADC Count	0		6	count	Ch0, Lux = 0
	0		6	count	Ch1, Lux = 0
ADC Count (Gain = 1)		95		count	Ch0, Lux = 200
		40		count	Ch1, Lux = 200
Dynamic Range 1	0.01		320	lux	0.005 lux / count
Dynamic Range 2	2		64k	lux	1 lux / count
Proximity Sensor					
Parameter	**Min.**	**Typ.**	**Max.**	**Unit**	**Condition**
Full Scale ADC Count			2047	count	
Peak Sensitivity		850		nm	
Detection Distance	20	50		mm	100mA, 8 pulses, 18% Gray Card
Ambient Light Suppression			50k	lux	Direct sunlight
LED Pulse Count	1		255	pulses	
LED Pulse Frequency	30k		100k	Hz	Increment of 10k Hz
LED Duty Cycle	25		100	%	Increment of 25%
LED Peak Current		5		mA	LED Peak Current = 000
		10		mA	LED Peak Current = 001
		20		mA	LED Peak Current = 010
		50		mA	LED Peak Current = 011
		100		mA	LED Peak Current = 100/101/110/111
Optical Rise / Fall Time	100			ns	

Notes:

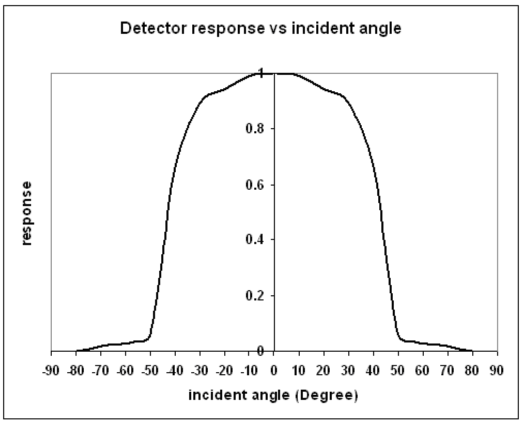
1. Startup Sequence



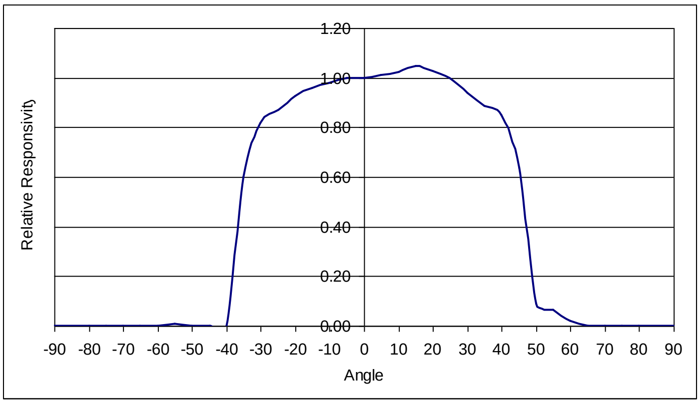
2. Normalized Radiation Pattern for the Emitter (Simulation data)



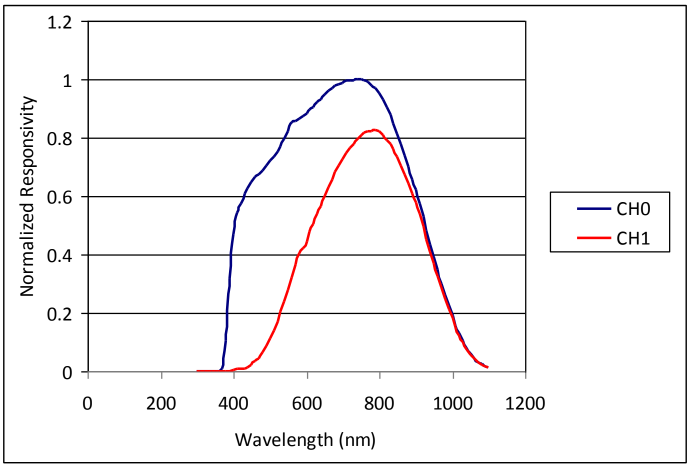
3. Normalized Sensitivity Response for the PS Detector (Simulation data)



4. Normalized Sensitivity Response for the ALS Detector



5. Spectral Responsivity

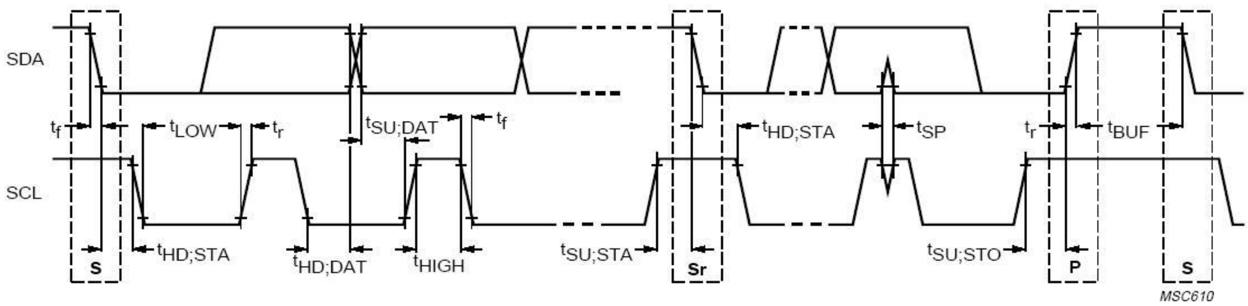


6. Calculating Lux
Please refer to Appendix A.

AC Electrical Characteristics

All specifications are at VBus = 1.8V, T_{ope} = 25°C, unless otherwise noted.

Parameter	Symbol	Min.	Max.	Unit
SCL clock frequency	f_{SCL}	1	400	kHz
Bus free time between a STOP and START condition	t_{BUF}	1.3		us
Hold time (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	0.6		us
LOW period of the SCL clock	t_{LOW}	1.3		us
HIGH period of the SCL clock	t_{HIGH}	0.6		us
Set-up time for a repeated START condition	$t_{SU;STA}$	0.6		us
Set-up time for STOP condition	$t_{SU;STO}$	0.6		us
Rise time of both SDA and SCL signals	t_r	30	300	ns
Fall time of both SDA and SCL signals	t_f	30	300	ns
Data hold time	$t_{HD;DAT}$	0.3	0.9	us
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



Definition of timing for I²C bus

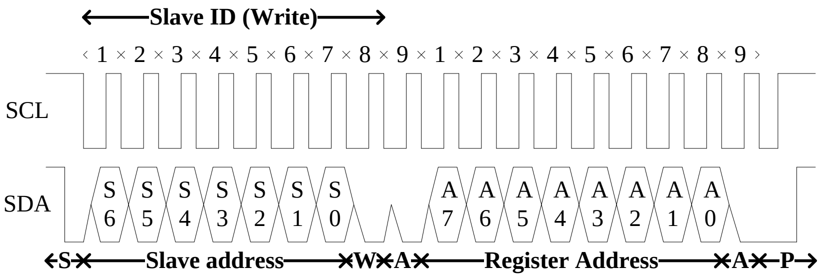
9. Principles of Operation

I2C Protocols

· I2C Write Protocol (type 1):

1	7	1	1	8	1	1
S	Slave address	W	A	Register Address	A	P

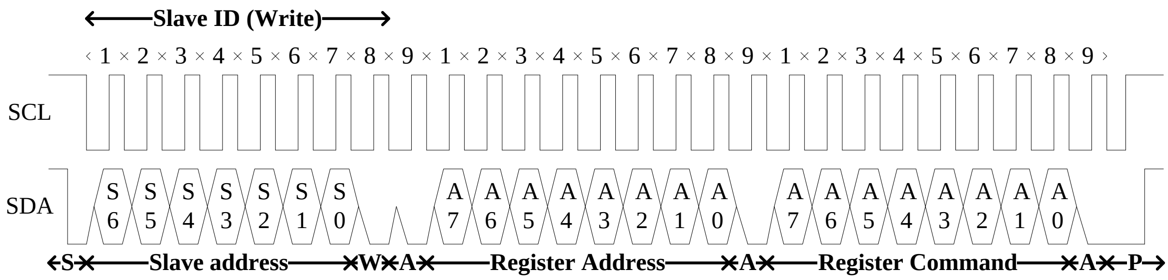
←Slave ID (Write)→



· I2C Write Protocol (type 2):

1	7	1	1	8	1	8	1	1
S	Slave address	W	A	Register Address	A	Register Command	A	P

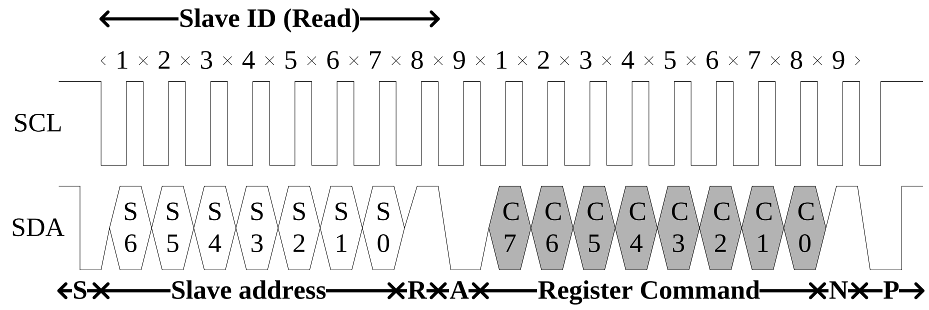
←Slave ID (Write)→



· I2C Read Protocol:

1	7	1	1	8	1	1
S	Slave address	R	A	Register Command	N	P

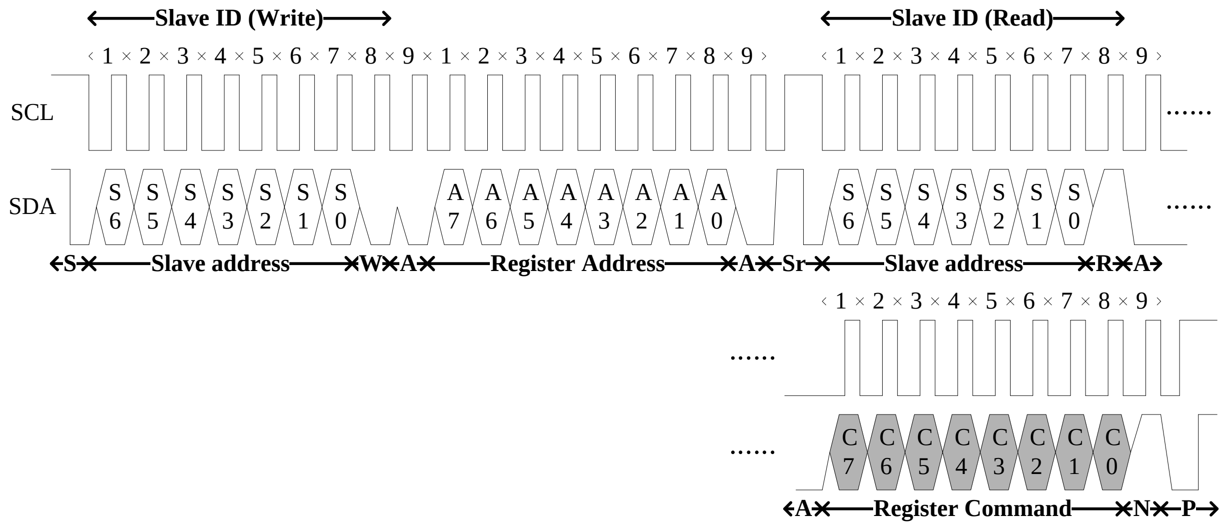
←Slave ID (Read)→



· I2C Read (Combined format) Protocol:

1	7	1	1	8	1	1	7	1	1	8	1	1
S	Slave address	W	A	Register Address	A	Sr	Slave address	R	A	Register Command	N	P

Slave ID (Write) — Slave ID (Read)



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)
■ (shaded)	Slave-to-master	□	Master-to-Slave

I2C Slave Address

The 7 bits slave address for this sensor is 0x23H. A read/write bit should be appended to the slave address by the master device to properly communicate with the sensor.

I2C Slave Address									
Command Type	(0x23H)							W/R	value
	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	
Write	0	1	0	0	0	1	1	0	0x46H
Read	0	1	0	0	0	1	1	1	0x47H

Register Set

Addr	R / W	Register Name	Description	Reset Value
0x80	R / W	ALS_CONTR	ALS operation mode control SW reset	0x00
0x81	R / W	PS_CONTR	PS operation mode control	0x00
0x82	R / W	PS_LED	PS LED setting	0x6B
0x83	R / W	PS_N_PULSES	PS number of pulses	0x7F
0x84	R / W	PS_MEAS_RATE	PS measurement rate in active mode	0x02
0x85	R / W	ALS_MEAS_RATE	ALS measurement rate in active mode	0x03
0x86	R	PART_ID	Part Number ID and Revision ID	0x80
0x87	R	MANUFAC_ID	Manufacturer ID	0x05
0x88	R	ALS_DATA_CH1_0	ALS measurement CH1 data, lower byte	0x00
0x89	R	ALS_DATA_CH1_1	ALS measurement CH1 data, upper byte	0x00
0x8A	R	ALS_DATA_CH0_0	ALS measurement CH0 data, lower byte	0x00
0x8B	R	ALS_DATA_CH0_1	ALS measurement CH0 data, upper byte	0x00
0x8C	R	ALS_PS_STATUS	ALS and PS new data status	0x00
0x8D	R	PS_DATA_0	PS measurement data, lower byte	0x00
0x8E	R	PS_DATA_1	PS measurement data, upper byte	0x00
0x8F	R / W	INTERRUPT	Interrupt settings	0x08
0x90	R / W	PS_THRES_UP_0	PS interrupt upper threshold, lower byte	0xFF
0x91	R / W	PS_THRES_UP_1	PS interrupt upper threshold, upper byte	0x07
0x92	R / W	PS_THRES_LOW_0	PS interrupt lower threshold, lower byte	0x00
0x93	R / W	PS_THRES_LOW_1	PS interrupt lower threshold, upper byte	0x00
0x97	R / W	ALS_THRES_UP_0	ALS interrupt upper threshold, lower byte	0xFF
0x98	R / W	ALS_THRES_UP_1	ALS interrupt upper threshold, upper byte	0xFF
0x99	R / W	ALS_THRES_LOW_0	ALS interrupt lower threshold, lower byte	0x00
0x9A	R / W	ALS_THRES_LOW_1	ALS interrupt lower threshold, upper byte	0x00
0x9E	R / W	INTERRUPT PERSIST	ALS / PS Interrupt persist setting	0x00

Notes:

1) *When reading ALS/PS data registers, read sequence should always be from lower address to higher address (E.g. For ALS data, Ch1 data should be read first followed by Ch0 data. Read sequence should be 0x88, 0x89, 0x8A, 0x8B. When 0x8B is read, all four ALS data registers will be populated with new set of data).*

2) *When setting of INTERRUPT register (addr 0x8F) is necessary, it should be done before the device is in Active mode.*

ALS_CONTR Register (0x80)

The ALS_CONTR register controls the ALS operation modes and software (SW) reset for the sensor. The ALS sensor can be set to either standby mode or active mode. At either of these modes, the I^2C circuitry is always active. The default mode after power up is standby mode. During standby mode, there is no ALS measurement performed but I^2C communication is allowed to enable read/write to all the registers.

0x80	ALS_CONTR (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved				*ALS Gain*	*SW Reset*	*ALS Mode*	

Field	BITS	Description
Reserved	7:4	Must write as 0
ALS Gain	3	0: Dynamic Range 2 (2 lux to 64k lux) (default) 1: Dynamic Range 1 (0.01 lux to 320 lux)
SW Reset	2	0: Software reset is NOT started (default) 1: Software reset is started, default value after reset is 0
ALS Mode	1:0	00 / 01: Standby Mode (default) 10 / 11: Active Mode

PS_CONTR Register (0x81)

The PS_CONTR register controls the PS operation modes. The PS sensor can be set to either standby mode or active mode. At either of these modes, the I^2C circuitry is always active. The default mode after power up is standby mode. During standby mode, there is no PS measurement performed but I^2C communication is allowed to enable read/write to all the registers.

0x81	PS_CONTR (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved				*PS Gain*		*PS Mode*	

Field	BITS	Description
Reserved	7:4	Must write as 0
PS Gain	3:2	00: x1 Gain (default) 01: x4 Gain 10: x8 Gain 11: x16 Gain
PS Mode	1:0	00 / 01: Standby Mode (default) 10 / 11: Active Mode

PS_LED Register (0x82)

The PS_LED register controls the LED pulse modulation frequency, LED current duty cycle and LED peak current.

0x82	PS_LED (default = 0x6B)							
	B7	B6	B5	B4	B3	B2	B1	B0
	LED Pulse Frequency			*LED Duty Cycle*		*LED Peak Current*		

Field	BITS	Description
LED Pulse Frequency	7:5	000: 30k Hz 001: 40k Hz 010: 50k Hz 011: 60k Hz (default) 100: 70k Hz 101: 80k Hz 110: 90k Hz 111: 100k Hz
LED Duty Cycle	4:3	00: 25% 01: 50% (default) 10: 75% 11: 100%
LED Peak Current	2:0	000: 5mA

		001: 10mA 010: 20mA 011: 50mA (default) Others: 100mA

PS_N_Pulses Register (0x83)

The PS_N_Pulses register controls the number of LED pulses to be emitted.

0x83	PS_N_Pulses (default = 0x7F)							
	B7	B6	B5	B4	B3	B2	B1	B0
	LED Pulse Count							

Field	BITS	Description
LED Pulse Count	7:0	0000 0000: Number of pulses = 0 0000 0001: Number of pulses = 1 0000 0010: Number of pulses = 2 … 0111 1111: Number of pulses = 127 (default) … 1111 1110: Number of pulses = 254 1111 1111: Number of pulses = 255

PS_MEAS_RATE Register (0x84)

The PS_MEAS_RATE register controls the timing of the periodic measurements of the PS in active mode. PS Measurement Repeat Rate is the interval between PS_DATA registers update.

0x84	PS_MEAS_RATE (default = 0x02)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved				*PS Measurement Repeat Rate*			

Field	BITS	Description
Reserved	7:4	Must write as 0
PS Measurement Repeat Rate	3:0	0000: 50ms 0001: 70ms 0010: 100ms (default) 0011: 200ms 0100: 500ms 0101: 1000ms 0110 / 0111: 2000ms 1XXX: Reserved

ALS_MEAS_RATE Register (0x85)

The ALS_MEAS_RATE register controls the integration time and timing of the periodic measurement of the ALS in active mode. ALS Measurement Repeat Rate is the interval between ALS_DATA registers update. ALS Integration Time is the measurement time for each ALS cycle.

ALS Measurement Repeat Rate must be set to be equal or larger than the ALS Integration Time. If ALS Measurement Repeat Rate is set to be smaller than ALS Integration Time, it will automatically be reset to be equal to ALS Integration Time by the IC internally.

0x85	ALS_MEAS_RATE (default = 0x03)							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	Reserved			***ALS Integration Time***		***ALS Measurement Repeat Rate***		

Field	BITS	Description
Reserved	7:5	Must write as 0
ALS Integration Time	4:3	00: 100ms (default) 01: 50ms (can only be used in Dynamic Range 2, effective resolution is 15-bit @ 2 lux / count) 10: 200ms (can only be used in Dynamic Range 1) 11: 400ms (can only be used in Dynamic Range 1)

ALS Measurement Repeat Rate	2:0	000: 50ms 001: 100ms 010: 200ms 011: 500ms (default) 100: 1000ms 101 / 110 / 111: 2000ms

PART_ID Register (0x86) (Read Only)

The PART_ID register defines the part number and revision identification of the sensor.

0x86	**PART_ID (default = 0x80)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	Part Number ID				***Revision ID***			

Field	BITS	Description
Part Number ID	7:4	0x08H
Revision ID	3:0	0x00H

MANUFAC_ID Register (0x87) (Read Only)

The MANUFAC_ID register defines the manufacturer identification of the sensor.

0x87	**MANUFAC_ID (default = 0x05)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	Manufacturer ID							

Field	BITS	Description
Manufacturer ID	7:0	0x05H

ALS_DATA_CH1 Register (0x88 / 0x89) (Read Only)

The ALS_DATA registers should be read as a group, with the lower address read back first (i.e. read 0x88 first, then read 0x89). These two registers should also be read before reading channel-0 data (from registers 0x8A, 0x8B).

When the I^2C read operation starts, all four ALS data registers are locked until the I^2C read operation of register 0x8B is completed. This will ensure that the data in the registers is from the same measurement even if an additional integration cycle ends during the read operation. New measurement data is stored into temporary registers and the ALS_DATA registers are updated as soon as there is no on-going I^2C read operation.

The ALS ADC channel-1 data is expressed as a 16-bit data spread over two registers. The ALS_DATA_CH1_0 and ALS_DATA_CH1_1 registers provide the lower and upper byte respectively.

0x88	ALS_DATA_CH1_0 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Data Ch1 Low							

0x89	ALS_DATA_CH1_1 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	ALS Data Ch1 High							

Field	Addr	BITS	Description
ALS Data Ch1 Low	0x88	7:0	ALS ADC channel 1 lower byte data
ALS Data Ch1 High	0x89	7:0	ALS ADC channel 1 upper byte data

ALS_DATA_CH0 Register (0x8A / 0x8B) (Read Only)

These two registers should be read after reading channel-1 data (from registers 0x88, 0x89). Lower address register should be read first (i.e read 0x8A first, then read 0x8B). See ALS_DATA_CH1 register information above.

The ALS ADC channel-0 data is expressed as a 16-bit data spread over two registers. The ALS_DATA_CH0_0 and ALS_DATA_CH0_1 registers provide the lower and upper byte respectively.

0x8A	**ALS_DATA_CH0_0 (default = 0x00)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Data Ch0 Low							

0x8B	**ALS_DATA_CH0_1 (default = 0x00)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Data Ch0 High							

Field	**Addr**	**BITS**	**Description**
ALS Data Ch0 Low	0x8A	7:0	ALS ADC channel 0 lower byte data
ALS Data Ch0 High	0x8B	7:0	ALS ADC channel 0 upper byte data

ALS_PS_STATUS Register (0x8C) (Read Only)

The ALS_PS_STATUS register stores the information about interrupt status and ALS and PS data status. New data means data has not been read yet. When the measurement is completed and data is written to the data register, the data status bit will be set to logic 1. When the data register is read, the data status bit will be set to logic 0.

Interrupt status determines if the ALS and PS interrupt criteria are met. It will check if the ALS or PS measurement data is outside of the range defined by the upper and lower threshold limits.

0x8C	**ALS_PS_STATUS (default = 0x00)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	Reserved			***ALS Gain***	***ALS Interrupt Status***	***ALS Data Status***	***PS Interrupt Status***	***PS Data Status***

Field	BITS	Description
Reserved	7:5	Do not care
ALS Gain	4	0: ALS measurement data is in dynamic range 2 (2 to 64k lux) 1: ALS measurement data is in dynamic range 1 (0.01 to 320 lux)
ALS Interrupt Status	3	0: ALS interrupt is clear or not yet triggered 1: ALS interrupt is triggered
ALS Data Status	2	0: ALS measurement data is old data (Data has been read) 1: ALS measurement data is new data (Data has not been read)
PS Interrupt Status	1	0: PS interrupt is clear or not yet triggered 1: PS interrupt is triggered
PS Data Status	0	0: PS measurement data is old data (Data has been read) 1: PS measurement data is new data (Data has not been read)

PS_DATA_0 Register (0x8D / 0x8E) (Read Only)

The PS ADC channel data are expressed as a 11-bit data spread over two registers. The PS_DATA_0 and PS_DATA_1 registers provide the lower and upper byte respectively. When the I^{2}C read operation starts, both the registers are locked until the I^{2}C read operation is completed. Lower address register should be read first. This will ensure that the data in the registers is from the same measurement even if an additional integration cycle ends during the read operation. New measurement data is stored into temporary registers and the PS_DATA registers are updated as soon as there is no on-going I^{2}C read operation.

0x8D	PS_DATA_0 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Data Low							

0x8E	PS_DATA_1 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved					*PS Data High*		

Field	Addr	BITS	Description
PS Data Low	0x8D	7:0	PS ADC lower byte data
Reserved	0x8E	7:3	Do not care
PS Data High	0x8E	2:0	PS ADC upper byte data

INTERRUPT Register (0x8F)

The INTERRUPT register controls the operation of the interrupt pin and functions. When the Interrupt Mode is set to 00, the INT output pin 2 is inactive / disabled and will not trigger any interrupt. However at this condition, the ALS_PS_STATUS register will still be updated.

Note that when this register is to be set with values other than its default values, it should be set before device is in Active mode.

0x8F	INTERRUPT (default = 0x08)							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	Reserved					***Interrupt Polarity***	***Interrupt Mode***	

Field	BITS	Description
Reserved	7:4	Must write as 0
Reserved	3	Don't Care. Value of this bit does not affect functionality/performance.
Interrupt Polarity	2	0: INT output pin 2 is considered active when it is a logic 0 (default) 1: INT output pin 2 is considered active when it is a logic 1
Interrupt Mode	1:0	00: INT output pin 2 is inactive / high impedance state (default) 01: Only PS measurement can trigger interrupt 10: Only ALS measurement can trigger interrupt 11: Both ALS and PS measurement can trigger interrupt

PS_THRES Register (0x90 / 0x91 / 0x92 / 0x93)

The PS_THRES_UP and PS_THRES_LOW registers determines the upper and lower limit of the interrupt threshold value respectively. These two values form a range and the interrupt function compares if the measurement value in PS_DATA registers is inside or outside the range. The interrupt function is active if the measurement data is outside the range defined by the upper and lower limits. The data format for PS_THRES must be the same as PS_DATA registers.

0x90	PS_THRES_UP_0 (default = 0xFF)							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Upper Threshold Low							

0x91	PS_THRES_UP_1 (default = 0x07)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved					*PS Upper Threshold High*		

0x92	PS_THRES_LOW _0 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Lower Threshold Low							

0x93	PS_THRES_LOW_1 (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	Reserved					*PS Lower Threshold High*		

Field	Addr	BITS	Description
PS Upper Threshold Low	0x90	7:0	PS upper threshold lower byte
Reserved	0x91	7:3	Must write as 0
PS Upper Threshold High	0x91	2:0	PS upper threshold upper byte
PS Lower Threshold Low	0x92	7:0	PS lower threshold lower byte

Reserved	0x93	7:3	Must write as 0
PS Lower Threshold High	0x93	2:0	PS lower threshold upper byte

ALS_THRES Register (0x97 / 0x98 / 0x99 / 0x9A)

The ALS_THRES_UP and ALS_THRES_LOW registers determines the upper and lower limit of the interrupt threshold value respectively. These two values form a range and the interrupt function compares if the measurement value in ALS_DATA registers is inside or outside the range. The interrupt function is active if the measurement data is outside the range defined by the upper and lower limits. The data format for ALS_THRES must be the same as ALS_DATA registers.

0x97	**ALS_THRES_UP_0 (default = 0xFF)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Upper Threshold Low							

0x98	**ALS_THRES_UP_1 (default = 0xFF)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Upper Threshold High							

0x99	**ALS_THRES_LOW _0 (default = 0x00)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Lower Threshold Low							

0x9A	**ALS_THRES_LOW_1 (default = 0x00)**							
	B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
	ALS Lower Threshold High							

Field	Addr	BITS	Description
ALS Upper Threshold Low	0x97	7:0	ALS upper threshold lower byte
ALS Upper Threshold High	0x98	7:0	ALS upper threshold upper byte
ALS Lower Threshold Low	0x99	7:0	ALS lower threshold lower byte
ALS Lower Threshold High	0x9A	7:0	ALS lower threshold upper byte

INTERRUPT PERSIST Register (0x9E)

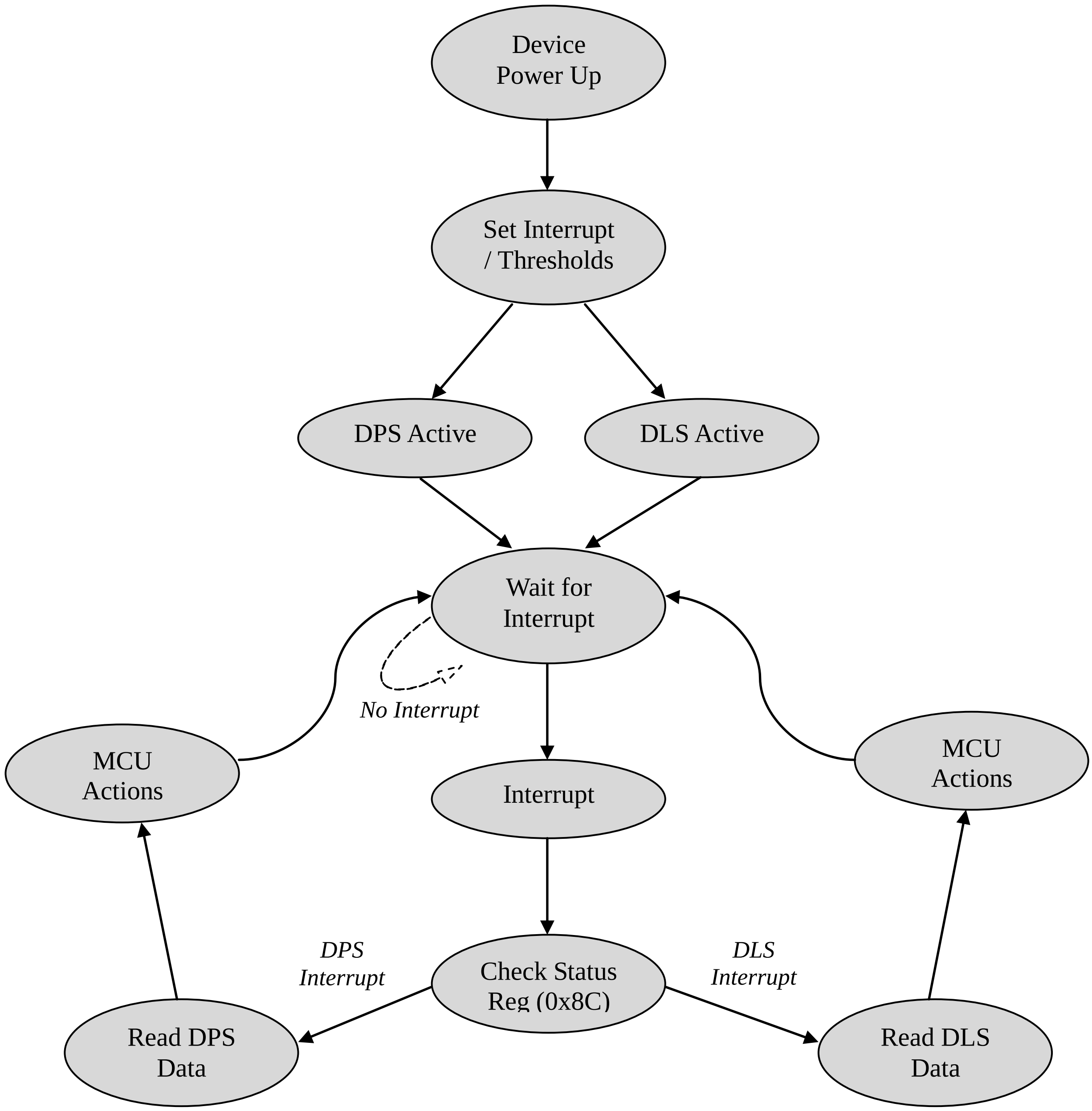
The INTERRUPT PERSIST register controls the N number of times the measurement data is outside the range defined by the upper and lower threshold limits before asserting the INT output pin 2.

0x9E	INTERRUPT PERSIST (default = 0x00)							
	B7	B6	B5	B4	B3	B2	B1	B0
	PS Persist				*ALS Persist*			

Field	BITS	Description
PS Persist	7:4	0000: Every PS measurement data will generate an interrupt (default) 0001: 1 consecutive PS measurement data outside the range 0010: 2 consecutive PS measurement data outside the range … 1111: 15 consecutive PS measurement data outside the range
ALS Persist	3:0	0000: Every ALS measurement data will generate an interrupt (default) 0001: 1 consecutive ALS measurement data outside the range 0010: 2 consecutive ALS measurement data outside the range … 1111: 15 consecutive ALS measurement data outside the range

10. Device Operation (using Interrupt)

Below flow diagram illustrates the LTR-558ALS operation involving the use of Thresholds and Interrupts.



11. Pseudo Codes Examples

Control Registers

```
// The Control Registers define the operating modes and gain settings of the ALS and PS of LTR-558.
// Default settings are 0x00 for both registers (both in Standby mode).

Slave_Addr = 0x23                       // Slave address of LTR-558 device

// Enable ALS (Dynamic Range 2)
Register_Addr = 0x80                    // ALS_CONTR register
Command = 0x03                          // Dynamic Range 2
                                        // For Dynamic Range 1, Command = 0x0B
WriteByte(Slave_Addr, Register_Addr, Command)


// Enable PS (Gain = 1)
Register_Addr = 0x81                    // PS_CONTR register
Command = 0x03                          // Gain = 1
                                        // For Gain = 4, Command = 0x07
                                        // For Gain = 8, Command = 0x0B
                                        // For Gain = 16, Command = 0x0F
WriteByte(Slave_Addr, Register_Addr, Command)
```

PS LED Registers

```
// The PS LED Registers define the LED pulse modulation frequency, duty cycle and peak current.
// Default setting is 0x6B (60kHz, 50%, 50mA).

Slave_Addr = 0x23                       // Slave address of LTR-558 device

// Set LED Pulse Freq 30kHz (duty cycle 50%, peak curr 50mA)
Register_Addr = 0x82                    // PS_LED register
Command = 0x0B                          // Pulse Freq = 30kHz, (duty cyc 50%, peak curr 50mA)
                                        // For Pulse Freq = 40kHz, (50%, 50mA), Command = 0x2B
                                        // For Pulse Freq = 50kHz, (50%, 50mA), Command = 0x4B
                                        // For Pulse Freq = 60kHz, (50%, 50mA), Command = 0x6B
                                        // For Pulse Freq = 70kHz, (50%, 50mA), Command = 0x8B
                                        // For Pulse Freq = 80kHz, (50%, 50mA), Command = 0xAB
                                        // For Pulse Freq = 90kHz, (50%, 50mA), Command = 0xCB
                                        // For Pulse Freq = 100kHz, (50%, 50mA), Command = 0xEB
WriteByte(Slave_Addr, Register_Addr, Command)


// Set LED Duty Cycle 25% (pulse freq 60kHz, peak curr 50mA)
Register_Addr = 0x82                    // PS_LED register
Command = 0x63                          // Duty Cycle = 25%, (pulse freq 60kHz, peak curr 50mA)
                                        // For Duty Cycle = 50%, (60kHz, 50mA), Command = 0x6B
                                        // For Duty Cycle = 75%, (60kHz, 50mA), Command = 0x73
                                        // For Duty Cycle = 100%, (60kHz, 50mA), Command = 0x7B
WriteByte(Slave_Addr, Register_Addr, Command)
```

```
// Set LED Peak Current 5mA (pulse freq 60kHz, duty cycle 50%)
Register_Addr = 0x82                 // PS_LED register
Command = 0x68                       // Peak Current = 5mA, (pulse freq 60kHz, duty cyc 50%)
                                     // For Peak Current = 10mA, (60kHz, 50%), Command = 0x69
                                     // For Peak Current = 20mA, (60kHz, 50%), Command = 0x6A
                                     // For Peak Current = 50mA, (60kHz, 50%), Command = 0x6C
WriteByte(Slave_Addr, Register_Addr, Command)
```

PS Measurement Rate

```
// The PS_MEAS_RATE register controls the PS measurement rate.
// Default setting of the register is 0x02 (repeat rate 100ms)

Slave_Addr = 0x23                    // Slave address of LTR-558 device

// Set PS Repeat Rate 50ms
Register_Addr = 0x84                 // PS_MEAS_RATE register
Command = 0x00                       // Meas rate = 50ms
                                     // For Meas rate = 500ms, Command = 0x04
WriteByte(Slave_Addr, Register_Addr, Command)
```

ALS Measurement Rate

```
// The ALS_MEAS_RATE register controls the ALS integration time and measurement rate.
// Default setting of the register is 0x03 (integration time 100ms, repeat rate 500ms)

Slave_Addr = 0x23                    // Slave address of LTR-558 device

// Set ALS Integration Time 200ms, Repeat Rate 200ms
Register_Addr = 0x85                 // ALS_MEAS_RATE register
Command = 0x12                       // Int time = 200ms, Meas rate = 200ms
                                     // For Int time = 400ms, Meas rate = 500ms, Command = 0x1B
WriteByte(Slave_Addr, Register_Addr, Command)
```

ALS Data Registers (Read Only)

```
// The ALS Data Registers contain the ADC output data for the respective channel.
// These registers should be read as a group, with the lower address being read first.

Slave_Addr = 0x23                    // Slave address of LTR-558 device

// Read back ALS_DATA_CH1
Register_Addr = 0x88                 // ALS_DATA_CH1 low byte address
ReadByte(Slave_Addr, Register_Addr, Data0)
Register_Addr = 0x89                 // ALS_DATA_CH1 high byte address
ReadByte(Slave_Addr, Register_Addr, Data1)

// Read back ALS_DATA_CH0
Register_Addr = 0x8A                 // ALS_DATA_CH0 low byte address
ReadByte(Slave_Addr, Register_Addr, Data2)
Register_Addr = 0x8B                 // ALS_DATA_CH0 high byte address
ReadByte(Slave_Addr, Register_Addr, Data3)

ALS_CH1_ADC_Data = (Data1 << 8) | Data0   // Combining lower and upper bytes to give 16-bit Ch1 data
ALS_CH0_ADC_Data = (Data3 << 8) | Data2   // Combining lower and upper bytes to give 16-bit Ch0 data
```

ALS / PS Status Register (Read Only)

// The ALS_PS_STATUS Register contains the information on Interrupt, ALS and PS data availability status.
// This register is read only.

Slave_Addr = 0x23 // Slave address of LTR-558 device

// Read back Register
Register_Addr = 0x8C // ALS_PS_STATUS register address
ReadByte(Slave_Addr, Register_Addr, Data)

Interrupt_Status = Data & 0x0A
// Interrupt_Status = 8(decimal) ➔ ALS Interrupt
// Interrupt_Status = 2(decimal) ➔ PS Interrupt
// Interrupt_Status = 10(decimal) ➔ Both Interrupt

NewData_Status = Data & 0x05
// NewData_Status = 4(decimal) ➔ ALS New Data
// NewData_Status = 1(decimal) ➔ PS New Data
// NewData_Status = 5(decimal) ➔ Both New Data

PS Data Registers (Read Only)

// The PS Data Registers contain the ADC output data.
// These registers should be read as a group, with the lower address being read first.

Slave_Addr = 0x23 // Slave address of LTR-558 device

// Read back PS_DATA registers
Register_Addr = 0x8D // PS_DATA low byte address
ReadByte(Slave_Addr, Register_Addr, Data0)
Register_Addr = 0x8E // PS_DATA high byte address
ReadByte(Slave_Addr, Register_Addr, Data1)

PS_ADC_Data = (Data1 << 8) | Data0 // Combining lower and upper bytes to give 16-bit PS data

Interrupt Registers

// The Interrupt register controls the operation of the interrupt pins and function.
// The default value for this register is 0x08 (Interrupt inactive)

Slave_Addr = 0x23 // Slave address of LTR-558 device

// Set Interrupt Polarity for Active Low, both ALS and PS trigger
Register_Addr = 0x8F // Interrupt Register address
Command = 0x03
// Interrupt is Active Low and both ALS and PS can trigger
// For Active High Interrupt, both trigger, Command = 0x07
// For Active High Interrupt, ONLY ALS trigger, Command = 0x06
// For Active High Interrupt, ONLY PS trigger, Command = 0x05
WriteByte(Slave_Addr, Register_Addr, Command)

ALS Threshold Registers

```
// The ALS_THRES_UP and ALS_THRES_LOW registers determines the upper and
// lower limit of the interrupt threshold value.
// Following example illustrates the setting of the ALS threshold window of
// decimal values of 200 (lower threshold) and 1000 (upper threshold)

Slave_Addr = 0x23                          // Slave address of LTR-558 device

// Upper Threshold Setting (decimal 1000)
ALS_Upp_Threshold_Reg_0 = 0x97             // ALS Upper Threshold Low Byte Register address
ALS_Upp_Threshold_Reg_1 = 0x98             // ALS Upper Threshold High Byte Register address
Data1 = 1000 >> 8                          // To convert decimal 1000 into two eight bytes register values
Data0 = 1000 & 0xFF
WriteByte(Slave_Addr, ALS_Upp_Threshold_Reg_0, Data0)
WriteByte(Slave_Addr, ALS_Upp_Threshold_Reg_1, Data1)


// Lower Threshold Setting (decimal 200)
ALS_Low_Threshold_Reg_0 = 0x99             // ALS Lower Threshold Low Byte Register address
ALS_Low_Threshold_Reg_1 = 0x9A             // ALS Lower Threshold High Byte Register address
Data1 = 200 >> 8                           // To convert decimal 200 into two eight bytes register values
Data0 = 200 & 0xFF
WriteByte(Slave_Addr, ALS_Low_Threshold_Reg_0, Data0)
WriteByte(Slave_Addr, ALS_Low_Threshold_Reg_1, Data1)
```

PS Threshold Registers

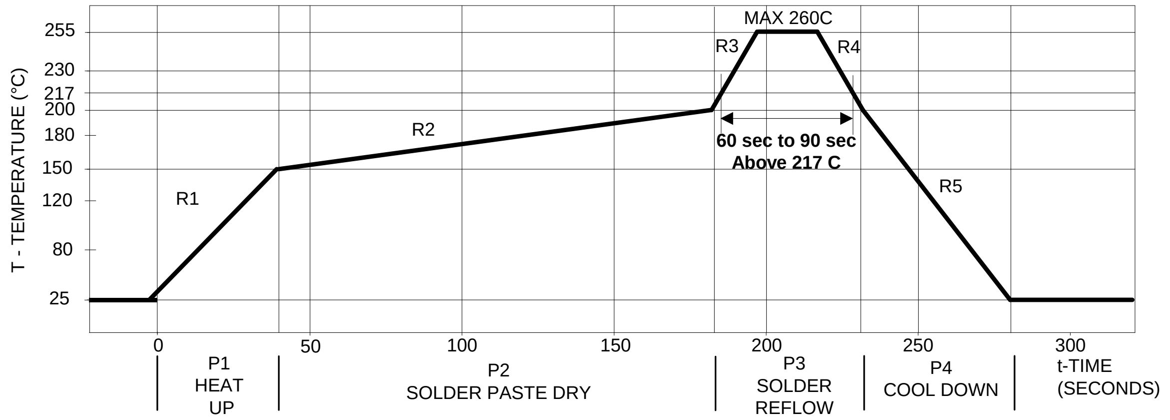
```
// The PS_THRES_UP and PS_THRES_LOW registers determines the upper and
// lower limit of the interrupt threshold value.
// Following example illustrates the setting of the PS threshold window of
// decimal values of 200 (lower threshold) and 1000 (upper threshold)

Slave_Addr = 0x23                          // Slave address of LTR-558 device

// Upper Threshold Setting (decimal 1000)
PS_Upp_Threshold_Reg_0 = 0x90              // PS Upper Threshold Low Byte Register address
PS_Upp_Threshold_Reg_1 = 0x91              // PS Upper Threshold High Byte Register address
Data1 = 1000 >> 8                          // To convert decimal 1000 into two eight bytes register values
Data0 = 1000 & 0xFF
WriteByte(Slave_Addr, PS_Upp_Threshold_Reg_0, Data0)
WriteByte(Slave_Addr, PS_Upp_Threshold_Reg_1, Data1)


// Lower Threshold Setting (decimal 200)
PS_Low_Threshold_Reg_0 = 0x92              // PS Lower Threshold Low Byte Register address
PS_Low_Threshold_Reg_1 = 0x93              // PS Lower Threshold High Byte Register address
Data1 = 200 >> 8                           // To convert decimal 200 into two eight bytes register values
Data0 = 200 & 0xFF
WriteByte(Slave_Addr, PS_Low_Threshold_Reg_0, Data0)
WriteByte(Slave_Addr, PS_Low_Threshold_Reg_1, Data1)
```

12. Recommended Lead-free 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

It is recommended to perform reflow soldering no more than twice.

13. Moisture Proof Packaging

All LTR-558ALS-01 are shipped in moisture proof package. Once opened, moisture absorption begins. This part is compliant to JEDEC J-STD-033A Level 3.

Time from Unsealing to Soldering

After removal from the moisture barrier bag, the parts should be stored at the recommended storage conditions and soldered within seven days. When the moisture barrier bag is opened and the parts are exposed to the recommended storage conditions for more than seven days, the parts must be baked before reflow to prevent damage to the parts.

Recommended Storage Conditions

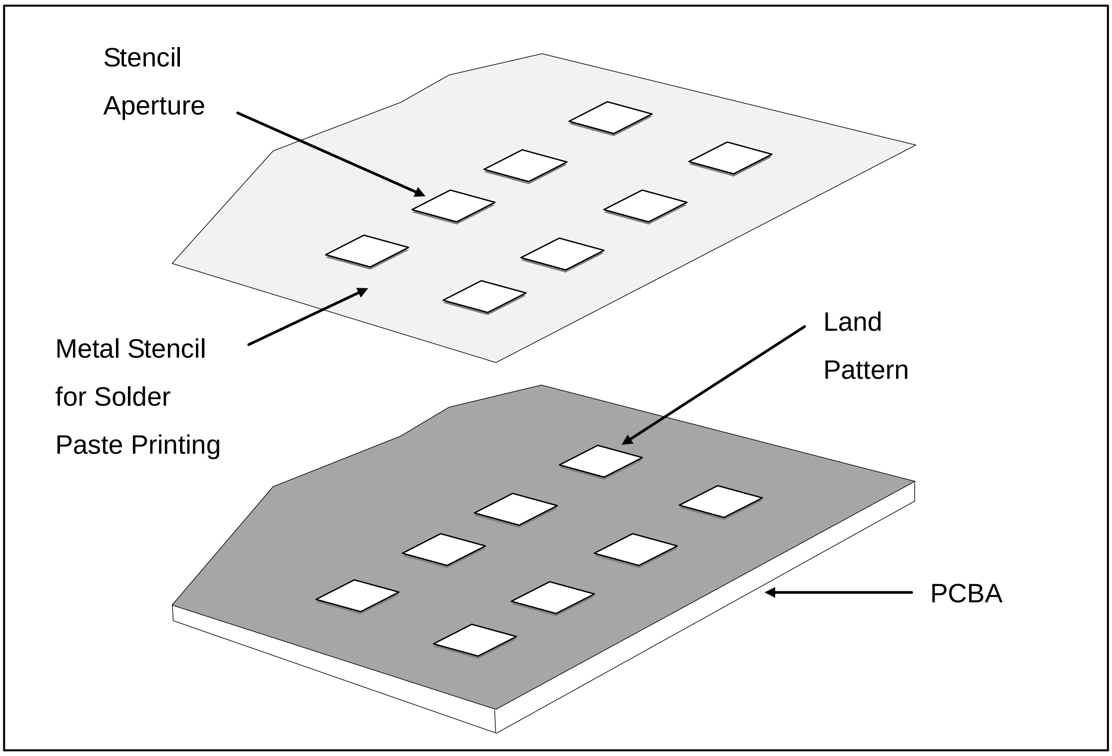
Storage Temperature	10°C to 30°C
Relative Humidity	Below 60% RH

Baking Conditions

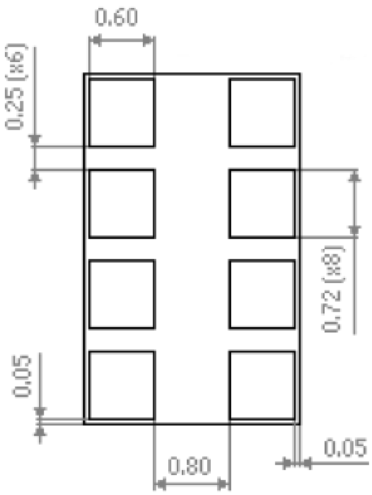
Package	Temperature	Time
In Reels	60°C	48 hours
In Bulk	100°C	4 hours

Baking should only be done once.

14. Recommended Land Pattern and Metal Stencil Aperture



Recommended Land Pattern



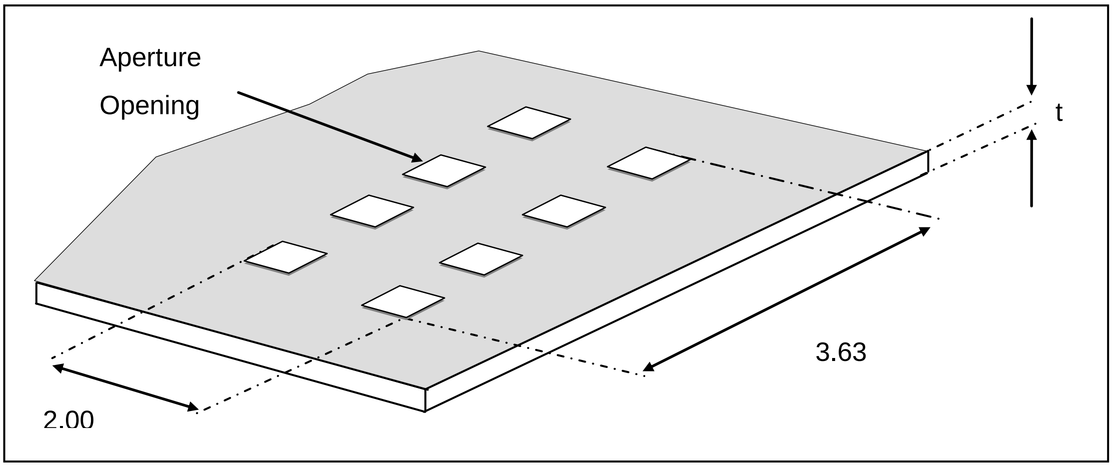
Note:

1. All dimensions are in millimeters

Recommended Metal Stencil Aperture

It is recommended that the metal stencil used for solder paste printing has a thickness (t) of 0.11mm (0.004 inches / 4 mils) or 0.127mm (0.005 inches / 5 mils).

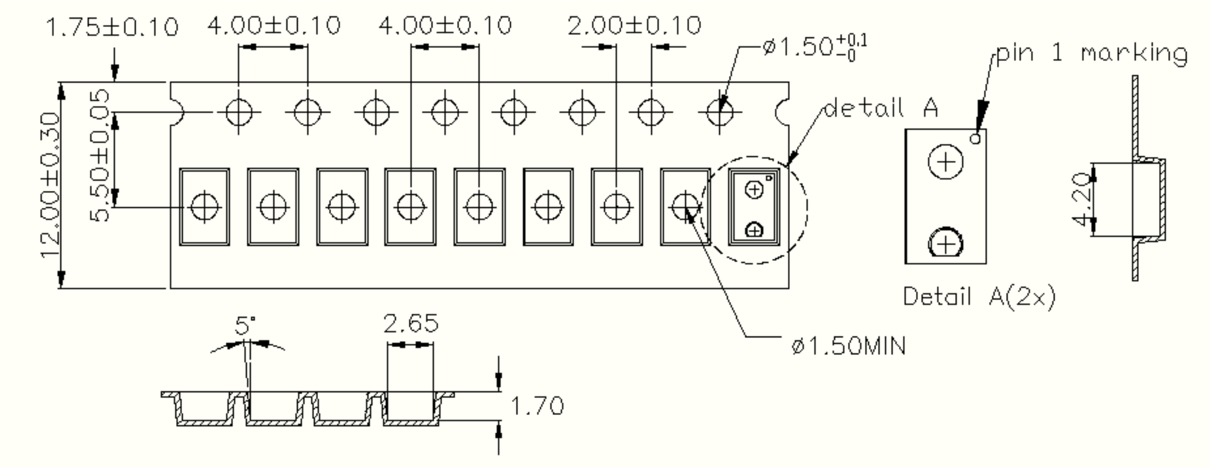
The stencil aperture opening is recommended to be 0.72mm x 0.60mm which has the same dimension as the land pattern. This is to ensure adequate printed solder paste volume and yet no shorting.



Note:

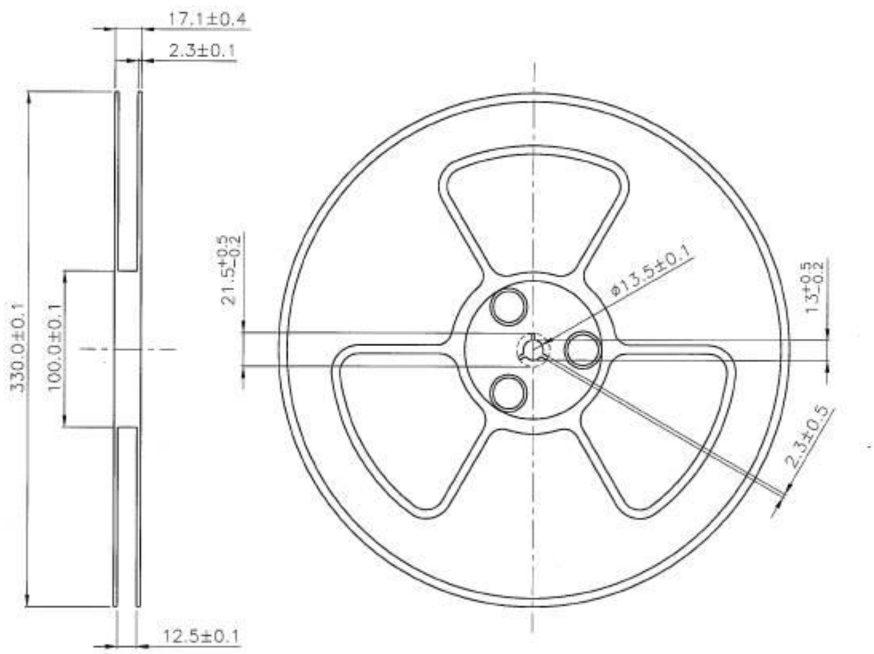
1. All dimensions are in millimeters

15. Package Dimension for Tape and Reel



Note:

1. All dimensions are in millimeters



Notes:

1. All dimensions are in millimeters (inches)
2. Empty component pockets sealed with top cover tape
3. 13 inch reel - 8000 pieces per reel
4. In accordance with ANSI/EIA 481-1-A-1994 specifications