LITEON®
OPTOELECTRONICS

Optical Sensor

Product Data Sheet

LTR-310RGB-01

Spec No.: DS86-2013-0010

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Revision: B

LITE-ON DCC

RELEASE

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OPTICAL SENSOR
LTR-310RGB-01

Description

The LTR-310RGB-01 is an integrated low voltage I^2C ambient light sensor (ALS) and color sensor (CS) in a single miniature chipled lead-free surface mount package.

With the advanced RGB color sensor, this sensor converts light (Red, Green, Blue, and White) intensity to a digital output signal capable of direct I^2C interface. The ALS provides a linear response over a wide dynamic range of 1:3000000, which is well suited to applications under very low or bright ambient brightness.

The sensor has a programmable interrupt with hysteresis to response to events and that removes the need to poll the sensor for a reading which improves system efficiency. This CMOS design and factory-set one time trimming capability ensure minimal sensor-to-sensor variations for ease of manufacturability to the end customers.

Application

To control brightness and color of the display panel, and/or object detection in mobile, computing, and consumer devices.

Features

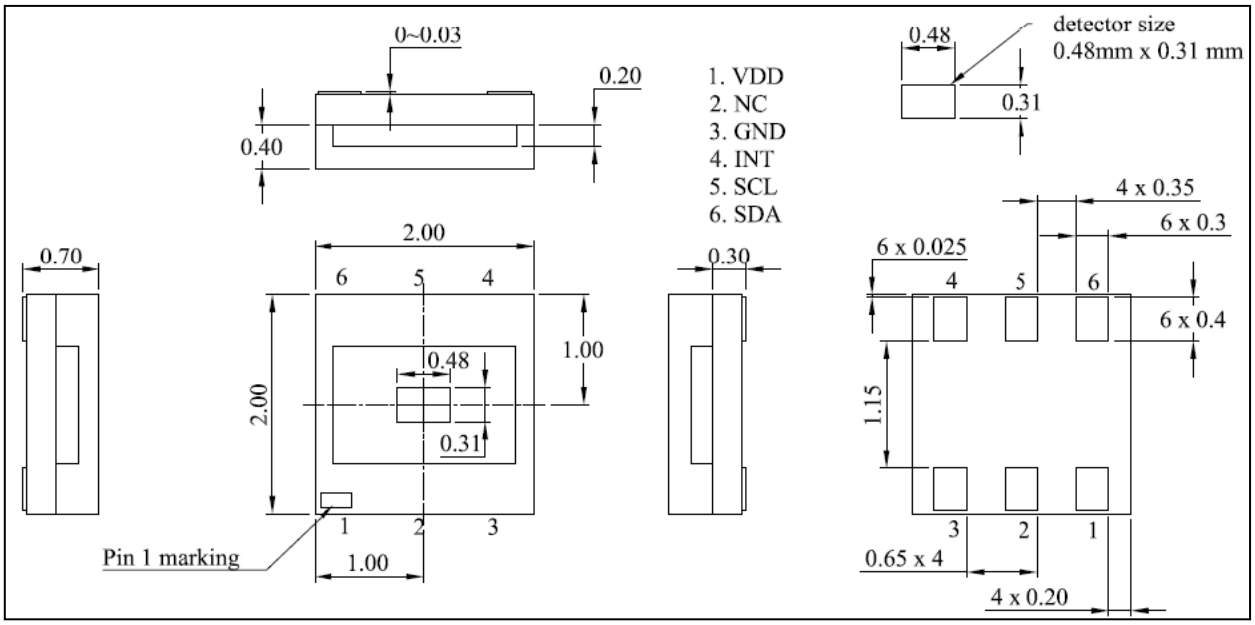
- I^2C interface (Standard mode @100kHz or Fast mode @400kHz)
- Ambient Light / Advanced RGB Technology and Proximity Sensing in one ultra-small ChipLED package
- Very low power consumption with sleep mode capability
- Operating voltage ranges: 2.4V to 3.6V
- Operating temperature ranges: -40 to +85 ºC
- Built-in temperature compensation circuit
- Programmable interrupt function for ALS with upper and lower thresholds
- RoHS and Halogen free compliant
- **CS/ALS Features**
  - 14 to 18 bits effective resolution
  - Wide dynamic range of 1:3000000 with linear response
  - Close to human eye spectral response
  - Automatic rejection for 50Hz/60Hz lighting flicker

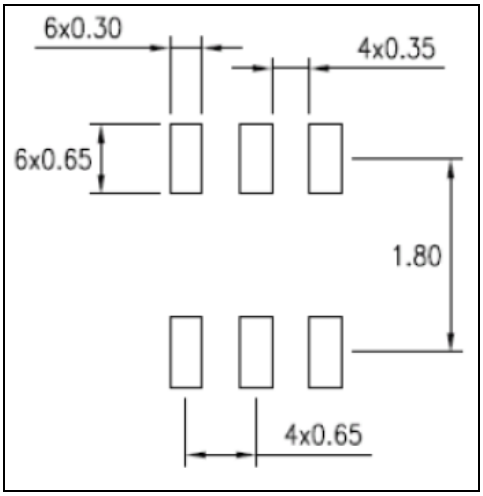
Ordering Information

Part Number	Packaging Type	Package	Quantity
LTR-310RGB-01	Tape and Reel	6-pin chipled package	2500

OPTICAL SENSOR
LTR-310RGB-01

1. Outline Dimensions



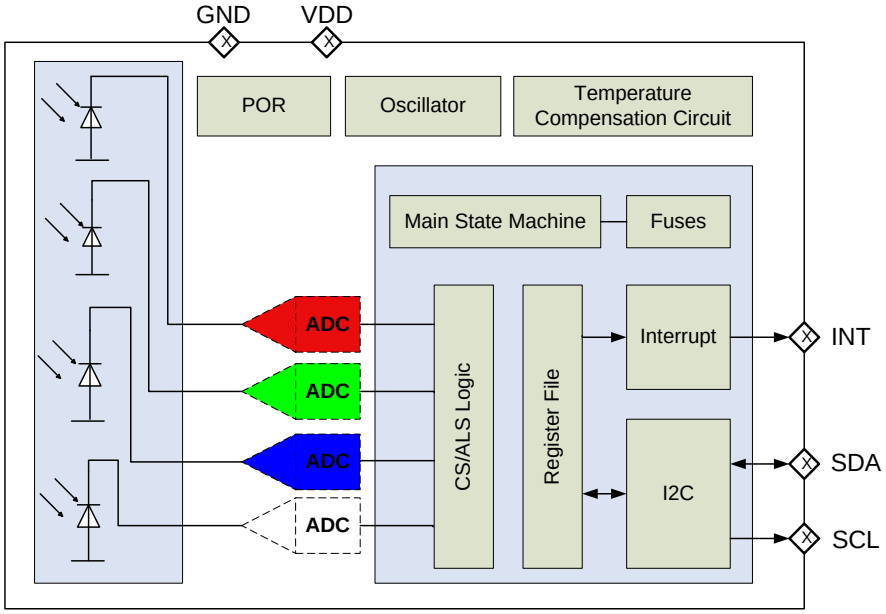


Note:

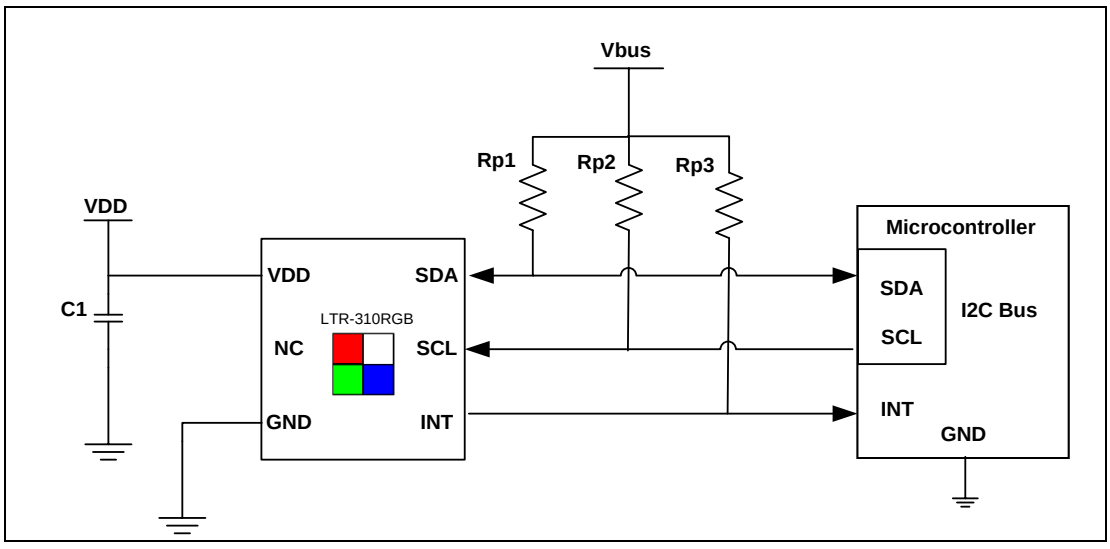
1. All dimensions are in millimeters
2. Tolerances is ± 0.2mm

2. Functional Block Diagram

LTR-310RGB-01 contains fours photodiodes (red, green, blue, and white channel) for respective photocurrent measurement. The photodiode currents are converted to digital values by ADCs. The sensor also included some peripheral circuits such as an internal oscillator, a current course, voltage reference, and internal fuses to store trimming information.



3. Application Circuit



I/O Pins Configuration Table

Pin	I/O Type	Symbol	Description
1	Supply	VDD	Power Supply Voltage
2	NC	NC	Not Connected
3	Ground	GND	Ground
4	OUT	INT	Interrupt
5	IN	SCL	I^2C serial data
6	IN/OUT	SDA	I^2C serial clock

Recommended Application Circuit Components

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

Note:

[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

4. Rating and Specification

4.1. Absolute Maximum Rating at Ta=25°C

Parameter	Symbol	Rating	Unit
Supply Voltage	VDD	4.0	V
Digital Voltage Range	SCL, SDA, INT	4.0	V
Digital Output Current	SCL, SDA, INT	10	mA
Storage Temperature	T_{stg}	-45 to 95	°C
Electrostatic Discharge Protection (Human Body Model JESD22-A114)	V_{HBM}	2000	V

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.

4.2. Recommended Operating Conditions

Description	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	VDD	2.4		3.6	V
Interface signal input high	$V_{I2Chigh}$	1.3		VDD	V
Interface signal input low	V_{I2Clow}	0		0.4	V
Operating Temperature	T_{ope}	-40		85	°C

4.3. Electrical Specifications (VDD = 3.0V, Ta=25°C, unless otherwise noted)

Parameter	Min.	Typ.	Max.	Unit	Condition
ALS Active Supply Current		175		uA	14-bit resolution 50ms measurement rate
CS Active Supply Current		250		uA	
Standby Current			5	uA	Standby / Sleep Mode
Initial Startup Time	100			ms	From VDD power up to Standby
Wakeup Time from Standby		5	10	ms	From Standby to Active mode where measurement can start

4.4. Characteristics Ambient Light / Color Sensor (VDD = 3.0V, Ta=25°C, unless otherwise noted)

Parameter	Min.	Typ.	Max.	Unit	Condition
ALS/CS Resolution	14		18	Bit	
Dark Level Count		0	5	count	0 Lux, T_{ope}=25°C, 14-bit resolution
Calibrated Lux Error In Gain Range 1	-10		+10	%	White LED, T_{ope}=25°C
Light Source Matching	-10		+10	%	Incandescent/Fluorescent light
Color Temperature Accuracy	-10		+10	%	
ALS Accuracy	-10		+10	%	
50/60 Hz flicker noise error	-5		+5	%	
Temperature Dependency	-0.25		+0.25	%/ºC	At 1000 Lux
Voltage Dependency	-5		+5	%	At 1000 Lux, At operating voltage ranges

4.4.1. Irradiance Responsivity at Characteristic Wavelengths

Table below describes the specifications for irradiance responsivity in units of counts/ (μW/cm^2).
Test conditions are VDD = 3.0V, T_{ope} = 25°C, Gain Mode = X1, Output Resolution =14-bit

Test Conditions	Red Channel Note1			Green Channel Note1			Blue Channel Note1		
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
λ_D = 470nm Note2	0%		16%	18%		54%	71%		107%
λ_D = 530nm Note3	15%		46%	83%		86%	0%		14%
λ_D = 625nm Note4	84%		114%	0%		17%	0%		14%

Notes:

1. The percentage shown represents the ratio of the respective red, green, or blue channel value to the white channel value.
2. The 470nm input irradiance is supplied by a blue LED with spectral bandwidth (50% irradiance) of 25nm.
3. The 530nm input irradiance is supplied by a green LED with spectral bandwidth (50% irradiance) of 33nm.
4. The 625nm input irradiance is supplied by a red LED with spectral bandwidth (50% irradiance) of 18nm.

4.5. Typical Device Parameter (VDD = 3.0V, Ta=25°C, default power-up settings, unless otherwise noted)

Photodiodes Spectral Response

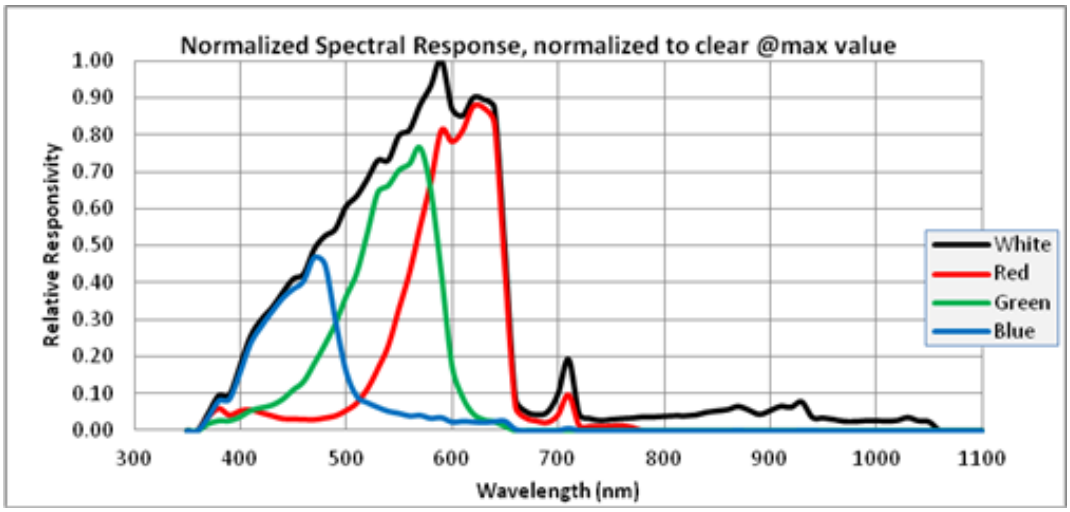


Figure 5.1 : Spectral response for R,G, B, W photodiodes.

ALS Angular Response

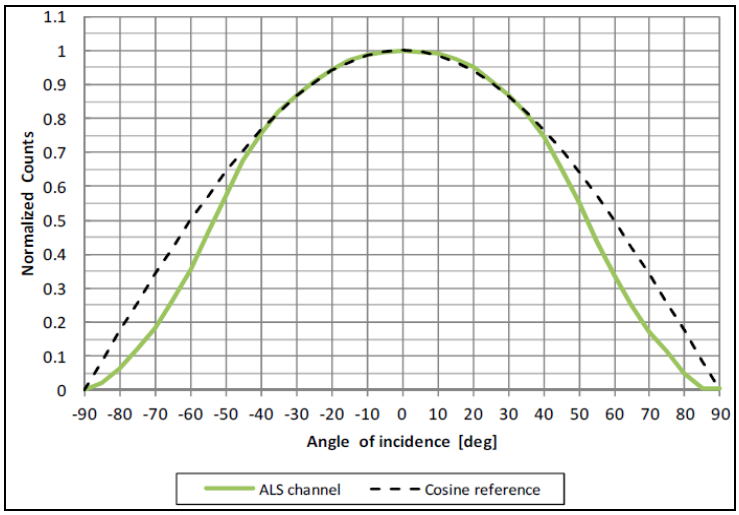
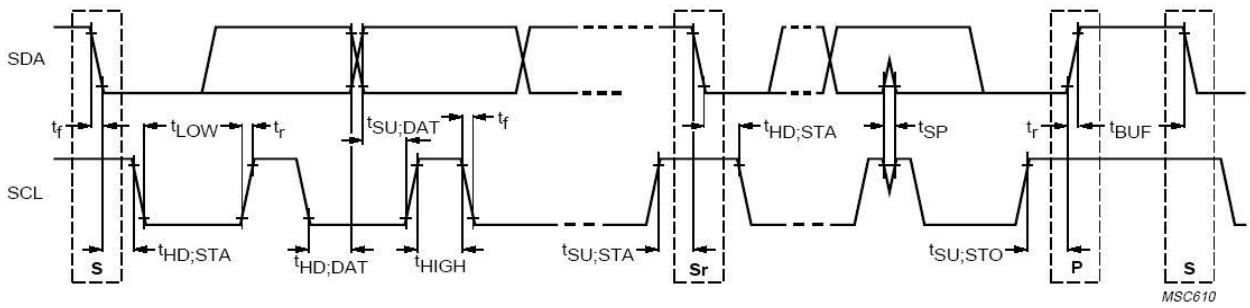


Figure 5.2 : ALS Sensitivity versus Angle of Incidence.

4.6. AC Electrical Characteristics

All specifications are at VBus = 1.7V, T_{ope} = 25°C, unless otherwise noted.

Parameter	Symbol	Standard (Min)	Fast (Min)	Unit
SCL clock frequency	f_{SCL}	100	400	KHz
Bus free time between a STOP and START condition	t_{BUF}	4.7		us
Hold time (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	4		us
LOW period of the SCL clock	t_{LOW}	4.7		us
HIGH period of the SCL clock	t_{HIGH}	4		us
Set-up time for a repeated START condition	$t_{SU;STA}$	4.7		us
Set-up time for STOP condition	$t_{SU;STO}$	4		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		us
Data setup time	$t_{SU;DAT}$	100	100	ns
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	0	50	ns

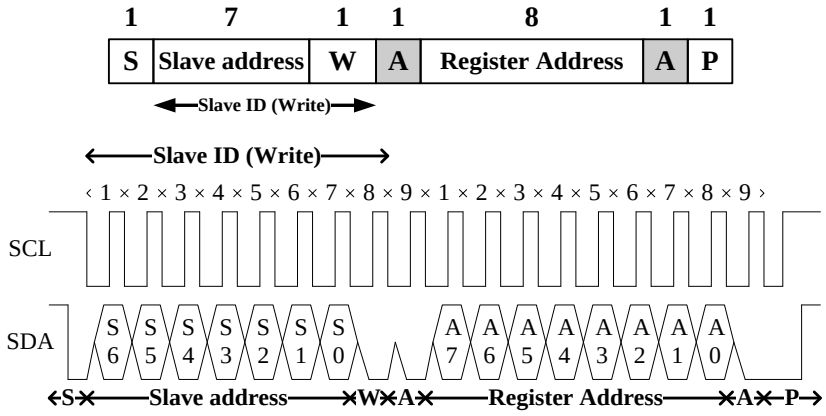


Definition of timing for I²C bus

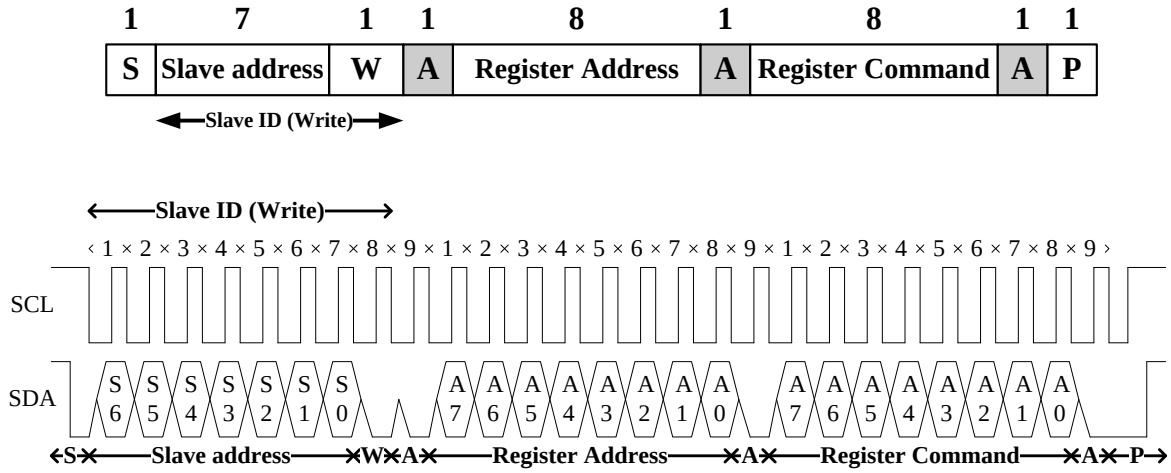
5. Principle of Operation

5.1. I2C Protocol

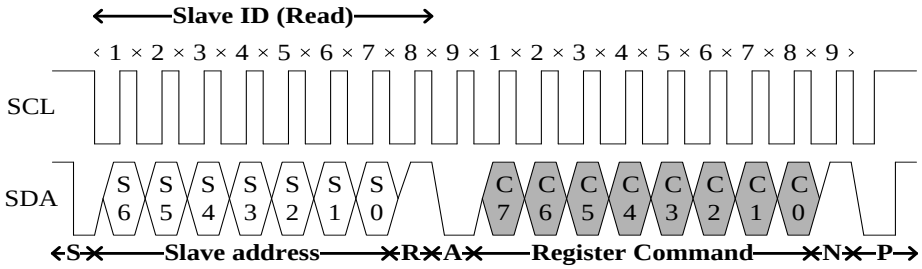
5.1.1. I2C Write Protocol (type 1)



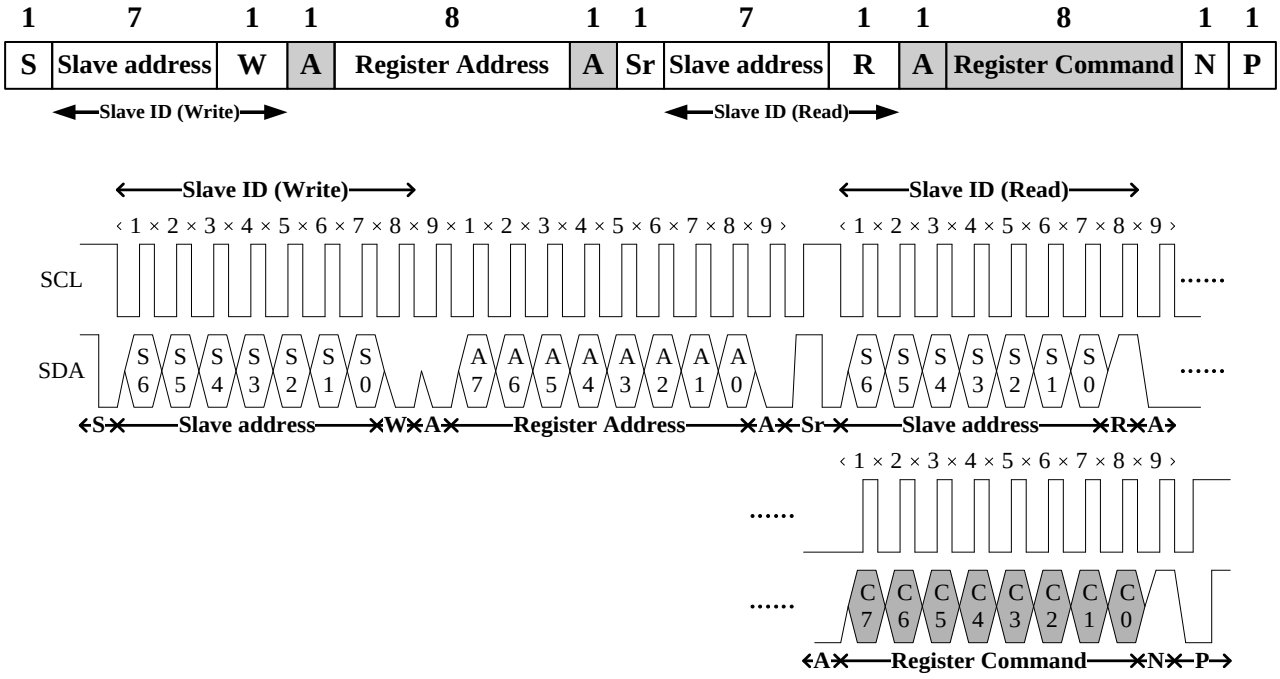
5.1.2. I2C Write Protocol (type 2)



5.1.3 I2C Read Protocol



5.1.4 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

5.2. I2C Slave Address

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.

I^2C Slave Address									
Command Type	(0x52)							W/R	value
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Write	1	0	1	0	0	1	0	0	0xA4
Read	1	0	1	0	0	1	0	1	0xA5

6. Register Set

Address	R / W	Register Name	Description	Reset Value
0x80	R/W	CS_ALS_CONTR	CS/ALS operation mode control SW reset	0x00
0x85	R/W	CS_ALS_MEAS_RATE	CS/ALS measurement rate in active mode, CS/ALS resolution, and ALS gain	0x83
0x86	R	PART_ID	Part number ID and revision ID	0xA0
0x87	--	Reserved	--	--
0x88	R	CS_ALS_STATUS	Interrupt status, and data status	0x00
0x8B	R	CS_DATA_RED_0	CS Red measurement data, Lower Byte	0x00
0x8C	R	CS_DATA_RED_1	CS Red measurement data, Middle Byte	0x00
0x8D	R	CS_DATA_RED_2	CS Red measurement data, Upper Byte	0x00
0x8E	R	CS_DATA_GREEN_0	CS Green measurement data, Lower Byte	0x00
0x8F	R	CS_DATA_GREEN_1	CS Green measurement data, Middle Byte	0x00
0x90	R	CS_DATA_GREEN_2	CS Green measurement data, Upper Byte	0x00
0x91	R	CS_DATA_BLUE_0	CS Blue measurement data, Lower Byte	0x00
0x92	R	CS_DATA_BLUE_1	CS Blue measurement data, Middle Byte	0x00
0x93	R	CS_DATA_BLUE_2	CS Blue measurement data, Upper Byte	0x00
0x94	R	CS_DATA_WHITE_0	CS White measurement data, Lower Byte	0x00
0x95	R	CS_DATA_WHITE_1	CS White measurement data, Middle Byte	0x00
0x96	R	CS_DATA_WHITE_2	CS White measurement data, Upper Byte	0x00
0x97	--	Reserved	--	--
0x98	R/W	INTERRUPT	Interrupt configuration	0x00
0x9D	--	Reserved	--	--
0xA0	R/W	CS_ALS_THRES_UP_0	CS/ALS interrupt upper threshold, Lower Byte	0xFF
0xA1	R/W	CS_ALS_THRES_UP_1	CS/ALS interrupt upper threshold, Middle Byte	0xFF
0xA2	R/W	CS_ALS_THRES_UP_2	CS/ALS interrupt upper threshold, Upper Byte	0x03
0xA3	R/W	CS_ALS_THRES_LOW_0	CS/ALS interrupt lower threshold, Lower Byte	0x00
0xA4	R/W	CS_ALS_THRES_LOW_1	CS/ALS interrupt lower threshold, Middle Byte	0x00
0xA5	R/W	CS_ALS_THRES_LOW_2	CS/ALS interrupt lower threshold, Upper Byte	0x00
0xA6	--	Reserved	--	--
0xA7	R/W	INTERRUPT_PERSIST	CS/ALS interrupt persist setting	0x00

6.1. CS_ALS_CONTR Register (Address: 0x80) (Read/Write)

This register controls the operation modes of CS/ALS, which can be set to either standby or active mode. When writing to this register, it will cause a stop to any ongoing measurements ALS/CS and start new measurement.

0x80	CS_ALS_CONTR (default = 0x00)							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved					***SW Reset***	***CS_ALS Enable***	

Field	Bits	Default	Description	
Reserved	7:3	0000 00	--	--
SW Reset	2	0	0	Software reset is NOT triggered (default)
			1	Software reset is triggered
CS_ALS Enable	1:0	00	00	CS/ALS on standby
			11	CS/ALS active
			10/01	Reserved

6.2. CS_ALS_MEAS_RATE Register (Address: 0x85) (Read/Write)

This register controls CS/ALS measurement resolution, Gain setting and measurement rate. When the measurement rate is programmed to be faster than possible for the programmed ADC measurement, the rate will be lowered than programmed (maximum speed).

0x85	CS_ALS_MEAS_RATE (default = 0x83)							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	CS/ALS Resolution / Bit Width			***CS/ALS Gain Range***		***CS/ALS Measurement Rate***		

Field	Bits	Default	Description	
CS/ALS Resolution / Bit Width	7:5	100	000	18 Bit, Conversion time = 800ms
			001	17 Bit, Conversion time = 400ms
			010	16 Bit, Conversion time = 200ms
			011	15 Bit, Conversion time = 100ms
			100	14 Bit, Conversion time = 50ms (default)
			101/110/111	Reserved
CS/ALS Gain Range	4:3	00	00	Gain X1 (2 to 32768 Lux) (default)
			01	Gain X5 (0.4 to 6554 Lux)
			10	Gain X10 (0.2 to 3277 Lux)
			11	Gain X20 (0.1 to 1638 Lux)
CS/ALS Measurement Rate	2:0	011	000	50ms
			001	100ms
			010	200ms
			011	500ms (default)
			100	1000ms
			101/110/111	2000ms

6.3. PART_ID Register (Address: 0x86) (Read Only)

This register defines the part number and revision identification of the sensor.

0x86	PART_ID (default = 0xA0)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Part Number ID				*Reserved*			

Field	Bits	Default	Description
Part Number ID	7:4	1010	Part Number ID
Reserved	3:0	0000	--

6.4. CS_ALS_STATUS Register (Address: 0x88) (Read Only)

This register stores the information about the CS/ ALS interrupts and data status. The interrupt status in Bit 1 determines if the CS/ALS interrupt criteria are met: its triggers when the CS/ALS data is above the upper or below the lower threshold for a specified number of consecutive measurements in respective interrupt persist settings.

0x88	CS_ALS_STATUS (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved		*CS/ALS interrupt status*	*CS/ALS data status*	*Reserved*			

Field	Bits	Default	Description	
Reserved	7:6	00	--	--
CS/ALS Interrupt Status	5	0	0	Interrupt is NOT triggered (default)
			1	Interrupt is triggered and will be cleared after read
CS/ALS Data Status	4	0	0	CS/ALS data is old data (Data has been read)
			1	CS/ALS data is new data (Data has not been read and will be cleared after read)
Reserved	3:0	0000	--	--

6.5. CS_DATA_RED Registers (Address: 0x8B / 0x8C / 0x8D) (Read Only)

The Color Sensor Red Channel digital output data are expressed as a 14 to 18 bit unsigned integer data. When I^2C read operation is active and points to any of the register address between 0x88 and 0x96, all 3 registers will be locked until the I^2C read operation has been completed or the specified address range is left. This is to ensure that the data in the registers is from the same measurement even if an additional measurement cycle ends during the read operation. New measurement data is stored into temporary registers and the CS_DATA_RED registers will be updated as soon as there is no on-going I^2C read operation to the address range 0x88 to 0x96.

0x8B	CS_DATA_RED_0 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS DATA RED, Low							
0x8C	CS_DATA_RED_1 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS DATA RED, Middle							
0x8D	CS_DATA_RED_2 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved						*CS DATA RED, High*	

Field	Address	Bits	Default	Description
CS Data Red, Low	0x8B	7:0	00000000	CS Data (Red) lower byte data
CS Data Red, Middle	0x8C	7:0	00000000	CS Data (Red) Middle byte data
CS Data Red, High	0x8D	7:2	000000	Reserved
		1:0	00	CS Data (Red) Higher byte data

6.6. CS_DATA_GREEN Registers (Address: 0x8E / 0x8F / 0x90) (Read Only)

The Color Sensor Green Channel digital output data are expressed as a 14 to 18 bit unsigned integer data. When I^2C read operation is active and points to any of the register address between 0x88 and 0x96, all 3 registers will be locked until the I^2C read operation has been completed or the specified address range is left. This is to ensure that the data in the registers is from the same measurement even if an additional measurement cycle ends during the read operation. New measurement data is stored into temporary registers and the CS_DATA_GREEN registers will be updated as soon as there is no on-going I^2C read operation to the address range 0x88 to 0x96.

0x8E	CS_DATA_GREEN_0 (default = 0x00)							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	CS DATA GREEN, Low							
0x8F	**CS_DATA_GREEN_1 (default = 0x00)**							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	CS DATA GREEN, Middle							
0x90	**CS_DATA_GREEN_2 (default = 0x00)**							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved						***CS DATA GREEN, High***	

Field	Address	Bits	Default	Description
CS Data Green, Low	0x8B	7:0	00000000	CS Data (Green) lower byte data
CS Data Green, Middle	0x8C	7:0	00000000	CS Data (Green) Middle byte data
CS Data Green, High	0x8D	7:2	000000	Reserved
		1:0	00	CS Data (Green) Higher byte data

6.7. CS_DATA_BLUE Registers (Address: 0x91 / 0x92 / 0x93) (Read Only)

The Color Sensor Blue Channel digital output data are expressed as a 14 to 18 bit unsigned integer data.

When I^2C read operation is active and points to any of the register address between 0x88 and 0x96, all 3 registers will be locked until the I^2C read operation has been completed or the specified address range is left. This is to ensure that the data in the registers is from the same measurement even if an additional measurement cycle ends during the read operation. New measurement data is stored into temporary registers and the CS_DATA_BLUE registers will be updated as soon as there is no on-going I^2C read operation to the address range 0x88 to 0x96.

0x91	CS_DATA_BLUE_0 (default = 0x00)							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	CS DATA BLUE, Low							
0x92	**CS_DATA_BLUE_1 (default = 0x00)**							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	CS DATA BLUE, Middle							
0x93	**CS_DATA_BLUE_2 (default = 0x00)**							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved						***CS DATA BLUE, High***	

Field	Address	Bits	Default	Description
CS Data Blue, Low	0x91	7:0	00000000	CS Data (Blue) Lower byte data
CS Data Blue, Middle	0x92	7:0	00000000	CS Data (Blue) Middle byte data
CS Data Blue, High	0x93	7:2	000000	Reserved
		1:0	00	CS Data (Blue) Higher byte data

6.8. CS_DATA_WHITE Registers (Address: 0x94 / 0x95 / 0x96) (Read Only)

The Color Sensor White Channel digital output data are expressed as a 14 to 18 bit unsigned integer data. When I^2C read operation is active and points to any of the register address between 0x88 and 0x96, all 3 registers will be locked until the I^2C read operation has been completed or the specified address range is left. This is to ensure that the data in the registers is from the same measurement even if an additional measurement cycle ends during the read operation. New measurement data is stored into temporary registers and the CS_DATA_WHITE registers will be updated as soon as there is no on-going I^2C read operation to the address range 0x88 to 0x96.

0x94	CS_DATA_WHITE_0 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS DATA WHITE, Low							

0x95	CS_DATA_WHITE_1 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS DATA WHITE, Middle							

0x96	CS_DATA_WHITE_2 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved				*CS DATA WHITE, High*			

Field	Address	Bits	Default	Description
CS Data White, Low	0x94	7:0	00000000	CS Data (White) lower byte data
CS Data White, Middle	0x95	7:0	00000000	CS Data (White) Middle byte data
CS Data White, High	0x96	7:4	0000	Reserved
		3:0	0000	CS Data (White) Higher byte data

6.9. INTERRUPT Register (Address: 0x98) (Read/Write)

This register controls the operation of the interrupt pin and functions. CS/ALS interrupt is enabled by Bit 0, and it is threshold triggered based.

0x98	INTERRUPT (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved							*CS/ALS INT PIN ENABLE*

Field	Bits	Default	Description	
Reserved	7:1	000 0000	--	Must be zero
CS/ALS Interrupt Pin Enable	0	0	0	CS/ALS interrupt disabled (default)
			1	CS/ALS interrupt enabled

6.10. CS_ALS_THRES Registers (Address: 0xA0-0xA2 / 0xA3-0xA5) (Read/Write)

The CS_ALS_THRES_UP (up to 18-bits) and CS_ALS_THRES_LOW (up to 18-bits) registers determines the upper and lower limit of the interrupt threshold value respectively. Interrupt will be triggered if measurement data in CS_ALS_DATA_GREEN registers is exceeding the upper and lower limits.

0xA0	CS_ALS_THRES_UP_0 (default = 0xFF)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS/ALS Upper Threshold, Low							
0xA1	CS_ALS_THRES_UP_1 (default = 0xFF)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS/ALS Upper Threshold, Mid							
0xA2	CS_ALS_THRES_UP_2 (default = 0xFF)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Reserved						*CS/ALS Upper Threshold, High*	
0xA3	CS_ALS_THRES_LOW_0 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS/ALS Lower Threshold, Low							

0xA4	CS_ALS_THRES_LOW_1 (default = 0x00)							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	CS/ALS Lower Threshold, Mid							
0xA5	**CS_ALS_THRES_LOW_2 (default = 0x00)**							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved						*CS/ALS Lower Threshold, High*	

Field	Address	Bits	Default	Description
CS/ALS Upper Threshold, Low	0xA0	7:0	11111111	CS/ALS upper interrupt threshold, Low byte
CS/ALS Upper Threshold, Mid	0xA1	7:0	11111111	CS/ALS upper interrupt threshold, Mid byte
CS/ALS Upper Threshold, High	0xA2	7:2	111111	Reserved
		1:0	11	CS/ALS upper interrupt threshold, High byte
CS/ALS Lower Threshold, Low	0xA3	7:0	00000000	CS/ALS lower interrupt threshold, Low byte
CS/ALS Lower Threshold, Mid	0xA4	7:0	00000000	CS/ALS lower interrupt threshold, Mid byte
CS/ALS Lower Threshold, High	0xA5	7:2	000000	Reserved
		1:0	00	CS/ALS lower interrupt threshold, High byte

6.11. INTERRUPT_PERSIST Register (Address: 0xA7) (Read/Write)

This register sets the CS/ALS persist level. Persist is the *N* number of times the measurement data is outside the range defined by the upper and lower threshold limits before asserting the interrupt.

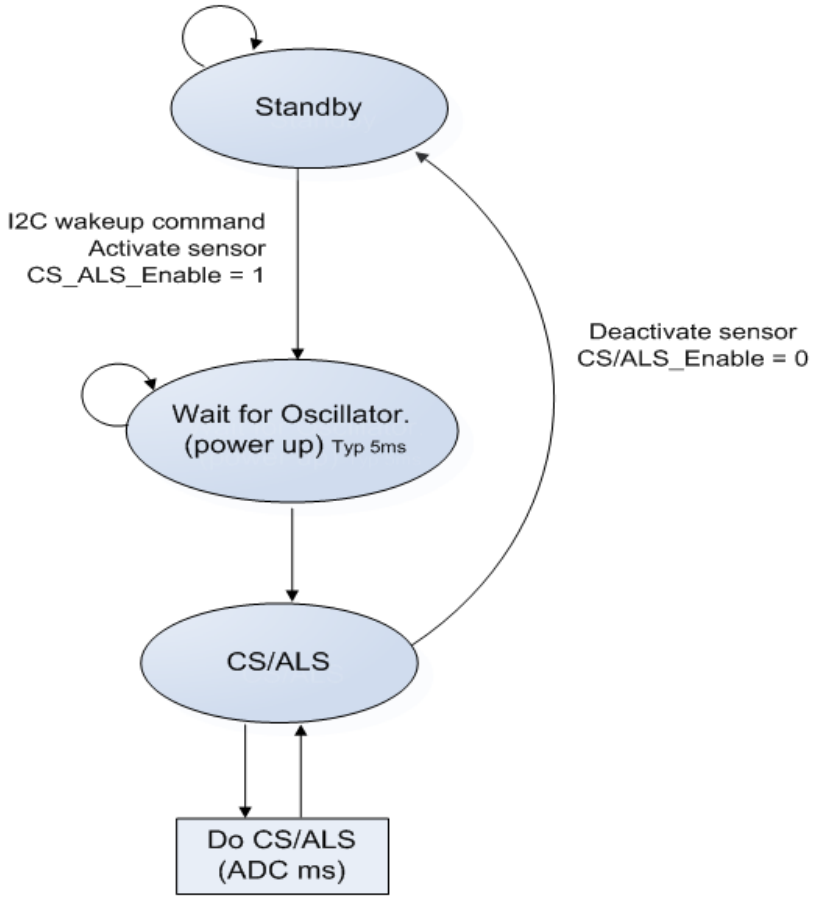
0xA7	INTERRUPT_PERSIST (default = 0x00)							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved				*CS/ALS Persist*			

Field	Bits	Default	Description	
Reserved	7:1	000 0000	--	Must be zero
CS/ALS Persist	3:0	0000	0000	Every CS/ALS value out of threshold range asserts an interrupt (default)
			0001	2 consecutive CS/ALS values out of threshold range assert an interrupt
			…	…
			1111	16 consecutive CS/ALS values out of threshold range assert an interrupt

7. Device Operation (State Machine and Interrupt Features)

7.1. State Machine

Below diagram is the main state machine of LTR-310RGB.



During the CS/ALS Operation, CS/ALS measurements can be activated by setting the CS_ALS_Enable bit to 1. As soon as the CS/ALS sensors become activated through an I2C command, the internal support blocks are powered on. Once the voltages and currents are settled (typically after 5ms), the state machine checks for trigger events from a measurement scheduler to start CS/ALS conversions according to the selected measurement repeat rates. Once CS_ALS_Enable is changed back to 0, a running conversion on the respective channel will be completed and the relevant ADCs and support blocks will move to power-down state.

7.2. Interrupt Features

The interrupt condition of this device is always evaluated after completion of a new conversion on the CS/ALS channels. Figure 8.1 below illustrates the interrupt status (In register 0x88) as well as interrupt pin signal (configure through register 0x98).

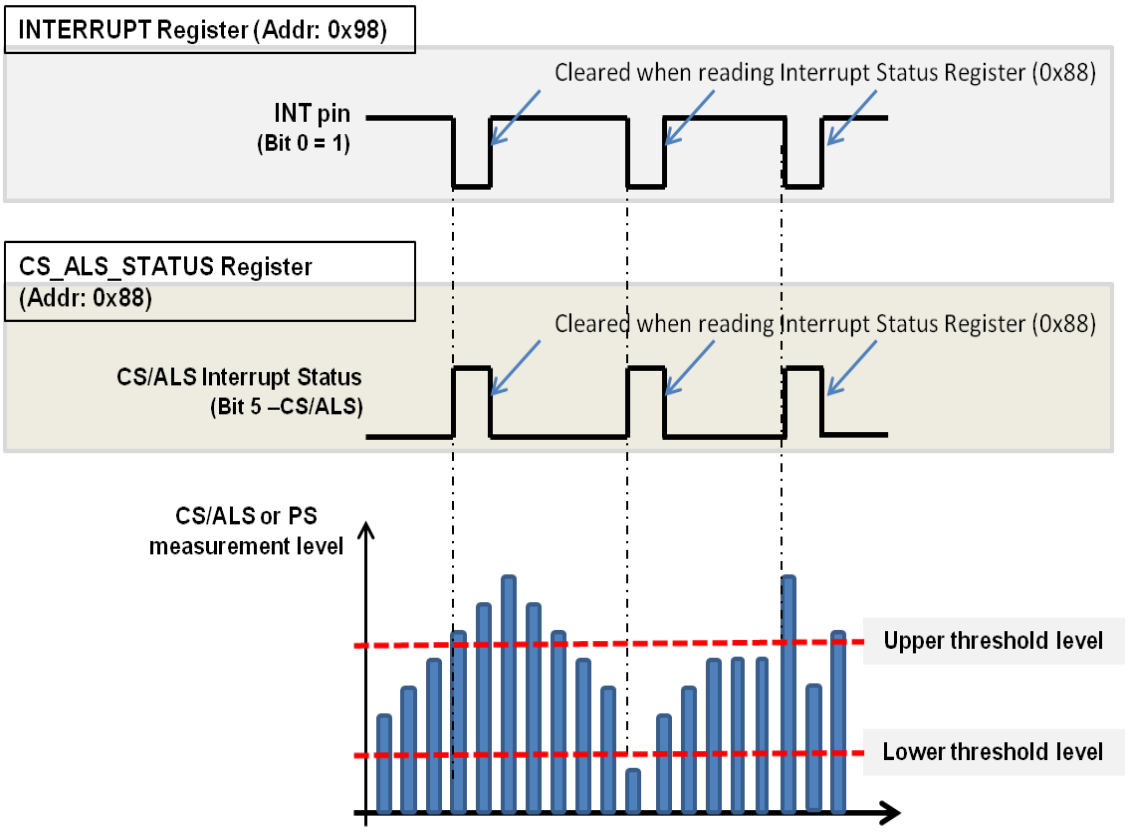


Figure 8.1 : Interrupt behavior for different interrupt configuration in register 0x98 and 0x88.

8. Pseudo Codes Examples

Slave address

// The I2C slave address of LTR-310.

```
Slave_Addr = 0xA4                    // Slave address
```

CS_ALS_CONTR Register

// This defines the operating modes of the CS/ALS
// Default settings is 0x00 in Standby mode.

```
Register_Addr = 0x80                 // CS_ALS_CONTR register
Command = 0x03                       // CS/ALS in Active Mode
WriteByte(Slave_Addr, Register_Addr, Command);
```

CS_ALS_MEAS_RATE

// This controls the CS/ALS measurement resolution, gain setting and measurement rate.
// Default setting of the register is 0x83 (Integration time 50ms or 14 bit resolution, Gain=x1, Measurement rate of 500ms)

```
Register_Addr = 0x85                 // CS_ALS_MEAS_RATE register
Command = 0x83                       // Resolution 14 bit, Gain =1, Meas rate =500ms
                                     // For Resolution 18 bit, Gain =1, Meas rate =500ms, Command =0x03
                                     // For Resolution 18 bit, Gain =20, Meas rate =500ms, Command =0x1B
                                     // For Resolution 18 bit, Gain =5, Meas rate =1000ms, Command =0x0C
                                     // For Resolution 16 bit, Gain =10, Meas rate =2000ms, Command =0x55
WriteByte(Slave_Addr, Register_Addr, Command)
```

CS_ALS_STATUS Register (Read Only)

// This Register contains the information on Interrupt, and CS/ALS data availability status.

```
Register_Addr = 0x88                 // CS_ALS _STATUS register address
Data = ReadByte(Slave_Addr, Register_Addr)

CS/ALS_Interrupt_Status = Data & 0x20   // If 0x20 Interrupt condition fulfilled,
                                        // If 0x00 Interrupt condition not fulfilled
CS/ALS_Data_Status = Data & 0x10        // If 0x10 New Data
                                        // If 0x00 Old (previously read) Data
```

CS_DATA_RED Registers (Read Only)

// The register 0x8B contains CS_RED ADC lower byte data.
//The register 0x8C contains CS_RED ADC 1 upper byte data.
//The register 0x8D contains CS_RED ADC 2 (top) upper byte data.
//These registers should be read as a group, with the lower address being read first.

```
Register_Addr = 0x8B                 // CS_DATA_RED0 low byte address
Data0=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x8C                 // CS_DATA_RED1 middle byte address
Data1=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x8D                 // CS_DATA_RED2 upper byte address
Data2=ReadByte(Slave_Addr, Register_Addr)
CS_RED_ADC_Data =(Data2<<16)| (Data1 << 8) | Data0
                                     // Shift and combine all register data to get CS_RED ADC Data
```

CS_DATA_GREEN Registers (Read Only)

```
// The register 0x8E contains CS_GREEN ADC lower byte data.
// The register 0x8F contains CS_GREEN ADC 1 upper byte data.
// The register 0x90 contains CS_GREEN ADC 2 (top) upper byte data.
// These registers should be read as a group, with the lower address being read first.

Register_Addr = 0x8E                    // CS_DATA_GREEN0 low byte address
Data0=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x8F                    // CS_DATA_GREEN1 middle byte address
Data1=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x90                    // CS_DATA_GREEN2 upper byte address
Data2=ReadByte(Slave_Addr, Register_Addr)
CS_GREEN_ADC_Data =(Data2<<16)| (Data1 << 8) | Data0
      // Shift and combine all register data to get CS_GREEN ADC Data
```

CS_DATA_BLUE Registers (Read Only)

```
// The register 0x91 contains CS_BLUE ADC lower byte data.
// The register 0x92 contains CS_BLUE ADC 1 upper byte data.
// The register 0x93 contains CS_BLUE ADC 2 (top) upper byte data.
// These registers should be read as a group, with the lower address being read first.

Register_Addr = 0x91                    // CS_DATA_BLUE0 low byte address
Data0=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x92                    // CS_DATA_BLUE1 middle byte address
Data1=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x93                    // CS_DATA_BLUE2 upper byte address
Data2=ReadByte(Slave_Addr, Register_Addr)
CS_BLUE_ADC_Data =(Data2<<16)| (Data1 << 8) | Data0
      // Shift and combine all register data to get CS_BLUE ADC Data
```

CS_DATA_WHITE Registers (Read Only)

```
//The register 0x94 contains CS_WHITE ADC lower byte data.
//The register 0x95 contains CS_WHITE ADC 1 upper byte data.
//The register 0x96 contains CS_WHITE ADC 2 (top) upper byte data.
//These registers should be read as a group, with the lower address being read first.

Register_Addr = 0x94                    // CS_DATA_WHITE0 low byte address
Data0=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x95                    // CS_DATA_WHITE1 middle byte address
Data1=ReadByte(Slave_Addr, Register_Addr)
Register_Addr = 0x96                    // CS_DATA_WHITE2 upper byte address
Data2=ReadByte(Slave_Addr, Register_Addr)
CS_WHITE_ADC_Data =(Data2<<16)| (Data1 << 8) | Data0
      // Shift and combine all register data to get CS_WHITE ADC Data
```

INTERRUPT Register

```
//This register controls the operation of the interrupt pins and options to trigger interrupt for CS/ALS.
//The default value for this INTERRUPT register is 0x00 (Interrupts inactive)

Register_Addr = 0x98                    // INTERRUPT Register address
Command = 0x00                          // ALS Interrupt Disable,
Command = 0x01                          // ALS Interrupt Enable,
WriteByte(Slave_Addr, Register_Addr, Command)
```

ALS_THRES Registers

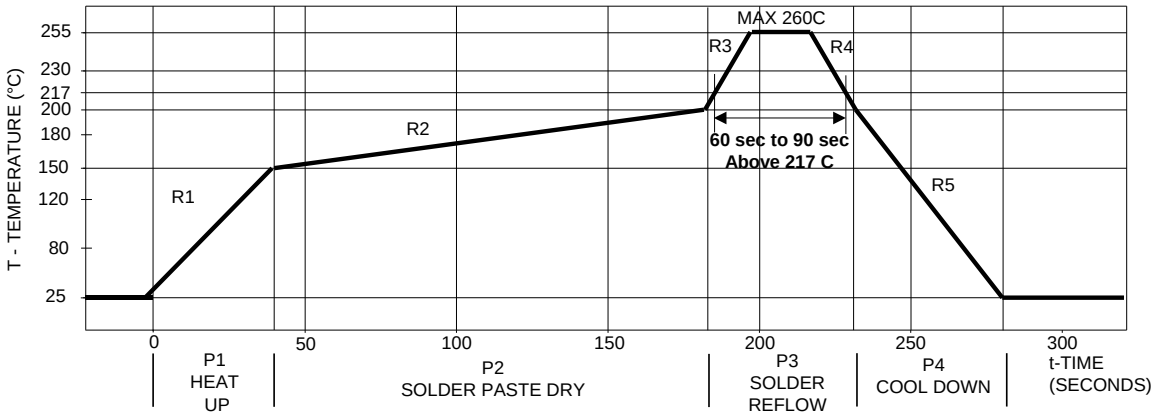
```
//The register 0xA0 contains CS/ALS Interrupt upper threshold lower byte data (ALS_THRES_UP_0)
//The register 0xA1 contains CS/ALS Interrupt upper threshold 1 upper byte data (ALS_THRES_UP_1)
//The register 0xA2 contains CS/ALS Interrupt upper threshold 2 upper byte data (ALS_THRES_UP_2)
```

```
//The register 0xA3 contains CS/ALS Interrupt lower threshold lower byte data (ALS_THRES_LOW_0)
//The register 0xA4 contains CS/ALS Interrupt lower threshold 1 upper byte data (ALS_THRES_LOW_1)
//The register 0xA5 contains CS/ALS Interrupt lower threshold 2 upper byte data (ALS_THRES_LOW_2)

// To set ALS Upper threshold for Interrupt
Upper_Threshold_Value=1000                  // Example 1000
Data2 = Upper_Threshold_Value >> 16         // Shift right to extract the 2 upper byte
Data1 = Upper_Threshold_Value >> 8          // Shift right to extract the 1 upper byte
Data0 = Upper_Threshold_Value & 0xFF        // Mask to extract lower byte.

Register_Addr = 0xA0                        // CS/ALS_THRES_UP_0 Register address
WriteByte(Slave_Addr, Register_Addr, Data0)
Register_Addr = 0xA1                        // CS/ALS_THRES_UP_1 Register address
WriteByte(Slave_Addr, Register_Addr, Data1)
Register_Addr = 0xA2                        // CS/ALS_THRES_UP_2 Register address
WriteByte(Slave_Addr, Register_Addr, Data2)

// To set ALS Lower threshold for Interrupt
Lower_Threshold_Value=100                   // Example 100
Data2 = Lower_Threshold_Value >> 16         // Shift right to extract the 2 upper byte
Data1 = Lower_Threshold_Value >> 8          // Shift right to extract the 1 upper byte
Data0 = Lower_Threshold_Value & 0xFF        // Mask to extract lower byte.

Register_Addr = 0xA3                        // CS/ALS_THRES_LOW_0 Register address
WriteByte(Slave_Addr, Register_Addr, Data0)
Register_Addr = 0xA4                        // CS/ALS_THRES_LOW_1 Register address
WriteByte(Slave_Addr, Register_Addr, Data1)
Register_Addr = 0xA5                        // CS/ALS_THRES_LOW_2 Register address
WriteByte(Slave_Addr, Register_Addr, Data2)
```

INTERRUPT_PERSIST Register

```
// This register sets the CS/ALS persist level.
// The default setting is 0x00. Interrupt at every CS/ALS reading outside set thresholds.

Register_Addr = 0xA7                        // INTERRUPT_PERSIST register
Command = 0x00                              // Interrupt for every CS/ALS value outside threshold
                                            // Subsequent 2 CS/ALS values, outside threshold range, Command =0x01
                                            // 8 subsequent CS/ALS values, outside threshold range, Command =0x07
                                            //16subsequent CS/ALS values, outside threshold range, Command =0x0F
WriteByte(Slave_Addr, Register_Addr, Command)
```

9. Recommended 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 P3, R4	200°C to 260°C 260°C to 200°C	3°C/s -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.

10. Moisture Proof Packaging

All LTR-310RGB-01 are shipped in moisture proof package. Once opened, moisture absorption begins. This part is compliant to JEDEC J-STD-033A Level 3.

10.1. 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.

10.1.1. Recommended Storage Conditions

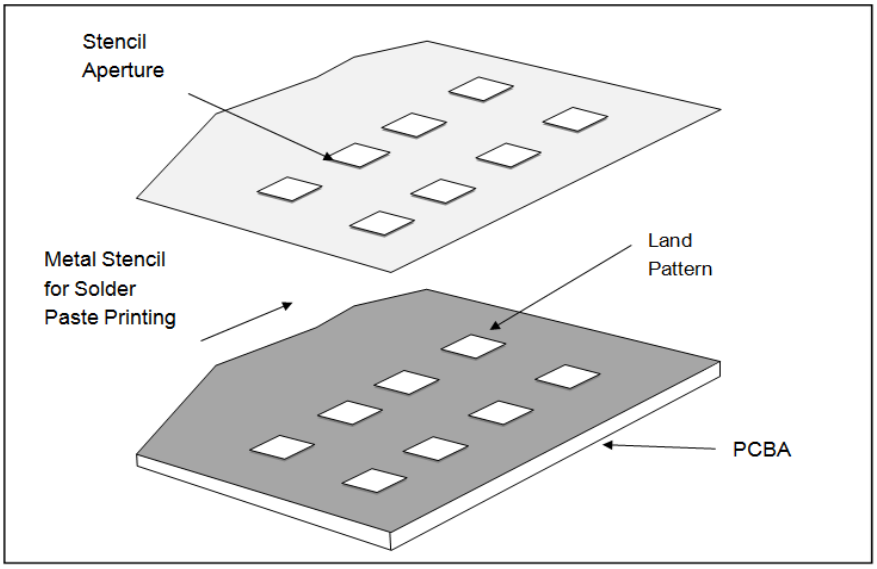
Storage Temperature	10°C to 30°C
Relative Humidity	Below 60% RH

10.1.2. Baking Conditions

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

Baking should only be done once.

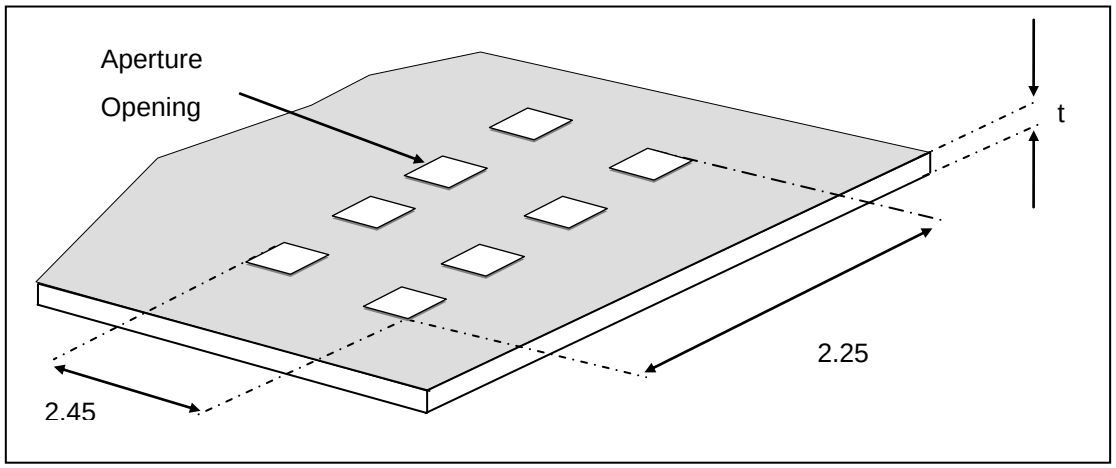
11. Recommended Land Pattern and Metal Stencil Aperture



11.1. 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).

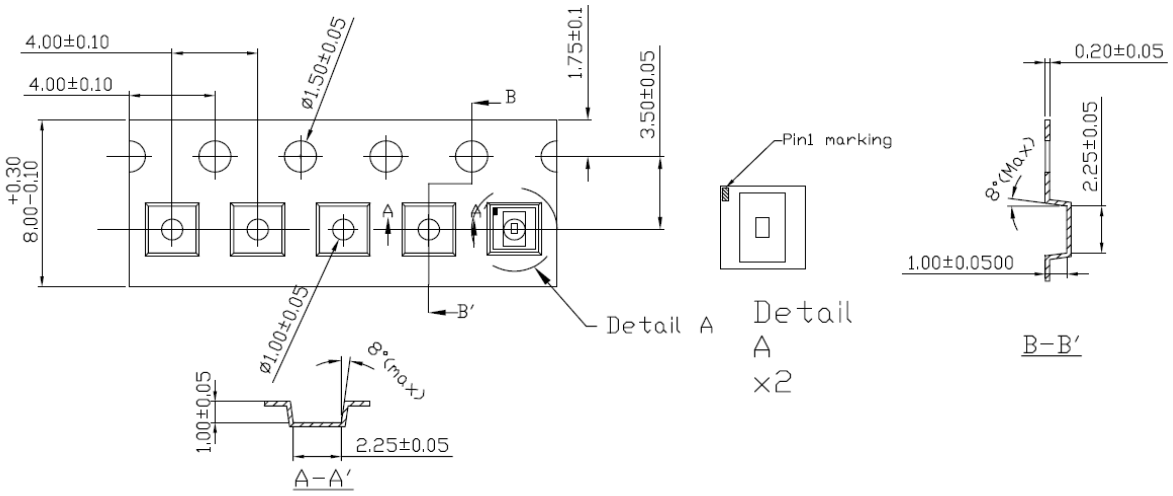
The stencil aperture opening is recommended to be 0.3mm x 0.65mm which has the same dimension as the land pattern. This is to ensure adequate printed solder paste volume and yet no shorting.



Note:

1. All dimensions are in millimeters

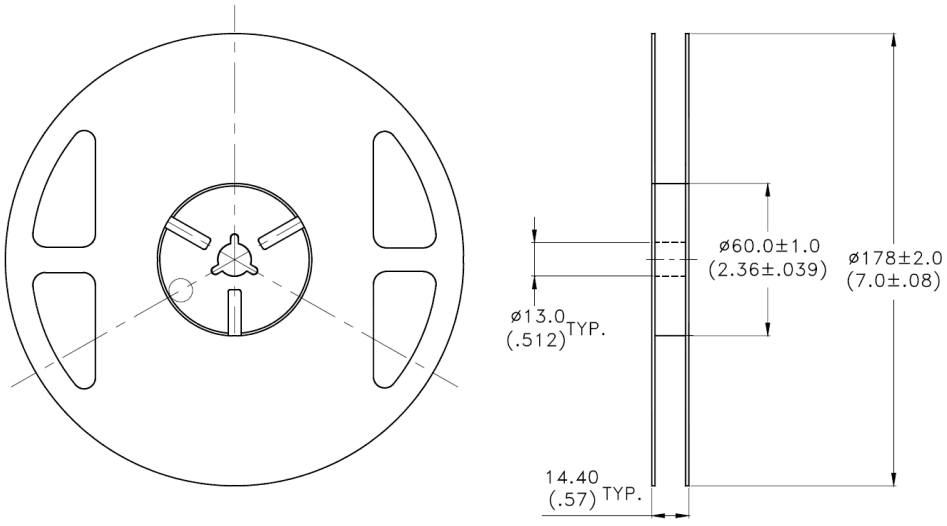
12. Package Dimension for Tape and Reel



Note:

1. All dimensions are in millimeters

12.1. Package Dimension of Reel



Notes:

1. All dimensions are in millimeters (inches)
2. Empty component pockets sealed with top cover tape
3. 7 inch reel - 2500 pieces per reel

Revision Table

Version	Update	Page	Date
1.0	Datasheet V1.0 as created	Total 30	01-Dec-13
1.1	Update Slave Address SEL pin (Only Float)	12	03-Mar-14
1.2	Add in Ambient Light min spec	7	24-Dec 14