SY22309AS22-J01

21-bit Dynamic Range True Ambient Light Sensor with Clear channel and High Speed I²C Interface

General Description

The SY22309AS22-J01 device, an ambient light sensor (ALS) with clear channel, features high sensitivity, wide dynamic range and fast communication speed through I²C interface.

The SY22309AS22-J01 has 2 photodiode arrays. ALS PD is to sense visible light which includes 6 sensitive ranges and Clear PD is to sense visible and infrared which includes 2 sensitive ranges. ALS channel reading (digital count) is proportional to the illuminance regardless of the light sources while Clear channel reading is related to light source due to its full spectrum response; furthermore, no extra data manipulation is required. It also has a built-in circuit to reject the 50Hz/60Hz flicker noise caused by indoor light sources. Due to a well-engineered optical coating on the top of the ALS PD, its spectral response is almost the same as human eye's photopic vision. Thus, system can tell the external light source type by checking the ratio of Clear/ALS channel data, then different preset correction coefficient can be chosen to adapt to different light sources.

The SY22309AS22-J01 is available in a small SMD L2.0mm×W1.5mm×H0.6mm package.

Features

- ALS Channel
  - Output Count Proportional to Lux
  - Indoor Light Source Flicker Noise Rejection
  - Matching Human Eye's Response (Photopic Vision Curve)
  - 6 Selectable Measurement Ranges
  - Finest Resolution: Down to 0.0079 lux/counts
  - Maximum Detection Range 16512 lux
- Clear Channel
  - Indoor Light Source Flicker Noise Rejection
  - 2 Selectable Measurement Ranges
- Green Power
  - Less than 110µA Supply Current
  - Less than 1µA Supply Current When Powered Down
- Easy to Use
  - SMBus Compatible I²C Interface
  - Temperature Compensation
- Wide Operating Voltage Range
  - 1.7V to 3.6V Supply for I²C Interface
  - 2.3V to 3.6V Supply for Sensor
- Wide Operating Temperature Range
  - -40°C to +85°C Ambient Temperature

Applications

- TV Panel Control
- Smart Phone
- Accessories
- Industrial Control
- Lighting Control
- Laptops (Intel ISH Qualified)

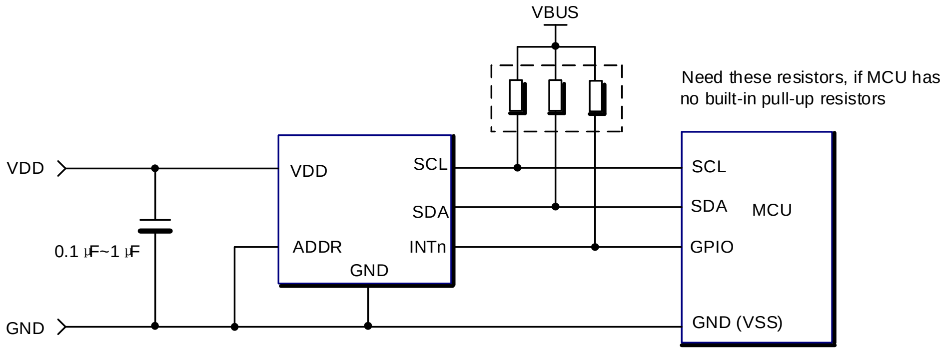


Figure 1. Typical Application Schematic Diagram [1]

Note 1: Bypass capacitors should be placed as close as possible to the device to eliminate noise.

Functional Block Diagram

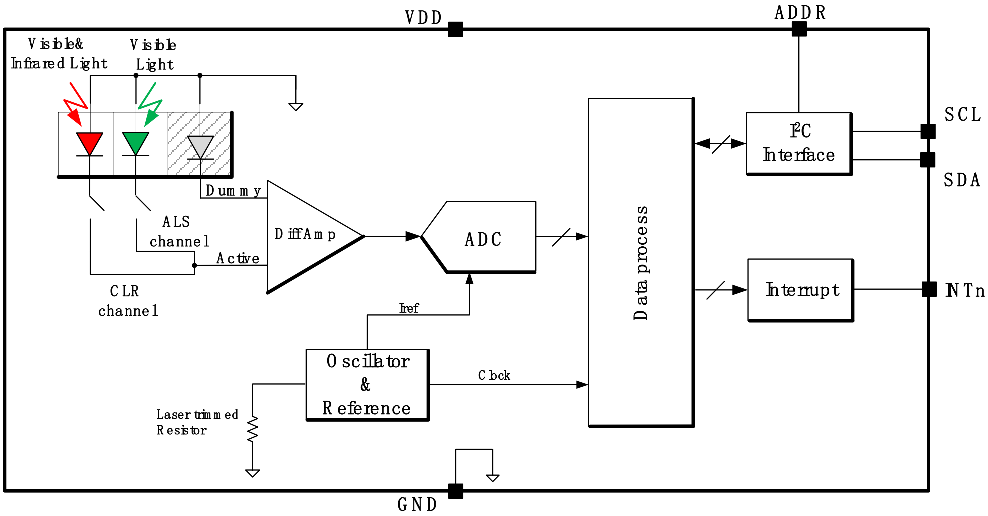
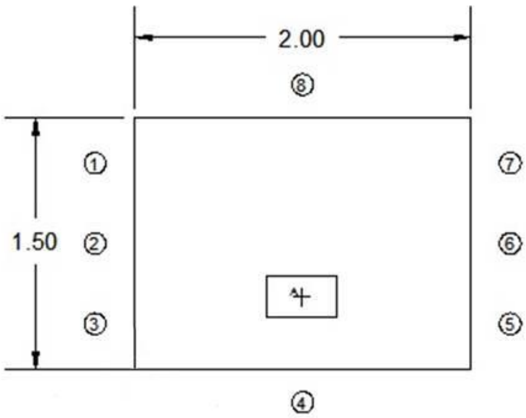


Figure 2. Block Diagram



Pin No	Pin Name	Pin Description
1	ADDR	I²C address pin - pulled high for address 0x45, pulled low for address 0x44. Floating is not allowed.
2	VDD	Positive supply: 2.3V to 3.6V.
3	GND	Ground pin.
4	NC	No connection.
5	SCL	I²C clock line. The I²C bus lines can be pulled from 1.7V to above VDD, 3.6V max.
6	SDA	I²C data line. The I²C bus lines can be pulled from 1.7V to above VDD, 3.6V max.
7	INTn	Interrupt output with open-drain configuration, low level active.
8	NC	No connection.

Absolute Maximum Ratings [1] T_A = +25°C	Min	Max	Unit
Supply Voltage	-0.3	4.0	V
I²C Bus Voltage	-0.3	4.0	V
I²C Bus Current		10	mA
Human Body Model	±2000		V
Charged Device Model	±500		V

Recommended Operation Conditions	Min	Max	Unit
Supply Voltage	2.3	3.6	V
Operating Temperature	-40	85	℃

Electrical Characteristics The general test conditions are V_{DD} = 3.0V, T_A = +25°C

Parmeter	Symbol	Condition	Min	Typ	Max	Unit
Power Supply Range	V_{DD}		2.3	3.0	3.6	V
Supply Current when ALS is Disabled	I_{DD_OFF}	ALS_EN = 0			0.1	µA
Supply Current for ALS Enabled	I_{DD_ONE}	ALS_EN =1, Range[2:0] = 3b'0xx	60	90	110	µA
		ALS_EN =1, Range[2:0] = 3b'1xx	50	80	100	µA
Full Scale Output ADC for Both Channels	$DATA_{ADC\_FS}$				65535	counts
Finest Resolution for ALS Channel [1]	RES_{finest}	Range[2:0] = 3b'100		0.0079		lux/counts
White LED, Ev=100lux	ADC count value ratio: Clear/ALS	Range[2:0]=3b'011 for Clear channel, range[2:0]=3b'000 for ALS channel		0.09		
Dark ADC Count	$DATA_{DARK}$	Ev = 0 lux, Range[2:0] = 3b'000			5	counts
ALS Count @Ev=100lux [2]	$DATA_{ALS}$	Range[2:0] = 3b'000	5710	6350	6990	counts

I²C Electrical Specifications [3] Unless otherwise specified, V_{DD} = 3.0V, T_A = +25°C

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply Voltage Range for I²C Interface	V_{I^2C}		1.7	-	V_{DD}+0.3	V
SCL Clock Frequency	f_{SCL}		-	-	750	kHz
Low Level Input Voltage of SCL and SDA	V_{IL}		-	-	0.55	V
High Level Input Voltage of SCL and SDA	V_{IH}		1.25	-	-	V
Hysteresis of Schmitt Trigger Input	V_{hys}		-	0.75	-	V
Low-level Output Voltage (Open-drain) at 4mA Sink Current	V_{OL}		-	-	0.4	V
Input Leakage for Each SDA, SCL	I_i		-10	-	10	µA
Pulse Width of Spikes Suppressed by the Input Filter	t_{SP}		-	-	50	ns
SCL Falling Edge to SDA Output Data Valid	t_{AA}		-	--	0.9	µs
Capacitance for Each SDA and SCL Pin	C_i		-	-	10	pF
Hold Time (Repeated) START Condition	$t_{HD:STA}$		0.6	-	-	µs
Low Period of the SCL Clock	t_{LOW}		1.3	-	-	µs
High Period of the SCL Clock	t_{HIGH}		0.6	-	-	µs
Set-up Time for A Repeated START Condition	$t_{SU:STA}$		0.6	-	-	µs
Data Hold Time	$t_{HD:DAT}$		30	-	-	ns
Data Set-up Time	$t_{SU:DAT}$		100	-	-	ns
Set-up Time for STOP Condition	$t_{SU:STO}$		0.6	-	-	µs
Bus Free Time between A STOP and START Condition	t_{BUF}		1.3	-	-	µs
Rise Time of Both SDA and SCL	t_R	$R_{pull-up}$ = 10kΩ, C_b = 10pF	-	95	-	ns
Fall Time of SDA and SCL	t_F	$R_{pull-up}$ = 10kΩ, C_b = 10pF	-	25	-	ns
Capacitive Load for Each Bus Line	C_b		-	-	0.4	nF
SDA and SCL System Bus Pull-up Reistor	$R_{pull-up}$	Maximum is determined by t_R and t_F	-	10	-	kΩ
Data Valid Time	$t_{VD:DAT}$		-	-	0.9	µs
Data Valid to Acknowledge Time	$t_{VD:ACK}$		-	-	0.9	µs
Noise Margin at the Low Level	V_{nL}		0.1 V_{DD}	-	-	V
Noise Margin at the High Level	V_{nH}		0.2 V_{DD}	-	-	V

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

Note 2: Fluorescent light (6500K) is used as light source unless otherwise specified. White LED is substituted in mass production.

Note 3: The I²C bus protocol was developed by Philips (now NXP). For a complete description of the I²C protocol, please review the NXP I²C design specification at http://www.I²C–bus.org/references/.

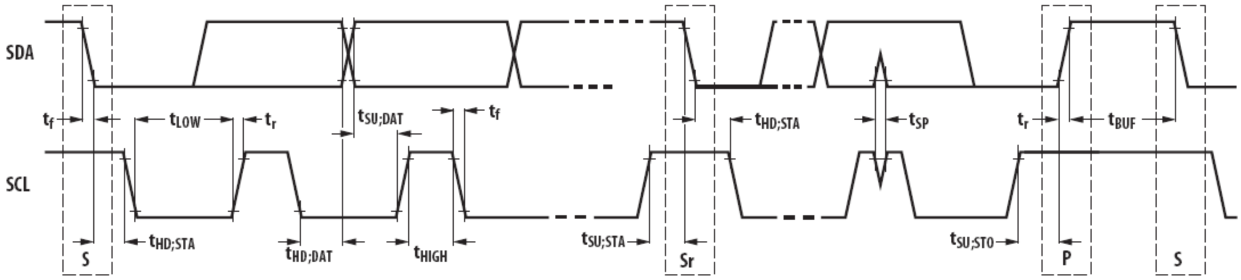
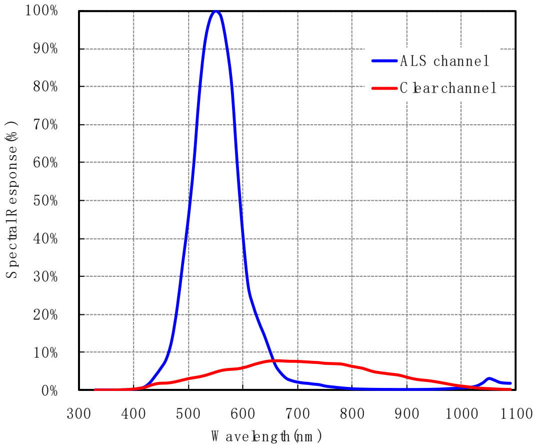


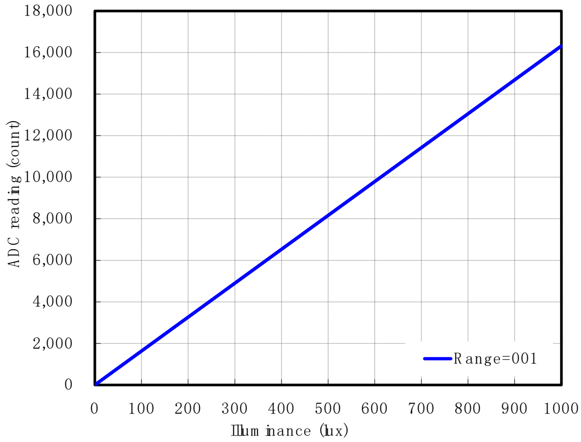
Figure 3. I²C Timing Diagram

Typical Performance Curves

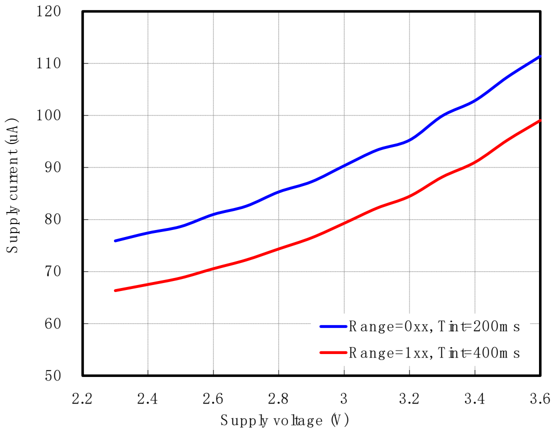
Spectral Response



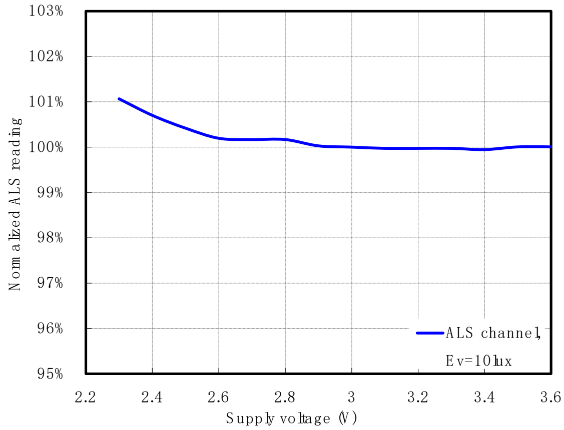
ADC Reading vs Illuminance



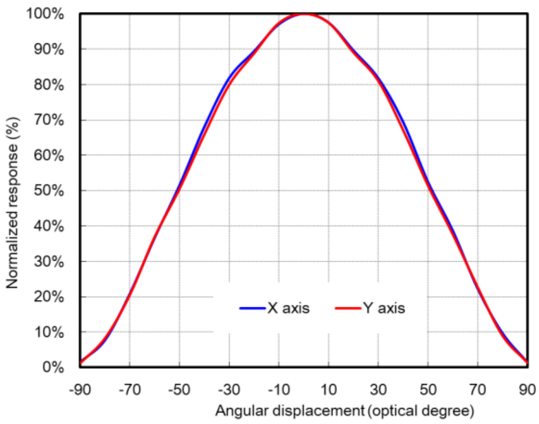
Supply Current vs. Supply Voltage



ALS Data vs. Supply Voltage



Normalized Output vs. Angular Displacement



Detailed Description

Ambient Light Sensing

Shown in Figure 4 is the relative spectral response of SY22309AS22-J01. The ALS channel spectral response accurately matches human eye's photopic vision curve. Under the same illuminance (lux), the ratio of ALS channel ADC reading of an incandescent lamp (rich of IR radiation) to that of a fluorescent lamp (no IR radiation) is close to 1.0.

Due to full spectral response of the Clear channel and lack of IR radiation for fluorescent and white LED light sources, the ratio of ADC reading of fluorescent to that of a white LED is also close to 1.0. When exposed to an incandescent light source (rich of IR radiation), the Clear channel ADC reading becomes significant. The Clear channel data can be used to identify the light source type and make the necessary corrections.

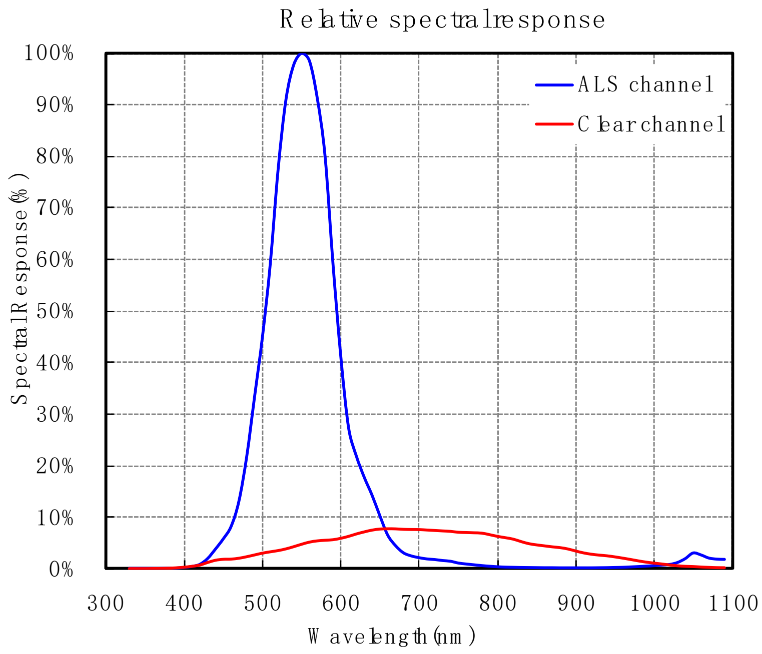


Figure 4. Spectral Responses of SY22309AS22-J01

The Power grids are using either 50Hz or 60Hz AC. The artificial light sources powered by the grid vary in intensity at the power grid frequencies. The varying light intensity is one of the noise sources for light sensors. To eliminate the noise caused by power grid, the integration time of the internal ADC shall be set as an integer multiple of noise signal period. For example, for a 50Hz grid eliminating the noise can be done by setting up the ADC integration time to n*20ms (n=1,2…n_i)

The Integration Time for SY22309AS22-J01 can be configured as either 200ms by setting bit 2 in register CON2 to 0, or 400ms by setting this bit to 1.

Interrupt Function

The ALS interrupts are governed by the high and low thresholds programmed in the registers 0x05 to 0x08. The INT_FLAG is set when the ALS reading (ALS_DATA) exceeds the high ALS interrupt threshold (INT_HTL & INT_HTH) or falls below the low ALS interrupt threshold (INT_LTL & INT_LTH).

To further control when an interrupt occurs, SY22309AS22-J01 provides a persistence filter which allows the user to specify the number of consecutive out-of-range ALS readings before an interrupt is asserted. See Figure 5 for details where PRST is 1. Once the persistence filter generates an interruption, INT_FLAG will be set and the open-drain output INTn will be set to low.

The interrupt flag is cleared when by using an I²C write to Register 0x01. The INTn open-drain output will be reset to high impedance (HZ) as a result.

If only the above-high-threshold interrupt is required, set the low threshold value 0x0000. If only the below-low-threshold interrupt is required, set the high threshold value 0xFFFF. If no interrupt is required, set the high threshold value 0xFFFF, and the low threshold value 0x0000, which is the default setting.

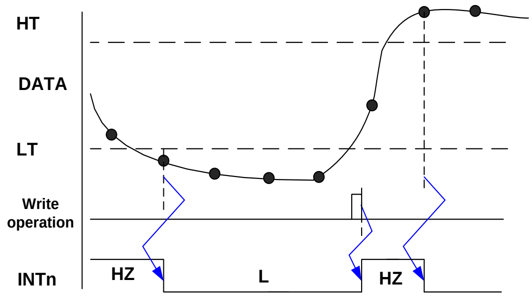


Figure 5. ALS Interrupt Example

Calculating Ambient Lux

ALS channel data is directly proportional to the illuminance at the surface of the IC, regardless of the light sources. No extra data manipulation needs to be done for simple lux calculation. Therefore, the illuminance (lux) can be obtained simply by multiplying ALS data (ALS_DATA) by its corresponding resolution.

Table 1. ALS Sensitivity at Different Ranges

Range Setting Range [2:0]	Resolution [lux/count]	Full Range [lux]
(1 0 0)	0.0079	516
(0 0 0)	0.0157	1032
(1 0 1)	0.0315	2064
(0 0 1)	0.063	4128
(1 1 0)	0.126	8256
(0 1 0)	0.2519	16512

However, in a typical application, the ambient light sensor is packaged or placed behind a window as shown in Figure 6. The transmittance of the sensor window ranges from 80% to 5%, or lesser. To obtain the actual illuminance, the transmittance has to be taken into account when calculating lux.

ALS_DATA = (Ambient Light in lux) * (Transmittance of Window)/Resolution

Example 1

The illuminance where the ambient light sensor is placed is 100 lux, the transmittance of sensor window is 20%, the resolution of the ambient light sensor is set at 0.0079lux/counts; the output count of the ambient light sensor is calculated as:

ALS_DATA = Illuminance * Transmittance/Resolution = 100 lux * 20%/(0.0079lux/counts) = 2532 counts.

It will result in a sensitivity of 25.32 counts/lux.

Example 2

The illuminance where the ambient light sensor is placed is 100 lux, the transmittance of sensor window is 5%, the resolution of the ambient light sensor is set at 0.0079lux/counts; the output count of the ambient light sensor is:

ALS_DATA = Illuminance * Transmittance/Resolution = 100 lux * 5%/(0.0079lux/counts) = 633 counts.

It will result in a sensitivity of 6.33 counts/lux.

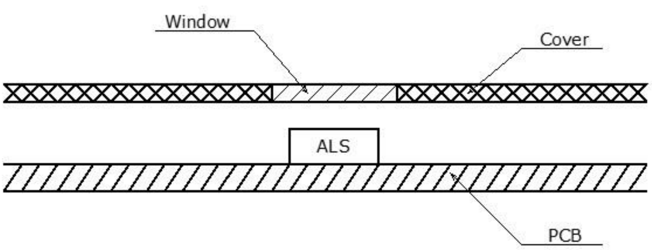


Figure 6. Ambient Light Sensor Mounted Inside an Apparatus

The light attenuation due to air gap between window bottom surface and top surface of sensor is neglected during above calculations. In actual applications, light attenuation can be induced by window transmittance, air gap, IC SMT error, etc. So normally actual test is recommended to get the system level sensitivity where all above factors will be taken into account.

VDD Power-up and Power Supply Considerations

Upon power-up, please ensure that the slew rate of VDD is greater than 0.5V/ms. After power-up, the supply voltage shall NOT drop below 2.0V. If this happens, please switch off the power, wait more than 1 second to discharge the device power supply rail (to get a reliable Power-On-Reset), and then power on the device again.

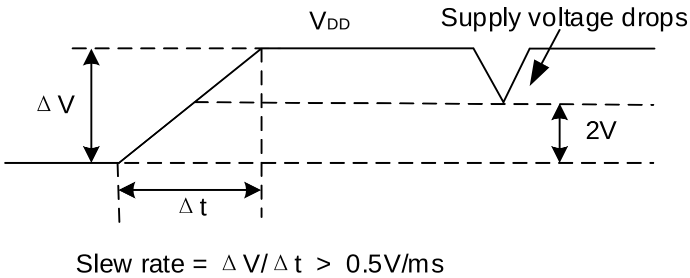


Figure 7. Waveform of Supply Voltage VDD

Layout Considerations

The SY22309AS22-J01 is designed to reduce the influences of the PCB layout. There are only a few considerations that will ensure best performance. Route the supply and I²C traces as far as possible from all sources of noise. A 0.1µF to 1µF decoupling capacitor needs to be placed close to the device.

I²C Read / Write Register Data

The IC's I²C slave address is 0x44 when ADDR pin is tied to GND or 0x45 when ADDR pin is tied to VDD. Figures 8 and 9 detail the protocol of writing or reading the register data inside the SY22309AS22-J01.

A : Acknowledge (0)
NA : Not Acknowledged (1)
P : Stop Condition
R : Read (1)
W : Write (0)
S : Start Condition
Sr : Repeat Start
:. : Continuation of Protocol
☐ : Mater to Slave
▒ : Slave to Mater

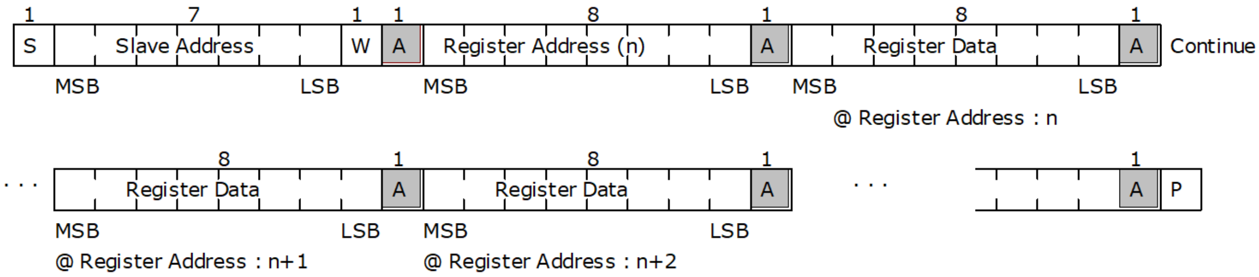


Figure 8. I²C Write-Register-Data Protocol

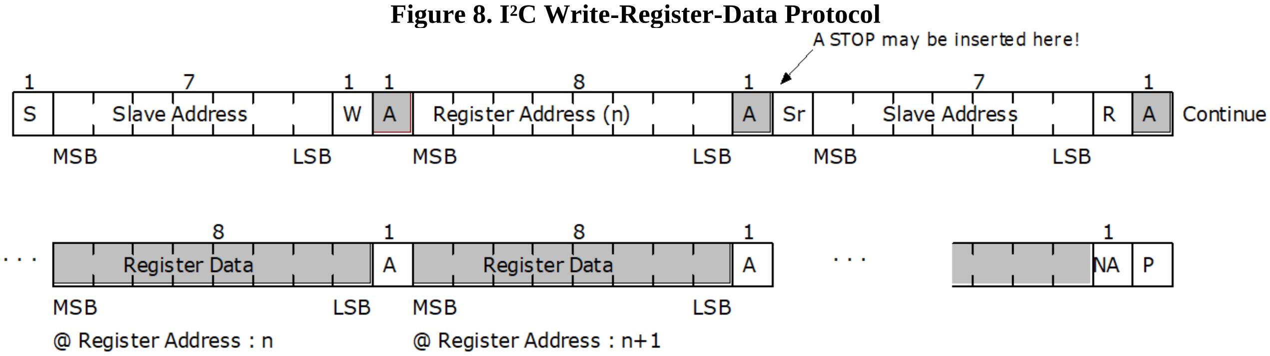


Figure 9. I²C Read-Register-Data Procotol

Register Map

There are nine 8-bit registers accessible via I²C. Register 0x00 has a fixed value 0x21 for communication test. Registers 0x01 and 0x02 configure the device's operation. Registers 0x03 and 0x04 contain the real time ADC data for either ALS or Clear channel. Registers 0x05 through 0x08 store the various thresholds which trigger interrupt events.

Registers and Register Bits

<table>
<tr><th rowspan="2">Register Address</th><th rowspan="2">Register Name</th><th colspan="8">Bit</th><th rowspan="2">Default</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0x00</td><td>COM_TEST</td><td colspan="8">Chip ID</td><td>0x21</td></tr>
<tr><td>0x01</td><td>CONFIG1</td><td>ALS_EN</td><td colspan="4">(Write 0)</td><td>INT_FLAG</td><td colspan="2">PRST [1:0]</td><td>0x00</td></tr>
<tr><td>0x02</td><td>CONFIG2</td><td colspan="5">(Write 0)</td><td colspan="3">RANGE [2:0]</td><td>0x00</td></tr>
<tr><td>0x03</td><td>ALS_DATAL</td><td colspan="8">ALS_DATA [7:0]</td><td>0x00</td></tr>
<tr><td>0x04</td><td>ALS_DATAH</td><td colspan="8">ALS_DATA [15:8]</td><td>0x00</td></tr>
<tr><td>0x05</td><td>INT_LTL</td><td colspan="8">INT_LT [7:0]</td><td>0x00</td></tr>
<tr><td>0x06</td><td>INT_LTH</td><td colspan="8">INT_LT [15:8]</td><td>0x00</td></tr>
<tr><td>0x07</td><td>INT_HTL</td><td colspan="8">INT_HT [7:0]</td><td>0xFF</td></tr>
<tr><td>0x08</td><td>INT_HTH</td><td colspan="8">INT_HT [15:8]</td><td>0xFF</td></tr>
</table>

Register 0x00 (COM_TEST) –Communication Test Register

Bit	Access	Default	Name	Description
7:0	RO	0x21	Chip_ID	Read this register through I²C interface to identify the device with chip ID is 0x21. It can also help to test whether the communication link is established or not

Register 0x01 (CON1) – Configure Registers 1

Bit	Access	Default	Name	Description
7	RW	0x00	ALS_EN	When =0, Power-down mode When =1, Normal operation mode
6:3	RW	0x00	Reserved	Unused register bit- write 0
2	R	0x00	INT_FLAG	When = 0, no interrupt has occurred since power-on or last "clear" When = 1, an interrupt event occurred
1:0	RW	0x00	PRST	For bits 1:0 = (see the following) 00, set INT_FLAG if 1 reading trips the threshold value 01, set INT_FLAG if 4 consecutive readings trip the threshold value 10, set INT_FLAG if 8 consecutive readings trip the threshold value 11, set INT_FLAG if 16 consecutive readings trip the threshold value

Register 0x02 (CON2) – Configure Register 2				
Bit	**Access**	**Default**	**Name**	**Description**
7:3	R/W	0x00	Reserved	Unused register bit- write 0
2:0	R/W	0x00	RANGE	For bits 2:0 = (see the following) 000, ALS channel detection range is 1032lux; 001, ALS channel detection range is 4128lux; 010, ALS channel detection range is 16512lux; 011, Clear channel is chosen, the detection range is 11200lux for fluorescent lamp, 1900lux for incandescent lamp; 100, ALS channel detection range is 516lux; 101, ALS channel detection range is 2064lux; 110, ALS channel detection range is 8256lux; 111, Clear channel is chosen, the detection range is 5600lux for fluorescent lamp, 950lux for incandescent lamp

Register 0x03 (ALS_DATAL) – Lower 8 Bits of ALS/CLEAR Data				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	R/W	0x00	ALS_DATAL	ALS_DATA [7..0] When Range [2:0] =3b'x11, it's the lower byte of Clear channel; When Range [2:0] = others, it's the lower byte of ALS channel

Register 0x04 (ALS_DATAH) – Upper 8 Bits of ALS/CLEAR Data				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	R/W	0x00	ALS_DATAH	ALS_DATA [15..8] When Range [2:0] =3b'x11, it's the upper byte of Clear channel; When Range [2:0] = others, it's the upper byte of ALS channel

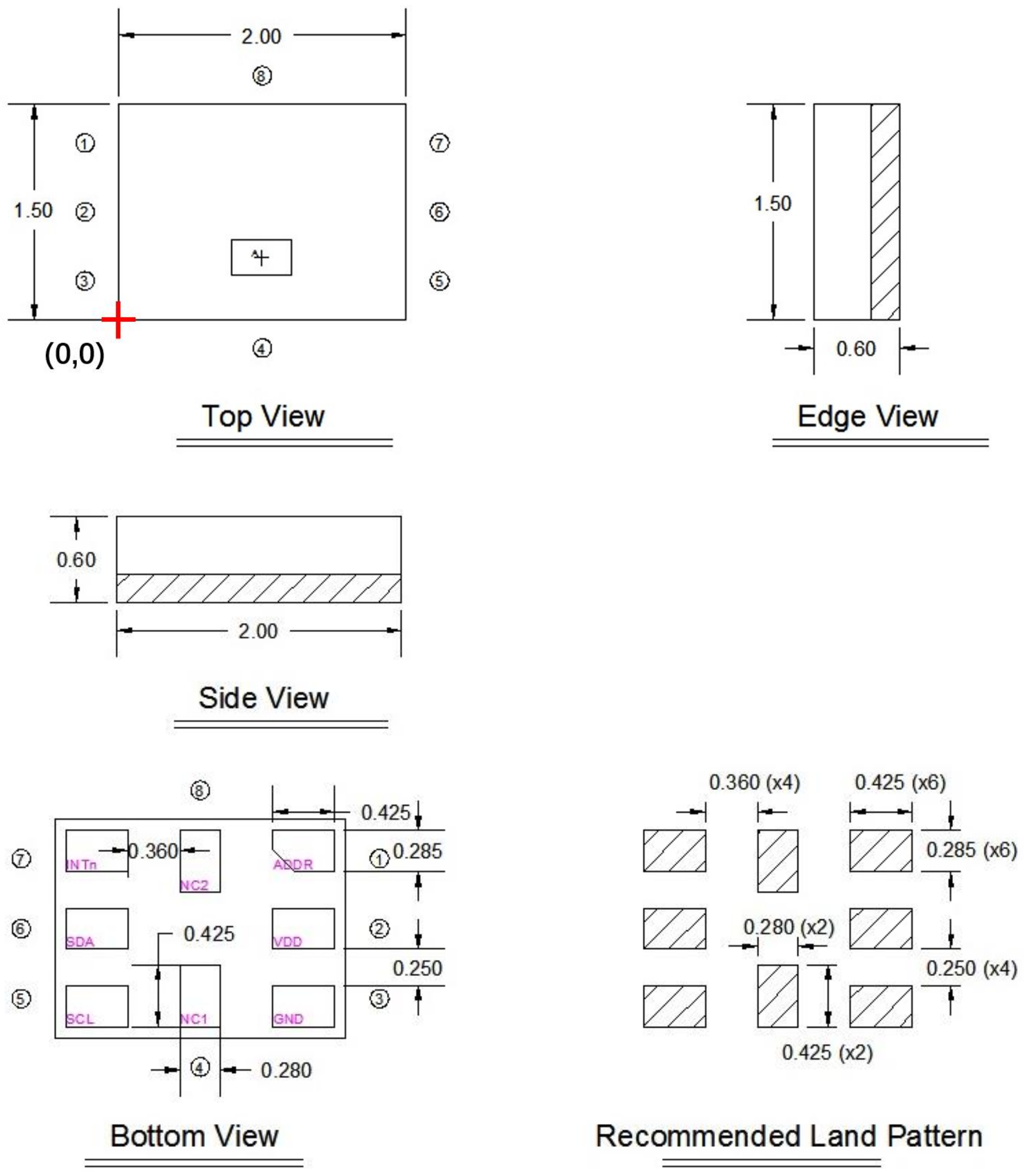
ALS Interrupt Threshold Registers (0x05)				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	RW	0x00	INT_LTL	Lower byte of interrupt low threshold, INT_LT [7..0]

ALS Interrupt Threshold Registers (0x06)				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	RW	0x00	INT_LTH	Upper byte of interrupt low threshold, INT_LT [15..8]

ALS Interrupt Threshold Registers (0x07)				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	RW	0xFF	INT_HTL	Lower byte of interrupt high threshold, INT_HT [7..0]

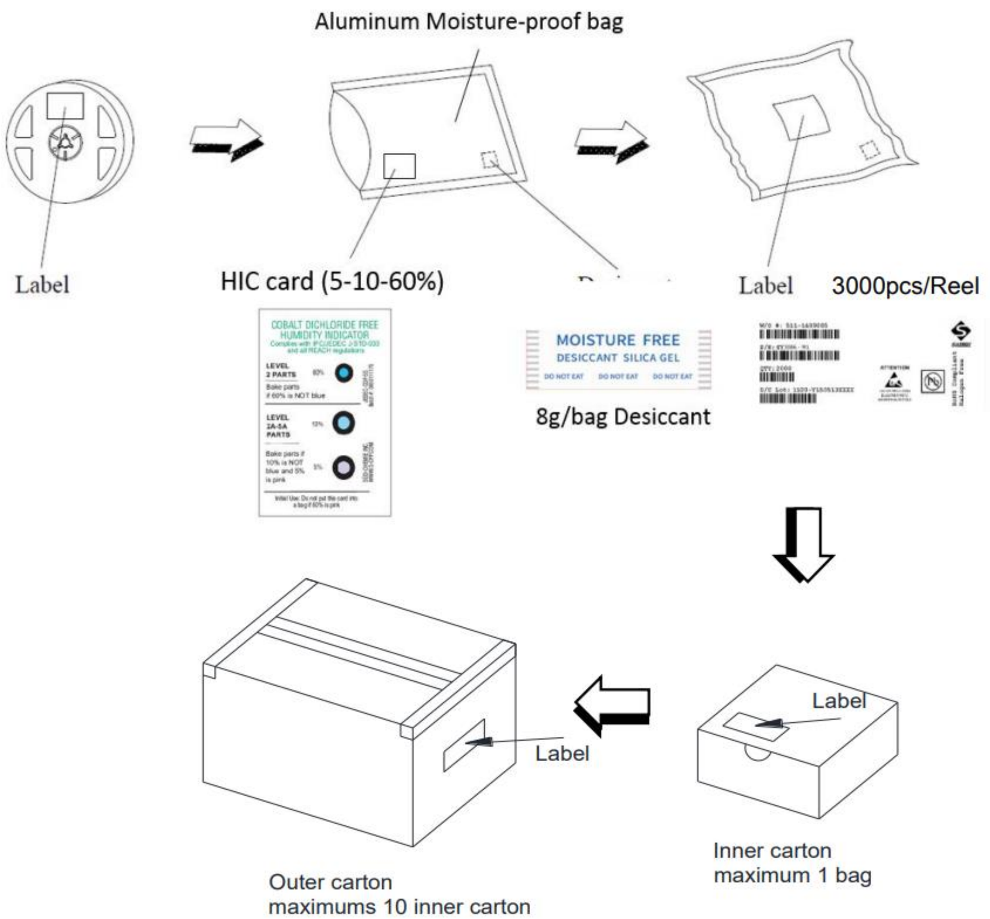
ALS Interrupt Threshold Registers (0x08)				
Bit	**Access**	**Default**	**Name**	**Description**
7:0	RW	0xFF	INT_HTH	Upper byte of interrupt high threshold, INT_HT [15..8]

Package Outline Dimensions



Notes 1: All tolerances are ±0.1mm, unless otherwise specified.
Notes 2: Sensing center coordinate is at point A (x,y) = (0.99, 0.43).
Notes 3: Sensitive area: 0.42mm x 0.25mm.
Notes 4: Unit is mm.

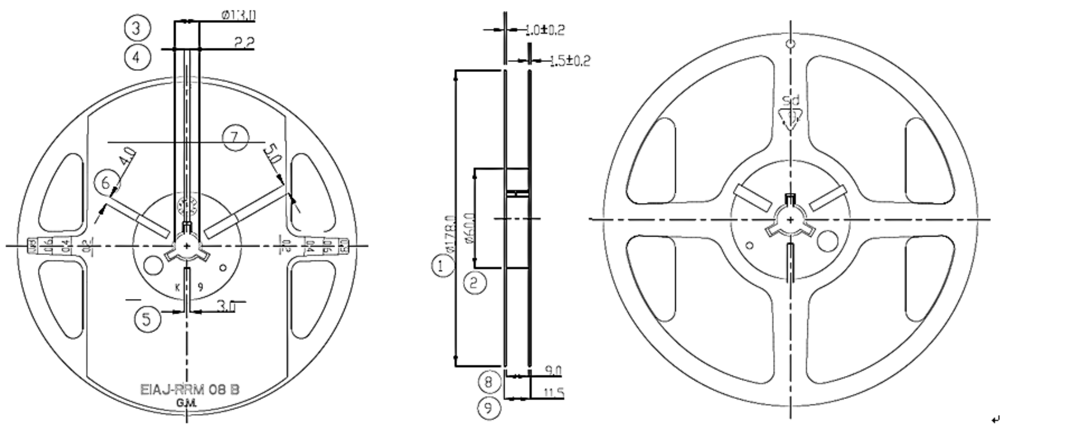
Packaging Quantity Specifications



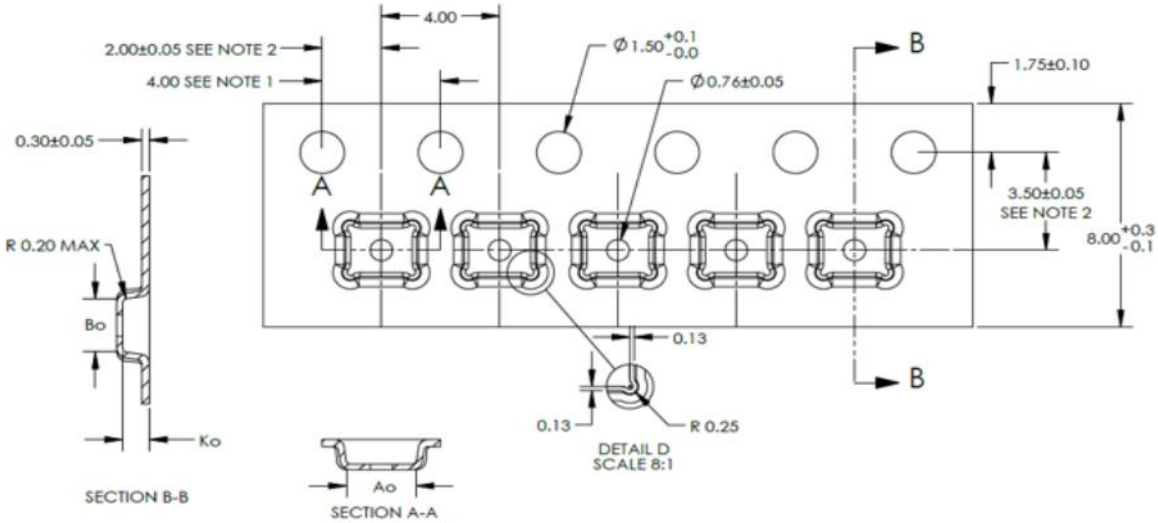
Dimensions of Reel (Unit: mm)

Width	1	2	3	4	5	6	7	8	9
7"	178±1	60±0.5	13±0.5	2.2±0.5	$3^{+0.5}_{-0}$	$4^{+0.5}_{-0}$	$5.0^{+0.5}_{-0}$	9±0.5	11.5±0.5

REV.	變更原因	DRAWN	DATE.
A-B	Format變更及圖面更正	Paul	05.31'16
B-C	變更料號	Willy	07.25'16
C-D	模具損耗，重新開模	Willy	02.16'17



Dimensions of Tape (Unit: mm)



	DIM	±
Ao	2.35	0.05
Bo	1.85	0.05
Ko	0.88	+0.05/-0.10

Recommended Method of Storage

Storage is recommended as soon as the bag has been opened to prevent moisture absorption. The following conditions should be observed, if bags are not available:

- Storage temperature: 10°C to 30°C
- Storage humidity: ≦60%RH max.
- Storage Time: ≦168hr max.

Moisture-Proof Package

To avoid moisture absorption by the resin, the product should be stored under the following conditions:

- Temperature: 23 ± 5°C
- Relative humidity: 60% (max)
- Baking is required if the devices have been stored unopened for more than six months.

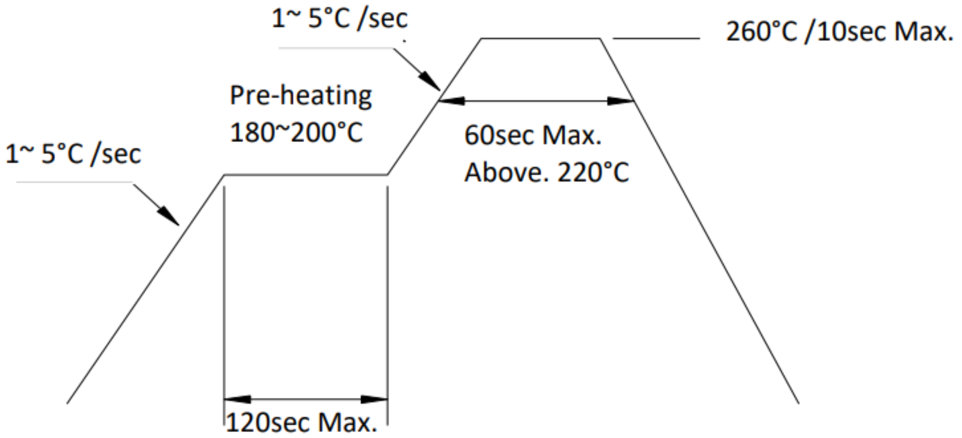
ESD Precaution

Proper storage and handling procedures should be followed to prevent ESD damage to the devices especially when they are removed from the Anti-static bag. Electro-Static Sensitive Devices warning labels are on the packing.

Make any necessary soldering correction manually

Temperature shall be no more than 350°C (25W for soldering iron) within 3 seconds. Make sure do not do this more than one time for any given pin.

Recommended Solder Profile



Notes 1: Reflow soldering should not be done more than twice.

Notes 2: Do not put stress on the devices during heating stage while soldering.

Notes 3: Do not warp the circuit board after soldering.

Revision History

Revision Number	Revision Date	Description	Pages changed
0.9	05/05/2019	Initial Release	
0.9A	08/23/2021	1. Update the block diagram. 2. Update the description of Pin 1 to "I²C address pin - pulled high for address 0x45, pulled low for address 0x44." 3. Update the description of "The I²C slave address of SY22309AS22-J01's is internally hardwired as 0b1000100 (0x44)" to "The IC's I²C slave address is 0x44 when ADDR pin is tied to GND or 0x45 when ADDR pin is tied to VDD."	
0.9B	11/17/2021	Update POD information	
1.0	11/17/2022	Production Release	

Revision history is for reference only and may not be comprehensive or complete.

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