

ISL29147

Low Power Ambient Light and Proximity Sensor with Enhanced Infrared Rejection

FN8409  
Rev 3.00  
January 6, 2015

The ISL29147 is a low power Ambient Light Sensor (ALS) and proximity (PROX) sensor. It has a built-in IR-LED for the proximity function. The ALS function measures the amount of light (in the visible spectrum) incident on the ISL29147.

The ALS function has a programmable ambient IR-rejection, which allows fine tuning of light source variations and is ideal for light sensor applications under dark protective glass. The ALS provides a 12-bit measurement. A passive optical filter removes unwanted wavelengths (IR or Ultraviolet) to ensure accurate ALS measurement.

The proximity function includes a new offset adjustment to compensate for the IR light reflected off the inside of the protective glass cover and back to the ISL29147 sensor. This offset adjustment allows the sensor to compensate for these internal reflections and preserve the dynamic range of the proximity measurement.

The built-in current-driver pulses an external infrared LED at a programmed current for 90µs. The infrared light that is reflected and received by the ISL29147 is digitized by an 8-bit ADC. The proximity sensor also has a passive optical filter designed to pass IR and reject visible wavelengths.

The ISL29147 provides a hardware pin to indicate an interrupt event. The interrupt pin saves power as the host microcontroller can 'wake-up' on an interrupt event and does not need to poll the device for an interrupt event. The interrupt generator is user configurable and provides several options for ALS and PROX trigger configurations. The ISL29147 supports an SMBus compatible I<sup>2</sup>C interface for configuration and control.

Features

- Internal IR-LED and sensor for a complete solution
- Ideal for applications under dark or tinted glass
- Enhanced ambient sunlight rejection to 40k Lux
- Programmable proximity sleep time between proximity measurements optimizes power consumption
- Hardware interrupt - no polling required
- Programmable IR compensation to fine-tune ALS performance for various glass compositions
- Programmable IR LED drive current to 250mA
- Operates from 2.25V to 3.63V V<sub>DD</sub>
- Power-down I<sub>DD</sub>, typical 0.2µA<sub>DC</sub>
- Tiny 2.40x4x1.2 (mm) optical co-package

Applications

- Display dimming and adjustment
  - Mobile devices: smart phones, PDA, GPS
  - Computing: monitors, laptops, notebooks
  - Picture frames, tablet-PCs, LCD-TV
- Object detection
  - Touchscreen disabling
  - Smart power-saving

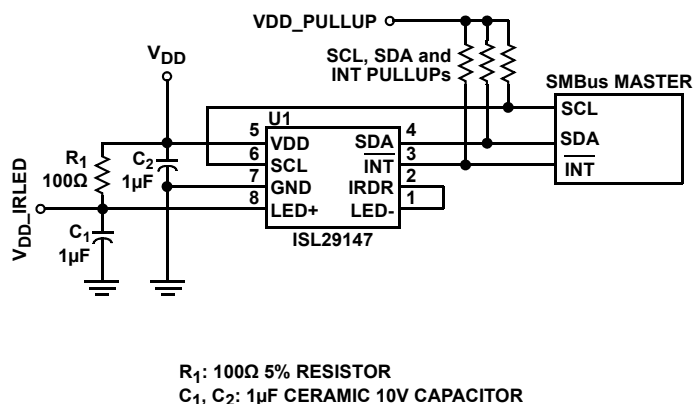


FIGURE 1. TYPICAL APPLICATIONS CIRCUIT

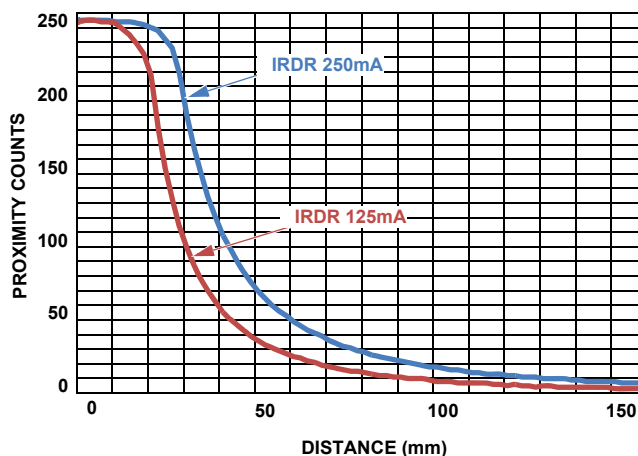
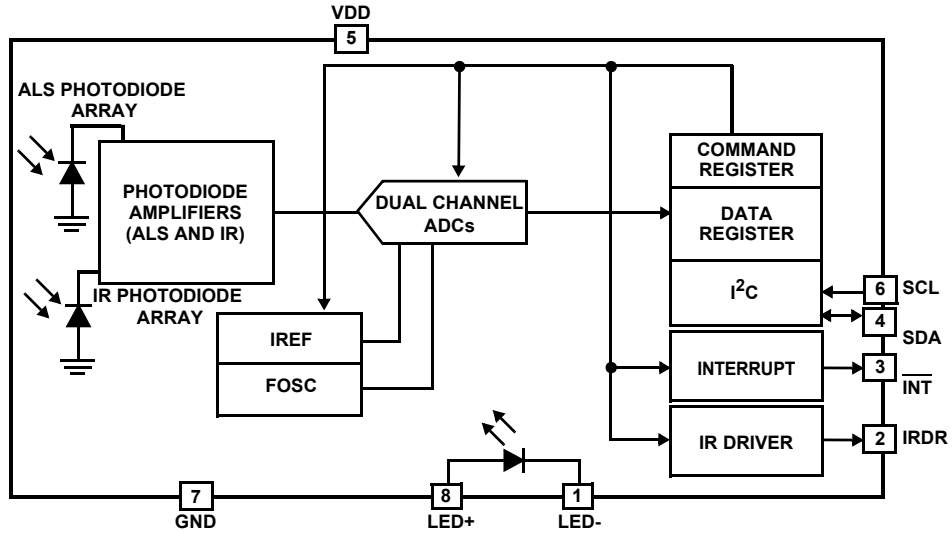


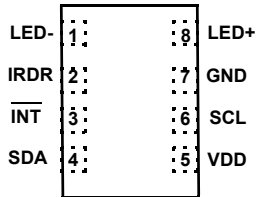
FIGURE 2. PROXIMITY SENSITIVITY

## Block Diagram



## Pin Configuration

ISL29147  
(8 LD 2.40x4 (mm) OPTICAL CO-PACKAGE)  
TOP VIEW



## Pin Description

| PIN# | NAME                    | DESCRIPTION                                     |
|------|-------------------------|---|
| 1    | LED-                    | Cathode of IR LED.                              |
| 2    | IRDR                    | IR-LED Driver Sink - Connect to IR LED Cathode. |
| 3    | $\overline{\text{INT}}$ | Active Low, Open-Drain Output.                  |
| 4    | SDA                     | $\text{i}^2\text{C}$ Serial Data Input/Output.  |
| 5    | VDD                     | Positive supply: 2.25V to 3.63V.                |
| 6    | SCL                     | $\text{i}^2\text{C}$ Serial Clock Input.        |
| 7    | GND                     | Ground.   |
| 8    | LED+                    | Anode of IR LED.                                |

## Ordering Information

| PART NUMBER<br>(Notes 1, 2, 3) | PART MARKING     | V <sub>DD</sub> RANGE<br>(V) | TEMP RANGE<br>(°C) | PACKAGE<br>(RoHS Compliant) | PKG.<br>DWG. # |
|--------------------------------|------------------|------------------------------|--------------------|-----------------------------|----------------|
| ISL29147IROMZ-T7               | N/A              | 2.25 to 3.63                 | -40 to +85         | 8 Ld Optical Co-package     | LS.2.40x4      |
| ISL29147IROMZ-EVALZ            | Evaluation Board |                              |                    |                             |                |

NOTES:

1. Please refer to [TB347](#) for details on reel specifications.
2. These Intersil Pb-free plastic packaged products employ special Pb-free material sets; molding compounds/die attach materials and NiPdAu plate - e4 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), please see product information page for [ISL29147](#). For more information on MSL, please see tech brief [TB363](#).

**Absolute Maximum Ratings**

|   |               |
|---|---------------|
| V <sub>DD</sub> Supply Voltage between VDD and GND  | 4.0V          |
| I <sup>2</sup> C Bus Pin Voltage (SCL, SDA)         | -0.5V to 4.0V |
| I <sup>2</sup> C Bus Pin Current (SCL, SDA)         | <10mA         |
| INT Pin Voltage                                     | -0.5V to 4.0V |
| INT Pin Current                                     | <10mA         |
| ESD Rating  |               |
| Human Body Model (Tested per JESD22-A114E) (Note 4) | 2kV           |

**Thermal Information**

|   |                           |
|---|---------------------------|
| Thermal Resistance (Typical)                      | $\theta_{JA}$ (°C/W)      |
| 8 Ld Optical Co-package (Note 5)                  | 425                       |
| Maximum Die Temperature                           | +90°C                     |
| Storage Temperature                               | -40°C to +85°C            |
| Operating Temperature                             | -40°C to +85°C            |
| Pb-Free Reflow Profile (*)                        | see <a href="#">TB487</a> |
| *Peak temperature during solder reflow +235°C max |                           |

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

**NOTES:**

- ESD on all pins is 2kV except IRDR, which is 1.5kV.
- $\theta_{JA}$  is measured in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief [TB379](#).

**Electrical Specifications** V<sub>DD</sub> = 3.0V, T<sub>A</sub> = +25°C.

| PARAMETER                    | DESCRIPTION  | TEST CONDITION   | MIN<br>(Note 10) | TYP  | MAX<br>(Note 10) | UNITS  |
|------------------------------|--|--|------------------|------|------------------|--------|
| <b>INPUT POWER</b>           |  |  |                  |      |                  |        |
| V <sub>DD</sub>              | Power Supply Range   |  | 2.25             | 3.0  | 3.63             | V      |
| I <sub>DD_OFF</sub>          | Supply Current when Powered Down   | ALS_EN = 0; PROX_EN = 0  |                  | 0.2  | 1.0              | μA     |
| I <sub>DD_NORM</sub>         | Supply Current for ALS+Prox in Sleep Time                                      | ALS_EN = 1; PROX_EN = 1  |                  | 125  | 140              | μA     |
| I <sub>DD_PRX_SLP</sub>      | Supply Current for Prox in Sleep Time  | ALS_EN = 0; PROX_EN = 1  |                  | 95   |                  | μA     |
| I <sub>DD_ALS</sub>          | Supply Current for ALS   | ALS_EN = 1; PROX_EN = 0  |                  | 95   |                  | μA     |
| <b>ADC (ALS and PROX)</b>    |  |  |                  |      |                  |        |
| t <sub>INTGR_ALS</sub>       | 12-bit ALS Conversion Time   |  | 80               | 95   | 110              | ms     |
| t <sub>INTGR_PROX</sub>      | 8-bit Prox Conversion Time   |  | 0.4              | 0.50 | 0.6              | ms     |
| DATA <sub>ALS_0</sub>        | ALS Result when Dark   | E <sub>AMBIENT</sub> = 0 Lux, 900 Lux range  |                  | 1    |                  | Counts |
| DATA <sub>ALS_F</sub>        | Full Scale ALS ADC Code  | E <sub>AMBIENT</sub> > selected range maximum Lux  |                  |      | 4095             | Counts |
| $\frac{\Delta DATA_1}{DATA}$ | Output Variation Over Light Sources:<br>Fluorescent, Incandescent and Sunlight | Ambient light sensing, no cover glass<br>After programmable active IR compensation<br>(Note 6)   |                  | ±10  |                  | %      |
| $\frac{\Delta DATA_2}{DATA}$ | Output Variation Over Light Sources:<br>Fluorescent, Incandescent and Sunlight | Ambient light sensing under cover glass<br>After programmable active IR compensation<br>(Note 6) |                  | ±10  |                  | %      |
| Linearity                    | ALS ADC Data Linearity   | 20% - 80% of full range  |                  | ±5   |                  | %      |
| DATA <sub>PROX_0</sub>       | Prox Data without Object in Path   |  |                  | 1    |                  | Counts |
| DATA <sub>PROX_F</sub>       | Full Scale Prox ADC Code   |  |                  |      | 255              | Counts |
| ProxWASH                     | Washout Bit Activation Level   | Norwood Solar Emulator   |                  | 40k  |                  | Lux    |
| ProxOffsetMax                | Maximum PROX Offset, Referenced to Proximity ADC Range                         |  |                  | 512  |                  | LSB    |
| ProxOffsetInc                | Proximity Offset Adjust Increment Referenced to Proximity ADC Range            |  |                  | 27   |                  | LSB    |

**Electrical Specifications**  $V_{DD} = 3.0V, T_A = +25^\circ C$ . (Continued)

| PARAMETER                    | DESCRIPTION                         | TEST CONDITION                                | MIN<br>(Note 10) | TYP   | MAX<br>(Note 10) | UNITS   |
|------------------------------|-------------------------------------|---|------------------|-------|------------------|---------|
| <b>LED DRIVER (IRDR PIN)</b> |                                     |   |                  |       |                  |         |
| $t_r$                        | Rise Time for IRDR Sink Current     | $R_{LOAD} = 15\Omega$ at IRDR pin, 20% to 80% |                  | 25    |                  | ns      |
| $t_f$                        | Fall time for IRDR Sink Current     | $R_{LOAD} = 15\Omega$ at IRDR pin, 80% to 20% |                  | 15    |                  | ns      |
| $I_{IRDR\_0}$                | IRDR Sink Current                   | PROX_DR = 0; $V_{IRDR} = 0.5V$                |                  | 31.25 |                  | mA      |
| $I_{IRDR\_1}$                | IRDR Sink Current                   | PROX_DR = 1; $V_{IRDR} = 0.5V$                |                  | 62.5  |                  | mA      |
| $I_{IRDR\_2}$                | IRDR Sink Current                   | PROX_DR = 2; $V_{IRDR} = 0.5V$                |                  | 125   |                  | mA      |
| $I_{IRDR\_3}$                | IRDR Sink Current                   | PROX_DR = 3; $V_{IRDR} = 0.5V$                |                  | 250   |                  | mA      |
| $I_{IRDR\_LEAK}$             | IRDR Leakage Current                | PROX_EN = 0; $V_{IRDR} = 3.63V$               |                  | 0.001 | 1                | $\mu A$ |
| $V_{IRDR}$                   | IRDR Pin Voltage Compliance         | Register bit PROX_DR = 0                      | 0.50             |       | 4.3              | V       |
| $t_{PULSE}$                  | $I_{IRDR}$ On Time Per PROX Reading |   |                  | 90    |                  | $\mu s$ |

**IR-LED Specifications**  $T_A = +25^\circ C$ .

| SYMBOL          | PARAMETER                     | TEST CONDITIONS | MIN<br>(Note 10) | TYP | MAX<br>(Note 10) | UNITS |
|-----------------|-------------------------------|-----------------|------------------|-----|------------------|-------|
| $V_F$           | IR-LED Forward Voltage        | $I_F = 100mA$   |                  | 1.8 |                  | V     |
| $V_R$           | IR-LED Reverse Voltage        |                 |                  |     | 5.5              | V     |
| $\lambda_p$     | IR-LED Peak Output Wavelength | $I_F = 100mA$   |                  | 855 |                  | nm    |
| $\Delta\lambda$ | IR-LED Spectral Half-Width    | $I_F = 100mA$   |                  | 30  |                  | nm    |
| $\Phi_E$        | IR-LED Radiant Power          | $I_F = 100mA$   |                  | 38  |                  | mW    |

**I<sup>2</sup>C Electrical Specifications** For SCL and SDA unless otherwise noted,  $V_{DD} = 3V, T_A = +25^\circ C$  (Note 8).

| SYMBOL       | PARAMETER   | TEST CONDITIONS                                       | MIN<br>(Note 10) | TYP | MAX<br>(Note 10) | UNITS   |
|--------------|---|---|------------------|-----|------------------|---------|
| $V_{I^2C}$   | Supply Voltage Range for I <sup>2</sup> C Interface               |   | 1.7              |     | 3.63             | V       |
| $f_{SCL}$    | SCL Clock Frequency   |   |                  |     | 400              | kHz     |
| $V_{IL}$     | SCL and SDA Input Low Voltage                                     |   |                  |     | 0.55             | V       |
| $V_{IH}$     | SCL and SDA Input High Voltage                                    |   | 1.25             |     |                  | V       |
| $V_{hys}$    | Hysteresis of Schmitt Trigger Input                               |   | $0.05V_{DD}$     |     |                  | V       |
| $V_{OL}$     | Low-level Output Voltage (open-drain) at 4mA Sink Current         |   |                  |     | 0.4              | V       |
| $I_i$        | Input Leakage for each SDA, SCL Pin                               |   | -10              |     | 10               | $\mu A$ |
| $t_{SP}$     | Pulse Width of Spikes that must be Suppressed by the Input Filter |   |                  |     | 50               | ns      |
| $t_{AA}$     | SCL Falling Edge to SDA Output Data Valid                         |   |                  |     | 900              | ns      |
| $C_i$        | Capacitance for each SDA and SCL Pin                              |   |                  |     | 10               | pF      |
| $t_{HD:STA}$ | Hold Time START Condition   | After this period, the first clock pulse is generated | 600              |     |                  | ns      |
| $t_{LOW}$    | LOW Period of the SCL Clock                                       | Measured at the 30% of $V_{DD}$ crossing              | 1300             |     |                  | ns      |
| $t_{HIGH}$   | HIGH Period of the SCL Clock                                      |   | 600              |     |                  | ns      |
| $t_{SU:STA}$ | Set-up Time for a START Condition                                 |   | 600              |     |                  | ns      |
| $t_{HD:DAT}$ | Data Hold Time  |   | 30               |     |                  | ns      |

## I<sup>2</sup>C Electrical Specifications

For SCL and SDA unless otherwise noted,  $V_{DD} = 3V$ ,  $T_A = +25^\circ C$  (Note 8). (Continued)

| SYMBOL        | PARAMETER  | TEST CONDITIONS                       | MIN<br>(Note 10)      | TYP | MAX<br>(Note 10) | UNITS      |
|---------------|--|---------------------------------------|-----------------------|-----|------------------|------------|
| $t_{SU:DAT}$  | Data Set-up Time                                 |                                       | 100                   |     |                  | ns         |
| $t_R$         | Rise Time of both SDA and SCL Signals            | (Note 9)                              | $20 + 0.1 \times C_b$ |     |                  | ns         |
| $t_F$         | Fall Time of both SDA and SCL Signals            | (Note 9)                              | $20 + 0.1 \times C_b$ |     |                  | ns         |
| $t_{SU:STO}$  | Set-up Time for STOP Condition                   |                                       | 600                   |     |                  | ns         |
| $t_{BUF}$     | Bus Free Time Between a STOP and START Condition |                                       | 1300                  |     |                  | ns         |
| $C_b$         | Capacitive Load for Each Bus Line                |                                       |                       |     | 400              | pF         |
| $R_{pull-up}$ | SDA and SCL System Bus Pull-Up Resistor          | Maximum determined by $t_R$ and $t_F$ | 1                     |     |                  | k $\Omega$ |
| $t_{VD:DAT}$  | Data Valid Time                                  |                                       |                       |     | 0.9              | $\mu s$    |
| $t_{VD:ACK}$  | Data Valid Acknowledge Time                      |                                       |                       |     | 0.9              | $\mu s$    |
| $V_{nL}$      | Noise Margin at the LOW Level                    |                                       | $0.1V_{DD}$           |     |                  | V          |
| $V_{nH}$      | Noise Margin at the HIGH Level                   |                                       | $0.2V_{DD}$           |     |                  | V          |

### NOTES:

6. Cover glass assumes fixed infrared/visible light transmissivity ratio of 10.
7. An 850nm infrared LED is used in production test for proximity/IR sensitivity testing.
8. All parameters in the I<sup>2</sup>C Electrical Specifications table are guaranteed by design and simulation.
9.  $C_b$  is the capacitance of the bus in pF.
10. Parameters with MIN and/or MAX limits are 100% tested at  $+25^\circ C$ , unless otherwise specified. Temperature limits established by characterization and are not production tested.

# ISL29147 Configuration and Control

## I<sup>2</sup>C Interface

The ISL29147 configuration and control is performed using the I<sup>2</sup>C or SMBus. The ISL29147's I<sup>2</sup>C interface slave address is internally hard wired as 8'b1000100x, where x denotes the R/W bit.

Every I<sup>2</sup>C transaction begins with the master asserting a start condition (SDA falling while SCL remains high). The first transmitted byte is initiated by the master and includes 7 address bits and a R/W bit. The slave is responsible for pulling SDA low during the ACK time after every transmitted byte.

Figure 4 shows a sample one-byte read. The I<sup>2</sup>C bus master always drives the SCL (clock) line, while either the master or the slave can drive the SDA (data) line.

Each I<sup>2</sup>C transaction ends with the master asserting a stop condition (SDA rising while SCL remains high). For more information about the I<sup>2</sup>C standard, consult the Philips™ I<sup>2</sup>C specification documents.

Timing specifications are included in "[I<sup>2</sup>C Electrical Specifications](#)" on page 4. The timing parameters are defined in Figure 3.

The I<sup>2</sup>C interface on the ISL29147 supports single and multiple byte read and write transfers using the random-read/write protocol. The ISL29147 does not support I<sup>2</sup>C 'Repeat Start' protocol.

NOTE: In most system implementations, the ISL29147 is connected to a single I<sup>2</sup>C master with one or more slave devices, consequently, absence of the "Repeat Start" function does not adversely affect I<sup>2</sup>C bus system performance.

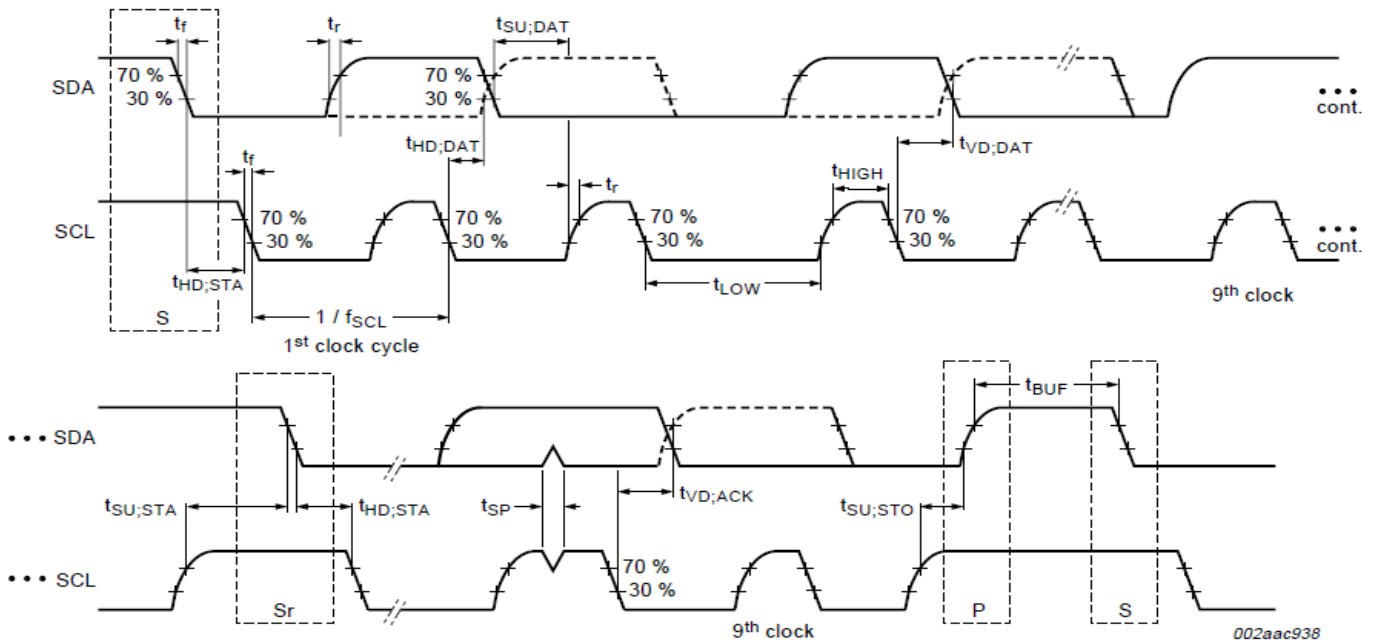


FIGURE 3. I<sup>2</sup>C TIMING DIAGRAM

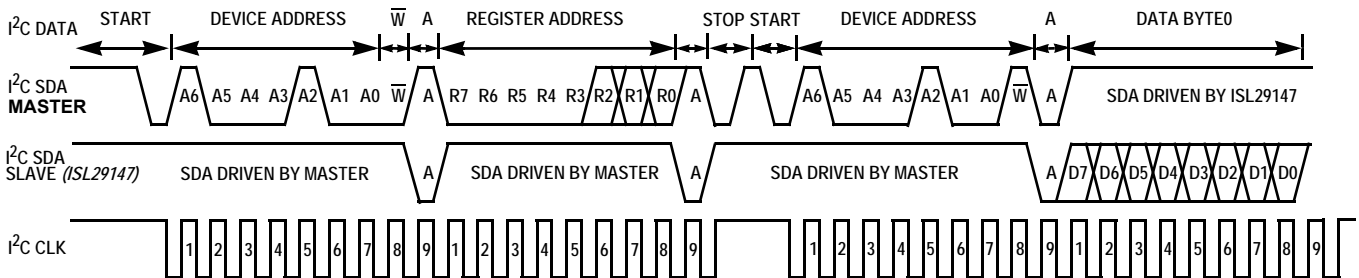


FIGURE 4. I<sup>2</sup>C DRIVER TIMING DIAGRAM FOR MASTER AND SLAVE CONNECTED TO COMMON BUS

## Typical Performance Curves

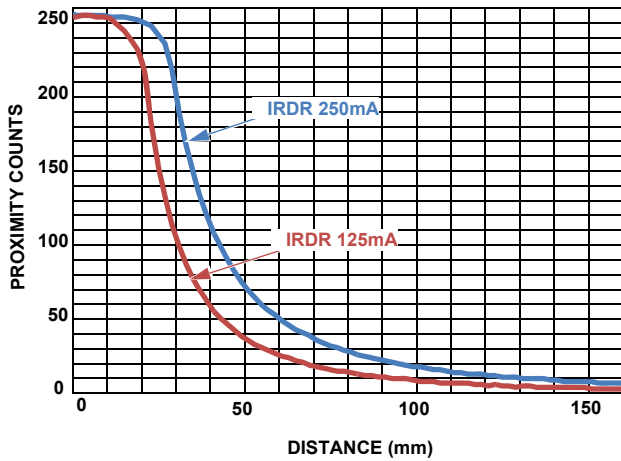


FIGURE 5. PROXIMITY SENSITIVITY (Note 11)

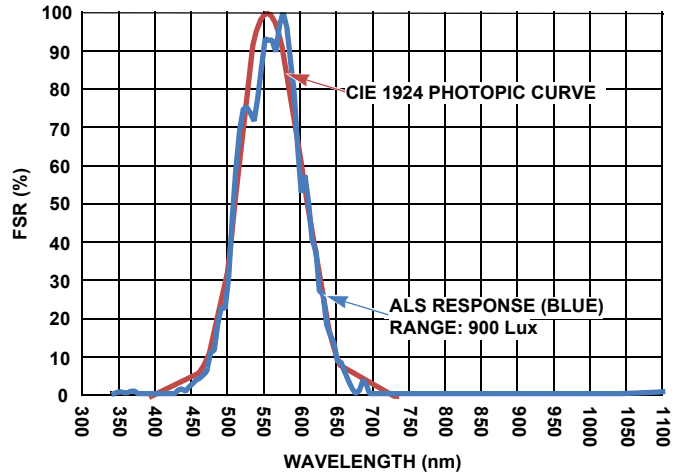


FIGURE 6. ALS SENSITIVITY (Note 12)

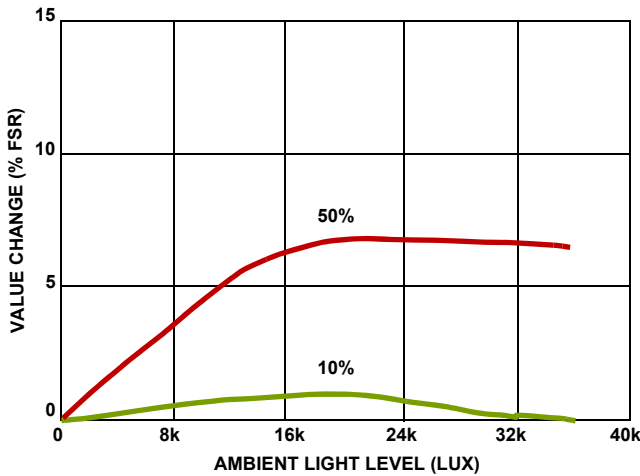


FIGURE 7. PROXIMITY AMBIENT LIGHT REJECTION (Note 13)

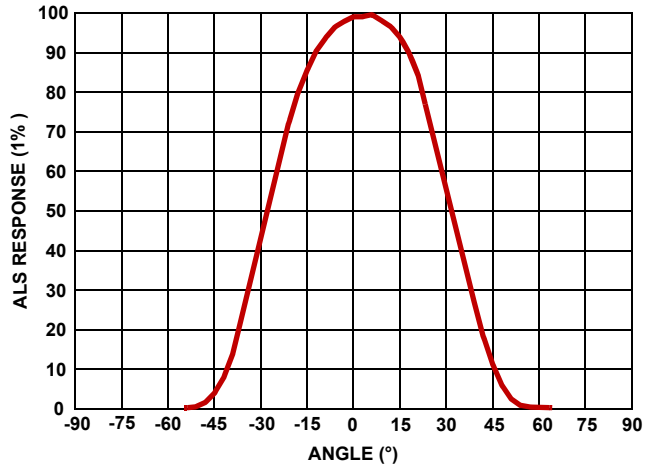


FIGURE 8. ALS ANGULAR SENSITIVITY (Note 14)

NOTES:

11. Figure 5 shows ISL29147 Proximity distance sweeps with different IRDR LED current settings using an 18% Grey card reflector.
12. Figure 6 shows ISL29147 Ambient Light Sensor Spectral response when compared to a theoretical CIE 1924 Photopic curve. The 'Blue' line shows the ISL29147 response and the 'Red' line depicts the CIE 1924 Photopic curve.
13. Figure 7 shows the ISL29147 Proximity Ambient Light Rejection using a Norwood Solar Emulator. At 40k Lux ambient light level, the Proximity Washout Count (Reg 0x0D[7:1]) is 127 indicating a saturation in Proximity Signal processing path. The Proximity Washout bit 0x0D[0] is active at approximately 90% of the maximum level. At 10% initial PROX count (due to optical leakage from IR LED to the ISL29147), the PROX data error is under 2%. At 50% initial PROX count (severe optical leakage), the PROX data error is about 7%.
14. Figure 8 shows the Ambient Light Sensor Angular Sensitivity of the ISL29147 using a white LED light source.

## ISL29147 Register Set

**TABLE 1. ISL29147 CONFIGURATION AND CONTROL REGISTERS**

| ADDRESS (HEX) | REGISTER NAME | POWER-ON DEFAULT | REGISTER ACCESS | BIT FIELDS | FUNCTION NAME/VALUE | FUNCTION                                     |
|---------------|---------------|------------------|-----------------|------------|---------------------|--|
| 0x00          | Device ID     | b11000xxx        | RO              | [7:0]      |                     | Device Identification                        |
|               |               |                  |                 | [7:3]      | [11000]             | ISL29147 Device ID                           |
|               |               |                  |                 | [2:0]      | [XXX]               | Reserved                                     |
| 0x01          | Config0       | 0x00             | RW              | [7:0]      |                     | Proximity Configuration                      |
|               |               |                  |                 | [7:6]      |                     | Reserved                                     |
|               |               |                  |                 | [5]        | PROX_EN             | Proximity Enable/Disable                     |
|               |               |                  |                 | [1]        |                     | Enable                                       |
|               |               |                  |                 | [0]        |                     | Disable                                      |
|               |               |                  |                 | [4:2]      | PROX_SLP            | Proximity Sleep Time Select                  |
|               |               |                  |                 | [000]      |                     | 400ms  |
|               |               |                  |                 | [001]      |                     | 100ms  |
|               |               |                  |                 | [010]      |                     | 50ms   |
|               |               |                  |                 | [011]      |                     | 25ms   |
|               |               |                  |                 | [100]      |                     | 12.5ms                                       |
|               |               |                  |                 | [101]      |                     | 6.25ms                                       |
|               |               |                  |                 | [110]      |                     | 3.125ms                                      |
|               |               |                  |                 | [111]      |                     | 0ms  |
|               |               |                  |                 | [1:0]      | IRDR_DRV            | IR LED Current                               |
| [00]          |               | 31.25mA          |                 |            |                     |  |
| [01]          |               | 62.5mA           |                 |            |                     |  |
| [10]          |               | 125mA            |                 |            |                     |  |
| [11]          |               | 250mA            |                 |            |                     |  |
| 0x02          | Config1       | 0x00             | RW              | [7:0]      |                     | Proximity/ALS Configuration                  |
|               |               |                  |                 | [7]        | INT_ALG             | Interrupt Algorithm                          |
|               |               |                  |                 | [0]        |                     | Hysteresis Window                            |
|               |               |                  |                 | [1]        |                     | Window Comparator                            |
|               |               |                  |                 | [6:3]      | PROX_OFFSET         | Proximity Offset Compensation                |
|               |               |                  |                 | [2]        | ALS_EN              | Ambient Light Sensing Enable/Disable         |
|               |               |                  |                 | [1]        |                     | Enable                                       |
|               |               |                  |                 | [0]        |                     | Disable                                      |
|               |               |                  |                 | [1:0]      | ALS_RANGE           | Ambient Light Sensor Range Select            |
|               |               |                  |                 | [00]       |                     | 56.25 Lux                                    |
|               |               |                  |                 | [01]       |                     | 112.5 Lux                                    |
| [10]          |               | 900 Lux          |                 |            |                     |  |
| [11]          |               | 1800 Lux         |                 |            |                     |  |
| 0x03          | Config2       | 0x00             | RW              | [7:0]      | ALS_IR_COMP         | Ambient Light Sensor IR Compensation         |
|               |               |                  |                 | [7:5]      |                     | Reserved                                     |
|               |               |                  |                 | [4:0]      | ALSIRComp           | ALS Infra Red Compensation (Unsigned Binary) |
| 0x04          | INTConfig     | 0x10             | RW              | [7:0]      | INTConfig           | Interrupt Configuration, Status and Control  |



TABLE 1. ISL29147 CONFIGURATION AND CONTROL REGISTERS (Continued)

| ADDRESS (HEX) | REGISTER NAME | POWER-ON DEFAULT | REGISTER ACCESS | BIT FIELDS   | FUNCTION NAME/VALUE | FUNCTION                               |  |
|---------------|---------------|------------------|-----------------|--|---------------------|--|--|
|               |               |                  | RO              | [7]  | PROX_INT_FLG        | Proximity Interrupt Flag               |  |
|               |               |                  |                 |  | [1]                 |  | Proximity Interrupt Event  |
|               |               |                  |                 |  | [0]                 |  | No Proximity Interrupt Event                                     |
|               |               |                  | RW              | [6:5]  | PROX_PRST           |  | Proximity Interrupt Reporting Persistency                        |
|               |               |                  |                 |  | [00]                |  | $\overline{\text{INT}}$ after 1 Proximity Flag Event             |
|               |               |                  |                 |  | [01]                |  | $\overline{\text{INT}}$ after 2 Consecutive Proximity Flag Event |
|               |               |                  |                 |  | [10]                |  | $\overline{\text{INT}}$ after 4 Consecutive Proximity Flag Event |
|               |               |                  |                 |  | [11]                |  | $\overline{\text{INT}}$ after 8 Consecutive Proximity Flag Event |
|               |               |                  | RO              | [4]  | PWR_FAIL            |  | Power Failure (Brown-out) Alarm                                  |
|               |               |                  |                 |  | [1]                 |  | Brown-Out Detected   |
|               |               |                  |                 |  | [0]                 |  | Normal Operation   |
|               |               |                  | RO              | [3]  | ALS_INT_FLG         |  | Ambient Light Sensor Interrupt Flag                              |
|               |               |                  |                 |  | [1]                 |  | ALS Interrupt Flag Event   |
|               |               |                  |                 |  | [0]                 |  | No ALS Interrupt Flag Event                                      |
|               |               |                  | RW              | [2:1]  | ALS_INT_PRST        |  | ALS Interrupt Reporting Persistency                              |
|               |               | [00]             |                 | $\overline{\text{INT}}$ after 1 ALS Flag Event             |                     |  |  |
|               |               | [01]             |                 | $\overline{\text{INT}}$ after 2 Consecutive ALS Flag Event |                     |  |  |
|               |               | [10]             |                 | $\overline{\text{INT}}$ after 4 Consecutive ALS Flag Event |                     |  |  |
|               |               | [11]             |                 | $\overline{\text{INT}}$ after 8 Consecutive ALS Flag Event |                     |  |  |
| RW            | [0]           | INT_CFG          |                 | Interrupt Output (Pin) Configuration                       |                     |  |  |
|               |               | [1]              |                 | Interrupt if ALS and PROX Event                            |                     |  |  |
|               |               | [0]              |                 | Interrupt if ALS or PROX Event                             |                     |  |  |
| 0x05          | PROX_INT_TL   | 0x00             | RW              | [7:0]  | PROX_INT_TL         | Proximity Interrupt LOW threshold      |  |
| 0x06          | PROX_INT_TH   | 0xFF             | RW              | [7:0]  | PROX_INT_TH         | Proximity Interrupt HIGH threshold     |  |
| 0x07          | ALS_INT_TL    | 0x00             | RW              | [7:0]  | ALS_INT_TL1         | ALS Interrupt LOW threshold bit[11:4]  |  |
| 0x08          | ALS_INT_TLH   | 0x0F             | RW              | [7:0]  |                     | ALS Interrupt LOW/HIGH threshold bits  |  |
|               |               |                  |                 | [7:4]  | ALS_INT_TL0         | ALS Interrupt LOW threshold bit[3:0]   |  |
|               |               |                  |                 | [3:0]  | ALS_INT_TH1         | ALS Interrupt HIGH threshold bit[11:8] |  |
| 0x09          | ALS_INT_TH    | 0xFF             | RW              | [7:0]  | ALS_INT_TH0         | ALS Interrupt HIGH threshold bit[7:0]  |  |
| 0x0A          | PROX_DATA     |                  | RO              | [7:0]  | PROX_DATA           | Proximity Data (Unsigned Binary)       |  |
| 0x0B          | ALS_DATA_HB   |                  | RO              | [7:0]  | ALS_DATA_HB         | ALS Data HIGH Byte                     |  |
|               |               |                  |                 | [7:4]  |                     | Set to 0000                            |  |
|               |               |                  |                 | [3:0]  |                     | ALS Data Bit[11:8]                     |  |
| 0x0C          | ALS_DATA_LB   |                  | RO              | [7:0]  | ALS_DATA_LB         | ALS Data Bit[7:0]                      |  |
| 0x0D          | PROX_AMBIR    |                  | RO              | [7:0]  | PROX_AMBIR          | Proximity Mode Ambient IR Measurement  |  |
|               |               |                  |                 | [7:1]  |                     | Proximity Mode Ambient IR Component    |  |
|               |               |                  | RO              | [0]  | PROX_WASH           | Proximity Washout Status               |  |
|               |               |                  |                 | [1]  |                     | Proximity Washout Detected             |  |
|               |               |                  |                 | [0]  |                     | Normal Proximity Operation             |  |
| 0x0E          | Config3       | 0x00             |                 | [7:0]  | SoftReset           | Software Reset                         |  |
|               |               |                  |                 |  | 0x38                | Initiate Soft Reset                    |  |
|               |               |                  |                 |  | 0x00                | Normal operation                       |  |

Registers 0x01 and 0x02 are used to configure the primary proximity and ALS parameters. Register 0x03 is used for optimizing IR compensation in ALS measurements. A procedure to optimize IR compensation is described in [“ALS IR Compensation” on page 11](#).

Register 0x04 is the Interrupt Configuration and Status Register, they are used primarily to indicate interrupt events from proximity and ALS measurements. A PWR\_FAIL bit to indicate a ‘Brown-Out’ event is available and is set in case of a power supply interruption. A ‘Brown-Out’ event does not generate a hardware interrupt. The host microcontroller must clear this bit by writing a ‘0’ to Reg 0x04[4].

Register 0x04 is also used to configure ALS and Proximity interrupt persistency and the operation of the  $\overline{\text{INT}}$  pin.

Registers 0x05 and 0x06 are used to set the proximity ‘LOW’ and ‘HIGH’ threshold for proximity interrupt event generation.

Registers 0x07, 0x08 and 0x09 are used to set the ALS ‘LOW’ and ‘HIGH’ threshold. Two 12-bit numbers span three address locations as shown in [Table 1](#).

Data registers 0x0A holds result of proximity conversion. The proximity result should be validated by ‘Washout’ bit in Reg 0x0D[0]. Registers 0x0B and 0x0C holds result of an ALS measurement.

The ALS data is 12 bits wide. Least Significant Byte of the ALS data is available at address 0x0C and Most Significant Byte (MSB) of ALS data is available at address 0x0B. The MSB is right justified, i.e., the upper nibble is always zero and lower nibble contains four data bits.

Register 0x0D[7:1] contains ambient IR measurement in proximity measurement phase. This measurement is for detecting ambient Wash out condition, which is indicated by Reg 0x0D[0] being ‘HIGH’. Proximity ‘Washout’ is described in [“Proximity Ambient Washout Detection” on page 11](#).

A software reset can be initiated by writing 0x38 to Register 0x0E.

## ISL29147 Operation

### Photodiodes and ADCs

The ISL29147 contains two photodiode arrays, which convert photons (light) into current. The ALS photodiodes are designed to mimic the human eye’s wavelength response curve to visible light. The ALS photodiodes’ current output is digitized by a 12-bit ADC.

The ALS ADC output is accessed by reading from Reg 0x0B and 0x0C when the ADC conversion is completed.

The ALS ADC converter uses a charge-balancing architecture. Charge-balancing is best suited for converting small current signals in the presence of periodic AC noise. The ISL29147 targets an integration time of 90ms, which can vary  $\pm 15\%$  from nominal. The ALS integration time is intended to minimize 60Hz flicker.

The proximity sensor uses an 8-bit ADC, which operates in a similar fashion. The IRDR pin drives (pulses) an infrared LED, the emitted IR reflects off an object back into the ISL29147, and the photo diodes convert the reflected IR to a current signal in 0.5ms. The ADC subtracts the IR reading before and after the LED is driven to remove ambient IR contribution.

The ALS runs continuously with new data available every 90ms. The proximity sensor runs continuously with a time between conversions controlled by PROX\_SLP (Reg 0x01[6:4]).

### Ambient Light Sensing

The ISL29147 is set for ambient light sensing when Register bit ALS\_EN = 1. Four measurement ranges from 56.25 Lux to 1800 Lux are available. The ALS measurement range is configured via Reg 0x02[1:0].

### Proximity Sensing

When proximity sensing is enabled (PROX\_EN = 1), the external IR LED is driven for 90 $\mu$ s by the built-in IR LED driver through the IRDR pin.

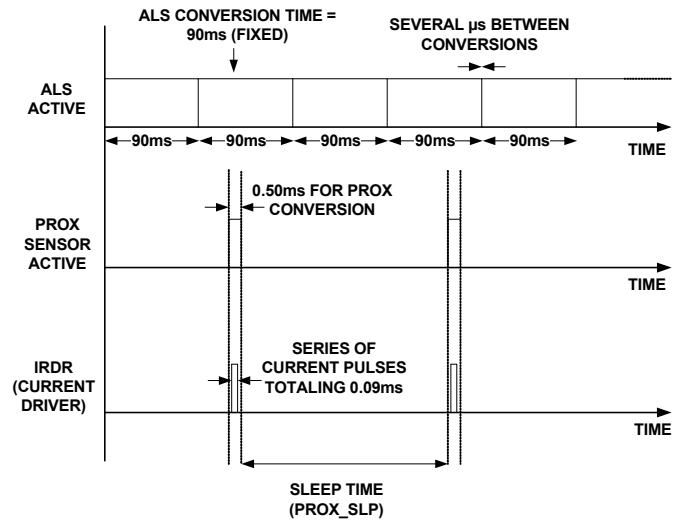


FIGURE 9. TIMING DIAGRAM FOR PROX/ALS EVENTS - NOT TO SCALE

The IR LED current depends on PROX\_DRV (Reg 0x01[1:0]). Drive current settings are as shown in [Table 1](#). The IR LED drive is in high impedance state when not active.

When the IR from the LED reaches an object and gets reflected back to the ISL29147, the reflected IR light is converted into a current. This current is converted to digital data using an 8-bit ADC. The proximity measurement takes 0.5ms for one conversion including the 90 $\mu$ s LED drive time. The period between proximity measurements is determined by PROX\_SLP (sleep time) in Reg 0x01[4:2].

Average LED driving current consumption is given by [Equation 1](#).

$$I_{\text{IRDR:AVE}} = \frac{I_{\text{IRDR:PEAK}} \times 90\mu\text{s}}{T_{\text{SLEEP}}} \quad (\text{EQ. 1})$$

A typical IRDR scheme is 250mA pulses every 400ms, averaging about 56 $\mu$ A DC.

## Total Current Consumption

Total current consumption is the sum of  $I_{DD}$  and  $I_{RDR}$ . The IRDR pin sinks current and the average IRDR current is calculated by using [Equation 1](#). The  $I_{DD}$  depends on voltage and the mode of operation. For simplicity, [Equation 1](#) ignores proximity ADC conversion time since it is much smaller than the sleep time.

## ALS IR Compensation

The ISL29147 is designed for operation under dark glass cover. Glass or plastic covers can significantly attenuate visible light and pass the Infrared light without much attenuation.

Consequently, the ISL29147 under a glass cover experiences an IR rich environment.

The on-chip ALS passive optical filter on the ISL29147 is designed to block most of the IR incident on the ALS photo diodes. In addition, the ISL29147 provides a programmable active IR compensation that subtracts residual IR still reaching the sensor.

The ALS\_IR\_COMP register (Reg 0x03[4:0]) allows fine tuning of the residual infrared component from the ALS output.

The recommended procedure for determining ALS IR compensation is as follows:

- Illuminate the ISL29147 based product with a light source without IR, such as a white LED. Record the ALS measurement and the Lux level.
- Illuminate the device with an IR LED and the White LED. Take an ALS measurement and Lux level measurement.
- Adjust the ALS\_IR\_COMP register (Reg 0x03, bits 4:0) to compensate for the IR contribution.
- Repeat steps above until the IR light source contribution to the ALS measurement is under 10 percent assuming no change in Lux level due to IR light source.

## Proximity Offset

Systems built with a protective glass cover over the ISL29147 can provide light 'leakage' or 'crosstalk' from the IR LED by reflection from the glass saturating the proximity sensor measurement system ([Figure 10](#)).

Saturation can occur when the reflection from the glass with no object in the proximity detection space exceeds the full scale of the measurement system. The ISL29147 proximity system provides a user programmable proximity offset correction to compensate for this reflection.

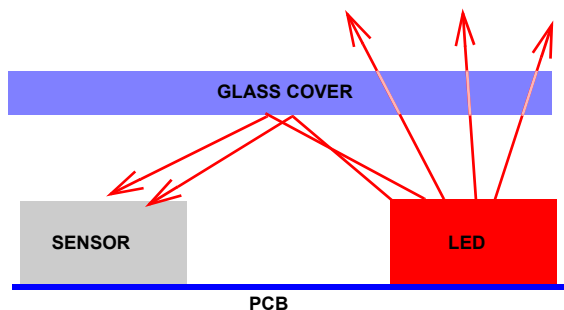


FIGURE 10. PROXIMITY SET-UP HIGHLIGHTING CROSSTALK REFLECTED FROM COVER GLASS

The PROX\_IR\_COMP register (Reg 0x02[6:3]) applies a corrective offset to the received signal prior to ADC conversion, which allows the signal to be brought within the usable range of the proximity measurement system.

## Proximity Ambient Washout Detection

Optical proximity sensor can saturate when illuminated with excessive ambient light. The ISL29147 provides a warning flag when the proximity measurement may be erroneous due to excessive ambient light. The PROX\_WASH register (Reg 0x0D[0]) reports this condition.

## Interrupts Events

The ISL29147 interrupts are designed to minimize host micro-controller overhead of continuous polling. The ISL29147 can generate interrupts on the results of an ALS measurement or proximity measurement.

The ALS interrupt event ALS\_FLAG (Reg 0x04[3]) is governed by Reg 0x07 through Reg 0x09. Two 12-bit high and low threshold values are written to these registers. The ISL29147 will set the ALS interrupt flag, if the ADC conversion count in Registers 0x0B and 0x0C are outside the programmed thresholds. The ALS\_FLAG is cleared by writing a '0' to Reg 0x04[3].

A proximity interrupt event (PROX\_FLAG) is governed by the high and low thresholds in Reg 0x05 and Reg 0x06 (PROX\_LT and PROX\_HT) are indicated by Reg 0x04[7]. PROX\_FLAG is set when the measured proximity data is more than the higher threshold. The proximity interrupt flag is cleared when the proximity data is lower than the low proximity threshold or by writing a '0' to Reg 0x04[7].

The Proximity interrupt generation can be selected between 'out-of-window' threshold and hysteresis schemes. When the PROX\_INT\_ALG register (Reg 0x02, Bit 7) is set to 0, proximity uses a hysteresis scheme; when set to 1, proximity uses a window comparator scheme.

In hysteresis mode, the interrupt event is generated if the proximity ADC count is higher than the PROX\_HT threshold and the interrupt event is cleared when the proximity ADC count is less than the PROX\_LT threshold. The interrupt event flag can also be cleared by writing a '0' to Reg 0x04[7].

## INTERRUPT PERSISTENCE

To minimize interrupt events due to 'transient' conditions, an interrupt persistency option is available for both ALS and proximity measurements. Persistency requires 'X-consecutive' interrupt flags before the INT pin is driven low. Both ALS and PROX have their own independent interrupt persistency options. ALS\_PRST and PROX\_PRST configuration are controlled from Reg 0x04.

## Power-Up and 'Brown-Out' Reset

The ISL29147 has an enhanced power-on-reset system. A 'Brown-Out' detector flag in Reg 0x04[4] informs the system that the device has powered-up properly. This flag should be reset as part of the initialization sequence.

A 'Brown-Out' condition is defined as an operating condition when the power supply voltage is not within the specified limits. To prevent this condition we recommend the power supply slew rate to be greater than 0.5 V/ms.

During the brown-out period at power-up, the I<sup>2</sup>C interface and the IR LED driver are inactive. Following brown-out, the I<sup>2</sup>C interface is reinitialized and the configuration registers are set to power-up default values. After power-up and during device initialization, host should examine that the PWR\_FAIL flag (Reg 0x04[4]) is set and then clear the flag by writing '0' to Reg 0x04[4].

Following power-up, a 'Brown-Out' condition, if detected, is reported by PWR\_FAIL flag by Reg 0x04[4]. Device configuration registers are not set to their power-up default after 'Brown-Out'. PWR\_FAIL flag should be periodically monitored to detect post power-up power supply interruption.

## Power-Down

Setting ALS\_EN (Reg 0x02[2]) and PROX\_EN (Reg 0x01[5]) to '0' puts the ISL29147 into a power-down state with power supply current dropping to less than 1 $\mu$ A. All configuration registers are maintained in power-down mode.

## Soft Reset

A software reset to ISL29147 can be initiated by writing 0x38 to Reg 0x0E. Following reset, all configuration registers are set to their default power-up state. After soft reset, the ISL29147 defaults to the power-down configuration.

## ALS Data Count Read Out

A two byte I<sup>2</sup>C read from ALS\_DATA\_HB outputs MSB 1<sup>st</sup> data on SDA. This data is LSB justified with a zero fill for unused bits.

NOTE: The MSB byte address precedes the LSB byte address. The ALS count is 256\*(ALS\_DATA\_HB) + ALS\_DATA\_LB.

## Proximity Detection of Various Objects

The Proximity sensing relies on the amount of IR reflected back from objects. A perfect black object would absorb all incident light and reflect no photons. The ISL29147 is sensitive enough to detect black ESD foam, which reflects only 1% of IR. Blonde hair typically reflects more than brown hair and skin tissue is more reflective than human hair.

IR penetrates into the skin and is reflected from within. As a result, the proximity count generally peaks at contact and monotonically decreases as skin moves away. The reflective characteristics of skin are very different from that of an inanimate object such as paper.

## Typical Application Circuit

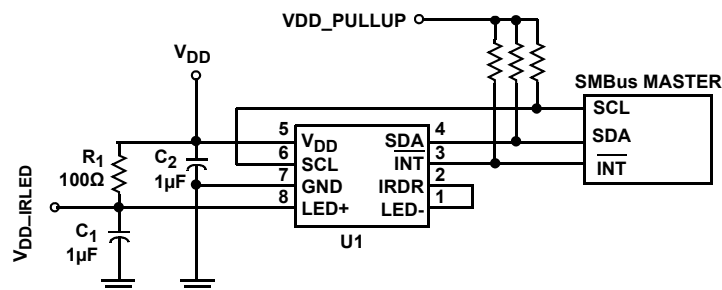
A typical application circuit for the ISL29147 is shown in Figure 11. The ISL29147's I<sup>2</sup>C address is internally hard wired as '1000100x', with x representing the R/W bit. The device can be connected to a system's I<sup>2</sup>C bus together with other I<sup>2</sup>C compliant devices. It is important to ensure that there is no address conflict with other I<sup>2</sup>C devices on the bus.

The SCL, SDA and  $\overline{\text{INT}}$  pins on the ISL29147 are open drain and require pull-up resistors for proper system operation. Values of the pull-up resistors is system dependent and can range from 2.2k to 10k depending upon the number of I<sup>2</sup>C devices on the bus.

The proximity sensing system can be powered using a dual power supply or using a single power supply. In dual supply configuration, the IR LED and the ISL29147 are powered from separate power supplies. The V<sub>DD</sub> IRLED can range from 2.25V to 5.0V and the V<sub>DD</sub> can range from 2.25V to 3.63V. In dual supply configuration, resistor R<sub>1</sub> should not be installed.

In single supply configuration, the IR LED and the ISL29147 are powered from the same power source. The V<sub>DD</sub> IRLED can range from 2.25V to 3.63V and the V<sub>DD</sub> is derived from V<sub>DD</sub> IRLED using resistor R<sub>1</sub>.

In either power supply configuration, a 1 $\mu$ F decoupling capacitor should be installed close to the VDD pin, and another 1 $\mu$ F decoupling capacitor should be placed close to the IR LED anode.



R<sub>1</sub>: 100 $\Omega$  5% RESISTOR  
C<sub>1</sub>, C<sub>2</sub>: 1 $\mu$ F CERAMIC 10V CAPACITOR  
FIGURE 11. TYPICAL APPLICATIONS CIRCUIT

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## Soldering Considerations

Convection heating is recommended for reflow soldering; direct-infrared heating is not recommended. The plastic optical co-package does not require a custom reflow soldering profile. A standard reflow soldering profile with a +260 °C maximum is recommended. Additional information regarding soldering the ISL29147 is included in Intersil Technical Brief [TB493](#).

## PCB Layout Considerations

The ISL29147 is relatively insensitive to PCB layout. Adherence to the following guidelines will ensure first pass success and best performance.

Route the I<sup>2</sup>C/SMBus SCL, SDA and the  $\overline{\text{INT}}$  traces away from sources of switching noise.

The ISL29147 pin GND should connect to a low impedance ground with low resistance and low inductance traces. Ferrite beads and inductors should be avoided in the ground path. If necessary, due to RF consideration, the effects of DCR (DC resistance) should be evaluated on ALS and Proximity system performance.

A 1 $\mu$ F ceramic decoupling capacitor should be placed as close to VDD pin as possible.

The ISL29147 drives the IR LED with 0.09ms current pulses. To supply this pulsed current, a 1 to 10 $\mu$ F bulk decoupling capacitor (C<sub>1</sub>) must be connected from the IR LED anode to the GND pin to minimize instantaneous resistive voltage drop. The connection from IR LED cathode to the IRDR pin should be short and with minimal inductance. Similarly, connection from IR LED anode to VDD\_IRLED must be made with a low impedance trace.

For most applications, a single power supply may be used to power the IR LED and the ISL29147. Use of resistor R<sub>1</sub> and capacitor C<sub>2</sub> ([Figure 11](#)) to help filter out the power supply noise generated from IR LED switching, is recommended for best ISL29147 performance when using a single power supply. For dual supply operation, resistor R<sub>1</sub> should not be installed.

## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest revision.

| DATE               | REVISION | CHANGE   |
|--------------------|----------|--|
| January 06, 2015   | FN8409.3 | Ordering information table on page 2: Corrected typo from ISL29147IROMZ-T7 to ISL29147IROMZ-T7 (changed from zero to letter "O")                   |
| January 14, 2014   | FN8409.2 | Updated POD L8.2.40x4 - from rev 4 to rev 5 - changes from rev 4: top view re-drawn - changed from round to oval detector and added dimensions.    |
| December 9, 2013   | FN8409.1 | Updated POD L8.2.40x4 - Bottom View changed Pin 1 Index Mark from Pin 1 index mark to Pin 4 index area. Updated Note 4 to show correct Pin number. |
| September 16, 2013 | FN8409.0 | Initial Release.   |

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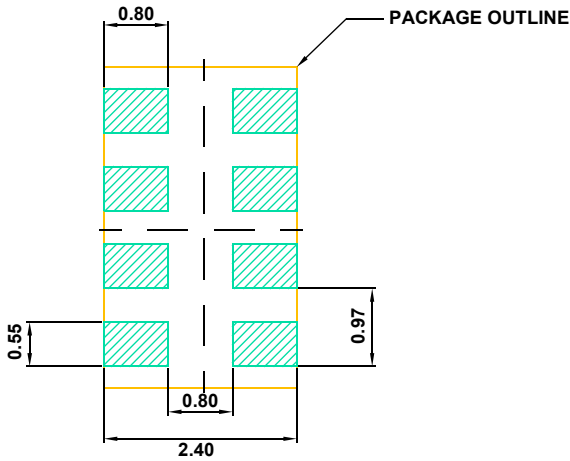
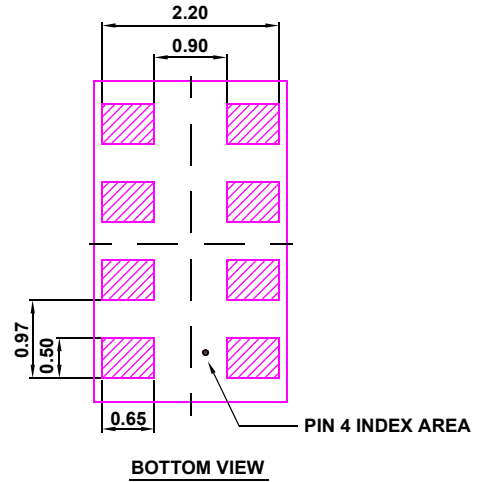
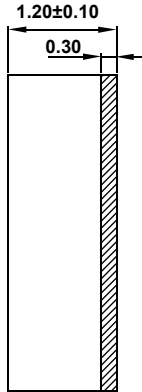
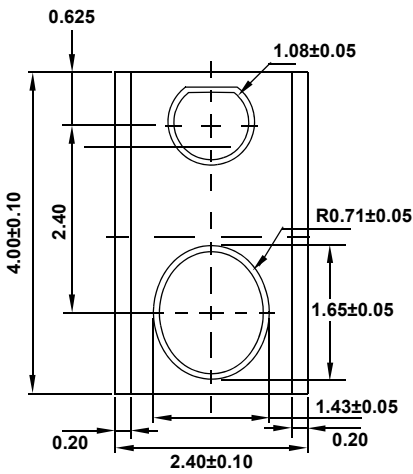
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# Package Outline Drawing

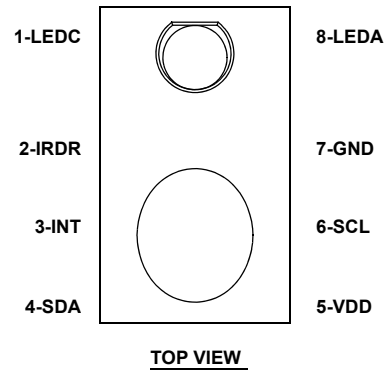
## L8.2.40x4

8 LEAD OPTICAL CO-PACKAGE

Rev 5, 12/13



**TYPICAL RECOMMENDED LAND PATTERN**



**NOTES:**

1. Dimensions are in millimeters.  
Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to ASME Y14.5m-1994.
3. Unless otherwise specified, tolerance: Decimal ± 0.05
4. Pin #4 identifier is a laser-etched dot on bottom surface.



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