

# Integrated Digital Light Sensor

## ISL29034

The ISL29034 is an integrated ambient and infrared light-to-digital converter with I<sup>2</sup>C (SMBus Compatible) Interface. Its advanced self-calibrated photodiode array emulates human eye response with excellent IR rejection. The on-chip ADC is capable of rejecting 50Hz and 60Hz flicker caused by artificial light sources. The Lux range select feature allows users to program the Lux range for optimized counts/Lux.

For ambient light sensing, an internal 16-bit ADC has been designed based upon the charge-balancing technique. The ADC conversion time is nominally 105ms and is user selectable from 11μs to 105ms, depending on oscillator frequency and ADC resolution. In normal operation, typical current consumption is 57μA. In order to further minimize power consumption, two power-down modes have been provided. If polling is chosen over continuous measurement of light, the auto-power-down function shuts down the whole chip after each ADC conversion for the measurement. The other power-down mode is controlled by software via the I<sup>2</sup>C interface. The power consumption can be reduced to less than 0.3μA when powered down.

The ISL29034 supports a software brownout condition detection. The device powers up with the brownout bit asserted until the host clears it through the I<sup>2</sup>C interface. Designed to operate on supplies from 2.25V to 3.63V with an I<sup>2</sup>C supply from 1.7V to 3.63V, the ISL29034 is specified for operation over the -40°C to +85°C ambient temperature range.

## Features

- Resolution . . . . . 16-bits ADC
- Wide dynamic range1: . . . . . 4,200,000
- Integrated noise reduction . . . . . 50/60Hz
- Close to human eye response with excellent IR/UV rejection
- Shutdown modes. . . . . Software and Automatic
- Supply current (typ) . . . . . 57μA
- Shutdown current (max) . . . . . 0.51μA
- I<sup>2</sup>C (SMB compatible) power supply . . . . . 1.7V to 3.63V
- Sensor power supply . . . . . 2.25V to 3.63V
- Operating temperature range. . . . . -40°C to +85°C
- Small form factor package . . . . . 4 Ld 1.5x1.3x0.75 ODFN

## Applications

- Mobile devices: smart phone, PDA, GPS
- Computing devices: notebook PC, MacBook, tablets
- Consumer devices: LCD-TV, digital picture frame, digital camera
- Industrial and medical light sensing

## Related Literature

- [AN1591](#), "Evaluation Hardware/Software Manual for ALS and Proximity Sensor"

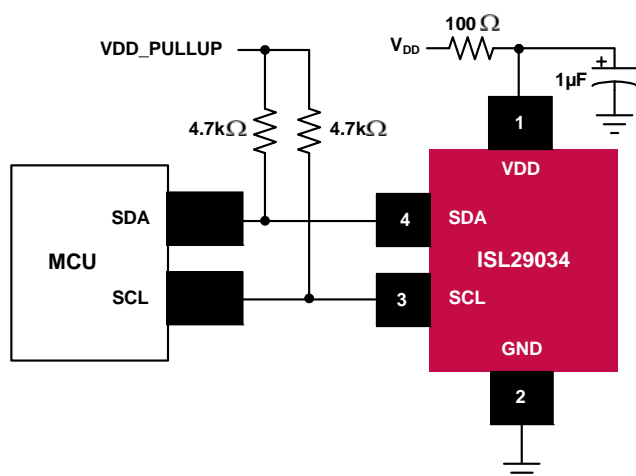


FIGURE 1. ISL29034 TYPICAL APPLICATION DIAGRAM

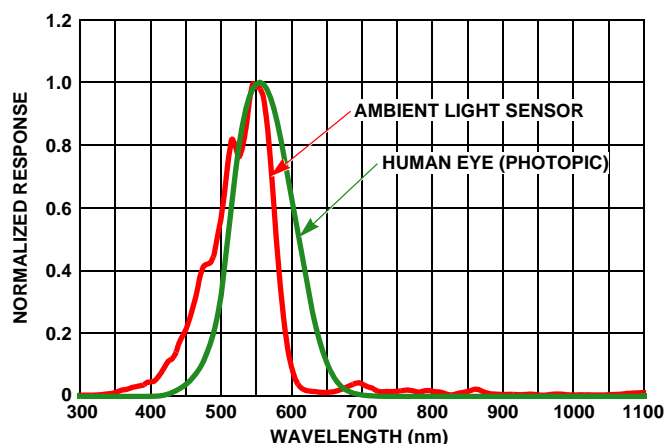
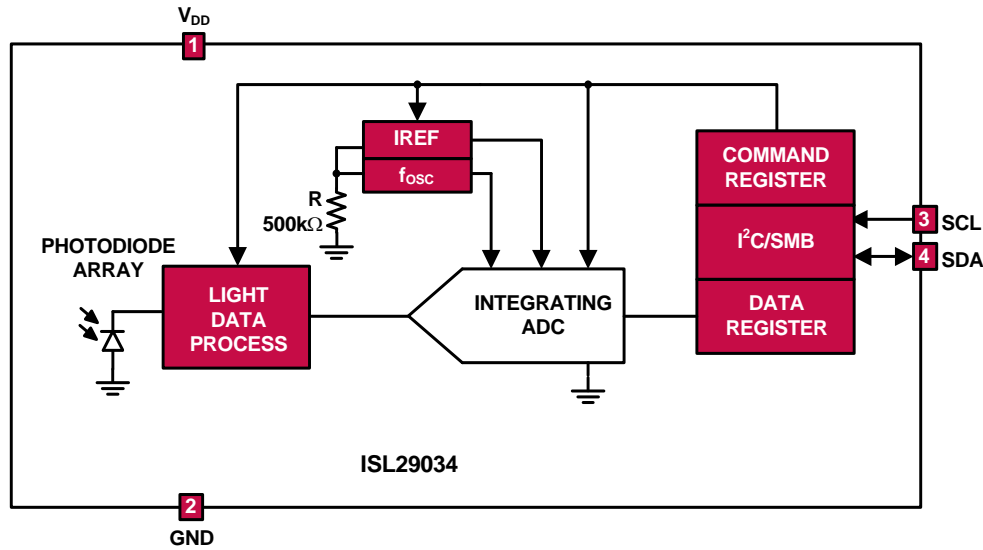


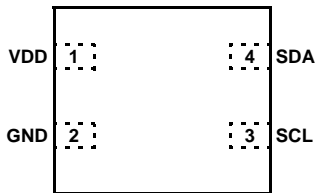
FIGURE 2. NORMALIZED SPECTRAL RESPONSE FOR AMBIENT LIGHT SENSING

## Block Diagram



## Pin Configuration

ISL29034  
(4 LD ODFN)  
TOP VIEW



## Pin Descriptions

| PIN NUMBER | PIN NAME | DESCRIPTION       |
|------------|----------|-------------------|
| 1          | VDD      | Positive supply   |
| 2          | GND      | Ground pin        |
| 3          | SCL      | I²C serial clock. |
| 4          | SDA      | I²C serial data.  |

## Ordering Information

| PART NUMBER<br>(Notes 2, 3) | TEMP RANGE<br>(°C) | PACKAGE<br>Tape & Reel<br>(RoHS Compliant) | PKG.<br>DWG. # |
|-----------------------------|--------------------|--|----------------|
| ISL29034IROZ-T7 (Note 1)    | -40 to +85         | 4 Ld ODFN                                  | L4.1.5x1.3     |
| ISL29034IROZ-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 device information page for [ISL29034](#). For more information on MSL please see tech brief [TB477](#).

# ISL29034

## Absolute Maximum Ratings

|   |               |
|---|---------------|
| VDD to GND                                  | +4.0V         |
| I <sup>2</sup> C Bus (SCL, SDA) Pin Voltage | -0.2V to 4.0V |
| I <sup>2</sup> C Bus (SCL, SDA) Pin Current | <10mA         |
| Input Voltage Slew Rate (Max)               | 0.1V/μs       |
| ESD Ratings                                 |               |
| Human Body Model                            | 3kV           |

## Thermal Information

|   |                           |
|---|---------------------------|
| Thermal Resistance (Typical)                      | θ <sub>JA</sub> (°C/W)    |
| 4 Ld ODFN Package (Note 4)                        | 287                       |
| Maximum Junction Temperature (T <sub>JMAX</sub> ) | +90°C                     |
| Storage Temperature Range                         | -40°C to +100°C           |
| Operating Temperature                             | 40°C to +85°C             |
| Pb-Free Reflow Profile                            | see <a href="#">TB493</a> |

**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.

### NOTE:

- θ<sub>JA</sub> is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief [TB379](#) for details.

## Electrical Specifications V<sub>DD</sub> = 3.0V, T<sub>A</sub> = +25°C, 16-bit ADC operation, unless otherwise specified.

| PARAMETER                   | DESCRIPTION   | TEST CONDITIONS   | MIN<br>(Note 7) | TYP   | MAX<br>(Note 7) | UNITS  |
|-----------------------------|---|---|-----------------|-------|-----------------|--------|
| V <sub>DD</sub>             | Power Supply Range                                  |   | 2.25            |       | 3.63            | V      |
| I <sub>DD</sub>             | Supply Current                                      |   |                 | 57    | 85              | μA     |
| I <sub>DD1</sub>            | Supply Current when Powered Down                    | Software disabled or auto power-down                              |                 | 0.24  | 0.51            | μA     |
| V <sub>I<sup>2</sup>C</sub> | Supply Voltage Range for I <sup>2</sup> C Interface |   | 1.7             |       | 3.63            | V      |
| t <sub>int</sub>            | ADC Integration/Conversion Time                     | 16-bit ADC data   |                 | 105   |                 | ms     |
| F <sub>I<sup>2</sup>C</sub> | I <sup>2</sup> C Clock Rate Range                   |   |                 | 400   |                 | kHz    |
| DATA_0                      | Count Output When Dark                              | E = 0 Lux, Range 0 (1k Lux)                                       |                 | 1     | 5               | Counts |
| DATA_F                      | Full Scale ADC Code                                 |   |                 |       | 65535           | Counts |
| %/Value                     | Part-to-Part Variation (3σ population)              | E = 300 Lux, Cold White LED<br>Range 0 (1k Lux)                   |                 | ±5    |                 | %      |
| ADC <sub>R0</sub>           | Light Count Output with LSB of 0.015 Lux/Count      | E = 300 Lux, Fluorescent light (Note 5),<br>ALS Range 0 (1k Lux)  | 15000           | 20473 | 25000           | Counts |
| ADC <sub>R1</sub>           | Light Count Output with LSB of 0.06 Lux/Count       | E = 300 Lux, Fluorescent light (Note 5),<br>ALS Range 1 (4k Lux)  |                 | 5100  |                 | Counts |
| ADC <sub>R2</sub>           | Light Count Output with LSB of 0.24 Lux/Count       | E = 300 Lux, Fluorescent light (Note 5),<br>ALS Range 2 (16k Lux) |                 | 1400  |                 | Counts |
| ADC <sub>R3</sub>           | Light Count Output with LSB of 0.96 Lux/Count       | E = 300 Lux, Fluorescent light (Note 5),<br>ALS Range 3 (64k Lux) |                 | 366   |                 | Counts |
| ADC_IR <sub>R0</sub>        | Infrared Count Output                               | Range 0 (1k Lux)  | 1402            | 1997  | 2598            |        |
| ADC_IR <sub>R1</sub>        | Infrared Count Output                               | Range 1 (4k Lux)  |                 | 481   |                 |        |
| ADC_IR <sub>R2</sub>        | Infrared Count Output                               | Range 2 (16k Lux)   |                 | 148   |                 |        |
| ADC_IR <sub>R3</sub>        | Infrared Count Output                               | Range 3 (64k Lux)   |                 | 42    |                 |        |
| I <sub>SDA</sub>            | SDA Current Sinking Capability                      |   | 4               | 5     |                 | mA     |

### NOTES:

- 550nm green LED is used in production test. The 550nm LED irradiance is calibrated to produce the same DATA count against an illuminance level of 300 Lux fluorescent light.
- 850nm IR LED is used in production test.
- Compliance to datasheet limits is assured by one or more methods: production test, characterization and/or design.

# ISL29034

## I<sup>2</sup>C Interface Specifications $V_{DD} = 3.0V$ , $T_A = +25^\circ C$ , 16-bit ADC operation, unless otherwise specified.

| SYMBOL                | PARAMETER  | TEST CONDITIONS   | MIN<br>(Note 7)       | TYP                  | MAX<br>(Note 7) | UNITS      |
|-----------------------|--|---|-----------------------|----------------------|-----------------|------------|
| $V_{IL}$              | SDA and SCL Input Buffer LOW Voltage                             |   |                       |                      | 0.55            | V          |
| $V_{IH}$              | SDA and SCL Input Buffer HIGH Voltage                            |   | 1.25                  |                      |                 | V          |
| $V_{Hys}$<br>(Note 8) | SDA and SCL Input Buffer Hysteresis                              |   |                       | $0.05 \times V_{DD}$ |                 | V          |
| $V_{OL}$<br>(Note 8)  | SDA Output Buffer LOW Voltage (open-drain), Sinking 4mA          |   | 0                     |                      | 0.4             | V          |
| $C_{PIN}$<br>(Note 8) | SDA and SCL Pin Capacitance                                      | $T_A = +25^\circ C$ , $f = 1MHz$ , $V_{DD} = 5V$ , $V_{IN} = 0V$ , $V_{OUT} = 0V$   |                       |                      | 10              | pF         |
| $f_{SCL}$             | SCL Frequency  |   |                       |                      | 400             | kHz        |
| $t_{IN}$              | Pulse Width Suppression Time at SDA and SCL Inputs               | Any pulse narrower than the max spec is suppressed  |                       |                      | 50              | ns         |
| $t_{AA}$              | SCL Falling Edge to SDA Output Data Valid                        |   |                       |                      | 900             | ns         |
| $t_{BUF}$             | Time the Bus Must be Free Before the Start of a New Transmission |   | 1300                  |                      |                 | ns         |
| $t_{LOW}$             | Clock LOW Time   |   | 1300                  |                      |                 | ns         |
| $t_{HIGH}$            | Clock HIGH Time  |   | 600                   |                      |                 | ns         |
| $t_{SU:STA}$          | START Condition Setup Time                                       |   | 600                   |                      |                 | ns         |
| $t_{HD:STA}$          | START Condition Hold Time  |   | 600                   |                      |                 | ns         |
| $t_{SU:DAT}$          | Input Data Setup Time  |   | 100                   |                      |                 | ns         |
| $t_{HD:DAT}$          | Input Data Hold Time   |   | 30                    |                      |                 | ns         |
| $t_{SU:STO}$          | STOP Condition Setup Time  |   | 600                   |                      |                 | ns         |
| $t_{HD:STO}$          | STOP Condition Hold Time   |   | 600                   |                      |                 | ns         |
| $t_{DH}$              | Output Data Hold Time  |   | 0                     |                      |                 | ns         |
| $t_R$<br>(Note 8)     | SDA and SCL Rise Time  |   | $20 + 0.1 \times C_b$ |                      |                 | ns         |
| $t_F$<br>(Note 8)     | SDA and SCL Fall Time  |   | $20 + 0.1 \times C_b$ |                      |                 | ns         |
| $C_b$<br>(Note 10)    | Capacitive Loading of SDA or SCL                                 | Total on-chip and off-chip  |                       |                      | 400             | pF         |
| $R_{PU}$<br>(Note 8)  | SDA and SCL Bus Pull-up Resistor Off-chip                        | Maximum is determined by $t_R$ and $t_F$ .<br>For $C_b = 400pF$ , max is about $2k\Omega \sim 2.5k\Omega$<br>For $C_b = 40pF$ , max is about $15k\Omega \sim 20k\Omega$ | 1                     |                      |                 | k $\Omega$ |

### NOTES:

8. Limits should be considered typical and are not production tested.
9. These are I<sup>2</sup>C specific parameters and are not tested, however, they are used to set conditions for testing devices to validate specification.
10.  $C_b$  is the capacitance of the bus in pF.

## SDA vs SCL Timing

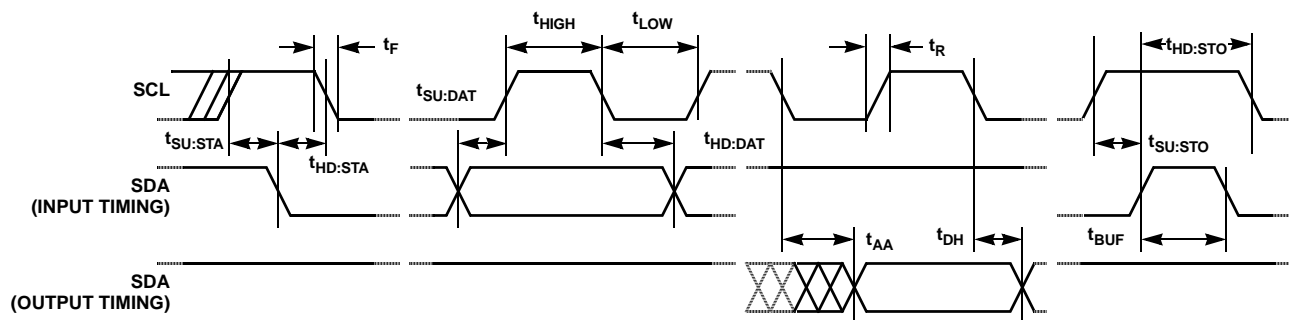


FIGURE 3. I<sup>2</sup>C BUS TIMING

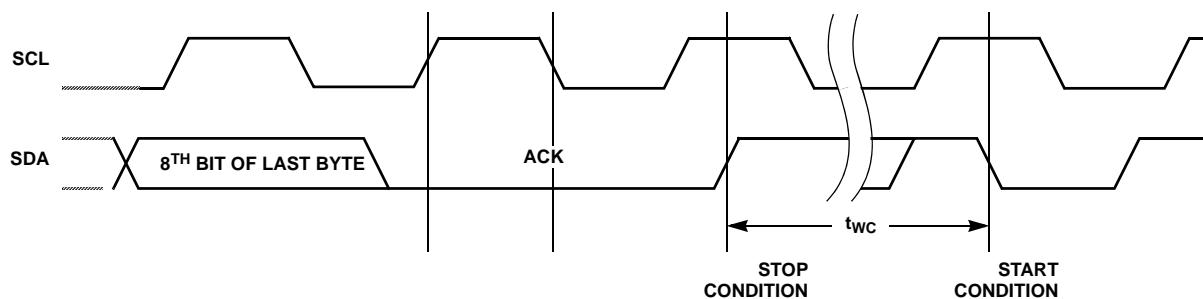


FIGURE 4. I<sup>2</sup>C WRITE CYCLE TIMING

## Typical Performance Curves

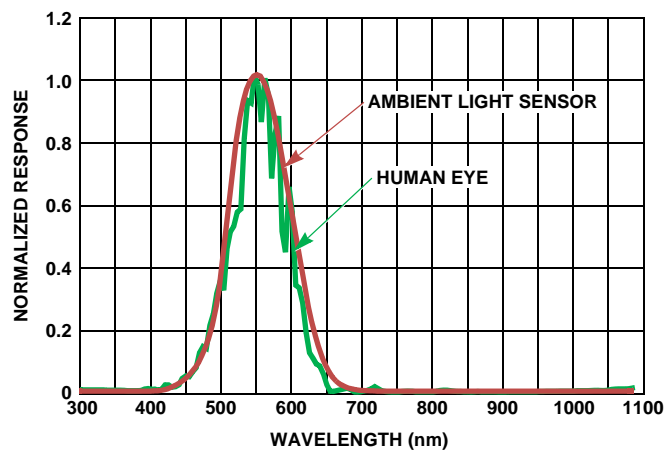


FIGURE 5. NORMALIZED SPECTRAL RESPONSE FOR AMBIENT LIGHT SENSING AND IR SENSING

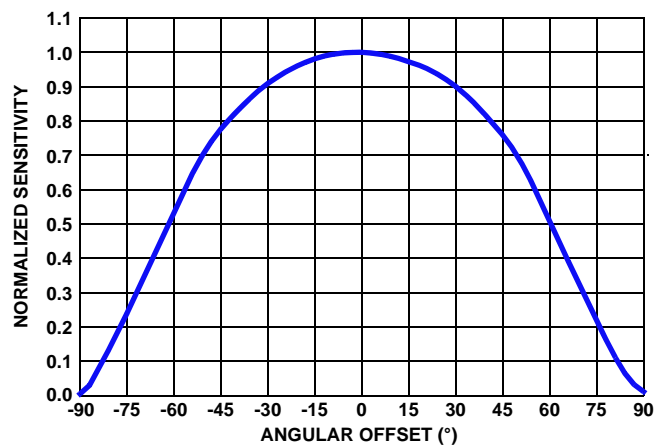


FIGURE 6. NORMALIZED RADIATION PATTERN

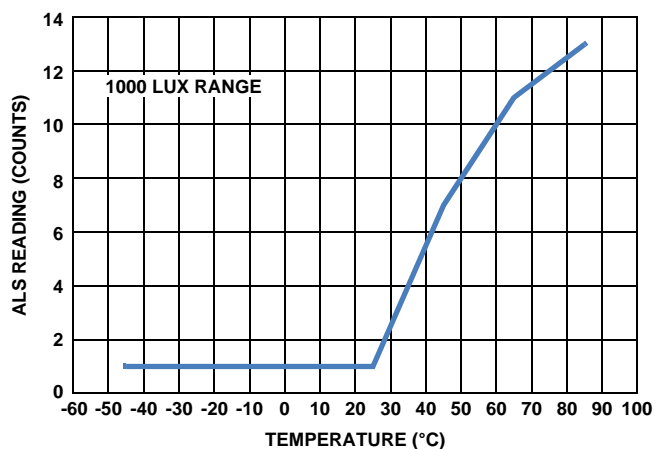


FIGURE 7. TEMPERATURE TEST IN DARK CONDITION

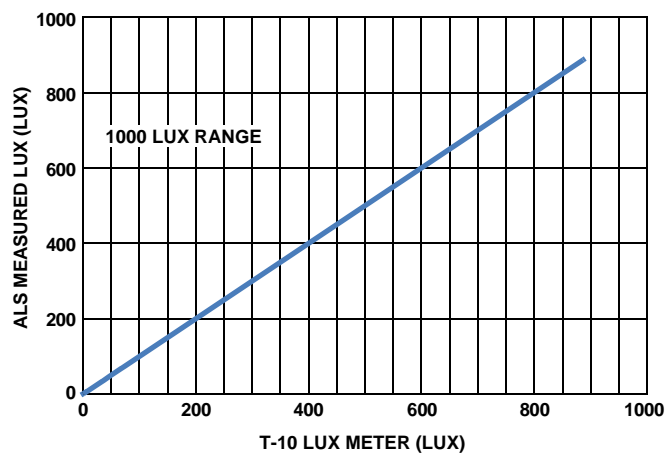


FIGURE 8. ALS TRANSFER FUNCTION UNDER F2 LIGHT SOURCE

## Principles of Operation

### Photodiodes and ADC

The ISL29034 contains two photodiode arrays, which convert light into current. A typical spectral response for ambient light sensing is shown in Figure 5 on page 6. After light is converted to current during the light signal process, the current output is converted to digital by a built-in 16-bit Analog-to-Digital Converter (ADC). An I<sup>2</sup>C command reads the ambient light intensity in counts.

The converter is a charge-balancing integrating type 16-bit ADC. The chosen method for conversion is best for converting small current signals in the presence of an AC periodic noise. A 105ms integration time, for instance, highly rejects 50Hz and 60Hz power line noise simultaneously.

The integration time of the built-in ADC is determined by the internal oscillator, and the n-bit (n = 4, 8, 12, 16) counter inside the ADC. A good balancing act of integration time and resolution (depending on the application) is required for optimal results.

The ADC has I<sup>2</sup>C programmable range select to dynamically accommodate various lighting conditions. For very dim conditions, the ADC can be configured at its lowest range (Range 0) in the ambient light sensing.

### Low-Power Operation

The ISL29034 initial operation is at the power-down mode after a supply voltage is provided. The data registers contain the default value at 0. When the ISL29034 receives an I<sup>2</sup>C command to do a one-time measurement from an I<sup>2</sup>C master, it will start the ADC conversion with light sensing. It will go to the power-down mode automatically after one conversion is finished and keep the conversion data available for the master to fetch anytime afterwards. The ISL29034 will continuously do ADC conversion with light sensing if it receives an I<sup>2</sup>C command of continuous measurement. It will continuously update the data registers with the latest conversion data. It will go to the power-down mode after it receives the I<sup>2</sup>C command of power-down.

### Ambient Light and IR Sensing

There are four operational modes in ISL29034: Programmable ALS once with auto power-down, programmable IR sensing once with auto power-down, programmable continuous ALS sensing and programmable continuous IR sensing. These four modes can be programmed in series to fulfill the application needs. The detailed program configuration is listed in "Command-I Register (Address: 0x00)" on page 10.

When the part is programmed for ambient light sensing, the ambient light with wavelength within the "Ambient Light Sensing" spectral response curve in Figure 14 is converted into current. With ADC, the current is converted to an unsigned n-bit (up to 16 bits) digital output.

When the part is programmed for infrared (IR) sensing, the IR light with wavelength within the "IR Sensing" spectral response curve in Figure 14 is converted into current. With ADC, the current is converted to an unsigned n-bit (up to 16-bits) digital output.

## Serial Interface

The ISL29034 supports the Inter-Integrated Circuit (I<sup>2</sup>C) bus data transmission protocol. The I<sup>2</sup>C bus is a two-wire serial bidirectional interface consisting of SCL (clock) and SDA (data). Both the wires are connected to the device supply via pull-up resistors. The I<sup>2</sup>C protocol defines any device that sends data onto the bus as a transmitter and the receiving device as the receiver. The device controlling the transfer is a master and the device being controlled is the slave. The transmitting device pulls down the SDA line to transmit a "0" and releases it to transmit a "1". The master always initiates the data transfer, only when the bus is not busy, and provides the clock for both transmit and receive operations. The ISL29034 operates as a slave device in all applications. The serial communication over the I<sup>2</sup>C interface is conducted by sending the most significant bit (MSB) of each byte of data first.

### Start Condition

During data transfer, the SDA line must remain stable while the SCL line is HIGH. All I<sup>2</sup>C interface operations must begin with a START condition, which is a HIGH-to-LOW transition of SDA while SCL is HIGH (refer to Figure 11). The ISL29034 continuously monitors the SDA and SCL lines for the START condition and does not respond to any command until this condition is met (refer to Figure 11). A START condition is ignored during the power-up sequence.

### Stop Condition

All I<sup>2</sup>C interface operations must be terminated by a STOP condition, which is a LOW-to-HIGH transition of SDA while SCL is HIGH (refer to Figure 11). A STOP condition at the end of a read/write operation places the device in its standby mode. If a stop is issued in the middle of a Data byte, or before 1 full Data byte + ACK is sent, then the serial communication of the ISL29034 resets itself without performing the read/write. The contents of the array are not affected.

### Acknowledge

An acknowledge (ACK) is a software convention used to indicate a successful data transfer. The transmitting device releases the SDA bus after transmitting 8-bits. During the ninth clock cycle, the receiver pulls the SDA line LOW to acknowledge the reception of the eight bits of data (refer to Figure 11). The ISL29034 responds with an ACK after recognition of a START condition followed by a valid Identification Byte, and once again, after successful receipt of an Address Byte. The ISL29034 also responds with an ACK after receiving a Data byte of a write operation. The master must respond with an ACK after receiving a Data byte of a read operation.

### Device Addressing

Following a START condition, the master must output a Device Address byte. The 7 MSBs of the Device Address byte are known as the device identifier. The device identifier bits of the ISL29034 are internally hard-wired as "1000100". The LSB of the Device Address byte is defined as a read or write (R/ $\overline{W}$ ) bit. When this R/ $\overline{W}$  bit is a "1", a read operation is selected and when "0", a write operation is selected (refer to Figure 9). The master generates a START condition followed by Device Address byte 1000100x (x as R/ $\overline{W}$ ) and the ISL29034 compares it with the internal device identifier. Upon a correct comparison, the device outputs an acknowledge

(LOW) on the SDA line (refer to Figure 11).

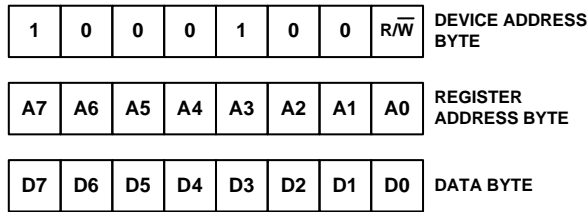


FIGURE 9. DEVICE ADDRESS, REGISTER ADDRESS, AND DATA BYTE

## Write Operation

### BYTE WRITE

In a byte write operation, the ISL29034 requires the Device Address byte, Register Address byte, and the Data byte. The master starts the communication with a START condition. Upon receipt of the Device Address byte, Register Address byte, and the Data byte, the ISL29034 responds with an acknowledge (ACK). Following the ISL29034 data acknowledge response, the master terminates the transfer by generating a STOP condition.

The ISL29034 then begins an internal write cycle of the data to the volatile memory. During the internal write cycle, the device inputs are disabled and the SDA line is in a high impedance state, so the device will not respond to any requests from the master (refer to Figure 10).

### BURST WRITE

The ISL29034 has a burst write operation, which allows the master to write multiple consecutive bytes from a specific address location. It is initiated in the same manner as the byte write operation, but instead of terminating the write cycle after the first Data byte is transferred, the master can write to the whole register array. After the receipt of each byte, the ISL29034 responds with an acknowledge, and the address is internally incremented by one. The address pointer remains at the last address byte written. When the counter reaches the end of the register address list, it "rolls over" and goes back to the first Register Address.

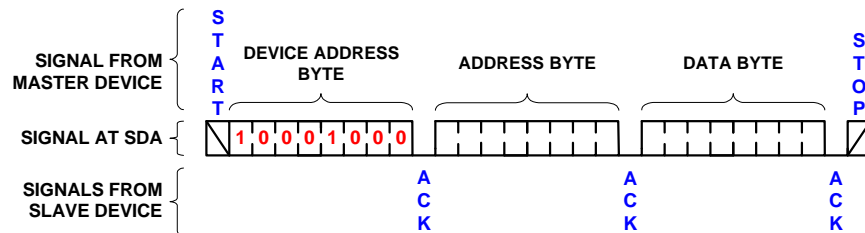


FIGURE 10. BYTE WRITE SEQUENCE

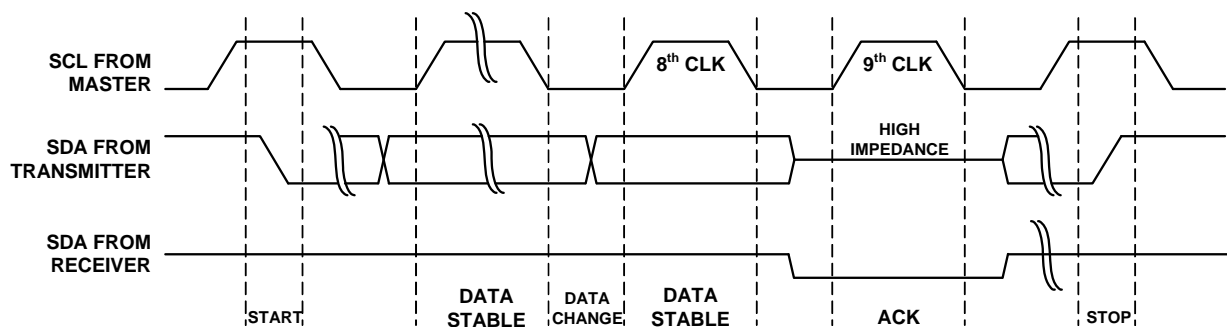


FIGURE 11. START, DATA STABLE, ACKNOWLEDGE, AND STOP CONDITION



## Read Operation

The ISL29034 has two basic read operations: Byte Read and Burst Read.

### BYTE READ

Byte read operations allow the master to access any register location in the ISL29034. The Byte read operation is a two step process. The master issues the START condition, and the Device Address byte with the R/W bit set to "0", receives an acknowledge, then issues the Register Address byte. After acknowledging receipt of the register address byte, the master immediately issues another START condition and the Device Address byte with the R/W bit set to "1". This is followed by an acknowledge from the device and then by the 8-bit data word. The master terminates the read operation by not responding with an acknowledge and then issuing a stop condition (refer to Figure 12).

### BURST READ

Burst read operation is identical to the Byte Read operation. After the first Data byte is transmitted, the master now responds with an acknowledge, indicating it requires additional data. The device continues to output data for each acknowledge received.

The master terminates the read operation by not responding with an acknowledge but issuing a STOP condition (refer to Figure 13).

For more information about the I<sup>2</sup>C standard, please consult the Phillips™ I<sup>2</sup>C specification documents.

## Power-On Reset

The Power-On Reset (POR) circuitry protects the internal logic against powering up in the incorrect state. The ISL29034 will power-up into Standby mode after V<sub>DD</sub> exceeds the POR trigger level and will power-down into Reset mode when V<sub>DD</sub> drops below the POR trigger level. This bidirectional POR feature protects the device against 'brown-out' failure following a temporary loss of power.

The POR is an important feature because it prevents the ISL29034 from starting to operate with insufficient voltage, prior to stabilization of the internal bandgap. The ISL29034 prevents communication to its registers and greatly reduces the likelihood of data corruption on power-up.

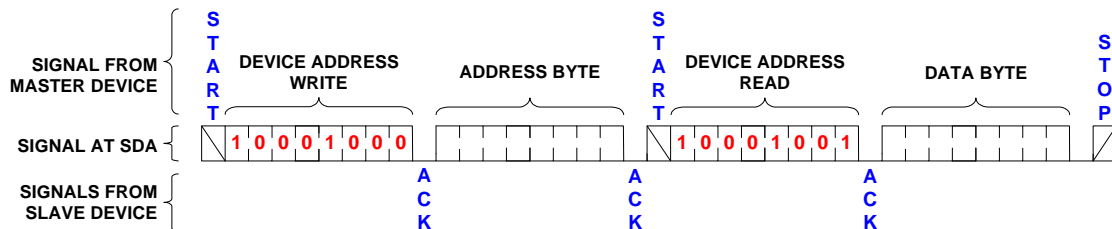


FIGURE 12. BYTE ADDRESS READ SEQUENCE

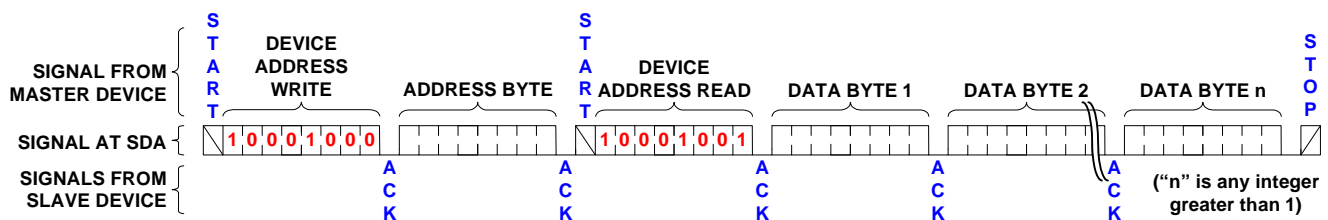


FIGURE 13. BURST READ SEQUENCE

TABLE 1. REGISTER MAP

| NAME                | REGISTER ADDRESS |      | REGISTER BITS |          |     |          |      |          |        |        | DEFAULT  | ACCESS |
|---------------------|------------------|------|---------------|----------|-----|----------|------|----------|--------|--------|----------|--------|
|                     | DEC              | HEX  | B7            | B6       | B5  | B4       | B3   | B2       | B1     | B0     |          |        |
| COMMAND-I           | 0                | 0x00 | OP2           | OP1      | OP0 | RESERVED |      |          |        |        | 0x00     | RW     |
| COMMAND-II          | 1                | 0x01 | RESERVED      |          |     |          | RES1 | RES0     | RANGE1 | RANGE0 | 0x00     | RW     |
| DATA <sub>LSB</sub> | 2                | 0x02 | D7            | D6       | D5  | D4       | D3   | D2       | D1     | D0     | 0x00     | RO     |
| DATA <sub>MSB</sub> | 3                | 0x03 | D15           | D14      | D13 | D12      | D11  | D10      | D9     | D8     | 0x00     | RO     |
| ID                  | 15               | 0x0F | BOUT          | RESERVED | 1   | 0        | 1    | RESERVED |        |        | 1x101xxx | RW     |

## Register Description

Following are detailed descriptions of the control registers related to the operation of the ISL29034 ambient light sensor device. These registers are accessed by the I<sup>2</sup>C serial interface. For details on the I<sup>2</sup>C interface, refer to “Serial Interface” on page 7.

All the features of the device are controlled by the registers. The ADC data can also be read. The following sections explain the details of each register bit. All RESERVED bits are Intersil used bits ONLY. The value of the reserved bit can change without notice.

## Decimal to Hexadecimal Conversion

To convert decimal value to hexadecimal value, divide the decimal number by 16, and write the remainder on the side as the least significant digit. This process is continued by dividing the quotient by 16 and writing the remainder until the quotient is 0. When performing the division, the remainders, which will represent the hexadecimal equivalent of the decimal number, are written beginning with the least significant digit (right) and each new digit is written to the next most significant digit (the left) of the previous digit. Consider the number 175 decimal.

TABLE 2. DECIMAL TO HEXADECIMAL

| DIVISION | QUOTIENT | REMAINDER | HEX NUMBER |
|----------|----------|-----------|------------|
| 175/16   | 10 = A   | 15 = F    | 0xAF       |

## Command-I Register (Address: 0x00)

TABLE 3. COMMAND-I REGISTER ADDRESS

| NAME      | ADDR (HEX) | REGISTER BITS |     |     |          |    |    |    |    | DFLT (Hex) |
|-----------|------------|---------------|-----|-----|----------|----|----|----|----|------------|
|           |            | B7            | B6  | B5  | B4       | B3 | B2 | B1 | B0 |            |
| COMMAND-I | 0x00       | OP2           | OP1 | OP0 | RESERVED |    |    |    |    | 0x00       |

The Command-I register consists three operation mode bits. The default register value is 0x00 at power-on.

## Command-I Register (Address: 0x0 Operation Mode Bits[7:5])

The ISL29034 has different operating modes. These modes are selected by setting B7 to B5 bits on register address 0x00. The device powers up on a disable mode. Table 4 lists the possible operating modes.

TABLE 4. OPERATING MODES BITS

| B7 | B6 | B5 | OPERATION   |
|----|----|----|---|
| 0  | 0  | 0  | Power-down the device (Default)   |
| 0  | 0  | 1  | The device measures ALS only once every integration cycle. This is the lowest operating mode. (Note 11) |
| 0  | 1  | 0  | IR once   |
| 0  | 1  | 1  | Reserved (DO NOT USE)   |
| 1  | 0  | 0  | Reserved (DO NOT USE)   |
| 1  | 0  | 1  | Measures ALS continuously   |
| 1  | 1  | 0  | Measures IR continuous  |
| 1  | 1  | 1  | Reserved (DO NOT USE)   |

NOTE:

11. Intersil does not recommend using this mode

## Command-II Register (Address: 0x01)

TABLE 5. COMMAND-II REGISTER BITS

| NAME       | Reg. Addr (Hex) | REGISTER BITS |    |    |    |      |      |        |        | DFLT (Hex) |
|------------|-----------------|---------------|----|----|----|------|------|--------|--------|------------|
|            |                 | B7            | B6 | B5 | B4 | B3   | B2   | B1     | B0     |            |
| COMMAND-II | 0x01            | RESERVED      |    |    |    | RES1 | RES0 | RANGE1 | RANGE0 | 0x00       |

The Command-II register consists of ADC control bits. In this register, there are two range bits and two ADAC resolution bits. The default register value is 0x00 at power-on.

## FULL SCALE LUX RANGE [B1:B0]

The full scale Lux range has four different selectable ranges. The range determines the full scale Lux range (1k, 4k, 16k, and 64k). Each range has a maximum allowable Lux value. Table 6 lists the possible values of FSR.

TABLE 6. RANGE REGISTER BITS

| RANGE SELECTION | B1 | B0 | FULL SCALE LUX RANGE (LUX) |
|-----------------|----|----|----------------------------|
| 0               | 0  | 0  | 1,000                      |
| 1               | 0  | 1  | 4,000                      |
| 2               | 1  | 0  | 16,000                     |
| 3               | 1  | 1  | 64,000                     |

## Integration Time ADC Resolution [B3:B2]

B2 and B3 determine the ADC's resolution and the number of clock cycles per conversion. Changing the number of clock cycles does more than just change the resolution of the device; it also changes the integration time, which is the period the device's analog-to-digital (A/D) converter samples the photodiode current signal for a measurement. Table 7 lists the possible ADC resolution. Only 16-bit ADC resolution can reject better 50/60Hz noise flickering light source.

TABLE 7. ADC RESOLUTION DATA WIDTH

| B3 | B2 | NUMBER OF CLOCK CYCLES | n-BIT ADC |
|----|----|------------------------|-----------|
| 0  | 0  | $2^{16} = 65,536$      | 16        |
| 0  | 1  | $2^{12} = 4,096$       | 12        |
| 1  | 0  | $2^8 = 256$            | 8         |
| 1  | 1  | $2^4 = 16$             | 4         |

## Integration Time

TABLE 8. INTEGRATION TIME OF n-BIT ADC

| n # ADC BITS | INTEGRATION TIME (ms) |
|--------------|-----------------------|
| 4            | 0.022                 |
| 8            | 0.352                 |
| 12           | 5.6                   |
| 16           | 105                   |

## Data Registers (Addresses: 0x02 & 0x03)

TABLE 9. ADC REGISTER BITS

| NAME                | Reg. Addr (Hex) | REGISTER BITS |     |     |     |     |     |    |    | DFLT (Hex) |
|---------------------|-----------------|---------------|-----|-----|-----|-----|-----|----|----|------------|
|                     |                 | B7            | B6  | B5  | B4  | B3  | B2  | B1 | B0 |            |
| DATA <sub>LSB</sub> | 0x02            | D7            | D6  | D5  | D4  | D3  | D2  | D1 | D0 | 0x00       |
| DATA <sub>MSB</sub> | 0x03            | D15           | D14 | D13 | D12 | D11 | D10 | D9 | D8 | 0x00       |

The ISL29034 has two 8-bit read-only registers to hold the upper and lower byte of the ADC value. The upper byte is accessed at address 0x03 and the lower byte is accessed at address 0x02. For 16-bit resolution, the data is from D0 to D15; for 12-bit resolution, the data is from D0 to D11; for 8-bit resolution, the data is from D0 to D7 and for 4-bit resolution, the data is from D0 to D3. The registers are refreshed after every conversion cycle. The default register value is 0x00 at power-on.

TABLE 10. ADC DATA REGISTERS

| ADDRESS (hex) | CONTENTS   |
|---------------|--|
| 0x02          | D0 is LSB for 4-, 8-, 12- or 16-bit resolution; D3 is MSB for 4-bit resolution; D7 is MSB for 8-bit resolution |
| 0x03          | D15 is MSB for 16-bit resolution; D11 is MSB for 12-bit resolution   |

## ID Register (Address: 0x0F)

TABLE 11. ID REGISTER BITS

| NAME | ADDR (Hex) | REGISTER BITS |          |    |    |    |          |    |    | DFLT     |
|------|------------|---------------|----------|----|----|----|----------|----|----|----------|
|      |            | B7            | B6       | B5 | B4 | B3 | B2       | B1 | B0 |          |
| ID   | 0x0F       | BOUT          | RESERVED | 1  | 0  | 1  | RESERVED |    |    | 1x101xxx |

The ID register has three different types of information.

### RESERVED BITS [B2:B0] AND [B6]

All RESERVED bits on the ISL29034 are Intersil used bits only. Bit0 to Bit2 and Bit6 are RESERVED bits where their value might change without any notification to the user. It is advised when using the identification bits to identify the device in a system the software should mask the Bit0 to Bit2 and Bit6 to Bit7 to properly identify the device.

### DEVICE ID BITS [B5:B3]

The ISL29034 provides 3-bits to identify the device in a system. These bits are located on register address 0x0F, Bit3 to Bit5. The identification bit value for the ISL29034 is xx101xxx. The device identification bits are read only bits. It is important to notice that Bit7 is a status bit for brownout condition (BOUT).

### BROWNOUT STATUS BIT TO BOUT [B7]

Bit7 on register address 0x0F is a status bit for brownout condition (BOUT). The default value of this bit is "BOUT = 1" during the initial power-up, which indicates the device may possibly have gone through a brownout condition. Therefore, the status bit should be reset to "BOUT = 0" by an I<sup>2</sup>C write command during the initial configuration of the device.

The default register value is 0xA8 at power-on.

## Applications Information

Figure 14 is a normalized spectral response of various type of light sources for reference.

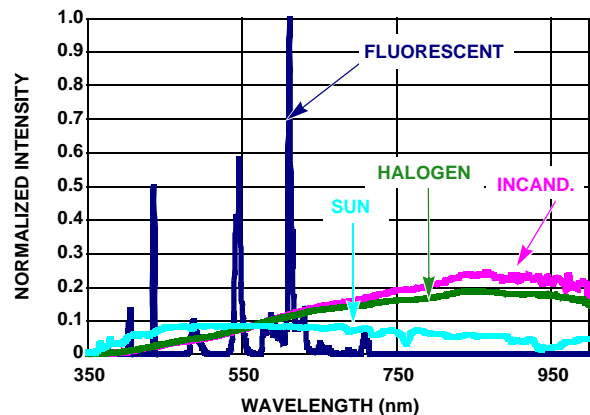


FIGURE 14. NORMALIZED SPECTRAL RESPONSE OF LIGHT SOURCES

## Calculating Lux

The ISL29034's ADC output codes, DATA, are directly proportional to Lux in the ambient light sensing.

$$E_{\text{cal}} = \alpha \times \text{DATA} \quad (\text{EQ. 1})$$

Where,  $E_{\text{cal}}$  is the calculated Lux reading. The constant  $\alpha$  is determined by the Full Scale Range and the ADC's maximum output counts. The constant is independent of the light sources (fluorescent, incandescent and sunlight) because the light sources IR component is removed during the light signal process. The constant can also be viewed as the sensitivity (the smallest Lux measurement the device can measure).

$$\alpha = \frac{\text{Range}}{\text{Count}_{\text{max}}} \quad (\text{EQ. 2})$$

Where, Range is defined in Table 6 on page 10.  $\text{Count}_{\text{max}}$  is the maximum output counts from the ADC.

The transfer function used for n-bits ADC becomes:

$$E_{\text{cal}} = \frac{\text{Range}}{2^n} \times \text{DATA} \quad (\text{EQ. 3})$$

Where,  $n = 4, 8, 12$  or  $16$ . This is the number of ADC bits programmed in the command register.  $2^n$  represents the maximum number of counts possible from the ADC output. Data is the ADC output stored in the data registers (02 hex and 03 hex).

## Enhancing EV Accuracy

The device has on chip passive optical filter designed to block (reject) most of the incident Infra Red. However, EV measurement may vary under differing IR-content light sources. In order to optimize the measurement variation between differing IR-content light sources, ISL29034 provides IR channel which is programmed at COMMAND-1 (Reg0x0) to measure IR level of differing IR-content light sources.

The ISL29034's ADC output codes, DATA, are directly proportional to the IR intensity received in the IR sensing.

$$\text{DATA}_{\text{IR}} = \beta \times E_{\text{IR}} \quad (\text{EQ. 4})$$

Then EV accuracy can be found in Equation 5:

$$E_{\text{V Accuracy}} = K \times \text{DATA}_{\text{EV}} + \beta \times \text{DATA}_{\text{IR}} \quad (\text{EQ. 5})$$

Here,  $\text{DATA}_{\text{EV}}$  is the received ambient light intensity ADC output codes. K is a resolution of visible portion. Its unit is Lux/count. The typical values of K is 0.82.  $\text{DATA}_{\text{IR}}$  is the received IR intensity. The constant  $\beta$  changes with the spectrum of background IR, such as A, F2 and D65 (Notes 8, 9 and 10). The  $\beta$  also changes with the ADC's range and resolution selections. A typical  $\beta$  for range1 and range2 is -11292.86 and range3 and range4 is 2137.14 without IR tinted glass.

## Noise Rejection

Electrical AC power worldwide is distributed at either 50Hz or 60Hz. Artificial light sources vary in intensity at the AC power frequencies. The undesired interference frequencies are infused on the electrical signals. This variation is one of the main sources of noise for the light sensors. Integrating type ADC's have excellent noise-rejection characteristics for periodic noise sources whose frequency is an integer multiple of the conversion rate. By setting the sensor's integration time to an integer multiple of periodic noise signal, the performance of an ambient light sensor can be improved greatly in the presence of noise. In order to reject the AC noise, the integration time of the sensor must be adjusted to match the AC noise cycle. For instance, a 60Hz AC unwanted signal's sum from 0ms to  $k \times 16.66\text{ms}$  ( $k = 1, 2, \dots, k_i$ ) is zero. Similarly, setting the device's integration time to be an integer multiple of the periodic noise signal greatly improves the light sensor output signal in the presence of noise.

## Suggested PCB Footprint

It is important that users check the "Surface Mount Assembly Guidelines for Optical Dual Flat Pack No Lead (ODFN) Package" before starting ODFN product board mounting: [TB477](#)

## Board Mounting Considerations

For applications requiring the light measurement, the board mounting location should be reviewed. The device uses an Optical Dual Flat Pack No Lead (ODFN) package, which subjects the die to mild stresses when the printed circuit (PC) board is heated and cooled, which slightly changes the shape. Because of these die stresses, placing the device in areas subject to slight twisting can cause degradation of reference voltage accuracy. It is normally best to place the device near the edge of a board, or on the shortest side, because the axis of bending is most limited in that location.

## Layout Considerations

The ISL29034 is relatively insensitive to layout. Like other I<sup>2</sup>C devices, it is intended to provide excellent performance even in significantly noisy environments. There are only a few considerations that will ensure best performance.

Route the supply and I<sup>2</sup>C traces as far as possible from all sources of noise. Use two power-supply decoupling capacitors, 1μF and 0.1μF, placed close to the device.

## Soldering Considerations

Convection heating is recommended for reflow soldering; direct-infrared heating is not recommended. The plastic ODFN package does not require a custom reflow soldering profile, and is qualified to +260°C. A standard reflow soldering profile with a +260°C maximum is recommended.

## Temperature Coefficient

The limits stated for temperature coefficient (TC) are governed by the method of measurement. The “Box” method is usually used for specifying the temperature coefficient. The overwhelming standard for specifying the temperature drift of a reference is to evaluate the maximum voltage change over the specified temperature range. This yields ppm/°C, and is calculated using and is calculated using Equation 4:

$$TC = \frac{V_{HIGH} - V_{LOW}}{V_{NOMINAL} \times (T_{HIGH} - T_{LOW})} \times 10^6 \quad (EQ. 6)$$

where:

$V_{HIGH}$  is the maximum reference voltage over the temperature range.

$V_{LOW}$  is the minimum reference voltage over the temperature range.

$V_{NOMINAL}$  is the nominal reference voltage at +25 °C.

$T_{HIGH} - T_{LOW}$  is the specified temperature range (°C)

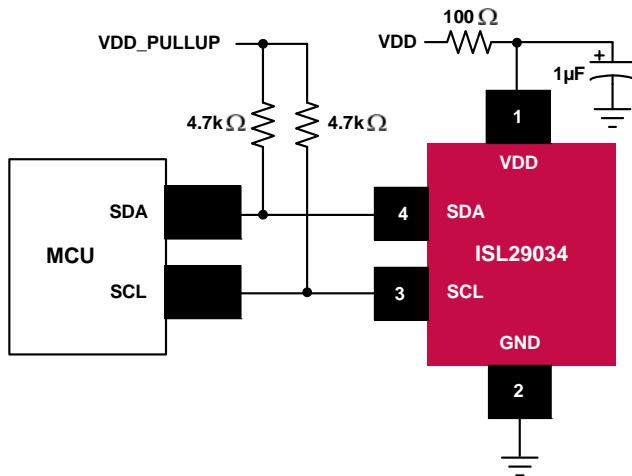


FIGURE 15. ISL29034 TYPICAL CIRCUIT

## Digital Inputs and Termination

The ISL29034 digital inputs are guaranteed to CMOS levels. The internal register is updated on the rising edge of the clock. To minimize reflections, proper termination should be implemented. If the lines driving the clock and the digital inputs are 50Ω lines, then 50Ω termination resistors should be placed as close to the sensor inputs as possible, connected to the digital ground plane (if separate grounds are used).

## Typical Circuit

A typical application for the ISL29034 is shown in Figure 15. The ISL29034's I²C address is internally hard-wired as 1000100. The device can be tied onto a system's I²C bus together with other I²C compliant devices.

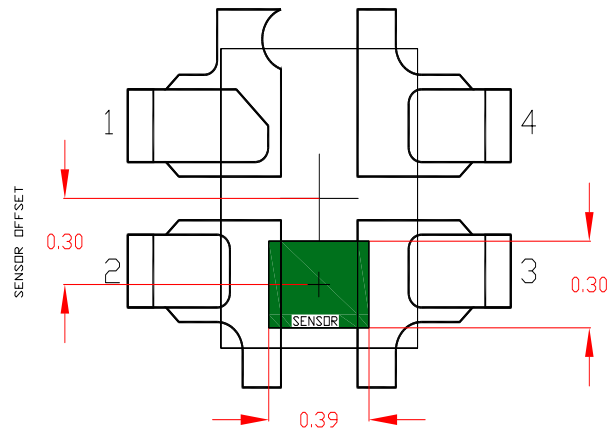


FIGURE 16. 4 LD ODFN SENSOR LOCATION OUTLINE

## 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          |
|---------------|----------|-----------------|
| April 9, 2014 | FN8370.1 | Initial Release |

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