# Wide Range Visible Light Sensor

**PRODUCTION DATA SHEET**

## DESCRIPTION

The LX1971 is a new technology light sensor with spectral response that emulates the human eye; it is pin to pin compatible to Microsemi's LX1970 visible light sensor however with a wider dynamic range.

This device is ideal for monitoring ambient light for the control of artificial lighting, operation of shades, LED signage and display, street lighting, automotive light sensors and control of backlight dimming. It has a unique photo diode arrangement (patents pending) with a peak response at 520nm while sharply attenuating both ultra violet and infrared wavelengths.

The photo sensor is a PIN diode array with an accurate and very repeatable current output.

Photo current is first multiplied by an integrated high gain amplifier then the square root is taken of the product of the amplifier and an internal reference current. Finally this is further multiplied converted to current and made available at two output pins; one a current source and the other a current sink.

These currents can easily be converted to voltage by adding a single resistor at either or both outputs. Voltage gain is determined by the resistor value typically in the 5KΩ to 50KΩ range.

With accurate internal gain amplifiers and square root transfer function, design complexity and cost are greatly reduced.

The LX1971 is available in the Clear 8-pin MSOP package.

**IMPORTANT:** For the most current data, consult *MICROSEMI*'s website: http://www.microsemi.com

Protected By U.S. Patents: 6,787,757; Patents Pending

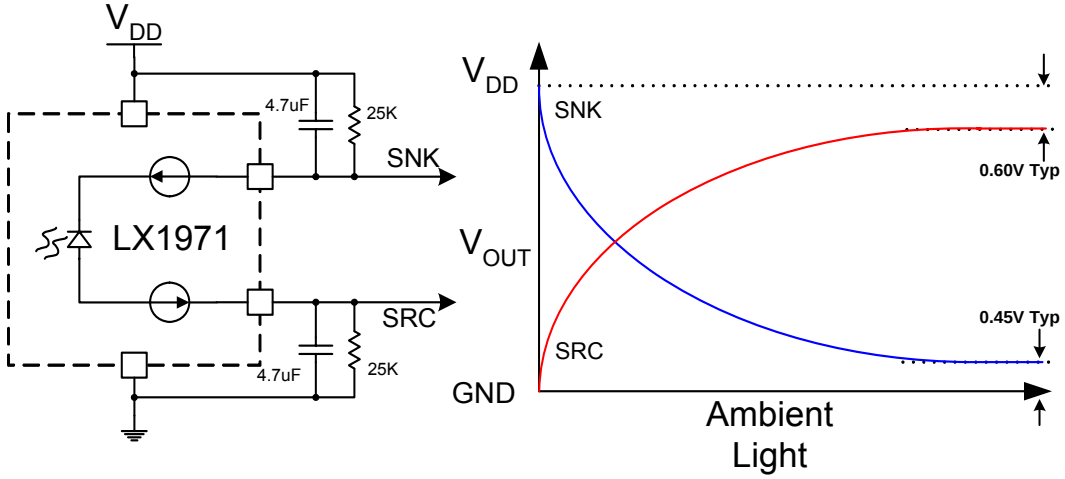
## KEY FEATURES

- Approximate Human Eye Spectral Response
- Low IR Sensitivity
- Highly Accurate & Repeatable Output Current vs. Light
- Square root transfer function
- Temperature Stable
- Integrated High Gain Photo Current Amplifiers
- Complementary Current Outputs
- No Optical Filters Needed

## BENIFITS

- Requires no wavelength filters
- Insensitive to UV and IR
- More than 4 decades usable light range
- Enables accurate lighting control systems

## PRODUCT HIGHLIGHT




## PACKAGE ORDER INFO

| $T_A$ (°C) | DU Plastic MSOP 8-Pin RoHS Compliant / Pb-free |
|---|---|
| -40 to 85 | LX1971IDU |

Note: Available in Tape & Reel. Append the letters "TR" to the part number. (i.e. LX1971IDU-TR)

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www.Microsemi.COM

LX1971

## ABSOLUTE MAXIMUM RATINGS

$V_{DD}$ ..... -0.3 to 6 $V_{DC}$
SNK/SRC (Output Compliance Voltage)..... -0.3 to $V_{DD}$ + 0.3$V_{DC}$
SNK/SRC (Maximum Output Current)..... Internally Limited
Operating Temperature Range ..... -40 to +85°C
Storage Temperature Range..... -40 to +100°C
Solder Reflow Peak Temperature (Soldering 10 seconds) .....240°C

Notes: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

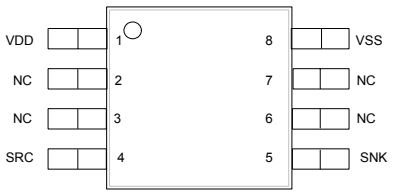
Solder reflow to follow: IPC/JEDEC J-STD-020B 7/02 Pb-SN Small Body Profile

## THERMAL DATA

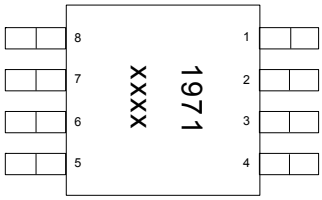
**DU** **Plastic MSOP 8-Pin**

| | |
|---|---|
| THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$ | 206°C/W |
| THERMAL RESISTANCE-JUNCTION TO CASE, $\theta_{JC}$ | 39°C/W |

## PACKAGE PIN OUT




DU PACKAGE
(Top View)




DU PACKAGE
(Bottom View)

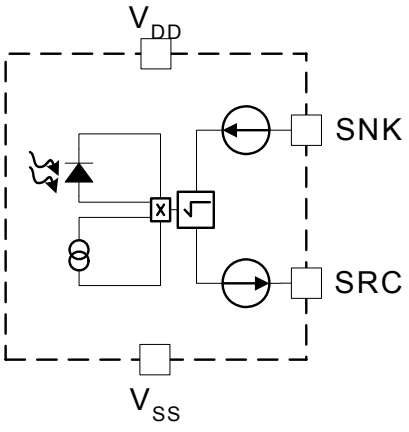
xxxx = Denotes Date Code / Lot Information

RoHS / Pb-free Gold Lead Finish
MSL 2 / 260°C / 1 Year

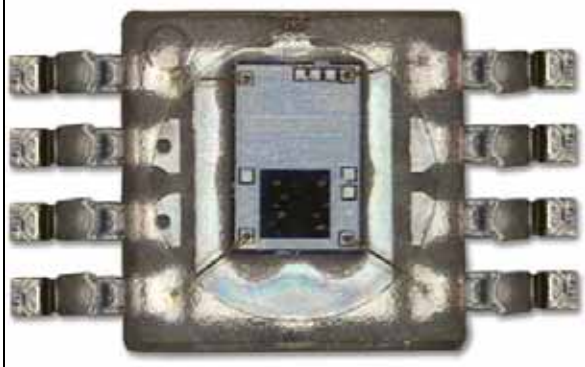
## FUNCTIONAL PIN DESCRIPTION

| NAME | DESCRIPTION |
|---|---|
| $V_{DD}$ | Input Supply Voltage |
| $V_{SS}$ | Ground Reference for Power and Signal Output |
| SNK | Output Current Sink |
| SRC | Output Current Source |

## SIMPLIFIED BLOCK DIAGRAM




## PACKAGE PHOTO





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## RECOMMENDED OPERATING CONDITIONS

| Parameter | LX1971 | | | Units |
|---|---|---|---|---|
| | Min | Typ | Max | |
| Supply Voltage ($V_{DD}$ ) | 3[1] | | 5.5 | V |
| SNK Compliance Voltage Range | $V_{SS}$ +0.6 | | $V_{DD}$ | V |
| SRC Compliance Voltage Range | $V_{SS}$ | | $V_{DD}$ - 0.75 | V |
| SNK/SRC Output Resistor Range | 5 | | 100 | KΩ |

[1]Outputs are functional down to $V_{DD}$=2.7V

## ELECTRICAL CHARACTERISTICS

Unless otherwise specified, the following specifications apply over the operating ambient temperature -40°C ≤ $T_A$ ≤ 85°C, $V_{DD}$ = 3V to 5.5V, $R_{LOAD}$= 25Kohms, Direct Light Input[2] of 584µW/cm$^2$ except where otherwise noted. Performance between -40°C and 0°C and between 70°C and 85°C are assured by design and characterization.

| Parameter | Symbol | Test Conditions | LX1971 | | | Units |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| Supply Voltage Range | $V_{DD}$ | | 3 | | 5.5 | $V_{DC}$ |
| Input Supply Current | $I_{DD}$ | $V_{DD}$ = 3.0V, $I_{SRC}$ = 62µA, $I_{SNK}$ = open | 350 | 590 | 750 | µA |
| Output Current | $I_{SRC}$ | $V_{DD}$ = 3.0V, Direct Light Input of 584µW/cm$^2$ @ 25°C | 55 | 61 | 67 | µA |
| | $I_{SRC}$ | $V_{DD}$ = 3.0V, Direct Light Input of 584µW/cm$^2$ | 52 | 61 | 70 | |
| | $I_{SNK}$ | $V_{DD}$ = 3.0V, Direct Light Input of 584µW/cm$^2$ | -70 | -61 | -52 | µA |
| | $I_{SRC}$ | $V_{DD}$ = 3.0V, Direct Light Input of 292µW/cm$^2$ | 34 | 41 | 48 | µA |
| | $I_{SRC}$ | $V_{DD}$ = 3.0V, Direct Light Input of 9.34µW/cm$^2$ | 5.5 | 7 | 8.5 | µA |
| Output SNK/SRC Current Matching | $I_{MATCH}$ | $V_{DD}$ = 3.0V | | 2 | 6 | % |
| SNK Minimum Compliance Voltage | $SNK_{VMIN}$ | $V_{DD}$ = 3.0V, @ 95% of nominal output current | | $V_{SS}$ +0.45 | $V_{SS}$ +0.6 | V |
| SRC Maximum Compliance Voltage | $SRC_{VMAX}$ | $V_{DD}$ = 3.0V, @ 95% of nominal output current | | $V_{DD}$ – 0.6 | $V_{DD}$ – 0.7 | V |
| SNK/SRC Output Dark Current | $I_{DARK3.0V}$ | $V_{DD}$ = 3V, No Light, 25°C | | 150 | 400 | nA |
| SNK/SRC Output Dark Current | $I_{DARK3.0V}$ | $V_{DD}$ = 3V, No Light, -40°C to 70°C | | 450 | 1000 | nA |
| SNK/SRC Output Dark Current | $I_{DARK3.0V}$ | $V_{DD}$ = 3V, No Light, 85°C | | 550 | 1150 | nA |
| SNK/SRC Output Dark Current | $I_{DARK5.5V}$ | $V_{DD}$ = 5.5V, No Light, 25°C | | 320 | | nA |
| Wavelength of Peak Sensitivity | $\lambda_{PS}$ | | | 520 | | nm |
| Half Reception Angle | $\theta_{½}$ | | | ±60 | | deg |
| Supply Voltage Coefficient of Output Current | PSRR | $V_{DD}$ = 3V to 5.5V | | 2.9 | 3.5 | %/V |
| Resolution Limit Due To Random Noise | $I_{MIN}$ | Minimum usable resolution | | 146 | | nW/cm$^2$ |
| Sensitivity Change @ 910nm | $I_{SRC}\Delta$ IR | Current responsivity change with additional direct light input of 584µW/cm$^2$ at 910nm, $T_A$ = 25°C, $V_{DD}$ = 3V | -10 | 0 | 10 | % of peak |
| Radiant Sensitive Area | A | Photodiode Area | | .369 | | mm$^2$ |

[2]The input irradiance is supplied from a white light-emitting diode (LED) optical source adjusted to impose 584µW/cm$^2$ at 555nm on the sensor's surface.

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## APPLICATION INFORMATION

The LX1971 is a light sensor with a spectral response that resembles the human visual system. It is packaged in clear MSOP package with the same pin out and same supply voltage range as Microsemi's LX1970 light sensor. The LX1971 responsiveness however differs from that of the LX1970. In general the LX1971 has lower sensitivity and a wider dynamic range.

Whereas the LX1970 has a responsiveness that is directly proportional to the intensity of light falling on the photo receptors. There are two different response equations for the LX1971 depending on the operating range (intensity of the light). Below 2500 lux, the response resembles a square root function. Above 2500 lux, the response fits a straight line curve.

$$I_{OUT} = \left(\sqrt{L} \times .808\right) + 1.1\mu A \text{ for L} < 2500 \text{ lux}$$

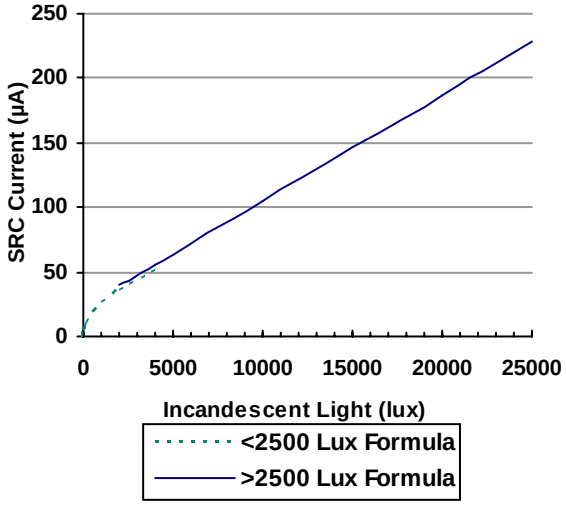
$$I_{OUT} = \left(L \times .0083\mu A\right) + 23\mu A \text{ for 2500 lux} < \text{L} < 20000 \text{ lux}$$

The LX1970 is best suited for applications where the light sensor is an integral part of a continuous lighting control system. For example, in an LCD backlighting application, the level of brightness of the backlight should be adjusted in proportion to the level of ambient lighting; the LX1970 can provide closed loop brightness control for this type of system. For most indoor applications, the 2500 lux saturation point of the LX1970 is usually not a limiting affect.

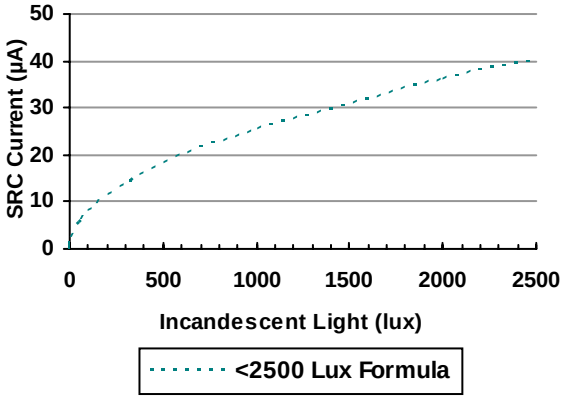
The LX1971 is best suited for applications where the system must respond to external events that affect the user's ability to see clearly. For example, a sensor to turn on headlights or a sensor to adjust the reflectivity of a rear view mirrors. These systems require the sensor to have dynamic range similar to sight. Like the human eye, the square root function of the LX1971 makes it extra sensitive to small changes at lower light levels. The wide dynamic range allows the LX1971 to sense the difference between twilight and daylight or sunshine and heavy cloud cover.

The following curves show the calculated responsiveness of the LX1971 without load resistors based on the formulas above. They can be used as baseline guidelines to calculate gain setting resistors. The compliance of the current source output may result in premature saturation of the output when load resistors are added. The SRC compliance voltage is specified typically at VDD-600mV @ about 4000 lux.

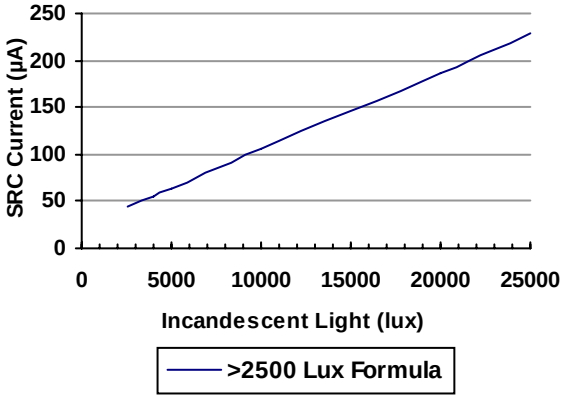
**LX1971 Calculated SRC Full Range Response**




**LX1971 Calculated SRC Low Level Response**




**LX1971 Calculated SRC High Level Response**



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## APPLICATION EXAMPLES

The following examples present both fully automatic (no user input) and semi-automatic, to fully manual override implementations. These general guidelines are applicable to a wide variety of potential light control applications. The LX1971 can be used for the control of artificial lighting, operation of shades, LED signage and display, street lighting, automotive light sensors and control of backlight dimming.

In each specific application it is important to recognize the need to correlate the sink and source current of the LX1971 for the target environment and its ambient light conditions. The mechanical mounting of the sensor, light aperture hole size, use of a light pipe or bezel are critical in determining the response of the LX1971 for a given exposure of light.

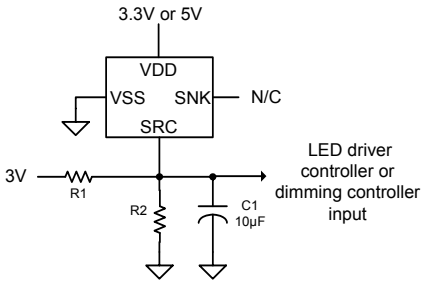


**Figure 1**

The example in figure one shows a fully automatic lighting control solution with no user interaction. Choose R1 and R2 values for any desired minimum brightness and slope. Choose C1 to adjust response time. As an example, let's say you wish to generate an output voltage from 0.25V to 1.25V to drive the input of an LED driver controller. The 0.25V represents the minimum LED brightness and 1.25V represent the maximum. The first step would be to determine the ratio of R1 and R2.

$R1 = R2\ [\ 3.0V/0.25V - 1] = 11 * R2$

Next the value of R2 can be calculated based on the maximum output source current coming from the LX1971 under the application's maximum light exposure, lets say this has been determined to be about 50uA . Thus R2 can be calculated first order as follows:

$R2 = [\ 1.25V / 50uA\ ] = 25K\Omega \therefore\ R1 = 11 * R2 = 275K\Omega$

The output node will actually reach 1.25V when the source current from the LX1971 is only about 44uA since about 6uA of current will be contributed from R1.

We are assuming a high impedance input to the LED driver. In Figure 2 user adjustable bias control has been added to allow control over the minimum and maximum output voltage. This allows the user to adjust the output brightness to personal preference over a limited range. The PWM input source could of course be replaced with an equivalent DC voltage.

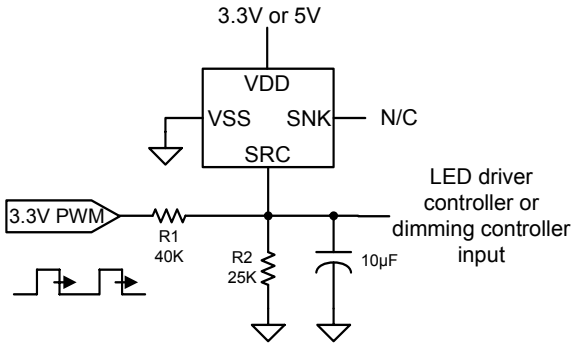


**Figure 2**

Figure 3 shows how a fully manual override can be quickly added to the example in figure 2. In addition to the gate to turn on and off the LX1971, a diode has been inserted to isolate the LX1971 when it is shut down.

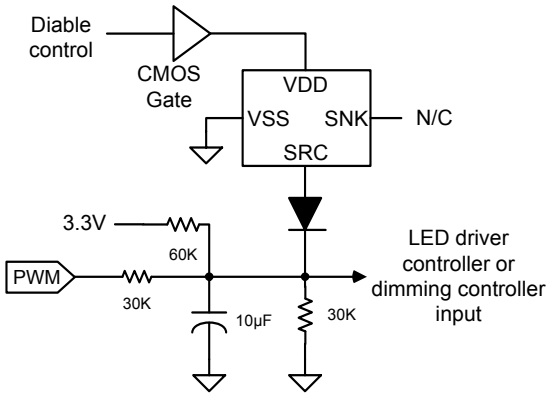


**Figure 3**

The preceding examples represent just a few of the many ways the sensor can be used. For example since there is also a complimentary sink output a resistor from VDD to SNK could develop a voltage that could be compared (with some hysteresis) to a fixed (or adjustable) reference voltage and develop a logic signal. In the case of street lighting or operation of shades such a signal would engage the function when reaching the correct ambient light level.



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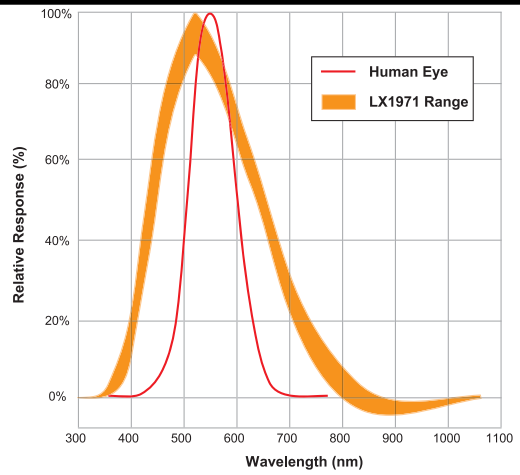
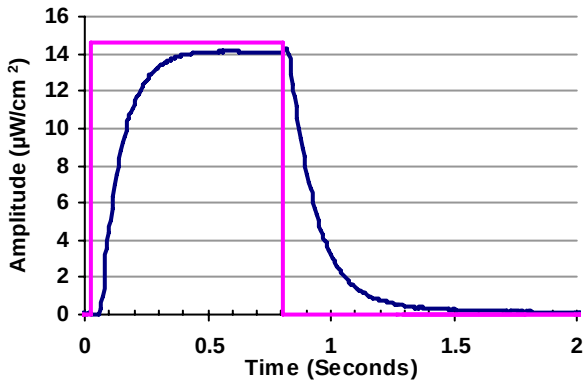
## RESPONSE VS WAVELENGTH

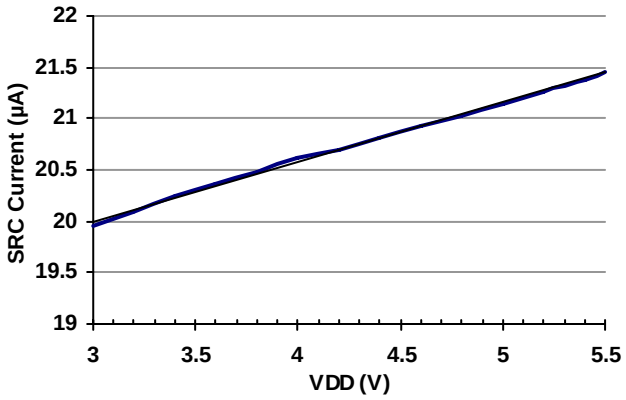



## ISRC STEP RESPONSE



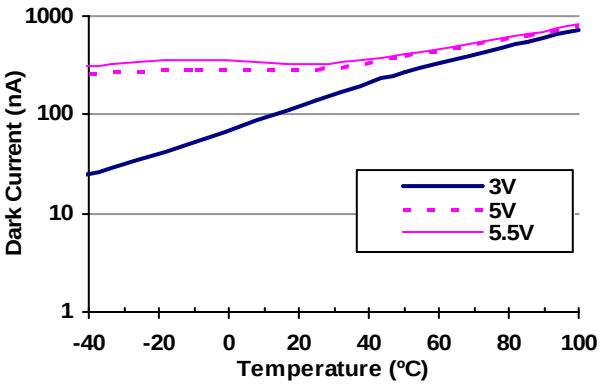

$V_{DD}$ = 3.0V; $R_{SRC}$ = 25K & 4.7uF

## LINE REGULATION



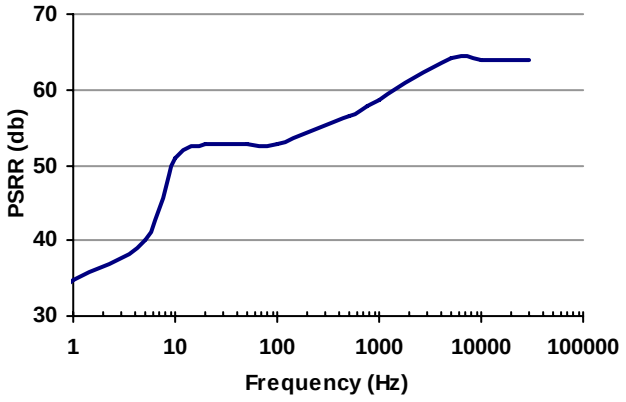

$V_{DD}$ = 3.5V; $R_{SRC}$ = 25K & 4.7uF

## DARK CURRENT VS TEMP



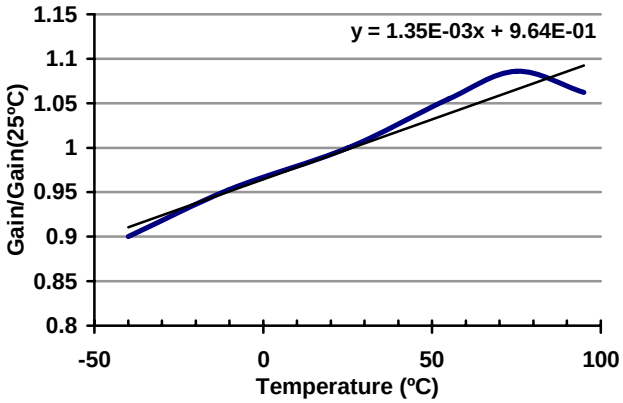

$R_{SRC}$ = 25K & 4.7uF

## SNK OUTPUT PSRR




$V_{DD}$ = 3.0V; $R_{SNK}$ = 25K & 4.7uF

## GAIN VS TEMP




$V_{DD}$ = 3.0V Direct Light Input of 13.14µW/cm$^2$



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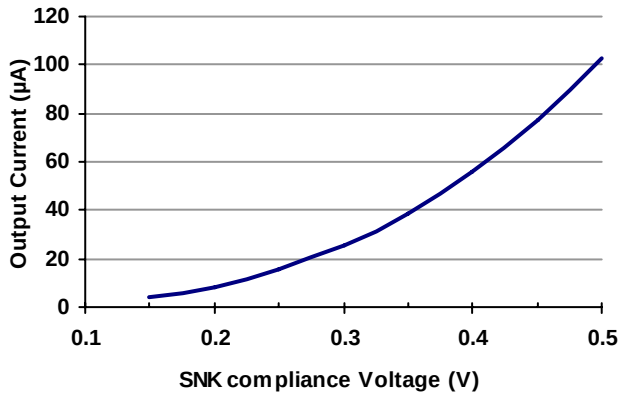
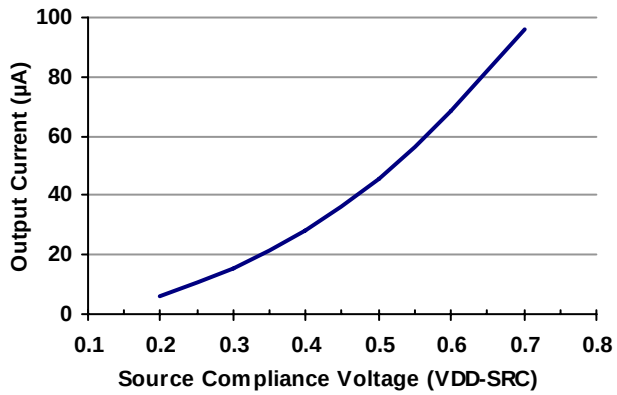
## SNK COMPLIANCE VS CURRENT



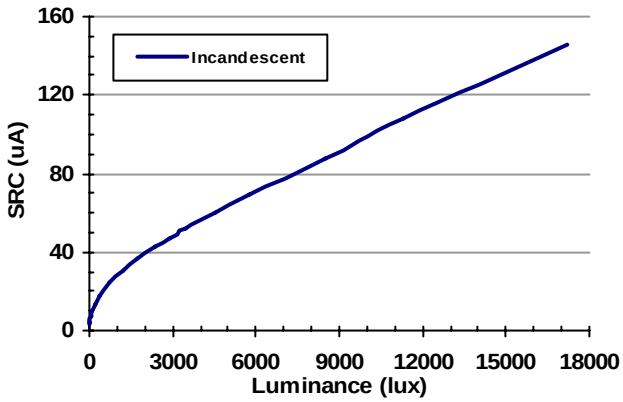

$V_{DD}$ = 3.0V; $R_{SNK}$ = 25K & 4.7µF

## SRC COMPLIANCE VS CURRENT



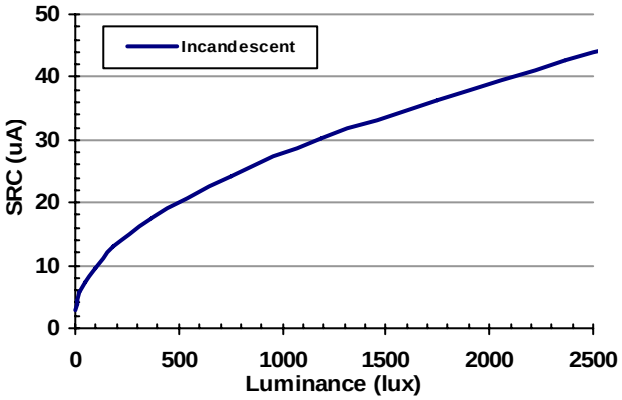

$V_{DD}$ = 3.0V; $R_{SRC}$ = 25K & 4.7µF

## SRC OUTPUT VS LUMINANCE(LUX)




$V_{DD}$ = 4.0V; $R_{SNK}$ = 10K & 4.7µF

## SRC OUTPUT VS LUMINANCE(LUX)




$V_{DD}$ = 4.0V; $R_{SNK}$ = 10K & 4.7µ



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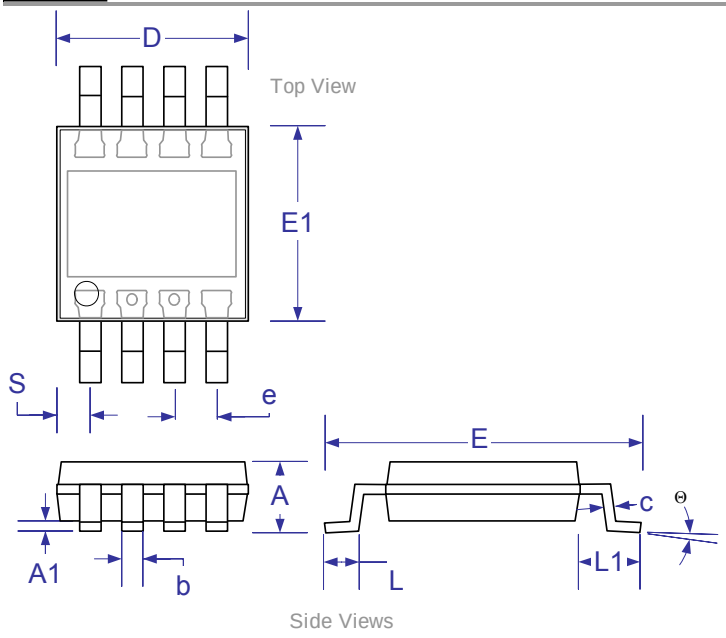
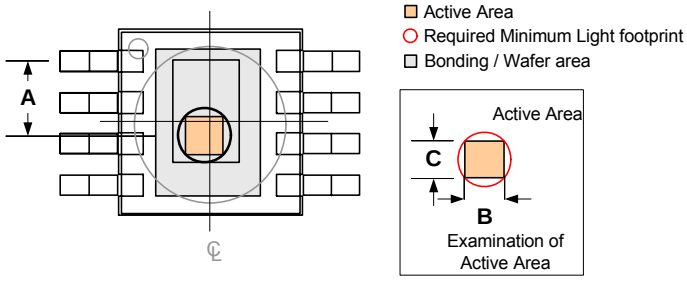
## PACKAGE DIMENSIONS

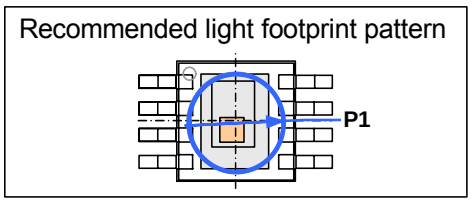
### DU 8-Pin Miniature Shrink Outline Package (MSOP)




| Dim | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | – | 1.10 | – | 0.043 |
| A1 | 0.05 | 0.15 | 0.002 | 0.006 |
| b | 0.26 | 0.41 | 0.010 | 0.016 |
| c | 0.13 | 0.23 | 0.005 | 0.009 |
| D | 2.90 | 3.10 | 0.114 | 0.122 |
| e | 0.65 BSC | | 0.025 BSC | |
| E | 4.75 | 5.05 | 0.187 | 0.198 |
| E1 | 2.90 | 3.10 | 0.114 | 0.122 |
| L | 0.41 | 0.71 | 0.016 | 0.028 |
| L1 | 0.95 BSC | | 0.037 BSC | |
| S | 0.525 BSC | | 0.021 BSC | |
| Θ | 3° | | 3° | |




| Dim | MILLIMETERS | INCHES |
|---|---|---|
| A | 1.22 | 0.048 |
| B | 0.60 | 0.024 |
| C | 0.60 | 0.024 |
| P1 | 2.5 | 0.98 |




**Note:**
P1 represents a possible light footprint and its dimensions are not subject to strict tolerances. Only the active area of the device is required to be covered with light. This larger footprint is designed to ensure coverage of the device's active area.



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