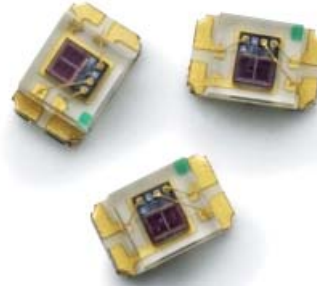


APDS-9002

Miniature Surface-Mount Ambient Light Photo Sensor



Data Sheet



Description

The APDS-9002 is a low-cost analog-output ambient light photo sensor in lowest cost miniature chipLED lead-free surface mount package. It consists of a spectrally suited phototransistor, which peaks in human luminosity curve. Hence, it provides an excellent responsivity that is close to the response of human eyes, as shown in Figure 2. It provides a design-alternative to the HSDL-9000 digital-output ambient light photo sensor is suitable for portable applications with its ultra small package design.

The APDS-9002 is ideal for applications in which the measurement of ambient light is used to control display backlighting. Mobile appliances such as the mobile phones and PDAs that draw heavy current from display backlighting will benefit from incorporating these photo sensor products in their designs by reducing power consumption significantly.

Features

- Excellent responsivity which peaks in the human luminosity curve
 - Close responsivity to the human eye
- Miniature chipLED lead-free surface-mount package
 - Height – 0.80 mm
 - Width – 2.00 mm
 - Depth – 1.25 mm
- Good output linearity across wide illumination range
- Low sensitivity variation across various light sources
- Guaranteed temperature performance: -40° C to 85° C
- VCC supply 2.4 to 5.5 V
- Lead-free package

Applications

- Detection of ambient light to control display backlighting
 - Mobile devices – mobile phones, PDAs
 - Computing devices – notebooks, webpads
 - Consumer devices – TVs, video cameras, digital still cameras
- Automatic residential and commercial lighting management
- Electronic signs and signals
- Daylight and artificial light exposed devices

Application Support Information

The Application Engineering Group is available to assist you with the application design associated with APDS-9002 ambient light photo sensor module. You can contact them through your local sales representatives for additional details.

Ordering Information

| Part Number | Packaging Type | Package | Quantity |
|---------------|----------------|------------------------|----------|
| APDS-9002-021 | Tape and Reel | 4-pins Chipped package | 2500 |

Typical Application Circuit

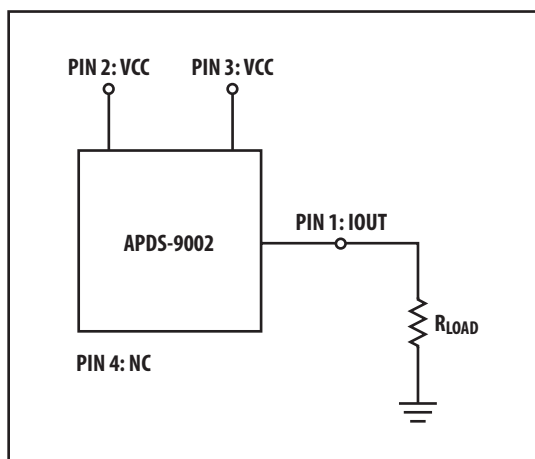


Figure 1. Typical application circuit for APDS-9002.

Figure 1 Table

| Component | Recommended Application Circuit Components |
|------------|--|
| R_{LOAD} | 1 k Ω |

I/O Pins Configuration Table

| Pin | Symbol | Description |
|-----|--------|-------------|
| 1 | IOUT | IOUT |
| 2 | VCC | VCC |
| 3 | VCC | VCC |
| 4 | NC | No Connect |

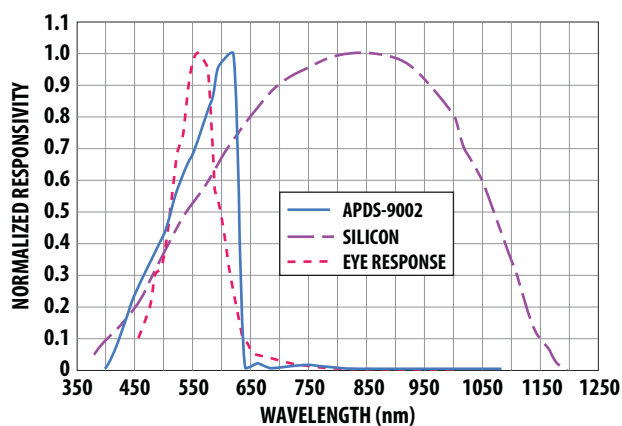


Figure 2. Relative spectral response vs. wavelength.

CAUTION: It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Absolute Maximum Ratings

For implementations where case to ambient thermal resistance is $\leq 50^{\circ}\text{C/W}$

| Parameter | Symbol | Min. | Max. | Units |
|-----------------------|----------|------|------|--------------------|
| Storage Temperature | T_S | -40 | 85 | $^{\circ}\text{C}$ |
| Operating Temperature | T_A | -40 | 85 | $^{\circ}\text{C}$ |
| Supply Voltage | V_{CC} | 2.4 | 5.5 | V |

Recommended Operating Conditions

| Parameter | Symbol | Min. | Max. | Units | Conditions |
|-----------------------|----------|------|------|--------------------|------------|
| Operating Temperature | T_A | -40 | 85 | $^{\circ}\text{C}$ | |
| Supply Voltage | V_{CC} | 2.4 | 5.5 | V | |

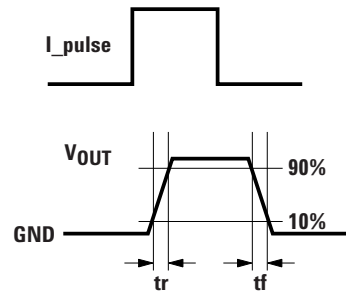
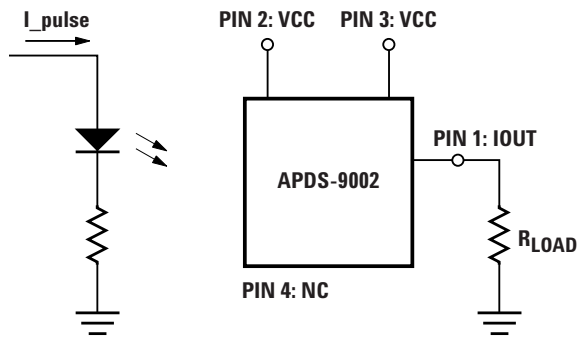
Electrical & Optical Specifications (T_A = 25° C)

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---------------------|-------------------------------------|------|------|------|-------|---|
| Photo Current (I) | I _{PH1} | 10 | 20 | 33 | μA | V _{CC} = 3.0 V, Lux = 10 ^[2] |
| Photo Current (II) | I _{PH2} | 136 | 250 | 410 | μA | V _{CC} = 3.0 V, Lux = 100 ^[2] |
| Photo Current (III) | I _{PH3} | – | 300 | – | μA | V _{CC} = 3.0 V, Lux = 100 ^[1] |
| Dark Current | I _{DARK} | – | 50 | 160 | nA | V _{CC} = 3.0 V, Lux = 0 |
| Light Current Ratio | I _{PH3} / I _{PH2} | – | 1.2 | – | – | – |
| Rise Time | T _{RISE} | – | 0.95 | 2 | ms | V _{CC} = 3.0 V, Lux = 100, R _{load} = 1 kΩ ^[3] |
| Fall Time | T _{FALL} | – | 0.8 | 2 | ms | V _{CC} = 3.0 V, Lux = 100, R _{load} = 1 kΩ ^[3] |

Notes:

1. Illuminance by CIE standard light source (incandescent lamp).
2. Fluorescent light is used as light source. White LED is substituted in mass production.
3. White LED is used as light source.

Light Measurement Circuit and Waveforms



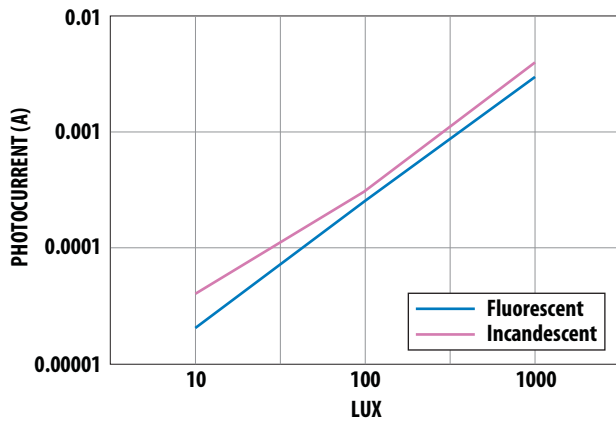


Figure 3. Photocurrent vs. luminance ($V_{CC} = 3\text{ V}$, $T_A = 25^\circ\text{ C}$).

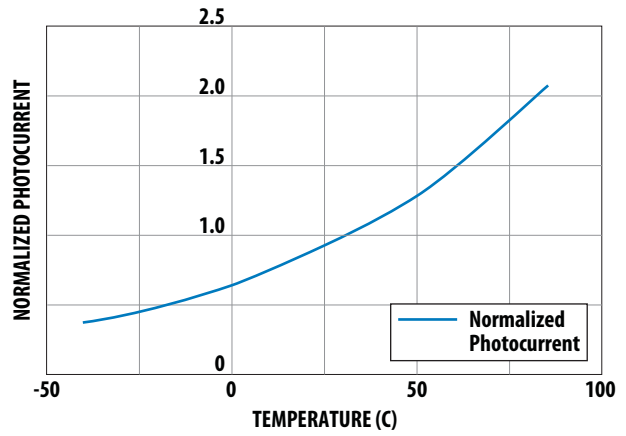


Figure 4. Normalized photocurrent vs. temperature ($V_{CC} = 3\text{ V}$, 100 LUX).

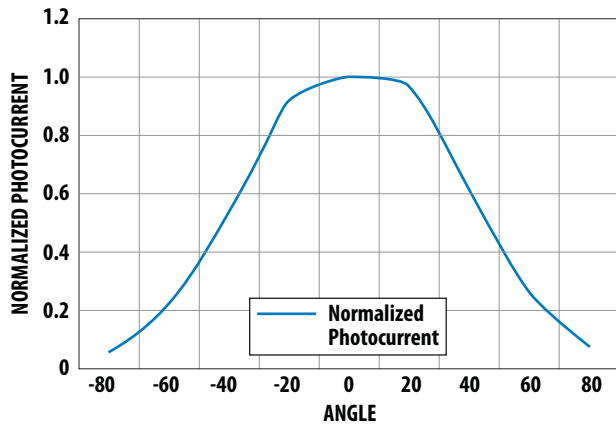


Figure 5. Normalized photocurrent vs. angle ($V_{CC} = 3\text{ V}$, $T_A = 25^\circ\text{ C}$).

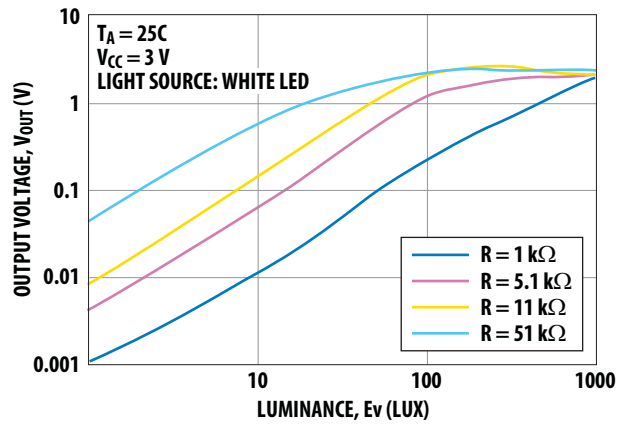


Figure 6. Output voltage vs. luminance at different load resistor.

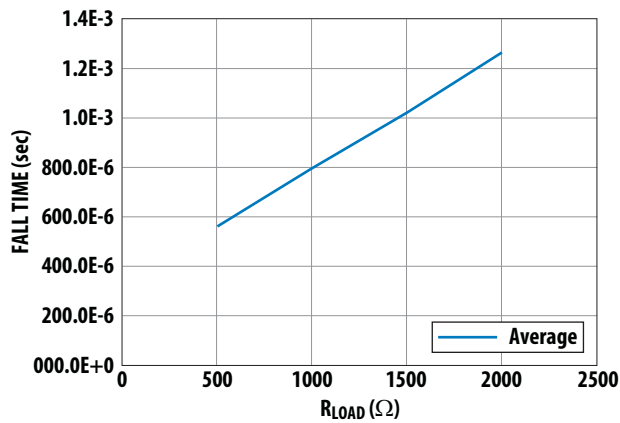


Figure 7. Fall time vs. R_{LOAD} .

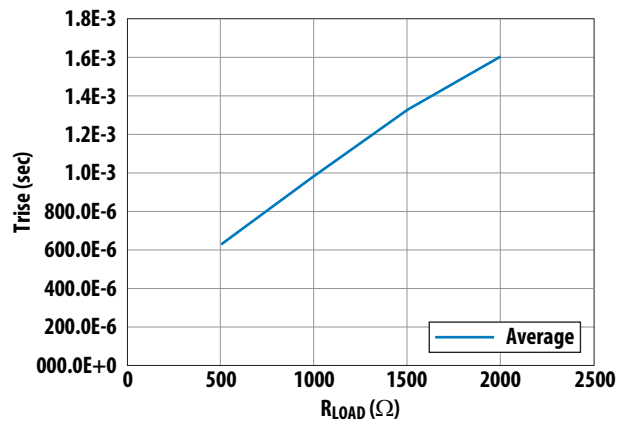
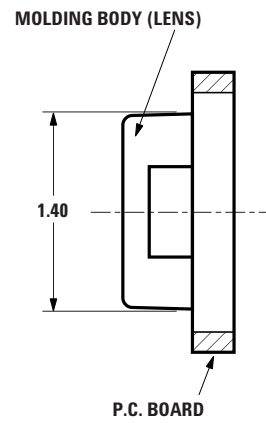
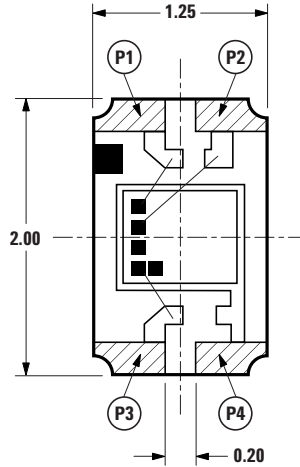
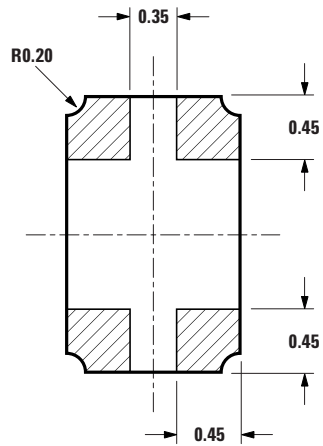


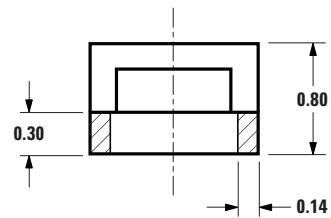
Figure 8. Rise time vs. R_{LOAD} .

APDS-9002 Package Outline

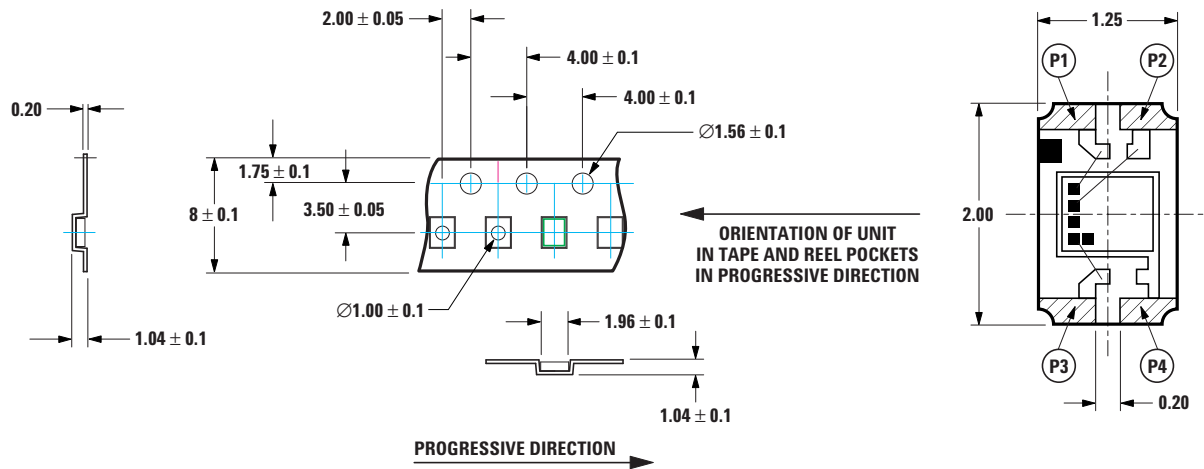


UNITS: in mm
TOLERANCE: ± 0.2 mm

PIN 1: IOUT
PIN 2: VCC
PIN 3: VCC
PIN 4: NC (NO CONNECT)



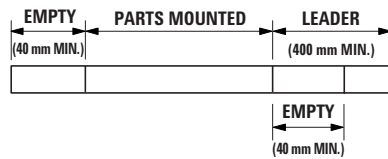
APDS-9002 Tape and Reel Dimensions



MATERIAL OF CARRIER TAPE: CONDUCTIVE POLYSTYRENE

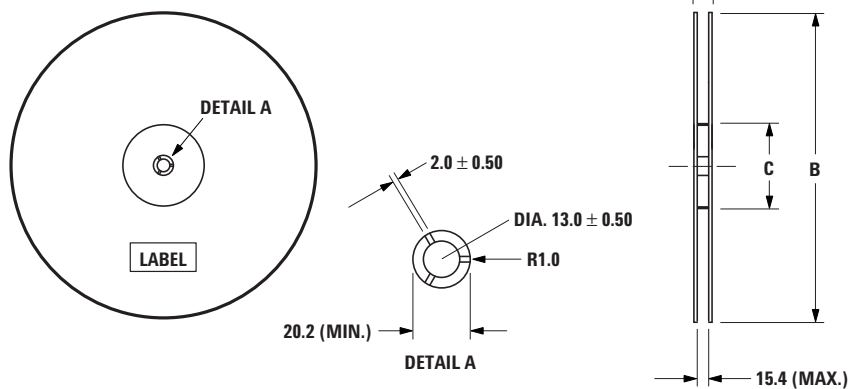
MATERIAL OF COVER TAPE: PVC

METHOD OF COVER: HEAT SENSITIVE ADHESIVE



| "B" | "C" |
|-----|-----|
| 178 | 75 |

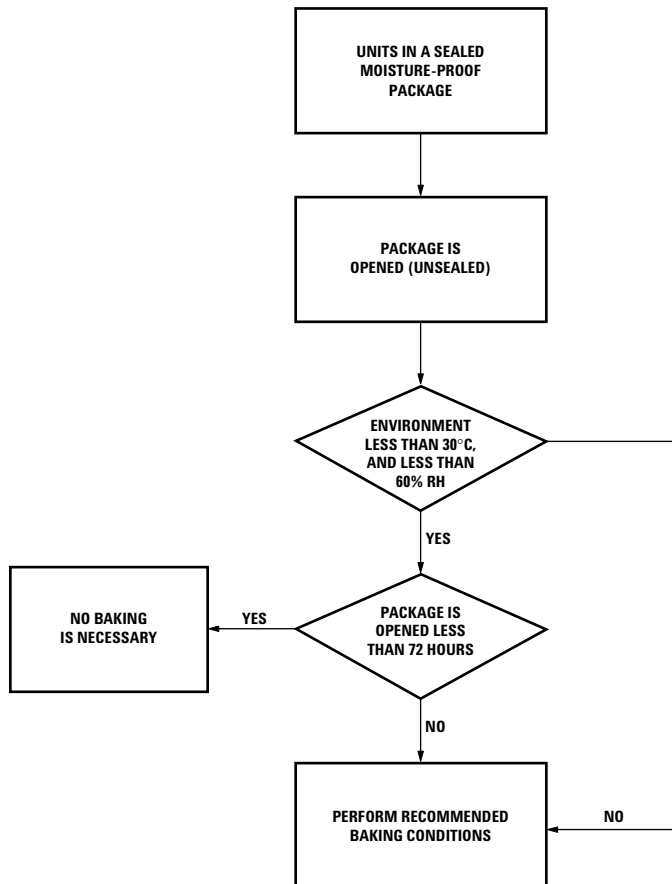
UNIT: mm



Moisture Proof Packaging

All APDS-9002 options are shipped in moisture proof package. Once opened, moisture absorption begins.

This part is compliant to JEDEC Level 4.



Baking Conditions

If the parts are not stored in dry conditions, they must be baked before reflow to prevent damage to the parts.

| Package | Temp. | Time |
|----------|--------|----------|
| In Reels | 60° C | 20 hours |
| In Bulk | 125° C | 5 hours |

Baking should only be done once.

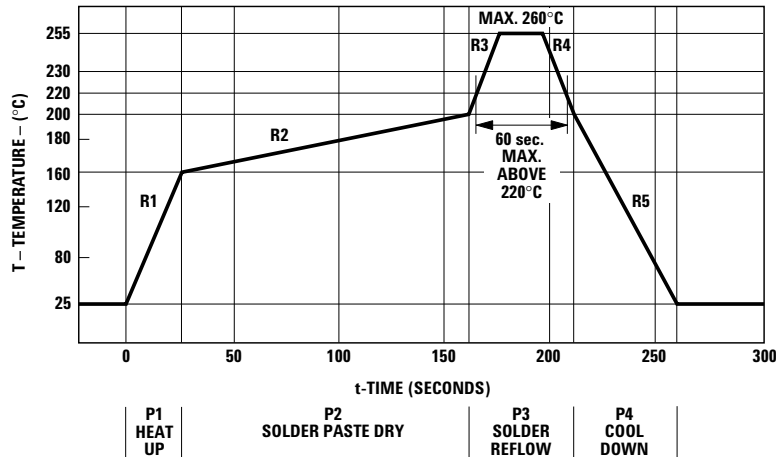
Recommended Storage Conditions

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

Time from Unsealing to Soldering

After removal from the bag, the parts should be soldered within three days if stored at the recommended storage conditions. If times longer than three days are needed, the parts must be stored in a dry box.

Recommended Reflow Profile



| Process Zone | Symbol | ΔT | Maximum $\Delta T/\Delta \text{Time}$ |
|------------------|--------|--|---------------------------------------|
| Heat Up | P1, R1 | 25° C to 160° C | 4°C/s |
| Solder Paste Dry | P2, R2 | 160° C to 200° C | 0.5°C/s |
| Solder Reflow | P3, R3 | 200° C to 255° C (260° C at 10 seconds max.) | 4°C/s |
| | P3, R4 | 255° C to 200° C | -6°C/s |
| Cool Down | P4, R5 | 200° C to 25° C | -6°C/s |

The reflow profile is a straightline representation of a nominal temperature profile for a convective reflow solder process. The temperature profile is divided into four process zones, each with different $\Delta T/\Delta \text{time}$ temperature change rates. The $\Delta T/\Delta \text{time}$ rates are detailed in the above table. The temperatures are measured at the component to printed circuit board connections.

In **process zone P1**, the PC board and APDS-9002 castellation pins are heated to a temperature of 160° C to activate the flux in the solder paste. The temperature ramp up rate, R1, is limited to 4° C per second to allow for even heating of both the PC board and APDS-9002 castellations.

Process zone P2 should be of sufficient time duration (60 to 120 seconds) to dry the solder paste. The temperature is raised to a level just below the liquidus point of the solder, usually 200° C (392° F).

Process zone P3 is the solder reflow zone. In zone P3, the temperature is quickly raised above the liquidus point of solder to 255° C (491° F) for optimum results. The dwell time above the liquidus point of solder should be between 20 and 60 seconds. It usually takes about 20 seconds to assure proper coalescing of the solder balls into liquid solder and the formation of good solder connections. Beyond a dwell time of 60 seconds, the intermetallic growth within the solder connections becomes excessive, resulting in the formation of weak and unreliable connections. The temperature is then rapidly reduced to a point below the solidus temperature of the solder, usually 200° C (392° F), to allow the solder within the connections to freeze solid.

Process zone P4 is the cool down after solder freeze. The cool down rate, R5, from the liquidus point of the solder to 25° C (77° F) should not exceed 6° C per second maximum. This limitation is necessary to allow the PC board and APDS-9002 castellations to change dimensions evenly, putting minimal stresses on the APDS-9002.

Appendix A: SMT Assembly Application Note

Avago APDS-9002: Miniature Surface-Mount Ambient Light Sensor

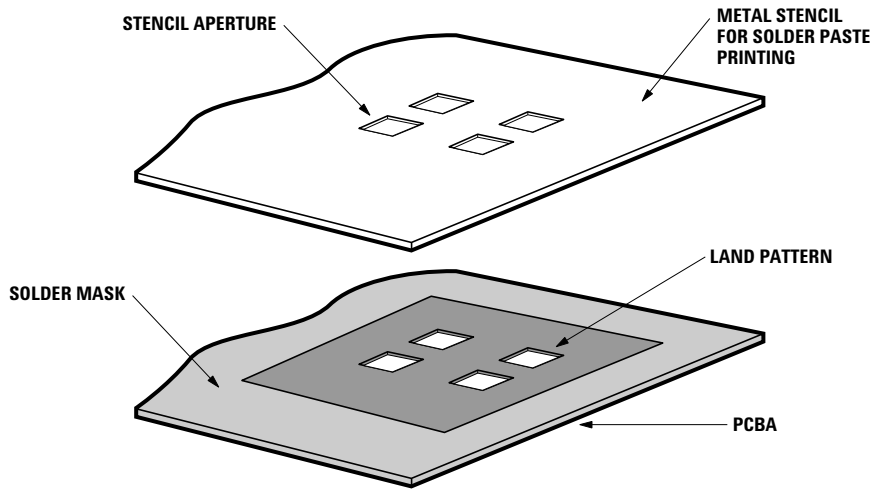
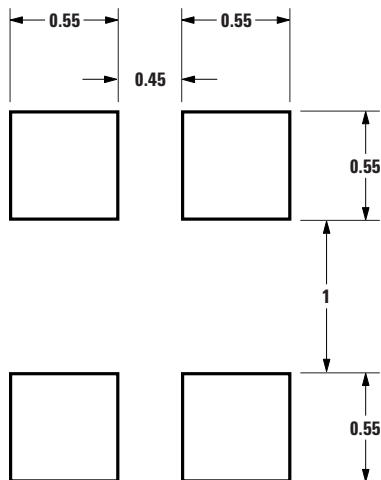


Figure 9. Stencil and PCBA.

1.1 Recommended Land Pattern



1.2 Recommended Metal Solder Stencil Aperture

It is recommended that a 0.10 mm (0.004 inches) thick stencil be used for solder paste printing. Aperture opening for shield pad is 0.6 mm x 0.6 mm. This is to ensure adequate printed solder paste volume and no shorting.

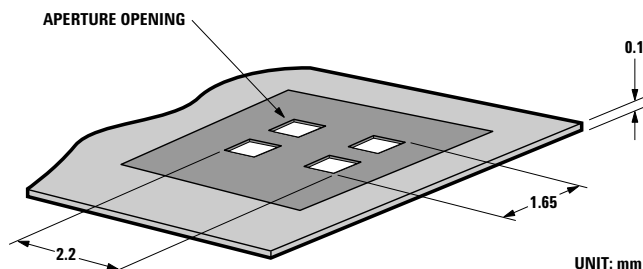


Figure 10. Solder stencil aperture.

1.3 Adjacent Land Keepout and Solder Mask Areas

Adjacent land keep-out is the maximum space occupied by the unit relative to the land pattern. There should be no other SMD components within this area.

The minimum solder resist strip width required to avoid solder bridging adjacent pads is 0.2 mm.

Note: Wet/Liquid Photo-Imageable solder resist/mask is recommended.

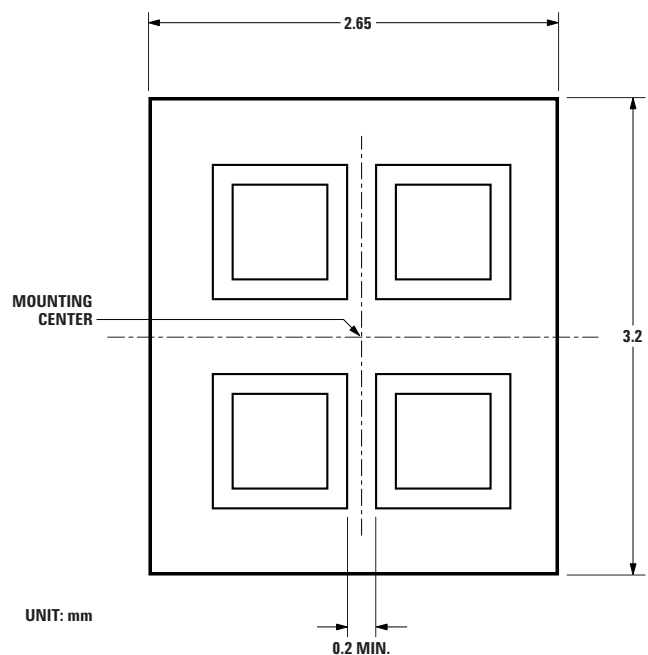


Figure 11. Adjacent land keepout and solder mask areas.

Appendix B: Optical Window Design for APDS-9002

2.0 Optical Window Dimensions

To ensure that the performance of the APDS-9002 will not be affected by improper window design, there are some constraints on the dimensions and design of the window. There is a constraint on the minimum size of the window, which is placed in front of the photo light sensor, so that it will not affect the angular response of the APDS-9002. This minimum dimension that is recommended will ensure at least a $\pm 35^\circ$ light reception cone.

If a smaller window is required, a light pipe or light guide can be used. A light pipe or light guide is a cylindrical

piece of transparent plastic, which makes use of total internal reflection to focus the light. The thickness of the window should be kept as minimum as possible because there is a loss of power in every optical window of about 8% due to reflection (4% on each side) and an additional loss of energy in the plastic material.

Figures 12(a) and 12(b) illustrate the two types of windows that we have recommended which could either be a flat window or a flat window with light guide.

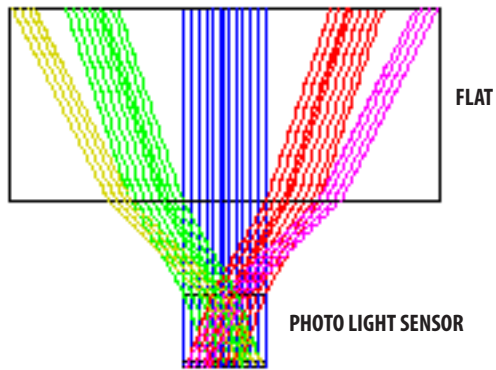


Figure 12(a). Window size determination for flat window.

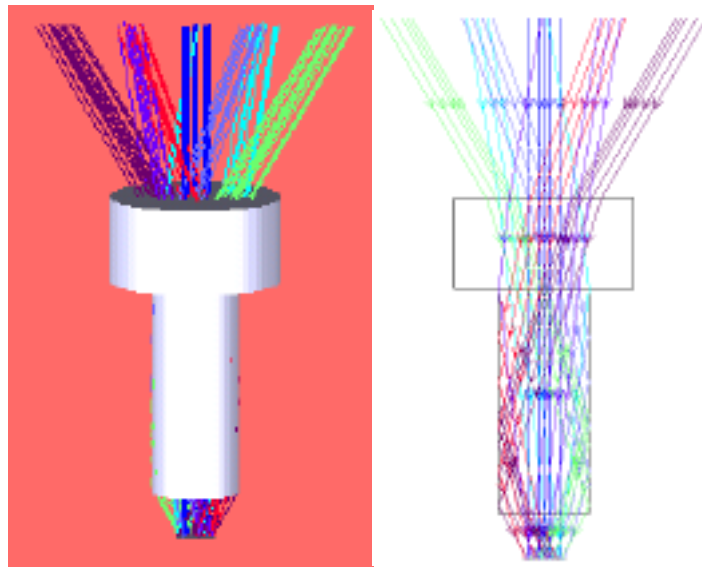


Figure 12(b). Window design of flat window with light guide.

Table 1 and Figure 13 below show the recommended dimensions of the window. These dimension values are based on a window thickness of 1.0 mm with a refractive index 1.585.

The window should be placed directly on top of the photo light sensor to achieve better performance and if a flat window with a light pipe is used, dimension D2 should be 1.5 mm to optimize the performance of APDS-9002.

Table 1. Recommended Dimension for Optical Window

All dimensions are in mm

| WD (T+L+Z) | Flat Window (L = 0.0) | | Flat Window with Light Pipe (D2 = 1.5; Z = 0.5) | |
|---------------|--------------------------|------|---|-----|
| | Z | D1 | D1 | L |
| 1.5 | 0.5 | 2.25 | – | – |
| 2.0 | 1.0 | 3.25 | – | – |
| 2.5 | 1.5 | 4.25 | – | – |
| 3.0 | 2.0 | 5.00 | 2.5 | 1.5 |

2.1 Optical Window Material

The material of the window is recommended to be polycarbonate. The surface finish of the plastic should be smooth, without any texture.

The recommended plastic material for use as a window is available from Bayer AG and Bayer Antwerp N. V. (Europe), Bayer Corp. (USA) and Bayer Polymers Co., Ltd. (Thailand), as shown in Table 2.

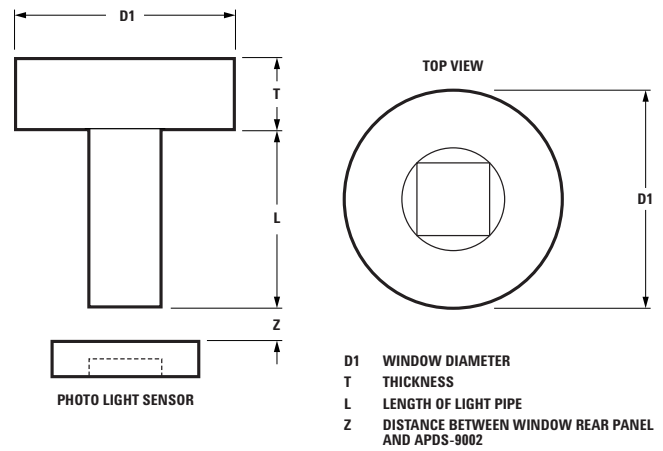


Figure 13. Recommended window dimensions.

Table 2. Recommended Plastic Materials

| Material Number | Visible Light Transmission | Refractive Index |
|-----------------|----------------------------|------------------|
| Makrolon LQ2647 | 87% | 1.587 |
| Makrolon LQ3147 | 87% | 1.587 |
| Makrolon LQ3187 | 85% | 1.587 |

Appendix C: General Application Guide for APDS-9002

The APDS-9002 is a low cost analog-output ambient light photo sensor which spectral response closely emulates the human eyes. APDS-9002 consists of a phototransistor that enables the photo sensor to produce a high gain photo current to a sufficient level that can be converted to voltage with a standard value of external resistor. APDS-9002 is then easily integrated into systems that use ADC input which is available for sampling of the external source, as shown in Figure 14 below.

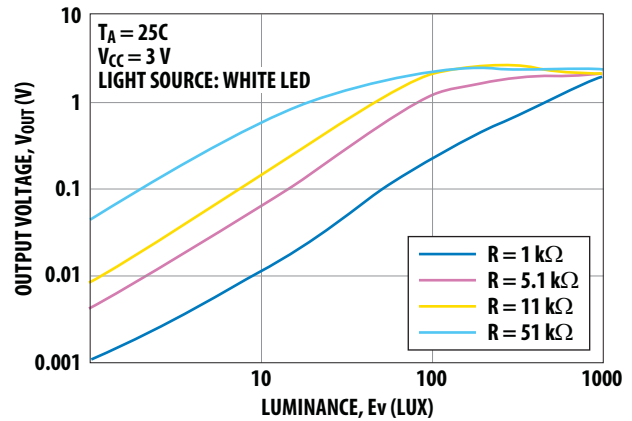
Selection of the load resistor R_L will determine the amount of current-to-voltage conversion in the circuit. Based on Figure 14 and using white LED as the light source, measurement has been carried out by using different load resistors to examine the variation of the output voltage towards the intense of LUX. The result is shown in Graph 1. APDS-9002 allows output voltage hits around 2.3 V, after this it saturates.

Light source, e.g., fluorescent light, consists of ac noise about 100 Hz frequency. A capacitor of 10 μ F, which acts as a low-pass filter, is recommended to add in parallel with resistor to by-pass the ripples.

The amount of converted voltage, V_{OUT} , is mainly dependant proportionally on the photo current which is generated by the brightness of the light shone on the

photo sensor and the load resistor used, R_L . Increasing the brightness of the light and/or the load resistor will increase the output voltage.

Brightness is measured as "LUX" unit, which describes how intense a light source that our eyes perceive. LUX meter is the equipment for "LUX" measurement. Light sources with the same LUX level appear at the same brightness to the human eyes.



Graph 1. Output voltage vs. luminance at different load resistor.

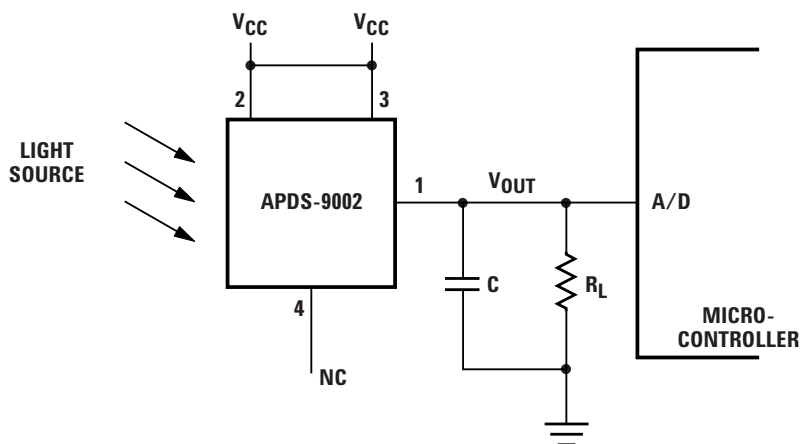


Figure 14. Configuration of APDS-9002 being used directly.

Avago has fabricated an evaluation board based on the configuration shown in Figure 14 for the designer to test the ambient light sensor under different lighting conditions. A reference layout of a 2-layer Avago evaluation board for APDS-9002 is shown in Figure 15 below.

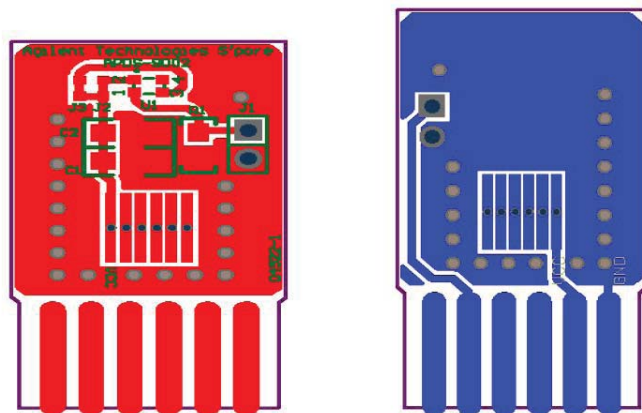


Figure 15. Evaluation board layout.

For product information and a complete list of distributors, please go to our web site: www.avagotech.com

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