APDS-9003

Miniature Surface-Mount Ambient Light Photo Sensor

Data Sheet

Description

The APDS-9003 is a low cost analog-output ambient light photo sensor in miniature chipLED lead-free surface mount package. It consists of a spectrally suited photo sensor, which provides excellent responsivity that is close to the response of the human eyes, as shown in figure 2. The APDS-9003 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.

Application Support Information

The Application Engineering Group is available to assist you with the application design associated with APDS-9003 ambient light photo sensor module. You can contact them through your local sales representatives for additional details.

Features

- Excellent responsivity
  Close responsivity to the human eye
- Miniature ChipLed Leadfree surface-mount package:
  Height – 0.55mm
  Width – 1.60mm
  Depth – 1.50mm
- Low sensitivity variation across various light sources
- Operating temperature: -40^{0}C to 85^{0}C
- Vcc supply 2.4 to 5.5V
- ROHS compliant and 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

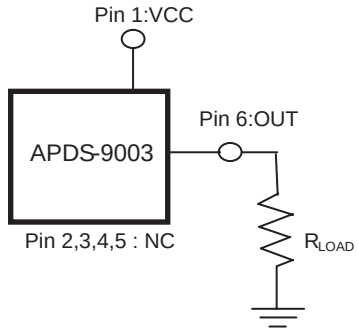
Ordering Information

Part Number	Packaging Type	Package	Quantity	Remarks
APDS-9003-020	Tape and Reel	6-pins Chipled package	2500	No Binning

Binning Available

Other binning options are available. Please contact your Avago Technologies representative for information on current available bins

Typical Application Circuit



Component	Recommended Application Circuit Component
Rload	1kΩ

Figure 1: Typical application circuit for APDS-9003

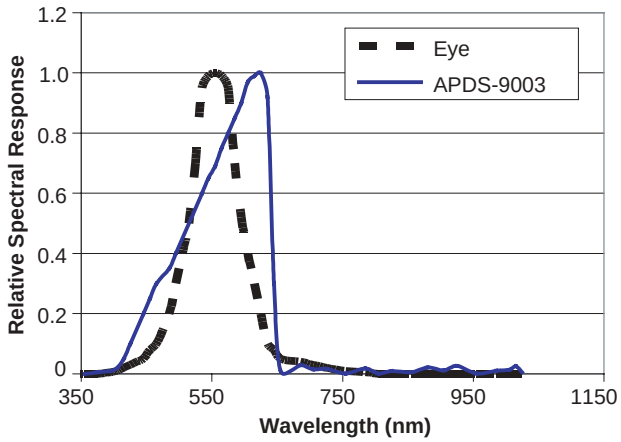


Figure 2: Relative Spectral Response Vs Wavelength

I/O Pins Configuration Table

Pin	Symbol	Description
1	VCC	VCC
2	NC	No Connect
3	NC	No Connect
4	NC	No Connect
5	NC	No Connect
6	Out	Out

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units
Storage Temperature	T_S	-40	85	°C
Supply Voltage	V_{CC}	0	6	V

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.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Conditions
Operating Temperature	T_A	-40	85	°C	
Supply Voltage	V_{CC}	2.4	5.5	V	

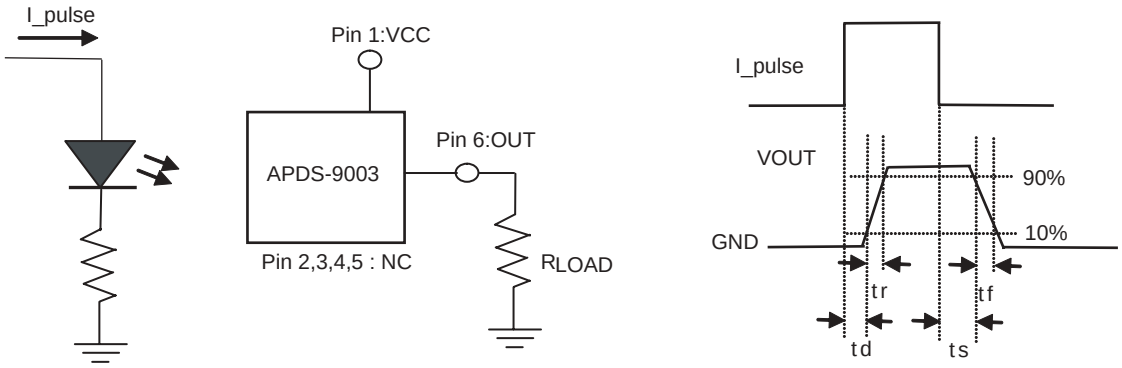
Electrical & Optical Specifications (Ta=25°C)

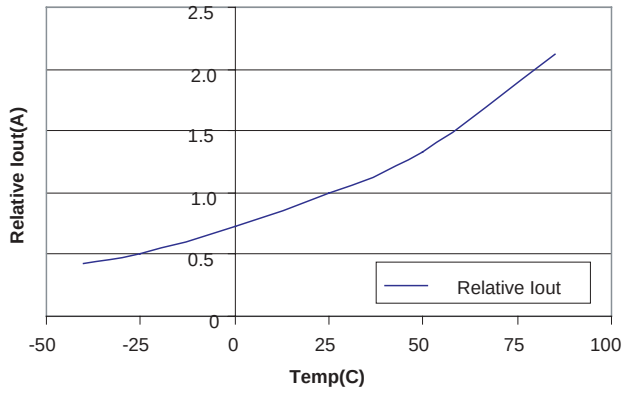
Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Current [4]	I_OUT1	6.3	19	31	uA	Vcc=3.0V,Lux=10 [Note 2]
Output Current [4]	I_OUT2	90	230	370	uA	Vcc=3.0V,Lux=100 [Note 2]
Output Current [4]	I_OUT3	-	276	-	uA	Vcc=3.0V,Lux=100 [Note 1]
Dark Current	I_DARK	-	50	160	nA	Vcc=3.0V,Lux=0
Light Current Ratio	I_OUT3 / I_OUT2	-	1.2	-	-	-
Rise Time	Tr	-	0.95	2	ms	Vcc=3.0V,Lux=100,Rload=1k [Note 3]
Fall Time	Tf	-	0.8	2	ms	Vcc=3.0V,Lux=100,Rload=1k [Note 3]
Supply Current	Icc	-	2.5	-	mA	Vcc=3.0V, LUX=1K [Note 3]
Saturation Output Voltage	Vo	2.2	2.32	-	V	Vcc=3.0V, LUX=100, Rload=1M
Peak Sensitivity Wavelength		-	620	-	nm	
Propagation Delay time	td	-	600	-	us	Vcc=3.0V, LUX=100,Rload=1k
Storage Delay time	ts	-	200	-	us	Vcc=3.0V, LUX=100,Rload=1k

Note:

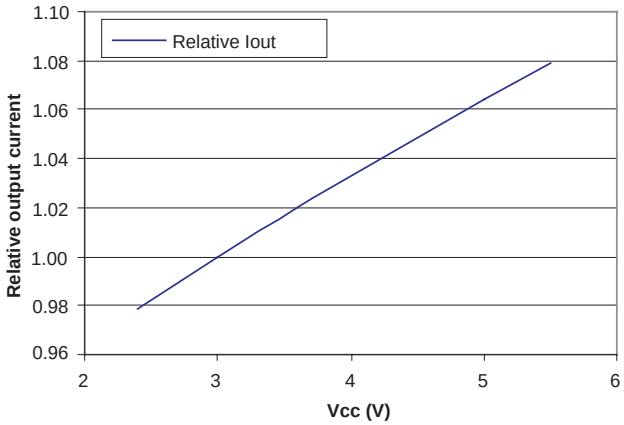
1. Illuminance by CIE standard light source (Incandescent lamp)
2. Fluorescent light is used as light source. White LED is substituted in mass production.
3. White LED is used as light source.
4. Other binning options are available. Please contact your Avago Technologies representative for information on current available bins

Light Measurement Circuit and Waveforms

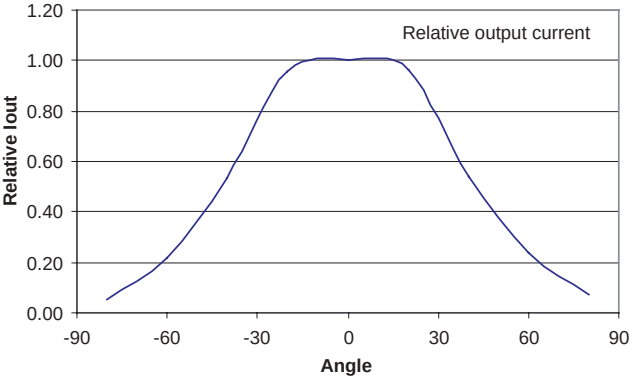




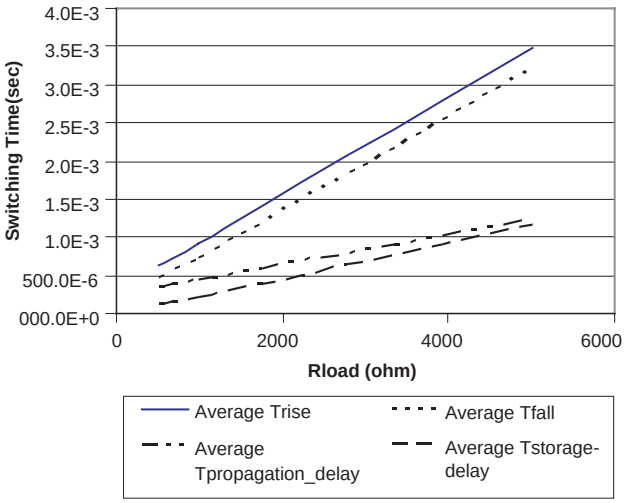
Relative Output Current Vs Temp (Vcc = 3.0V, 100 Lux)



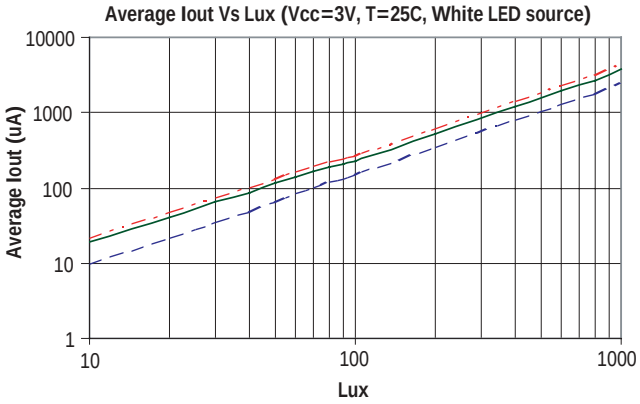
Relative Output Current Vs Vcc (Ta =25C, 100 Lux)

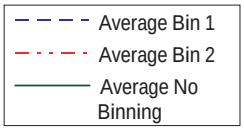


Relative Iout Vs Angle (Vcc=3V, Ta=25C)



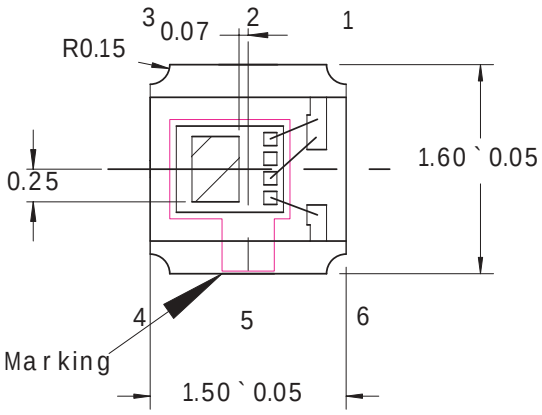
Switching Charecteristics (TA = 25C, Vcc = 3V)





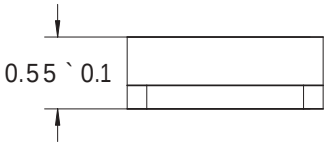
Average Iout Vs Lux (Vcc = 3V, T = 25C, White LED source)

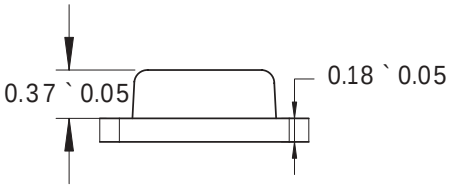
APDS-9003 Package Outline

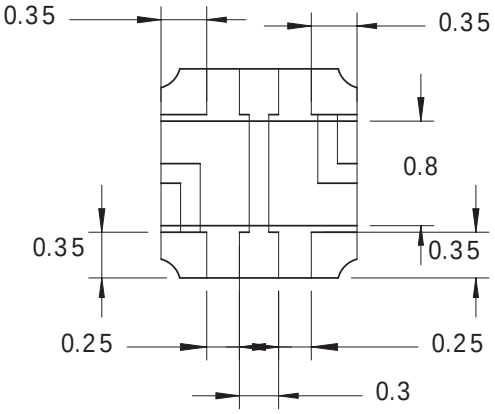


Unit : mm
Tolerance : ` 0.1

Light receiving area
(0.505mm x 0.360mm)



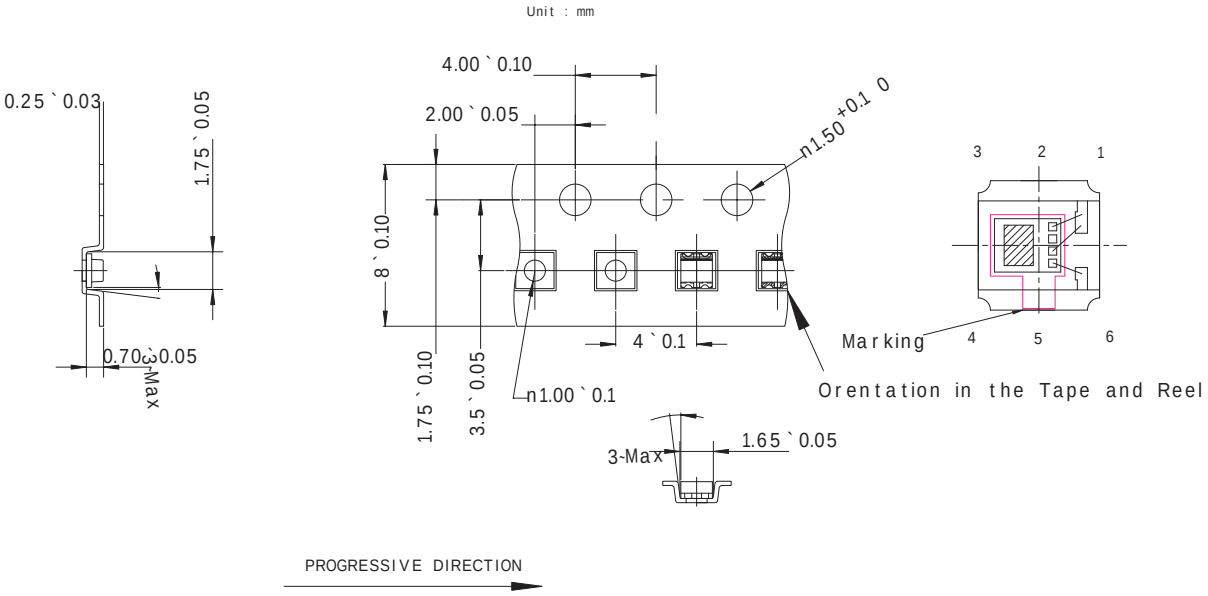




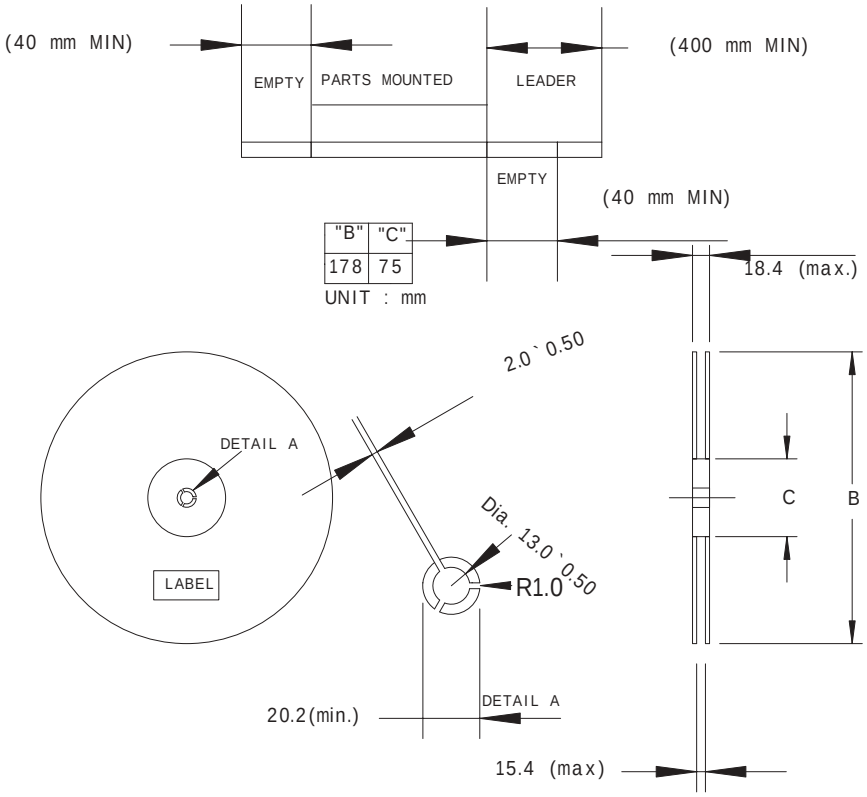
Pin Configuration

1. VCC
2. NC
3. NC
4. NC
5. NC
6. OUT

APDS-9003 Tape and Reel Dimension

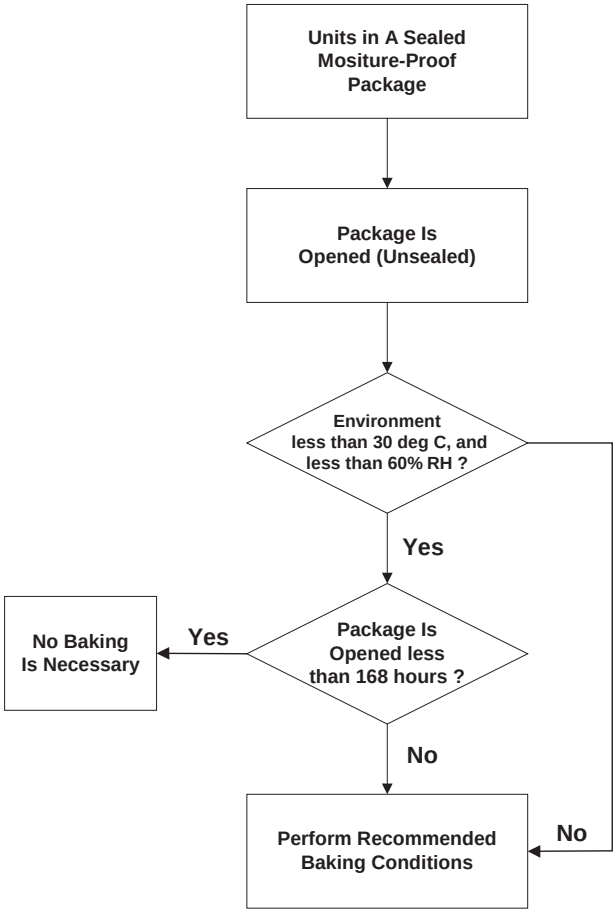


Material of Carrier Tape : Conductive Polystrene
Material of Cover Tape : PVC
Method of Cover : Heat Sensitive Adhesive



Moisture Proof Packaging

All APDS-9003 options are shipped in moisture proof package. Once opened, moisture absorption begins. This part is compliant to JEDEC Level 3.



Baking Conditions:

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

Package	Temperature	Time
In Reel	60°C	48 hours
In Bulk	100°C	4 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 168 hours if stored at the recommended storage conditions. If times longer than 168 hours are needed, the parts must be stored in a dry box.

Recommended Reflow Profile

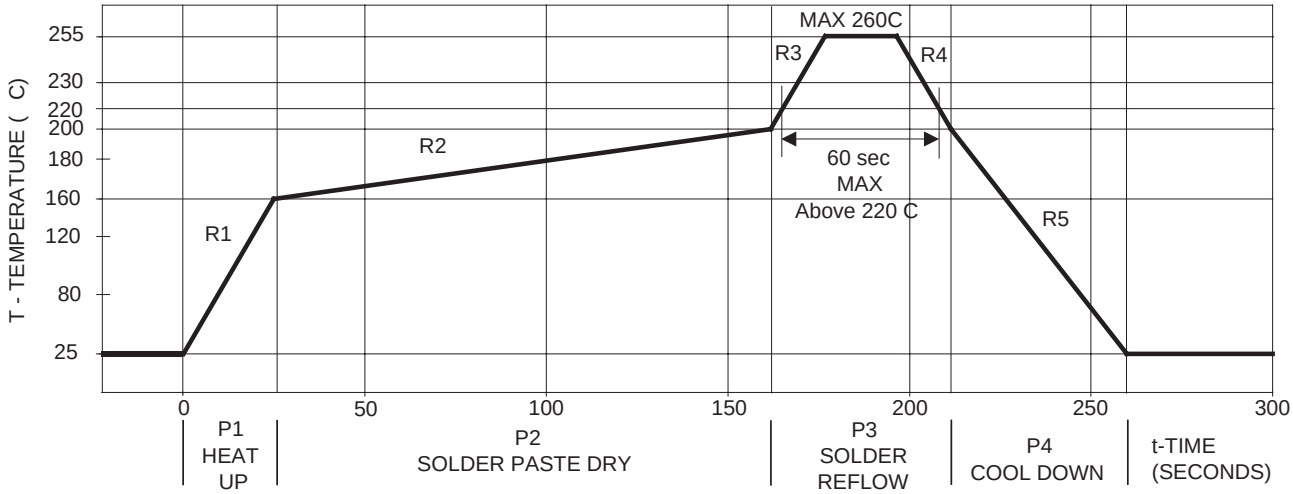
The reflow profile is a straight-line representation of a nominal temperature profile for a convective reflow solder process. The temperature profile is divided into four process zones, each with different DT/Dtime temperature change rates. The DT/Dtime rates are detailed in the above table. The temperatures are measured at the component to printed circuit board connections.

In process zone P1, the PC board and APDS-9003 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-9003 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-9003 castellations to change dimensions evenly, putting minimal stresses on the APDS-9003.



Process Zone	Symbol	ΔT	Maximum ΔT/ 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 P3, R4	200°C to 255°C (260°C at 10 seconds max) 255°C to 200°C	4°C/s -6°C/s
Cool Down	P4, R5	200°C to 25°C	-6°C/s

Appendix A: SMT Assembly Application Note

1.0 Solder Pad, Mask and Metal Stencil Aperture

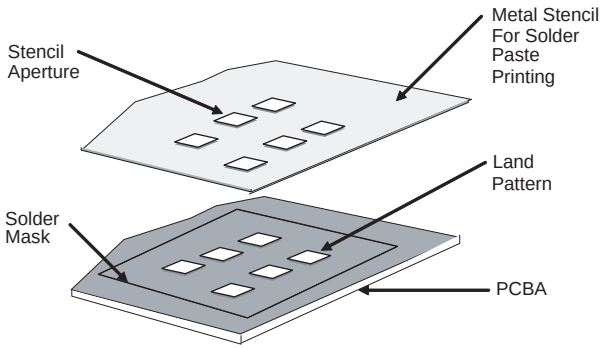


Figure 1: Stencil and PCBA

1.1 Recommended Land Pattern

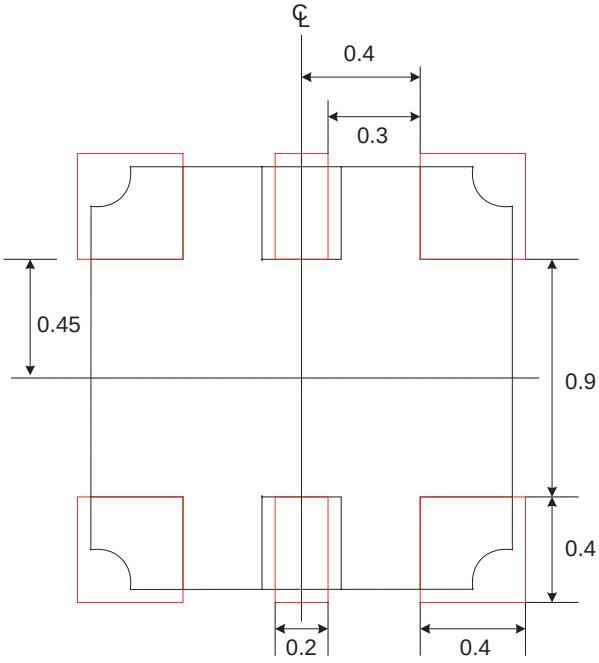


Figure 2: Recommended Land Pattern

1.2 Recommended Metal Solder Stencil Aperture

It is recommended that a 0.11 mm (0.004 inches) thick stencil be used for solder paste printing. Aperture opening for shield pad is 0.4mm x 0.4mm and 0.2mm x 0.4mm (as per land pattern). This is to ensure adequate printed solder paste volume and no shorting.

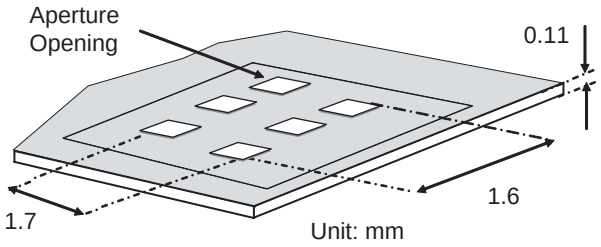


Figure 3: Solder Stencil Aperture

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.

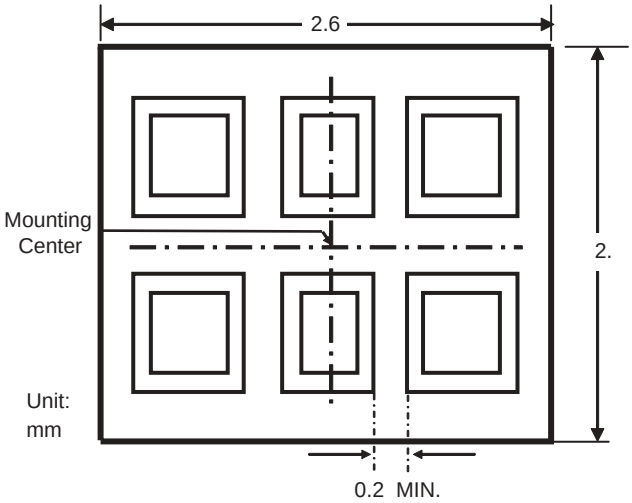


Figure 4: Adjacent Land Keepout and Solder Mask Areas

Appendix B: Optical Window Design for APDS-9003

2.0 Optical Window Dimensions

To ensure that the performance of the APDS-9003 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-9003. This minimum dimension that is recommended will ensure at least a ±35° 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.

Figure 5a and 5b illustrate the two types of window that we have recommended which could either be a flat window or a flat window with light pipe.

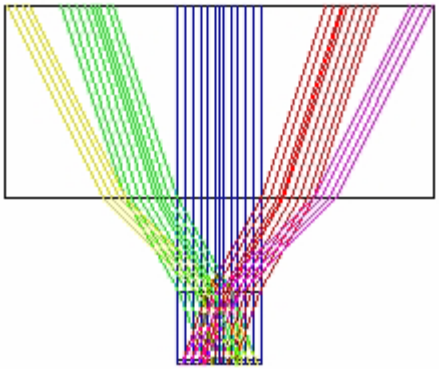


Figure 5(a): Window Size Determination for Flat Window

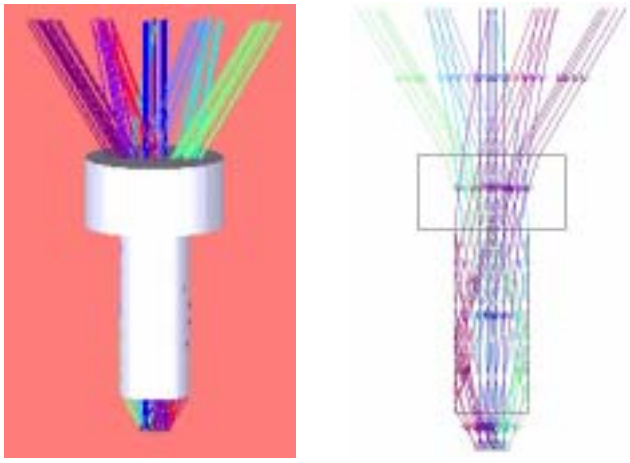


Figure 5(b): Window Design of Flat Window with Light Guide

Table 1 and Fgure 6 below show the recommended dimensions of the window. These dimension values are based on a window thickness of 1.0mm with a refractive index 1.585.

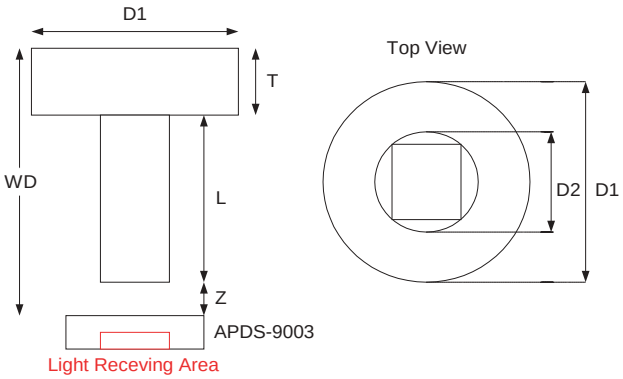


Figure 6: Recommended Window Dimensions

WD: Working Distance between window front panel & APDS-9003

D1: Window Diameter

T: Thickness

L: Length of Light Pipe

D2: Light Pipe Diameter

Z: Distance between window rear panel and APDS-9003

Table 1: Recommended dimension for optical window

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

All dimensions are in mm

The window should be placed directly on top of the photo sensor to achieve better performance and if a flat window with a light pipe is used, dimension D2 should be 1.5mm to optimize the performance of APDS-9003.

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.

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-9003

The APDS-9003 is a low cost analog-output ambient light photo sensor whose spectral response closely emulates the human eyes. APDS-9003 consists of a photo sensor that is able 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-9003 can easily be integrated into systems that use ADC input which is available for sampling of the external source, as shown in figure 7 below.

The amount of converted voltage, Vout, is mainly dependant proportionally on the photo current which 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 or/and 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.

Selection of the load resistor R_L will determine the amount of current-to-voltage conversion in the circuit. APDS-9003 allows a saturation output voltage of typically 2.32V @ VCC=3V.

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

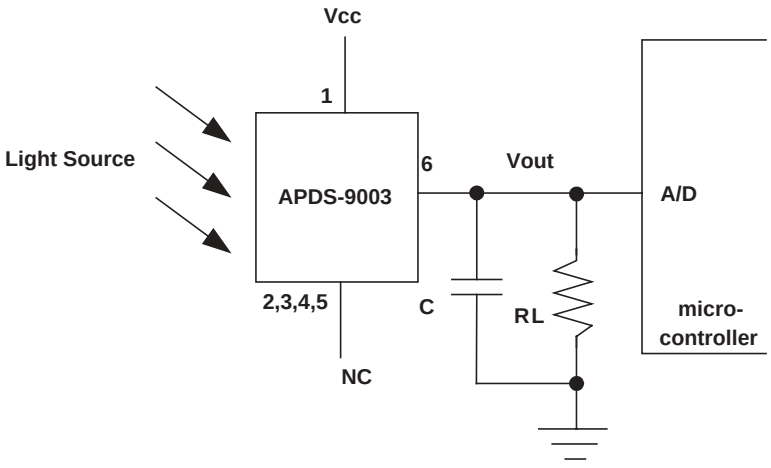


Figure 7: Configuration of APDS-9003

Avago, Avago Technologies, and the A logo are trademarks of Avago Technologies, Pte. in the United States and other countries.
Data subject to change. Copyright © 2006 Avago Technologies Pte. All rights reserved.
AV01-0238EN - June 8, 2006