ADNS-9800

Eye Safety Calculations

Application Note 5541

Lead (Pb) Free
RoHS 6 fully compliant

Introduction

The eye safety calculations presented in this application note apply to the Avago Technologies' ADNS-9800 sensor and ADNS-6190-002 lens.

As the ADNS-9800 navigation system contains a laser, eye safety analysis and hazard classification is important. The manufacturer of the final system, not the manufacturer of the individual pieces, holds the responsibility of final product classification. Since Avago Technologies, manufactures the above components and not the final product sold to consumers, Avago Technologies is not responsible for final classification. This document is provided as a convenience to aid the final manufacturer in product classification.

Avago Technologies calibrates the sensor's laser output power (LOP) to Class 1 Eye Safety level and store the registers values that control the LOP prior shipping out, thus no LOP calibration is required in complete mouse system at manufacturer site. ADNS-9800 sensor is designed to maintain the laser output power using ADNS-6190-002 lens within Class 1 Eye Safety requirements over components manufacturing tolerances under the recommended operating conditions and application circuits of Figure 6 as specified in the ADNS-9800 datasheet. Under normal operating conditions, the sensor generates the drive current for the VCSEL. Increasing the LOP by other means on hardware and software can result in a violation of the Class 1 eye safety limit of 716μW.

The International Electrotechnical Commission (IEC) governs standardization for electrical and electronic fields. Optical radiation (eye) safety limits and classification levels are specified in IEC 60825-1, Edition 1.2, 2001-08. This will be referred to as the IEC document in the rest of this document. To determine the eye safety limits for the optical output of the VCSEL (laser), which is integrated in the sensor package mounted in an assembly including a lens, several factors need to be known.

1. The apparent source size (or equivalent angular subtense of the source)
2. The wavelength of the VCSEL.
3. The appropriate emission or exposure time.

Source Angular Subtense Angle (α) or Apparent Source Size Measurement

The source angular subtense α for the spectral range of interest is specified in the IEC document (page 31) as:

"For the determination of the AEL retinal thermal hazard limits (400 nm to 1400 nm), the value of the angular subtense of a rectangular or linear source is determined by the arithmetic mean of the two angular dimensions of the source. Any angular dimension that is greater than αmax or less than αmin shall be limited to αmax or αmin respectively, prior to calculating the mean"

In the optical design of the ADNS-6190-002 lens, the emitted beam size is collimated with approximately 2mm diameter beam (see section "Measuring the Beam size"). Since the beam is collimated, the optical equivalent is an extended source of approximately 2.0mm at a very large (theoretically infinite) distance. The angular subtense of such a source is infinitesimally small. Therefore, the source is considered to be a small source (IEC document, clause 3.79, definition of small source). For such a source, the angular subtense is taken to be 1.5 mrad (milliradians), equivalent to a source of 150 mm in linear extent. The derived value of the C_6 parameter is 1.0. (IEC document, Table 4 Note 2, page 40)

For further determination of the AEL and MPE, αmin will be used to determine which equations to use; yet the actual value is independent of α and therefore no measurements for the exact apparent source size need to be performed.

Calculating the Accessible Exposure Limits (AEL)

Since the VCSEL wavelength range is specified in the ADNS-9800 datasheet as 832 to 865nm, only the thermal limits apply for this VCSEL, not the photochemical. To determine which set of equations to use, t (appropriate exposure time for MPE; appropriate emission time for AEL) must also be known.

The IEC document (Section 8.4e, page 31) specifically discusses the time base for these calculations. For wavelengths of greater than 400nm with Class 1 intention, 100 seconds is used for t, exposure time.

From Table 1, page 37 of the IEC document, "Accessible emission limits for Class 1 and Class 1M laser products", there are three different formulas for the allowed thermal energy when the exposure time is greater than 10 seconds and the illumination wavelength is between 700 and 1050 nm:

$3.9 \times 10^{-4} C_4 C_7$ W
If $t > T_2$ and $\alpha \leq 1.5$mrad (1)

$7 \times 10^{-4} C_4 C_6 C_7 T_2^{-25.0}$ W
If $t > T_2$ and $\alpha > 1.5$ mrad (2)

Or

$7 \times 10^{-4} t^{0.75} C_4 C_6 C_7$ J
If $t \leq T_2$ (3)

Since the value for t defaults to 100 seconds, T_2 must be calculated to determine which formula (1, 2, or 3 above) is to be used. From the IEC document (page 40, Note 2a) for the wavelength range of 400 to 1400 nm:

$T_2 = 10$ s
If $\alpha < 1.5$ mrad (4)

$T_2 = 10 \times 10^{[(\alpha-\alpha min)/98.5]}$ s
If 1.5 mrad $< \alpha <$ 100 mrad (5)

$T_2 = 100$ s
If $\alpha > 100$ mrad (6)

As discussed, α is less than 1.5 mrad, so equation 4 then determines T_2 to be 10 seconds.

Since the measurement time t is greater than 10 seconds, and therefore T_2 is less than t, formula 1 is used to determine the AEL.

$3.9 \times 10^{-4} C_4 C_7$ W

To continue with the calculation of the AEL, C_4 and C_7 need to be determined. C_7 for the range of 700 to 1150 nm is set to 1 (IEC document, page 40, Note 2). An equation defines C_4 for the spectral region from 700 to 1050nm (IEC document, page 40, note 2). Using $\lambda = 832$ nm, the minimum and therefore worst case value in the range from the ADNS-9800 sensor datasheet, the value of C_4 is calculated:

$C_4 = 10^{\,0.002(\lambda-700)}$
$= 10^{\,0.002(832-700)}$
$= 1.8365$ (7)

Substituting into the equation 1 above, the Accessible Emission Limit (AEL) allowed for the ADNS-9800 and ADNS-6190-002 navigation system to meet Class 1 is:

AEL = 716 μW *

This value therefore is the limit for the device to be Class 1, its emission must be less than or equal to this value (IEC document, 9.2g, page 33).

Class 1M is another level of classification that under acceptable conditions, might allow for a greater emission limit. This classification does not apply to the design. Two options are given per the standard (IEC document, section 8.2, page 28). One option is for a diverging beam, which does not apply. The second valid option applies to collimated beams where the diameter is larger than the stated 50mm aperture stop determined from IEC document, Table 10, page 35. This also does not apply in the given case; therefore Class 1M is not an applicable standard for the navigation system of ADNS-9800 sensor and ADNS-6190-002 lens.

Determining the Maximum Permissible Exposure (MPE)

The Maximum Permissible Exposure value is a critical value that relates to injury studies that have been done on the eye.

"Maximum permissible exposure values are for the users and are set below known hazard levels, and are based on the best available information from experimental studies. The MPE values should be used as guides in the control of exposures" (IEC document, page 49).

To calculate this guideline for ADNS-9800 AND ADNS-6190-002 navigation system, refer to the MPE Table 6 (IEC document, page 53).

As with calculating the AEL, 832 nm is used as the wavelength when referring to the equation table. Exposure time, t, is also necessary again to find the appropriate equations to calculate the MPE from Table 6. Given the same variable options, the equation (labeled 8 below) for $\alpha \leq 1.5$ mrad is once again chosen:

$$10 \times C_4\, C_7\, \mathrm{W} \bullet \mathrm{m}^{-2} \qquad (8)$$

which results in an MPE of 18.37 $\mathrm{W.m}^{-2}$. Assuming a 7 mm diameter aperture (fully dilated human eye), the power through the aperture is 707µW. Given the limited precision (one or two decimal places) of the constants in the formulas, the value of 707µW is essentially the same as the value of 716µW determined through the Class 1 calculation. This is as it should be, since for a product to have a Class 1 classification, a person must not be subjected to an exposure exceeding the MPE.

Measuring the Beam Size

The ADNS-6190-002 lens is placed at a 100 mm standard distance to confirm that αmin is an accurate value for the ADNS-9800 sensor and ADNS-6190-002 lens optical setup. If the diameter of the laser at this distance is significantly less than 7 mm (fully dilated human eye) then it can be claimed with confidence that $\alpha < \alpha_{min}$ and Class 1M does not apply to the ADNS-9800.

For the beam diameter measurement, the camera and sensor fixture should be placed in line with a distance of 100 mm from the camera's imaging surface to the lens surface. Measurements of the VCSEL beam can be taken using Coherent's Beam View Analyzer TM software.

Data gathered from the BeamView Analyzer software reports the effective diameter along with several other characteristics of the single VCSEL beam is shown in Figure 1. The effective diameter at 100 mm measurement distance as specified in the IEC document was measured to be << 7 mm and therefore it can confidently be said that $\alpha < \alpha_{min}$ as well as Class 1M does not apply to the ADNS-9800 sensor and ADNS-6190-002 lens optical setup (IEC document, page 31).

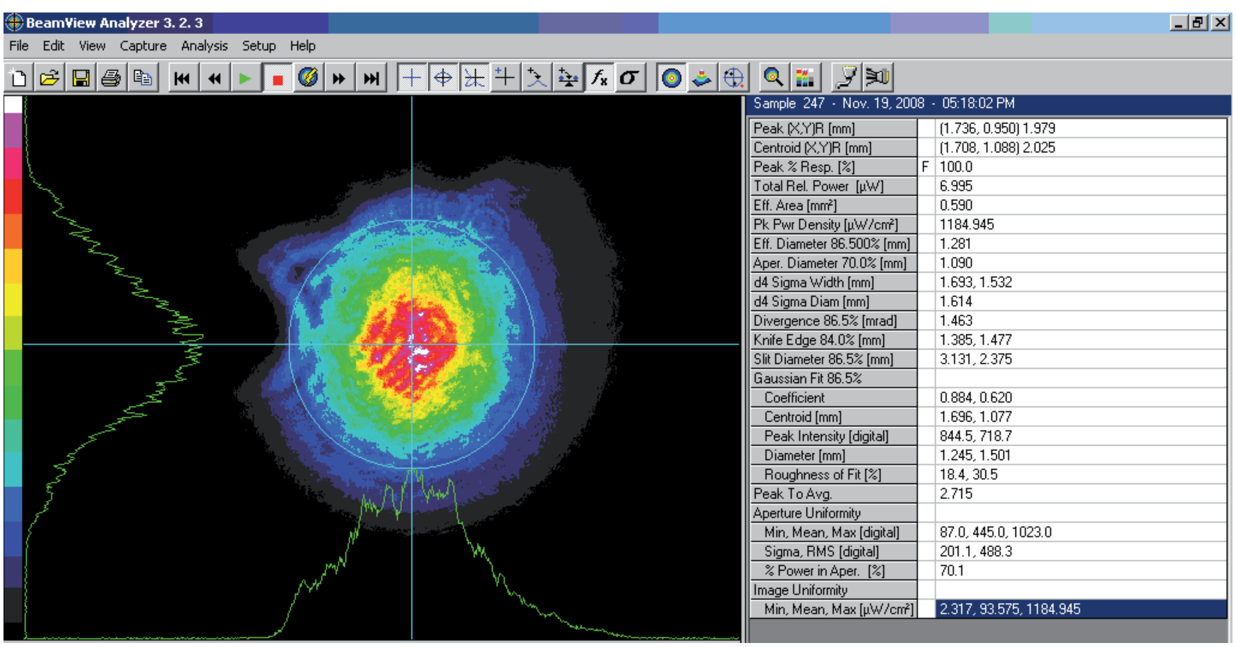

Figure 1. Beam Profile of a representative VCSEL, set at 100mm from the camera at ~506uW

Factors contributing to overall system Class 1 AEL

All factors that contribute to a variance in the light output power (LOP) of the integrated VCSEL must be considered; therefore a target LOP must be set and then a worst-case analysis of the LOP of the integrated VCSEL must be guard-banded. This analysis must prove that the system for ADNS-9800 sensor and ADNS-6190-002 lens, under worst-case conditions, as defined by the datasheet, is still within the Class 1 AEL limit. The factors that contribute to a change in the LOP are discussed below.

1. Integrated VCSEL's Light Output Power (LOP) vs. Current

The integrated VCSEL has a light output (LOP) curve similar to the typical unit data shown below in Figure 2. From this curve it is apparent that the Class 1 AEL limit could be exceeded if the current is not controlled below the necessary limit to make it safe. Avago provides a manufacturing guideline on how to confirm the outgoing product is meeting the eye safety limit on the pre-calibrated ADNS-9800 sensor. This information is included in the ADNS-9800 sensor datasheets. All tolerances in the current control must be factored into a targeted LOP to ensure that the system for ADNS-9800 sensor and ADNS-6190-002 lens will remain within the Class 1 AEL limit.

Following the guidelines in the datasheet is critical to correctly manufacture a Class 1 eye safe product.

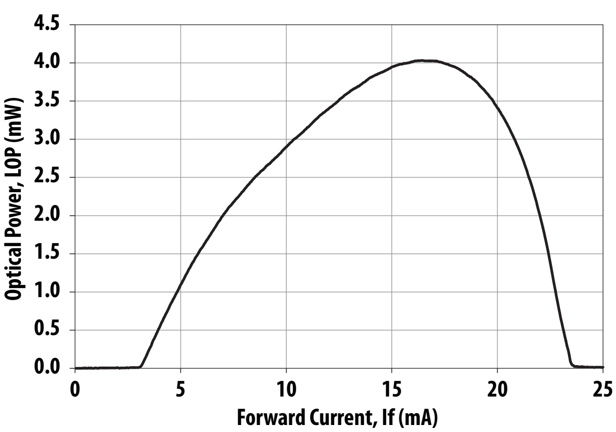

Figure 2. Typical Light Output Power LOP for the Integrated VCSEL in ADNS-9800 sensor Package.

2. Light Output Power vs. Temperature

As discussed in the above section, the LOP is dependant upon the current driving the integrated VCSEL. Temperature is another variable that affects the LOP. In manufacturing, Avago performs tests on the VCSEL and sensor in the ADNS-9800 sensor, which ensure that the change from room temperature to the operating temperature extremes is acceptable.

Avago has designed the laser system to be safe within the operating temperature range of 5 to 40°C for the ADNS-9800 sensor and ADNS-6190-002 lens. It is likely that the system for ADNS-9800 sensor and ADNS-6190-002 lens will exceed the maximum Eye Safety limit on some units if operated outside these temperatures.

Since the temperature of the system for ADNS-9800 sensor and ADNS-6190-002 lens is a function of the system (mouse) design, and the thermal properties of the material that makeup that system, Avago recommends that manufacturers perform testing at the system level to determine the need for any special safety circuitry, or warnings.

Single Fault Considerations

The IEC document specifies that products must be single fault tolerant.

"The above tests shall be made under each and every reasonably foreseeable single-fault condition; however, faults which result in the emission of radiation in excess of the AEL for a limited period only, and for which it is not reasonably foreseeable that human access to the radiation will occur before the product is taken out of service, need not be considered." (IEC document, section 9.1, page 32).

This requirement does not apply to components, but rather to the final product. Listed below are some theoretical single faults. This is not intended to be a complete list, rather a representation of foreseeable faults and their results. The application schematic found in the datasheet for this product will be used as a reference for this discussion. Below is a list of foreseeable faults and associated results.

1. Broken wire on any USB/PS2 cable pin (Power, Ground, Data lines) for corded application: This fault will not increase the VCSEL LOP.
2. A shorted wire between any USB/PS2 cable pins (Power, Ground, Data lines) for corded application: This fault will not increase the VCSEL LOP.
3. Sensor's VDD power supply voltage increase of greater than 50mV above the voltage used during LOP calibration. The lifetime of the mouse bundle may be shortened and the VCSEL drive current may increase; therefore, Technologies advises the manufacturer to take necessary steps to prevent such a voltage increase.
4. Resistive path or short circuit between adjacent sensor pins and test pads on the sensor package as detailed in Figure 3 and Table 1 & Table 2.
5. Short to ground or short to VDD at each sensor pin. See Table 3 & Table 4.
6. ESD event: Tests of the sensor to 2kV (per the human body model) all resulted in safe LOP levels. Avago recommends that the manufacturer:
   - Follow ESD-safe handling manufacturing processes
   - Warn end-users that the mouse is not to be opened or tampered with
   - Provide safety precautions such that if a mouse is opened, the laser current drive is disabled.
   - Design the mouse case and PC board to prevent ESD exposure above 2kV.

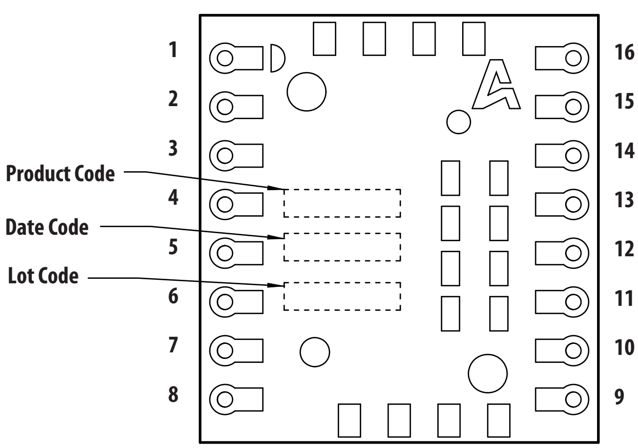

Figure 3. ADNS-9800 Sensor Package Pinout

7. Defective PMOS: Laser current at internal (-VCSEL) pin, I_{LAS} continues to limit current to correct value.
8. Noise event on VDD or clock corrupts internal memory values: an event such as this can in concept affect the laser current. The current adjustment settings are kept in two memory locations in different forms. In each frame, the sensor checks for corruption and reduces to the minimum laser power if found therefore minimizes the "foreseeable" chance that this event would result in unsafe LOP levels.
9. Fault detection relies on proper operation of the ADNS-9800 sensor. Proper operation should be confirmed by periodically reading the Product ID register and its inverse as documented in the ADNS-9800 sensor datasheet. Once proper operation is assured, the Fault bit and LP_Valid bit in the Motion register should be read to detect a fault condition.

Conclusion

Analysis of the system for ADNS-9800 sensor and ADNS-6190-002 lens for eye safety per IEC 60825-1, Edition 1.2, 2001-08 shows that given proper current control of the integrated VCSEL and detailed adherence to the manufacture instructions in the sensor datasheet, this product has the ability to meet product classification standards with a rating of Class 1.

Table 1. Resistive Path or Short Circuit between Adjacent Sensor Pins for 5V Mode

Pin	Resistive Path	Effect
Pin 1 to Pin 2	+VCSEL to LASER_NEN	Laser power drops since most current channel out to LASER_NEN low resistive path. Fault triggered
Pin 2 to Pin 3	LASER_NEN to NCS	No effect on laser.
Pin 3 to Pin 4	NCS to MISO	No effect on laser. Lost communication
Pin 4 to Pin 5	MISO to SCLK	No effect on laser. Lost communication
Pin 5 to Pin 6	SCLK to MOSI	No effect on laser. Lost communication
Pin 6 to Pin 7	MOSI to MOTION	No effect on laser. Lost communication
Pin 7 to Pin 8	MOTION to XYLASER	Laser power turns off. Fault triggered.
Pin 9 to Pin 10	VDD5 to PWR_OPT	Laser power turns off. Sensor requires system reset to recover.
Pin 10 to Pin 11	PWR_OPT to GND	No effect on laser.
Pin 11 to Pin 12	GND to REFB	Laser power turns off. Sensor requires system reset to recover.
Pin 12 to Pin 13	VDD3 to REFA	No effect on laser.
Pin 13 to Pin 14	REFA to DGND	No effect on laser. Digital circuitry cannot function properly.
Pin 14 to Pin 15	DGND to VDDIO	No effect on laser.
Pin 15 to Pin 16	VDDIO to –VCSEL	Laser power turns off. Fault triggered.

Test Pad	Resistive Path	Effect
Pin 1 to Pad 1	+VCSEL to Pad 1	VCSEL power drops. Fault triggered
Pad 1 to Pad 2	Pad 1 to Pad 2	No effect on laser.
Pad 2 to Pad 3	Pad 2 to Pad 3	No effect on laser.
Pad 3 to Pad 4	Pad 3 to Pad 4	No effect on laser.
Pad 4 to Pin-16	Pad 4 to –VCSEL	Laser power turns off. Fault triggered.
Pad 5 to Pad 6	Pad 5 to Pad 6	No effect on laser.
Pad 5 to Pad 7	Pad 5 to Pad 7	No effect on laser.
Pad 6 to Pin 13	Pad 6 to REFA	No effect on laser.
Pad 6 to Pin 14	Pad 6 to DGND	No effect on laser.
Pad 6 to Pad 8	Pad 6 to Pad 8	No effect on laser.
Pad 7 to Pad 8	Pad 7 to Pad 8	No effect on laser. Digital circuitry can't function properly.
Pad 7 to Pad 9	Pad 7 to Pad 9	No effect on laser.
Pad 8	Pad 8 to GND	No effect on laser. Digital circuitry can't function properly.
Pad 8 to Pin 12	Pad 8 to REFB	No effect on laser.
Pad 8 to Pin 13	Pad 8 to REFA	No effect on laser.
Pad 8 to Pad 10	Pad 8 to Pad 10	No effect on laser.
Pad 9 to Pad 10	Pad 9 to Pad 10	Laser power turns off. Sensor requires system reset to recover.
Pad 9 to Pad 11	Pad 9 to Pad 11	No effect on laser.
Pad 10 to Pin 11	Pad 10 to GND	Laser power turns off. Sensor requires system reset to recover.
Pad 10 to Pin 12	Pad 10 to REFB	No effect on laser.
Pad 10 to Pad 12	Pad 10 to Pad 12	Laser power drops. Fault triggered
Pad 11 to Pad 12	Pad 11 to Pad 12	Laser power turns off. Sensor requires system reset to recover.
Pad 11 to Pad 13	Pad 11 to Pad 13	Laser power turns off. Fault triggered.
Pad 12 to Pin 10	Pad 12 to PWR_OPT	Laser power turns off. Sensor requires system reset to recover.
Pad 12 to Pin 11	Pad 12 to GND	Laser power turns off. Sensor requires system reset to recover.
Pad 13 to Pad 14	Pad 13 to Pad 14	No effect on laser.
Pad 14 to Pad 15	Pad 14 to Pad 15	No effect on laser.
Pad 15 to Pad 16	Pad 15 to Pad 16	No effect on laser.
Pad 16 to Pin 9	Pad 17 to VDD5	Laser power turns off. Fault triggered.

Table 2. Resistive Path or Short Circuit between Adjacent Sensor Pins for 3V Mode (VDD3 = 2.8V)

Pin	Resistive Path	Effect
Pin 1 to Pin 2	VCSEL +ve to LASER_NEN	Laser power drop since most current channel out to LASER_NEN low resistive path. Fault triggered
Pin 2 to Pin 3	LASER_NEN to NCS	No effect on laser.
Pin 3 to Pin 4	NCS to MISO	No effect on laser. Lost communication
Pin 4 to Pin 5	MISO to SCLK	No effect on laser. Lost communication
Pin 5 to Pin 6	SCLK to MOSI	No effect on laser. Lost communication
Pin 6 to Pin 7	MOSI to MOTION	No effect on laser. Lost communication
Pin 7 to Pin 8	MOTION to XYLASER	Laser power turns off. Fault triggered.
Pin 9 to Pin 10	VDD3 to PWR_OPT	No effect on laser.
Pin 10 to Pin 11	PWR_OPT to GND	Laser power turns off. Sensor requires system reset to recover.
Pin 11 to Pin 12	GND to VDD3	Laser power turns off. Sensor requires system reset to recover.
Pin 12 to Pin 13	VDD3 to REFA	No effect on laser.
Pin 13 to Pin 14	REFA to DGND	No effect on laser. Digital circuitry cannot function properly.
Pin 14 to Pin 15	DGND to VDDIO	No effect on laser.
Pin 15 to Pin 16	VDDIO to -VCSEL	Laser power turns off. Fault triggered.

Test Pad	Resistive Path	Effect
Pin 1 to Pad 1	+VCSEL to Pad 1	VCSEL power drops. Fault triggered
Pad 1 to Pad 2	Pad 1 to Pad 2	No effect on laser.
Pad 2 to Pad 3	Pad 2 to Pad 3	No effect on laser.
Pad 3 to Pad 4	Pad 3 to Pad 4	No effect on laser.
Pad 4 to Pin 16	Pad 4 to –VCSEL	Laser power turns off. Fault triggered.
Pad 5 to Pad 6	Pad 5 to Pad 6	No effect on laser.
Pad 5 to Pad 7	Pad 5 to Pad 7	No effect on laser.
Pad 6 to Pin 13	Pad 6 to REFA	No effect on laser.
Pad 6 to Pin 14	Pad 6 to DGND	No effect on laser.
Pad 6 to Pad 8	Pad 6 to Pad 8	No effect on laser.
Pad 7 to Pad 8	Pad 7 to Pad 8	No effect on laser. Digital circuitry can't function properly.
Pad 7 to Pad 9	Pad 7 to Pad 9	No effect on laser.
Pad 8	Pad 8 to GND	No effect on laser. Digital circuitry can't function properly.
Pad 8 to Pin 12	Pad 8 to VDD3	No effect on laser.
Pad 8 to Pin 13	Pad 8 to REFA	No effect on laser.
Pad 8 to Pad 10	Pad 8 to Pad 10	No effect on laser.
Pad 9 to Pad 10	Pad 9 to Pad 10	Laser power turns off. Sensor requires system reset to recover.
Pad 9 to Pad 11	Pad 9 to Pad 11	No effect on laser.
Pad 10 to Pin 11	Pad 10 to GND	Laser power turns off. Sensor requires system reset to recover.
Pad 10 to Pin 12	Pad 10 to VDD3	No effect on laser.
Pad 10 to Pad 12	Pad 10 to Pad 12	Laser power drops. Fault triggered
Pad 11 to Pad 12	Pad 11 to Pad 12	Laser power turns off. Sensor requires system reset to recover.
Pad 11 to Pad 13	Pad 11 to Pad 13	Laser power turns off. Fault triggered.
Pad 12 to Pin 10	Pad 12 to PWR_OPT	Laser power turns off. Sensor requires system reset to recover.
Pad 12 to Pin 11	Pad 12 to GND	Laser power turns off. Sensor requires system reset to recover.
Pad 13 to Pad 14	Pad 13 to Pad 14	No effect on laser.
Pad 14 to Pad 15	Pad 14 to Pad 15	No effect on laser.
Pad 15 to Pad 16	Pad 15 to Pad 16	No effect on laser.
Pad 16 to Pin 9	Pad 17 to VDD3	Laser power turns off. Fault triggered.

Table 3. Shorting Effect at Each Sensor Pin for 5V Mode

Pin/ Test Pad	Name	SHORT TO REFB (3V)	SHORT TO GND	SHORT to VDD5
Pin 1	+VCSEL	Laser power drops	Sensor detects a short to GND, thus turn off the laser.	Laser power dropped
Pin 2	LASER_NEN	Laser turns off since PMOS off	No effect on laser on high frame rate	Laser turns off since PMOS off
Pin 3	NCS	No effect on laser, lost communication	No effect on laser, lost communication	No effect on laser, lost communication
Pin 4	MISO	No effect on laser, lost communication	No effect on laser, lost communication	No effect on laser, lost communication
Pin 5	SCLK	No effect on laser, lost communication	No effect on laser, lost communication	No effect on laser, lost communication
Pin 6	MOSI	No effect on laser, lost communication	No effect on laser, lost communication	No effect on laser, lost communication
Pin 7	MOTION	No effect on laser	No effect on laser	No effect on laser
Pin 8	XYLASER	Laser turn off, fault triggered	Laser turn off, fault triggered	Laser turn off, fault triggered
Pin 9	VDD5	Laser power drop	Laser power turn off. Sensor requires system reset to recover.	No effect on laser
Pin 10	PWR_OPT	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pin 11	GND	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pin 12	REFB	No effect on laser	Laser power turn off. Sensor requires system reset to recover.	Laser power drop
Pin 13	REFA	No effect on laser	No effect on laser, lost communication	No effect on laser
Pin 14	DGND	Laser power reduced to 0	No effect on laser	Laser power reduced to 0
Pin 15	VDDIO	No effect on laser	No effect on laser, lost communication	No effect on laser
Pin 16	-VCSEL	Laser turn off, fault triggered	Laser turn off, fault triggered	Laser turn off, fault triggered
Pad 1	Pad 1	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 2	Pad 2	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 3	Pad 3	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 4	Pad 4	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 5	Pad 5	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pad 6	Pad 6	No effect on laser	No effect on laser, lost communication	No effect on laser
Pad 7	Pad 7	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pad 8	Pad 8	No effect on laser	No effect on laser, lost communication	No effect on laser
Pad 9	Pad 9	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pad 10	Pad 10	No effect on laser	Laser power turn off. Sensor requires system reset to recover.	Laser power drop, fault triggered
Pad 11	Pad 11	Laser power turn off. Sensor requires system reset to recover.	No effect on laser	Laser power turn off. Sensor requires system reset to recover.
Pad 12	Pad 12	Laser power drop	Laser power turn off. Sensor requires system reset to recover.	No effect on laser
Pad 13	Pad 13	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 14	Pad 14	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 15	Pad 15	No effect on laser	No effect on laser	Laser power reduced, fault triggered
Pad 16	Pad 16	No effect on laser	No effect on laser	Laser power reduced, fault triggered

Table 4. Shorting Effect at Each Sensor Pin for 3V Mode (VDD3 = 2.8V)

Pin/ Test Pad	Name	SHORT TO VDD3	SHORT TO GND
Pin 1	+VCSEL	Laser power drop	Sensor detects a short to GND, thus turn off the laser.
Pin 2	LASER_NEN	Laser turns off since PMOS off	Laser turned off due to fault
Pin 3	NCS	No effect on laser, lost communication	No effect on laser
Pin 4	MISO	No effect on laser, lost communication	No effect on laser, lost communication
Pin 5	SCLK	No effect on laser, lost communication	No effect on laser, lost communication
Pin 6	MOSI	No effect on laser, lost communication	No effect on laser, lost communication
Pin 7	MOTION	No effect on laser	No effect on laser
Pin 8	XYLASER	Laser turn off, fault triggered	Laser turn off, fault triggered
Pin 9	VDD3	No effect on laser	Laser power reduced to 0
Pin 10	PWR_OPT	No effect on laser	Laser power reduced to 0
Pin 11	GND	Laser power reduced to 0	No effect on laser
Pin 12	VDD3	No effect on laser	Laser power reduced to 0
Pin 13	REFA	No effect on laser	No effect on laser, lost communication
Pin 14	DGND	Laser power reduced to 0	No effect on laser
Pin 15	VDDIO	Laser power reduced to 0	No effect on laser, lost communication
Pin 16	-VCSEL	Laser turn off, fault triggered	Laser turn off, fault triggered
Pad 1	Pad 1	No effect on laser	No effect on laser
Pad 2	Pad 2	No effect on laser	No effect on laser
Pad 3	Pad 3	No effect on laser	No effect on laser
Pad 4	Pad 4	No effect on laser	No effect on laser
Pad 5	Pad 5	Laser power reduced to 0	No effect on laser
Pad 6	Pad 6	No effect on laser	No effect on laser, lost communication
Pad 7	Pad 7	Laser power reduced to 0	No effect on laser
Pad 8	Pad 8	No effect on laser	No effect on laser, lost communication
Pad 9	Pad 9	Laser power reduced to 0	No effect on laser
Pad 10	Pad 10	No effect on laser	Laser power reduced to 0
Pad 11	Pad 11	Laser power reduced to 0	No effect on laser
Pad 12	Pad 12	No effect on laser	Laser power reduced to 0
Pad 13	Pad 13	No effect on laser	No effect on laser
Pad 14	Pad 14	No effect on laser	No effect on laser
Pad 15	Pad 15	No effect on laser	No effect on laser
Pad 16	Pad 16	No effect on laser	No effect on laser

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

AV02-3316EN - Janaury 9, 2012