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Report Date: 16th April 2019
Test Date: 15th April 2019
Report Number: 2132

Laser Classification Report to IEC/EN 60825-1:2014

Product Name: AD-96TOF1-EBZ
Product Serial Number: unknown

SUMMARY

The unit is a camera which uses four IR VCSELs for illumination.

This product meets the power requirements for a Class 1 Laser product to IEC/EN 60825-1 (2014) under normal operating conditions and those of single fault failure.

Client

Analog Devices International
Raheen Business Park,
Sluggary,
Limerick,
V94 RT99,
Ireland

Manufacture/Supplier

Analog Devices International
Raheen Business Park,
Sluggary,
Limerick,
V94 RT99,
Ireland

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1) Optical sources

a) Manufacturer(s) and type details

I940-G2332-NBC VCSEL manufactured by Finisar.

b) Wavelength(s)

938 nm to 942 nm with a peak at 939 nm

Measured on Spectrometer LM-SPC-001; see Annex A for spectrum.

c) Pulsed or continuous

Pulsed

If pulsed:

i) Manufacturers stated data:

Pulse Repetition Frequency: 5.62 MHz

Pulse Duration: 33.3 ns

Pulses are grouped in bursts of 33 ms

Number of pulses per burst is 60 000

ii) Measured data:

N/A

d) Other relevant data

Beam is widely divergent.

e) Accessibility of Radiation

Radiation is directly accessible during normal use.

2) Apparent Source size/angular subtense.

a) Manufacturer's data.

None given.

b) Measured.

The apparent source size was measured with a CCD camera (LM-CAM-001) and an oscilloscope (LM-OSC-001) following Procedure LM-PROC-003.

The apparent source size was measured to be 0.883 mm, equating to an angular subtense (α) of 8.83 mrad at 100 mm.

Each VCSEL is more than 10 mm apart; they should therefore be treated as separate sources.

Source size measurements were taken in accordance with Research Report 345 'Investigation of a measurement technique to determine the apparent source size for light emitting diodes, prepared by National Physical Laboratory and Europtics Ltd for the Health & Safety Executive 2005.

3) Measurement Conditions:

a) Control Settings

The unit has three power settings. For the purposes of testing, the highest power setting was used.

b) AEL

i) Correction Factors

$$C_4 = 3.01$$

$$C_5 = 0.4$$

$$C_6 = 5.89$$

$$C_6 = 3.33 \text{ (for a pulse)}$$

ii) Time Bases:

$$T = 100 \text{ s}$$

$$T_2 = 11.9 \text{ s}$$

$$T_2 = 10.9 \text{ s (for a pulse)}$$

$$T_i = 5.0 \text{ } \mu\text{s}$$

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iii) Equations:

$$\text{Class 1 AEL}_{\text{single}} = 7 \times 10^{-8} \times C_6 \times C_4 = 772 \text{ nJ}$$

$$\text{Class 1 AEL}_{\text{sp train}} = \text{Class 1 AEL}_{\text{single}} \times C_5 = 309 \text{ nJ}$$

$$\text{Class 1 AEL}_T = 7 \times 10^{-4} \times C_4 \times C_6 \times T_2^{-0.25} = 6.68 \text{ mW}$$

$$\text{Class 1 AEL}_{\text{burst}} = 7 \times 10^{-4} \times t^{0.75} \times C_4 \times C_6 = 413 \text{ } \mu\text{J}$$

c) Measurement Apertures and distances.

All measurements were taken at 100 mm from the apparent source using a 7 mm aperture.

4) Measurements.

a) Meter(s) used for measurement:

The optical output was measured with Lasermet's calibrated ADM 1000 power meter LM-PM-008.

Lasermet's power meters are regularly cross-checked for calibration against a power meter calibrated by the UK National Physical Laboratory.

b) Maximum Readings

Top VCSEL:

Average power = 137 μW

Hence energy per pulse = 24.4 pJ

Hence energy per burst = 1.46 μJ

EHV = 2.05% PASS Class 1

EHV = 0.00790% PASS Class 1

EHV = 0.354% PASS Class 1

Left VCSEL:

Average power = 139 μW

Hence energy per pulse = 24.7 pJ

Hence energy per burst = 1.48 μJ

EHV = 2.08% PASS Class 1

EHV = 0.00799% PASS Class 1

EHV = 0.351% PASS Class 1

Right VCSEL:

Average power = 152 μW

Hence energy per pulse = 27.0 pJ

Hence energy per burst = 1.62 μJ

EHV = 2.28% PASS Class 1

EHV = 0.00874% PASS Class 1

EHV = 0.392% PASS Class 1

Bottom VCSEL:

Average power = 231 μW

Hence energy per pulse = 41.1 pJ

Hence energy per burst = 2.47 μJ

EHV = 3.46% PASS Class 1

EHV = 0.0133% PASS Class 1

EHV = 0.598% PASS Class 1

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c) Corrections, if any.

None.

d) Reasonably foreseeable failures

The pulse structure is software controlled; it must therefore be considered foreseeable that the peak power could become continuous. As such, the peak power of each VCSEL was calculated from the average power and compared to AEL_T .

Top VCSEL:

Average power = 137 μ W

Peak power = 732 μ W

EHV = 11.0% PASS Class 1

Left VCSEL:

Average power = 139 μ W

Peak power = 741 μ W

EHV = 11.1% PASS Class 1

Right VCSEL:

Average power = 152 μ W

Peak power = 810 μ W

EHV = 12.1% PASS Class 1

Bottom VCSEL:

Average power = 231 μ W

Peak power = 1.23 mW

EHV = 18.4% PASS Class 1

The only potential single fault identified in the circuit was a short on a MOSFET. When this was implemented, the VCSEL emitted one pulse of 16 ms before switching off.

The Class 1 AEL_{single} for this pulse is $7 \times 10^{-4} \times C_4 \times C_6 \times t^{0.75} = 558 \mu$ J

The peak power of the pulse was measured to be 2.27 mW at 100 mm from the apparent source using a 7 mm aperture. This equates to an energy of 36.3 μ J. This is 6.51% of the Class 1 limit.

e) CONCLUSION (tentative classification)

The product does not exceed the Class 1 limits under any hazard condition.

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5) Required Accuracy of Measurements, Uncertainties.

The peak output was less than 20% of the Class 1 limit under any hazard condition. The total estimated measurement uncertainty was $\pm 4.00\%$ at 95% confidence.

6) Engineering Controls:

None required – Class 1.

7) Labelling:

The labelling required for a Class 1 product is shown below. All labels shall be legible, durable and permanently attached.



(Present)

8) User Information:

- Adequate instructions for proper assembly, maintenance and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous laser radiation. (Present)
- A description of the radiation emitted from the product, including wavelength, divergence, and maximum average power. (Present)
- Legible reproductions of all required labels and hazard warnings to be affixed to the laser product. The corresponding position of each label shall be indicated. (Present)
- List of controls, adjustments and procedures for operation and maintenance, including the warning "Caution – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure". (Present)

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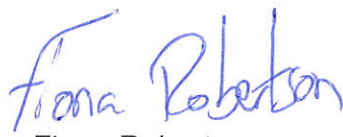
9) Class Awarded:

Class 1

Conditions (state changes required for full conformity)

This classification is based on the performance of the lasers supplied to us for testing and is only valid for the products listed in this report. The manufacturer is responsible for ensuring that sufficient quality control during manufacturing is in place.

Signature



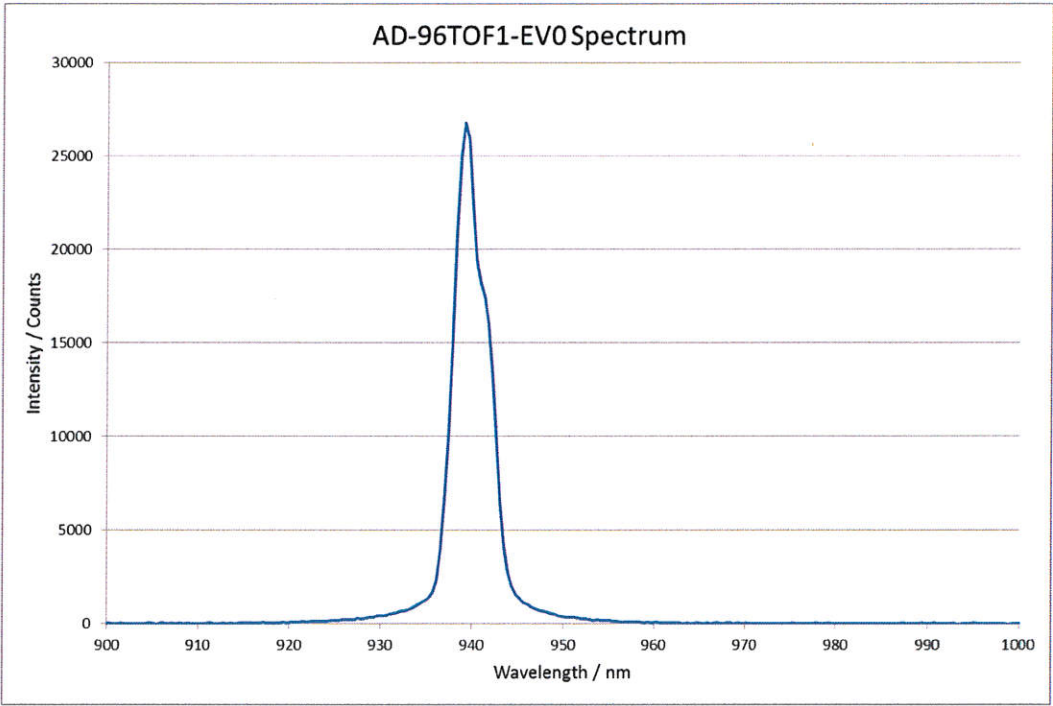
Fiona Robertson

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Annex A



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Annex B

Source of uncertainty	value (\pm)	prob distribution	divisor	c_i	u_i	$(u_i)^2$	v_i
power meter calibration	3.00%	normal	2	1	1.50%	0.02%	∞
Experimental set up	2.00%	Normal	2	1	1.00%	0.01%	∞
Continuous Power Laser	No						
CW Laser power resolution, power meter reading	0.53%	rectangular	1.732	1	0.31%	0.00%	∞
Pulse Laser by Peak Power	No						
Pulse Laser Peak power resolution	0.53%	rectangular	1.732	1	0.31%	0.00%	∞
oscilloscope resolution, (voltage representing current, 70 is the voltage reading)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
oscilloscope resolution, (sig-gen peak power)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
Oscilloscope resolution, (photodiode peak power)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
Oscilloscope voltage uncertainty, (quoted)	0.50%	normal	2	1	0.25%	0.00%	∞
Pulse laser by Average Power	Yes						
Pulse Laser Average power resolution	0.53%	rectangular	1.732	1	0.31%	0.00%	∞
oscilloscope resolution, (voltage representing current, 70 is the voltage reading)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
oscilloscope resolution, (sig-gen peak power)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
Oscilloscope resolution, (photodiode peak power)	0.19%	rectangular	1.732	1	0.11%	0.00%	∞
Oscilloscope voltage uncertainty, (quoted)	0.50%	normal	2	1	0.25%	0.00%	∞
osc pulse length resolution (quoted)	5.00%	rectangular	1.732		2.89%	0.08%	∞
Beam Size Measurement	Yes						
Measuring Element	0.85%	rectangular	1.732	1	0.49%	0.00%	∞
Voltage Cal: Oscilloscope	0.50%	normal	2	1	0.25%	0.00%	∞
Time Cal: Oscilloscope	0.50%	normal	2	1	0.25%	0.00%	∞
Trigger jitter	0.79%	rectangular	1.732	1	0.46%	0.00%	∞
Repeatability	2.00%	normal	2	1	1.00%	0.01%	∞
Optical attenuator	2.00%	rectangular	1.732	1	1.15%	0.01%	∞
Measuring distance	2.00%	rectangular	1.732	2	1.15%	0.01%	∞
Standard deviation of the mean	0.11%	normal	2	1	0.05%	0.00%	9
combined standard uncertainty		normal			4.00%	0.16%	>500
expanded uncertainty		normal (k=2)			8.00%		>500