	<p>Test Report issued under the responsibility of: The Standards Institution of Israel</p>
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**TEST REPORT
IEC 60825-1
Safety of laser products -
Part 1: Equipment classification and requirements**

Report Number :	9812307461
Date of issue :	22/04/2018
Total number of pages	29 pages
Name of Testing Laboratory preparing the Report :	The Standards Institution of Israel
Applicant's name	Mantis Vision Ltd.
Address :	24 Imber St. 4951158 Petah Tikva ISRAEL
Test specification:	
Standard :	IEC 60825-1:2014 (Third Edition)
Test procedure	CB Scheme
Non-standard test method	N/A
Test Report Form No.	IEC60825_1E
Test Report Form(s) Originator :	ÖVE
Master TRF :	Dated 2014-07

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Test item description :	3D Camera
Trade Mark :	 MANTIS VISION 3D that works for you
Manufacturer	Mantis Vision Ltd.
Model/Type reference	SMART F6
Ratings	5Vdc, 0.5A, 2.5W Class 1 laser product



Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):	
<input checked="" type="checkbox"/> CB Testing Laboratory:	The Standards Institution of Israel
Testing location/ address.....:	42 Chaim Levanon St., Tel Aviv 69977, ISRAEL
<input type="checkbox"/> Associated CB Testing Laboratory:	
Testing location/ address.....:	
Tested by (name, function, signature).....:	Zohar Cohen 
Approved by (name, function, signature)....:	Irina Antonov 
<input type="checkbox"/> Testing procedure: TMP/CTF Stage 1:	
Testing location/ address.....:	
Tested by (name, function, signature).....:	
Approved by (name, function, signature)....:	
<input type="checkbox"/> Testing procedure: WMT/CTF Stage 2:	
Testing location/ address.....:	
Tested by (name, function, signature).....:	
Witnessed by (name, function, signature) .:	
Approved by (name, function, signature)....:	
<input type="checkbox"/> Testing procedure: SMT/CTF Stage 3 or 4:	
Testing location/ address.....:	
Tested by (name, function, signature).....:	
Witnessed by (name, function, signature) .:	
Approved by (name, function, signature)....:	
Supervised by (name, function, signature) :	



List of Attachments (including a total number of pages in each attachment): 1. Photos..... 1 Page 2. Laser Classifications and Calculations..... 6 Pages 3.S.F.C..... 1 Page 4. Measurement of laser Wavelength..... 1 Page 5.Risk Analysis for S.F.C..... 5 Pages	
Summary of testing: The device comply with requirements of IEC 60825-1 ED3	
Tests performed (name of test and test clause): Clause 5.4.3 - Evaluation condition for extended sources	Testing location: The Standards Institution of Israel 42 Chaim Levanon St., Tel Aviv 69977, ISRAEL
Summary of compliance with National Differences: List of countries addressed: N/A	
Copy of marking plate: The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCBs that own these marks. Class 1 laser product – Provided in User Manual (UM)	



Test item particulars	:	
Classification of installation and use	:	Class III (Electrical)
Supply Connection	:	USB 2.0 connection
.....	:	
Possible test case verdicts:		
- test case does not apply to the test object	:	N/A
- test object does meet the requirement	:	P (Pass)
- test object does not meet the requirement	:	F (Fail)
Testing	:	
Date of receipt of test item	:	12/06/2017
Date (s) of performance of tests	:	06/2017 and 18.03.2018
General remarks:		
<p>"(See Enclosure #)" refers to additional information appended to the report. "(See appended table)" refers to a table appended to the report.</p> <p>Throughout this report a <input type="checkbox"/> comma / <input checked="" type="checkbox"/> point is used as the decimal separator.</p>		
Manufacturer's Declaration per sub-clause 4.2.5 of IEC 60730-2:		
The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided.....		<input type="checkbox"/> Yes <input checked="" type="checkbox"/> Not applicable
When differences exist; they shall be identified in the General product information section.		
Name and address of factory (ies)	:	24 Imber St. 4951158 Petah Tikva ISRAEL
General product information:		
<p>The EUT "SMART F6" is used to visualize the environment in 3D. The sender emits pulsed radiation at a peak wavelength of about 850±8 nm. This radiation is reflected by the environment and detected by infrared camera. The radiation is generated by an array of VCSELs (vertical cavity surface emitting lasers; type: PQCW-CS49-10-W0850 manufacturer: PRINCETON OPTRONICS). This laser source is placed behind a mask (Optical Filter), which is then imaged to infinity by means of a lens system (referred to as sender optics). The 3D-information is calculated by analyzing the change of the pattern. The device is powered and controlled via the USB port. It is specified to be operated at ambient temperatures different than room temperature. The maximum working distance is about 4 m.</p>		



According to information provided by the manufacturer, the divergence of the laser beam (field of view of the product) is about 68.1 degree (x-axis) x 56.1 degree (y-axis).

The max current through the laser diode is pre-adjusted by software and cannot be exceeded by the user of the device. This current sets the peak power of the optical pulses. The maximum value is shown in the measurement tables . Also the pulse duration and the frame rate (i.e. the pulse period) can be varied by software (the pulse duration can be varied from 0.2 ms to 4 ms; frame rate 5-8Hz.

The duty cycle, however, is limited to a maximum value of 2%-5%. This limitation is realized by software.

Pulse durations longer than 6 ms are not possible due to hardware limitations.

The device firmware contains an activation table that employ various activation regimes where the activation per pulse rate and per activation pulse width have maximal allowed application of current through the device. Altogether obtaining Class 1 emitting power under all use cases of the device.



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
4	CLASSIFICATION PRINCIPLES		
4.3	Classification rules		---
4.3 a	Radiation of a single wavelength	850±8 nm	Pass
4.3 b	Radiation of multiple wavelengths	Only one	N / A
	1) Laser product emits at two or more wavelengths shown as additive in Table 1		N / A
	2) Laser product emits at two or more wavelengths not shown as additive in Table 1		N / A
4.3 c	Radiation from extended sources (see 5.4.3)	Extended sources	Pass
4.3 d	Non-uniform, non-circular or multiple apparent source		N / A
4.3 e	Time bases		---
	1) 0,25 s		N / A
	2) 100 s		N / A
	3) 30000 s	Max	Pass
4.3 f	Repetitively pulsed or modulated lasers	The product work with PWM mode	Pass
	1) Any single pulse	0.2 - 4ms	Pass
	2) Average power for pulse trains	See Appendix 2	Pass
	3) Pulse duration $t \leq T_i$: Number of pulses N and C_5 :		N / A
	3) Pulse duration $t > T_i$: Number of pulses N and C_5 :	For wide lens M14B0228IRD9 0.2-4ms > 5µs , $C_5=1$ (According to Interpretation Sheet 1)	Pass
4.4	Laser products designed to function as conventional lamps.	Not function as conventional lamps.	N / A
	α measured at 200 mm distance from closest point of human access ($\alpha > 5$ mrad).	As above	N / A
	Un-weighted radiance L measured at 200 mm distance (comparison with $L_T = 1 \text{ MWm}^{-2}\text{sr}^{-1}/\alpha$) under reasonably foreseeable single fault conditions.	As above	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
	Evaluation of emission according to IEC 62471 series (optional): Standard applied (IEC 62471 series).....: Risk Group.....: Labelling.....: Classification of product based on accessible laser radiation (if no laser radiation accessible: Class 1).	No LED emission	N / A

5	DETERMINATION OF THE ACCESSIBLE EMISSION LEVEL and PRODUCT CLASSIFICATION		
5.1	Tests		---
	Compliance under reasonably foreseeable single fault conditions.	See Appendixes 3,5	Pass
5.3	Determination of the class of the laser product ... : For Class 1C: vertical safety standard applied with requirements for Class 1C.	Class 1 laser product	---
5.4	Measurement geometry		---
5.4.1	General	Extended sources evaluation	---
5.4.2	Default (simplified) evaluation		N / A
	Conditions applied		N / A
	Aperture diameter		N / A
	Reference point :.....		N / A
	Measurement distance		N / A
	(for each condition)		
5.4.3	Evaluation condition for extended sources		Pass
	Conditions applied	According to Conditions 1,and,3	Pass
	Most restrictive position	100mm@7mm	Pass
	(distance from reference point)		
	Angular subtense of the apparent source α and C_6 : (for each condition)	See appendix 2 for classification	Pass
5.4.3 a	Aperture diameters (for each condition).	As above	Pass
5.4.3 b	Angle of acceptance (for each condition).....		N / A

Measured accessible laser radiation and comparison with AEL: See appendix 2



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

6	ENGINEERING SPECIFICATIONS		
6.2	Protective housing		---
6.2.1	General		---
	Protective housing prevents access to energy levels in excess of the AEL for Class 1.	Class 1 Laser product	N / A
	Protective housing prevents access to energy levels equivalent to Class 4 and withstands exposures under reasonably foreseeable single fault conditions.	Class 1 Laser product	N / A
	Maintenance of Class 1, 1C, 1M, 2, 2M, or 3R (access to emissions of Class 3B or 4 is prevented).	There is no maintenance for this products	N / A
	Maintenance of Class 3B product (access to emission of Class 4 is prevented).	Class 1 laser product	N / A
6.2.2	Service	Any part of the enclosure of the laser product that can be removed or displaced for service are secured in such a way that removal or displacement of the parts require the use of a screwdriver.	Pass
6.2.3	Removable laser system (laser system complies with requirements of Clauses 6 and 7).	Complies with requirements of Clauses 6 and 7 Not a removable laser system	Pass
6.3	Access panels and safety interlocks		---
6.3.1	Panel is intended to be removed during operation (or maintenance) and would give access to higher energy levels (see Table 13).		N / A
	Accessible emission (after removal of the panel) corresponds to product Class (designated by "X" in Table 13)	Class 4 laser inside Access panel for class 4 laser is not intended to be removed or displaced Any part of the enclosure of laser can't be removed or displaced without a tool.	N / A
	Emission through the opening if interlocked panel of Class 1, 1C, 1M, 2, or 2M is removed (Emission < AEL of Class 1M or 2M).	As above	N / A
	Emission through the opening if interlocked panel of Class 3R, 3B, or 4 is removed (Emission < AEL of Class 3R).	As above	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
	Requirements regarding reasonably foreseeable single fault condition.	As above	N / A
6.3.2	Override mechanism		N / A
	Behaviour of override in operation when the panel is replaced.		N / A
	Visible or audible warning for override mode.	Class 1 laser product	N / A
6.4	Remote interlock connector	Class 1 laser product	N / A
6.5	Manual reset	Class 1 laser product	N / A
6.6	Key control	Class 1 laser product	N / A
6.7	Laser radiation emission warning		---
6.7.1	Laser product is a 3R ($\lambda < 400$ nm; $\lambda > 700$ nm), 1C, 3B or 4 laser systems.	Class 1 laser product	N / A
6.7.2	Audible or visible warning.	Class 1 laser product	N / A
	Warning is fail safe or redundant.	Class 1 laser product	N / A
	Viewing of the visible warning does not require exposure to emissions > AEL for Class 1M and 2M	Class 1 laser product	N / A
6.7.3	Operational control and laser aperture are provided with a warning device when they are separated more than 2 m from warning device.	Class 1 laser product	N / A
6.7.4	Visible indication of output aperture if laser emission may be distributed through more than one output.	Class 1 laser product	N / A
6.7.5	Switch for handheld Class 3R device must be depressed for emission (in lieu of emission indicator).	Class 1 laser product	N / A
6.8	Beam stop or attenuator	No beam stop or attenuator are needed for class 1 laser product	N / A
6.9	Controls	Class 1 laser product	N / A
6.10	Viewing optics	Class 1 laser product	N / A
	a) Human access to laser radiation in excess of Class 1M prevented when the shutter is opened or attenuation varied.		N / A
	b) Opening of the shutter or variation of the attenuation prevented when exposure to laser radiation in excess of Class 1M is possible.		N / A
6.11	Scanning safeguard	No laser scanner	N / A
6.12	Safeguard for Class 1C products	Class 1 laser product	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
	a) Human access to laser radiation in excess of AEL for Class 1 measured under Condition 3 is prevented.	Class 1 laser product	N / A
	b) Human access to laser radiation in excess of AEL for Class 3B measured through 3,5 mm aperture at 5 mm distance from applicator is prevented.	Class 1 laser product	N/A
6.13	Walk-in access		N / A
	a) Means provided so that any person inside the housing can prevent activation of Class 3B or 4 laser hazards.	Class 1 laser product	N / A
	b) A warning device provides adequate warning of emission to any person within the housing.	Class 1 laser product	N / A
	c) Where "walk-in" access during operation is intended or reasonably foreseeable, emission of laser radiation that is equivalent to Class 3B or 4 while someone is present inside the enclosure of Class 1, Class 2 or Class 3R product is prevented by engineering means.	Class 1 laser product	N / A
6.14	Environmental conditions	Equipment was tested in normal environmental conditions	---
	- climatic conditions	Not evaluated	N / A
	- vibration and shock	Not evaluated	N / A
6.15	Protection against other hazards		---
6.15.1	Non-optical hazards (product safety standard)	Not evaluated	N / A
	- electrical hazards;	Not evaluated	N / A
	- excessive temperature;	Not evaluated	N / A
	- spread of fire from the equipment;	Not evaluated	N / A
	- sound and ultrasonics;	Not evaluated	N / A
	- harmful substances;	Not evaluated	N / A
	- explosion;	Not evaluated	N / A
6.15.2	Collateral radiation		N / A
6.16	Power limiting circuit	See Appendix 3	N / A

7	LABELLING		
7.1	General		---
	Labels durable, permanently affixed	Class 1 laser product	N / A
	Labels clearly visible	Class 1 laser product	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
	Reading of labels is possible without exposure to laser radiation in excess of AEL for Class 1.	Class 1 laser product	N / A
	Colour combination	Class 1 laser product	N / A
	Labelling impractical due to the size or design of the product.	Class 1 laser product	N / A
	Warning label – Hazard symbol (Figure 3)	Class 1 laser product	N / A
7.2 - 7.7	Text on explanatory label or pictogram (laser class, warning text)	Class 1 laser product – see in UM	Pass
7.8	Aperture label	Class 1 laser product	N / A
7.9	Radiation output and standards information	Class 1 laser product	N / A
	Max output of laser radiation	Class 1 laser product	N / A
	Pulse duration	Class 1 laser product	N / A
	Emitted wavelength(s)	Class 1 laser product	N / A
	Name and publication date of the standard	Class 1 laser product IEC60825-1:2014	Pass
7.10	Labels for access panels		---
7.10.1 a) – f)	Labels for panels - warning wording used	No access panels	N / A
7.10.2	Labels for safety interlocked panels - Warning wording used	No interlock - Class 1 laser product	N / A
7.11	Warning for invisible laser radiation	As above	N / A
7.12	Warning for visible laser radiation	As above	N / A
7.13	Warning for potential hazard to the skin or anterior parts of the eye - warning wording used.....	Class 1 laser product	N / A

8	OTHER INFORMATIONAL REQUIREMENTS		
8.1	Information for the user		---
	a) adequate instructions for assembly, maintenance and safe use and description of the classification limitations, if appropriate.	Provided in User Manual	Pass
	b) additional warning for Class 1M and 2M	Class 1 Laser product	N / A
	c) laser beam parameters for radiation above the AEL of Class 1	Class 1 Laser product	---
	• Wavelength	Class 1 Laser product	N / A
	• Beam divergence	Class 1 Laser product	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
	<ul style="list-style-type: none"> Pulse pattern : (pulse duration, repetition rate, ...) 	Class 1 Laser product	N / A
	<ul style="list-style-type: none"> Maximum power or energy output : 	Class 1 Laser product	N / A
	d) safety instruction for embedded laser products and other incorporated laser products.		N / A
	e) MPE and NOHD for Class 3B and 4 laser products; For collimated beam Class 1M and 2M lasers the extended NOHD (ENOHHD).	Class 1 laser product	N / A
	f) information for the selection of eye protection.	Not required for class 1 laser product	N / A
	g) reproduction of all required labels and warnings.	Not required for class 1 laser product	N / A
	h) location of laser apertures	Not required for class 1 laser product	N / A
	i) list of controls, adjustments of procedures for operation and maintenance - and warning statement.	Not required for class 1 laser product	N / A
	j) information (compatibility requirements) about laser energy source if not incorporated.	Not required for class 1 laser product	N / A
	k) additional warning for Class 1, 1M, 2, 2M, and 3R regarding skin or corneal burns.		N / A
	l) Information for Class 1C products (e.g. warning that repeated application may pose a risk).	Class 1 laser product	N / A
8.2	Purchasing and service information	Class 1 laser product	N / A
	a) safety classification of each laser product stated in all descriptive material (e.g. brochures).	Class 1 laser product	N / A
	b) adequate instructions for servicing available: <ul style="list-style-type: none"> warnings and precautions regarding exposure of laser emission above Class 1 maintenance schedule list of controls and procedures that could increase accessible emissions description of displaceable parts protective procedures for service personnel reproduction of labels and hazard warnings 	Not required for class 1 laser product	N / A



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict
9	ADDITIONAL REQUIREMENTS FOR SPECIFIC LASER PRODUCTS		
9.1	Applicable other parts of the standard series IEC 60825		---
	IEC 60825-2 (Safety of optical communication systems)		N / A
	IEC 60825-4 (Laser guards)		N / A
	IEC 60825-12 (Safety of free space optical communication systems used for transmission of information)		N / A
9.2	Medical laser products: Class 3B and Class 4 medical laser products comply with IEC 60601-2-22		N / A
9.3	Laser processing machines: Comply with IEC/ISO 11553 series.		N / A
9.4	Electric toys: Comply with IEC 62115		N / A
9.5	Consumer electronic products: Comply with IEC 60950 (IT-equipment) or IEC 60065 (AV equipment)		N / A

TABLE: Critical components information					Pass
Object / part No.	Manufacturer/ trademark	Type / model	Technical data	Standard	Mark(s) of conformity ¹⁾
VCSEL	Princeton Optronics (PO)	Part # PQCW-CS49-10- W0850	$\lambda=850\pm 8\text{nm}$ Power(max) Pp=10W		Accepted



IEC 60825-1			
Clause	Requirement + Test	Result - Remark	Verdict

List of test equipment used:

A completed list of used test equipment shall be provided in the Test Reports when a Manufacturer Testing Laboratory according to TMP/CTF stage 1 or WMT/CTF stage 2 procedure has been used.

Clause	Measurement / testing	Testing / measuring equipment / material used, (Equipment ID)	Range used	Last Calibration date	Calibration due date
5.4	Power /energy	Laser Power/Energy Monitor / VEGA	all	10/16 10/17	10/17 10/18
5.4	Power /energy	Thermopile head 3A-P-FS	Wavelength: 190 nm - 20000 nm Radiant Power Range: 60µW - 3W 15µJ to 2J	12/16 12/17	12/17 12/18
5.4	Power /energy	Photodiode sensors and integrating spheres 3A-IS	Wavelength: 420 nm -1100 nm Radiant Power Range: 1µW - 3W	10/17	10/18
5.4	Wavelength	High resolution Spectrometer USB HR2000+	200nm- 1100nm	----	----

Appendix 1 Photos





Appendix 3

Laser Classifications and Calculations For Wide lens M14B0228IRD9

Product under test F6 (00100077)

Laser Parameters

$P_{av} := 0.126 \text{ W}$ -Radiant power at laser output@18A with 3ms pulse duration

$\lambda := 847 \text{ nm}$ -Minimum Wavelength of laser radiation

$t_p := 0.003 \text{ s}$ -Max Pulse duration

$PRF := 8 \text{ Hz}$ -Max Pulse repetition frequency

$a_{source} := 0.510 \text{ mm}$ -Apparent source

$Q_{PULSE} := \frac{P_{av}}{PRF} = 15.75 \cdot 10^{-3} \text{ J}$ -Radiant energy at output

$T := 100 \text{ s}$ -Time base

$r_{measured} := 100 \text{ mm}$ -Measurement distance

$\alpha_{min} := 1.5 \text{ mrad}$ -Minimum angular subtense

$\alpha_{source} := \frac{a_{source}}{r_{measured}} = 0.0051 \text{ rad}$ -Angular subtense of the apparent source

$\alpha_{ISH1} := 0.005 \text{ mrad}$ -According to Interpretation Sheet 1 (IEC60825-1:2014/ISH1:2017)

$C_6 := \frac{\alpha_{ISH1}}{\alpha_{min}} \cdot 1000 = 3.33$ -Correction factors for average power

$\alpha_{max} := 200 \cdot t_p^{0.5} = 10.95 \text{ mrad}$ -Max angular subtense for pulse

$T_2 := 10 \cdot 10^{\frac{(5.1 - 1.5)}{98.5}} = 10.88$ -Time breakpoints

$C_4 := 10^{(0.002 \cdot (\lambda - 700))} = 1.968$ -Correction factors

Calculations for normal condition (Pulse mode)

AEL (Accessible emission limits) for Class 1/1M :

The exposure from any single pulse within a pulse train shall not exceed the AEL for a single pulse

According to IEC60825-1 2014 , Table 4, for t=3ms and wavelength 848nm:

AEL for single pulse:

$$AEL_{single} := 7 \cdot 10^{-4} \cdot t_p^{0.75} \cdot C_4 \cdot C_6 = 58.86 \cdot 10^{-6} \quad J \quad (i) \quad \text{-Most restrictive}$$

The average power for a pulse train of emission duration T shall not exceed the power corresponding to the AEL for a single pulse of duration T (AELT).

According to IEC60825-1 2014 , Table 4, for T₂= 12.5 and Wavelength 848nm:

Since there are PRF= 8 , The average energy criteria results in a single pulse radiant exposure of:

$$AEL_{AV} := 7 \cdot 10^{-4} \cdot C_4 \cdot C_6 \cdot T_2^{-0.25} = 2.53 \cdot 10^{-3} \quad W$$

$$AEL_T := \frac{AEL_{AV}}{PRF} = 316.05 \cdot 10^{-6} \quad J \quad (ii) \quad \text{AEL-average pulse}$$

AEL for single pulse in pulse train

According to IEC60825-1 2014 , Claus 4.3.f.3:

The energy per pulse shall not exceed the AEL for a single pulse multiplied by the correction factor C₅

T_i= 5μs for wavelength 400nm to 1050nm , t_p pulse width=3ms

If pulse duration t_p>T_i and α_{max} > α > 5mrad:

C₅=1 ; **According to Interpretation Sheet 1 (IEC60825-1:2014/ISH1:2017)**

AEL-for pulse train:

$$C_5 := 1$$

$$AEL_{s.p.train} := AEL_{single} \cdot C_5 = 58.9 \cdot 10^{-6} \quad J \quad (iii)$$

Measurement in normal conditions:

r – Distance *d* – Aperture_stop

Condition_1 NA Laser with Large divergence

Condition_3 *r* := 100 mm *d* := 7 mm --■ $P_{AV_measured_con3} := 0.0004076 \text{ W}$

Pulse Energy Calculation:

$$E_{LASER_con3} := \frac{P_{AV_measured_con3}}{PRF} = 51 \cdot 10^{-6} \text{ J}$$

$$AEL_{s,p_CLASS1} > E_{LASER_NC} \quad \text{For condition 3}$$

$$PLR := \frac{E_{LASER_con3}}{AEL_{single}} = 0.87 \quad \text{-Power To Limit Ratio (If } PLR < 1 \text{ the laser classified as Class 1)}$$

Measurement in Single Fault Condition (Pulse energy increased by 8% * see RISK Analysis):

r – Distance *d* – Aperture_stop

Condition_3 *r* := 100 mm *d* := 7 mm

$$E_{LASER_SFC} := E_{LASER_con3} \cdot 1.08 = 55.026 \cdot 10^{-6} \text{ J}$$

Comper radiant exposuer to AEL's for SFC

$$AEL_{s,p_CLASS1} < E_{LASER_SFC}$$

Conclusion:

The Laser product is classified as Class 1 in normal condition and single fault condition*

* See Risk Analysis for S.F.C

**Summary of measurement and calculation for normal conditions****For 5 PRF - Wide lens M14B0228IRD9**

Current	PRF	Pulse time ms	av power μW	Q	av power μW	Pulse energy μJ	S.P AEL μJ	PLR S.P	S.P TRAIN AEL	PLR S.P.T
13	5	0.5	37	0.771	28.53	5.71	15.68	0.36	15.68	0.36
12	5	1.0	61.056	0.771	47.07	9.41	26.37	0.36	26.37	0.36
11	5	1.5	80.666	0.771	62.19	12.44	35.74	0.35	35.74	0.35
11	5	2.0	107.59	0.771	82.95	16.59	44.34	0.37	44.34	0.37
10	5	3.0	137.588	0.771	106.08	21.22	60.10	0.35	60.10	0.35
10	5	4.0	178	0.771	137.24	27.45	74.57	0.37	74.57	0.37

Remarks:

1. PLR-Power To Limit Ratio. This value gives us an indication of how we are close / far from the Class 1 limit (If $PLR < 1$, Class 1 Laser)
2. Uncertainty of measurement (W) Coverage factor $k=2$, 95% confidence level is $\pm 5.5\%$
3. $C_5=1$ According to Interpretation Sheet 1 (IEC60825-1:2014/ISH1:2017)

Summary of measurement and calculation for normal conditions

For 8 PRF - Wide lens M14B0228IRD9

Current	PRF	Pulse time ms	AV power μ W	Q	AV power μ W	Pulse energy μ J	s.p AEL μ J	PLR s.p	S.P TRAIN AEL	PLR S.P.T
14	8	0.5	59.36	0.771	45.77	5.72	15.68	0.36	15.68	0.36
12	8	1.0	96.46	0.771	74.37	9.30	26.37	0.35	26.37	0.35
11	8	1.5	131.44	0.771	101.34	12.67	35.74	0.35	35.74	0.35
11	8	2.0	165.36	0.771	127.49	15.94	44.34	0.36	44.34	0.36
10	8	3.0	222.49	0.771	171.54	21.44	60.10	0.36	60.10	0.36
9	8	4.0	253.23	0.771	195.24	24.41	74.57	0.33	74.57	0.33

Remarks:

1. PLR-Power To Limit Ratio. This value gives us an indication of how we are close / far from the Class 1 limit (If $PLR < 1$, Class 1 Laser)
2. Uncertainty of measurement (W) Coverage factor $k=2$, 95% confidence level is $\pm 5.5\%$
3. $C_5=1$ According to Interpretation Sheet 1 (IEC60825-1:2014/ISH1:2017)

New Measurement and calculation (Tested at 18.3.2018)

Current	PRF	Pulse time ms	AV power μ W	Q	AV power μ W	Pulse energy μ J	s.p AEL μ J	PLR s.p	S.P TRAIN AEL	PLR S.P.T
13	8	1	129	0.790	101.91	12.74	25.85	0.49	25.85	0.49
13	8	3	370	0.790	292.30	36.54	58.92	0.62	58.92	0.62
15	8	1	156	0.790	123.24	15.41	25.85	0.60	25.85	0.60
15	8	3	426	0.790	336.54	42.07	58.92	0.71	58.92	0.71
18	8	1	186	0.790	146.94	18.37	25.85	0.71	25.85	0.71
18	8	3	516	0.790	407.64	50.96	58.92	0.86	58.92	0.86
20	8	1	209	0.790	165.11	20.64	25.85	0.80	25.85	0.80

Remarks:

1. PLR-Power To Limit Ratio. This value gives us an indication of how we are close / far from the Class 1 limit (If $PLR < 1$, Class 1 Laser)
2. Uncertainty of measurement (W) Coverage factor $k=2$, 95% confidence level is $\pm 5.5\%$
3. $C_5=1$ According to Interpretation Sheet 1 (IEC60825-1:2014/ISH1:2017)

Appendix 3 SFC – Measurement

Clause no.	Description of single fault condition	Results observed	Hazardous situation (yes/no)
5.1	table: single fault conditions in		
	Failure of components		
1	Resistor R89 shorted, transistor Q3 or Q4 shorted	There was no change in the laser power	No Hazard Class 1 Laser
2	Capacitor C107 short/disconnect	C107 Shot- The laser power increased by 8%. C107 Disconnect- The laser has stopped working.	No Hazard Class 1 Laser
3	Capacitor C110 short/disconnect, capacitor C114 shorted	There was no change in the laser power	No Hazard Class 1 Laser
4	Capacitor C114 shorted	There was no change in the laser power	No Hazard Class 1 Laser
5	R54 disconnect, capacitor C114 shorted	There was no change in the laser power, after a few milliseconds drop to 0W	No Hazard Class 1 Laser
6	Transistor Q3 or Q4 shorted	There was no change in the laser power	No Hazard Class 1 Laser

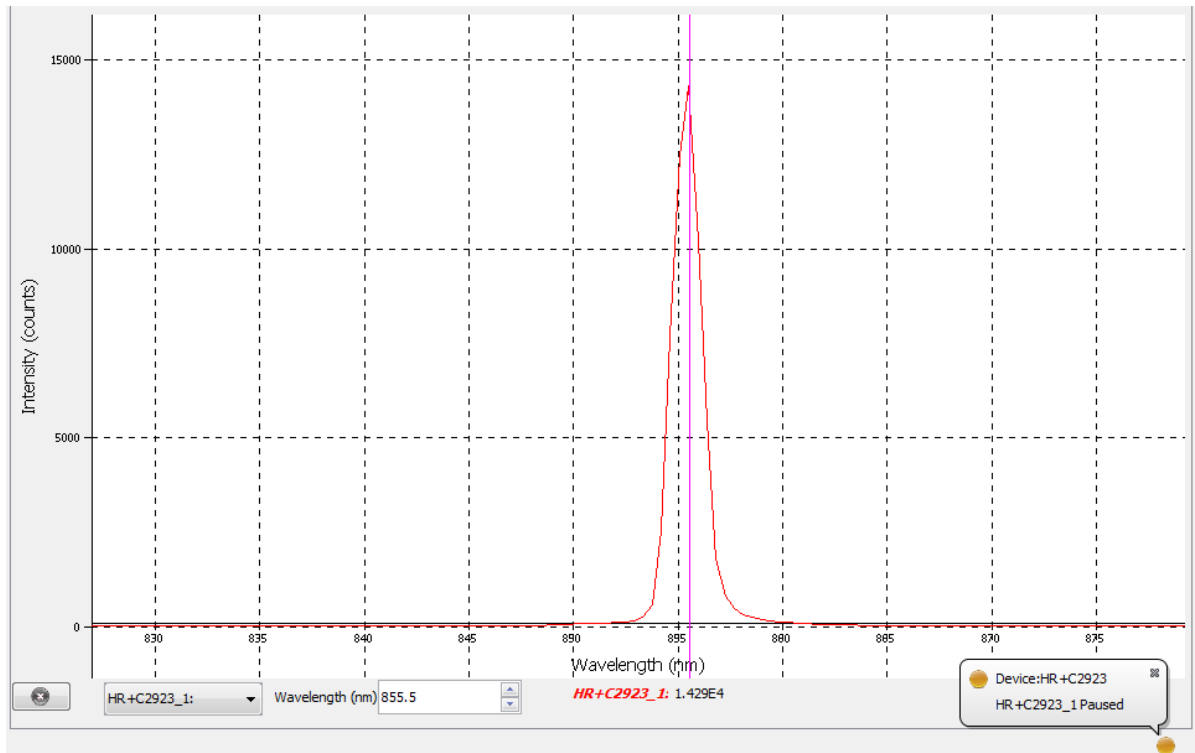
Conclusion:

In Normal and Single Fault Conditions equipment is classified as Class 1 Laser Product (Based on Manufacturer Risk Analysis (see Appendix 5))



Appendix 4 Measurement of laser Wavelength

Measured 855.5 nm





Appendix 5 Risk Analysis



MANTIS VISION
3D that works for you

Risk Analysis for Eye Safety Testing of Single Fault occurrence in the Smart F6.

Apr , 2017

Ver : 0.1



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Risk Analysis

1 Introduction

This document discusses the risk analysis associated with eye safety testing conducted for the Autocube device for Mantis-Vision. Testing carried out by the Standard Institution of Israel (SII).

2 Revision History

Ver	Date	Description
0.1	11-Apr-17	Initial

3 References.

[1] TEST REPORT IEC 60825-1 Safety of laser products for Autocube Device. By The Standard Institution of Israel.

[2] Risk analysis relevant for laser products under IEC 60825-1. ILSC® 2013 Conference Proceedings. By Karl Schulmeister.

[3] Ceramic Capacitor Data Sheet. Ceramic capacitor, 0.1UF 16V X7R 0402.

4 Overview.

During the tests. As reported in [1] one of the Single Fault case tested exhibit continues power increase of 8%. See below snapshot from the test report.



Appendix 3			
SFC – Measurement			
Clause no.	Description of single fault condition	Results observed	Hazardous situation (yes/no)
5.1	table: single fault conditions in		
	Failure of components		
1	Resistor R89 shorted, transistor Q3 or Q4 shorted	There was no change in the laser power	No Hazard Class 1 Laser
2	Capacitor C107 short/disconnect	C107 Shot- The laser power increased by 8%. C107 Disconnect- The laser has stopped working.	No Hazard Class 1 Laser

Figure 1: Single Fault test Result with 8% power increase.

In this work we will do preliminary risk analysis to evaluate the risk associated with this fault and show that it's *not reasonably foreseeable* so as the Class 1 eye safety of normal conditions should now be affected by this single fault analysis.

5 Single Fault Risk Analysis.

At [2] there is a detailed explanation of the risk analysis that should be carried out for the Single Fault case. This paper was written by Dr Karl Schulmeister which is one of the leading worldwide experts for eye safety and known in the Eye Safety Certification community. He participates in the IEC standards committees and actually many of eye safety regulation laws prepared by him and the Seibersdorf Laboratories GmbH where he works.

In this work the single fault risk analysis is considered by the following:

- The Single Fault condition is either affecting or not affecting normal conditions. In case its affecting, then normal conditions of work are to be considered and the light source is emitting power as if the fault exist and hence restricting the eye safety limits to the emission power of the device.
- Risk analysis of the should consider the fault occurrence is reasonably foreseeable combined with the chances of injury hazard probability.
- exceeding of AEL by 8%: it is generally known that exceeding AEL by 8% is negligible risk for injury, therefore permitted probability to call this “not reasonably foreseeable” is quite high, so that normal failure rates of a normal component can usually be assumed to have lower probability and therefore not reasonably foreseeable.
- The component, named C107 is a ceramic capacitor. It's datasheet given at [3]. Where the failure chances of such passive element are very low.



The above analysis is discussed at [2] in detail.

6 Summary.

It quite obvious that in this case of single fault power increase of 8% should be considered as “not reasonably foreseeable” and therefore should not restrict the AutoCube device for working under normal conditions of eye safety Class 1.