Micron Optics, Inc.
1852 Century Place • Atlanta, GA 30345 • Phone: 404.325.0005 • moi@micronoptics.com

Environmental Simulation & Electrical Testing Report of Compliance

for the

sm125, Swept Laser Interrogator

Tests From:

NEBS GR-63-CORE, Issue 1, October 1995;

RF Emissions Standards EN55022, FCC,
Part 15, Subpart B Rules and Regulations
Class A limits, EN61000-3-2 and
EN61000-3-3 Rules and Regulations;

Immunity standard EN61326-1 (2000);

Safety Standard EN 61010-1

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Section 1. Environmental Testing

I. Executive Summary

A. Thermal Testing

The operating and storage temperature ranges are dictated by the limits of the major components and subsystems. A complete summary of these parts can be seen in table 1.

SLI Platform Environmental Specification: Major Components and Subsystems

Subsystem or Component	Operating Temp		Storage Temp		Relative Humidity
	Low	High	Low	High	
Single Board Computer	0	60	n/s	n/s	0 to 90%, non-condensing
Data Acquisition Card	0	70	- 40	- 85	Not specified
MOI FFP-TF	0	65	-20	80	0 to 95% @ 40 degrees C max
Optical Gain Medium	0	70	-40	85	hermetically sealed
Optical comb Reference	0	70	n/s	n/s	hermetically sealed
Acetylene Gas Cell	-20	80	-40	100	not specified
Reference Grating	0	80	n/s	n/s	0 to 85%, non-condensing
TEC Controller	-20	100	-65	150	not specified
Optical BPF	0	65	-40	85	GR-1221
Optical Isolator	-20	70	-40	85	na
Optical fiber couplers	-40	85	-40	85	na
Photo-Detector	- 40	85	- 40	85	not specified

Table 1. Thermal Specifications for major components and subsystems.

1. Storage Temperature

a. **Requirement 1.1.1** Low Temperature Shock: the EUT will be held at a constant temperature of –40 °C for 72 hours, transferred to room temperature, and evaluated for performance. The transition from RT to –40 will take place at a rate of ~30°C/hour. Transition from –40 to RT will take 5 minutes or less.

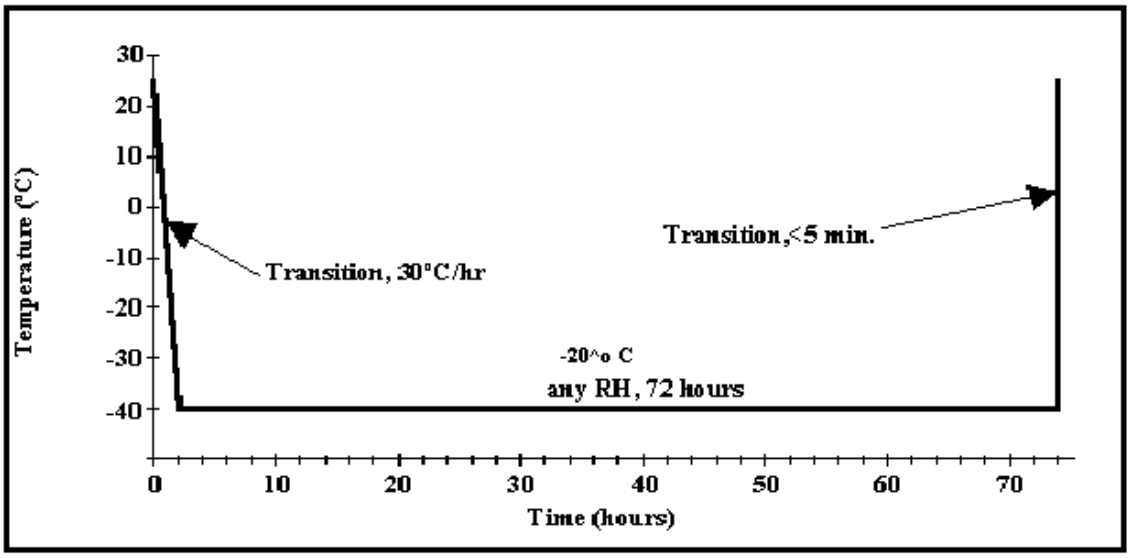


Figure 1. Low Temperature Thermal Shock

b. **Requirement 1.1.2** High Temperature Shock: the EUT will be held at a constant temperature of 70 °C for 72 hours, transferred to room temperature, and evaluated for performance. The transition from RT to 70 °C will take place at a rate of ~30°C/hour. Transition from 70°C to RT will take 5 minutes or less.

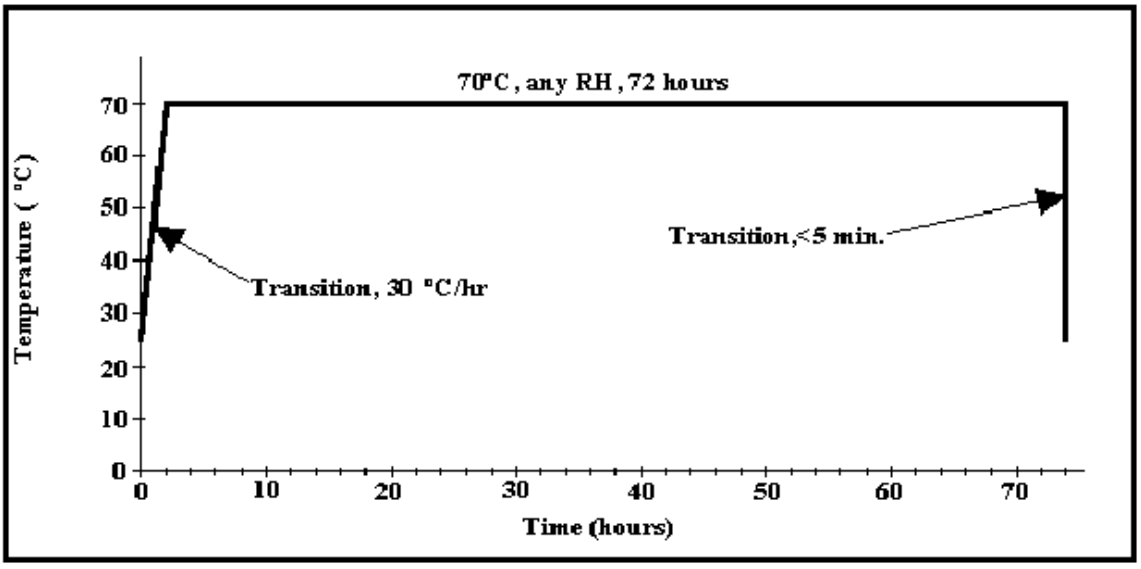


Figure 2. High Temperature Thermal Shock

c. **Requirement 1.1.3** High Relative Humidity Exposure: the EUT will be held at 40°C and 95% RH for 96 hours, transferred to room temperature and humidity, and evaluated for performance. The transition from RT to 40°C will take place at ~30°C per hour. The RH will increase to 95% over a four-hour period. Following the 96 hour soak, the temperature and RH will return to ambient at a rate of ~30°C/hour.

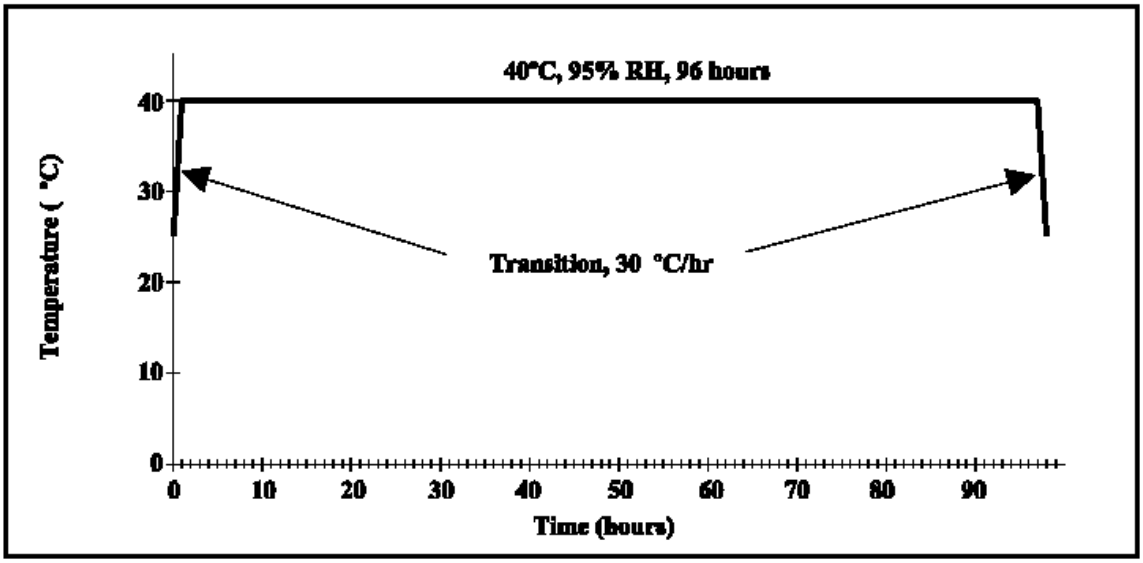


Figure 3. High Relative Humidity Exposure

2. Operating Temperature

Requirement 1.2 Operating Temperature testing will take place according to the sequence described in Figure 4.

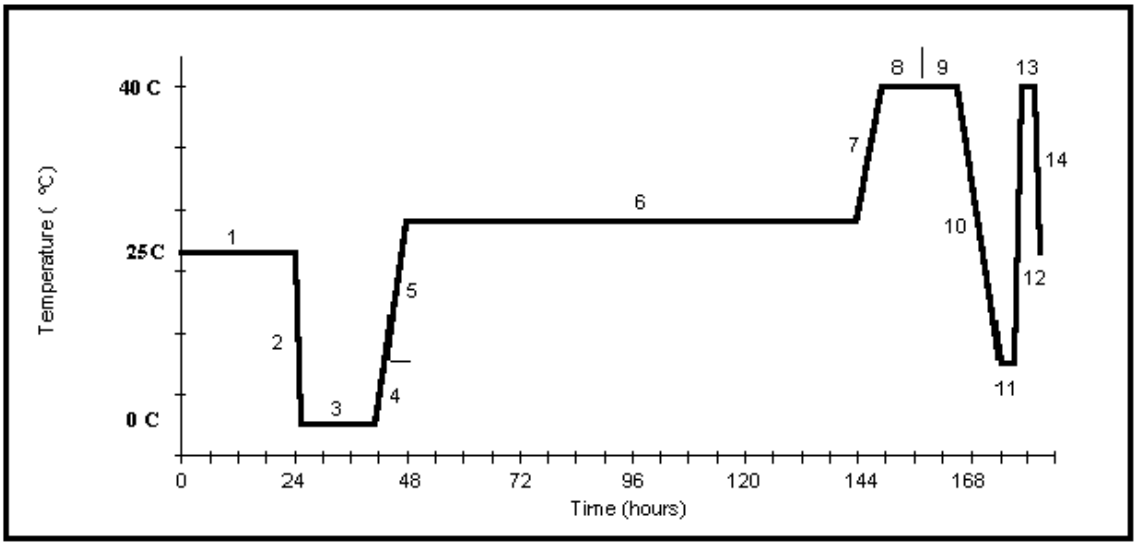


Figure 4. Operating Temperature and Humidity Test

a. The EUT is installed in the temperature chamber and conditioned for 24 hours, at 23°C (+/-2°C) and 50% RH. **(Figure 4, step 1)**
b. Following the 24 hour period, the EUT is functionally evaluated.
c. The chamber temperature is decreased to 0°C as measured by the chamber controller. The RH is not controlled. **(Figure 4, step 2)**
d. The 0°C test condition is held for 16 hours. **(Figure 4, step 3)**
e. The chamber temperature is increased to 10°C as measured by the chamber controller. The RH is not controlled. **(Figure 4, step 4)**
f. The chamber temperature is increased to 25° C (+/- 2°C) at a uniform rate of ~5°C per hour (or faster), as measured by the chamber controller while the humidity is increased to 90% RH. **(Figure 4, step 5)**
g. The test temperature is maintained at 25°C, 90% RH for 96 hours. The EUT functionality is measured throughout this period. **(Figure 4, step 6)**
h. The chamber temperature is increased to 40°C, at a uniform rate of ~5°C per hour (or faster). The humidity is decreased to 32%RH. **(Figure 4, step 7)**
i. The test temperature is maintained at 40°C for 12 hours. **(Figure 4, step 8)**
j. The test temperature is maintained at 40°C for an additional 4 hours while the humidity is decreased to less than 15%. **(Figure 4, step 9)**
k. The chamber temperature is decreased to 10°C (+/- 2°C) at a uniform rate of ~5°C per hour (or faster) while maintaining the humidity to less than 15%. **(Figure 4, step 10)**
l. The test temperature is maintained at 10°C, <15% RH for 3 hours. **(Figure 4, step 11)**
m. The chamber temperature is increased to 40°C at a uniform rate of ~30°C per hour (or faster). The RH is not controlled. **(Figure 4, step 12)**
n. The test temperature is maintained at 40°C for 3 hours. **(Figure 8, step 13)**
o. The chamber temperature is decreased to 25°C at a uniform rate of ~30°C per hour (or faster). The RH is not controlled. **(Figure 4, step 14)**
p. The 25° C test condition is held until the EUT average internal air temperature changes at a rate of less than 2°C per hour.
q. The EUT functionality is evaluated after the EUT temperature stabilizes.

Note: To evaluate operation, a single stabilized sensor value will be used as the test artifact for the EUT. For informational purposes, the data will be collected throughout the operational test.

B. Handling Tests

1. Handling Drop Tests – Packaged Equipment, Requirement 3.1

a. The EUT is subjected to drops from a height of 750mm (~29.5 inches).
b. The EUT is dropped on each of the following (see Figure 5).

Surface	S1, S2, S3
Edge	E1, E2, E3
Corner	C1, C2, C3, C4

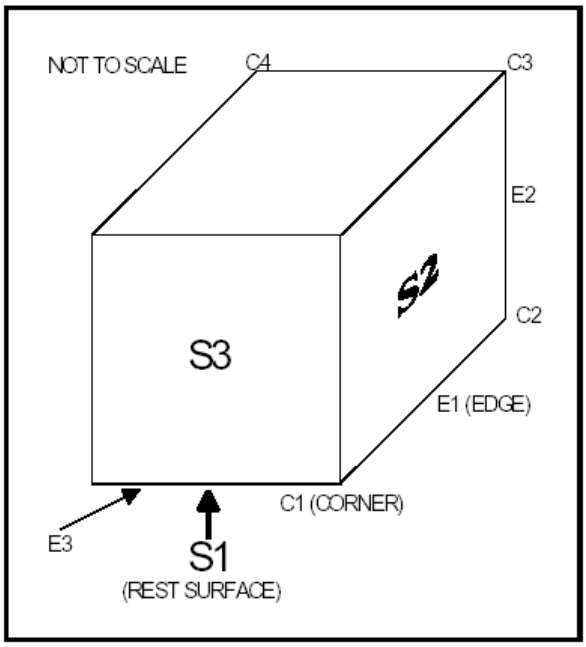


Figure 5. Drop Surfaces for Handling Test - Packaged Container

c. The test is performed on a smooth concrete floor.
d. The package is dropped from a hand-held position. Care is taken to ensure that rotational or sideways forces are not imparted to the EUT package upon release.
e. The packaged EUT is raise to the height specified (750mm). The EUT is dropped once on each impact surface, from the specified height. For corner drops, the EUT is oriented such that a straight line drawn through the struck corner and the package's geometric center is approximately perpendicular to the impact surface.
f. One minute between drops is allowed for the cushioning to recover its shape.

2. Unpackaged Equipment Drop Tests, Requirement 3.2

a. The test is performed on an unpackaged EUT. The EUT is subjected to the following drops from a height of 100mm (~3.9 inches).
b. The EUT is dropped once on each of the following sides. (see Figure 6)

Surface	S1
Edge	E1, E3
Corner	C1, C2

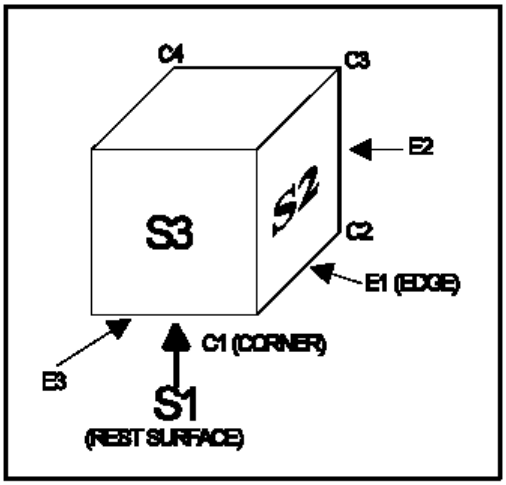


Figure 6. Drop Surfaces for Unpackaged Equipment

c. The test is performed on a smooth, concrete floor.
d. The package is dropped from a hand-held position. Care is taken to ensure that rotational or sideways forces are not imparted to the EUT package upon release.
e. The packaged EUT is raise to the height specified (750mm). The EUT is dropped once on each impact surface, from the specified height. For corner drops, the EUT is oriented such that a straight line drawn through the struck corner and the package's geometric center is approximately perpendicular to the impact surface.

II. Requirements and Objectives Matrices

EUT Serial Number	EUT 1			
Requirements/Summary	**Conformance**			
	YES	NO	N/A	Comments
Storage Environment				
1.1.1 Low Temp Shock	•			none
1.1.2 High Temp Shock	•			none
1.1.3 High RH Exposure	•			none
Operating Environment				
1.2 Operating Temp	•			none
Handling Tests				
2.1 Packaged Drop Testing	•			Shipping Box damaged slightly, unit works perfectly
2.2 Unpackaged Drop Testing	•			Sheet metal damaged slightly, unit works perfectly
IEC Compliance Testing				
RF Emissions			•	EN55022, FCC Part 15, EN61000-3-2, EN61000-3-3
Immunity			•	EN61326-1
Safety			•	EN 61010-1
Transportation Vibration	•			Per Telcordia GR-63 Standards

EUT Serial Number	EUT 2			
Requirements/Summary	**Conformance**			
	YES	NO	N/A	Comments
Storage Environment				
1.1.1 Low Temp Shock			•	
1.1.2 High Temp Shock			•	
1.1.3 High RH Exposure			•	
Operating Environment				
1.2 Operating Temp			•	
Handling Tests				
2.1 Packaged Drop Testing			•	
2.2 Unpackaged Drop Testing			•	
IEC Compliance Testing				
RF Emissions	•			EN55022, FCC Part 15, EN61000-3-2, EN61000-3-3
Immunity	•			EN61326-1
Safety	•			EN 61010-1
Transportation Vibration			•	Per Telcordia GR-63 Standards

III. General

A. Overview – Environmental Testing Plan for the sm125, Optical Sensing Interrogator

The environmental qualification test plan for the sm125 was based largely on the requirements set forth for the General Requirements for telecom equipment in Telcordia GR-63. Those items which either do not apply to the sm125, have not been requested by any customer, or are not feasible for MOI to test locally have be omitted for this round of testing.

The general areas for testing are as follows: thermal shock testing, operating environmental testing, drop/shock testing (both packaged and unpackaged), and office/transportation vibration. The items from GR-63 that will not be tested are: Altitude testing, heat dissipation, fire testing, and airborne contaminants.

The first EUT has been subjected to the complete battery of thermal tests, drop/shock testing, as well as office and transportation vibration testing, while EUT2 underwent emissions/immunity/safety testing. Successful completion of each test has been decided by the outcome of a total performance qualification following each test. The optical performance testing procedures will be laid out in a later part of this document.

B. Test Sites

Thermal shock, high humidity exposure, operating temperature, packaged drop and unpackaged drop tests were all performed on site at Micron Optics, Inc., 1852 Century Place, Atlanta, GA 30043.

Office and Transportation vibration tests were performed by Engent, Inc., 3140 Northwoods Parkway, Suite 300, Norcross, Georgia 30071.

RF emissions, immunity, and safety measurements were performed by EMC Testing Laboratories, Inc., 2210 Justin Trail, Alpharetta, GA 30004.

All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

C. Description of Test Sample

Micron Optics Swept Wavelength Interrogators facilitate a wide variety of rapid, accurate optical sensor measurements. Drawing from the strengths of proprietary swept wavelength laser technology, MOI Interrogators offer a combination of measurement speed, accuracy, dynamic range, environmental performance and measurement capability that cannot be duplicated with any other technology.

D. Test Configuration

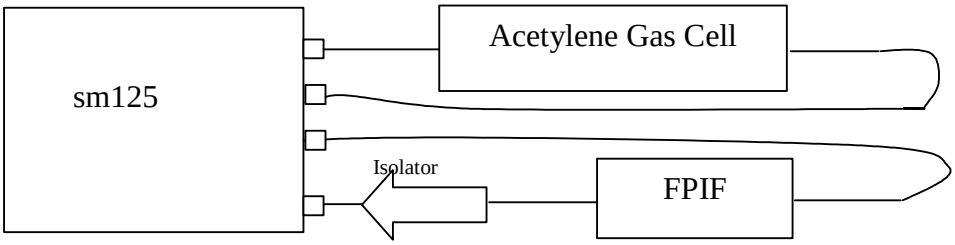


Figure 7: Block Diagram of Test Configuration

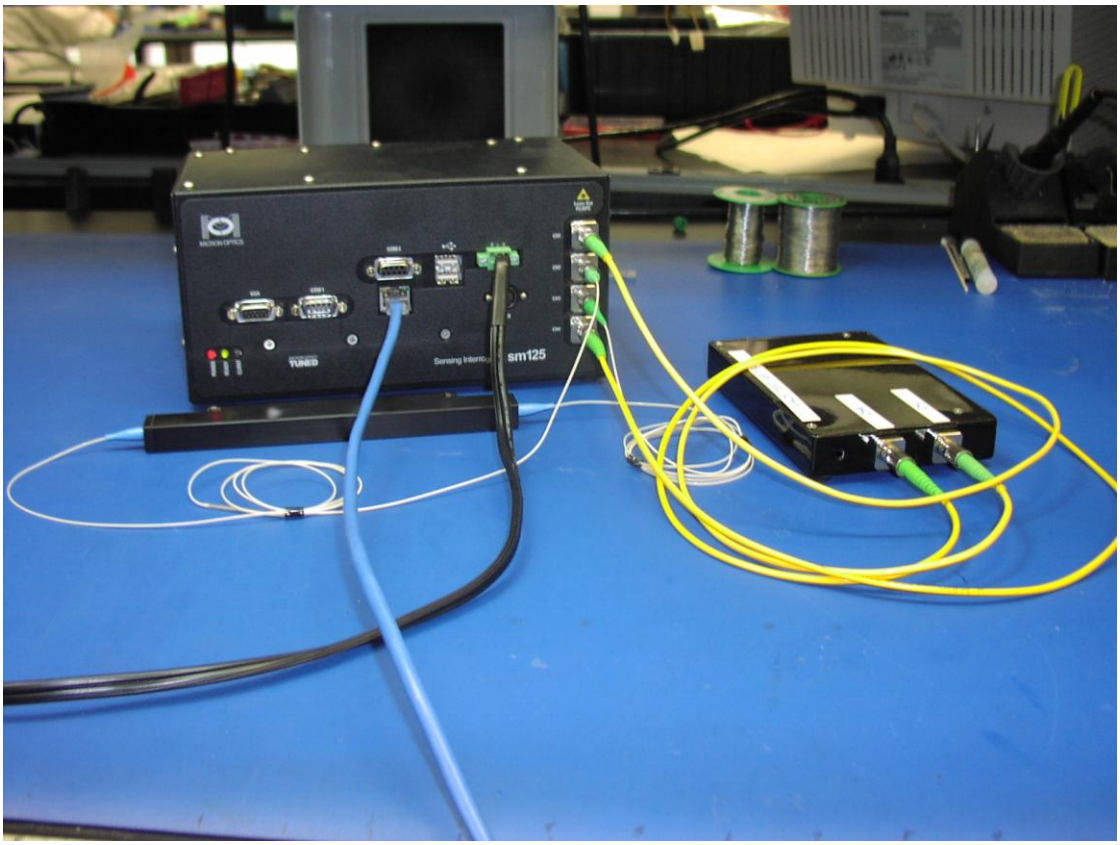


Figure 8. Test setup used for accuracy measurements.

TEST/SUPPORT EQUIPMENT USED			
Quantity	**Type**	**Manufacturer**	**Model Number**
1	Computer	Compaq	Deskpro
1	Flat Panel Monitor	NEC	
1	Optical isolator	Finisar	IU15PBAB00
1	HCN Gas Cell	Wavelength References	C2H2-MINI-STD-200-none
1	FPIF	Fibera	FFIFAA23991
1	Environmental Chamber	Espec	

Table 1. Test and support equipment used during qualification testing.

Figure 9. Espec environmental chamber used for testing.

Figure 10. EUT inside test chamber.

E. Modifications

No modifications were made to the EUT prior to testing.

F. General Test Setup

The EUT was configured according to the procedures defined by Micron Optics, Inc. and was operated in a manner representative of the typical usage of the equipment.

For Packaged Drop Testing, the EUT was packaged in standard Micron Optics packing material, representative of the materials used for typical shipments.

Operational verifications were performed using standard Micron Optics test limits and procedures, and are identical to those used during standard manufacturing.

G. Method of Monitoring EUT Operation

Each sm125 unit is undergoes a calibration and testing procedure to validate operation over time, temperature and wavelength. In order to characterize the absolute accuracy of the sm125, measurements are made of a Hydrogen Cyanide (HCN) gas cell. The National Institute of Standards and Technology has listed HCN as Standard Reference Material 2519A intended for wavelength calibration in the spectral region from 1530nm to 1565nm. The absorption profile of HCN has been characterized by NIST to an uncertainty ranging from ±0.0001nm to ±0.0006nm. The location of these lines is measured by the sm125, and the variance from the NIST values is assessed to be the error of the sm125. In order to test a complete spectrum of sensor measurements, a

fixed Fabry-Perot Interferometer (FPI) is used to emulate a series of sensors with bandwidths of 0.08nm. A reference instrument that has a calibrated accuracy of ±0.0003nm has been used to characterize this test artifact. The FPI is measured by the sm125, a comparison to the reference values is made, and the difference is assessed to be the error of the sm125. These measurements are repeated over time and temperature to ensure accurate, reliable measurements over the specified conditions for the instrument.

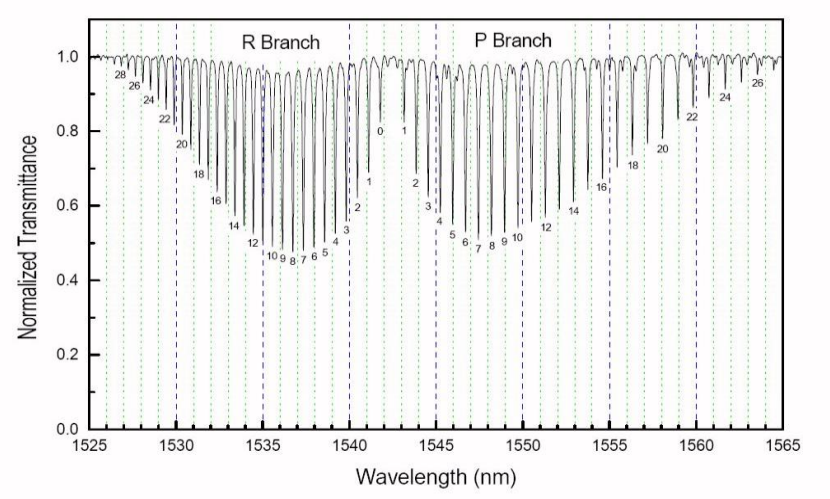


Figure 11. Plot of the HCN absorption spectrum as characterized by NIST

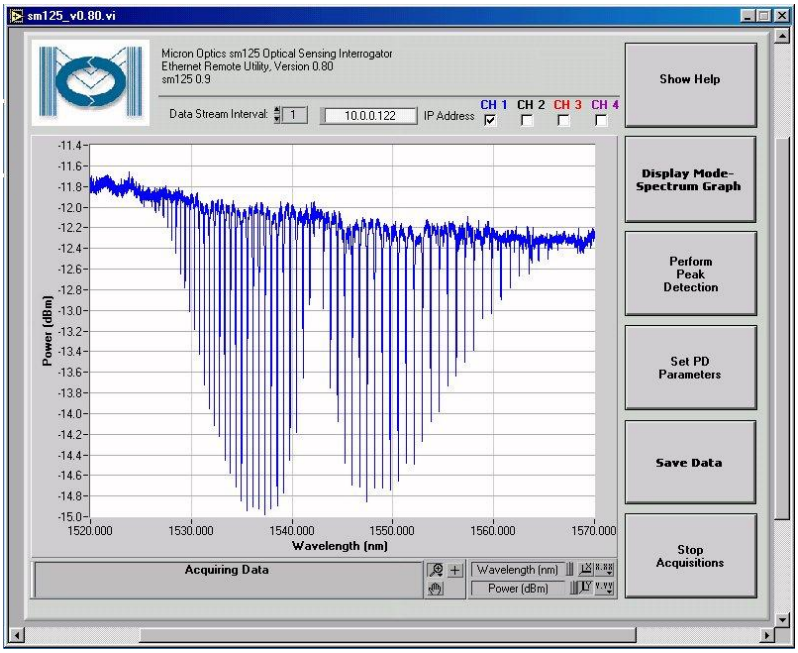


Figure 12. HCN Absorption spectrum as measured by an sm125

IV. Temperature and Humidity Test Results

Test results will be arranged first by test type, then by EUT serial number.

1.1.1 Low Temperature Shock

Test Requirements

The EUT shall not sustain any damage or performance deterioration after it has been exposed to the environment described in Figure 1.

Test Results

EUT 1 – PASS. Test unit EUT 1 passed all parameters following section 1.1.1 of the qualification testing.

1.1.2 High Temperature Shock

Test Requirements

The EUT shall not sustain any damage or performance deterioration after it has been exposed to the environment described in Figure 2.

Test Results

EUT 1 – PASS. Test unit EUT 1 passes all parameters following section 1.1.2 of the qualification testing.

1.1.3 High Relative Humidity Exposure

Test Requirements

The EUT shall not sustain any damage or performance deterioration after it has been exposed to the environment described in Figure 3.

Test Results

EUT 1 – PASS. Test unit EUT 1 passes all parameters following section 1.1.3 of the qualification testing.

1.1.2 Operating Temperature

Test Requirements

The EUT shall not sustain any damage or performance deterioration during its operating life while within the conditions specified in Figure 4.

Test Results

EUT 1 – PASS. Test unit EUT 1 passes all parameters during and after section 1.1.2 of the qualification testing.

Additional Thermal Testing Data

The operating temperature range of the sm125 is defined to be 0 to 50°C. That having been said, additional testing has shown that repeatable, low noise wavelength measurements are possible outside of the operating temperature range. While use of the instrument outside of the 0 to 50°C range is not recommended, it is worth noting that the optical source, detection, and referencing systems are quite stable, providing a comfortable safety margin.

V. Handling Test Results

2.1 Packaged Drop Test

Test Requirements

The EUT shall not sustain any physical damage or performance deterioration after it has been exposed to the shock levels described in Figure 5.

Figure 13. Packaged Drop Test – edge 3

Test Results

EUT 1 – **PASS.** Test unit EUT 1 was dropped 10 times on all of the appropriate sides, edges and corners from a height of 750mm above a hard concrete surface. Minor damage of the outer cardboard box was observed, but the carrying case and the sm125 were unaffected. The unit passed all accuracy tests following drop testing.

Figures 14: Damaged corner of outer shipping container.

Figure15. sm125 and carrying case unaffected by drop tests.

2.2 Unpackaged Drop Test

Test Requirements

The EUT shall not sustain any physical damage or performance deterioration after it has been exposed to the shock levels described in Figure 6.

Test Results

EUT 1 – PASS. Test unit EUT 1 was dropped 10 times on all of the appropriate sides, edges and corners from a height of 100mm onto a smooth concrete floor. Following the drops, the unit initialized and performed all accuracy tests within specification.

Figure 16. Slight physical damage to the corner of the sm125 after unpackaged drop testing.

VI. Vibration Test Results

Date: May 5, 2005

Engent Report Number: MCRO-0415054-01

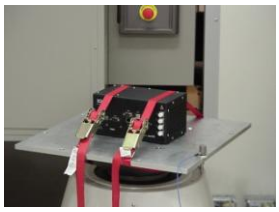
Specification: The devices supplied by Micron Optics were exposed to the customer specifications listed below:

Test Condition 1 (Operating)

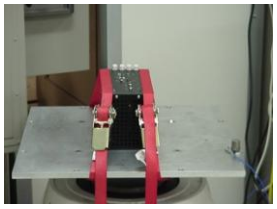
Swept sine wave from 5 to 100Hz and return
1.0 g acceleration
0.25 octaves/min
3 Axis (X,Y,Z)

Test Condition 2 (Transportation)
Swept sine wave from 5 to 500 Hz and return
5-100Hz at 1.0 g and a rate of 0.1 octaves/min
100-500Hz at 1.0 g and a rate of 0.25 octaves/min
3 Axis (X,Y,Z)

Procedure: All tests were performed while the device under test (DUT) was **not** supplied power. The DUT was mounted directly to the vibration table as shown in the photographs below.


X-Axis


Y-Axis


Z-Axis

Office Vibration Test:
The DUT was subjected to a swept sine survey at an acceleration of 1.0g from 5 to 100 Hz and back to 5 Hz at a rate of 0.25 octave/minute. The sweep was repeated for each of three mutually perpendicular axes. This test was performed for both customer samples provided to Engent.

Transportation Vibration Test:
The DUT was subjected to a sine sweep of 1g from 5 to 100 Hz at a rate of 0.1 Octaves/min. Next it was subjected to a sine sweep of 1g from 100 to 500 Hz at a rate of 0.25 Octaves/min. The DUT was then returned to 5 Hz using the same profile in reverse. The sweep was repeated for each of three mutually perpendicular axes. This test was performed for both customer samples provided to Engent.

Author

Name: Tom Cwetna
Title: Process Engineer
ENGENT Inc.
Office: (678) 990-3320
Fax: (678) 990-3324

Test Results

EUT 1 – PASS. Test unit EUT1 performance checked following the vibration tests and passed all tests. It was then opened for a visual inspection, and was found to be in as-manufactured condition.

Section 2. RF Emissions Test Report

To Determine Compliance with: EN55022, FCC, Part 15, Subpart B Rules and Regulations Class A limits, EN61000-3-2 and EN61000-3-3 Rules and Regulations

Contents Section

I. General Information

Manufacturer:	Micron Optics, Inc. 1852 Century Place, N.E. Atlanta, GA 30345
Manufacturer representative:	Mr. Jim Marihew
Equipment covered by this report:	Model nos. sm125 and sm041
Options covered by this report:	None
Equipment serial no.	Prototype
Test specifications:	EN55022 (98) w/A2 (03) EN61000-3-2 (01) EN61000-3-3 (95) w/A2 (02) FCC, Part 15, Subpart B (98)
Test report number:	05-181A
Test commenced:	May 12, 2005
Test completed:	May 15, 2005
Test engineer:	**Edward Barnes**

Test Facility: The test facility used to perform these tests is on file with the FCC under registration number 637500 and located at:

EMC Testing Laboratories, Inc.
2210 Justin Trail, Alpharetta, GA 30004

II. Test Report

Summary:

Tests	Results
FCC, Part 15, Class A, Radiated emissions:	**Pass**
FCC, Part 15, Class A, Conducted emissions:	**Pass**
EN55022, Class A, Radiated emissions	**Pass**
EN55022, Class A, Conducted emissions	**Pass**
EN61000-3-2, Quasi-Stationary Current Harmonics test	**Pass**
EN61000-3-3, Voltage Fluctuation and Flicker Test	**Pass**

1- The product(s) covered by this report was found to comply with the Class A limits of the FCC, Part 15, Subpart B Rules and Regulations, CISPR 22/EN55022, Quasi-Stationary Current Harmonics test EN61000-3-2 and Voltage Fluctuation and Flicker Test EN61000-3-3, Class D.

2- The minimum margin of compliance was **–7.5** dBμv/m at 32.0 MHz followed by **–9.6** dBμv/m at 72.4 MHz.

3- The test results apply only to the products identified on the test report.

Product description:

The model no. sm041 is an optical multiplexer, which allows the model no. sm125 to monitor up to 16 optical sensor arrays. It achieves this by utilizing solid state optical switches which are controlled directly by the sm125 via the electrical interconnect cable.

The enclosure is constructed of metal with overall dimensions measuring 22.5 cm wide by 11.2 cm high by 13 cm deep. Provide with eight rows of twelve 3 mm diameter opening at each end and encloses the following printed wiring boards judged as critical:

Model no. sm125

Name	**Part no.**	Rev. no.
Transmitter	221782B	B
Receiver	221783B	B
Interface	221781F	F
Advantech	PCM-9370F Single Board Computer	
Mesa Electronics	4A24 high speed 16 bit A-D card	

Model no. sm041:

Name	**Part no.**	**Rev. no.**
Optical Switch Module	221765	A

Test configuration:

The equipment under test (EUT) was set-up and configured as specified by the manufacturer as follows:

1- The EUT was connected to the following support peripherals:

A- Computer, manufactured by Compaq, model no. MaxPro8010, serial no. mv0000104026.
B- Monitor, manufactured by ViewSonic, model no. VCDTS21683-1M, serial no. 218004202259.
C- Test box, manufactured by Micron Optics, model no. "CTS assembly/FFT"

2- The EUT utilized the following cables and were connected as indicated below:

A- Two unshielded and unterminated DB-9 cables connected at model no. sm125.
B- An unshielded and unterminated DB-15 cable connected at model no. sm125.
C- Two un-terminated USB cables connected at model no. sm125.
D- A DIN connector with cable connected between the model nos. sm125 and sm041.
E- Two fiber-optic cables connected between the model nos. sm125 and sm041.
F- An unshielded cable between the model no. sm125 and the external power supply.

Test operation:

For all measurements, the equipment under test was caused to function in a continuous mode of operation for maximum electrical activity as specified by the manufacturer. Specifically, the sm041 is an optical multiplexer, which allows the sm125 to monitor up to 16 optical sensor arrays. It achieves this by utilizing solid state optical switches which are controlled directly by the sm125 via the electrical interconnect cable.

Instruction Manual Information:

For equipment sold in Europe, the following warning is included in the user manuals:

> **Warning:** This is a Class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

Modifications:

The following modifications were required to comply with the emission limits:

1- None

Engineering Statement:

All measurement data of this test report was taken in accordance with the European Normative standards indicated above and the FCC standard, ANSI C63.4-2003 by EMC Testing Laboratories, Inc. located in Alpharetta, Georgia. Although this data is taken under stringent laboratory conditions and to the best of our knowledge, represents accurate data, it must be recognized that emissions from or immunity to this type equipment may be greatly affected by the final installation of the equipment. Therefore, EMC Testing Laboratories, Inc., while supporting the accuracy of the data in this report, takes no responsibility for use of equipment based on these tests. The manufacturer of this equipment must take full responsibility for any field problems which may arise, and agrees that EMC Testing Laboratories, Inc., in performing its functions in accordance with its objectives and purposes, does not assume or undertake to discharge any responsibility of the manufacturer to any other party or parties.

Conclusion:

With the above indicated modifications, the product(s) covered by this report has been tested and found to comply with the limits for all above mentioned standards

Tested by: **Edward Barnes, RF Engineer**

Approved by: _____
Gene Bailey, Engineering Manager, EMC Testing Laboratories, Inc.

III. Standard Reference

The following primary standards were used for this test:

1- **ANSI C63.4-2003:**
Method of Measurements of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment in the 9 Khz to 40 GHz.

2- **US Code of Federal Regulations (CFR) (1998):**
Title 47, Part 15, Radio Frequency Devices, Subpart B, Unintentional Radiators.

3- **C.I.S.P.R 22 (2003):**
Limit and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.

4- **EN55022 (1998) wA2 (03):**
Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.

5- **EN61000-3-2(01):**
Section 2. Limits for harmonic current emissions (equipment input current $\leq$ 16 A per phase).

6- **EN61000-3-3 (1995) wA2 (02):**
Section 3. Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current $\leq$ 16 A.

Note: Applicable amendments were applied to all standards.

IV. EMI Test Method

INTRODUCTION:

The product(s) covered by this report were subjected to electromagnetic interference emissions measurements to determine compliance with the EMI portion of the EC directive 92/336/EEC as specified in CISPR 22/EN55022. In addition, the product was evaluated for compliance with the FCC, Part 15 requirements.

Radiated and conducted emissions were measured in accordance with the Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment, C.I.S.P.R 22 /EN55022 and Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 Khz to 40 GHz, ANSI C63.4.

MEASUREMENT CALCULATIONS:

Radiated Emissions:

For radiated emissions measurements, the signal attenuation due to impedance losses in the antenna and signal cable were significant and was added to the spectrum analyzer reading to give corrected signal strength reading. If a preamplifier was used, the signal gain was subtracted from the signal strength reading. Radiated emissions data was specified as decibels above 1 microvolt per meter (dBμV/m) of radiated field strength.

Radiated emissions (dBμV) = Analyzer reading (dBμV) plus antenna factor (dB) plus cable factor (dB) minus Amplifier gain (dB)

Conducted Emissions:

For conducted emissions, the signal attenuation due to impedance losses in the LISN and signal cables were negligible and assumed to be 0dB. The conducted emissions were directly equal to the spectrum analyzer reading. Conducted emissions data was specified as decibels above 1 microvolt (dBμV) of conducted line voltage.

Conducted emissions (dBμV) = Analyzer reading (dBμV)

RADIATED EMISSIONS MEASUREMENT:

Radiated emissions measurements were performed at an open field test site. The receiving antenna was positioned 3 meters from the equipment under test along the center axis of the test site. Measurements were made with broadband antennas and if necessary, detected emissions were verified with dipole antennas. The dipole antenna was manually tuned to the signal frequency by adjusting the length of the antenna elements. The radiated emissions were measured for both the horizontal and vertical signal planes by rotating the antennas. Additionally, the EUT was rotated by the turntable and the antenna height was raised and lowered 1 to 4 meters to locate the maximum emission strength at each frequency.

The radiated emissions were measured over the frequency span of 30 MHz to 5000 MHz. The following antennas were used to measure the radiated emissions within the specified frequency spans.

Antenna	**Frequency Span**
Biconical	20 - 200 MHz
Log Periodic	200 - 1000 MHz
Dipoles	20 - 1000 MHz
Horn	1-18 GHz

CONDUCTED EMISSIONS MEASUREMENT:

Conducted emissions measurements were performed on a ground plane that was electrically bonded to earth ground. The equipment under test was positioned 0.8 meter above the ground plane and 0.8 meter minimum from the LISN that was positioned on the ground plane. The LISN housings were electrically bonded to the ground plane. The conducted emissions for both the ungrounded supply conductor (L1) and the grounded conductor (L2) of the power supply cord were measured. The conducted emissions were measured over the frequency span of 0.15 to 30 MHz. The measurements were conducted in the quasi-peak and average detector modes.

INSTRUMENTATION:

Radiated and conducted signal strength measurements were taken with a spectrum analyzer. Radiated emissions were measured with broadband and tuned dipole antennas. Conducted emissions were measured with a 50 UH line impedance stabilization network (LISN). The test equipment consists of the following:

Test Equipment	Model No.	Serial No.	Cal. Due
Spectrum Analyzer	HP 8591A	3144A02506	01-06-06
Spectrum Analyzer	8592L	3649A00744	01-10-06
LISN	94641-1	0145/0146	06-05-05
LISN	3825/2	9305-2088	08-26-05
LISN	LI-210	25145	07-10-05
Biconical Antenna	3110B	1708	10-08-05
Biconical Antenna	BIA-25	2451	09-23-05
Log Periodic	LPA25	1112	10-08-05
Dipole Antenna	DM-105A-T1	31402-110	06-05-05
Dipole Antenna	DM-105A-T2	31402-105	06-05-05
Dipole Antenna	DM-105A-T3	31402-109	06-05-05
Horn Antenna	3115	9405-4264	10-08-05
R.F. Amplifier	QB-820	11602	01-11-06
Preamplifier	8449B	3008A00914	01-07-06
Harmonics/ Flicker test system	6842A	3531A00171	06-18-05

DETECTOR FUNCTION:

Unless otherwise indicated in this report, all measurements were taken using a peak hold signal detector function. In this mode, the spectrum analyzer makes continuous scans across the frequency band and stores the highest emission value detected at each frequency for all scans. The peak hold integration will detect transient or low duty cycle emissions peak which might be missed on single scan measurement. The emission value at each frequency was a true value.

SPECTRUM ANALYZER SETTING:

For all measurements, the spectrum analyzer was set for a 10 dB input attenuation, 10 dB/Division vertical scale and 90 or 100 dBμV reference level. The resolution bandwidth was set at 9 Khz for the 0.15 - 30 MHz span and at 120 Khz for 30 - 1000 MHz span and 1 MHz for measurement above 1000 MHz. The video bandwidth and sweep rate were automatically coupled by the analyzer.

V. Radiated Emissions Measurements

Model numbers: sm125 and sm041 **Test Date:** May 12, 2005

Frequency MHz	Measurement Reading dBμV/m	Corrected Reading dBμV/m	EN55022 Limit dBμV/m	FCC Limit dBμV/m	Minimum Margin dBμV/m
Vertical					
32.0	50.1 *	42.0	50.5	49.5	**-7.5**
33.1	47.3 *	38.9	50.5	49.5	-10.6
36.2	45.3 *	36.1	50.5	49.5	-13.4
41.8	43.1	32.8	50.5	49.5	-16.7
44.3	48.7	38.1	50.5	49.5	-11.4
53.9	46.2	34.9	50.5	49.5	-14.6
56.8	47.9	36.6	50.5	49.5	-12.9
63.4	48.3	36.9	50.5	49.5	-12.6
66.4	47.3	36.0	50.5	49.5	-13.5
71.2	49.3	38.1	50.5	49.5	-11.4
72.4	51.1	39.9	50.5	49.5	**-9.6**
75.2	46.8	35.6	50.5	49.5	-13.9

Model numbers: sm125 and sm041 **Test Date:** May 12, 2005

Frequency MHz	Measurement Reading dBμV/m	Corrected Reading dBμV/m	EN55022 Limit dBμV/m	FCC Limit dBμV/m	Minimum Margin dBμV/m
Vertical					
80.4	47.4	36.2	50.5	49.5	-13.3
84.4	49.3	38.2	50.5	49.5	-11.3
118.5	50.5	40.3	50.5	54.0	-13.7
122.8	48.2	38.7	50.5	54.0	-15.3
130.3	52.4	43.3	50.5	54.0	-10.7
134.7	46.2	37.4	50.5	54.0	-16.6
223.8	43.4	34.8	50.5	56.0	-21.2
268.8	41.8	35.4	57.5	56.0	-20.6

Model numbers: sm125 and sm041 **Test Date:** May 12, 2005

Frequency MHz	Measurement Reading dBμV/m	Corrected Reading dBμV/m	EN55022 Limit dBμV/m	FCC Limit dBμV/m	Minimum Margin dBμV/m
Horizontal					
32.1	41.7 *	34.7	50.5	49.5	-14.8
36.2	42.0	33.6	50.5	49.5	-15.9
37.3	41.4	32.6	50.5	49.5	-16.9
61.6	43.7	31.9	50.5	49.5	-17.6
84.4	44.0	32.8	50.5	49.5	-16.7
125.9	41.3	32.4	50.5	54.0	-21.6
128.1	43.8	35.0	50.5	54.0	-19.0
188.1	42.5	35.8	50.5	54.0	-18.2

VI. Conducted Emissions Measurements

Model number: sm125 and sm041

Test voltage: 120V 60Hz **Test Date:** May 13, 2005

Frequency MHz	Reading dBuV, L1	Frequency MHz	Reading dBuV, L2	FCC Limit, dBuV	Margin dBuV
There were no measurable emissions within 15 dBuV from the limits					

Test voltage: 240V 50Hz

Frequency MHz	Reading dBuV, L1	Frequency MHz	Reading dBuV, L2	FCC Limit, dBuV	Margin dBuV
There were no measurable emissions within 15 dBuV from the limits					

VII. Harmonic Current Emissions Test

Purpose

To verify compliance with the limitation of harmonic current injected into the public supply system in accordance with the electromagnetic compatibility, Part 3. Limits, Section 2. Limits for harmonic current emissions (equipment input current ≤ 16A per phase) EN61000-3-2

Test method

The power cord of the equipment covered by this report was connected to the measurement/power port of a Harmonic/Flicker test system manufactured by Hewlett Packard, model no. 6842A and operated as described in "Test operation" above.

The Harmonic/Flicker test system was controlled by software specifically designed to measure harmonic current emissions as stated in the referenced standard EN61000-3-2.

Conclusion

The product was considered compliant with the limits as outlined in clause 7 of EN61000-3-2.

For detailed test results see Section 8 of this report (Harmonic/Flicker, Lab. data sheets).

VIII. Harmonic/Flicker, Lab. Data Sheets

IEC 1000-3-2/EN 61000-3-2 Quasi-stationary Current Harmonics Test
Date Performed: 05/16/05

Test Executed By: EMC Testing Laboratories, Inc
Company Name: Micronoptics, Inc.
Test Description: EN61000-3-2
Device Under Test ID: SM041 and SM125
Test ID: 05-181A

Approved by: _____

Signature: _____ Date: _____

Final Test Result: PASS

Settings and Test Conditions Compliant to the Standard: Yes

Test Equipment Used:

HP 6842A Harmonic/Flicker Test System with serial number:
HFTS Software Version: A.05.02
Date Last Calibrated:

Test Equipment Settings:

Line Voltage: 230.00 V	Current Measurement Range: High
Line Frequency: 50 Hz	Measurement Delay: 10.0 seconds
Device Class: A	Quasi-stationary Harmonics Test Duration: 5.00 minutes
Class Determination Pre-test Duration: 10.00 seconds	

Overrides:

Test Limit Source (Power Measurements/Statistics): N/A
Power Overrides: N/A
Test Limit Overrides: None

Pre-test Results for Class Determination:

Percent in Envelope: 100.0%	Fundamental Current: 0.115 A
Class D Equipment?: No	Real Power: 26.0 W
Voltage THD Out-of-Specification?: No	Power Factor: 0.479
Maximum Power: 27.1 W	Mean Power: 26.0 W

Total Number of Failures:	Total Number of Errors:
None	None

Remarks

Test ID: 05-181A 1 of 1 Test Data File: 05-181A.STA

IEC 1000-3-2/EN 61000-3-2 Fluctuating Current Harmonics Test
Date Performed: 05/16/05

Test Executed By: EMC Testing Laboratories, Inc
Company Name: Micronoptics, Inc.
Test Description: EN61000-3-2
Device Under Test ID: SM041 and SM125
Test ID: 05-181A

Approved by: _____

Signature: _____ Date: _____

Final Test Result: PASS

Settings and Test Conditions Compliant to the Standard: Yes

Test Equipment Used:

HP 6842A Harmonic/Flicker Test System with serial number:
HFTS Software Version: A.05.02
Date Last Calibrated:

Test Equipment Settings:

Line Voltage: 230.00 V	Current Measurement Range: High
Line Frequency: 50 Hz	Measurement Delay: 10.0 seconds
Device Class: A	Fluctuating Harmonics Test Duration: 5.00 minutes
Class Determination Pre-test Duration: 10.00 seconds	

Overrides:

Test Limit Source (Power Measurements/Statistics): N/A
Power Overrides: N/A
Test Limit Overrides: None

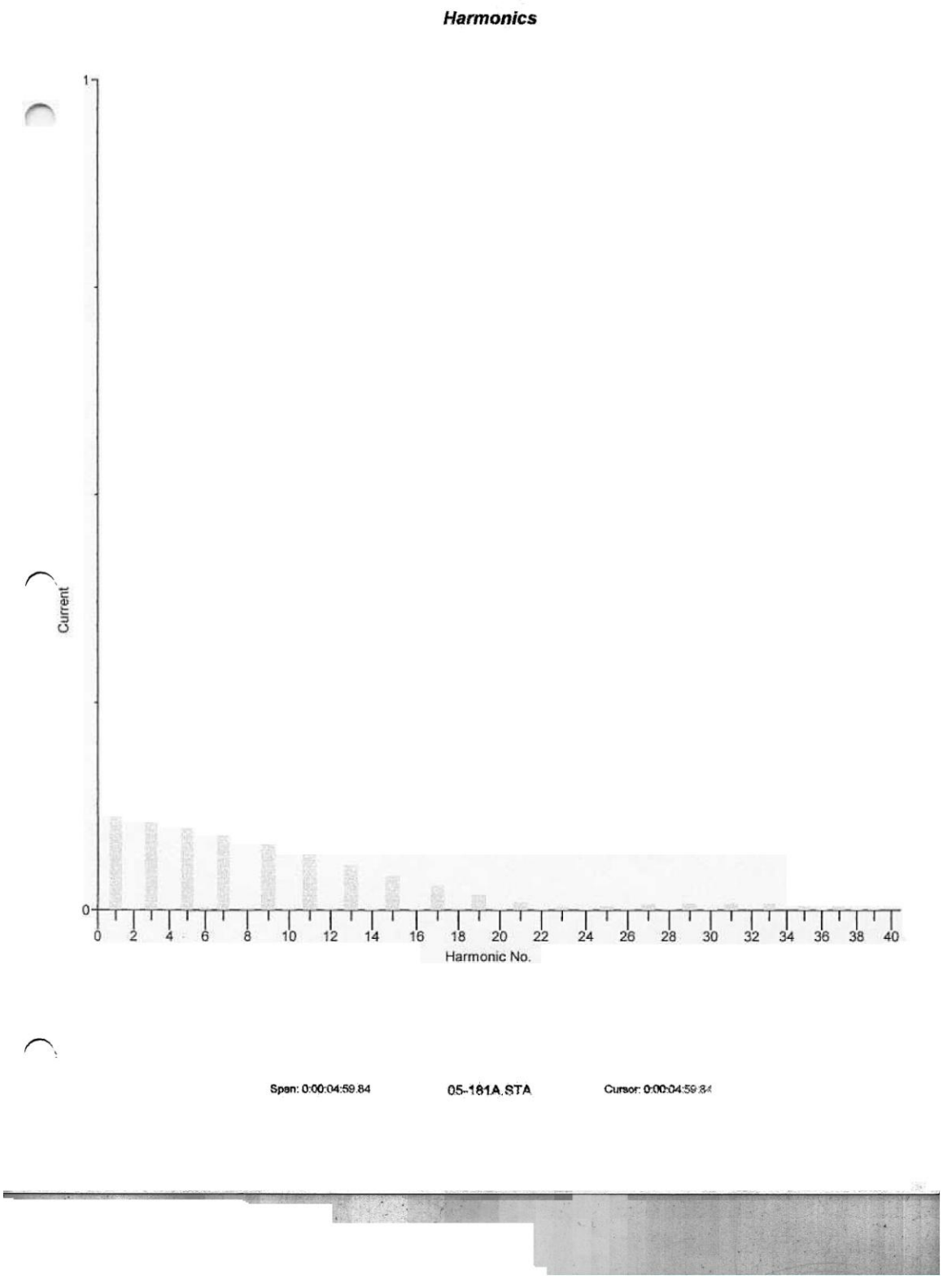
Pre-test Results for Class Determination:

Percent in Envelope: 100.0%	Fundamental Current: 0.115 A
Class D Equipment?: No	Real Power: 25.8 W
Voltage THD Out-of-Specification?: No	Power Factor: 0.468
Maximum Power: 26.6 W	Mean Power: 25.8 W

Total Number of Failures:	Total Number of Errors:
None	None

Remarks

Test ID: 05-181A 1 of 1 Test Data File: 05-181A.FLU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0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Harmonic No.
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05-181A.STA
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IX. Voltage Fluctuations and Flicker Test

Purpose

To verify compliance with the limitation of voltage fluctuations and flicker impressed onto the public supply system in accordance with the Electromagnetic compatibility, Part 3. Limits – Section 3 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current $\leq$ 16 A, EN61000-3-3.

Test method

The power cord of the equipment covered by this report was connected to the measurement/power port of a Harmonic/Flicker test system manufactured by Hewlett Packard, model no. 6842A and operated as described in "Test operation" above.

The Harmonic/Flicker test system was controlled by software specifically designed to measure harmonic current emissions as stated in the referenced standard EN61000-3-3.

Conclusion

The product was considered compliant with the limits as outlined in clause 5 of EN61000-3-3.

For detailed test results see Section 10 of this report (Voltage Fluctuations and Flicker, Lab. data sheets).

X. Voltage Fluctuations and Flicker, Lab. Data Sheets

IEC 1000-3-3/EN 61000-3-3 Voltage Fluctuation and Flicker Test
Date Performed: 05/16/05

Test Executed By: EMC Testing Laboratories, Inc.
Company Name: Micronoptics, Inc.
Test Description: EN61000-3-3
Device Under Test ID: SM041 and SM125
Test ID: 5-181A

Approved by: _____

Signature:_____ Date:_____

Final Test Result: PASS

Settings and Test Conditions Compliant to the Standard: Yes

Test Equipment Used:

HP 6842A Harmonic/Flicker Test System with serial number:
HFTS Software Version: A.05.02
Date Last Calibrated:

Test Equipment Settings:

Line Voltage: 230.00 V	Pst Integration Time: 10 minutes
Line Frequency: 50 Hz	Pst Integration Periods: 1
Measurement Delay: 10.0 seconds	Test Duration: 00:10:00

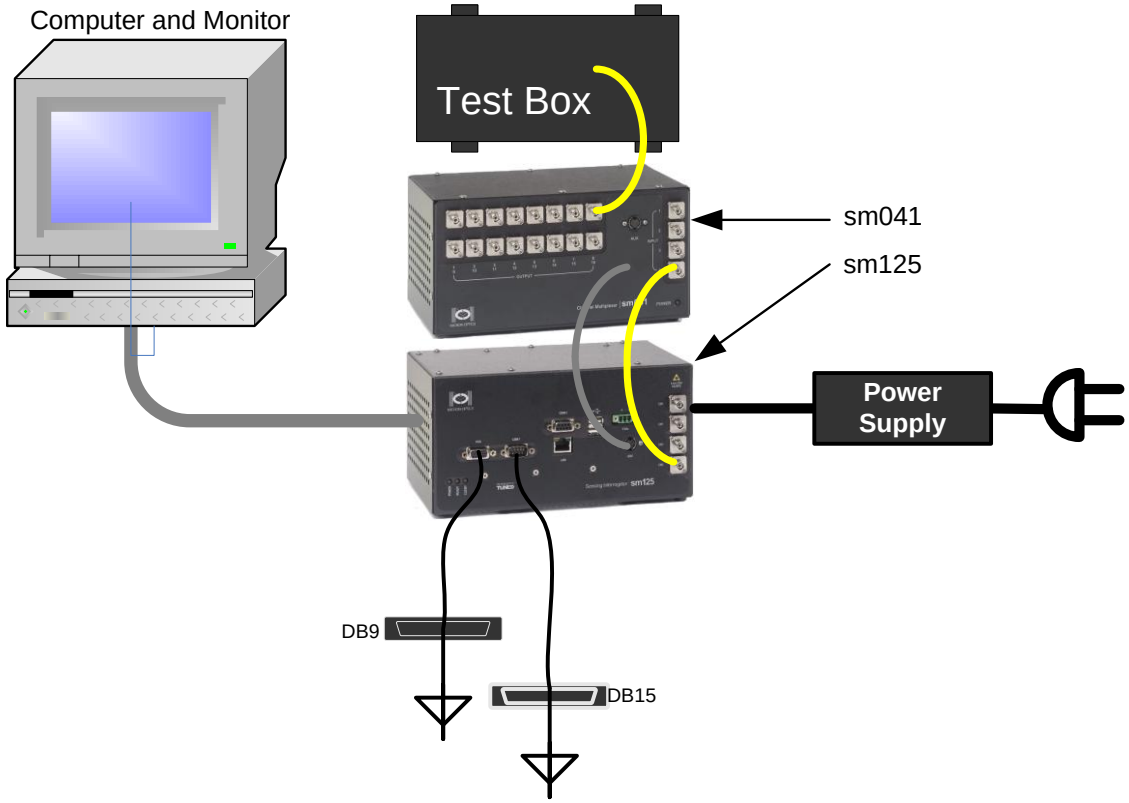
Overrides:
Pst/Plt Test Limit Overrides: NONE
RMS Test Limit Overrides: NONE

Total Number of Failures:			Total Number of Errors:
Pst: 0	Dc:	0	None
Plt: 0	Dmax: 0		
	Dt: 0		

Remarks

Test ID:)5-181A 1 of 1 Test Data File: 05-181A.FLK

XI. Configuration



XII. Photographs

Section 3. Immunity Measurements Report

To Determine Compliance With: Electrical Equipment for Measurement, Control, and Laboratory use, EN61326-1

Contents Section

I. Introduction

Manufacturer:	Micron Optics, Inc. 1852 Century Place, N.E. Atlanta, GA 30345
Manufacturer representative:	**Mr. Jim Marihew**
Equipment covered by this report:	Model nos. sm041 and sm125
Options covered by this report:	None
Equipment serial no.	Prototype
Test specifications:	EN61326-1 (97) A1 (98)
Test report number:	05-181B
Test commenced:	May 14, 2005
Test completed:	May 19, 2005
Test engineer:	**Edward Barnes**

Test Facility: The test facility used to perform these tests is on file with the FCC under registration number 637500 and located at:

EMC Testing Laboratories, Inc.

2210 Justin Trail

Alpharetta, GA 30004

Purpose -
The purpose of these tests is to evaluate the product(s) (EUT) covered by this report for compliance to the Electromagnetic Compatibility (EMC) requirements as specified in the reference standards.

Specifically, these tests evaluated the immunity of the EUT to the following:

EN61326-1 (97) A1 (98)	Electrical Equipment for Measurement, Control and Laboratory use - EMC Requirements
EN61000-4-2 (95)	Electrostatic Discharge Immunity Test
EN61000-4-3 (02	Radiated Electromagnetic Fields
EN61000-4-4 (05)	Electrical Fast Transient/Burst
EN61000-4-5 (95)	Surge Immunity Test
EN61000-4-6 (96)	Immunity To Conducted Disturbances
EN61000-4-11 (04)	Voltage Dips, Short Interruptions and Voltage Variations

Note: All applicable amendments were applied to the appropriate standards.

Summary tables utilized in this report indicate overall performance of the EUT to a specific test. Detailed data sheets for each test are on file and copies are available upon written request from an authorized agent for the company indicated on the front of the report.

Product description:
The model no. sm041 is an optical multiplexer, which allows the model no. sm125 to monitor up to 16 optical sensor arrays. It achieves this by utilizing solid state optical switches which are controlled directly by the sm125 via the electrical interconnect cable.

The enclosure is constructed of metal with overall dimensions measuring 22.5 cm wide by 11.2 cm high by 13 cm deep. Provide with eight rows of twelve 3 mm diameter opening at each end and encloses the following printed wiring boards judged as critical:

Model no. sm125:

Name	Part no.	Rev. no.
Transmitter	221782B	B
Receiver	221783B	B
Interface	221781F	F
Advantech	PCM-9370F Single Board Computer	
Mesa Electronics	4A24 high speed 16 bit A-D card	

Model no. sm041:

Name	Part no.	Rev. no.
Optical Switch Module	221765	A

Test configuration:
The equipment under test (EUT) was set-up and configured as specified by the manufacturer as follows:

1- The EUT was connected to the following support peripherals:

A- Computer, manufactured by Compaq, model no. MaxPro8010, serial no. mv0000104026
B- Monitor, manufactured by ViewSonic, model no. VCDTS21683-1M, serial no. 218004202259.
C- Test box, manufactured by Micronoptics, model no. CTS assembly/FFT

2- The EUT utilized the following cables and were connected as indicated below:

A- Two unshielded and unterminated DB-9 cables connected at model no. sm125.
B- An unshielded and unterminated DB-15 cable connected at model no. sm125.
C- Two unterminated USB cables connected at model no. sm125.
D- A DIN connector with cable connected between the model nos. sm125 and sm041.
E- Two fiber-optic cables connected between the model nos. sm125 and sm041.
F- An unshielded cable between the model no. sm125 and the external power supply.

Test operation:
For all measurements, the equipment under test was caused to function in a continuous mode of operation for maximum electrical activity as specified by the manufacturer. Specifically, the sm041 is an optical multiplexor, which allows the sm125 to monitor up to 16 optical sensor arrays. It achieves this by utilizing solid state optical switches which are controlled directly by the sm125 via the electrical interconnect cable.

During these tests, any effects caused to the EUT by the test, was noted as a change of measured light wave as indicated by the monitors.

Operating conditions:
During these tests, the following conditions were noted:

1- The data contained in this report reflects only the product(s) tested in the configuration and mode of operation described above.

2- An attempt has been made to arrange the EUT, with the equipment provided, into a test configuration which maximizes the observed emissions and exploits the vulnerability characteristics of the EUT while simulating, as close as practical, a typical end-use installation.

Options covered by this report:
None

Climatic conditions:
All tests in this report were conducted in a climatic condition as specified in the specific standards.

Modifications:
None

Conclusion:
The EUT was considered to comply with the indicated tests at the levels indicated in table 1.

Table 1

Test	Level	Pass/Fail
ESD	Level 2, 4.0 kV Contact Level 3, 8.0 kV Air	**Pass**
Radiated Electromagnetic Field	Level 2, 3 V/m	**Pass**
EFT/B	Level 2, 1.0 kV/AC lines, Level 2, 0.5 kV on I/O lines	**Pass**
Surge Immunity Test	Level 1, 0.5 kV, line-line Level 2, 1.0 kV, line-ground	**Pass**
Conducted Immunity	Level 2, 3 V_{rms} on AC and I/O lines	**Pass**
Voltage Dips, Short Interruptions	Level 100% interruptions	**Pass**

Engineering Statement:
All measurement data of this test report was taken in accordance with the European normative EN61326-1 (97) A1 (98) by EMC Testing Laboratories, Inc. located in Alpharetta, Georgia. Although this data is taken under stringent laboratory conditions and to the best of our knowledge represents accurate data, it must be recognized that emissions from or immunity to this type equipment may be greatly affected by the final installation of the equipment. Therefore, EMC Testing Laboratories, Inc., while supporting the accuracy of the data in this report, takes no responsibility for use of equipment based on these tests. The manufacturer of this equipment must take full responsibility for any field problems which may arise, and agrees that EMC Testing Laboratories, Inc., in performing its functions in accordance with its objectives and purposes, does not assume or undertake to discharge any responsibility of the manufacturer to any other party or parties.

Conclusion:
With the above indicated modifications, the product(s) covered by this report has been tested and found to comply with the limits for all above mentioned standards

Tested by: **Edward Barnes, RF Engineer**

Approved by: _____
Gene Bailey, Engineering Manager, EMC Testing Laboratories, Inc.

II. General Requirements

General
Immunity testing evaluated the ability of the EUT to operate within its intended design parameters while being subjected to various electrical stresses.

Acceptability criteria: General
In consideration of the design parameters and intended end-use, the following criteriawas used to evaluate the effects of the electromagnetic interference on the operation ofthe EUT.

Acceptability criteria: Specific operation conditions/responses
Unacceptable operating conditions/responses are:

1 - Any variation in operation not consistent with manufacturer's specifications or not consistent with the criteria requirements indicated in the reference standards.

2 - Permanent damage to the EUT.

Except for specific exemptions outlined below, any of the above responses would indicate the EUT did not meet the minimum acceptable level of immunity.

Exemptions:
Conditions 1 and 2 above do not apply if the response of the EUT is such that all the following exemptions are met:

1 - None

Observation Criteria:
The following codes are used as the observation noted during testing.

1 - No observed response
2 - EUT self-reset no operator intervention.
3 - EUT required operator intervention.
4 - EUT damaged.

III. EN61000-4-2: Electrostatic Discharge Immunity Test

Standard:
Primary standard Electrostatic Discharge Immunity, EN61000-4-2

Measurements:
Measurements performed in this part, evaluated the immunity of the EUT to Electrostatic Discharges.

Mode of operation:
During this test, the EUT was operated as described in Section 1 under 'Operating configuration' and 'Operating conditions'.

Measurement details:
Unless otherwise indicated on the following data sheets, the testing was performed as described in the primary standard and as outlined below.

A - Contact and Air Discharge:
A minimum of 10 discharges, at each level (contact discharge: 2, 4, 6 and 8 kV, air discharges: 2, 4, 8 and 15 kV) was applied at each point at 1 second intervals.

B - Contact Discharge:
The ESD gun was held perpendicular to the surface to be discharged and the return cable was a minimum of 0.2 meters from the EUT.

C - Air Discharge:
The round tip is used for this test and the tip is brought into contact with the EUT as fast as possible (without causing damage).

D - Vertical Coupling Plane:
The vertical coupling plane was positioned 0.1 meter from the EUT. The vertical coupling plane is moved such that all four sides of the EUT are subjected to the test.

Test Points Locations
The following locations of the product were subject to the applicable discharges:

1 – Left Side 2 – Right Side 3 – Top

Discharge Potential: 4KV

Note: 4KV is minimum level (2) for contact
4KV is minimum level (2) for air

Measurement summary:
In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 2 represents a summary of the test results.

Discharge applications:

Table 2

Test Point	ESD Level, kV	Polarity	Contact/ Air	Number of Applications	Observations
1-3	2, 4	Both	Contact	240*	1
HCP	2, 4	Both	Contact	160	1
VCP	2, 4	Both	Contact	160	1

The models sm041 and sm125 were in turn subjected to these tests

IV. EN61000-4-3: Radiated Electromagnetic Field Requirements

Standard:
Primary standard Radiated Electromagnetic Fields, EN61000-4-3

Measurements:
Measurements performed in this section, evaluated the immunity of the EUT to radiated electromagnetic field requirements. All four sides, of the EUT were inturn subjected to this test.

Mode of operation:
During this test, the EUT was operated as described in Section 1 under 'Operating configuration' and 'Operating conditions'.

Measurement details:
The EUT was subjected to a 3V/m electromagnetic field with 80 percent amplitude modulation from 80 MHz to 1000 MHz. During this test, the transmitting antenna was at a 3 meter distance.

Measurement summary:
In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 3 represents a summary of the test results.

Table 3

Test Voltage	Level	Observations
3 V/m	2	1

V. EN61000-4-4: Electrical Fast Transient/Burst Requirements

Standard:
Primary standard Electrical Fast Transient/Burst, EN61000-4-4

Measurements:
Measurements performed in this section, evaluated the immunity of the EUT to electrical fast transient/burst (EFT/B) interference. Points of application for the EFT/B interference included the AC cord and all signal cables.

Mode of operation:
During this test, the EUT was operated as described in Section 1 under 'Operating configuration' and 'Operating conditions'.

Measurements details:
Measurements were performed on a horizontal ground reference plane. The ground reference plane (GRP) also served as the reference point for all measurements as well as equipment protective earth (PE).

The test equipment consisted of an EFT/B generator, manufactured by Shaffner, model NSG1025 and a capacitive coupling clamp, manufactured by Shaffner, model CDN 125. The EFT/B generator and capacitive coupling clamp comply with the requirements as outlined in EN61000-4-4.

The EUT was placed on a non-metallic table as specified in the reference standard for a table top product. The EFT/B generator was positioned on and bonded to the GRP directly below the EUT.

EFT/B applications:
EFT/B applications were performed as indicated in table 4

Table 4

Level	Test Point	Test Voltage	Repetition Rate	Burst Duration	Burst Period
2	Power Conductors	1.0 kV	5.0 Khz	15 mSec.	300 mSec.
2	Data I/O	0.5 kV	5.0 Khz	15 mSec.	300 mSec.

Measurement summary:
In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 5 is a summary of the test results.

Table 5

Test Voltage	Level	Applied Point	Observations
1.0 kV	2	Power Conductors	1
0.5 kV	2	I/O cable	1

VI. EN61000-4-5: Surge Immunity Test

Standard:
Primary standard Surge Immunity, EN61000-4-5

Measurements:
Measurements performed in this section, evaluated the immunity of the EUT to power line surges and transient overvoltage events in accordance with the EN61000-4-5 standard.

Mode of operation:
During this test, the EUT was operated as described in Section 1 under 'Operating configuration' and 'Operating conditions'.

Measurement details:
The EUT was placed on a non-metallic table of 1 meter height and a minimum of 1 meter from any metallic structures.

Electrical power was provided to the EUT via the internal coupler/decoupler of the surge generator. For tests conducted in this section, the protective earth (PE) of the EUT was also provided via the surge generator.

The following are the Surge/Transient overvoltage generator's characteristics used for these tests:

- Open circuit output voltage ..... 0.5 to 4.0 kV
- Short circuit output current ..... 0.25 to 2kA
- Open circuit voltage risetime ..... 1.2 μs ±30%
- Open circuit voltage duration ..... 50 μs ±20%
- Short circuit current risetime ..... 8 μs ±20%
- Short circuit current duration ..... 20 μs ±20%

The surge/transient overvoltage was applied for the following modes of appearance:

1. Line with respect to neutral
2. Line with respect to PE
3. Neutral with respect to PE

The tests were performed for the following surge/transient overvoltage levels at the indicated polarities and AC line phase angles. Five surges were applied at each indicated voltage level and at each mode of appearance, for the applicable polarity to phase angle relationships.

The tests were carried out at each of the mode appearance, with relationship to phase angle and polarity at the lower prescribed voltage levels before being repeated at the next higher levels.

Measurement summary:
In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 6 is a summary of the test results.

Input lead length : 1.2 meters
Input lead gauge : 16 AWG

Table 6

Mode of Appearance	Polarity, Max. Voltage Potential	AC Line Phase Angle Degrees	Application Rate	Total Surges	Observations
Line with respect to Neutral	+/-, 0.5kV	0°,90°,270°	1/min	30	1
Line with respect to PE	+/-, 0.5kV	0°,90°,270°	1/min	30	1
Line with respect to PE	+/-, 1.0kV	0°,90°,270°	1/min	30	1
Neutral with respect to PE	+/-, 0.5kV	0°,90°,270°	1/min	30	1
Neutral with respect to PE	+/-, 1.0kV	0°,90°,270°	1/min	30	1

VII. EN61000-4-6: Immunity to Conducted Disturbances

Standard:
Primary standard Immunity to Conducted Disturbances, EN61000-4-6

Measurements:
Measurements performed in this section, evaluated the ability of the EUT to operate as intended, while radio frequency signals were coupled onto the signal cables on the EUT.

Mode of operation:
As described in section 1, under 'Operating configuration' and 'Operating conditions'.

Measurements details:
Measurements were performed while the EUT was supported on a non-metallic table, 10 cm high. The table was positioned on a horizontal ground reference plane. The ground reference plane (GRP) also served as the reference point for all measurements as well as equipment protective earth (PE).

Signal cables:
During this test, the injection clamp was placed ten cm from the connector (on the EUT) of the cable being subjected to the interference source.

A.C. line:
During this test, the EUT was connected to a Coupling Decoupling Network which is bonded to the GRP.

Testing was performed at discreet frequencies from 150 Khz to 80 MHz with a step size not exceeding 1.0 percent of the center frequency. The minimum dwell time per frequency was 1.0 seconds.

Testing was performed, for carrier modulation at a depth of 80 percent, at a frequency of 1.0 Khz for the induced currents. The modulation waveform was sinusoidal.

Measurement summary:
In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 7 is a summary of the test results.

Table 7

Test Voltage	Level	Observation
I/O cables 3 V_{rms}	2	1
AC lines 3 V_{rms}	2	1

VIII. EN61000-4-11: Immunity to Voltage Dips, Shorts Interruptions and Voltage Variations

Standard:
Voltage dips, short interruptions and voltage variations, EN61000-4-11.

Measurements:
Measurements were taken to demonstrate the immunity of the equipment to short duration dips (reductions) and interruptions of the A.C. mains voltage, such as those caused by load switching and operation of protection devices on the mains network.

Mode of Operation:
The EUT was configured to operate as outlined in Section 1 under 'Operating configuration' and 'Operating conditions'.

Measurement details:
Measurements were performed utilizing a Harmonic/Flicker tester (AC power source) manufactured by HP, model 6842A. This (AC power source) complies with all the requirements as outlined in EN61000-4-11. The EUT was monitored for proper operation according to the manufacturer's specification during the application of voltage dips and interruptions.

Voltage dips and, short interruptions applications:
Voltage dips and short interruptions applications were performed as specified in table 8 of EN61000-4-11.

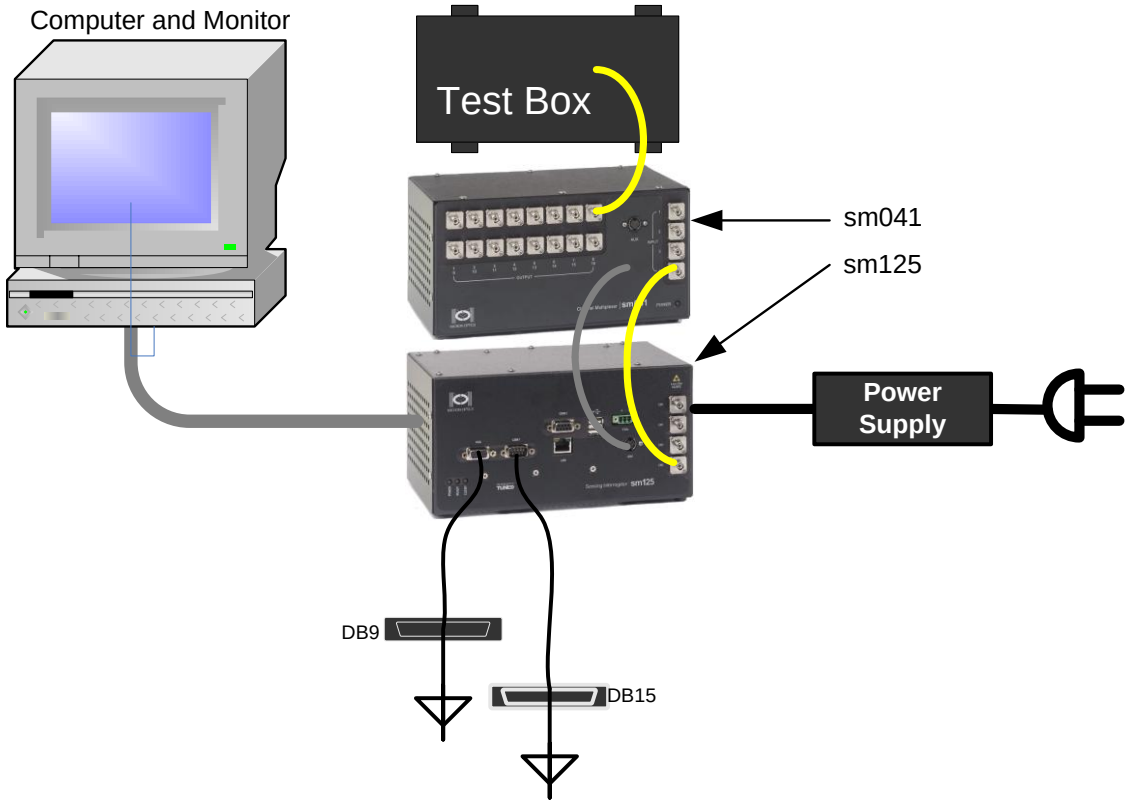
Measurement summary:
1) Upon completion of all tests the EUT was functional and found to operate in accordance with the manufacturer's specifications.

2) In the configuration and operating conditions described, the observed responses exhibited by the EUT were determined to be acceptable as judged against the criteria established in section 2 under 'Acceptability criteria'. Table 8 represents a summary of the test results.

Table 8

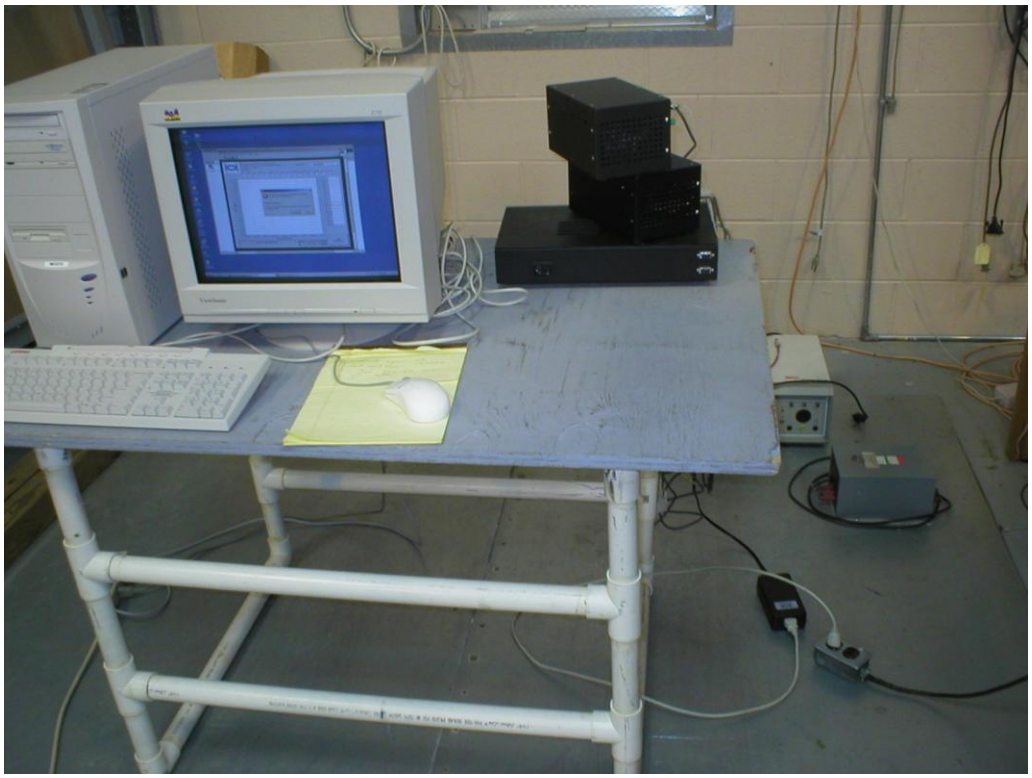
Voltage Reduction	Duration (Cycles)	Number of Reductions	Interval (Seconds)	Point of Occurrence	Observation
100%	1	10	10	0°	1

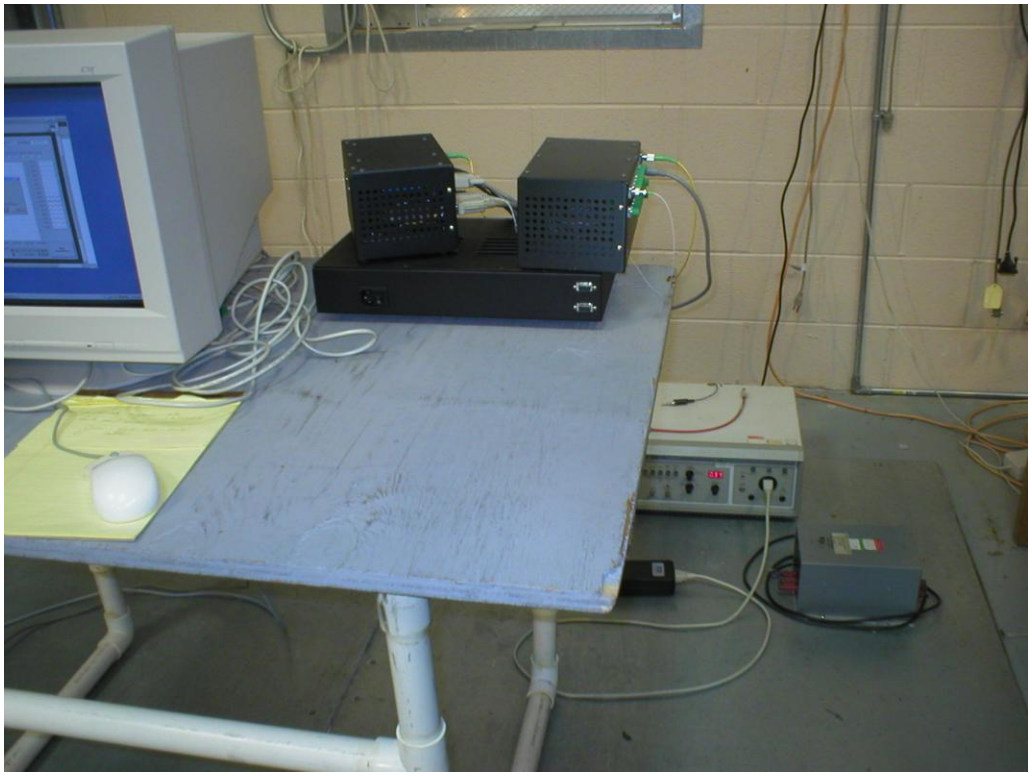
IX. Configuration

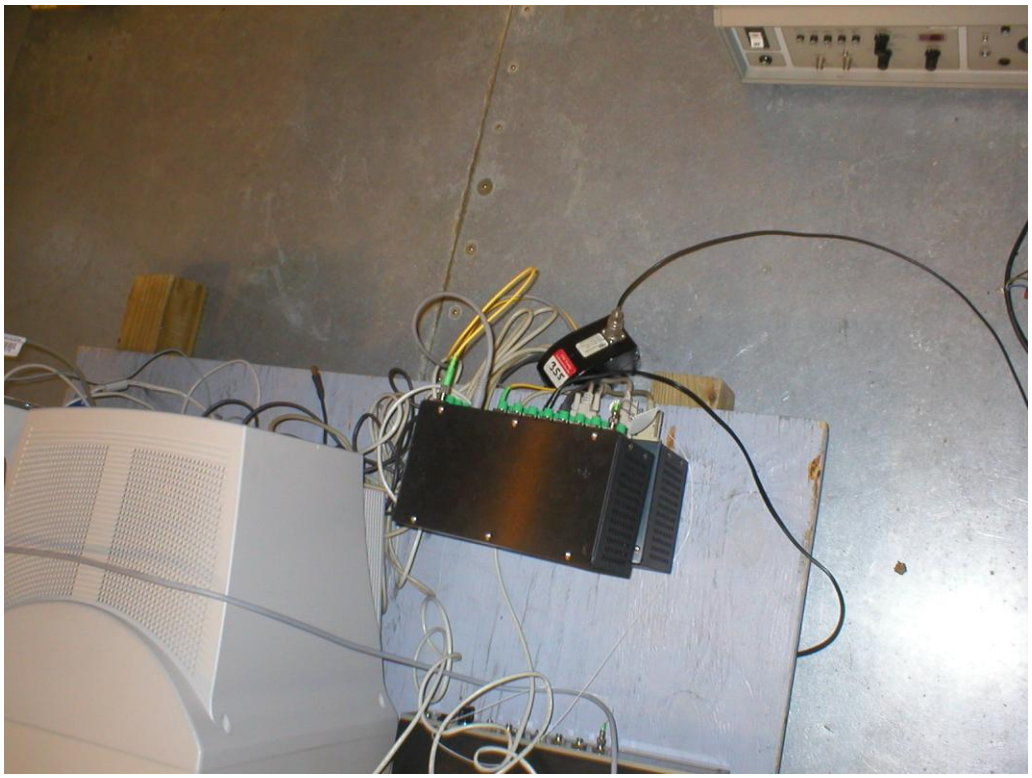


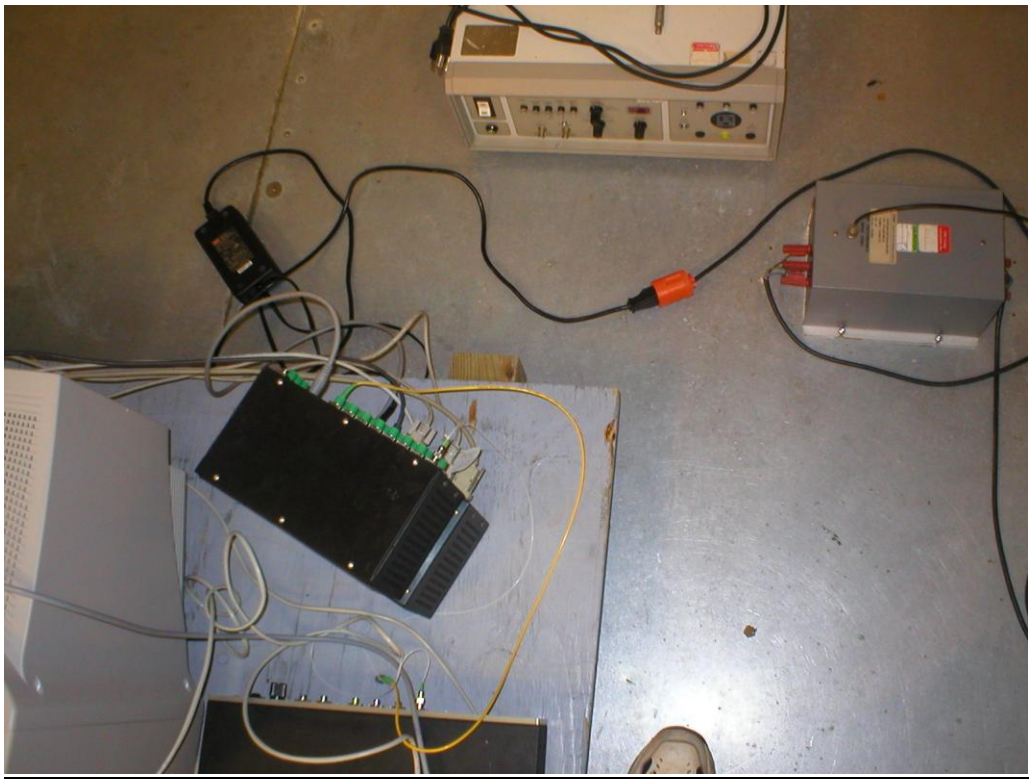
X. Photographs

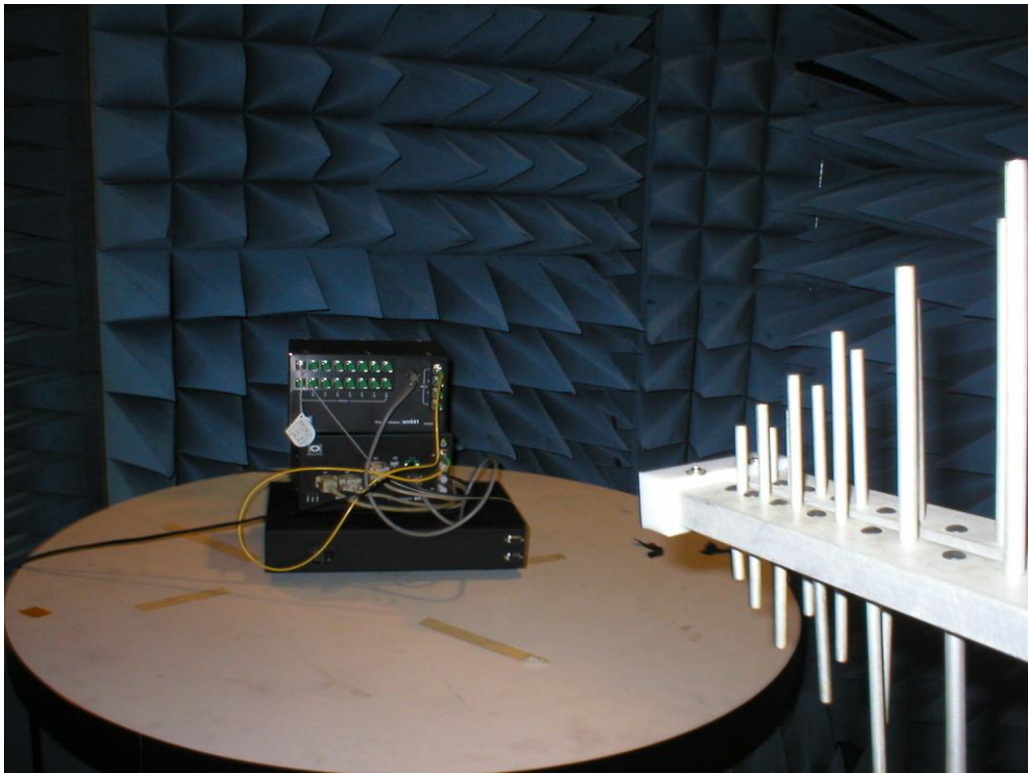
Photographs are not necessarily in the same order testing was performed.











XI. Test Equipment

The following equipment was used during these tests:

Equipment	Manufacturer	Model no.	Serial no.
Power Amplifier	IFI	SMX100	1978-0896
Antenna	Emco	3142	9607-1053
Signal generator	HP	8648A	3426A0918
Computer	IBM	Value Point	23-F0349
Variac	Powerstat	236	09
Clamp	Tegam	95236-1	12275
Eft generator	Schaffner	NSG1025	225-9044
Capacitance clamp	Schaffner	CDN125	527
CDN	Fisher	FCC-801-M3-16	224
ESD	Schaffner	NSG433	379
Surge Generator	Haefely	Psurge 4	083 342-14
Oscilloscope	Tektronics	TDS 210	B011464
Harmonic/Flicker	HP	6842A	3531A00171

All test equipment are calibrated annually.

Section 4. Safety Standard Test Report

To Determine Compliance with EN 61010-1

Contents Section

I. General Information

Manufacturer: Micron Optics, Inc.
1852 Century Place, N.E.
Atlanta, GA 30345

Manufacturer representative: **Mr. Jim Marihew**

Equipment covered by this report: Model nos. sm041, sm125

.

Options covered by this report: None

Equipment serial no. Prototype

Test report number: 05-181C

Test specifications: To determine compliance with theSafety Standard EN 61010-1(01)

Conclusion:
The product(s) covered by this report has been tested and found to comply with the safety standard, EN 61010-1 (01) and all applicable amendments.

Test Facility: The test facility used to perform these tests is located at:

EMC Testing Laboratories, Inc.

2210 Justin Trail

Alpharetta, GA 30004

Tested by: **Edward Barnes, RF Engineer**

Approved by: _____
Gene Bailey, Engineering Manager,
EMC Testing Laboratories, Inc.

II. Product Information

Model numbers: sm041 and sm125

Marked electrical ratings: 5 Vdc, 6.0 amps max.

Connection to supply: Product utilizes an external power supply

Installation overvoltage category: I

Pollution degree: II

Equipment class: Class III

Equipment function: The model no. sm041 is an optical multiplexer, which allows the model no. sm125 to monitor up to 16 optical sensor arrays. It achieves this by utilizing solid state optical switches which are controlled directly by the sm125 via the electrical interconnect cable.

At the manufacturers request the laser source utilized by the equipment covered in this report was not evaluated during this project. For the manufacturers Declaration of Conformity for the laser source with IEC 60825-1 (94) and applicable amendments see appendix A .

Mode of operation: Continuous

Degree of mobility: Moveable

Construction Details: Refer to critical components below and the following**:**

Internal wiring - must be approved by a recognized agency and suitable for the voltages, current and temperatures involved. All wiring conductors are routed and secured away from sharp edges, hot or moving parts. Ribbon Cables are UL flame rated 94V-1 minimum and suitable for the voltages involved and are routed and mechanically secured away from high-voltage circuits and wiring.

Insulation Tubing/Sleeving - Approved by a recognized agency and rated 80°C minimum and 250V.

Nameplate Marking - Manufacturers name, model number and electrical ratings. Marking is located on the equipment in an area not necessary for gaining access to the marking and the part of which the marking is located is not likely to be discarded or lost.

Mechanical Assembly - Unless otherwise stated, all enclosure parts and component mounting assemblies are secured by welding, thread-forming screws, or machine bolts provided with nuts and lock washers or star washers.

Mechanical Electrical Connections - For electric connection, internal wiring and leads of transformers and components are provided with crimp-on terminals such as closed-loop, spade type with upturned ends, quick-connect with integral detent, or locking type, or are mechanically secured and soldered.

Wiring Connections may also be accomplished by UL Listed wire connectors suitable for the temperature, wire gauge, and number of conductors.

Soldered Connection - All soldered connections are mechanically secured before soldering. When hand soldered, Leads on printed wiring boards are bent over prior to soldering.

Tolerances - Unless otherwise specified, all dimensions are nominal.

III. Product Description

General:

The following is a general description of the products and critical components.

1. Enclosure:

Constructed of painted or plated metal, measuring 1mm minimum thickness, with overall dimensions measuring 22.8cm wide by 11.4cm high by 13.3cm deep. Enclosure secured together with metal screws. Provided with eight rows of twelve 4mm diameter openings at each side.

2. Printed Wiring Boards:

All boards are UL flame rated 94V-1 minimum and with a > 175 CTI and consists of the following:

Model no. sm125

Name	Part no.	Rev. no.
Transmitter	221782B	B
Receiver	221783B	B
Interface	221781F	F
Advantech	PCM-9370F Single Board Computer	
Mesa Electronics	4A24 high speed 16 bit A-D card	

Model no. sm041:

Name	Part no.	Rev. no.
Optical Switch Module	221765	A

3. Internal Wiring:

All internal wiring is UL approved, wiring material rated 300V and 80° C minimum. All soldered connections are mechanically secured before soldering.

4. Power Supply:

Model no. sm125. Provided with external power supply. Manufactured by Sinpro, model no. U45S102-P2J, input rated 100-240V, 1.35A, 47 – 63 Hz. Output rated 5-6 Vdc, 40 w maximum. TUV and UL listed ITE and CE marked power supply. Model no. sm041 receives power from the sm125.

5. Laser source:

Model no. sm125 only. The laser source consists of a Linear Optical Amplifier that is manufactured by Finisar Corporation, part number G111, rated at and integrated 200μW ASE output. The LOA is assembled into a ring configuration, using the semiconductor chip as the gain medium for the laser. A Micron Optics Fiber Fabry-Perot Tunable filter is used to select the low-loss wavelength to enable lasing in the ring, and facilitates tuning over a range of 1510 to 1580nm. Other optical

components in the ring include and optical band pass filter, two optical isolators, and a 50% output coupler as the laser output. These components are available from a variety of vendors, and the actual source of the components is not critical to the operation of the laser.

6. Ribbon cable:
UL approved ribbon cable, rated 150 volts minimum.

7. Insulating sleeving:
UL approved insulating sleeving, rated 150 volts minimum.

8. DC to DC Converter:
UL approved. Manuafctured by Beta Dyne, part no. DN10D5/5. Rated 5V, 10 W.

9. LED's:
All are manufactured by Digikey and provided as follows:

Model no. sm041, Manufactured by Digikey, part no. CMD91-21SRC/TR9

Model no. sm125, Manufactured by Digikey, part no. SML-LX06031W. Manufactured by Chicago Miniature lamp, part nos. 7016X5, 7016X1 and 7016X3

10. Markings:
The following markings are silk screened or on UL recognized label material as follows:

A- On outside of enclosure:

Manufacturer's name and model number, electrical ratings 5 Vdc, 6.0 A max.

Date of manufacturing by month and year. Date of manufacturing may be incorporated in the serial number.

B- On the outside of the enclosure the following statements:

No operator serviceable parts inside. Do not remove cover. Refer servicing to qualified personnel only.

For use by qualified personnel only.

C- On the outside of the enclosure:

An explanatory marking in accordance with the requirements of EN60825-1, figure 15. The label shall indicate "CLASS 1 LASER PRODUCT".

11 Documentation:

The following information is provided in the User manuals provided with all products.

A-Technical specification,
B-Instruction for use,
C-Name and address of manufacturer or supplier from whom technical assistance may be obtained,
D-The electrical ratings in volts, frequency and current,
E-A description of all input and output connections,
F-The environmental conditions as follows should be stated:
-Indoor use,
-Operating temperature range of +10 ^{0}C to +40 ^{0}C,
-Maximum relative humidity 80% for temperature up to 31 ^{0}C decreasing linearly to 50% relative humidity at 40 ^{0}C,

G- Towards the front of the manual all warning statements and a clear explanation of warning symbols marked on the equipment are provided as indicated below:

11.1 Safety Symbols:

The following symbols and messages may be marked on the unit. The purpose of safety symbols is to attract your attention to possible dangers. The safety symbols and the explanations with them deserve your careful attention and understanding. The safety warnings do not by themselves eliminate any danger. The instructions or warnings they give are not substitutes for proper accident prevention measures.

Symbol	Description
	Laser Safety. Refer to user's manual for safety instructions for use and handling.
	Refer to user's manual for safety instructions for use and handling.
	Caution. Risk of electric shock.
	Frame or chassis terminal for electrical earth ground.
	Electrostatics discharge (ESD). Refer to user's manual for safety instructions in use and handling.
	Protective conductor terminal for electrical earth ground.
WARNING	This sign indicates a procedure with the potential to cause serious injury or loss of life to the user if not performed with strict adherence to all safety instructions. Ensure that all conditions are fully understood and met before proceeding.
CAUTION	This sign indicates a procedure with the potential to cause serious damage to or destruction of the unit if not performed with strict adherence to the all safety instructions. Ensure that all conditions are fully understood and met before proceeding.

IV. Test Report

Clause	Summary of Inspection	Complies	Not applicable
4	Single fault condition	(X)	( )
5	Marking and documentation	(X)	( )
6	Protection against electric shock	(X)	( )
7	Protection against mechanical hazards	(X)	( )
8	Mechanical resistance to shock, vibration and impact	(X)	( )
9	Equipment temperature limits and protection against the spread of fire	(X)	( )
10	Resistance to heat	(X)	( )
11	Resistance to moisture and liquids	(X)	( )
12	Protection against radiation including Laser sources and against sonic and ultrasonic pressure	(X)	( )
13	Protection against liberated gases, explosion and implosion	(X)	( )
14	Components	(X)	( )
15	Protection by interlocks	( )	(X)

Clause	Requirement	Complies	Not applicable
4.4	Testing in SINGLE FAULT CONDITION (SFC). List all SFC not covered by 4.4.2.1 to 4.4.2.12. *TUV and UL listed external power supply*	(X)	( )
4.4.2.1	Protective impedance, *TUV and UL listed external power supply*	(X)	( )
4.4.2.2	Protective conductor, *TUV and UL listed external power supply*	(X)	( )
4.4.2.3	Equipment or parts for short-term or intermittent operations,	( )	(X)
4.4.2.4	Motors, None provided	( )	(X)
4.4.2.5	Capacitors, *TUV and UL listed external power supply*	(X)	( )
4.4.2.6	Mains transformers. Attach drawing of Mains showing all protective devices,. *TUV and UL listed external power supply*	(X)	( )
4.4.2.7	Outputs, *TUV and UL listed external power supply*	(X)	( )
4.4.2.8	Equipment for more than one supply,	( )	(X)
4.4.2.9	Cooling,	(X)	( )
4.4.2.10	Heating devices, none provided	( )	(X)
4.4.2.11	Insulation between circuits and parts *TUV and UL listed external power supply*	(X)	( )
4.4.2.12	Interlocks	( )	(X)

Clause	Requirement	Complies	Not applicable
5.0	Marking and documentation		
5.1.1	General All equipment markings are:		
	- visible from the exterior; or	(X)	( )
	- visible after removing a cover or opening a door;	(X)	( )
	- not put on parts which can be removed by an Operator;	(X)	( )
	- visible after removal from a rack or panel;	(X)	( )
	- Letter symbols (IEC 27)	(X)	( )
	- Graphic symbols (table 1)	(X)	( )
5.1.2	Identification Equipment is identifiable by:		
	- manufacturer's name or registered trade mark;	(X)	( )
	- model number, name, or other means.	(X)	( )
5.1.3	Mains supply Equipment is marked as follows:		
	a) Nature of supply:		
	- a.c. Rated mains frequency or range of frequencies;	(X)	( )
	- d.c. with symbol.	( )	(X)
	b) Rated supply voltage(s), or range.	(X)	( )
	c) Maximum Rated power in watts or volt-amperes, or maximum Rated input current.	(X)	( )

Clause	Requirement	Complies	Not applicable
	d) Equipment which the Operator can set for different Rated supply voltages:	( )	(X)
	- indicates the equipment set voltage;	( )	(X)
	- Portable Equipment indication is visible from the exterior;	( )	(X)
	- for Operator voltage setting changes the indication.	( )	(X)
	e) Accessory mains socket-outlets accepting standard mains plugs are marked:	( )	(X)
	- with the voltage if it is different from the mains supply voltage;	( )	(X)
	- if for use with specific equipment.	( )	(X)
	If not marked as above it is marked with:		
	- the maximum Rated current or power, and maximum permitted leakage current;	( )	(X)
	or		
	- symbol 14 with full details in the documentation;	( )	(X)
	Fuses	( )	(X)
5.1.4	Operator replaceable fuse marking Information provided for fuses not replaceable by the Operator	( )	(X)
5.1.5	Measuring circuits Terminals		

Clause	Requirement	Complies	Not applicable
	Voltage and current measuring circuit Terminals shall b marked with the rated maximum working voltage or current as applicable.	( )	(X)
	Marking of measuring input circuit terminals to be connected to voltages above 50Vac or 120Vdc		
	Means for identifying these Terminals is provided.	( )	(X)
	Marking is close to Terminals	( )	(X)
	or (if sufficient space) the marking is:		
	- on the Rating plate;	( )	(X)
	- or scale plate;	( )	(X)
	- the Terminal is marked with symbol 14.	( )	(X)
5.1.6	Terminals and operating device		
	Disconnect device marked indicating on-position and off-position.	( )	(X)
	Terminals and operating devices are marked as follows:	(X)	( )
	a) Functional Earth Terminals (symbol 5)	( )	(X)
	b) Protective Conductor Terminals (symbol 6)	(X)	( )
	- Symbol is placed adjacent to or on the Terminal	(X)	( )
	c) Terminals of measuring and control circuits (symbol 7).	( )	(X)
	d) Terminals supplied from the interior (symbol 14).	( )	(X)

Clause	Requirement	Complies	Not applicable
	e) Accessible Functional Earth Terminals (symbol 8).	( )	(X)
5.1.7	Equipment protected by Double Insulation or Reinforced Insulation		
	Protected throughout (symbol 11).	( )	(X)
	Only partially protected (symbol 11 not used).	( )	(X)
5.1.8	Battery charging		
	Equipment with means to recharge rechargeable batteries is marked;		
	- to warn against the charging of non-rechargeable batteries;	( )	(X)
	- to indicate the type of rechargeable batteries used.	( )	(X)
5.2	Warning markings		
	- are visible during Normal Use	(X)	( )
	- marked with symbol 14;	(X)	( )
	- are near or on particular parts;	(X)	( )
	- warnings for hazardous voltages in operator access in which a tool is needed to gain access	( )	(X)
	- advise how to avoid contact with Hazardous Live parts and Hazardous moving parts	( )	(X)
	- Terminals voltage exceeds 1 kV (symbol 12);	( )	(X)
	- Heated easily touched parts.	( )	(X)

Clause	Requirement	Complies	Not applicable
5.3	Durability of markings		
	Markings are clear and legible.	(X)	( )
	Markings resist the effects of cleaning agents.	(X)	( )
	Markings are clearly legible after compliance tests.	(X)	( )
	Adhesive labels are not loose or curled.	(X)	( )
	Note - Marking labels are UL approved marking materials		
5.4	Documentation		
5.4.1	General		
	Equipment is accompanied by documentation which includes:		
	- technical specification;	(X)	( )
	- instructions for use;	(X)	( )
	- name and address of manufacturer or supplier;	(X)	( )
	- the information specified in 5.4.2 to 5.4.5;	(X)	( )
	- definition of relevant INSTALLATION CATEGORY (OVERVOLTAGE CATEGORY	(X)	( )
	A clear explanation of warning symbols is in the documentation and marked on the equipment; or	(X)	( )
	Information is durably and legibly marked on the equipment;	(X)	( )
5.4.2	Equipment Ratings		
	Documentation includes:		
	- supply voltage or voltage range;	(X)	( )

Clause	Requirement	Complies	Not applicable
	- the frequency or frequency range;	(X)	( )
	- the power or current Ratings;	(X)	( )
	- a description of all input and output connections;	(X)	( )
	- the Rating of insulation of external circuits, when such circuits are nowhere Accessible;	(X)	( )
	- statement of the range of environmental conditions.	(X)	( )
5.4.3	Equipment installation		
	Documentation includes instructions for:		
	- assembly, location and mounting;	(X)	( )
	- protective earthing;	( )	(X)
	- connections to the supply	(X)	( )
	- ventilation requirements	(X)	( )
	- special services.	(X)	( )
	- maximum sound power level produced	( )	(X)
	- instructions relating to sound pressure level.	( )	(X)
	Additionally information for Permanently Connected Equipment:		
	- supply wiring;	( )	(X)
	- external switch or circuit-breaker and external overcurrent protection use.	( )	(X)
	- recommendation on circuit-breaker location.	( )	(X)

Clause	Requirement	Complies	Not Applicable
5.4.4	Equipment operation		
	Instructions for use include:		
	- identification of operating controls;	(X)	( )
	- positioning instructions;	(X)	( )
	- interconnection requirements;	(X)	( )
	- specification of intermittent operation limits;	( )	(X)
	- explanation of required symbols;	(X)	( )
	- replacement of consumable;	(X)	( )
	- cleaning;	(X)	( )
	- a statement against use in a manner not specified by the manufacturer;	(X)	( )
5.4.5	Equipment maintenance		
	Instructions include:		
	- sufficient preventive maintenance and inspection information;	(X)	( )
	- specific battery type;	( )	(X)
	- any manufacturer specified parts;	(X)	( )
	- Rating and characteristics of fuses;	( )	(X)
6	Protection against electrical shock		
6.1	General		
	Compliance is checked by the determination of 6.2 and 6.3 followed by the tests of 6.4 to 6.12.		

Clause	Requirement	Complies	Not applicable
6.1.1	Exceptions		
	- parts Accessible after lamp removal;	( )	(X)
	_____		
	_____		
	_____		
	_____		
	_____		
	- parts which may be Hazardous Live;		
	_____		
	_____		
	_____	( )	(X)
	_____		
	- Terminals and sockets of operating and measuring circuits (except 6.6.2)	( )	(X)
	_____		
	_____		
	- Terminals and sockets above which remain charged from an internal capacitor, do not:		
	- remain Hazardous Live 10 s after supply interruption;		
	_____	( )	(X)
	_____		
	- exceed the levels of 6.3.1.3.		
6.2	Determination of Accessible parts Operator actions in Normal Use	( )	(X)
		(X)	( )

Clause	Requirement	Complies	Not applicable
6.2.1	General examination		
	Hazardous Live parts are prevented from being touched by:		
	- Jointed test finger	(X)	( )
	- Rigid test finger	(X)	( )
6.2.2	Openings above parts which are hazardous live.		
	- Test pin (4 mm diameter x 100 mm) for top openings	( )	(X)
6.2.3	Openings for pre-set controls		
	- Test pin (3 mm diameter) for present control openings	( )	(X)
6.3	Permissible limits for Accessible parts	(X)	( )
6.3.1	Values in Normal Condition	(X)	( )
6.3.1.1	Voltage		\
	TUV and UL listed external power supply	(X)	( )
6.3.1.2	Current		
	TUV and UL listed external power supply	(X)	( )
6.3.1.3	Capacitance		
	TUV and UL listed external power supply	(X)	( )

Clause	Requirement	Complies	Not applicable
6.3.2	Values in Single Fault Condition	(X)	( )
6.3.2.1	Voltage	(X)	( )
	TUV and UL listed external power supply		
6.3.2.2	Current	(X)	( )
	TUV and UL listed external power supply		
6.3.2.3	Capacitance	(X)	( )
	TUV and UL listed external power supply		
6.4	Protection in Normal Condition		
	Accessible parts:		
	- Basic Insulation (see annex E) In combination with the enclosure basic insulation provides hazardous live components from becoming accessible to the operator.	(X)	( )
	- Enclosures or Barriers Enclosure provides hazardous live components Components from becoming accessible to the operator.	(X)	( )
	- Protective Impedance (see 6.5.3)	( )	(X)
	Enclosures And Barriers:		
	- meet the rigidity requirements of 8.1;	(X)	( )
	- meet the requirements for Basic Insulation.	(X)	( )

Clause	Requirement	Complies	Not applicable
	Clearances, Creepage Distances and insulation:		
	- meet the requirements of 6.7;	(X)	( )
	- meet the values for Basic Insulation (tables D.1 to D.6)	(X)	( )
6.5	Protection in Single Fault Condition		
	Additional protection is provided as specified in 6.5.1 to 6.5.3 (except as in 6.5.4); or	(X)	( )
	- by automatic disconnection of supply.	( )	(X)
6.5.1	Protective earthing		
	Accessible conductive parts:		
	- are bonded to the Protective Conductor Terminal; or	( )	(X)
	- are separated from parts which are Hazardous Live; or	( )	(X)
	- indirect bonding (measurement and test equipment)	( )	(X)
6.5.1.1	Protective Bonding		
	Protective Bonding consists of directly connected structural parts; or	( )	(X)
	discrete conductors; or both.	( )	(X)
6.5.1.2	Bonding impedance of plug-connected equipment	( )	(X)

Clause	Requirement	Complies	Not applicable
6.5.1.3	Bonding impedance of Permanently Connected Equipment	( )	(X)
6.5.1.4	Indirect bonding for measuring and test equipment	( )	(X)
6.5.2	Double Insulation and Reinforced Insulation		
	Clearance and Creepage Distances		
	- meet the applicable requirements of annex D;	( )	(X)
	- pass the dielectric strength test of 6.8.	( )	(X)
	Other test results are in 6.7, 6.8 and 6.9.2.		
6.5.3	Protective Impedance		
	A Protective Impedance is one or more of the following:		
	- an appropriate High Integrity single component (see 14.6);	( )	(X)
	Component Location _____ _____ _____ _____ _____ _____		
	- a combination of components;	( )	(X)
	Component Location _____ _____ _____ _____ _____ _____		

Clause	Requirement	Complies	Not applicable
	- a combination of Basic Insulation and a current or voltage limiting device.	(X)	( )
	Component Location Fuse Inside power supply Basic insulation Power supply		
	Components, wires and connections are Rated.	(X)	( )
6.5.4	Built-in Panel meters		
	The requirements of 6.5.1 to 6.5.3 were waived YES/NO.	NO	
	If YES proceed as follows:		
	- the equipment has no Accessible conductive parts;	( )	(X)
	- Accessible surfaces are separated;	( )	(X)
	- Accessible surfaces of parts intended to be grasped are separated.	( )	(X)
6.6	External circuits		
6.6.1	Separation of internal circuits		
	Internal circuits with external circuit connections.	(X)	( )
	Separation is provided between internal circuits.	(X)	( )
	If the values of 6.3.2 are exceeded in Normal Condition one of the following means is applied:	( )	(X)

Clause	Requirement	Complies	Not applicable
	- Double Insulation or Reinforced Insulation; _____ _____	( )	(X)
	- Protective Impedance; _____ _____	( )	(X)
	- Basic Insulation and protective screening _____ _____	( )	(X)
	- Basic Insulation and low impedance Protective Bonding; _____ _____	(X)	( )
	Even if the other internal circuit exceeds the values of 6.3.2 in Normal Condition, Basic Insulation is provided.	(X)	( )
	The following statements are included in the manufacturer's instructions;		
	- the Terminal is for use only with equipment which has no Accessible live parts;	( )	(X)
	- the Rating of the insulation required for external circuits;	( )	(X)
	- the connection to be used at the remote end of external circuits;	( )	(X)
	- the type of equipment which may be connected to the Terminal.	(X)	( )
	- any of the above were waived;	( )	(X)

Clause	Requirement	Complies	Not applicable
	- the equipment passed the dielectric strength test (see 6.8).	(X)	( )
6.6.2	Terminals for external circuits		
	Accessible Terminals are not Hazardous Live except as permitted	(X)	( )
	The following Terminals are not Hazardous Live:		
	- Protective Conductor Terminals;	( )	(X)
	- Functional Earth Terminals;	( )	(X)
	- Headphone Terminals;	( )	(X)
	Terminal which receive a charge from an internal capacitor.	( )	(X)
	The following Terminals energized from the interior are not Accessible:		
	- Terminals with Hazardous Live voltage exceeding 1 kV.	( )	(X)
	- Terminals with floating voltage exceeding 1 kV;	( )	(X)
6.6.3	Circuits with Terminals which are Hazardous Live		
	No mains circuits are connected to Accessible conductive parts.	( )	(X)
	For other Hazardous Live circuits with one terminal at earth potential.	( )	(X)
	Circuits designed to be operated with one Accessible Terminal contact floating.	( )	(X)

Clause	Requirement	Complies	Not applicable
6.7	Clearances and Creepage Distances		
	Clearances and Creepage Distances between circuits and parts. See Test record T1	(X)	( )
	There was no reduction when the rigid test finger was applied with:		
	- a 10 N force;	(X)	( )
	- a 30 N force.	(X)	( )
	Test details to be recorded in Test record T1		
6.8	Dielectric strength test		
	Requirements of 6.4 to 6.6 are met.	(X)	( )
	Protection against the spread of fire.	(X)	( )
6.8.1	Reference test earth		
	The reference earth points selected for the voltage tests of 6.8.4.		
6.8.2	Humidity preconditioning The unit was put in a humidity chamber and the temp. was brought to 42°C for four hours the unit was then subjected to humidity of 92.5% r.h. for 48 hrs.		
6.8.3	Conduct of tests The test specified in 6.8.4 was completed within 1 hr of the end of the recovery period after humidity preconditioning.		
6.8.4	The voltage test did not result in any breakdown or repeated flashover. *TUV and UL listed external power supply*	(X)	( )

Clause	Requirement	Complies	Not applicable
6.9	Constructional requirements for protection against electric shock		
6.9.1	General		
	In circuits exceeding the values of 6.3.2:		
	- Security of wiring connections;		
	All wiring is mechanically secured before soldering	( )	(X)
	- Screws securing removable covers;	( )	(X)
	- accidental loosening.	( )	(X)
6.9.2	Enclosure of equipment with Double or Reinforced Insulation	( )	(X)
	Enclosure which surrounds all metal parts.	( )	(X)
	Small metal parts are separated.	( )	(X)
	Enclosures or parts made of insulating material.	( )	(X)
	Protection for metal Enclosures or parts is provided by one of the following:		
	- provision of an insulating coating or Barrier on the inside of the Enclosure;	( )	(X)
	- Clearances and Creepage Distances cannot be reduced by loosening of parts or wires.	( )	(X)
6.9.3	Equipment using Protective Bonding		
	a) Operator removable parts.	( )	(X)
	b) Movable conductive connections.	( )	(X)
	c) Exterior metal braids of cables.	( )	(X)
	d) Mains supply is passed through the equipment.	( )	(X)

Clause	Requirement	Complies	Not applicable
	e) Protective earthing conductors.	( )	(X)
	Exceptions:		
	- earthing braids,	( )	(X)
	- internal protective conductors.	( )	(X)
	f) Equipment using Protective Bonding	( )	(X)
6.9.4	Over range indication	( )	(X)
6.10	Connection to mains supply source		
6.10.1	Mains supply cords		
	Mains supply cords are Rated;	( )	(X)
	The cable used complies with IEC 227 or IEC 245	( )	(X)
	Green/yellow covered conductors used.	( )	(X)
	Mains supply cords are certified.	( )	(X)
	All conductors have the same degree of insulation.	( )	(X)
	Detachable cords with IEC 320 mains connectors comply with:		
	- IEC 799;	( )	(X)
	- the current Rating of the mains connector.	( )	(X)
6.10.2	Fitting of non-detachable mains supply cords		
6.10.2.1	Cord entry		
	Non-detachable mains supply cords are protected by one of the following:		
	- An inlet or bushing is provided which has:	( )	(X)

Clause	Requirement	Complies	Not applicable
	a smooth rounded bell-mouthed opening;	( )	(X)
	- An insulated reliably-fixed cord guard.	( )	(X)
6.10.2.2	Cord anchorage		
	The cord anchorage:		
	- relieves the conductors from strains and twisting;	( )	(X)
	- protects the conductor from abrasion;	( )	(X)
	The protective earth conductor is the last to take the strain.	( )	(X)
	Cord anchorage's:		
	- the cord is not clamped;	( )	(X)
	- knots are not used;	( )	(X)
	- it is not possible to push the cord into the equipment, to could cause a hazard;	( )	(X)
	- failure of the cord insulation in a cord anchorage which has metal parts.	( )	(X)
	- A compression bushing is not used unless:		
	- it has provision for clamping; or	( )	(X)
	- it is designed to terminate a screened mains supply cord;	( )	(X)
	- the cord replacement does not cause a hazard.	( )	(X)
6.10.3	Plugs and connectors		
	a) Plugs, connectors and appliance couplers, comply with the relevant specifications.	(X)	( )

Clause	Requirement	Complies	Not applicable
	b) Equipment is designed to be supplied at voltages below 6.3.2.1.	( )	(X)
	c) Plug pins of cord-connected equipment which receive a charge from an internal capacitor.	( )	(X)
	d) Equipment with accessory mains socket-outlets:	( )	(X)
	- there is a marking according to 5.1.3 e);	( )	(X)
	- outlets with a Terminal contact.	( )	(X)
6.11	Terminals		
6.11.1	Accessible Terminals	( )	(X)
	a) Flexible cord contact.	( )	(X)
	- self evident or marked;	( )	(X)
	- passes the free strand test.	( )	(X)
	b) Are anchored.	( )	(X)
6.11.2	Protective Conductor Terminal		
	a) Connection of an appliance inlet.	( )	(X)
	b) Equipment provided with a rewireable flexible cord.	( )	(X)
	c) Equipment not requiring connection to a mains supply.	( )	(X)
	- Where the circuit has external Terminals.	( )	(X)
	d) Protective Conductor Terminals for mains circuits.	( )	(X)

Clause	Requirement	Complies	Not applicable
	e) Soldered connections.	( )	(X)
	Such connections are not used for other purposes.	( )	(X)
	Screw connections are secured.	( )	(X)
	f) The contact surfaces of Protective Conductor Terminals.	( )	(X)
	g) Plug-in type Protective Conductor Terminals.	( )	(X)
	h) Equipment dependent on a protective conductor in a single fault condition.	( )	(X)
6.11.3	Functional Earth Terminals	( )	(X)
6.12	Disconnection from supply source		
6.12.1	General		
	Except as specified in 6.12.1.1.	(X)	( )
6.12.1.1	Exceptions		
	Short circuit or overload cannot cause a hazard.	( )	(X)
	If it does give reasons below: _____ _____		
6.12.2	Requirements according to type of equipment		
6.12.2.1	Permanently Connected Equipment	( )	(X)
	Permanently Connected Equipment and multi-phase equipment.	( )	(X)

Clause	Requirement	Complies	Not applicable
	The following disconnect devices are used:	( )	(X)
	_____		
	Where a switch is not part of the equipment documentation for equipment shall specify that;	( )	(X)
6.12.2.2	Single-phase cord-connected equipment		
	A disconnect device is used: A separate plug, without a locking device, to mate with a socket-outlet in the building	(X)	( )
6.12.2.3	Hazards arising from function		
	An emergency switch is provided.	( )	(X)
	The emergency switch is correctly located.	( )	(X)
6.12.3	Disconnecting devices		
	A disconnecting device is part of the equipment.	(X)	( )
	(Exception: EMI suppression circuits.)		
6.12.3.1	Switches and circuit-breakers		
	Switches or circuit-breakers acting as disconnection devices.	( )	(X)
	Switches or circuit-breakers with contacts for disconnecting and other contacts for other purposes	( )	(X)
6.12.3.2	Appliance couplers and plugs		
	Where an appliance coupler or separable plug is used as the disconnecting device (see 6.12.2.2):		
	- it is readily identifiable and easily reached by the Operator.	(X)	( )

Clause	Requirement	Complies	Not applicable
	- single phase Portable Equipment cord length.	( )	(X)
	The protective earth conductor connected.	(X)	( )
7.0	Protection against mechanical hazards		
7.1	General		
	Handling during Normal Use.	(X)	( )
	Protection against expelled parts.		
7.2	Moving parts	( )	(X)
	Moving parts not able to crush, etc.		
	Maintenance of equipment with hazardous moving parts	( )	(X)
	- access requires use of tool;		
	- proper instructions are given including training statement for operators;	( )	(X)
	- access covers provided with warning statements or alternatively symbol 14 with additional warnings in manual;	( )	(X)
7.3	Stability		
	Equipment and assemblies of equipment are stable in Normal Use.	(X)	( )
	Stability is maintained and automatic means or warning markings comply with 5.2.	( )	(X)
7.4	Provisions for lifting and carrying	( )	(X)
	Carrying handles or grips supplied.	( )	(X)

Clause	Requirement	Complies	Not applicable
	Equipment or parts weight ≥ 18 kg; or	( )	(X)
	Directions given in the manufacturer's documentation.	( )	(X)
7.5	Expelled parts		
	Equipment contains or limits the energy.	( )	(X)
	Protection not removable without the aid of a Tool.	( )	(X)
8.0	Mechanical resistance to shock and impact	( )	(X)
8.1	Rigidity test	( )	(X)
8.2	Impact hammer test	( )	(X)
8.3	Not used		
8.4	Drop test		
8.4.1	Equipment other than hand held	( )	(X)
8.4.1.1	Corner drop test	( )	(X)
8.4.1.2	Face drop test	( )	(X)
8.4.2	Hand-held equipment	( )	(X)
9.0	Equipment temperature limits and protection against the spread of fire		
9.1	General		
	Heating does not cause a hazard, either:		
	- in Normal Condition or	(X)	( )
	- in Single Fault Condition	(X)	( )
	- nor cause spread of fire outside the equipment.	(X)	( )

Clause	Requirement	Complies	Not applicable
	Easily touched heated surfaces (see 5.2).	( )	(X)
	Separation of circuits at least by Basic Insulation.	(X)	( )
	Alternative protection - annex F	( )	(X)
	See details in Test record T1		
9.2	Temperature tests	(X)	( )
	Values of table 3.		
9.2.1	Heating equipment	( )	(X)
9.2.2	Equipment intended for installation in a cabinet or wall.	(X)	( )
9.3	Guards		
	Surfaces liable to exceed 100 °C.	( )	(X)
	Guards removable	( )	(X)
9.4	Field-wiring Terminal boxes		
	Field-wiring Terminal box or compartment.	( )	(X)
	Temperature Rating of the cable.	( )	(X)
	Marking adjacent to the field-wiring Terminals, or visible:	( )	(X)
	- During installation;	( )	(X)
	- After installation.	( )	(X)

Clause	Requirement	Complies	Not applicable
	Overtemperature protection devices		
	Loss of cooling		
	Equipment having a heating control system.	( )	(X)
	Overtemperature protection device which operates in a Single Fault Condition.	( )	(X)
9.5	Devices actuated by temperature, liquid level, airflow or other means.	( )	(X)
	Overtemperature protection device does not operated in normal use.	( )	(X)
	Self-resetting overtemperature device.	( )	(X)
9.6	Overcurrent protection	( )	(X)
	Mains operated equipment protected by:		
	- fuses; - circuit-breakers; - thermal cut-outs; - impedance limiting circuits or similar means.	(X) ( ) ( ) ( )	( ) (X) (X) (X)
	(See also 6.5)		
9.6.1	Permanently Connected Equipment		
	Overcurrent protection devices fitted.	( )	(X)
	Manufacturer's instructions specify devices.	( )	(X)
9.6.2	Other equipment		
	Protection provided within the equipment.	( )	(X)
	Overcurrent protection devices not in the protective conductor.	( )	(X)
	Fuses or single pole circuit-breakers not fitted.	( )	(X)

Clause	Requirement	Complies	Not applicable
10.0	Resistance to heat		
10.1	Integrity of Clearances and Creepage Distances	(X)	( )
10.2	Resistance to heat of non-metallic		
	Enclosures	( )	(X)
	For details of non-metallic enclosures See details in Test record T1.		
10.3	Resistance to heat of insulating material		
	- For mains supply.	( )	(X)
	- For Terminals.	( )	(X)
11.0	Protection against hazards form fluids		
11.1	General	( )	(X)
11.2	Cleaning	( )	(X)
11.3	Spillage	( )	(X)
11.4	Overflow	( )	(X)
11.5	Battery electrolyte	( )	(X)
	Battery electrolyte leakage presents no hazard.		

Clause	Requirement	Complies	Not applicable
11.6	Specially protected equipment		
	Where the equipment is Rated and marked by the manufacturer.	( )	(X)
11.7	Fluid pressure and leakage		
11.7.1	Maximum pressure	( )	(X)
11.7.2	Leakage and rupture at high pressure	( )	(X)
11.7.3	Leakage from low pressure parts	( )	(X)
11.7.4	Overpressure safety device	( )	(X)
12.0	Protection against radiation, including laser sources, and against sonic and ultrasonic pressure		
12.1	General		
12.2	Equipment producing ionizing radiation	( )	(X)
12.2.1	Ionizing radiation	( )	(X)
12.2.2	Accelerated electrons	( )	(X)
12.3	Ultra-violet radiation	( )	(X)
12.4	Micro-wave radiation	( )	(X)
12.5	Sonic and ultrasonic pressure	( )	(X)
12.5.1	Sound pressure level	( )	(X)
12.5.2	Ultrasonic pressure	( )	(X)

Clause	Requirement	Complies	Not applicable
12.6	Laser sources (see IEC 825)	(X)	( )
13.0	Protection against liberated gases, explosion and implosion		
13.1	Poisonous and injurious gases	( )	(X)
13.2	Explosion and implosion	( )	(X)
13.2.1	Components		
	Components liable to explode (see also 7.5)	( )	(X)
	Pressure release devices correctly located.	( )	(X)
	Pressure release device not obstructed.	( )	(X)
13.2.2	Batteries		
	- Battery (explosion/fire hazard)	( )	(X)
	- Protection is incorporated in the equipment.	( )	(X)
	- Instructions specify batteries to be used.	( )	(X)
	- Warning marking or symbol 14.	( )	(X)
	- Battery compartment design.	( )	(X)
13.3	Implosion of high-vacuum devices	( )	(X)
	High vacuum devices are:		
	- intrinsically protected; or	( )	(X)
	-Enclosure provides protection.	( )	(X)
	Non-intrinsically protected tube.	( )	(X)
	Separate glass screen.	( )	(X)

Clause	Requirement	Complies	Not applicable
	Cathode-ray tube or high-vacuum device mounting.	( )	(X)
	Cathode-ray tube meet IEC 65	( )	(X)
14.0	Components		
14.1	General		
	Safety components comply with IEC standards (see section 2).	(X)	( )
	Components are marked and operated within their marked ratings.	(X)	( )
14.2	Motors	( )	(X)
14.2.1	Motor temperatures	( )	(X)
14.2.2	Series excitation motors	( )	(X)
14.3	Overtemperature protection devices		
	Devices operating in a Single Fault Condition:		
	- are constructed and tested;	( )	(X)
	- are Rated for voltage and current interrupt;	( )	(X)
	- are Rated for the maximum surface temperature;	( )	(X)
	- meet the requirements of 9.5.	( )	(X)
14.4	Fuse holders	(X)	( )
14.5	Mains voltage selecting devices	( )	(X)

Clause	Requirement	Complies	Not applicable
14.6	High Integrity components	( )	(X)
	Positions of use (see section 2).		
	Evaluated to IEC Publications.		
	A single electronic device.		
14.7	Mains transformers	(X)	( )
14.7.1	Short-circuit tests		
	Tested	(X)	( )
	Transformers meet 4.4.4.1 to 4.4.4.3.	(X)	( )
	TUV and UL listed external power supply		
14.7.2	Overload tests		
	Transformer meets 4.4.4.1 to 4.4.4.3.	(X)	( )
	TUV and UL listed external power supply		
15.0	Protection by interlocks		
15.1	General		
	Interlocks are designed to remove a hazard.	( )	(X)
	Exceptions for 2 s	( )	(X)
	- Easily touched parts;	( )	(X)
	- Moving parts; or	( )	(X)
	- marking used.	( )	(X)
	Warning markings.		
15.2	Prevention of reactivation	( )	(X)
15.3	Reliability	( )	(X)

V. Test Record T1

Clause 4.4 Testing in single fault condition

TESTS

Clause	Fault description	Test terminated because;	Test duration	Comments
4.4.2.1	N/A			
4.4.2.2	N/A			
4.4.2.7	Short-circuited all operator accessible I/O ports	**Timed out**	1 Hour	No hazard
4.4.2.9	**N/A**			
4.4.2.11	N/A			

Comments: During the single fault condition testing no hazard was introduced and equipment complied with the dielectric strength test after each fault.

Clause 5.3 Durability of markings

The markings on the equipment were tested with agent A or B and then agent C

Agents:

A- The cleaning agent specified by the manufacturer, N/A

B- Water

C- Isopropyl Alcohol

RESULTS

Clause 5.1.2, Identification	Pass
Clause 5.1.3, Mains supply	Pass
Clause 5.1.4, Fuses	N/A
Clause 5.1.5, Measuring circuit terminals	N/A
Clause 5.1.6, Terminals and operating devices	N/A
Clause 5.1.7, Double/Reinforced equipment	N/A
Clause 5.1.8, Battery charging	N/A
Clause 5.2, Warning markings	Pass

Marking condition:

Still legible after rubbing	Yes
Did adhesive labels become loose	No
Did adhesive labels curl at the edges	No

Clause 6.3.1 Values in normal condition

RESULTS
Clause 6.3.1.1 Voltage

Location	Maximum voltage measured between	V rms	V peak	V d.c	Comments
DB-9 & DB-15	No voltage available				Pass
Mini-din connectors	1, 2, 4, 5			24.0	Pass

Clause 6.3.2 Values in Single fault condition

RESULTS

Clause 6.3.2.1 Voltage

Location	Maximum voltage measured between	V rms	V peak	V d.c	Comments
DB-9 & DB-15	No voltage available				Pass
Mini-din connectors	No voltage available				Pass

Clause 7.3 Stability

METHOD

Clause 7.3	Comments
Tilted each side 10 degrees	**Pass**
Force of 250N applied to large equipment	**Not Applicable**

Clause 7.4 Provisions for lifting and carrying

Clause 7.4	Comments
Not Applicable Equipment weight is less than 18 Kg	

Clause 7.3 Stability

Test	Comments
Tilted each side 10 degrees	**Unit did not tip over**
Tilted each side 10 degrees	**Unit did not tip over**

8.1 Rigidity test

Location	Comments
Top rear side of enclosure	**No Hazard**

8.2 Impact hammer test

Location	Comments
Appliance Receptacle	**No Hazard**

8.4.1.1 Corner drop test

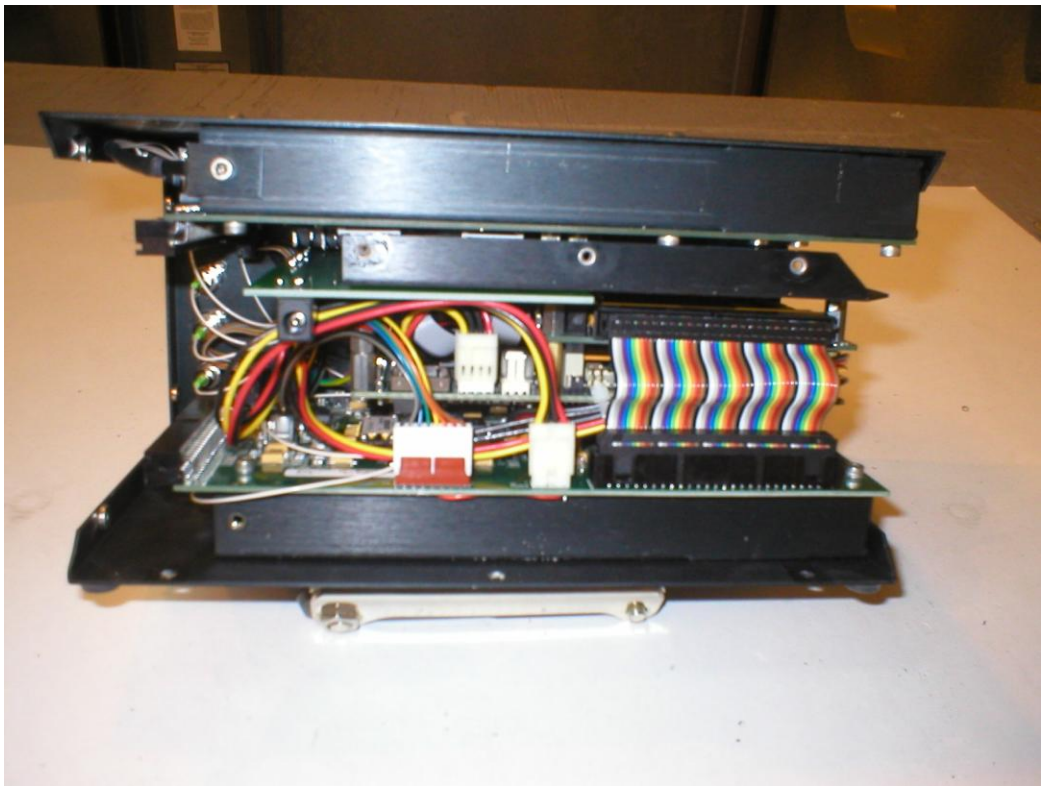
Location	Comments
All 4 corners subjected	**No Hazard**

8.4.1.2 Face drop test

Location	Comments
All 4 sides subjected	**No Hazard**

VII. Photographs


MICRON OPTICS
TUNED
sm125



Section 5. Laser Safety Test Report

To Determine Compliance with: FDA Classification 21 CFR 1040.10 and IEC 60825-1

I. Introduction

Manufacturers of laser products are required to categorize each laser into one of four categories, depending upon the risk of potentially damaging ocular exposure to optical energy. In the United States, requirements are set forth by the Center for Devices and Radiological Health (CDRH), which operates under the Food and Drug Administration (FDA). Internationally, laser safety standards are governed by the International Electrotechnical Commission (IEC). The FDA and IEC qualify laser products in a similar manner. Both methodologies and the resultant FDA and IEC classifications for the MOI Swept Laser Interrogator Platform are covered in this document.

II. FDA Classification 21 CFR 1040.10

A. Test Procedures and Calculations

For a laser product to be classified as a Class 1 under FDA requirements, the accessible emission level (AEL) must be below a certain level for each of three wavelength ranges. In the case of the MOI Swept Laser, which lases in the 1510nm to 1580nm wavelength range, the following limit applies:

- $AEL_1 = 7.9 \times 10^{-4}$ W for λ = 1400nm to 2500nm

The AEL is measured, according to the FDA standards, at a distance of 20cm through a 7mm aperture. If the AEL for a particular product as measured through the 7mm aperture at a distance of 20cm is below the limit stated above, then the product is Class 1. If the AEL exceeds the above limit, then the product is Class 3b, unless the AEL exceeds 500mW, in which case it is Class 4.

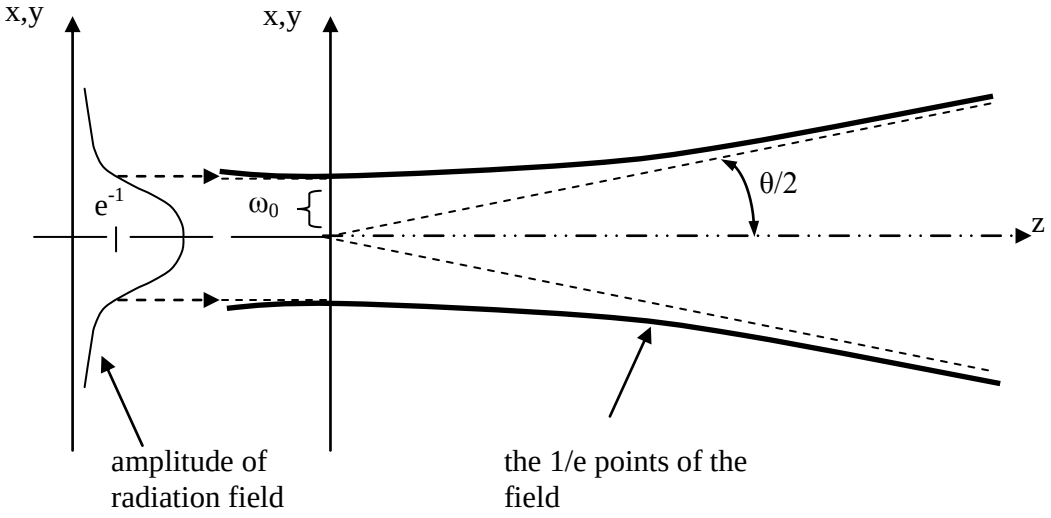


Figure 1. Beam divergence of $TEM_{0,0}$ mode from single mode fiber.

The optical power from a fiber output of a laser that would pass through a 7mm aperture at a distance of 20cm can be calculated using the total optical output power from the fiber, the wavelength of the laser, and the mode field diameter of the optical fiber at the output. For a Gaussian beam, the total power passing through an aperture of diameter D_0 at a distance L can be expressed in terms of a coupling factor.

Equation 1: $$\eta = \left[1 - e^{-\left(\frac{D_0}{D_L}\right)^2}\right],$$

where D_L is the beam diameter at the 1/e points at the aperture distance.

The diameter of the beam emanating from a single mode fiber is a function of the mode field diameter of the fiber, ω_0, and the wavelength of the beam, λ, and is given by the following equation.

Equation 2: $$D_L = \frac{2L\lambda}{\pi\omega_0}$$

Equation 3 is used to calculate the beam divergence angle, θ, where n is the optical index of refraction.

Equation 3: $$\theta = \frac{2\lambda}{\pi n \omega_0}$$

In the case of the MOI Swept Laser, the wavelength selected for analysis is 1510nm. This wavelength, which is the shortest emitted from the SL, has a larger coupling factor than would the higher wavelength extreme of 1580nm, and as such represents a worst case condition for emitted laser radiation through the fixed 7mm aperture at 20cm distance.

Evaluating Equations 1 and 2 for λ = 1510nm, ω_0 = 10.5μm, L = 20cm, and D_0 = 20cm,

from (2), $$D_L = \frac{2(20cm)(1.51um)}{\pi(10.5um)} = 1.83cm$$

from (1), $$\eta = \left[1 - e^{-\left(\frac{0.7}{1.83}\right)^2}\right] = 0.136$$

Given that the max AEL_1 for FDA Class 1 is 7.9 x 10^{-4} W for λ = 1400nm to 2500nm passing through the 7mm aperture at 20cm, the total allowable output power from the fiber can be calculated as follows:

$$\frac{AEL_1}{\eta} = \frac{0.790\,mW}{0.136} = 5.81mW = 7.6dBm$$

Thus, if the maximum output power from the fiber as measured for 10^4 seconds does not exceed 7.6 dBm, then the MOI Swept Laser can be classified as a Class 1 laser product under FDA guidelines.

Evaluating Equation 3 for λ = 1580nm, ω_0 = 10.5μm, and n = 1, gives the divergence angle θ.

from (3), $$\theta = \frac{2(1550\,nm)}{\pi(1)(10.5um)} = 0.093 \text{ radians} = 5.38°$$

B. Measurement Results

As measured with an optical power meter, the MOI si425 Swept Laser output measures to be -6dBm at worst case, over 10 units. This output power is well below the 7.6dBm limit for Class 1. As such the si425 is an FDA Class 1 laser product. These results carry over to si225 and sm420 instruments, by design.

As measured with an optical power meter, the MOI si720 Swept Laser output measures to be +2.0 dBm at worst case, over 10 units. This output power is well below the 7.6dBm limit for Class 1. As such, the si720 is an FDA Class 1 laser product. These results carry over to the CTS, HR-SLI, si125, si725, and si730, by design.

III. IEC 60825-1 Classification

A. Test Procedures and Calculations

For a laser product to be classified as a Class 1 under IEC requirements, the accessible emission level (AEL) must be below a certain level for each of five wavelength ranges. In the case of the MOI Swept Laser, which lases in the 1510nm to 1580nm wavelength range, the following limit applies:

- AEL = 10mW for λ = 1400nm to 4000nm

IEC standards call for a test condition at L = 50mm with an aperture of 50mm, with a measurement time of 100 seconds. As with the FDA standards, we can back calculate the total allowable output power from the fiber from the aperture limited AEL.

Evaluating Equations 1 and 2 for λ = 1510nm, ω_0 = 10.5μm, L = 100mm, and D_0 = 50mm,

from (2),
$$D_L = \frac{2(100\,mm)(1.51um)}{\pi(10.5um)} = 9.15mm$$

from (1), $$\eta = \left[1 - e^{-\left(\frac{50}{9.15}\right)^2}\right] \cong 1$$

Since at a distance of 100mm, the 9mm beam diameter is much smaller than the 50mm aperture, all of the light would pass through that aperture, thus leading to a coupling factor of 1.

Given that the max AEL_1 for IEC Class 1 is 10mW for λ = 1400nm to 4000nm passing through the 50mm aperture at 100mm, the total allowable output power from the fiber can be calculated as follows:

$$\frac{AEL_1}{\eta} = \frac{10mW}{1} = 10mW = 10dBm$$

Thus, if the maximum output power from the fiber as measured for 100 seconds does not exceed 10 dBm, then the MOI Swept Laser can be classified as a Class 1 laser product under IEC guidelines.

Under no circumstances, including single faults, can the circuit supply sufficient current to cause the si425 laser to emit more than –6dBm. Even under single fault conditions, the si425 output power is always within IEC 60825 Class 1 AEL limits. These results carry over to si225 and sm420 instruments, by design.

Under no circumstances, including single faults, can the circuit supply sufficient current to cause the si720 laser to emit more than +2dBm. Even under single fault conditions, the si425 output power is always within IEC 60825 Class 1 AEL limits. These results carry over to the CTS, HR-SLI, si125, si725, and si730, by design.

B. Measurement Results

As measured with an optical power meter, the MOI si425 Swept Laser output measures to be -6dBm at worst case, over 10 units. This output power is well below the 10dBm limit for Class 1. As such the si425 is an IEC Class 1 laser product. These results carry over to si225 and sm420 instruments, by design.

As measured with an optical power meter, the MOI si720 Swept Laser output measures to be +2.0 dBm at worst case. This output power is well below the 10dBm limit for Class 1. As such, the si720 is an IEC Class 1 laser product. These results carry over to the CTS, HR-SLI, si125, si725, and si730 by design.

IV. Conclusions

Under the stipulations of both the FDA 21 CFR 1040.10 and IEC 60825-1, the si425 qualifies as a Class 1 laser product. As such, the FDA requires no warning labels or control measures. Under IEC guidelines, Class 1 laser products should have fixed an explanatory label bearing the words: CLASS 1 LASER PRODUCT. An example is seen below, in Figure 1.

Figure 1. Explanatory label required by IEC 60825-1.

Micron Optics will also label APC connectors with the emblem seen in Figure 2 or a similar emblem, indicating the apparent source of laser radiation.

Figure 2. Emblem warning of laser radiation.

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