



MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*

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May 20, 2013

Paragon Robotics, LLC
27331 Tungsten Rd.
Euclid, Ohio 44132

Dear Julian Lamb,

Enclosed is the EMC Wireless test report for compliance testing of the Paragon Robotics, LLC, OE2x as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15, Subpart B and ICES-003, Issue 4 February 2004 for a Class B Digital Device, and FCC Part 15 Subpart C and RSS-210, Issue 8, Dec. 2010 for Intentional Radiators.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
MET LABORATORIES, INC.

Jennifer Warnell
Documentation Department

Reference: (\Paragon Robotics, LLC\EMC38425-FCC247 Rev. 1)

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Electromagnetic Compatibility Criteria Test Report

for the

**Paragon Robotics, LLC
OE2x**

Tested under
the FCC Certification Rules
contained in
Title 47 of the CFR, Parts 15 Subpart B & ICES-003
for Class B Digital Devices
&
15.247 Subpart C & RSS-210, Issue 8, Dec. 2010
for Intentional Radiators

MET Report: EMC38425-FCC247 Rev. 1

May 20, 2013

Prepared For:

**Paragon Robotics, LLC
27331 Tungsten Rd.
Euclid, Ohio 44132**

Prepared By:
MET Laboratories, Inc.
914 W. Patapsco Ave
Baltimore, MD 21230

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Benjamin Taylor, Project Engineer
Electromagnetic Compatibility Lab



Jennifer Warnell
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Parts 15B, 15.247 and Industry Canada standards ICES-003, Issue 4 February 2004, RSS-210, Issue 8, Dec. 2010 under normal use and maintenance.



Asad Bajwa,
Director, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	May 15, 2013	Initial Issue.
1	May 20, 2013	Revised to reflect engineer corrections.

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List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB_μA	Decibels above one microamp
dB_μV	Decibels above one microvolt
dB_μA/m	Decibels above one microamp per meter
dB_μV/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μH	microhenry
μ	microfarad
μs	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Paragon Robotics, LLC OE2x, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the OE2x. Paragon Robotics, LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the OE2x, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with Paragon Robotics, LLC, purchase order number 2013-0671. All tests were conducted using measurement procedure ANSI C63.4-2003.

FCC Reference 47 CFR Part 15.247:2005	IC Reference RSS-210 Issue 8: 2010; RSS-GEN Issues 3: 2010	Description	Compliance
47 CFR Part 15.107 (a)	ICES-003 Issue 4 February 2004	Conducted Emission Limits for a Class B Digital Device	Not Applicable
47 CFR Part 15.109 (a)	ICES-003 Issue 4 February 2004	Radiated Emission Limits for a Class B Digital Device	Compliant
Title 47 of the CFR, Part 15 §15.203	N/A	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	RSS-GEN (7.2.4)	Conducted Emission Limits	Not Applicable
Title 47 of the CFR, Part 15 §15.247(a)(1)	RSS-Gen(4.6)	20 dB Occupied Bandwidth	Compliant
		99% Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(1)	RSS-210(A8.1)	Average Time of Occupancy (Dwell Time)	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(1)	RSS-210(A8.1)	Number of RF Channels	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(1)	RSS-210(A8.1)	RF Channel Separation	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	RSS-210(A8.4)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	RSS-210(A8.5)	Radiated Spurious Emissions	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RSS-210(A8.5)	Spurious Conducted Emissions	Compliant
Title 47 of the CFR, Part 15 §15.247(g) & (h)	RSS-210(A8.1)	Declaration Statements for FHSS	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	RSS-GEN (5.6)	Maximum Permissible Exposure (MPE)	Compliant
N/A	RSS-GEN (4.10)	Receiver Spurious Emissions	Not Applicable

Table 1. Executive Summary of EMC Part 15.247 Compliance Testing

II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by Paragon Robotics, LLC to perform testing on the OE2x, under Paragon Robotics, LLC's purchase order number 2013-0671.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Paragon Robotics, LLC, OE2x.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	OE2x	
Model(s) Covered:	OE2x	
EUT Specifications:	Primary Power: +1.8 – +3.6 V	
	FCC ID: 2AAA2-OE2X	
	IC: 11091A-OE2X	
	Type of Modulations:	FHSS
	Equipment Code:	DSS
	Peak RF Output Power:	6.84dBm
	EUT Frequency Ranges:	902-928MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Ben Taylor	
Report Date(s):	May 20, 2013	

Table 2. EUT Summary Table

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
CFR 47, Part 15, Subpart B	Electromagnetic Compatibility: Criteria for Radio Frequency Devices
RSS-210, Issue 8, Dec. 2010	Low-power Licence-exempt Radiocommunications Devices (All Frequency Bands): Category I Equipment
RSS-GEN, Issue 3, Dec. 2010	General Requirements and Information for the Certification of Radio Apparatus
ICES-003, Issue 4 February 2004	Electromagnetic Compatibility: Criteria for Radio Frequency Devices
ANSI C63.4:2003	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2009	American National Standard for Testing Unlicensed Wireless Devices

Table 3. References

C. Test Site

All testing was performed at MET Laboratories, Inc., 914 W. Patapsco Ave., Baltimore, MD 21230. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

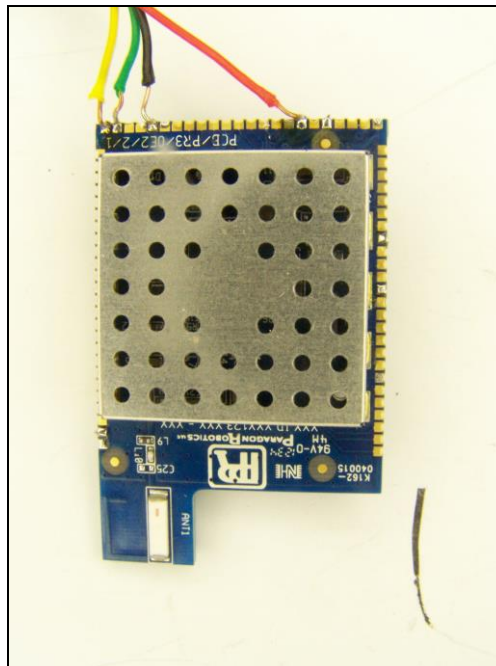
Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

D. Description of Test Sample

The Paragon Robotics, LLC OE2x, Equipment Under Test (EUT), is a wireless transceiver module designed to allow peer-to-peer communications between equipped devices on a wireless network. The OE2 is intended to be installed as a component module, or daughter board on a parent device, typically a printed circuit board (PCB). The module is programmed with Paragon Robotics' Halo/S stack, which provides mechanisms for wireless connectivity, as well as various electronic input/output (I/O) capabilities and end-user customization.

In-range devices equipped with an OE2x module can communicate wirelessly amongst each other using the proprietary Halo/S wireless protocol. The OE2x's transceiver operates in the 902-928 MHz frequency band, and is realized via Silicon Labs' Si102x wireless MCU, which integrates a majority of the radio components. The frequency hopping protocol is controlled by the Halo/S stack and is entirely transparent to the end-user.

User accessible functions of the OE2x module include up to 49 digital I/O pins, up to 11 analog-to-digital inputs, 11 capacitive sense channels, 11 multiplexed comparator inputs, integrated temperature sensor, low-power digital pulse counter, I2C interface, UART, and programmable frequency I/O. These functions can be integrated into complete systems to perform any number of tasks. Data can be shared between devices and is accessed internally via the Halo/S API.



Photograph 1. Paragon Robotics, LLC OE2x

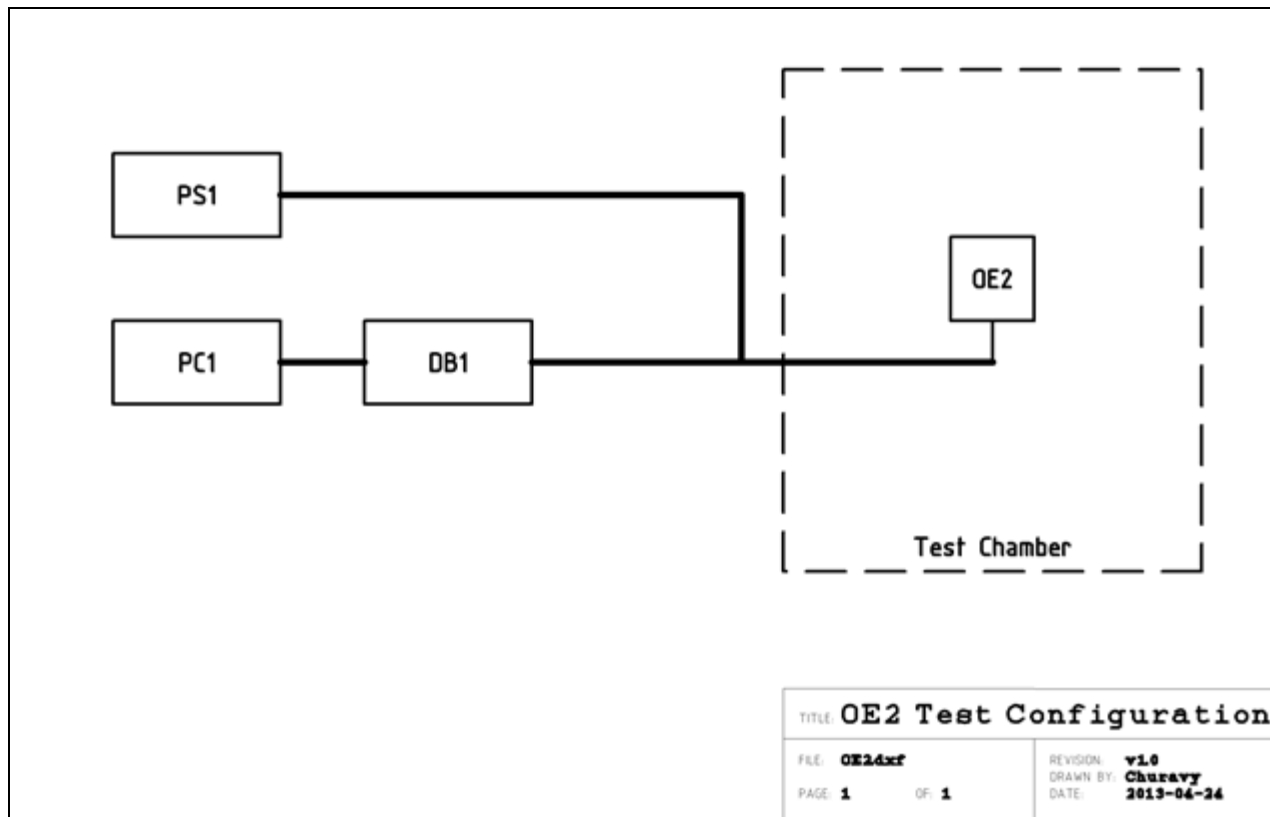


Figure 1. Block Diagram of Test Configuration

E. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Name / Description	Model Number	Serial Number
OE2x	OE2x Wireless Module	OE2x	N/A

Table 4. Equipment Configuration

F. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number
PS1	DC Power Supply	BK Precision	--
DB1	USB Debug Adapter	Silicon Labs	DEBUGADPTR1-USB
PC1	Laptop	Dell	--

Table 5. Support Equipment

G. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Length (m)	Shielded (Y/N)	Termination Point
CAB1	Debug/Power	Provides debug connections and power to EUT	1	25ft	Y	PS1(+,-), OE2x(25,32,47,48)
CAB2	USB	Connects PC to debugger	1	6ft	Y	DB1-USB-B

Table 6. Ports and Cabling Information

H. Mode of Operation

The OE2x is generally installed on a parent device, typically a PCB. There are 73 castellated pads on the OE2x perimeter that allow for it to be surface mounted to a parent device. Normal operation is controlled by the installed firmware.

I. Method of Monitoring EUT Operation

Fail if overall current draw > 200mA. Monitor by power supply current reading.

J. Modifications

- a) **Modifications to EUT**
No modifications were made to the EUT.
- b) **Modifications to Test Standard**
No modifications were made to the test standard.

K. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Paragon Robotics, LLC upon completion of testing.

III. Electromagnetic Compatibility Criteria for Unintentional Radiators

Electromagnetic Compatibility Criteria

§ 15.107 Conducted Emissions Limits

Test Requirement(s): **15.107 (a)** Except for Class A digital devices, for equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 7. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

15.107 (b) For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 7. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals. The lower limit applies at the band edges.

15.207(a), Except as shown in paragraphs (b) and (c) of this section*, charging, AC adapters or battery eliminators the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the Table 7, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency range (MHz)	Class A Conducted Limits (dB μ V)		*Class B Conducted Limits (dB μ V)	
	Quasi-Peak	Average	Quasi-Peak	Average
* 0.15- 0.45	79	66	66 - 56	56 - 46
0.45 - 0.5	79	66	56	46
0.5 - 30	73	60	60	50
Note 1 — The lower limit shall apply at the transition frequencies. Note 2 — The limit decreases linearly with the logarithm if the frequency in the range 0.15 MHz to 0.5 MHz. * -- Limits per Subsection 15.207(a).				

Table 7. Conducted Limits for Radio Frequency Devices calculated from FCC Part 15 Subsections 15.107(a) (b) and 15.207(a)

Test Results: The EUT was not applicable with the Class B requirement(s) of this section. The EUT is battery operated.

Radiated Emission Limits

§ 15.109 Radiated Emissions Limits

Test Requirement(s): **15.109 (a)** Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the Class B limits expressed in Table 8.

15.109 (b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the Class A limits expressed in Table 8.

Frequency (MHz)	Field Strength (dB μ V/m)	
	§15.109 (b), Class A Limit (dB μ V) @ 10m	§15.109 (a), Class B Limit (dB μ V) @ 3m
30 - 88	39.00	40.00
88 - 216	43.50	43.50
216 - 960	46.40	46.00
Above 960	49.50	54.00

Table 8. Radiated Emissions Limits calculated from FCC Part 15, §15.109 (a) (b)

Test Procedures: The EUT was placed on a non-metallic table, 80 cm above the ground plane on the turntable inside a semi-anechoic chamber. The method of testing and test conditions of ANSI C63.4 were used. An antenna was located 3 m from the EUT on an adjustable mast. A pre-scan was first performed in order to find prominent radiated emissions. For final emissions measurements at each frequency of interest, the EUT was rotated and the antenna height was varied between 1 m and 4 m in order to maximize the emission. Measurements in both horizontal and vertical polarities were made and the data was recorded. Unless otherwise specified, measurements were made using a quasi-peak detector with a 120 kHz bandwidth.

Test Results: The EUT was Compliant with the Class B requirement(s) of this section. Measured emissions were below applicable limits.

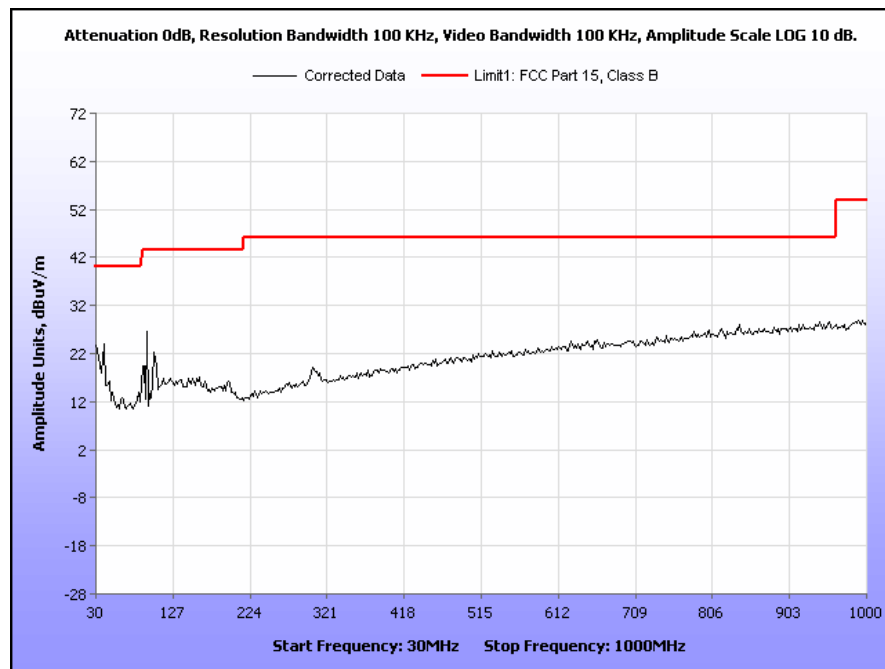
Test Engineer(s): Ben Taylor

Test Date(s): 05/02/13

Radiated Emissions Limits Test Results, Class B

Frequency (MHz)	EUT Azimuth (Degrees)	Antenna Polarity (H/V)	Antenna HEIGHT (m)	Uncorrected Amplitude (dBuV)	Antenna Correction Factor (dB) (+)	Cable Loss (dB) (+)	Distance Correction Factor (dB) (-)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
52.54509	98	H	1.44	5.50	7.99	0.49	0.00	13.98	40.00	-26.02
52.54509	112	V	1.33	6.02	7.99	0.49	0.00	14.50	40.00	-25.50
70.025663	67	H	1.46	5.65	8.20	0.63	0.00	14.48	40.00	-25.52
70.025663	52	V	1.44	5.72	8.20	0.63	0.00	14.55	40.00	-25.45
95.100009	48	H	1.28	5.95	8.93	0.75	0.00	15.63	43.50	-27.87
95.100009	82	V	1.35	16.54	8.93	0.75	0.00	26.22	43.50	-17.28
104.31062	31	H	1.33	6.09	11.46	0.78	0.00	18.33	43.50	-25.17
104.31062	53	V	1.28	11.28	11.46	0.78	0.00	23.52	43.50	-19.98
693.33667	62	H	1.46	5.42	20.77	2.29	0.00	28.48	46.00	-17.52
693.33667	26	V	1.37	5.42	20.77	2.29	0.00	28.48	46.00	-17.52
995.99198	39	H	1.42	6.02	23.70	2.98	0.00	32.70	54.00	-21.30
995.99198	54	V	1.37	5.95	23.70	2.98	0.00	32.63	54.00	-21.37

Table 9. Radiated Emissions Limits, Test Results, 30 MHz – 1 GHz, FCC Limits

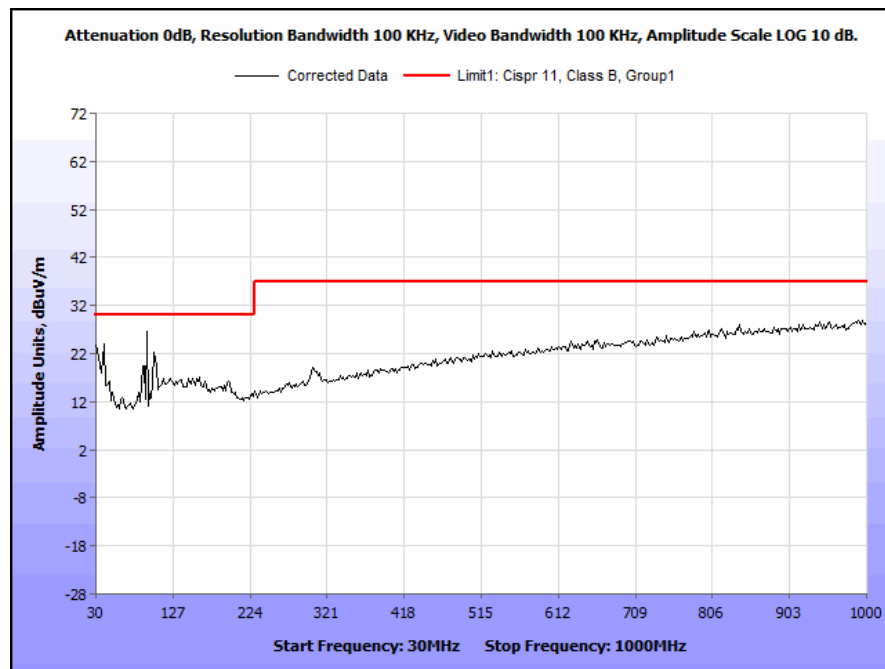


Plot 1. Radiated Emissions, 30 MHz - 1 GHz, FCC Limits

Radiated Emissions Limits Test Results, Class B

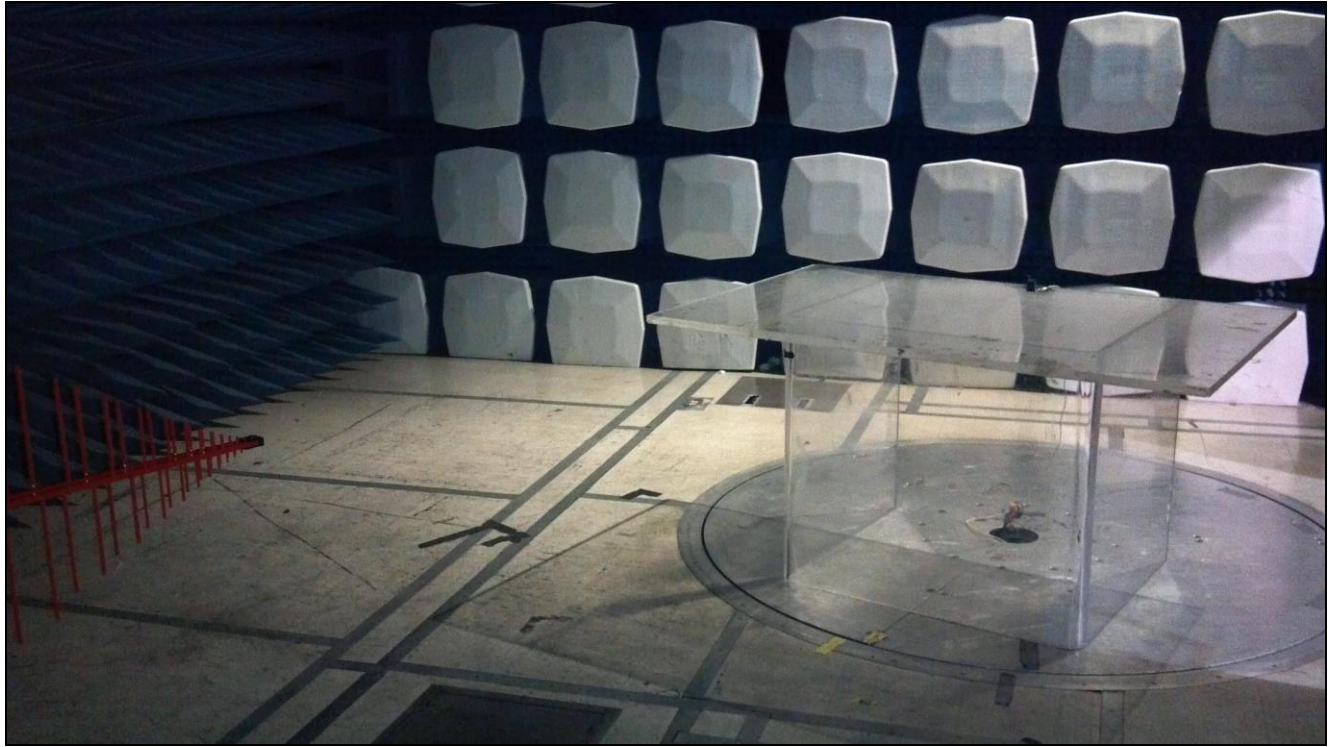
Frequency (MHz)	EUT Azimuth (Degrees)	Antenna Polarity (H/V)	Antenna HEIGHT (m)	Uncorrected Amplitude (dBuV)	Antenna Correction Factor (dB) (+)	Cable Loss (dB) (+)	Distance Correction Factor (dB) (-)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
52.54509	98	H	1.44	5.50	7.99	0.49	10.46	3.52	30.00	-26.48
52.54509	112	V	1.33	6.02	7.99	0.49	10.46	4.04	30.00	-25.96
70.025663	67	H	1.46	5.65	8.20	0.63	10.46	4.02	30.00	-25.98
70.025663	52	V	1.44	5.72	8.20	0.63	10.46	4.09	30.00	-25.91
95.100009	48	H	1.28	5.95	8.93	0.75	10.46	5.17	30.00	-24.83
95.100009	82	V	1.35	16.54	8.93	0.75	10.46	15.76	30.00	-14.24
104.31062	31	H	1.33	6.09	11.46	0.78	10.46	7.87	30.00	-22.13
104.31062	53	V	1.28	11.28	11.46	0.78	10.46	13.06	30.00	-16.94
693.33667	62	H	1.46	5.42	20.77	2.29	10.46	18.02	37.00	-18.98
693.33667	26	V	1.37	5.42	20.77	2.29	10.46	18.02	37.00	-18.98
995.99198	39	H	1.42	6.02	23.70	2.98	10.46	22.24	37.00	-14.76
995.99198	54	V	1.37	5.95	23.70	2.98	10.46	22.17	37.00	-14.83

Table 10. Radiated Emissions Limits, Test Results, ICES-003 Limits



Plot 2. Radiated Emissions, 30 MHz - 1 GHz, ICES-003 Limits

Radiated Emissions Test Setup



Photograph 2. Radiated Emissions, Test Setup

IV. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement:

§ 15.203: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

- a.) Antenna must be permanently attached to the unit.
- b.) Antenna must use a unique type of connector to attach to the EUT.
- c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results:

The EUT as tested is compliant the criteria of §15.203. EUT has an integral antenna.

Test Engineer(s):

Ben Taylor

Test Date(s):

05/03/13

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207(a) Conducted Emissions Limits

Test Requirement(s): § 15.207 (a): For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Σ line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dB μ V)	
	Quasi-Peak	Average
* 0.15- 0.45	66 - 56	56 - 46
0.45 - 0.5	56	46
0.5 - 30	60	50

Table 11. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Results: The EUT was not applicable with this requirement. The EUT is battery operated.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1) 20 dB Occupied Bandwidth

Test Requirements: § 15.247(a): Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. For DTS, the minimum 6 dB bandwidth shall be at least 500 kHz. For frequency hopping systems, the EUT shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Procedure: The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth. The 20 dB bandwidth was measured and recorded.

Test Results The EUT was compliant with § 15.247 (a)(2).

Test Engineer(s): Ben Taylor

Test Date(s): 05/03/13

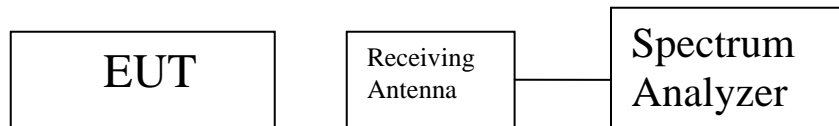
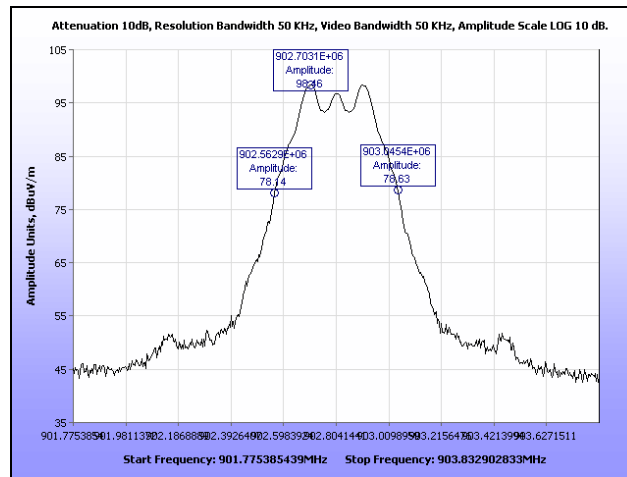
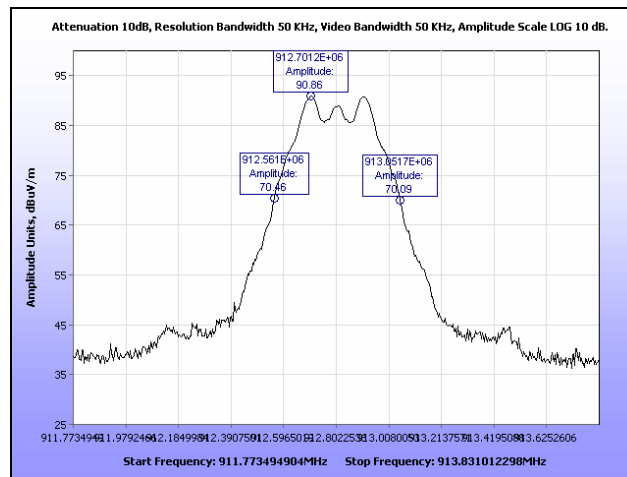


Figure 2. Block Diagram, Occupied Bandwidth Test Setup

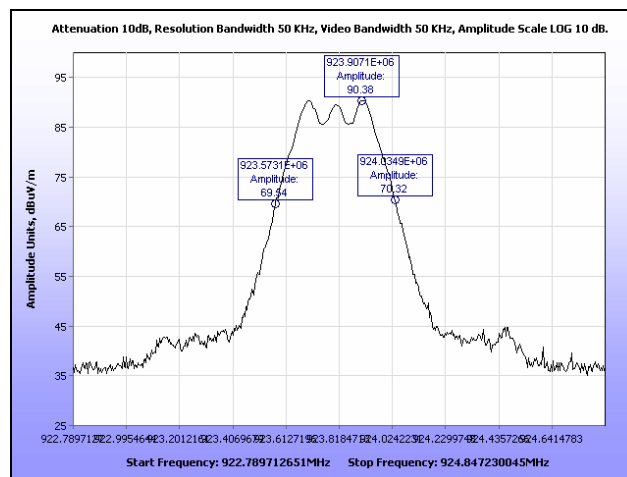
20 dB Occupied Bandwidth Test Results



Plot 3. 20 dB Occupied Bandwidth, Low Channel (482.5 kHz; 500 kHz Limit)

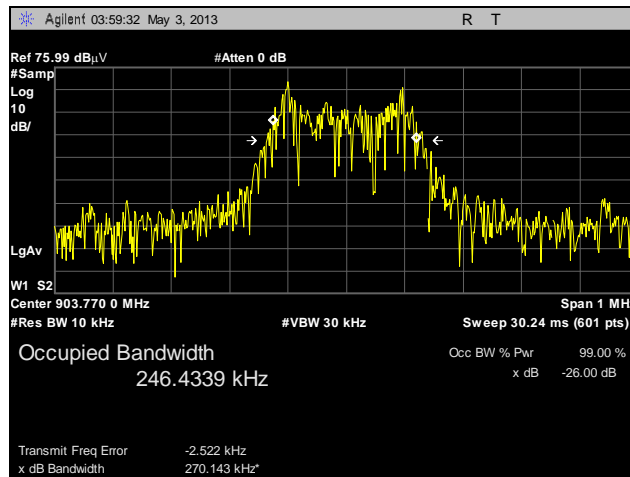


Plot 4. 20 dB Occupied Bandwidth, Mid Channel (490.7 kHz; 500 kHz Limit)

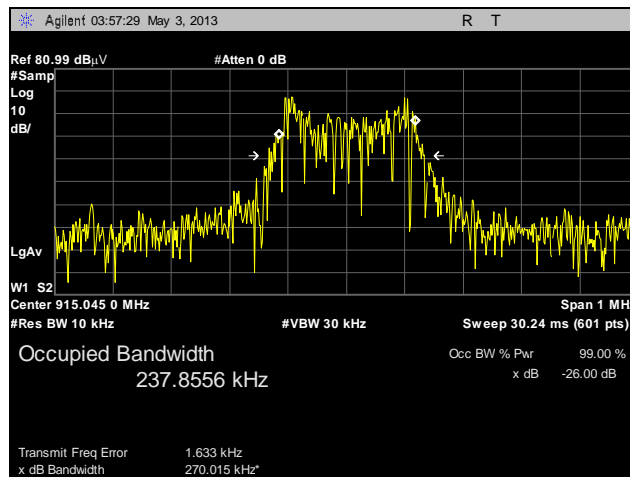


Plot 5. 20 dB Occupied Bandwidth, High Channel (461.8 kHz; 500 kHz Limit)

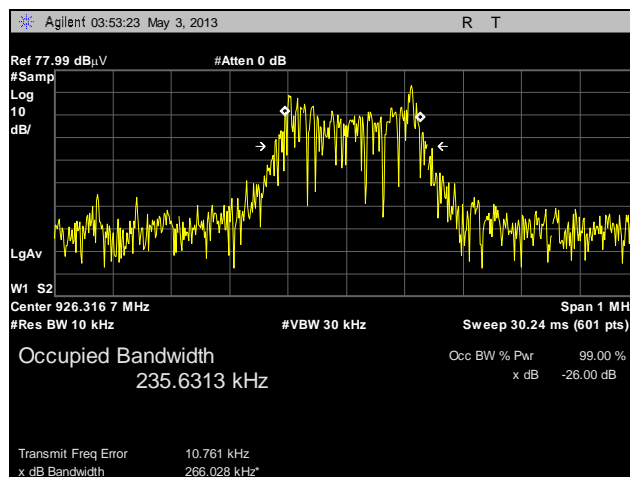
99% Occupied Bandwidth Test Results



Plot 6. 99% Occupied Bandwidth, Low Channel



Plot 7. 99% Occupied Bandwidth, Mid Channel



Plot 8. 99% Occupied Bandwidth, High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1) Average Time of Occupancy (Dwell Time)

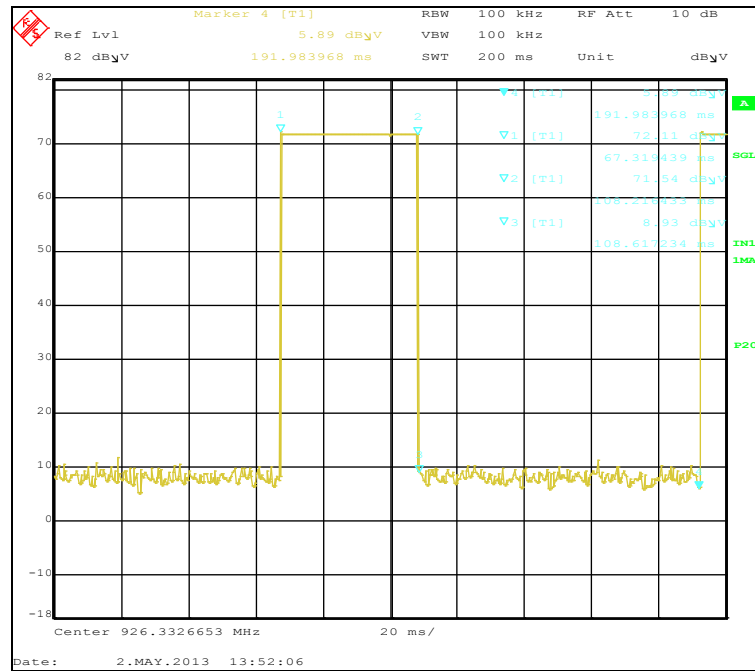
Remarks: The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

Total hopping channels is 25, GFSK Modulation. The EUT meets the specifications of Section 15.247(a) (1) (iii) for Number of Hopping Channels.

Modulation	# of Channels	Dwell Time	# of pulses in 10 Seconds (Pulses*10)	Average Time of Occupancy in 10 Seconds	Limit	Margin
		ms		ms	ms	ms
GFSK	25	40.8	3	122.4	400	-277.6

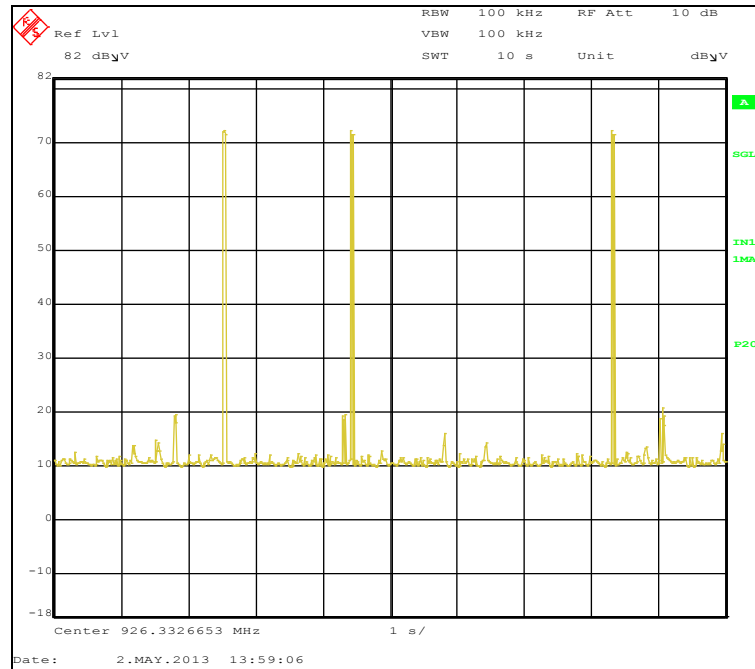
Table 12. Average Time of Occupancy

Dwell Time



Plot 9. Dwell Time (0.0408 S)

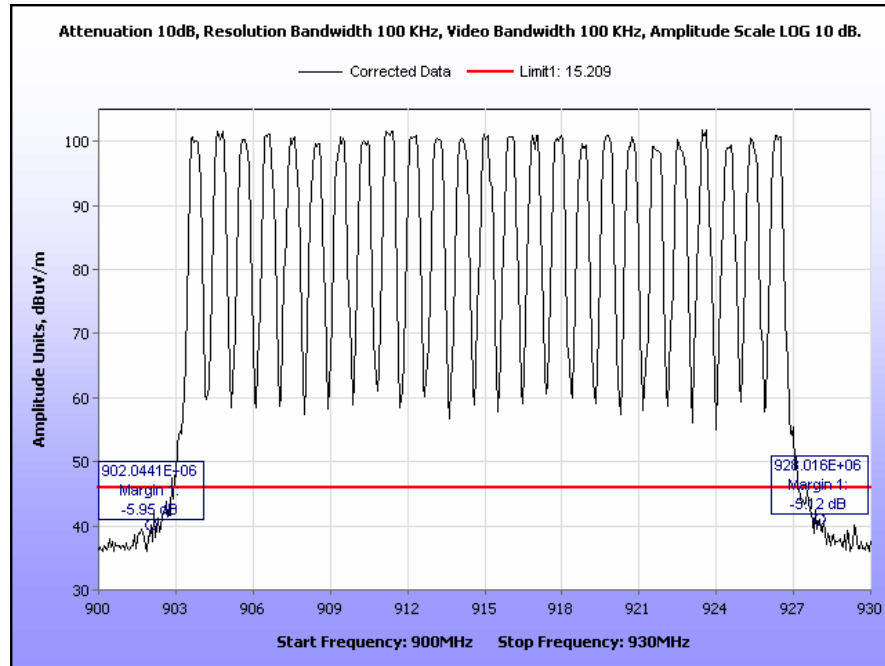
Number of Pulses



Plot 10. Number of Pulses (10 Second Sweep)

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1) Number of RF Channels



Plot 11. Number of Channels, 902 – 928 MHz (25 Channels)

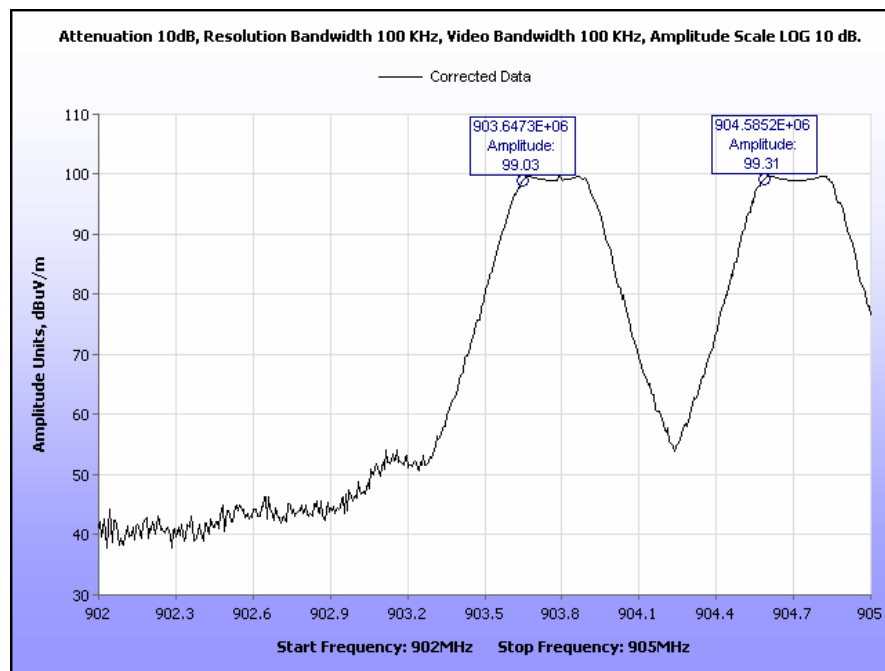
Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(1) RF Channel Separation

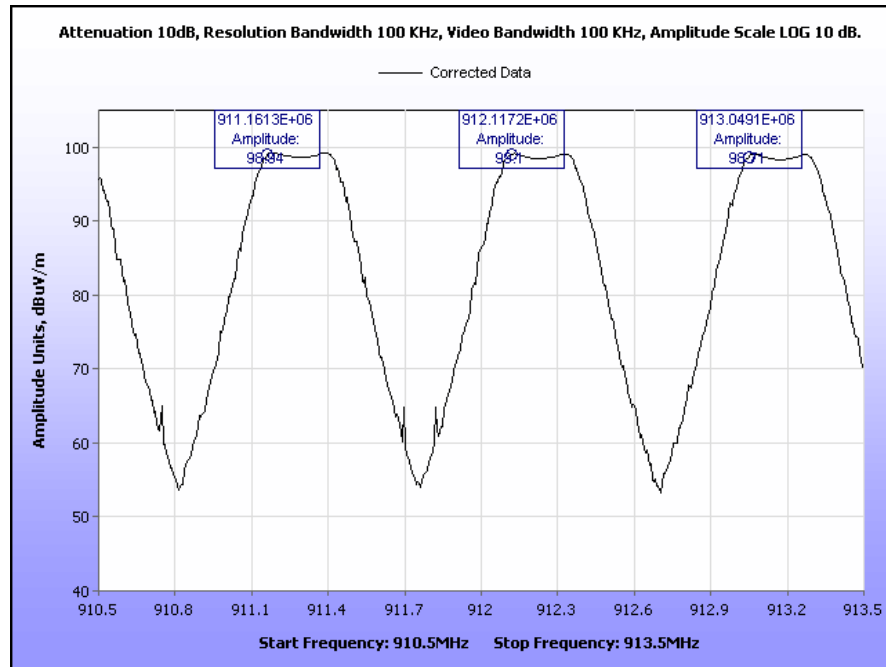
Requirement: Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Remarks: EUT operates below 125mW (20dBm). Channels are separated by more than two thirds of the -20dB Bandwidth.

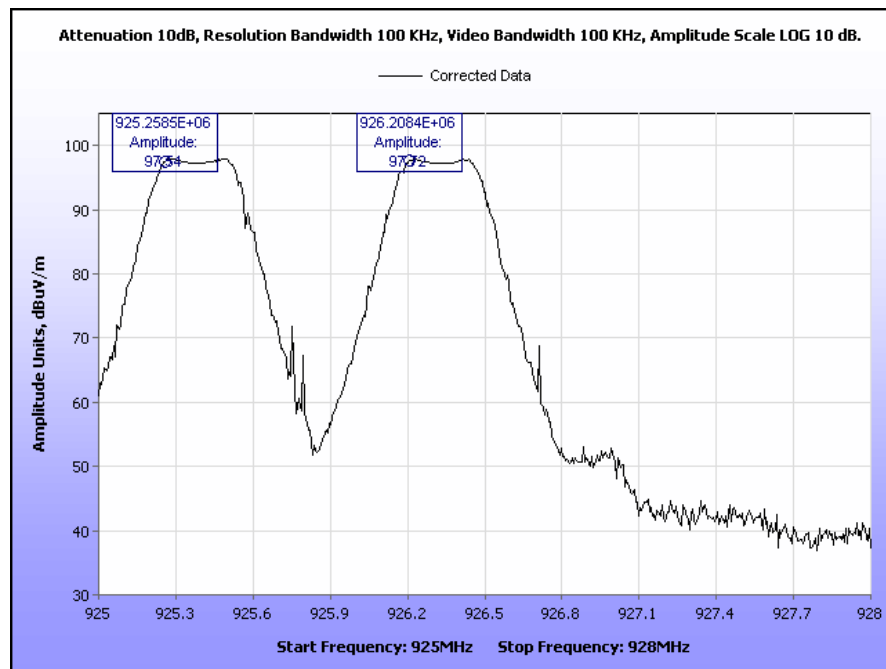
EDR – $\frac{2}{3} \times 1.393 \text{ MHz (20dB Bandwidth)} = 929 \text{ kHz Minimum Separation Distance}$



Plot 12. 25 kHz Channel Separation, Low Channel (937.9 kHz)



Plot 13. 25 kHz Channel Separation, Mid Channel (959.9 kHz)



Plot 14. 25 kHz Channel Separation, High Channel (949.9 kHz)

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: §15.247(b)(2): For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

Test Procedure: All testing was performed Radiated, as the EUT has an integrated antenna. The transmitter was activated in its full power mode in a semi-anechoic chamber, with a receiving antenna connected to a spectrum analyzer. The following equation was used to calculate a conducted value (dBm) from the field strength measurements, as all testing was performed radiated:

$$EIRP = E_0 + 20\log(d) - 104.8$$

The EUT has an integral antenna with a gain of 0dBi; its limit is 24dBm.

Test Results: The EUT was compliant with the Peak Power Output limits of §15.247(b).

Test Engineer(s): Ben Taylor

Test Date(s): 05/03/13

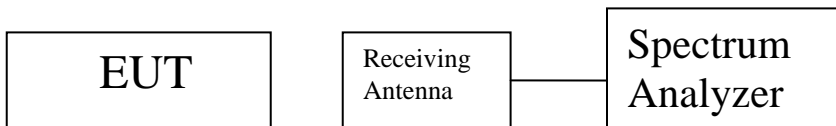
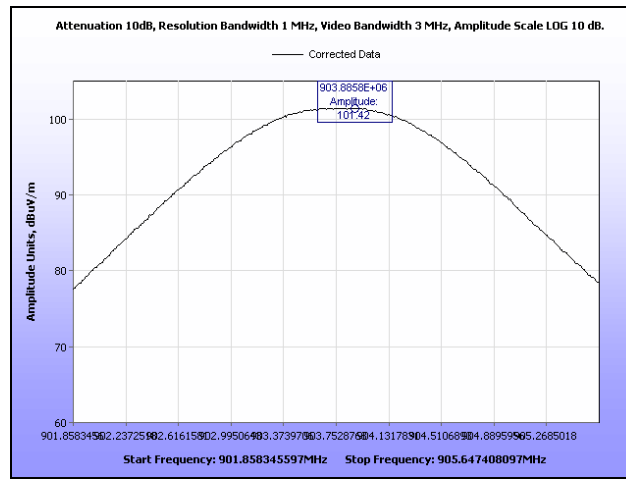


Figure 3. Peak Power Output Test Setup

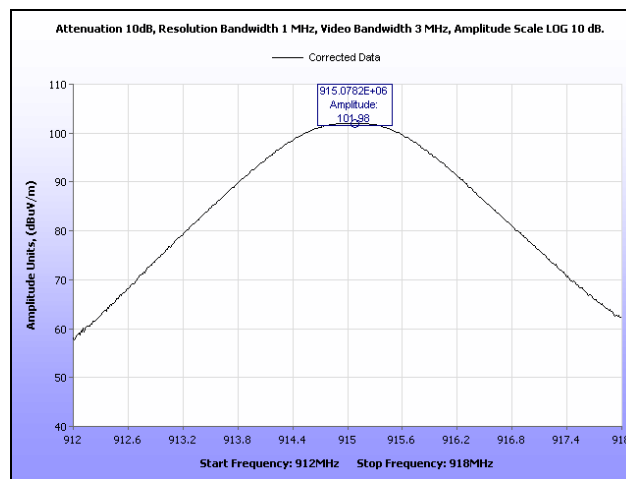
Carrier Channel	Peak Power Measurements					
	Frequency (MHz)	Measured Field Strength (dBμV)	Antenna Gain (dBi)	Conducted Power Value (dBm)	Limit (dBm)	Margin (dB)
Low	904MHz	101.42	0	6.19	24	-17.81
Mid	915MHz	101.98	0	6.75	24	-17.25
High	926MHz	102.07	0	6.84	24	-17.16

Table 13. Peak Output Power, Test Results

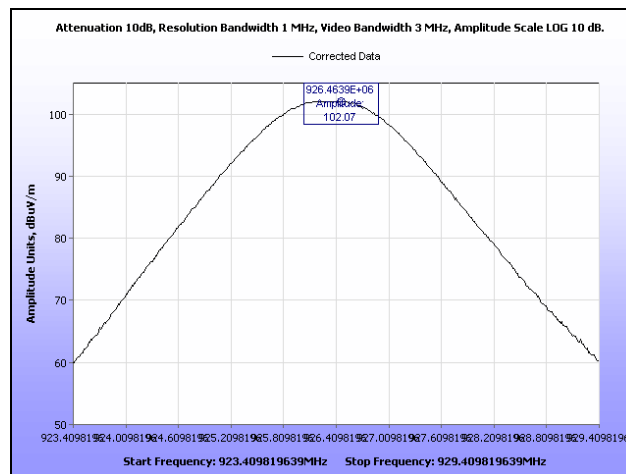
Peak Power Output Test Results



Plot 15. Peak Power Output, Low Channel



Plot 16. Peak Power Output, Mid Channel



Plot 17. Peak Power Output, High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge

Test Requirements: §15.247(d); §15.205: Emissions outside the frequency band.

§15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110-----	16.42–16.423	399.9–410	4.5–5.15
¹ 0.495–0.505-----	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905-----	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128-----	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775-----	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775-----	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218-----	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825-----	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225-----	123–138	2200–2300	14.47–14.5
8.291–8.294-----	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366-----	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675-----	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475-----	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293-----	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025-----	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725-----	322–335.4	3600–4400	(²)

Table 14. Restricted Bands of Operation

¹ Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

² Above 38.6

Test Requirement(s): § 15.209 (a): Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 15.

Frequency (MHz)	§ 15.209(a), Radiated Emission Limits (dB μ V) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 15. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

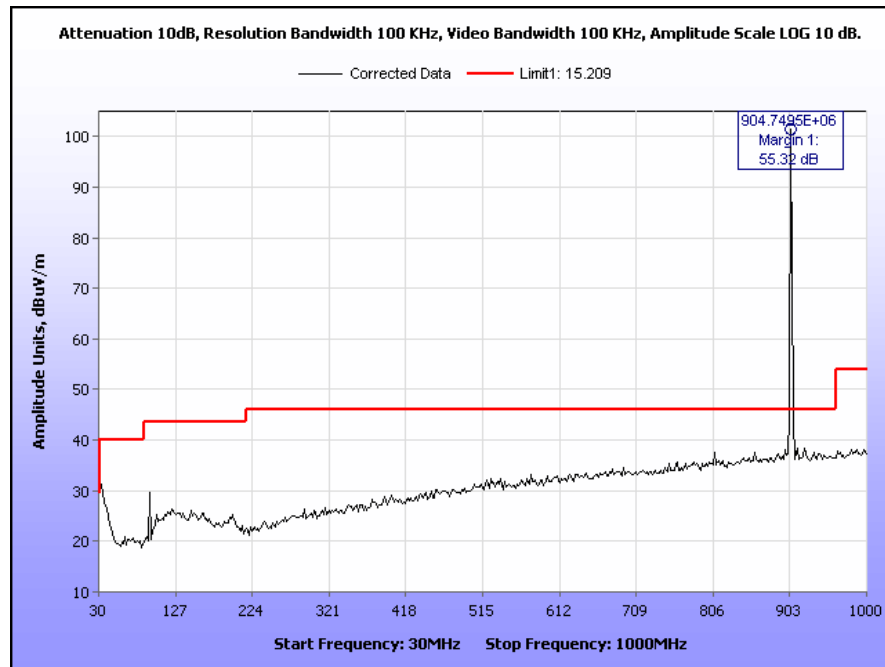
Test Procedure: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

Test Results: The EUT was compliant with the requirements of §15.247(d).

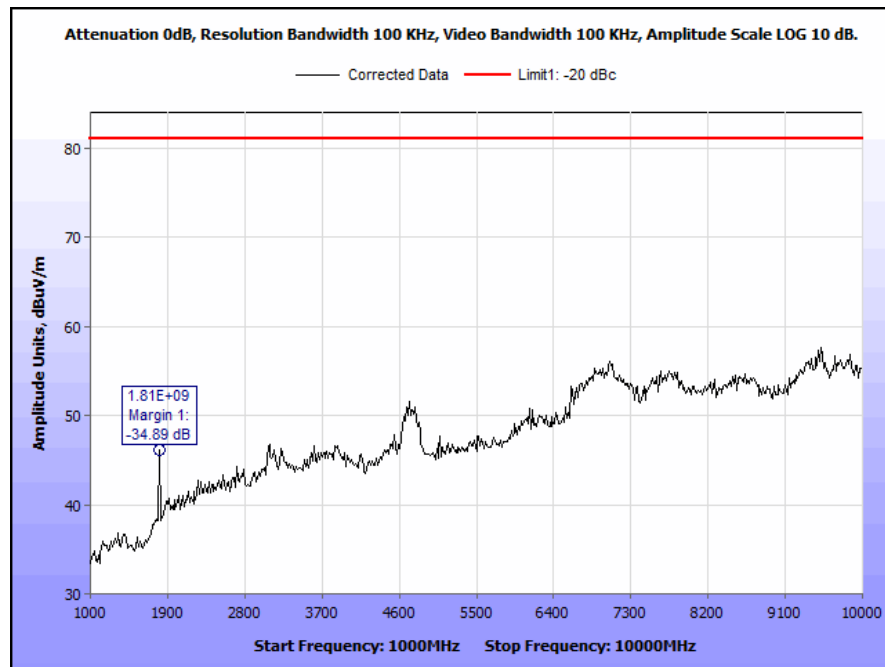
Test Engineer(s): Ben Taylor

Test Date(s): 05/03/13

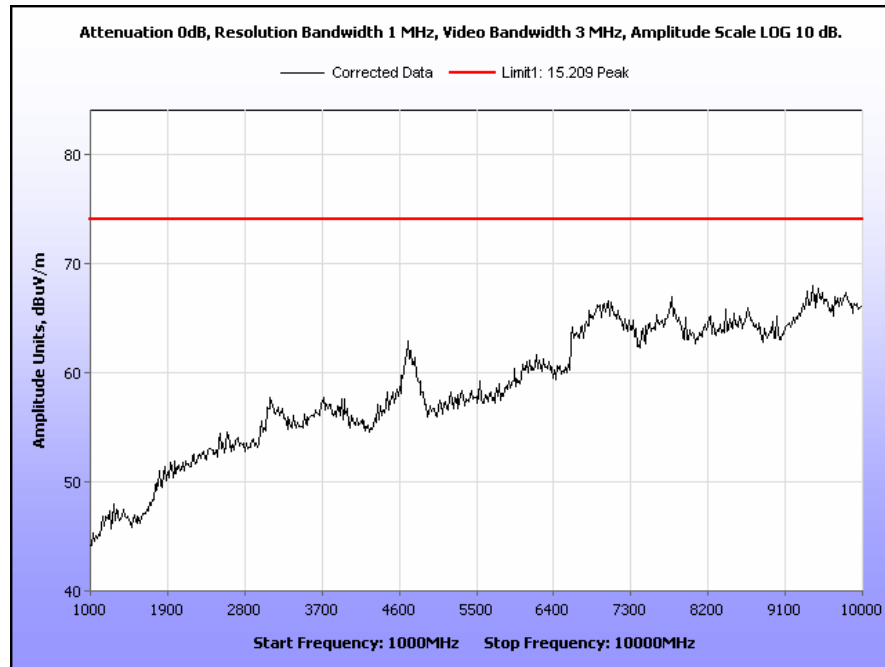
Radiated Spurious Emissions Test Results



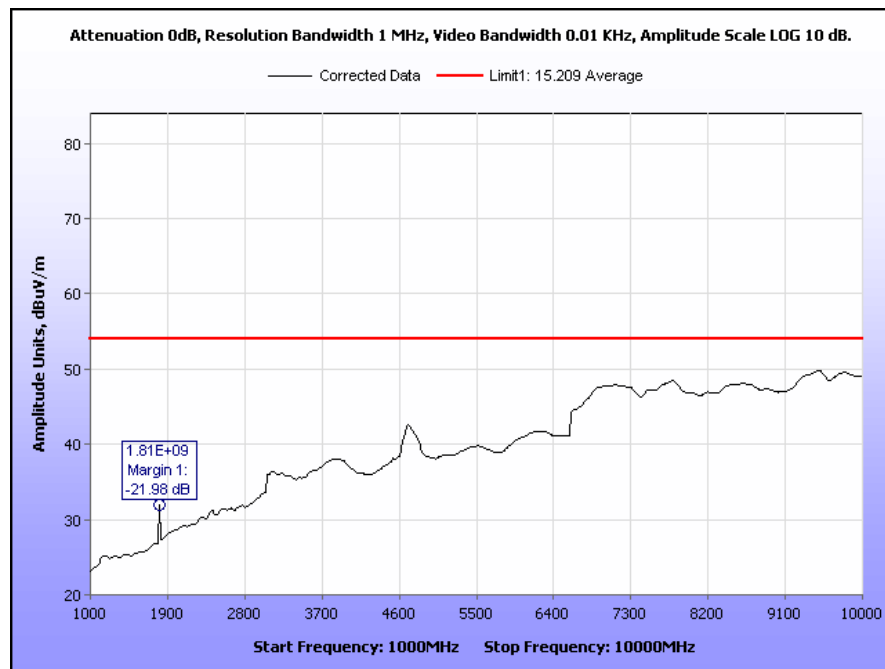
Plot 18. Radiated Spurious Emissions, Low Channel, 30 MHz – 1 GHz



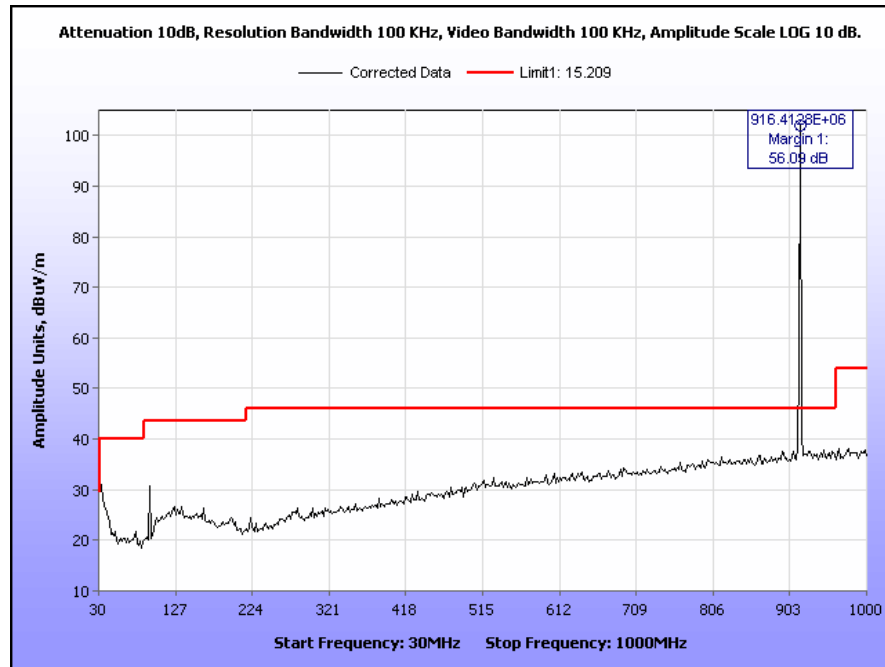
Plot 19. Radiated Spurious Emissions, Low Channel, 1 GHz – 10 GHz, 100 kHz



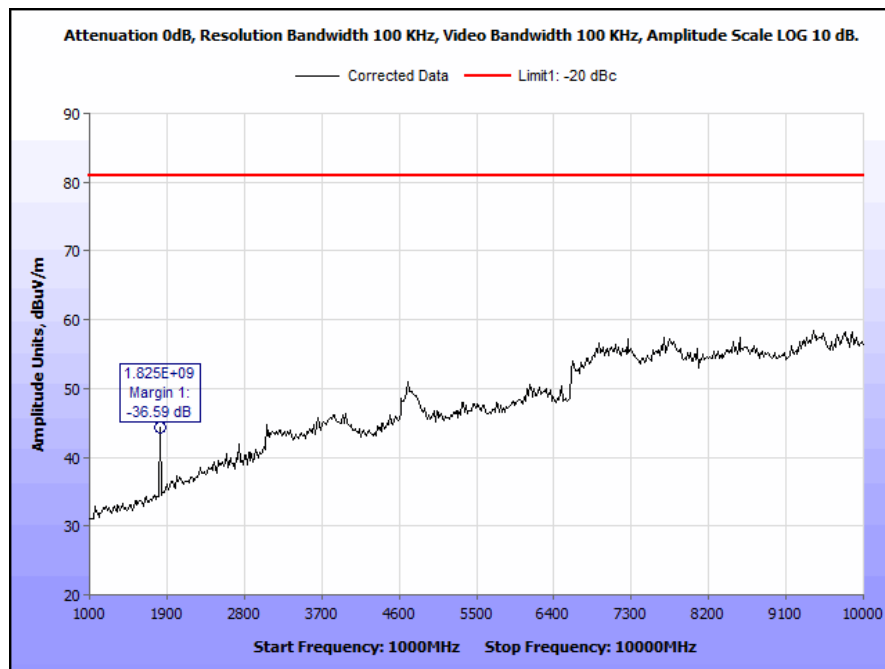
Plot 20. Radiated Spurious Emissions, Low Channel, 1 GHz – 10 GHz, Peak



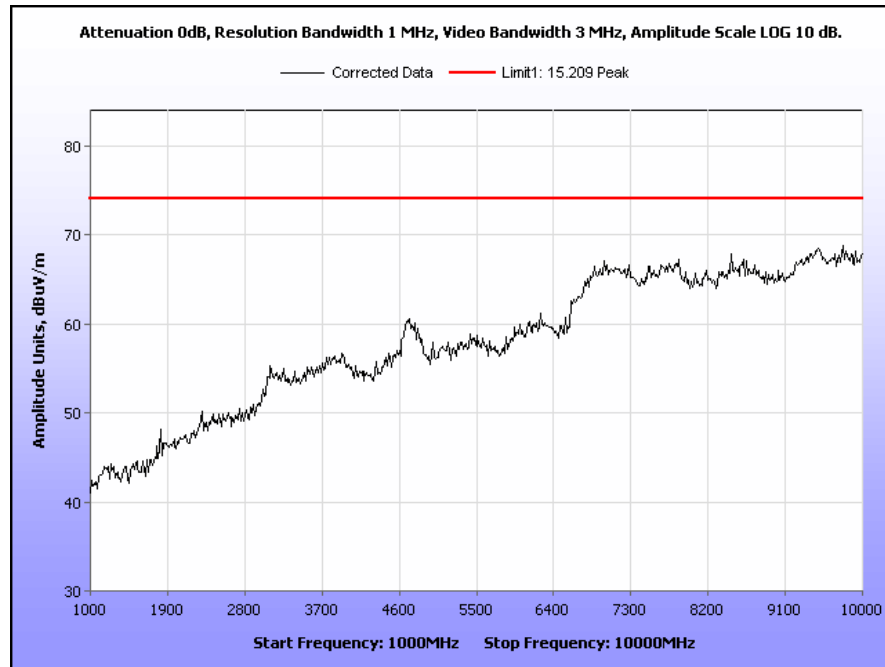
Plot 21. Radiated Spurious Emissions, Low Channel, 1 GHz – 10 GHz, Average



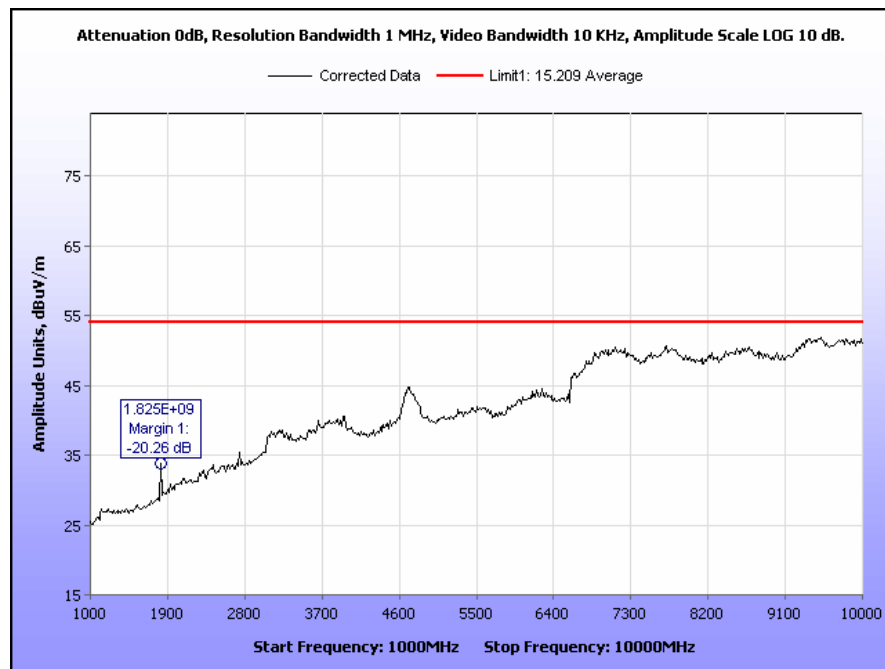
Plot 22. Radiated Spurious Emissions, Mid Channel, 30 MHz – 1 GHz



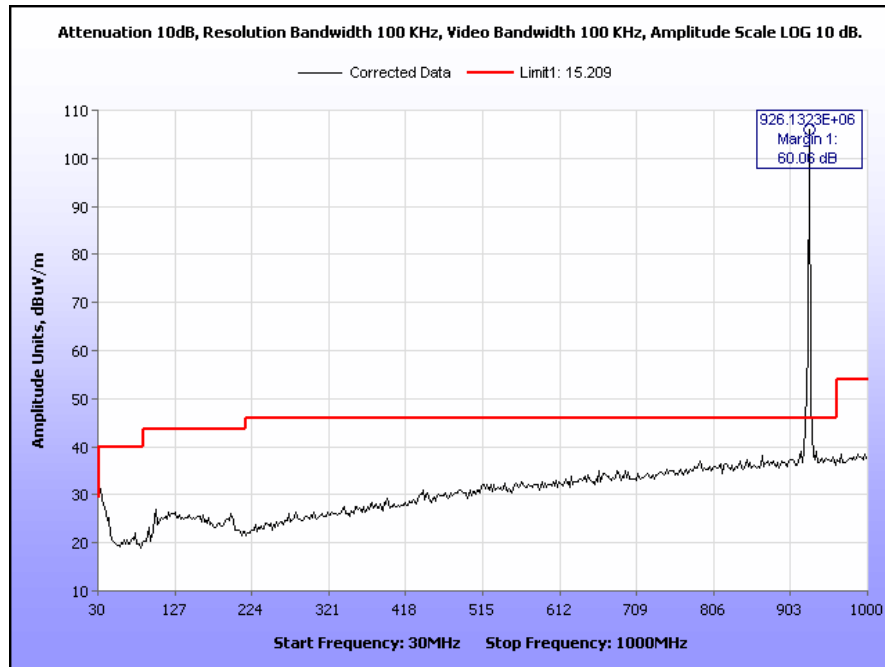
Plot 23. Radiated Spurious Emissions, Mid Channel, 1 GHz – 10 GHz, 100 kHz



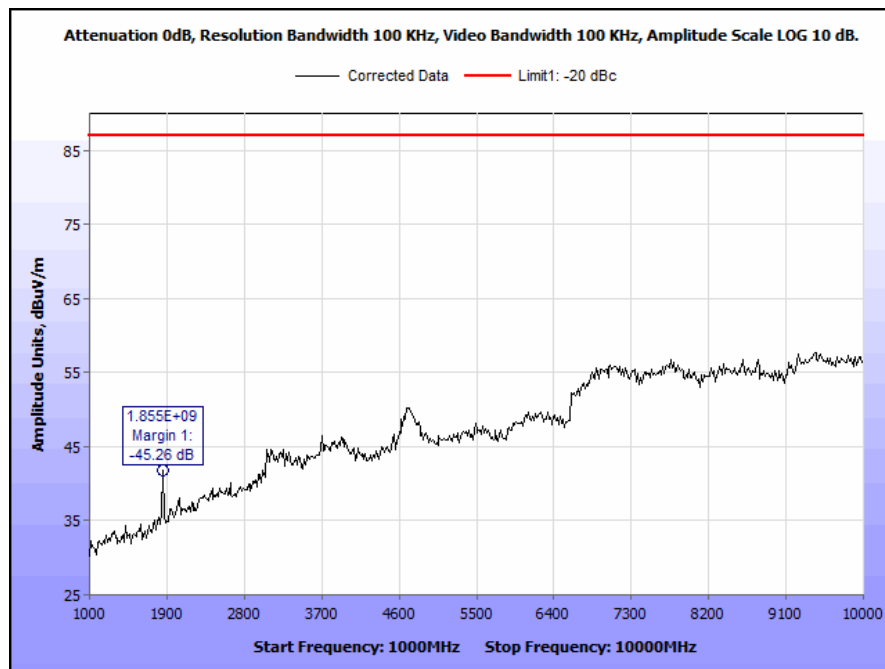
Plot 24. Radiated Spurious Emissions, Mid Channel, 1 GHz – 10 GHz, Peak



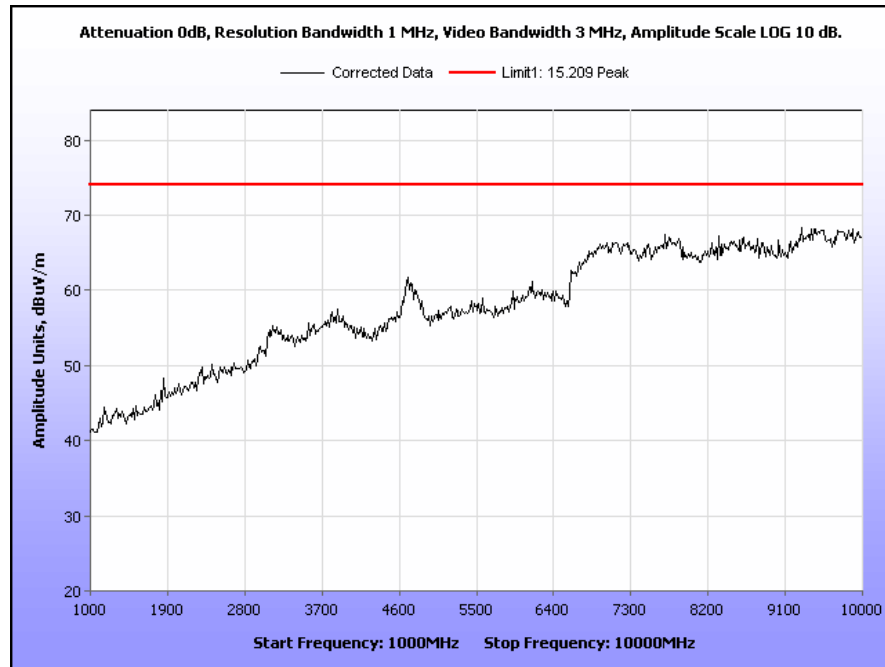
Plot 25. Radiated Spurious Emissions, Mid Channel, 1 GHz – 10 GHz, Average



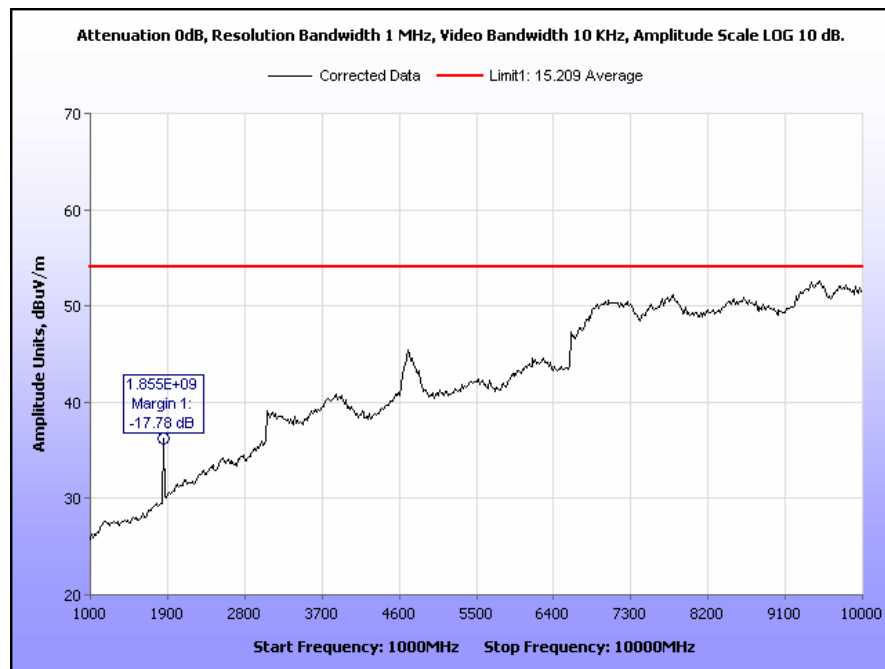
Plot 26. Radiated Spurious Emissions, High Channel, 30 MHz – 1 GHz



Plot 27. Radiated Spurious Emissions, High Channel, 1 GHz – 10 GHz, 100 kHz

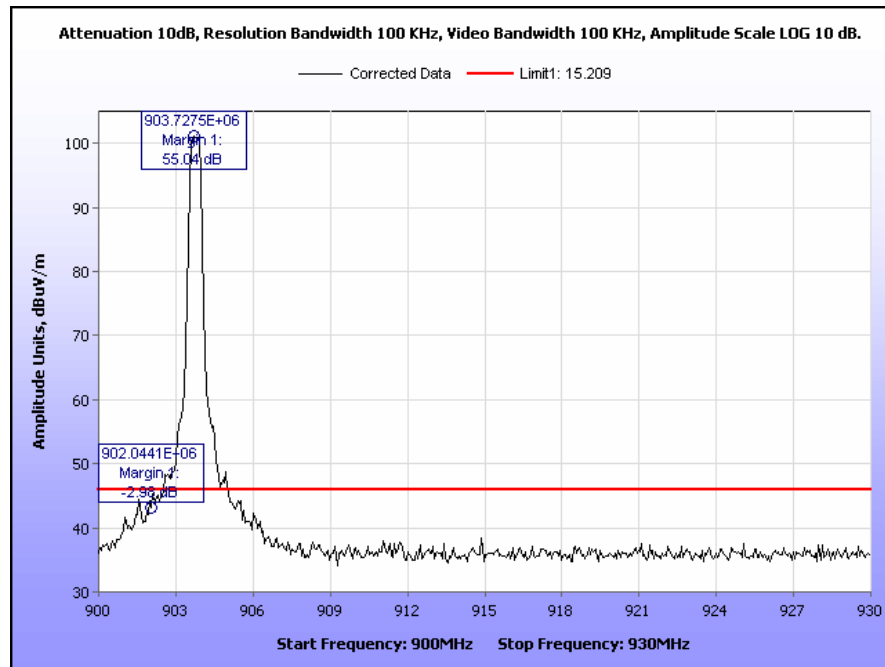


Plot 28. Radiated Spurious Emissions, High Channel, 1 GHz – 10 GHz, Peak

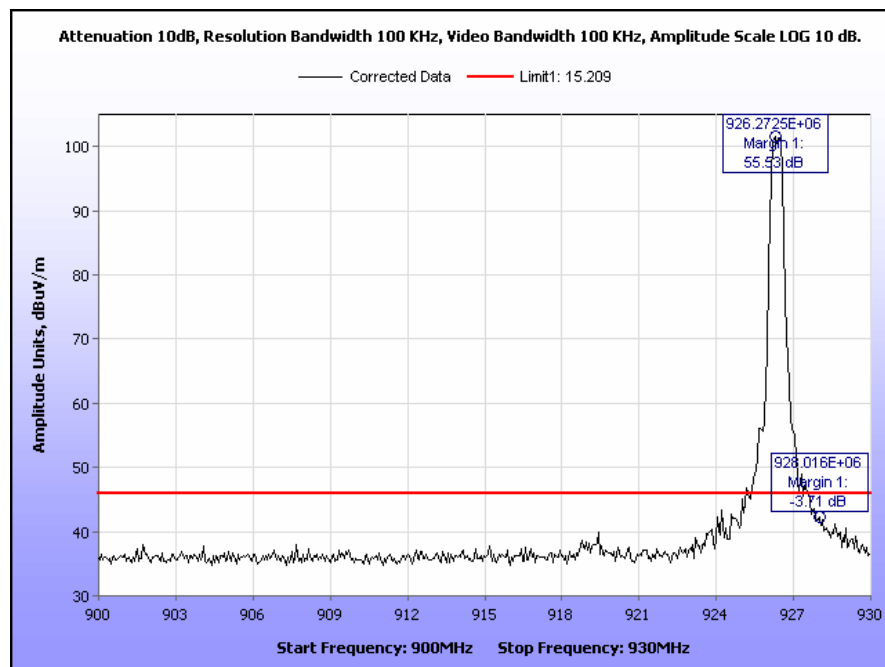


Plot 29. Radiated Spurious Emissions, High Channel, 1 GHz – 10 GHz, Average

Radiated Spurious Emissions Band Edge

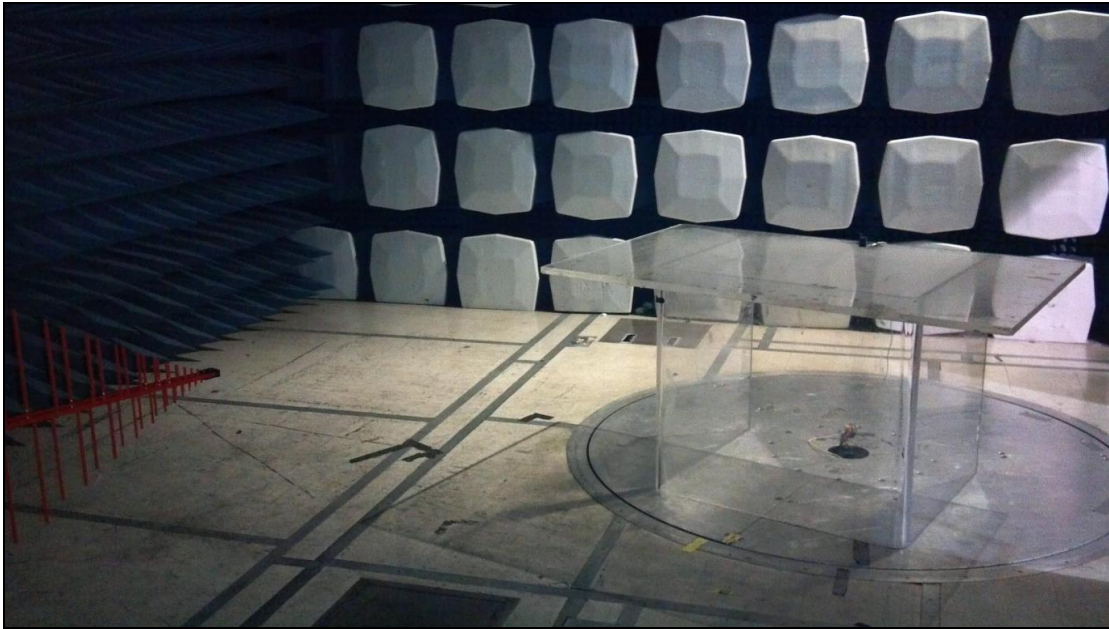


Plot 30. Band Edge, Low Channel

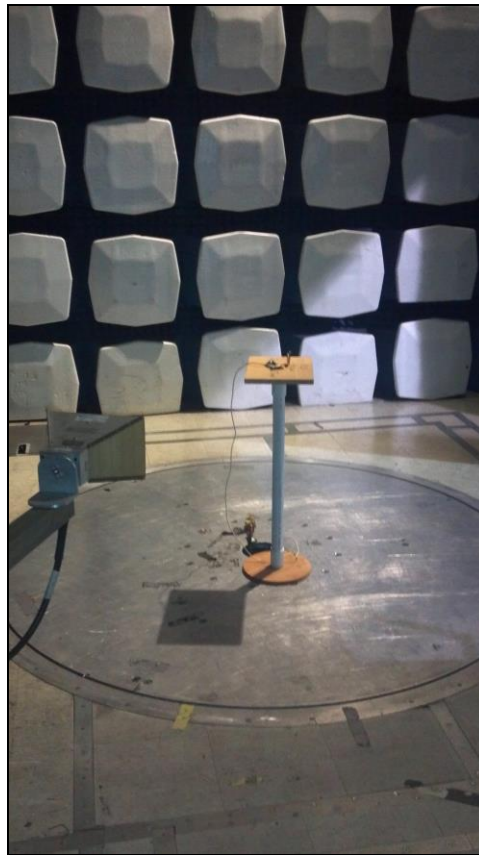


Plot 31. Band Edge, High Channel

Radiated Spurious Emissions Test Setup



Photograph 3. Radiated Spurious Emissions, Test Setup, 30 MHz – 1 GHz



Photograph 4. Radiated Spurious Emissions, Test Setup, 1 GHz – 10 GHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(i) Maximum Permissible Exposure

RF Exposure Requirements: §1.1307(b)(1) and §1.1307(b)(2): Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: §1.1310: As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

MPE Limit Calculation: EUT's operating frequencies @ 902-928 MHz; highest conducted power = *6.84dBm* (peak) therefore, **Limit for Uncontrolled exposure: 0.6 mW/cm²**

EUT maximum antenna gain = *0 dBi*.

Equation from page 18 of OET 65, Edition 97-01

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density (1 mW/cm²)
P = Power Input to antenna (4.83mW)
G = Antenna Gain (1.26 numeric)

$$R = (4.83 * 1.26 / 4 * 3.14 * 1.0)^{1/2} = (6.09 / 12.56)^{1/2} = 0.696 \text{ cm}$$

Electromagnetic Compatibility Criteria for Intentional Radiators

RSS-GEN Receiver Spurious Emissions Requirements

Test Requirements: The following receiver spurious emission limits shall be complied with:

- (a) If a radiated measurement is made, all spurious emissions shall comply with the limits of Table 16.

Spurious Frequency (MHz)	Field Strength (microvolt/m at 3 metres)
30 – 88	100
88 – 216	150
216 – 960	200
Above 960	500

Table 16. Spurious Emission Limits for Receivers

- (b) If a conducted measurement is made, no spurious output signals appearing at the antenna terminals shall exceed 2 nanowatts per any 4 kHz spurious frequency in the band 30-1000 MHz, or 5 nanowatts above 1 GHz.

Test Results: Equipment is not applicable with the Receiver Spurious Emissions Requirements of RSS-GEN. Receiver Spurious Emissions is not applicable, as it applies to devices that are exclusively receivers.

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

MET Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1T4300	SEMI-ANECHOIC CHAMBER # 1 (NSA)	EMC TEST SYSTEMS	NONE	07/24/2012	01/24/2014
1T4409	EMI RECEIVER	ROHDE & SCHWARZ	ESIB7	07/16/2012	07/16/2013
1T4751	ANTENNA - BILOG	SUNOL SCIENCES	JB6	01/08/2013	07/08/2014
1T2665	ANTENNA; HORN	EMCO	3115	09/05/2012	03/05/2014
1T4771	PSA SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4446A	02/15/2013	08/15/2014
1T4786	HYGROMETER / THERMOMETER / BAROMETER / DEW POINT PEN	CONTROL COMPANY	15-078-198, FB70423, 245CD	02/01/2012	02/01/2014

Table 17. Test Equipment List

V. Certification & User's Manual Information

Certification & User's Manual Information

A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

- (a) The various types of radio communication transmitting devices described throughout this chapter.
- (b) *The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*
- (c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.
- (d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

- (a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:
 - (1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or
 - (2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.
- (d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

- (e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:
- (i) *Compliance testing*;
 - (ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or
 - (v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.
- (e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.
- (f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

- (a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.¹ *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.*
- (b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

- (a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.
- (b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

¹ In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

- (a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.
 - (1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.
 - (i) *If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*
 - (ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.
 - (2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

Certification & User's Manual Information

1. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) *In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

- (1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- (2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

- (3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- (4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.
- (5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

- (a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

- (b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

ICES-003 Procedural & Labeling Requirements

From the Industry Canada Electromagnetic Compatibility Advisory Bulletin entitled, "Implementation and Interpretation of the Interference-Causing Equipment Standard for Digital Apparatus, ICES-003" (EMCAB-3, Issue 2, July 1995):

"At present, CISPR 22: 2002 and ICES technical requirements are essentially equivalent. Therefore, if you have CISPR 22: 2002 approval by meeting CISPR Publication 22, the only additional requirements are: to attach a note to the report of the test results for compliance, indicating that these results are deemed satisfactory evidence of compliance with ICES-003 of the Canadian Interference-Causing Equipment Regulations; to maintain these records on file for the requisite five year period; and to provide the device with a notice of compliance in accordance with ICES-003."

Procedural Requirements:

According to Industry Canada's Interference Causing Equipment Standard for Digital Apparatus ICES-003 Issue 4, February 2004:

- Section 6.1: A record of the measurements and results, showing the date that the measurements were completed, shall be retained by the manufacturer or importer for a period of at least five years from the date shown in the record and made available for examination on the request of the Minister.
- Section 6.2: A written notice indicating compliance must accompany each unit of digital apparatus to the end user. The notice shall be in the form of a label that is affixed to the apparatus. Where because of insufficient space or other constraints it is not feasible to affix a label to the apparatus, the notice may be in the form of a statement in the user's manual.

Labeling Requirements:

The suggested text for the notice, in English and in French, is provided below, from the Annex of ICES-003:

This Class [²] digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe [¹] est conforme à la norme NMB-003 du Canada.

² Insert either A or B but not both as appropriate for the equipment requirements.

End of Report