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May 13, 2015

Autonet Mobile
1700 Montgomery Suite 111
San Francisco, CA 94111

Dear Doug Moeller,

Enclosed is the EMC Wireless test report for compliance testing of the Autonet Mobile, Kanaan4 as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15, Subpart B for a Class B Digital Device and FCC Part 15 Subpart C 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: (\Autonet Mobile\EMCS42581A-FCC247 Rev. 1)

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Electromagnetic Compatibility Criteria
Test Report

for the

Autonet Mobile
Kanaan4

Tested under
the FCC Certification Rules
contained in
Title 47 of the CFR, Parts 15 Subpart B
for Class B Digital Devices
&
15.247 Subpart C for Intentional Radiators

MET Report: EMCS42581A-FCC247 Rev. 1

May 13, 2015

Prepared For:

Autonet Mobile
1700 Montgomery Suite 111
San Francisco, CA 94111

Prepared By:
MET Laboratories, Inc.
3162 Belick St.
Santa Clara, CA 95054

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Tested under
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Title 47 of the CFR, Parts 15 Subpart B
for Class B Digital Devices
&
15.247 Subpart C for Intentional Radiators

Ajaz Khan, 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 under normal use and maintenance.

Asad Bajwa,
Director, Electromagnetic Compatibility Lab

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Report Status Sheet

Revision	Report Date	Reason for Revision
∅	April 29, 2015	Initial Issue.
1	May 13, 2015	Engineer corrections.

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

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I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Autonet Mobile Kanaan4, 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 Kanaan4. Autonet Mobile should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Kanaan4, 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 Autonet Mobile, purchase order number 739. All tests were conducted using measurement procedure ANSI C63.4-2003.

FCC Reference 47 CFR Part 15.247:2005	Description	Compliance
47 CFR Part 15.107 (a)	Conducted Emission Limits for a Class B Digital Device	Not Applicable – The unit is DC powered.
47 CFR Part 15.109 (a)	Radiated Emission Limits for a Class B Digital Device	Compliant
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	Not Applicable – The unit is DC powered.
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RF Conducted Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RF Conducted Band Edge	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	Maximum Permissible Exposure (MPE)	Compliant

Table 1. Executive Summary of EMC Part 15.247 ComplianceTesting

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II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by Autonet Mobile to perform testing on the Kanaan4, under Autonet Mobile's purchase order number 739.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Autonet Mobile, Kanaan4.

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

Model(s) Tested:	Kanaan4	
Model(s) Covered:	Kanaan4	
EUT Specifications:	Primary Power: 12 VDC, 50 Hz	
	FCC ID: VOI-ANMKNN4RTR-01	
	Type of Modulations:	OFDM
	Equipment Code:	DTS
	Peak RF Output Power:	15.69dBm
	EUT Frequency Ranges:	2412 – 2462 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Ajaz Khan	
Report Date(s):	May 13, 2015	

Table 2. EUT Summary Table

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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
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
ANSI/NCSL Z540-1-1994	Calibration Laboratories and Measuring and Test Equipment - General Requirements
ANSI/ISO/IEC 17025:2000	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., 3162 Belick St., Santa Clara, CA 95054. 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 5 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.

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D. Description of Test Sample

The Autonet Mobile Kanaan4, Equipment Under Test (EUT), is as follows:

Telematics Control Unit (TCU) for cars which provides connectivity for embedded applications in the head unit or standalone applications that can be accessed from a smartphone with desktop.

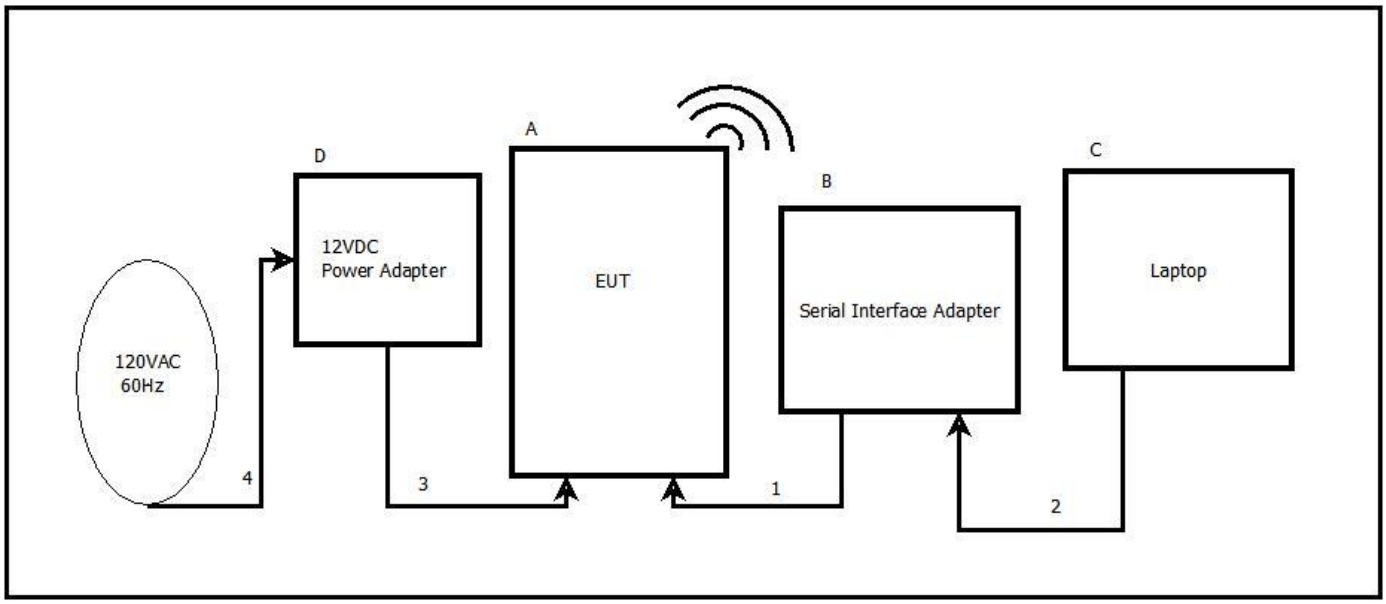

Figure 1. Block Diagram of Test Configuration

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
1	802.11b/g and Bluetooth Access Point	Kanaan	--

Table 4. Equipment Configuration

F. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Length (m)	Shielded (Y/N)	Termination Point
1	Data	wiring harness	1	--	--	--
2	12 VDC Power input	DC Power Cable	1	1.5	No	120VAC 60Hz

Table 5. Ports and Cabling Information

G. Mode of Operation

2 AC power connectors simulate battery power and ignition power. When ignition power is applied the unit will turn on. Battery power should be applied all of the time.

H. Monitoring Method

1. A Wifi hotspot named autonet-XXXX is visible (where XXXX is the last 4 digits of the serial number).
2. WiFi hotspot is not visible.

I. 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.

J. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Autonet Mobile upon completion of testing.

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III. Electromagnetic Compatibility Criteria for Unintentional Radiators

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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 6. 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 6. 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 6, as measured using a 50 µH/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 (dBµV)		*Class B Conducted Limits (dBµV)	
	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 6. 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 unit is DC powered.

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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 7.

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 7.

Frequency (MHz)	Field Strength (dBµV/m)	
	§15.109 (b), Class A Limit (dBµV) @ 10m	§15.109 (a),Class B Limit (dBµV) @ 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 7. 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 inside a semi-anechoic chamber. The method of testing and test conditions of ANSI C63.4 were used. An antenna was located 3m 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): Dan Phan

Test Date(s): 02/03/15

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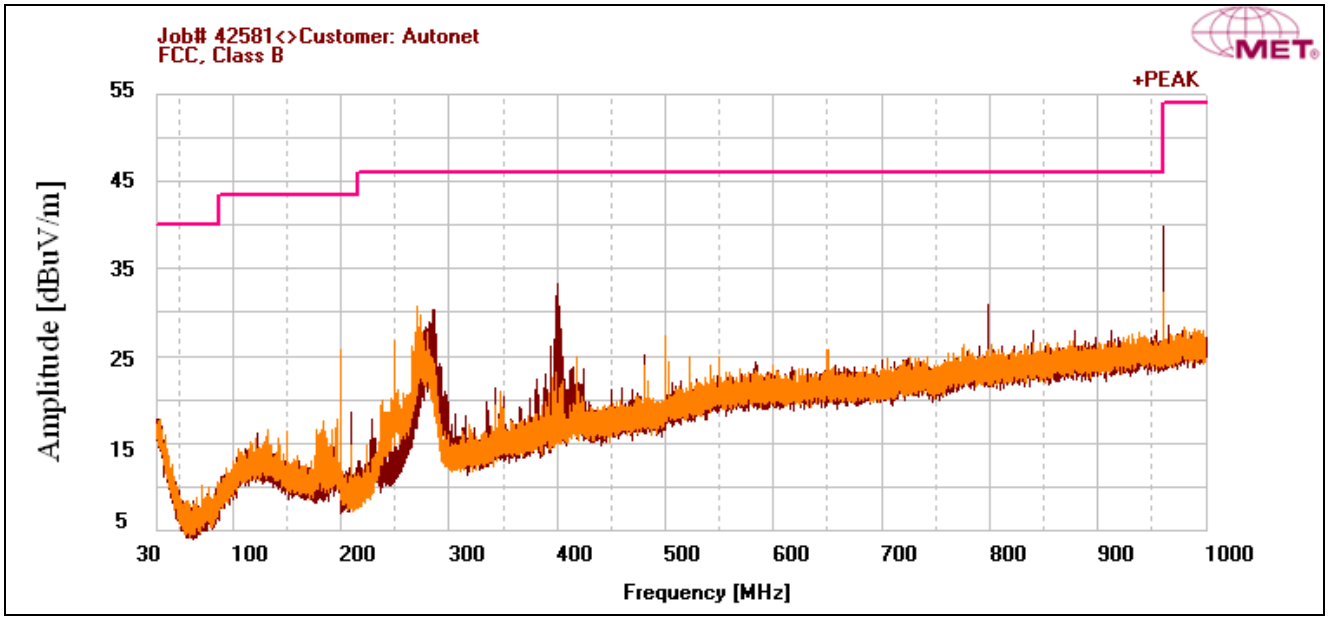
Radiated Emissions Limits Test Results, Class B

Frequency (MHz)	Antenna Polarity	EUT Azimuth (Degrees)	Antenna Height (cm)	Uncorrected Amplitude (dBµV)	ACF (dB/m)	Pre Amp Gain (dB)	CBL (dB)	DCF (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)
270.701	V	137	100	9.21	12.596	0	2.992	0	24.798	46	-21.202
284.457	H	109	100	11.5	12.774	0	3.063	0	27.337	46	-18.663
400.936	H	305	100	2.9	15.6	0	3.613	0	22.113	46	-23.887
960.014	H	111	100	14.26	20.841	0	5.677	0	40.778	54	-13.222
798.014	H	91	100	6.39	19.706	0	5.174	0	31.27	46	-14.73
249.99	V	198	100	18.53	12.079	0	2.884	0	33.493	46	-12.507

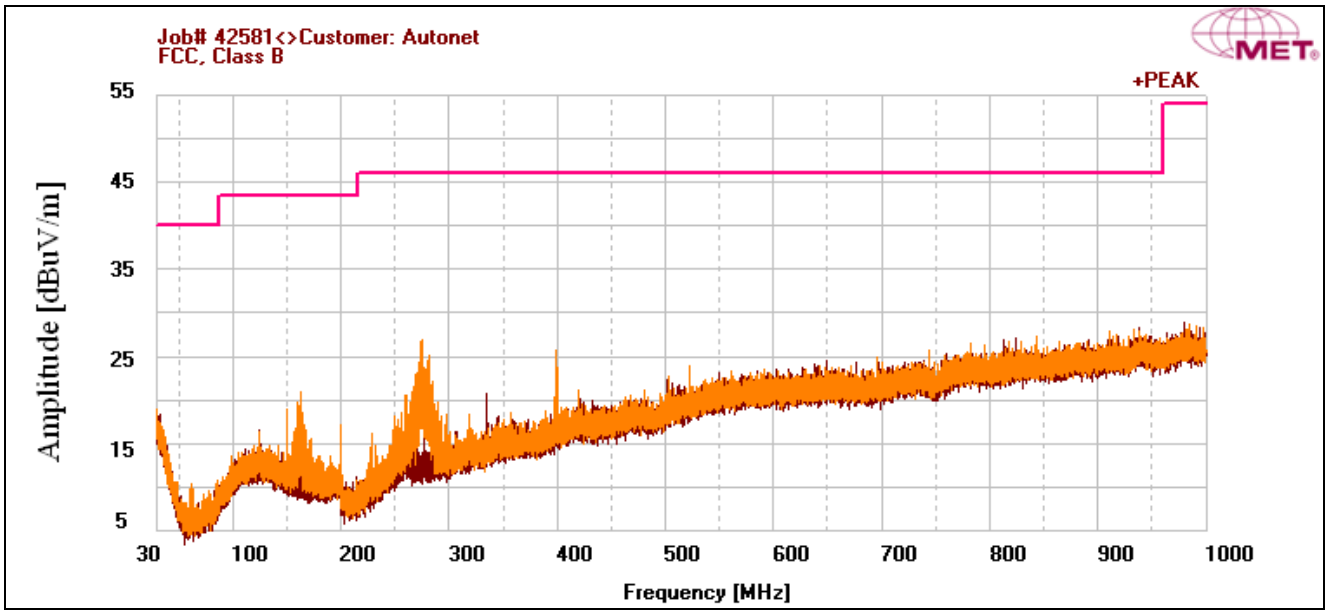
Table 8. Radiated Emissions Limits, Test Results, 30 MHz – 1 GHz, Active Mode



Plot 1. Radiated Emissions, 30 MHz - 1 GHz, Active Mode

Frequency (MHz)	Antenna Polarity	EUT Azimuth (Degrees)	Antenna Height (cm)	Uncorrected Amplitude (dBµV)	ACF (dB/m)	Pre Amp Gain (dB)	CBL (dB)	DCF (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)
154.811	V	360	100	-5.06	10.569	0	2.226	0	7.735	43.5	-35.765
199.94	V	360	100	-4.58	9.327	0	2.512	0	7.259	43.5	-36.241
274.988	V	360	100	-6.58	12.695	0	3.014	0	9.129	46	-36.871
335.17	H	87	100	1.59	13.774	0	3.302	0	18.666	46	-27.334
396.593	V	0	100	-6.29	15.448	0	3.594	0	12.752	46	-33.248
519.478	V	0	100	-5.22	17.322	0	4.113	0	16.215	46	-29.785

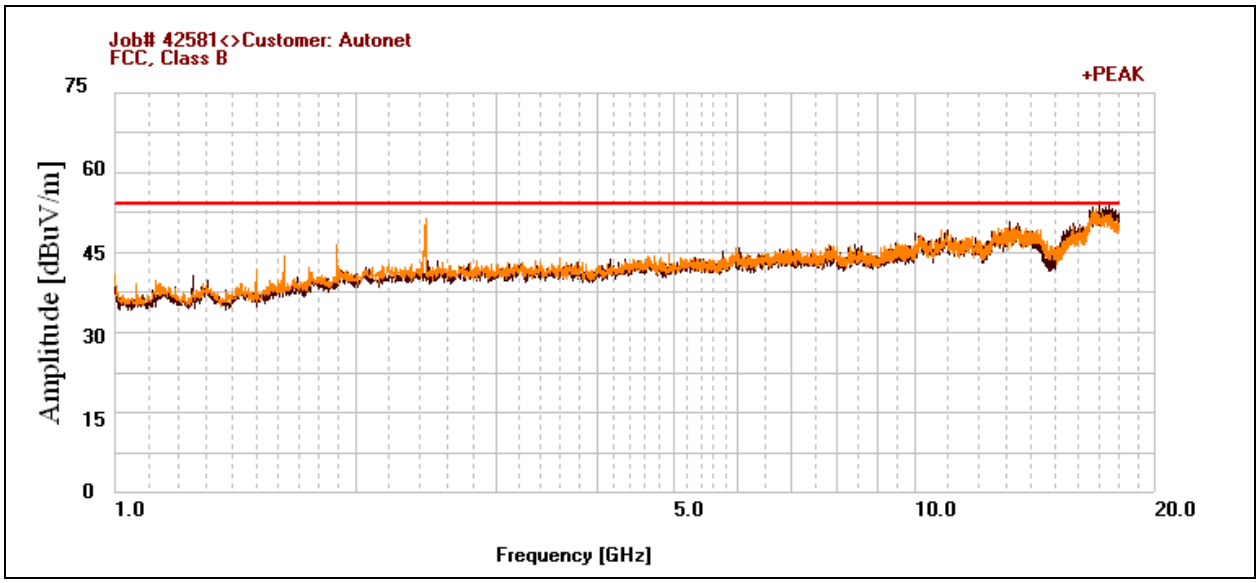
Table 9. Radiated Emissions Limits, Test Results, 30 MHz – 1 GHz, Standby Mode



Plot 2. Radiated Emissions, 30 MHz - 1 GHz, Standby Mode

Frequency (MHz)	Antenna Polarity	EUT Azimuth (Degrees)	Antenna Height (cm)	Uncorrected Amplitude (dBµV)	ACF (dB/m)	Pre Amp Gain (dB)	CBL (dB)	DCF (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)
16763.33	H	0	100	26.43	42.4	28.341	0	0	40.489	54	-13.511
17545.833	H	0	100	26.06	42.1	27.766	0	0	40.394	54	-13.606
2413.333	V	0	100	32.35	32.596	34.023	0	0	30.923	54	-23.077
1626.667	V	360	100	31.09	29.213	33.287	0	0	27.016	54	-26.984
1500	V	360	100	41.79	28.2	33.34	0	0	36.65	54	-17.35
1925	V	360	100	30.6	31.18	33.162	0	0	28.618	54	-25.382

Table 10. Radiated Emissions Limits, Test Results, 1 GHz – 18 GHz, Standby Mode



Plot 3. Radiated Emissions, 1 GHz – 18 GHz, Standby Mode

Radiated Emission Limits Test Setup

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

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IV. Electromagnetic Compatibility Criteria for Intentional Radiators

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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. The EUT has an integral antenna.

Test Engineer(s): Ajaz Khan

Test Date(s): 02/02/15

Gain	Type	Manufacturer
1.88dBi	Ceramic Chip	Autonet

Table 11. Antenna List

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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 μH/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 (dBμV)	
	Quasi-Peak	Average
* 0.15- 0.45	66 - 56	56 - 46
0.45 - 0.5	56	46
0.5 - 30	60	50

Table 12. 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 powered by 12 VDC from car battery.

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** 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. The minimum 6dB bandwidth shall be at least 500 kHz.

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately 1% of the total emission bandwidth, VBW > RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

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

The 6 dB Bandwidth was determined from the plots on the following pages.

Test Engineer(s): Ajaz Khan

Test Date(s): 02/03/15

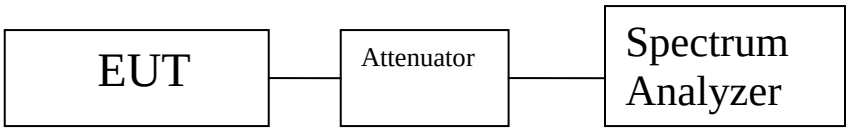

Figure 2. Block Diagram, Occupied Bandwidth Test Setup

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Occupied Bandwidth Test Results

Occupied Bandwidth			
Mode	**Carrier Channel**	**Frequency (MHz)**	**Measured 6 dB Bandwidth (MHz)**
802.11b	Low	2412	10.208
	Mid	2437	11.597
	High	2462	10.842
802.11g	Low	2412	15.368
	Mid	2437	16.521
	High	2462	16.526

Table 13. 6 dB Occupied Bandwidth, Test Results

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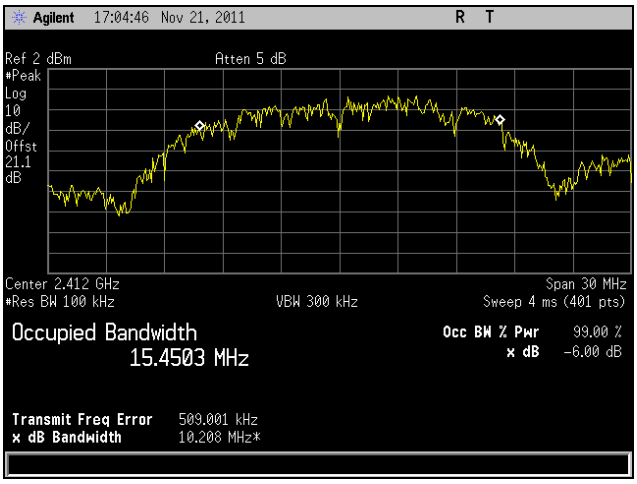
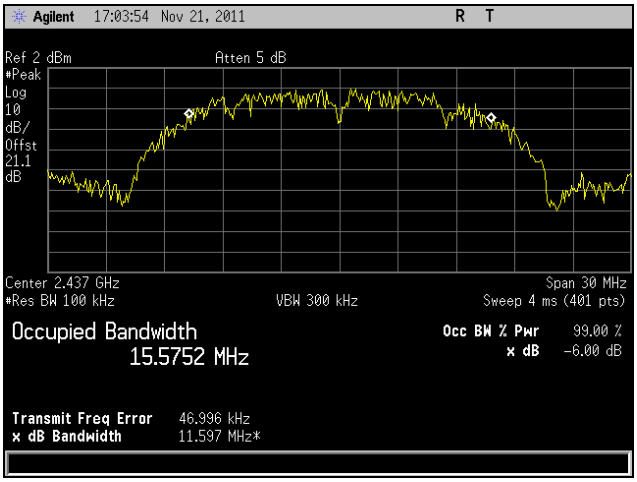
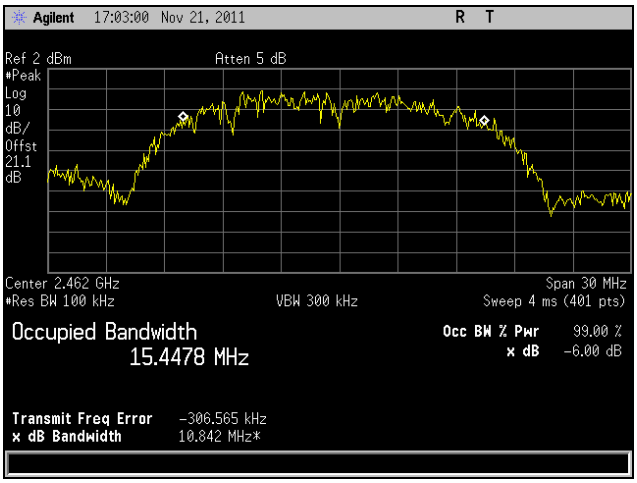
Occupied Bandwidth Test Results, 802.11b



Plot 4. 6 dB Occupied Bandwidth, Low Channel, 802.11b



Plot 5. 6 dB Occupied Bandwidth, Mid Channel, 802.11b



Plot 6. 6 dB Occupied Bandwidth, High Channel, 802.11b

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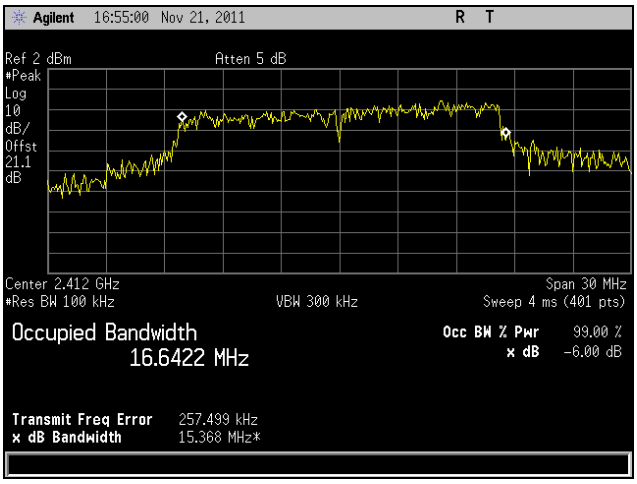
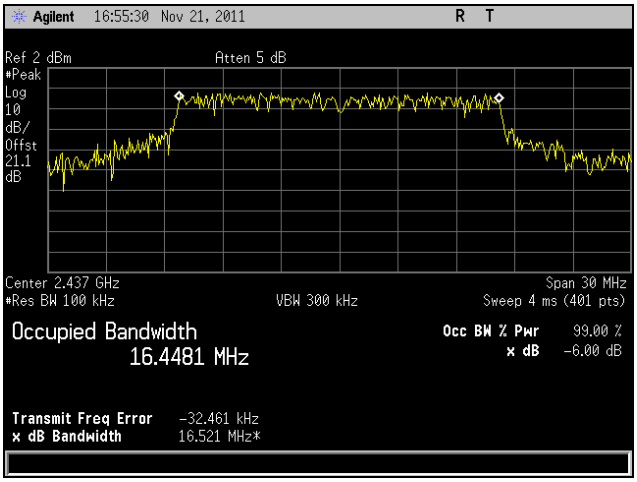
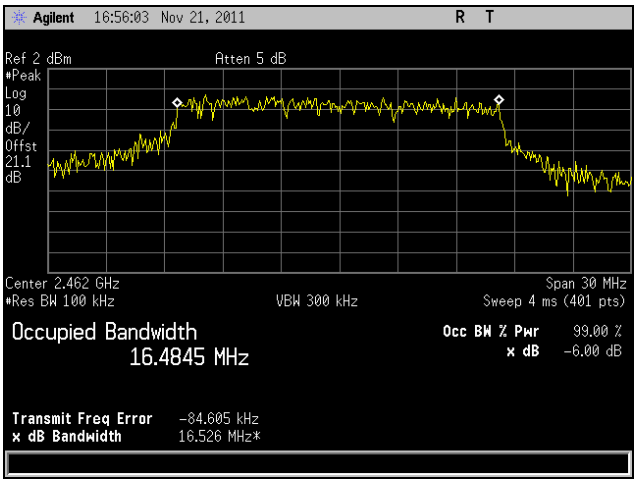
Occupied Bandwidth Test Results, 802.11g



Plot 7. 6 dB Occupied Bandwidth, Low Channel, 802.11g



Plot 8. 6 dB Occupied Bandwidth, Mid Channel, 802.11g



Plot 9. 6 dB Occupied Bandwidth, High Channel, 802.11g

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit (Watts)
902-928	1.000
2400–2483.5	1.000
5725– 5850	1.000

Table 14. Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the Table 14, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400 – 2483.5 MHz band and using a point to point application may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Fixed, point-to-point operation excludes the use of point-to-multipoint systems, Omni-directional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

Test Procedure: The transmitter was connected to a calibrated spectrum analyzer. The EUT was measured at the low, mid and high channels of each band at the maximum power level.

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

Test Engineer(s): Ajaz Khan

Test Date(s): 02/02/15

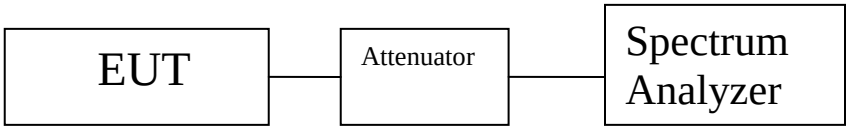


Figure 3. Peak Power Output Test Setup

Peak Power Output Test Results

Peak Conducted Output Power		
Carrier Channel	**Frequency (MHz)**	**Measured Peak Output Power dBm**
Low	2412	4.55
Mid	2437	9.82
High	2462	8.15

Table 15. Peak Power Output, Test Results, 802.11b

Peak Conducted Output Power		
Carrier Channel	**Frequency (MHz)**	**Measured Peak Output Power dBm**
Low	2412	10.38
Mid	2437	15.69
High	2462	14.24

Table 16. Peak Power Output, Test Results, 802.11g

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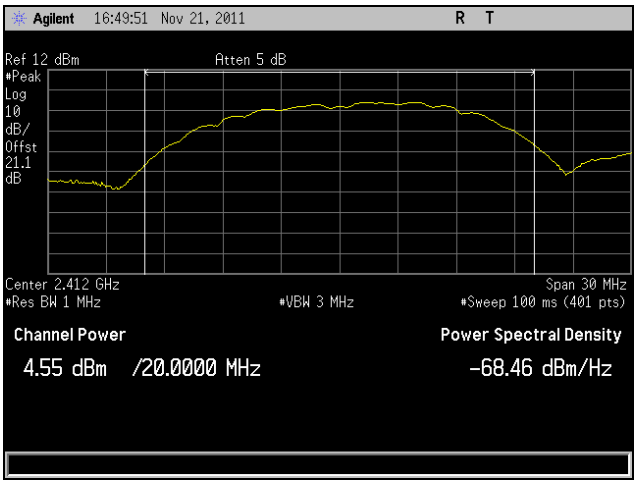
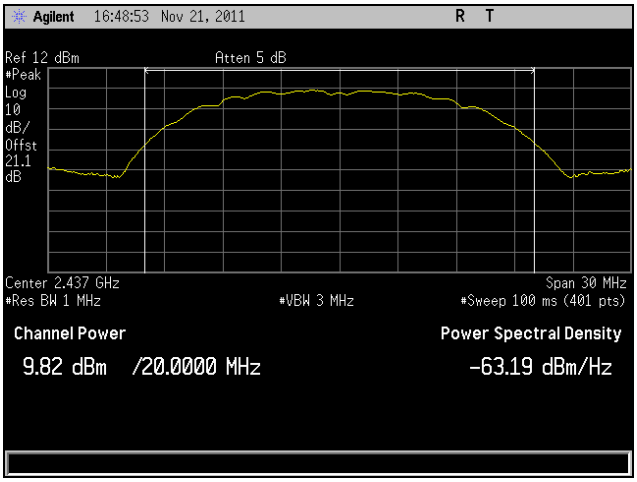
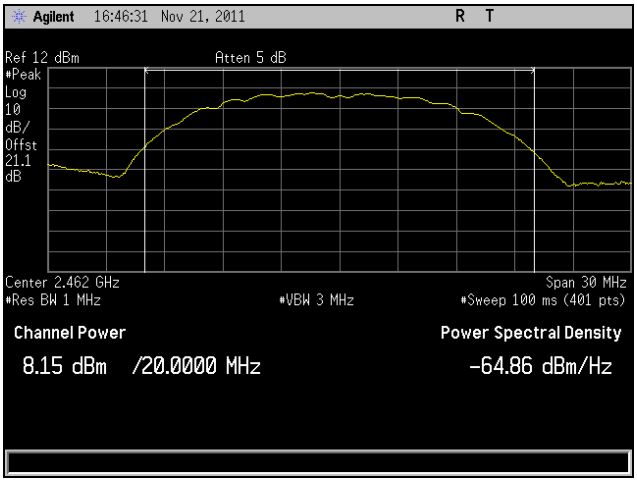
Peak Power Output Test Results, 802.11b



Plot 10. Peak Power Output, Low Channel, 802.11b

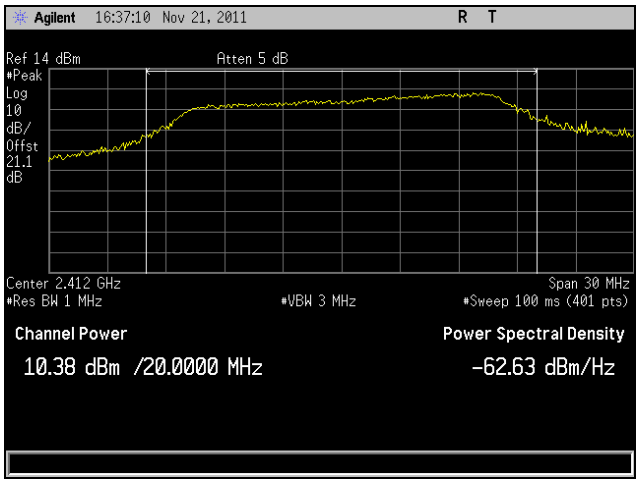


Plot 11. Peak Power Output, Mid Channel, 802.11b

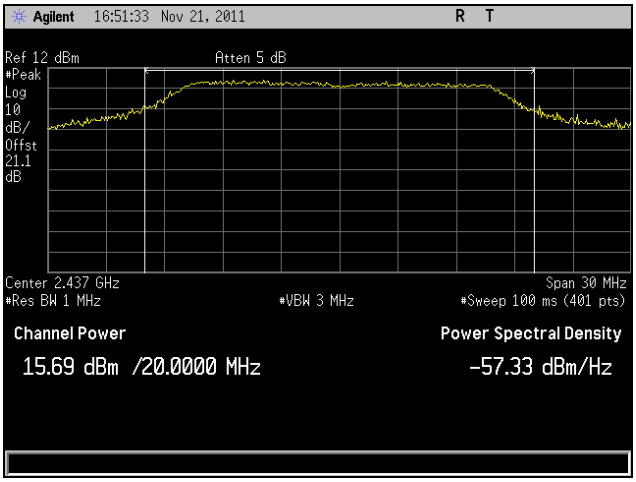


Plot 12. Peak Power Output, High Channel, 802.11b

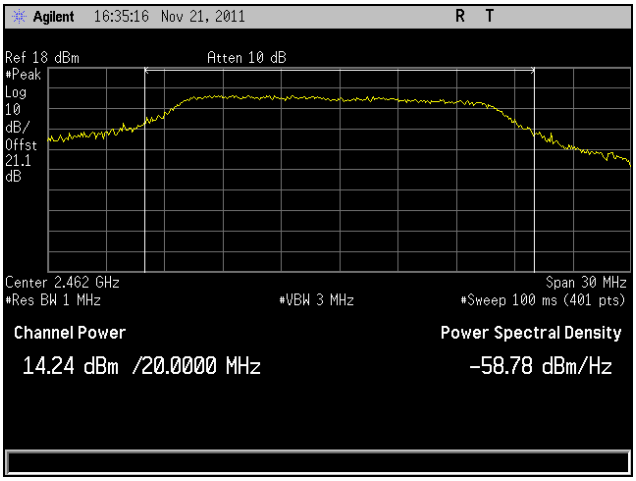
Peak Power Output Test Results, 802.11g



Plot 13. Peak Power Output, Low Channel, 802.11g



Plot 14. Peak Power Output, Mid Channel, 802.11g



Plot 15. Peak Power Output, High Channel, 802.11g

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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 17. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.
[2] Above 38.6

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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 18.

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

Table 18. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: 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. Only noise floor was measured above 18 GHz.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of **§ 15.247(d)**.

Test Engineer(s): Ajaz Khan

Test Date(s): 02/03/15

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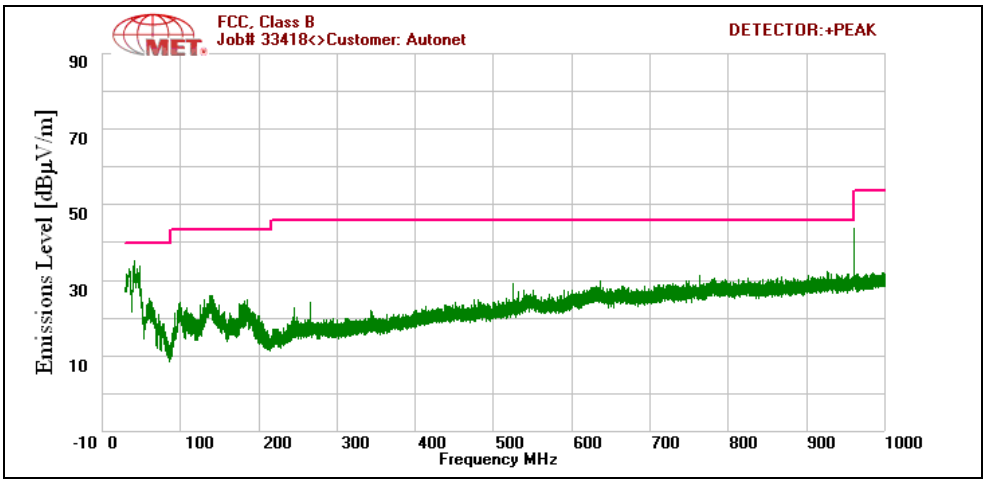
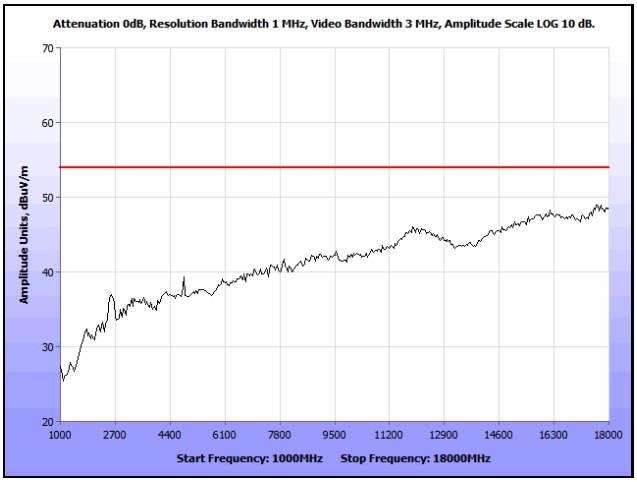
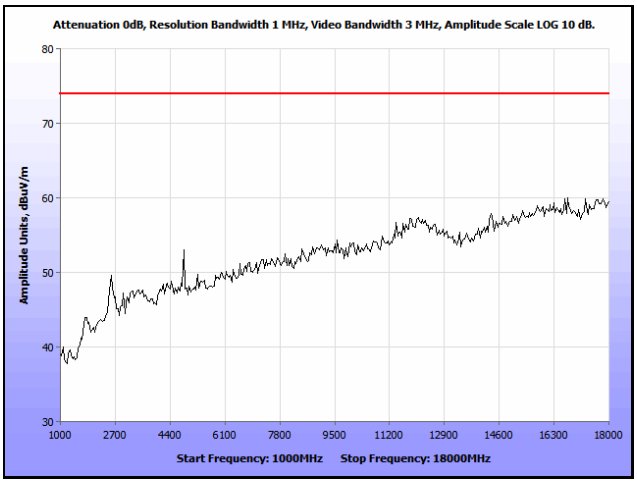
Radiated Spurious Emissions Test Results, 802.11b



Plot 16. Radiated Spurious Emissions, Low Channel, 802.11b, 30 MHz – 1 GHz



Plot 17. Radiated Spurious Emissions, Low Channel, 802.11b, 1 GHz – 18 GHz, Average



Plot 18. Radiated Spurious Emissions, Low Channel, 802.11b, 1 GHz – 18 GHz, Peak

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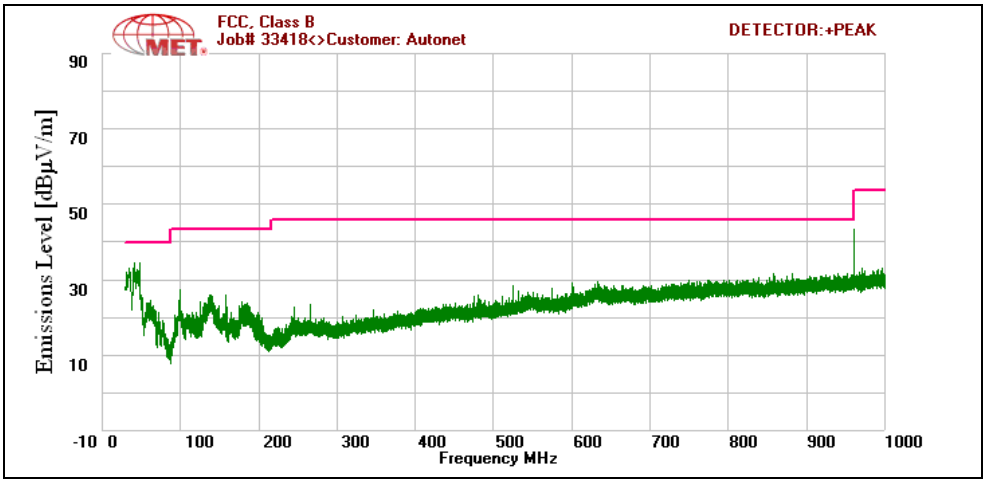
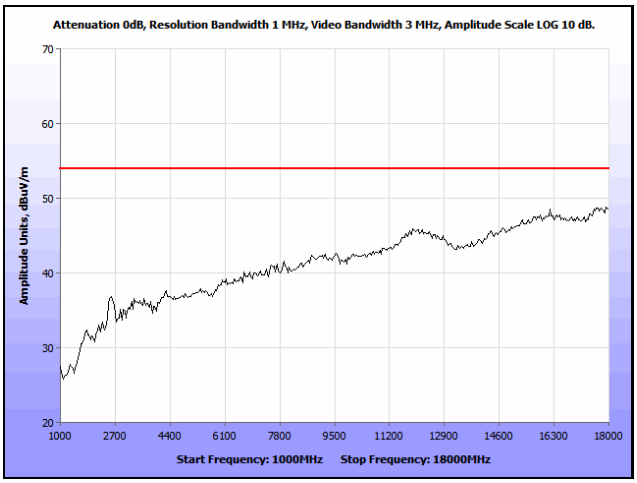
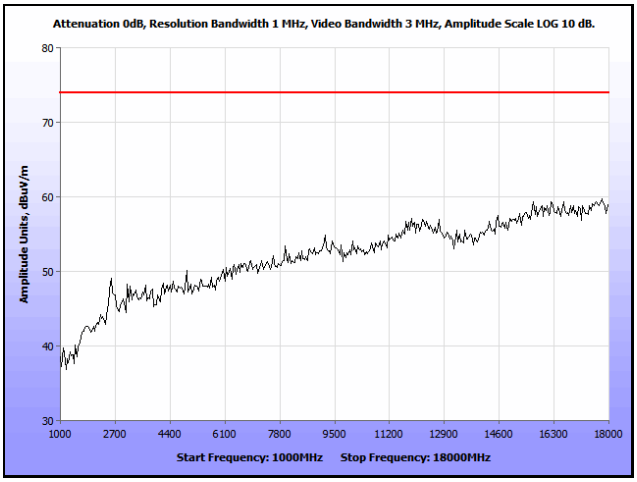


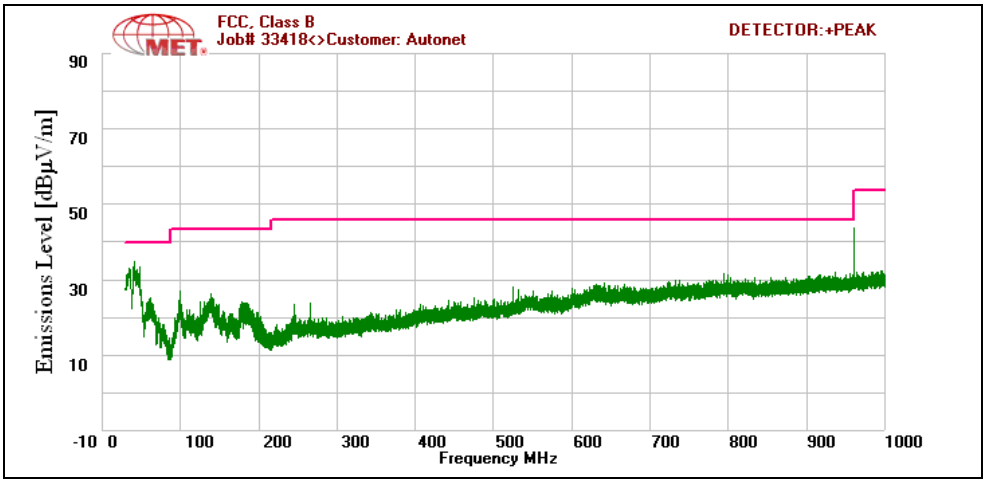
Plot 19. Radiated Spurious Emissions, Mid Channel, 802.11b, 30 MHz – 1 GHz



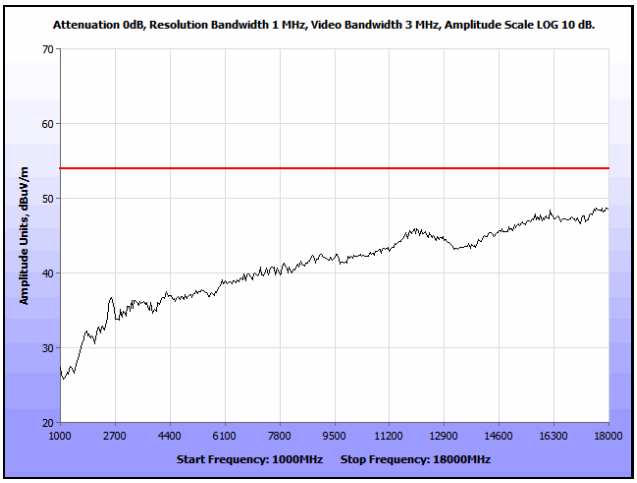
Plot 20. Radiated Spurious Emissions, Mid Channel, 802.11b, 1 GHz – 18 GHz, Average



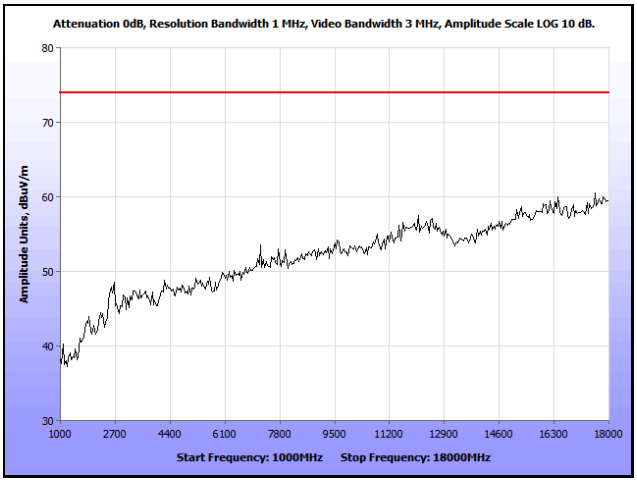
Plot 21. Radiated Spurious Emissions, Mid Channel, 802.11b, 1 GHz – 18 GHz, Peak



Plot 22. Radiated Spurious Emissions, High Channel, 802.11b, 30 MHz – 1 GHz



Plot 23. Radiated Spurious Emissions, High Channel, 802.11b, 1 GHz – 18 GHz, Average



Plot 24. Radiated Spurious Emissions, High Channel, 802.11b, 1 GHz – 18 GHz, Peak

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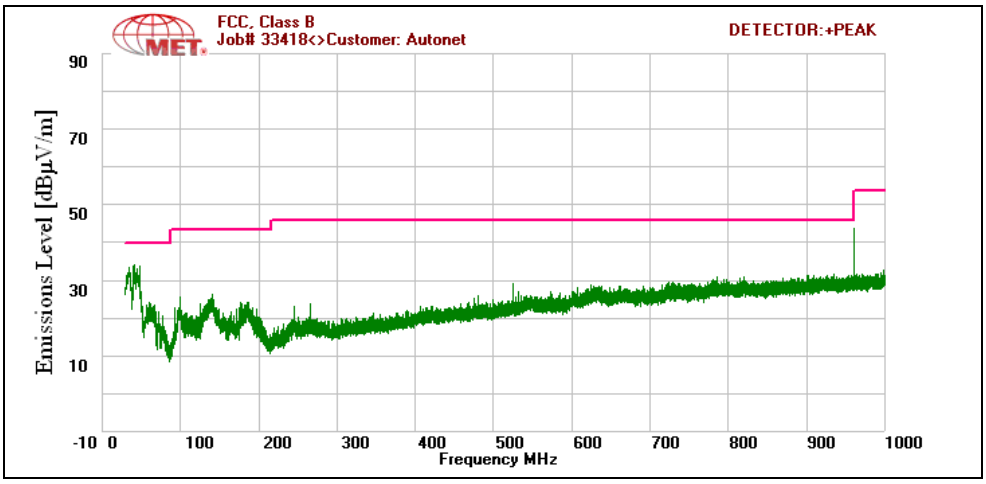
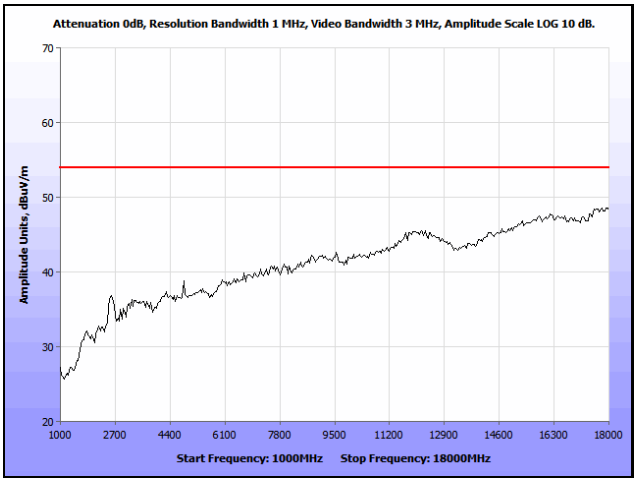
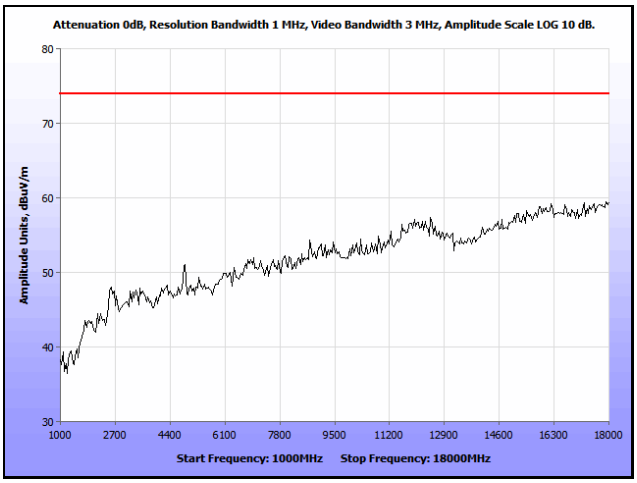
Radiated Spurious Emissions Test Results, 802.11g



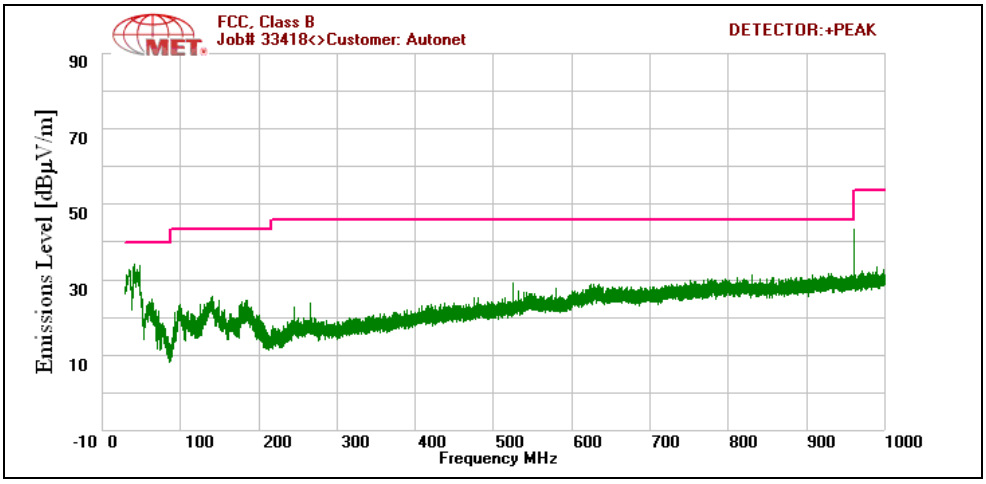
Plot 25. Radiated Spurious Emissions, Low Channel, 802.11g, 30 MHz – 1 GHz



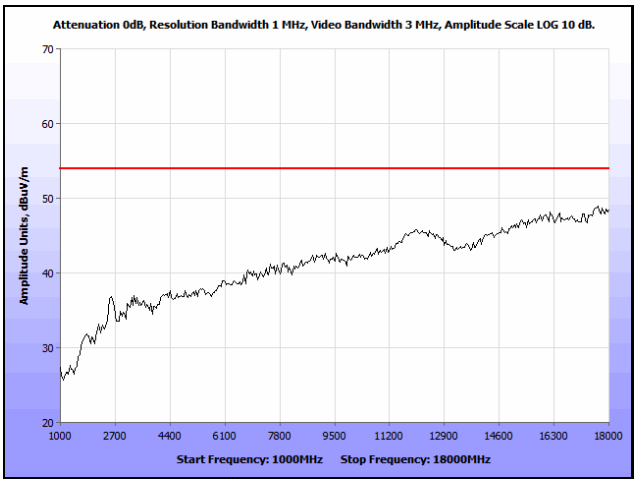
Plot 26. Radiated Spurious Emissions, Low Channel, 802.11g, 1 GHz – 18 GHz, Average



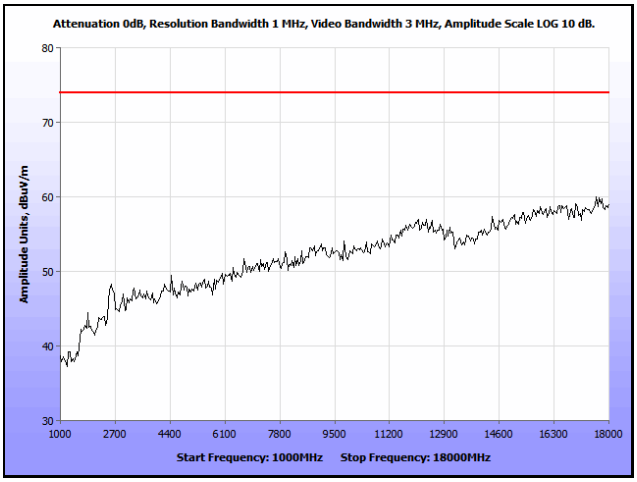
Plot 27. Radiated Spurious Emissions, Low Channel, 802.11g, 1 GHz – 18 GHz, Peak



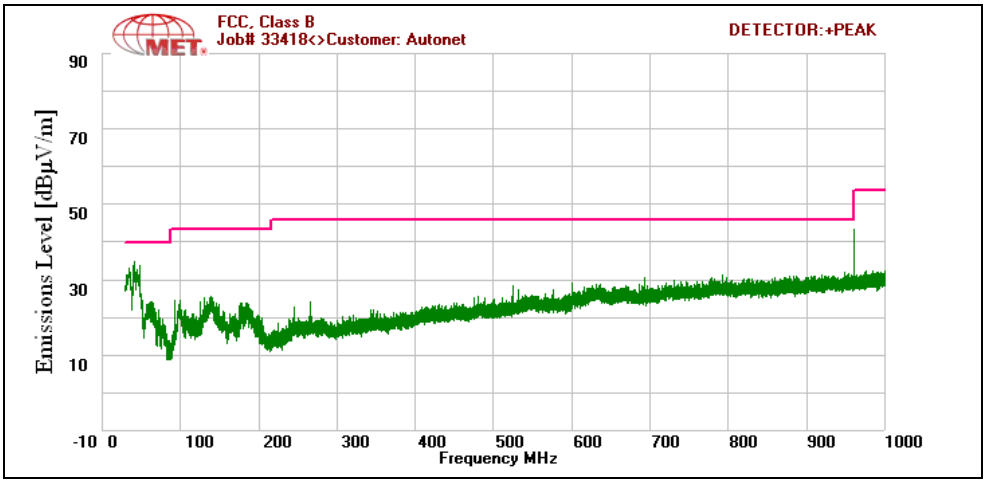
Plot 28. Radiated Spurious Emissions, Mid Channel, 802.11g, 30 MHz – 1 GHz



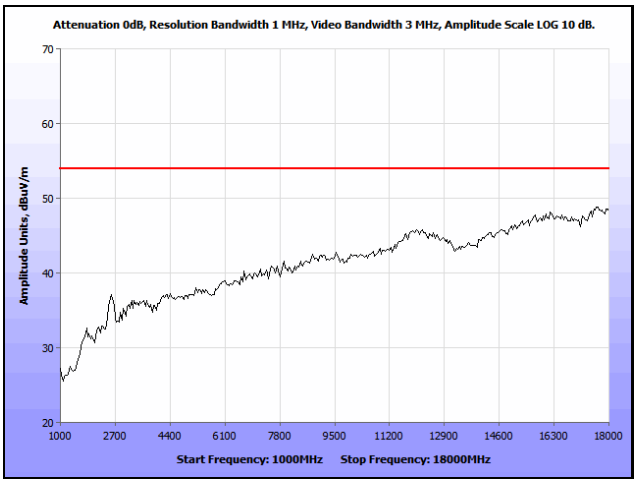
Plot 29. Radiated Spurious Emissions, Mid Channel, 802.11g, 1 GHz – 18 GHz, Average



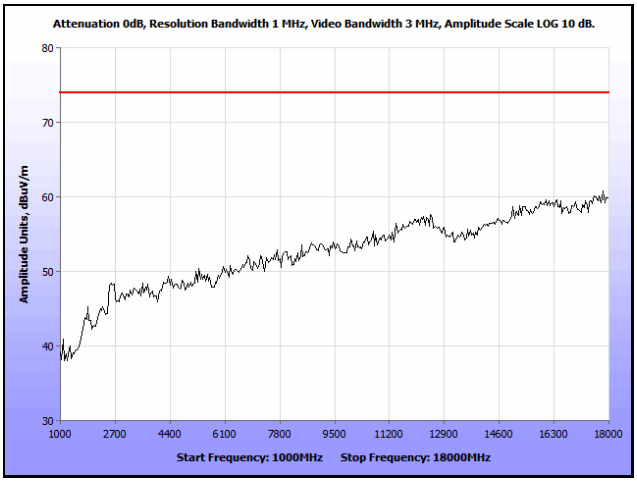
Plot 30. Radiated Spurious Emissions, Mid Channel, 802.11g, 1 GHz – 18 GHz, Peak



Plot 31. Radiated Spurious Emissions, High Channel, 802.11g, 30 MHz – 1 GHz



Plot 32. Radiated Spurious Emissions, High Channel, 802.11g, 1 GHz – 18 GHz, Average

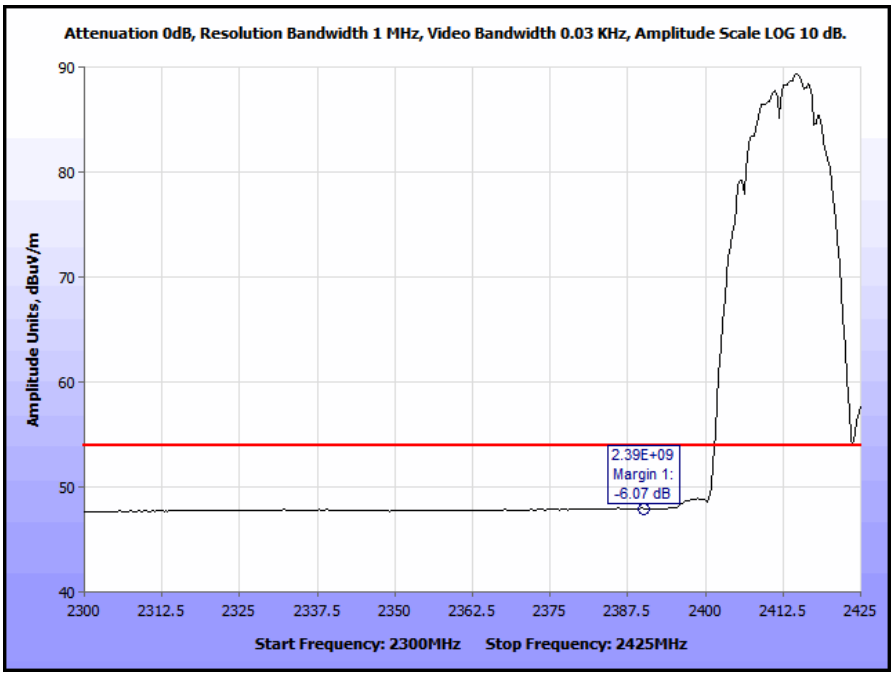


Plot 33. Radiated Spurious Emissions, High Channel, 802.11g, 1 GHz – 18 GHz, Peak

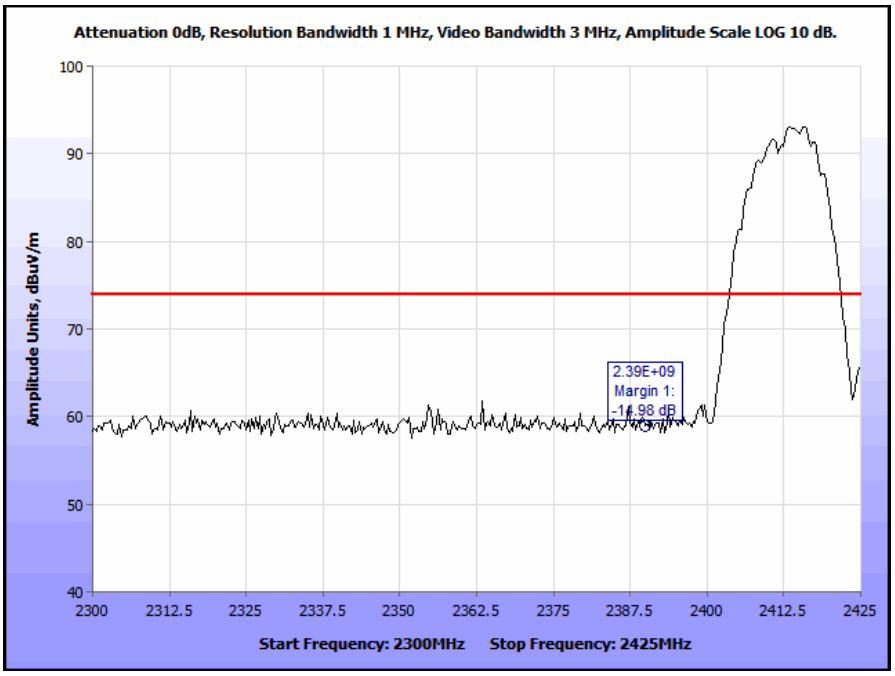
Radiated Band Edge Measurements

Test Procedures: The transmitter was turned on. Measurements were performed of the low 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.

Radiated Band Edge Measurements, 802.11b



Plot 34. Radiated Restricted Band Edge, Low Channel, 802.11b, Average



Plot 35. Radiated Restricted Band Edge, Low Channel, 802.11b, Peak

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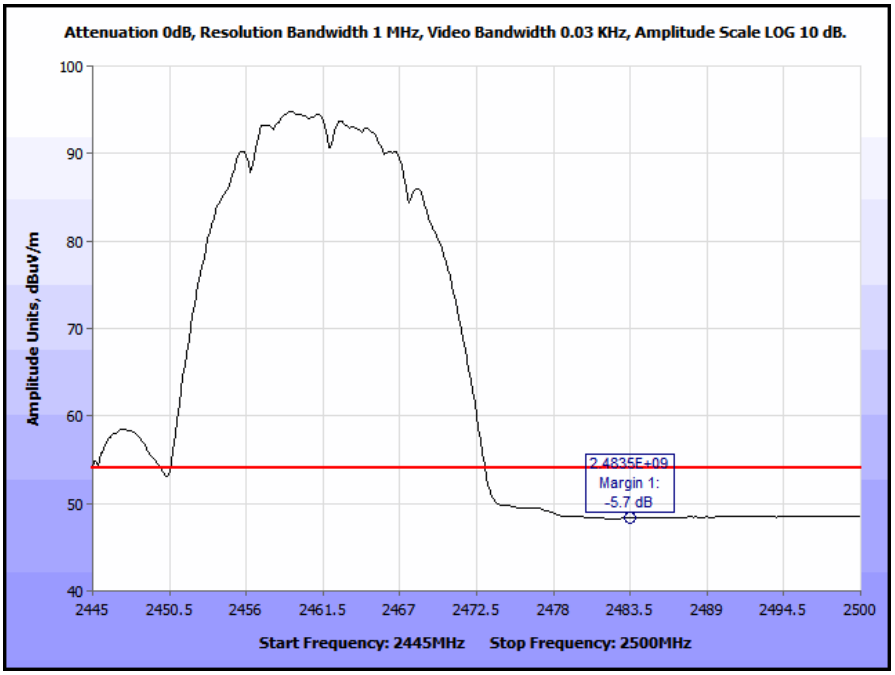
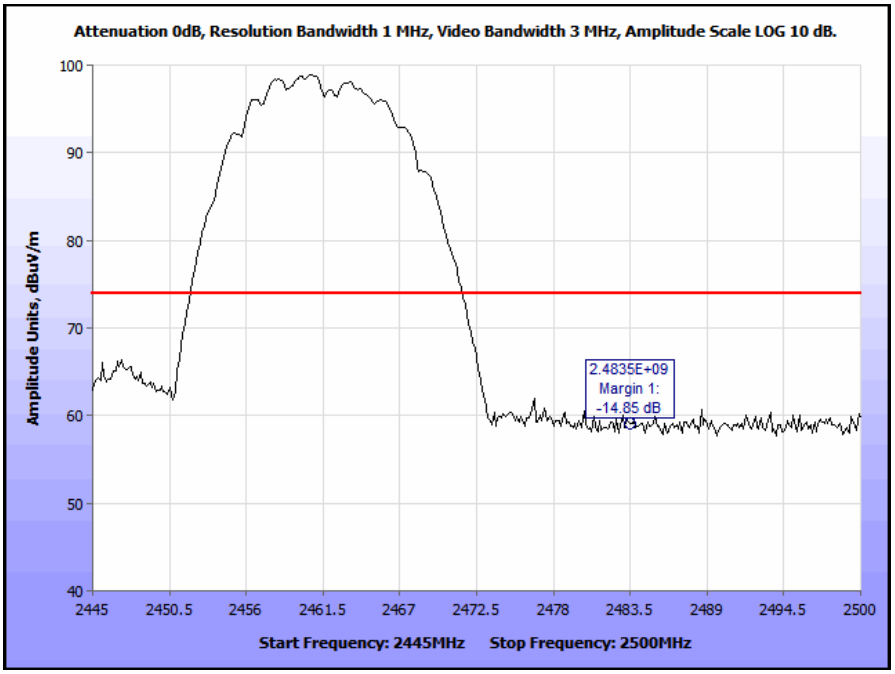


Plot 36. Radiated Restricted Band Edge, High Channel, 802.11b, Average



Plot 37. Radiated Restricted Band Edge, High Channel, 802.11b, Peak

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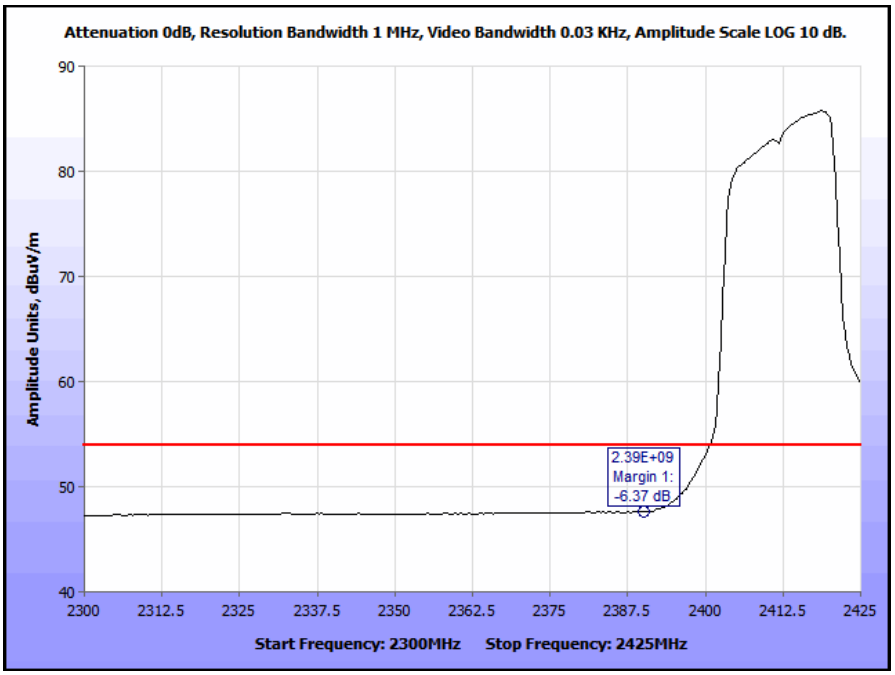
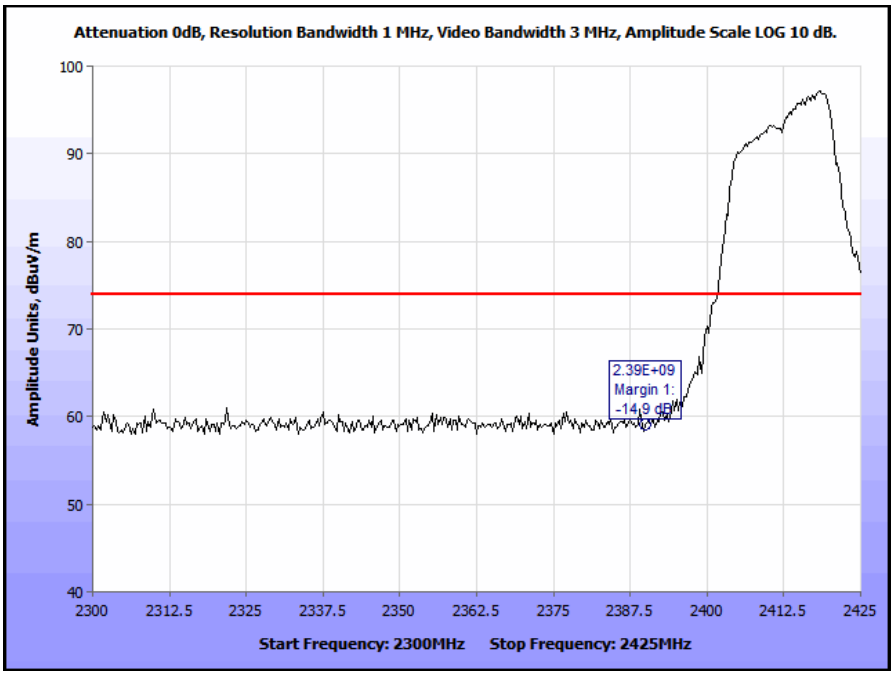
Radiated Band Edge Measurements, 802.11g



Plot 38. Radiated Restricted Band Edge, Low Channel, 802.11g, Average



Plot 39. Radiated Restricted Band Edge, Low Channel, 802.11g, Peak

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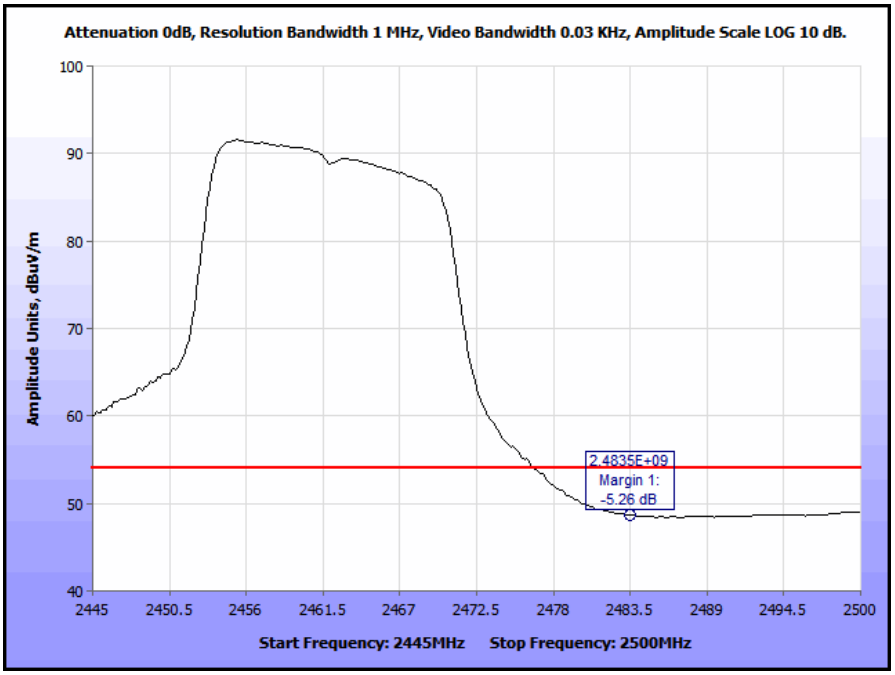
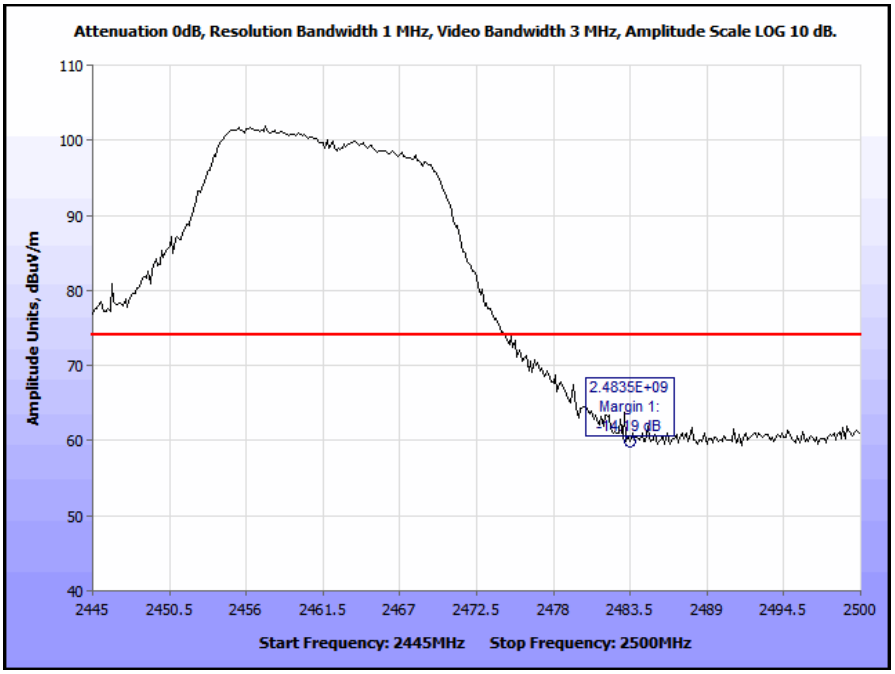


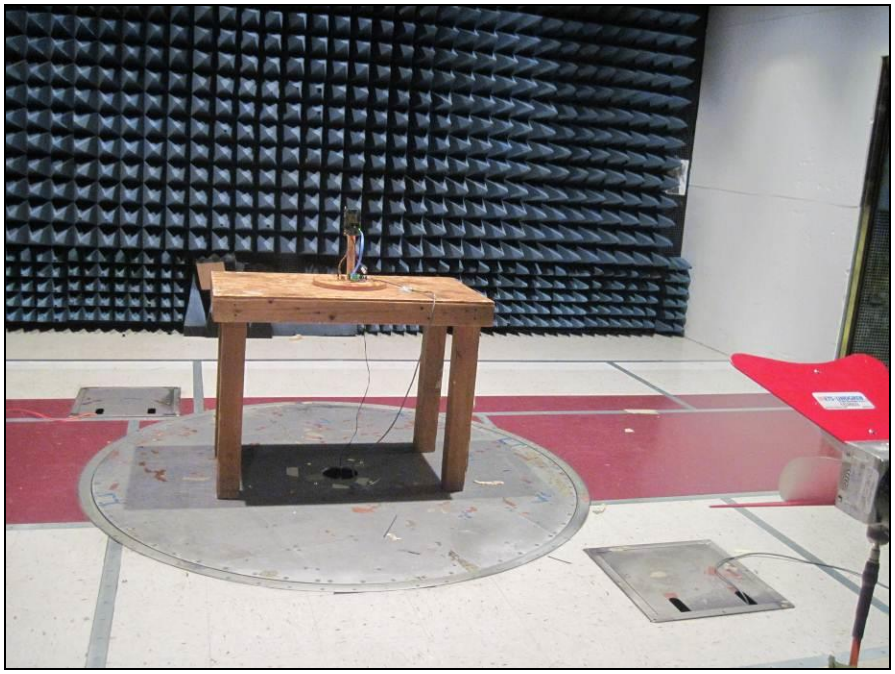
Plot 40. Radiated Restricted Band Edge, High Channel, 802.11g, Average



Plot 41. Radiated Restricted Band Edge, High Channel, 802.11g, Peak

Radiated Spurious Emissions Test Setup

Photograph 2. Radiated Spurious Emissions, 30 MHz – 18 GHz, Test Setup



Photograph 3. Radiated Spurious Emissions, 1 GHz – 18 GHz, Test Setup

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge

Test Requirement: **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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

See following pages for detailed test results with RF Conducted Spurious Emissions.

Test Results: The EUT was compliant with the Conducted Spurious Emission limits of **§15.247(d)**.

Test Engineer(s): Ajaz Khan

Test Date(s): 02/03/15

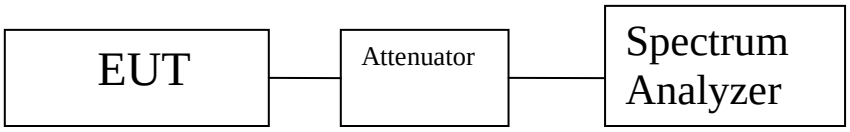

Figure 4. Block Diagram, Conducted Spurious Emissions Test Setup

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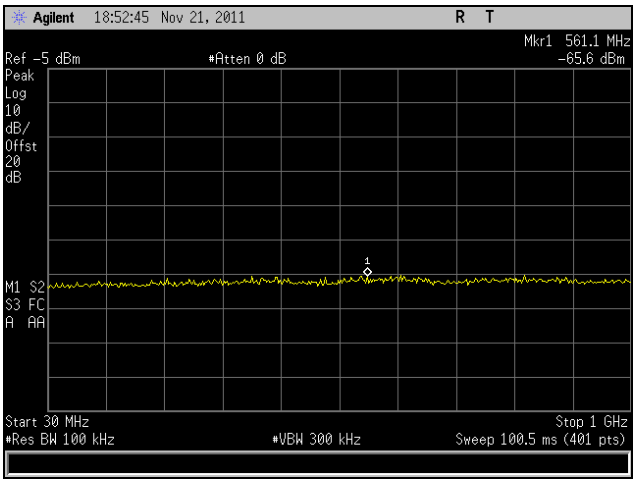
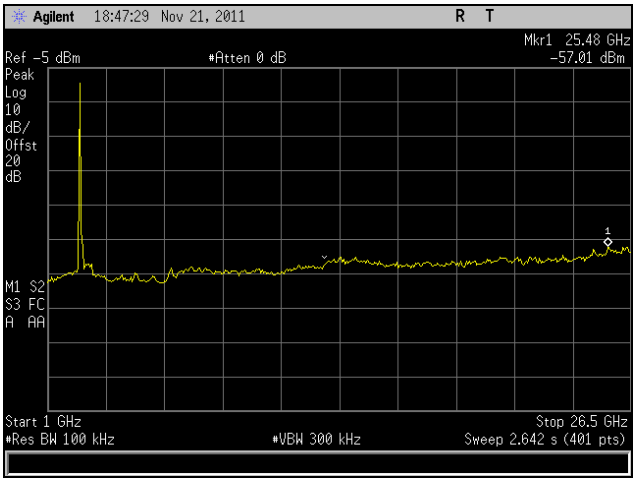
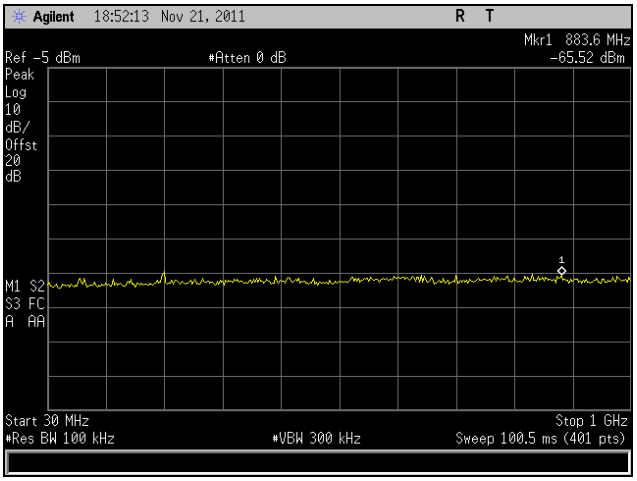
Conducted Spurious Emissions Test Results, 802.11b



Plot 42. Conducted Spurious Emissions, Low Channel, 30 MHz – 1 GHz, 802.11b

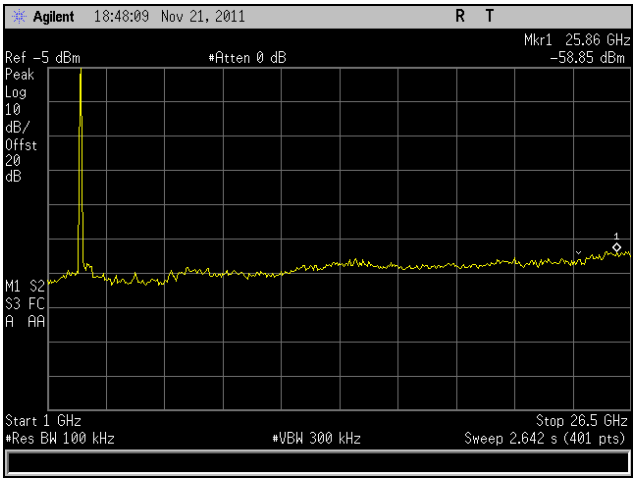


Plot 43. Conducted Spurious Emissions, Low Channel, 1 GHz – 26.5 GHz, 802.11b

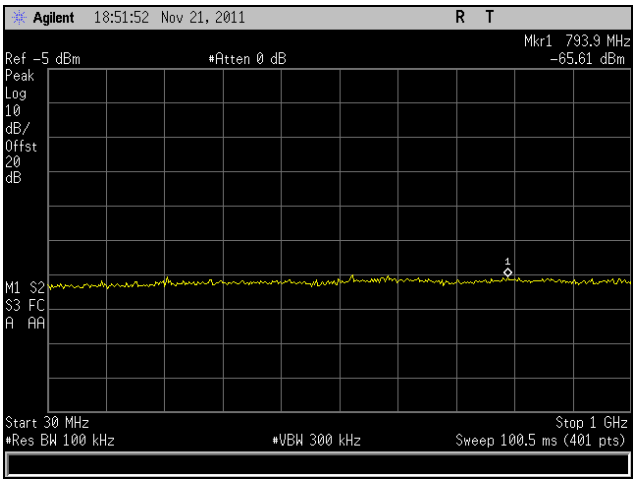


Plot 44. Conducted Spurious Emissions, Mid Channel, 30 MHz – 1 GHz, 802.11b

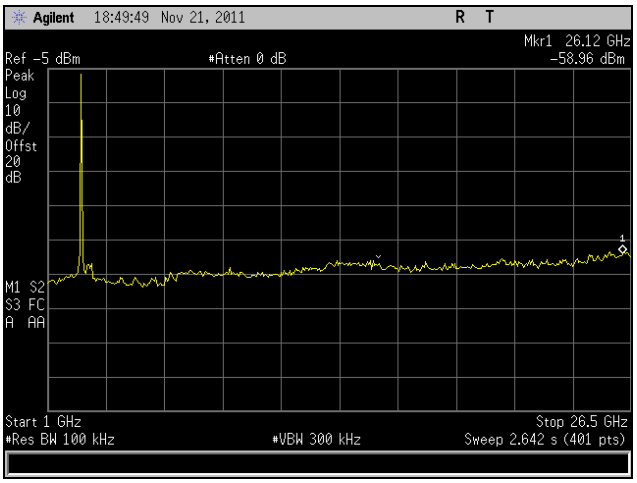
 © 2015, MET Laboratories, Inc.



Plot 45. Conducted Spurious Emissions, Mid Channel, 1 GHz – 26.5 GHz, 802.11b

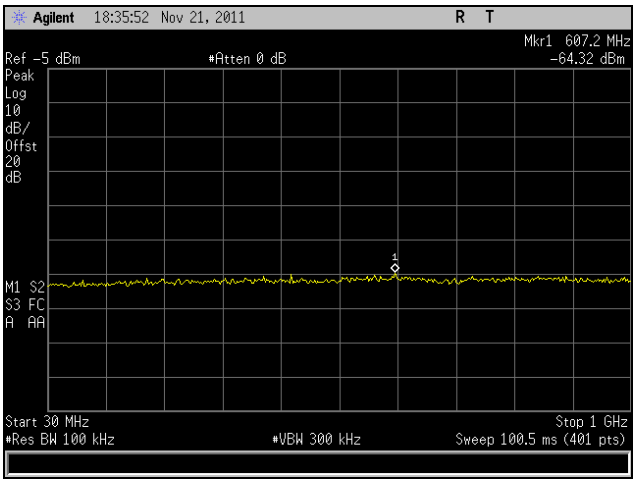


Plot 46. Conducted Spurious Emissions, High Channel, 30 MHz – 1 GHz, 802.11b

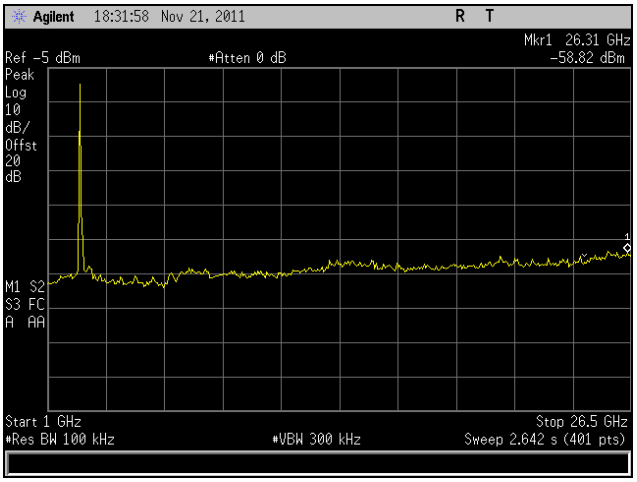


Plot 47. Conducted Spurious Emissions, High Channel, 1 GHz – 26.5 GHz, 802.11b

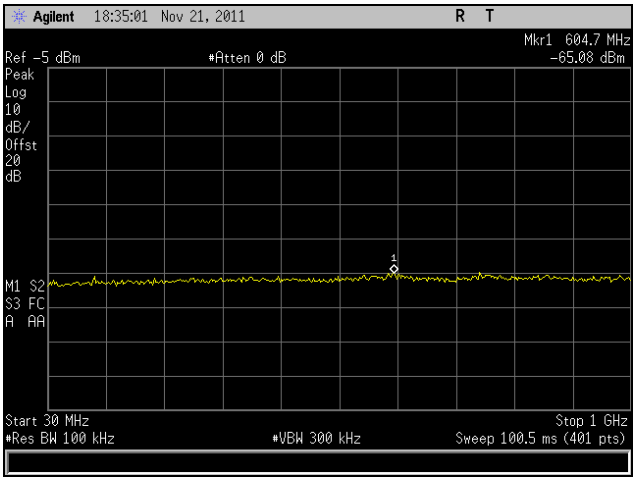
Conducted Spurious Emissions Test Results, 802.11g



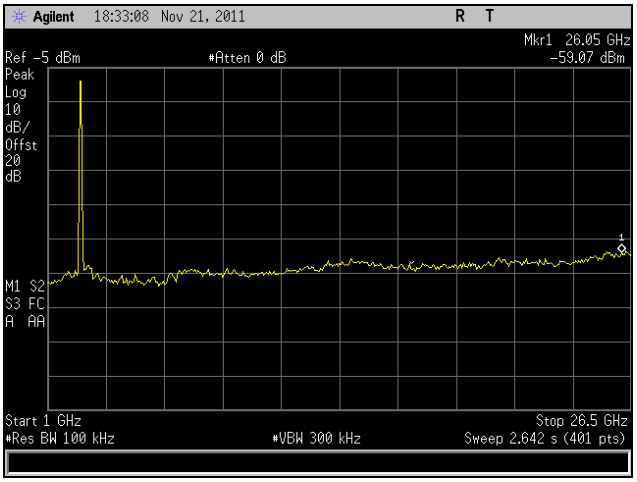
Plot 48. Conducted Spurious Emissions, Low Channel, 30 MHz – 1 GHz, 802.11g



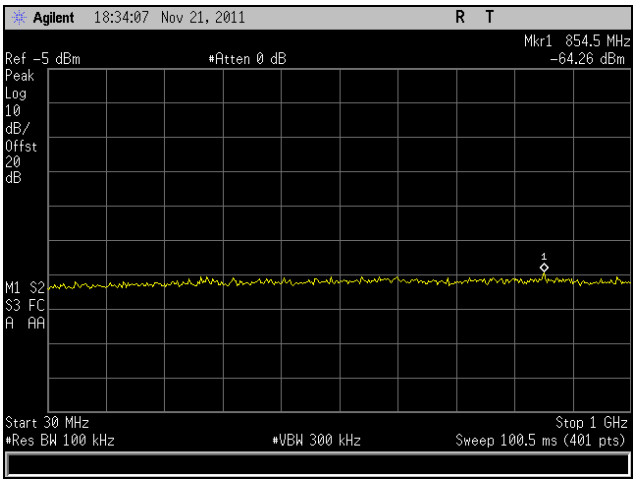
Plot 49. Conducted Spurious Emissions, Low Channel, 1 GHz – 26.5 GHz, 802.11g



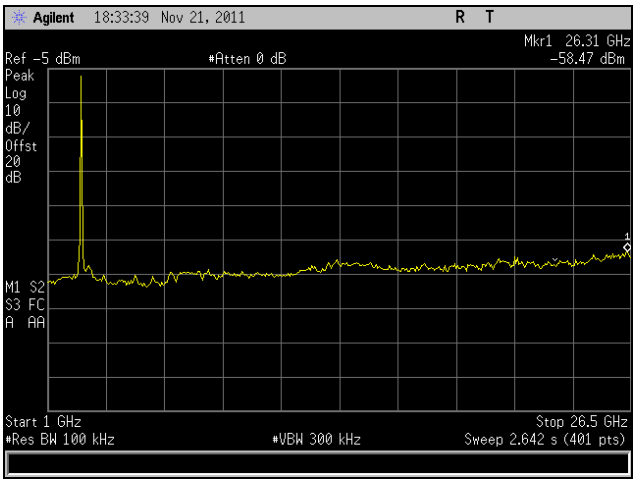
Plot 50. Conducted Spurious Emissions, Mid Channel, 30 MHz – 1 GHz, 802.11g



Plot 51. Conducted Spurious Emissions, Mid Channel, 1 GHz – 26.5 GHz, 802.11g

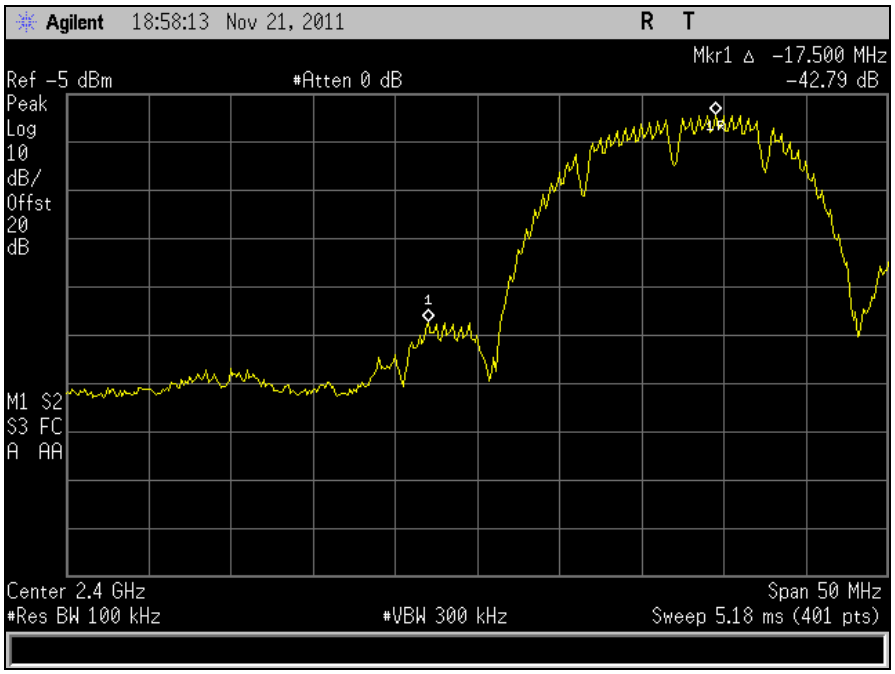


Plot 52. Conducted Spurious Emissions, High Channel, 30 MHz – 1 GHz, 802.11g

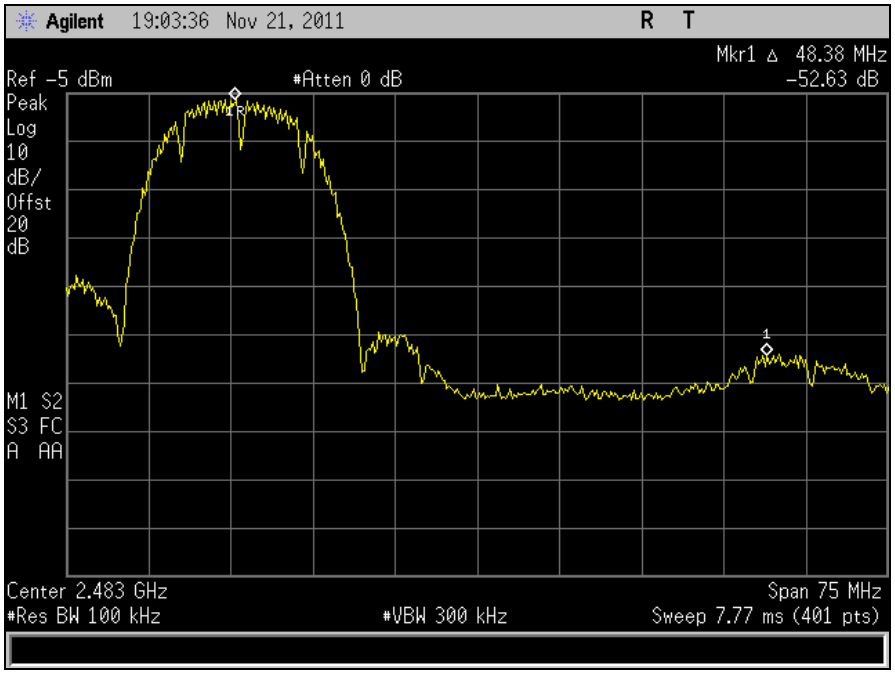


Plot 53. Conducted Spurious Emissions, High Channel, 1 GHz – 26.5 GHz, 802.11g

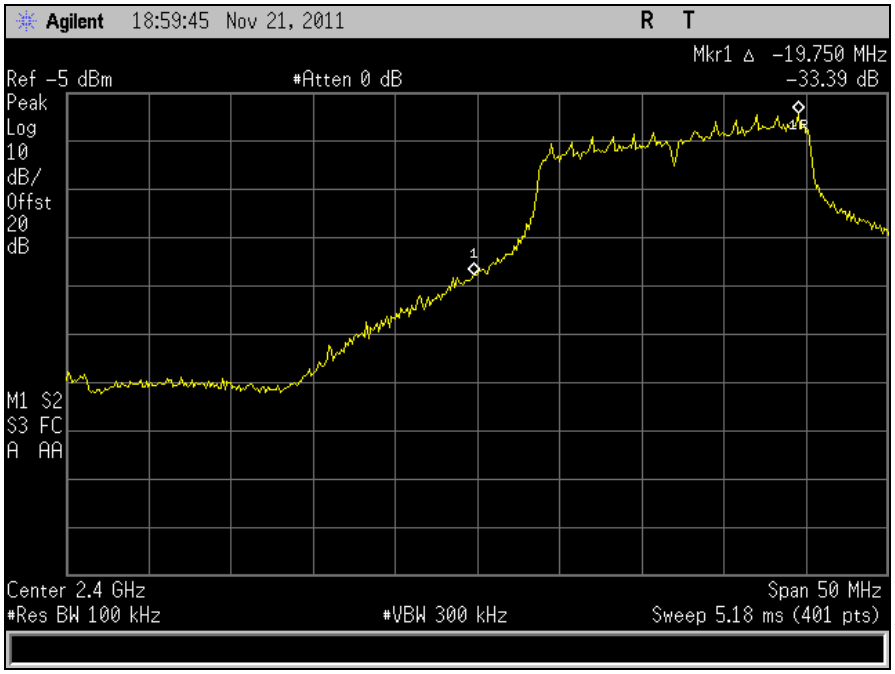
Conducted Band Edge Test Results



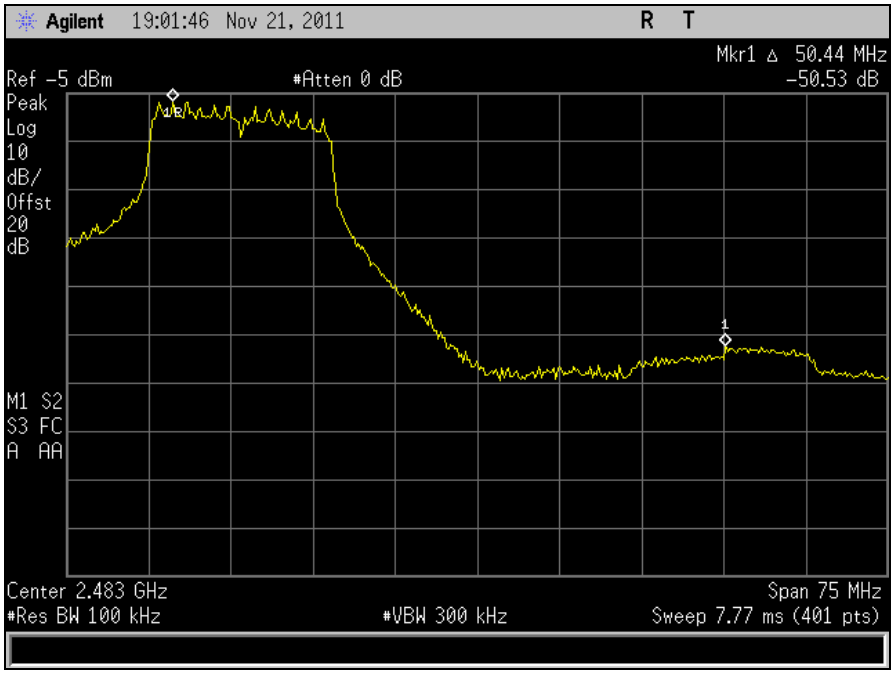
Plot 54. Conducted Band Edge, 802.11b, Low Channel



Plot 55. Conducted Band Edge, 802.11b, High Channel



Plot 56. Conducted Band Edge, 802.11g, Low Channel



Plot 57. Conducted Band Edge, 802.11g, High Channel

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

Test Requirements: **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level. A RBW of 1 MHz and VBW of 3 MHz were used to determine the peak emissions within the band. The Spectrum analyzer was then set to a RBW of 3 kHz and VBW was set to 10 kHz. The SPAN of the analyzer was set to 1 MHz with a 333.3 second sweep. Measurements were carried out at the low, mid and high channels.

Test Results: The EUT was compliant with the peak power spectral density limits of **§ 15.247 (e**

The peak power spectral density was determined from plots on the following page(s).

Test Engineer: Ajaz Khan

Test Date: 02/02/15

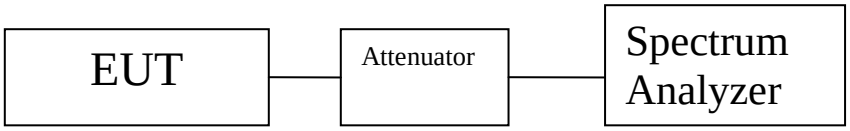

Figure 5. Block Diagram, Peak Power Spectral Density Test Setup

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Peak Power Spectral Density Test Results

Peak Power Spectral Density				
Carrier Channel	**Frequency (MHz)**	**Measured PPSD (dBm)**	**Limit (dBm)**	**Margin (dB)**
Low	2412	-22.08	8	-30.08
Mid	2437	-17.94	8	-25.94
High	2462	-19.01	8	-27.01

Table 19. Peak Power Spectral Density, Test Results, 802.11b

Peak Power Spectral Density				
Carrier Channel	**Frequency (MHz)**	**Measured PPSD (dBm)**	**Limit (dBm)**	**Margin (dB)**
Low	2412	-21.93	8	-29.93
Mid	2437	-17.93	8	-25.93
High	2462	-19.89	8	-27.89

Table 20. Peak Power Spectral Density, Test Results, 802.11g

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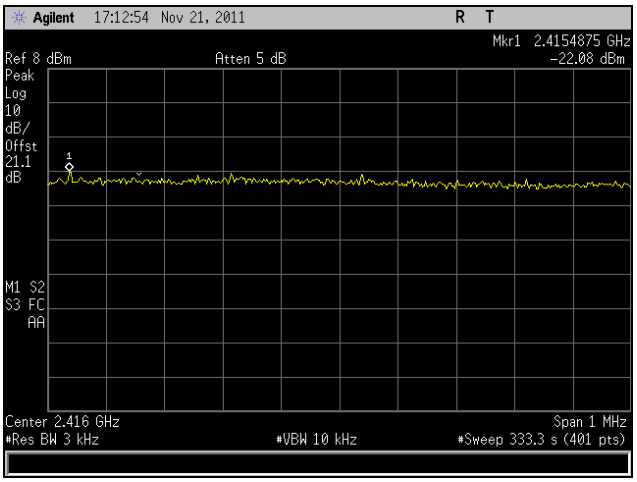
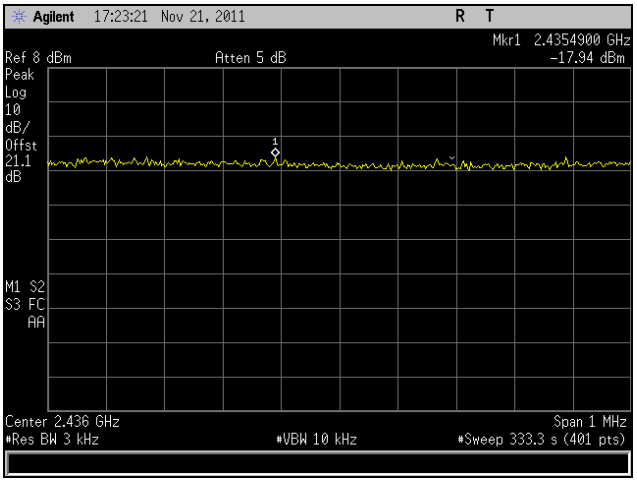
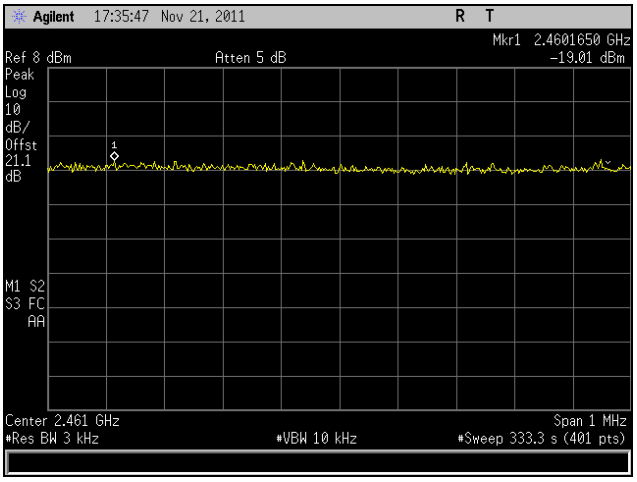
Peak Power Spectral Density, 802.11b



Plot 58. Peak Power Spectral Density, Low Channel, 802.11b

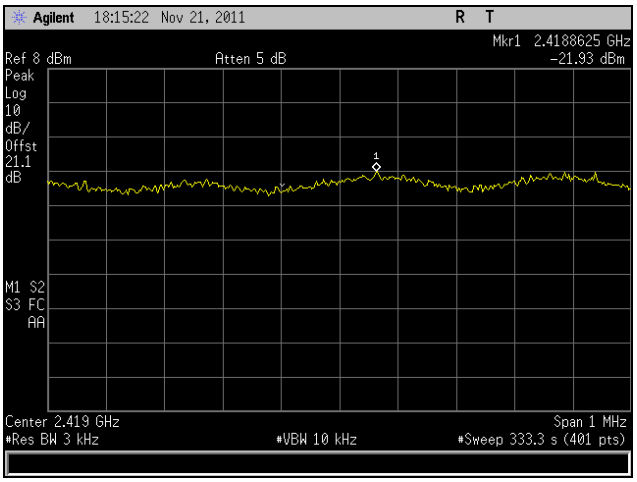


Plot 59. Peak Power Spectral Density, Mid Channel, 802.11b

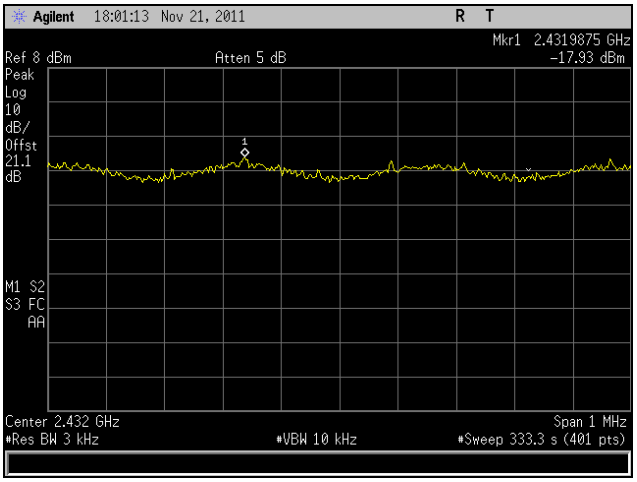


Plot 60. Peak Power Spectral Density, High Channel, 802.11b

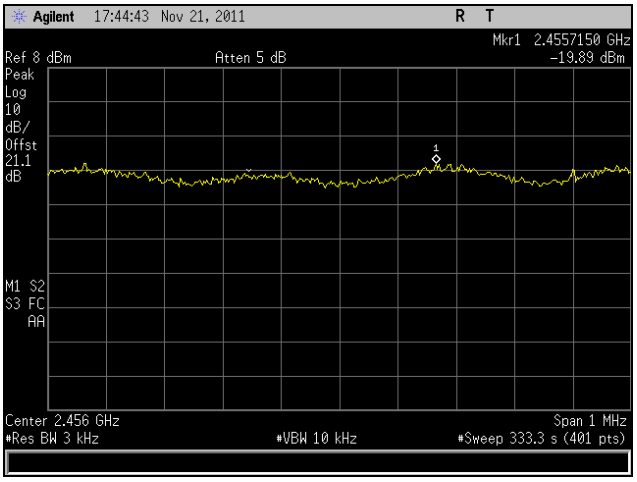
Peak Power Spectral Density, 802.11g



Plot 61. Peak Power Spectral Density, Low Channel, 802.11g



Plot 62. Peak Power Spectral Density, Mid Channel, 802.11g



Plot 63. Peak Power Spectral Density, High Channel, 802.11g

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 @ 2400-2483.5 MHz; highest conducted power = *15.69 dBm* (peak) therefore, **Limit for Uncontrolled exposure: 1 mW/cm^2 or 10 W/m^2**

EUT maximum antenna gain = *1.88 dBi.*

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

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

where, S = Power Density (1 mW/cm^2)
P = Power Input to antenna (37.068mW)
G = Antenna Gain (1.542 numeric)
R = Minimum Distance between User and Antenna (20 cm)

$S = (37.068*1.542)/(4*3.14*20^2) = 57.159/5024 = 0.011$ mW/cm^2

Since S < 1 mW/cm^2, the minimum distance (R) is 20cm

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IV. Test Equipment

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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
1S2607	SPECTRUM ANALYZER ESA	AGILENT/HP	E4407B	9/11/2014	3/11/2016
1S2691	DUAL-LINE V-LISN	TESEQ	NNB-51	12/5/2014	12/5/2015
1S2633	TRANSIENT LIMITER	FISCHER CUSTOM COMMUNICATIONS INC.	FCC-450B-2.4-N	1/8/2014	1/8/2016
1S2399	TURNTABLE CONTROLLER	SUNOL SCIENCE	SC99V	N/A	
1S2501	EMI TEST RECEIVER 20HZ-40GHZ	ROHDE & SCHWARZ	ESU40	9/12/2014	9/12/2015
1S2482	5 METER CHAMBER	PANASHIELD	641431	8/12/2013	2/12/2015
1S2460	SPECTRUM ANALYZER	AGILENT	E4407B	2/27/2014	8/27/2015
1S2583	SPECTRUM ANALYZER	AGILENT/HP	E4447A	11/1/2013	5/1/2015
1S2600	BILOG ANTENNA	TESEQ	CBL6112D	8/29/2013	8/29/2015
1S2523	PREAMP (1-26.5GHZ)	AGILENT	8449B	SEE NOTE	
1S2198	HORN ANTENNA	EMCO	3115	5/20/2014	11/20/2015
N/A	HIGH PASS FILTER	MICRO-TRONICS	HPM13147	SEE NOTE	

Table 21. Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

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V. Certification & User's Manual Information

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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.

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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.

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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.

End of Report

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