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

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January 4, 2017

CommScope Technologies LLC
250 Apollo Drive
Chelmsford, MA 01824

Dear Kevin Craig,

Enclosed is the EMC Wireless test report for compliance testing of the CommScope Technologies LLC, Small Cell/ Model S1000R as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Title 47 of the CFR, Part 15.407, Subpart E (UNII 1) 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: (\CommScope Technologies LLC\ EMC91761-FCC407 UNII 1 Rev. 2)

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Electromagnetic Compatibility Criteria
Test Report

for the

CommScope Technologies LLC
Model Small Cell/ Model S1000R

Tested under
The FCC Certification Rules
contained in
Title 47 of the CFR, Part 15.407 for Intentional Radiators

MET Report: EMC91761-FCC407 UNII 1 Rev. 2

January 4, 2017

Prepared For:

CommScope Technologies LLC
250 Apollo Drive
Chelmsford, MA 01824

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 Parts 15B, 15.407, of the FCC Rules under normal use and maintenance.

Asad Bajwa,
Director, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	October 21, 2016	Initial Issue.
1	December 8, 2016	Editorial corrections.
2	January 4, 2017	EUT Photos Removed for Short Term Confidentiality

Table of Contents

I. Executive Summary 1
A. Purpose of Test 2
B. Executive Summary 2
II. Equipment Configuration 3
A. Overview 4
B. References 5
C. Test Site 5
D. Description of Test Sample 5
E. Equipment Configuration 6
F. Support Equipment 6
G. Ports and Cabling Information 7
H. Mode of Operation 7
I. Method of Monitoring EUT Operation 7
J. Modifications 7
a) Modifications to EUT 7
b) Modifications to Test Standard 7
K. Disposition of EUT 7
III. Electromagnetic Compatibility Criteria for Intentional Radiators 8
§ 15.203 Antenna Requirement 9
§ 15.207(a) Conducted Emissions Limits 10
§ 15.403(c) 26dB Bandwidth 13
§15.407(a)(1)(i) & §15.407(a)(3) RF Power Output 20
§15.407(a)(1)(i) & §15.407(a)(3) Peak Power Spectral Density 22
§15.407(b)(1), §15.407(b)(6), & §15.407(b)(7) Undesirable Emissions 24
§ 15.407(f) RF Exposure 42
IV. Test Equipment 43
V. Certification & User's Manual Information 45
A. Certification Information 46
B. Label and User's Manual Information 50

List of Tables

Table 1. Executive Summary of EMC Part 15.407 ComplianceTesting 2
Table 2. EUT Summary 4
Table 3. References 5
Table 4. Equipment Configuration 6
Table 5. Support Equipment 6
Table 6. Ports and Cabling Information 7
Table 7. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a) 10
Table 8. Conducted Emissions, 15.207(a), Phase Line, Test Results 11
Table 9. Conducted Emissions, 15.207(a), Neutral Line, Test Results 12
Table 10. 26 dB Occupied Bandwidth, Test Results 14
Table 11. RF Output Power, Test Results 21
Table 12. RF Output Power, Test Results, Summed Ports 21
Table 13. Peak Power Spectral Density, Test Results 23
Table 14. Test Equipment List 44

List of Figures

Figure 1. Occupied Bandwidth, Test Setup 13
Figure 2. Power Output Test Setup 20
Figure 3. Power Spectral Density Test Setup 22

List of Plots

Plot 1. Conducted Emissions, 15.207(a), Phase Line 11
Plot 2. Conducted Emissions, 15.207(a), Neutral Line 12
Plot 3. Occupied Bandwidth, 802.11a 20 MHz, Low Channel, 5180 MHz, Port A 15
Plot 4. Occupied Bandwidth, 802.11a 20 MHz, Mid Channel, 5200 MHz, Port A 15
Plot 5. Occupied Bandwidth, 802.11a 20 MHz, High Channel, 5240 MHz, Port A 15
Plot 6. Occupied Bandwidth, 802.11ac 20 MHz, Low Channel, 5180 MHz, Port A 16
Plot 7. Occupied Bandwidth, 802.11ac 20 MHz, Mid Channel, 5200 MHz, Port A 16
Plot 8. Occupied Bandwidth, 802.11ac 20 MHz, High Channel, 5240 MHz, Port A 16
Plot 9. Occupied Bandwidth, 802.11n 20 MHz, Low Channel, 5180 MHz, Port A 17
Plot 10. Occupied Bandwidth, 802.11n 20 MHz, Mid Channel, 5200 MHz, Port A 17
Plot 11. Occupied Bandwidth, 802.11n 20 MHz, High Channel, 5240 MHz, Port A 17
Plot 12. Occupied Bandwidth, 802.11ac 40 MHz, Low Channel, 5190 MHz, Port A 18
Plot 13. Occupied Bandwidth, 802.11ac 40 MHz, High Channel, 5230 MHz, Port A 18
Plot 14. Occupied Bandwidth, 802.11n 40 MHz, Low Channel, 5190 MHz, Port A 18
Plot 15. Occupied Bandwidth, 802.11n 40 MHz, High Channel, 5230 MHz, Port A 19
Plot 16. Occupied Bandwidth, 802.11ac 80 MHz, 5210 MHz, Port A 19
Plot 17. Radiated Spurious Emissions, 5180 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz 25
Plot 18. Radiated Spurious Emissions, 5180 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz 25
Plot 19. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 30 MHz – 1 GHz 25
Plot 20. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz 26
Plot 21. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz 26
Plot 22. Radiated Spurious Emissions, 5240 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz 26
Plot 23. Radiated Spurious Emissions, 5240 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz 27
Plot 24. Radiated Spurious Emissions, 5180 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz 27
Plot 25. Radiated Spurious Emissions, 5180 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz 27
Plot 26. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 30 MHz – 1 GHz 28
Plot 27. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz 28
Plot 28. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz 28

Plot 29. Radiated Spurious Emissions, 5240 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz 29
Plot 30. Radiated Spurious Emissions, 5240 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz 29
Plot 31. Radiated Spurious Emissions, 5180 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz 29
Plot 32. Radiated Spurious Emissions, 5180 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz 30
Plot 33. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 30 MHz – 1 GHz 30
Plot 34. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz 30
Plot 35. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz 31
Plot 36. Radiated Spurious Emissions, 5240 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz 31
Plot 37. Radiated Spurious Emissions, 5240 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz 31
Plot 38. Radiated Spurious Emissions, 5190 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz 32
Plot 39. Radiated Spurious Emissions, 5190 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz 32
Plot 40. Radiated Spurious Emissions, 5230 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz 32
Plot 41. Radiated Spurious Emissions, 5230 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz 33
Plot 42. Radiated Spurious Emissions, 5190 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz 33
Plot 43. Radiated Spurious Emissions, 5190 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz 33
Plot 44. Radiated Spurious Emissions, 5230 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz 34
Plot 45. Radiated Spurious Emissions, 5230 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz 34
Plot 46. Radiated Spurious Emissions, 5210 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz 34
Plot 47. Radiated Spurious Emissions, 5210 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz 35
Plot 48. Radiated Band Edge, 802.11a, 5180 MHz @ 5150 MHz, Average 36
Plot 49. Radiated Band Edge, 802.11a, 5180 MHz @ 5150 MHz, Peak 36
Plot 50. Radiated Band Edge, 802.11a, 5240 MHz @ 5350 MHz 36
Plot 51. Radiated Band Edge, 802.11ac 20 MHz, 5180 MHz @ 5150 MHz, Average 37
Plot 52. Radiated Band Edge, 802.11ac 20 MHz, 5180 MHz @ 5150 MHz, Peak 37
Plot 53. Radiated Band Edge, 802.11ac 20 MHz, 5240 MHz @ 5350 MHz 37
Plot 54. Radiated Band Edge, 802.11n 20 MHz, 5180 MHz @ 5150 MHz, Average 38
Plot 55. Radiated Band Edge, 802.11n 20 MHz, 5180 MHz @ 5150 MHz, Peak 38
Plot 56. Radiated Band Edge, 802.11n 20 MHz, 5240 MHz @ 5350 MHz 38
Plot 57. Radiated Band Edge, 802.11ac 40 MHz, 5190 MHz @ 5150 MHz, Average 39
Plot 58. Radiated Band Edge, 802.11ac 40 MHz, 5190 MHz @ 5150 MHz, Peak 39
Plot 59. Radiated Band Edge, 802.11ac 40 MHz, 5230 MHz @ 5350 MHz 39
Plot 60. Radiated Band Edge, 802.11n 40 MHz, 5190 MHz @ 5150 MHz, Average 40
Plot 61. Radiated Band Edge, 802.11n 40 MHz, 5190 MHz @ 5150 MHz, Peak 40
Plot 62. Radiated Band Edge, 802.11n 40 MHz, 5230 MHz @ 5350 MHz 40
Plot 63. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5150 MHz, Average 41
Plot 64. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5150 MHz, Peak 41
Plot 65. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5350 MHz 41

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
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

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the CommScope Technologies LLC Small Cell/ Model S1000R, with the requirements of Part 15, §15.407. 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 Small Cell/ Model S1000R. CommScope Technologies LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Small Cell/ Model S1000R, 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, §15.407, in accordance with CommScope Technologies LLC, purchase order number 60521. All tests were conducted using measurement procedure ANSI C63.4-2003.

FCC Reference	Description	Results
§15.203	Antenna Requirements	Compliant
§15.207	AC Conducted Emissions 150KHz – 30MHz	Compliant
§15.403 (i)	26dB Occupied Bandwidth	Compliant
§15.407 (a)(1)(ii)	Conducted Transmitter Output Power	Compliant
§15.407 (a)(1)(ii)	Power Spectral Density	Compliant
§15.407 (b)(1), (6), (7)	Undesirable Emissions (15.205/15.209 - General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Compliant
§15.407(f)	RF Exposure	Compliant

Table 1. Executive Summary of EMC Part 15.407 ComplianceTesting

II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by CommScope Technologies LLC to perform testing on the Small Cell/ Model S1000R, under CommScope Technologies LLC's purchase order number 60521.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the CommScope Technologies LLC Small Cell/ Model S1000R.

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

Model(s) Tested:	Small Cell/ Model S1000R	
Model(s) Covered:	Small Cell/ Model S1000R	
EUT Specifications:	Primary Power: 120 VAC, 60 Hz	
	FCC ID: QHY-S1000R	
	Type of Modulations:	OFDM
	Equipment Code:	NII
	Peak RF Output Power:	24.46dBm
	EUT Frequency Ranges:	5.180 to 5.240 GHz
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:	Benjamin Taylor	
Report Date(s):	January 4, 2017	

Table 2. EUT Summary

B. References

CFR 47, Part 15, Subpart E	Unlicensed National Information Infrastructure Devices (UNII)
ANSI C63.4:2014	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 C63.10-2013	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 CommScope Technologies LLC Small Cell/ Model S1000R, Equipment Under Test (EUT), is a LTE/Wi-Fi Low Power Femto Backhaul Relay Base Station. It is intended to be use in the Small to Medium Business's to provide indoor voice and data coverage.

E. Equipment Configuration

All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Name / Description	Model Number	Part Number
1	Femto Backhaul Relay Base Station	S1000R	800239
2	DYS Switching Mode Power Supply	DYS650-120400W-1	DYS650-120400-16419

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	Customer Supplied Calibration Data
1	MXA Analyzer	Agilent	N9020A	10-14-2015
2	Rubidium	Stanford Research Systems	FS725	06-06-2016
3	Waveform Generator	Keysight	33500B	not applicable
4	Wi-Fi Router	Linksys	EA2700	not applicable
5	Laptop	Dell	Latitude E6440	not applicable
6	USB Optical Mouse	Dell		not applicable
7	AC Adapter for Laptop	Dell		not applicable
8	Cat5 cables			not applicable
9	RF Test cables	Murata	MXHS83QE3000	not applicable

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
1	Data	RG59 Coax	1	15	Yes	B. TX
2	AC Input	3 conductor, 18 awg	1	2	No	(230v/50hz)

Table 6. Ports and Cabling Information

H. Mode of Operation

The Femto Backhaul Relay Base station will be operating in 2 modes LTE and Wi-Fi.

LTE - The Backhaul relay radio transmits in Bands 25 & 26 (FDD) Bandwidth 3, 5 & 10 MHz & Band 41 (TDD) sub bands 2500-2570 MHz & 2620-2690 MHz. Test mode uses the suppliers test software CLI in order to be able to provide a continuous transmit stream for EMC testing. Transmitters shall be at max power of Band 25 (+22dBm), Band 26 (+20dBm) & Band 41(+22dBm).

LTE - The service radio transmits in Band 41 (TDD). Test mode uses the chipset suppliers test software TMU in order to be able to provide a continuous transmit stream for EMC testing. Transmitters shall be at max power of +20dBm.

Wi-Fi – The Wi-Fi radios, 2.4 & 5 MHz, will be tested uses the chipset suppliers test software ART. Transmitters shall be at max power of +17dBm.

A laptop using telnet sessions and test scripts will be used to control the radio for LTE and Wi-Fi during EMC testing.

A laptop using a serial connection and test scripts will be used during LTE Radio & Safety testing.

I. Method of Monitoring EUT Operation

Consistent with the Mode of Operation section above, there needs to be a means of continuously monitoring the operation of the EUT.

1. All radios can be monitored by the software indicating the state of the radio links via CLI. Also the DC power consumed is an indicator of the state of the system.
2. Same as above.

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 CommScope Technologies LLC upon completion of testing.

III. 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. The EUT employs an integral antenna.

Test Engineer(s): Benjamin Taylor

Test Date(s): 03/31/15

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

Test Procedure: The EUT was placed on a 0.8 m-high wooden table inside a screen room. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 μH Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.4-2003 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz"*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω/50 μH LISN as the input transducer to an EMC/field intensity meter. For the purpose of this testing, the transmitter was turned on. Scans were performed with the transmitter on.

Test Results: The EUT was compliant with this requirement.

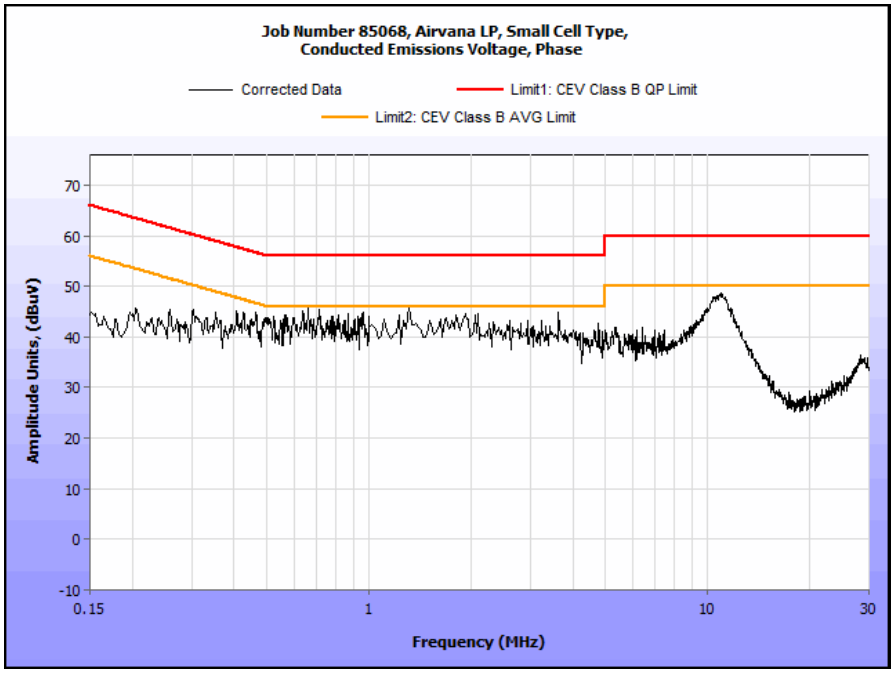
Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15

15.207(a) Conducted Emissions Test Results

Line Under Test:		Phase								
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Margin (dB) AVG
0.248	43.61	0	43.61	56	-12.39	38.98	0	38.98	46	-7.02
0.441	45.19	0	45.19	56	-10.81	43.24	0	43.24	46	-2.76
0.559	49.51	0	49.51	56	-6.49	42.56	0	42.56	46	-3.44
1.32	48.68	0	48.68	56	-7.32	40.91	0	40.91	46	-5.09
5.67	49.12	0.17	49.29	60	-10.71	43.95	0.17	44.12	50	-5.88
11.91	50.5	0.17	50.67	60	-9.33	44.17	0.17	44.34	50	-5.66

Table 8. Conducted Emissions, 15.207(a), Phase Line, Test Results

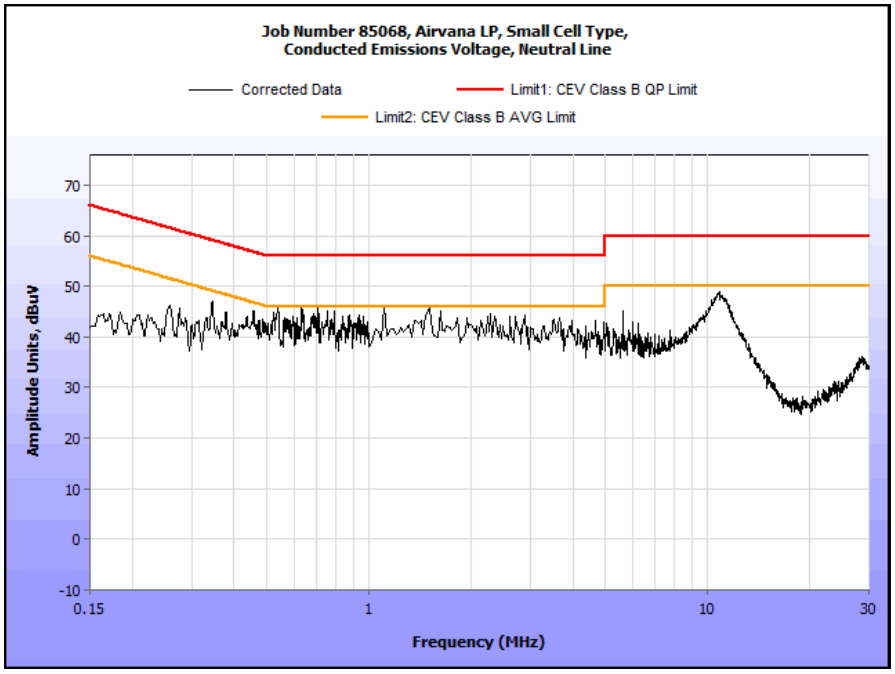


Plot 1. Conducted Emissions, 15.207(a), Phase Line

15.207(a) Conducted Emissions Test Results

Line Under Test:		Neutral								
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Margin (dB) AVG
0.249	42.56	0	42.56	56	-13.44	39.45	0	39.45	46	-6.55
0.339	46.18	0	46.18	56	-9.82	42.34	0	42.34	46	-3.66
0.541	48.65	0	48.65	56	-7.35	41.57	0	41.57	46	-4.43
1.29	49.63	0	49.63	56	-6.37	41.54	0	41.54	46	-4.46
5.68	48.6	0.17	48.77	60	-11.23	41.6	0.17	41.77	50	-8.23
11.99	49.66	0.17	49.83	60	-10.17	45.45	0.17	45.62	50	-4.38

Table 9. Conducted Emissions, 15.207(a), Neutral Line, Test Results



Plot 2. Conducted Emissions, 15.207(a), Neutral Line

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 403(i) 26dB Bandwidth

Test Requirements: **§ 15.403 (i):** For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

Test Procedure: The transmitter was set to low, mid, and high operating frequencies at the highest output power and connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth, VBW > RBW. The 26 dB Bandwidth was measured and recorded.

Test Results The 26 dB Bandwidth was compliant with the requirements of this section and was determined from the plots on the following pages.

Test Engineer(s): Benjamin Taylor

Test Date(s): 04/01/15

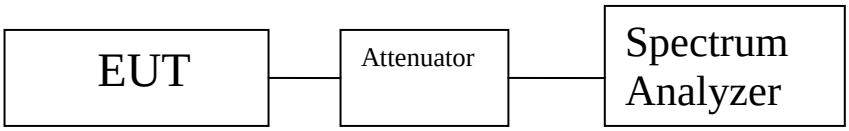
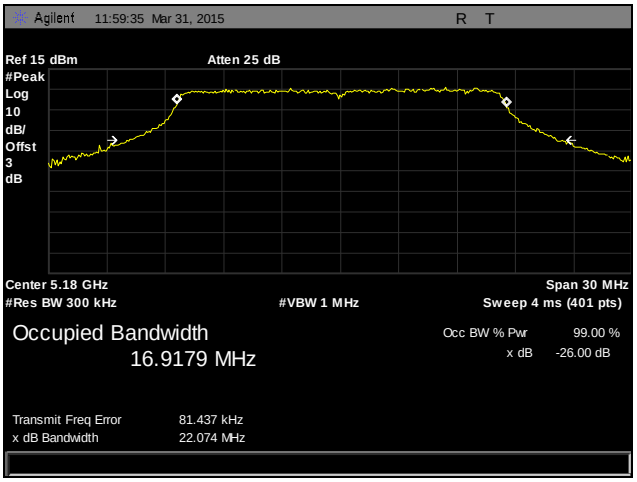


Figure 1. Occupied Bandwidth, Test Setup

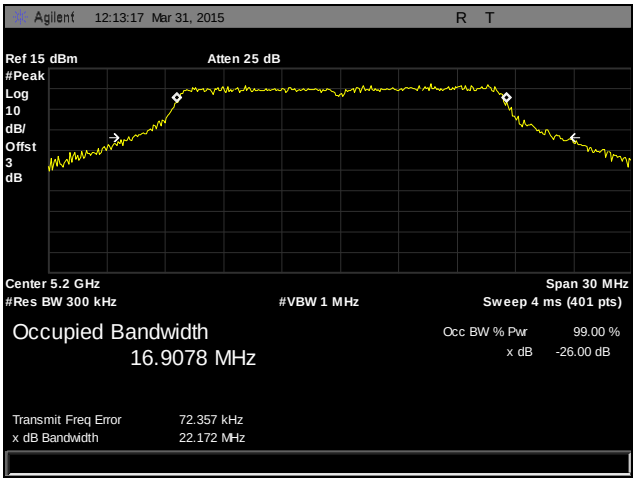
Occupied Bandwidth		
Carrier Channel Mode	**Frequency (MHz)**	**Measured 26 dB Bandwidth (MHz)**
802.11a 20MHz	5180	22.074
802.11a 20MHz	5200	22.172
802.11a 20MHz	5240	22.758
802.11ac 20MHz	5180	22.694
802.11ac 20MHz	5200	22.420
802.11ac 20MHz	5240	23.943
802.11n 20MHz	5180	22.585
802.11n 20MHz	5200	22.956
802.11n 20MHz	5240	22.758
802.11ac 40MHz	5190	43.624
802.11ac 40MHz	5230	43.342
802.11n 40MHz	5190	41.574
802.11n 40MHz	5230	38.738
802.11ac 80MHz	5210	91.268

Table 10. 26 dB Occupied Bandwidth, Test Results

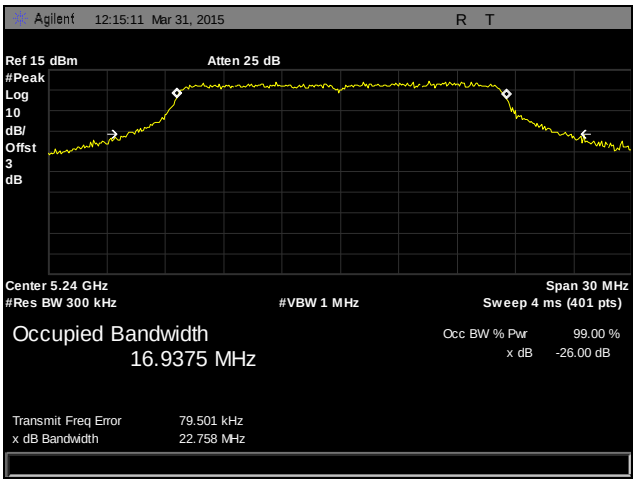
Occupied Bandwidth Test Results



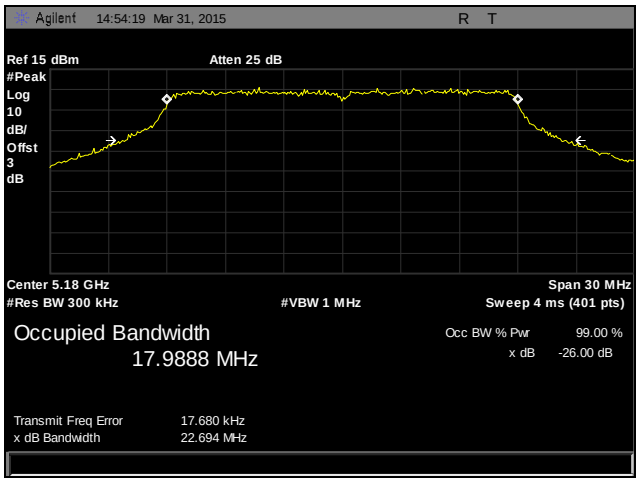
Plot 3. Occupied Bandwidth, 802.11a 20 MHz, Low Channel, 5180 MHz, Port A



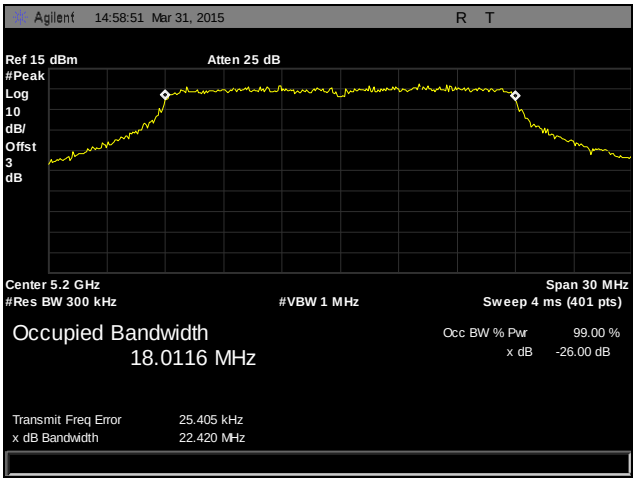
Plot 4. Occupied Bandwidth, 802.11a 20 MHz, Mid Channel, 5200 MHz, Port A



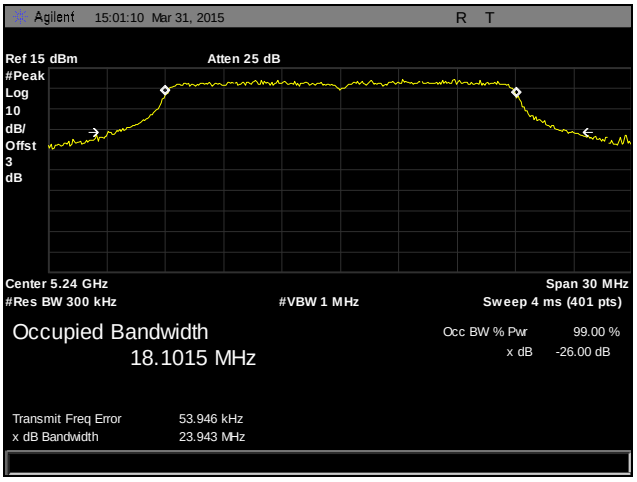
Plot 5. Occupied Bandwidth, 802.11a 20 MHz, High Channel, 5240 MHz, Port A



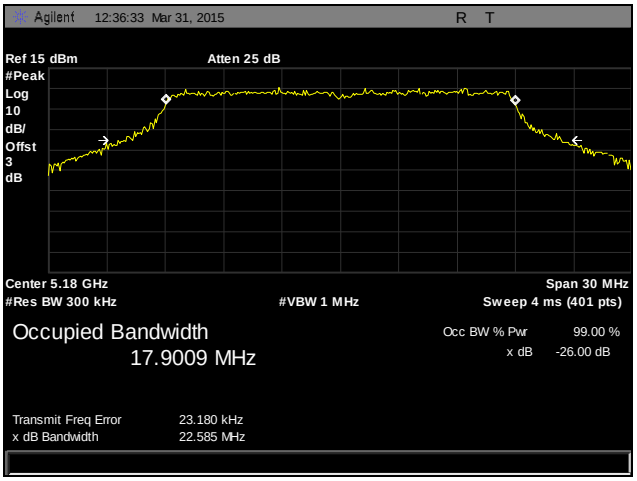
Plot 6. Occupied Bandwidth, 802.11ac 20 MHz, Low Channel, 5180 MHz, Port A



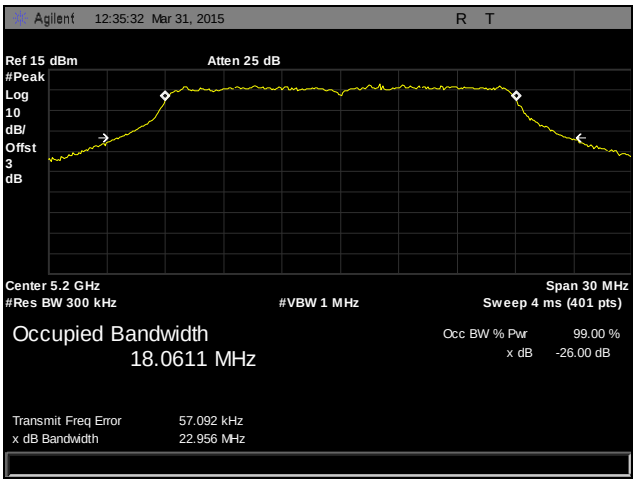
Plot 7. Occupied Bandwidth, 802.11ac 20 MHz, Mid Channel, 5200 MHz, Port A



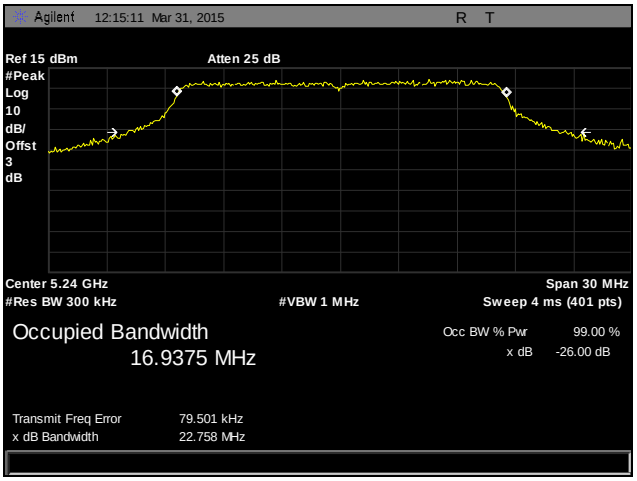
Plot 8. Occupied Bandwidth, 802.11ac 20 MHz, High Channel, 5240 MHz, Port A



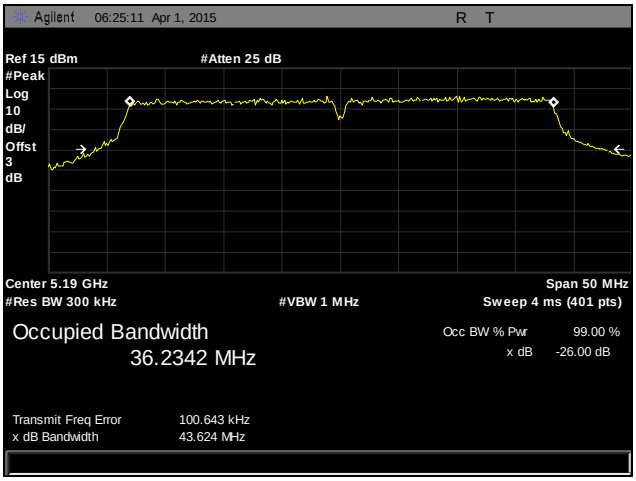
Plot 9. Occupied Bandwidth, 802.11n 20 MHz, Low Channel, 5180 MHz, Port A



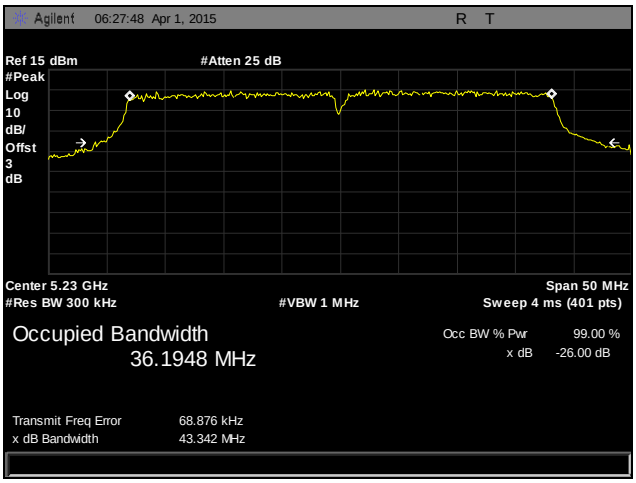
Plot 10. Occupied Bandwidth, 802.11n 20 MHz, Mid Channel, 5200 MHz, Port A



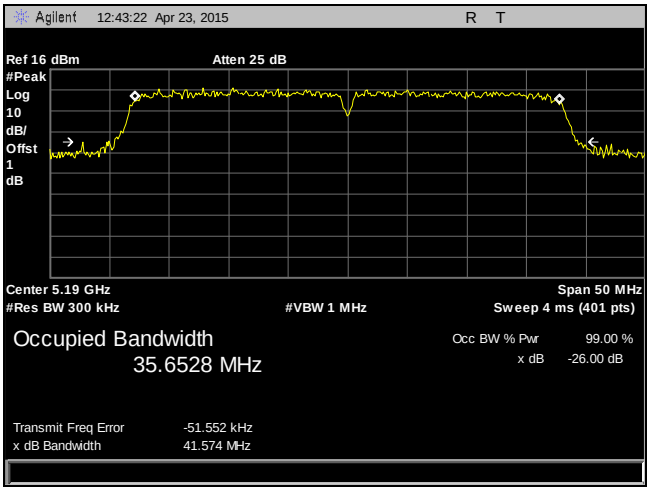
Plot 11. Occupied Bandwidth, 802.11n 20 MHz, High Channel, 5240 MHz, Port A



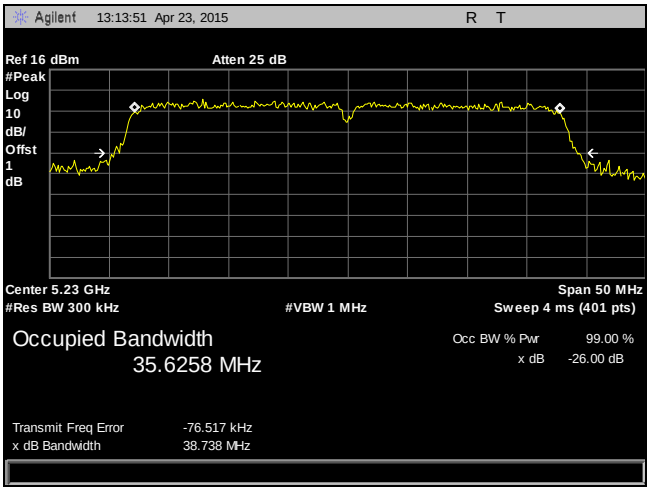
Plot 12. Occupied Bandwidth, 802.11ac 40 MHz, Low Channel, 5190 MHz, Port A



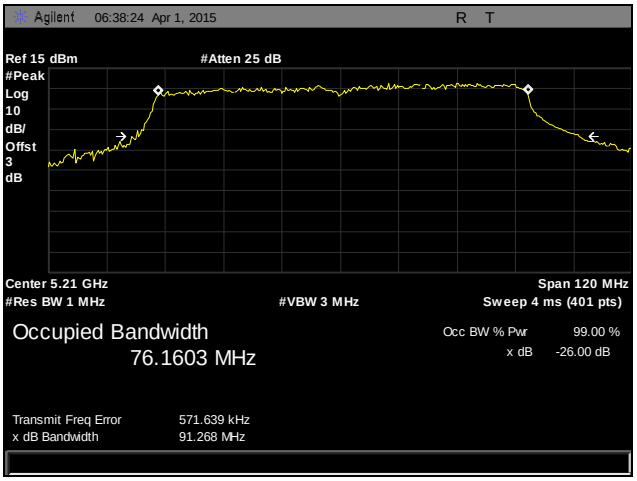
Plot 13. Occupied Bandwidth, 802.11ac 40 MHz, High Channel, 5230 MHz, Port A



Plot 14. Occupied Bandwidth, 802.11n 40 MHz, Low Channel, 5190 MHz, Port A



Plot 15. Occupied Bandwidth, 802.11n 40 MHz, High Channel, 5230 MHz, Port A



Plot 16. Occupied Bandwidth, 802.11ac 80 MHz, 5210 MHz, Port A

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 407(a)(1)(ii) RF Power Output

Test Requirements: **§15.407(a)(1)(ii):** For an indoor access point operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi.

Test Procedure: The EUT was connected to a spectrum analyzer through an attenuator and set to transmit continuously on the low, mid, and high channels. Its power was measured according to measurement method SA-1, as described in 789033 D02 General UNII Test Procedures New Rule v01. Plots were corrected for attenuator and cable loss. Power levels shown in tables below are the maximum that will be used for each type of antenna in 15.203.

Test Results: Equipment was compliant with the Peak Power Output limits of §15.401(a)(1)(ii).

Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15

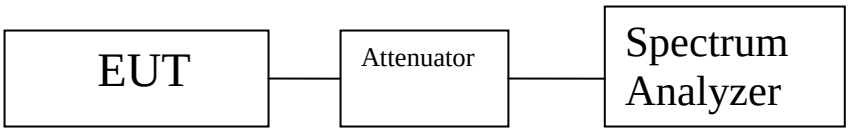


Figure 2. Power Output Test Setup

Average Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11a Port 5GHz	Low	5180	18.79
	Mid	5200	22.42
	High	5240	18.45
802.11n 20 MHz Port 5GHz-Port1	Low	5180	17.55
	Mid	5200	21.31
	High	5240	17.81
802.11n 20 MHz Port 5GHz-Port2	Low	5180	17.98
	Mid	5200	21.45
	High	5240	17.71
802.11n 40MHz Port 5GHz-Port1	Low	5190	13.54
	High	5230	12.80
802.11n 40 MHz Port 5GHz-Port2	Low	5190	14.01
	High	5230	15.10
802.11ac 20 MHz Port 5GHz-Port1	Low	5180	17.02
	Mid	5200	20.99
	High	5240	21.87
802.11ac 20 MHz Port 5GHz-Port2	Low	5180	16.98
	Mid	5200	21.09
	High	5240	20.98
802.11ac 40MHz Port 5GHz-Port1	Low	5190	12.12
	High	5230	20.45
802.11ac 40 MHz Port 5GHz-Port2	Low	5190	13.45
	High	5230	21.41
802.11ac 80MHz Port 5GHz-Port1		5210	12.02
802.11ac 80MHz Port 5GHz-Port2		5210	13.78

Table 11. RF Output Power, Test Results

Summed Average Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11n 20 MHz Summed	Low	5180	20.78
	Mid	5200	24.39
	High	5240	20.77
802.11n 40 MHz Summed	Low	5190	16.79
	High	5230	17.11
802.11ac 20MHz Summed	Low	5180	20.01
	Mid	5200	24.05
	High	5240	24.46
802.11ac 40MHz Summed	Low	5190	15.85
	High	5230	23.97
802.11ac 80MHz Summed	High	5210	16.00

Table 12. RF Output Power, Test Results, Summed Ports

Electromagnetic Compatibility Criteria for Intentional Radiators

§15.407(a)(1)(ii) Peak Power Spectral Density

Test Requirements: **§ 15.407(a)(1)(ii):** In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level on the EUT. The RBW was set to 1MHz and the VBW was set to 3MHz. The method of measurement used was method SA-1 from 789033 D02 General UNII Test Procedures New Rule v01. Plots are correct for attenuators and cable loss.

Test Results: Equipment was compliant with the peak power spectral density limits of §15.407 (a)(1)(ii) The peak power spectral density was determined from plots on the following page(s).

Test Engineer(s): Benjamin Taylor

Test Date(s): 04/02/15

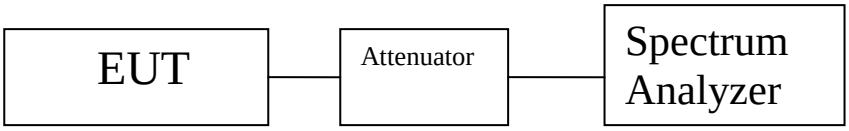


Figure 3. Power Spectral Density Test Setup

Frequency (MHz)	Mode	Port 1 PSD (dBm)	Port 2 PSD (dBm)	Summed PSD (dBm)	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
5180	802.11a 20MHz	11.54	--	11.54	3.20	17.00	-5.46
5200	802.11a 20MHz	13.19	--	13.19	3.20	17.00	-3.81
5240	802.11a 20MHz	13.82	--	13.82	3.20	17.00	-3.18
5180	802.11n 20MHz	6.85	6.98	9.92	3.20	17.00	-7.08
5200	802.11n 20MHz	7.99	6.98	10.52	3.20	17.00	-6.48
5240	802.11n 20MHz	10.23	7.30	12.02	3.20	17.00	-4.98
5190	802.11n 40MHz	8.77	7.04	11.00	3.20	17.00	-6.00
5230	802.11n 40MHz	7.09	6.70	9.91	3.20	17.00	-7.09
5180	802.11ac 20MHz	7.10	7.80	10.48	3.20	17.00	-6.52
5200	802.11ac 20MHz	7.20	7.00	10.11	3.20	17.00	-6.89
5240	802.11ac 20MHz	8.68	7.275	11.04	3.20	17.00	-5.96
5190	802.11ac 40MHz	9.90	9.709	12.81	3.20	17.00	-4.19
5230	802.11ac 40MHz	9.72	9.401	12.57	3.20	17.00	-4.43
5210	802.11ac 80MHz	8.648	6.792	10.8287	3.20	17.00	-6.1713

Table 13. Peak Power Spectral Density, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§15.407(b)(1), §15.407(b)(6), & §15.407(b)(7) Undesirable Emissions

Test Requirements: **§15.407(b)(1), § 15.407(b)(6), § 15.407(b)(7); §15.205:** Emissions outside the frequency band.

§15.407(b)(1): For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of –27 dBm/MHz.

§15.407(b)(6): Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in Section 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in Section 15.207.

§15.407(b)(7): The provisions of Section 15.205 of this part apply to intentional radiators operating under this section.

Test Procedure: The transmitter was placed on an 80cm wooden table inside in a semi-anechoic chamber. Measurements were performed with the EUT rotated 360 degrees and varying the adjustable antenna mast height to determine worst case orientation for maximum emissions. A preamp was used in the range from 7-18GHz to improve noise floor. Plots were corrected for cable loss, antenna, and preamp gain.

For frequencies from 30 MHz to 1 GHz, measurements were made using a quasi-peak detector with a 120 kHz bandwidth. The procedure was used for average.

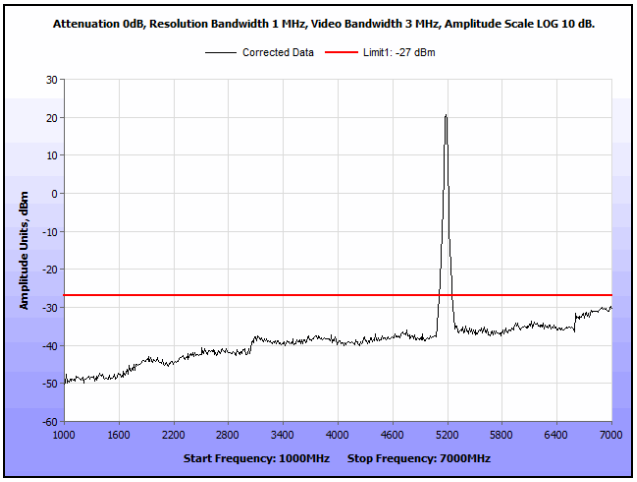
For measurements above 1 GHz, measurements were made with a Peak detector with 1 MHz resolution bandwidth. A notch filter was use to filter out the transmitting channel. Where the spurious emissions fell into a restricted band, measurements were also made with an average detector to make sure they complied with 15.209 limits. Only noise floor was seen above 18 GHz. Worst case emissions shown by antenna.

Test Results: The EUT was compliant with the Radiated Emission limits for Intentional Radiators. See following pages for detailed test results. All emissions above 18 GHz were at the noise floor of the receiver.

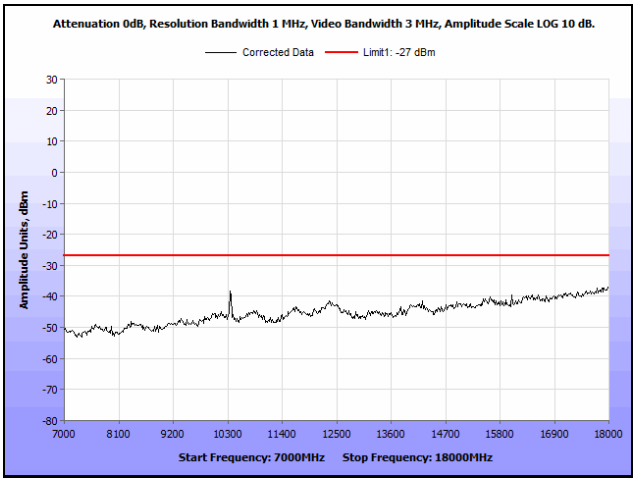
Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15

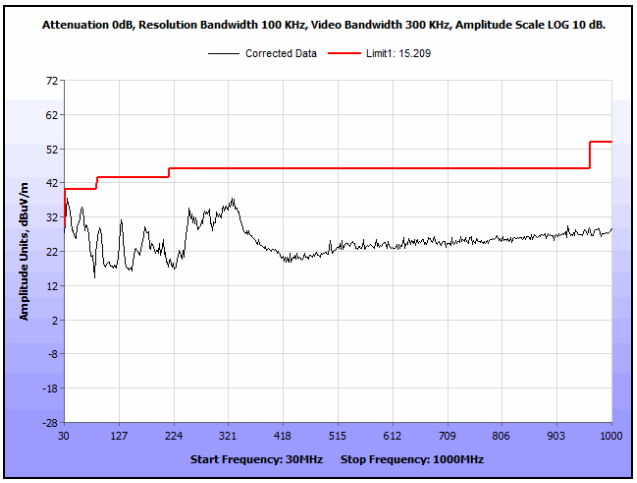
Radiated Spurious Emissions



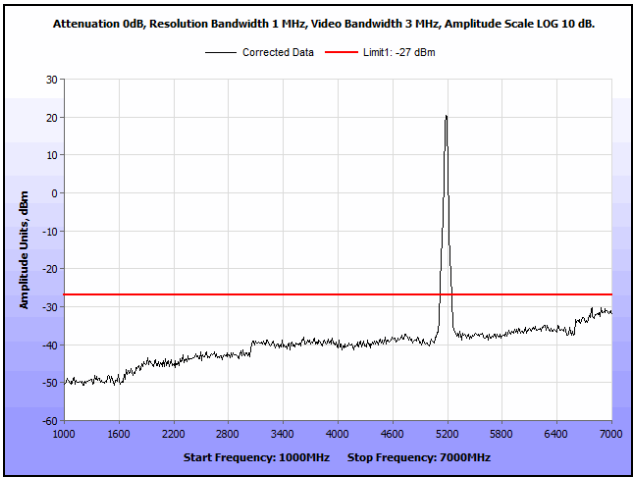
Plot 17. Radiated Spurious Emissions, 5180 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



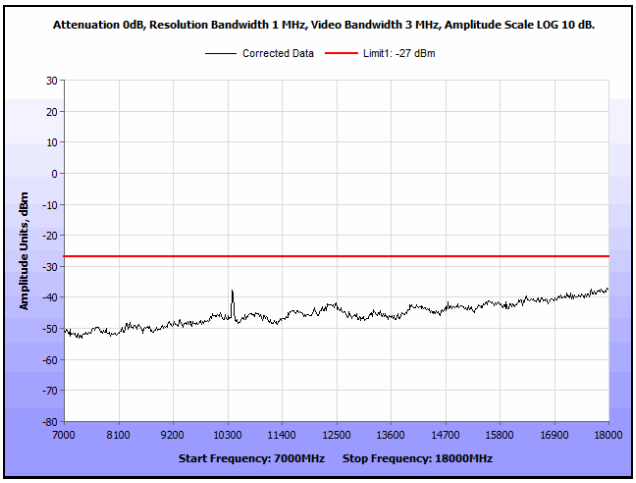
Plot 18. Radiated Spurious Emissions, 5180 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



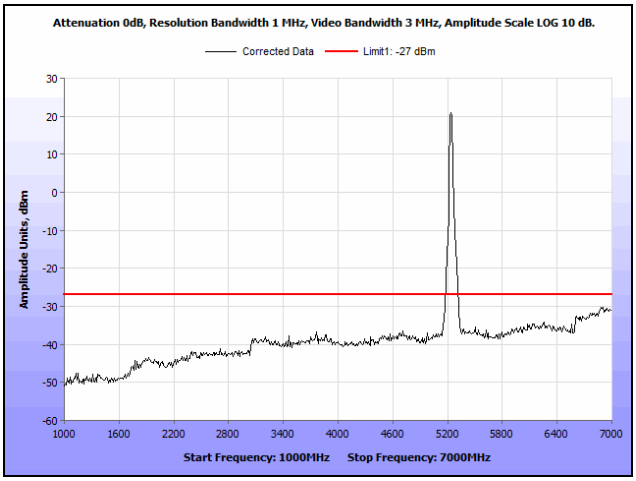
Plot 19. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 30 MHz – 1 GHz



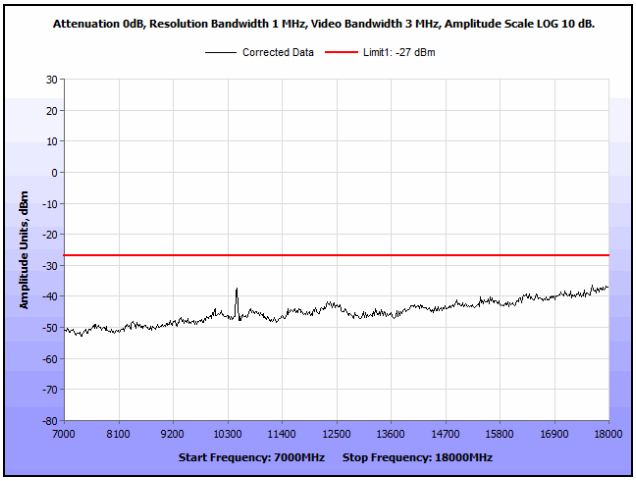
Plot 20. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



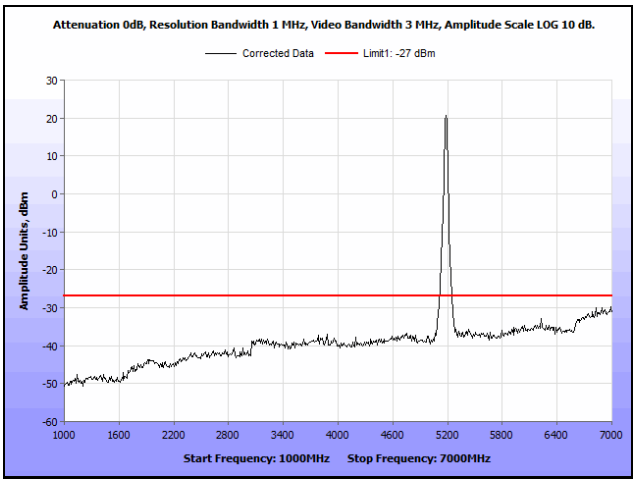
Plot 21. Radiated Spurious Emissions, 5200 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



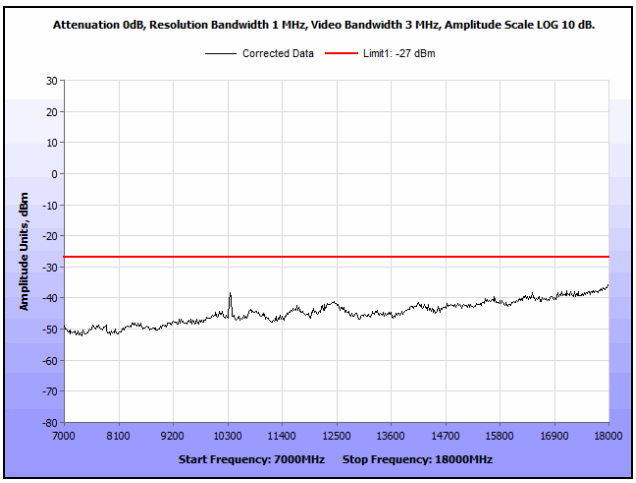
Plot 22. Radiated Spurious Emissions, 5240 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



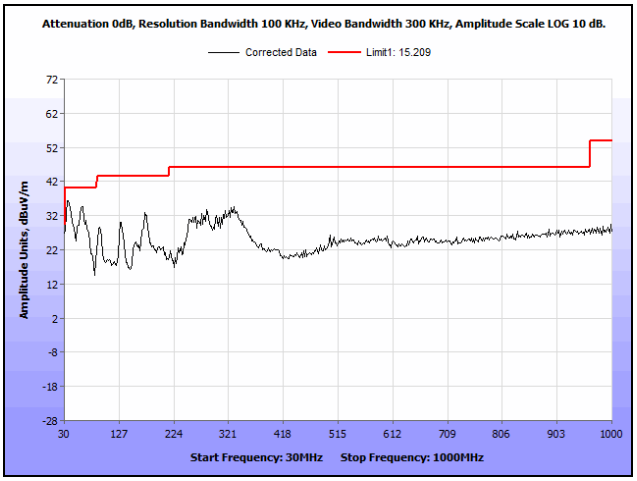
Plot 23. Radiated Spurious Emissions, 5240 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



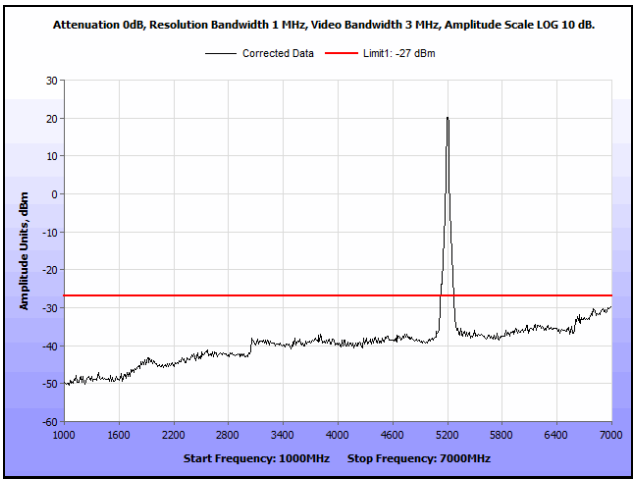
Plot 24. Radiated Spurious Emissions, 5180 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



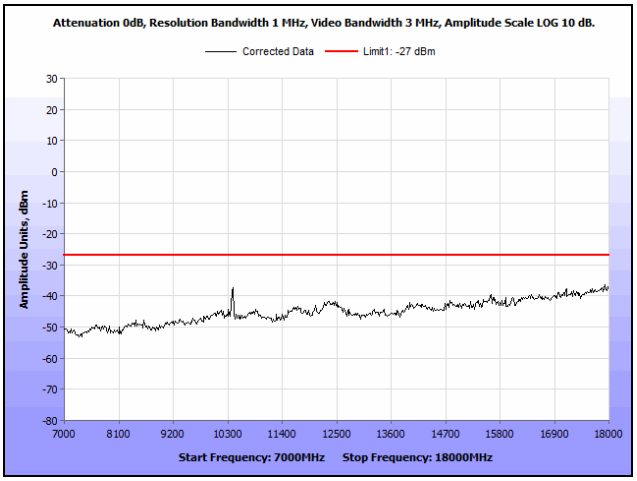
Plot 25. Radiated Spurious Emissions, 5180 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



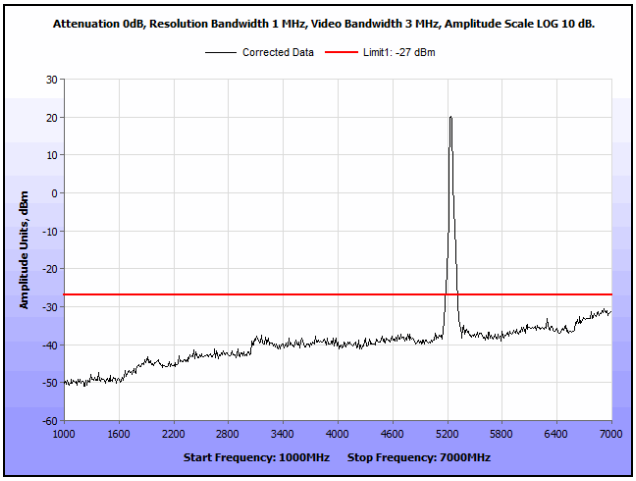
Plot 26. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 30 MHz – 1 GHz



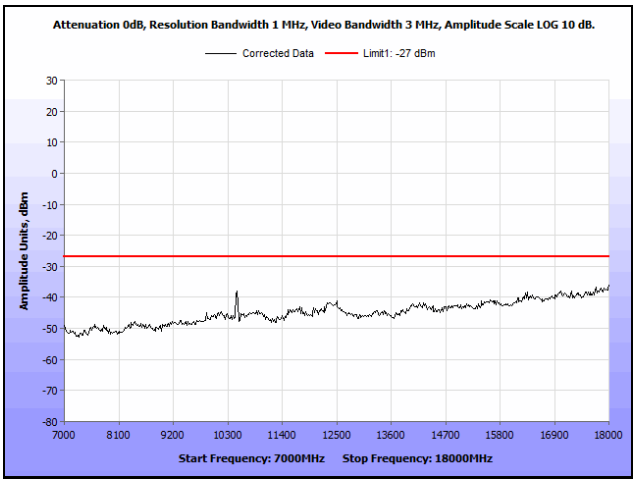
Plot 27. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



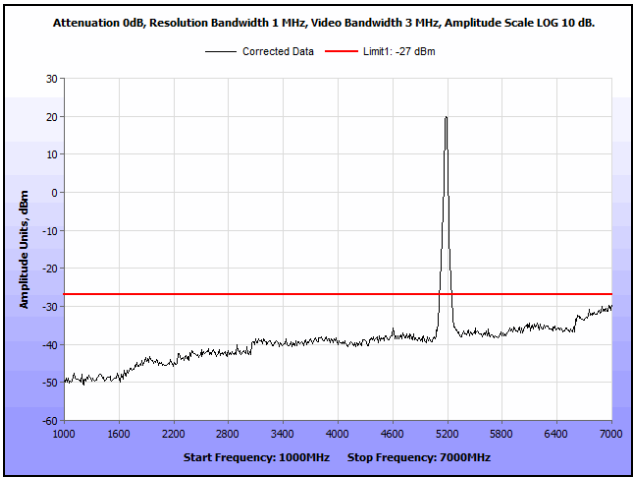
Plot 28. Radiated Spurious Emissions, 5200 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



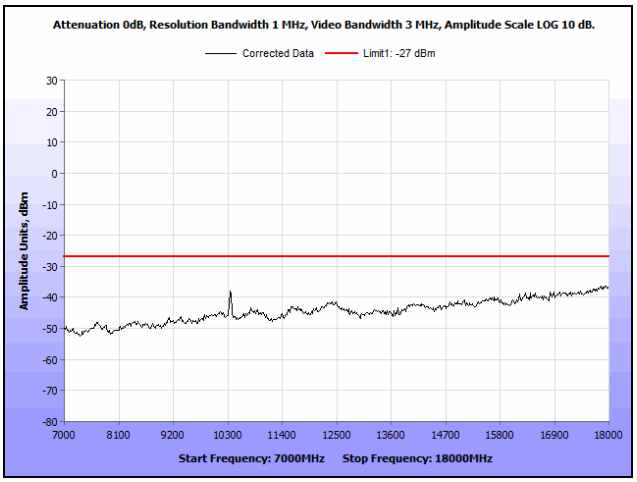
Plot 29. Radiated Spurious Emissions, 5240 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



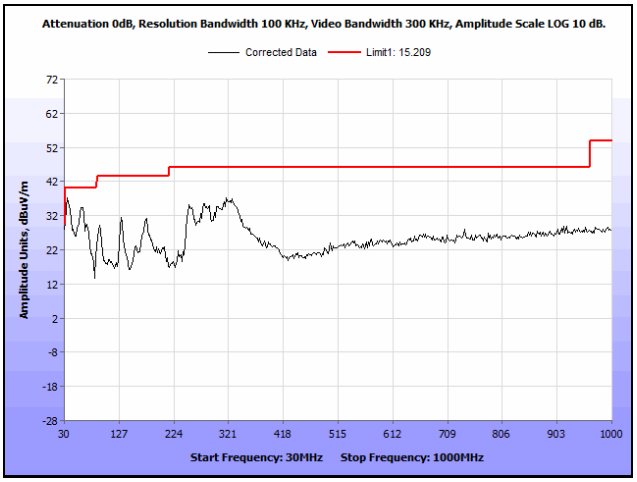
Plot 30. Radiated Spurious Emissions, 5240 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



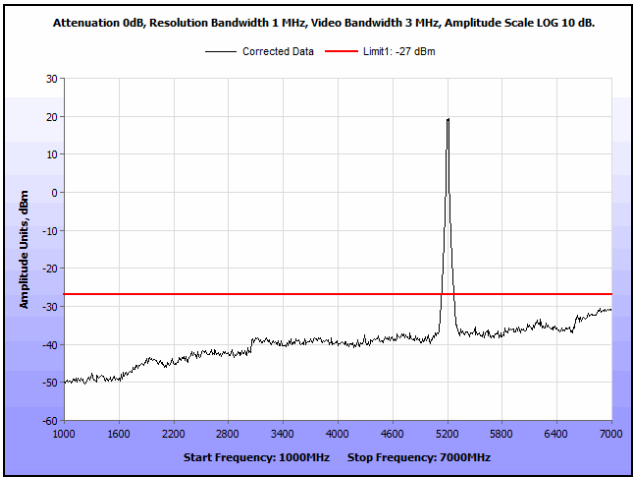
Plot 31. Radiated Spurious Emissions, 5180 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



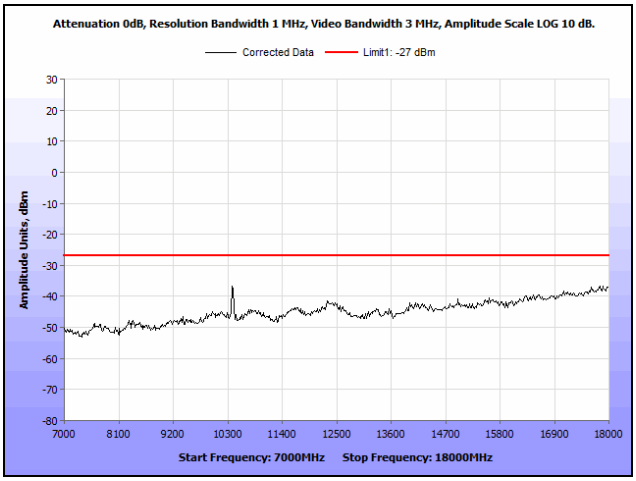
Plot 32. Radiated Spurious Emissions, 5180 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



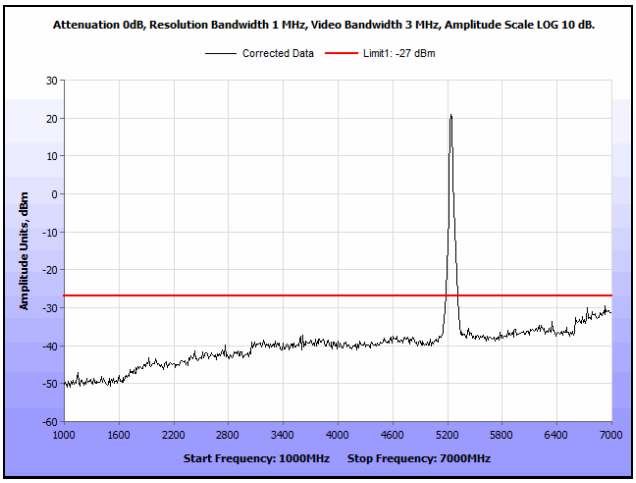
Plot 33. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 30 MHz – 1 GHz



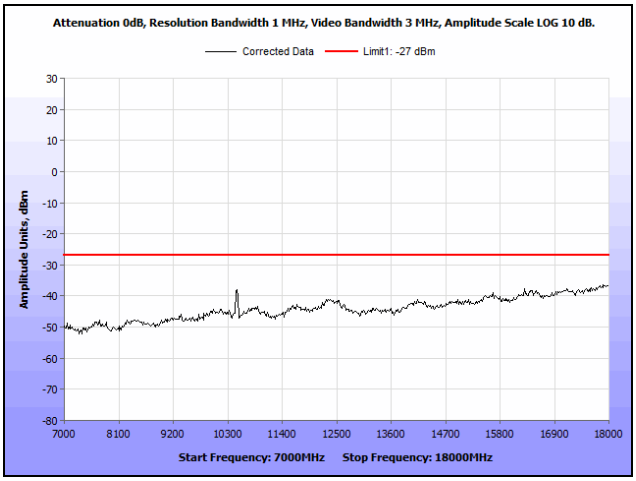
Plot 34. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



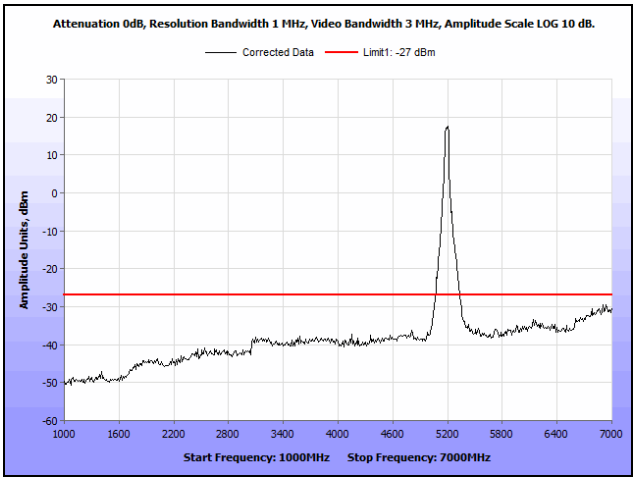
Plot 35. Radiated Spurious Emissions, 5200 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



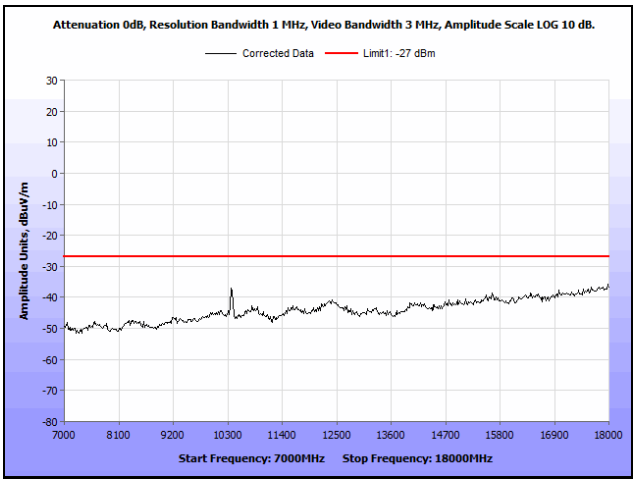
Plot 36. Radiated Spurious Emissions, 5240 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



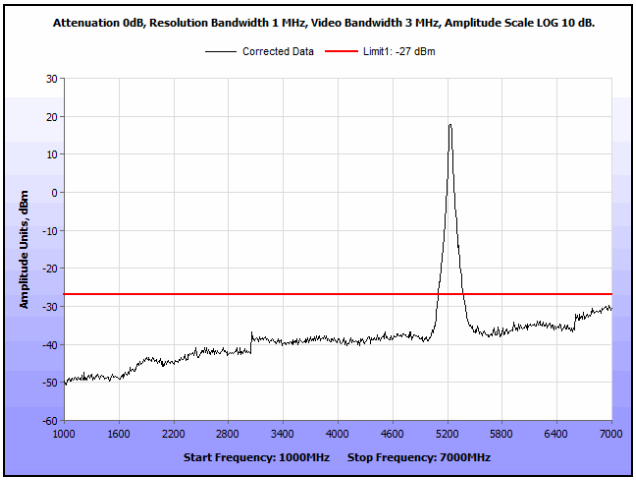
Plot 37. Radiated Spurious Emissions, 5240 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



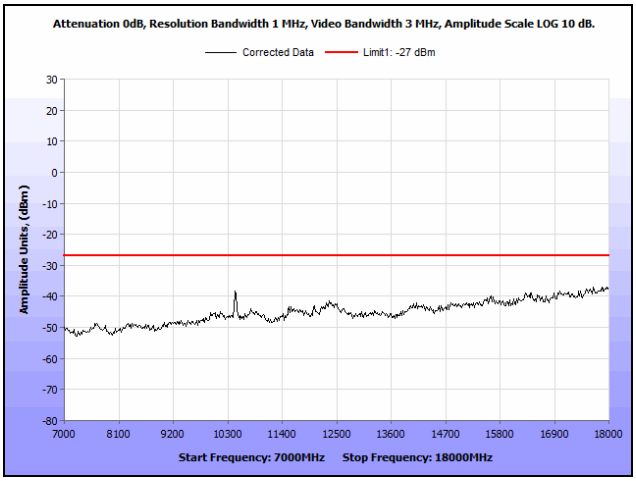
Plot 38. Radiated Spurious Emissions, 5190 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



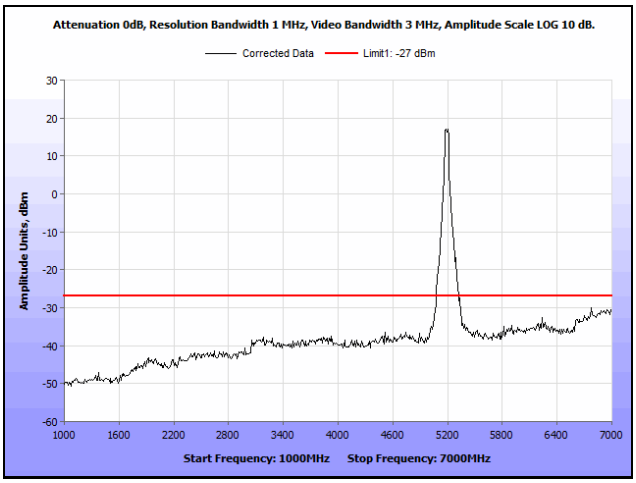
Plot 39. Radiated Spurious Emissions, 5190 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



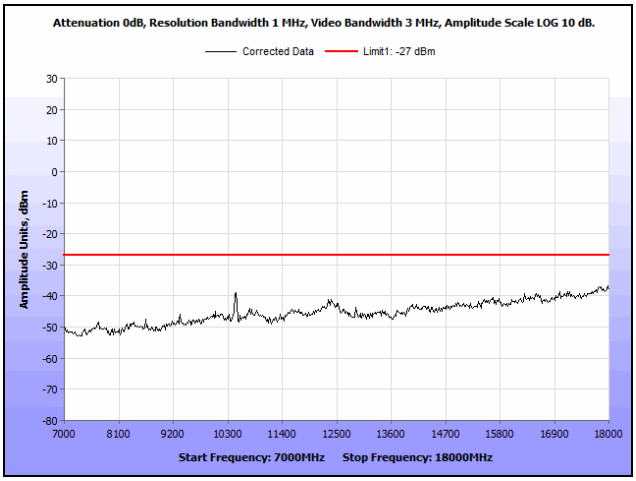
Plot 40. Radiated Spurious Emissions, 5230 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



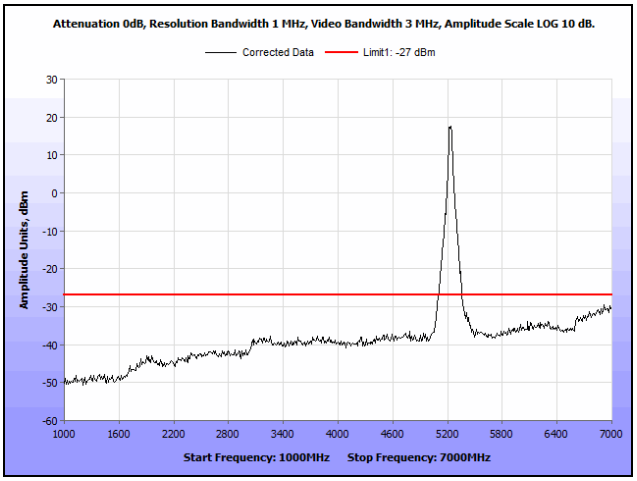
Plot 41. Radiated Spurious Emissions, 5230 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



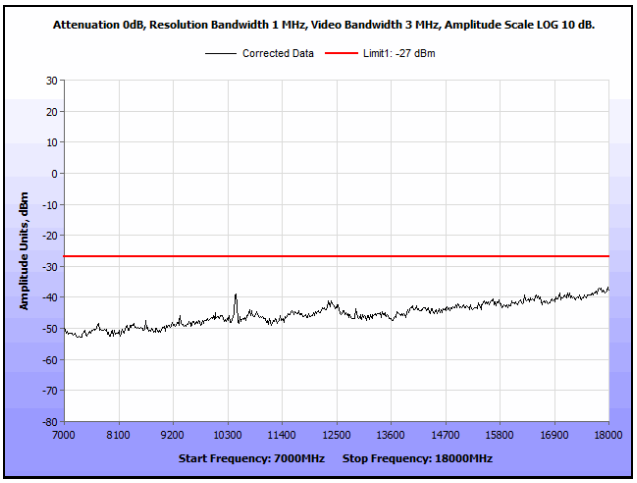
Plot 42. Radiated Spurious Emissions, 5190 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



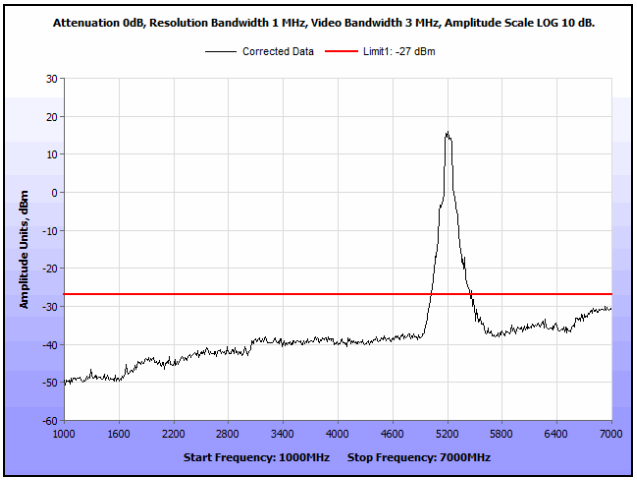
Plot 43. Radiated Spurious Emissions, 5190 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



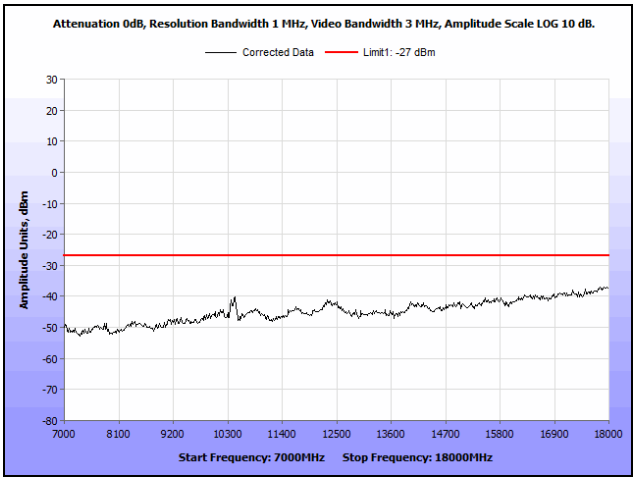
Plot 44. Radiated Spurious Emissions, 5230 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



Plot 45. Radiated Spurious Emissions, 5230 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz

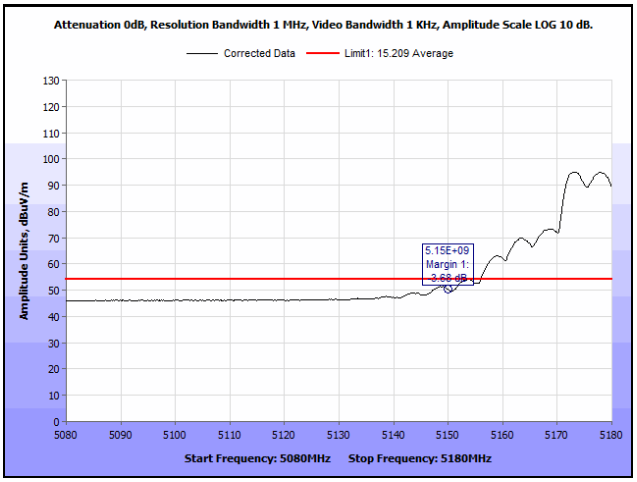


Plot 46. Radiated Spurious Emissions, 5210 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz

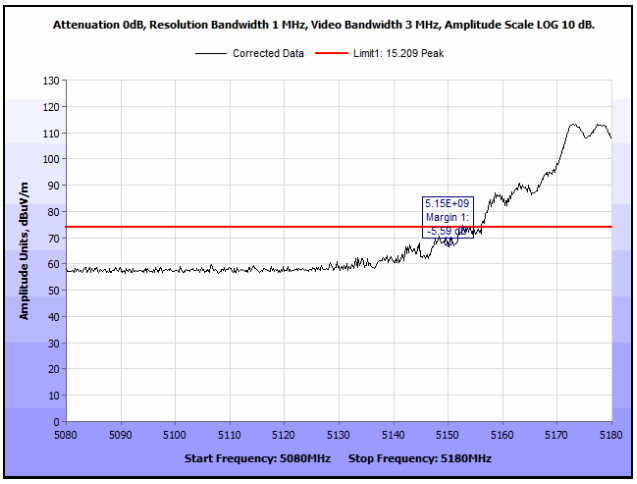


Plot 47. Radiated Spurious Emissions, 5210 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz

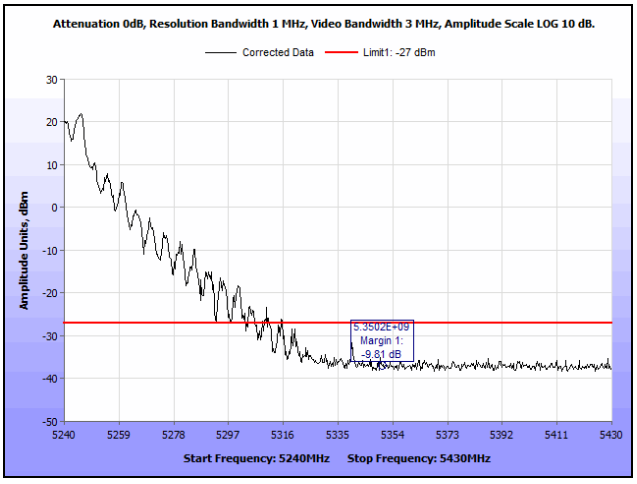
Radiated Band Edge



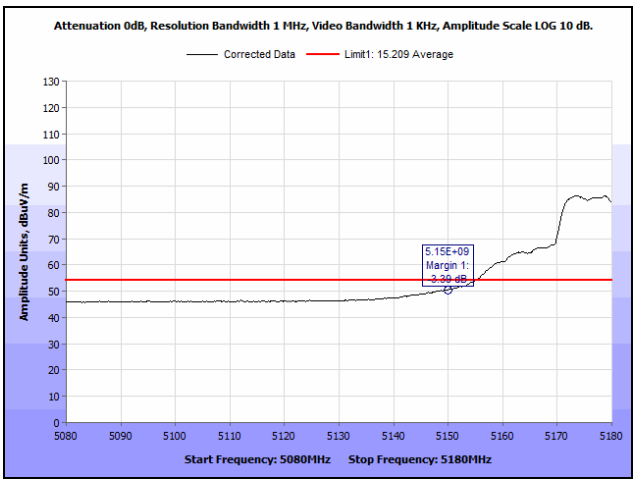
Plot 48. Radiated Band Edge, 802.11a, 5180 MHz @ 5150 MHz, Average



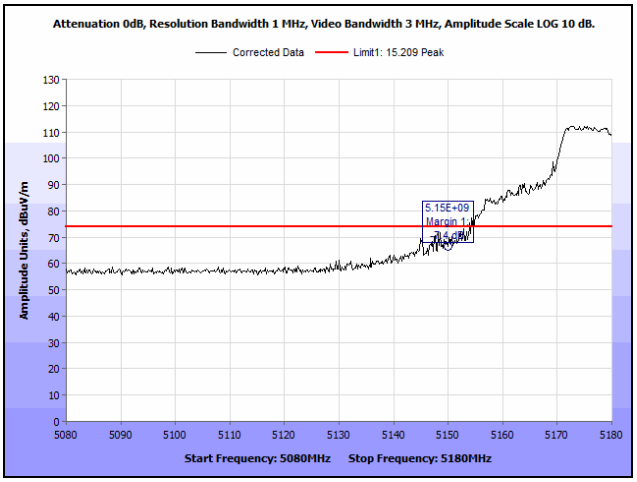
Plot 49. Radiated Band Edge, 802.11a, 5180 MHz @ 5150 MHz, Peak



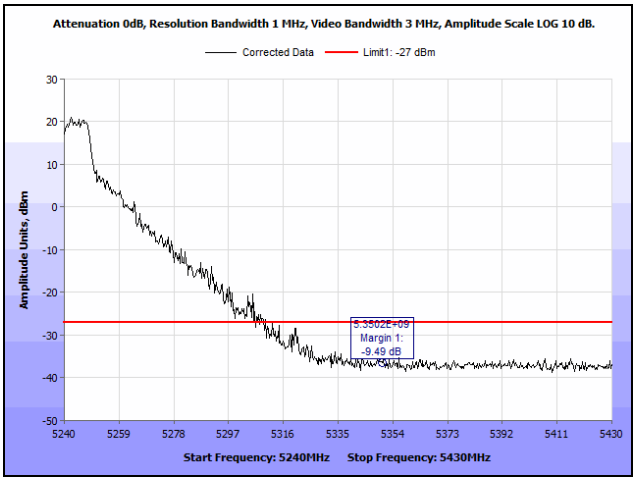
Plot 50. Radiated Band Edge, 802.11a, 5240 MHz @ 5350 MHz



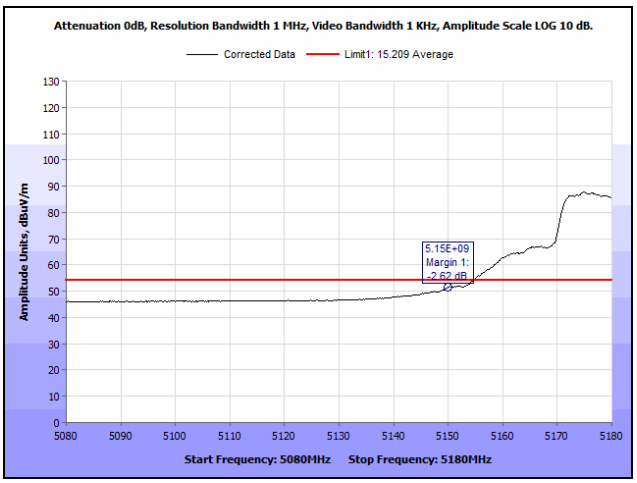
Plot 51. Radiated Band Edge, 802.11ac 20 MHz, 5180 MHz @ 5150 MHz, Average



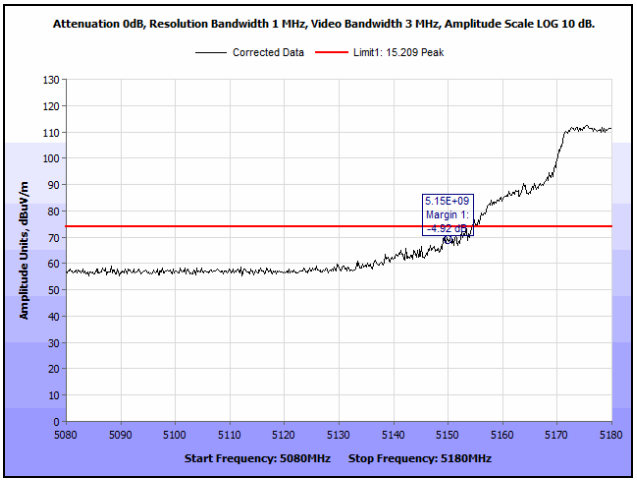
Plot 52. Radiated Band Edge, 802.11ac 20 MHz, 5180 MHz @ 5150 MHz, Peak



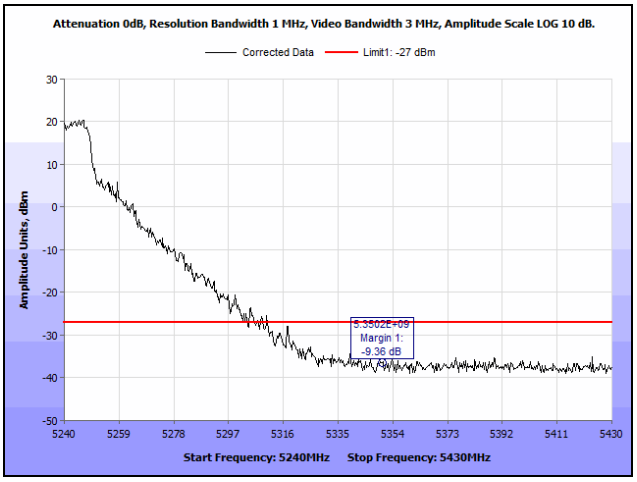
Plot 53. Radiated Band Edge, 802.11ac 20 MHz, 5240 MHz @ 5350 MHz



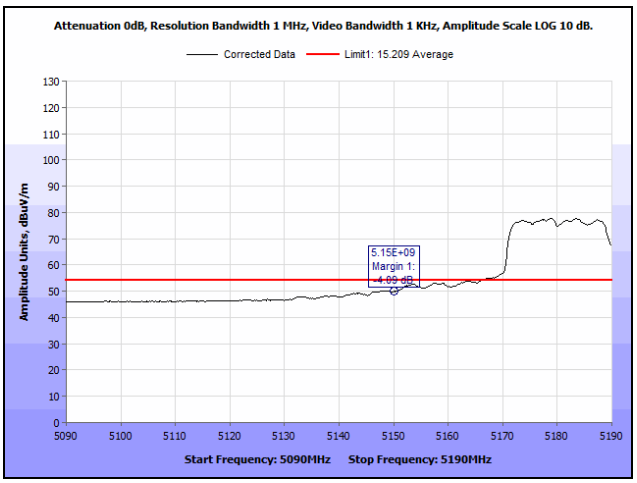
Plot 54. Radiated Band Edge, 802.11n 20 MHz, 5180 MHz @ 5150 MHz, Average



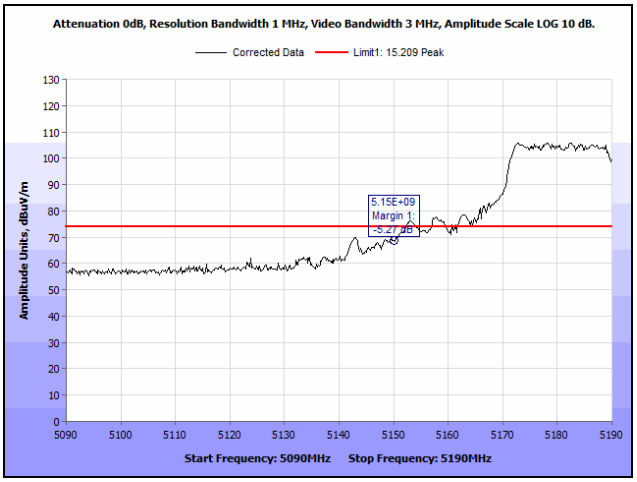
Plot 55. Radiated Band Edge, 802.11n 20 MHz, 5180 MHz @ 5150 MHz, Peak



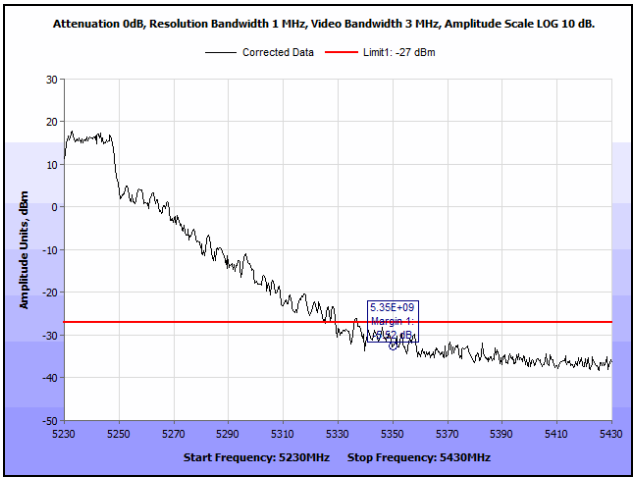
Plot 56. Radiated Band Edge, 802.11n 20 MHz, 5240 MHz @ 5350 MHz



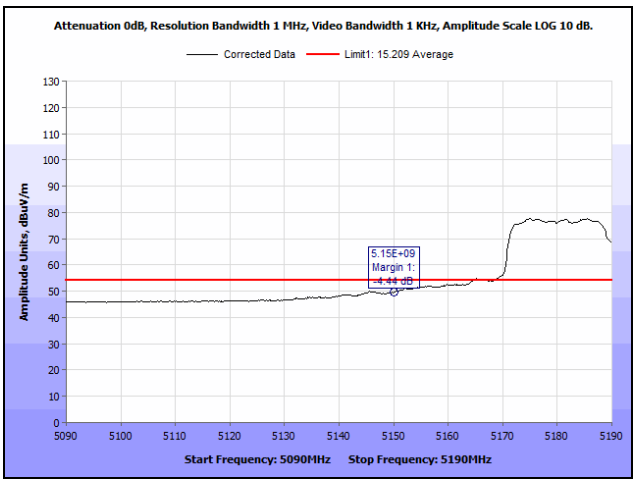
Plot 57. Radiated Band Edge, 802.11ac 40 MHz, 5190 MHz @ 5150 MHz, Average



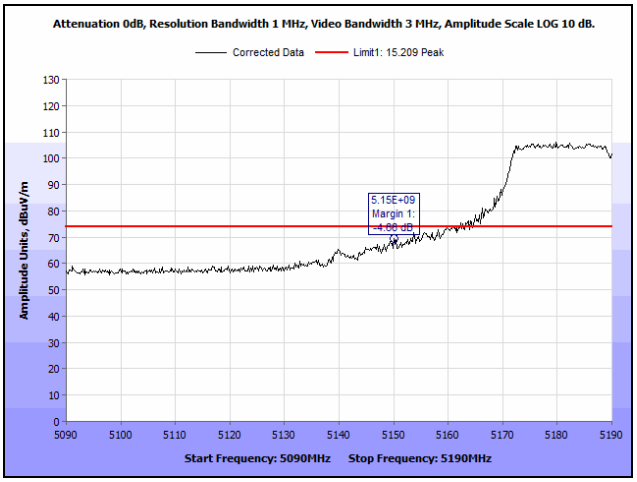
Plot 58. Radiated Band Edge, 802.11ac 40 MHz, 5190 MHz @ 5150 MHz, Peak



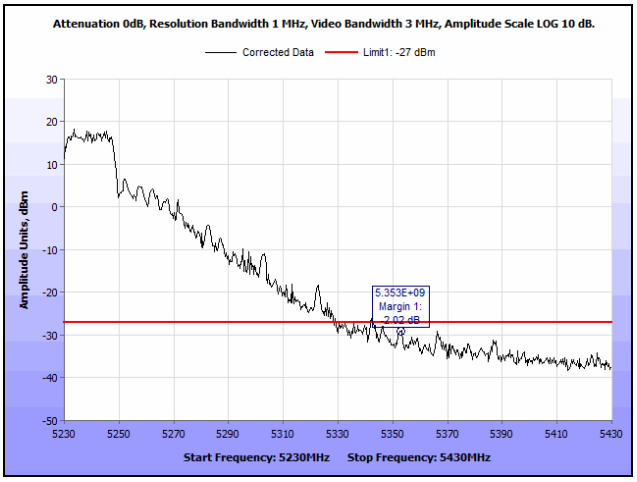
Plot 59. Radiated Band Edge, 802.11ac 40 MHz, 5230 MHz @ 5350 MHz



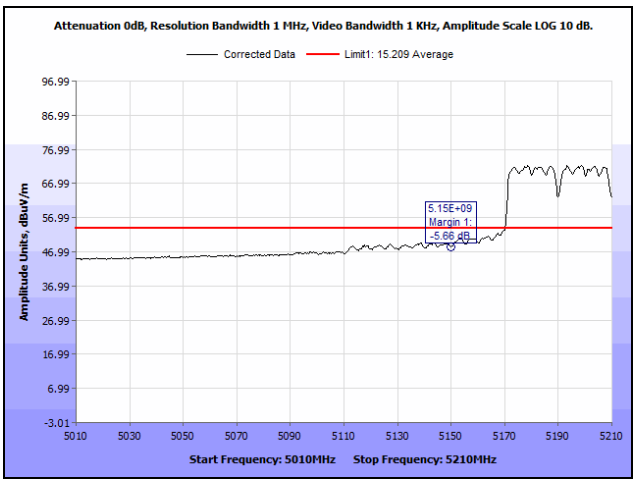
Plot 60. Radiated Band Edge, 802.11n 40 MHz, 5190 MHz @ 5150 MHz, Average



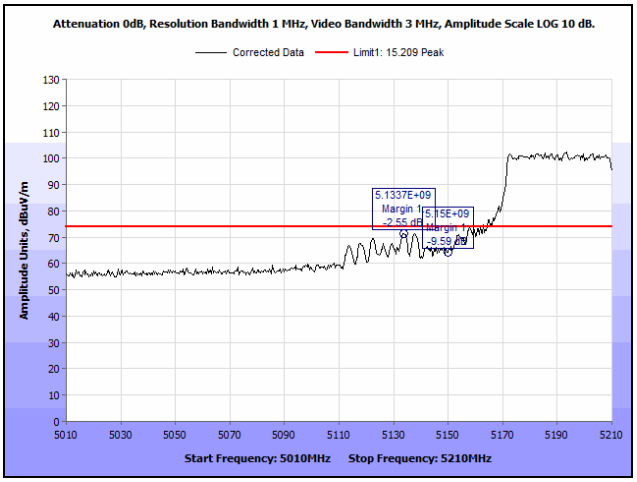
Plot 61. Radiated Band Edge, 802.11n 40 MHz, 5190 MHz @ 5150 MHz, Peak



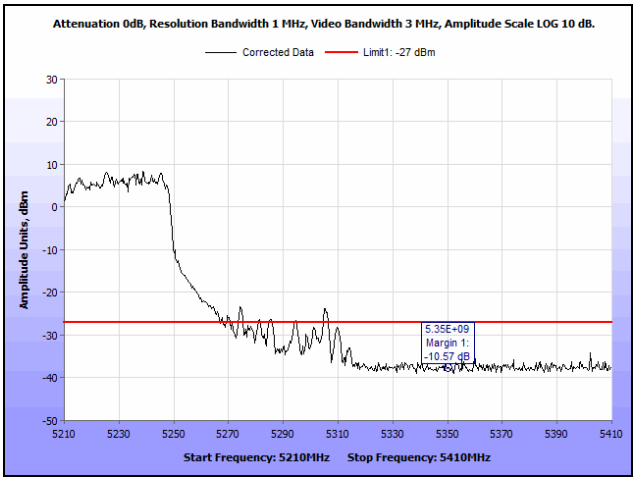
Plot 62. Radiated Band Edge, 802.11n 40 MHz, 5230 MHz @ 5350 MHz



Plot 63. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5150 MHz, Average



Plot 64. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5150 MHz, Peak



Plot 65. Radiated Band Edge, 802.11ac 80 MHz, 5210 MHz @ 5350 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(f) RF 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 @ 5150-5250 MHz; **Limit for Uncontrolled exposure: 1 mW/cm^2 or 10 W/m^2**

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

$$S = PG / 4\pi R2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density
P = Power Input to antenna=24.46 dBm (279.254 mW)
G = Antenna Gain 3.2 dBi (2.09 linear)
R = Minimum Distance between User and Antenna (20cm)

$$S = (2.09*2.09*279.254)/(4*3.14*400) = 0.243 \text{ mW/cm2}$$

Since S < 1 mW/cm2, the minimum distance (R) is 20cm

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 #	Equipment	Manufacturer	Model#	Cal Date	Cal Due
1S2607	SPECTRUM ANALYZER ESA-E	AGILENT/HEWLETT PACKARD	E4407B	3/23/2016	9/23/2017
1T4564	LISN (24 AMP)	SOLAR ELECTRONICS COMPANY	9252-50-R-24-BNC	7/22/2016	7/22/2017
1T4504	SHIELDED ROOM	UNIVERSAL SHIELDING CORP	N/A	NOT REQUIRED	
1T4859	DIGITAL BAROMETER, HYGROMETER, THERMOMETER	CONTROL COMPANY	15-078-198, FB70423, 245CD	2/10/2016	2/10/2018
1S2421	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESIB7	12/31/2015	12/31/2016
1T4751	ANTENNA - BILOG	SUNOL SCIENCES	JB6	2/26/2016	8/26/2017
1T4771	PSA SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4446A	8/10/2016	2/10/2018
1T4483	ANTENNA; HORN	ETS-LINDGREN	3117	10/8/2015	4/8/2017
1T4565	LISN (24 AMP)	SOLAR ELECTRONICS COMPANY	9252-50-R-24-BNC	7/25/2016	7/25/2017

Table 14. Test Equipment List

V. Certification & User's Manual Information

Certification & User's Manual Information

L. 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

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.