



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

914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230-3432 • PHONE (410) 354-3300 • FAX (410) 354-3313

33439 WESTERN AVENUE • UNION CITY, CALIFORNIA 94587 • PHONE (510) 489-6300 • FAX (510) 489-6372

3162 BELICK STREET • SANTA CLARA, CALIFORNIA 95054 • PHONE (408) 748-3585 • FAX (510) 489-6372

13501 MCCALLEN PASS • AUSTIN, TX 78753 • PHONE (512) 287-2500 • FAX (512) 287-2513

July 15, 2015

Airvana
250 Apollo Drive
Chelmsford, MA 01824

Dear Gary Falk,

Enclosed is the EMC Wireless test report for compliance testing of the Airvana, Small Cell Type 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 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: (\Airvana\EMC85068-FCC407 UNII 2 Rev. 1)

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Electromagnetic Compatibility Criteria Test Report

for the

**Airvana
Small Cell Type**

Tested under

the Certification Rules
contained in

Title 47 of the CFR, Part 15, Subpart B
for Unintentional Radiators
and

Title 47 of the CFR, Part 15.407
for Intentional Radiators

MET Report: EMC85068-FCC407 UNII 2 Rev. 1

July 15, 2015

Prepared For:

**Airvana
250 Apollo Drive
Chelmsford, MA 01824**

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

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Title 47 of the CFR, Part 15.407
for Intentional Radiators



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
Ø	June 29, 2015	Initial Issue.
1	July 15, 2015	Engineer corrections.

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List of Terms and Abbreviations

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

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Airvana Small Cell Type, 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 Type. Airvana 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 Type, 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 Airvana, purchase order number 52229. 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)(2)	Conducted Transmitter Output Power	Compliant
15.407 (a)(2)	Power Spectral Density	Compliant
15.407 (b)(2), (3), (5), (6)	Undesirable Emissions (15.205/15.209 – General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Compliant
15.407(f)	RF Exposure	Compliant
15.407(h)(2)	DFS Channel Bandwidth	Compliant
15.407 (h)(2)(ii)	Initial Channel Availability Check Time (CACT)	Compliant
15.407 (h)(2)(ii)	Radar Burst at the Beginning of CACT	Compliant
15.407 (h)(2)(ii)	Radar Burst at the End of CACT	Compliant
15.407 (h)(2)(iii)	Channel Move and Closing Time	Compliant
15.407 (h)(2)(iv)	Non-Occupancy Period	Compliant
15.407 (h)(2)	Statistical Performance Check	Compliant

Table 1. Executive Summary of EMC Part 15.407 Compliance Testing

II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by Airvana to perform testing on the Small Cell Type, under Airvana's purchase order number 52229.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Airvana Small Cell Type.

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

Model(s) Tested:	Small Cell Type		
Model(s) Covered:	Small Cell Type		
EUT Specifications:	Primary Power: 120 VAC, 60 Hz		
	FCC ID: QHY-S1000-RP		
	Type of Modulations:	OFDM	
	Equipment Code:	NII	
	Peak RF Output Power:	23.90 dBm	
	EUT Frequency Ranges:	5260 – 5320 MHz 5500-5700 MHz	
Analysis:	The results obtained relate only to the item(s) tested.		
Environmental Test Conditions:	Temperature: 15-35° C		
	Relative Humidity: 30-60%		
	Barometric Pressure: 860-1060 mbar		
Evaluated by:	Djed Mouada and Benjamin Taylor		
Report Date(s):	July 15, 2015		

Table 2. EUT Summary

B. References

CFR 47, Part 15, Subpart E	Unlicensed National Information Infrastructure Devices (UNII)
ANSI C63.4:2003	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2009	American National Standard for Testing Unlicensed Wireless Devices
KDB 789033 D02	D02 General UNII Test Procedures New Rules v01

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 Airvana Small Cell Type, Equipment Under Test (EUT), is a small cell intended for small to medium size business and residential application. The EUT has uncorrelated data streams.

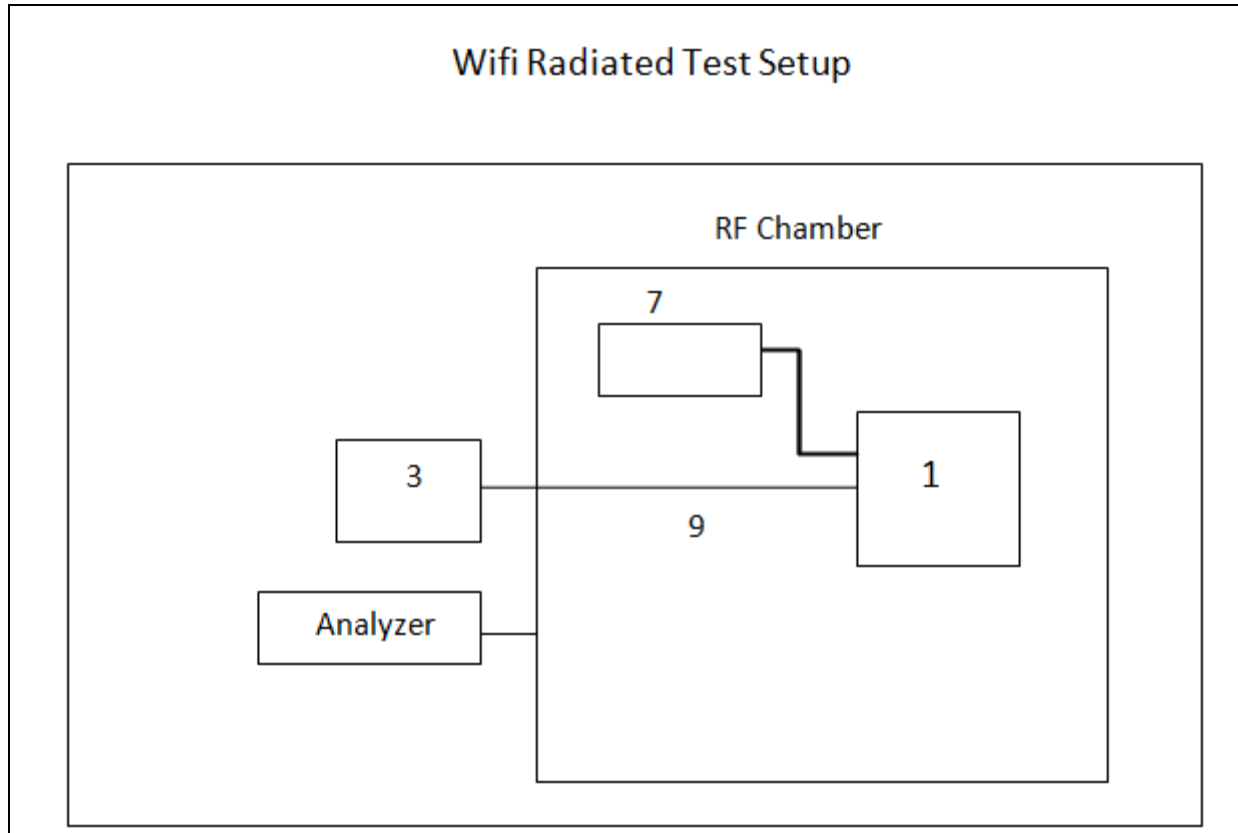


Figure 1. Block Diagram of Test Configuration

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	Serial Number	Revision
1	NSC	--	800238	15046000032	--
7	MLF AC Adapter	--	(MLF -A0030120250000051)	--	--

Table 4. Equipment Configuration

F. Support Equipment

Airvana supplied support equipment necessary for the operation and testing of the Small Cell Type. All support equipment supplied is listed in the following Support Equipment List.

Ref. ID	Name / Description	Manufacturer	Model Number
3	Laptop (Airvana 02682)	Dell	Latitude 6410
4	Laptop (NTQALAPXP2)	Dell	Vostro 1510
5	AC Adapter for Dell Latitude 6410	Dell	DA130PE1-00
6	AC Adapter for Dell Vostro 1510	Dell	DA90PM130

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
8	Power Port (J10)	--	1	--	--	--
9	Ethernet Port (J1204/5)	--	2	--	--	--
10	Console Port (J1323)	--	1	--	--	--

Table 6. Ports and Cabling Information

H. Mode of Operation

2.4GHz - transmitter modes of operation supported:

1. 802.11 b (22MHz BW – CCK modulation)
2. 802.11g (20MHz BW – OFDM modulation)
3. 802.11 n (20 and 40MHz bandwidth, OFDM modulation)

5 GHz

1. 802.11n (20 and 40MHz bandwidth OFDM modulation)
2. 802.11ac (20, 40 and 80MHz bandwidths – BPSK, QPSK, 16QAM, 64QAM, 256QAM modulation)
3. DFS supported

Band 41 licensed spectrum LTE – Not being tested.

EMC testing is not being done.

I. Method of Monitoring EUT Operation

1. ART has software to support all operating modes. Console port access to laptops is supplied with scripts to set and monitor modes.
2. Same as above. Software will be monitored.

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 Airvana 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 Conducted Emissions Limits

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

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

Table 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 μ H 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 μ H 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.

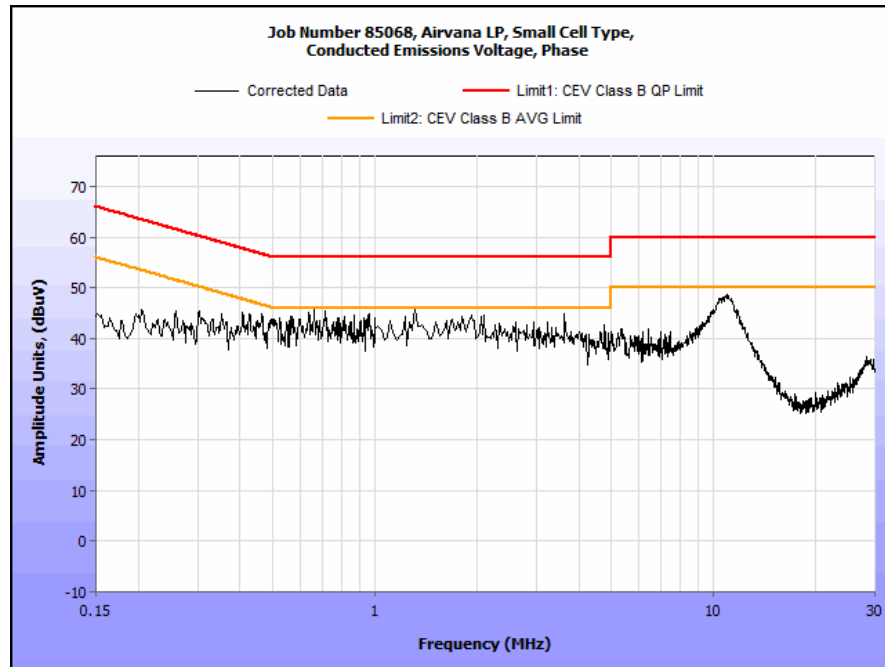
Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15

15.207(a) Conducted Emissions Test Results

Frequency (MHz)	Uncorrected Meter Reading (dBμV) QP	Cable Loss (dB)	Corrected Measurement (dBμV) QP	Limit (dBμV) QP	Margin (dB) QP	Uncorrected Meter Reading (dBμV) Avg.	Cable Loss (dB)	Corrected Measurement (dBμV) AVG	Limit (dBμV) AVG	Margin (dB) AVG
0.248	43.61	0	43.61	79	-35.39	38.98	0	38.98	66	-27.02
0.441	45.19	0	45.19	79	-33.81	43.24	0	43.24	66	-22.76
0.559	49.51	0	49.51	73	-23.49	42.56	0	42.56	60	-17.44
1.32	48.68	0	48.68	73	-24.32	40.91	0	40.91	60	-19.09
5.67	49.12	0.17	49.29	73	-23.71	43.95	0.17	44.12	60	-15.88
11.91	50.5	0.17	50.67	73	-22.33	44.17	0.17	44.34	60	-15.66

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

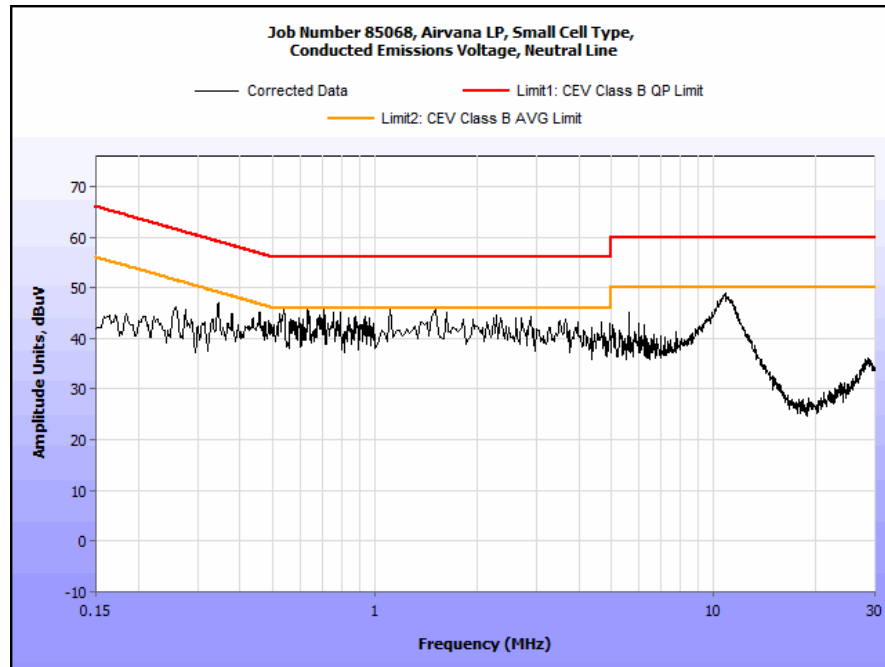


Plot 1. Conducted Emissions, 15.207(a), Phase Line

15.207(a) Conducted Emissions Test Results

Frequency (MHz)	Uncorrected Meter Reading (dBμV) QP	Cable Loss (dB)	Corrected Measurement (dBμV) QP	Limit (dBμV) QP	Margin (dB) QP	Uncorrected Meter Reading (dBμV) Avg.	Cable Loss (dB)	Corrected Measurement (dBμV) AVG	Limit (dBμV) AVG	Margin (dB) AVG
0.249	42.56	0	42.56	79	-36.44	39.45	0	39.45	66	-26.55
0.339	46.18	0	46.18	79	-32.82	42.34	0	42.34	66	-23.66
0.541	48.65	0	48.65	73	-24.35	41.57	0	41.57	60	-18.43
1.29	49.63	0	49.63	73	-23.37	41.54	0	41.54	60	-18.46
5.68	48.6	0.17	48.77	73	-24.23	41.6	0.17	41.77	60	-18.23
11.99	49.66	0.17	49.83	73	-23.17	45.45	0.17	45.62	60	-14.38

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

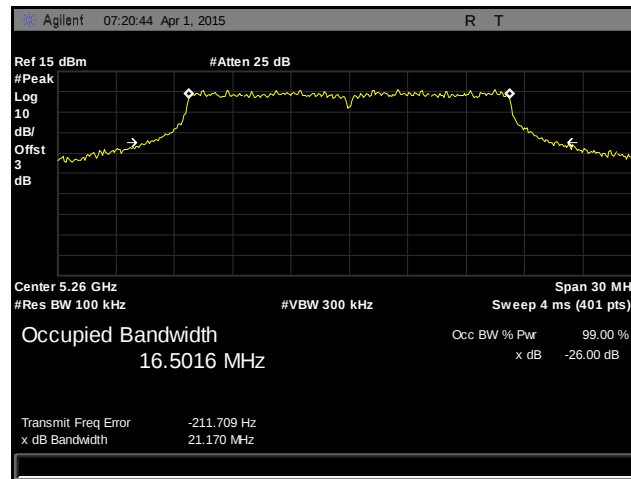


Figure 2. Occupied Bandwidth, Test Setup

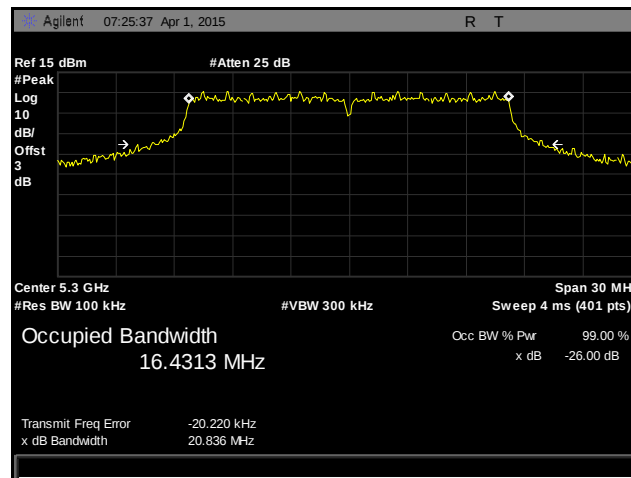
Occupied Bandwidth		
Carrier Channel Mode	Frequency (MHz)	Measured 26 dB Bandwidth (MHz)
802.11a 20MHz	5260	21.170
802.11a 20MHz	5300	20.836
802.11a 20MHz	5320	20.086
802.11ac 20MHz	5260	20.079
802.11ac 20MHz	5300	20.256
802.11ac 20MHz	5320	20.816
802.11n 20MHz	5260	20.993
802.11n 20MHz	5300	20.261
802.11n 20MHz	5320	20.795
802.11ac 40MHz	5270	43.791
802.11ac 40MHz	5310	43.442
802.11n 40MHz	5270	42.784
802.11n 40MHz	5310	42.045
802.11ac 80MHz	5290	88.768
802.11a 20MHz	5500	19.462
802.11a 20MHz	5580	19.540
802.11a 20MHz	5700	19.074
802.11ac 20MHz	5500	20.037
802.11ac 20MHz	5580	20.481
802.11ac 20MHz	5700	20.023
802.11n 20MHz	5500	20.525
802.11n 20MHz	5580	20.910
802.11n 20MHz	5700	20.499
802.11ac 40 MHz	5510	42.015
802.11ac 40 MHz	5550	42.987
802.11ac 40 MHz	5670	43.009
802.11n 40MHz	5510	42.471
802.11n 40MHz	5550	41.964
802.11n 40MHz	5670	42.271
802.11ac 80MHz	5530	95.117
802.11ac 80MHz	5610	94.403

Table 10. Occupied Bandwidth Test Results

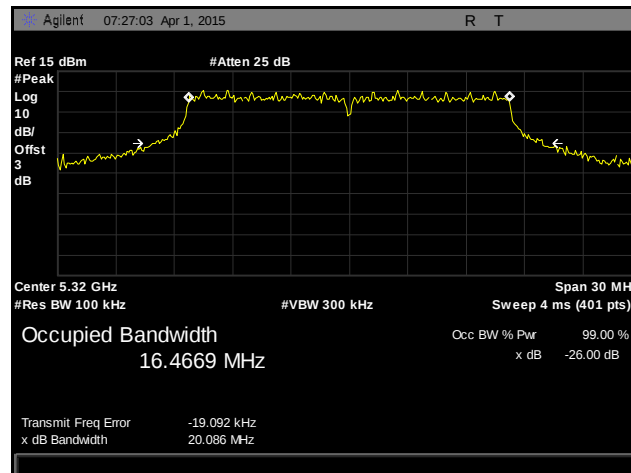
Occupied Bandwidth Test Results



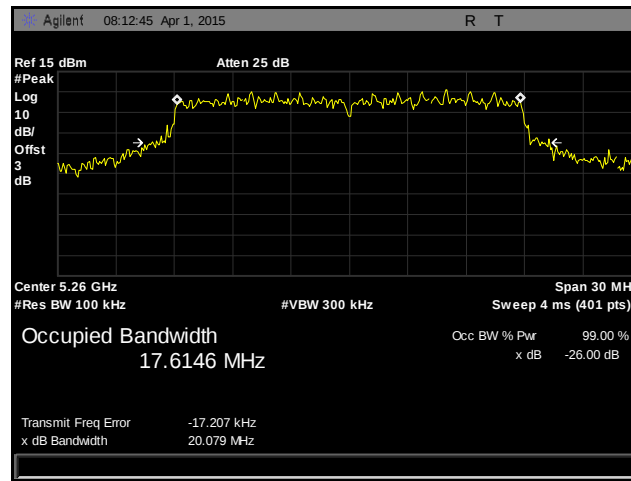
Plot 3. Occupied Bandwidth, 802.11a 20 MHz, Low Channel, 5260 MHz, Port A



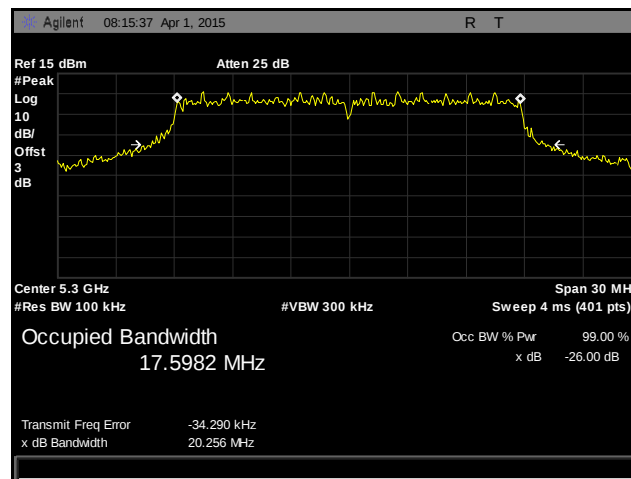
Plot 4. Occupied Bandwidth, 802.11a 20 MHz, Mid Channel, 5300 MHz, Port A



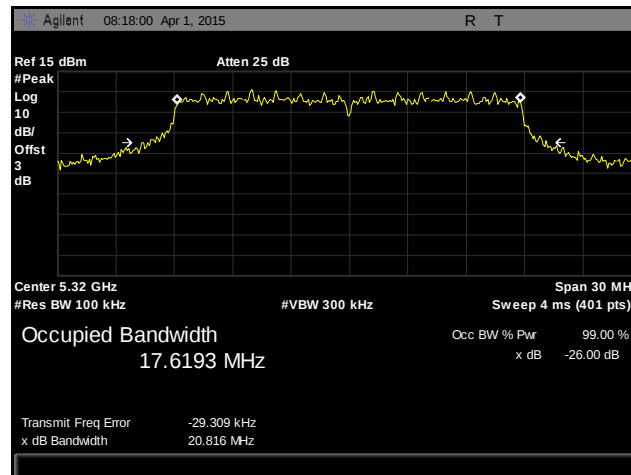
Plot 5. Occupied Bandwidth, 802.11a 20 MHz, High Channel, 5320 MHz, Port A



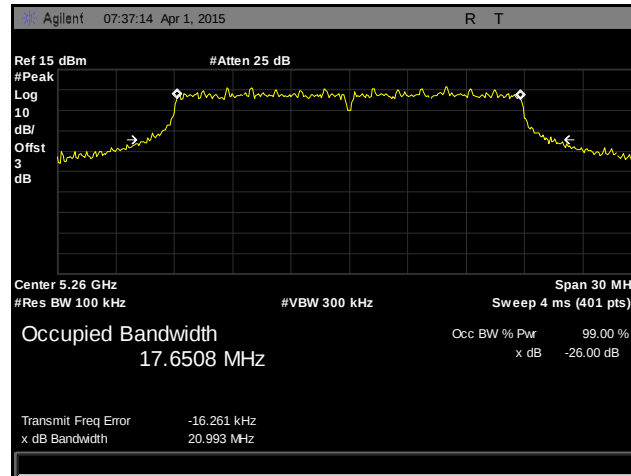
Plot 6. Occupied Bandwidth, 802.11ac 20 MHz, Low Channel, 5260 MHz, Port A



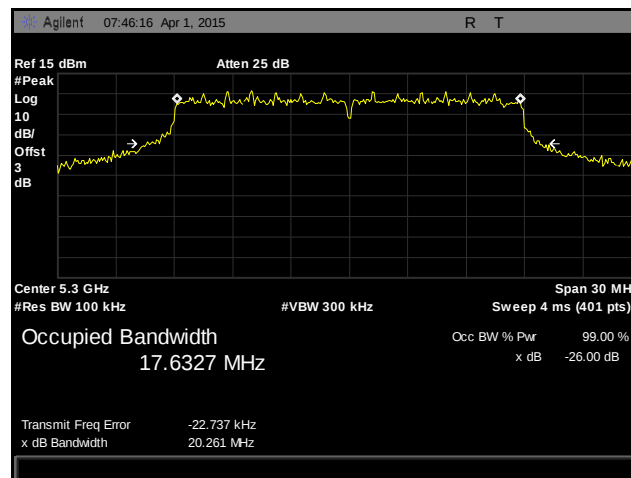
Plot 7. Occupied Bandwidth, 802.11ac 20 MHz, Mid Channel, 5300 MHz, Port A



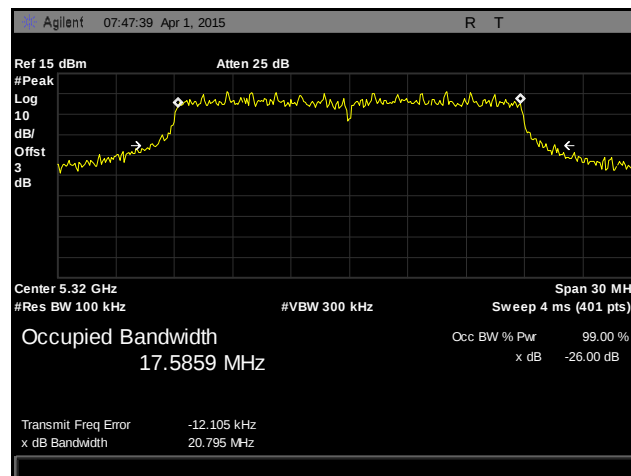
Plot 8. Occupied Bandwidth, 802.11ac 20 MHz, High Channel, 5320 MHz, Port A



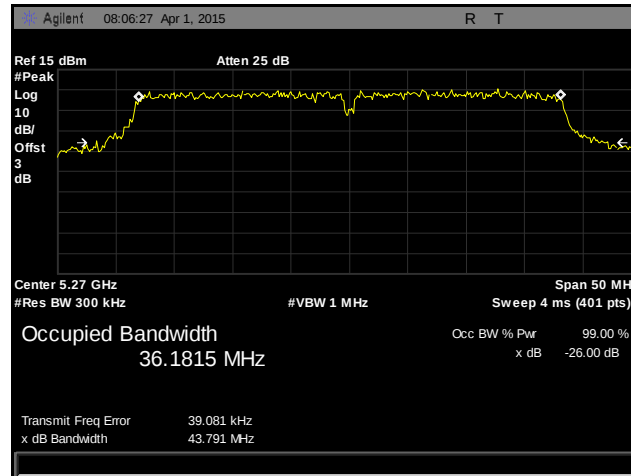
Plot 9. Occupied Bandwidth, 802.11n 20 MHz, Low Channel, 5260 MHz, Port A



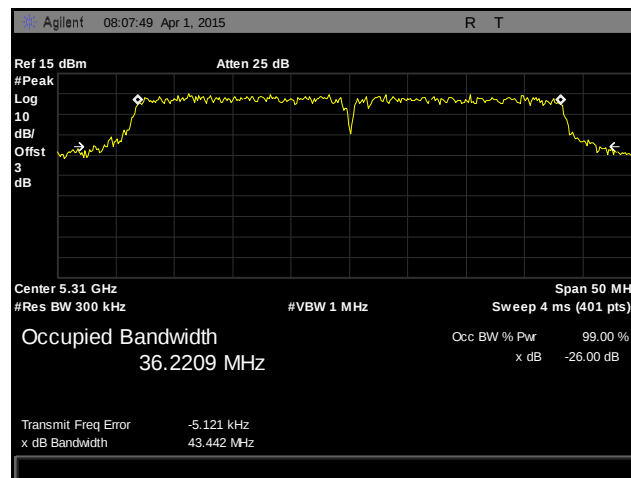
Plot 10. Occupied Bandwidth, 802.11n 20 MHz, Mid Channel, 5300 MHz, Port A



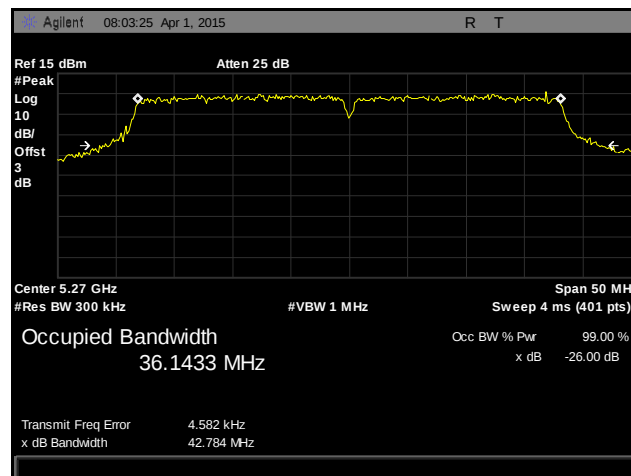
Plot 11. Occupied Bandwidth, 802.11n 20 MHz, High Channel, 5320 MHz, Port A



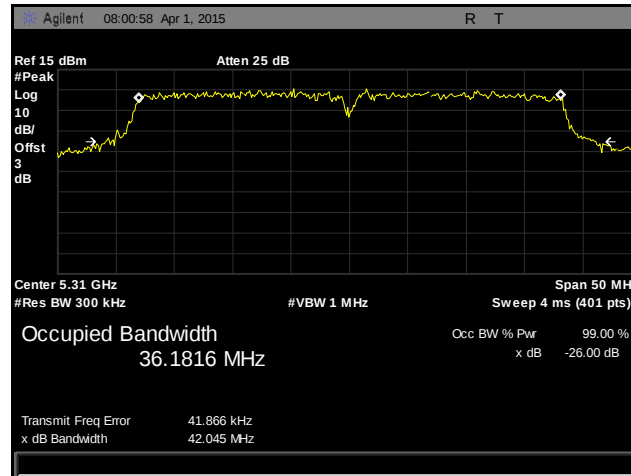
Plot 12. Occupied Bandwidth, 802.11ac 40 MHz, Low Channel, 5270 MHz, Port A



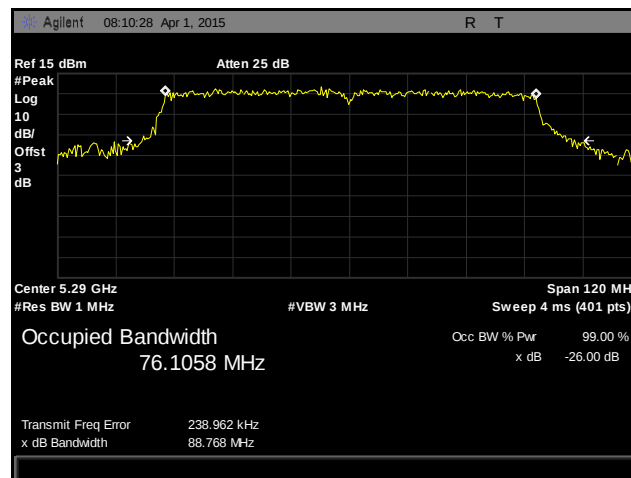
Plot 13. Occupied Bandwidth, 802.11ac 40 MHz, High Channel, 5310 MHz, Port A



Plot 14. Occupied Bandwidth, 802.11n 40 MHz, Low Channel, 5270 MHz, Port A

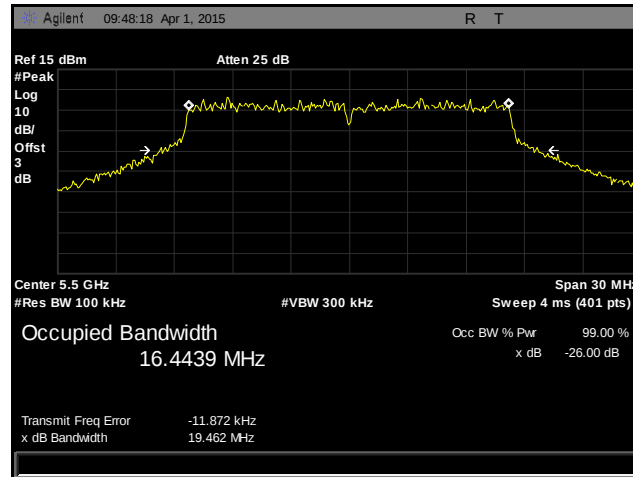


Plot 15. Occupied Bandwidth, 802.11n 40 MHz, High Channel, 5310 MHz, Port A

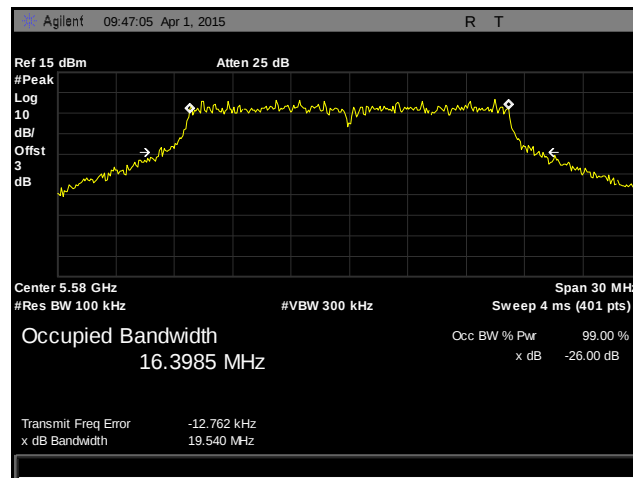


Plot 16. Occupied Bandwidth, 802.11ac 80 MHz, 5290 MHz, Port A

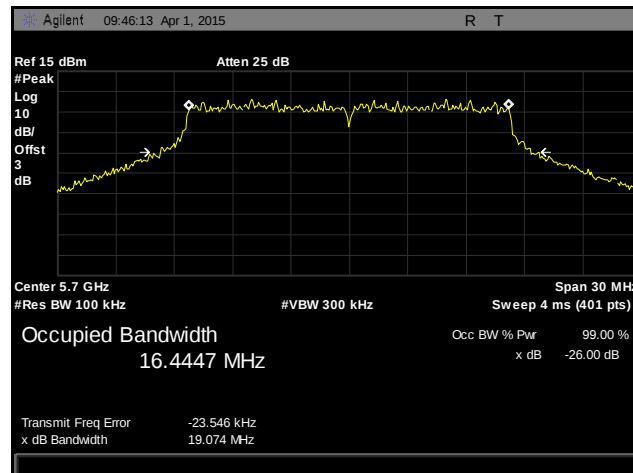
Occupied Bandwidth Test Results



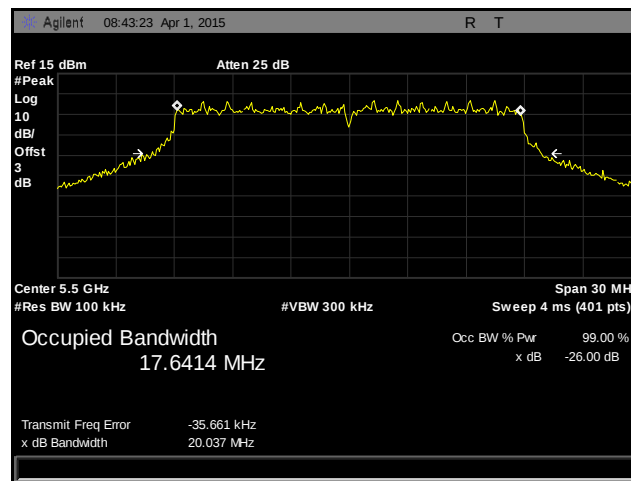
Plot 17. Occupied Bandwidth, 802.11a 20 MHz, Low Channel, 5500 MHz, Port A



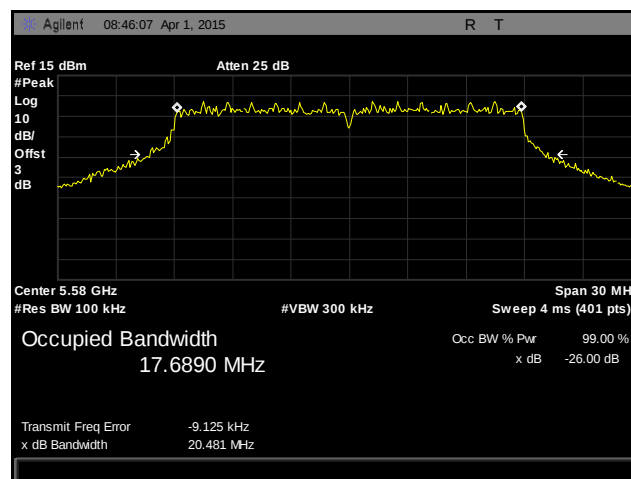
Plot 18. Occupied Bandwidth, 802.11a 20 MHz, Mid Channel, 5580 MHz, Port A



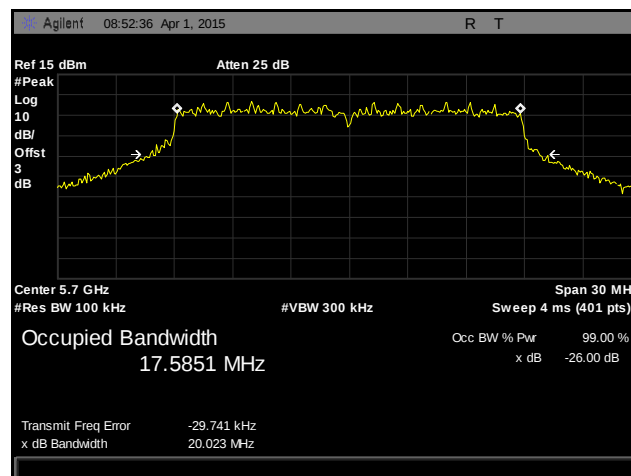
Plot 19. Occupied Bandwidth, 802.11a 20 MHz, High Channel, 5700 MHz, Port A



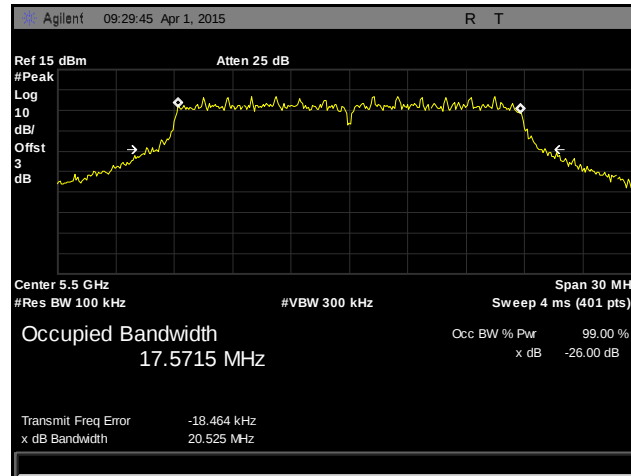
Plot 20. Occupied Bandwidth, 802.11ac 20 MHz, Low Channel, 5500 MHz, Port A



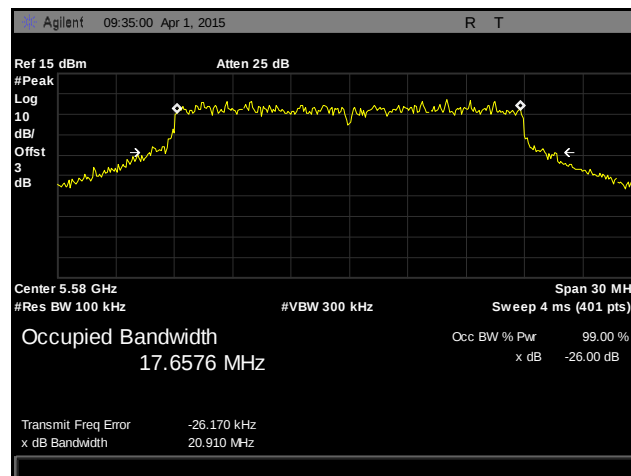
Plot 21. Occupied Bandwidth, 802.11ac 20 MHz, Mid Channel, 5580 MHz, Port A



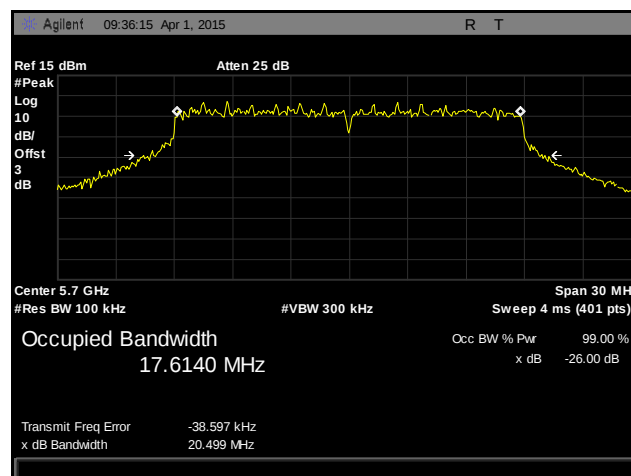
Plot 22. Occupied Bandwidth, 802.11ac 20 MHz, High Channel, 5700 MHz, Port A



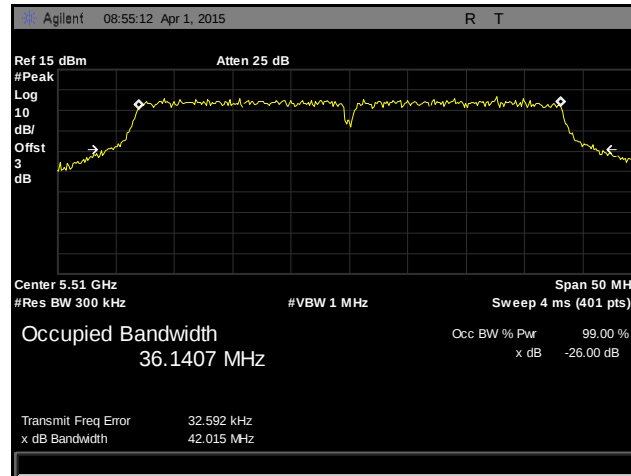
Plot 23. Occupied Bandwidth, 802.11n 20 MHz, Low Channel, 5500 MHz, Port A



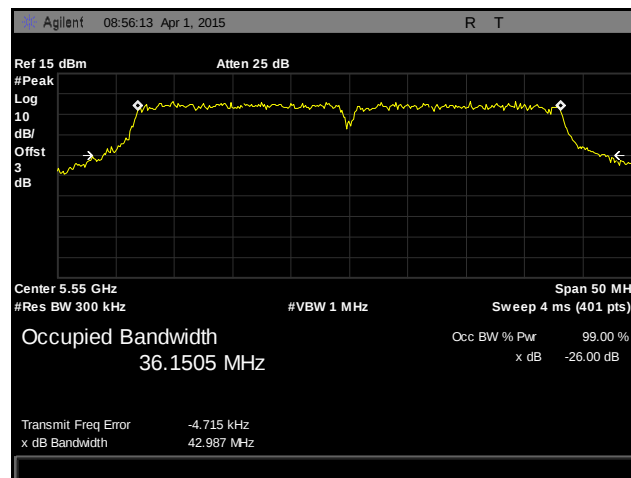
Plot 24. Occupied Bandwidth, 802.11n 20 MHz, Mid Channel, 5580 MHz, Port A



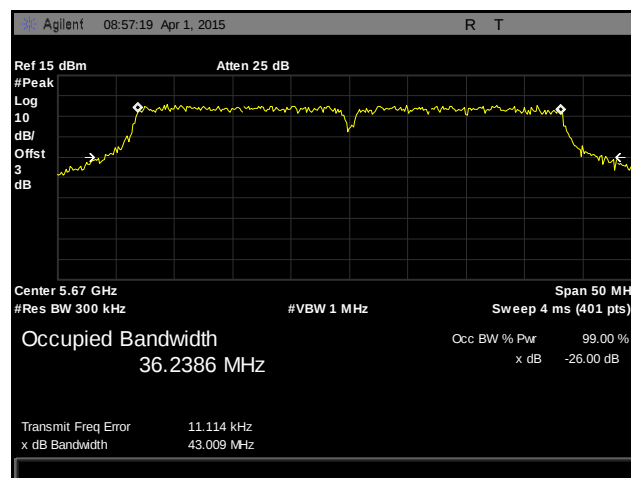
Plot 25. Occupied Bandwidth, 802.11n 20 MHz, High Channel, 5700 MHz, Port A



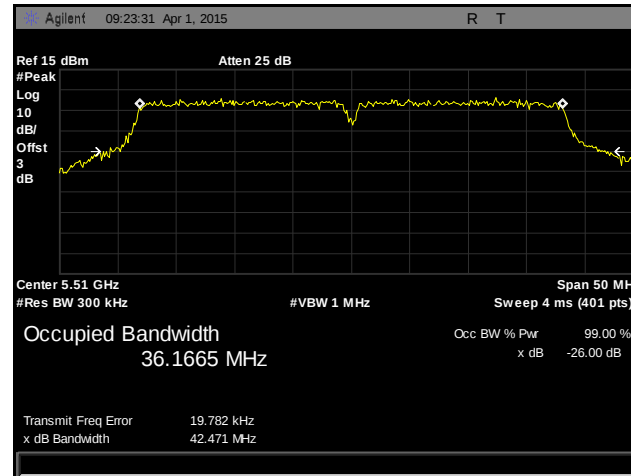
Plot 26. Occupied Bandwidth, 802.11ac 40 MHz, Low Channel, 5510 MHz, Port A



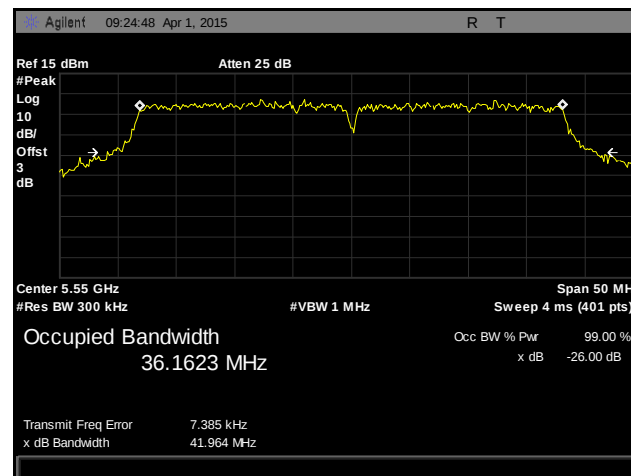
Plot 27. Occupied Bandwidth, 802.11ac 40 MHz, Mid Channel, 5550 MHz, Port A



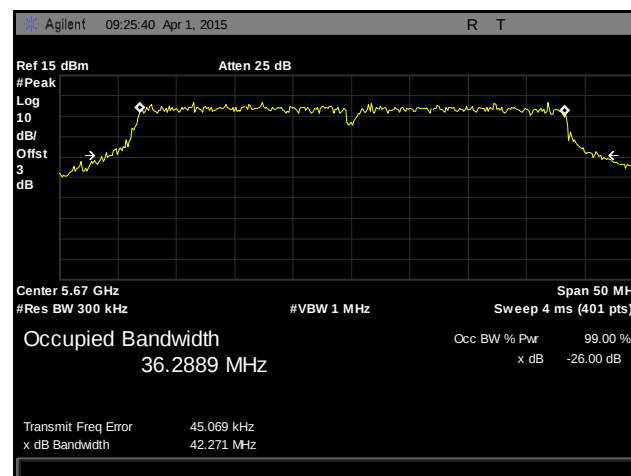
Plot 28. Occupied Bandwidth, 802.11ac 40 MHz, High Channel, 5670 MHz, Port A



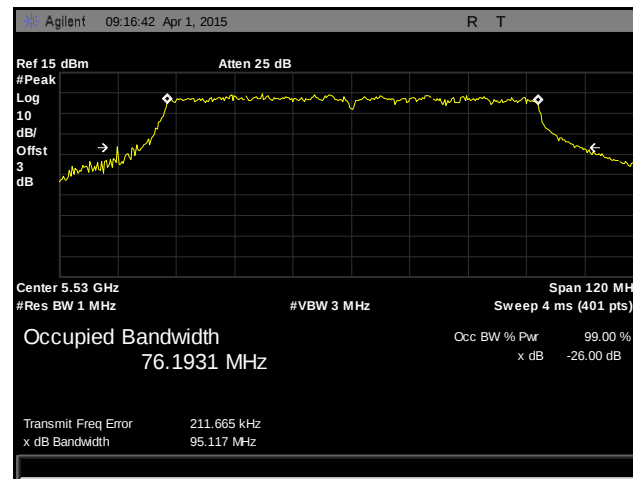
Plot 29. Occupied Bandwidth, 802.11n 40 MHz, Low Channel, 5510 MHz, Port A



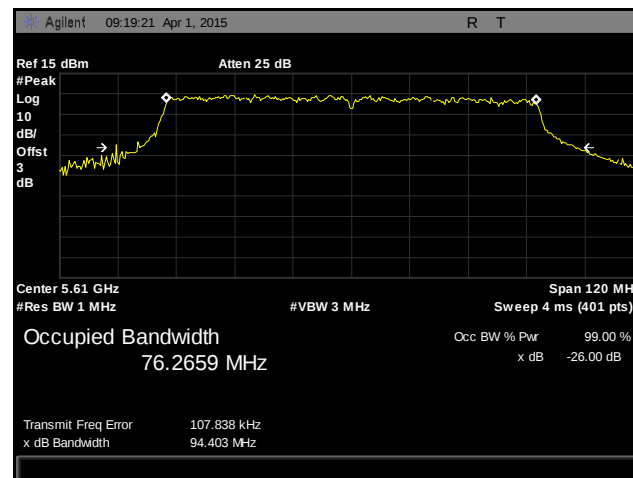
Plot 30. Occupied Bandwidth, 802.11n 40 MHz, Mid Channel, 5550 MHz, Port A



Plot 31. Occupied Bandwidth, 802.11n 40 MHz, High Channel, 5670 MHz, Port A



Plot 32. Occupied Bandwidth, 802.11ac 80 MHz, Low Channel, 5530 MHz, Port A



Plot 33. Occupied Bandwidth, 802.11ac 80 MHz, High Channel, 5610 MHz, Port A

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15. 407(a)(2) RF Power Output

Test Requirements: §15.407(a)(2): For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz..

Test Procedure: The EUT was connected to a spectrum analyzer through a 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 Rules v01.

Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15



Figure 3. Power Output Test Setup

Average Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11a Port 5GHz	Low	5260	22.19
	Mid	5300	22.35
	High	5320	20.21
802.11n 20 MHz Port 5GHz-P1	Low	5260	20.99
	Mid	5300	20.78
	High	5320	20.20
802.11n 20 MHz Port 5GHz-P2	Low	5260	20.78
	Mid	5300	20.01
	High	5320	17.24
802.11n 40MHz Port 5GHz-P1	Low	5270	19.38
	High	5310	13.68
802.11n 40 MHz Port 5GHz-P2	Low	5270	18.99
	High	5310	14.00
802.11ac 20 MHz Port 5GHz-P1	Low	5260	20.73
	Mid	5300	21.10
	High	5320	19.54
802.11ac 20 MHz Port 5GHz-P2	Low	5260	20.64
	Mid	5300	20.01
	High	5320	19.1
802.11ac 40MHz Port 5GHz-P1	Low	5270	20.96
	High	5310	16.10
802.11ac 40 MHz Port 5GHz-P2	Low	5270	20.09
	High	5310	15.57
802.11ac 80MHz Port 5GHz-P1		5290	14.23
802.11ac 80MHz Port 5GHz-P2		5290	13.85
Summed Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11n 20 MHz Summed	Low	5260	23.90
	Mid	5300	23.42
	High	5320	21.98
802.11n 40 MHz Summed	Low	5270	22.20
	High	5310	16.85
802.11ac 20MHz Summed	Low	5260	23.70
	Mid	5300	23.60
	High	5320	22.34
802.11ac 40MHz Summed	Low	5270	23.56
	High	5310	18.85
802.11ac 80MHz Summed	High	5290	17.05

Table 11. RF Power Output, UNII 2A, Test Results

Average Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11a Port 5GHz	Low	5500	18.23
	Mid	5580	21.08
	High	5700	14.94
802.11n 20 MHz Port 5GHz-P1	Low	5500	17.44
	Mid	5580	20.01
	High	5700	15.10
802.11n 20 MHz Port 5GHz-P2	Low	5500	18.08
	Mid	5580	20.16
	High	5700	15.87
802.11n 40MHz Port 5GHz-P1	Low	5510	15.27
	Mid	5550	20.07
	High	5670	15.70
802.11n 40 MHz Port 5GHz-P2	Low	5510	14.78
	Mid	5550	20.22
	High	5670	15.98
802.11ac 20 MHz Port 5GHz-P1	Low	5500	20.08
	Mid	5580	20.01
	High	5700	17.78
802.11ac 20 MHz Port 5GHz-P2	Low	5500	21.45
	Mid	5580	20.97
	High	5700	18.07
802.11ac 40MHz Port 5GHz-P1	Low	5510	18.78
	Mid	5550	20.09
	High	5670	19.01
802.11ac 40 MHz Port 5GHz-P2	Low	5510	19.01
	Mid	5550	20.01
	High	5670	19.05
802.11ac 80MHz Port 5GHz-P1	Low	5530	13.98
	High	5610	15.21
802.11ac 80MHz Port 5GHz-P2	Low	5530	14.00
	High	5610	15.87
Summed Conducted Output Power			
	Carrier Channel	Frequency (MHz)	Measured Output Power dBm
802.11n 20 MHz Summed	Low	5500	20.78
	Mid	5600	23.09
	High	5700	18.51
802.11n 40 MHz Summed	Low	5510	18.04
	Mid	5590	23.16
	High	5670	18.85
802.11ac 20MHz Summed	Low	5500	23.83
	Mid	5600	23.53
	High	5700	20.94
802.11ac 40MHz Summed	Low	5510	21.91
	Mid	5590	23.15
	High	5670	22.04
802.11ac 80MHz Summed	Low	5530	17.00
	High	5610	18.56

Table 12. RF Power Output, UNII 2C, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(a)(2) Peak Power Spectral Density

Test Requirements: § 15.407(a)(2): In addition, the peak power spectral density shall not exceed 11 dBm in any 1 megahertz band.

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 from 789033 D01 General UNII Test Procedures New Rules v01.

Test Results: Equipment was compliant with the peak power spectral density limits of § 15.407 (a)(2). The peak power spectral density was determined from plots on the following page(s).

The following table presents the 99% bandwidth measurements and their average peak spectral density per MHz.

Test Engineer(s): Benjamin Taylor

Test Date(s): 04/02/15



Figure 4. Power Spectral Density Test Setup

Frequency (MHz)	Mode	Port R1-A PSD (dBm)	Port R1-B PSD (dBm)	Summed PSD (dBm)	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
5260	802.11a 20MHz	10.98		10.98	3.20	11.00	-0.02
5300	802.11a 20MHz	10.79		10.79	3.20	11.00	-0.21
5320	802.11a 20MHz	10.93		10.93	3.20	11.00	-0.07
5260	802.11n 20MHz	8.01	7.78	10.91	3.20	11.00	-0.09
5300	802.11n 20MHz	7.98	7.87	10.94	3.20	11.00	-0.06
5320	802.11n 20MHz	7.79	8.01	10.91	3.20	11.00	-0.09
5270	802.11n 40MHz	7.51	8.41	10.99	3.20	11.00	-0.01
5310	802.11n 40MHz	7.43	8.26	10.87	3.20	11.00	-0.13
5260	802.11ac 20MHz	8.15	7.77	10.97	3.20	11.00	-0.03
5300	802.11ac 20MHz	8.57	7.27	10.98	3.20	11.00	-0.02
5320	802.11ac 20MHz	7.43	8.42	10.96	3.20	11.00	-0.04
5270	802.11ac 40MHz	8.00	7.98	11.00	3.20	11.00	0.00
5310	802.11ac 40MHz	7.94	7.31	10.65	3.20	11.00	-0.35
5290	802.11ac 80MHz	8.7	7.03	10.95508	3.20	11.00	-0.04492

Table 13. Peak Power Spectral Density, Test Results, Lower Bands

Frequency (MHz)	Mode	Port R1-A PSD (dBm)	Port R1-B PSD (dBm)	Summed PSD (dBm)	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
5500	802.11a 20MHz	10.79		10.79	3.20	11.00	-0.21
5580	802.11a 20MHz	10.85		10.85	3.20	11.00	-0.15
5700	802.11a 20MHz	10.96		10.96	3.20	11.00	-0.04
5500	802.11n 20MHz	9.53	9.53	9.53	3.20	11.00	-1.47
5580	802.11n 20MHz	10.29	9.97	10.29	3.20	11.00	-0.71
5700	802.11n 20MHz	7.79	8.07	10.94	3.20	11.00	-0.06
5510	802.11n 40MHz	6.94	7.84	10.42	3.20	11.00	-0.58
5550	802.11n 40MHz	6.90	7.05	9.98	3.20	11.00	-1.02
5670	802.11n 40MHz	8.12	7.32	10.75	3.20	11.00	-0.25
5500	802.11ac 20MHz	8.02	7.78	10.91	3.20	11.00	-0.09
5580	802.11ac 20MHz	7.63	8.27	10.97208	3.20	11.00	-0.02792
5700	802.11ac 20MHz	7.98	7.85	10.92579	3.20	11.00	-0.07421
5510	802.11ac 40MHz	7.252	6.972	10.12456	3.20	11.00	-0.87544
5550	802.11ac 40MHz	8.46	7.067	10.82941	3.20	11.00	-0.17059
5670	802.11ac 40MHz	8.178	7.684	10.94832	3.20	11.00	-0.05168
5530	802.11ac 80MHz	5.507	5.41	8.469071	3.20	11.00	-2.53093
5610	802.11ac 80MHz	5.507	5.596	8.562028	3.20	11.00	-2.43797

Table 14. Peak Power Spectral Density, Test Results, Upper Bands

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.407(b)(2), (3), (7) Undesirable Emissions

Test Requirements: § 15.407(b)(2), (3), (7); §15.205: Emissions outside the frequency band.

§ 15.407(b)(2): For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.

§ 15.407(b)(3): For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.

§ 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 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.

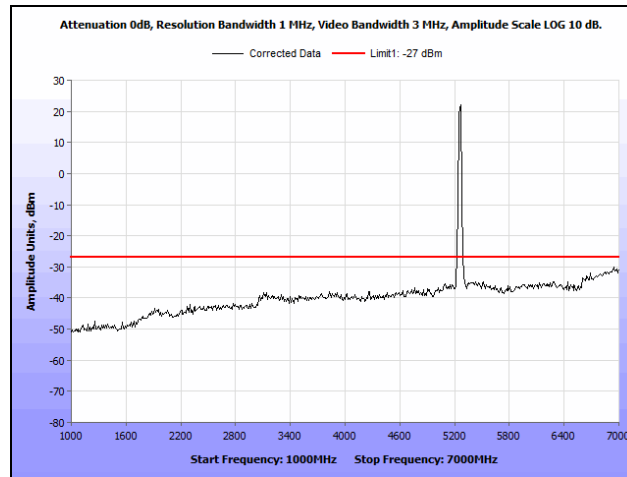
For measurements above 1 GHz, measurements were made with a Peak detector with 1 MHz resolution bandwidth. A notch filter was use to filter out the transmitting channel. Where the spurious emissions fell into a restricted band, measurements were also made with an average detector to make sure they complied with 15.209 limits. Only noise floor was seen above 18 GHz. Worst case emissions shown by antenna. Measurements in the 30 MHz to 1 GHz range proved to not change between different modes of operation; only the mid-channel per mode plots are displayed in this report.

Test Results: The EUT was compliant with the Radiated Emission limits for Intentional Radiators. See following pages for detailed test results.

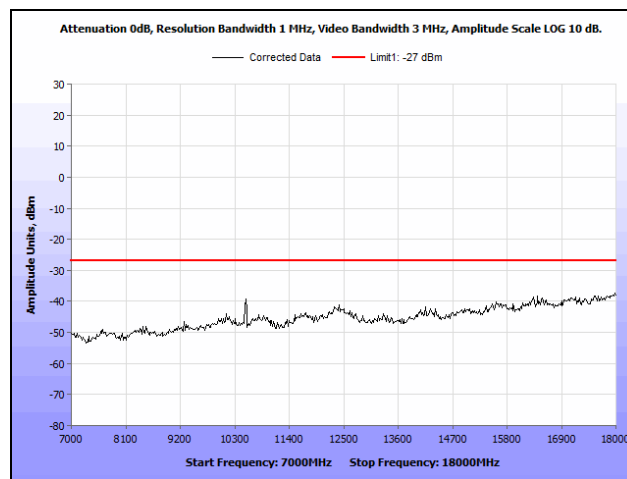
Test Engineer(s): Benjamin Taylor

Test Date(s): 05/01/15

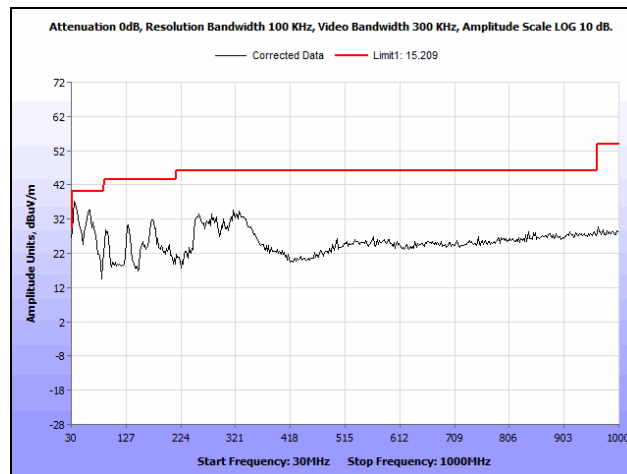
Radiated Spurious Emissions



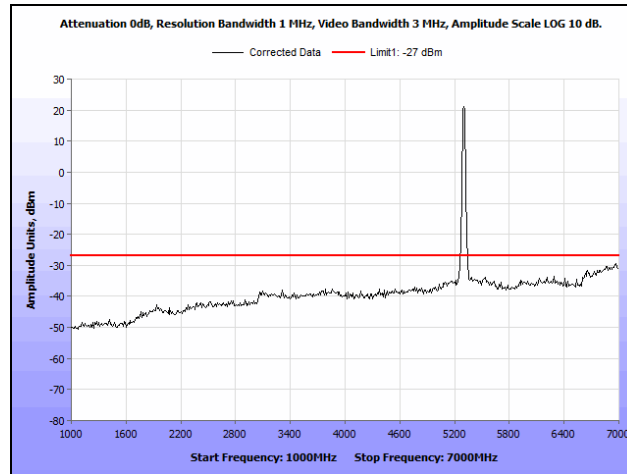
Plot 34. Radiated Spurious Emissions, 5260 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



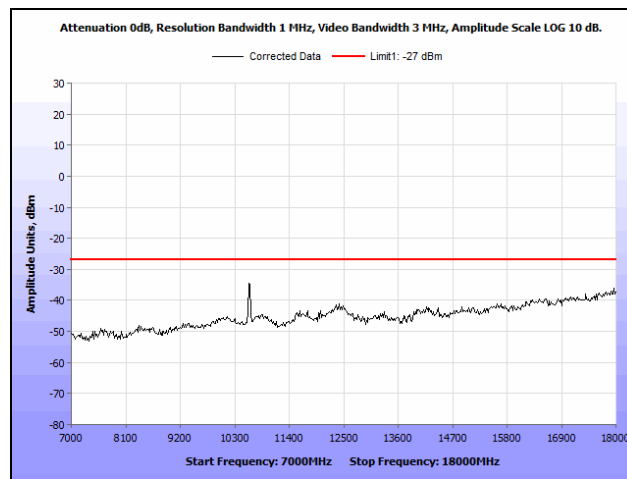
Plot 35. Radiated Spurious Emissions, 5260 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



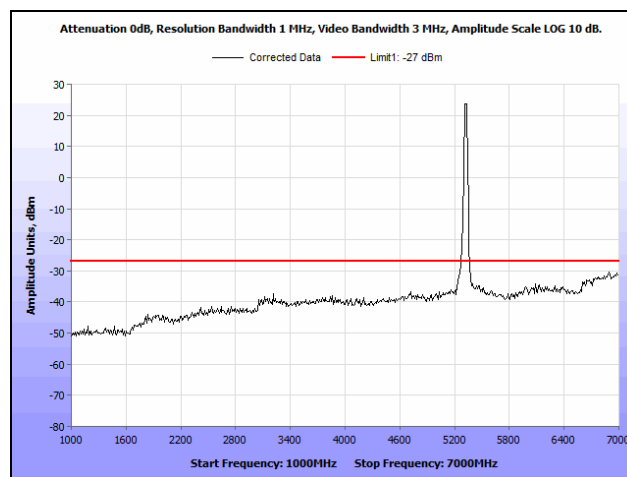
Plot 36. Radiated Spurious Emissions, 5300 MHz, 802.11a 20 MHz, 30 MHz – 1 GHz



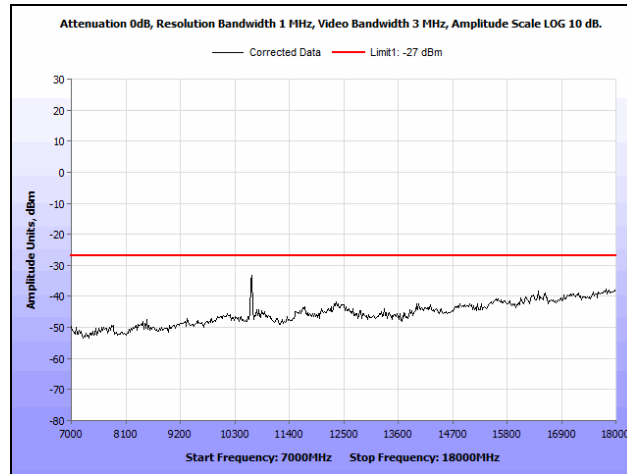
Plot 37. Radiated Spurious Emissions, 5300 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



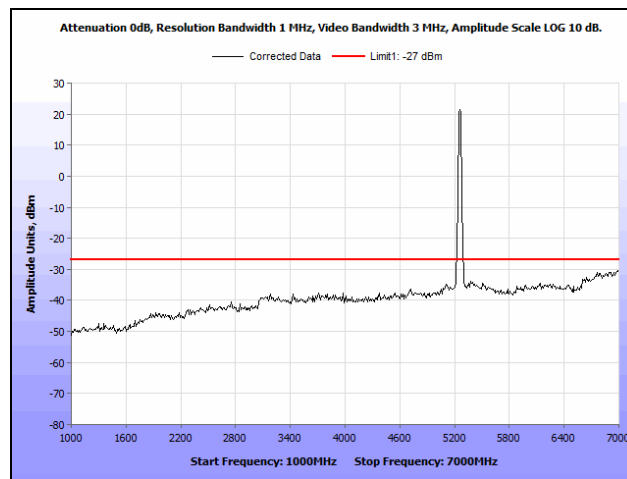
Plot 38. Radiated Spurious Emissions, 5300 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



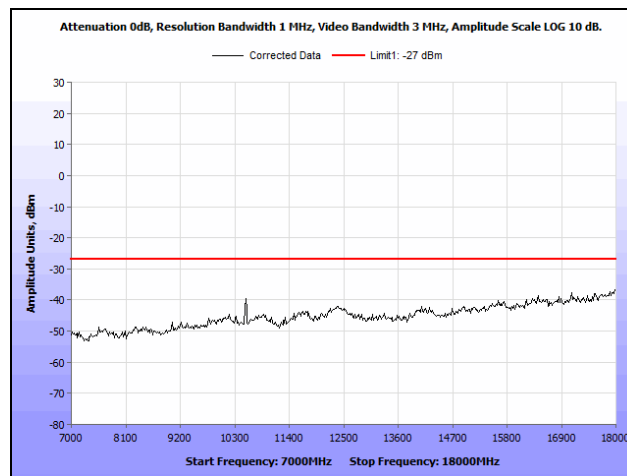
Plot 39. Radiated Spurious Emissions, 5320 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



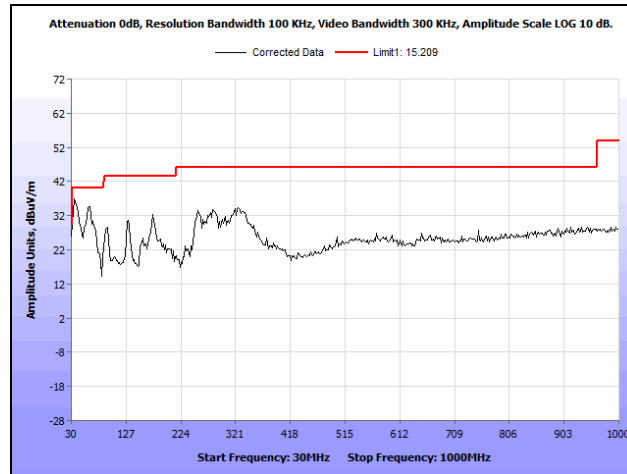
Plot 40. Radiated Spurious Emissions, 5320 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



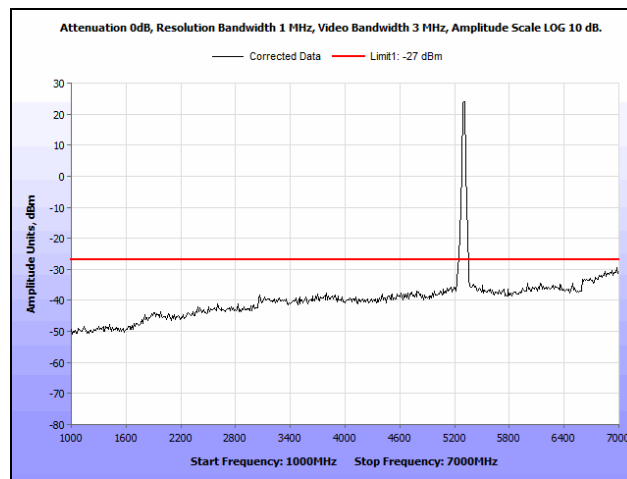
Plot 41. Radiated Spurious Emissions, 5260 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



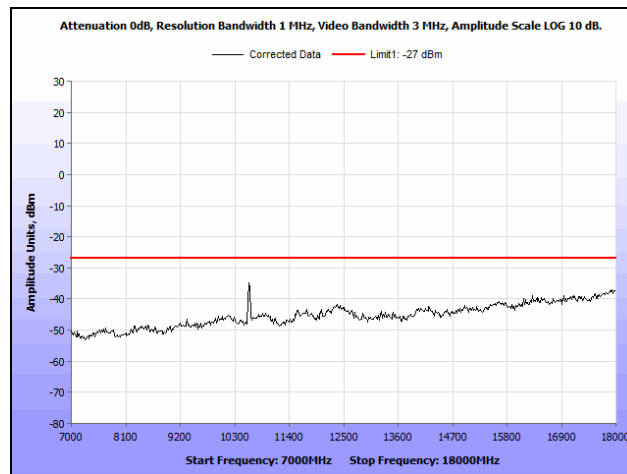
Plot 42. Radiated Spurious Emissions, 5260 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



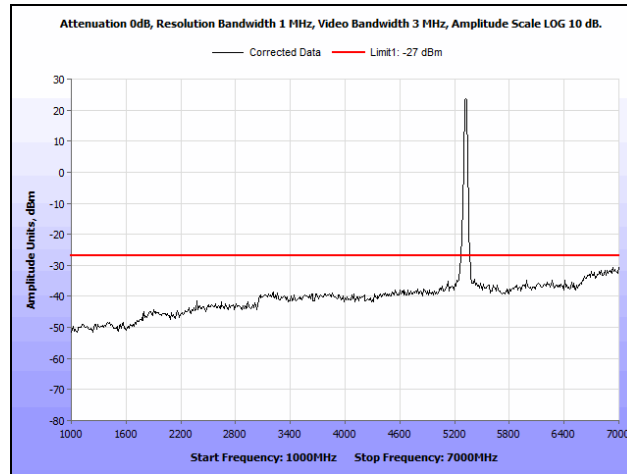
Plot 43. Radiated Spurious Emissions, 5300 MHz, 802.11ac 20 MHz, 30 MHz – 1 GHz



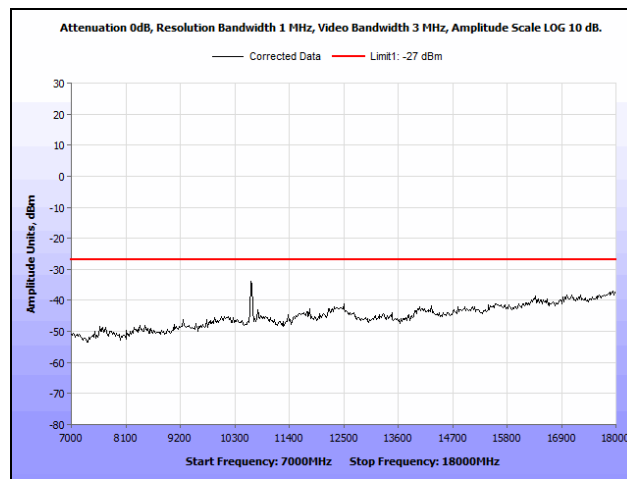
Plot 44. Radiated Spurious Emissions, 5300 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



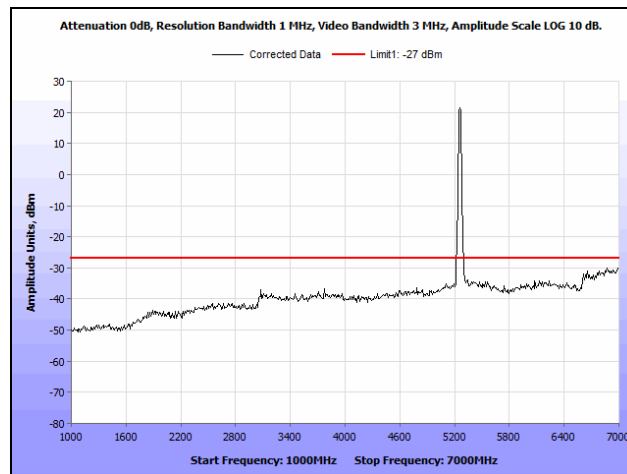
Plot 45. Radiated Spurious Emissions, 5300 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



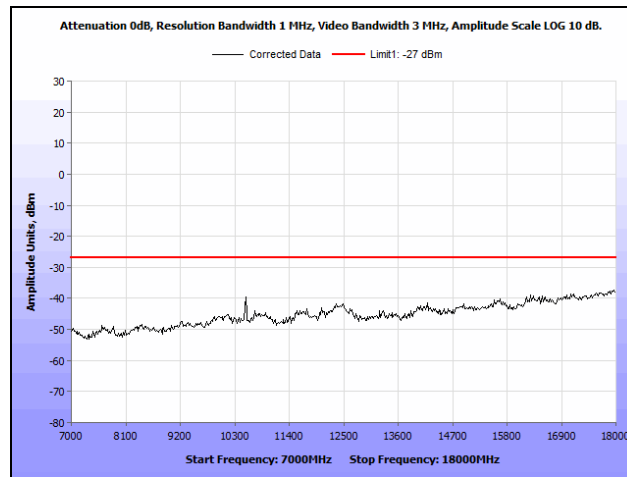
Plot 46. Radiated Spurious Emissions, 5320 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



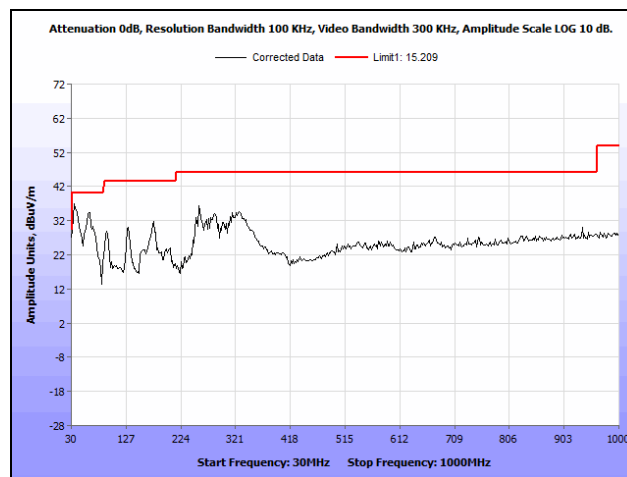
Plot 47. Radiated Spurious Emissions, 5320 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



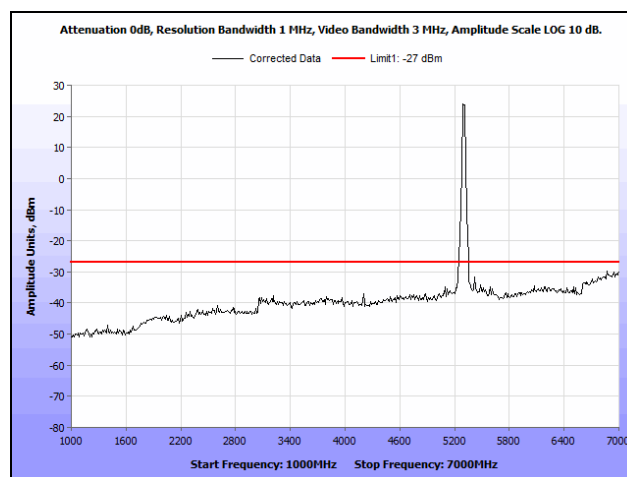
Plot 48. Radiated Spurious Emissions, 5260 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



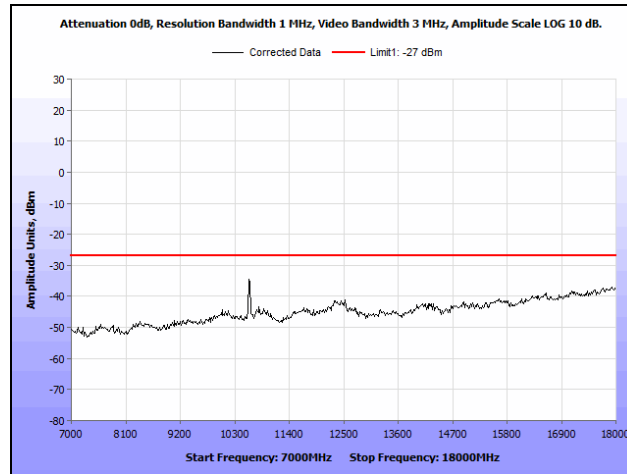
Plot 49. Radiated Spurious Emissions, 5260 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



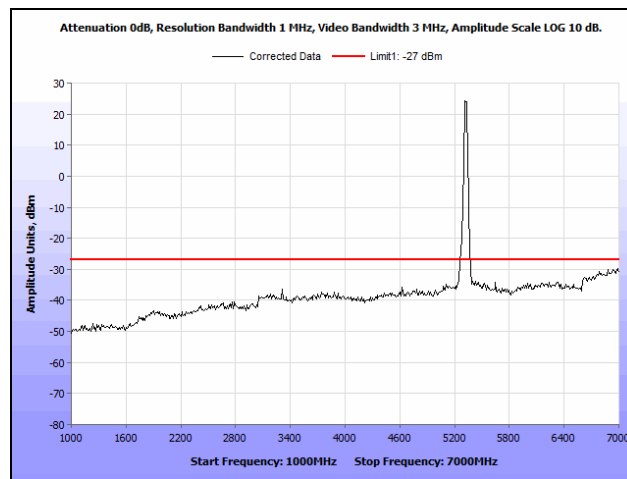
Plot 50. Radiated Spurious Emissions, 5300 MHz, 802.11n 20 MHz, 30 MHz – 1 GHz



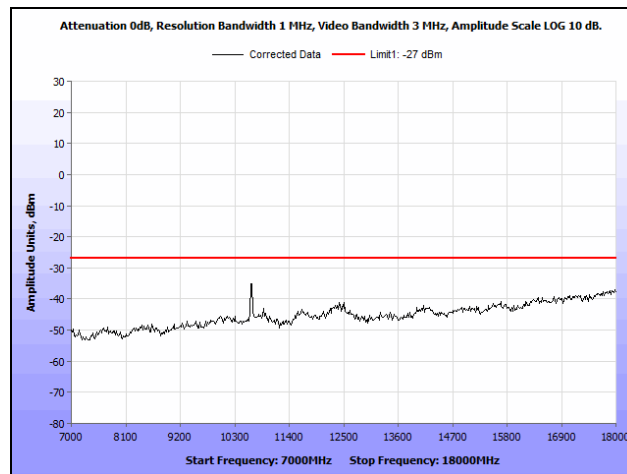
Plot 51. Radiated Spurious Emissions, 5300 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



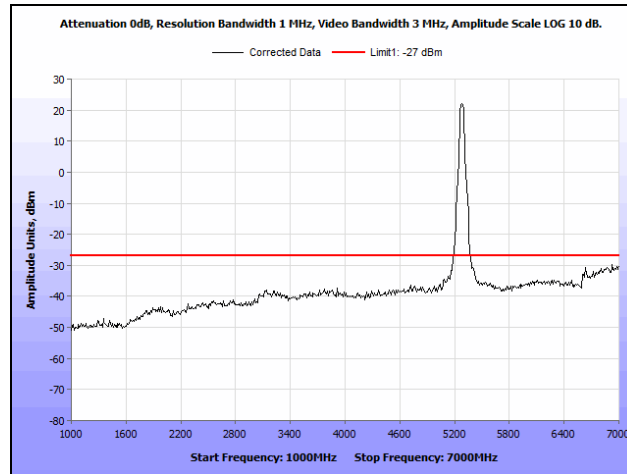
Plot 52. Radiated Spurious Emissions, 5300 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



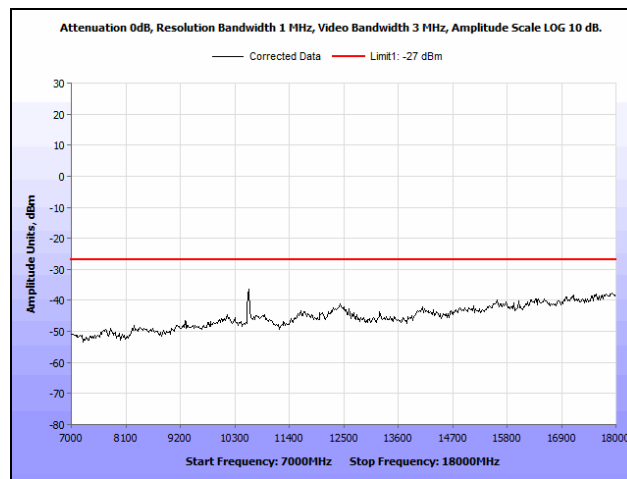
Plot 53. Radiated Spurious Emissions, 5320 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



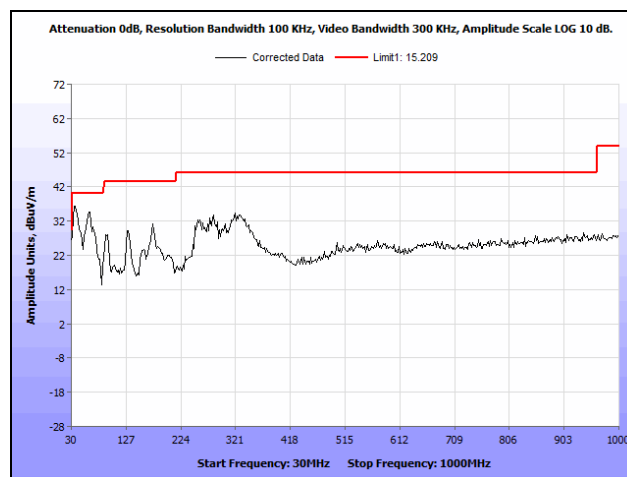
Plot 54. Radiated Spurious Emissions, 5320 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



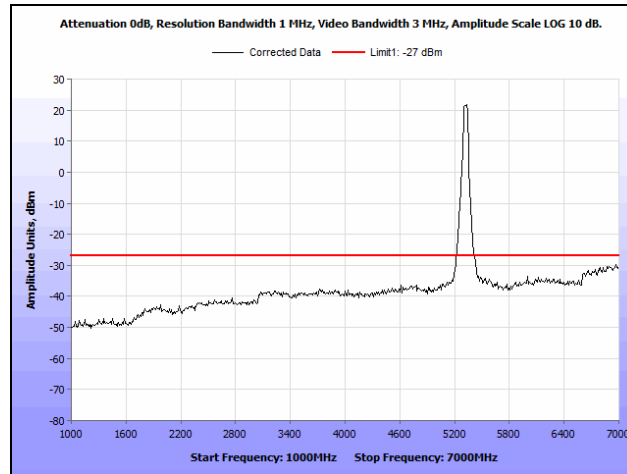
Plot 55. Radiated Spurious Emissions, 5270 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



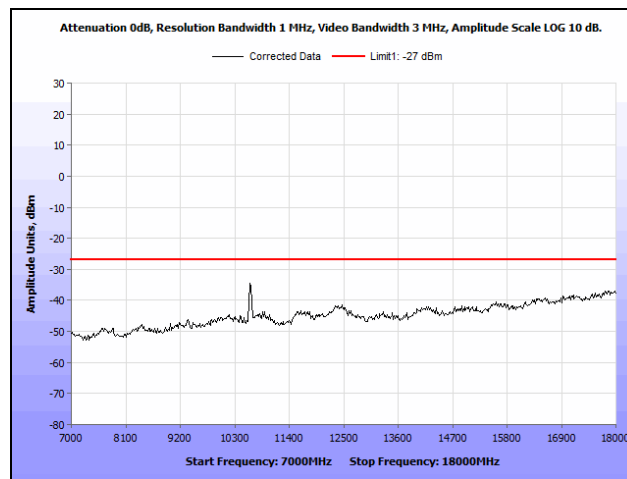
Plot 56. Radiated Spurious Emissions, 5270 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



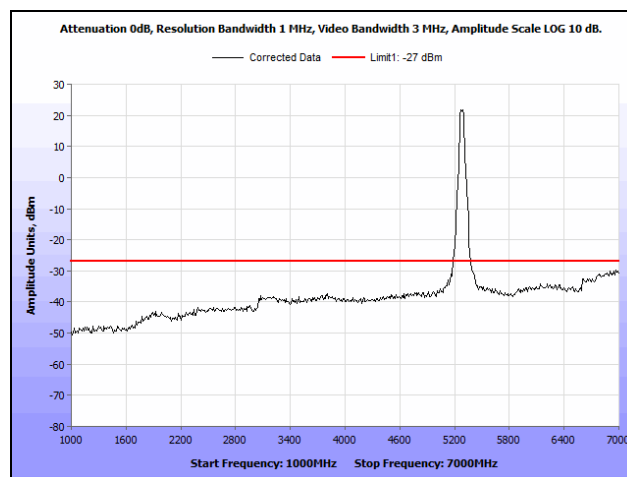
Plot 57. Radiated Spurious Emissions, 5310 MHz, 802.11ac 40 MHz, 30 MHz – 1 GHz



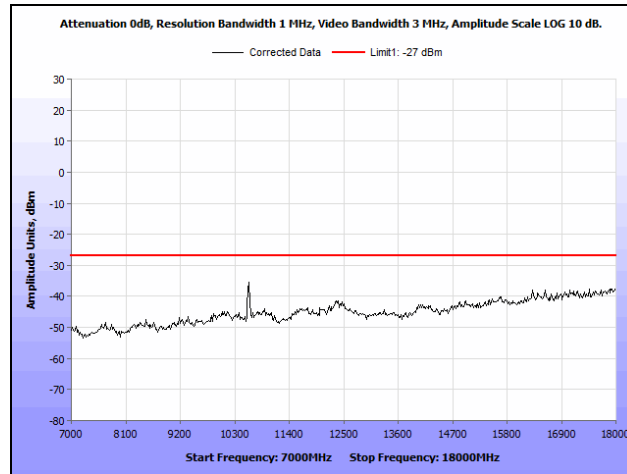
Plot 58. Radiated Spurious Emissions, 5310 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



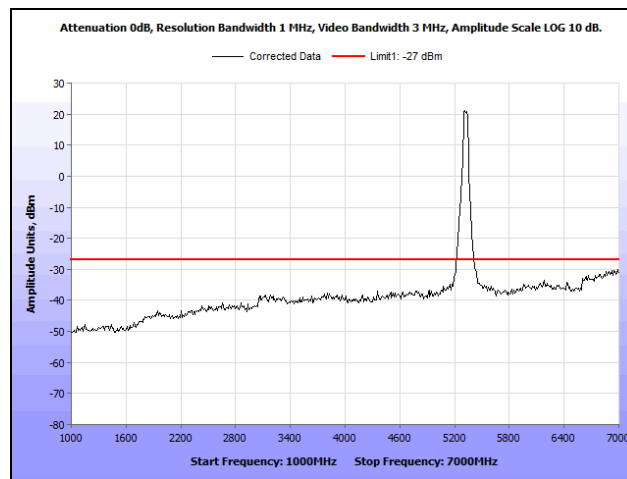
Plot 59. Radiated Spurious Emissions, 5310 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



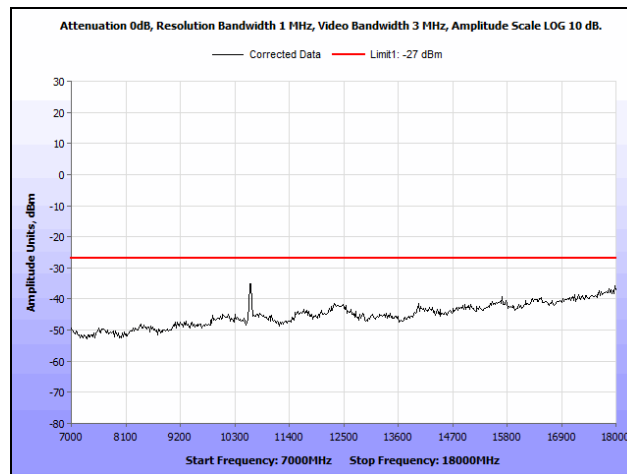
Plot 60. Radiated Spurious Emissions, 5270 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



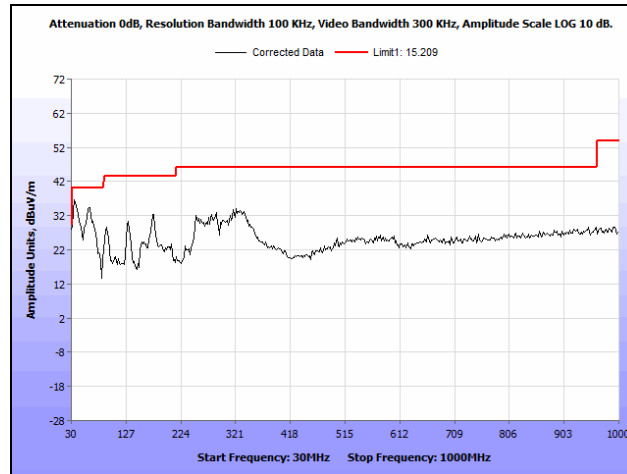
Plot 61. Radiated Spurious Emissions, 5270 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



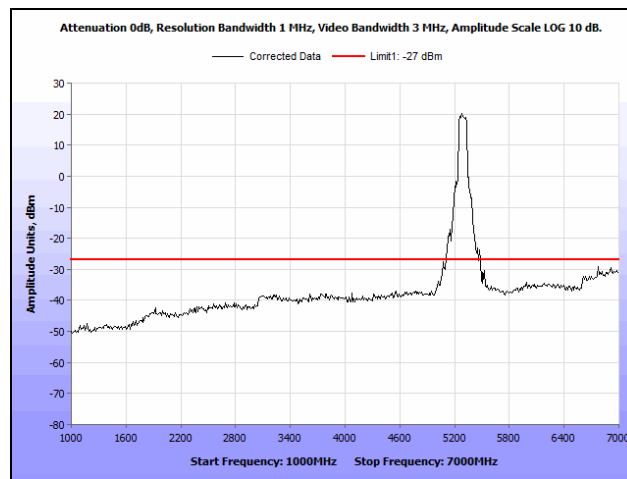
Plot 62. Radiated Spurious Emissions, 5310 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



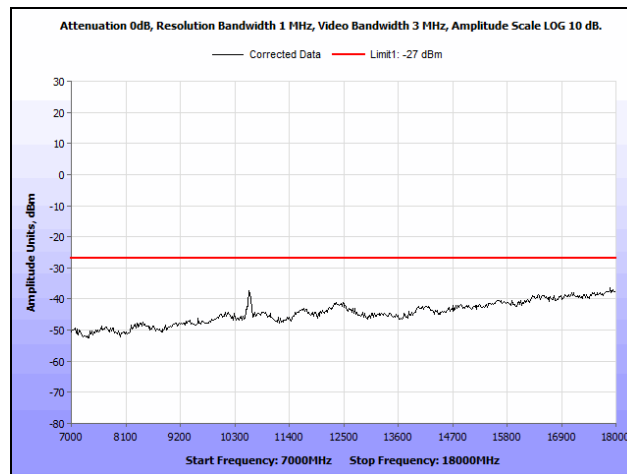
Plot 63. Radiated Spurious Emissions, 5310 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



Plot 64. Radiated Spurious Emissions, 5290 MHz, 802.11ac 80 MHz, 30 MHz – 1 GHz

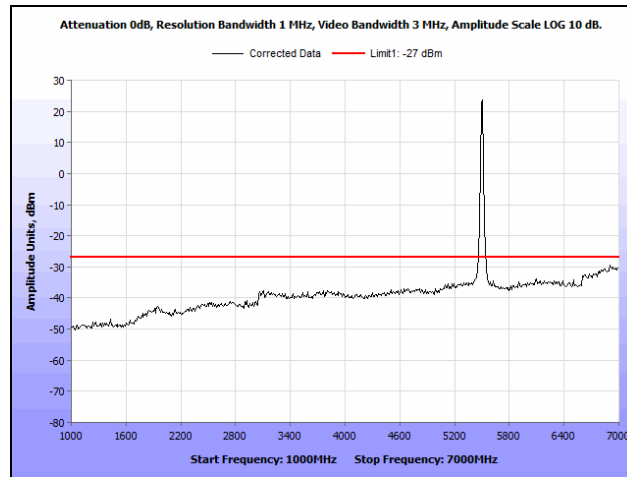


Plot 65. Radiated Spurious Emissions, 5290 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz

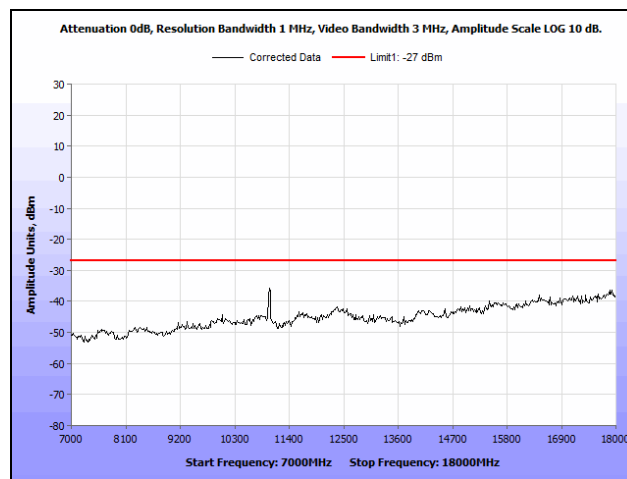


Plot 66. Radiated Spurious Emissions, 5290 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz

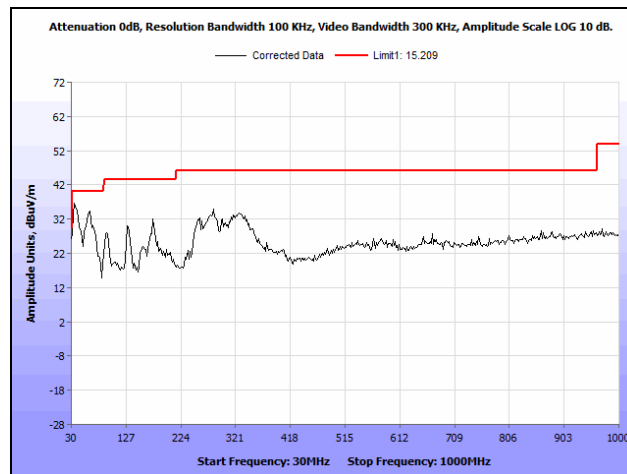
Radiated Spurious Emissions



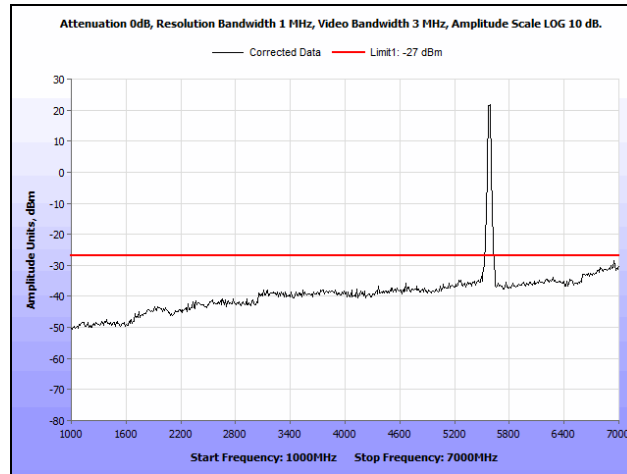
Plot 67. Radiated Spurious Emissions, 5500 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



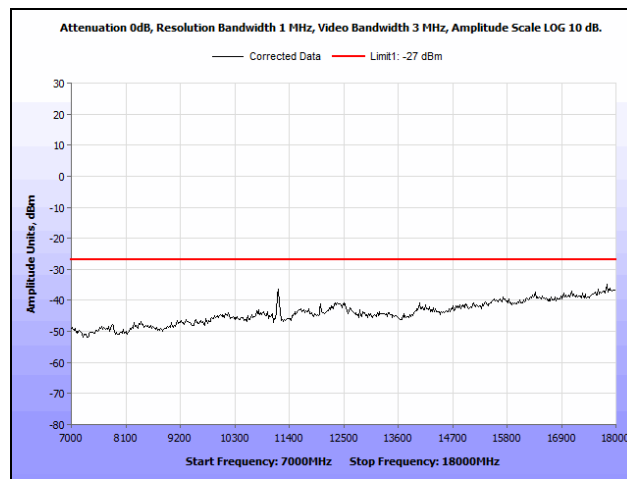
Plot 68. Radiated Spurious Emissions, 5500 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



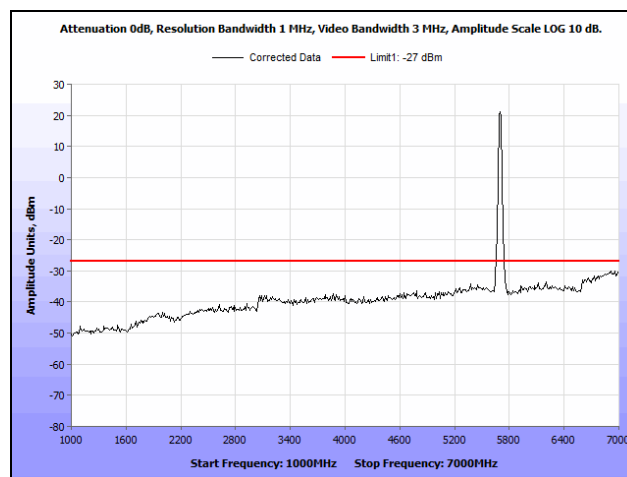
Plot 69. Radiated Spurious Emissions, 5580 MHz, 802.11a 20 MHz, 30 MHz – 1 GHz



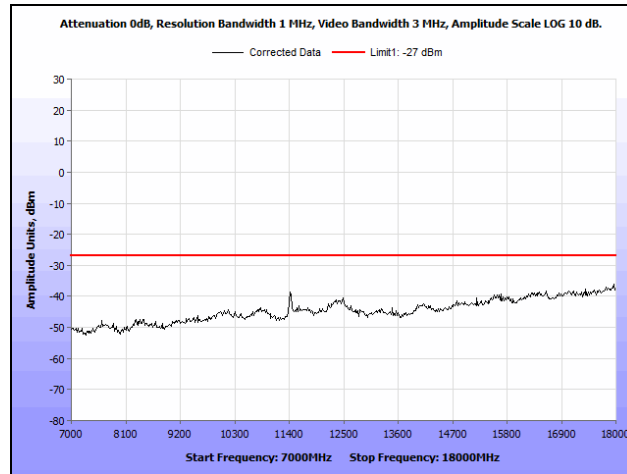
Plot 70. Radiated Spurious Emissions, 5580 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



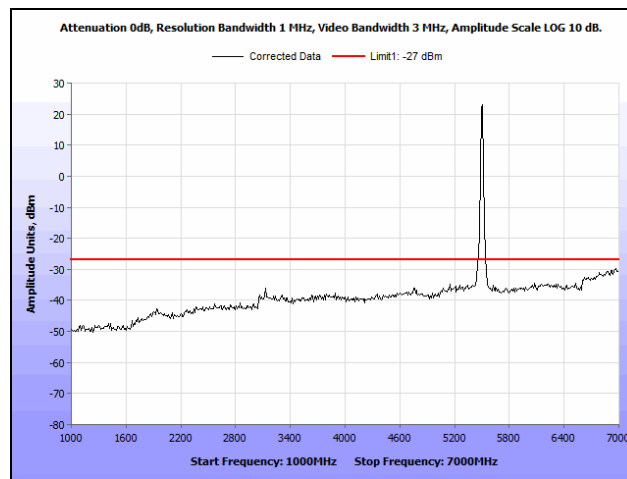
Plot 71. Radiated Spurious Emissions, 5580 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



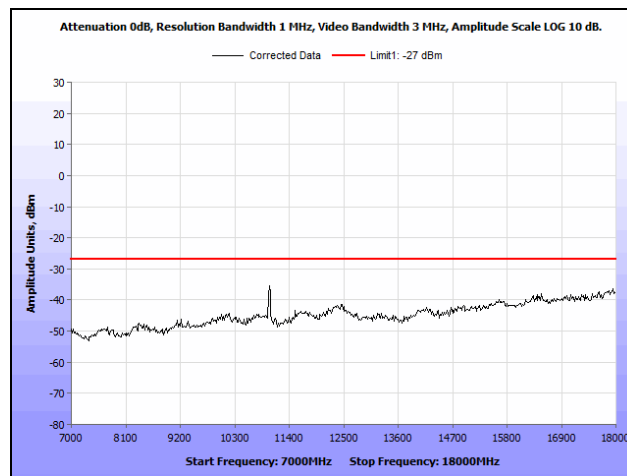
Plot 72. Radiated Spurious Emissions, 5700 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



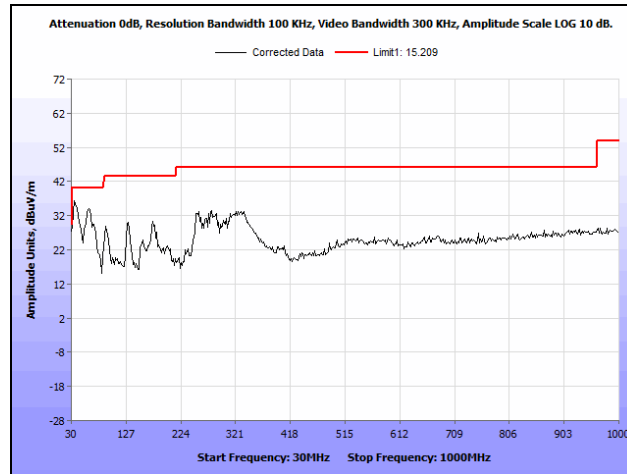
Plot 73. Radiated Spurious Emissions, 5700 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



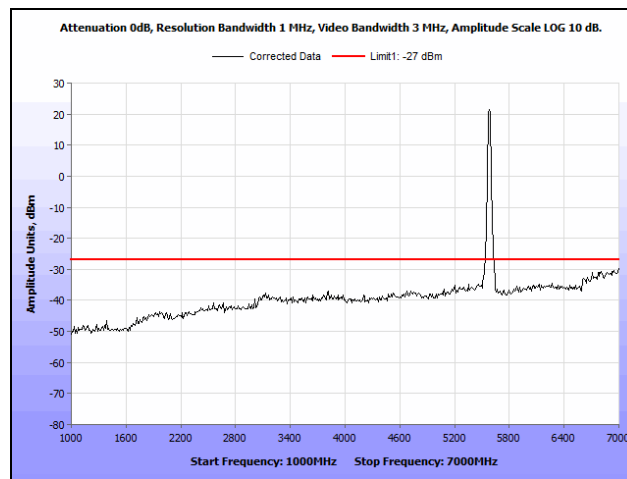
Plot 74. Radiated Spurious Emissions, 5500 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



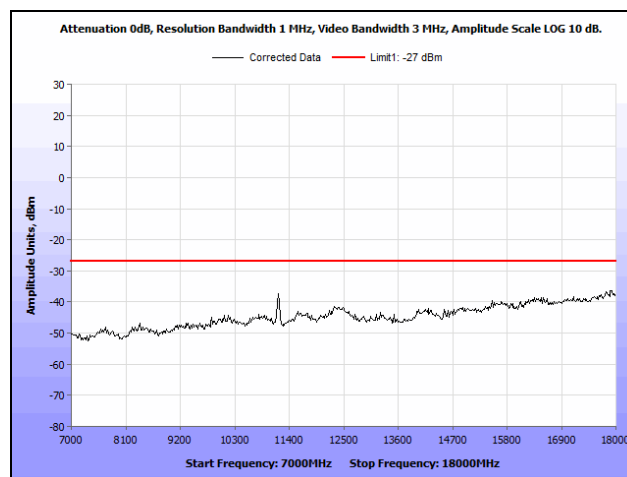
Plot 75. Radiated Spurious Emissions, 5500 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



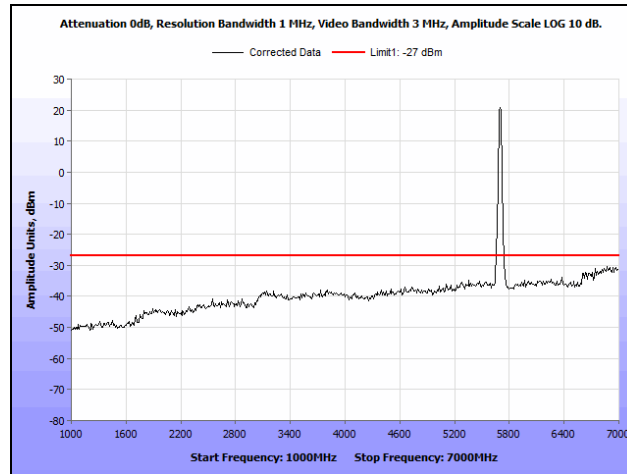
Plot 76. Radiated Spurious Emissions, 5580 MHz, 802.11ac 20 MHz, 30 MHz – 1 GHz



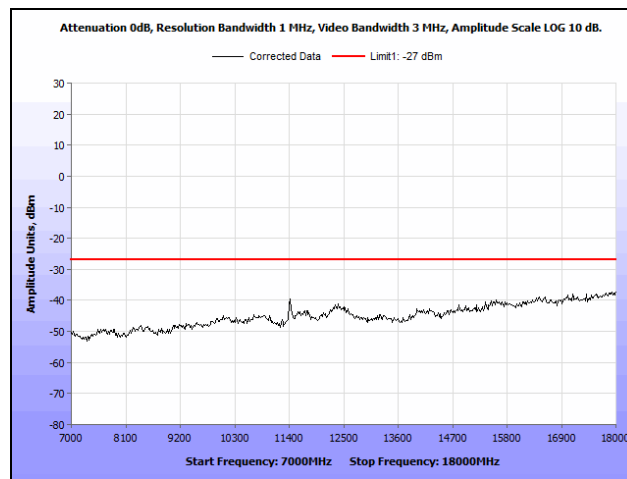
Plot 77. Radiated Spurious Emissions, 5580 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



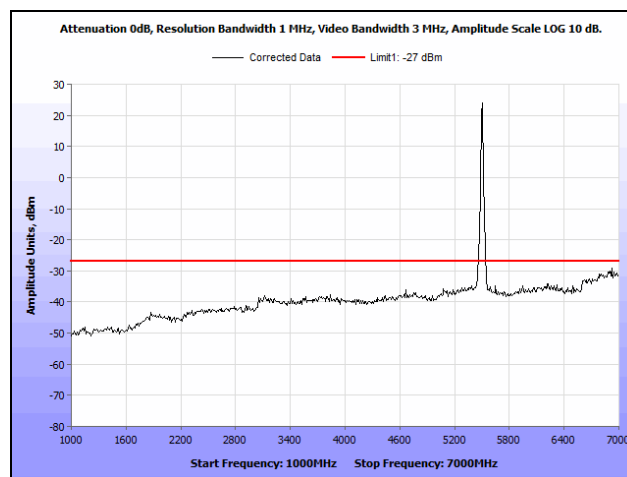
Plot 78. Radiated Spurious Emissions, 5580 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



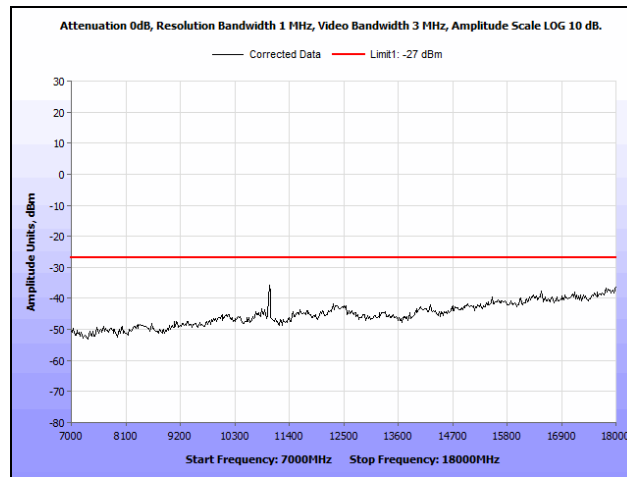
Plot 79. Radiated Spurious Emissions, 5700 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



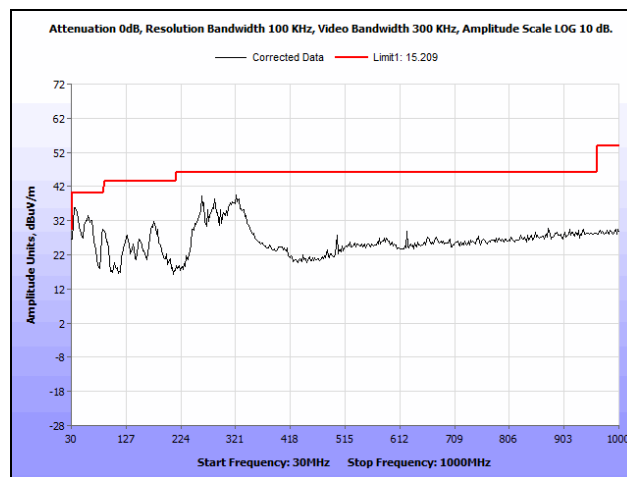
Plot 80. Radiated Spurious Emissions, 5700 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



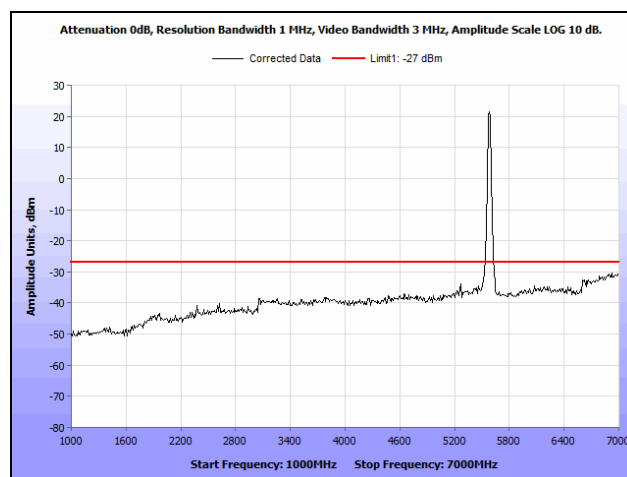
Plot 81. Radiated Spurious Emissions, 5500 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



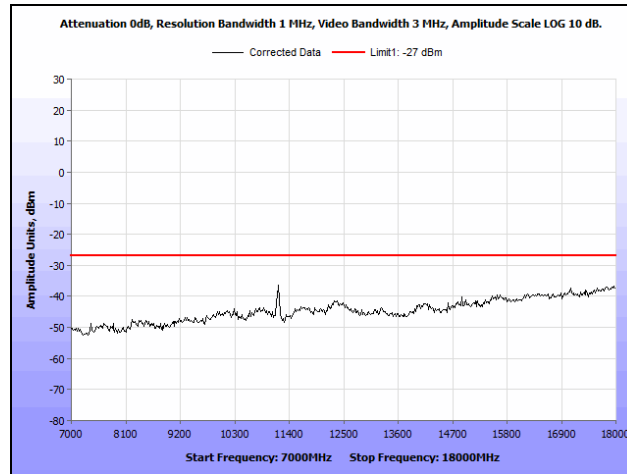
Plot 82. Radiated Spurious Emissions, 5500 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



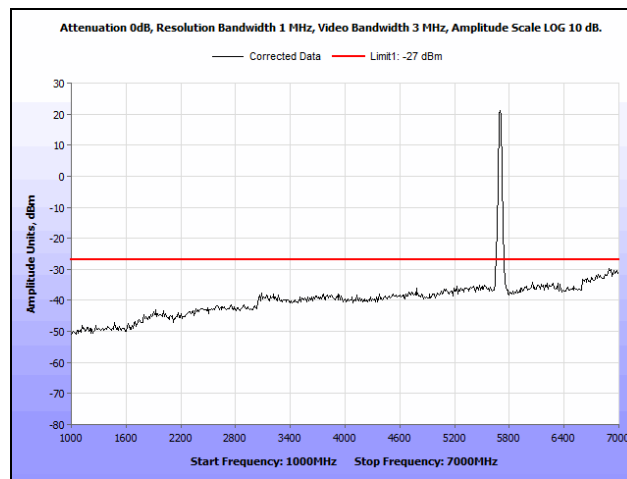
Plot 83. Radiated Spurious Emissions, 5580 MHz, 802.11n 20 MHz, 30 MHz – 1 GHz



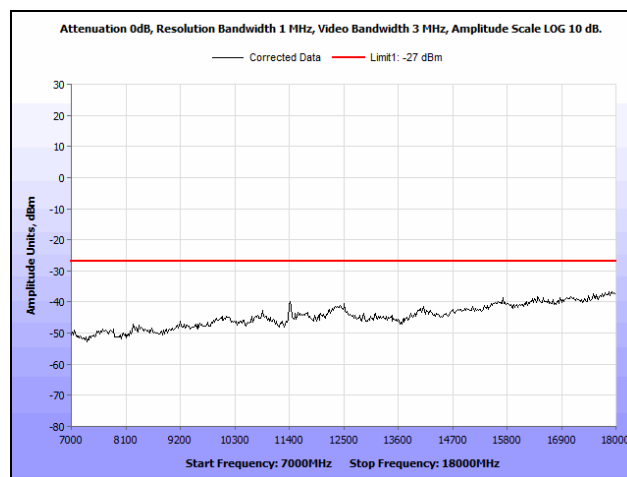
Plot 84. Radiated Spurious Emissions, 5580 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



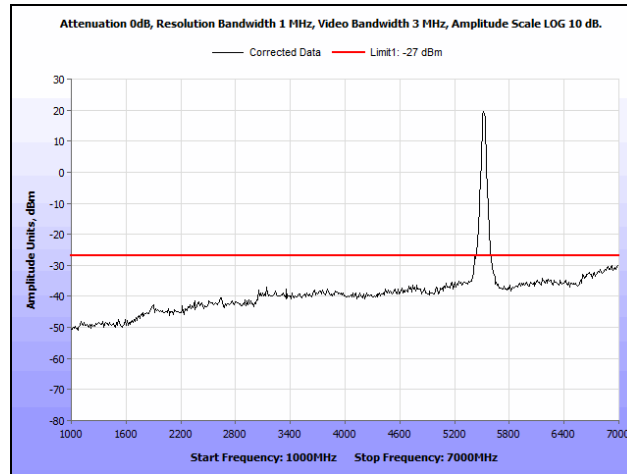
Plot 85. Radiated Spurious Emissions, 5580 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



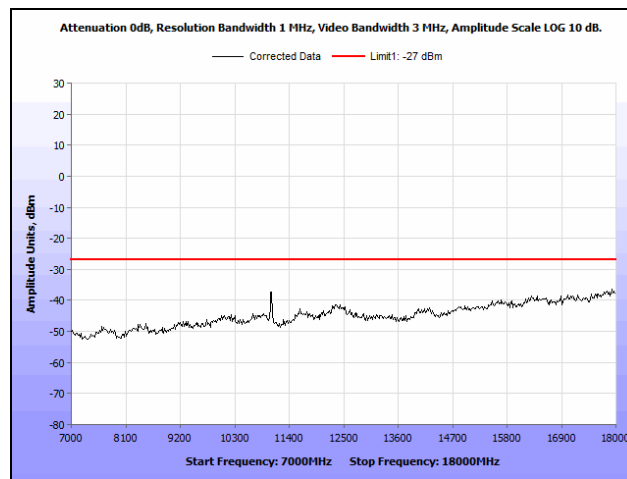
Plot 86. Radiated Spurious Emissions, 5700 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



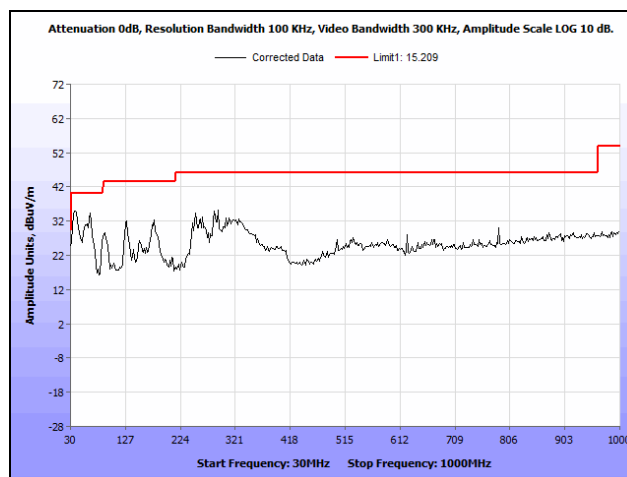
Plot 87. Radiated Spurious Emissions, 5700 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



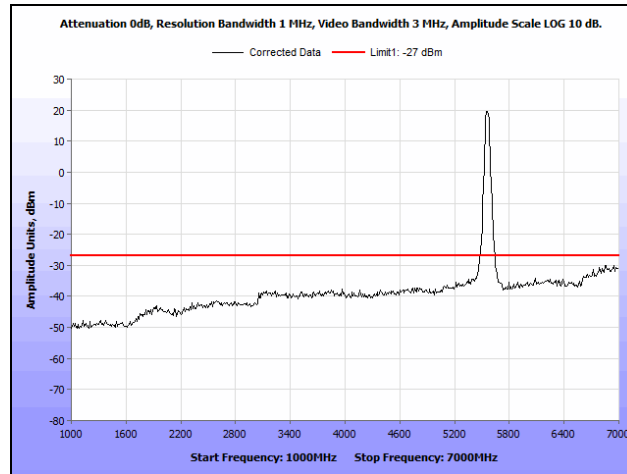
Plot 88. Radiated Spurious Emissions, 5510 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



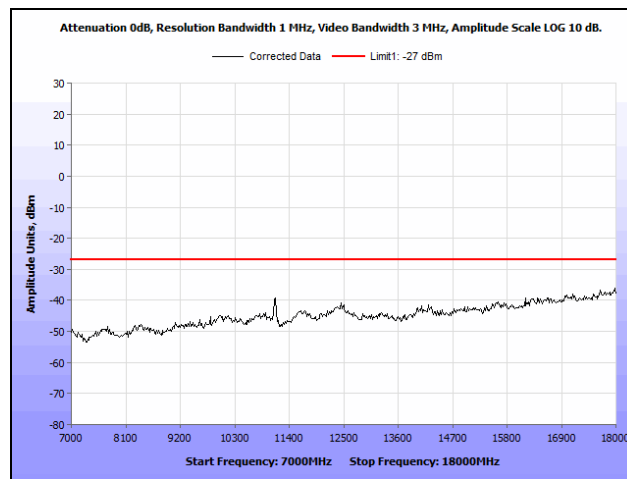
Plot 89. Radiated Spurious Emissions, 5510 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



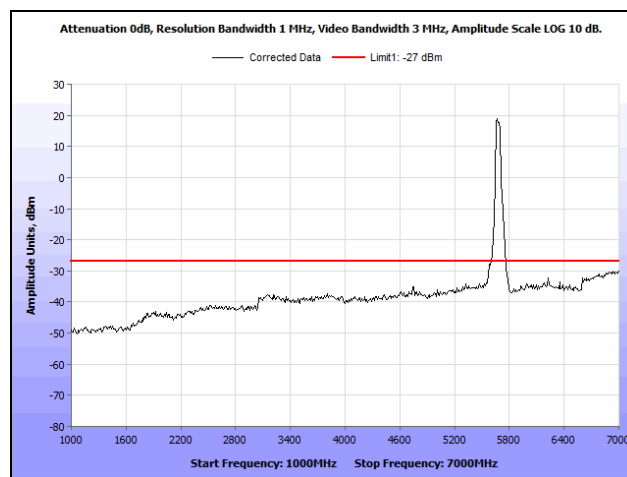
Plot 90. Radiated Spurious Emissions, 5550 MHz, 802.11ac 40 MHz, 30 MHz – 1 GHz



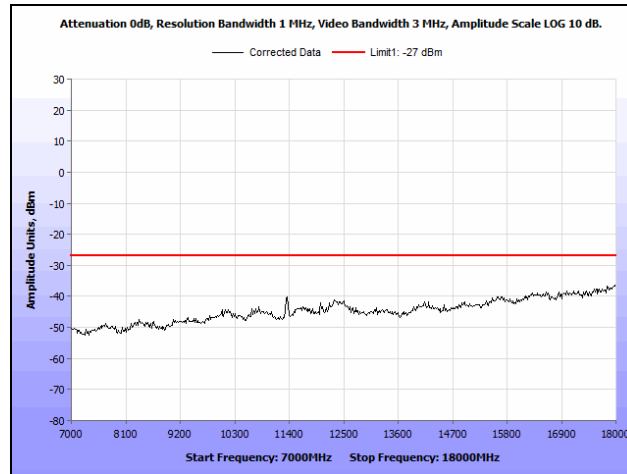
Plot 91. Radiated Spurious Emissions, 5550 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



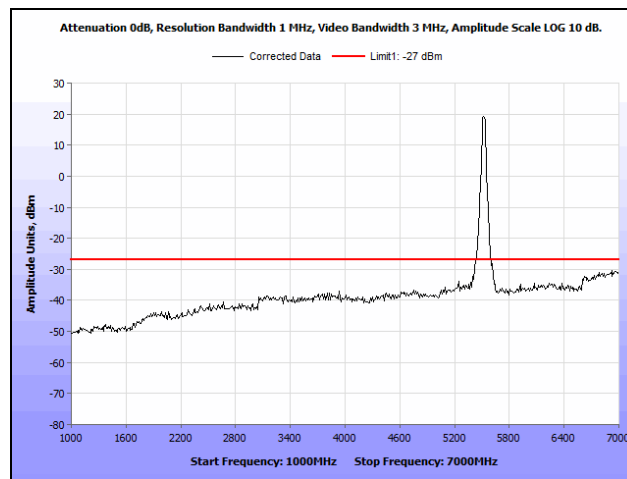
Plot 92. Radiated Spurious Emissions, 5550 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



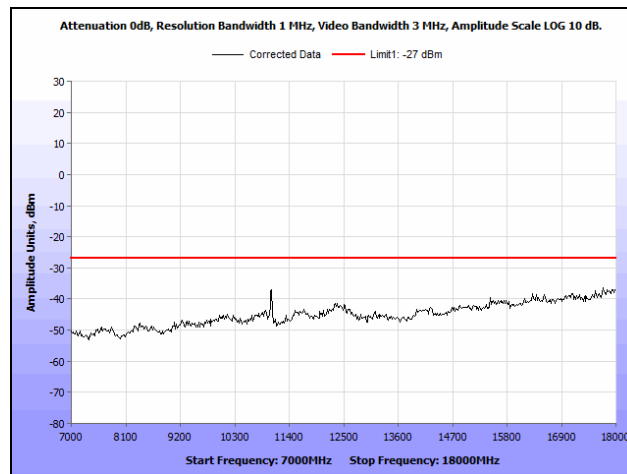
Plot 93. Radiated Spurious Emissions, 5670 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



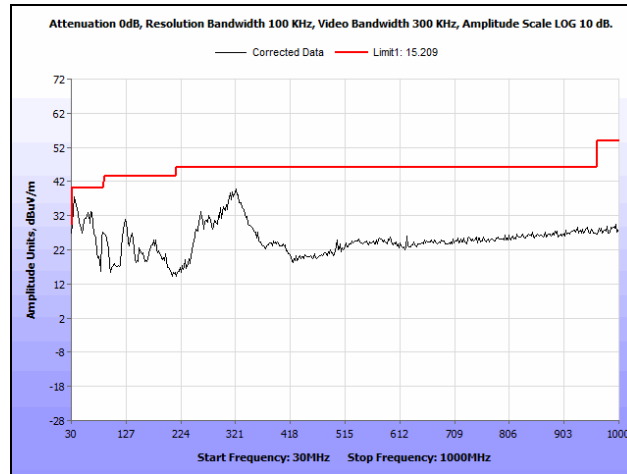
Plot 94. Radiated Spurious Emissions, 5670 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



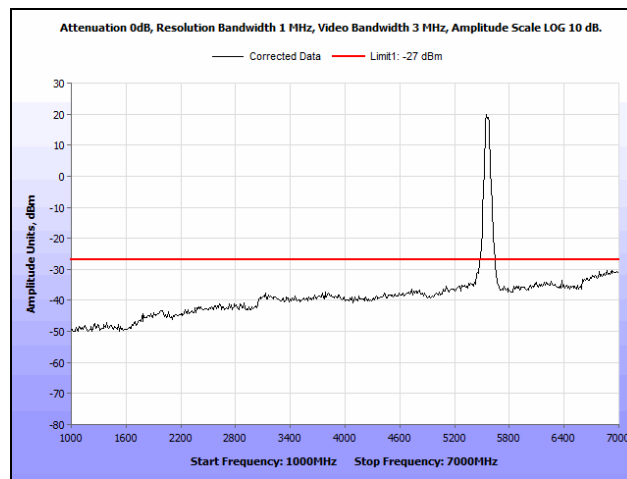
Plot 95. Radiated Spurious Emissions, 5510 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



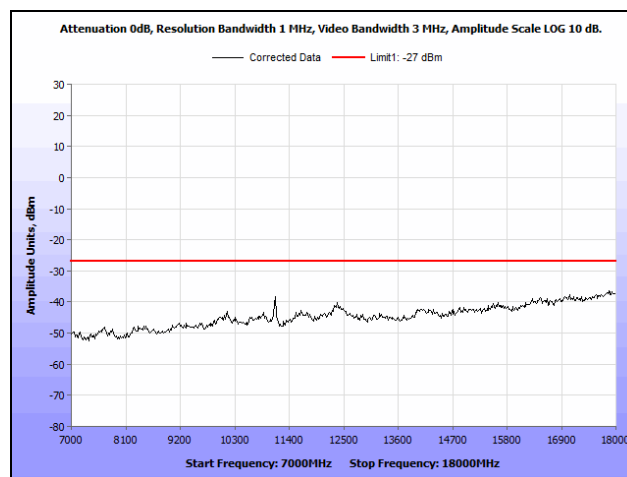
Plot 96. Radiated Spurious Emissions, 5510 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



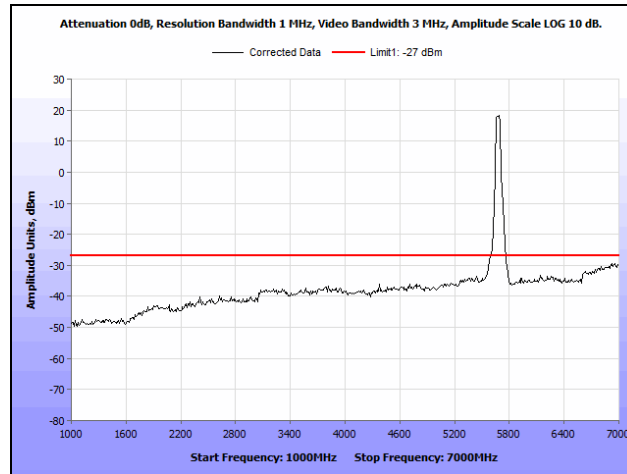
Plot 97. Radiated Spurious Emissions, 5550 MHz, 802.11n 40 MHz, 30 MHz – 1 GHz



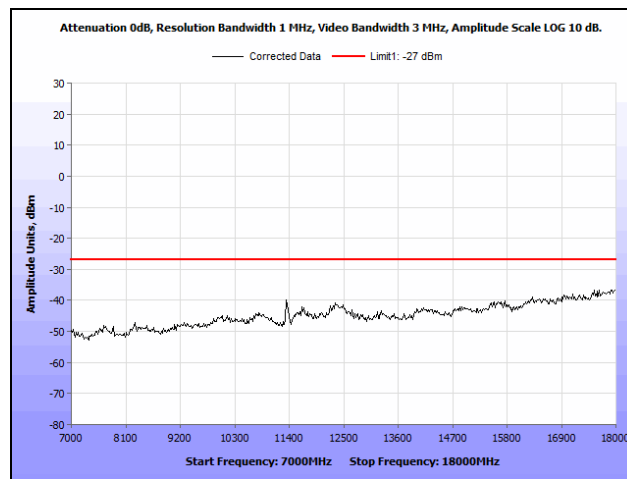
Plot 98. Radiated Spurious Emissions, 5550 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



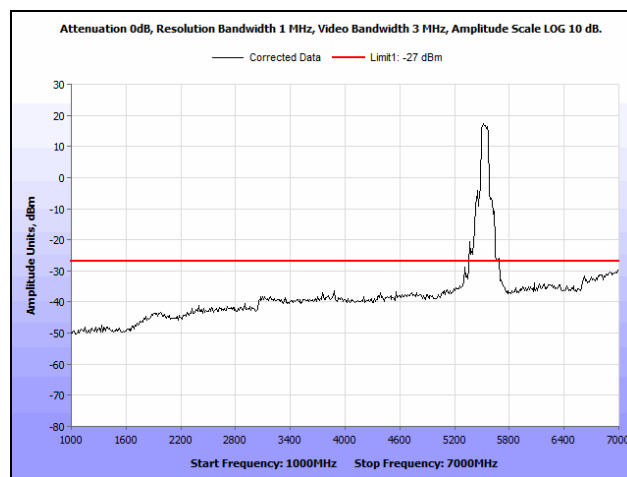
Plot 99. Radiated Spurious Emissions, 5550 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



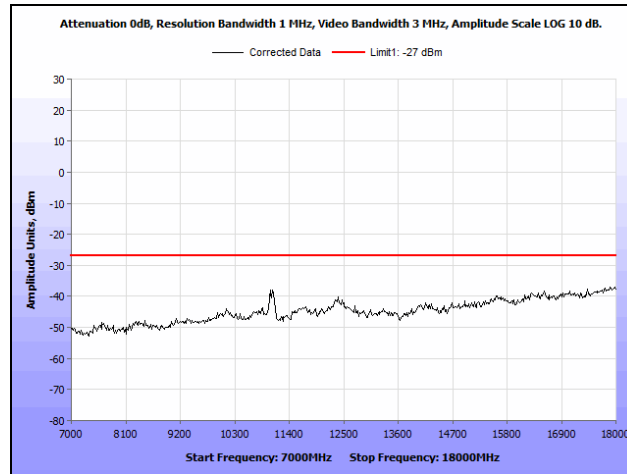
Plot 100. Radiated Spurious Emissions, 5670 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



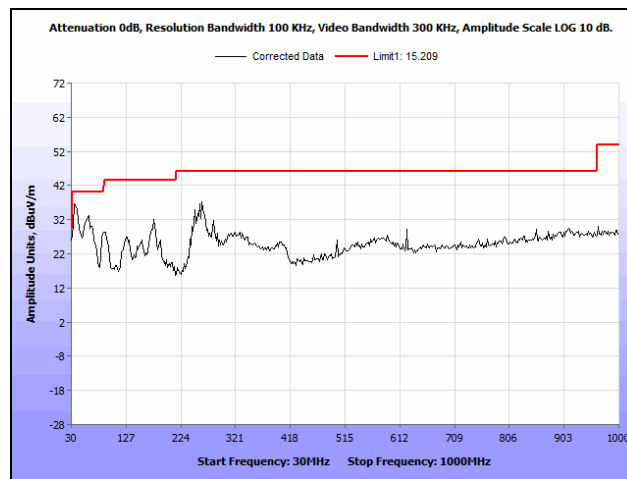
Plot 101. Radiated Spurious Emissions, 5670 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



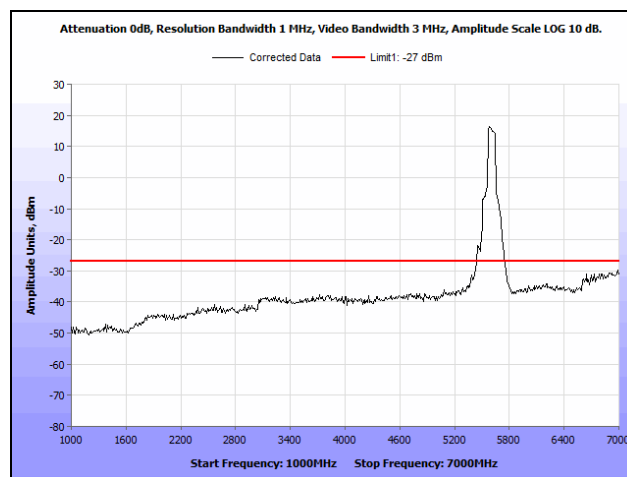
Plot 102. Radiated Spurious Emissions, 5530 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz



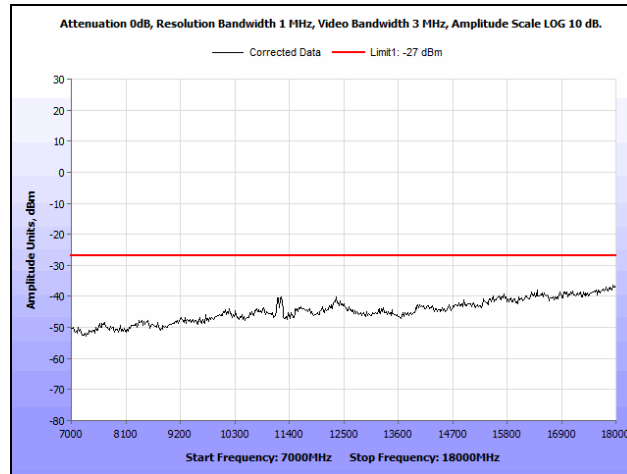
Plot 103. Radiated Spurious Emissions, 5530 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz



Plot 104. Radiated Spurious Emissions, 5610 MHz, 802.11ac 80 MHz, 30 MHz – 1 GHz

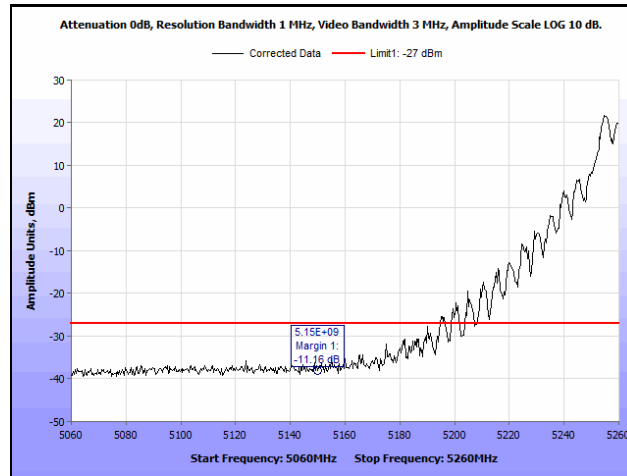


Plot 105. Radiated Spurious Emissions, 5610 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz

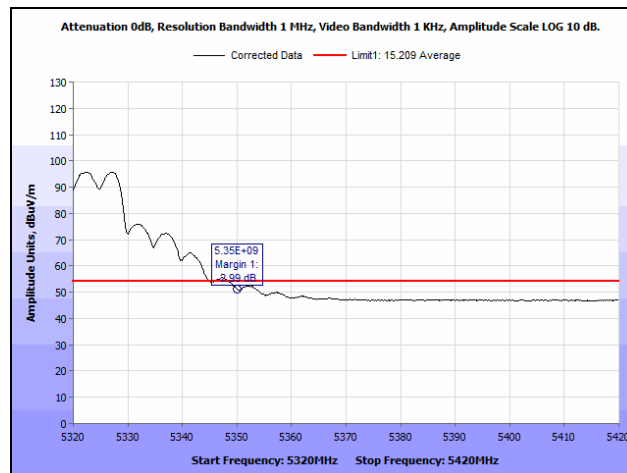


Plot 106. Radiated Spurious Emissions, 5610 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz

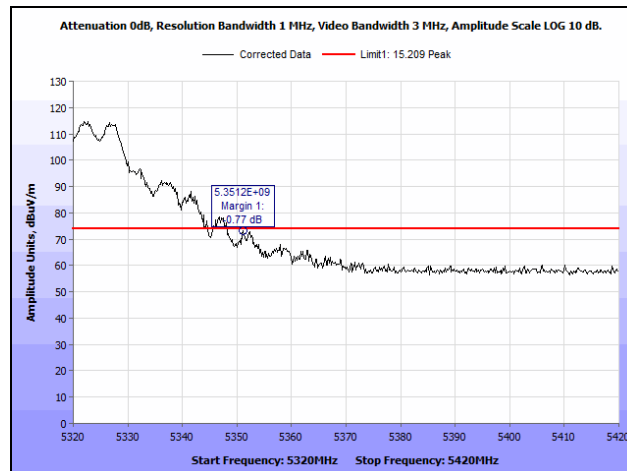
Radiated Band Edge



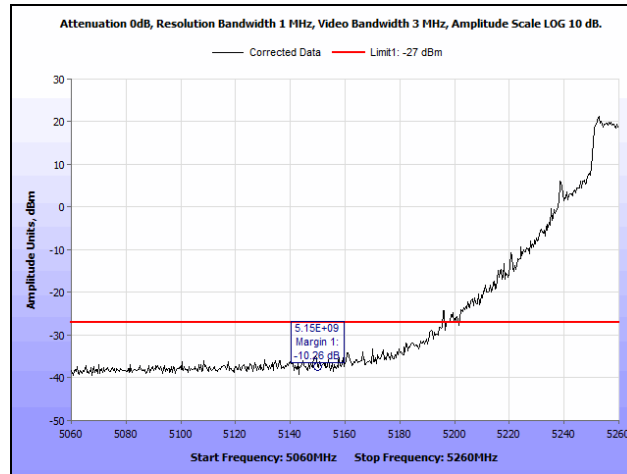
Plot 107. Radiated Band Edge, 802.11a 20 MHz, Low Channel, 5260 MHz @ 5150 MHz Edge



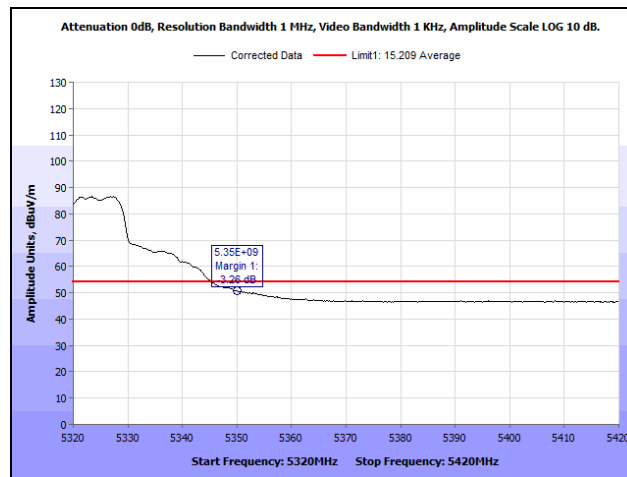
Plot 108. Radiated Band Edge, 802.11a 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



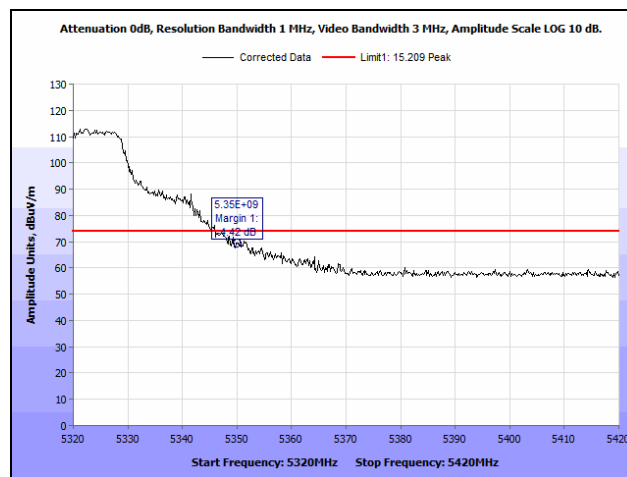
Plot 109. Radiated Band Edge, 802.11a 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



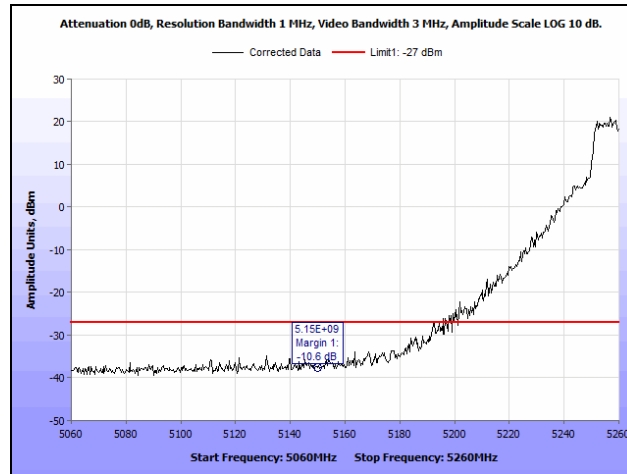
Plot 110. Radiated Band Edge, 802.11ac 20 MHz, Low Channel, 5260 MHz @ 5150 MHz Edge



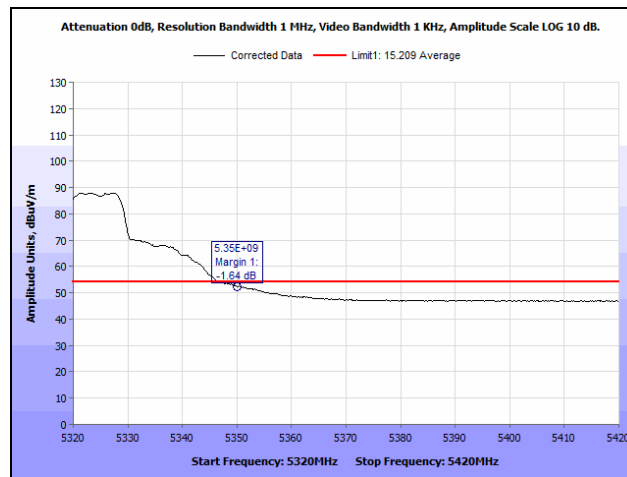
Plot 111. Radiated Band Edge, 802.11ac 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



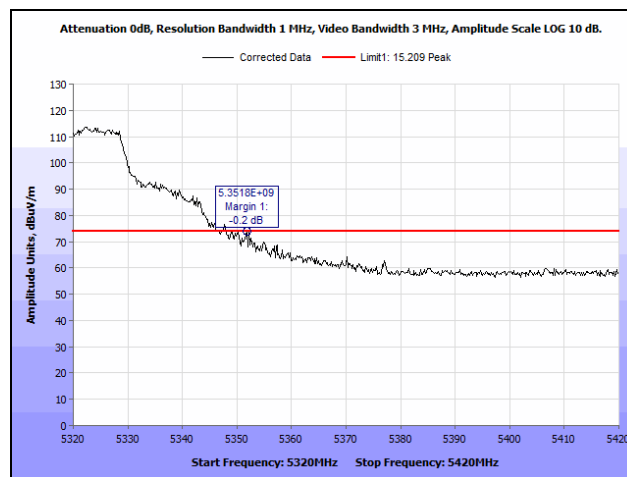
Plot 112. Radiated Band Edge, 802.11ac 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



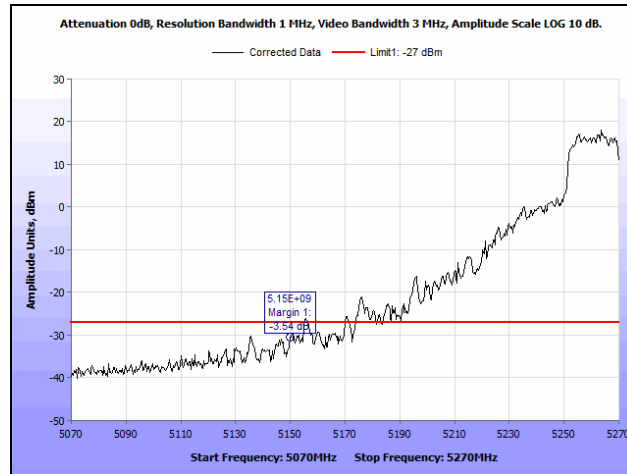
Plot 113. Radiated Band Edge, 802.11n 20 MHz, Low Channel, 5260 MHz @ 5150 MHz Edge



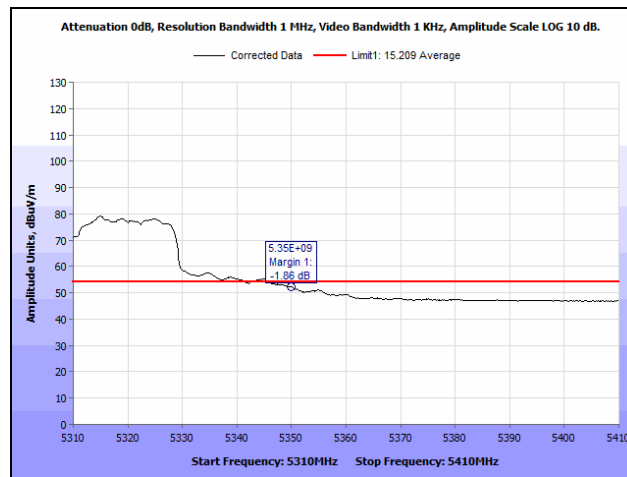
Plot 114. Radiated Band Edge, 802.11n 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



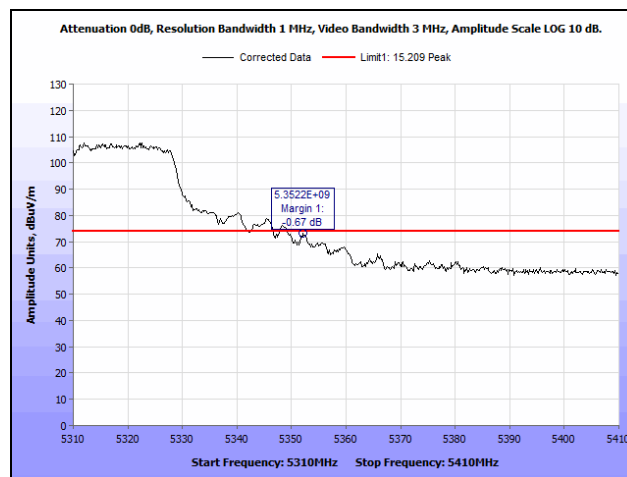
Plot 115. Radiated Band Edge, 802.11n 20 MHz, High Channel, 5320 MHz @ 5350 MHz Edge, Average



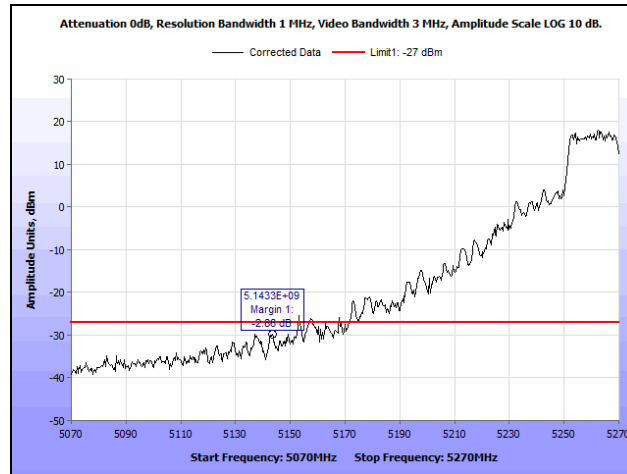
Plot 116. Radiated Band Edge, 802.11ac 40 MHz, Low Channel, 5270 MHz @ 5150 MHz Edge



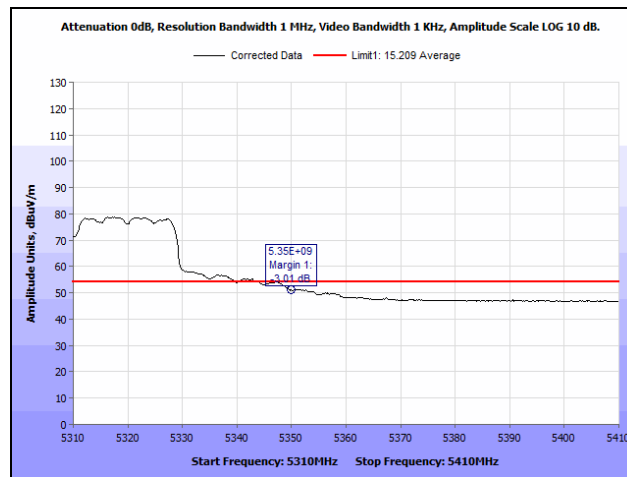
Plot 117. Radiated Band Edge, 802.11ac 40 MHz, High Channel, 5310 MHz @ 5350 MHz Edge, Average



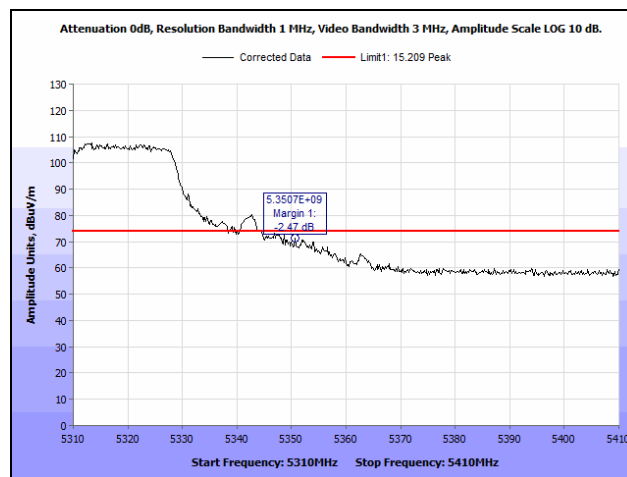
Plot 118. Radiated Band Edge, 802.11ac 40 MHz, High Channel, 5310 MHz @ 5350 MHz Edge, Average



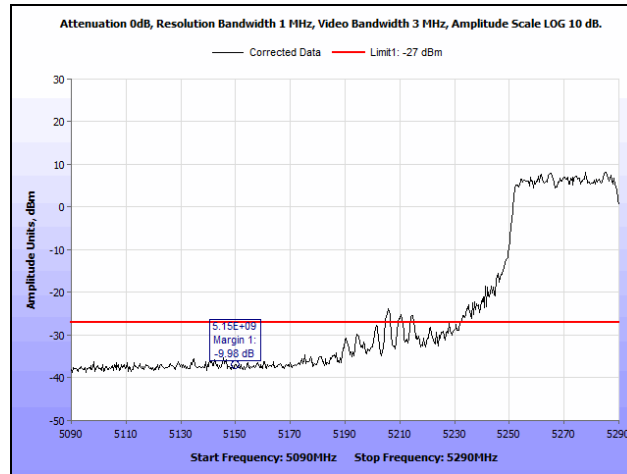
Plot 119. Radiated Band Edge, 802.11n 40 MHz, Low Channel, 5270 MHz @ 5150 MHz Edge



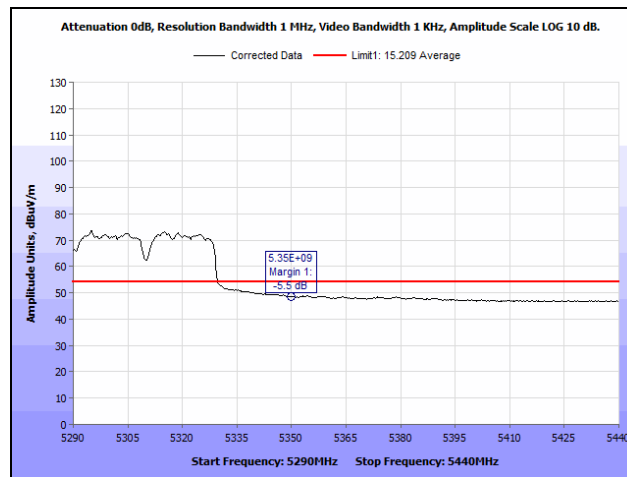
Plot 120. Radiated Band Edge, 802.11n 40 MHz, High Channel, 5310 MHz @ 5350 MHz Edge, Average



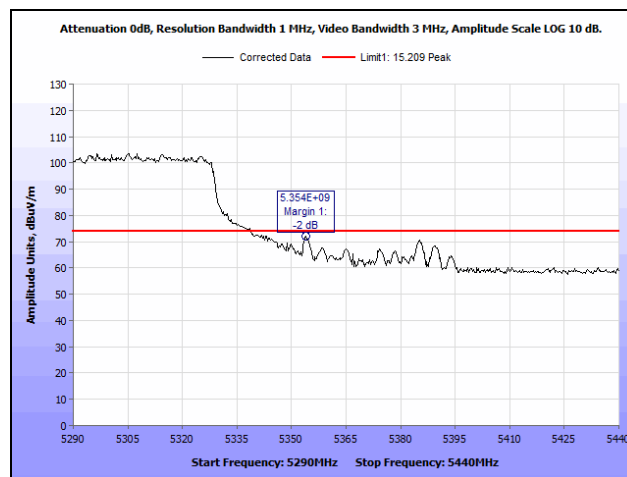
Plot 121. Radiated Band Edge, 802.11n 40 MHz, High Channel, 5310 MHz @ 5350 MHz Edge, Average



Plot 122. Radiated Band Edge, 802.11ac 80 MHz, Low Channel, 5290 MHz @ 5150 MHz Edge

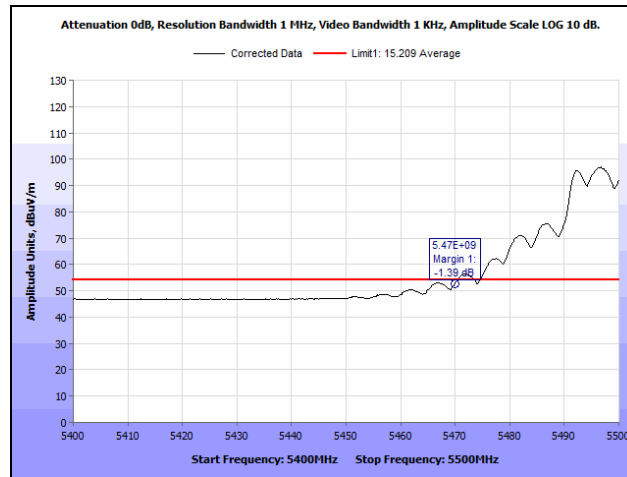


Plot 123. Radiated Band Edge, 802.11ac 80 MHz, High Channel, 5290 MHz @ 5350 MHz Edge, Average

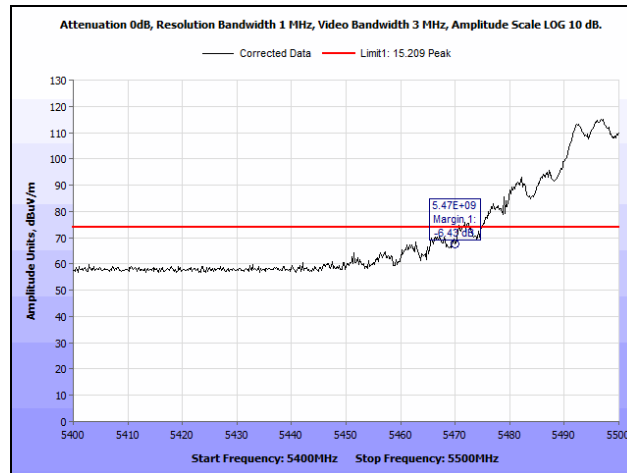


Plot 124. Radiated Band Edge, 802.11ac 80 MHz, High Channel, 5290 MHz @ 5350 MHz Edge, Average

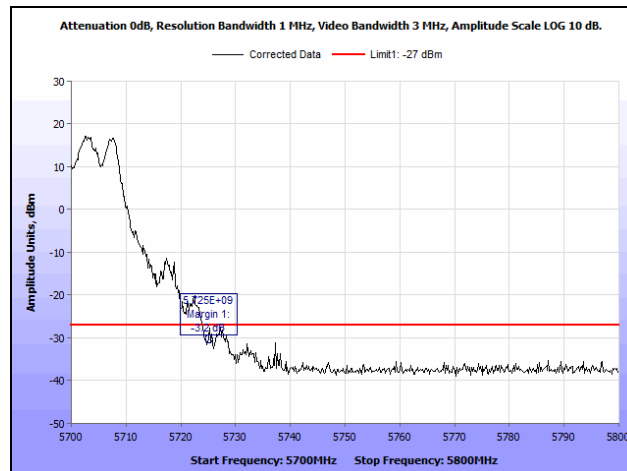
Radiated Band Edge



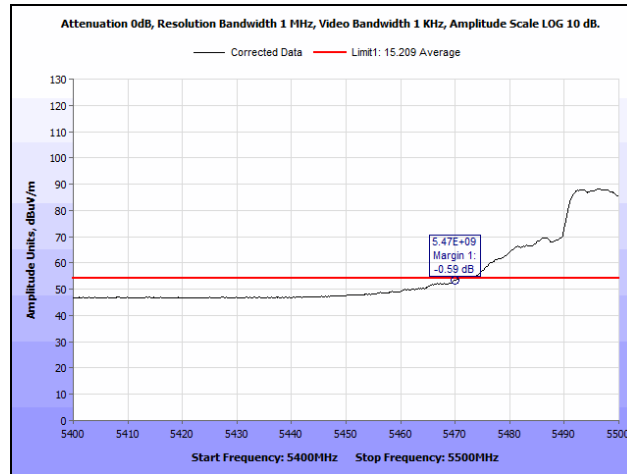
Plot 125. Radiated Band Edge, 802.11a 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Average



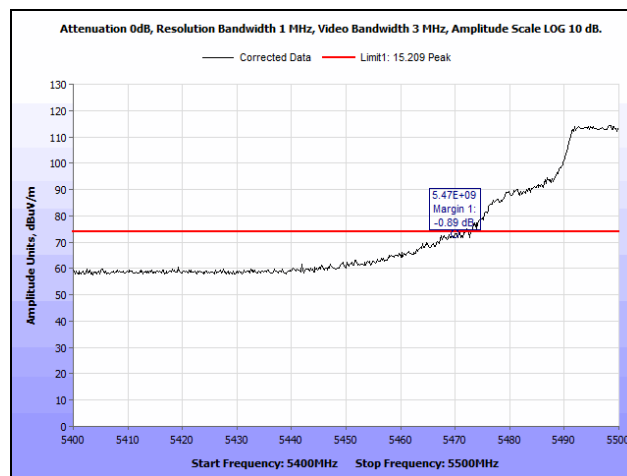
Plot 126. Radiated Band Edge, 802.11a 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Peak



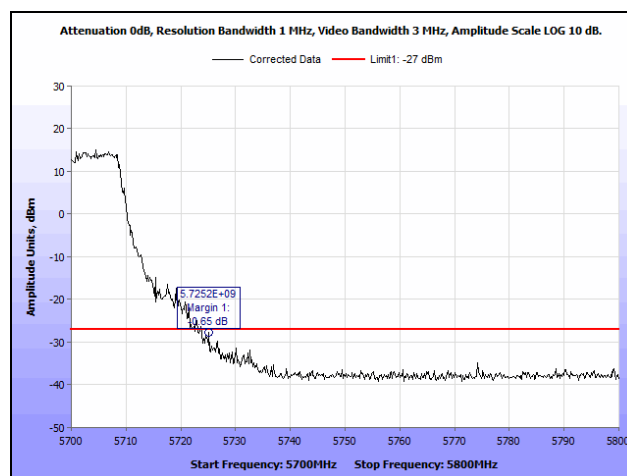
Plot 127. Radiated Band Edge, 802.11a 20 MHz, High Channel, 5700 MHz @ 5725 MHz Edge



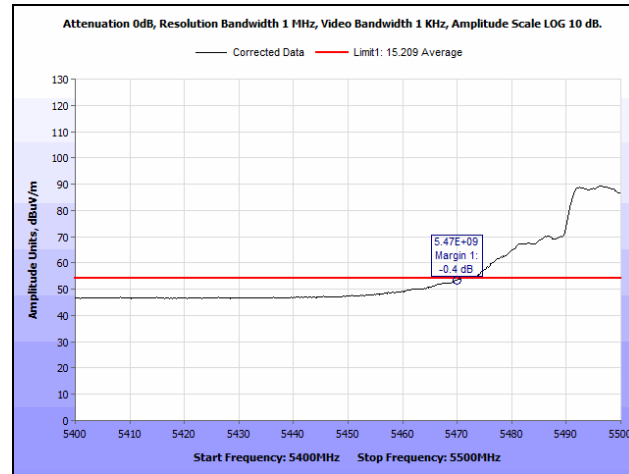
Plot 128. Radiated Band Edge, 802.11ac 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Average



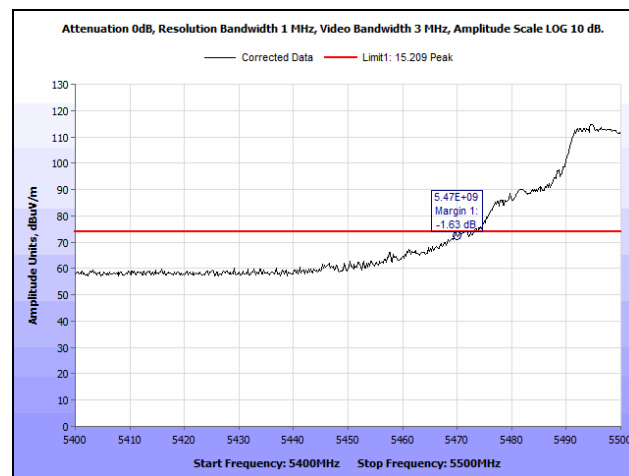
Plot 129. Radiated Band Edge, 802.11ac 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Peak



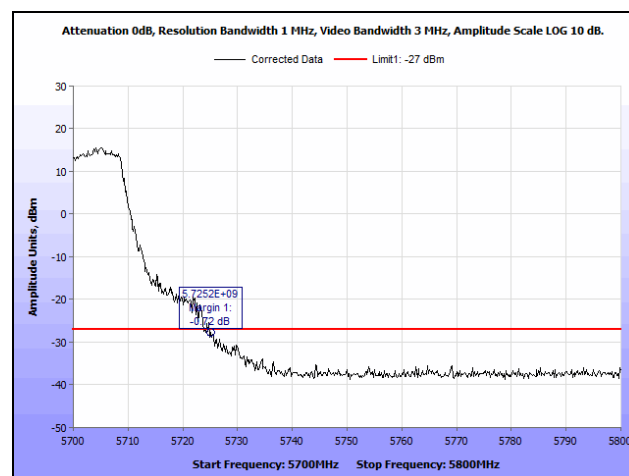
Plot 130. Radiated Band Edge, 802.11ac 20 MHz, High Channel, 5700 MHz @ 5725 MHz Edge



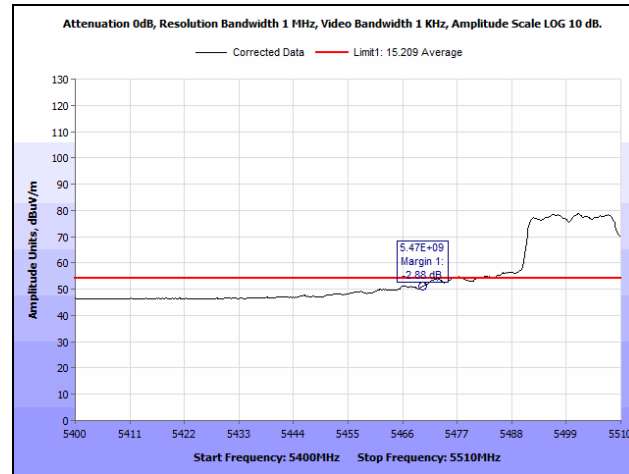
Plot 131. Radiated Band Edge, 802.11n 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Average



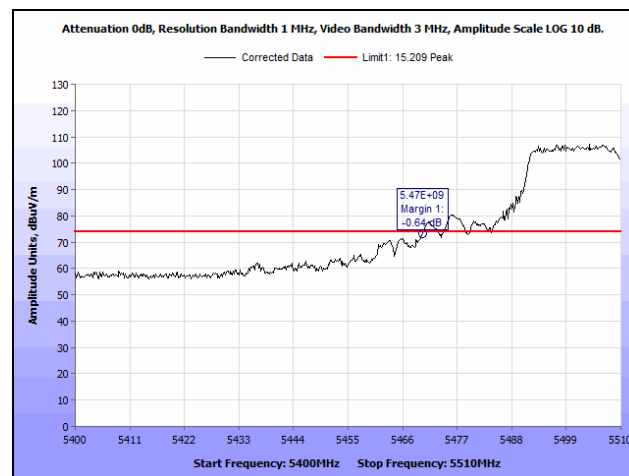
Plot 132. Radiated Band Edge, 802.11n 20 MHz, Low Channel, 5500 MHz @ 5470 MHz Edge, Peak



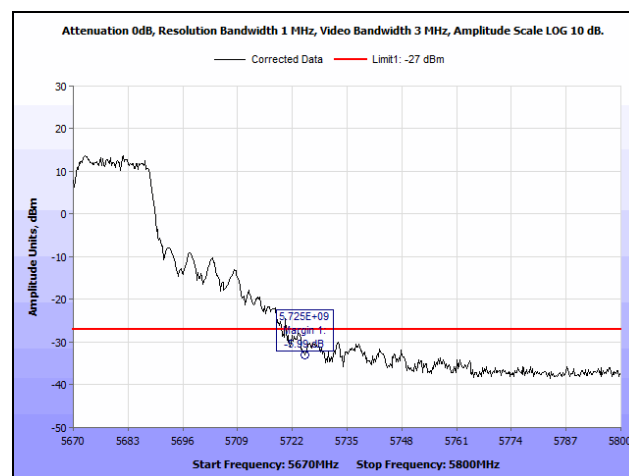
Plot 133. Radiated Band Edge, 802.11n 20 MHz, High Channel, 5700 MHz @ 5725 MHz Edge



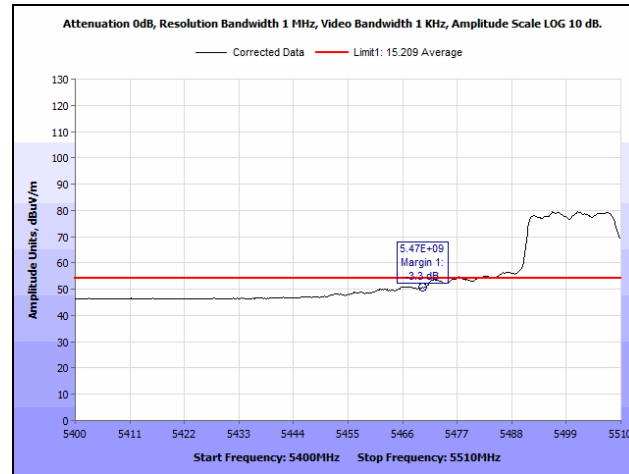
Plot 134. Radiated Band Edge, 802.11ac 40 MHz, Low Channel, 5510 MHz @ 5470 MHz Edge, Average



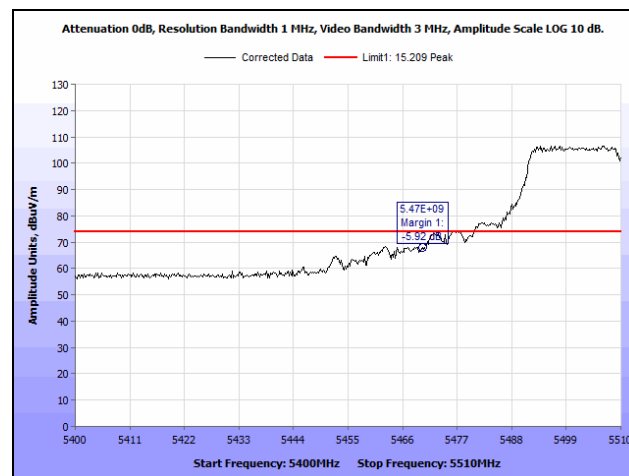
Plot 135. Radiated Band Edge, 802.11ac 40 MHz, Low Channel, 5510 MHz @ 5470 MHz Edge, Peak



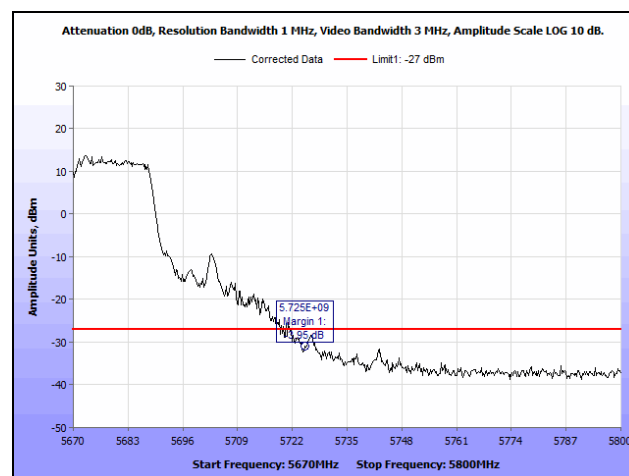
Plot 136. Radiated Band Edge, 802.11ac 40 MHz, High Channel, 5670 MHz @ 5725 MHz Edge



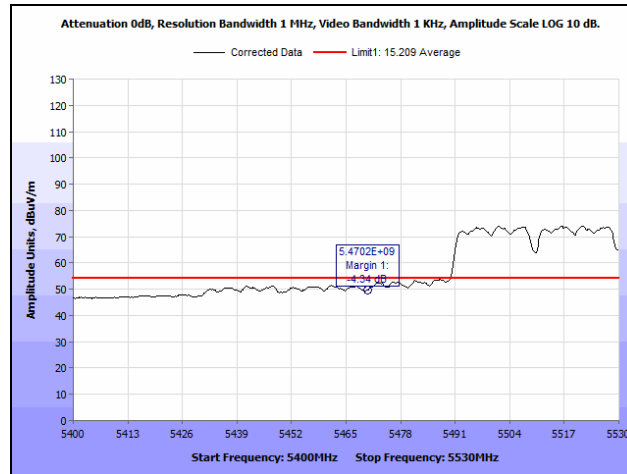
Plot 137. Radiated Band Edge, 802.11n 40 MHz, Low Channel, 5510 MHz @ 5470 MHz Edge, Average



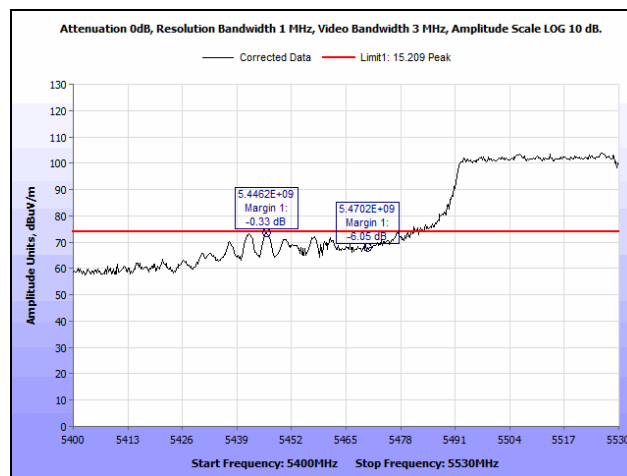
Plot 138. Radiated Band Edge, 802.11n 40 MHz, Low Channel, 5510 MHz @ 5470 MHz Edge, Peak



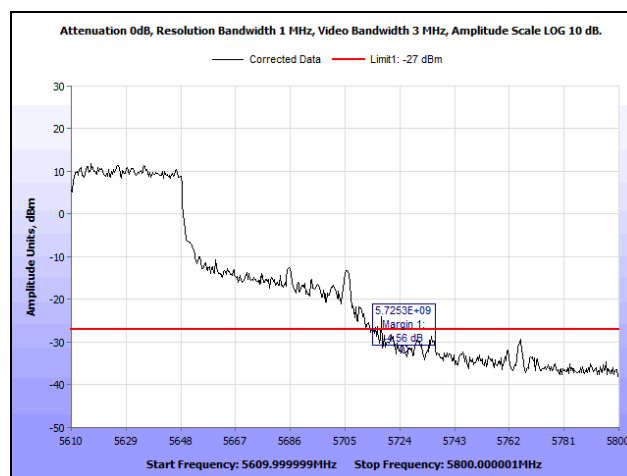
Plot 139. Radiated Band Edge, 802.11n 40 MHz, High Channel, 5670 MHz @ 5725 MHz Edge



Plot 140. Radiated Band Edge, 802.11n 80 MHz, Low Channel, 5530 MHz @ 5470 MHz Edge, Average



Plot 141. Radiated Band Edge, 802.11n 80 MHz, Low Channel, 5530 MHz @ 5470 MHz Edge, Peak



Plot 142. Radiated Band Edge, 802.11n 80 MHz, High Channel, 5610 MHz @ 5725 MHz Edge

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 @ 5.25-5.35 GHz and 5.47-5.725 GHz; highest conducted power = 23.90dBm (Avg) therefore, **Limit for Uncontrolled exposure: 1 mW/cm² or 10 W/m²**

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

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

where, S = Power Density (<1 mW/cm²)

P = Power Input to antenna (245.47 mW)

G = Antenna Gain (3.2 dBi, 2.09 numeric)

R = Minimum Distance between User and Antenna (20 cm)

$$S = (245.47 \times 2.09) / (4 \times 3.14 \times 20^2) = 0.102 \text{ mW/cm}^2$$

Since $S < 1 \text{ mW/cm}^2$, the minimum distance (R) is 20cm

IV. DFS Requirements and Radar Waveform Description & Calibration

A. DFS Requirements

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
<i>Non-Occupancy Period</i>	Yes	Not required	Yes
<i>DFS Detection Threshold</i>	Yes	Not required	Yes
<i>Channel Availability Check Time</i>	Yes	Not required	Not required
<i>Uniform Spreading</i>	Yes	Not required	Not required
<i>U-NII Detection Bandwidth</i>	Yes	Not required	Yes

Table 15. Applicability of DFS Requirements Prior to Use of a Channel

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
<i>DFS Detection Threshold</i>	Yes	Not required	Yes
<i>Channel Closing Transmission Time</i>	Yes	Yes	Yes
<i>Channel Move Time</i>	Yes	Yes	Yes
<i>U-NII Detection Bandwidth</i>	Yes	Not required	Yes

Table 16. Applicability of DFS Requirements During Normal Operation

Maximum Transmit Power	Value
≥ 200 milliwatt	-64 dBm
< 200 milliwatt	-62 dBm
Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.	

Table 17. DFS Detection Thresholds for Master or Client Devices Incorporating DFS

Parameter	Value
<i>Non-occupancy period</i>	Minimum 30 minutes
<i>Channel Availability Check Time</i>	60 seconds
<i>Channel Move Time</i>	10 seconds See Note 1
<i>Channel Closing Transmission Time</i>	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2
<i>U-NII Detection Bandwidth</i>	Minimum 80% of the 99% power bandwidth. See Note 3.
Note 1: The instant that the <i>Channel Move Time</i> and the <i>Channel Closing Transmission Time</i> begins is as follows: • For the Short pulse radar Test Signals this instant is the end of the <i>Burst</i>. • For the Frequency Hopping radar Test Signal, this instant is the end of the last radar <i>Burst</i> generated. • For the Long Pulse radar Test Signal this instant is the end of the 12 second period defining the radar transmission. Note 2: The <i>Channel Closing Transmission Time</i> is comprised of 200 milliseconds starting at the beginning of the <i>Channel Move Time</i> plus any additional intermittent control signals required facilitating <i>Channel</i> changes (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions. Note 3: During the <i>U-NII Detection Bandwidth</i> detection test, radar type 1 is used and for each frequency step the minimum percentage of detection is 90%. Measurements are performed with no data traffic.	

Table 18. DFS Response Requirement Values

B. Radar Test Waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance. Step intervals of 0.1 microsecond for Pulse Width, 1 microsecond for PRI, 1 MHz for chirp width and 1 for the number of pulses will be utilized for the random determination of specific test waveforms.

Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Trials
1	1	1428	18	60%	30
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120

A minimum of 30 unique waveforms are required for each of the short pulse radar types 2 through 4. For short pulse radar type 1, the same waveform is used a minimum of 30 times. If more than 30 waveforms are used for short pulse radar types 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms. The aggregate is the average of the percentage of successful detections of short pulse radar types 1-4.

Long Pulse Radar Test Waveform

Radar Type	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	Number of Pulses per Bursts	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse radar test signal. If more than 30 waveforms are used for the Long Pulse radar test signal, then each additional waveform must also be unique and not repeated from the previous waveforms.

Each waveform is defined as follows:

- 1) The transmission period for the Long Pulse Radar test signal is 12 seconds.
- 2) There are a total of 8 to 20 Bursts in the 12 second period, with the number of Bursts being randomly chosen. This number is Burst_Count.
- 3) Each Burst consists of 1 to 3 pulses, with the number of pulses being randomly chosen. Each Burst within the 12 second sequence may have a different number of pulses.
- 4) The pulse width is between 50 and 100 microseconds, with the pulse width being randomly chosen. Each pulse within a Burst will have the same pulse width. Pulses in different Bursts may have different pulse widths.
- 5) Each pulse has a linear FM chirp between 5 and 20 MHz, with the chirp width being randomly chosen. Each pulse within a Burst will have the same chirp width. Pulses in different Bursts may have different chirp widths. The chirp is centered on the pulse. For example, with radar frequency of 5300 MHz and a 20 MHz chirped signal, the chirp starts at 5290 MHz and ends at 5310 MHz.
- 6) If more than one pulse is present in a Burst, the time between the pulses will be between 1000 and 2000 microseconds, with the time being randomly chosen. If three pulses are present in a Burst, the time between the first and second pulses is chosen independently of the time between the second and third pulses.
- 7) The 12 second transmission period is divided into even intervals. The number of intervals is equal to Burst_Count. Each interval is of length $(12,000,000 / \text{Burst_Count})$ microseconds. Each interval contains one Burst. The start time for the Burst, relative to the beginning of the interval, is between 1 and $[(12,000,000 / \text{Burst_Count}) - (\text{Total Burst Length}) + (\text{One Random PRI Interval})]$ microseconds, with the start time being randomly chosen. The step interval for the start time is 1 microsecond. The start time for each Burst is chosen independently.

A representative example of a Long Pulse radar test waveform:

- 1) The total test signal length is 12 seconds.
- 2) 8 Bursts are randomly generated for the Burst_Count.
- 3) Burst 1 has 2 randomly generated pulses.
- 4) The pulse width (for both pulses) is randomly selected to be 75 microseconds.
- 5) The PRI is randomly selected to be at 1213 microseconds.
- 6) Bursts 2 through 8 are generated using steps 3 – 5.
- 7) Each Burst is contained in even intervals of 1,500,000 microseconds. The starting location for Pulse 1, Burst 1 is randomly generated (1 to 1,500,000 minus the total Burst 1 length + 1 random PRI interval) at the 325,001 microsecond step. Bursts 2 through 8 randomly fall in successive 1,500,000 microsecond intervals (i.e. Burst 2 falls in the 1,500,001 – 3,000,000 microsecond range).

Graphical Representation of a Long Pulse radar Test Waveform

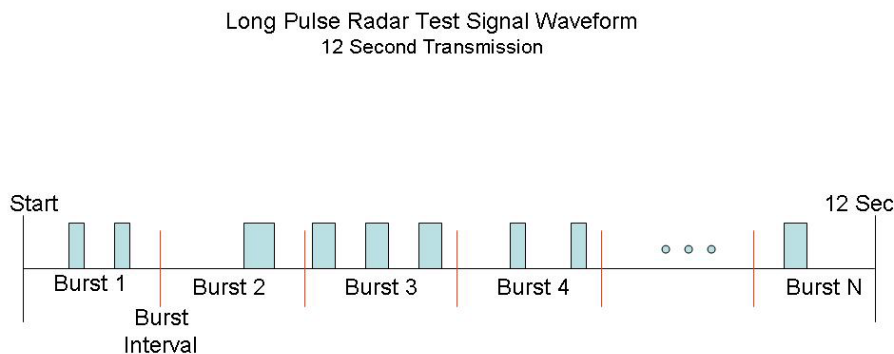


Figure 5. Long Pulse Radar Test Signal Waveform

Frequency Hopping Radar Test Waveform

Radar Type	Pulse Width (μsec)	PRI (μsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	9	.333	300	70%	30

For the Frequency Hopping Radar Type, the same *Burst* parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected from the hopping sequence defined by the following algorithm:

The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set. For selection of a random frequency, the frequencies remaining within the group are always treated as equally likely.

C. Radar Waveform Calibration

The following equipment setup was used to calibrate the radiated Radar Waveform. A spectrum analyzer was used to establish the test signal level for each radar type. During this process there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) mode at the frequency of the Radar Waveform generator. Peak detection was utilized. The spectrum analyzer's resolution bandwidth (RBW) was set to 3 MHz and the video bandwidth (VBW) was set to 3 MHz. The calibration setup is diagrammed in Figure 6, and the radar test signal generator is shown in Photograph 1.

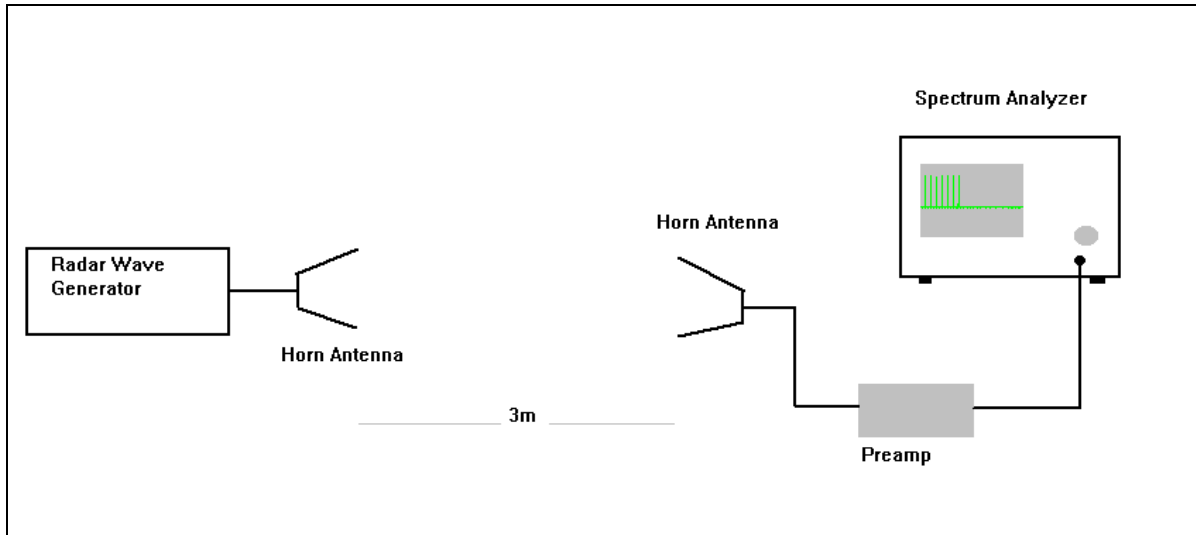
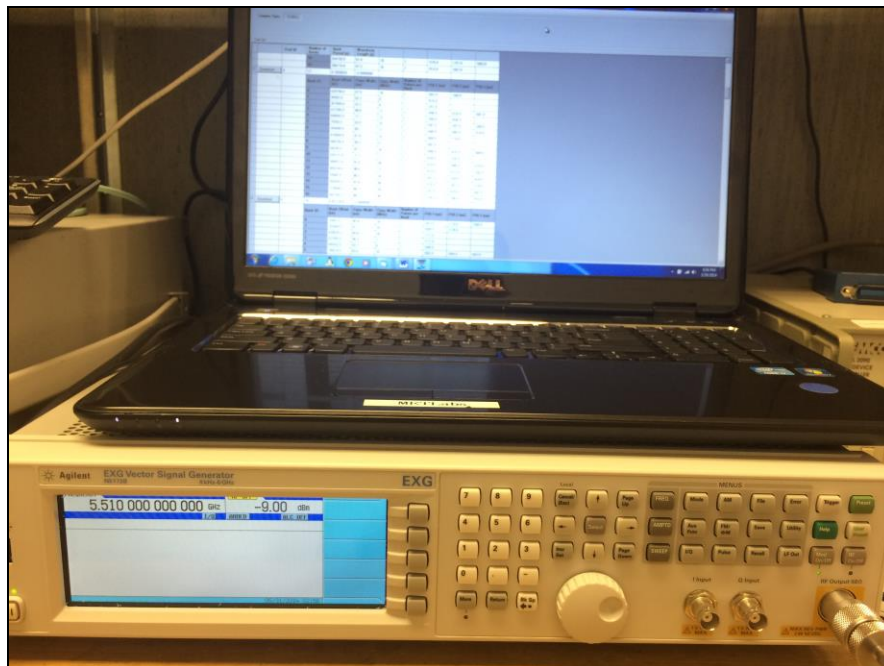
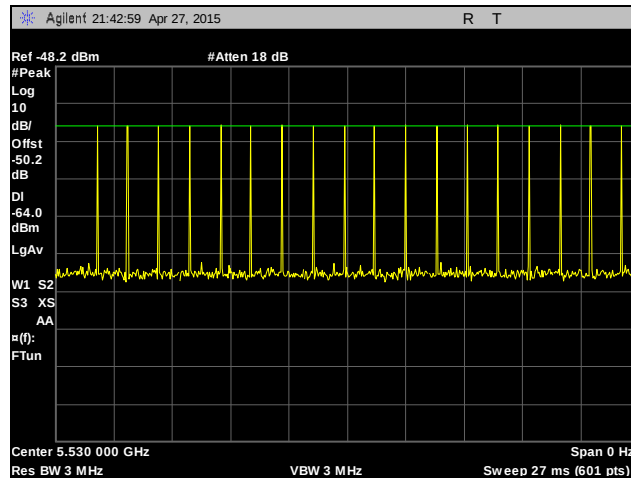


Figure 6. Calibration Test setup

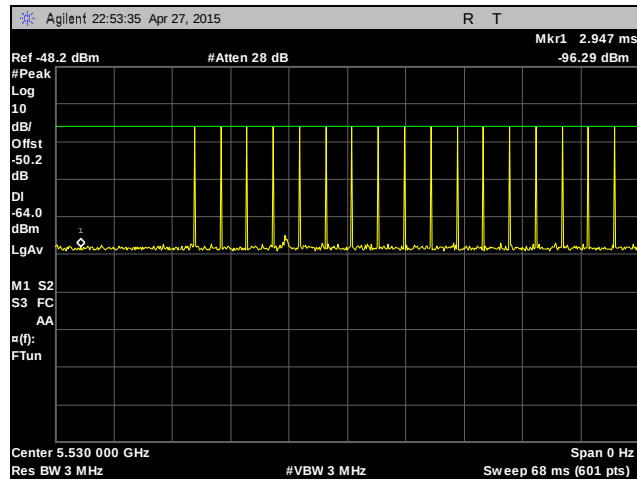


Photograph 1. DFS Radar Test Signal Generator

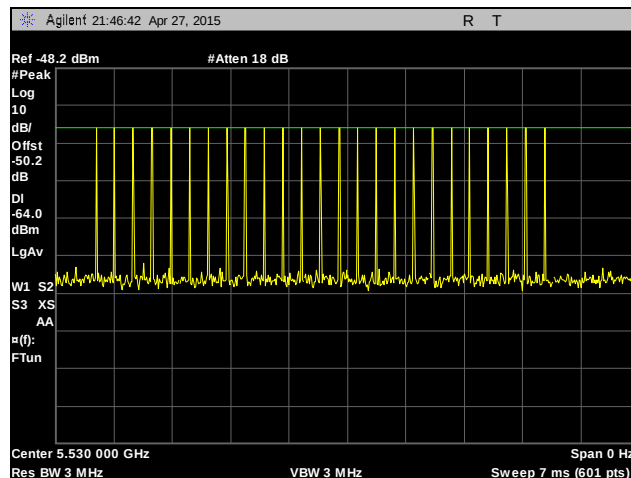
Radar Waveform Calibration



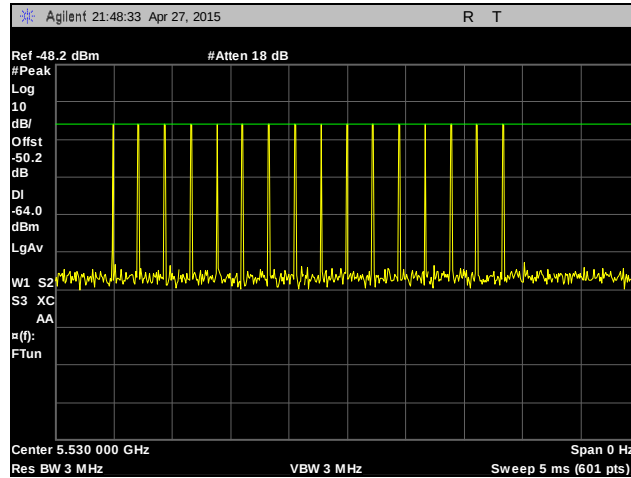
Plot 143. Calibration, Type 0



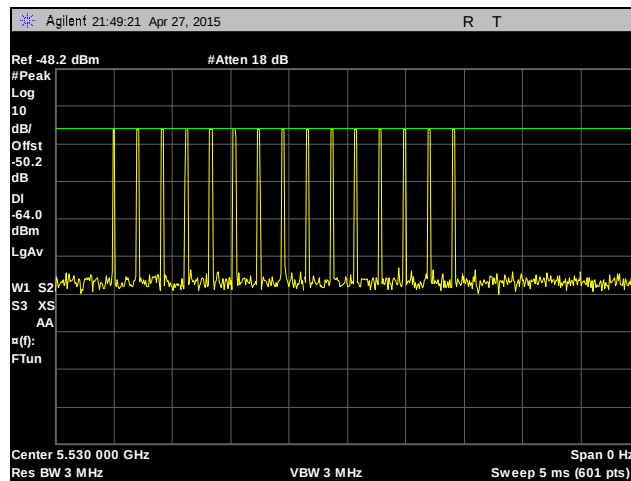
Plot 144. Calibration, Type 1



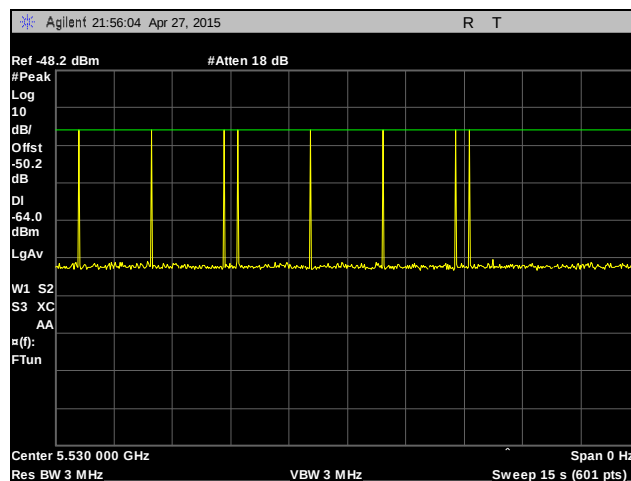
Plot 145. Calibration, Type 2



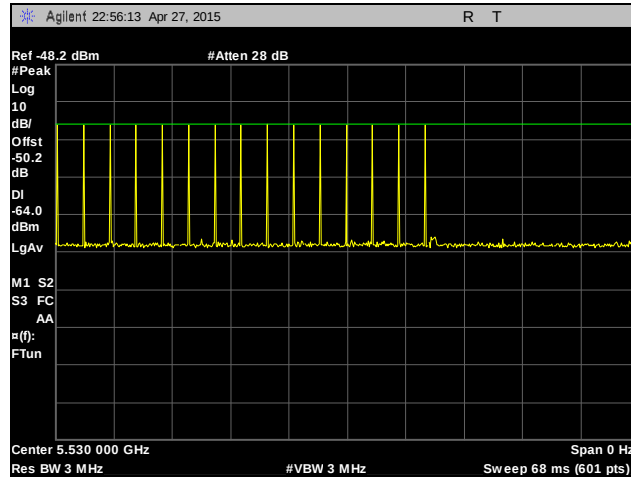
Plot 146. Calibration, Type3



Plot 147. Calibration, Type 4



Plot 148. Calibration, Type 5



Plot 149. Calibration, Type 6

V. DFS Test Procedure and Test Results