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

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 3) 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 3 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 3 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

Electromagnetic Compatibility Criteria
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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 9, 2016	Engineer corrections.
2	January 4, 2017	EUT Photos Removed for Short Term Confidentiality

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**K**ilo**h**ert**z**
kPa	**K**ilo**pa**scal
kV	**K**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**Microh**enry
µ	**Microf**arad
µs	**Micros**econds
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)(3)	Conducted Transmitter Output Power	Compliant
§15.407 (a)(3)	Power Spectral Density	Compliant
§15.407 (b)(4), (6), (7)	Undesirable Emissions (15.205/15.209 - General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Compliant
§15.407 (e)	6 dB Bandwidth	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:	UNII
	Peak RF Output Power:	24.40dBm
	EUT Frequency Ranges:	5745MHz-5825 MHz 5755MHz-5795MHz
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
KDB 789033 D02	General UNII Test Procedures

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

T 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.

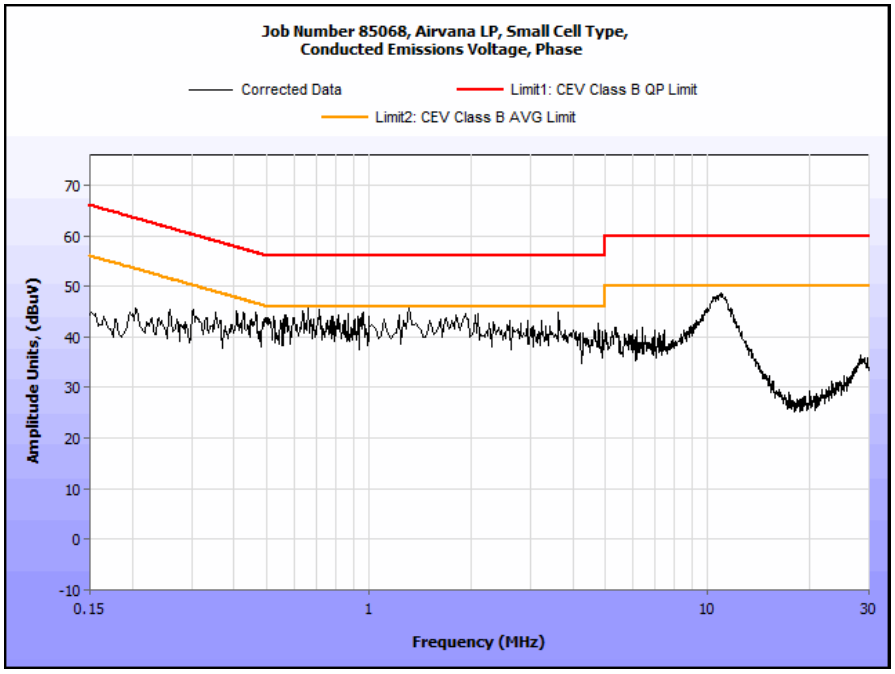
Test Engineer(s): Benjamin Taylor

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

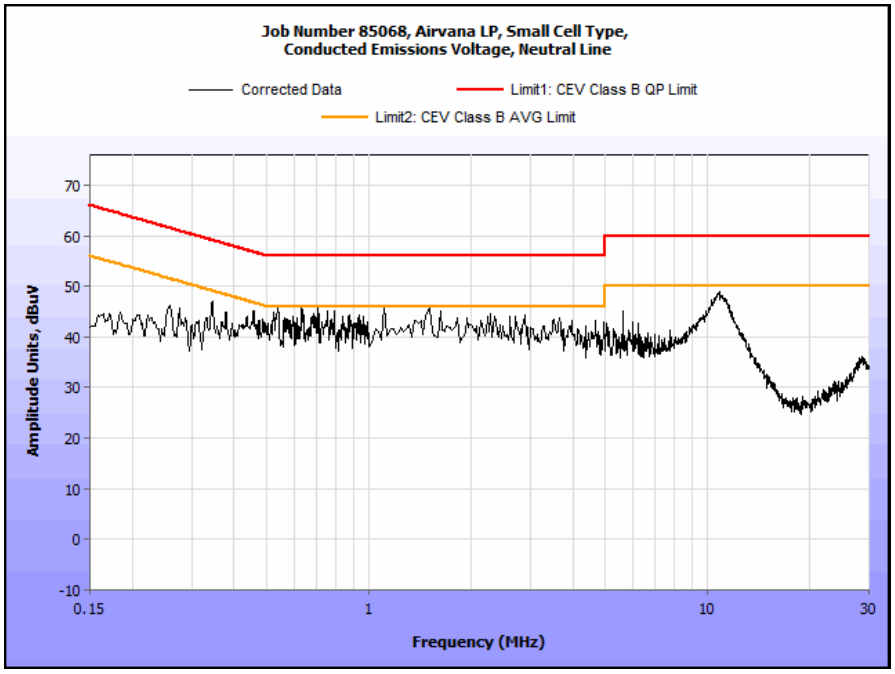


Plot 1. Conducted Emissions, 15.207(a), Phase Line

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, and 99% Bandwidth was measured and recorded. Sampling detector was not practical to obtain a clear measurement with this radio; peak detector was used for the 99% Bandwidth measurements as well.

Test Results The 26 dB and 99% Bandwidth were 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

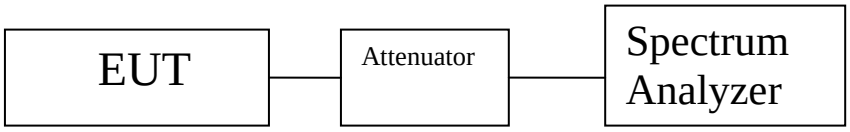
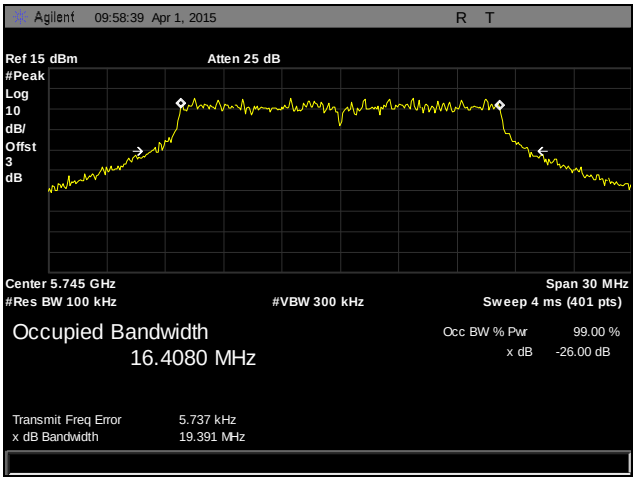


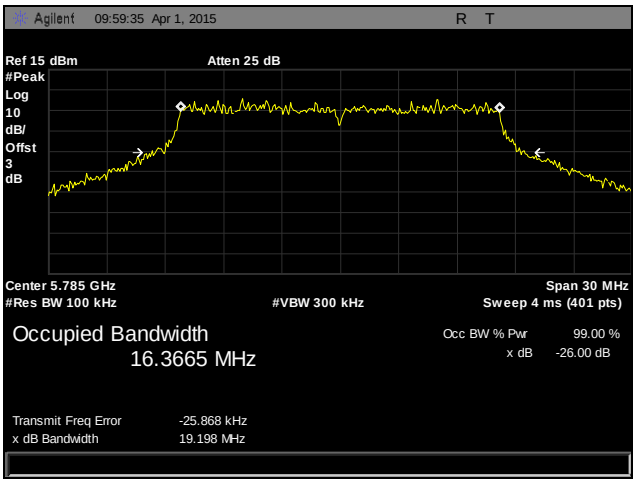
Figure 1. Occupied Bandwidth, Test Setup

Occupied Bandwidth			
Carrier Channel Mode	**Frequency (MHz)**	**Measured 26 dB Bandwidth (MHz)**	**Measured 99% Bandwidth (MHz)**
802.11a	5745	19.391	16.4080
802.11a	5785	19.198	16.3665
802.11a	5825	20.121	16.4355
802.11ac 20MHz	5745	20.344	17.6157
802.11ac 20MHz	5785	20.590	17.5946
802.11ac 20MHz	5825	20.212	17.6169
802.11n 20MHz	5745	20.490	17.6012
802.11n 20MHz	5785	20.599	17.6663
802.11n 20MHz	5825	20.121	16.4355
802.11ac 40MHz	5755	42.837	36.2029
802.11ac 40MHz	5795	41.813	36.2295
802.11n 40MHz	5755	42.529	36.2075
802.11n 40MHz	5795	42.644	36.2213
802.11ac 80MHz	5775	84.729	75.7582

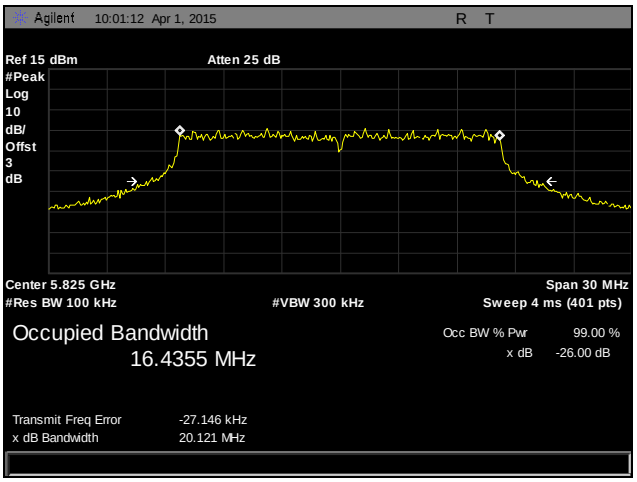
Table 10. Occupied Bandwidth, Test Results



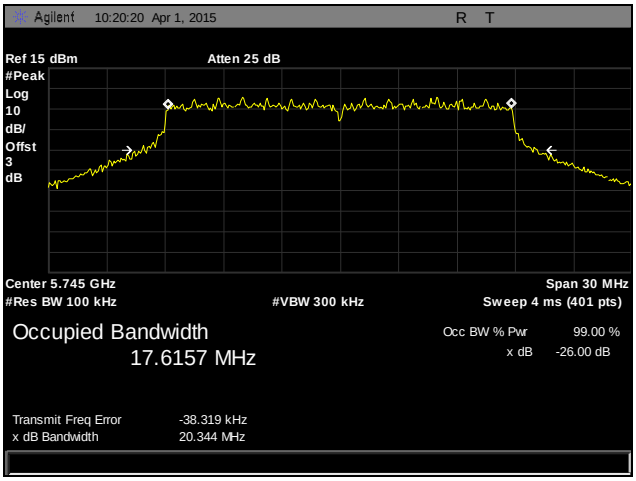
Plot 3. Occupied Bandwidth, 802.11a, Low Channel, 5745 MHz, Port A



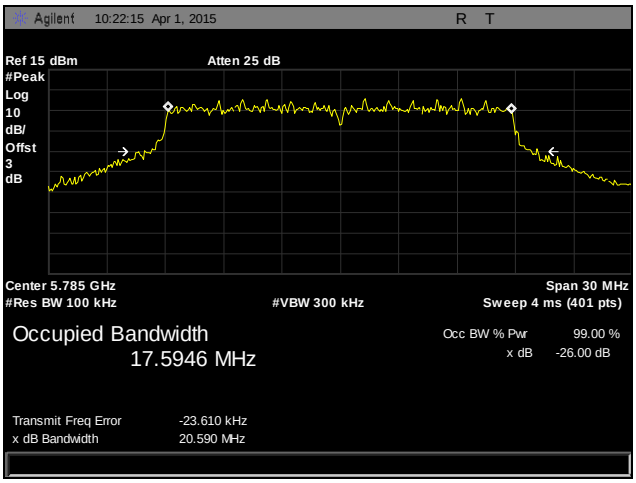
Plot 4. Occupied Bandwidth, 802.11a, Mid Channel, 5785 MHz, Port A



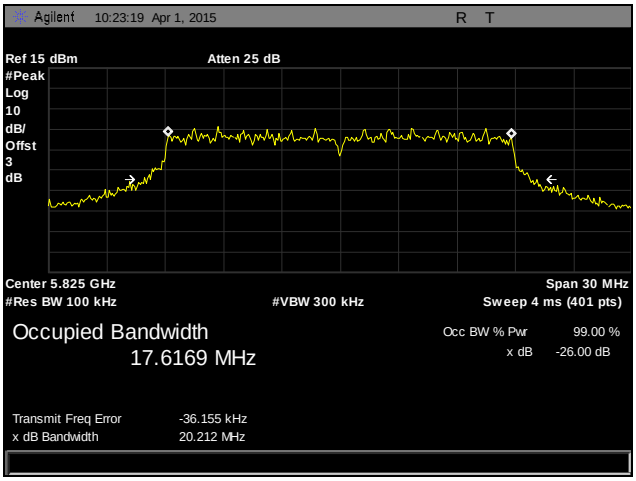
Plot 5. Occupied Bandwidth, 802.11a, High Channel, 5825 MHz, Port A



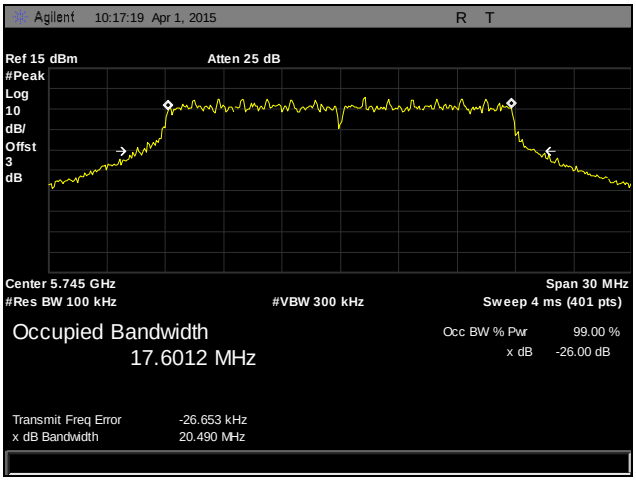
Plot 6. Occupied Bandwidth, 802.11ac 20 MHz, Low Channel, 5745 MHz, Port A



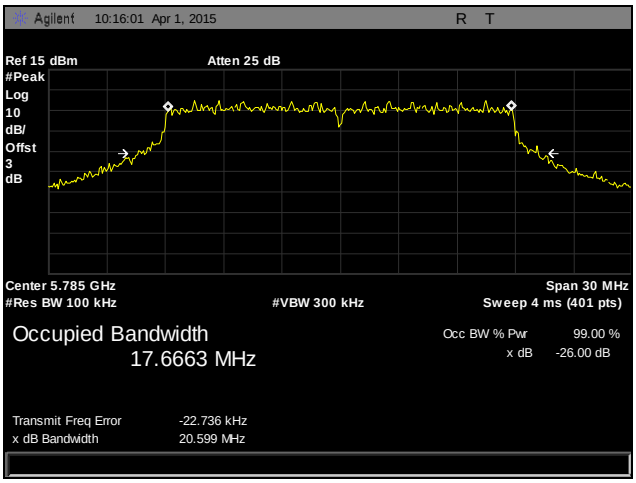
Plot 7. Occupied Bandwidth, 802.11ac 20 MHz, Mid Channel, 5785 MHz, Port A



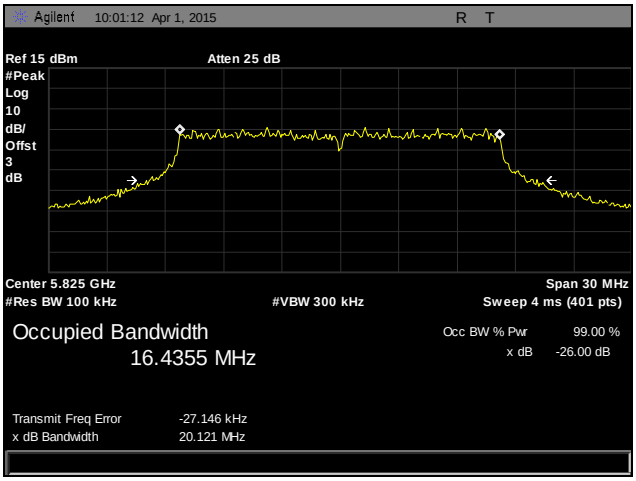
Plot 8. Occupied Bandwidth, 802.11ac 20 MHz, High Channel, 5825 MHz, Port A



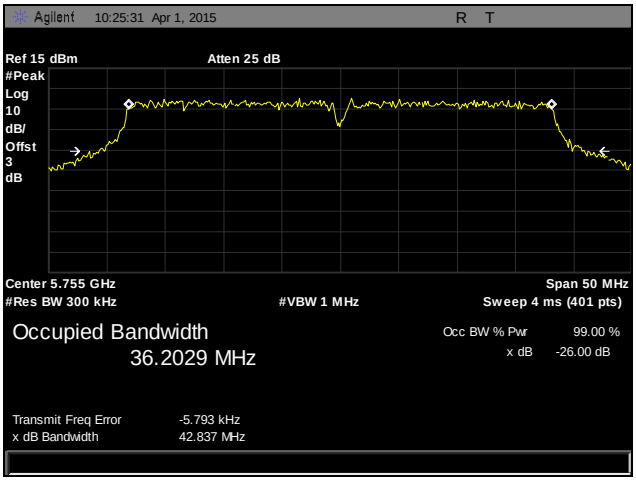
Plot 9. Occupied Bandwidth, 802.11n 20 MHz, Low Channel, 5745 MHz, Port A



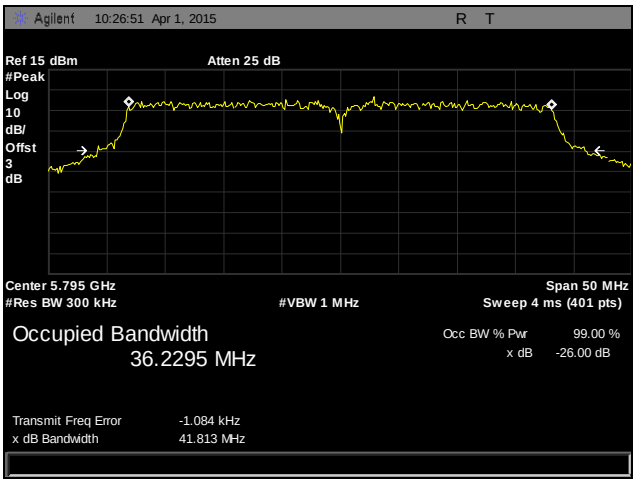
Plot 10. Occupied Bandwidth, 802.11n 20 MHz, Mid Channel, 5785 MHz, Port A



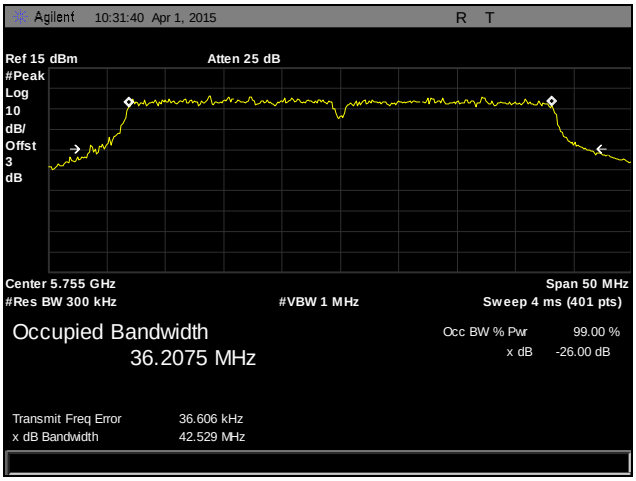
Plot 11. Occupied Bandwidth, 802.11n 20 MHz, High Channel, 5825 MHz, Port A



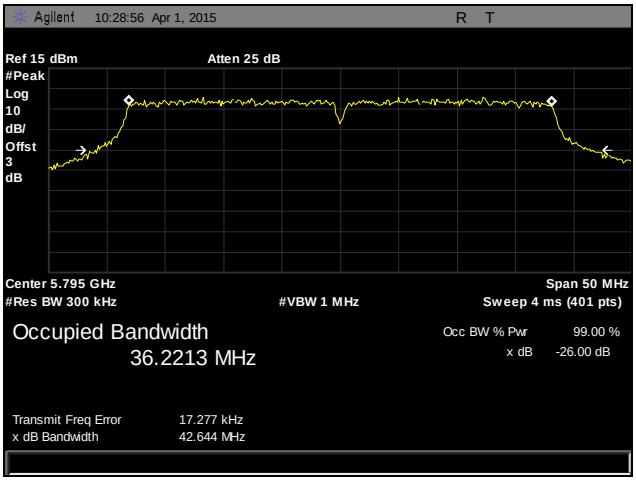
Plot 12. Occupied Bandwidth, 802.11ac 40 MHz, Low Channel, 5755 MHz, Port A



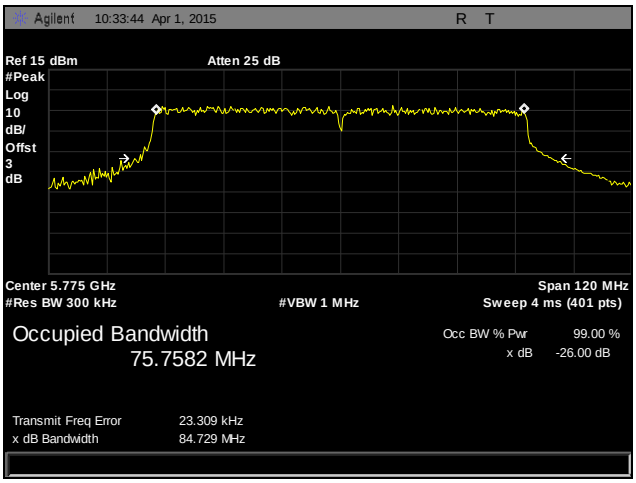
Plot 13. Occupied Bandwidth, 802.11ac 40 MHz, High Channel, 5795 MHz, Port A



Plot 14. Occupied Bandwidth, 802.11n 40 MHz, Low Channel, 5755 MHz, Port A



Plot 15. Occupied Bandwidth, 802.11n 40 MHz, High Channel, 5795 MHz, Port A



Plot 16. Occupied Bandwidth, 802.11ac 80 MHz, High Channel, 5775 MHz, Port A

Electromagnetic Compatibility Criteria for Intentional Radiators

§§15.407(a)(3) RF Power Output

Test Requirements: **§15.407(a)(3):** For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W (30dBm).

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.

Test Results: Equipment was compliant with the Peak Power Output limits of §15.407(a)(3).

Test Engineer(s): Benjamin Taylor

Test Date(s): 05/06/15

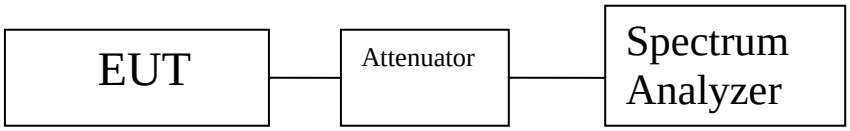


Figure 2. Power Output Test Setup

Average Conducted Output Power			
	Carrier Channel	**Frequency (MHz)**	**Measured Average Output Power (dBm)**
802.11a Port 5GHz	Low	5745	13.54
	Mid	5785	17.43
	High	5825	10.50
802.11n 20 MHz Port 5GHz-Port1	Low	5745	14.17
	Mid	5785	20.23
	High	5825	10.02
802.11n 20 MHz Port 5GHz-Port2	Low	5745	15.32
	Mid	5785	21.01
	High	5825	9.99
802.11n 40MHz Port 5GHz-Port1	Low	5755	15.26
	High	5795	15.24
802.11n 40 MHz Port 5GHz-Port2	Low	5755	16.01
	High	5795	15.78
802.11ac 20 MHz Port 5GHz-Port1	Low	5745	16.05
	Mid	5785	21.78
	High	5825	10.45
802.11ac 20 MHz Port 5GHz-Port2	Low	5745	16.21
	Mid	5785	20.97
	High	5825	10.02
802.11ac 40MHz Port 5GHz-Port1	Low	5755	15.06
	High	5795	14.83
802.11ac 40 MHz Port 5GHz-Port2	Low	5755	14.96
	High	5795	14.94
802.11ac 80MHz Port 5GHz-Port1		5775	12.82
802.11ac 80MHz Port 5GHz-Port2		5775	13.05

Table 11. RF Output Power, Test Results

Summed Average Conducted Output Power			
	Carrier Channel	**Frequency (MHz)**	**Measured Average Output Power (dBm)**
802.11n 20 MHz Summed	Low	5745	17.79
	Mid	5785	23.65
	High	5825	13.02
802.11n 40 MHz Summed	Low	5755	18.66
	High	5795	18.53
802.11ac 20MHz Summed	Low	5745	19.14
	Mid	5785	24.40
	High	5825	13.25
802.11ac 40MHz Summed	Low	5755	18.02
	High	5795	17.90
802.11ac 80MHz Summed	High	5775	15.95

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

Electromagnetic Compatibility Criteria for Intentional Radiators

§15.407(a)(3) Peak Power Spectral Density

Test Requirements: **§15.407(a)(3):** In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz 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 method SA-1 from 789033 D02 General UNII Test Procedures New Rule v01. Data was correct to account for attenuators and cable loss.

Test Results: Equipment was compliant with the peak power spectral density limits of §15.407(a)(3) The peak power spectral density was determined from plots on the following page(s).

Test Engineer(s): Benjamin Taylor

Test Date(s): 04/03/15

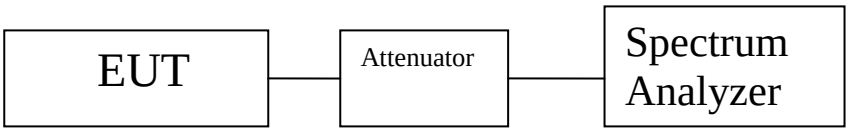


Figure 3. Power Spectral Density Test Setup

Frequency (MHz)	Mode	Port 1 PSD (dBm)	Port 2 PSD (dBm)	Summed PSD (dBm)	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
5745	802.11a 20MHz	11.76	--	11.76	3.2	30.00	-18.24
5785	802.11a 20MHz	11.28	--	11.28	3.2	30.00	-18.72
5825	802.11a 20MHz	-3.54	--	-3.54	3.2	30.00	-33.54
5745	802.11n 20MHz	8.50	8.63	11.58	3.2	30.00	-18.42
5785	802.11n 20MHz	8.43	10.35	12.50	3.2	30.00	-17.5
5825	802.11n 20MHz	-5.90	-5.58	-2.73	3.2	30.00	-32.73
5755	802.11n 40MHz	7.25	8.43	10.89	3.2	30.00	-19.11
5795	802.11n 40MHz	6.19	10.23	11.67	3.2	30.00	-18.33
5745	802.11ac 20MHz	9.17	9.19	12.19	3.2	30.00	-17.81
5785	802.11ac 20MHz	8.16	8.99	11.60	3.2	30.00	-18.4
5825	802.11ac 20MHz	-6.25	-5.897	-3.06	3.2	30.00	-33.06
5755	802.11ac 40MHz	8.417	8.427	11.432303	3.2	30.00	-18.5677
5795	802.11ac 40MHz	8.53	8.9	11.729239	3.2	30.00	-18.2708
5775	802.11ac 80MHz	6.139	5.904	9.03	3.2	30.00	-20.97

Table 13. Peak Power Spectral Density, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§15.407(b)(4), §15.407(b)(6) & §15.407(b)(7) Undesirable Emissions

Test Requirements:

§15.407(b)(4) For transmitters operating in the 5.725-5.85 GHz band: All emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of −17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an e.i.r.p. 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.

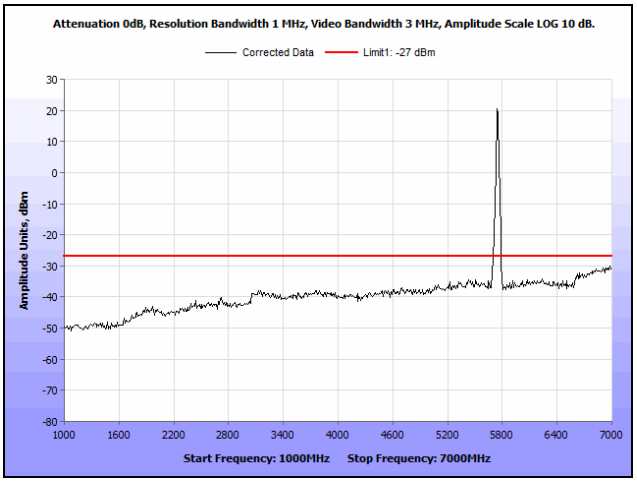
Test Results:

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.

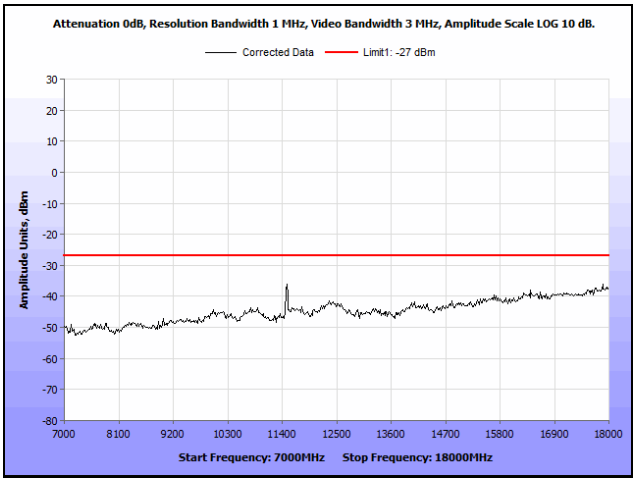
Test Engineer(s): Benjamin Taylor

Test Date(s): 04/18/15

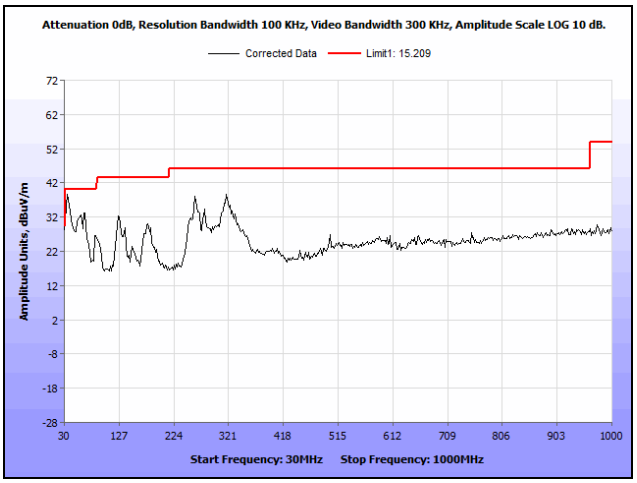
Radiated Spurious Emissions



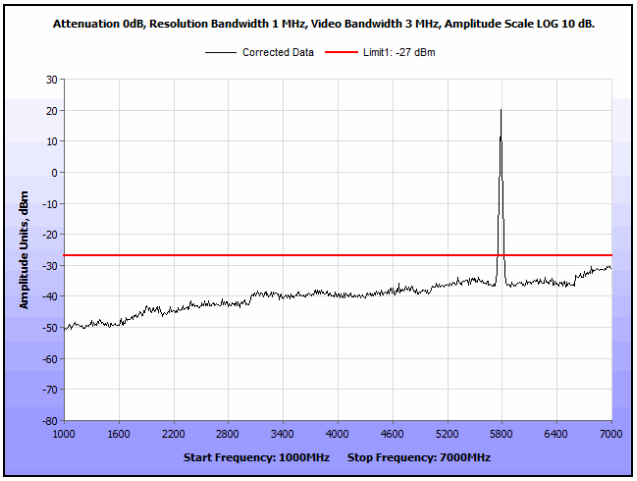
Plot 17. Radiated Spurious Emissions, 5745 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



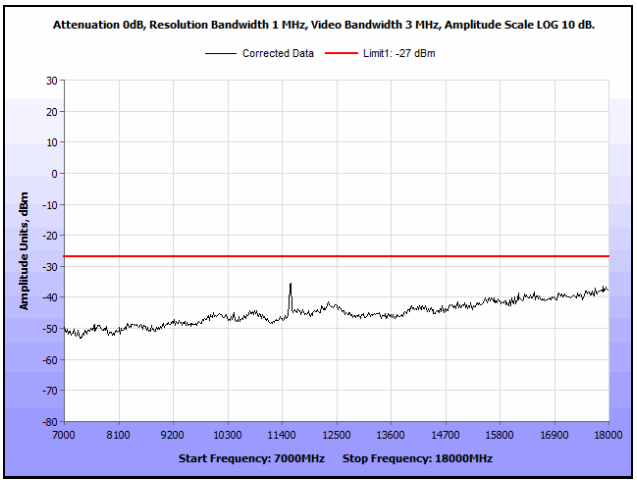
Plot 18. Radiated Spurious Emissions, 5745 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



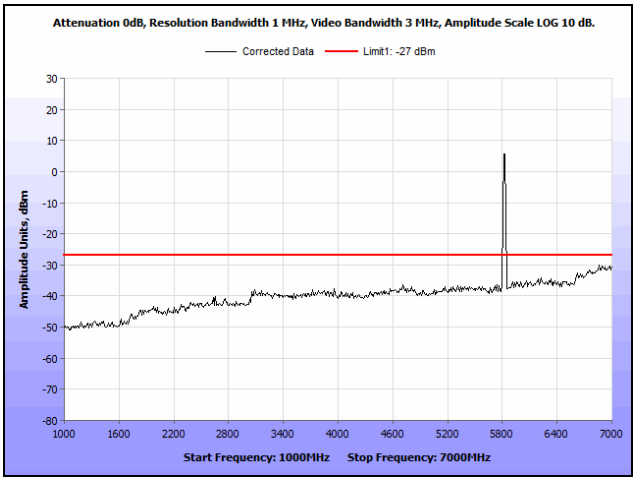
Plot 19. Radiated Spurious Emissions, 5785 MHz, 802.11a 20 MHz, 30 MHz – 1 GHz



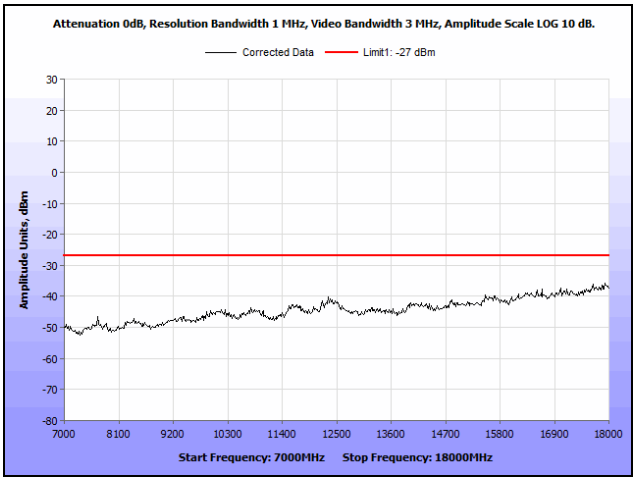
Plot 20. Radiated Spurious Emissions, 5785 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



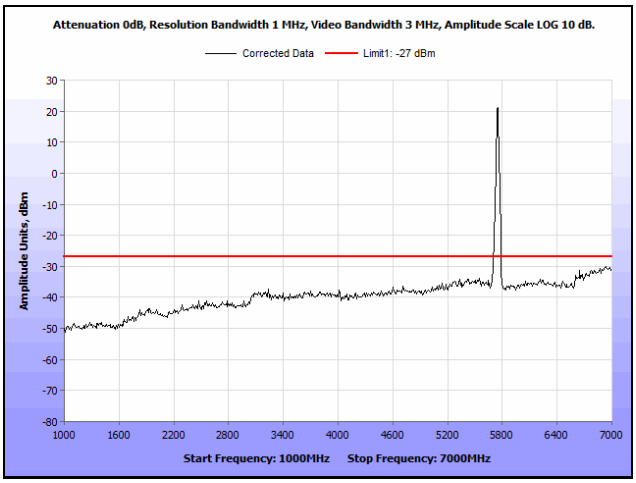
Plot 21. Radiated Spurious Emissions, 5785 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



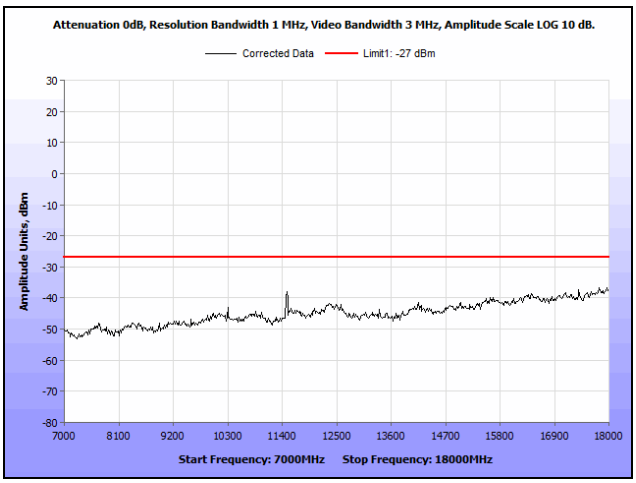
Plot 22. Radiated Spurious Emissions, 5825 MHz, 802.11a 20 MHz, 1 GHz – 7 GHz



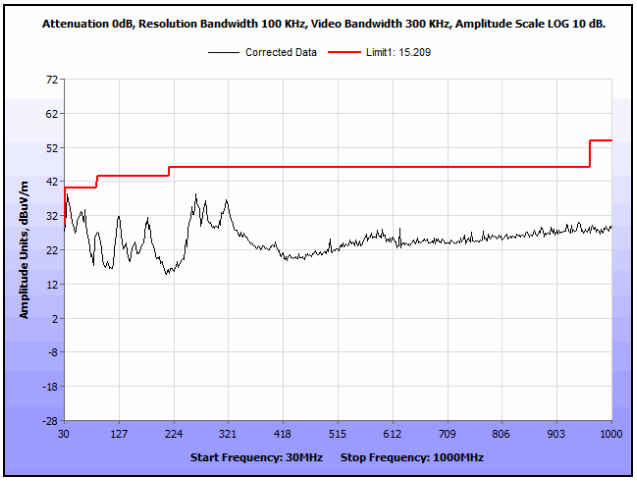
Plot 23. Radiated Spurious Emissions, 5825 MHz, 802.11a 20 MHz, 7 GHz – 18 GHz



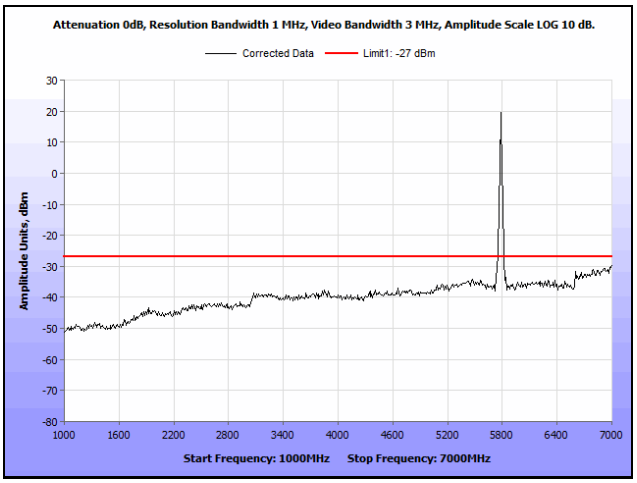
Plot 24. Radiated Spurious Emissions, 5745 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



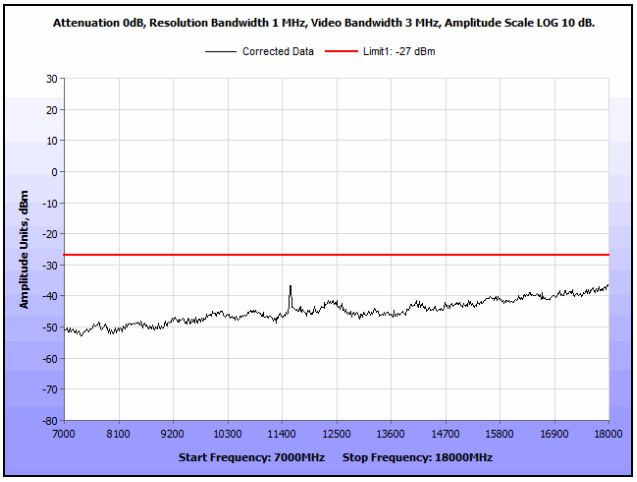
Plot 25. Radiated Spurious Emissions, 5745 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



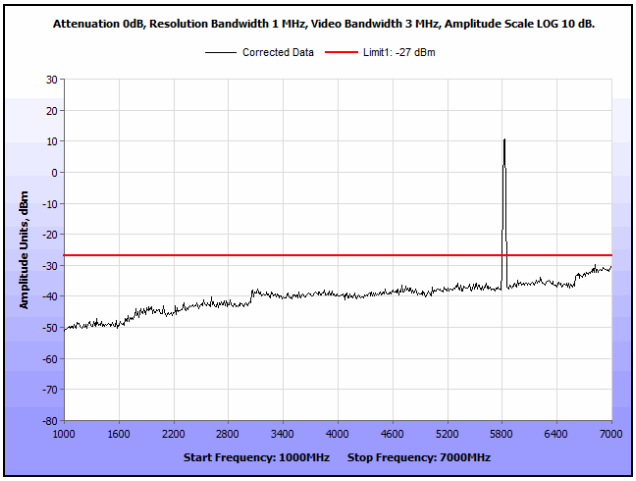
Plot 26. Radiated Spurious Emissions, 5785 MHz, 802.11ac 20 MHz, 30 MHz – 1 GHz



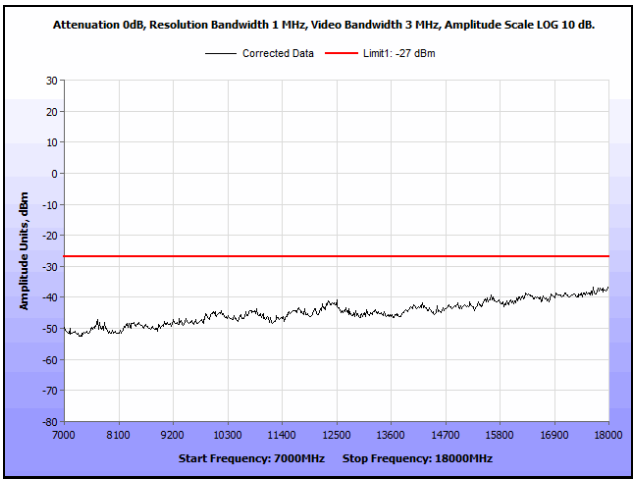
Plot 27. Radiated Spurious Emissions, 5785 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



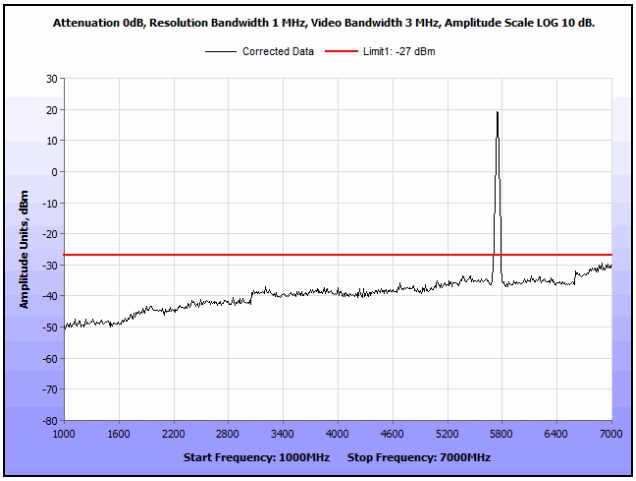
Plot 28. Radiated Spurious Emissions, 5785 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



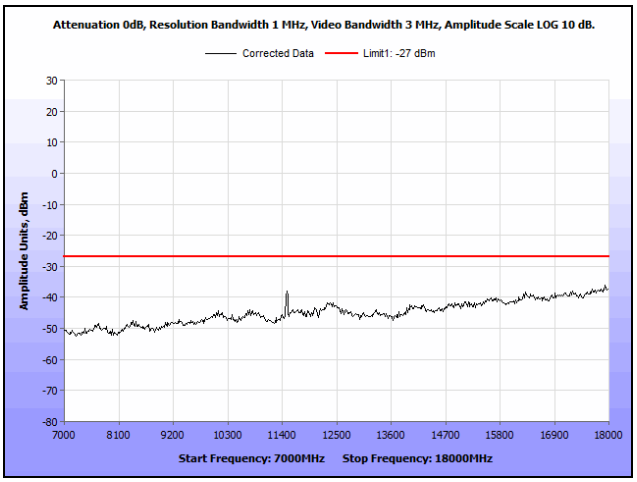
Plot 29. Radiated Spurious Emissions, 5825 MHz, 802.11ac 20 MHz, 1 GHz – 7 GHz



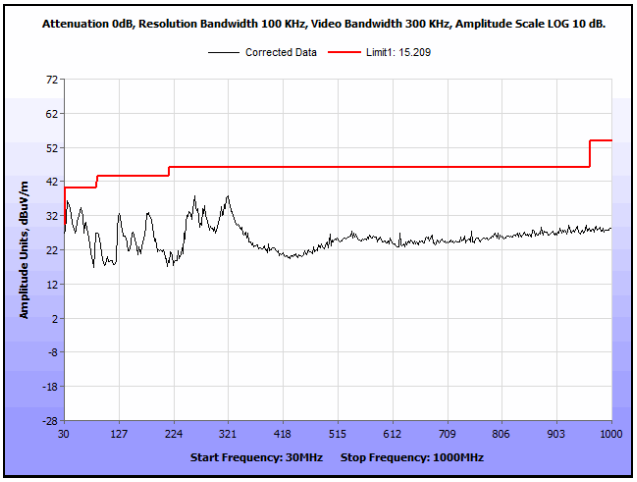
Plot 30. Radiated Spurious Emissions, 5825 MHz, 802.11ac 20 MHz, 7 GHz – 18 GHz



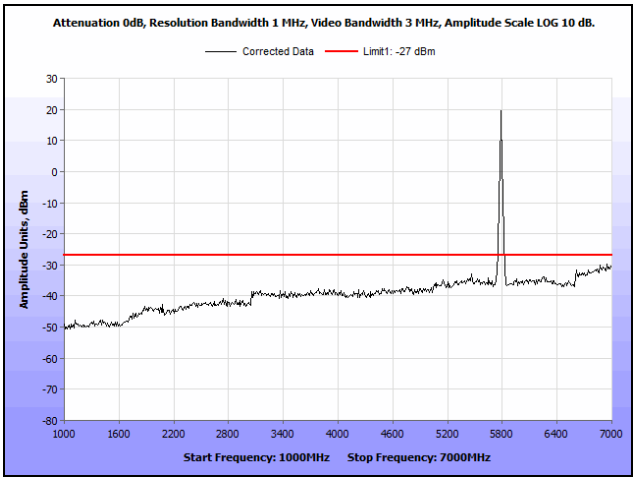
Plot 31. Radiated Spurious Emissions, 5745 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



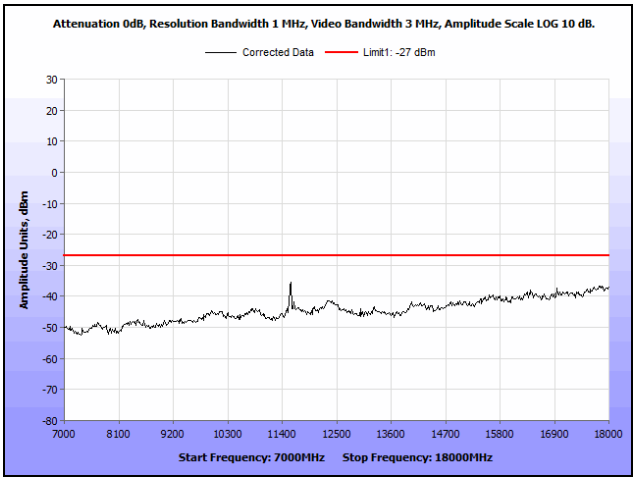
Plot 32. Radiated Spurious Emissions, 5745 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



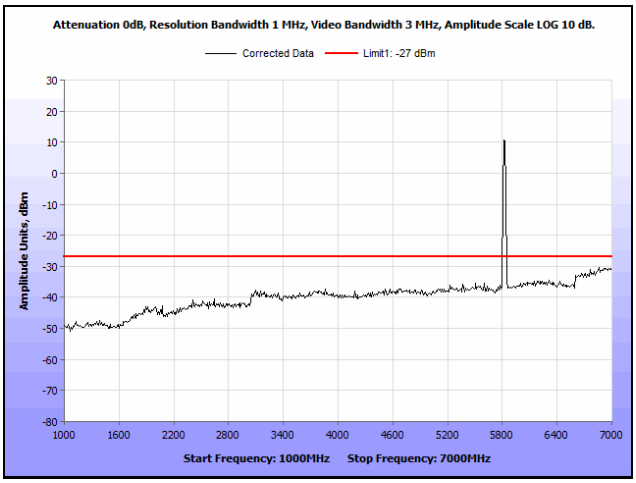
Plot 33. Radiated Spurious Emissions, 5785 MHz, 802.11n 20 MHz, 30 MHz – 1 GHz



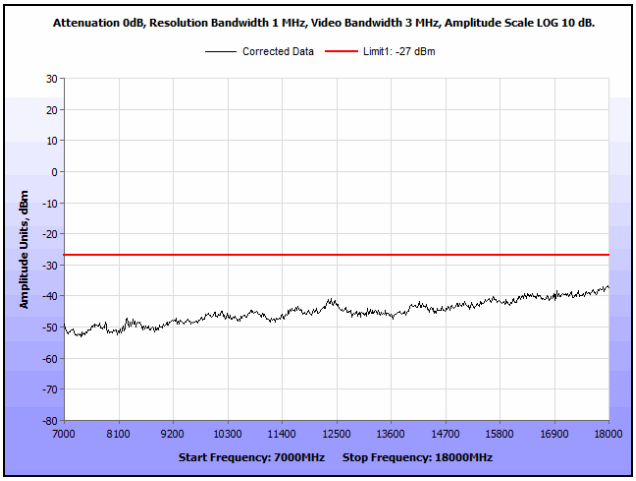
Plot 34. Radiated Spurious Emissions, 5785 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



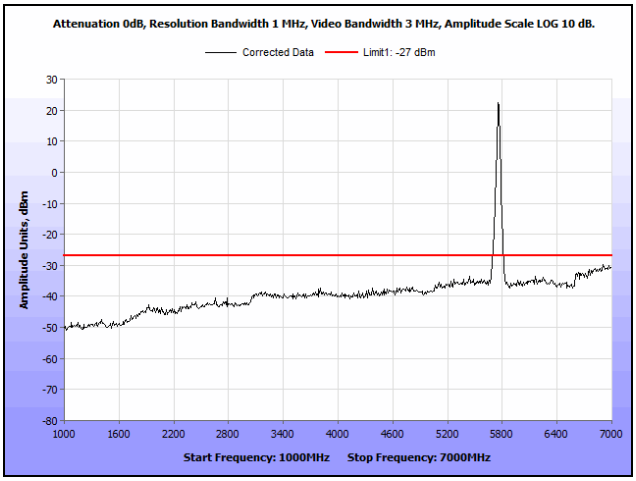
Plot 35. Radiated Spurious Emissions, 5785 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



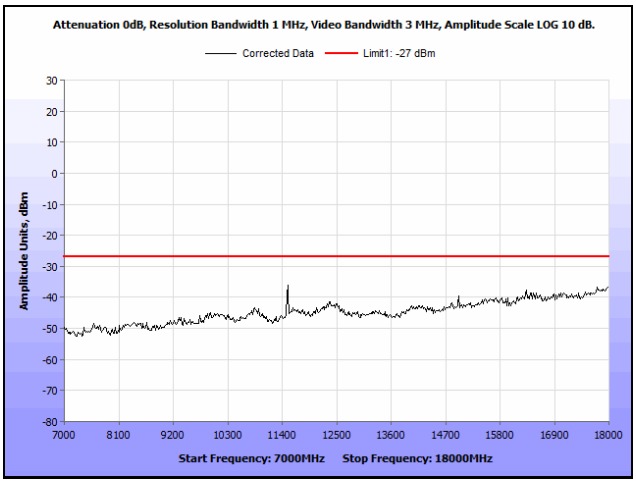
Plot 36. Radiated Spurious Emissions, 5825 MHz, 802.11n 20 MHz, 1 GHz – 7 GHz



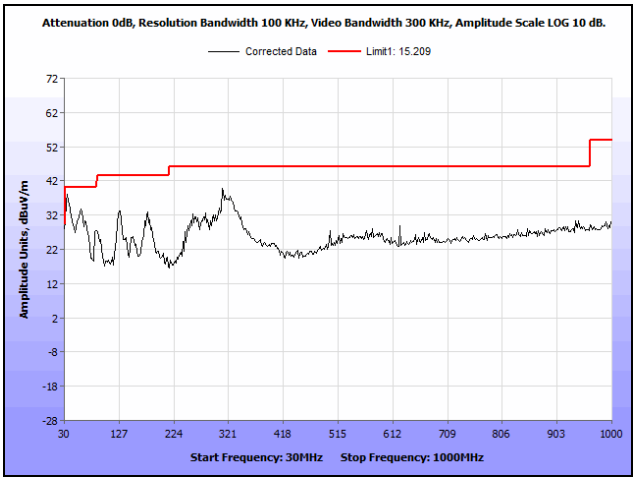
Plot 37. Radiated Spurious Emissions, 5825 MHz, 802.11n 20 MHz, 7 GHz – 18 GHz



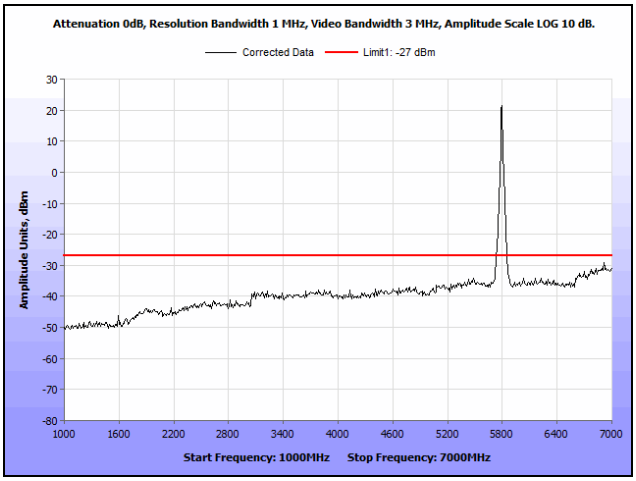
Plot 38. Radiated Spurious Emissions, 5755 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



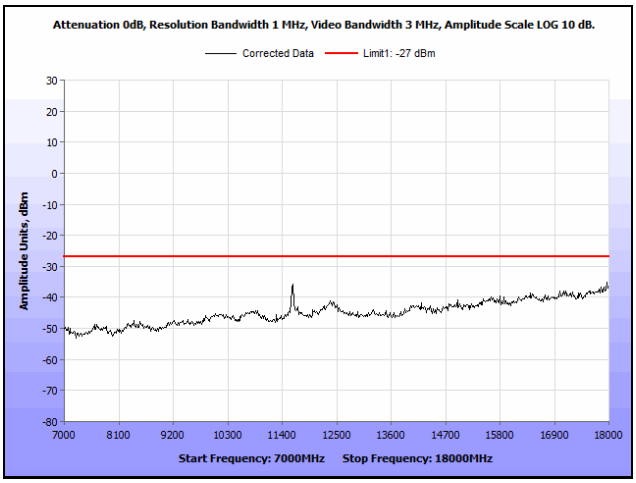
Plot 39. Radiated Spurious Emissions, 5755 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



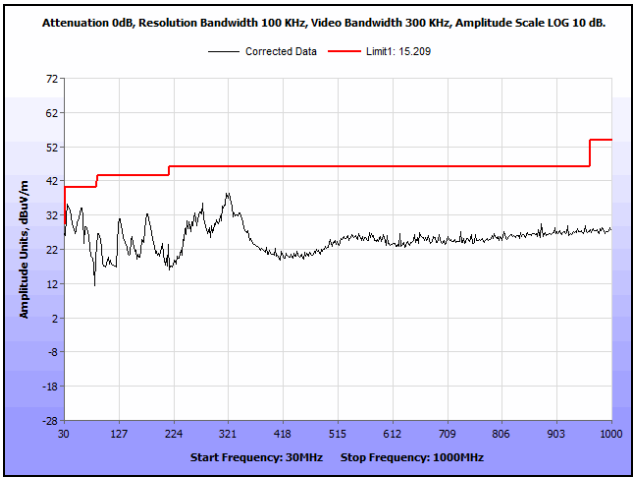
Plot 40. Radiated Spurious Emissions, 5795 MHz, 802.11ac 40 MHz, 30 MHz – 1 GHz



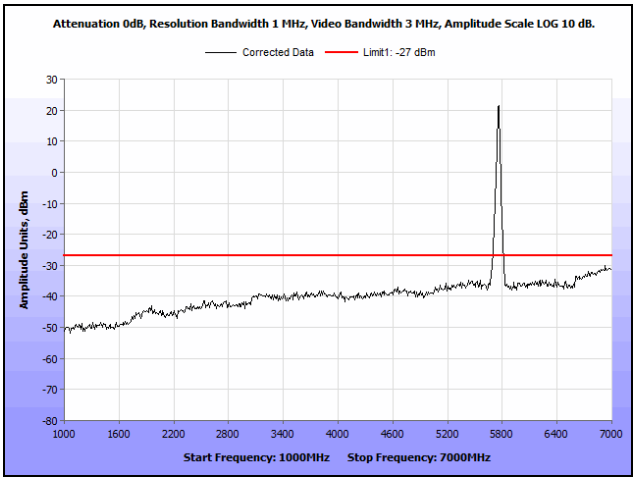
Plot 41. Radiated Spurious Emissions, 5795 MHz, 802.11ac 40 MHz, 1 GHz – 7 GHz



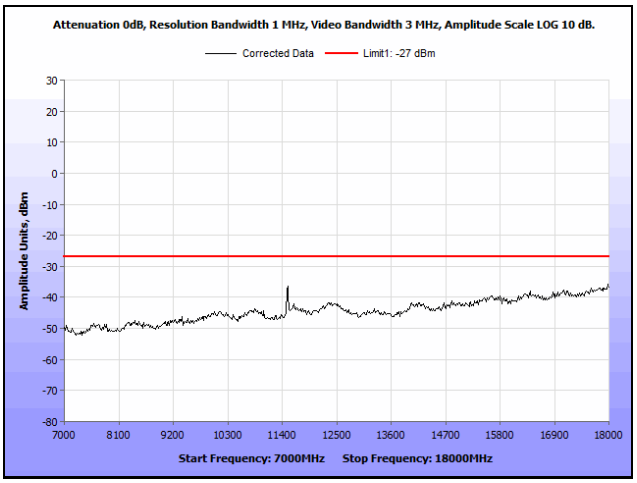
Plot 42. Radiated Spurious Emissions, 5795 MHz, 802.11ac 40 MHz, 7 GHz – 18 GHz



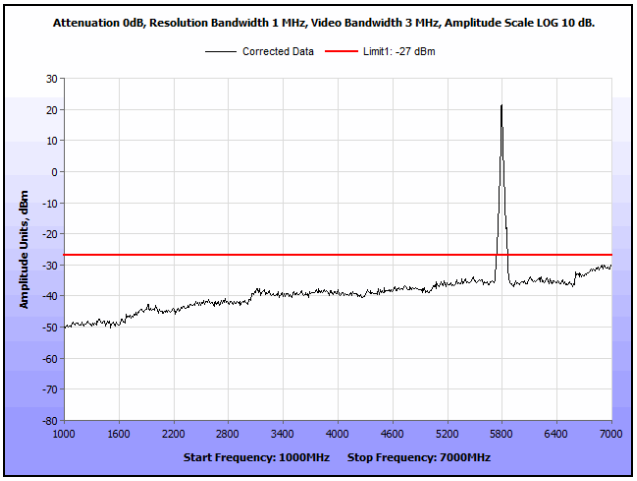
Plot 43. Radiated Spurious Emissions, 5755 MHz, 802.11n 40 MHz, 30 MHz – 1 GHz



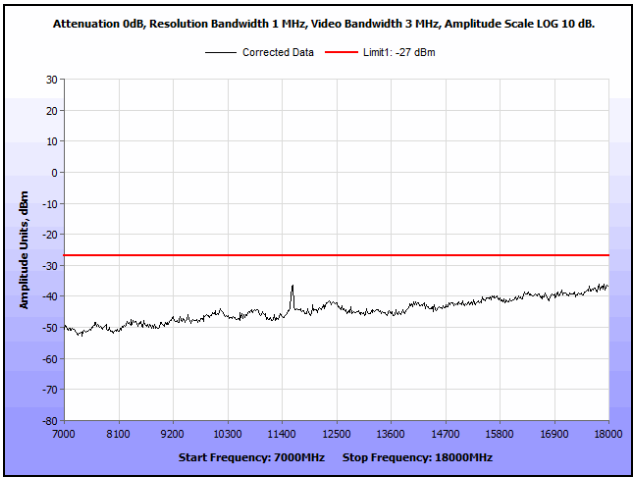
Plot 44. Radiated Spurious Emissions, 5755 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



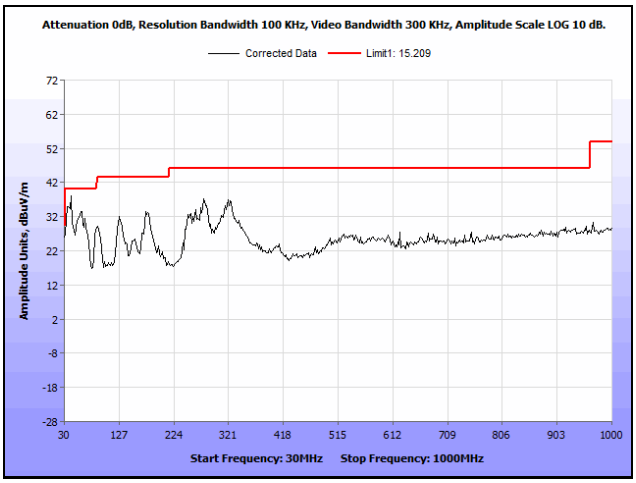
Plot 45. Radiated Spurious Emissions, 5755 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



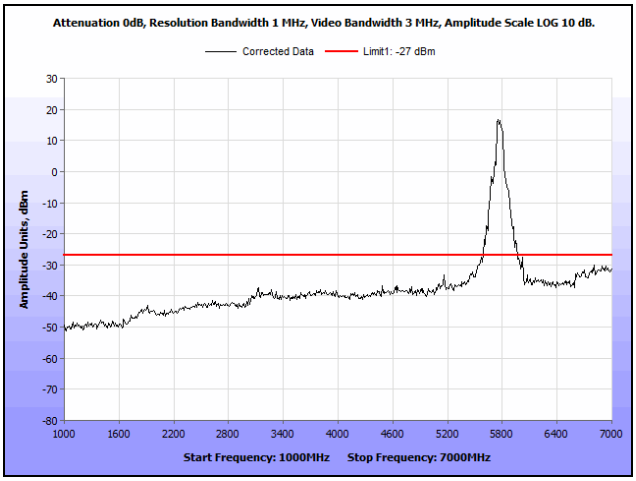
Plot 46. Radiated Spurious Emissions, 5795 MHz, 802.11n 40 MHz, 1 GHz – 7 GHz



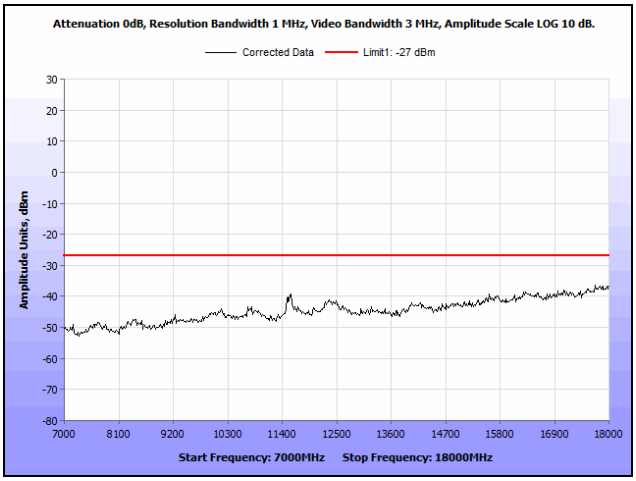
Plot 47. Radiated Spurious Emissions, 5795 MHz, 802.11n 40 MHz, 7 GHz – 18 GHz



Plot 48. Radiated Spurious Emissions, 5775 MHz, 802.11ac 80 MHz, 30 MHz – 1 GHz

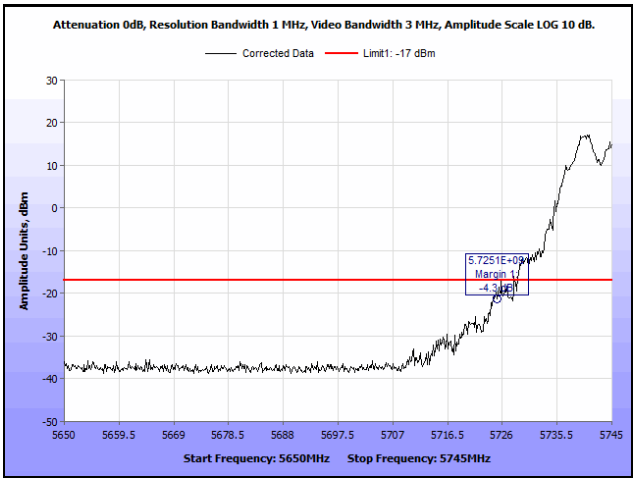


Plot 49. Radiated Spurious Emissions, 5775 MHz, 802.11ac 80 MHz, 1 GHz – 7 GHz

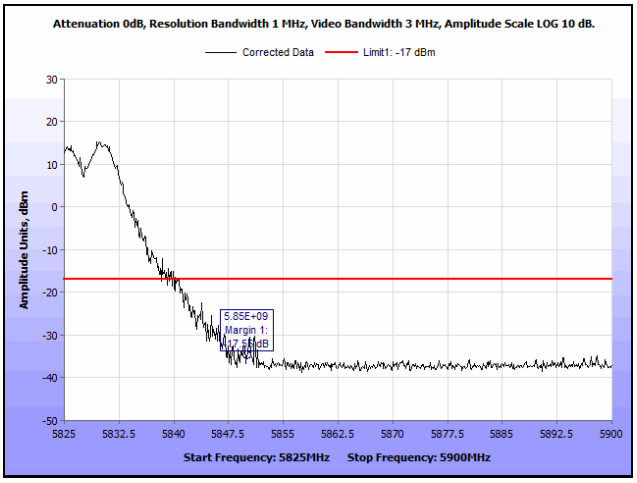


Plot 50. Radiated Spurious Emissions, 5775 MHz, 802.11ac 80 MHz, 7 GHz – 18 GHz

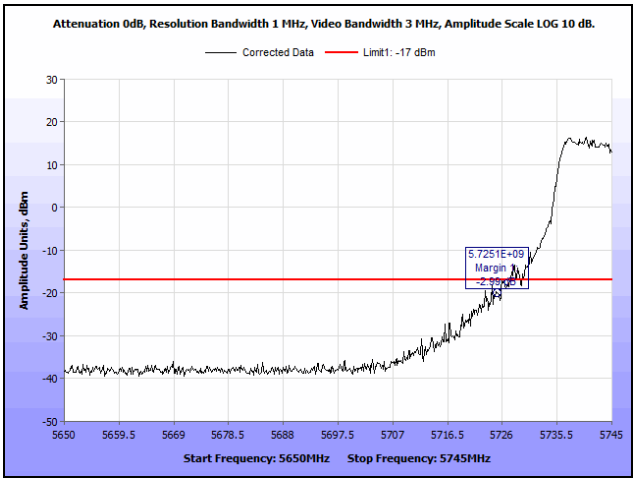
Radiated Band Edge



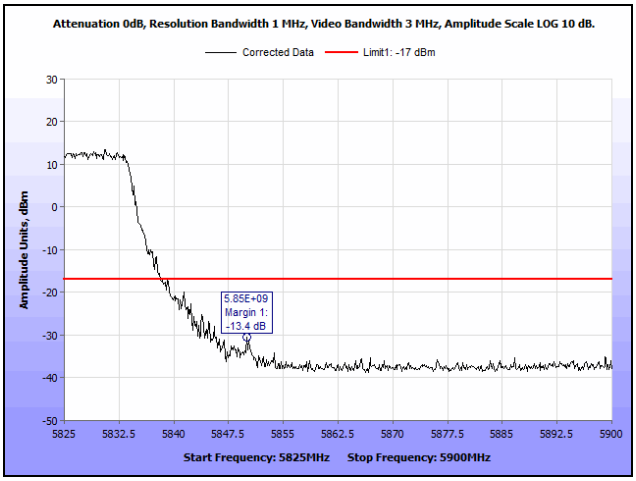
Plot 51. Radiated Band Edge, 802.11a, 5745 MHz @ 5725 MHz



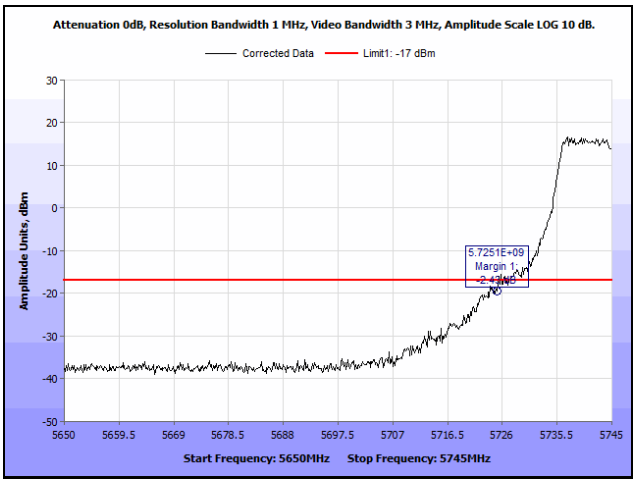
Plot 52. Radiated Band Edge, 802.11a, 5825 MHz @ 5850 MHz



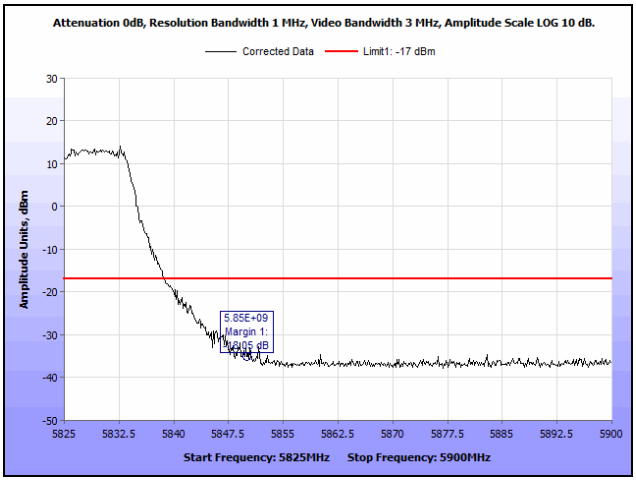
Plot 53. Radiated Band Edge, 802.11ac 20 MHz, 5745 MHz @ 5725 MHz



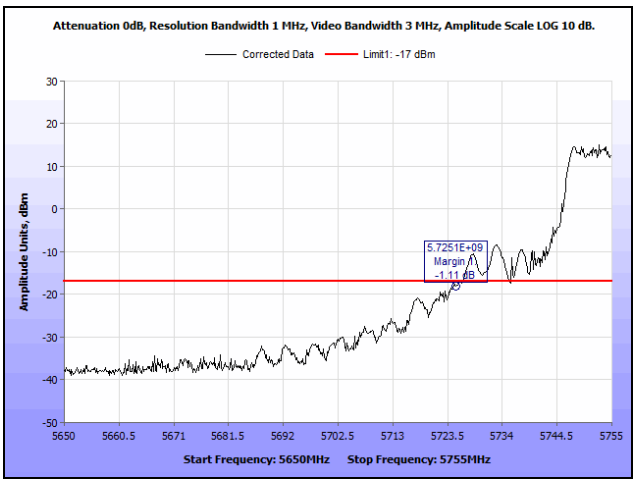
Plot 54. Radiated Band Edge, 802.11ac 20 MHz, 5825 MHz @ 5850 MHz



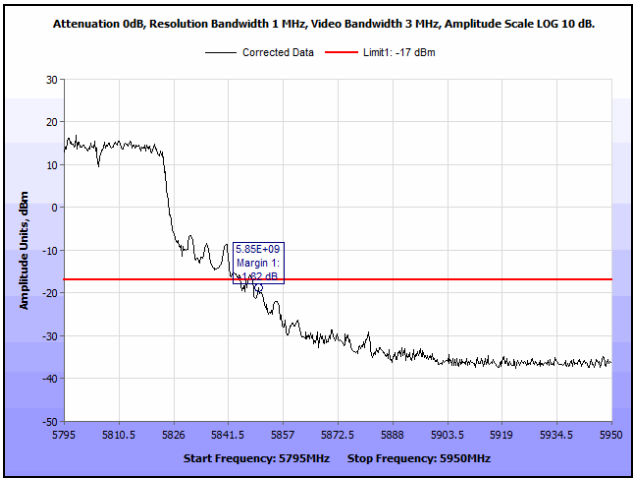
Plot 55. Radiated Band Edge, 802.11n 20 MHz, 5745 MHz @ 5725 MHz



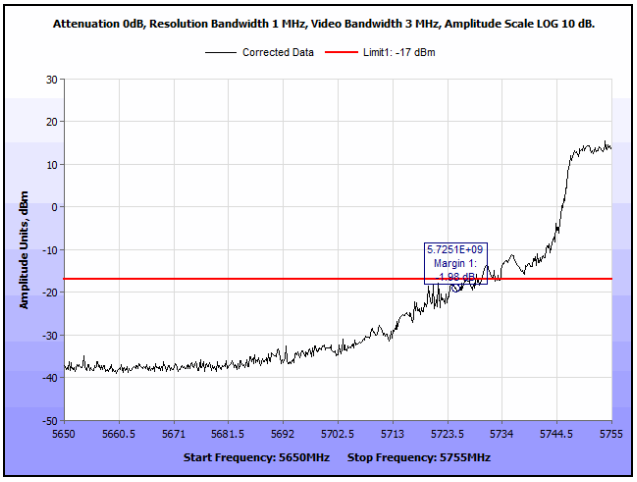
Plot 56. Radiated Band Edge, 802.11n 20 MHz, 5825 MHz @ 5850 MHz



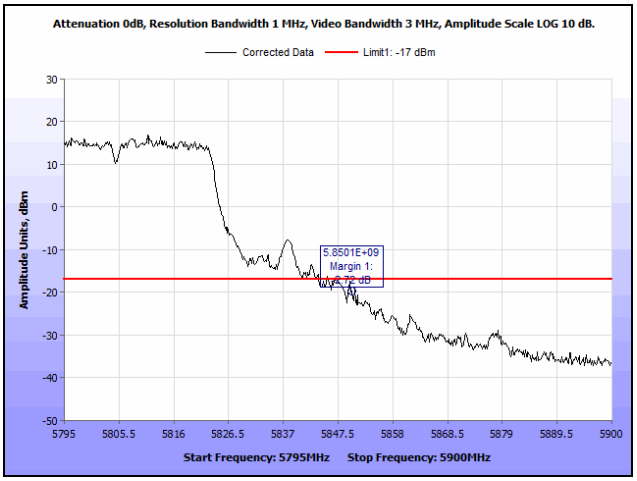
Plot 57. Radiated Band Edge, 802.11ac 40 MHz, 5755 MHz @ 5725 MHz



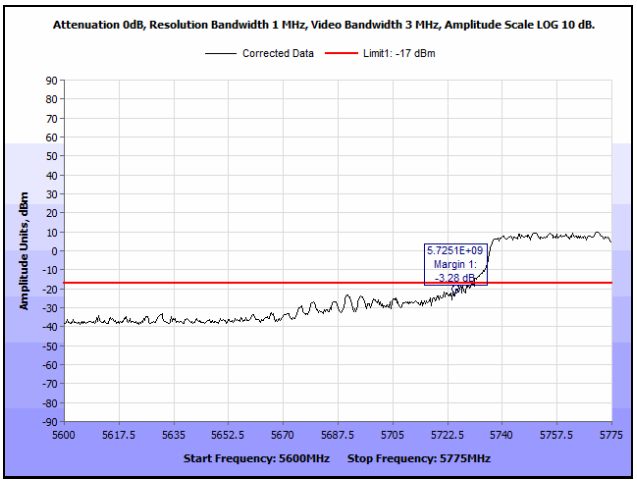
Plot 58. Radiated Band Edge, 802.11ac 40 MHz, 5795 MHz @ 5850 MHz



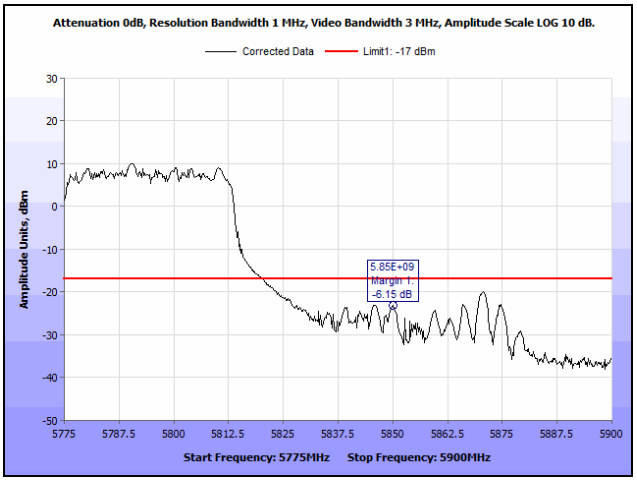
Plot 59. Radiated Band Edge, 802.11n 40 MHz, 5755 MHz @ 5725 MHz



Plot 60. Radiated Band Edge, 802.11n 40 MHz, 5795 MHz @ 5850 MHz



Plot 61. Radiated Band Edge, 802.11ac 80 MHz, 5775 MHz @ 5725 MHz



Plot 62. Radiated Band Edge, 802.11ac 80 MHz, 5775 MHz @ 5850 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 @ 5745-5825 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 =24.40 dBm = 275.42 mW
G = Antenna Gain 3.2 dBi (2.09 linear)
R = Minimum Distance between User and Antenna (20 cm)

$$S = (275.42*2.09*2.09)/(4*3.14*400) = 0.239 \text{ mW/cm2}$$

Therefore the uncontrolled exposure limit is achieved at 20 cm.

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.