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May 12, 2021

NoiseAware
2800 Routh Street, Suite 215
Dallas, TX 75201

Dear Jake Umbrage,

Enclosed is the EMC Wireless test report for compliance testing of the NoiseAware, Gen 3.1 Collector as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins Electrical and Electronic Testing NA, Inc. If you have any questions regarding these results or if Eurofins Electrical and Electronic Testing NA, Inc. can be of further service to you, please feel free to contact me.

Sincerely yours,
Eurofins Electrical and Electronic Testing NA, Inc.

Michelle Tawmging

Michelle Tawmging
Documentation Department

Reference: (\NoiseAware\WIRA111308A-FCC247 WLAN Rev. 1)

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Electromagnetic Compatibility Criteria
Test Report

for the

NoiseAware
Gen 3.1 Collector

Tested under
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

Report: WIRA111308A-FCC247 WLAN Rev. 1

May 12, 2021

Prepared For:

NoiseAware
2800 Routh Street Suite 215
Dallas, TX 75201

Prepared By:
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Electromagnetic Compatibility Criteria
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Report: WIRA111308A-FCC247 WLAN Rev. 1

May 12, 2021

Adan Arab, Project Engineer
Electromagnetic Compatibility Lab

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.

Jonathan Tavira,
Director, Electromagnetic Compatibility Lab

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Report Status Sheet

Revision	Report Date	Reason for Revision
∅	April 20, 2021	Initial Issue.
1	May 12, 2021	Implemented TCB Revisions.

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List of Terms and Abbreviations

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

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Executive Summary

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A. Purpose of Test

An EMC evaluation was performed to determine compliance of the NoiseAware Gen 3.1 Collector, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the Gen 3.1 Collector. NoiseAware should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Gen 3.1 Collector, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with NoiseAware, purchase order number 180910-1. All tests were conducted using measurement procedure ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2020	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
ANSI C63.10-2013 (11.6)	Duty Cycle	Completed
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	Maximum Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	Conducted Spurious Emissions in Non-restricted Bands	Not Applicable[1]
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	Maximum Permissible Exposure (MPE)	Compliant
Not Applicable[1]: The EUT did not have an antenna ports temporal or permanent, Spurious Emissions in 100 KHz Bandwidth test and the rest of the tests was performed on a radiated setup.		

Figure 1: Executive Summary of EMC Part 15.247 Compliance Testing

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Equipment Configuration

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A. Overview

Eurofins Electrical and Electronic Testing NA, Inc. was contracted by NoiseAware to perform testing on the Gen 3.1 Collector, under NoiseAware's purchase order number 180910-1.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the NoiseAware, Gen 3.1 Collector.

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

Model(s) Tested:	Gen3.1 Collector	
Model(s) Covered:	Gen3.1 Collector	
EUT Specifications:	Primary Power: 120VAC 60Hz	
	FCC: 2AQIP-NA3N301	
	Type of Modulations:	OFDM, QPSK
	Equipment Code:	DTS
	Peak RF Output Power:	5.7 dBm
	EUT Frequency Ranges:	2412-2462 MHz
	Antenna Gain:	3 dBi
	Antenna Type:	Trace Antenna
	EUT Software as tested:	Custom Software Version 2.0.0
	Support Software:	VNC Viewer
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:	Adan Arab	
Report Date(s):	May 12, 2021	

Figure 2: EUT Summary Table

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
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 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
KDB 558074 v04	Guidance For Performing Compliance Measurements On Digital Transmission Systems (DTS) Operating Under Section 15.247

Figure 3: References

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C. Test Site

All testing was performed at Eurofins Electrical and Electronic Testing NA, Inc., 13501 McCallen Pass, Austin, TX 78753. 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 a10 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 Eurofins Electrical and Electronic Testing NA, Inc.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%
Radiated Emissions, (30 MHz – 1 GHz)	±2.95 dB	2	95%
Radiated Emissions, (1 GHz – 18 GHz)	±3.54 dB	2	95%
Radiated Emissions, (18 GHz – 25 GHz)	±4.53 dB	2	95%

Figure 4: Uncertainty Calculations Summary

E. Description of Test Sample

The Gen3.1 Collector, Equipment Under Test (EUT), is a WiFi-enabled noise monitoring device that mounts to most common US power outlets with an included screw. The device monitors volume levels and also acts as a gateway for the Outdoor Noise Sensor (Gen 3 Node), receiving data over Sub-1 GHz and relaying it over WiFi. It is intended to be used by professional property managers in indoor areas of short-term rental residences.

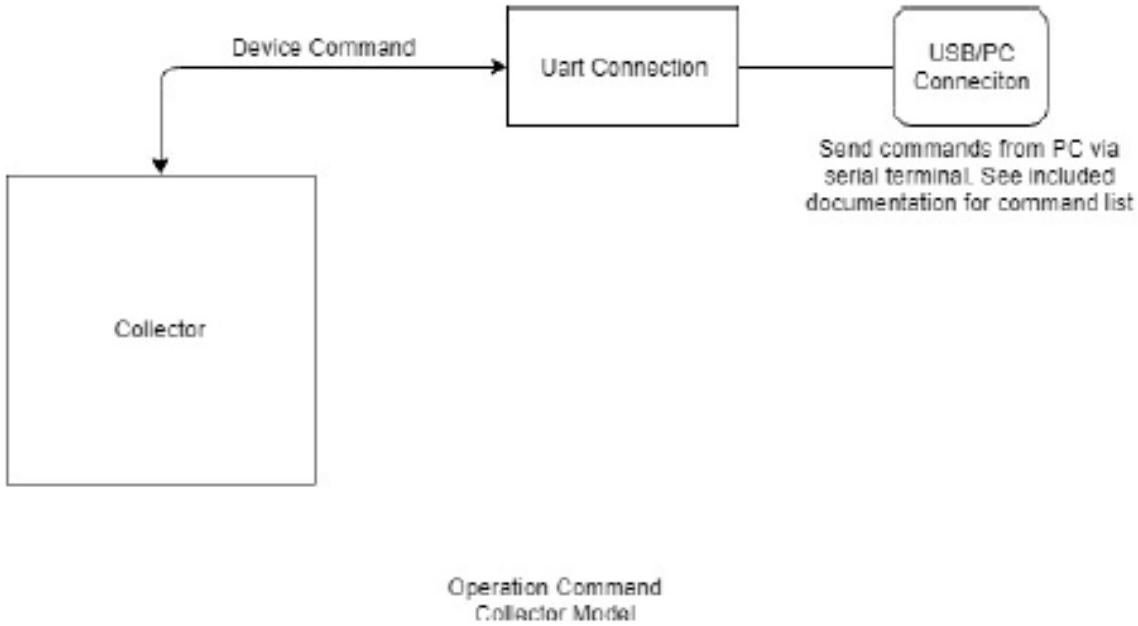

Figure 5: Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 5, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Slot #	Name / Description	Model Number	Part Number	Serial Number	Rev. #
1	N/A	Gen3.1 Collector	NA3N101	N/A	N/A	N/A

Figure 6: Equipment Configuration

G. 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	Raspberry Pi	Raspberry Pii	B v1.1	N/A
2	Laptop	BOCCONI	N3350	N/A
3	Ethernet USB Adapter	BOCCONI	N/A	N/A
4	Outdoor Sensor	NoiseAware	NA3N102	N/A
The 'Customer Supplied Calibration Data' column will be marked as either not applicable, not available, or will contain the calibration date supplied by the customer.				

Figure 7: Support Equipment

H. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Desc. or reason for none	QTY	Length as tested (m)	Max Length (m)	Shielded?	Termination Box ID & Port Name
1	Power	Power adaptor	2	0.1	N/A	No	AC Mains
2	Pi 2 USB Port	USB	2	1	N/A	No	AC/DC Adapter
3	Pi 2 Ethernet port	Ethernet	1	0.5	N/A	No	Support PC

Figure 8: Port and Cabling Information

I. Mode of Operation

We will provide several samples that demonstrate the different modes. When you click the VNC Tool you will see multiple icons corresponding to the provided different samples. When you click the outdoor shortcut, it opens the RF testing interface, choose executive terminal, the Menu has two working modes, choose BLE/WLAN Test mode and you will see the EUT is flashed with a debug enabled firmware for testing. The EUT flashing is completed, these options will be available to change the Modulation, channels and enable and change power setting. When you choose a specific channel, modulation and power setting then click start will start the operation. For WLAN, these modes will be 2412 MHz/2422 MHz, 2437 MHz and 2462/2452 MHz 802.11b, 802.11g and 802.11n_HT20 single channels, Low, mid, High. These modes can all be used to measure characteristics of the RF system during normal operation while stop will reset the sensor back to normal mode.

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J. Method of Monitoring EUT Operation

While the device is powered, the LED indicator at the rear of the device indicates two modes of operation: 1) During normal operation the LED is off. 2) During setup mode the LED will blink periodically to indicate it is broadcasting a discoverable AP. The LED will blink quickly and then turn off when device has been set up successfully. The device can be reset into setup mode by depressing the button on the side of the device.

K. 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.

L. Disposition of EUT

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

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Electromagnetic Compatibility Criteria for Intentional Radiators

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

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

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

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Test Results: The EUT as tested is compliant the criteria of §15.203. Gen3.1 Collector (Indoor) Utilizes Integral Trace Antenna which is not accessible to the end user with the gain of 3 dBi as declared by the manufacturer. The EUT is complaint with the provisions of section 15.203.

Antenna Gain	Antenna Type
3 dBi	Integral Trace Antenna

Figure 8: Antenna List

Test Engineer: Adan Arab

Test Date: March 16, 2021

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Duty Cycle

Test Procedure: The EUT was measured with spectrum analyzer and was ran at the maximum achievable duty cycle for all modes. The duty cycle was measured in accordance with section 11.6 of ANSI C63.10-2013.

Test Engineer(s): Adan Arab

Test Date(s): February 25, 2021

Test Results: The EUT as tested was completed to the criteria of this section.

Duty cycle = ($T_{ON}/T_{ON}+T_{OFF}$)
=(600uS/6.6ms)
=0.09
Duty cycle (%)= 9%

Duty Cycle Correction Factor = 10log(1/d)
=10log (1/0.09)
=10.46 dB

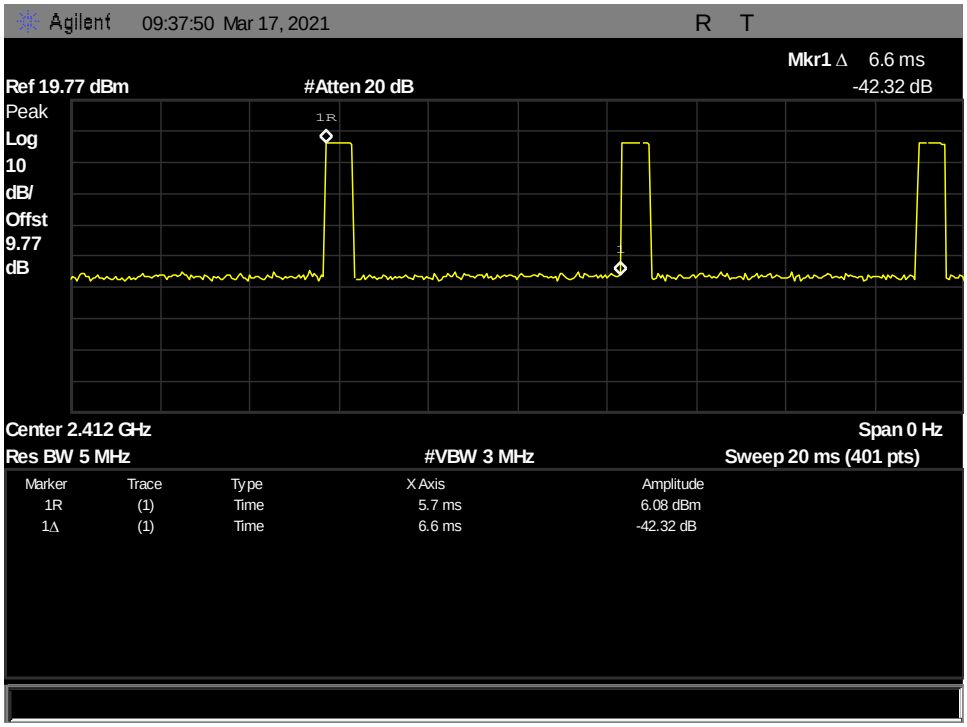

Figure 9: Duty Cycle, 802.11b, 802.11g, 802.11n_HT20, ON+OFF Time

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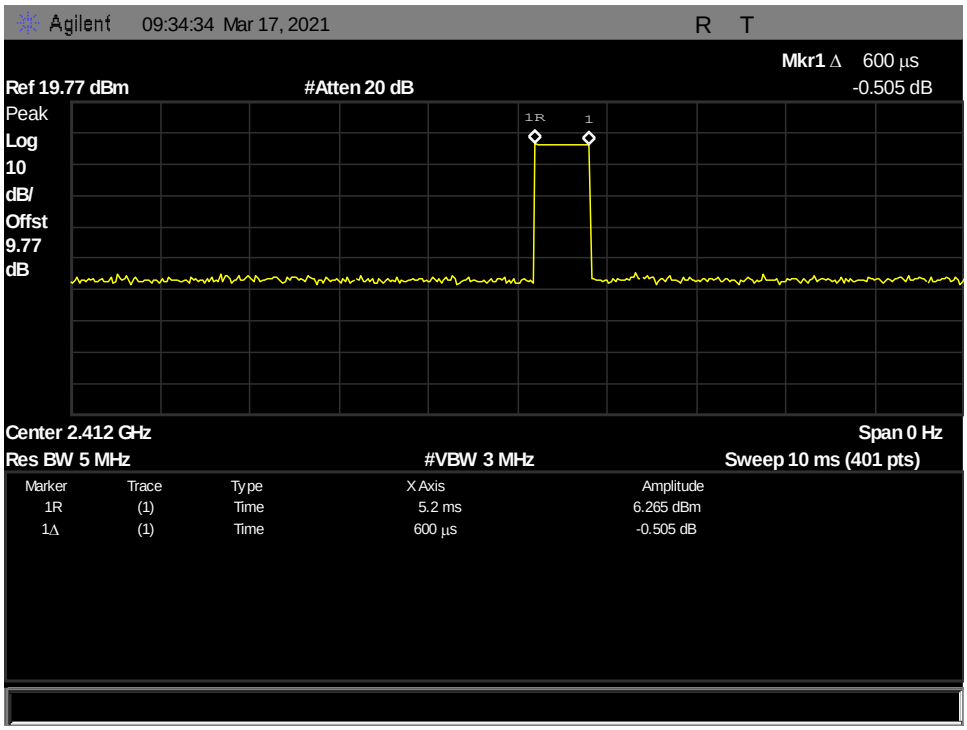

Figure 10: Duty Cycle, 802.11b, 802.11g, 802.11n_HT20, ON-Time

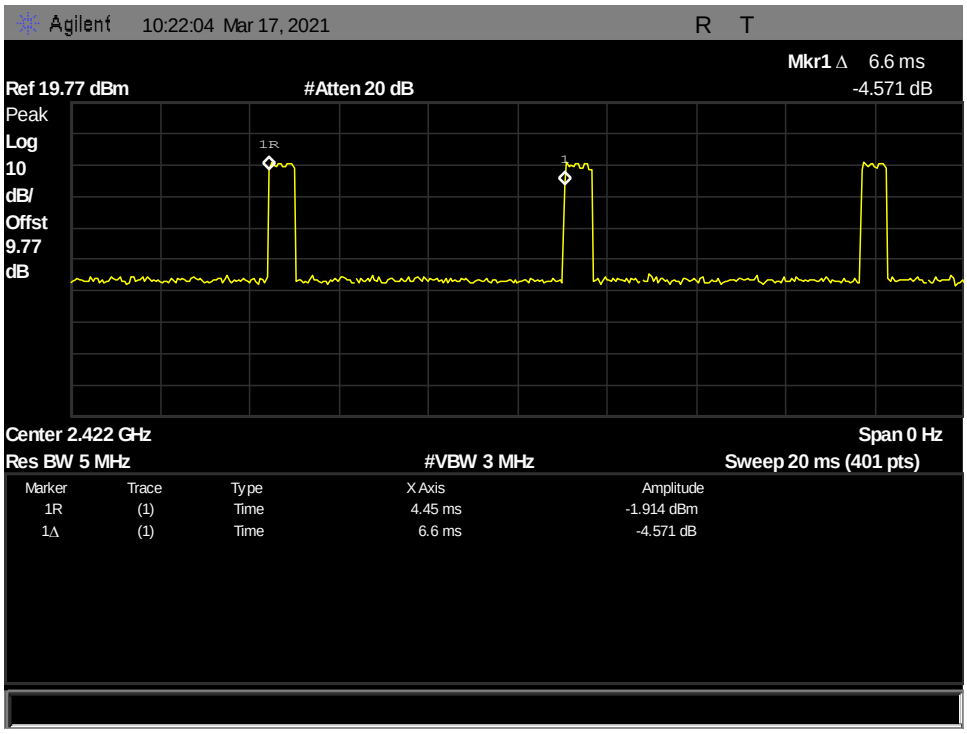

Figure 11: Duty Cycle, 802.11n_HT40, ON+OFF Time

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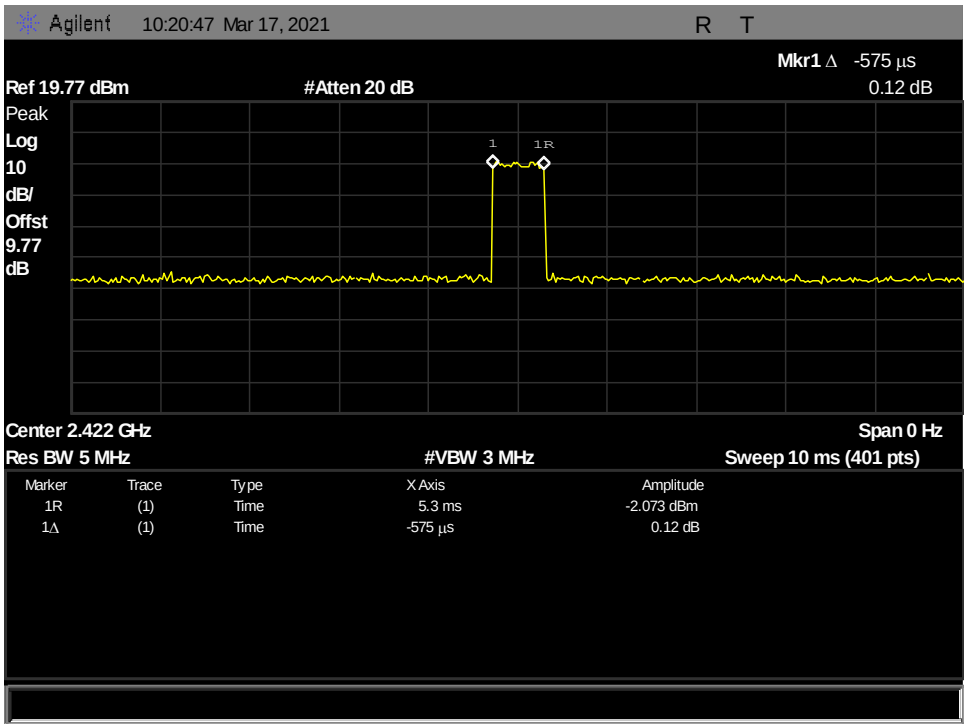

Figure 12: Duty Cycle, 802.11n_HT40, ON-Time

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207(a) Conducted Emissions Limits

Test Requirement(s): **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω 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- 0.5	66 - 56	56 - 46
0.5 - 5	56	46
5 - 30	60	50

Figure 13: Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Procedure: The EUT was placed on a 0.8m high non-conductive table. 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). An EMI receiver, connected to the measurement port of the LISN. The EMI receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.10-2013*. All peak emissions close to the limit were re-measured using a quasi-peak and/or average detector as appropriate.

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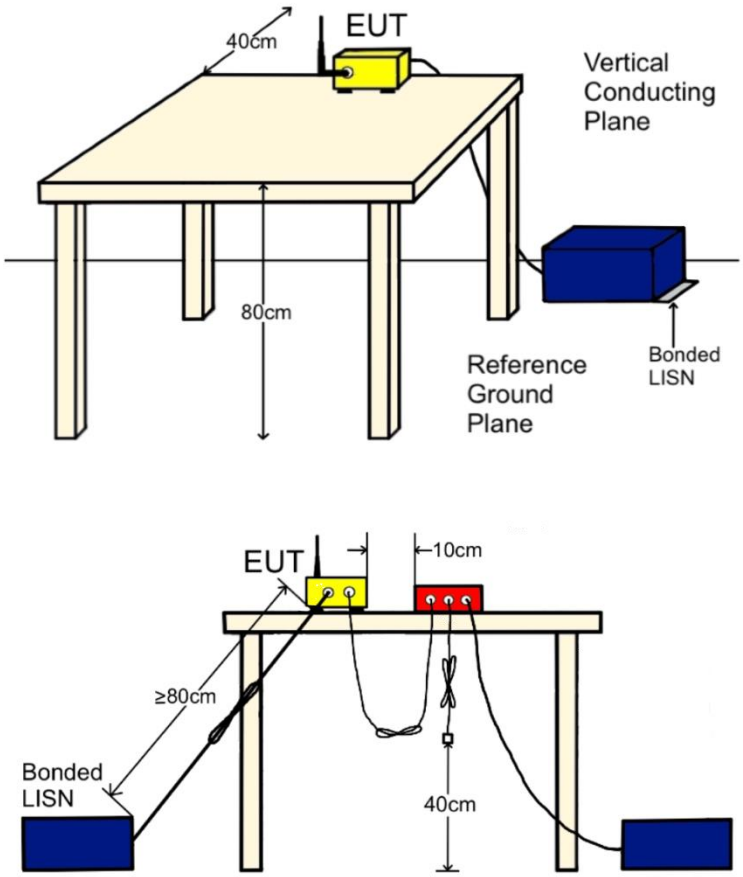

Figure 14: CEV Test Setup

Test Results: The EUT was **compliant** with this requirement **§ 15.207 (a)**. Measured emissions were below applicable limits. Photographs of test setup and the test results are presented below.

Test Engineer(s): Adan Arab

Test Date(s): March 15, 2021

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Conducted Emissions Test Results

Meas. Location	Meas. m	Limit	Result
Bonding measurement from LISN ground to ground plane	1.9 mΩ	< 2.5 mΩ	Pass

Line Name	Freq (MHz)	QP Amplitude (dBµV)	QP Limit (dBµV)	Margin (dB)	Result	Average Amplitude (dBµV)	Average Limit (dBµV)	Margin (dB)	Result
Line_120VAC 60Hz	0.374	47.1	58.432	-11.332	Pass	35.7	48.432	-12.732	Pass
Line_120VAC 60Hz	0.390	45.3	58.085	-12.785	Pass	32.5	48.085	-15.585	Pass
Line_120VAC 60Hz	0.422	44.9	57.432	-12.532	Pass	32.4	47.432	-15.032	Pass
Line_120VAC 60Hz	3.162	33.8	56	-22.2	Pass	22.7	46	-23.3	Pass
Line_120VAC 60Hz	0.402	46.6	57.834	-11.234	Pass	36.4	47.834	-11.434	Pass
Line_120VAC 60Hz	0.442	40	57.049	-17.049	Pass	27.9	47.049	-19.149	Pass
Neutral_120VAC 60Hz	0.422	43.5	57.432	-13.932	Pass	30.6	47.432	-16.832	Pass
Neutral_120VAC 60Hz	0.434	36.9	57.2	-20.3	Pass	24.5	47.2	-22.7	Pass
Neutral_120VAC 60Hz	1.090	34.2	56	-21.8	Pass	22.7	46	-23.3	Pass
Neutral_120VAC 60Hz	0.346	41.6	59.077	-17.477	Pass	29.9	49.077	-19.177	Pass
Neutral_120VAC 60Hz	0.358	43.2	58.794	-15.594	Pass	28	48.794	-20.794	Pass
Neutral_120VAC 60Hz	2.554	31.8	56	-24.2	Pass	20.9	46	-25.1	Pass

Figure 15: Conducted Emissions, 802.11b, Test Data

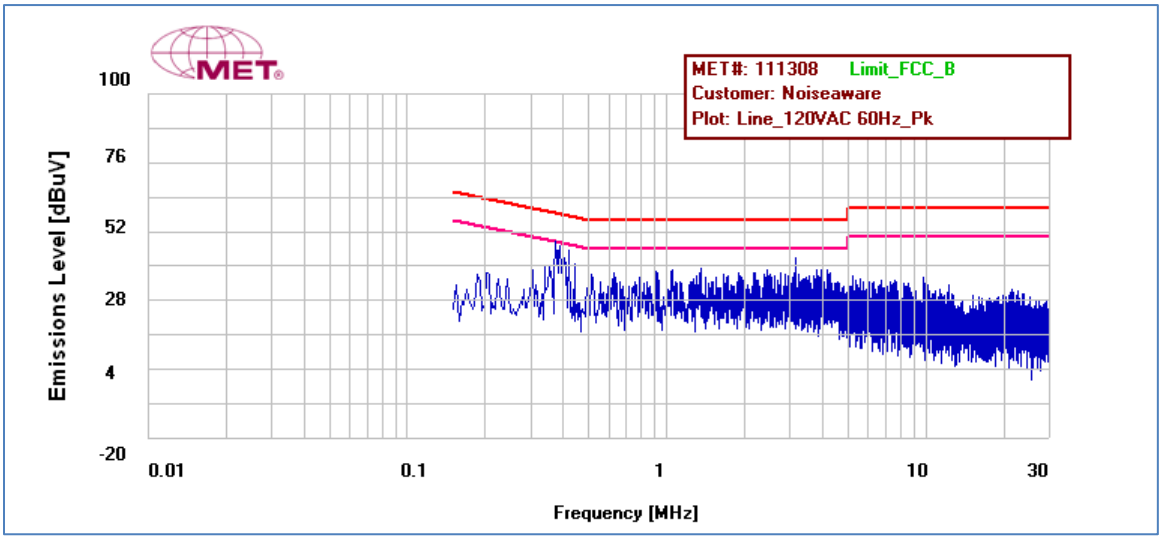

Figure 16: Conducted Emissions, 802.11b, Line Plot

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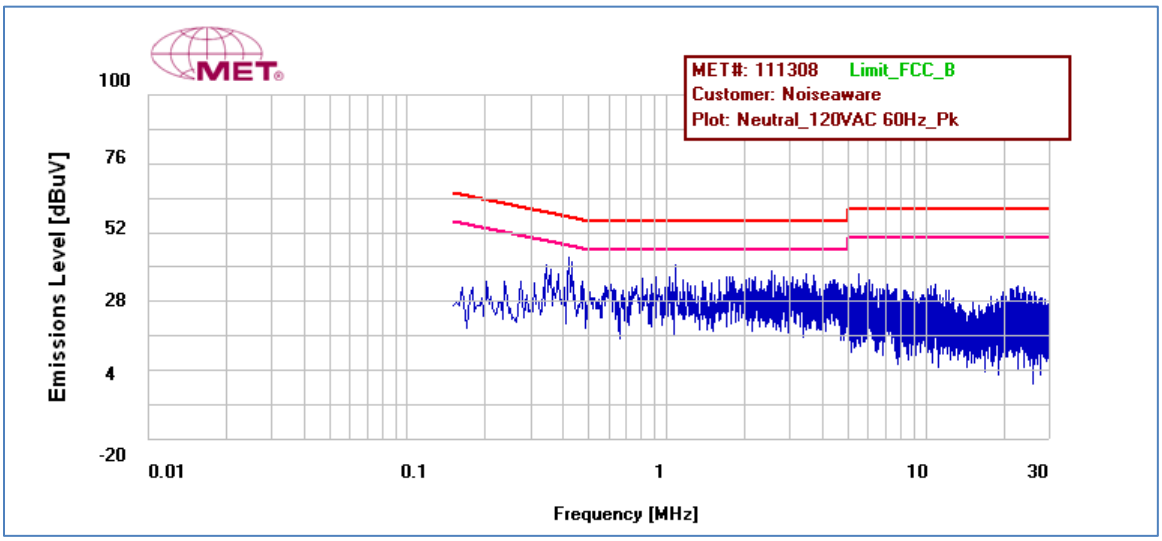

Figure 17: Conducted Emissions, 802.11b, Neutral Plot

Meas. Location	Meas. m	Limit	Result
Bonding measurement from LISN ground to ground plane	1.9 mΩ	< 2.5 mΩ	Pass

Line Name	Freq (MHz)	QP Amplitude (dBµV)	QP Limit (dBµV)	Margin (dB)	Result	Average Amplitude (dBµV)	Average Limit (dBµV)	Margin (dB)	Result
Line_120VAC 60Hz	0.422	44.8	57.432	-12.632	Pass	32.3	47.432	-15.132	Pass
Line_120VAC 60Hz	0.410	45.8	57.671	-11.871	Pass	34.5	47.671	-13.171	Pass
Line_120VAC 60Hz	0.374	47.1	58.432	-11.332	Pass	35.9	48.432	-12.532	Pass
Line_120VAC 60Hz	0.382	46.8	58.257	-11.457	Pass	36.2	48.257	-12.057	Pass
Line_120VAC 60Hz	0.154	39.4	65.782	-26.382	Pass	24	55.782	-31.782	Pass
Line_120VAC 60Hz	0.350	44.1	58.982	-14.882	Pass	32.9	48.982	-16.082	Pass
Neutral_120VAC 60Hz	0.370	45.7	58.521	-12.821	Pass	31.9	48.521	-16.621	Pass
Neutral_120VAC 60Hz	0.406	45.3	57.752	-12.452	Pass	31.9	47.752	-15.852	Pass
Neutral_120VAC 60Hz	1.482	33.8	56	-22.2	Pass	23.2	46	-22.8	Pass
Neutral_120VAC 60Hz	0.622	36.4	56	-19.6	Pass	25.6	46	-20.4	Pass
Neutral_120VAC 60Hz	0.382	46.5	58.257	-11.757	Pass	34	48.257	-14.257	Pass
Neutral_120VAC 60Hz	1.866	31.7	56	-24.3	Pass	23.5	46	-22.5	Pass

Figure 18: Conducted Emissions, 802.11g, Test Data

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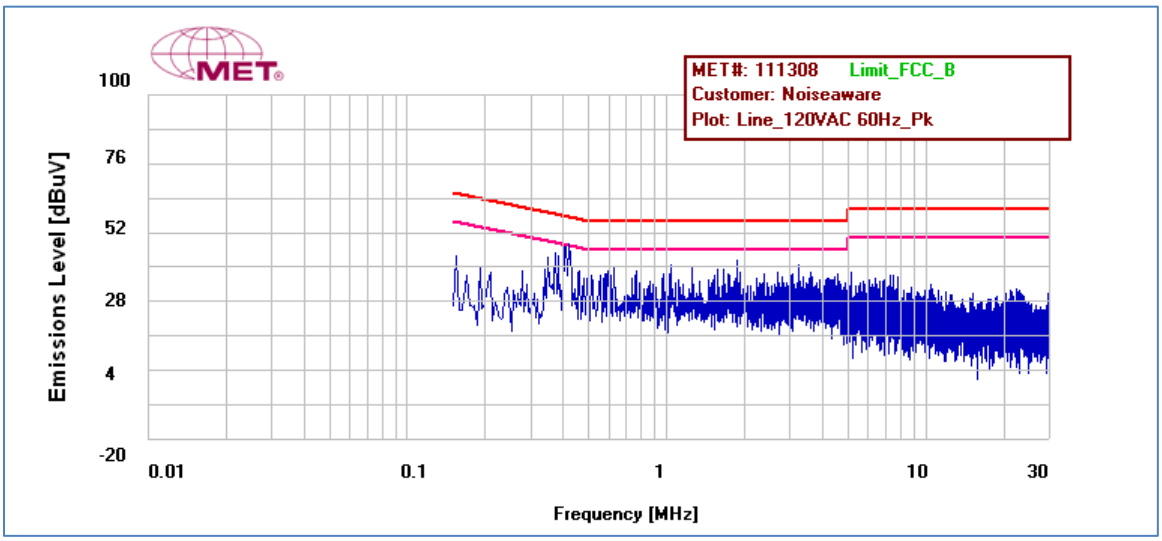

Figure 19: Conducted Emissions, 802.11g, Line Plot

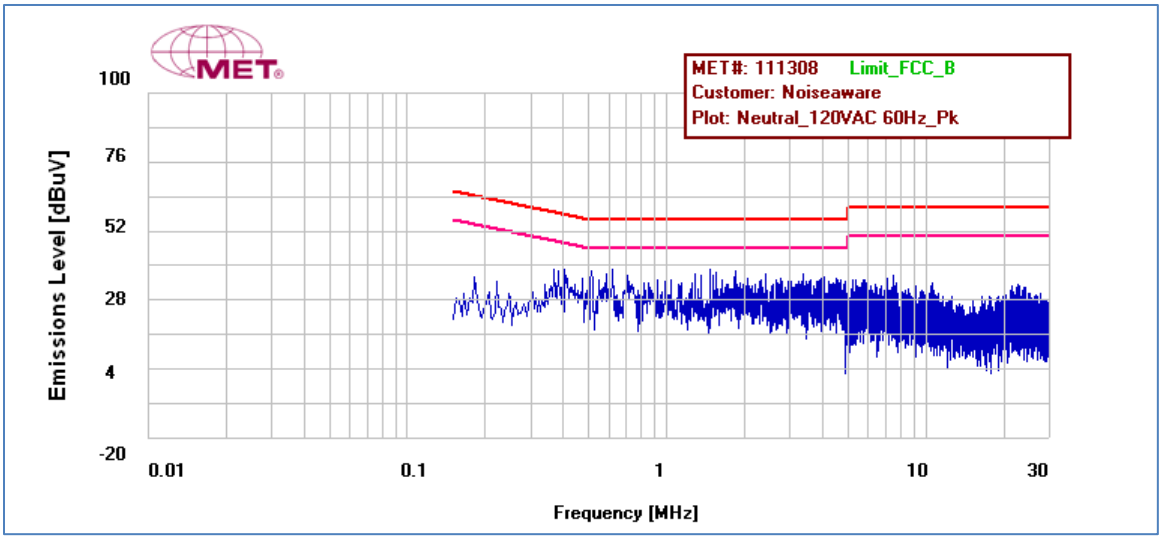

Figure 20: Conducted Emissions, 802.11g, Neutral Plot

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Meas. Location	Meas. m	Limit	Result
Bonding measurement from LISN ground to ground plane	1.86 mΩ	< 2.5 mΩ	Pass

Line Name	Freq (MHz)	QP Amplitude (dBµV)	QP Limit (dBµV)	Margin (dB)	Result	Average Amplitude (dBµV)	Average Limit (dBµV)	Margin (dB)	Result
Line_120VAC 60Hz	0.422	44.7	57.432	-12.732	Pass	32.3	47.432	-15.132	Pass
Line_120VAC 60Hz	0.362	45	58.702	-13.702	Pass	30.5	48.702	-18.202	Pass
Line_120VAC 60Hz	0.386	46.3	58.171	-11.871	Pass	34.8	48.171	-13.371	Pass
Line_120VAC 60Hz	0.350	43.9	58.982	-15.082	Pass	32.9	48.982	-16.082	Pass
Line_120VAC 60Hz	1.130	35.1	56	-20.9	Pass	23.2	46	-22.8	Pass
Line_120VAC 60Hz	0.850	35.9	56	-20.1	Pass	24	46	-22	Pass
Neutral_120VAC 60Hz	0.426	42.1	57.354	-15.254	Pass	28	47.354	-19.354	Pass
Neutral_120VAC 60Hz	0.178	36.7	64.582	-27.882	Pass	24.1	54.582	-30.482	Pass
Neutral_120VAC 60Hz	0.370	46.1	58.521	-12.421	Pass	32.1	48.521	-16.421	Pass
Neutral_120VAC 60Hz	0.206	35.1	63.372	-28.272	Pass	25	53.372	-28.372	Pass
Neutral_120VAC 60Hz	1.818	32.8	56	-23.2	Pass	23.9	46	-22.1	Pass
Neutral_120VAC 60Hz	3.398	31.8	56	-24.2	Pass	23.4	46	-22.6	Pass

Figure 21: Conducted Emissions, 802.11n_HT20, Test Data

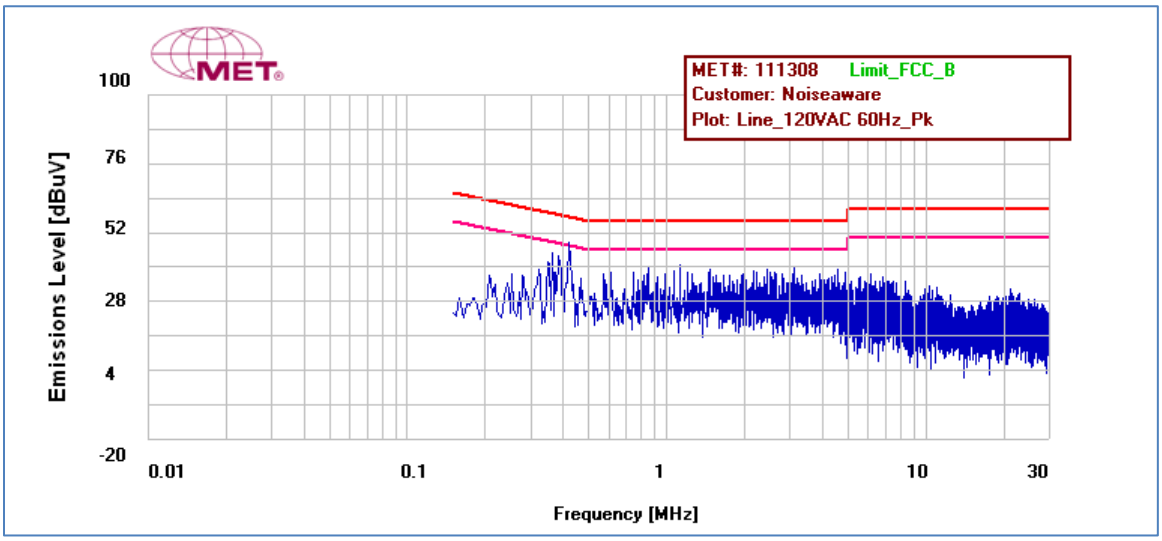

Figure 22: Conducted Emissions, 802.11n_HT20, Line Plot

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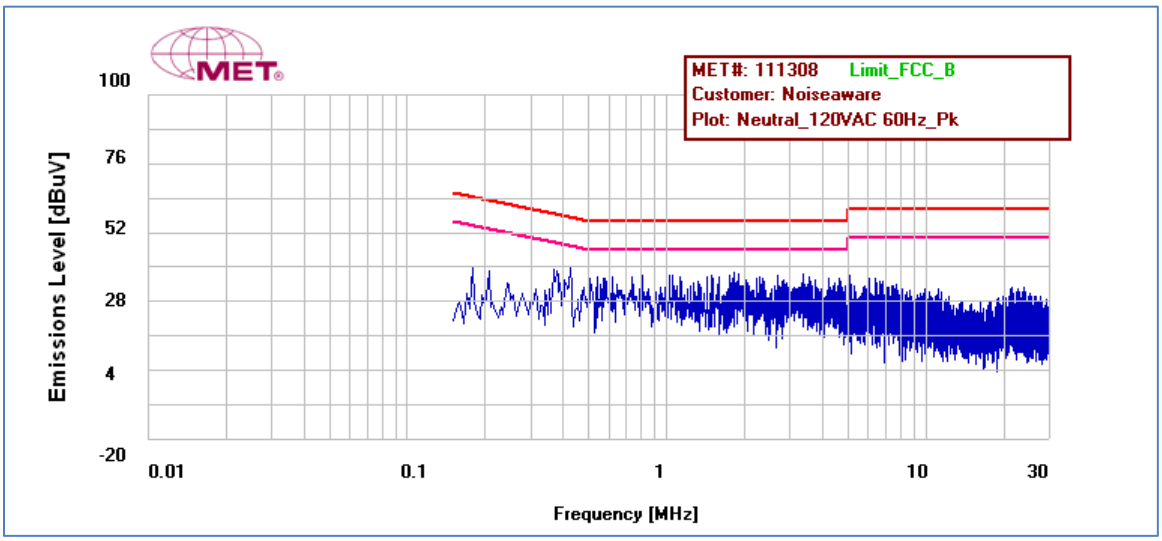

Figure 23: Conducted Emissions, 802.11n_HT20, Neutral Plot

Meas. Location	Meas. m	Limit	Result
Bonding measurement from LISN ground to ground plane	1.86 mΩ	< 2.5 mΩ	Pass

Line Name	Freq (MHz)	QP Amplitude (dBµV)	QP Limit (dBµV)	Margin (dB)	Result	Average Amplitude (dBµV)	Average Limit (dBµV)	Margin (dB)	Result
Line_120VAC 60Hz	0.418	45.4	57.511	-12.111	Pass	33.7	47.511	-13.811	Pass
Line_120VAC 60Hz	0.382	47.1	58.257	-11.157	Pass	36	48.257	-12.257	Pass
Line_120VAC 60Hz	0.350	44	58.982	-14.982	Pass	32.7	48.982	-16.282	Pass
Line_120VAC 60Hz	0.362	44.1	58.702	-14.602	Pass	29.8	48.702	-18.902	Pass
Line_120VAC 60Hz	4.674	32.5	56	-23.5	Pass	22.6	46	-23.4	Pass
Line_120VAC 60Hz	0.322	34.8	59.672	-24.872	Pass	23.4	49.672	-26.272	Pass
Neutral_120VAC 60Hz	0.402	44.3	57.834	-13.534	Pass	29.7	47.834	-18.134	Pass
Neutral_120VAC 60Hz	0.182	35.9	64.398	-28.498	Pass	23.4	54.398	-30.998	Pass
Neutral_120VAC 60Hz	0.998	33.3	56	-22.7	Pass	23.7	46	-22.3	Pass
Neutral_120VAC 60Hz	7.342	30.8	60	-29.2	Pass	23	50	-27	Pass
Neutral_120VAC 60Hz	0.622	36.3	56	-19.7	Pass	25.6	46	-20.4	Pass
Neutral_120VAC 60Hz	1.722	33.1	56	-22.9	Pass	23.9	46	-22.1	Pass

Figure 24: Conducted Emissions, 802.11n_HT40, Test Data

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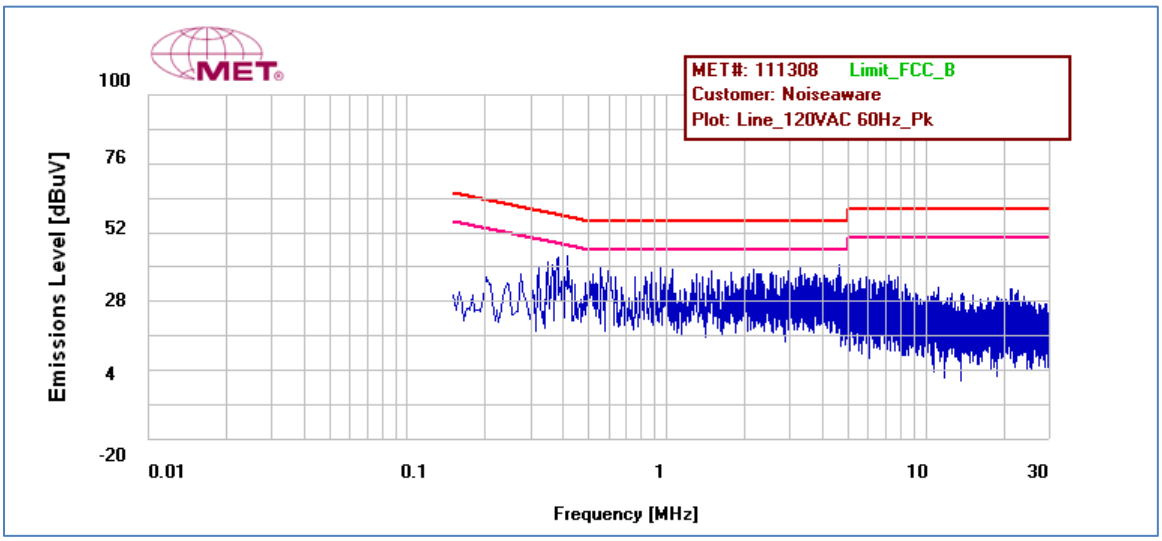

Figure 25: Conducted Emissions, 802.11n_HT40, Line Plot

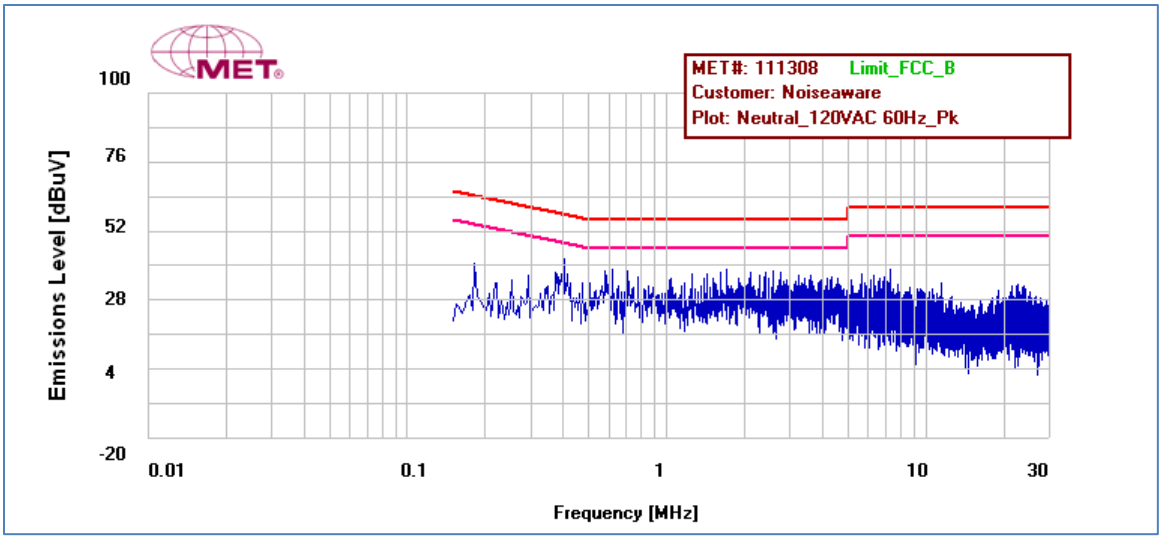

Figure 26: Conducted Emissions, 802.11n_HT40, Neutral Plot

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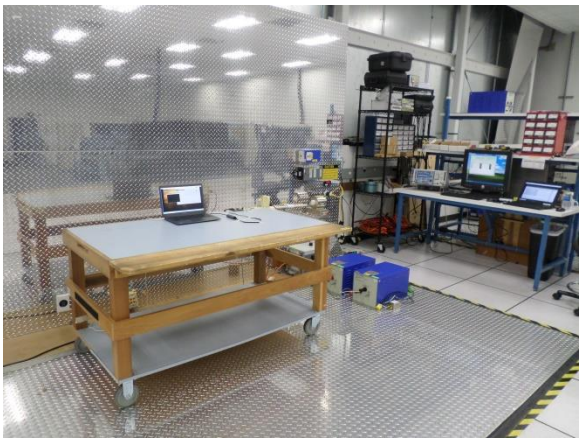

Figure 27: Conducted Emissions, Setup Front View

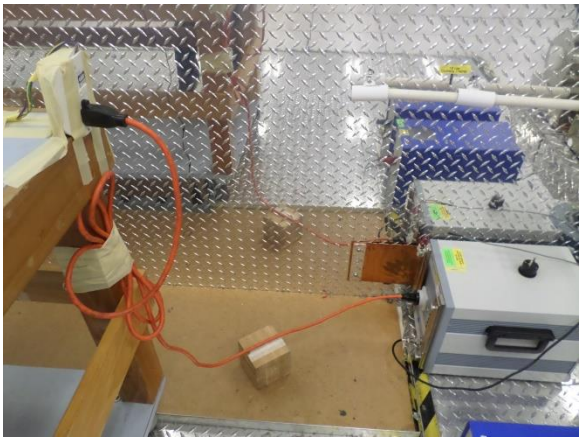

Figure 28: Conducted Emissions, Setup LISN View

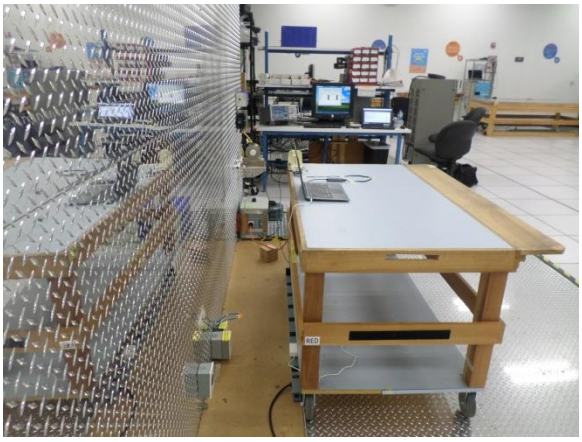

Figure 29: Conducted Emissions, Setup Rear View

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW = 100kHz, VBW = 3*RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid, and high channels.

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

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

Test Engineer: Adan Arab

Test Date(s): March 16, 2021

Mode	Center Frequency (MHz)	6 dB Occupied Bandwidth (MHz)	Limit (MHz)
802.11b	2412	9.596	>500
802.11b	2437	10.054	>500
802.11b	2462	9.594	>500
802.11g	2412	16.428	>500
802.11g	2437	16.399	>500
802.11g	2462	16.428	>500
802.11n_HT20	2412	17.628	>500
802.11n_HT20	2437	17.564	>500
802.11n_HT20	2462	17.374	>500
802.11n_HT40	2422	36.590	>500
802.11n_HT40	2437	36.030	>500
802.11n_HT40	2452	36.048	>500

Figure 30: 6 dB Occupied Bandwidth, Test Results

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Occupied Bandwidth Test Results

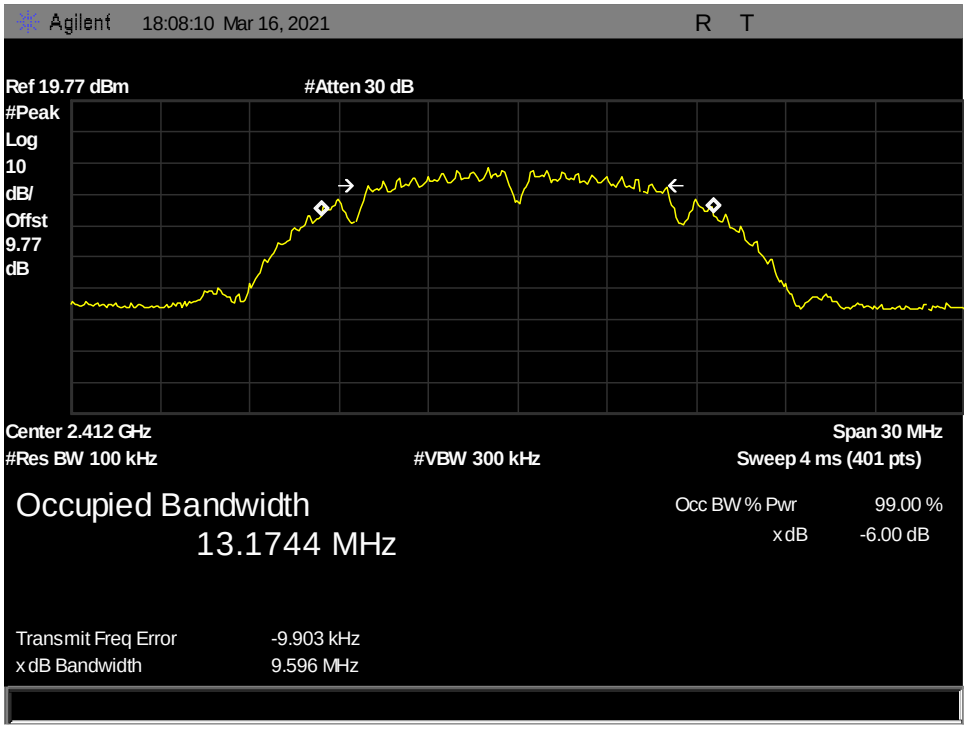

Figure 31: 6 dB Occupied Bandwidth, 802.11b, 2412 MHz

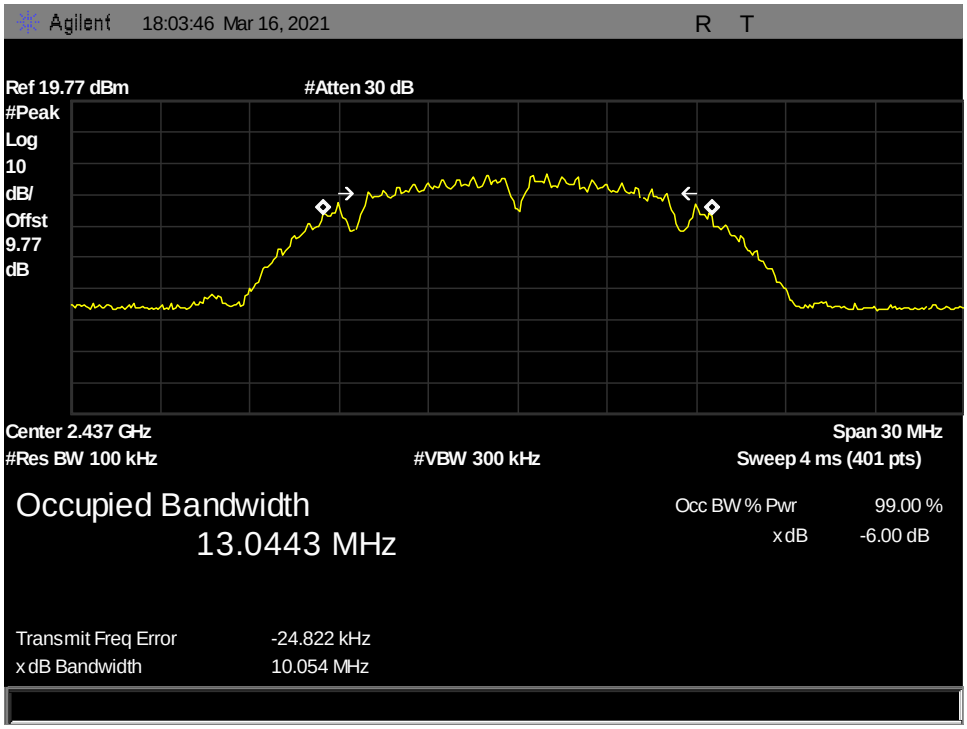

Figure 32: 6 dB Occupied Bandwidth, 802.11b, 2437 MHz

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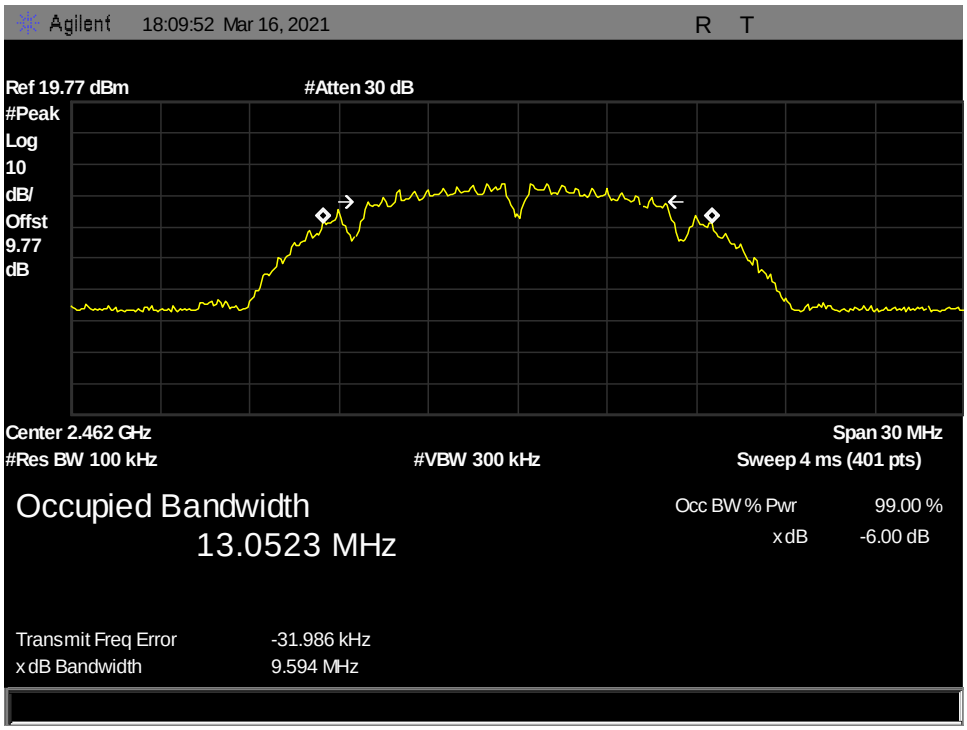

Figure 33: 6 dB Occupied Bandwidth, 802.11b, 2462 MHz

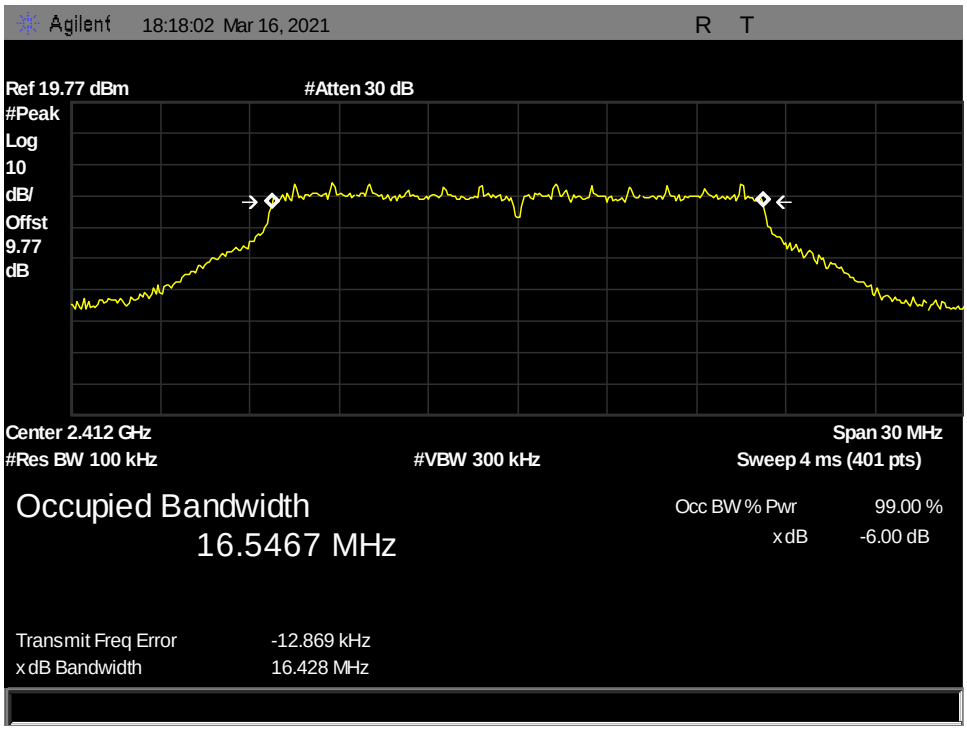

Figure 34: 6 dB Occupied Bandwidth, 802.11g, 2412 MHz

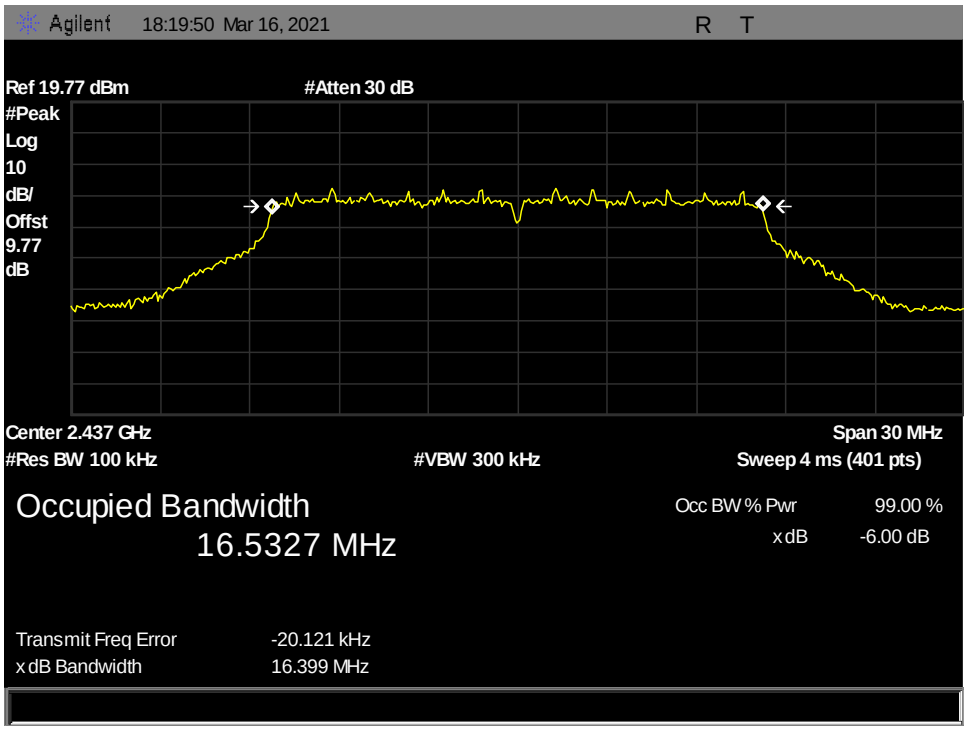

Figure 35: 6 dB Occupied Bandwidth, 802.11g, 2437 MHz

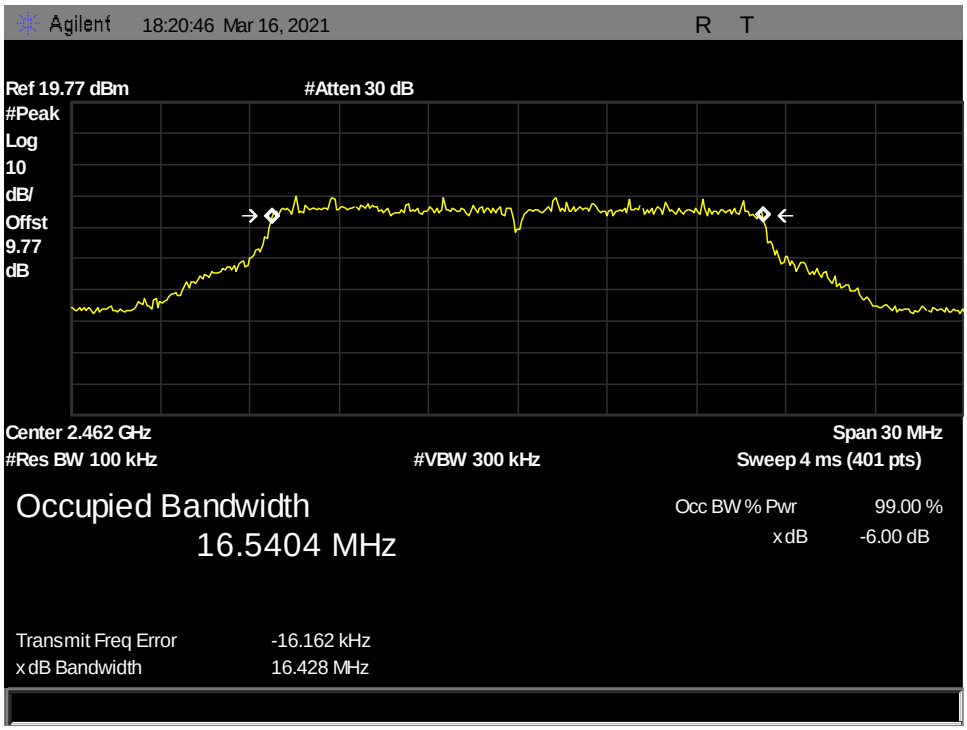

Figure 36: 6 dB Occupied Bandwidth, 802.11g, 2462 MHz

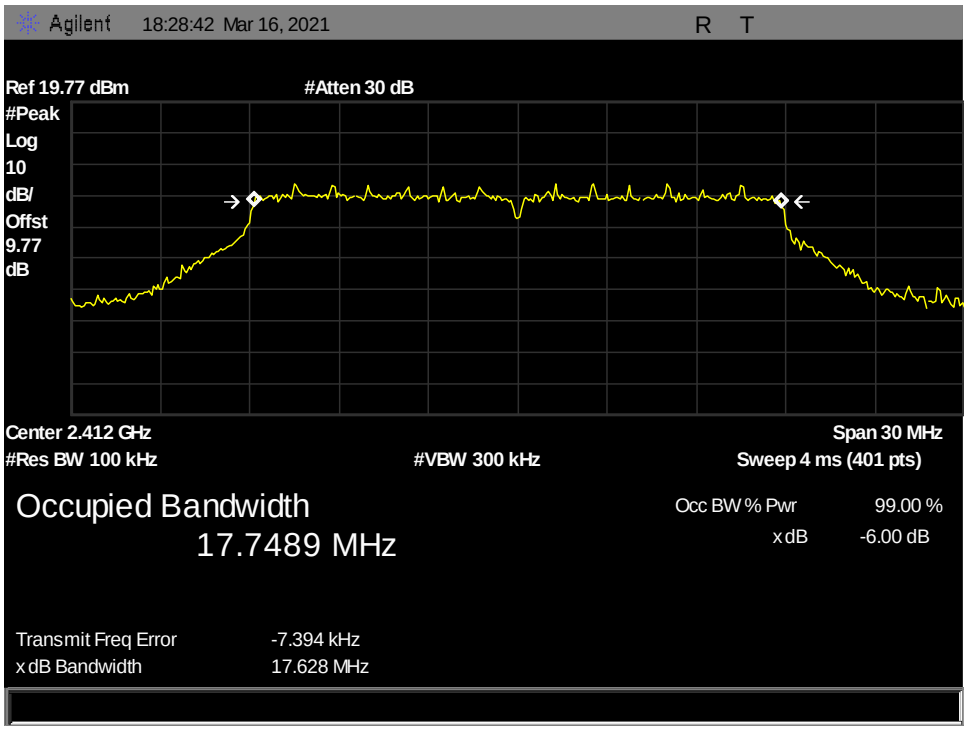

Figure 37: 6 dB Occupied Bandwidth, 802.11n_HT20, 2412 MHz

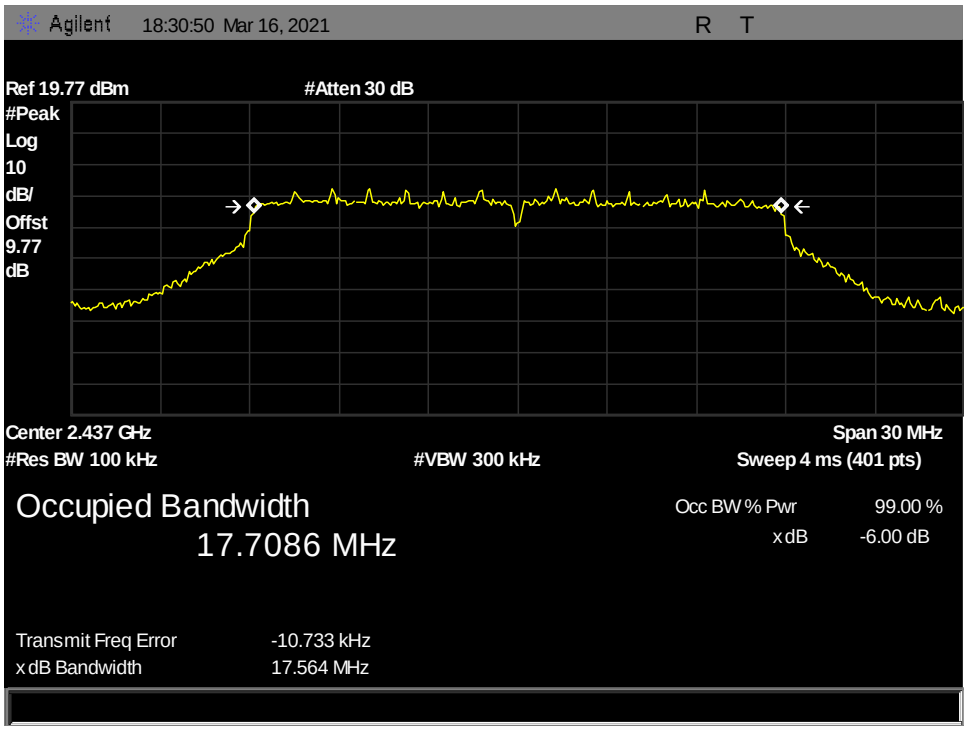

Figure 38: 6 dB Occupied Bandwidth, 802.11n_HT20, 2437 MHz

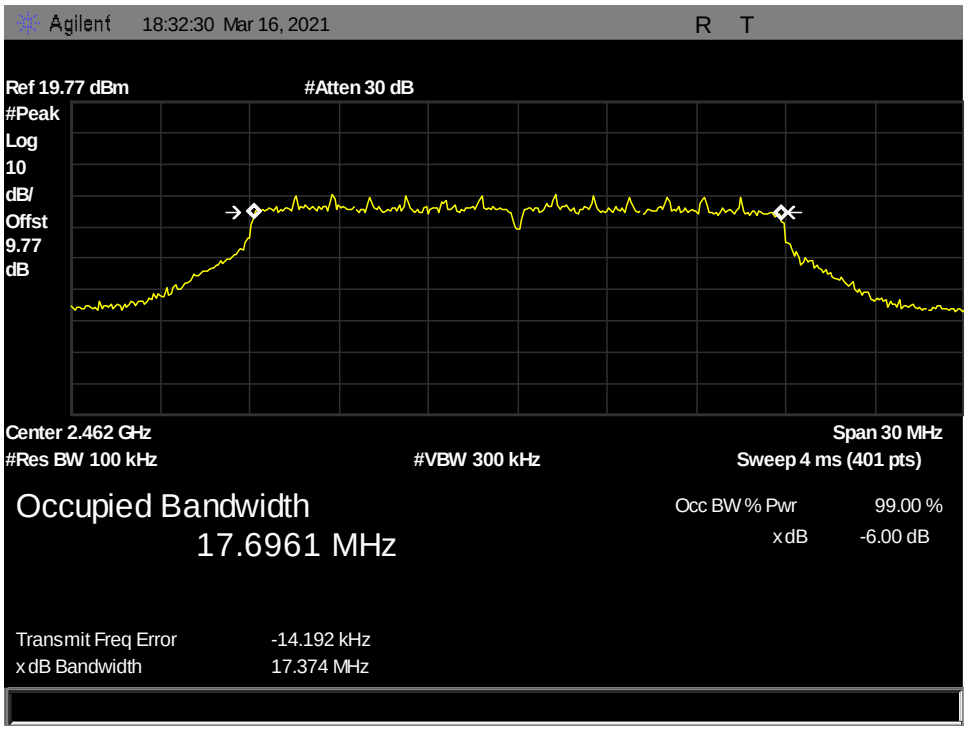

Figure 39: 6 dB Occupied Bandwidth, 802.11n_HT20, 2462 MHz

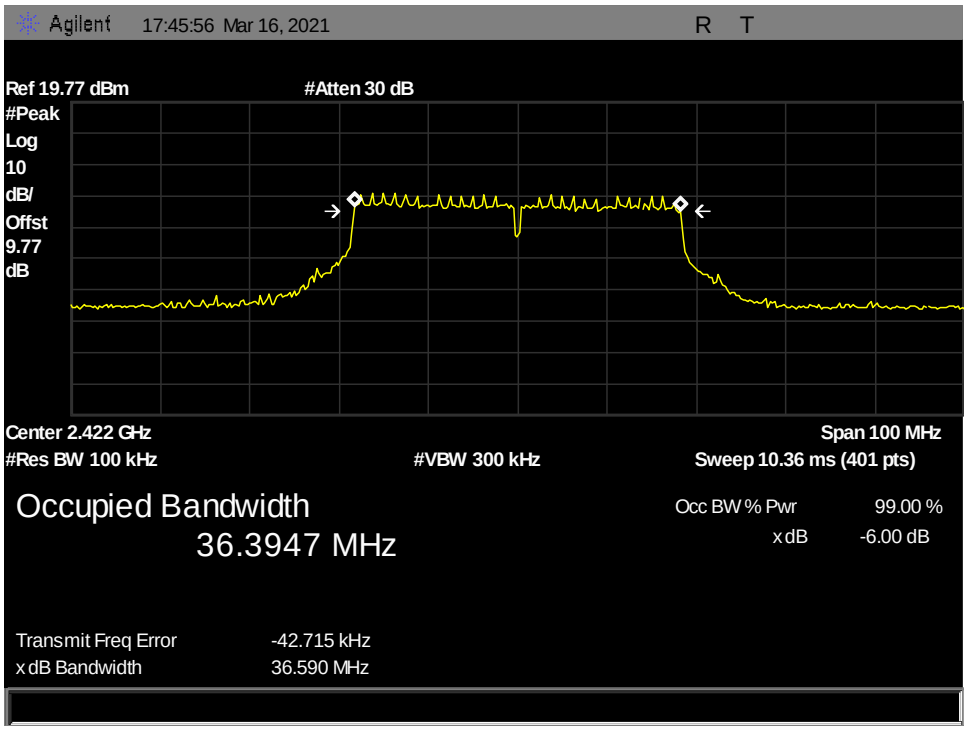

Figure 40: 6 dB Occupied Bandwidth, 802.11n_HT40, 2422 MHz

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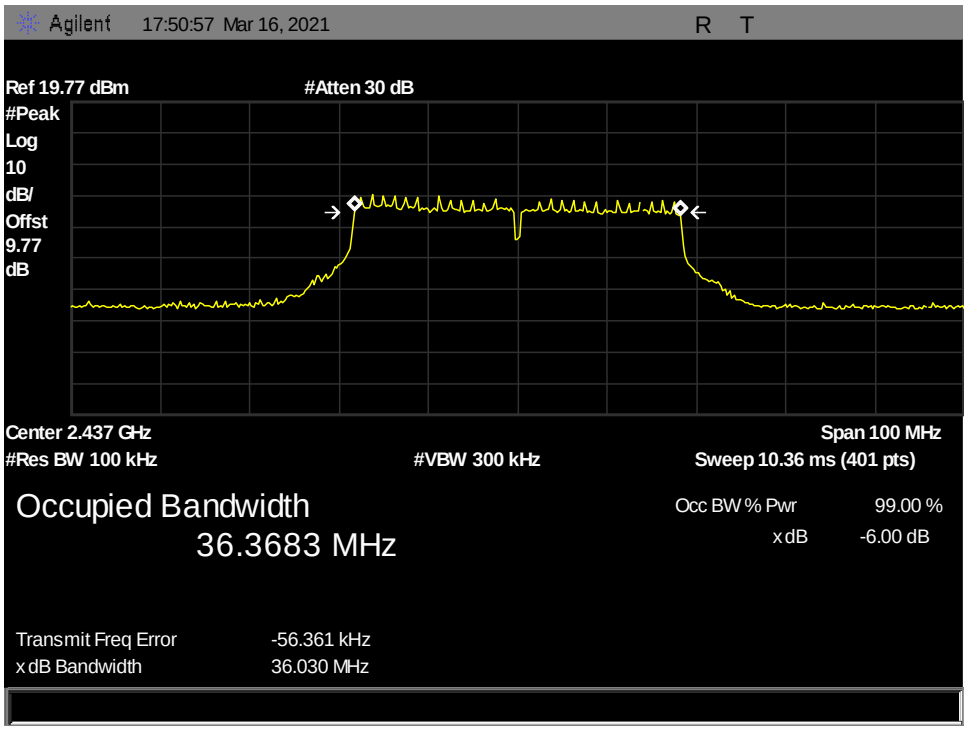

Figure 41: 6 dB Occupied Bandwidth, 802.11n_HT40, 2437 MHz

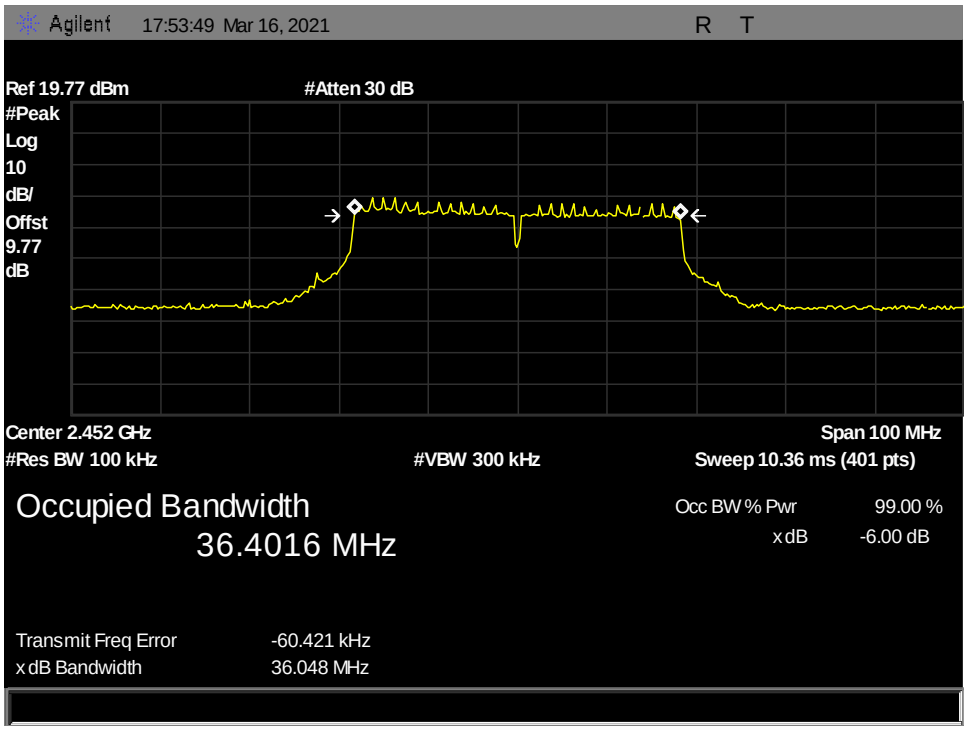

Figure 42: 6 dB Occupied Bandwidth, 802.11n_HT40, 2452 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Maximum Power Output

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

Digital Transmission Systems (MHz)	Output Limit (Watts)
2400–2483.5	1.000

Figure 43: Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the figure 43 above, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test Procedure: The RBW was set to 1% to 5% of OBW 300 kHz and a VBW set to 1 MHz. The spectrum analyzer was set to an auto sweep time and an Average detector was used. Measurements were carried out at the low, mid and high channels of each band at the maximum power level. Test method and test procedures of ANSI C63.10-2013 section 11.9.2.2.4 Method AVGSA-2 is used.

The EUT possessed an integral antenna that did not make it possible to perform conducted RF measurements. Power measurements were then taken as a field strength at 3m from the EUT and converted to conducted EIRP value.

The Spectrum analyzer is programed to convert the measured EIRP to conducted output power by adding back distance correction factor and EIRP conversion factor. The measured conducted average power is the corrected with the duty cycle correction factor of 10.46 dB. The reading in the captured plots is the converted and corrected conducted power before adding the DCCF.

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

Test Engineer: Adan Arab

Test Date(s): March 17, 2021

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Mode	Frequency (MHz)	Uncorrected Conducted Output Power Power (dBm)	Duty Cycle Correction Factor (dB)	Corrected Conducted Output Power (dBm)	Limit (dBm)	Result
802.11b	2412	-4.76	10.46	5.7	30	Pass
802.11b	2437	-7.59	10.46	2.87	30	Pass
802.11b	2462	-10.34	10.46	0.12	30	Pass
802.11g	2412	-6.88	10.46	3.58	30	Pass
802.11g	2437	-9.59	10.46	0.87	30	Pass
802.11g	2462	-12.39	10.46	-1.93	30	Pass
802.11n_HT20	2412	-7.30	10.46	3.16	30	Pass
802.11n_HT20	2437	-10.05	10.46	0.41	30	Pass
802.11n_HT20	2462	-12.67	10.46	-2.21	30	Pass
802.11n_HT40	2422	-8.65	10.46	1.81	30	Pass
802.11n_HT40	2437	-10.59	10.46	-0.13	30	Pass
802.11n_HT40	2452	-12.39	10.46	-1.93	30	Pass

Figure 44: Maximum Output Power, Test Results

Maximum Power Output Test Results:

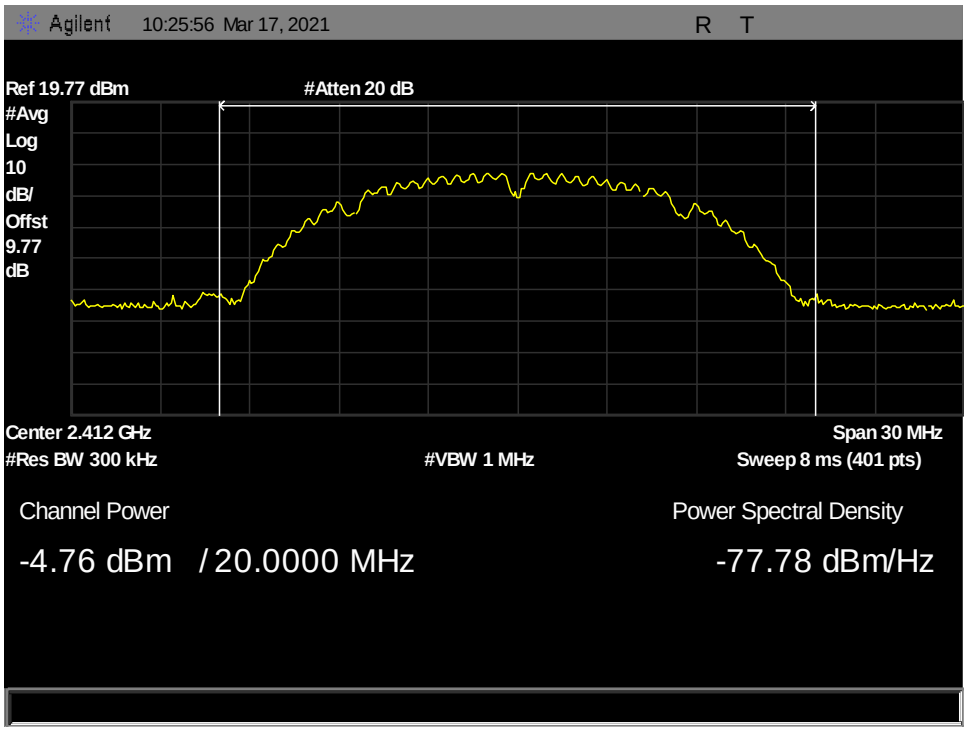

Figure 45: Maximum Power Output, 802.11b, 2412 MHz

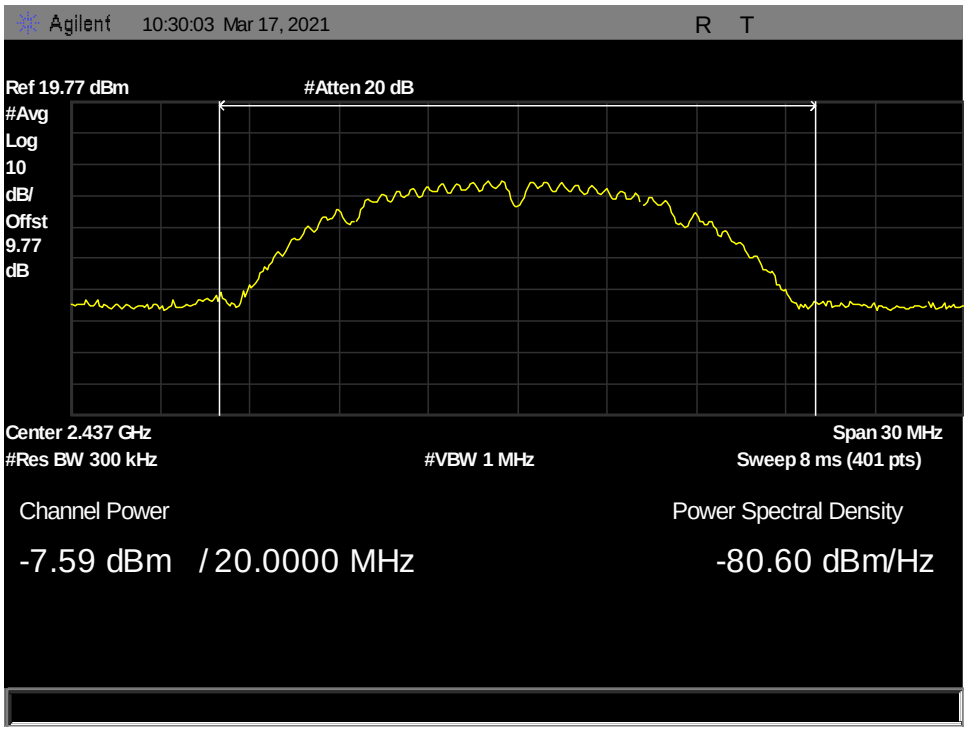

Figure 46: Maximum Power Output, 802.11b, 2437 MHz

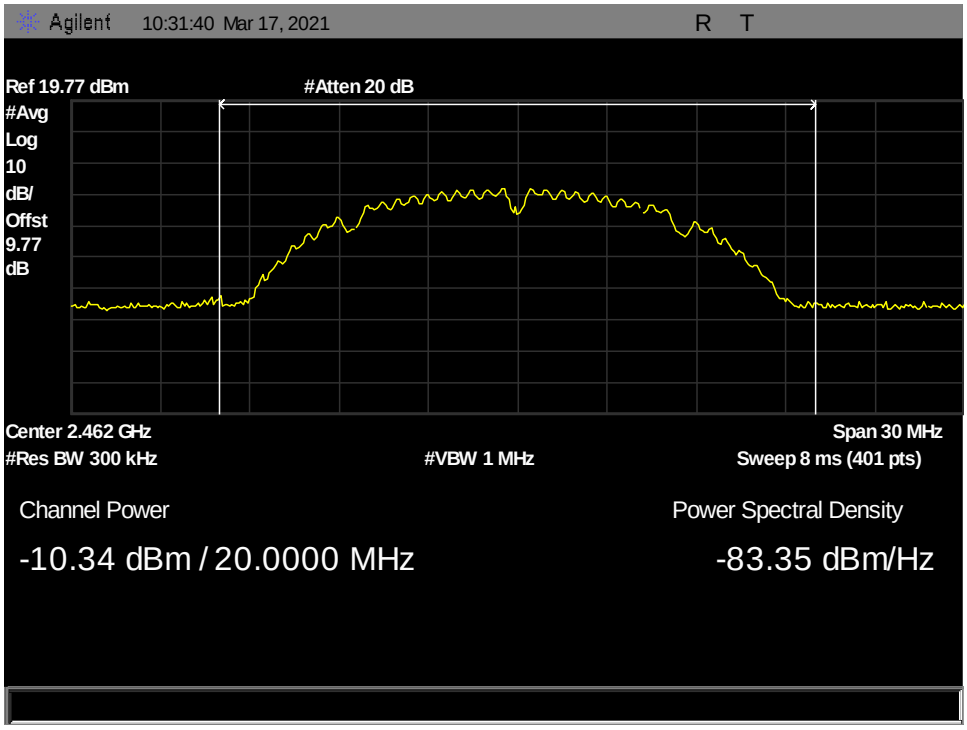

Figure 47: Maximum Power Output, 802.11b, 2462 MHz

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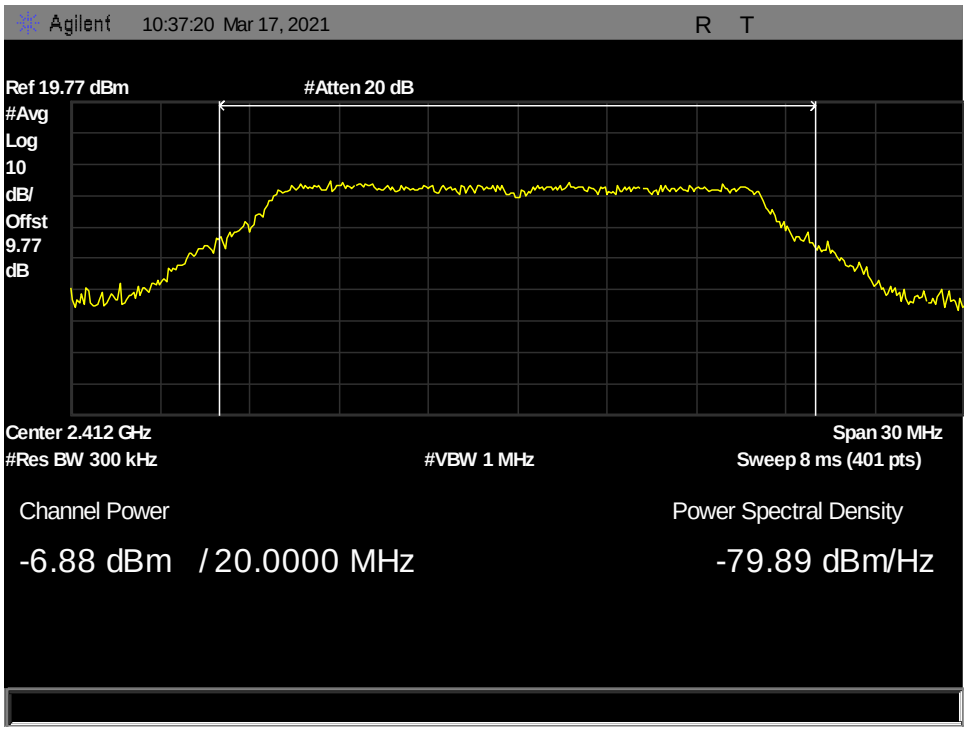

Figure 48: Maximum Power Output, 802.11g, 2412 MHz

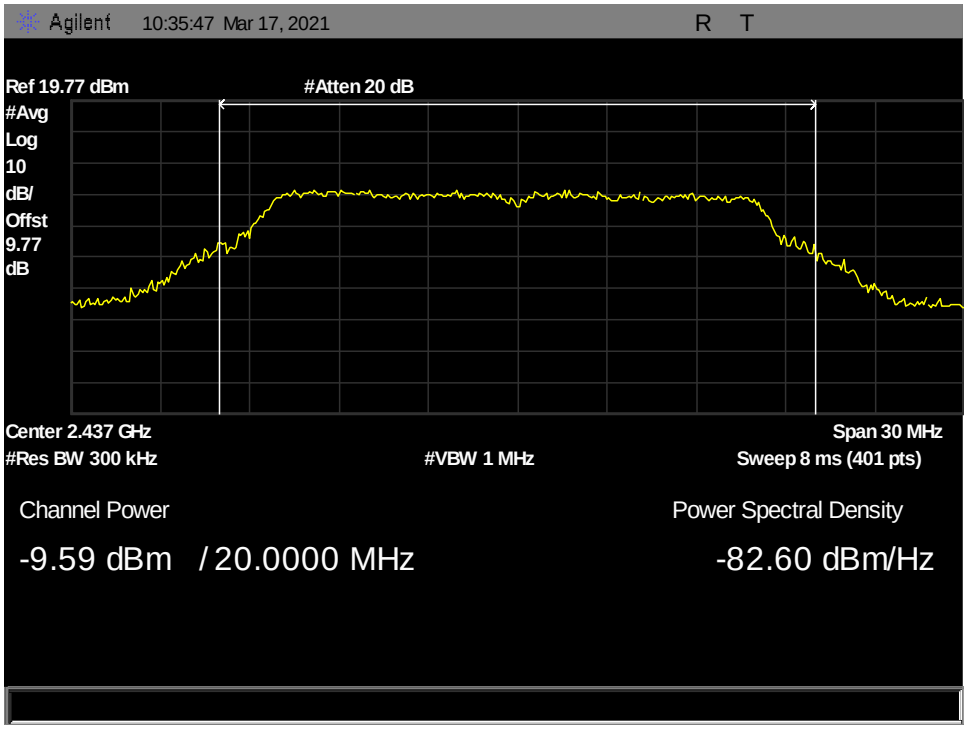

Figure 49: Maximum Power Output, 802.11g, 2437 MHz

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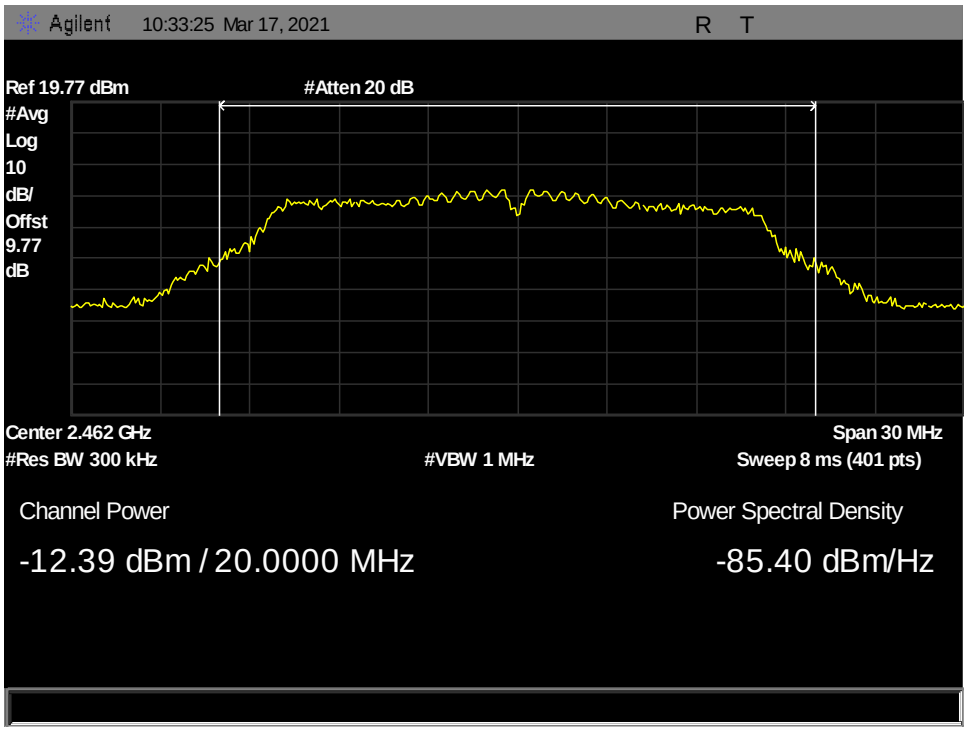

Figure 50: Maximum Power Output, 802.11g, 2462 MHz

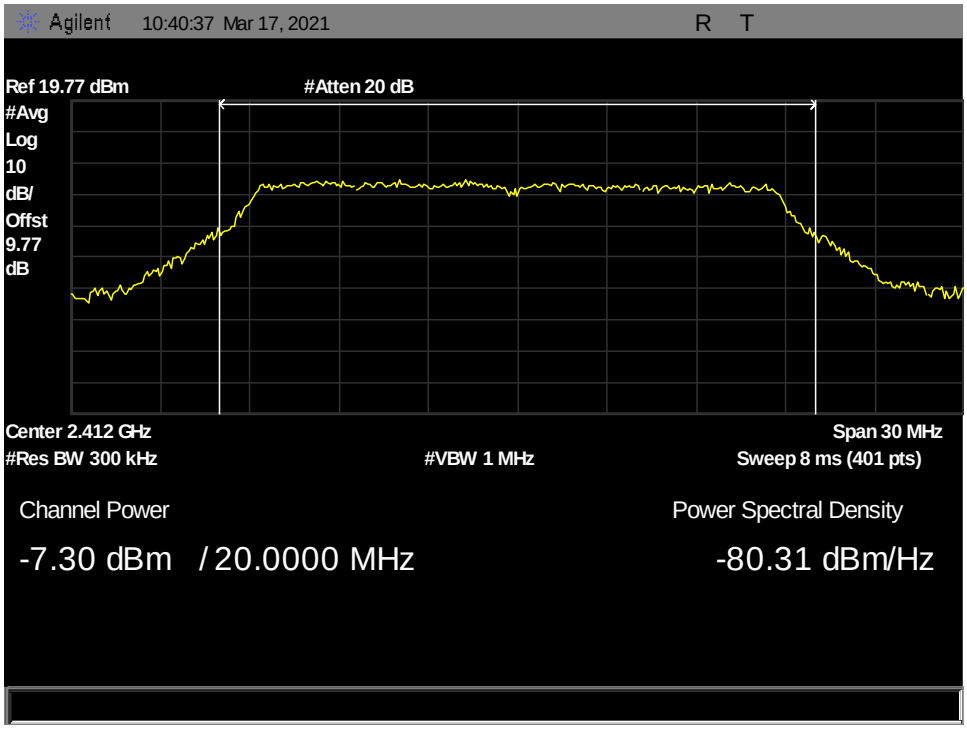

Figure 51: Maximum Power Output, 802.11n_HT20, 2412 MHz

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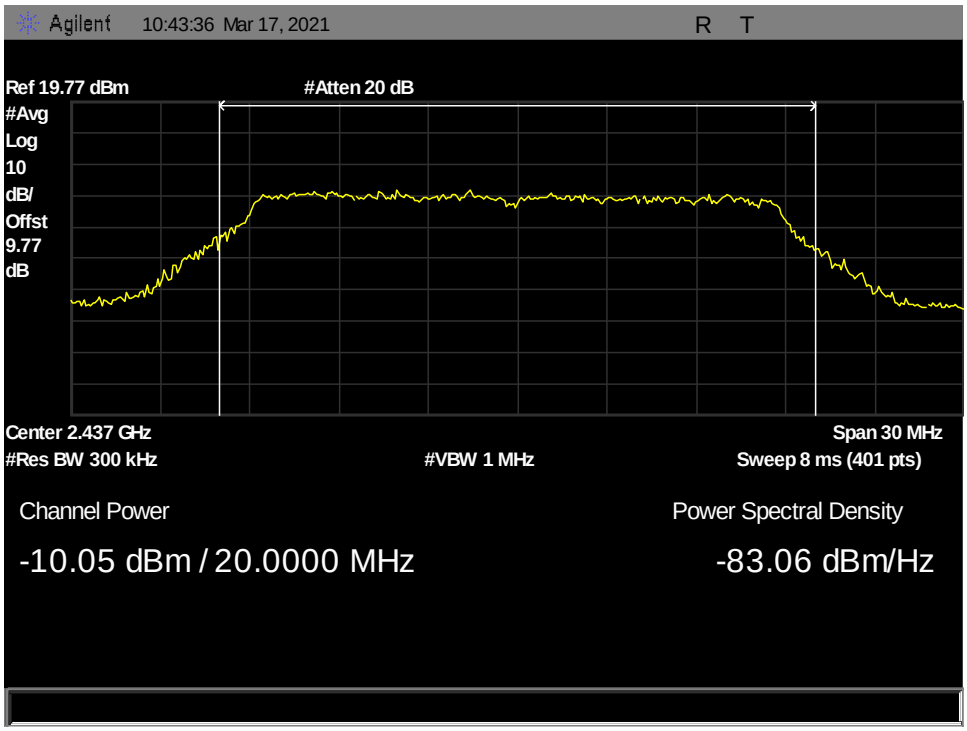

Figure 52: Maximum Power Output, 802.11n_HT20, 2437 MHz

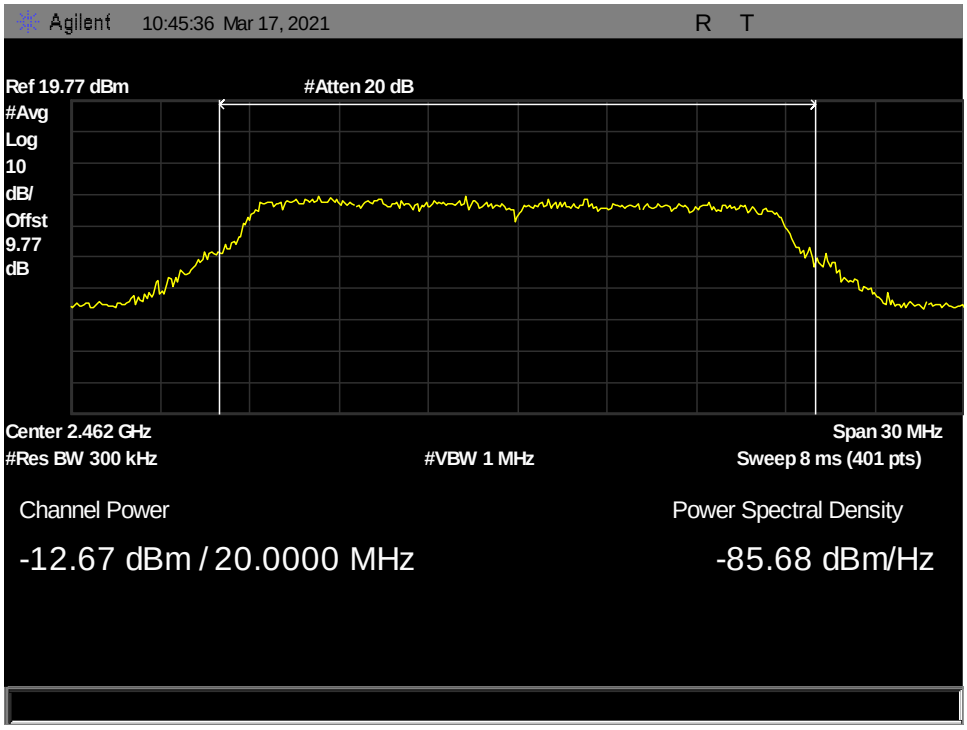

Figure 53: Maximum Power Output, 802.11n_HT20, 2462 MHz

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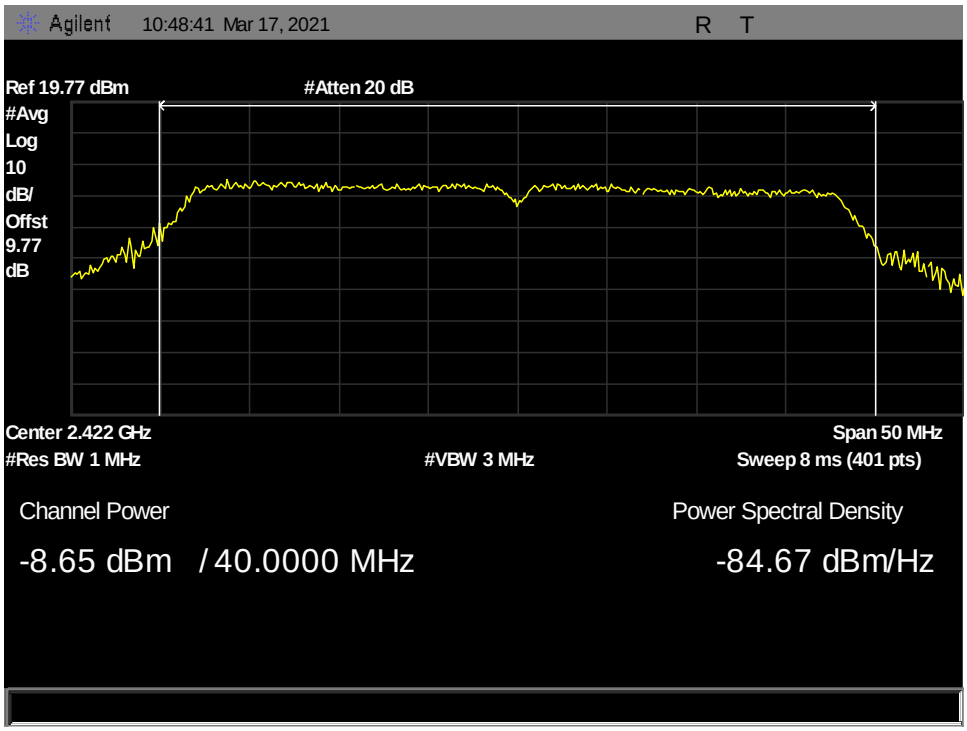

Figure 54: Maximum Power Output, 802.11n_HT40, 2422 MHz

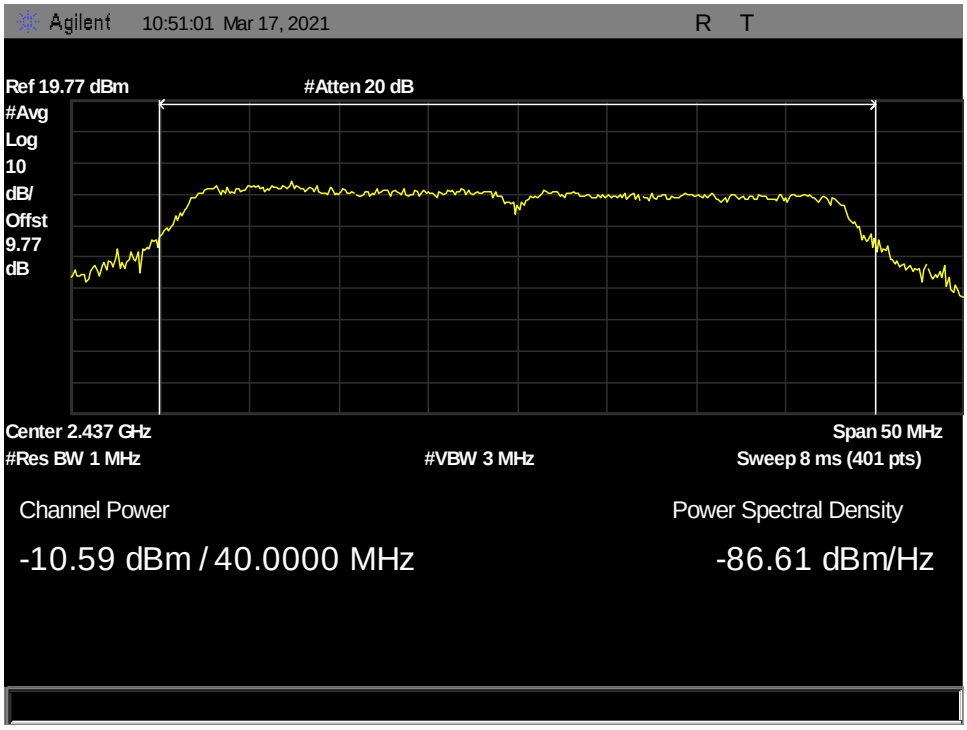

Figure 55: Maximum Power Output, 802.11n_HT40, 2437 MHz

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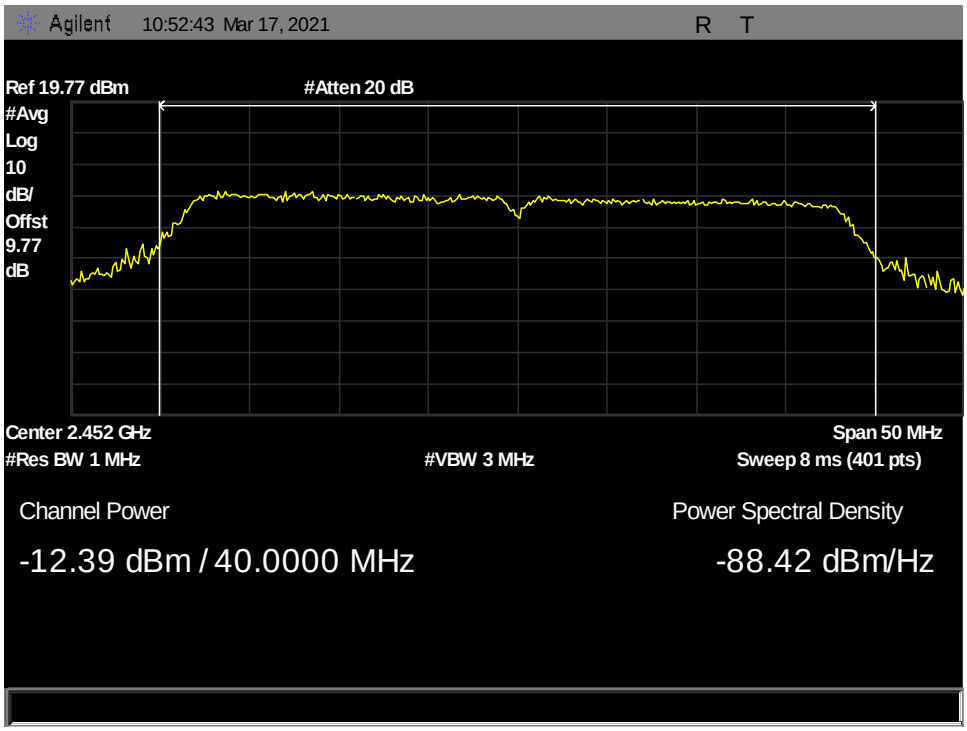

Figure 56: Maximum Power Output, 802.11n_HT40, 2452 MHz

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.209 Radiated Spurious Emissions Requirements and Band Edge

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

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

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

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

Figure 57: Restricted Bands of Operation

[2] Above 38.6

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Test Requirement(s): **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Figure 58.

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

Figure 58: Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The transmitter was set to the mid channel at the highest output power and placed on a 0.8 m high non-conductive table inside in a semi-anechoic chamber. Measurements were performed with the EUT rotated 360 degrees and varying the adjustable antenna mast with 1 m to 4 m height to determine worst case orientation for maximum emissions. Measurement were repeated the measurement at the low and highest channels.

For frequencies below 1 GHz, measurements were performed at 10m from the EUT and using a quasi-peak detector with a 120 kHz bandwidth.

For frequencies above1 GHz, measurements were performed at 3m from the EUT and using a peak detector with a 1 MHz bandwidth and then compared with average limit for worst case.

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

In accordance with §15.35(b) the limit on the radio frequency emissions as measured using instrumentation with a peak detector function shall be 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules.

The EUT possessed an integral antenna, therefore Spurious Emissions in 100 KHz Bandwidth was performed using a radiated setup.

EUT Field Strength Final Amplitude = Raw Amplitude – Preamp gain + Antenna Factor + Cable Loss – Distance Correction Factor.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of **§ 15.247(d) and § 15.209**. Measured emissions were within applicable limits.

Test Engineer: Adan Arab

Test Date(s): March 17, 2021

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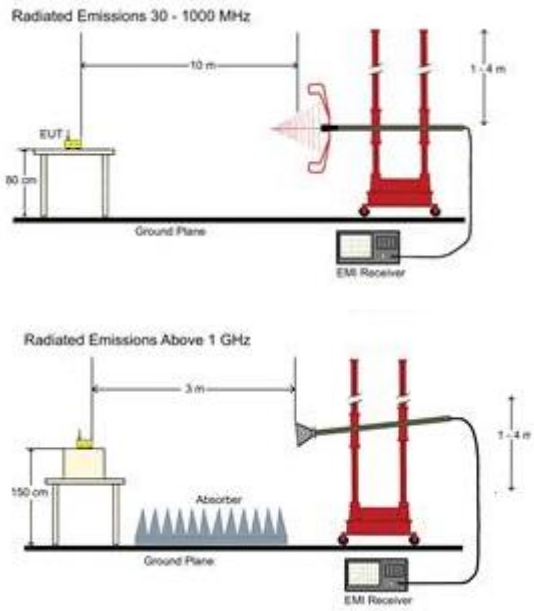

Figure 59: Radiated Spurious Emissions Test Setup

Radiated Spurious Emissions, Test Results

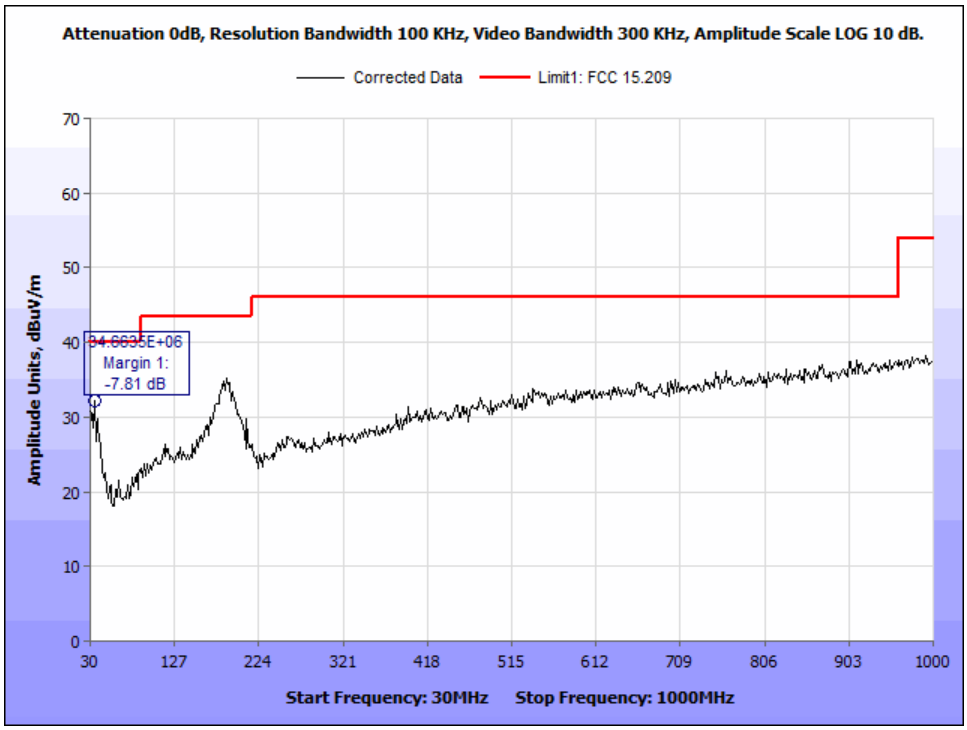

Figure 60: Radiated Spurious Emissions, 802.11b, 2412 MHz - 30MHz-1000MHz - Horizontal

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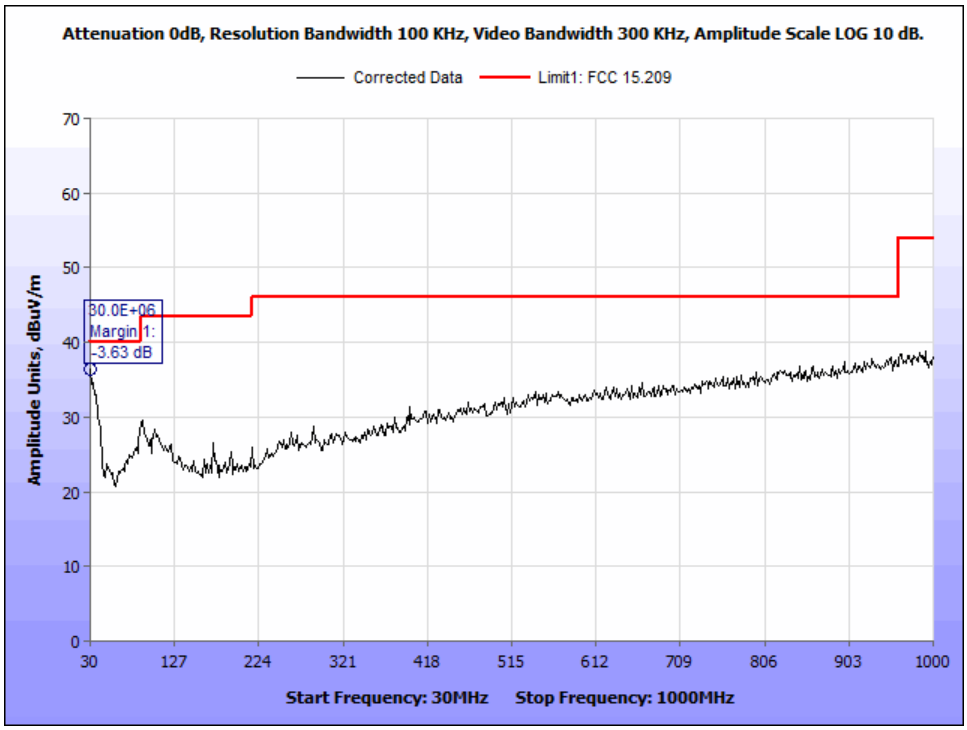

Figure 61: Radiated Spurious Emissions, 802.11b, 2412 MHz - 30MHz-1000MHz - Vertical

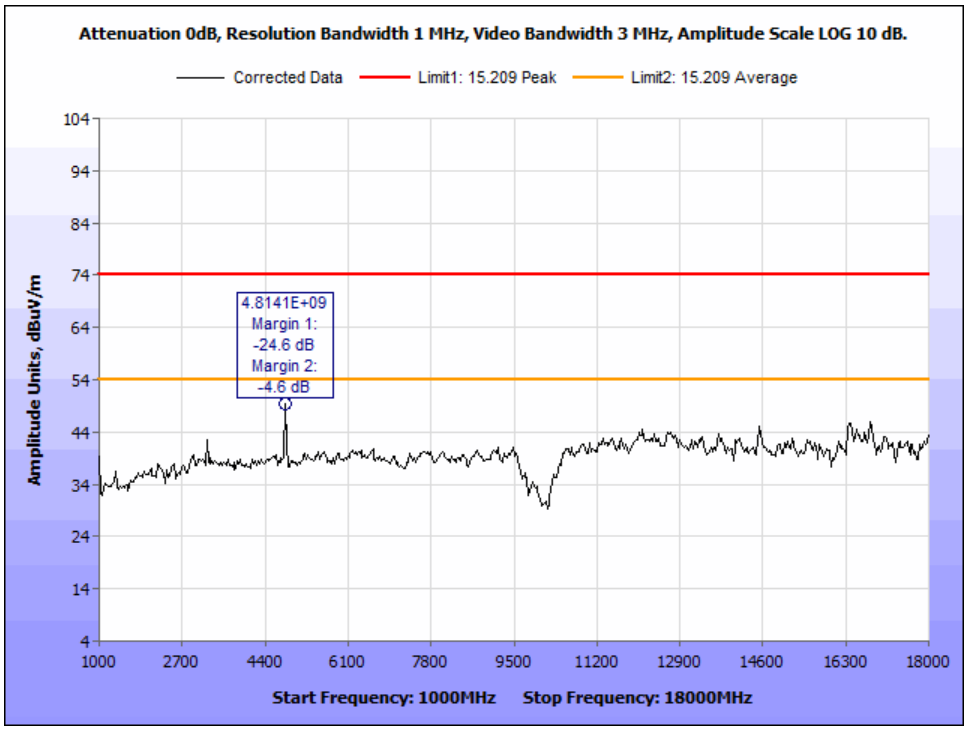

Figure 62: Radiated Spurious Emissions, 802.11b, 2412 MHz - 1GHz-18GHz - Peak - Horizontal

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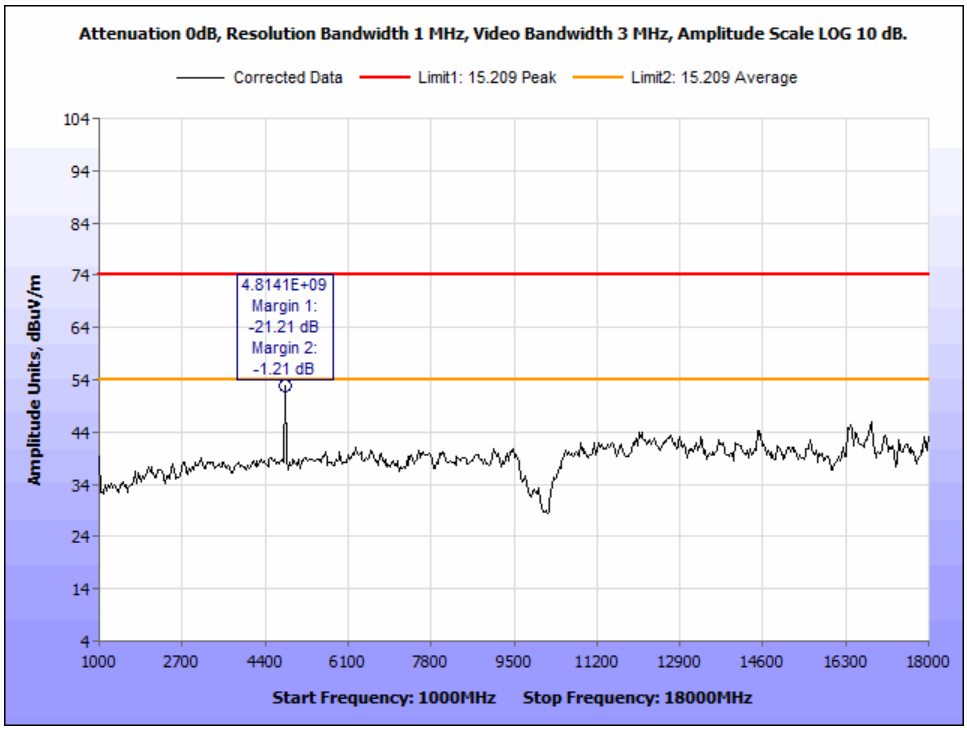

Figure 63: Radiated Spurious Emissions, 802.11b, 2412 MHz - 1GHz-18GHz - Peak – Vertical

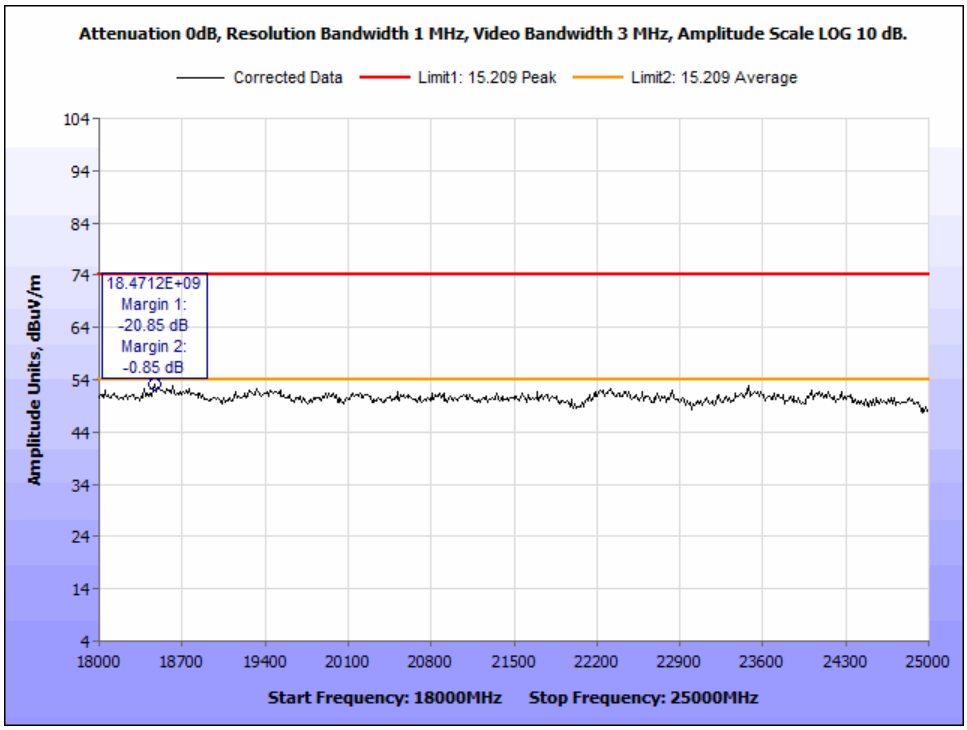

Figure 64: Radiated Spurious Emissions, 802.11b, 2412 MHz - 18-25GHz - Peak - Horizontal

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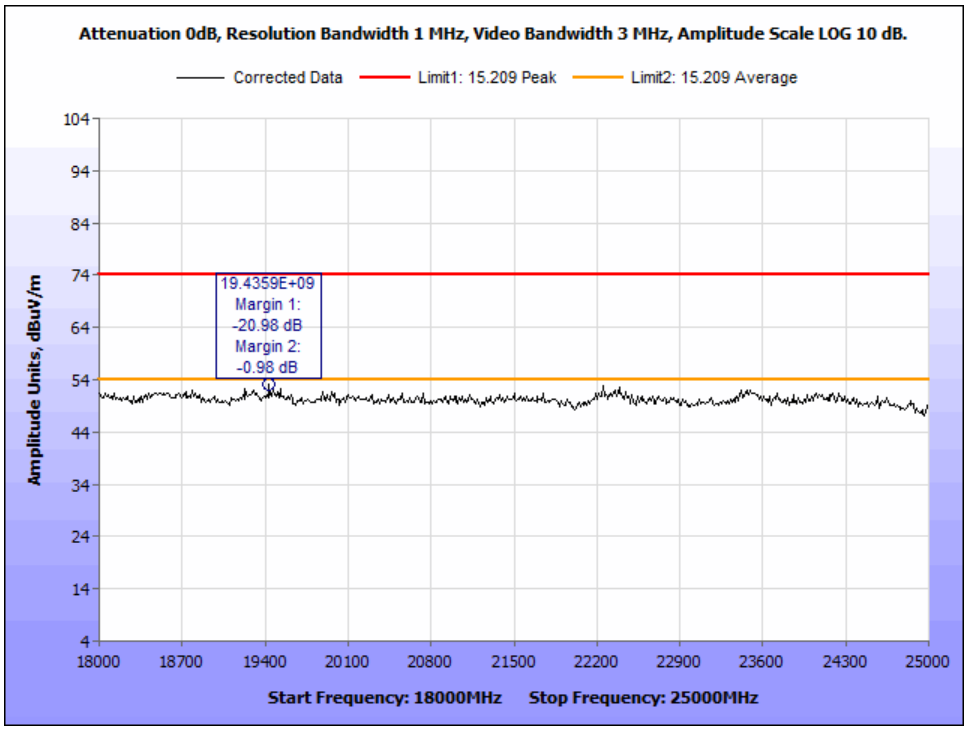

Figure 65: Radiated Spurious Emissions, 802.11b, 2412 MHz - 18-25GHz - Peak - Vertical

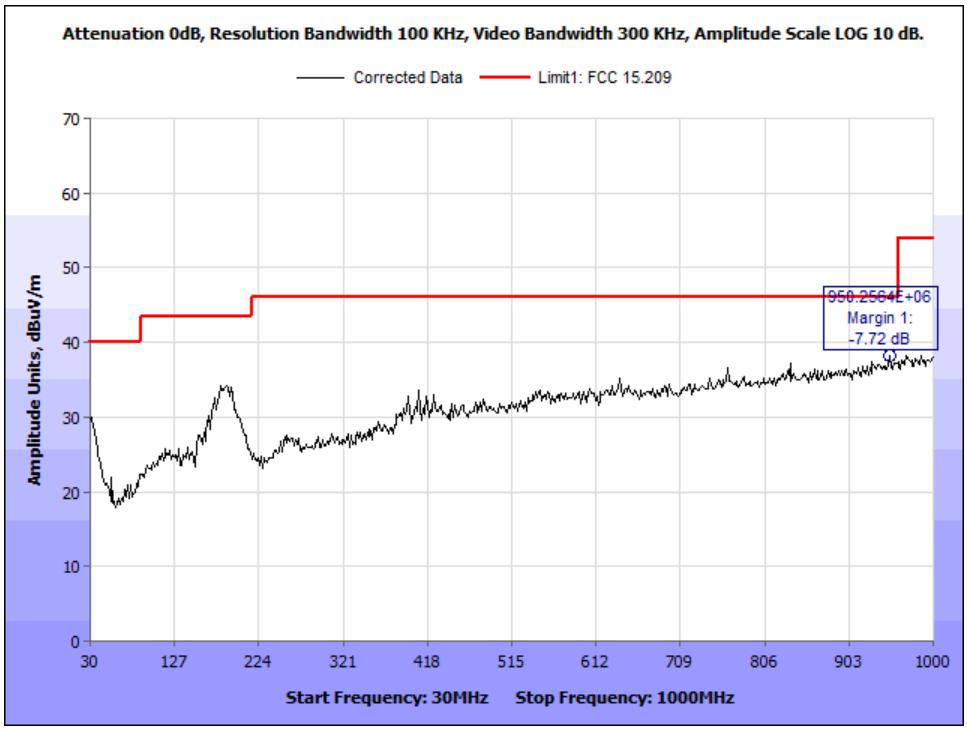

Figure 66: Radiated Spurious Emissions, 802.11b, 2437 MHz - 30MHz-1000MHz - Horizontal

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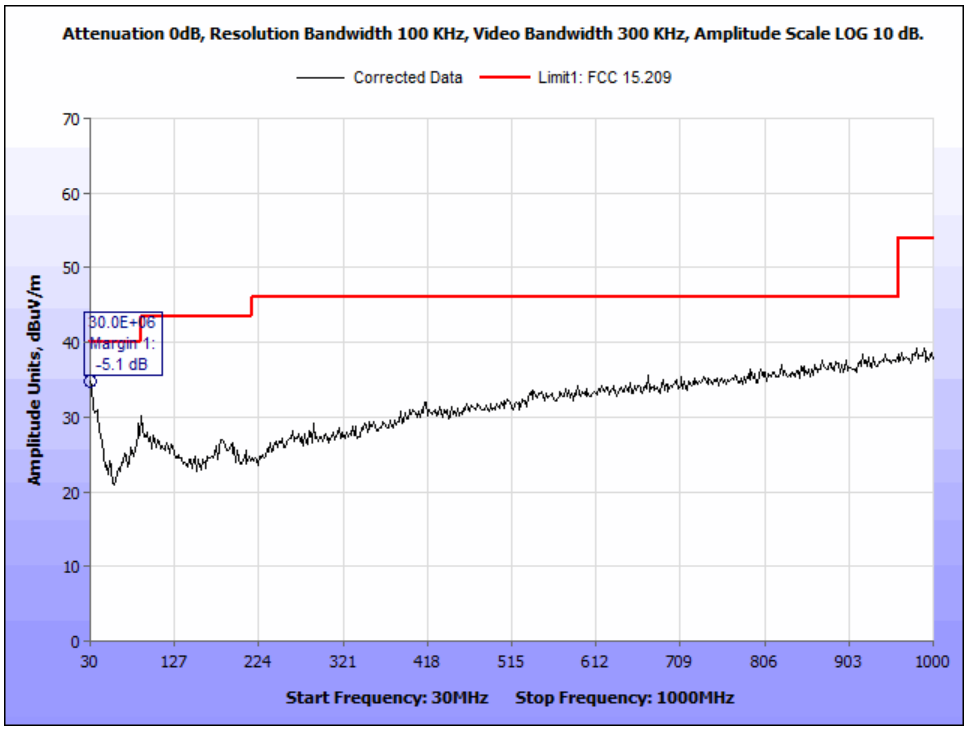

Figure 67: Radiated Spurious Emissions, 802.11b, 2437 MHz - 30MHz-1000MHz - Vertical

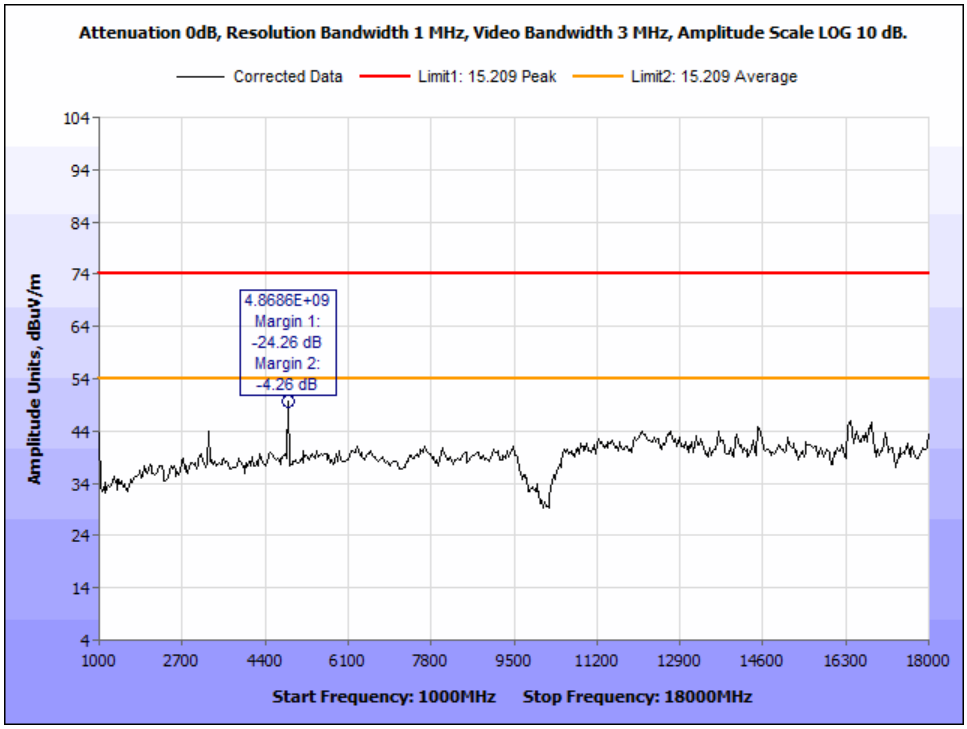

Figure 68: Radiated Spurious Emissions, 802.11b, 2437 MHz - 1GHz-18GHz - Peak - Horizontal

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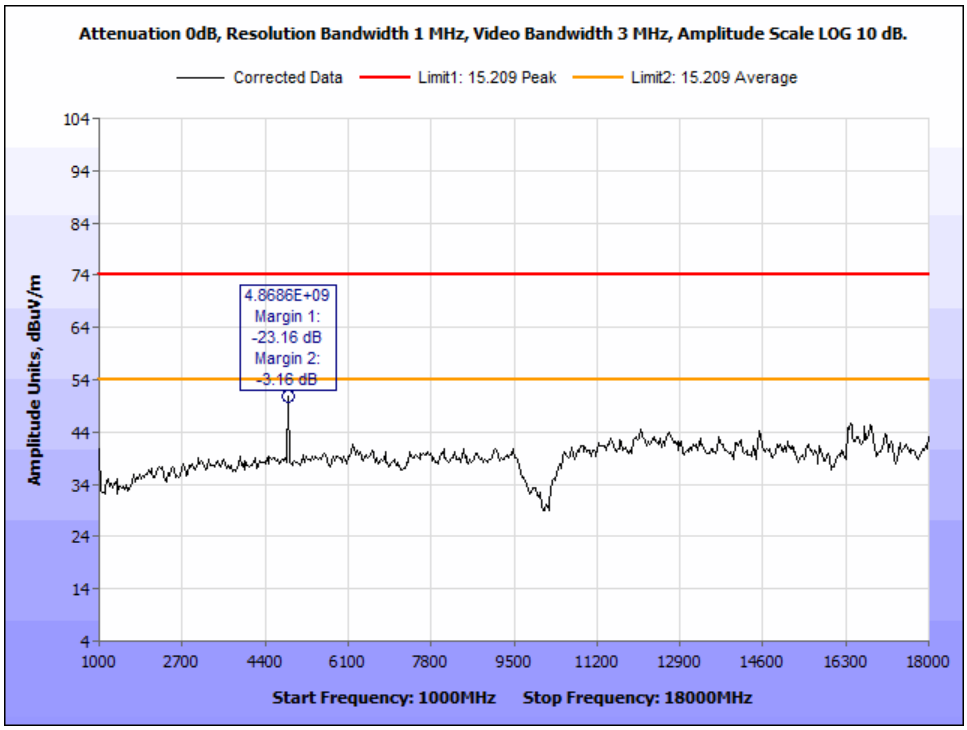

Figure 69: Radiated Spurious Emissions, 802.11b, 2437 MHz - 1GHz-18GHz - Peak – Vertical

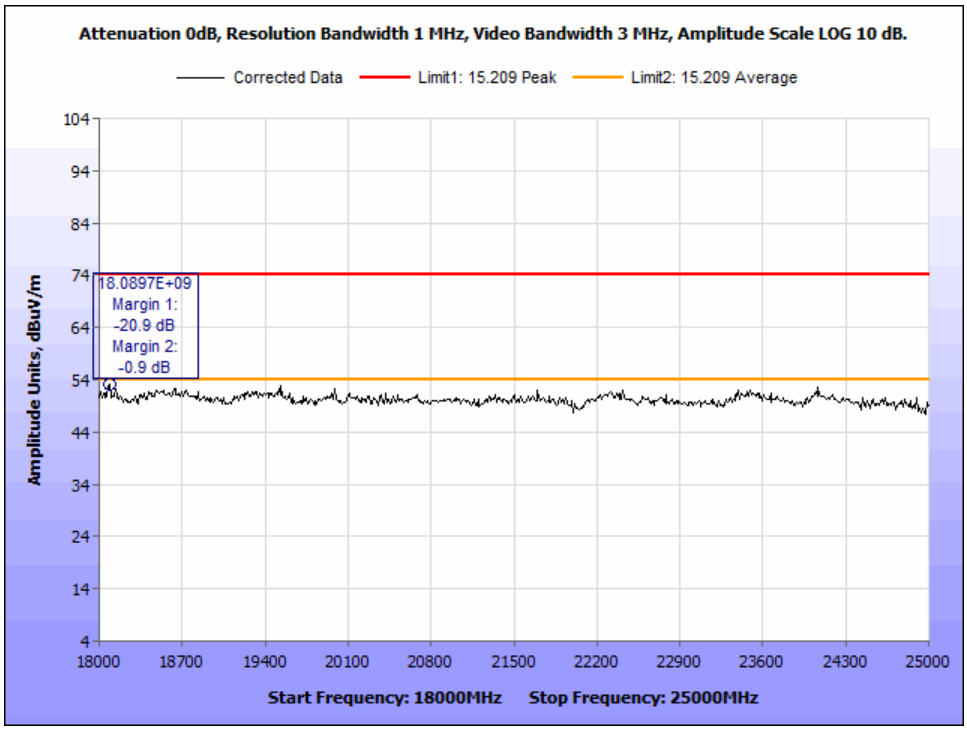

Figure 70: Radiated Spurious Emissions, 802.11b, 2437 MHz - 18-25GHz - Peak - Horizontal

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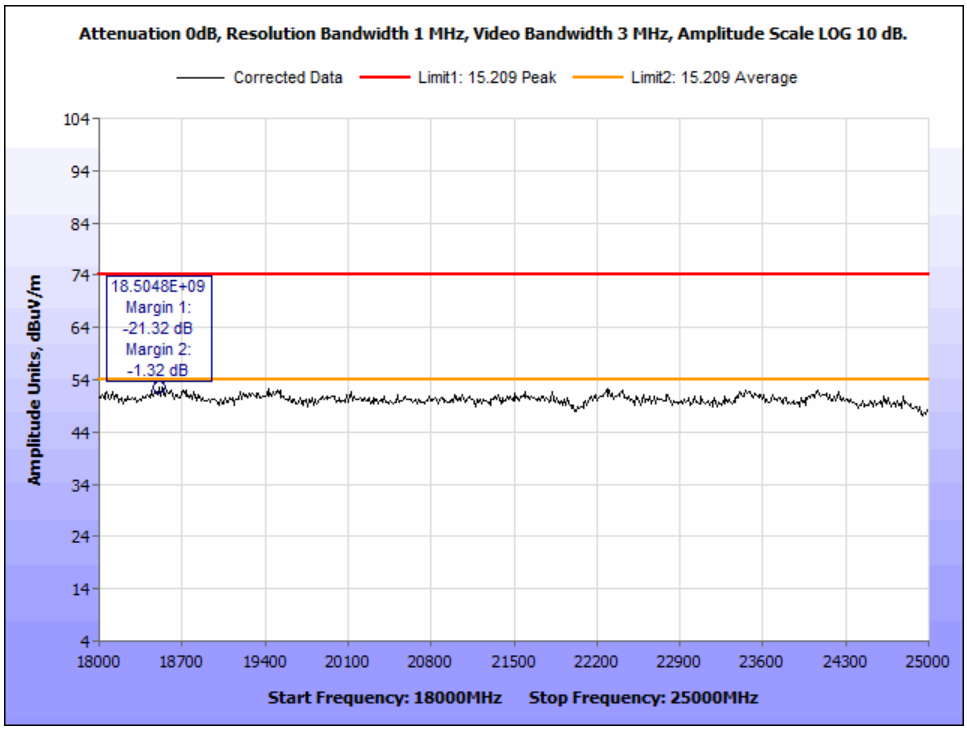

Figure 71: Radiated Spurious Emissions, 802.11b, 2437 MHz - 18-25GHz - Peak - Vertical

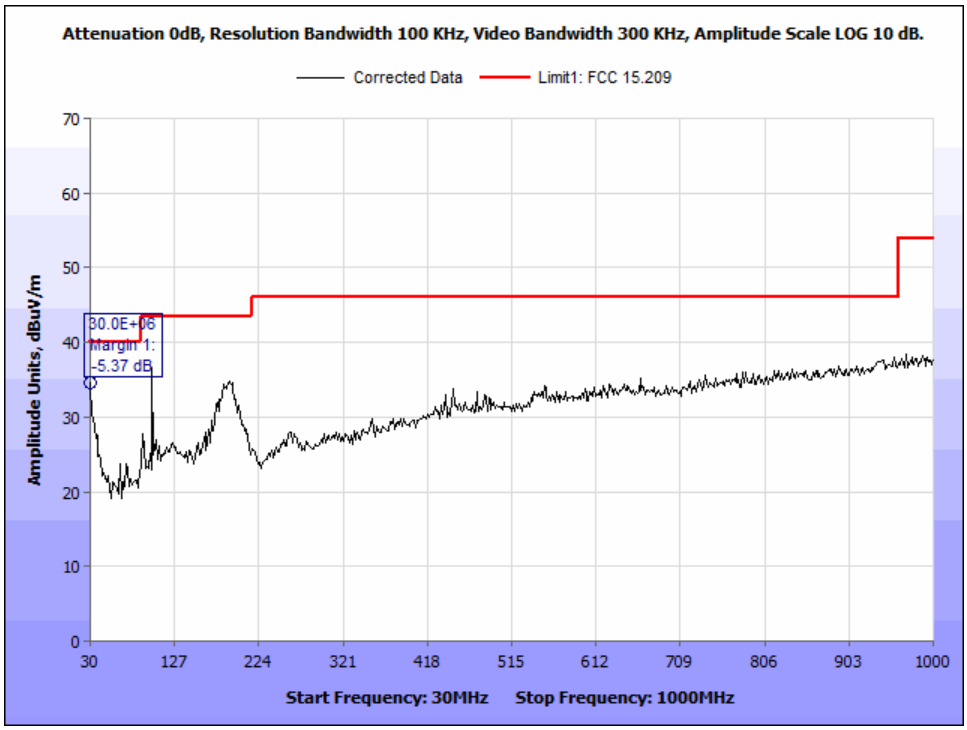

Figure 72: Radiated Spurious Emissions, 802.11b, 2462 MHz - 30MHz-1000MHz - Horizontal

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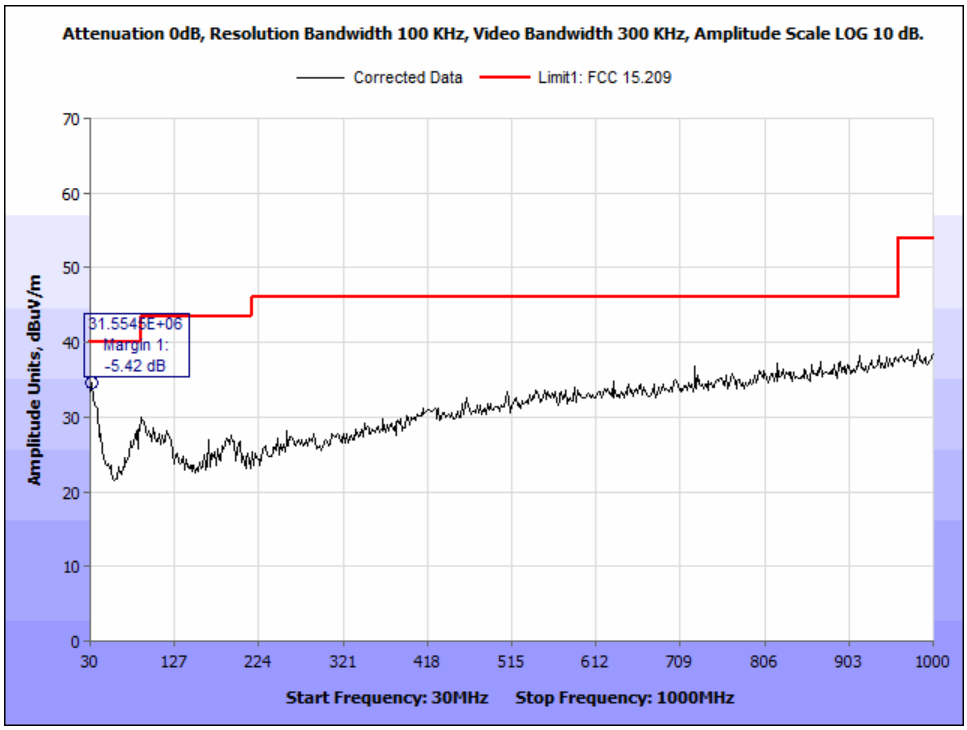

Figure 73: Radiated Spurious Emissions, 802.11b, 2462 MHz - 30MHz-1000MHz - Vertical

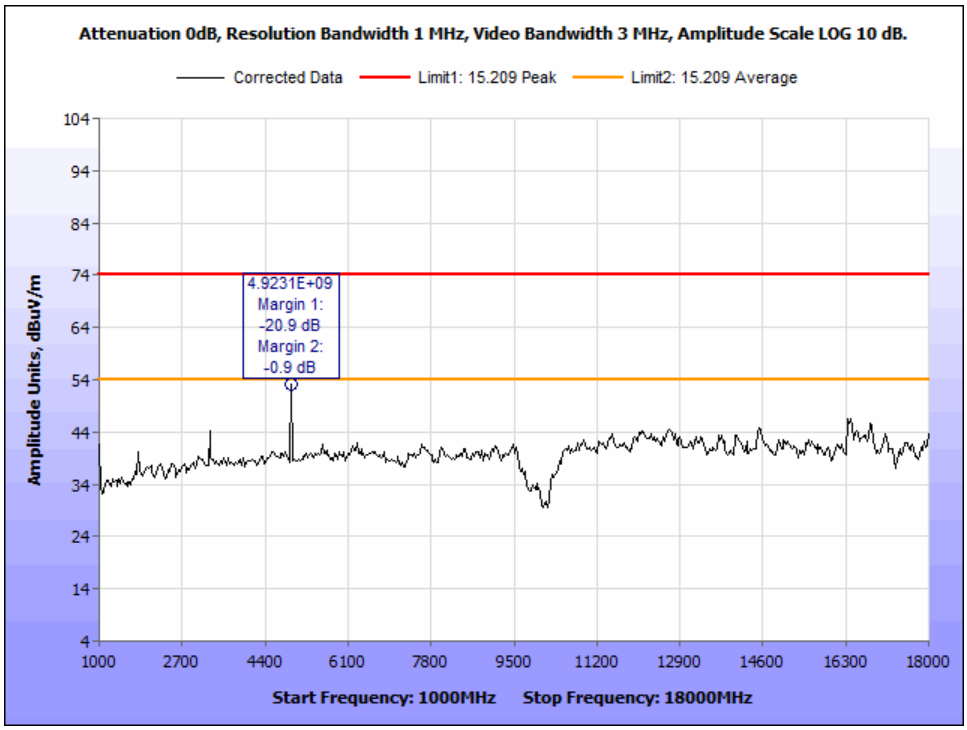

Figure 74: Radiated Spurious Emissions, 802.11b, 2462 MHz - 1GHz-18GHz - Peak - Horizontal

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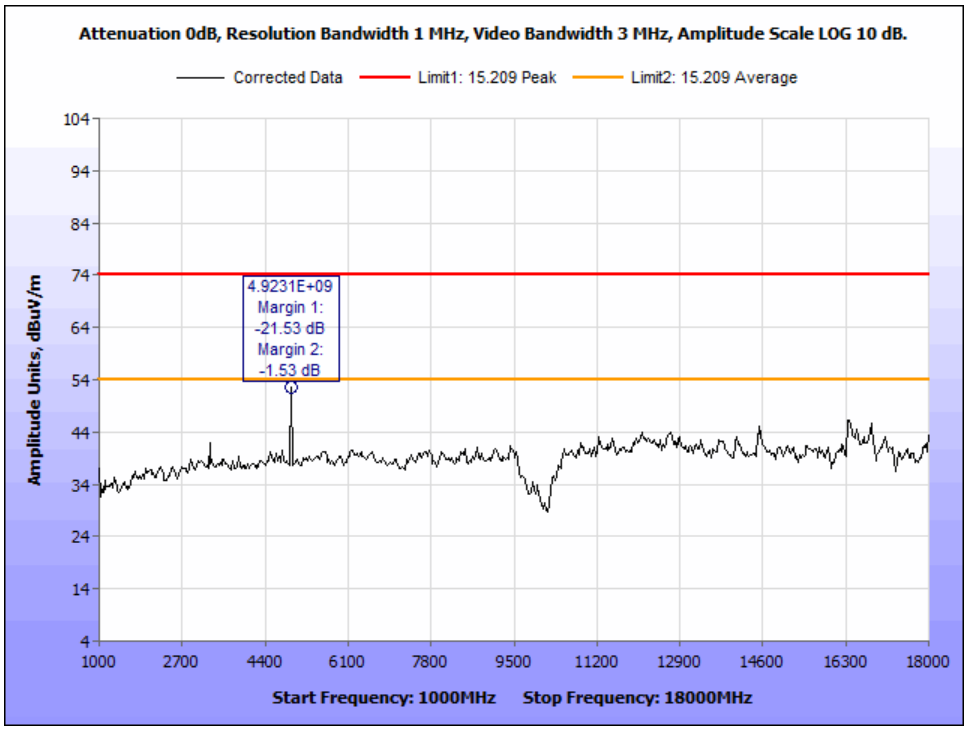

Figure 75: Radiated Spurious Emissions, 802.11b, 2462 MHz - 1GHz-18GHz - Peak - Vertical

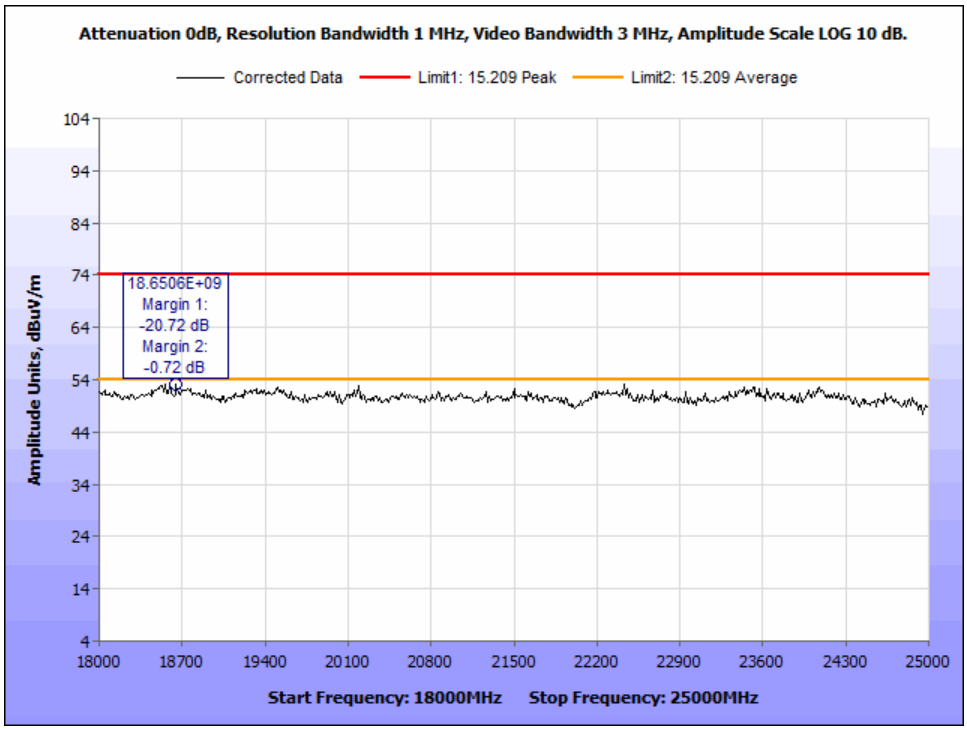

Figure 76: Radiated Spurious Emissions, 802.11b, 2462 MHz - 18-25GHz - Peak - Horizontal

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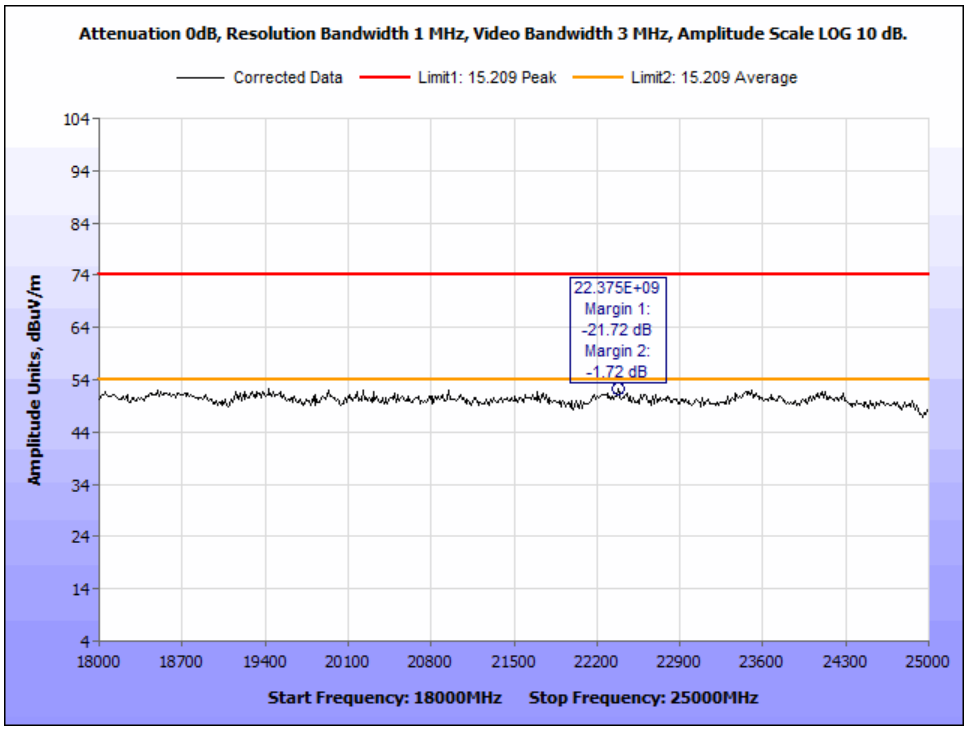

Figure 77: Radiated Spurious Emissions, 802.11b, 2462 MHz - 18-25GHz - Peak – Vertical

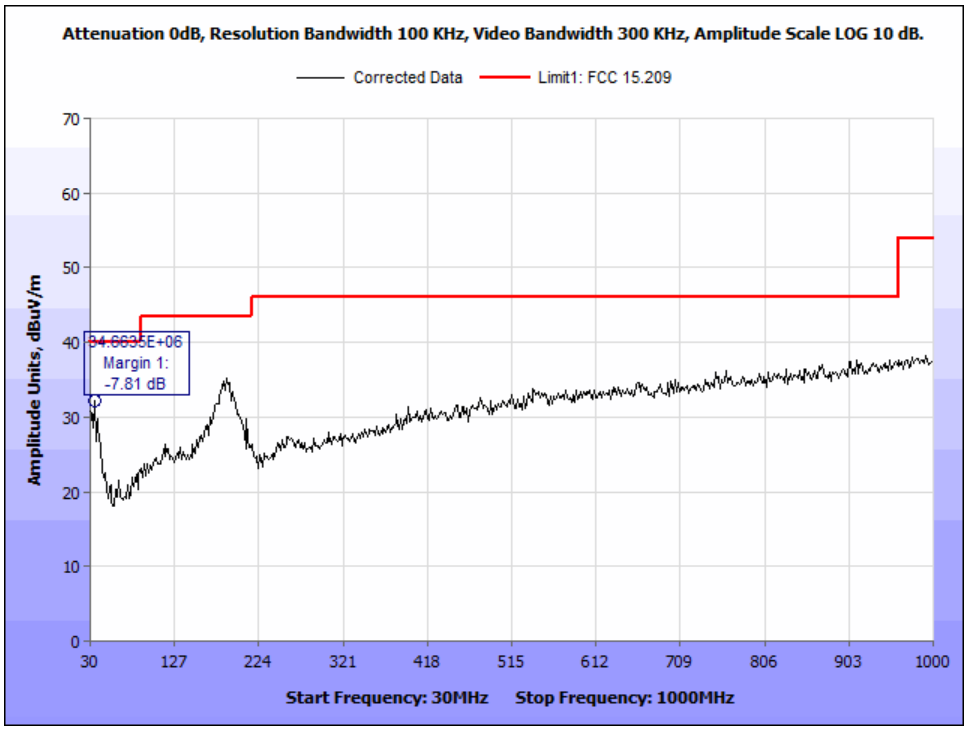

Figure 78: Radiated Spurious Emissions, 802.11g, 2412 MHz - 30MHz-1000MHz - Horizontal

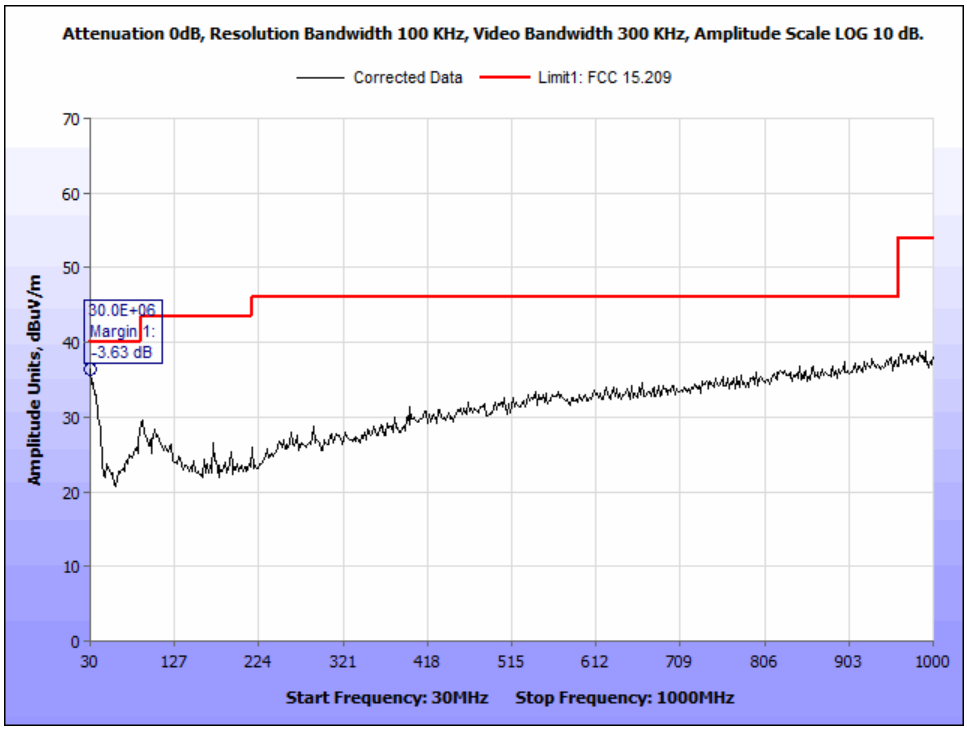

Figure 79: Radiated Spurious Emissions, 802.11g, 2412 MHz - 30MHz-1000MHz - Vertical

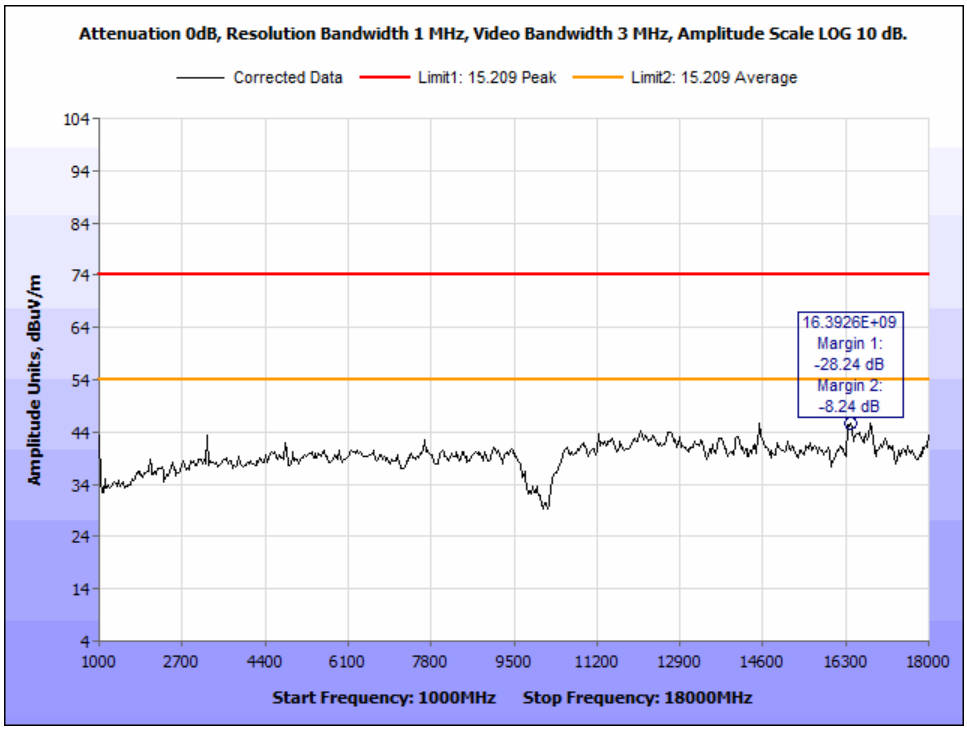

Figure 80: Radiated Spurious Emissions, 802.11g, 2412 MHz - 1GHz-18GHz - Peak - Horizontal

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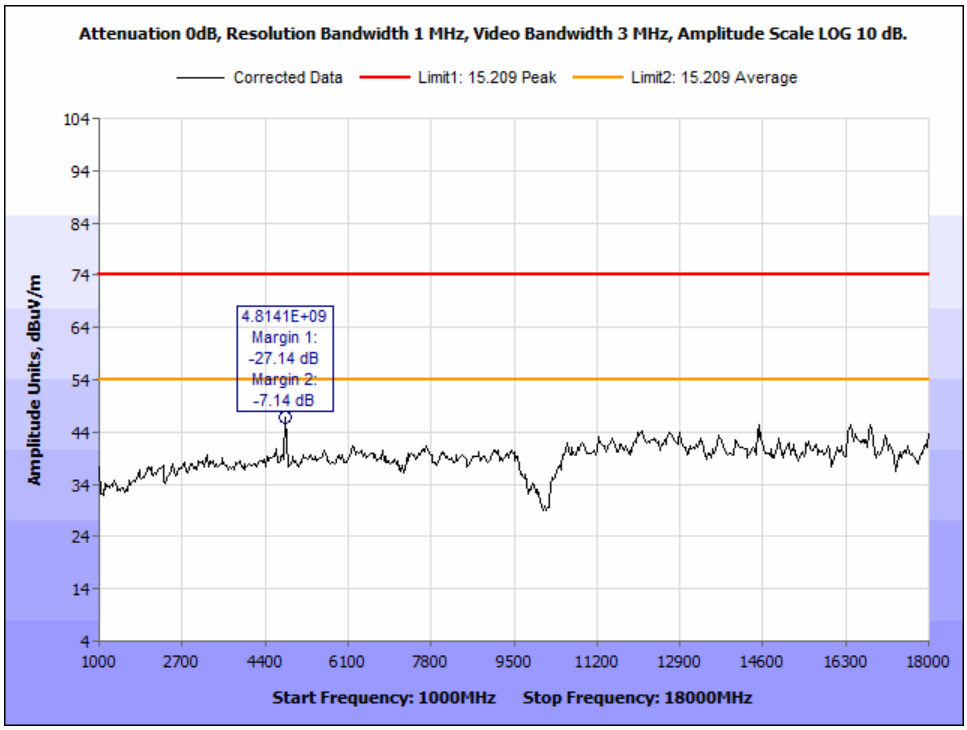

Figure 81: Radiated Spurious Emissions, 802.11g, 2412 MHz - 1GHz-18GHz - Peak – Vertical

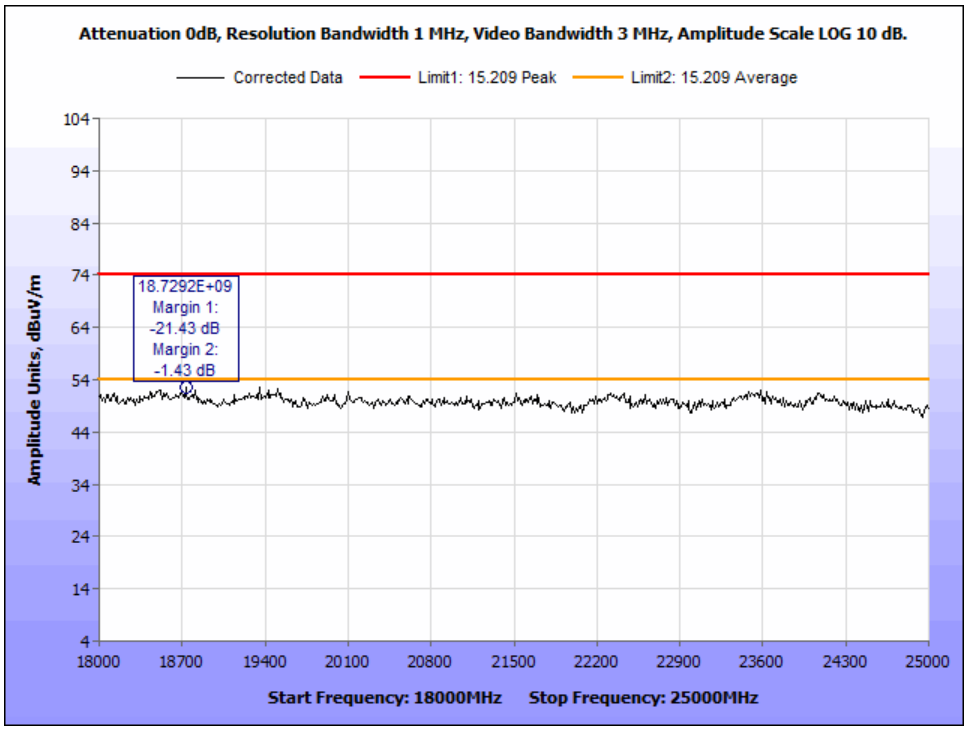

Figure 82: Radiated Spurious Emissions, 802.11g, 412 MHz - 18-25GHz - Peak - Horizontal

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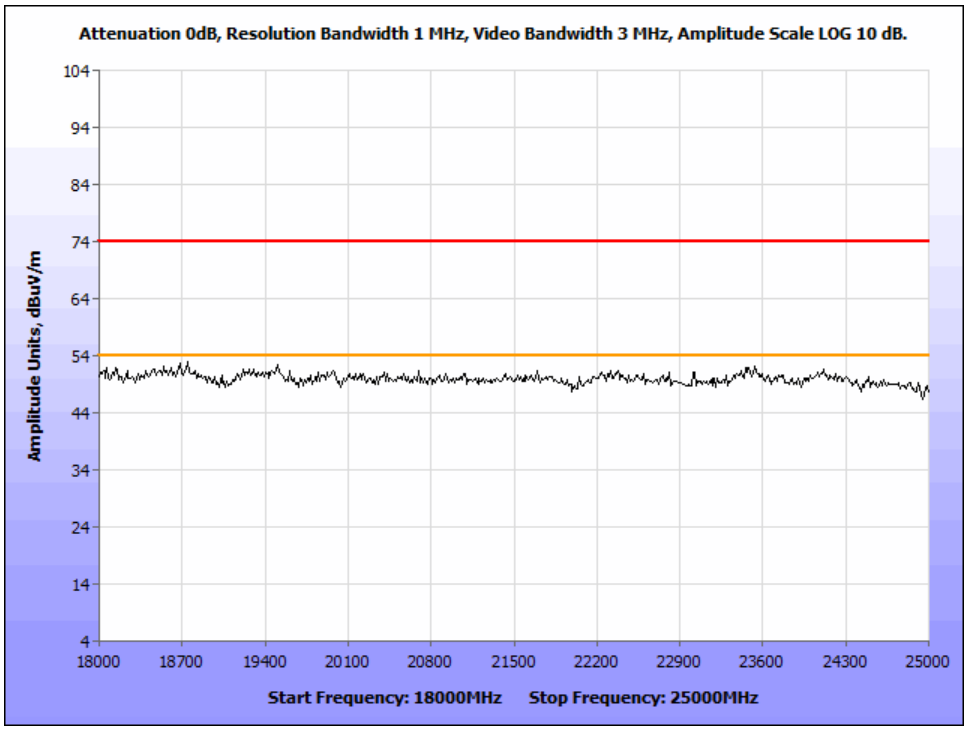

Figure 83: Radiated Spurious Emissions, 802.11g, 2412 MHz - 18-25GHz - Peak - Vertical

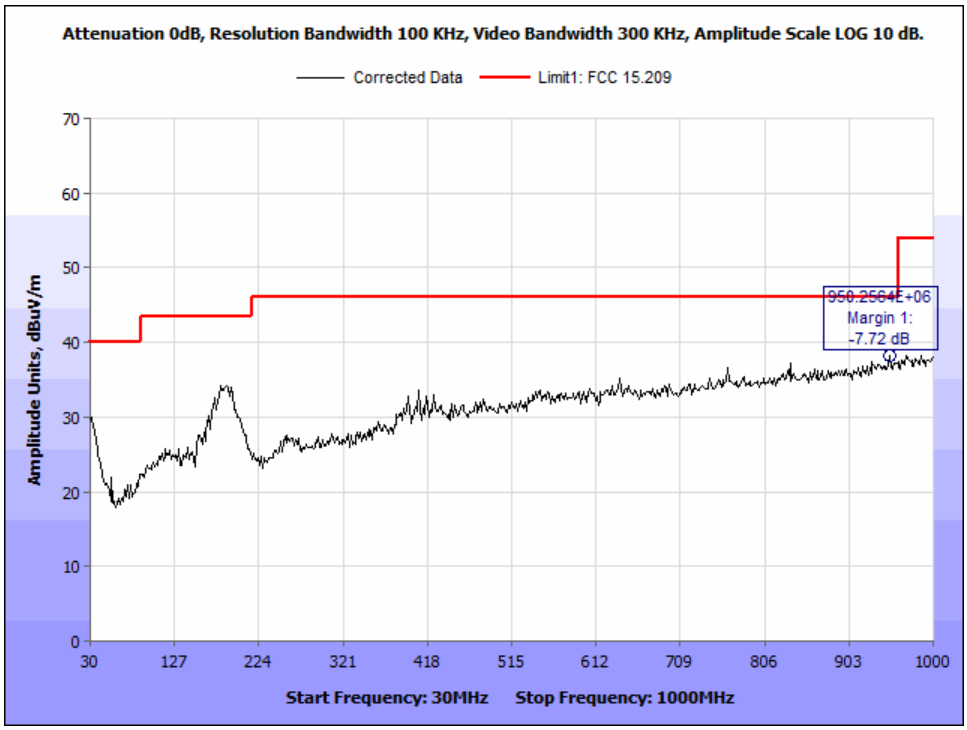

Figure 84: Radiated Spurious Emissions, 802.11g, 2437 MHz - 30MHz-1000MHz - Horizontal

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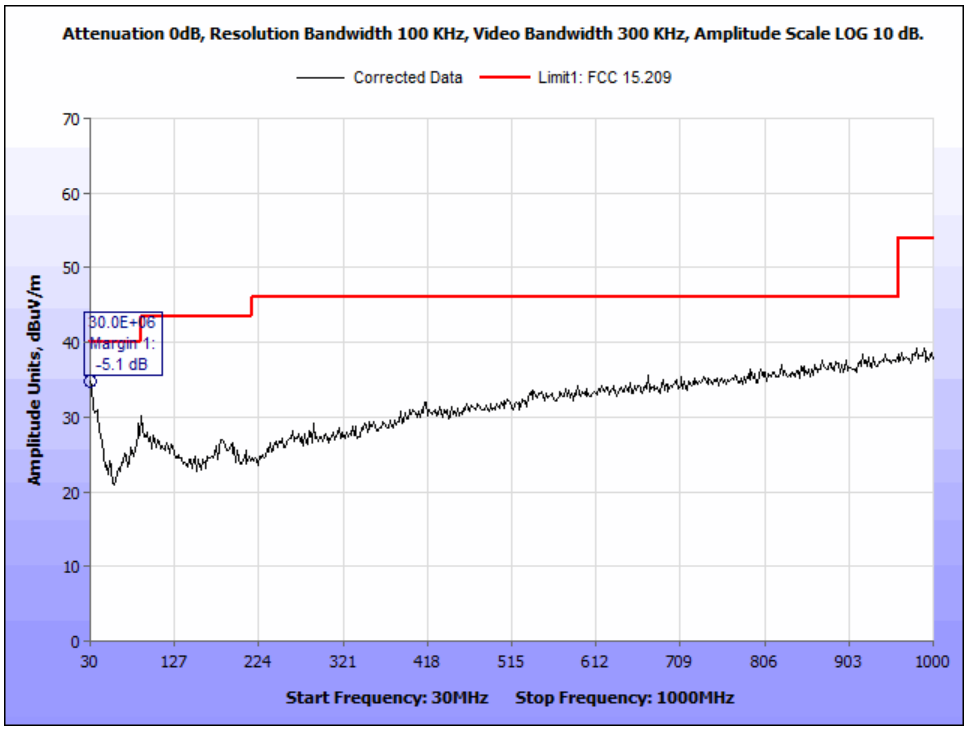

Figure 85: Radiated Spurious Emissions, 802.11g, 2437 MHz - 30MHz-1000MHz - Vertical

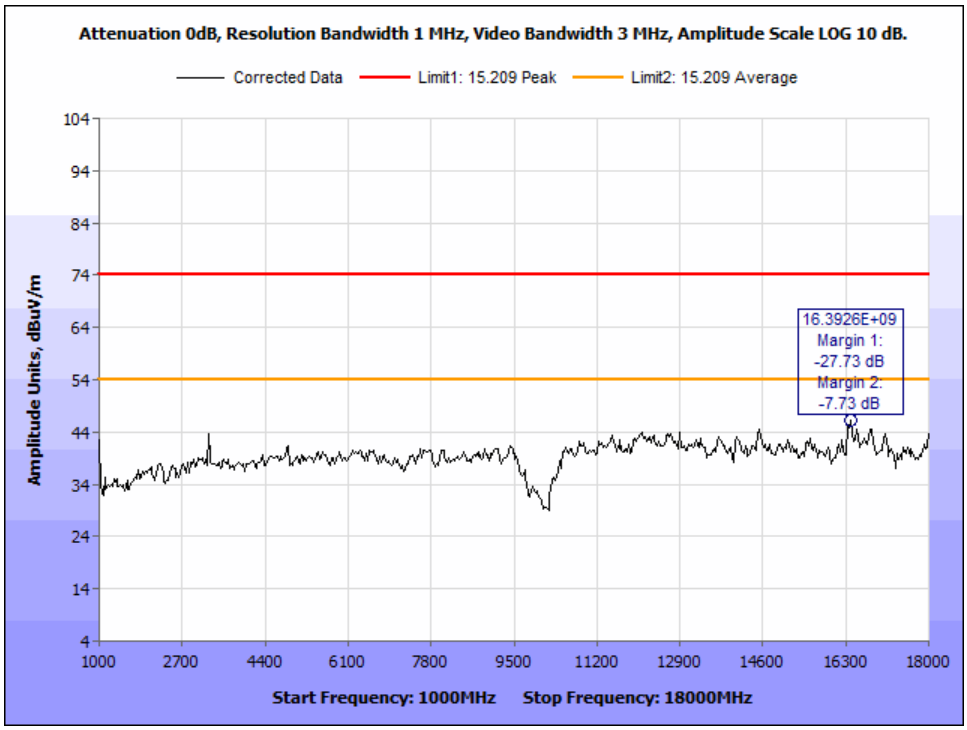

Figure 86: Radiated Spurious Emissions, 802.11g, 2437 MHz - 1GHz-18GHz - Peak - Horizontal

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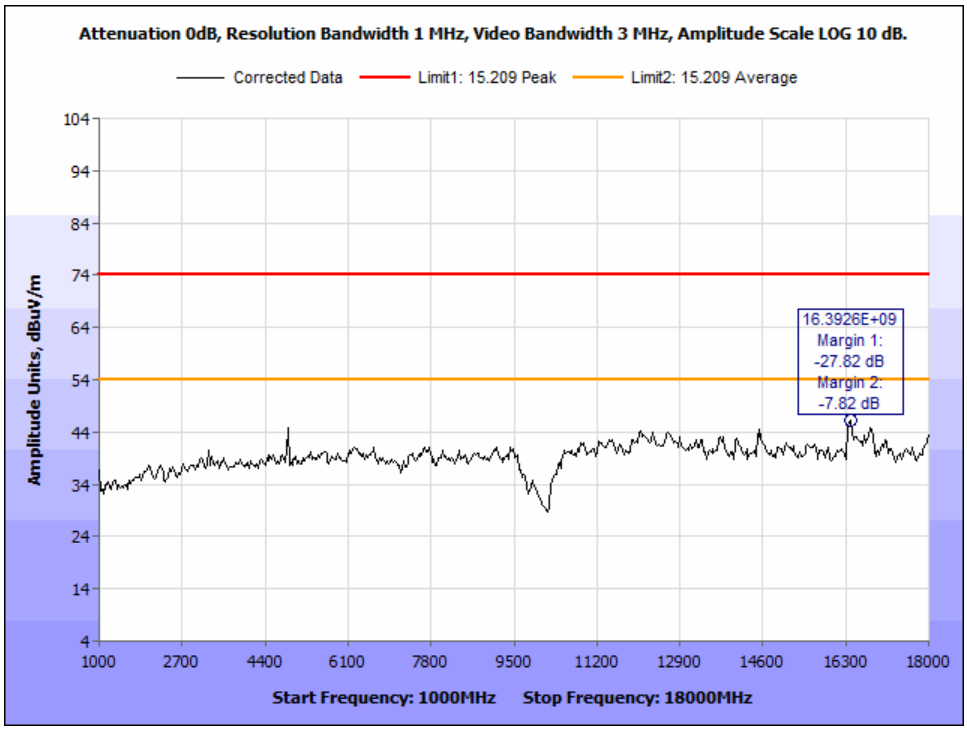

Figure 87: Radiated Spurious Emissions, 802.11g, 2437 MHz - 1GHz-18GHz - Peak – Vertical

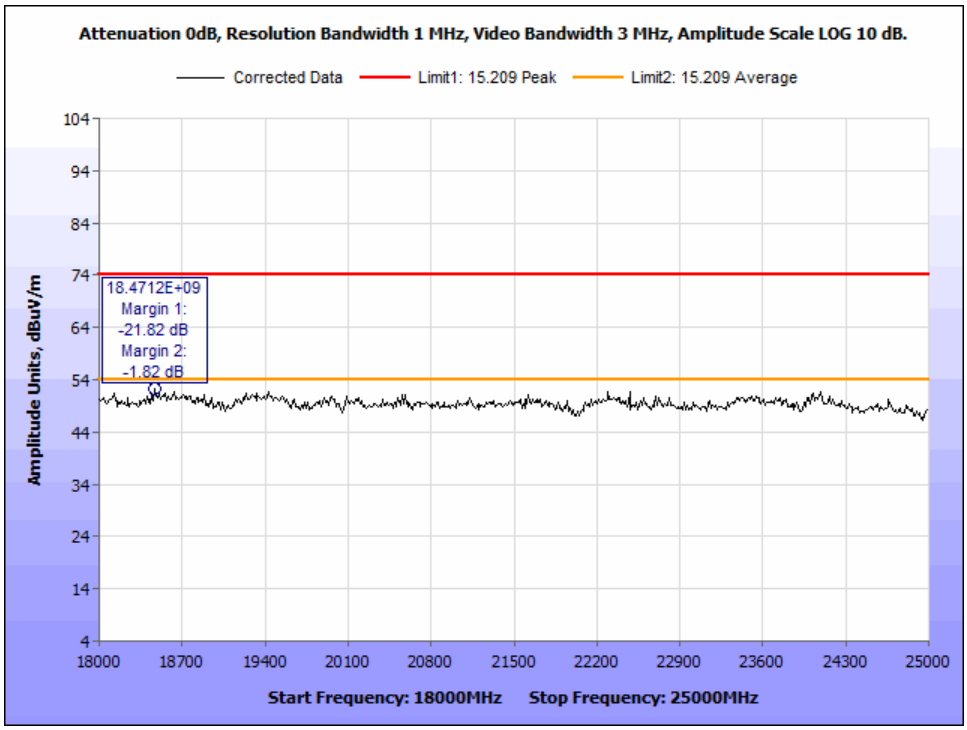

Figure 88: Radiated Spurious Emissions, 802.11g, 2437 MHz - 18-25GHz - Peak - Horizontal

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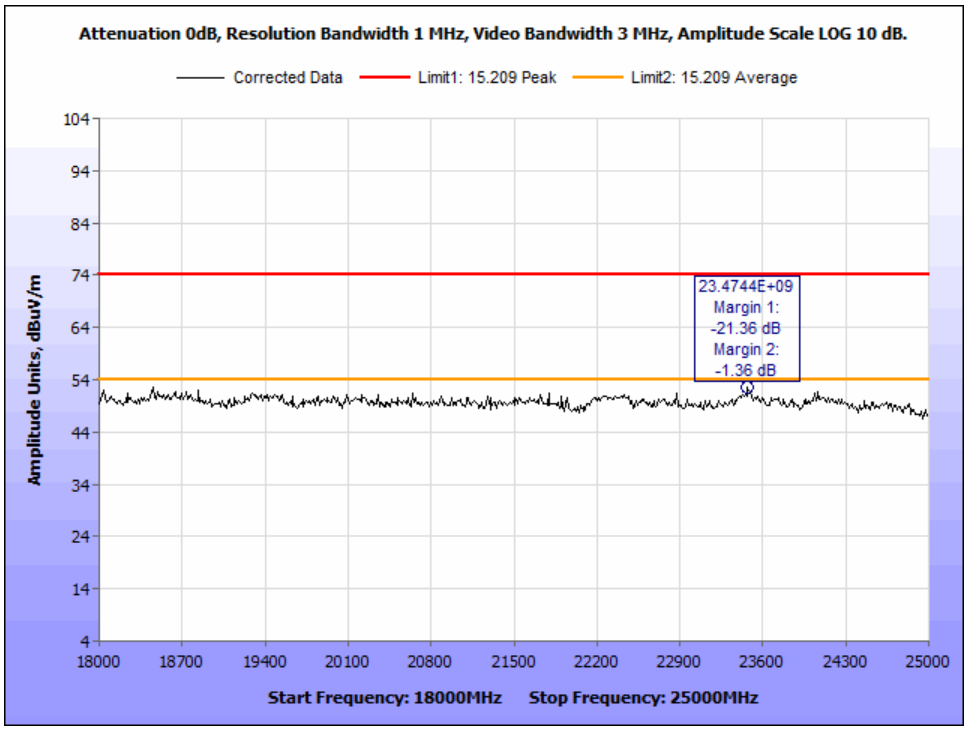

Figure 89: Radiated Spurious Emissions, 802.11g, 2437 MHz - 18-25GHz - Peak - Vertical

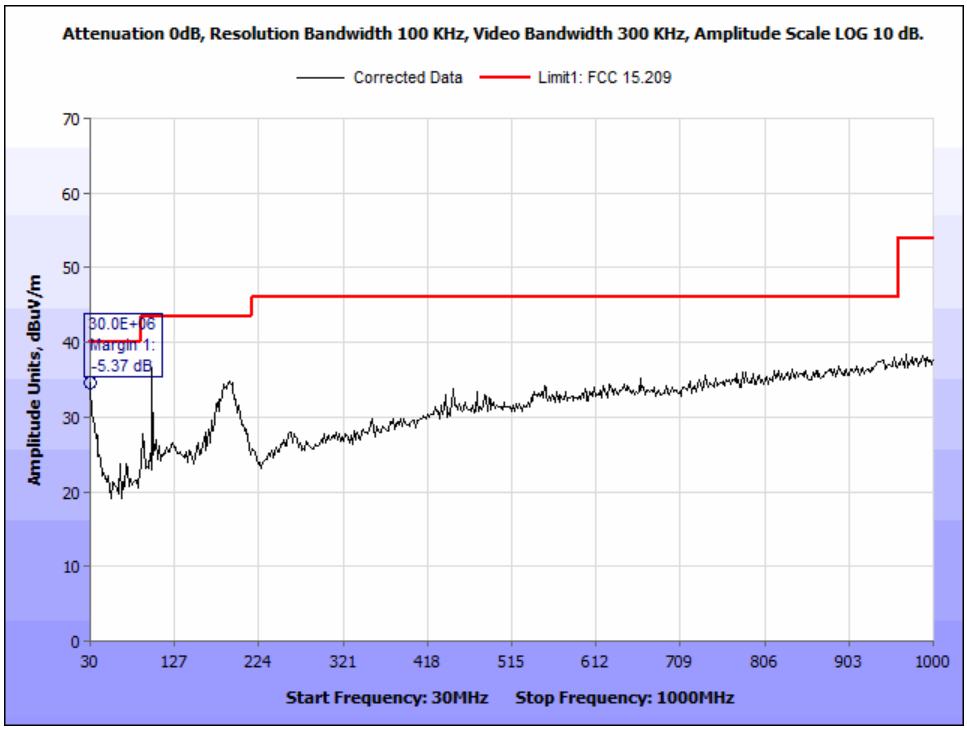

Figure 90: Radiated Spurious Emissions, 802.11g, 2462 MHz - 30MHz-1000MHz - Horizontal

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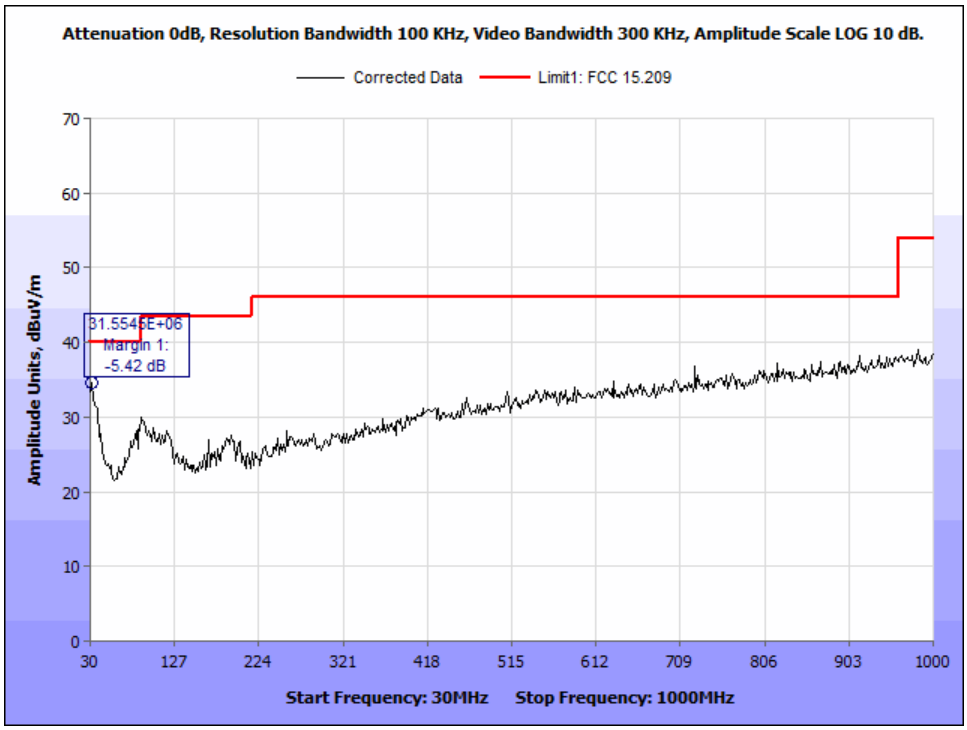

Figure 91: Radiated Spurious Emissions, 802.11g, 2462 MHz - 30MHz-1000MHz - Vertical

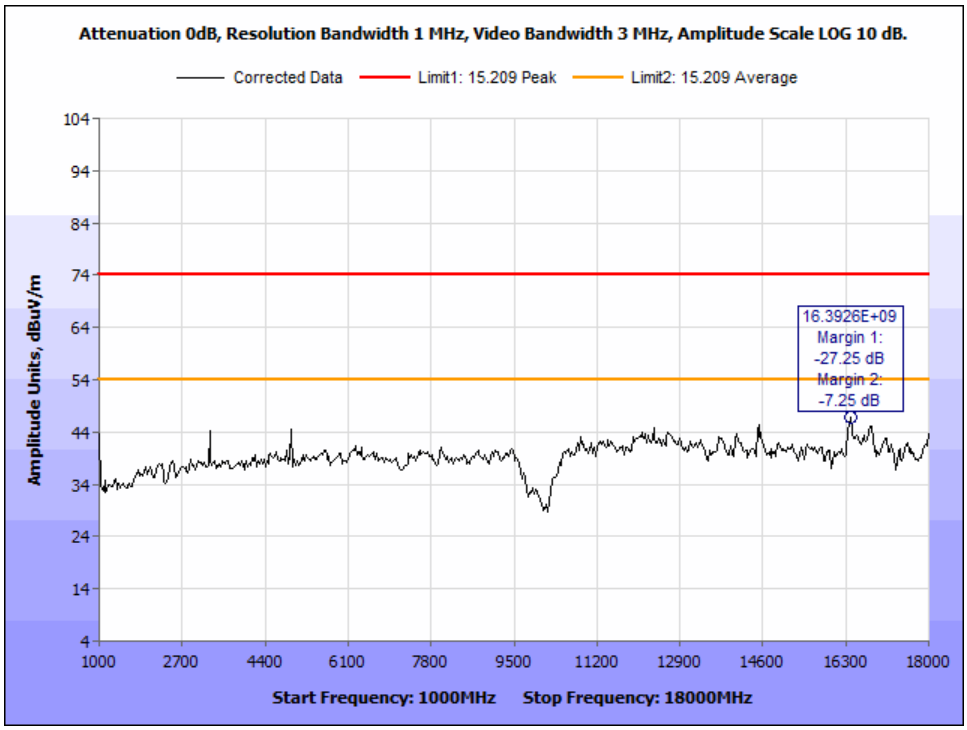

Figure 92: Radiated Spurious Emissions, 802.11g, 2462 MHz - 1GHz-18GHz - Peak - Horizontal

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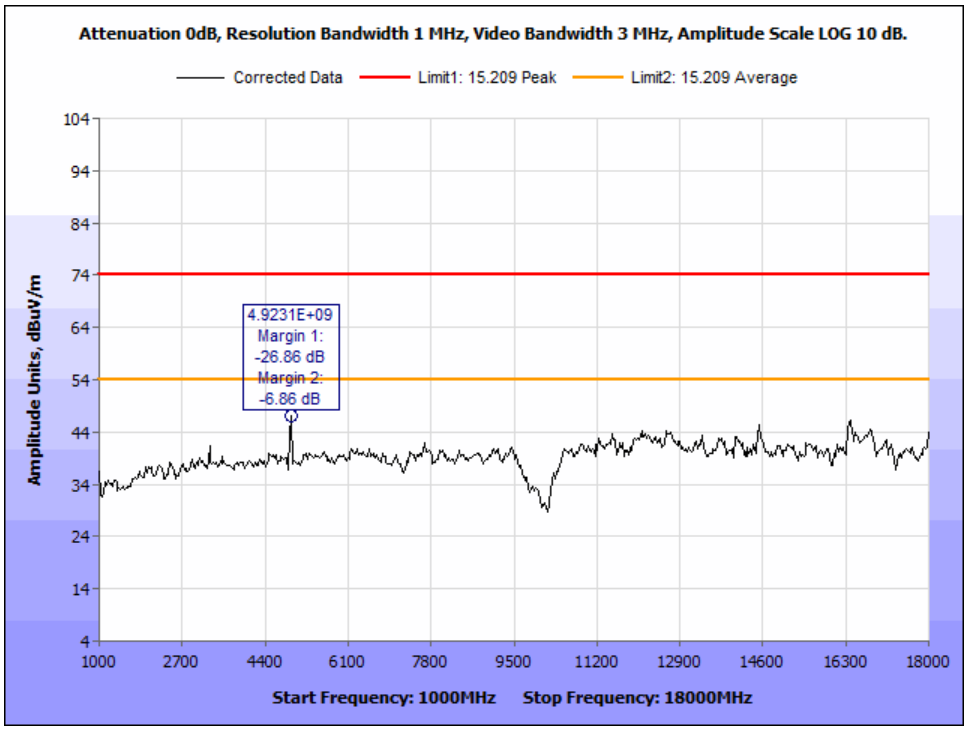

Figure 93: Radiated Spurious Emissions, 802.11g, 2462 MHz - 1GHz-18GHz - Peak - Vertical

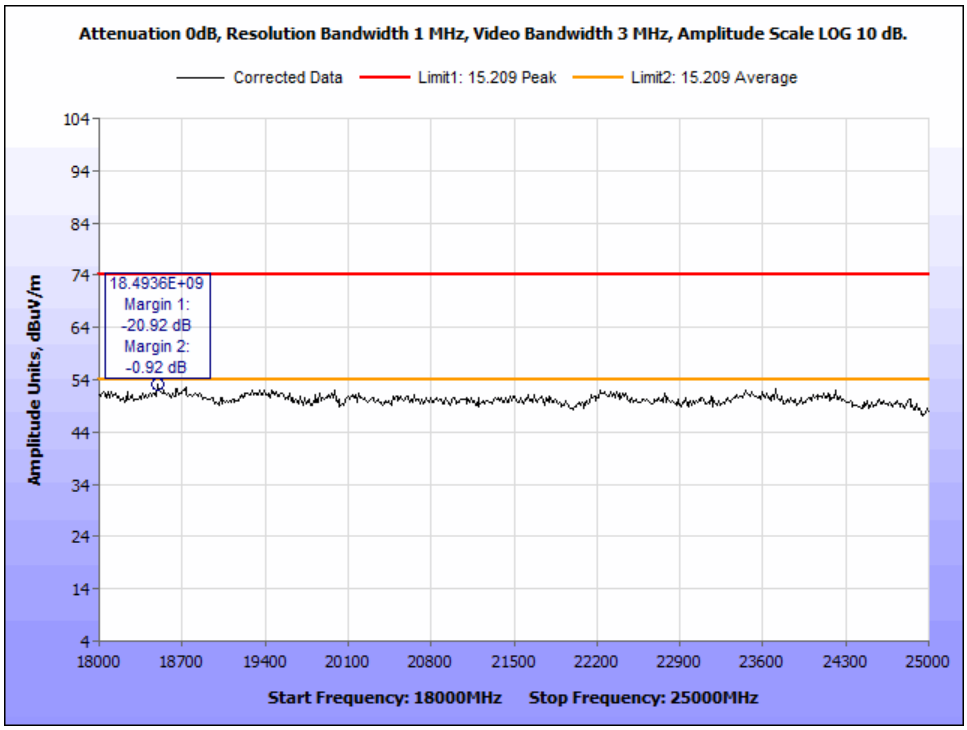

Figure 94: Radiated Spurious Emissions, 802.11g, 2462 MHz - 18-25GHz - Peak - Horizontal

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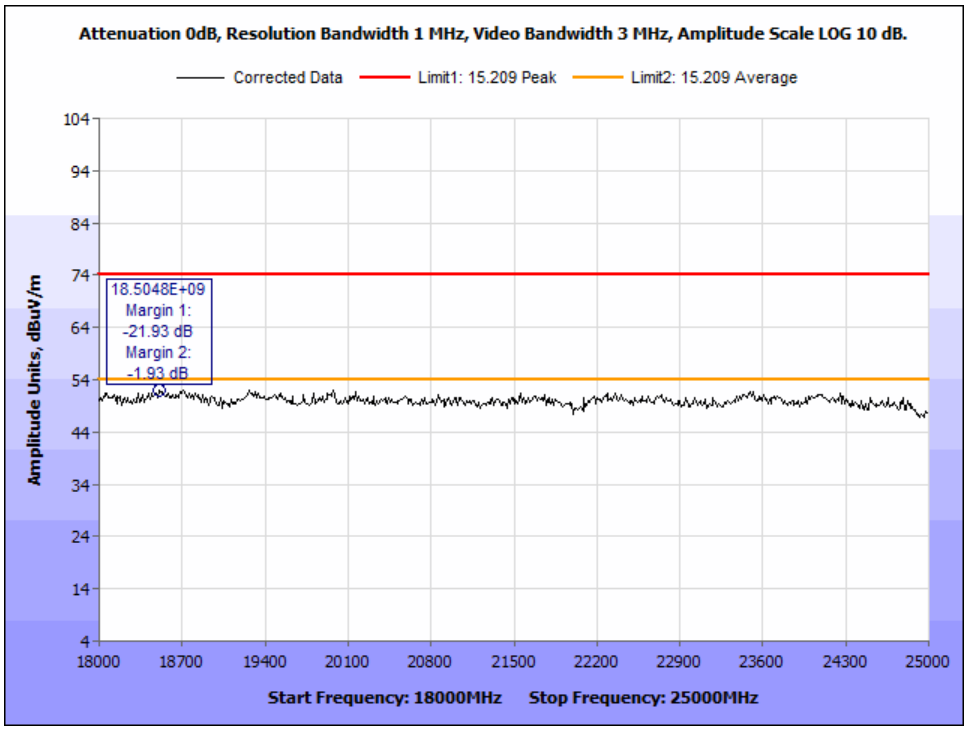

Figure 95: Radiated Spurious Emissions, 802.11g, 2462 MHz - 18-25GHz - Peak – Vertical

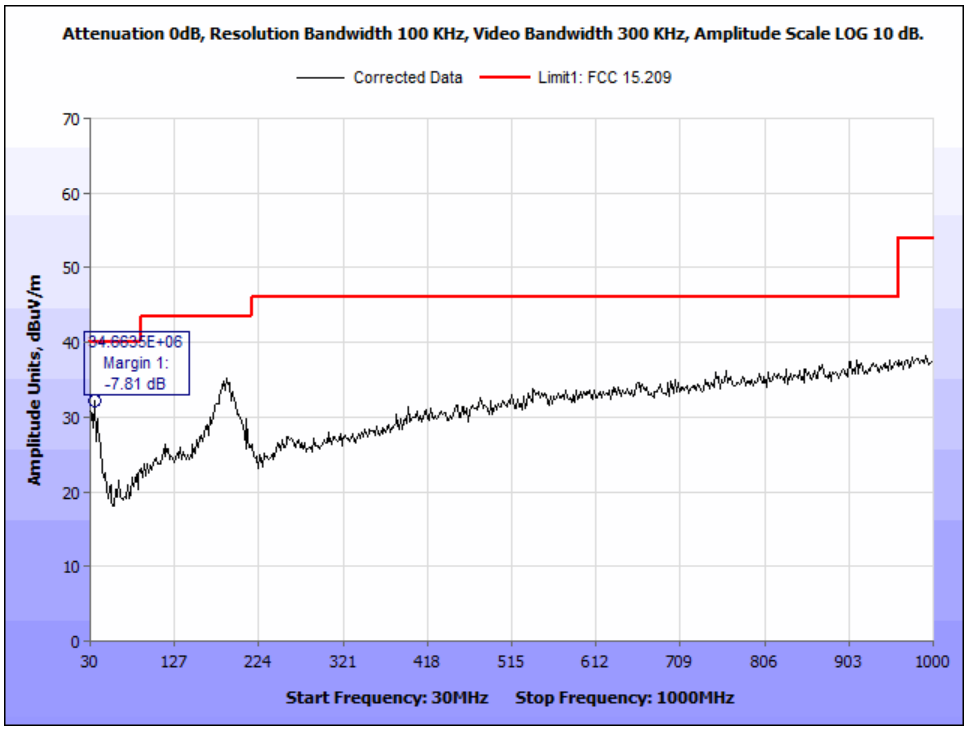

Figure 96: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 30MHz-1000MHz - Horizontal

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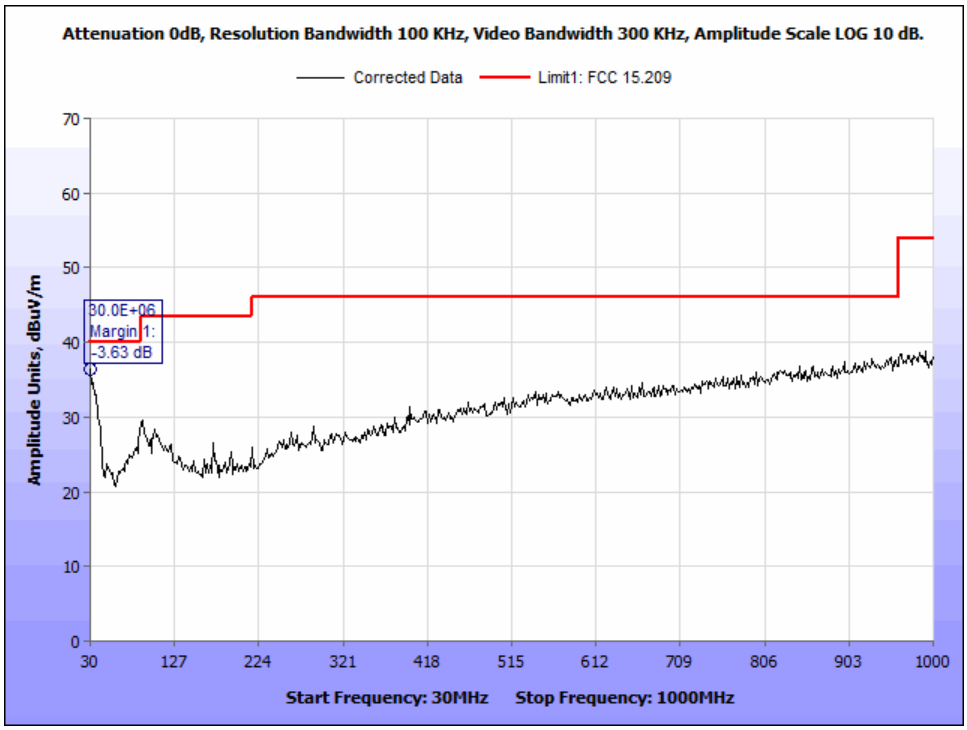

Figure 97: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 30MHz-1000MHz - Vertical

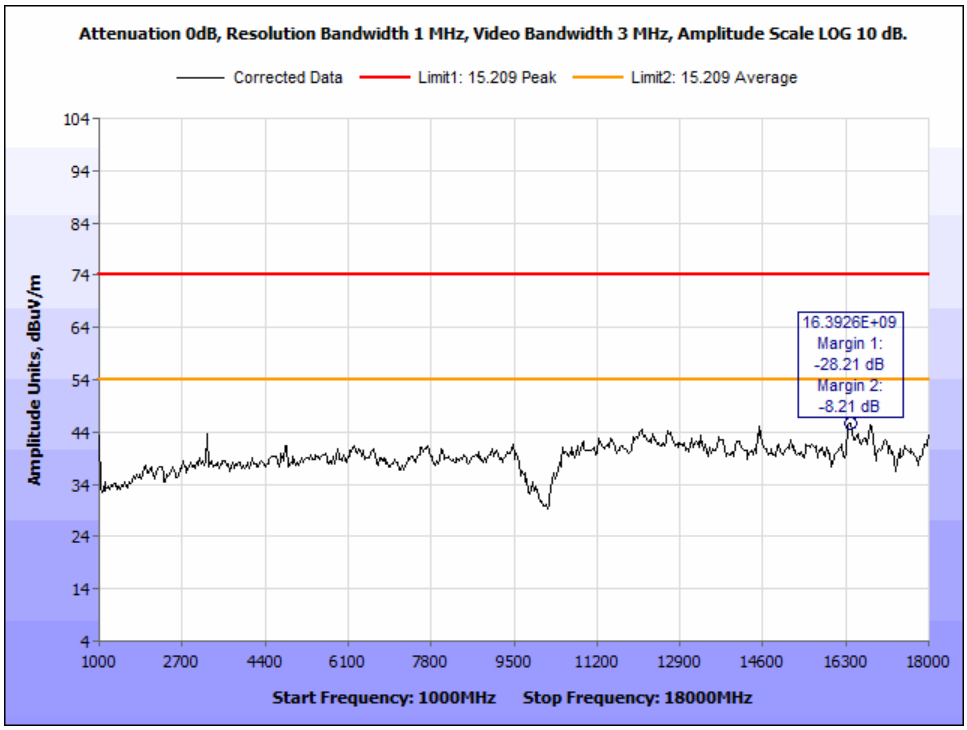

Figure 98: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 1GHz-18GHz - Peak - Horizontal

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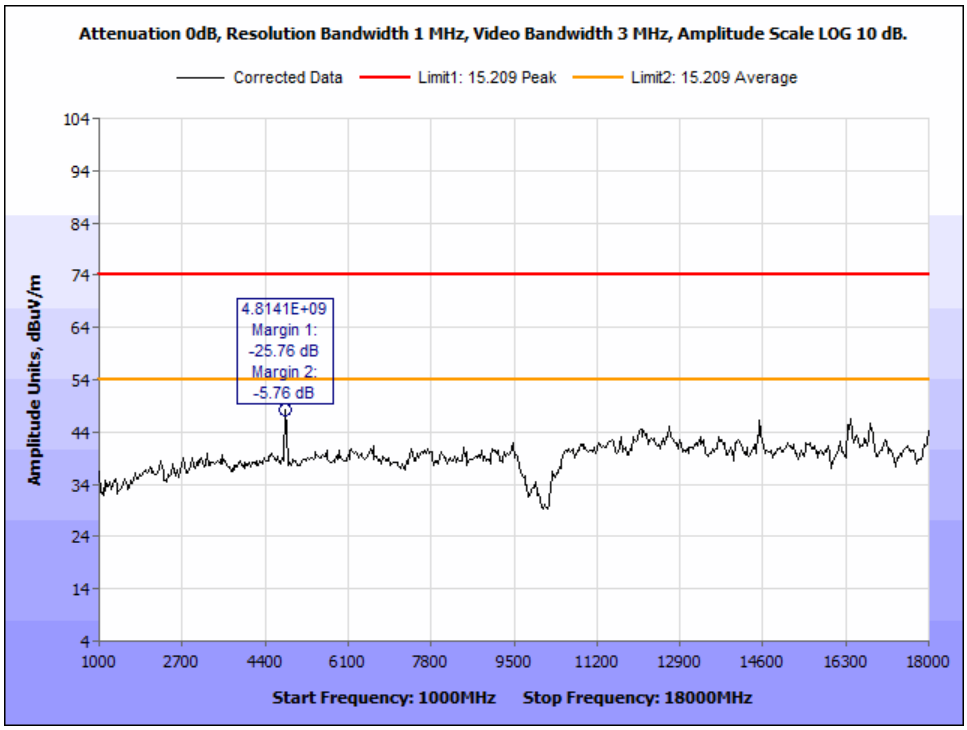

Figure 99: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 1GHz-18GHz - Peak – Vertical

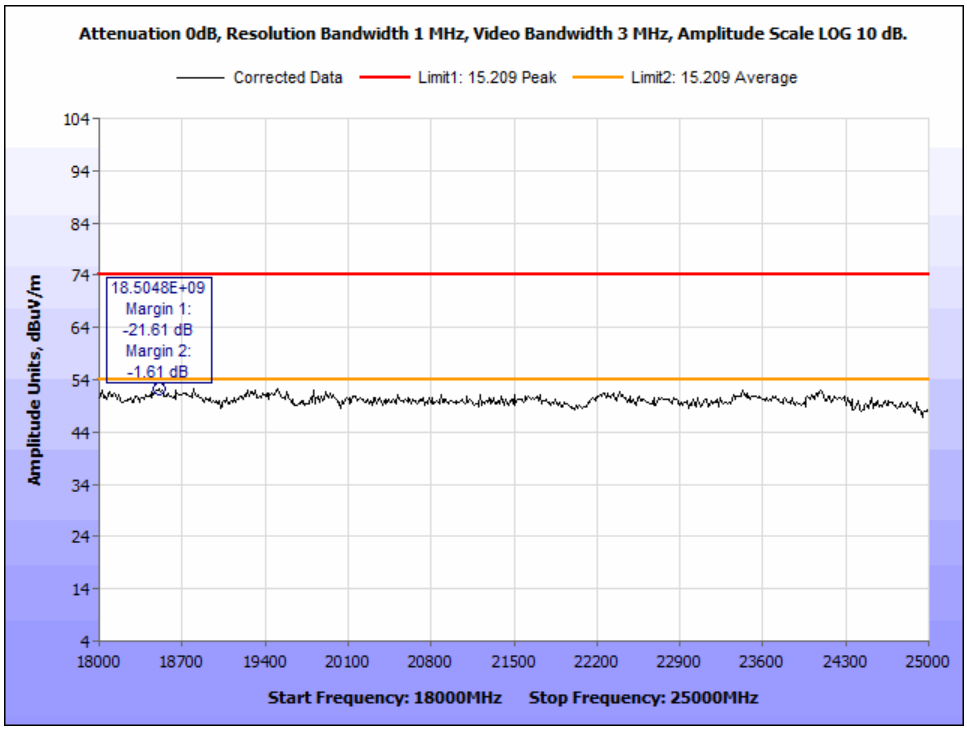

Figure 100: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 18-25GHz - Peak - Horizontal

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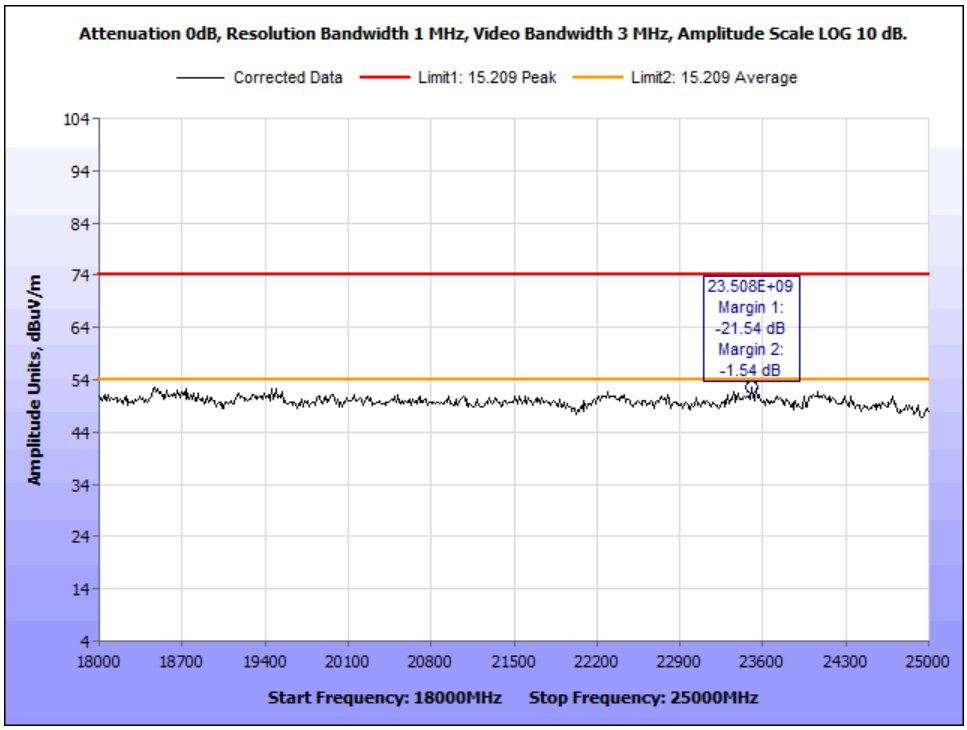

Figure 101: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 18-25GHz - Peak - Vertical

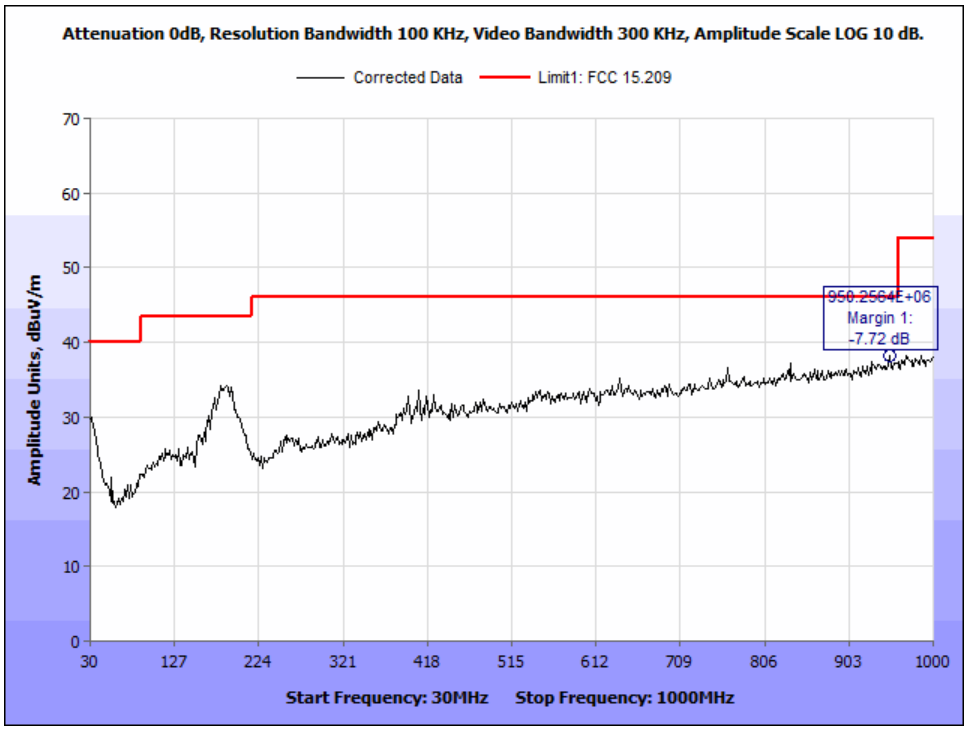

Figure 102: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 30MHz-1000MHz - Horizontal

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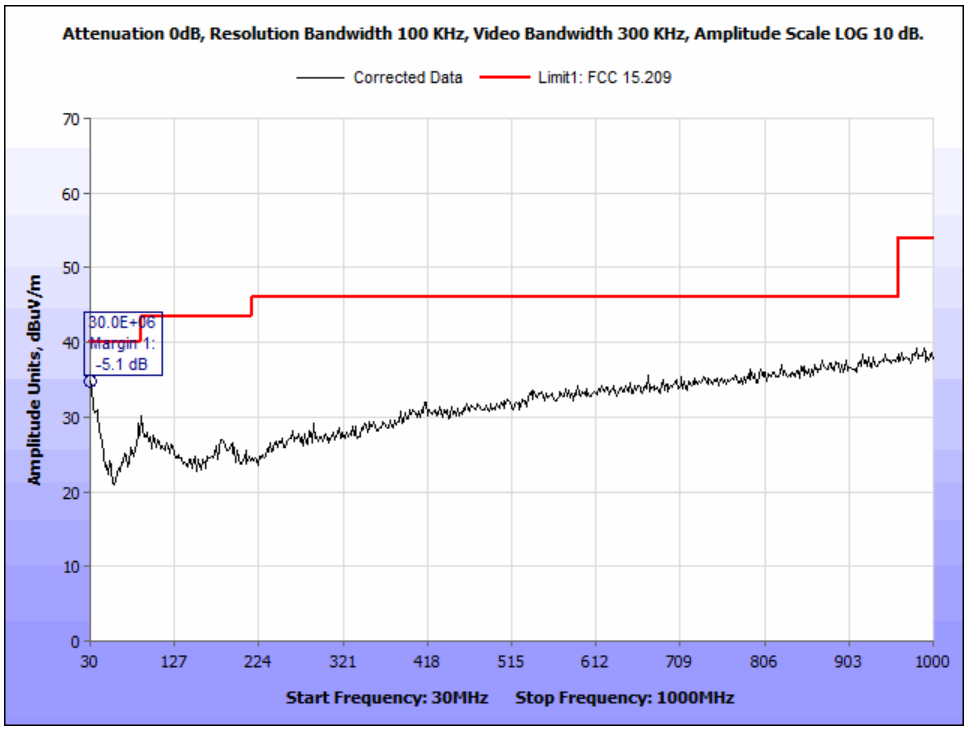

Figure 103: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 30MHz-1000MHz - Vertical

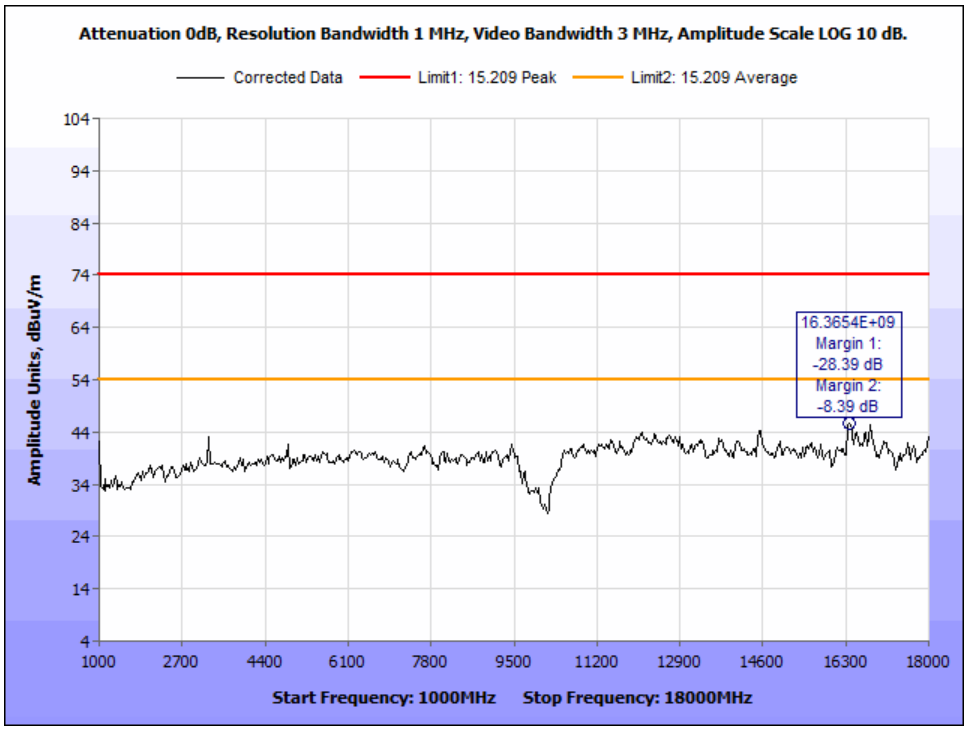

Figure 104: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 1GHz-18GHz - Peak - Horizontal

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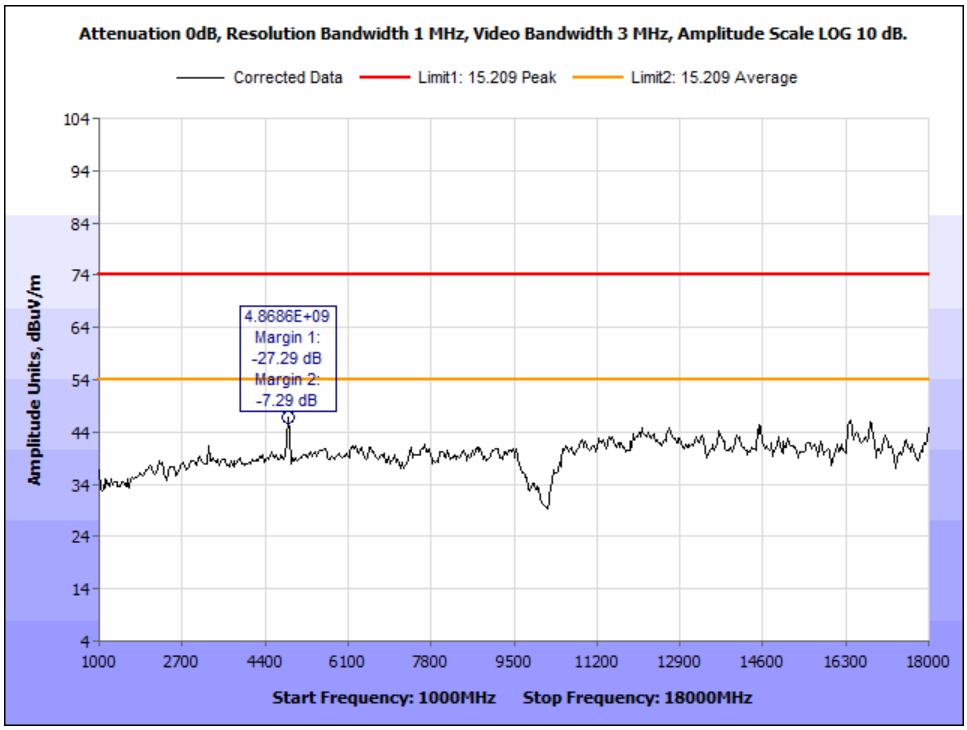

Figure 105: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 1GHz-18GHz - Peak – Vertical

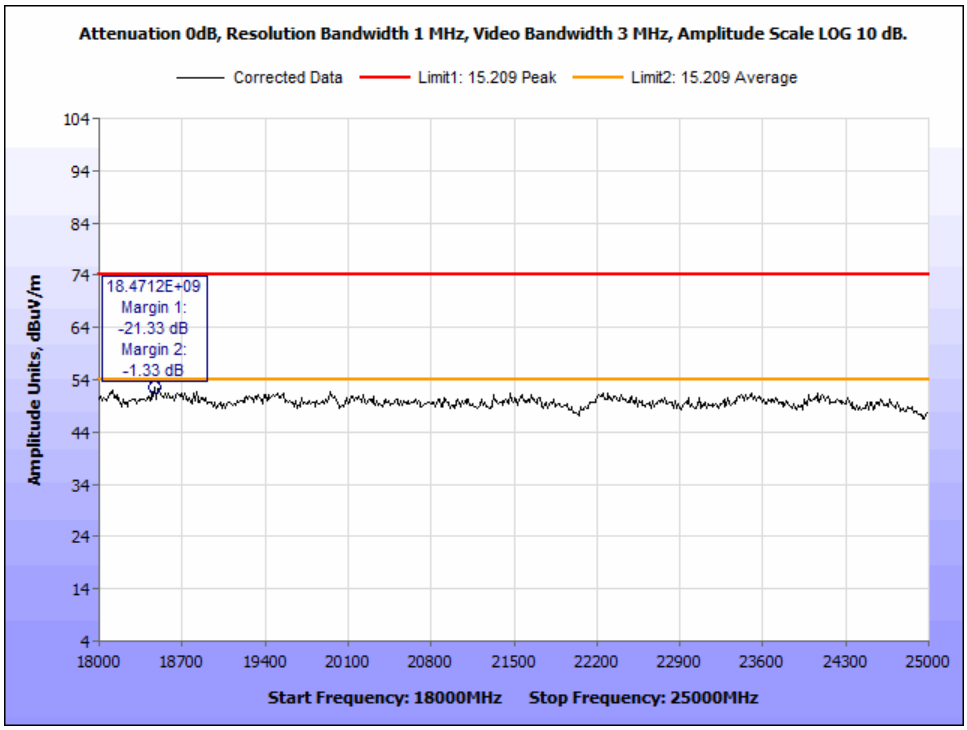

Figure 106: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 18-25GHz - Peak - Horizontal

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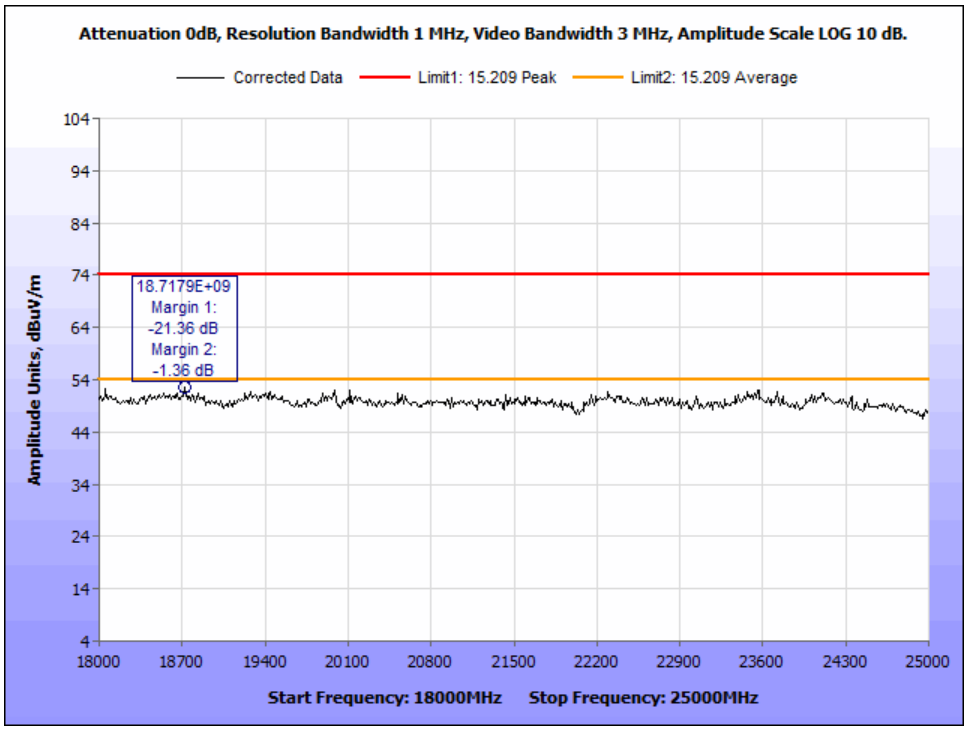

Figure 107: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 18-25GHz - Peak - Vertical

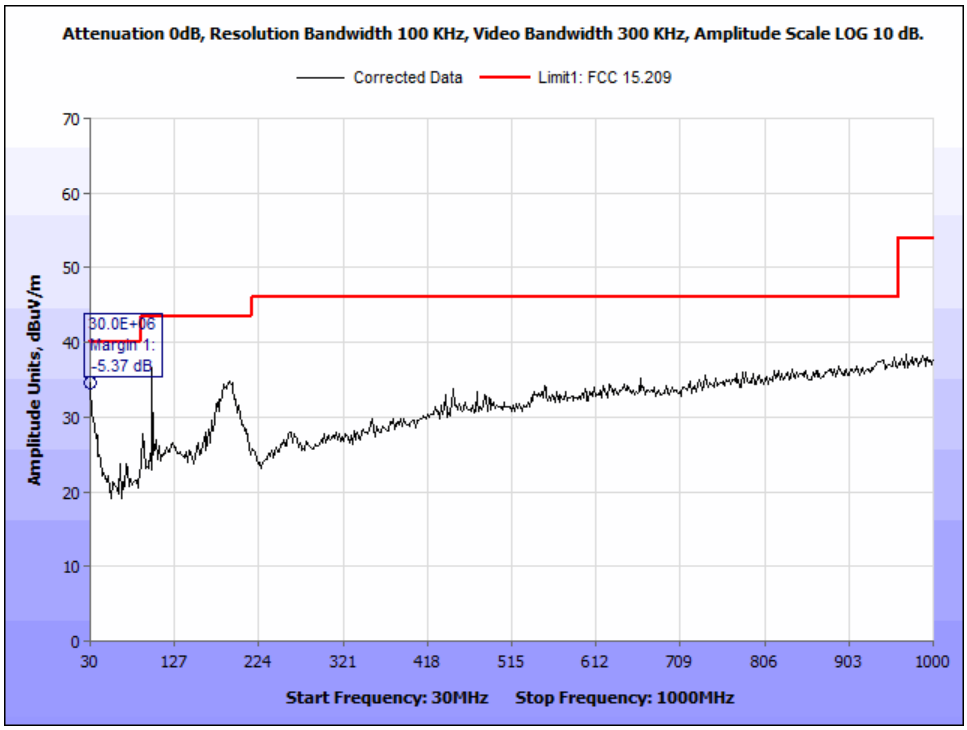

Figure 108: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 30MHz-1000MHz - Horizontal

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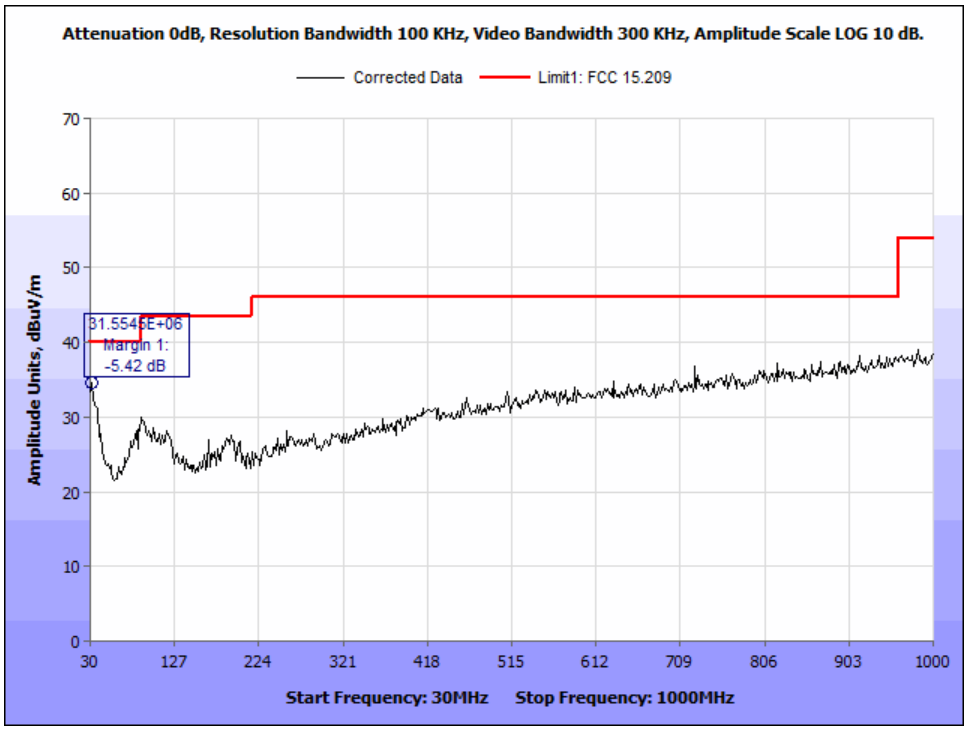

Figure 109: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 30MHz-1000MHz - Vertical

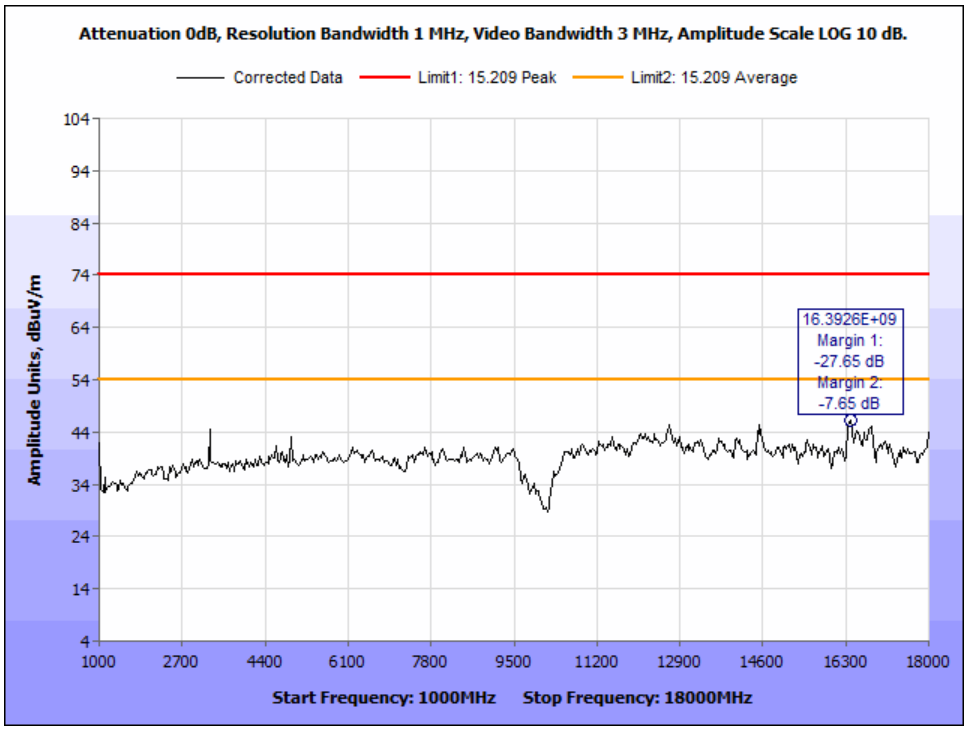

Figure 110: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 1GHz-18GHz - Peak - Horizontal

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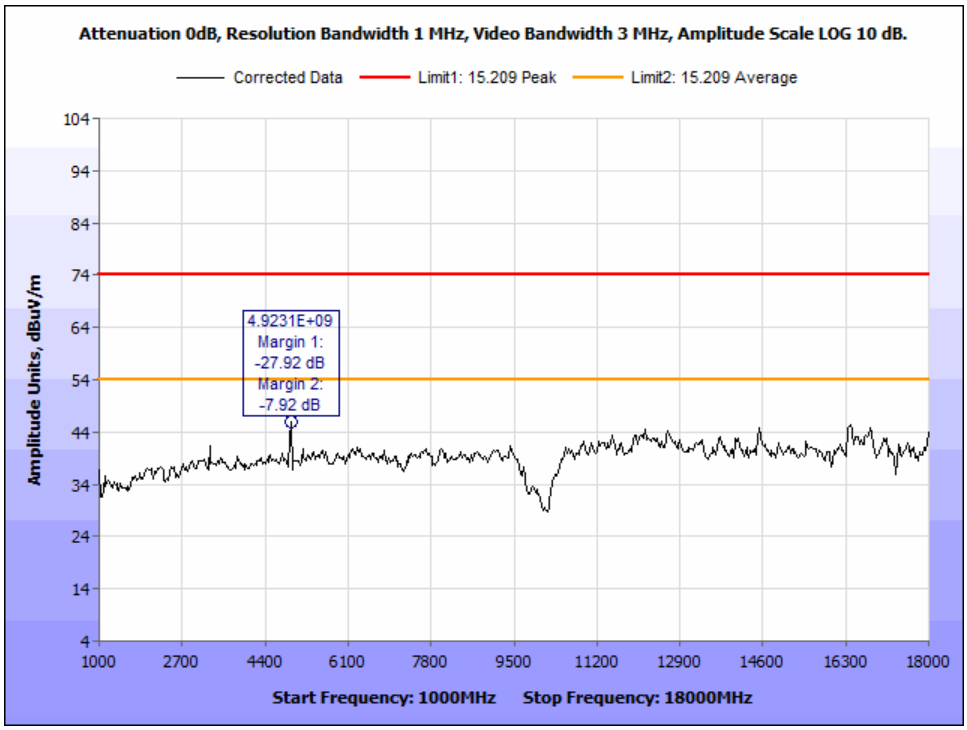

Figure 111: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 1GHz-18GHz - Peak - Vertical

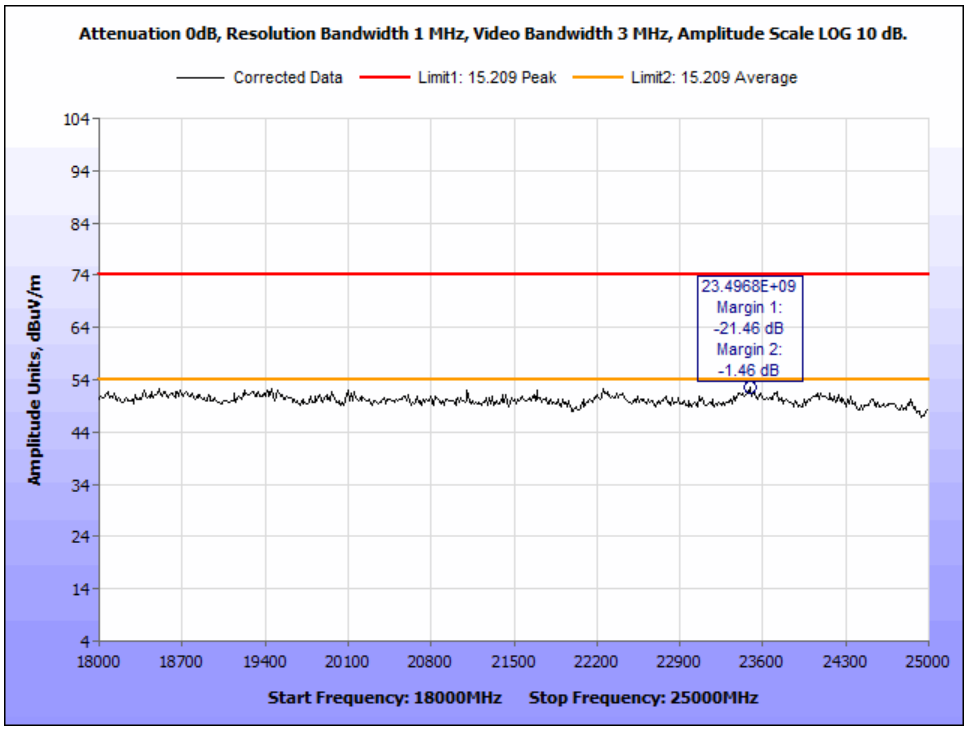

Figure 112: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 18-25GHz - Peak - Horizontal

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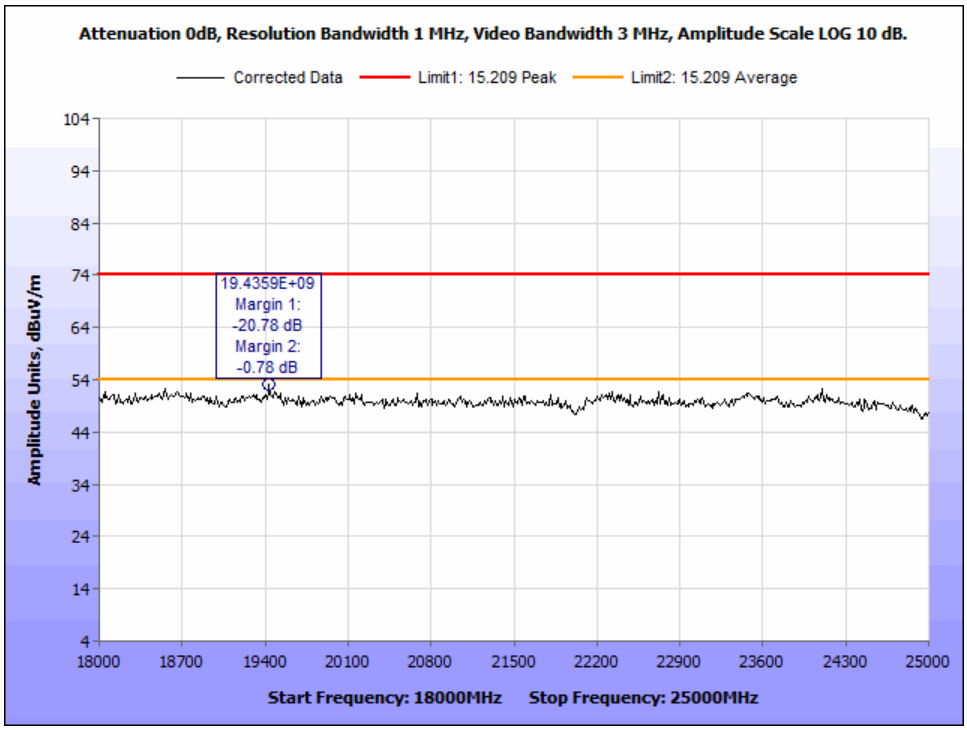

Figure 113: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 18-25GHz - Peak - Vertical

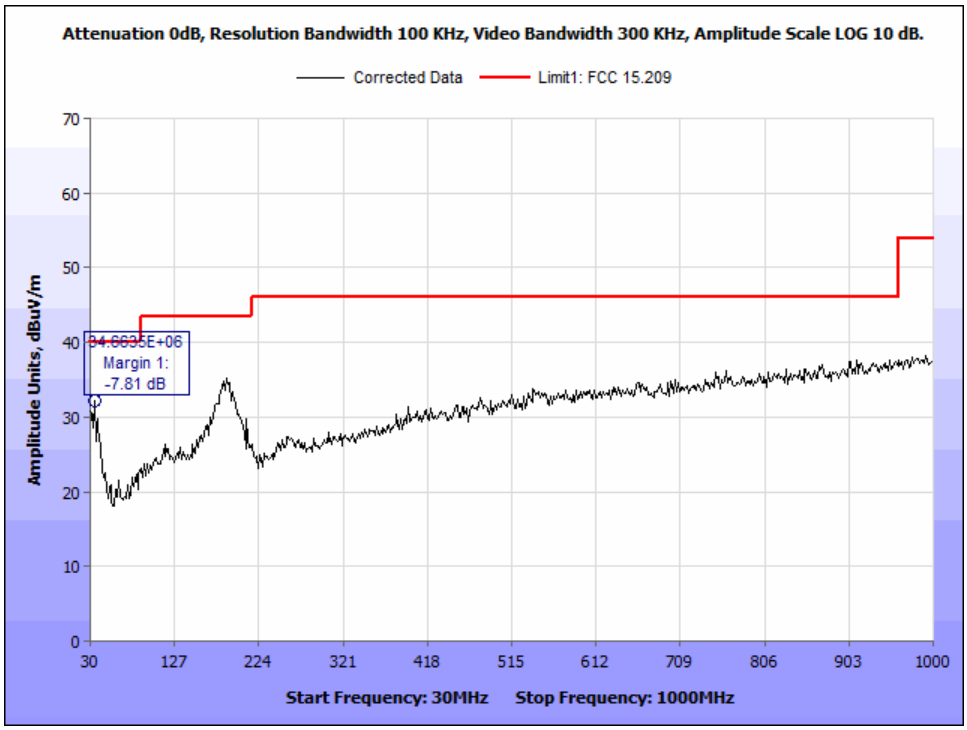

Figure 114: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 30MHz-1000MHz - Horizontal

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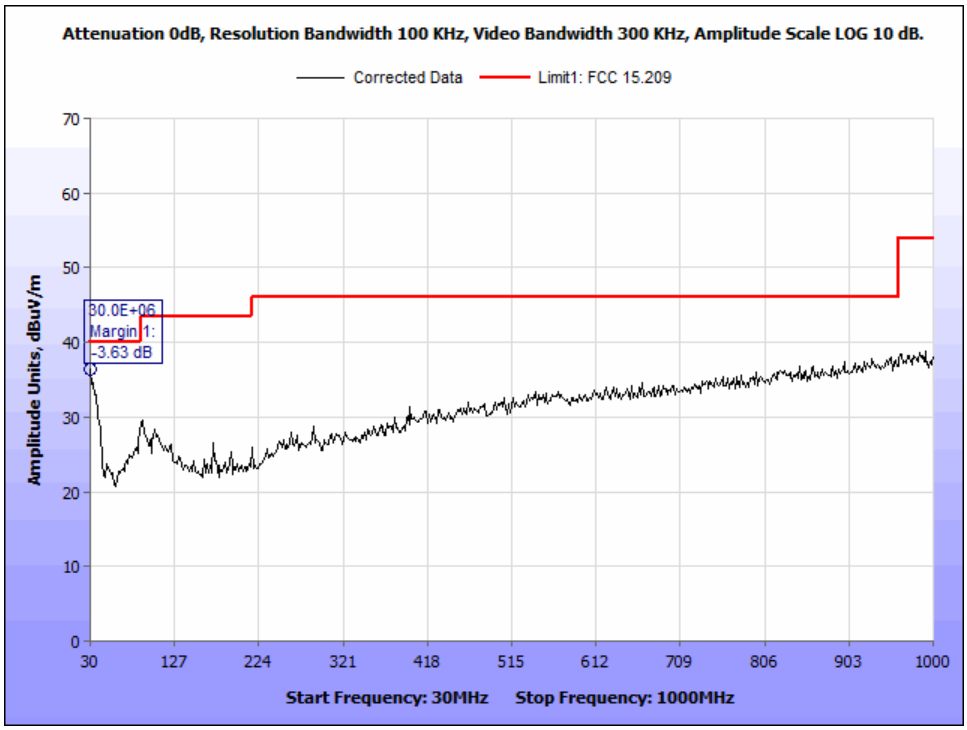

Figure 115: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 30MHz-1000MHz - Vertical

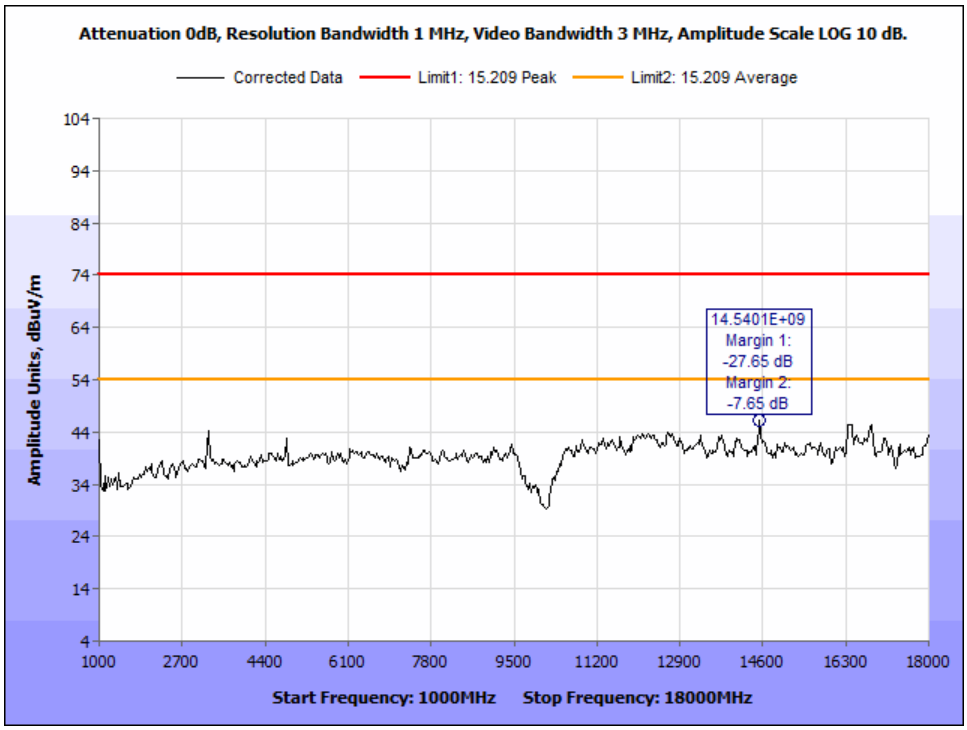

Figure 116: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 1GHz-18GHz - Peak - Horizontal

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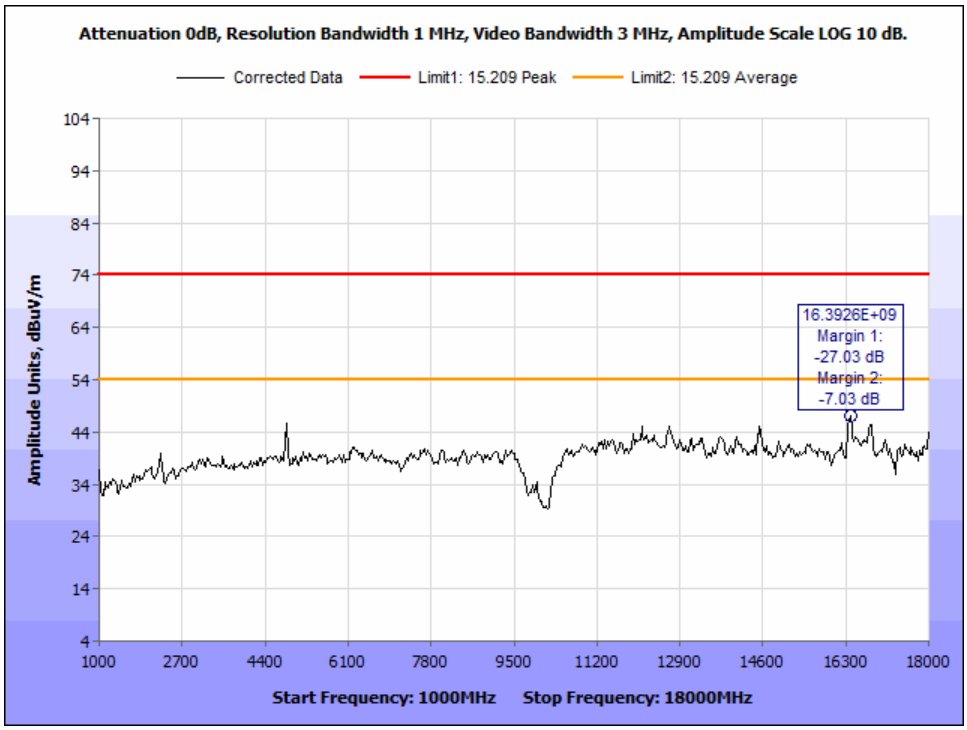

Figure 117: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 1GHz-18GHz - Peak – Vertical

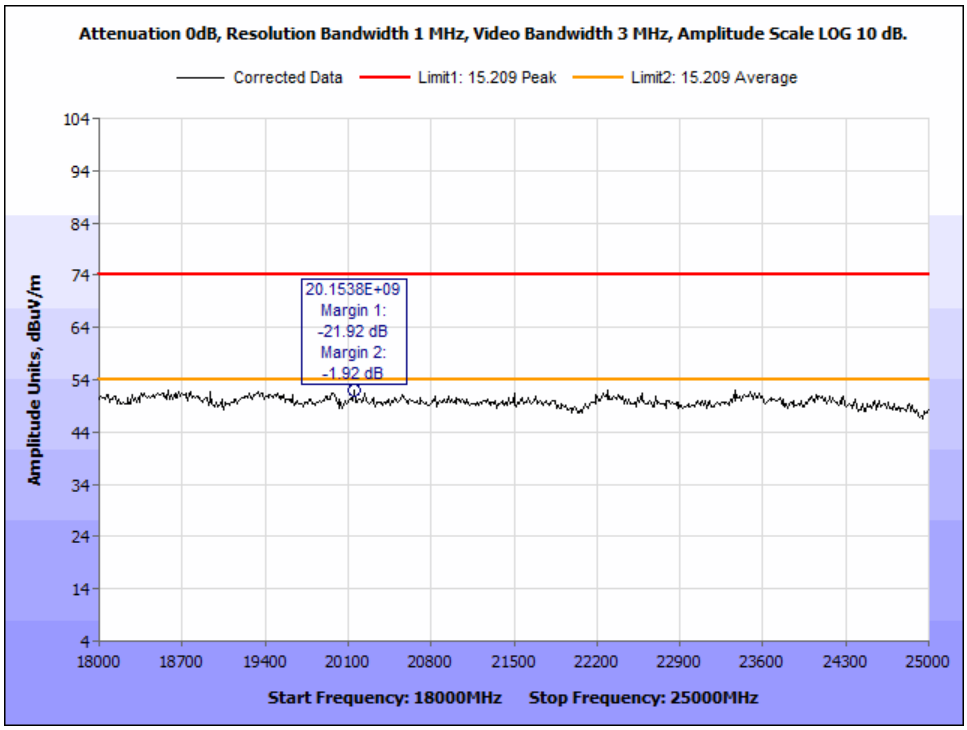

Figure 118: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 18-25GHz - Peak - Horizontal

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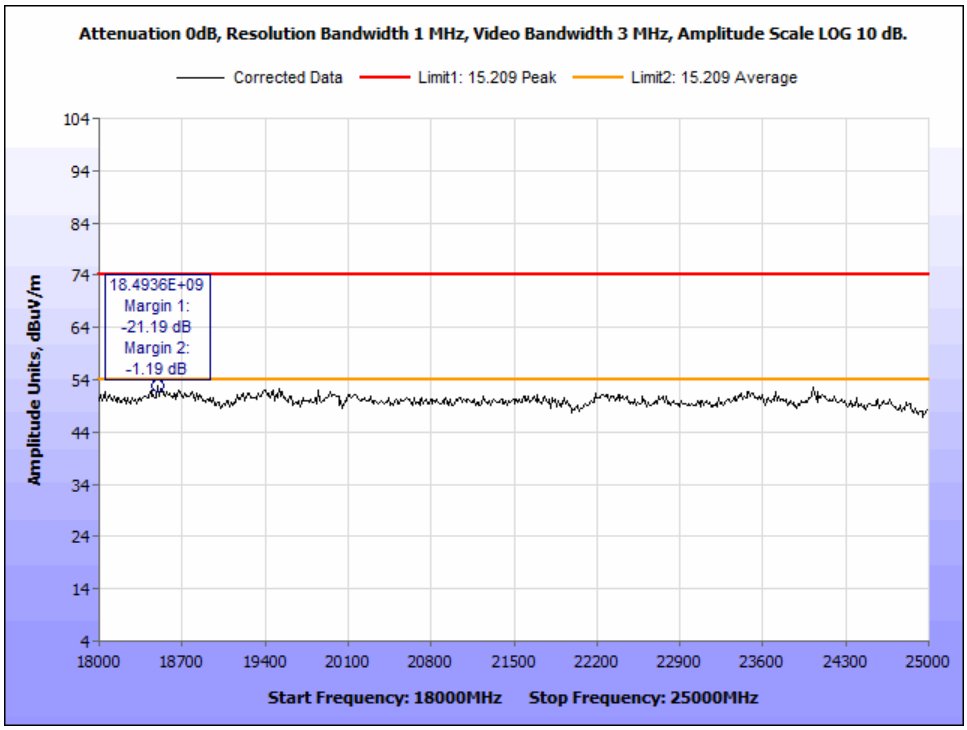

Figure 119: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 18-25GHz - Peak - Vertical

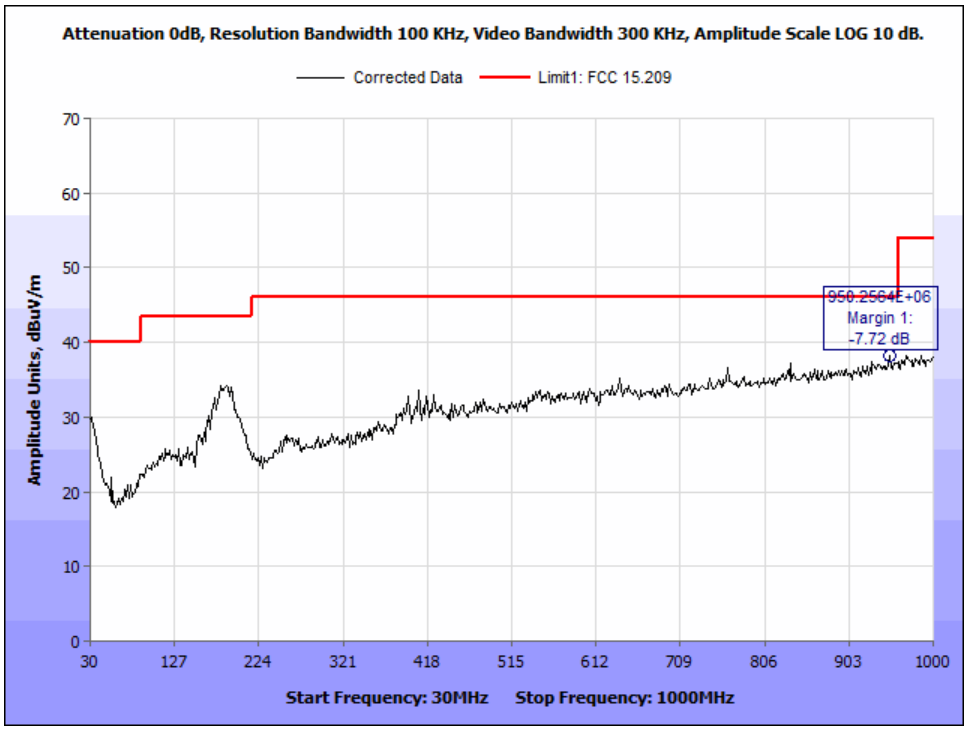

Figure 120: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 30MHz-1000MHz - Horizontal

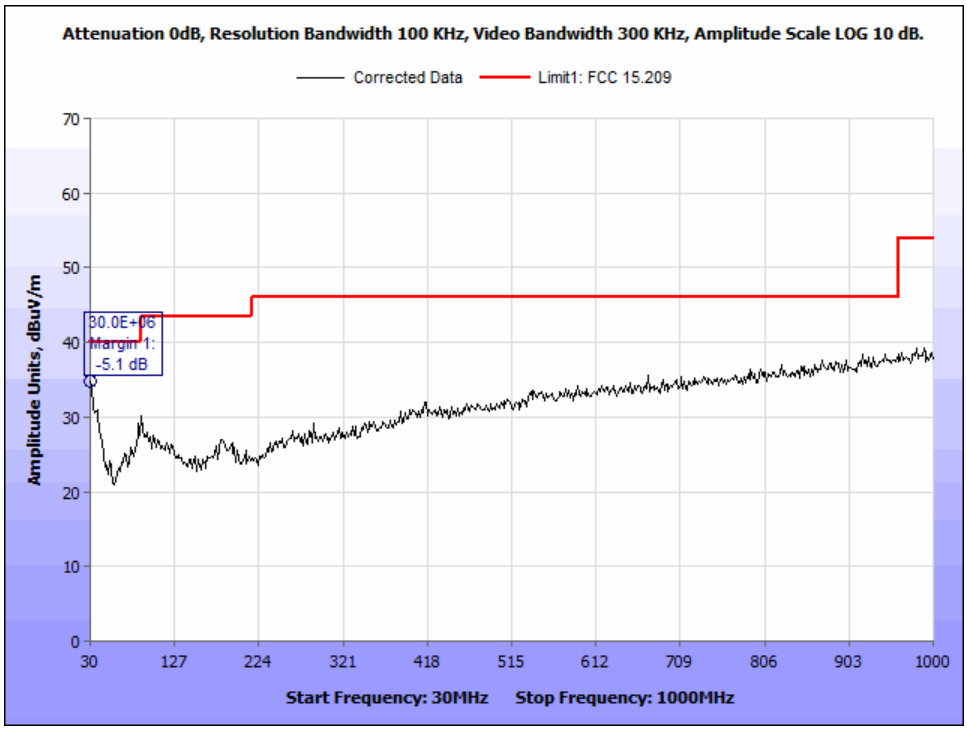

Figure 121: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 30MHz-1000MHz - Vertical

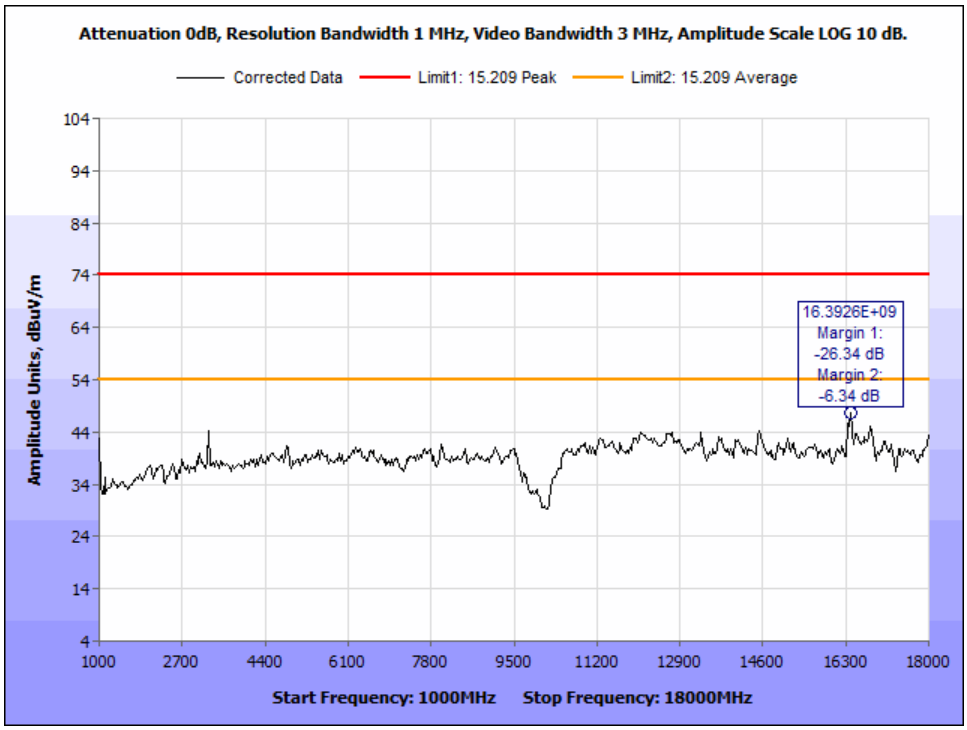

Figure 122: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 1GHz-18GHz - Peak - Horizontal

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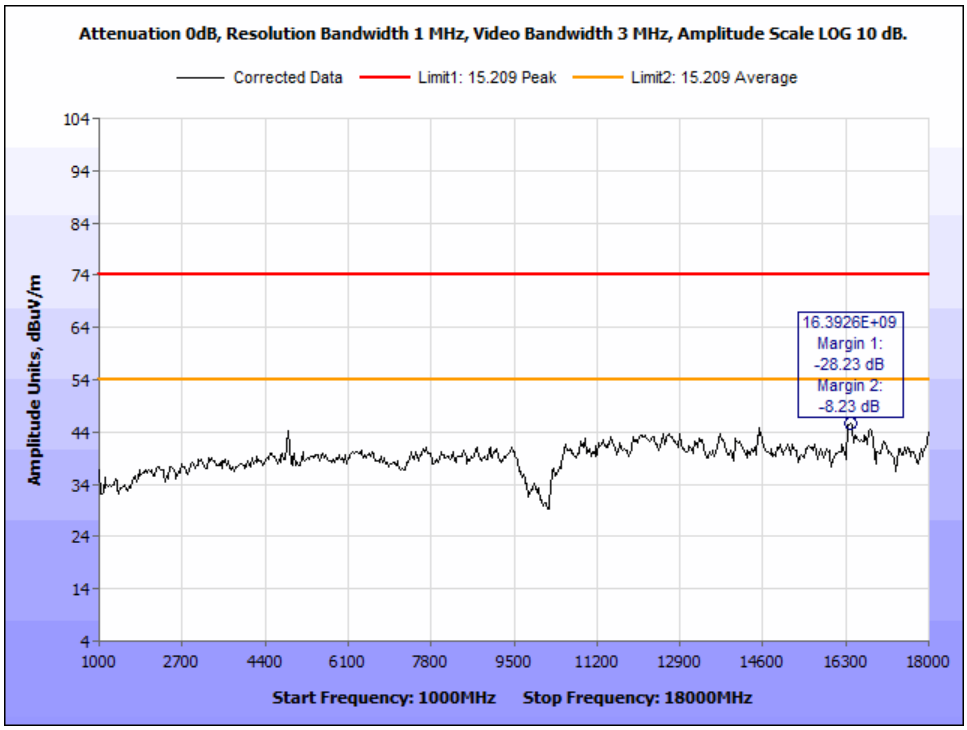

Figure 123: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 1GHz-18GHz - Peak – Vertical

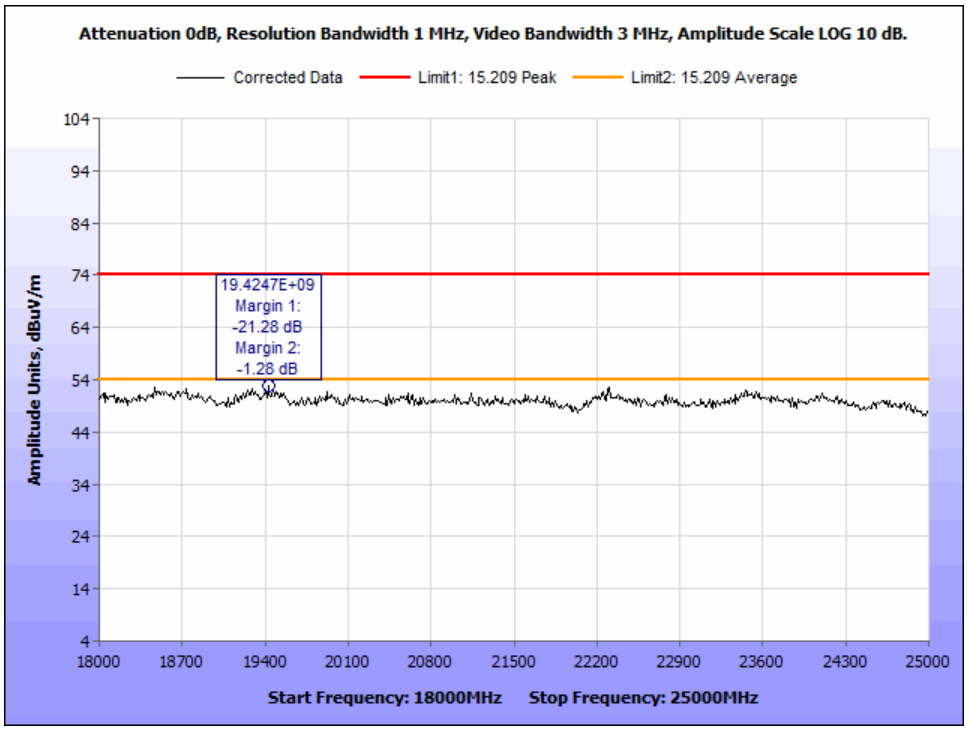

Figure 124: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 18-25GHz - Peak - Horizontal

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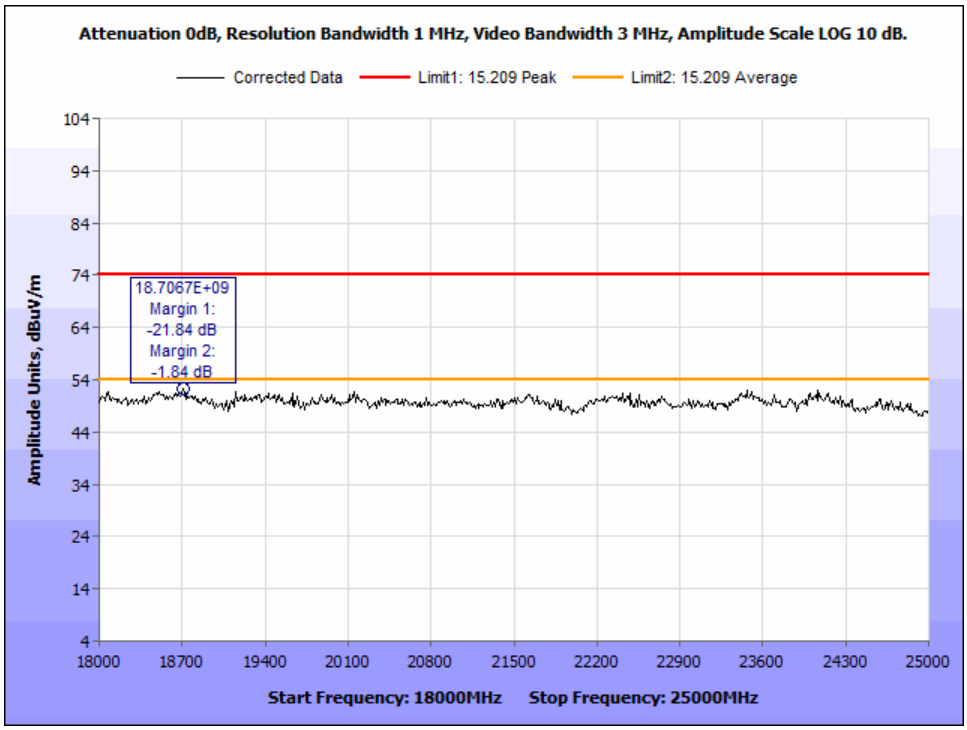

Figure 125: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 18-25GHz - Peak - Vertical

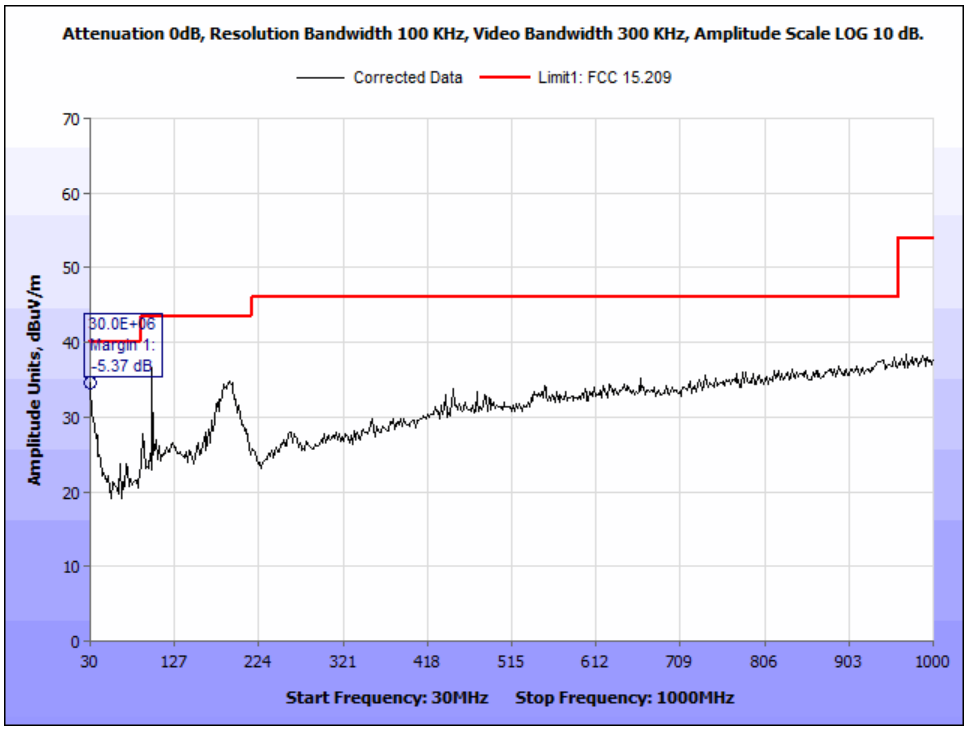

Figure 126: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 30MHz-1000MHz - Horizontal

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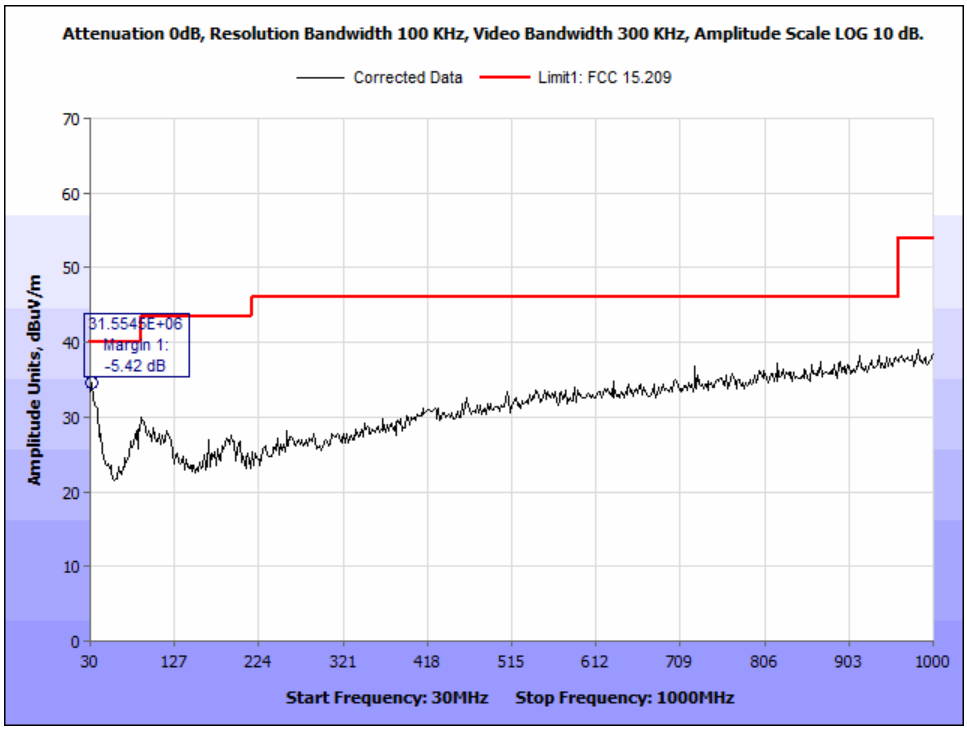

Figure 127: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 30MHz-1000MHz - Vertical

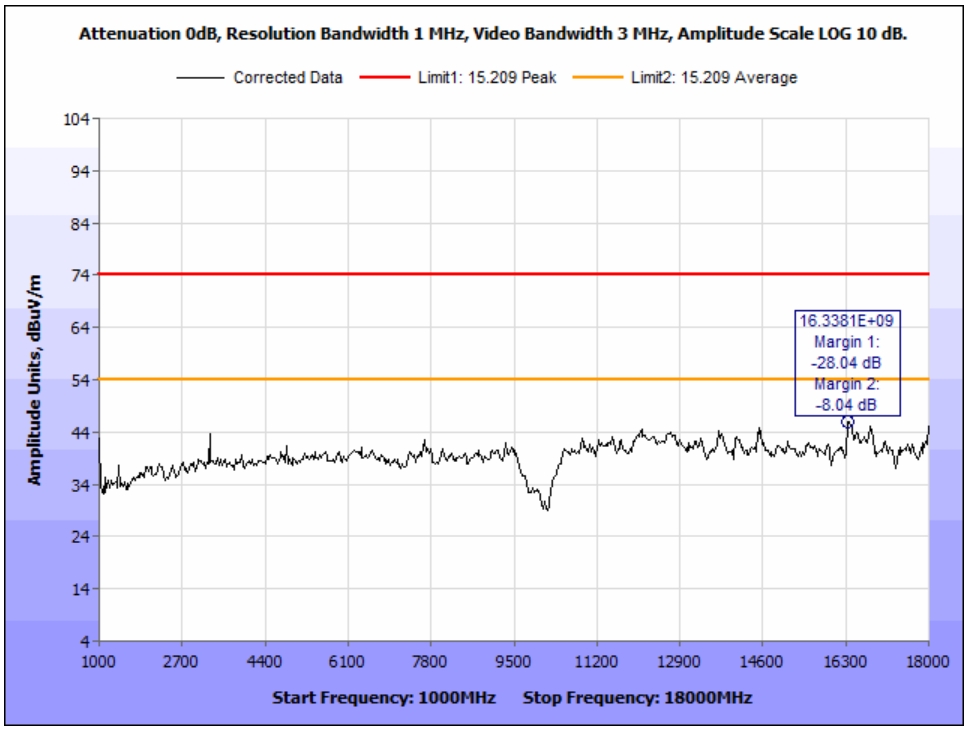

Figure 128: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 1GHz-18GHz - Peak - Horizontal

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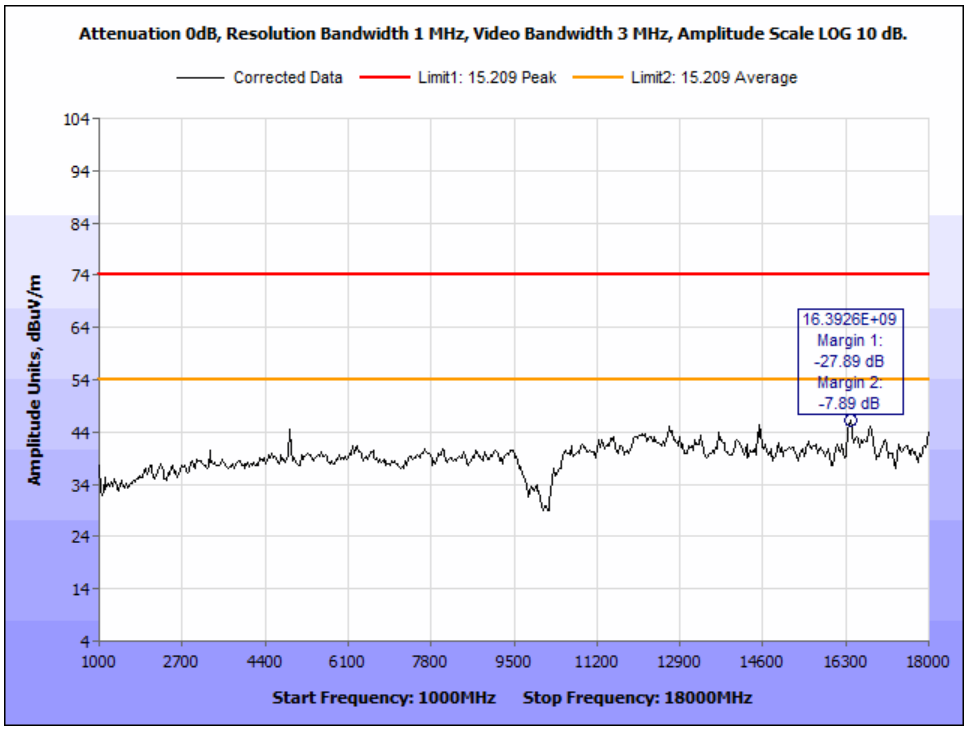

Figure 129: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 1GHz-18GHz - Peak - Vertical

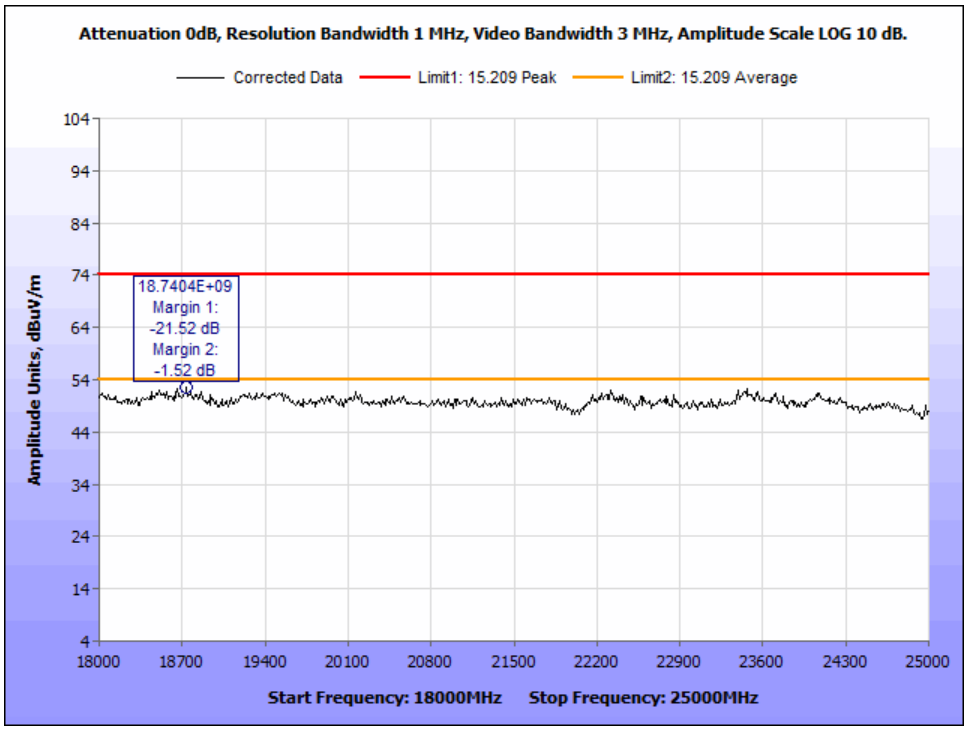

Figure 130: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 18-25GHz - Peak - Horizontal

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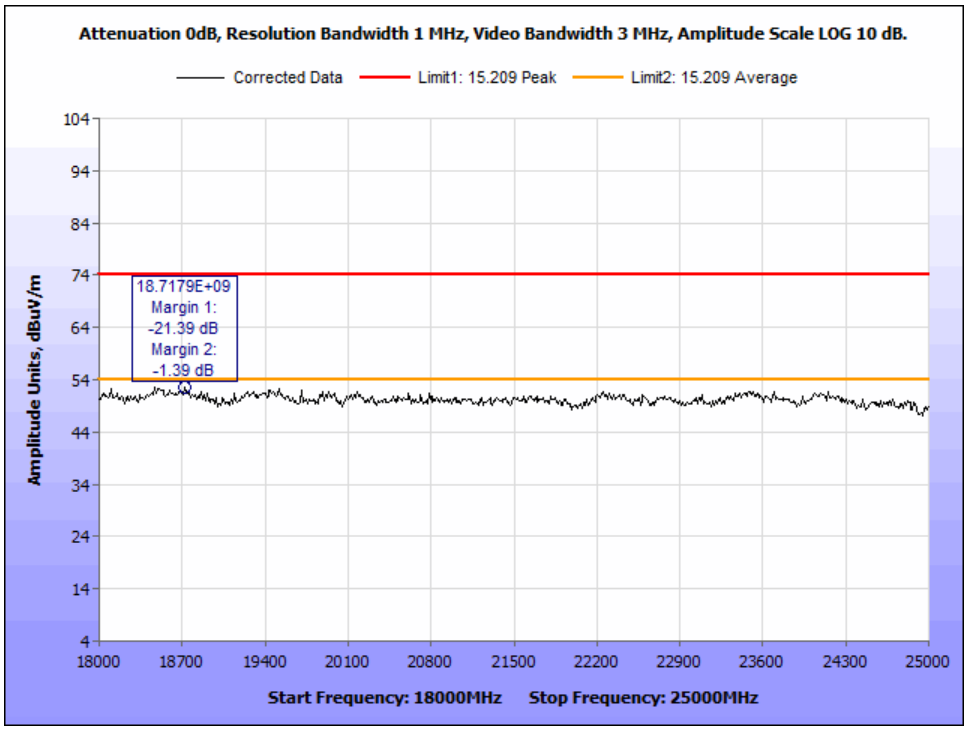

Figure 131: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 18-25GHz - Peak - Vertical

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Radiated Band Edge Measurements

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

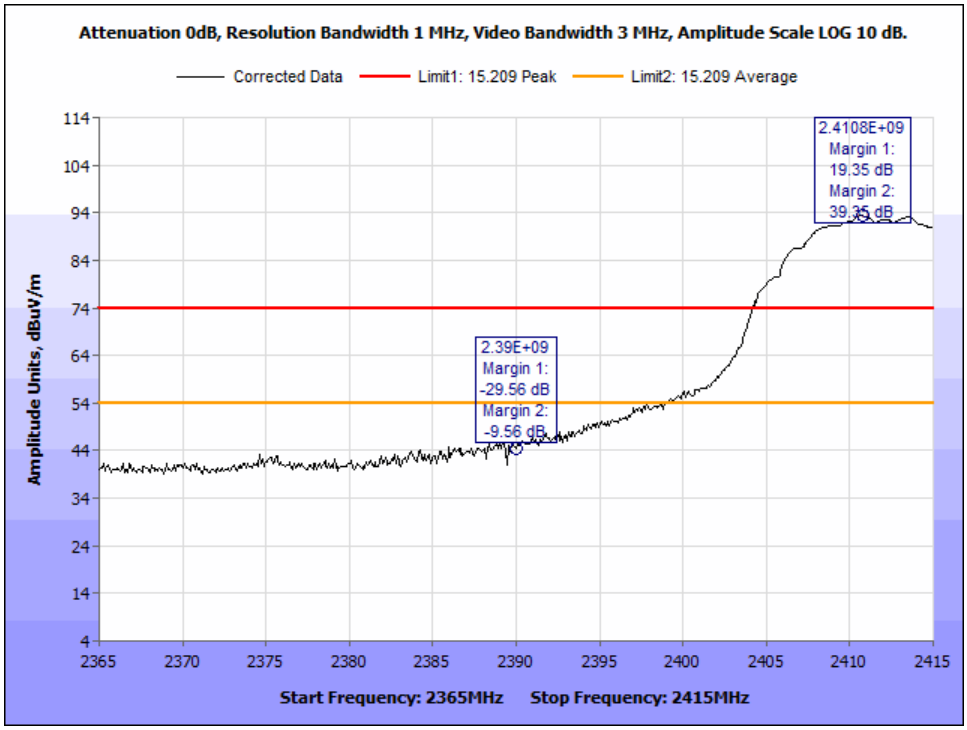

Figure 132: Radiated Band Edge, 802.11b, 2412 MHz - Peak - Horizontal

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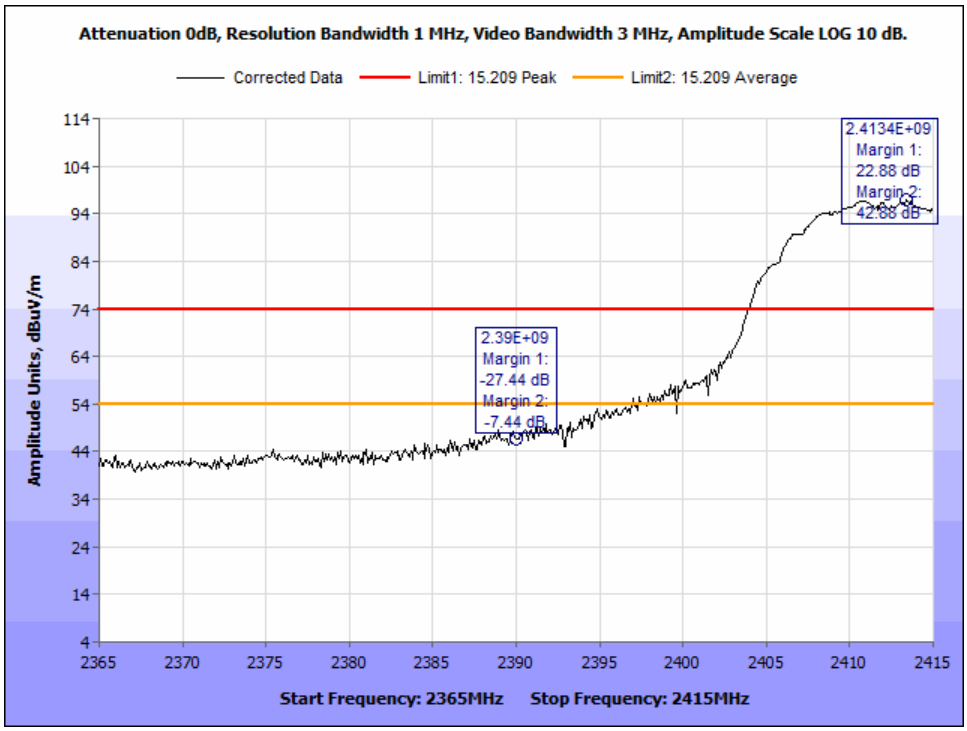

Figure 133: Radiated Band Edge, 802.11b, 2412 MHz - Peak - Vertical

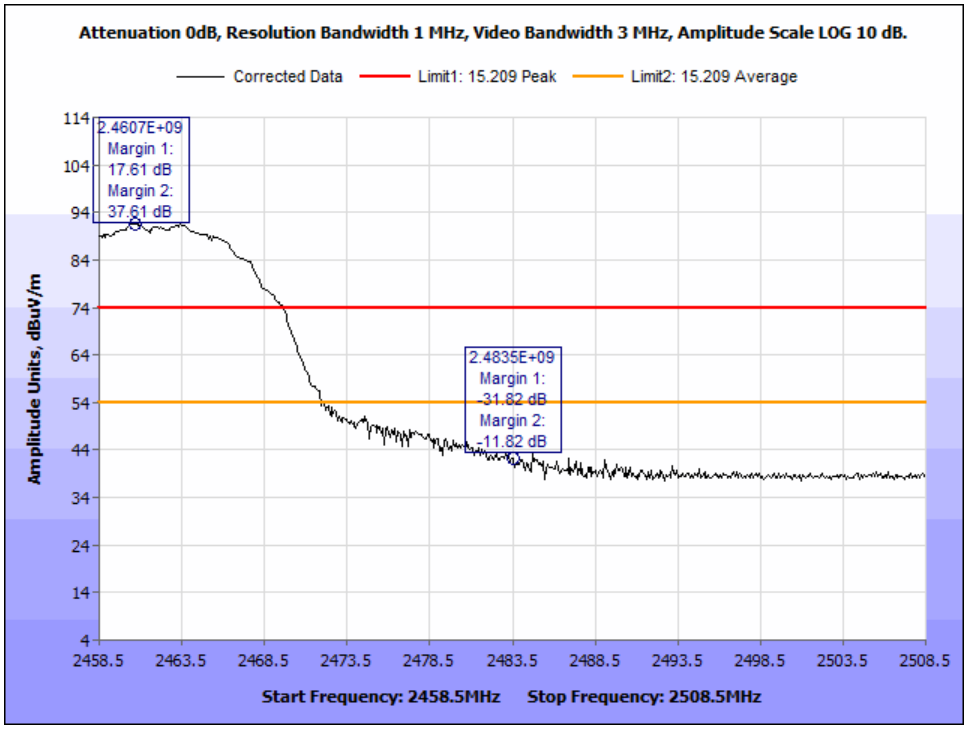

Figure 134: Radiated Band Edge, 802.11b, 2462 MHz - Peak - Horizontal

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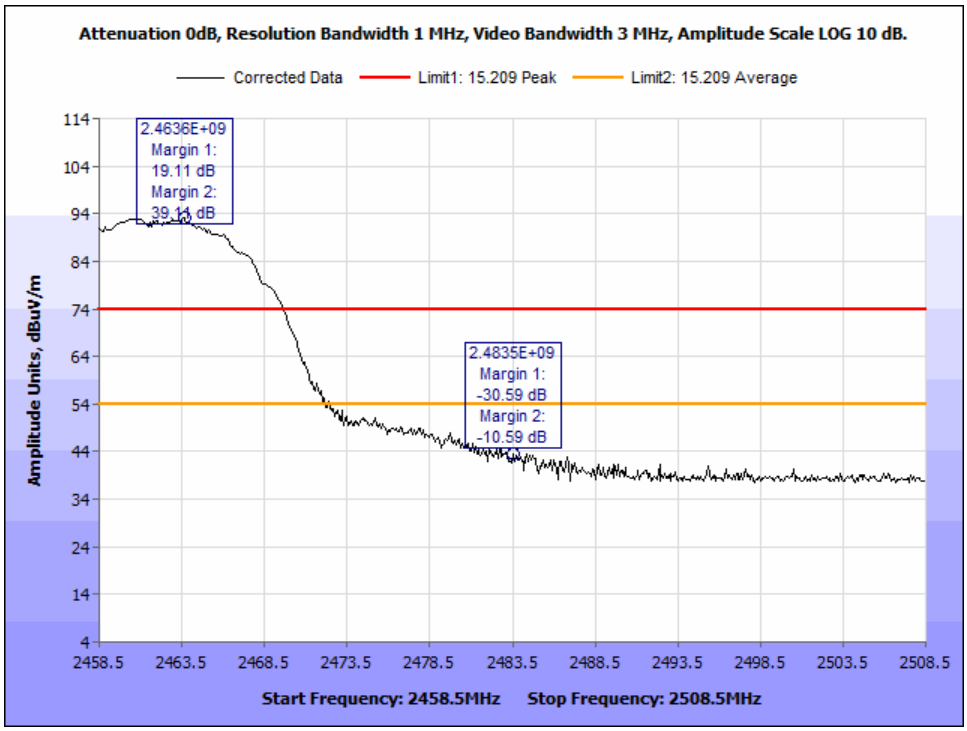

Figure 135: Radiated Band Edge, 802.11b, 2462 MHz - Peak - Vertical

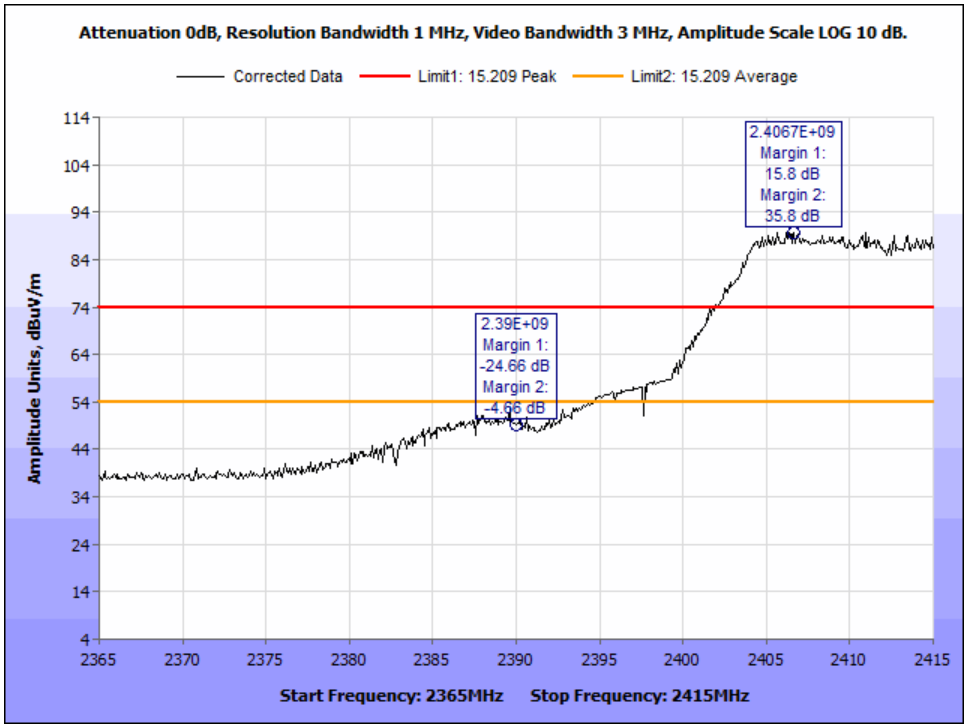

Figure 136: Radiated Band Edge, 802.11g, 2412 MHz - Peak - Horizontal

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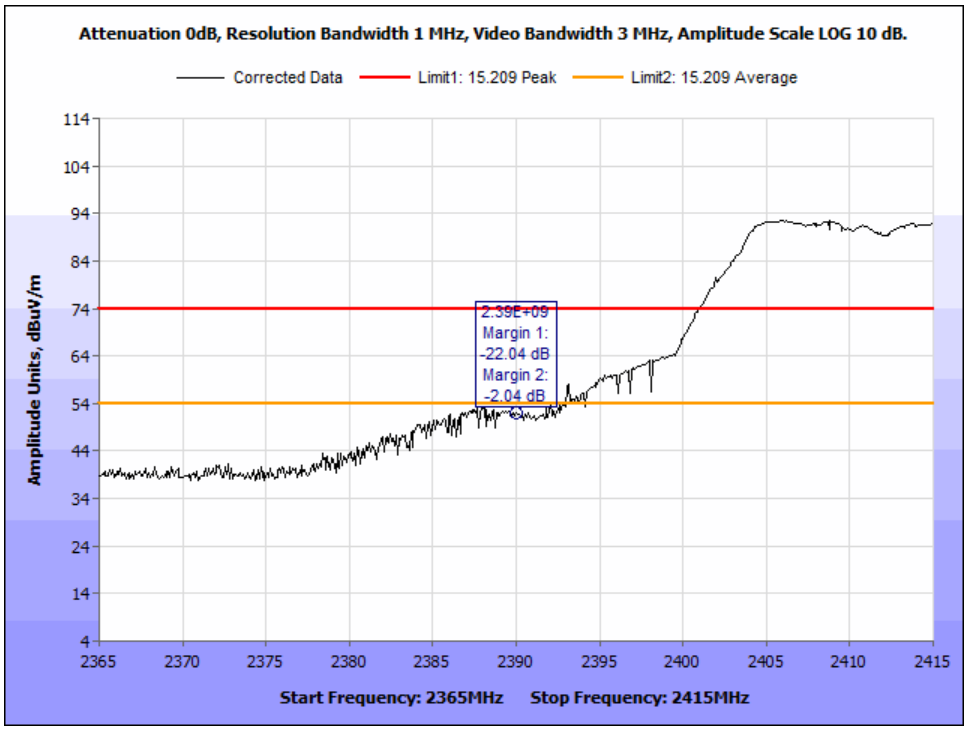

Figure 137: Radiated Band Edge, 802.11g, 2412 MHz - Peak - Vertical

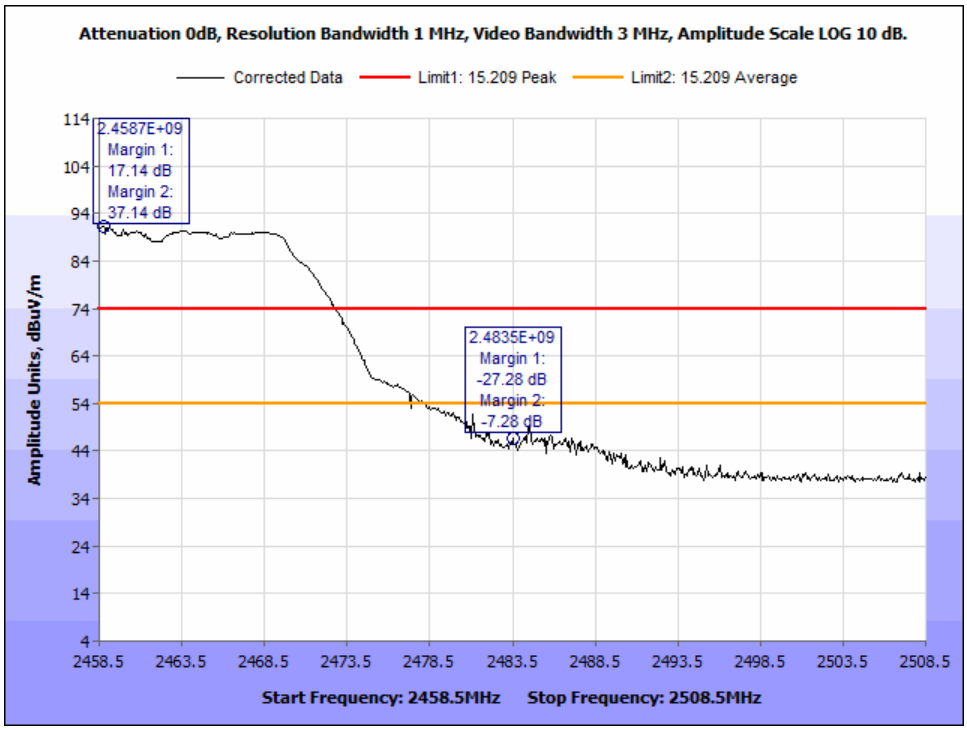

Figure 138: Radiated Band Edge, 802.11g, 2462 MHz - Peak - Horizontal

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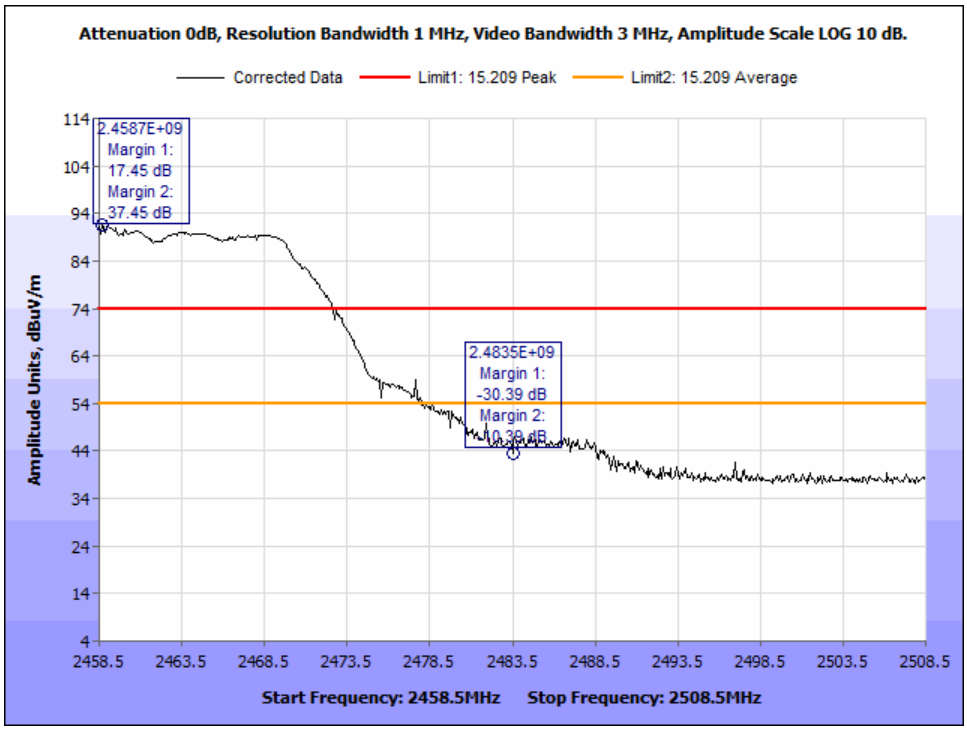

Figure 139: Radiated Band Edge, 802.11g, 2462 MHz - Peak - Vertical

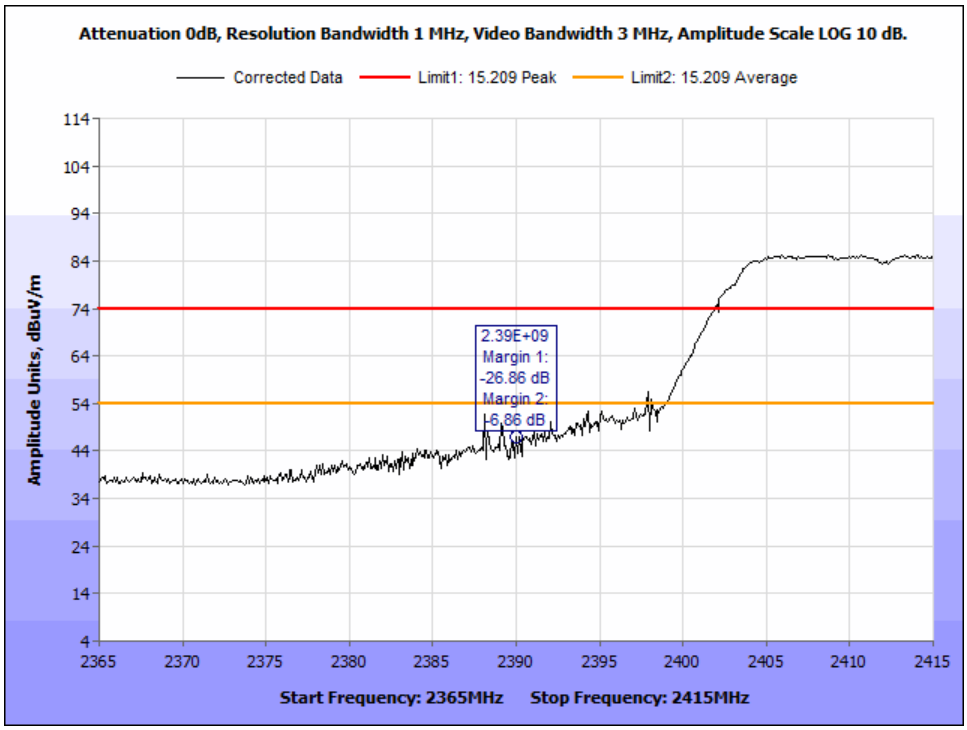

Figure 140: Radiated Band Edge, 802.11n_HT20, 2412 MHz - Peak - Horizontal

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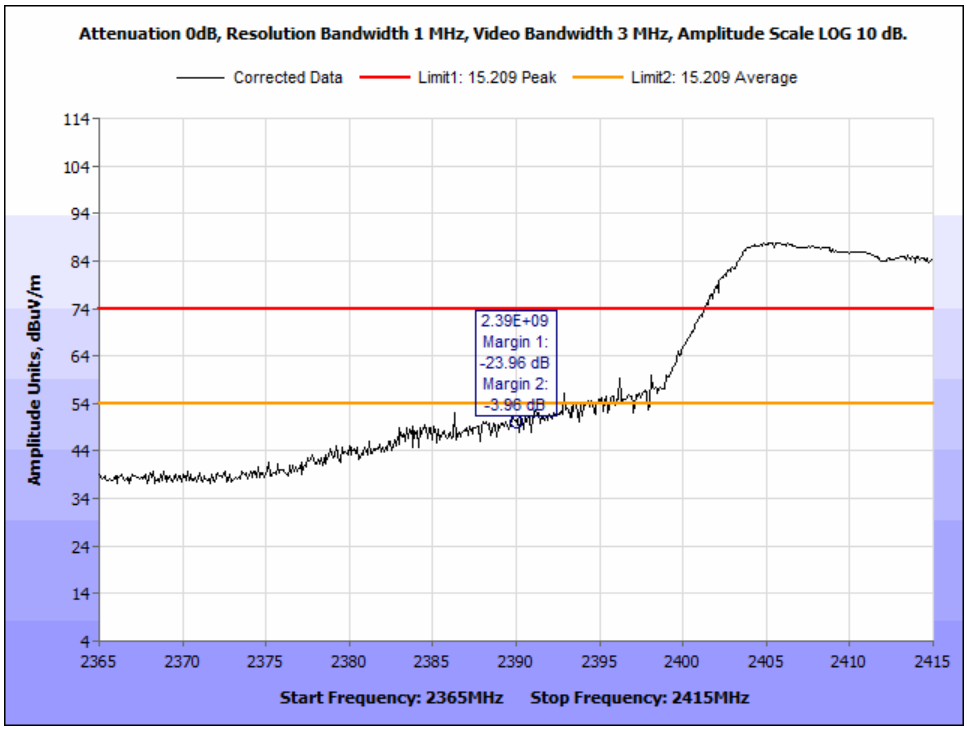

Figure 141: Radiated Band Edge, 802.11n_HT20, 2412 MHz - Peak - Vertical

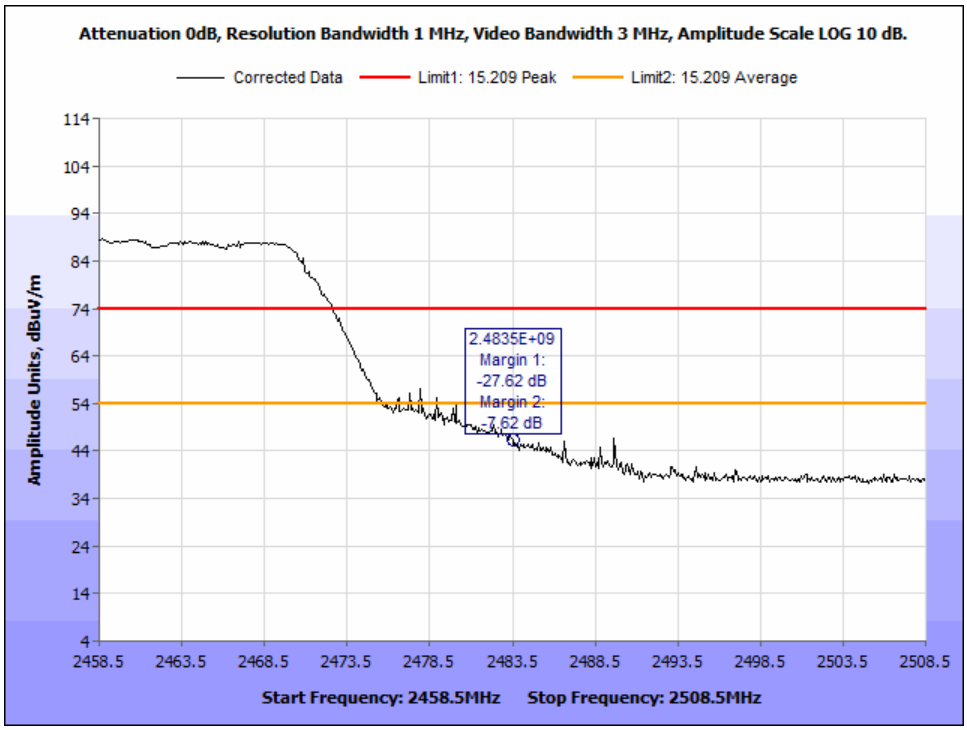

Figure 142: Radiated Band Edge, 802.11n_HT20, 2462 MHz - Peak - Horizontal

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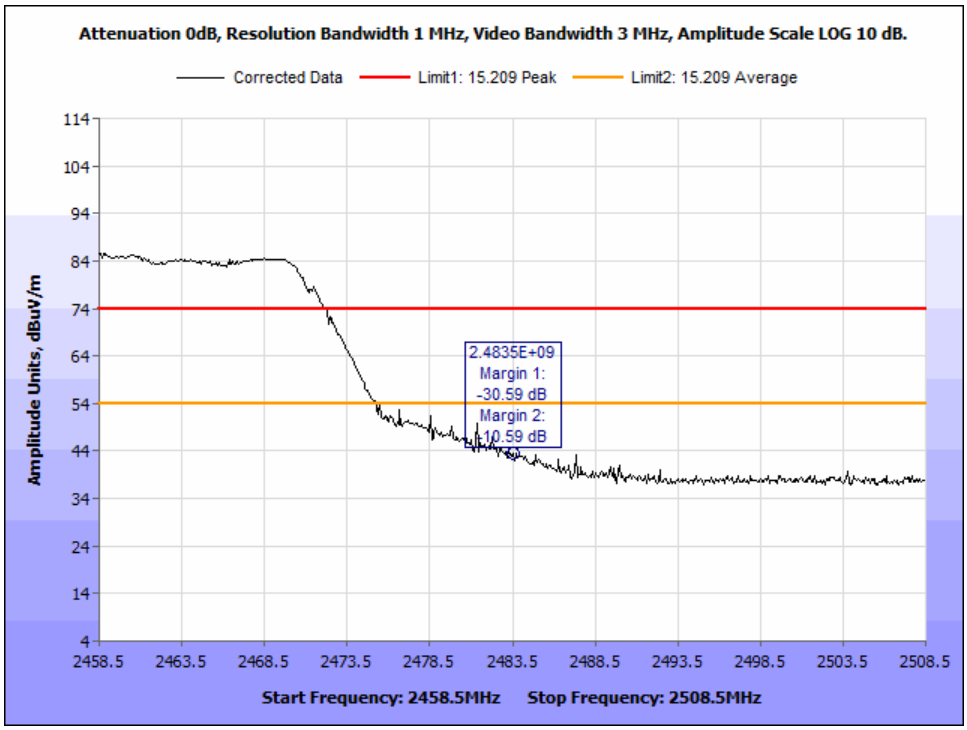

Figure 143: Radiated Band Edge, 802.11n_HT20, 2462 MHz - Peak - Vertical

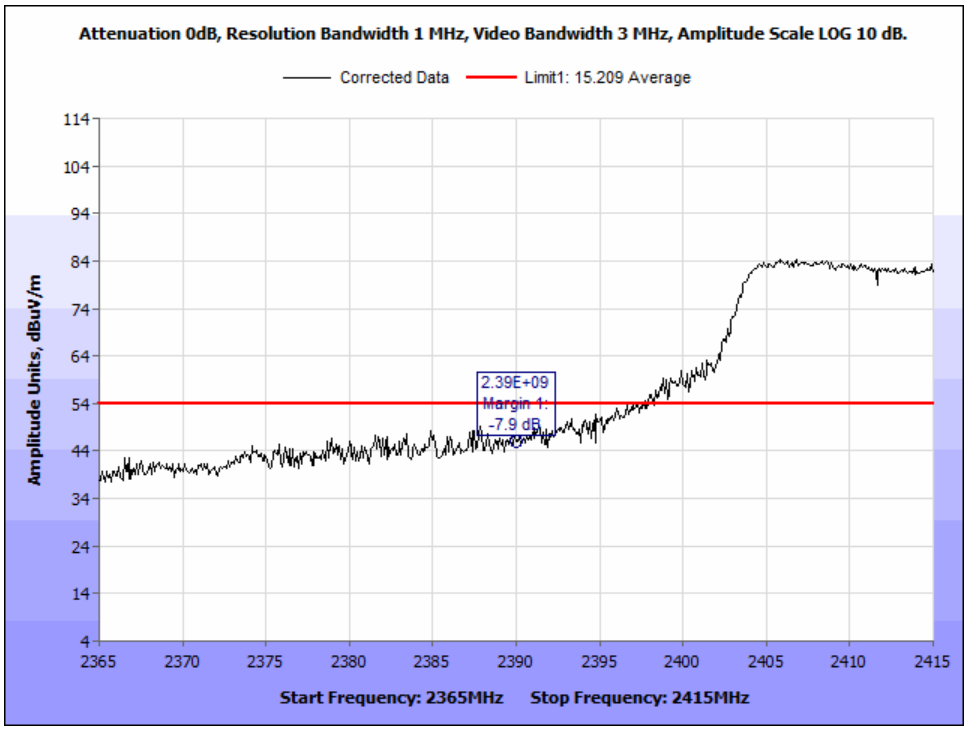

Figure 144: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - Average - Horizontal

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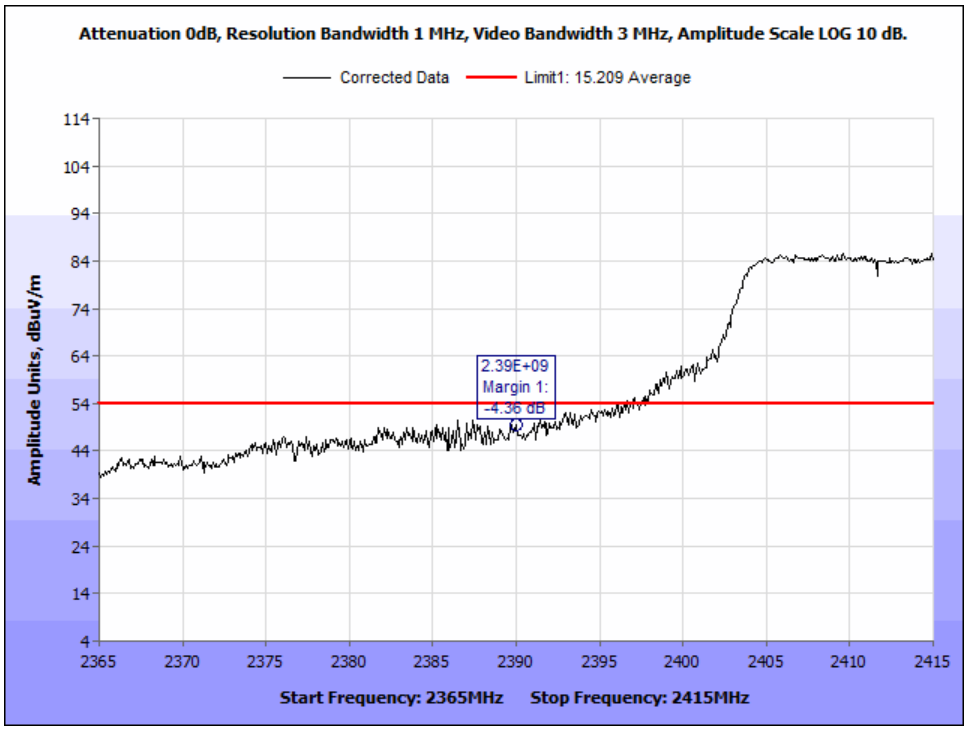

Figure 145: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - Average - Vertical

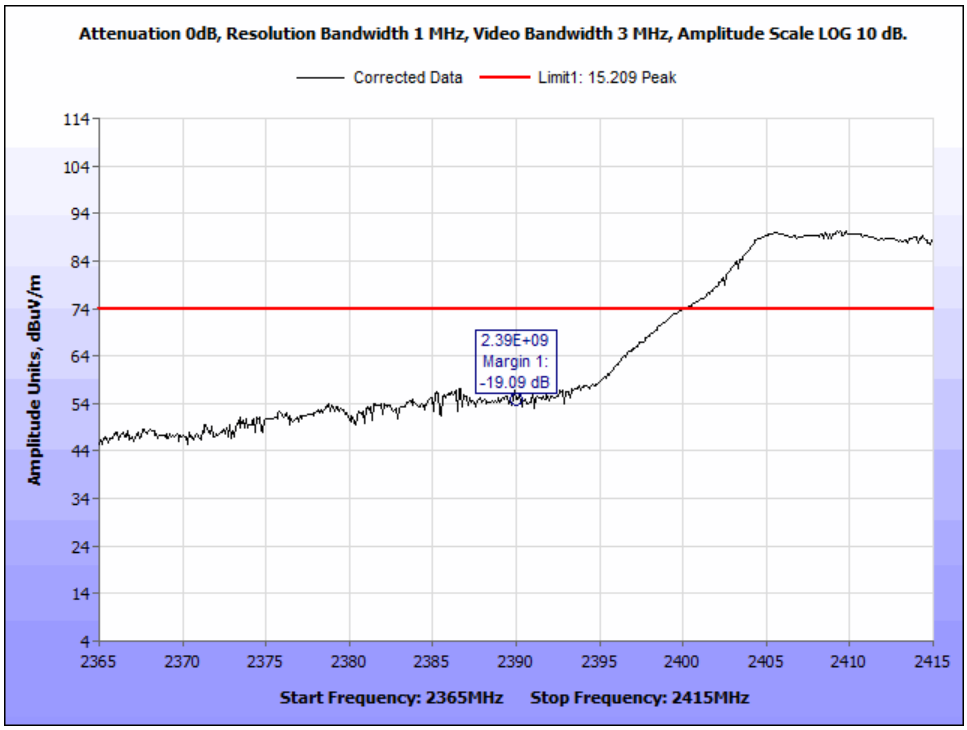

Figure 146: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - Peak - Horizontal

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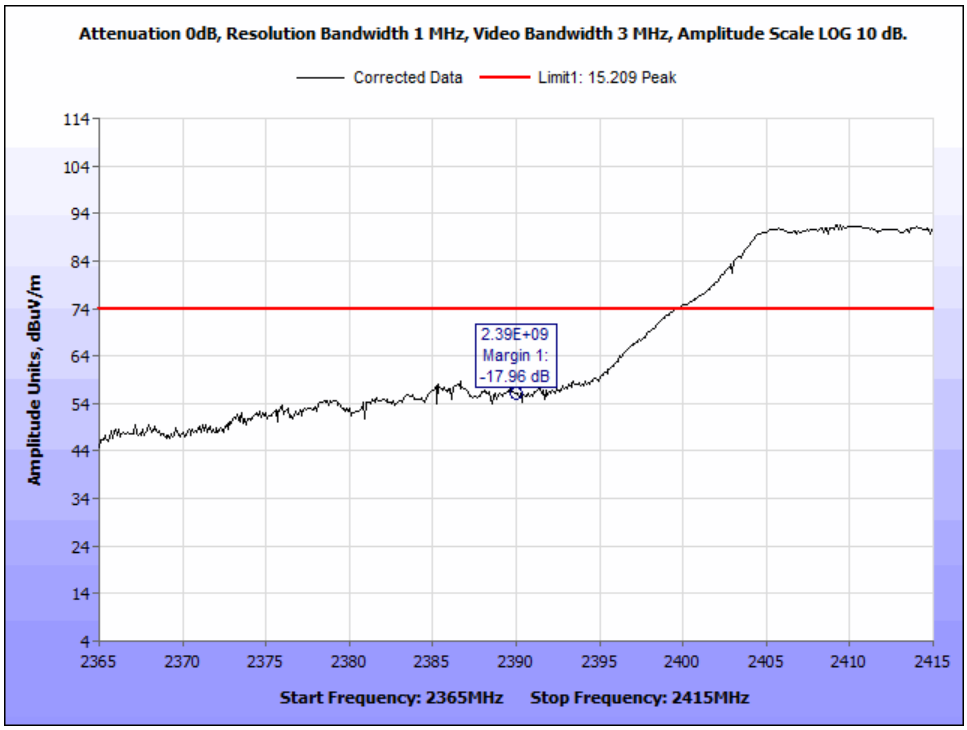

Figure 147: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - Peak - Vertical

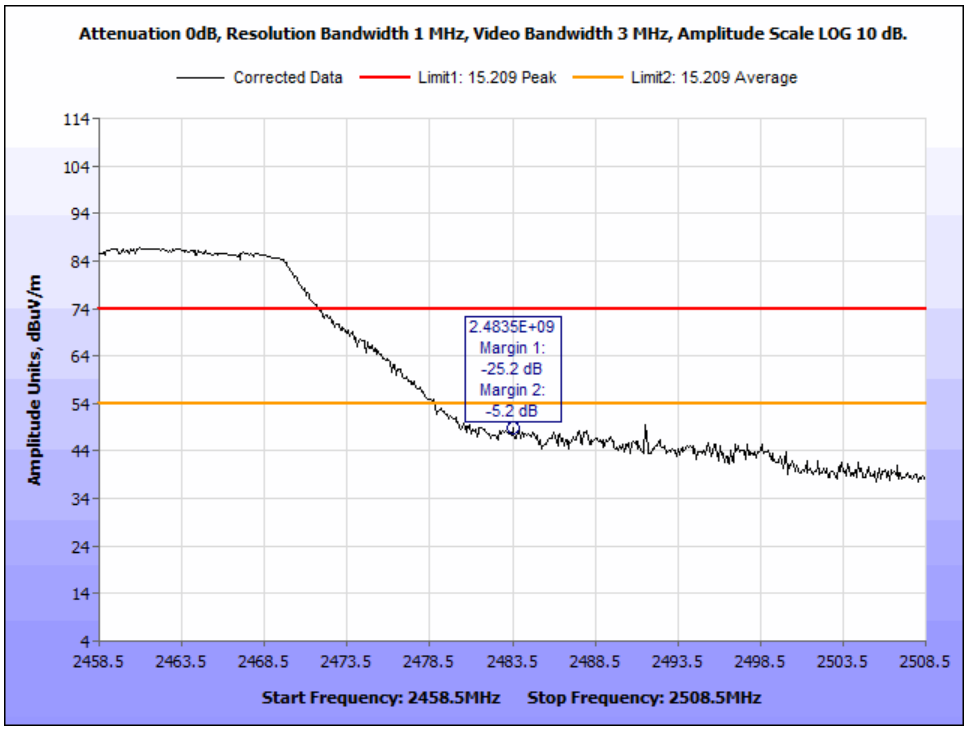

Figure 148: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - Peak - Horizontal

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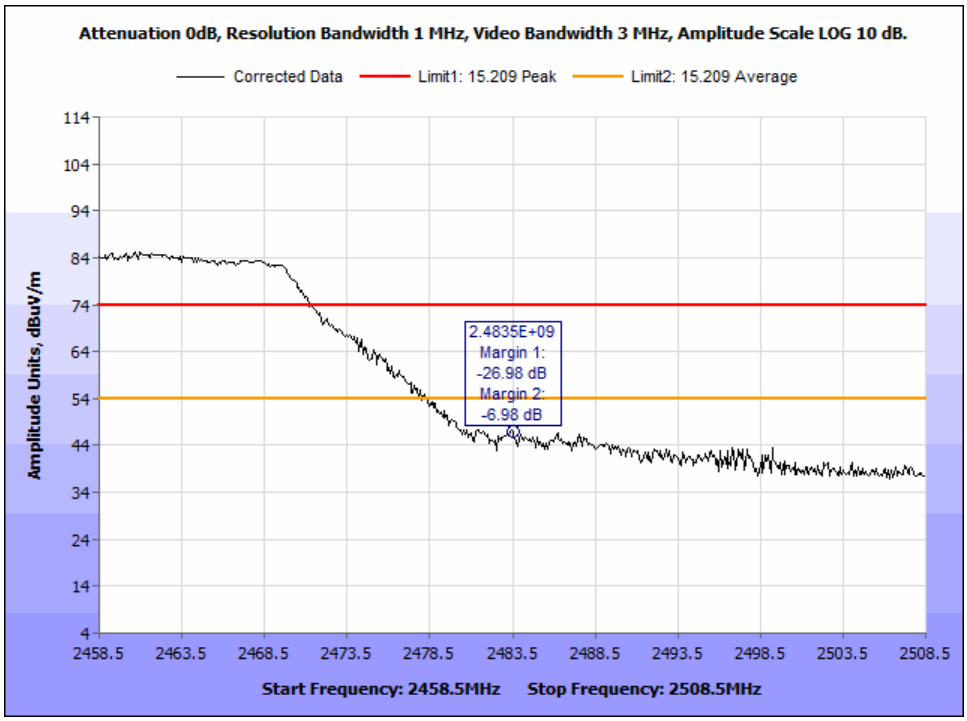

Figure 149: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - Peak - Vertical

100 KHz Bandwidth Radiated Spurious Emissions Test Results

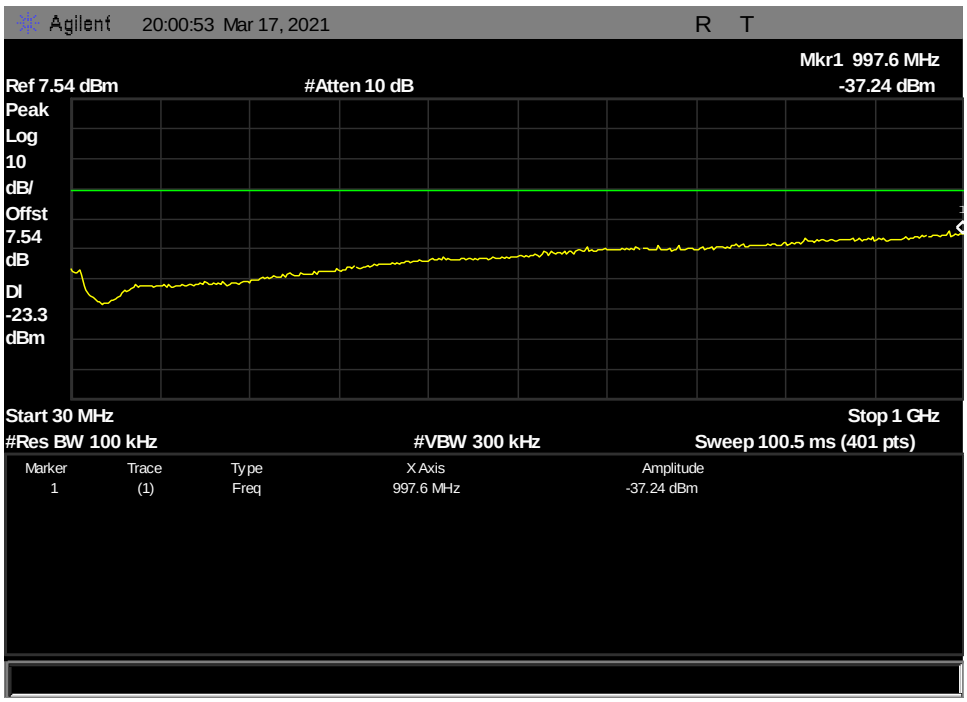

Figure 150: Radiated Spurious Emissions, 802.11b, 2412 MHz - 30MHz-1GHz

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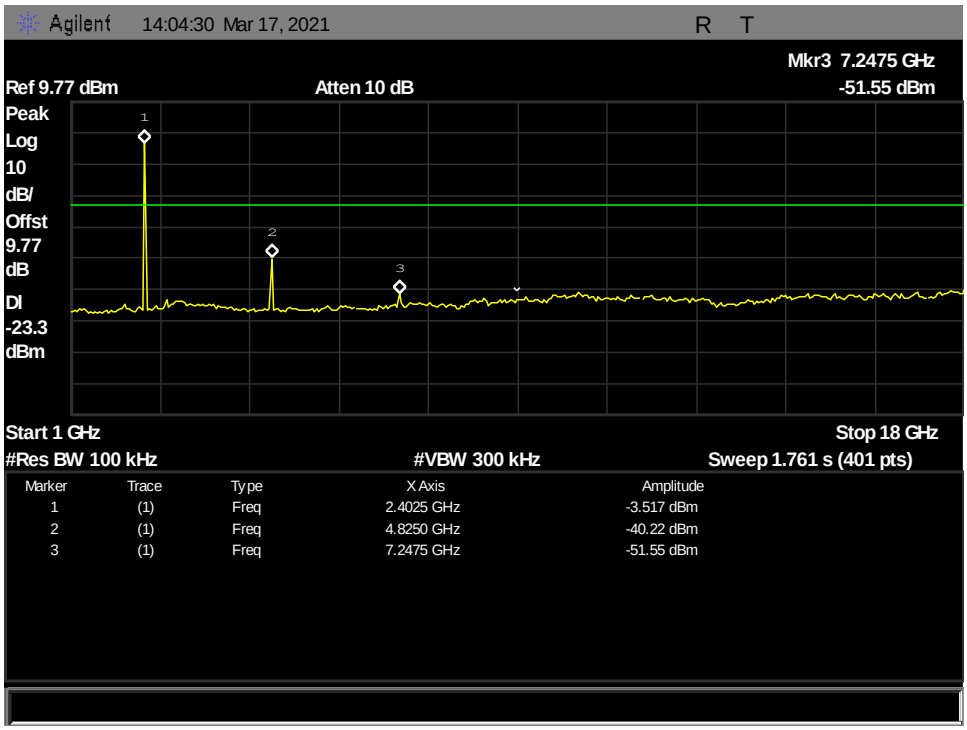

Figure 151: Radiated Spurious Emissions, 802.11b, 2412 MHz - 1GHz-18GHz

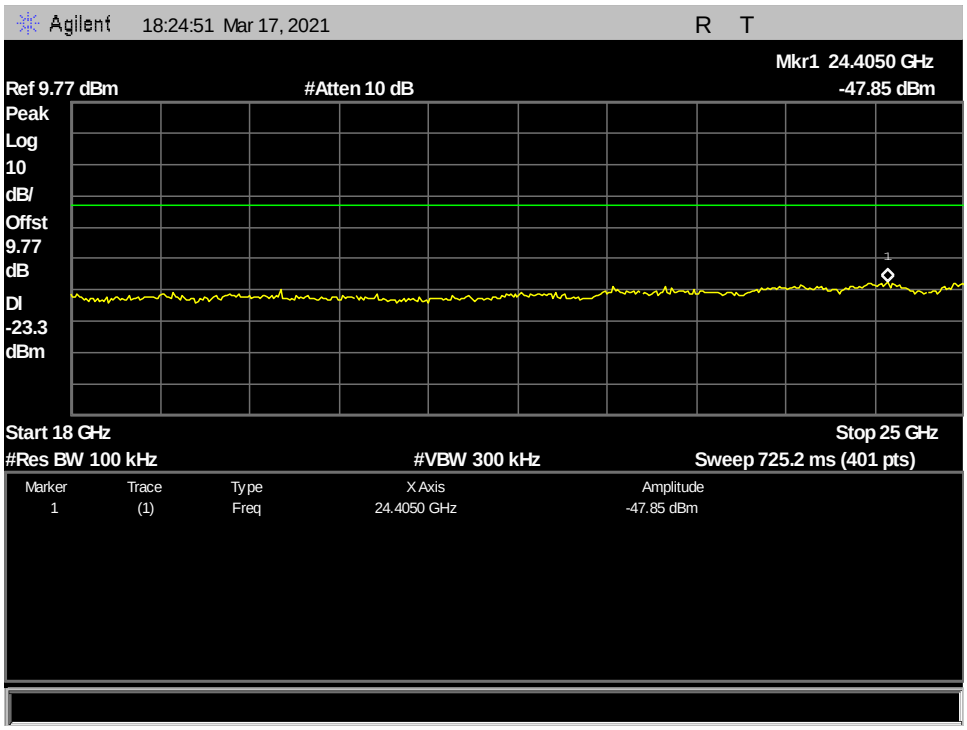

Figure 152: Radiated Spurious Emissions, 802.11b, 2412 MHz - 18GHz-25GHz

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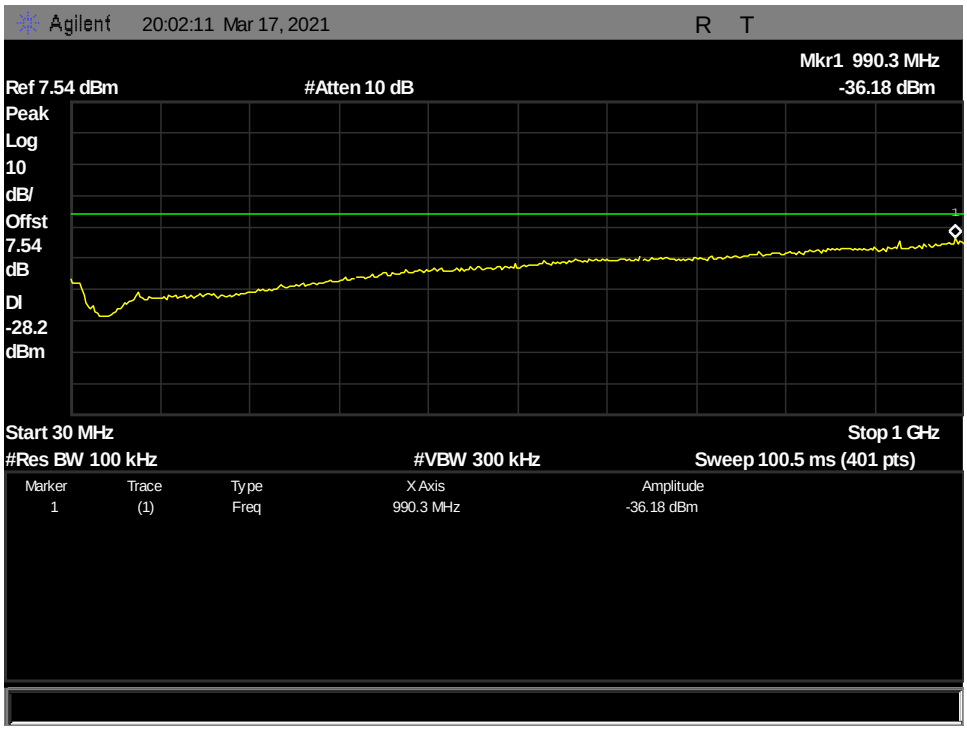

Figure 153: Radiated Spurious Emissions, 802.11b, 2437 MHz - 30MHz-1GHz

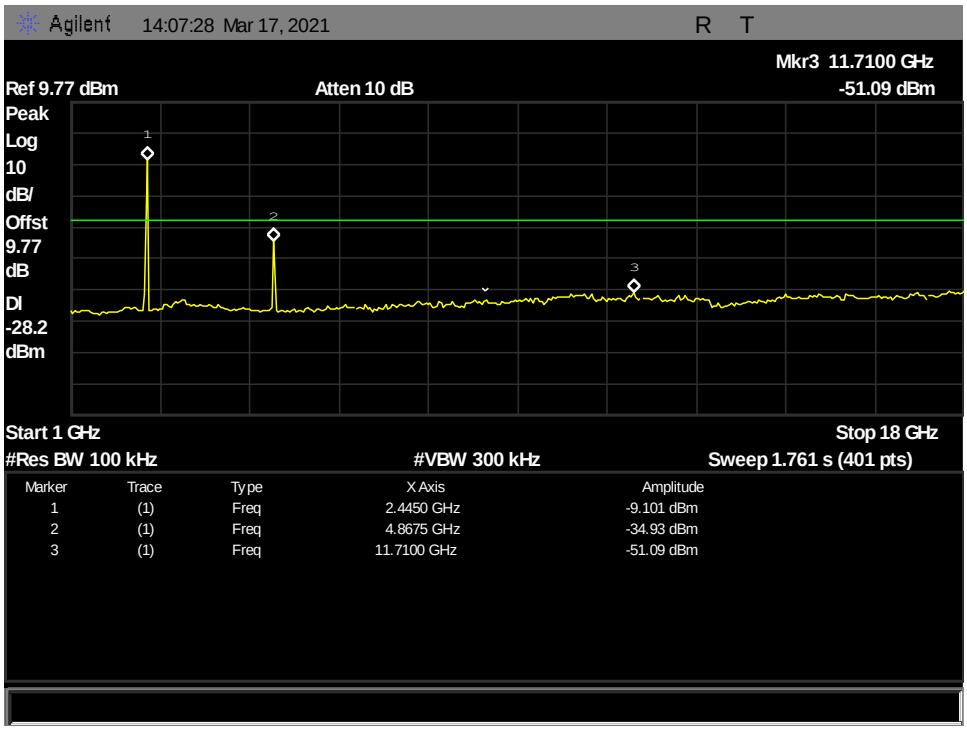

Figure 154: Radiated Spurious Emissions, 802.11b, 2437 MHz - 1GHz-18GHz

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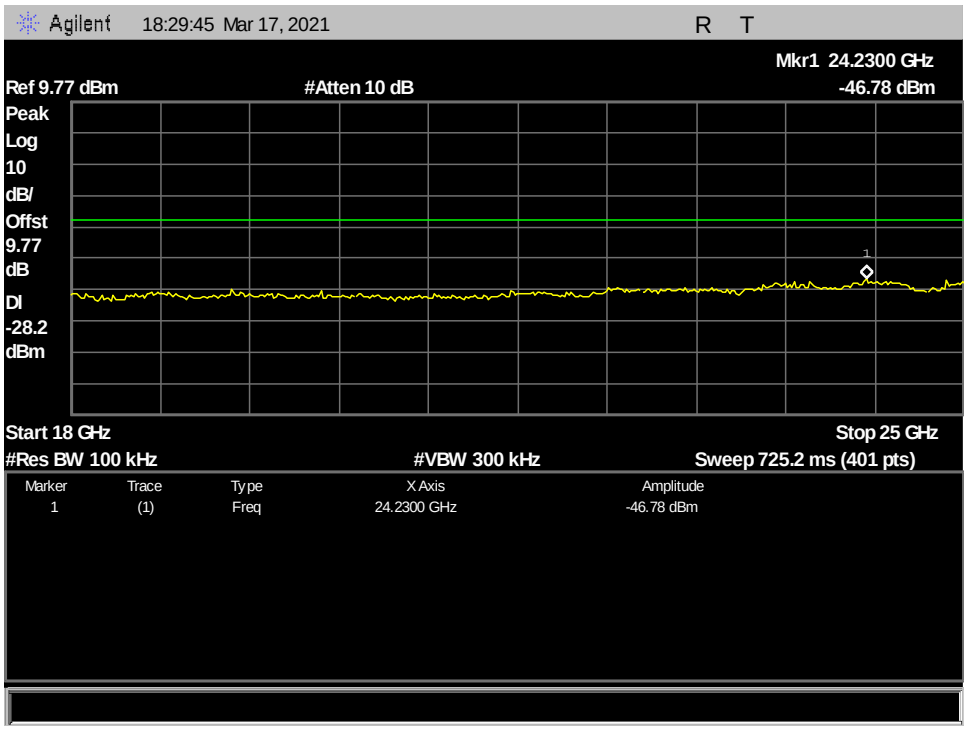

Figure 155: Radiated Spurious Emissions, 802.11b, 2437 MHz - 18GHz-25GHz

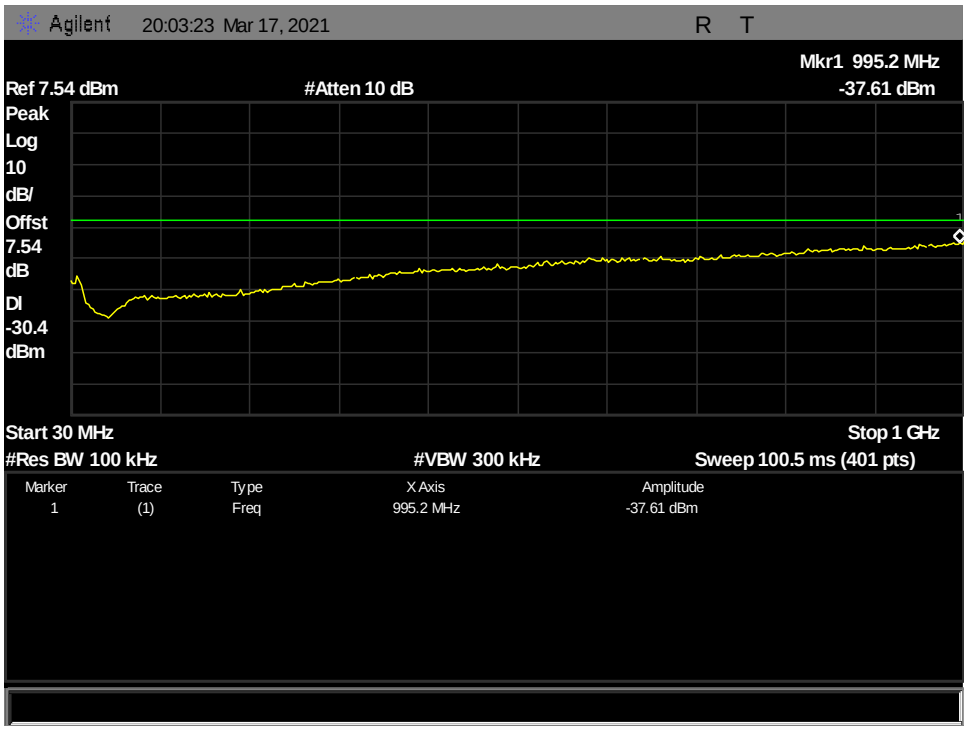

Figure 156: Radiated Spurious Emissions, 802.11b, 2462 MHz - 30MHz-1GHz

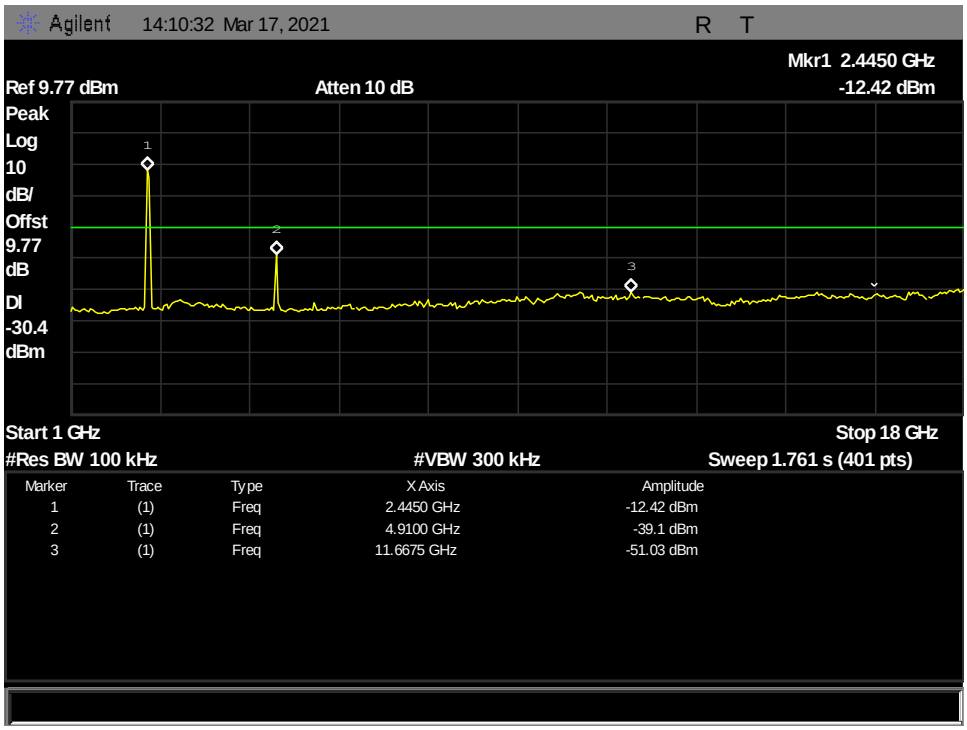

Figure 157: Radiated Spurious Emissions, 802.11b, 2462 MHz - 1GHz-18GHz

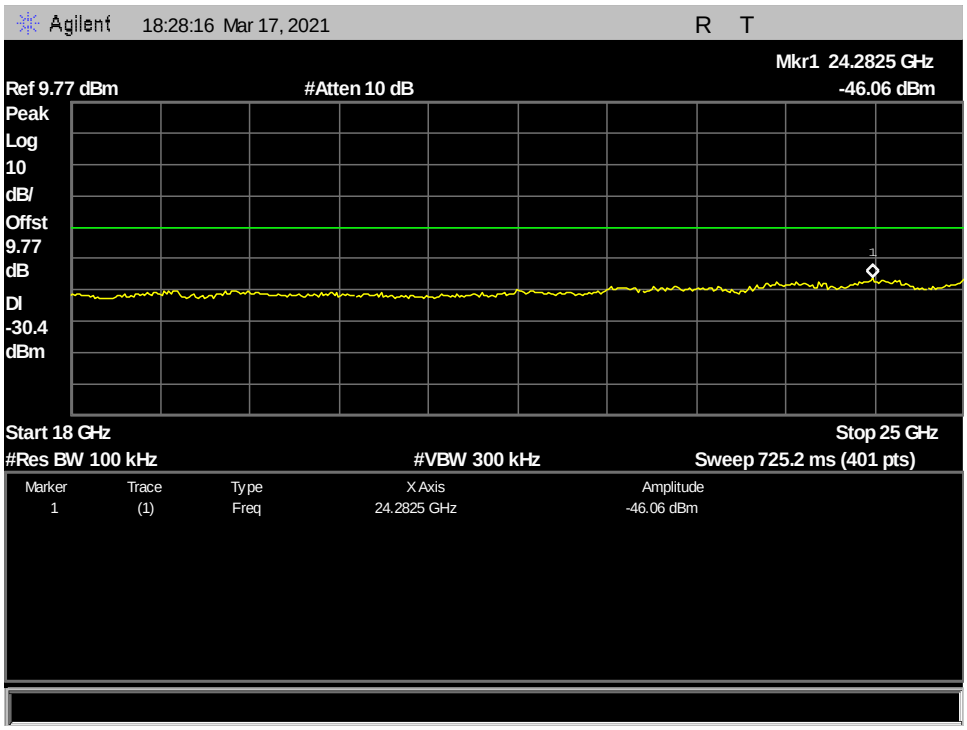

Figure 158**: Radiated Spurious Emissions, 802.11b, 2462 MHz - 18GHz-25GHz**

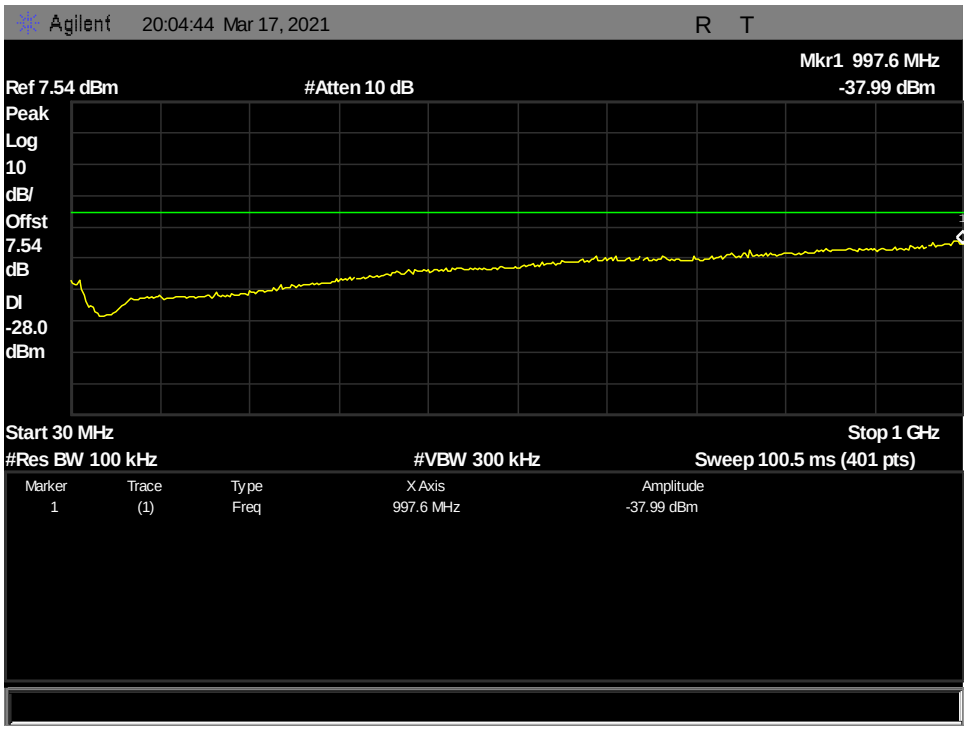

Figure 159: Radiated Spurious Emissions, 802.11g, 2412 MHz - 30MHz-1GHz

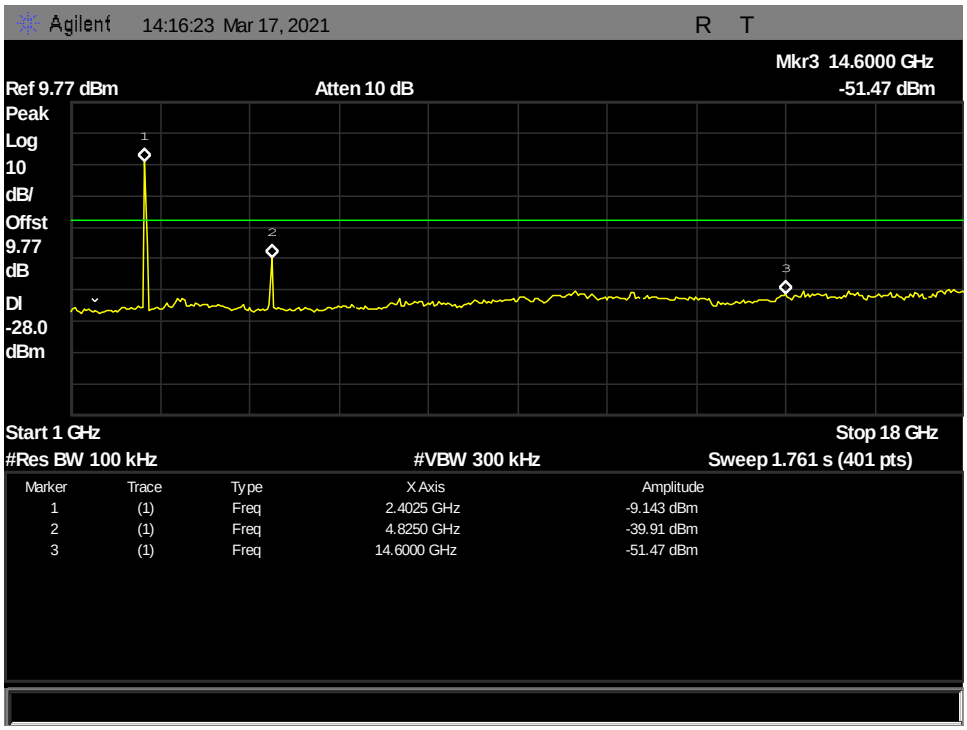

Figure 160: Radiated Spurious Emissions, 802.11g, 2412 MHz - 1GHz-18GHz

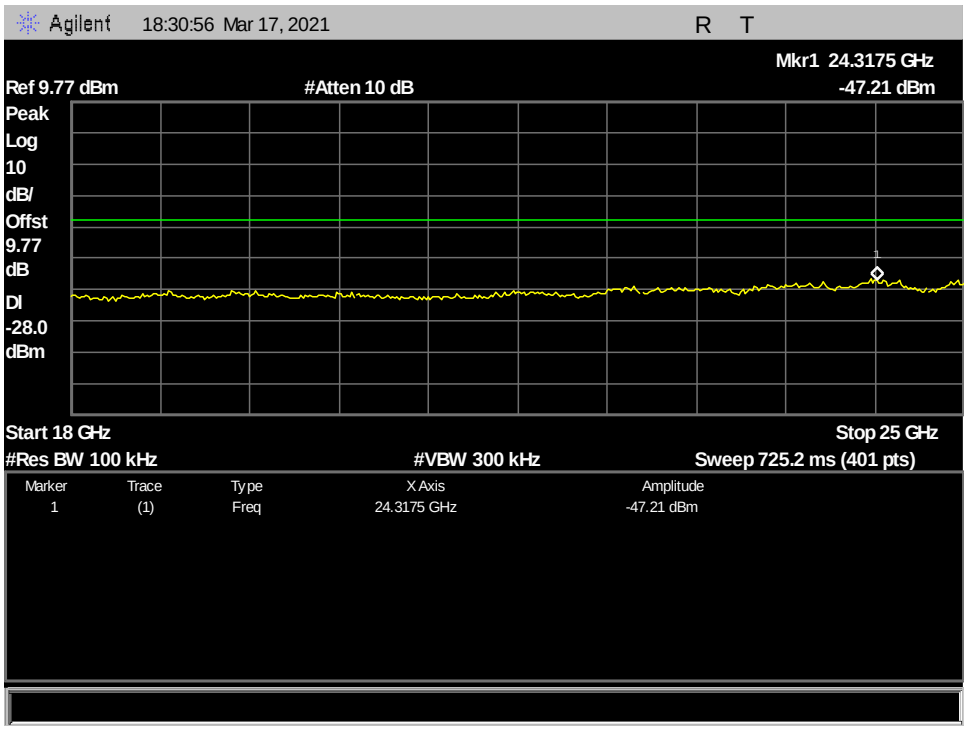

Figure 161: Radiated Spurious Emissions, 802.11g, 2412 MHz - 18GHz-25GHz

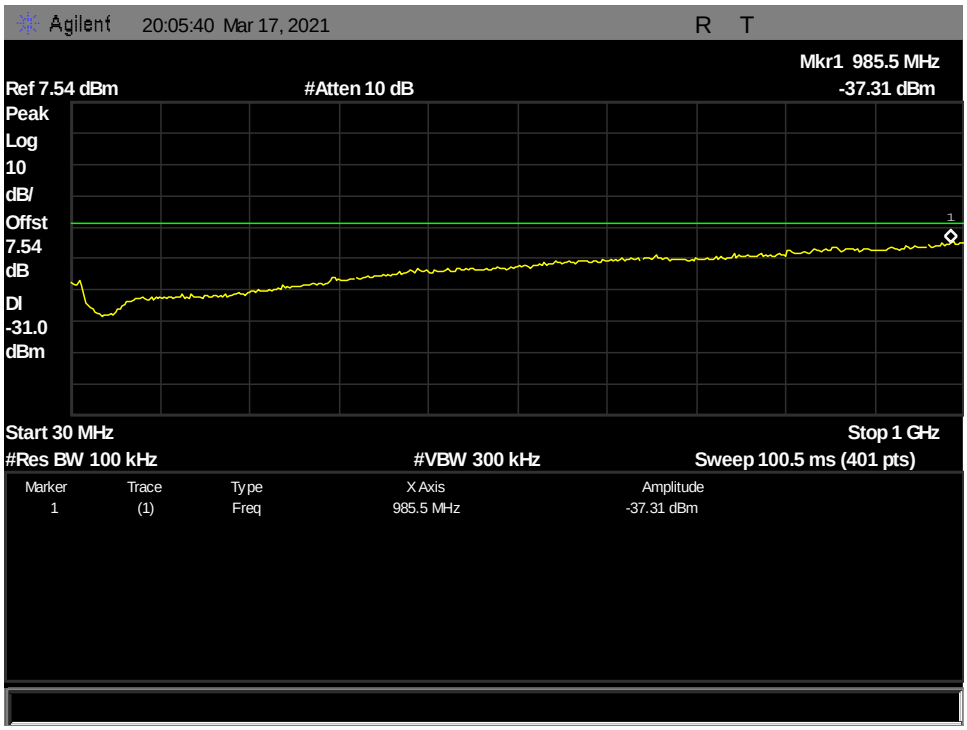

Figure 162: Radiated Spurious Emissions, 802.11g, 2437 MHz - 30MHz-1GHz

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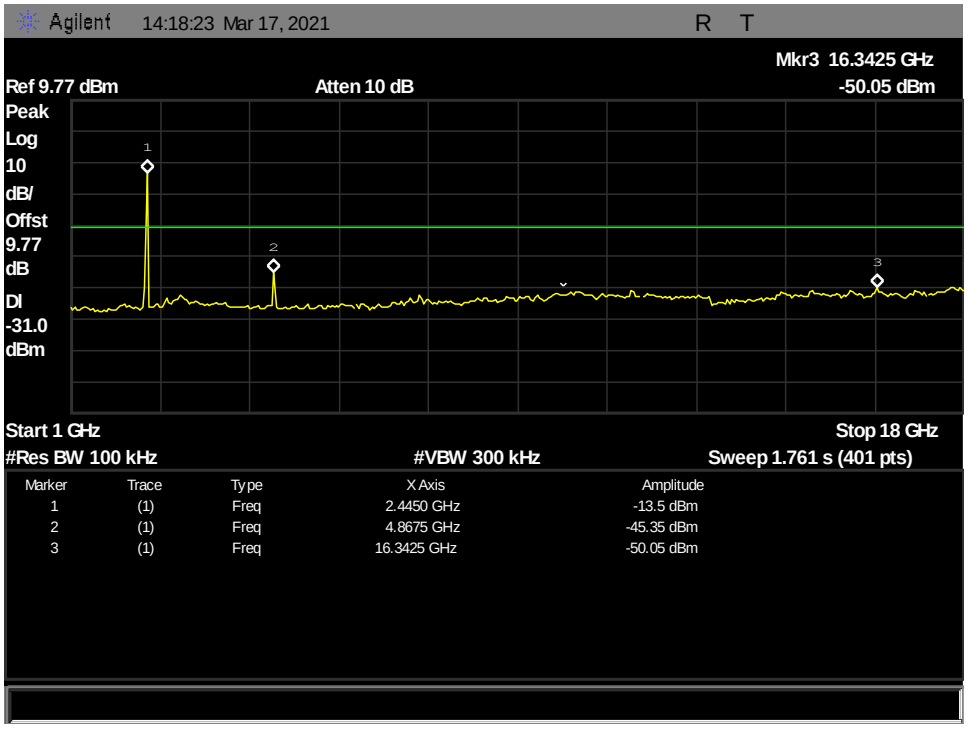

Figure 163: Radiated Spurious Emissions, 802.11g, 2437 MHz - 1GHz-18GHz

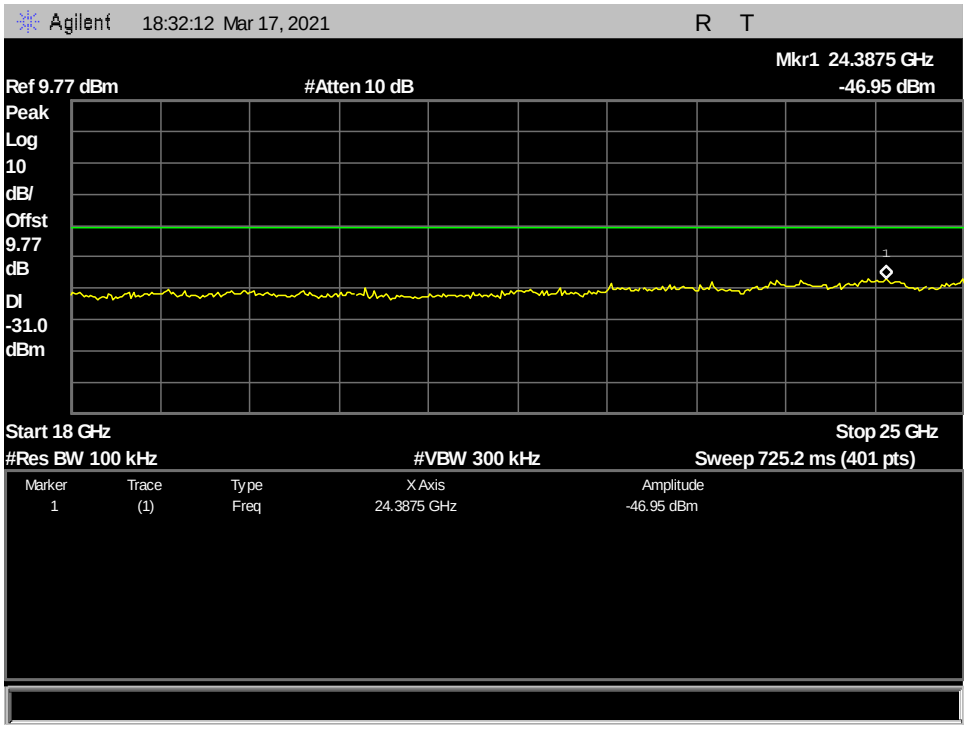

Figure 164: Radiated Spurious Emissions, 802.11g, 2437 MHz - 18GHz-25GHz

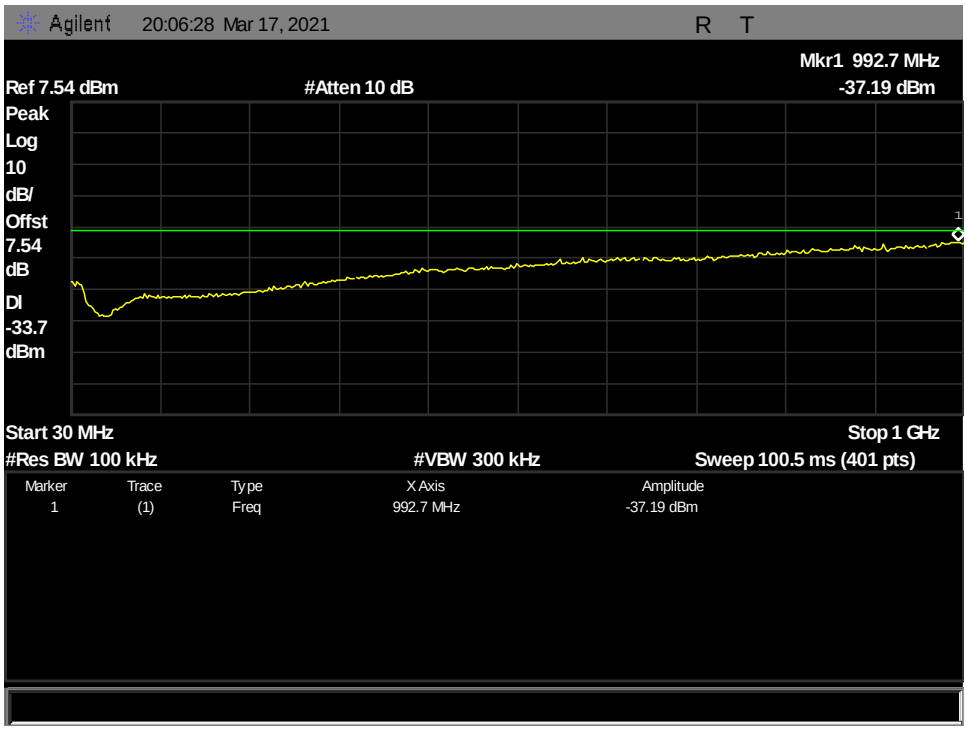

Figure 165: Radiated Spurious Emissions, 802.11g, 2462 MHz - 30MHz-1GHz

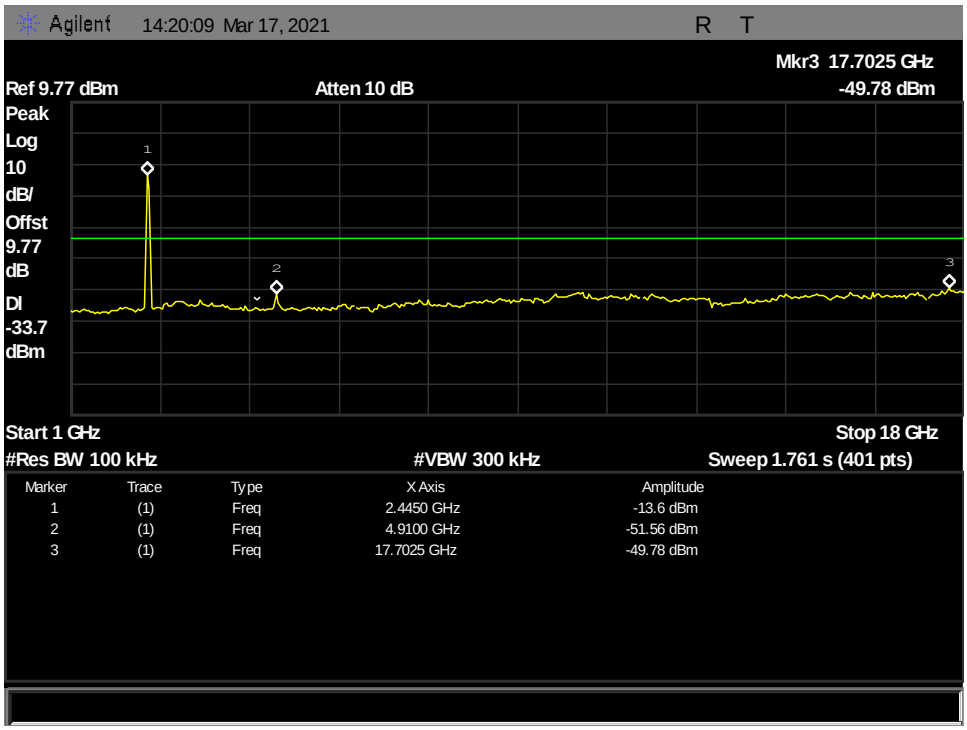

Figure 166: Radiated Spurious Emissions, 802.11g, 2462 MHz - 1GHz-18GHz

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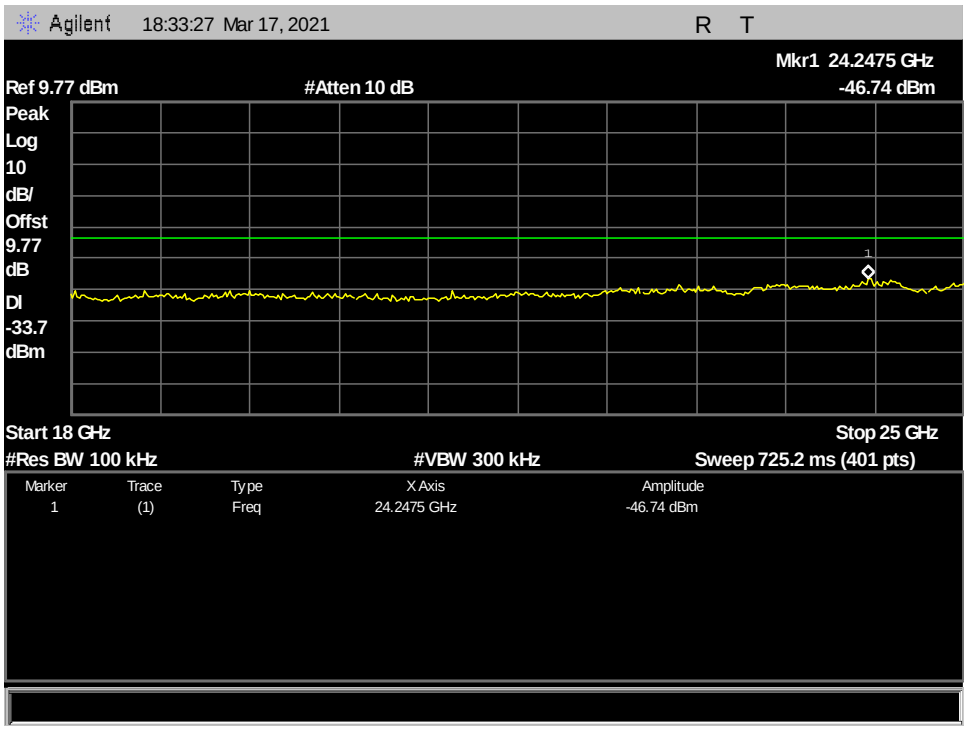

Figure 167: Radiated Spurious Emissions, 802.11g, 2462 MHz - 18GHz-25GHz

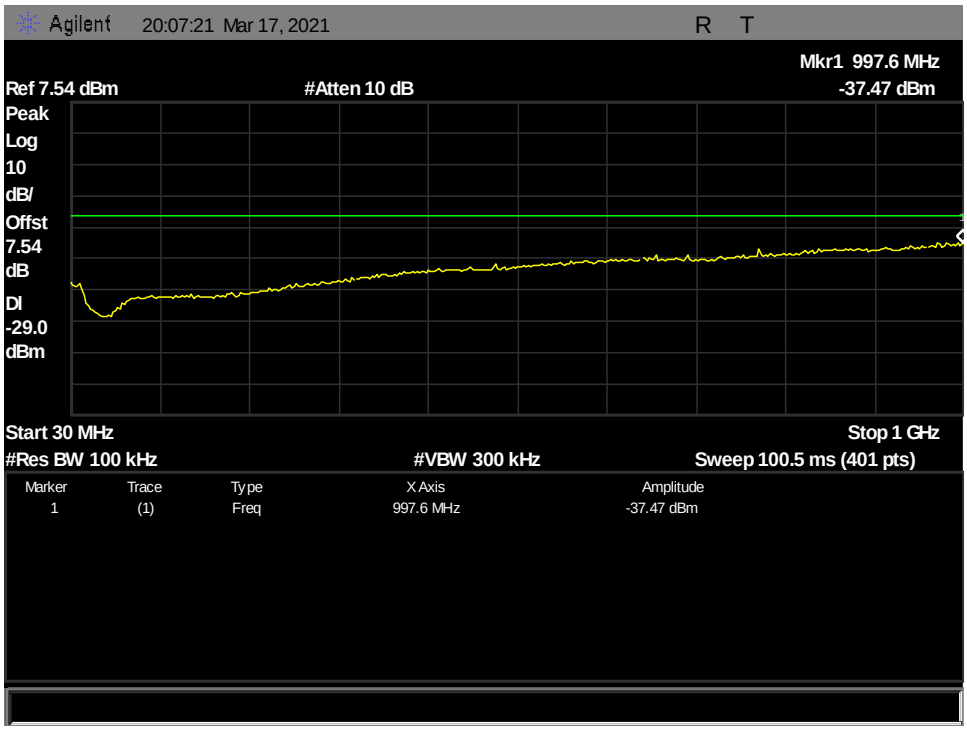

Figure 168: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 30MHz-1GHz

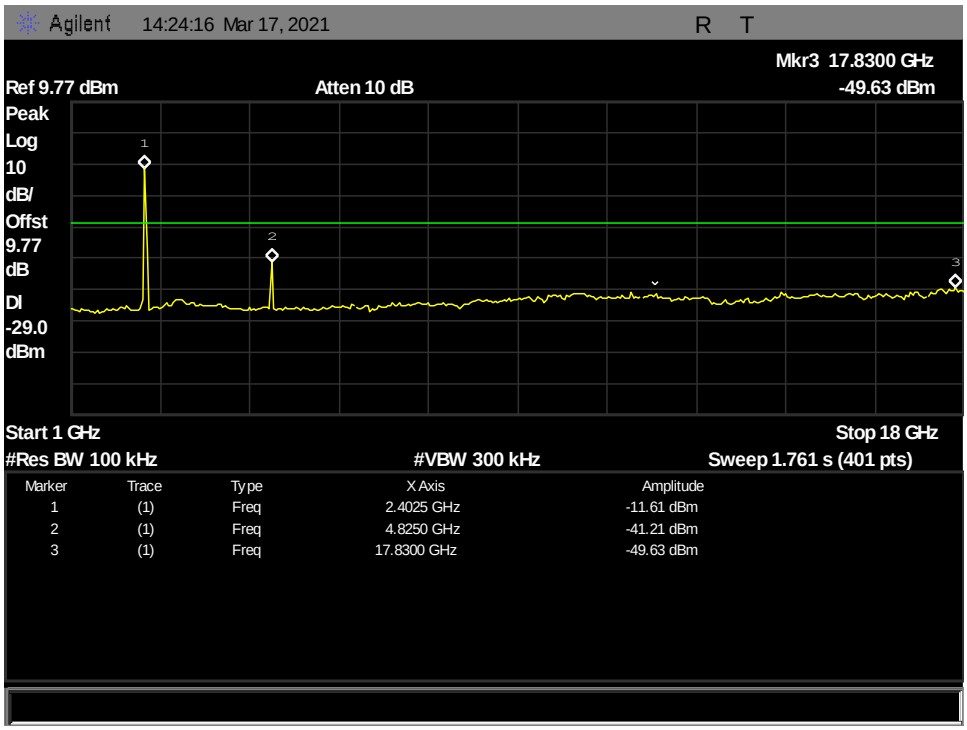

Figure 169: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 1GHz-18GHz

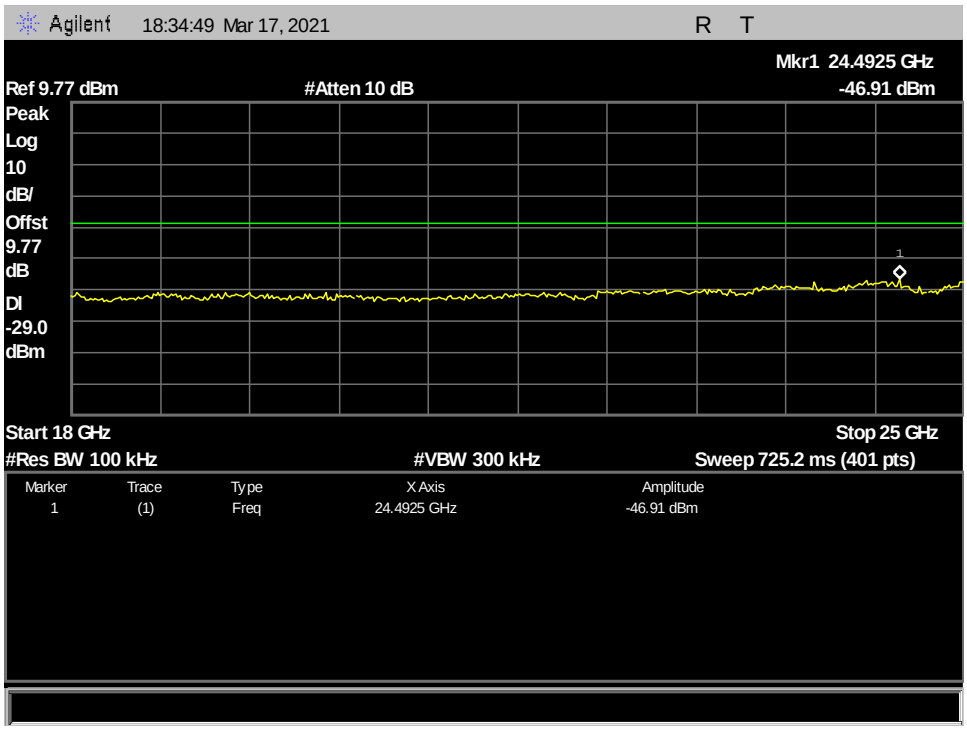

Figure 170: Radiated Spurious Emissions, 802.11n_HT20, 2412 MHz - 18GHz-25GHz

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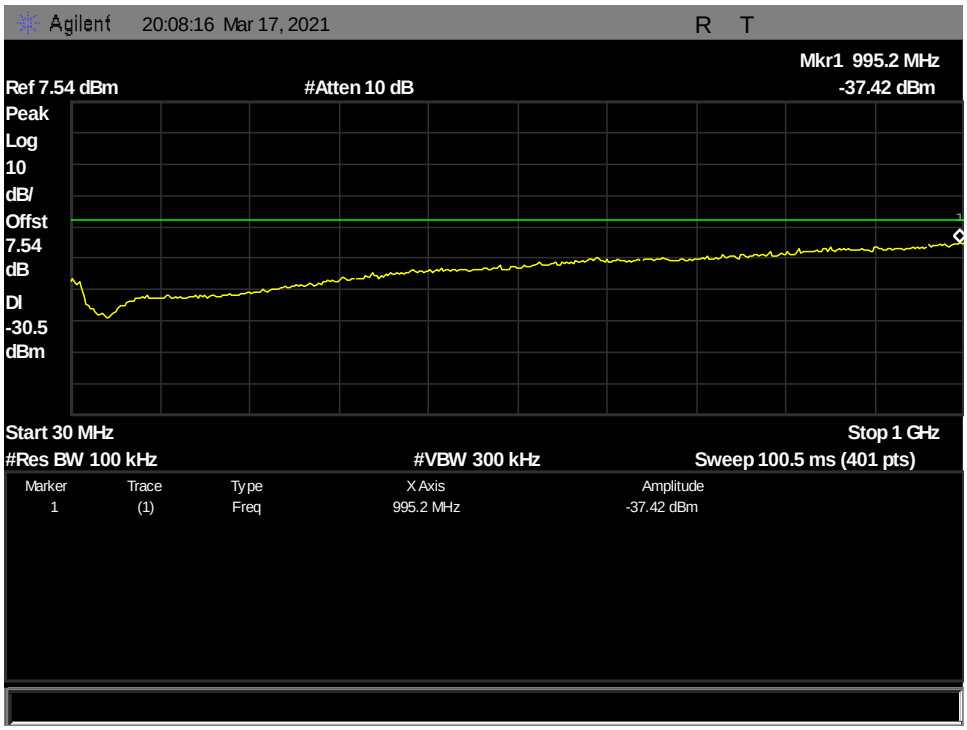

Figure 171: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 30MHz-1GHz

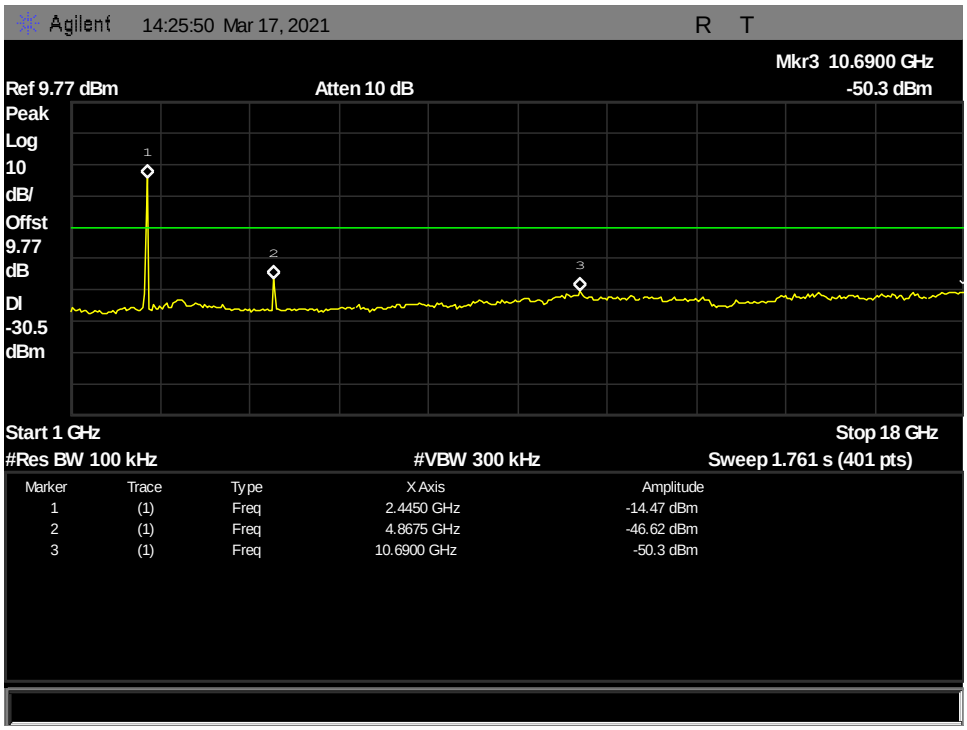

Figure 172: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 1GHz-18GHz

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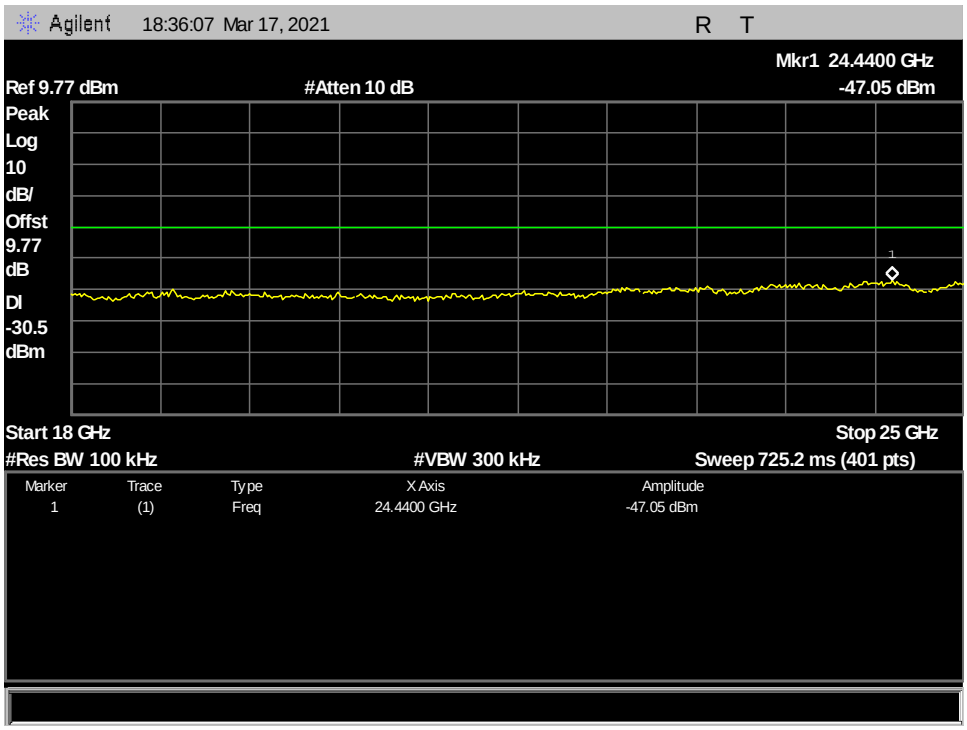

Figure 173: Radiated Spurious Emissions, 802.11n_HT20, 2437 MHz - 18GHz-25GHz

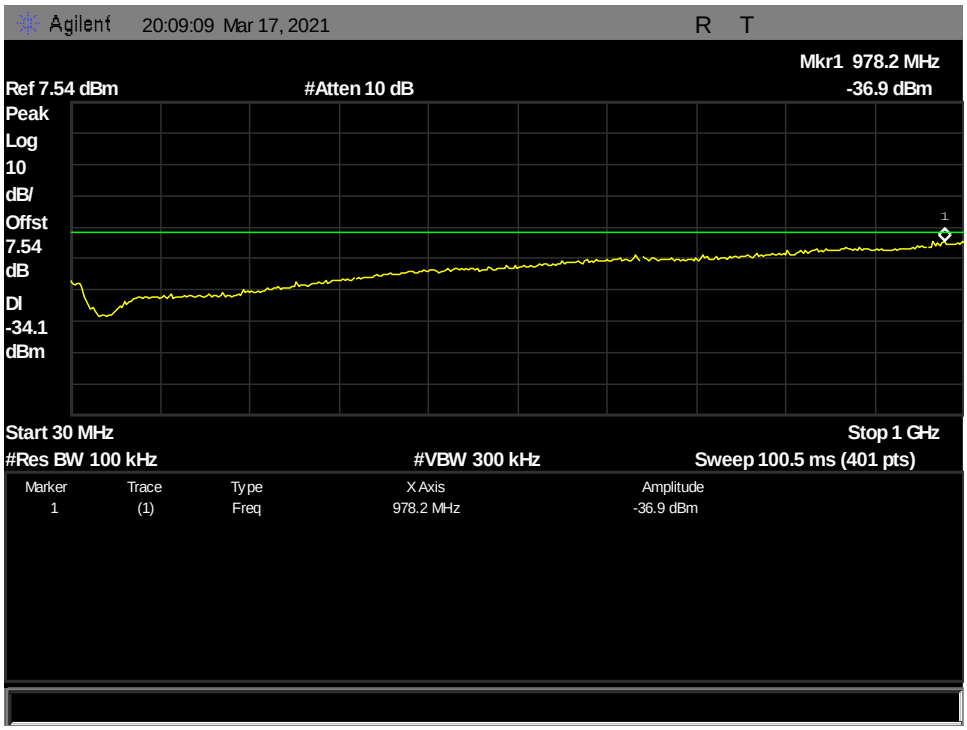

Figure 174: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 30MHz-1GHz

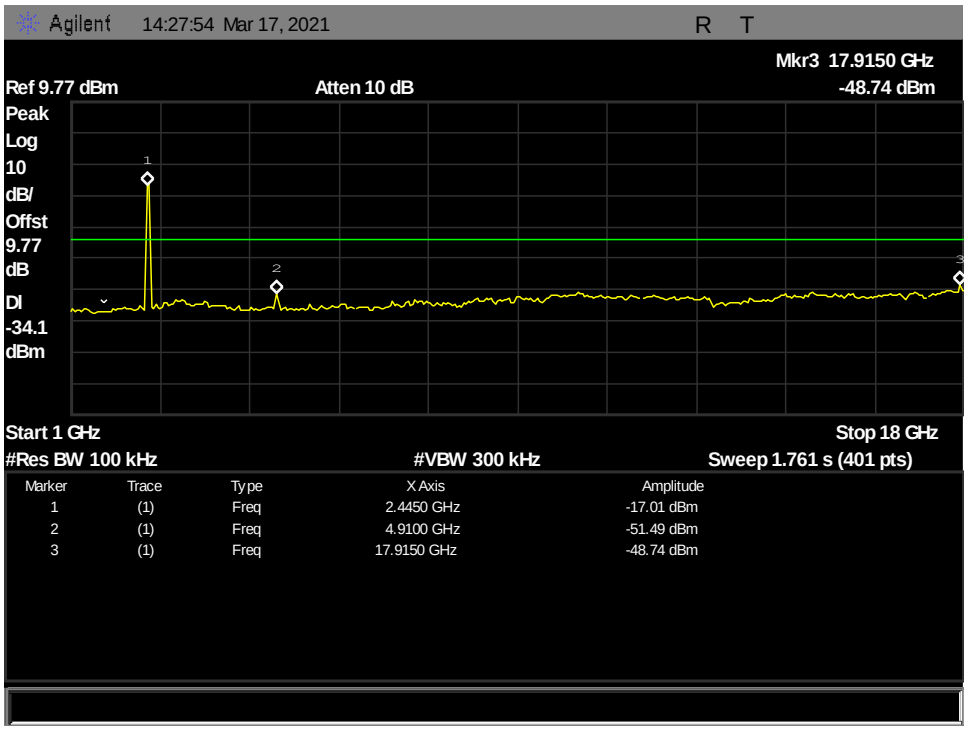

Figure 175: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 1GHz-18GHz

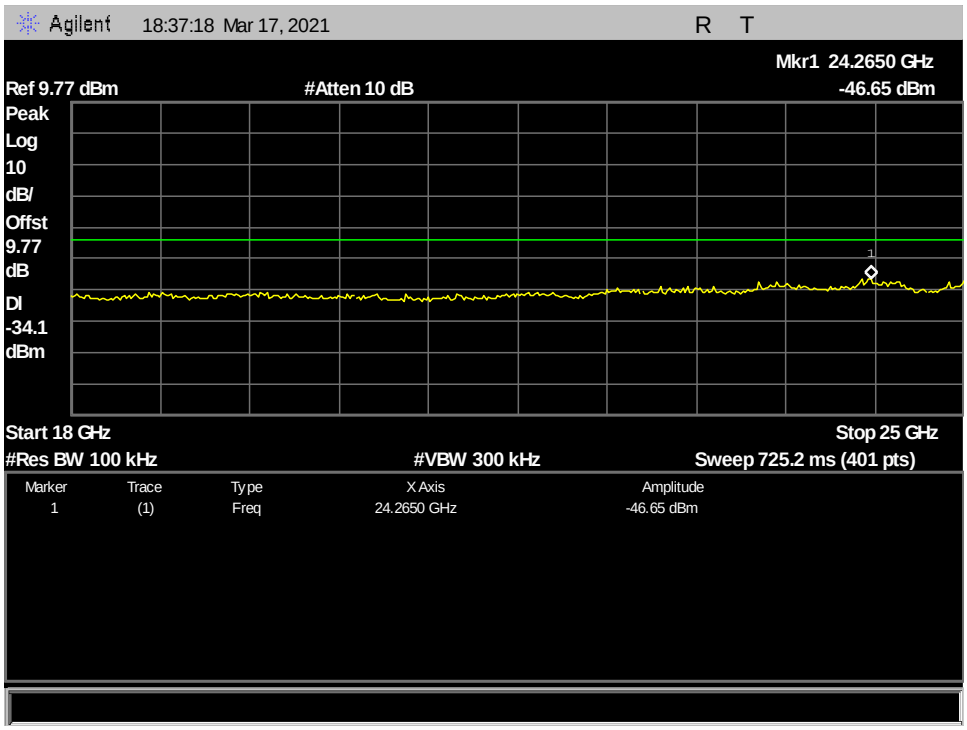

Figure 176: Radiated Spurious Emissions, 802.11n_HT20, 2462 MHz - 18GHz-25GHz

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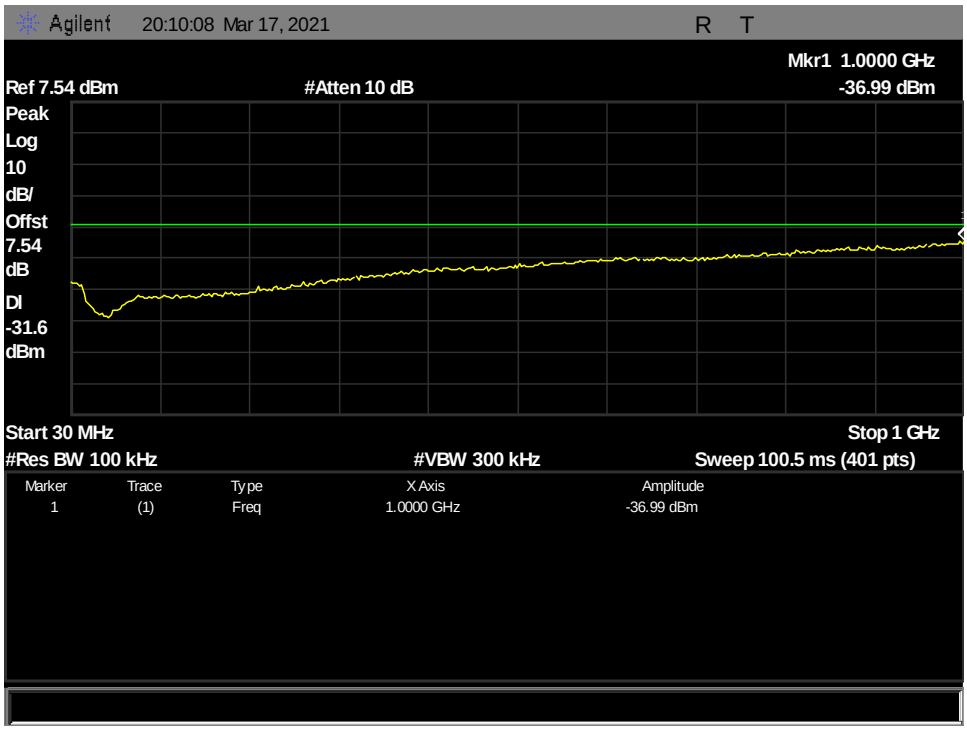

Figure 177: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 30MHz-1GHz

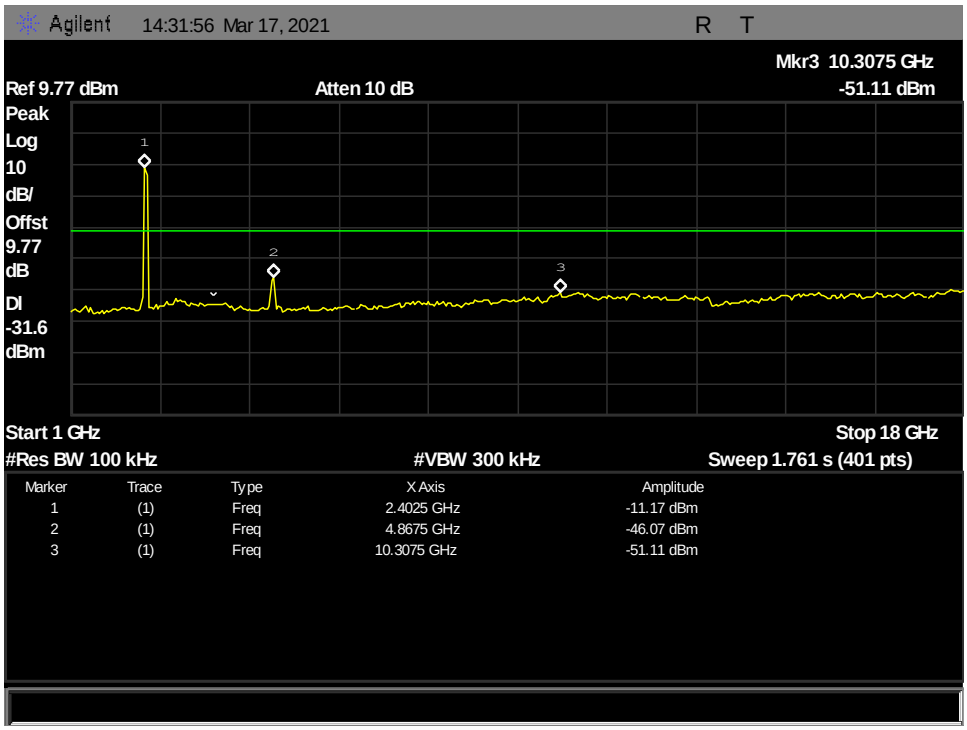

Figure 178: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 1GHz-18GHz

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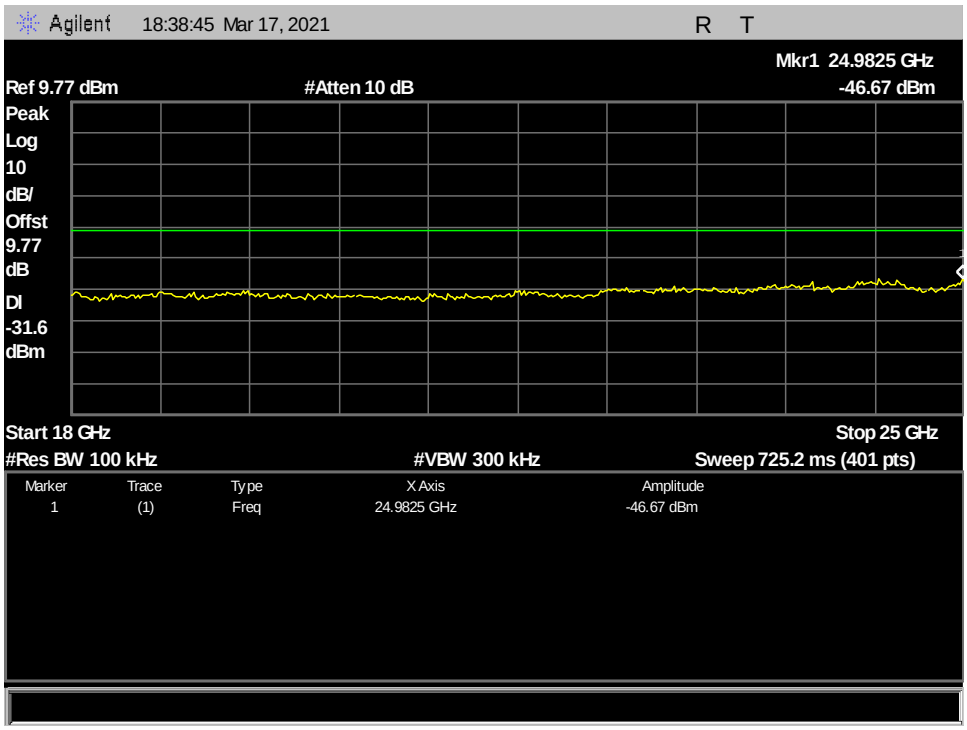

Figure 179: Radiated Spurious Emissions, 802.11n_HT40, 2422 MHz - 18GHz-25GHz

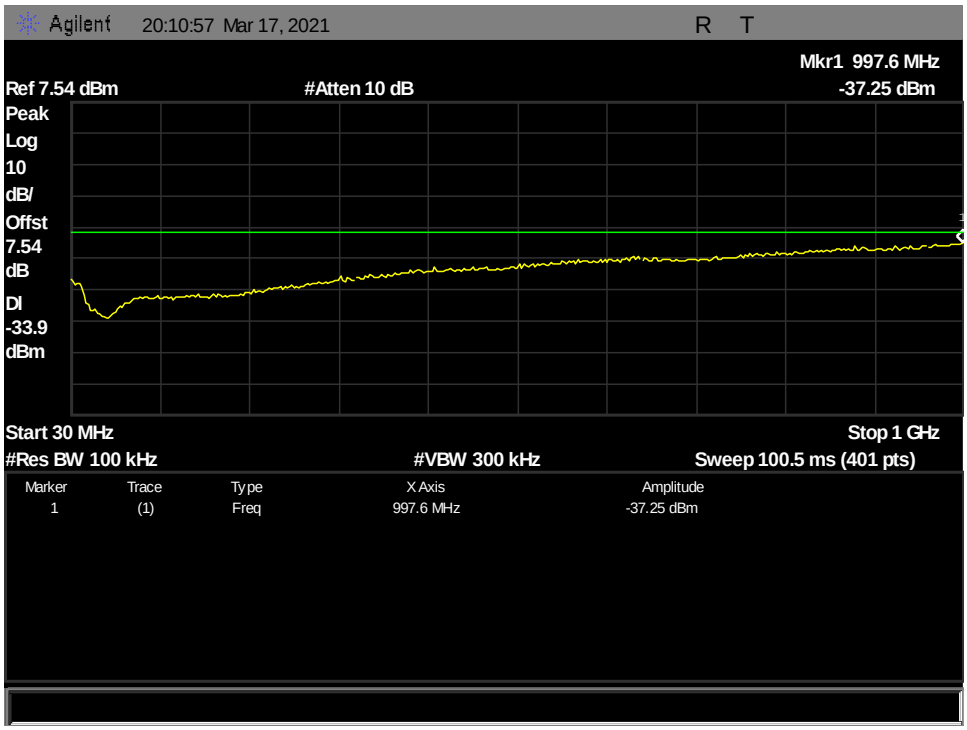

Figure 180: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 30MHz-1GHz

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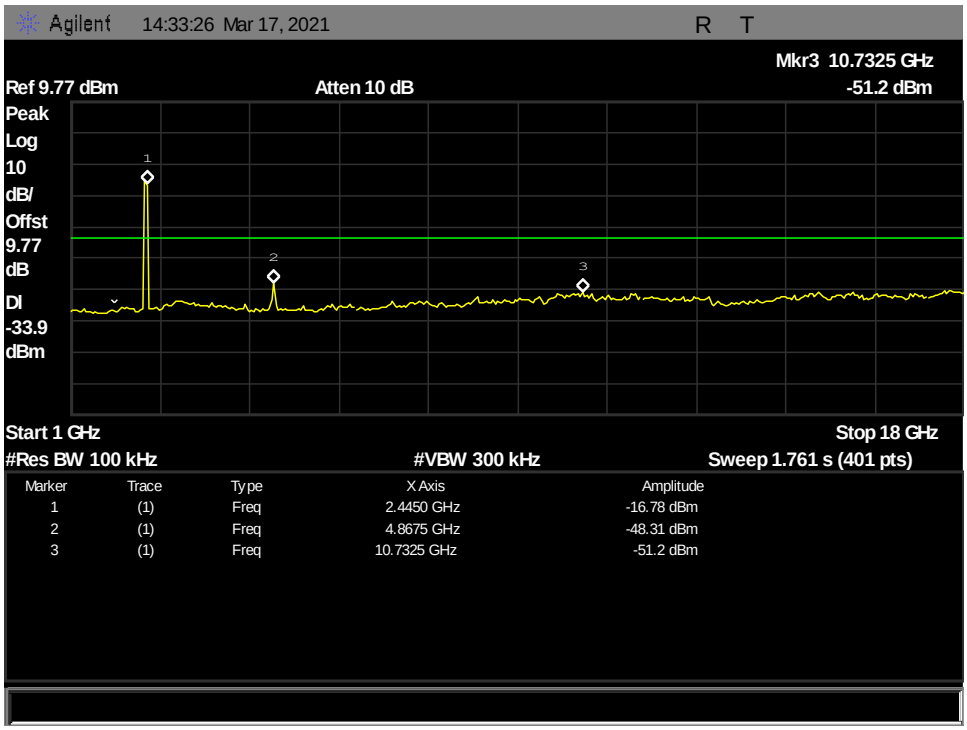

Figure 181**: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 1GHz-18GHz**

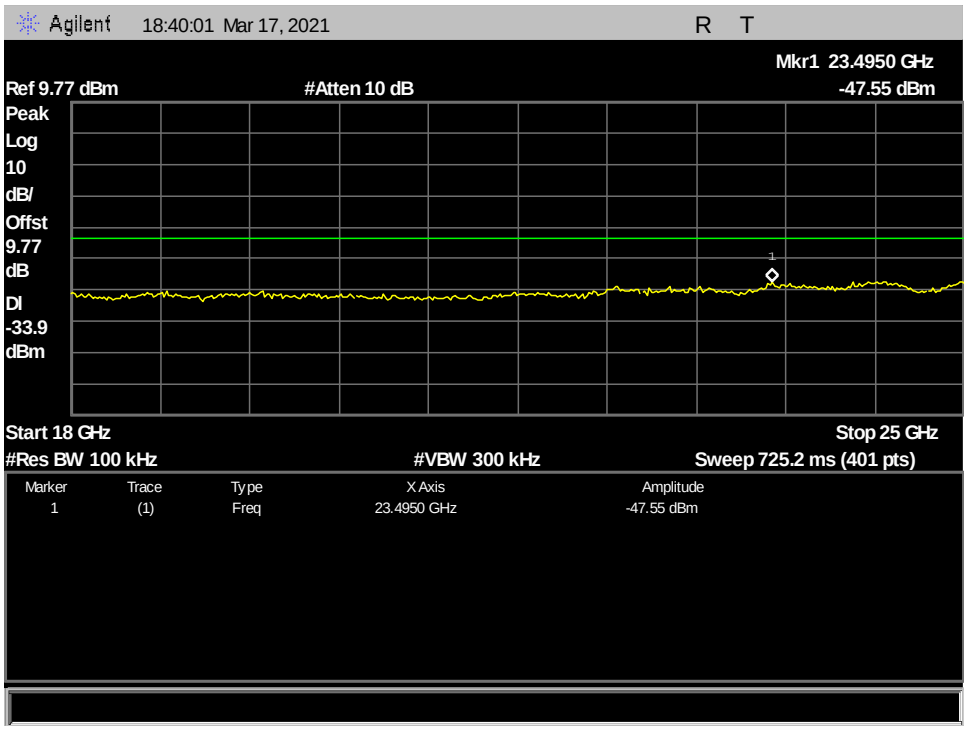

Figure 182: Radiated Spurious Emissions, 802.11n_HT40, 2437 MHz - 18GHz-25GHz

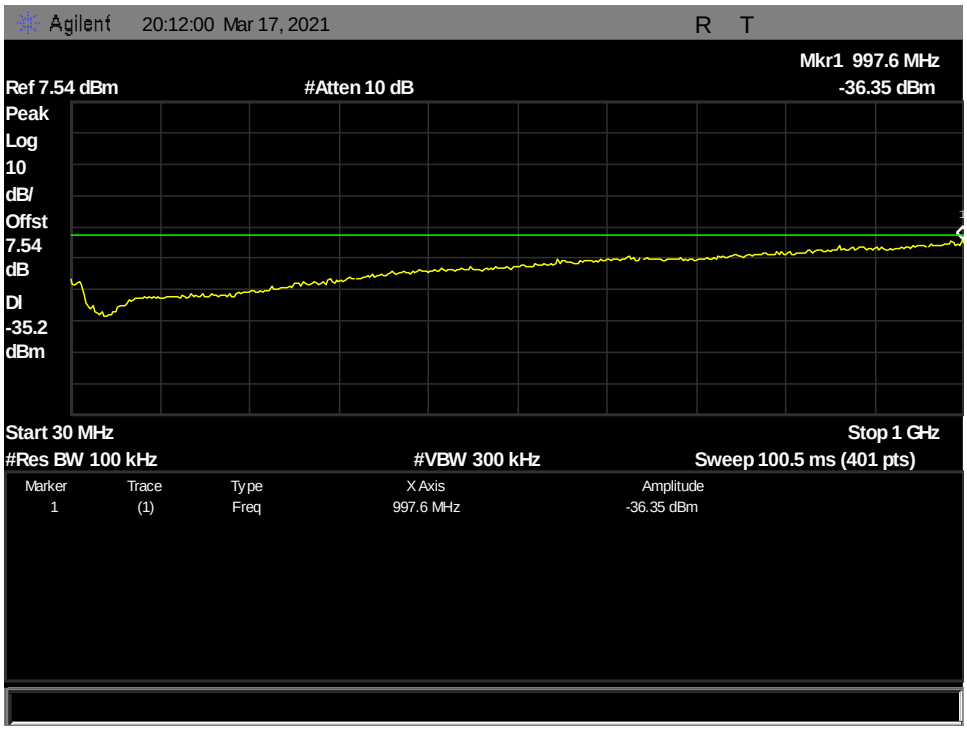

Figure 183: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 30MHz-1GHz

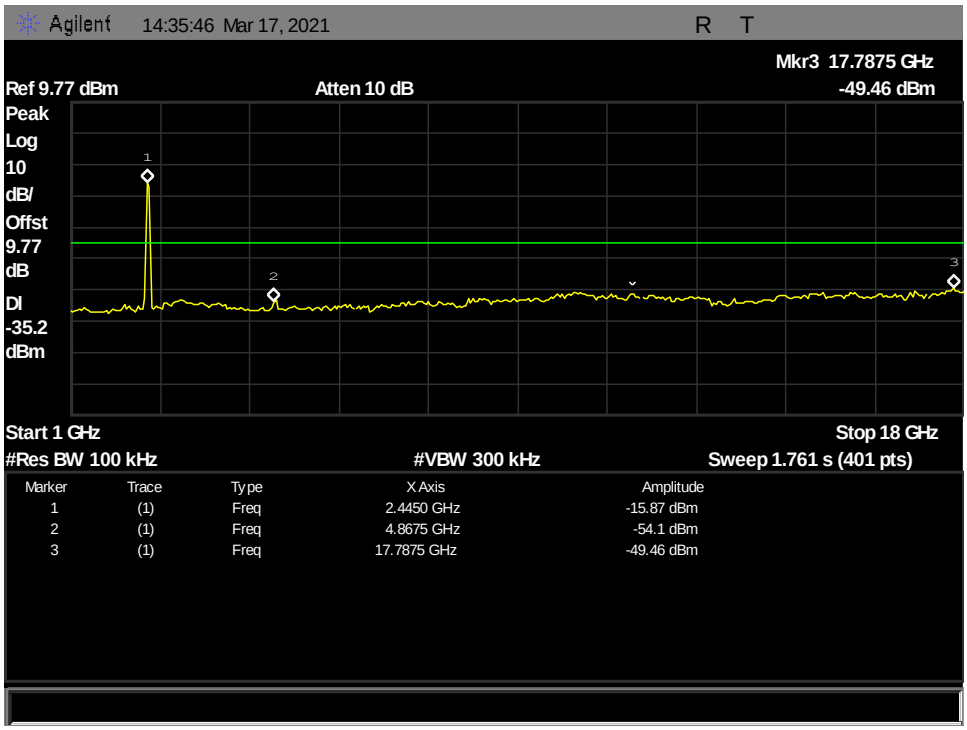

Figure 184: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 1GHz-18GHz

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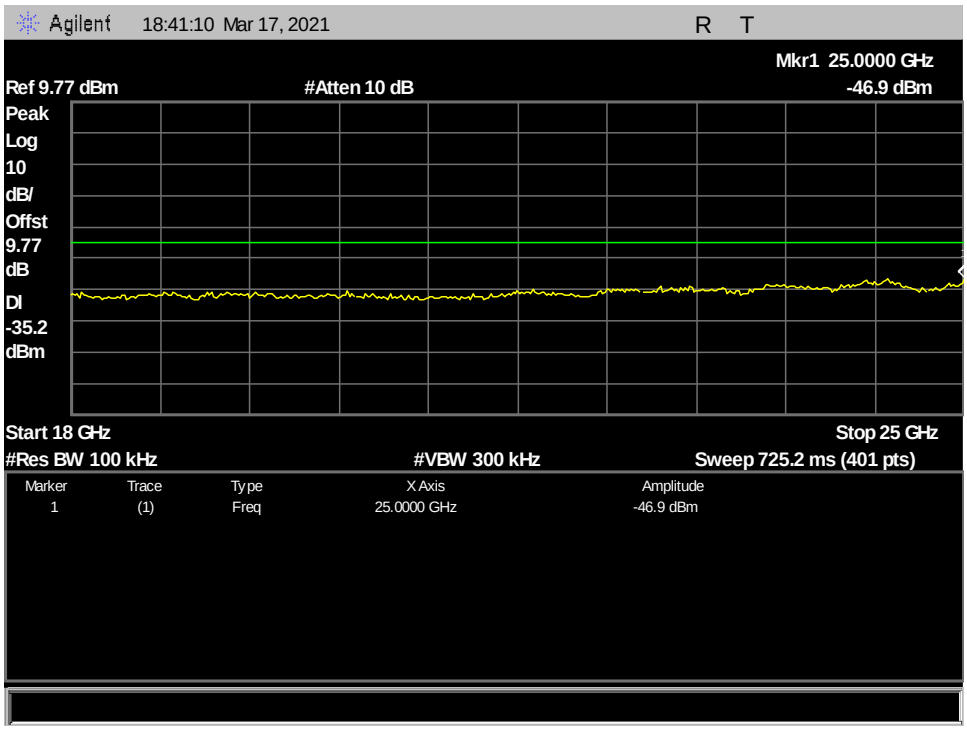

Figure 185: Radiated Spurious Emissions, 802.11n_HT40, 2452 MHz - 18GHz-25GHz

Radiated Band Edge

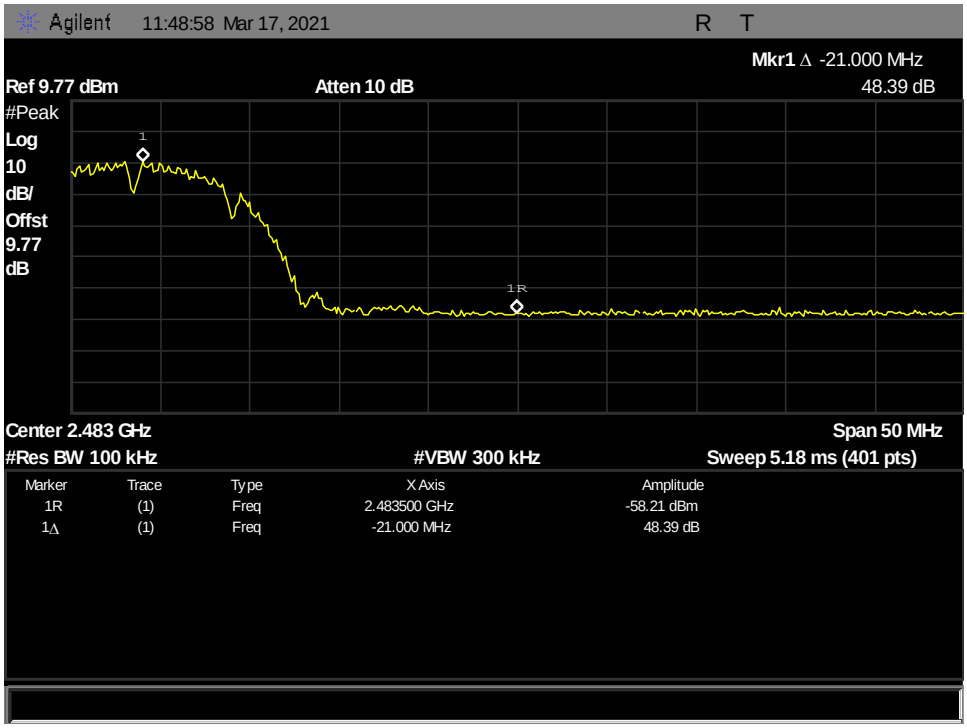

Figure 186: Radiated Band Edge, 802.11b, High - 2462 MHz

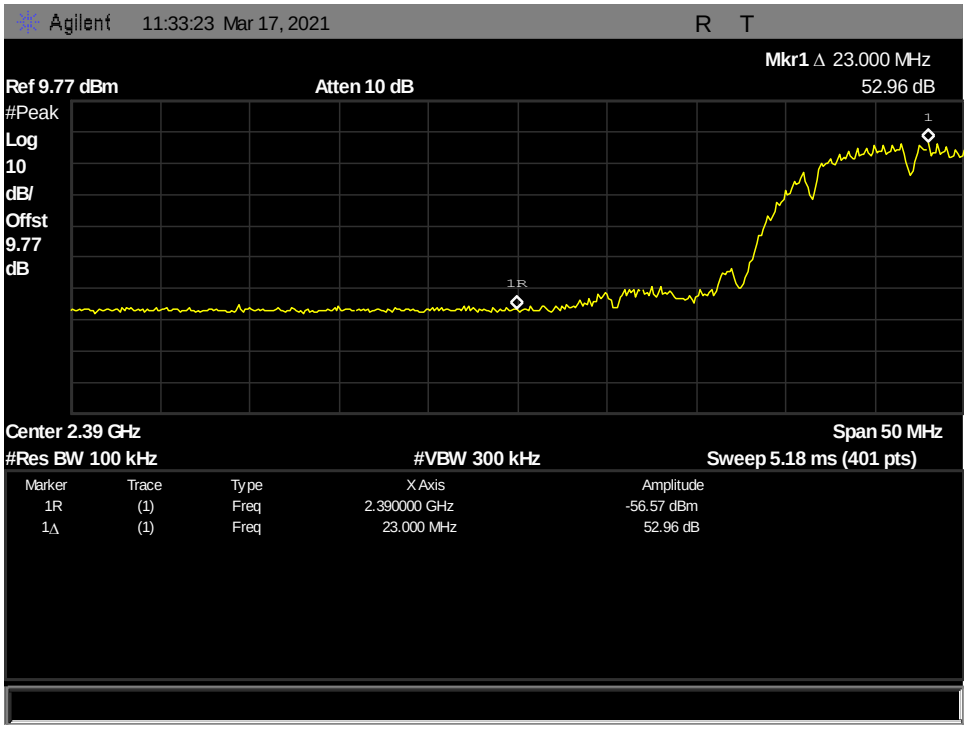

Figure 187: Radiated Band Edge, 802.11b, Low - 2412 MHz

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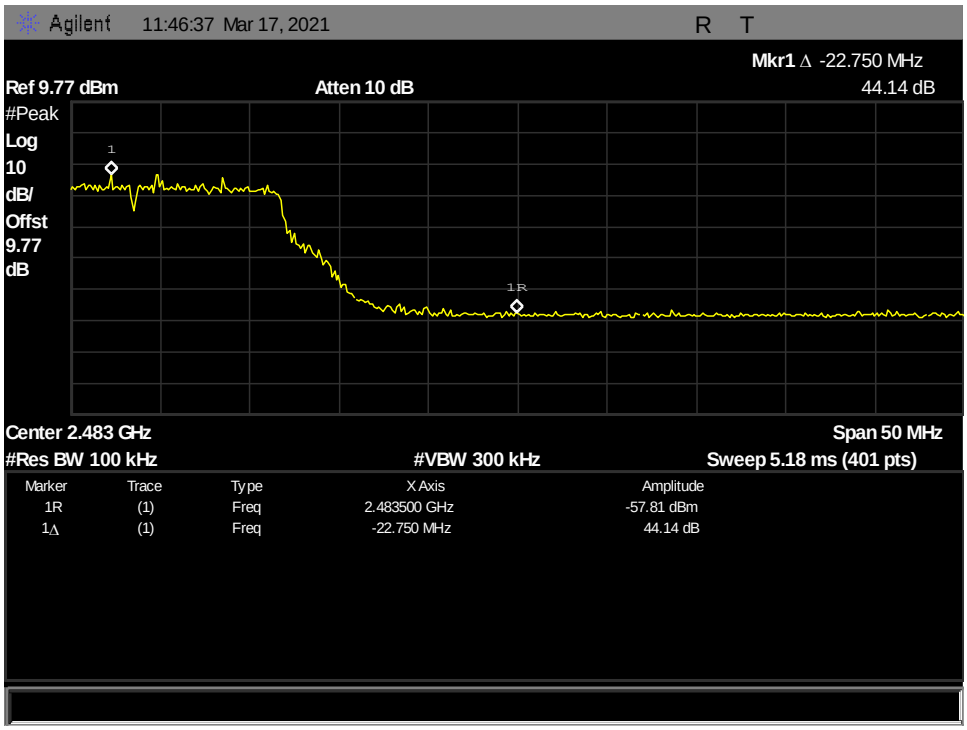

Figure 188: Radiated Band Edge, 802.11g, High - 2462 MHz

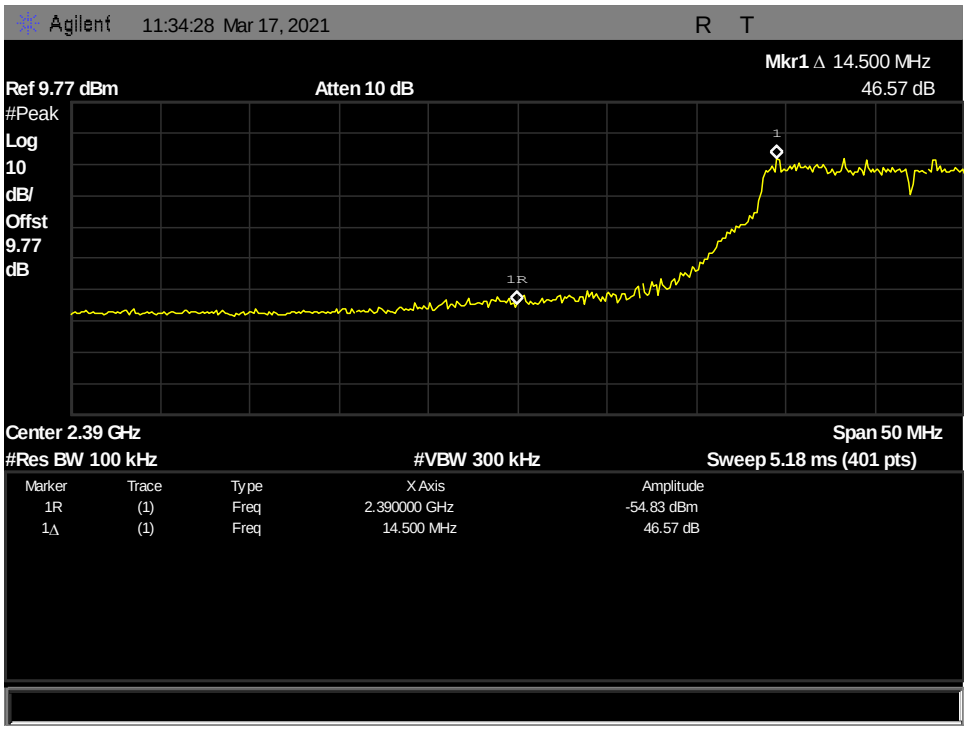

Figure 189: Radiated Band Edge, 802.11g, Low - 2412 MHz

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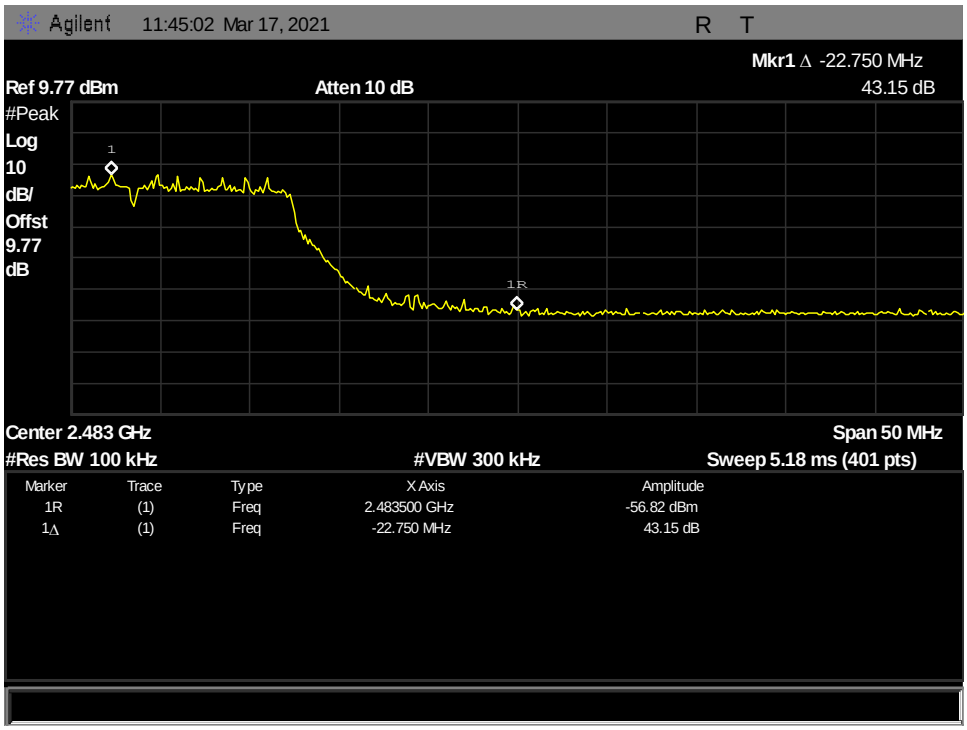

Figure 190: Radiated Band Edge, 802.11n_HT20, High- 2462 MHz

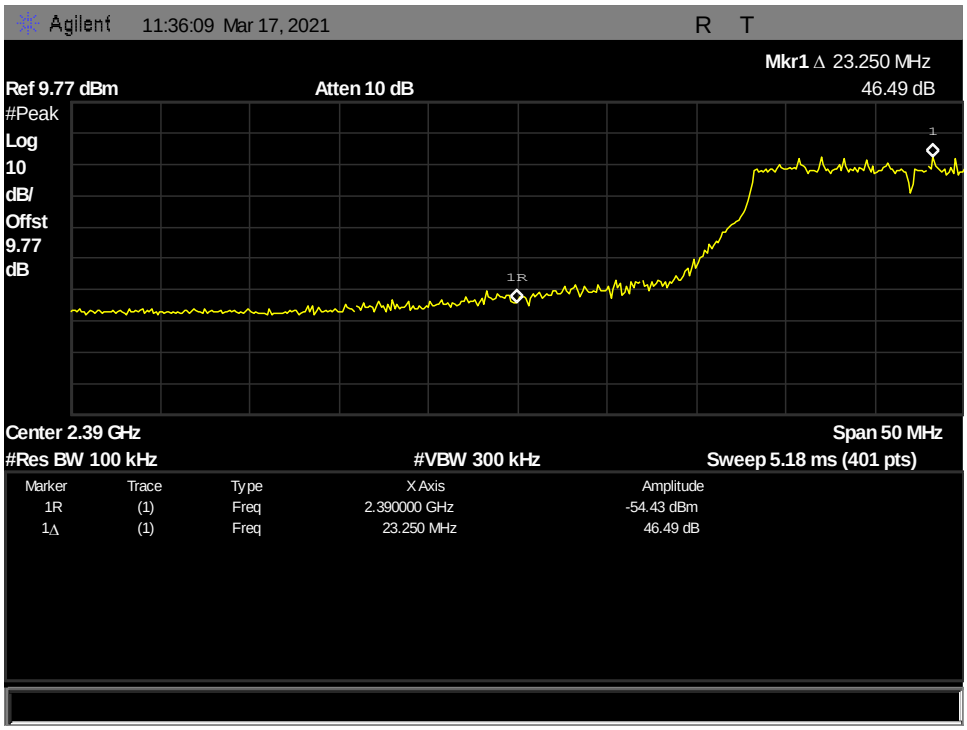

Figure 191: Radiated Band Edge, 802.11n_HT20, Low - 2412 MHz

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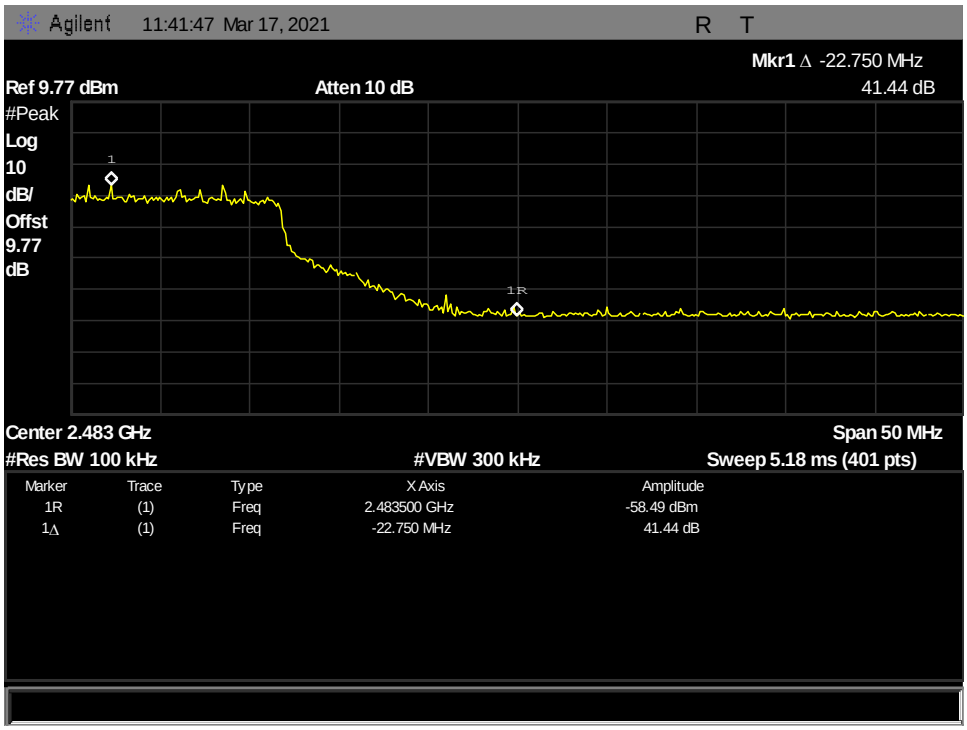

Figure 192: Radiated Band Edge, 802.11n_HT40, High- 2452 MHz

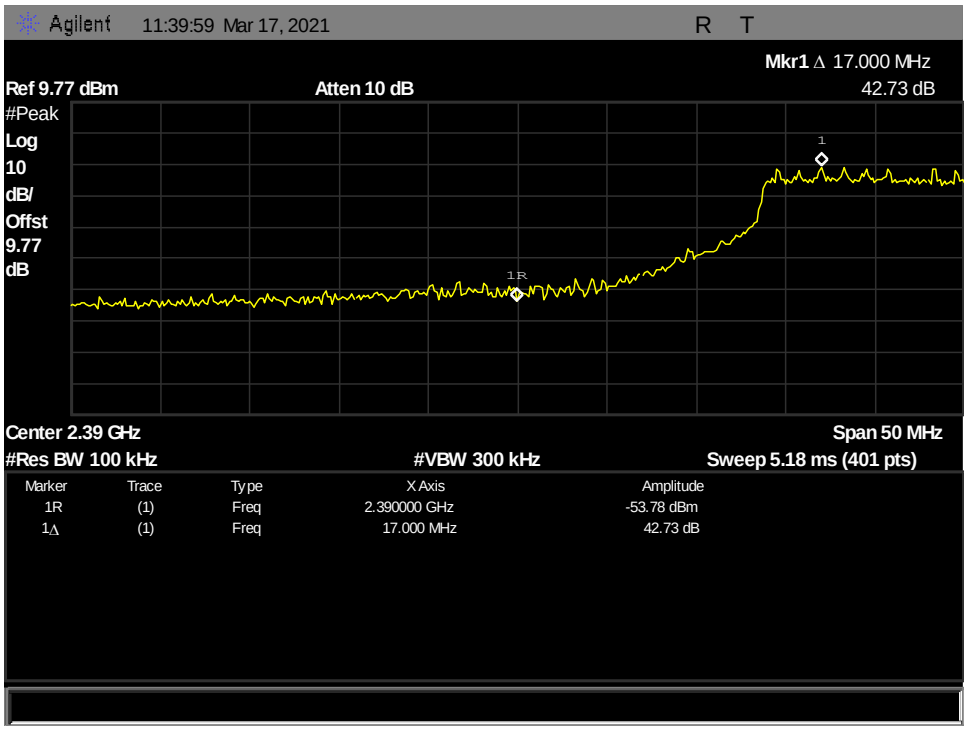

Figure 193: Radiated Band Edge, 802.11n_HT40, Low - 2422 MHz

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Radiated Spurious Emissions Test Setup

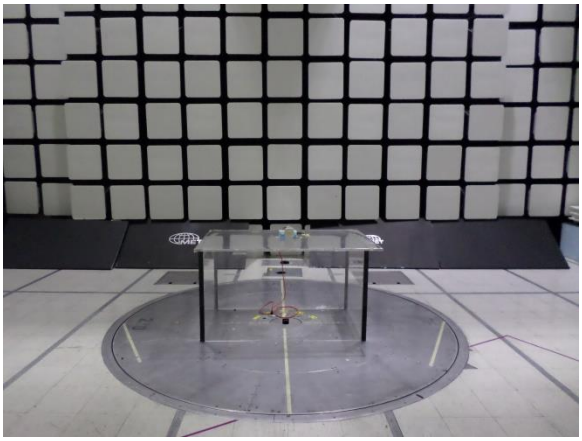

Figure 194: Radiated Spurious Emissions Test Setup, 30MHz-1000MHz - Setup Front View

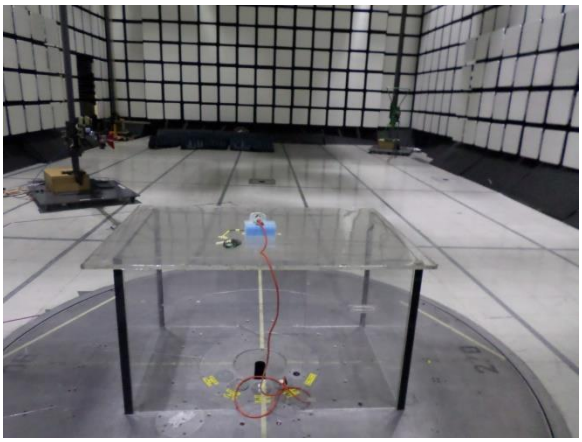

Figure 195: Radiated Spurious Emissions Test Setup, 30MHz-1000MHz - Setup Rear View

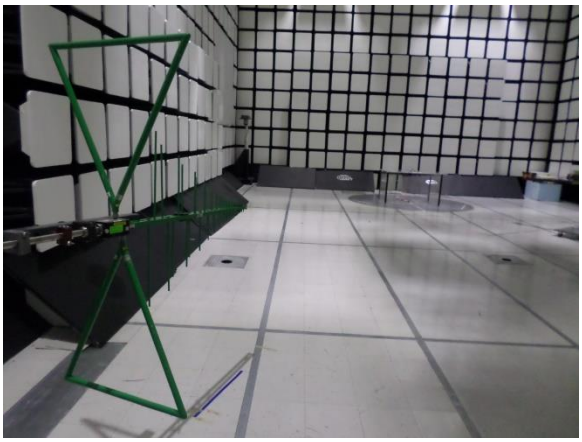

Figure 196: Radiated Spurious Emissions Test Setup, 30MHz-1000MHz - Setup Antenna View

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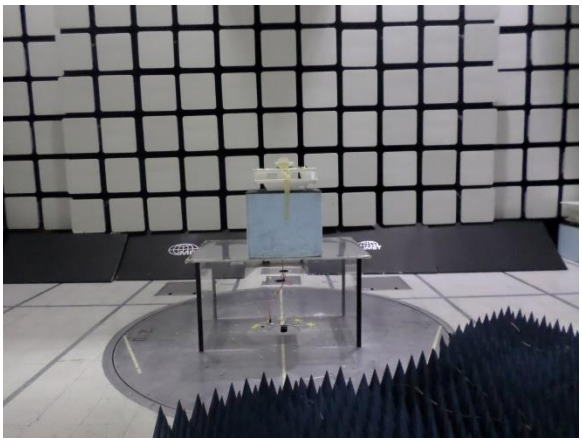

Figure 197: Radiated Spurious Emissions Test Setup, 1GHz-18GHz - Setup Front View

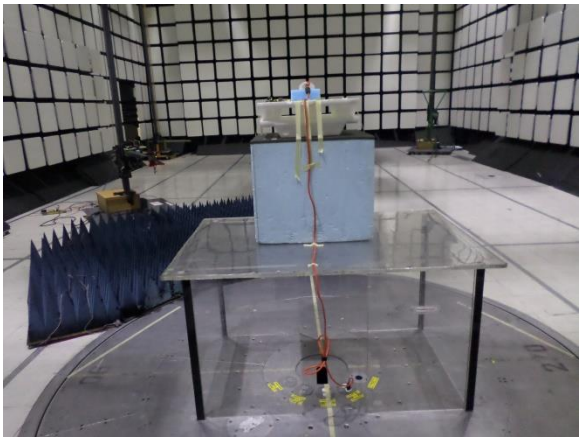

Figure 198: Radiated Spurious Emissions Test Setup, 1GHz-18GHz - Setup Rear View

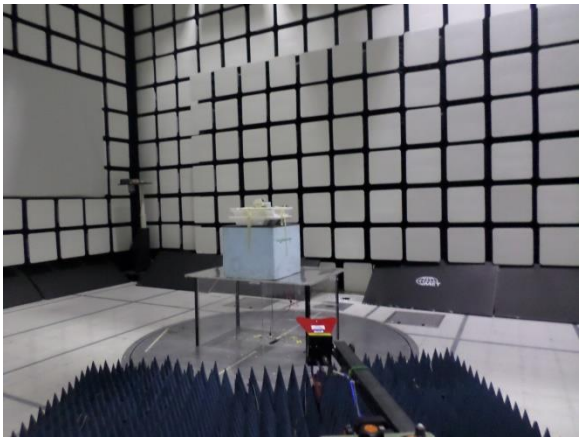

Figure 199: Radiated Spurious Emissions Test Setup, 1GHz-18GHz - Setup Antenna View

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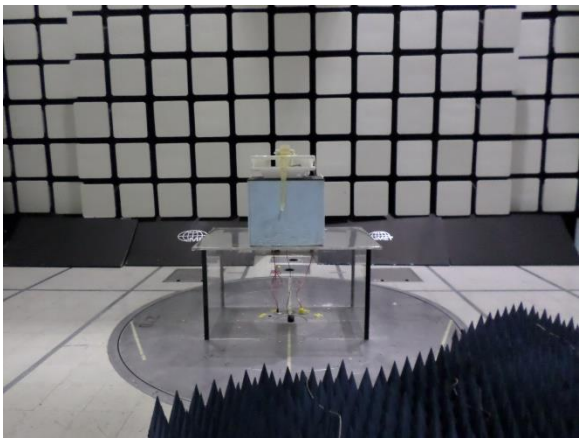

Figure 200: Radiated Spurious Emissions Test Setup, 18GHz-25GHz - Setup Front View

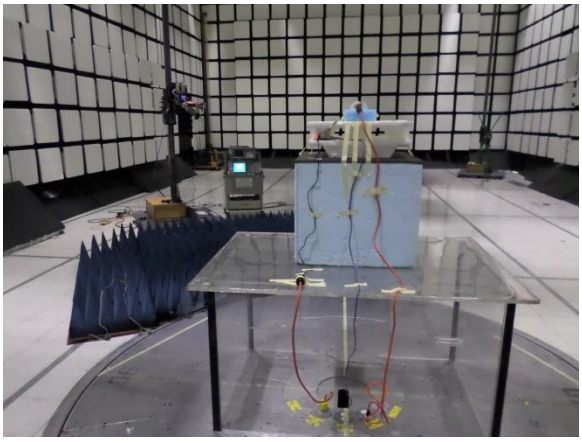

Figure 201: Radiated Spurious Emissions Test Setup, 18GHz-25GHz - Setup Rear View

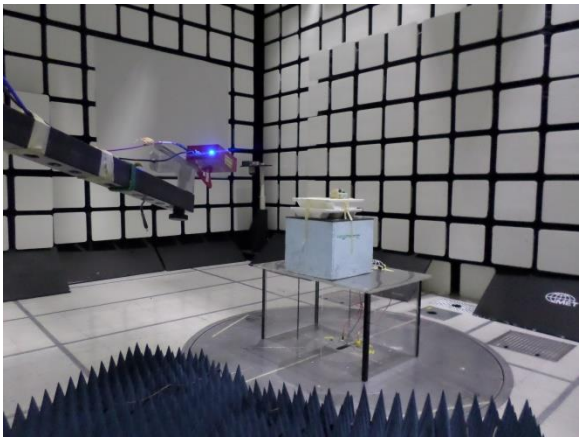

Figure 202: Radiated Spurious Emissions Test Setup, 18GHz-25GHz - Setup Antenna View

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

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

Test Procedure: The RBW was set to 100 kHz and a VBW set to 300 kHz. The spectrum analyzer was set to an auto sweep time and an Average detector was used. Measurements were carried out at the low, mid and high channels. Test method and the test procedure of ANSI C63.10-2013 section 11.10.5 Method AVGPSD-2 was used.

The EUT did not have an antenna ports temporal or permanent, average power spectral density test was performed on a radiated setup at distance of 3m from the EUT.

The Spectrum analyzer is programed to convert the measured EIRP to conducted power spectral density by adding back distance correction factor and EIRP conversion factor. The measured conducted average power spectral density is the corrected with the duty cycle correction factor of 10.46 dB. The reading in the captured plots is the converted and corrected conducted power spectral density before adding the DCCF.

Test Results: The EUT was compliant with the Power Spectral Density limits of **§ 15.247 (e)**.

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

Test Engineer: Adan Arab

Test Date(s): March 17, 2021

Mode	Frequency (MHz)	Uncorrected Power Spectral Density (dBm)	Duty Cycle Correction Factor (dB)	Corrected Power Spectral Density (dBm)	Limit (dBm/3 KHz)	Result
802.11b	2412	-5.008	10.46	5.452	8	Pass
802.11b	2437	-8.66	10.46	1.8	8	Pass
802.11b	2462	-10.81	10.46	-0.35	8	Pass
802.11g	2412	-8.41	10.46	2.05	8	Pass
802.11g	2437	-11.51	10.46	-1.05	8	Pass
802.11g	2462	-14.11	10.46	-3.65	8	Pass
802.11n_HT20	2412	-9.442	10.46	1.018	8	Pass
802.11n_HT20	2437	-10.91	10.46	-0.45	8	Pass
802.11n_HT20	2462	-14.55	10.46	-4.09	8	Pass
802.11n_HT40	2422	-12.05	10.46	-1.59	8	Pass
802.11n_HT40	2437	-14.39	10.46	-3.93	8	Pass
802.11n_HT40	2452	-15.68	10.46	-5.22	8	Pass

Figure 203: Power Spectral Density, Test Results

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Power Spectral Density Test Plots:

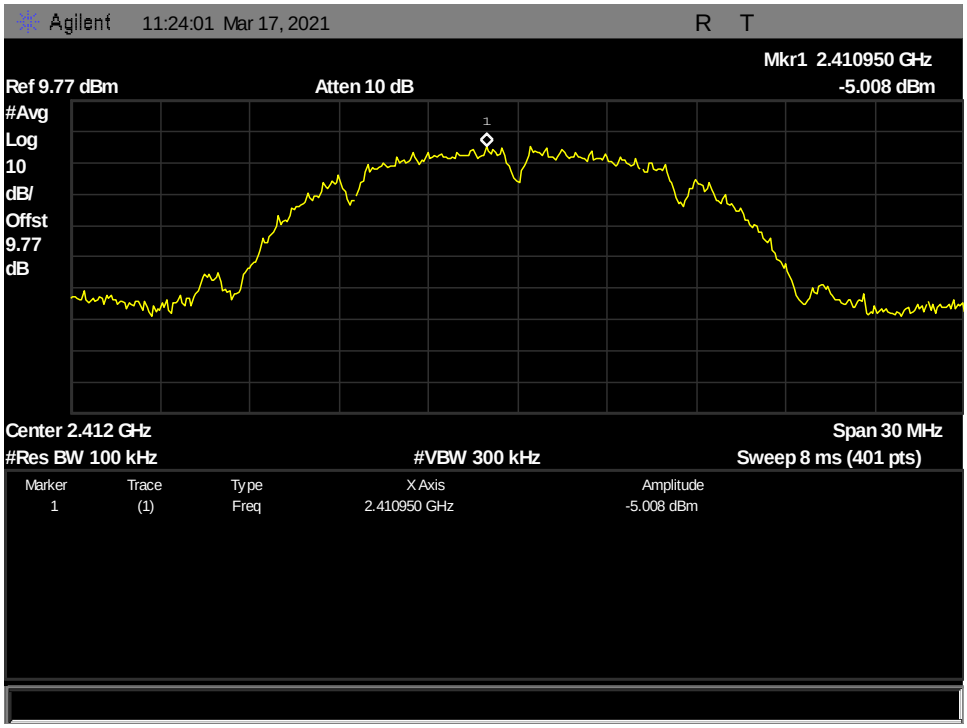

Figure 204: Power Spectral Density, 802.11b, Average PSD - 2412 MHz

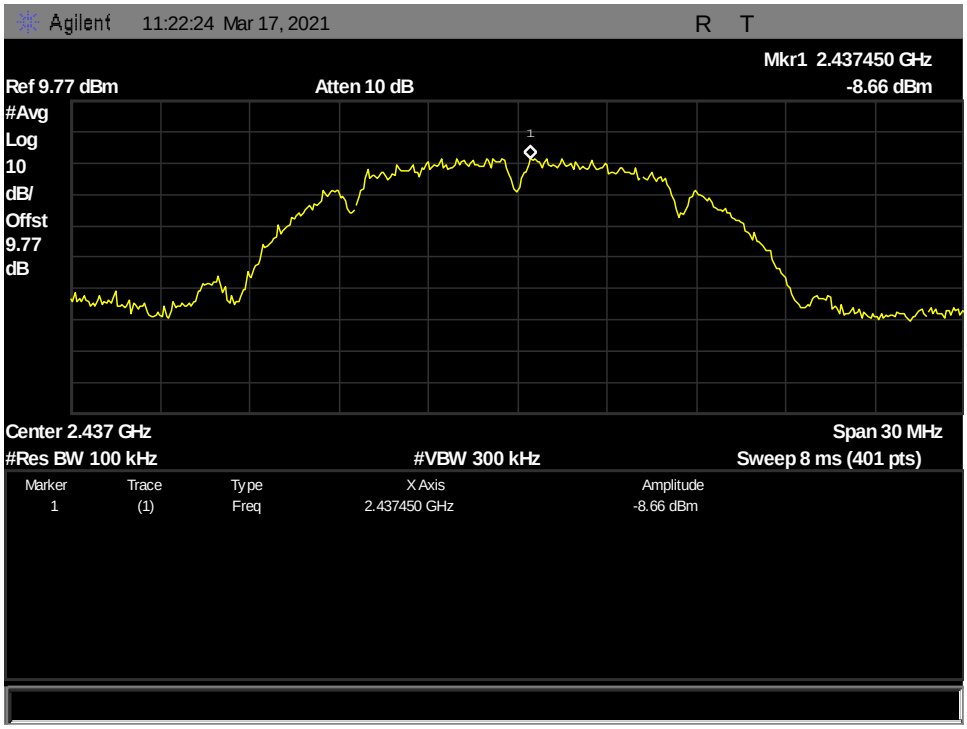

Figure 205: Power Spectral Density, 802.11b, Average PSD - 2437 MHz

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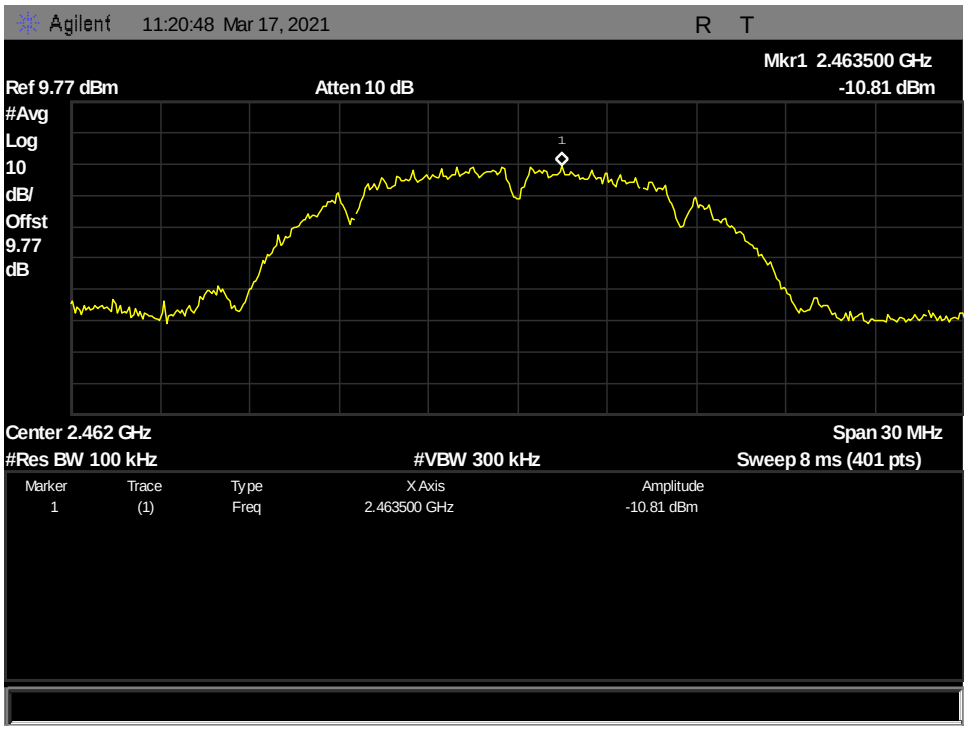

Figure 206: Power Spectral Density, 802.11b, Average PSD - 2462 MHz

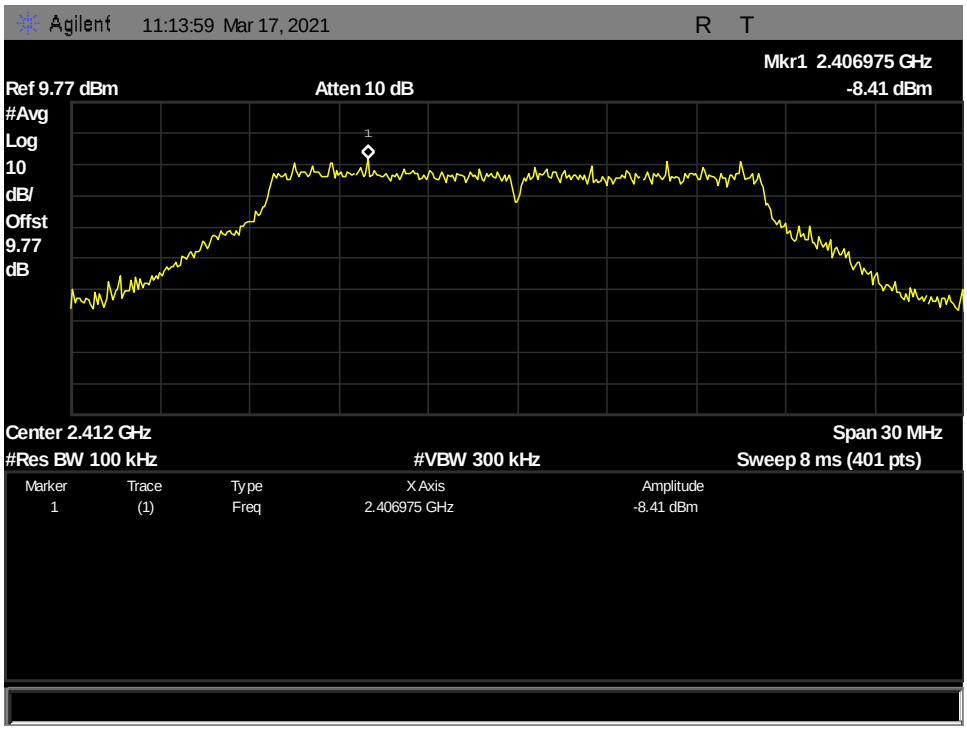

Figure 207: Power Spectral Density, 802.11g, Average PSD - 2412 MHz

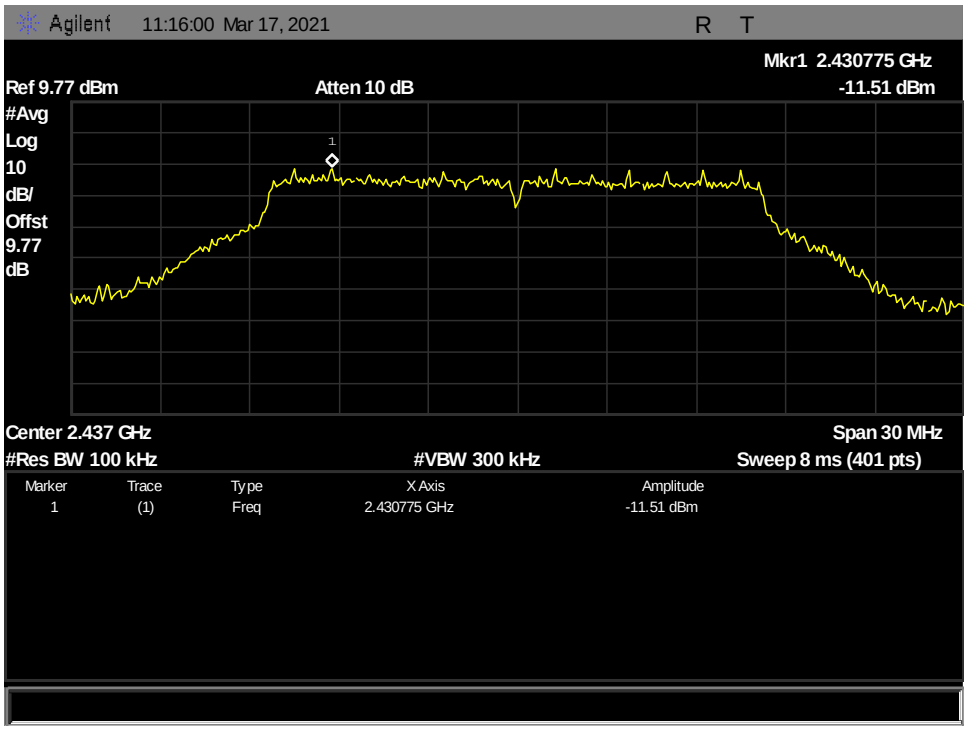

Figure 208: Power Spectral Density, 802.11g, Average PSD - 2437 MHz

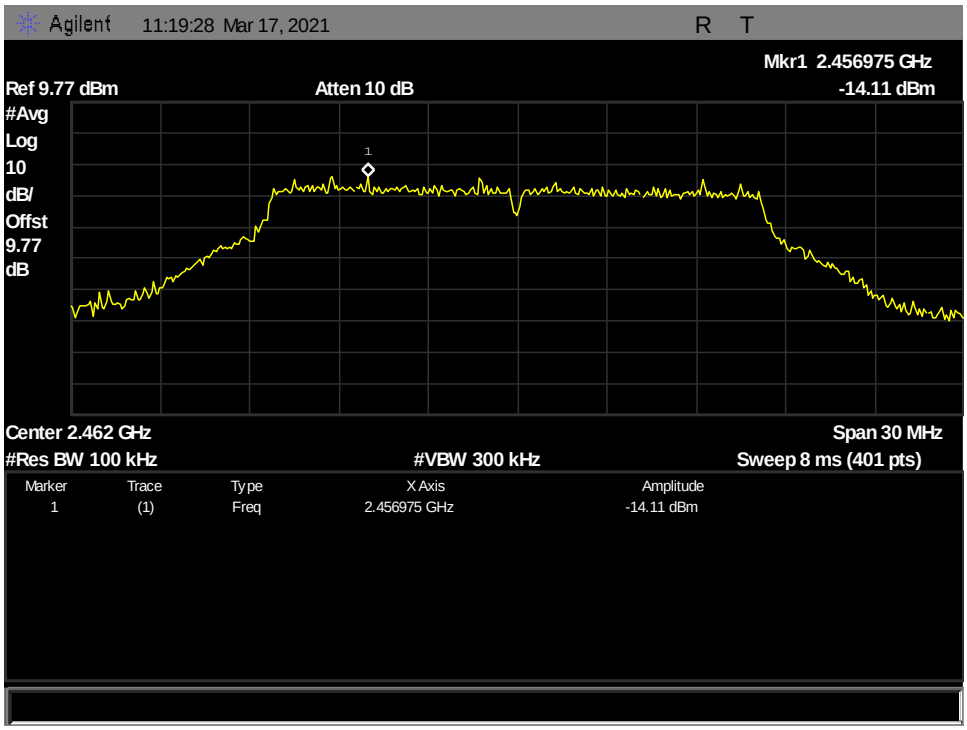

Figure 209: Power Spectral Density, 802.11g, Average PSD - 2462 MHz

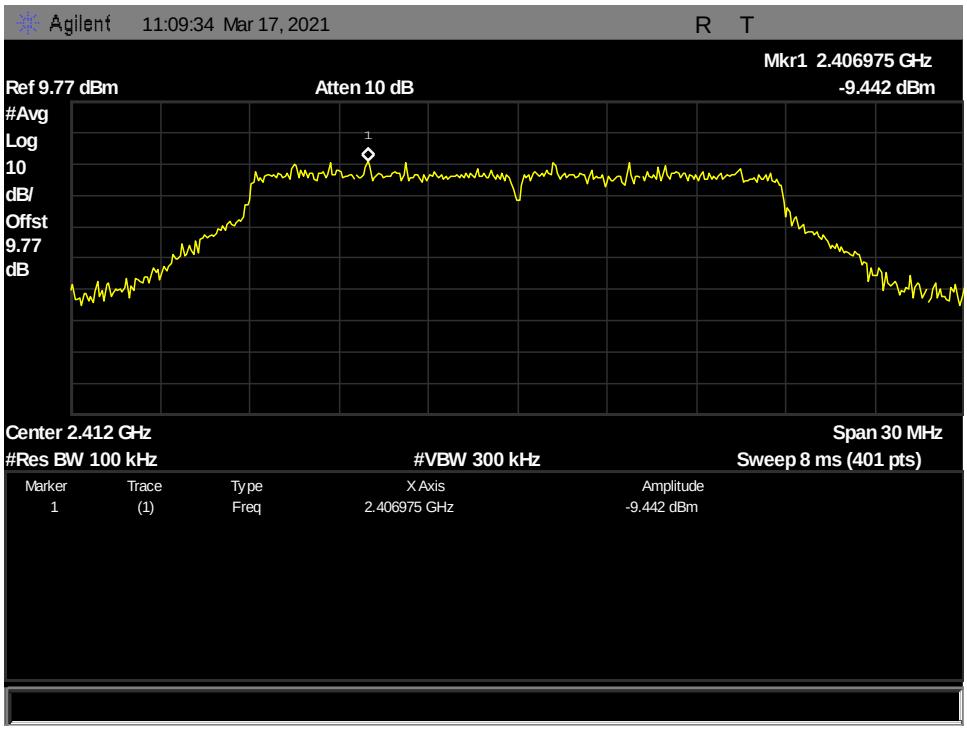

Figure 210: Power Spectral Density, 802.11n_HT20, Average PSD - 2412 MHz

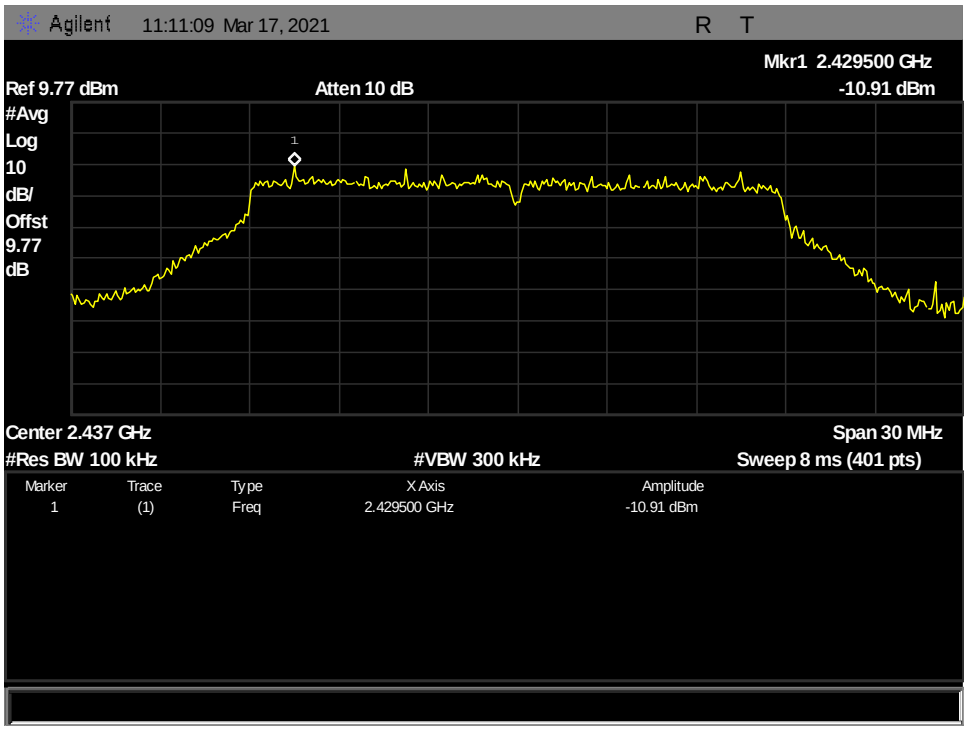

Figure 211: Power Spectral Density, 802.11n_HT20, Average PSD - 2437 MHz

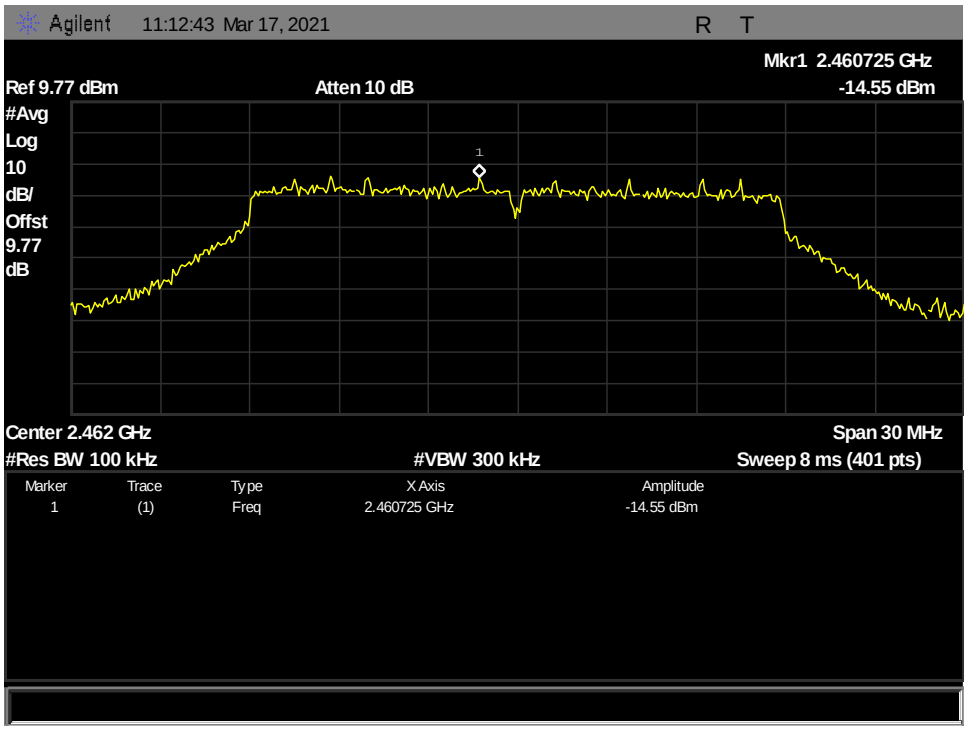

Figure 212: Power Spectral Density, 802.11n_HT20, Average PSD - 2462 MHz

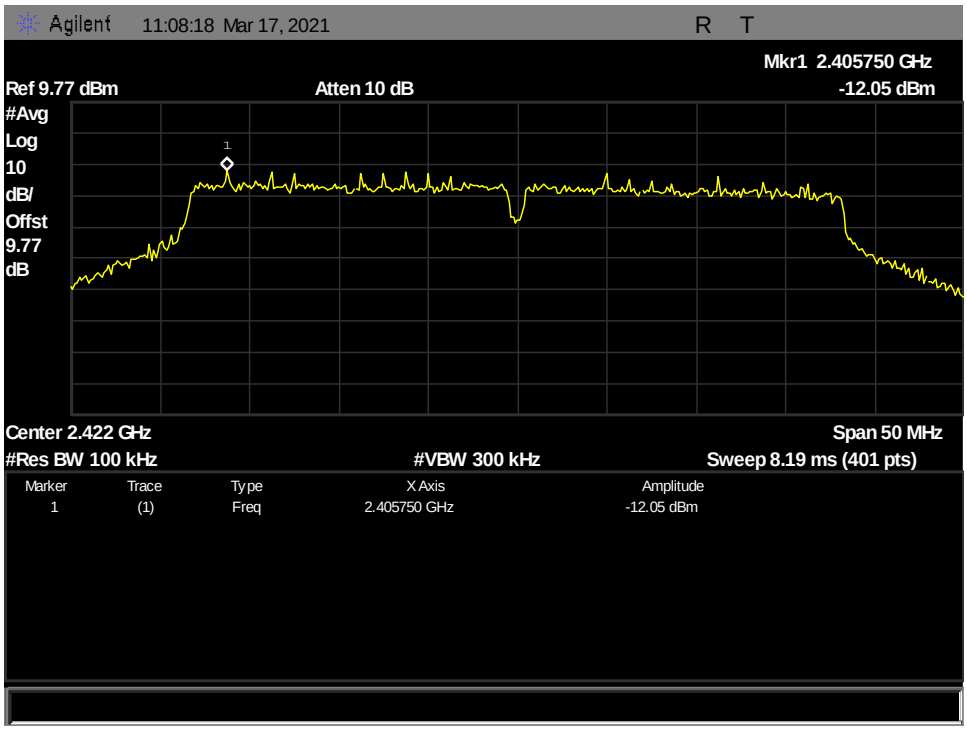

Figure 213: Power Spectral Density, 802.11n_HT40, Average PSD - 2422 MHz

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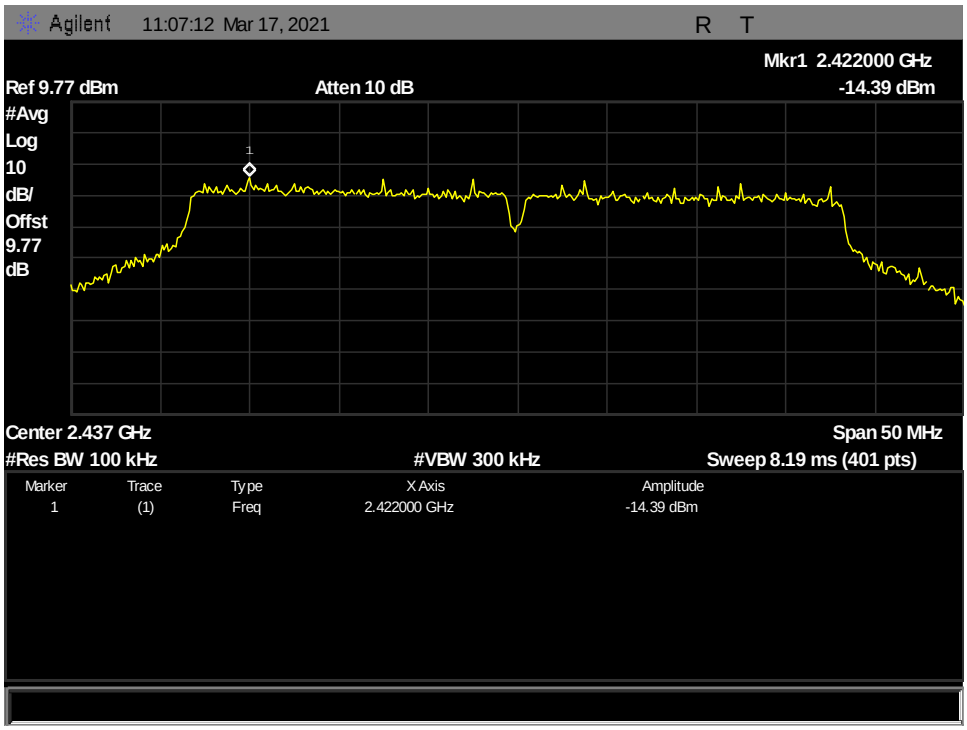

Figure 214: Power Spectral Density, 802.11n_HT40, Average PSD - 2437 MHz

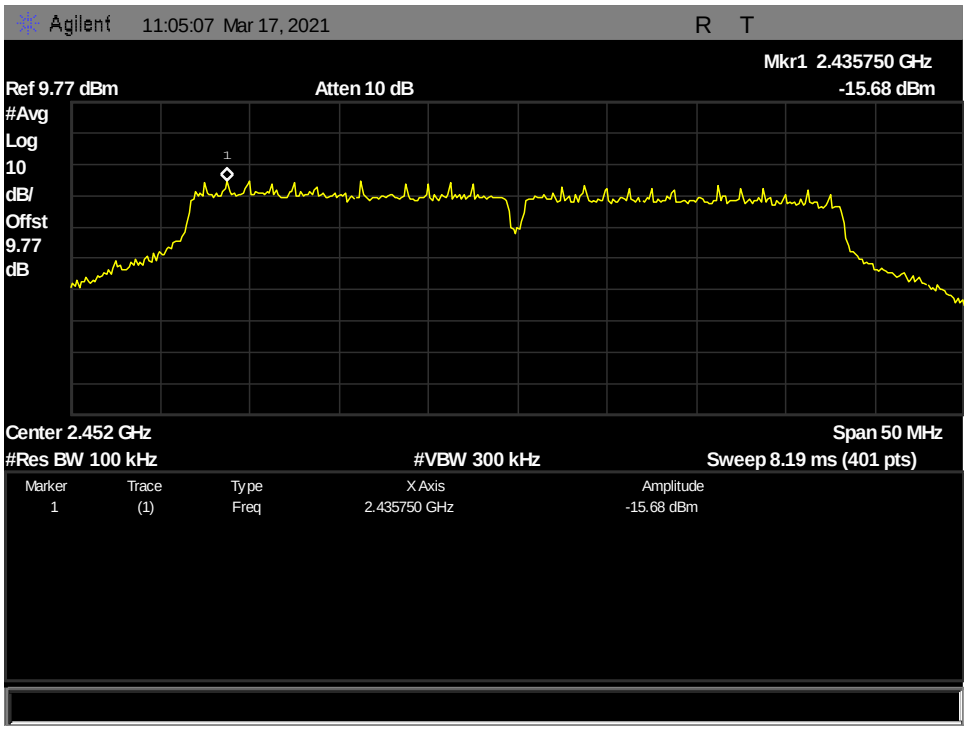

Figure 215: Power Spectral Density, 802.11n_HT40, Average PSD - 2452 MHz

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Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(i) Maximum Permissible Exposure

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

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

MPE Limit: EUT's operating frequencies @ 2400-2483.5 MHz; **Limit for Uncontrolled exposure: 1 mW/cm^2 or 10 W/m^2**

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

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

where, S = Power Density (mW/cm^2)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)

Test Results:

FCC										
Mode	**Frequency (MHz)**	**Conducted Power (dBm)**	**Conducted Power (mW)**	**Antenna Gain (dBi)**	**Antenna Gain numeric**	**Pwr. Density (mW/cm^2)**	**Limit (mW/cm^2)**	**Margin**	**Distance (cm)**	**Result**
802.11b	2412	5.7	3.715	3	1.995	0.00147	1	0.99853	20	Pass

Figure 216: RF Exposure Evaluation, Test Results

The safe distance where Power Density is less than the MPE Limit listed above was found to be 20 cm.

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Test Equipment

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Test Equipment

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

ASSET #	NOMENCLATURE	MANUFACTURER	MODEL	LAST CAL	CAL DUE
1A1065	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESCI	06/22/2020	06/22/2021
1A1177	PULSE LIMITER	ROHDE & SCHWARZ	ESH3-Z2	06/10/2020	06/10/2021
1A1227	TRUE RMS METER	FLUKE	114	10/16/2020	10/16/2021
1A1119	CONDUCTED EMISSIONS GROUND PLANE	N/A	N/A	06/10/2020	06/10/2021
1A1149	DC MILLIOHM METER	GW INSTEK	GOM-802	06/10/2020	06/10/2021
1A1169	TEMPERATURE, HUMIDITY AND PRESSURE RECORDER	OMEGA	OM-CP-PRHTEMP2000	02/19/2021	02/19/2022
1A1184	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	08/24/2020	08/24/2021
1A1083	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESU40	10/16/2020	10/16/2021
1A1147	BILOG ANTENNA (30-1000 MHZ)	SUNOL SCIENCES CORP	JB3	06/05/2019	01/05/2021
1A1183	DOUBLE RIDGED WAVEGUIDE ANTENNA (1-18 GHZ)	ETS LINDGREN	3117	06/01/2020	06/01/2022
1A1161	DRG HORN ANTENNA	ETS LINDGREN	3116C-PA	06/03/2020	06/03/2022
1A1099	1A1099	GENERATOR	COM-POWER CORP	SEE NOTE	SEE NOTE
1A1044	1A1044	GENERATOR	COM-POWER CORP	SEE NOTE	SEE NOTE
1A1088	PRE-AMP	ROHDE & SCHWARZ	TS-PR1	SEE NOTE	SEE NOTE
1A1080	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	SEE NOTE
1A1073	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	SEE NOTE
1A1180	PRE-AMP	MITEQ	AMF-7D-01001800-22-10P	SEE NOTE	SEE NOTE
1A1106	10M SEMI-ANECHOIC CHAMBER	LINDGREN	N/A	SEE NOTE	SEE NOTE

Figure 217: Test Equipment List

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

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Certification & User's Manual Information

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Certification & User's Manual Information

M. 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.

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(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.

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Certification & User's Manual Information

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

§ 2.901 Basis and Purpose

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

(b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

(a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.

(b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

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

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Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

(a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.

(1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.

(i) If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.

(ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.

(2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

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Certification & User's Manual Information

1. Label and User's Manual Information

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

§ 15.19 Labeling requirements.

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

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

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

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

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

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

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

(4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

(5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

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

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Verification & User's Manual Information

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

§ 15.105 Information to the user.

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

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

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

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

– Reorient or relocate the receiving antenna.

– Increase the separation between the equipment and receiver.

– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

– Consult the dealer or an experienced radio/TV technician for help.

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End of Report

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