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Radio
Test Report

EUT Name (PMN): Blade

Model No. (HVIN): 447

CFR 47 Part 15.247: 2018 and RSS 247, Issue 2

Prepared for:

Vuzix Corporation
25 Hendrix Rd
West Henrietta, NY 14586

Prepared by:

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Report/Issue Date:	July 3, 2018
Job #	0000155206
Report Number:	31851724.001
Revision Number:	2

Revisions

Revision No.	Date	Reason for Change	Author
0	June 11, 2018	Original Document	D. Foster
1	June 25, 2018	Updated according to TCB comments	D. Foster
2	July 3, 2018	Updated according to TCB comments	J. Sabado

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Vuzix Corporation 25 Hendrix Rd West Henrietta, NY 14586
Name of Equipment:	Blade
Model No.	447
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2018 and RSS 247, Issue 2
Test Dates:	19 March 2018 to 10 June 2018

Guidance Documents:

FCC Part 15.247

RSS-247, Issue 2

Test Methods:

ANSI C63.10 - 2013, KDB 558074 D01 DTS Measurement Guidance v04

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Josie Sabado		Isaac Aguilar	
Test Engineer	Date: July 3, 2018	Lab Signatory	Date July 3, 2018

Testing Cert #3331.02 **US1131** **2932M**

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247: 2018 and RSS 247, Issue 2 based on the results of testing performed on 19 March 2018 to 10 June 2018 on the Blade Model 447 manufactured by Vuzix Corporation This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report. The 2412 MHz to 2462 MHz frequency band for WiFi are covered in this document.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method	Test Parameters (Worst Case Measured)	Result
DTS Bandwidth	KDB 558074, section 8.1 ANSI C63.10, section 11.8.1	802.11b: 9.96 MHz 802.11g: 15.57 MHz 802.11n: 15.86 MHz	**Complied**
Fundamental Emission Output Power (Peak)	KDB 558074, section 9.1.3 ANSI C63.10, section 11.9.1.3	802.11b: 20.4 802.11g: 25.6 802.11n: 25.9	**Complied**
Peak Power Spectral Density	KDB 558074, section 10.2 ANSI C63.10, section 11.10.2	802.11b: -3.60 802.11g: -5.96 802.11n: -6.81	**Complied**
Emissions in non-restricted frequency bands	KDB 558074, section 11.0 ANSI C63.10, section 11.11	-39.61 dBm @ 24.89 GHz	**Complied**
Emissions in restricted frequency bands	KDB 558074, section 12.1 ANSI C63.10, section 11.12	27.32 dBµV/m @ 960 MHz	**Complied**
Band-edge measurements	KDB 558074, section 13.3.1 ANSI C63.10, section 11.13.3.1	73.70 dBµV/m @ 2390.4 MHz	**Complied**
AC Power Conducted Emission	CFR 47 Part 15.207 RSS-GEN Sect.8.8	46.69 dBµV @ 520 kHz	**Complied**

1.4 Test Software

Proprietary test software was used to enable a test mode for WLAN. The test software forced the radio to transmit WLAN at maximum power with 100% duty cycle. The test software was used to change the channel and modulations. Maximum power setting is 80, which corresponds to a theoretical average power of 20 dBm. Theoretical average power is calculated as *(power setting)/4*.

1.5 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.6 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 is recognized by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US1131). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / A2LA

TUV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:1999 and ISO 9002 (Lab Code Testing Cert #3331.02). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0261

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / A2LA accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBµV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBµV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty

Per CISPR 16-4-2	U_{lab}	U_{cispr}
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB
Disturbance Power		
30 MHz– 300 MHz	3.92 dB	4.3 dB

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Customer

Table 2: Customer Information

Company Name	Vuzix Corporation
Address	25 Hendrix Rd
City, State, Zip	West Henrietta, NY 14586
Country	USA

3.2 Product Description

The Model 447, Blade, are smart glasses capable of operating in the 2.4 GHz WLAN frequency bands over 20 MHz nominal bandwidth channels.

3.3 Equipment Under Test (EUT)

Table 3: EUT Specifications

EUT Specifications	
Dimensions	210 x 161 x 42 mm (L x W x H)
AC Input	100-240V AC, 50 – 60 Hz
Multiple Feeds for 802.11b/g/n:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	Blade
Hardware Version Identification Number (HVIN)	447

Table 4: Radio Specifications

802.11 b/g/n-radio specific information	
Operating Mode	802.11b, 802.11g, 802.11n (HT20)
Transmitter Frequency Band	2.4 GHz – 2.4835 GHz
Low Channel – High Channel Center Frequencies	2.412 – 2.462 GHz
Antenna Type	Chip
Antenna Gain	1.6 dBi
Modulation Type	☐ Thread (Zigbee) ☐ BLE ☒ CCK ☒ OFDM ☐ Other describe:
TX/RX Chain (s)	SISO (1x1)
Type of Equipment	☒ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Wearable

Table 5: Antenna Information

Antenna	Internal / External	Antenna Type	Frequency Range (MHz)	Antenna Gain (dBi)
2.4 GHz WLAN / Bluetooth	Internal	Chip	2400 – 2483.5	1.6

3.4 Equipment Configuration

The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of a EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing.

3.5 Sample used for Testing

Table 6: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
Blade	WLAN MAC ADDRESS: DC:EF:CA:A4:42:58	Chip Antenna	Emissions in restricted frequency bands, Band-edge measurements, AC Power Conducted Emission
	s/n 0123456789ABCDEF	Direct Connection	DTS Bandwidth, Fundamental Emission Output Power, Peak Power Spectral Density, Emissions in non-restricted frequency bands

4 Measurement Results

4.1 Unique Antenna Connector

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. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.219, or 15.221.

4.1.1 Results

The EUT is equipped with an internal soldered down chip antenna.

4.2 DTS Bandwidth

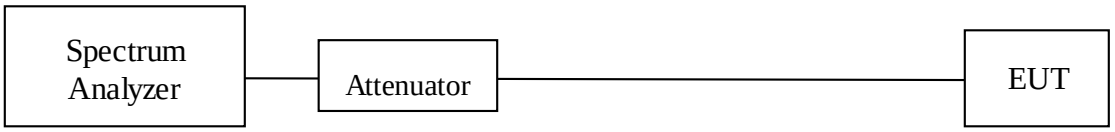
The DTS bandwidth is measured at an amplitude level reduced from the reference level by 6 dB. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The minimum 6 dB bandwidth shall be at least 500 kHz.

4.2.1 Test Method

The conducted method was used to measure the DTS bandwidth according to KDB 558074 section 8.1 and ANSI C63.10:2013 section 11.8.1. The measurement was performed with modulation on the low, middle and high channels of the operating frequency range: 2412 MHz (ch 1)to 2462 MHz (ch 11). The lowest data rate was tested because it has the longest transmit time per packet length.

Test Setup:



4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 7: DTS Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: FPCB	**Power Setting:** 80	
Duty Cycle: 100%		
Ambient Temp.: 22° C	**Relative Humidity:** 38%	
DTS Bandwidth for 802.11b (CCK)		
Freq. (MHz)	**99% Bandwidth (MHz)**	**6dB Bandwidth (MHz)**
2412	14.01	9.96
2437	14.01	9.03
2462	14.01	9.49
Note: 1. The bandwidth was measured at 1.0 Mbps.		
DTS Bandwidth for 802.11g		
Freq. (MHz)	**99% Bandwidth (MHz)**	**6dB Bandwidth (MHz)**
2412	16.32	15.57
2437	16.32	15.34
2462	16.32	15.51
Note: 1. The bandwidth was measured at 6.0 Mbps		
DTS Bandwidth for 802.11n		
Freq. (MHz)	**99% Bandwidth (MHz)**	**6dB Bandwidth (MHz)**
2412	17.54	15.63
2437	17.54	15.86
2462	17.54	15.34
Note: 1. The bandwidth was measured at HT20 MCS0		

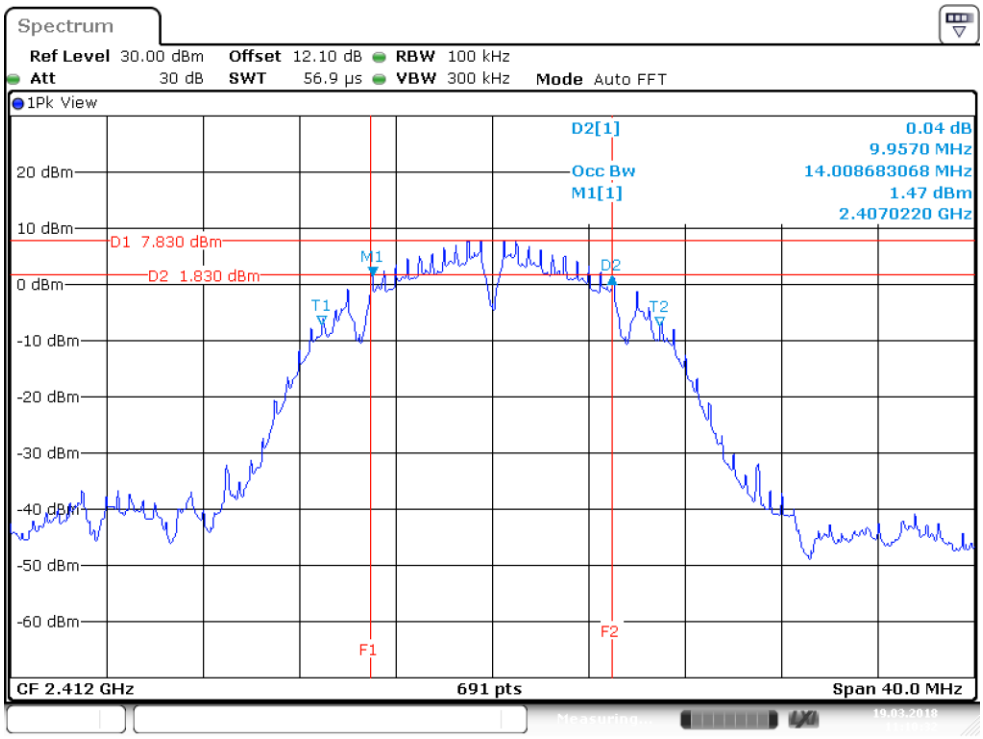


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Figure 1: Bandwidth, 2412 MHz 802.11b

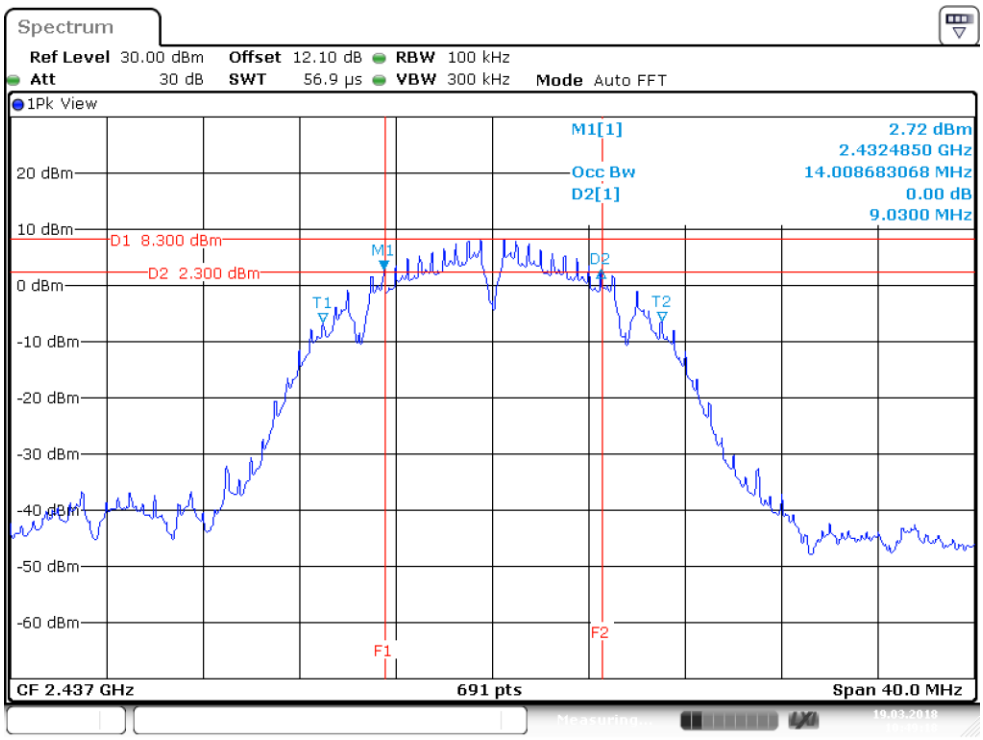

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Figure 2: Bandwidth, 2437 MHz 802.11b

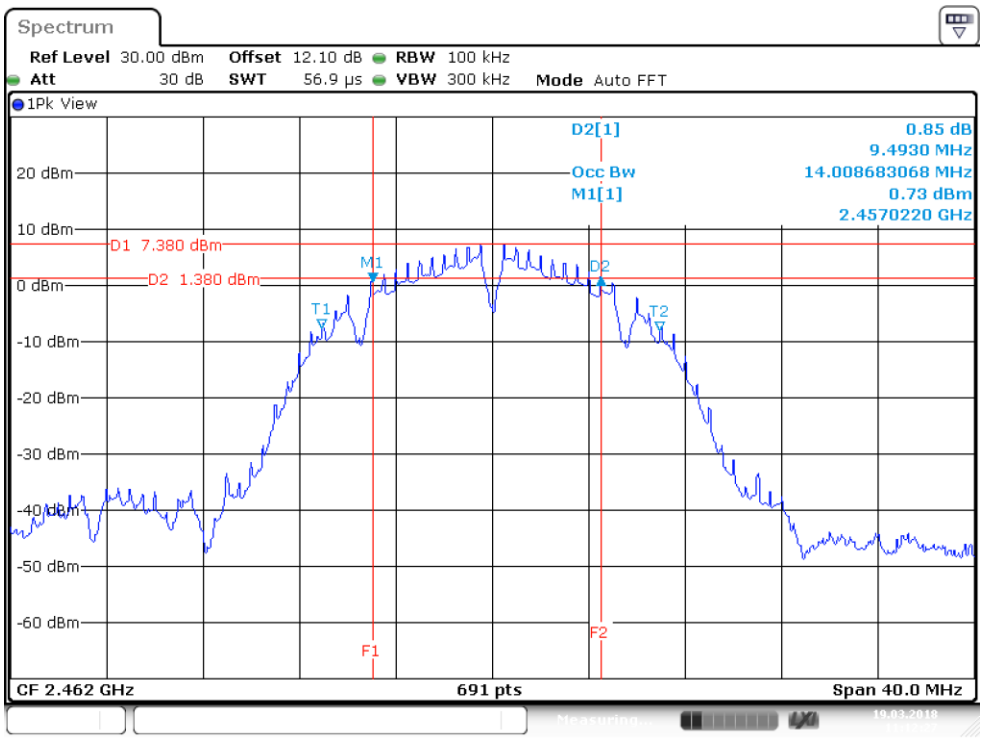

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Figure 3: Bandwidth, 2462 MHz 802.11b

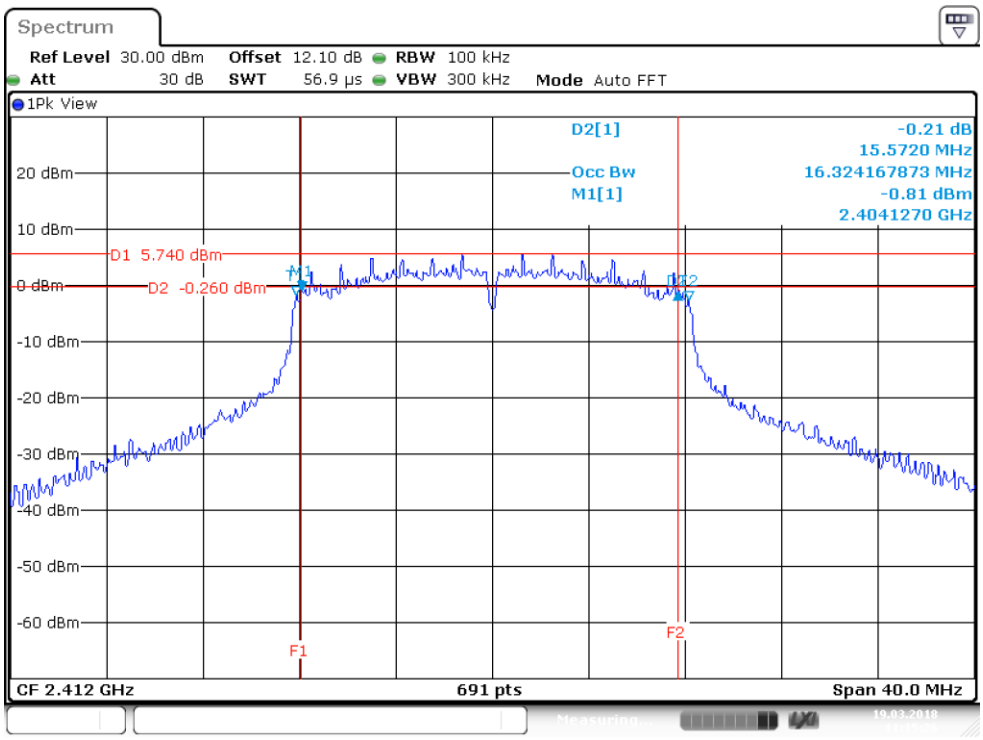

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Figure 4: Bandwidth, 2412 MHz at 802.11g

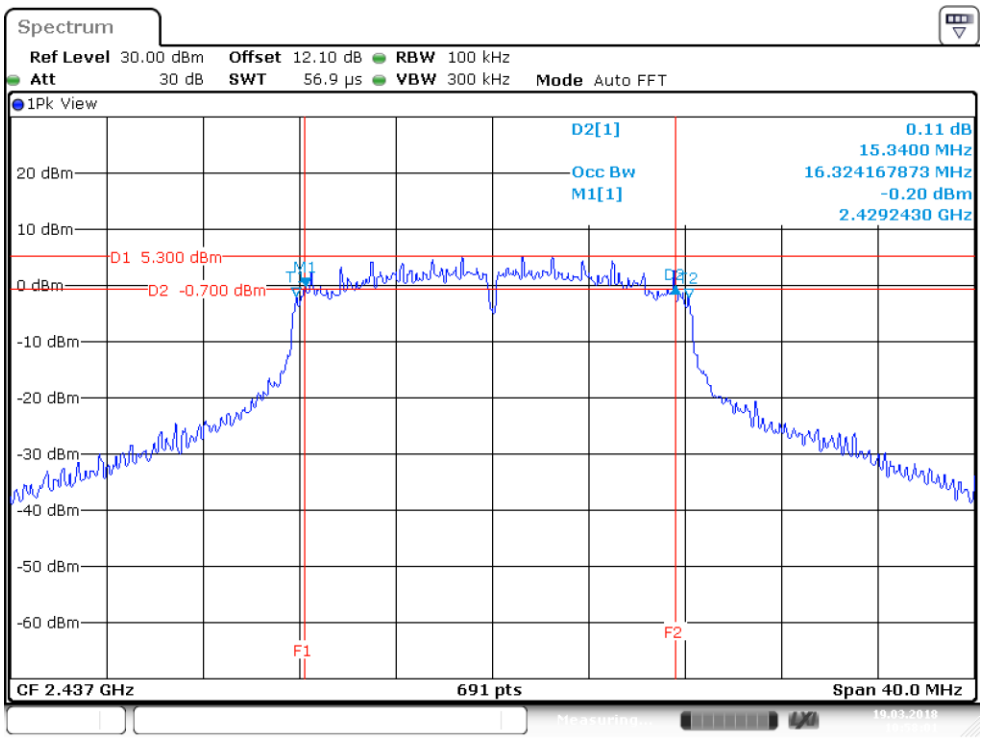

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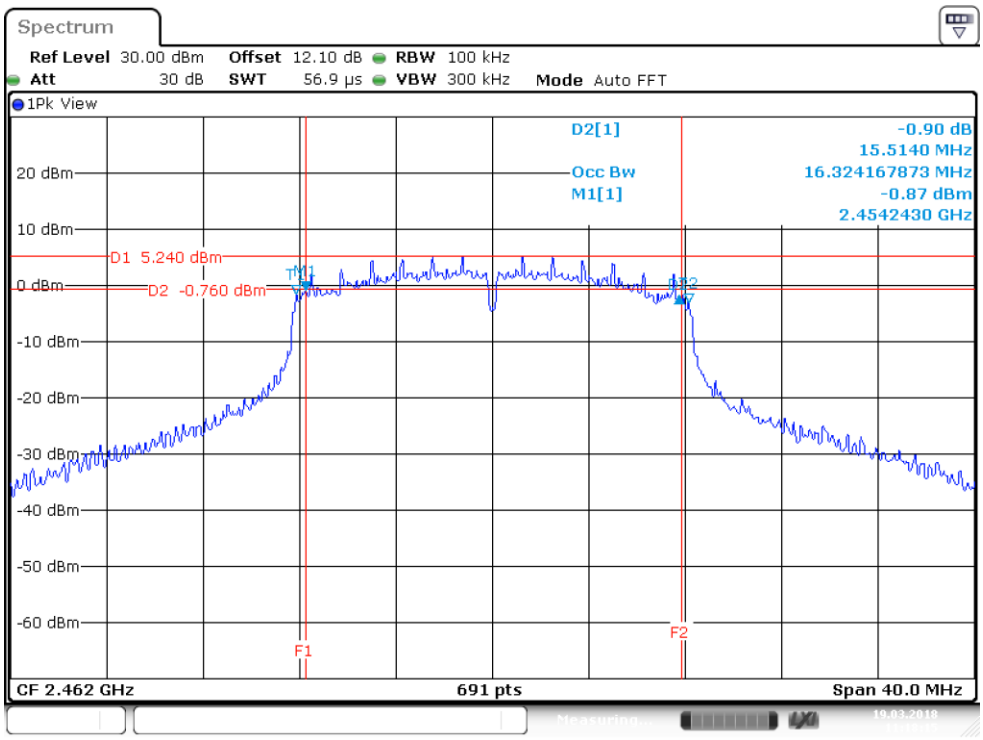
Figure 5: Bandwidth, 2437 MHz at 802.11g



Date: 19.MAR.2018 11:18:15

Figure 6: Bandwidth, 2462 MHz at 802.11g

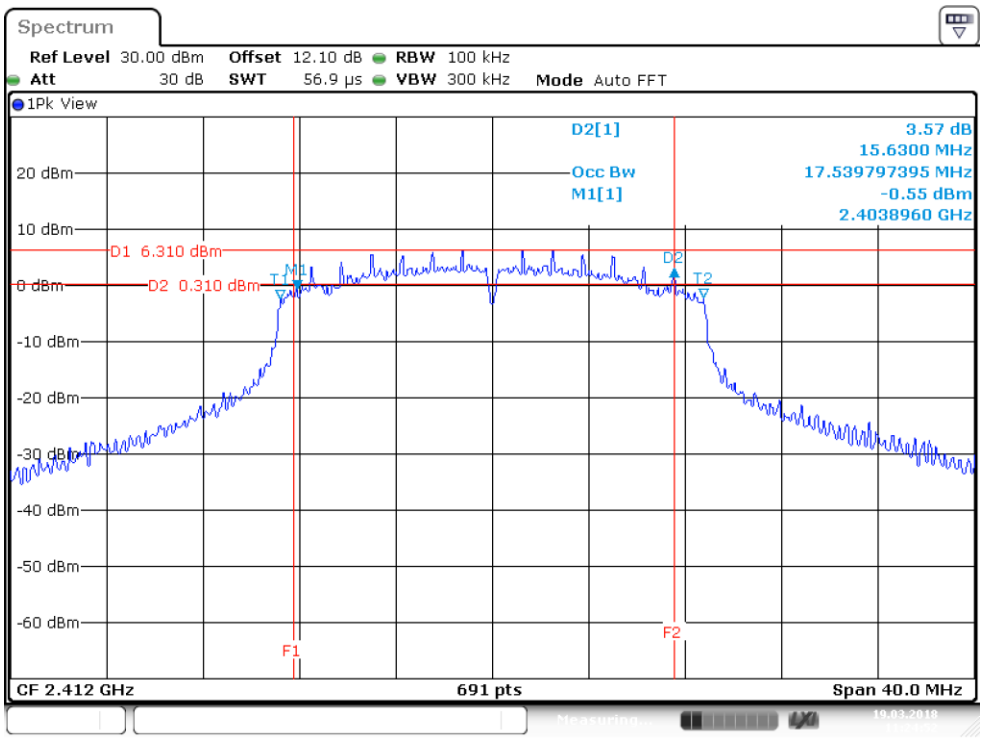


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Figure 7: Bandwidth, 2412 MHz 802.11n

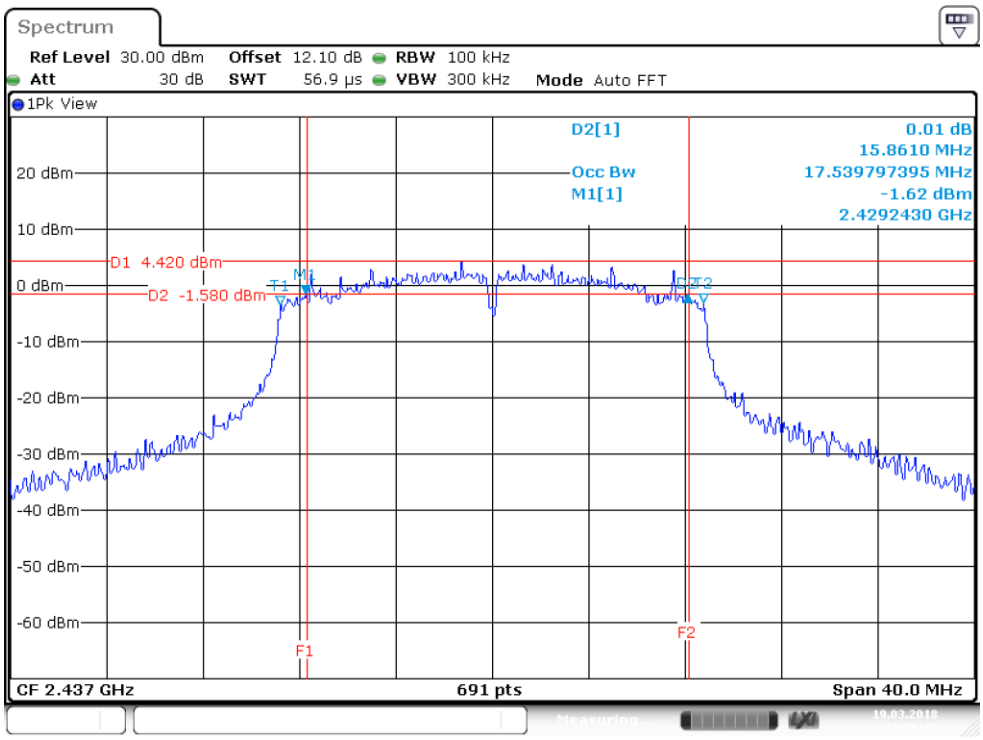

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Figure 8: Bandwidth, 2437 MHz 802.11n

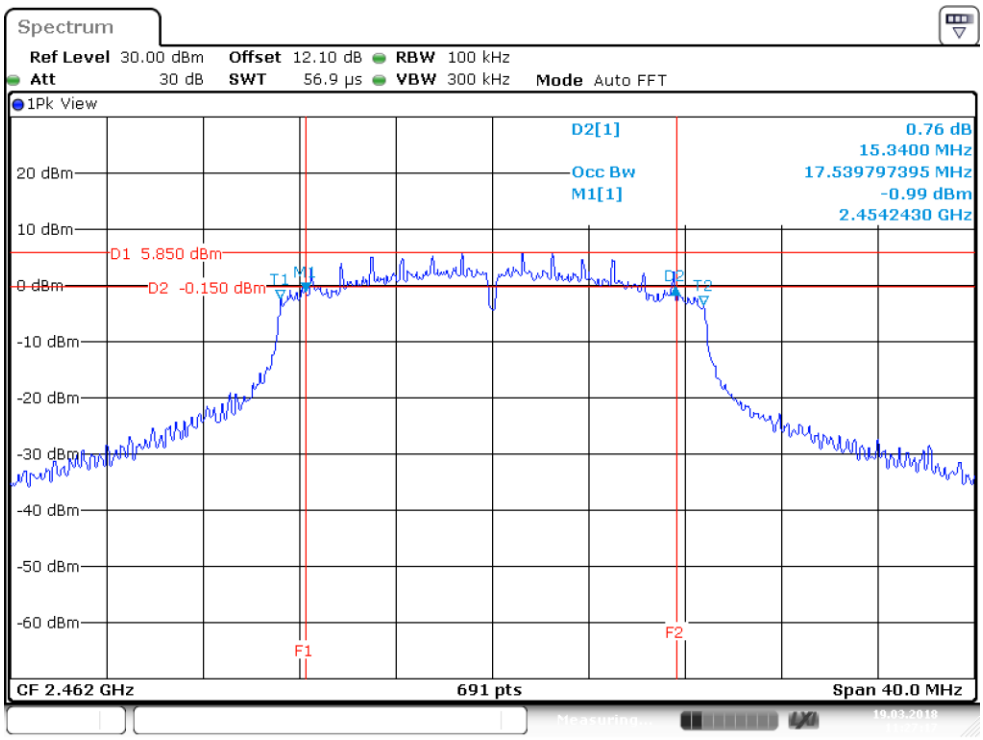

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Figure 9: Bandwidth, 2462 MHz 802.11n

4.3 Fundamental Emission Output Power

The fundamental emission output power requirement is the maximum conducted power delivered to the transmitting antenna under specified conditions of measurements in the presence of modulation.

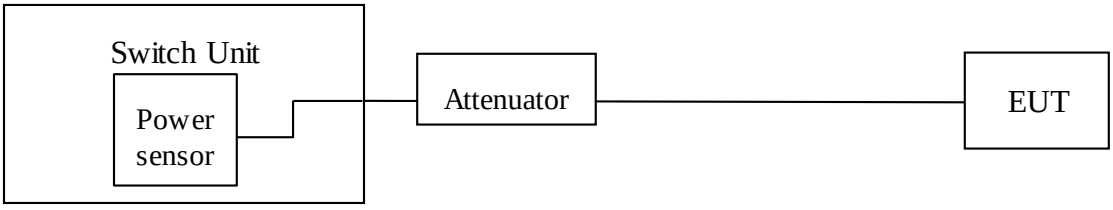
The maximum output power shall not exceed CFR47 Part 15.247 and RSS 247 Sect. 5.4 (d).

The maximum transmitted power in the band 2400-2483.5 MHz: 1 W

4.3.1 Test Method

Conducted method was used to measure the channel power output. The preliminary investigation was performed at different data rate / chain to determine the highest power output for each mode. The worst findings were conducted on three channels in each operating range. The lowest data rate was tested because it has the longest transmit time per packet length.

Test Setup:



The measurement method from KDB 558074, section 9.1.3 and ANSI C63.10, section 11.9.1 was used.

4.3.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 8: RF Output Power at the Antenna Port – Test Results

Test Conditions: Conducted Measurement, Normal Temperature			
Detector: Peak			
Antenna Type: Chip	**Power Setting:** 802.11 g/n Channel 74, All other channels 80		
Max. Antenna Gain: 1.6 dBi			
Signal State: Modulated		**Duty Cycle:** 100%	
Ambient Temp.: 22° C		**Relative Humidity:** 38%	
802.11b			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (Peak) [dBm]**	**Margin from limit [dB]**
2412.00	30.00	20.4	9.6
2437.00	30.00	20.3	9.7
2462.00	30.00	20.0	10.0
Note: 1.The highest output power was observed at 802.11b mode, 1.0 Mbps			
802.11g			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (Peak) [dBm]**	**Margin from limit [dB]**
2412.00	30.00	25.5	4.5
2437.00	30.00	25.6	4.4
2462.00	30.00	23.3	6.7
Note: 1.The highest output power was observed at 802.11b mode, 1.0 Mbps			
802.11n (HT20)			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (Peak) [dBm]**	**Margin [dB]**
2412.00	30.00	25.9	4.1
2437.00	30.00	25.8	4.2
2462.00	30.00	23.2	6.8
Note: The highest output power was observed at HT20 MCS0			

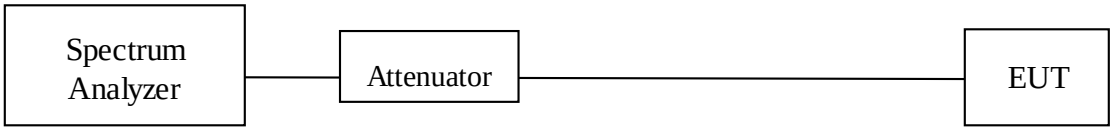
4.4 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e) and RSS 247 Sect.5.2 (b), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.4.1 Test Method

The conducted method was used to measure the channel power output per KDB 558074, section 10.2 and ANSI C63.10, section 11.10.2. The measurement was performed with modulation. The worst findings were conducted on 3 channels in each operating frequency range of 2400 MHz to 2483.5 MHz. The worst sample result indicated below.

Test Setup:



4.4.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 9: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Chip	**Power Setting:** 802.11 g/n Channel 74, All other channels 80		
Max. Antenna Gain: 1.6 dBi			
Signal State: Modulated		**Duty Cycle:** 100%	
Ambient Temp.: 22° C		**Relative Humidity:** 38%	
Peak Power Spectral Density			
802.11b			
Freq. (MHz)	**PSD in 3 kHz [dBm]**	**Limit in 3 kHz [dBm]**	**Margin [dB]**
2412	-3.75	8.0	-11.75
2437	-3.60	8.0	-11.60
2462	-3.80	8.0	-11.80
Note: 1. The highest peak output power was observed at **802.11b 1Mbps** per data stream.			
802.11g			
Freq. (MHz)	**PSD in 3 kHz [dBm]**	**Limit in 3 kHz [dBm]**	**Margin [dB]**
2412	-5.96	8.0	-13.96
2437	-6.30	8.0	-14.30
2462	-8.27	8.0	-16.27
Note: 1. The highest peak output power was observed at **802.11g 6Mbps** per data stream.			
802.11n HT20			
Freq. (MHz)	**PSD in 3 kHz [dBm]**	**Limit in 3 kHz [dBm]**	**Margin [dB]**
2412	-6.81	8.0	-14.81
2437	-7.89	8.0	-15.89
2462	-8.46	8.0	-16.46
Note: 1. The highest peak output power was observed at **HT20 MCS0** per data stream.			

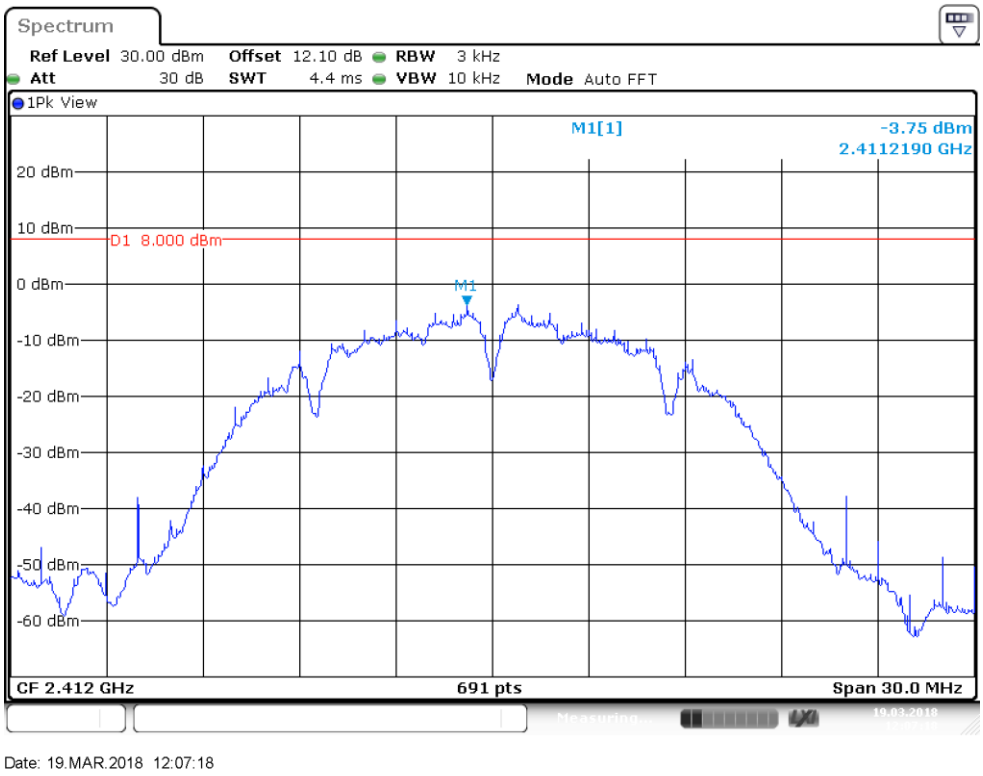


Figure 10: Power Spectral Density, 2412 MHz at 802.11b 1Mbps

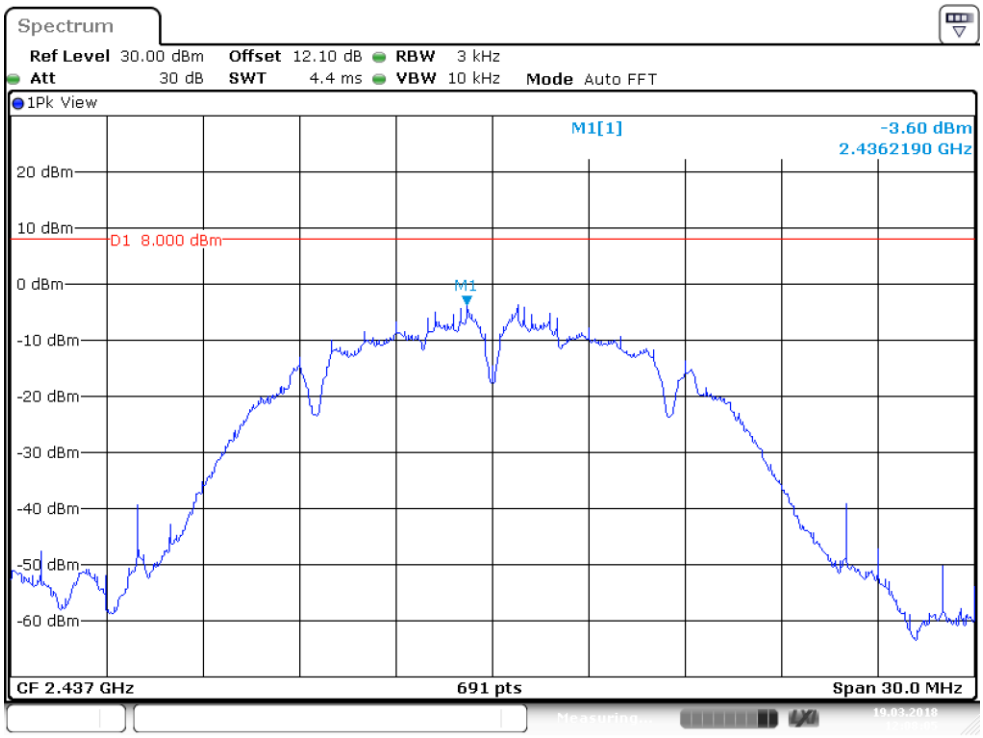


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Figure 11: Power Spectral Density, 2437 MHz at 802.11b 1Mbps

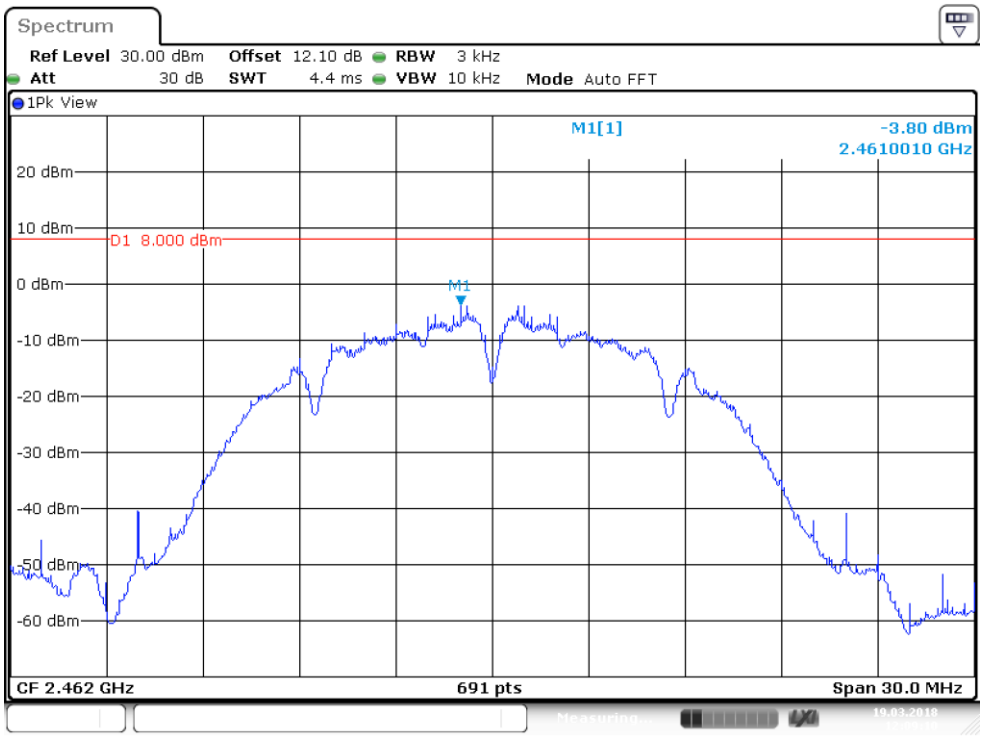

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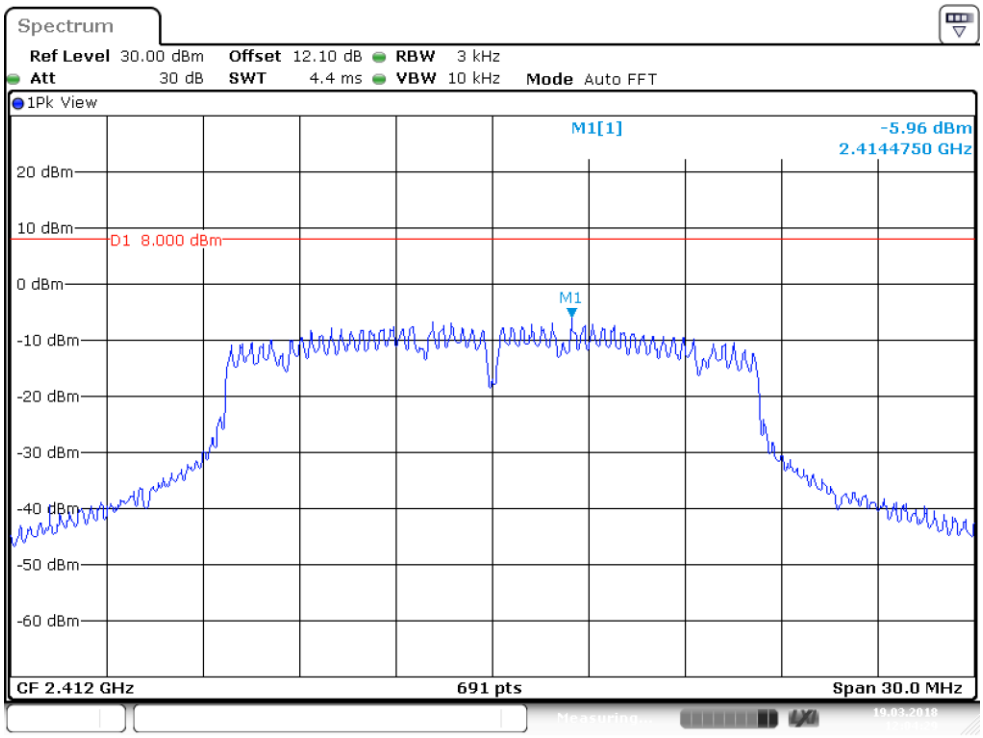
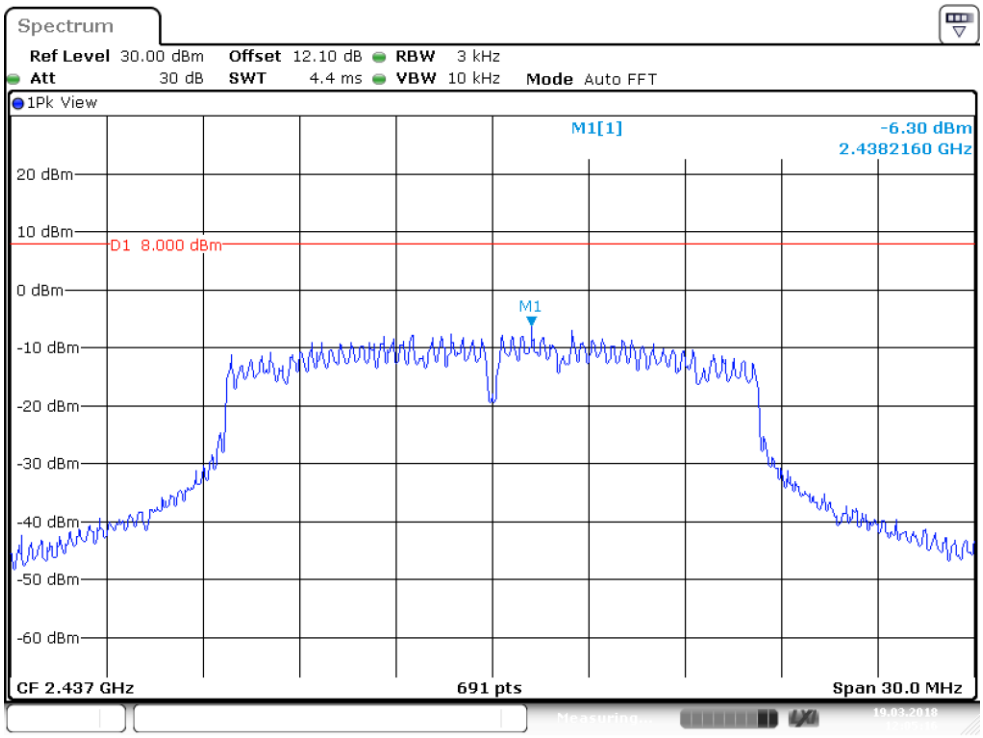
Figure 12: Power Spectral Density, 2462 MHz at 802.11b 1Mbps



Date: 19.MAR.2018 12:04:30

Figure 13: Power Spectral Density, 2412 MHz at 802.11g 6Mbps



Date: 19.MAR.2018 12:05:16

Figure 14: Power Spectral Density, 2437 MHz at 802.11g 6Mbps

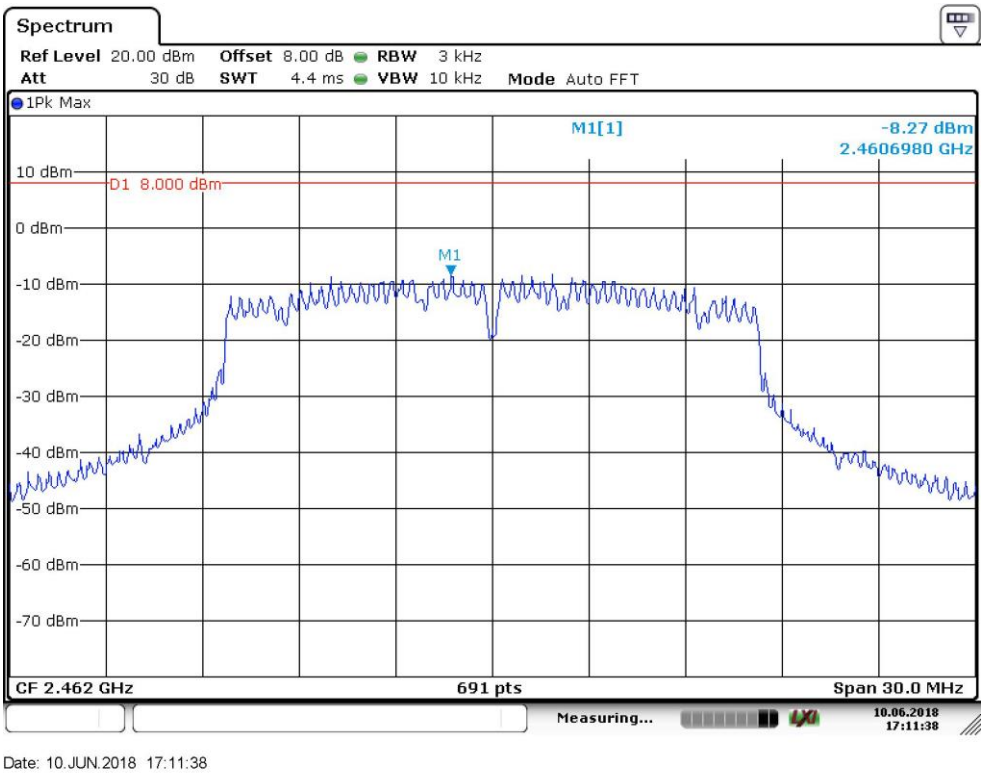
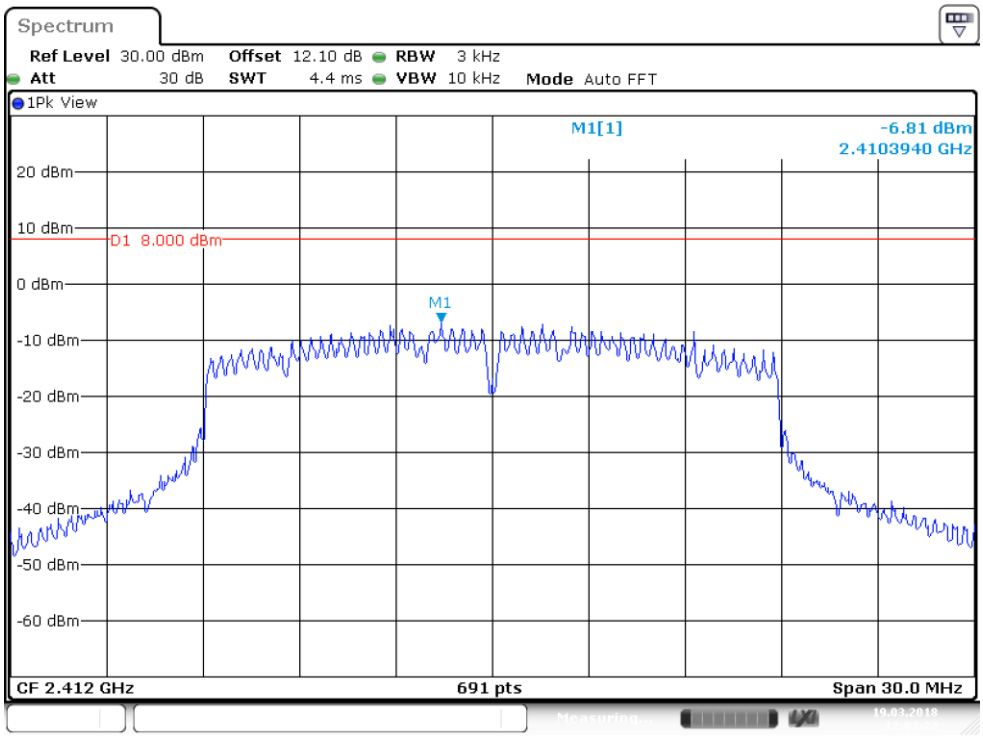
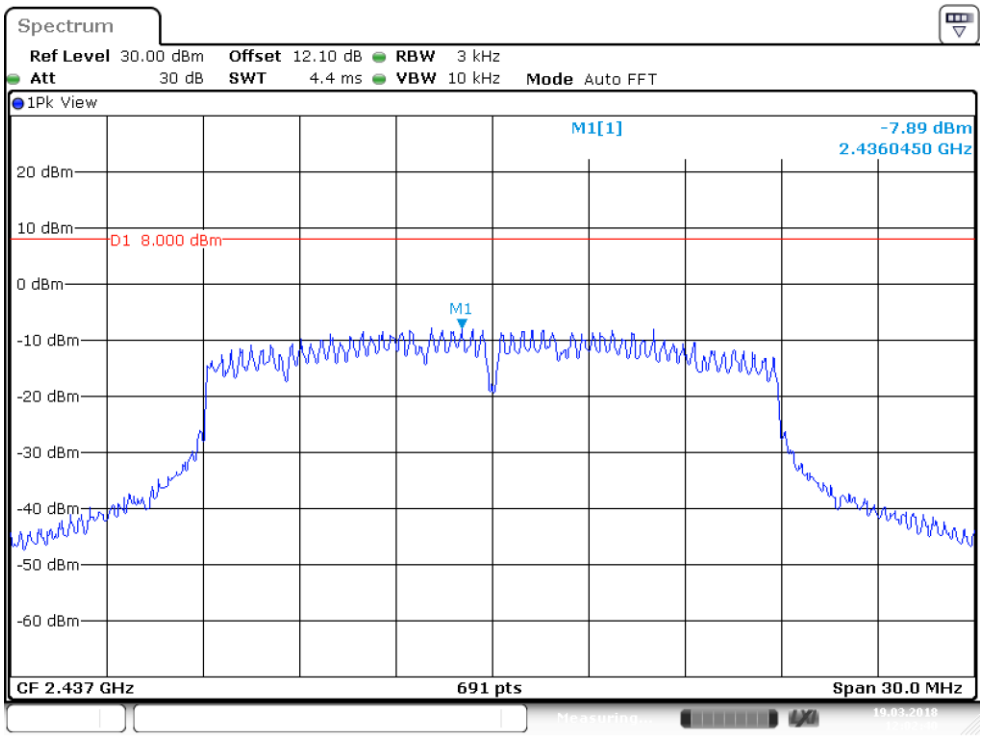


Figure 15: Power Spectral Density, 2462 MHz at 802.11g 6Mbps



Date: 19.MAR.2018 12:03:22

Figure 16: Power Spectral Density, 2412 MHz at 802.11n HT20 MCS0



Date: 19.MAR.2018 12:02:40

Figure 17: Power Spectral Density, 2437 MHz at 802.11n HT20 MCS0

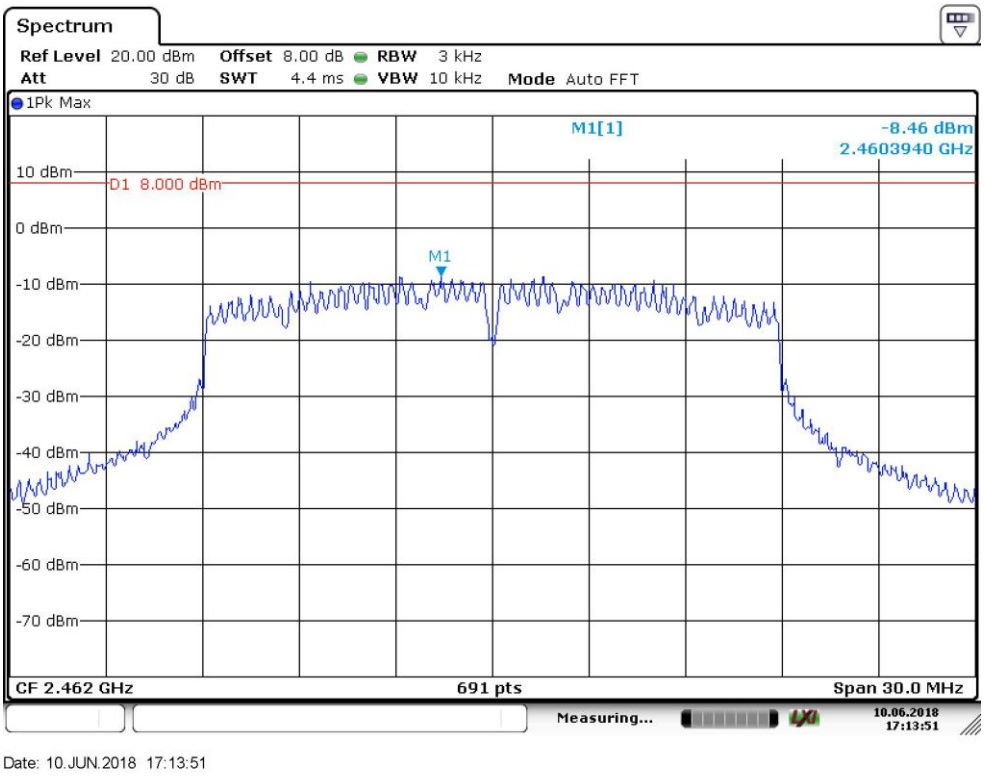


Figure 18: Power Spectral Density, 2462 MHz at 802.11n MCS0

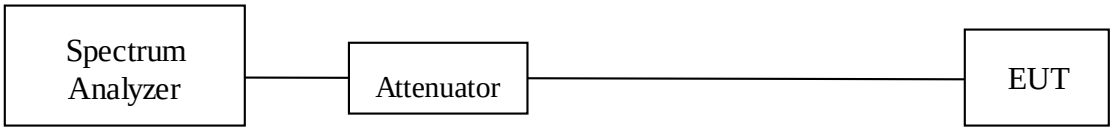
4.5 Out of Band Emissions: Non-Restricted Bands

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR 47Part 15.247(d), RSS-247 Sect. 5.5.

4.5.1 Test Method

Conducted measurements per KDB 558074, section 11.0 and ANSI C63.10, section 11.11 were used to measure the undesirable emission requirement in non-restricted bands. The measurement was performed with modulation. This test was conducted on 3 channels in each mode on the EUT. The worst-case measurement of each channel is recorded in this report.

Test Setup:



4.5.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

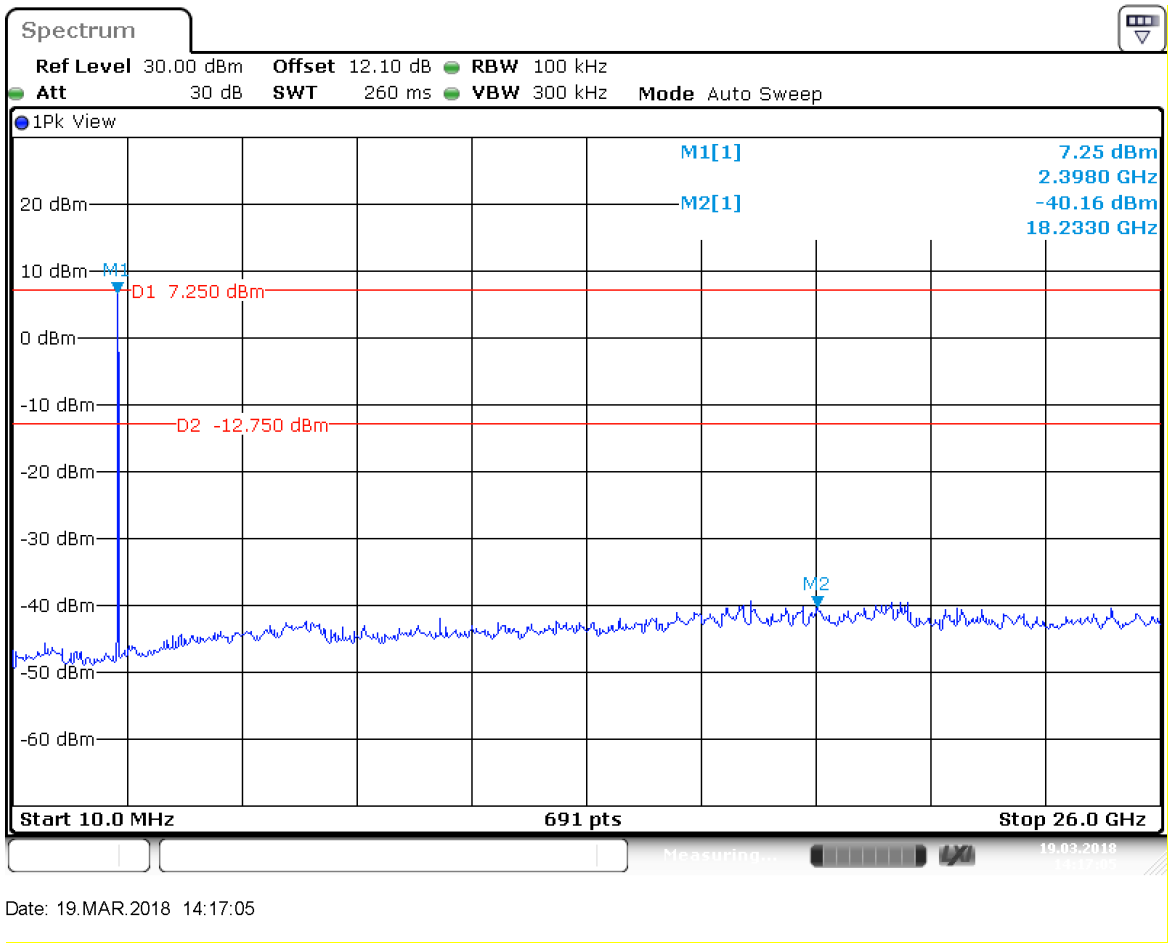


Figure 19: 802.11b 1Mbps at 2412 MHz

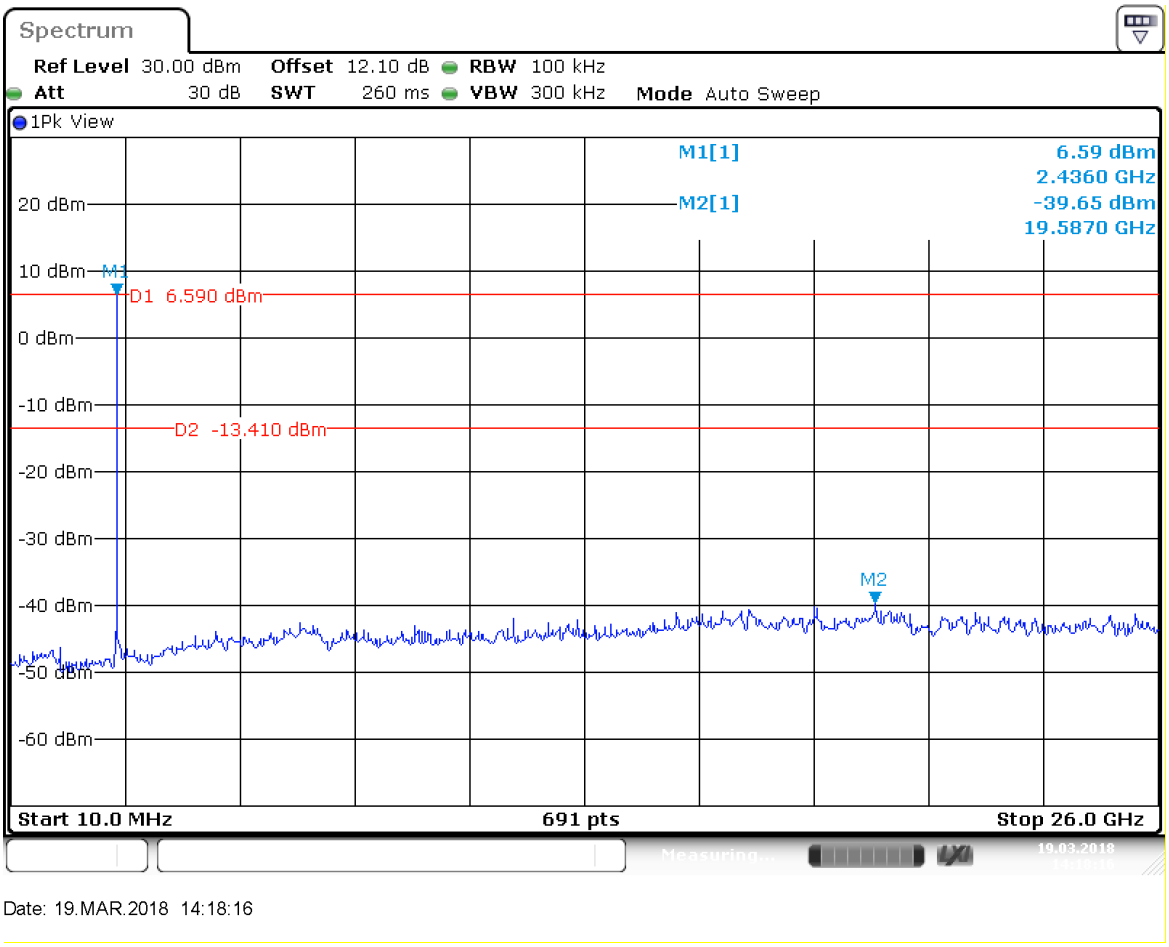
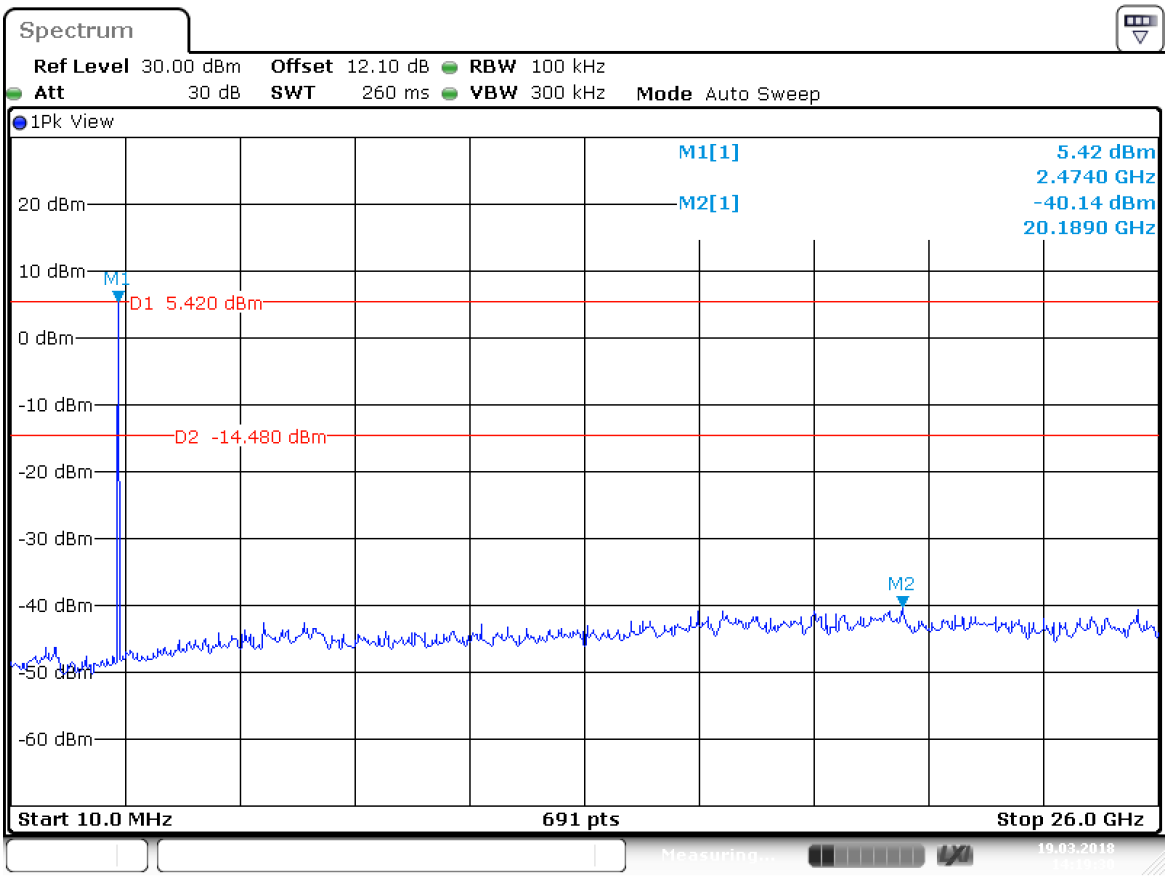
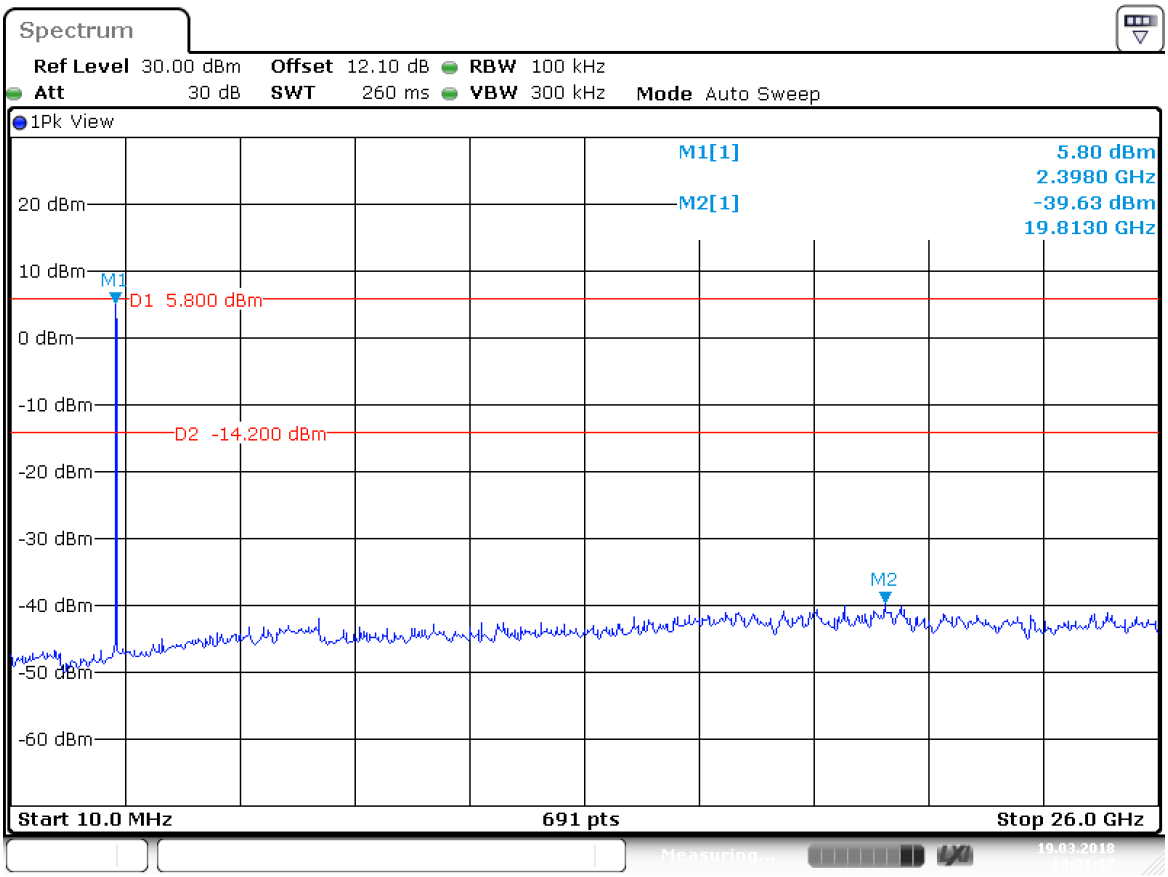


Figure 20: 802.11b 1Mbps at 2437 MHz



Date: 19.MAR.2018 14:19:30

Figure 21: 802.11b 1Mbps at 2462 MHz



Date: 19.MAR.2018 14:21:17

Figure 22: 802.11g 6Mbps at 2412 MHz

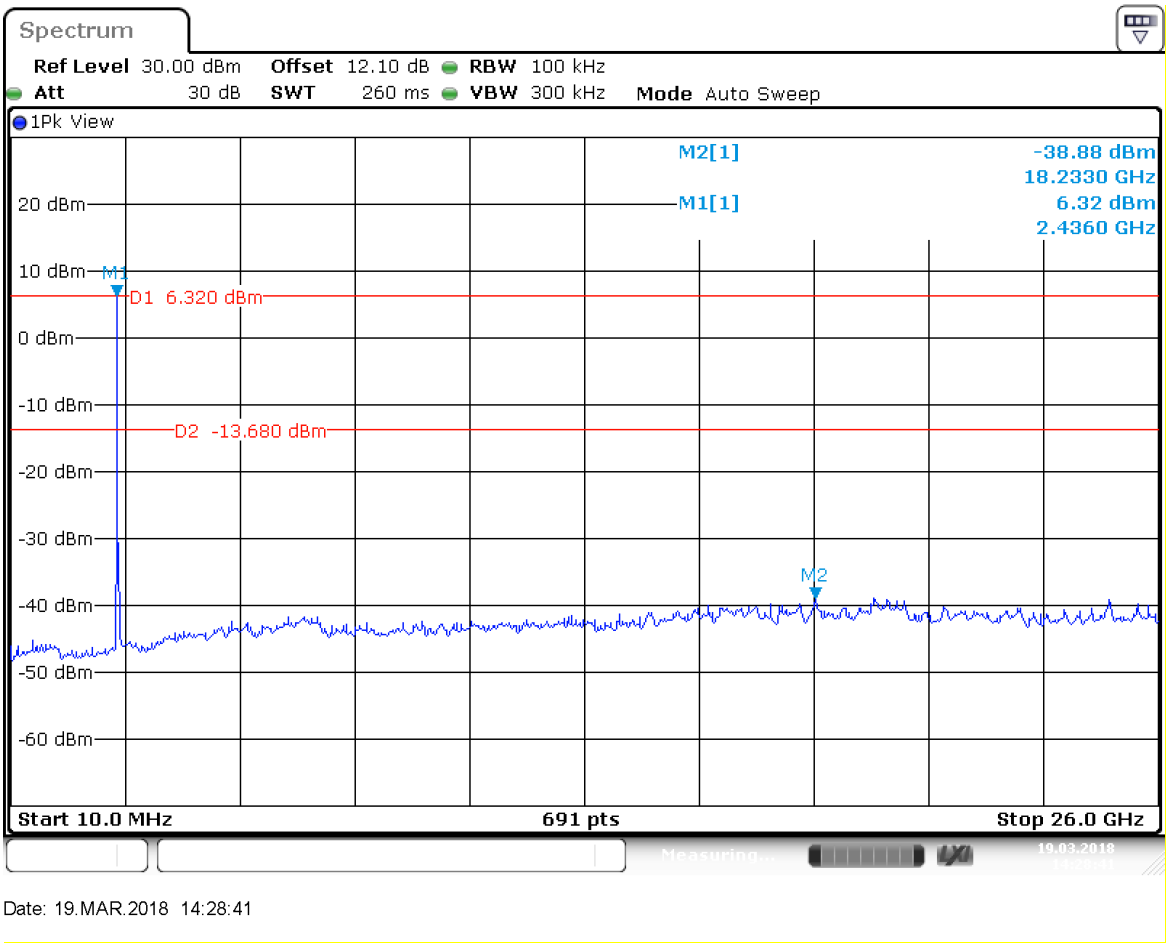


Figure 23: 802.11g 6Mbps at 2437 MHz

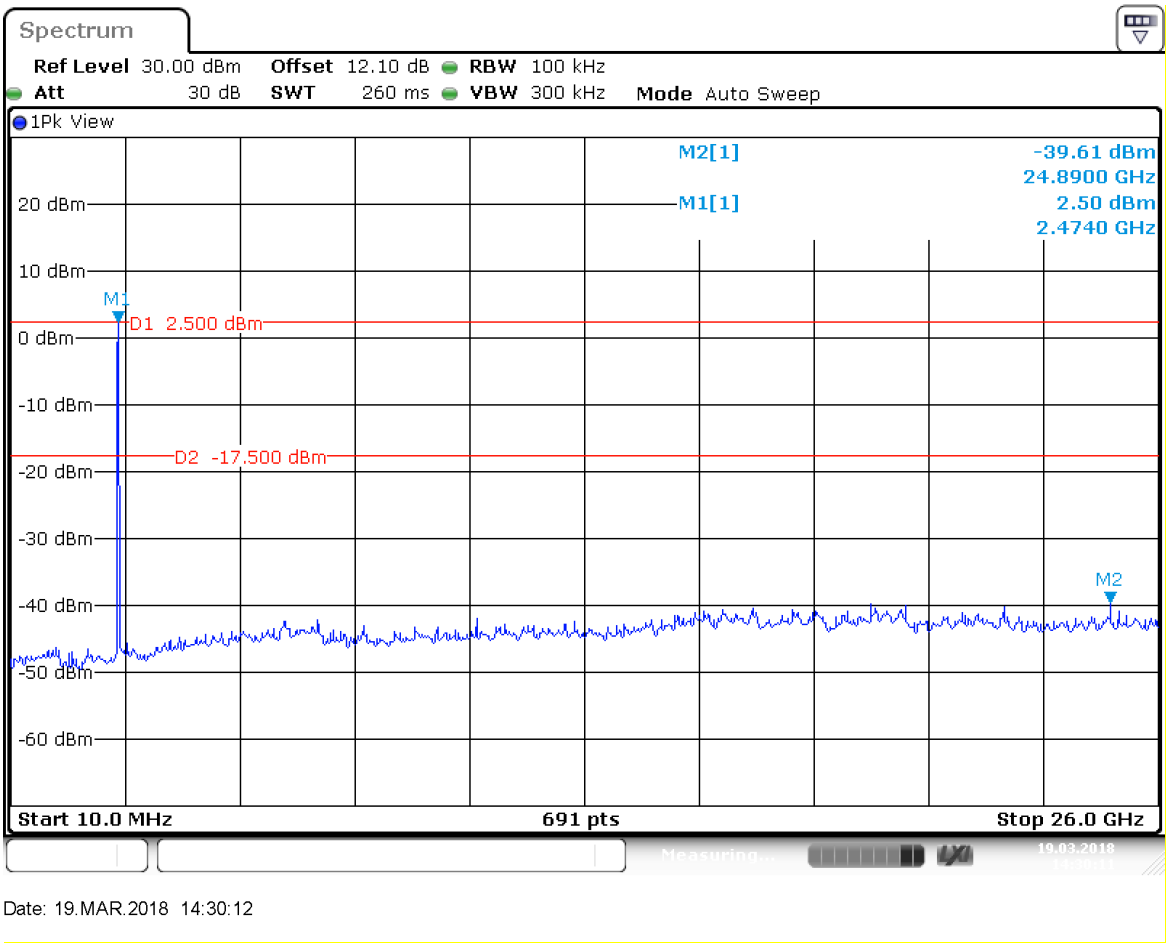
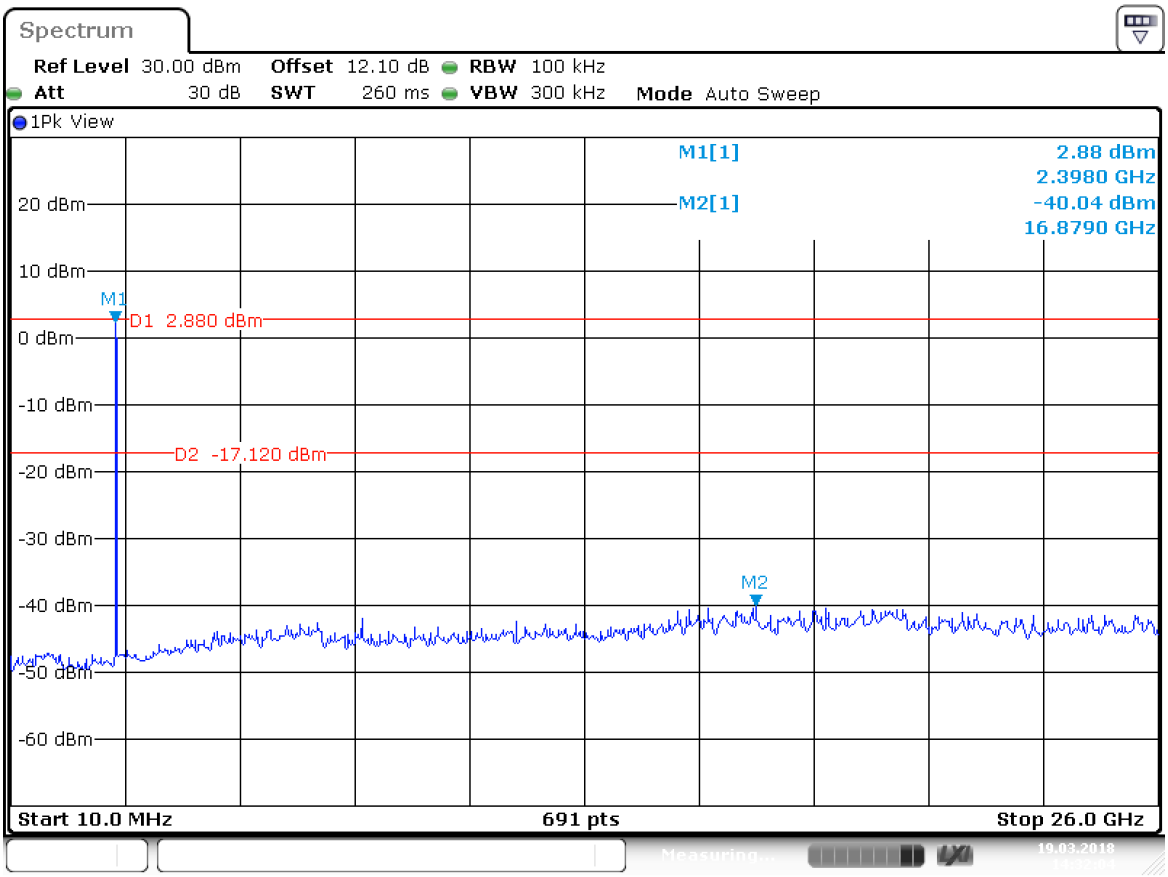


Figure 24: 802.11g 6Mbps at 2462 MHz



Date: 19.MAR.2018 14:32:04

Figure 25: 802.11n 6.5Mbps at 2412 MHz

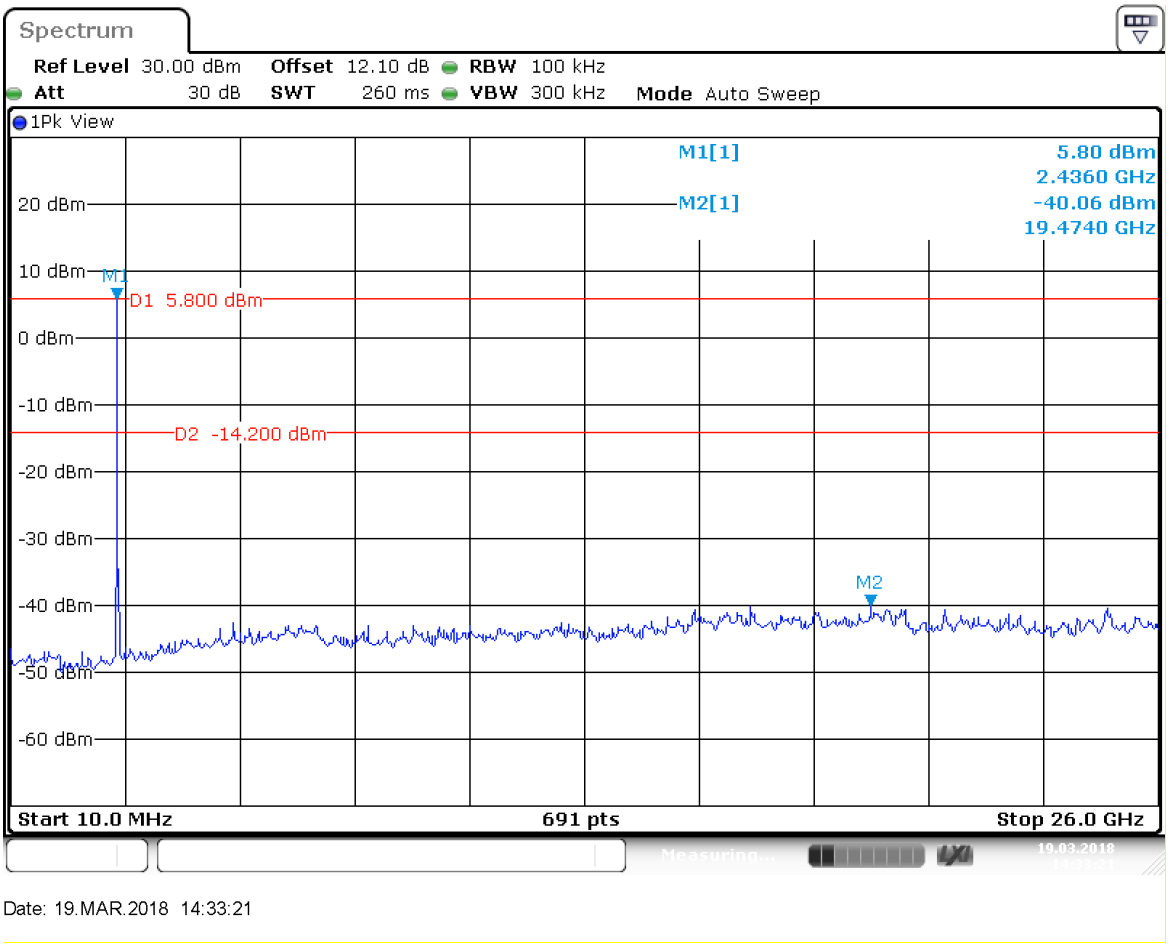


Figure 26: 802.11n 6.5Mbps at 2437 MHz

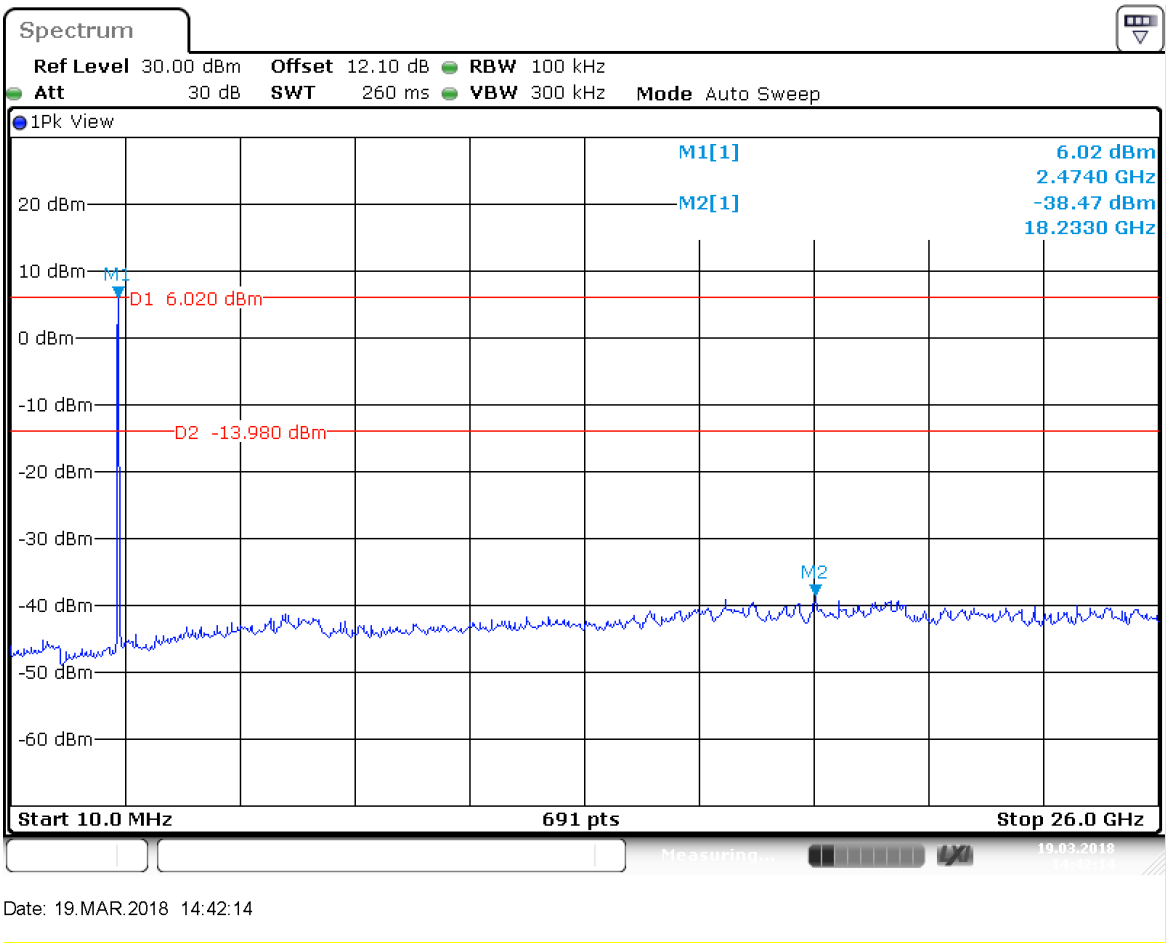


Figure 27: 802.11n 6.5Mbps at 2462 MHz

4.6 Emissions in restricted frequency bands

Emissions in restricted frequency bands *are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR 47Part 15.247(d)* and *RSS 247 Sect.5.5.*

4.6.1 Test Methodology

4.6.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Pre-scans were performed to determine the worst data rate.

4.6.1.2 Final Test

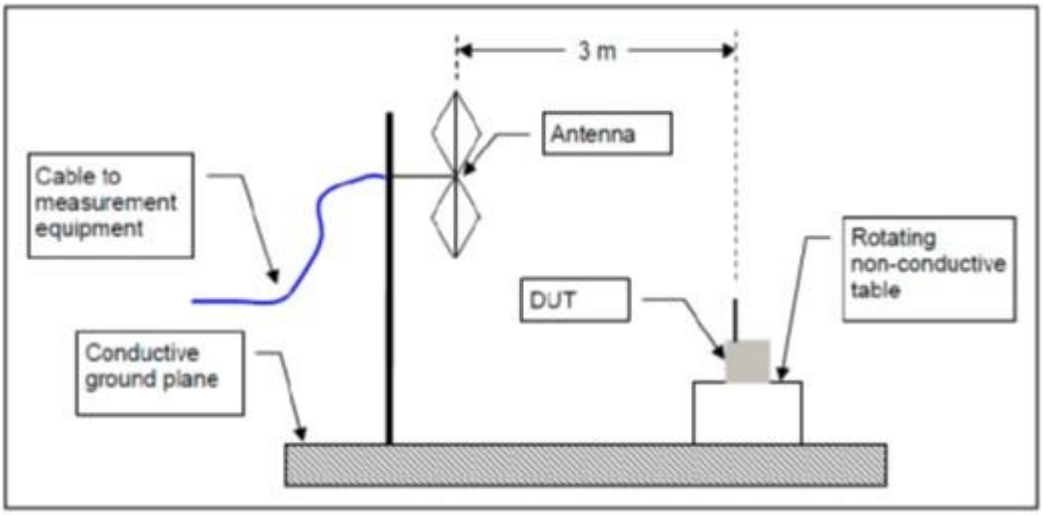
For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

4.6.1.3 Deviations

None.

4.6.2 Test Setup:



The DUT was stimulated by manufacturer provided test software that is not available to the end user.

4.6.3 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.209 and RSS Gen Sect. 8.9 and 8.10.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F(kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

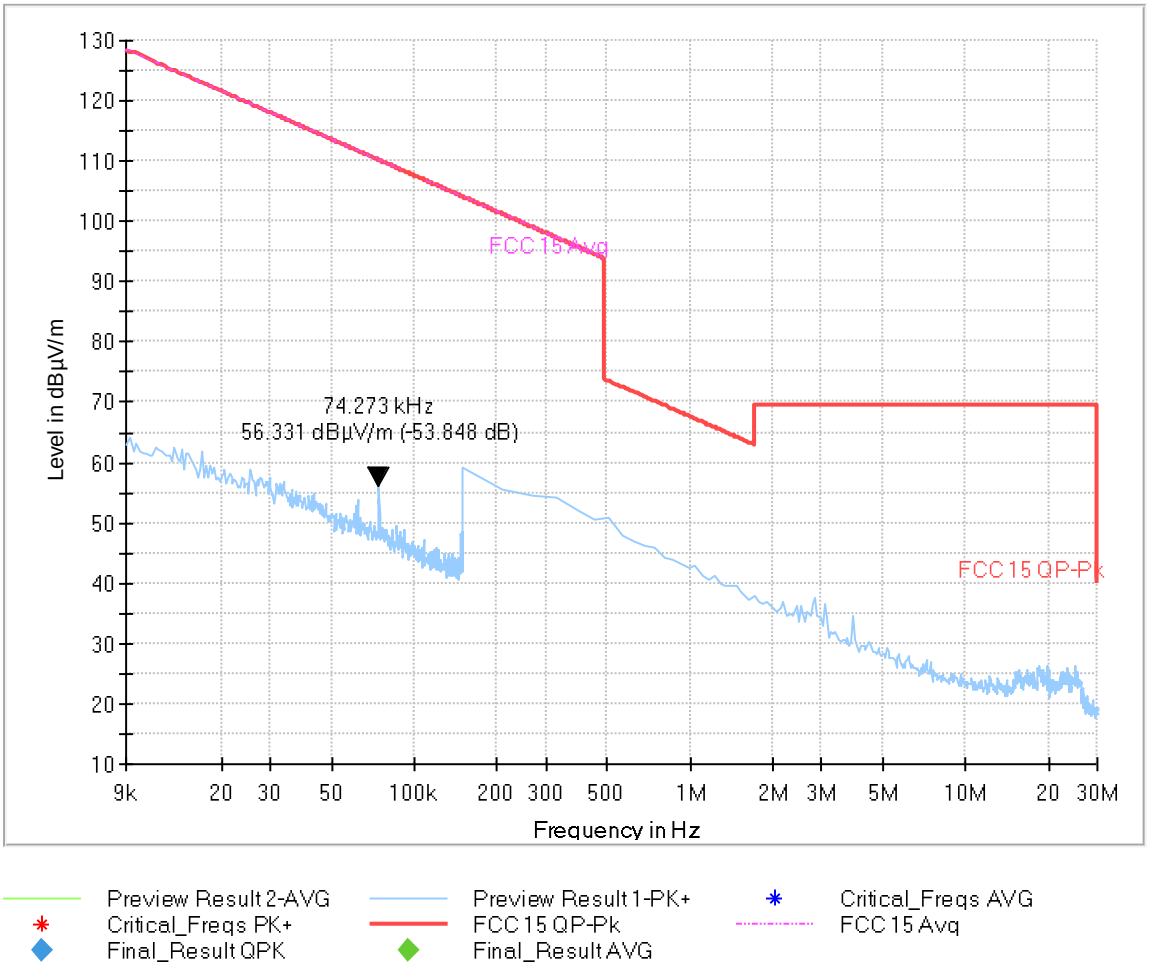
4.6.4 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions.

802.11n is the worst case operating mode.

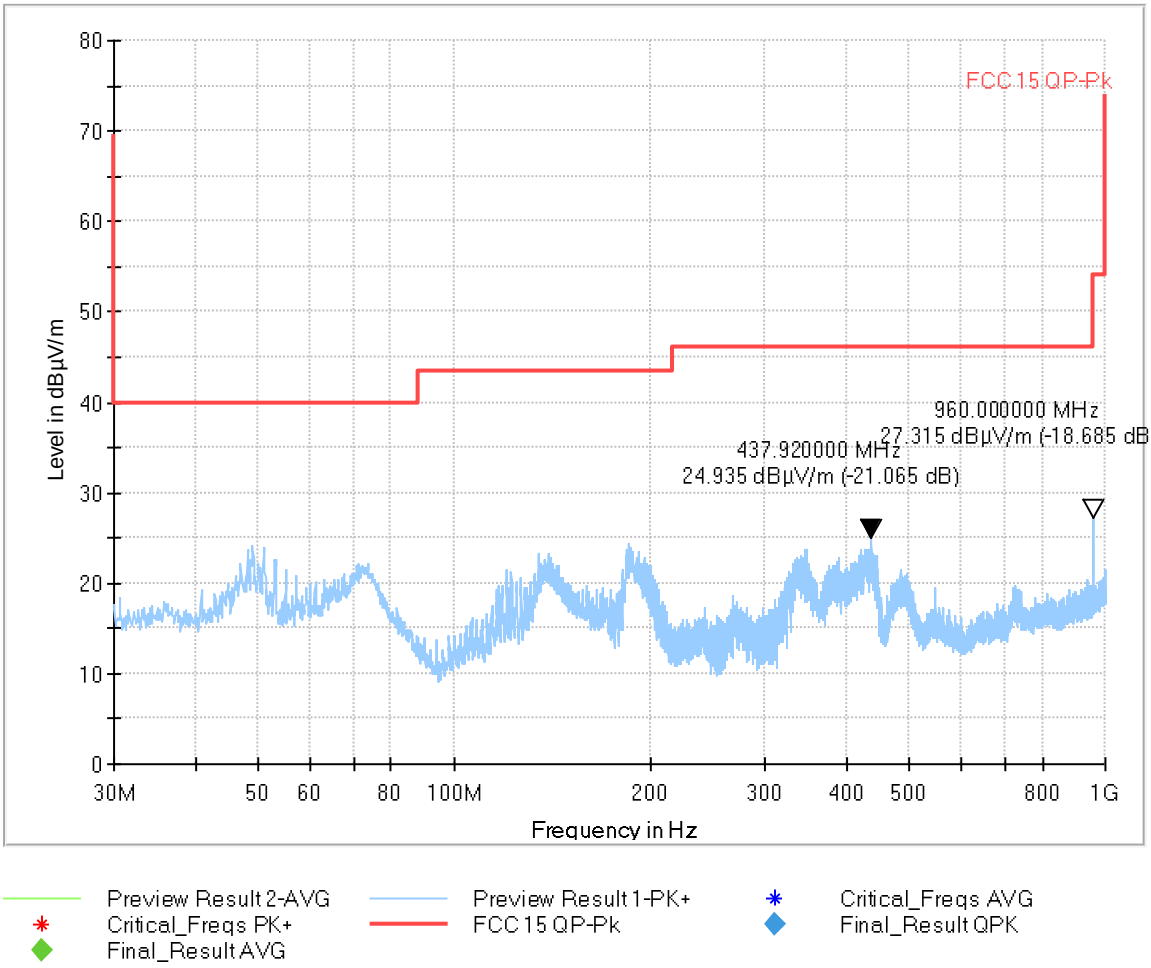
Measurements were performed on June 10, 2018.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).



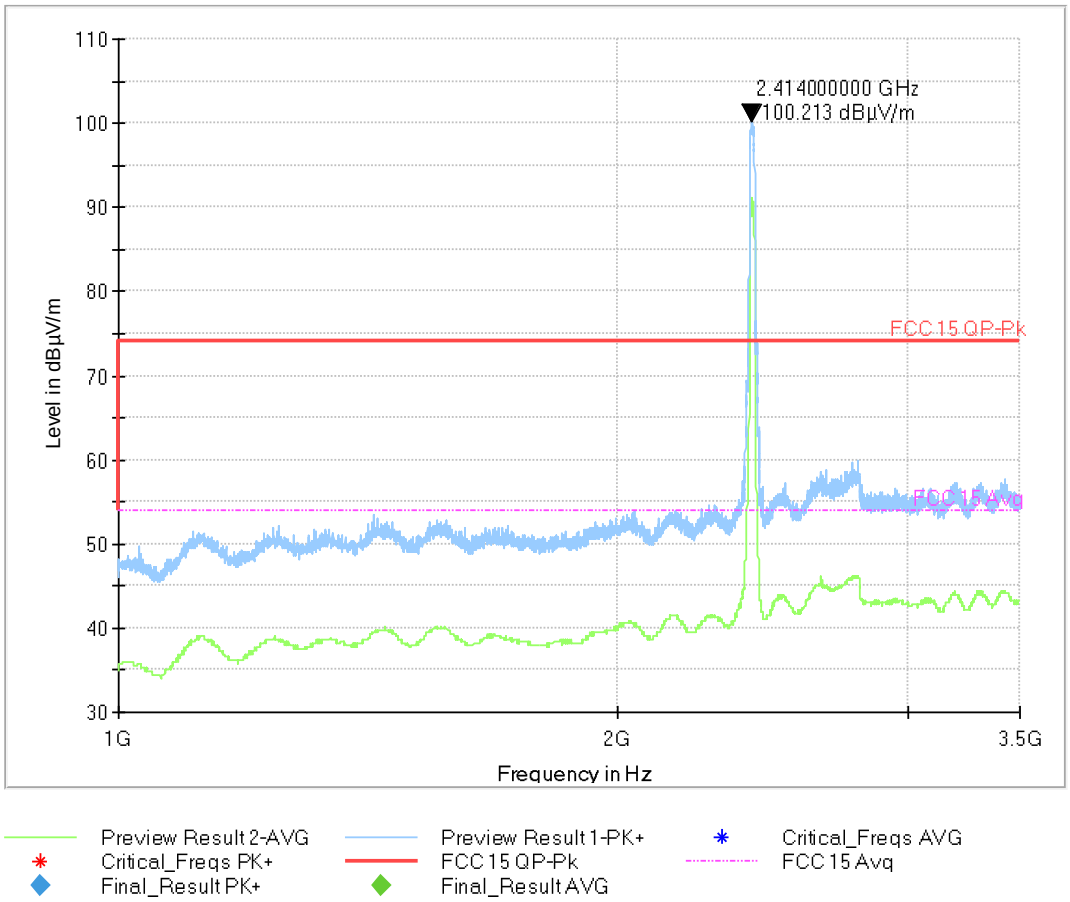
Worst case for all channels

Figure 28: 9 kHz – 30 MHz, 802.11n MCS0 at 2437 MHz



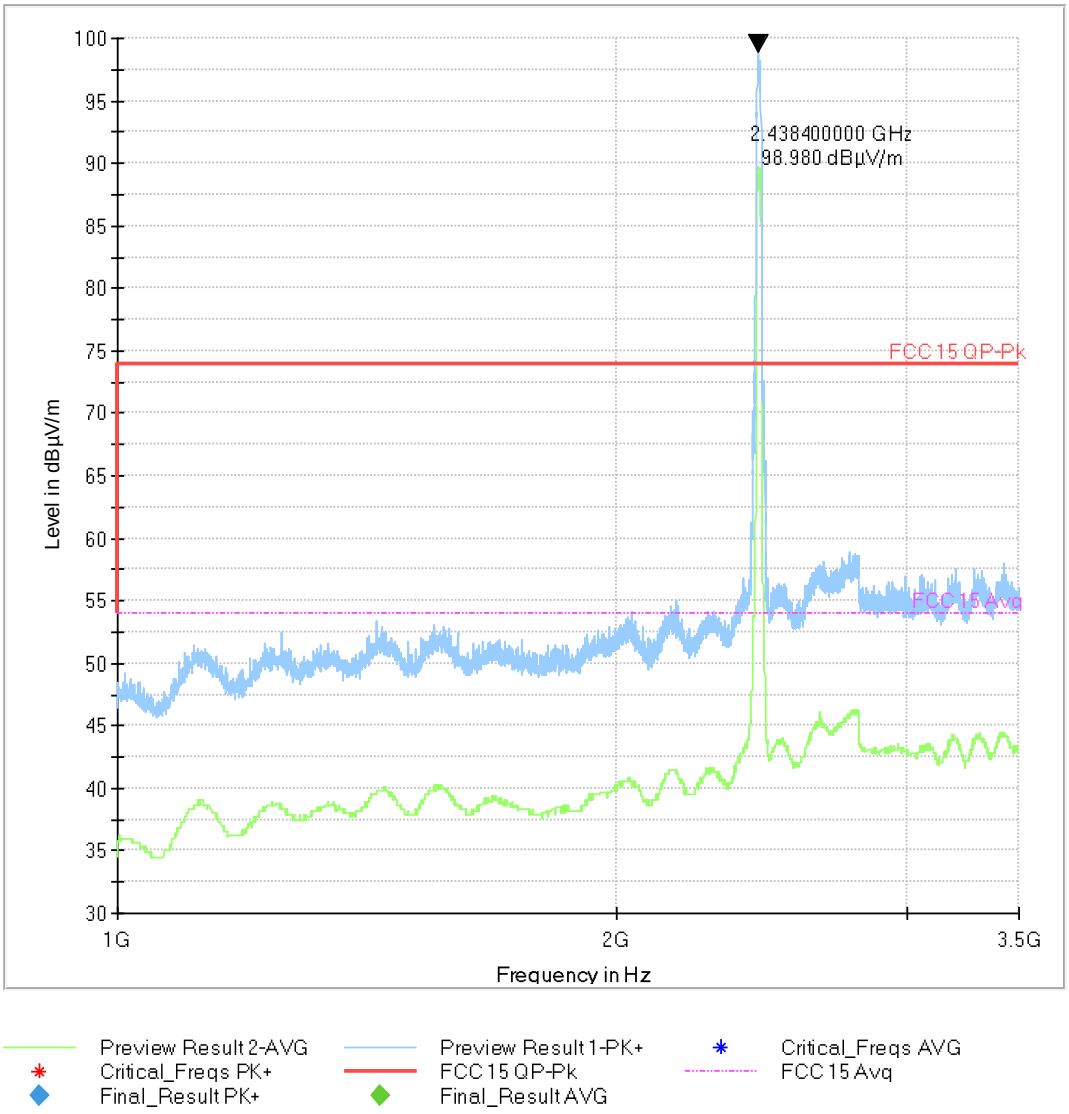
Worst case for all channels

Figure 29: 30 MHz -1 GHz, 802.11n MCS0 at 2437 MHz



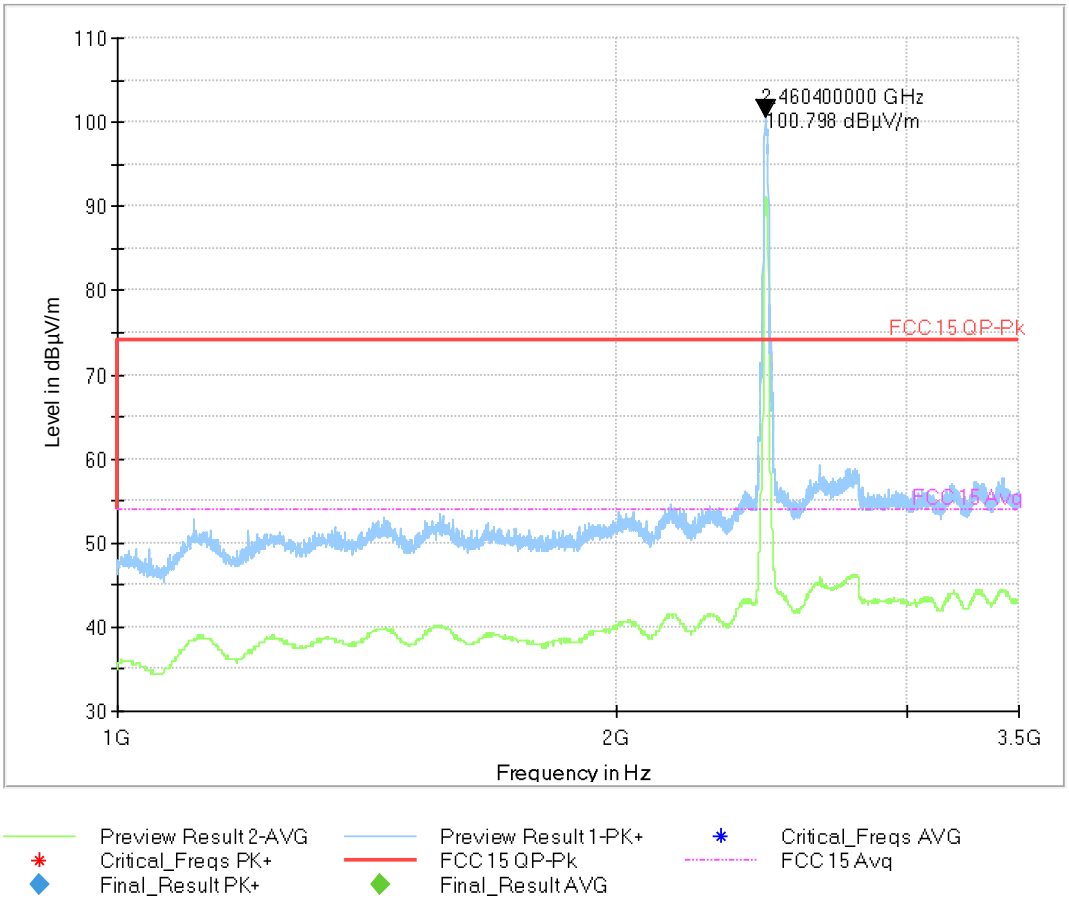
Peak above the limit is the carrier

Figure 30: 1 – 3.5 GHz, 802.11n MCS0 at 2412 MHz



Peak above the limit is the carrier

Figure 31: 1 – 3.5 GHz, 802.11n MCS0 at 2437 MHz



Peak above the limit is the carrier

Figure 32: 1 – 3.5 GHz, 802.11n MCS0 at 2462 MHz

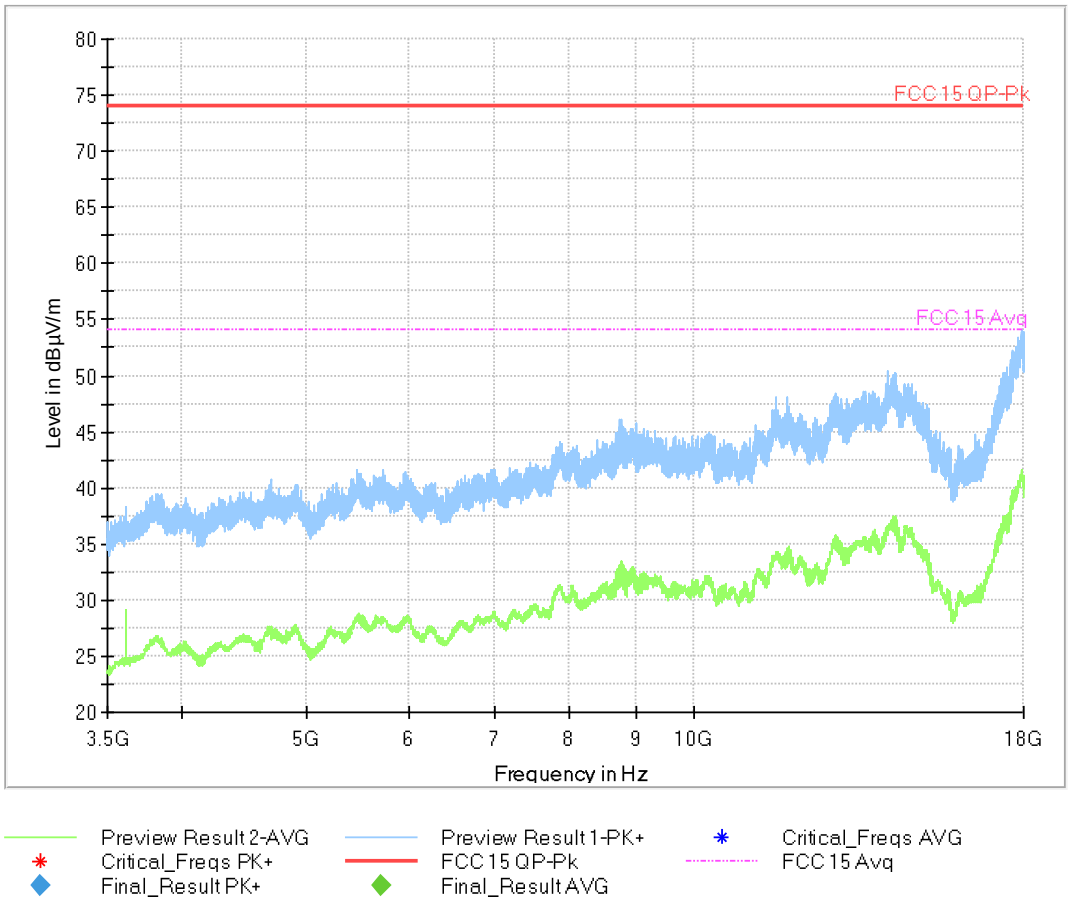


Figure 33: 3.5 – 18 GHz, 802.11n MCS0 at 2412 MHz

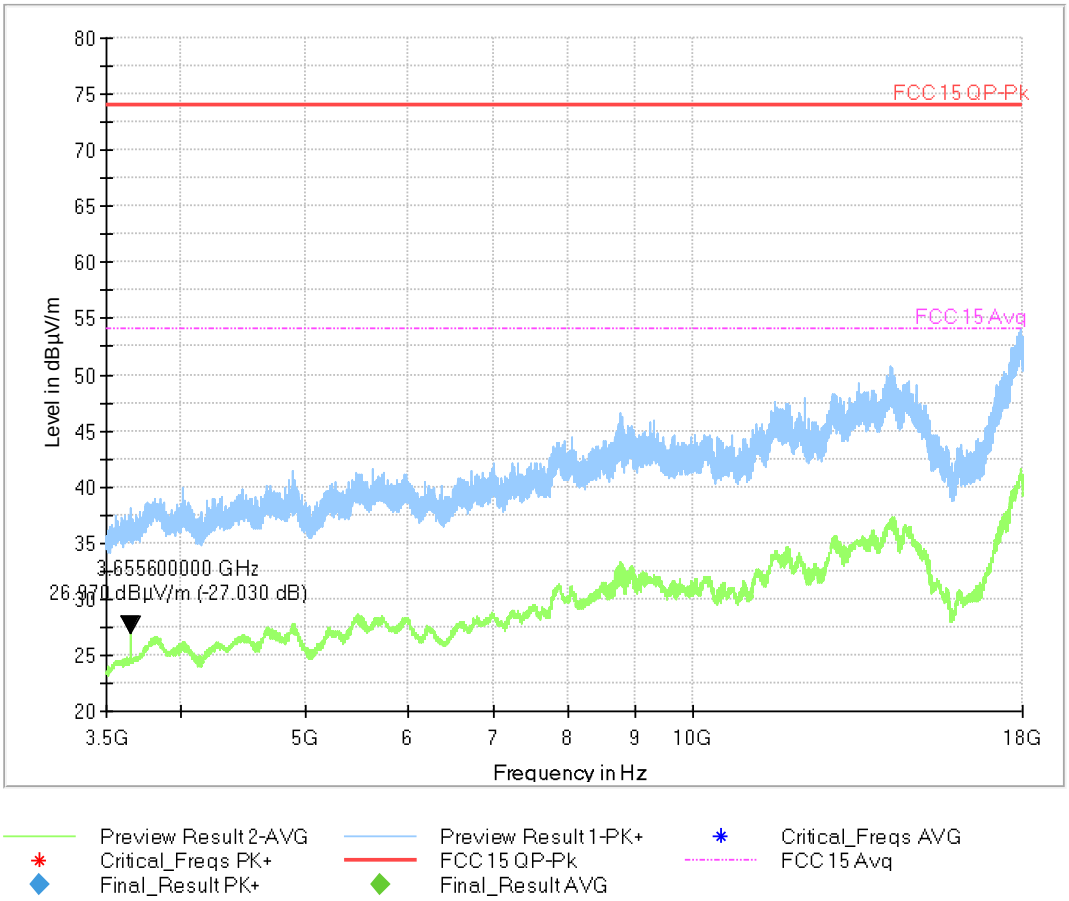


Figure 34: 3.5 – 18 GHz, 802.11n MCS0 at 2437 MHz

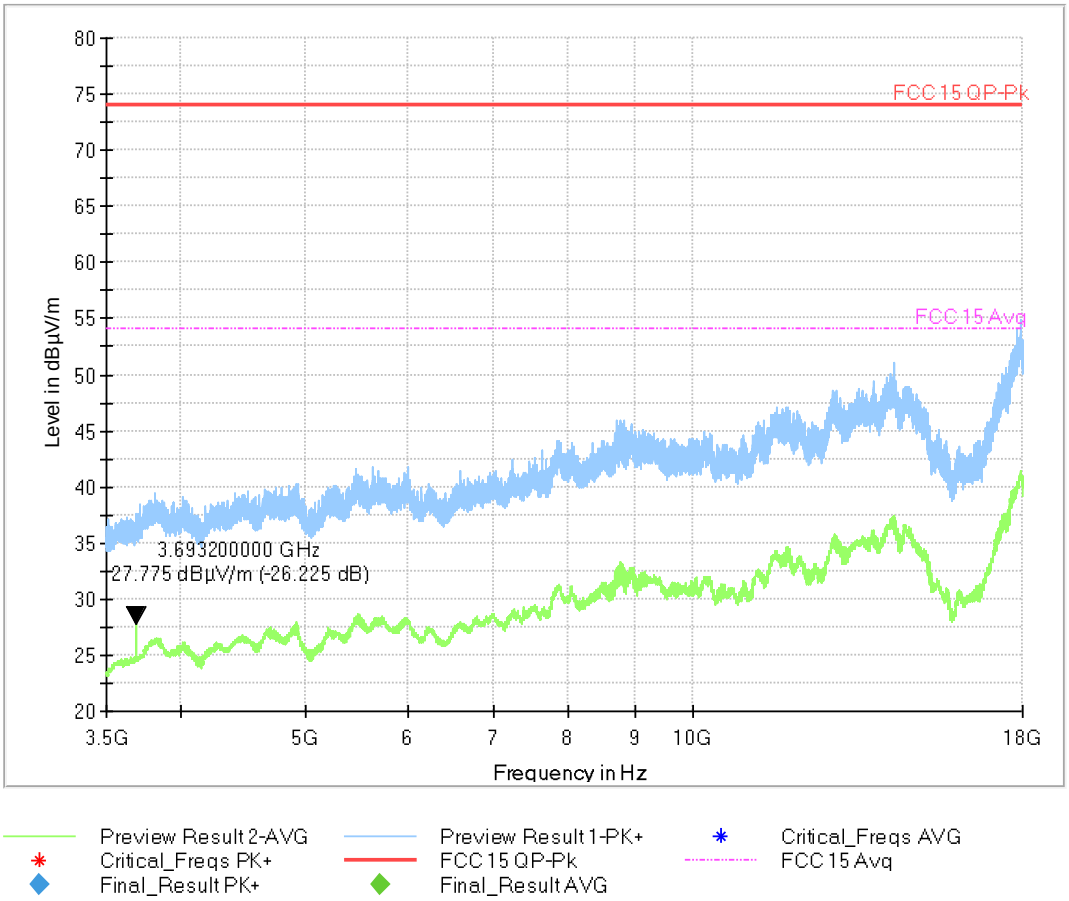
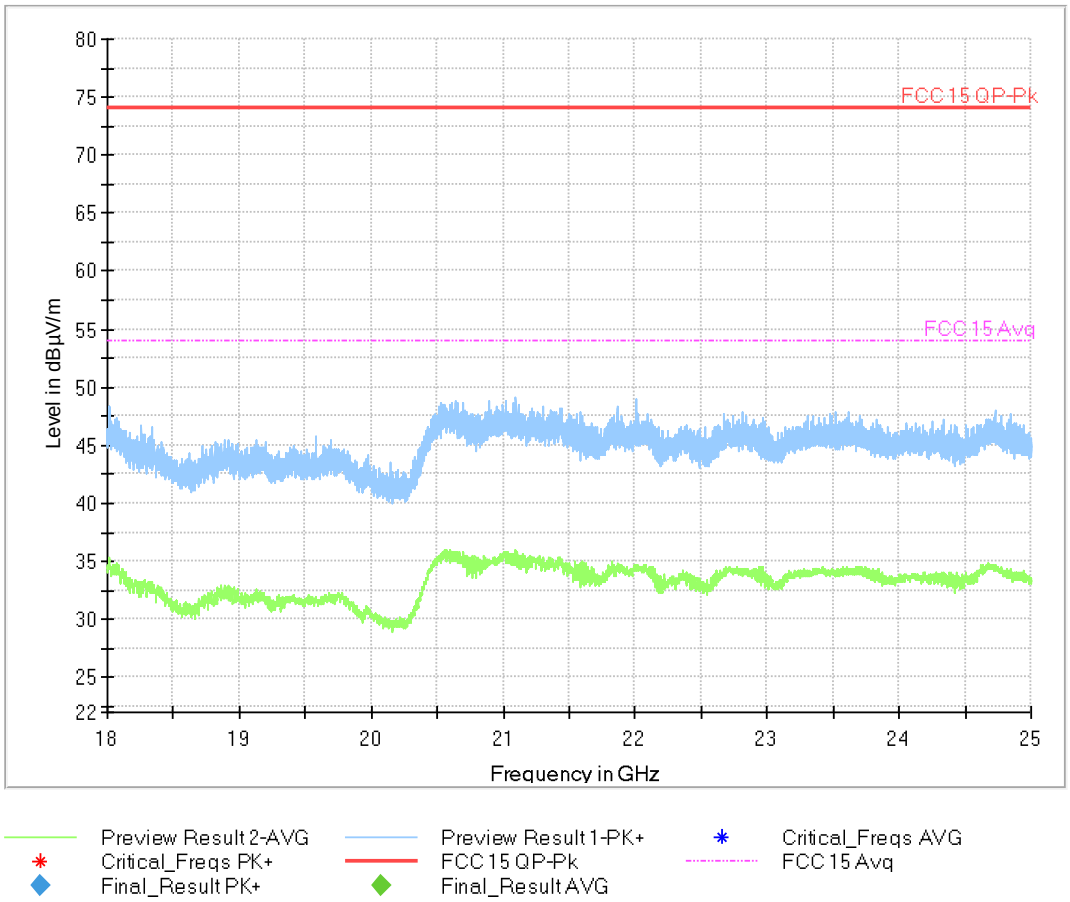


Figure 35: 3.5 – 18 GHz, 802.11n MCS0 at 2462 MHz



Worst case for all channels

Figure 36: 18 – 25 GHz, 802.11n MCS0 at 2437 MHz

4.7 Out of Band Emissions: Restricted Band Edge

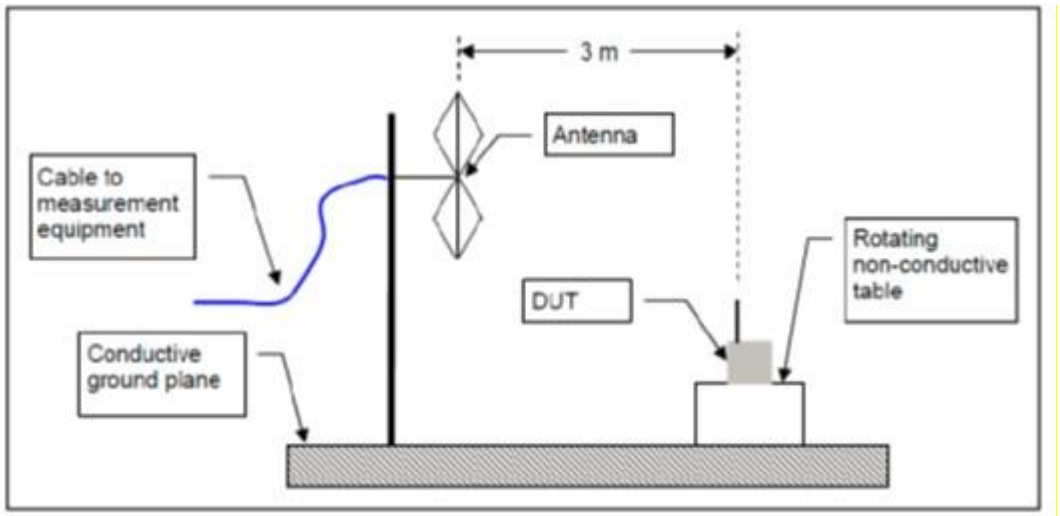
Restricted band edge spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR 47 Part 15.247(d), RSS-247 Sect. 5.5.

4.7.1 Test Method

Radiated measurements per ANSI C63.10 section 6.10.5 were used to measure the undesirable emission requirement in restricted bands. The measurement was performed with modulation. This test was conducted on low and high channels in each mode on the EUT.

Spectrum Analyzer Settings:

	Peak Measurement	Average Measurement
Detector	Peak	Peak
Trace	Max Hold	Max Hold
RBW	1 MHz	1 MHz
VBW	3 MHz	10 Hz
Sweep Points	501	501
Sweep Time	Coupled	Coupled
Span	See Plots	See Plots, (Maximum of RBW/2 per sweep point)



The DUT was stimulated by manufacturer provided test software that is not available to the end user.

4.7.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 10: Emissions at the Band-Edge – Test Results

Test Conditions: Radiated Measurement							
Antenna Type: Chip			**Power Setting:** 802.11g/n Ch. 11: 74; All other channels: 80				
Max. Antenna Gain: 1.6 dBi							
Signal State: Modulated 100% duty cycle							
Ambient Temp.: 22° C				**Relative Humidity:** 38%			
Lower Restricted Band Edge							
Freq. (MHz)	**Mode**	**Channel**	**Detector (Average/Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2385.84	802.11b 1Mbps	1	Average	48.201	54	-5.799	Pass
2386.64	802.11b 1Mbps	1	Peak	59.547	74	-14.453	Pass
2389.90	802.11g 6 Mbps	1	Average	51.763	54	-2.237	Pass
2389.38	802.11g 6 Mbps	1	Peak	73.698	74	-0.302	Pass
2389.90	802.11n HT20 MCS0	1	Average	53.361	54	-0.639	Pass
2389.38	802.11n HT20 MCS0	1	Peak	73.594	74	-0.406	Pass
Upper Restricted Band Edge							
Freq. (MHz)	**Mode**	**Channel**	**Detector (Average/Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2488.21	802.11b 1Mbps	11	Average	46.321	54	-7.679	Pass
2488.21	802.11b 1Mbps	11	Peak	60.037	74	-13.963	Pass
2483.52	802.11g 6 Mbps	11	Average	50.959	54	-3.041	Pass
2483.52	802.11g 6 Mbps	11	Peak	72.697	74	-1.303	Pass
2483.52	802.11n HT20 MCS0	11	Average	51.168	54	-2.832	Pass
2483.76	802.11n HT20 MCS0	11	Peak	72.824	74	-1.176	Pass

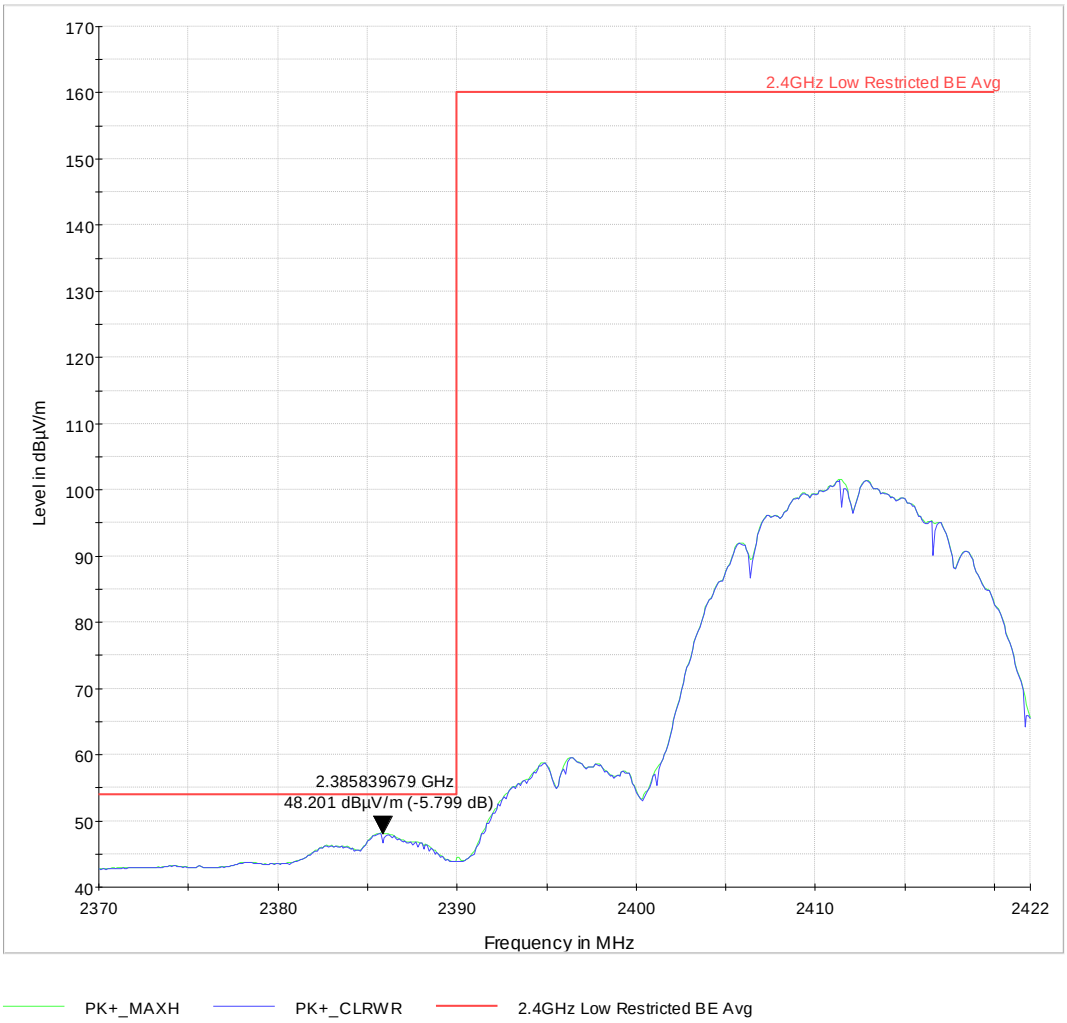


Figure 37: Low Band Edge (restricted) for 802.11b CCK 1 Mbps at 2412 MHz-Average

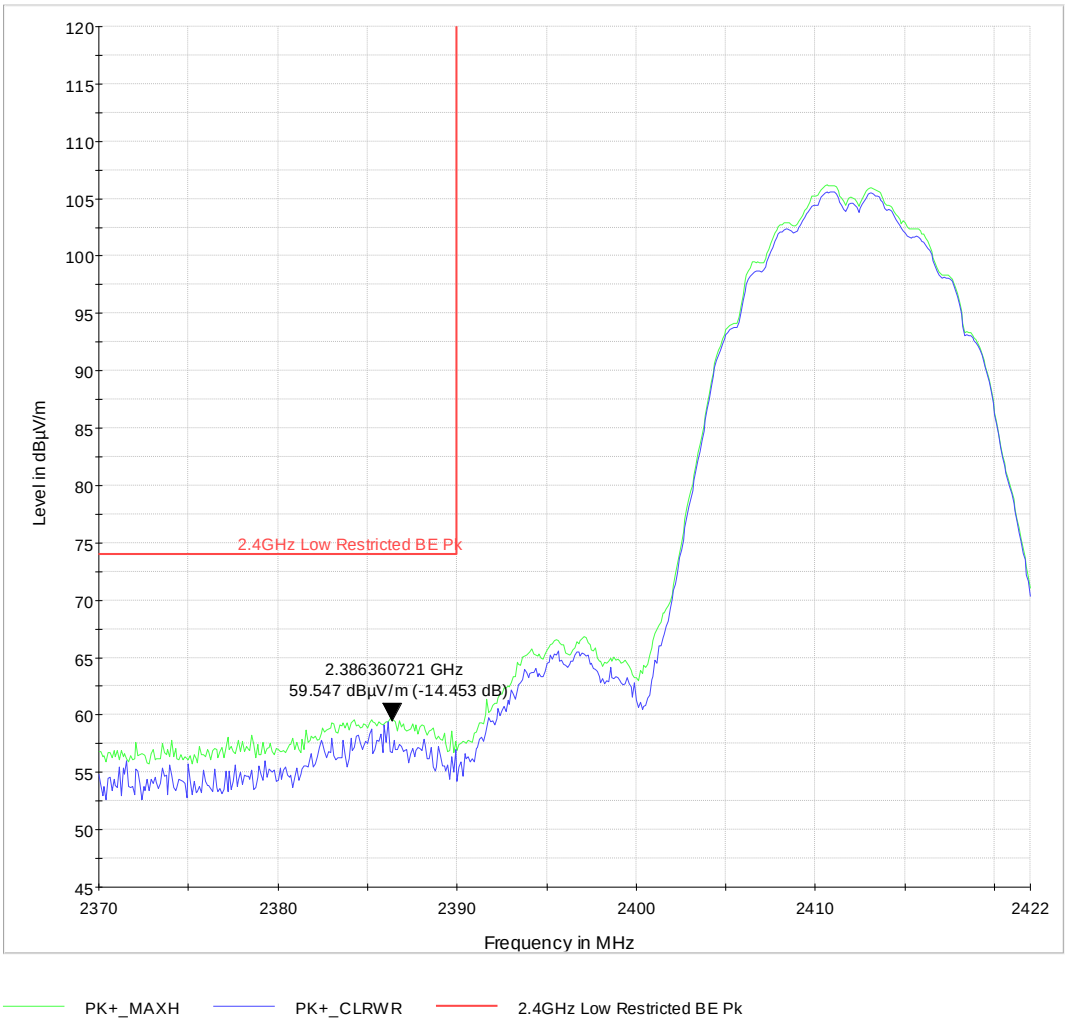


Figure 38: Low Band Edge (restricted) for 802.11b CCK 1 Mbps at 2412 MHz-Peak

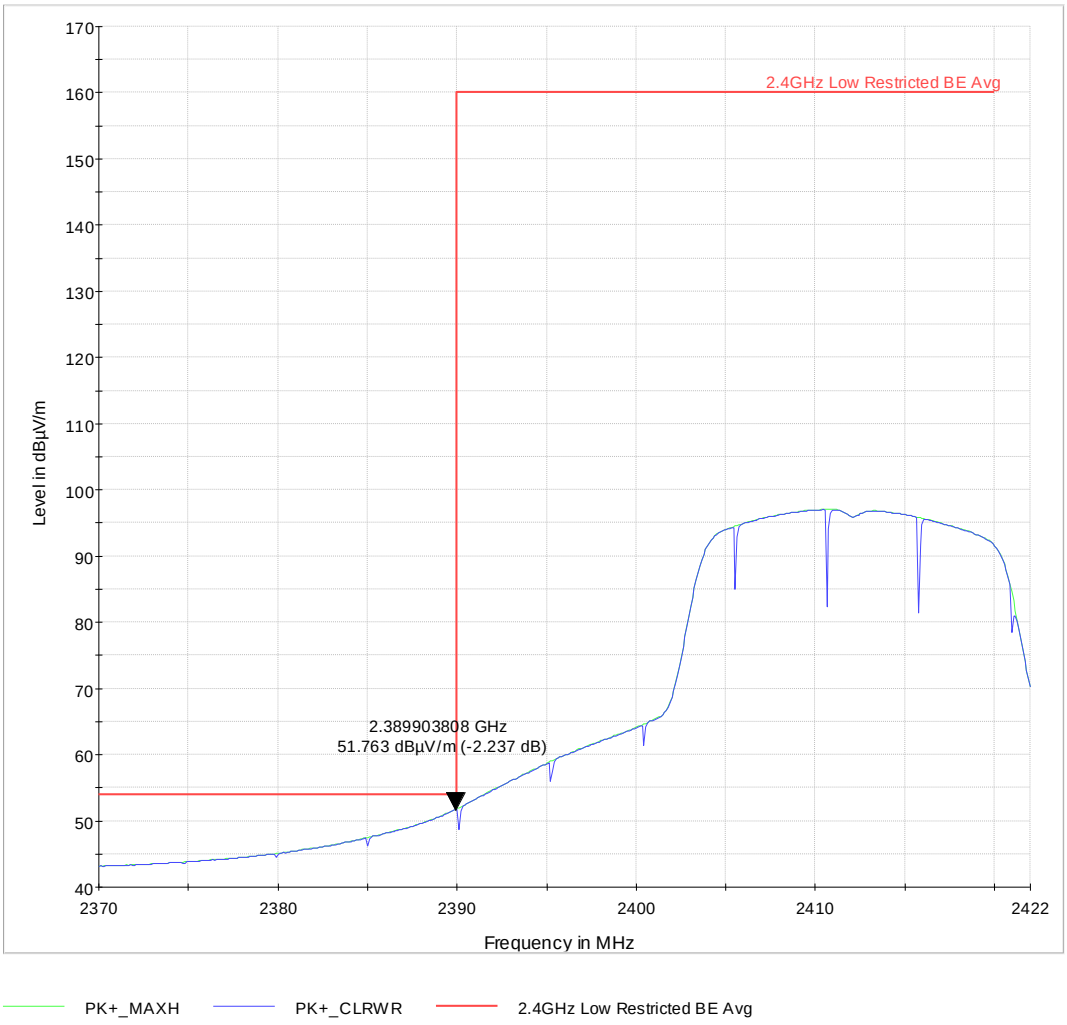


Figure 39: Low Band Edge (restricted) for 802.11g 6 Mbps at 2412 MHz-Average

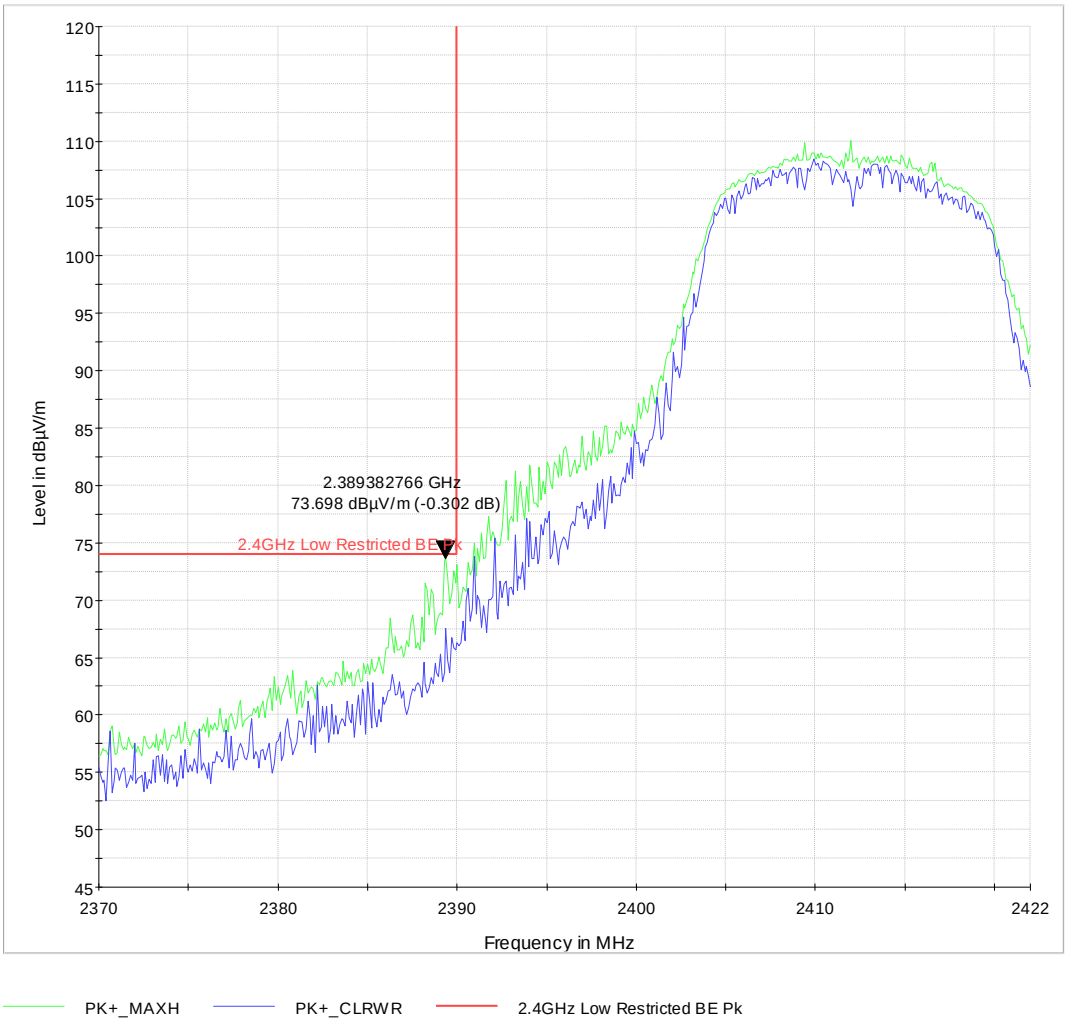


Figure 40: Low Band Edge (restricted) for 802.11g 6 Mbps at 2412 MHz-Peak

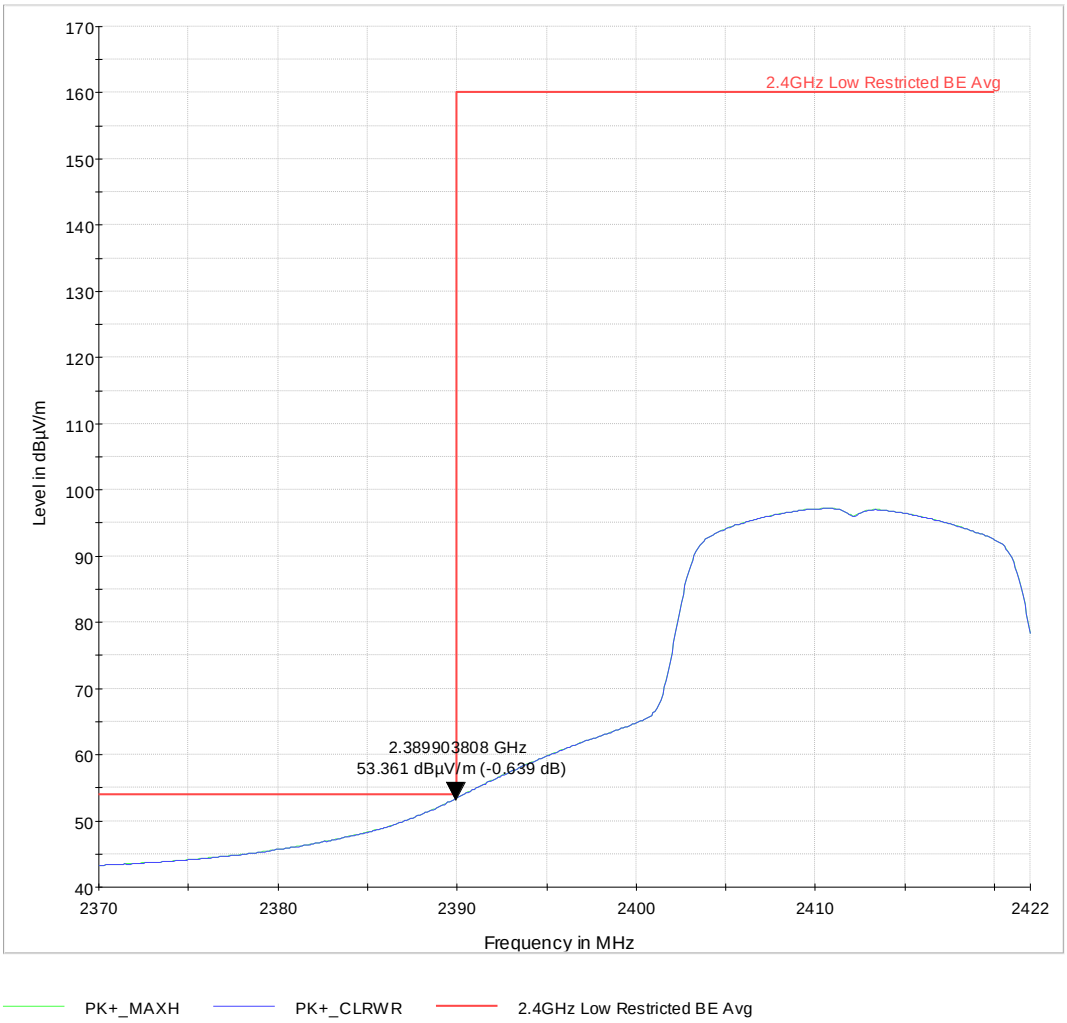


Figure 41: Low Band Edge (restricted) for 802.11n HT20 MCS0 at 2412 MHz-Average

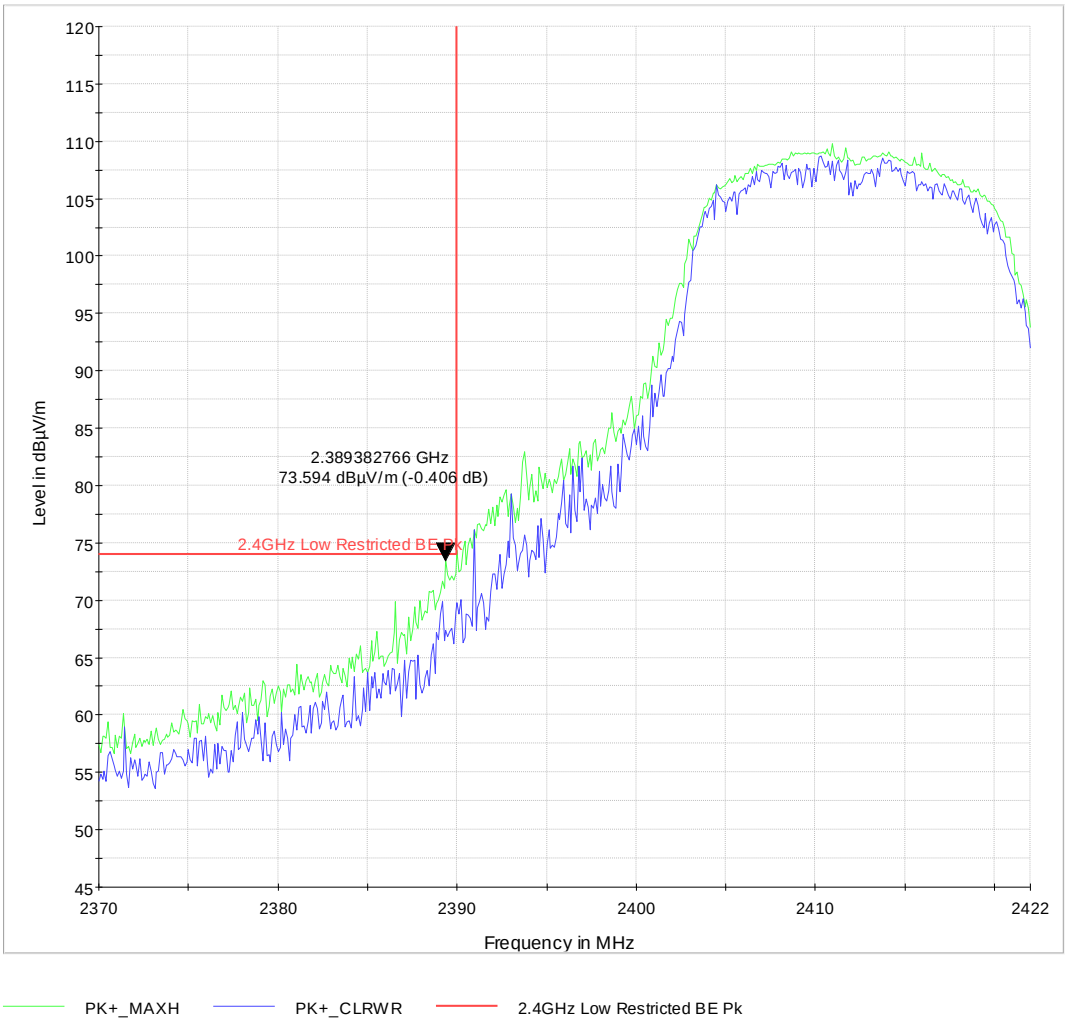


Figure 42: Low Band Edge (restricted) for 802.11n HT20 MCS0 at 2412 MHz-Peak

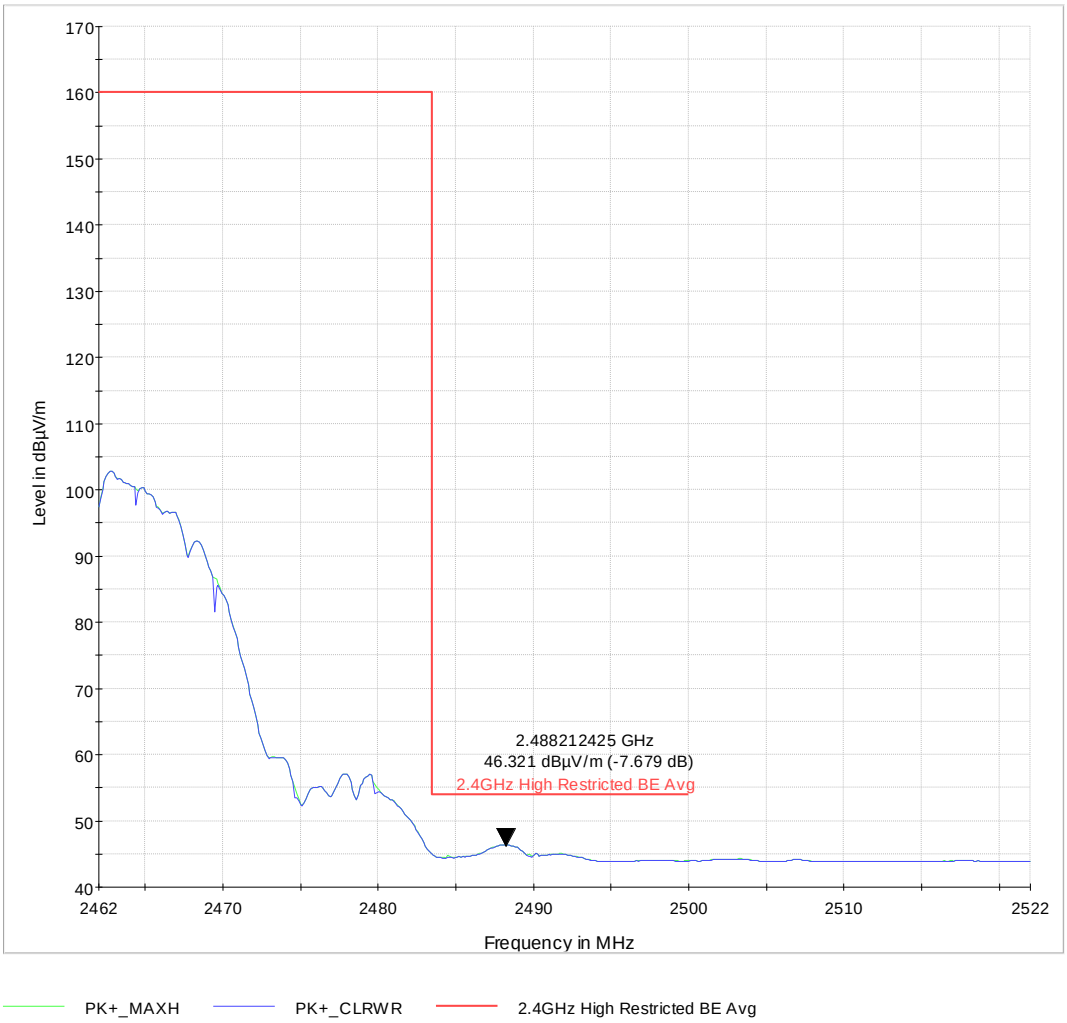


Figure 43: High Band Edge (restricted) for 802.11b CCK 1 Mbps at 2462 MHz-Average

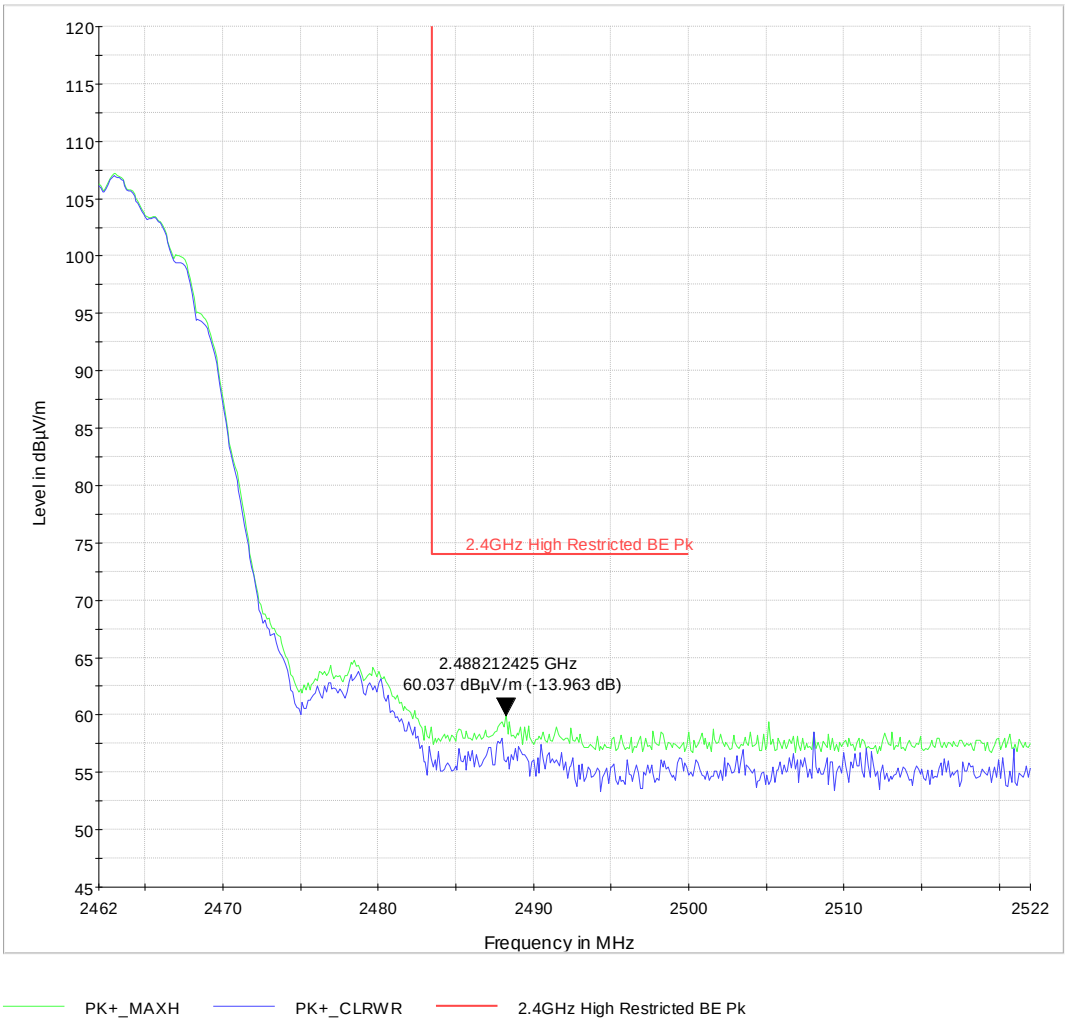


Figure 44: High Band Edge (restricted) for 802.11b CCK 1 Mbps at 2462 MHz-Peak

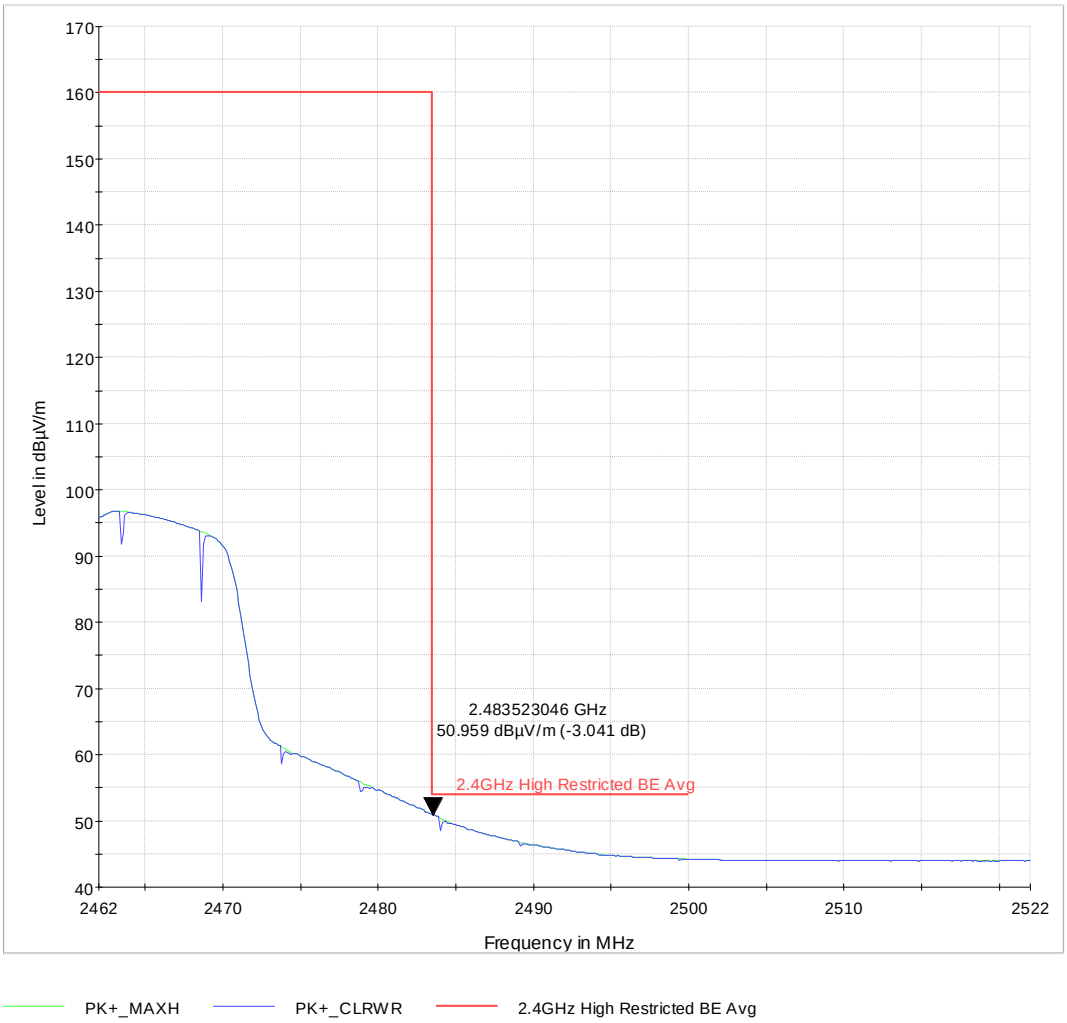


Figure 45: High Band Edge (restricted) for 802.116 Mbps at 2462 MHz-Average

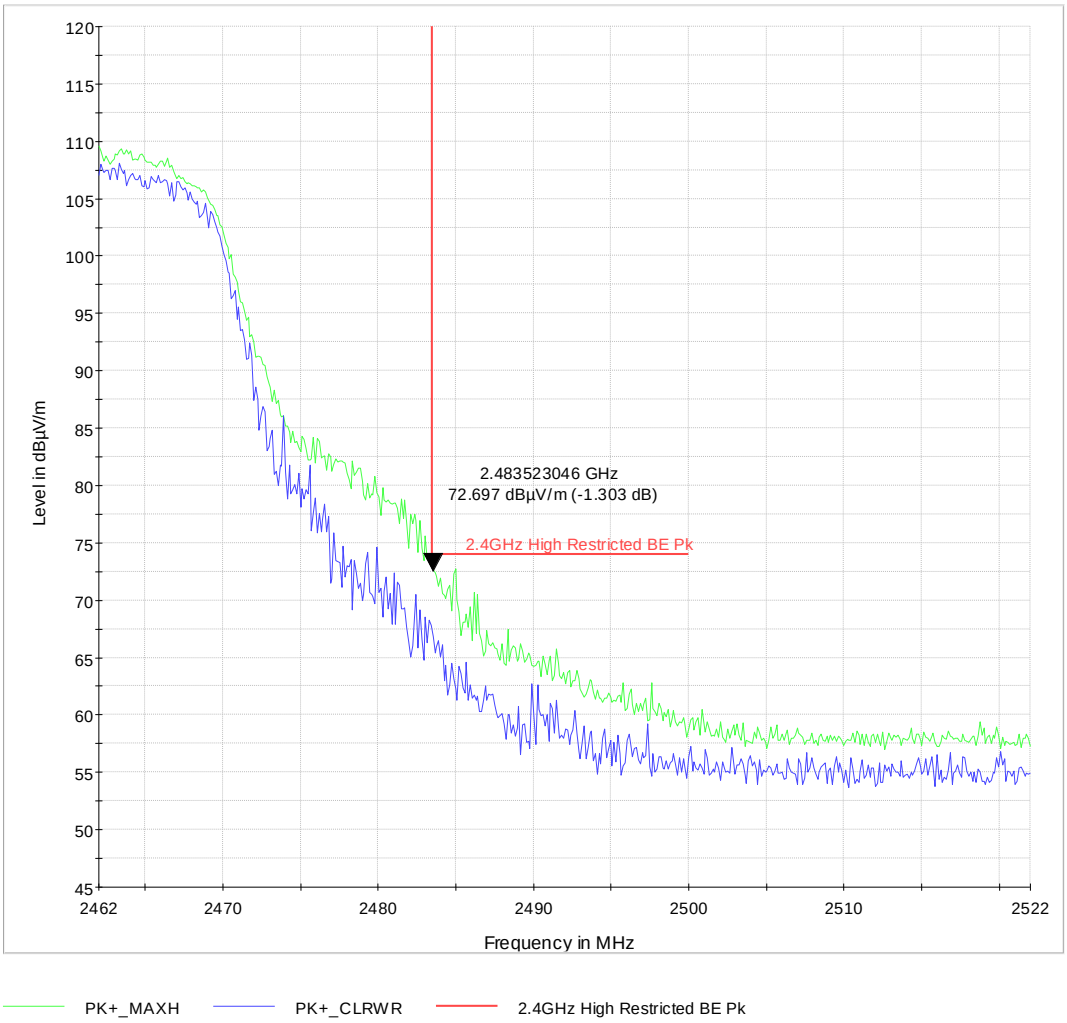


Figure 46: High Band Edge (restricted) for 802.11g 6 Mbps at 2462 MHz-Peak

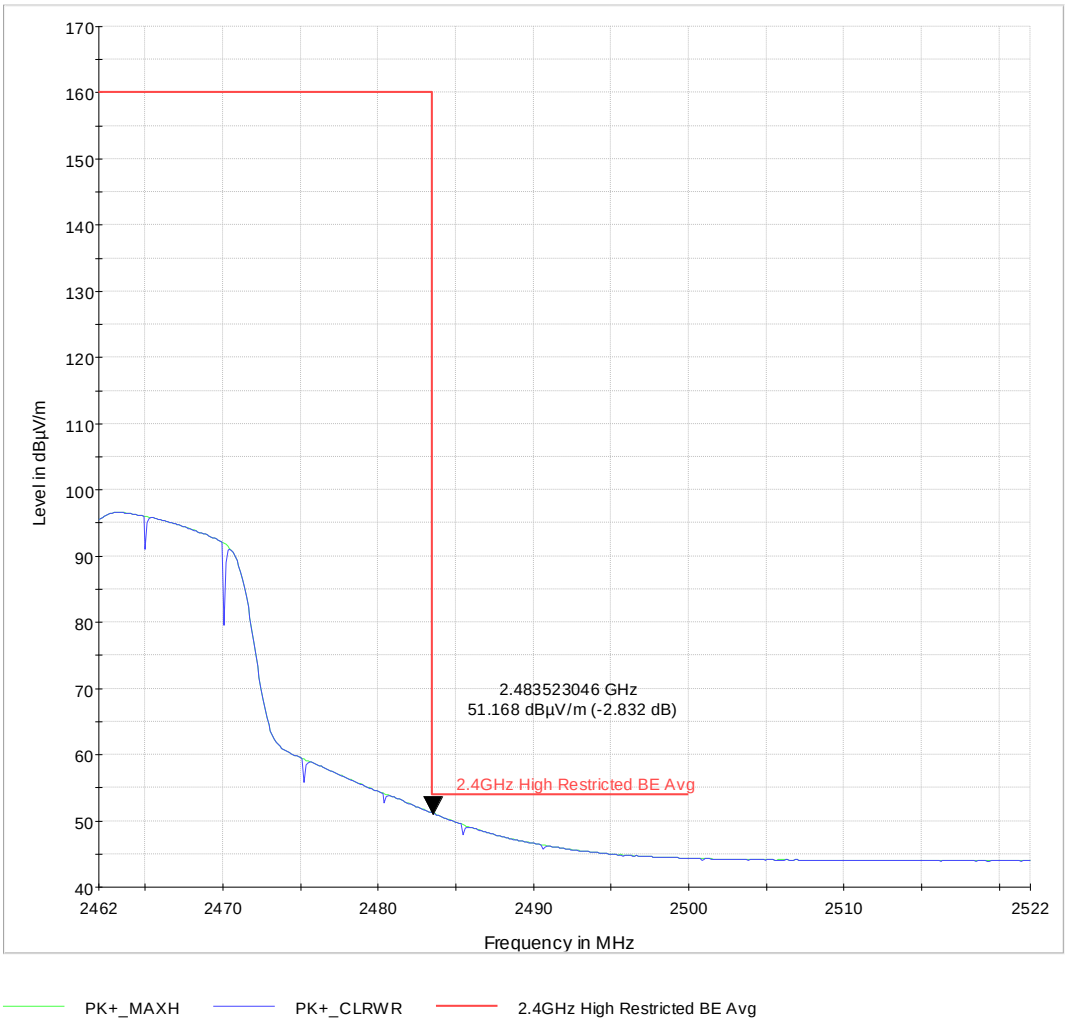


Figure 47: High Band Edge (restricted) for 802.11n HT20 MCS0 at 2462 MHz-Average

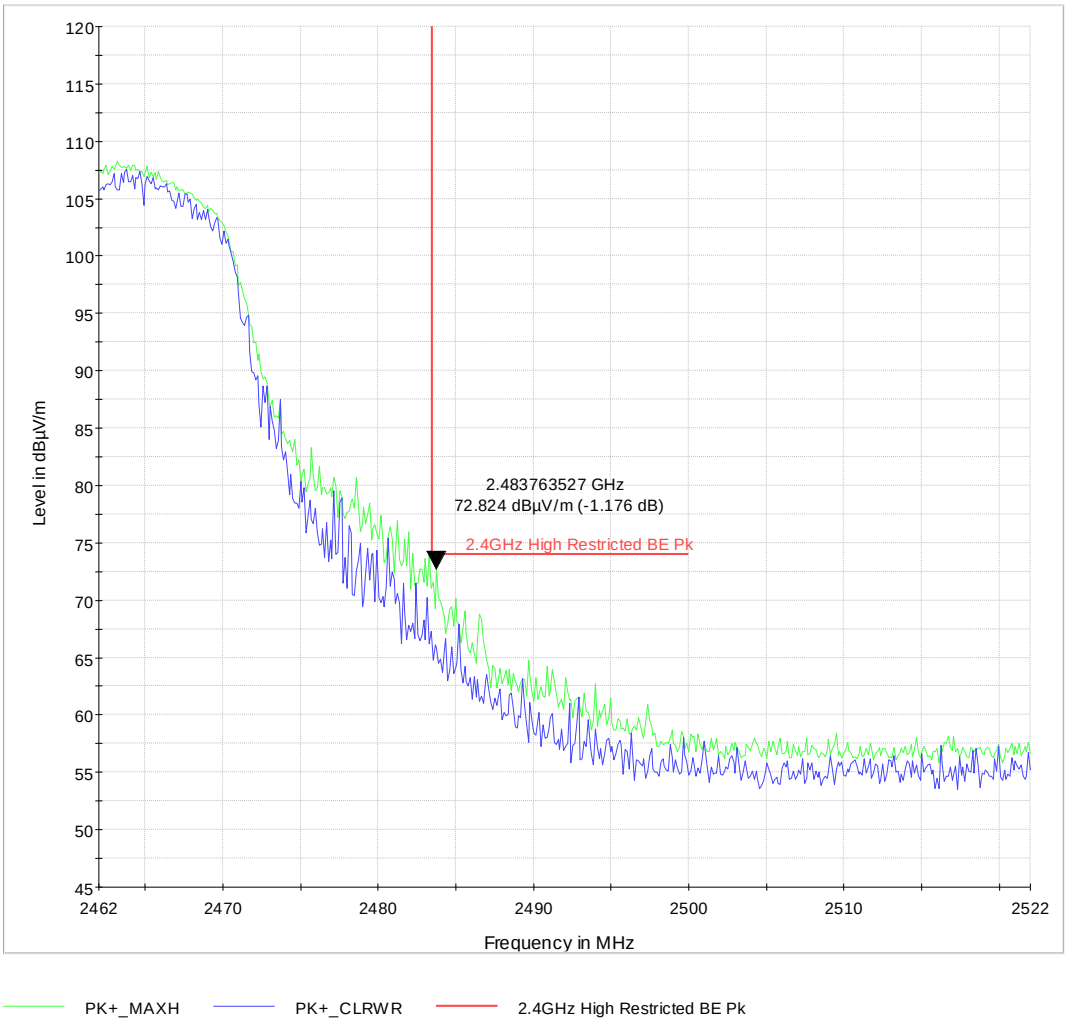


Figure 48: High Band Edge (restricted) for 802.11n HT20 MCS0 at 2462 MHz-Peak

4.8 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.10:2013. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR 47 Part 15.207 and RSS-GEN. Sect. 8.8.

4.8.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.

Testing is performed in Lab 5. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

802.11n was tested because it is the worst case operating mode.

4.8.1.1 Deviations

There were no deviations from this test methodology.

4.8.2 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 11: AC Conducted Emissions – Test Results

Test Conditions: Power line conducted measurement at normal conditions		
Antenna Type: FPCB	**Power Level Setting:** 80	
AC Power: 120 Vac/60 Hz	**Configuration:** Tabletop	
Ambient Temperature: 21° C	**Relative Humidity:** 44% RH	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Hot)	0.15 to 30 MHz	Pass
Line 2 (Neutral)	0.15 to 30 MHz	Pass

Conducted Emissions

Tracking # 31851724.001

EUT Name	Blade	**Date**	June 10, 2018
EUT Model	447	**Temp / Hum in**	22° C / 41% rh
EUT Serial	WLAN MAC: DC:EF:CA:A4:42:58	**Temp / Hum out**	N/A
EUT Config.	802.11n HT20 MCS0 Channel 6	**Line AC / Freq**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Line 1	**Performed by**	Josie Sabado

Frequency	Raw	Ins. Loss	Cal Factor	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.15187	42.44	9.82	0.06	52.32	Quasi Peak	Live	65.9	-13.58	Pass
0.15187	27.33	9.82	0.06	37.2	Average	Live	55.9	-18.69	Pass
0.22292	41.7	9.83	0.04	51.57	Quasi Peak	Live	62.71	-11.14	Pass
0.22292	27.45	9.83	0.04	37.32	Average	Live	52.71	-15.39	Pass
0.299579	39.46	9.83	0.03	49.32	Quasi Peak	Live	60.25	-10.93	Pass
0.299579	25.31	9.83	0.03	35.17	Average	Live	50.25	-15.09	Pass
0.374369	38.1	9.84	0.03	47.97	Quasi Peak	Live	58.4	-10.43	Pass
0.374369	24.57	9.84	0.03	34.44	Average	Live	48.4	-13.97	Pass
0.458507	32.32	9.84	0.03	42.19	Quasi Peak	Live	56.72	-14.53	Pass
0.458507	16.81	9.84	0.03	26.68	Average	Live	46.72	-20.04	Pass
0.520208	36.82	9.84	0.03	46.69	Quasi Peak	Live	56	-9.31	Pass
0.520208	25.83	9.84	0.03	35.7	Average	Live	46	-10.3	Pass
0.593128	34.95	9.85	0.03	44.83	Quasi Peak	Live	56	-11.17	Pass
0.593128	22.02	9.85	0.03	31.9	Average	Live	46	-14.1	Pass
0.619305	26.69	9.85	0.03	36.57	Quasi Peak	Live	56	-19.43	Pass
0.619305	14.71	9.85	0.03	24.59	Average	Live	46	-21.41	Pass
0.671657	34.78	9.86	0.03	44.67	Quasi Peak	Live	56	-11.33	Pass
0.671657	22.85	9.86	0.03	32.73	Average	Live	46	-13.27	Pass
0.735228	33.81	9.86	0.03	43.7	Quasi Peak	Live	56	-12.3	Pass
0.735228	24.89	9.86	0.03	34.78	Average	Live	46	-11.22	Pass
0.826846	32.83	9.87	0.03	42.73	Quasi Peak	Live	56	-13.27	Pass
0.826846	22.32	9.87	0.03	32.22	Average	Live	46	-13.78	Pass
0.897896	33.25	9.87	0.03	43.15	Quasi Peak	Live	56	-12.85	Pass
0.897896	22.53	9.87	0.03	32.43	Average	Live	46	-13.57	Pass
0.950248	32.32	9.87	0.03	42.22	Quasi Peak	Live	56	-13.78	Pass
0.950248	22.07	9.87	0.03	31.97	Average	Live	46	-14.03	Pass

Frequency	Raw	Ins. Loss	Cal Factor	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
1.122265	30.74	9.87	0.03	40.65	Quasi Peak	Live	56	-15.35	Pass
1.122265	24.51	9.87	0.03	34.41	Average	Live	46	-11.59	Pass
1.44386	30.43	9.88	0.03	40.34	Quasi Peak	Live	56	-15.66	Pass
1.44386	21.7	9.88	0.03	31.61	Average	Live	46	-14.39	Pass

Spec Margin = QP./Ave. - Limit, ± Uncertainty

Combined Standard Uncertainty $u_c(y) = \pm 1.2$ dB Expanded Uncertainty $U = ku_c(y)$ $k = 2$ for 95% confidence

Conducted Emissions

Tracking # 31851724.001

EUT Name	Blade	**Date**	June 10, 2018
EUT Model	447	**Temp / Hum in**	22° C / 41% rh
EUT Serial	WLAN MAC: DC:EF:CA:A4:42:58	**Temp / Hum out**	N/A
EUT Config.	802.11n HT20 MCS0 Channel 6	**Line AC / Freq**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Neutral	**Performed by**	Josie Sabado

Frequency	Raw	Ins. Loss	Cal Factor	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.15187	43.24	9.82	0.06	53.12	Quasi Peak	Neutral	65.9	-12.78	Pass
0.15187	31.57	9.82	0.06	41.45	Average	Neutral	55.9	-14.45	Pass
0.228529	37.87	9.83	0.04	47.74	Quasi Peak	Neutral	62.5	-14.76	Pass
0.228529	23.22	9.83	0.04	33.09	Average	Neutral	52.5	-19.41	Pass
0.299579	38.89	9.83	0.03	48.75	Quasi Peak	Neutral	60.25	-11.5	Pass
0.299579	24.05	9.83	0.03	33.91	Average	Neutral	50.25	-16.35	Pass
0.378108	36.14	9.84	0.03	46.01	Quasi Peak	Neutral	58.32	-12.31	Pass
0.378108	18.87	9.84	0.03	28.74	Average	Neutral	48.32	-19.58	Pass
0.389327	27.01	9.84	0.03	36.88	Quasi Peak	Neutral	58.08	-21.2	Pass
0.389327	14.64	9.84	0.03	24.51	Average	Neutral	48.08	-23.57	Pass
0.452898	35.16	9.84	0.03	45.03	Quasi Peak	Neutral	56.82	-11.79	Pass
0.452898	20.09	9.84	0.03	29.96	Average	Neutral	46.82	-16.87	Pass
0.523948	36.13	9.84	0.03	46	Quasi Peak	Neutral	56	-10	Pass
0.523948	21.23	9.84	0.03	31.1	Average	Neutral	46	-14.9	Pass
0.594998	34.64	9.85	0.03	44.52	Quasi Peak	Neutral	56	-11.48	Pass
0.594998	23.21	9.85	0.03	33.09	Average	Neutral	46	-12.91	Pass
0.675397	34.16	9.86	0.03	44.05	Quasi Peak	Neutral	56	-11.95	Pass
0.675397	22.01	9.86	0.03	31.9	Average	Neutral	46	-14.1	Pass
0.746447	33.73	9.86	0.03	43.63	Quasi Peak	Neutral	56	-12.37	Pass
0.746447	19.15	9.86	0.03	29.05	Average	Neutral	46	-16.95	Pass
0.832455	32.19	9.87	0.03	42.09	Quasi Peak	Neutral	56	-13.91	Pass
0.832455	18.07	9.87	0.03	27.97	Average	Neutral	46	-18.03	Pass
0.922202	28.89	9.87	0.03	38.79	Quasi Peak	Neutral	56	-17.21	Pass
0.922202	18.13	9.87	0.03	28.03	Average	Neutral	46	-17.97	Pass
0.968946	31.87	9.87	0.03	41.77	Quasi Peak	Neutral	56	-14.23	Pass
0.968946	18.35	9.87	0.03	28.25	Average	Neutral	46	-17.75	Pass

Frequency	Raw	Ins. Loss	Cal Factor	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.998862	28.15	9.87	0.03	38.05	Quasi Peak	Neutral	56	-17.95	Pass
0.998862	15.34	9.87	0.03	25.24	Average	Neutral	46	-20.76	Pass
1.071782	29.18	9.87	0.03	39.08	Quasi Peak	Neutral	56	-16.92	Pass
1.071782	14.86	9.87	0.03	24.76	Average	Neutral	46	-21.24	Pass
1.236319	29.53	9.87	0.03	39.44	Quasi Peak	Neutral	56	-16.56	Pass
1.236319	16.91	9.87	0.03	26.81	Average	Neutral	46	-19.19	Pass
1.307369	28.9	9.87	0.03	38.8	Quasi Peak	Neutral	56	-17.2	Pass
1.307369	15.49	9.87	0.03	25.4	Average	Neutral	46	-20.6	Pass
Spec Margin = QP./Ave. - Limit, ± Uncertainty									
Combined Standard Uncertainty $u_c(y) = \pm 1.2$ dB Expanded Uncertainty $U = ku_c(y)$ $k = 2$ for 95% confidence									

Conducted Emissions		Tracking #	31851724.001
EUT Name	Blade	**Date**	June 10, 2018
EUT Model	447	**Temp / Hum in**	22° C / 41% rh
EUT Serial	WLAN MAC: DC:EF:CA:A4:42:58	**Temp / Hum out**	N/A
EUT Config.	802.11n HT20 MCS0 Channel 6	**Line AC**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Live	**Performed by**	Josie Sabado

150 kHz to 30 MHz Plot for Line 1 (Live)

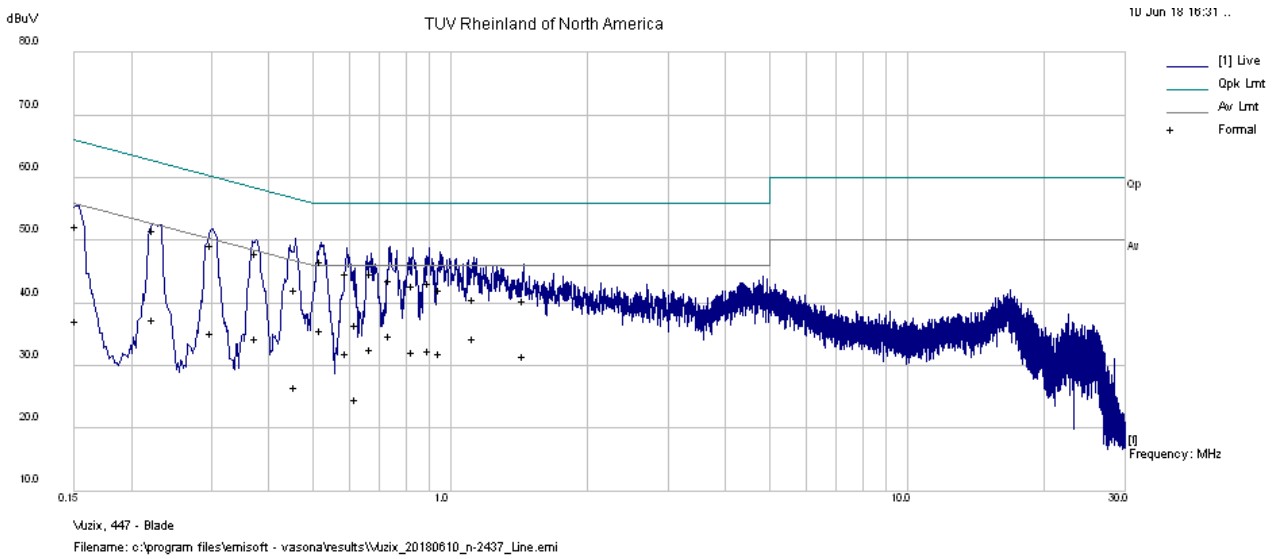


Figure 49: Power line conducted emissions for 802.11n HT20 MCS0 at 2437MHz - Live

Conducted Emissions		Tracking #	31851724.001
EUT Name	Blade	**Date**	June 10, 2018
EUT Model	447	**Temp / Hum in**	22° C / 41% rh
EUT Serial	WLAN MAC: DC:EF:CA:A4:42:58	**Temp / Hum out**	N/A
EUT Config.	802.11n HT20 MCS0 Channel 6	**Line AC**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Neutral	**Performed by**	Josie Sabado

150 kHz to 30 MHz Plot for Line 1 (Neutral)

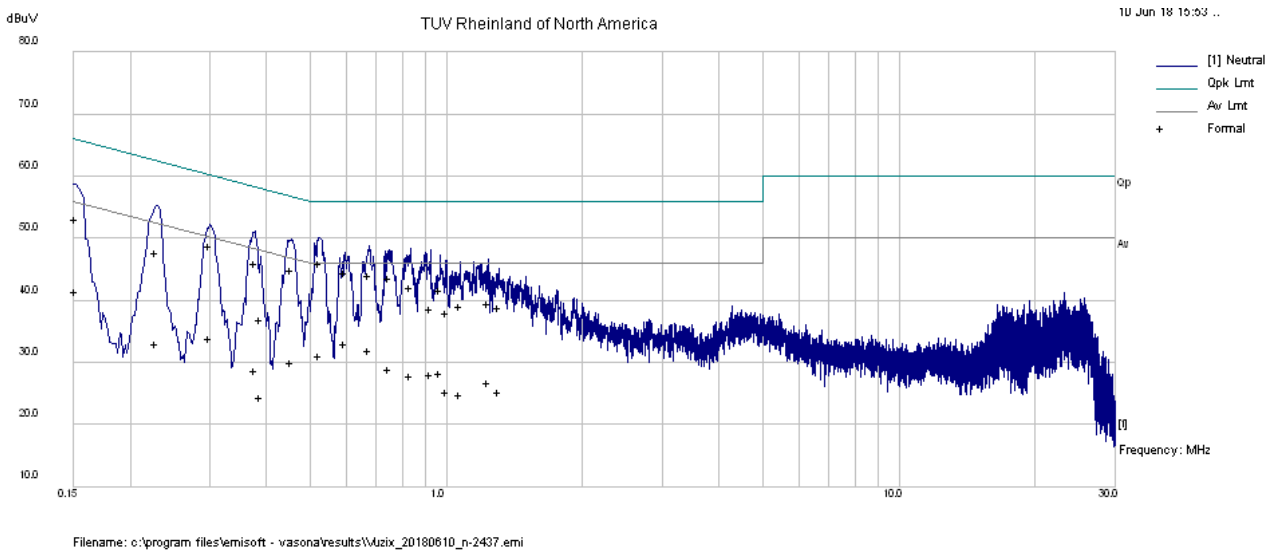


Figure 50: Power line conducted emissions for 802.11n HT20 MCS0 at 2437MHz - Neutral

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Bilog Antenna	Sunol Sciences	JB3	A102606	06/15/2016	06/15/2018
Horn Antenna	Sunol Sciences	3115	9211-3969	05/16/2018	06/16/2020
Horn Antenna (18-40 GHz)	Com-Power	AHA-840	105005	01/16/2018	01/16/2019
Loop Antenna	EMCO	6502	9110-2683	05/23/2017	05/23/2019
Spectrum Analyzer	Rohde Schwarz	ESIB40	832427/002	01/22/2018	01/22/2019
Spectrum Analyzer	Rohde Schwarz	FSV40	101410	09/19/2017	09/19/2018
Amplifier	Sonoma Instruments	310	185516	01/25/2018	01/25/2019
Amplifier	Miteq	TTA1800-30-HG	1842452	01/13/2018	01/13/2019
Switch Unit / Power Sensors	Rohde & Schwarz	OSP120	101181	01/18/2018	01/18/2019
LISN	Com-Power	LI-215A	19200	01/24/2018	01/24/2019
10 dB Attenuator	Pasternack	N/A	N/A	N/A	N/A
3 dB Attenuator	Pasternack	N/A	N/A	N/A	N/A
1 dB Attenuator	Mini-Circuits	15542	VUU83701027	N/A	N/A
9 kHz – 30 MHz RF Cable	Coleman	RG214	RG214-60-01	N/A	N/A
1 – 18 GHz RF Cable	Huber & Suhner	Sucoflex	PL-A-33	N/A	N/A
18 – 40 GHz RF Cable	Huber & Suhner	Sucoflex	PL-N-31	N/A	N/A
9 kHz-1 GHz RF Cable	ETS-Lindgren	Ferrited	Pigtail5	N/A	N/A

END OF REPORT