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Emissions Test Report

EUT Name: Norton Core Secure WiFi Router

Model No.: 518

CFR 47 Part 15.247: 2018 and RSS 247: 2017

Prepared for:

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Mountain View, CA 94043

Prepared by:

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	7/19/2018	Original Document	DA

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Symantec Corporation 350 Ellis Street Mountain View, CA 94043
Requester / Applicant:	Symantec Corporation
Name of Equipment:	Norton Core Secure WiFi Router
Model No.	518
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2018 and RSS 247: 2017
Test Dates:	26 Dec 2017 to 15 June 2018

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r05, KDB 662911 D01 Multiple Transmitter Output v02r01

Test Methods:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r05, KDB 662911 D01 Multiple Transmitter Output v02r01

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.

Douglas Antioco		Josie Sabado	
Test Engineer	Date July 19, 2018	A2LA Signatory	Date July 19, 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: 2017 based on the results of testing performed on 26 Dec 2017 to 15 June 2018 on the Norton Core Secure WiFi Router Model 518 manufactured by Symantec 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 ANSI C63.4	Worse Case (Measured)	Result
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	9.4 dB Margin @16.3 MHz Neutral, Average (802.11b 1Mbps)	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2 (a)	8.5 MHz (802.11b 1Mbps Channel 6, Chain 2)	**Complied**
Maximum Output Power	CFR47 15.247 (b), RSS 247 Sect. 5.4 (d)	26.2* dBm RMS (802.11b 1Mbps)	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2 (b)	3.9 dBm/3KHz (802.11b 1Mbps Channel 1)	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-30.3 dBc @ 3230 MHz (802.11n HT40 MCS0 Channel 3, Chain 0)	**Complied**
Out of Band Emissions: Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	3.6 dB Margin @ 2374.4 MHz, Average (802.11b 1Mbps Channel 1)	**Complied**
Transmitter Spurious Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	4.6 dB margin @ 4824 MHz, Average (802.11b Mode 1Mbps Channel 1)	**Complied**

Note 1: This test report covers 2400 MHz to 2483.5 MHz band. * = summed power.

Note 2: Class B limits were applied where applicable.

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 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). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). 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

Voltech PM6000A

The estimated combined standard uncertainty for harmonic current and flicker measurements is ± 5.0%.	Per CISPR 16-4-2 Methods

2.3.3 Measurement Uncertainty Immunity

The estimated combined standard uncertainty for ESD immunity measurements is ± 8.2%.	Per IEC 61000-4-2
The estimated combined standard uncertainty for radiated immunity measurements is ± 4.10 dB.	Per IEC 61000-4-3
The estimated combined standard uncertainty for conducted immunity measurements with CDN is ± 3.66 dB	Per IEC 61000-4-6
The estimated combined standard uncertainty for power frequency magnetic field immunity is ± 2.9%.	Per IEC 61000-4-8

Thermo KeyTek EMC Pro

The estimated combined standard uncertainty for EFT fast transient immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for surge immunity measurements is ± 2.6%.

The estimated combined standard uncertainty for voltage variation and interruption measurements is ± 1.74%.

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

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 Product Description

The Model 518, Norton Core Secure WiFi Router, is a 4x4 secure wireless router that protects your connected home network, while delivering the highest level of security and performance. It is intended to work as a dual band (2.4GHz and 5GHz) wireless router. The router will be in compliance with regulatory standards of regions it will be operating in.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. 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 an 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 and to place the EUT in the most susceptible state for immunity testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

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

3.4 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.

3.4.1 Results

The Norton Core Secure WiFi Router has four stamped metal antennas that has maximum gain of + 2.7 dBi. They are connected via RF connectors that are not easily accessible to the end user.

Refer to Table 30 for additional antenna information.

3.5 Worst Case Test Modes

The worst case chain was determined by using a gated average power meter as described by ANSI C63.10-2013 Section 11.9.2.3.2. Each chain was measured with the power meter while the remaining chains were terminated with 50 ohms.

3.5.1 Worse Case Chain

Power setting=15, HT20 mode, Channel 6 (2437MHz)

Chain 0	Chain 1	**Chain 2**	Chain 3
14.1	13.4	**14.2**	14

Chain 2 is found worse case with respect to output power.

3.5.2 Worse Case Modulation

Channel 6 (2437MHz), All 4 Chains measured per ANSI C63.10-2013 section 11.9.2.3.2 and section 14.3.2.2.

Mode	Modulation	Data Rate (Mbps)	Power Setting	Power Measured (dBm)
802.11b CCK	BPSK	1	21	**26.0**
	QPSK	2	21	26.0
	QPSK	5.5	21	25.9
	QPSK	11	21	25.9
802.11g No HT	BPSK	6	14	19.5
	BPSK	9	14	19.5
	QPSK	12	14	19.1
	QPSK	18	14	19.4
	16-QAM	24	14	19.4
	16-QAM	36	13	18.3
	64-QAM	48	12	17.3
	64-QAM	54	10	15.3
802.11n HT20	BPSK (MCS0)	6.5	15	**20.2**
	QPSK (MCS1)	13	15	20.2
	QPSK (MCS2)	19.5	15	20.2
	16-QAM (MCS3)	26	14.5	20.2
	16-QAM (MCS4)	39	13	18.2
	64-QAM (MCS5)	54	12	17.2
	64-QAM (MCS6)	58.5	10	15.3
	64-QAM (MCS7)	65	8	13.3
802.11ac VHT20	BPSK (MCS0)	6.5	15	20.2
	QPSK (MCS1)	13	15	20.2
	QPSK (MCS2)	19.5	15	20.1
	16-QAM (MCS3)	26	14	19.8
	16-QAM (MCS4)	39	14	19.3
	64-QAM (MCS5)	54	12	17.3
	64-QAM (MCS6)	58.5	10	15.2
	64-QAM (MCS7)	65	8	13.3

Mode	Modulation	Data Rate (Mbps)	Power Setting	Power Measured (dBm)
802.11n HT40	BPSK (MCS0)	13.5	9	**14.3**
	QPSK (MCS1)	27	9	14.2
	QPSK (MCS2)	40.5	9	14.2
	16-QAM (MCS3)	54	8.5	13.9
	16-QAM (MCS4)	81	7	12.4
	64-QAM (MCS5)	108	6	11.4
	64-QAM (MCS6)	121.5	4	9.1
	64-QAM (MCS7)	135	2	7.0
802.11ac VHT40	BPSK (MCS0)	13.5	9	14.3
	QPSK (MCS1)	27	9	14.3
	QPSK (MCS2)	40.5	9	14.3
	16-QAM (MCS3)	54	8.5	13.9
	16-QAM (MCS4)	81	8	13.4
	64-QAM (MCS5)	108	6	11.5
	64-QAM (MCS6)	121.5	4	9.2
	64-QAM (MCS7)	135	2	7.1

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2018 and RSS 247: 2017. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

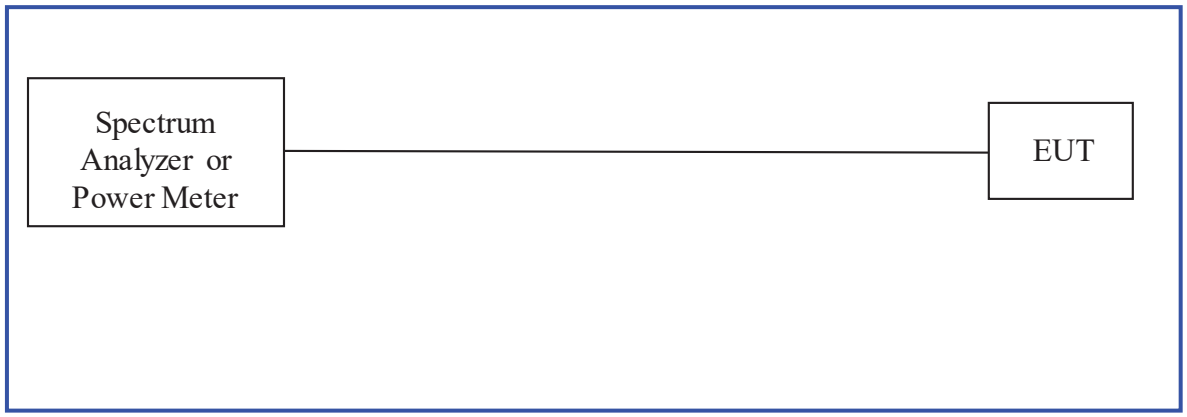
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b):2016 and RSS 247: 2017 Sect. 5.4 (d).

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

4.1.1 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 3 channels in each operating range per CFR47 Part 15.247(b) and RSS 247 Sect. 5.4(d); 2400 MHz to 2483.5 MHz. The worst mode results indicated below.

Test Setup:



For CCK and HT20 Mode, the measurement method from ANSI C63.10-2013 Section 11.9.2.3.2 was used. Each chain was measured individually and applied the measure-and-sum approach per section 14.3.2.2 of ANSI C63.10-2013.

For HT40 Mode, the measurement method from ANSI C63.10-2013 Section 11.9.1.2 was used. The worst case chain (chain 2) was used for the measurement and $10\log(N_{ant})$ was applied per section 14.3.2.2 of ANSI C63.10-2013.

4.1.2 Results

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

Table 2: RF Output Power at the Antenna Port – Test Results – Non Beamforming

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Stamped Metal		**Power Setting:** 21 (CCK), 15 (HT20)	
Max. Antenna Gain: 2.7 dBi			
Signal State: Modulated at 96.7% Duty Cycle.			
Ambient Temp.: 22° C		**Relative Humidity:** 38%	
802.11b (CCK)			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (RMS) [dBm]**	**Margin [dB]**
2412.00	30.00	26.0	4.0
2437.00	30.00	26.0	4.0
2462.00	30.00	26.2	3.8
Note: 1.The highest output power was observed at 802.11b mode, 1.0 Mbps, 1 Data Streams. 2. The sum of Chains 0, 1, 2, and 3 is the total power.			
802.11n (HT20)			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (RMS) [dBm]**	**Margin [dB]**
2412.00	30.00	20.1	9.9
2437.00	30.00	20.1	9.9
2462.00	30.00	20.2	9.8
Note: 1. The highest output power was observed at HT20 MCS0, 1 Data Streams. 2. The sum of Chains 0, 1, 2, and 3 is the total power.			

Table 3: RF Output Power at the Antenna Port – Test Results – Non Beamforming Continued

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Stampled Metal		**Power Setting:** 9	
Max. Antenna Gain: 2.7 dBi			
Signal State: Modulated at 93.5% Duty Cycle.			
Ambient Temp.: 22° C		**Relative Humidity:** 38%	
802.11n (HT40)			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power (Peak) [dBm]**	**Margin [dB]**
2422.00	30.00	14.3	15.7
2437.00	30.00	14.3	15.7
2452.00	30.00	14.4	15.6
Note: 1. The highest output power was observed at HT40 MCS0, 1 Data Streams. 2. The sum of Chains 0, 1, 2, and 3 is the total power.			

Beamforming Mode:
The same power settings and modulations that are used for 802.11n mode are are used for Beamforming mode (802.11ac). In a conducted setup, there is no difference in output power from the antenna port since beamforming is a spatially dependent phenomena.

The only difference is the directional gain (in a radiated setup), thus for a 4x4 system the beamforming gain is 6 dB, which accounts for a total maximum directional gain of 8.7 dBi. This gain reduces the RF Output power limit to 28 dBm for Beamforming mode per 15.247 (c)(2)(ii). The margin showed by the same modulation family in non-beamforming mode (802.11n) is sufficient to prove compliance to the reduced output power limits for beamforming mode. Spotchecks were done to verify that 802.11ac mode power setting consistency (Section 3.5.2) in relation to 802.11n modes.

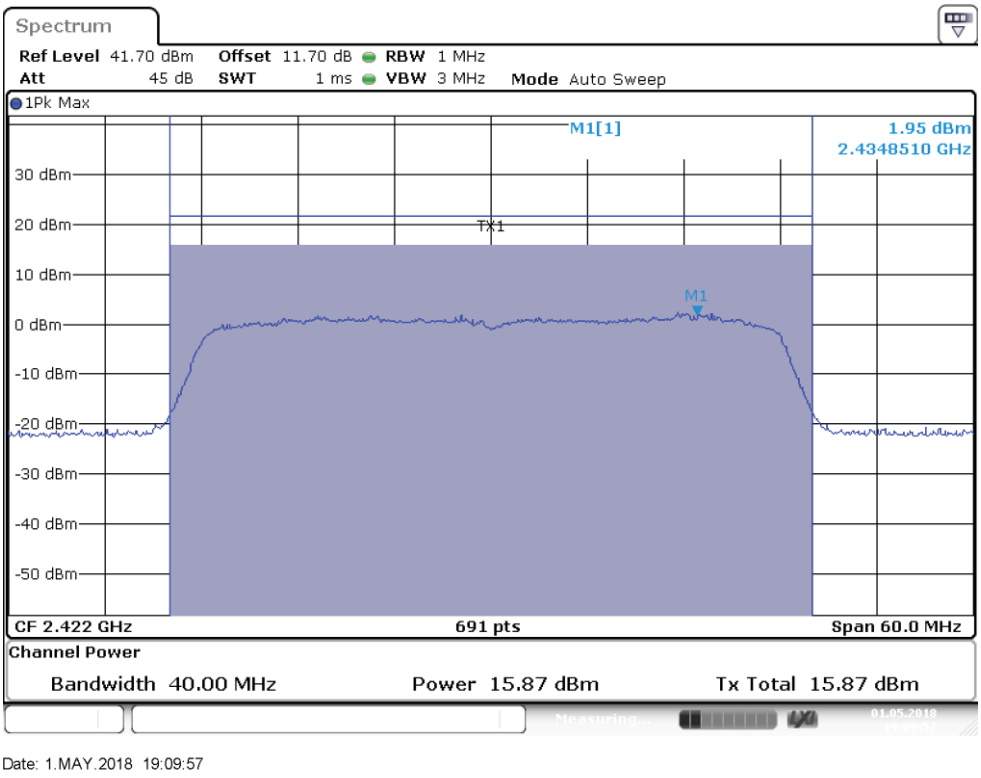
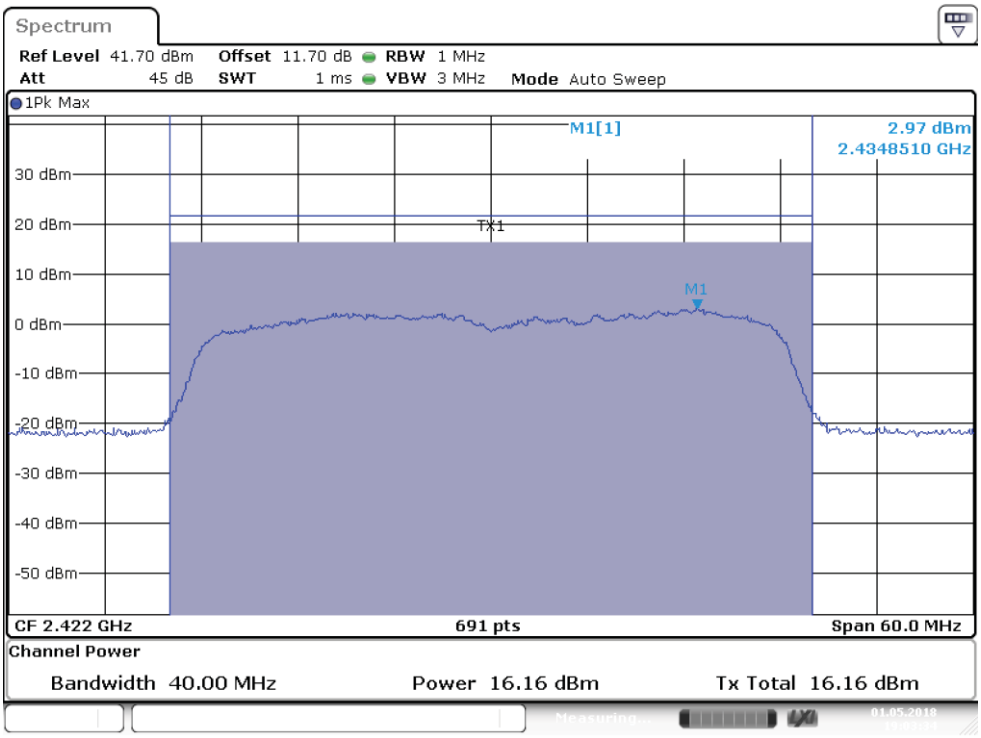


Figure 1: Maximum Transmitted Peak Power (Peak), 2422 MHz at 802.11n HT40 MCS0, Chain 0



Date: 1.MAY.2018 19:03:34

Figure 2: Maximum Transmitted Peak Power (Peak), 2422 MHz at 802.11n HT40 MCS0, Chain 1

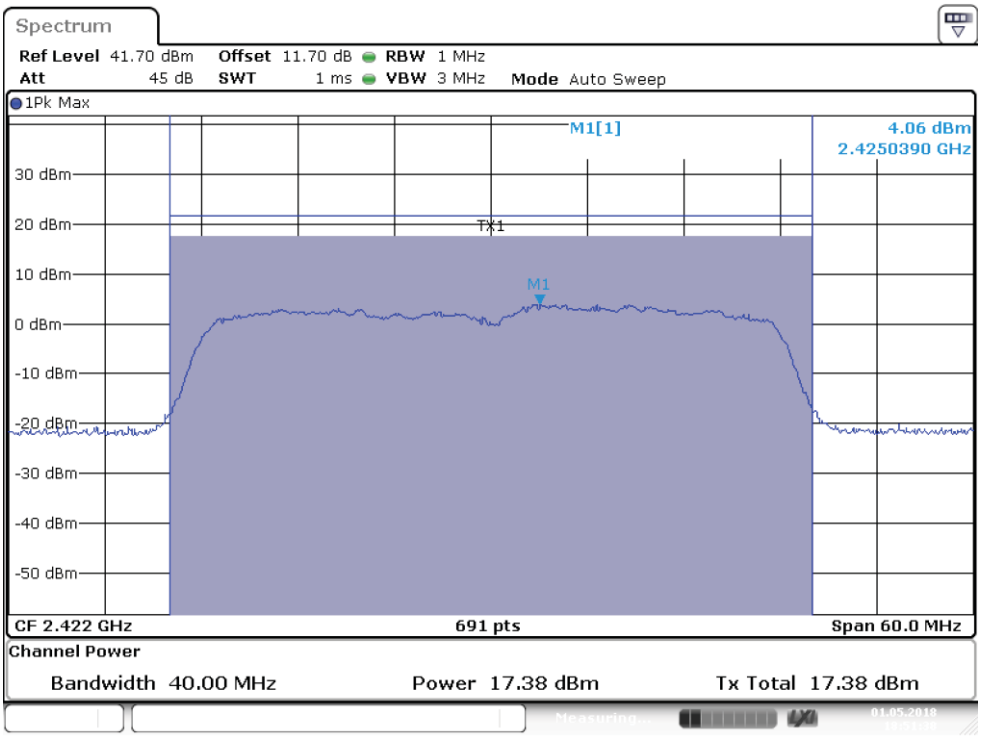


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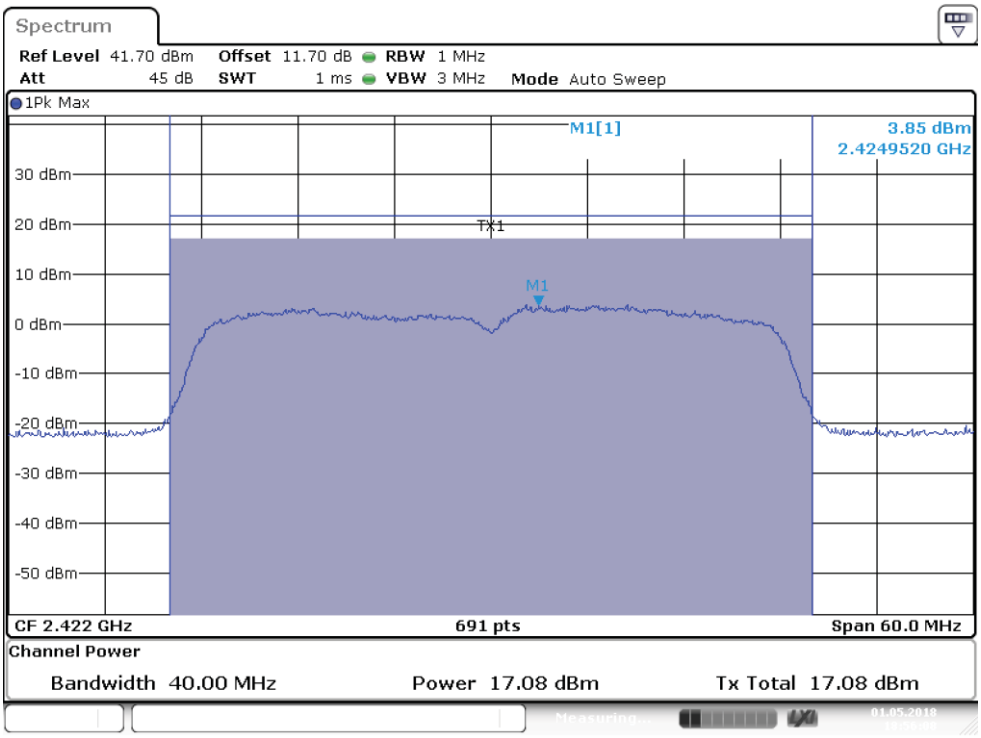
Figure 3: Maximum Transmitted Peak Power (Peak), 2422 MHz at 802.11n HT40 MCS0, Chain 2



Date: 1.MAY.2018 18:56:09

Figure 4: Maximum Transmitted Peak Power (Peak), 2422 MHz at 802.11n HT40 MCS0, Chain 3

4.2 DTS Bandwidth (6dB) and Occupied Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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

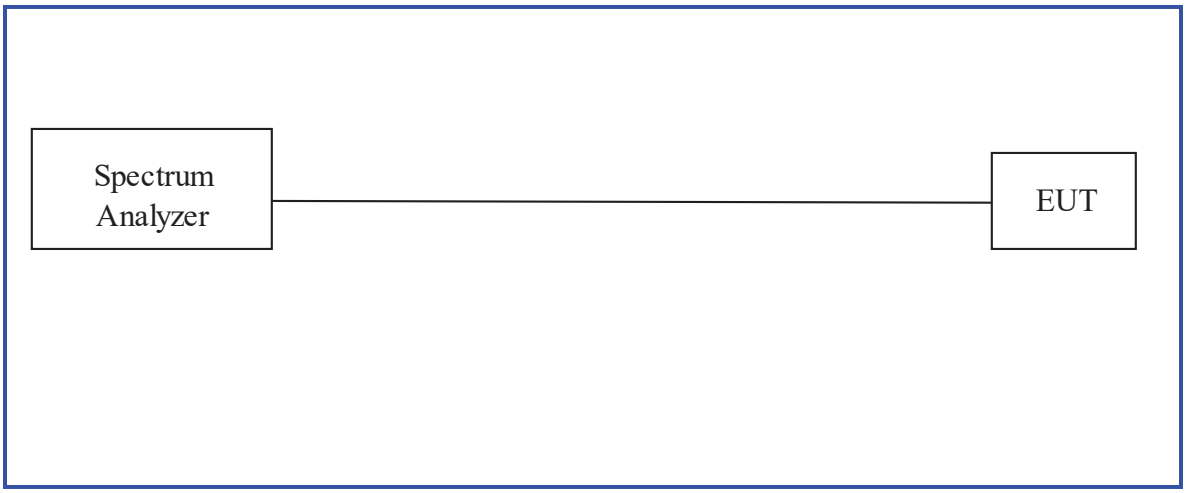
4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth according to ANSI C63.10:2013 Section 11.8. The measurement was performed with modulation per CFR47 15.247 (a) (2) 2016 and RSS Gen Sect. 6.6 2014. If necessary, measurements were performed on the low, middle and high channels of the operating frequency range; 2400 MHz to 2483.5 MHz.

Test reduction are based on margins to limits as specified in ANSI C63.10-2013 Section 5.6.2.1.

Chain 2 was tested as worse case (Section 3.5.1). Beamforming mode (802.11ac) was not measured since they have the same output powers and modulation characteristics as 802.11n mode (OFDM).

Test Setup:



4.2.2 Results

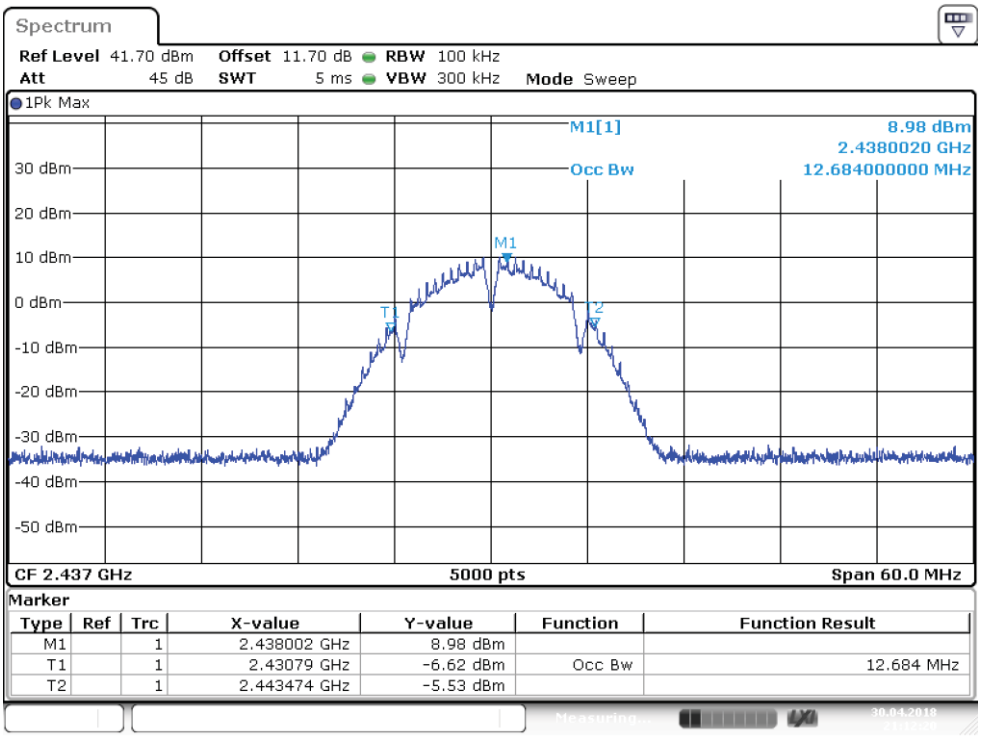
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: Stamped Metal		**Power Setting:** 21 (CCK), 15 (HT20)
Max. Antenna Gain: 2.7 dBi		
Signal State: Modulated at 96.7% Duty Cycle.		
Ambient Temp.: 22° C		**Relative Humidity:** 38%
Bandwidth (MHz) for 802.11b (CCK)		
Freq. (MHz)	**99% Bandwidth (MHz) Chain 2**	**6dB Bandwidth (MHz) Chain 2**
2412	N/A (See Note 2)	N/A
2437	12.7	8.5
2462	N/A (See Note 2)	N/A
Note: 1. The bandwidth was measured at 1.0 Mbps. 2. Not required per ANS C63.10 5.6.2.1.		
Bandwidth (MHz) for 802.11n		
Freq. (MHz)	**99% Bandwidth (MHz) Chain 2**	**6dB Bandwidth (MHz) Chain 2**
2412	N/A (See Note 2)	N/A
2437	17.6	17.1
2462	N/A (See Note 2)	N/A
Note: 1. The bandwidth was measured at HT20 MCS0, 1 Data Streams. 2. Not required per ANS C63.10 5.6.2.1.		

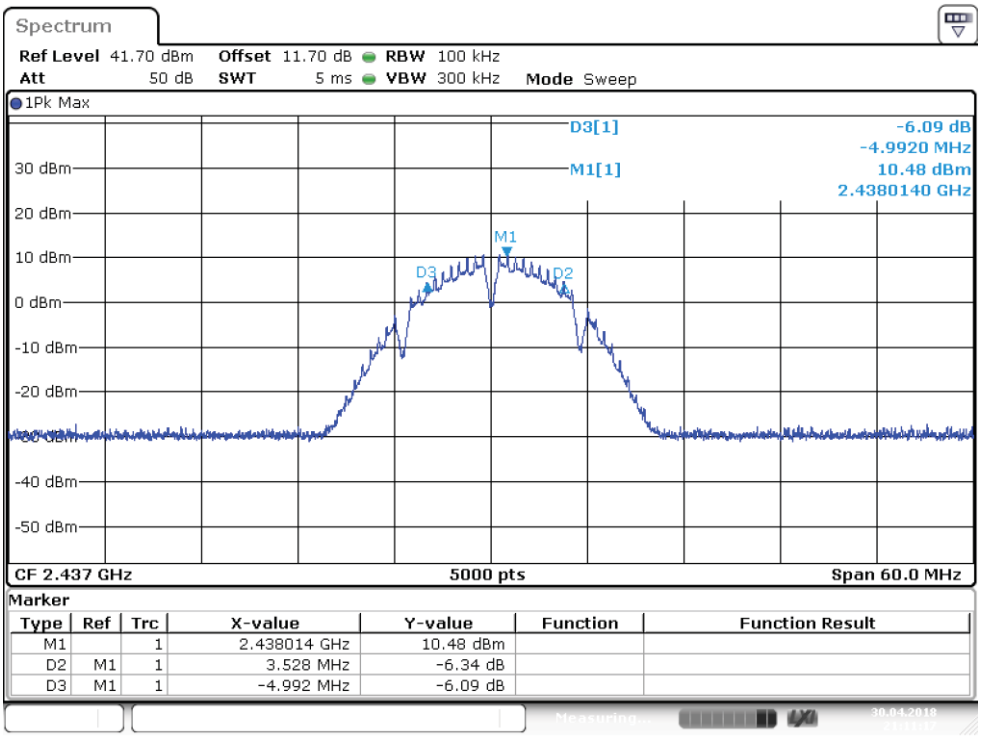
Table 5: Occupied Bandwidth – Test Results Continued

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: Stamped Metal		**Power Setting:** 9
Max. Antenna Gain: 2.7 dBi		
Signal State: Modulated at 93.5% Duty Cycle.		
Ambient Temp.: 22° C		**Relative Humidity:** 38%
Bandwidth (MHz) for 802.11n		
Freq. (MHz)	**99% Bandwidth (MHz)**	**6dB Bandwidth (MHz)**
	Chain 2	**Chain 2**
2437	36.2	35.9
Note: 1. The bandwidth was measured at HT40 MCS0, 1 Data Streams.		



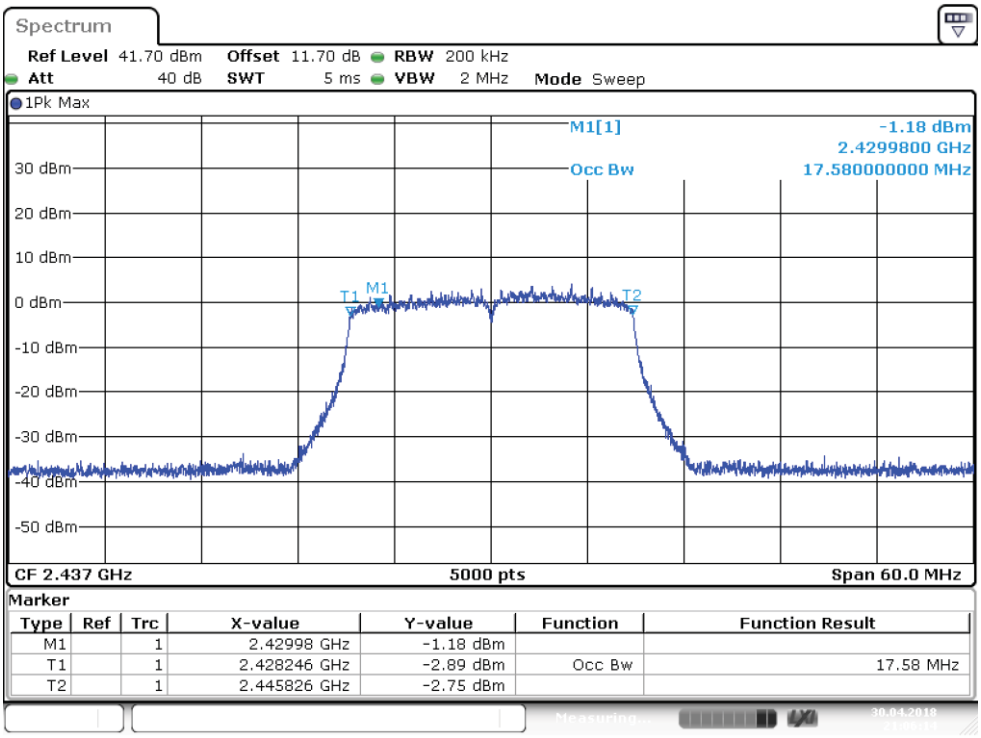
Date: 30.APR.2018 21:12:20

Figure 5: 99% Bandwidth, 2437 MHz 802.11b, Chain 2



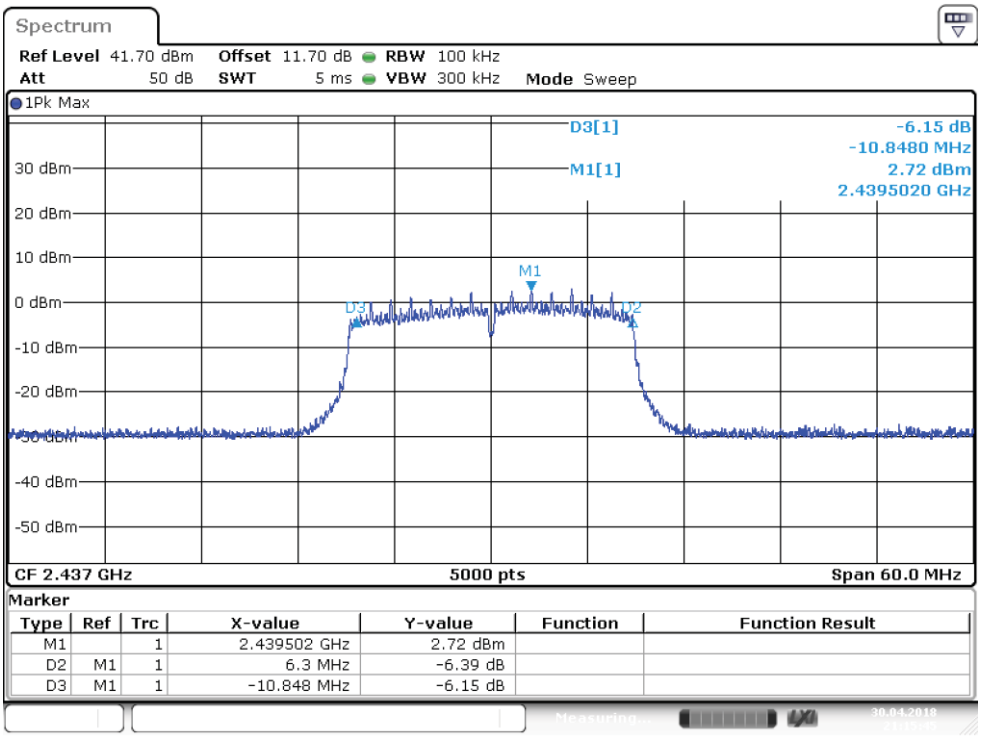
Date: 30.APR.2018 21:11:18

Figure 6: 6dB Bandwidth, 2437 MHz 802.11b, Chain 2



Date: 30.APR.2018 21:06:14

Figure 7: 99% Bandwidth, 2437 MHz at 802.11n (HT20), Chain 2



Date: 30.APR.2018 21:15:45

Figure 8: 6dB Bandwidth, 2437 MHz at 802.11n (HT20), Chain 2

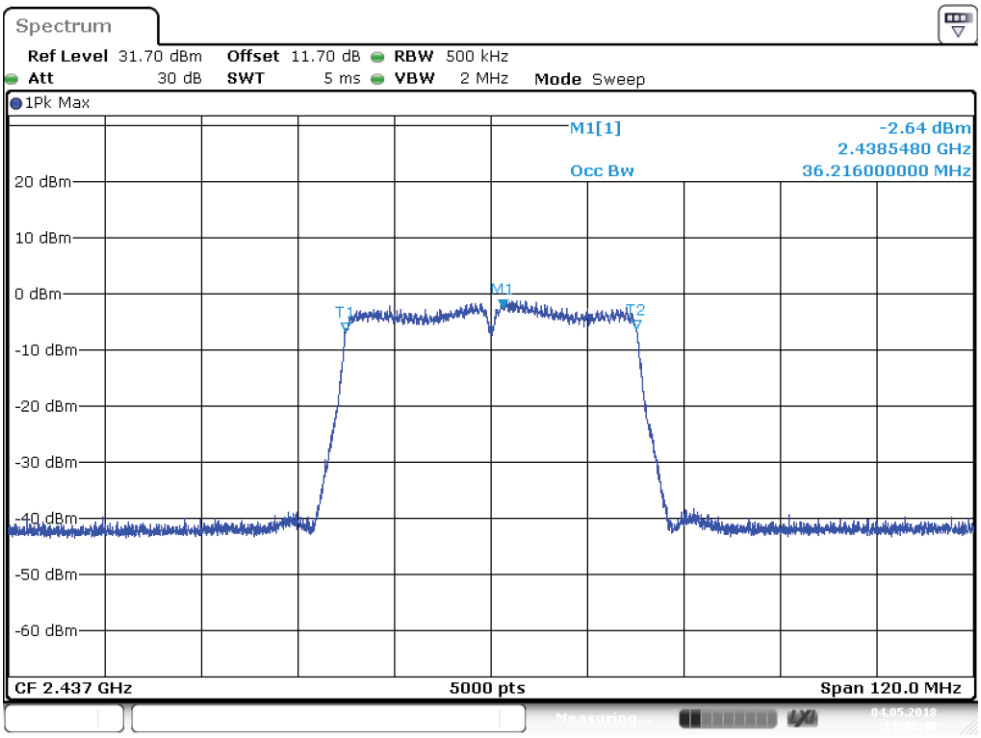


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Figure 9: 99% Bandwidth, 2437 MHz at 802.11n (HT40), Chain 2

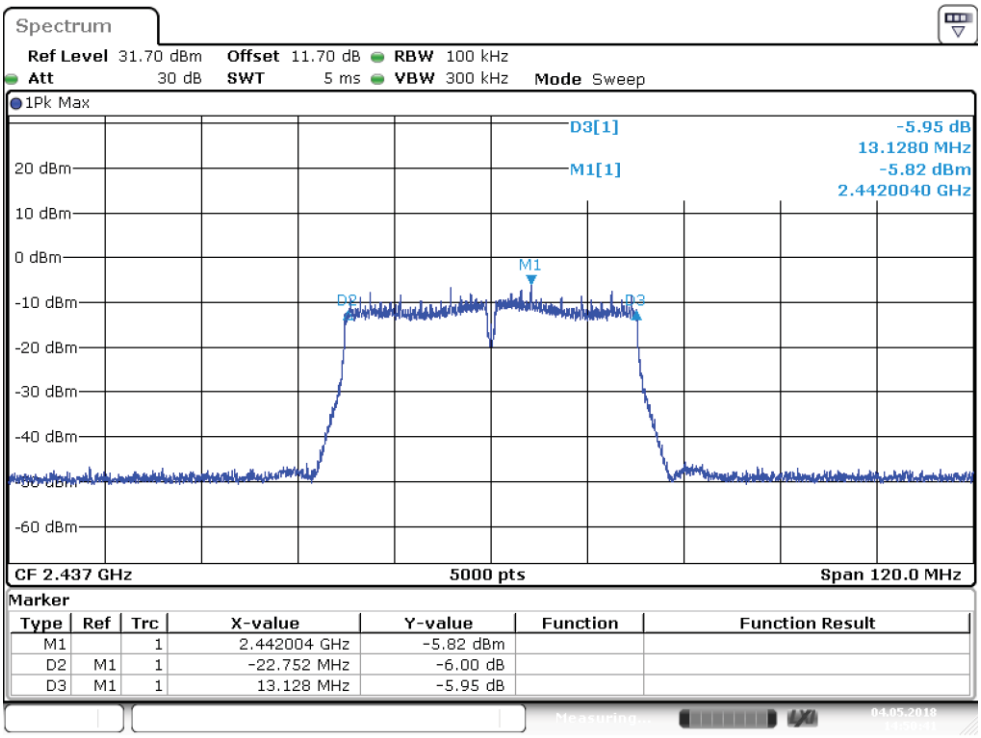


Figure 10: 6dB Bandwidth, 2422 MHz at 802.11n (HT40), Chain 2

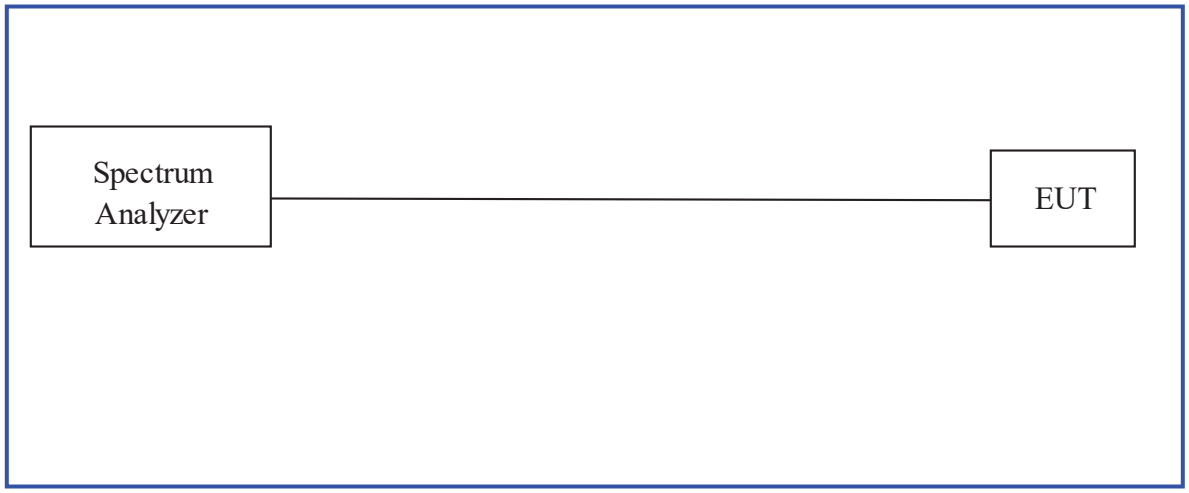
4.3 Peak Power Spectral Density

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.

4.3.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10-2013 Section 11.10.2. The measurement was performed with modulation per CFR47 Part 15.247 (e) and RSS 247 Sect.5.2 (b). A pre-evaluation was performed to find the worst case chains (Section 3.5.1) and modes (Section 3.5.2). 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. Beamforming mode (802.11ac) was not measured since they have the same output powers and modulation characteristics as 802.11n mode (OFDM).

Test Setup:



Method PKPSD of "KDB 558074 – DTS Measurement Guidance v04" was used.

The worst case chain (Chain 2) was measured and a correction factor of $10*\log(N_{ant})$ dB applied per ANSI C63.10-2013 Section 14.3.2.3.

4.3.2 Results

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

Table 6: Peak Power Spectral Density – Test Results – Non Beamforming

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Stamped Metal			**Power Setting:** 21 (CCK), 15 (HT20)	
Max. Antenna Gain: 2.7 dBi				
Signal State: Modulated at 96.7% Duty Cycle.				
Ambient Temp.: 22° C			**Relative Humidity:** 38%	
Peak Power Spectral Density				
802.11b CCK				
Freq. (MHz)	**Chain 2 [dBm]**	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
2412	-3.1	2.9	8.0	5.1
2437	-2.2	3.8	8.0	4.2
2462	-2.1	3.9	8.0	4.1
Note: 1. The highest peak output power was observed at **802.11b 1Mbps** per data stream.				
802.11n HT20				
Freq. (MHz)	**Chain 2 [dBm]**	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
2412	-11.2	-5.2	8.0	13.2
2437	-10.5	-4.5	8.0	12.5
2462	-12.3	-6.3	8.0	14.3
Note: 1. The highest peak output power was observed at **HT20 MCS0** per data stream.				

Table 7: Peak Power Spectral Density – Test Results – Non Beamforming Continued

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Stamped Metal		**Power Setting:** 9		
Max. Antenna Gain: 2.7 dBi				
Signal State: Modulated at 93.5% Duty Cycle.				
Ambient Temp.: 22° C		**Relative Humidity:** 38%		
Peak Power Spectral Density				
802.11n HT40				
Freq. (MHz)	**Chain 2 [dBm]**	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
2422	-19.6	-13.6	8.0	21.6
2437	-19.4	-13.4	8.0	21.4
2452	-19.6	-13.6	8.0	21.6
Note: 1. The highest peak output power was observed at **HT40 MCS0** per data stream.				

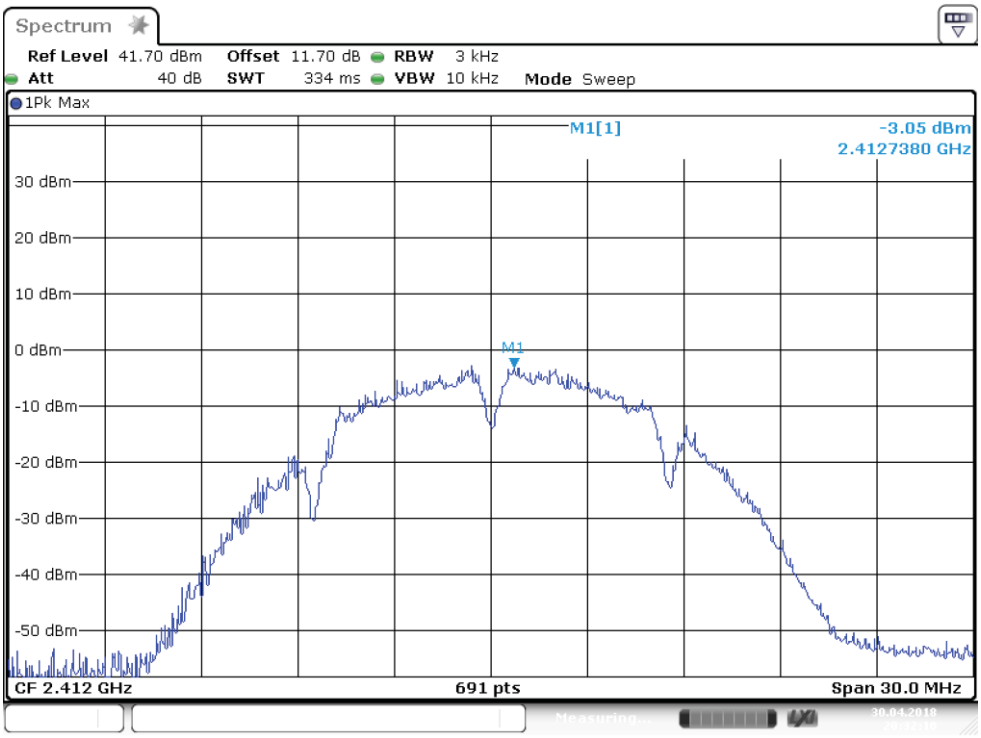


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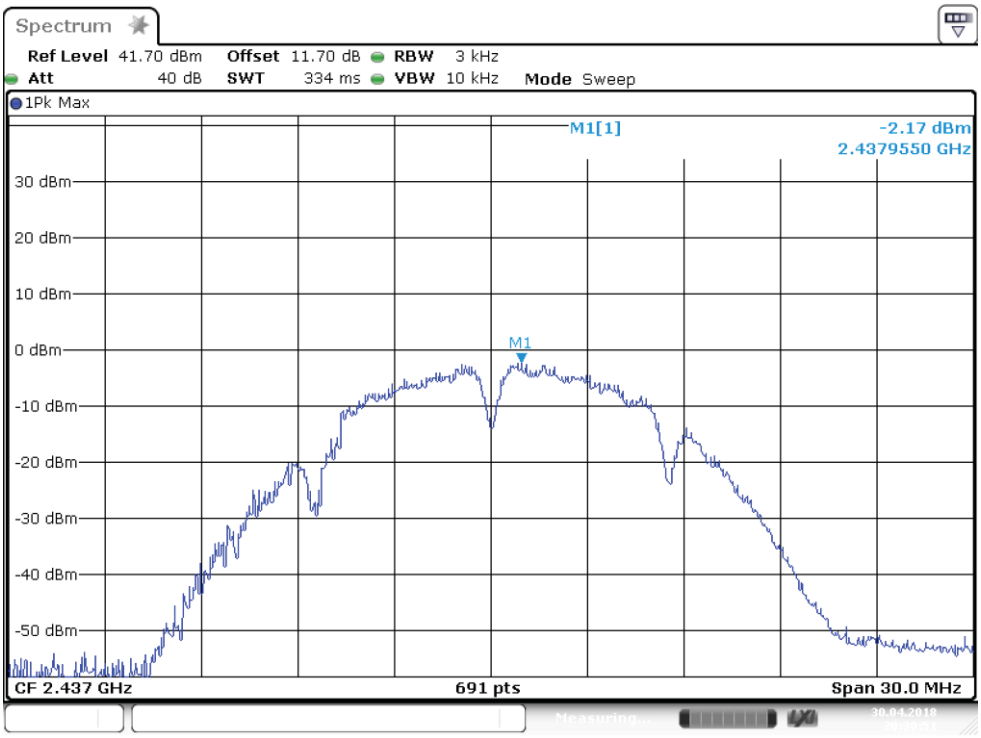
Figure 11: Power Spectral Density, 2412 MHz at 802.11b 1Mbps, Chain 2



Date: 30.APR.2018 20:30:51

Figure 12: Power Spectral Density, 2437 MHz at 802.11b 1Mbps, Chain 2

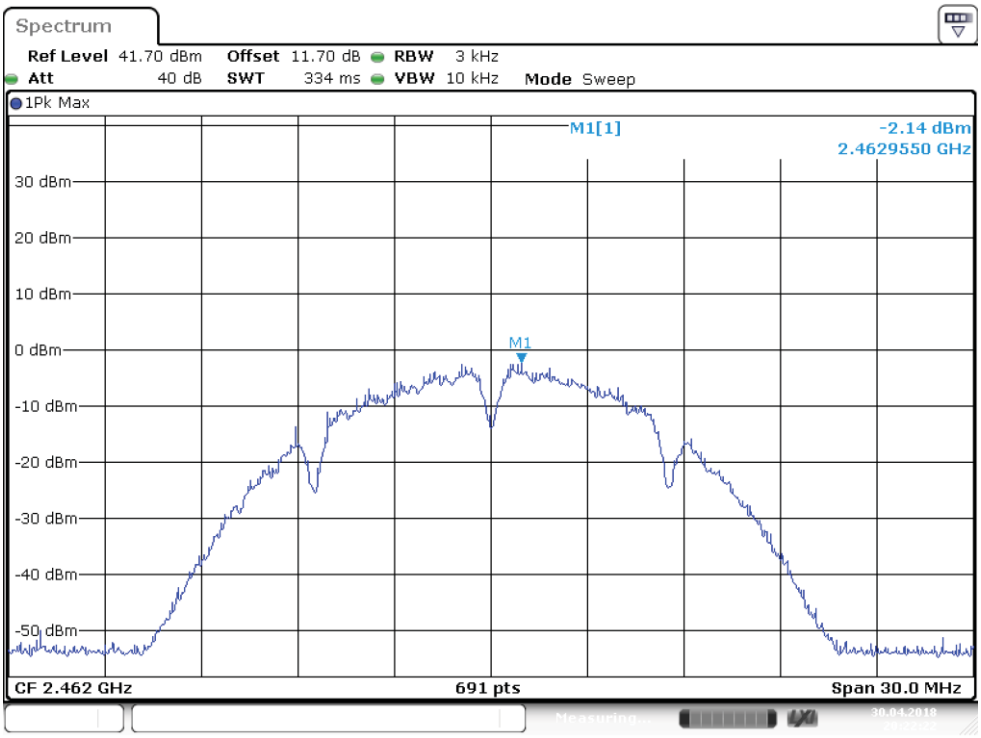
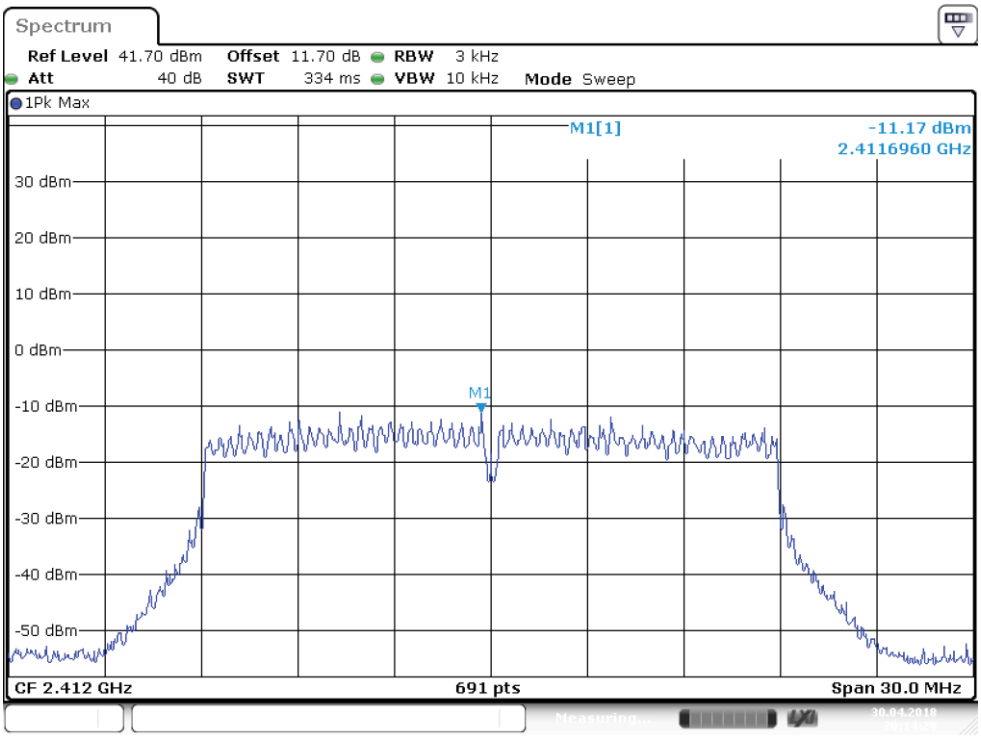


Figure 13: Power Spectral Density, 2462 MHz at 802.11b 1Mbps, Chain 2



Date: 30.APR.2018 20:14:29

Figure 14: Power Spectral Density, 2412 MHz at 802.11n HT20 MCS0, Chain 2

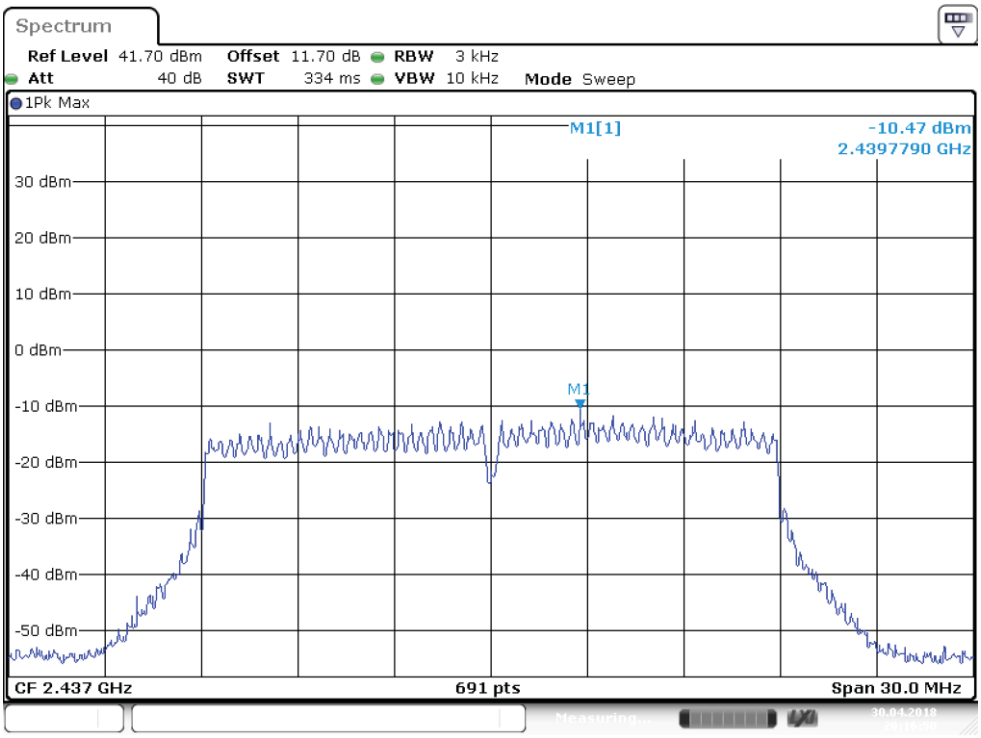


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Figure 15: Power Spectral Density, 2437 MHz at 802.11n HT20 MCS0, Chain 2

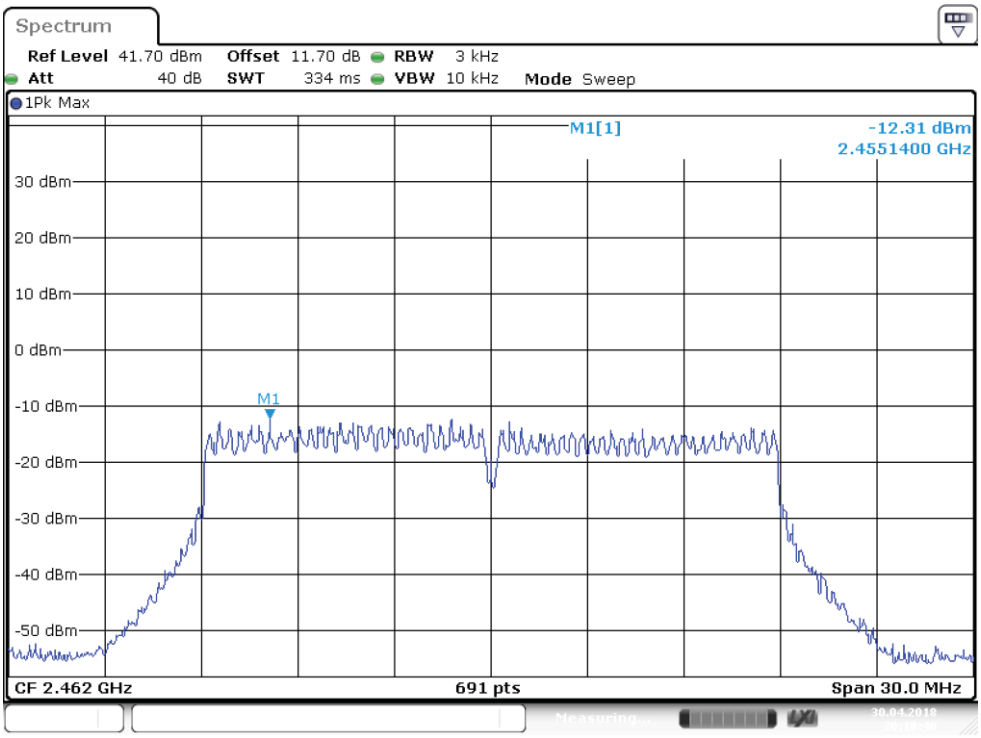

Figure 16: Power Spectral Density, 2462 MHz at 802.11n MCS0, Chain 2

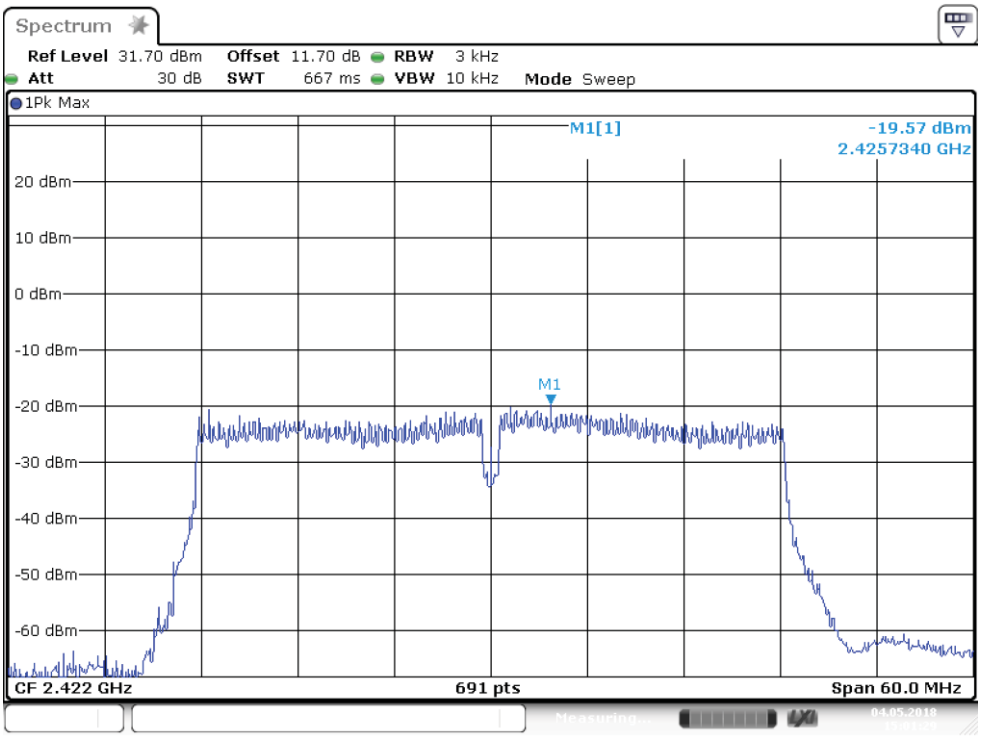

Figure 17: Power Spectral Density, 2422 MHz at HT40 MCS0, Chain 2

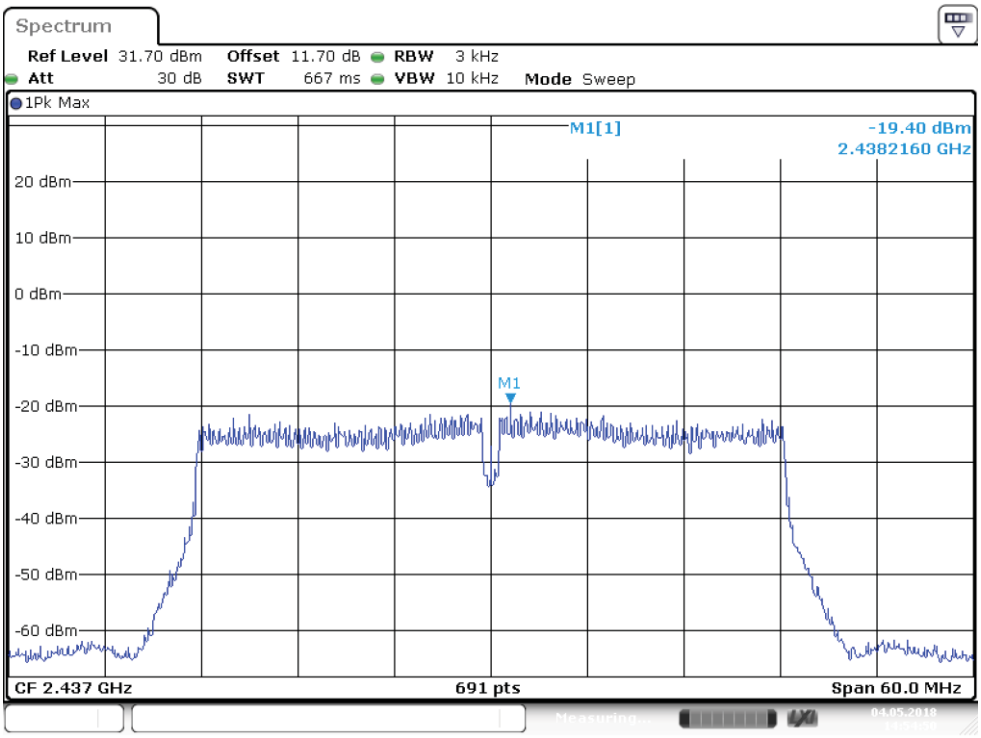

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Figure 18: Power Spectral Density, 2437 MHz at HT40 MCS0, Chain 2

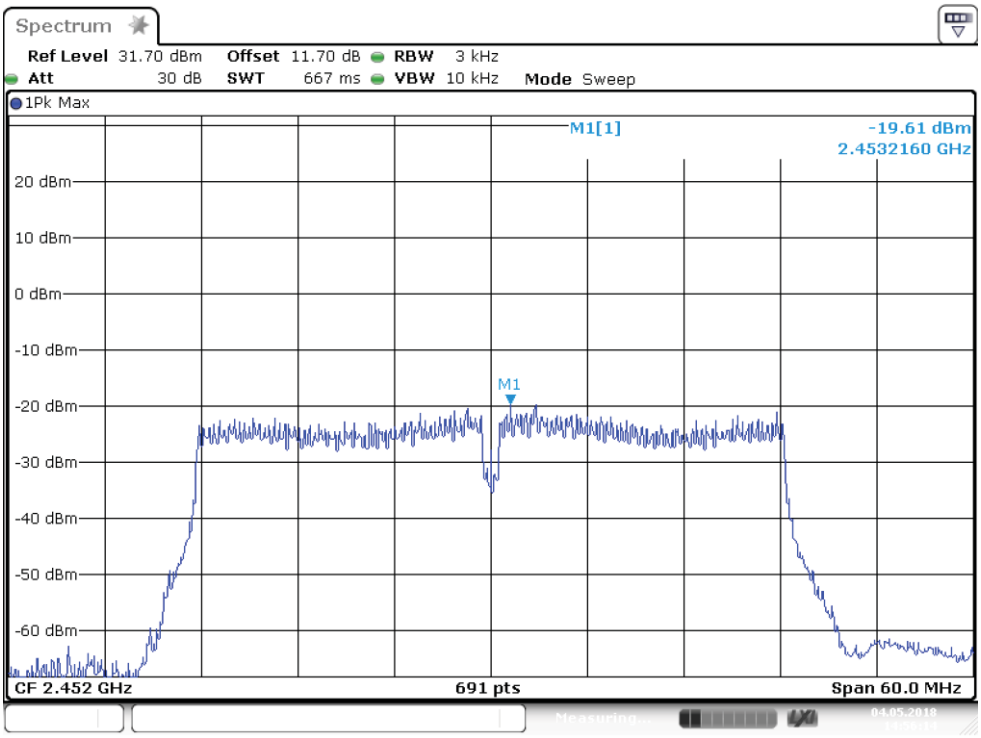


Figure 19: Power Spectral Density, 2452 MHz at HT40 MCS0, Chain 2

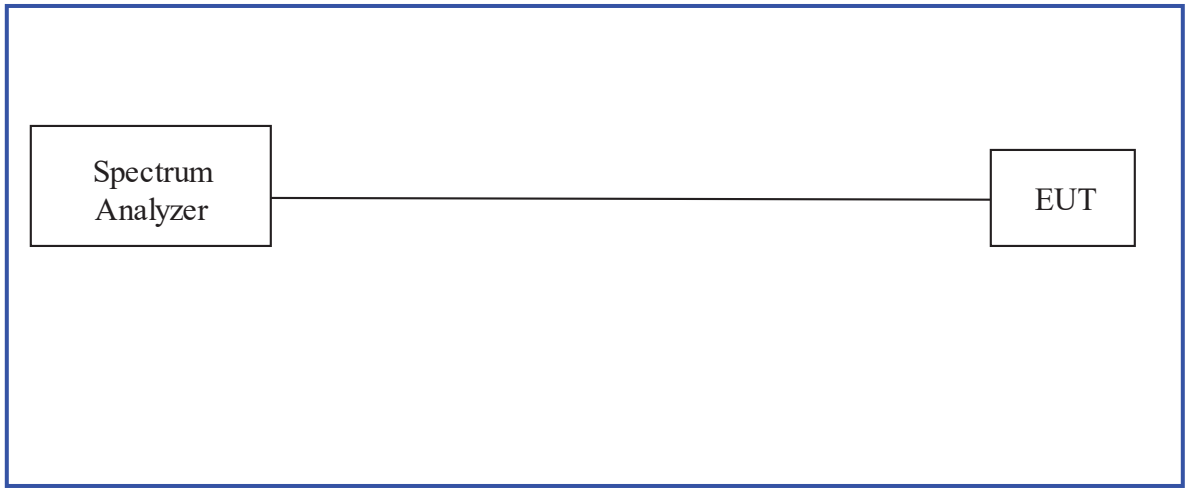
4.4 Out of Band Emissions: Non-Restricted Bands

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

4.4.1 Test Method

Conducted measurements per ANSI C63.10-2013 Sections 6.10, 11.11, 14.3.3 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. Beamforming mode (802.11ac) was not measured since they have the same output powers and modulation characteristics as 802.11n mode (OFDM).

Test Setup:



4.4.2 Results

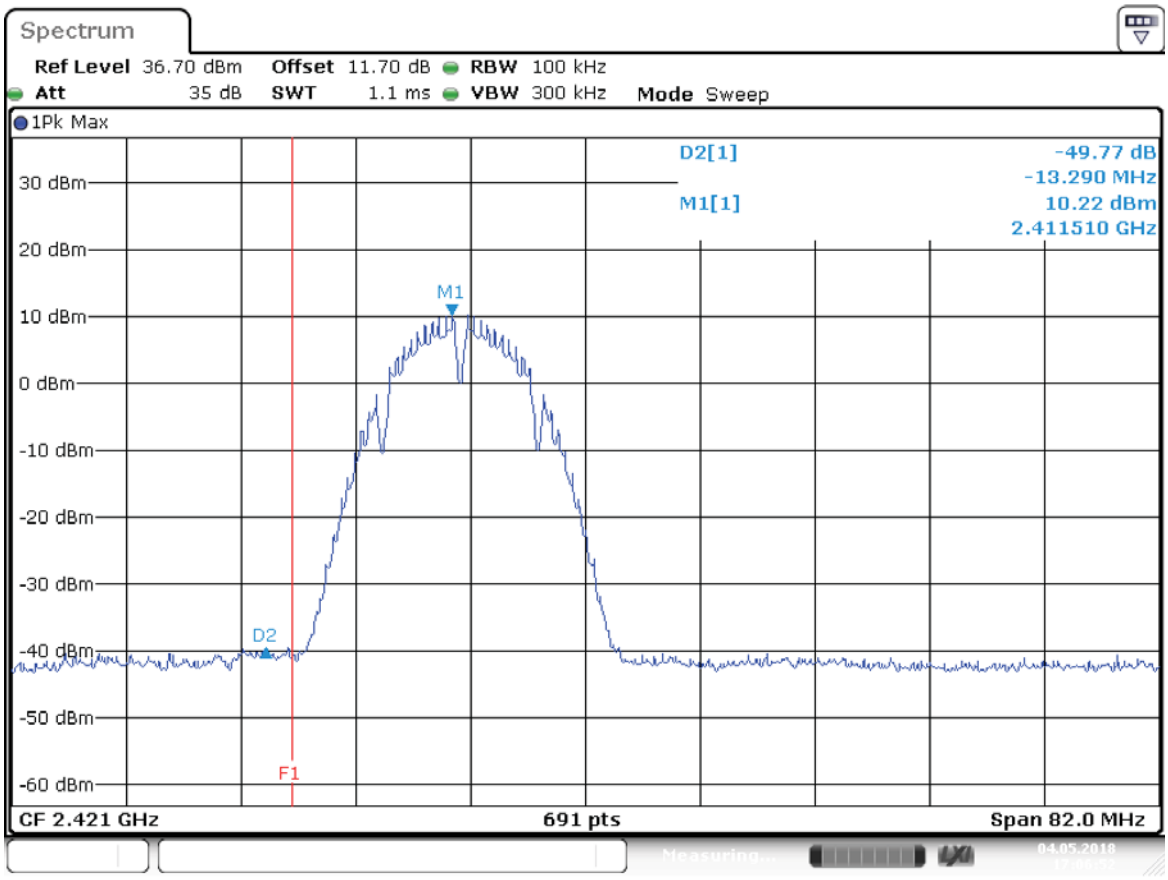
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 8: Emissions at the Band-Edge – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only						
Antenna Type: Stamped Metal			**Power Setting:** 21 (CCK), 15 (HT20), 9 (HT40)			
Max. Antenna Gain: 2.7 dBi						
Signal State: Modulated at 99.4% (CCK), 96.7% (HT20), and 93.5% (HT40) Duty Cycle.						
Ambient Temp.: 22° C			**Relative Humidity:** 38%			
Non-Restricted Frequency Band Emissions						
Freq. (MHz)	**Mode**	**Chain**	**Measured (dBc)**	**Limit (dBc)**	**Worst Case Channel**	**Results**
2397.9	802.11b 1Mbps	0	-49.8	30	1	Pass
2398.1	802.11b 1Mbps	1	-52.8	30	1	Pass
2398.0	802.11b 1Mbps	2	-52.6	30	1	Pass
2397.5	802.11b 1Mbps	3	-49.5	30	1	Pass
3215.8	802.11b 1Mbps	0	-37.0	30	1	Pass
3248.9	802.11b 1Mbps	1	-49.2	30	6	Pass
3215.8	802.11b 1Mbps	2	-49.0	30	1	Pass
3215.8	802.11b 1Mbps	3	-49.0	30	1	Pass
2399.9	802.11n HT20 MCS0	0	-42.3	30	1	Pass
2400.0	802.11n HT20 MCS0	1	-40.5	30	1	Pass
2400.0	802.11n HT20 MCS0	2	-45.1	30	1	Pass
2399.9	802.11n HT20 MCS0	3	-40.6	30	1	Pass
3216.1	802.11n HT20 MCS0	0	-30.9	30	1	Pass
3249.4	802.11n HT20 MCS0	1	-39.1	30	6	Pass
3216.1	802.11n HT20 MCS0	2	-41.9	30	1	Pass
3216.0	802.11n HT20 MCS0	3	-45.8	30	1	Pass

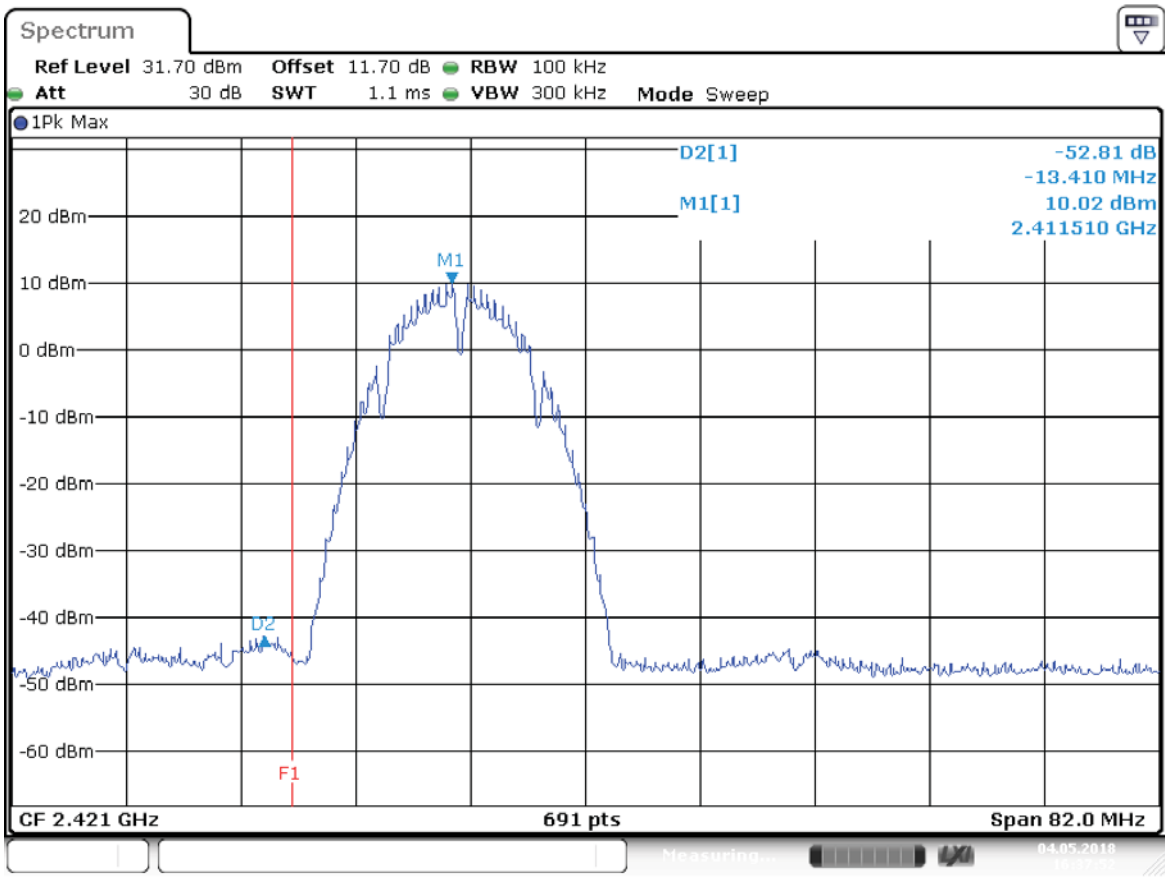
2397.4	802.11n HT40 MCS0	0	-38.8	20	3	Pass
2396.5	802.11n HT40 MCS0	1	-40.2	20	3	Pass
2397.1	802.11n HT40 MCS0	2	-43.0	20	3	Pass
3230.0	802.11n HT40 MCS0	3	-42.1	20	3	Pass
3230.0	802.11n HT40 MCS0	0	-30.3	20	3	Pass
3248.8	802.11n HT40 MCS0	1	-31.1	20	6	Pass
3230.0	802.11n HT40 MCS0	2	-40.5	20	3	Pass
3230.0	802.11n HT40 MCS0	3	-42.1	20	3	Pass

Note: 1. The worst case measurement of each channel is recorded.



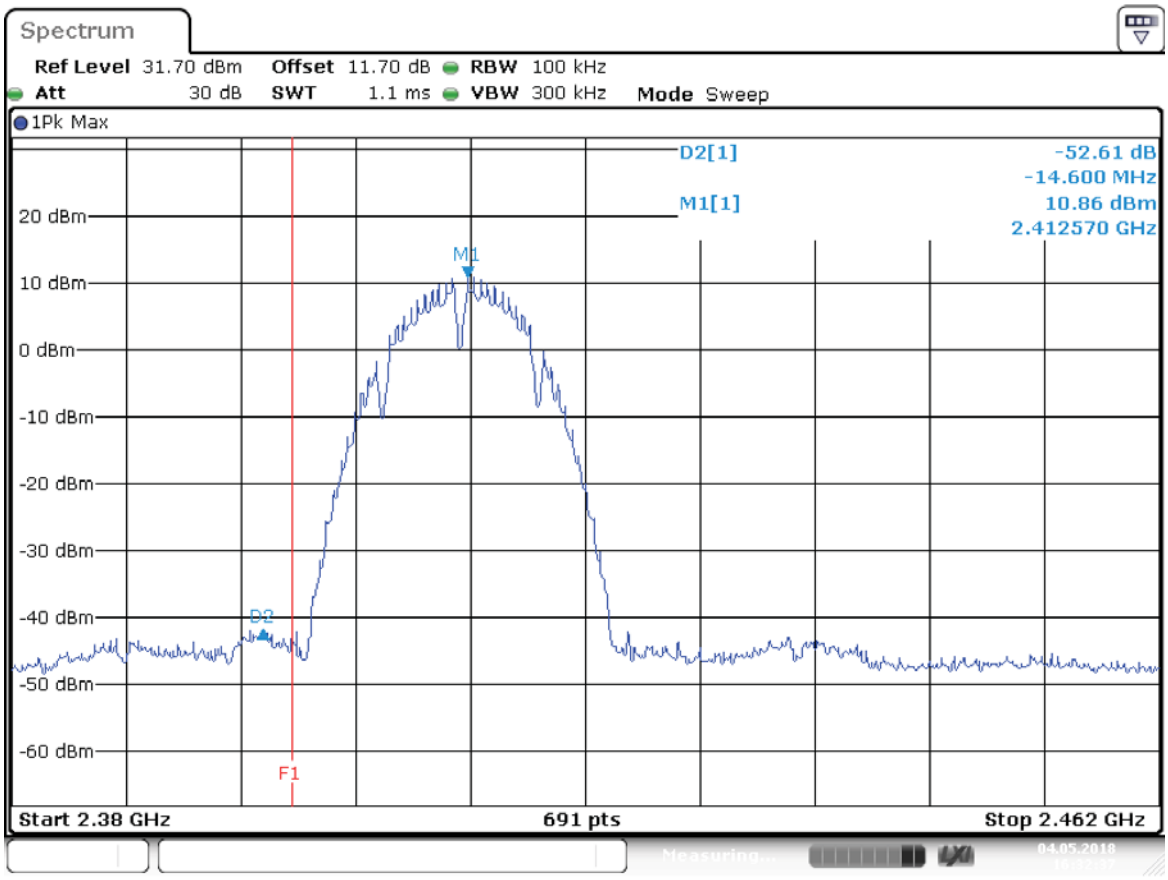
Date: 4.MAY.2018 17:06:53

Figure 20: Low Bandedge(non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 0



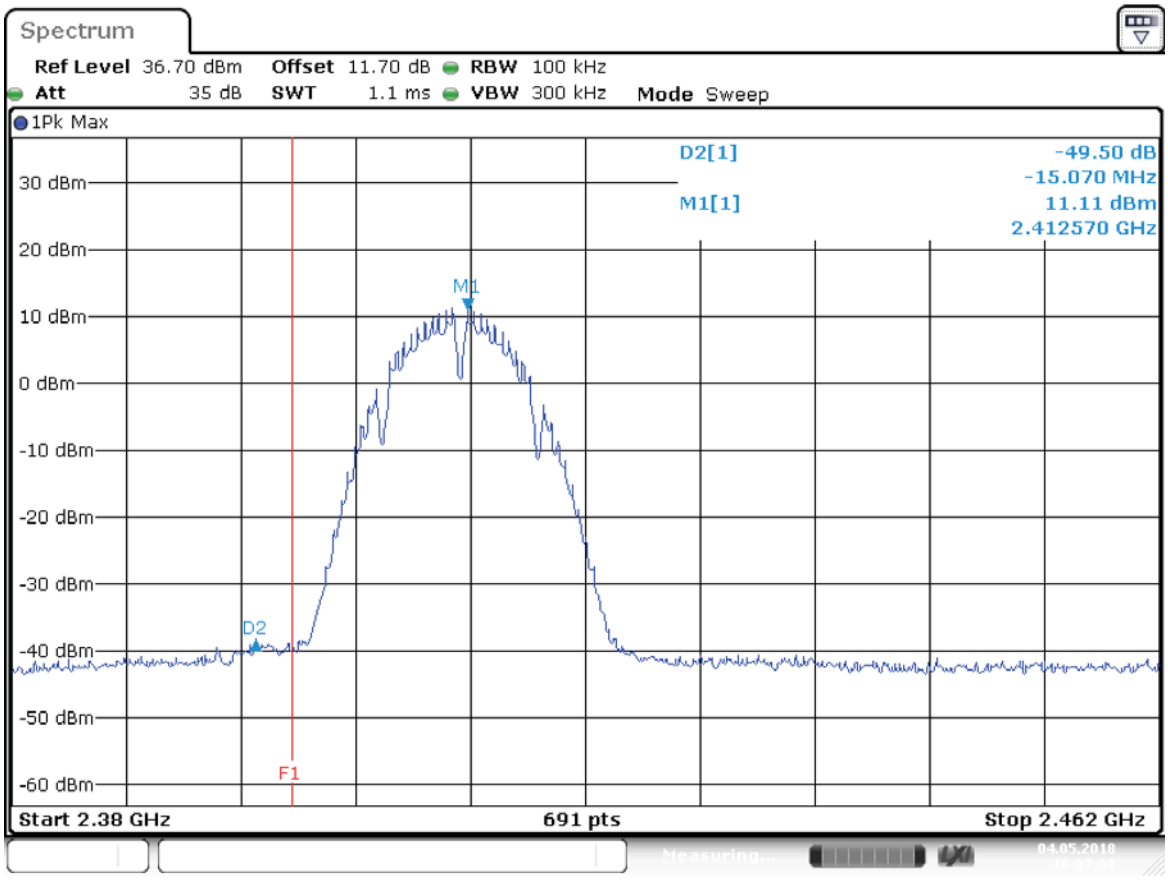
Date: 4.MAY.2018 16:37:52

Figure 21: Low Bandedge(non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 1



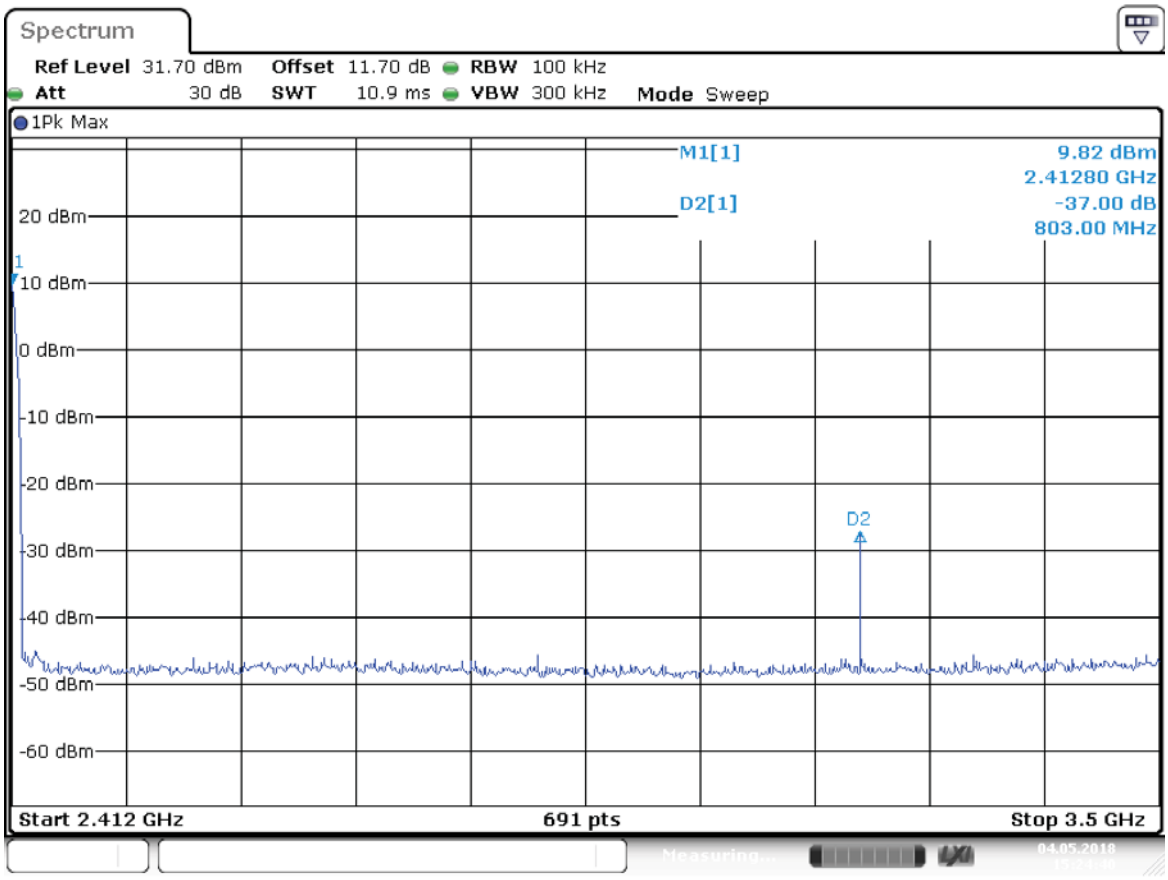
Date: 4.MAY.2018 16:32:37

Figure 22: Low Bandedge (non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 2



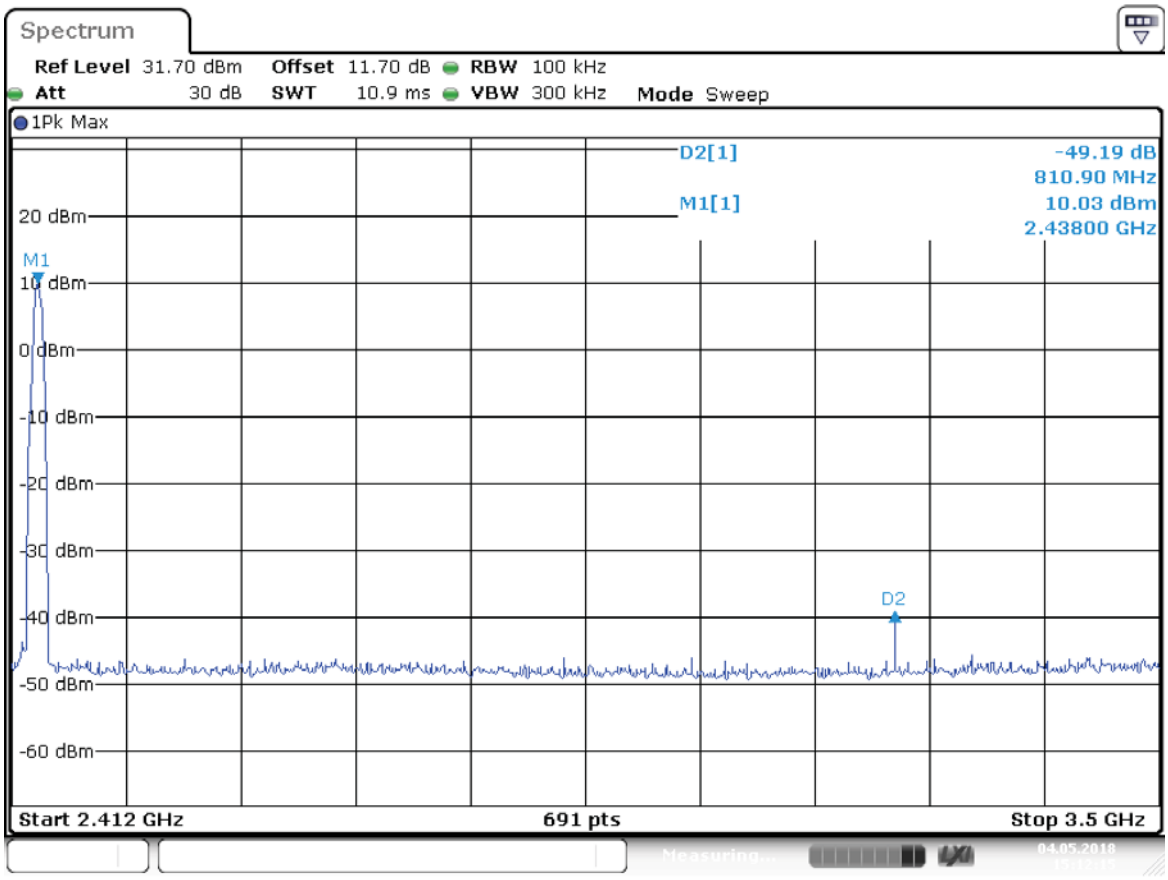
Date: 4.MAY.2018 16:07:08

Figure 23: Low Bandedge (non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 3



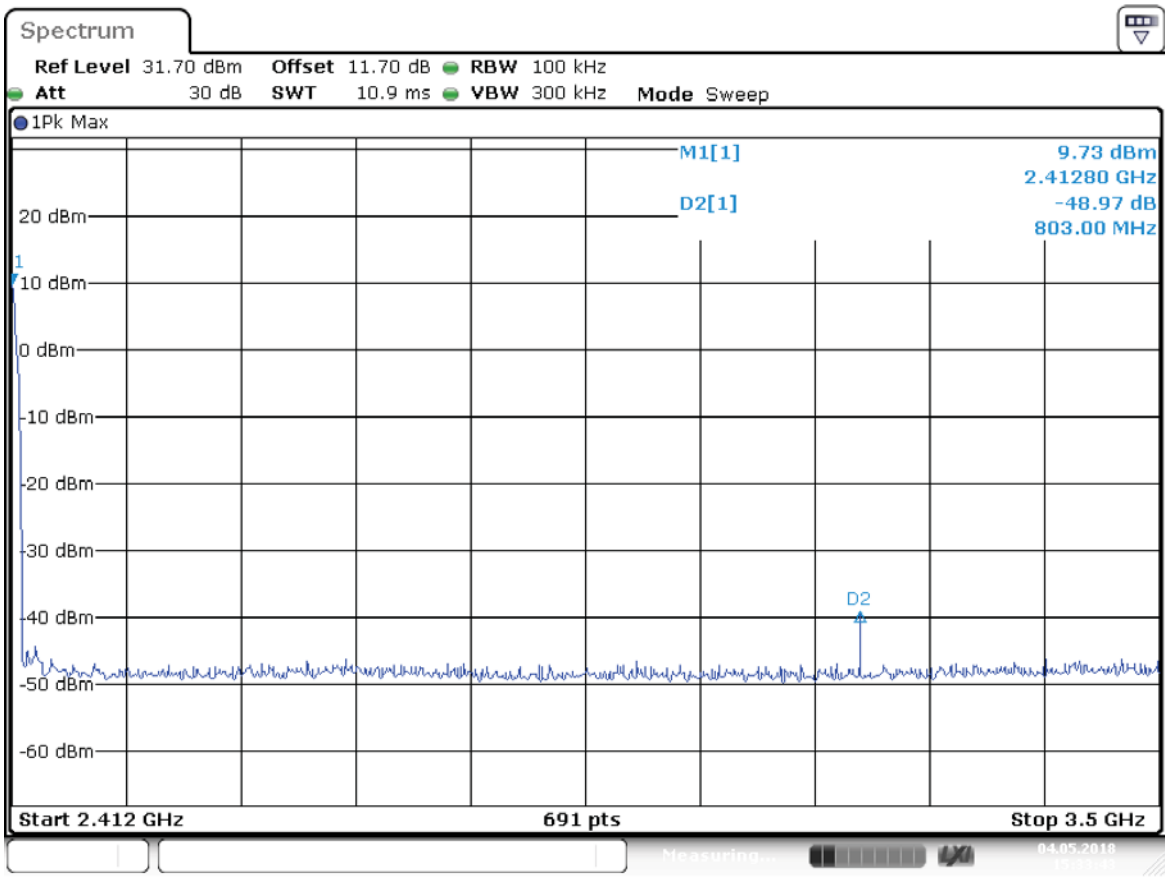
Date: 4.MAY.2018 15:24:40

Figure 24: High Bandedge (non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 0



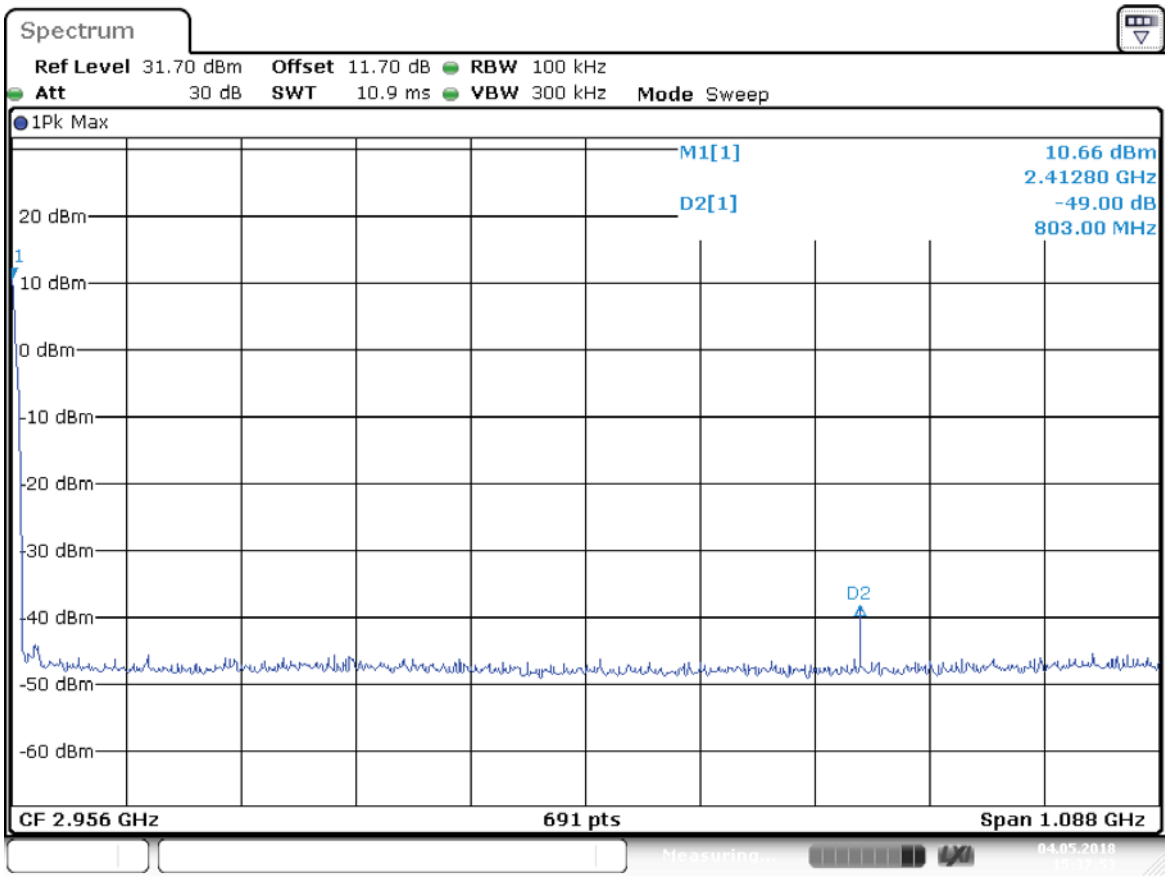
Date: 4.MAY.2018 15:12:15

Figure 25: High Bandedge (non-restricted) for 802.11b 1Mbps at 2437 MHz, Chain 1



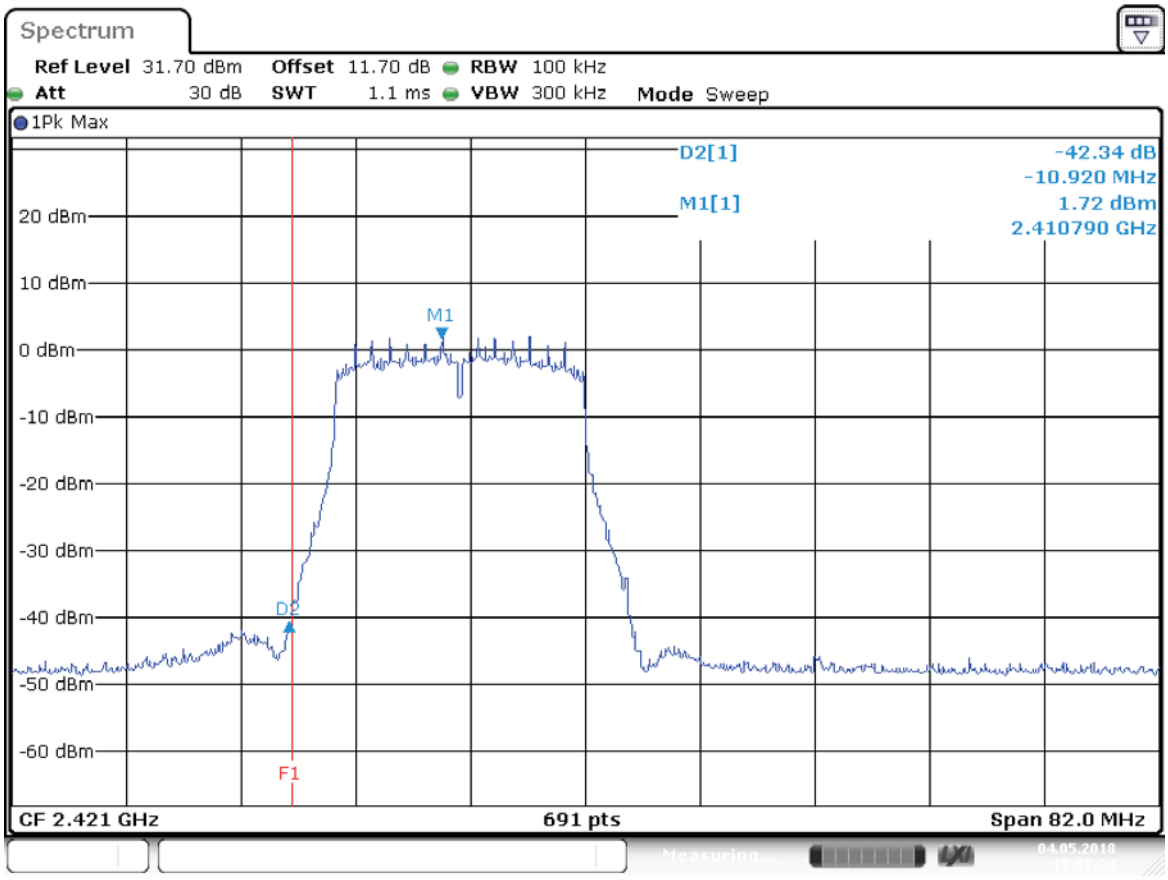
Date: 4.MAY.2018 15:33:44

Figure 26: High Bandedge (non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 2



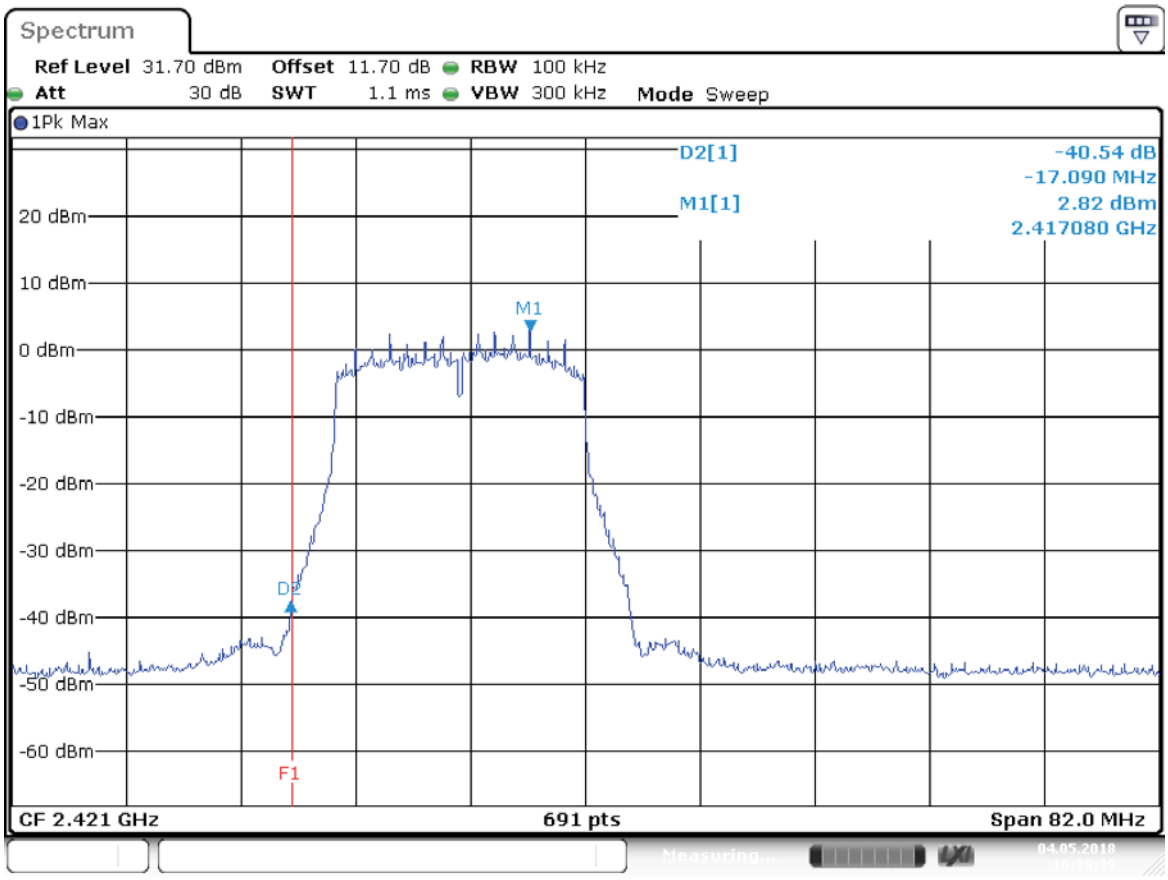
Date: 4.MAY.2018 15:37:53

Figure 27: High Bandedge (non-restricted) for 802.11b 1Mbps at 2412 MHz, Chain 3



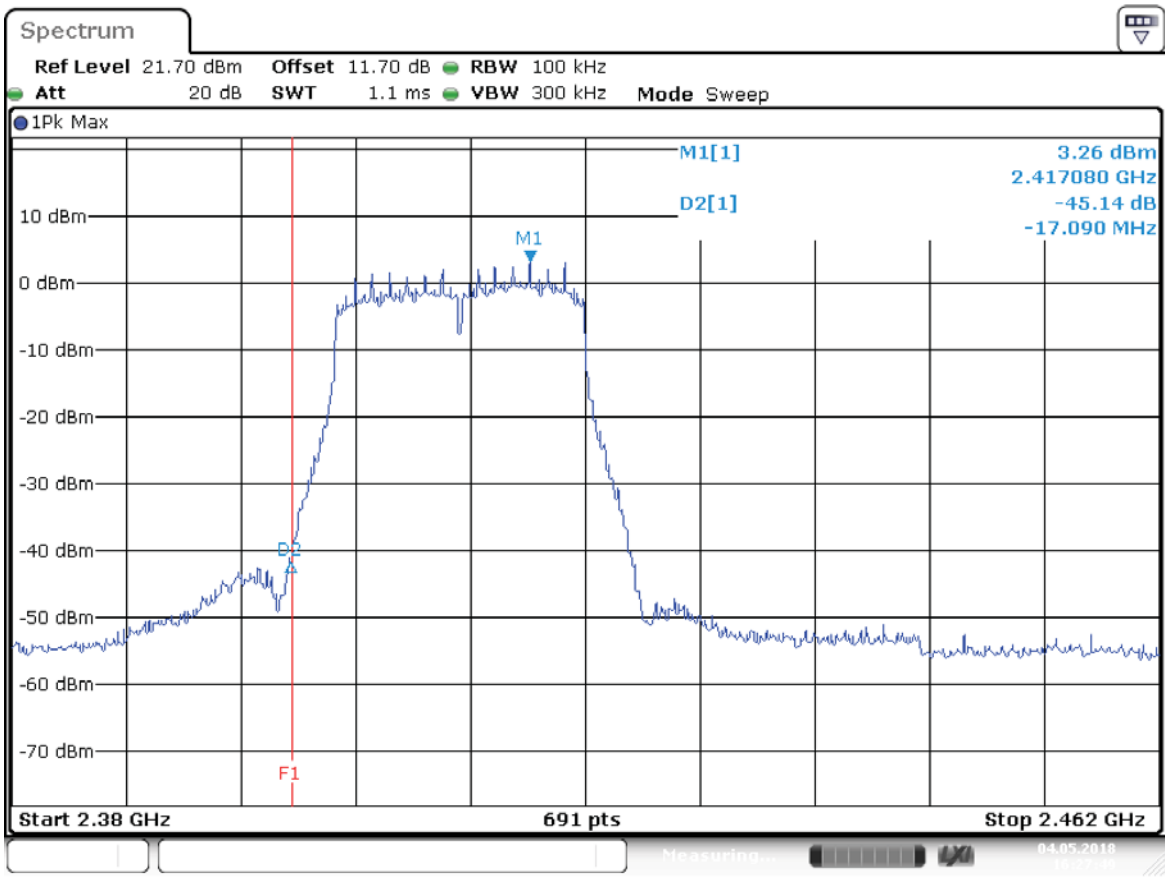
Date: 4.MAY.2018 17:02:23

Figure 28: Low Bandedge(non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 0



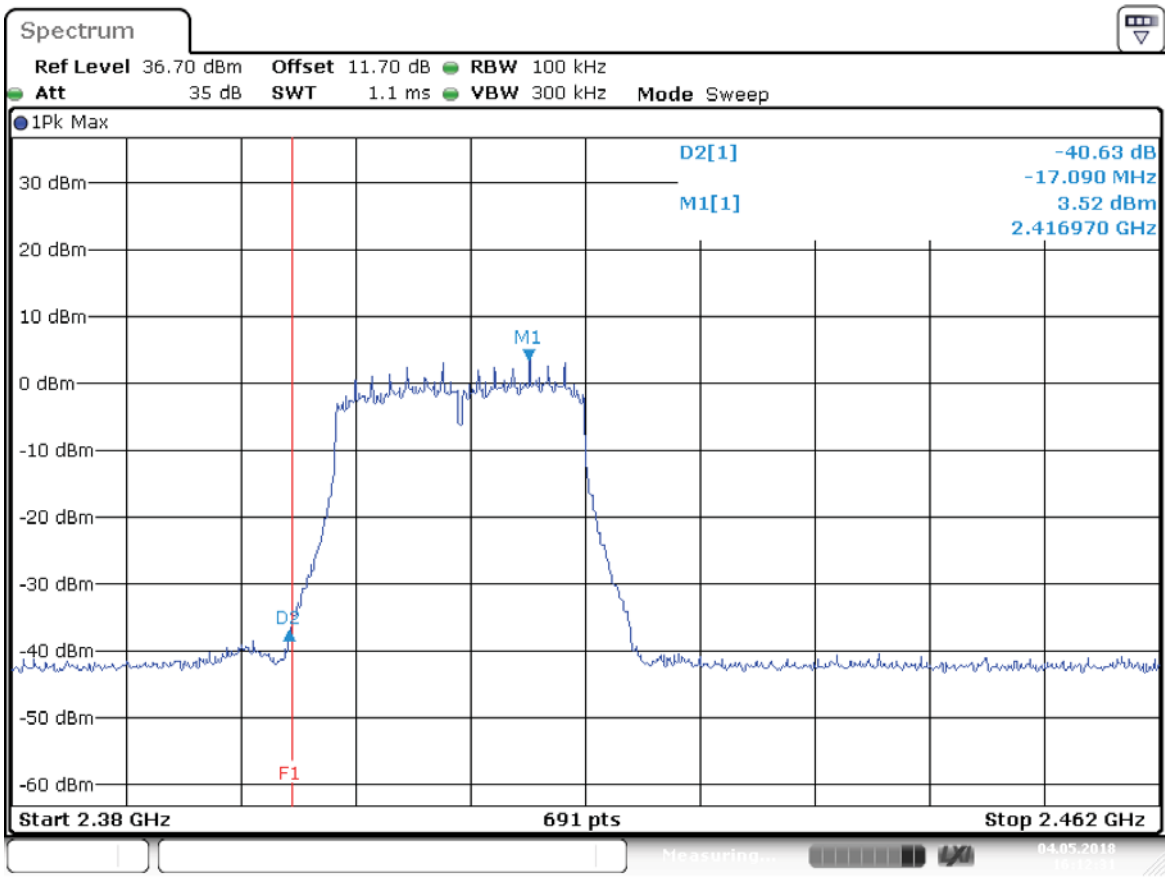
Date: 4.MAY.2018 16:39:39

Figure 29: Low Bandedge(non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 1



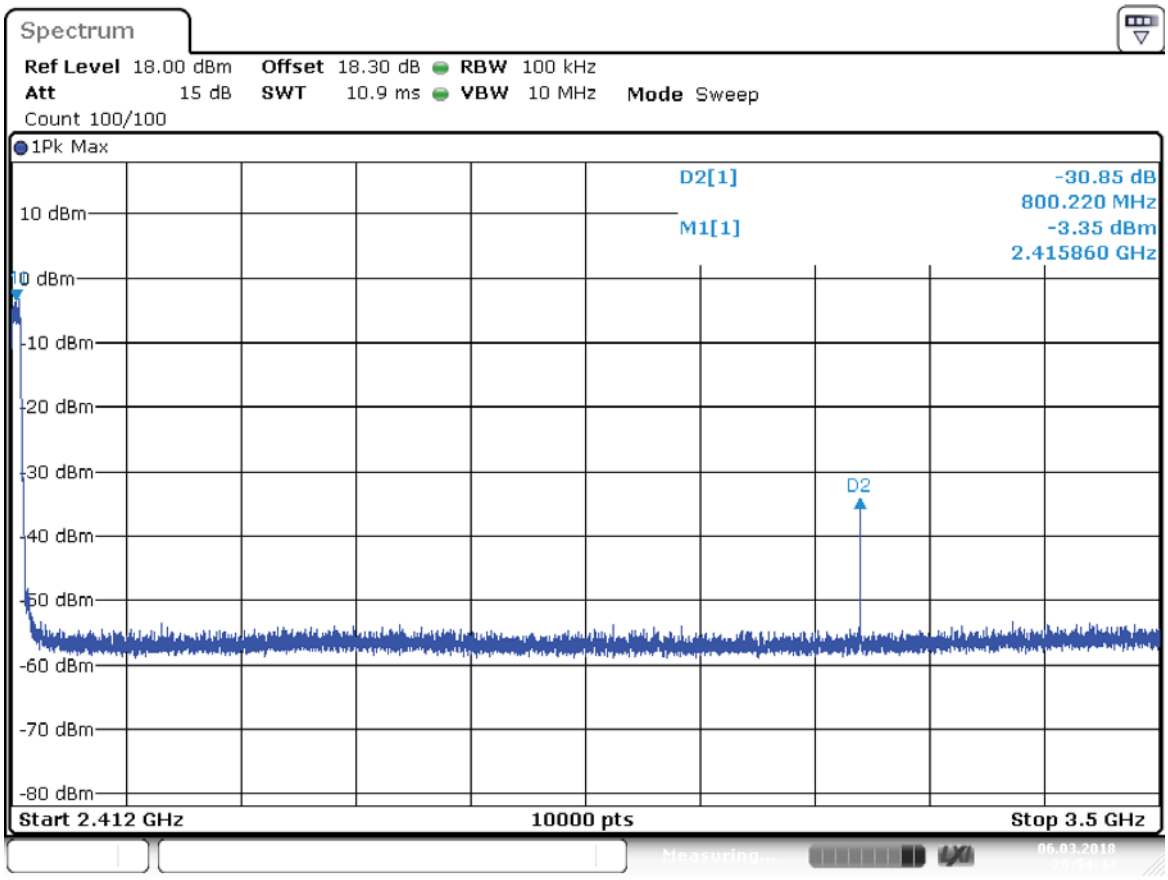
Date: 4.MAY.2018 16:27:49

Figure 30: Low Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 2



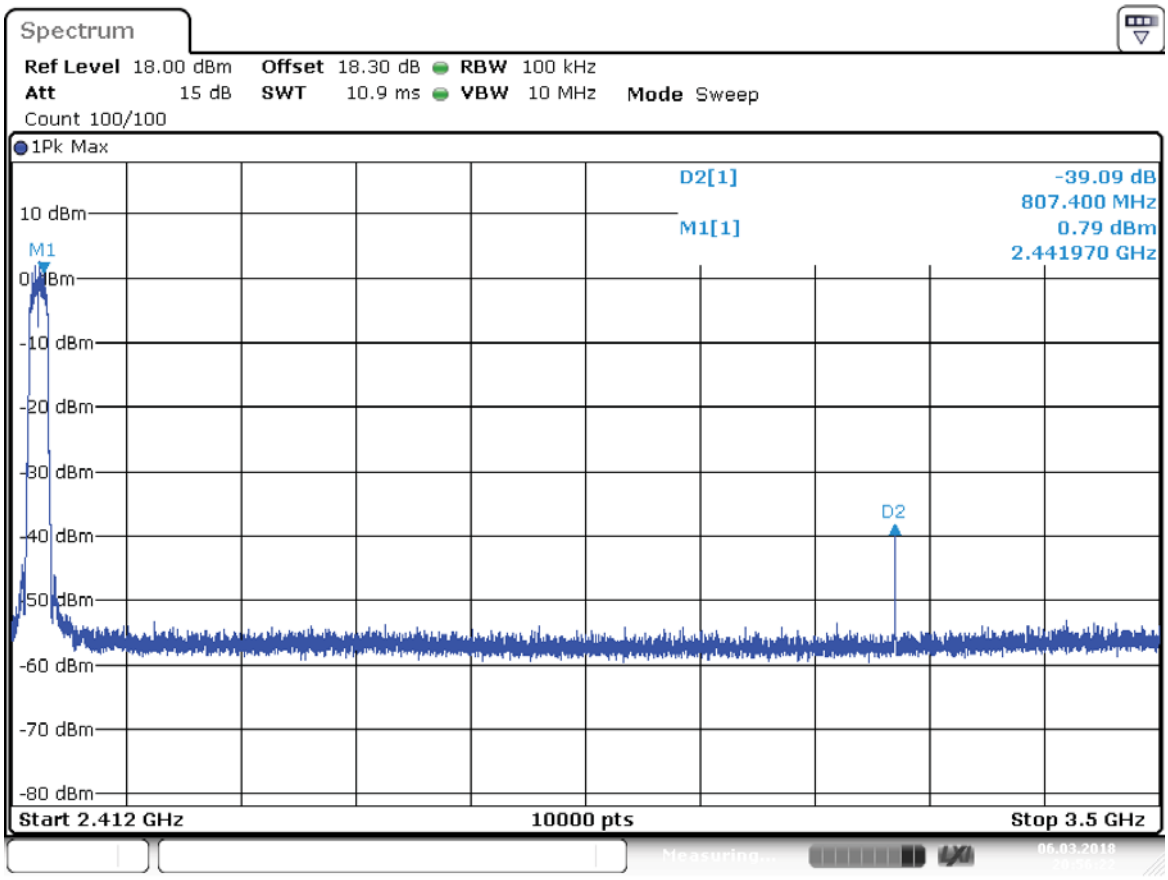
Date: 4.MAY.2018 16:12:32

Figure 31: Low Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 3



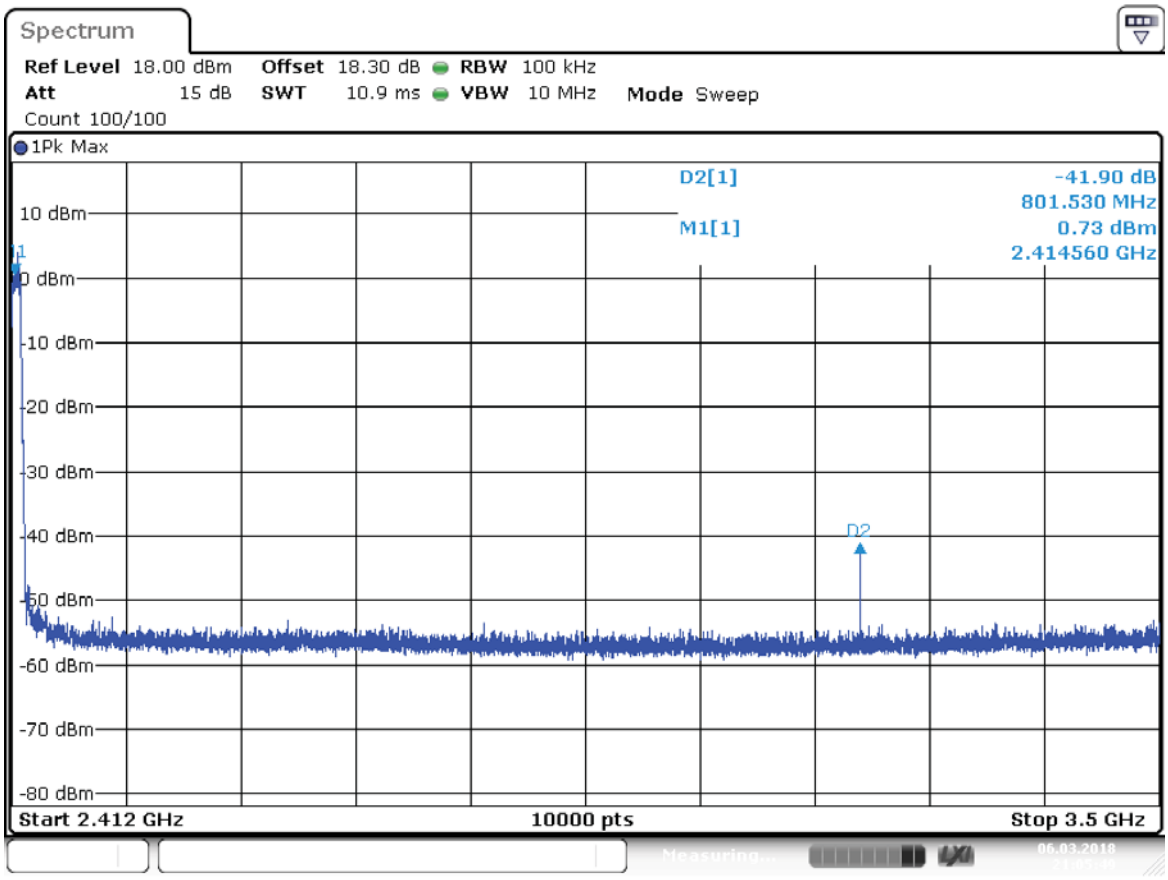
Date: 6.MAR.2018 20:54:45

Figure 32: High Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 0



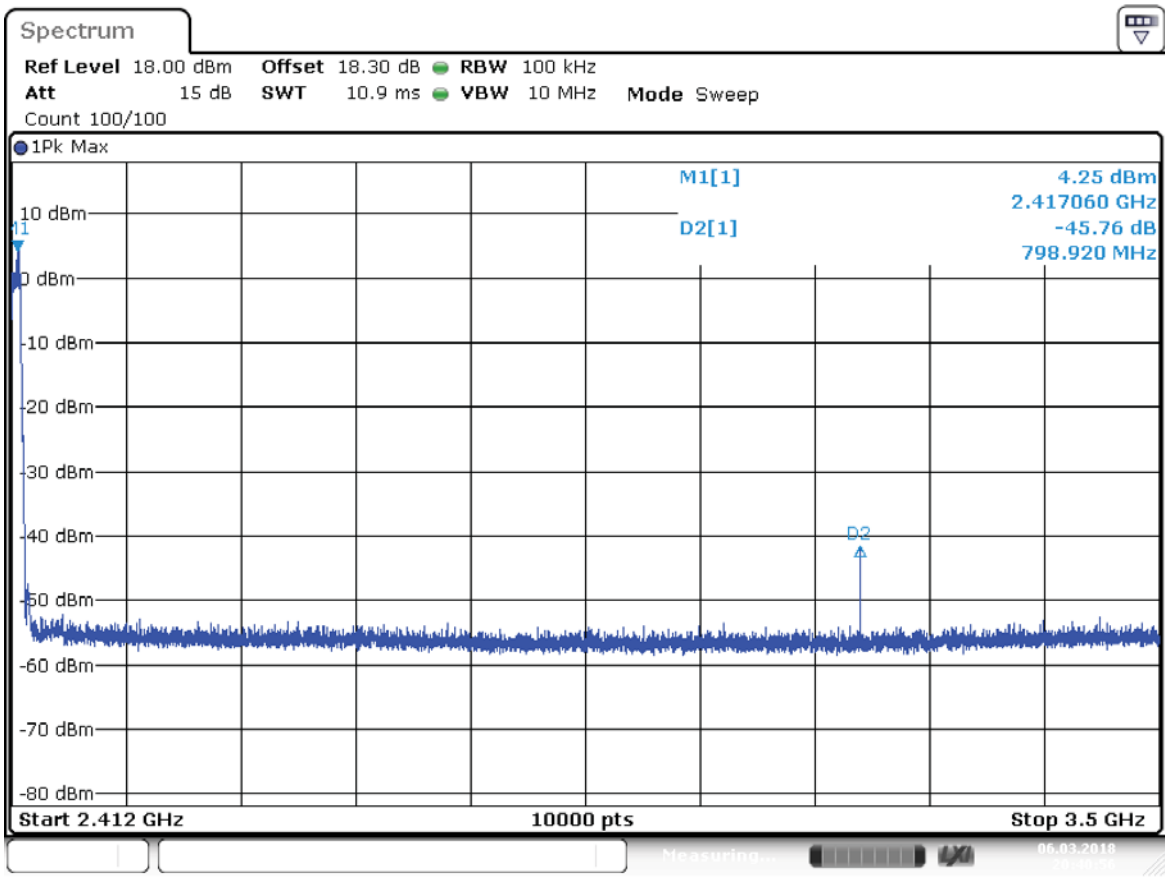
Date: 6.MAR.2018 20:56:22

Figure 33: High Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2437 MHz, Chain 1



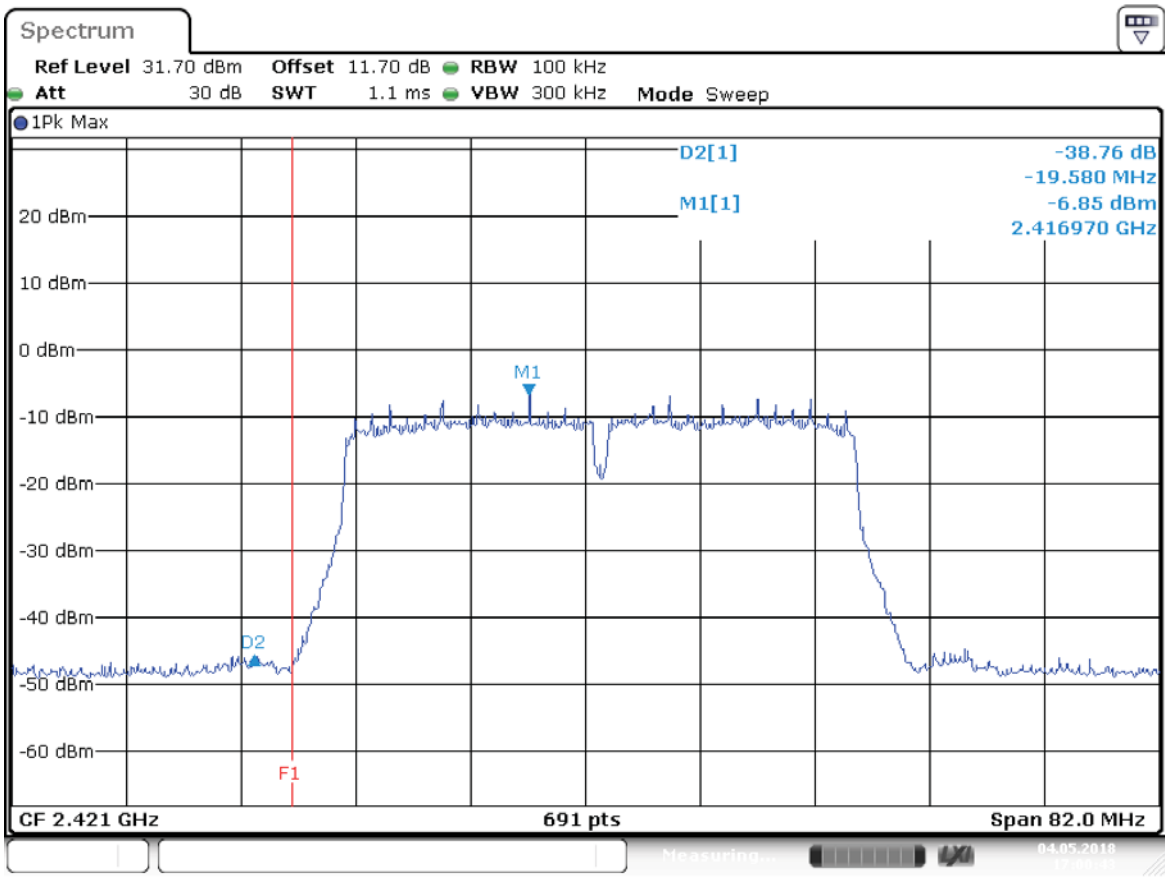
Date: 6.MAR.2018 21:05:49

Figure 34: High Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 2



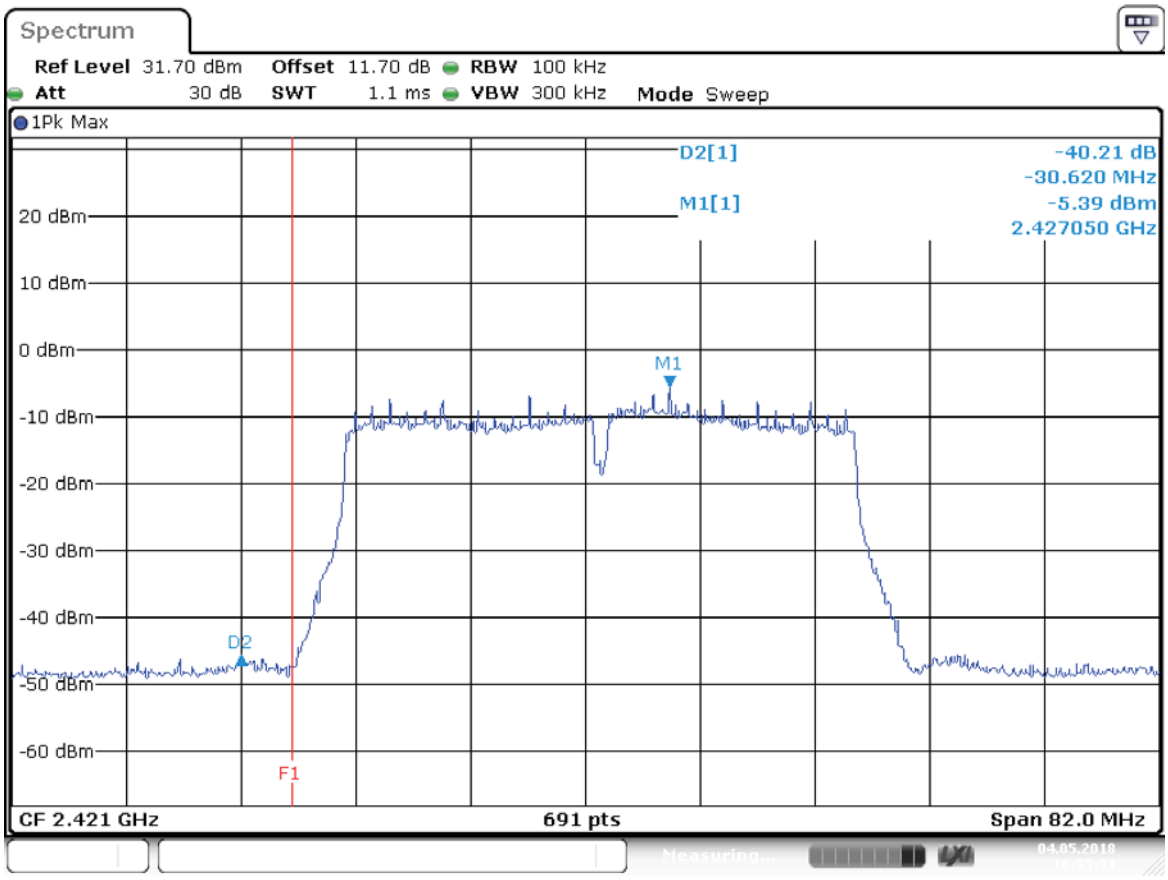
Date: 6.MAR.2018 20:40:56

Figure 35: High Bandedge (non-restricted) for 802.11n HT20 MCS0 at 2412 MHz, Chain 3



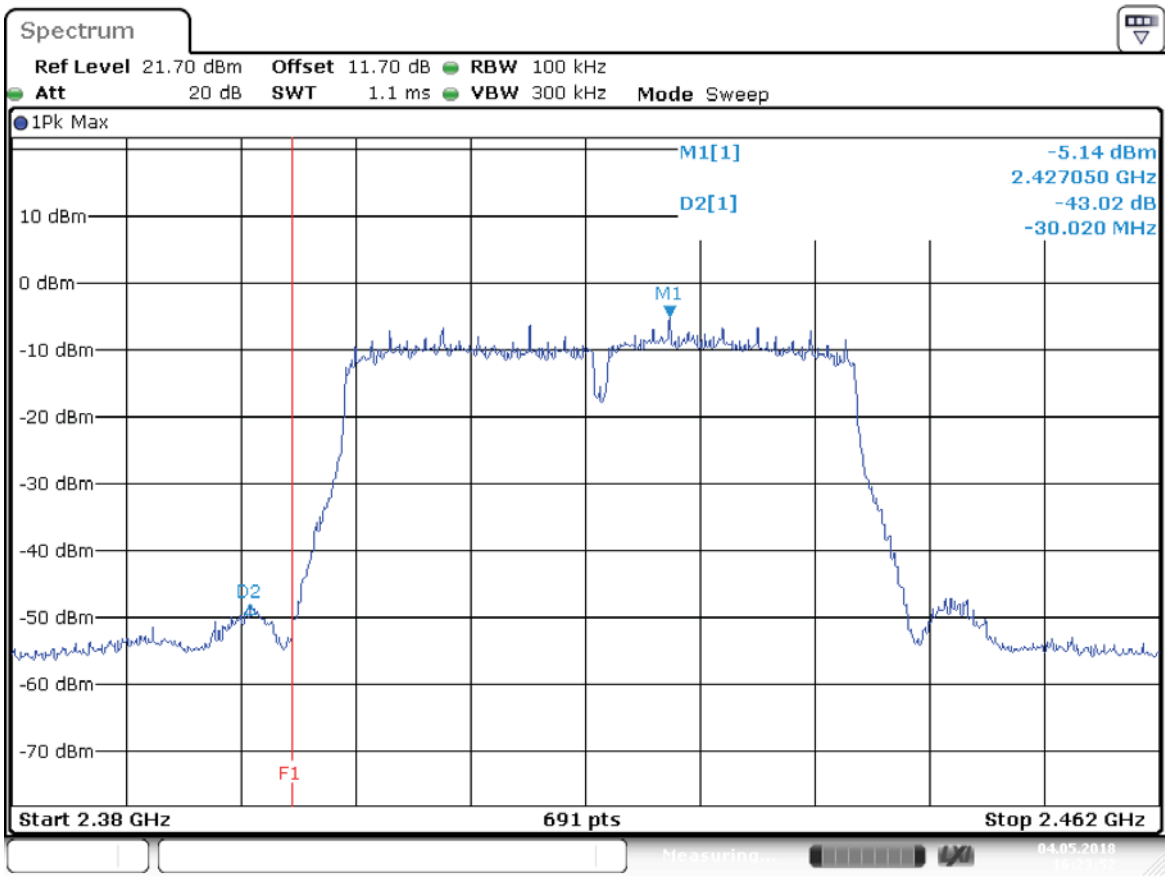
Date: 4.MAY.2018 17:00:44

Figure 36: Low Bandedge(non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 0



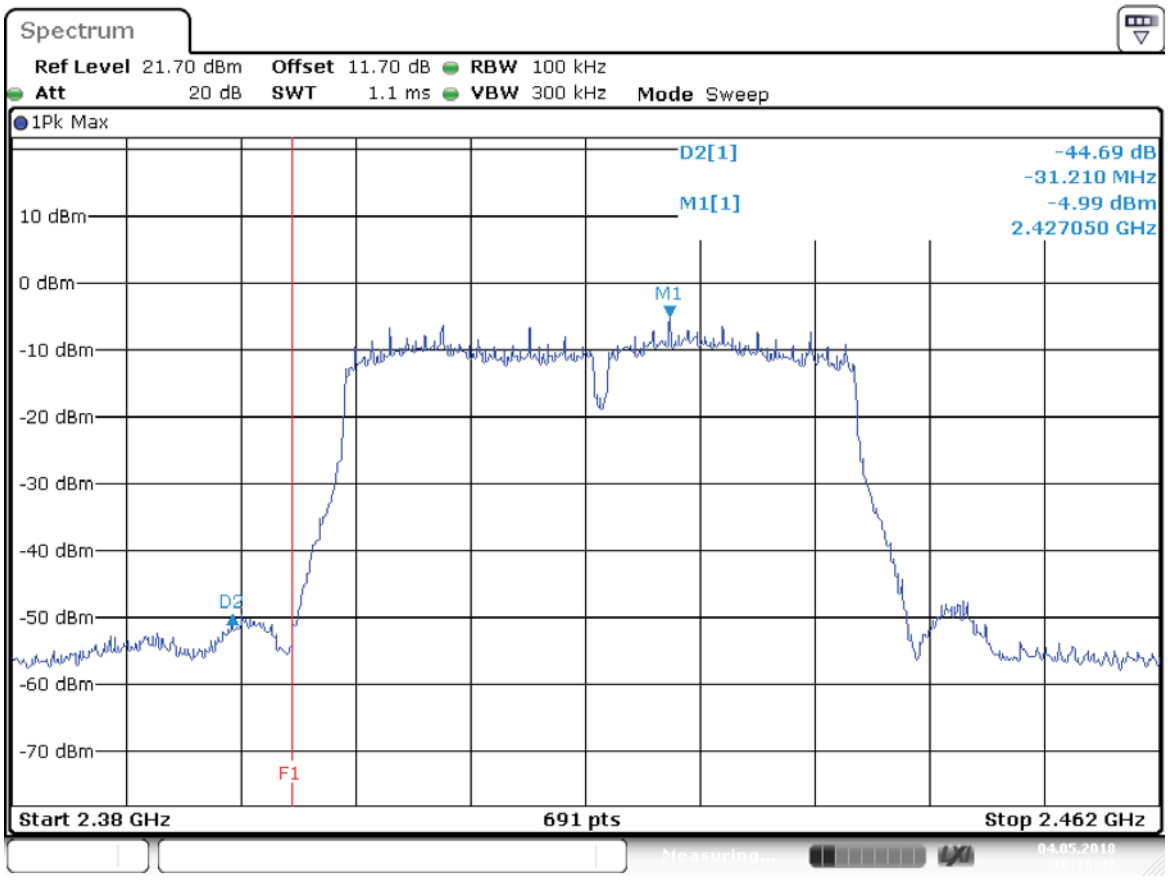
Date: 4.MAY.2018 16:55:31

Figure 37: Low Bandedge(non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 1



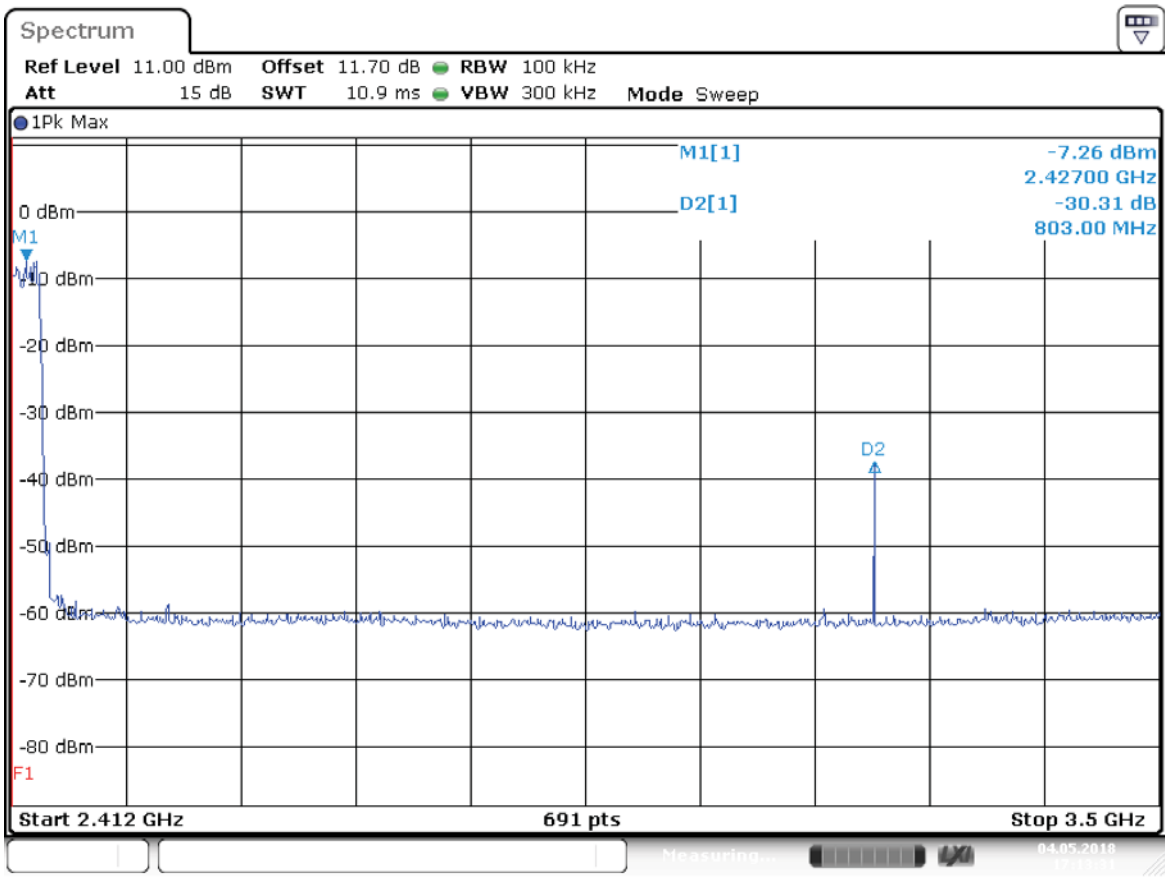
Date: 4.MAY.2018 16:23:52

Figure 38: Low Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 2



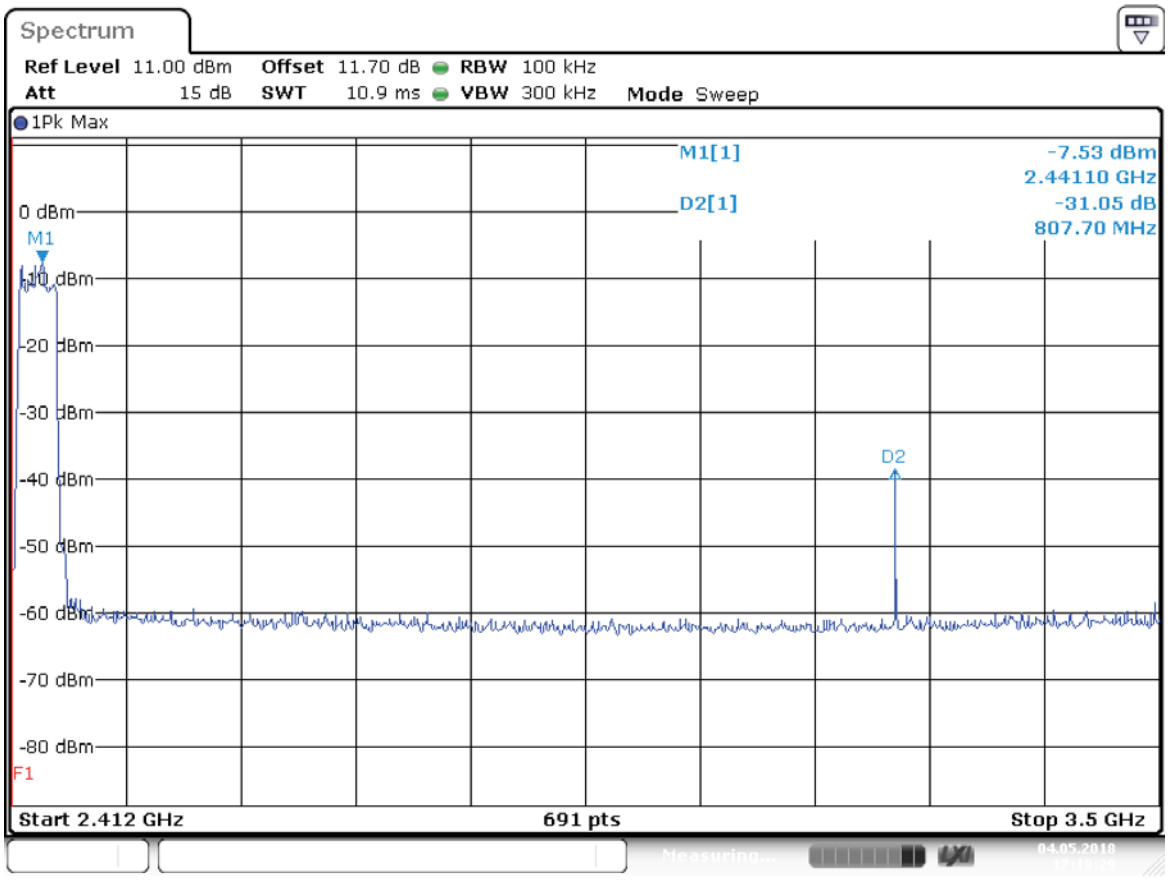
Date: 4.MAY.2018 16:16:42

Figure 39: Low Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 3



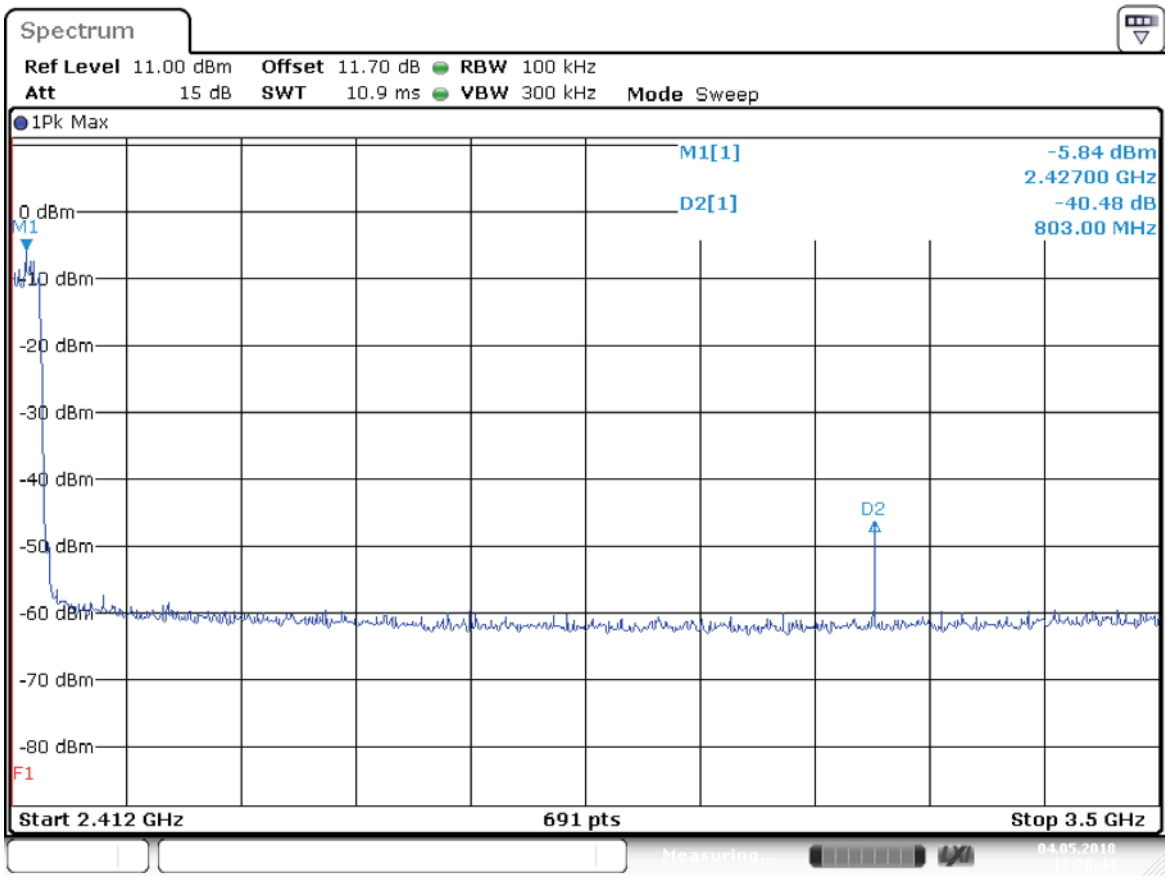
Date: 4.MAY.2018 17:13:31

Figure 40: High Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 0



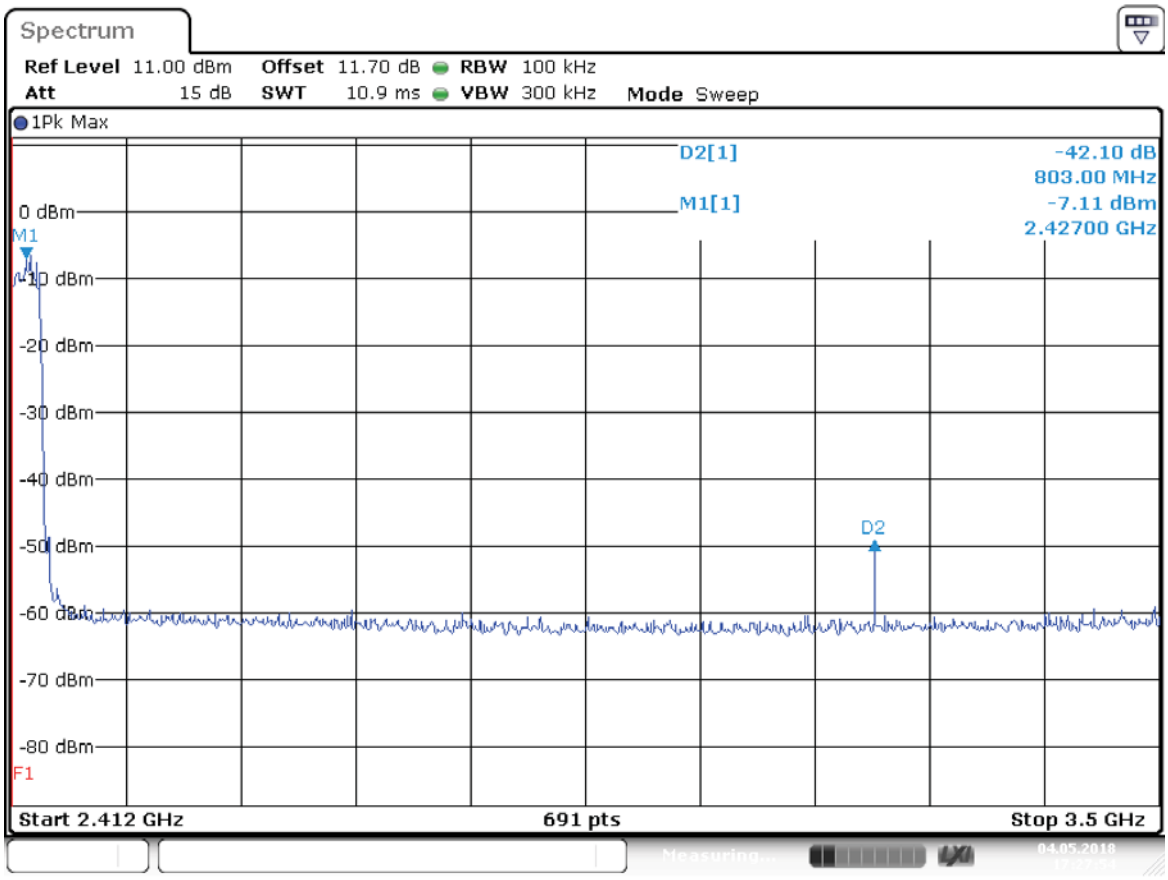
Date: 4.MAY.2018 17:18:29

Figure 41: High Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2437 MHz, Chain 1



Date: 4.MAY.2018 17:20:44

Figure 42: High Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 2



Date: 4.MAY.2018 17:27:54

Figure 43: High Bandedge (non-restricted) for 802.11n HT40 MCS0 at 2422 MHz, Chain 3

4.5 Out of Band Emissions: Restricted Band Edge

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

4.5.1 Test Method

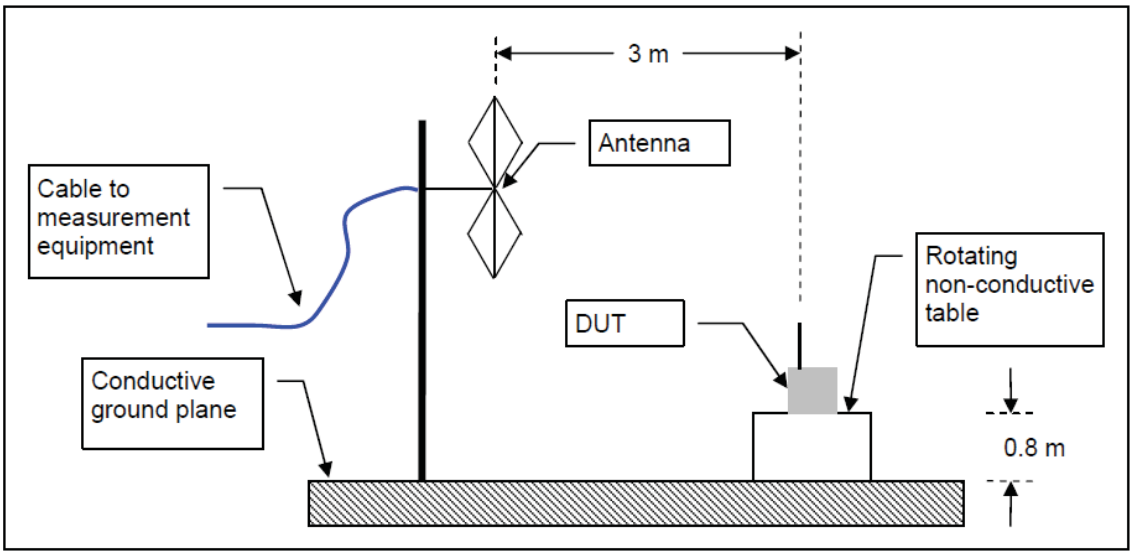
Radiated measurements per ANSI C63.10-2013 Section 6.10.5 were used to measure the undesirable emission requirement in restricted bands. The measurement was performed with modulation. This test was conducted on 3 channels in each mode on the EUT. The worst case measurement of each channel is recorded in this report. All modes were tested in 4x4 configuration since all antenna configurations use the same power settings as 4x4 MIMO mode.

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)

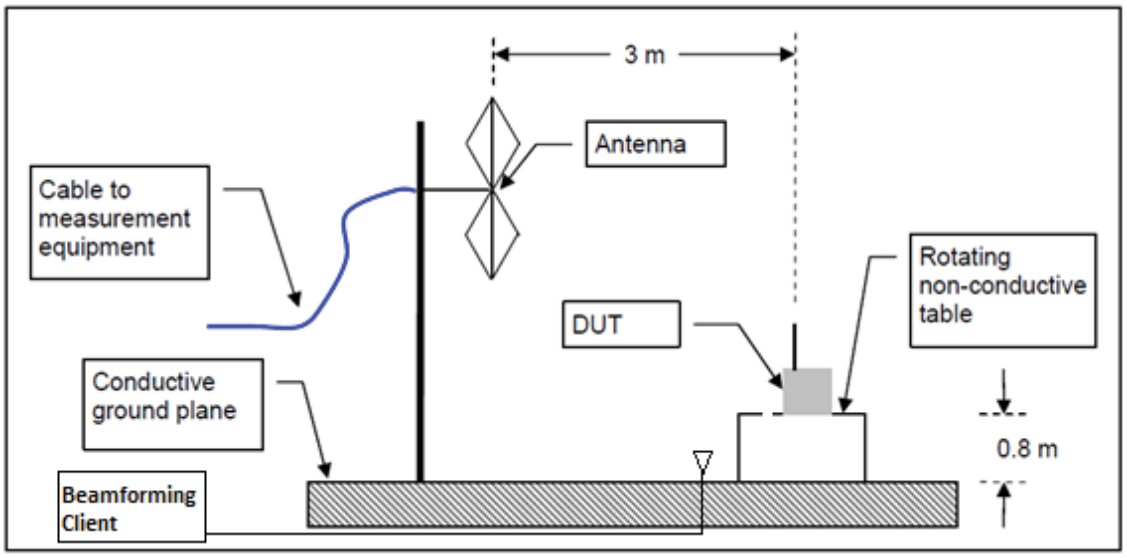
The Average Measurement is corrected with a Duty Cycle Correction Factor as determined in Section 4.5.2 of this report.

CDD Mode



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

Beamforming (BF) Mode



A conducted 4x4 MIMO client that supports beamforming was used to lock the beam. The clients antenna was routed in the chamber and put on the turntable outside the measuring antenna's beamwidth for the fundamental frequency. The EUT uses circular beamforming with a lockable beam as defined in ANSI C63.10-2013 Section 13. Network throughput software tool, iperf3, was used to stimulate the DUT's transmissions with a high duty cycle.
A customized software tool developed by the manufacturer was used to associate the DUT and the Client to any required data rates, channels and power settings before transmissions were initiated.

Iperf3 Command Line for DUT:
iperf -c 192.168.16.1 -p 5021 -i 10 -t 4200 -w 320k -u -b 300M -P 4 -l24000

Iperf3 Command Line for Client (Support Equipment):
iperf3 -s

4.5.2 Duty Cycle

CDD mode duty cycles were measured by the gated power meter used for measurements in section 4.1 of this report. Beamforming (802.11ac) duty cycles were measured with a spectrum analyzer.

Mode	Measured Duty Cycle	Duty Cycle Correction Factor (dB)
802.11b	99.4%	N/A
802.11n HT20	96.7%	0.1
802.11n HT40	93.5%	0.3
802.11ac HT20 (BF)	94.6%	0.2
802.11ac HT40 (BF)	90.0%	0.5

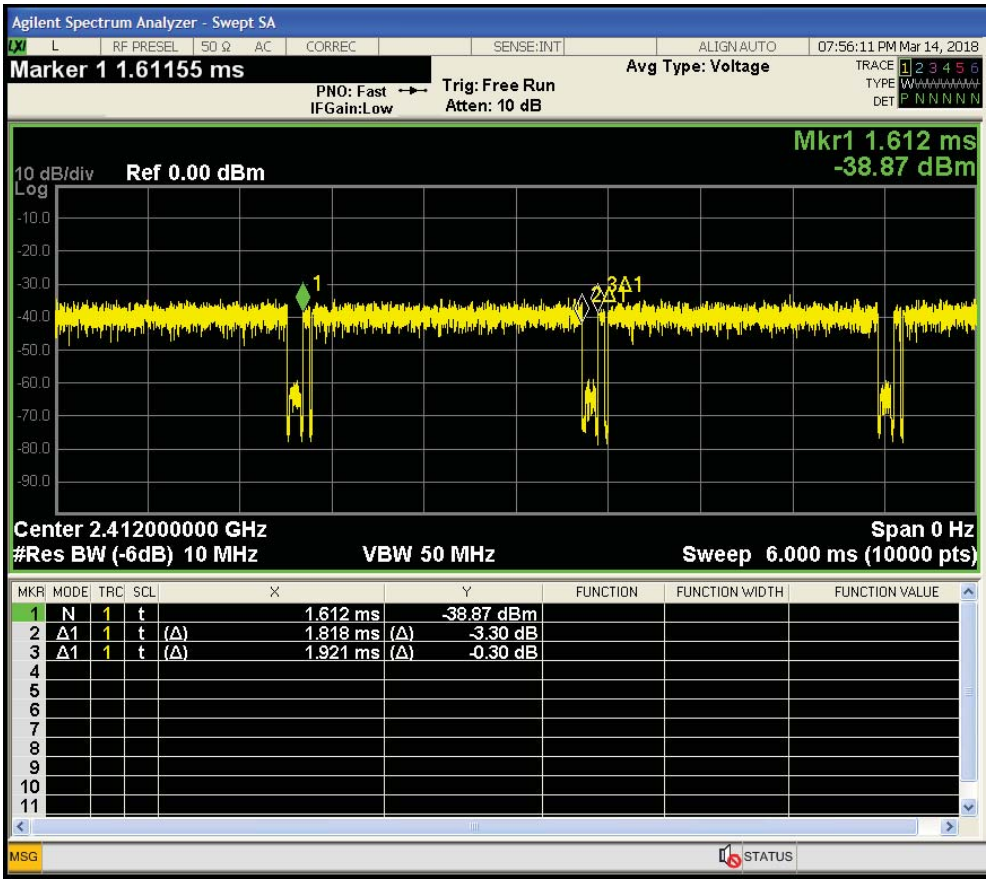


Figure 44: Duty Cycle for 802.11ac HT20 (BF)

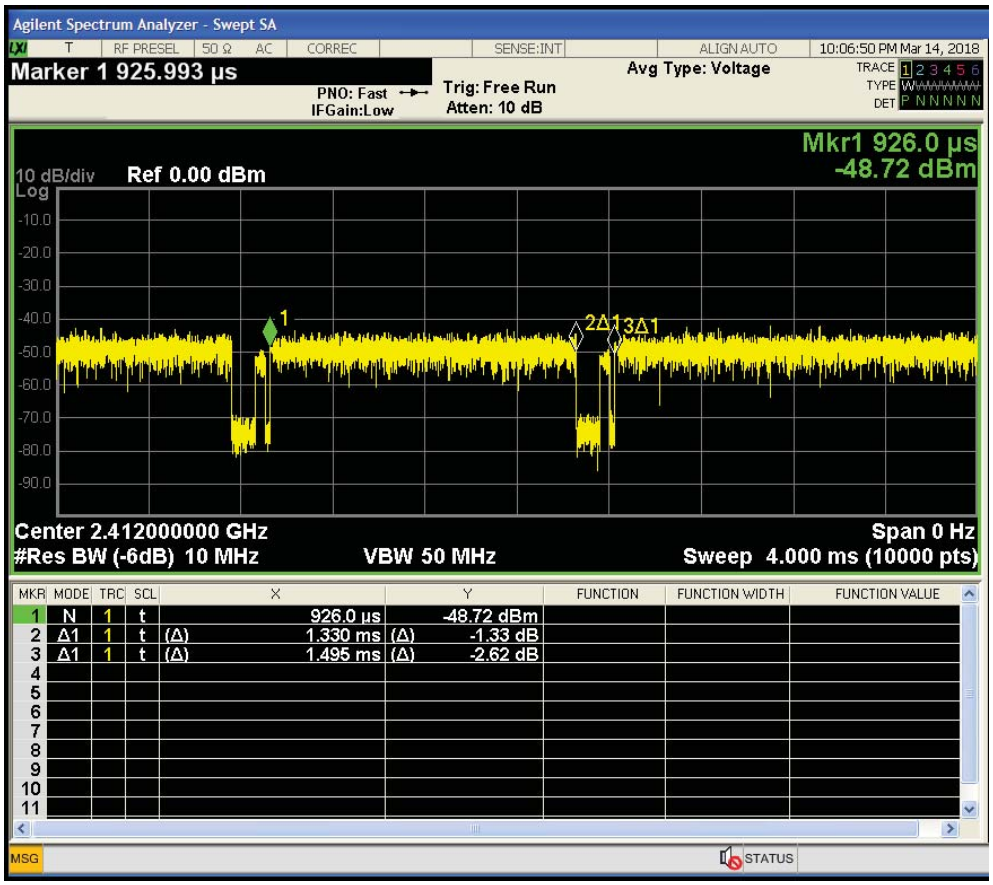


Figure 45: Duty Cycle for 802.11ac HT40 (BF)