FCC and ISEDC Test Report

Apple Inc
Model: A2179

In accordance with FCC 47 CFR Part 15C, ISEDC RSS-247 and ISEDC RSS-GEN

Prepared for: Apple Inc
One Apple Park Way
Cupertino, California, 95014, USA

FCC ID: BCGA2179 IC: 579C-A2179

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Document 75945251-12 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Matthew Russell	RF Team Leader	Authorised Signatory	10 February 2020

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C, ISEDC RSS-247 and ISEDC RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	George Porter	10 February 2020	
Testing	Ahmad Javid	10 February 2020	
Testing	Mohammad Malik	10 February 2020	
Testing	Jay Balendrarajah	10 February 2020	
Testing	Cristian Onaca	10 February 2020	
Testing	Mohamud Mohamud	10 February 2020	
Testing	Faisal Malyar	10 February 2020	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

ISEDC Accreditation
12669A Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2018, ISEDC RSS-247: Issue 2 (2017-02) and ISEDC RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) for the tests detailed in section 1.3.

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	10 February 2020

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2179
Serial Number(s)	C02ZC002M8MM and C02ZC00WM8M5
Hardware Version(s)	REV 1.0
Software Version(s)	19C4
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2018 ISEDC RSS-247: Issue 2 (2017-02) ISEDC RSS-GEN: Issue 5 (04-2018) + A1 (03-2019)
Order Number Date	0540189084 25-February-2019
Date of Receipt of EUT	04-October-2019 and 14-November-2019
Start of Test	19-November-2019
Finish of Test	06-February-2020
Name of Engineer(s)	George Porter, Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud and Faisal Malyar
Related Document(s)	ANSI C63.10 (2013) KDB 662911 D01 v02r01

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C, ISEDC RSS-247 and ISEDC RSS-GEN is shown below.

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: 2.4 GHz WLAN						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013) KDB 662911 D01 v02r01
2.2	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	ANSI C63.10 (2013) KDB 662911 D01 v02r01
2.3	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	ANSI C63.10 (2013)
2.4	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.5	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.6	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)

Table 2

1.4 Product Information

1.4.1 Technical Description

The Equipment Under Test (EUT) was a laptop computer with Bluetooth, Bluetooth Low Energy and 802.11 a/b/g/n/ac capabilities in the 2.4 GHz and 5 GHz bands.

The EUT featured two IEEE 802.11 radios, one set only for 2.4 GHz operation and one set only for 5 GHz operation. Both support up to 2x2 MIMO operation (cores 0 & 1). Both radios share common antenna connections, with the core 0 output also shared with the Bluetooth radio.

1.4.2 Test Modes

The EUT's 2.4 GHz 802.11 radio supports SISO and 2x2 MIMO. It supports 802.11b, g and n at 20 MHz channel bandwidths for both SISO and MIMO.

The EUT uses different output powers per core dependent on how many cores are used. The EUT also uses different power tables for Cyclic Delay Diversity (CDD) and transmit beamforming (TxBF) modes. It uses the same conducted power across all cores in any given mode, but due to the different antenna gains the radiated powers per core differs.

After preliminary investigations were performed, the EUT was therefore tested in the following worst-case modes:

- SISO Modes (Core 0):
  - 802.11b
  - 802.11g
  - 802.11n HT20

- 2x2 MIMO Modes (Core 0+1):
  - 802.11b - CDD
  - 802.11g - CDD
  - 802.11n HT20 - CDD and TxBF

1.4.3 Test Set-up

For conducted tests the EUT antennas were disconnected and replaced with U.FL to SMA test cables to enable conducted testing on each core. The loss of these test cables were known and compensated for in any conducted measurements.

For transmit beamforming (TxBF) modes the EUT was set up communicating with a support notebook computer provided by the applicant, configured with custom commands to act as an access point. The test laptop was also set to a low output power (approximately 0 dBm) so in conjunction with the rest of the set-up configuration, would give negligible power at the measuring equipment and would not affect the test result. The support laptop's test network set the channel and bandwidth to which the EUT could connect. The EUT then set up a communications link to the support laptop, operating in normal communications mode but with beamforming modes forced on, with auto rate and TPC disabled via terminal commands so the EUT could be limited to worst-case modes. The EUT transmit duty cycle was then maximized by using iPerf bandwidth testing software to keep the transmit output buffer full and generate more traffic from the EUT to the support laptop than the link could sustain. The EUT therefore could fully operate its beamforming mode but with strictly controlled test parameters.

For all other testing the EUT was put into a continuous transmit test mode with the chipset manufacturer's test commands via a script running in the EUTs terminal application. The EUT then transmitted the required type of packeted 802.11 data frames of fixed length, containing the standard headers and with pseudo-random data content, ensuring the measured signals were representative and contained all the symbols at the highest power control level.

1.4.4 Antenna Gain Table

Core 0

Frequency (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
2400 - 2480	3.07	1.0

Table 3

Core 1

Frequency (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
2400 - 2480	2.85	1.0

Table 4

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test programme.

The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Model: A2179, Serial Number: C02ZC00WM8M5			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2179, Serial Number: C02ZC002M8MM			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 5

1.7 Test Location

TÜV SÜD conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz WLAN		
Maximum Conducted Output Power	George Porter	UKAS
Power Spectral Density	George Porter	UKAS
Emission Bandwidth	George Porter	UKAS
Authorised Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud and Faisal Malyar	UKAS
Restricted Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud and Faisal Malyar	UKAS
Spurious Radiated Emissions	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud and Faisal Malyar	UKAS

Table 6

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Maximum Conducted Output Power

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)
ISEDC RSS-247, Clause 5.4
ISEDC RSS-GEN, Clause 6.12

2.1.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC002M8MM - Modification State 0

2.1.3 Date of Test

20-November-2019 to 12-December-2019

2.1.4 Test Method

The test was performed in accordance with ANSI C63.10 clause 11.9.2.3.2 Method AVGPM-G

The output power was verified as being the same from each transmit core, but the antenna gains were not identical, therefore the modes reported for SISO or 2x2 MIMO operation are those giving the highest EIRP and/or lowest conducted limit based on the combination of antennas giving highest total directional gain.

MIMO output port summing was performed in accordance with KDB 662911 D01:

- For the CDD results the Directional Gain was calculated in accordance with clause F)2)f)(ii) using the calculations from F)2)f)(i) with worst-case individual gain and an array gain of zero.
- For transmit beamforming (TxBF) mode it was calculated in accordance with clause F)2)d)(i).

2.1.5 Environmental Conditions

Ambient Temperature	22.7 - 25.6 °C
Relative Humidity	26.8 - 42.1 %

2.1.6 Test Results

2.4 GHz WLAN

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Conducted Power (dBm)	19.91	19.75	12.82
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	22.98	22.82	15.89

Table 7 - 802.11b / 1 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	18.69	19.68	12.47
Conducted Power Core 1 (dBm)	18.98	19.92	12.16
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Total Conducted Power (dBm)	21.85	22.81	15.32
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	24.92	25.88	18.39

Table 8 - 802.11b / 1 Mbps / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Conducted Power (dBm)	14.76	19.92	-1.53
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	17.83	22.99	1.54

Table 9 - 802.11g / 6 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	13.78	19.56	2.35
Conducted Power Core 1 (dBm)	13.80	19.62	-2.92
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Total Conducted Power (dBm)	16.80	22.60	3.48
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	19.87	25.67	6.55

Table 10 - 802.11g / 6 Mbps / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Conducted Power (dBm)	14.81	19.92	2.91
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	17.88	22.99	5.98

Table 11 - 802.11n / HT20 MCS0 / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	13.84	19.58	-1.16
Conducted Power Core 1 (dBm)	13.82	19.62	-2.40
Antenna Directional Gain (dBi)	3.07	3.07	3.07
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Total Conducted Power (dBm)	16.84	22.61	1.28
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	19.91	25.68	4.35

Table 12 - 802.11n / HT20 MCS0 / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	11.92	17.68	-2.56
Conducted Power Core 1 (dBm)	11.70	17.48	-2.54
Antenna Directional Gain (dBi)	5.97	5.97	5.97
15.247 Conducted Power Limit (dBm)	30.00	30.00	30.00
RSS-247 Conducted Power Limit (dBm)	30.00	30.00	30.00
Total Conducted Power (dBm)	14.82	20.59	0.46
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	20.79	26.56	6.43

Table 13 - 802.11n / HT20 MCS0 / MIMO TxBF / Cores 0+1

FCC 47 CFR Part 15, Limit Clause 15.247 (b)(3)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt.

ISEDC RSS-247, Limit Clause 5.4 (b)

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e) of the specification.

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Attenuator (10 dB)	Weinschel	47-10-34	481	-	O/P Mon
Attenuator (20 dB, 2 W)	Pasternack	PE7004-20	489	-	O/P Mon
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	16-Apr-2020
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
2 metre N-Type Cable	Florida Labs	NMS-235SP-78.8-NMS	4622	12	12-Jul-2020
PXA Signal Analyser	Keysight Technologies	N9030A	4653	12	06-Feb-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
Network Analyser	Keysight Technologies	E5063A	5018	12	20-May-2020
Cable (18 GHz)	Rosenberger	LU7-036-2000	5035	-	O/P Mon
Cable (18 GHz)	Rosenberger	LU7-071-1000	5098	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5108	12	06-Oct-2020
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	21-May-2020
AC Programmable Power Supply	iTech	IT7324	5227	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5235	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon

Table 14

O/P Mon – Output Monitored using calibrated equipment

2.2 Power Spectral Density

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (e)
ISEDC RSS-247, Clause 5.2
ISEDC RSS-GEN, Clause 6.12

2.2.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC002M8MM - Modification State 0

2.2.3 Date of Test

20-November-2019 to 12-December-2019

2.2.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.10.3 (AVGPSD-1), 11.10.5 (AVGPSD-2) or 11.10.7 (AVGPSD-3).

Where the EUT duty cycle was < 98 % and repeatable within 2%, the spectrum analyser was set to trace (power) averaging and a duty cycle correction was added as calculated in the result tables below (Method AVGPSD-2). Where the duty cycle was = 98 % the spectrum analyser was set to trace (power) averaging and no duty cycle correction made (Method AVGPSD-1). In all other cases the spectrum analyser trace was set to max hold (Method AVGPSD-3).

The output power was verified as being the same from each transmit core (within negligible tolerances), but the antenna gains were not identical. Therefore, the modes reported here for SISO or 2x2 MIMO operation are those giving the highest EIRP and/or lowest conducted limit based on the combination of antennas giving highest total directional gain.

2.2.5 Environmental Conditions

Ambient Temperature	22.7 - 25.6 °C
Relative Humidity	26.8 - 42.1 %

2.2.6 Test Results

2.4 GHz WLAN

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Raw Conducted PSD (dBm/30kHz)	-0.79	-1.19	-8.87
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-0.79	-1.19	-8.87

Table 15 - 802.11b / 1 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted PSD Core 0 (dBm/30kHz)	-2.01	-0.90	-9.32
Conducted PSD Core 1 (dBm/30kHz)	-1.79	-0.66	-9.70
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	1.11	2.24	-6.50

Table 16 - 802.11b / 1 Mbps / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Raw Conducted PSD (dBm/30kHz)	-9.83	-3.40	-24.88
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-9.83	-3.40	-24.88

Table 17 - 802.11g / 6 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted PSD Core 0 (dBm/30kHz)	-10.84	-3.58	-20.97
Conducted PSD Core 1 (dBm/30kHz)	-10.87	-3.77	-26.33
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-7.84	-0.66	-19.86

Table 18 - 802.11g / 6 Mbps / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Raw Conducted PSD (dBm/30kHz)	-9.68	-3.26	-20.21
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-9.68	-3.26	-20.21

Table 19 - 802.11n / HT20 MCS0 / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted PSD Core 0 (dBm/30kHz)	-10.58	-3.56	-17.72
Conducted PSD Core 1 (dBm/30kHz)	-10.06	-3.47	-25.60
Duty Cycle Correction (dB)	N/A SA-1	N/A SA-1	N/A SA-1
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-7.30	-0.50	-17.07

Table 20 - 802.11n / HT20 MCS0 / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted PSD Core 0 (dBm/30kHz)	-13.70	-7.71	-28.48
Conducted PSD Core 1 (dBm/30kHz)	-13.51	-7.50	-28.60
Duty Cycle Correction (dB)	0.29	0.40	0.34
15.247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
RSS-247 Conducted PSD Limit (dBm/3kHz)	8.00	8.00	8.00
Conducted PSD Result (dBm/30kHz)	-10.30	-4.19	-25.19

Table 21 - 802.11n / HT20 MCS0 / MIMO TxBF / Cores 0+1

FCC 47 CFR Part 15, Limit Clause 15.247 (e)

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.

ISEDC RSS-247, Limit Clause 5.2(b)

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Attenuator (10 dB)	Weinschel	47-10-34	481	-	O/P Mon
Attenuator (20 dB, 2 W)	Pasternack	PE7004-20	489	-	O/P Mon
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	16-Apr-2020
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
2 metre N-Type Cable	Florida Labs	NMS-235SP-78.8-NMS	4622	12	12-Jul-2020
PXA Signal Analyser	Keysight Technologies	N9030A	4653	12	06-Feb-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
Network Analyser	Keysight Technologies	E5063A	5018	12	20-May-2020
Cable (18 GHz)	Rosenberger	LU7-036-2000	5035	-	O/P Mon
Cable (18 GHz)	Rosenberger	LU7-071-1000	5098	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5108	12	06-Oct-2020
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	21-May-2020
AC Programmable Power Supply	iTech	IT7324	5227	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5235	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon

Table 22

O/P Mon – Output Monitored using calibrated equipment

2.3 Emission Bandwidth

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(2)
ISEDC RSS-247, Clause 5.2
ISEDC RSS-GEN, Clause 6.7

2.3.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC002M8MM - Modification State 0

2.3.3 Date of Test

20-November-2019 to 12-December-2019

2.3.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.2

For modes of operation using multiple cores, measurements were made on each core but only the worst case results are reported. Worst case was considered as the narrowest results for 6 dB bandwidth and the widest result for 26 dB bandwidth and 99% occupied bandwidth.

2.3.5 Environmental Conditions

Ambient Temperature	22.7 - 25.6 °C
Relative Humidity	26.8 - 42.1 %

2.3.6 Test Results

2.4 GHz WLAN

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	8.160	8.700	7.680
99% Bandwidth (MHz)	13.073	13.067	13.132

Table 23 - 802.11b / 1 Mbps / SISO / Core 0

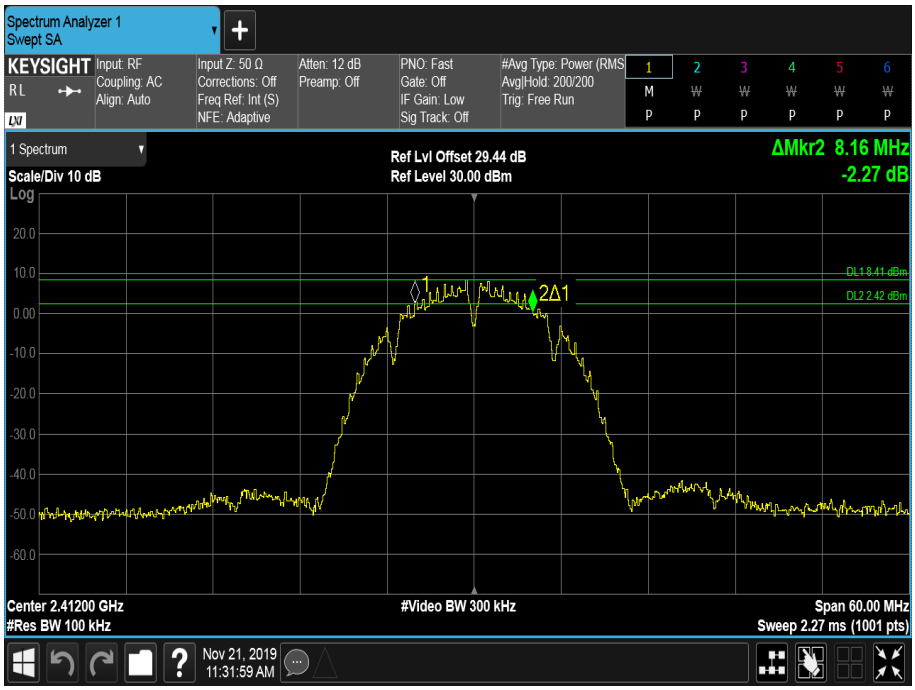

Figure 1 - 2412 MHz - 6 dB DTS Bandwidth

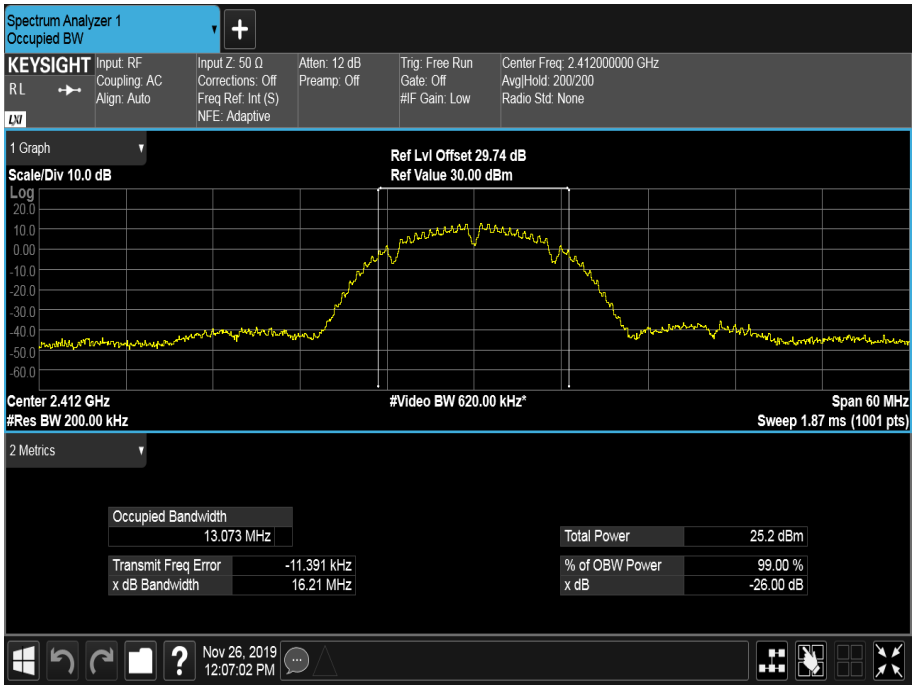

Figure 2 - 2412 MHz - 99% Occupied Bandwidth

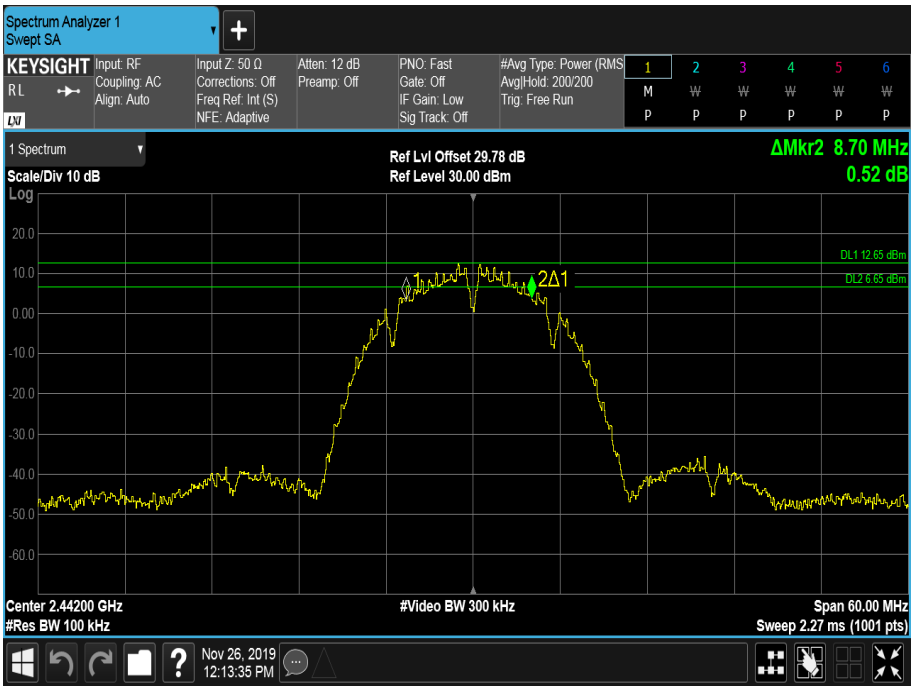

Figure 3 - 2442 MHz - 6 dB DTS Bandwidth

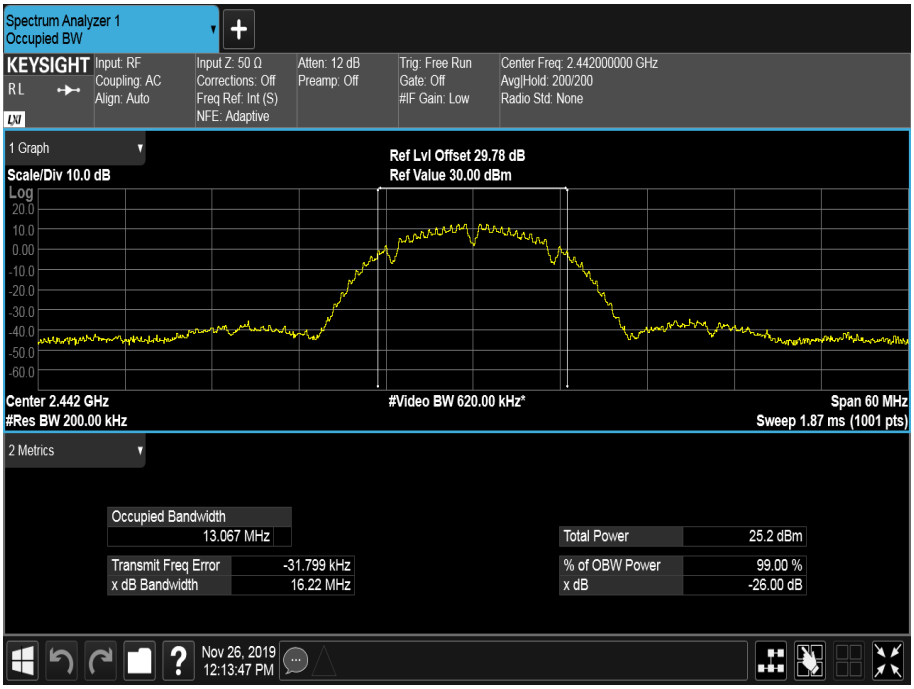

Figure 4 - 2442 MHz - 99% Occupied Bandwidth

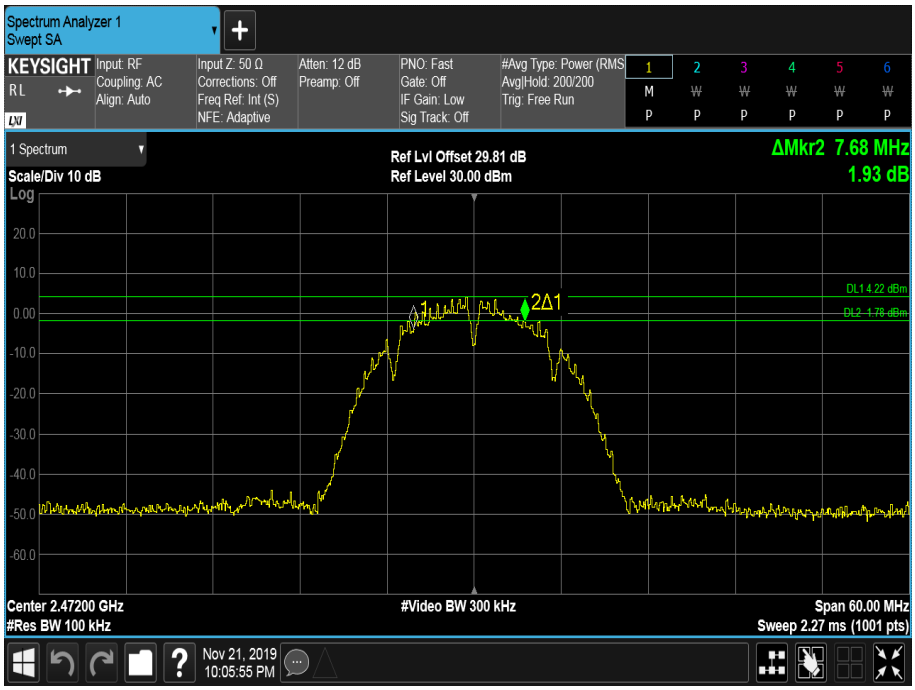

Figure 5 - 2472 MHz - 6 dB DTS Bandwidth

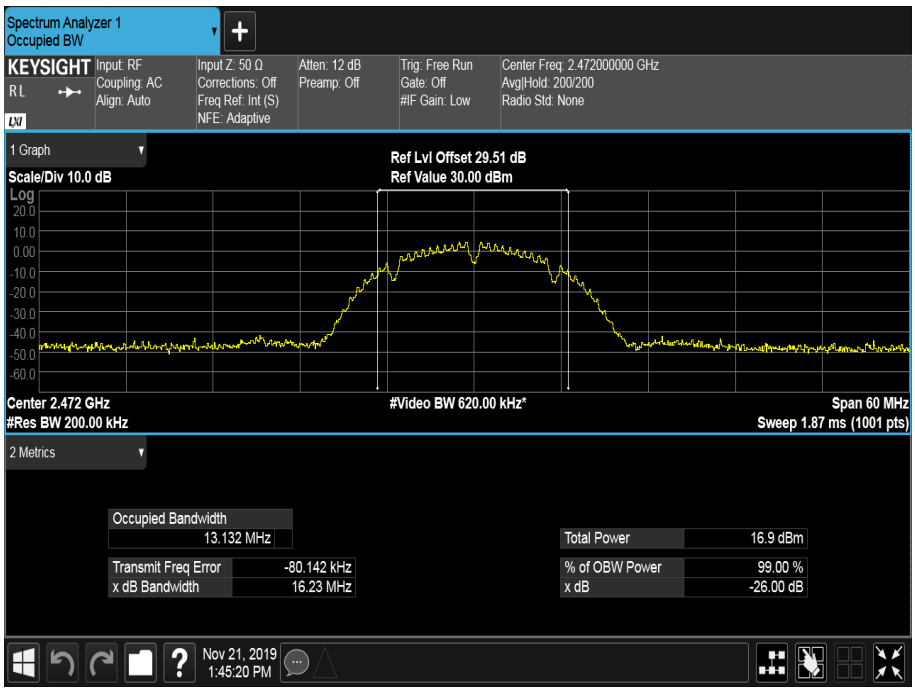

Figure 6 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	8.160	8.160	8.100
99% Bandwidth (MHz)	13.081	13.075	13.167

Table 24 - 802.11b / 1 Mbps / MIMO CDD / Cores 0+1

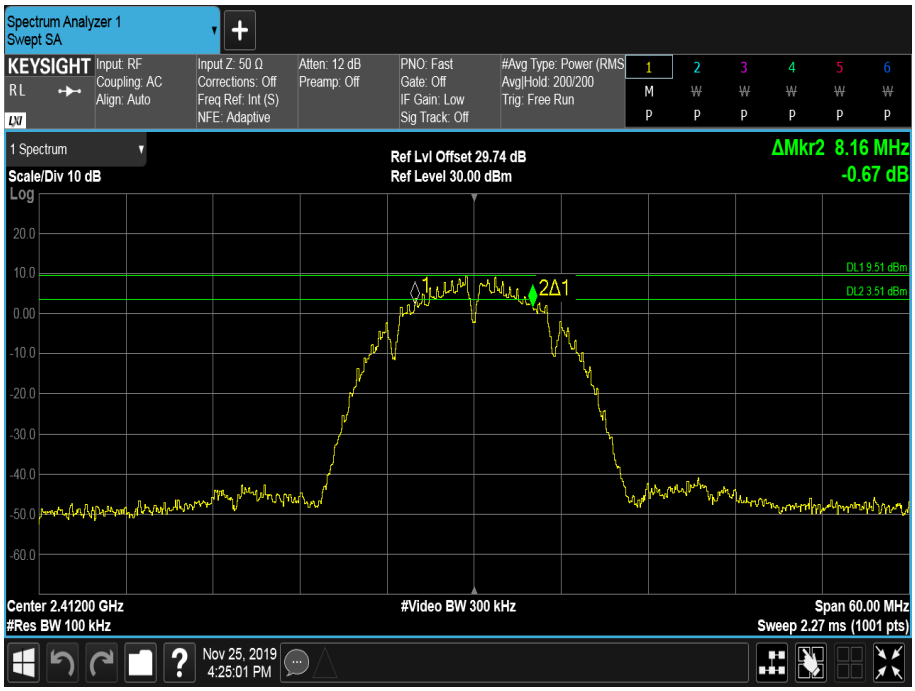

Figure 7 - 2412 MHz - 6 dB DTS Bandwidth

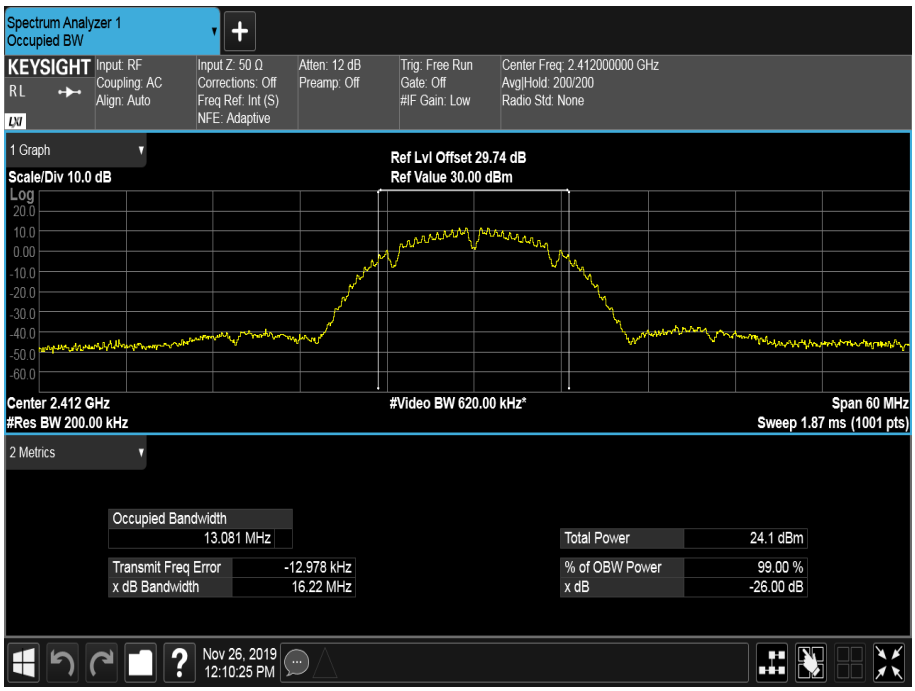

Figure 8 - 2412 MHz - 99% Occupied Bandwidth

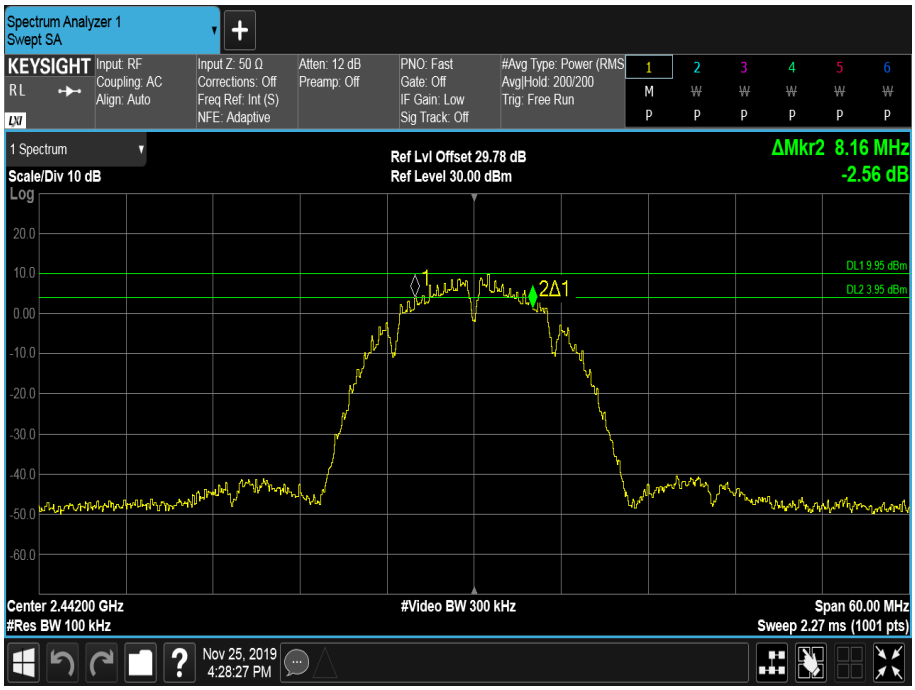

Figure 9 - 2442 MHz - 6 dB DTS Bandwidth

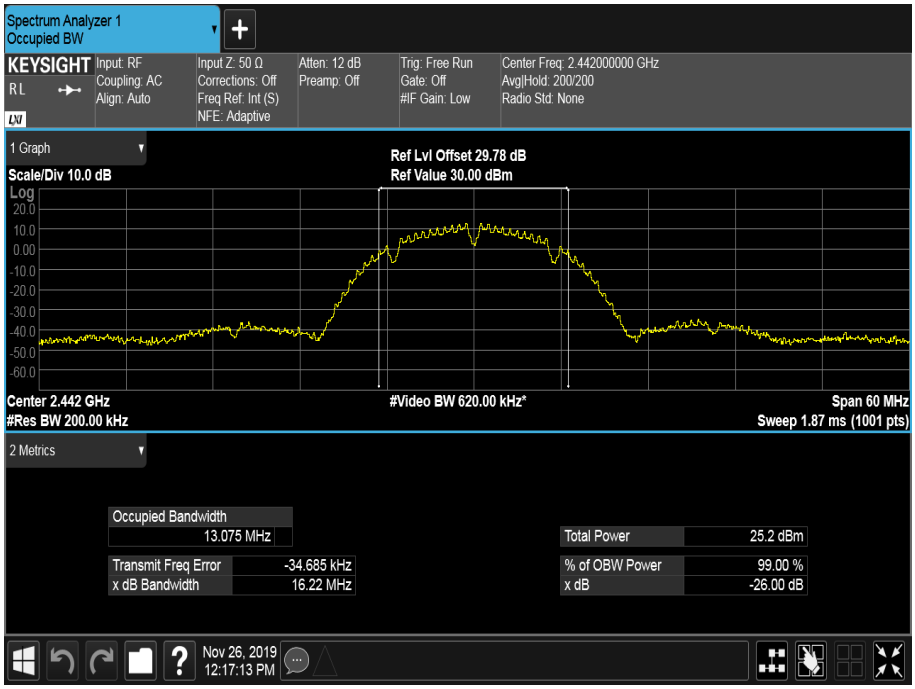

Figure 10 - 2442 MHz - 99% Occupied Bandwidth

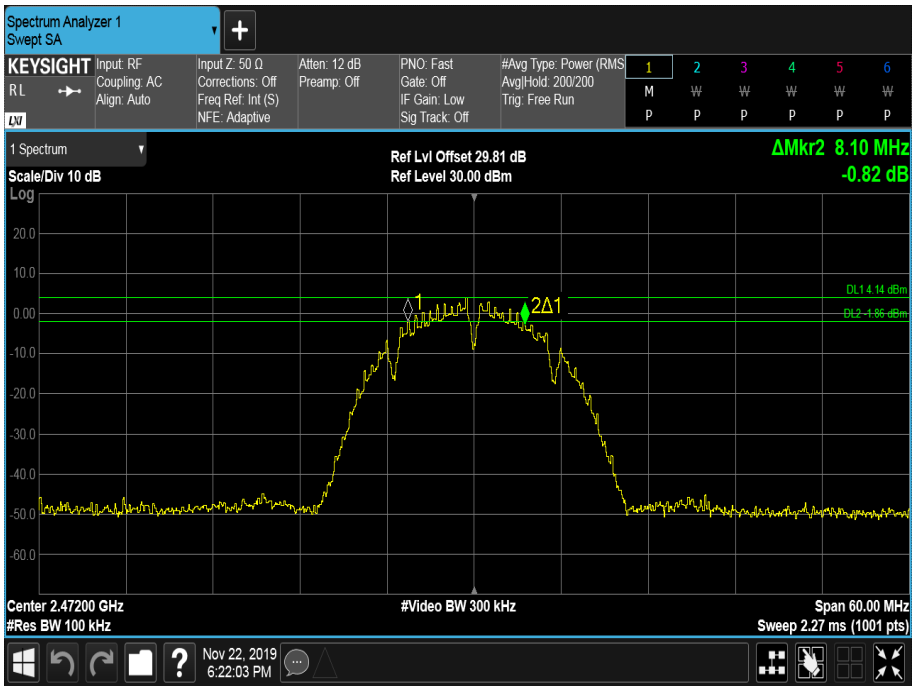

Figure 11 - 2472 MHz - 6 dB DTS Bandwidth

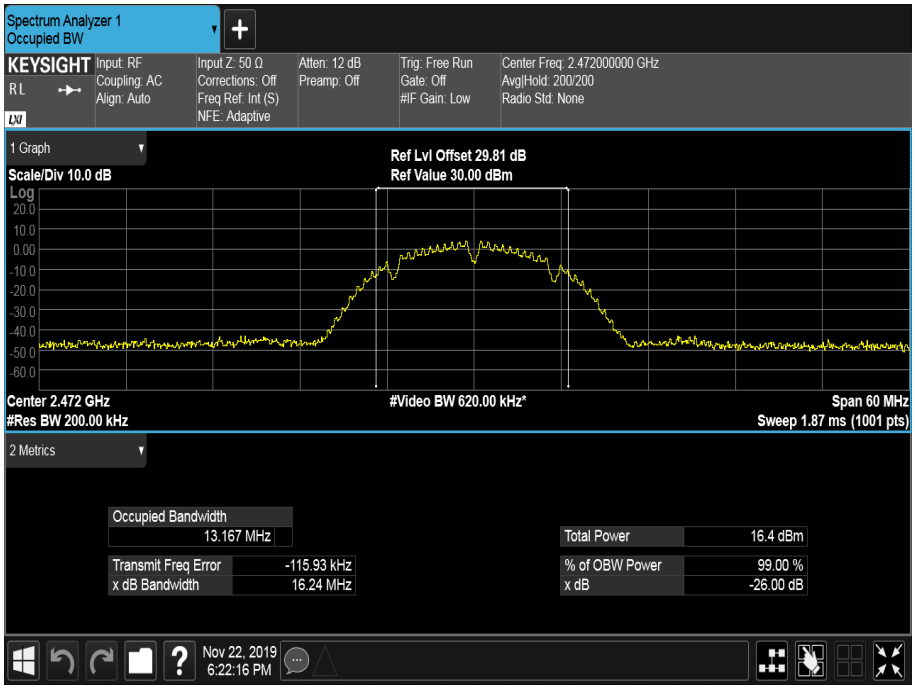

Figure 12 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	16.440	16.440	16.500
99% Bandwidth (MHz)	16.633	16.627	16.622

Table 25 - 802.11g / 6 Mbps / SISO / Core 0

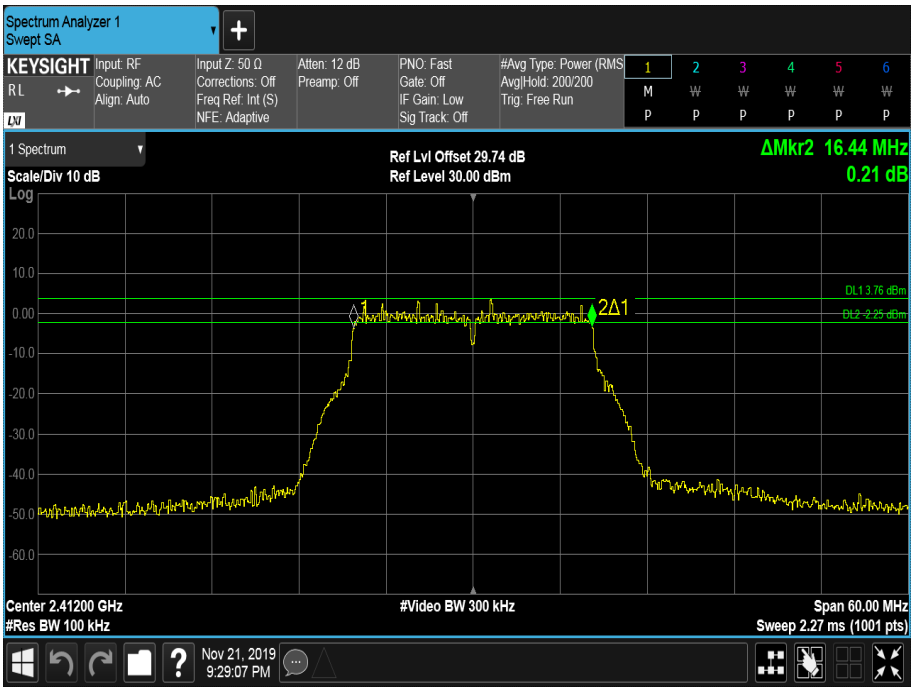

Figure 13 - 2412 MHz - 6 dB DTS Bandwidth

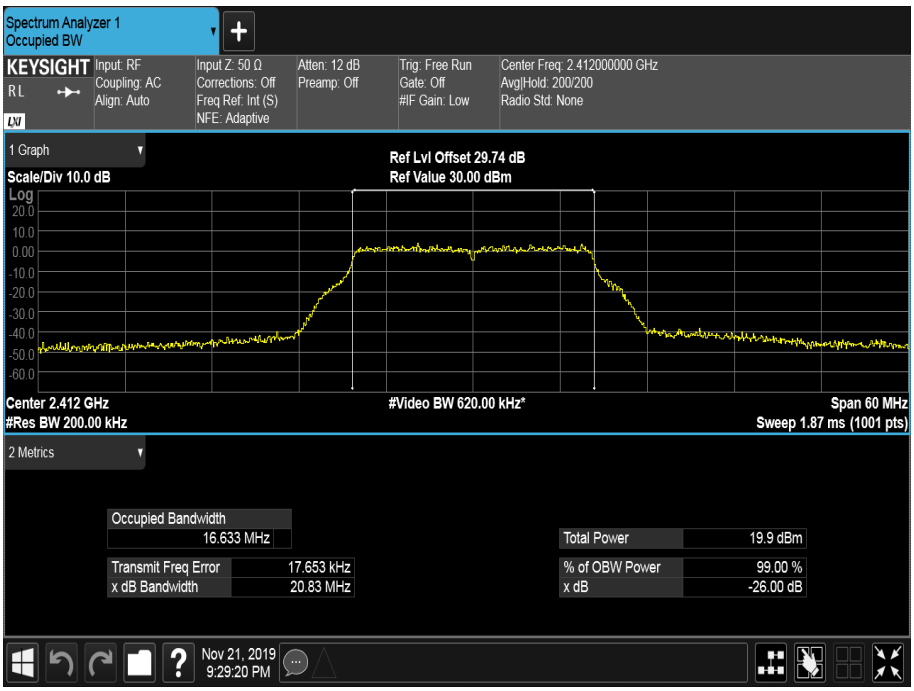

Figure 14 - 2412 MHz - 99% Occupied Bandwidth

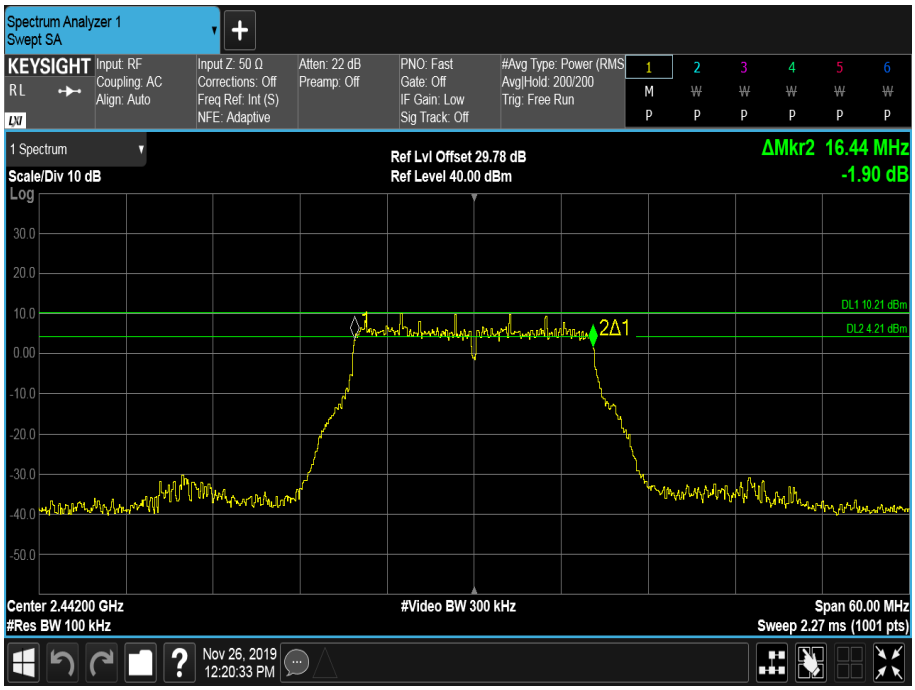

Figure 15 - 2442 MHz - 6 dB DTS Bandwidth

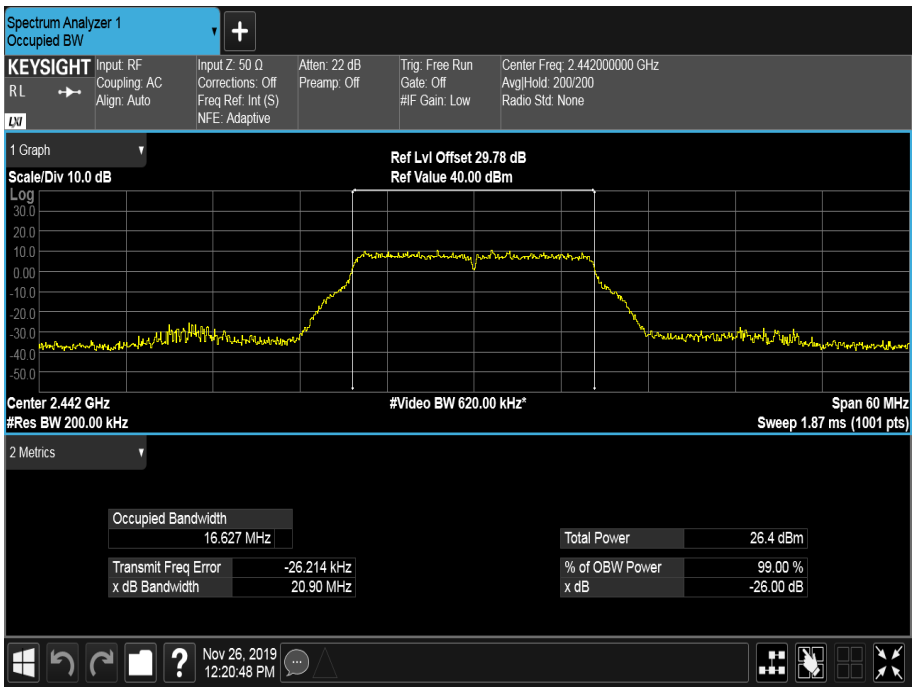

Figure 16 - 2442 MHz - 99% Occupied Bandwidth

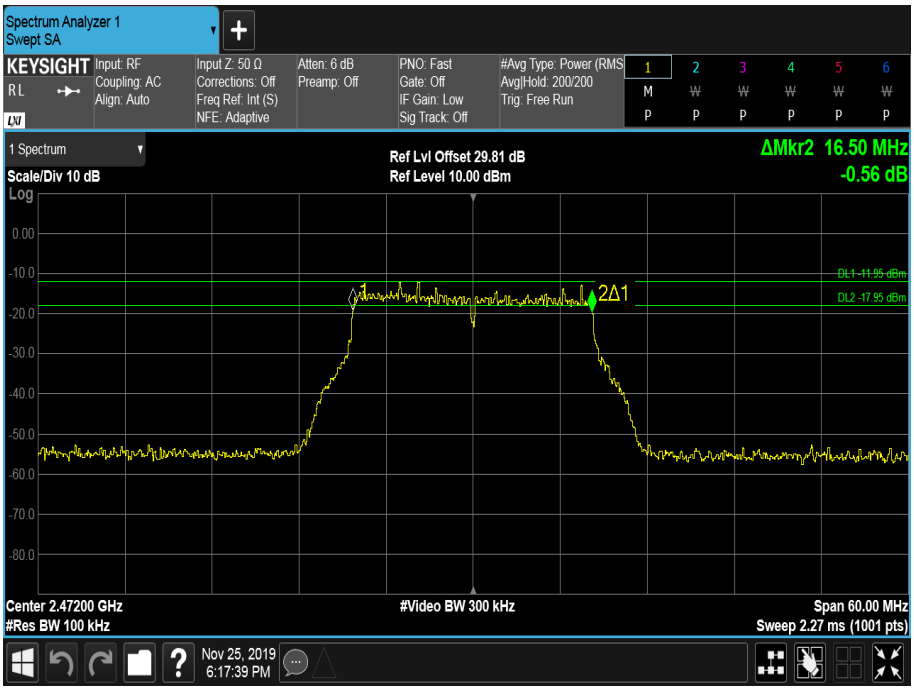

Figure 17 - 2472 MHz - 6 dB DTS Bandwidth

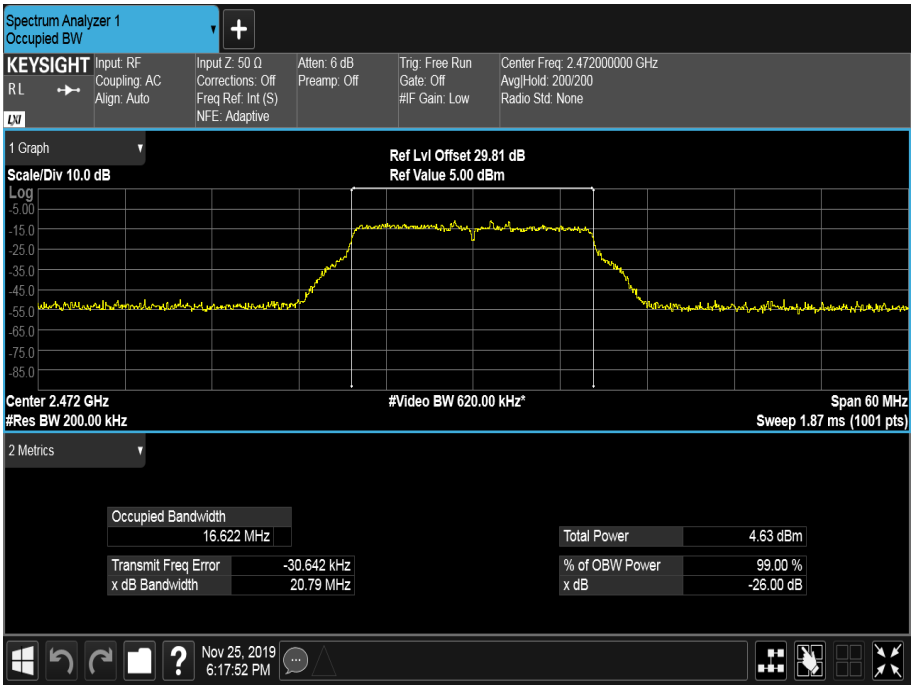

Figure 18 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	16.440	16.440	16.500
99% Bandwidth (MHz)	16.637	16.609	16.622

Table 26 - 802.11g / 6 Mbps / MIMO CDD / Cores 0+1

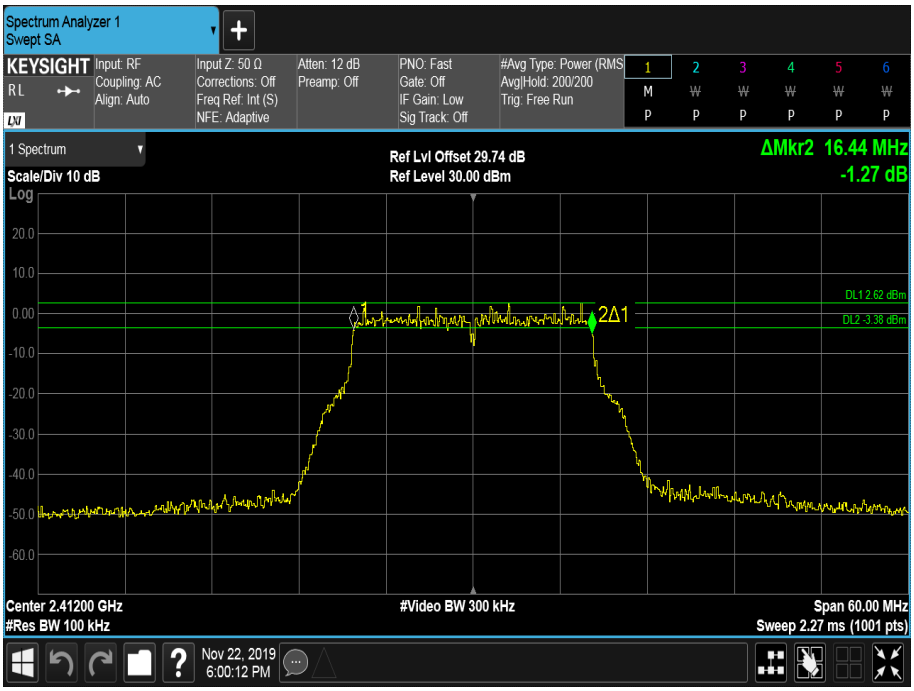

Figure 19 - 2412 MHz - 6 dB DTS Bandwidth

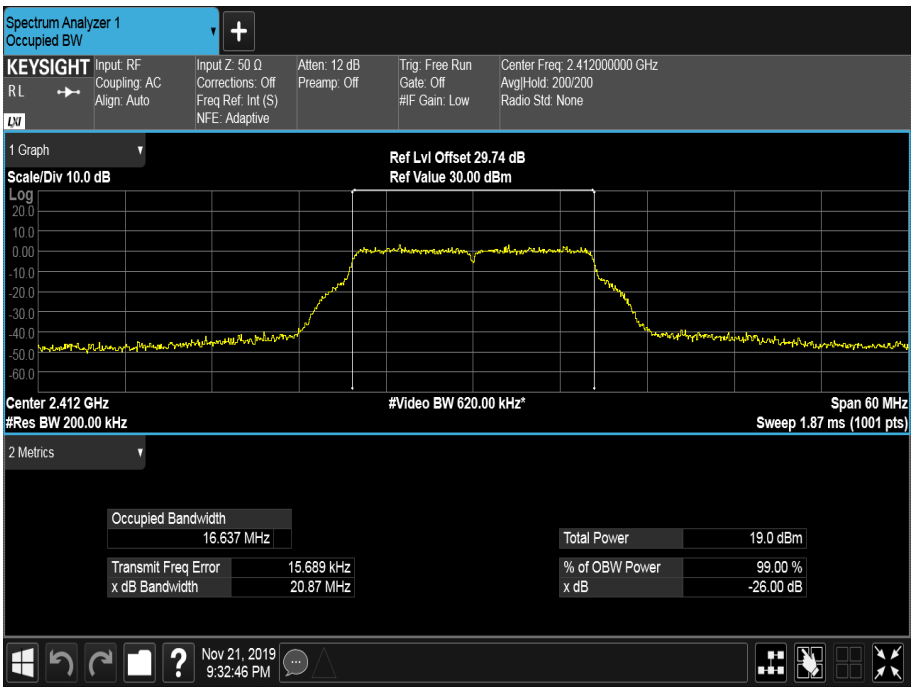

Figure 20 - 2412 MHz - 99% Occupied Bandwidth

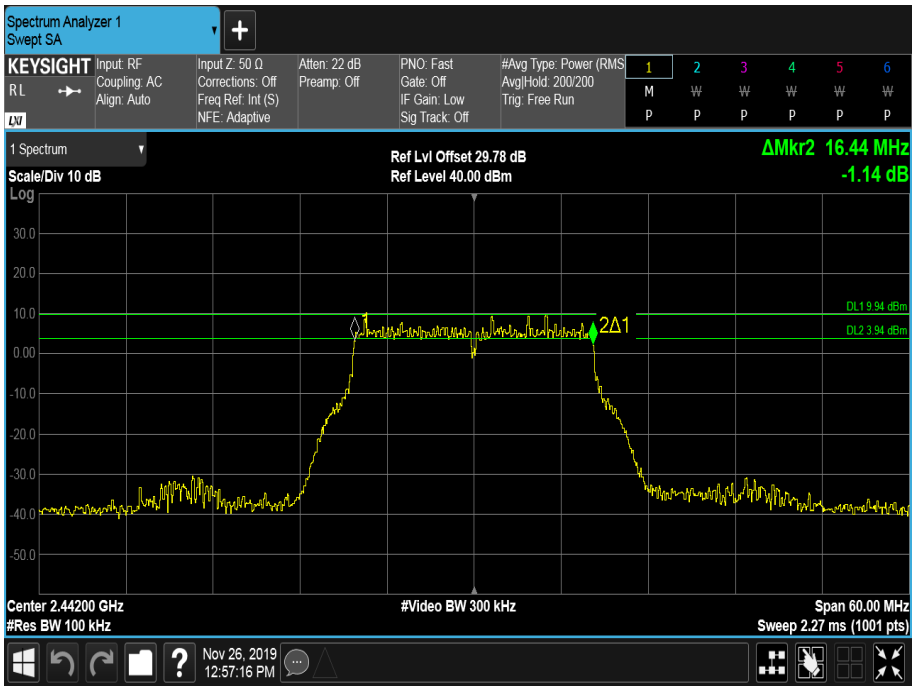

Figure 21 - 2442 MHz - 6 dB DTS Bandwidth

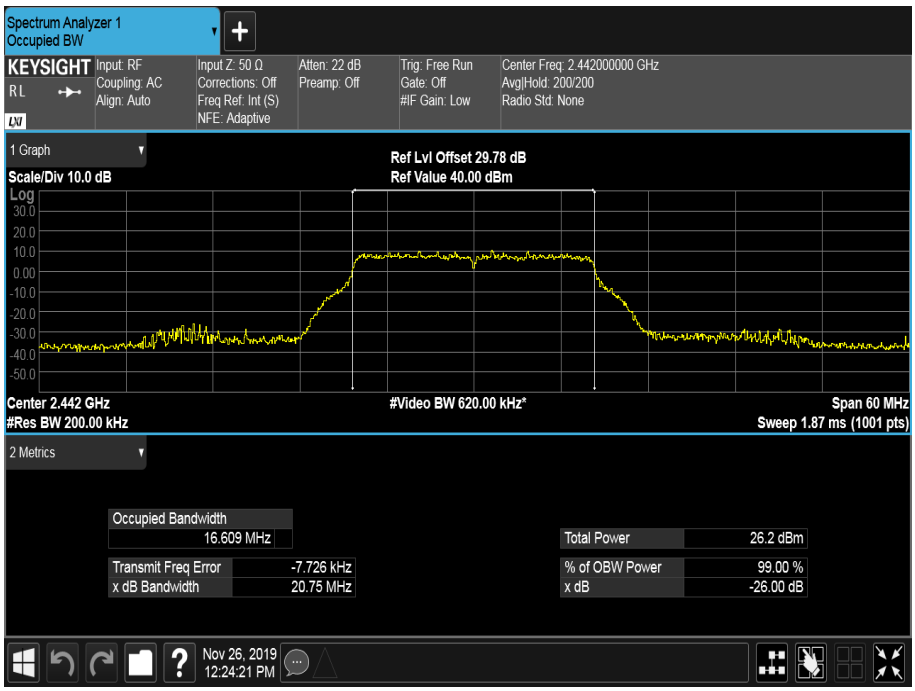

Figure 22 - 2442 MHz - 99% Occupied Bandwidth

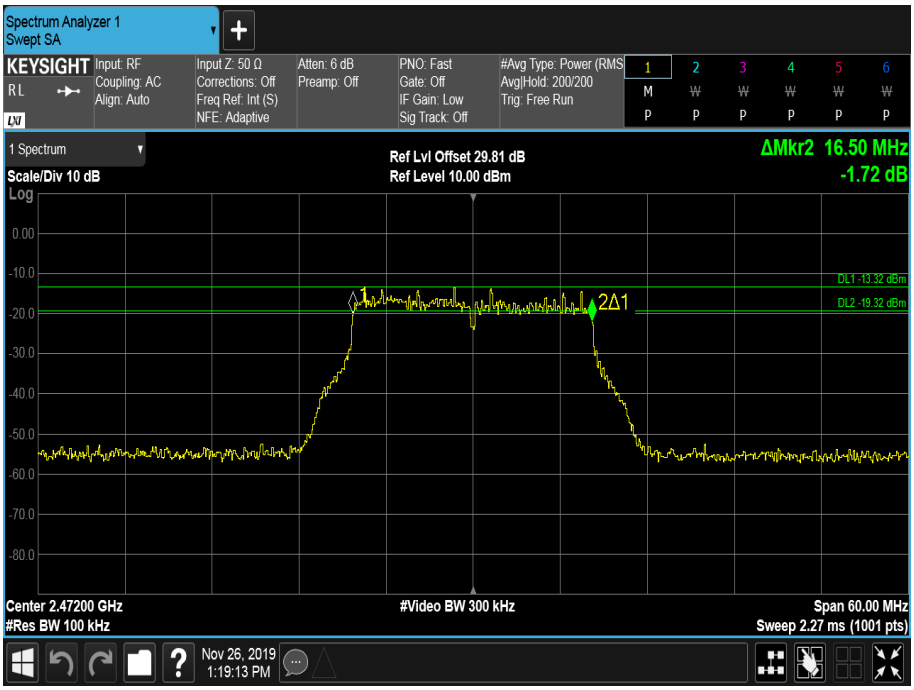

Figure 23 - 2472 MHz - 6 dB DTS Bandwidth

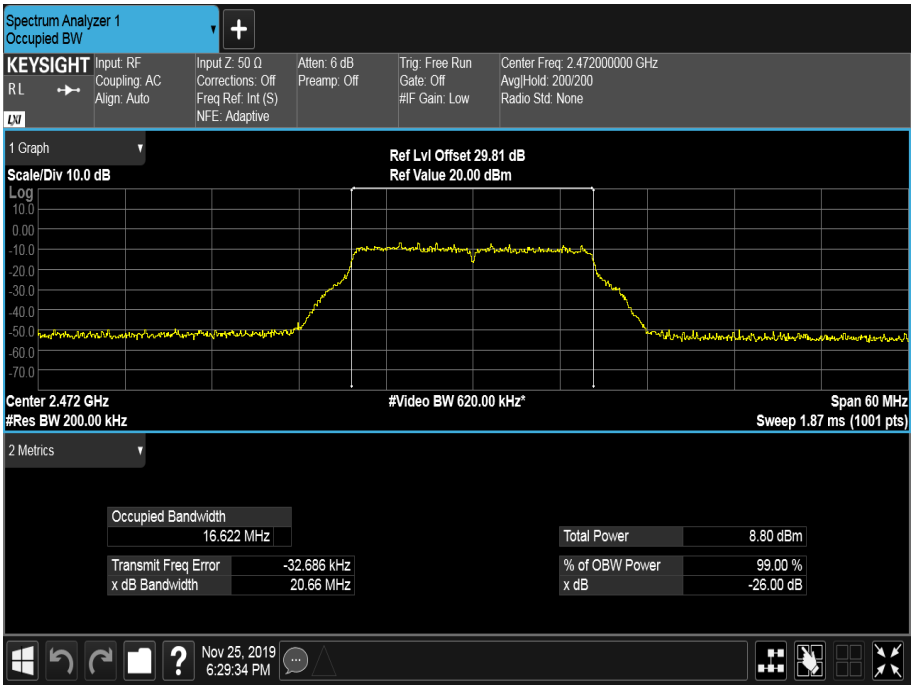

Figure 24 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	17.700	17.700	17.700
99% Bandwidth (MHz)	17.870	17.848	17.823

Table 27 - 802.11n / HT20 MCS0 / SISO / Core 0

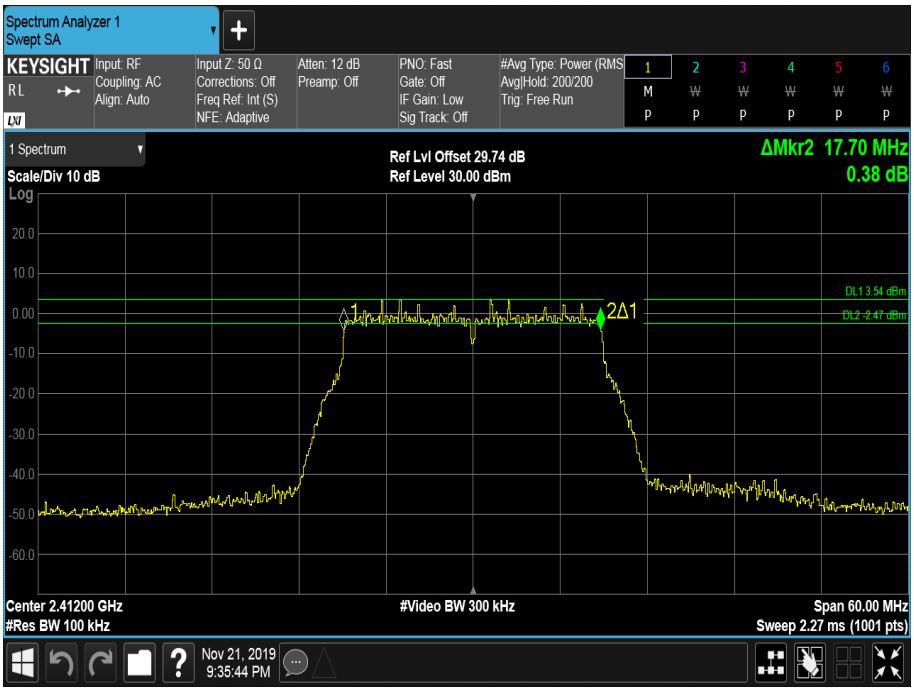

Figure 25 - 2412 MHz - 6 dB DTS Bandwidth

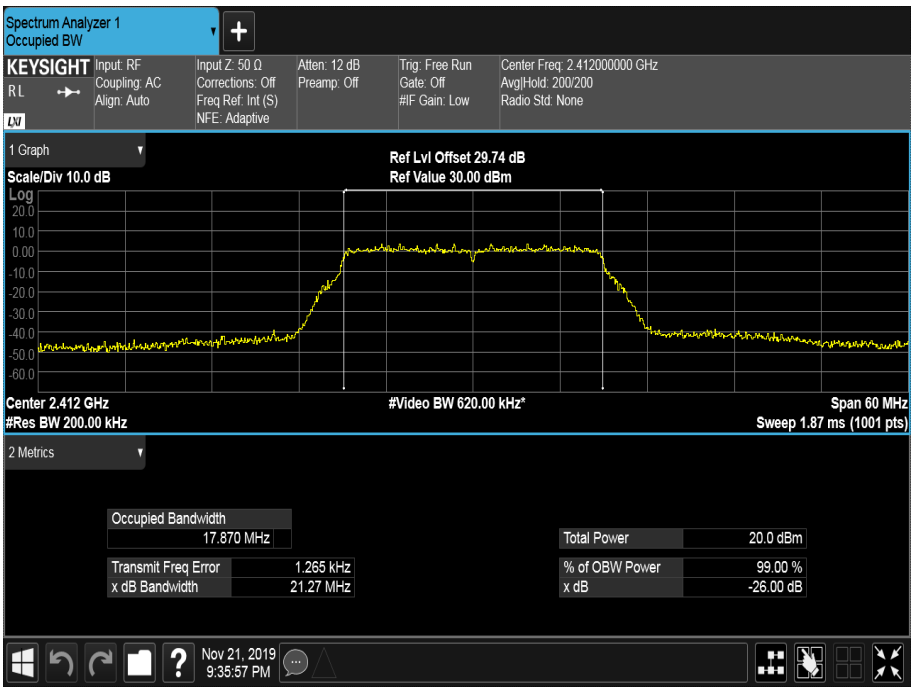

Figure 26 - 2412 MHz - 99% Occupied Bandwidth

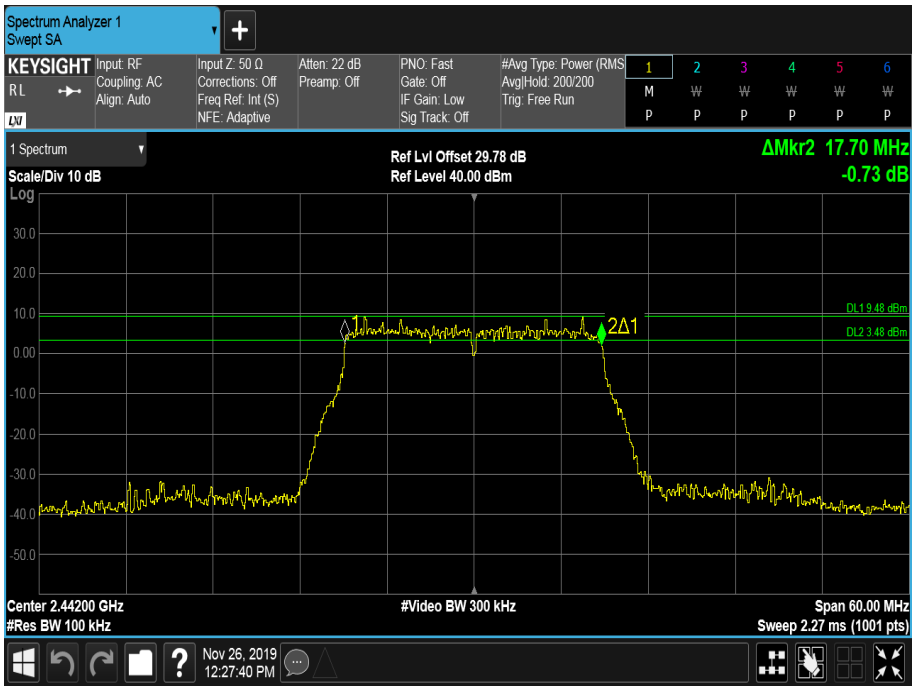

Figure 27 - 2442 MHz - 6 dB DTS Bandwidth

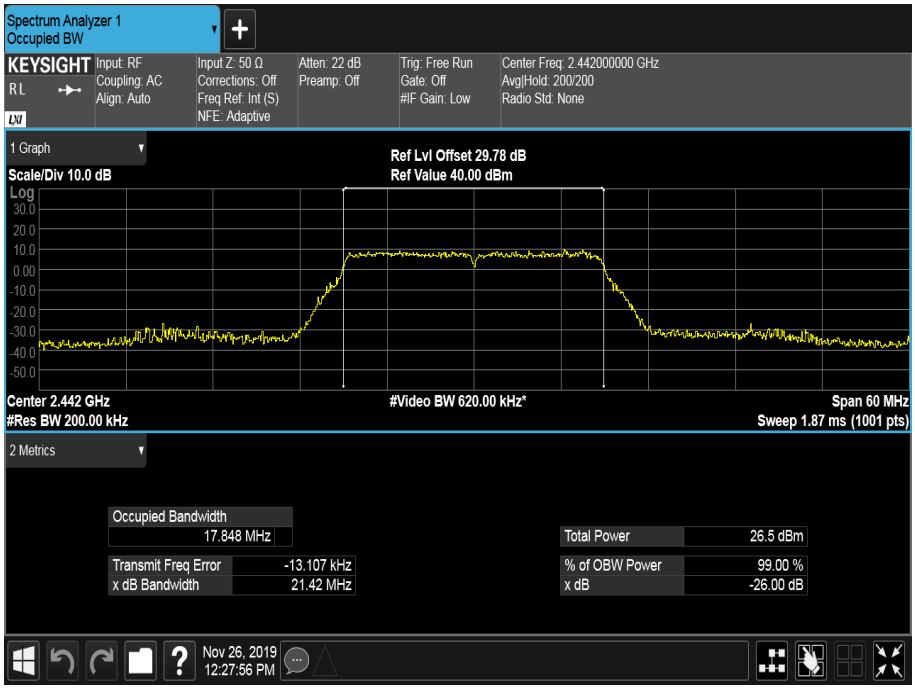

Figure 28 - 2442 MHz - 99% Occupied Bandwidth

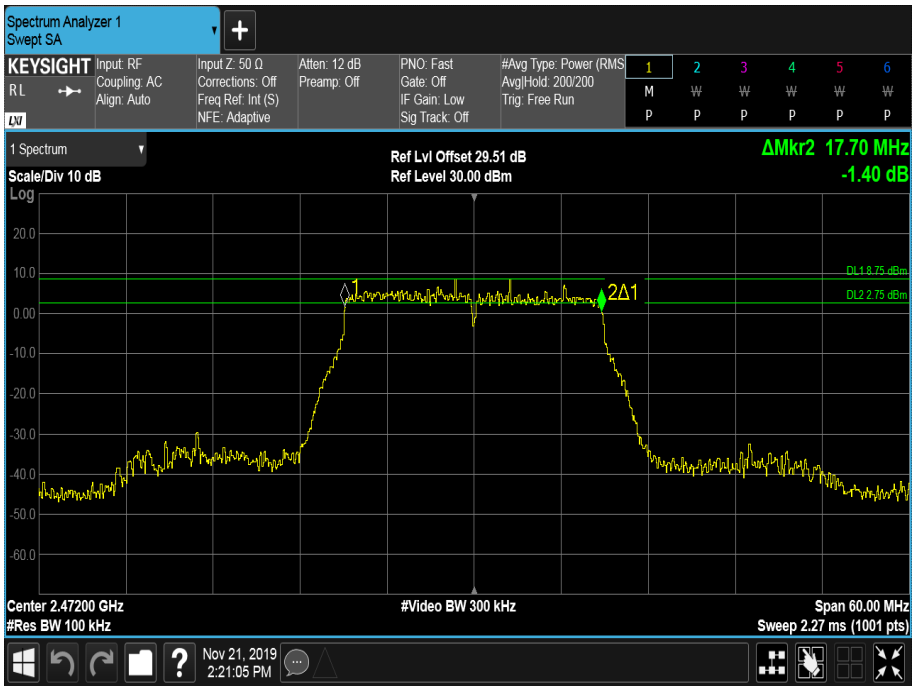

Figure 29 - 2472 MHz - 6 dB DTS Bandwidth

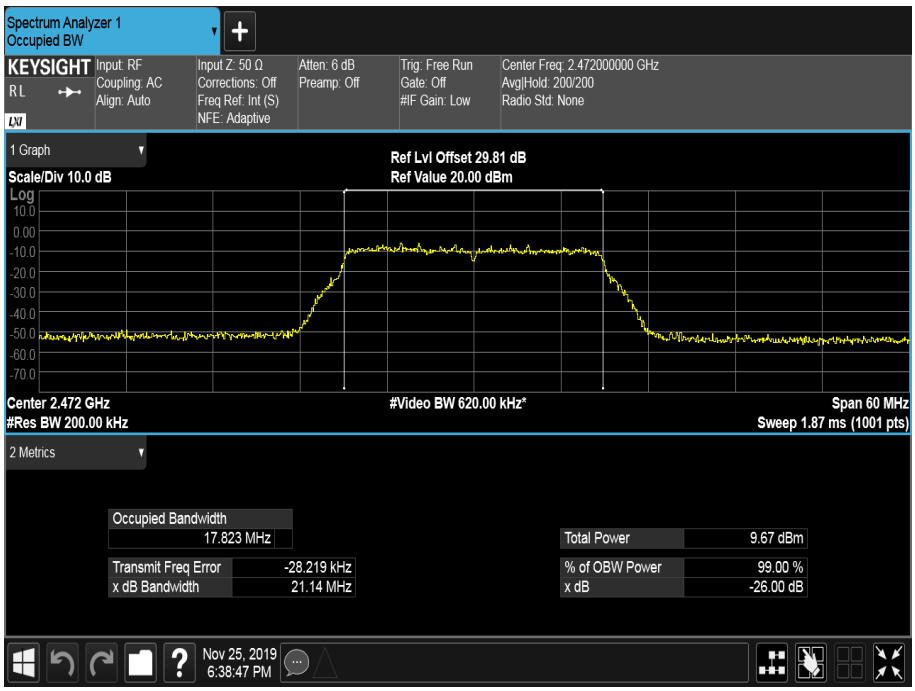

Figure 30 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	17.640	17.700	17.700
99% Bandwidth (MHz)	17.826	17.840	17.837

Table 28 - 802.11n / HT20 MCS0 / MIMO CDD / Cores 0+1

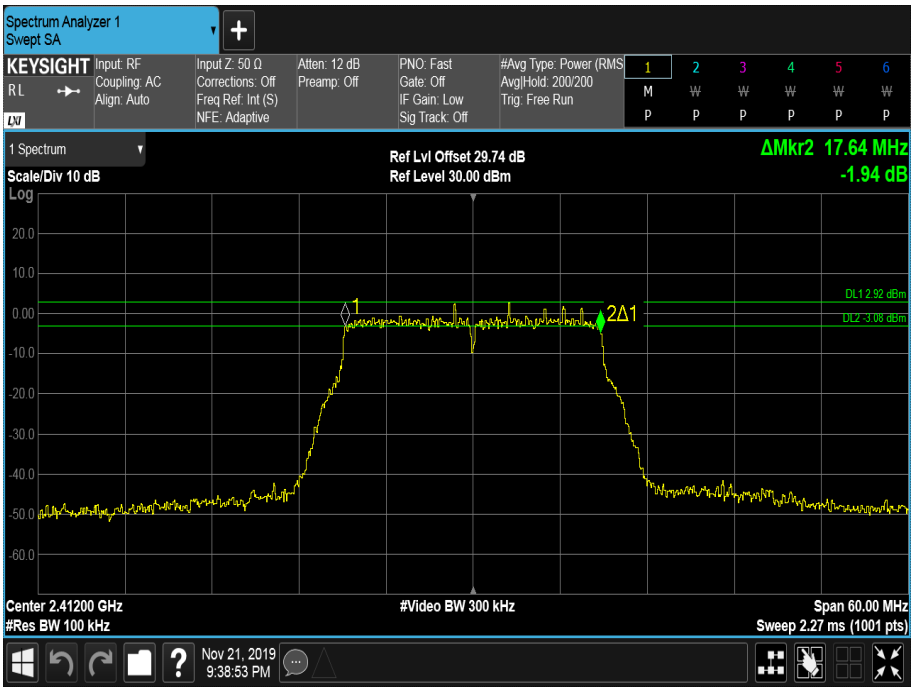

Figure 31 - 2412 MHz - 6 dB DTS Bandwidth

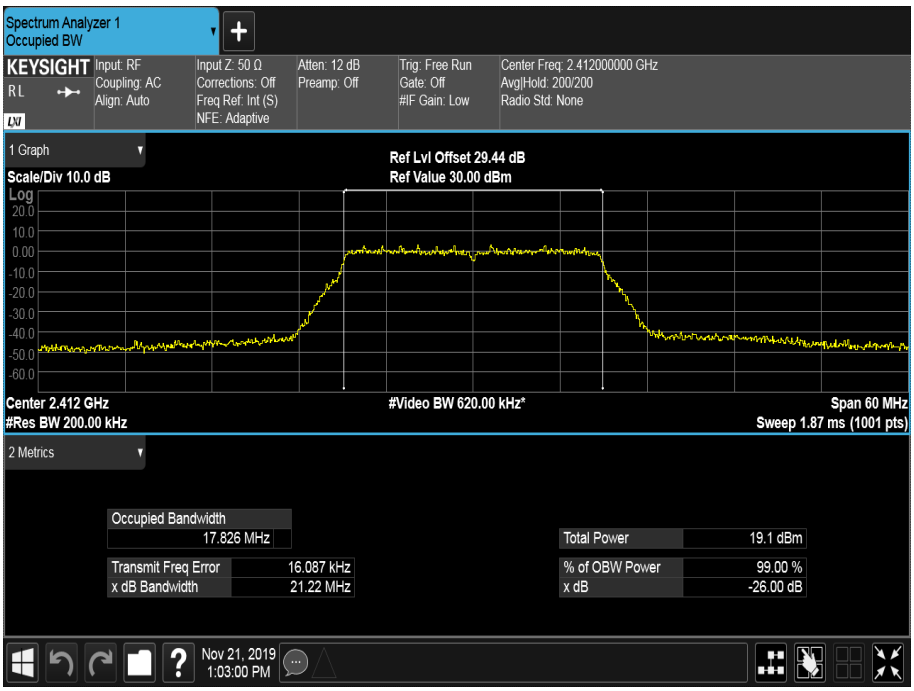

Figure 32 - 2412 MHz - 99% Occupied Bandwidth

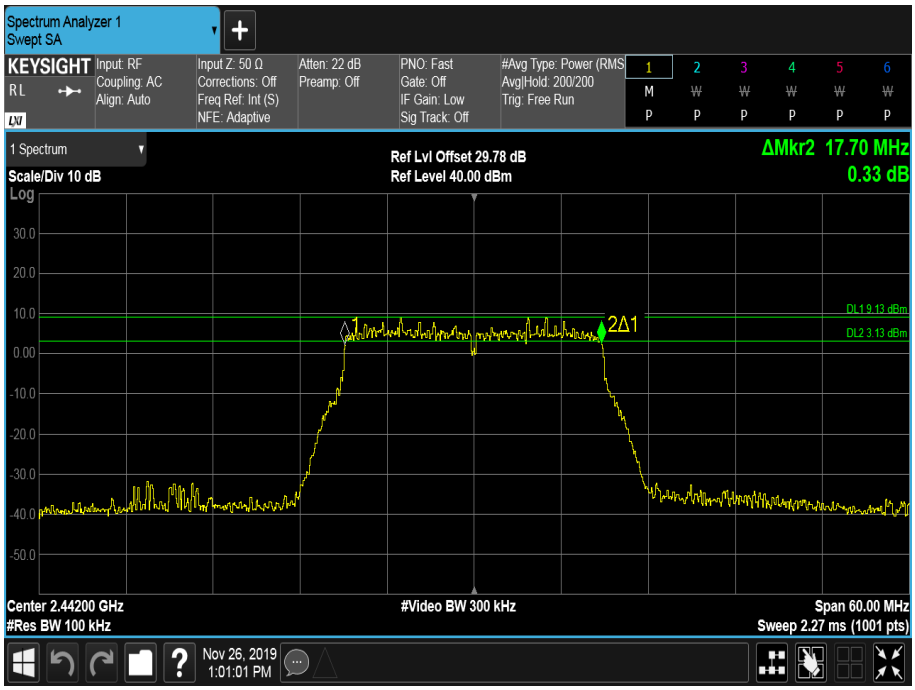

Figure 33 - 2442 MHz - 6 dB DTS Bandwidth

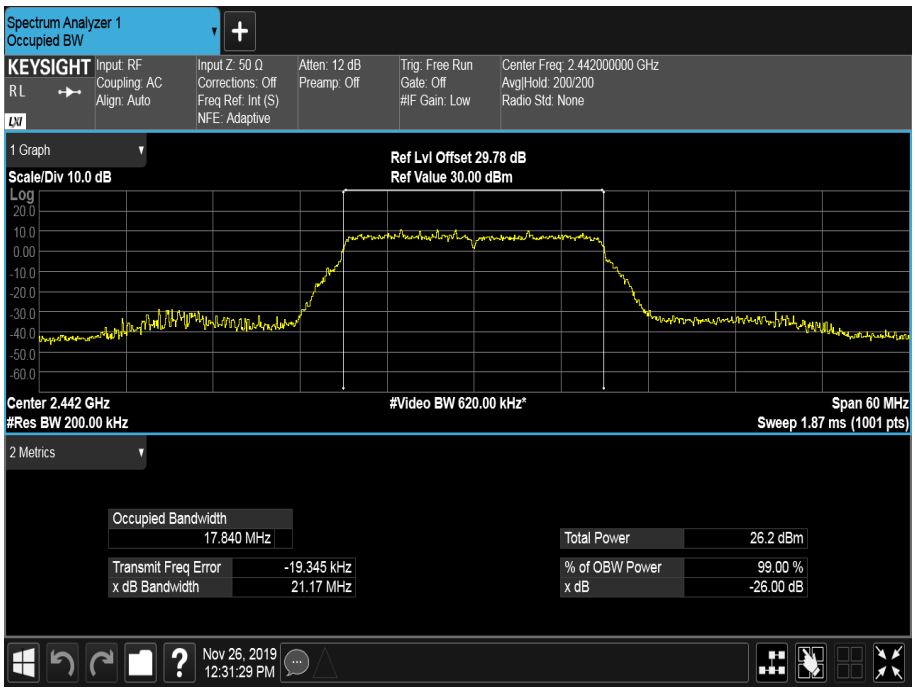

Figure 34 - 2442 MHz - 99% Occupied Bandwidth

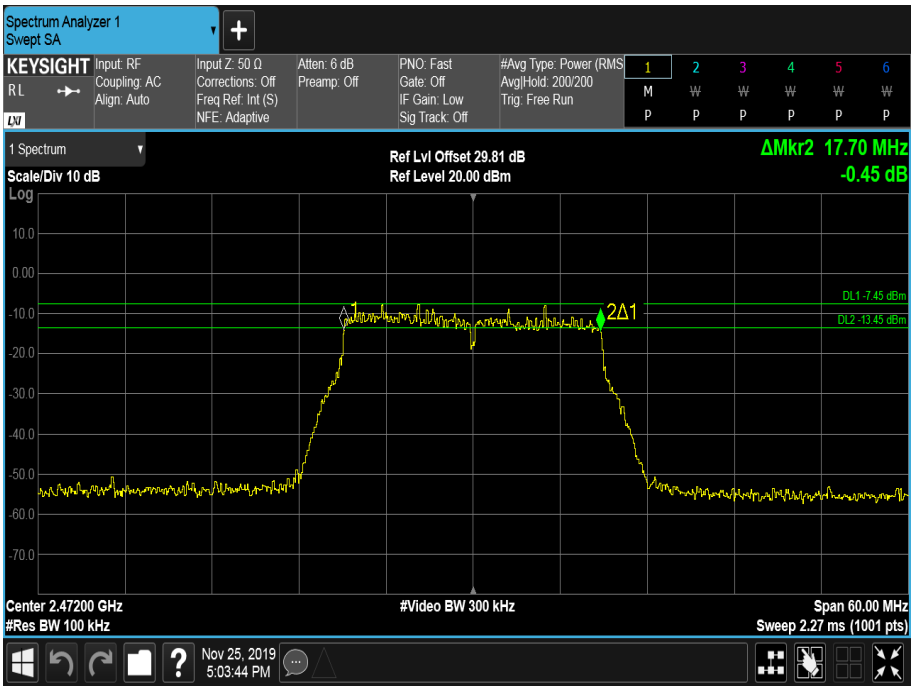

Figure 35 - 2472 MHz - 6 dB DTS Bandwidth

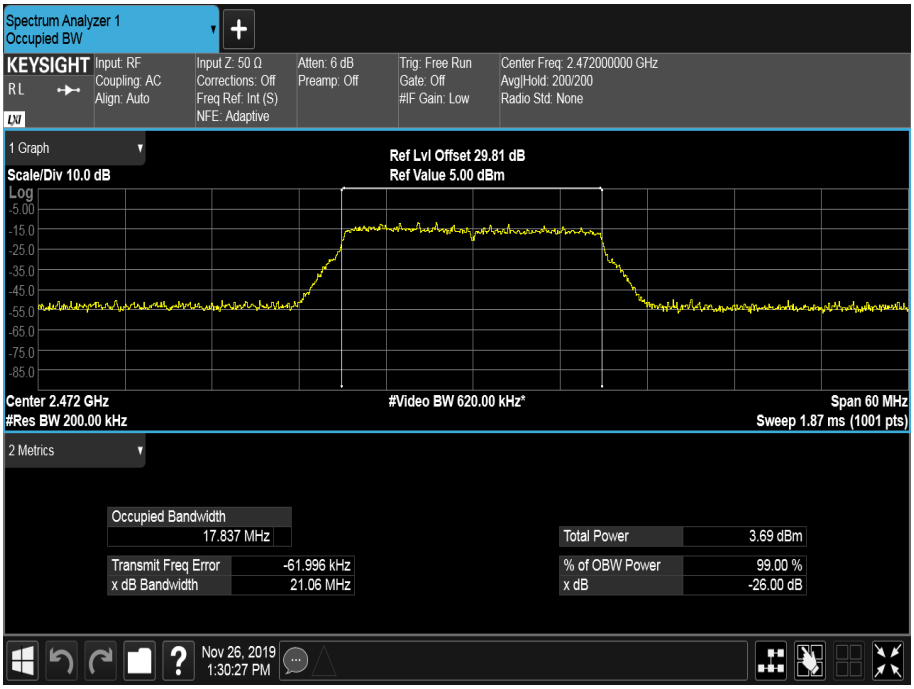

Figure 36 - 2472 MHz - 99% Occupied Bandwidth

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	17.760	17.640	17.340
99% Bandwidth (MHz)	17.700	17.804	17.786

Table 29 - 802.11n / HT20 MCS0 / MIMO TxBF / Cores 0+1

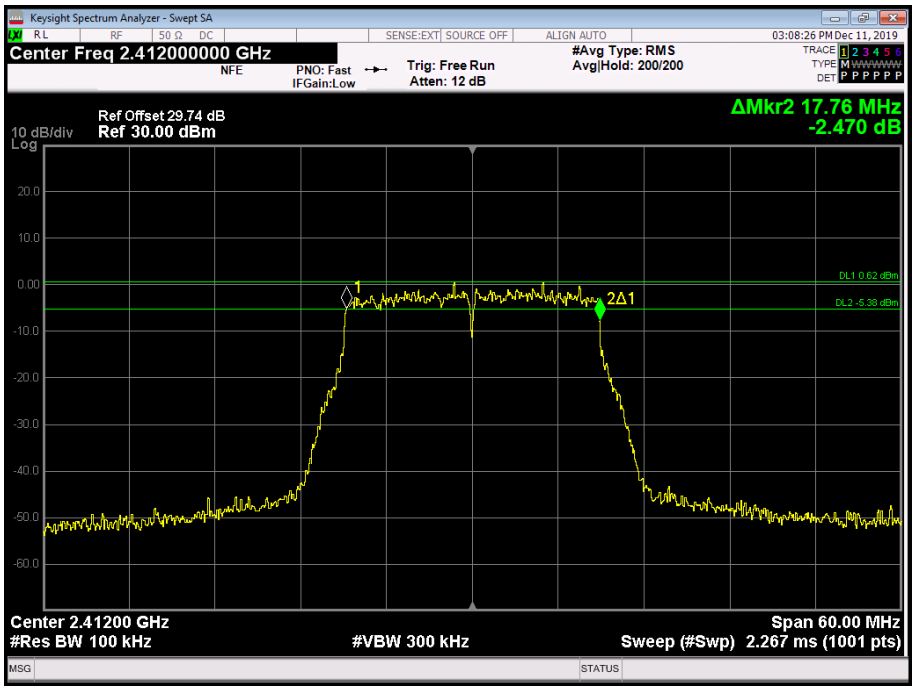

Figure 37 - 2412 MHz - 6 dB DTS Bandwidth

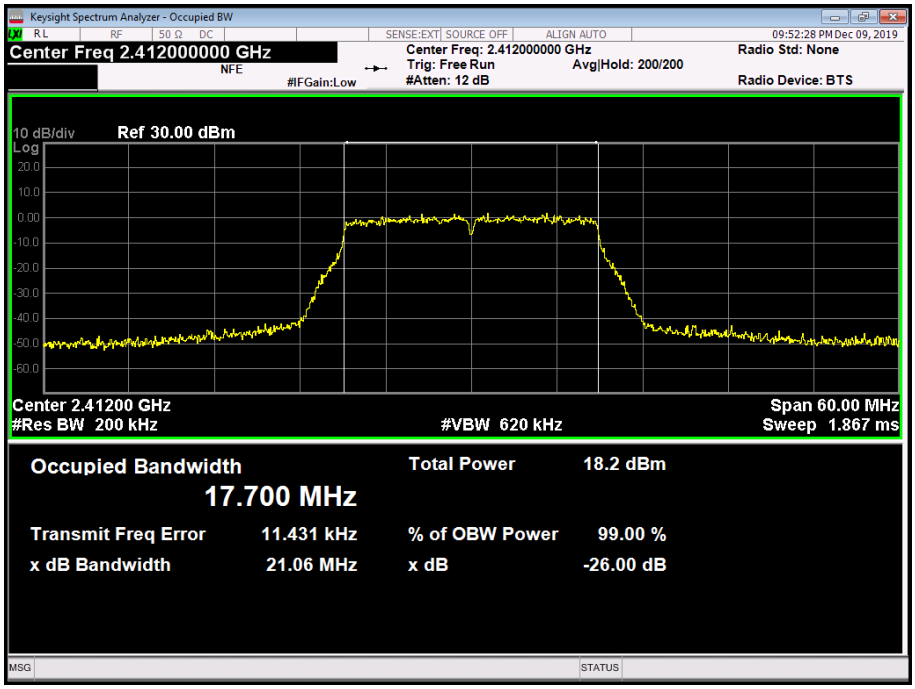

Figure 38 - 2412 MHz - 99% Occupied Bandwidth

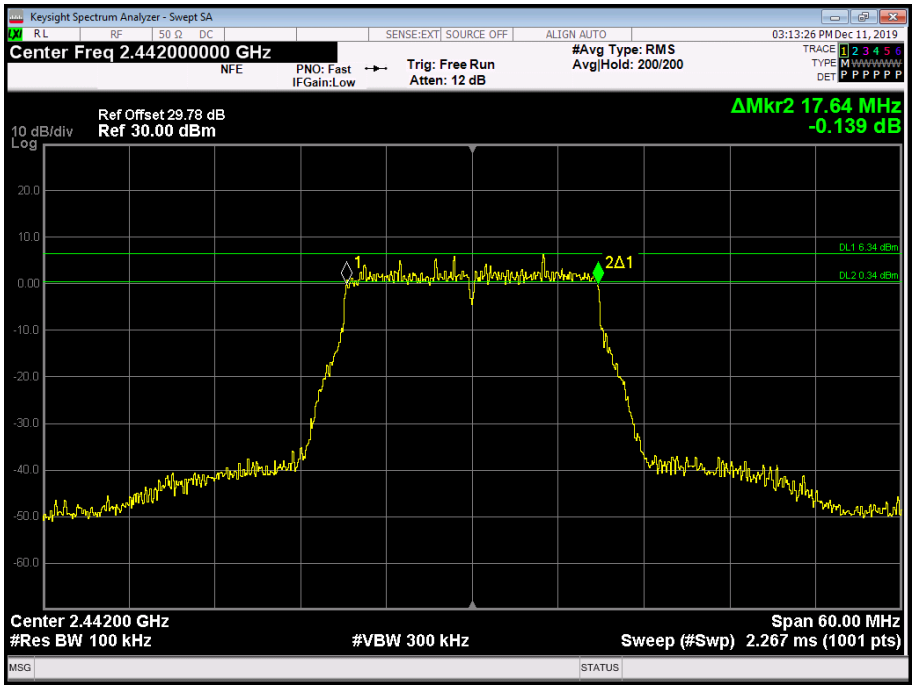

Figure 39 - 2442 MHz - 6 dB DTS Bandwidth

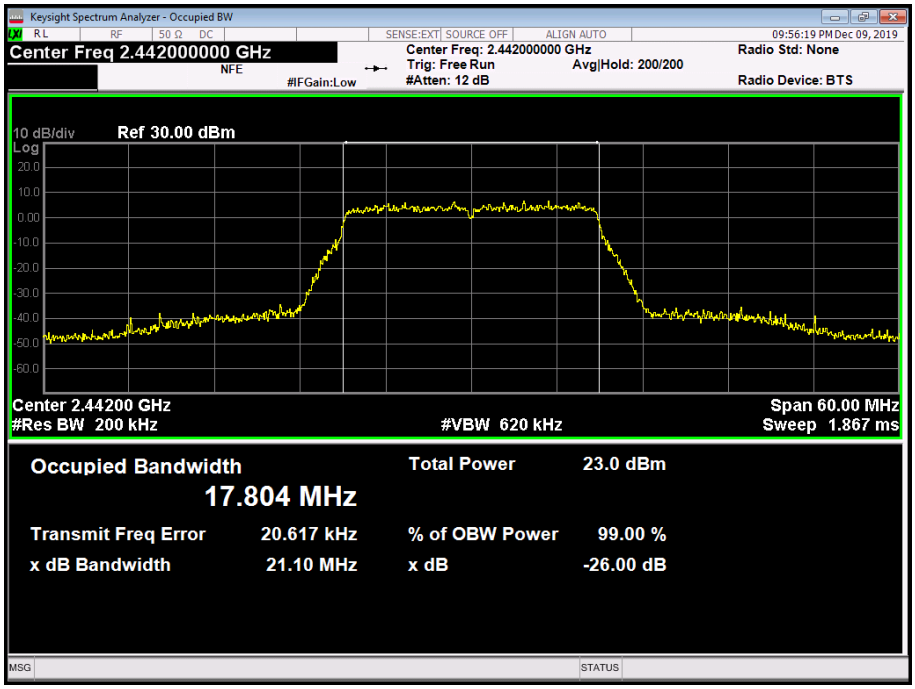

Figure 40 - 2442 MHz - 99% Occupied Bandwidth

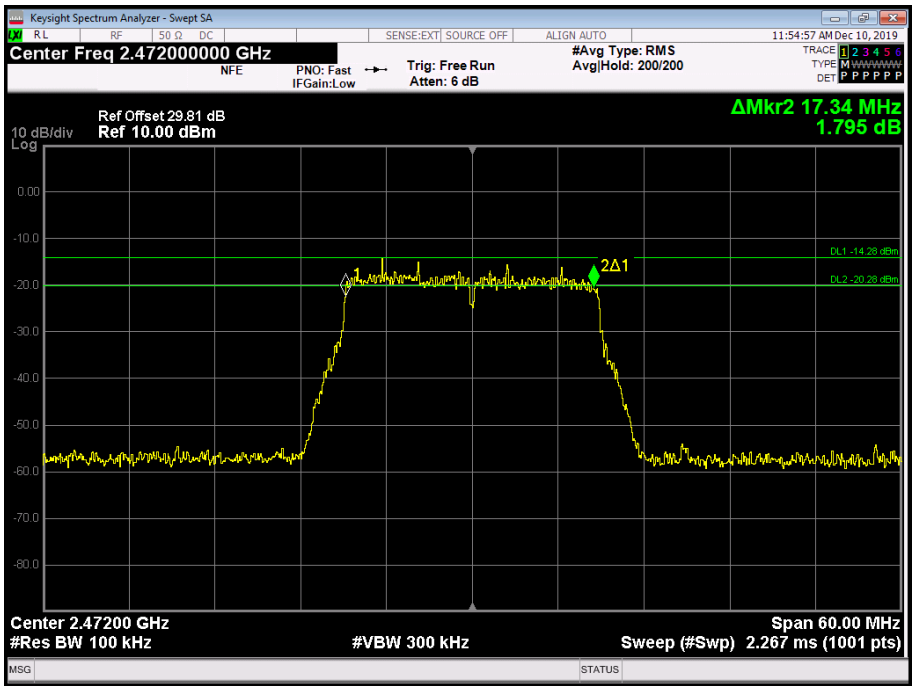

Figure 41 - 2472 MHz - 6 dB DTS Bandwidth

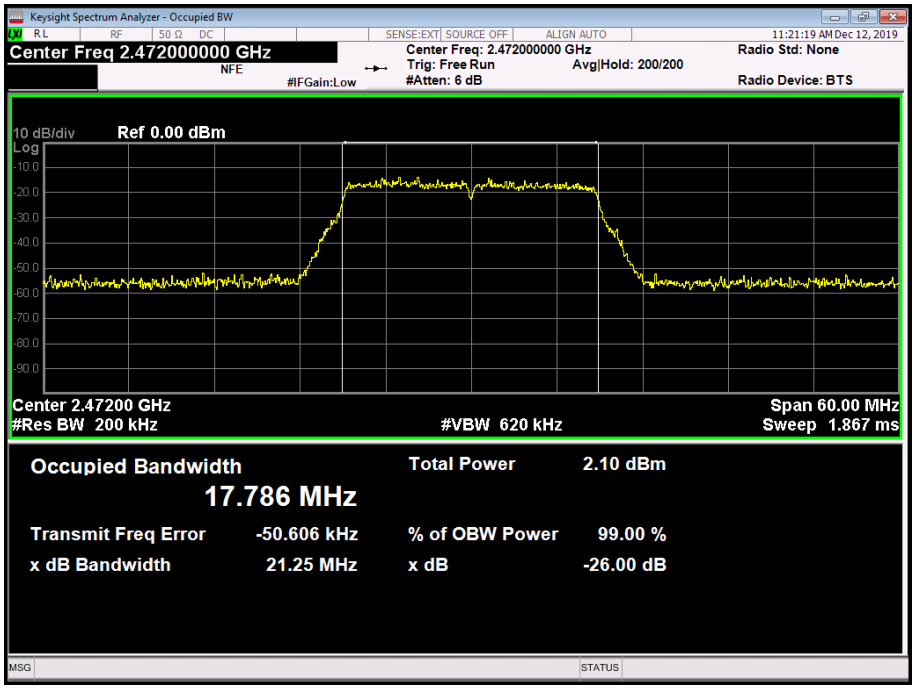

Figure 42 - 2472 MHz - 99% Occupied Bandwidth

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2) and ISEDC RSS-247, Clause 5.2(a)

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

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Attenuator (10 dB)	Weinschel	47-10-34	481	-	O/P Mon
Attenuator (20 dB, 2 W)	Pasternack	PE7004-20	489	-	O/P Mon
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	16-Apr-2020
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
2 metre N-Type Cable	Florida Labs	NMS-235SP-78.8-NMS	4622	12	12-Jul-2020
PXA Signal Analyser	Keysight Technologies	N9030A	4653	12	06-Feb-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
EXA	Keysight Technologies	N9010B	4968	12	23-Dec-2019
Network Analyser	Keysight Technologies	E5063A	5018	12	20-May-2020
Cable (18 GHz)	Rosenberger	LU7-036-2000	5035	-	O/P Mon
Cable (18 GHz)	Rosenberger	LU7-071-1000	5098	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5108	12	06-Oct-2020
Electronic Calibration Module	Keysight Technologies	85093C	5188	12	21-May-2020
AC Programmable Power Supply	iTech	IT7324	5227	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5235	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon

Table 30

O/P Mon – Output Monitored using calibrated equipment

2.4 Authorised Band Edges

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d)
ISEDC RSS-247, Clause 5.5

2.4.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC00WM8M5 - Modification State 0

2.4.3 Date of Test

19-November-2019 to 16-December-2019

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.10.4.

Authorised band edge measurements were performed, with the device operating in SISO and MIMO configurations, across the various modes supported by the device.

Since compliance with the power limits in section 2.1 was shown by RMS averaging across all symbols in the signaling alphabet, a 30 dBc limit rather than 20 dBc limit was applied in accordance with FCC 47 CFR Part 15.247 paragraph (d) and RSS-247 section 5.5.

2.4.5 Environmental Conditions

Ambient Temperature	20.9-23.2 °C
Relative Humidity	40.8-56.2 %

2.4.6 Test Results

2.4 GHz WLAN

Mode	Data Rate	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
802.11b, Core 0	1 Mbps	2412	2400	56.69
802.11g, Core 0	6 Mbps	2412	2400	48.77
802.11n, Core 0	MCS0	2412	2400	47.95

Table 31 – SISO

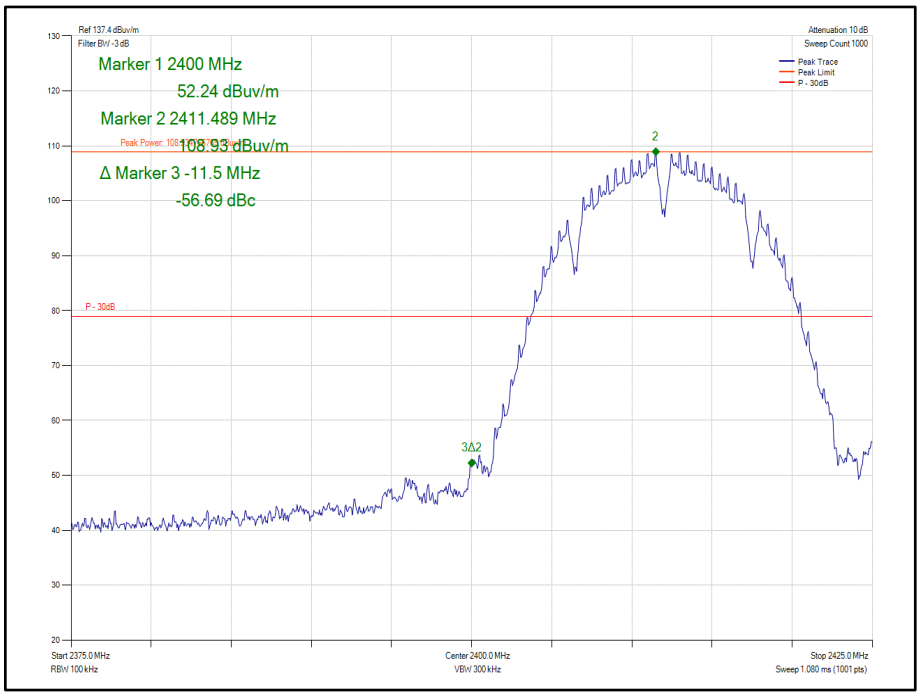

Figure 43 - 802.11b, Core 0 - 2412 MHz
Band Edge Frequency 2400 MHz

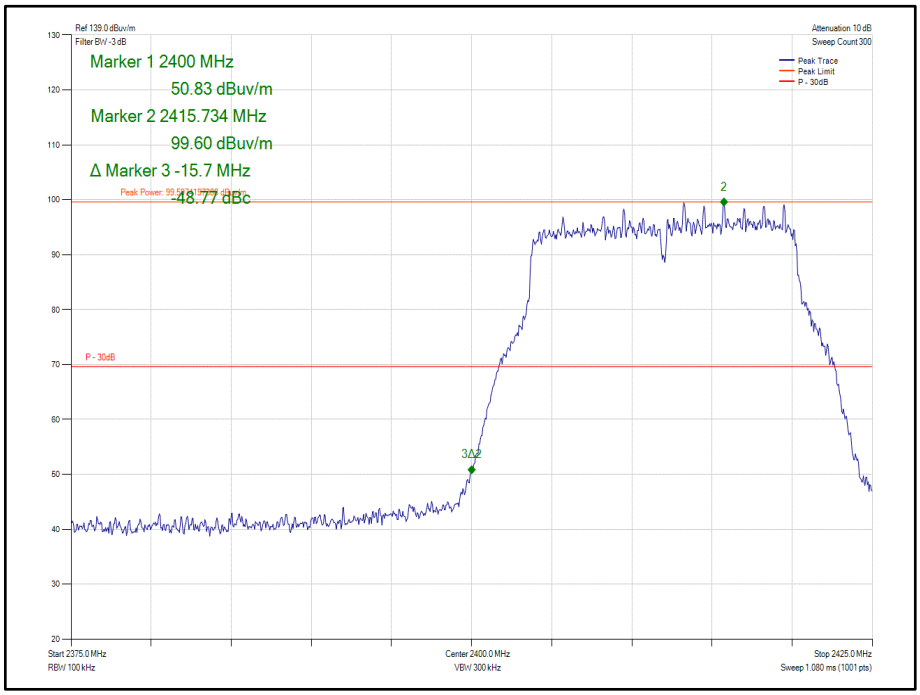

Figure 44 - 802.11g, Core 0 - 2412 MHz
Band Edge Frequency 2400 MHz

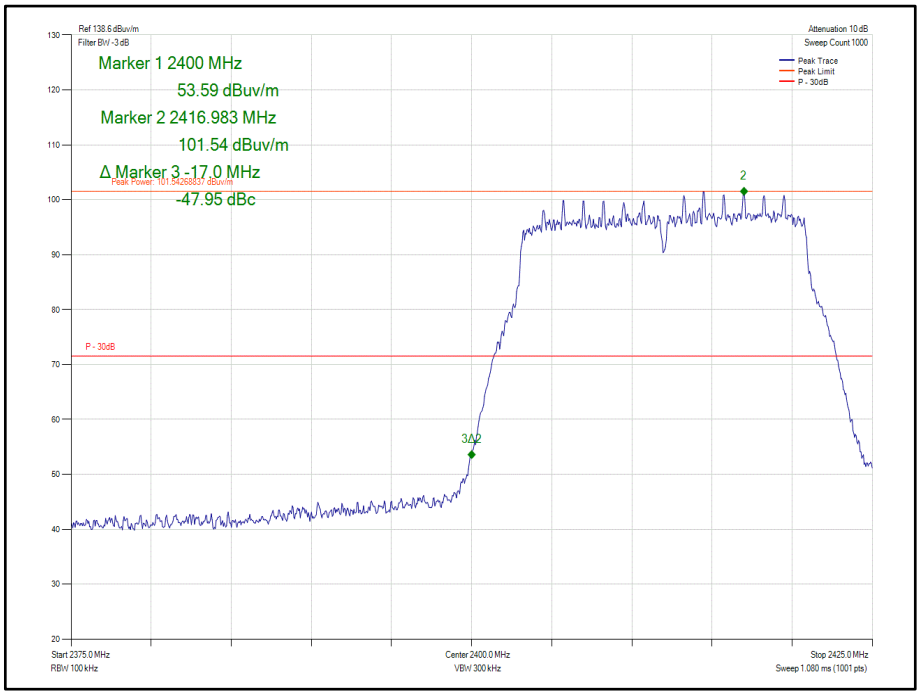

Figure 45 - 802.11n, Core 0 - 2412 MHz
Band Edge Frequency 2400 MHz

Mode	Data Rate	Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
802.11b, Core 0-1	1 Mbps	2412	2400	56.34
802.11n, Core 0-1	MCS0	2412	2400	48.80

Table 32 – MIMO 2Tx

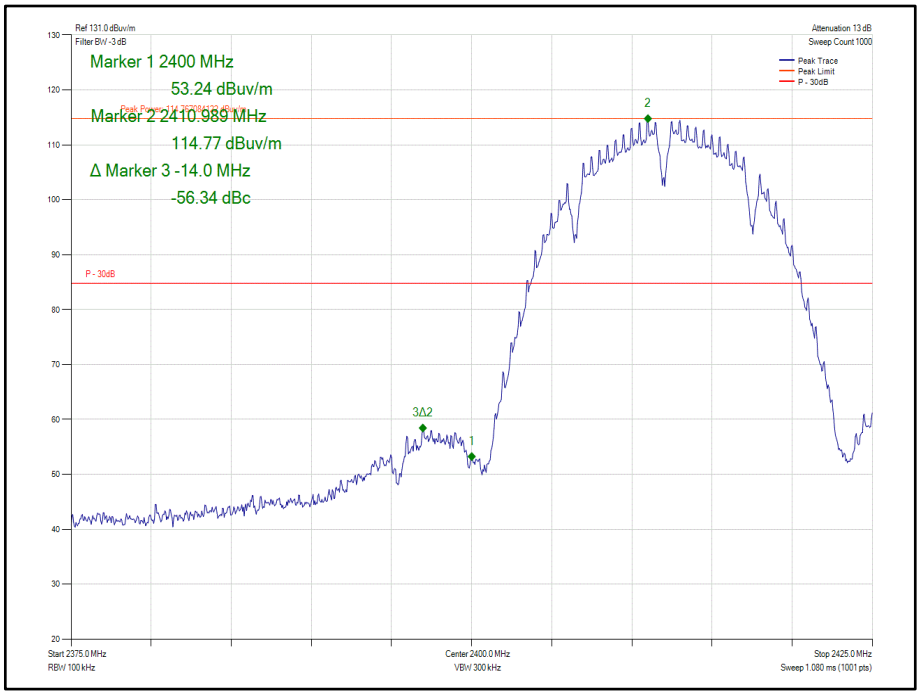

Figure 46 - 802.11b, Core 0-1 - 2412 MHz
Band Edge Frequency 2400 MH

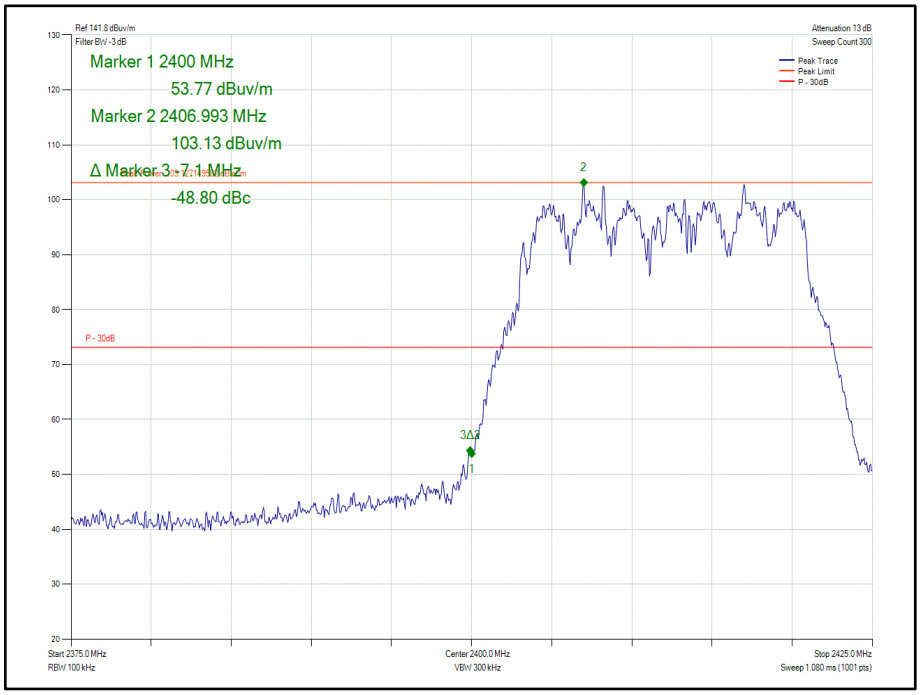

Figure 47 - 802.11n, Core 0-1 - 2412 MHz
Band Edge Frequency 2400 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

ISEDC RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	11-Dec-2019*
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5095	12	04-Dec-2019*
Cable (18 GHz)	Rosenberger	LU7-071-1000	5103	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5105	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	06-Oct-2020
EmX Emissions Software	TUV SUD	EmX, V.V1.5.2	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8 Meter Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
Pre Amp 1 – 26.5 GHz	Agilent Technologies	8449B	5445	-	O/P Mon

Table 33

TU – Traceability Unscheduled
O/P Mon – Output monitored using calibrated equipment.

*As testing was performed over multiple days it may appear that some equipment was used outside of a valid calibration period, however, TUV SUD confirms that when equipment was used it held a valid calibration and has records of this.

2.5 Restricted Band Edges

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205
ISEDC RSS-GEN, Clause 8.10

2.5.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC00WM8M5 - Modification State 0

2.5.3 Date of Test

19-November-2019 to 06-February-2019

2.5.4 Test Method

Testing was performed in accordance with ANSI C63.10, clause 6.10.5, 11.12.1 and Clause 11.13.3.4

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

Restricted band edge measurements were performed, with the device operating in SISO and MIMO configurations, across the various modes supported by the device.

2.5.5 Environmental Conditions

Ambient Temperature	20.9-23.2 °C
Relative Humidity	40.8-56.2 %

2.5.6 Test Results

2.4 GHz WLAN

Mode	Data Rate	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
802.11b, Core 0	1 Mbps	2412	2390.0	56.08	45.31
802.11b, Core 0	1 Mbps	2462	2483.5	57.13	47.58
802.11b, Core 0	1 Mbps	2467	2483.5	57.90	47.43
802.11b, Core 0	1 Mbps	2472	2483.5	64.28	48.20
802.11g, Core 0	6 Mbps	2412	2390.0	54.23	43.30
802.11g, Core 0	6 Mbps	2462	2483.5	56.56	46.20
802.11g, Core 0	6 Mbps	2467	2483.5	57.16	45.85
802.11g, Core 0	6 Mbps	2472	2483.5	64.43	48.04
802.11n, Core 0	MCS0	2412	2390.0	56.66	44.04
802.11n, Core 0	MCS0	2462	2483.5	56.22	45.64
802.11n, Core 0	MCS0	2467	2483.5	61.73	49.35
802.11n, Core 0	MCS0	2472	2483.5	56.30*	46.20*

Table 34 - SISO

* Field strength determined using the integration method specified in ANSI C63.10-2013 Clause 11.13.3.4

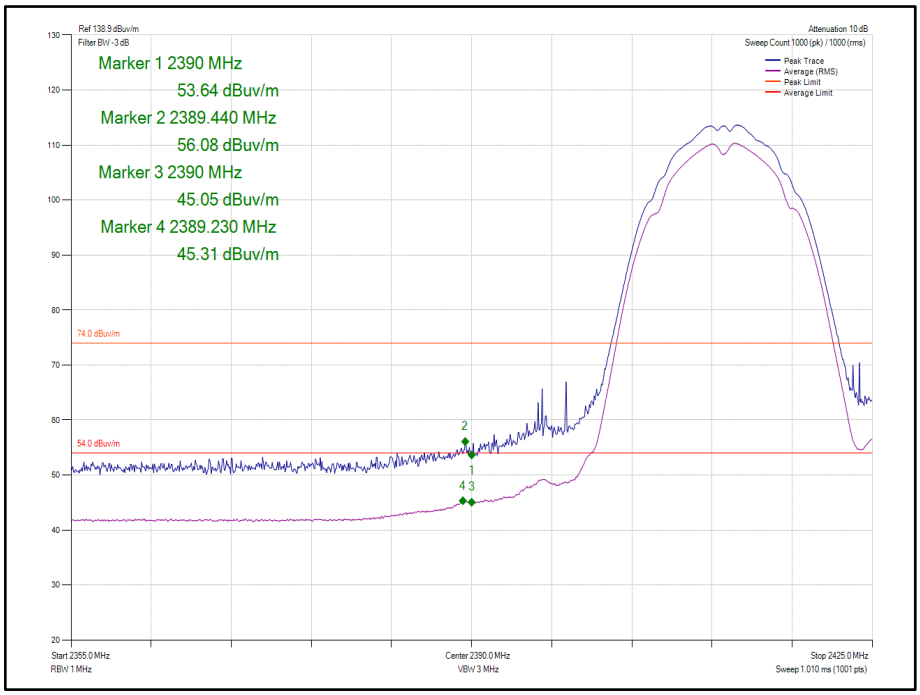

Figure 48 - 802.11b, Core 0 - 2412 MHz
Band Edge Frequency 2390.0 MHz

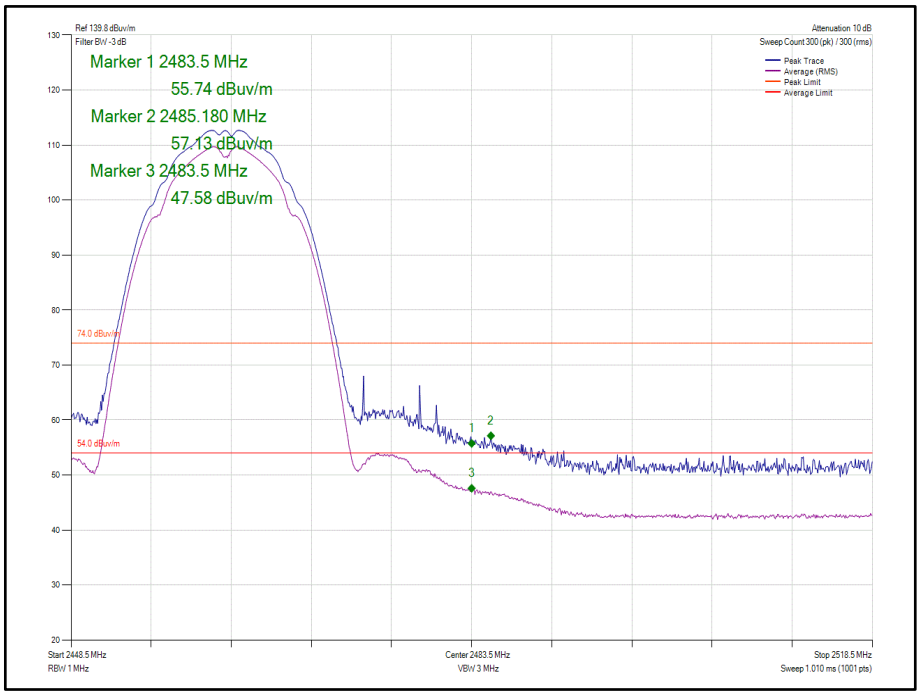

Figure 49 - 802.11b, Core 0 - 2462 MHz
Band Edge Frequency 2483.5 MHz

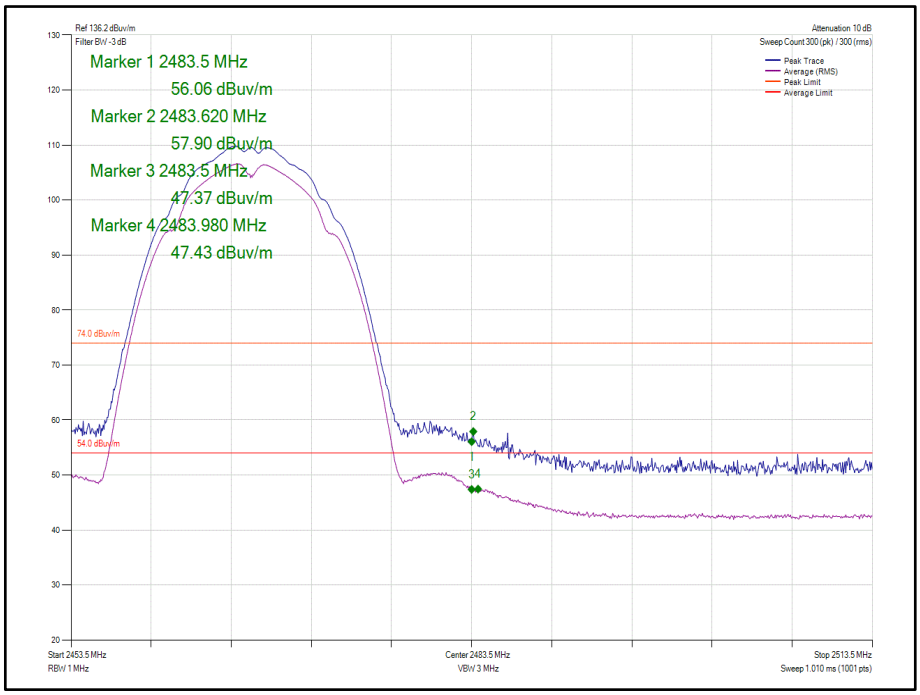

Figure 50 - 802.11b, Core 0 - 2467 MHz
Band Edge Frequency 2483.5 MHz

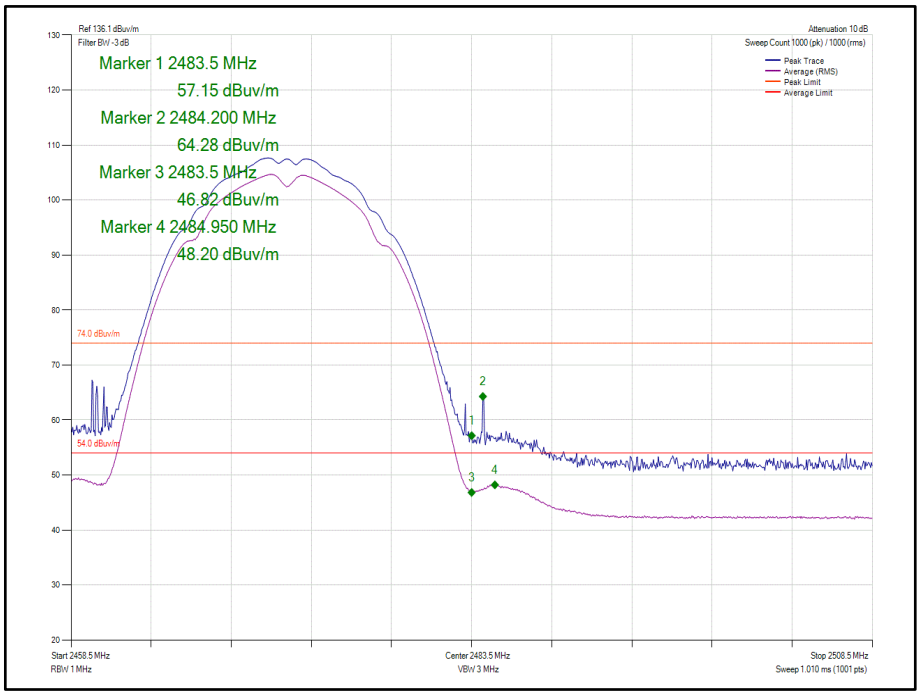

Figure 51 - 802.11b, Core 0 - 2472 MHz
Band Edge Frequency 2483.5 MHz

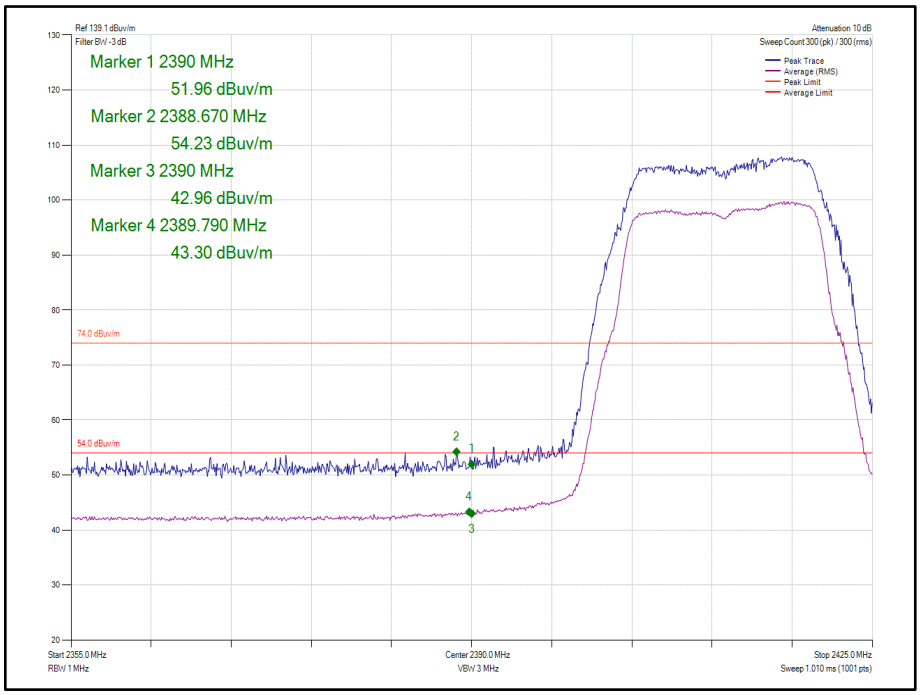

Figure 52 - 802.11g, Core 0 - 2412 MHz
Band Edge Frequency 2390.0 MHz

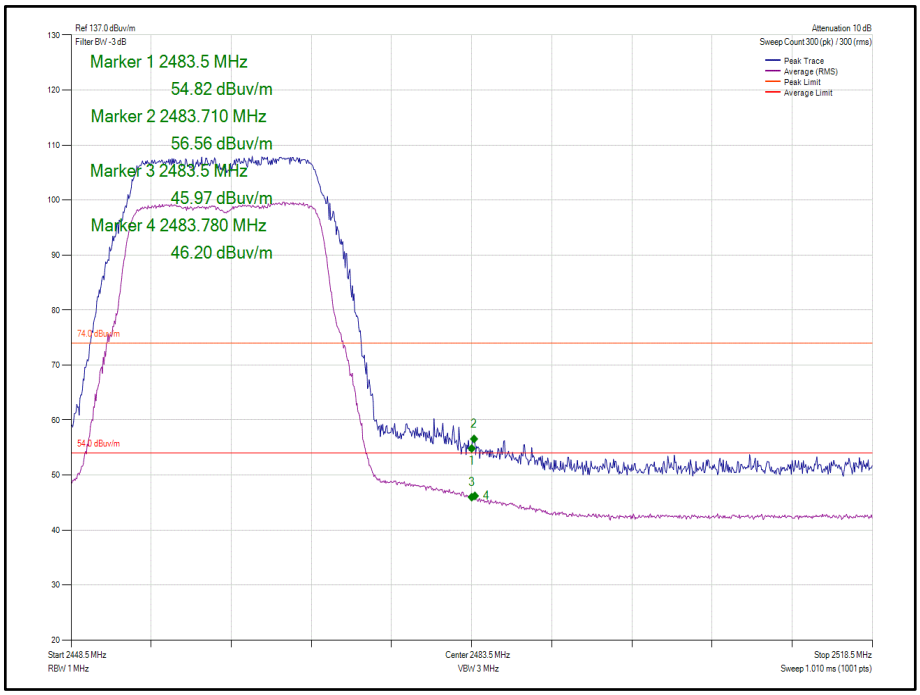

Figure 53 - 802.11g, Core 0 - 2462 MHz
Band Edge Frequency 2483.5 MHz

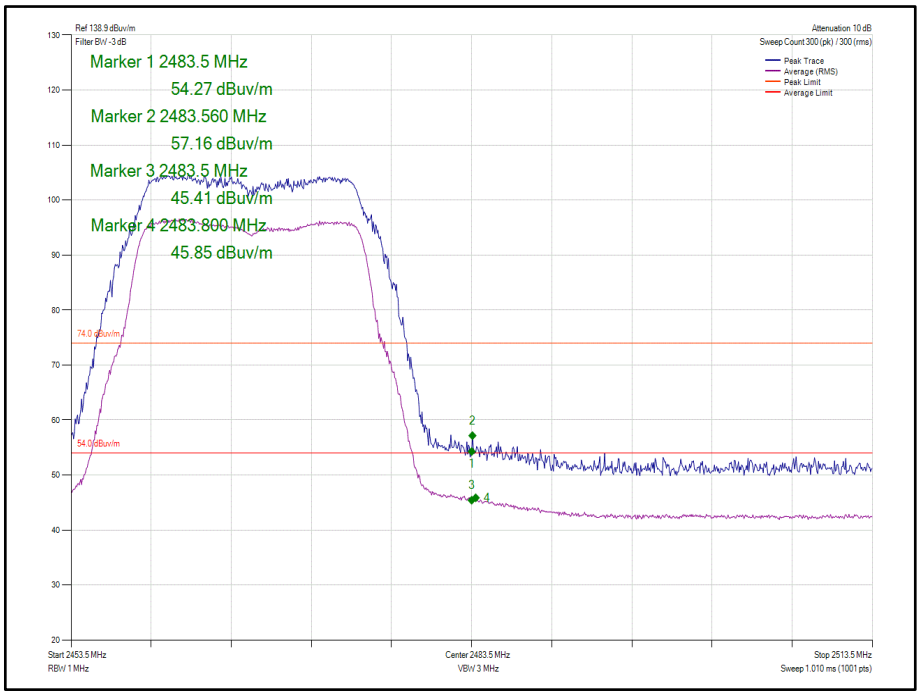

Figure 54 - 802.11g, Core 0 - 2467 MHz
Band Edge Frequency 2483.5 MHz

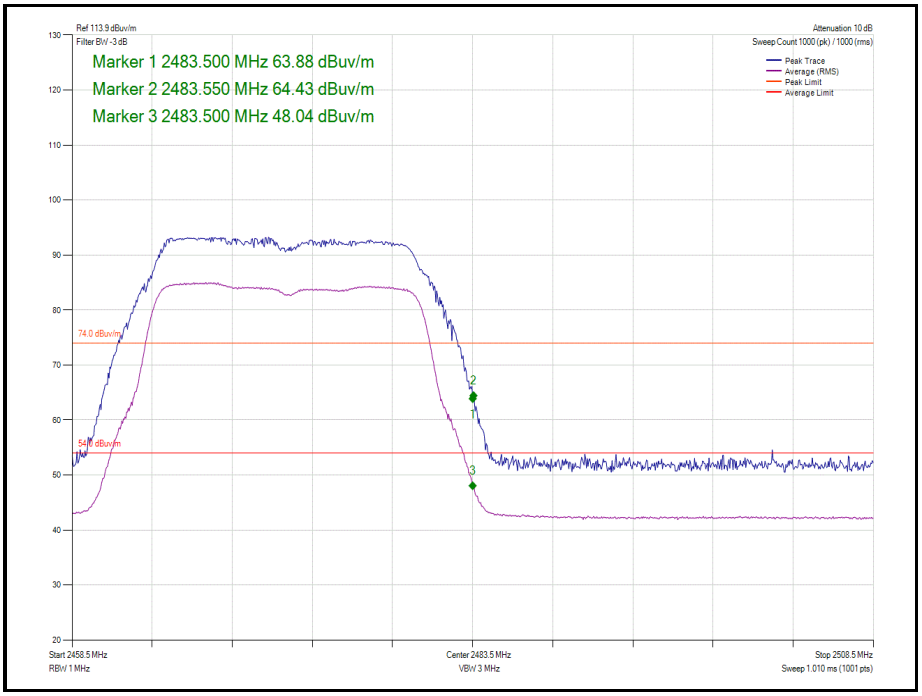

Figure 55 - 802.11g, Core 0 - 2472 MHz
Band Edge Frequency 2483.5 MHz

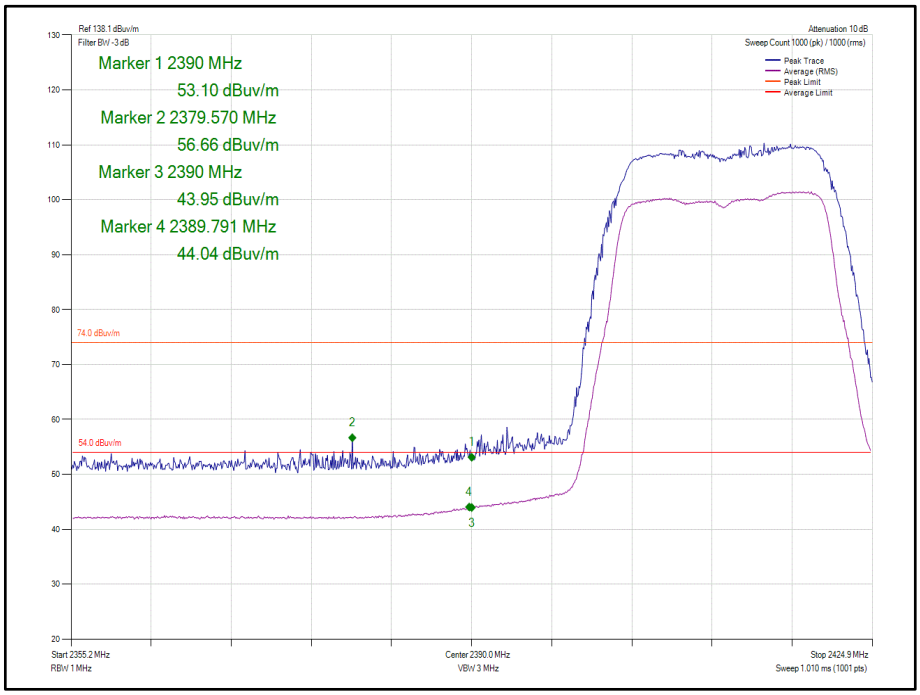

Figure 56 - 802.11n, Core 0 - 2412 MHz
Band Edge Frequency 2390 MHz

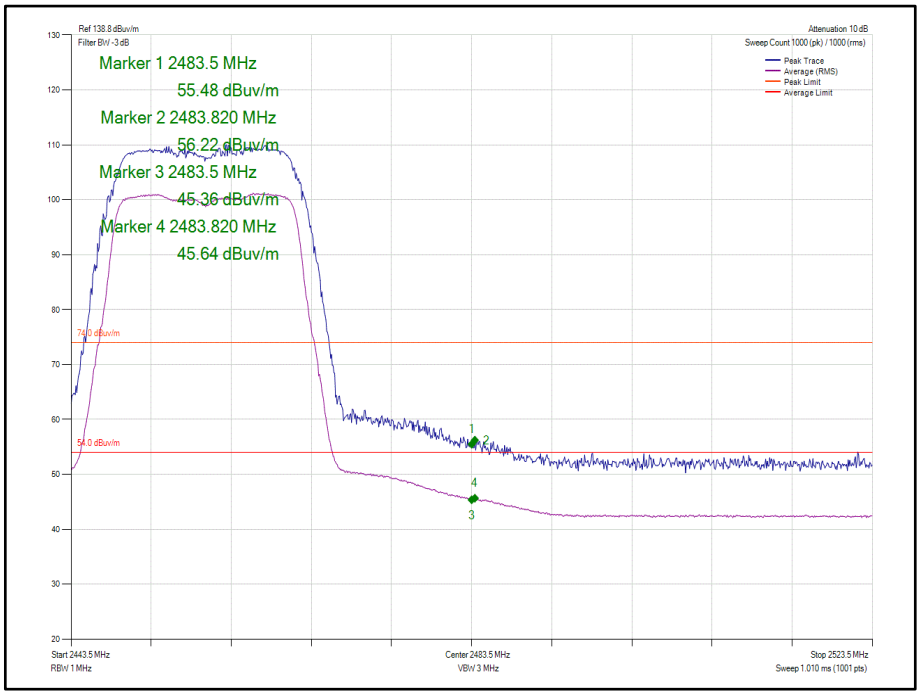

Figure 57 - 802.11n, Core 0 - 2462 MHz
Band Edge Frequency 2483.5 MHz

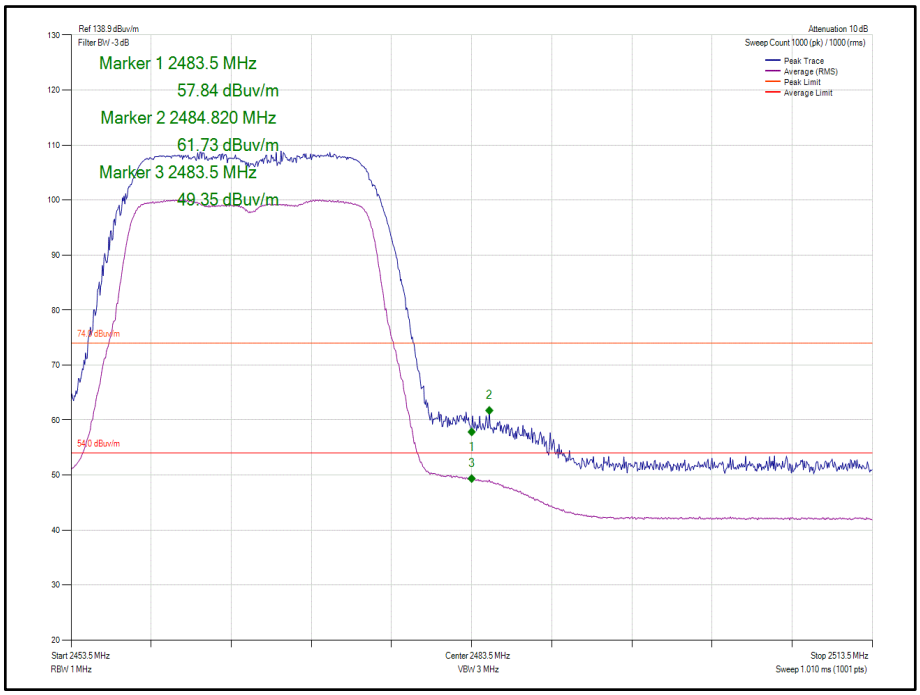

Figure 58 - 802.11n, Core 0 - 2467 MHz
Band Edge Frequency 2483.5 MHz

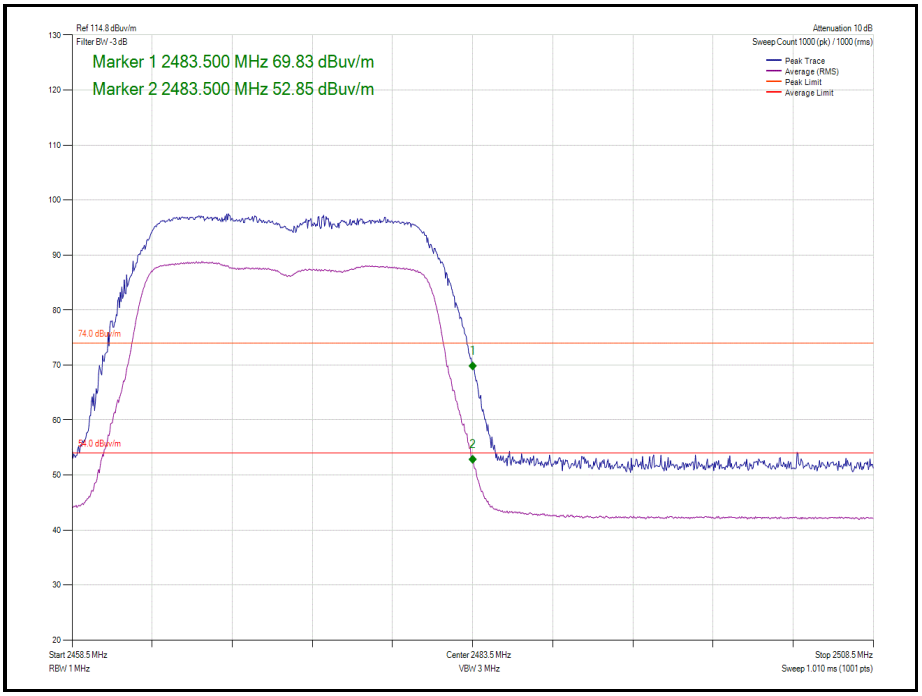

Figure 59 - 802.11n, Core 0 - 2472 MHz
Band Edge Frequency 2483.5 MHz

(Please refer to table 34 for final measurements determined using the integration method specified in ANSI C63.10-2013 Clause 11.13.3.4)

Mode	Data Rate	Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
802.11b, Core 0-1	1 Mbps	2412	2390.0	58.04	46.22
802.11b, Core 0-1	1 Mbps	2462	2483.5	58.10	48.05
802.11b, Core 0-1	1 Mbps	2467	2483.5	58.21	48.72
802.11b, Core 0-1	1 Mbps	2472	2483.5	58.50	48.34
802.11n, Core 0-1	MCS0	2412	2390.0	55.09	44.81
802.11n, Core 0-1	MCS0	2462	2483.5	62.15	48.98
802.11n, Core 0-1	MCS0	2467	2483.5	61.48	50.21
802.11n, Core 0-1	MCS0	2472	2483.5	58.04*	48.14*

Table 35 – MIMO 2Tx

* Field strength determined using the integration method specified in ANSI C63.10-2013 Clause 11.13.3.4

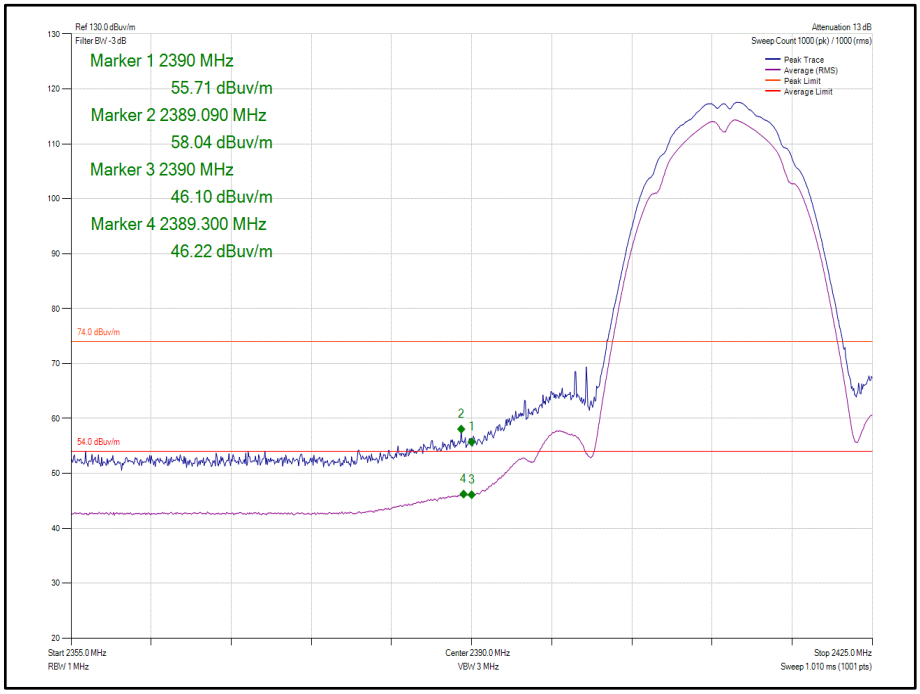

Figure 60 - 802.11b, Core 0-1 - 2412 MHz
Band Edge Frequency 2390 MHz

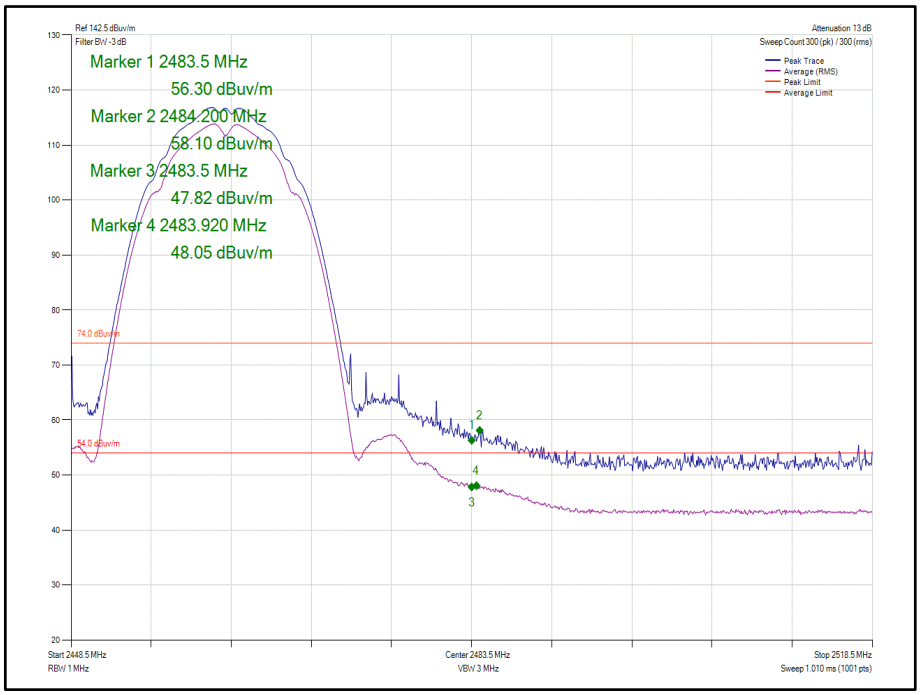

Figure 61 - 802.11b, Core 0-1 - 2462 MHz
Band Edge Frequency 2483.5 MHz

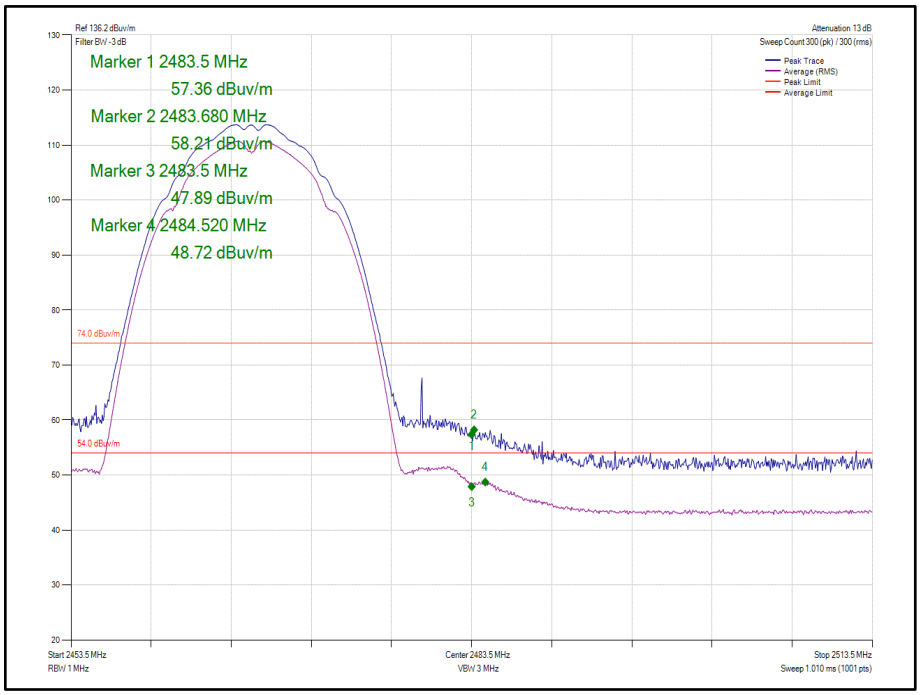

Figure 62 - 802.11b, Core 0-1 - 2467 MHz
Band Edge Frequency 2483.5 MHz

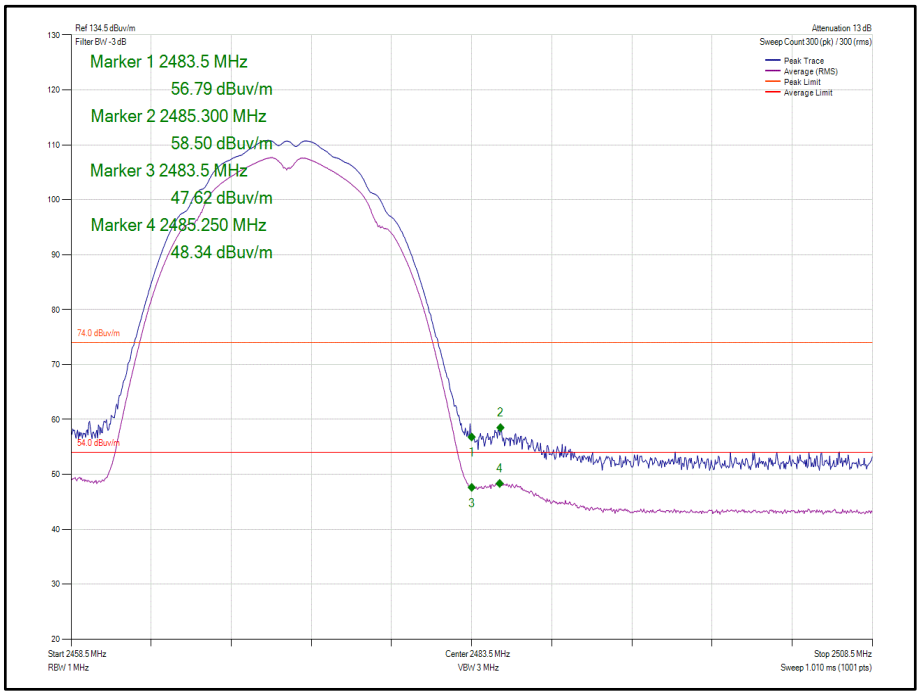

Figure 63 - 802.11b, Core 0-1 - 2472 MHz
Band Edge Frequency 2483.5 MHz

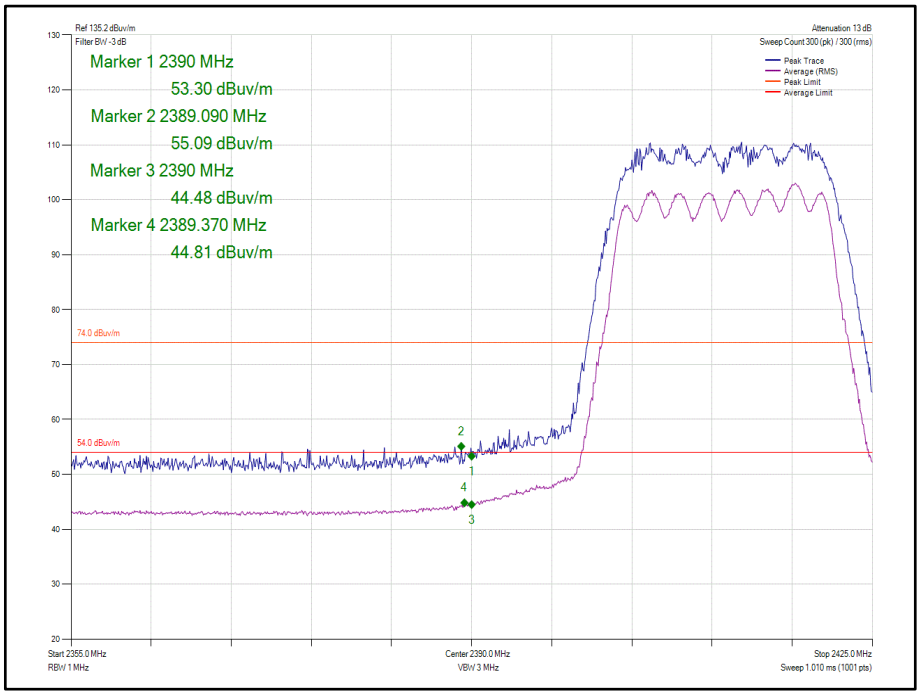

Figure 64 - 802.11n, Core 0-1 - 2412 MHz
Band Edge Frequency 2390 MHz

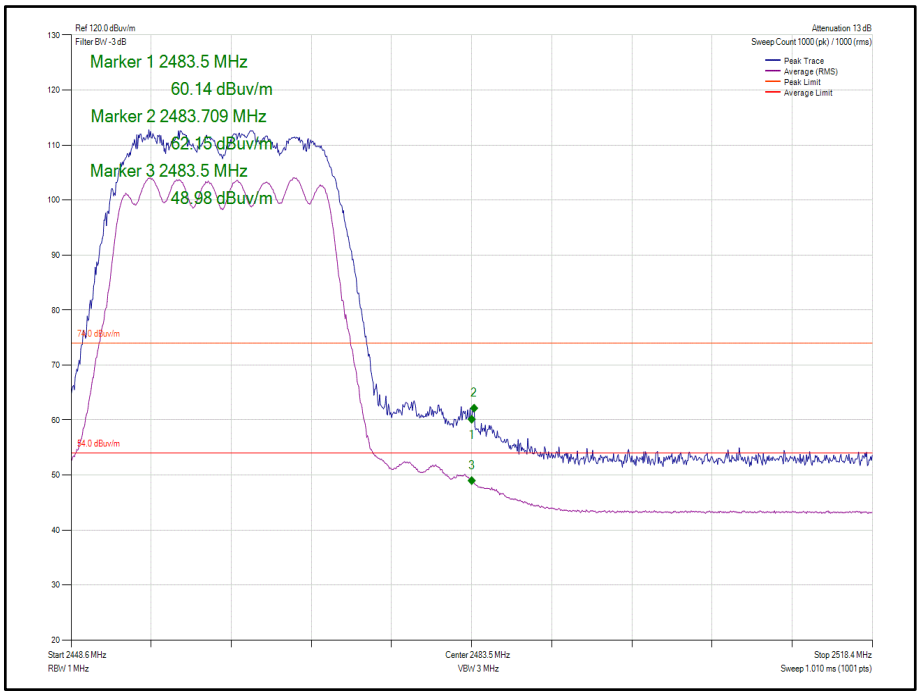

Figure 65 - 802.11n, Core 0-1 - 2462 MHz
Band Edge Frequency 2483.5 MHz

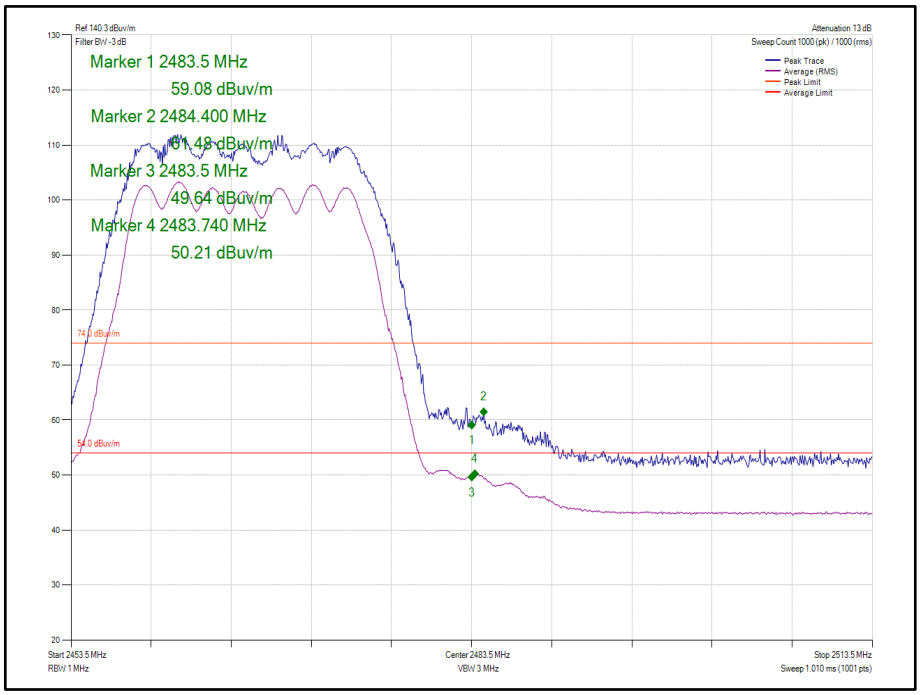

Figure 66 - 802.11n, Core 0-1 - 2467 MHz
Band Edge Frequency 2483.5 MHz

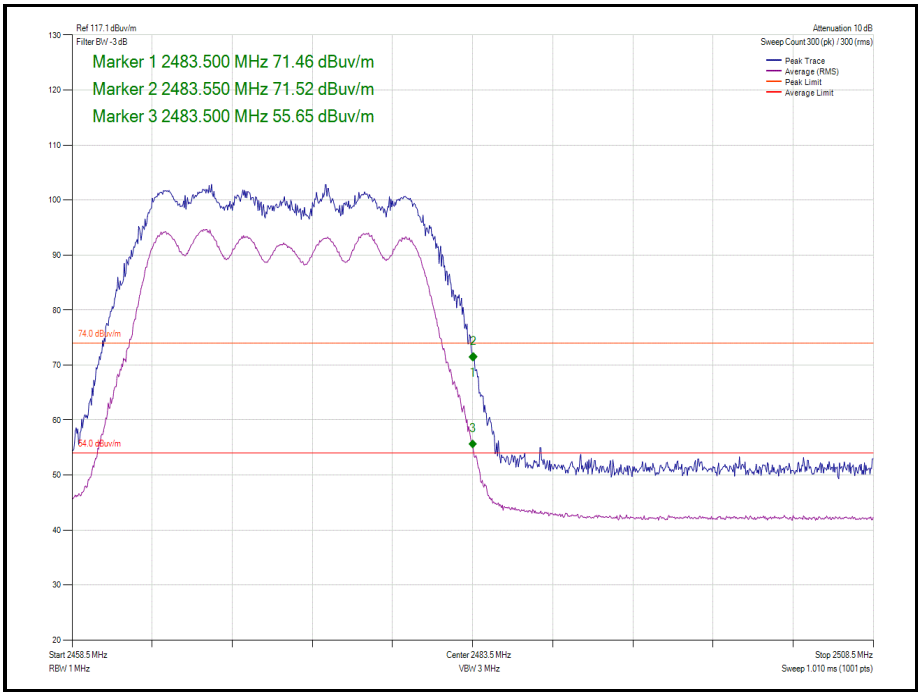

Figure 67 - 802.11n, Core 0-1 - 2472 MHz
Band Edge Frequency 2483.5 MHz

(Please refer to table 35 for final measurements determined using the integration method specified in ANSI C63.10-2013 Clause 11.13.3.4)

FCC 47 CFR Part 15, Limit Clause 15.209

Frequency (MHz)	Field Strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 36

ISEDC RSS-GEN, Limit Clause 8.9

Frequency (MHz)	Field Strength (µV/m at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

Table 37

*Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	11-Dec-2019*
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5095	12	04-Dec-2019*
Cable (18 GHz)	Rosenberger	LU7-071-1000	5103	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5105	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	06-Oct-2020
EmX Emissions Software	TUV SUD	EmX, V.V1.5.2	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8 Meter Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
Pre Amp 1 – 26.5 GHz	Agilent Technologies	8449B	5445	-	O/P Mon

Table 38

TU – Traceability Unscheduled
O/P Mon – Output monitored using calibrated equipment.

*As testing was performed over multiple days it may appear that some equipment was used outside of a valid calibration period, however, TUV SUD confirms that when equipment was used it held a valid calibration and has records of this.

2.6 Spurious Radiated Emissions

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205
ISEDC RSS-247, Clause 5.5
ISEDC RSS-GEN, Clause 6.13

2.6.2 Equipment Under Test and Modification State

A2179, S/N: C02ZC00WM8M5 - Modification State 0

2.6.3 Date of Test

19-November-2019 to 16-December-2019

2.6.4 Test Method

Testing was performed in accordance with ANSI C63.10, clause 6.3, 6.5 and 6.6.

In the 30 MHz to 1 GHz range pre-scans were only performed on the mid channel (2442 MHz)

The plots shown are the characterization of the EUT. The limits on the plots represent the most stringent case for restricted bands, (54/74 dBuV/m @ 3 m and 64/84 dBuV/m @ 1m) when compared to 20 dBc (Peak) and 30 dBc (Average) outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBµV/m to µV/m:
10^(Field Strength in dBµV/m / 20).

Spurious Radiated Emissions measurements were performed, with the device operating in MIMO 2TX during tests as this was defined as worst case.

The EUT was powered and charging from 120 V AC, 60 Hz. Ports on the device, were connected to suitable accessorise, peripherals and cables, in line with ANSI C63.10, clause 5.10.7.

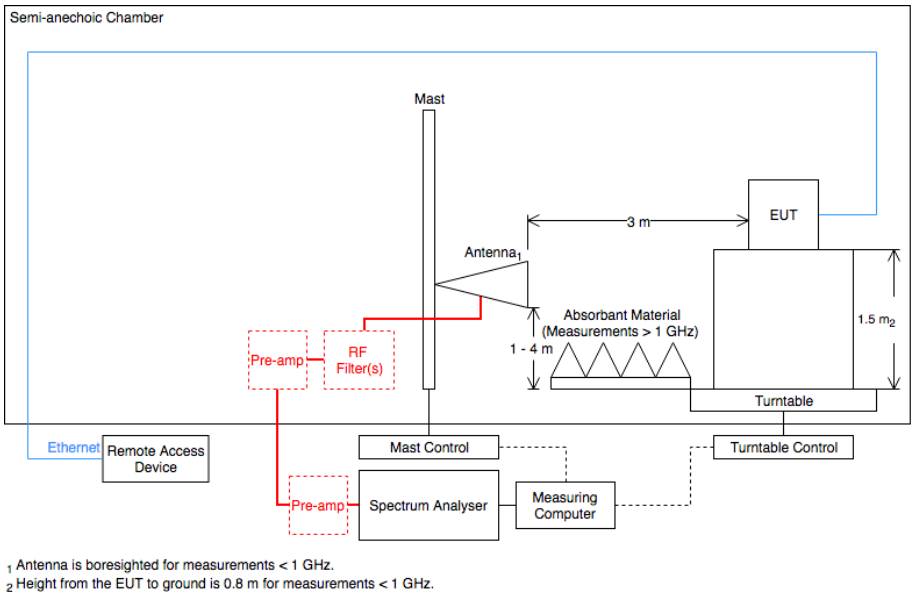

Figure 68 - Radiated Emissions Test Setup Diagram

2.6.5 Environmental Conditions

Ambient Temperature 20.9-23.2 °C
Relative Humidity 40.8-56.2 %

2.6.6 Test Results

2.4 GHz WLAN

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
4823.9	-	41.3	-	53.98	-	-12.7

Table 39 – 802.11b, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz

No other emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
252.4	27.1	46.0	-18.9	Q-Peak

Table 40 - 802.11b, Core 0-1, 2442 MHz - 30 MHz to 1000 MHz

No other emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 41 – 802.11b, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 42 – 802.11b, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

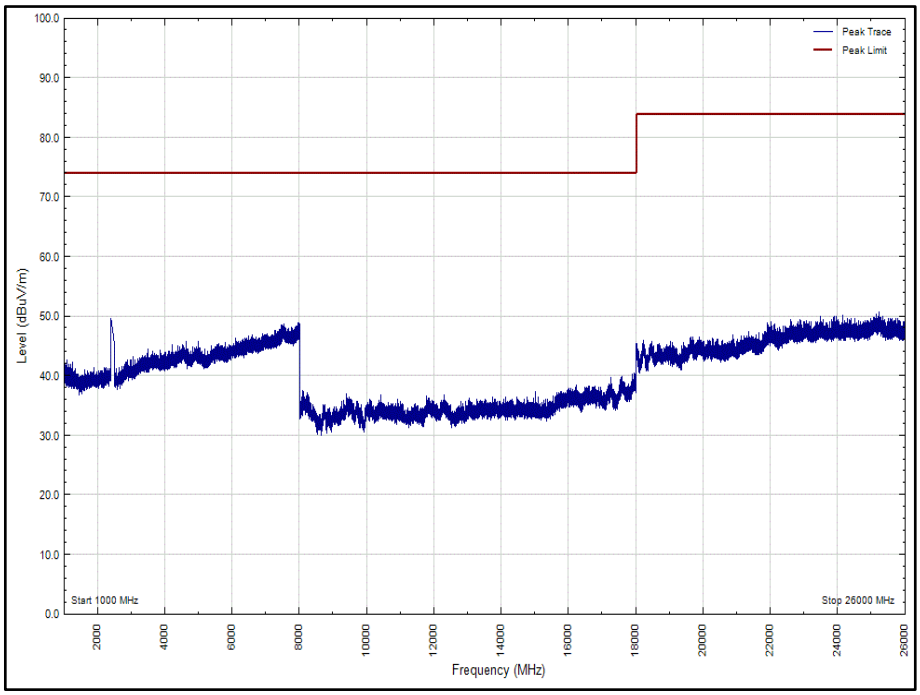

Figure 69 - 802.11b, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

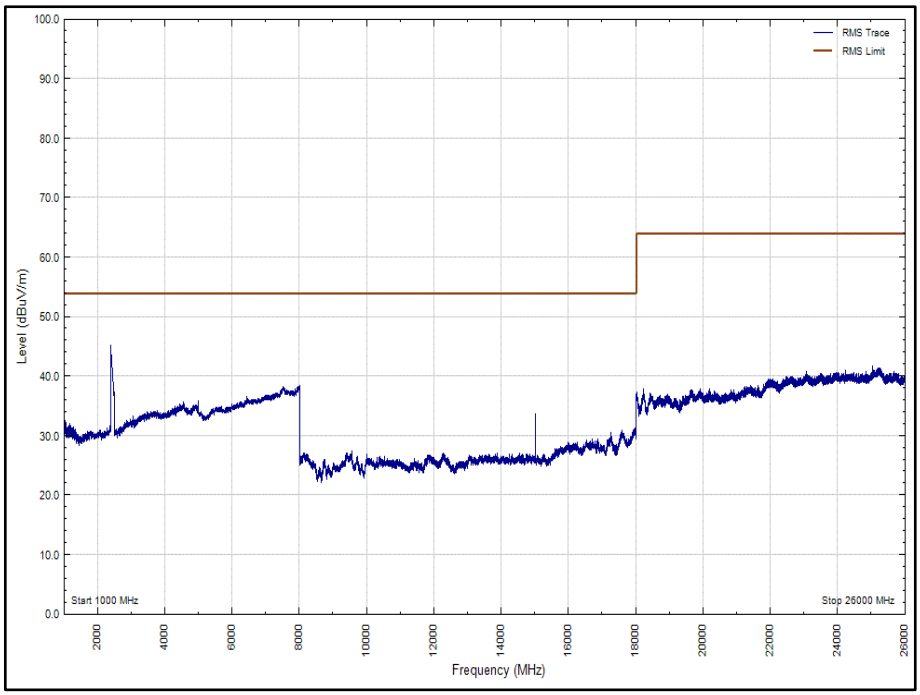

Figure 70 - 802.11b, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal - Average

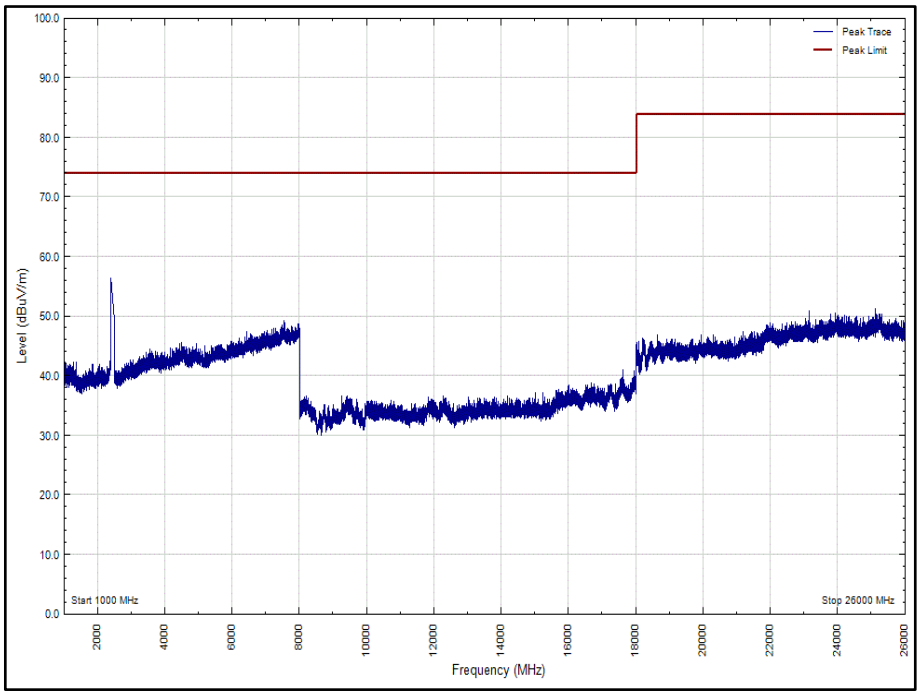

Figure 71 - 802.11b, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

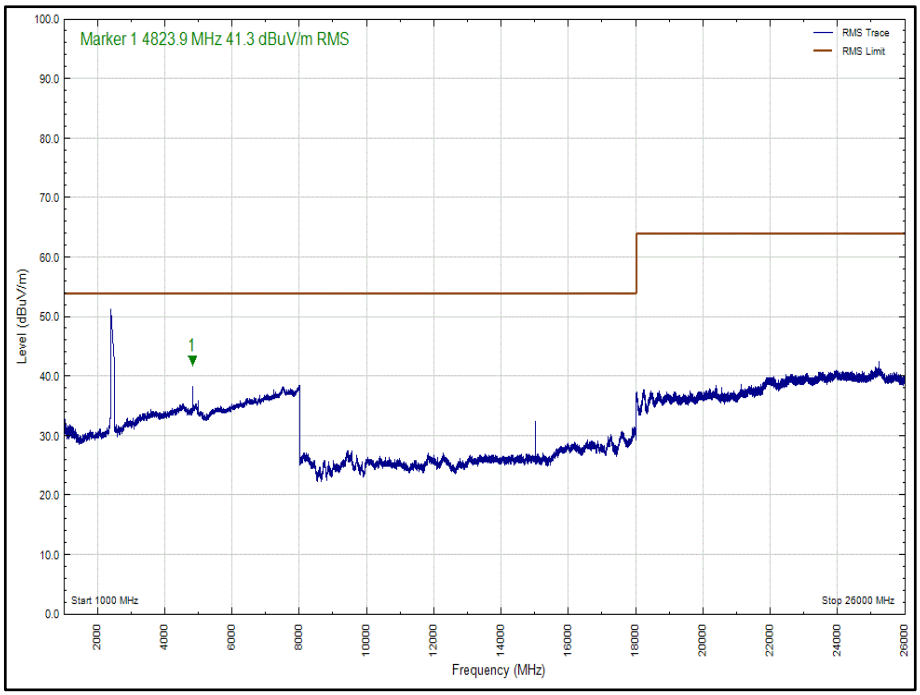

Figure 72 - 802.11b, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Average

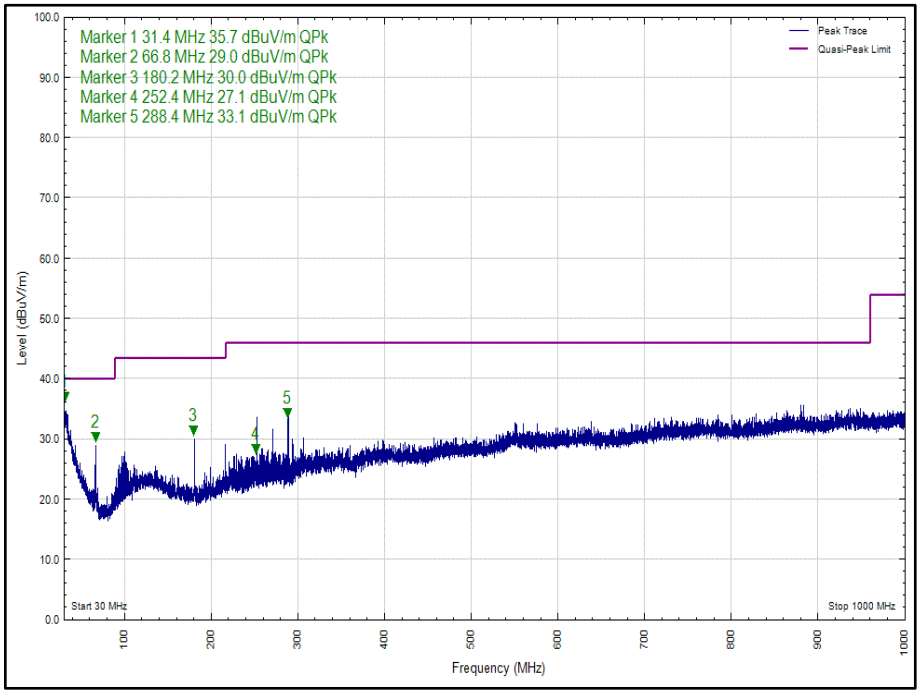

Figure 73 - 802.11b, Core 0-1, 2442 MHz – 30 MHz to 1000 MHz, Horizontal – Peak

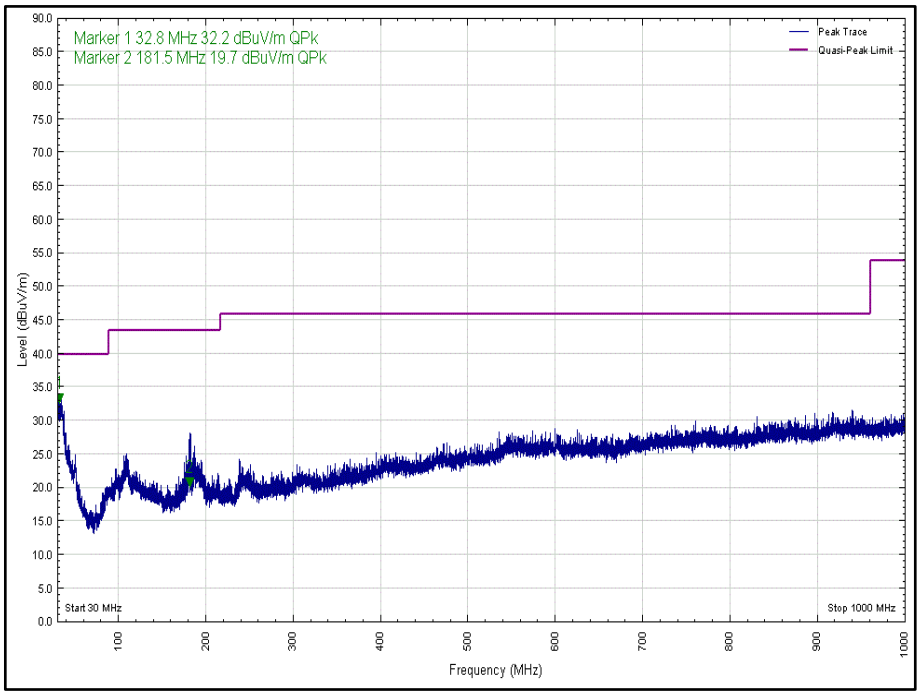

Figure 74 - 802.11b, Core 0-1, 2442 MHz – 30MHz to 1000 MHz, Vertical – Peak

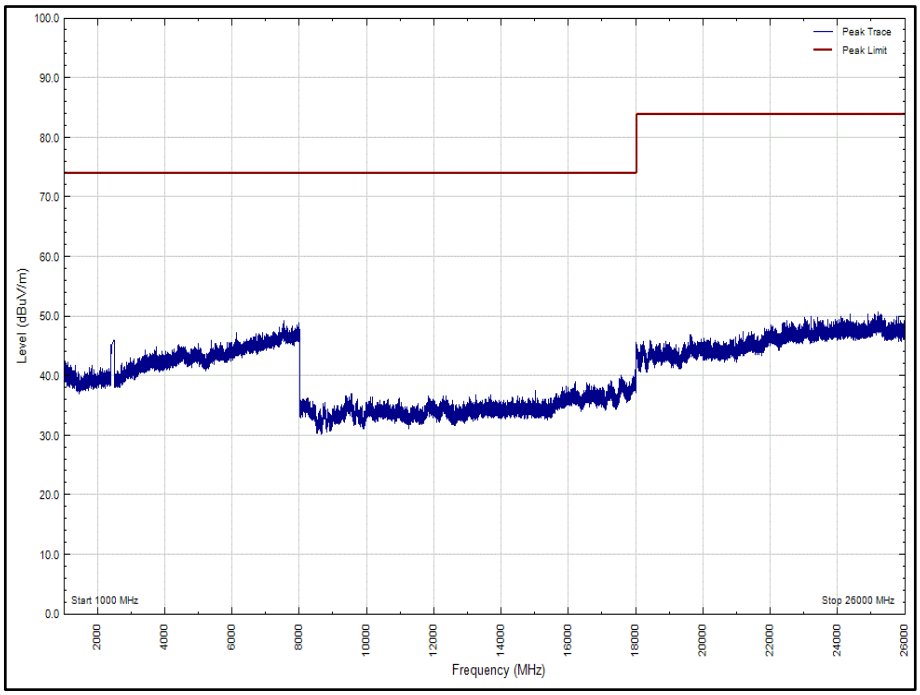

Figure 75 - 802.11b, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

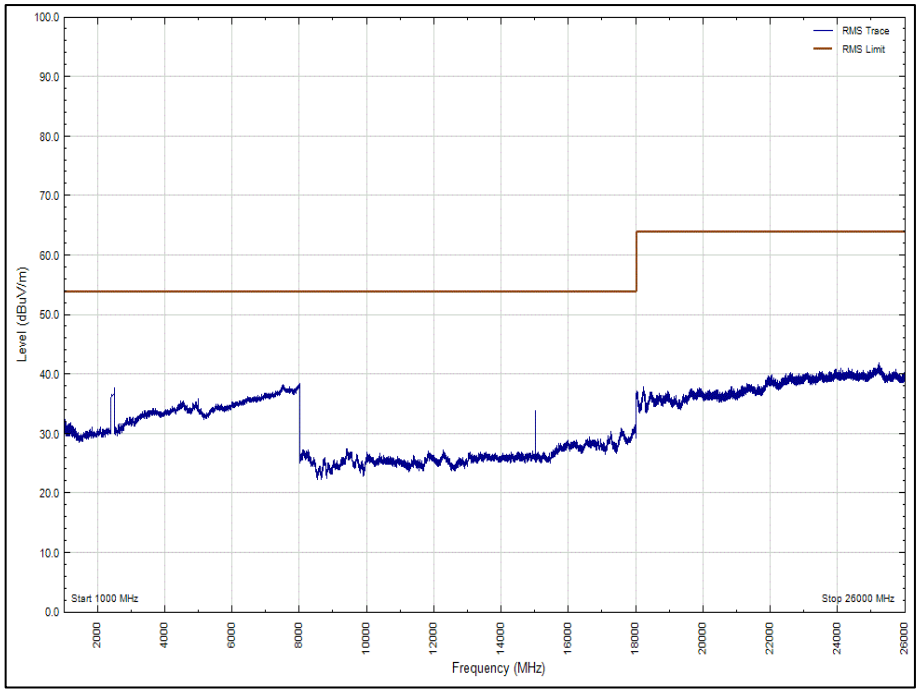

Figure 76 - 802.11b, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

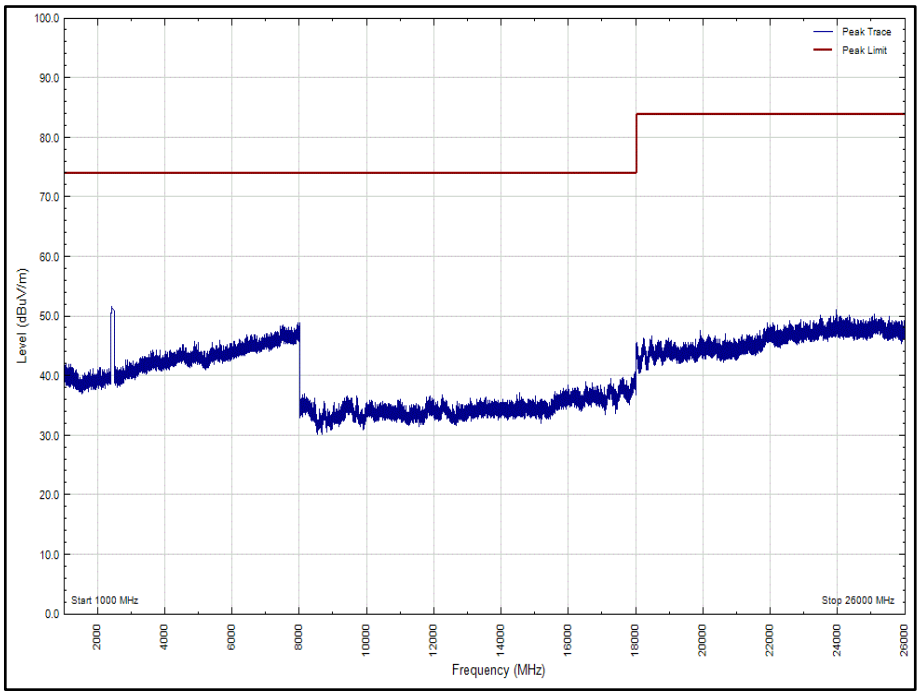

Figure 77 - 802.11b, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

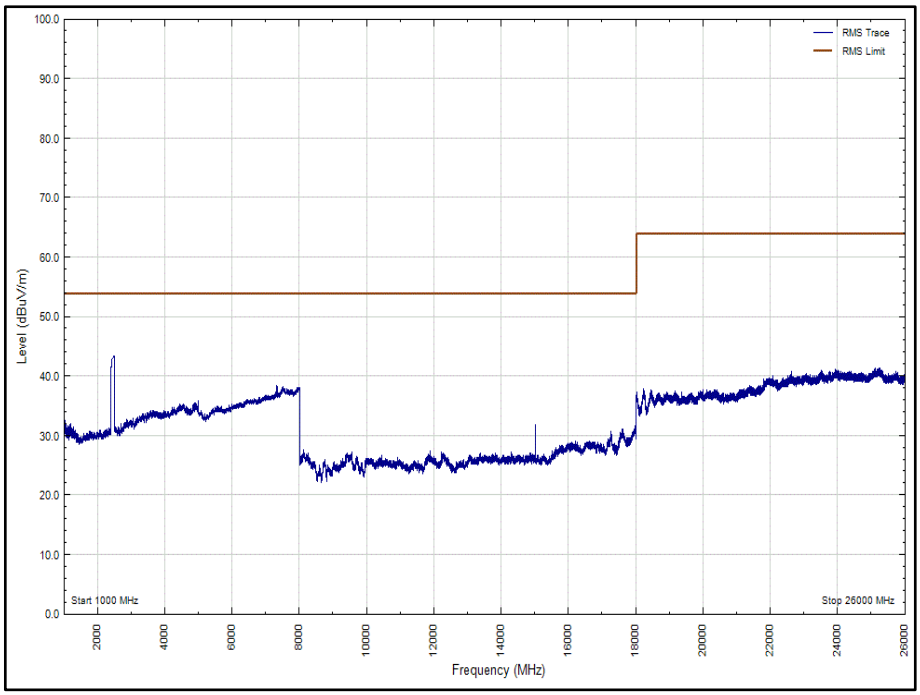

Figure 78 - 802.11b, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Average

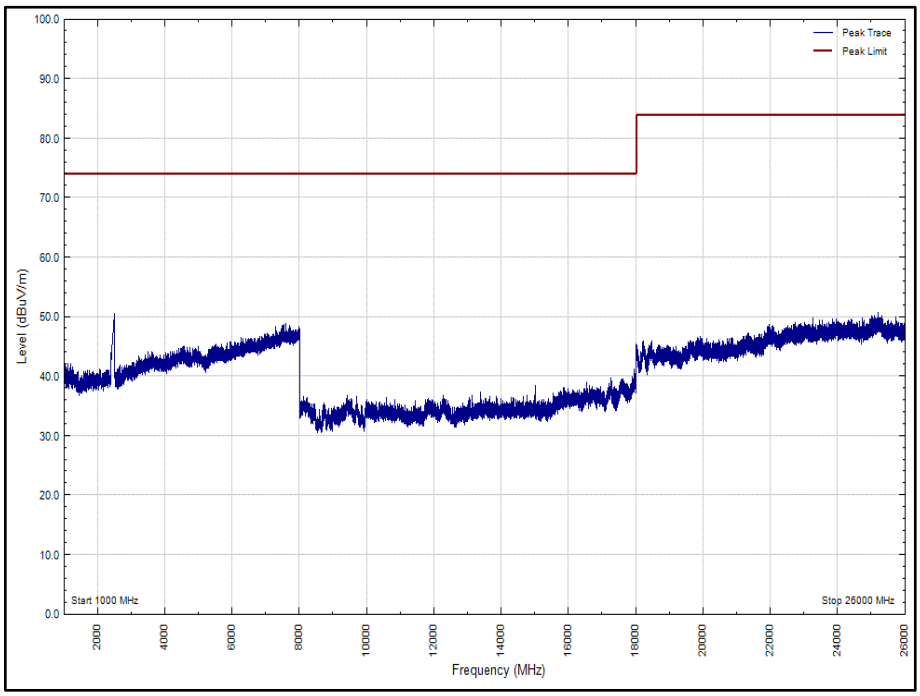

Figure 79 - 802.11b, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

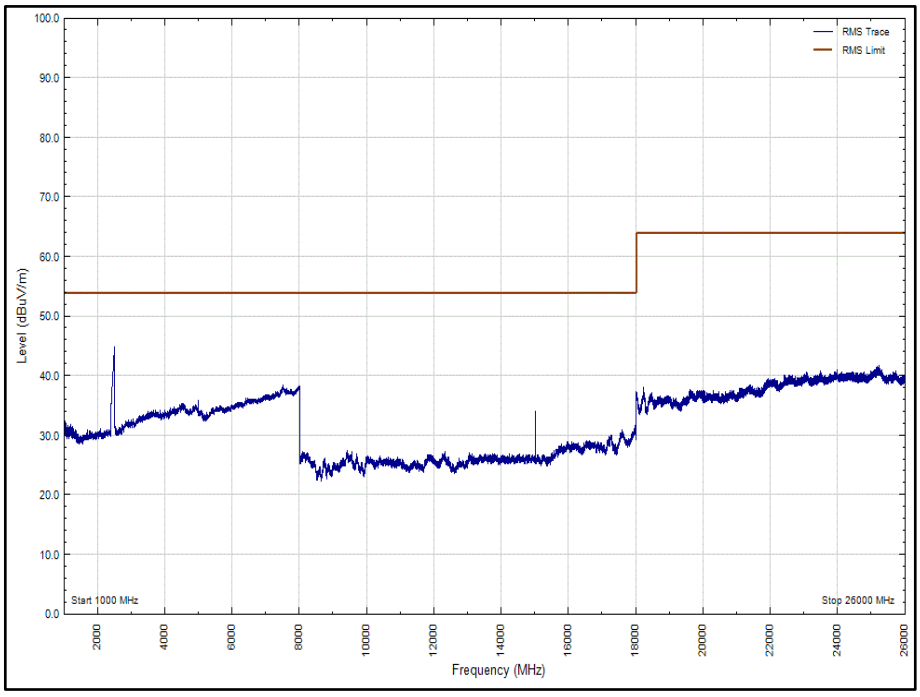

Figure 80 - 802.11b, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

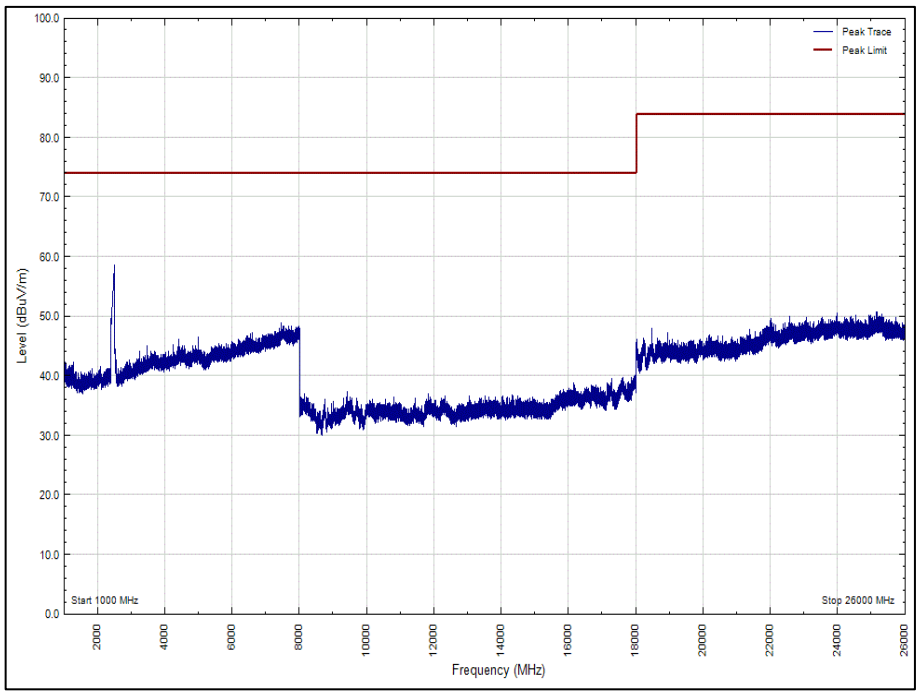

Figure 81 - 802.11b, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

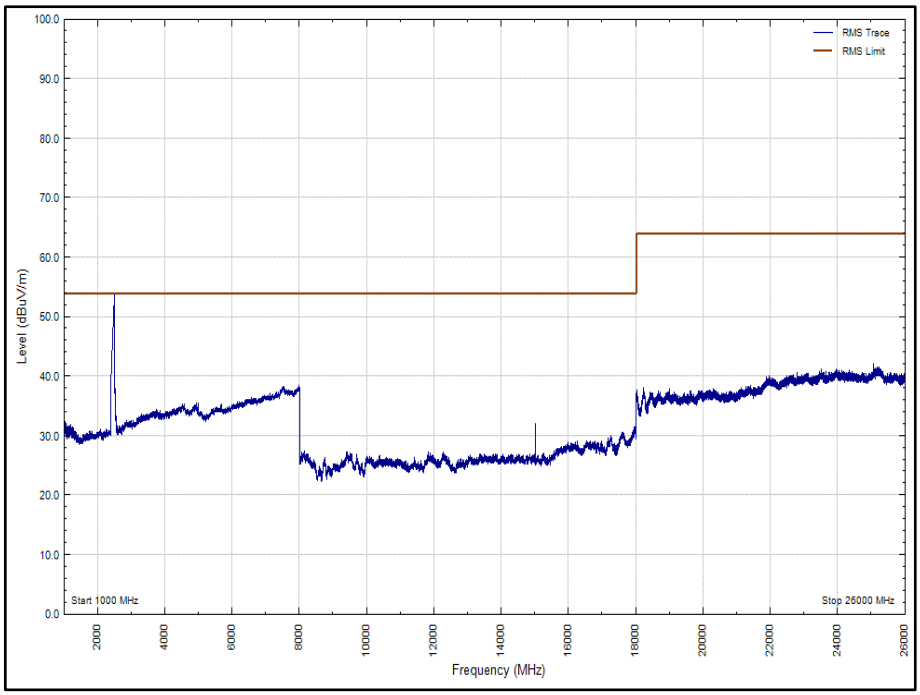

Figure 82 - 802.11b, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical - Average

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 43 – 802.11g, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
*				

Table 44 - 802.11g, Core 0-1, 2442 MHz - 30 MHz to 1000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 45 – 802.11g, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 46 – 802.11g, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

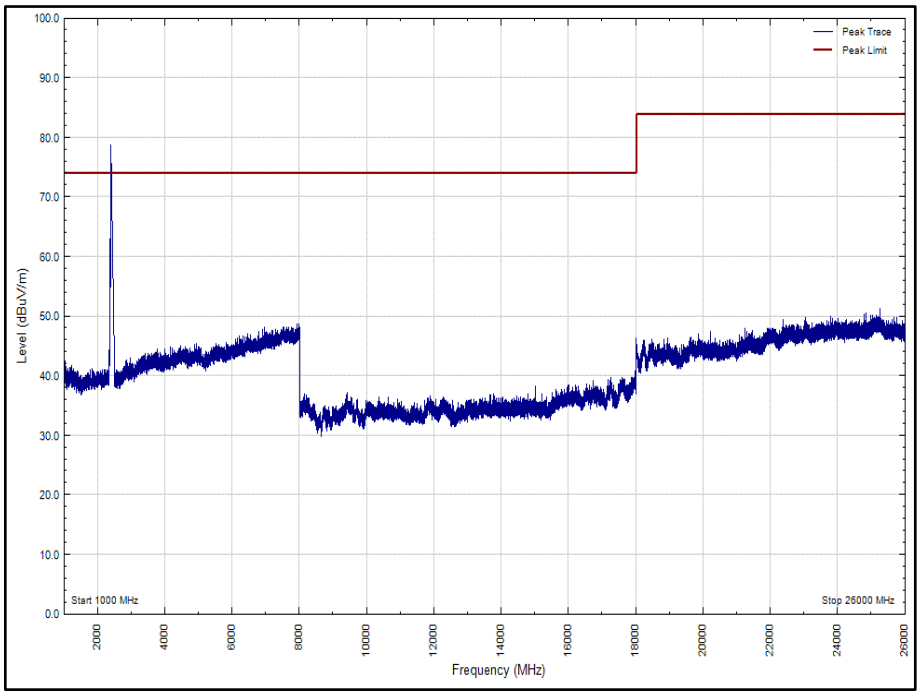

Figure 83 - 802.11g, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

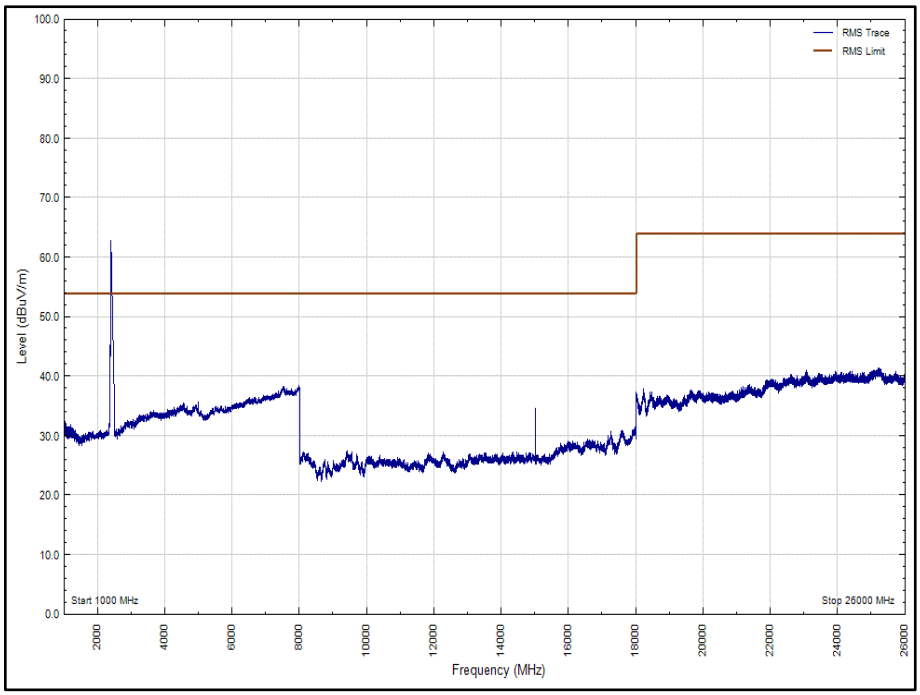

Figure 84 - 802.11g, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

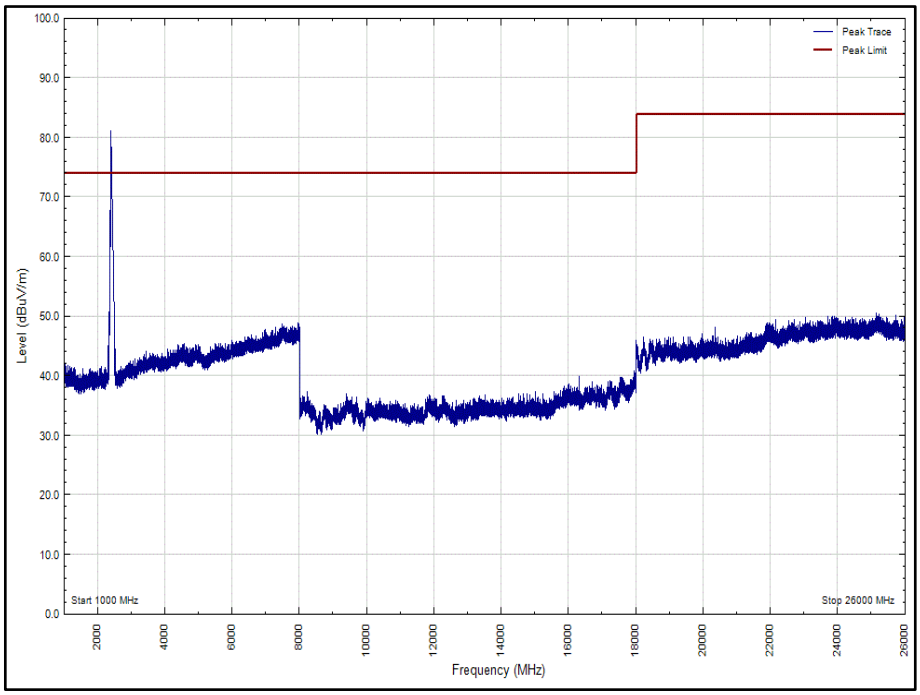

Figure 85 - 802.11g, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

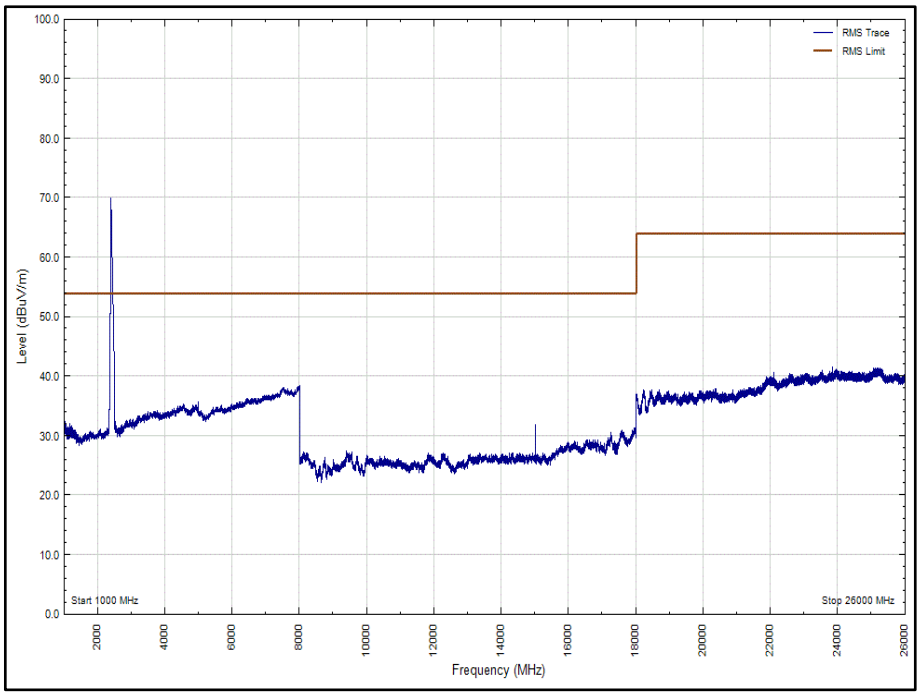

Figure 86 - 802.11g, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Average

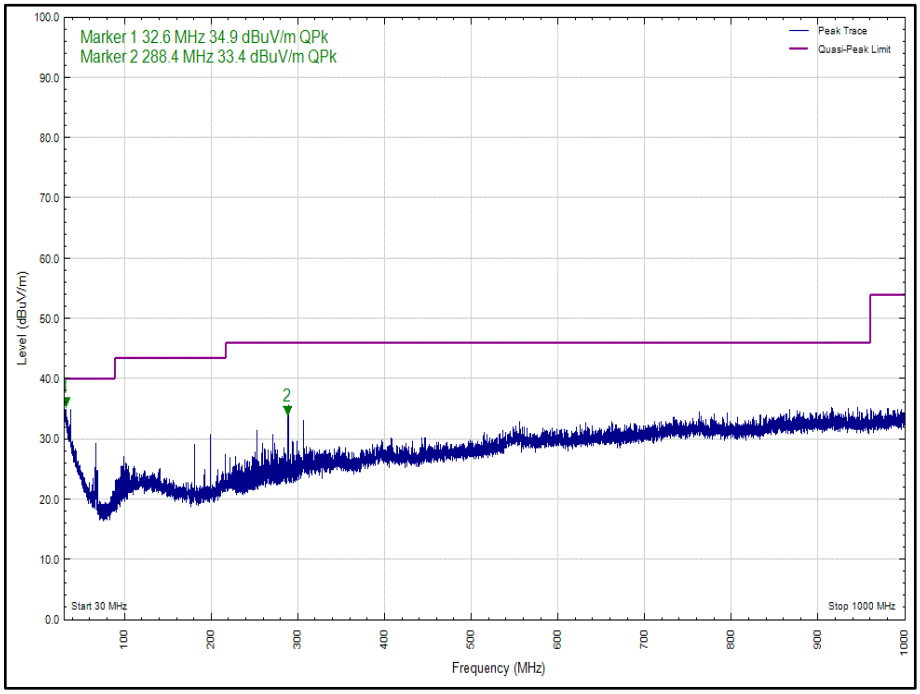

Figure 87 - 802.11g, Core 0-1, 2442 MHz – 30 MHz to 1000 MHz, Horizontal – Peak

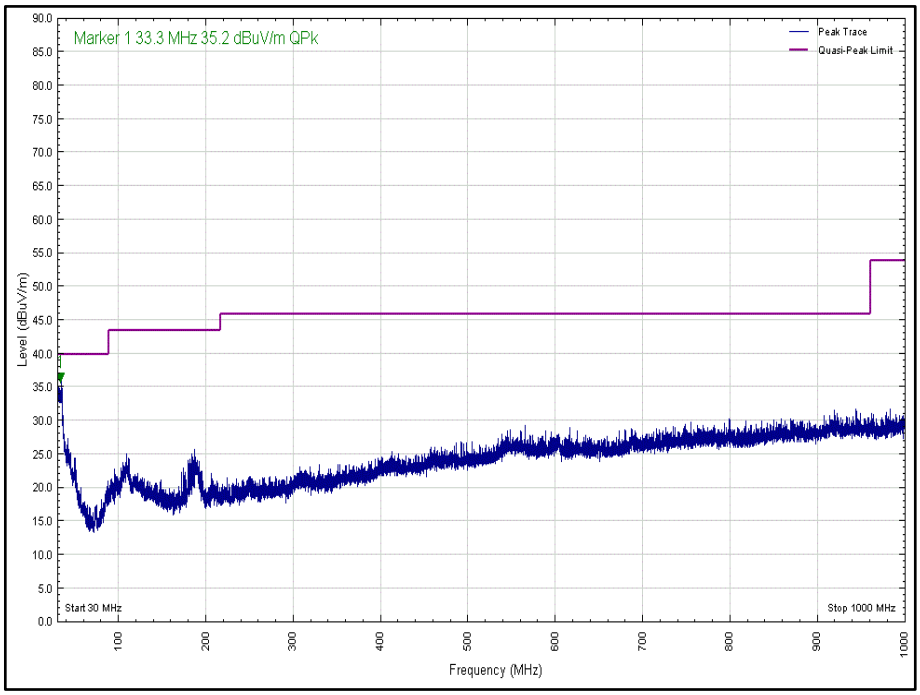

Figure 88 - 802.11g, Core 0-1, 2442 MHz – 30MHz to 1000 MHz, Vertical – Peak

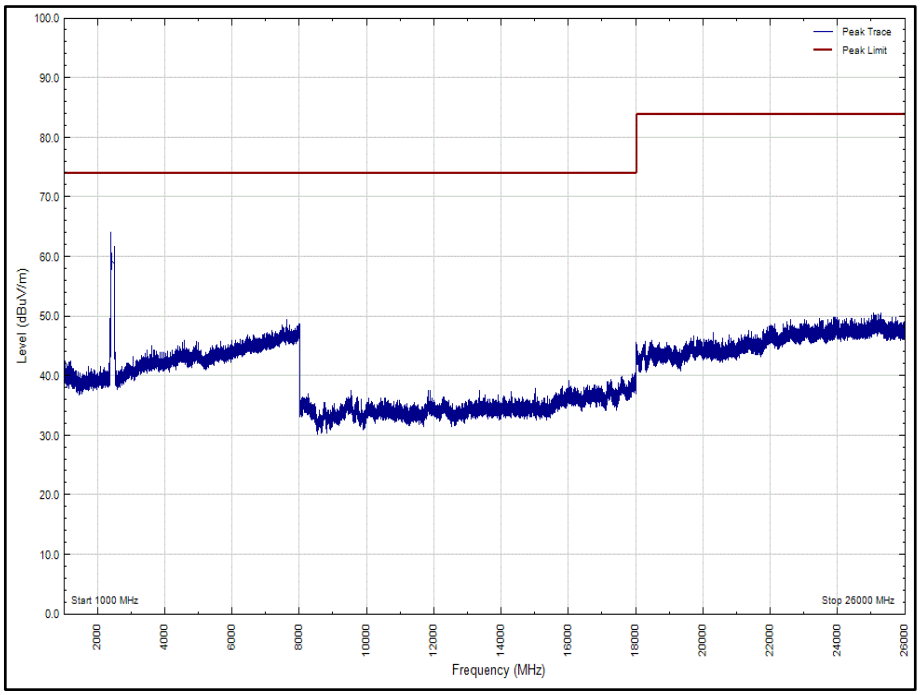

Figure 89 - 802.11g, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

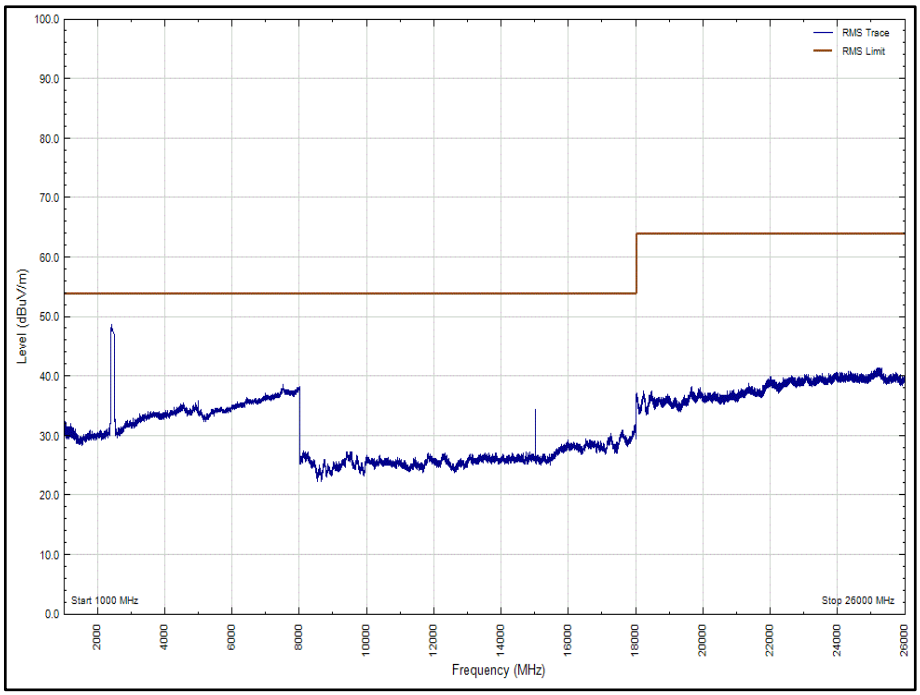

Figure 90 - 802.11g, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal - Average

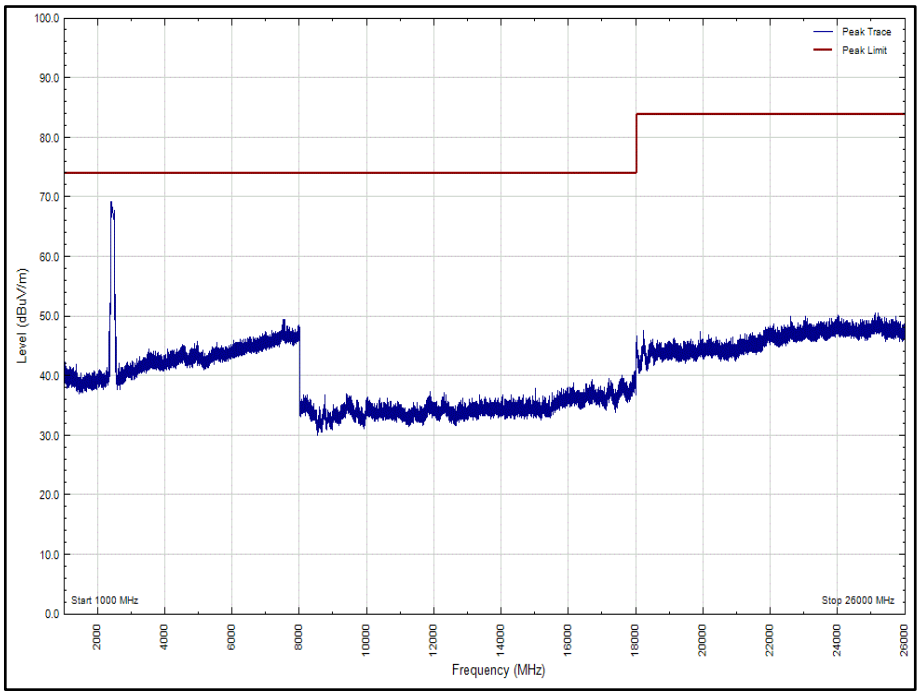

Figure 91 - 802.11g, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

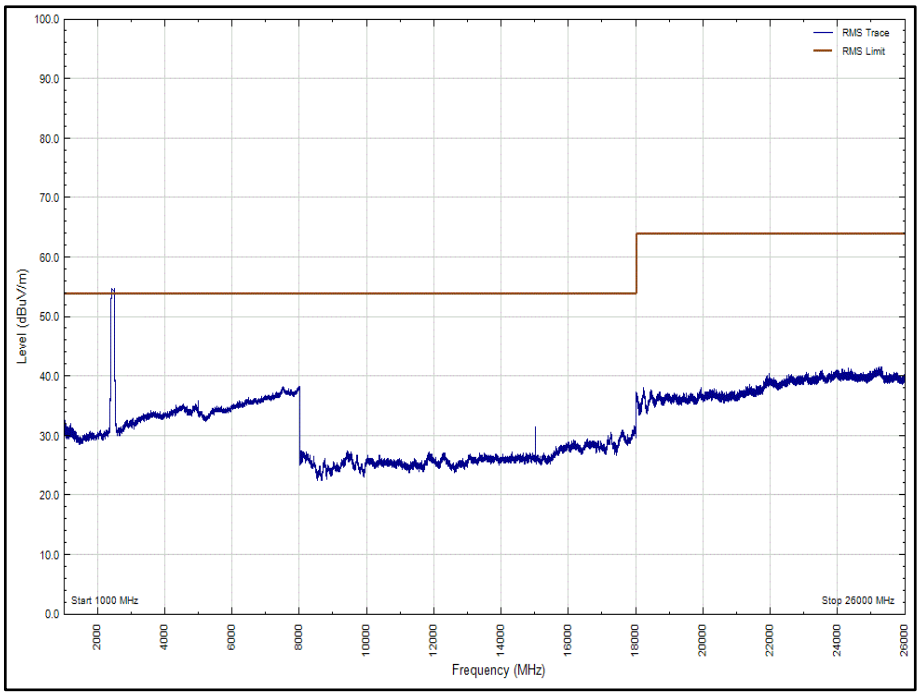

Figure 92 - 802.11g, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Average

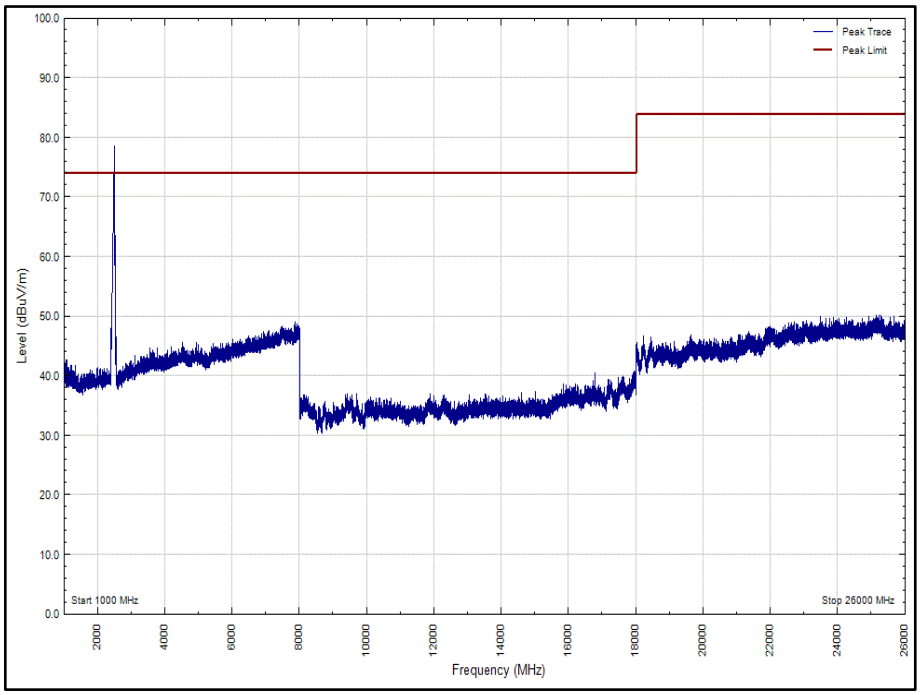

Figure 93 - 802.11g, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

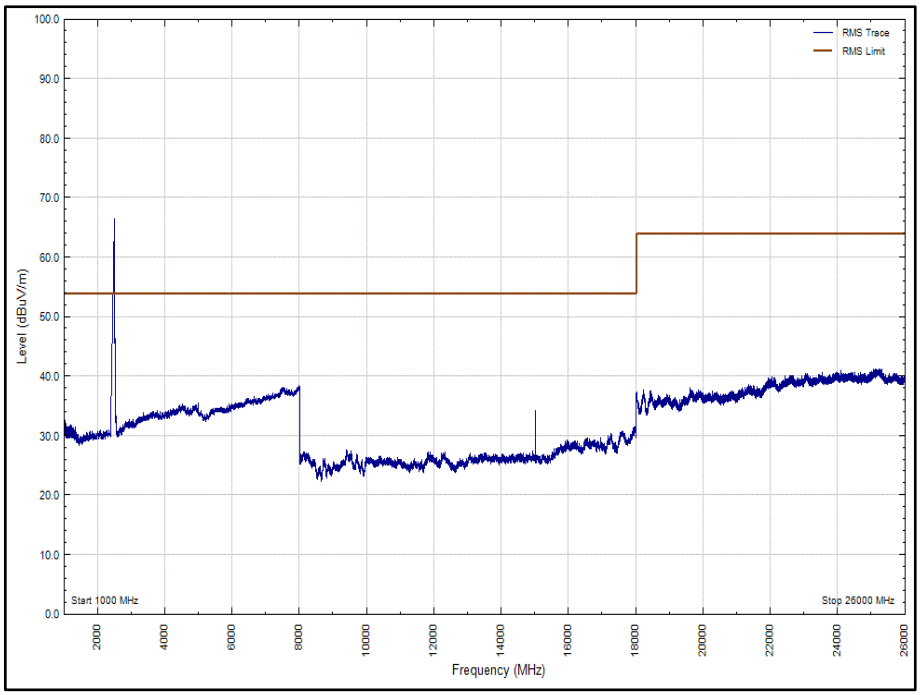

Figure 94 - 802.11g, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

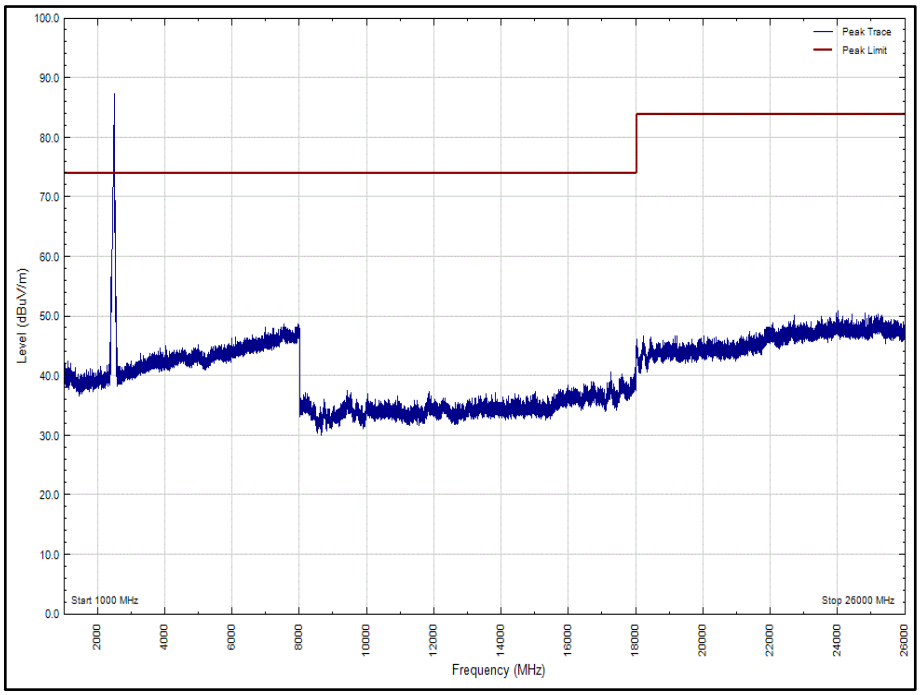

Figure 95 - 802.11g, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

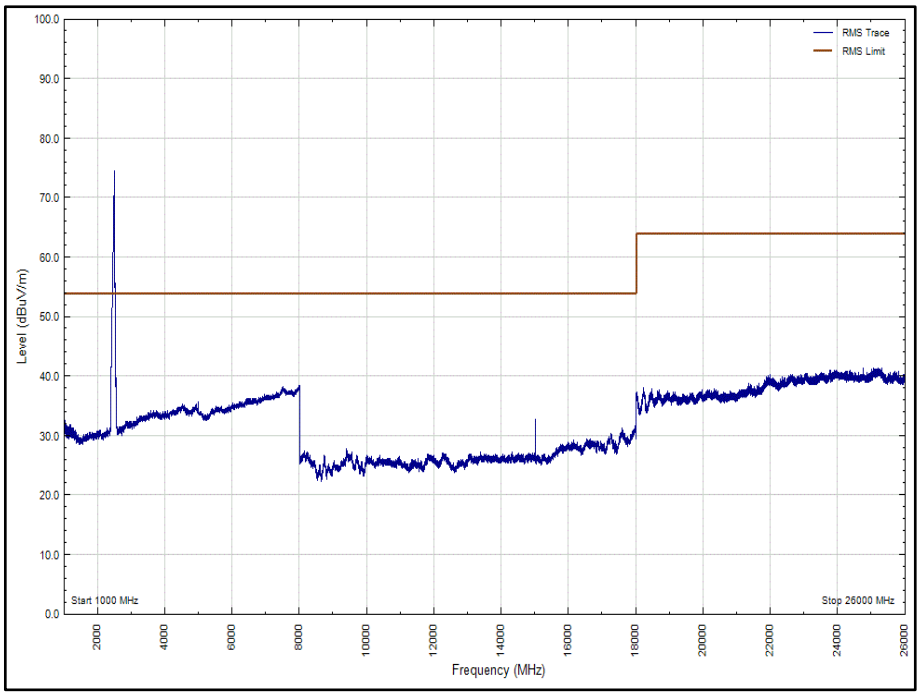

Figure 96 - 802.11g, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical - Average

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 47 – 802.11n, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
*				

Table 48 - 802.11n, Core 0-1, 2442 MHz - 30 MHz to 1000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 49 – 802.11n, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

Frequency (MHz)	Level (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 50 – 802.11n, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz

*No emissions were detected within 10 dB of the limit.

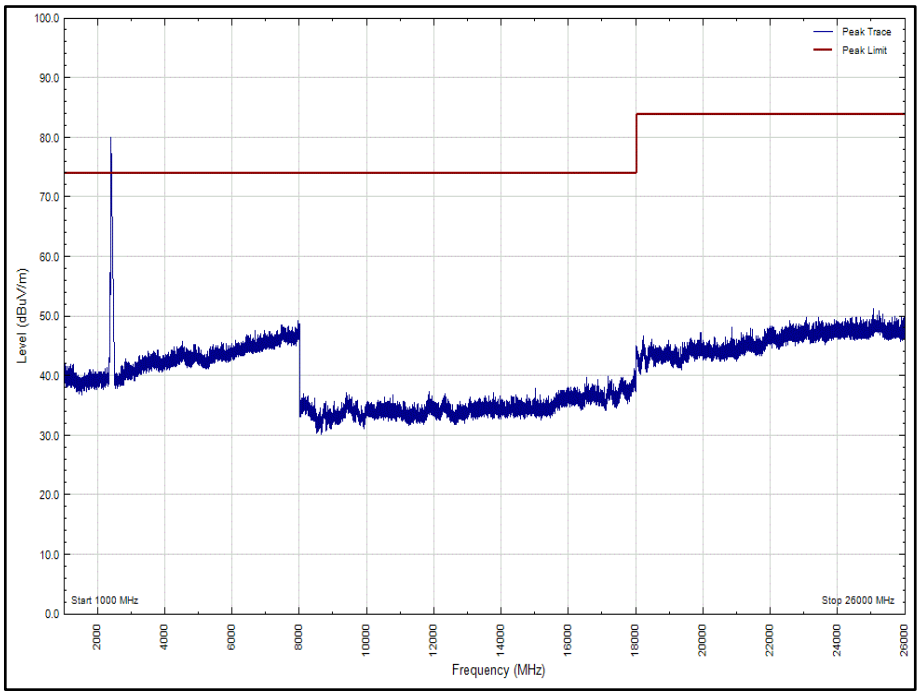

Figure 97 - 802.11n, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

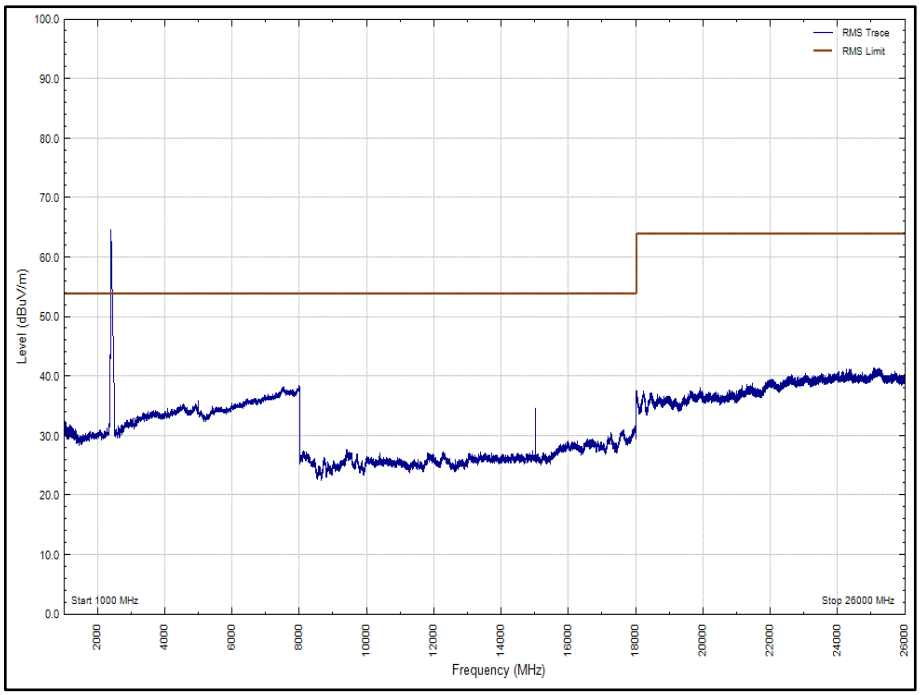

Figure 98 - 802.11n, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Horizontal - Average

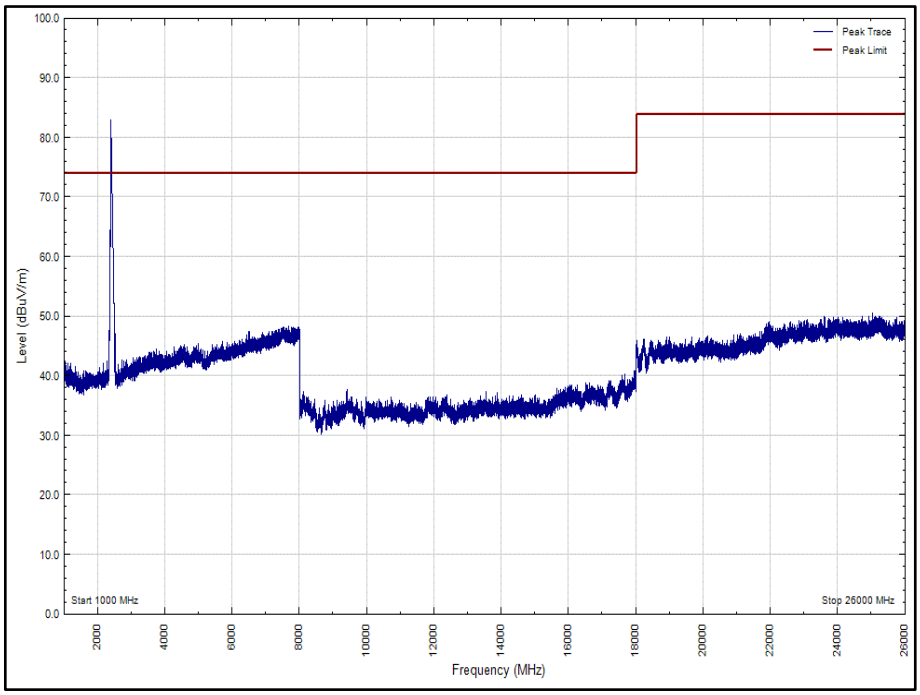

Figure 99 - 802.11n, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

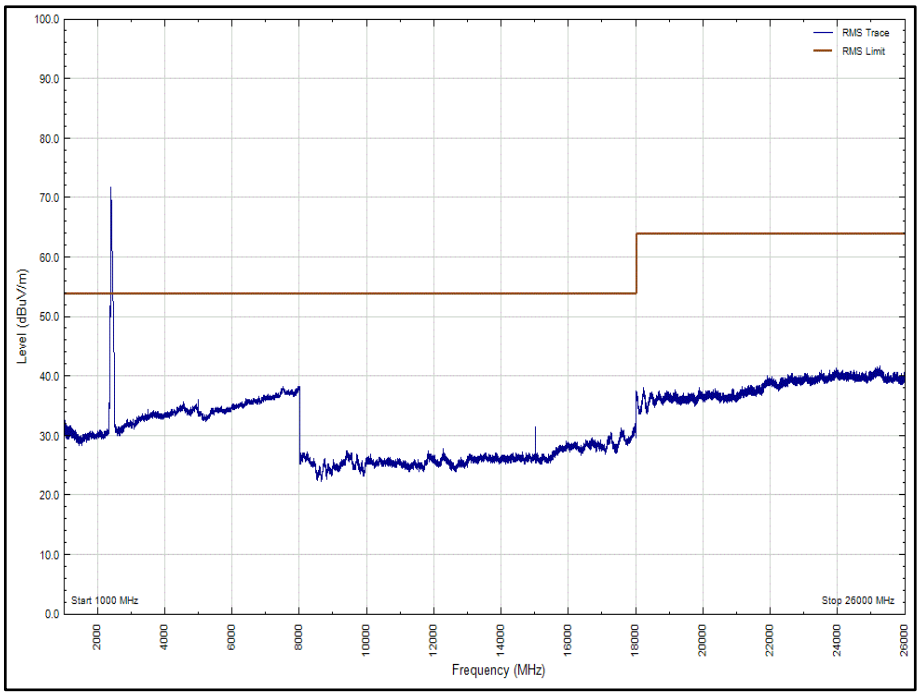

Figure 100 - 802.11n, Core 0-1, 2412 MHz - 1000 MHz to 26000 MHz, Vertical – Average

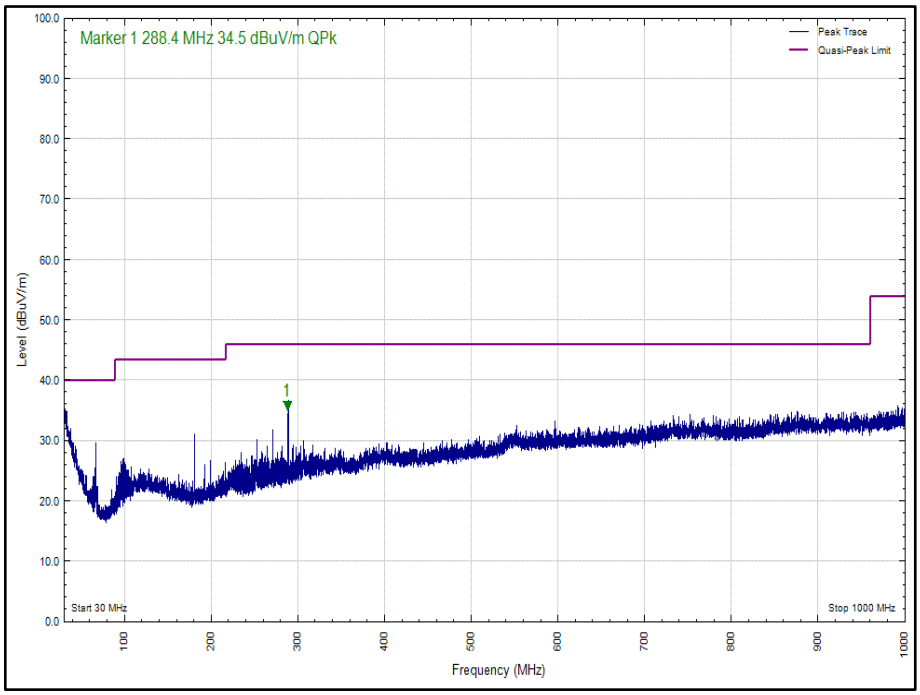

Figure 101 - 802.11n, Core 0-1, 2442 MHz – 30 MHz to 1000 MHz, Horizontal – Peak

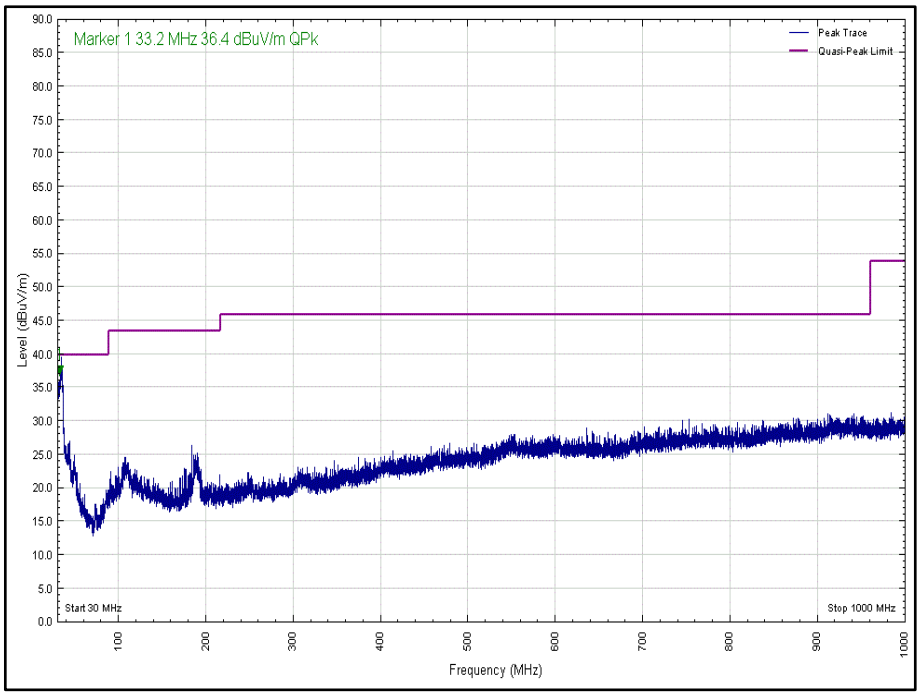

Figure 102 - 802.11n, Core 0-1, 2442 MHz – 30MHz to 1000 MHz, Vertical – Peak

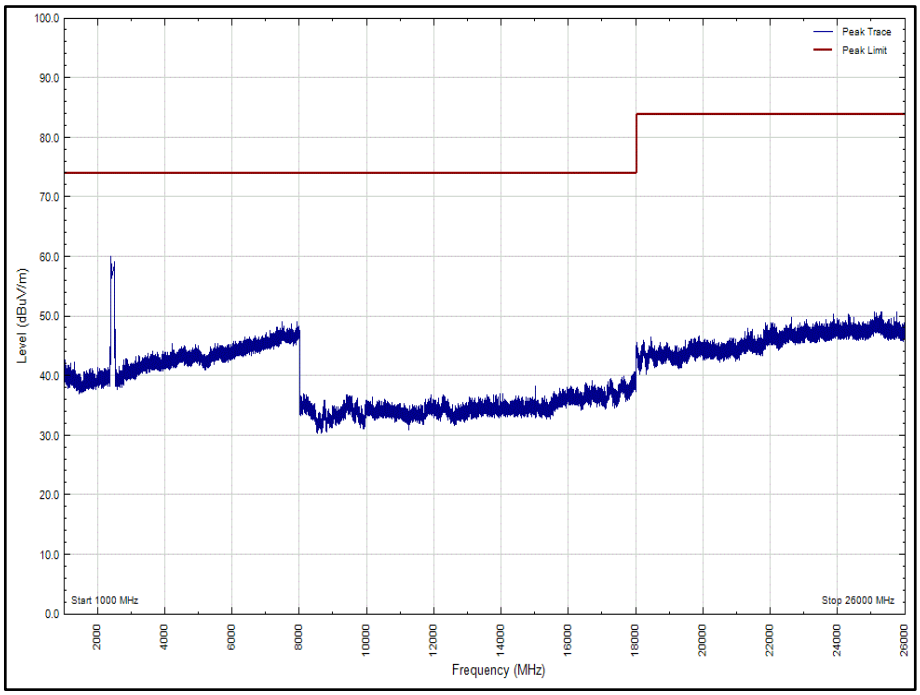

Figure 103 - 802.11n, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

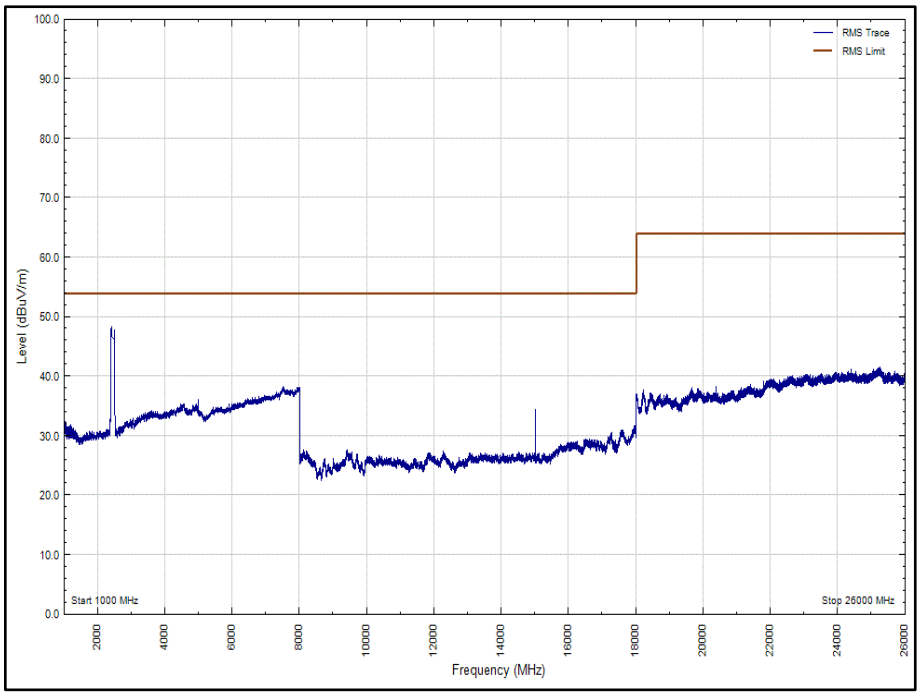

Figure 104 - 802.11n, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

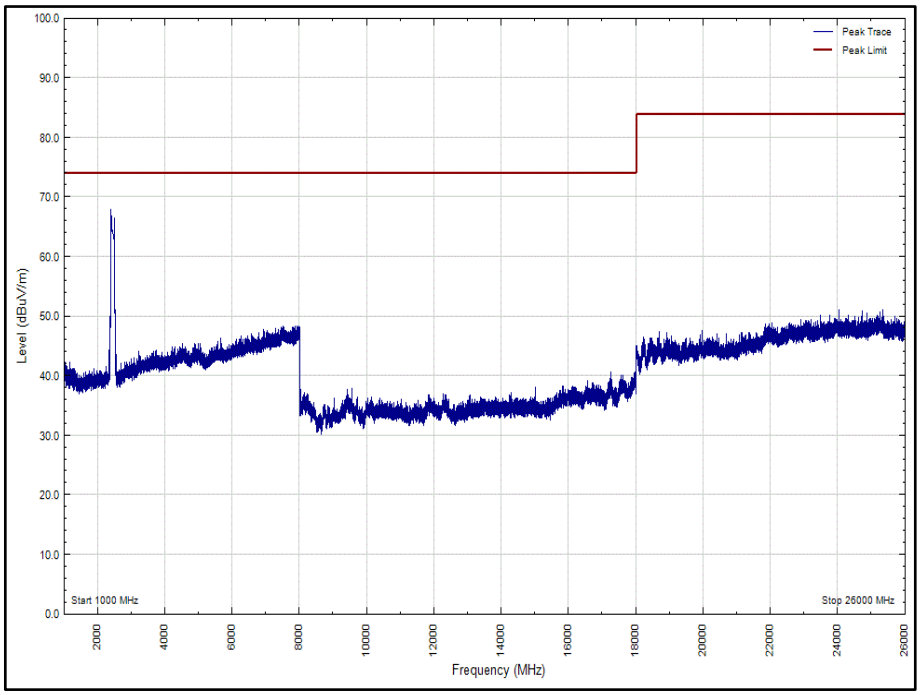

Figure 105 - 802.11n, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

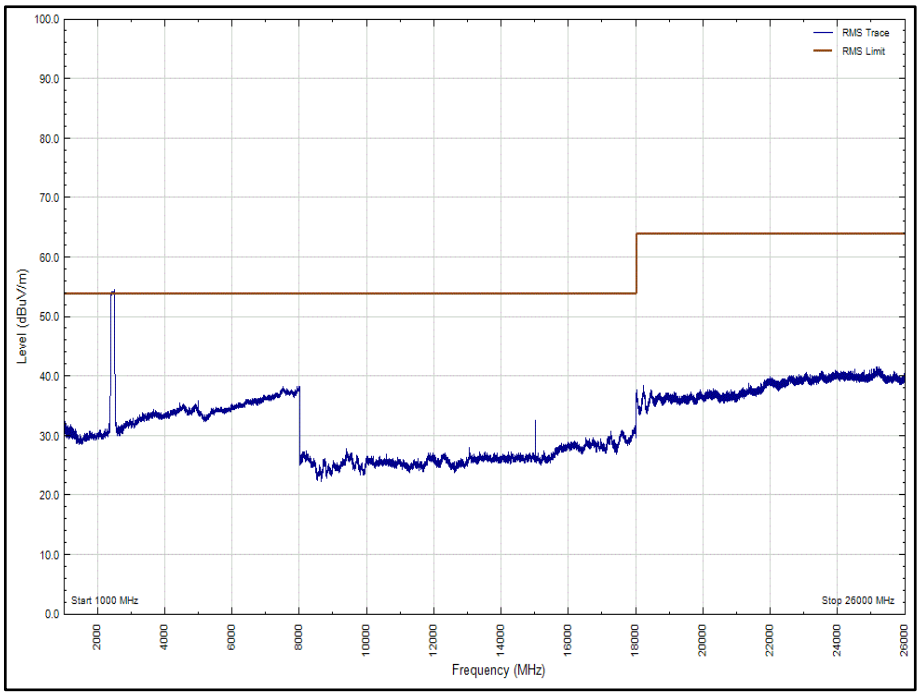

Figure 106 - 802.11n, Core 0-1, 2442 MHz - 1000 MHz to 26000 MHz, Vertical – Average

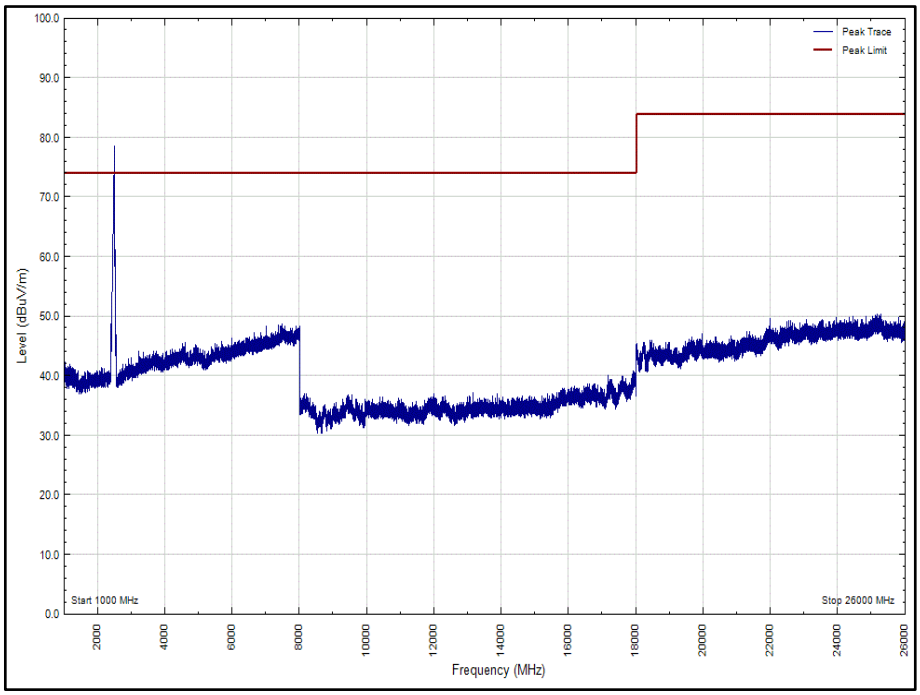

Figure 107 - 802.11n, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Peak

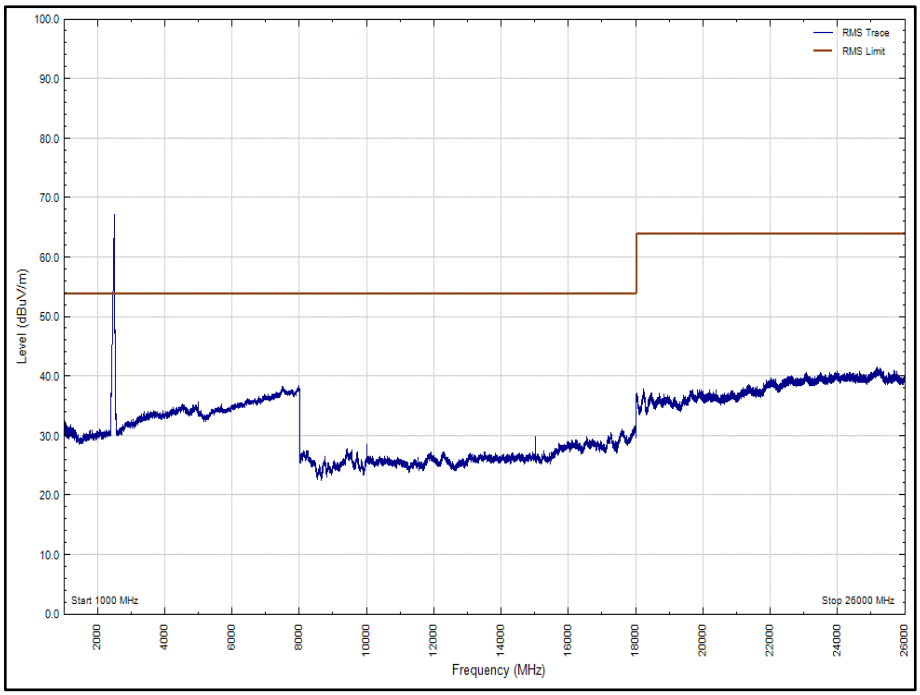

Figure 108 - 802.11n, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Horizontal – Average

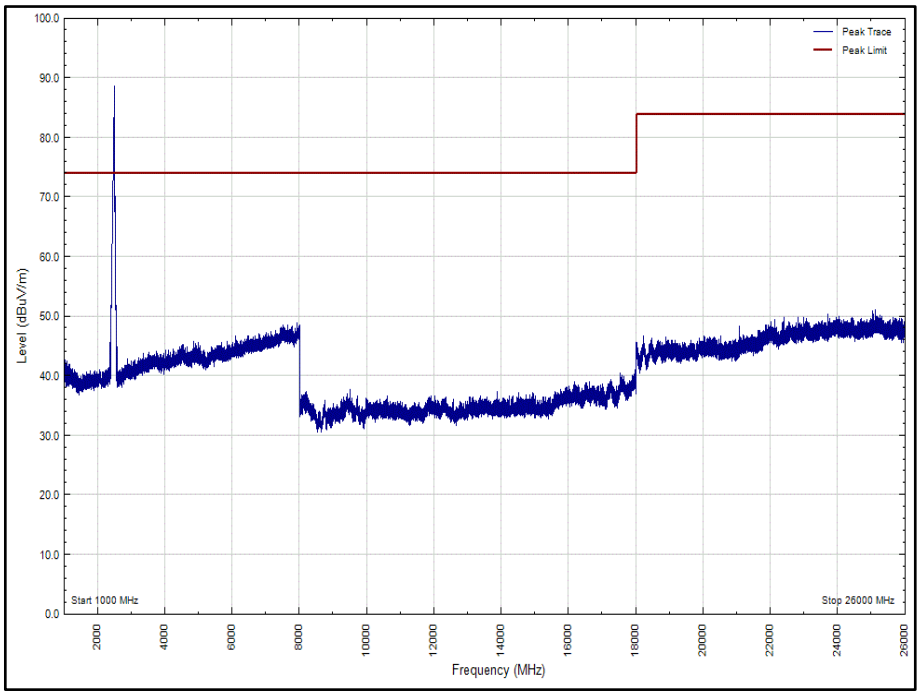

Figure 109 - 802.11n, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical – Peak

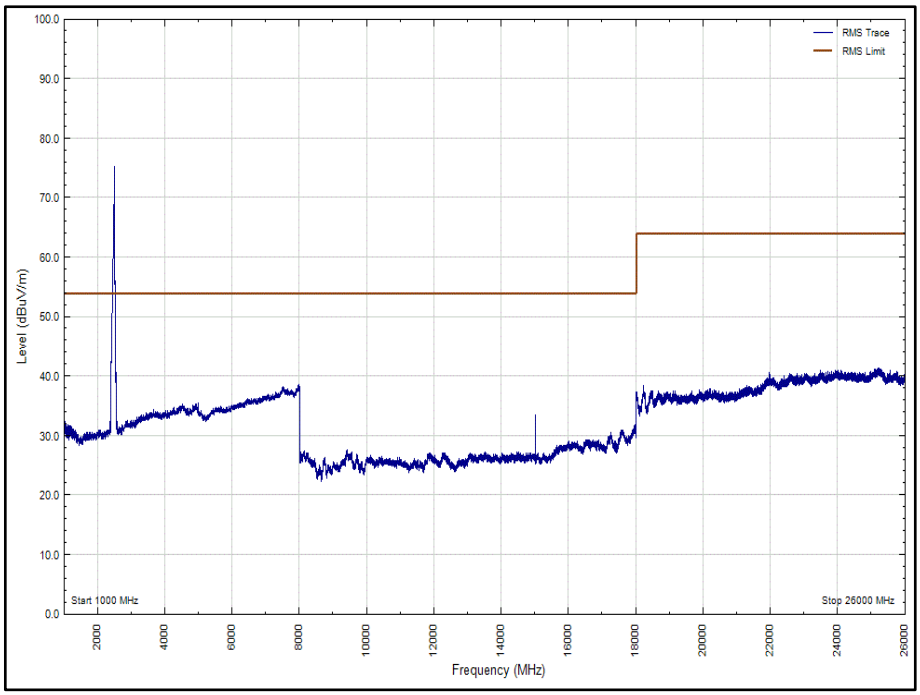

Figure 110 - 802.11n, Core 0-1, 2472 MHz - 1000 MHz to 26000 MHz, Vertical - Average

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in 15.209(a)

ISEDC RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna with permanent attenuator (Bilog)	Schaffner	CBL6143	287	24	15-May-2020
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
Pre-Amplifier	Phase One	PS04-0086	1533	12	08-Feb-2020
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
High Pass Filter (4GHz)	K&L Microwave	11SH10-4000/X18000-0/0	4599	12	05-Sep-2020
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Band Reject Filter - 2.425 GHz	Wainwright	WRCGV14-2390-2400-2450-2460-50SS	5066	12	01-Oct-2020
Band Reject Filter - 2.425 GHz	Wainwright	WRCGV14-2390-2400-2450-2460-50SS	5067	12	01-Oct-2020
Band Reject Filter - 2.4585 GHz	Wainwright	WRCGV14-2423.5-2433.5-2483.5-2493.5-50SS	5068	12	01-Oct-2020
Band Reject Filter - 2.4585 GHz	Wainwright	WRCGV14-2423.5-2433.5-2483.5-2493.5-50SS	5069	12	01-Oct-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5095	12	04-Dec-2019*
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
EmX Emissions Software	TUV SUD	EmX	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8m N-Type RF Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
DRG Horn Antenna (7.5-18GHz)	Schwarzbeck	HWRD750	5216	12	11-Mar-2020
Horn Antenna (15-40GHz)	Schwarzbeck	BBHA 9170	5217	12	09-Apr-2020
Preamplifier (30 dB 18-40GHz)	Schwarzbeck	BBV 9721	5218	12	09-Apr-2020

Table 51

TU - Traceability Unscheduled

3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Restricted Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Authorised Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Emission Bandwidth	± 530036.80 Hz
Power Spectral Density	± 3.2 dB
Maximum Conducted Output Power	± 3.2 dB

Table 52

Measurement Uncertainty Decision Rule

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115: 2007, clause 4.4.3 and 4.5.1.