

FCC and ISED Test Report

Apple Inc
Model: A2337

In accordance with FCC 47 CFR Part 15C, ISED
RSS-247 and ISED RSS-GEN (2.4 GHz WLAN)

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

FCC ID: BCGA2337 IC: 579C-A2337

COMMERCIAL-IN-CONFIDENCE

Document 75949395-11 Issue 01



Add value.
Inspire trust.

SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Simon Bennett	Innovations Manager	Authorised Signatory	13 October 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, ISED RSS-247 and ISED 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	13 October 2020	
Testing	Philip Harrison	13 October 2020	
Testing	Liang Tian	13 October 2020	
Testing	Connor Lee	13 October 2020	
Testing	Aasim Butt	13 October 2020	
Testing	Graeme Lawler	13 October 2020	
Testing	Mohammad Malik	13 October 2020	
Testing	Faisal Malyar	13 October 2020	
Testing	Ahmad Javid	13 October 2020	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

ISED 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: 2019, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) for the tests detailed in section 1.3.



DISCLAIMER AND COPYRIGHT

This non-binding report has been prepared by TÜV SÜD with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD. No part of this document may be reproduced without the prior written approval of TÜV SÜD. © 2020 TÜV SÜD. This report relates only to the actual item/items tested.

ACCREDITATION

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation. Results of tests not covered by our UKAS Accreditation Schedule are marked NUA (Not UKAS Accredited).

TÜV SÜD
is a trading name of TÜV SÜD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TÜV SÜD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuv-sud.co.uk

TÜV SÜD
Octagon House
Concorde Way
Fareham
Hampshire PO15 5RL
United Kingdom



Contents

1	Report Summary	2
1.1	Report Modification Record.....	2
1.2	Introduction.....	2
1.3	Brief Summary of Results	3
1.4	Product Information	4
1.5	Deviations from the Standard.....	5
1.6	EUT Modification Record	5
1.7	Test Location	6
2	Test Details	7
2.1	Emission Bandwidth	7
2.2	Maximum Conducted Output Power	39
2.3	Authorised Band Edges	44
2.4	Restricted Band Edges.....	52
2.5	Spurious Radiated Emissions	73
2.6	Power Spectral Density.....	111
3	Measurement Uncertainty	118



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	13 October 2020

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2337
Serial Number(s)	C02D200EQ9MQ and C02D200WQ9MQ
Hardware Version(s)	REV 1.0
Software Version(s)	20A523220f
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2019 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019)
Order Number	0540196335
Date	29-June-2020
Date of Receipt of EUT	23-July-2020 and 18-August-2020
Start of Test	02-August-2020
Finish of Test	17-September-2020
Name of Engineer(s)	George Porter, Philip Harrison, Liang Tian, Connor Lee, Aasim Butt, Graeme Lawler, Mohammad Malik, Faisal Malyar and Ahmad Javid
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, ISED RSS-247 and ISED 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						
-	15.203	-	-	Antenna Requirement	N/T	The devices complies with the provisions of this section, as it uses a permanently attached antenna
2.1	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	
2.2	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.3	15.247 (d)	5.5	-	Authorised Band Edges	Pass	
2.4	15.205	-	8.10	Restricted Band Edges	Pass	
2.5	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	
2.6	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	

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/ax capabilities in the 2.4 GHz and 5 GHz bands

1.4.2 Test Modes

The 2.4 GHz 802.11 radio supports SISO and 2x2 MIMO. 802.11b and 802.11g only supports SISO operation. 802.11n and 802.11ax are supported for both SISO and 2x2 MIMO at 20 MHz channel bandwidths only. 802.11ax supports Single User (SU) and Multi-User MIMO (MU-MIMO) modes. MU-MIMO modes support Resource Unit (RU) sizes of 26/52/106/242 subcarriers.

The EUT uses different output powers per core dependent on how many cores are used. It uses the same conducted power across all cores in any given mode, but due to the different antenna gains the radiated power per core differs.

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

- SISO Modes (Core 1):
 - 802.11b 1 Mbps
 - 802.11g 6 Mbps
 - 802.11n HT20 MCS7
 - 802.11ax HE20 MCS7 SU & MU

- 2x2 MIMO Modes (Core 0 + Core 1):
 - 802.11n HT20 MCS7 – CDD
 - 802.11ax HE20 MCS7 CDD SU & MU

For 802.11ax modes, only SU modes (highest power) are reported for Output Power. For Bandwidth tests, only SU modes (widest BW) and MU-MIMO with 26 subcarriers (narrowest) are reported. For Power Spectral Density (PSD), RU sizes of 26 to 106 subcarriers are reported.



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 all tests, 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.

All testing was performed with the EUT powered via a 120 V AC, 60 Hz source.

1.4.4 Antenna Gain Table (2.4GHz WLAN)

Antenna Port	Frequency Range (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
2.4 GHz Core 0	2400 to 2480	4.03	1.0
2.4 GHz Core 1	2400 to 2480	3.22	1.0

Table 3

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: A2337, Serial Number: C02D200WQ9MQ			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2337, Serial Number: C02D200EQ9MQ			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 4



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		
Emission Bandwidth	George Porter and Philip Harrison	UKAS
Maximum Conducted Output Power	George Porter and Philip Harrison	UKAS
Authorised Band Edges	Liang Tian, Connor Lee, Aasim Butt and Graeme Lawler	UKAS
Restricted Band Edges	Liang Tian, Connor Lee, Aasim Butt and Graeme Lawler	UKAS
Spurious Radiated Emissions	Mohammad Malik, Faisal Malyar and Ahmad Javid	UKAS
Power Spectral Density	George Porter and Philip Harrison	UKAS

Table 5

Office Address:

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



2 Test Details

2.1 Emission Bandwidth

2.1.1 Specification Reference

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

2.1.2 Equipment Under Test and Modification State

A2337, S/N: C02D200WQ9MQ - Modification State 0

2.1.3 Date of Test

10-September-2020 to 17-September-2020

2.1.4 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 99% occupied bandwidth.

2.1.5 Environmental Conditions

Ambient Temperature 21.6 - 23.5 °C
Relative Humidity 39.8 - 60.7 %

2.1.6 Test Results

2.4 GHz WLAN

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	8.640	8.100	8.640
99% Bandwidth (MHz)	13.054	12.891	13.041

Table 6 - 802.11b / 1 Mbps / SISO / Core 0

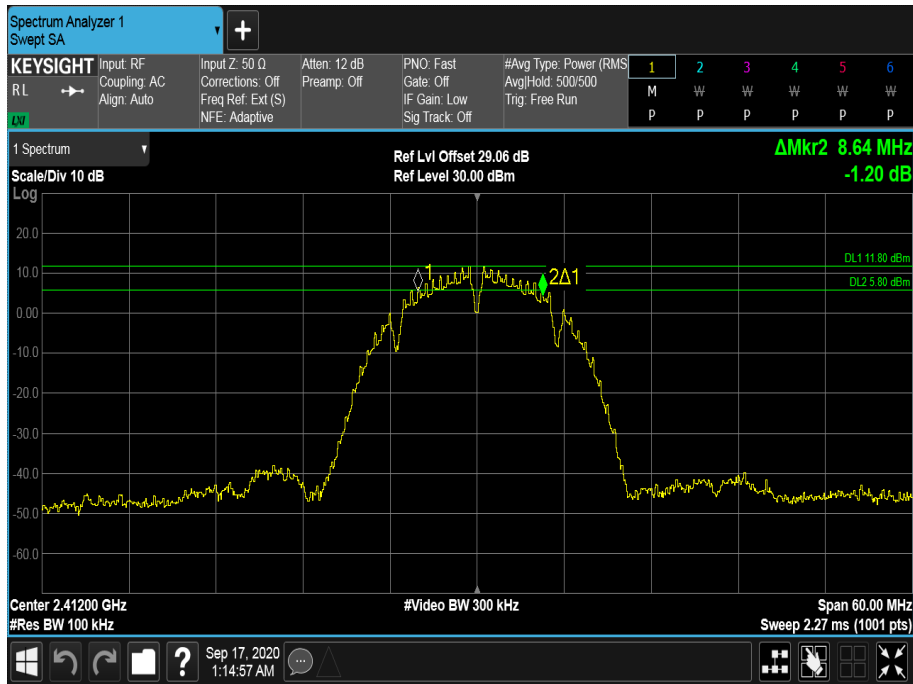


Figure 1 - 2412 MHz - 6 dB DTS Bandwidth

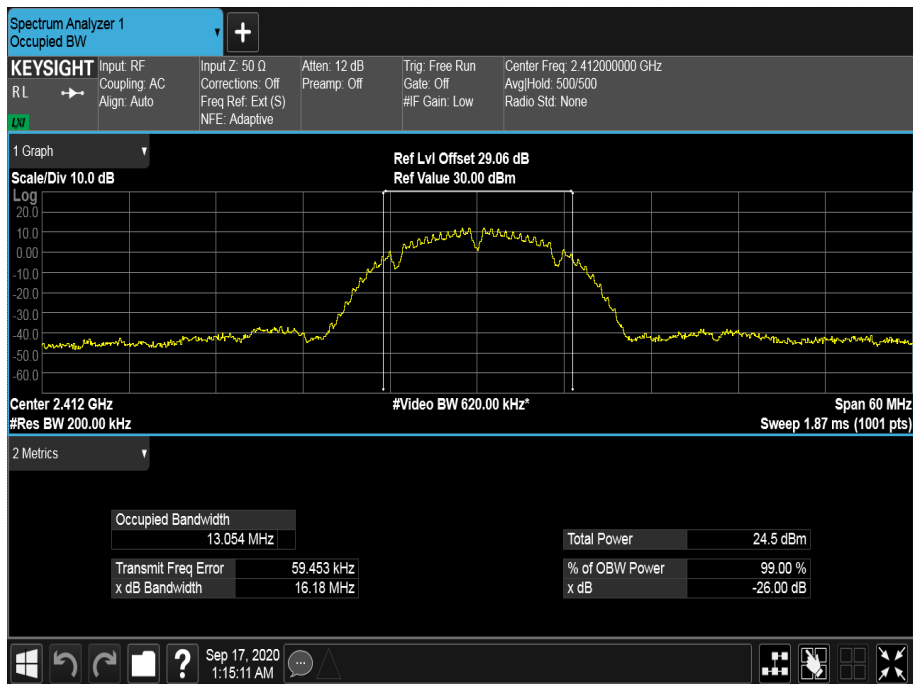


Figure 2 - 2412 MHz - 99% Occupied Bandwidth

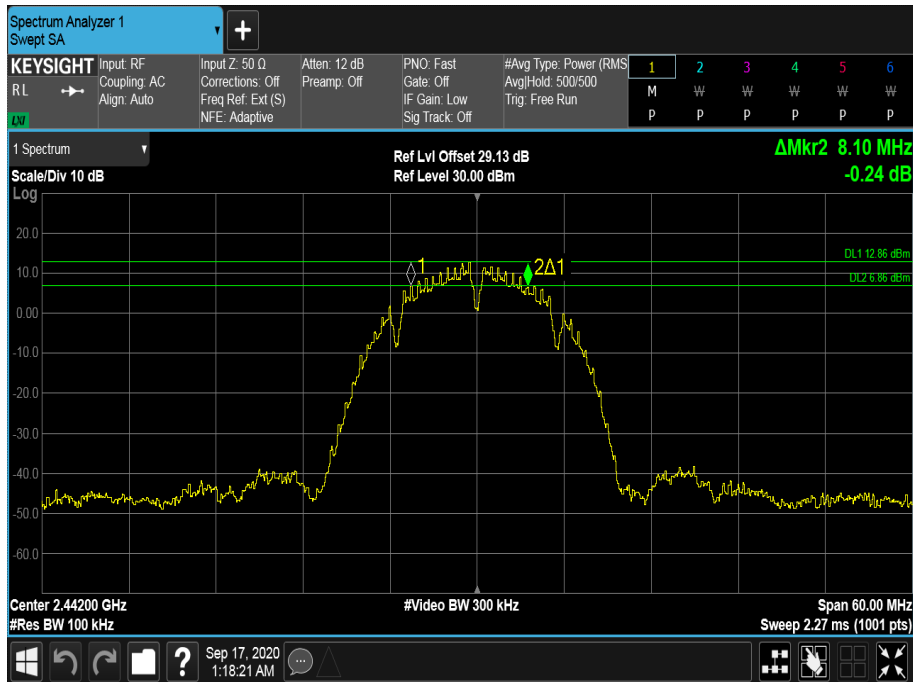


Figure 3 - 2442 MHz - 6 dB DTS Bandwidth

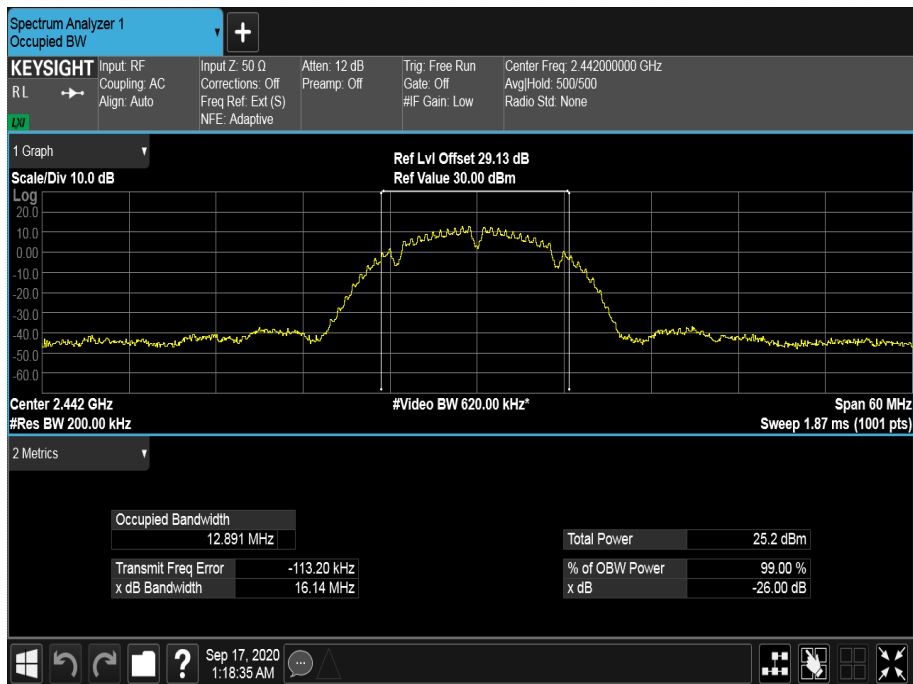


Figure 4 - 2442 MHz - 99% Occupied Bandwidth

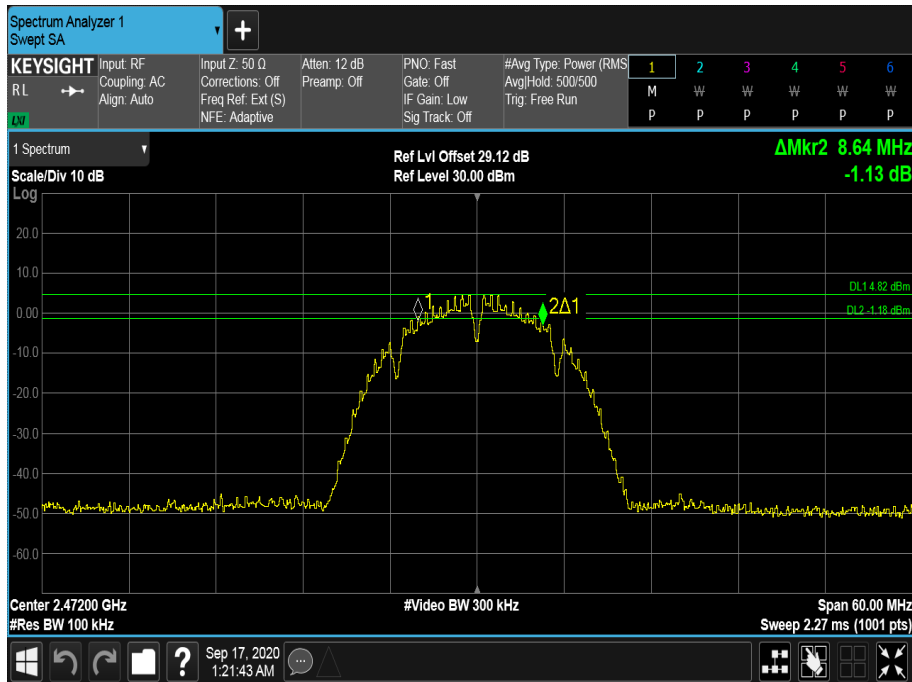


Figure 5 - 2472 MHz - 6 dB DTS Bandwidth

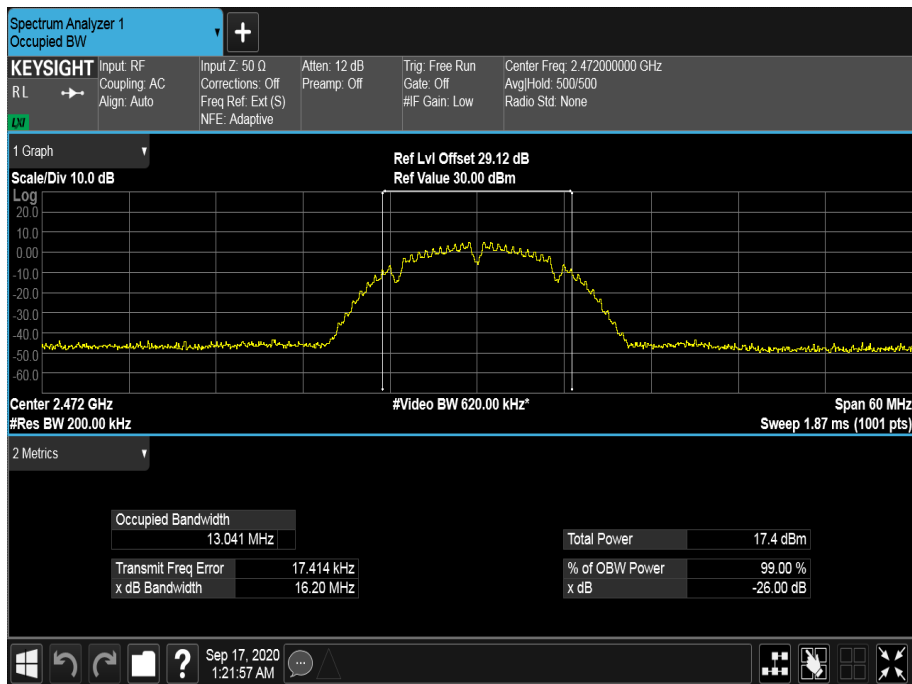


Figure 6 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	15.240	15.480	14.040
99% Bandwidth (MHz)	16.383	16.347	16.318

Table 7 - 802.11g / 6 Mbps / SISO / Core 0

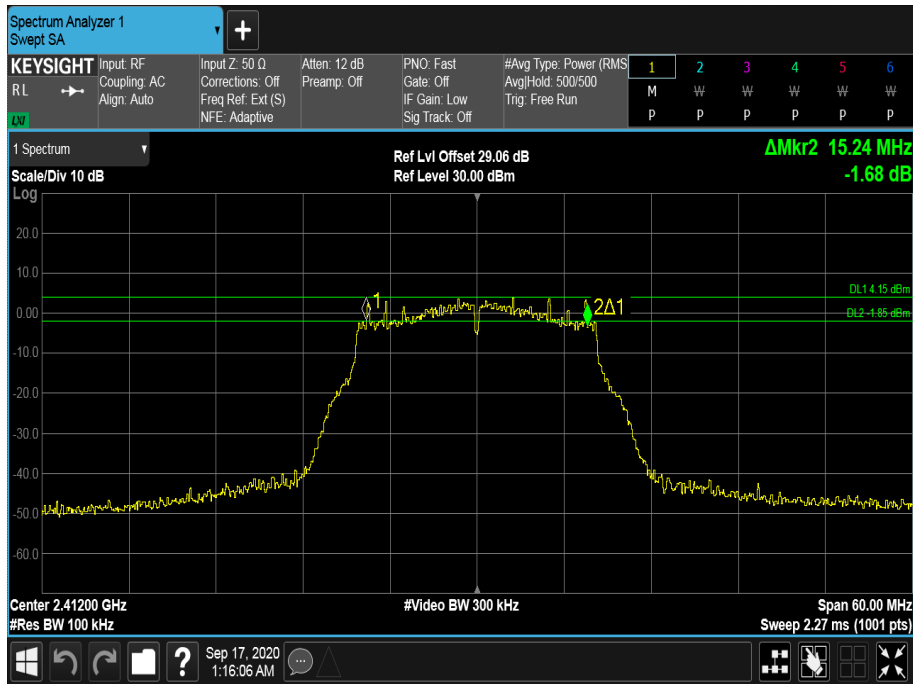


Figure 7 - 2412 MHz - 6 dB DTS Bandwidth

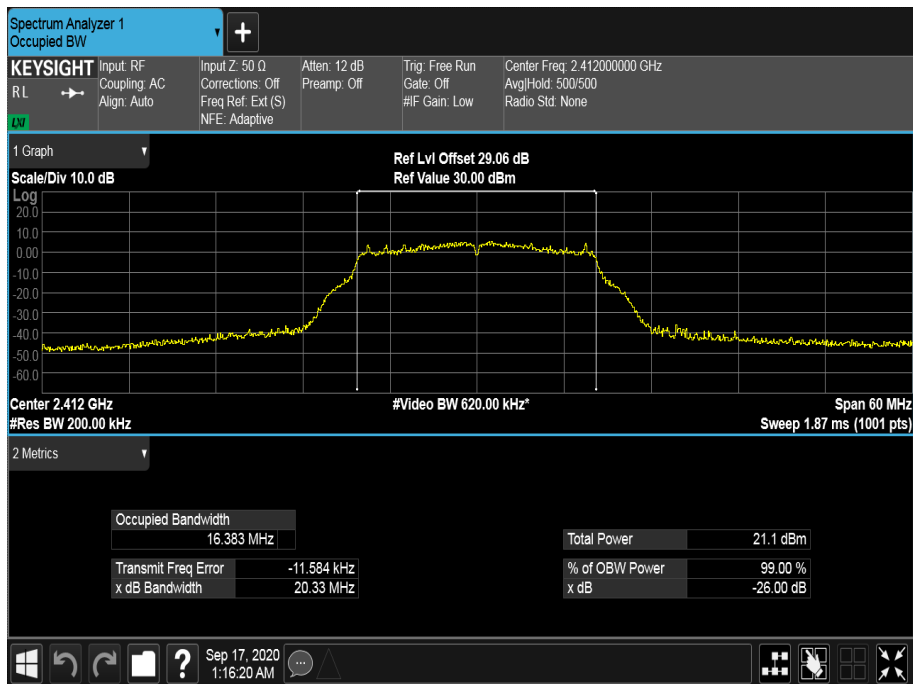


Figure 8 - 2412 MHz - 99% Occupied Bandwidth

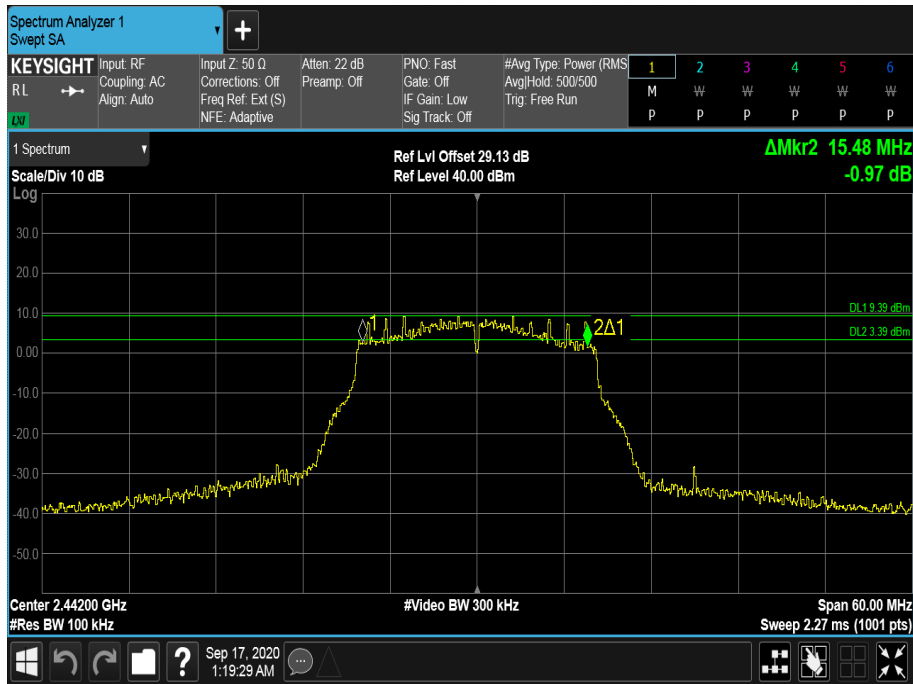


Figure 9 - 2442 MHz - 6 dB DTS Bandwidth

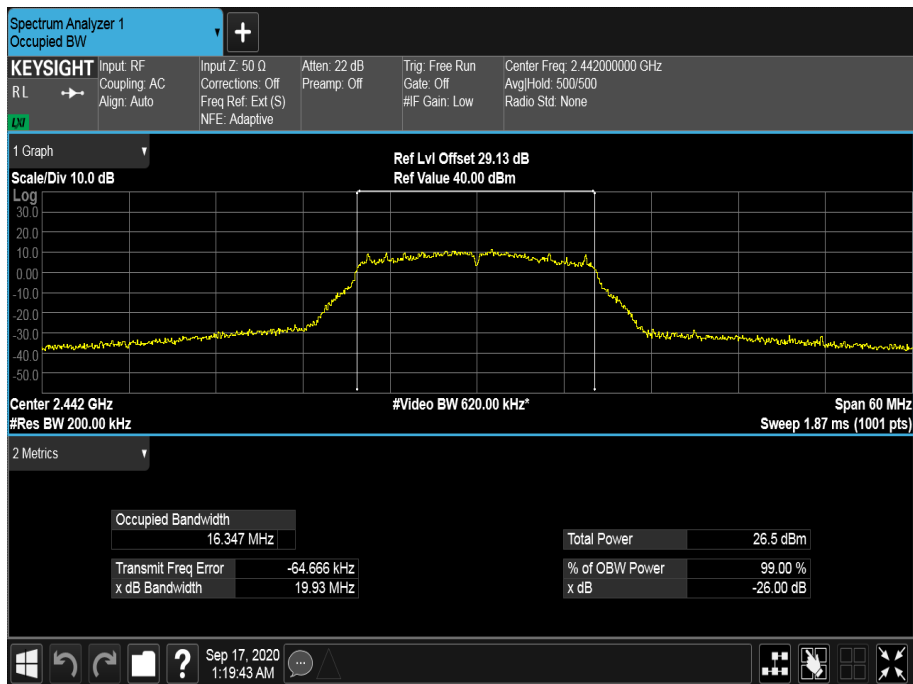


Figure 10 - 2442 MHz - 99% Occupied Bandwidth

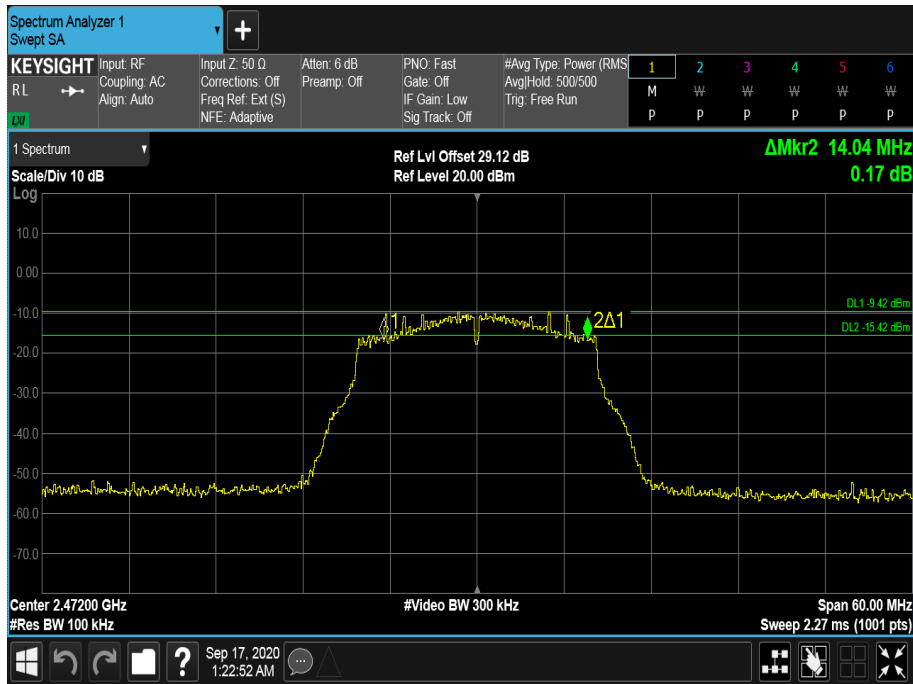


Figure 11 - 2472 MHz - 6 dB DTS Bandwidth

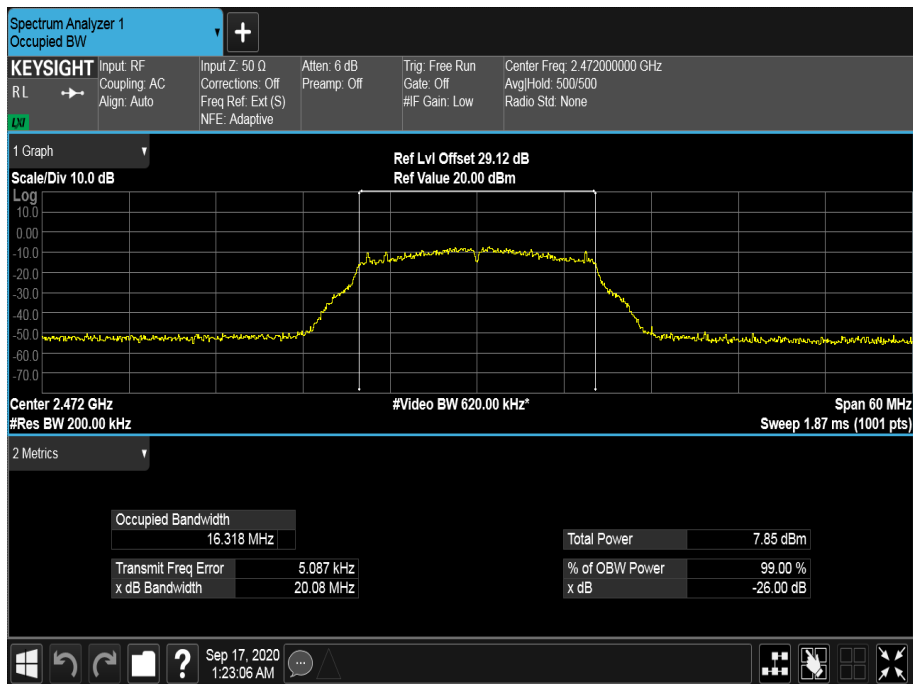


Figure 12 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	17.820	17.760	17.760
99% Bandwidth (MHz)	17.728	17.722	17.707

Table 8 - 802.11n / HT20 MCS7 / SISO / Core 0

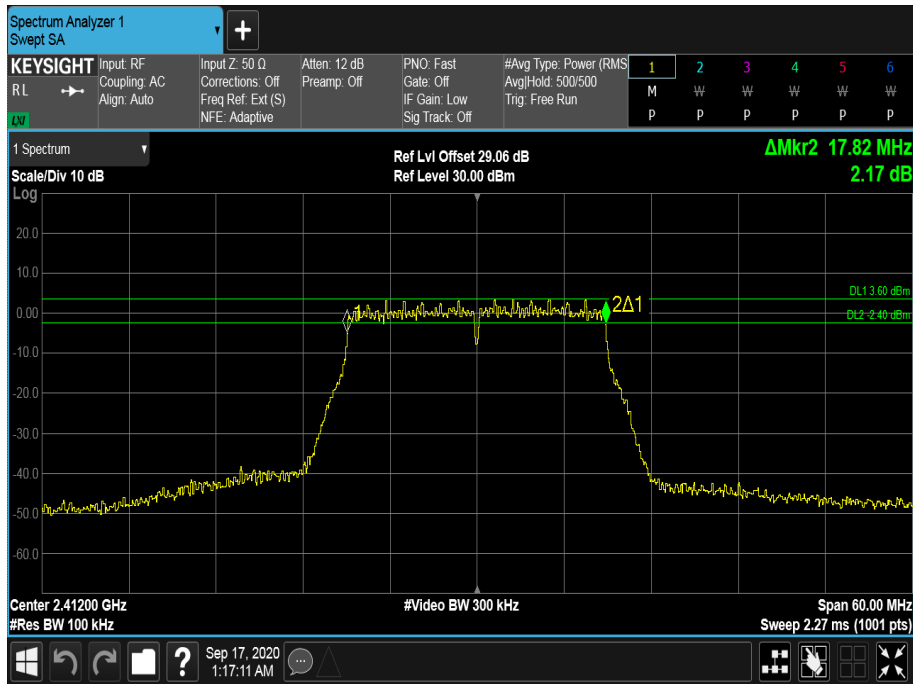


Figure 13 - 2412 MHz - 6 dB DTS Bandwidth

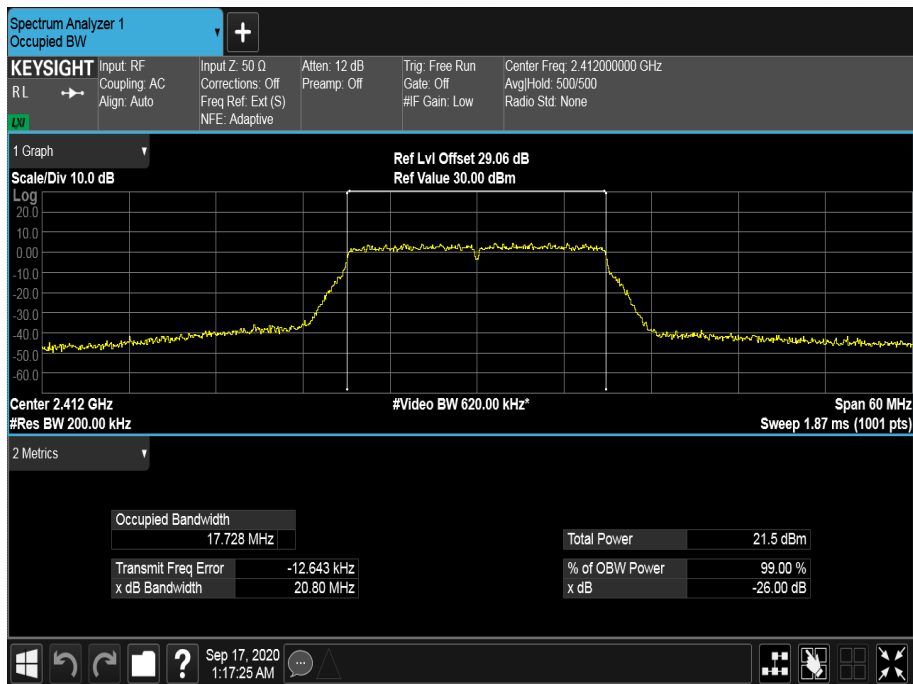


Figure 14 - 2412 MHz - 99% Occupied Bandwidth

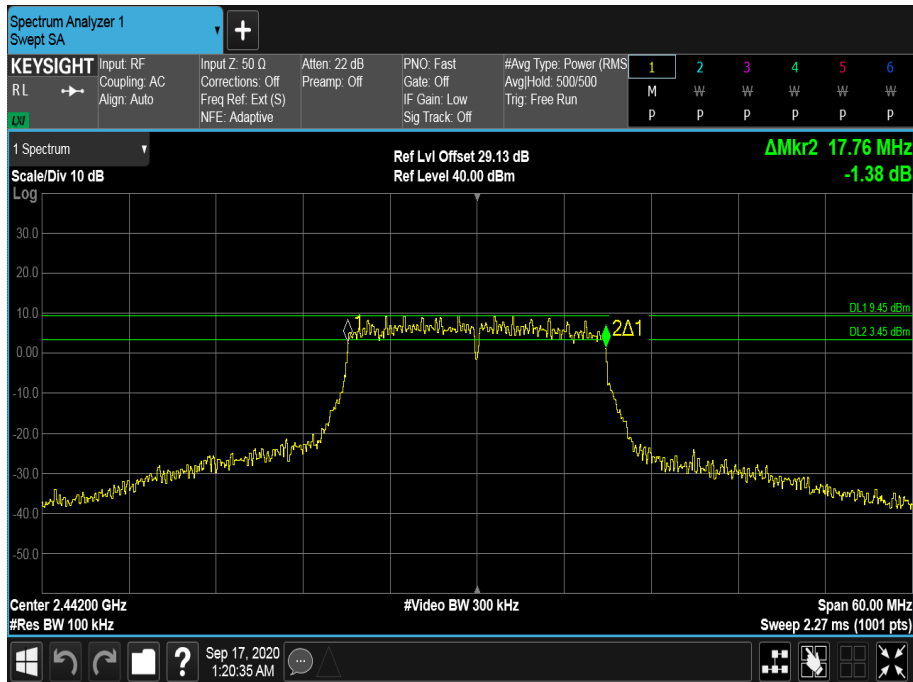


Figure 15 - 2442 MHz - 6 dB DTS Bandwidth

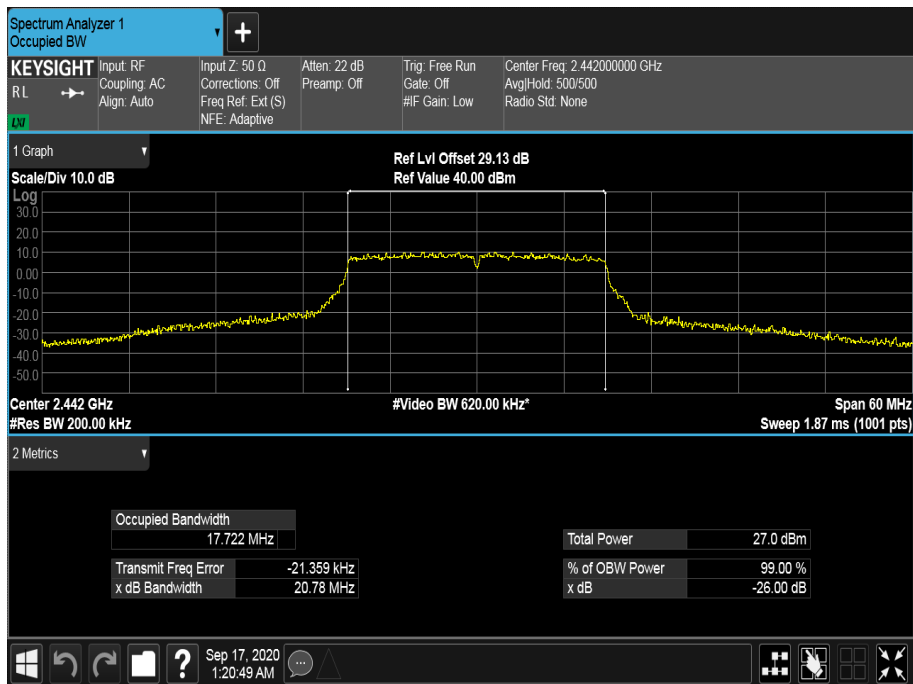


Figure 16 - 2442 MHz - 99% Occupied Bandwidth

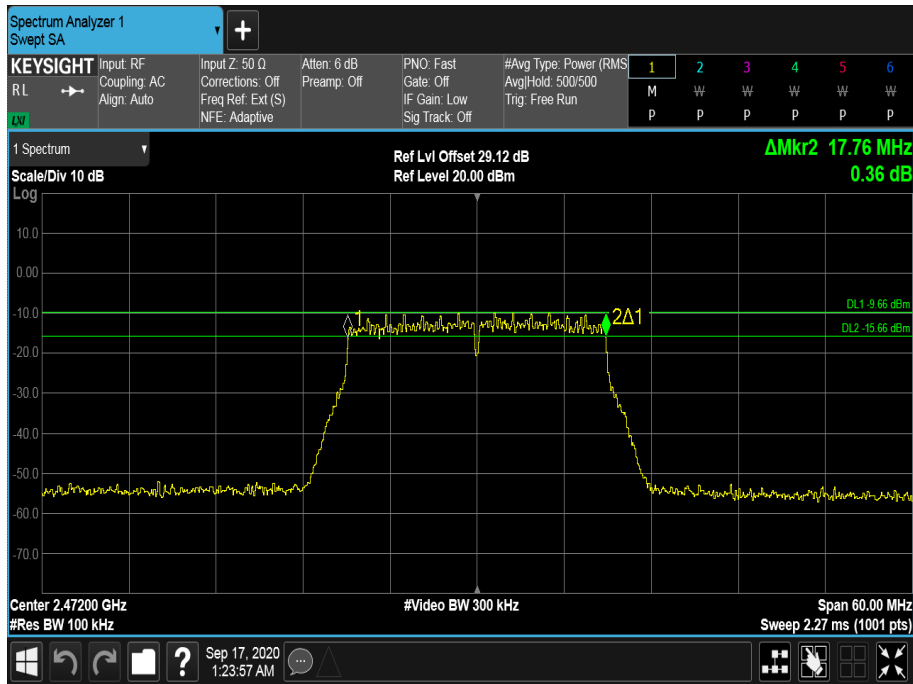


Figure 17 - 2472 MHz - 6 dB DTS Bandwidth

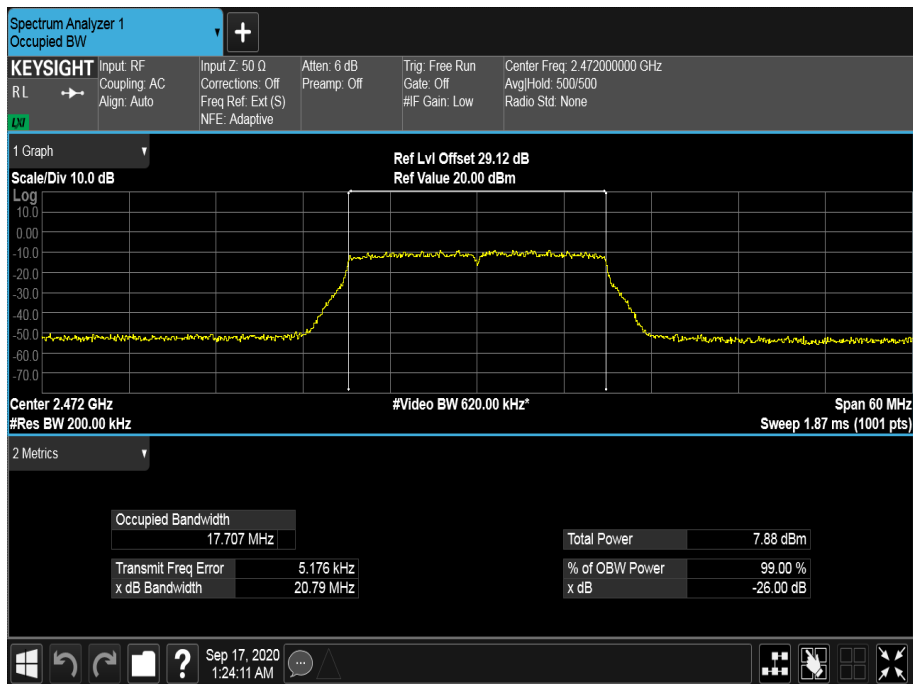


Figure 18 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	17.820	17.700	17.760
99% Bandwidth (MHz)	17.735	17.692	17.709

Table 9 - 802.11n / HT20 MCS7 / MIMO CDD / Cores 0+1

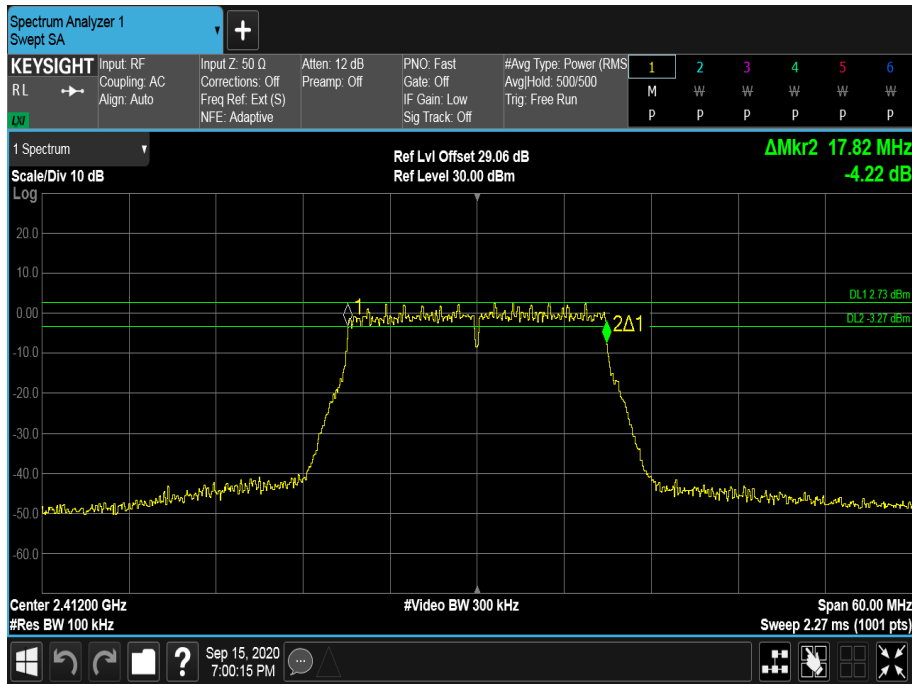


Figure 19 - 2412 MHz - 6 dB DTS Bandwidth

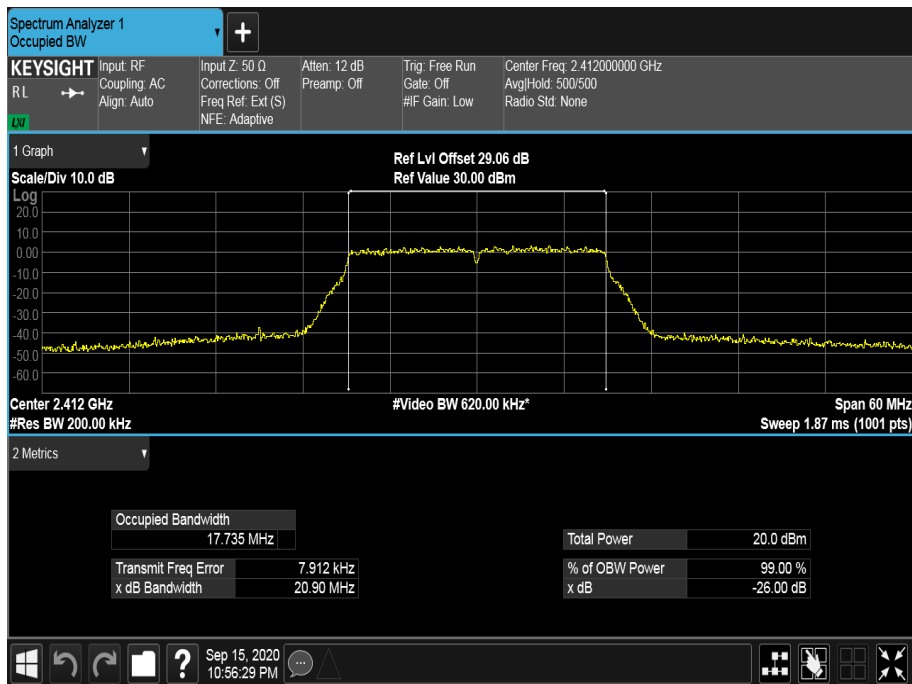


Figure 20 - 2412 MHz - 99% Occupied Bandwidth

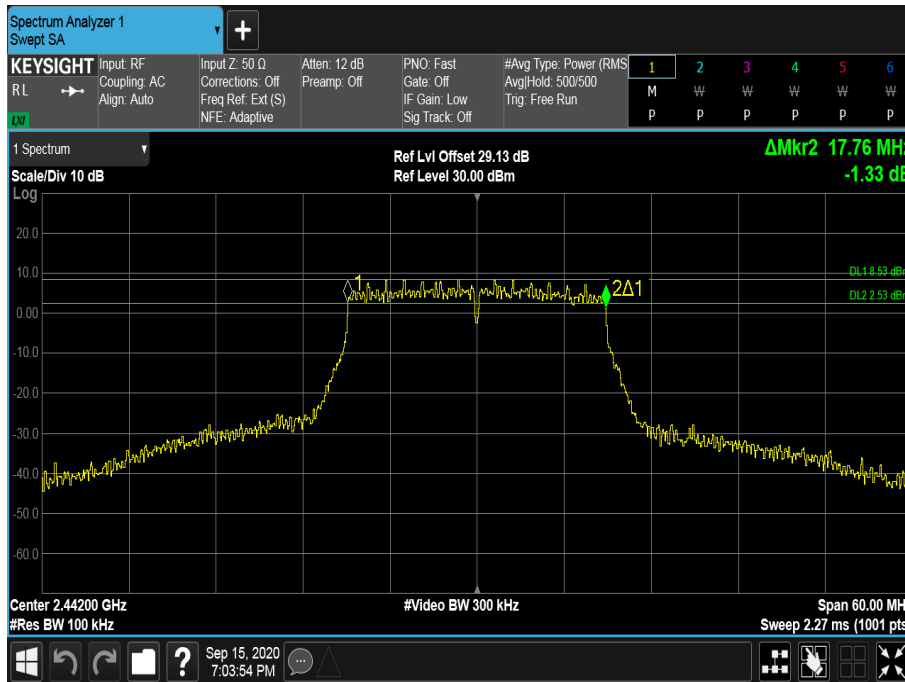


Figure 21 - 2442 MHz - 6 dB DTS Bandwidth

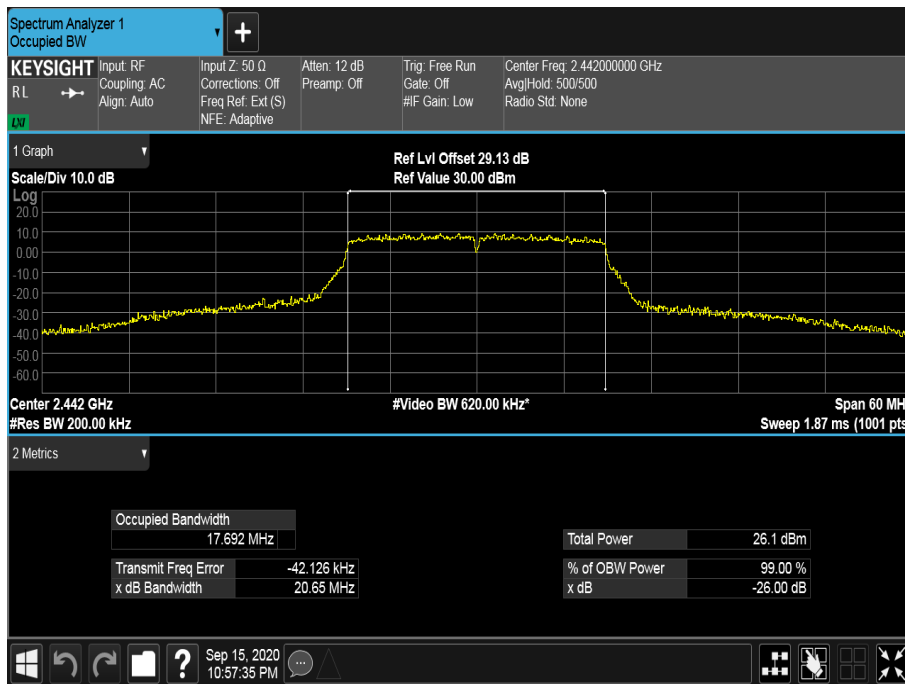


Figure 22 - 2442 MHz - 99% Occupied Bandwidth

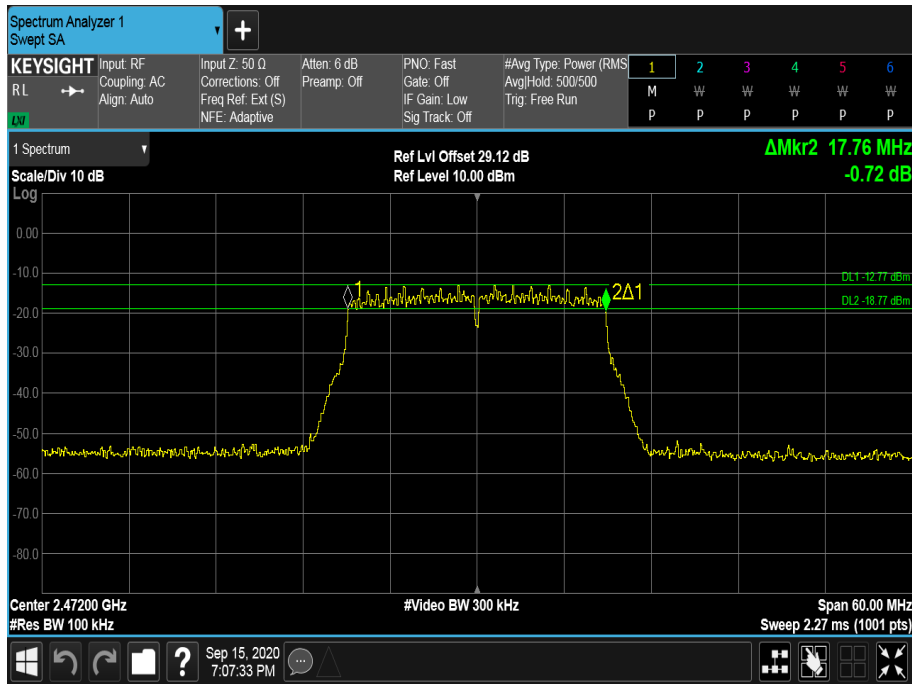


Figure 23 - 2472 MHz - 6 dB DTS Bandwidth

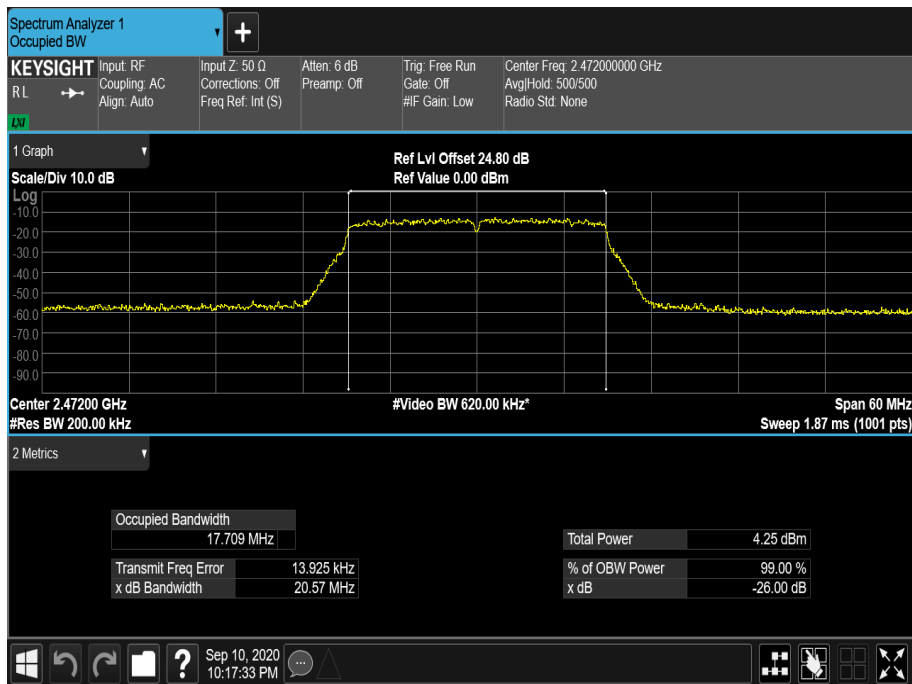


Figure 24 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	19.140	18.960	19.140
99% Bandwidth (MHz)	18.949	18.905	18.920

Table 10 - 802.11ax / HE20 MCS7x1 / SU / SISO / Core 0

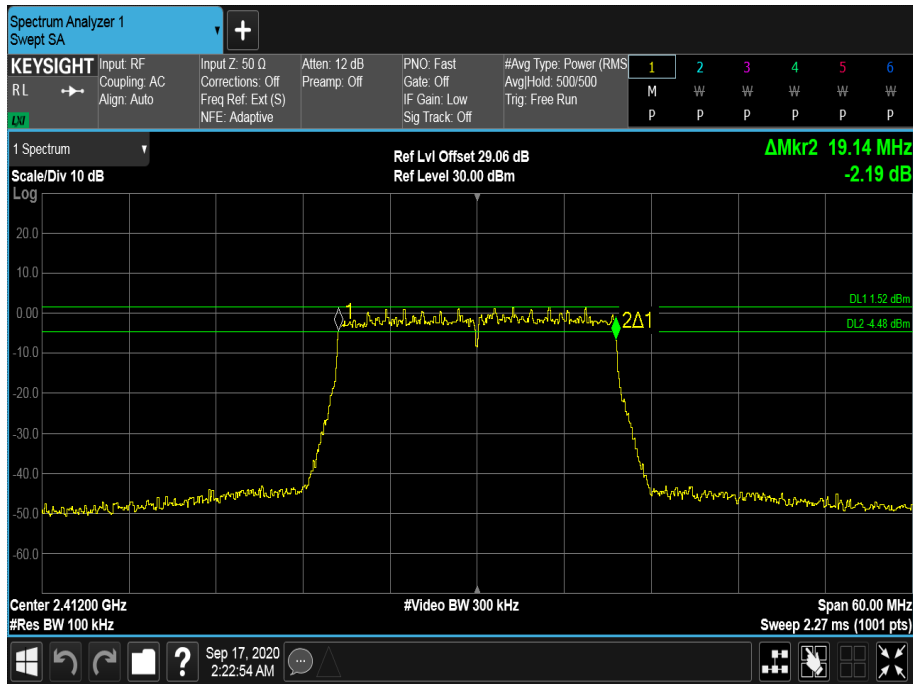


Figure 25 - 2412 MHz - 6 dB DTS Bandwidth

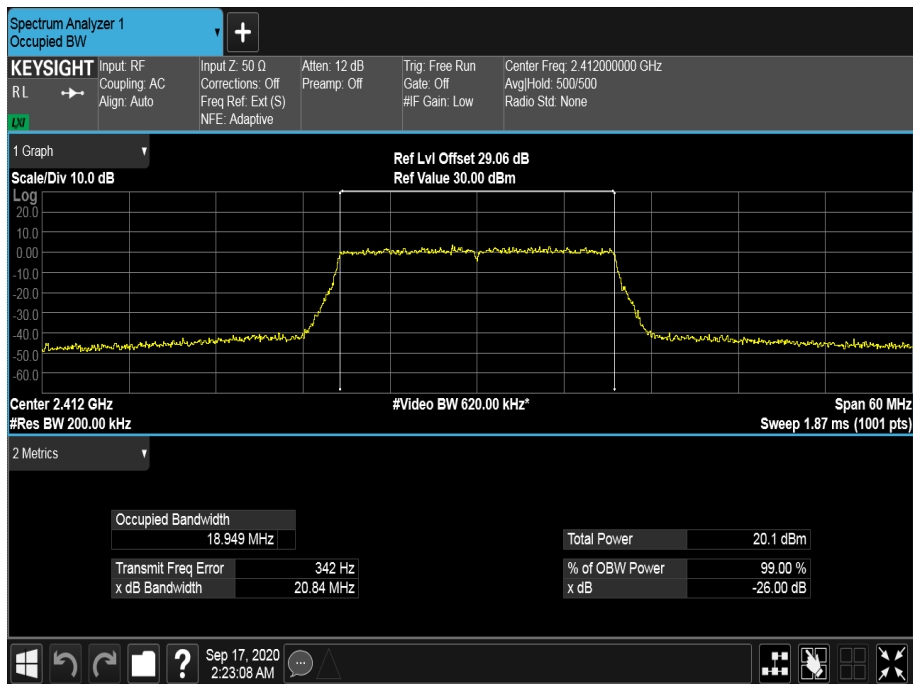


Figure 26 - 2412 MHz - 99% Occupied Bandwidth

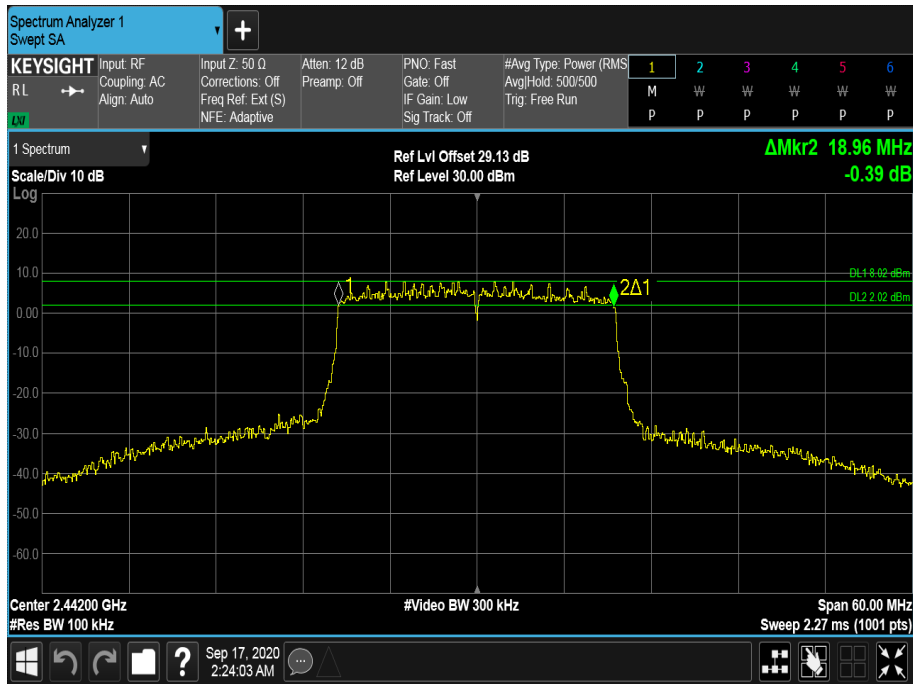


Figure 27 - 2442 MHz - 6 dB DTS Bandwidth

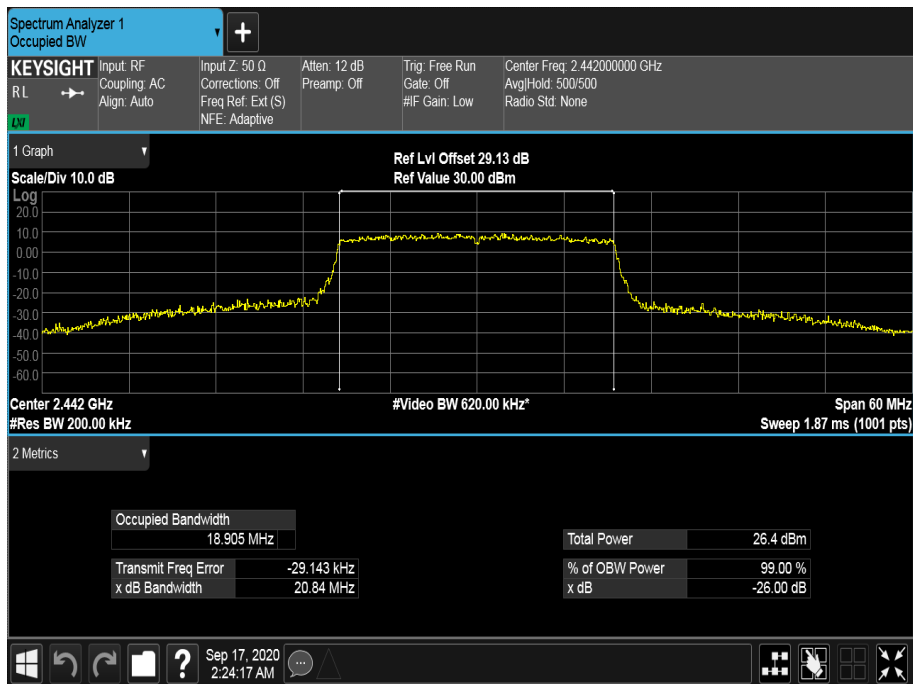


Figure 28 - 2442 MHz - 99% Occupied Bandwidth

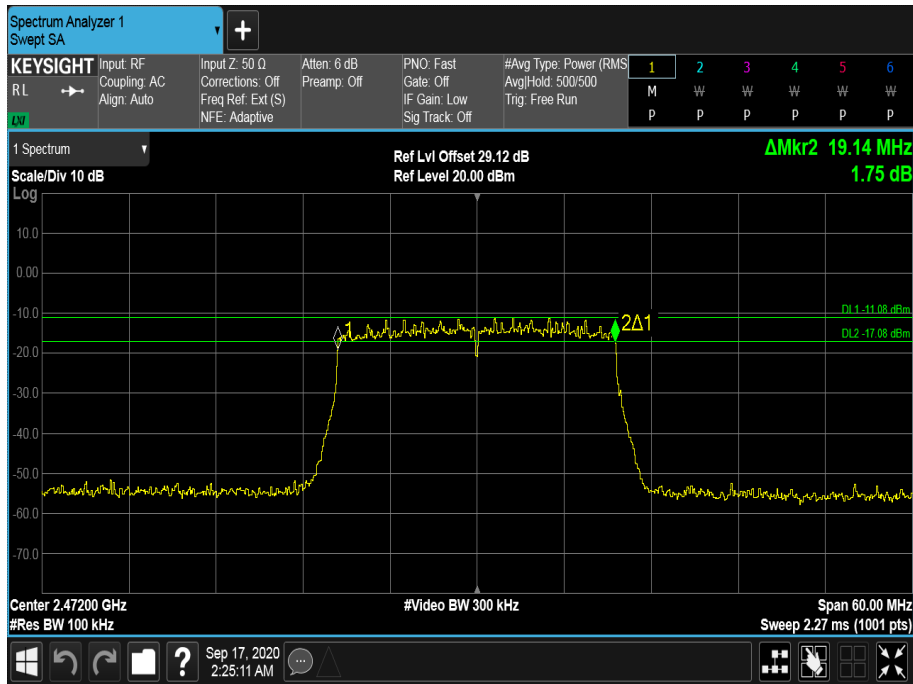


Figure 29 - 2472 MHz - 6 dB DTS Bandwidth

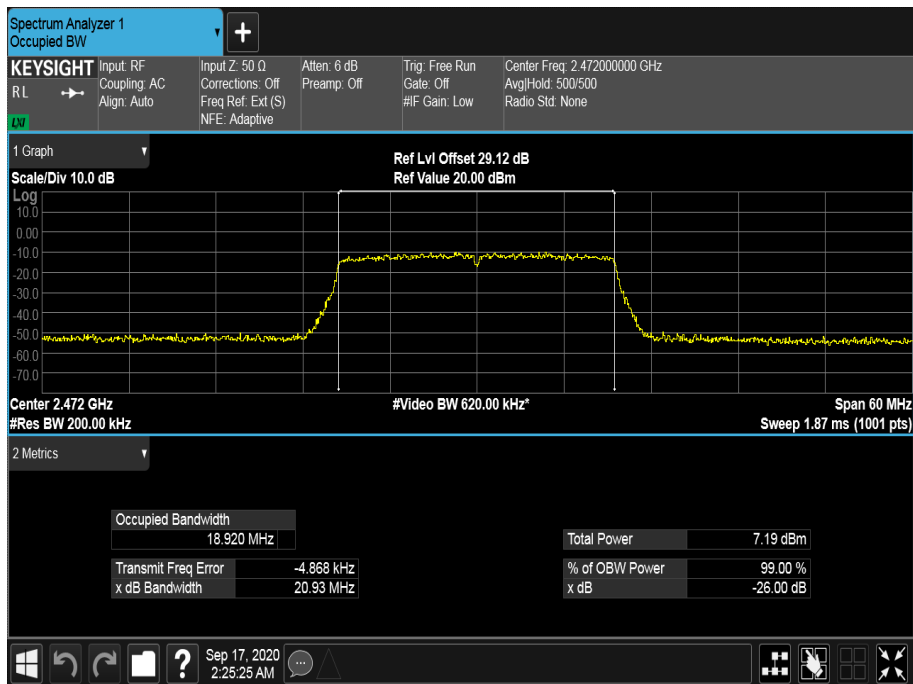


Figure 30 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	2.160	2.160	2.220
99% Bandwidth (MHz)	18.291	18.206	18.278

Table 11 - 802.11ax / HE20 MCS7x1 / RU 26-0 / SISO / Core 0

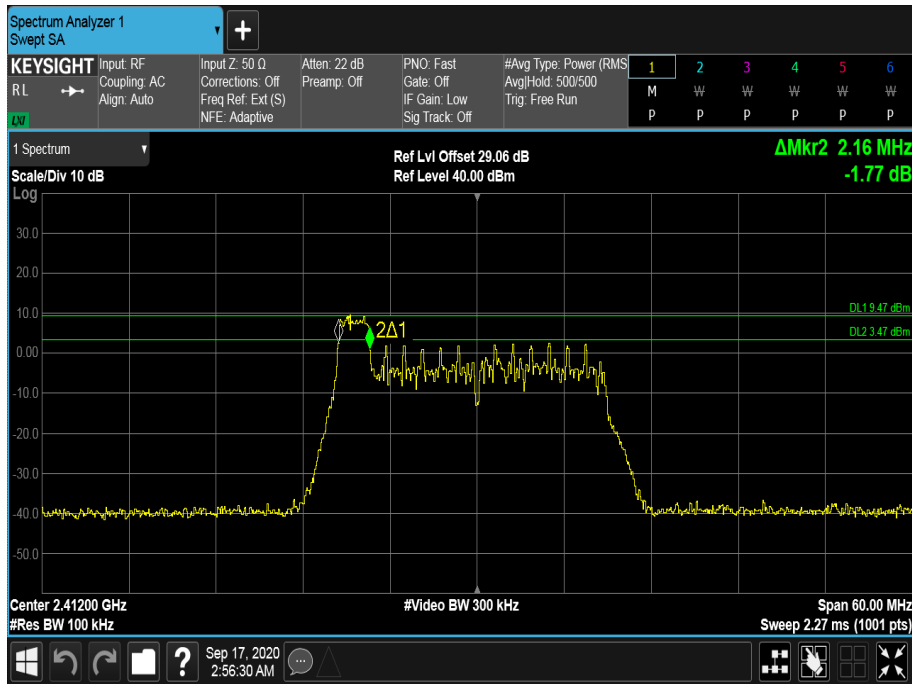


Figure 31 - 2412 MHz - 6 dB DTS Bandwidth

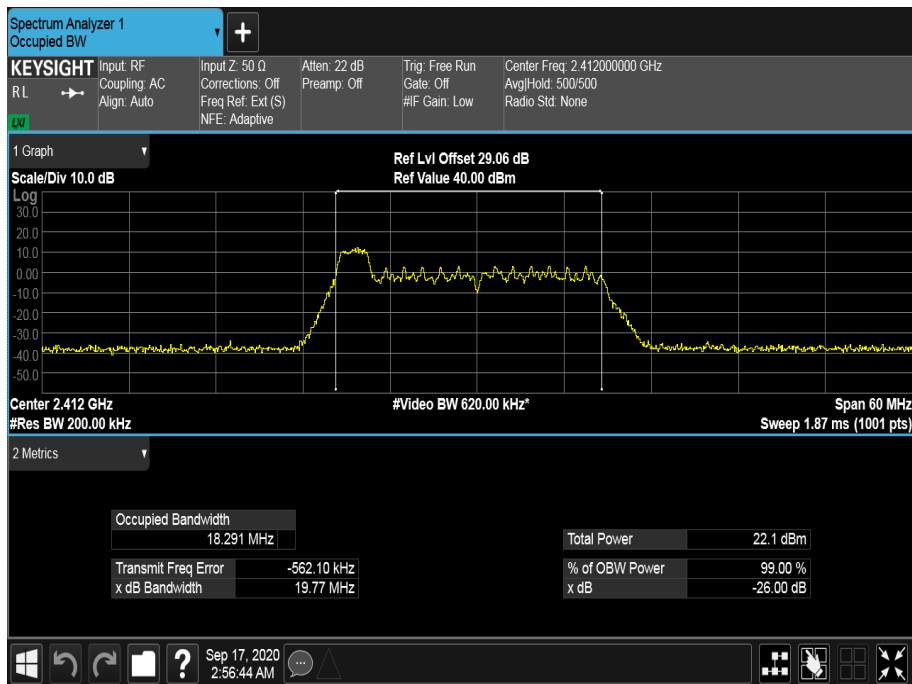


Figure 32 - 2412 MHz - 99% Occupied Bandwidth

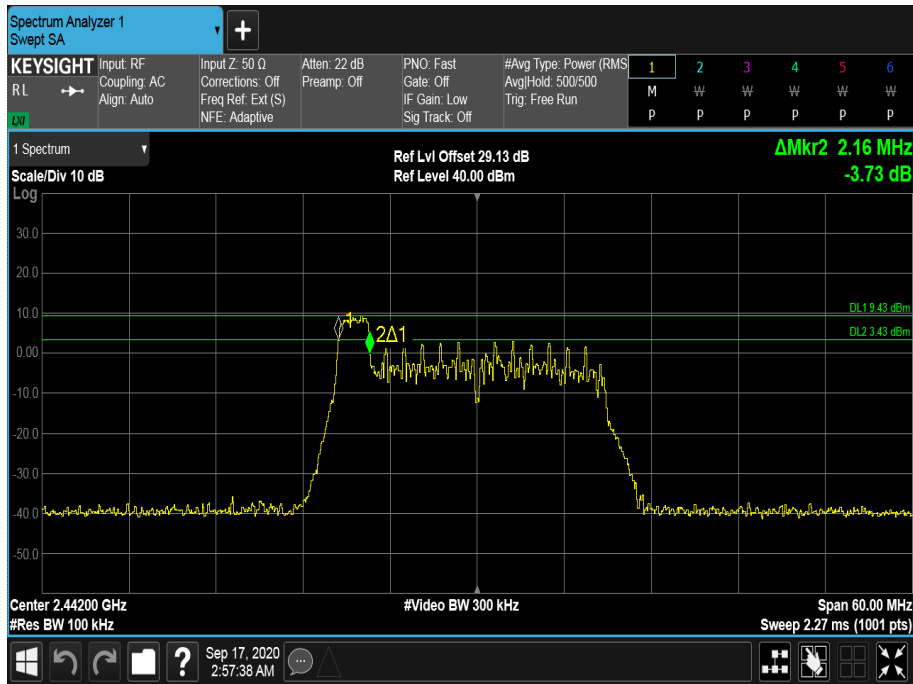


Figure 33 - 2442 MHz - 6 dB DTS Bandwidth

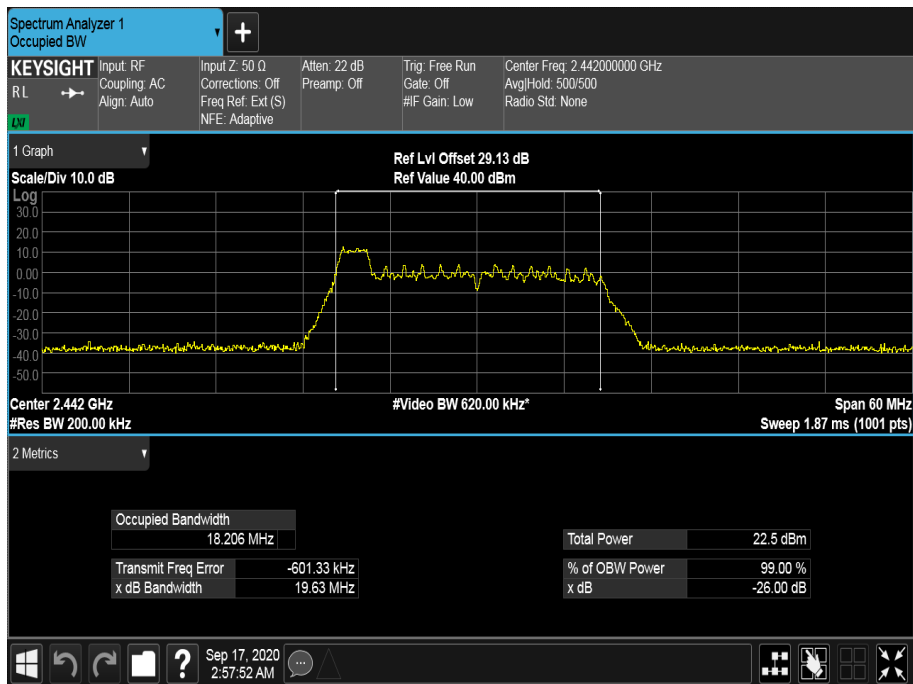


Figure 34 - 2442 MHz - 99% Occupied Bandwidth

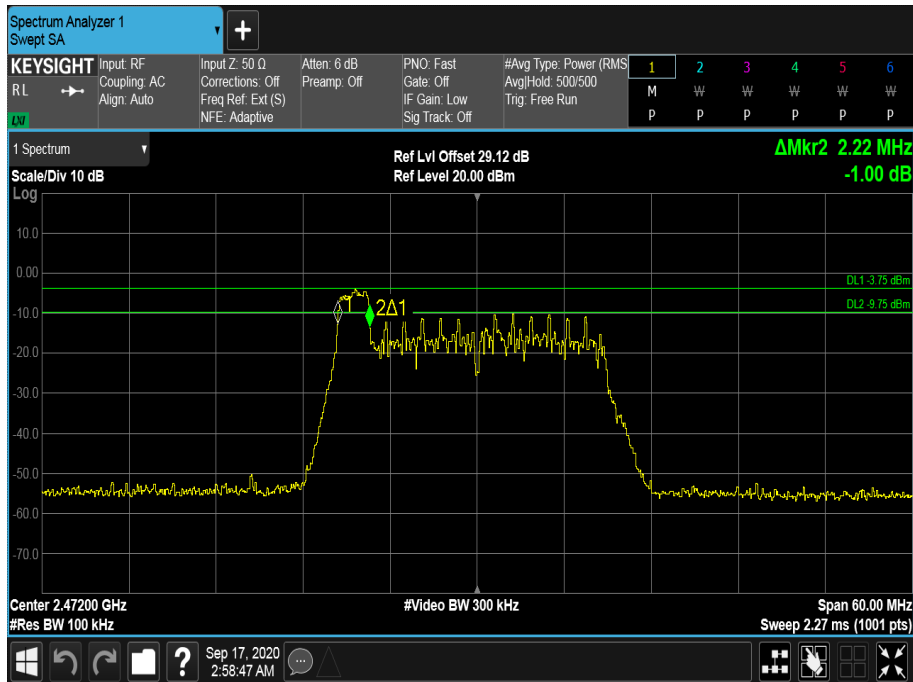


Figure 35 - 2472 MHz - 6 dB DTS Bandwidth

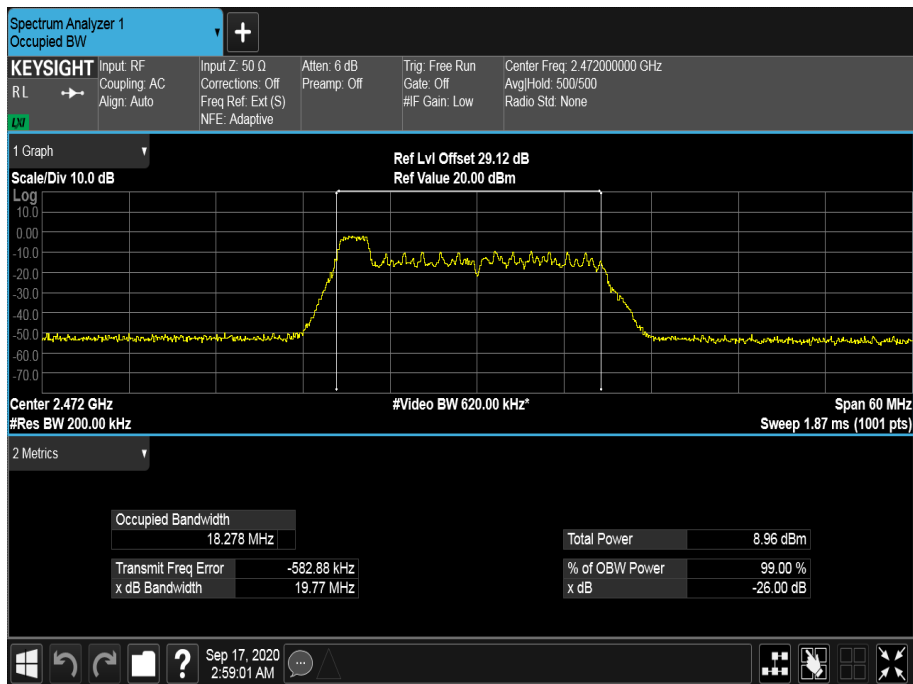


Figure 36 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	2.220	2.160	2.160
99% Bandwidth (MHz)	18.462	18.493	18.394

Table 12 - 802.11ax / HE20 MCS7x1 / RU 26-8 / SISO / Core 0

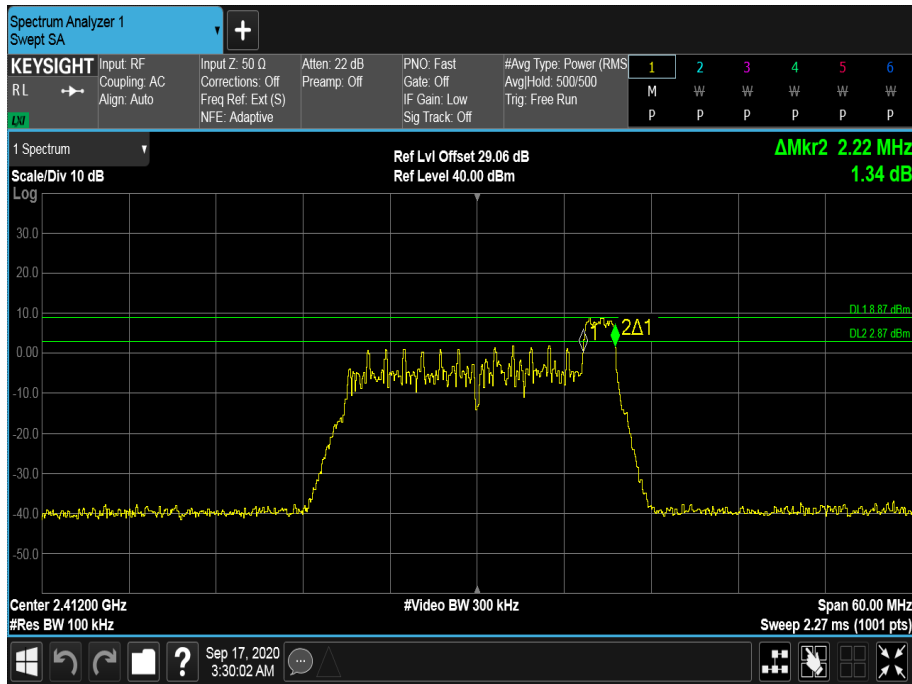


Figure 37 - 2412 MHz - 6 dB DTS Bandwidth

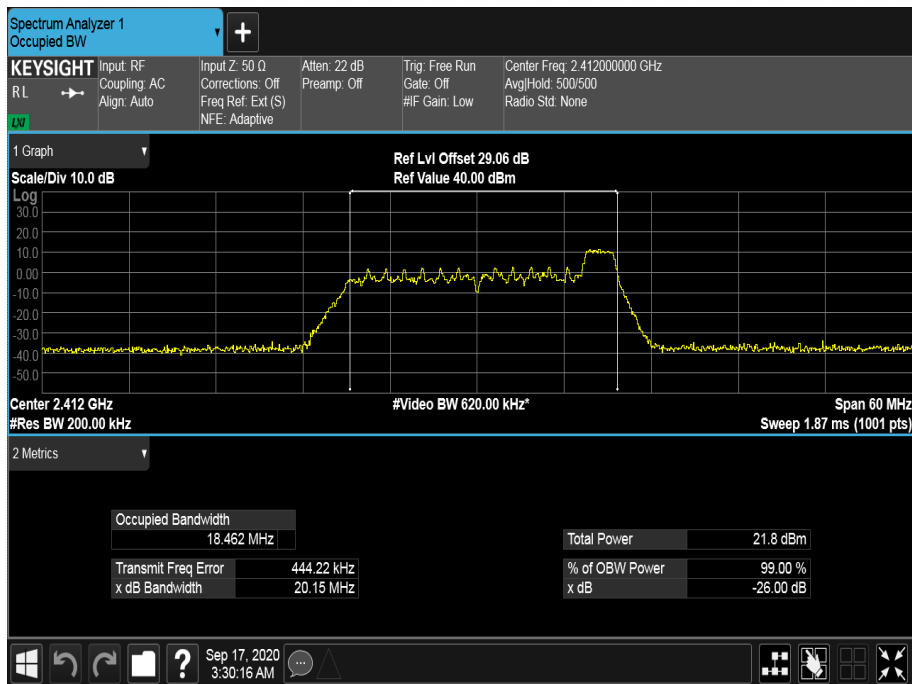


Figure 38 - 2412 MHz - 99% Occupied Bandwidth

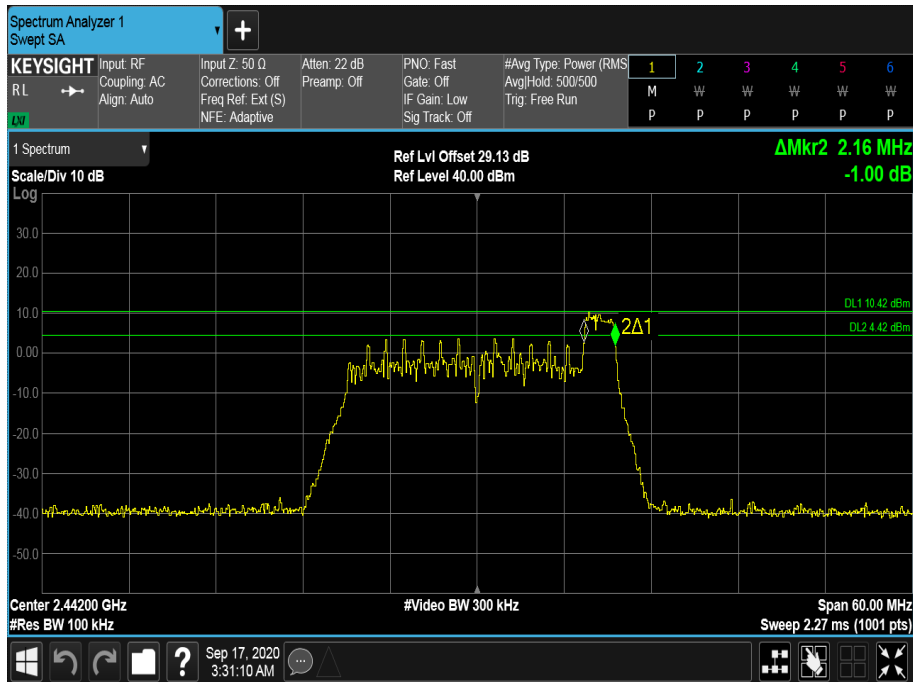


Figure 39 - 2442 MHz - 6 dB DTS Bandwidth

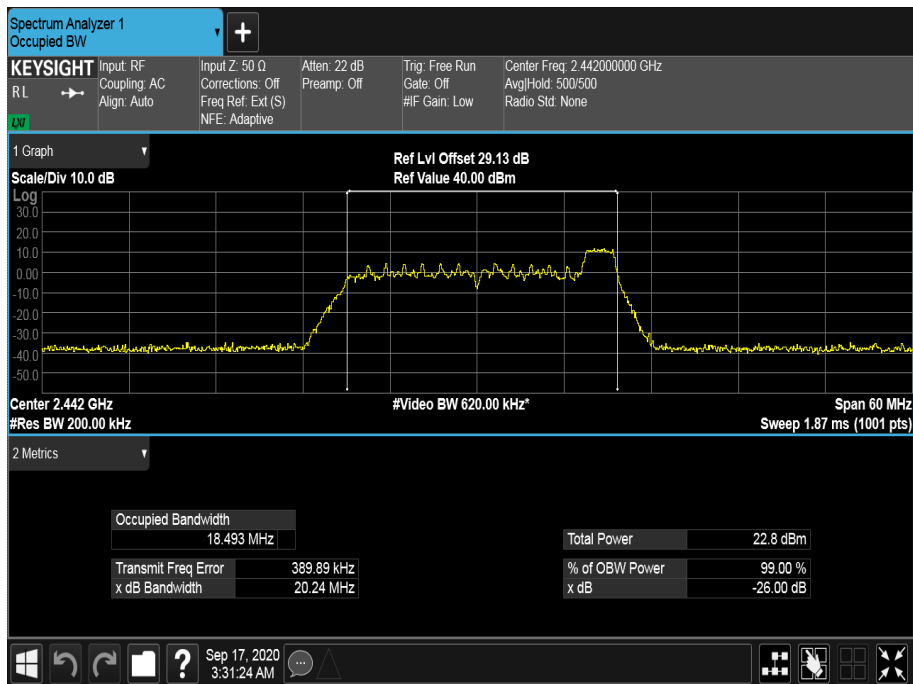


Figure 40 - 2442 MHz - 99% Occupied Bandwidth

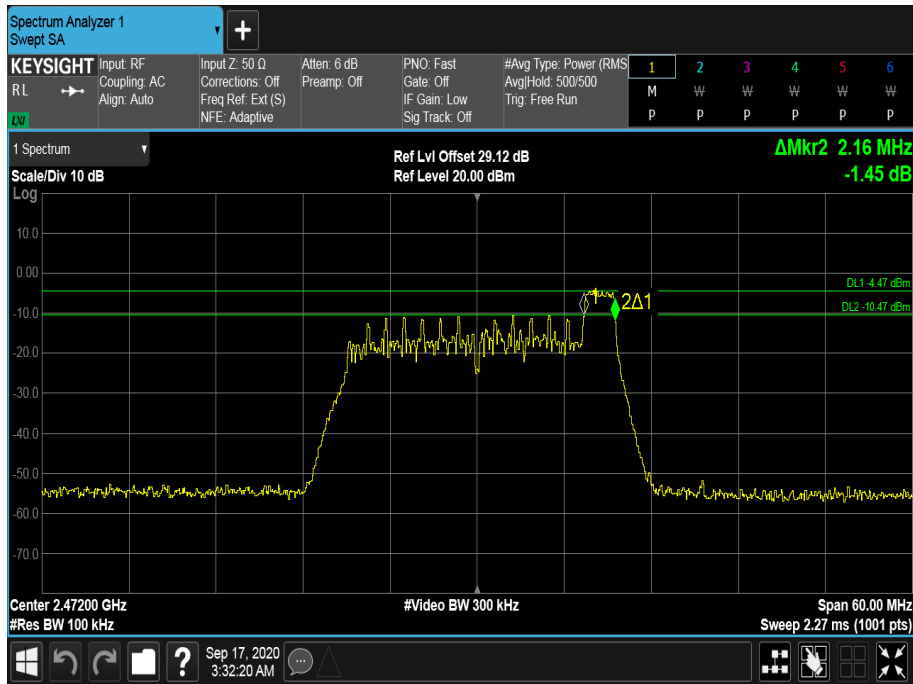


Figure 41 - 2472 MHz - 6 dB DTS Bandwidth

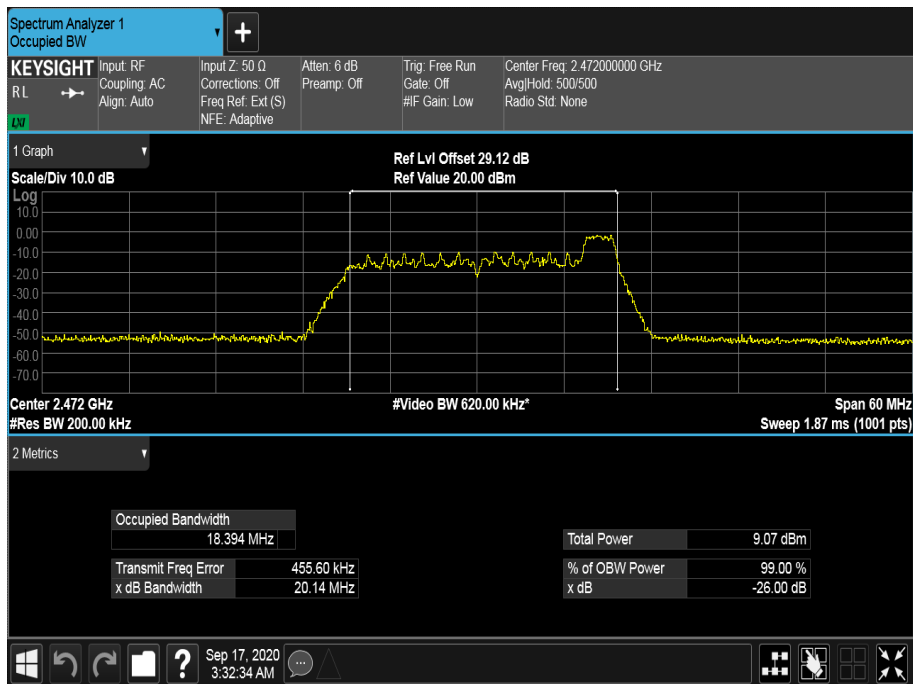


Figure 42 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	19.080	19.020	18.960
99% Bandwidth (MHz)	18.965	18.942	18.955

Table 13 - 802.11ax / HE20 MCS7x1 / SU / MIMO CDD / Cores 0+1

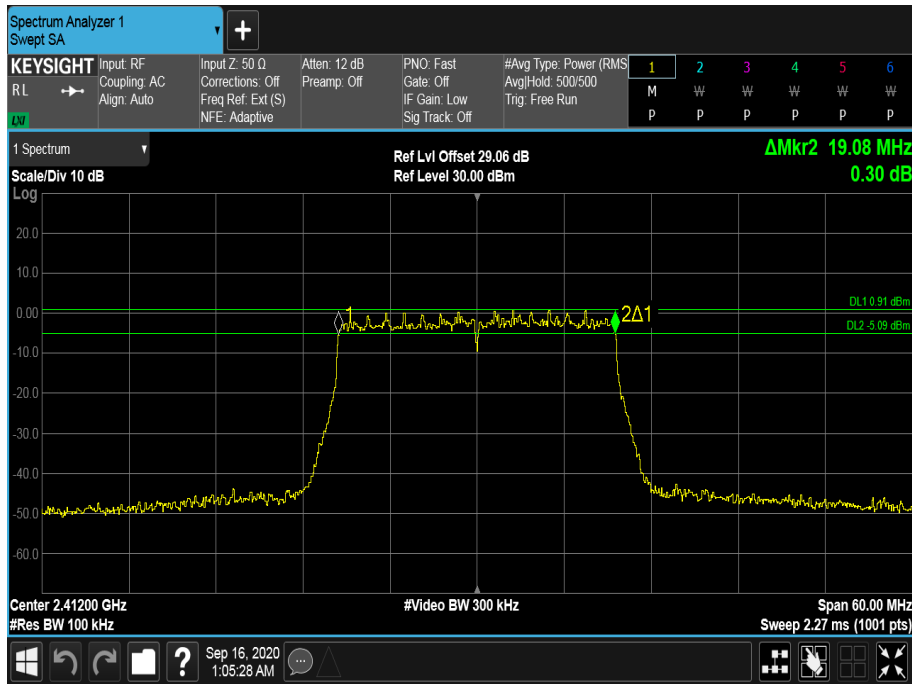


Figure 43 - 2412 MHz - 6 dB DTS Bandwidth

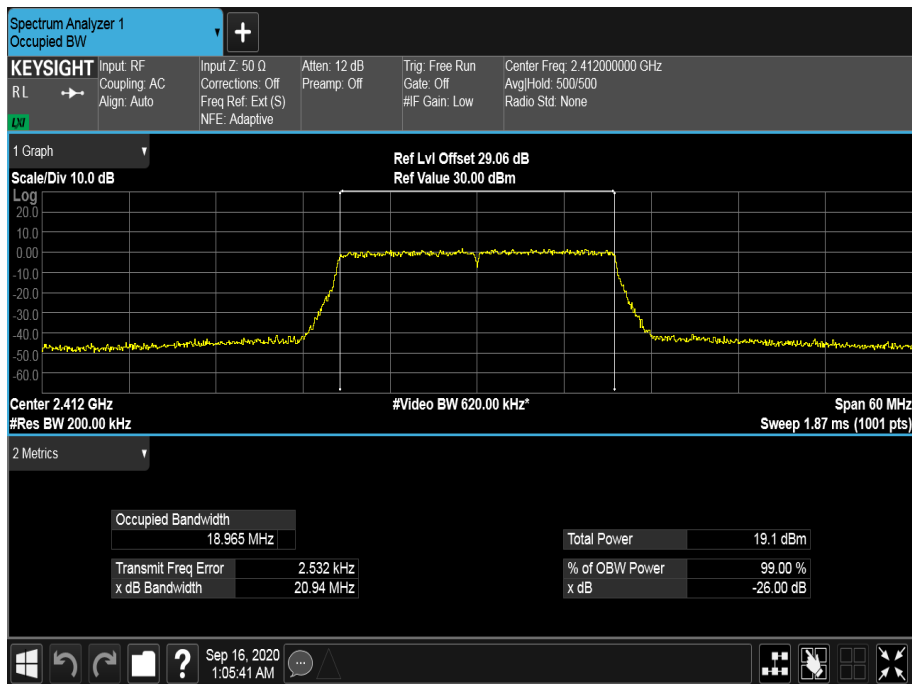


Figure 44 - 2412 MHz - 99% Occupied Bandwidth

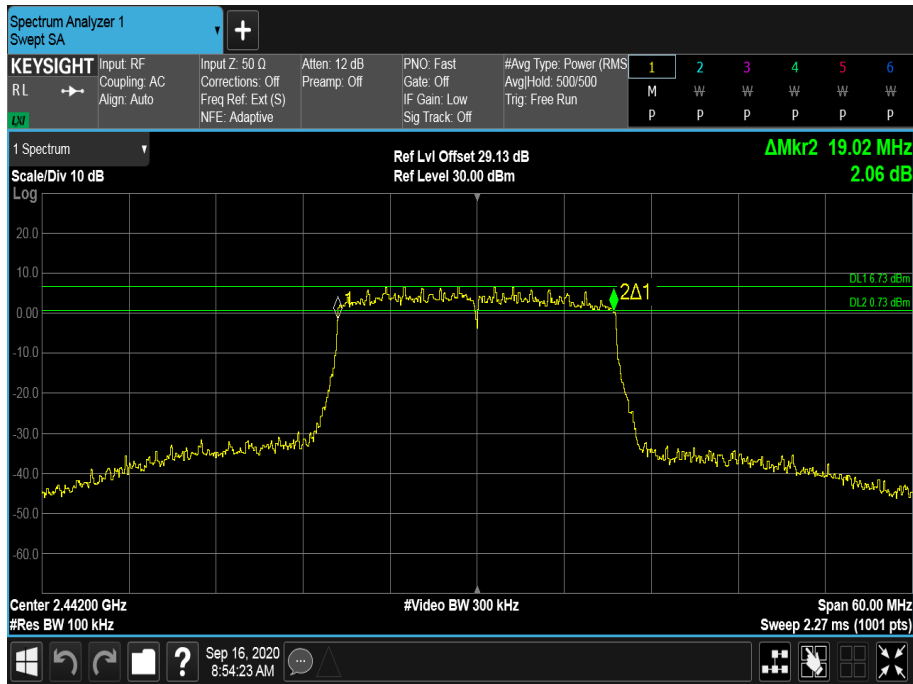


Figure 45 - 2442 MHz - 6 dB DTS Bandwidth

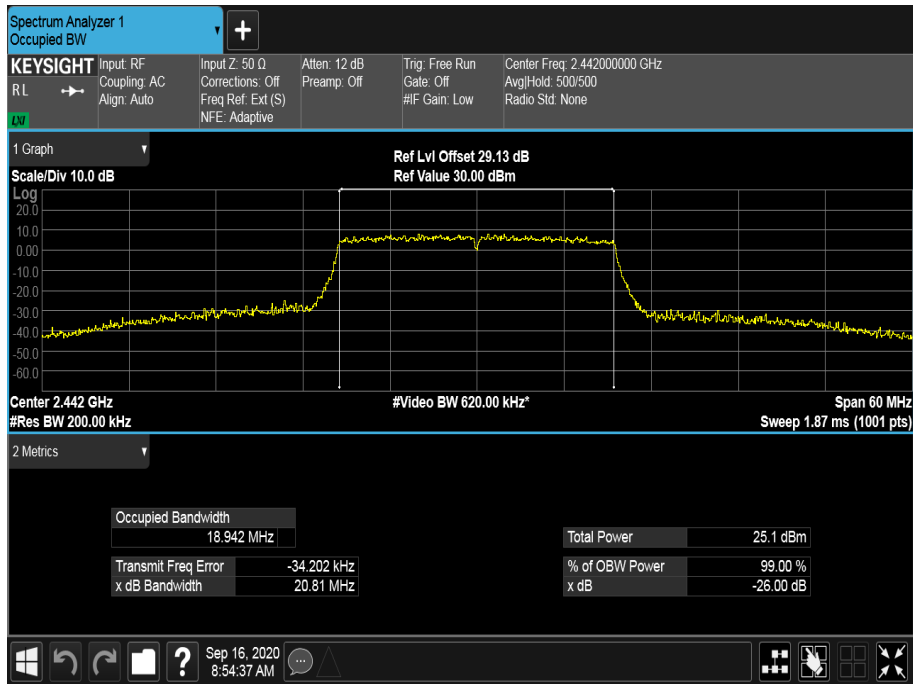


Figure 46 - 2442 MHz - 99% Occupied Bandwidth

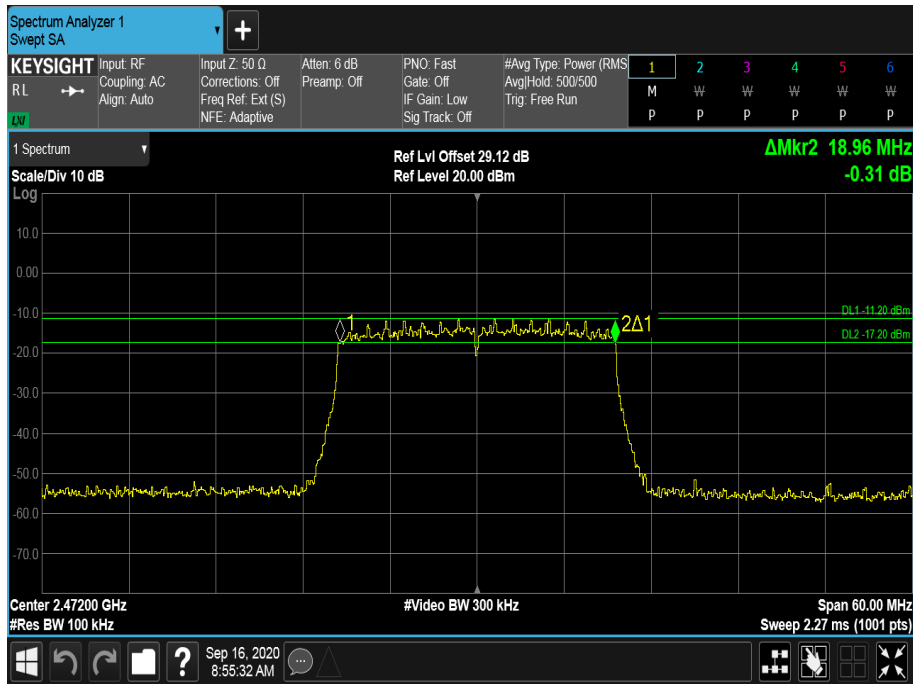


Figure 47 - 2472 MHz - 6 dB DTS Bandwidth

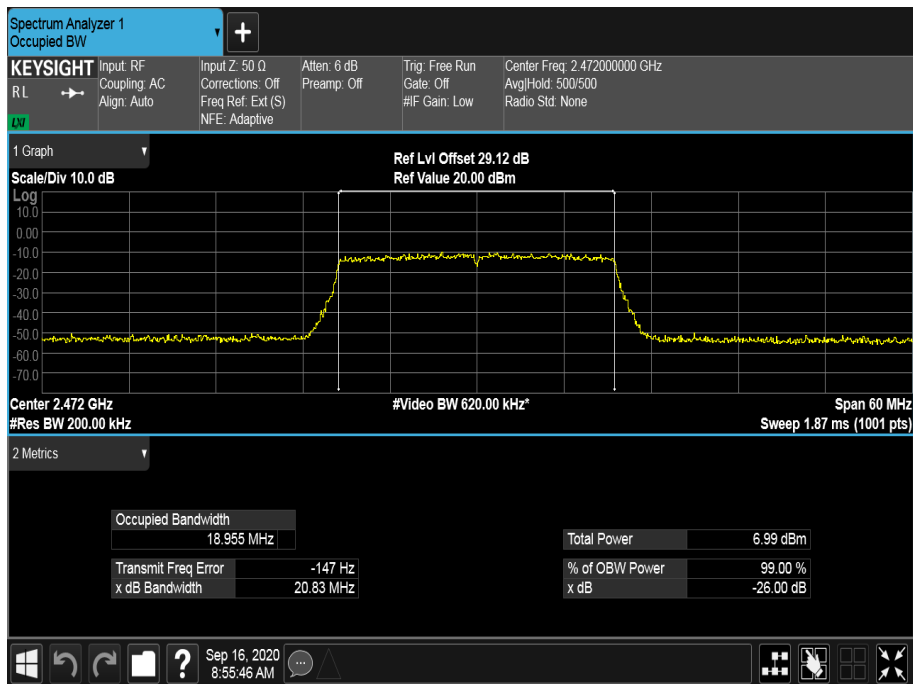


Figure 48 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	2.220	2.220	2.160
99% Bandwidth (MHz)	18.330	18.171	18.267

Table 14 - 802.11ax / HE20 MCS7x1 / RU 26-0 / MIMO CDD / Cores 0+1

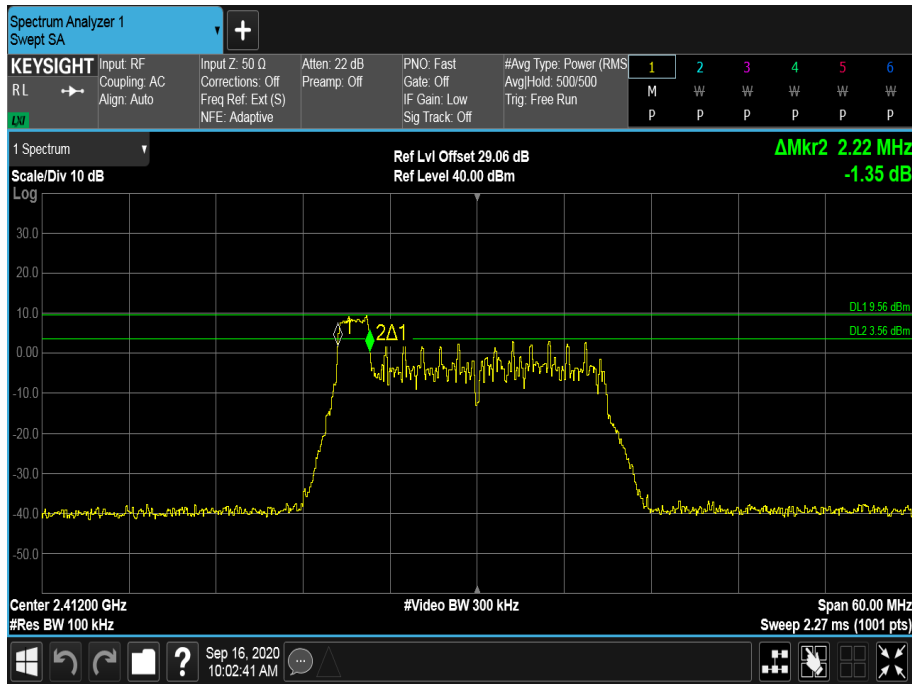


Figure 49 - 2412 MHz - 6 dB DTS Bandwidth

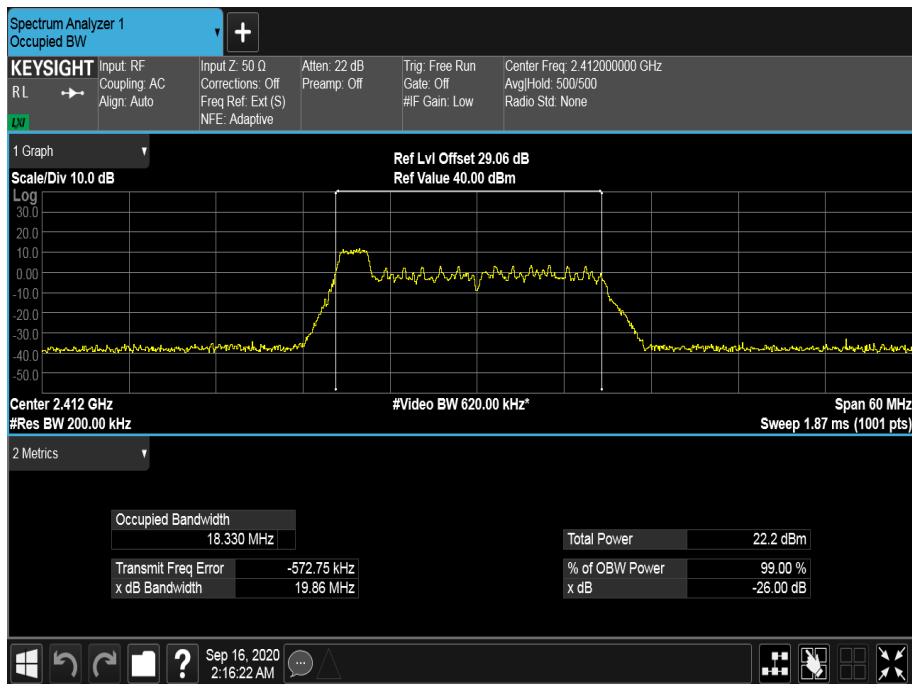


Figure 50 - 2412 MHz - 99% Occupied Bandwidth

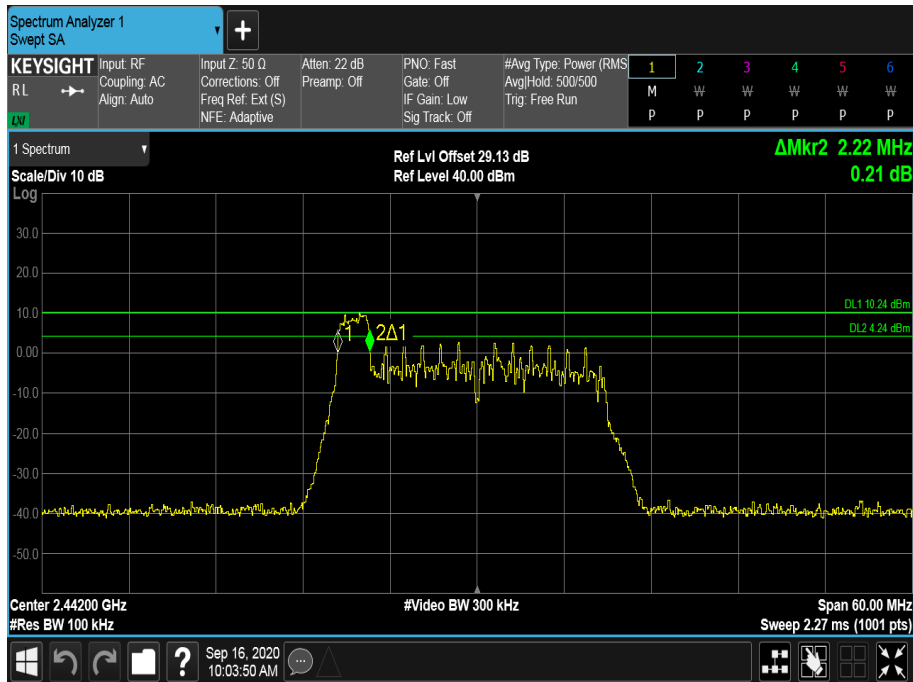


Figure 51 - 2442 MHz - 6 dB DTS Bandwidth

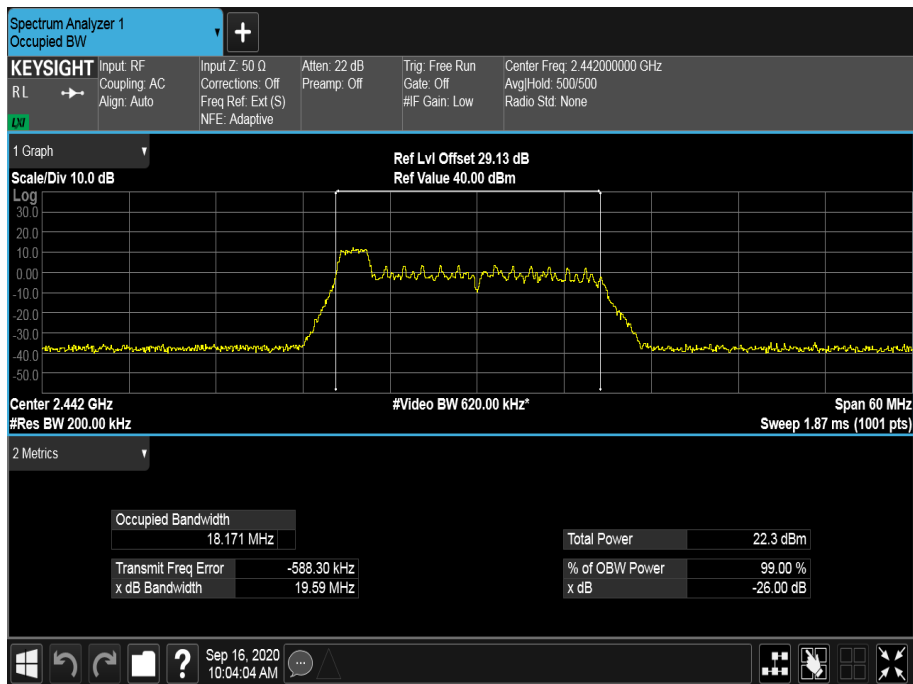


Figure 52 - 2442 MHz - 99% Occupied Bandwidth

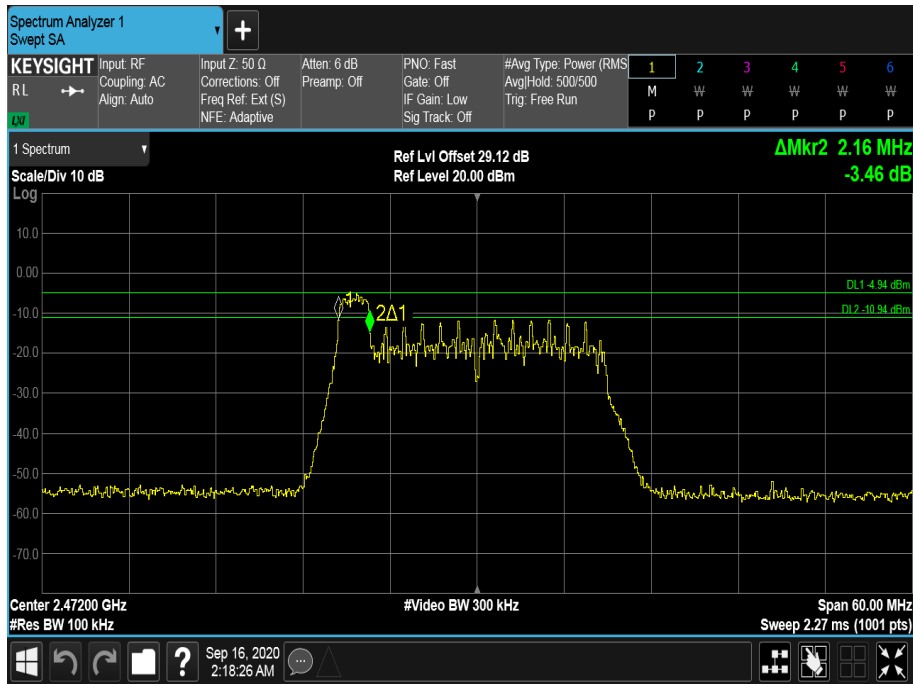


Figure 53 - 2472 MHz - 6 dB DTS Bandwidth

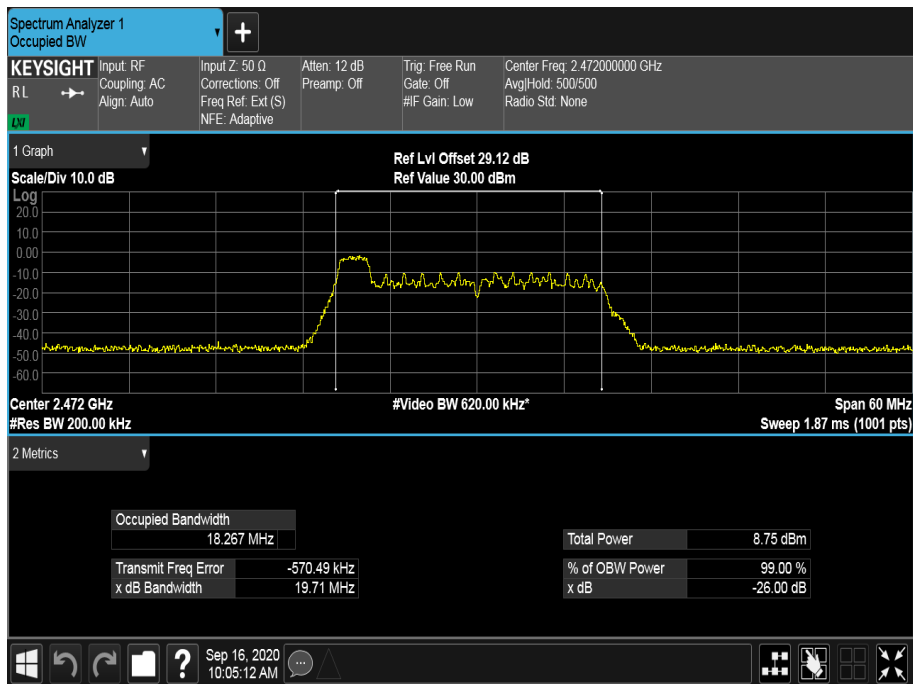


Figure 54 - 2472 MHz - 99% Occupied Bandwidth



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
6 dB Bandwidth (MHz)	2.160	10.860	2.160
99% Bandwidth (MHz)	18.416	18.485	18.410

Table 15 - 802.11ax / HE20 MCS7x1 / RU 26-8 / MIMO CDD / Cores 0+1

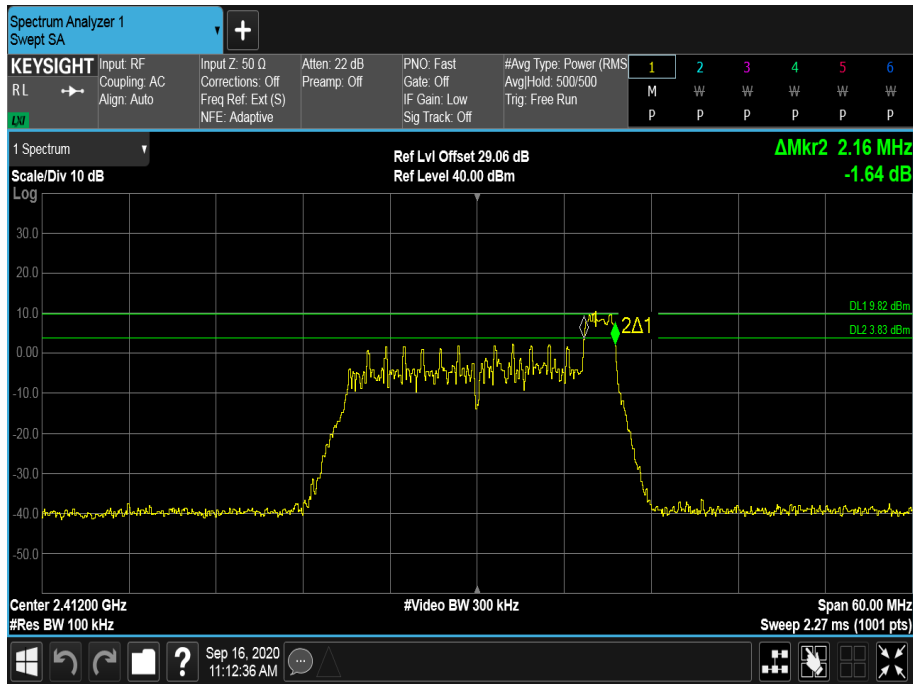


Figure 55 - 2412 MHz - 6 dB DTS Bandwidth

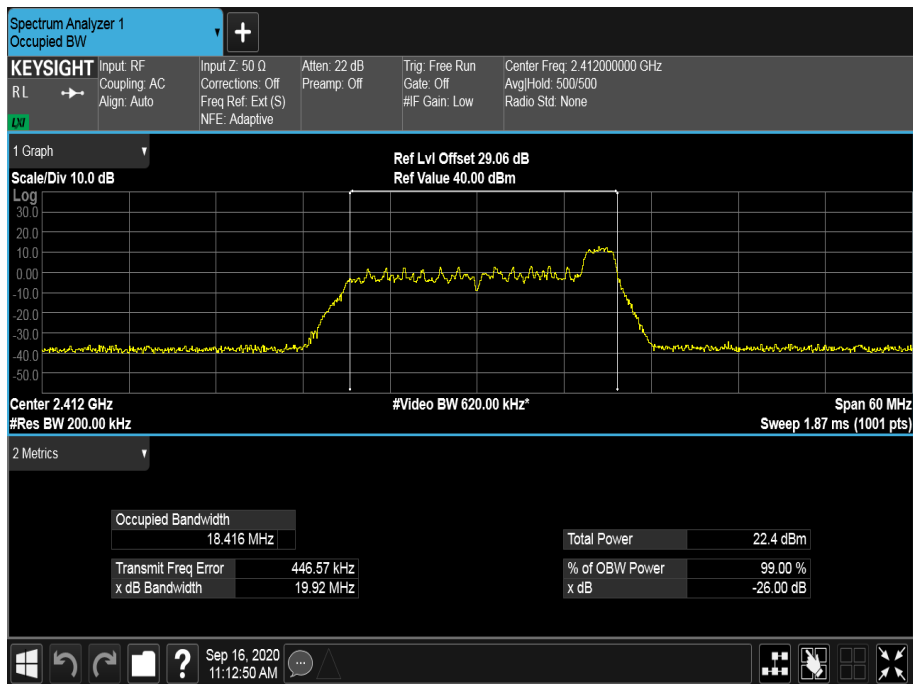


Figure 56 - 2412 MHz - 99% Occupied Bandwidth

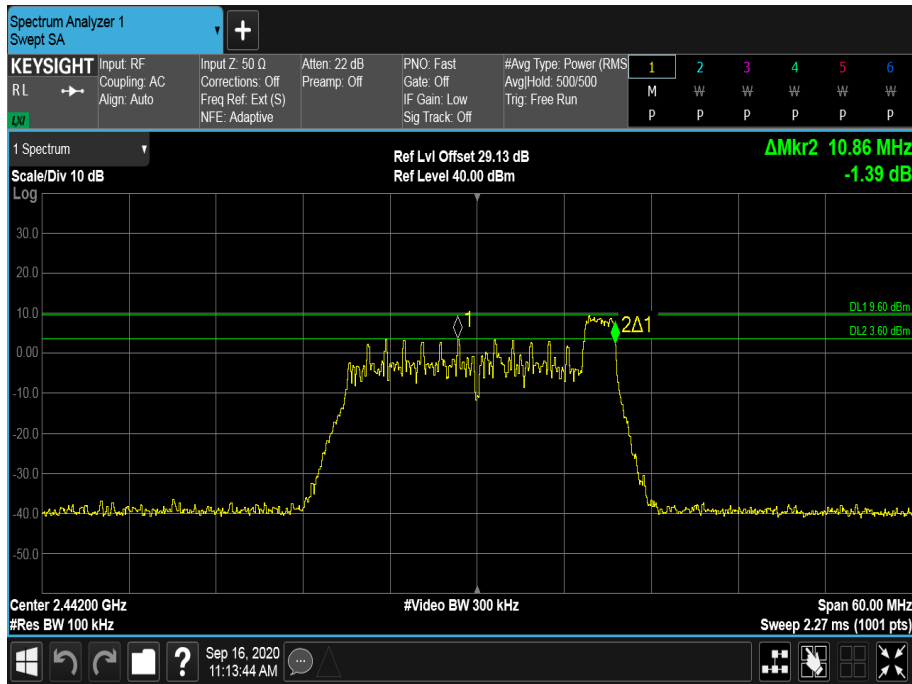


Figure 57 - 2442 MHz - 6 dB DTS Bandwidth

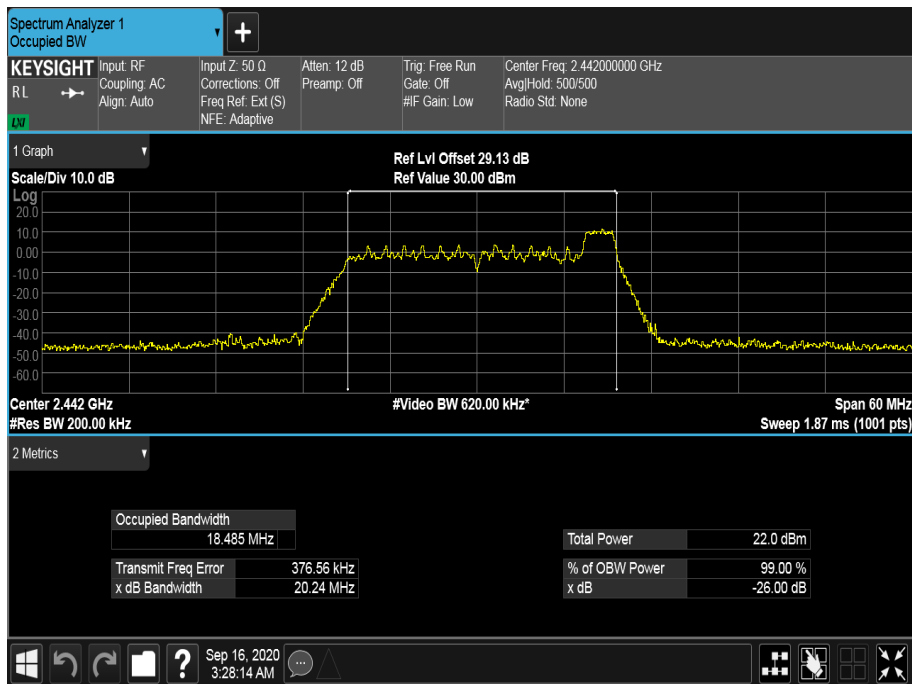


Figure 58 - 2442 MHz - 99% Occupied Bandwidth

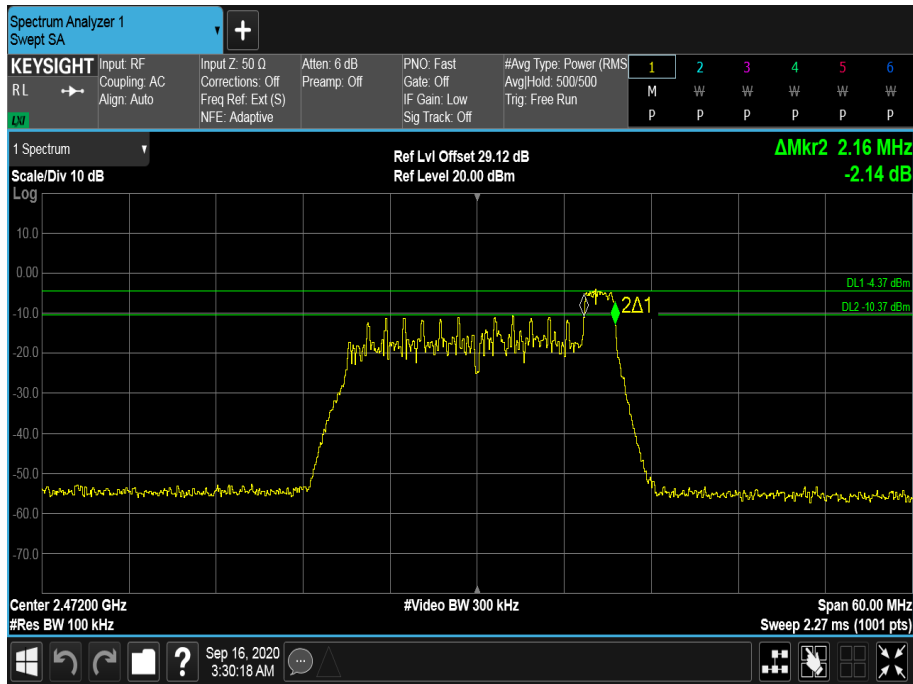


Figure 59 - 2472 MHz - 6 dB DTS Bandwidth

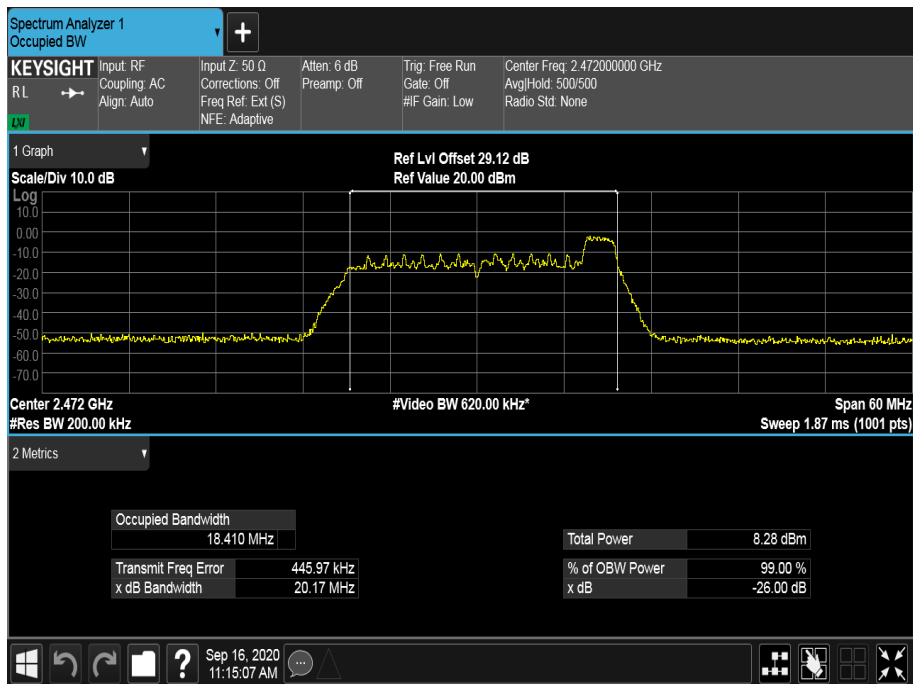


Figure 60 - 2472 MHz - 99% Occupied Bandwidth

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

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



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
10dB/1W SMA Attenuator DC-18GHz	Seaelectro	60-674-1010-89	395	-	O/P Mon
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	08-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	08-Nov-2020
Attenuator (10dB, 1W)	Seaelectro	60-674-1010-89	1224	-	O/P Mon
Attenuator (20dB, 1W)	Seaelectro	60-674-1020-89	1520	-	O/P Mon
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4742	12	29-Nov-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
EXA Signal Analyser	Keysight Technologies	N9010B	4968	24	23-Dec-2021
USB Power Sensor	Boonton	RTP5006	5186	12	28-Nov-2020
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon
Power Splitter, 2 way	Mini-Circuits	ZN2PD2-63-S+	5238	-	O/P Mon
USB Power Sensor	Boonton	RTP5006	5280	12	27-Apr-2021
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5417	12	22-Jun-2021
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5418	12	22-Jun-2021
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5425	12	22-Jun-2021
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5426	12	22-Jun-2021
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5493	12	14-Apr-2021
MXA Signal Analyser	Keysight Technologies	N9020B	5529	24	4-Mar-2022
Attenuator 2W 10dB DC-10GHz	Telegartner	J01156A0031	5576	-	O/P Mon
Attenuator 2W 10dB DC-10GHz	Telegartner	J01156A0031	5580	-	O/P Mon
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
AC Programmable Power Supply	iTech	IT7324	5225	-	O/P Mon

Table 16

O/P Mon – Output Monitored using calibrated equipment



2.2 Maximum Conducted Output Power

2.2.1 Specification Reference

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

2.2.2 Equipment Under Test and Modification State

A2337, S/N: C02D200WQ9MQ - Modification State 0

2.2.3 Date of Test

10-September-2020 to 17-September-2020

2.2.4 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.

2.2.5 Environmental Conditions

Ambient Temperature	21.6 - 23.5 °C
Relative Humidity	39.8 - 58.8 %



2.2.6 Test Results

2.4 GHz WLAN

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	19.72	20.48	12.66
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	23.74	24.51	16.69

Table 17 - 802.11b / 1 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	14.84	20.39	1.90
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	18.87	24.42	5.93

Table 18 - 802.11g / 6 Mbps / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	14.90	20.48	1.86
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	18.93	24.51	5.89

Table 19 - 802.11n / HT20 MCS7 / SISO / Core 0



Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	14.00	19.64	0.28
Conducted Power Core 1 (dBm)	13.71	19.75	0.16
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	16.87	22.71	3.23
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	20.90	26.74	7.26

Table 20 - 802.11n / HT20 MCS7 / MIMO CDD / Cores 0+1

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	13.40	19.39	0.27
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	17.43	23.42	4.30

Table 21 - 802.11ax / HE20 MCS7x1 / SU / SISO / Core 0

Channel	Bottom	Middle	Top
Frequency (MHz)	2412	2442	2472
Conducted Power Core 0 (dBm)	12.24	18.18	-1.75
Conducted Power Core 1 (dBm)	12.45	18.02	-1.56
Antenna Directional Gain (dBi)	4.03	4.03	4.03
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)	15.36	21.11	1.35
RSS-247 EIRP Limit (dBm)	36.00	36.00	36.00
EIRP Power (dBm)	19.39	25.14	5.38

Table 22 - 802.11ax / HE20 MCS7x1 / SU / MIMO CDD / 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.

ISED RSS-247, Limit Clause 5.4 (b)

For DTSSs 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.



2.2.7 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
10dB/1W SMA Attenuator DC-18GHz	Seaelectro	60-674-1010-89	395	-	O/P Mon
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	08-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	08-Nov-2020
Attenuator (10dB, 1W)	Seaelectro	60-674-1010-89	1224	-	O/P Mon
Attenuator (20dB, 1W)	Seaelectro	60-674-1020-89	1520	-	O/P Mon
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4742	12	29-Nov-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
EXA Signal Analyser	Keysight Technologies	N9010B	4968	24	23-Dec-2021
USB Power Sensor	Boonton	RTP5006	5186	12	28-Nov-2020
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon
Power Splitter, 2 way	Mini-Circuits	ZN2PD2-63-S+	5238	-	O/P Mon
USB Power Sensor	Boonton	RTP5006	5280	12	27-Apr-2021
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5417	12	22-Jun-2021
3.5 mm 1m Cable	Junkosha	MWX221-01000DMS	5418	12	22-Jun-2021
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5425	12	22-Jun-2021
3.5 mm 2m Cable	Junkosha	MWX221-02000DMS	5426	12	22-Jun-2021
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5493	12	14-Apr-2021
MXA Signal Analyser	Keysight Technologies	N9020B	5529	24	4-Mar-2022
Attenuator 2W 10dB DC-10GHz	Telegartner	J01156A0031	5576	-	O/P Mon
Attenuator 2W 10dB DC-10GHz	Telegartner	J01156A0031	5580	-	O/P Mon
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
AC Programmable Power Supply	iTech	IT7324	5225	-	O/P Mon

Table 23

O/P Mon – Output Monitored using calibrated equipment



2.3 Authorised Band Edges

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

A2337, S/N: C02D200EQ9MQ - Modification State 0

2.3.3 Date of Test

03-August-2020 to 22-August-2020

2.3.4 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(d) and RSS-247 clause 5.5.

The measurements displayed within this report, have in some cases been limited to those modes which have been shown to be worst case. Further measurements are held on file by TÜV SÜD and are available if required.

2.3.5 Environmental Conditions

Ambient Temperature	19.8-23.2°C
Relative Humidity	48.1-68.2%

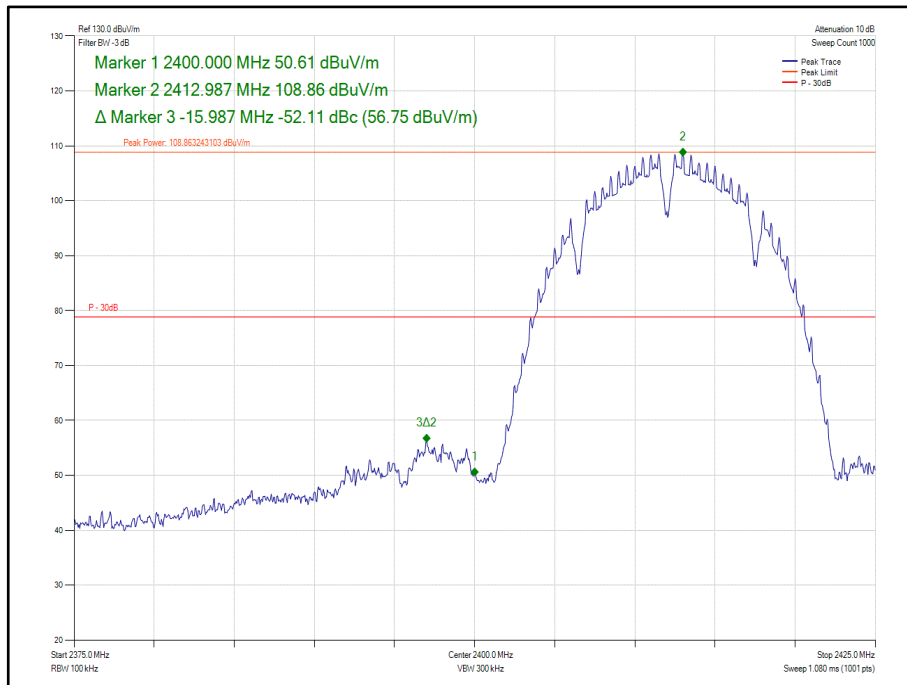


2.3.6 Test Results

2.4 GHz WLAN

Mode	Data Rate /MCS	Resource size	Resource Index	TX Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
802.11b, Core 0	1 Mbps	-	-	2412	2400	-52.11
802.11g, Core 0	6 Mbps	-	-	2412	2400	-44.28
802.11n HT20, Core 0	MCS7	-	-	2412	2400	-43.43
802.11ax HE20, Core 0	MCS7	SU	-	2412	2400	-45.13
802.11ax HE20, Core 0	MCS7	26	0	2412	2400	-49.30

Table 24 - SISO Authorised Band Edge Results



**Figure 61 - 802.11b, Core 0 - 2412 MHz
 Band Edge Frequency 2400 MHz**

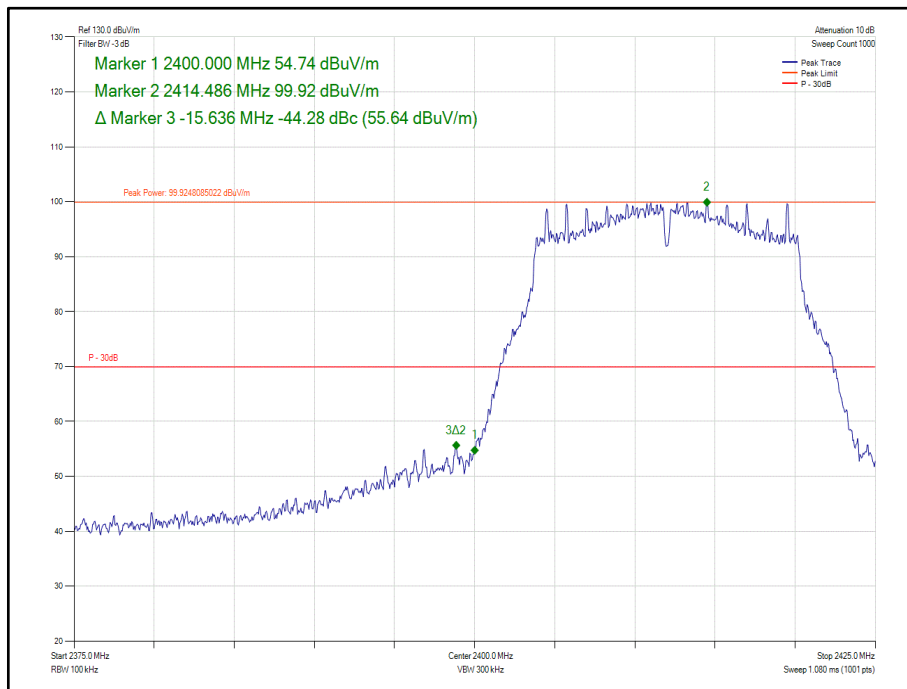


Figure 62- 802.11g, Core 0 - 2412 MHz
Band Edge Frequency 2400 MHz

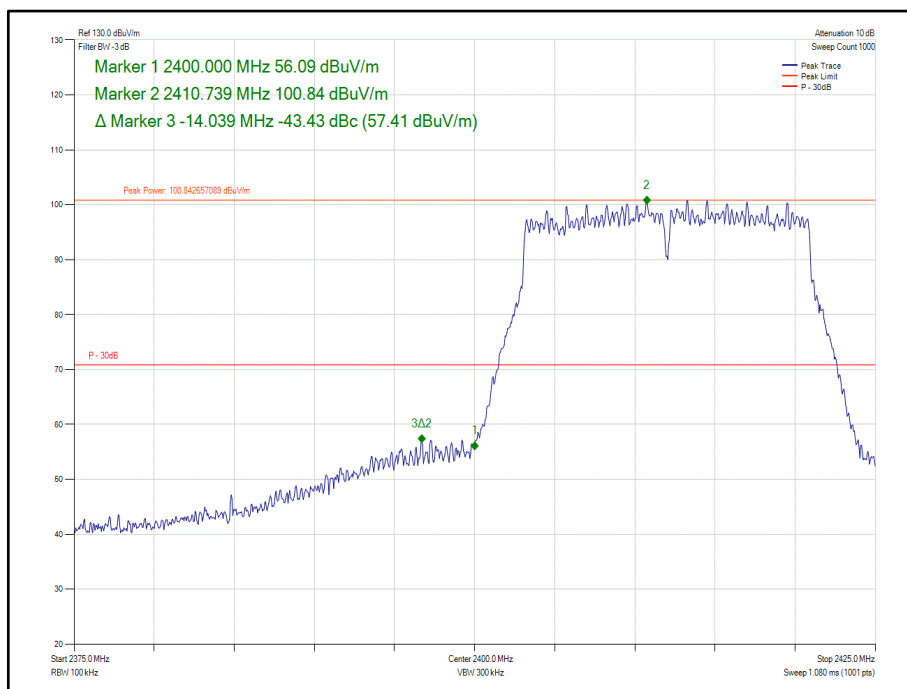


Figure 63- 802.11n HT20, Core 0 - 2412 MHz
Band Edge Frequency 2400 MHz

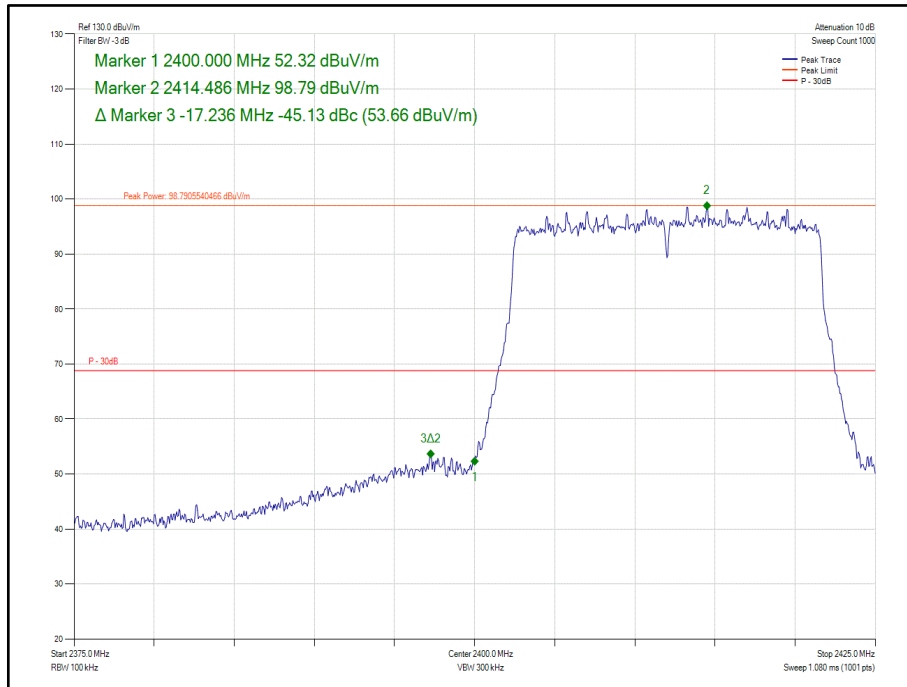


Figure 64- 802.11ax HE20, Core 0, SU - 2412 MHz
Band Edge Frequency 2400 MHz

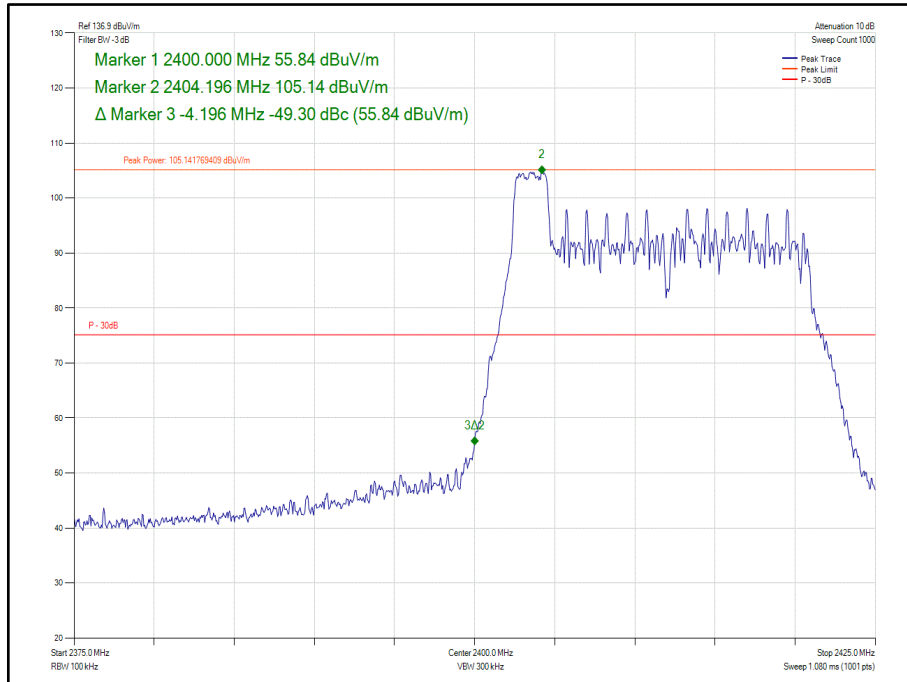
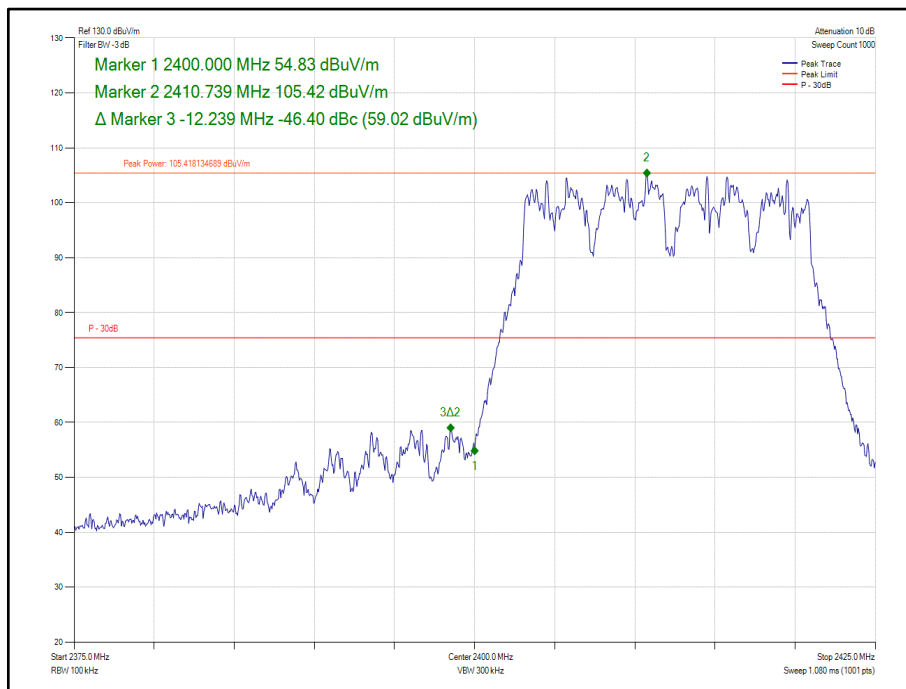


Figure 65- 802.11ax HE20, Core 0, 26-0 - 2412 MHz
Band Edge Frequency 2400 MHz



Mode	Data Rate /MCS	Resource size	Resource Index	TX Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
802.11n HT20, Cores 0-1	MCS7	-	-	2412	2400	-46.40
802.11ax HE20, Cores 0 -1	MCS7	SU	-	2412	2400	-49.29
802.11ax HE20, Cores 0 -1	MCS7	26	0	2412	2400	-54.49

Table 25 - MIMO 2TX Authorised Band Edge Results



**Figure 66 - 802.11n HT20, Cores 0-1 - 2412 MHz
 Band Edge Frequency 2400 MHz**

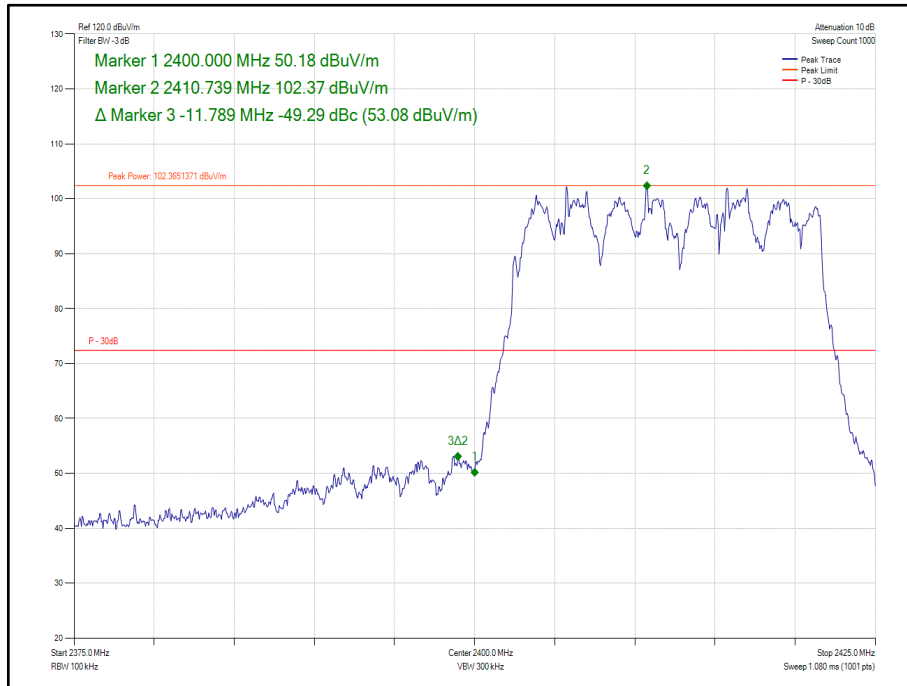


Figure 67- 802.11ax HE20, Cores 0-1, SU - 2412 MHz
Band Edge Frequency 2400 MHz

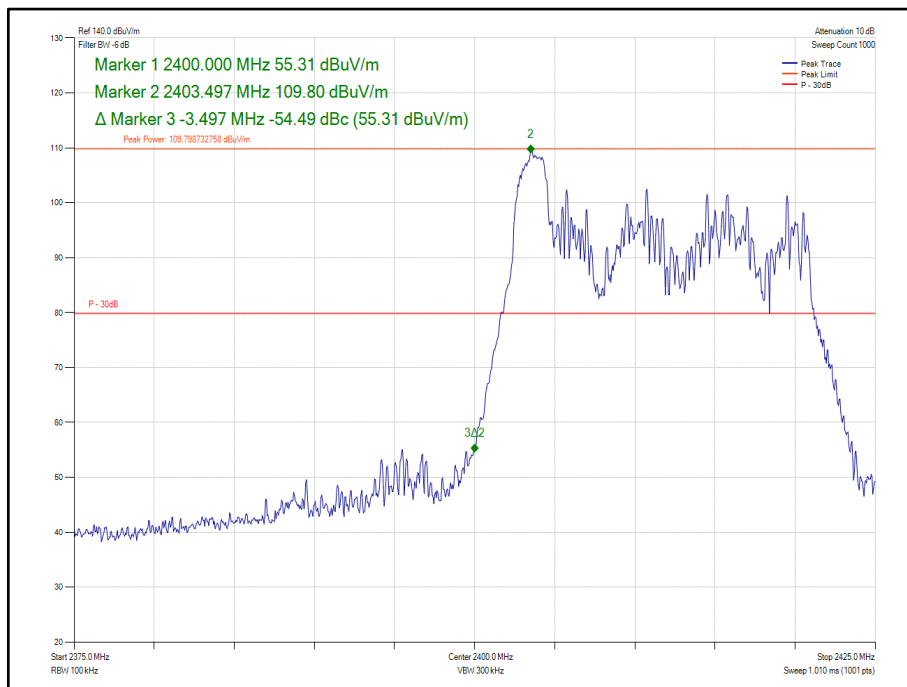


Figure 68- 802.11ax HE20, Cores 0-1, 26-0 - 2412 MHz
Band Edge Frequency 2400 MHz



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.

ISED 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.



2.3.7 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
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-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
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	10-Mar-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	17-Mar-2021
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5518	12	01-Apr-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5522	12	24-Mar-2021

Table 26

TU - Traceability Unscheduled
 O/P Mon – Output Monitored using calibrated equipment



2.4 Restricted Band Edges

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

A2337, S/N: C02D200EQ9MQ - Modification State 0

2.4.3 Date of Test

02-August-2020 to 19-August-2020

2.4.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5.

Plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.5. These are shown for information purposes and were used to determine the worst-case measurement point. Final average measurements were then taken in accordance with ANSI C63.10, clause 4.1.4.2.2 to obtain the measurement result recorded in the test results tables.

Where duty cycle corrections were required for average results, these are included in the result tables but are not shown on the plots.

The following conversion can be applied to convert from dB μ V/m to μ V/m:
 $10^{(\text{Field Strength in dB}\mu\text{V/m}/20)}$.

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

The measurements displayed within this report, have been limited to those modes which have been shown to be worst case. Further measurements are held on file by TÜV SÜD, and are available if required.

2.4.5 Environmental Conditions

Ambient Temperature	19.8-23.2°C
Relative Humidity	48.1-68.2%



2.4.6 Test Results

2.4 GHz WLAN

Mode	Data Rate /MCS	Resource Size	Resource Index	TX Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
802.11b, Core 0	1 Mbps	-	-	2412	2390.0	58.35	47.11
802.11b, Core 0	1 Mbps	-	-	2462	2483.5	57.36	46.72
802.11b, Core 0	1 Mbps	-	-	2467	2483.5	58.47	49.16
802.11b, Core 0	1 Mbps	-	-	2472	2483.5	57.28	46.96
802.11g, Core 0	6 Mbps	-	-	2412	2390.0	57.39	45.86
802.11g, Core 0	6 Mbps	-	-	2462	2483.5	56.93	45.76
802.11g, Core 0	6 Mbps	-	-	2467	2483.5	65.15	47.03
802.11g, Core 0	6 Mbps	-	-	2472	2483.5	64.70	49.40
802.11n HT20, Core 0	MCS7	-	-	2412	2390.0	64.46	48.82
802.11n HT20, Core 0	MCS7	-	-	2462	2483.5	59.31	47.80
802.11n HT20, Core 0	MCS7	-	-	2467	2483.5	60.61	47.59
802.11n HT20, Core 0	MCS7	-	-	2472	2483.5	67.31	50.59
802.11ax HE20, Core 0	MCS7	SU	-	2412	2400.0	60.04	46.66
802.11ax HE20, Core 0	MCS7	26	0	2412	2400.0	56.24	44.86
802.11ax HE20, Core 0	MCS7	SU	-	2462	2483.5	58.38	46.69
802.11ax HE20, Core 0	MCS7	26	8	2462	2483.5	55.62	44.71
802.11ax HE20, Core 0	MCS7	SU	-	2467	2483.5	58.74	46.47
802.11ax HE20, Core 0	MCS7	26	8	2467	2483.5	57.87	45.42
802.11ax HE20, Core 0	MCS7	SU	-	2472	2483.5	66.59	47.98
802.11ax HE20, Core 0	MCS7	26	8	2472	2483.5	66.99	49.03

Table 27 - SISO Restricted Band Edge Results

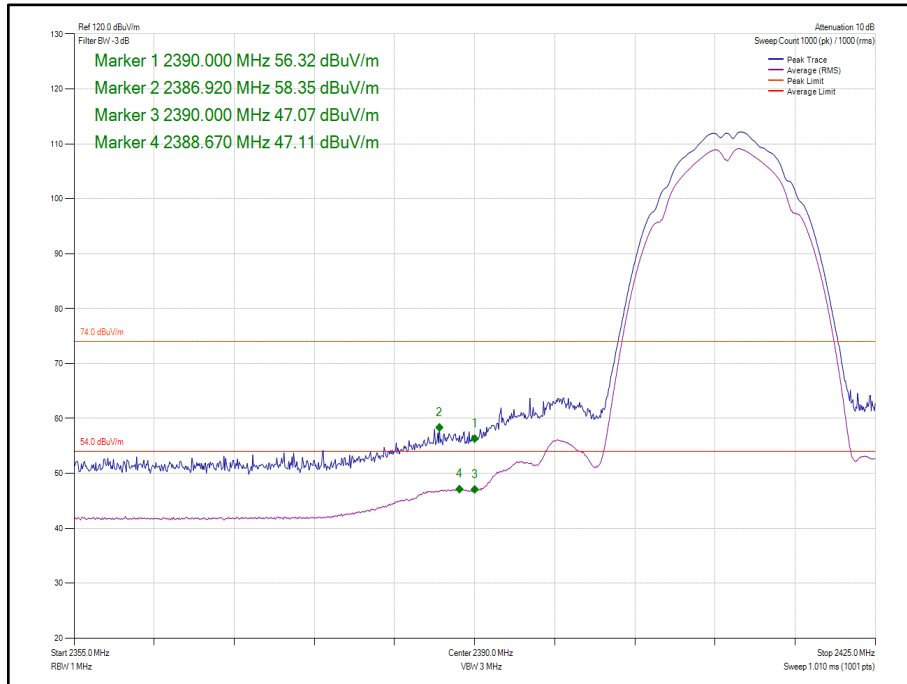


Figure 69 - 802.11b, Core 0 - 2412 MHz, Band Edge Frequency 2390.0 MHz

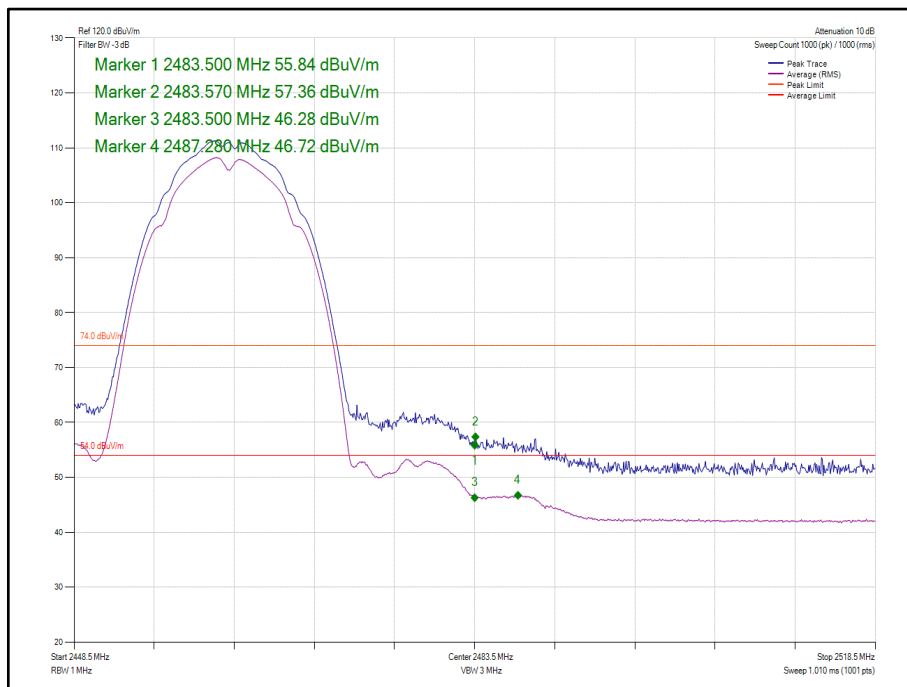


Figure 70 - 802.11b, Core 0 - 2462 MHz, Band Edge Frequency 2483.5 MHz

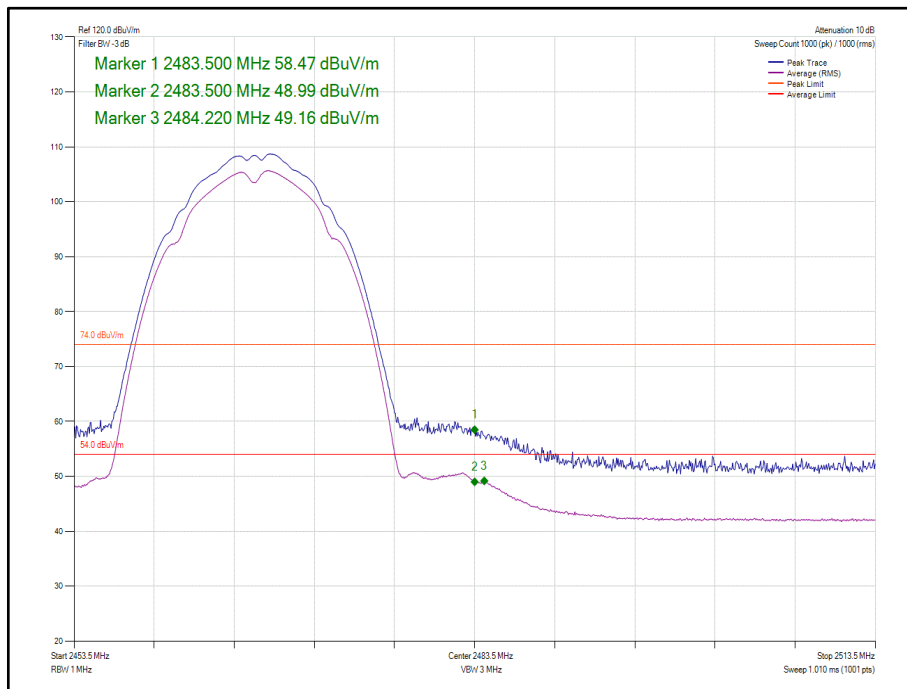


Figure 71 - 802.11b, Core 0 - 2467 MHz, Band Edge Frequency 2483.5 MHz

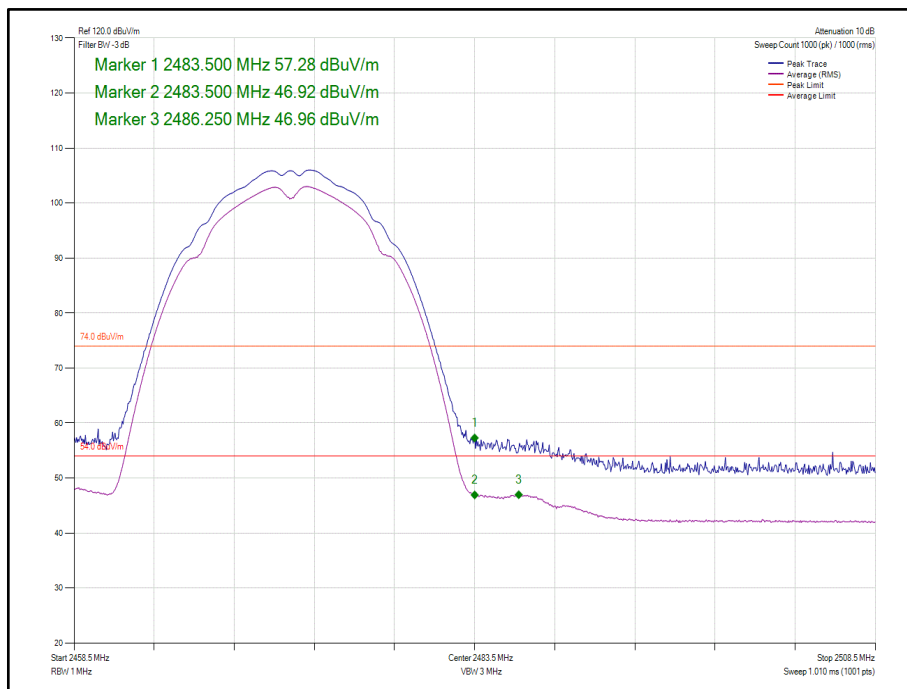


Figure 72 - 802.11b, Core 0 - 2472 MHz, Band Edge Frequency 2483.5 MHz

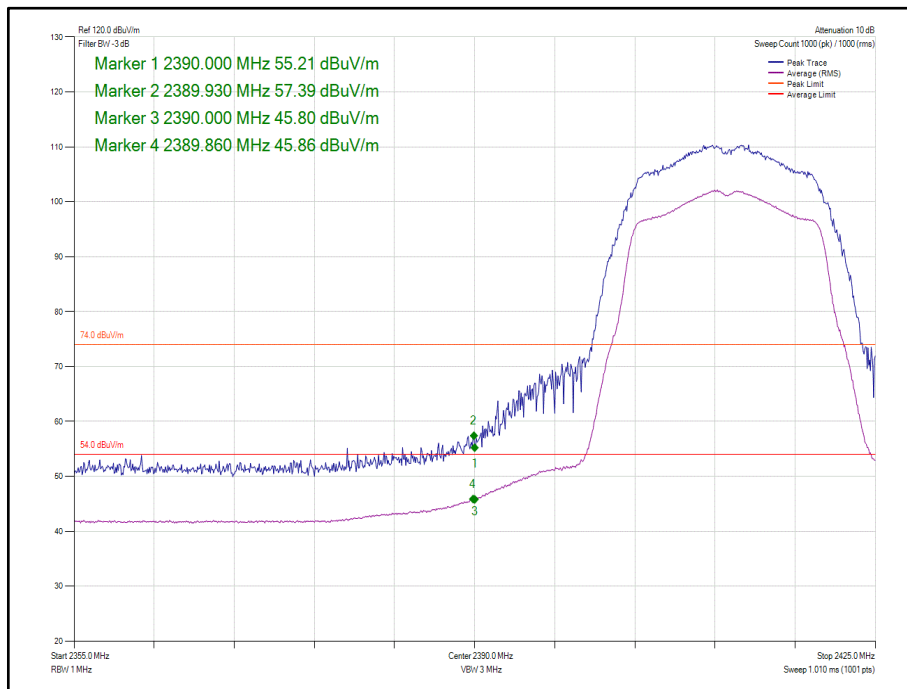


Figure 73 - 802.11g, Core 0 - 2412 MHz, Band Edge Frequency 2390.0 MHz

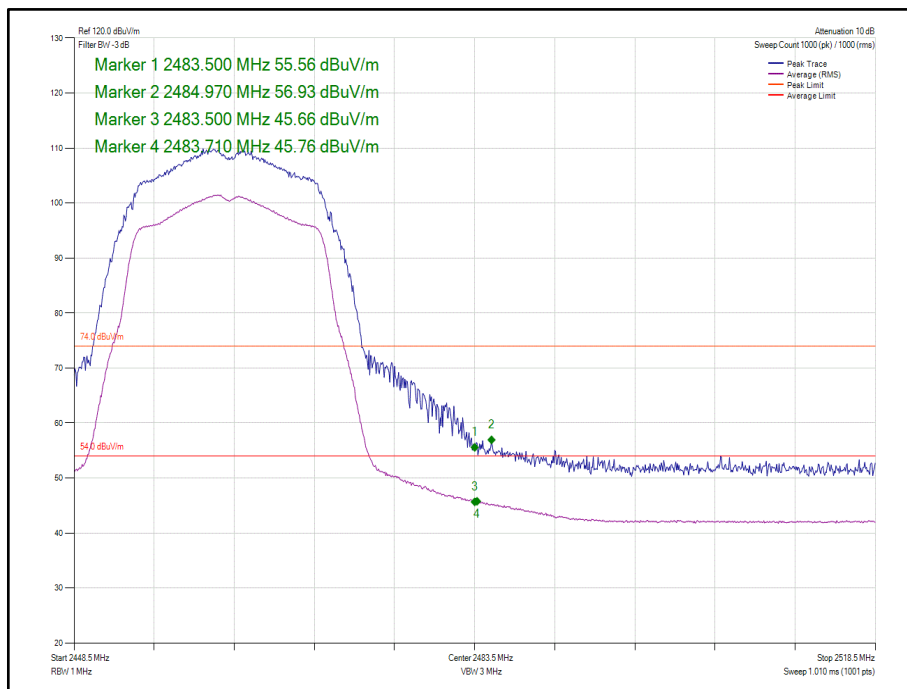


Figure 74 - 802.11g, Core 0 - 2462 MHz, Band Edge Frequency 2483.5 MHz

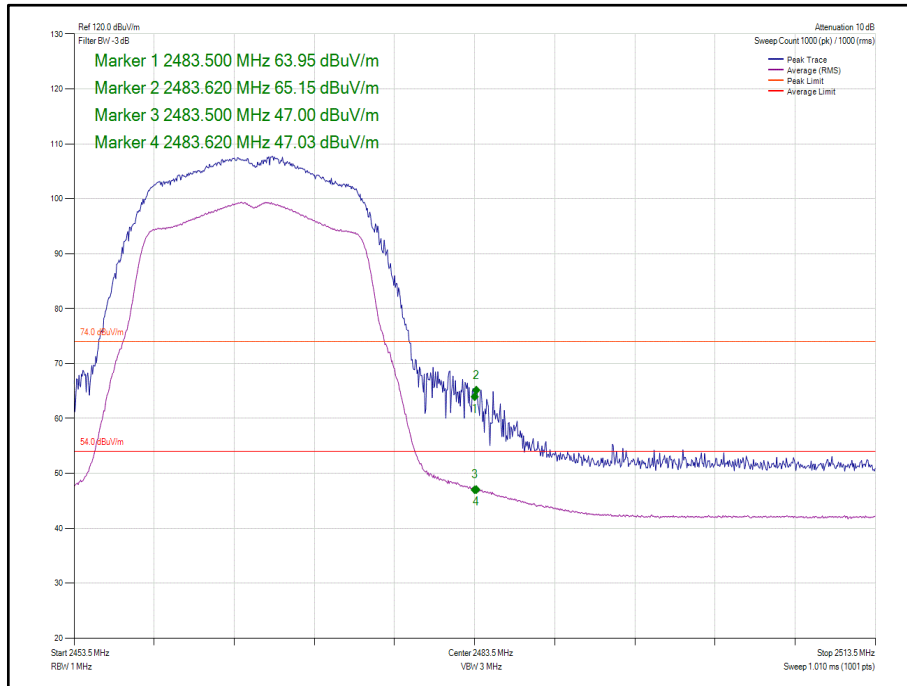


Figure 75 - 802.11g, Core 0 - 2467 MHz, Band Edge Frequency 2483.5 MHz

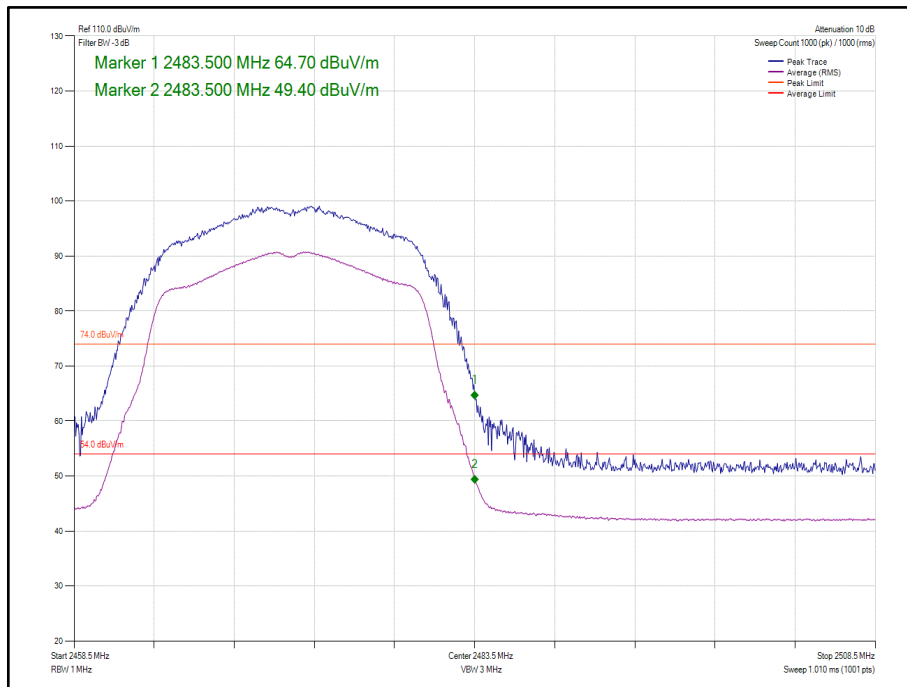


Figure 76 - 802.11g, Core 0 - 2472 MHz, Band Edge Frequency 2483.5 MHz

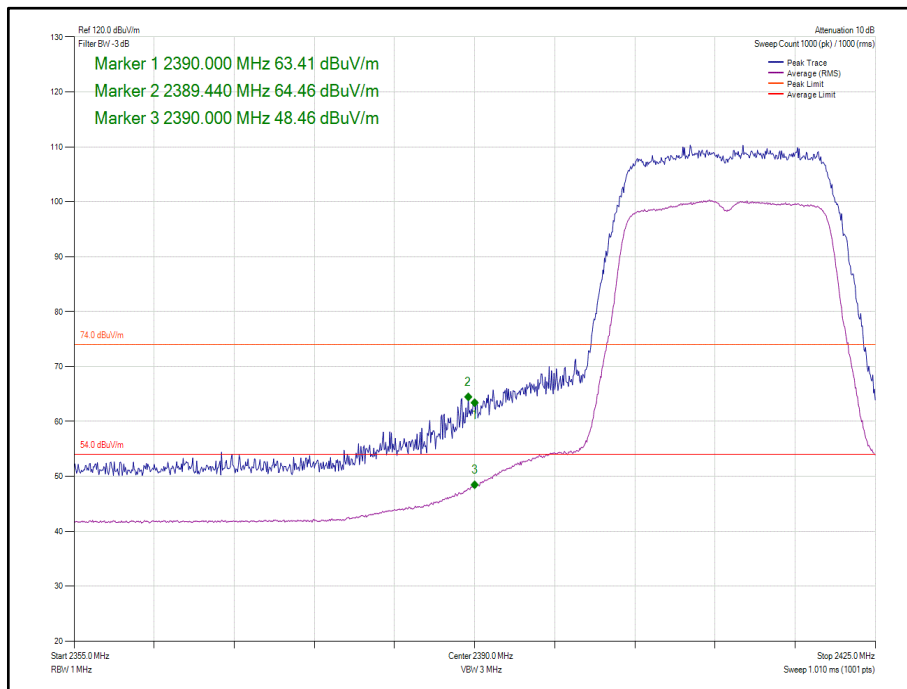


Figure 77 - 802.11n, HT20, Core 0 - 2412 MHz, Band Edge Frequency 2390 MHz

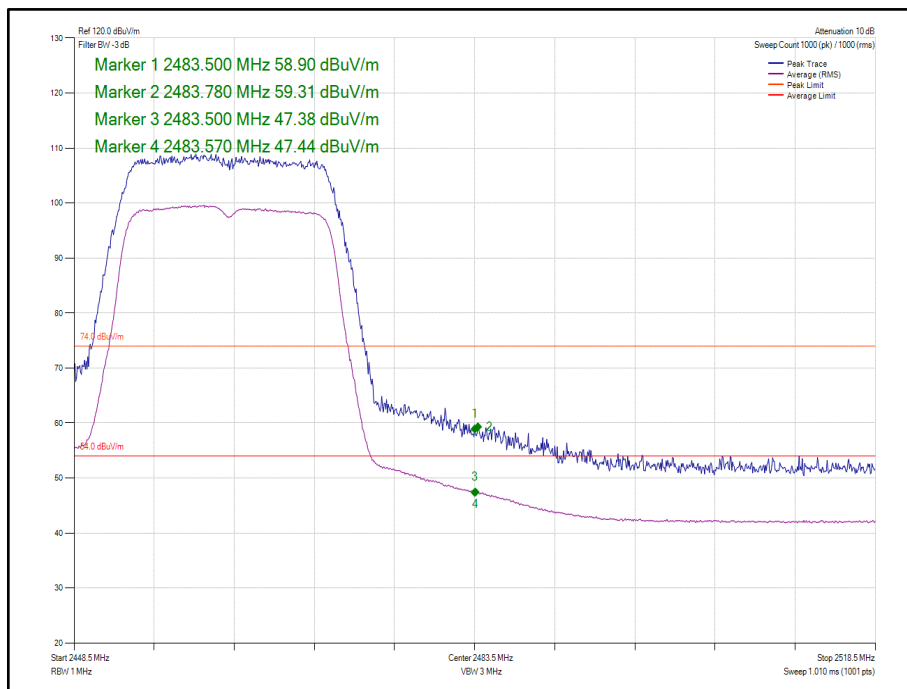


Figure 78 - 802.11n HT20, Core 0 - 2462 MHz, Band Edge Frequency 2483.5 MHz

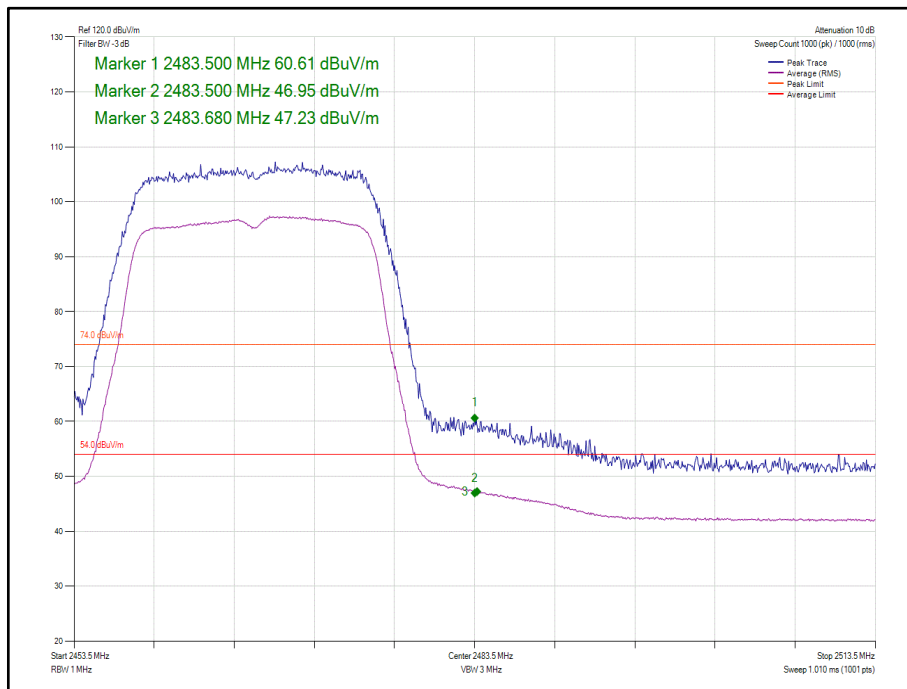


Figure 79 - 802.11n HT20, Core 0 - 2467 MHz, Band Edge Frequency 2483.5 MHz

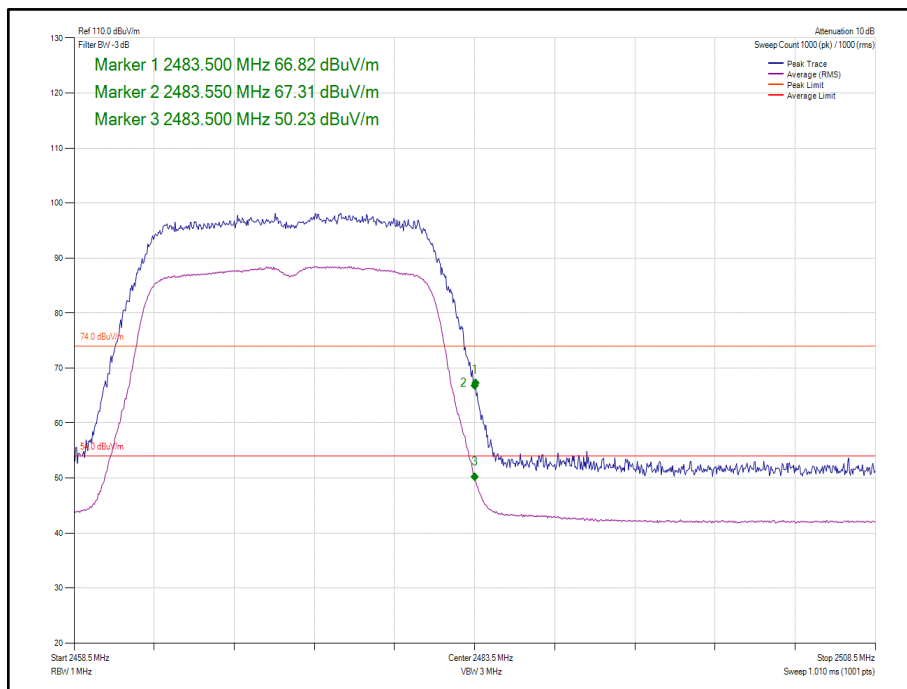


Figure 80 - 802.11n HT20, Core 0 - 2472 MHz, Band Edge Frequency 2483.5 MHz