

# FCC and ISED Test Report

Apple Inc  
Model: A2338

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: BCGA2338

IC: 579C-A2338

## COMMERCIAL-IN-CONFIDENCE

Document 75948987-11 Issue 01



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### SIGNATURE

| NAME          | JOB TITLE       | RESPONSIBLE FOR      | ISSUE DATE      |
|---------------|-----------------|----------------------|-----------------|
| Phil Harrison | Senior Engineer | Authorised Signatory | 06 October 2020 |

Signatures in this approval box have checked this document in line with the requirements of TUV SUD 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   | 06 October 2020 |           |
| Testing         | Philip Harrison | 06 October 2020 |           |
| Testing         | Ahmad Javid     | 06 October 2020 |           |
| Testing         | Faisal Malyar   | 06 October 2020 |           |
| Testing         | Connor Lee      | 06 October 2020 |           |
| Testing         | Liang Tian      | 06 October 2020 |           |
| Testing         | Colin Brain     | 06 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.



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# 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           | 06 October 2020 |

**Table 1**

## 1.2 Introduction

|                               |                                                                                                                |
|-------------------------------|----------------------------------------------------------------------------------------------------------------|
| Applicant                     | Apple Inc                                                                                                      |
| Manufacturer                  | Apple Inc                                                                                                      |
| Model Number(s)               | A2338                                                                                                          |
| Serial Number(s)              | C02CX02PQC36 and C02CX01FQC36                                                                                  |
| Hardware Version(s)           | REV 1.0                                                                                                        |
| Software Version(s)           | 20W112771j                                                                                                     |
| Number of Samples Tested      | 2                                                                                                              |
| Test Specification/Issue/Date | FCC 47 CFR Part 15C: 2019<br>ISED RSS-247: Issue 2 (02-2017)<br>ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) |
| Order Number                  | 0540201117                                                                                                     |
| Date                          | 05-May-2020                                                                                                    |
| Date of Receipt of EUT        | 17-July-2020 and 17-August-2020                                                                                |
| Start of Test                 | 17-July-2020                                                                                                   |
| Finish of Test                | 21-September-2020                                                                                              |
| Name of Engineer(s)           | George Porter, Philip Harrison, Ahmad Javid, Faisal Malyar, Connor Lee, Liang Tian and Colin Brain             |
| Related Document(s)           | ANSI C63.10 (2013)<br>KDB 662911 D01 v02r02                                                                    |



### 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 | 5.2     | 6.12    | 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 was 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          | 1.18            | 1.0                       |
| 2.4 GHz Core 1 | 2400 to 2480          | 0.57            | 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: A2338, Serial Number: C02CX01FQC36 |                                                 |                        |                          |
| 0                                         | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2338, Serial Number: C02CX02PQC36 |                                                 |                        |                          |
| 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 |                                        |               |
| Maximum Conducted Output Power       | George Porter and Philip Harrison      | UKAS          |
| Emission Bandwidth                   | George Porter and Philip Harrison      | UKAS          |
| Authorised Band Edges                | Ahmad Javid and Faisal Malyar          | UKAS          |
| Restricted Band Edges                | Ahmad Javid and Faisal Malyar          | UKAS          |
| Spurious Radiated Emissions          | Connor Lee, Liang Tian and Colin Brain | 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

A2338, S/N: C02CX01FQC36 - Modification State 0

#### 2.1.3 Date of Test

10-September-2020 to 21-September-2020

#### 2.1.4 Test Method

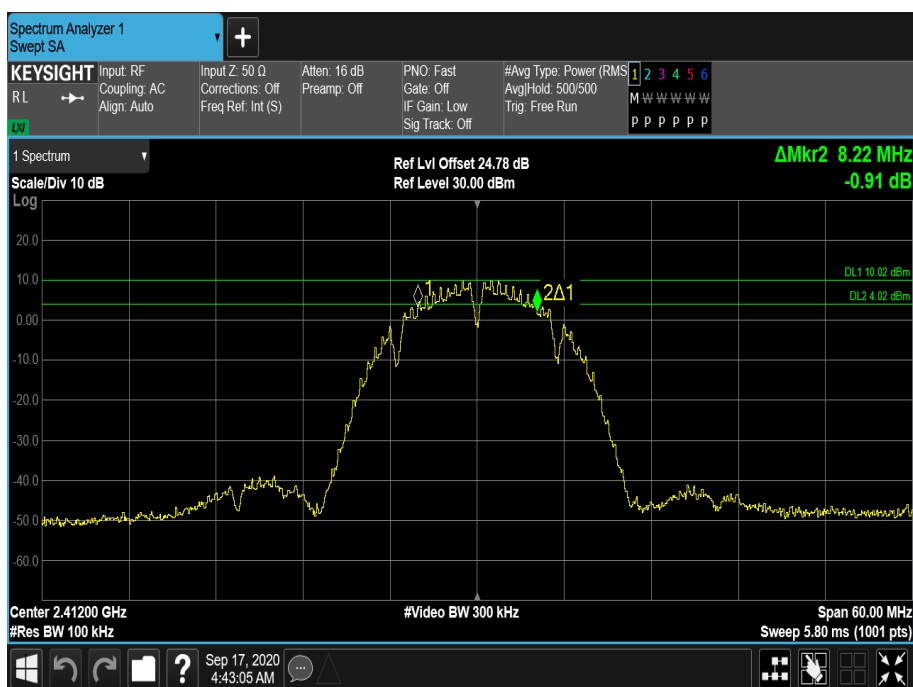
This test was performed in accordance with ANSI C63.10, clause 11.8.2

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 %  |

## 2.4 GHz WLAN

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

**Figure 1 - 2412 MHz - 6 dB DTS Bandwidth**

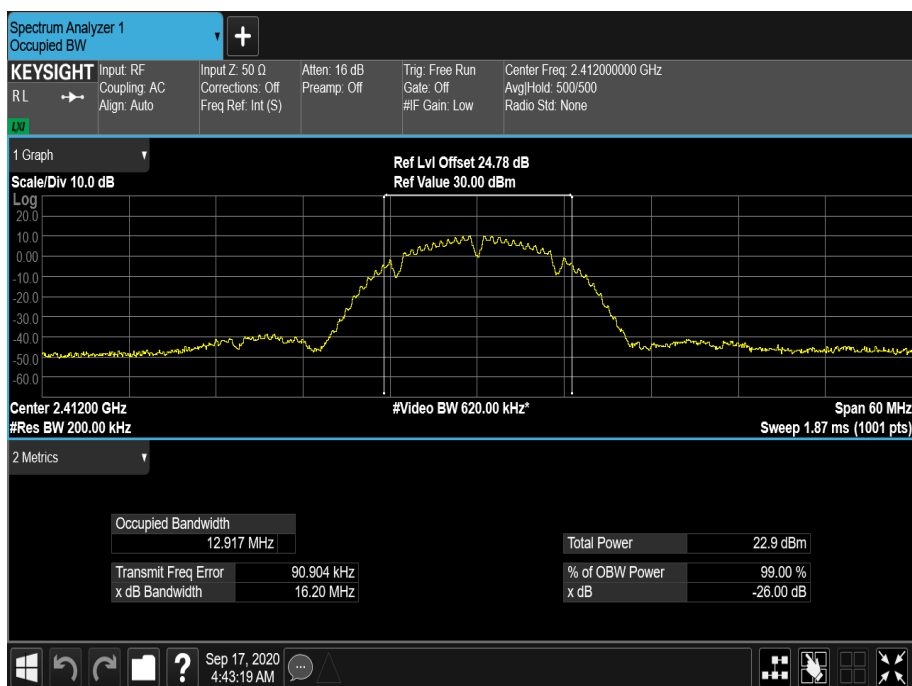


Figure 2 - 2412 MHz - 99% Occupied Bandwidth

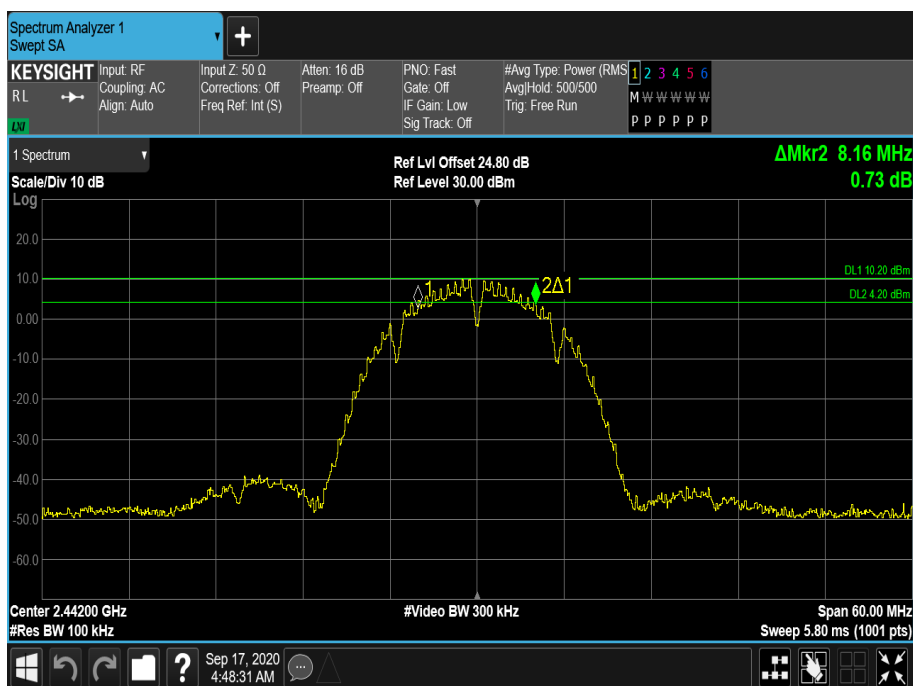


Figure 3 - 2442 MHz - 6 dB DTS Bandwidth

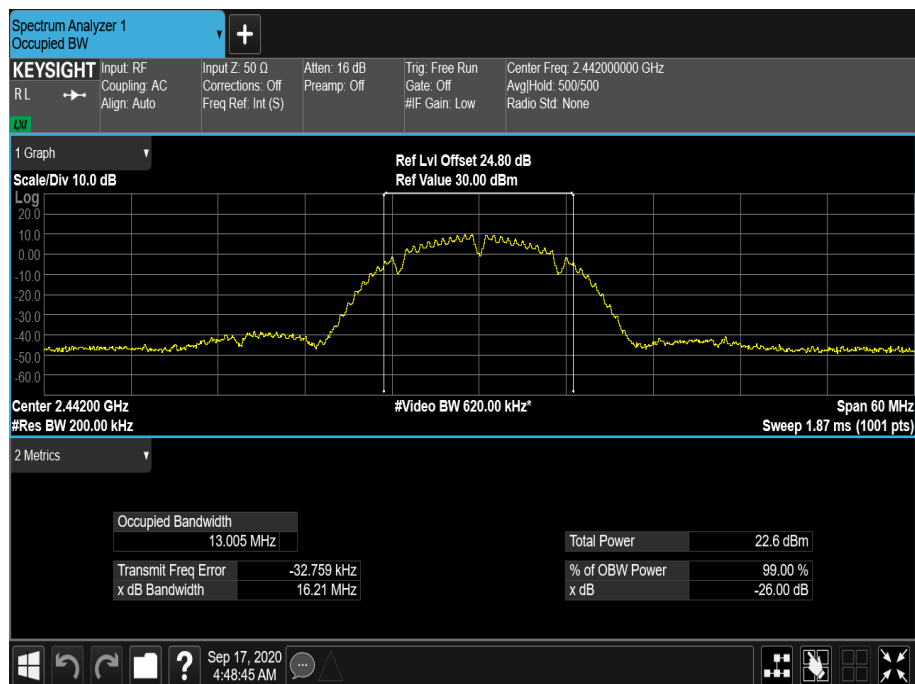


Figure 4 - 2442 MHz - 99% Occupied Bandwidth

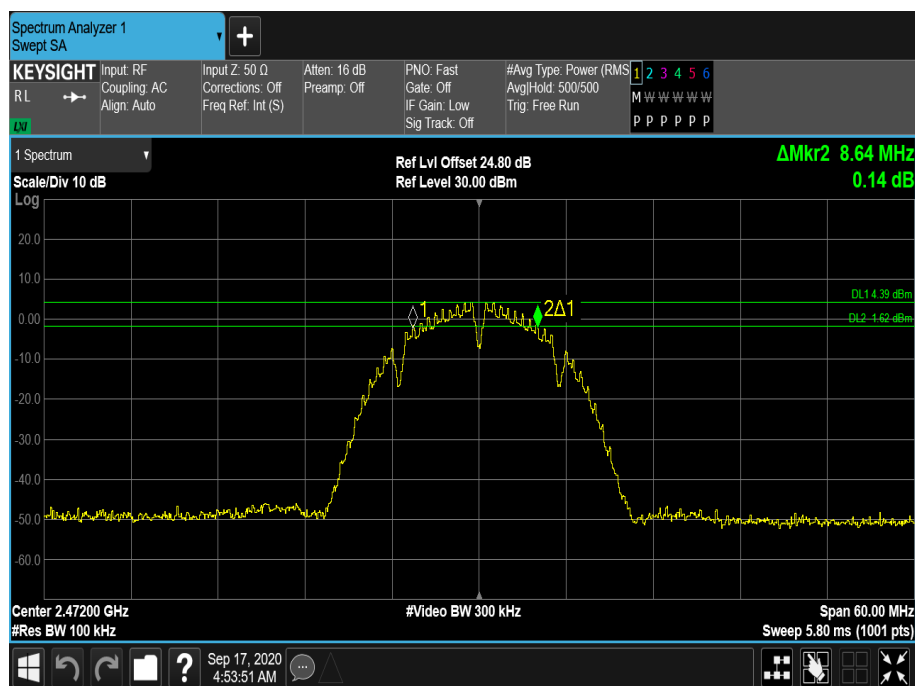


Figure 5 - 2472 MHz - 6 dB DTS Bandwidth

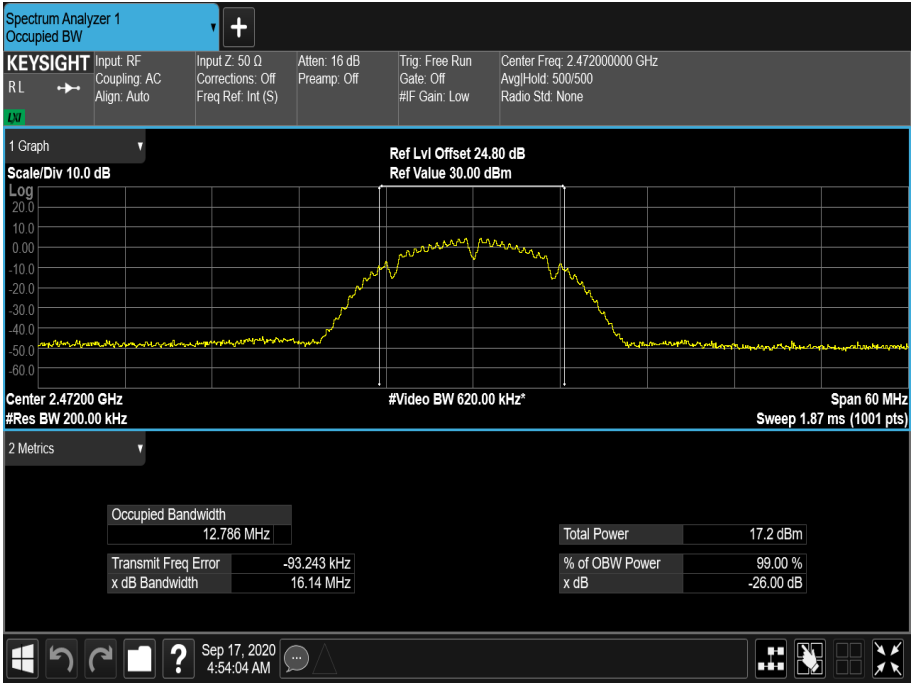


Figure 6 - 2472 MHz - 99% Occupied Bandwidth

| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 15.300 | 15.240 | 15.240 |
| 99% Bandwidth (MHz)  | 16.283 | 16.302 | 16.278 |

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

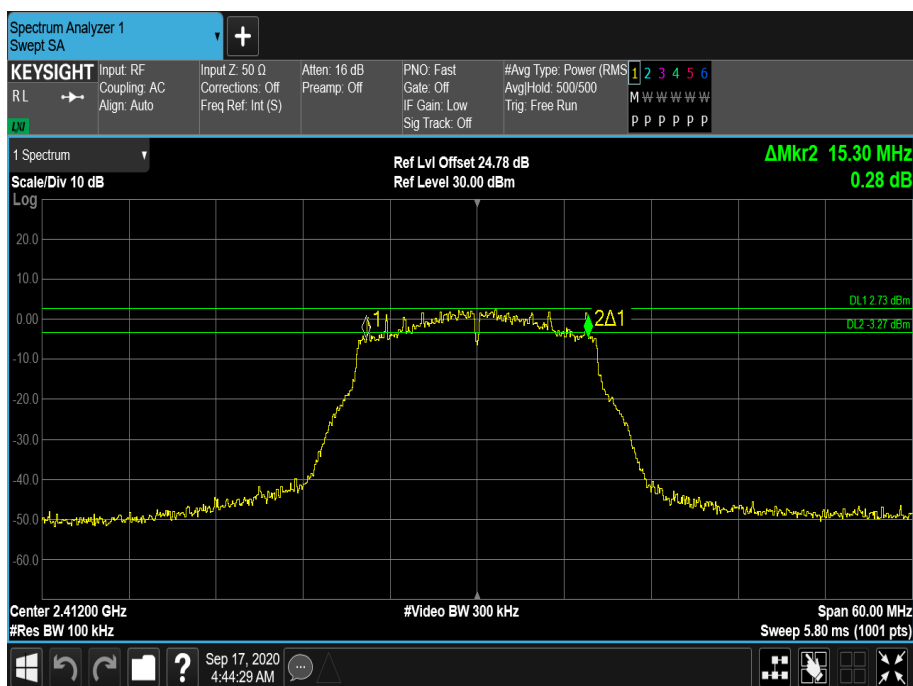


Figure 7 - 2412 MHz - 6 dB DTS Bandwidth

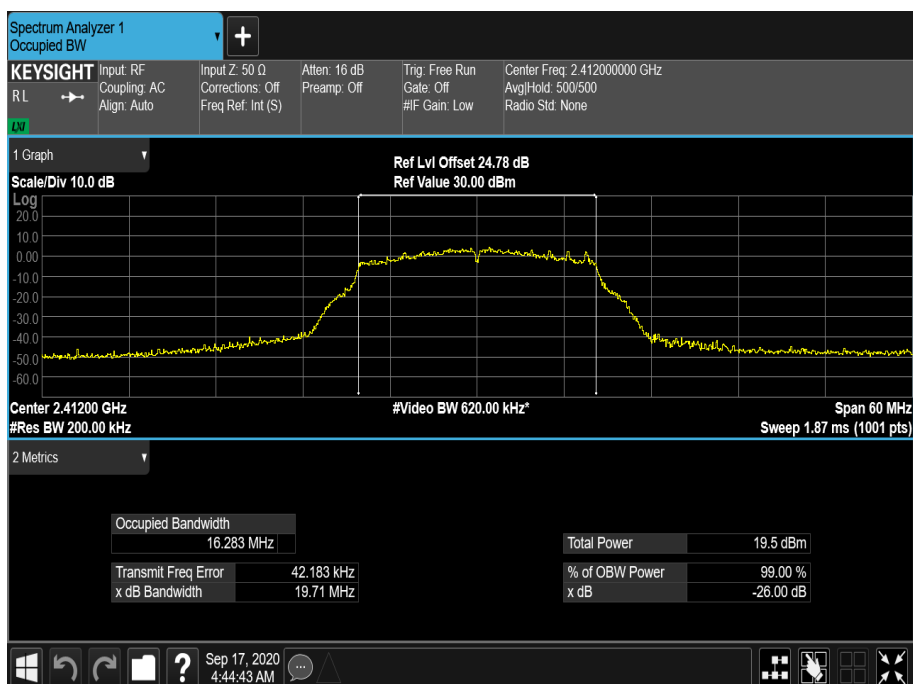


Figure 8 - 2412 MHz - 99% Occupied Bandwidth

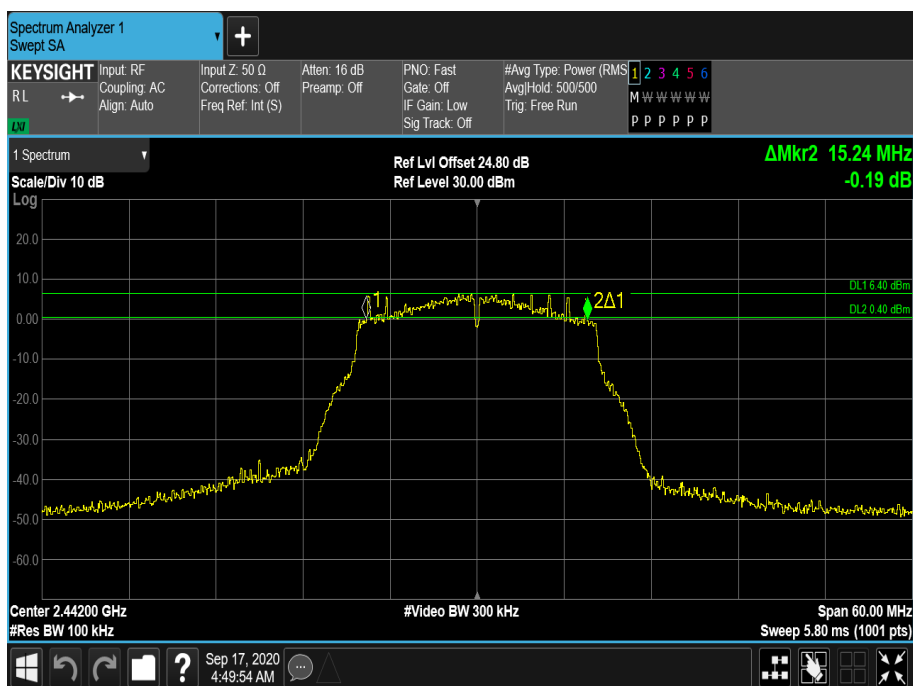


Figure 9 - 2442 MHz - 6 dB DTS Bandwidth

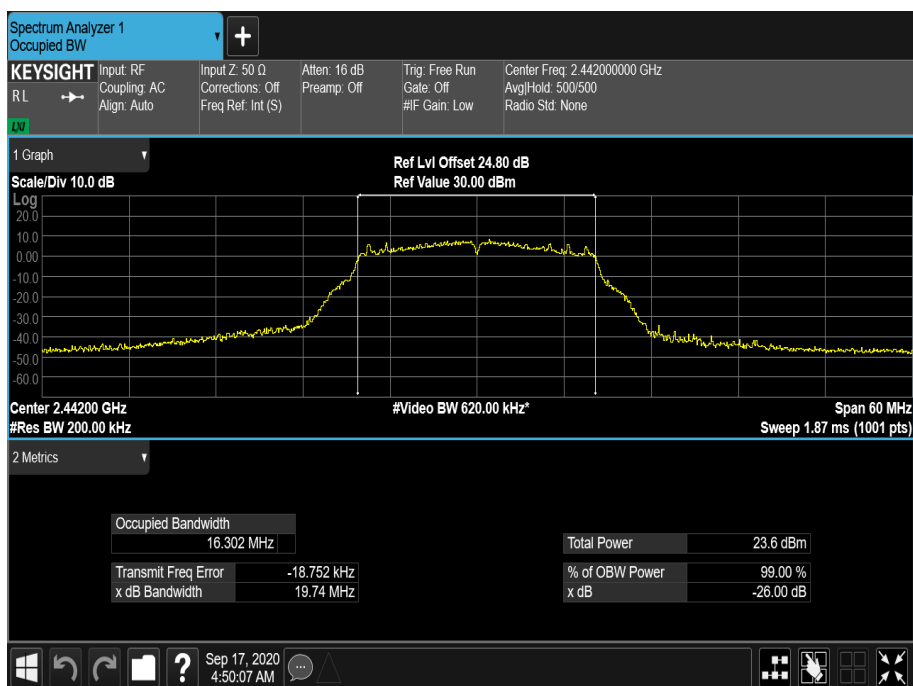


Figure 10 - 2442 MHz - 99% Occupied Bandwidth

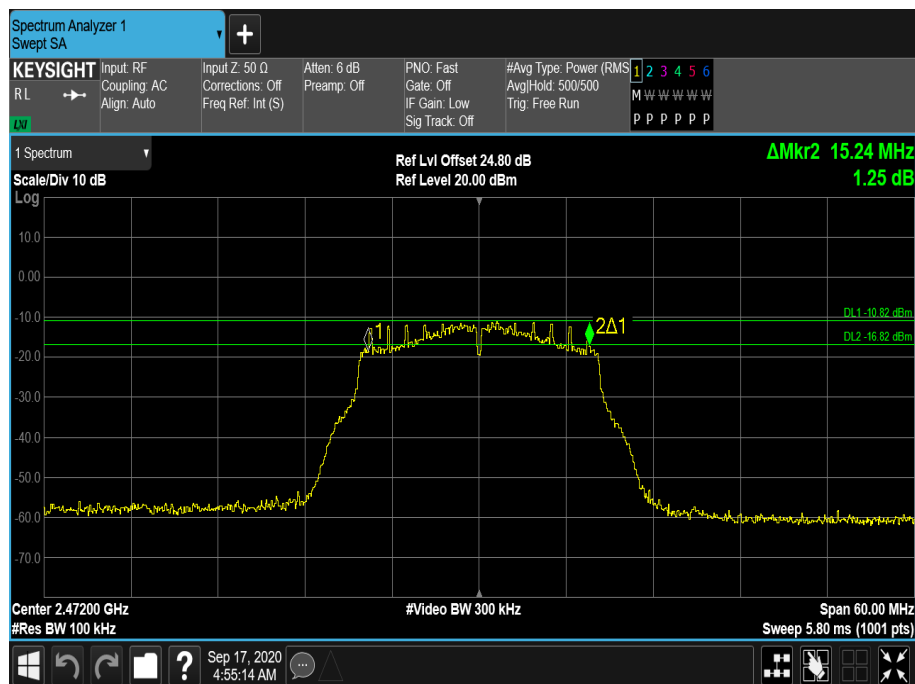


Figure 11 - 2472 MHz - 6 dB DTS Bandwidth

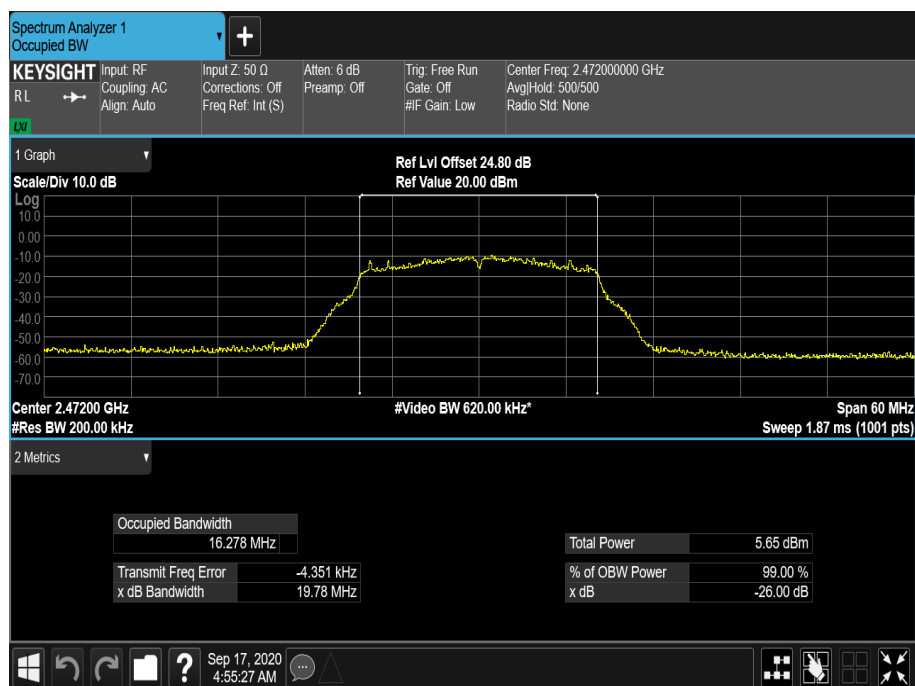


Figure 12 - 2472 MHz - 99% Occupied Bandwidth

| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 17.460 | 17.760 | 17.640 |
| 99% Bandwidth (MHz)  | 17.683 | 17.659 | 17.615 |

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

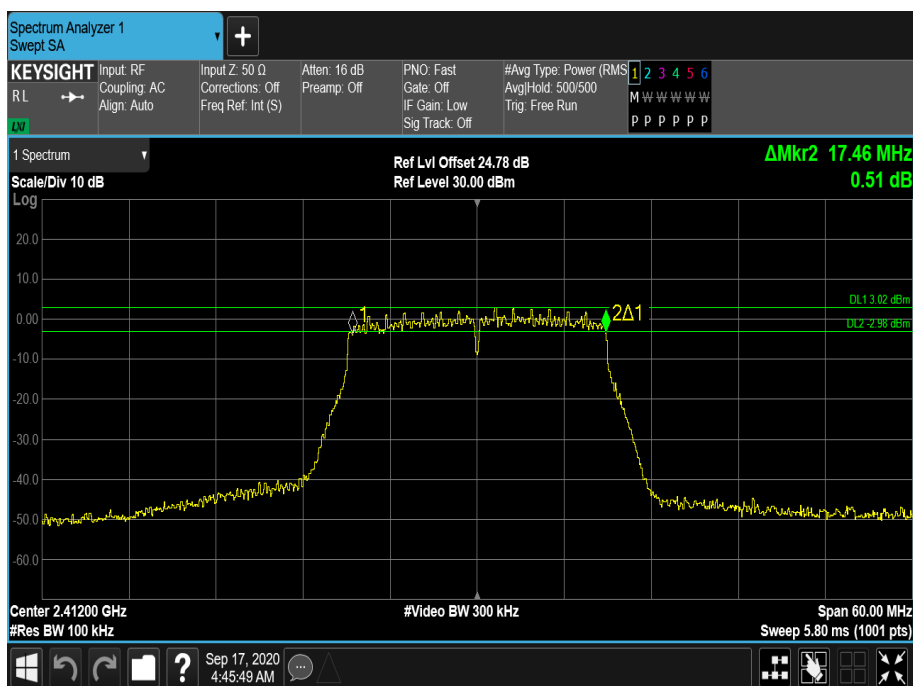


Figure 13 - 2412 MHz - 6 dB DTS Bandwidth

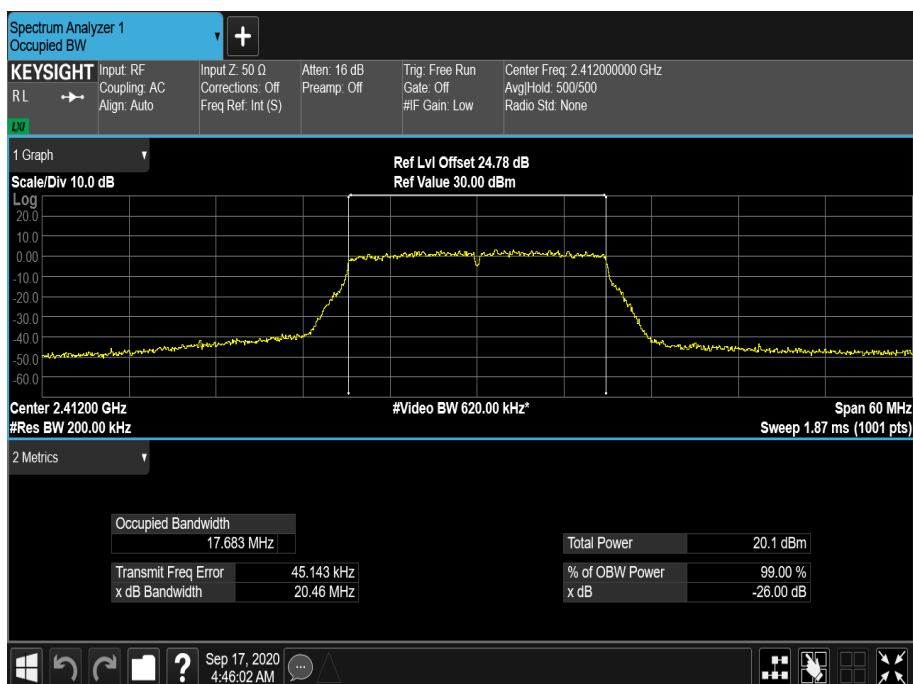


Figure 14 - 2412 MHz - 99% Occupied Bandwidth

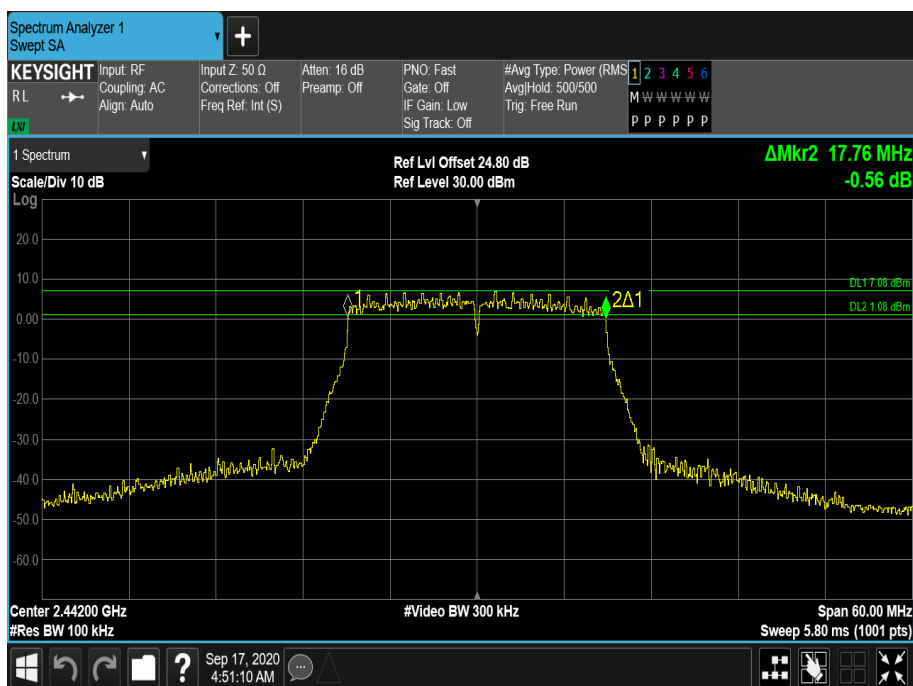


Figure 15 - 2442 MHz - 6 dB DTS Bandwidth

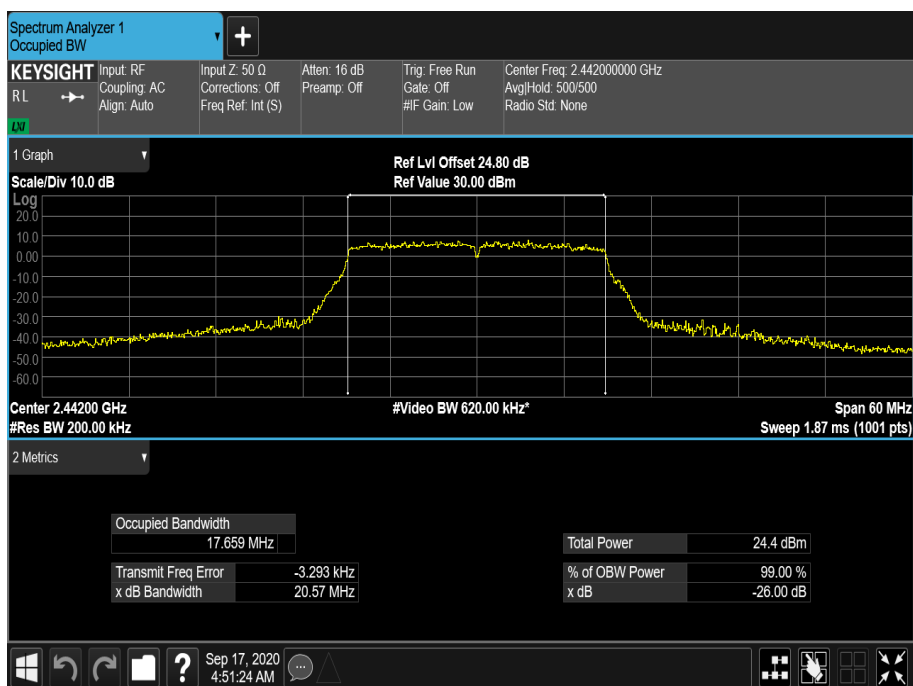


Figure 16 - 2442 MHz - 99% Occupied Bandwidth

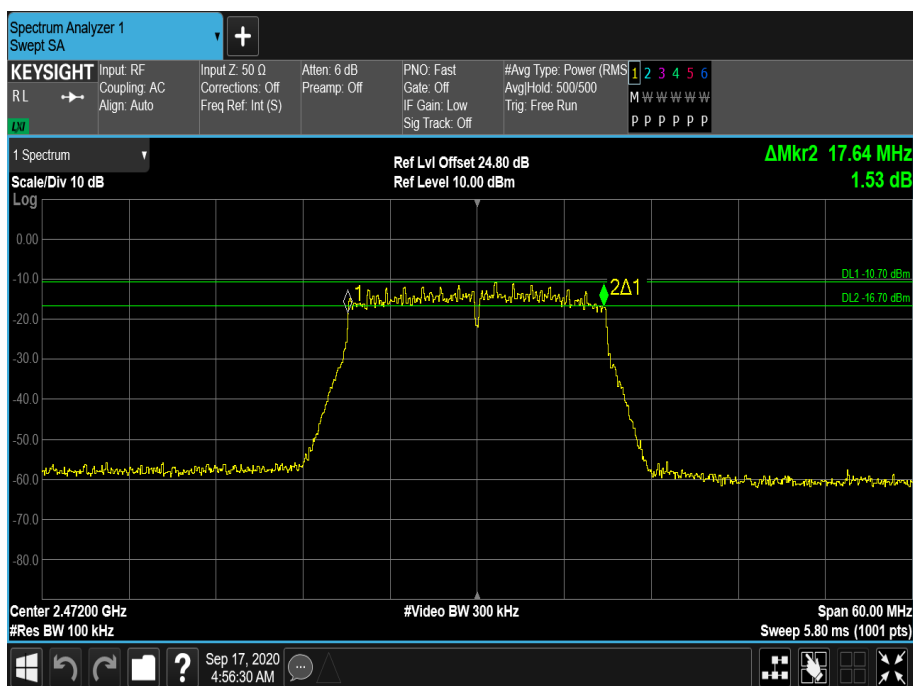


Figure 17 - 2472 MHz - 6 dB DTS Bandwidth

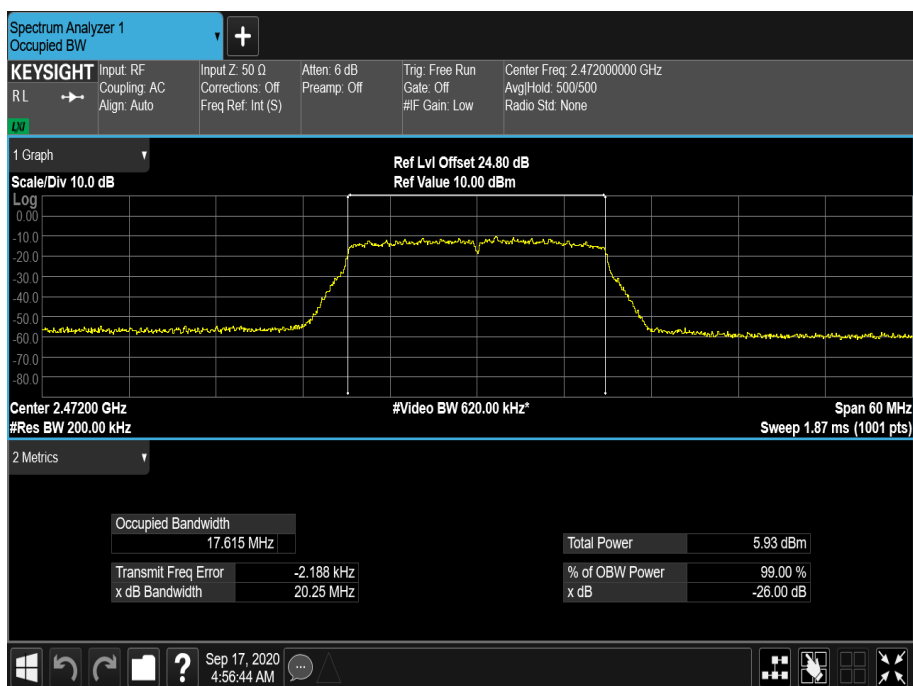


Figure 18 - 2472 MHz - 99% Occupied Bandwidth

| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 17.700 | 17.760 | 17.760 |
| 99% Bandwidth (MHz)  | 17.716 | 17.686 | 17.686 |

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

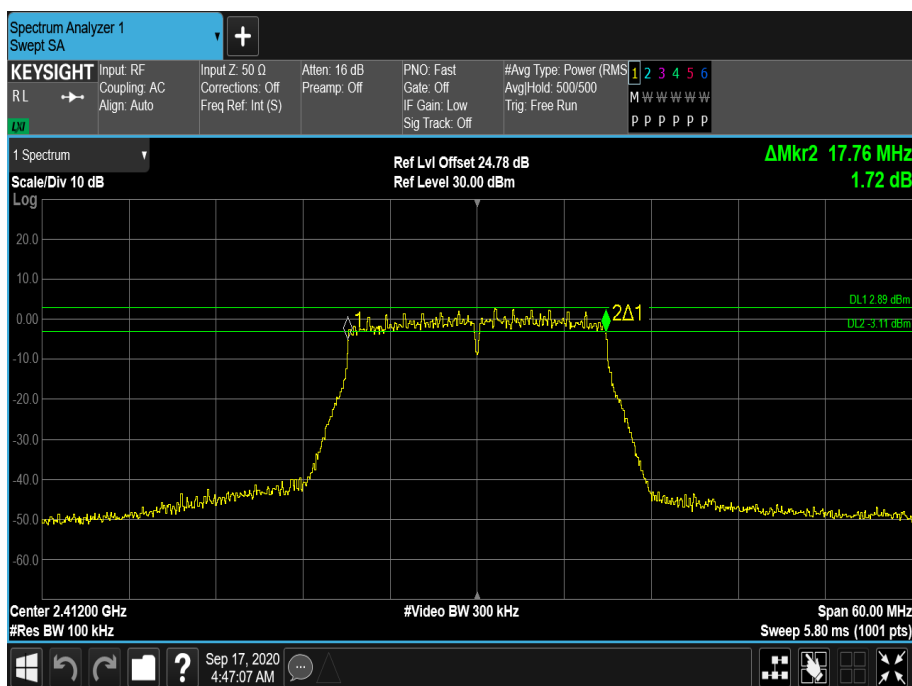


Figure 19 - 2412 MHz - 6 dB DTS Bandwidth

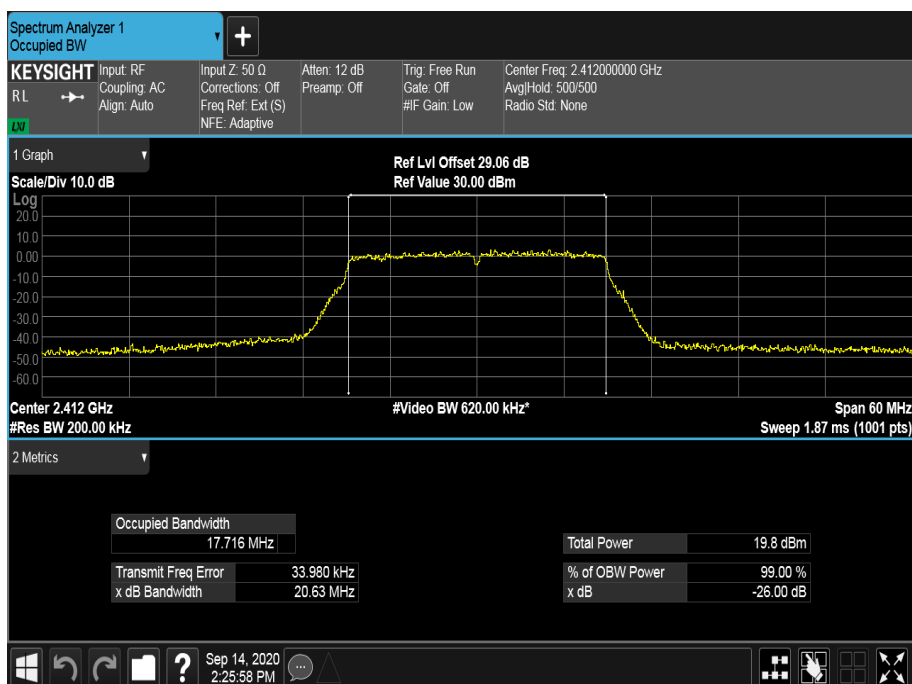


Figure 20 - 2412 MHz - 99% Occupied Bandwidth

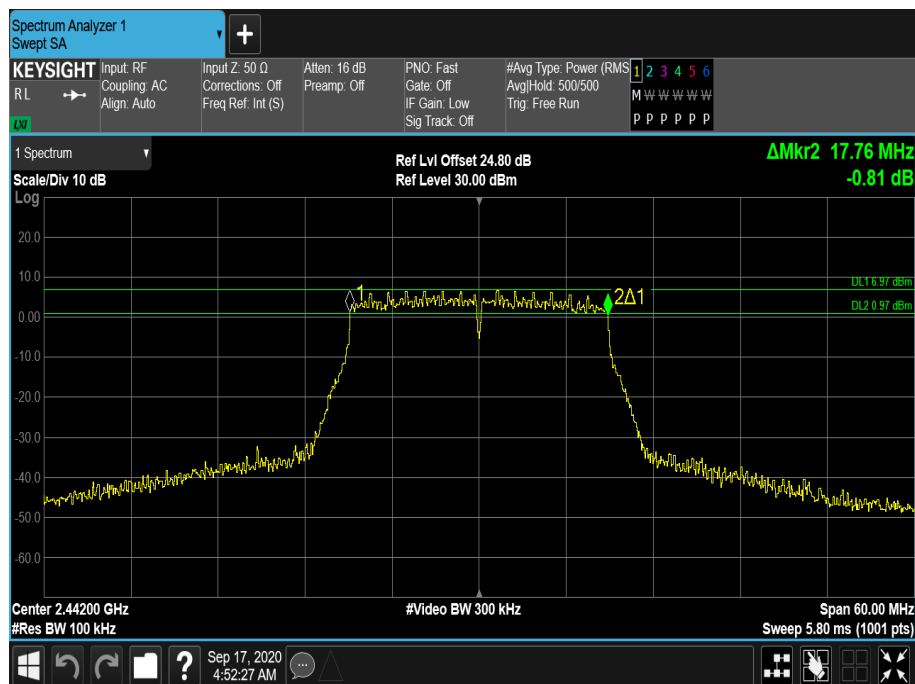


Figure 21 - 2442 MHz - 6 dB DTS Bandwidth

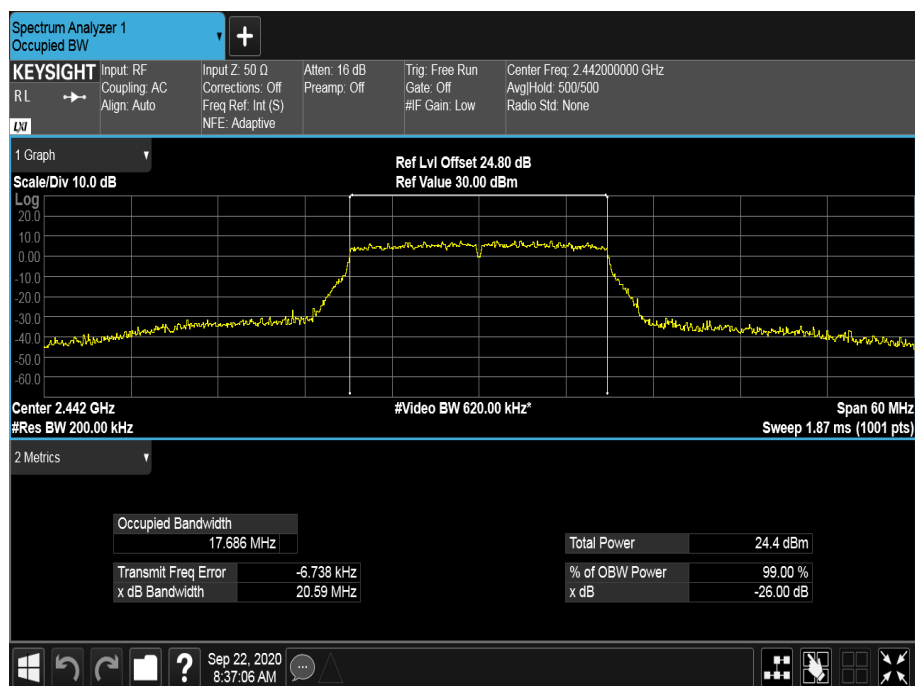


Figure 22 - 2442 MHz - 99% Occupied Bandwidth

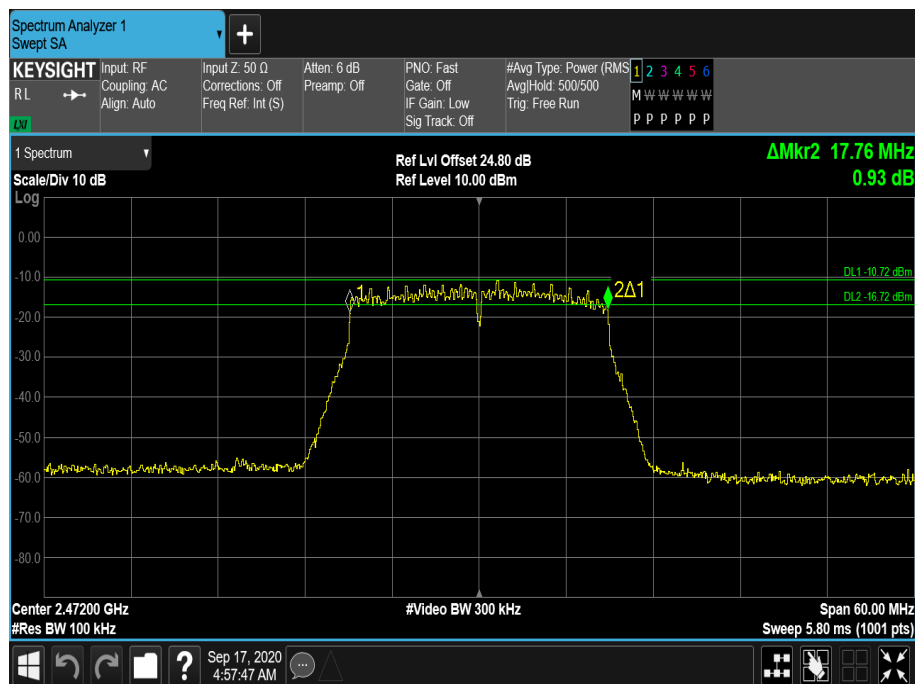


Figure 23 - 2472 MHz - 6 dB DTS Bandwidth

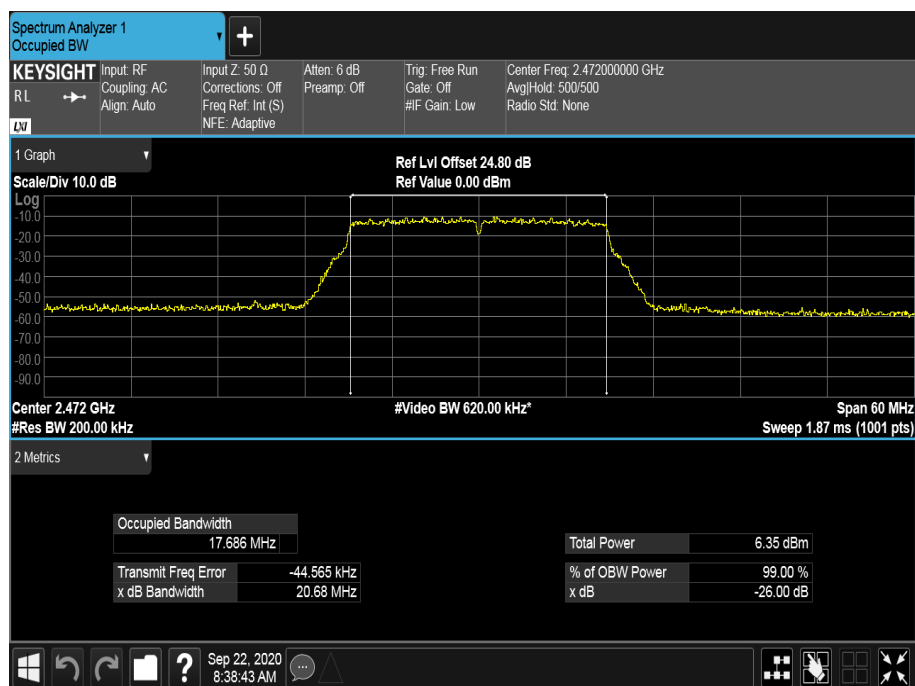


Figure 24 - 2472 MHz - 99% Occupied Bandwidth

| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 19.020 | 19.080 | 18.300 |
| 99% Bandwidth (MHz)  | 18.920 | 18.904 | 18.862 |

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

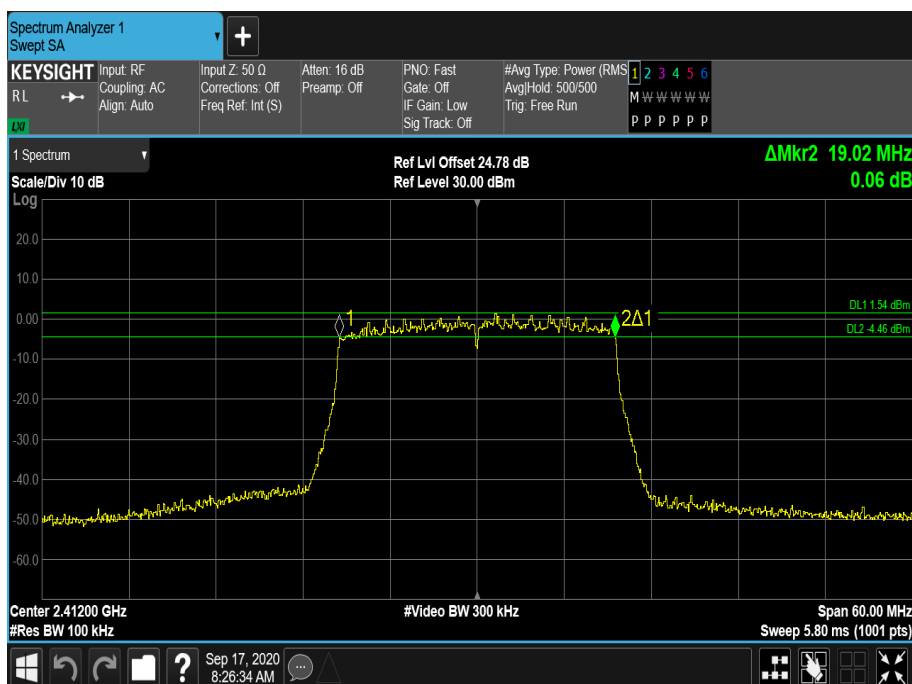


Figure 25 - 2412 MHz - 6 dB DTS Bandwidth

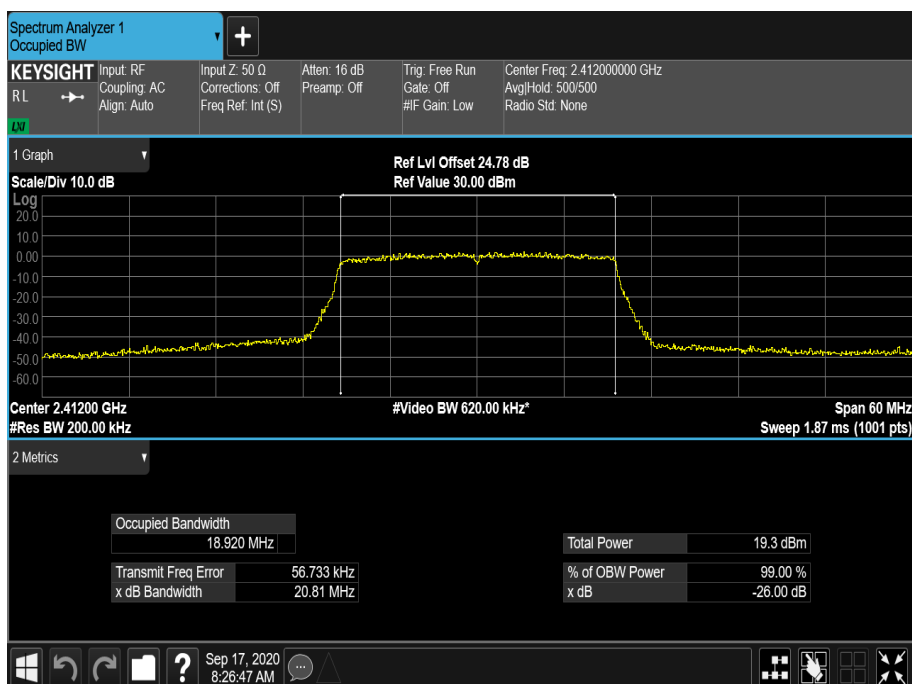


Figure 26 - 2412 MHz - 99% Occupied Bandwidth

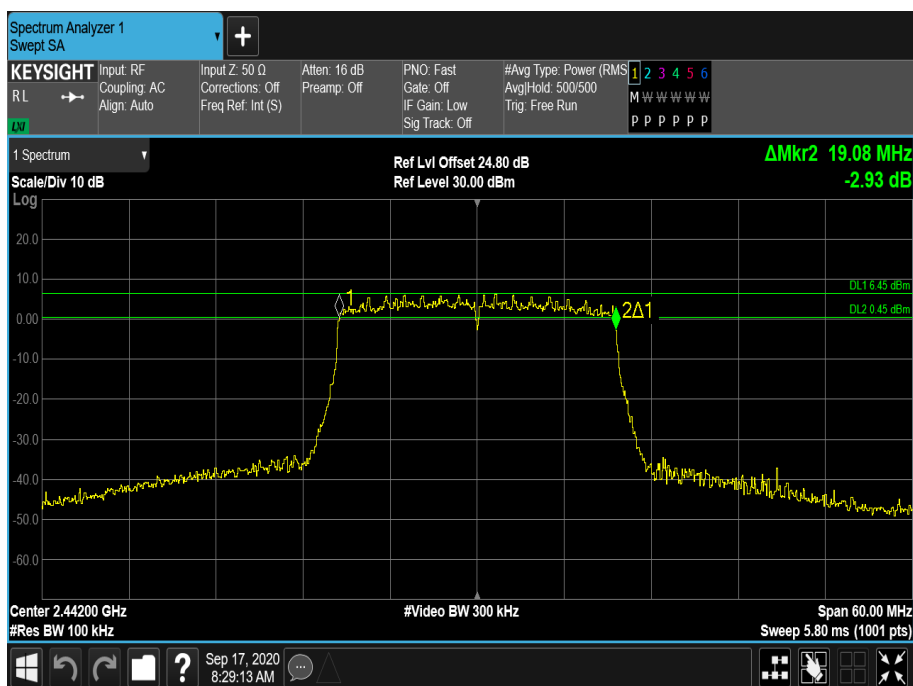


Figure 27 - 2442 MHz - 6 dB DTS Bandwidth

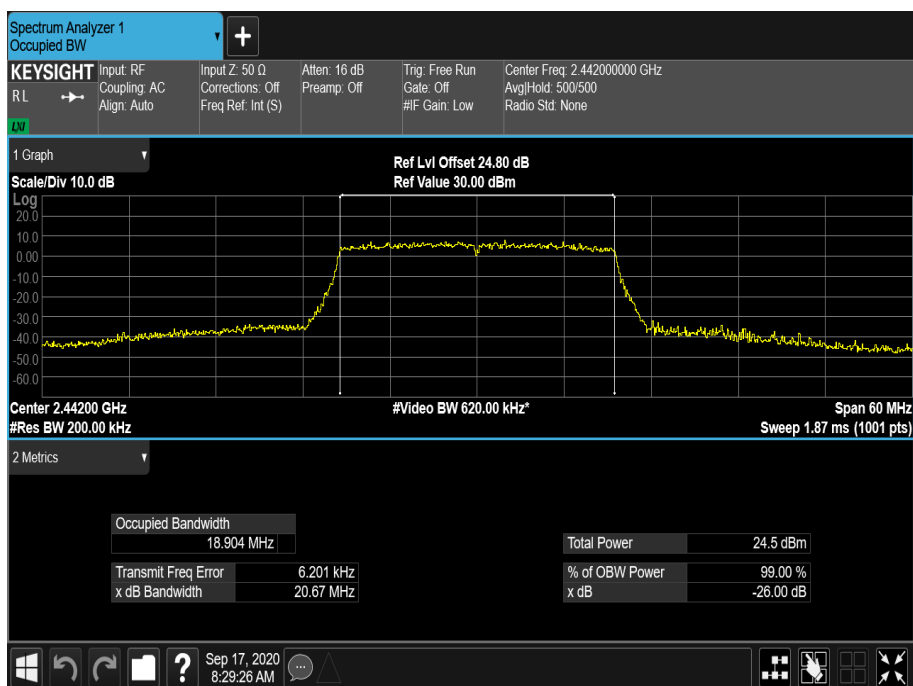


Figure 28 - 2442 MHz - 99% Occupied Bandwidth

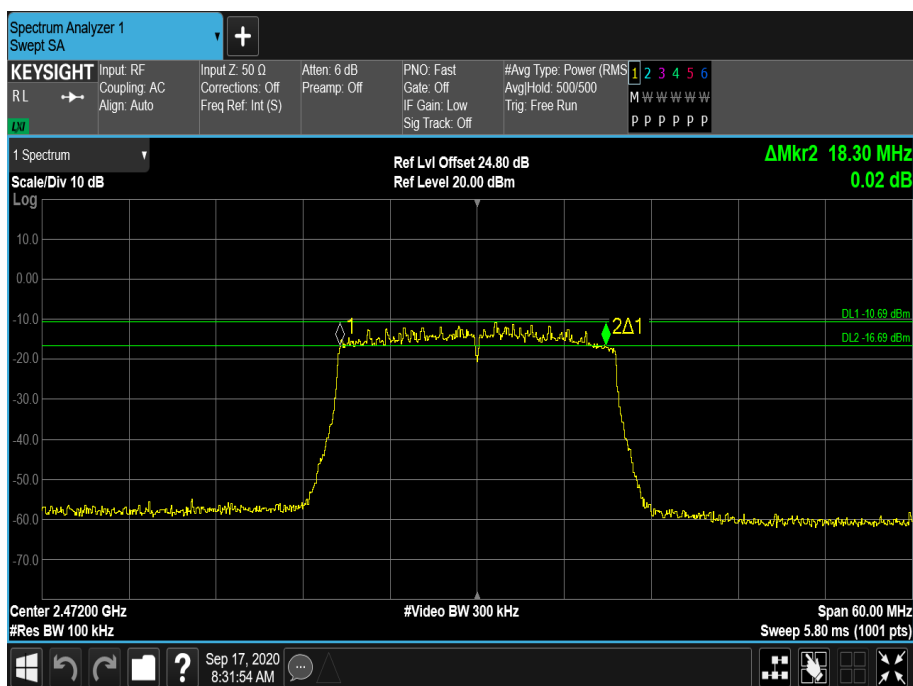


Figure 29 - 2472 MHz - 6 dB DTS Bandwidth

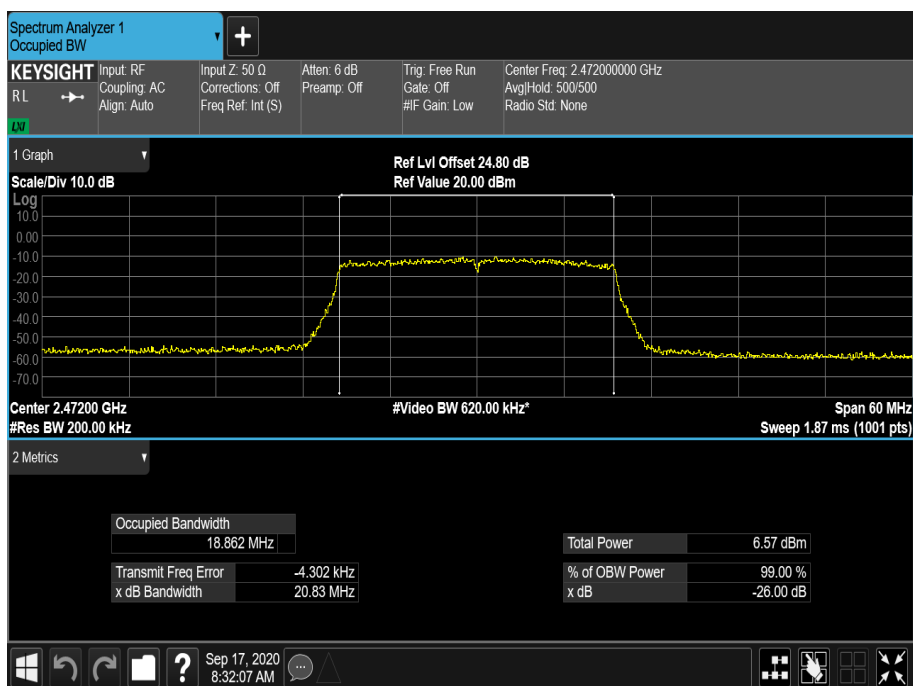


Figure 30 - 2472 MHz - 99% Occupied Bandwidth



| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 14.640 | 2.160  | 10.920 |
| 99% Bandwidth (MHz)  | 18.286 | 18.169 | 18.154 |

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

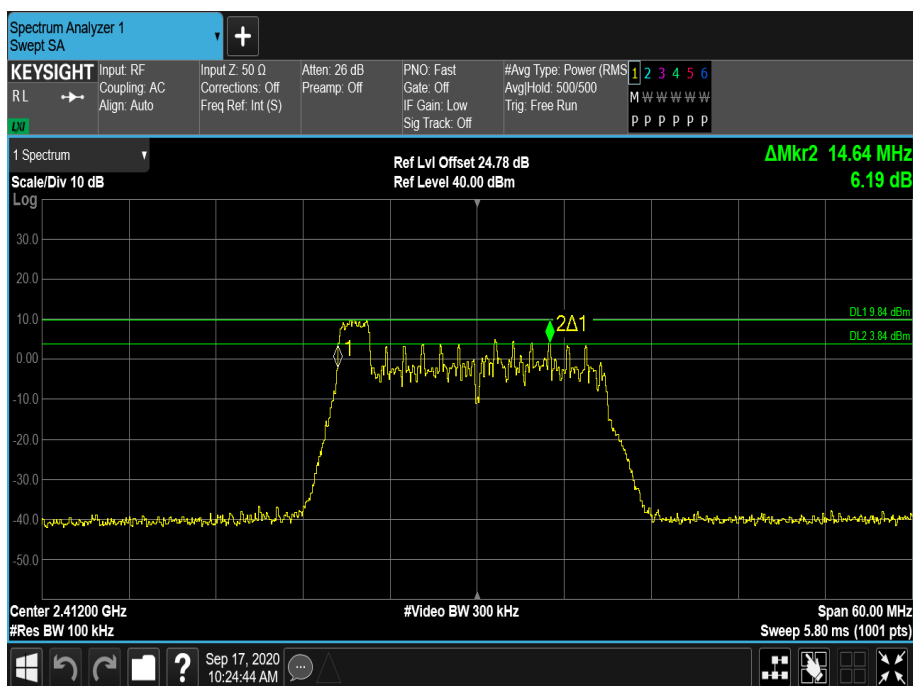


Figure 31 - 2412 MHz - 6 dB DTS Bandwidth

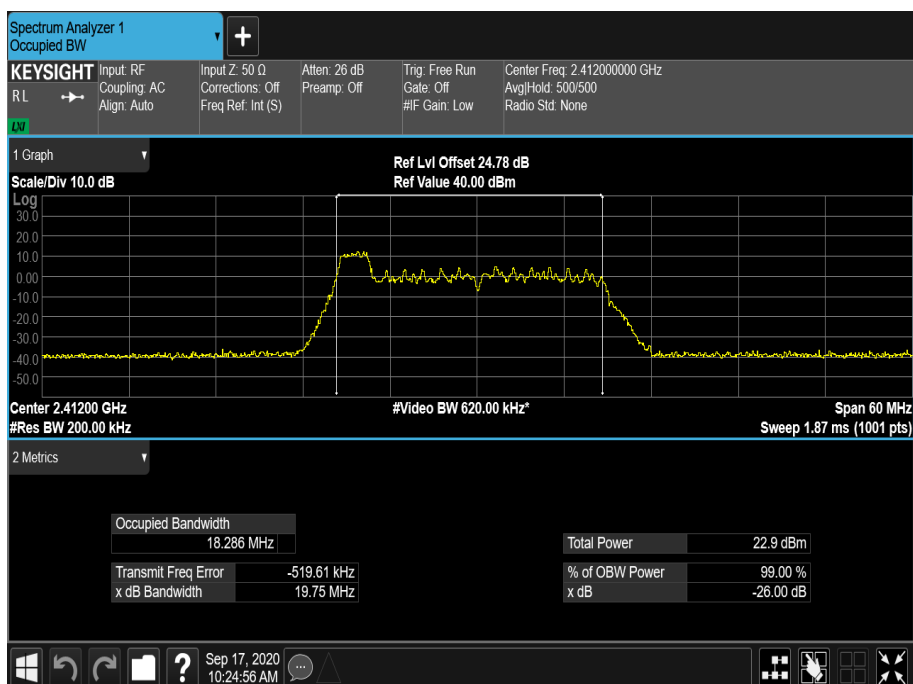


Figure 32 - 2412 MHz - 99% Occupied Bandwidth

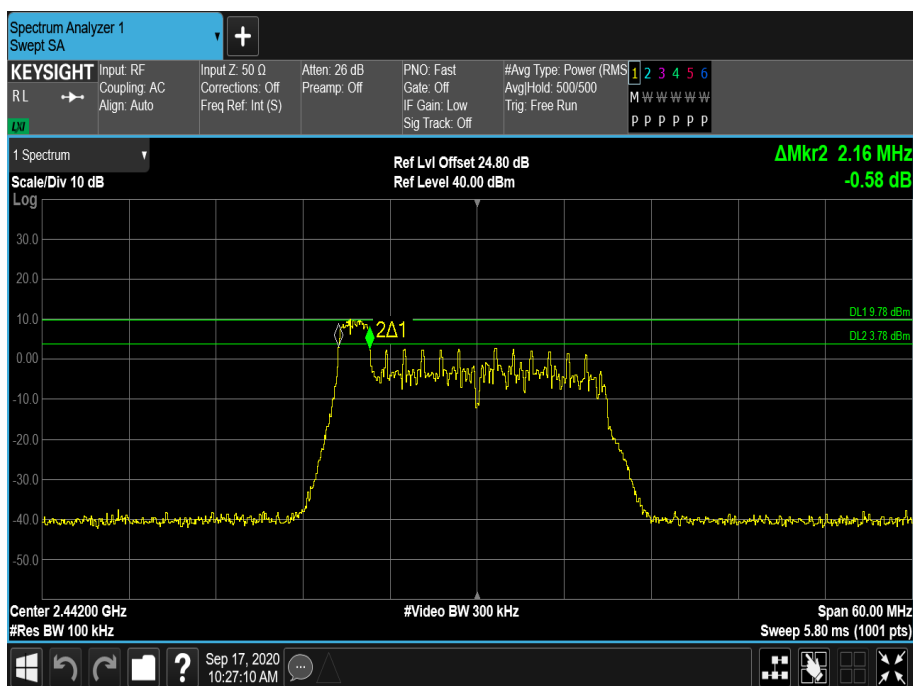


Figure 33 - 2442 MHz - 6 dB DTS Bandwidth

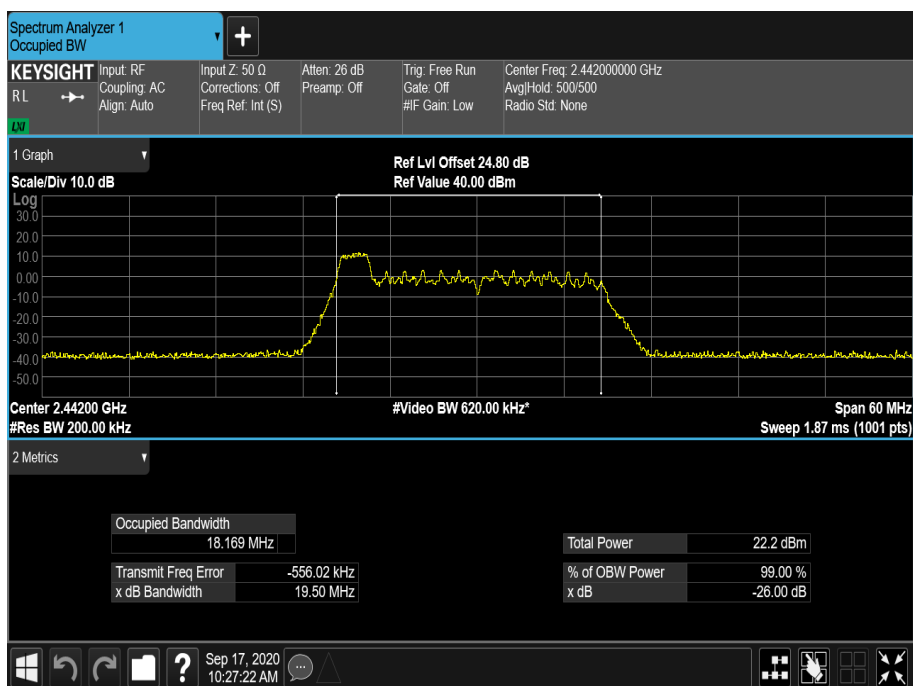


Figure 34 - 2442 MHz - 99% Occupied Bandwidth

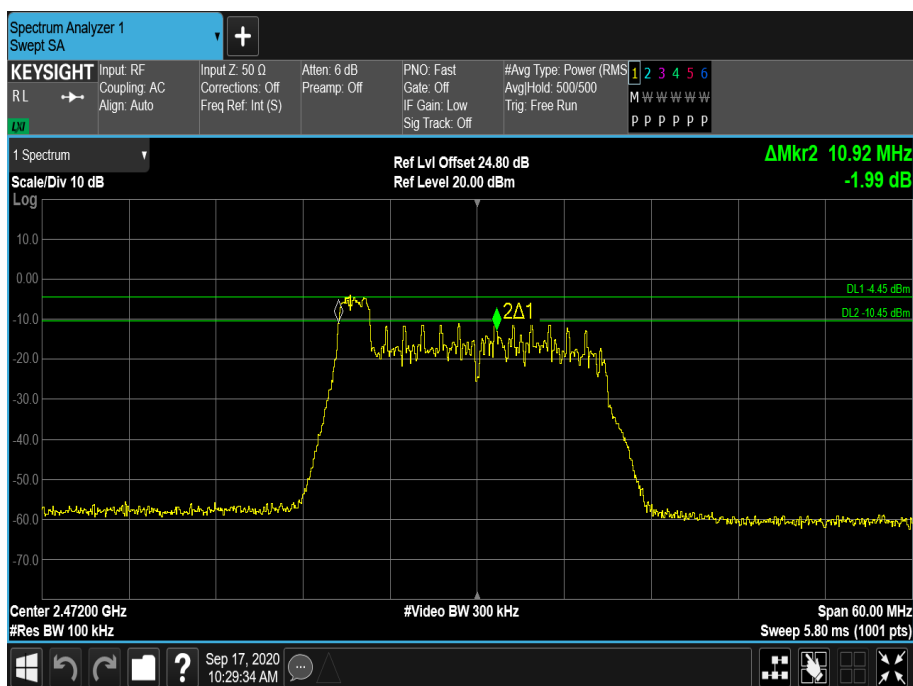


Figure 35 - 2472 MHz - 6 dB DTS Bandwidth

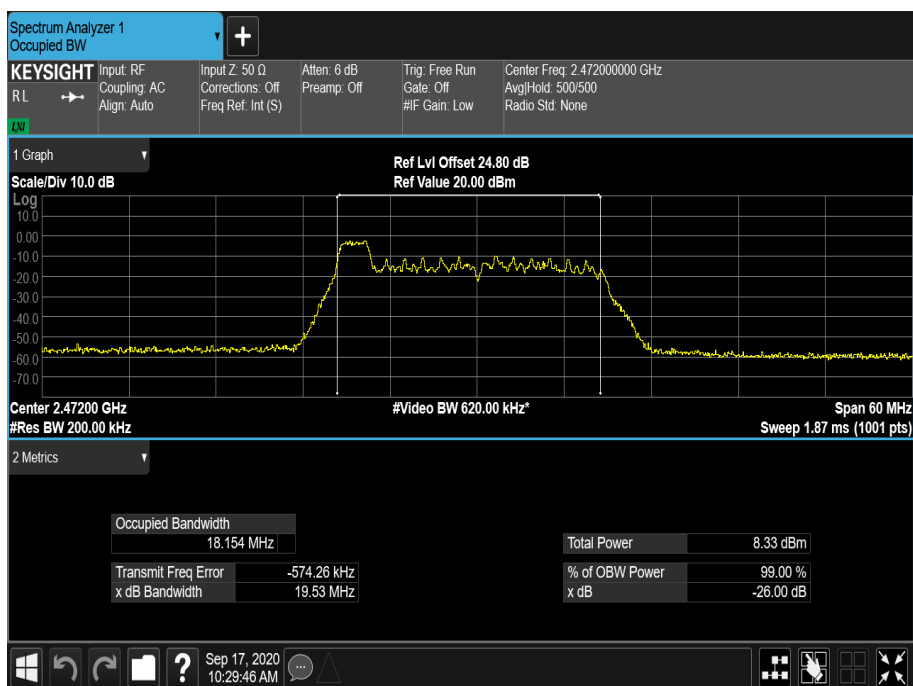


Figure 36 - 2472 MHz - 99% Occupied Bandwidth



| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 2.160  | 8.340  | 14.580 |
| 99% Bandwidth (MHz)  | 18.309 | 18.423 | 18.393 |

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

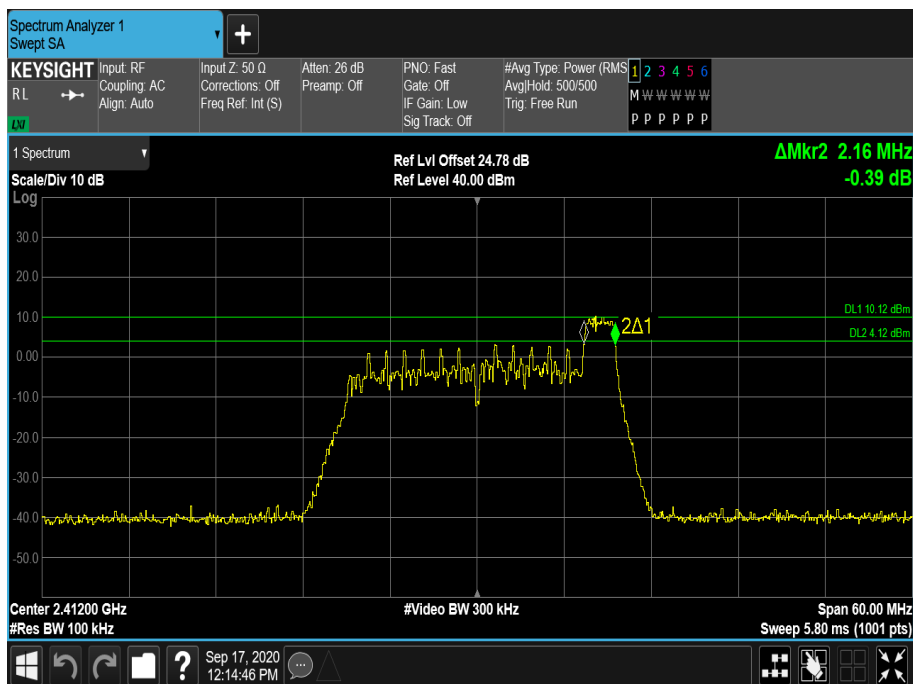


Figure 37 - 2412 MHz - 6 dB DTS Bandwidth

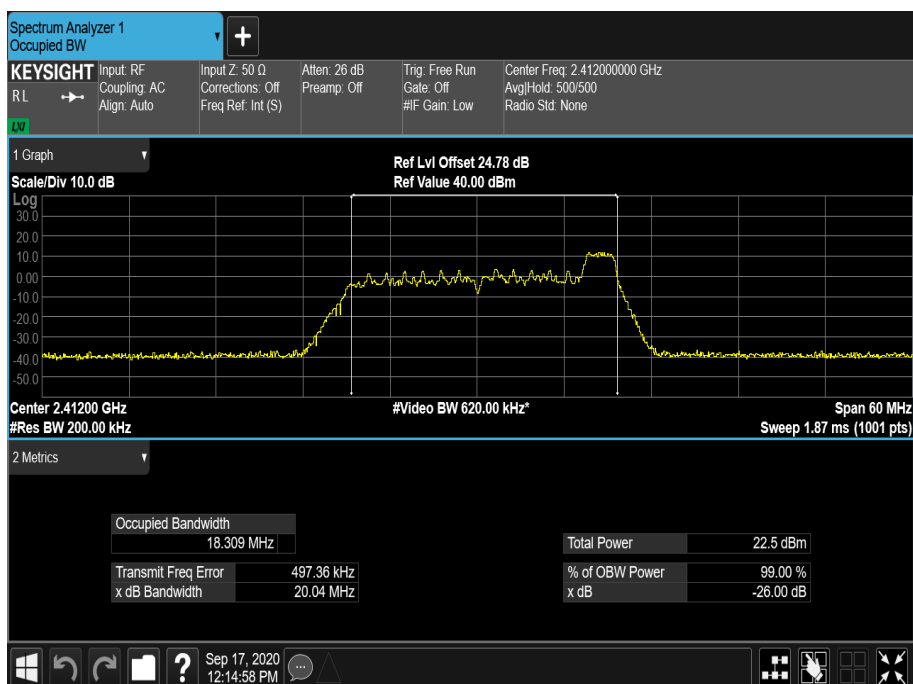


Figure 38 - 2412 MHz - 99% Occupied Bandwidth

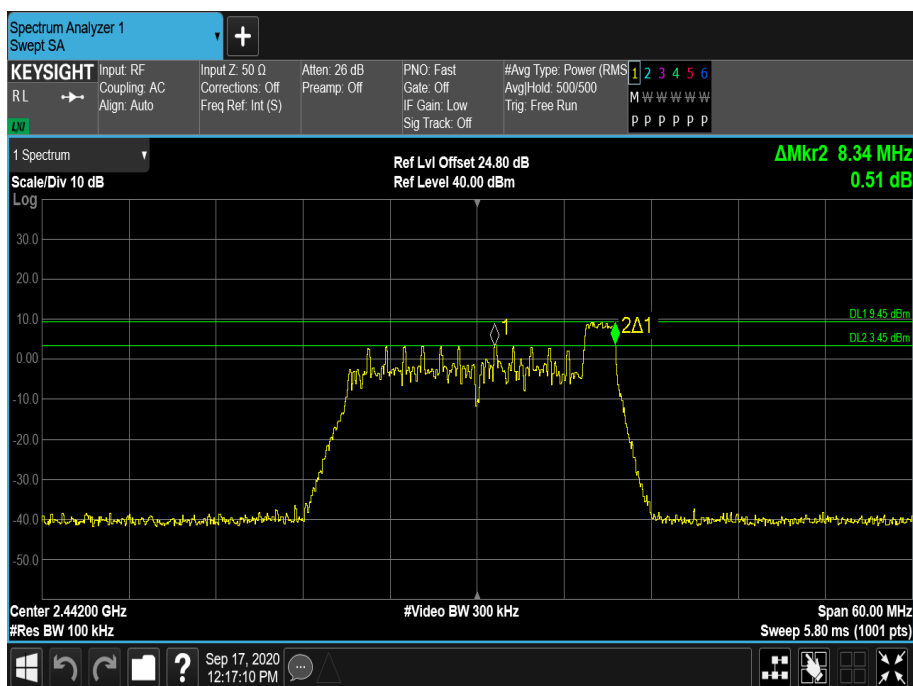


Figure 39 - 2442 MHz - 6 dB DTS Bandwidth

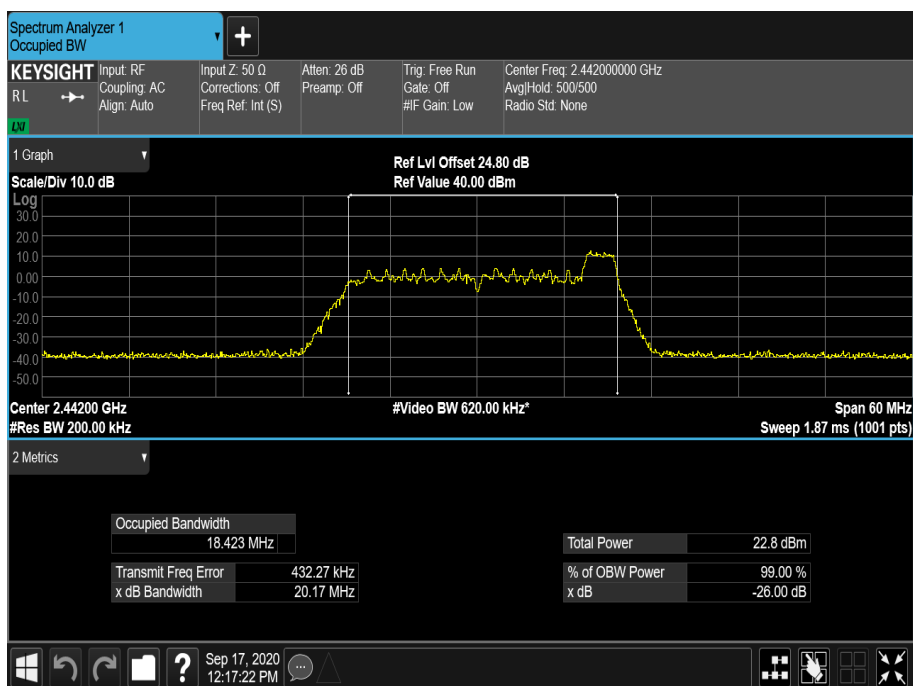


Figure 40 - 2442 MHz - 99% Occupied Bandwidth

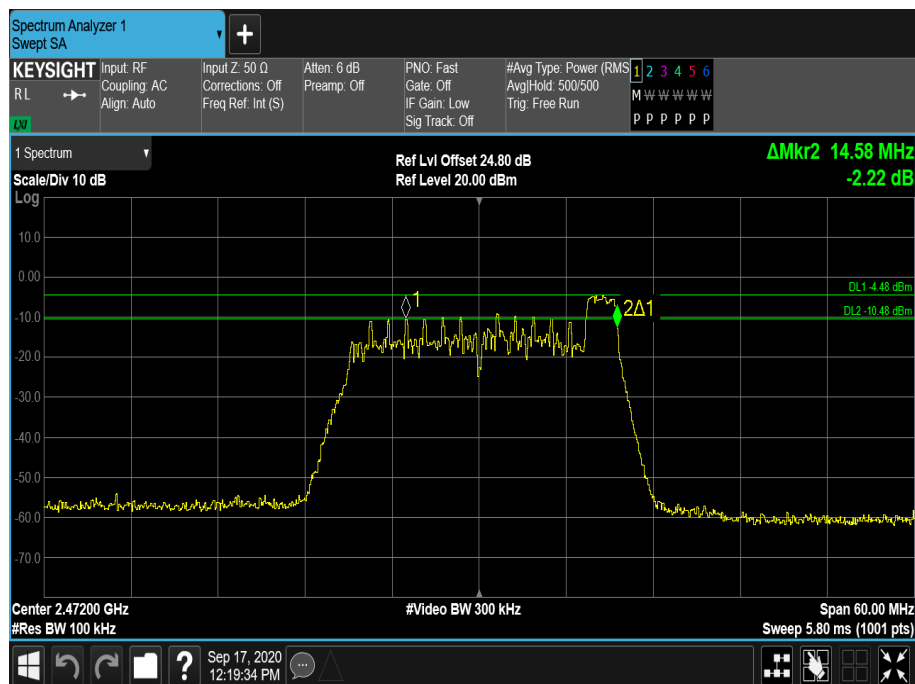


Figure 41 - 2472 MHz - 6 dB DTS Bandwidth

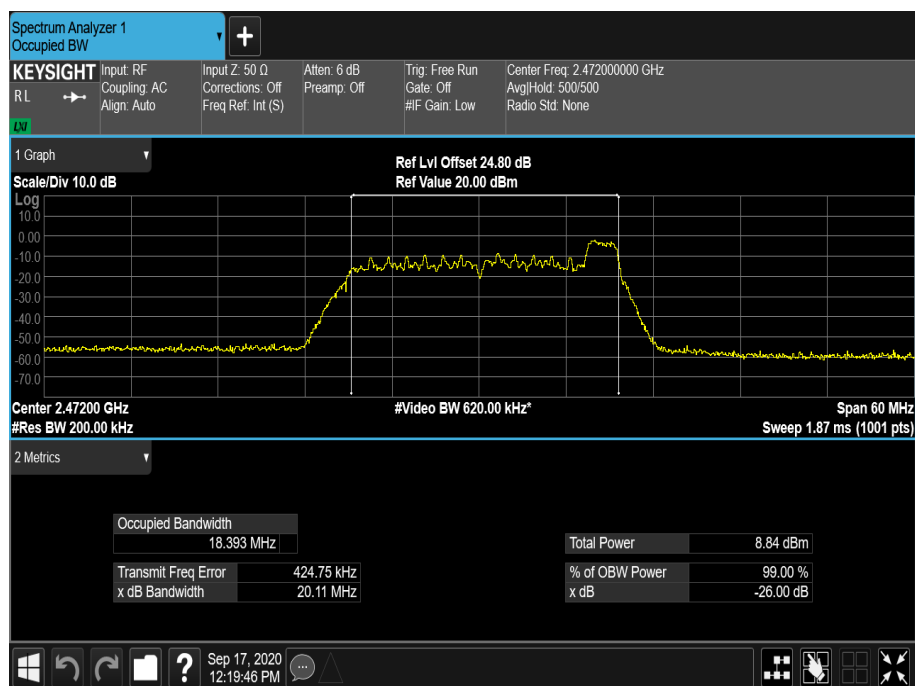


Figure 42 - 2472 MHz - 99% Occupied Bandwidth

| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 18.780 | 19.020 | 18.420 |
| 99% Bandwidth (MHz)  | 18.960 | 18.965 | 18.935 |

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

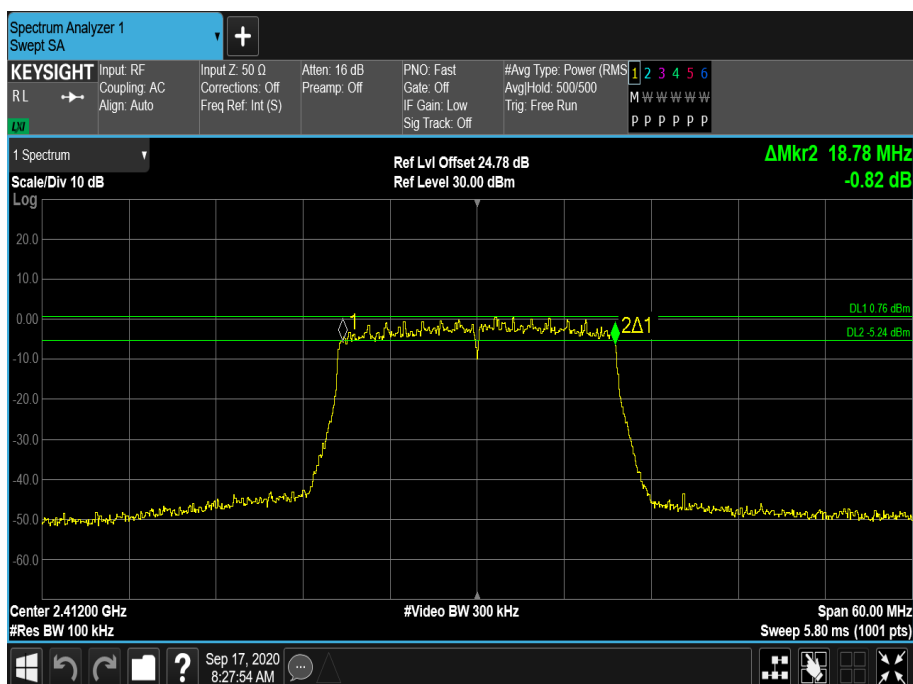


Figure 43 - 2412 MHz - 6 dB DTS Bandwidth

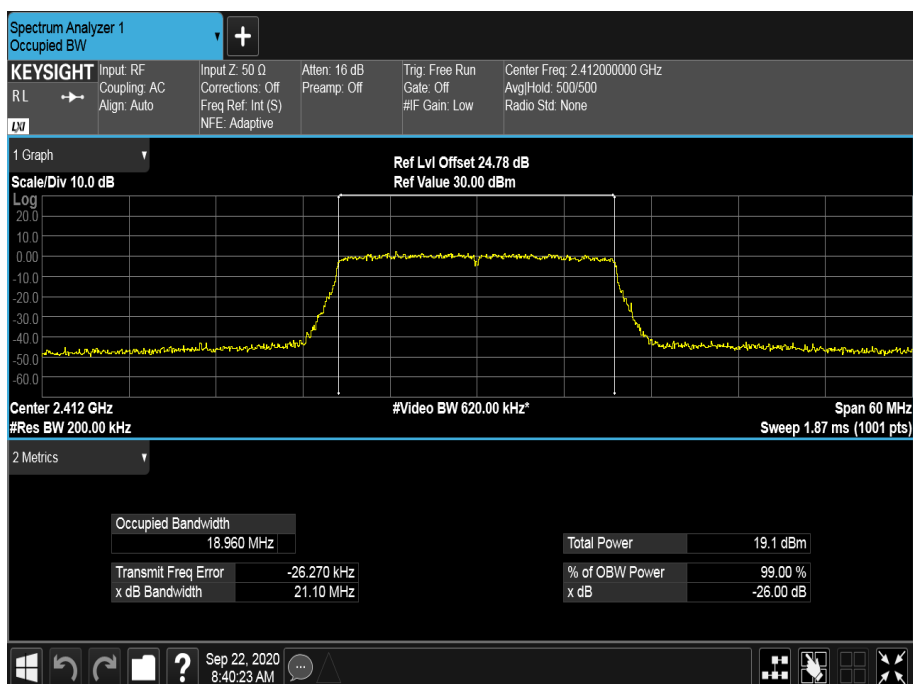


Figure 44 - 2412 MHz - 99% Occupied Bandwidth

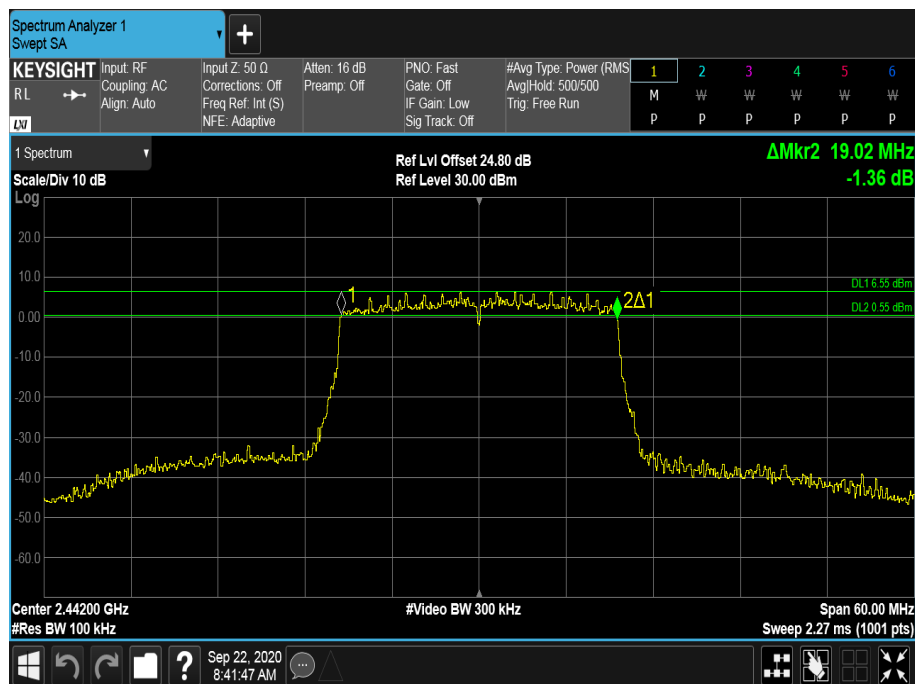


Figure 45 - 2442 MHz - 6 dB DTS Bandwidth

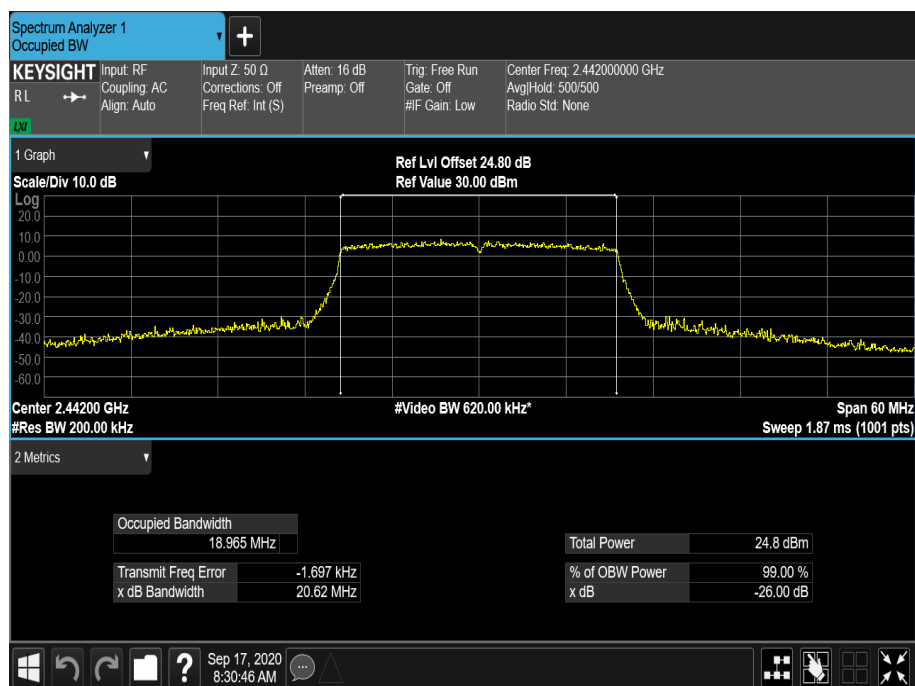


Figure 46 - 2442 MHz - 99% Occupied Bandwidth

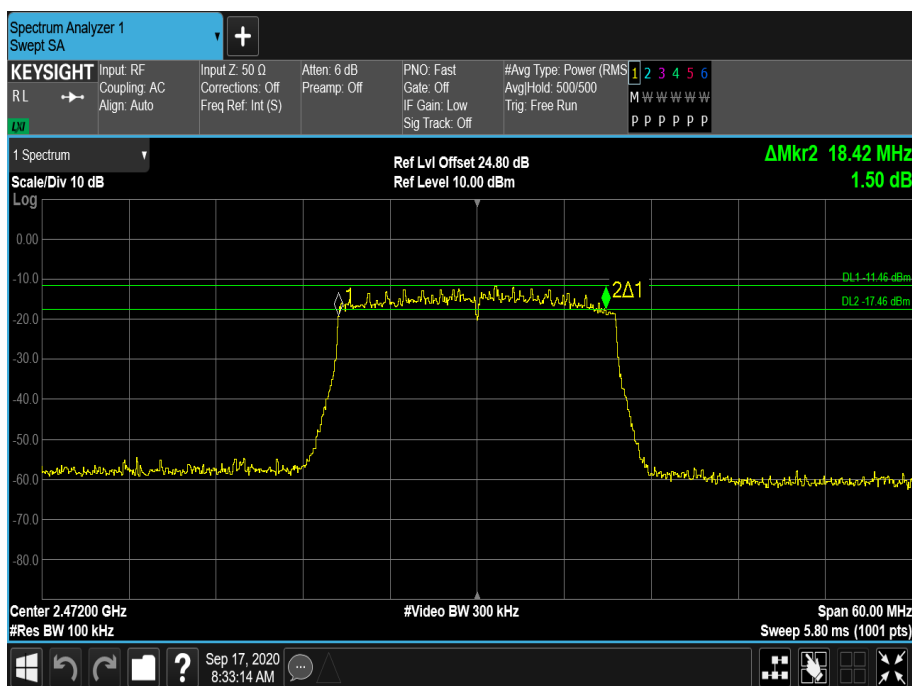


Figure 47 - 2472 MHz - 6 dB DTS Bandwidth

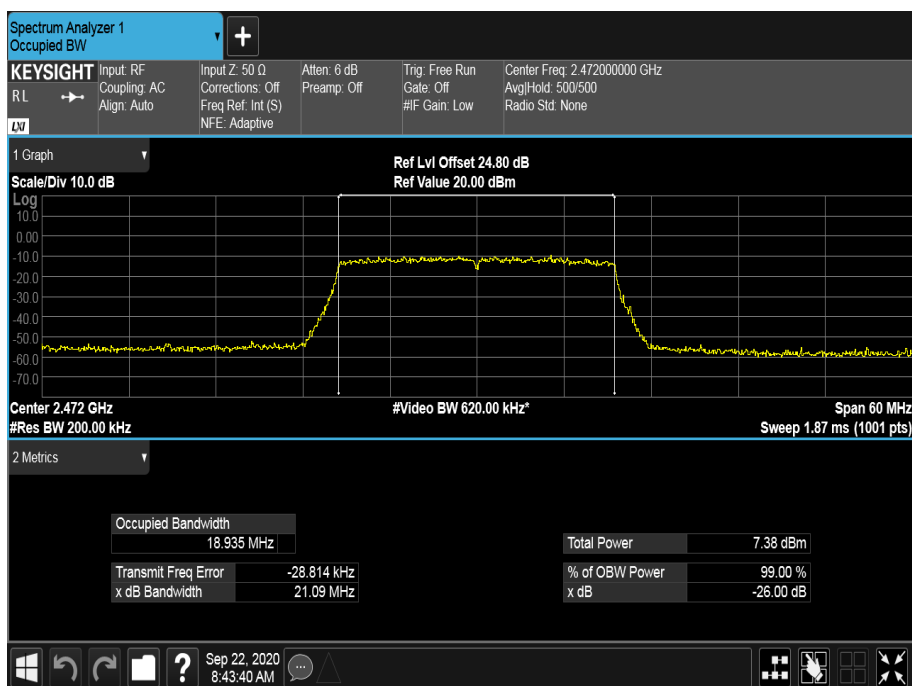


Figure 48 - 2472 MHz - 99% Occupied Bandwidth



| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 2.160  | 2.160  | 2.160  |
| 99% Bandwidth (MHz)  | 18.280 | 18.218 | 18.148 |

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

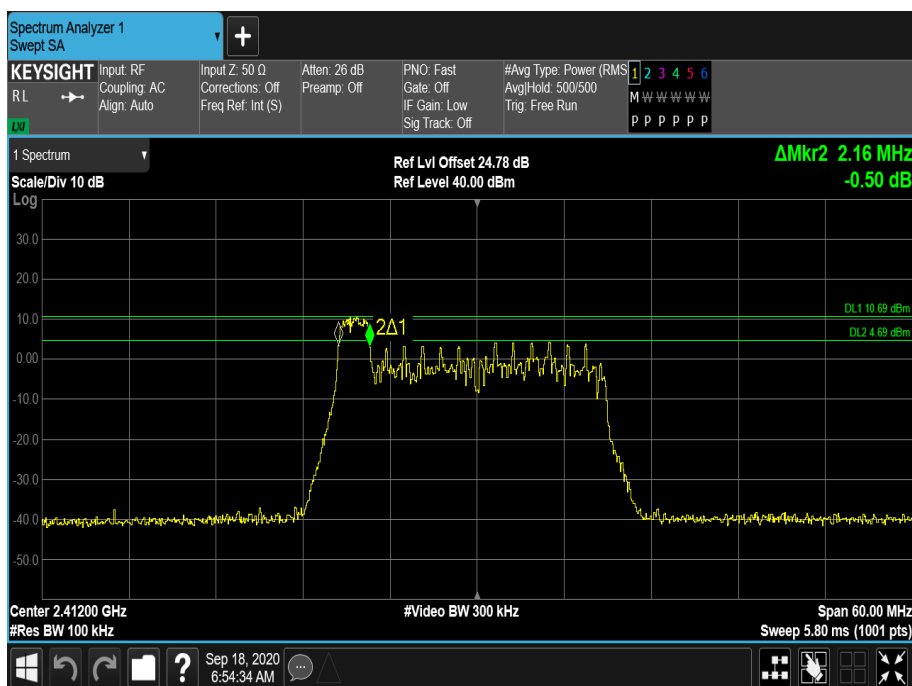


Figure 49 - 2412 MHz - 6 dB DTS Bandwidth

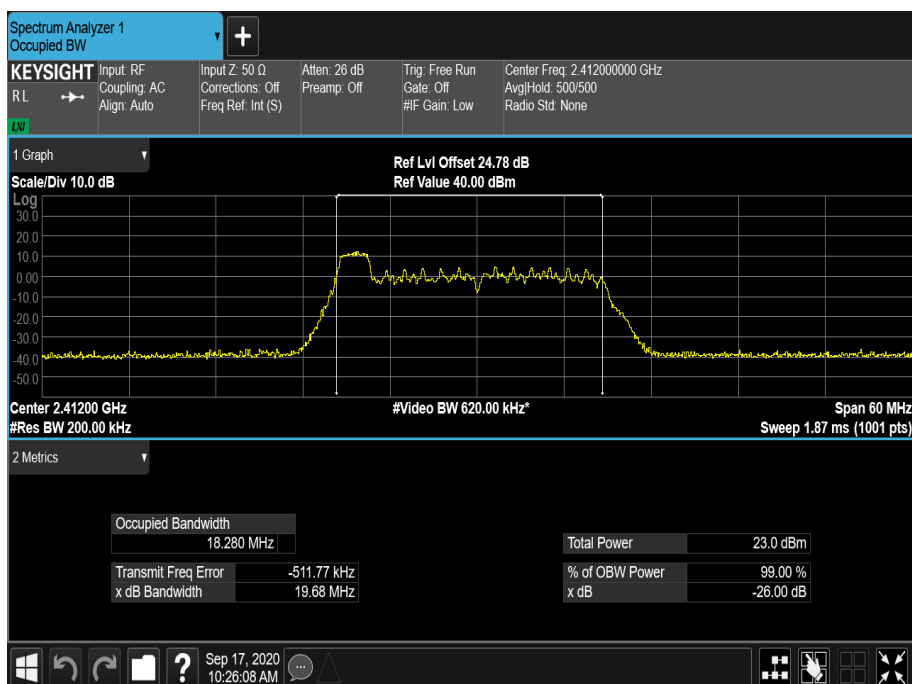


Figure 50 - 2412 MHz - 99% Occupied Bandwidth

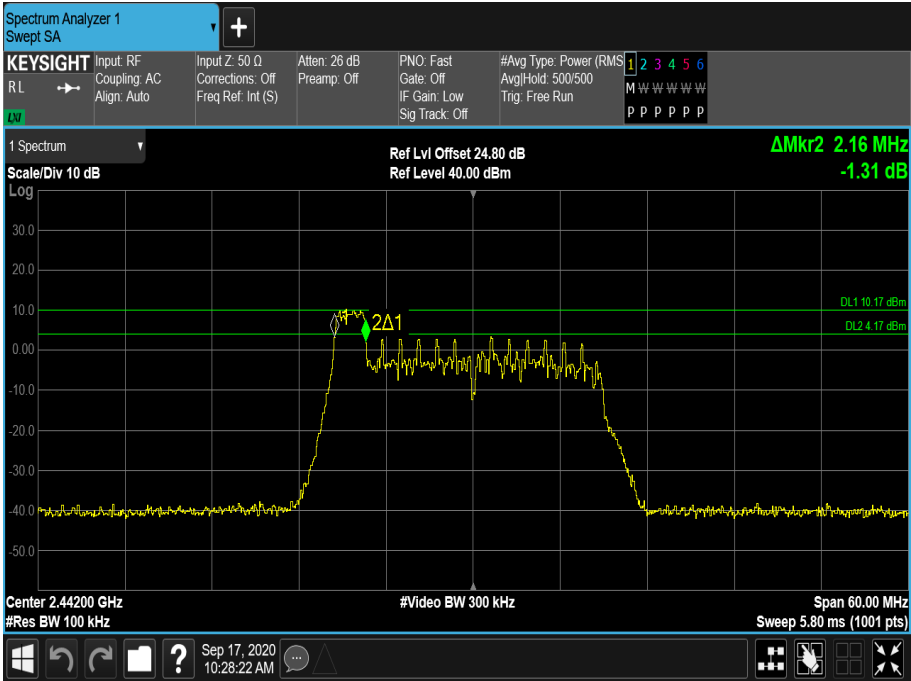


Figure 51 - 2442 MHz - 6 dB DTS Bandwidth

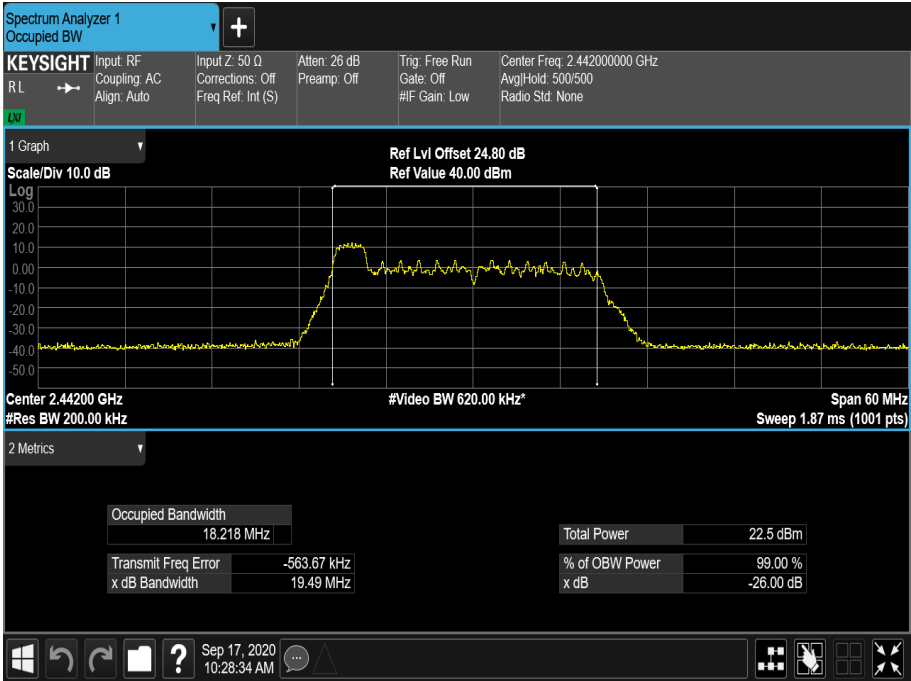


Figure 52 - 2442 MHz - 99% Occupied Bandwidth

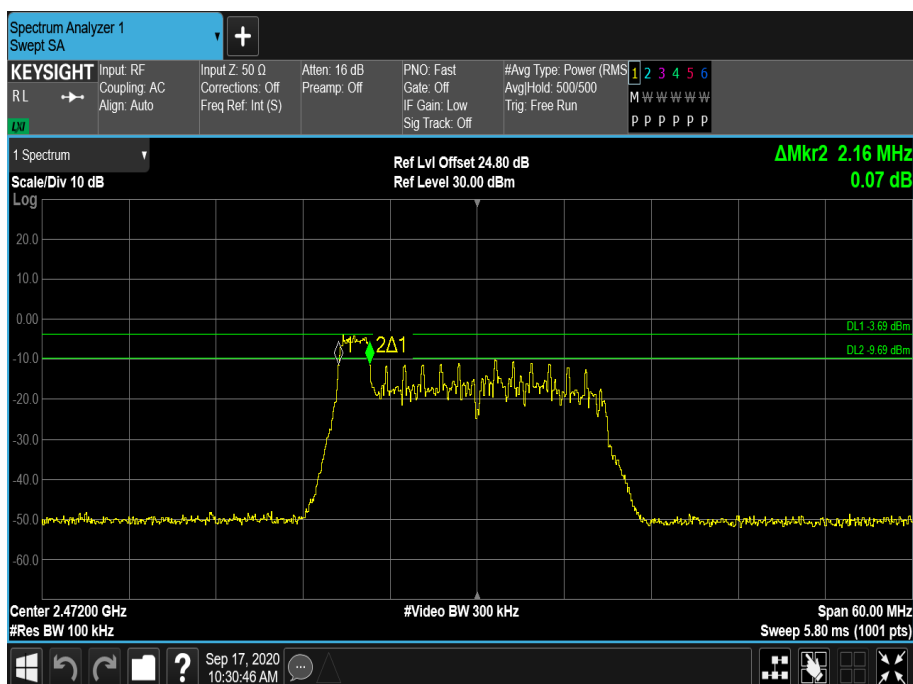


Figure 53 - 2472 MHz - 6 dB DTS Bandwidth

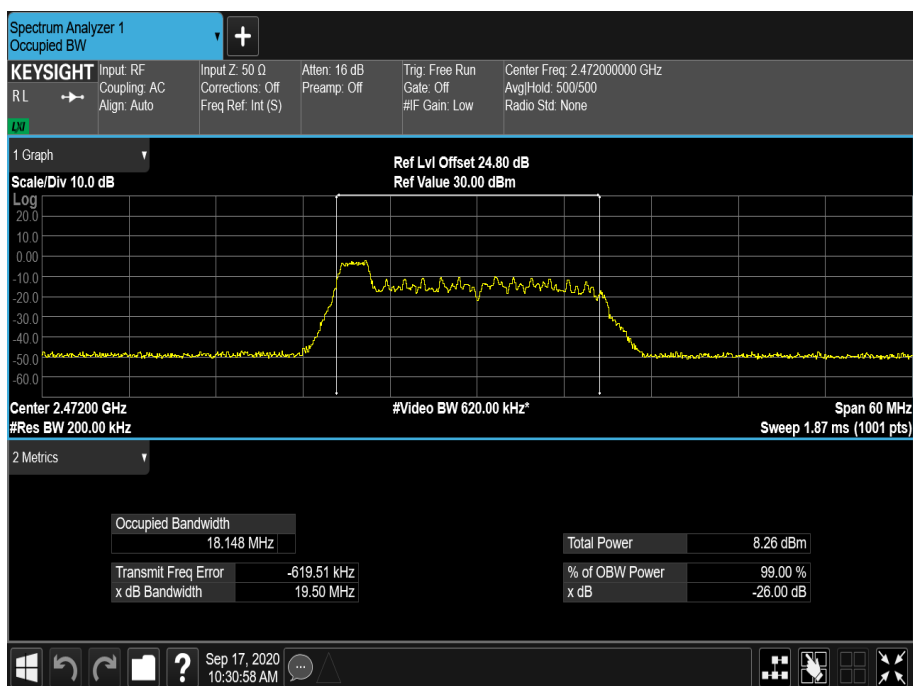


Figure 54 - 2472 MHz - 99% Occupied Bandwidth



| Channel              | Bottom | Middle | Top    |
|----------------------|--------|--------|--------|
| Frequency (MHz)      | 2412   | 2442   | 2472   |
| 6 dB Bandwidth (MHz) | 2.160  | 2.220  | 8.340  |
| 99% Bandwidth (MHz)  | 18.306 | 18.500 | 18.441 |

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

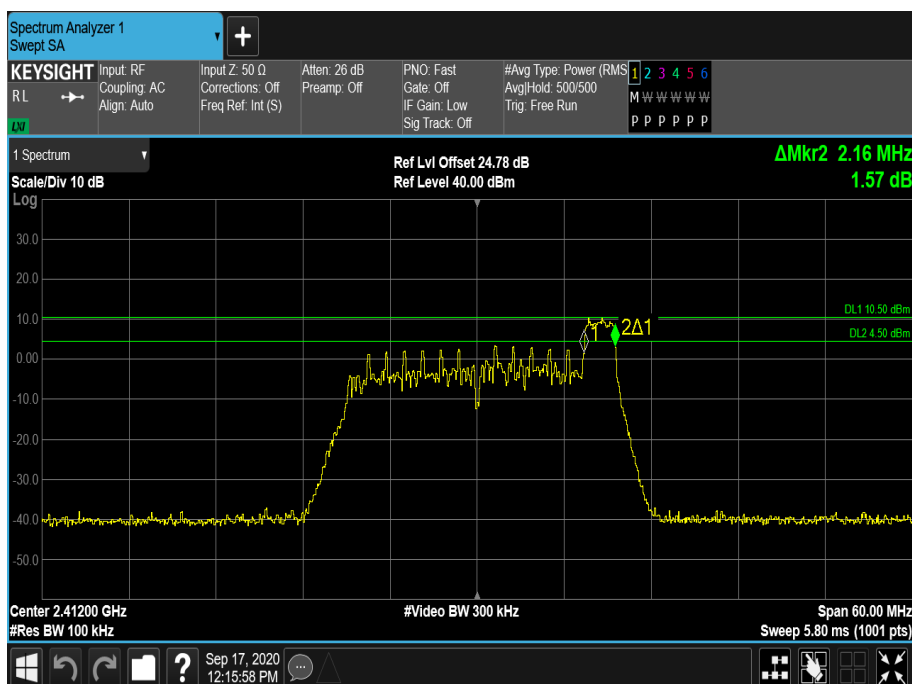


Figure 55 - 2412 MHz - 6 dB DTS Bandwidth

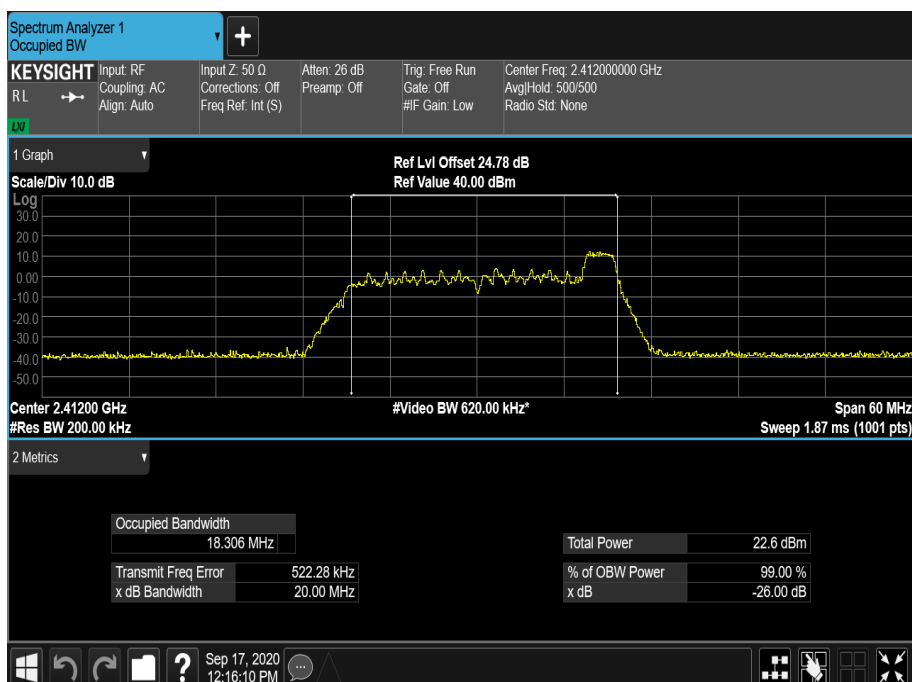


Figure 56 - 2412 MHz - 99% Occupied Bandwidth

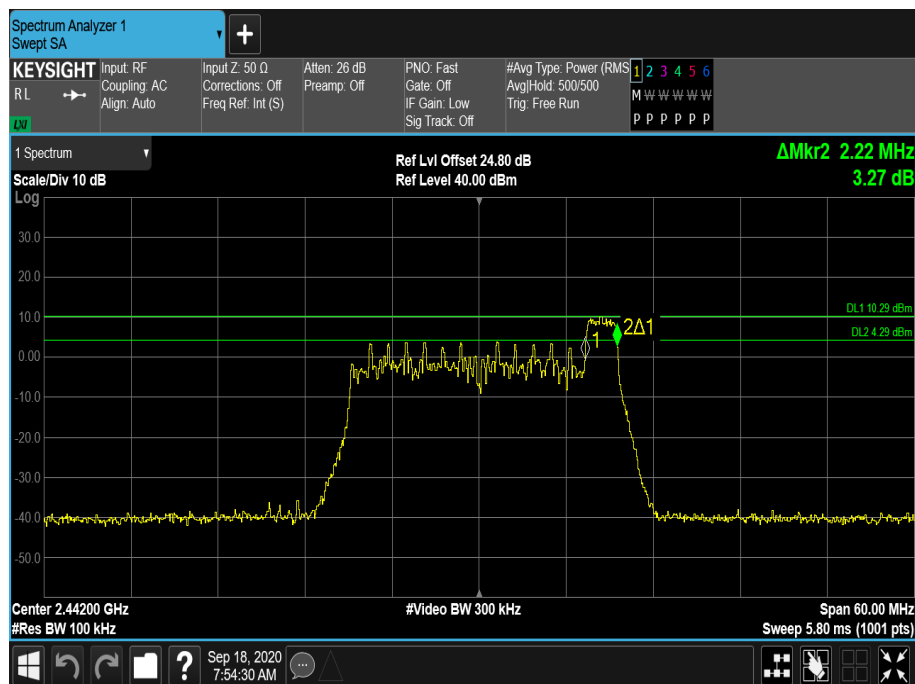


Figure 57 - 2442 MHz - 6 dB DTS Bandwidth

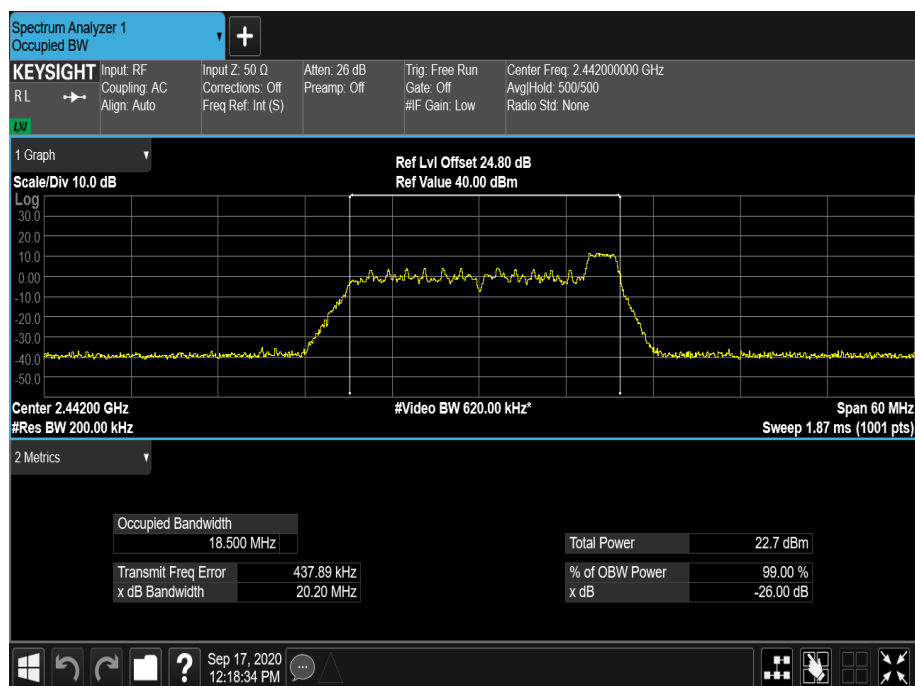


Figure 58 - 2442 MHz - 99% Occupied Bandwidth

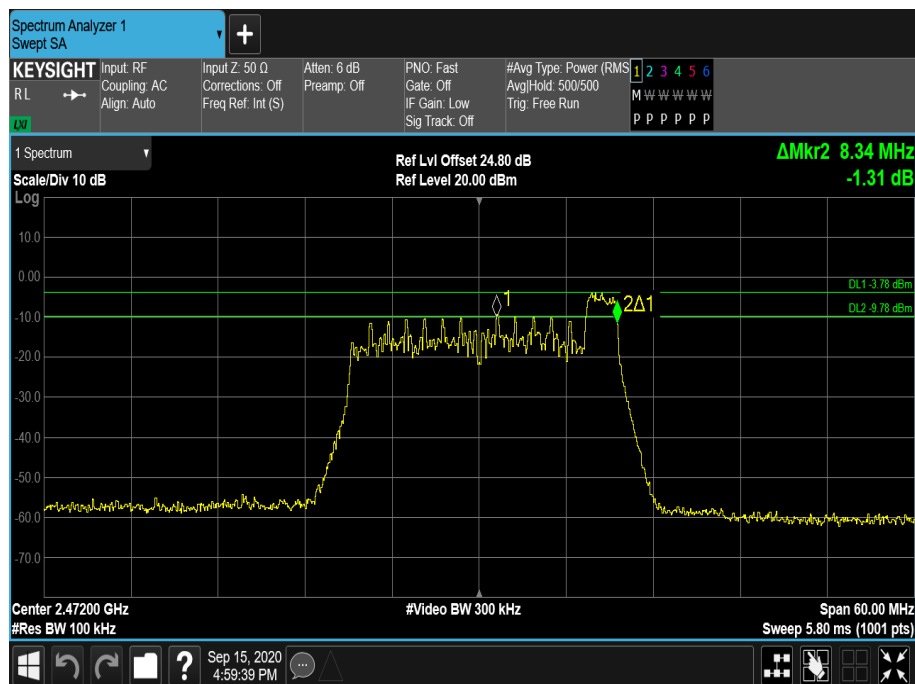


Figure 59 - 2472 MHz - 6 dB DTS Bandwidth

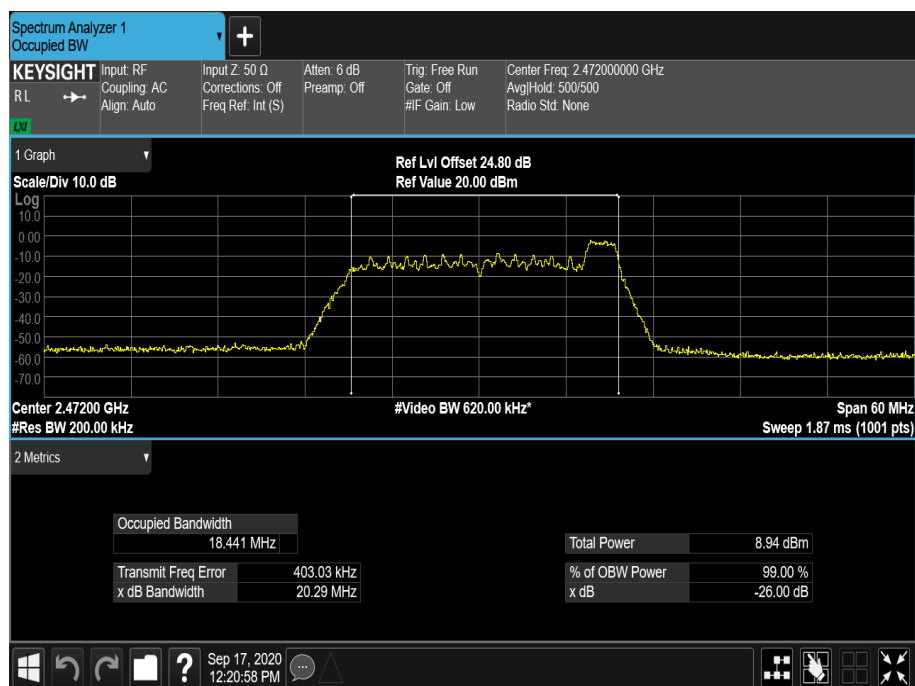


Figure 60 - 2472 MHz - 99% Occupied Bandwidth

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                  | Sealectro             | 60-674-1010-89            | 395   | -                           | O/P Mon         |
| Attenuator (10dB, 1W)                              | Sealectro             | 60-674-1010-89            | 1224  | -                           | O/P Mon         |
| Rubidium Standard                                  | Rohde & Schwarz       | XSRM                      | 1316  | 6                           | 08-Nov-2020     |
| Attenuator (20dB, 1W)                              | Sealectro             | 60-674-1020-89            | 1520  | -                           | O/P Mon         |
| 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                           | 08-Nov-2020     |
| 2 metre SMA Cable                                  | Florida Labs          | SMS-235SP-78.8-SMS        | 4517  | 12                          | 22-Jun-2021     |
| 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     |
| Wireless Cable & Fibre Router - AC 1900, Dual-band | Asus                  | RT-AC68U                  | 4881  | -                           | TU              |
| EXA                                                | Keysight Technologies | N9010B                    | 4968  | 24                          | 23-Dec-2021     |
| AC Programmable Power Supply                       | iTech                 | IT7324                    | 5225  | -                           | O/P Mon         |
| 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         |
| 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                          | 04-Mar-2022     |
| Attenuator 2W 10dB DC-10GHz                        | Telegartner           | J01156A0031               | 5579  | -                           | O/P Mon         |
| Attenuator 2W 10dB DC-10GHz                        | Telegartner           | J01156A0031               | 5580  | -                           | O/P Mon         |

**Table 16**

TU - Traceability Unscheduled

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**

A2338, S/N: C02CX01FQC36 - Modification State 0

### **2.2.3 Date of Test**

10-September-2020 to 21-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   | 5.0 - 60.7 %   |



## 2.2.6 Test Results

### 2.4 GHz WLAN

| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)               | 17.90  | 17.71  | 12.29 |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 19.08  | 18.89  | 13.47 |

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

| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)               | 13.44  | 17.78  | -0.06 |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 14.62  | 18.96  | 1.12  |

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

| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)               | 13.46  | 17.89  | -0.05 |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 14.64  | 19.07  | 1.13  |

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



| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Conducted Power Core 0 (dBm)        | 13.27  | 17.85  | 0.26  |
| Conducted Power Core 1 (dBm)        | 13.44  | 18.00  | -0.34 |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)         | 16.36  | 20.94  | 2.98  |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 17.54  | 22.12  | 4.16  |

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

| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)               | 11.93  | 17.71  | -0.02 |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 13.11  | 18.89  | 1.16  |

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

| Channel                             | Bottom | Middle | Top   |
|-------------------------------------|--------|--------|-------|
| Frequency (MHz)                     | 2412   | 2442   | 2472  |
| Conducted Power Core 0 (dBm)        | 11.73  | 17.97  | -0.32 |
| Conducted Power Core 1 (dBm)        | 11.92  | 17.98  | -0.04 |
| Antenna Directional Gain (dBi)      | 1.18   | 1.18   | 1.18  |
| 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)         | 14.84  | 20.99  | 2.83  |
| RSS-247 EIRP Limit (dBm)            | 36.00  | 36.00  | 36.00 |
| EIRP Power (dBm)                    | 16.02  | 22.17  | 4.01  |

**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 |
|----------------------------------------------------|-----------------|---------------------------|-------|-----------------------------|-----------------|
| Attenuator (10dB, 1W)                              | Sealectro       | 60-674-1010-89            | 1224  | -                           | O/P Mon         |
| Rubidium Standard                                  | Rohde & Schwarz | XSRM                      | 1316  | 6                           | 08-Nov-2020     |
| Attenuator (20dB, 1W)                              | Sealectro       | 60-674-1020-89            | 1520  | -                           | O/P Mon         |
| 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                           | 08-Nov-2020     |
| 2 metre SMA Cable                                  | Florida Labs    | SMS-235SP-78.8-SMS        | 4517  | 12                          | 22-Jun-2021     |
| 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     |
| Wireless Cable & Fibre Router - AC 1900, Dual-band | Asus            | RT-AC68U                  | 4881  | -                           | TU              |
| AC Programmable Power Supply                       | iTech           | IT7324                    | 5225  | -                           | O/P Mon         |
| 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                   | 5279  | 12                          | 27-Apr-2021     |
| 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           | 5426  | 12                          | 22-Jun-2021     |
| 3.5 mm 2m Cable                                    | Junkosha        | MWX221-02000DMS           | 5430  | 12                          | 22-Jun-2021     |
| Attenuator 5W 10dB DC-18GHz                        | Aaren           | AT40A-4041-D18-10         | 5493  | 12                          | 14-Apr-2021     |
| Attenuator 2W 10dB DC-10GHz                        | Telegartner     | J01156A0031               | 5576  | -                           | O/P Mon         |
| Attenuator 2W 10dB DC-10GHz                        | Telegartner     | J01156A0031               | 5579  | -                           | O/P Mon         |
| Attenuator 2W 10dB DC-10GHz                        | Telegartner     | J01156A0031               | 5580  | -                           | O/P Mon         |

**Table 23**

TU - Traceability Unscheduled

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**

A2338, S/N: C02CX02PQC36 - Modification State 0

### **2.3.3 Date of Test**

17-July-2020 to 26-July-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 | 21.5-22.5 °C |
| Relative Humidity   | 48.7-63.4 %  |



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                      | -49.51      |
| 802.11g, Core 0       | 6 Mbps         | -             | -              | 2412               | 2400                      | -43.94      |
| 802.11n HT20, Core 0  | MCS7           | -             | -              | 2412               | 2400                      | -42.84      |
| 802.11ax HE20, Core 0 | MCS7           | SU            | -              | 2412               | 2400                      | -44.97      |
| 802.11ax HE20, Core 0 | MCS7           | 26            | 0              | 2412               | 2400                      | -49.50      |

Table 24 - SISO Authorised Band Edge Results

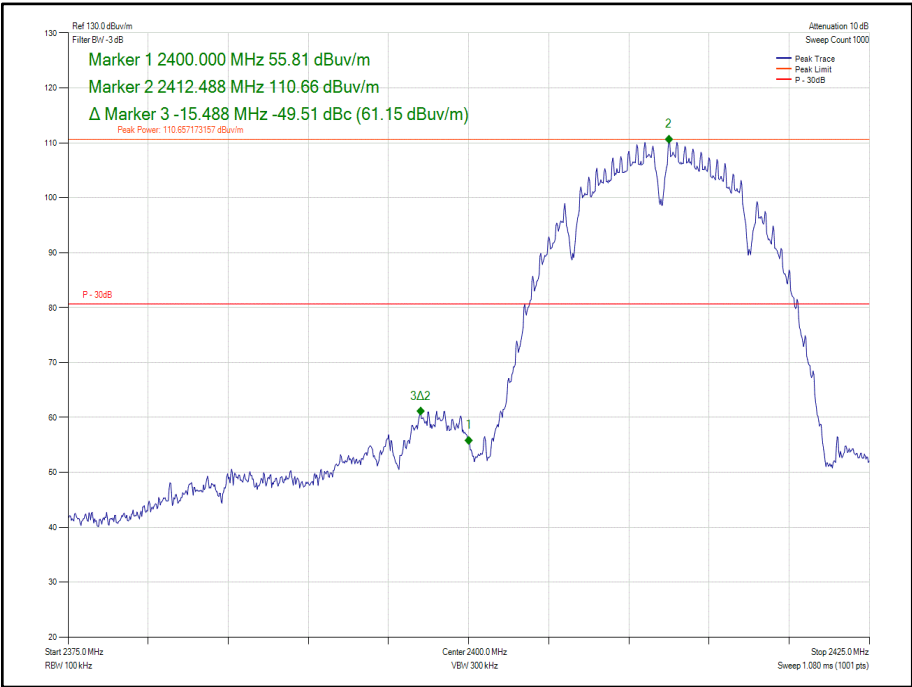


Figure 61 - 802.11b, Core 0 - 2412 MHz  
Band Edge Frequency 2400 MHz

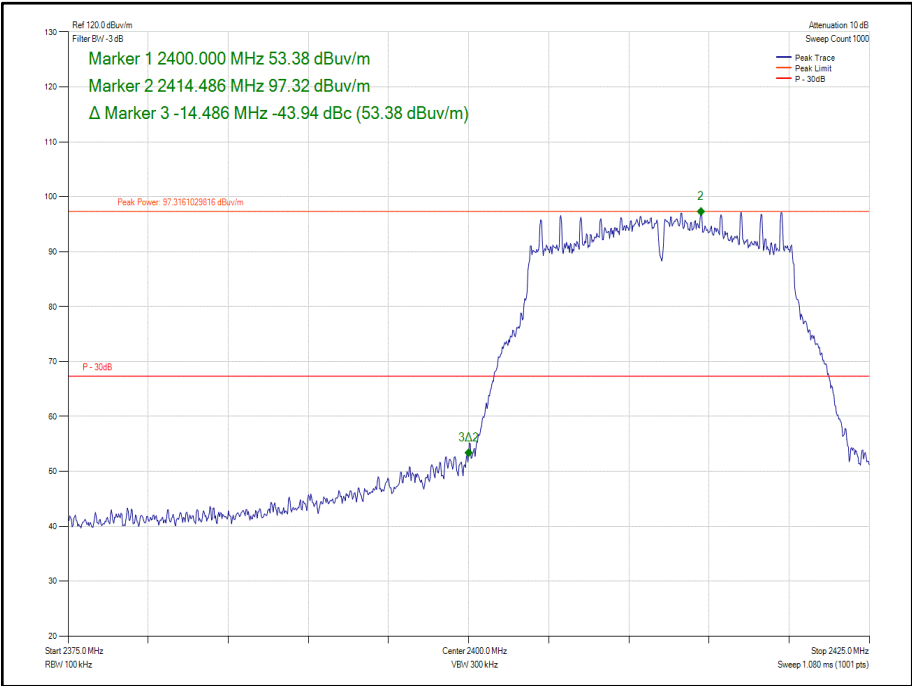


Figure 62- 802.11g, Core 0 - 2412 MHz  
Band Edge Frequency 2400 MHz

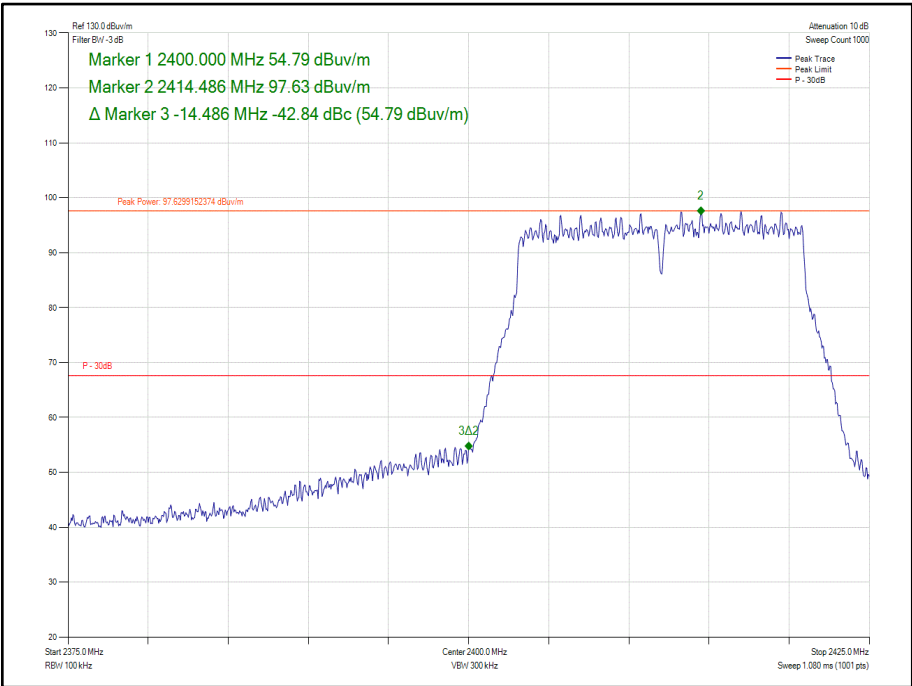


Figure 63- 802.11n HT20, Core 0 - 2412 MHz  
Band Edge Frequency 2400 MHz

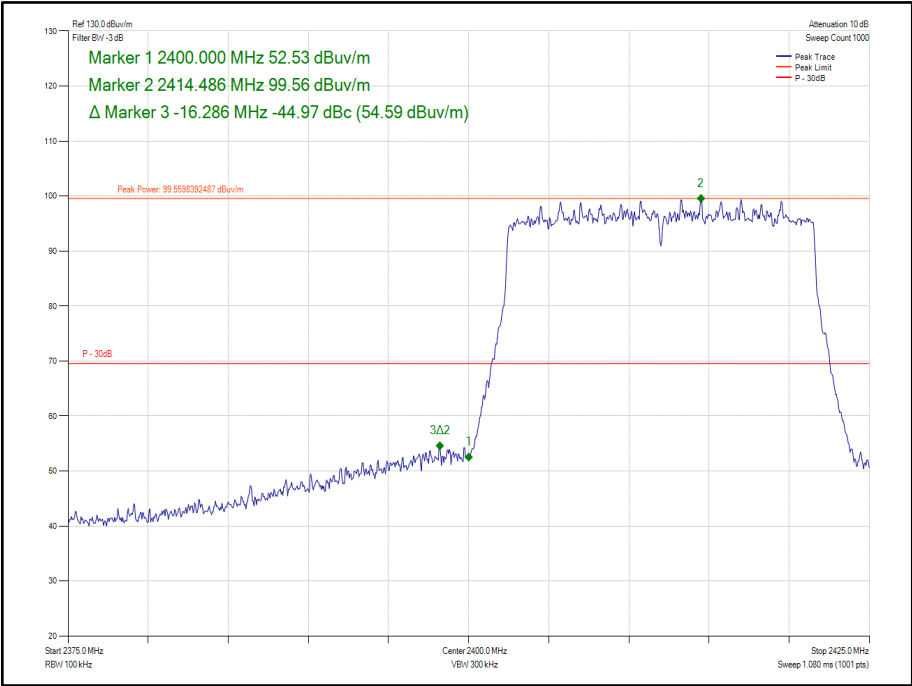


Figure 64- 802.11ax HE20, Core 0, SU - 2412 MHz  
Band Edge Frequency 2400 MHz

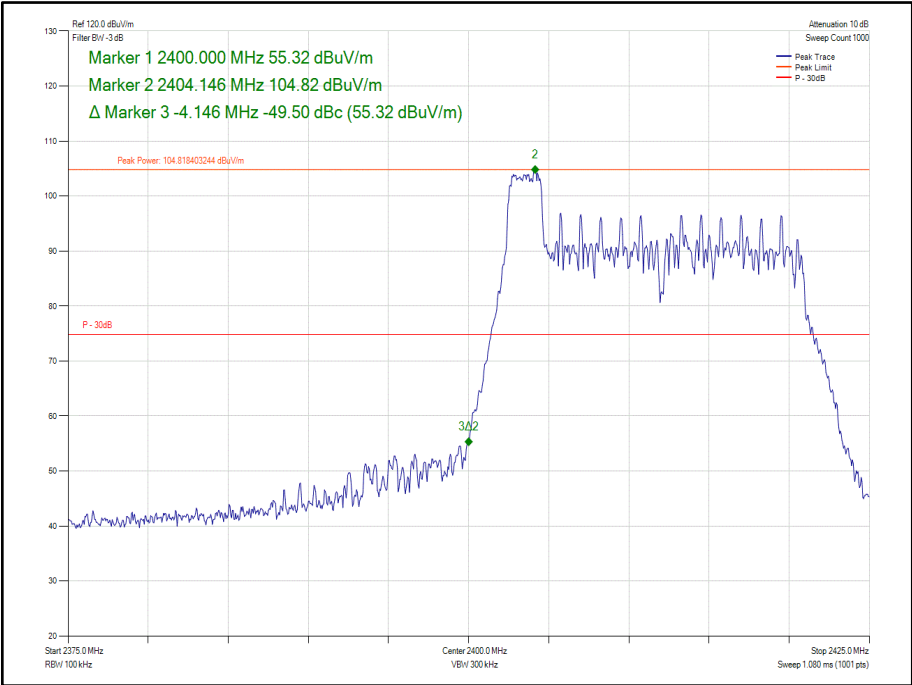


Figure 65- 802.11ax HE20, Core 0, 26-0 - 2412 MHz  
Band Edge Frequency 2400 MHz



| 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                      | -45.27      |
| 802.11ax HE20, Cores 0 -1 | MCS7           | SU            | -              | 2412               | 2400                      | -48.58      |
| 802.11ax HE20, Cores 0 -1 | MCS7           | 26            | 0              | 2412               | 2400                      | -49.81      |

Table 25 - MIMO 2TX Authorised Band Edge Results

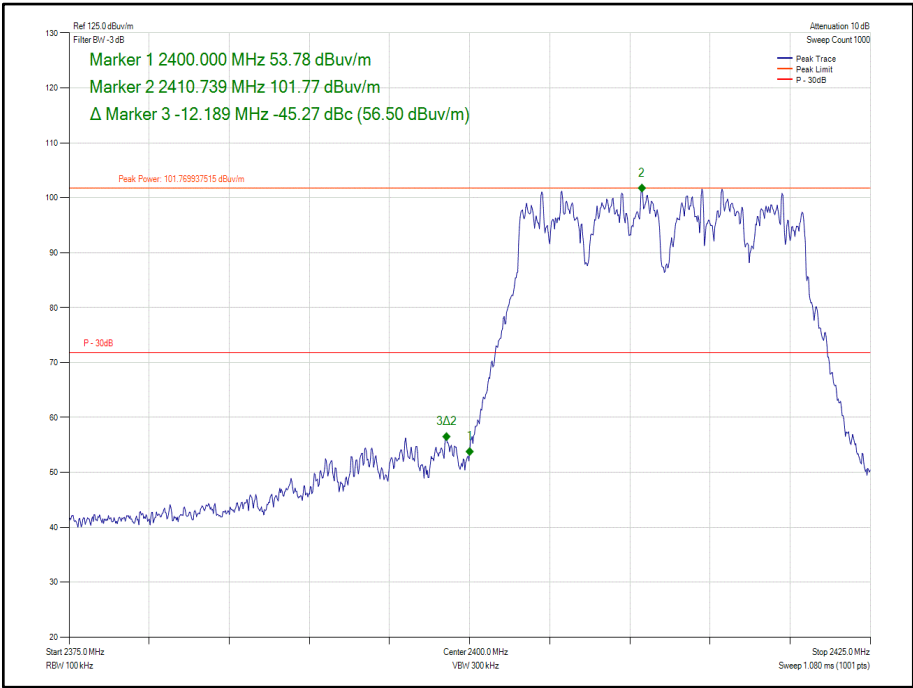


Figure 66 - 802.11n HT20, Cores 0-1 - 2412 MHz  
Band Edge Frequency 2400 MHz

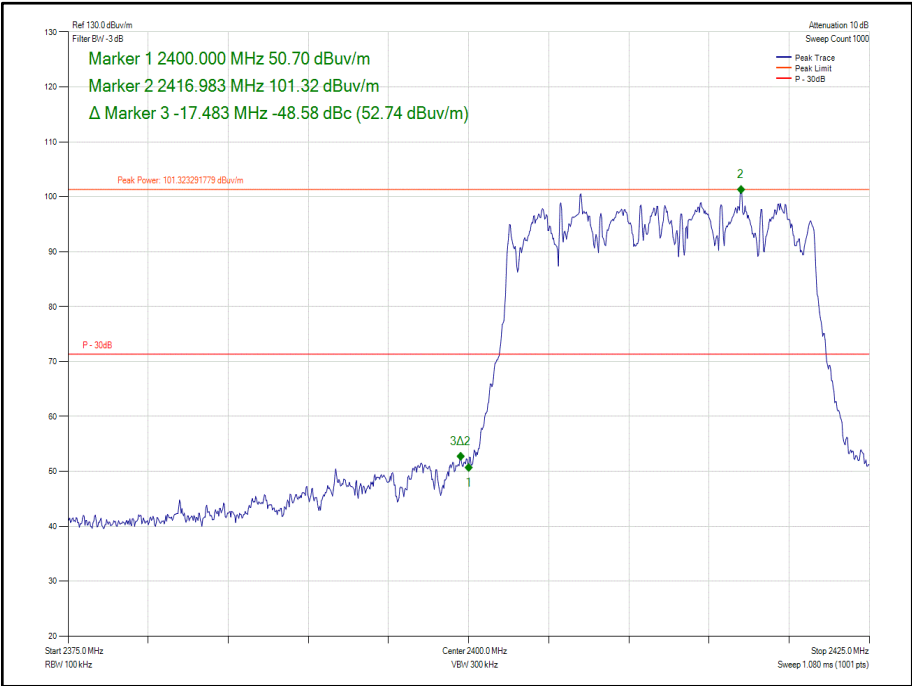


Figure 67- 802.11ax HE20, Cores 0-1, SU - 2412 MHz  
Band Edge Frequency 2400 MHz

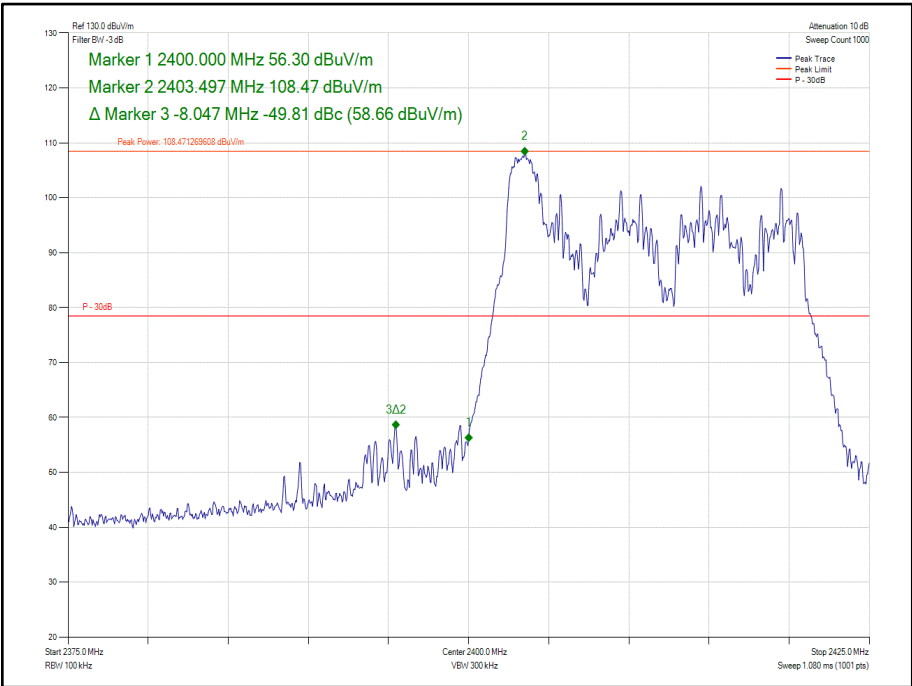


Figure 68- 802.11ax HE20, Cores 0-1, 26-0 - 2412 MHz  
Band Edge Frequency 2400 MHz



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



## **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**

A2338, S/N: C02CX02PQC36 - Modification State 0

### **2.4.3 Date of Test**

17-July-2020 to 26-July-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 $\mu$ V/m to  $\mu$ 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 | 21.5 - 22.5 °C |
| Relative Humidity   | 54.6 - 63.4 %  |



## 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                    | 60.03               | 50.11                  |
| 802.11b, Core 0       | 1 Mbps         | -             | -              | 2462               | 2483.5                    | 60.59               | 49.90                  |
| 802.11b, Core 0       | 1 Mbps         | -             | -              | 2467               | 2483.5                    | 60.19               | 50.09                  |
| 802.11b, Core 0       | 1 Mbps         | -             | -              | 2472               | 2483.5                    | 59.88               | 49.20                  |
| 802.11g, Core 0       | 6 Mbps         | -             | -              | 2412               | 2390.0                    | 58.36               | 46.96                  |
| 802.11g, Core 0       | 6 Mbps         | -             | -              | 2462               | 2483.5                    | 57.66               | 46.41                  |
| 802.11g, Core 0       | 6 Mbps         | -             | -              | 2467               | 2483.5                    | 65.10               | 47.57                  |
| 802.11g, Core 0       | 6 Mbps         | -             | -              | 2472               | 2483.5                    | 66.55               | 49.96                  |
| 802.11n HT20, Core 0  | MCS7           | -             | -              | 2412               | 2390.0                    | 62.38               | 47.30                  |
| 802.11n HT20, Core 0  | MCS7           | -             | -              | 2462               | 2483.5                    | 61.01               | 48.43                  |
| 802.11n HT20, Core 0  | MCS7           | -             | -              | 2467               | 2483.5                    | 60.21               | 48.92                  |
| 802.11n HT20, Core 0  | MCS7           | -             | -              | 2472               | 2483.5                    | 66.46               | 50.76                  |
| 802.11ax HE20, Core 0 | MCS7           | SU            | -              | 2412               | 2400                      | 63.22               | 47.90                  |
| 802.11ax HE20, Core 0 | MCS7           | 26            | 0              | 2412               | 2400                      | 57.01               | 44.17                  |
| 802.11ax HE20, Core 0 | MCS7           | SU            | -              | 2462               | 2483.5                    | 60.09               | 47.53                  |
| 802.11ax HE20, Core 0 | MCS7           | 26            | 8              | 2462               | 2483.5                    | 59.05               | 46.07                  |
| 802.11ax HE20, Core 0 | MCS7           | SU            | -              | 2467               | 2483.5                    | 59.71               | 47.00                  |
| 802.11ax HE20, Core 0 | MCS7           | 26            | 8              | 2467               | 2483.5                    | 60.29               | 47.71                  |
| 802.11ax HE20, Core 0 | MCS7           | SU            | -              | 2472               | 2483.5                    | 63.01               | 45.80                  |
| 802.11ax HE20, Core 0 | MCS7           | 26            | 8              | 2472               | 2483.5                    | 46.41               | 47.24                  |

Table 27 - SISO Restricted Band Edge Results

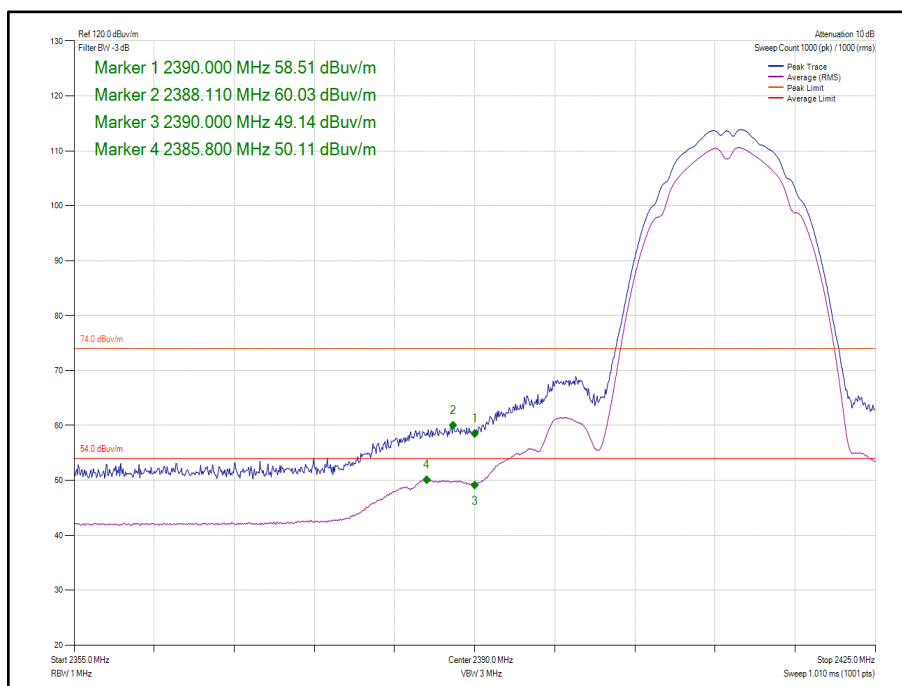


Figure 69 - 802.11b, Core 0 - 2412 MHz, Band Edge Frequency 2390.0 MHz

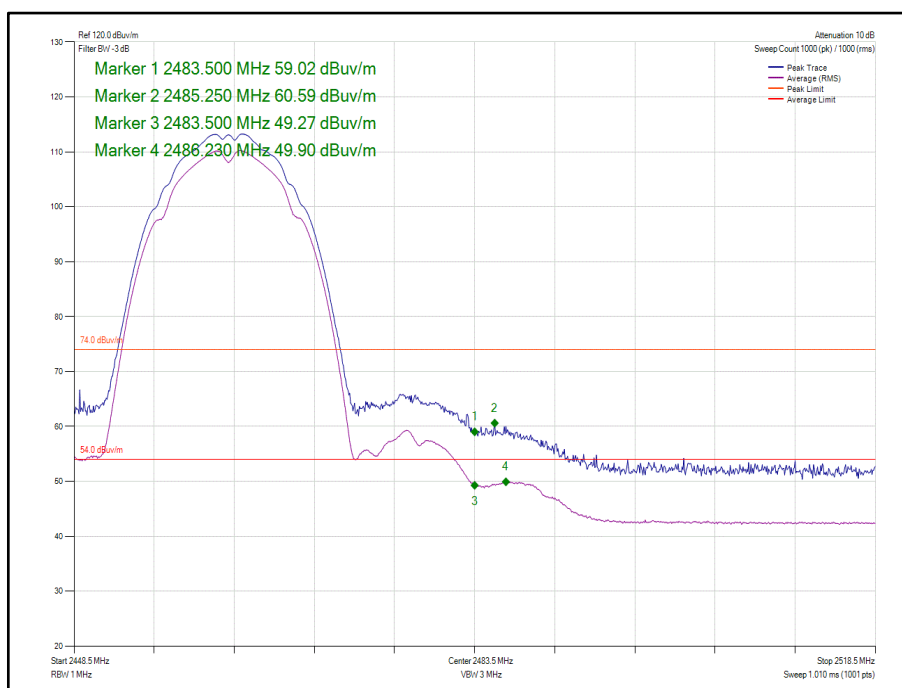


Figure 70 - 802.11b, Core 0 - 2462 MHz, Band Edge Frequency 2483.5 MHz

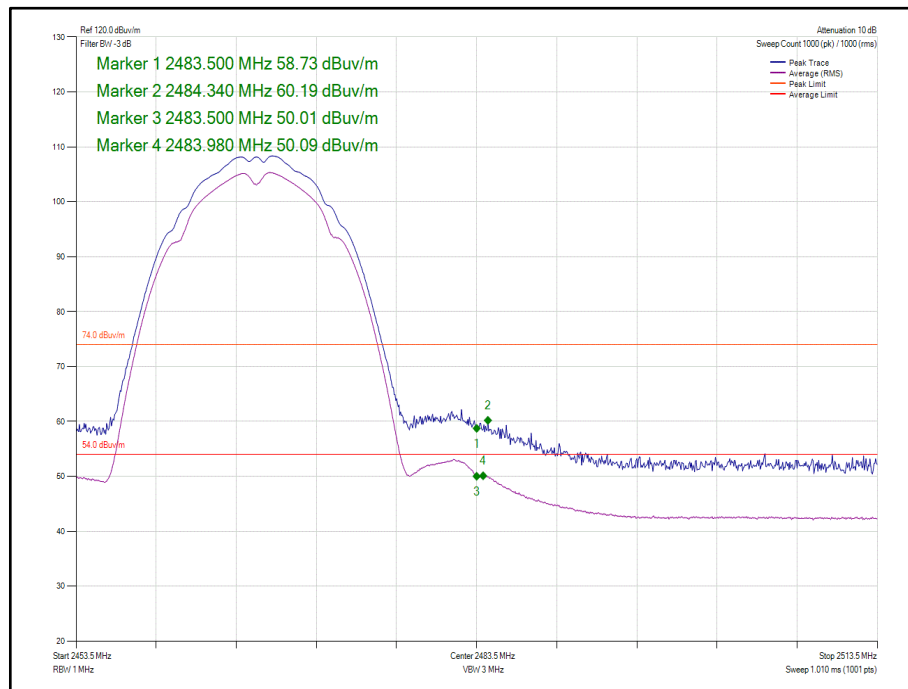


Figure 71 - 802.11b, Core 0 - 2467 MHz, Band Edge Frequency 2483.5 MHz

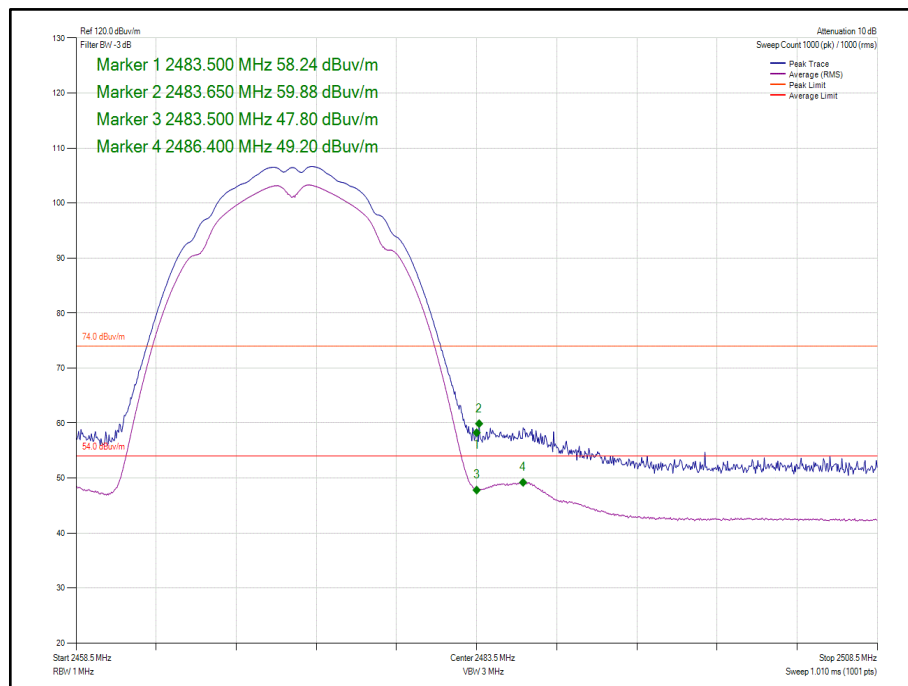


Figure 72 - 802.11b, Core 0 - 2472 MHz, Band Edge Frequency 2483.5 MHz