

# FCC and ISED Test Report

Apple Inc  
Model: A2991

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



Add value.  
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FCC ID: BCGA2991

IC: 579C-A2991

## COMMERCIAL-IN-CONFIDENCE

Document 75957632-70 Issue 02

### SIGNATURE

| NAME         | JOB TITLE                   | RESPONSIBLE FOR      | ISSUE DATE      |
|--------------|-----------------------------|----------------------|-----------------|
| Steven White | Senior Technical Specialist | Authorised Signatory | 11 October 2023 |

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 |
|-------------------|----------------|-----------------|-----------|
| Report Generation | Lauren Walters | 11 October 2023 |           |

FCC Accreditation

553713/UK2026 Concorde Park, Fareham Test Laboratory

ISED Accreditation

28798 Concorde Park, Fareham Test Laboratory

### EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2021, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) 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                  | 15-September-2023 |
| 2     | Sections 2.1 and 2.4 updated | 11-October-2023   |

**Table 1**

## 1.2 Introduction

|                               |                                                                                                                                                                    |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Applicant                     | Apple Inc                                                                                                                                                          |
| Manufacturer                  | Apple Inc                                                                                                                                                          |
| Model Number(s)               | A2991                                                                                                                                                              |
| Serial Number(s)              | N7RTH0WPW3, XNJWHY732L, LRYJMC4D4 and Y7RPXWJ9N9                                                                                                                   |
| Hardware Version(s)           | REV 1.0                                                                                                                                                            |
| Software Version(s)           | 23A32390z, 23A32390z, 23A32390z and 23A32391n                                                                                                                      |
| Number of Samples Tested      | 4                                                                                                                                                                  |
| Test Specification/Issue/Date | FCC 47 CFR Part 15C: 2021<br>ISED RSS-247: Issue 2 (02-2017)<br>ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021)                                                     |
| Start of Test                 | 26-June-2023                                                                                                                                                       |
| Finish of Test                | 10-August-2023                                                                                                                                                     |
| Name of Engineer(s)           | Colin Brain, Elliot Callender, Ioan-Alexandru Bogatu, Morsalin Hossain, Vineeth Nagaraj, Feda Hussein, Michael Evans, Tony Baby and Akhil Rajendran Bhaskaran Nair |
| Related Document(s)           | ANSI C63.10 (2013)<br>KDB 662911 D01 v02r01<br>ANSI C63.4 (2014)                                                                                                   |



### 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 device complies with the provisions of this section, as it uses permanently attached integral antennas. |
| 2.1                                  | 15.205                | 3.3         | 8.10         | Restricted Band Edges          | Pass   | ANSI C63.10 (2013)                                                                                          |
| 2.2                                  | 15.247 (a)(2)         | 5.2         | 6.7          | Emission Bandwidth             | Pass   | ANSI C63.10 (2013)                                                                                          |
| 2.3                                  | 15.247 (b)            | 5.4         | 6.12         | Maximum Conducted Output Power | Pass   | KDB 662911 D01 v02r01<br>ANSI C63.10 (2013)                                                                 |
| 2.4                                  | 15.247 (d)            | 5.5         | -            | Authorised Band Edges          | Pass   | ANSI C63.10 (2013)                                                                                          |
| 2.5                                  | 15.209 and 15.247 (d) | 3.3 and 5.5 | 6.13 and 8.9 | Spurious Radiated Emissions    | Pass   | ANSI C63.10 (2013)<br>ANSI C63.4 (2014)                                                                     |
| 2.6                                  | 15.247 (e)            | 5.2         | 6.12         | Power Spectral Density         | Pass   | KDB 662911 D01 v02r01<br>ANSI C63.10 (2013)                                                                 |

**Table 2**



## 1.4 Product Information

### 1.4.1 Technical Description

The equipment under test (EUT) was a portable laptop computer.

### 1.4.2 Test Modes

The EUT's 2.4 GHz 802.11 radio supports SISO (Single Input/Single Output) and 2x2 MIMO (Multiple Input/Multiple Output). It supports 802.11b and g for SISO and 802.11n and ax at 20 MHz channel bandwidths for SISO and MIMO. 802.11ax supports RU 26/52/106/242.

The EUT uses different output powers per core dependent on the transmit mode and how many cores are used. It uses the same power across all cores in any given mode.

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 12 Mbps
- 802.11n HT20 MCS2
- 802.11ax HE20 MCS2x1 SU, RU26/52/106\*

2x2 MIMO Modes (Core 0 + Core 1):

- 802.11n HT20 MCS2 – CDD
- 802.11ax HE20 MCS2x1 – CDD SU, RU26/52/106\*

\*Note: The RU offset for bottom and middle channels were placed in the lowest position and on the top channel, the offset was placed in the upper most position.

### 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. 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

| Antenna Port | Frequency Range (MHz) | Peak Gain (dBi) | Conducted Cable Loss (dB) |
|--------------|-----------------------|-----------------|---------------------------|
| Core 0       | 2400 to 2480          | 3.10            | 0.71                      |
| Core 1       | 2400 to 2480          | 5.30            | 0.71                      |

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: A2991, Serial Number: N7RTH0WPW3 |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2991, Serial Number: XNJWHY732L |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2991, Serial Number: Y7RPXWJ9N9 |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2991, Serial Number: LRYJMC4D4  |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |

**Table 4**



## 1.7 Test Location

TÜV SÜD conducted the following tests at our Concorde Park Test Laboratory.

| Test Name                            | Name of Engineer(s)                                                                                                  | Accreditation |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------|
| Configuration and Mode: 2.4 GHz WLAN |                                                                                                                      |               |
| Restricted Band Edges                | Colin Brain, Elliot Callender, Ioan-Alexandru Bogatu, Morsalin Hossain and Vineeth Nagaraj                           | UKAS          |
| Emission Bandwidth                   | Feda Hussein                                                                                                         | UKAS          |
| Maximum Conducted Output Power       | Feda Hussein                                                                                                         | UKAS          |
| Authorised Band Edges                | Colin Brain, Elliot Callender, Ioan-Alexandru Bogatu, Michael Evans, Morsalin Hossain, Tony Baby and Vineeth Nagaraj | UKAS          |
| Spurious Radiated Emissions          | Akhil Rajendran Bhaskaran Nair, Michael Evans and Vineeth Nagaraj                                                    | UKAS          |
| Power Spectral Density               | Feda Hussein                                                                                                         | UKAS          |

**Table 5**

Office Address:

TÜV SÜD  
Concorde Park  
Concorde Way  
Fareham  
Hampshire  
PO15 5FG  
United Kingdom



## 2 Test Details

### 2.1 Restricted Band Edges

#### 2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205  
ISED RSS-247, Clause 3.3  
ISED RSS-GEN, Clause 8.10

#### 2.1.2 Equipment Under Test and Modification State

A2991, S/N: N7RTH0WPW3 - Modification State 0  
A2991, S/N: XNJWHY732L - Modification State 0  
A2991, S/N: LRYJMC4D4 - Modification State 0

#### 2.1.3 Date of Test

26-June-2023 to 04-August-2023

#### 2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5 and 11.12.1.

Plots for average measurements were taken in accordance with ANSI C63.10, clause 11.12.2.5.2.

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

#### 2.1.5 Environmental Conditions

|                     |                |
|---------------------|----------------|
| Ambient Temperature | 22.4 - 24.2 °C |
| Relative Humidity   | 41.5 - 46.7 %  |



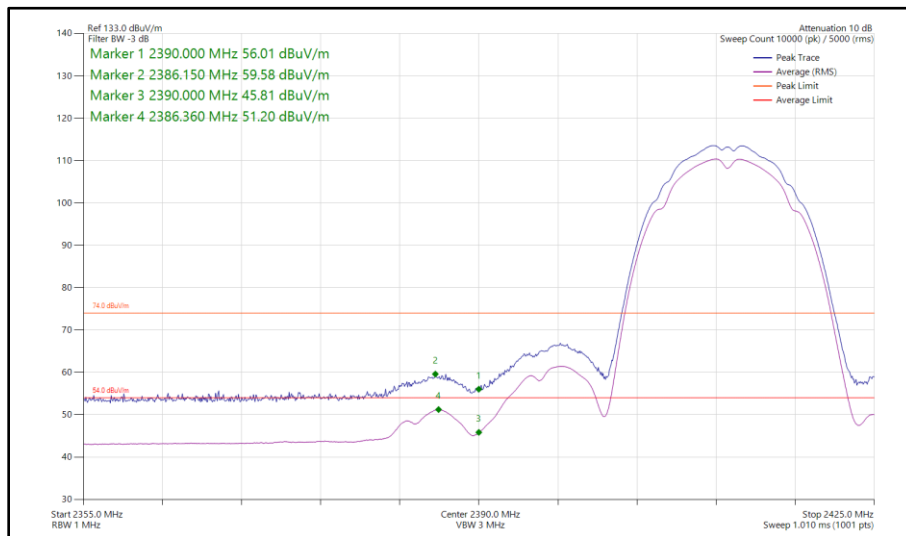
## 2.1.6 Test Results

### 2.4 GHz WLAN

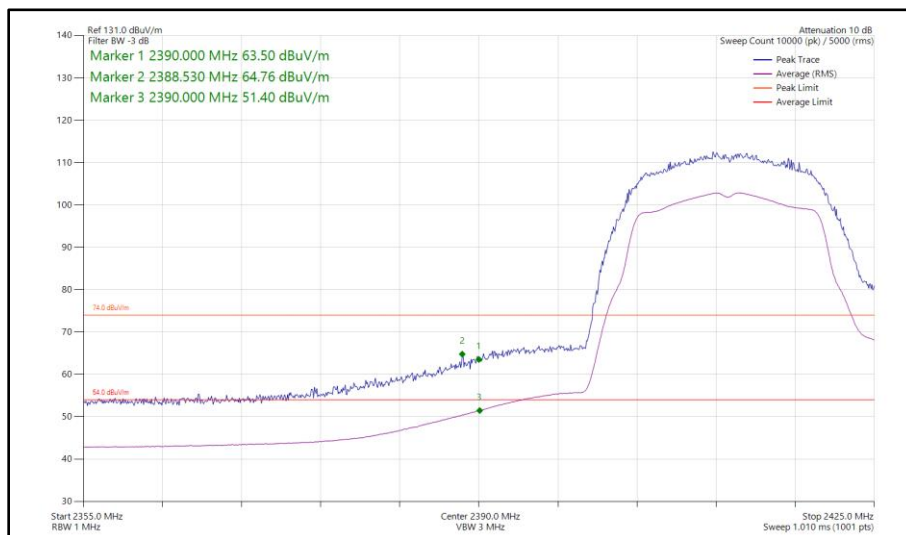
#### 20 MHz Bandwidth - Core 0 (SISO)

| Mode          | Data Rate/<br>MCS | Resource<br>Size | Resource<br>Index | TX<br>Frequency<br>(MHz) | Band Edge<br>Frequency<br>(MHz) | Peak Level<br>(dBμV/m) | Average<br>Level<br>(dBμV/m) |
|---------------|-------------------|------------------|-------------------|--------------------------|---------------------------------|------------------------|------------------------------|
| 802.11b       | 1 Mbps            | -                | -                 | 2412                     | 2390                            | 59.58                  | 51.20                        |
| 802.11g       | 12 Mbps           | -                | -                 | 2412                     | 2390                            | 64.76                  | 51.40                        |
| 802.11n HT20  | MCS2              | -                | -                 | 2412                     | 2390                            | 65.21                  | 50.82                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2412                     | 2390                            | 65.48                  | 51.44                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2412                     | 2390                            | 69.05                  | 50.23                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2462                     | 2483.5                          | 59.52                  | 51.31                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2467                     | 2483.5                          | 59.31                  | 51.04                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2472                     | 2483.5                          | 58.27                  | 51.38                        |
| 802.11g       | 24 Mbps           | -                | -                 | 2462                     | 2483.5                          | 67.01                  | 51.43                        |
| 802.11g       | 24 Mbps           | -                | -                 | 2467                     | 2483.5                          | 65.05                  | 51.48                        |
| 802.11g       | 24 Mbps           | -                | -                 | 2472                     | 2483.5                          | 65.39                  | 51.44                        |
| 802.11n HT20  | MCS4              | -                | -                 | 2462                     | 2483.5                          | 65.69                  | 50.96                        |
| 802.11n HT20  | MCS2              | -                | -                 | 2467                     | 2483.5                          | 63.12                  | 51.42                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2472                     | 2483.5                          | 65.56                  | 51.44                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2462                     | 2483.5                          | 65.16                  | 51.39                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2462                     | 2483.5                          | 66.26                  | 48.16                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2467                     | 2483.5                          | 63.16                  | 51.31                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2467                     | 2483.5                          | 69.48                  | 47.67                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2472                     | 2483.5                          | 66.67                  | 51.49                        |
| 802.11ax HE20 | MCS9x1            | 26               | 0                 | 2472                     | 2483.5                          | 69.48                  | 48.61                        |

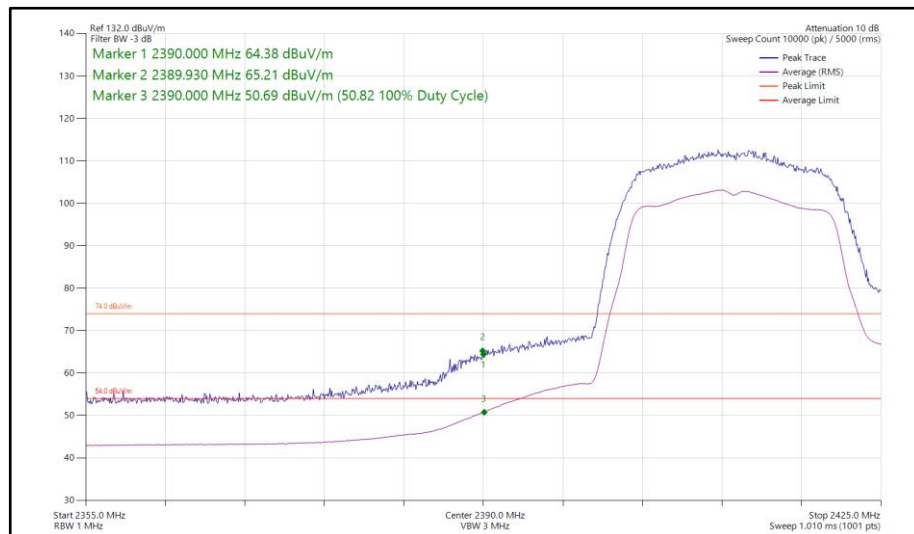
**Table 6 - SISO Restricted Band Edge Results**



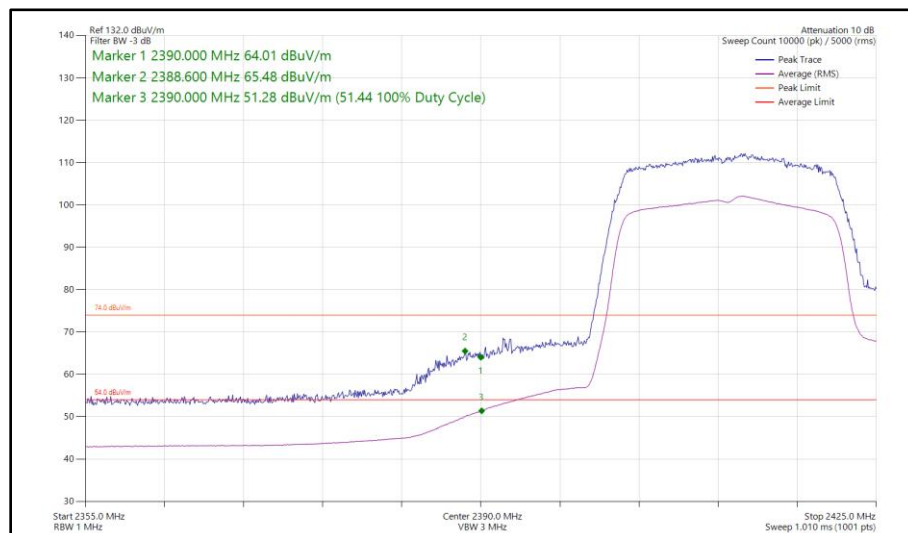
**Figure 1 - 802.11b, SISO, Core 0 - 2412 MHz  
Band Edge Frequency 2390 MHz**



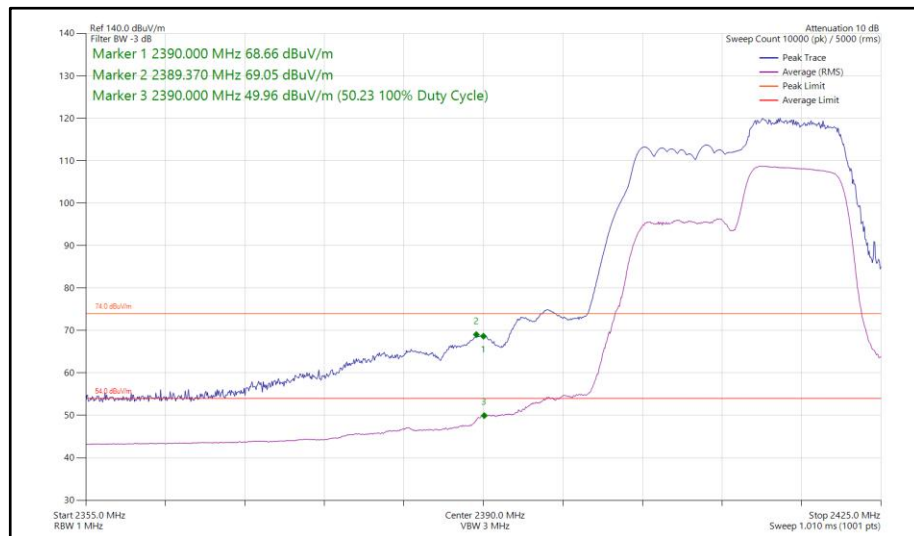
**Figure 2 - 802.11g, SISO, Core 0 - 2412 MHz  
Band Edge Frequency 2390 MHz**



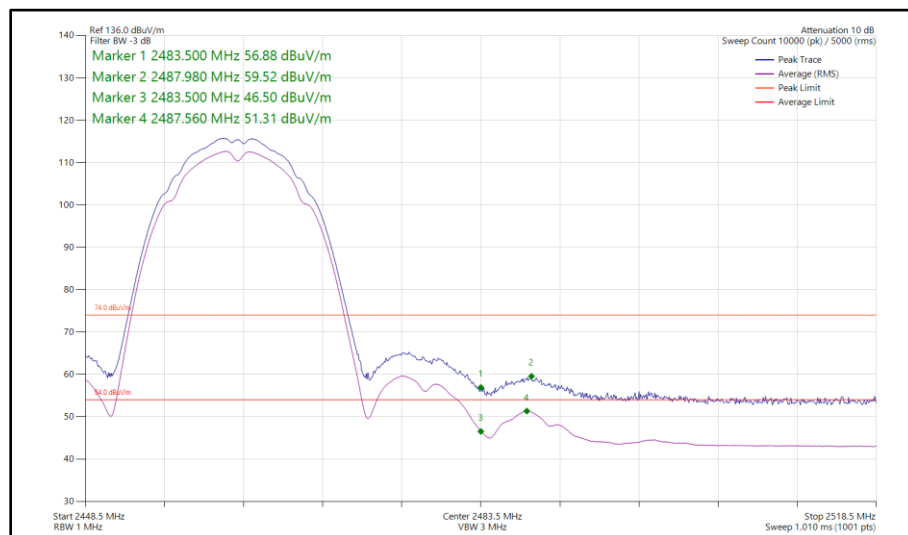
**Figure 3 - 802.11n HT20, SISO, Core 0 - 2412 MHz  
Band Edge Frequency 2390 MHz**



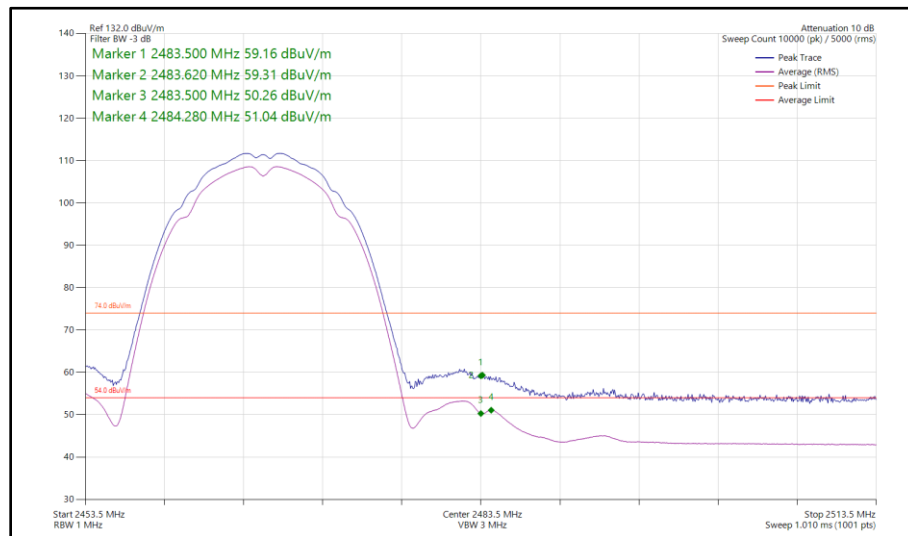
**Figure 4 - 802.11ax HE20, SU, SISO, Core 0 - 2412 MHz  
Band Edge Frequency 2390 MHz**



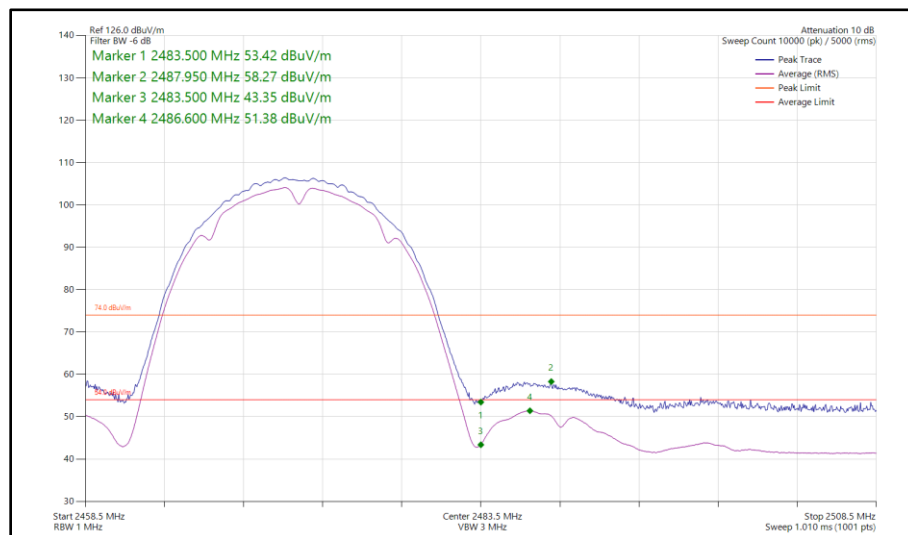
**Figure 5 - 802.11ax HE20, RU 106-54, SISO, Core 0 - 2412 MHz  
Band Edge Frequency 2390 MHz**



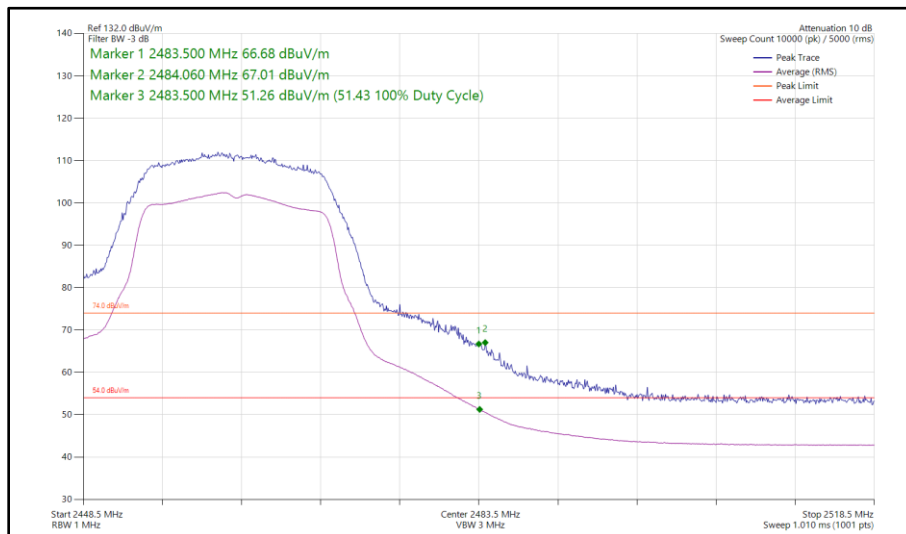
**Figure 6 - 802.11b, SISO, Core 0 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



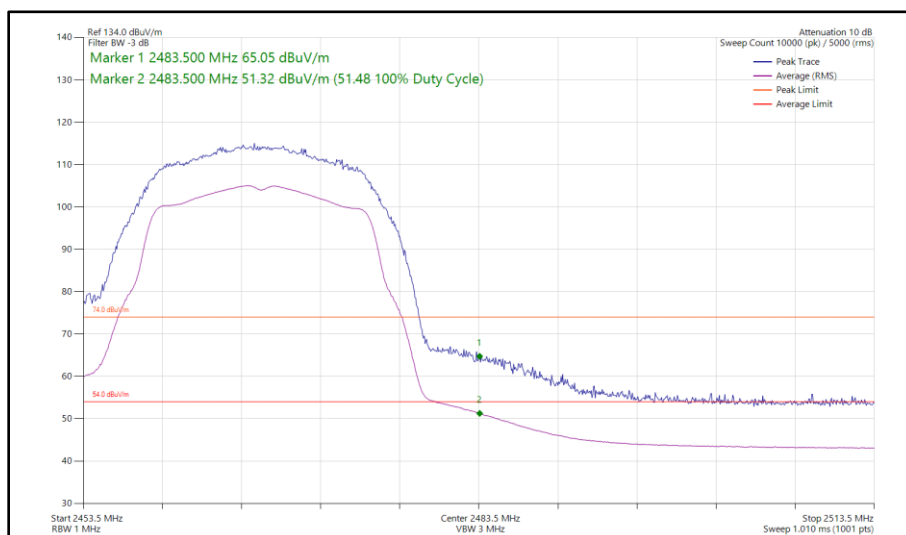
**Figure 7 - 802.11b, SISO, Core 0 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



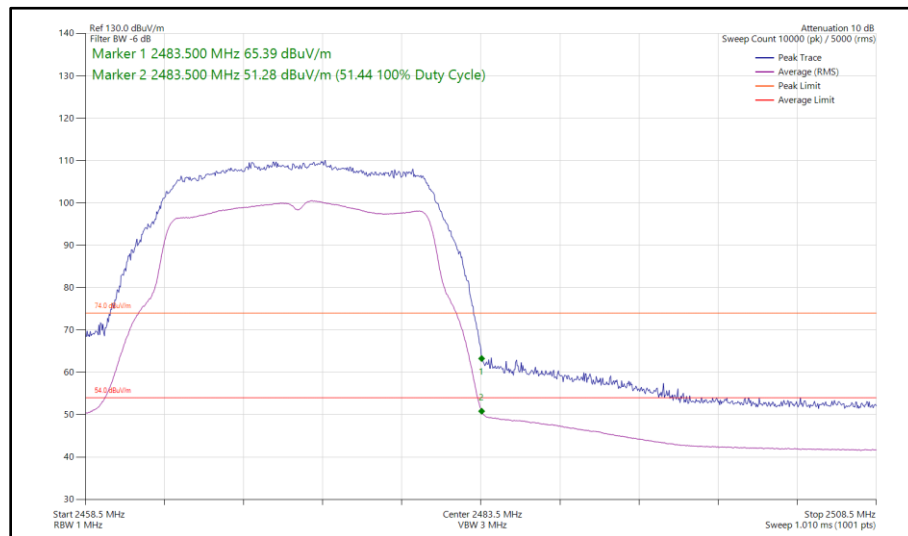
**Figure 8 - 802.11b, SISO, Core 0 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



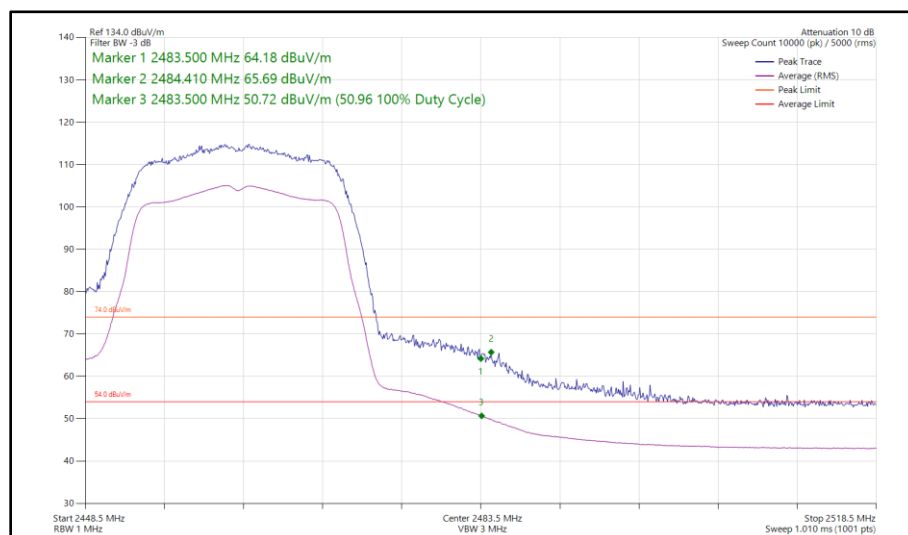
**Figure 9 - 802.11g, SISO, Core 0 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



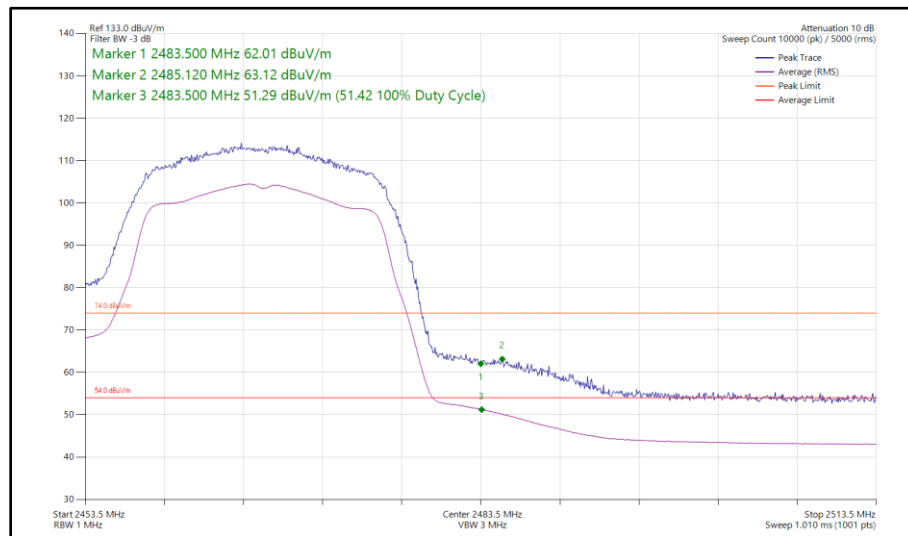
**Figure 10 - 802.11g, SISO, Core 0 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



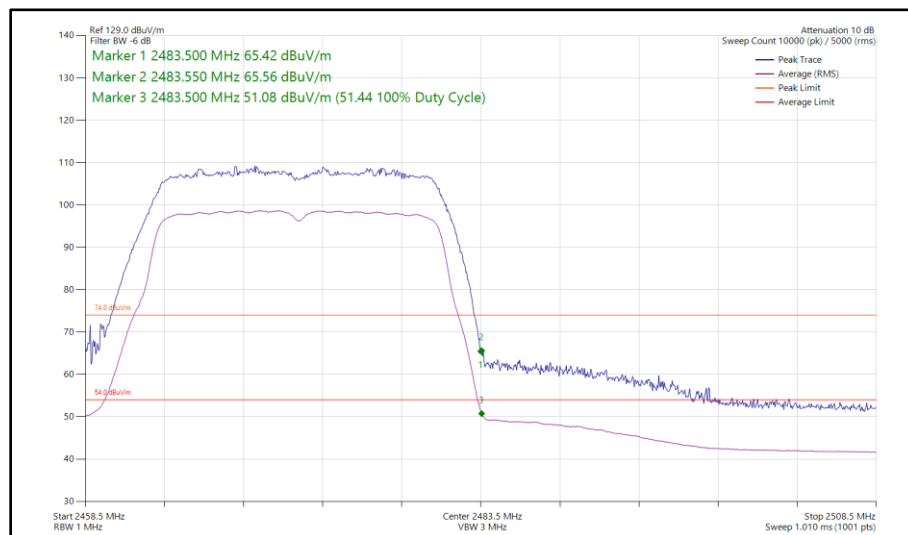
**Figure 11 - 802.11g, SISO, Core 0 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



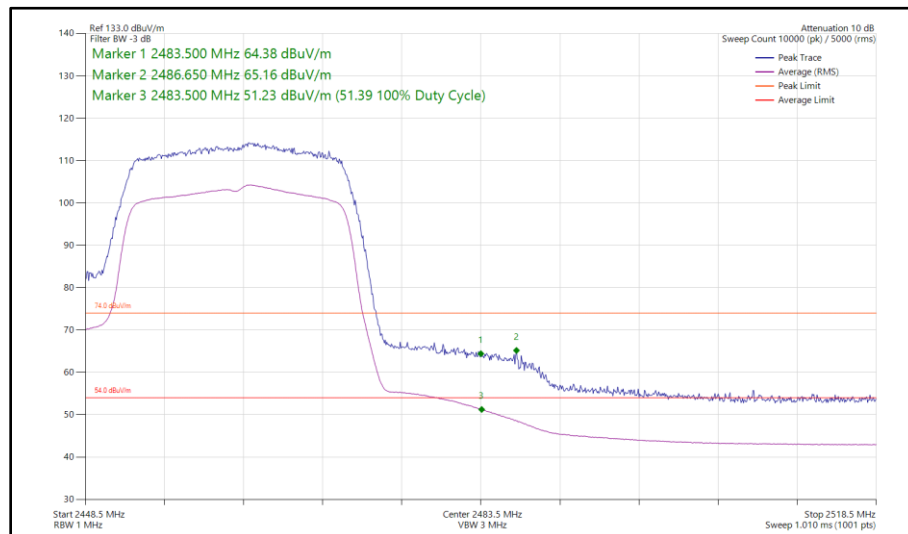
**Figure 12 - 802.11n HT20, SISO, Core 0 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



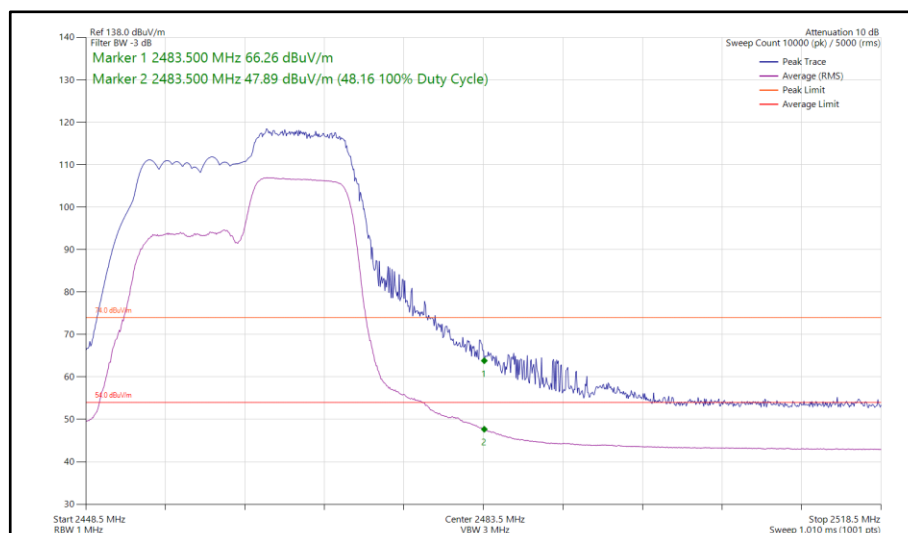
**Figure 13 - 802.11n HT20, SISO, Core 0 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



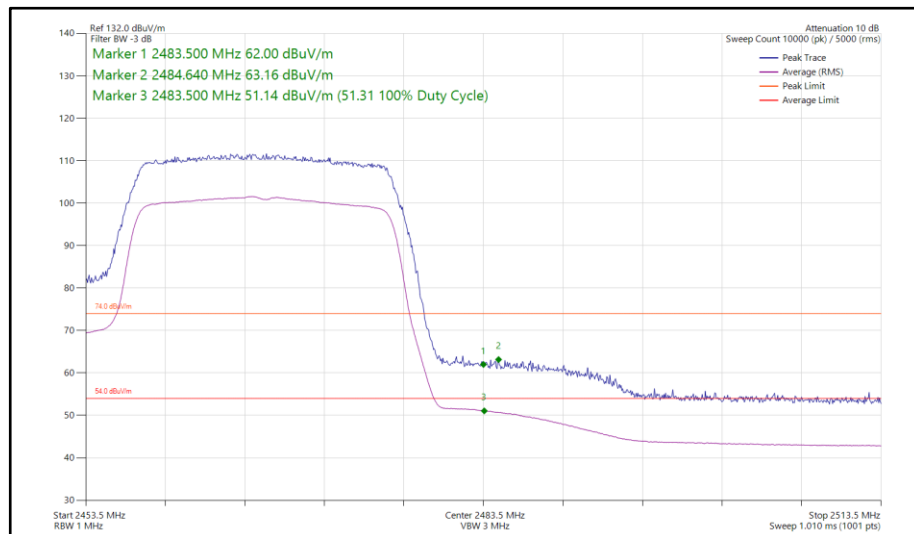
**Figure 14 - 802.11n HT20, SISO, Core 0 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



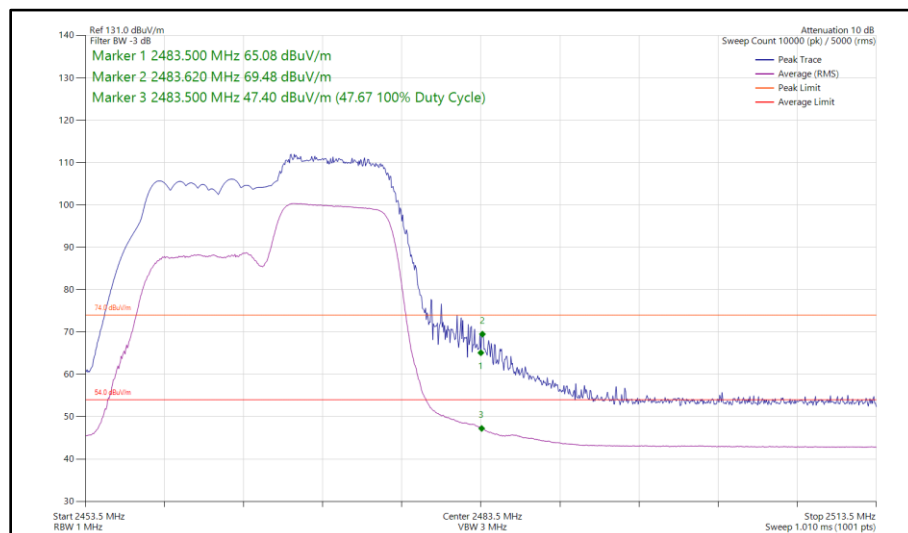
**Figure 15 - 802.11ax HE20, SU, SISO, Core 0 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



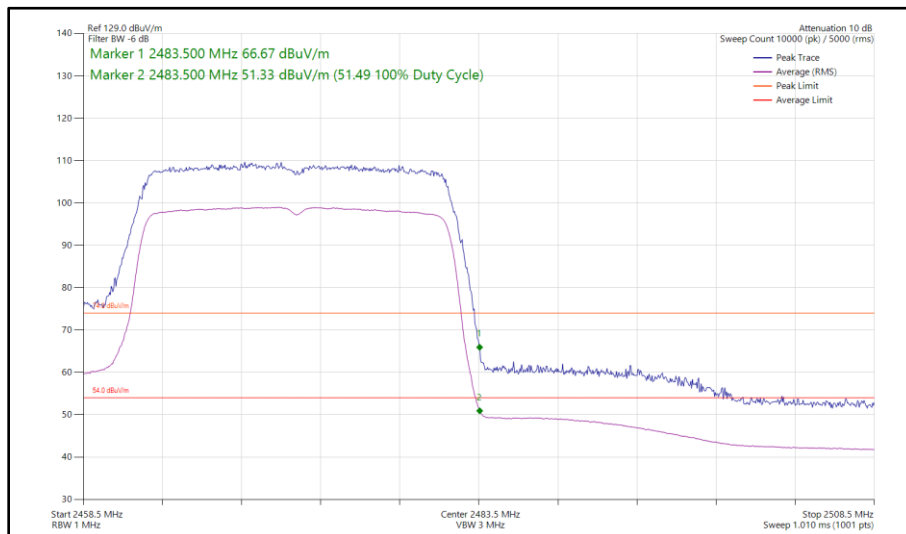
**Figure 16 - 802.11ax HE20, RU 106-54, SISO, Core 0 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



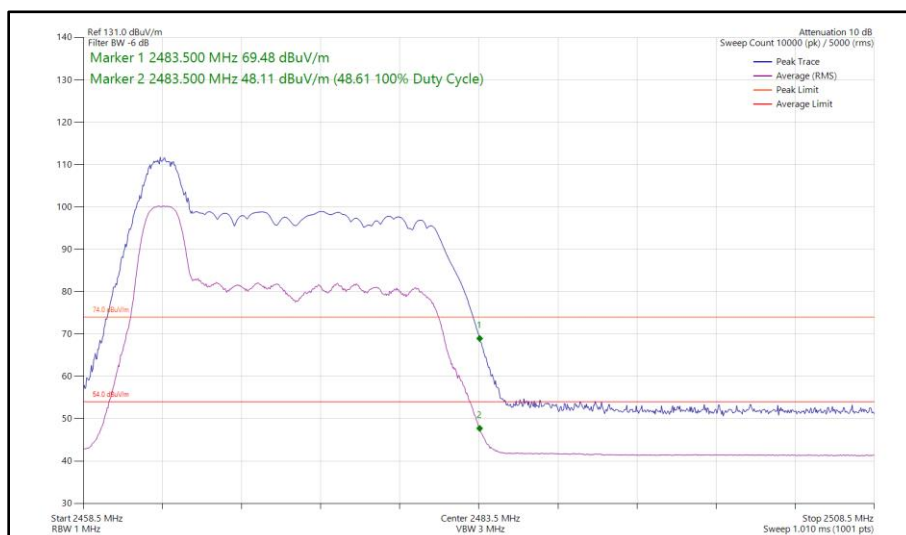
**Figure 17 - 802.11ax HE20, SU, SISO, Core 0 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 18 - 802.11ax HE20, RU 106-54, SISO, Core 0 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 19 - 802.11ax HE20, SU, SISO, Core 0 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



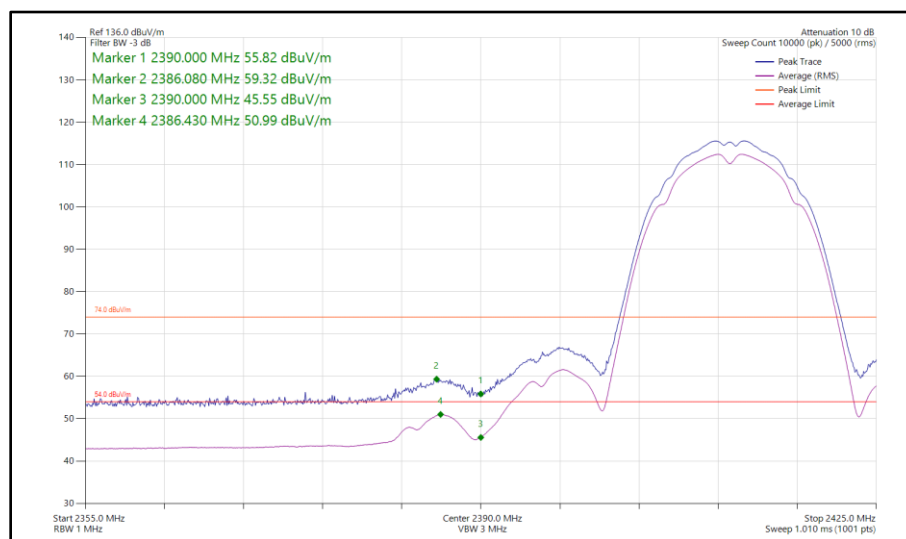
**Figure 20 - 802.11ax HE20, RU 26-0, SISO, Core 0 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



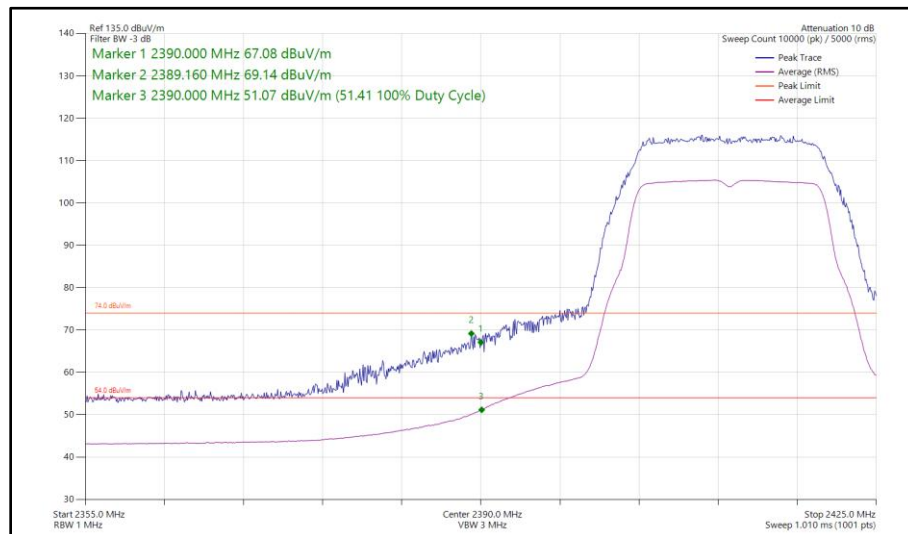
20 MHz Bandwidth - Core 1 (SISO)

| Mode          | Data Rate/<br>MCS | Resource<br>Size | Resource<br>Index | TX<br>Frequency<br>(MHz) | Band Edge<br>Frequency<br>(MHz) | Peak Level<br>(dBμV/m) | Average<br>Level<br>(dBμV/m) |
|---------------|-------------------|------------------|-------------------|--------------------------|---------------------------------|------------------------|------------------------------|
| 802.11b       | 1 Mbps            | -                | -                 | 2412                     | 2390                            | 59.32                  | 50.99                        |
| 802.11g       | 54 Mbps           | -                | -                 | 2412                     | 2390                            | 69.14                  | 51.41                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2412                     | 2390                            | 67.81                  | 51.41                        |
| 802.11ax HE20 | MCS9x1            | SU               | -                 | 2412                     | 2390                            | 66.55                  | 51.45                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2412                     | 2390                            | 69.34                  | 49.39                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2462                     | 2483.5                          | 59.85                  | 51.15                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2467                     | 2483.5                          | 59.54                  | 51.42                        |
| 802.11b       | 1 Mbps            | -                | -                 | 2472                     | 2483.5                          | 58.61                  | 51.24                        |
| 802.11g       | 24 Mbps           | -                | -                 | 2462                     | 2483.5                          | 66.05                  | 51.17                        |
| 802.11g       | 12 Mbps           | -                | -                 | 2467                     | 2483.5                          | 64.32                  | 51.48                        |
| 802.11g       | 54 Mbps           | -                | -                 | 2472                     | 2483.5                          | 66.50                  | 51.39                        |
| 802.11n HT20  | MCS4              | -                | -                 | 2462                     | 2483.5                          | 66.53                  | 51.43                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2467                     | 2483.5                          | 66.43                  | 51.18                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2472                     | 2483.5                          | 66.28                  | 51.43                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2462                     | 2483.5                          | 64.59                  | 51.45                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2462                     | 2483.5                          | 67.32                  | 48.99                        |
| 802.11ax HE20 | MCS9x1            | SU               | -                 | 2467                     | 2483.5                          | 66.29                  | 51.08                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2467                     | 2483.5                          | 68.86                  | 49.58                        |
| 802.11ax HE20 | MCS9x1            | SU               | -                 | 2472                     | 2483.5                          | 67.11                  | 51.36                        |
| 802.11ax HE20 | MCS9x1            | 52               | 37                | 2472                     | 2483.5                          | 69.27                  | 49.84                        |

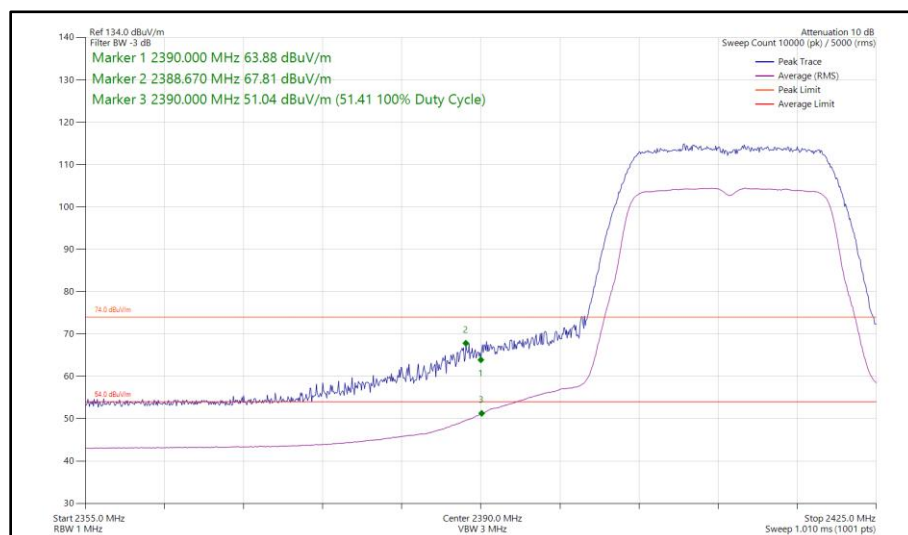
**Table 7 - SISO Restricted Band Edge Results**



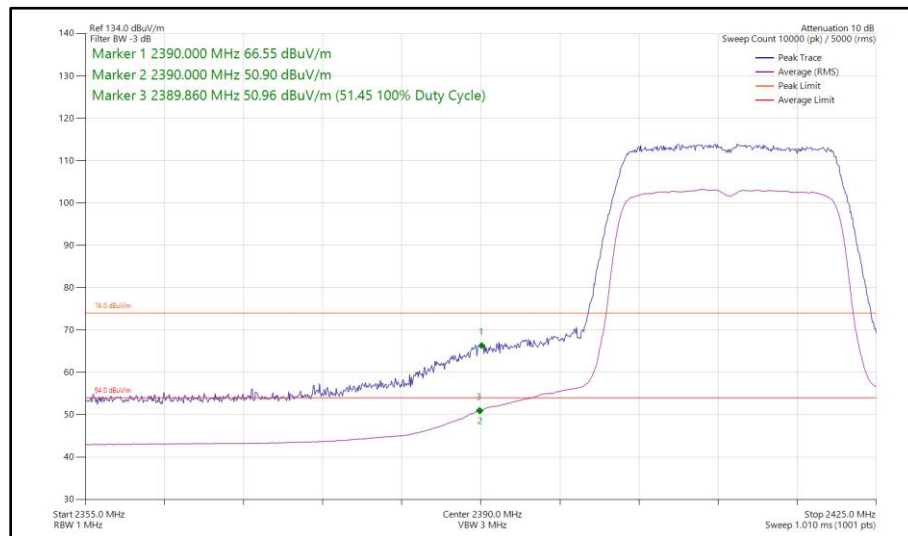
**Figure 21 - 802.11b, SISO, Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



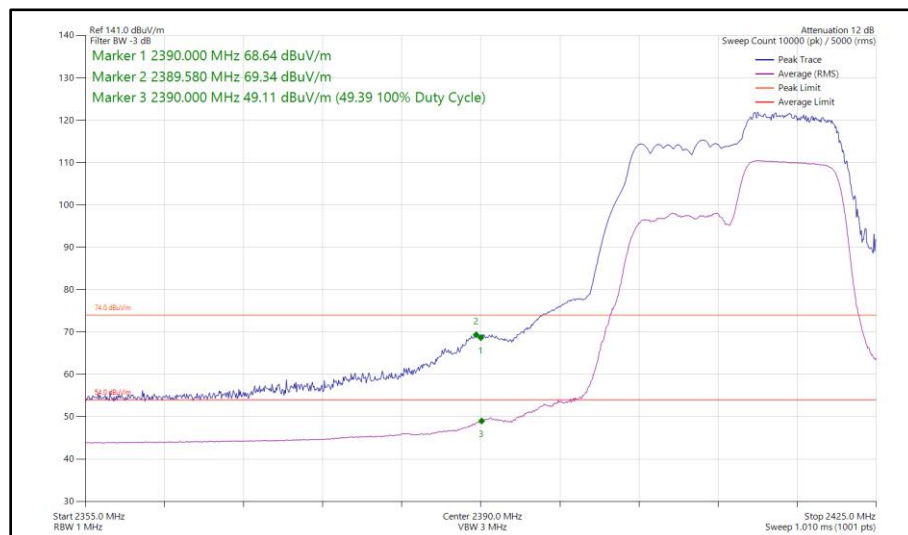
**Figure 22 - 802.11g, SISO, Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



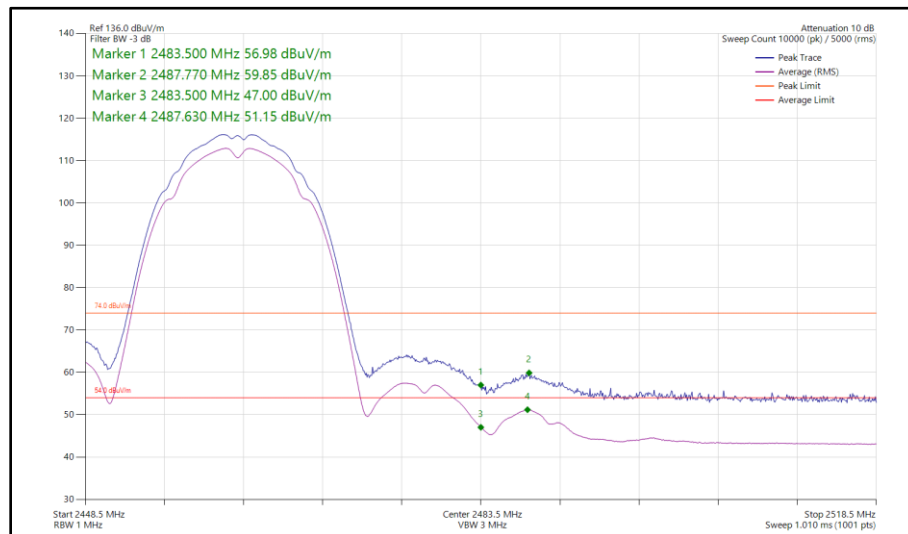
**Figure 23 - 802.11n HT20, SISO, Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



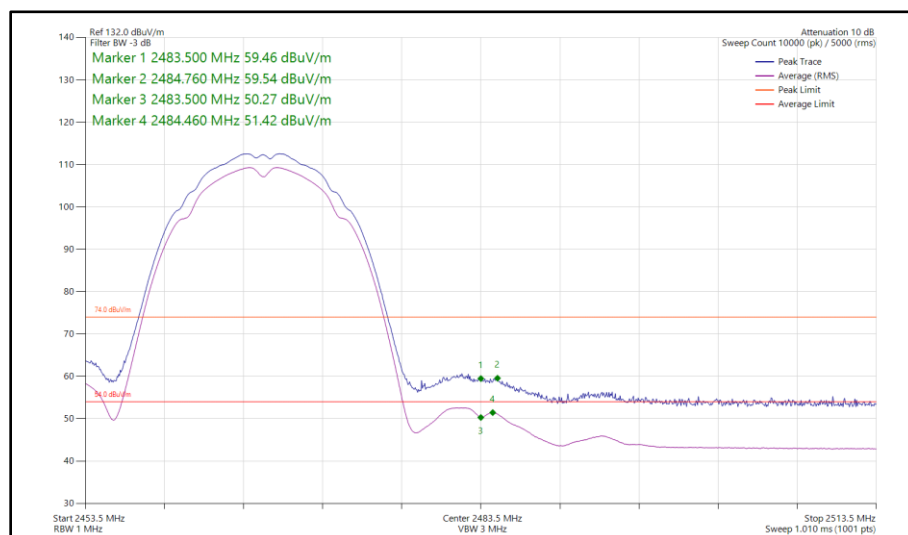
**Figure 24 - 802.11ax HE20, SU, SISO, Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



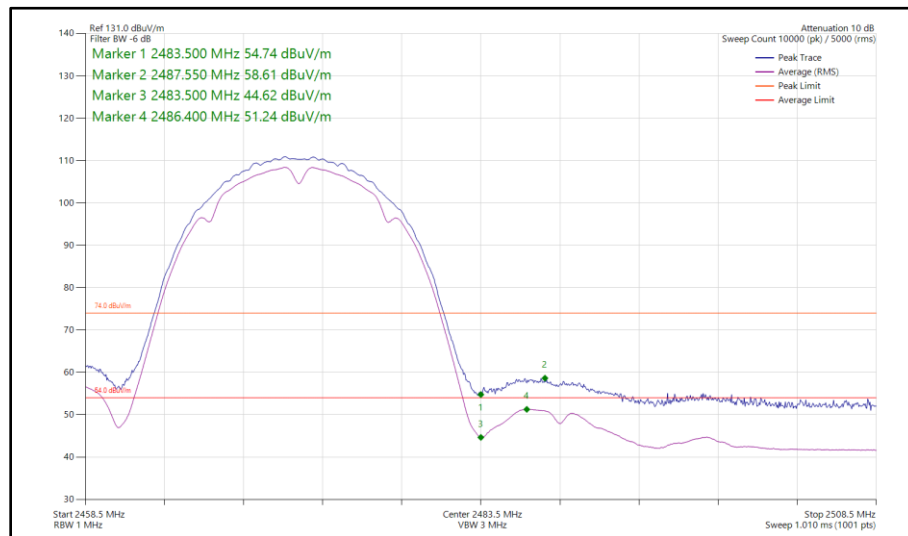
**Figure 25 - 802.11ax HE20, RU 106-54, SISO, Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



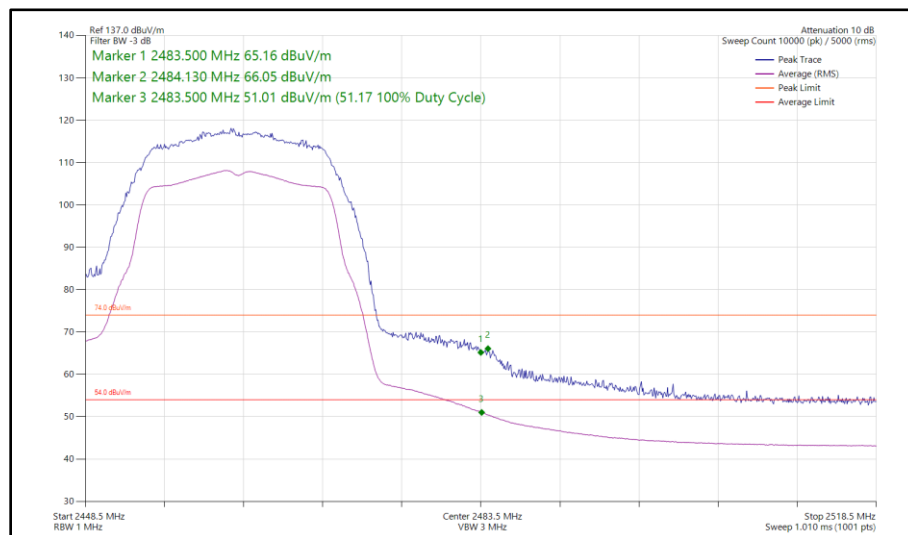
**Figure 26 - 802.11b, SISO, Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



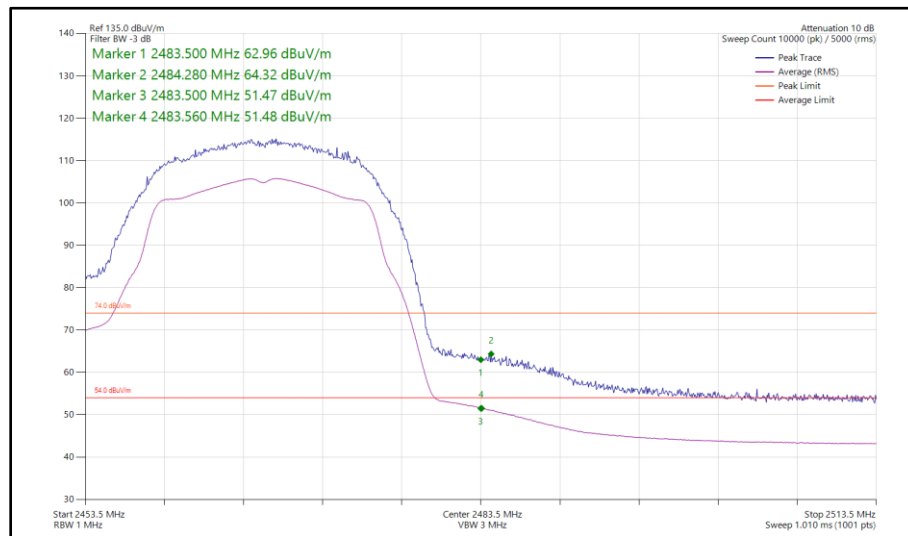
**Figure 27 - 802.11b, SISO, Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



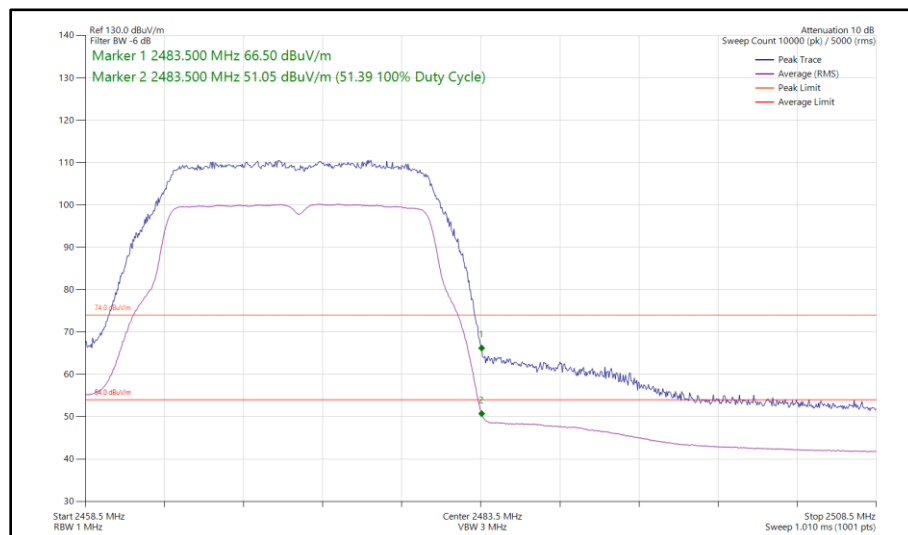
**Figure 28 - 802.11b, SISO, Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



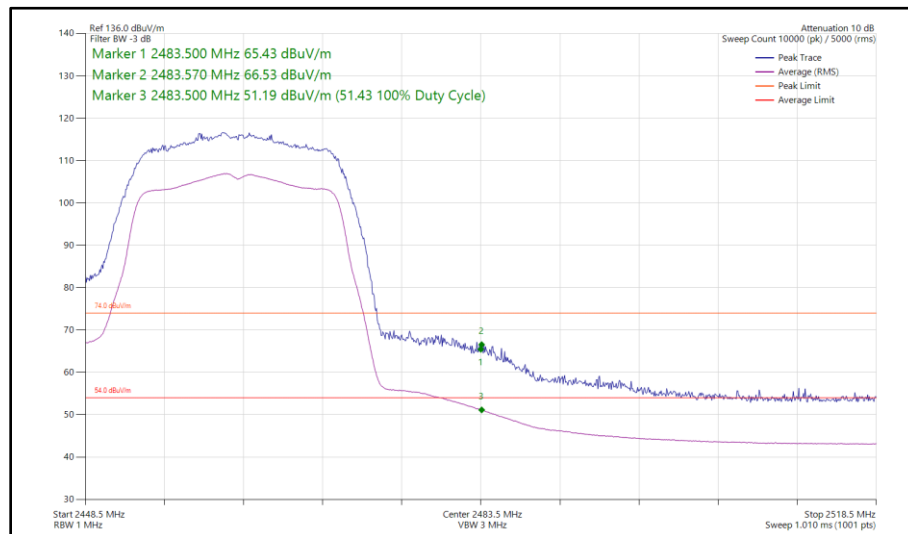
**Figure 29 - 802.11g, SISO, Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



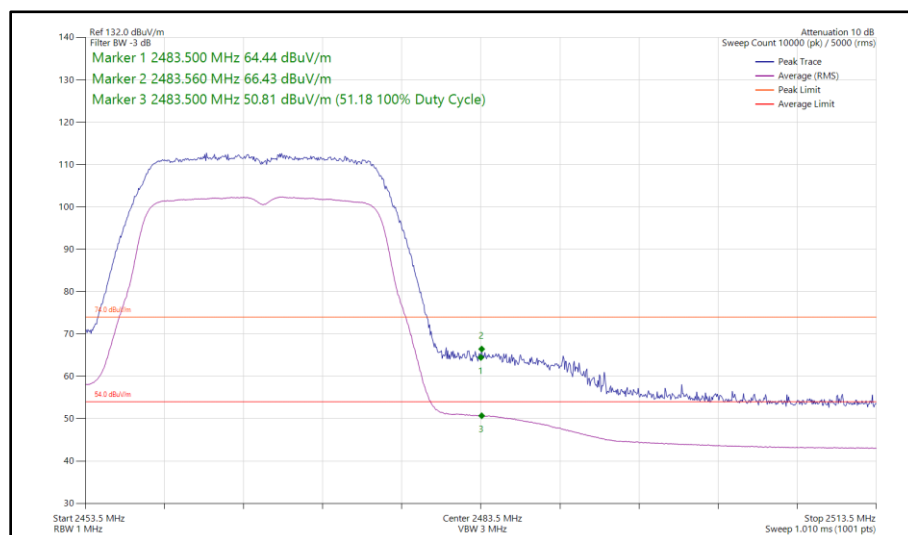
**Figure 30 - 802.11g, SISO, Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



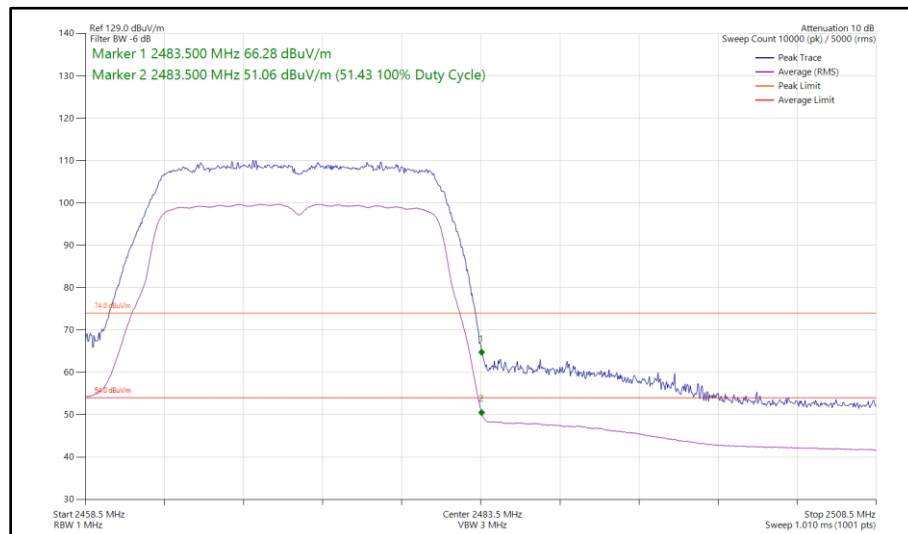
**Figure 31 - 802.11g, SISO, Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



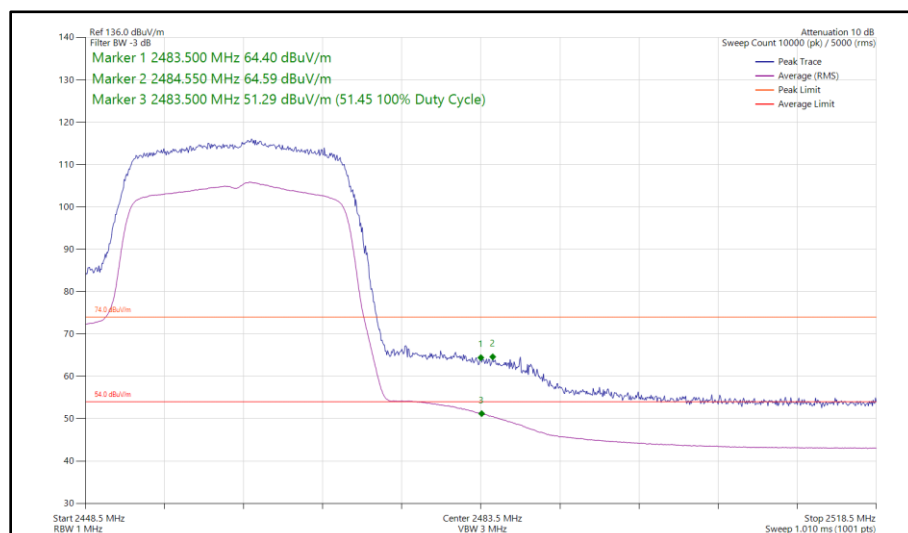
**Figure 32 - 802.11n HT20, SISO, Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



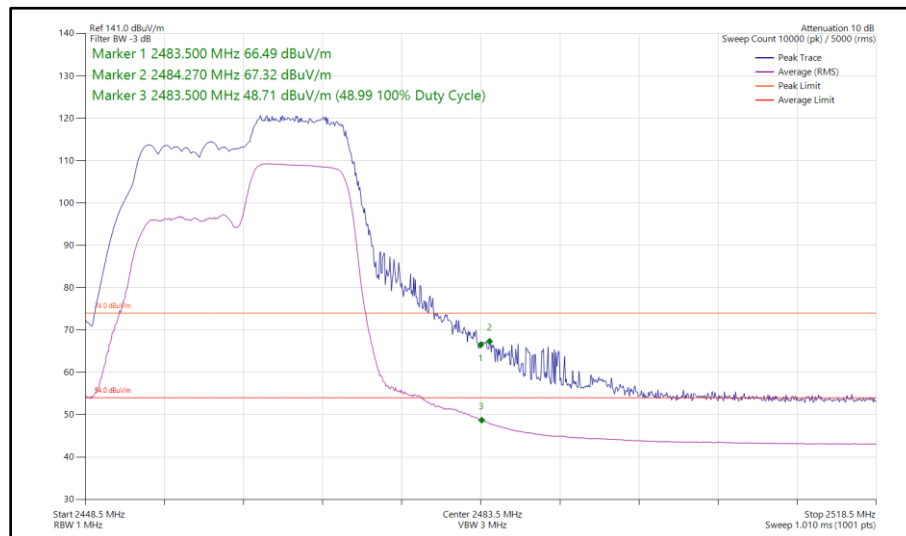
**Figure 33 - 802.11n HT20, SISO, Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



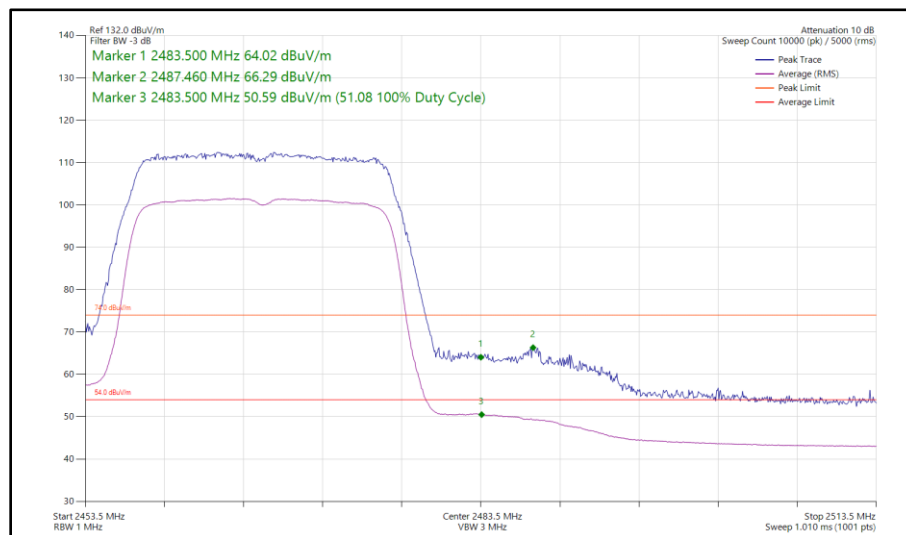
**Figure 34 - 802.11n HT20, SISO, Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



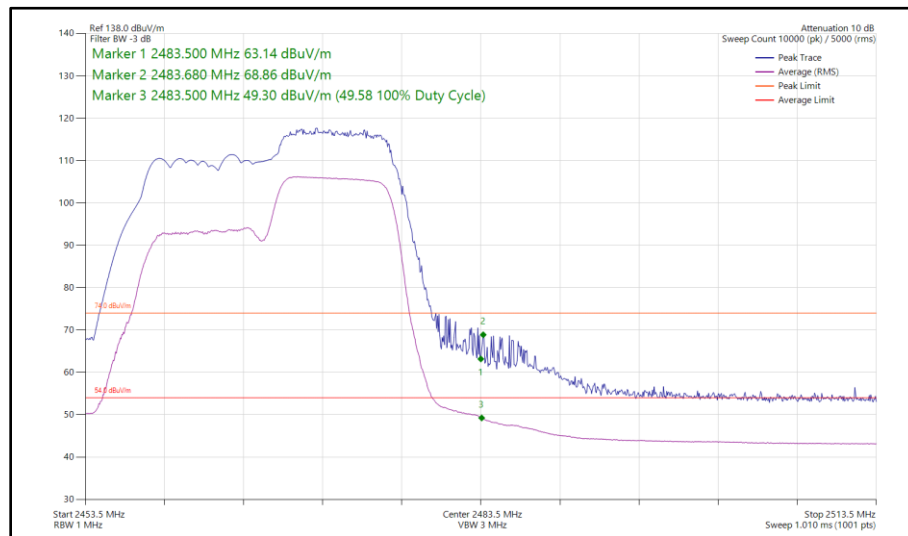
**Figure 35 - 802.11ax HE20, SU, SISO, Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



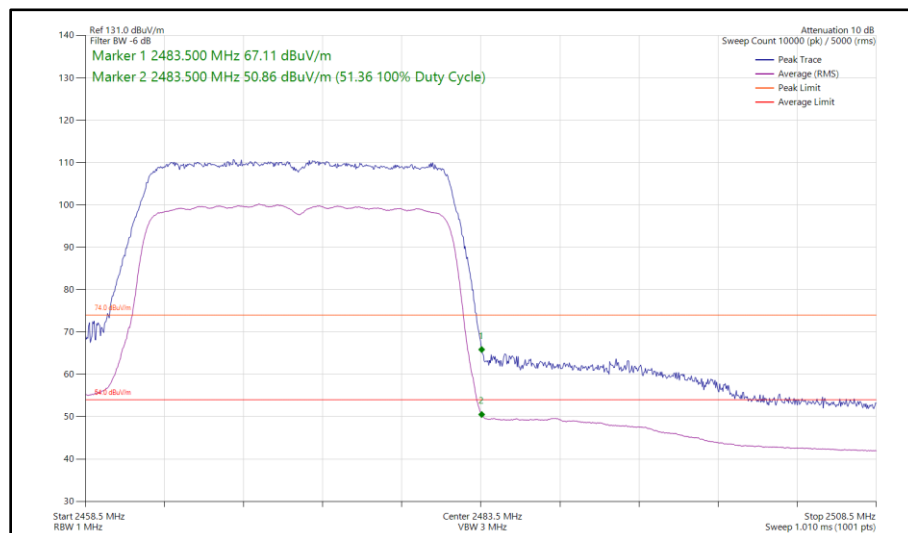
**Figure 36 - 802.11ax HE20, RU 106-54, SISO, Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



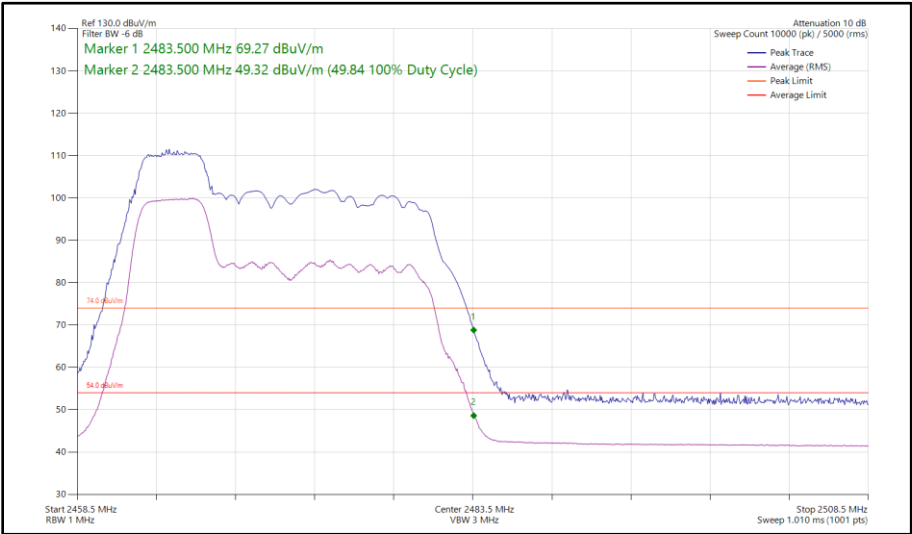
**Figure 37 - 802.11ax HE20, SU, SISO, Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 38 - 802.11ax HE20, RU 106-54, SISO, Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 39 - 802.11ax HE20, SU, SISO, Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



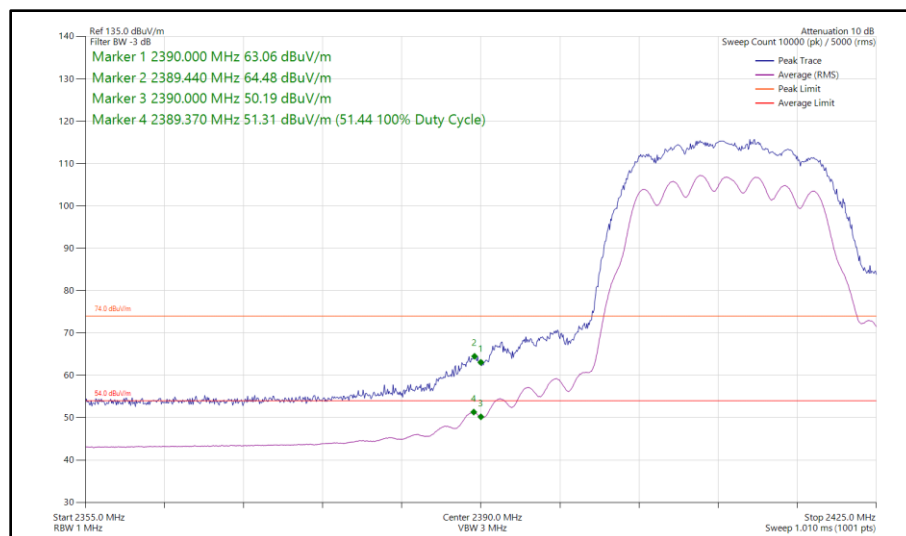
**Figure 40 - 802.11ax HE20, RU 52-37, SISO, Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



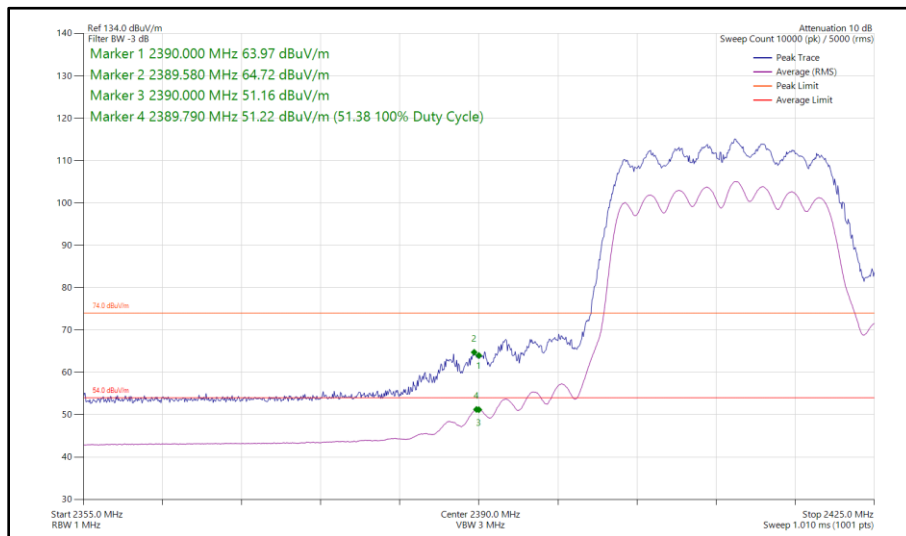
20 MHz Bandwidth - Core 0 + Core 1 (CDD)

| Mode          | Data Rate/<br>MCS | Resource<br>Size | Resource<br>Index | TX<br>Frequency<br>(MHz) | Band Edge<br>Frequency<br>(MHz) | Peak Level<br>(dBμV/m) | Average<br>Level<br>(dBμV/m) |
|---------------|-------------------|------------------|-------------------|--------------------------|---------------------------------|------------------------|------------------------------|
| 802.11n HT20  | MCS2              | -                | -                 | 2412                     | 2390                            | 64.48                  | 51.44                        |
| 802.11ax HE20 | MCS2x1            | SU               | -                 | 2412                     | 2390                            | 64.72                  | 51.38                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2412                     | 2390                            | 69.38                  | 49.31                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2462                     | 2483.5                          | 66.92                  | 51.45                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2467                     | 2483.5                          | 66.22                  | 51.49                        |
| 802.11n HT20  | MCS7              | -                | -                 | 2472                     | 2483.5                          | 65.38                  | 51.35                        |
| 802.11ax HE20 | MCS9x1            | SU               | -                 | 2462                     | 2483.5                          | 66.74                  | 51.35                        |
| 802.11ax HE20 | MCS9x1            | 106              | 54                | 2462                     | 2483.5                          | 67.68                  | 51.47                        |
| 802.11ax HE20 | MCS9x1            | SU               | -                 | 2467                     | 2483.5                          | 65.37                  | 51.48                        |
| 802.11ax HE20 | MCS9x1            | 106              | 53                | 2467                     | 2483.5                          | 69.13                  | 51.27                        |
| 802.11ax HE20 | MCS4x1            | SU               | -                 | 2472                     | 2483.5                          | 66.58                  | 51.35                        |
| 802.11ax HE20 | MCS9x1            | 52               | 37                | 2472                     | 2483.5                          | 69.37                  | 49.27                        |

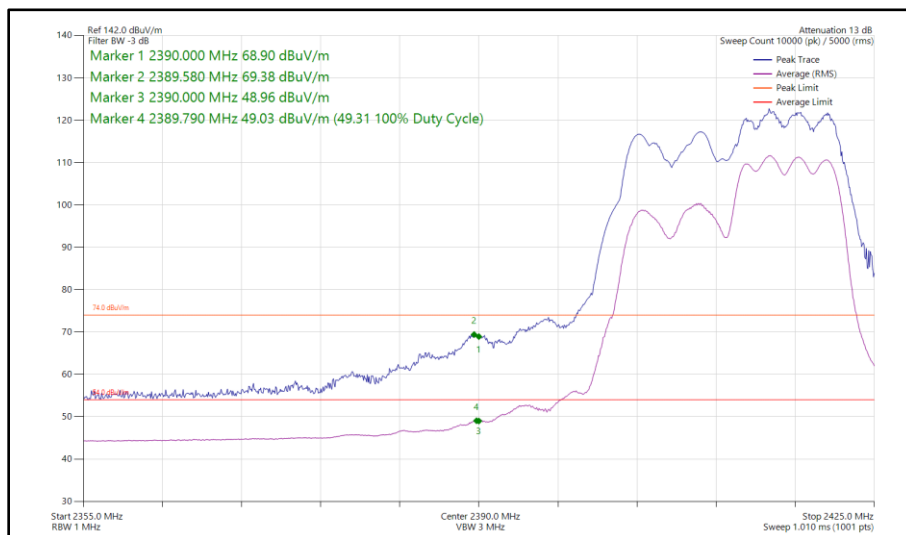
**Table 8 - CDD Restricted Band Edge Results**



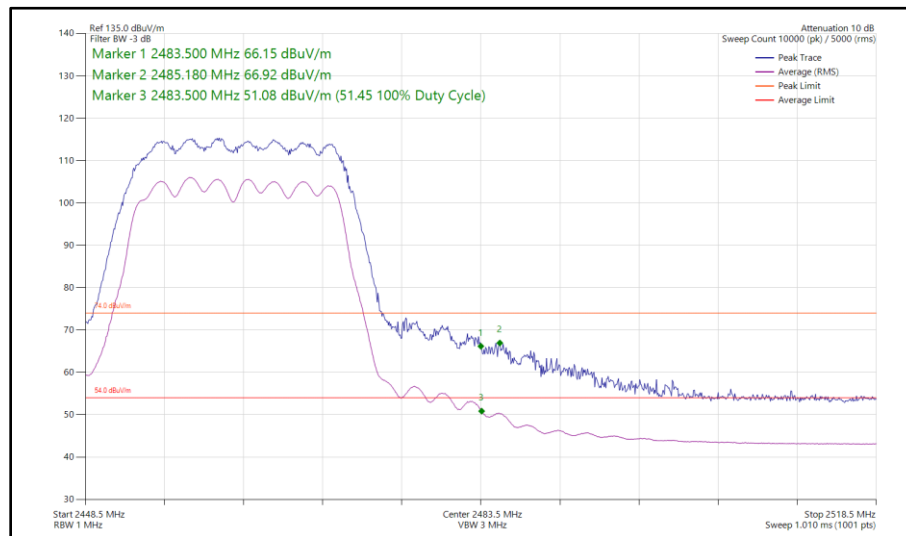
**Figure 41 - 802.11n HT20, CDD, Core 0 + Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



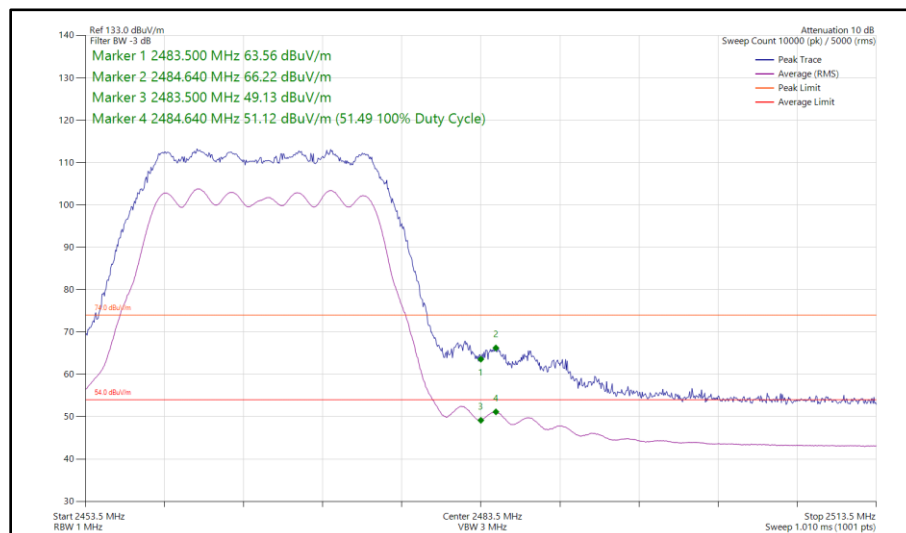
**Figure 42 - 802.11ax HE20, SU, CDD, Core 0 + Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



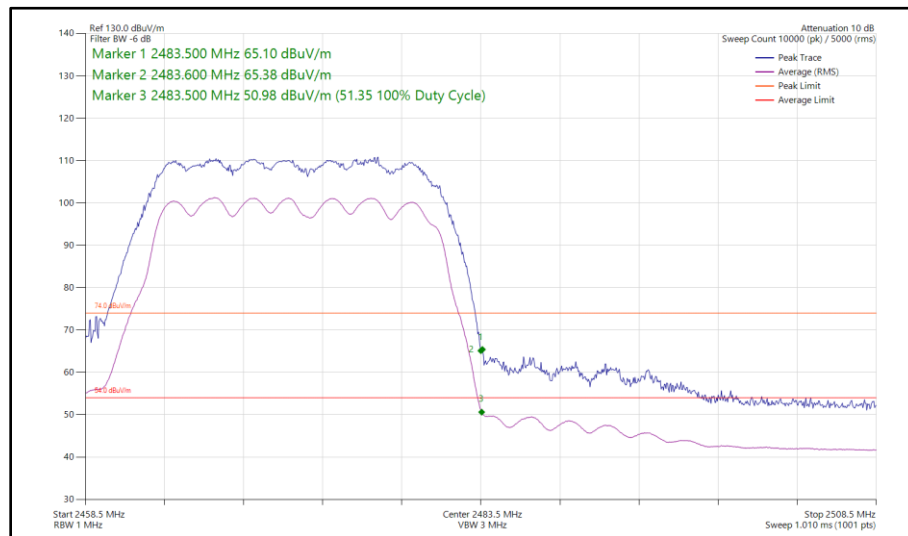
**Figure 43 - 802.11ax HE20, RU 106-54, CDD, Core 0 + Core 1 - 2412 MHz  
Band Edge Frequency 2390 MHz**



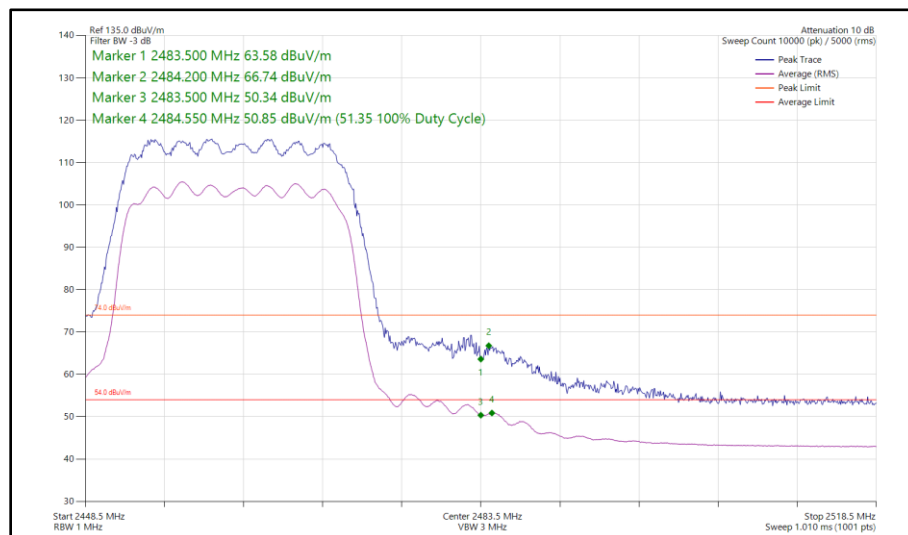
**Figure 44 - 802.11n HT20, CDD, Core 0 + Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



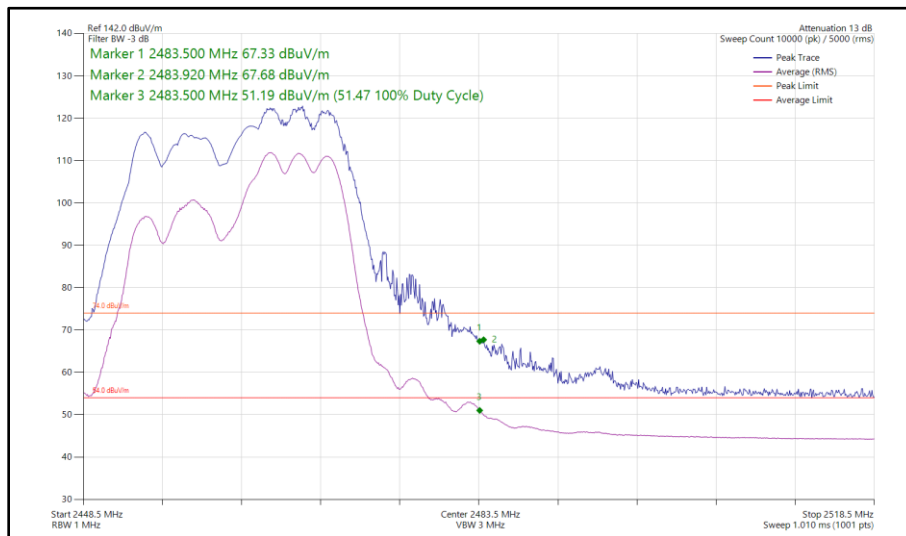
**Figure 45 - 802.11n HT20, CDD, Core 0 + Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



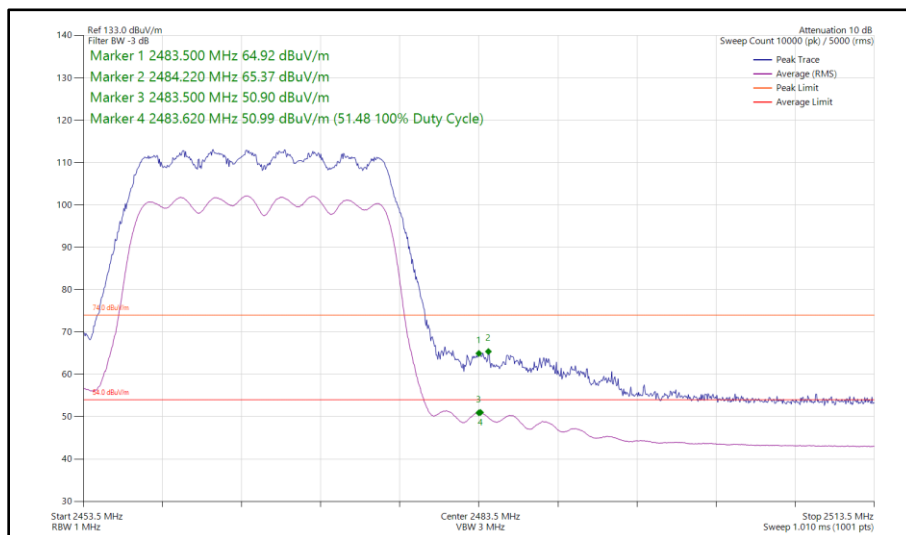
**Figure 46 - 802.11n HT20, CDD, Core 0 + Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 47 - 802.11ax HE20, SU, CDD, Core 0 + Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



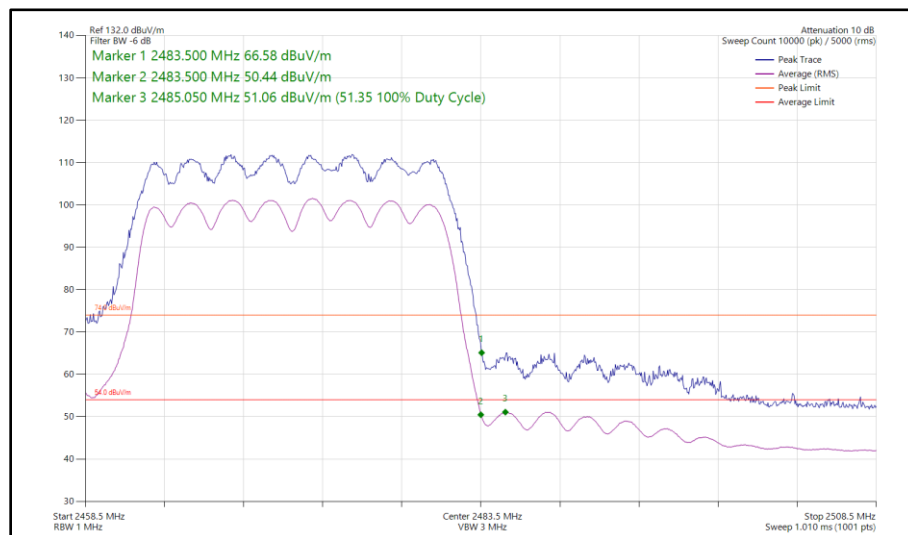
**Figure 48 - 802.11ax HE20, RU 106-54, CDD, Core 0 + Core 1 - 2462 MHz  
Band Edge Frequency 2483.5 MHz**



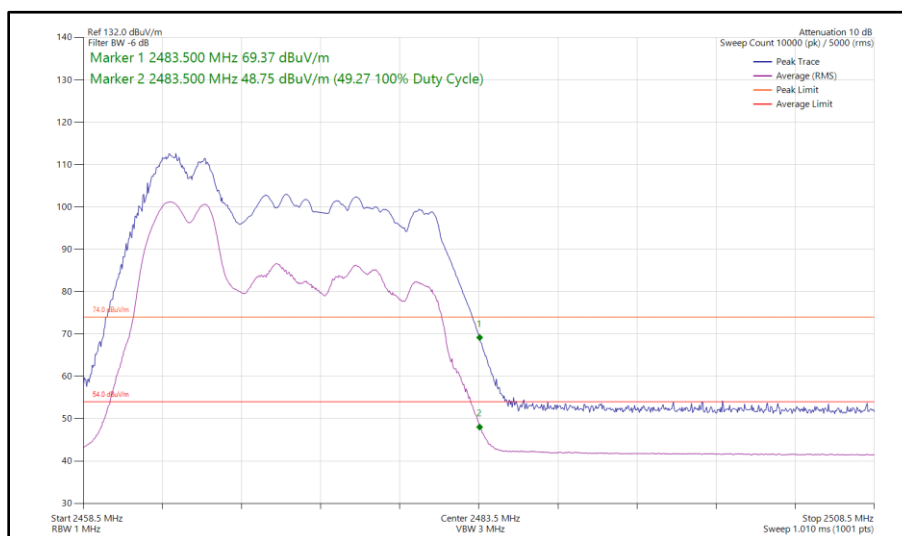
**Figure 49 - 802.11ax HE20, SU, CDD, Core 0 + Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 50 - 802.11ax HE20, RU 106-53, CDD, Core 0 + Core 1 - 2467 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 51 - 802.11ax HE20, SU, CDD, Core 0 + Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**



**Figure 52 - 802.11ax HE20, RU 52-37, CDD, Core 0 + Core 1 - 2472 MHz  
Band Edge Frequency 2483.5 MHz**

FCC 47 CFR Part 15, Limit Clause 15.209

| Frequency (MHz) | Field Strength ( $\mu\text{V}/\text{m}$ at 3 m) |
|-----------------|-------------------------------------------------|
| 30 to 88        | 100                                             |
| 88 to 216       | 150                                             |
| 216 to 960      | 200                                             |
| Above 960       | 500                                             |

**Table 9**

ISED RSS-GEN, Limit Clause 8.9

| Frequency (MHz) | Field Strength ( $\mu\text{V}/\text{m}$ at 3 m) |
|-----------------|-------------------------------------------------|
| 30 to 88        | 100                                             |
| 88 to 216       | 150                                             |
| 216 to 960      | 200                                             |
| Above 960*      | 500                                             |

**Table 10**

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



## 2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 14 and RF Chamber 15.

| Instrument                           | Manufacturer       | Type No.             | TE No. | Calibration Period (months) | Calibration Expiry Date |
|--------------------------------------|--------------------|----------------------|--------|-----------------------------|-------------------------|
| Cable (18 GHz)                       | Rosenberger        | LU7-071-1000         | 5096   | 12                          | 23-Oct-2023             |
| Emissions Software                   | TUV SUD            | EmX V3.1.12          | 5125   | -                           | Software                |
| Pre-amplifier (30 dB, 1GHz to 18GHz) | Schwarzbeck        | BBV 9718 C           | 5261   | 12                          | 14-Apr-2024             |
| EMI Test Receiver                    | Rohde & Schwarz    | ESW44                | 5911   | 12                          | 05-May-2024             |
| Test Receiver                        | Rohde & Schwarz    | ESW44                | 5914   | 12                          | 24-Feb-2024             |
| 1500W (300V 12A) AC Power Supply     | iTech              | IT7324               | 5955   | -                           | O/P Mon                 |
| 1500W (300V 12A) AC Power Supply     | iTech              | IT7324               | 5956   | -                           | O/P Mon                 |
| 5m Semi-Anechoic Chamber (Dual-Axis) | Albatross Projects | RF Chamber 14        | 5958   | 36                          | 26-Apr-2025             |
| Compact Antenna Mast                 | Maturo Gmbh        | CAM4.0-P             | 5959   | -                           | TU                      |
| Mast & Turntable Controller          | Maturo Gmbh        | FCU3.0               | 5960   | -                           | TU                      |
| Tilt Antenna Mast                    | Maturo Gmbh        | BAM4.5-P             | 5961   | -                           | TU                      |
| Turntable                            | Maturo Gmbh        | TT1.5SI              | 5962   | -                           | TU                      |
| 5m Semi-Anechoic Chamber (Dual-Axis) | Albatross Projects | RF Chamber 15        | 5963   | 36                          | 28-Apr-2025             |
| Compact Antenna Mast                 | Maturo Gmbh        | CAM4.0-P             | 5964   | -                           | TU                      |
| Mast & Turntable Controller          | Maturo Gmbh        | FCU3.0               | 5966   | -                           | TU                      |
| Tilt Antenna Mast                    | Maturo Gmbh        | BAM4.5-P             | 5967   | -                           | TU                      |
| Turntable                            | Maturo Gmbh        | TT1.5SI              | 5968   | -                           | TU                      |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 5996   | 12                          | 05-Jun-2024             |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 5997   | 12                          | 14-Sep-2023             |
| Cable (SMA to SMA 6.5m)              | Junkosha           | MWX221-06500AMSAMS/B | 6003   | 12                          | 05-Jun-2024             |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 6007   | 12                          | 05-Jun-2024             |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 6008   | 12                          | 05-Jun-2024             |
| Cable (N to N 1m)                    | Junkosha           | MWX221-01000AMSAMS/B | 6009   | 12                          | 05-Jun-2024             |
| Cable (SMA to SMA 6.5m)              | Junkosha           | MWX221-06500AMSAMS/B | 6014   | 12                          | 08-Aug-2023             |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/B | 6019   | 12                          | 05-Jun-2024             |
| Horn Antenna (1-10 GHz)              | Schwarzbeck        | BBHA9120B            | 6140   | 12                          | 21-Aug-2023             |
| Horn Antenna (1-10 GHz)              | Schwarzbeck        | BBHA9120B            | 6141   | 12                          | 21-Aug-2023             |
| SAC Switch Unit                      | TUV SUD            | TUV_Ssu_001          | 6144   | 12                          | 05-Dec-2023             |
| Digital Multimeter                   | Fluke              | 115                  | 6145   | 12                          | 15-Jun-2024             |



| Instrument                     | Manufacturer   | Type No.             | TE No. | Calibration Period (months) | Calibration Expiry Date |
|--------------------------------|----------------|----------------------|--------|-----------------------------|-------------------------|
| Digital Multimeter             | Fluke          | 115                  | 6147   | 12                          | 16-Jun-2024             |
| Humidity & Temperature meter   | R.S Components | 1364                 | 6149   | 12                          | 17-Sep-2023             |
| SAC Switch Unit                | TUV SUD        | TUV_SSU_001          | 6191   | 12                          | 12-Dec-2023             |
| Cable (SMA to SMA 1m)          | Junkosha       | MWX221-01000AMSAMS/A | 6315   | 12                          | 04-Feb-2024             |
| Humidity and Temperature Meter | R.S Components | 1364                 | 6486   | 12                          | 18-Apr-2024             |

**Table 11**

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



## **2.2 Emission Bandwidth**

### **2.2.1 Specification Reference**

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

### **2.2.2 Equipment Under Test and Modification State**

A2991, S/N: Y7RPXWJ9N9 - Modification State 0

### **2.2.3 Date of Test**

10-August-2023

### **2.2.4 Test Method**

This test was performed in accordance with ANSI C63.10, clause 11.8.1 for 6 dB BW and 6.9.3 for 99% occupied bandwidth measurements.

### **2.2.5 Environmental Conditions**

|                     |         |
|---------------------|---------|
| Ambient Temperature | 22.2 °C |
| Relative Humidity   | 52.4 %  |

## 2.2.6 Test Results

### 2.4 GHz WLAN

| Protocol         | 6 dB Bandwidth (MHz) |         |
|------------------|----------------------|---------|
|                  | Minimum              | Maximum |
| 802.11b          | 8.640                | 9.120   |
| 802.11g          | 15.480               | 16.140  |
| 802.11n HT20     | 15.780               | 17.100  |
| 802.11ax HE20 SU | 18.720               | 19.080  |

Table 12 - 6 dB Bandwidth Summary Results - SISO

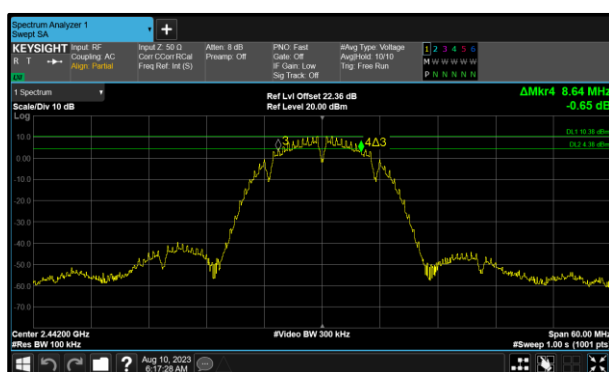


Figure 53 - 802.11b Minimum 6 dB EBW

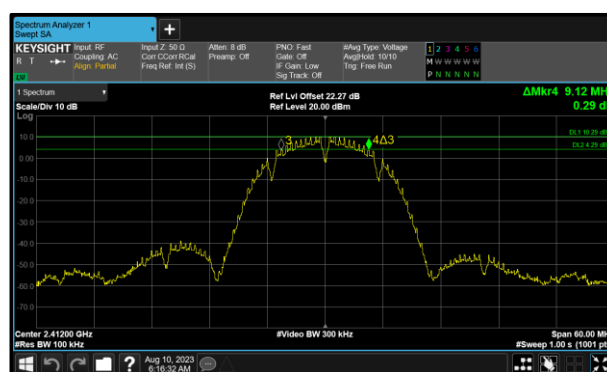


Figure 54 - 802.11b Maximum 6 dB EBW

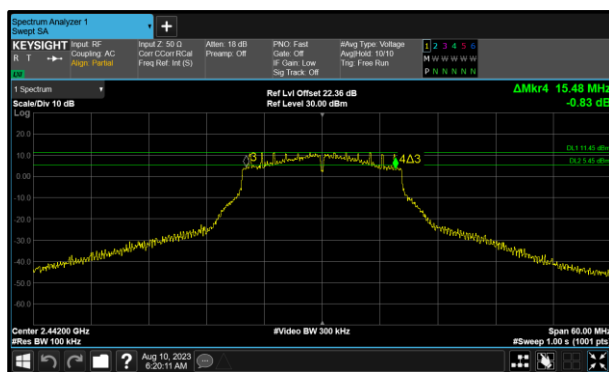


Figure 55 - 802.11g Minimum 6 dB EBW



Figure 56 - 802.11g Maximum 6 dB EBW

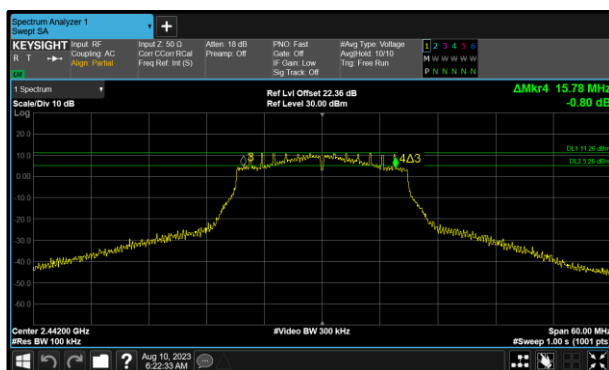


Figure 57 - 802.11n HT20 Minimum 6 dB EBW

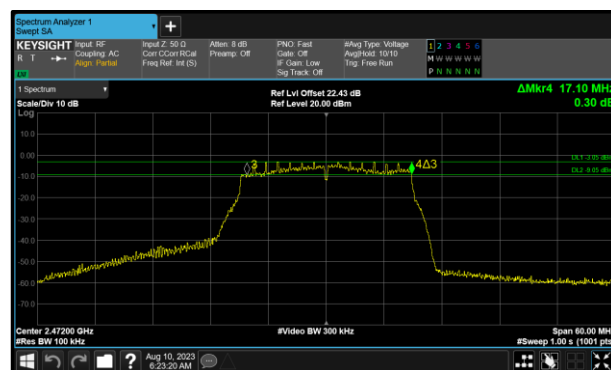


Figure 58 - 802.11n HT20 Maximum 6 dB EBW

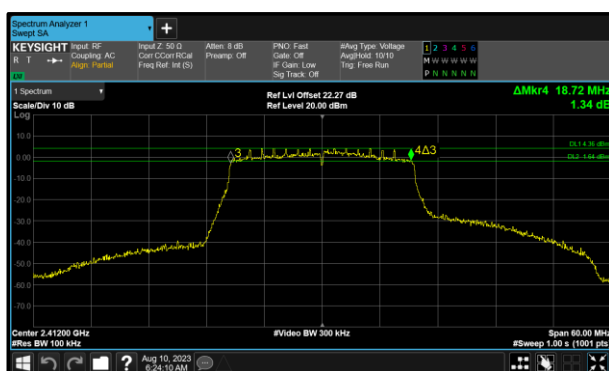


Figure 59 - 802.11ax HE20 SU Minimum 6 dB  
EBW

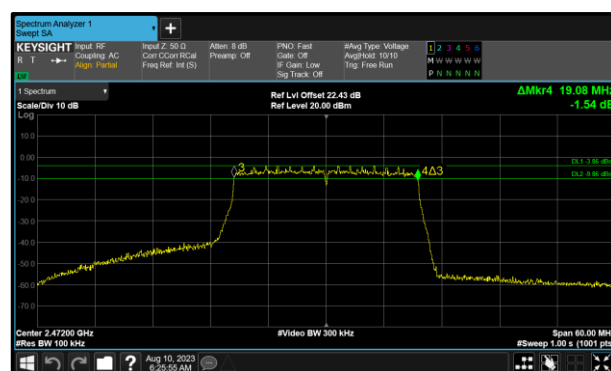


Figure 60 - 802.11ax HE20 SU Maximum 6 dB  
EBW

| Protocol         | 6 dB Bandwidth (MHz) |         |
|------------------|----------------------|---------|
|                  | Minimum              | Maximum |
| 802.11n HT20     | 15.240               | 17.700  |
| 802.11ax HE20 SU | 18.540               | 19.140  |

Table 13 - 6 dB Bandwidth Summary Results - MIMO CDD

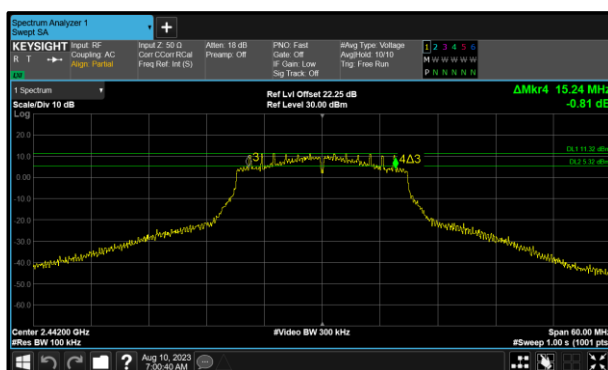


Figure 61 - 802.11n HT20 Minimum 6 dB EBW

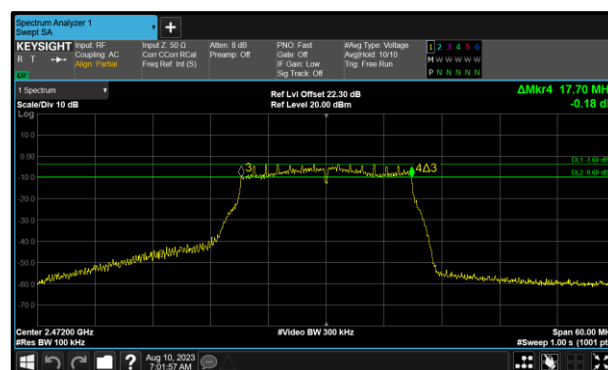


Figure 62 - 802.11n HT20 Maximum 6 dB EBW

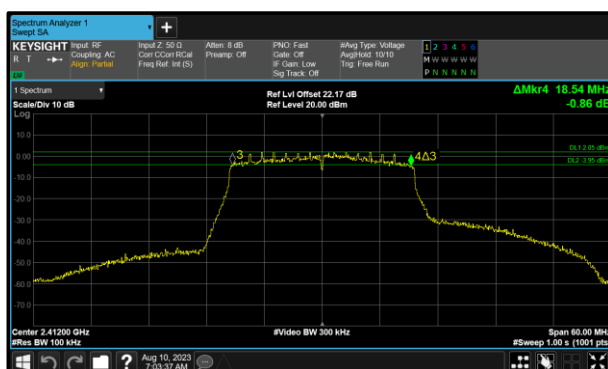


Figure 63 - 802.11ax HE20 SU Minimum 6 dB EBW

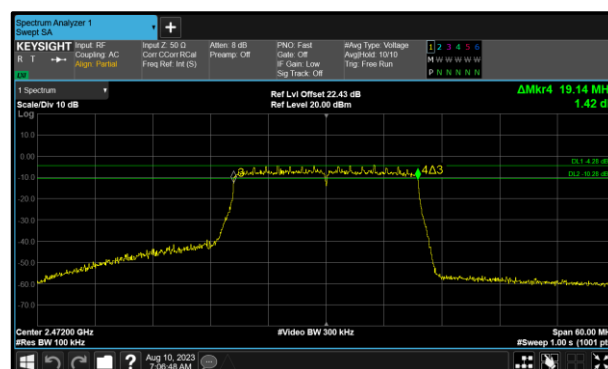


Figure 64 - 802.11ax HE20 SU Maximum 6 dB EBW

| Protocol         | 99% Bandwidth (MHz) |         |
|------------------|---------------------|---------|
|                  | Minimum             | Maximum |
| 802.11b          | 12.960              | 12.960  |
| 802.11g          | 16.380              | 16.620  |
| 802.11n HT20     | 17.580              | 17.700  |
| 802.11ax HE20 SU | 18.960              | 18.960  |

Table 14 - 99% Bandwidth Summary Results - SISO

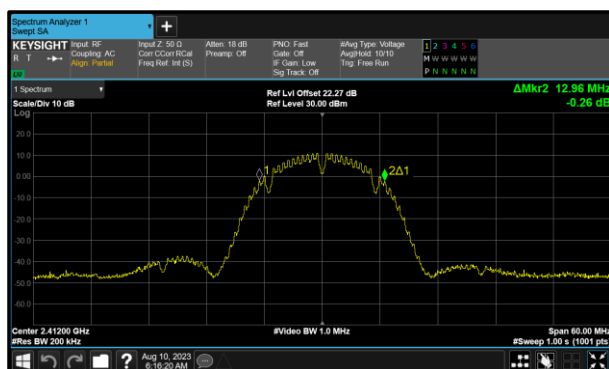


Figure 65 - 802.11b Minimum 99% OBW

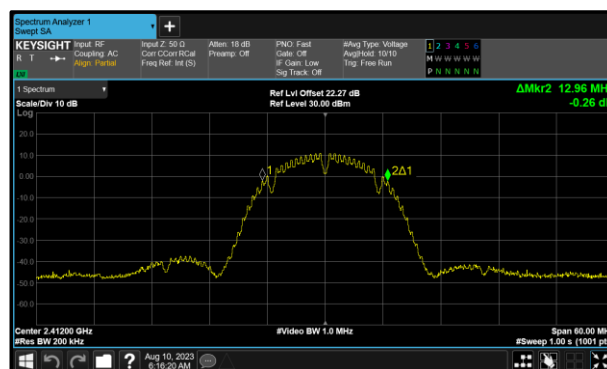


Figure 66 - 802.11b Maximum 99% OBW

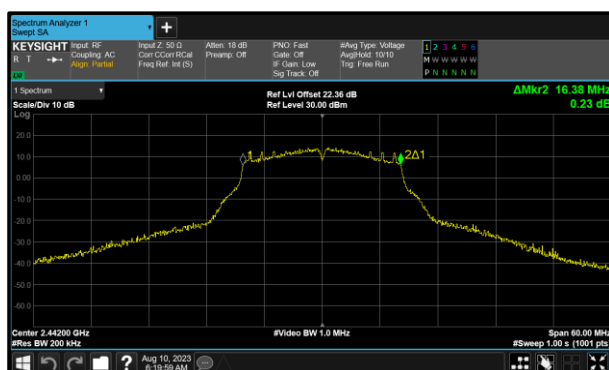


Figure 67 - 802.11g Minimum 99% OBW

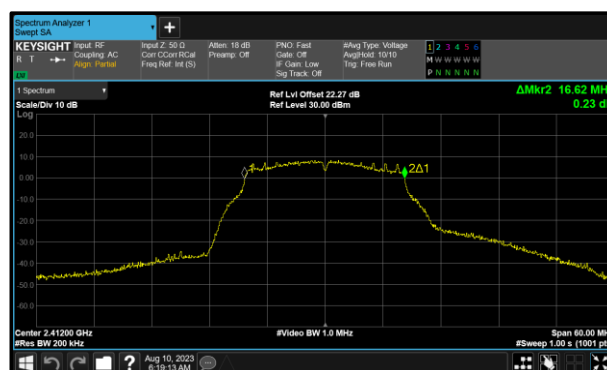


Figure 68 - 802.11g Maximum 99% OBW

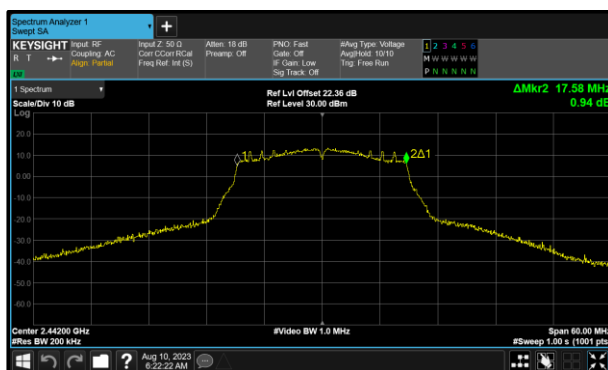


Figure 69 - 802.11n HT20 Minimum 99% OBW

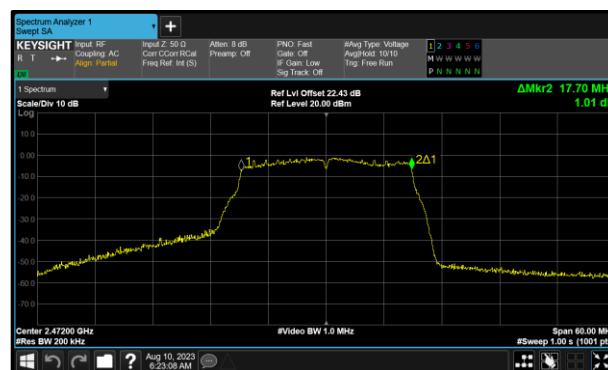


Figure 70 - 802.11n HT20 Maximum 99% OBW

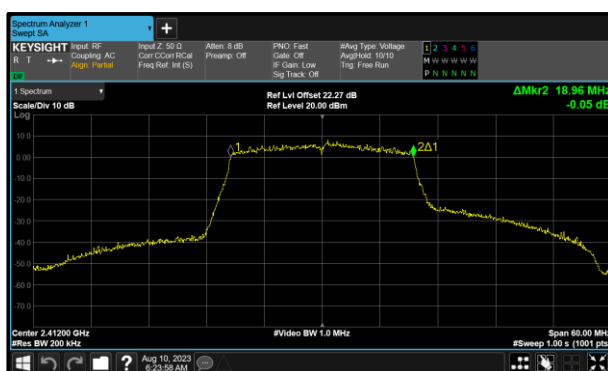


Figure 71 - 802.11ax HE20 SU Minimum 99% OBW



Figure 72 - 802.11ax HE20 SU Maximum 99% OBW

| Protocol         | 99% Bandwidth (MHz) |         |
|------------------|---------------------|---------|
|                  | Minimum             | Maximum |
| 802.11n HT20     | 17.580              | 17.700  |
| 802.11ax HE20 SU | 18.900              | 18.960  |

Table 15 - 99% Bandwidth Summary Results - MIMO CDD

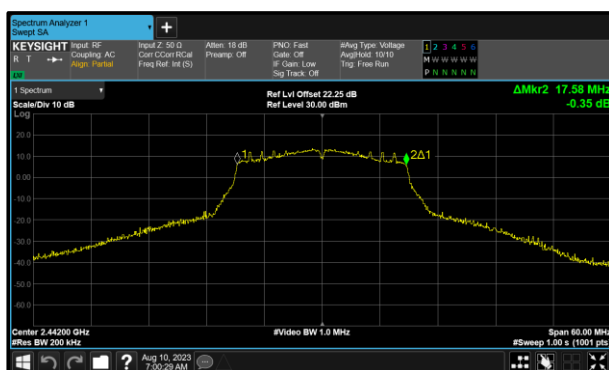


Figure 73 - 802.11n HT20 Minimum 99% OBW

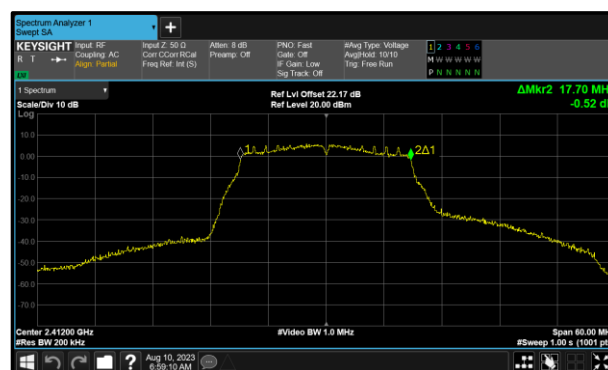


Figure 74 - 802.11n HT20 Maximum 99% OBW

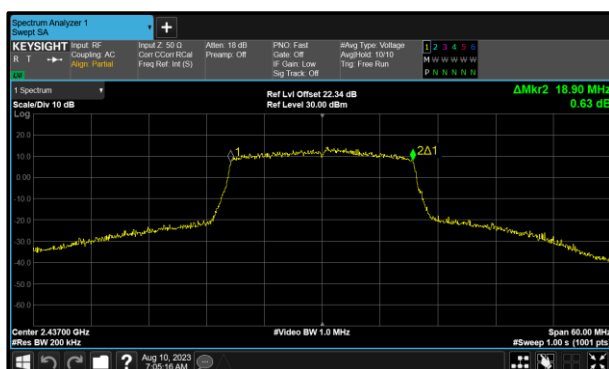


Figure 75 - 802.11ax HE20 SU Minimum 99% OBW

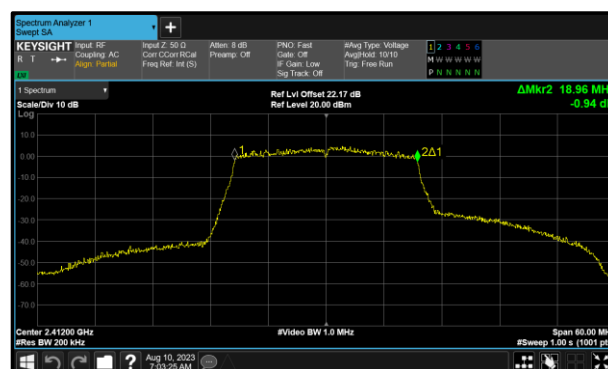


Figure 76 - 802.11ax HE20 SU Maximum 99% OBW



## SISO

| Test Configuration       |                                 |                 |                               |
|--------------------------|---------------------------------|-----------------|-------------------------------|
| Frequency Range:         | 2400-2483.5 MHz                 | Band:           | 2.4 GHz                       |
| Limit Clause(s):         | 15.247 (a)(2)<br>RSS-247 5.2 a) | Test Method(s): | C63.10 6.9.3<br>C63.10 11.8.1 |
| Additional Reference(s): | -                               |                 |                               |

| DUT Configuration      |            |                          |   |
|------------------------|------------|--------------------------|---|
| Mode:                  | 802.11b    | Duty Cycle (%):          | - |
| Data Rate:             | 1 Mbps     | DCCF (dB):               | - |
| Antenna Configuration: | SISO       | Peak Antenna Gain (dBi): | - |
| Active Port(s):        | C (Core 1) | Active Chain(s):         | 1 |

| Test Frequency (MHz) | 6 dB Bandwidth (MHz) |   |       |   | Limit (kHz) |
|----------------------|----------------------|---|-------|---|-------------|
|                      | A                    | B | C     | D |             |
| 2412                 | -                    | - | 9.120 | - | ≥500.0      |
| 2442                 | -                    | - | 8.640 | - | ≥500.0      |
| 2472                 | -                    | - | 9.120 | - | ≥500.0      |

**Table 16 - 6 dB Bandwidth Results**

| Test Frequency (MHz) | 99% Bandwidth (MHz) |   |        |   | Limit (kHz) |
|----------------------|---------------------|---|--------|---|-------------|
|                      | A                   | B | C      | D |             |
| 2412                 | -                   | - | 12.960 | - | -           |
| 2442                 | -                   | - | 12.960 | - | -           |
| 2472                 | -                   | - | 12.960 | - | -           |

**Table 17 - 99% Bandwidth Results**