

## FCC/ISED Test Report

**Prepared for:** Garmin International, Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** AA4448

**Test Report No:** R20230808-00-E5A

**Approved by:**



Fox Lane  
EMC Test Engineer

**DATE:** September 29, 2023

**Total Pages:** 85

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Prepared for:	Garmin International, Inc.		

## REVISION PAGE

Rev. No.	Date	Description
0	28 September 2023	Issued by FLane Reviewed by KVepuri Prepared by ESchmidt/FLane
A	29 September 2023	Corrected Customer information Page 5 - FL



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## 1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

### FCC Part 15.247

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISSED RSS-Gen, Issue 5
- (3) ISSED RSS-247, Issue 3

APPLIED STANDARDS AND REGULATIONS		
Standard Section	Test Type	Result
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 3 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 3 Section 5.2 (a)	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 3 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 3 Section 5.2 (b)	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 3 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass



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## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary and Operating Condition:

<b>EUT</b>	AA4448
<b>FCC ID</b>	IPH-A4448
<b>IC</b>	1792A-A4448
<b>EUT Received</b>	24 August 2023
<b>EUT Tested</b>	28 August 2023 - 14 September 2023
<b>Serial No.</b>	3452787535 (Radiated Measurements) 3452787439 (Conducted Measurements)
<b>Operating Band</b>	2400 – 2483.5 MHz
<b>Device Type</b>	<input type="checkbox"/> GMSK <input type="checkbox"/> GFSK <input type="checkbox"/> BT BR <input type="checkbox"/> BT EDR 2MB <input type="checkbox"/> BT EDR 3MB <input checked="" type="checkbox"/> 802.11x
<b>Power Supply / Voltage</b>	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

### 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

Data Rates:

Modulation	Low/High Data rate
802.11b	1MB/11MB
802.11g	6MB/54MB
802.11n	MCS0/MCS7


For 802.11x Transmissions:

Channel	Frequency
Low	2412 MHz
Mid	2437 MHz
High	2462 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequencies and designations.

### 2.3 DESCRIPTION OF SUPPORT UNITS

None

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### 3.0 LABORATORY AND GENERAL TEST DESCRIPTION

#### 3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)  
 4740 Discovery Drive  
 Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of  $35 \pm 4\%$   
 Temperature of  $22 \pm 3^{\circ}$  Celsius




#### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing, Review, and Report
2	Blake Winter	Test Engineer	Testing
3	Ethan Schmidt	Test Technician	Testing and Report
4	Karthik Vepuri	Test Engineer	Review/Testing

**Notes:**

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

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### 3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 17, 2023	July 17, 2025
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	July 17, 2023	July 17, 2025
Keysight EXA Signal Analyzer	N9010A	MY56070862	July 18, 2023	July 17, 2025
SunAR RF Motion	JB1	A091418	July 27, 2023	July 26, 2024
ETS-Lindgren Red Horn Antenna	3115	218576	July 31, 2023	July 30, 2024
EMCO Horn Antenna	3116	2576	July 31, 2023	July 30, 2024
Com-Power LISN, Single Phase	LI-220C	20070017	July 17, 2023	July 17, 2025
Agilent Preamp*	87405A	3950M00669	June 5, 2023	June 5, 2025
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	June 5, 2023	June 5, 2025
Trilithic High Pass Filter*	6HC330	23042	June 5, 2023	June 5, 2025
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	June 5, 2023	June 5, 2025
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	June 5, 2023	June 5, 2025
RF Cable (control room bulkhead to test receiver)	FSCM 64639	01F1206	June 5, 2023	June 5, 2025
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	June 5, 2023	June 5, 2025
N connector bulkhead (control room)	PE9128	NCEEBH2	June 5, 2023	June 5, 2025
TDK Emissions Lab Software	V11.25	700307	NA	NA
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2024
NCEE Labs-NSA on 10m Chamber	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2025

\*Internal Characterization

#### Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

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### 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

#### Conducted ☒

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.



Figure 1 - Bandwidth Measurements Test Setup

#### Radiated ☒

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

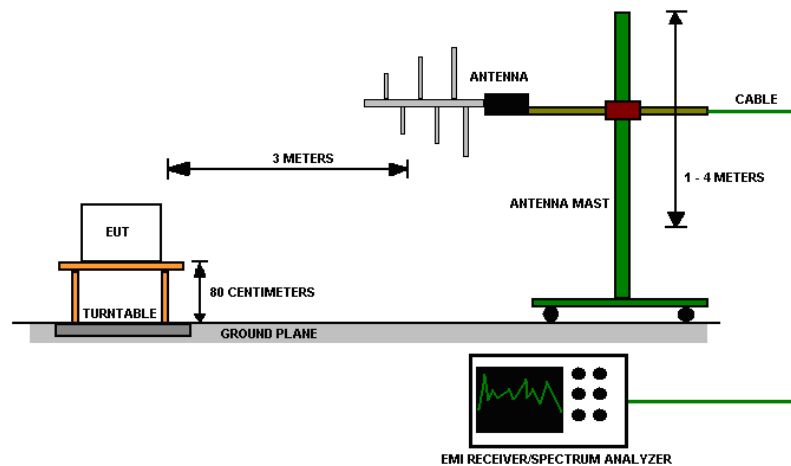


Figure 2 - Radiated Emissions Test Setup





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**4.0 RESULTS****DTS Radio Measurements Low Data Rate**

CHANNEL	Transmitter	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	802.11 b	15.64	10.07	17.160	52.000	-5.576	PASS
Mid	802.11 b	15.83	10.07	17.150	51.880	2.632	PASS
High	802.11 b	15.97	10.08	17.360	54.450	2.722	PASS
Low	802.11 g	17.31	16.55	15.070	32.137	-9.004	PASS
Mid	802.11 g	18.08	16.50	15.360	34.356	-8.889	PASS
High	802.11 g	19.12	16.53	15.510	35.563	-7.93	PASS
Low	802.11 n	17.61	17.63	13.650	23.174	-10.97	PASS
Mid	802.11 n	17.91	17.64	13.870	24.378	-9.178	PASS
High	802.11 n	17.64	17.66	13.990	25.061	-11.7	PASS

Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz

Output Power Limit = 30 dBm; PSD Limit = 8 dBm

**Unrestricted Band-Edge Low Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dB $\mu$ V)	Relative Fundamental (dB $\mu$ V)	Delta (dB)	Min Delta (dB)	Result
Low	802.11 b	2400.00	84.84	115.38	30.55	30.00	PASS
Low	802.11 g	2400.00	78.43	108.59	30.16	30.00	PASS
Low	802.11 n	2400.00	69.01	105.75	36.74	30.00	PASS
High	802.11 b	2483.50	60.75	115.24	54.49	30.00	PASS
High	802.11 g	2483.50	71.15	103.88	32.73	30.00	PASS
High	802.11 n	2483.50	71.85	106.66	34.81	30.00	PASS

**Radiated Peak Restricted Band-Edge Low Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dB $\mu$ V/m @ 3m)	Measurement Type	Limit (dB $\mu$ V/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	52.31	Peak	73.98	21.67	PASS
Low	802.11 g	2390.00	55.30	Peak	73.98	18.68	PASS
Low	802.11 n	2390.00	59.36	Peak	73.98	14.62	PASS
High	802.11 b	2483.50	55.45	Peak	73.98	18.53	PASS
High	802.11 g	2483.50	64.70	Peak	73.98	9.28	PASS
High	802.11 n	2483.50	65.94	Peak	73.98	8.04	PASS

\*Limit shown is the peak limit taken from FCC Part 15.209

**Radiated Average Restricted Band-Edge Low Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dB $\mu$ V/m @ 3m)	Measurement Type	Limit (dB $\mu$ V/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	41.86	Average	53.98	12.12	PASS
Low	802.11 g	2390.00	41.98	Average	53.98	12.00	PASS
Low	802.11 n	2390.00	44.77	Average	53.98	9.21	PASS
High	802.11 b	2483.50	46.99	Average	53.98	6.99	PASS
High	802.11 g	2483.50	48.60	Average	53.98	5.38	PASS
High	802.11 n	2483.50	50.52	Average	53.98	3.46	PASS

\*Limit shown is the average limit taken from FCC Part 15.209



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**DTS Radio Measurements High Data Rate**

CHANNEL	Transmitter	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	802.11 b	15.03	9.06	16.880	48.753	-6.45	PASS
Mid	802.11 b	15.16	9.04	17.220	52.723	-6.119	PASS
High	802.11 b	15.21	9.04	17.440	55.463	-5.814	PASS
Low	802.11 g	16.67	16.56	12.260	16.827	-11.067	PASS
Mid	802.11 g	16.69	16.53	12.490	17.742	-11.53	PASS
High	802.11 g	16.72	16.53	12.520	17.865	-11.492	PASS
Low	802.11 n	17.57	17.68	10.530	11.298	-13.113	PASS
Mid	802.11 n	17.59	17.63	10.810	12.050	-12.948	PASS
High	802.11 n	17.59	17.67	10.990	12.560	-13.107	PASS

Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz

Output Power Limit = 30 dBm; PSD Limit = 8 dBm

**Unrestricted Band-Edge High Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dB $\mu$ V)	Relative Fundamental (dB $\mu$ V)	Delta (dB)	Min Delta (dB)	Result
Low	802.11 b	2400.00	83.14	114.95	31.81	30.00	PASS
Low	802.11 g	2400.00	73.81	106.69	32.88	30.00	PASS
Low	802.11 n	2400.00	69.87	105.53	35.67	30.00	PASS
High	802.11 b	2483.50	71.09	115.51	44.42	30.00	PASS
High	802.11 g	2483.50	71.93	107.32	35.39	30.00	PASS
High	802.11 n	2483.50	70.71	106.30	35.59	30.00	PASS

**Radiated Peak Restricted Band-Edge High Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dB $\mu$ V/m @ 3m)	Measurement Type	Limit (dB $\mu$ V/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	52.40	Peak	73.98	21.59	PASS
Low	802.11 g	2390.00	57.23	Peak	73.98	16.76	PASS
Low	802.11 n	2390.00	59.35	Peak	73.98	14.63	PASS
High	802.11 b	2483.50	56.43	Peak	73.98	17.55	PASS
High	802.11 g	2483.50	66.47	Peak	73.98	7.51	PASS
High	802.11 n	2483.50	62.69	Peak	73.98	11.29	PASS

\*Limit shown is the peak limit taken from FCC Part 15.209

**Radiated Average Restricted Band-Edge High Data Rate**

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dB $\mu$ V/m @ 3m)	Measurement Type	Limit (dB $\mu$ V/m @ 3m)	Margin	Result
Low	802.11 b	2390.00	41.57	Average	53.98	12.41	PASS
Low	802.11 g	2390.00	42.95	Average	53.98	11.03	PASS
Low	802.11 n	2390.00	43.60	Average	53.98	10.38	PASS
High	802.11 b	2483.50	45.71	Average	53.98	8.27	PASS
High	802.11 g	2483.50	49.54	Average	53.98	4.44	PASS
High	802.11 n	2483.50	45.85	Average	53.98	8.13	PASS

\*Limit shown is the average limit taken from FCC Part 15.209



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#### 4.1 OUTPUT POWER

**Test Method:**

Power measurements were performed using ANSI C63.10, Section 11.9.2.2.2.

**Limits of power measurements:**

**For FCC Part 15.247 Device:**

The maximum allowed output power is 30 dBm.

**Test procedures:**

Details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Details can be found in section 3.4 of this report.

**EUT operating conditions:**


Details can be found in section 2.1 of this report.

**Test results:**

**Pass**

**Comments:**

1. All the output power plots can be found in Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.

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## 4.2 BANDWIDTH

### Test Method:

All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

### Limits of bandwidth measurements:

#### For FCC Part 15.247 Device:

The 99% occupied bandwidth is for informational purposes only. The 6dB bandwidth of the signal must be greater than 500 kHz.

### Test procedures:

Details can be found in section 3.4 of this report.

### Deviations from test standard:

No deviation.

### Test setup:

Test setup details can be found in section 3.4 of this report.

### EUT operating conditions:

Details can be found in section 2.1 of this report.

### Test results:

## Pass

#### Comments:

1. All the bandwidth plots can be found in Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.



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### 4.3 DUTY CYCLE

#### Test Method:

All Modulations/Transmitters in this report had a duty cycle of >98%

#### 4.4 RADIATED EMISSIONS

**Test Method:** ANSI C63.10-2013, Section 6.5, 6.6

**Limits for radiated emissions measurements:**

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

**NOTE:**

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) =  $20 * \log * \text{Emission level } (\mu\text{V/m})$ .
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worst-case emissions were produced while running off of USB power, so results from this mode are presented.

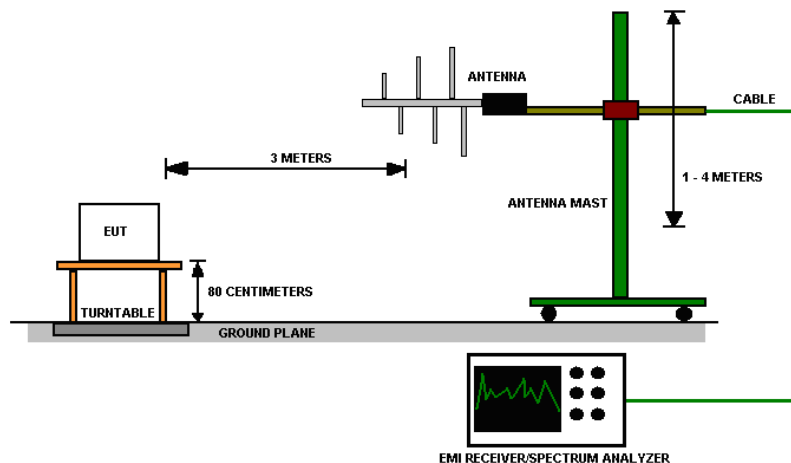


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**Test procedures:**

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise, the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

### Test setup:



**Figure 3 - Radiated Emissions Test Setup**

### NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

### Deviations from test standard:

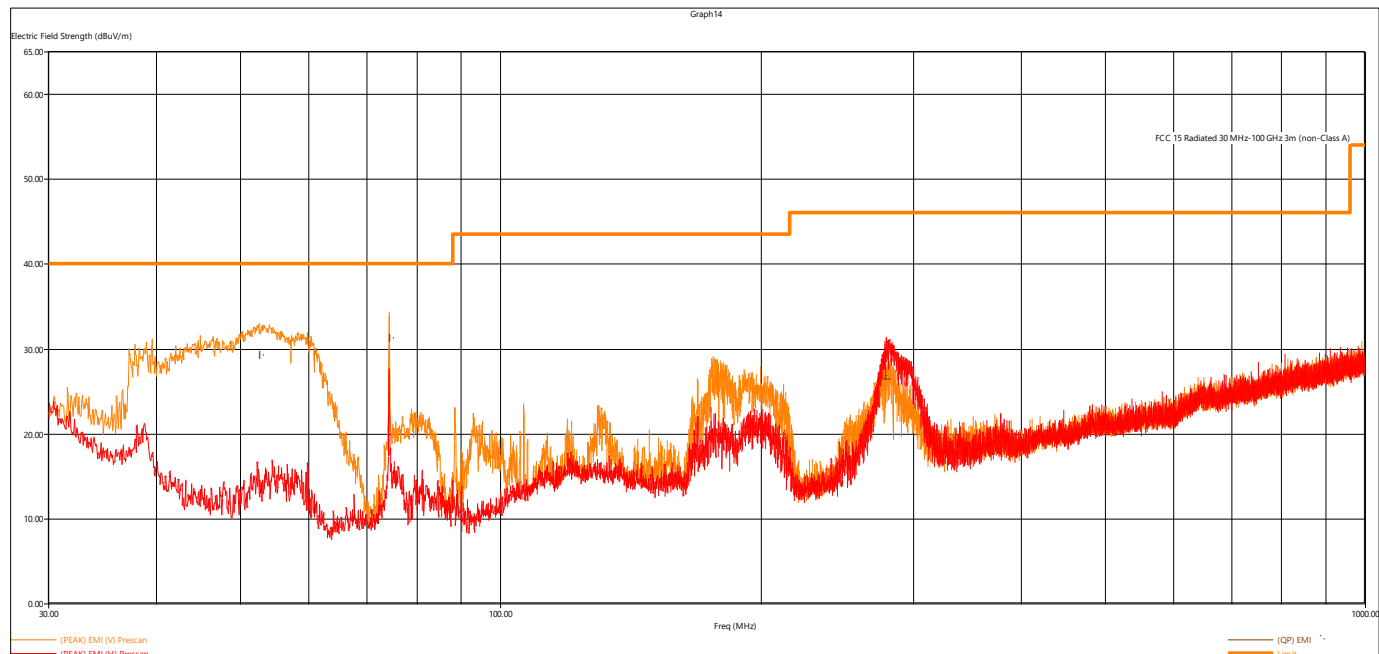
No deviation.

### EUT operating conditions

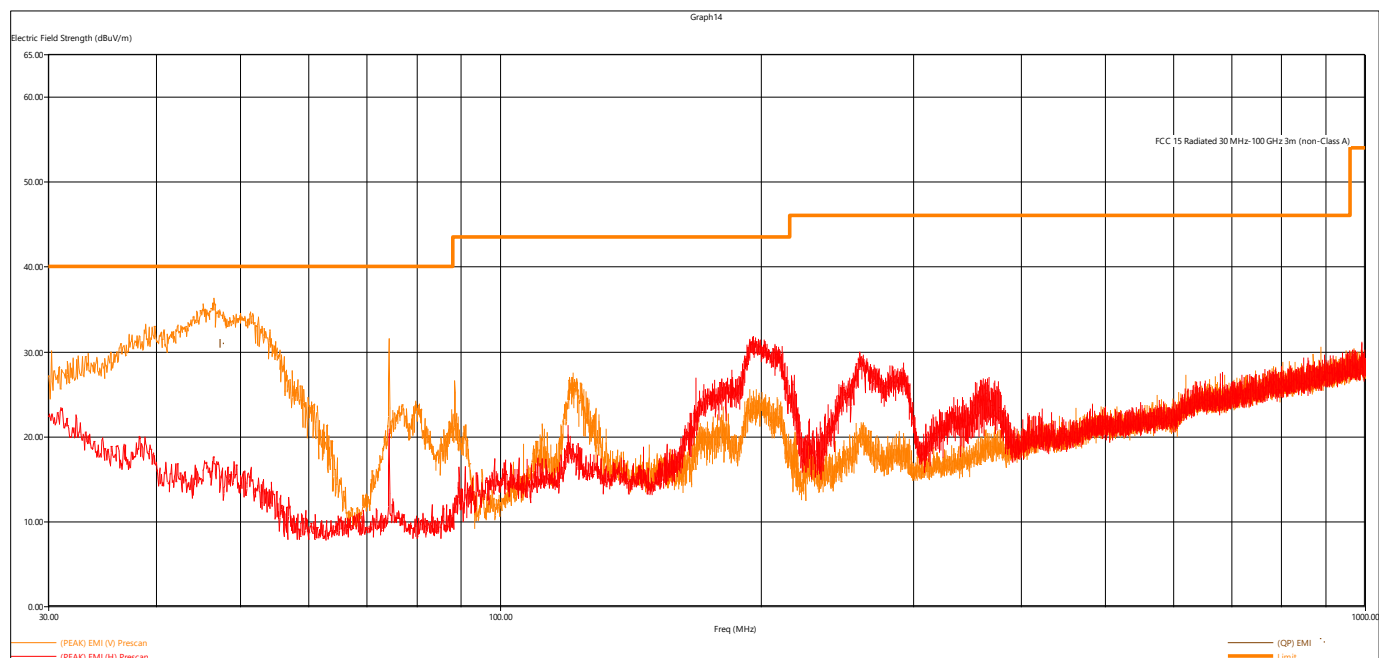
Details can be found in section 2.1 of this report.



**Test results:**



**Figure 4 - Radiated Emissions Plot, Receive**



**Figure 5 - Radiated Emissions Plot, 802.11b 1MB**

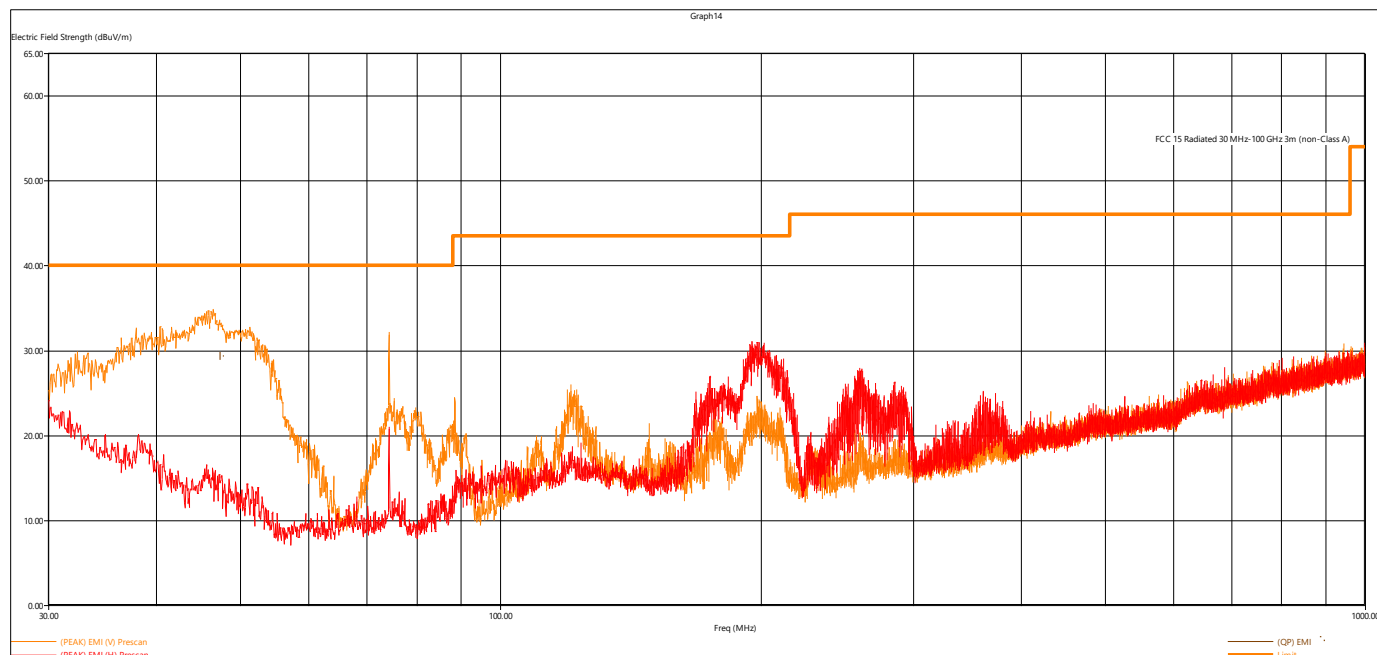


Figure 6 - Radiated Emissions Plot, 802.11b 11MB

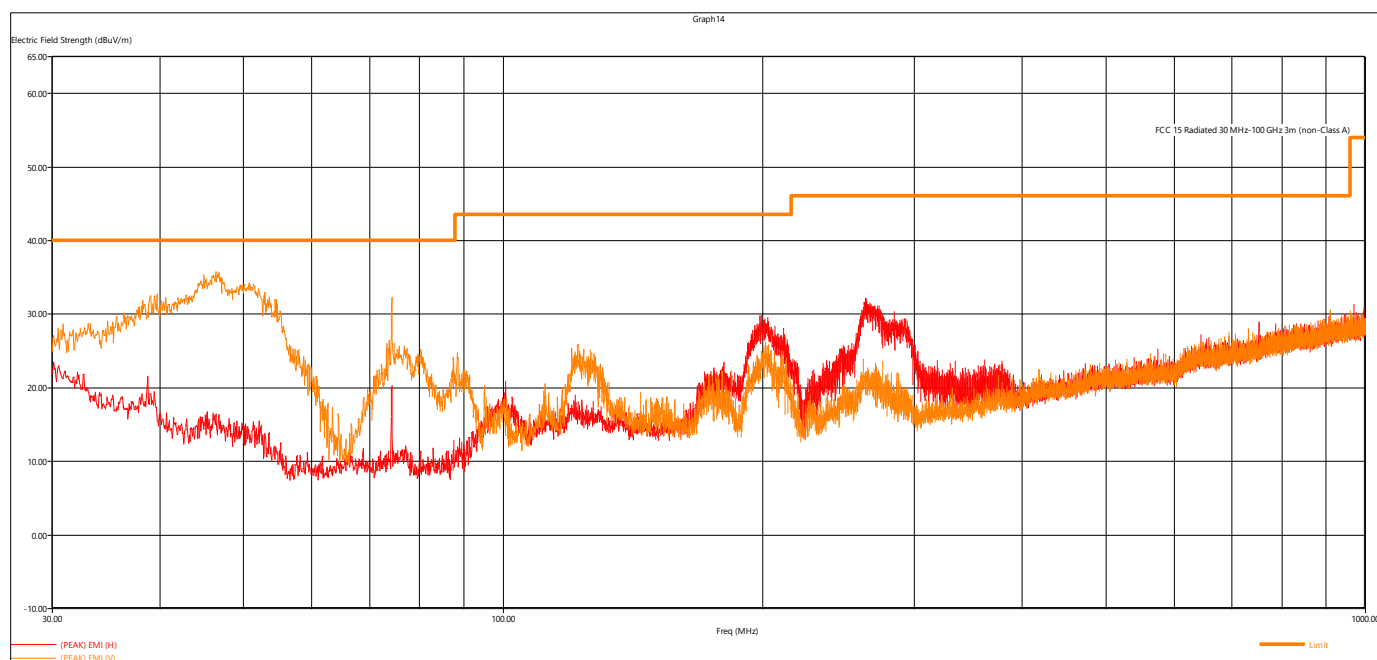
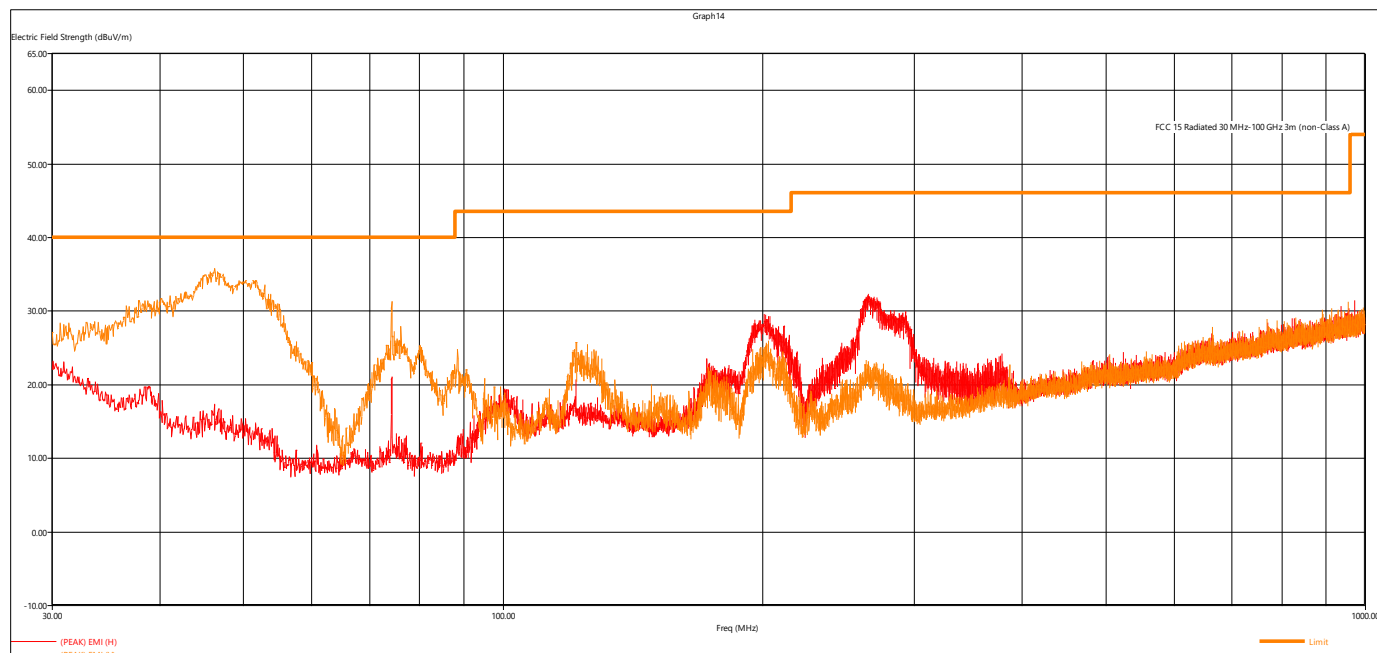
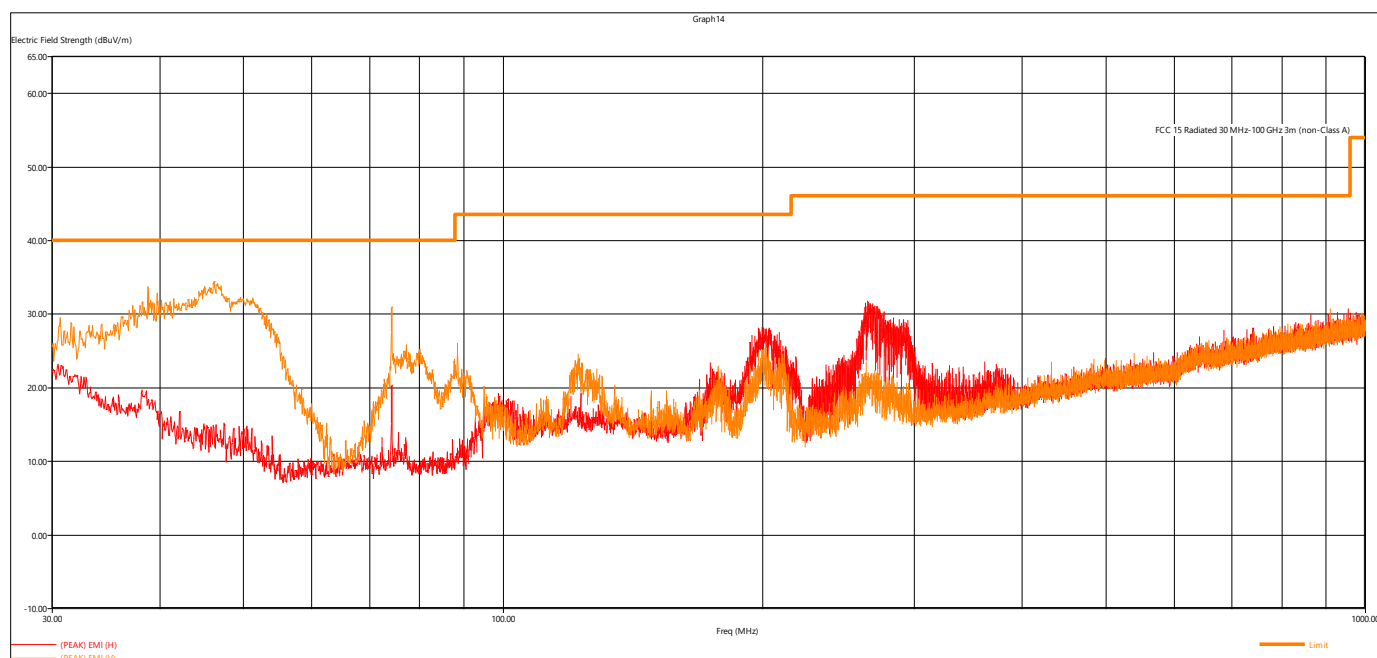


Figure 7 - Radiated Emissions Plot, 802.11g 6MB



**Figure 8 - Radiated Emissions Plot, 802.11g 54MB**



**Figure 9 - Radiated Emissions Plot, 802.11n MCS0**

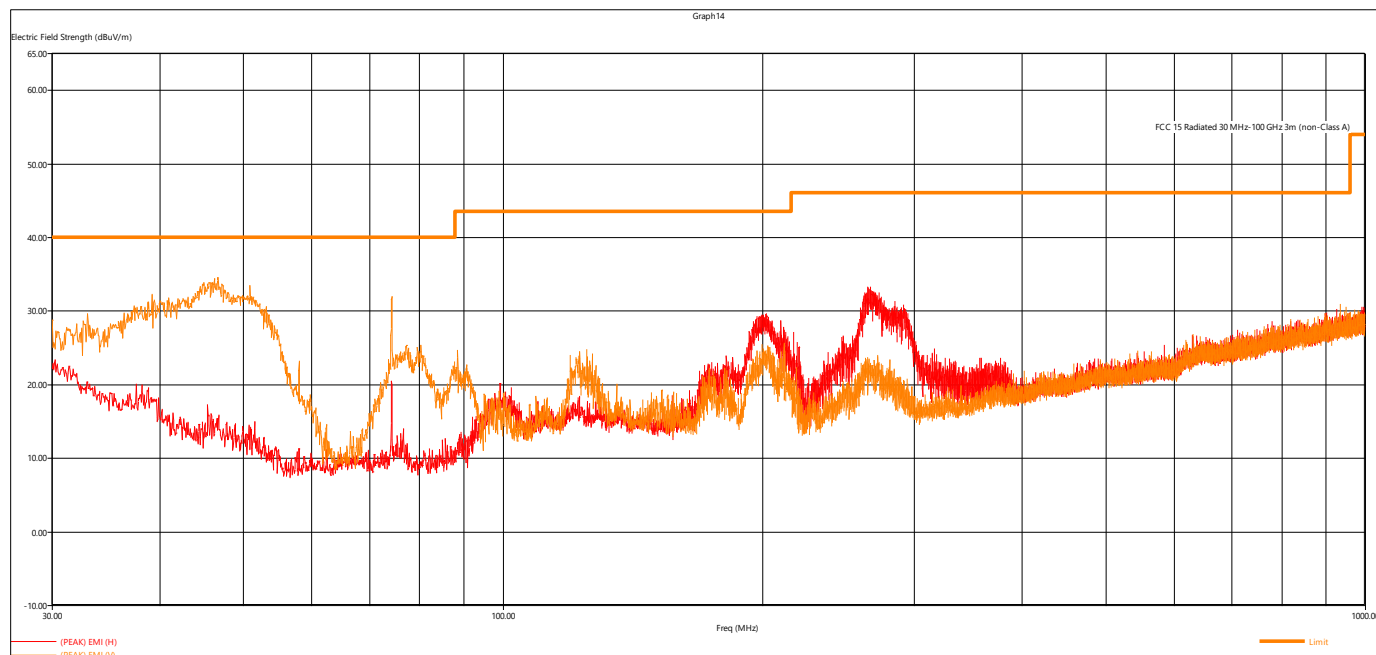


Figure 10 - Radiated Emissions Plot, 802.11n MCS7

#### REMARKS:

1. Emission level (dBμV /m) = Raw Value (dBμV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value - Emission level



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Quasi-Peak Measurements								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.			
278.853840	26.38	46.02	19.64	109.04	184.75	H	Receive	
52.500240	29.23	40.00	10.77	104.50	1.75	V	Receive	
74.217600	31.23	40.00	8.77	111.61	313.00	V	Receive	
47.375040	30.86	40.00	9.14	106.35	45.25	V	Wifi B 1MB	
47.120160	29.28	40.00	10.72	105.76	134.00	V	Wifi B 11MB	

All other measurements were found to be at least 6 dB below the limit. Worst case emissions are reported.  
The EUT was maximized on all 3 orthogonal axes. The worst-case is shown in the plot and table above.



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#### 4.5 CONDUCTED SPURIOUS EMISSIONS

**Test Method:**

ANSI C63.10-2013, Section 6.7

**Limits of spurious emissions:**

**From FCC Part 15.247:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

**Test procedures:**

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 30dB below the fundamental. More details can be found in section 3.4 of this report. The line shown in the plots is a reference line placed at -20dBm.

**Deviations from test standard:**

None.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.

**Test results:**

Data rates and channels were investigated and worst case was reported. No emissions exceeded the limits.

There was no distinguishable difference between low and high data rate.

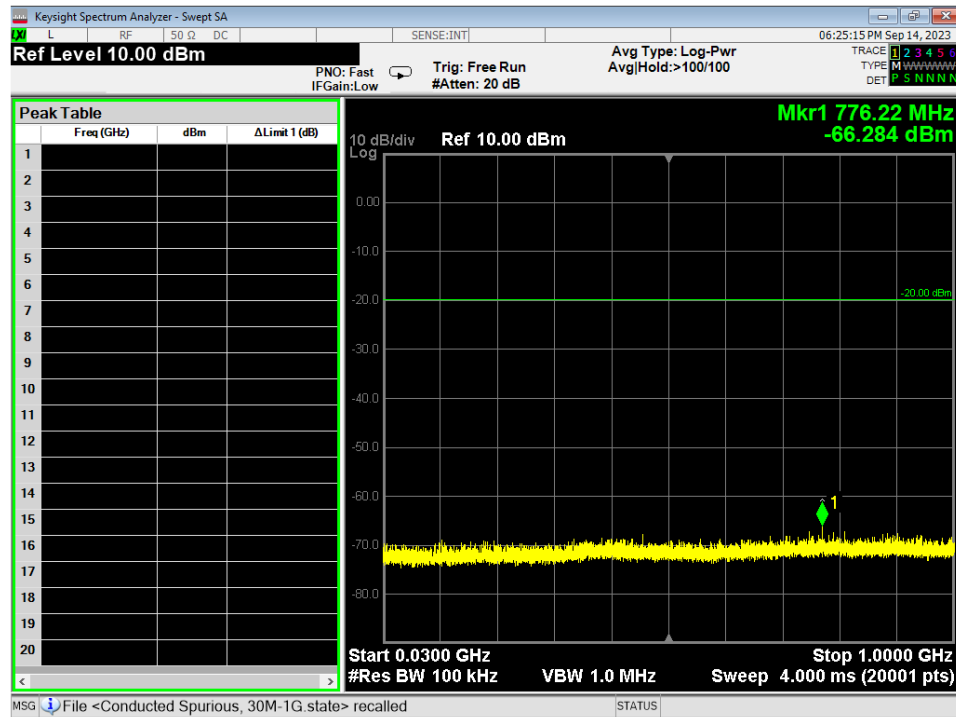


Figure 11 - Radiated Emissions Plot, WIFI 802.11b, 30M – 1G, Low

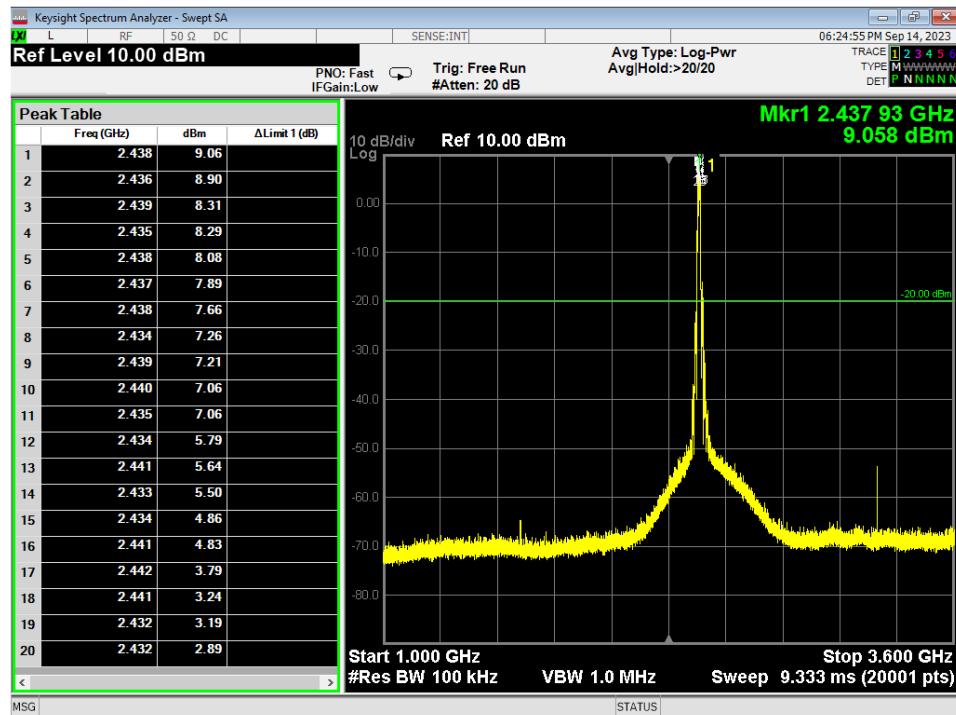


Figure 12 - Radiated Emissions Plot, WIFI 802.11b, 1G – 3.6G, Low

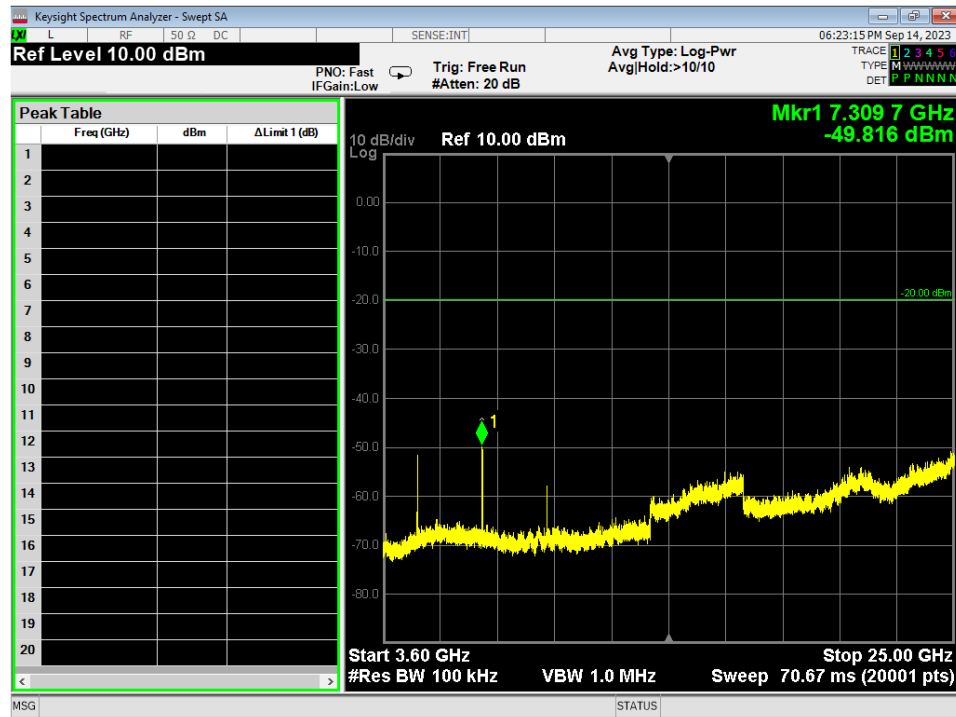


Figure 13 - Radiated Emissions Plot, WIFI 802.11b, 3.6G – 25G, Low

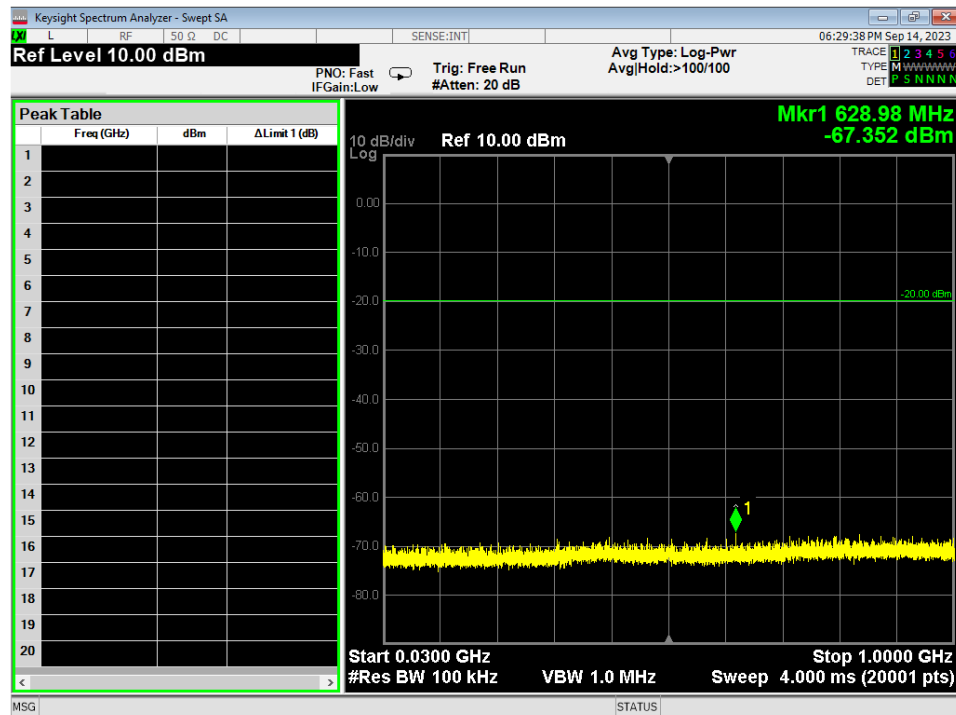


Figure 14 - Radiated Emissions Plot, WIFI 802.11g, 30M – 1G, Low





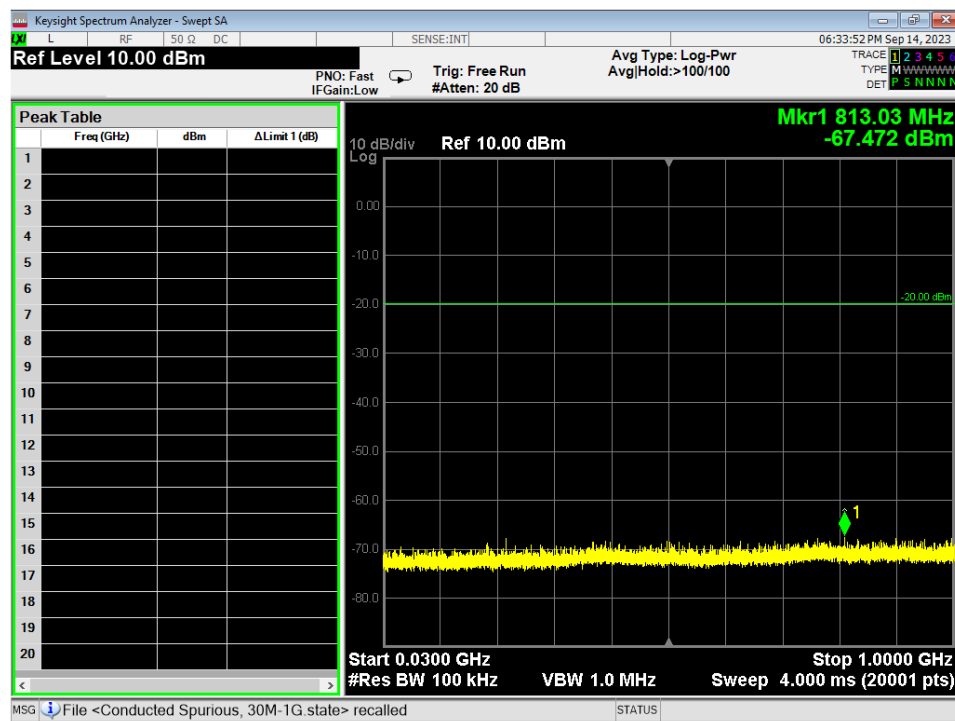


Figure 17 - Radiated Emissions Plot, WIFI 802.11n, 30M – 1G, Low

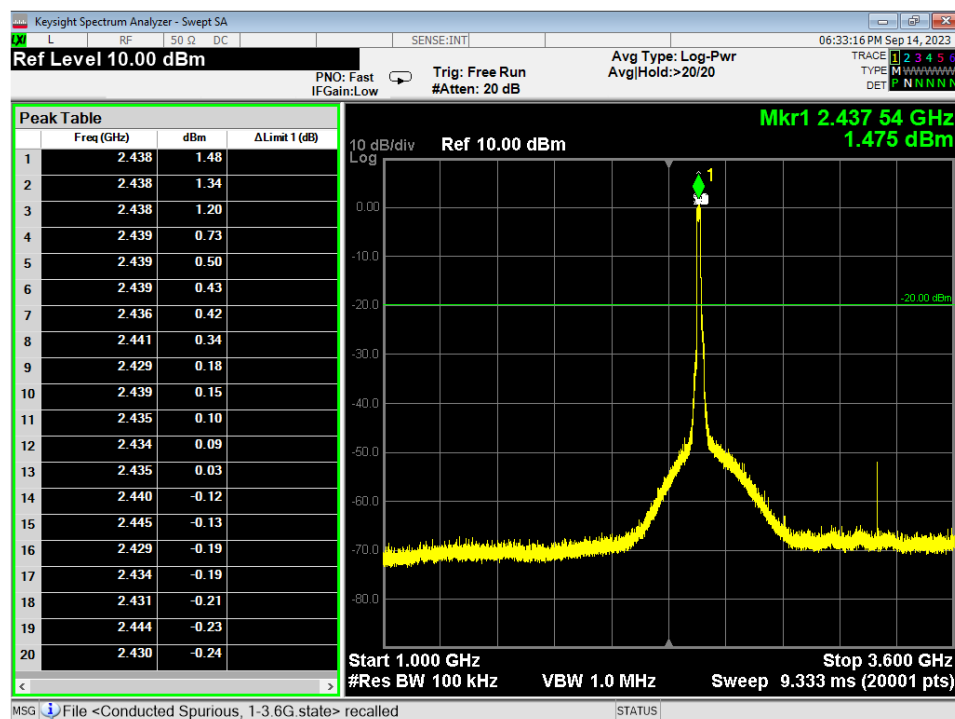


Figure 18 - Radiated Emissions Plot, WIFI 802.11n, 1G – 3.6G, Low

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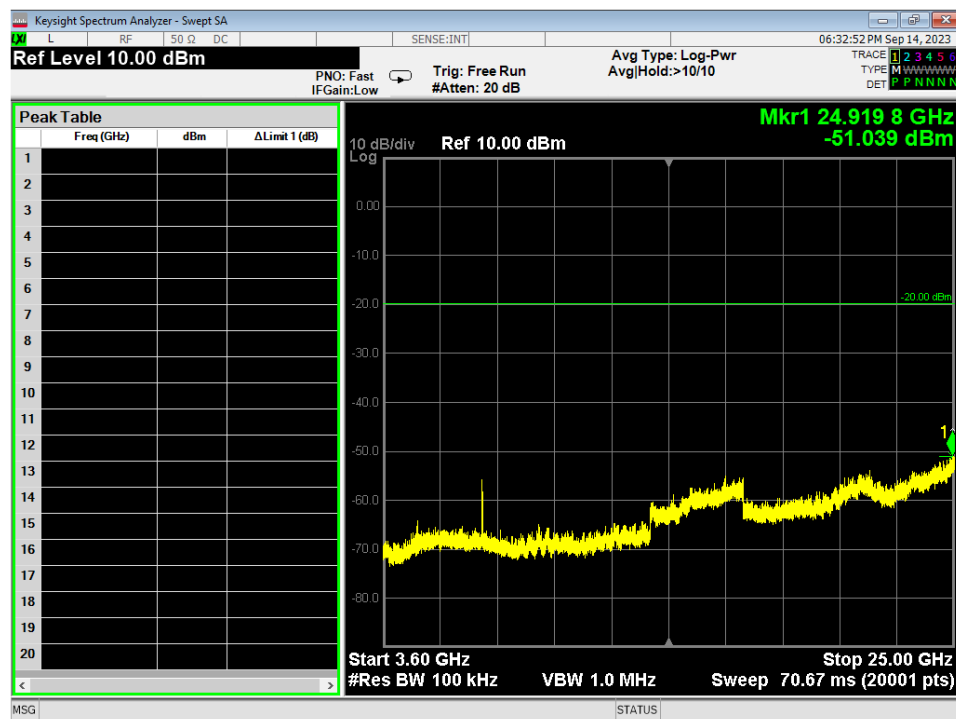


Figure 19 - Radiated Emissions Plot, WIFI 802.11n, 3.6G – 25G, Low



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#### 4.6 BAND EDGES

**Test Method:**

All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:****For FCC Part 15.247 Device:**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

**Test procedures:**

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**

No deviation.

**Test setup:**

Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**

Details can be found in section 2.1 of this report.



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**Test results:**

**Pass**

Comments:

1. All the band edge plots can be found in Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing it to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.



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## 4.7 POWER SPECTRAL DENSITY

### Test Method:

All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

### Limits of power measurements:

### For FCC Part 15.247 Device:

The maximum PSD allowed is 8 dBm.

### Test procedures:

Details can be found in section 3.4 of this report.

### Deviations from test standard:

No deviation.

### Test setup:

Details can be found in section 3.4 of this report.

### EUT operating conditions:

Details can be found in section 2.1 of this report.

### Test results:

## Pass

### Comments:

1. All the Power Spectral Density (PSD) plots can be found in Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.

## 4.8 CONDUCTED AC MAINS EMISSIONS

### Test Method:

ANSI C63.10-2013, Section(s) 6.2

### Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

### Notes:

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

### Test Procedures:

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

### Deviation from the test standard:

No deviation

### EUT operating conditions:

Details can be found in section 2.1 of this report.

### Test Results:

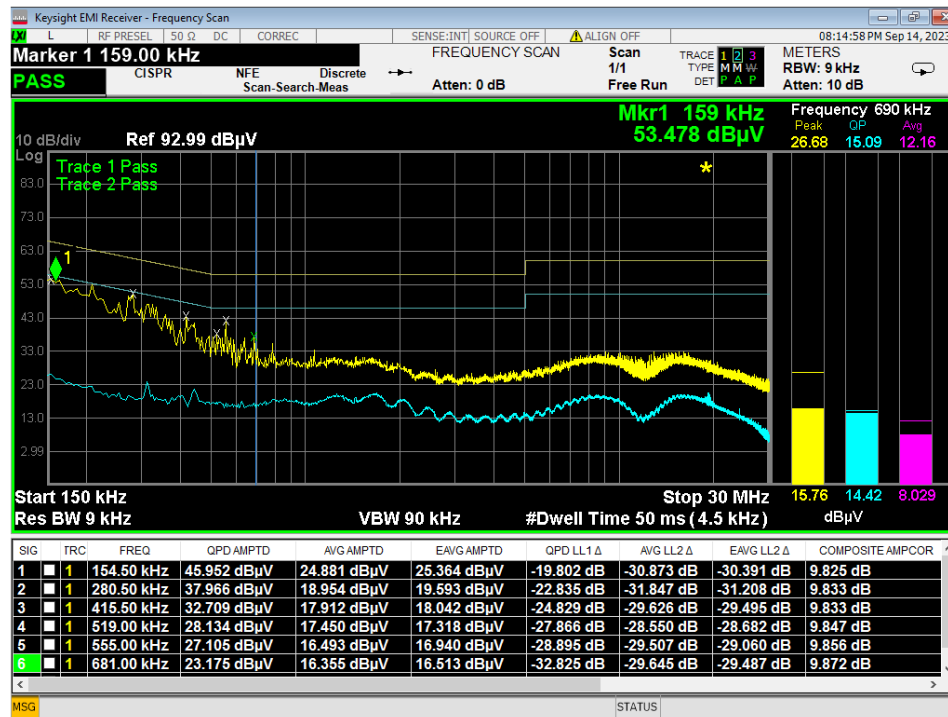


Figure 20 - Conducted Emissions Plot, Line, TX

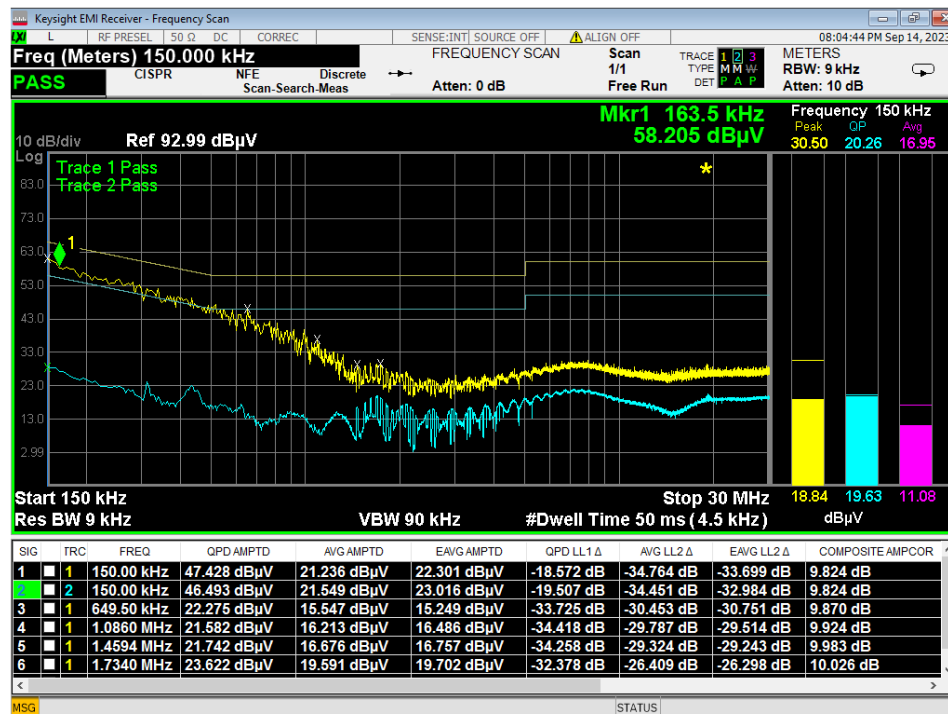


Figure 21 - Conducted Emissions Plot, Neutral, TX



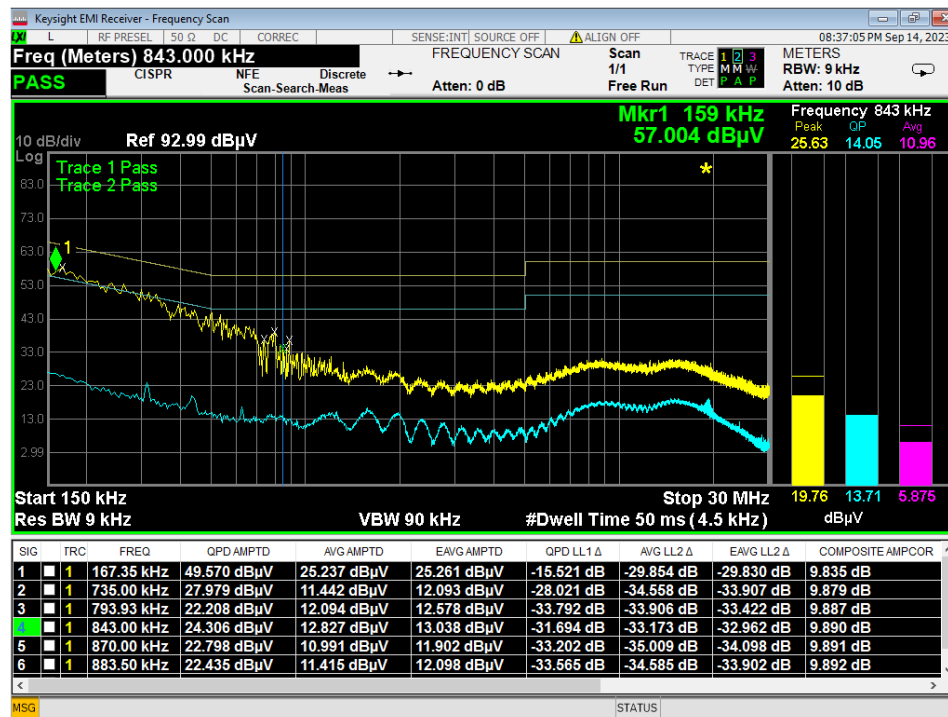


Figure 22 - Conducted Emissions Plot, Line, IDLE

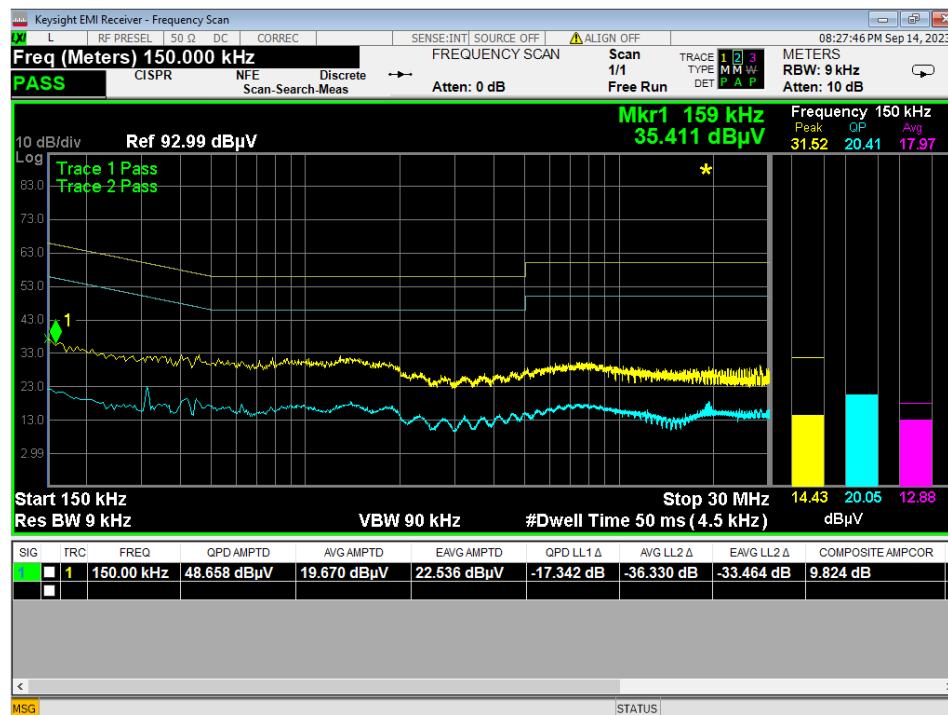


Figure 23 - Conducted Emissions Plot, Neutral, IDLE



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## APPENDIX A: SAMPLE CALCULATION

### Field Strength Calculation

The field strength is calculated by adding the Antenna Factor, Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

Where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB $\mu$ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB $\mu$ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by taking the  $20 \cdot \log(T_{\text{on}}/100)$  where  $T_{\text{on}}$  is the maximum transmission time in any 100ms window.



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**EIRP Calculations**

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

*EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]<sup>2</sup> / 30*  
*Power (watts) = 10<sup>^</sup>[Power (dBm)/10] / 1000*  
*Voltage (dBμV) = Power (dBm) + 107 (for 50Ω measurement systems)*  
*Field Strength (V/m) = 10<sup>^</sup>[Field Strength (dBμV/m) / 20] / 10<sup>^</sup>6*  
*Gain = 1 (numeric gain for isotropic radiator)*  
*Conversion from 3m field strength to EIRP (d=3):*

*EIRP = [FS(V/m) x d<sup>^</sup>2]/30 = FS [0.3]     for d = 3*  
*EIRP(dBm) = FS(dBμV/m) – 10(log 10<sup>^</sup>9)+ 10log[0.3] = FS(dBμV/m) - 95.23*  
*10log(10<sup>^</sup>9) is the conversion from micro to milli*



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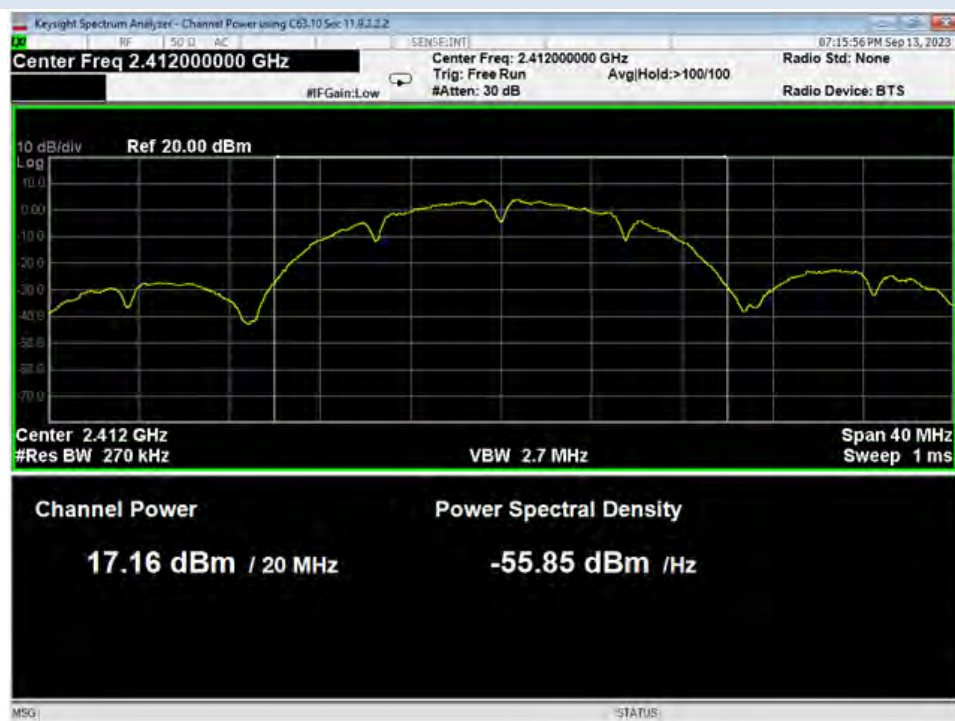
## APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

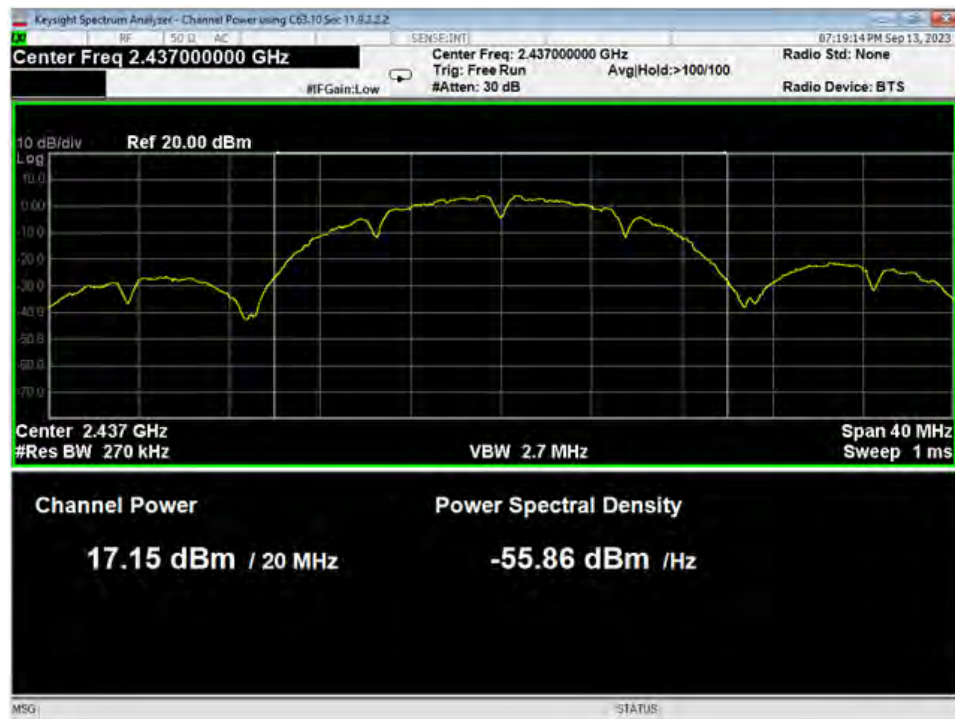
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

Expanded uncertainty values are calculated to a confidence level of 95%.

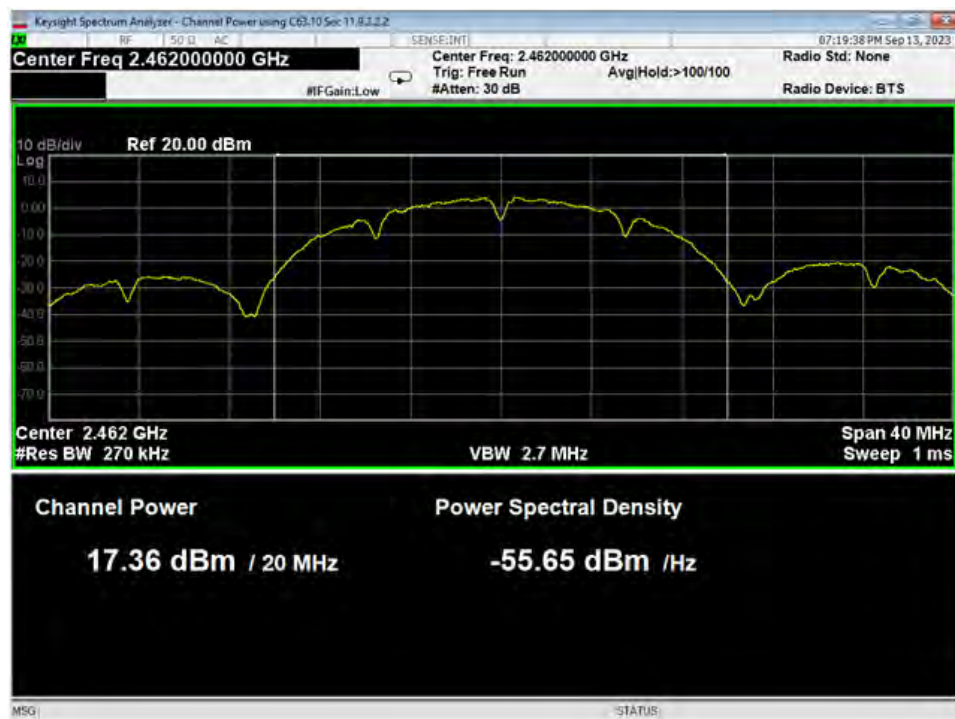
## APPENDIX C – GRAPHS AND TABLES



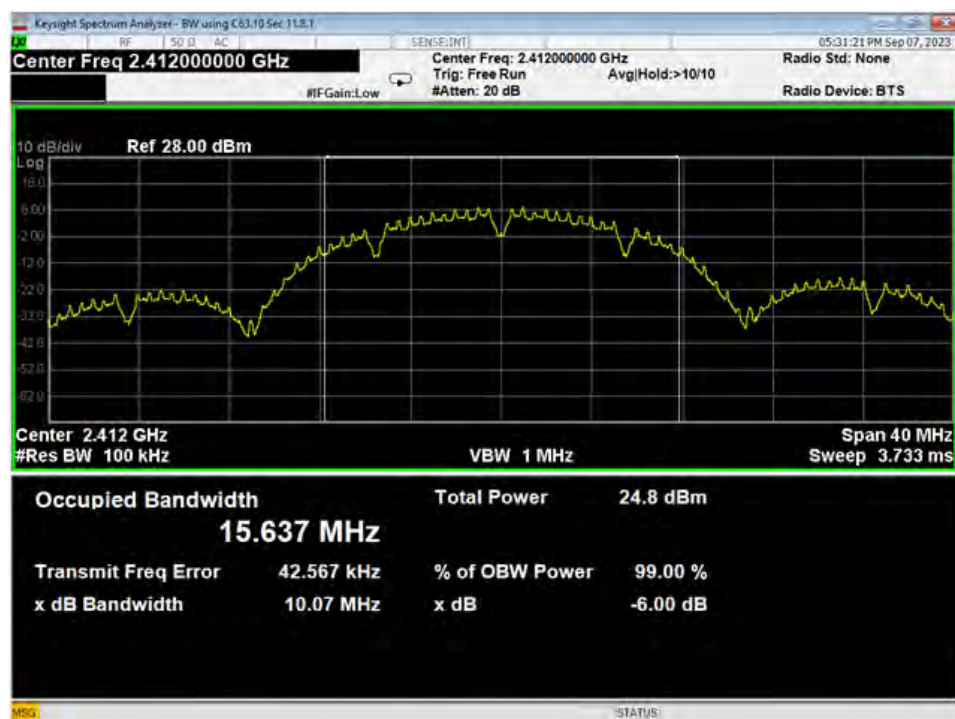
01 Average Power, Low, Wifi B, Low Data Rate



02 Average Power, Mid, Wifi B, Low Data Rate

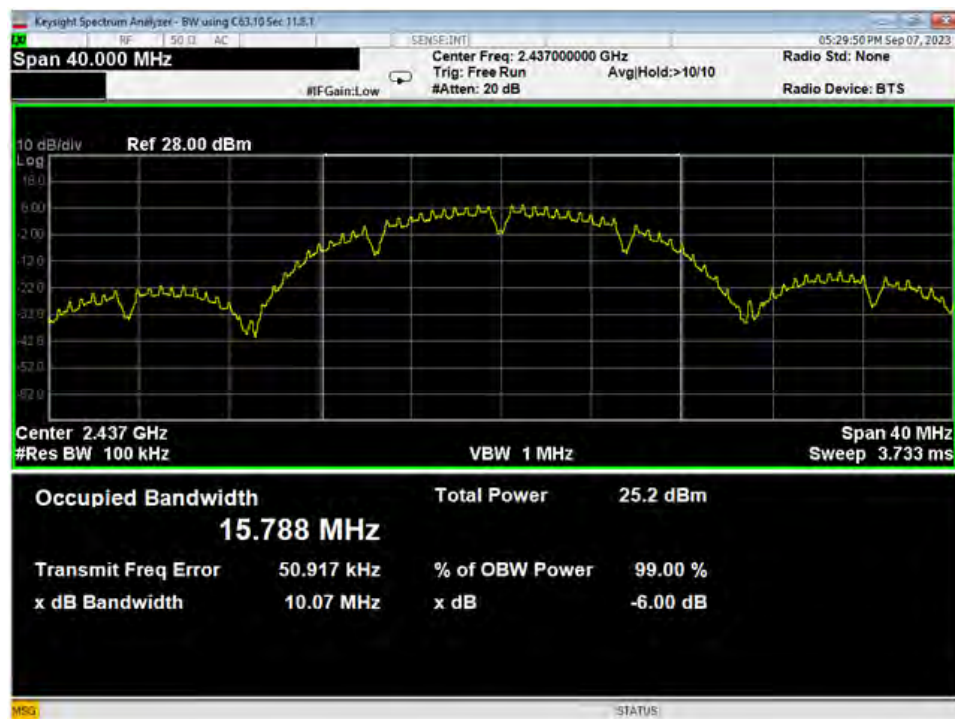


03 Average Power, High, Wifi B, Low Data Rate

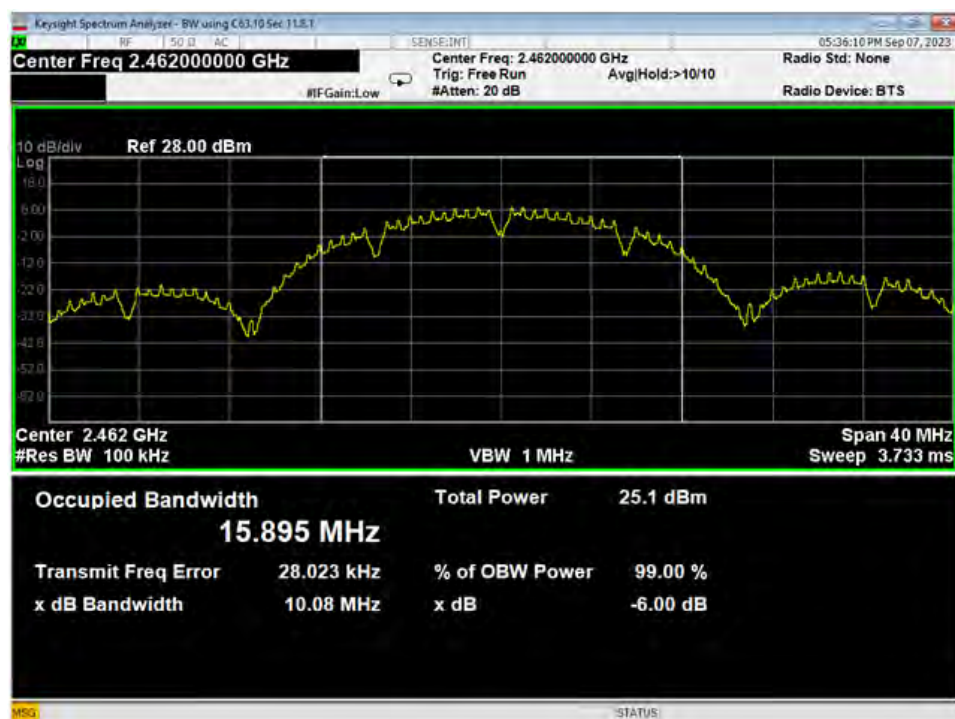


04 6dB Bandwidth, Low, Wifi B, Low Data Rate





05 6dB Bandwidth, Mid, Wifi B, Low Data Rate

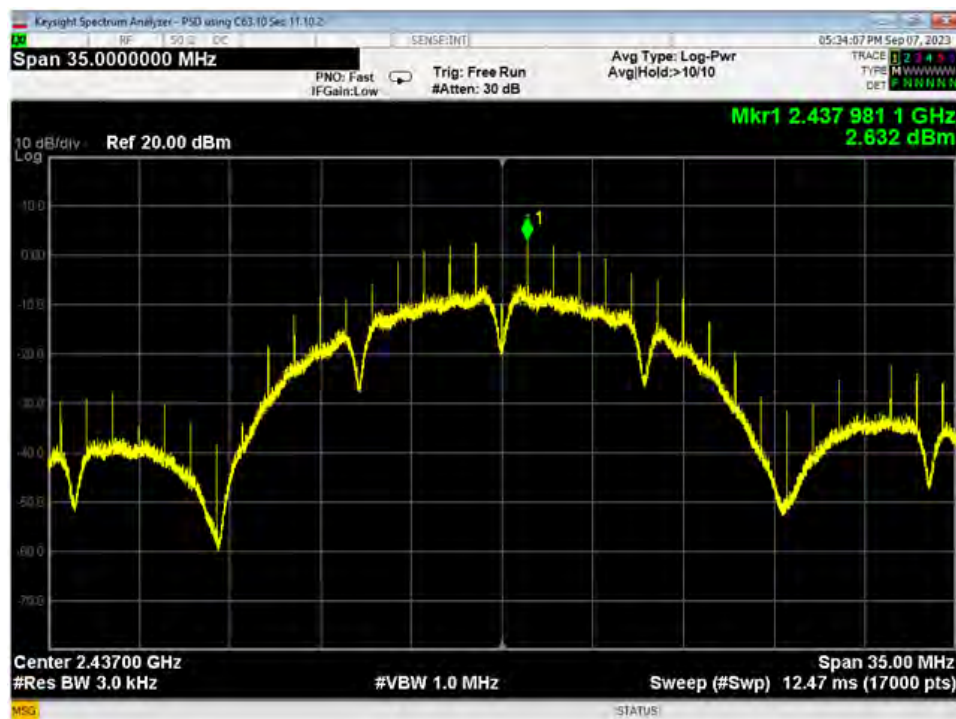


06 6dB Bandwidth, High, Wifi B, Low Data Rate

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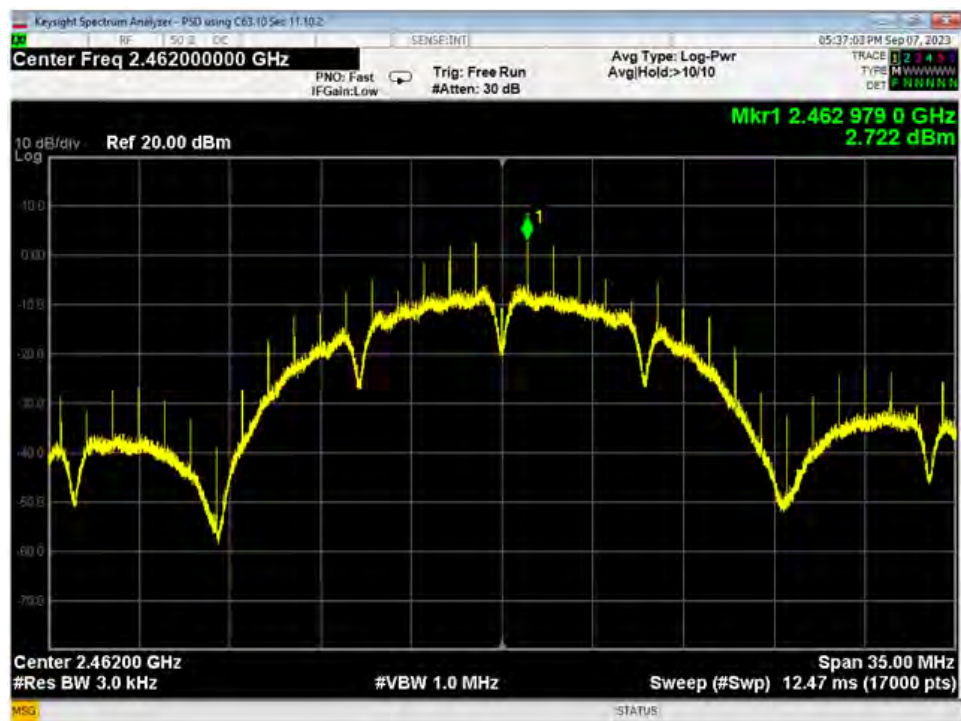


07 PSD, Low, Wifi B, Low Data Rate



08 PSD, Mid, Wifi B, Low Data Rate





09 PSD, High, Wifi B, Low Data Rate

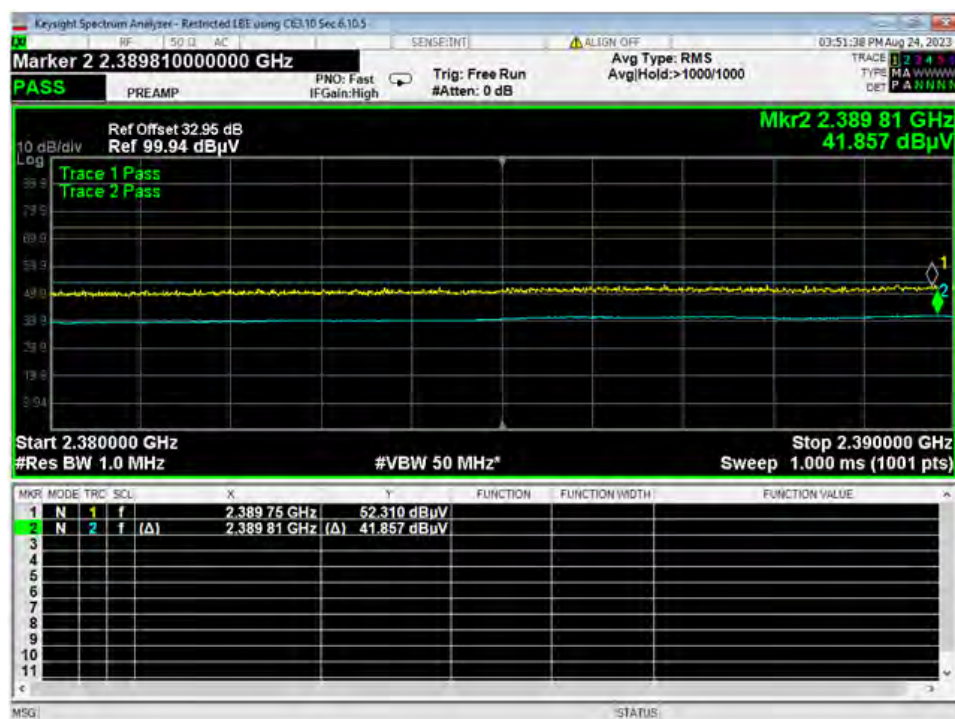


10 Lower Bandedge, Unrestricted, Wifi B, Low Data Rate

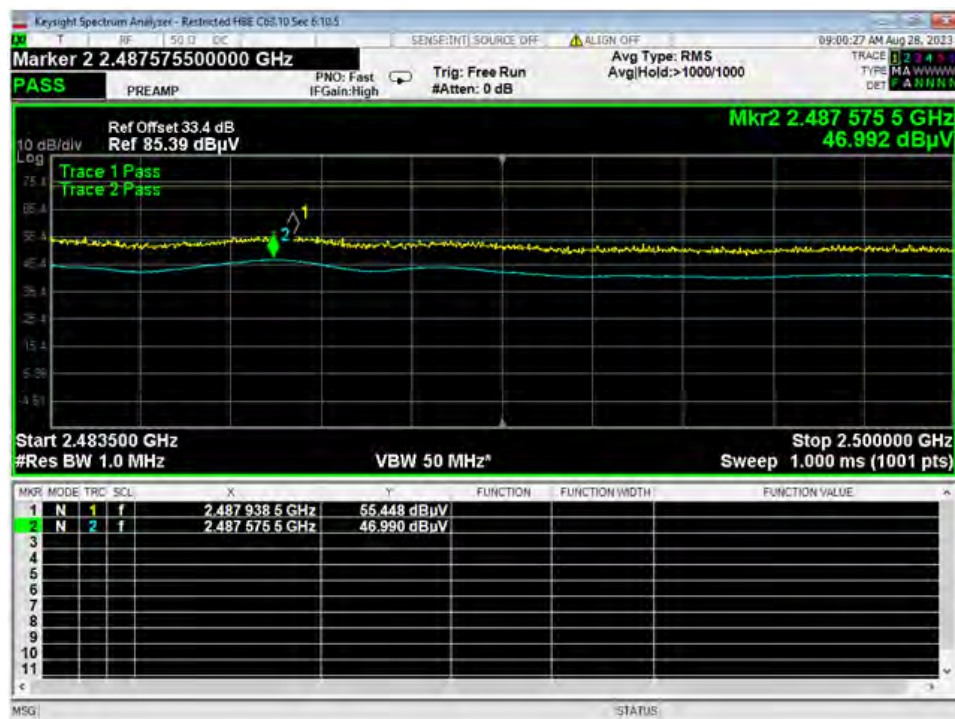
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11 Higher Bandedge, Unrestricted, Wifi B, Low Data Rate



12 Lower Bandedge, Restricted, Wifi B, Low Data Rate

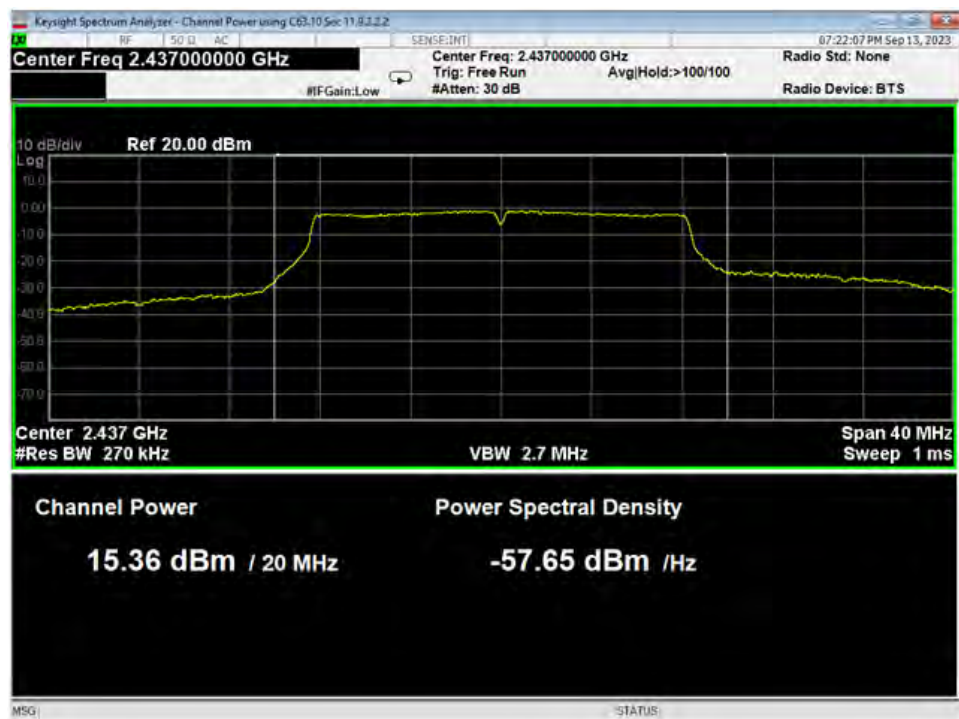


13 Higher Bandedge, Restricted, Wifi B, Low Data Rate

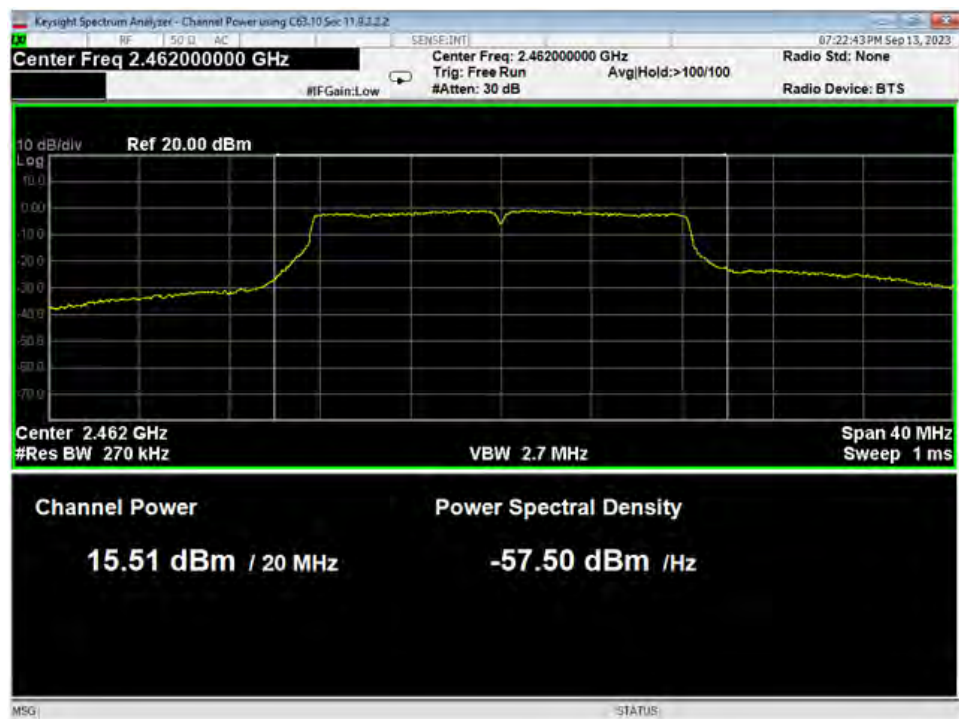


14 Average Power, Low, Wifi G, Low Data Rate



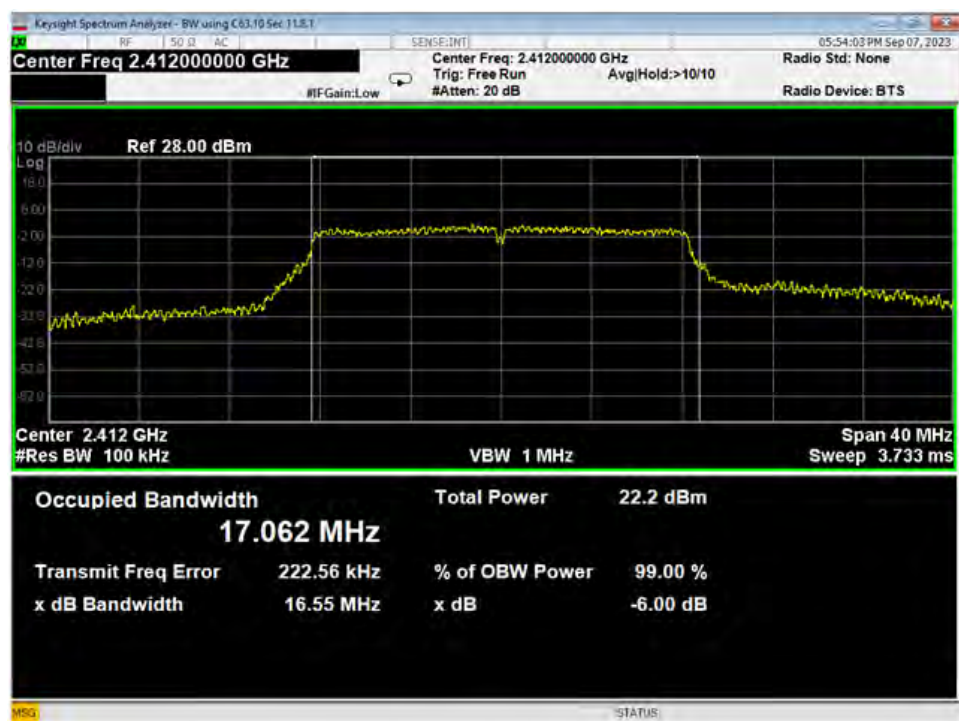


15 Average Power, Mid, Wifi G, Low Data Rate



16 Average Power, High, Wifi G, Low Data Rate

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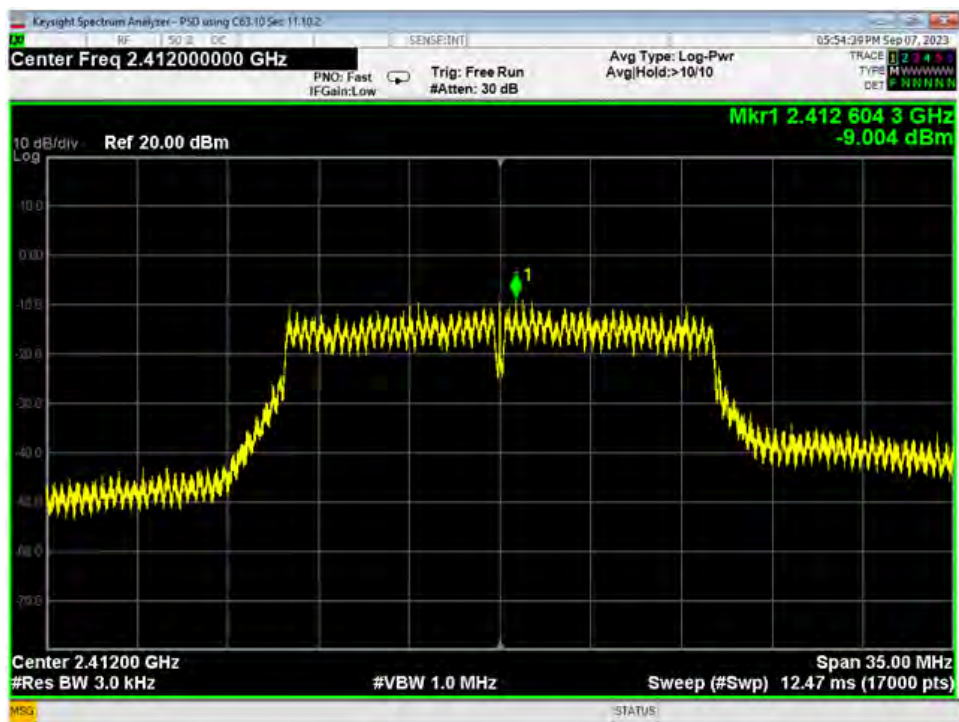
17 6dB Bandwidth, Low, Wifi G, Low Data Rate



18 6dB Bandwidth, Mid, Wifi G, Low Data Rate



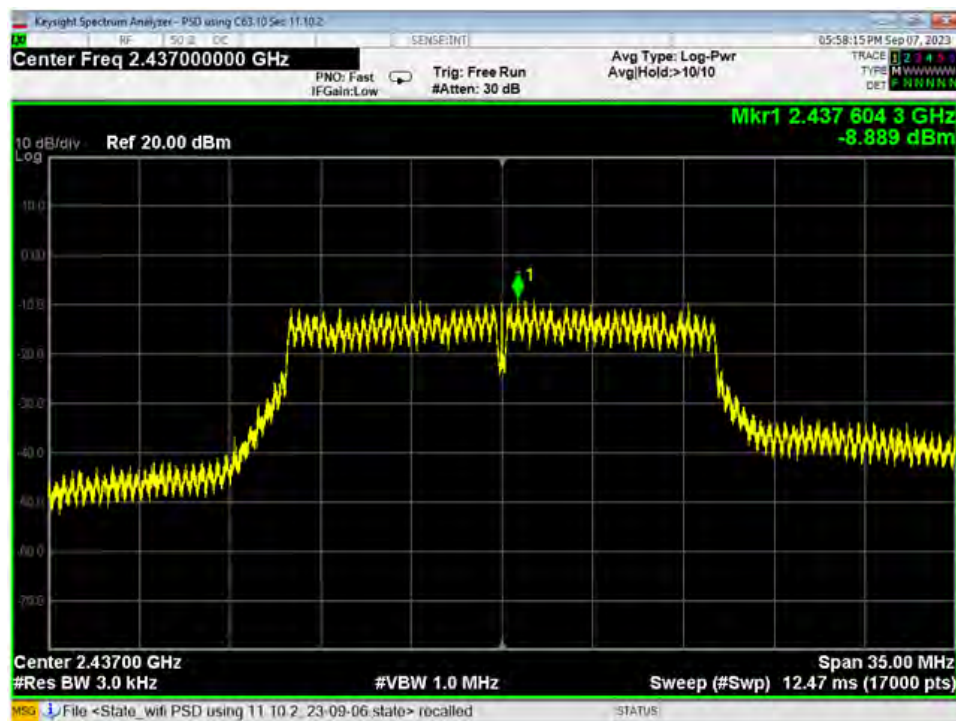
19 6dB Bandwidth, High, Wifi G, Low Data Rate



20 PSD, Low, Wifi G, Low Data Rate



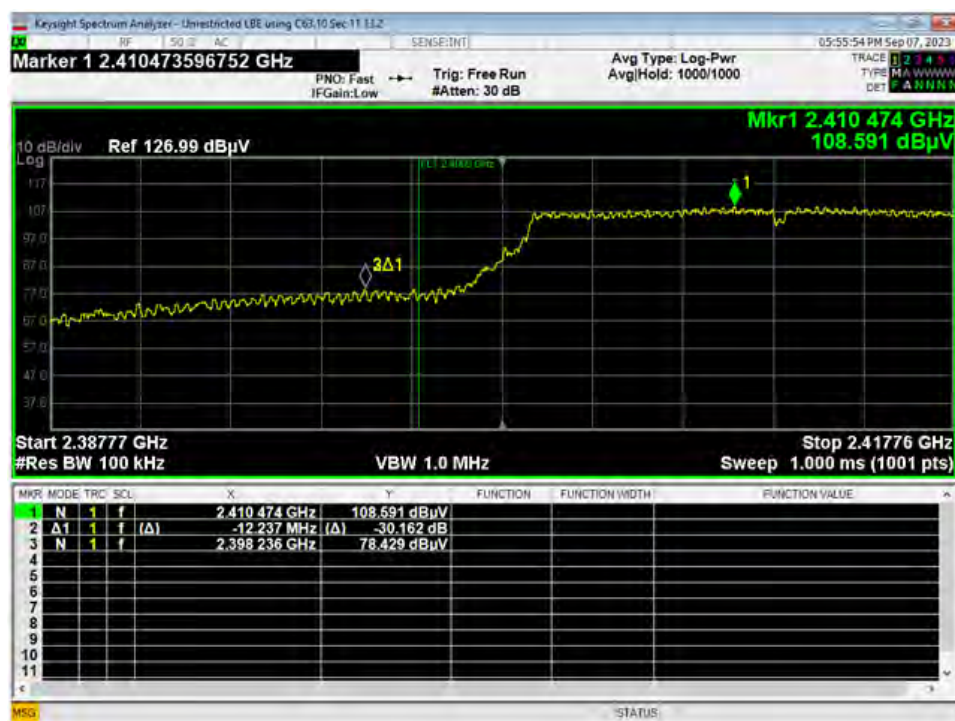
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21 PSD, Mid, Wifi G, Low Data Rate



22 PSD, High, Wifi G, Low Data Rate

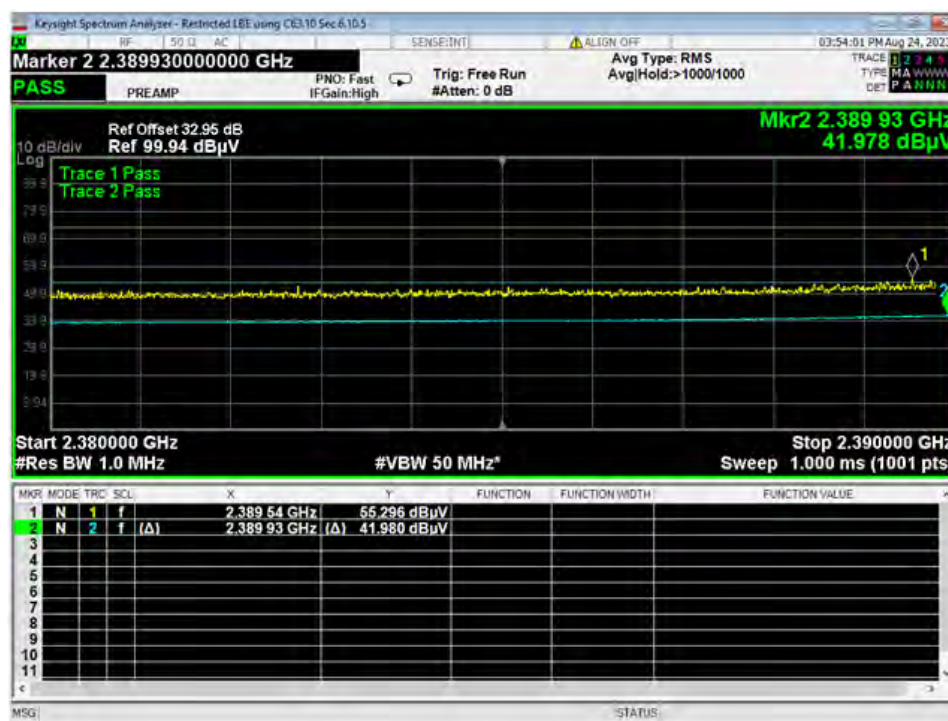


23 Lower Bandedge, Unrestricted, Wifi G, Low Data Rate

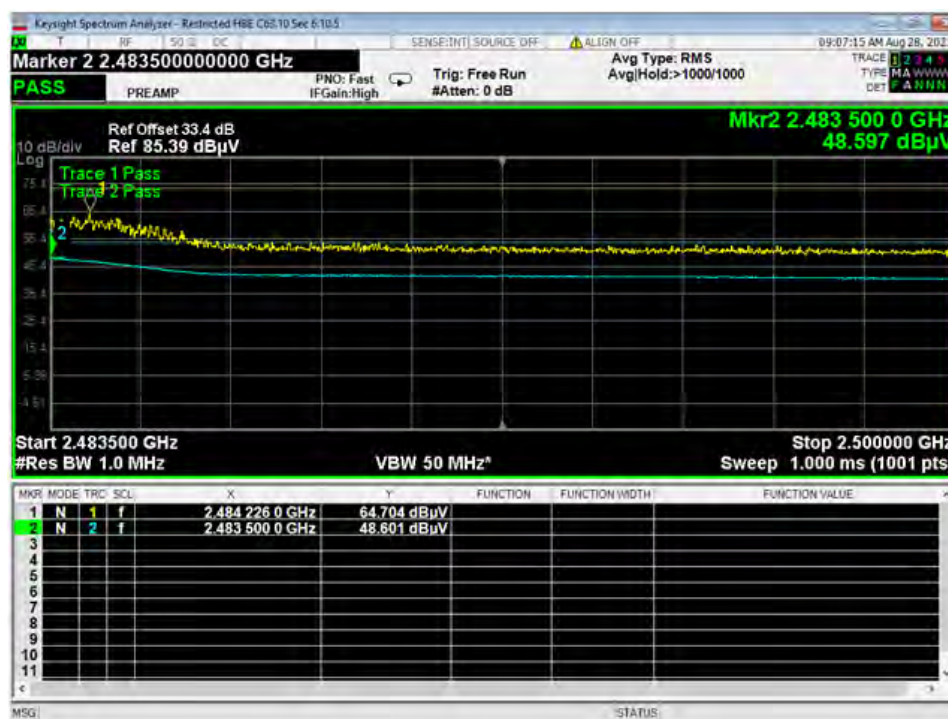


24 Higher Bandedge, Unrestricted, Wifi G, Low Data Rate



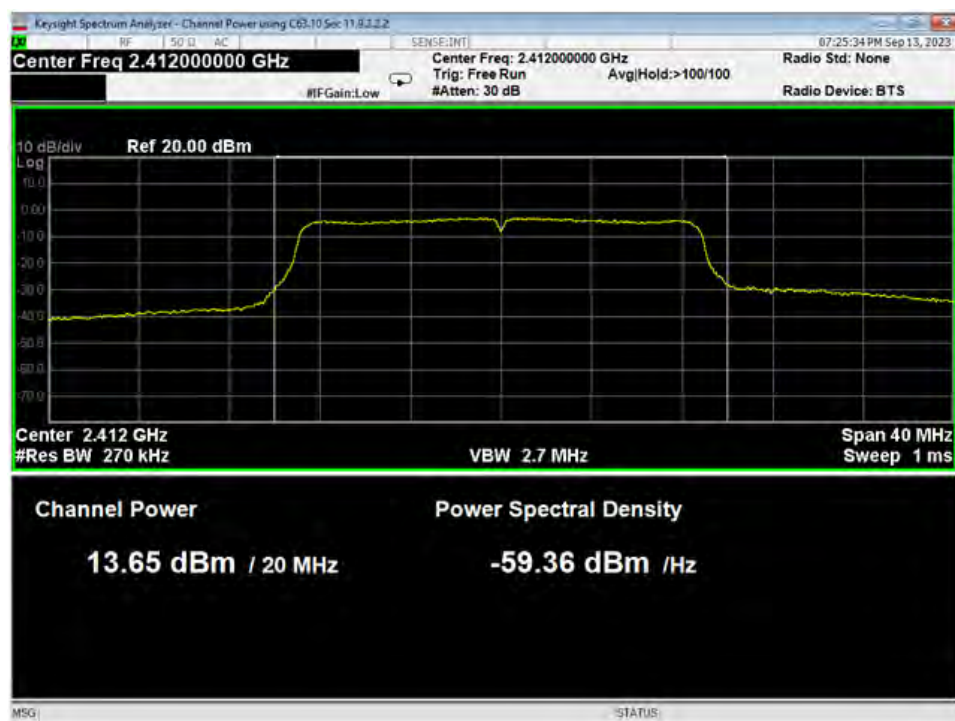


25 Lower Bandedge, Restricted, Wifi G, Low Data Rate

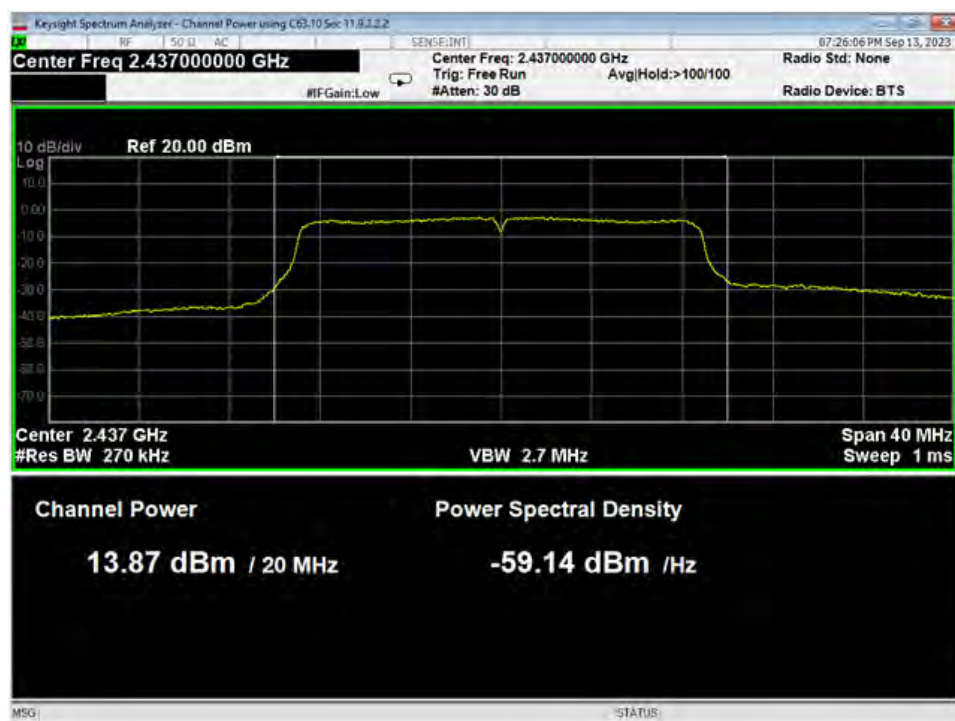


26 Higher Bandedge, Restricted, Wifi G, Low Data Rate

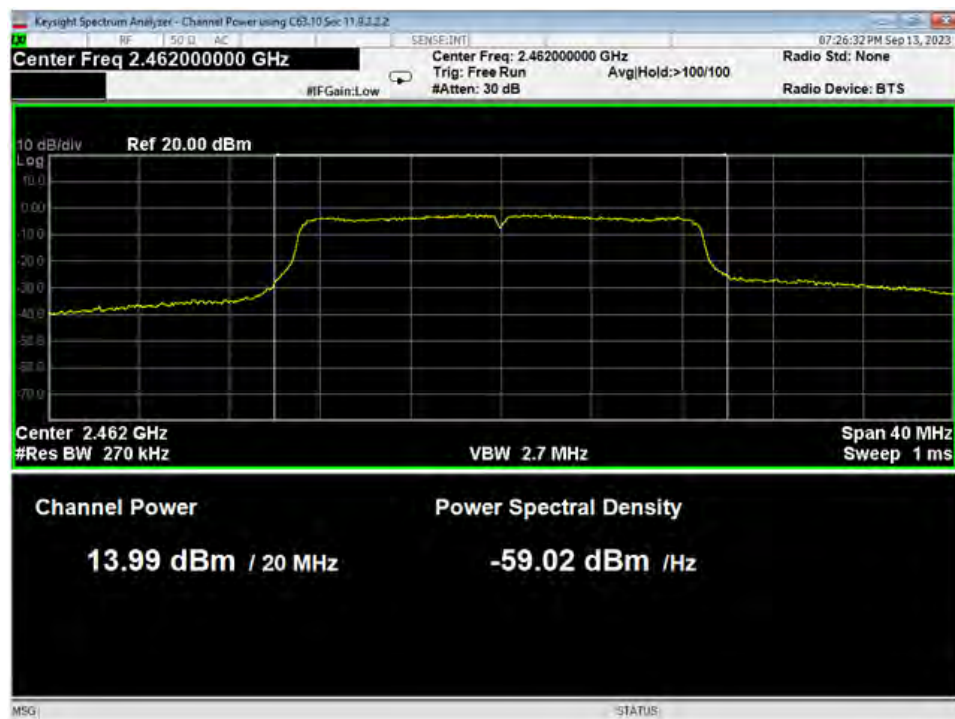
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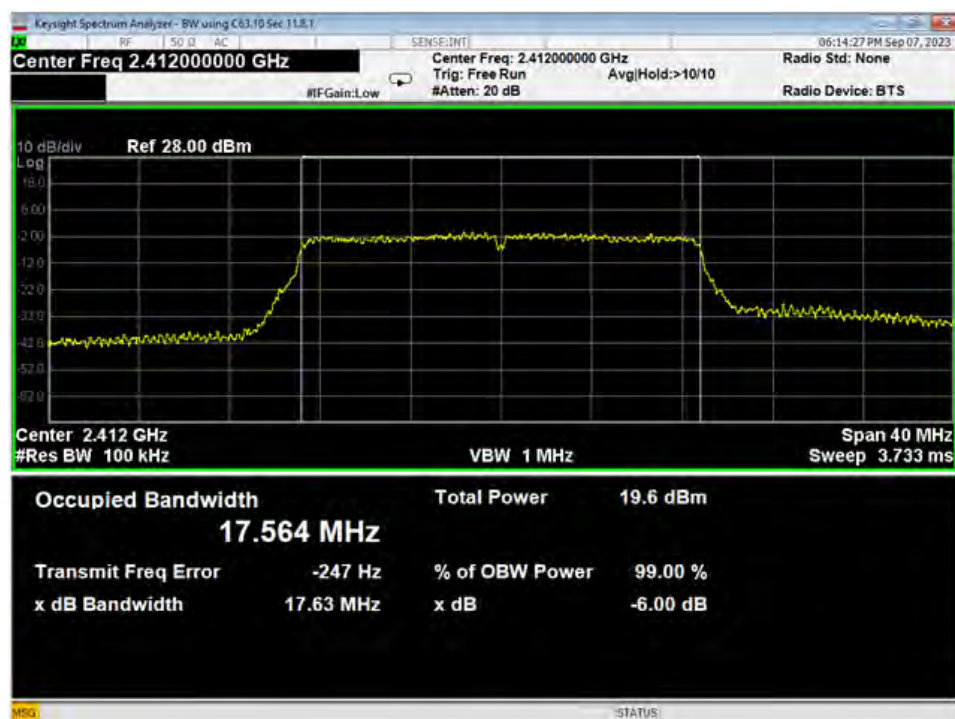
27 Average Power, Low, Wifi N, Low Data Rate



28 Average Power, Mid, Wifi N, Low Data Rate

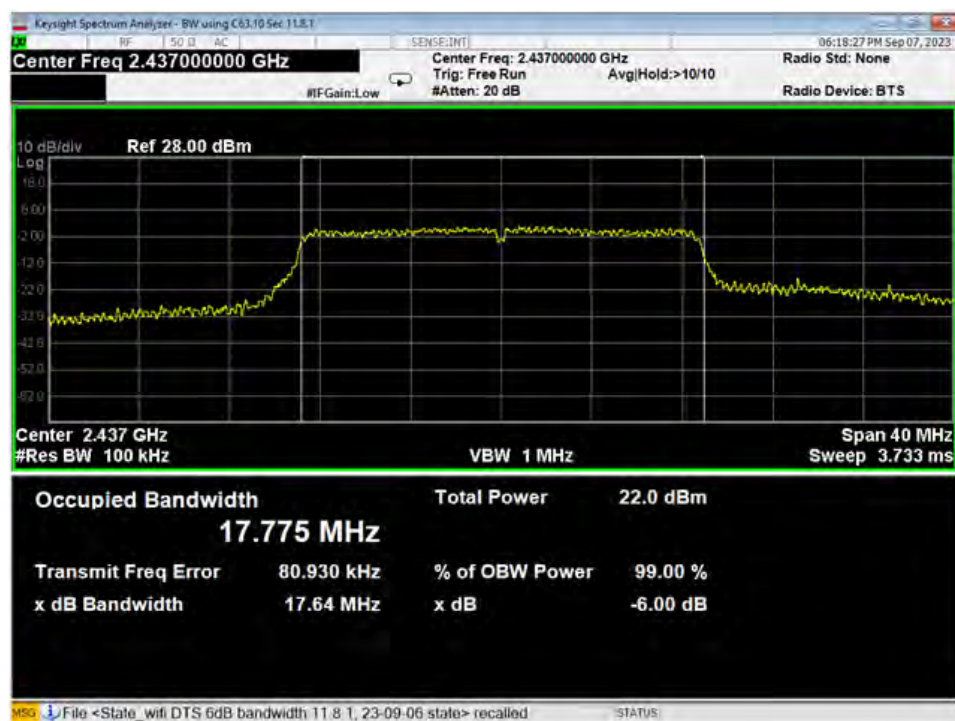


29 Average Power, High, Wifi N, Low Data Rate

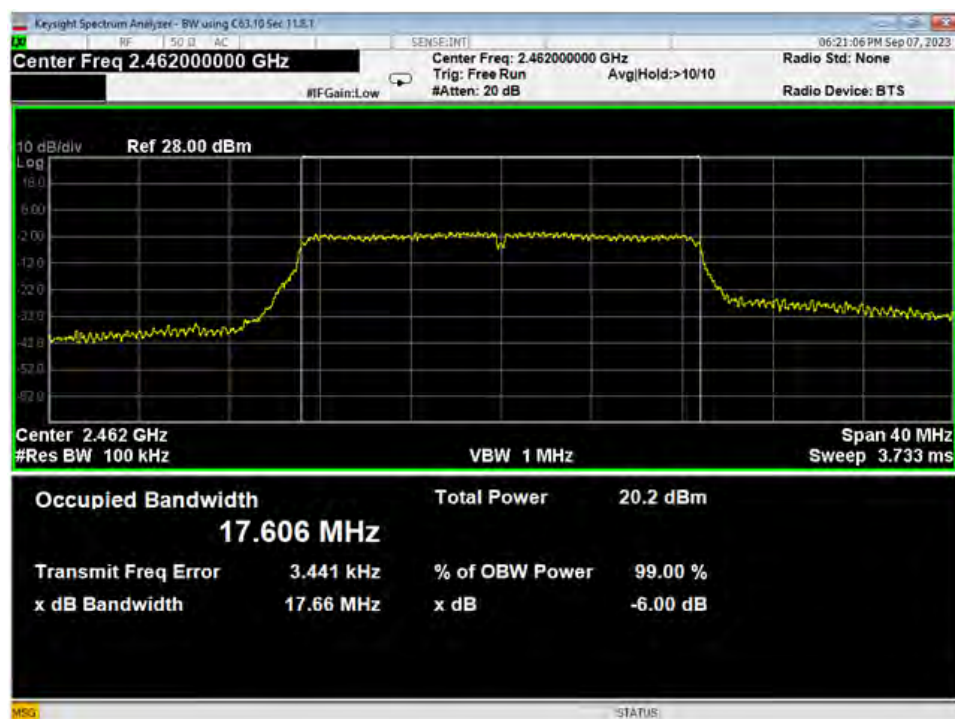


30 6dB Bandwidth, Low, Wifi N, Low Data Rate



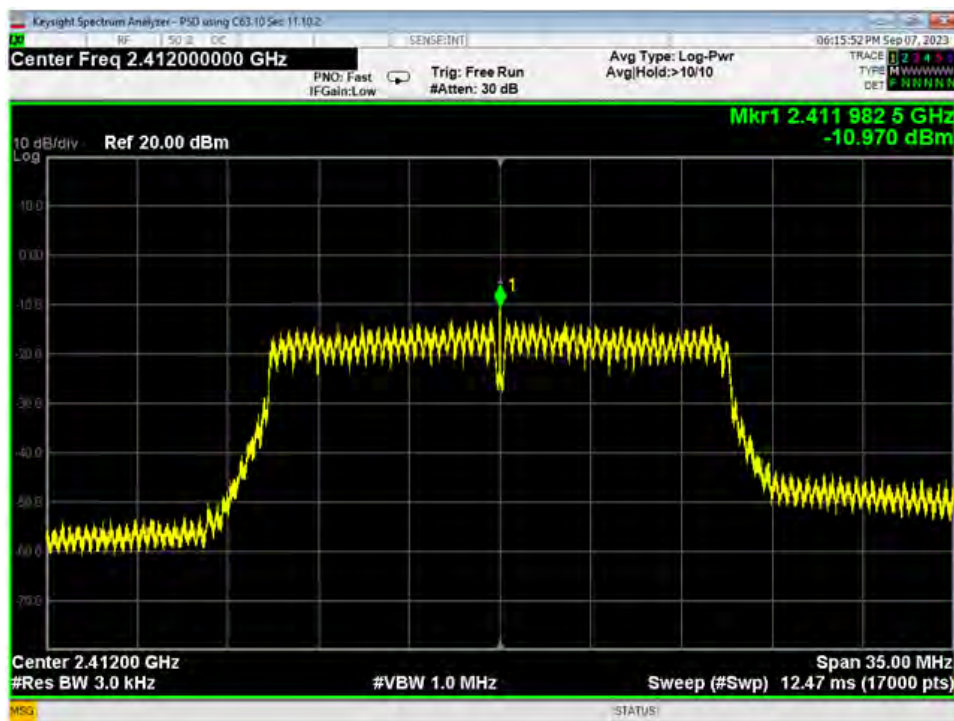


31 6dB Bandwidth, Mid, Wifi N, Low Data Rate

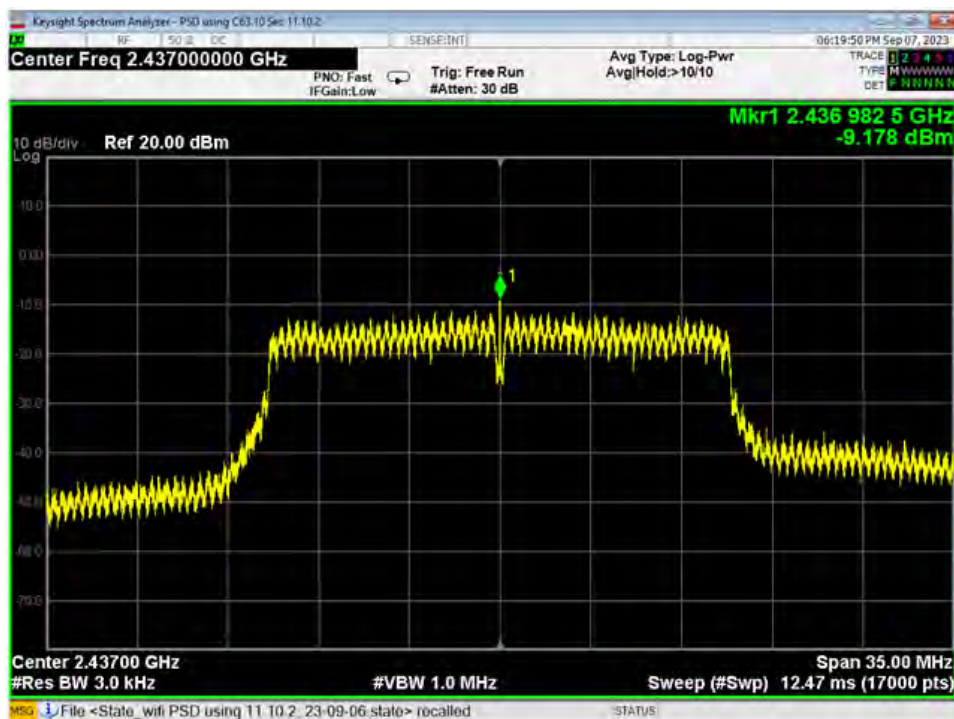


32 6dB Bandwidth, High, Wifi N, Low Data Rate

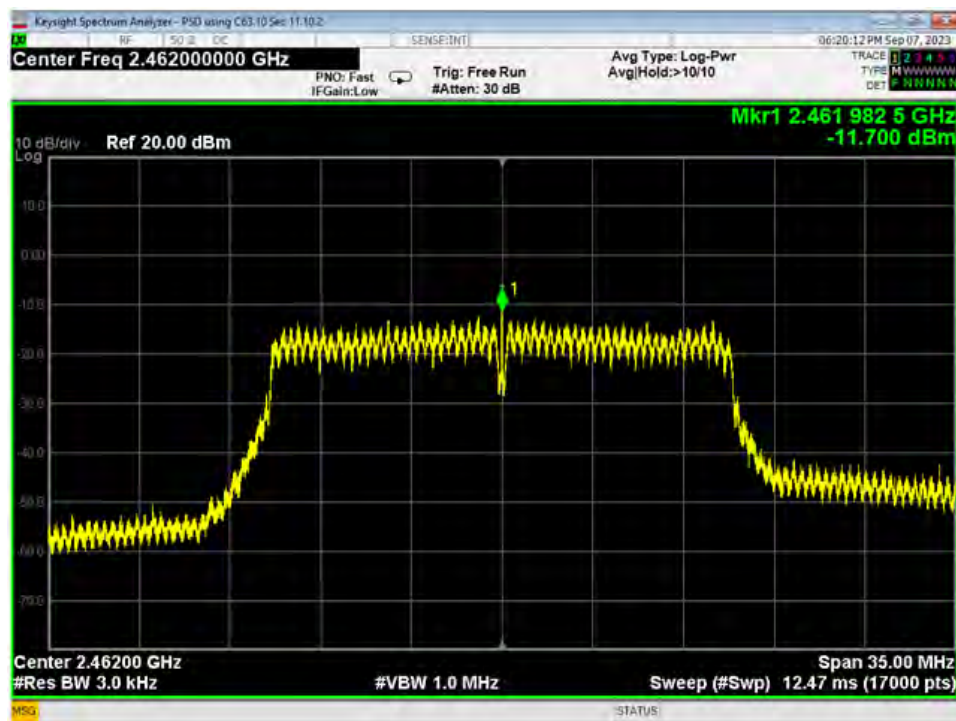
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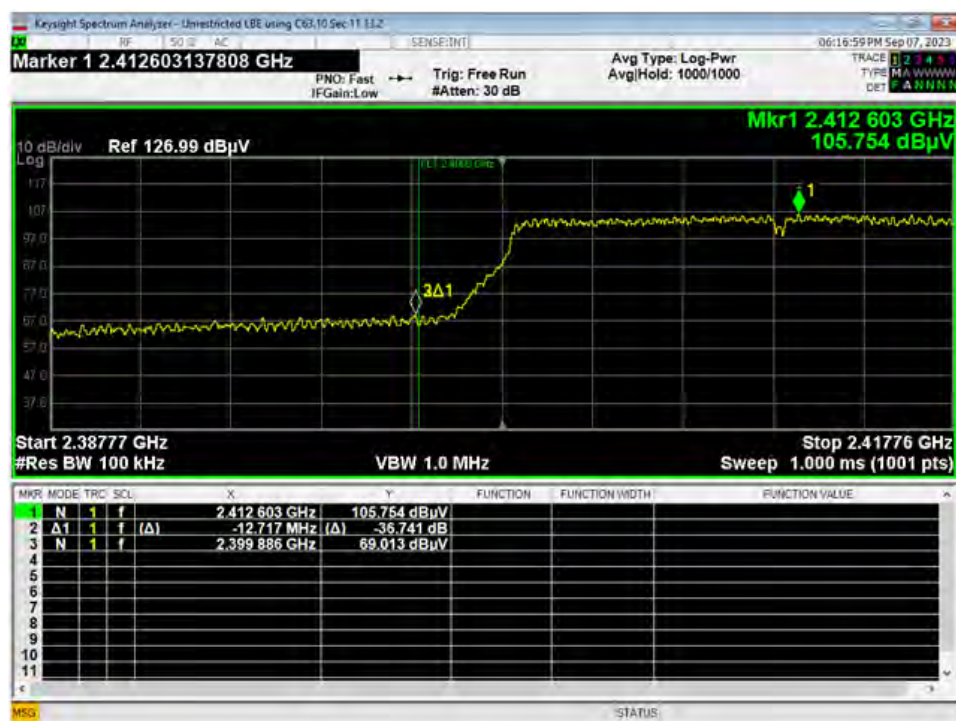
33 PSD, Low, Wifi N, Low Data Rate



34 PSD, Mid, Wifi N, Low Data Rate



35 PSD, High, Wifi N, Low Data Rate

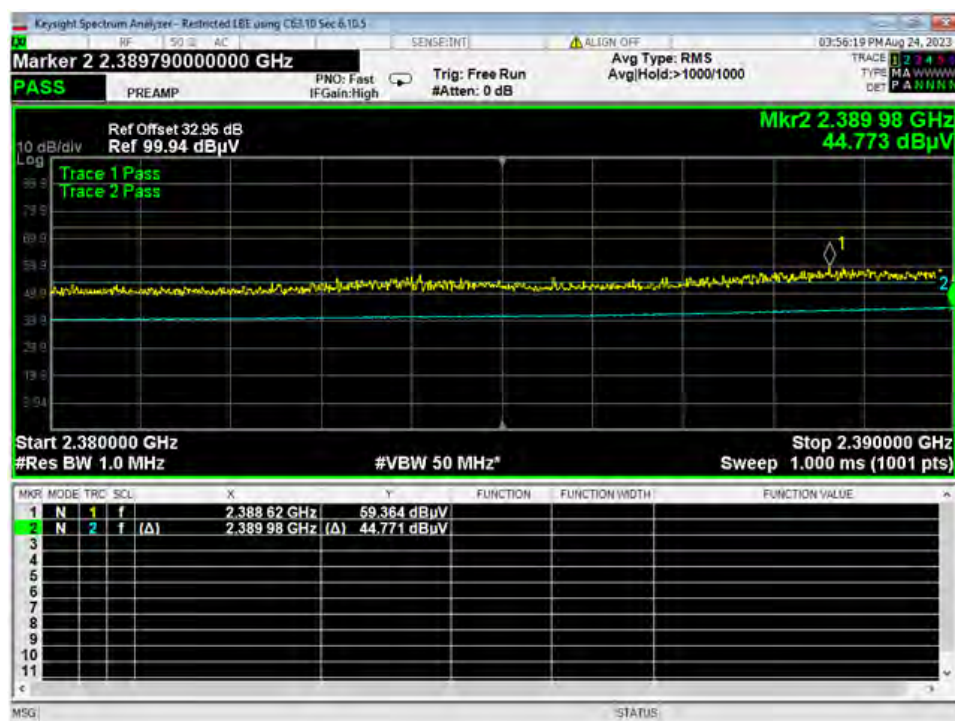


36 Lower Bandedge, Unrestricted, Wifi N, Low Data Rate



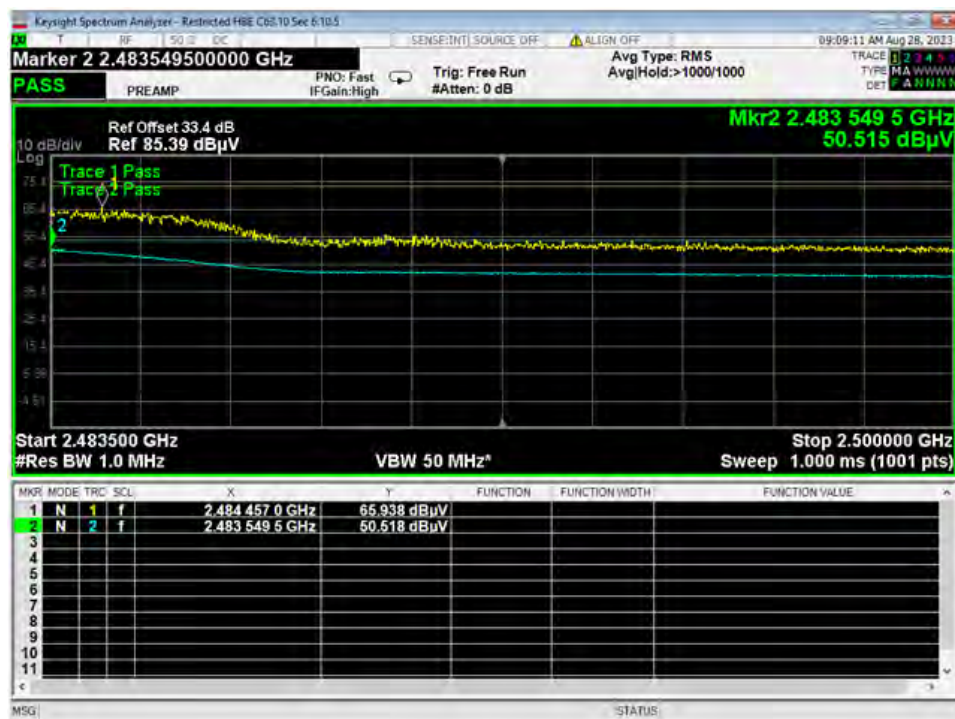


37 Higher Bandedge, Unrestricted, Wifi N, Low Data Rate

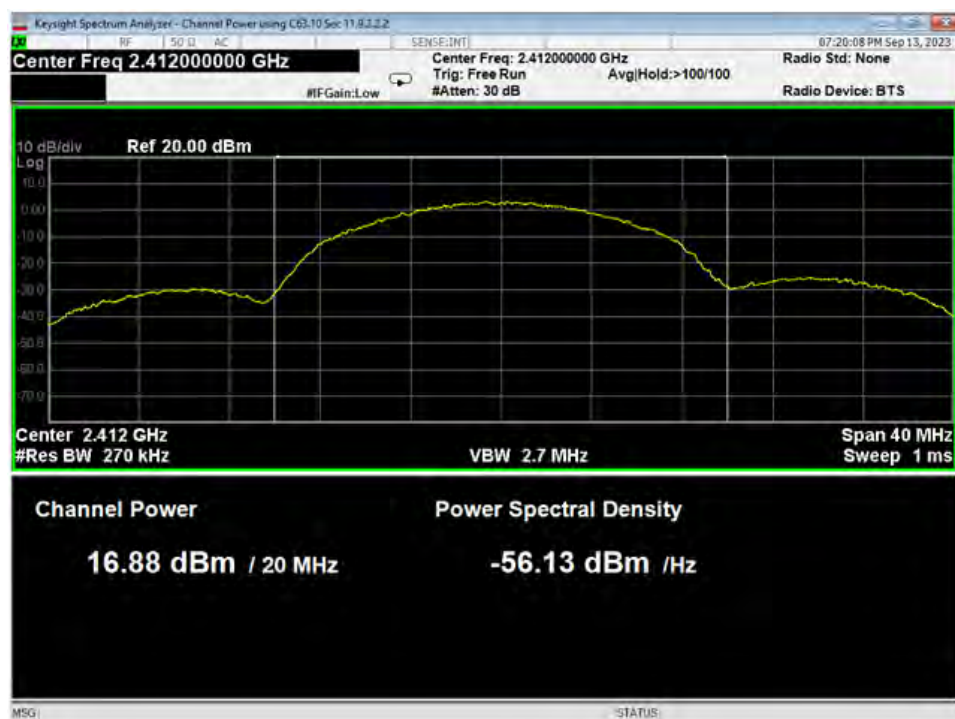


38 Lower Bandedge, Restricted, Wifi N, Low Data Rate

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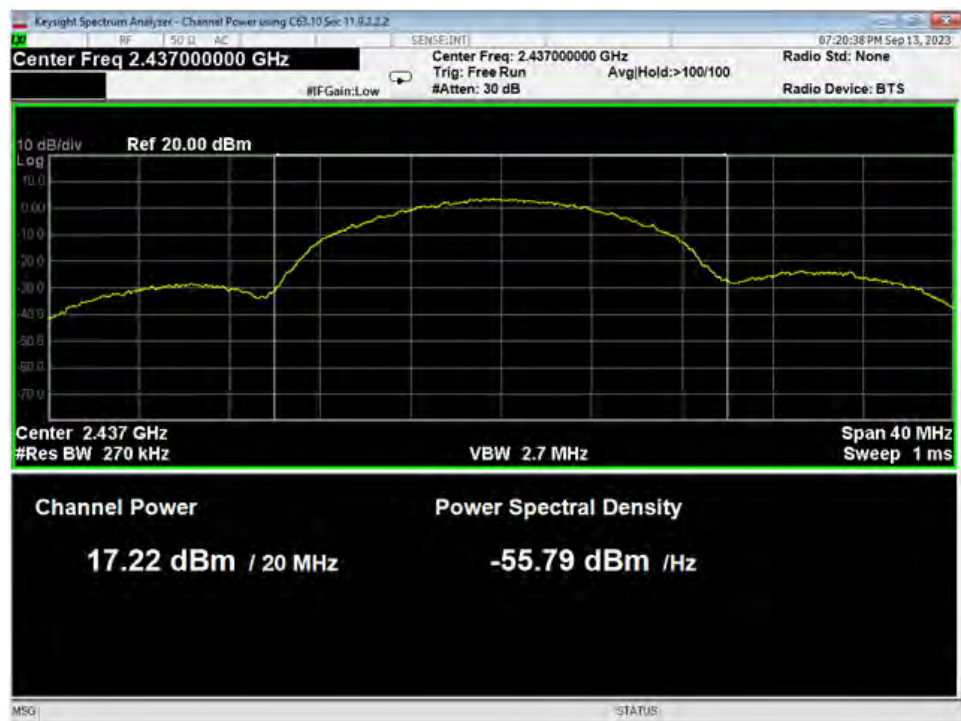
39 Higher Bandedge, Restricted, Wifi N, Low Data Rate



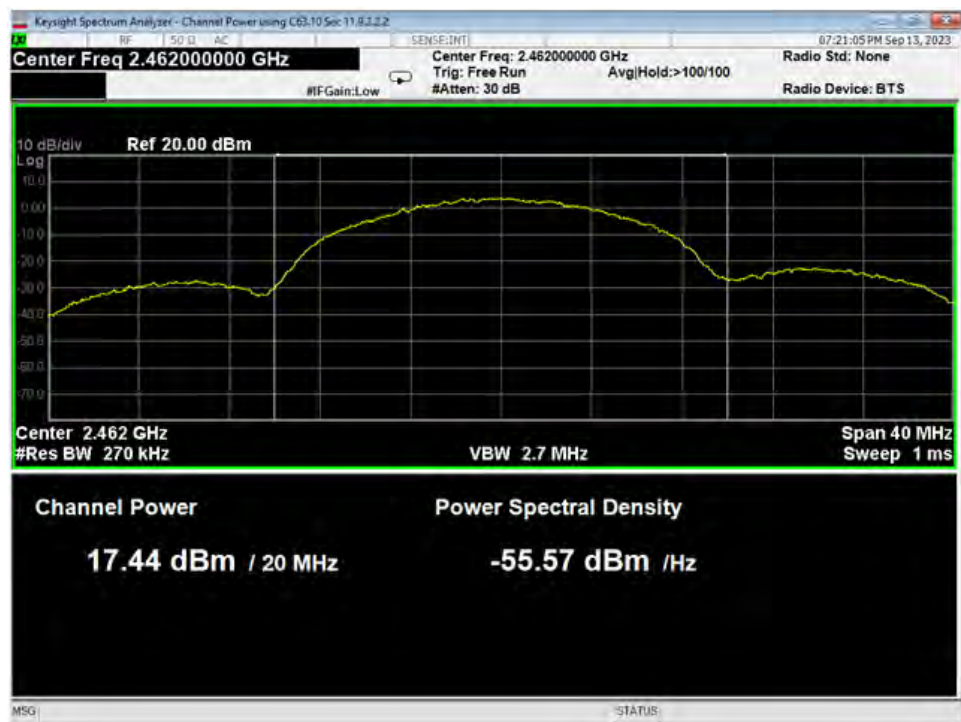
40 Average Power, Low, Wifi B, High Data Rate



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41 Average Power, Mid, Wifi B, High Data Rate



42 Average Power, High, Wifi B, High Data Rate



43 6dB Bandwidth, Low, Wifi B, High Data Rate

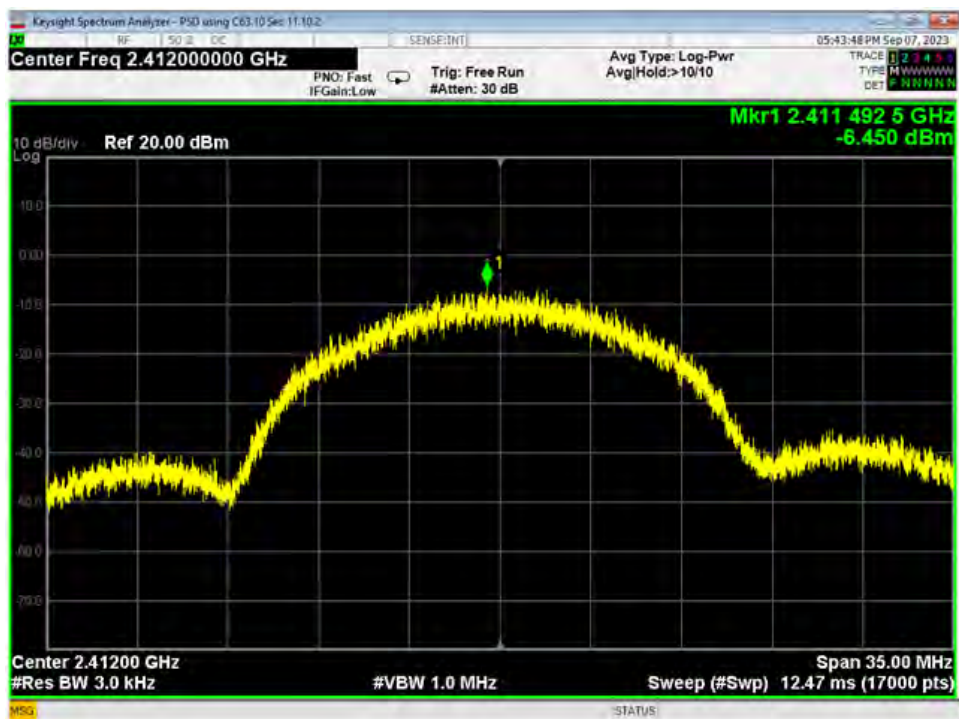


44 6dB Bandwidth, Mid, Wifi B, High Data Rate

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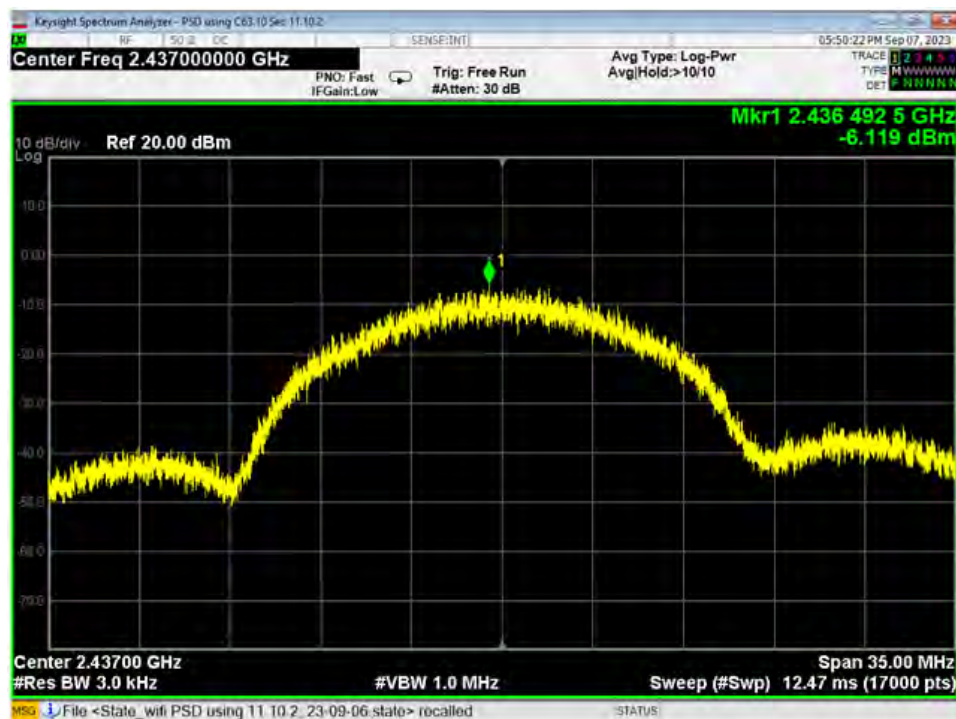


45 6dB Bandwidth, High, Wifi B, High Data Rate

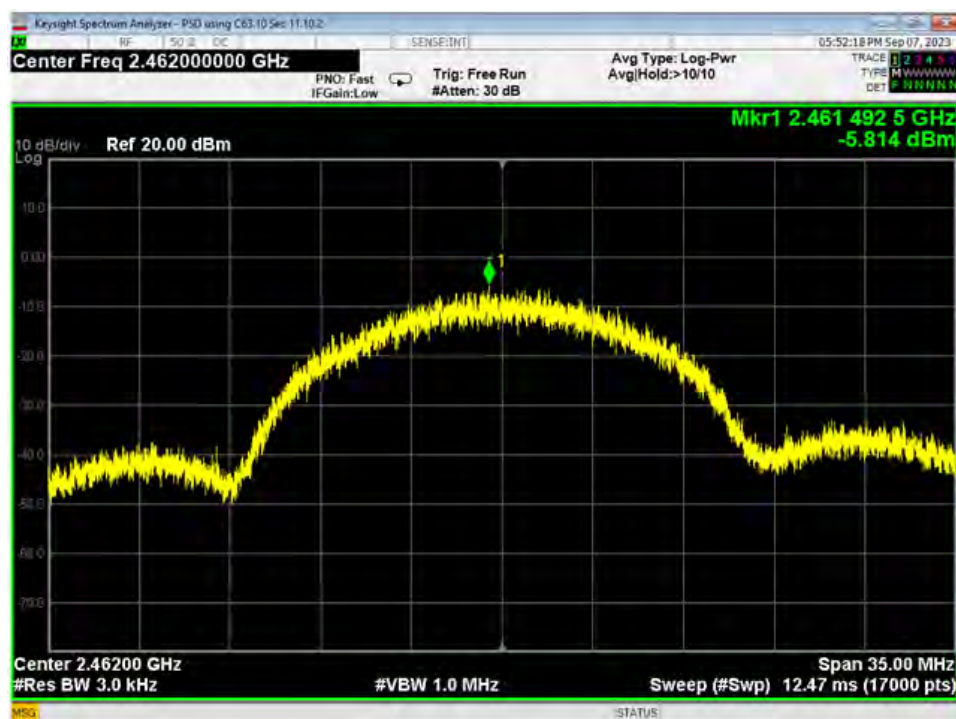


46 PSD, Low, Wifi B, High Data Rate





47 PSD, Mid, Wifi B, High Data Rate



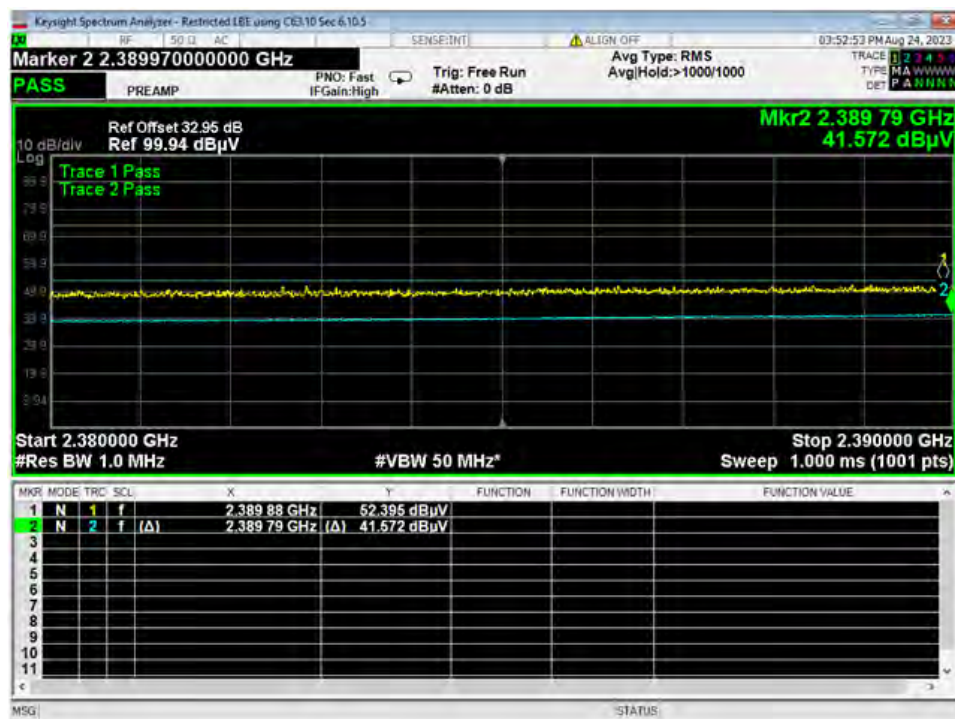
48 PSD, High, Wifi B, High Data Rate



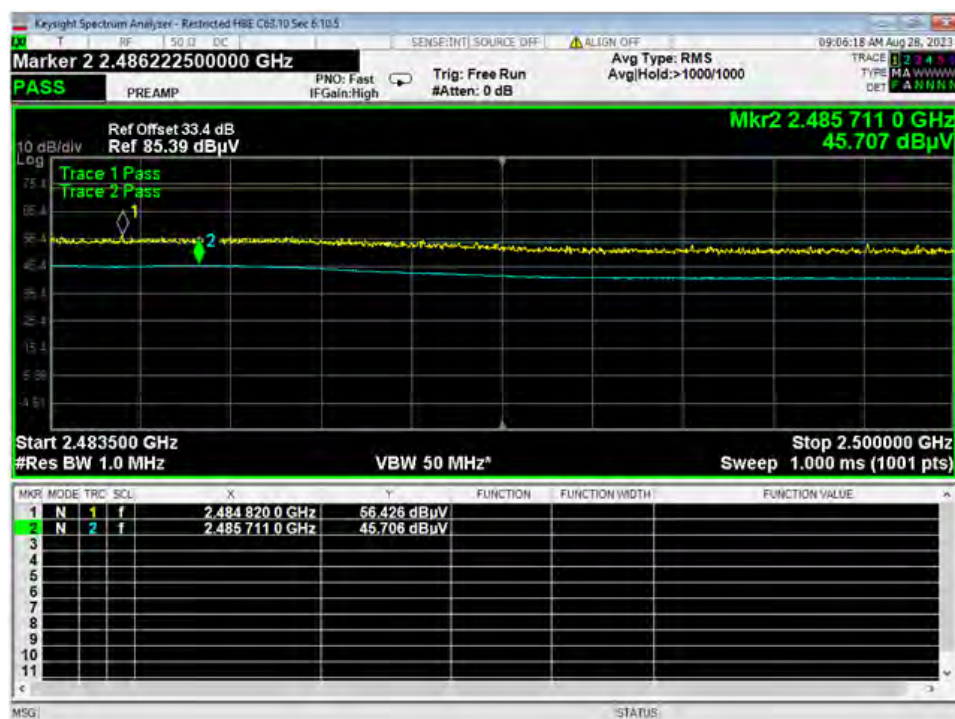
49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



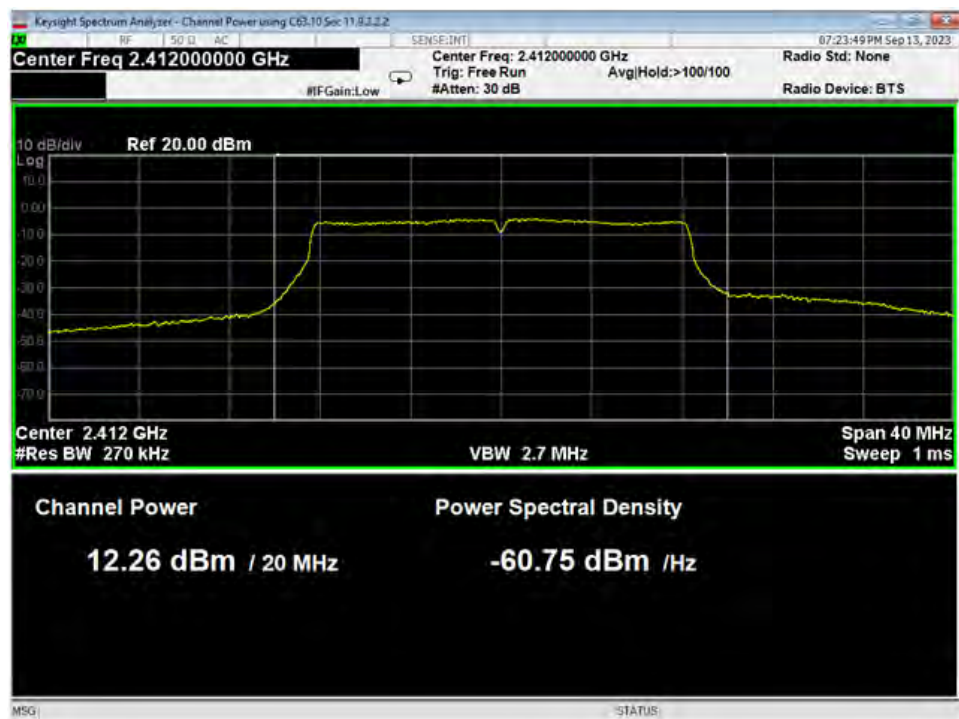
51 Lower Bandedge, Restricted, Wifi B, High Data Rate



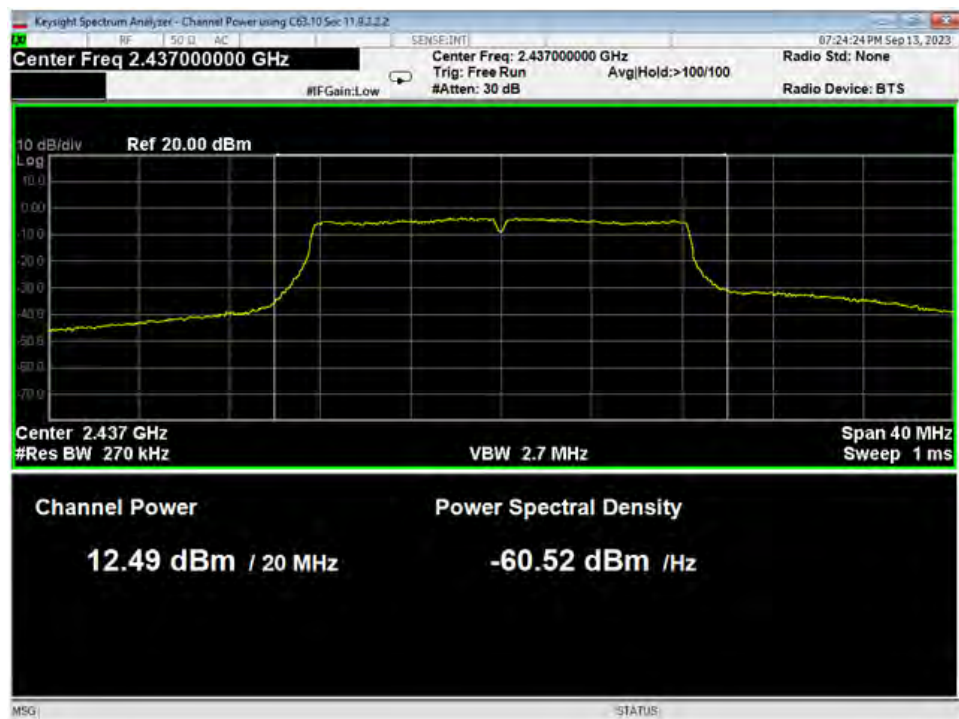
52 Higher Bandedge, Restricted, Wifi B, High Data Rate



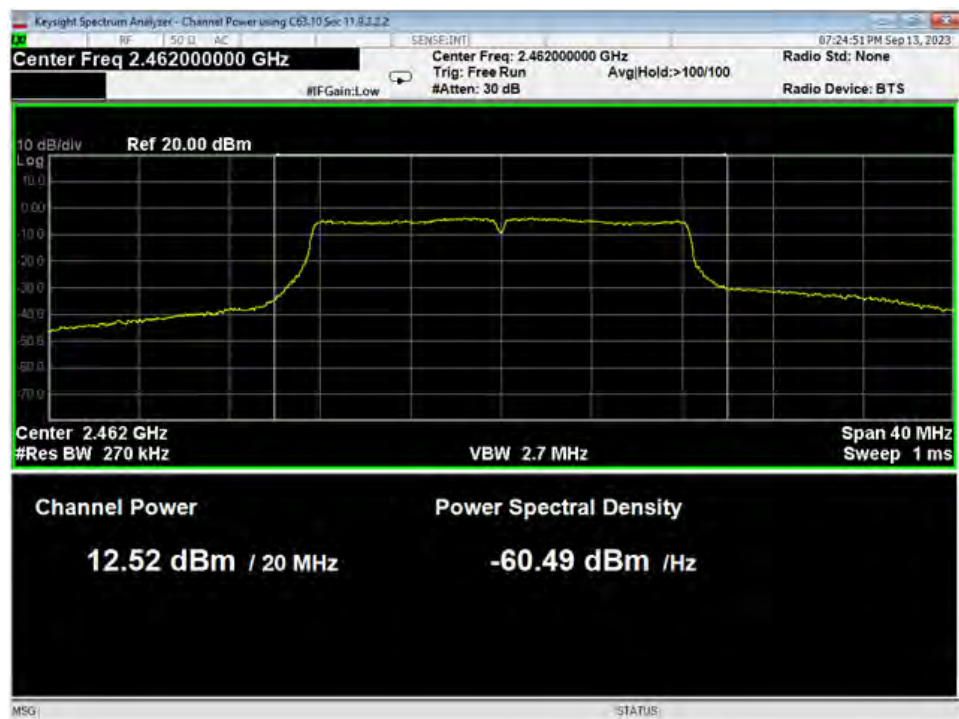
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53 Average Power, Low, Wifi G, High Data Rate



54 Average Power, Mid, Wifi G, High Data Rate



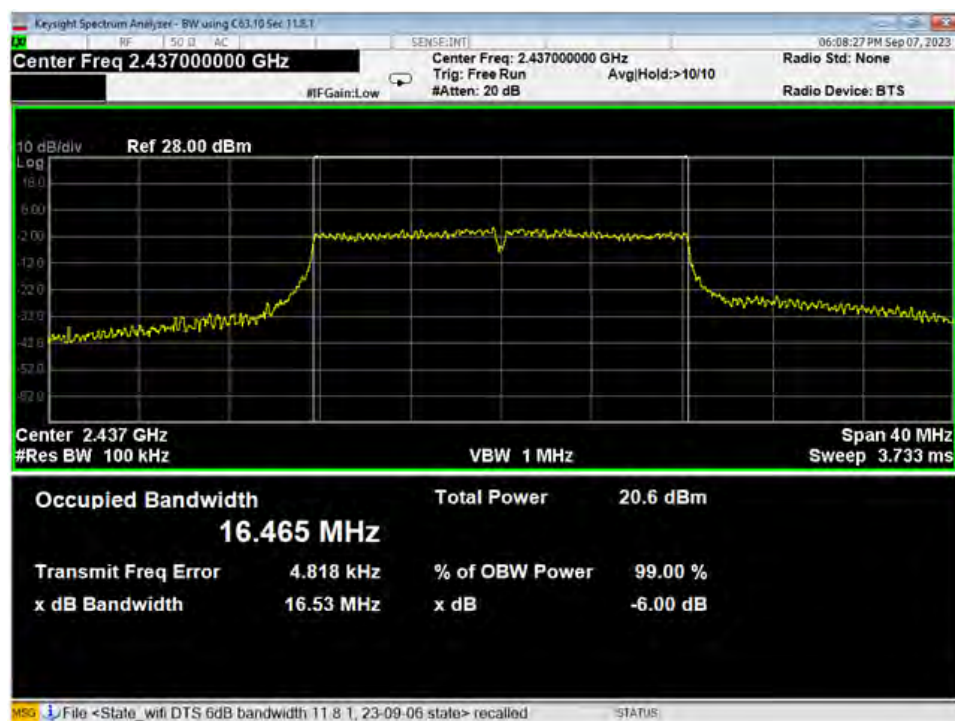
55 Average Power, High, Wifi G, High Data Rate



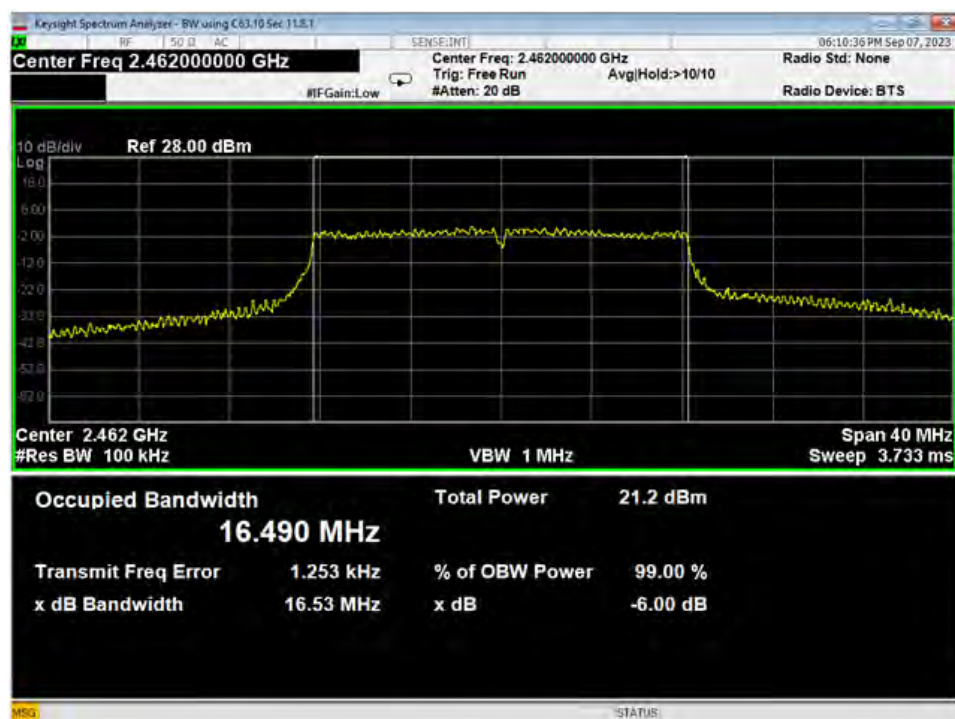
56 6dB Bandwidth, Low, Wifi G, High Data Rate



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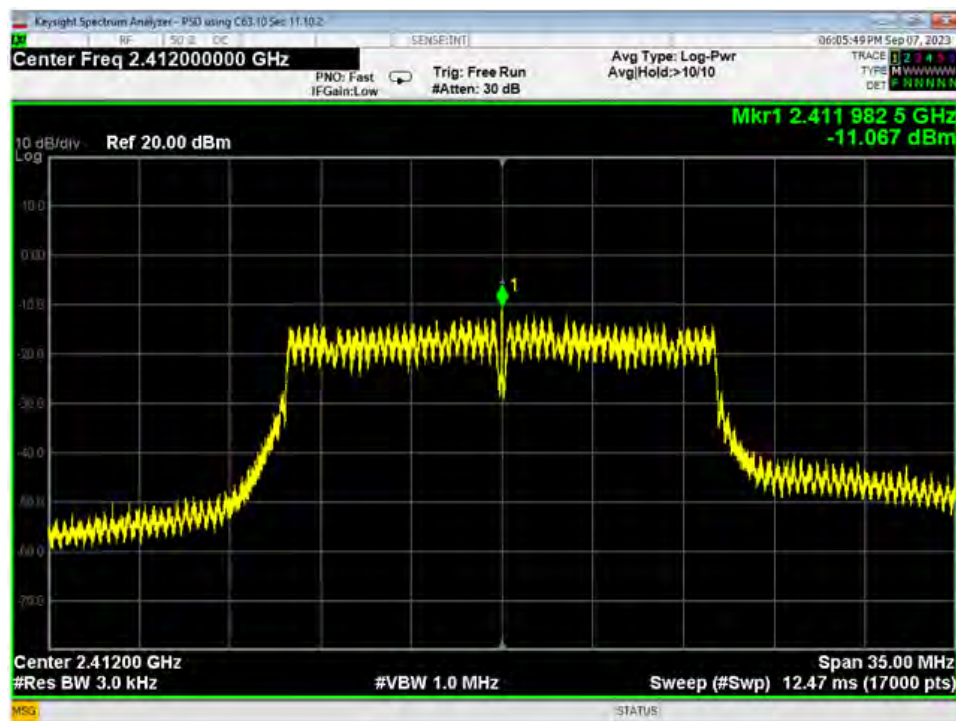


57 6dB Bandwidth, Mid, Wifi G, High Data Rate

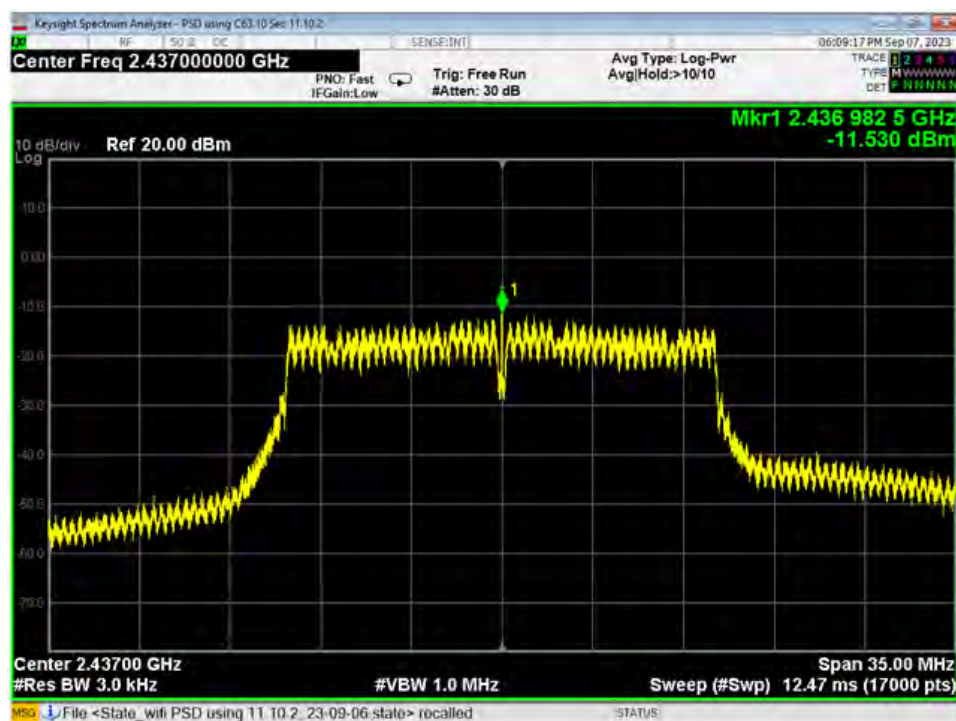


58 6dB Bandwidth, High, Wifi G, High Data Rate

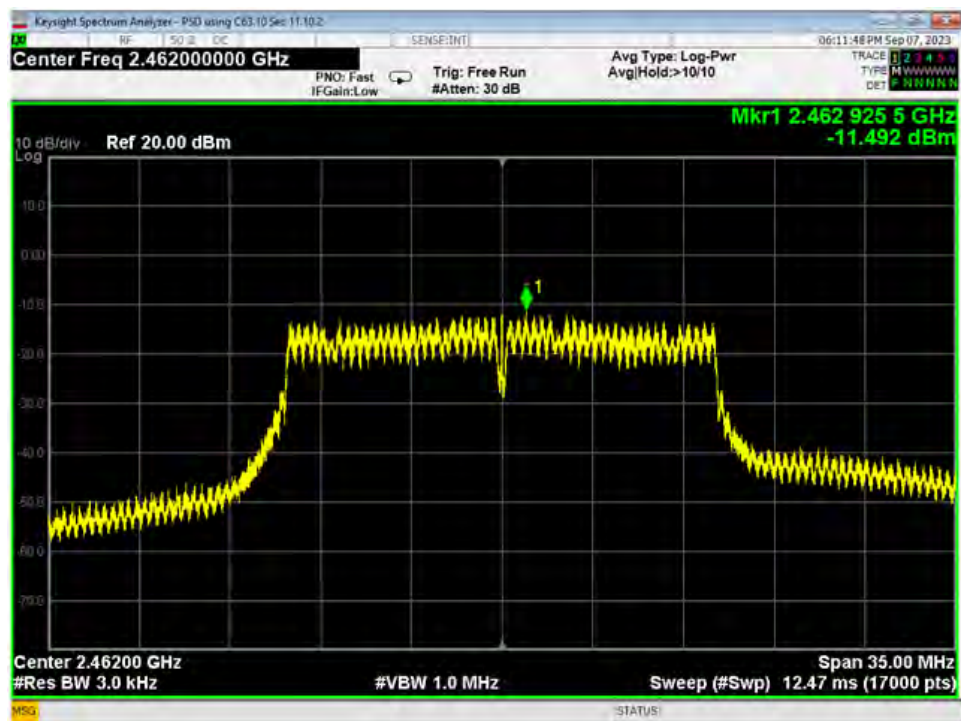
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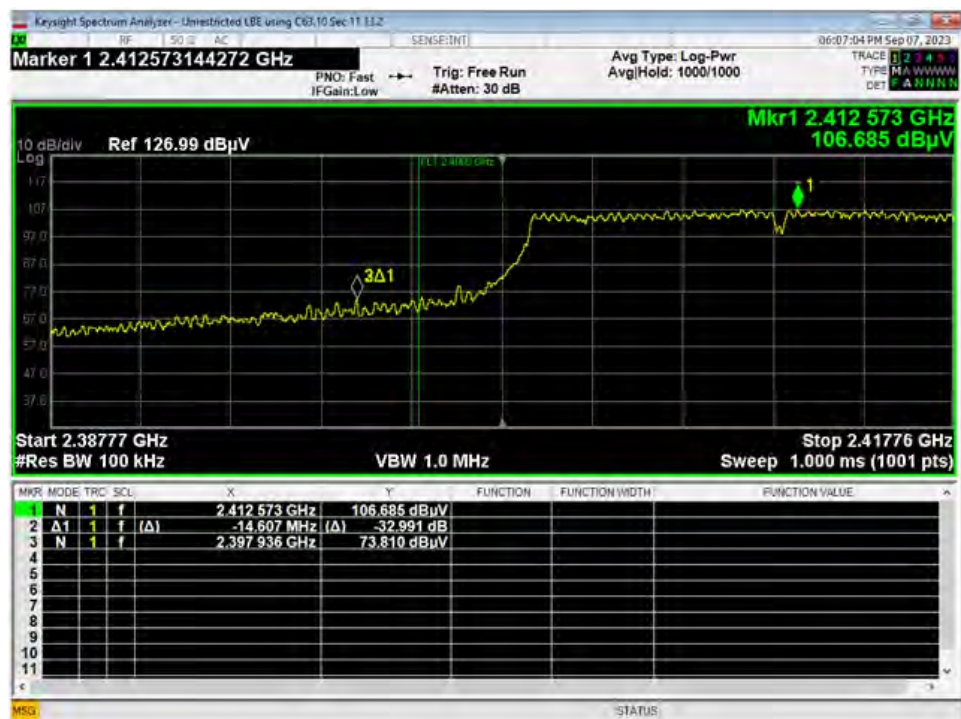
59 PSD, Low, Wifi G, High Data Rate



60 PSD, Mid, Wifi G, High Data Rate



61 PSD, High, Wifi G, High Data Rate

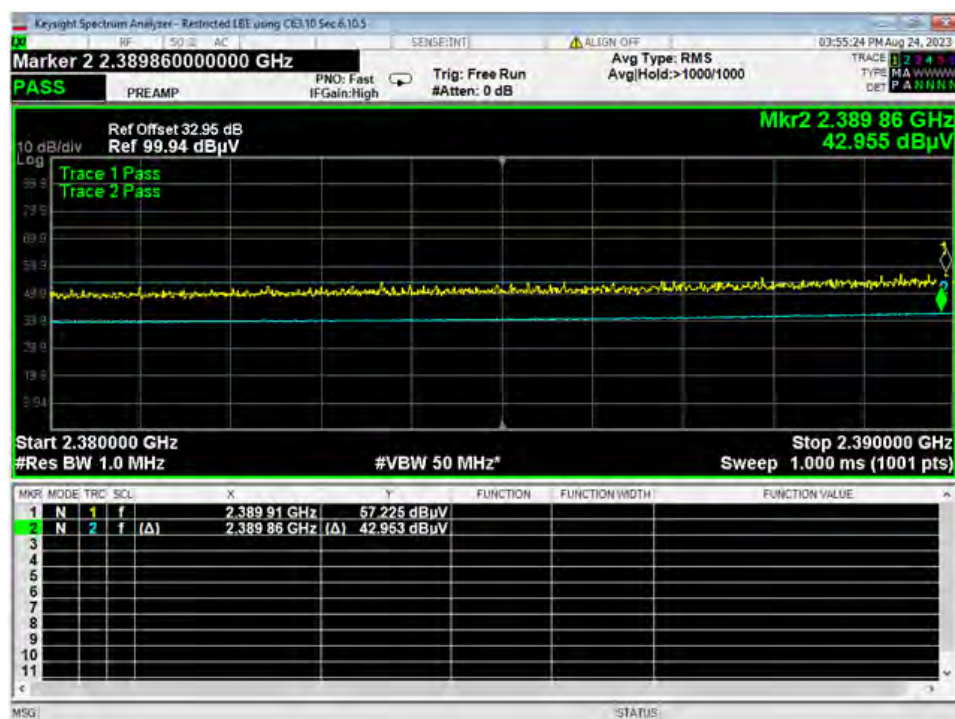


62 Lower Bandedge, Unrestricted, Wifi G, High Data Rate



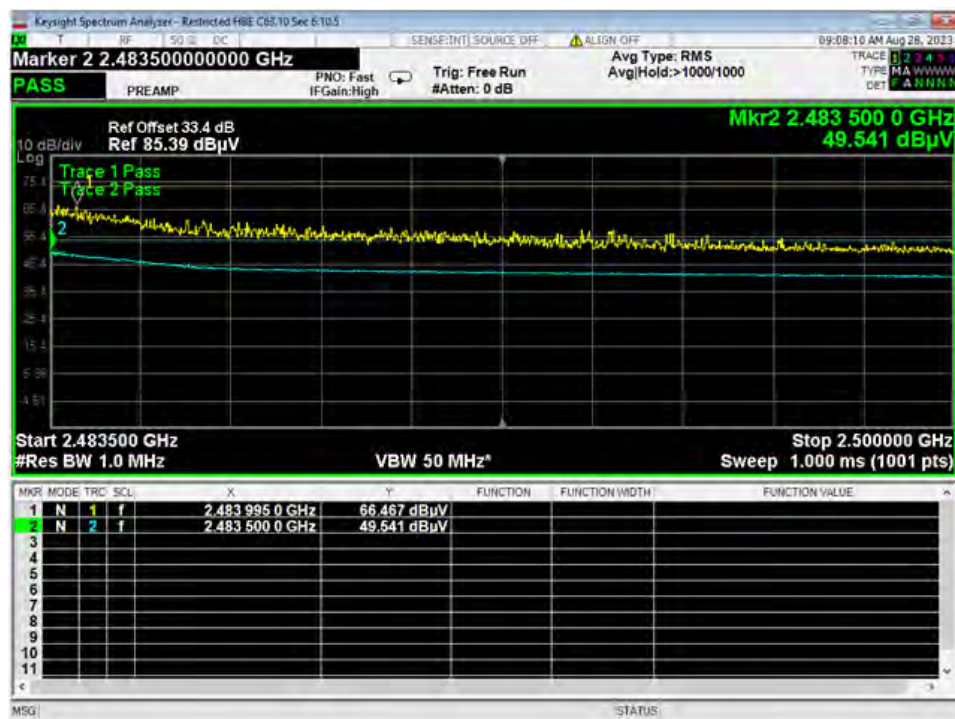


63 Higher Bandedge, Unrestricted, Wifi G, High Data Rate

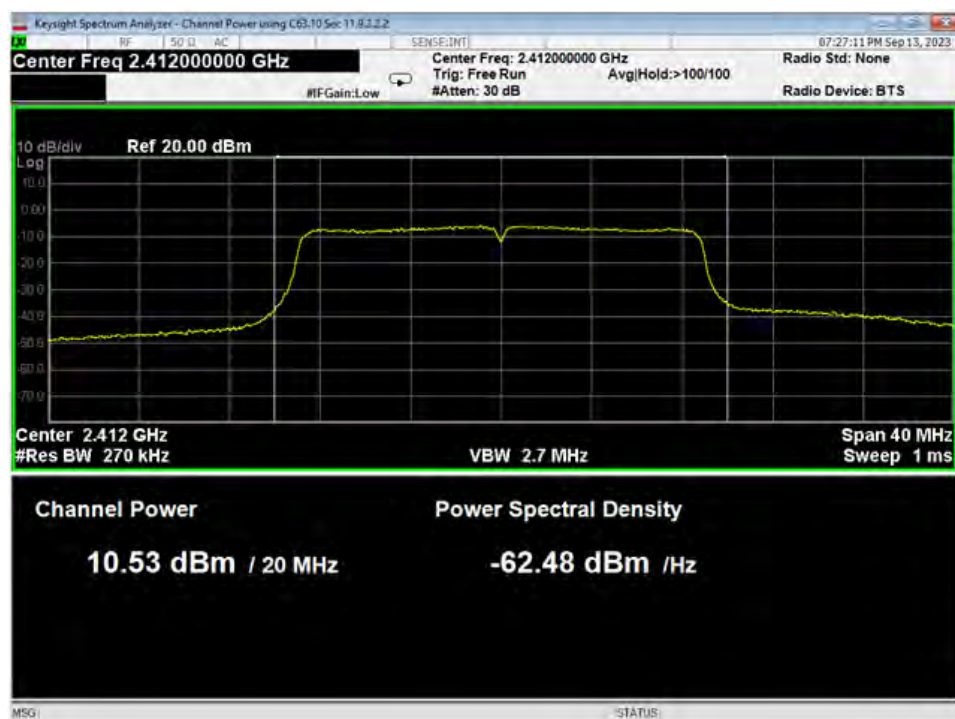


64 Lower Bandedge, Restricted, Wifi G, High Data Rate

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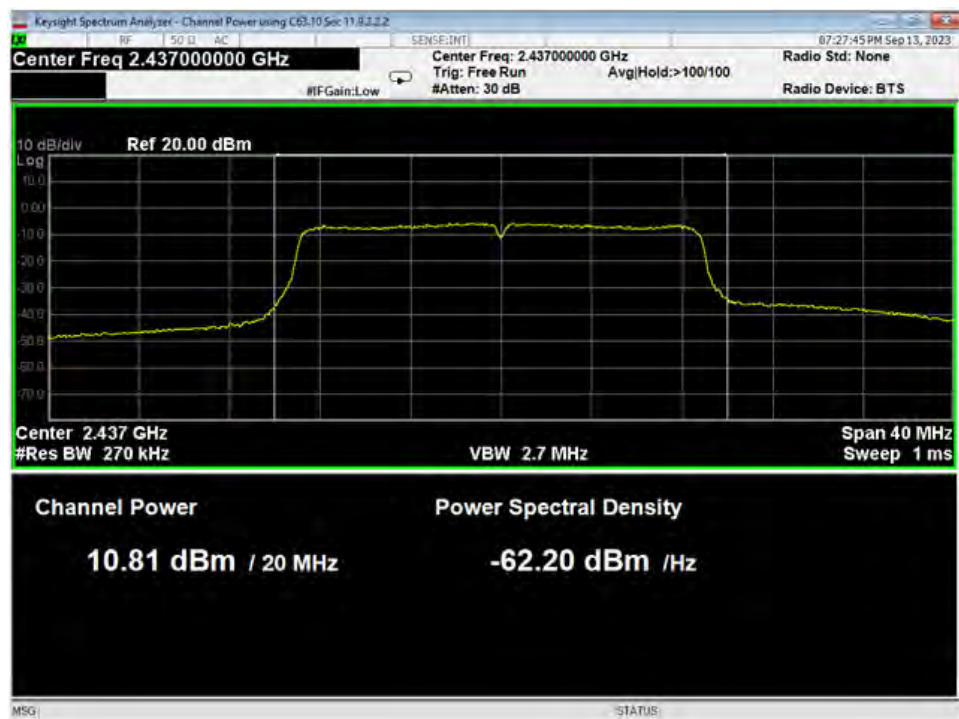


65 Higher Bandedge, Restricted, Wifi G, High Data Rate

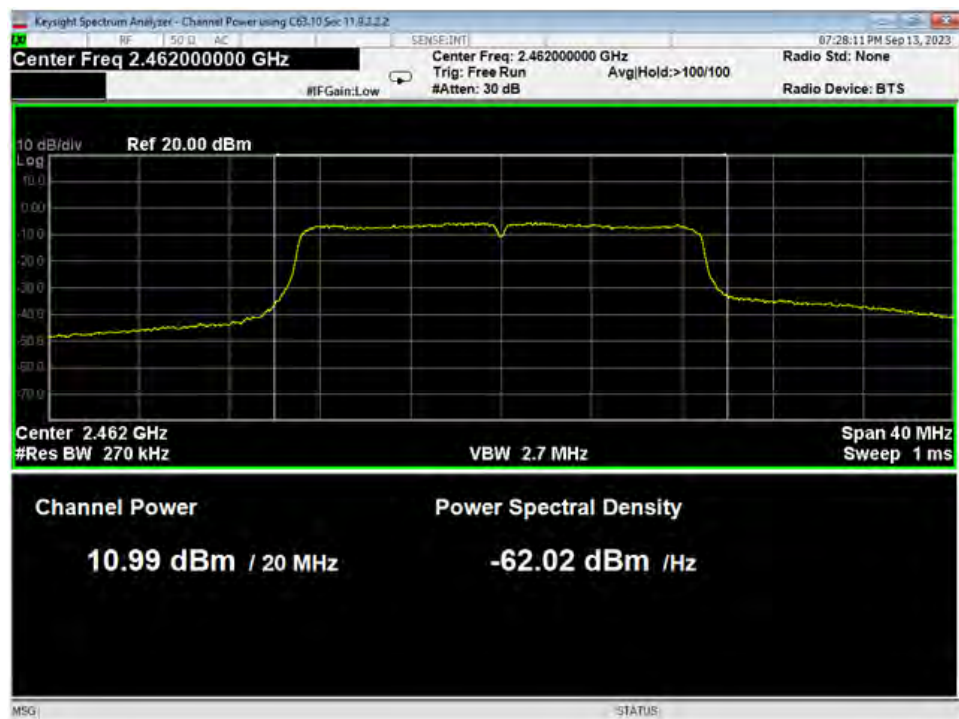


66 Average Power, Low, Wifi N, High Data Rate

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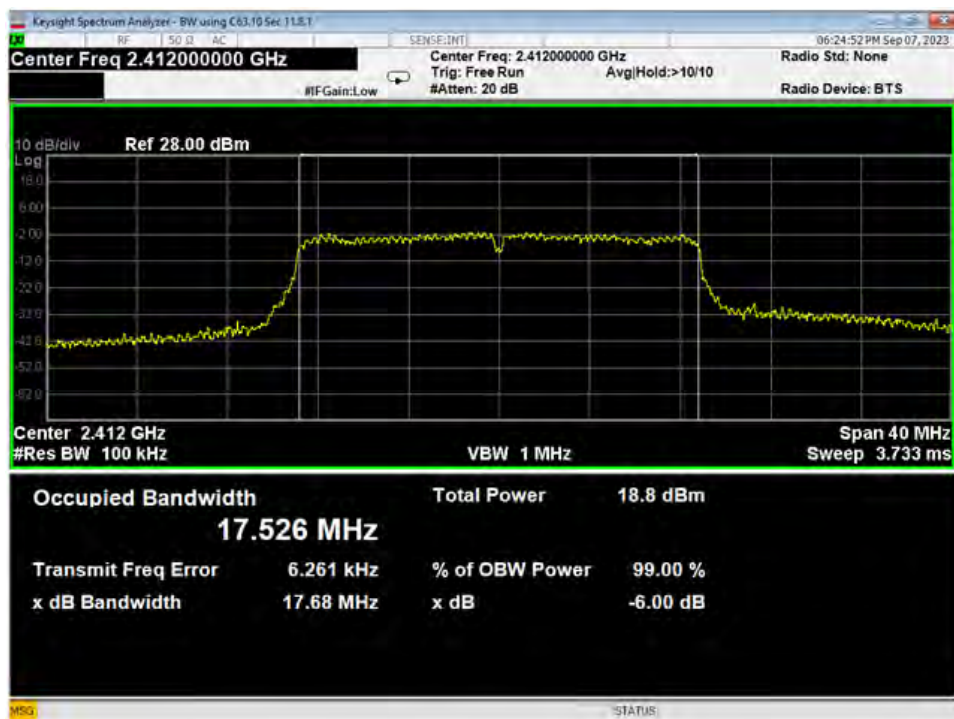


67 Average Power, Mid, Wifi N, High Data Rate

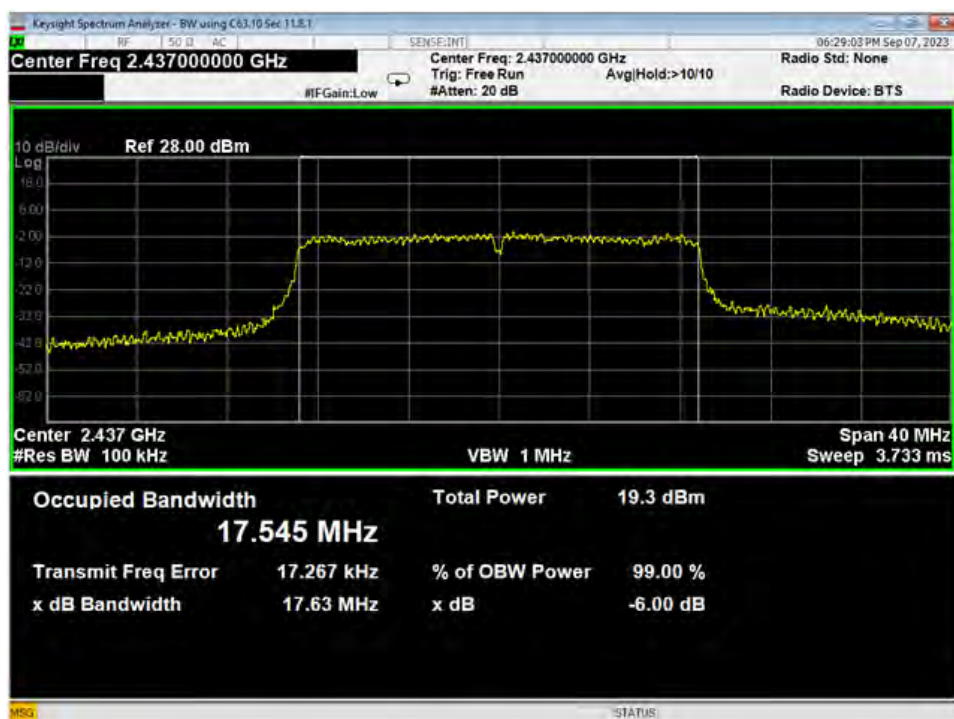


68 Average Power, High, Wifi N, High Data Rate

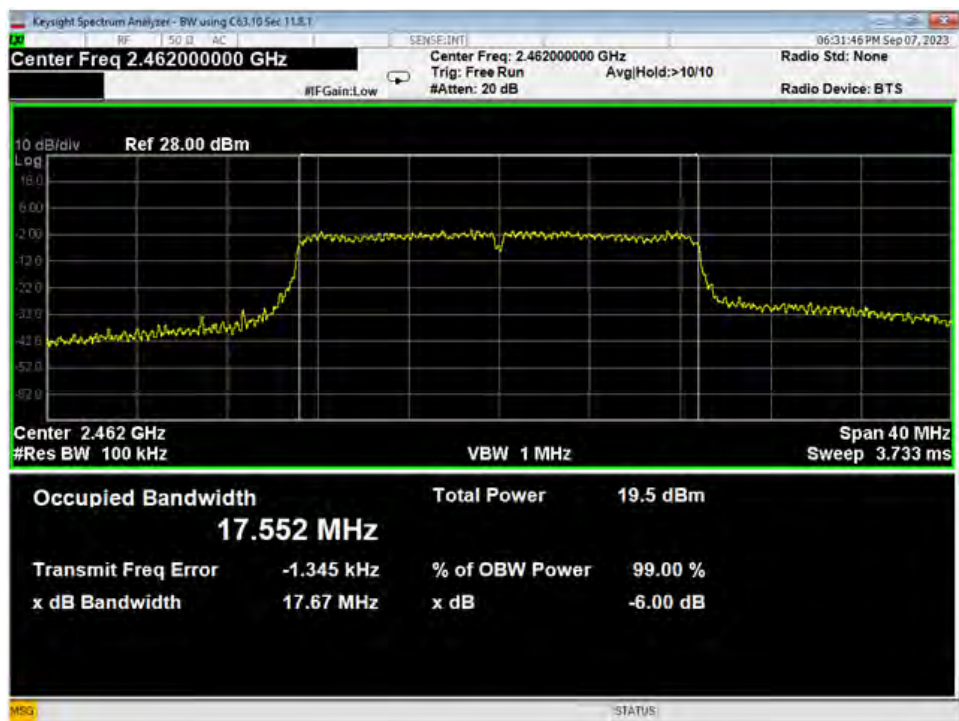




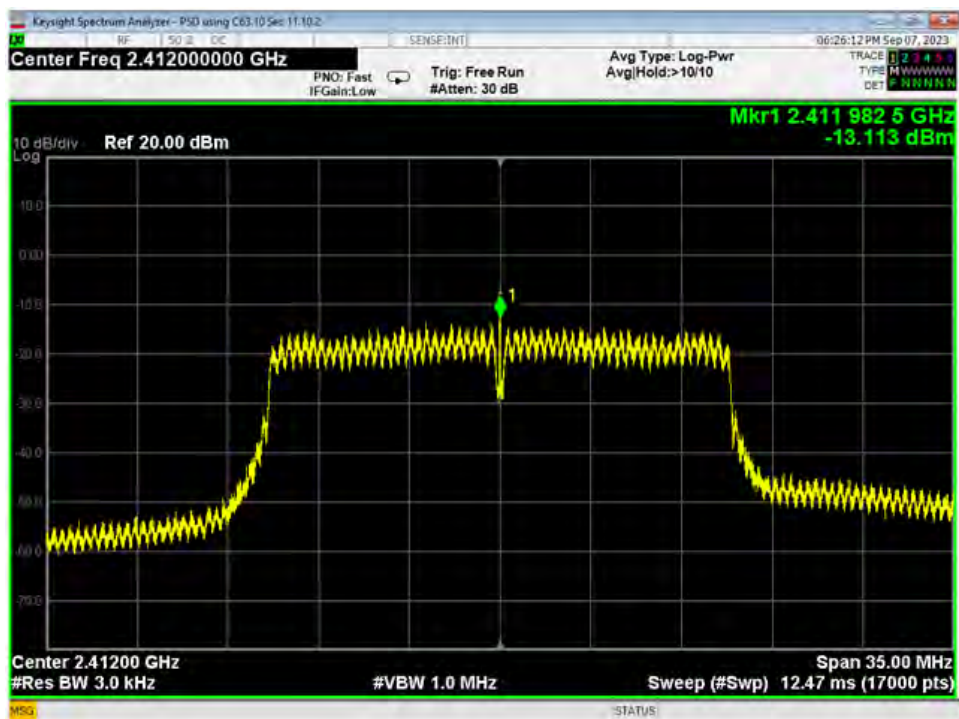
69 6dB Bandwidth, Low, Wifi N, High Data Rate



70 6dB Bandwidth, Mid, Wifi N, High Data Rate



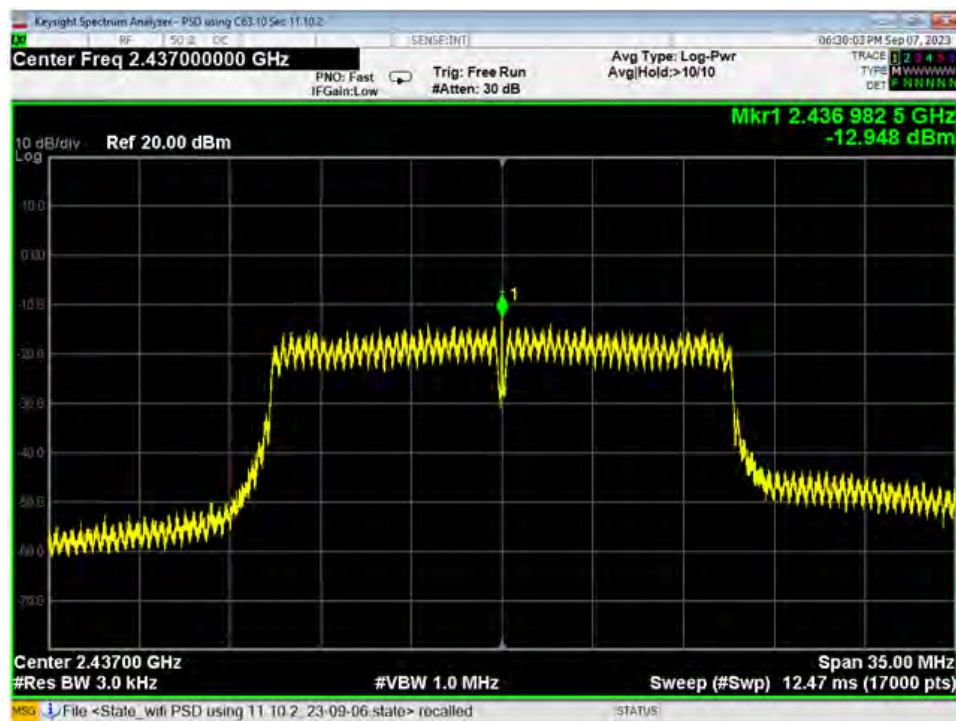
71 6dB Bandwidth, High, Wifi N, High Data Rate



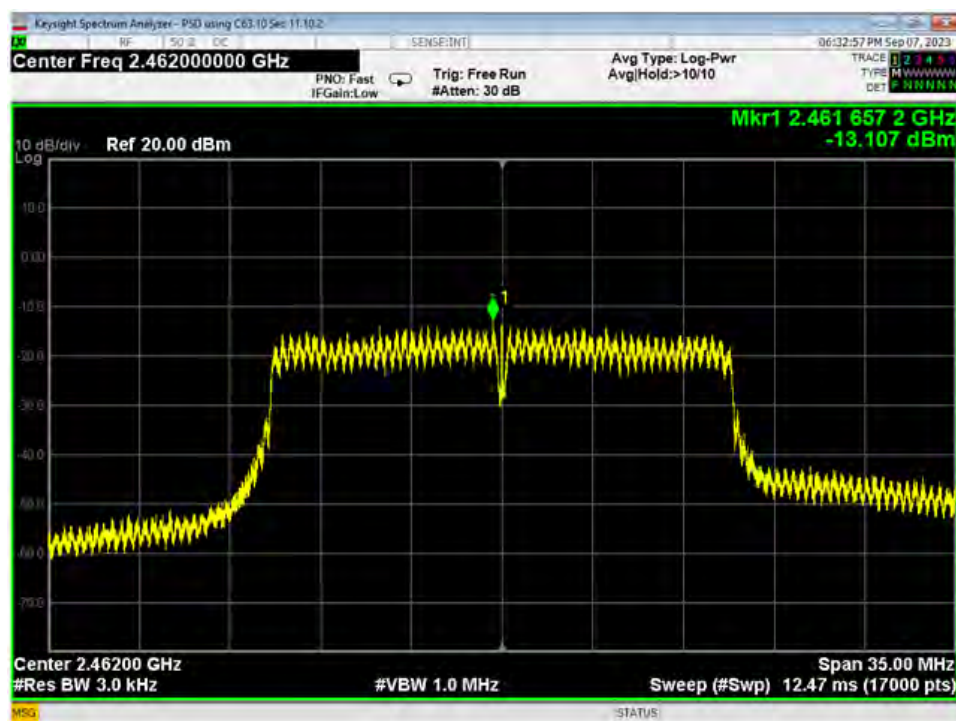
72 PSD, Low, Wifi N, High Data Rate



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73 PSD, Mid, Wifi N, High Data Rate



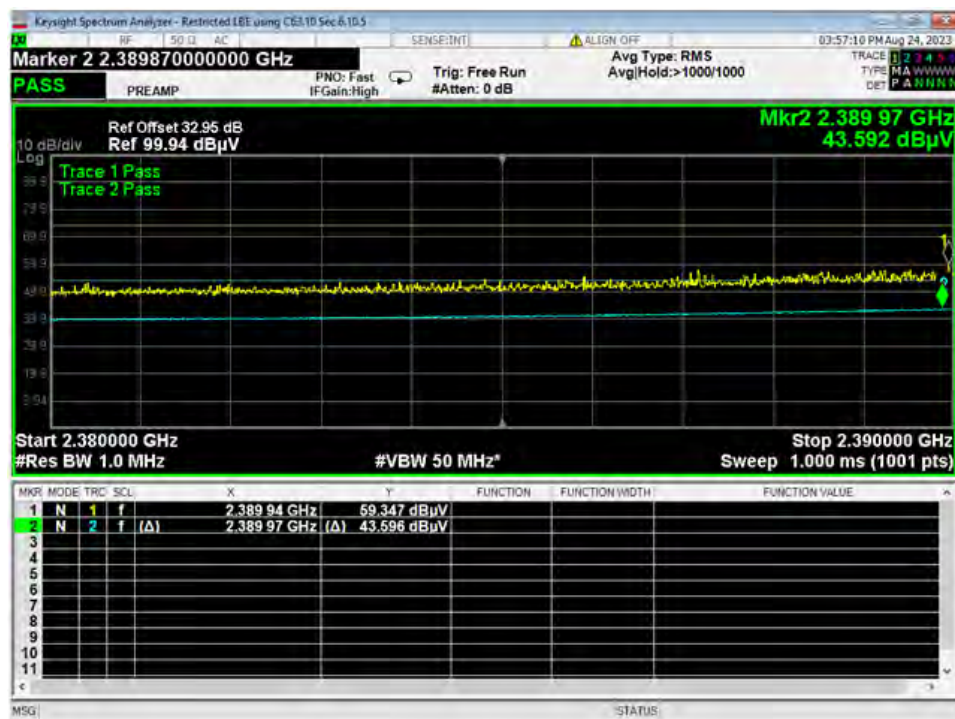
74 PSD, High, Wifi N, High Data Rate



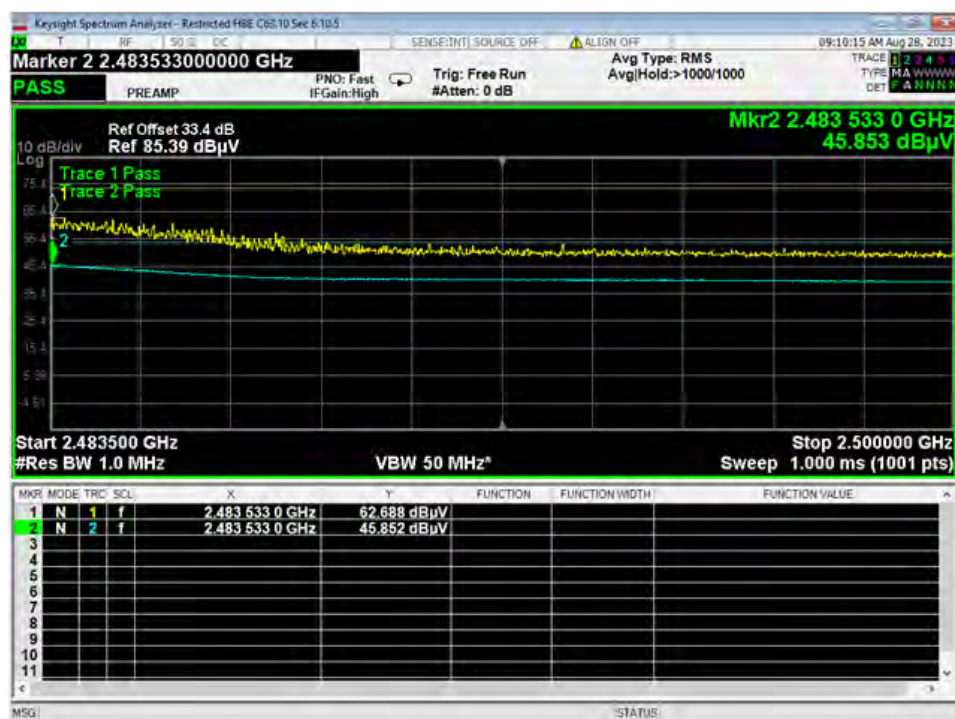
75 Lower Bandedge, Unrestricted, Wifi N, High Data Rate



76 Higher Bandedge, Unrestricted, Wifi N, High Data Rate



77 Lower Bandedge, Restricted, Wifi N, High Data Rate



78 Higher Bandedge, Restricted, Wifi N, High Data Rate





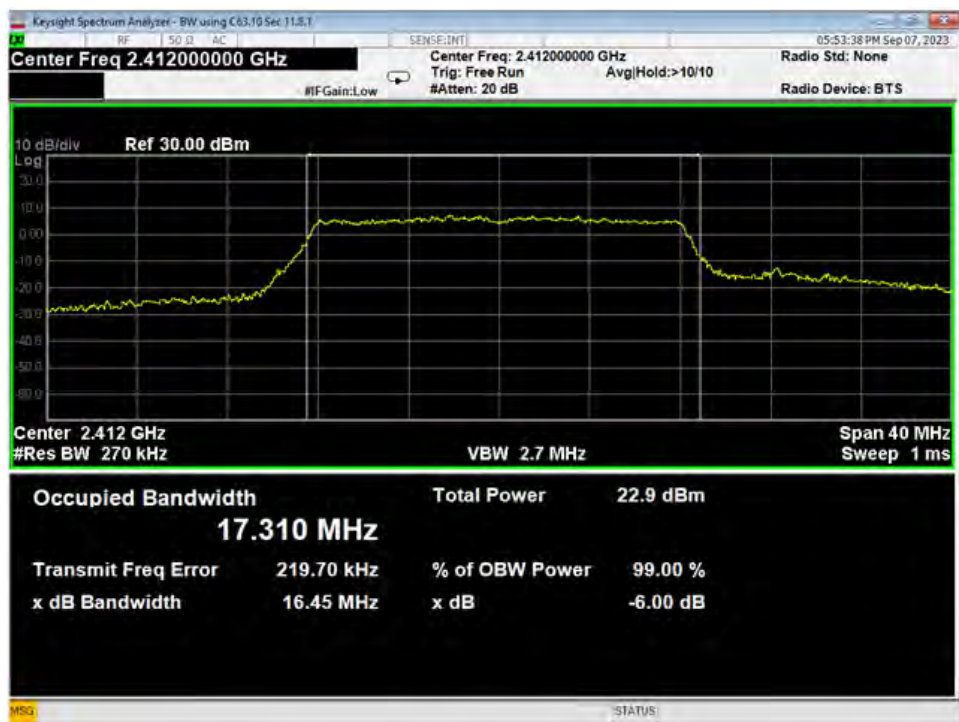
79 Occupied Bandwidth, Low, Wifi B, Low Data Rate



80 Occupied Bandwidth, Mid, Wifi B, Low Data Rate



81 Occupied Bandwidth, High, Wifi B, Low Data Rate

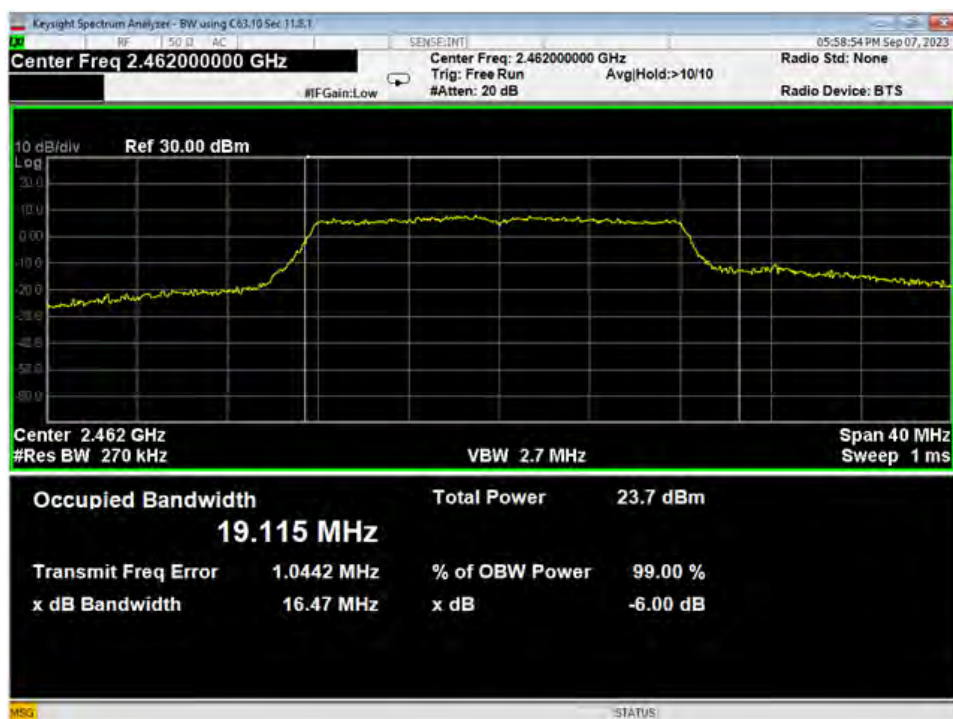


82 Occupied Bandwidth, Low, Wifi G, Low Data Rate

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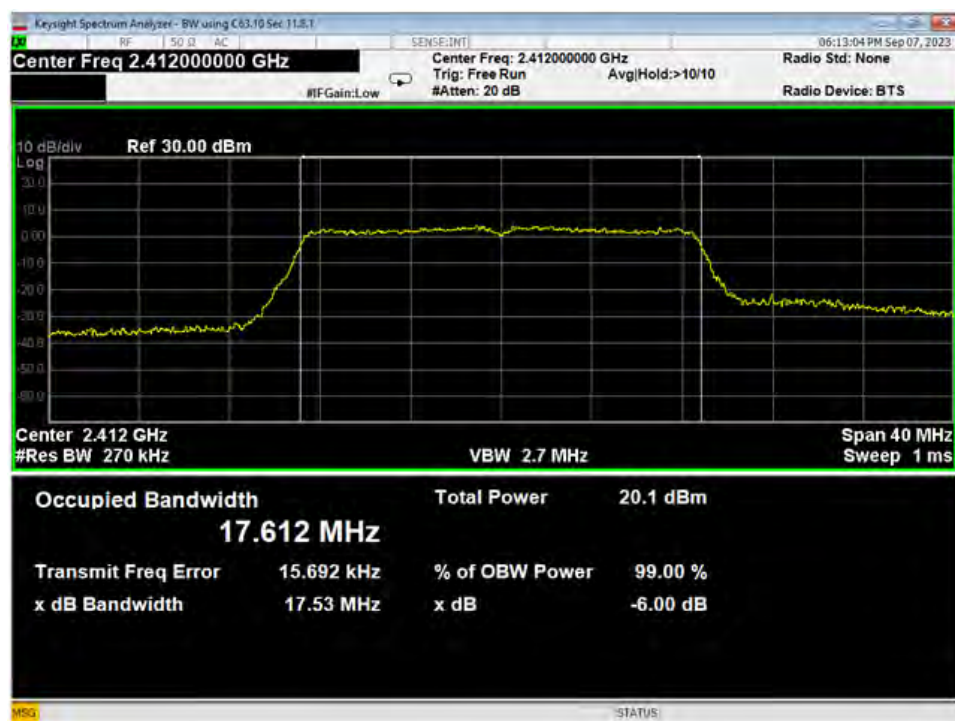


83 Occupied Bandwidth, Mid, Wifi G, Low Data Rate

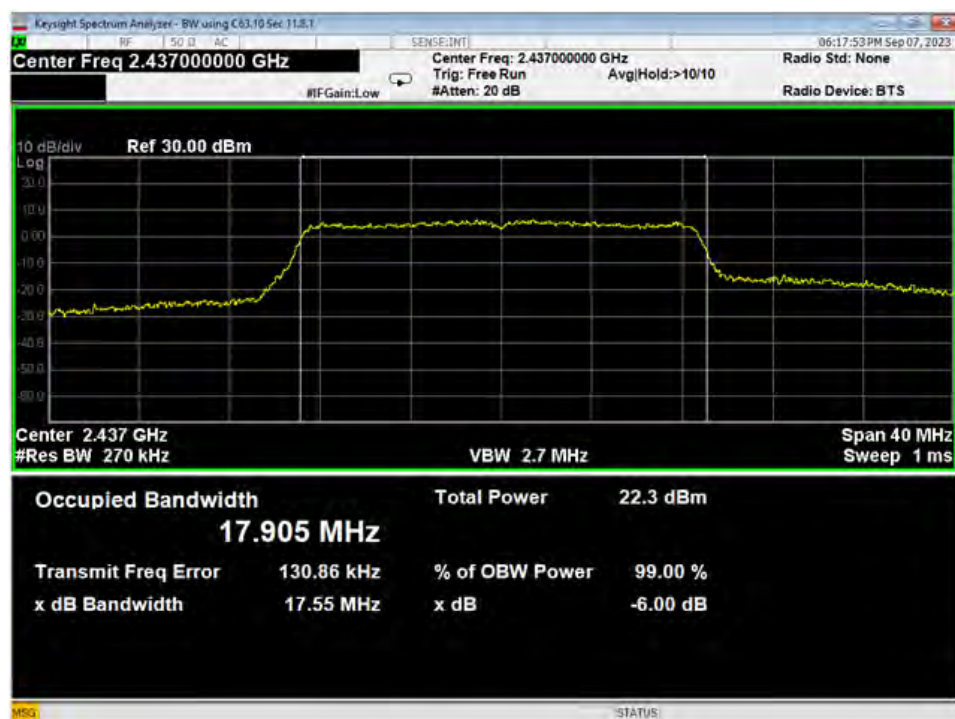


84 Occupied Bandwidth, High, Wifi G, Low Data Rate

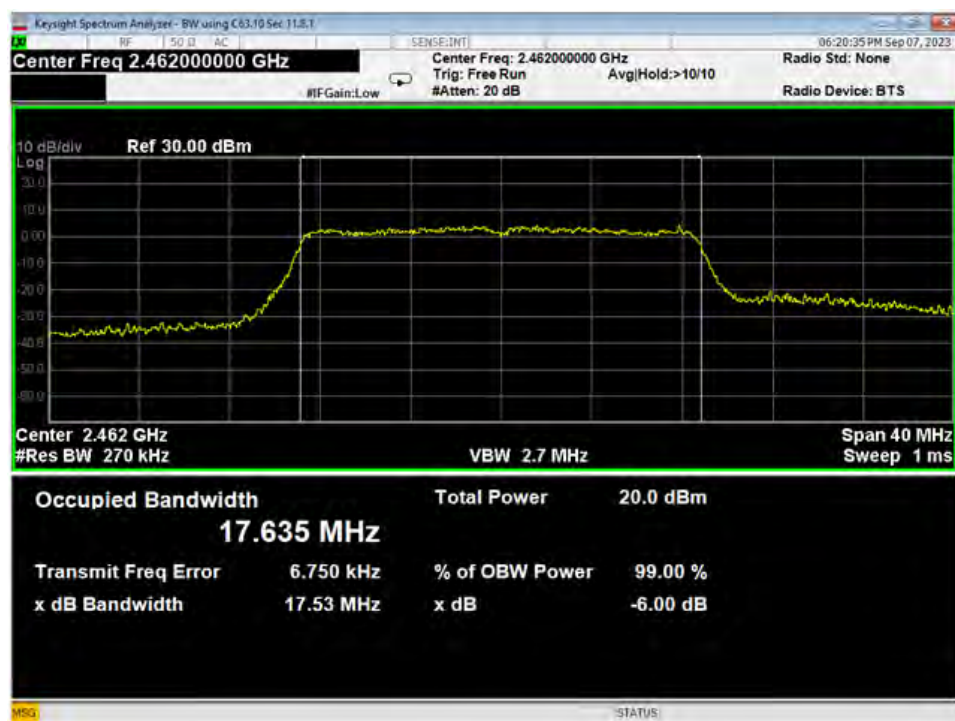




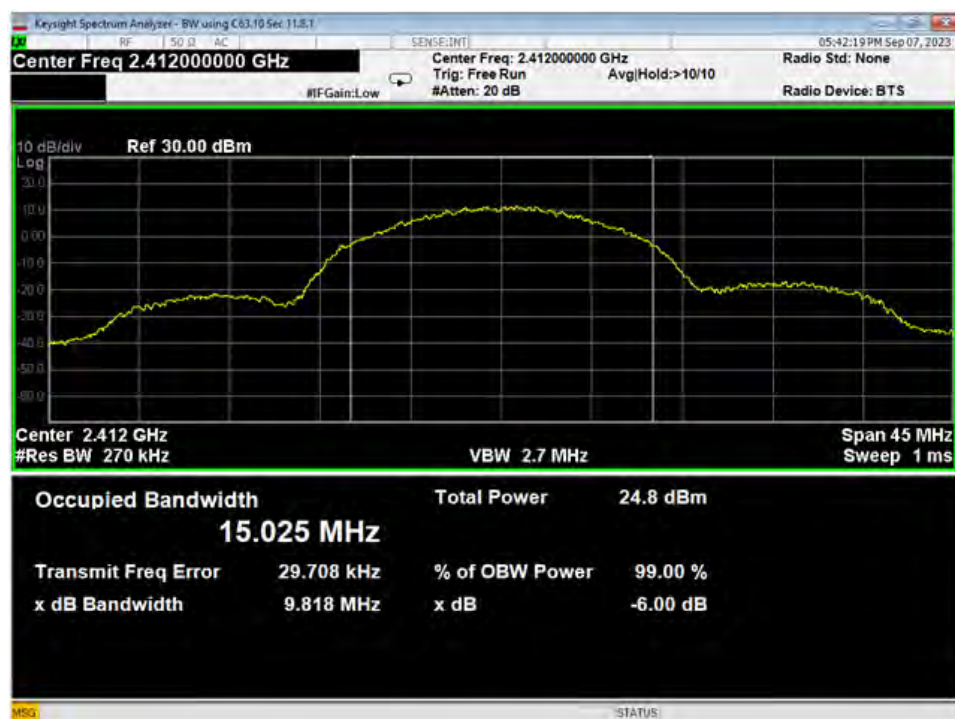
85 Occupied Bandwidth, Low, Wifi N, Low Data Rate



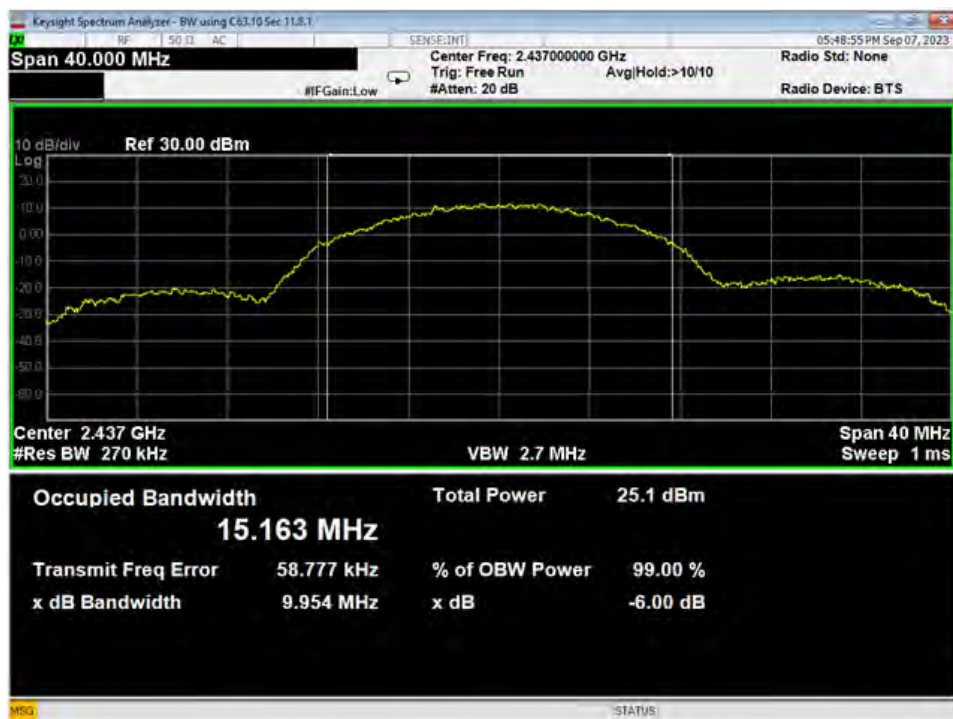
86 Occupied Bandwidth, Mid, Wifi N, Low Data Rate



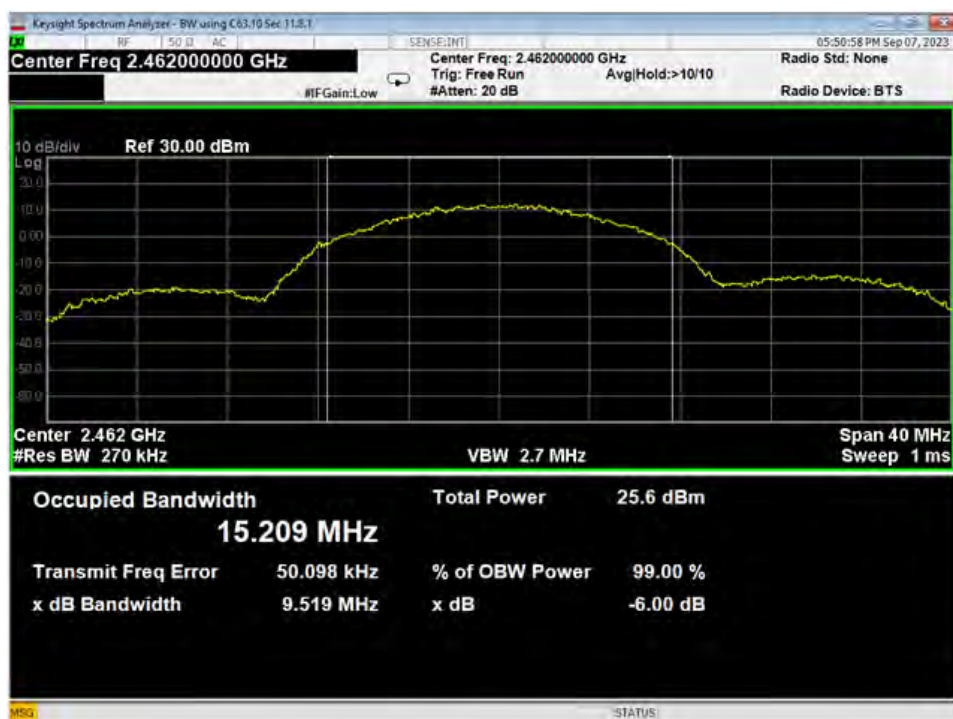
87 Occupied Bandwidth, High, Wifi N, Low Data Rate



88 Occupied Bandwidth, Low, Wifi B, High Data Rate

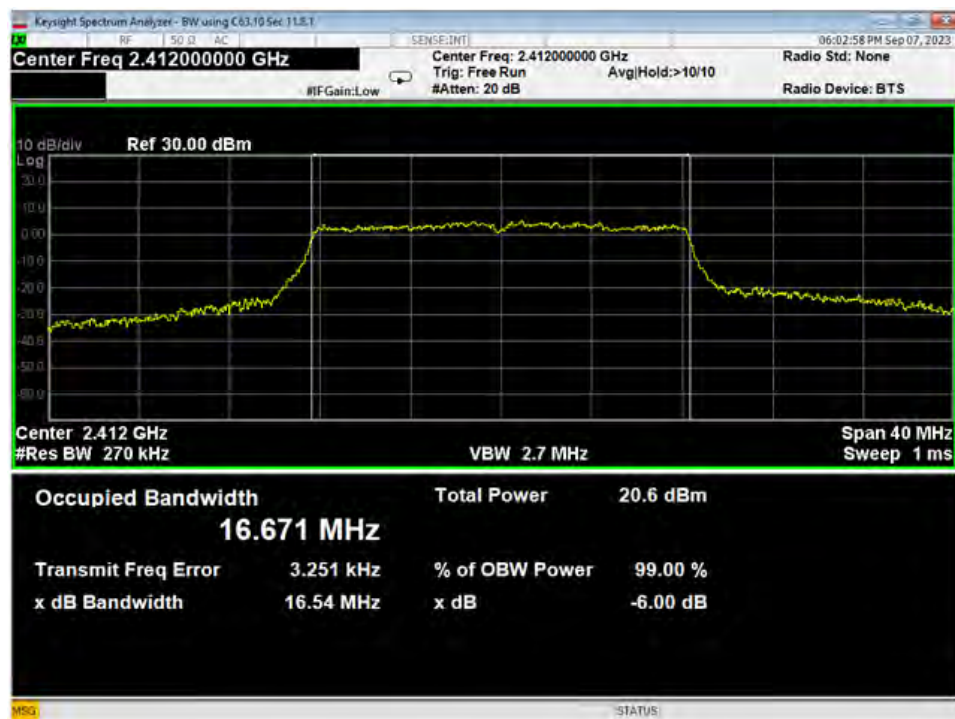


89 Occupied Bandwidth, Mid, Wifi B, High Data Rate

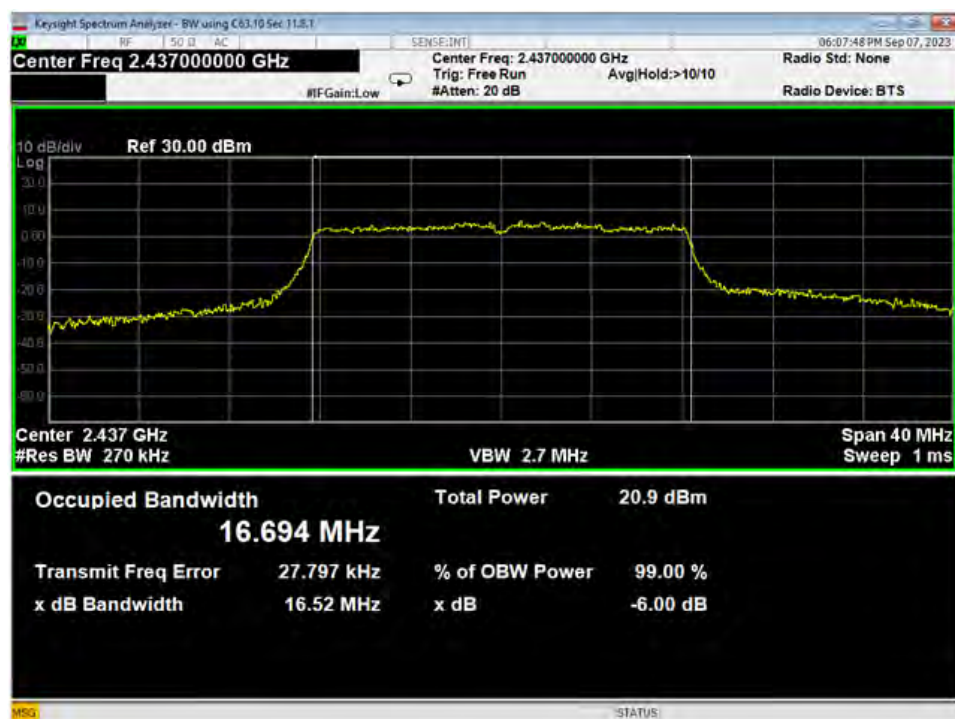


90 Occupied Bandwidth, High, Wifi B, High Data Rate

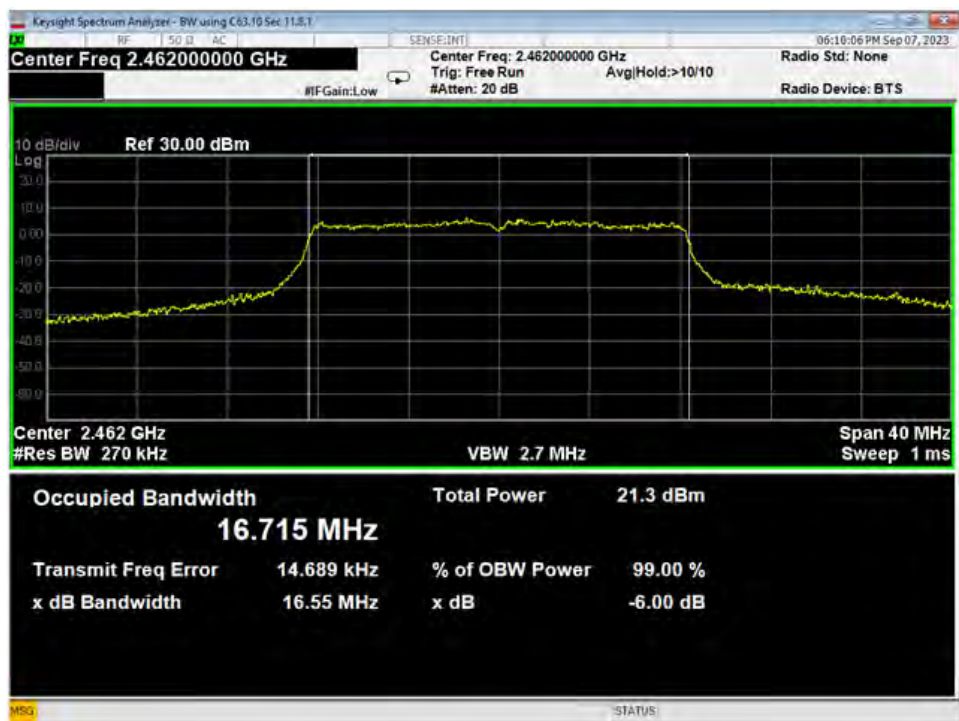




91 Occupied Bandwidth, Low, Wifi G, High Data Rate



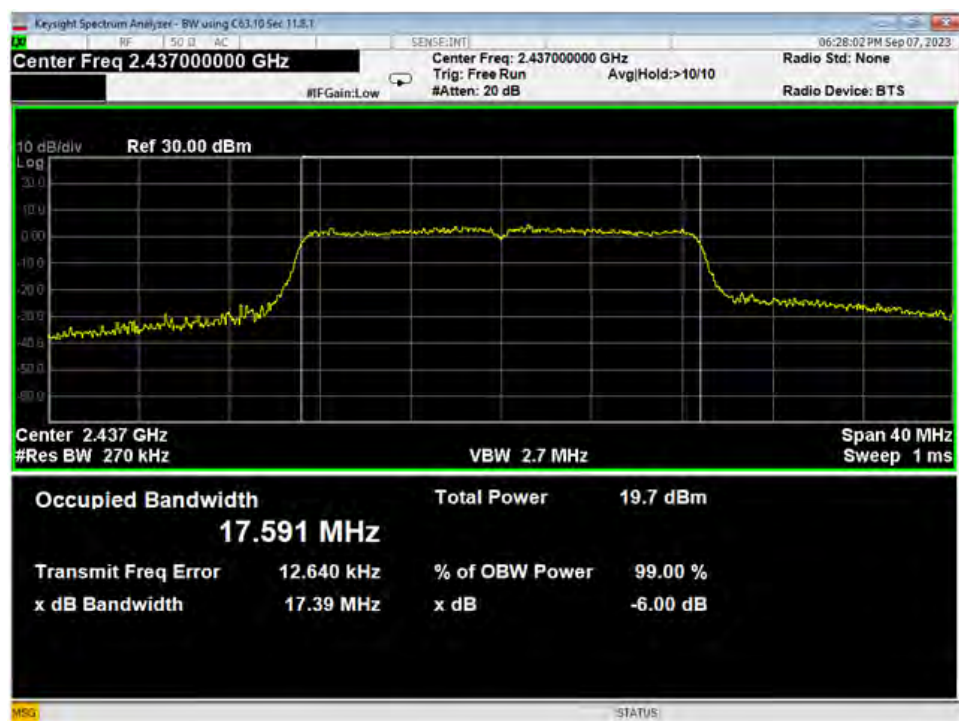
92 Occupied Bandwidth, Mid, Wifi G, High Data Rate



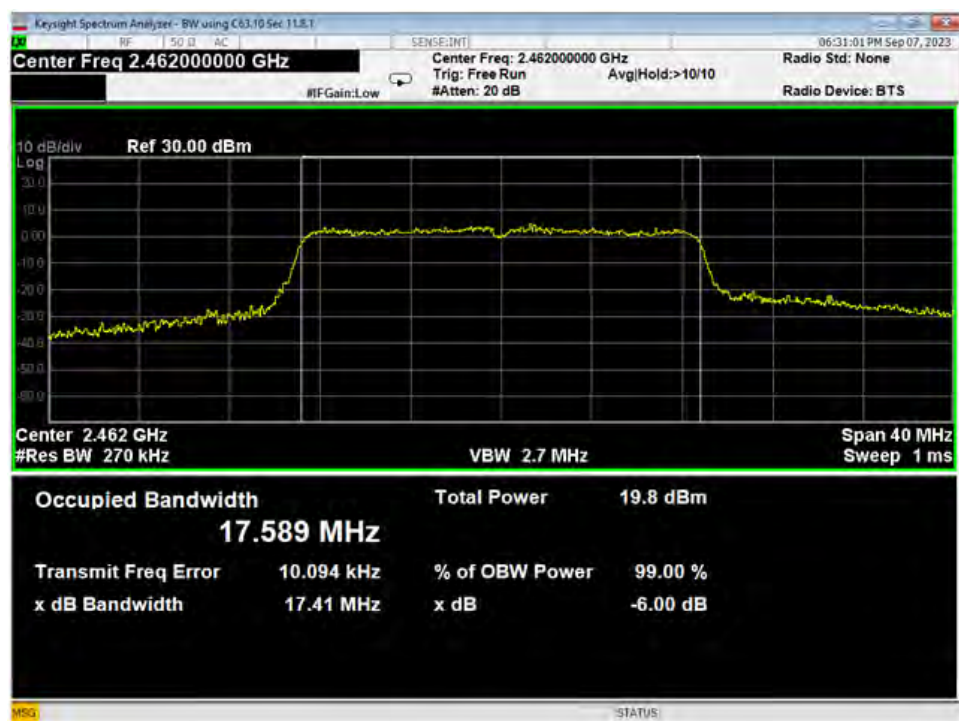
93 Occupied Bandwidth, High, Wifi G, High Data Rate



94 Occupied Bandwidth, Low, Wifi N, High Data Rate



95 Occupied Bandwidth, Mid, Wifi N, High Data Rate



96 Occupied Bandwidth, High, Wifi N, High Data Rate





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