4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

FCC/ISED Test Report

Prepared for: Garmin International, Inc.

Address: 1200 E. 151st Street
Olathe, Kansas, 66062, USA

Product: A04109

Test Report No: R20230926-21-E4

Approved by:

Fox Lane
EMC Test Engineer

DATE: May 2, 2023

Total Pages: 138

REVISION PAGE

Rev. No.	Date	Description
0	2 May 2023	Issued by FLane Reviewed by KVepuri Prepared by FLane, GLarsen

CONTENTS

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) ISED RSS-Gen, Issue 5
(3) ISED RSS-247, Issue 2

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 2 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	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 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04109
IC	IPH-04109
FCC ID	1792A-04109
EUT Received	3 March 2023
EUT Tested	3 March 2023- 17 April 2023
Serial No.	FF7 (Radiated Measurements) 010966 (Lab Assigned Serial Number) (Conducted Measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	☐ GMSK ☐ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☒ 802.11x
Power Supply / Voltage	30VDC lithium battery pack

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 frequency and designations.

2.3 DESCRIPTION OF SUPPORT UNITS

None

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 ± 4%
Temperature of 22 ± 3° 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	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing and Report

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

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 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	July 26, 2022	July 26, 2023
EMCO Horn Antenna	3115	6416	July 28, 2021	July 28, 2022
EMCO Horn Antenna***	3116	2576	March 9, 2020	March 9, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preamplifier**	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	March 21, 2022	March 21, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)*	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

*Internal Characterization
**2 Year Cal Cycle
***3 Year Cal Cycle

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

3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

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 the 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.

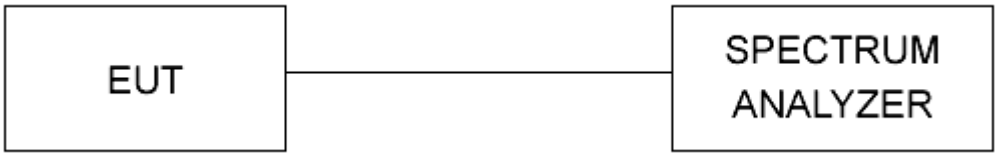


Figure 1 - Bandwidth Measurements Test Setup

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 the 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.

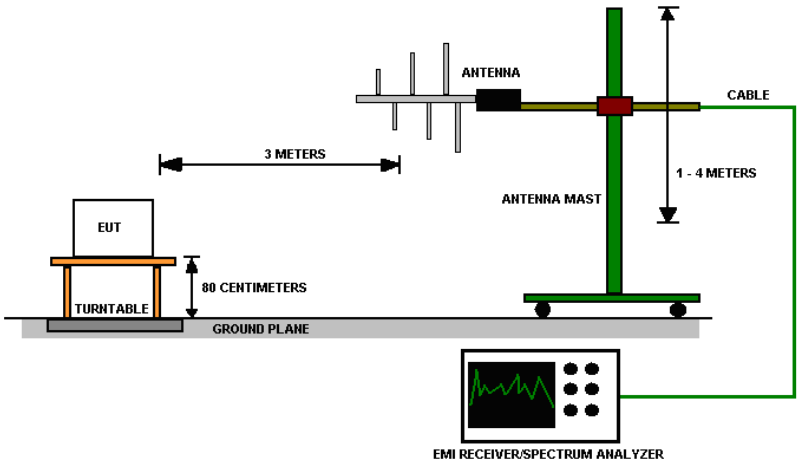


Figure 2 - Radiated Emissions Test Setup

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	14.02	9.07	15.650	36.728	2.179	PASS
Mid	802.11 b	14.04	9.11	17.090	51.168	-4.365	PASS
High	802.11 b	13.66	8.60	15.980	39.628	-5.178	PASS
Low	802.11 g	16.78	15.37	11.480	14.060	-12.426	PASS
Mid	802.11 g	17.32	15.49	16.440	44.055	-7.275	PASS
High	802.11 g	16.72	15.50	11.900	15.488	-10.591	PASS
Low	802.11 n	17.82	15.45	10.960	12.474	-12.398	PASS
Mid	802.11 n	18.10	15.47	15.970	39.537	-8.295	PASS
High	802.11 n	17.78	15.97	11.450	13.964	-12.649	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 (dBuV)**	**Relative Fundamental (dBuV)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	802.11 b	2400.00	65.47	106.14	40.67	30.00	PASS
Low	802.11 g	2400.00	63.70	99.38	35.68	30.00	PASS
Low	802.11 n	2400.00	62.81	99.01	36.20	30.00	PASS
High	802.11 b	2483.50	42.82	105.73	62.91	30.00	PASS
High	802.11 g	2483.50	47.33	99.09	51.76	30.00	PASS
High	802.11 n	2483.50	48.05	98.48	50.43	30.00	PASS

Radiated Peak Restricted Band-Edge Low Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	53.94	Peak	73.98	20.04	PASS
Low	802.11 g	2390.00	59.56	Peak	73.98	14.42	PASS
Low	802.11 n	2390.00	66.35	Peak	73.98	7.63	PASS
High	802.11 b	2483.50	55.07	Peak	73.98	18.91	PASS
High	802.11 g	2483.50	65.49	Peak	73.98	8.49	PASS
High	802.11 n	2483.50	67.02	Peak	73.98	6.96	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Average Restricted Band-Edge, Low Data Rate									
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**DCCF (For Emissions)**	**Corrected Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	42.09	0.36	42.44	Average	53.98	11.54	PASS
Low	802.11 g	2390.00	44.08	0.34	44.42	Average	53.98	9.56	PASS
Low	802.11 n	2390.00	45.79	1.17	46.96	Average	53.98	7.02	PASS
High	802.11 b	2483.50	43.67	0.36	44.02	Average	53.98	9.96	PASS
High	802.11 g	2483.50	45.56	0.34	45.89	Average	53.98	8.09	PASS
High	802.11 n	2483.50	47.42	1.17	48.59	Average	53.98	5.39	PASS
*Limit shown is the average limit taken from FCC Part 15.209									

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	13.44	8.83	15.480	35.318	-5.969	PASS
Mid	802.11 b	13.43	9.19	16.920	49.204	-4.735	PASS
High	802.11 b	13.37	8.05	15.770	37.757	-6.254	PASS
Low	802.11 g	16.54	16.38	9.840	9.638	-13.489	PASS
Mid	802.11 g	16.63	16.36	15.220	33.266	-8.224	PASS
High	802.11 g	16.55	16.36	10.370	10.889	-12.466	PASS
Low	802.11 n	17.71	17.18	8.940	7.834	-13.653	PASS
Mid	802.11 n	17.72	17.54	14.120	25.823	-8.023	PASS
High	802.11 n	17.69	16.37	9.240	8.395	-13.72	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 (dBuV)**	**Relative Fundamental (dBuV)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	802.11 b	2400.00	64.17	104.87	40.71	30.00	PASS
Low	802.11 g	2400.00	59.31	98.69	39.38	30.00	PASS
Low	802.11 n	2400.00	57.96	99.09	41.13	30.00	PASS
High	802.11 b	2483.50	43.75	104.44	60.69	30.00	PASS
High	802.11 g	2483.50	49.67	98.74	49.07	30.00	PASS
High	802.11 n	2483.50	49.82	98.84	49.03	30.00	PASS

Radiated Peak Restricted Band-Edge High Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	54.07	Peak	73.98	19.92	PASS
Low	802.11 g	2390.00	58.56	Peak	73.98	15.42	PASS
Low	802.11 n	2390.00	60.30	Peak	73.98	13.68	PASS
High	802.11 b	2483.50	63.21	Peak	73.98	10.78	PASS
High	802.11 g	2483.50	63.65	Peak	73.98	10.33	PASS
High	802.11 n	2483.50	63.99	Peak	73.98	9.99	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Average Restricted Band-Edge, with DCCF									
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Average Highest out of band level (dBuV/m @ 3m)**	**DCCF (For Emissions)**	**Corrected Average Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)***	**Margin**	**Result**
Low	802.11 b	2390.00	42.02	0.97	42.99	Average	53.98	10.99	PASS
Low	802.11 g	2390.00	43.60	3.99	47.59	Average	53.98	6.39	PASS
Low	802.11 n	2390.00	43.08	6.16	49.24	Average	53.98	4.74	PASS
High	802.11 b	2483.50	43.21	0.97	44.18	Average	53.98	9.80	PASS
High	802.11 g	2483.50	46.56	3.99	50.55	Average	53.98	3.43	PASS
High	**802.11 n**	**2483.50**	**46.62**	**6.16**	**52.78**	**Average**	**53.98**	**1.20**	**PASS**

*Limit shown is the average limit taken from FCC Part 15.209
For more information on DCCF, see Sec 4.3

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.

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 purpose 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.

4.3 DUTY CYCLE

Test Method:

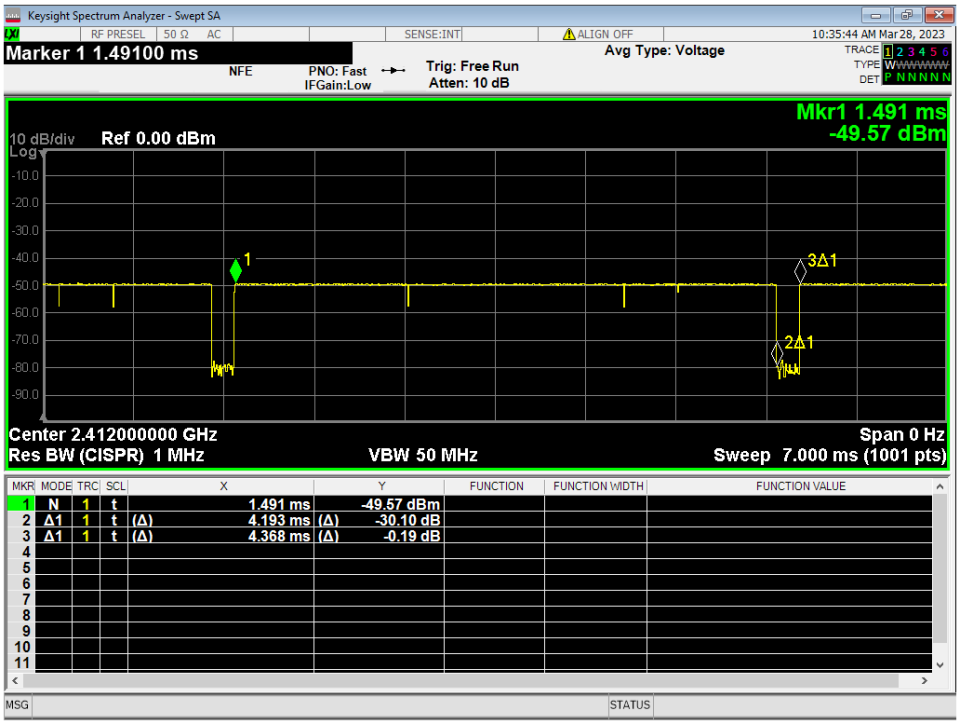


Figure 3 - Duty Cycle, WIFI B 1MB

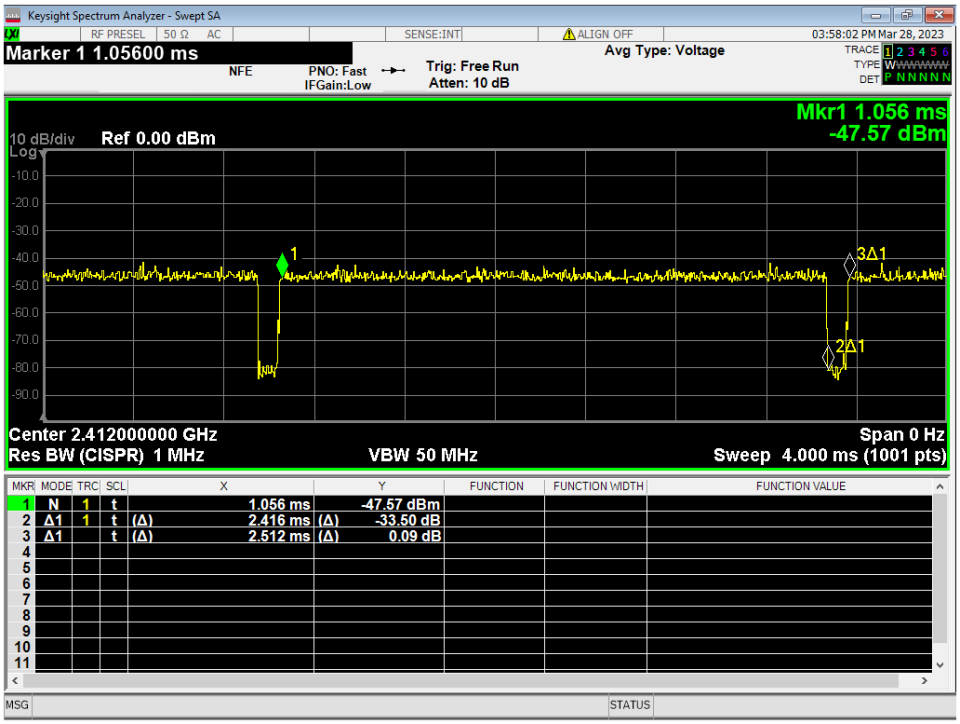


Figure 4 - Duty Cycle, WIFI G 6MHz

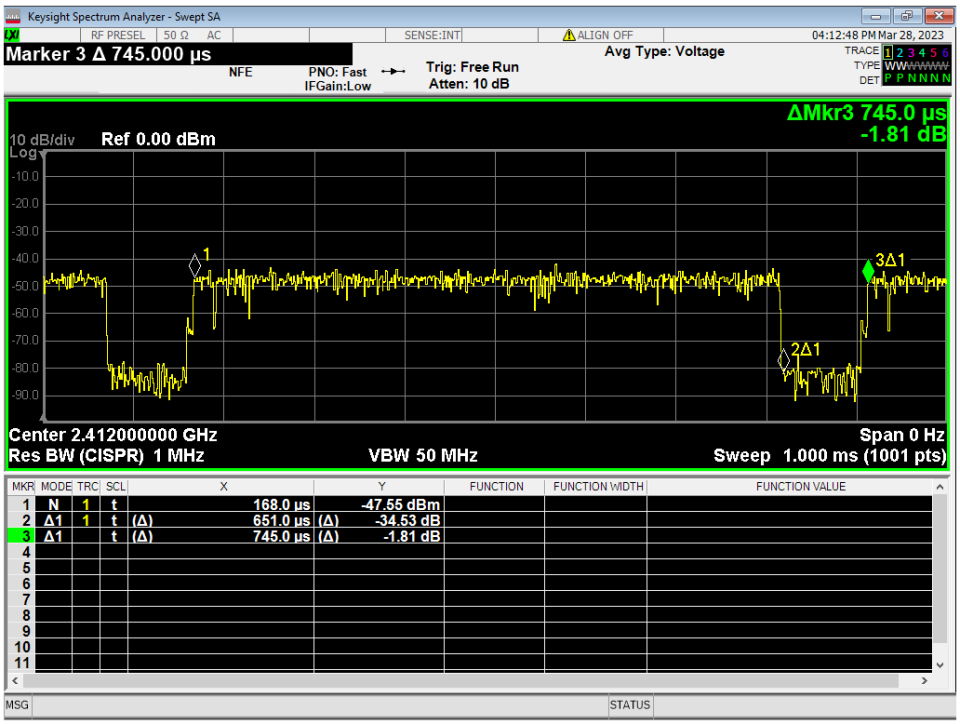


Figure 5 - Duty Cycle, WIFI N MCS0

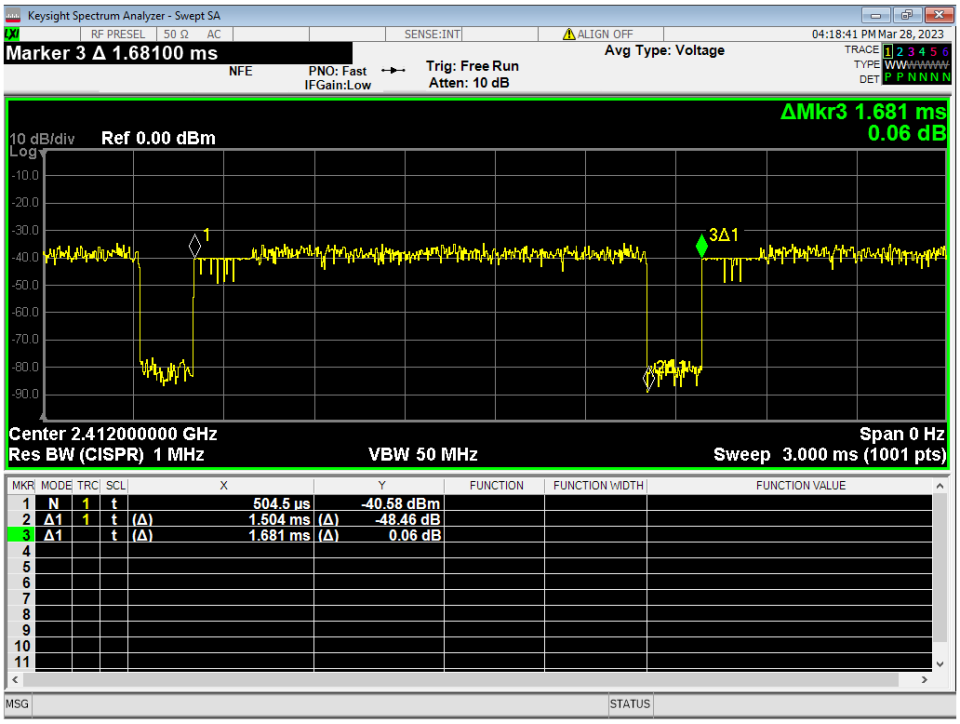


Figure 6 - Duty Cycle, WIFI B 11MB

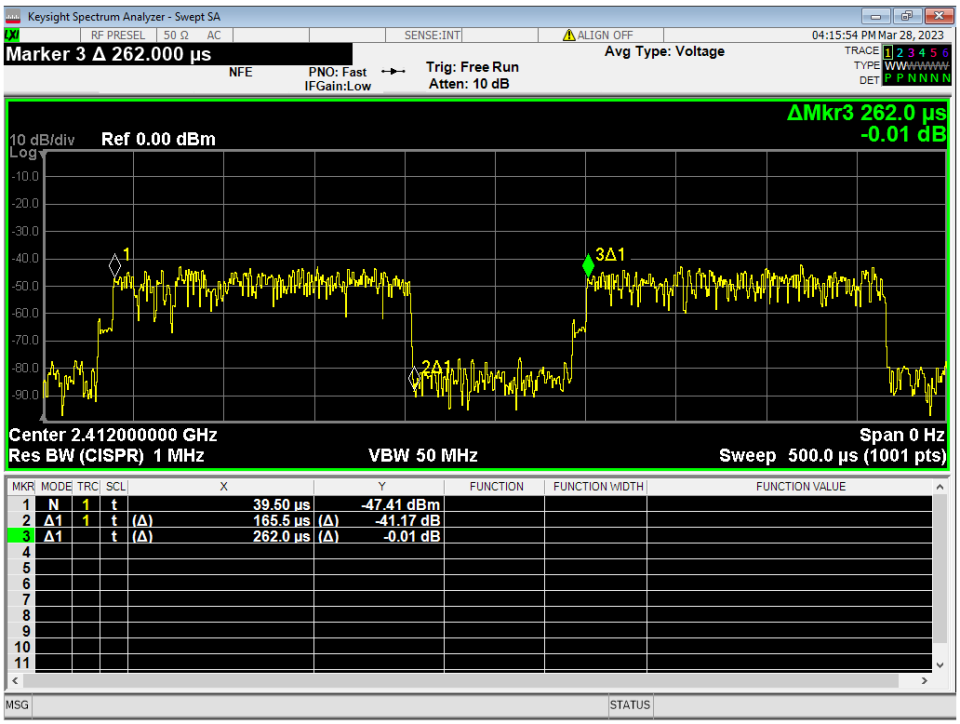


Figure 7 - Duty Cycle, WIFI G 54MHz

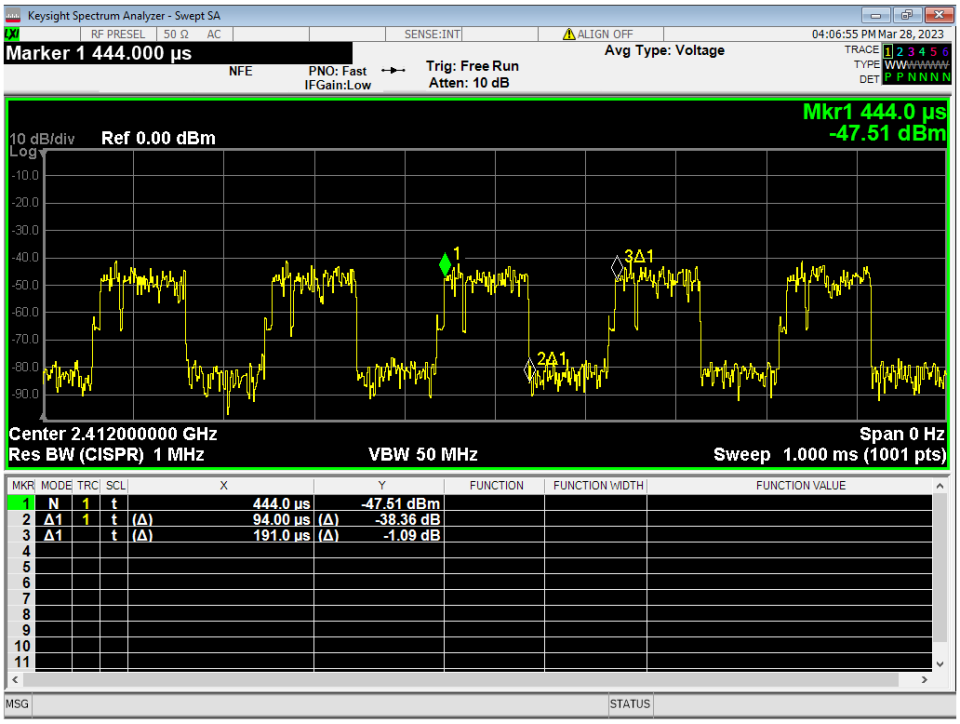


Figure 8 - Duty Cycle, WIFI N MCS7

The following duty cycle and duty cycle correction factors (DCCF) were used where applicable.

Duty Cycle correction factor (for emissions) = 20 * log(1 / Duty cycle)
Duty Cycle correction factor (for power) = 10 * log(1 / Duty cycle)

Duty Cycle for WIFI B 1MB: **0.960**
Duty cycle correction factor (for emissions) for WIFI B 1MB: **0.36**
Duty cycle correction factor (for power) for WIFI B 1MB: **0.18**

Duty Cycle for WIFI B 11MB: **0.895**
Duty cycle correction factor (for emissions) for WIFI B 11MB: **0.97**
Duty cycle correction factor (for power) for WIFI B 11MB: **0.48**

Duty Cycle for WIFI G 6MHz: **0.962**
Duty cycle correction factor (for emissions) for WIFI G 6MHz: **0.34**
Duty cycle correction factor (for power) for WIFI G 6MHz: **0.17**

Duty Cycle for WIFI G 54MHz: **0.632**
Duty cycle correction factor (for emissions) for WIFI G 54MHz: **3.99**
Duty cycle correction factor (for power) for WIFI G 54MHz: **1.99**

Duty Cycle for WIFI N MCS0: **0.874**
Duty cycle correction factor (for emissions) for WIFI N MCS0: **1.17**
Duty cycle correction factor (for power) for WIFI N MCS0: **0.58**

Duty Cycle for WIFI N MCS7: **0.492**
Duty cycle correction factor (for emissions) for WIFI N MCS7: **6.16**
Duty cycle correction factor (for power) for WIFI N MCS7: **3.08**

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 (μV/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 * Emission level (μV/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 worse-case emissions were produced while running off of USB power, so results from this mode are presented.

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:

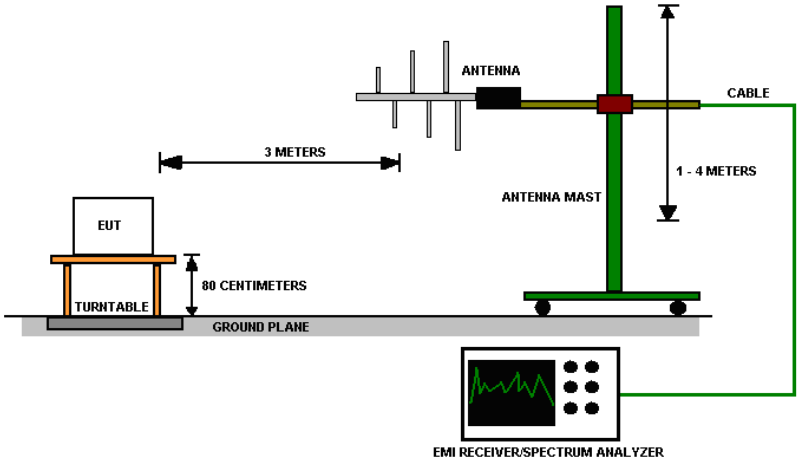


Figure 9 - Radiated Emissions Test Setup

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:

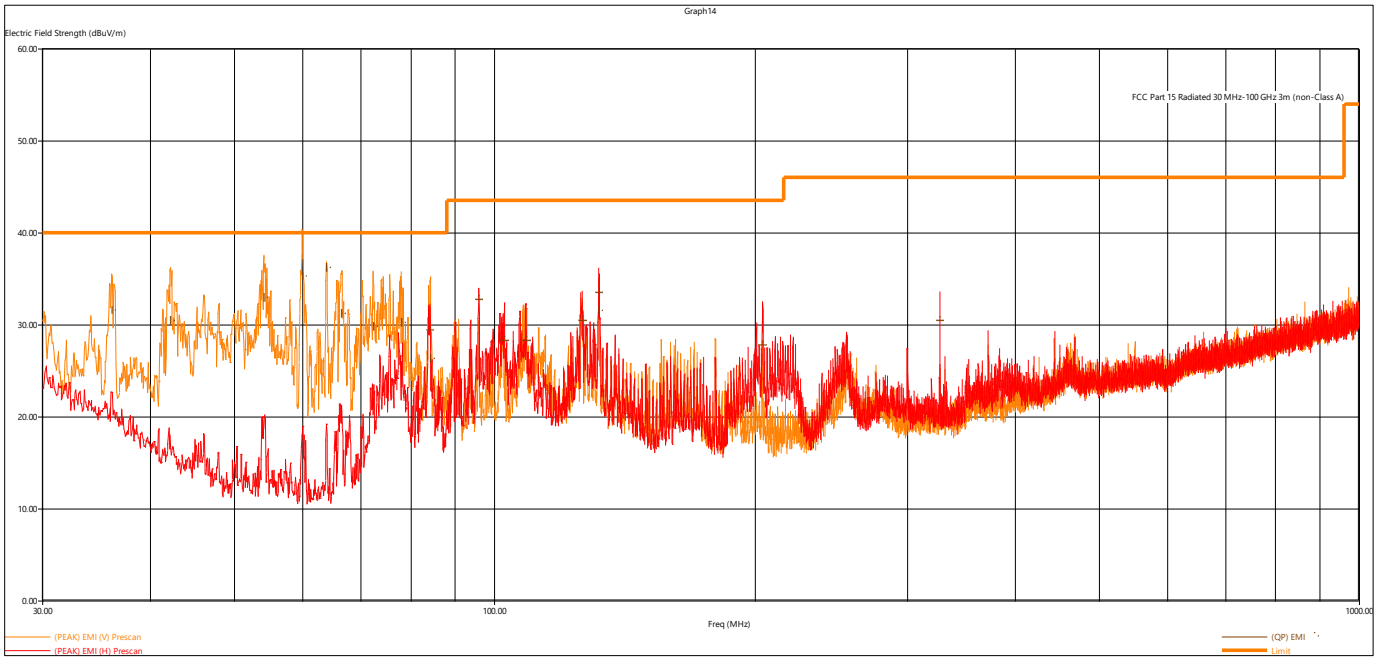


Figure 10 - Radiated Emissions Plot, Receive

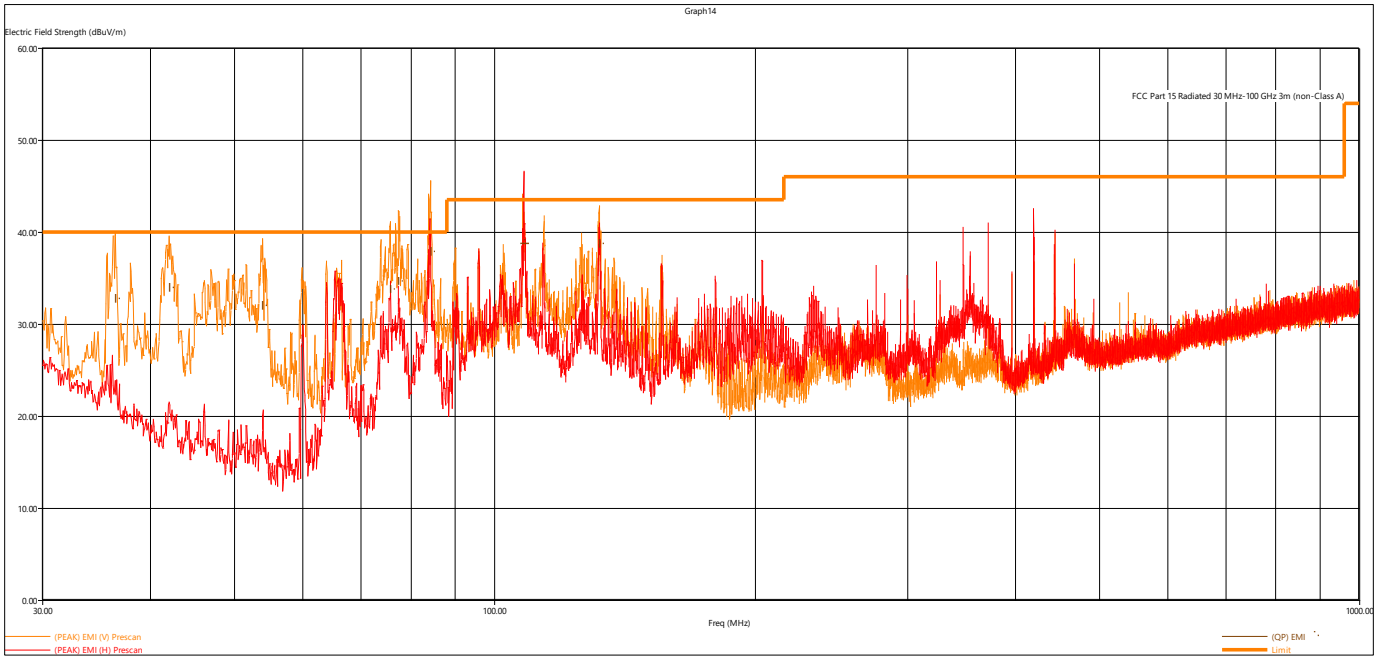


Figure 11 - Radiated Emissions Plot, 802.11b 1MB

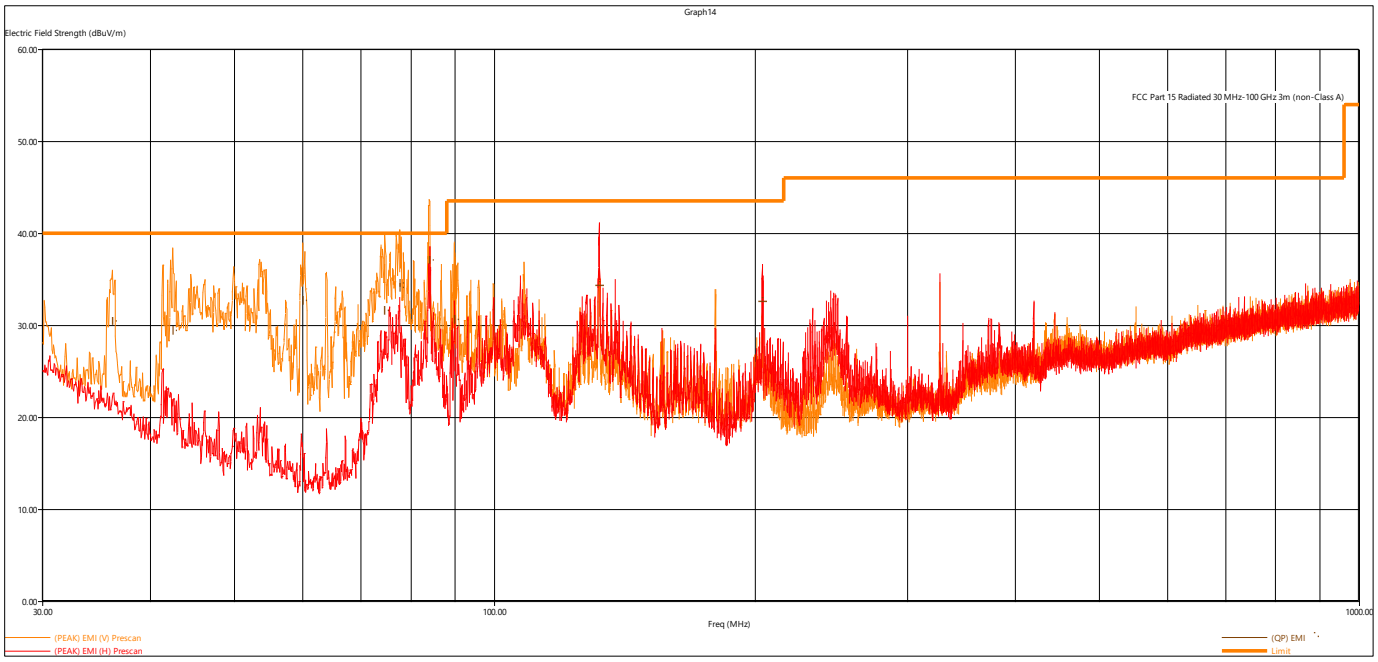


Figure 12 - Radiated Emissions Plot, 802.11b 11MB

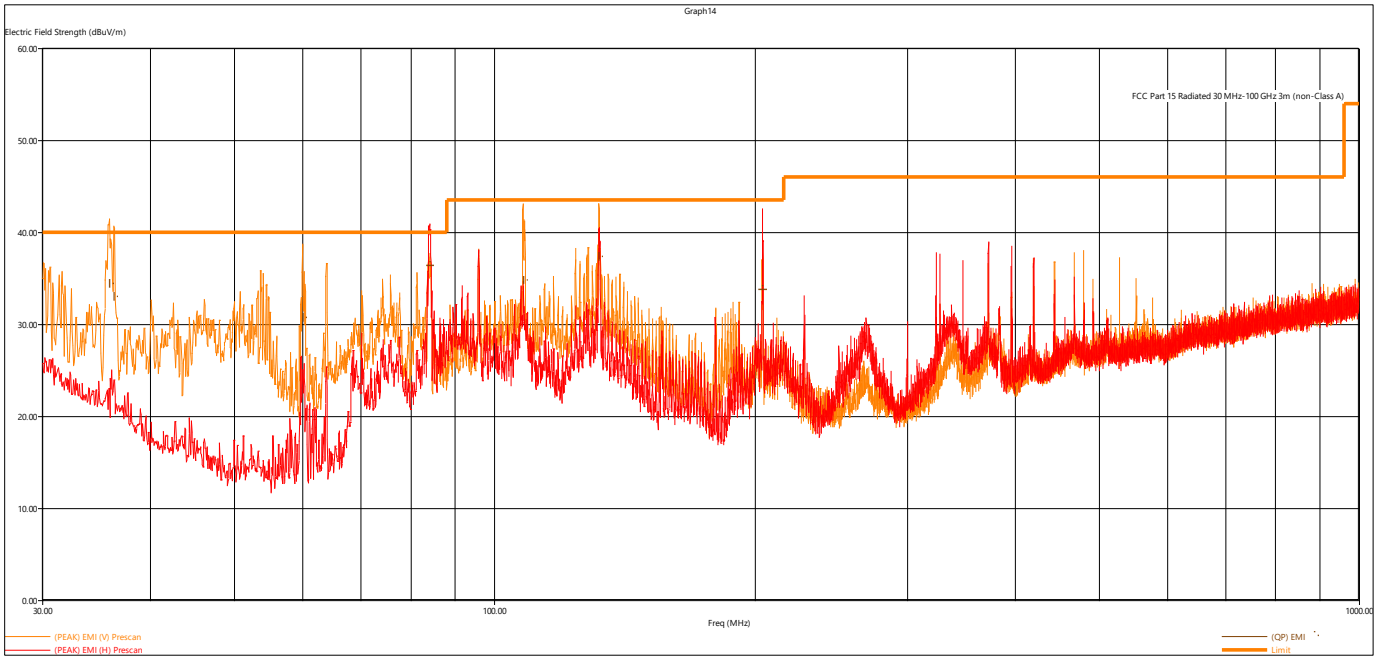


Figure 13 - Radiated Emissions Plot, 802.11g 6MB

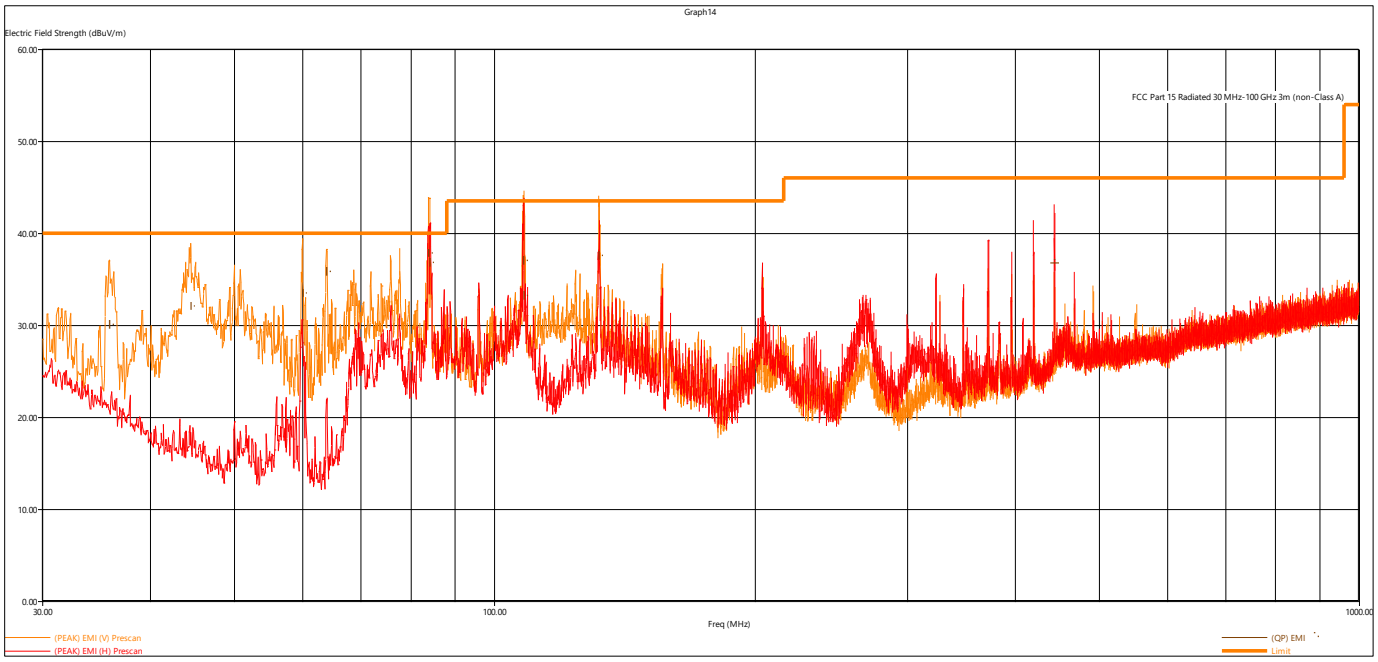


Figure 14 - Radiated Emissions Plot, 802.11g 54MB

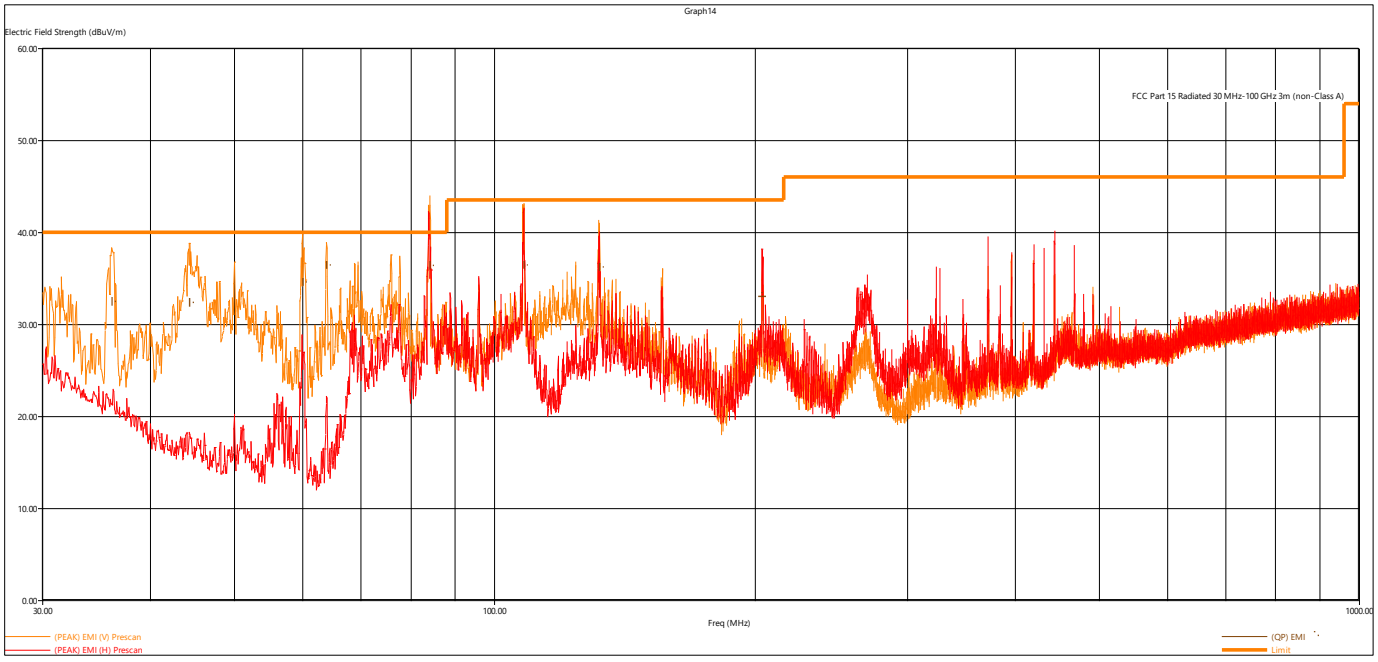


Figure 15 - Radiated Emissions Plot, 802.11n MCS0

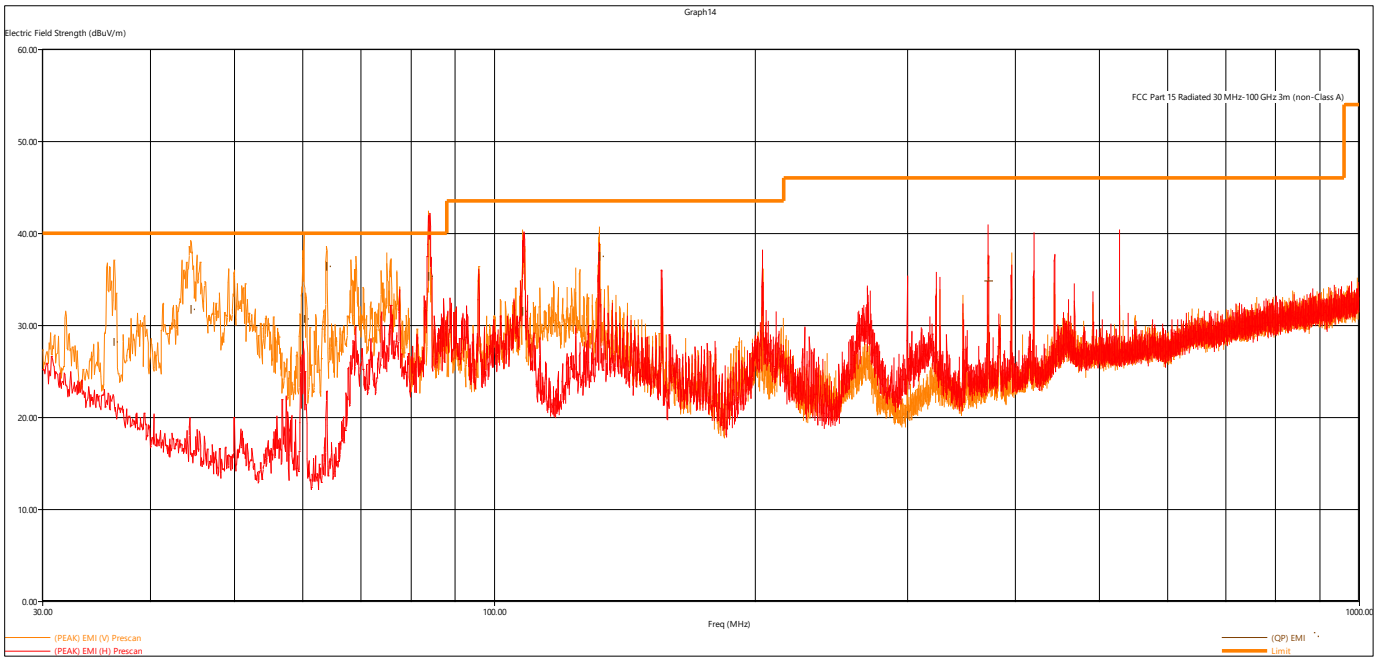


Figure 16 - Radiated Emissions Plot, 802.11n MCS7

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + 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 = Emission level - Limit value

Quasi-Peak Measurements, 802.11x								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
108.005040	38.66	43.52	4.86	234.00	264.00	H	Low	WIFI B 1MB
77.403840	34.61	40.00	5.39	113.00	236.00	V	Low	WIFI B 1MB
84.320400	37.80	40.00	2.20	107.00	41.00	V	Low	WIFI B 1MB
131.928480	38.66	43.52	4.86	112.00	208.00	V	Low	WIFI B 1MB
132.133920	34.32	43.52	9.20	238.00	342.00	H	Low	WIFI B 11MB
203.905680	32.51	43.52	11.01	124.00	127.00	H	Low	WIFI B 11MB
36.049440	30.42	40.00	9.58	108.00	145.00	V	Low	WIFI B 11MB
42.265440	29.37	40.00	10.63	121.00	192.00	V	Low	WIFI B 11MB
60.038640	32.67	40.00	7.33	119.00	136.00	V	Low	WIFI B 11MB
74.793120	31.59	40.00	8.41	120.00	155.00	V	Low	WIFI B 11MB
77.658720	34.57	40.00	5.43	140.00	125.00	V	Low	WIFI B 11MB
77.626800	34.08	40.00	6.88	133.00	126.00	V	Low	WIFI B 11MB
83.930640	37.05	40.00	2.95	120.00	147.00	V	Low	WIFI B 11MB
89.938560	30.57	43.52	12.95	119.00	270.00	V	Low	WIFI B 11MB
84.057120	36.33	40.00	3.67	234.00	360.00	H	Low	WIFI G 6MB
204.220320	33.73	43.52	9.79	192.00	34.00	H	Low	WIFI G 6MB
35.820720	34.39	40.00	5.61	129.00	48.00	V	Low	WIFI G 6MB
36.181680	32.98	40.00	7.02	117.00	54.00	V	Low	WIFI G 6MB
59.825760	30.67	40.00	9.33	104.00	31.00	V	Low	WIFI G 6MB
107.761920	34.76	43.52	8.76	109.00	179.00	V	Low	WIFI G 6MB
131.911200	37.34	43.52	6.18	148.00	44.00	V	Low	WIFI G 6MB
443.940240	36.72	46.02	9.30	173.00	287.00	H	Low	WIFI G 54MB
35.624160	30.02	40.00	9.98	119.00	43.00	V	Low	WIFI G 54MB
44.435280	32.06	40.00	7.94	111.00	193.00	V	Low	WIFI G 54MB
60.049920	33.44	40.00	6.56	108.00	265.00	V	Low	WIFI G 54MB
63.857520	35.80	40.00	4.20	119.00	355.00	V	Low	WIFI G 54MB
84.090720	37.81	40.00	2.19	114.00	46.00	V	Low	WIFI G 54MB
84.131520	36.80	40.00	3.20	108.00	51.00	V	Low	WIFI G 54MB
107.716080	36.92	43.52	6.60	112.00	297.00	V	Low	WIFI G 54MB
108.310560	33.19	43.52	10.33	109.00	316.00	V	Low	WIFI G 54MB
131.904960	37.50	43.52	6.02	190.00	47.00	V	Low	WIFI G 54MB
203.877840	33.00	43.52	10.52	163.00	37.00	H	Low	WIFI N MCS0
36.015360	32.46	40.00	7.54	105.00	76.00	V	Low	WIFI N MCS0
44.251440	32.37	40.00	7.63	104.00	163.00	V	Low	WIFI N MCS0
59.841360	34.56	40.00	5.44	118.00	247.00	V	Low	WIFI N MCS0

63.901920	36.40	40.00	3.60	111.00	0.00	V	Low	WIFI N MCS0
84.145680	36.36	40.00	3.64	106.00	53.00	V	Low	WIFI N MCS0
108.161520	36.44	43.52	7.08	119.00	294.00	V	Low	WIFI N MCS0
132.182160	36.20	43.52	7.32	181.00	60.00	V	Low	WIFI N MCS0
371.886480	34.76	46.02	11.26	110.00	336.00	H	Low	WIFI N MCS7
36.403440	28.09	40.00	11.91	108.00	114.00	V	Low	WIFI N MCS7
44.432640	31.65	40.00	8.35	131.00	138.00	V	Low	WIFI N MCS7
60.399360	30.59	40.00	9.41	127.00	260.00	V	Low	WIFI N MCS7
63.910560	36.30	40.00	3.70	119.00	269.00	V	Low	WIFI N MCS7
84.031920	35.23	40.00	4.77	266.00	258.00	V	Low	WIFI N MCS7
107.508240	31.44	43.52	12.08	114.00	301.00	V	Low	WIFI N MCS7
132.020640	37.44	43.52	6.08	195.00	65.00	V	Low	WIFI N MCS7
83.93784	29.37	40.00	10.63	224	270	H	Receive	
36.1296	31.57	40.00	8.43	106	332	V	Receive	
42.08592	30.38	40.00	9.62	123	21	V	Receive	
54.0504	32.92	40.00	7.08	105	11	V	Receive	
59.8236	35.2	40.00	4.80	125	341	V	Receive	
63.8736	36.2	40.00	3.80	105	281	V	Receive	
66.53664	31.2	40.00	8.80	105	259	V	Receive	
72.516	29.76	40.00	10.24	111	260	V	Receive	
77.80296	30.15	40.00	9.85	105	131	V	Receive	
84.32688	26.23	40.00	13.77	111	356	V	Receive	
95.79672	32.66	43.52	10.86	337	134	H	Receive	
102.55848	28.21	43.52	15.31	276	142	H	Receive	
108.91128	28.23	43.52	15.29	306	139	H	Receive	
126.25416	30.38	43.52	13.14	203	154	H	Receive	
131.87736	33.47	43.52	10.05	186	146	H	Receive	

All other measurements were found to be at least 6 dB below the limit. Worst case emissions are reported.

Peak Measurements, 802.11x								
Frequency	**Peak Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2411.098000	104.78	NA	NA	437.00	213.00	H	Low	WIFI B 1MB
2436.136000	106.94	NA	NA	430.00	216.00	H	Mid	WIFI B 1MB

All harmonics and spurious emissions >1GHz were found to be at least 6dB below the respective limit line

Average Measurements, 802.11x									
Frequency	**DCCF**	**Avg Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dB**	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2411.098000	0.36	104.42	NA	NA	437.00	213.00	H	Low	WIFI B 1MB
2436.136000	0.36	106.58	NA	NA	430.00	216.00	H	Mid	WIFI B 1MB

Avg Level = Peak Level - DCCF

All harmonics and spurious emissions >1GHz were found to be at least 6dB below the respective limit line

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:
Test performed at 120kHz RBW

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.

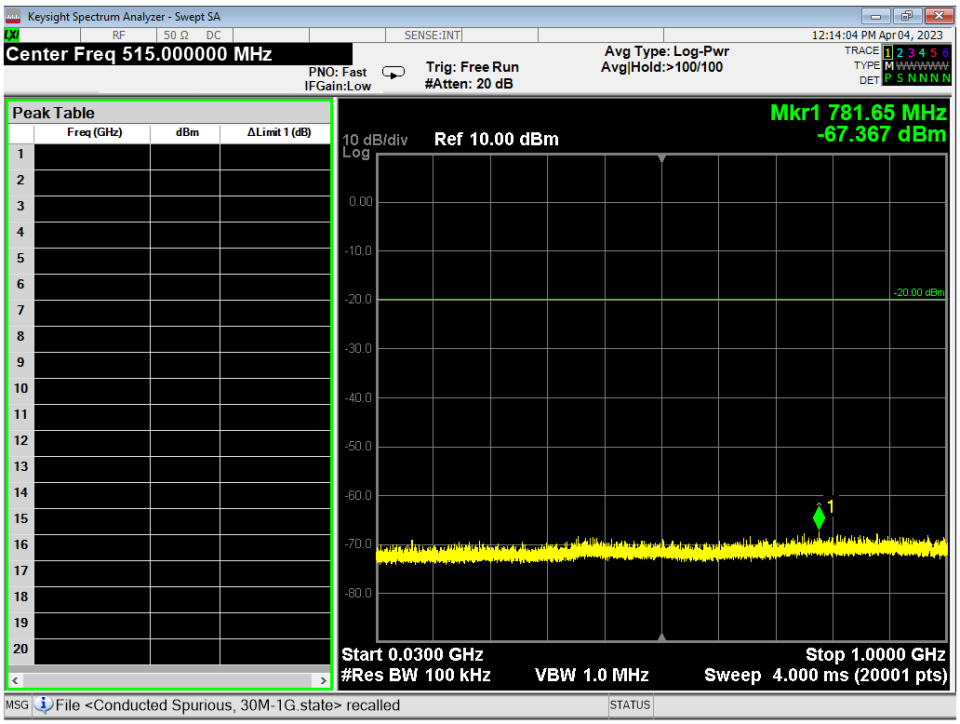


Figure 17 - Radiated Emissions Plot, WIFI 802.11b, 30M – 1G, Mid

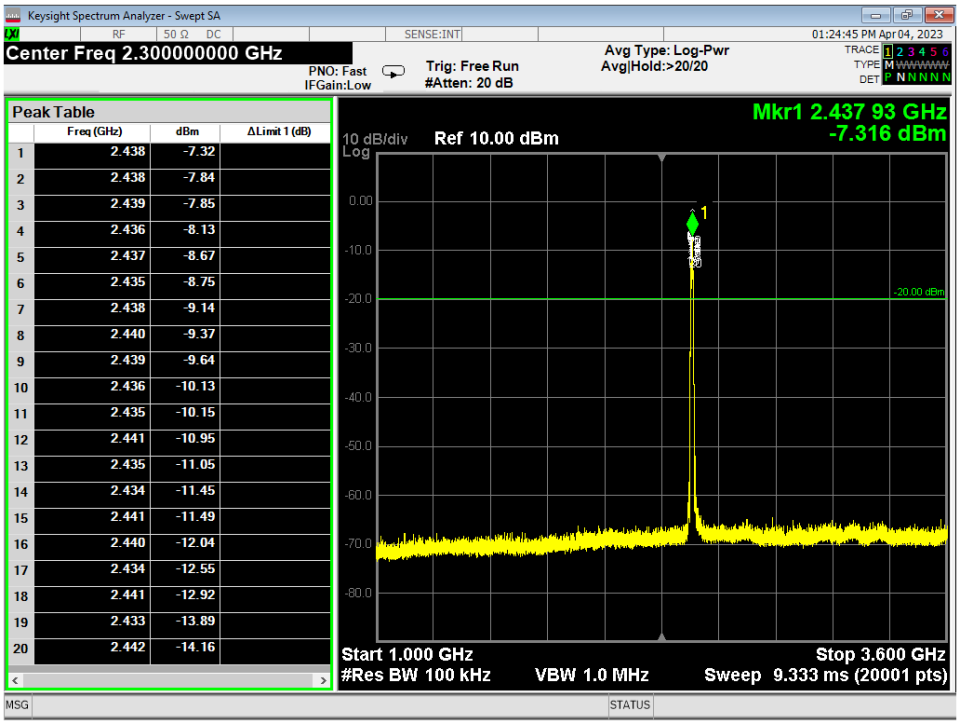


Figure 18 - Radiated Emissions Plot, WIFI 802.11b, 1G – 3.6G, Mid

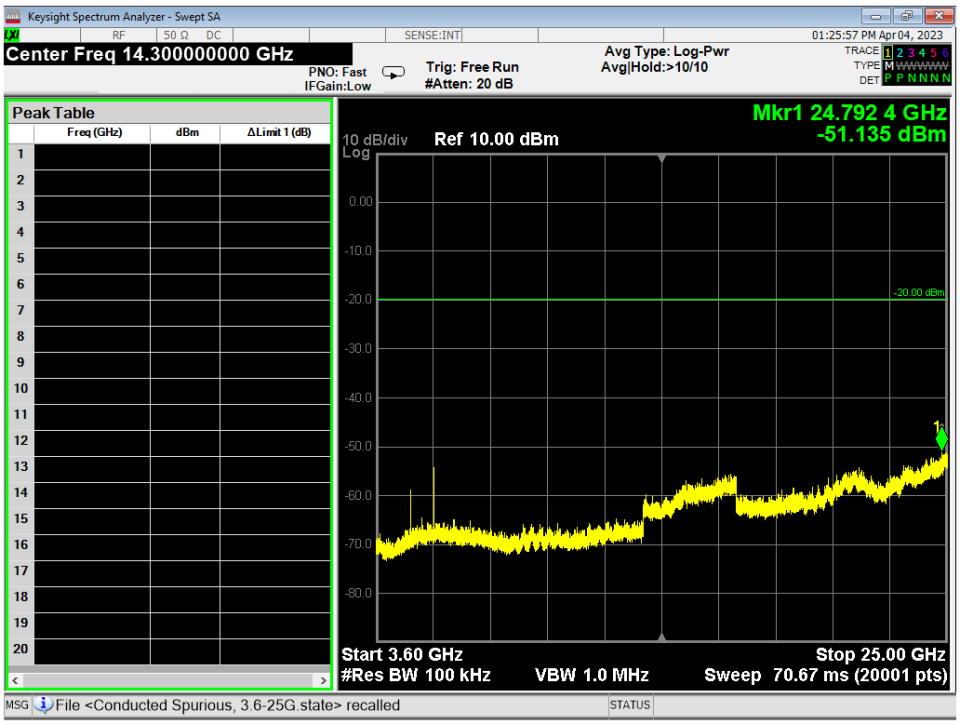


Figure 19 - Radiated Emissions Plot, WIFI 802.11b, 3.6G – 25G, Mid

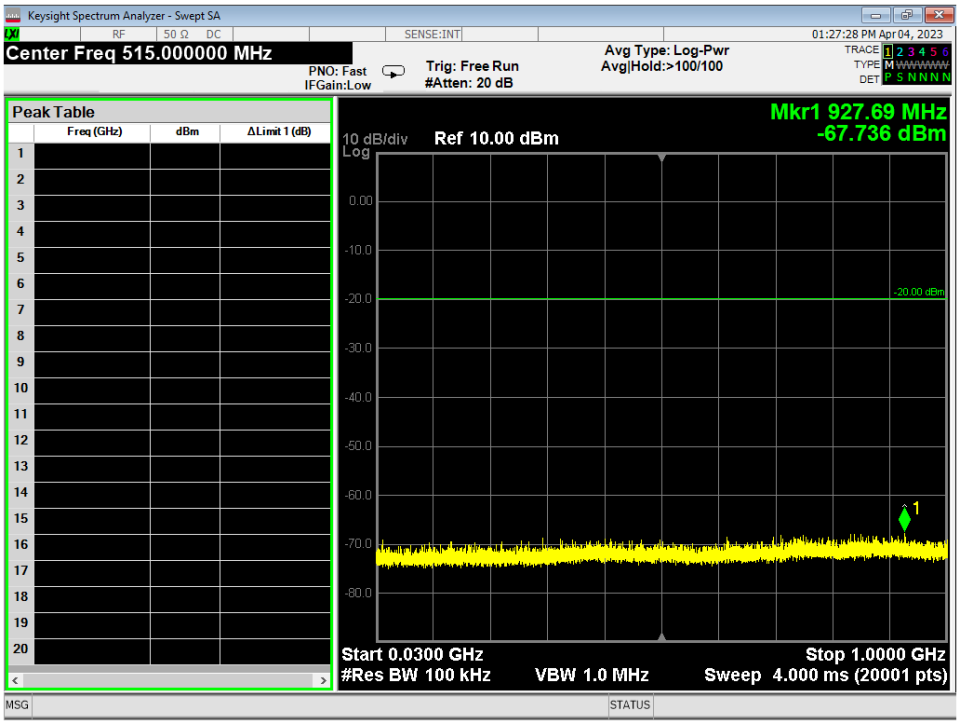


Figure 20 - Radiated Emissions Plot, WIFI 802.11g, 30M – 1G, Mid

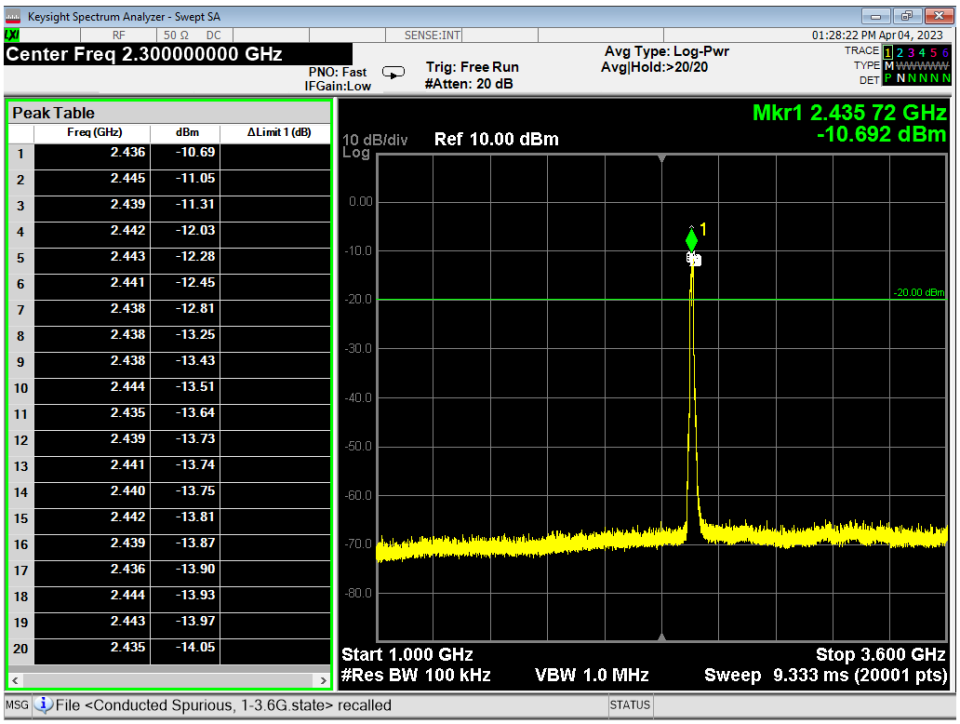


Figure 21 - Radiated Emissions Plot, WIFI 802.11g, 1G – 3.6G, Mid

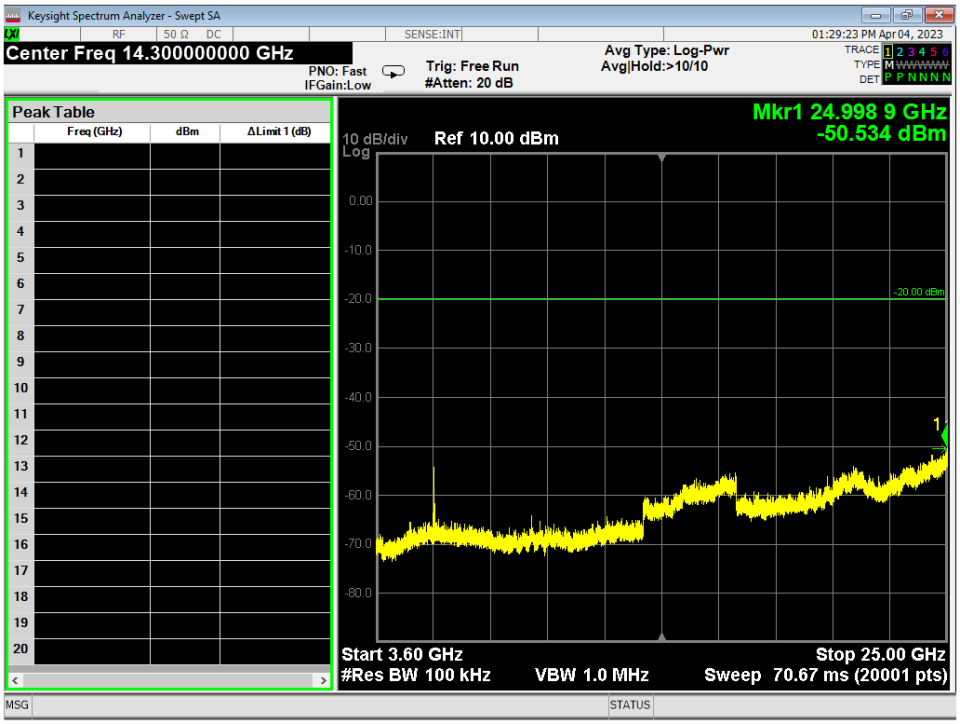


Figure 22 - Radiated Emissions Plot, WIFI 802.11g, 3.6G – 25G, Mid

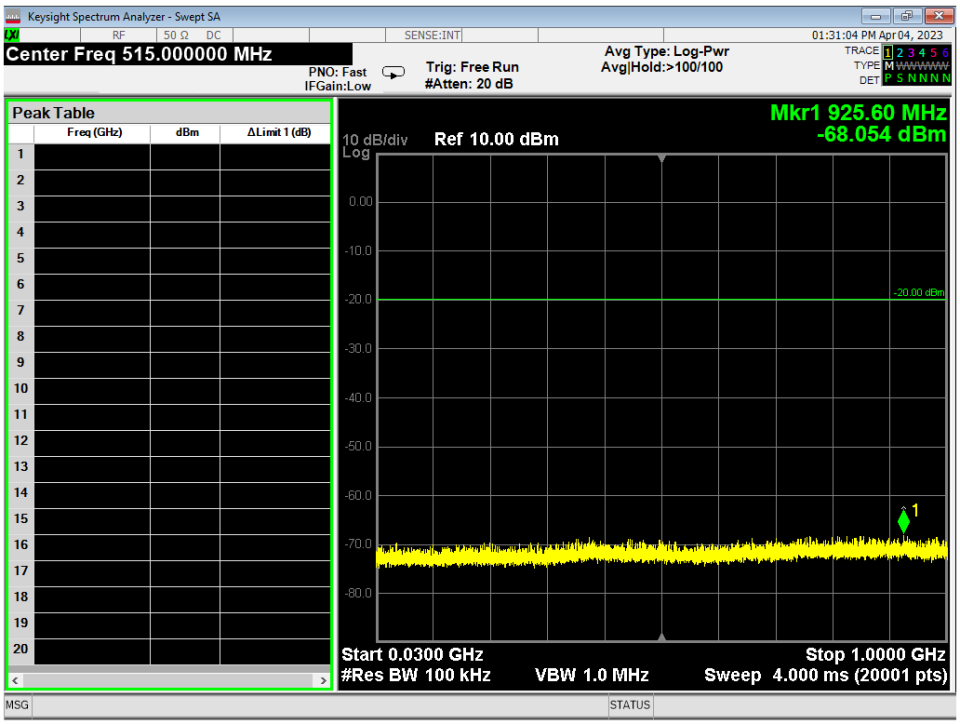


Figure 23 - Radiated Emissions Plot, WIFI 802.11n, 30M – 1G, Mid

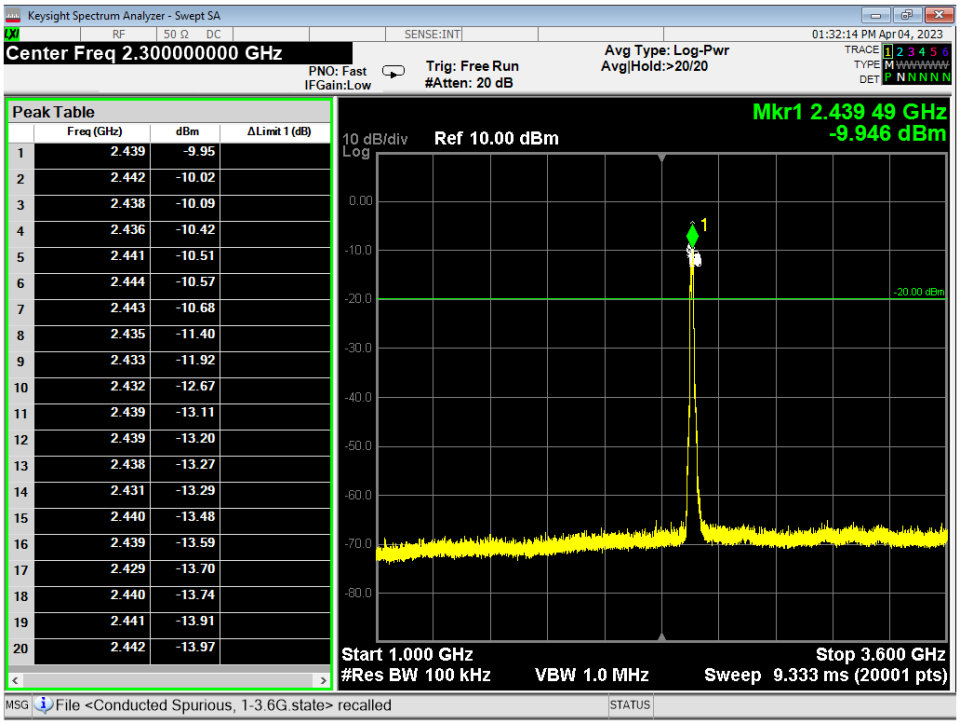


Figure 24 - Radiated Emissions Plot, WIFI 802.11n, 1G – 3.6G, Mid

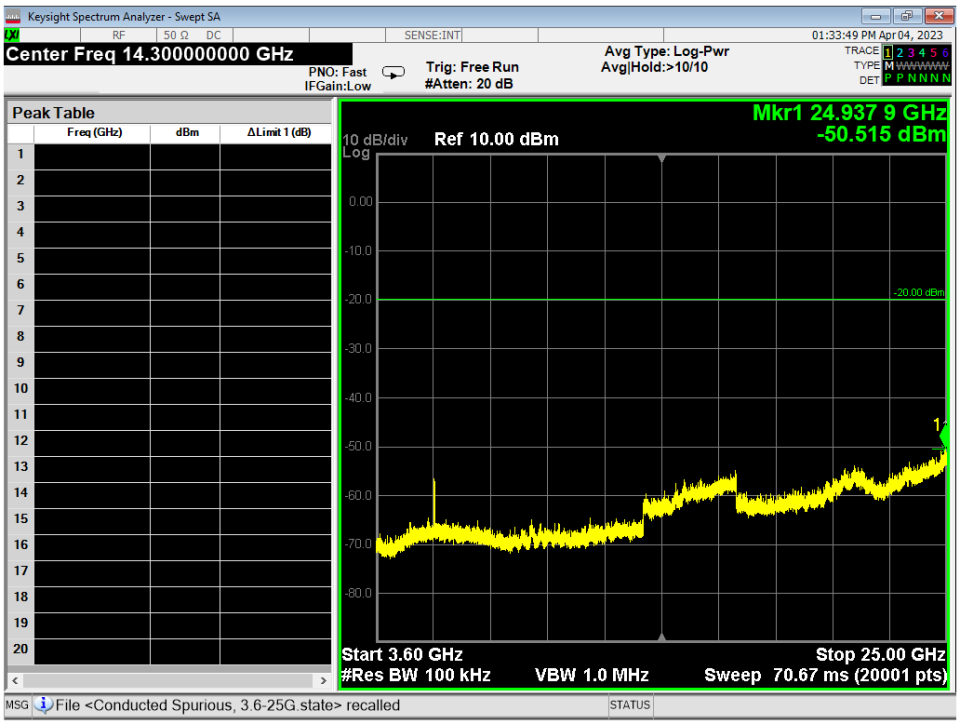


Figure 25 - Radiated Emissions Plot, WIFI 802.11n, 3.6G – 25G, Mid

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.

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 30 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

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.

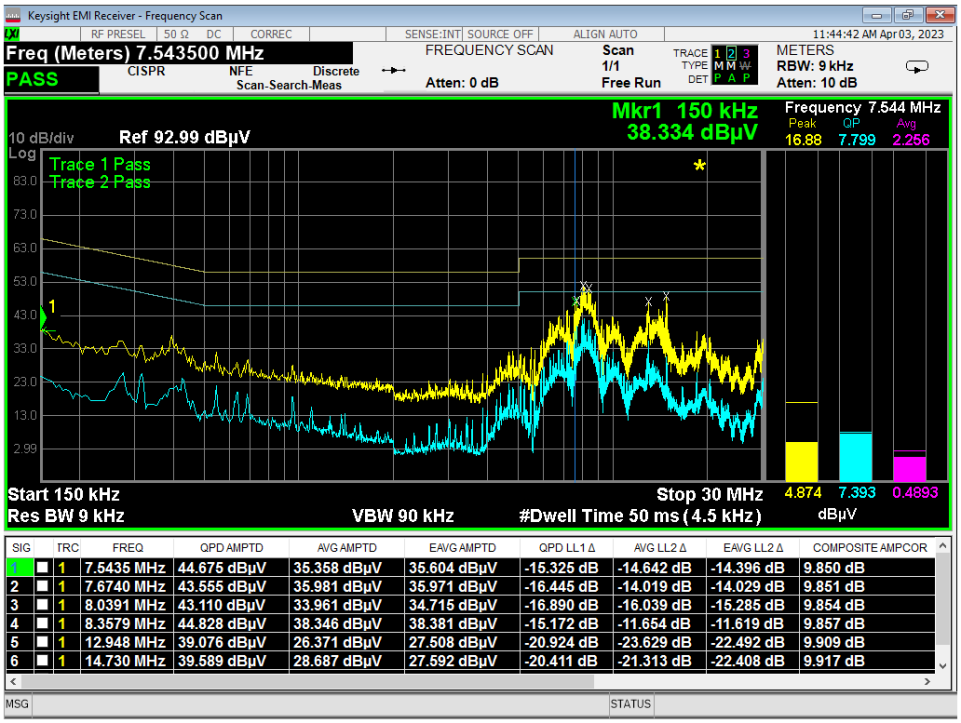
Test Procedures:

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

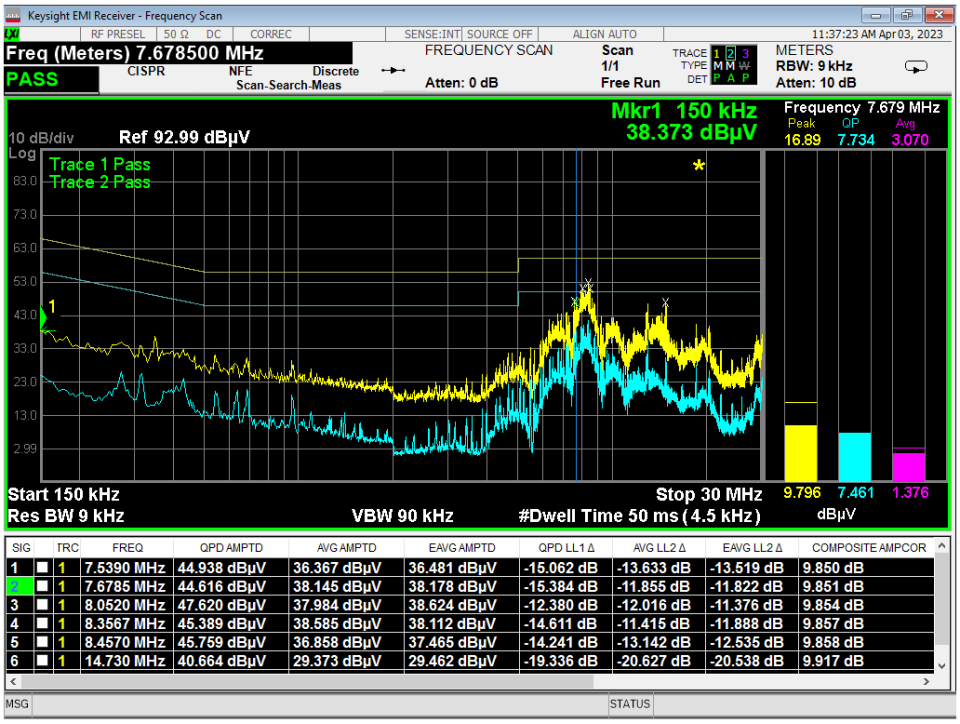
EUT operating conditions:
Details can be found in section 2.1 of this report.

Test Results:



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
1	1	7.5435 MHz	44.675 dBµV	35.358 dBµV	35.604 dBµV	-15.325 dB	-14.642 dB	-14.396 dB	9.850 dB
2	1	7.6740 MHz	43.555 dBµV	35.981 dBµV	35.971 dBµV	-16.445 dB	-14.019 dB	-14.029 dB	9.851 dB
3	1	8.0391 MHz	43.110 dBµV	33.961 dBµV	34.715 dBµV	-16.890 dB	-16.039 dB	-15.285 dB	9.854 dB
4	1	8.3579 MHz	44.828 dBµV	38.346 dBµV	38.381 dBµV	-15.172 dB	-11.654 dB	-11.619 dB	9.857 dB
5	1	12.948 MHz	39.076 dBµV	26.371 dBµV	27.508 dBµV	-20.924 dB	-23.629 dB	-22.492 dB	9.909 dB
6	1	14.730 MHz	39.589 dBµV	28.687 dBµV	27.592 dBµV	-20.411 dB	-21.313 dB	-22.408 dB	9.917 dB

Figure 26 - Conducted Emissions Plot, Pos+, TX



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
1	1	7.5390 MHz	44.938 dBµV	36.367 dBµV	36.481 dBµV	-15.062 dB	-13.633 dB	-13.519 dB	9.850 dB
2	1	7.6785 MHz	44.616 dBµV	38.145 dBµV	38.178 dBµV	-15.384 dB	-11.855 dB	-11.822 dB	9.851 dB
3	1	8.0520 MHz	47.620 dBµV	37.984 dBµV	38.624 dBµV	-12.380 dB	-12.016 dB	-11.376 dB	9.854 dB
4	1	8.3567 MHz	45.389 dBµV	38.585 dBµV	38.112 dBµV	-14.611 dB	-11.415 dB	-11.888 dB	9.857 dB
5	1	8.4570 MHz	45.759 dBµV	36.858 dBµV	37.465 dBµV	-14.241 dB	-13.142 dB	-12.535 dB	9.858 dB
6	1	14.730 MHz	40.664 dBµV	29.373 dBµV	29.462 dBµV	-19.336 dB	-20.627 dB	-20.538 dB	9.917 dB

Figure 27 - Conducted Emissions Plot, Neg-, TX

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and 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 dBμV 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 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

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

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)]^2 / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

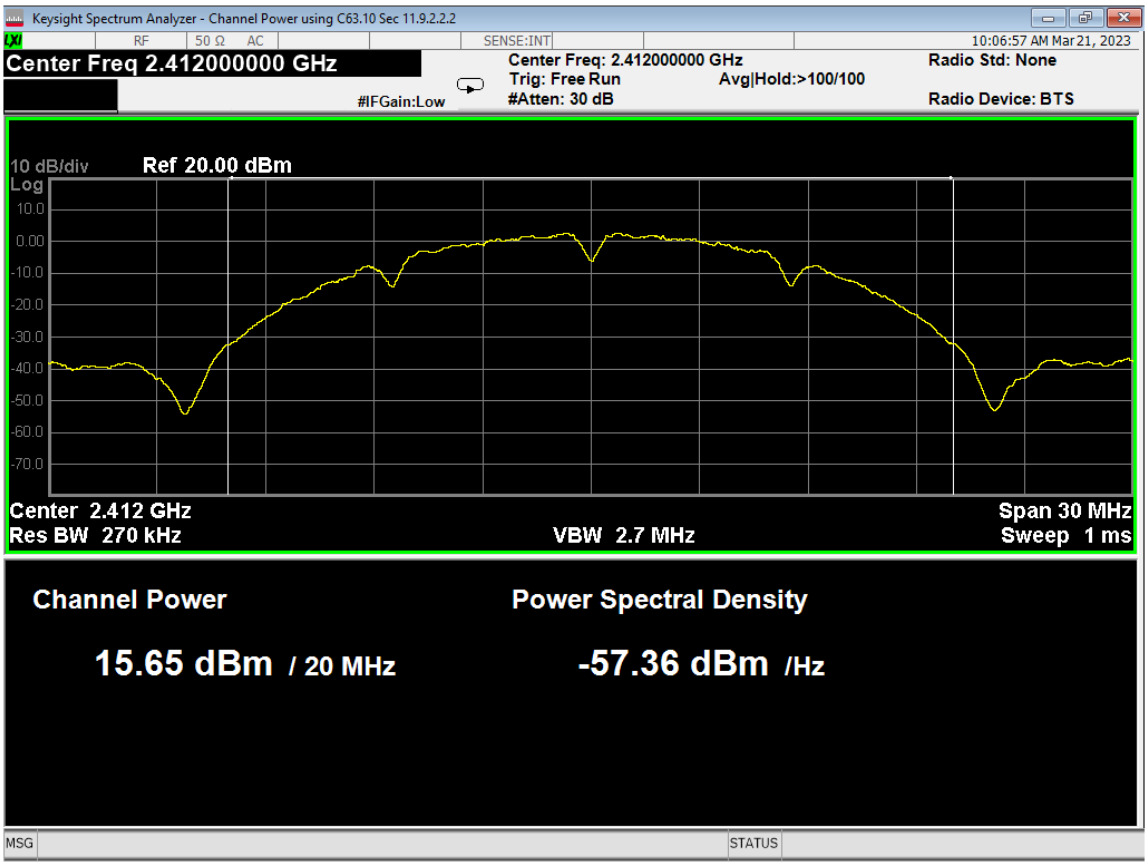
APPENDIX B – MEASUREMENT UNCERTAINTY

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

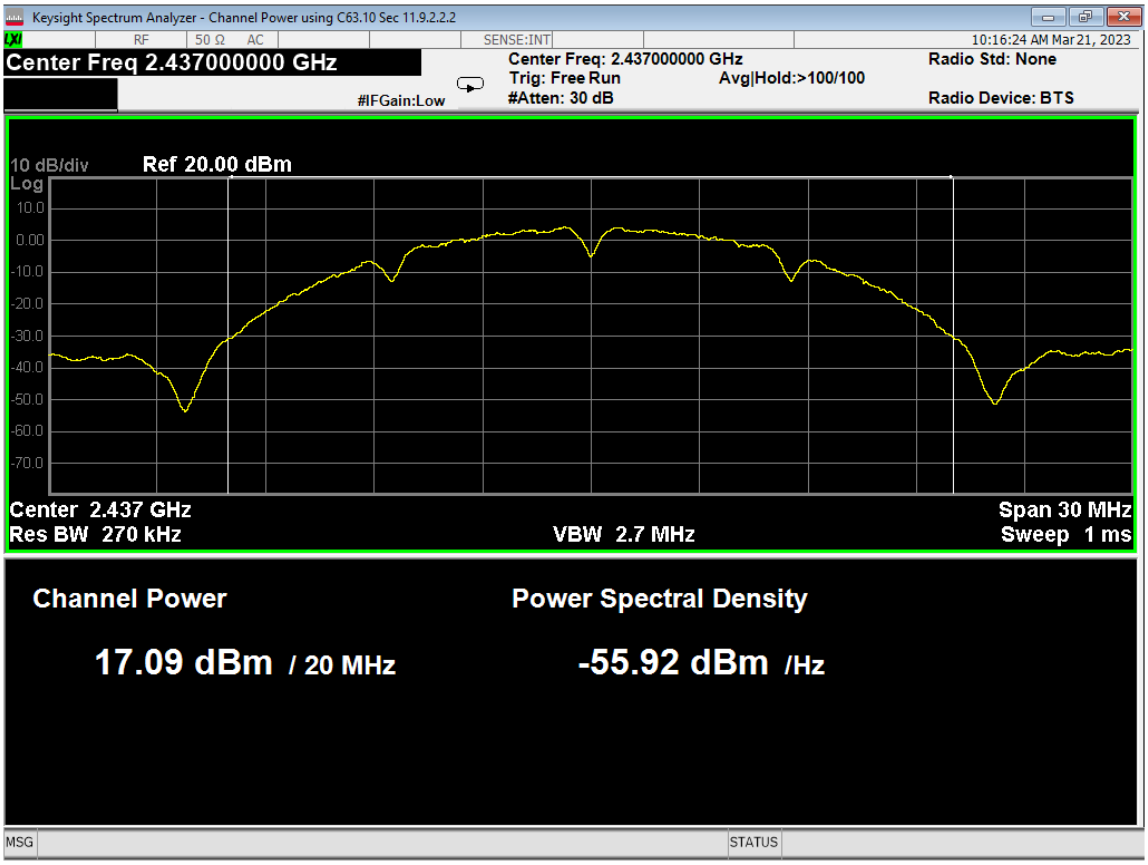
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

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

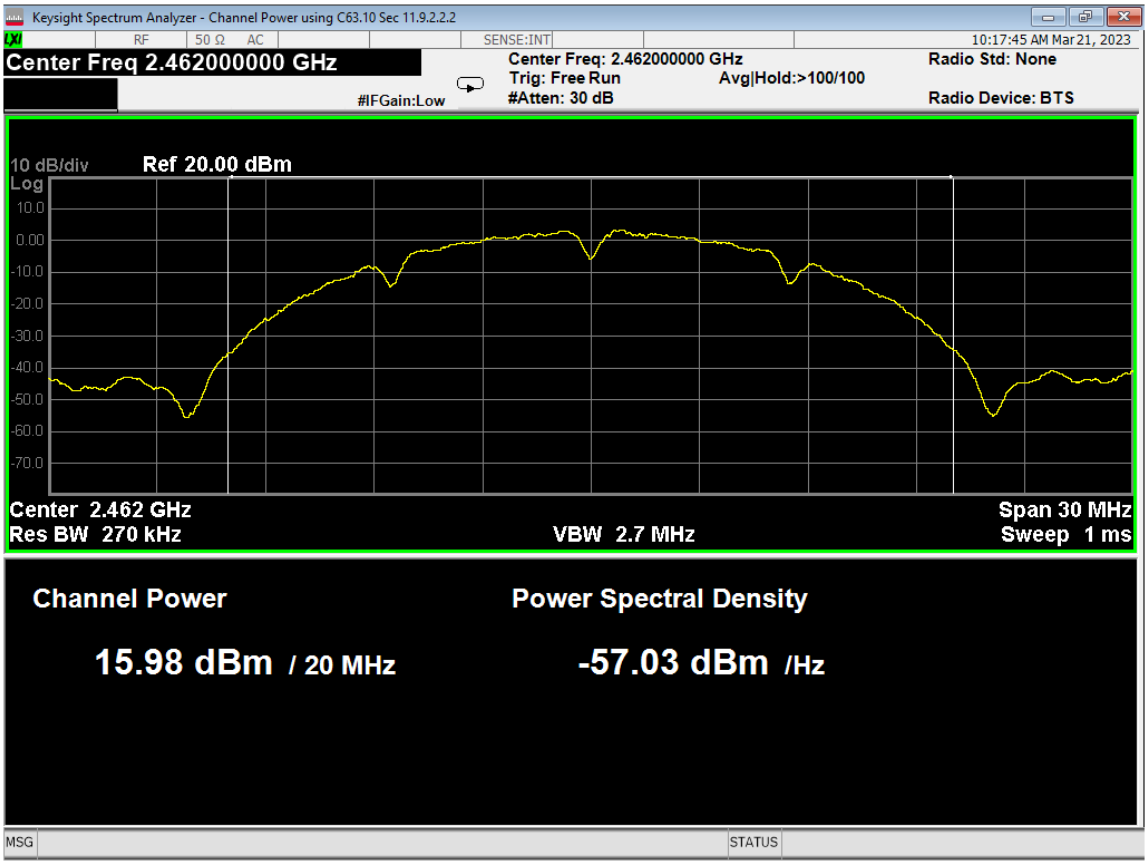
APPENDIX C – GRAPHS AND TABLES



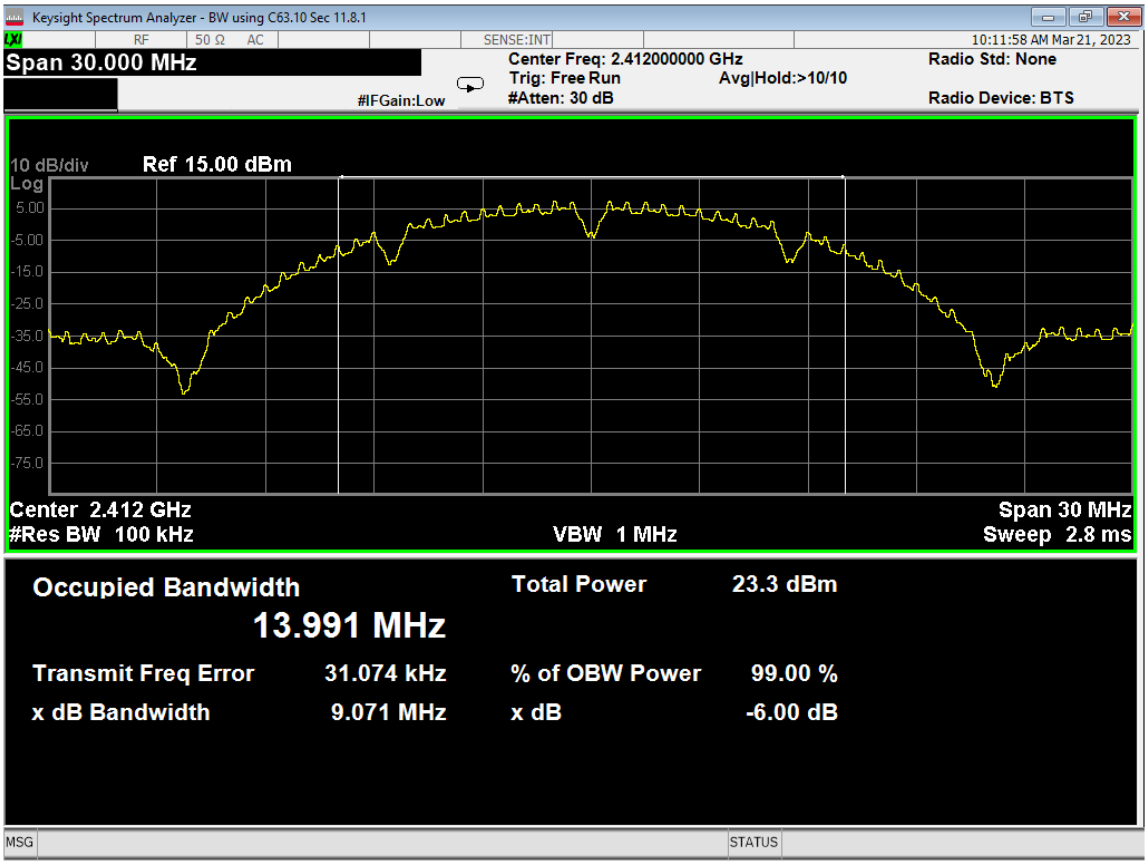
01 Average Power, Low, Wifi B, Low Data Rate



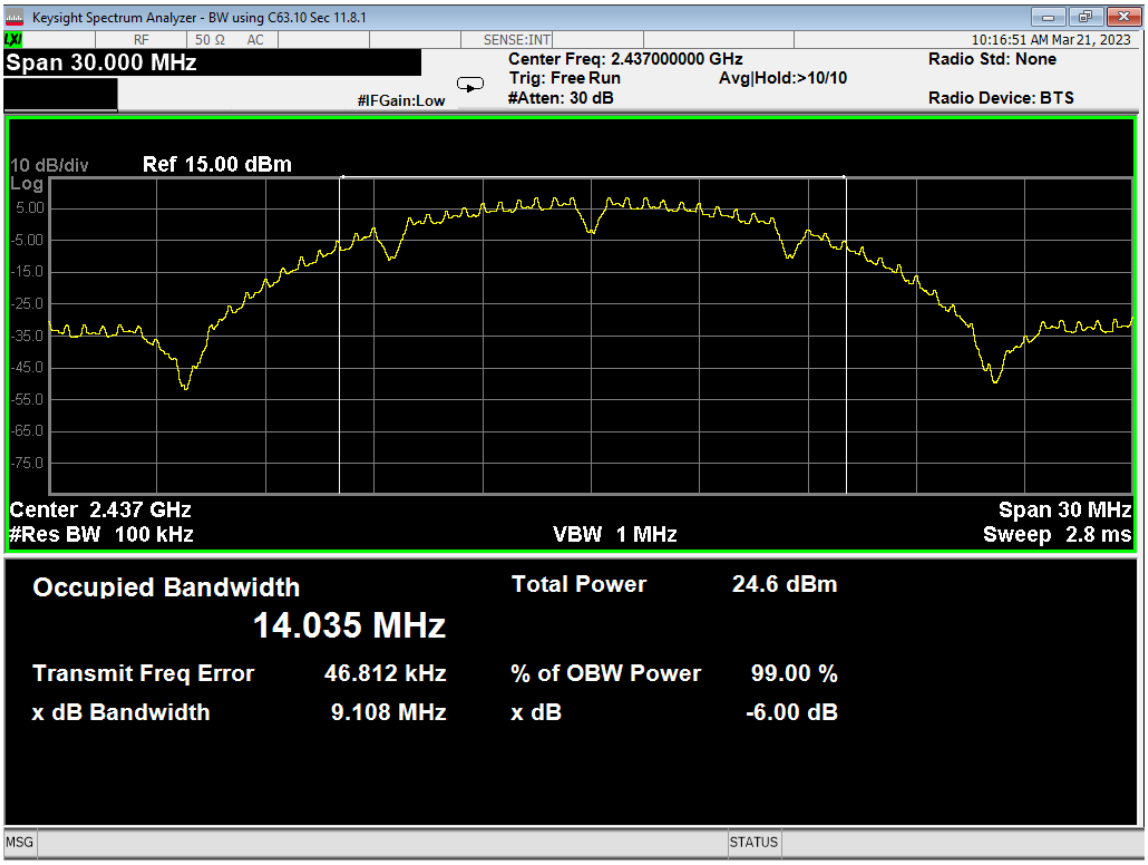
02 Average Power, Mid, Wifi B, Low Data Rate



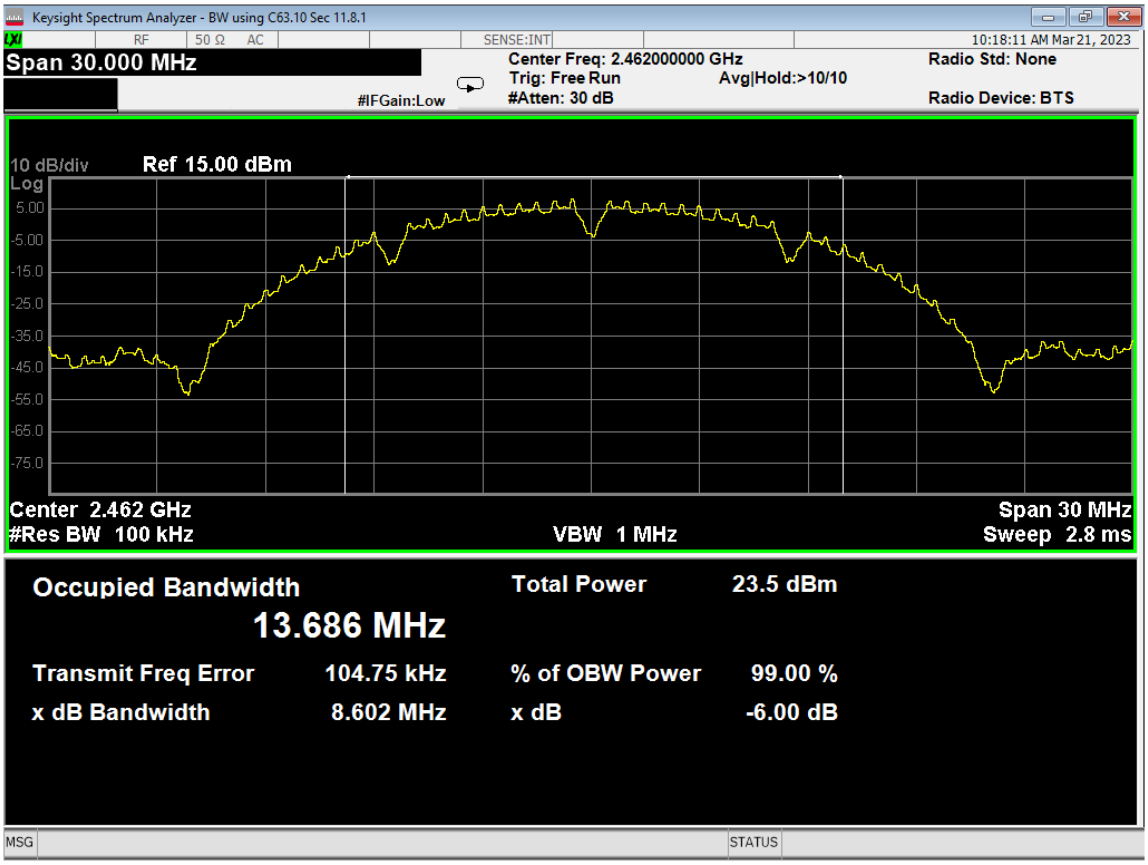
03 Average Power, High, Wifi B, Low Data Rate



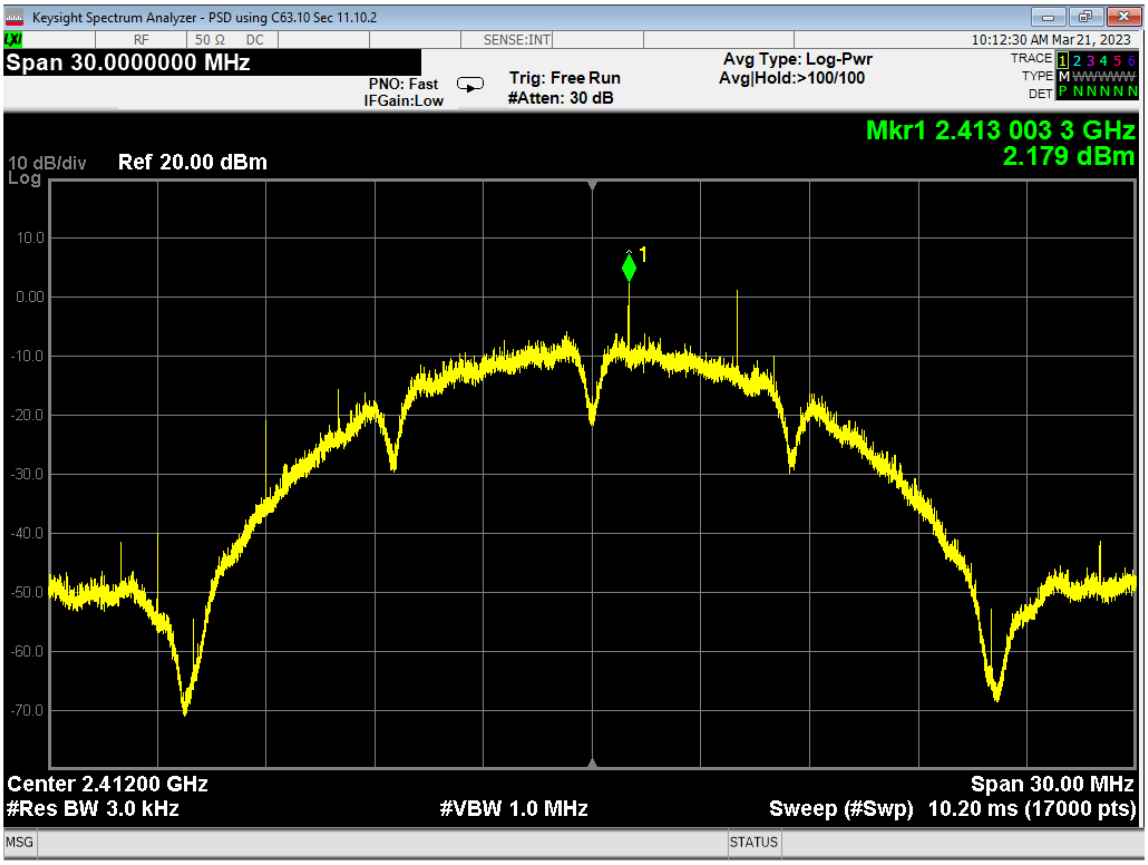
04 6dB Bandwidth, Low, Wifi B, Low Data Rate



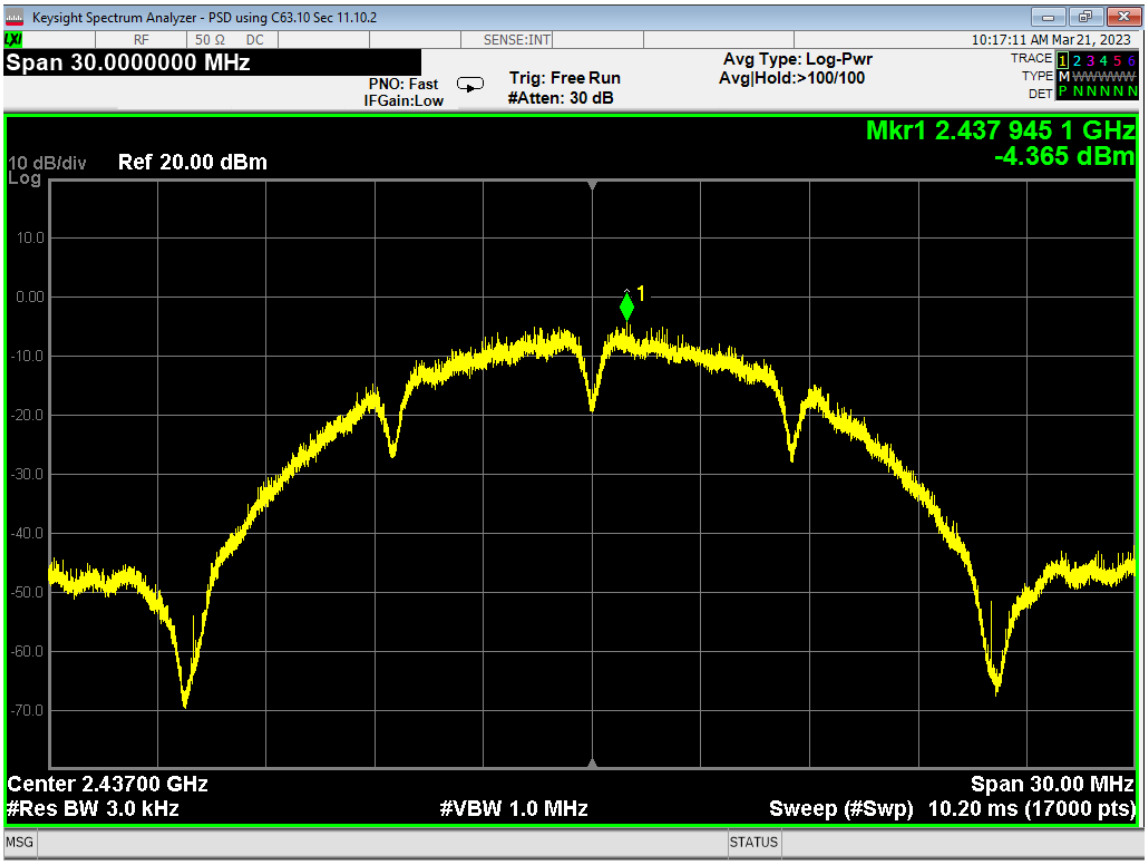
05 6dB Bandwidth, Mid, Wifi B, Low Data Rate



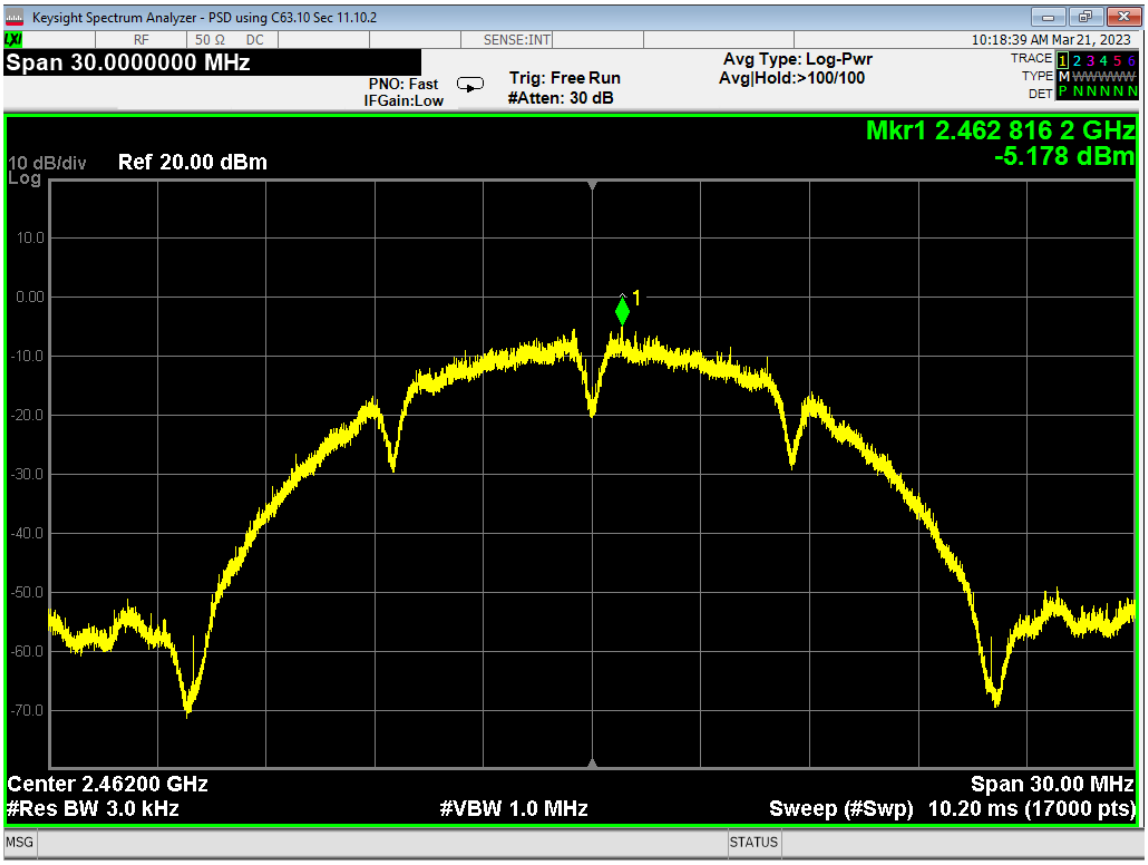
06 6dB Bandwidth, High, Wifi B, Low Data Rate



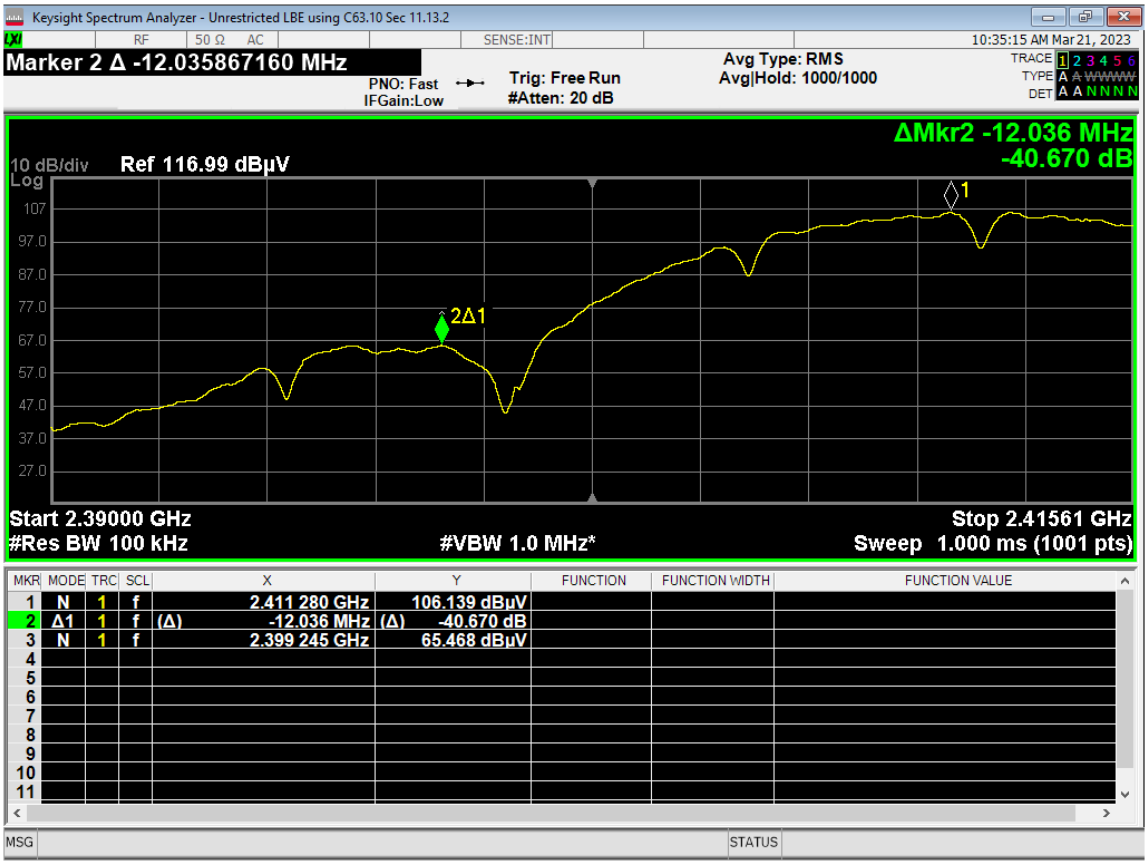
07 PSD, Low, Wifi B, Low Data Rate



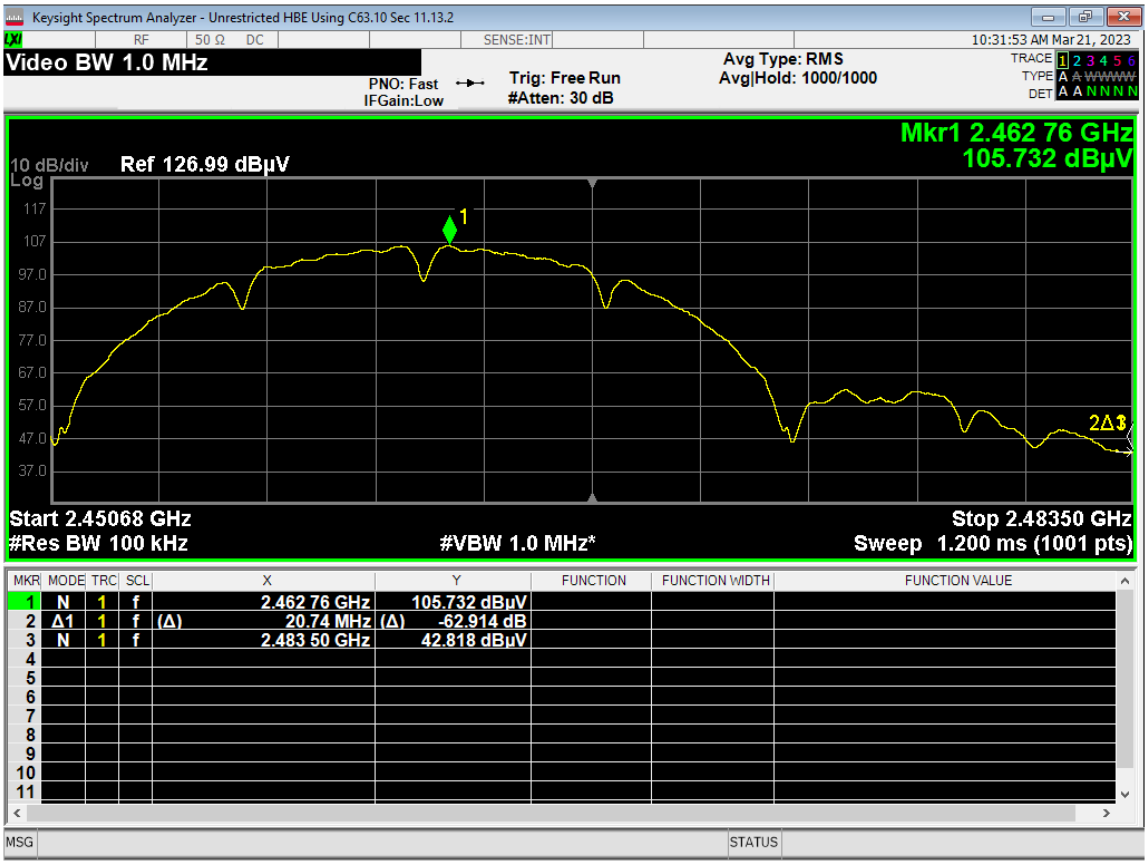
08 PSD, Mid, Wifi B, Low Data Rate



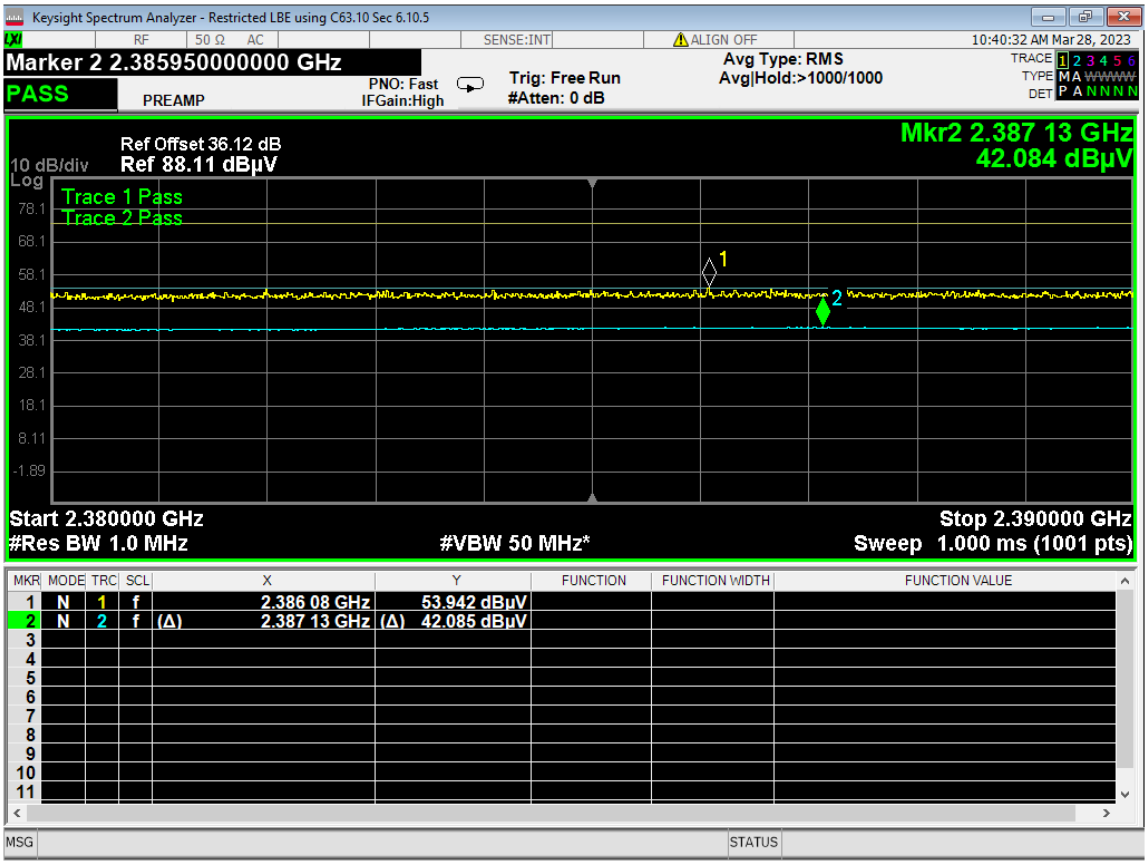
09 PSD, High, Wifi B, Low Data Rate



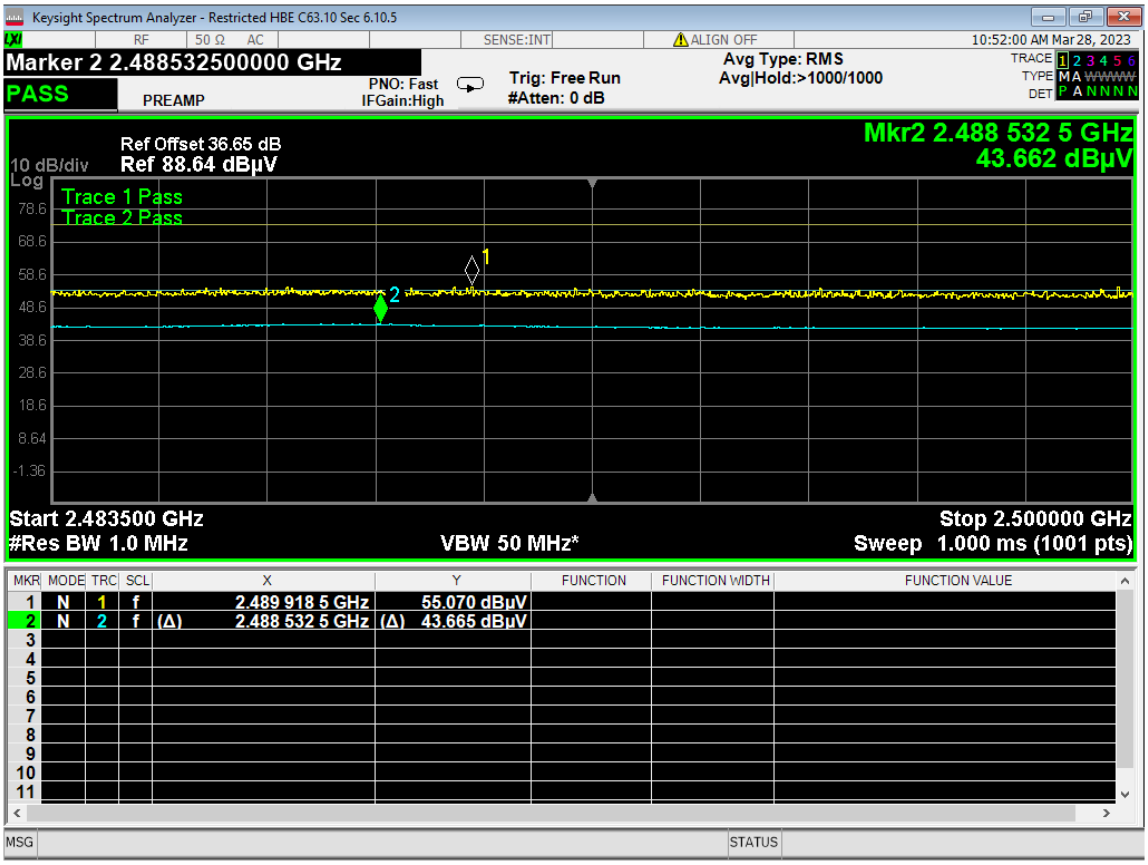
10 Lower Bandedge, Unrestricted, Wifi B, Low Data Rate



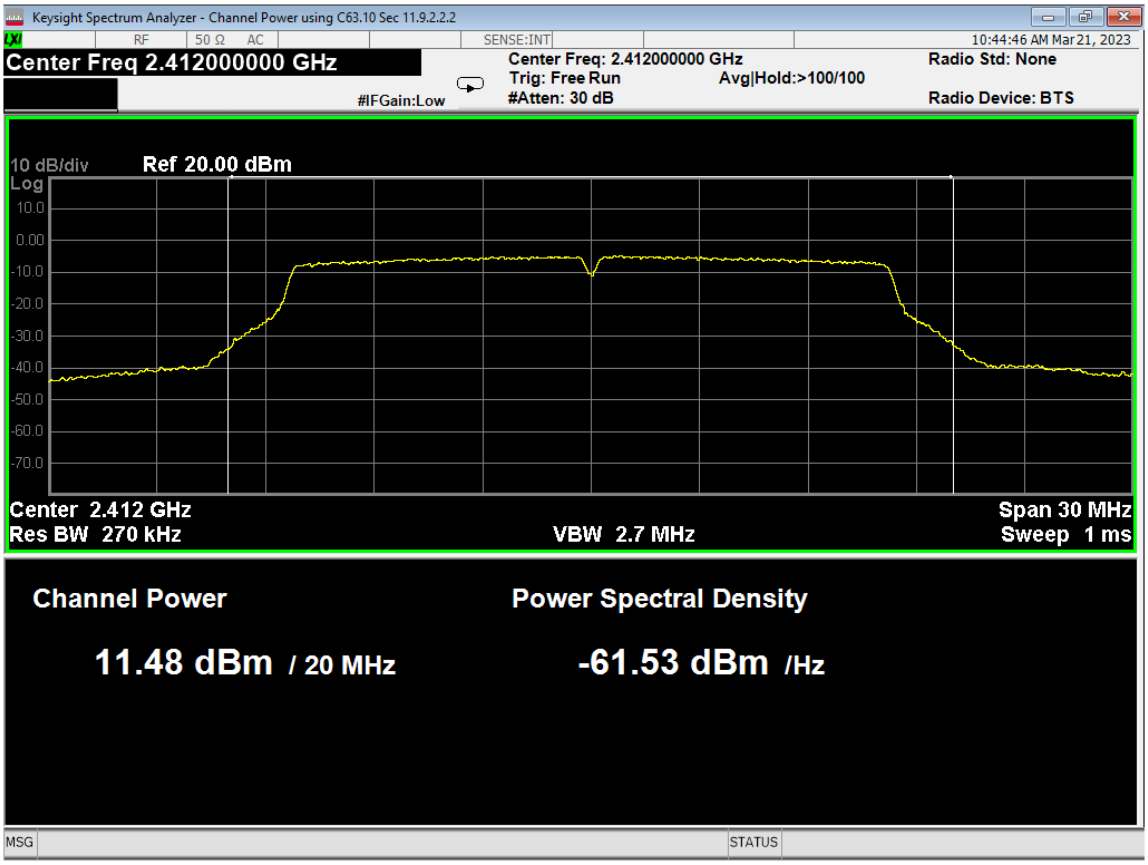
11 Higher Bandedge, Unrestricted, Wifi B, Low Data Rate



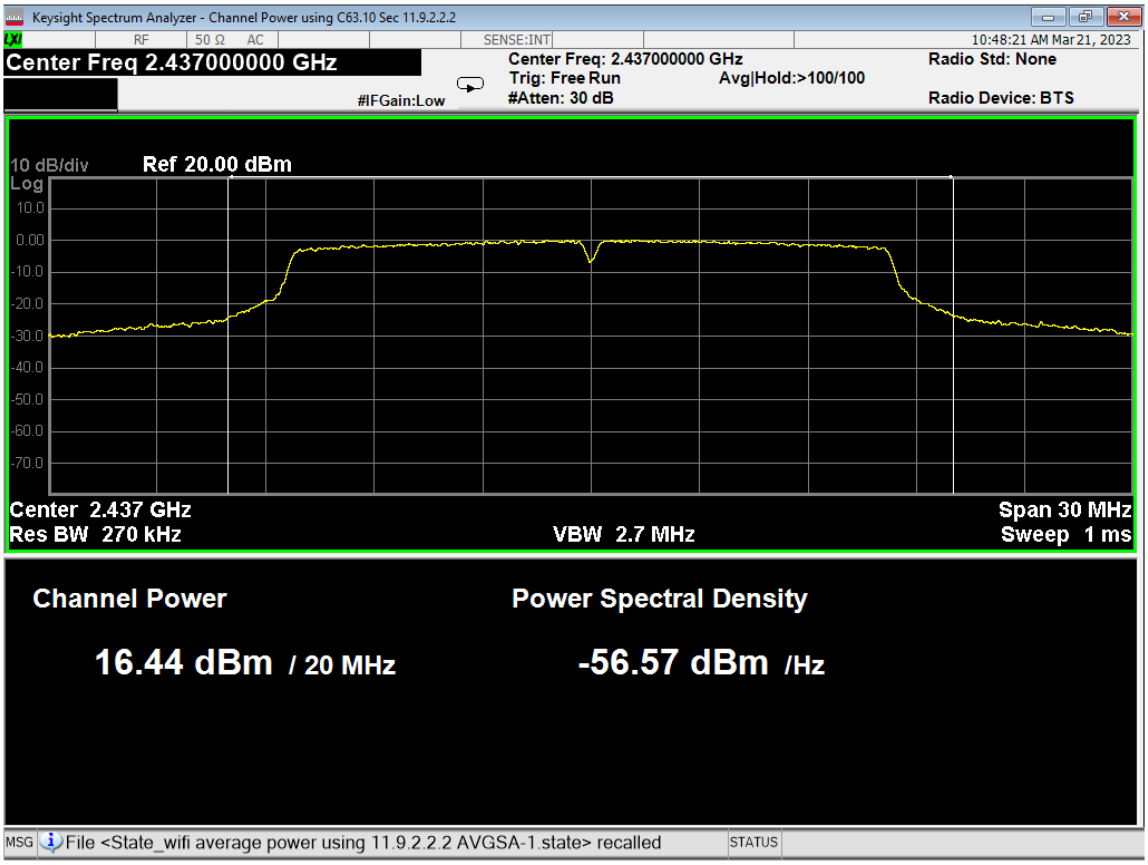
12 Lower Bandedge, Restricted, Wifi B, Low Data Rate



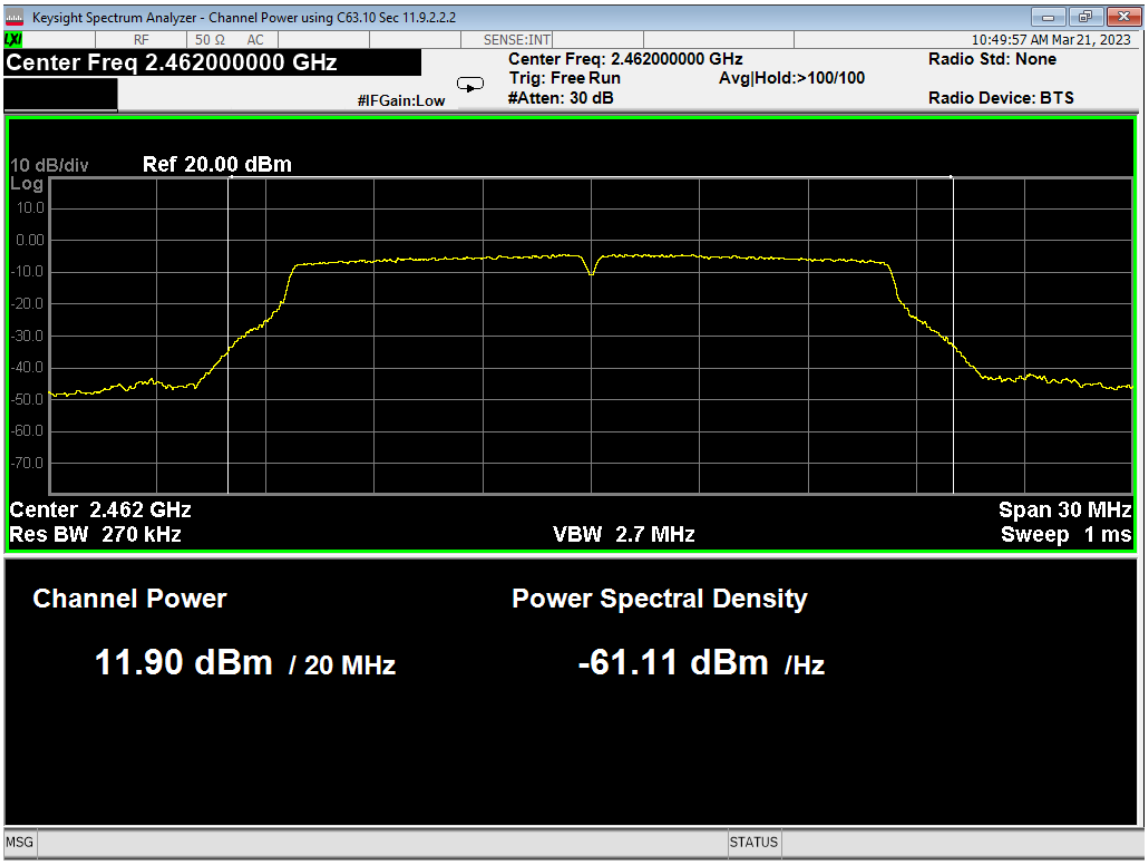
13 Higher Bandedge, Restricted, Wifi B, Low Data Rate



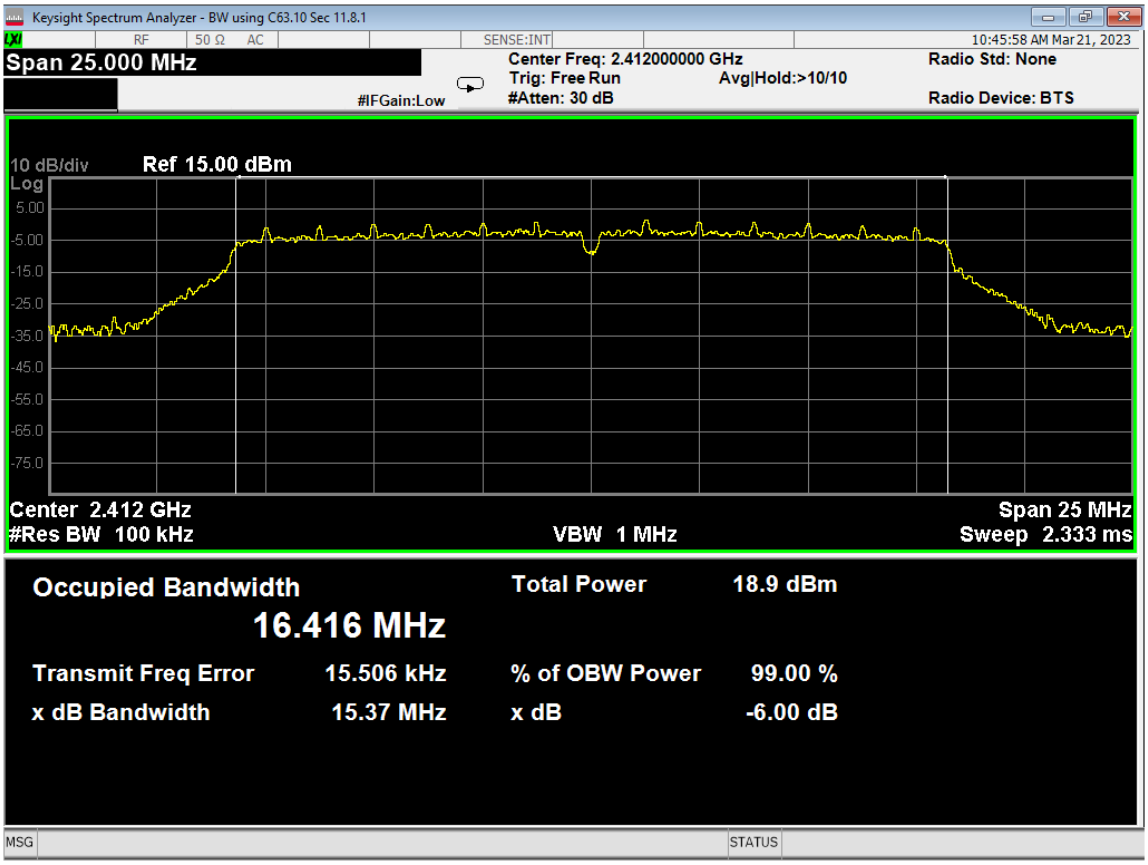
14 Average Power, Low, Wifi G, Low Data Rate



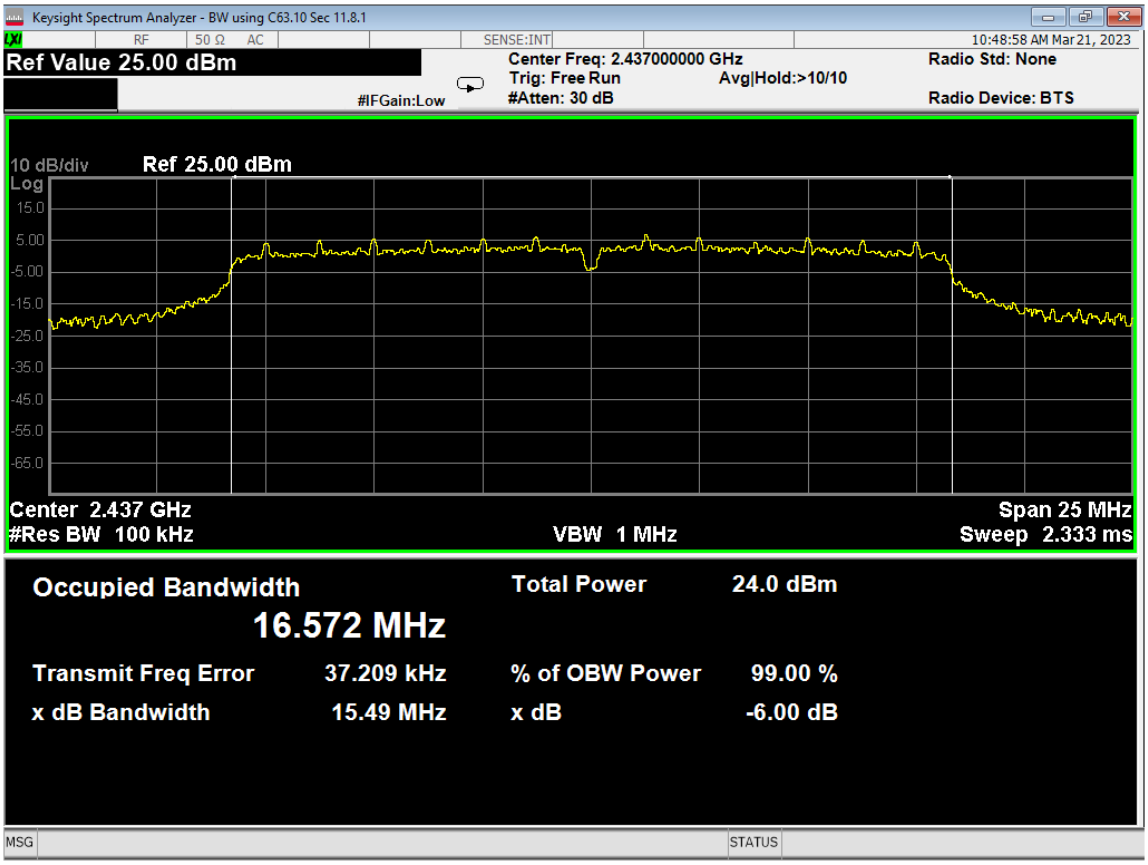
15 Average Power, Mid, Wifi G, Low Data Rate



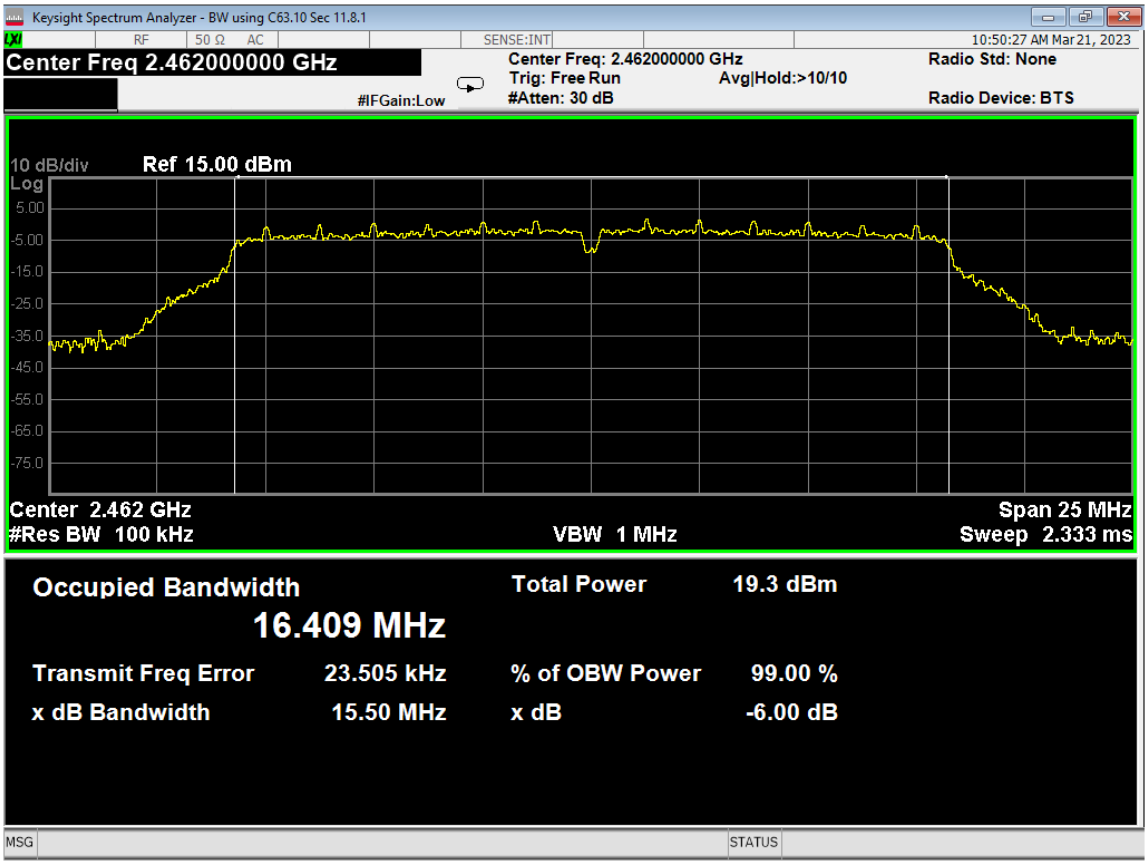
16 Average Power, High, Wifi G, Low Data Rate



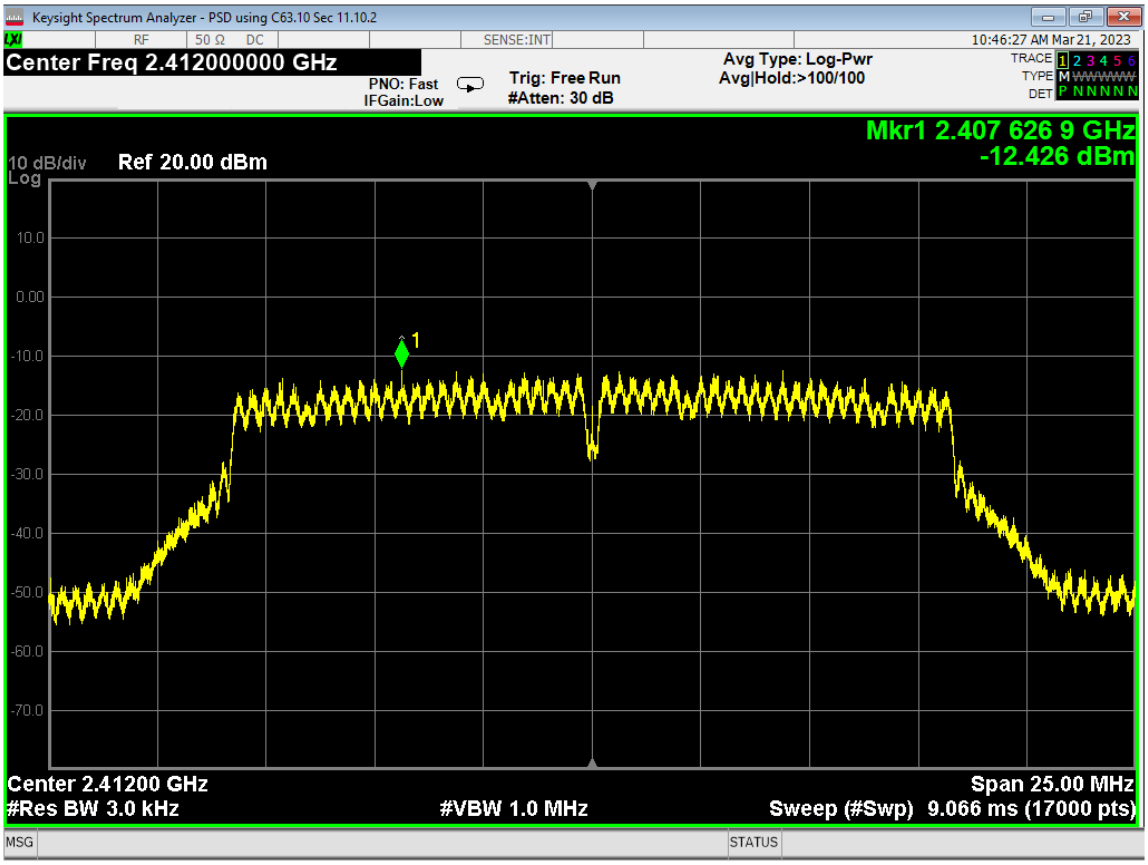
17 6dB Bandwidth, Low, Wifi G, Low Data Rate



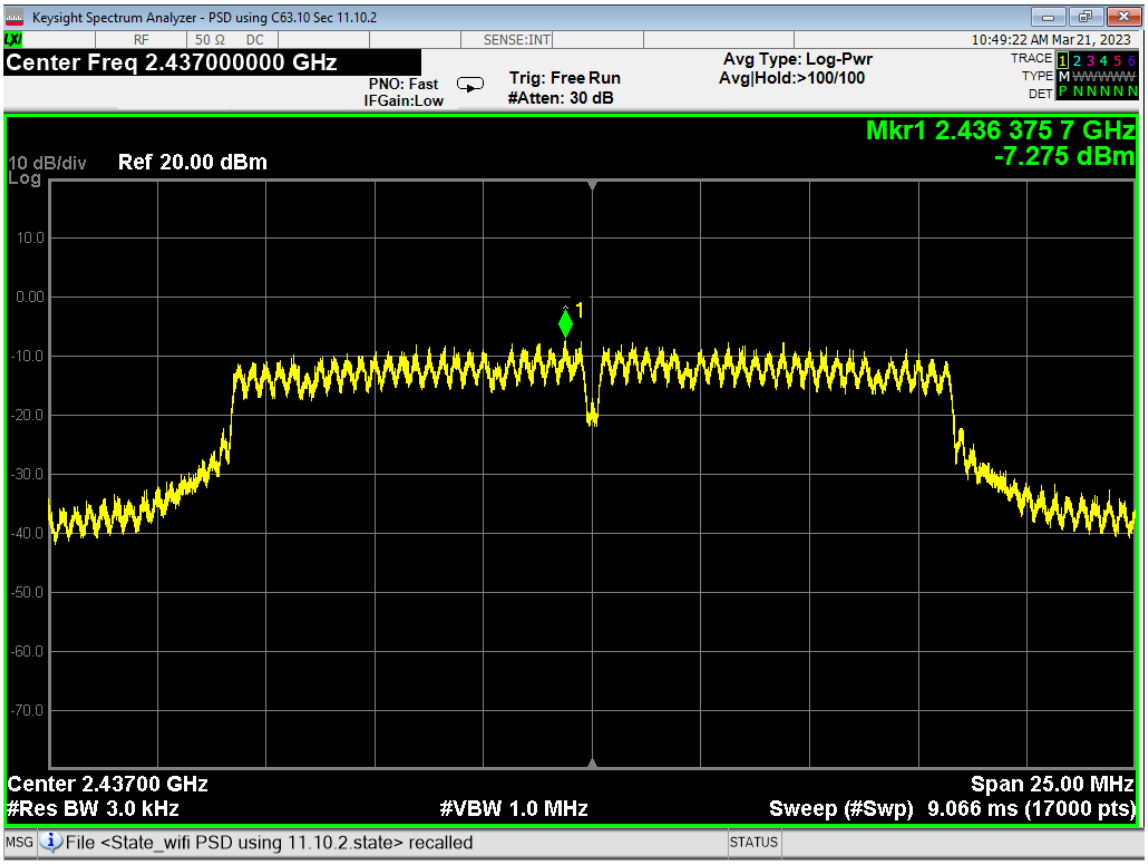
18 6dB Bandwidth, Mid, Wifi G, Low Data Rate



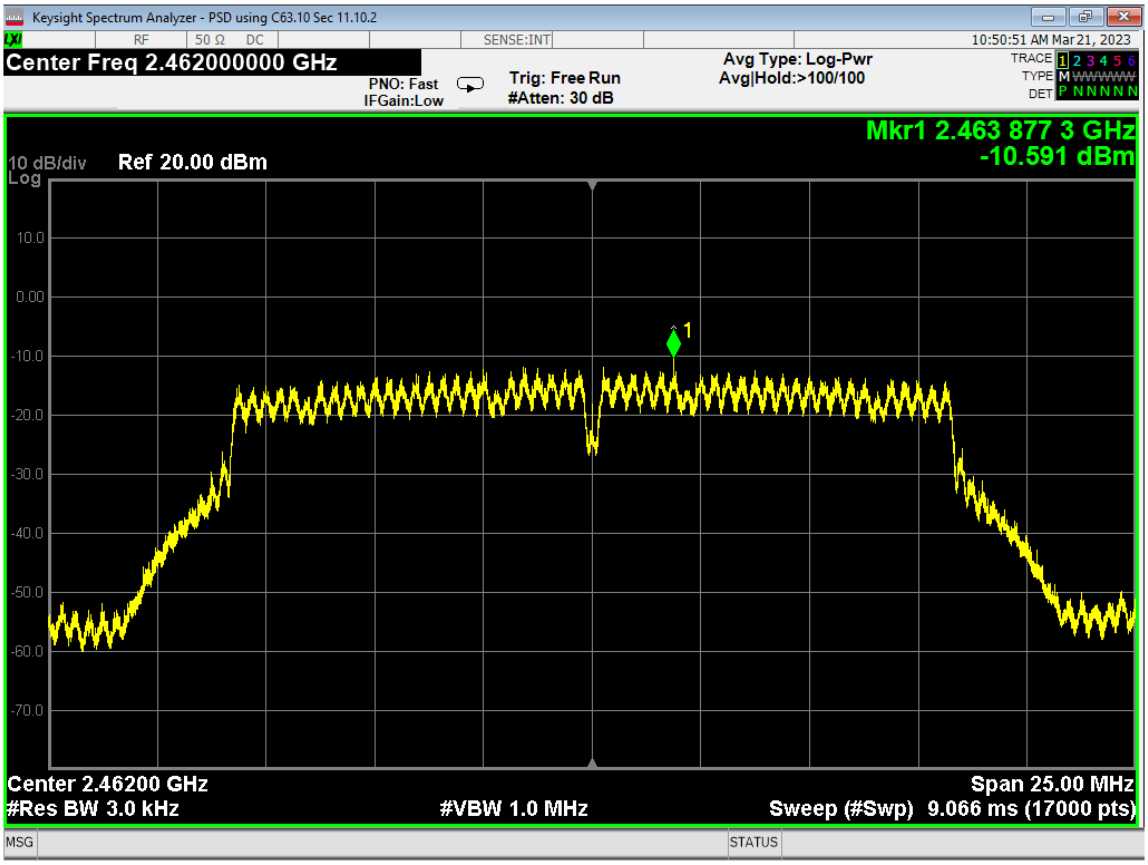
19 6dB Bandwidth, High, Wifi G, Low Data Rate



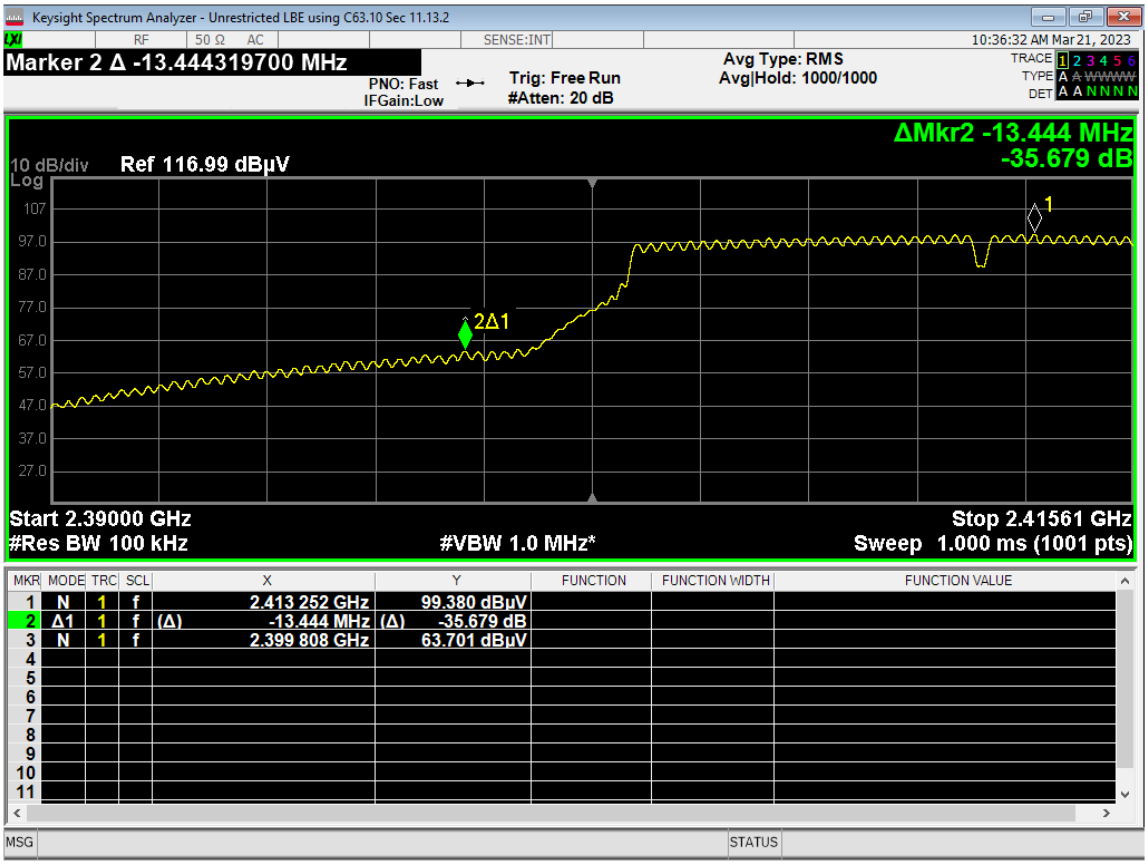
20 PSD, Low, Wifi G, Low Data Rate



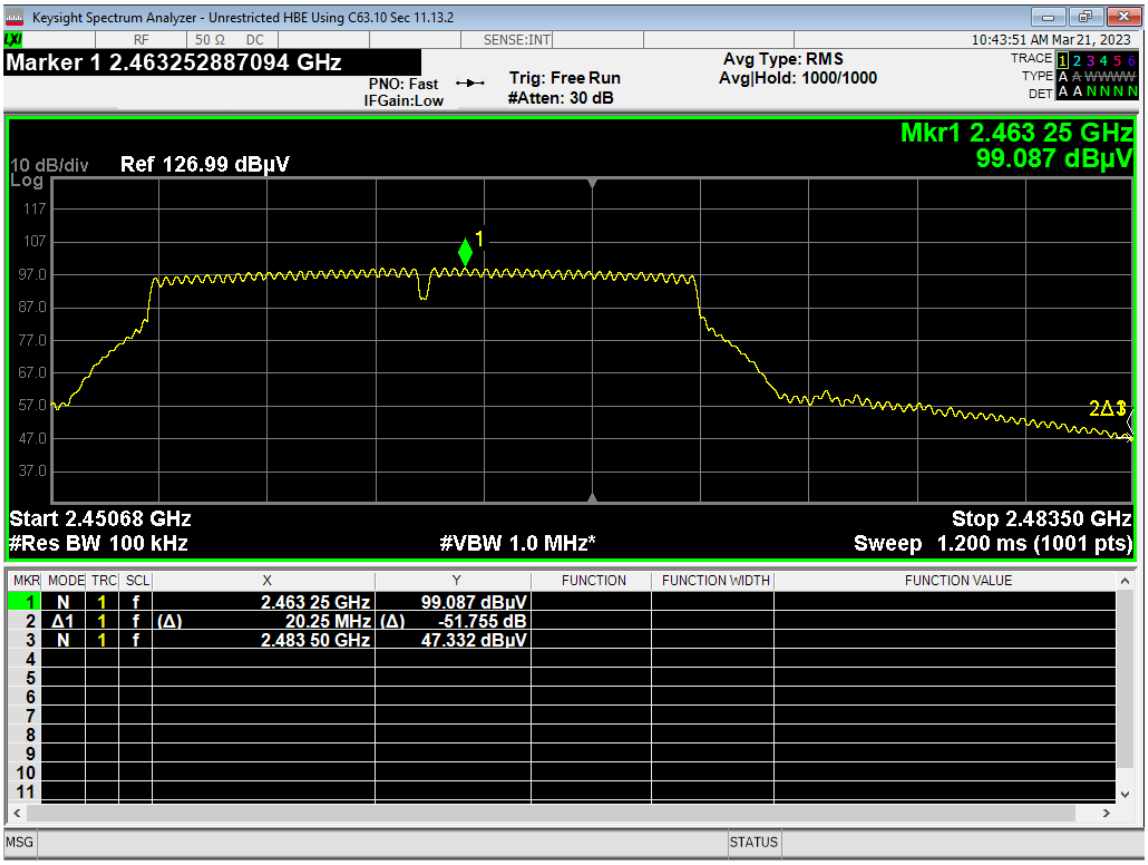
21 PSD, Mid, Wifi G, Low Data Rate



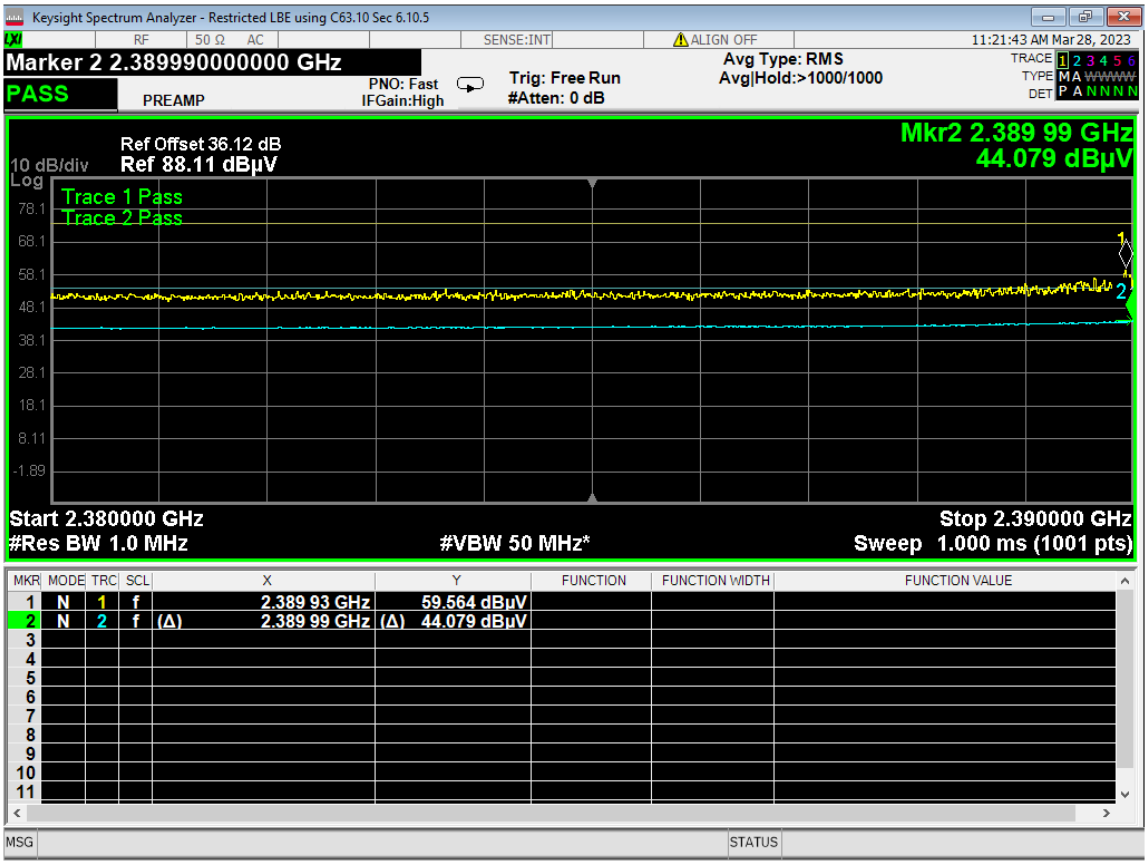
22 PSD, High, Wifi G, Low Data Rate



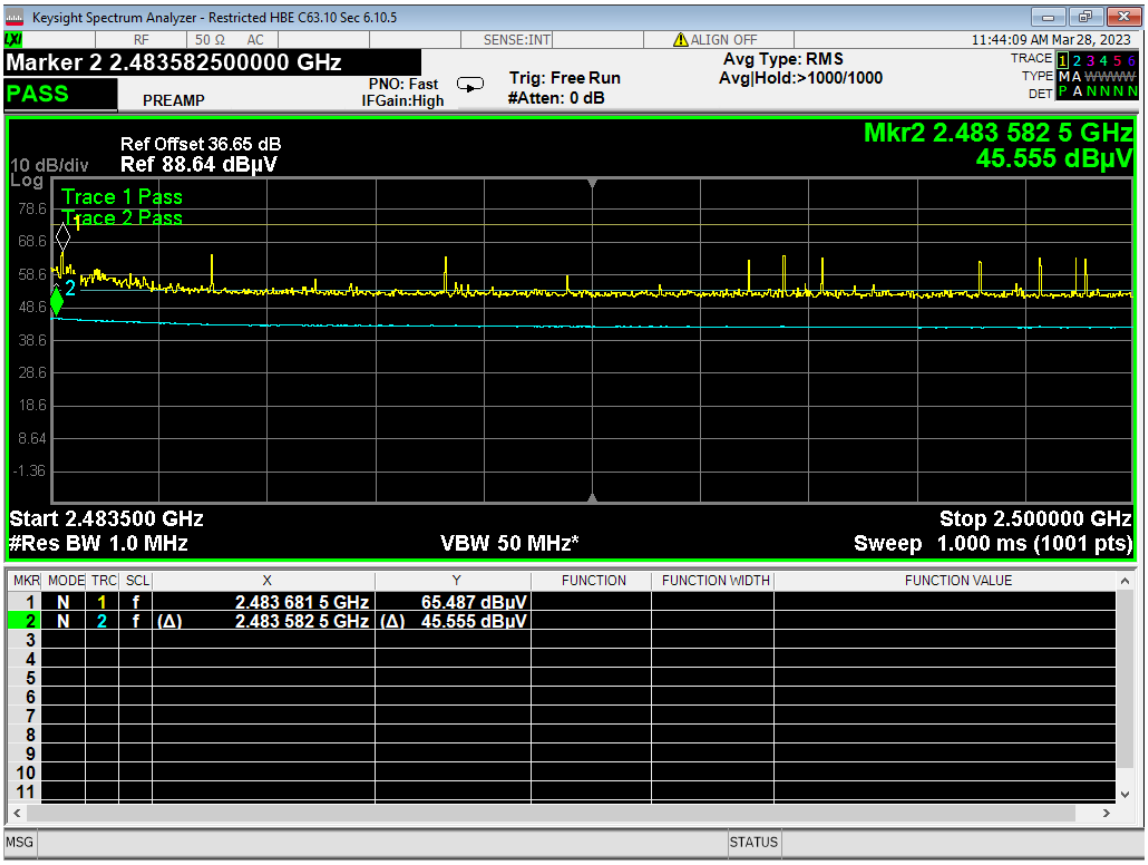
23 Lower Bandedge, Unrestricted, Wifi G, Low Data Rate



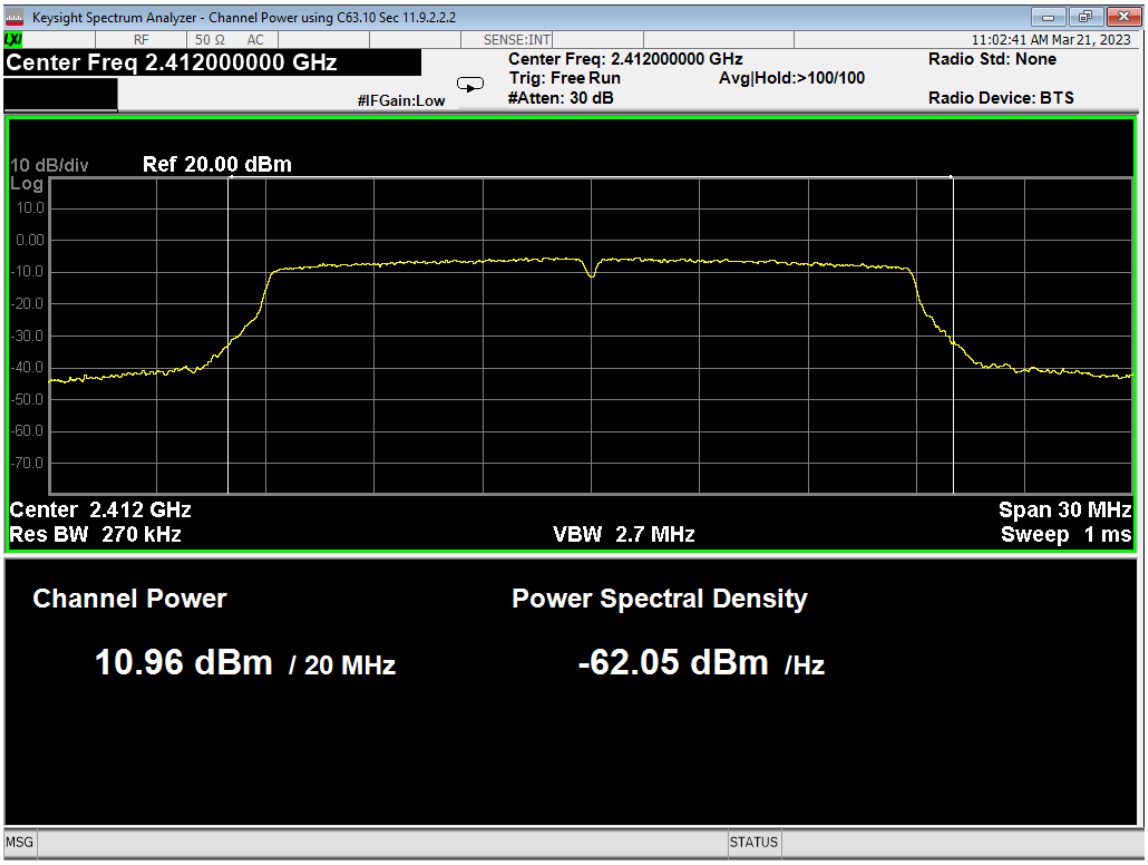
24 Higher Bandedge, Unrestricted, Wifi G, Low Data Rate



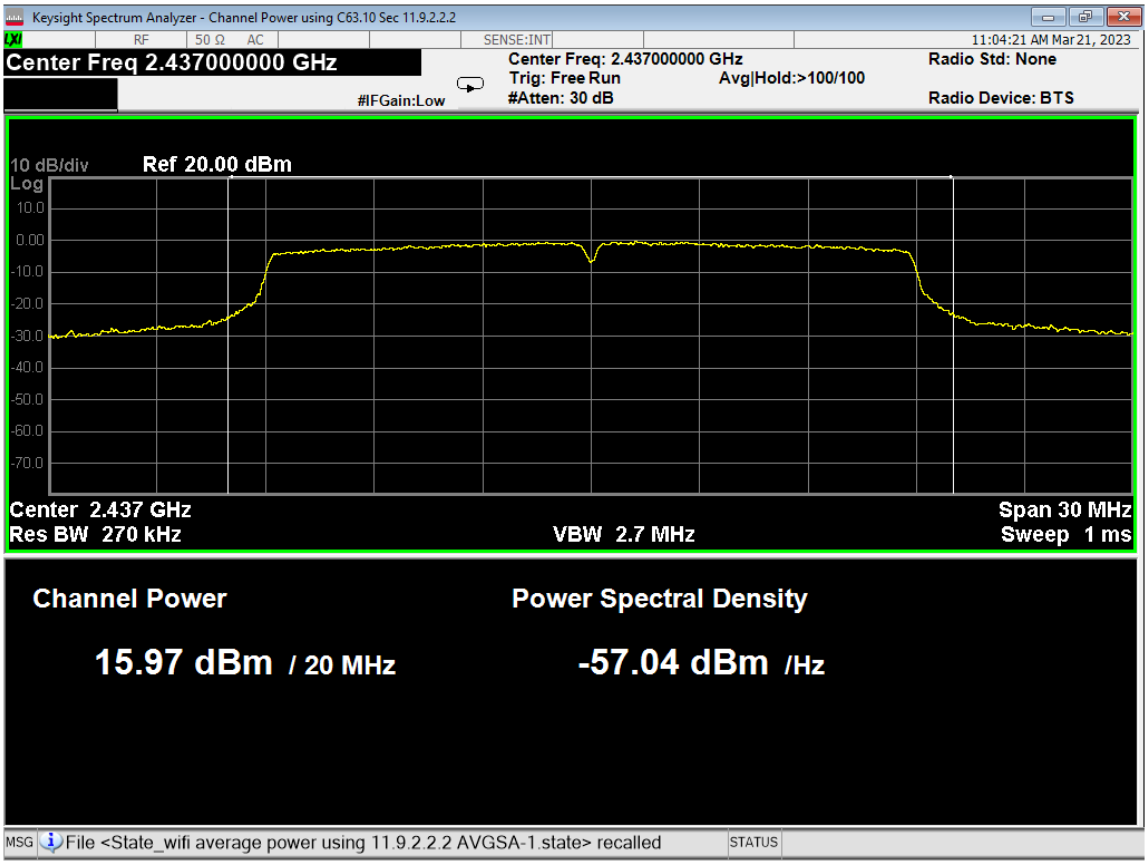
25 Lower Bandedge, Restricted, Wifi G, Low Data Rate



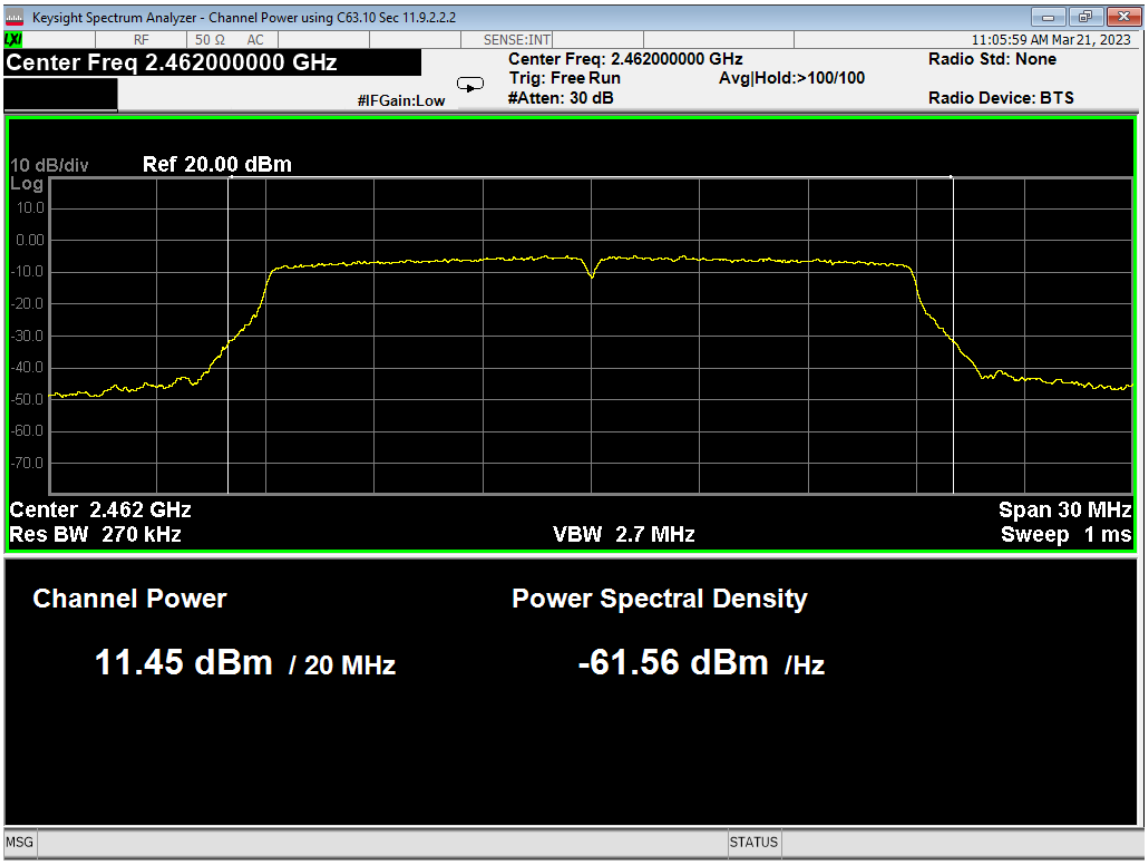
26 Higher Bandedge, Restricted, Wifi G, Low Data Rate



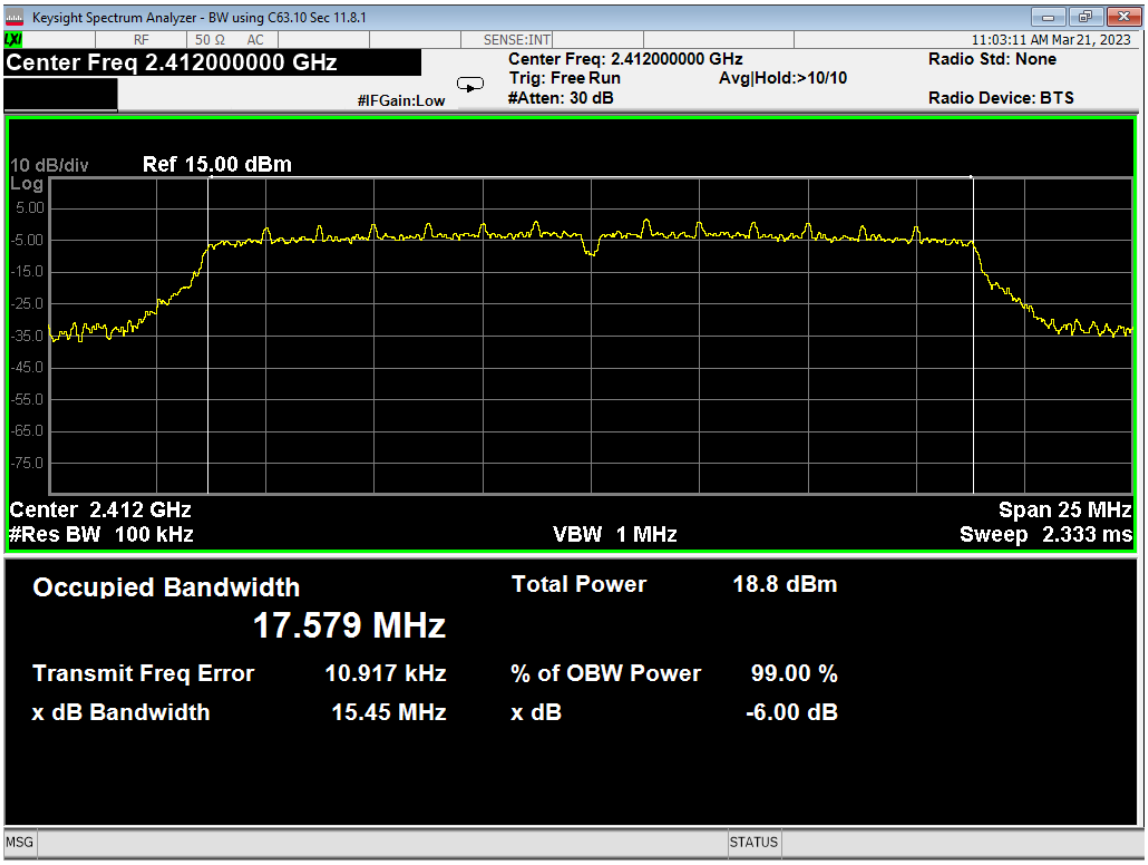
27 Average Power, Low, Wifi N, Low Data Rate



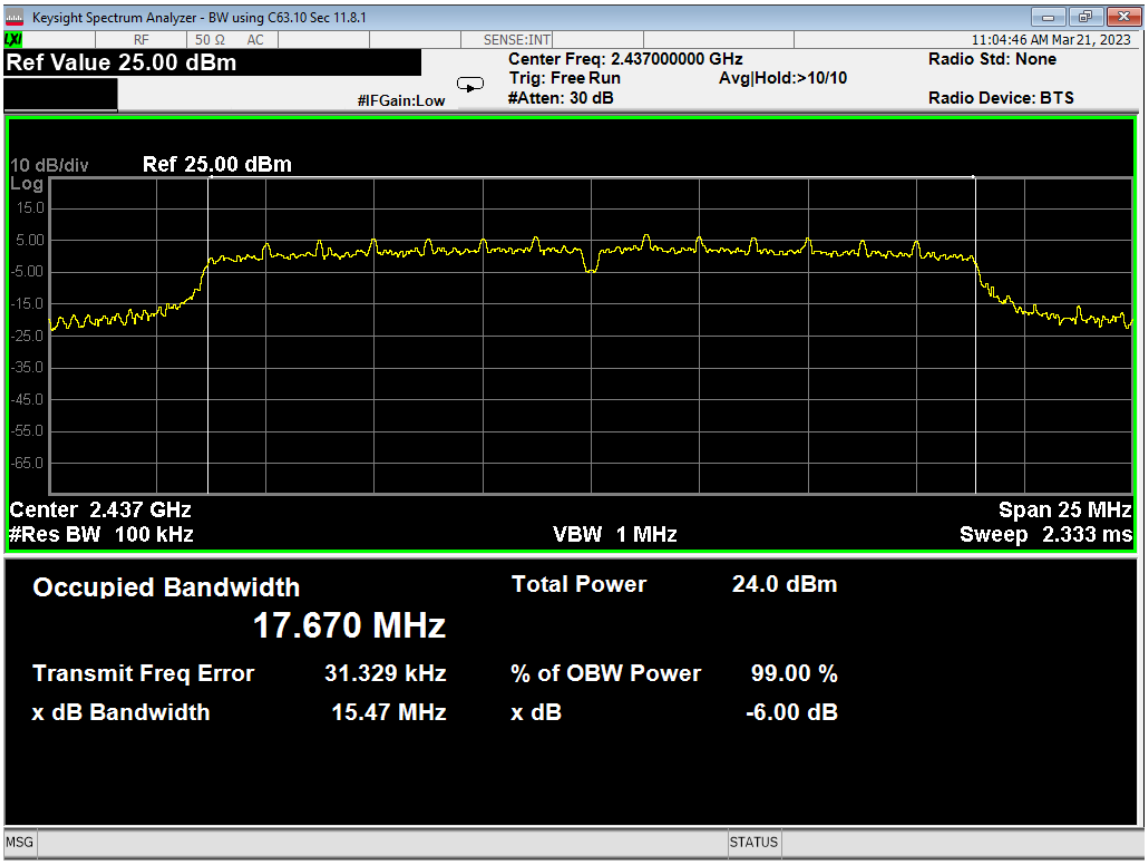
28 Average Power, Mid, Wifi N, Low Data Rate



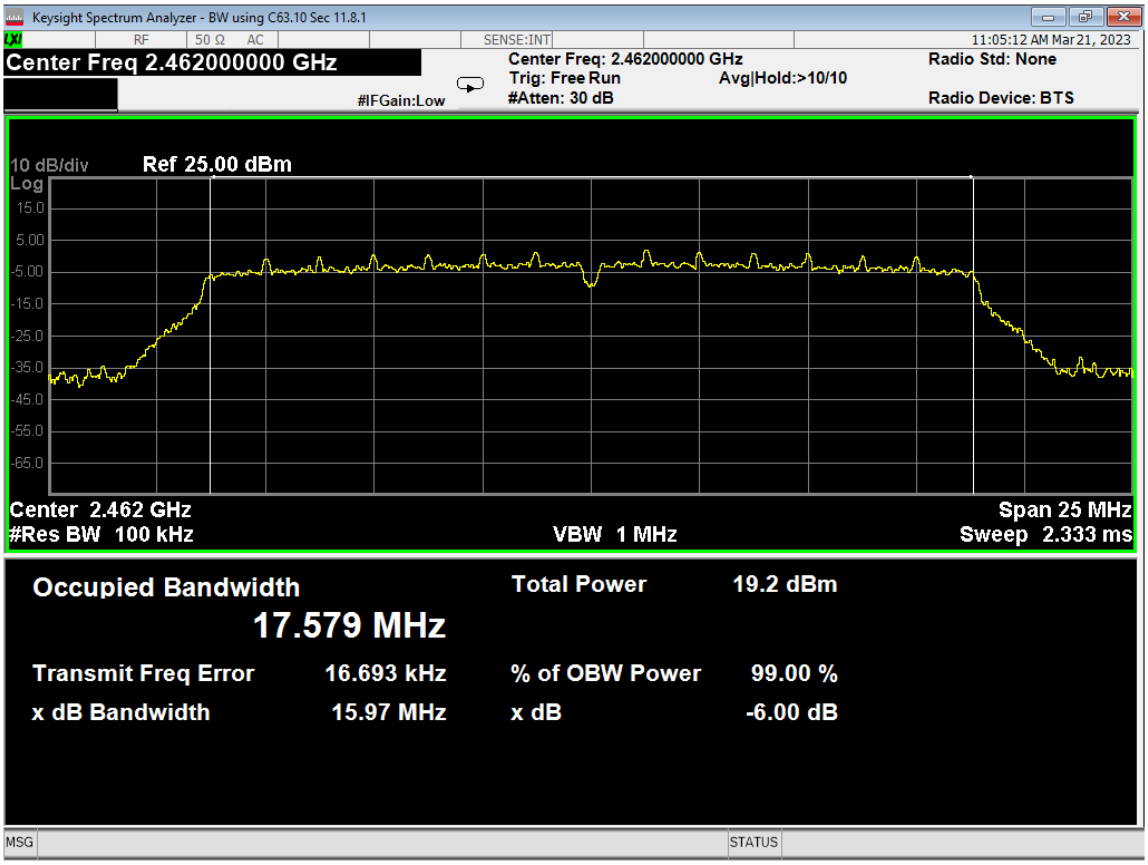
29 Average Power, High, Wifi N, Low Data Rate



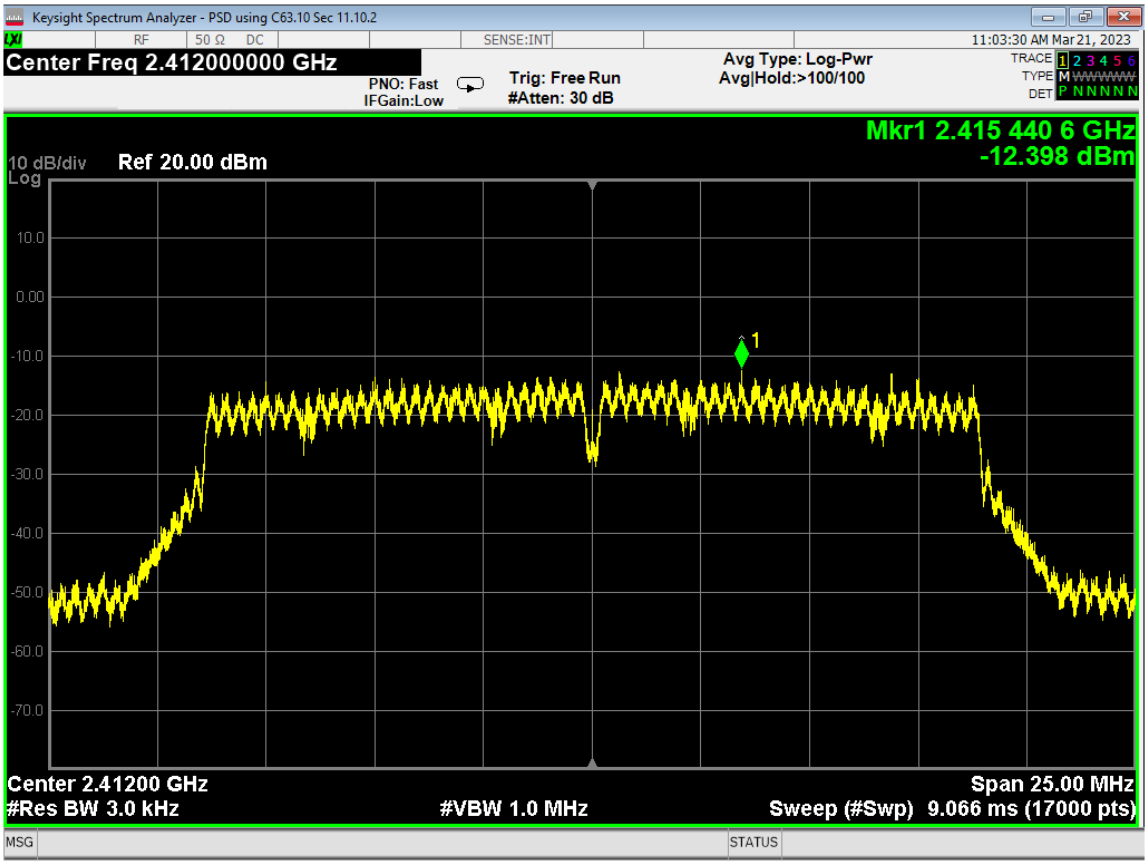
30 6dB Bandwidth, Low, Wifi N, Low Data Rate



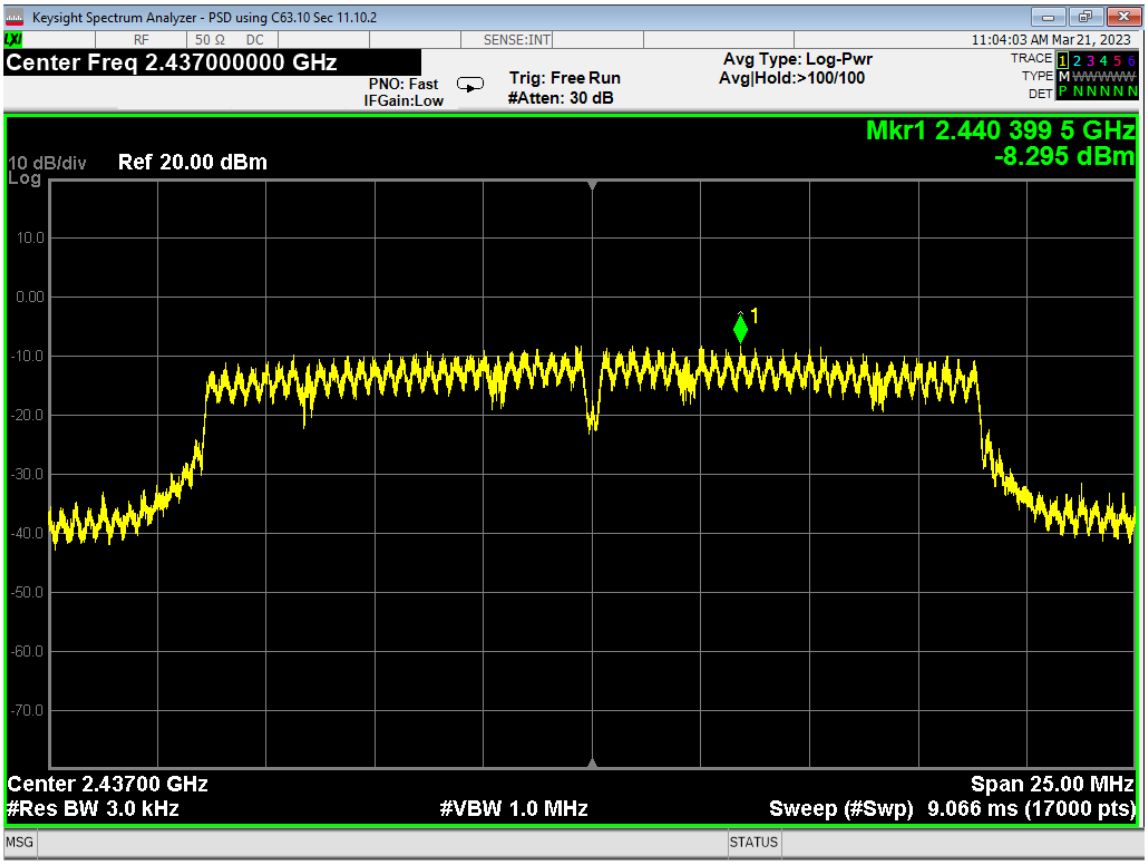
31 6dB Bandwidth, Mid, Wifi N, Low Data Rate



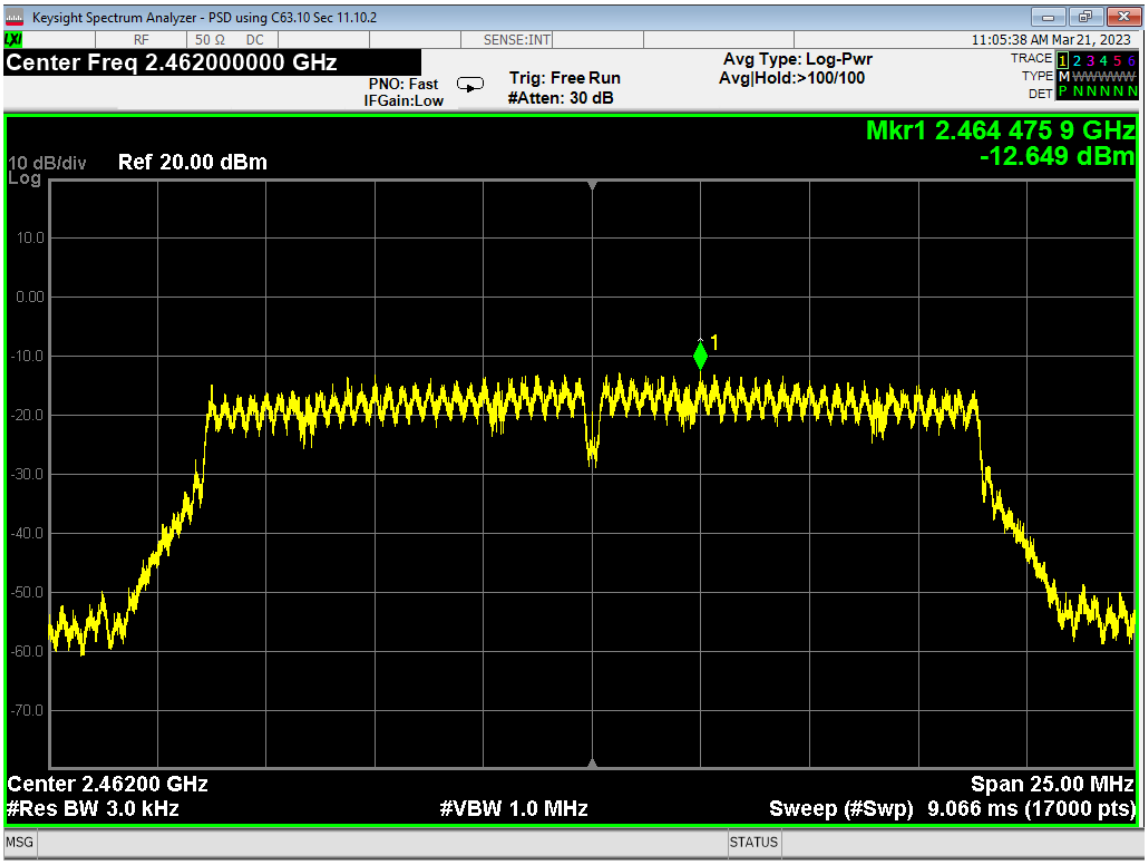
32 6dB Bandwidth, High, Wifi N, Low Data Rate



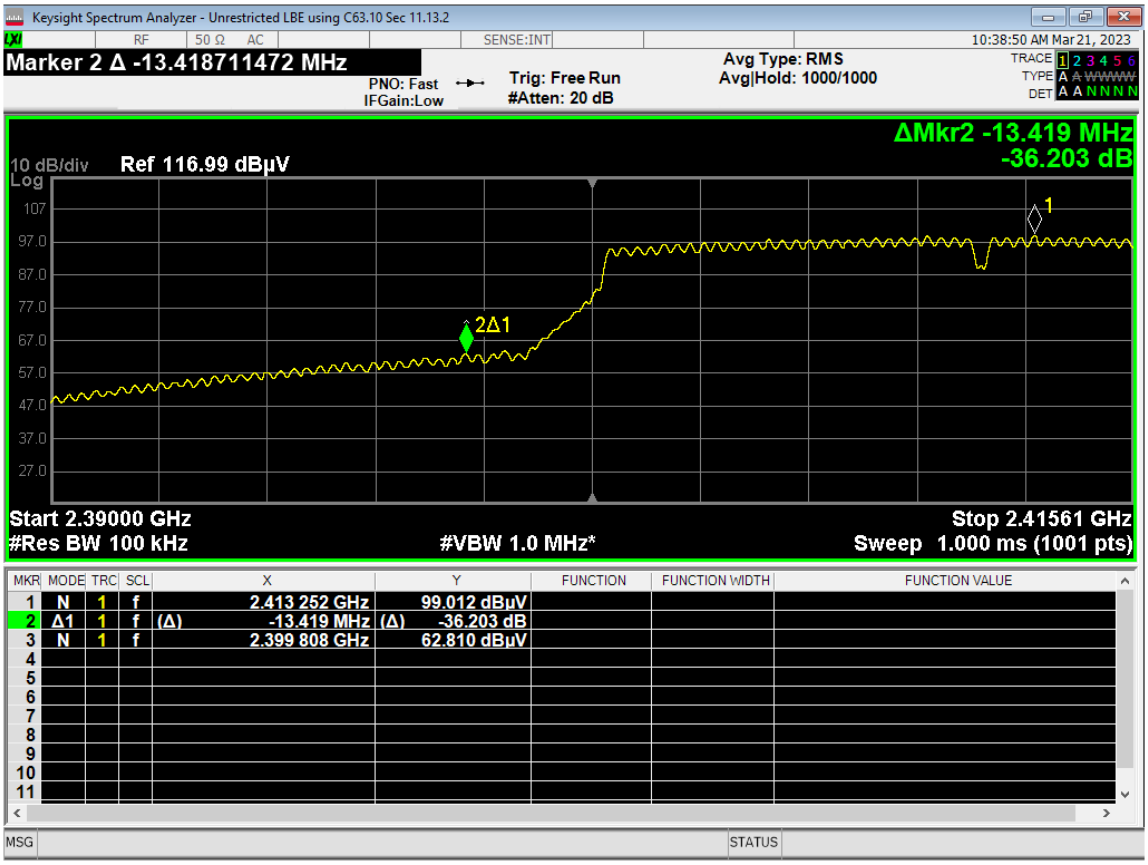
33 PSD, Low, Wifi N, Low Data Rate



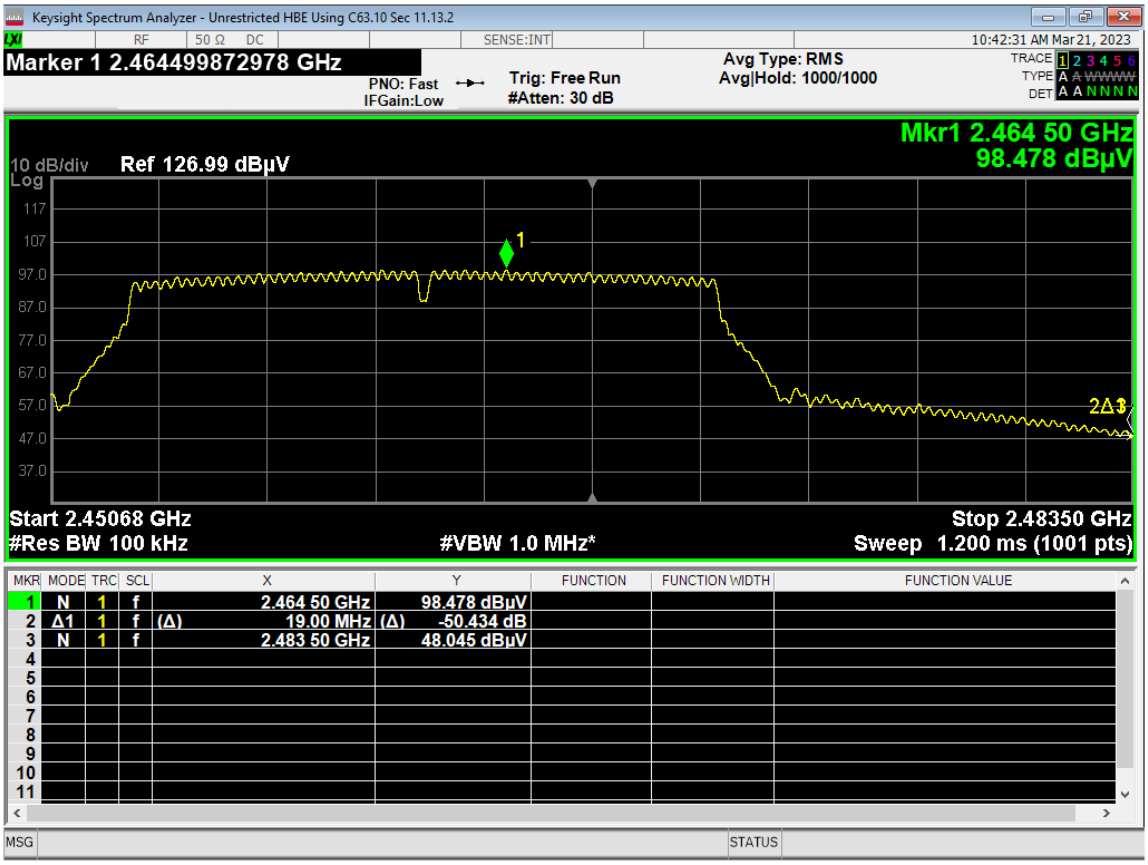
34 PSD, Mid, Wifi N, Low Data Rate



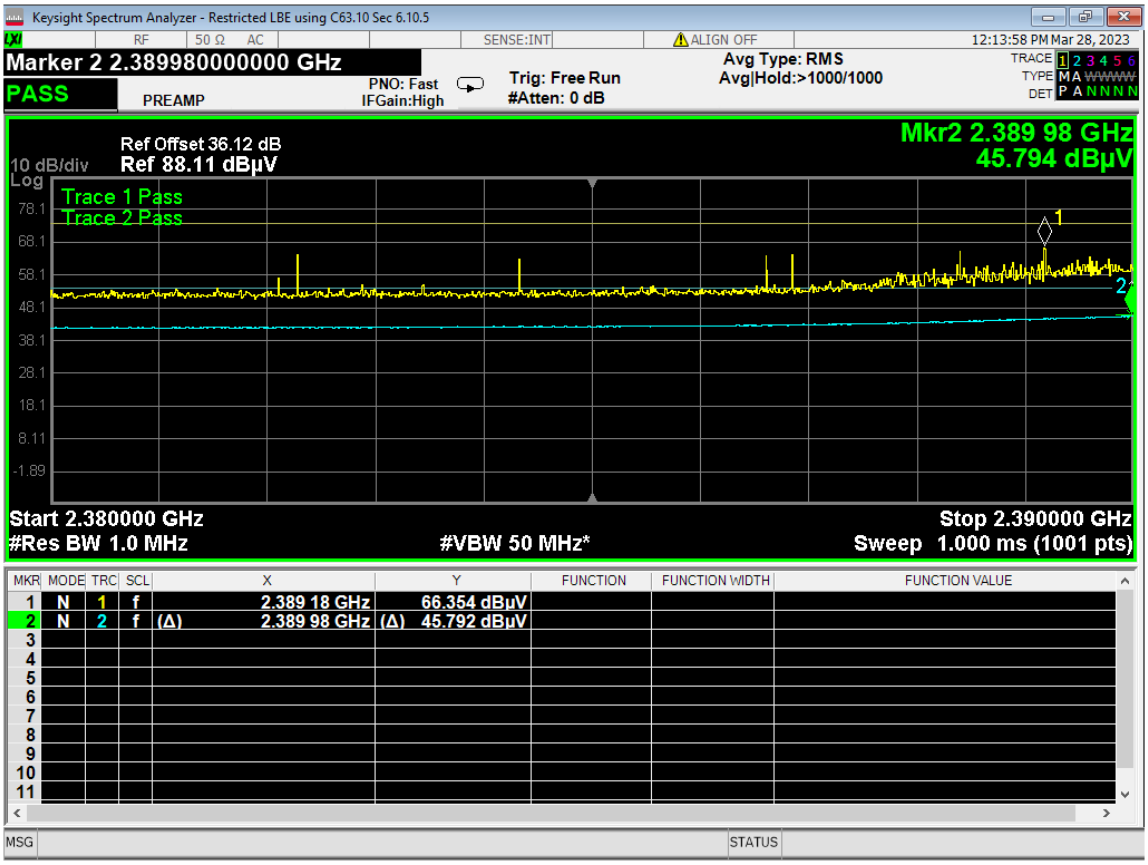
35 PSD, High, Wifi N, Low Data Rate



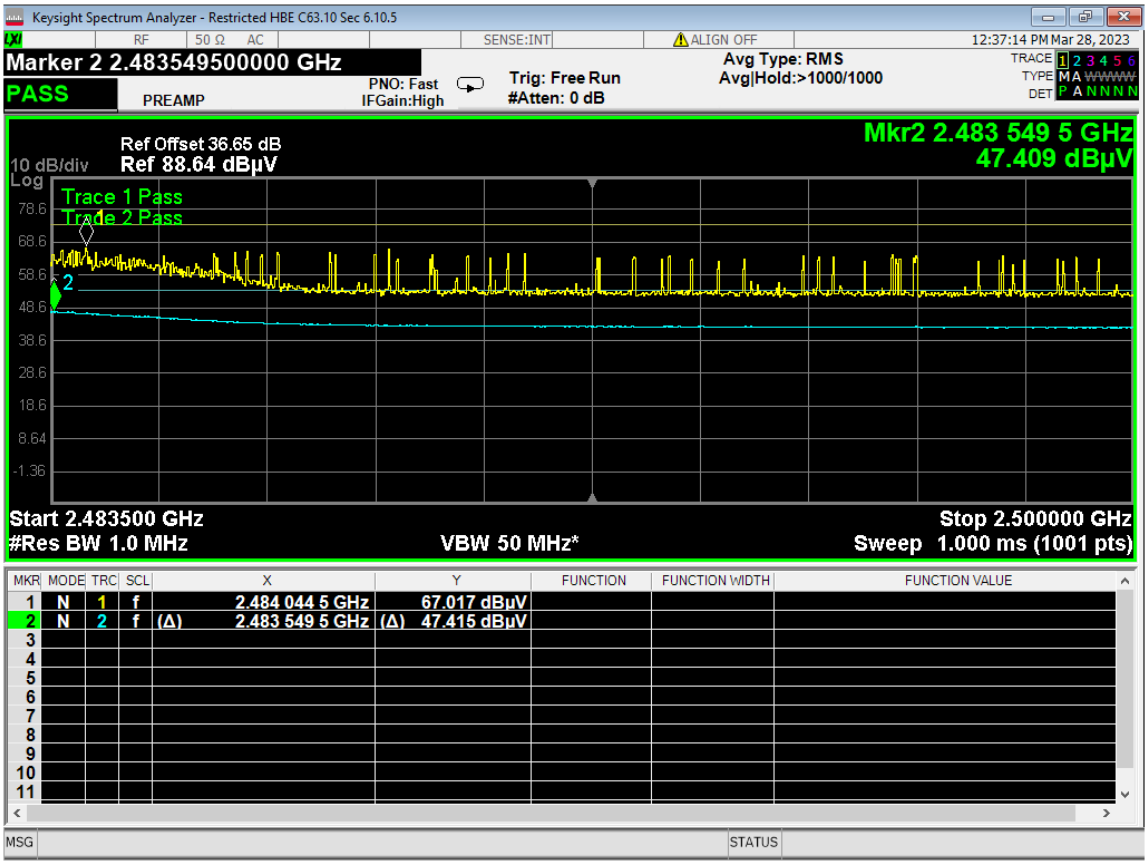
36 Lower Bandedge, Unrestricted, Wifi N, Low Data Rate



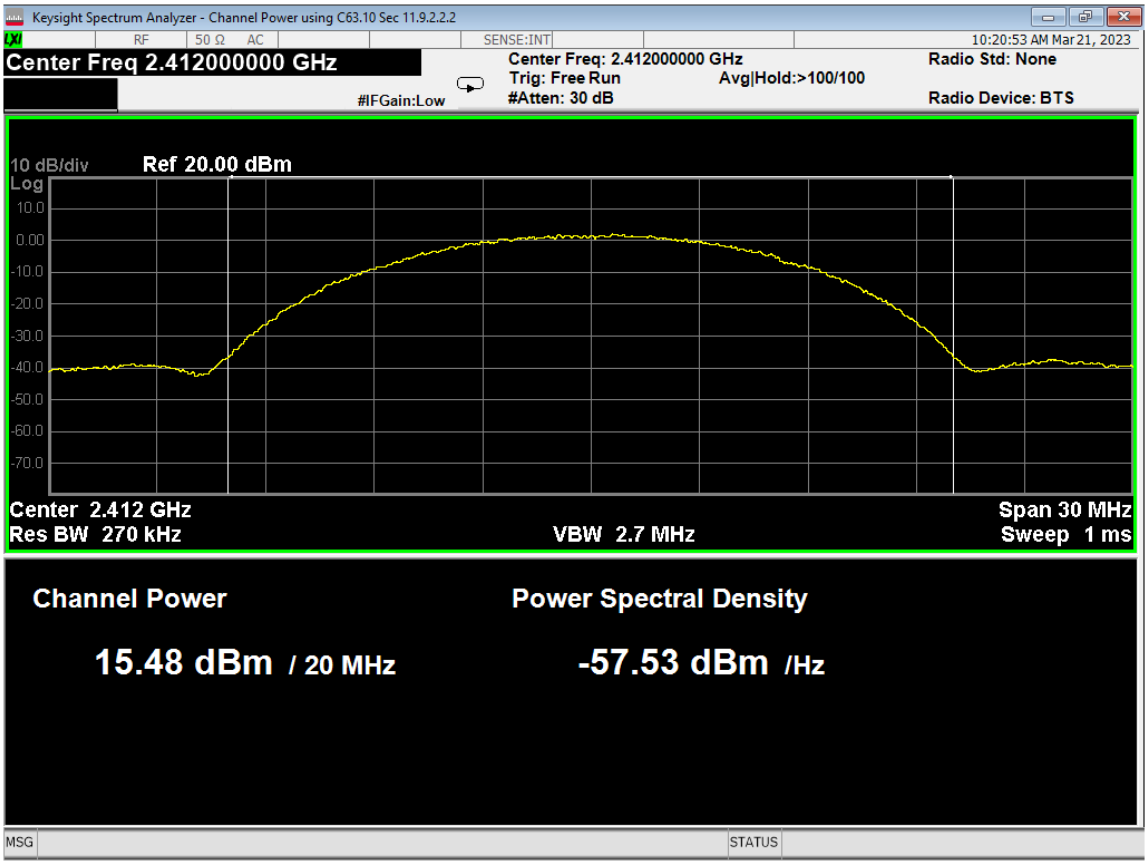
37 Higher Bandedge, Unrestricted, Wifi N, Low Data Rate



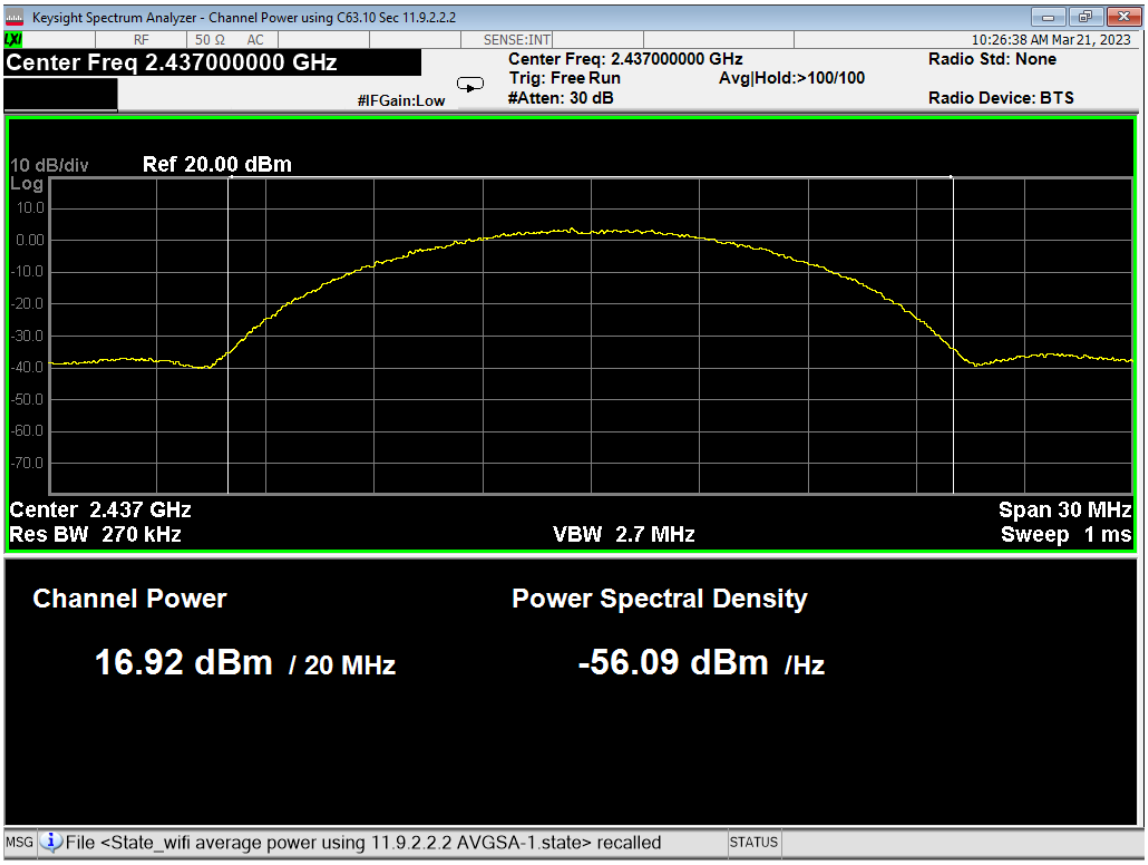
38 Lower Bandedge, Restricted, Wifi N, Low Data Rate



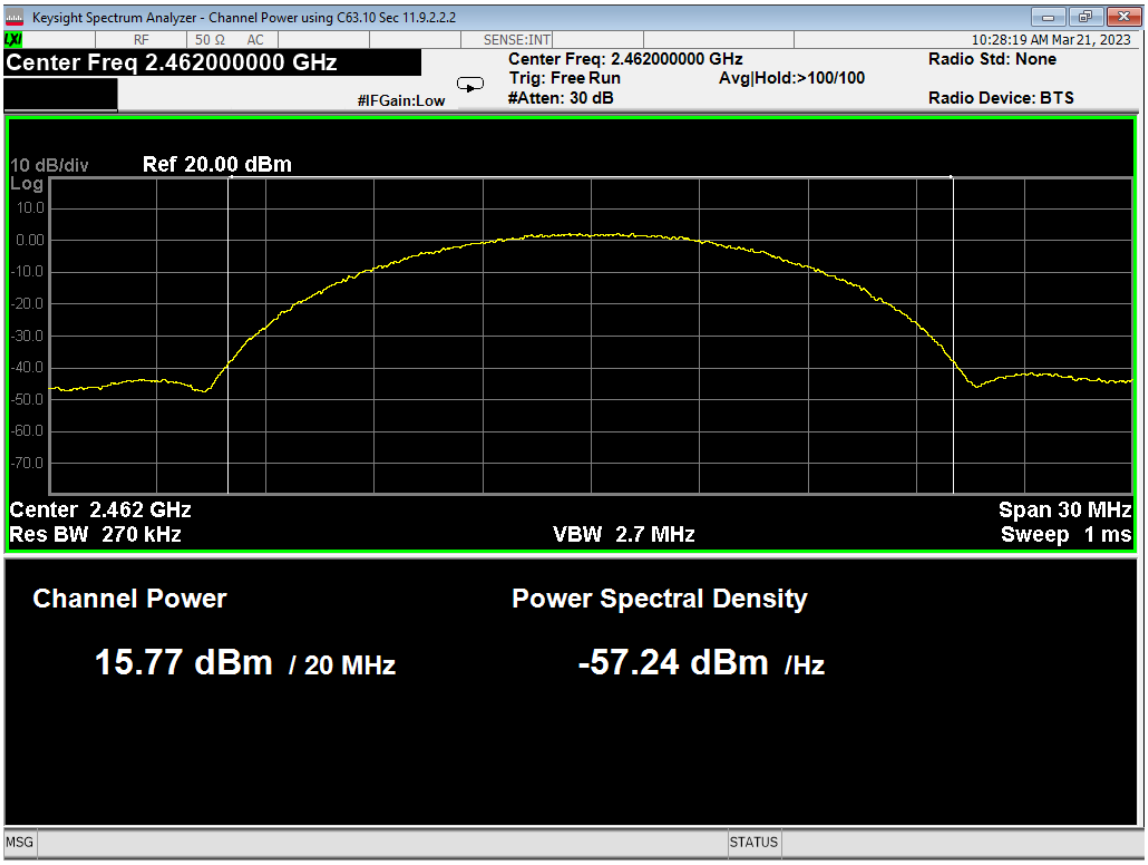
39 Higher Bandedge, Restricted, Wifi N, Low Data Rate



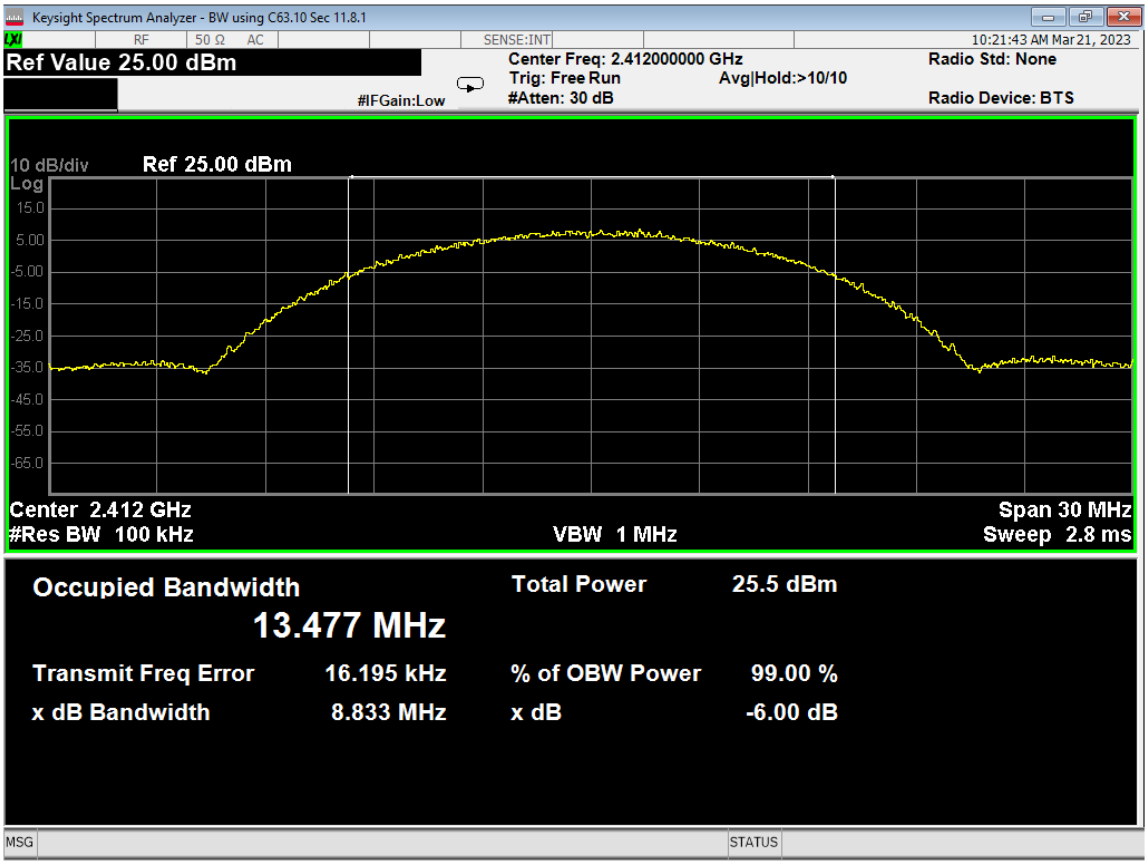
40 Average Power, Low, Wifi B, High Data Rate



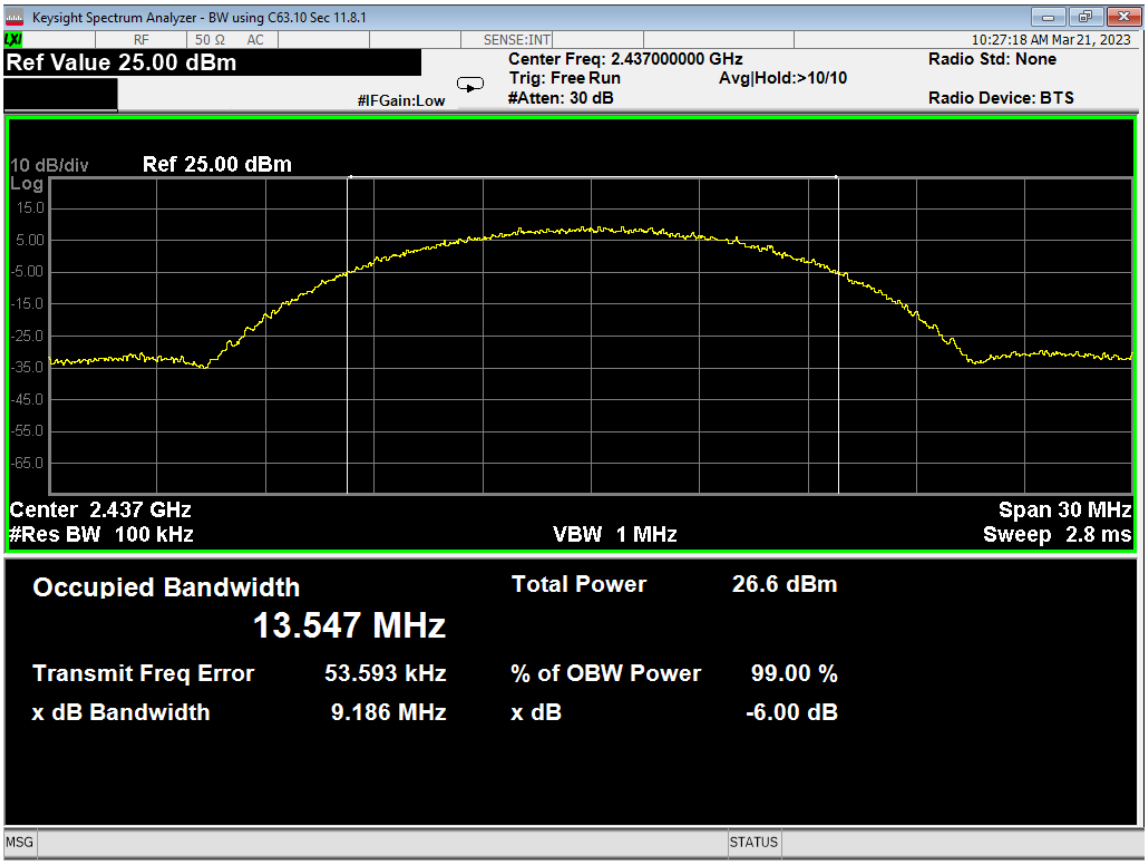
41 Average Power, Mid, Wifi B, High Data Rate



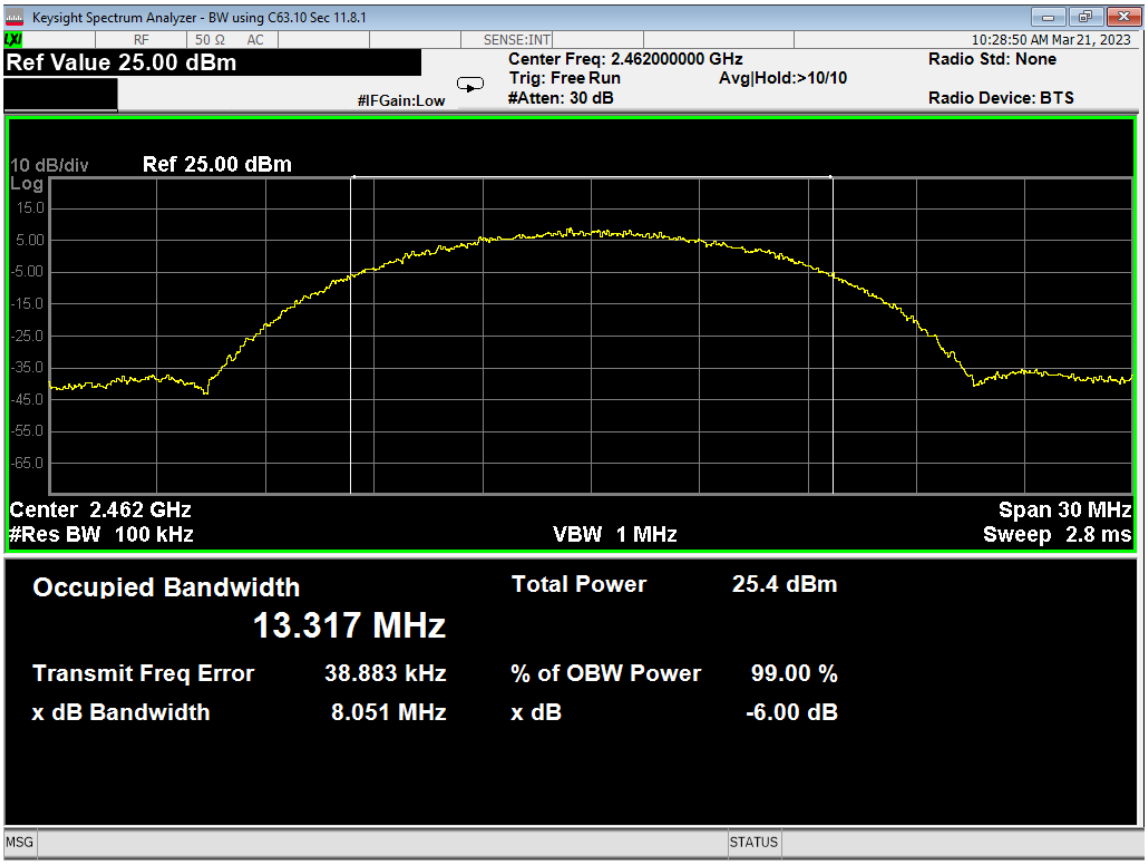
42 Average Power, High, Wifi B, High Data Rate



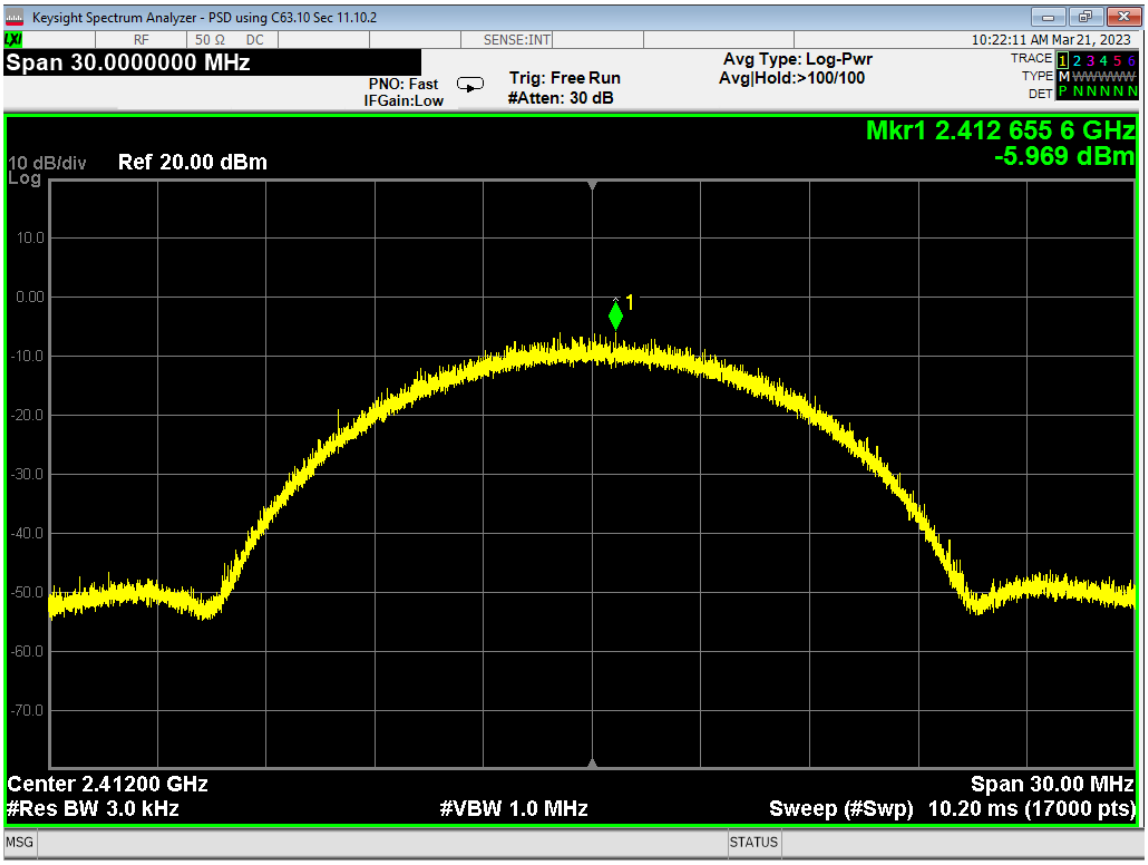
43 6dB Bandwidth, Low, Wifi B, High Data Rate



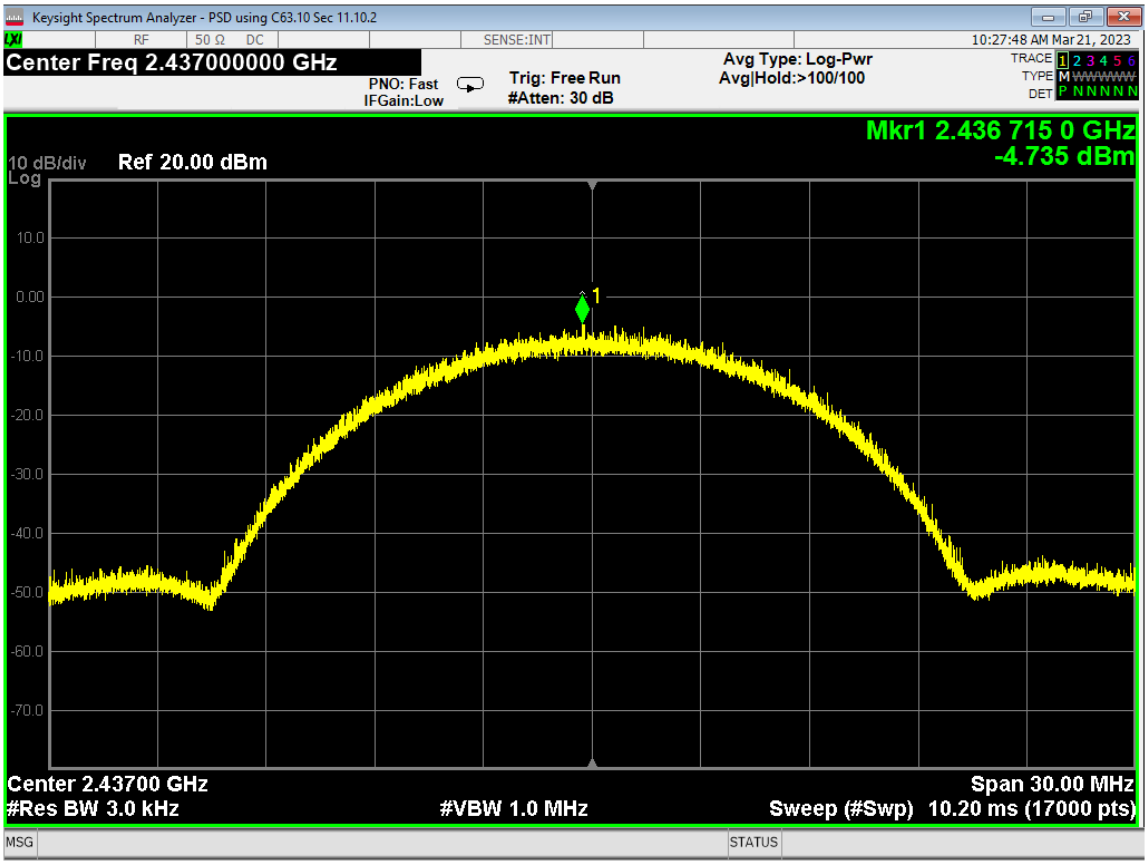
44 6dB Bandwidth, Mid, Wifi B, High Data Rate



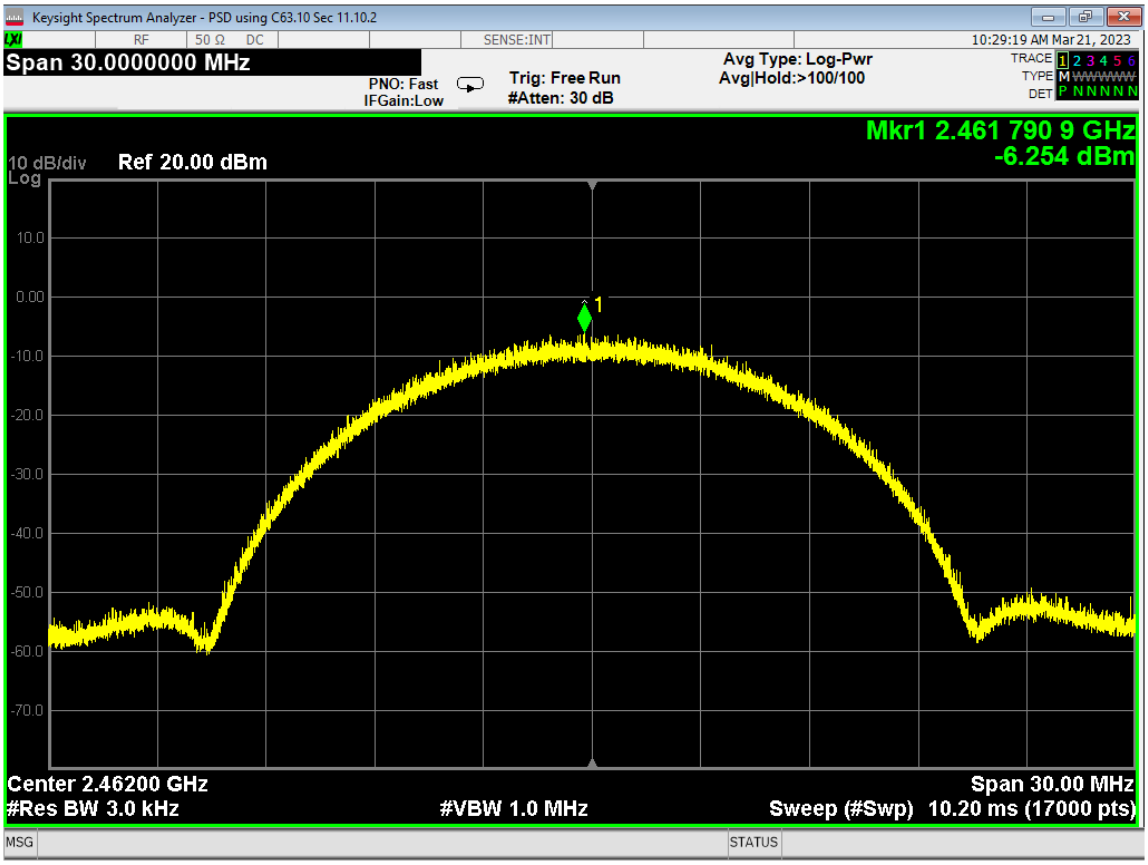
45 6dB Bandwidth, High, Wifi B, High Data Rate



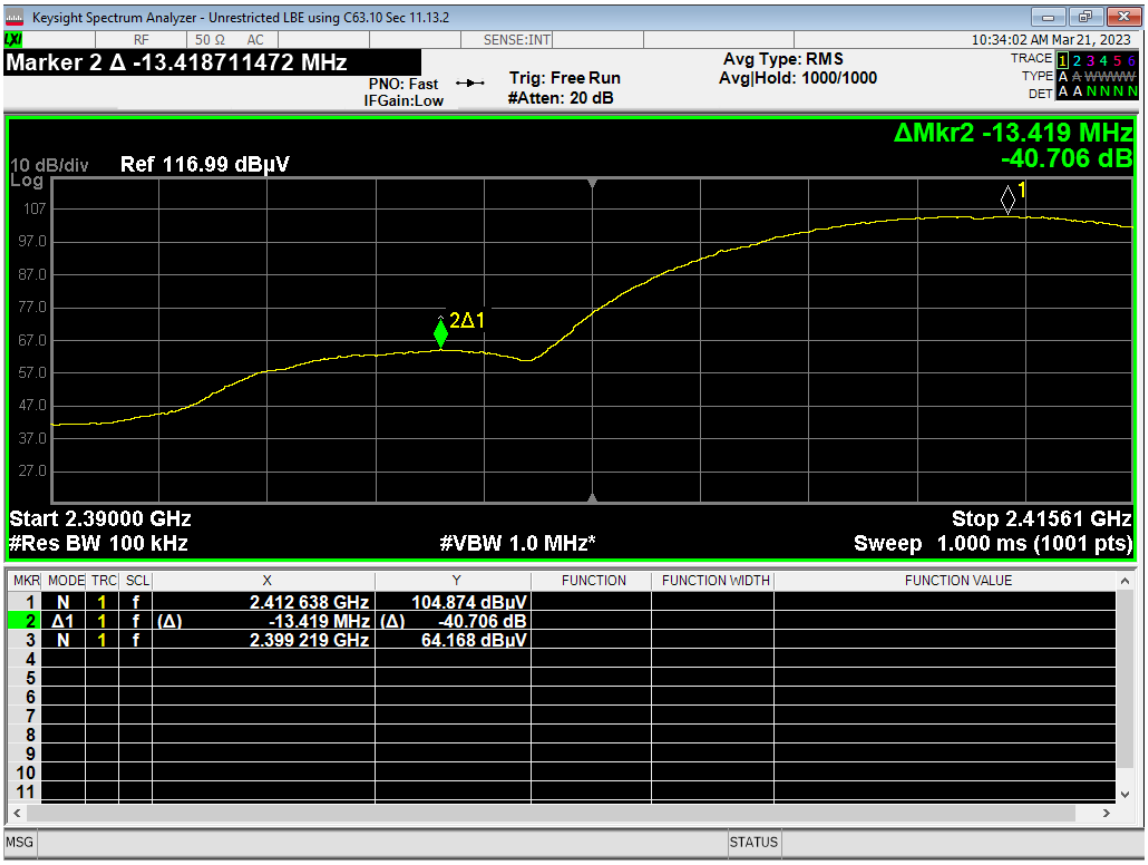
46 PSD, Low, Wifi B, High Data Rate



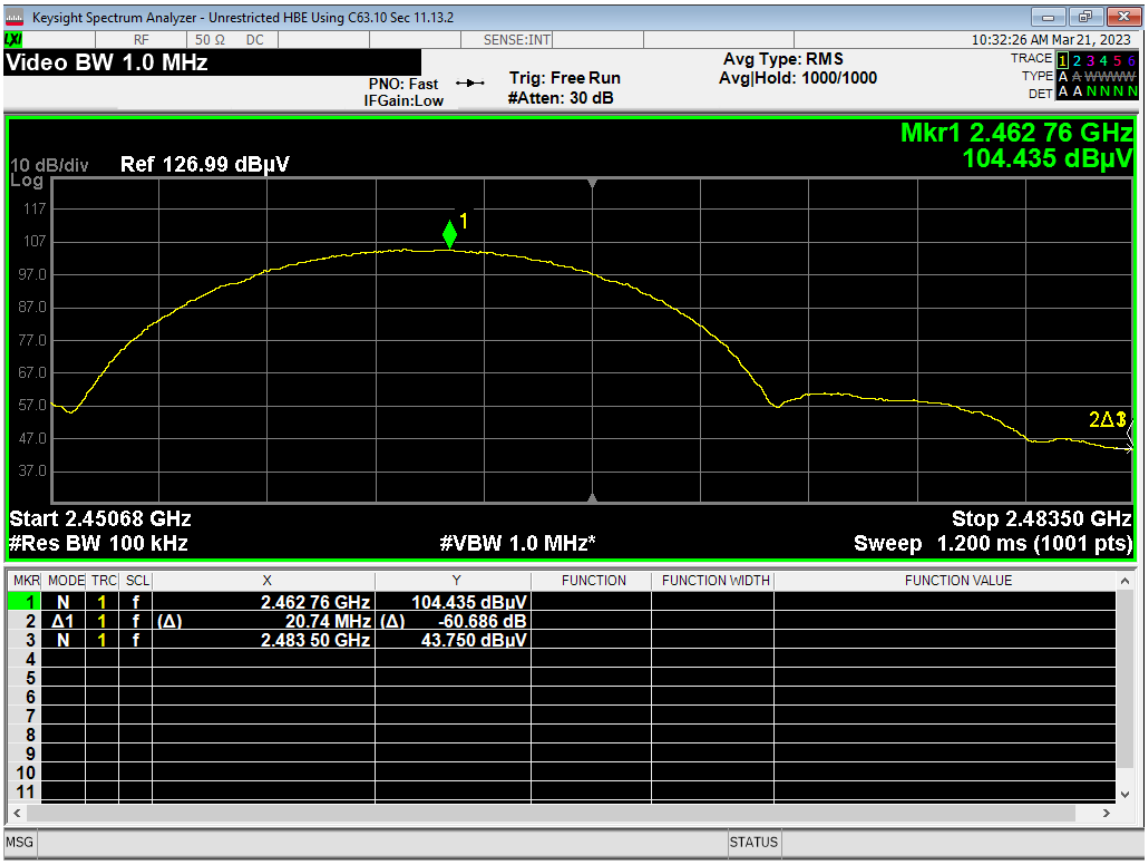
47 PSD, Mid, Wifi B, High Data Rate



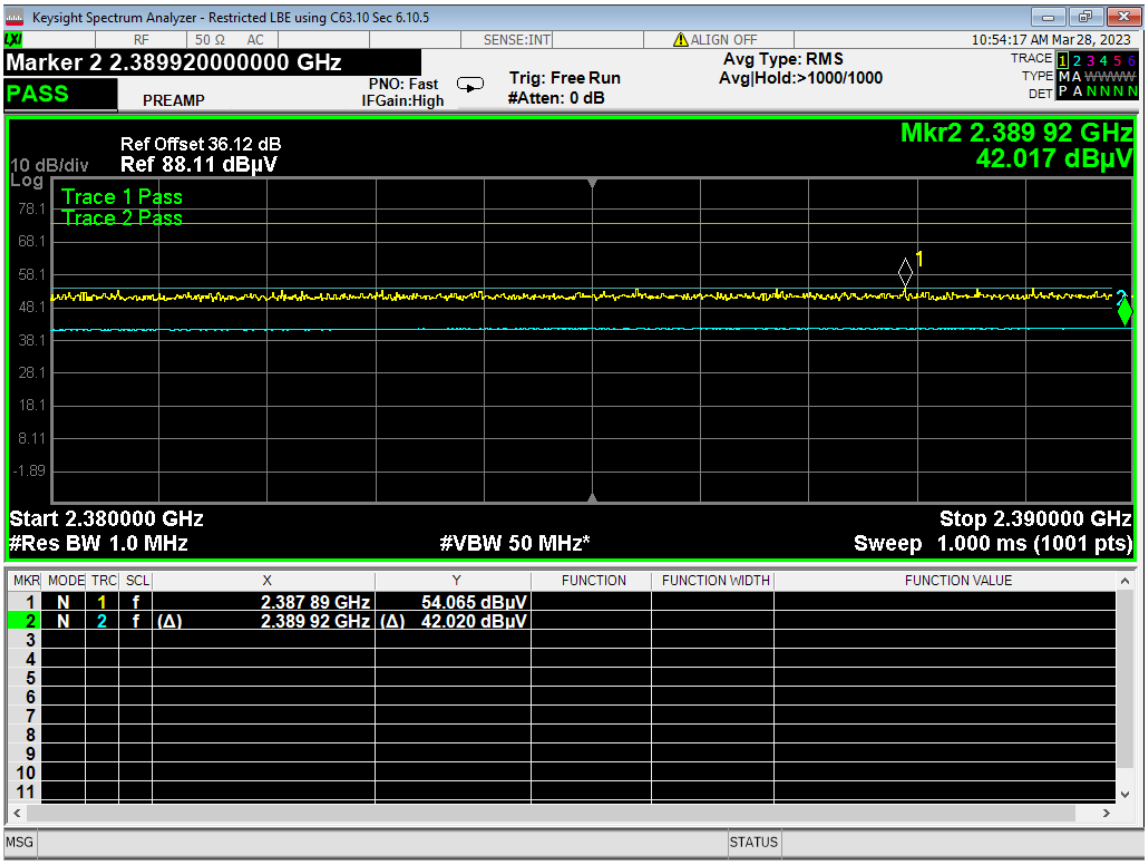
48 PSD, High, Wifi B, High Data Rate



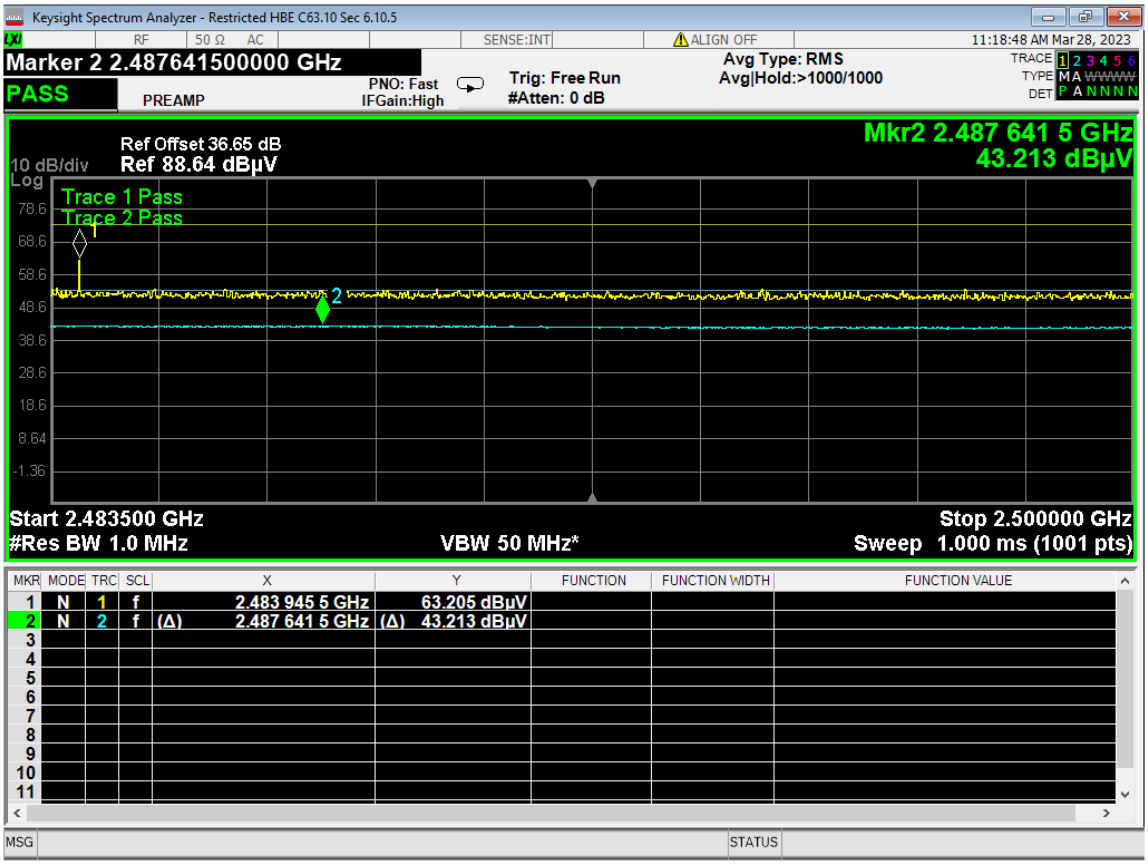
49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



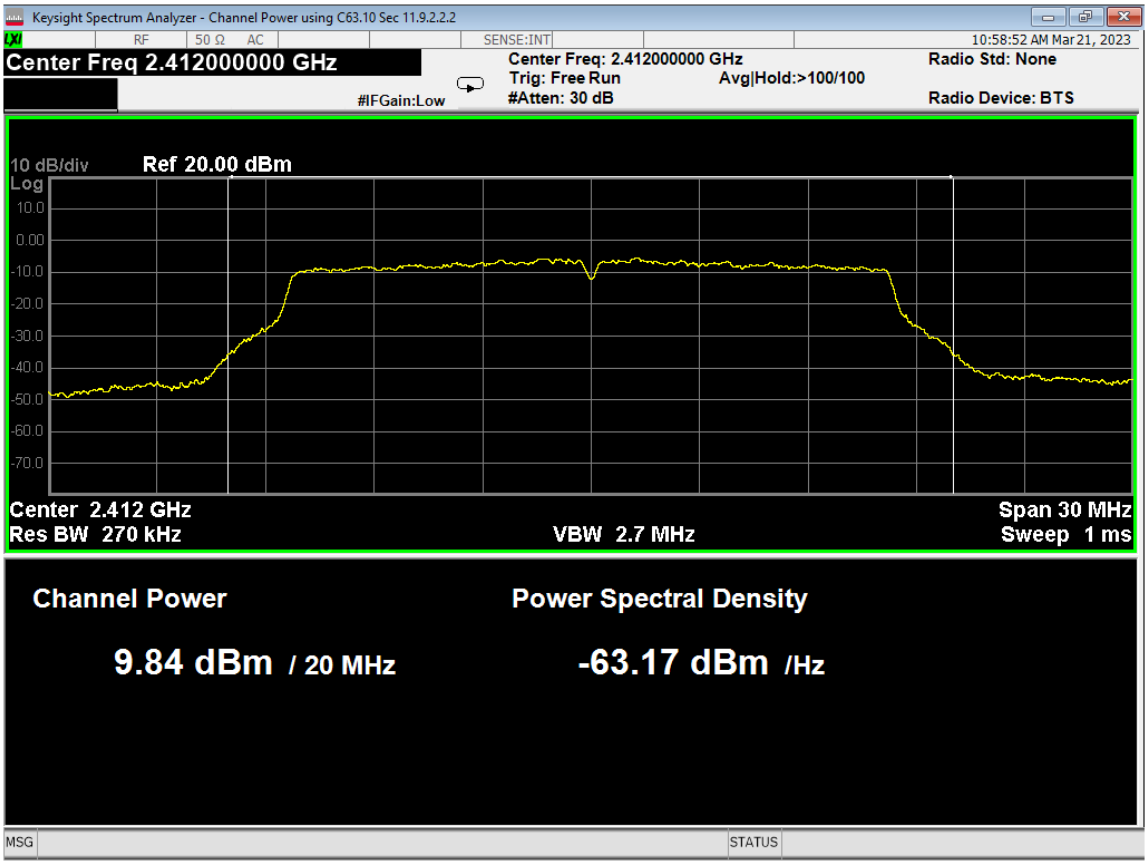
50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



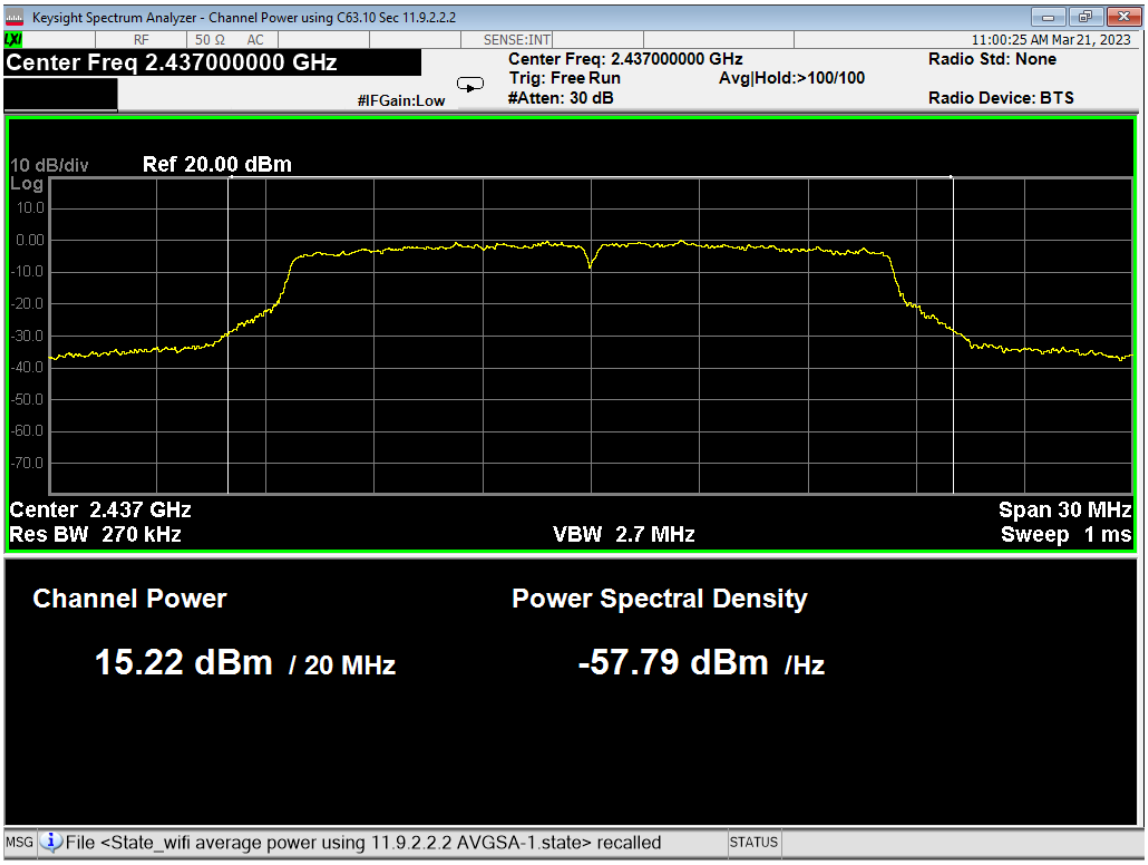
51 Lower Bandedge, Restricted, Wifi B, High Data Rate



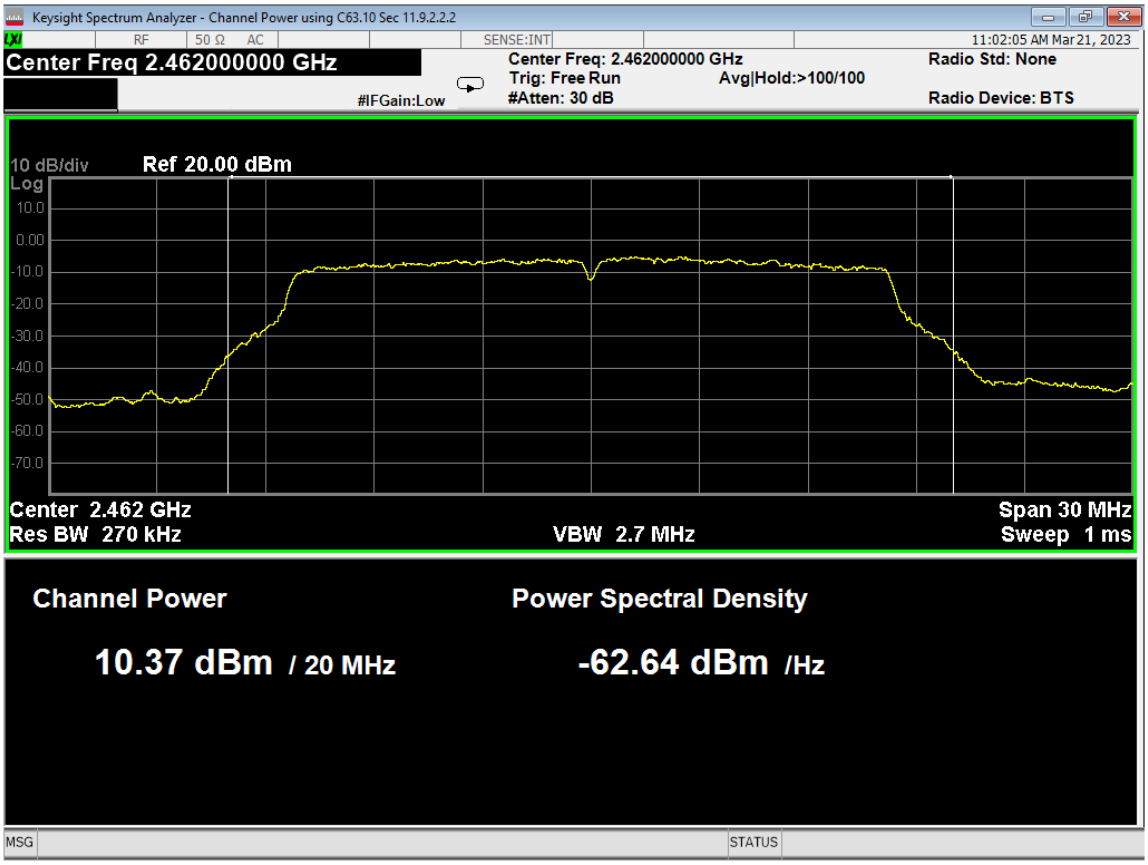
52 Higher Bandedge, Restricted, Wifi B, High Data Rate



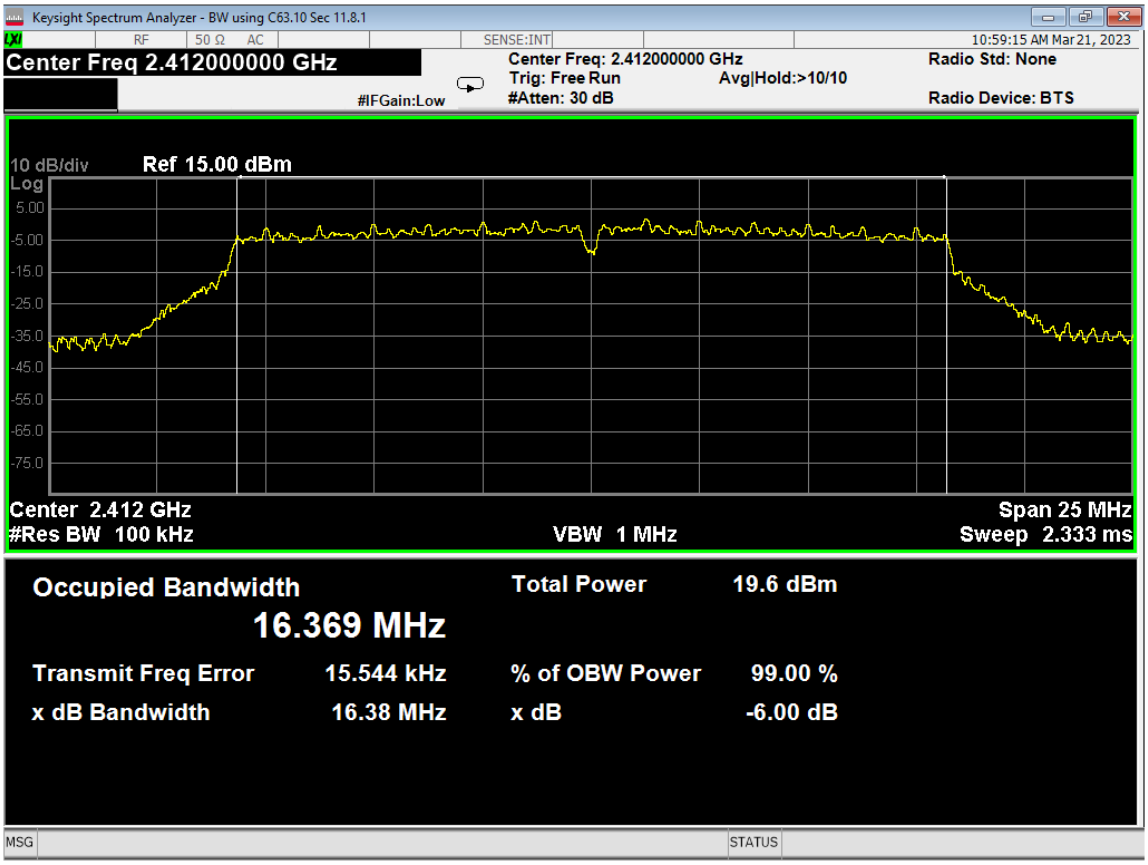
53 Average Power, Low, Wifi G, High Data Rate



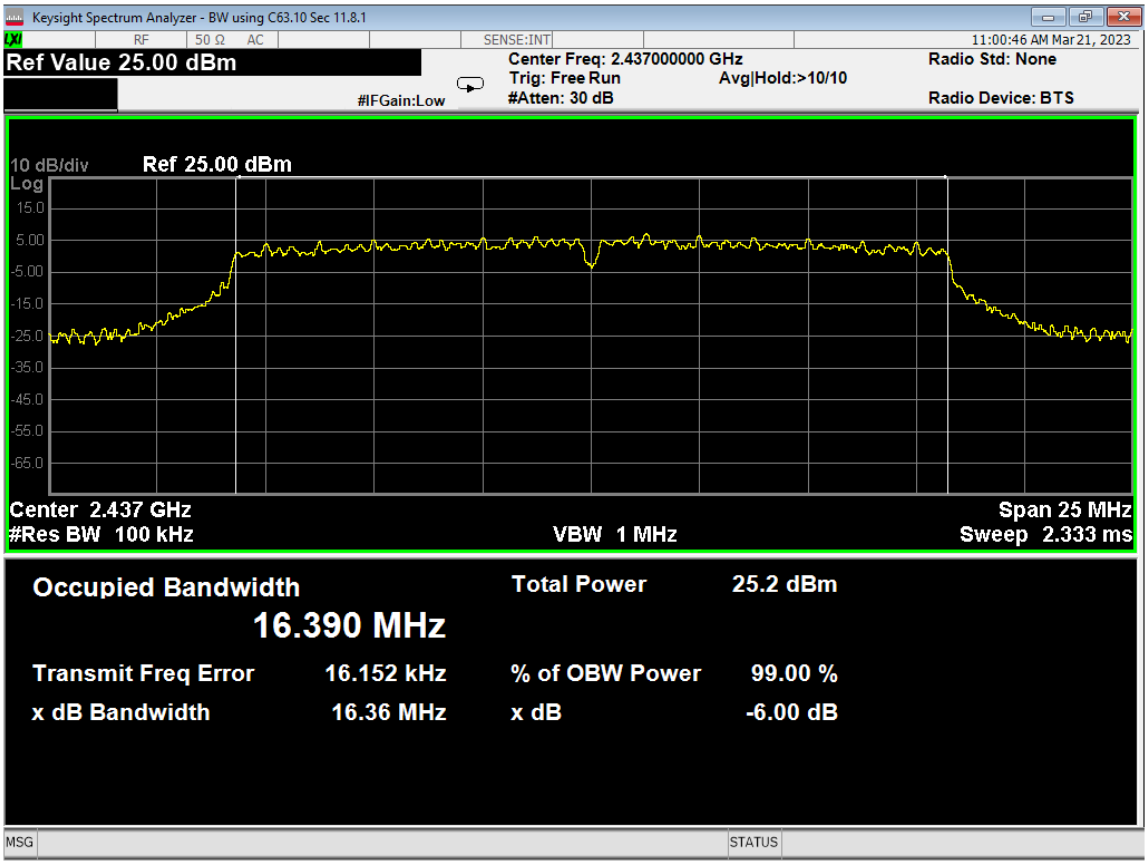
54 Average Power, Mid, Wifi G, High Data Rate



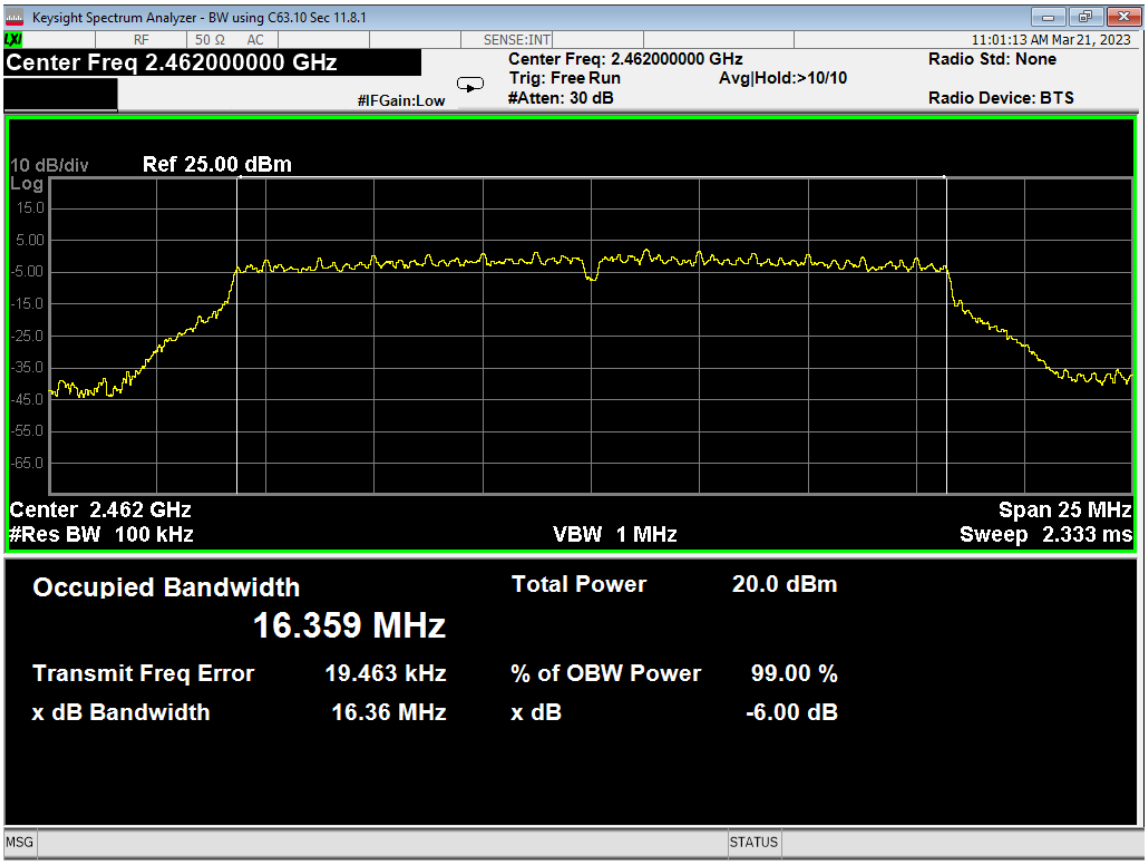
55 Average Power, High, Wifi G, High Data Rate



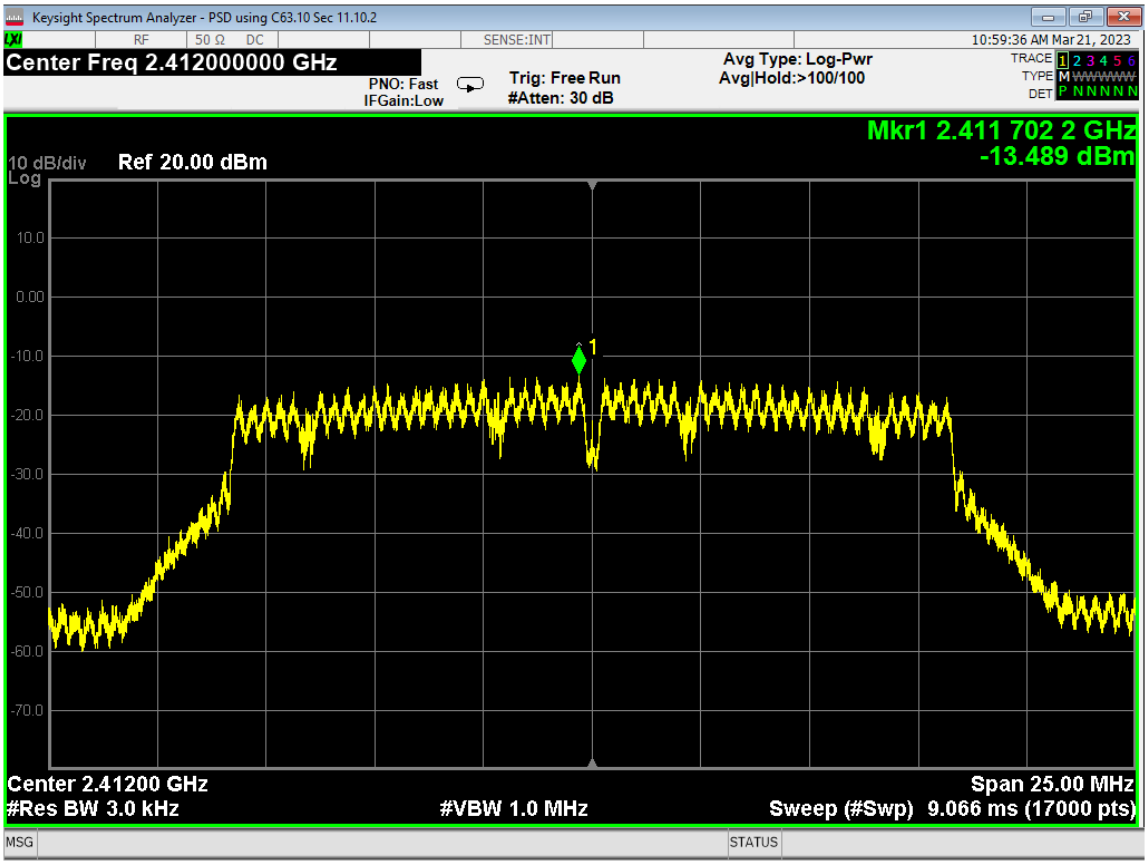
56 6dB Bandwidth, Low, Wifi G, High Data Rate



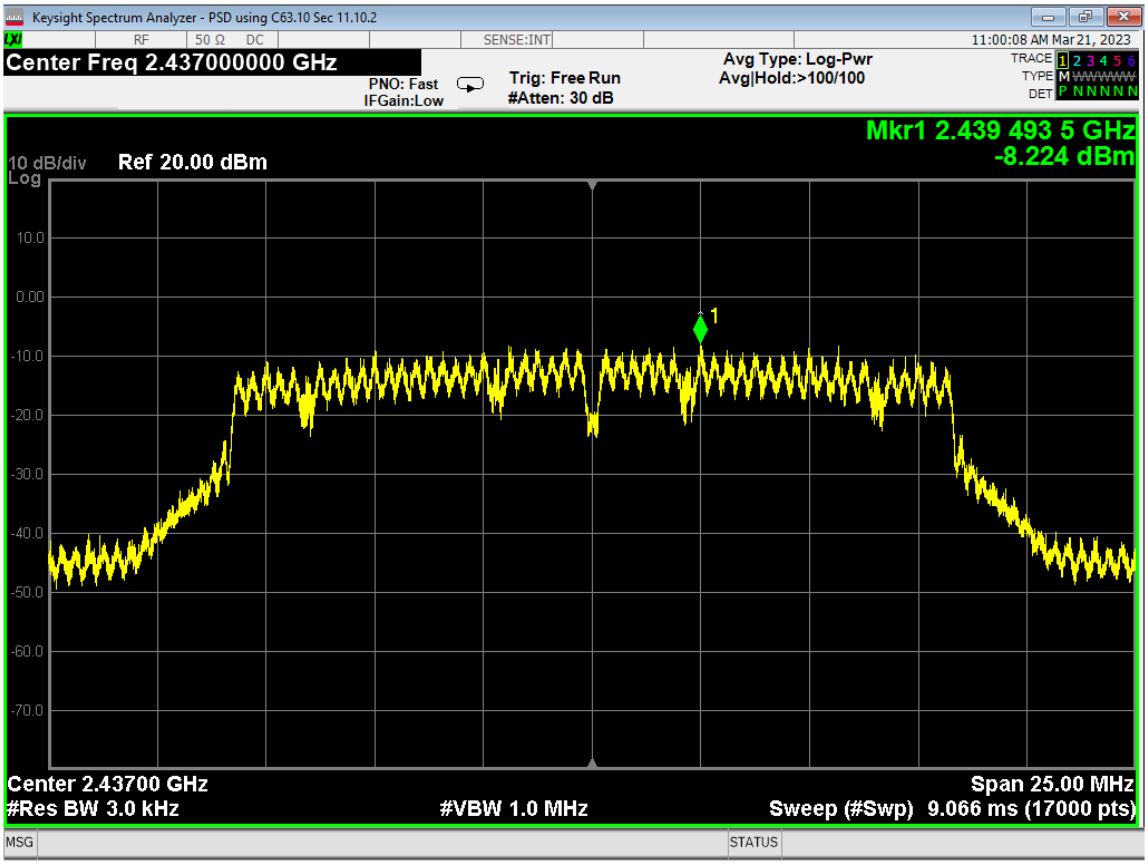
57 6dB Bandwidth, Mid, Wifi G, High Data Rate



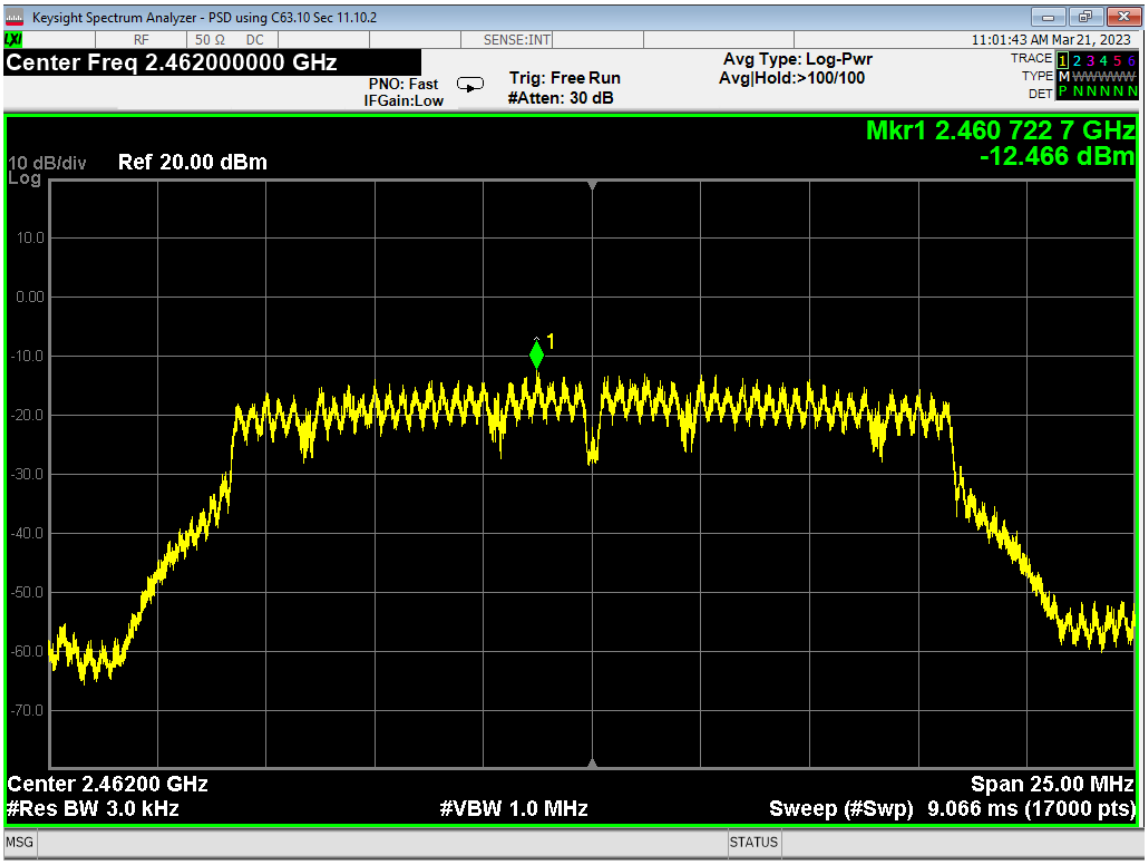
58 6dB Bandwidth, High, Wifi G, High Data Rate



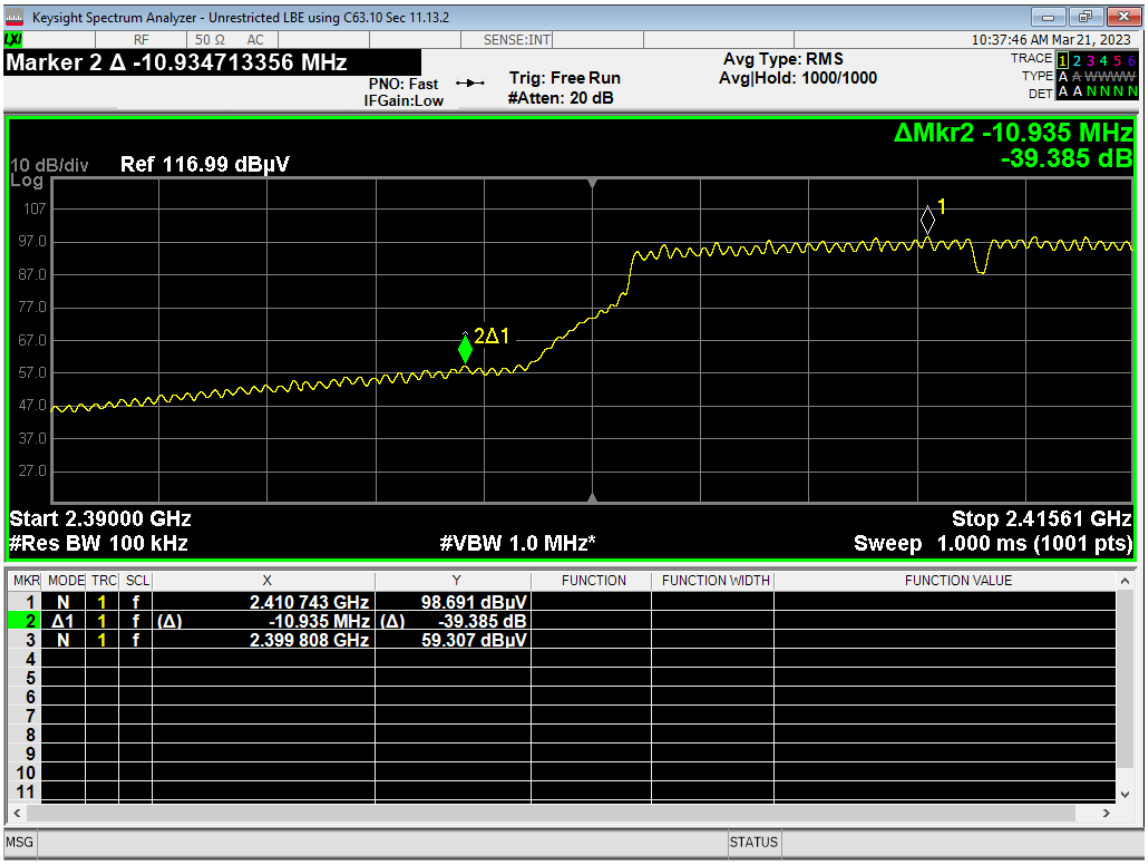
59 PSD, Low, Wifi G, High Data Rate



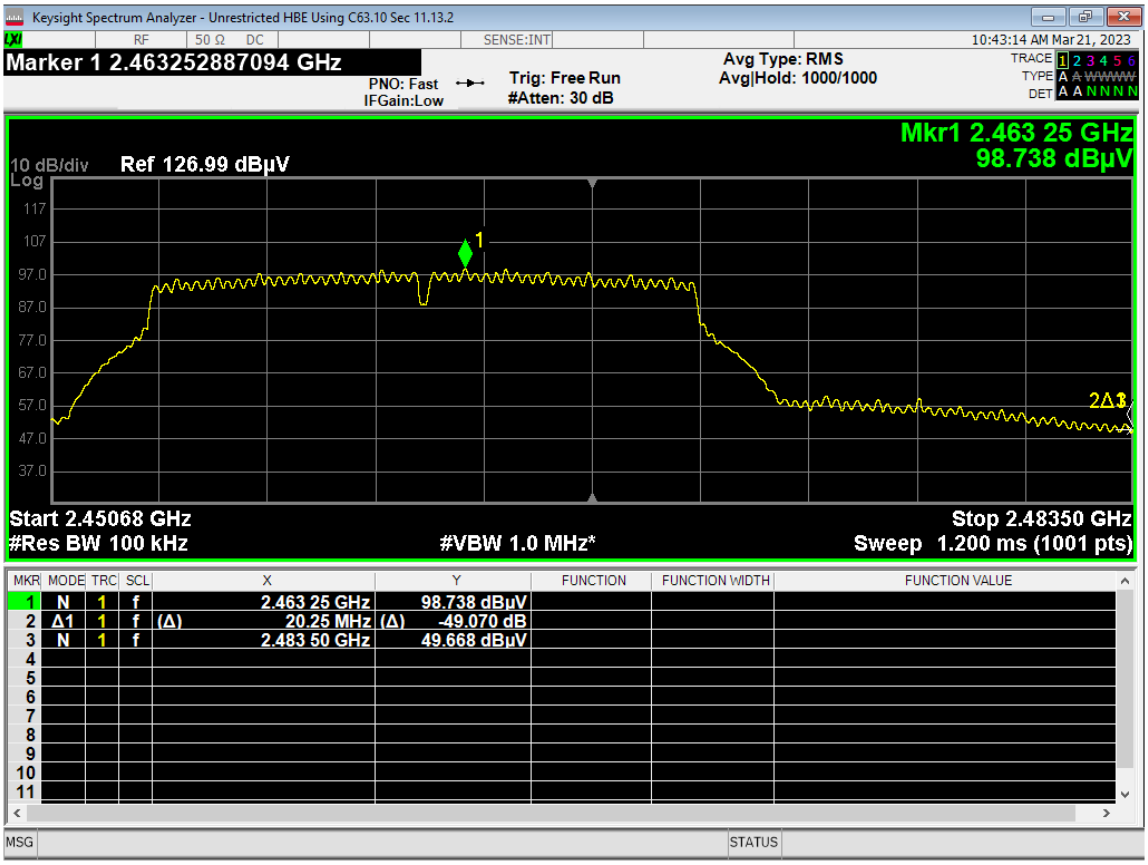
60 PSD, Mid, Wifi G, High Data Rate



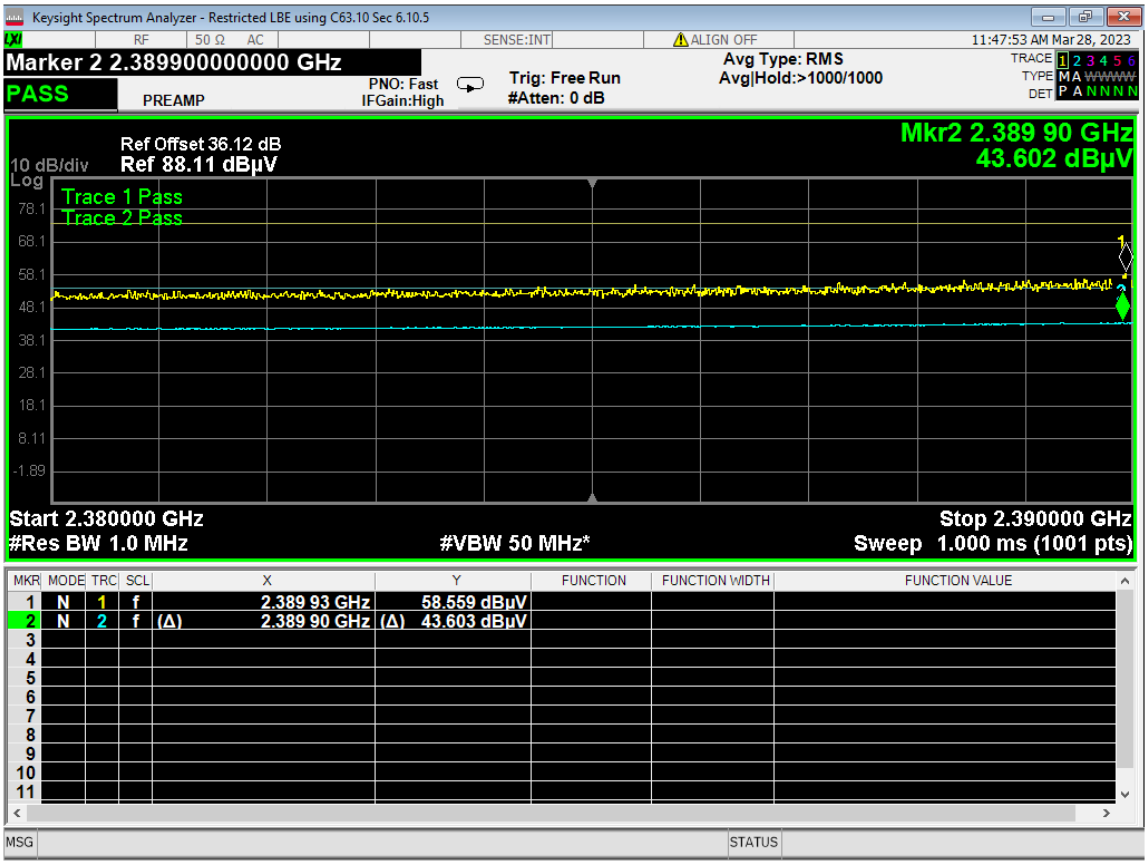
61 PSD, High, Wifi G, High Data Rate



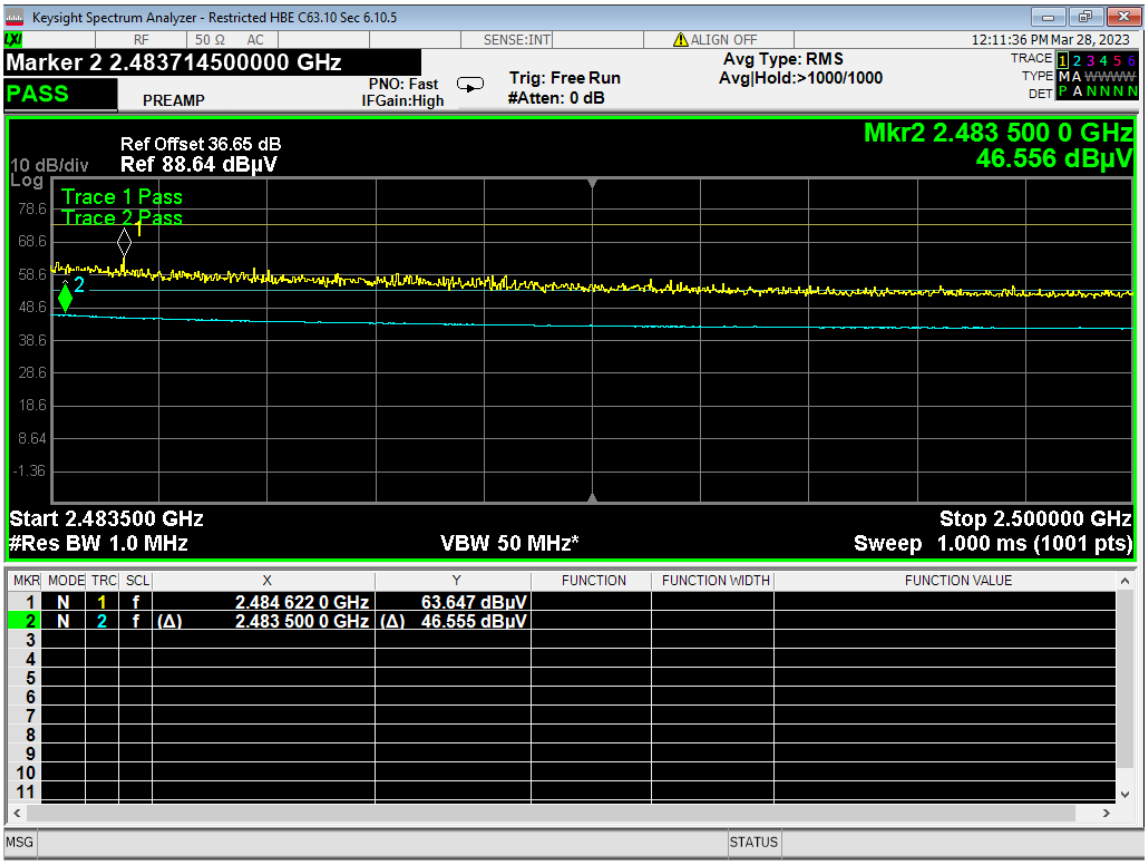
62 Lower Bandedge, Unrestricted, Wifi G, High Data Rate



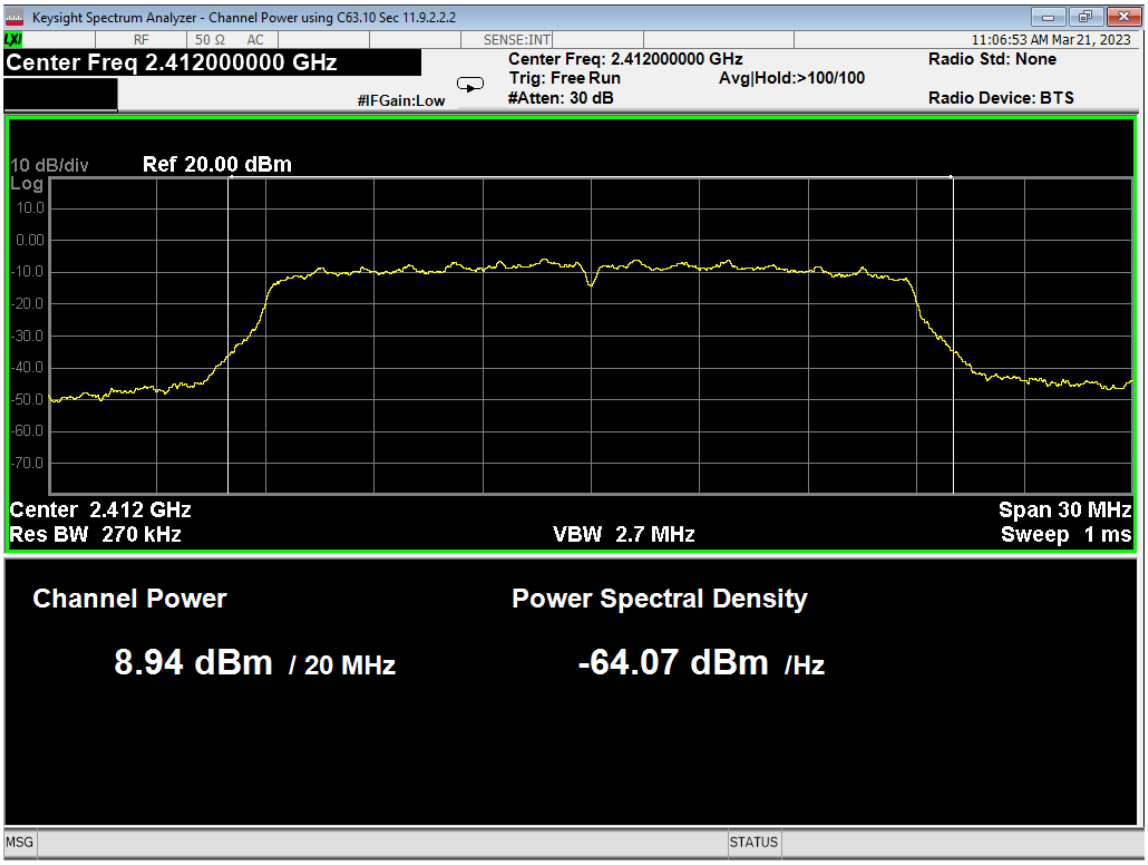
63 Higher Bandedge, Unrestricted, Wifi G, High Data Rate



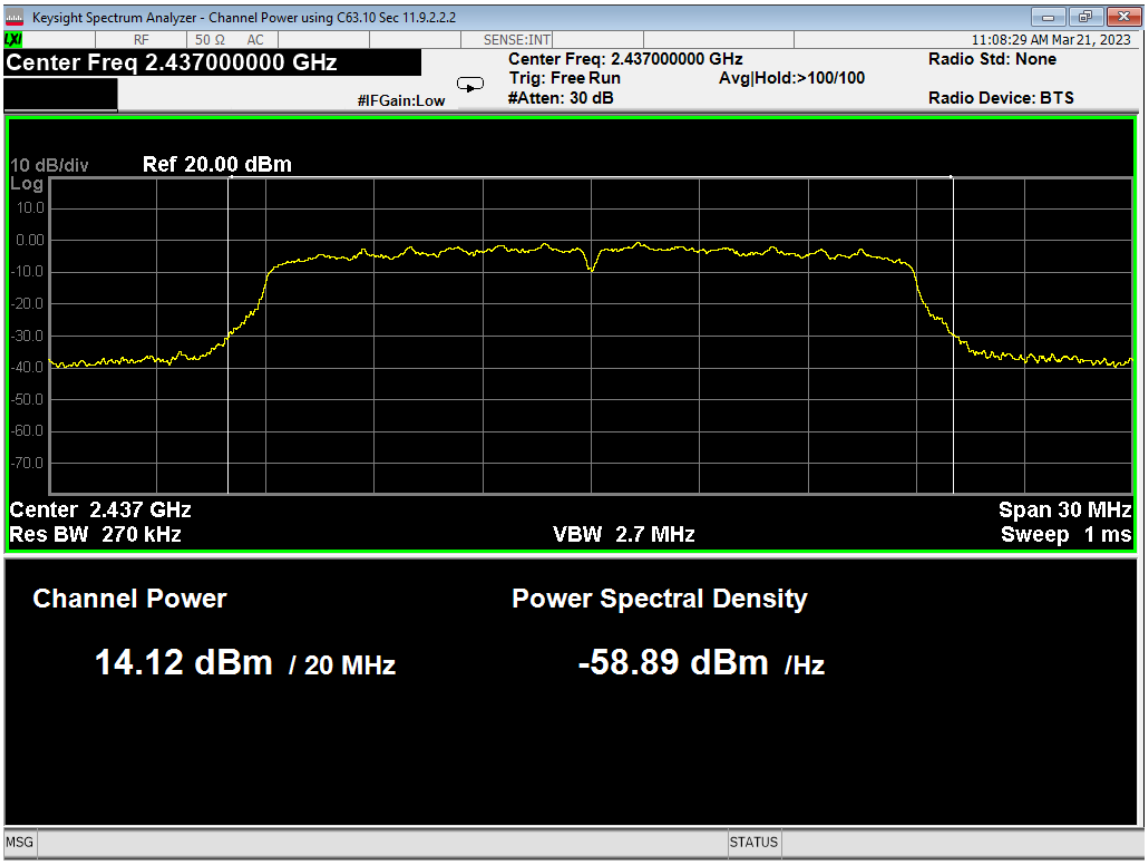
64 Lower Bandedge, Restricted, Wifi G, High Data Rate



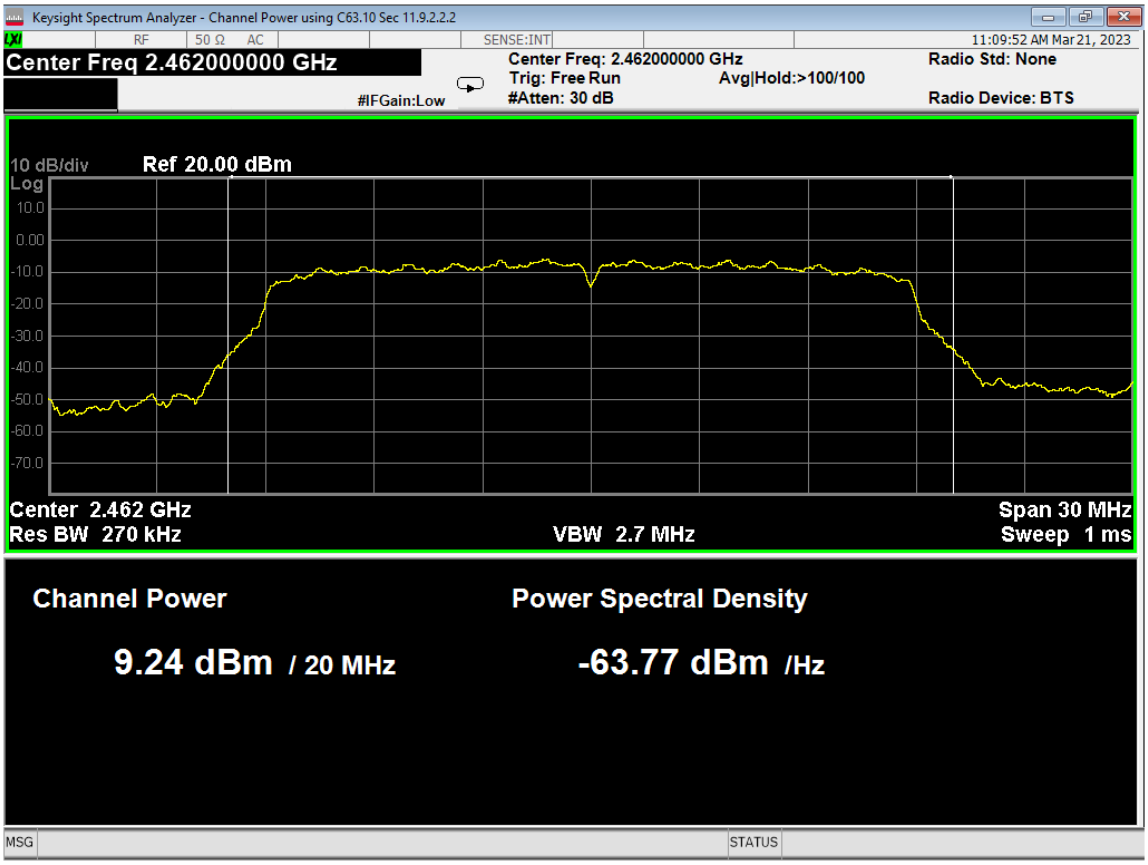
65 Higher Bandedge, Restricted, Wifi G, High Data Rate



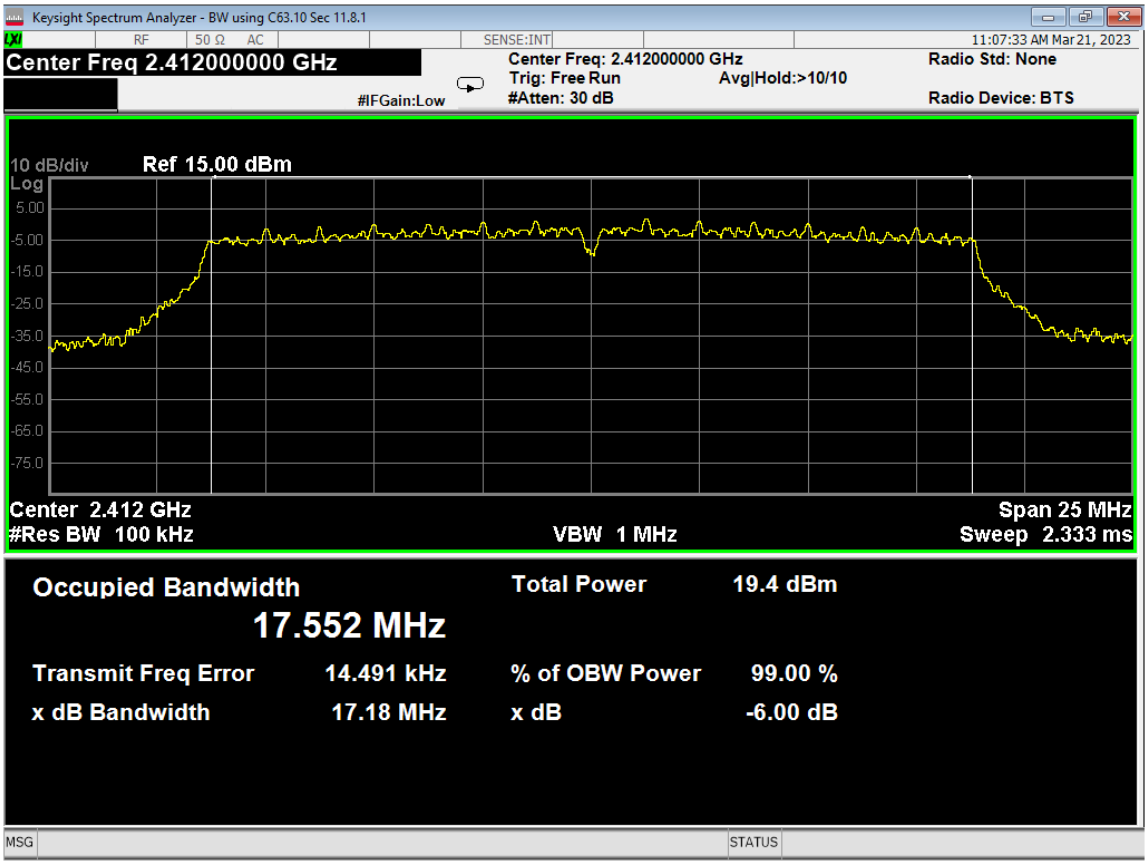
66 Average Power, Low, Wifi N, High Data Rate



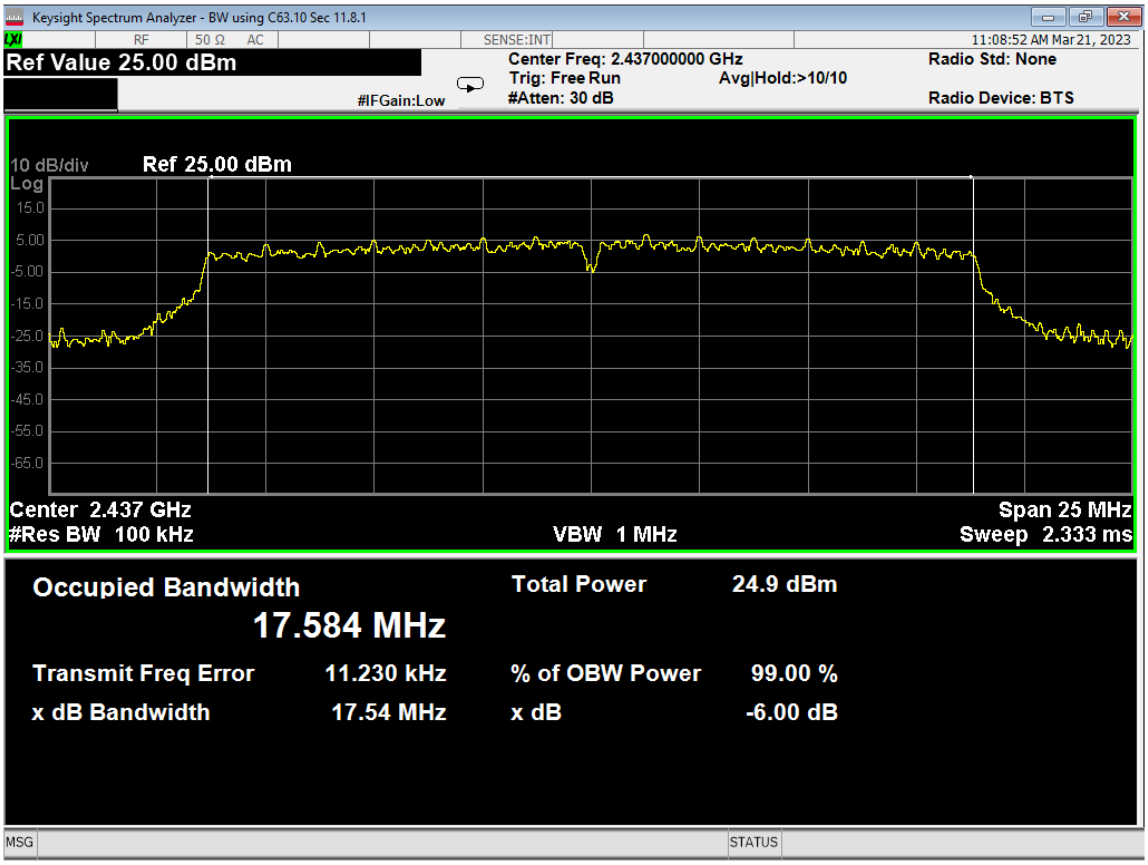
67 Average Power, Mid, Wifi N, High Data Rate



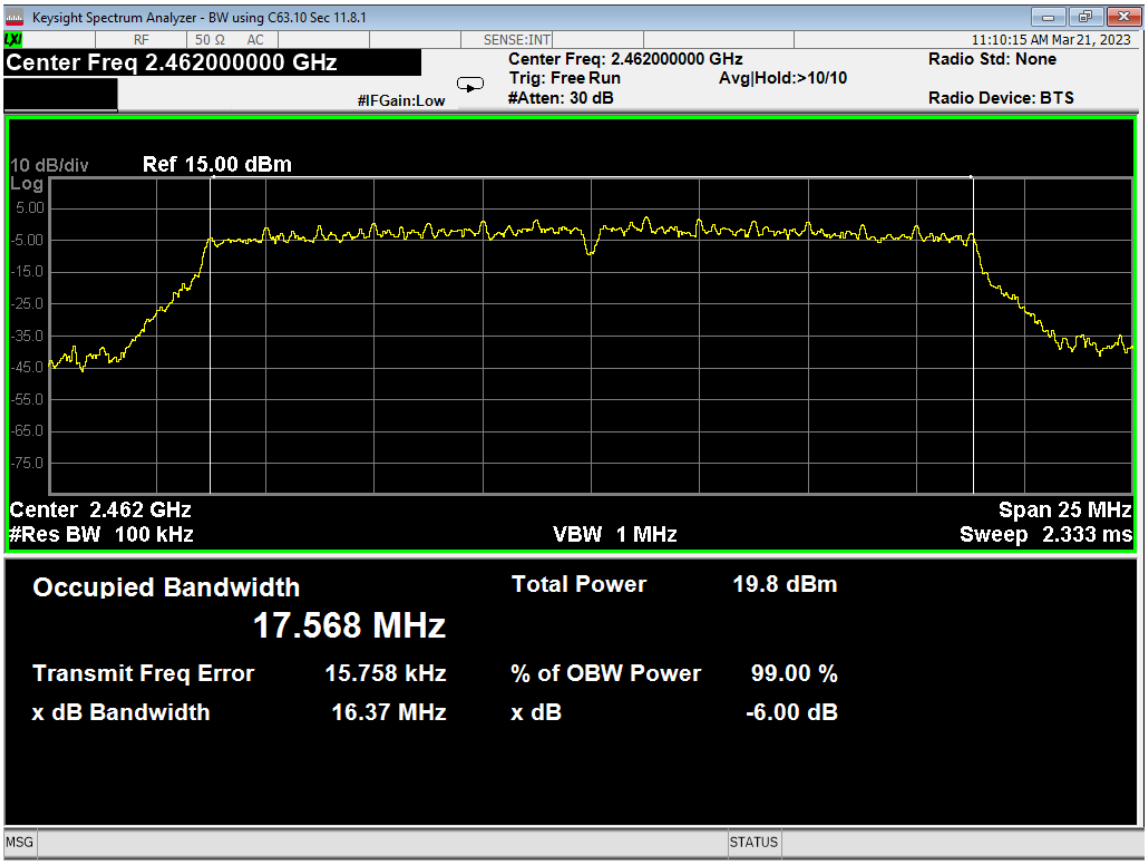
68 Average Power, High, Wifi N, High Data Rate



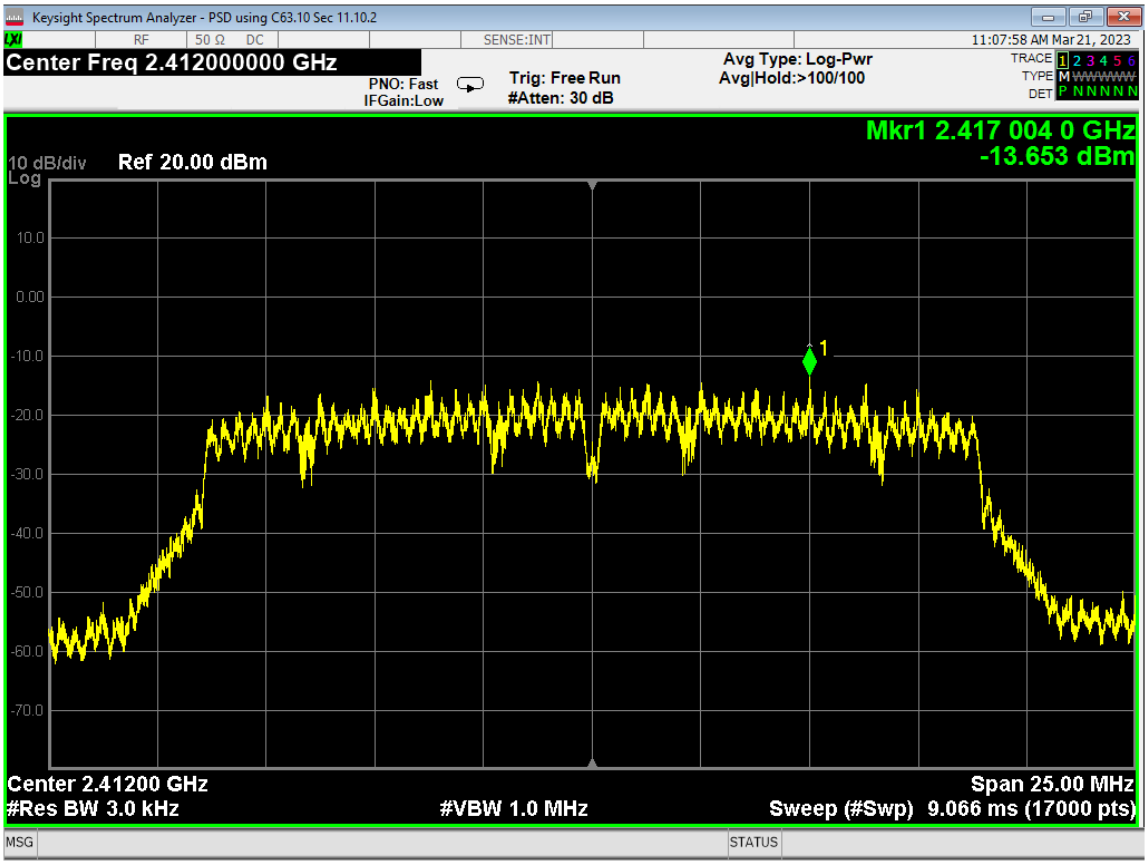
69 6dB Bandwidth, Low, Wifi N, High Data Rate



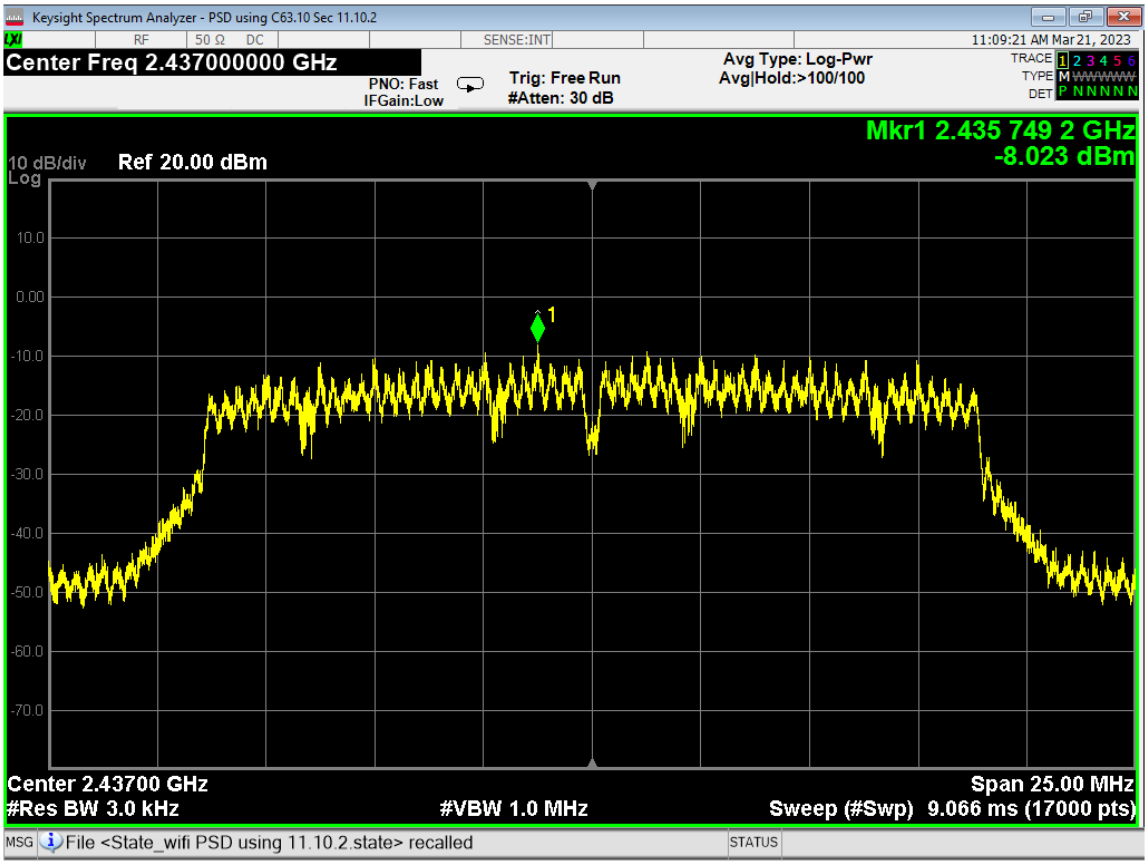
70 6dB Bandwidth, Mid, Wifi N, High Data Rate



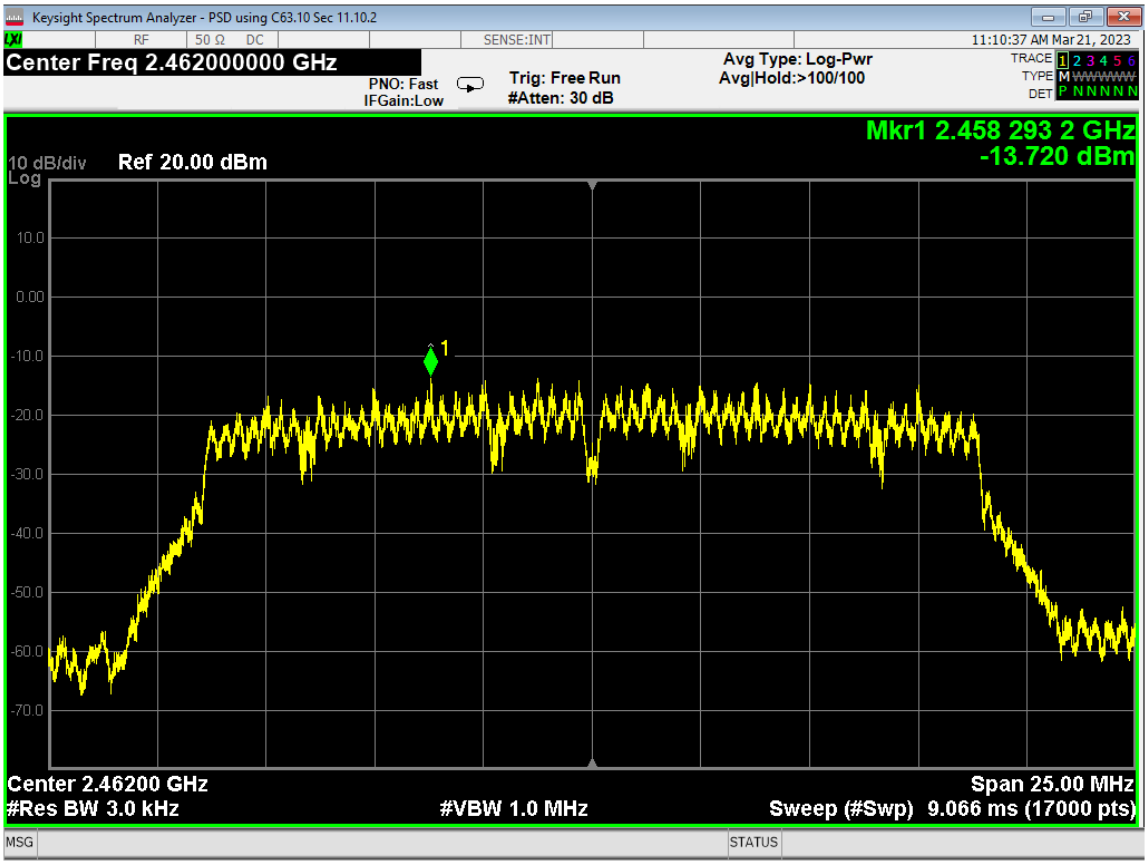
71 6dB Bandwidth, High, Wifi N, High Data Rate



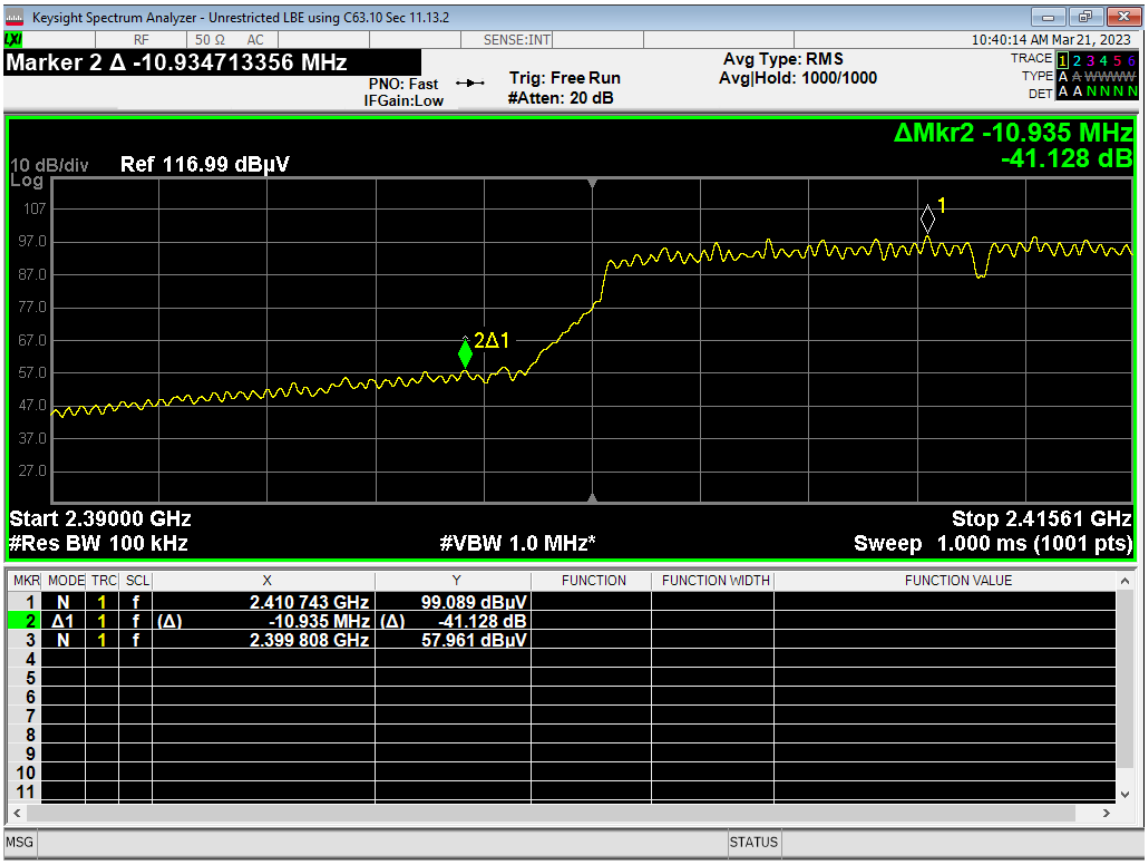
72 PSD, Low, Wifi N, High Data Rate



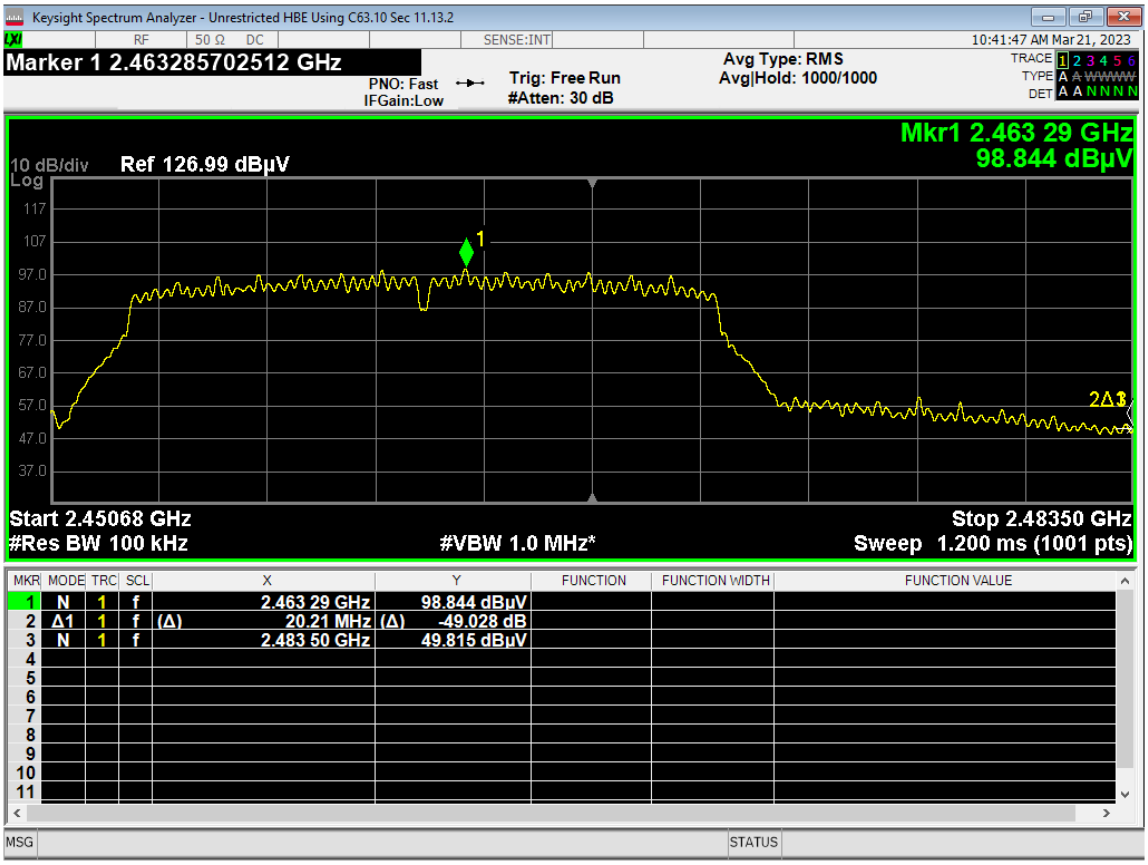
73 PSD, Mid, Wifi N, High Data Rate



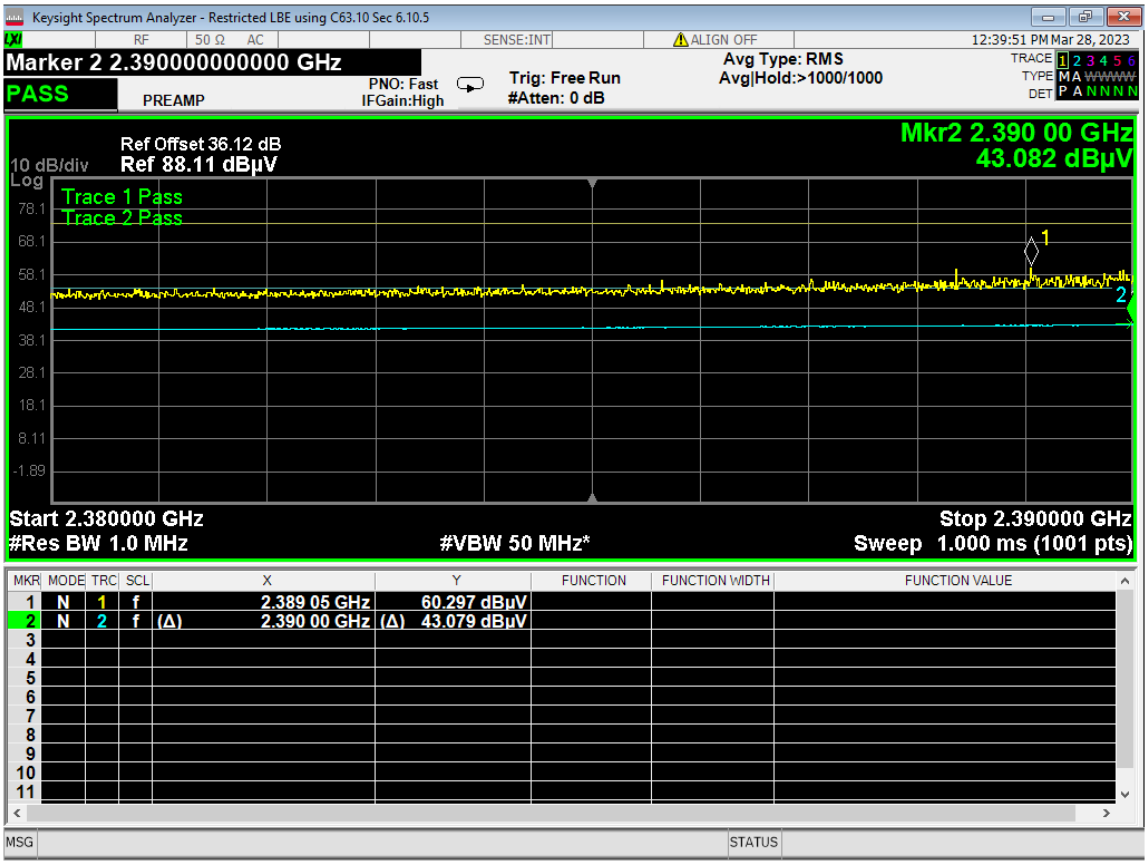
74 PSD, High, Wifi N, High Data Rate



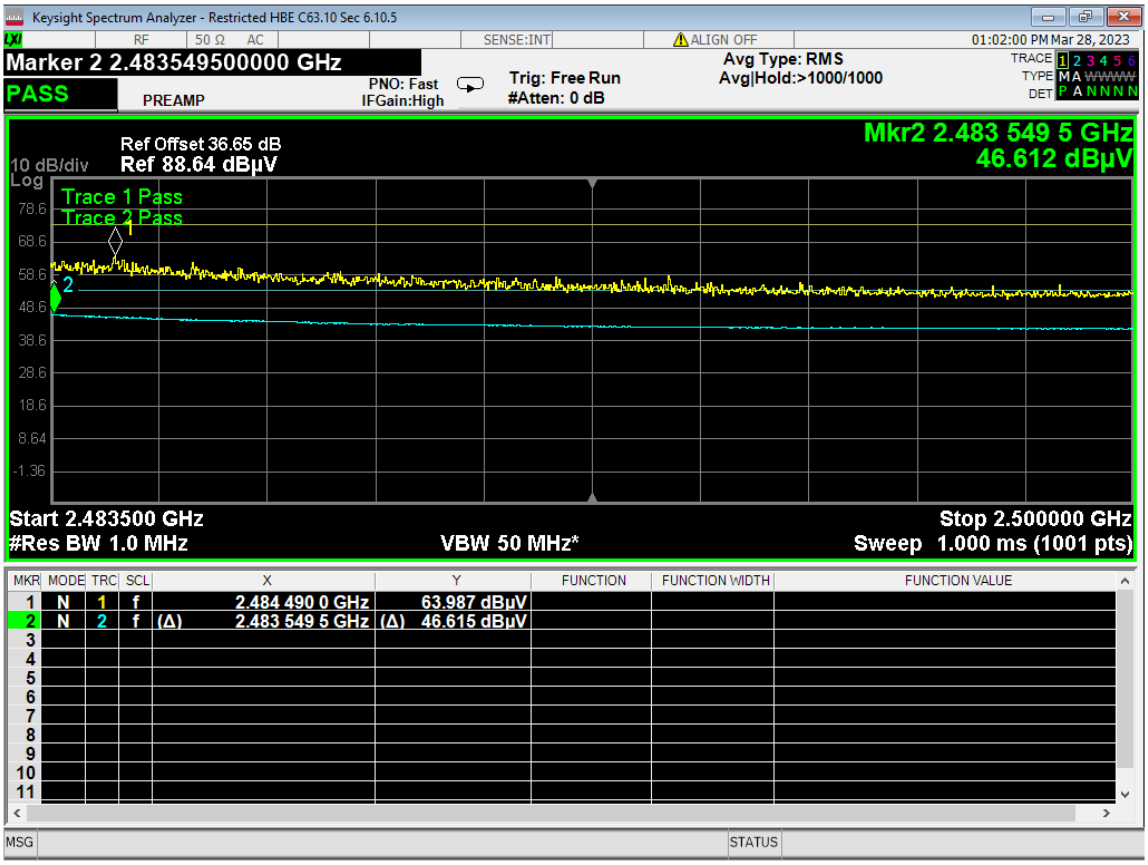
75 Lower Bandedge, Unrestricted, Wifi N, High Data Rate



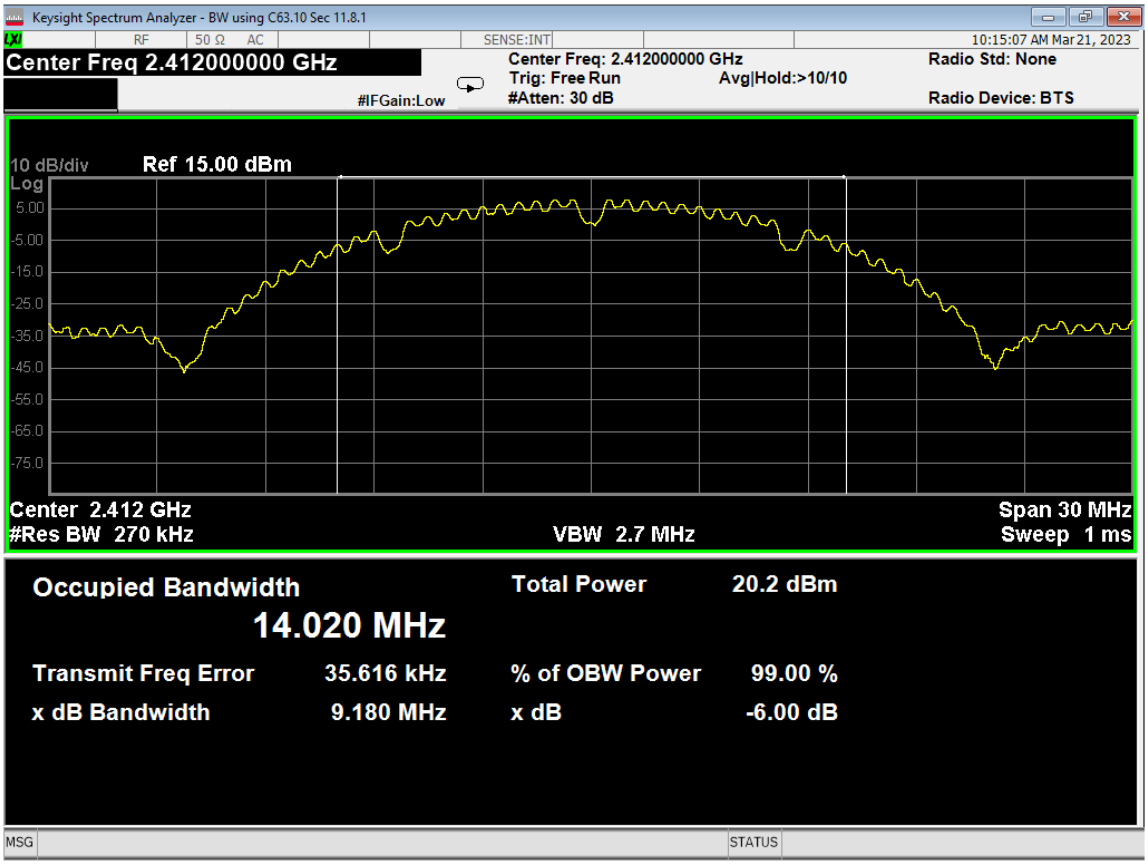
76 Higher Bandedge, Unrestricted, Wifi N, High Data Rate



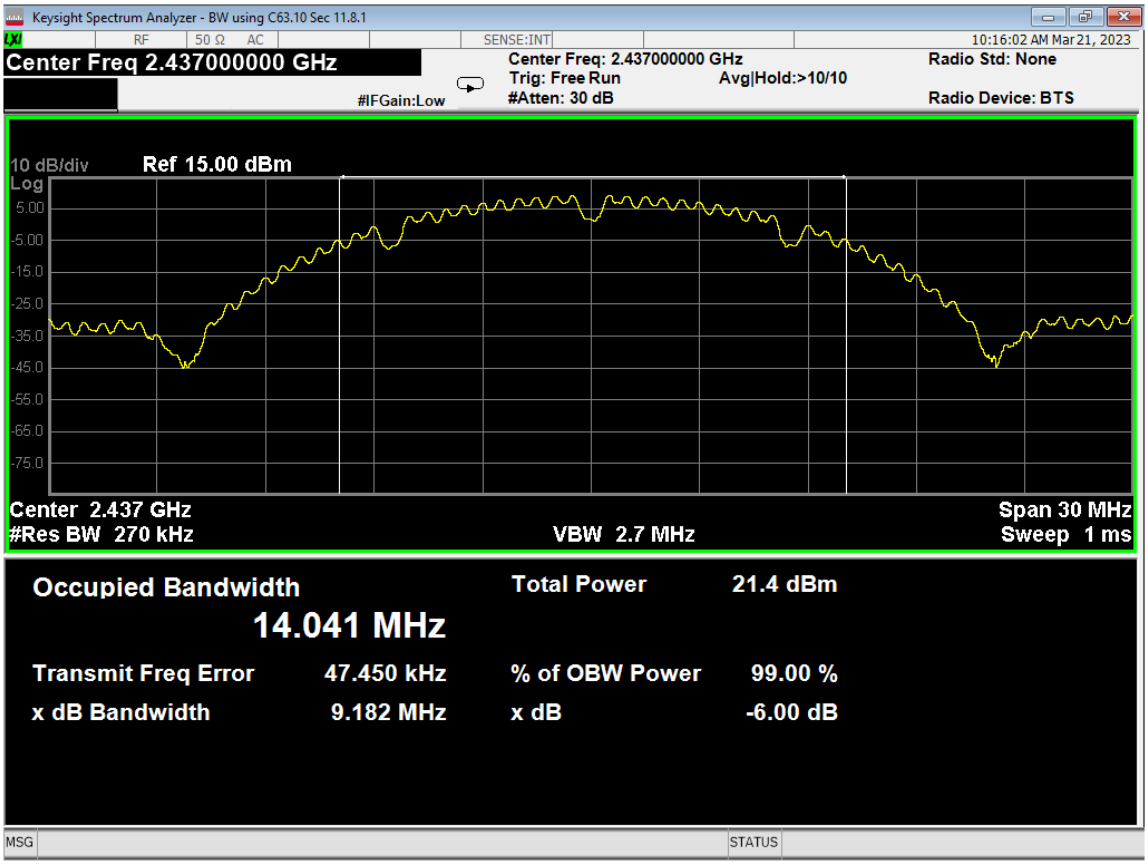
77 Lower Bandedge, Restricted, Wifi N, High Data Rate



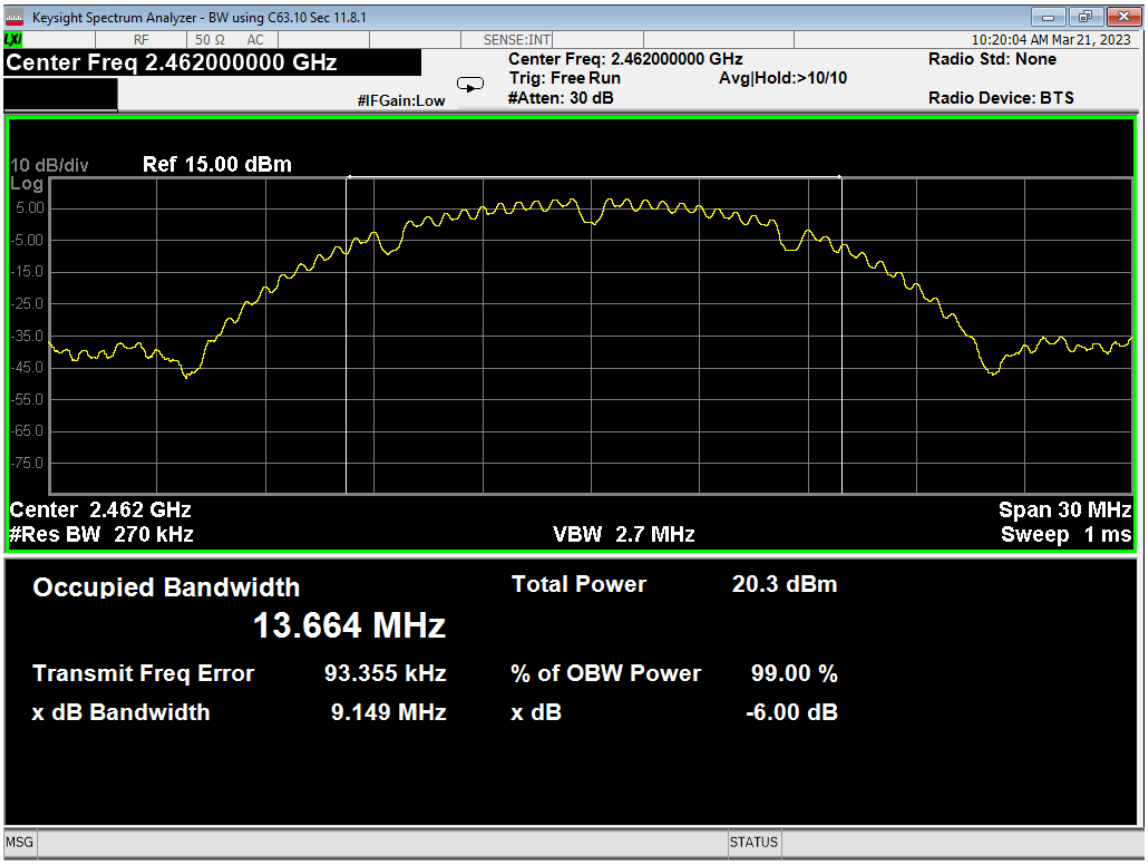
78 Higher Bandedge, Restricted, Wifi N, High Data Rate



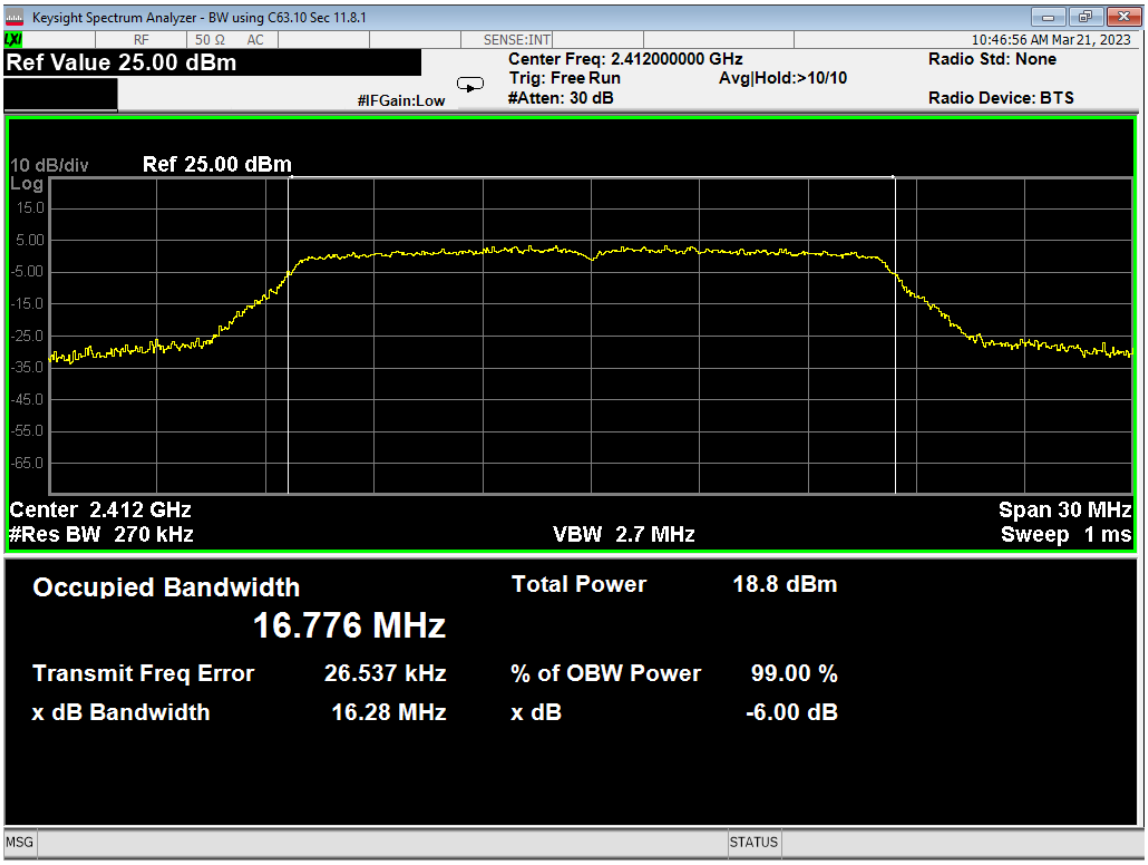
79 Occupied Bandwidth, Low, Wifi B, Low Data Rate



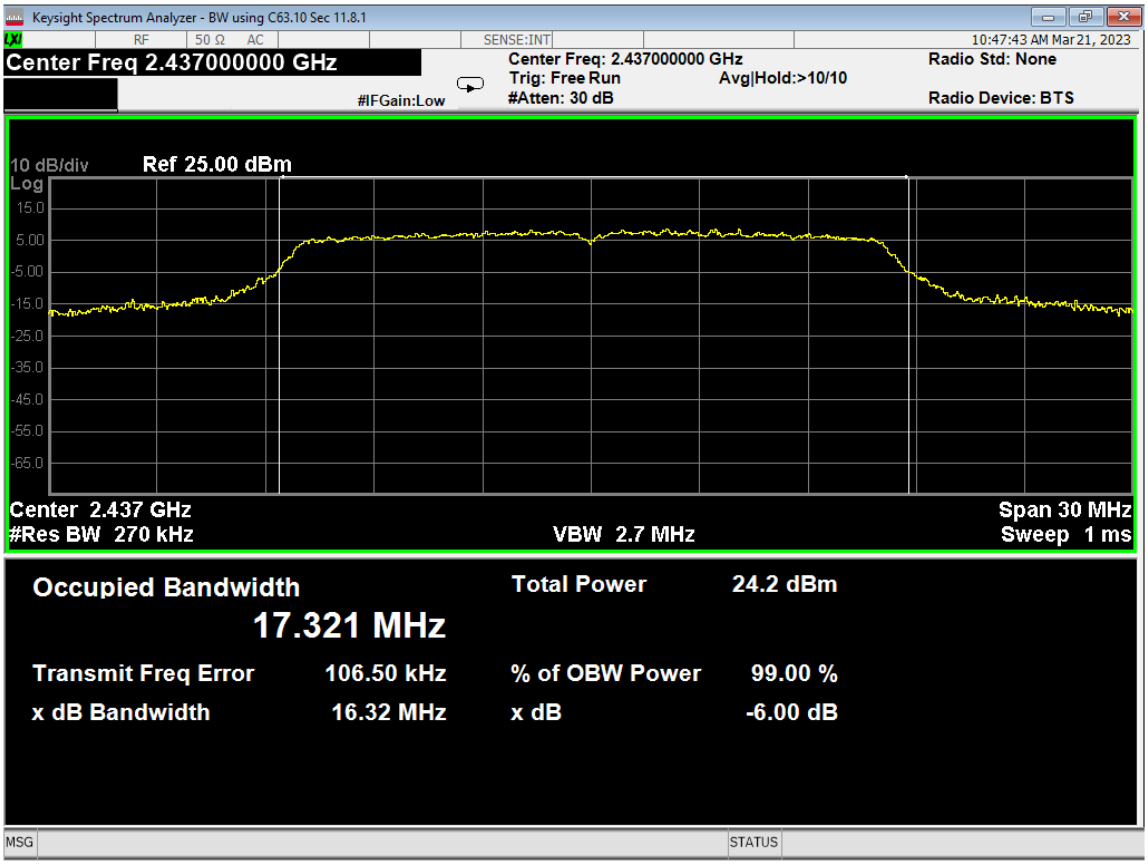
80 Occupied Bandwidth, Mid, Wifi B, Low Data Rate



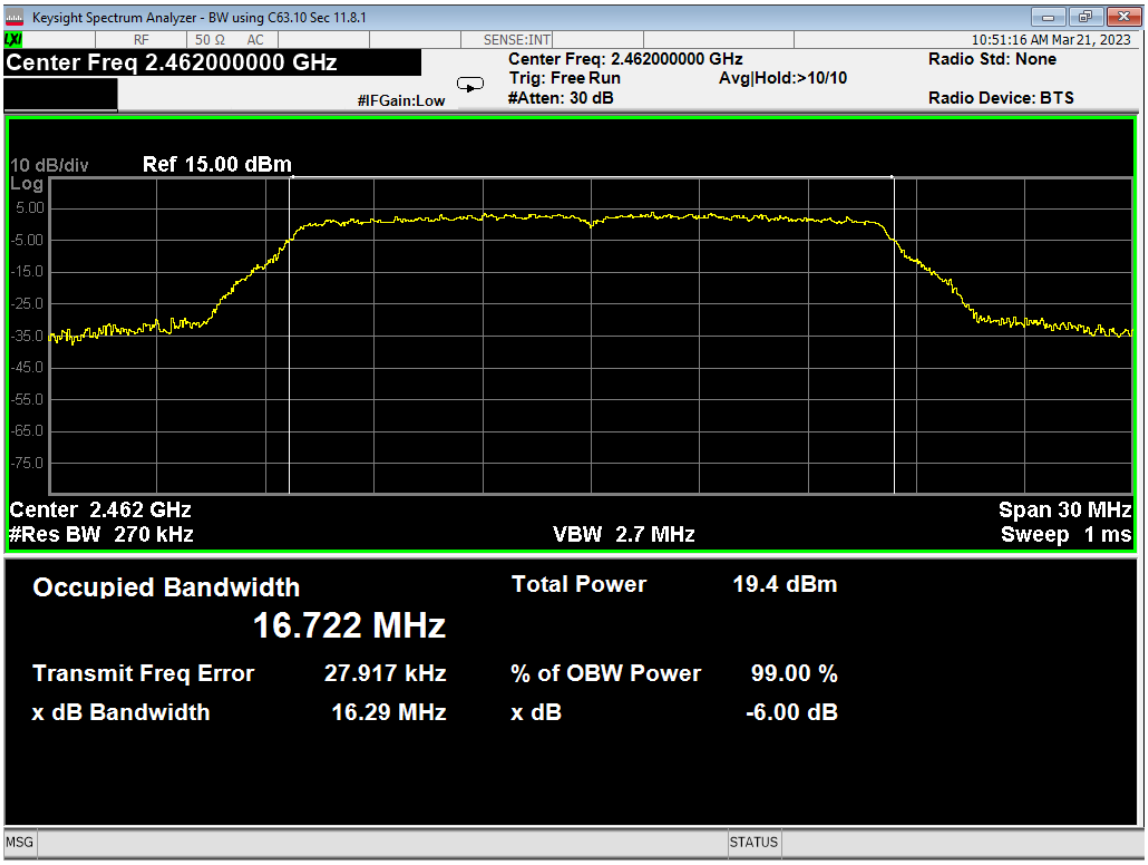
81 Occupied Bandwidth, High, Wifi B, Low Data Rate



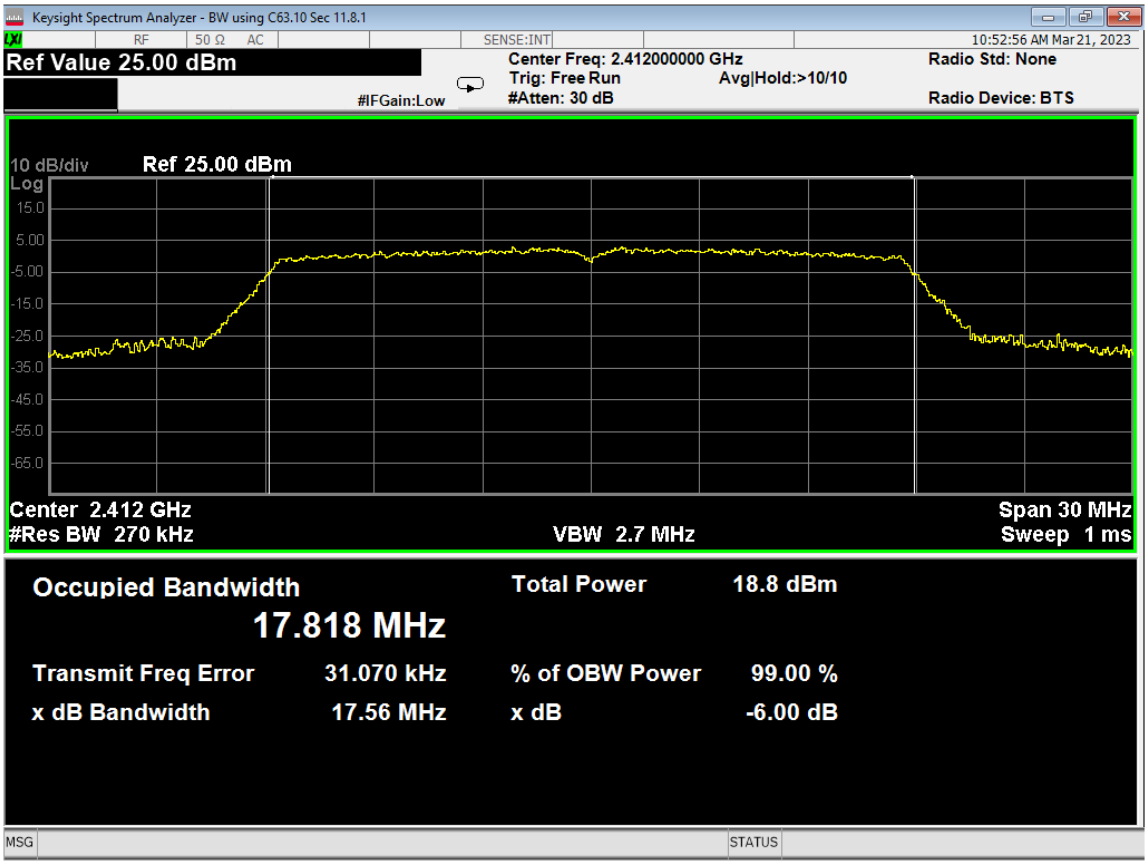
82 Occupied Bandwidth, Low, Wifi G, Low Data Rate



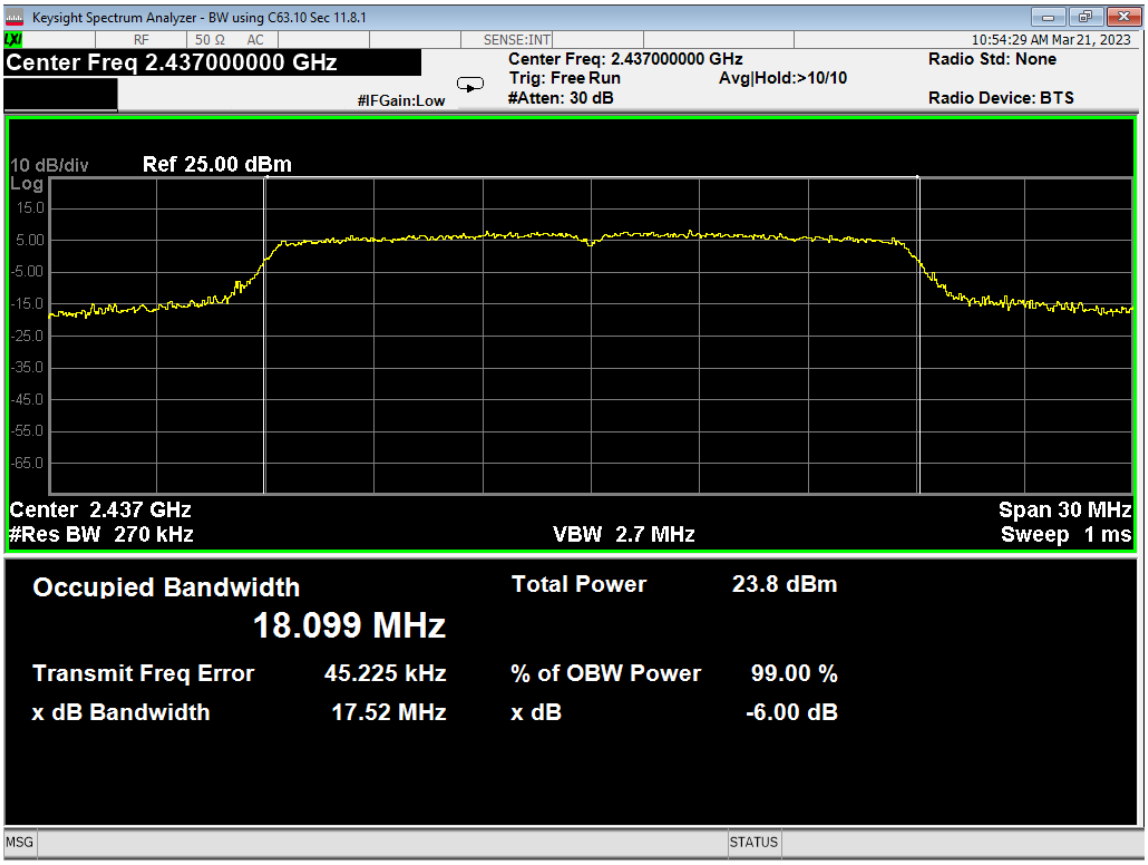
83 Occupied Bandwidth, Mid, Wifi G, Low Data Rate



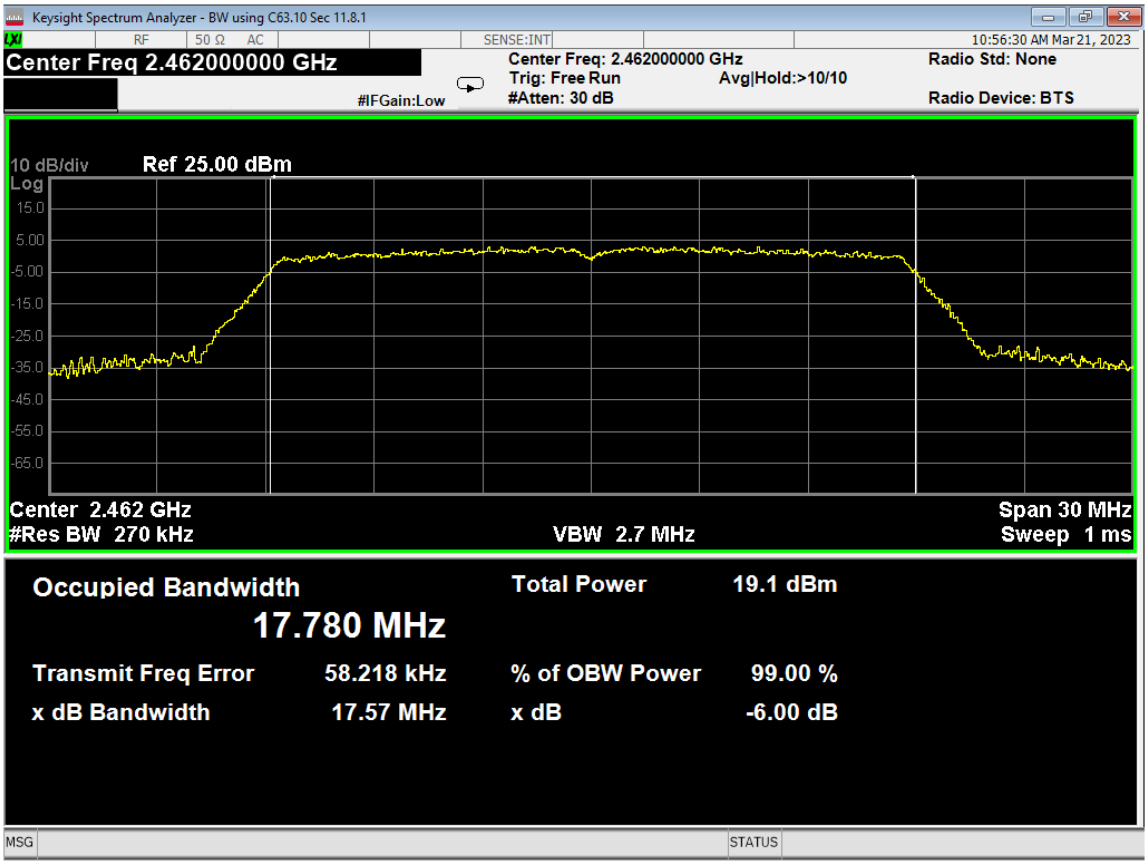
84 Occupied Bandwidth, High, Wifi G, Low Data Rate



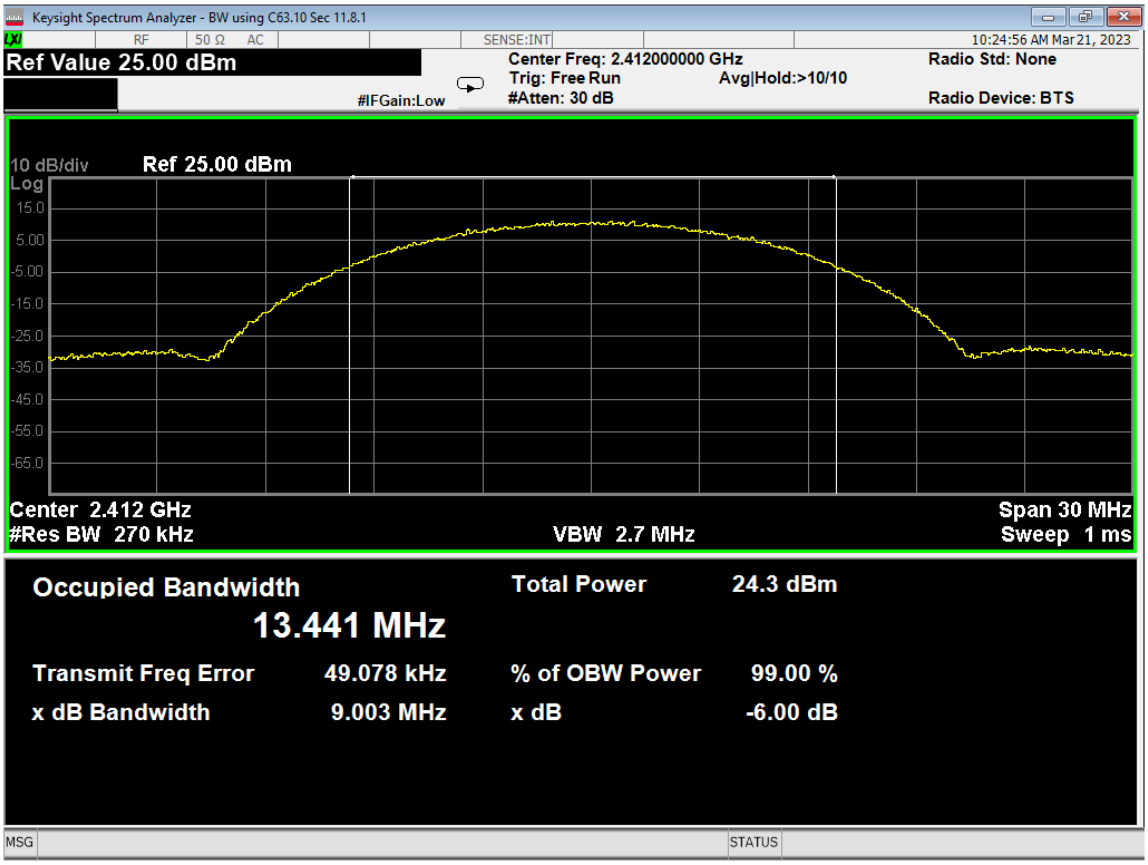
85 Occupied Bandwidth, Low, Wifi N, Low Data Rate



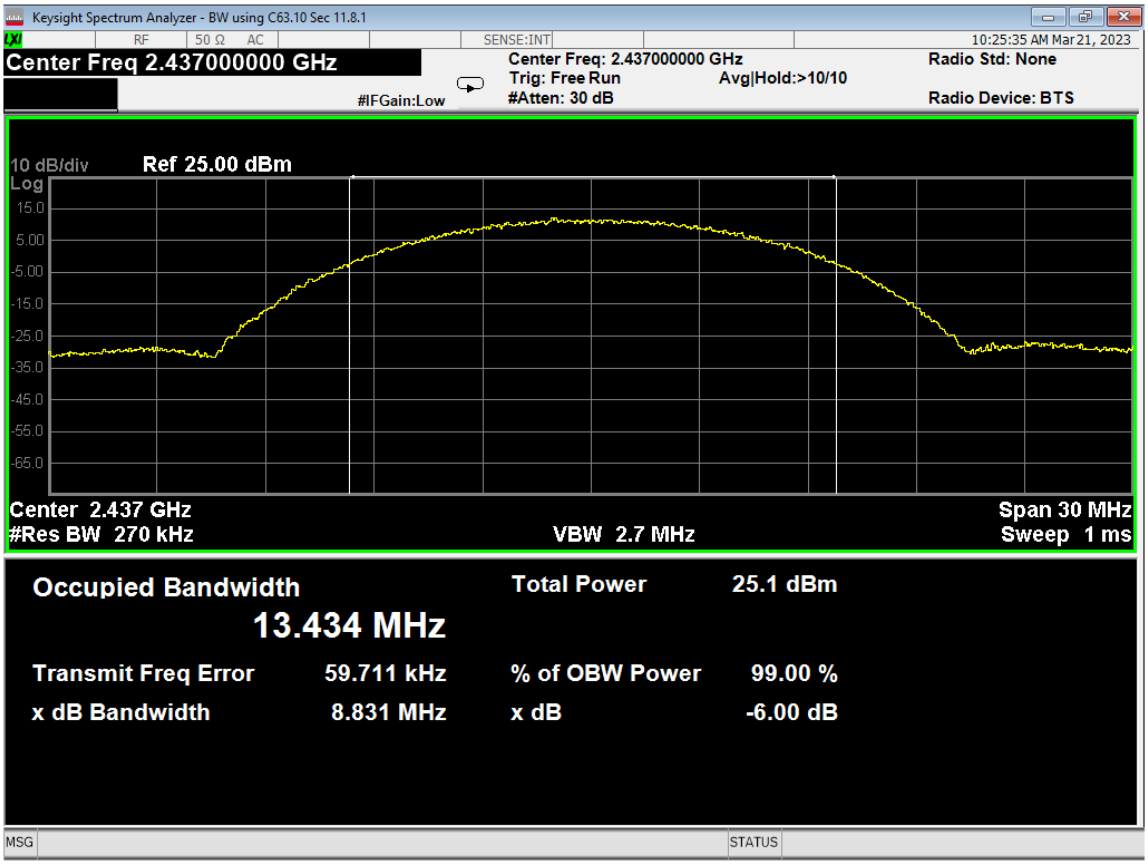
86 Occupied Bandwidth, Mid, Wifi N, Low Data Rate



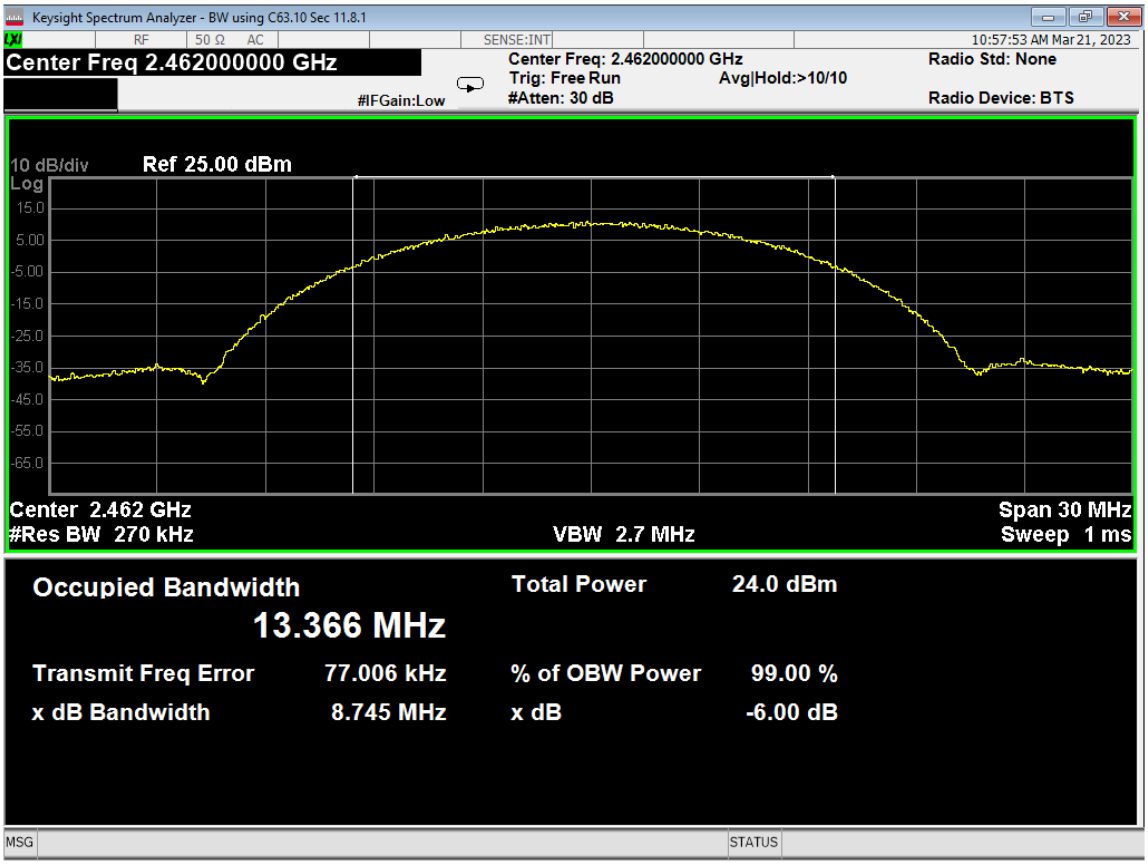
87 Occupied Bandwidth, High, Wifi N, Low Data Rate



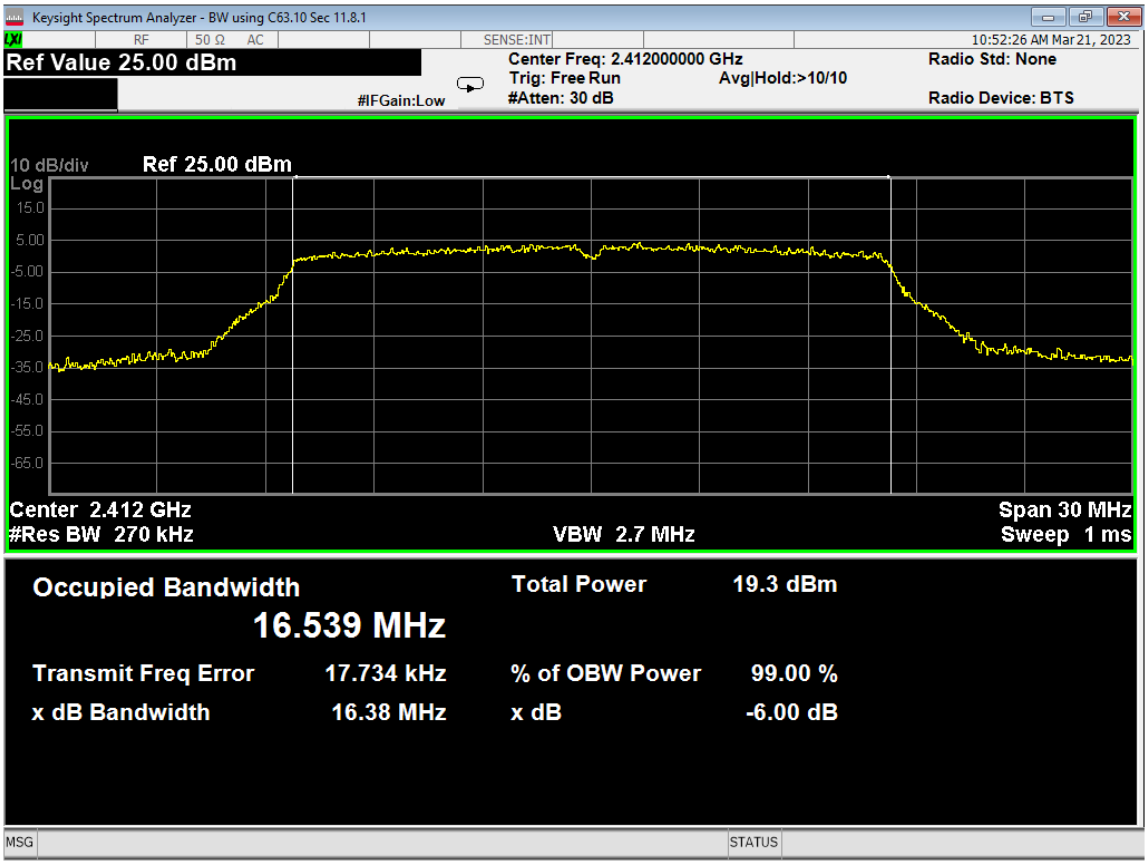
88 Occupied Bandwidth, Low, Wifi B, High Data Rate



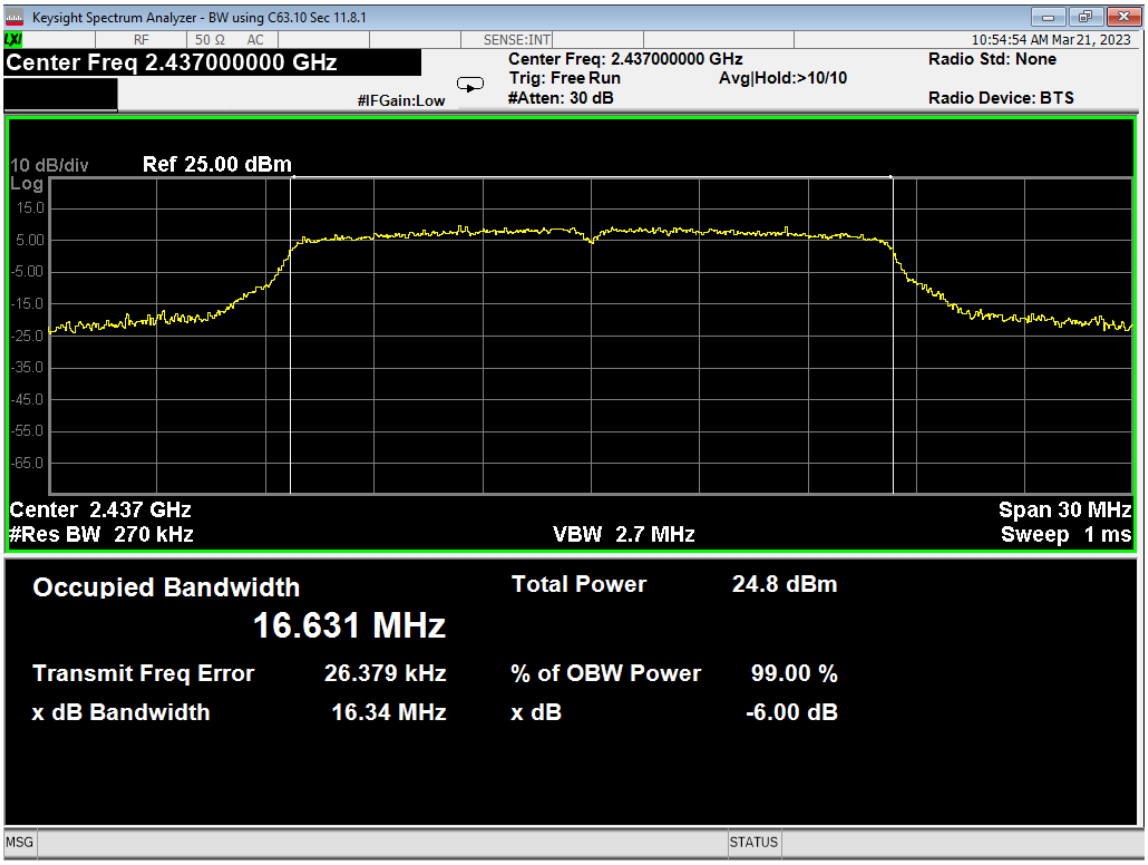
89 Occupied Bandwidth, Mid, Wifi B, High Data Rate



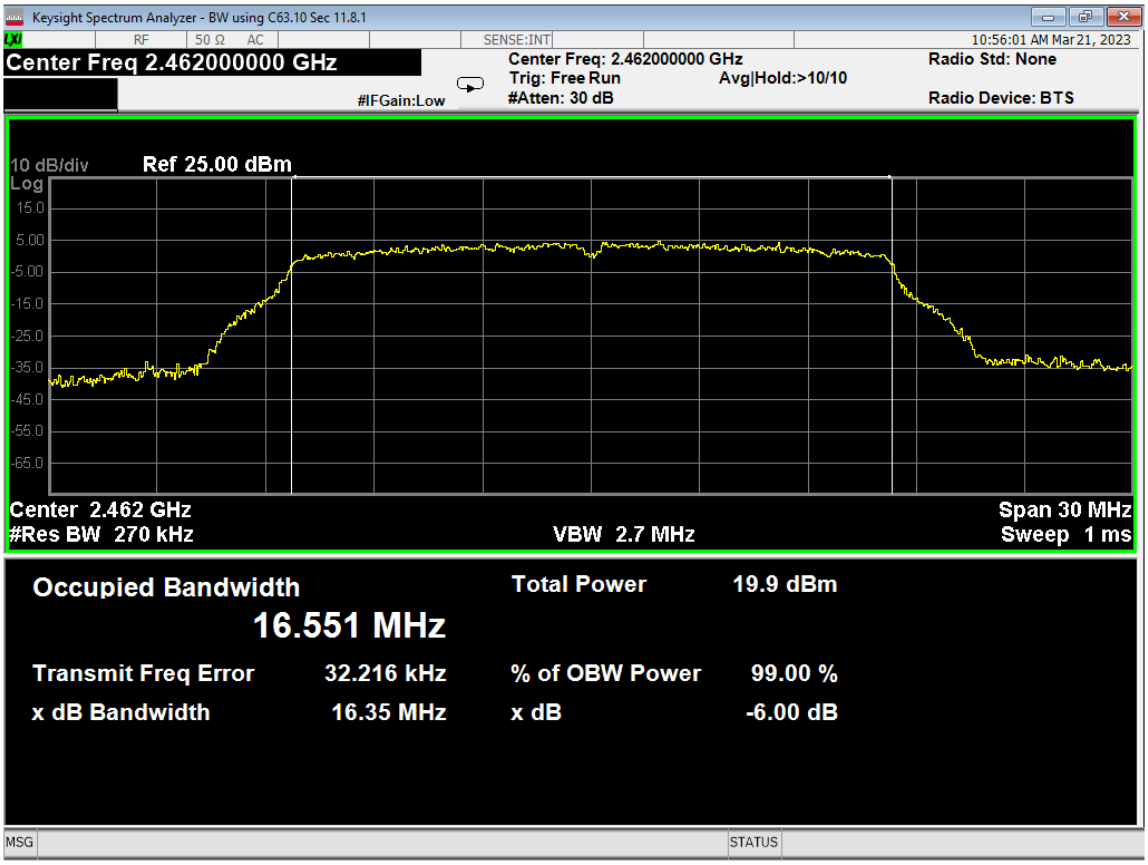
90 Occupied Bandwidth, High, Wifi B, High Data Rate



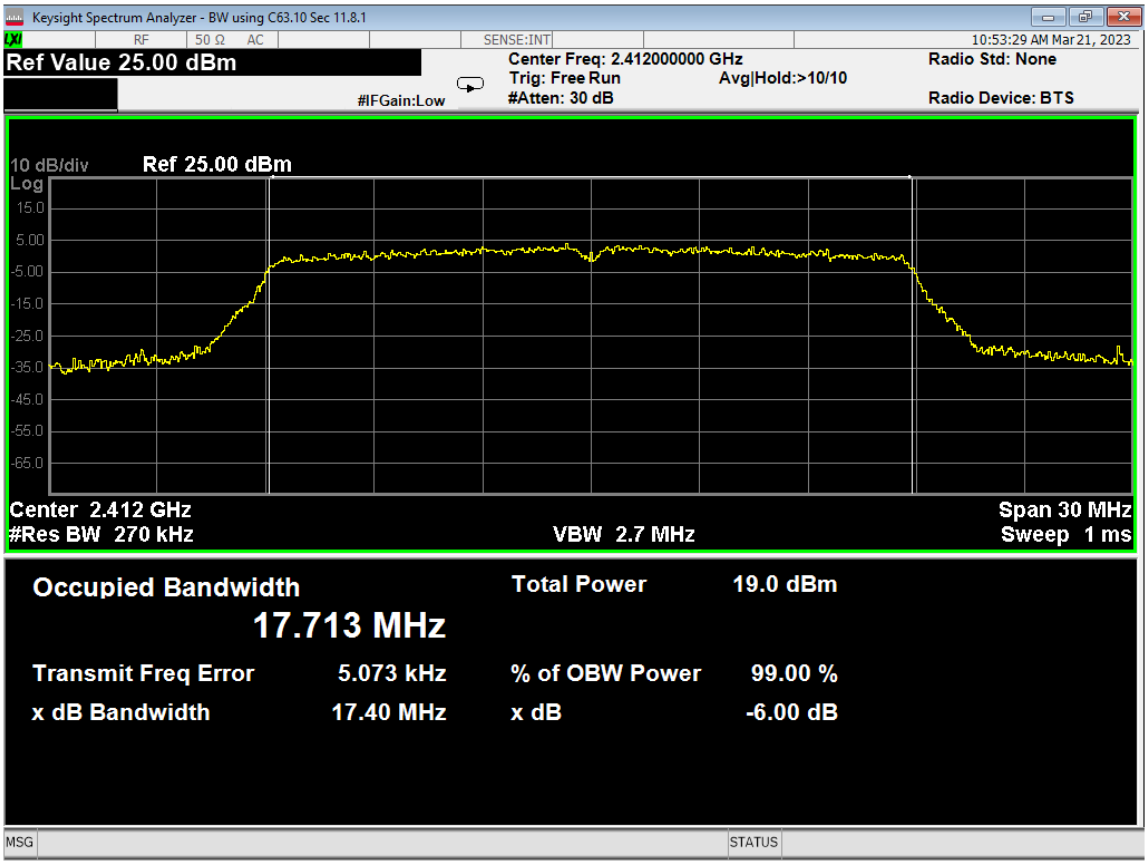
91 Occupied Bandwidth, Low, Wifi G, High Data Rate



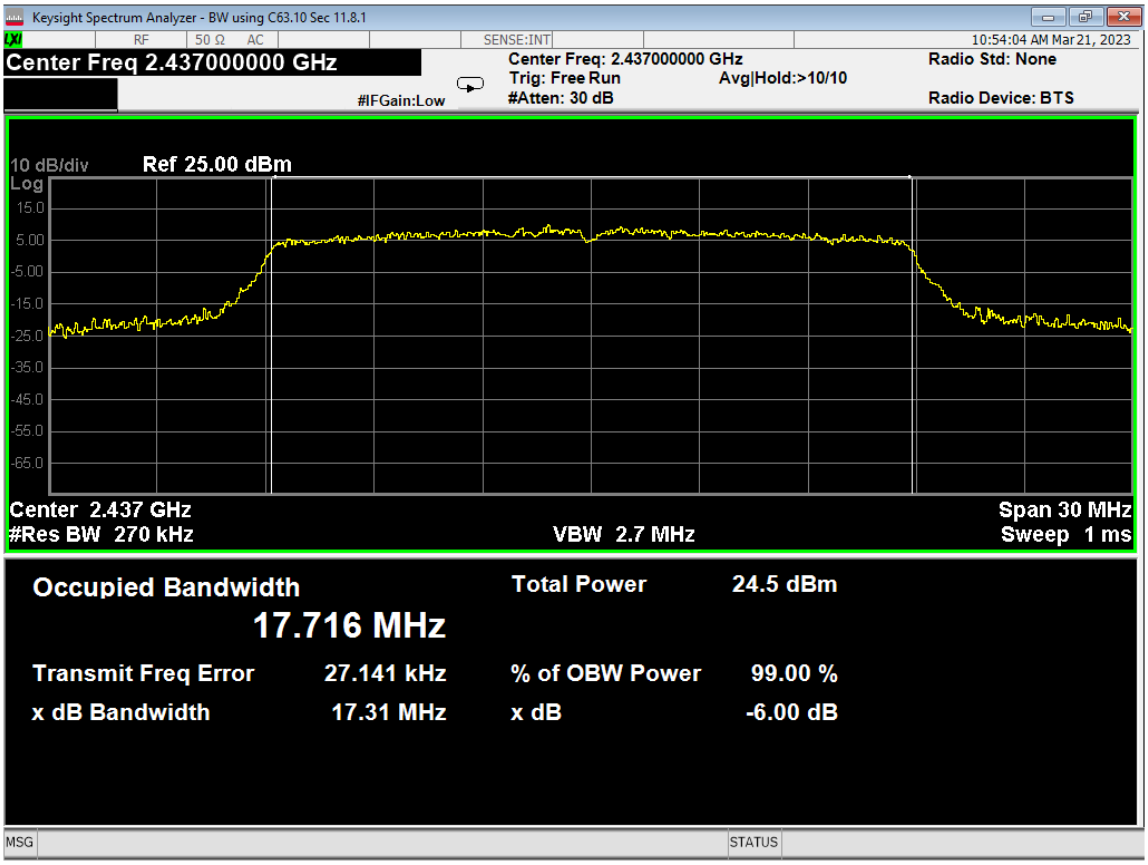
92 Occupied Bandwidth, Mid, Wifi G, High Data Rate



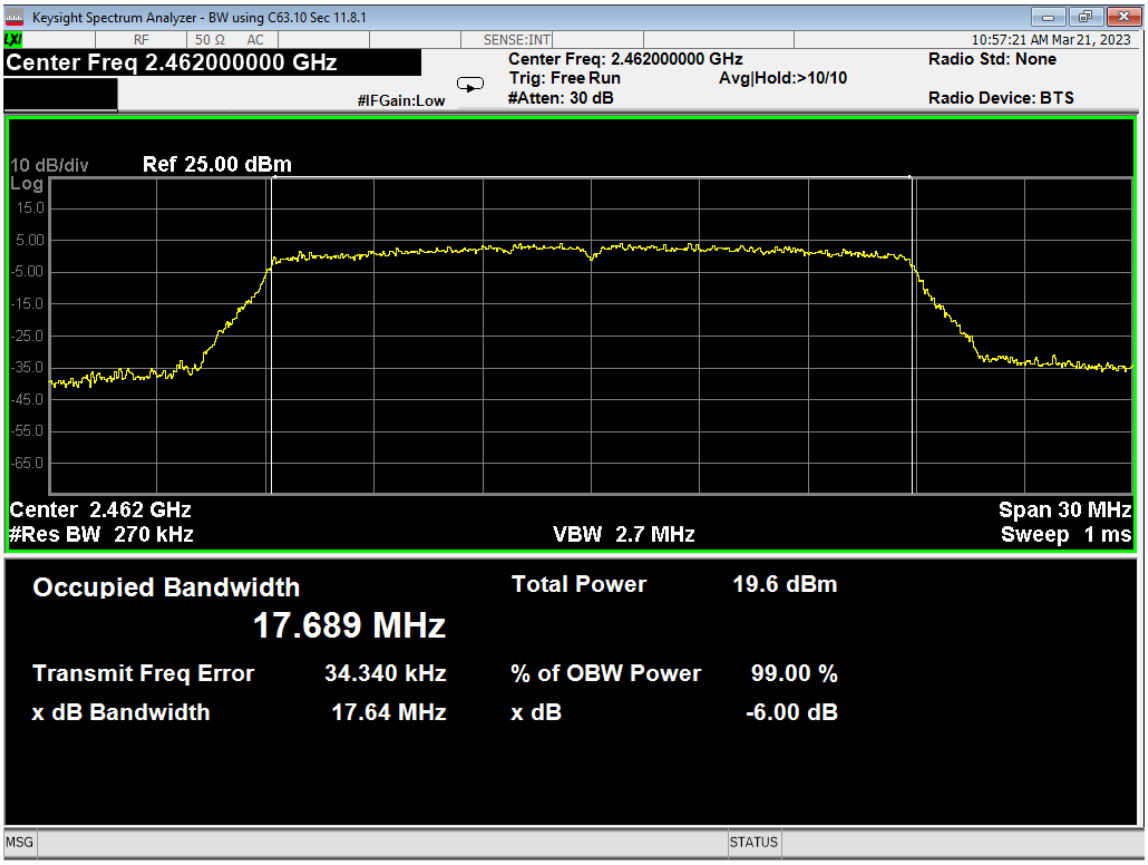
93 Occupied Bandwidth, High, Wifi G, High Data Rate



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

REPORT END