RF TEST REPORT

Applicant	Quectel Wireless Solutions Company Limited
FCC ID	XMR202309AF55C
Product	Wi-Fi & Bluetooth Module
Brand	Quectel
Model	AF55C
Report No.	R2411A1826-R1
Issue Date	December 25, 2024

Eurofins TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC CFR47 Part 15C (2023)**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

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Summary of Measurement Results

Number	Test Case	Clause in FCC rules	Verdict
1	Maximum output power	15.247(b)(3)	PASS
2	99% Bandwidth and 6dB Bandwidth	15.247(a)(2) C63.10 6.9	PASS
3	Power spectral density	15.247(e)	PASS
4	Band Edge	15.247(d)	PASS
5	Spurious RF Conducted Emissions	15.247(d)	PASS
6	Unwanted Emissions	15.247(d), 15.205, 15.209	PASS
7	Conducted Emissions	15.207	PASS
Date of Testing: September 20, 2023 ~ December 1, 2023 Date of Sample Received: September 11, 2023			
Note: All indications of Pass/Fail in this report are opinions expressed by Eurofins TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.			

AF55C (Report No.: R2411A1826-R1) is a variant model of AF55C (Report No.: R2308A0966-R1V2).
The difference between the two models is shown in the table below:

Item	Original	Variant
HW Version	R1.0	R1.1
Filter	IC RF BPF WIFI&BT 2400-2500MHZ34dBm PINS551.1x0.9mm H0.6mm RO	IC RF TX filter WLAN 2.4G 36dBm1.1x0.9mm H0.7mm RO
Voltage	Max 3.8 V	Max 4.8 V
Others	The same	

This report also verifies Maximum output power and Spurious RF Conducted Emissions (CH 19 for Bluetooth LE; 802.11b CH 11 for Wi-Fi Ant1), powers of new variant are varied due to measurement uncertainty, and sample tolerance of the acceptance range, so they were not recorded in the report.

Test values all duplicated from original report (Report No.: R2308A0966-R1V2).

The detailed product change description please refers to the *Difference Declaration Letter.*

1. Test Laboratory

1.1. Notes of the Test Report

This report shall not be reproduced in full or partial, without the written approval of **Eurofins TA Technology (Shanghai) Co., Ltd.** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein .Measurement Uncertainties were not taken into account and are published for informational purposes only. This report is written to support regulatory compliance of the applicable standards stated above.

1.2. Test Facility

FCC (Designation number: CN1179, Test Firm Registration Number: 446626)

Eurofins TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform measurements.

A2LA (Certificate Number: 3857.01)

Eurofins TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform measurement.

1.3. Testing Location

Company:	Eurofins TA Technology (Shanghai) Co., Ltd.
Address:	Building 3, No.145, Jintang Rd, Pudong Shanghai, P.R.China
City:	Shanghai
Post code:	201201
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Website:	https://www.eurofins.com/electrical-and-electronics
E-mail:	Kain.Xu@cpt.eurofinscn.com

2. General Description of Equipment Under Test

2.1. Applicant and Manufacturer Information

Applicant	Quectel Wireless Solutions Company Limited
Applicant address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233
Manufacturer	Quectel Wireless Solutions Company Limited
Manufacturer address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233

2.2. General Information

EUT Description		
Model	AF55C	
SN	Conducted	P1C23GK0B001141
	Radiated	P1C23GK0B000182
Hardware Version	R1.1	
Software Version	NA	
Power Supply	External power supply	
Antenna Type	Dipole Antenna	
Antenna Connector	RP SMA Male antenna (meet with the standard FCC Part 15.203 requirement)	
Antenna Gain	-0.10 dBi	
Additional Beamforming Gain	NA	
Direction Gain	Power: -0.10 dBi PSD: 2.91 dBi	
Operating Frequency Range(s)	802.11b/g/n(HT20)/ax(HE20): 2412 ~ 2462 MHz Bluetooth LE V5.2: 2402 ~2480 MHz	
Modulation Type	802.11b: DSSS 802.11g/n: OFDM 802.11ax (Support Full RU only): OFDM Bluetooth LE: GFSK	
Max. Output Power	Wi-Fi 2.4G: 18.72 dBm Bluetooth LE: 7.72 dBm	
Auxiliary test equipment		
Switching Adapter	Manufacturer: Dong Guan City GangQi Electronic Co.Ltd Model: GQ36-120300-AX	
Note: 1. The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.		

3. Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

Test standards:

FCC CFR47 Part 15C (2023) Radio Frequency Devices

ANSI C63.10-2013

Reference standard:

KDB 558074 D01 15.247 Meas Guidance v05r02

KDB 662911 D01 Multiple Transmitter Output v02r01

4. Test Configuration

Test Mode

The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application.

The radiated emission was measured in the following position: EUT stand-up position (Z axis), lie-down position (X, Y axis). The worst emission was found in lie-down position (X axis) and the loop antenna is vertical, the others are vertical and horizontal. and the worst case was recorded.

In order to find the worst case condition, Pre-tests are needed at the presence of different data rate. Preliminary tests have been done on all the configuration for confirming worst case. Data rate below means worst-case rate of each test item.

Worst-case data rates are shown as following table.

Test Mode	Data Rate
Bluetooth(Low Energy)	1Mbps; 2Mbps
Bluetooth (Low Energy) (S=2)	500kbps
Bluetooth (Low Energy) (S=8)	125kbps

Test Mode	Data Rate		
	Antenna 1	Antenna 2	MIMO
802.11b	1 Mbps	1 Mbps	/
802.11g	6 Mbps	6 Mbps	/
802.11n HT20	MCS0	MCS0	MCS8
802.11ax HE20	MCS0	MCS0	MCS0

The worst case Antenna mode for each of the following tests for Wi-Fi:

Test Cases	Antenna 1	Antenna 2	MIMO
Maximum output power	O	O	802.11n HT20 802.11ax HE20
6dB Bandwidth	802.11b/g	--	802.11n HT20 802.11ax HE20
Band Edge	802.11b/g	--	802.11n HT20 802.11ax HE20
Power Spectral Density	O	O	802.11n HT20 802.11ax HE20
Spurious RF Conducted Emissions	802.11b/g	--	802.11n HT20 802.11ax HE20
Unwanted Emissions	--	802.11b/g	802.11n HT20 802.11ax HE20
Conducted Emission	--	--	802.11n HT20
Note: “O”: test all bands			

5. Test Case Results

5.1. Maximum output power

Ambient Condition

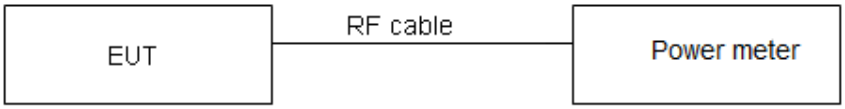
Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

Methods of Measurement

During the process of the testing, The EUT was connected to Power meter with a known loss. The EUT is max power transmission with proper modulation.

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

Test Setup



Limits

Rule Part 15.247 (b) (3) specifies that " For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz: 1 Watt.”

Average Output Power	≤ 1W (30dBm)

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 0.44 dB.

Test Results

SISO Power Index				
Channel	802.11b	802.11g	802.11n HT20	802.11ax HE20
CH1	16	16	16	15
CH6	16	16	16	15
CH11	16	16	16	15

MIMO Power Index		
Channel	802.11n HT20	802.11ax HE20
CH1	16	15
CH6	16	15
CH11	16	15

Power Index	
Channel	Bluetooth (Low Energy)
CH0	default
CH19	default
CH39	default

Test Mode	Duty cycle	Duty cycle correction Factor (dB)
802.11b	0.989	0.00
802.11g	0.935	0.29
802.11n HT20	0.930	0.32
802.11ax HE20	0.913	0.40
Bluetooth LE (1M)	0.626	2.03
Bluetooth LE (2M)	0.313	5.04
Bluetooth LE (S=2)	0.564	2.49
Bluetooth LE (S=8)	0.826	0.83
Note: when Duty cycle⩾0.98, Duty cycle correction Factor not required.		

SISO Antenna 1

Test Mode	Carrier frequency (MHz))/ Channel	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
802.11b	2412/CH 1	15.13	15.13	30	PASS
	2437/CH 6	15.34	15.34	30	PASS
	2462/CH 11	15.48	15.48	30	PASS
802.11g	2412/CH 1	15.59	15.88	30	PASS
	2437/CH 6	15.66	15.95	30	PASS
	2462/CH 11	15.94	16.23	30	PASS
802.11n HT20	2412/CH 1	15.57	15.89	30	PASS
	2437/CH 6	15.83	16.15	30	PASS
	2462/CH 11	15.88	16.20	30	PASS
802.11ax HE20	2412/CH 1	14.86	15.26	30	PASS
	2437/CH 6	14.87	15.27	30	PASS
	2462/CH 11	14.82	15.22	30	PASS
Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor					

SISO Antenna 2

Test Mode	Carrier frequency (MHz))/ Channel	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
802.11b	2412/CH 1	15.26	15.26	30	PASS
	2437/CH 6	14.23	14.23	30	PASS
	2462/CH11	14.97	14.97	30	PASS
802.11g	2412/CH 1	15.53	15.82	30	PASS
	2437/CH 6	14.36	14.65	30	PASS
	2462/CH11	15.09	15.38	30	PASS
802.11n HT20	2412/CH 1	15.32	15.64	30	PASS
	2437/CH 6	14.22	14.54	30	PASS
	2462/CH11	14.95	15.27	30	PASS
802.11ax HE20	2412/CH 1	14.45	14.85	30	PASS
	2437/CH 6	13.64	14.04	30	PASS
	2462/CH11	14.14	14.54	30	PASS
Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor					

MIMO

Test Mode	Carrier frequency (MHz) / Channel	MIMO Antenna 1		MIMO Antenna 2		Total Power (dBm)	Limit (dBm)	Conclusion
		Average Power Measured (dBm)	Average Power with duty factor (dBm)	Average Power Measured (dBm)	Average Power with duty factor (dBm)			
802.11n HT20	2412/CH 1	15.69	16.01	15.07	15.39	18.72	30	PASS
	2437/CH 6	15.32	15.64	14.61	14.93	18.31	30	PASS
	2462/CH11	15.82	16.14	14.76	15.08	18.65	30	PASS
802.11ax HE20	2412/CH 1	14.55	14.95	13.94	14.34	17.67	30	PASS
	2437/CH 6	14.41	14.81	13.73	14.13	17.49	30	PASS
	2462/CH11	14.68	15.08	13.75	14.15	17.65	30	PASS

Note: 1.Average Power with duty factor = Average Power Measured +Duty cycle correction factor

2. For Total Power, according to KDB 662911 D01 Multiple Transmitter Output v02r01 1),

The Total Power =$10\log(10^{(\text{Power antenna1 in dBm}/10)}+10^{(\text{Power antenna2 in dBm}/10)})$.

3. According to KDB 662911 D01 Multiple Transmitter Output v02r01 F)2)f)(i): If all antennas have the same gain,

Directional gain = G_{ANT} + Array Gain,

For power measurements on IEEE 802.11 devices,

Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$;

Array Gain = 0 dB (i.e., no array gain) for channel widths ≥ 40 MHz for any N_{ANT};

Array Gain = 5 log(N_{ANT}/N_{SS}) dB or 3 dB, whichever is less, for 20-MHz channel widths with $N_{ANT} \geq 5$.

So directional gain = G_{ANT} + Array Gain = (-0.1)+0= -0.1 dBi <6dBi. So the power limit is 30dBm

Test Mode	Carrier frequency (MHz))/ Channel	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
Bluetooth (Low Energy) (1M)	2402/CH0	4.36	6.39	30	PASS
	2440/CH19	5.43	7.46	30	PASS
	2480/CH39	5.05	7.08	30	PASS
Bluetooth (Low Energy) (2M)	2402/CH0	1.54	6.58	30	PASS
	2440/CH19	2.68	7.72	30	PASS
	2480/CH39	1.92	6.96	30	PASS
Bluetooth (Low Energy) (S=2)	2402/CH0	3.94	6.43	30	PASS
	2440/CH19	4.97	7.46	30	PASS
	2480/CH39	4.52	7.01	30	PASS
Bluetooth (Low Energy) (S=8)	2402/CH0	5.54	6.37	30	PASS
	2440/CH19	6.68	7.51	30	PASS
	2480/CH39	6.32	7.15	30	PASS

Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor

5.2. 99% Bandwidth and 6dB Bandwidth

Ambient Condition

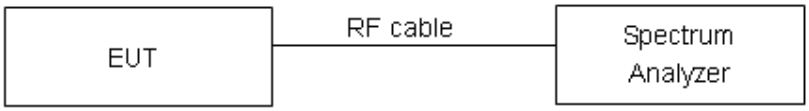
Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable. RBW is set to 100 kHz; VBW is set to 300 kHz on spectrum analyzer.
Dector=Peak, Trace mode=max hold.

The EUT was connected to the spectrum analyzer through a known loss cable. The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value.

Test Setup



Limits

Rule Part 15.247 (a) (2) specifies that “Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.”

minimum 6 dB bandwidth	≥ 500 kHz

Measurement Uncertainty

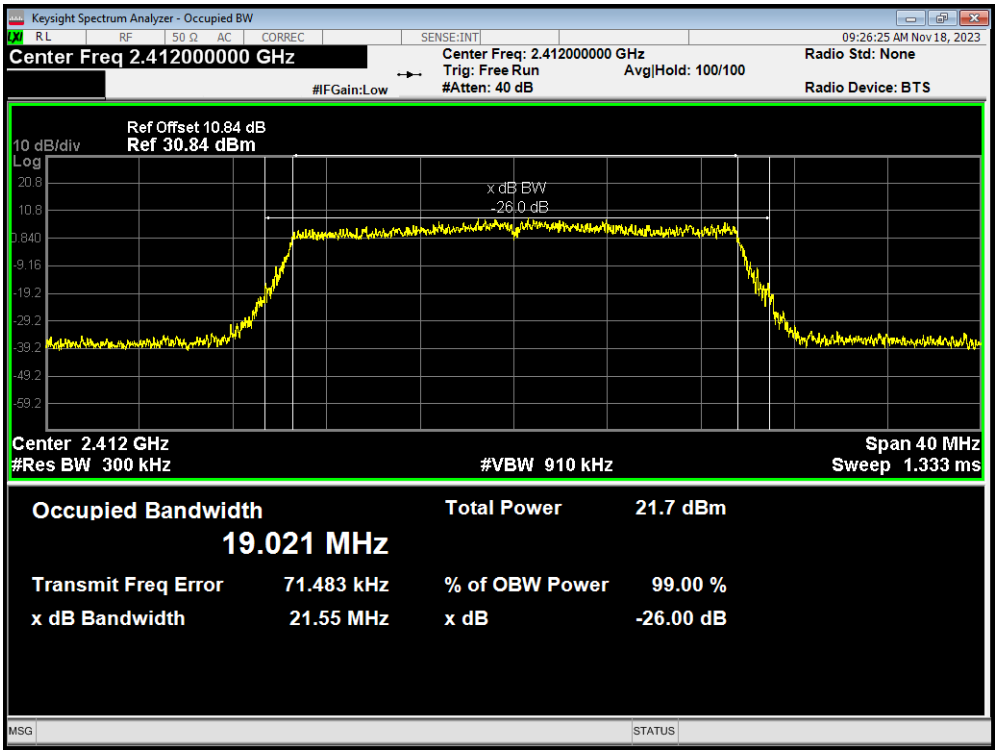
The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 936 Hz.

Test Results:

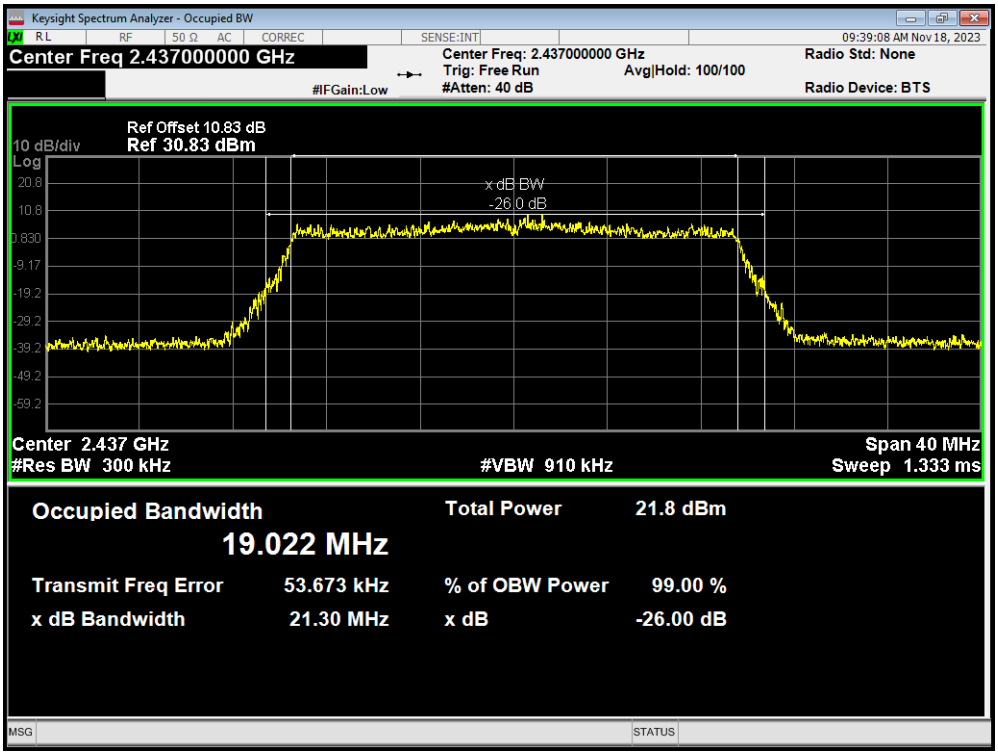
Test Mode	Carrier frequency (MHz)	99% bandwidth (MHz)	Minimum 6 dB bandwidth (MHz)	Limit (kHz)	Conclusion
802.11b	2412	12.010	8.577	500	PASS
	2437	12.051	8.114	500	PASS
	2462	11.990	8.564	500	PASS
802.11g	2412	16.761	15.066	500	PASS
	2437	16.804	14.964	500	PASS
	2462	16.707	11.283	500	PASS
802.11n HT20	2412	17.878	14.601	500	PASS
	2437	17.904	15.414	500	PASS
	2462	17.846	14.991	500	PASS
802.11ax HE20	2412	19.021	17.665	500	PASS
	2437	19.022	18.892	500	PASS
	2462	18.990	18.821	500	PASS
Bluetooth (Low Energy) (1M)	2402	1.046	0.658	500	PASS
	2440	1.040	0.661	500	PASS
	2480	1.045	0.664	500	PASS
Bluetooth (Low Energy) (2M)	2402	2.034	1.226	500	PASS
	2440	2.037	1.246	500	PASS
	2480	2.031	1.231	500	PASS
Bluetooth (Low Energy) (S=2)	2402	1.033	0.693	500	PASS
	2440	1.032	0.666	500	PASS
	2480	1.031	0.658	500	PASS
Bluetooth (Low Energy) (S=8)	2402	1.065	0.681	500	PASS
	2440	1.068	0.680	500	PASS
	2480	1.064	0.678	500	PASS

99%bandwidth

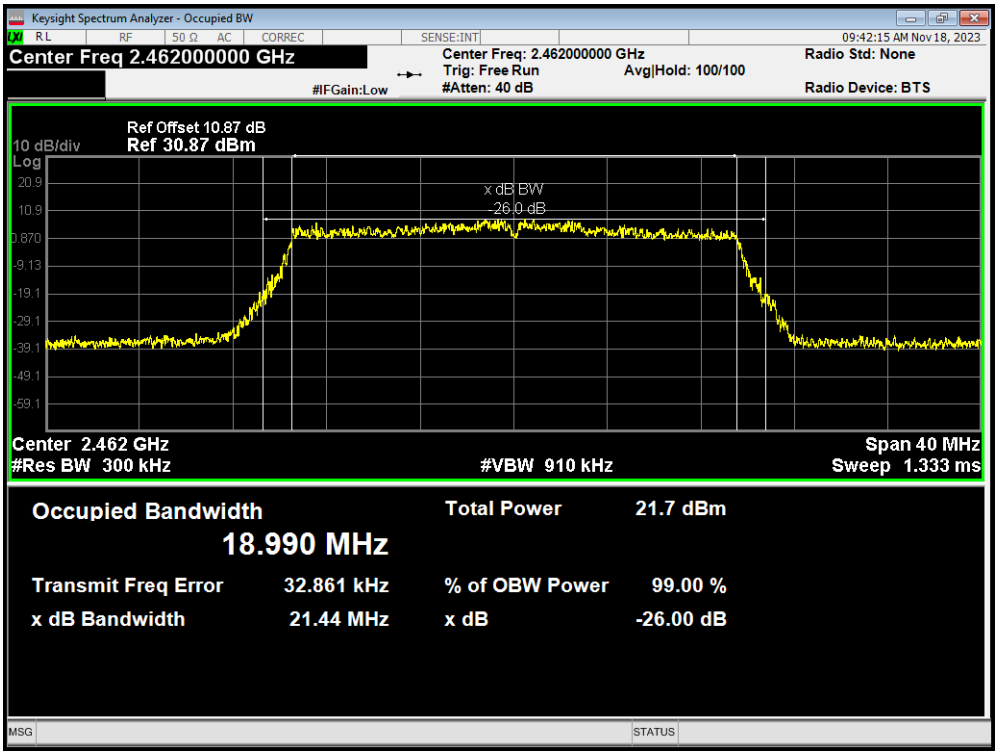
OBW 802.11ax(HE20) 2412MHz



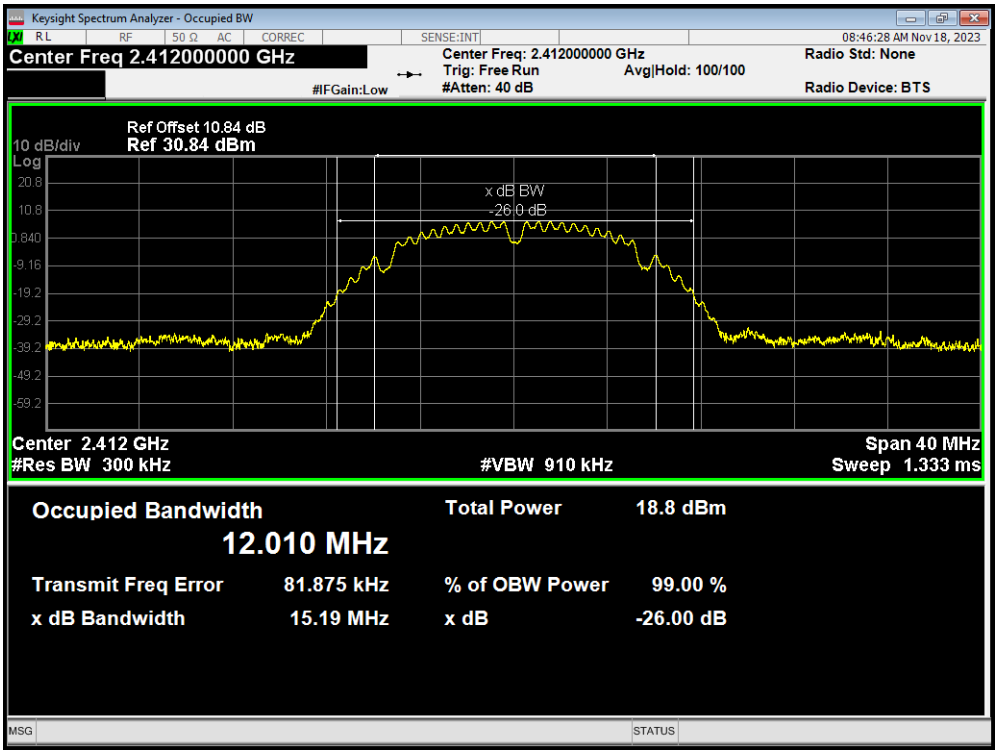
OBW 802.11ax(HE20) 2437MHz



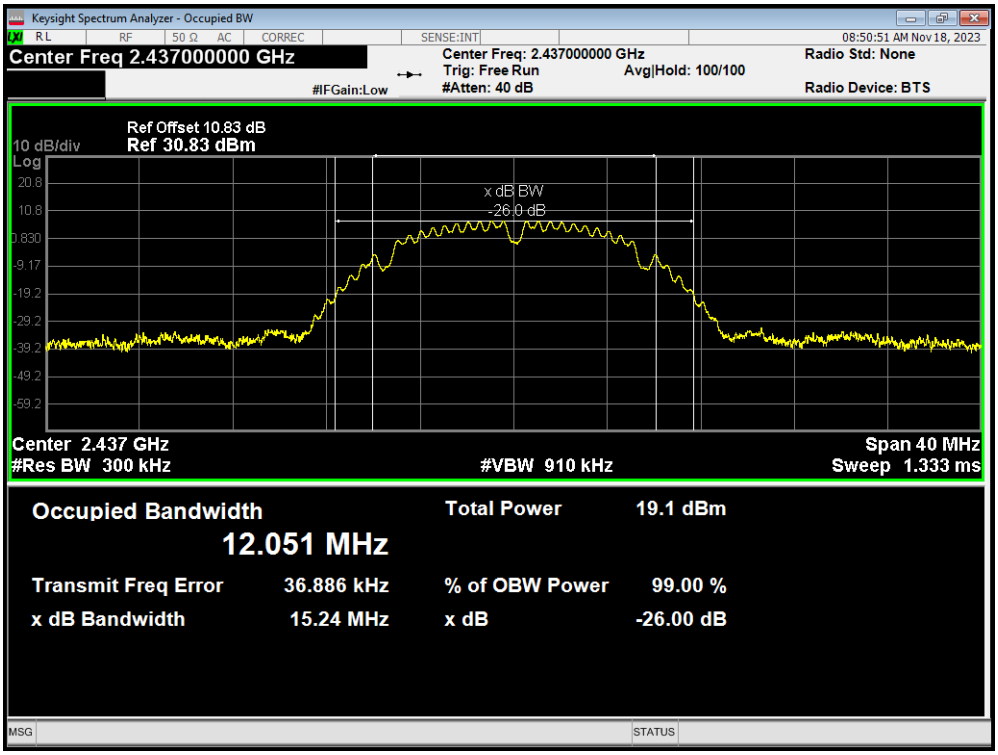
OBW 802.11ax(HE20) 2462MHz



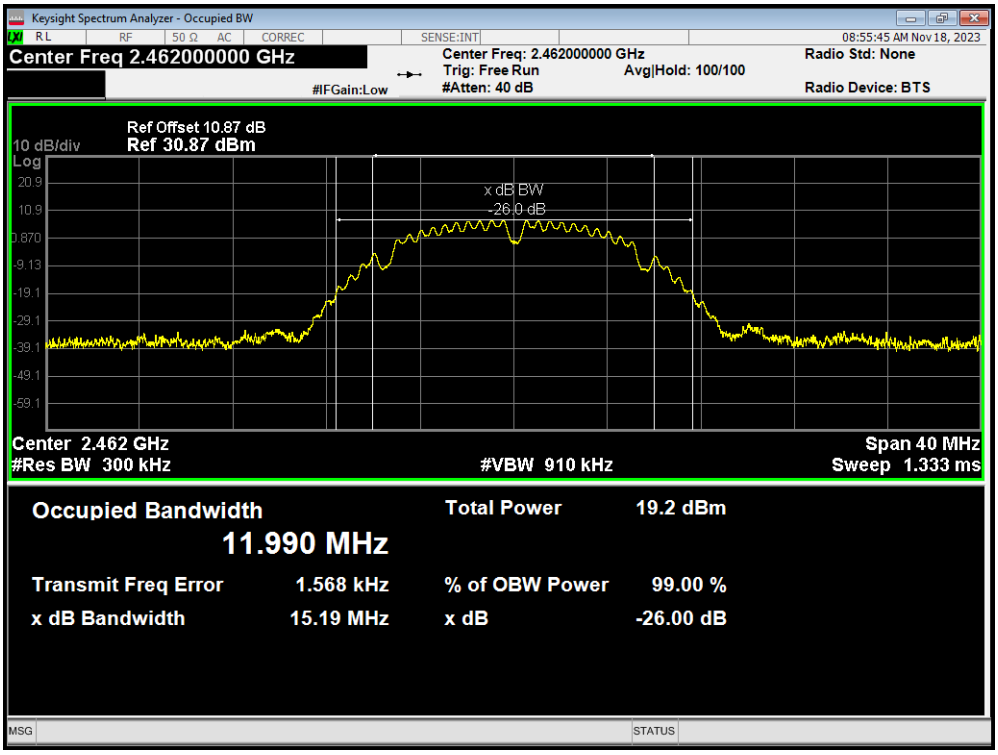
OBW 802.11b 2412MHz



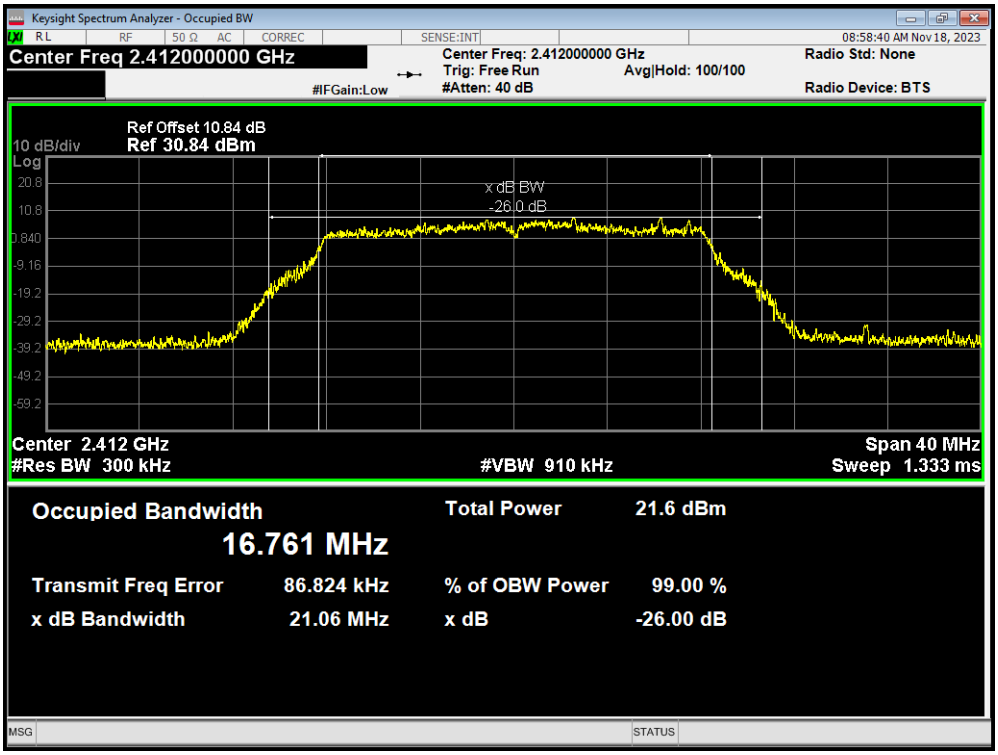
OBW 802.11b 2437MHz



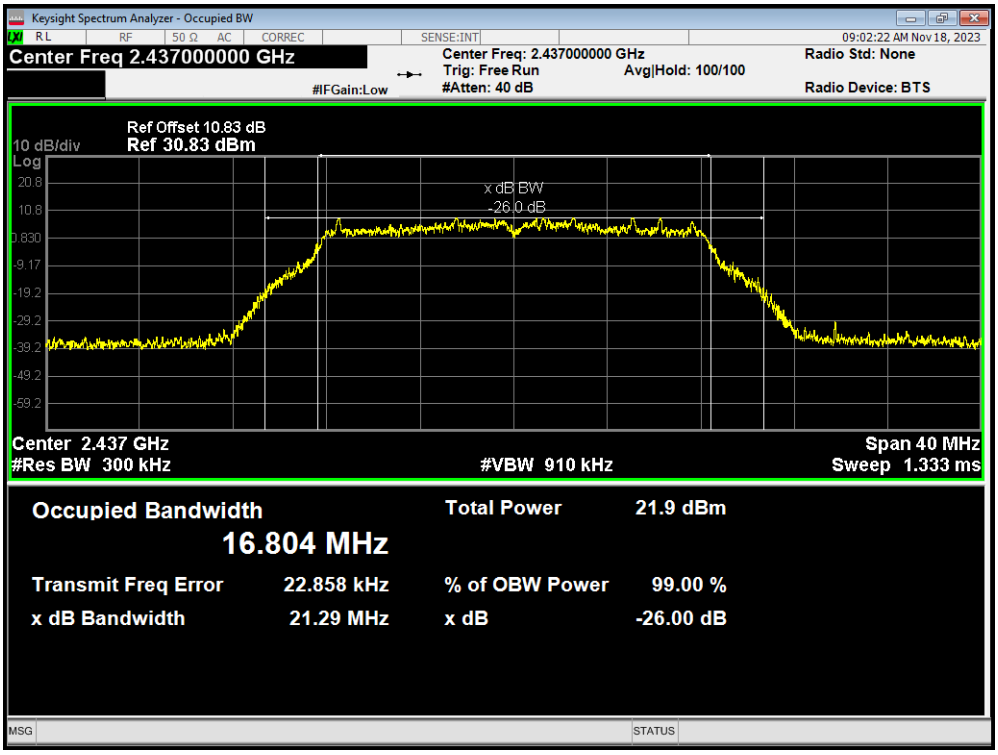
OBW 802.11b 2462MHz



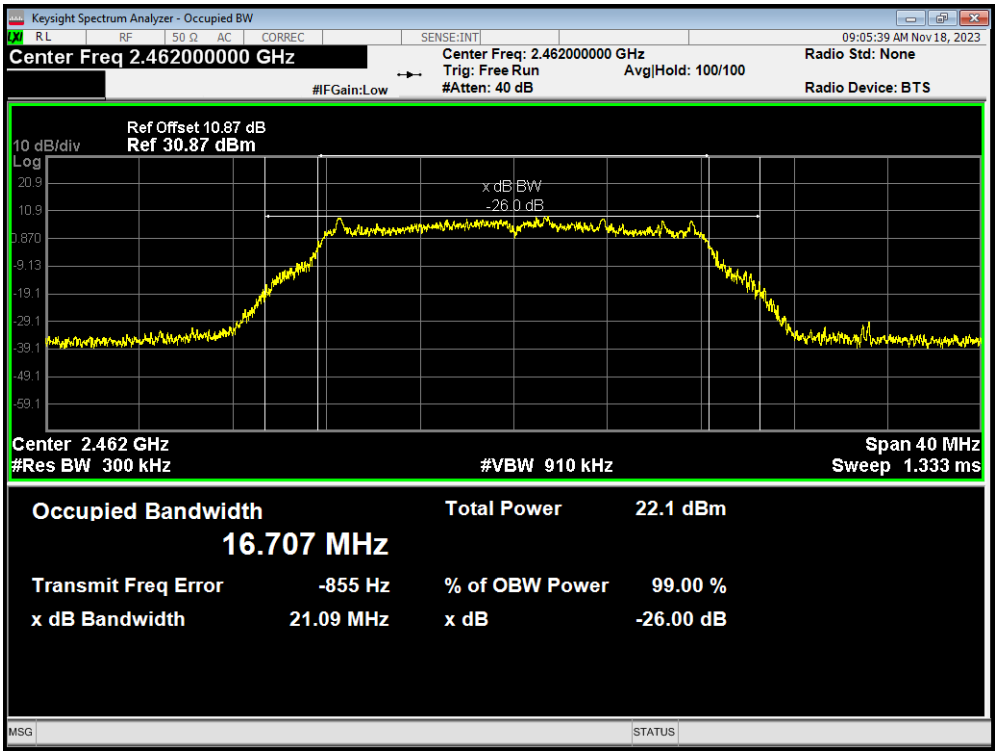
OBW 802.11g 2412MHz



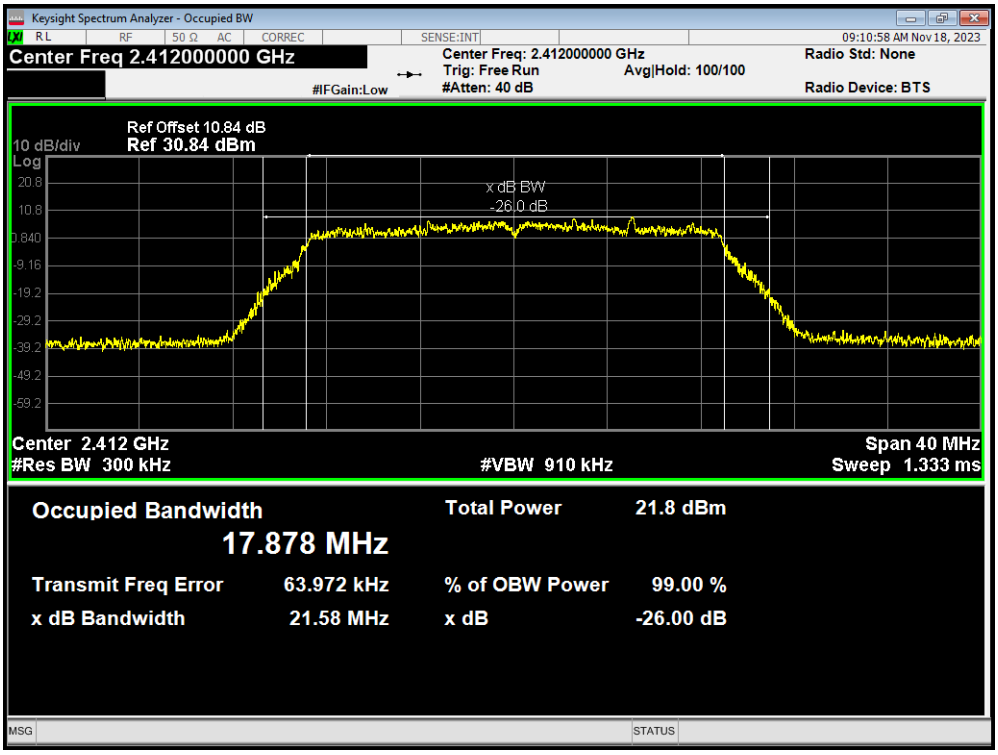
OBW 802.11g 2437MHz



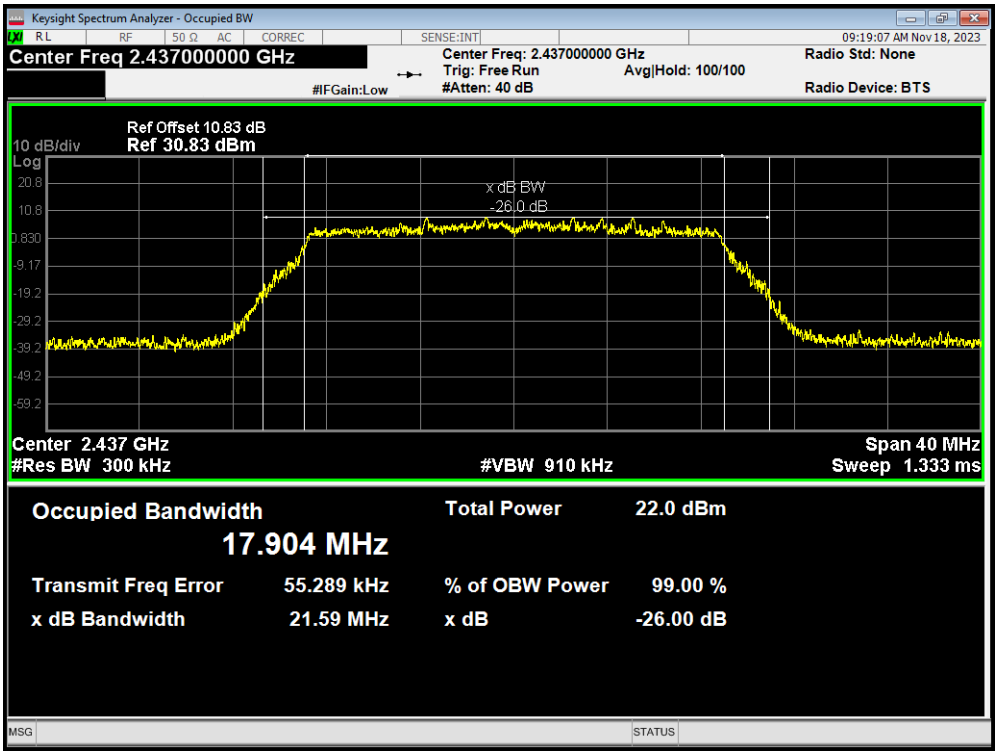
OBW 802.11g 2462MHz



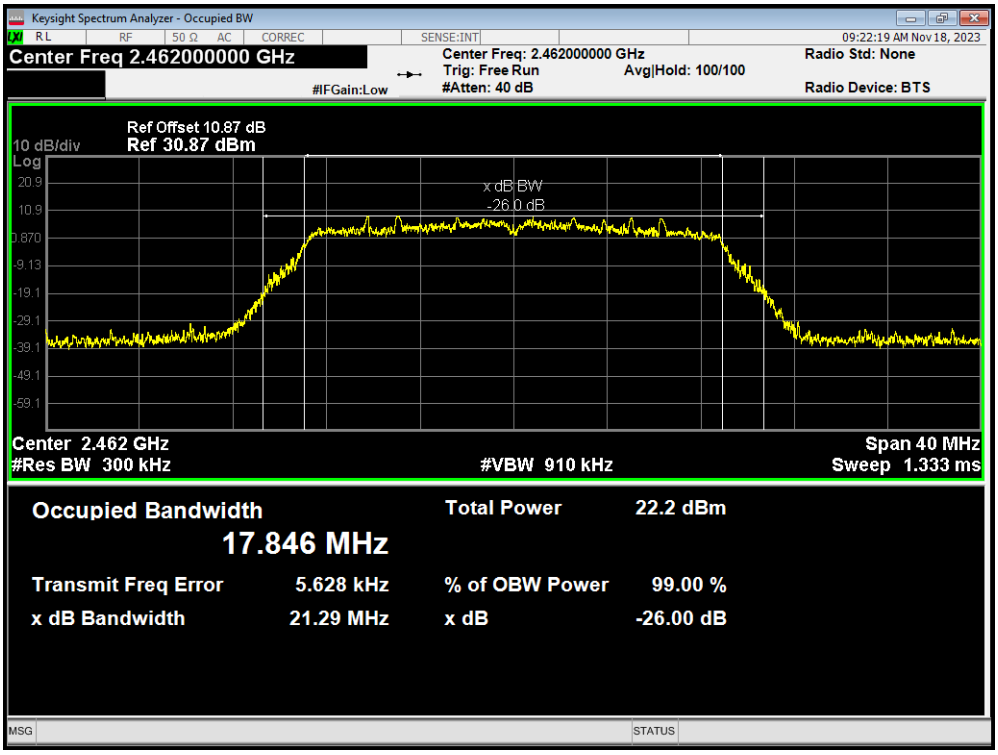
OBW 802.11n(HT20) 2412MHz



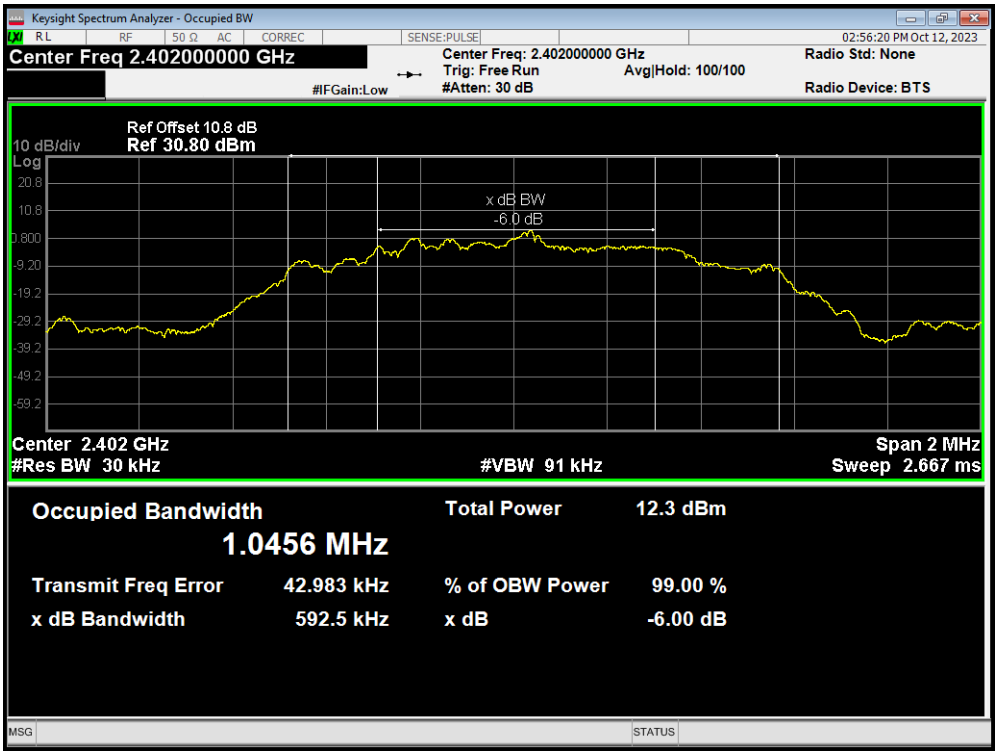
OBW 802.11n(HT20) 2437MHz



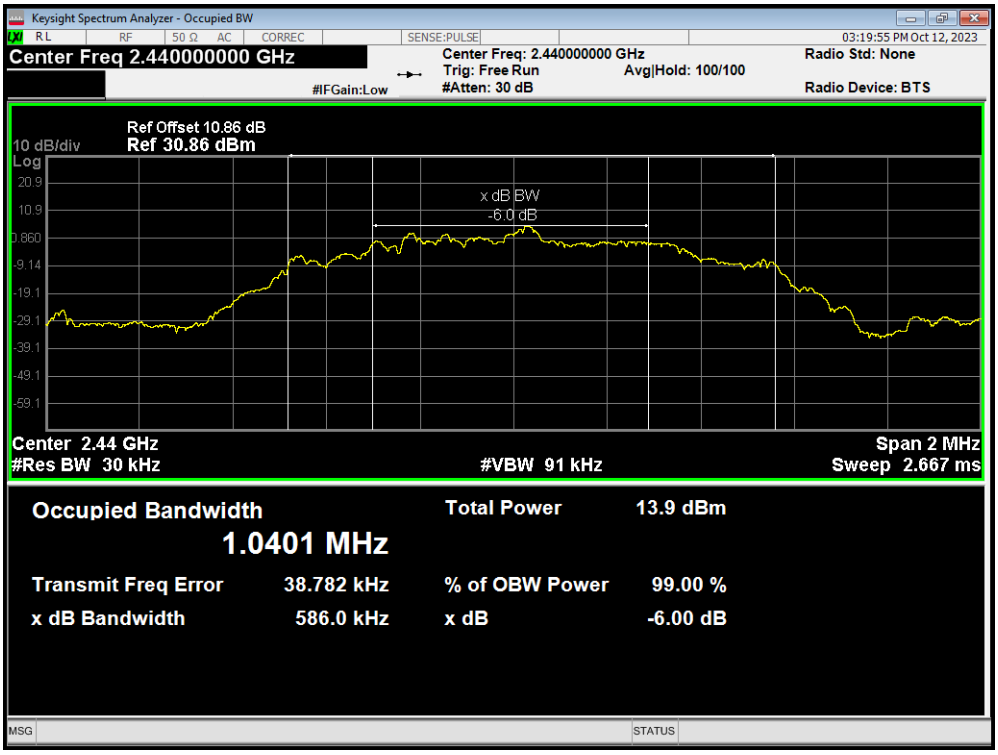
OBW 802.11n(HT20) 2462MHz



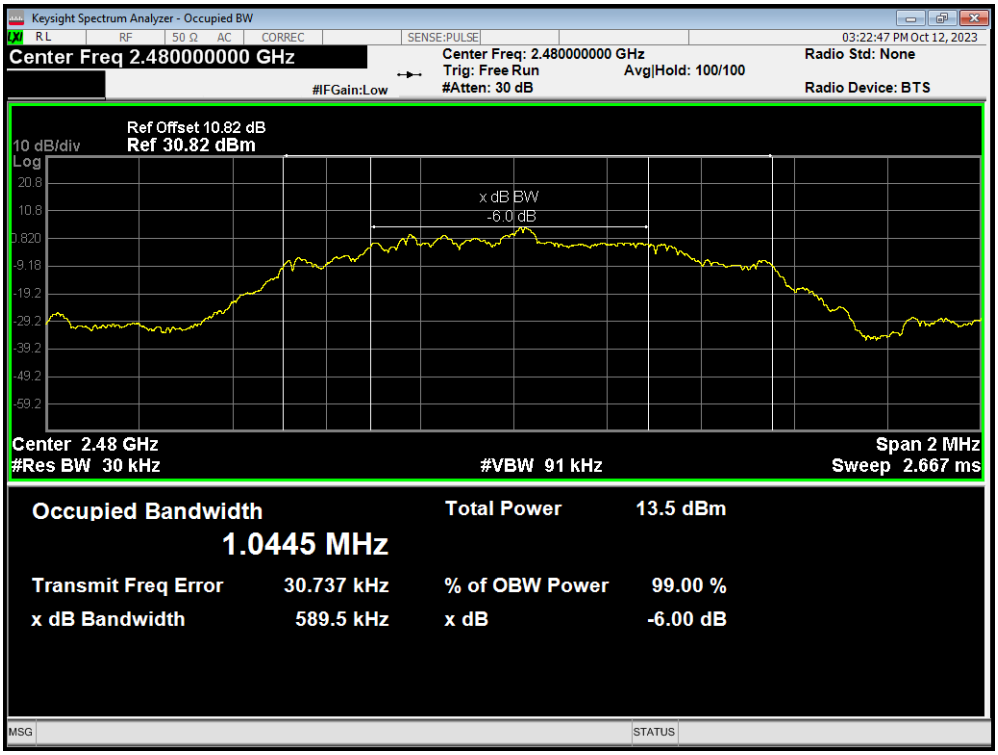
OBW Bluetooth LE(1M)2402MHz



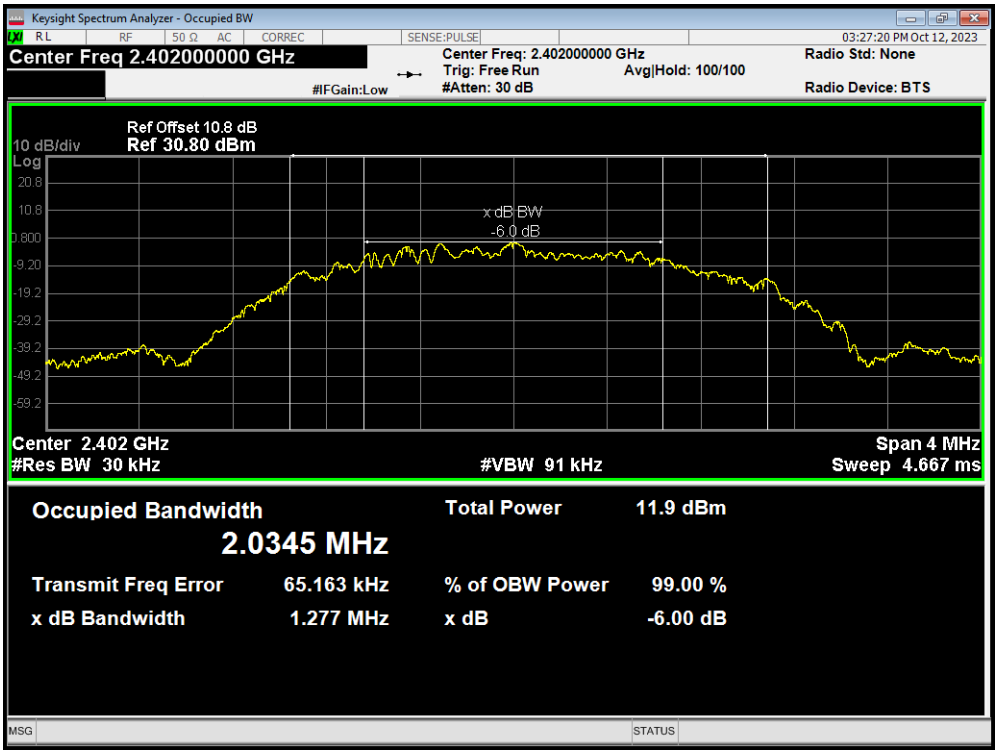
OBW Bluetooth LE(1M)2440MHz



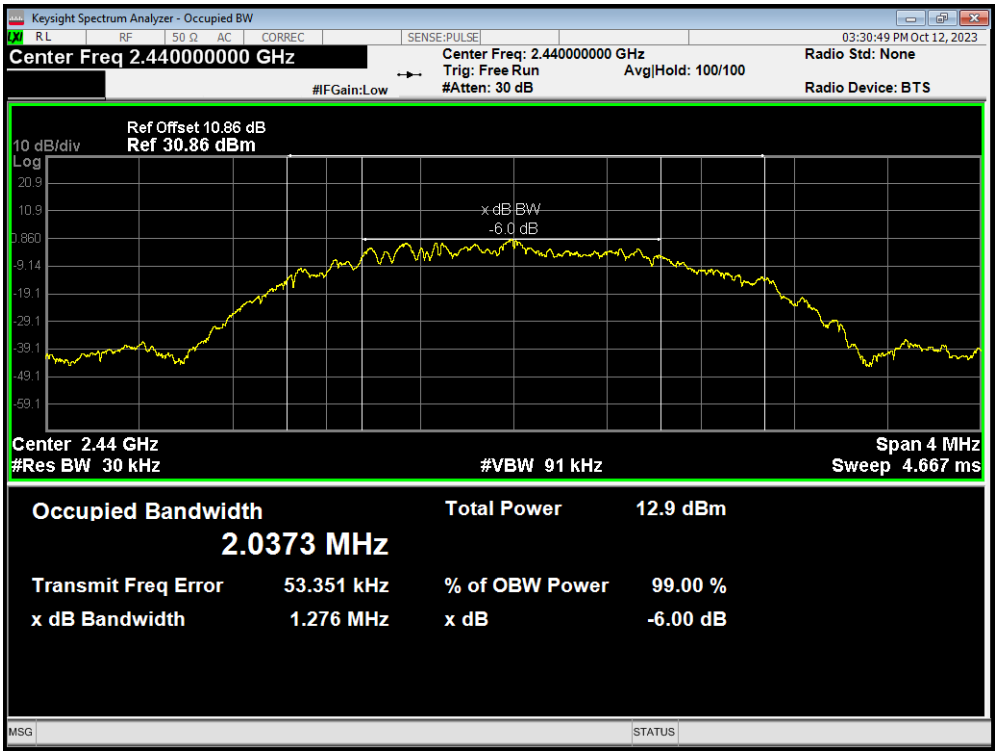
OBW Bluetooth LE(1M)2480MHz



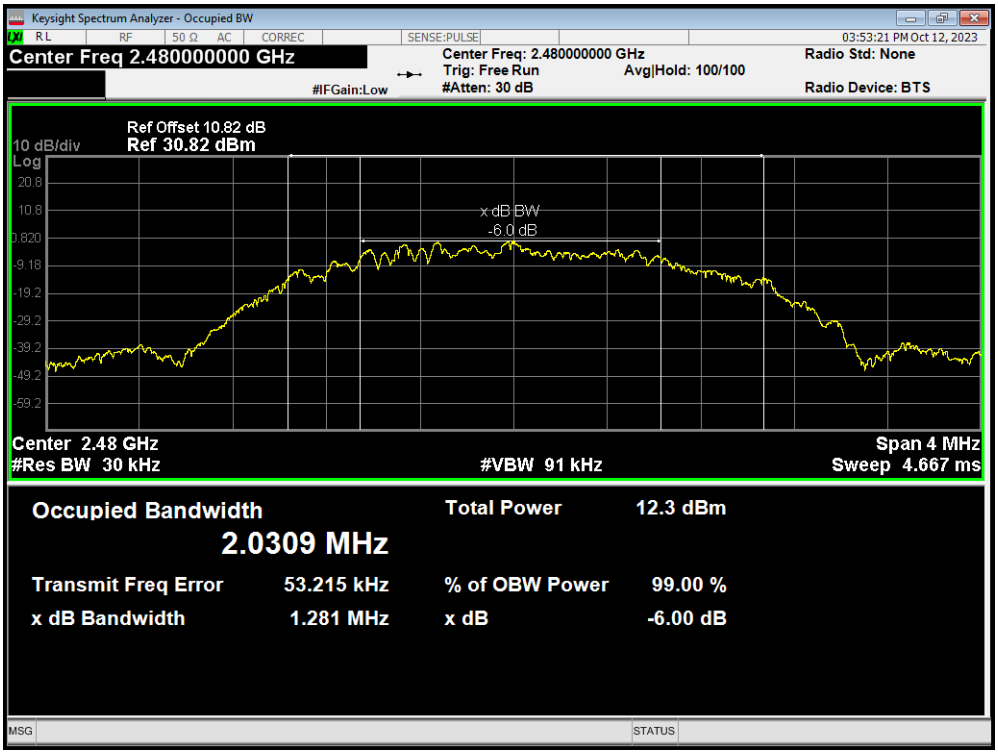
OBW Bluetooth LE(2M) 2402MHz



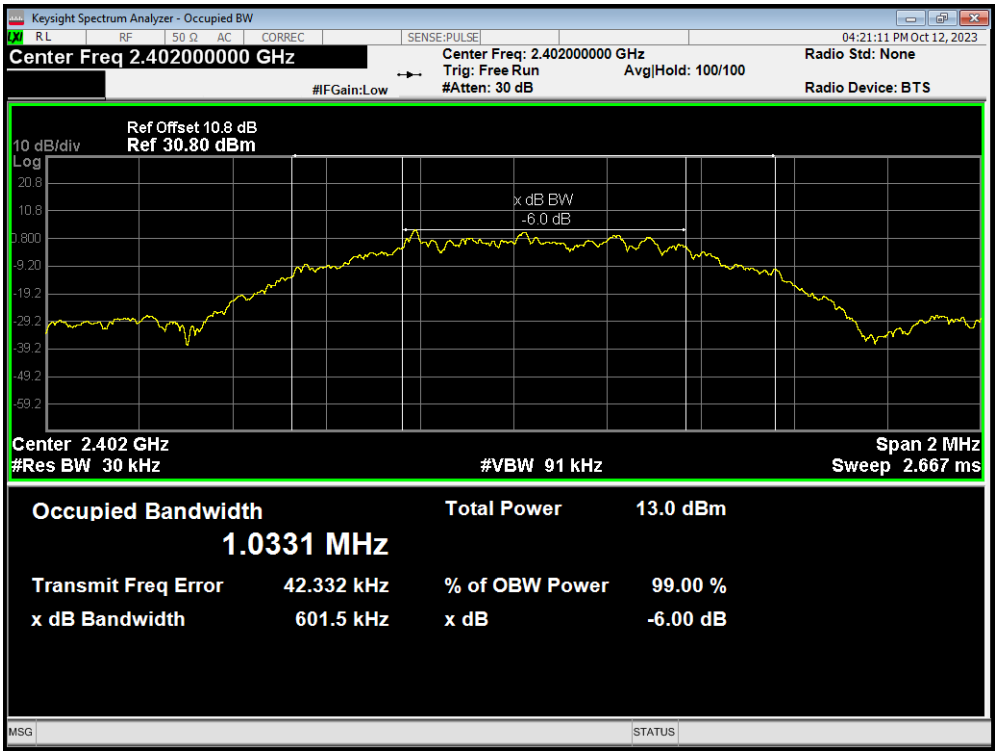
OBW Bluetooth LE(2M) 2440MHz



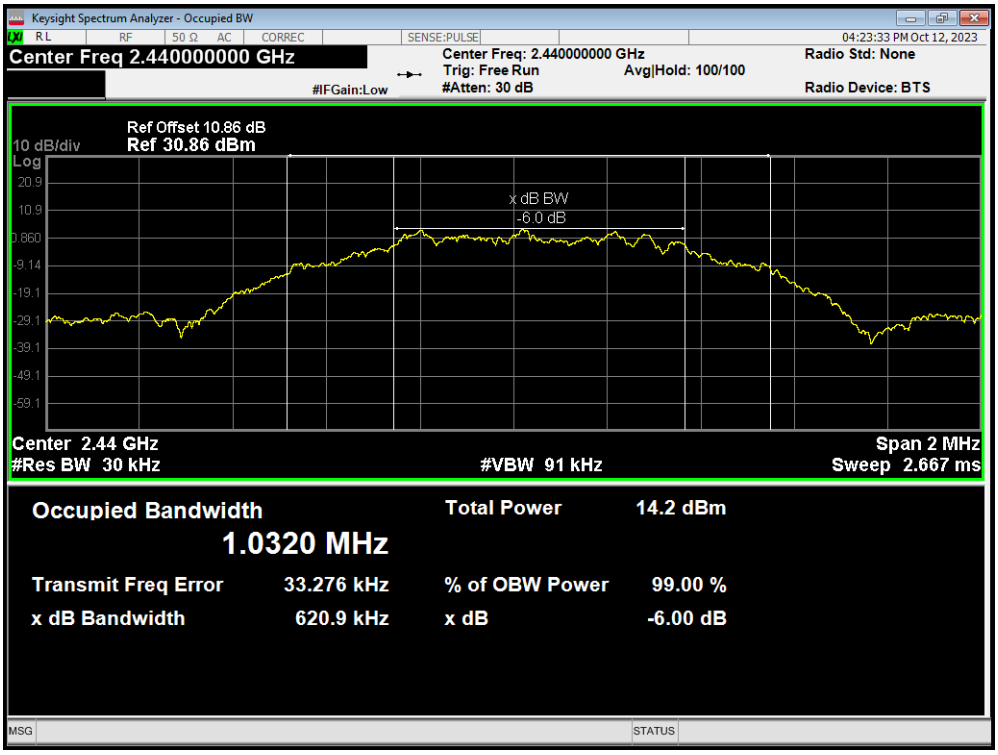
OBW Bluetooth LE(2M) 2480MHz



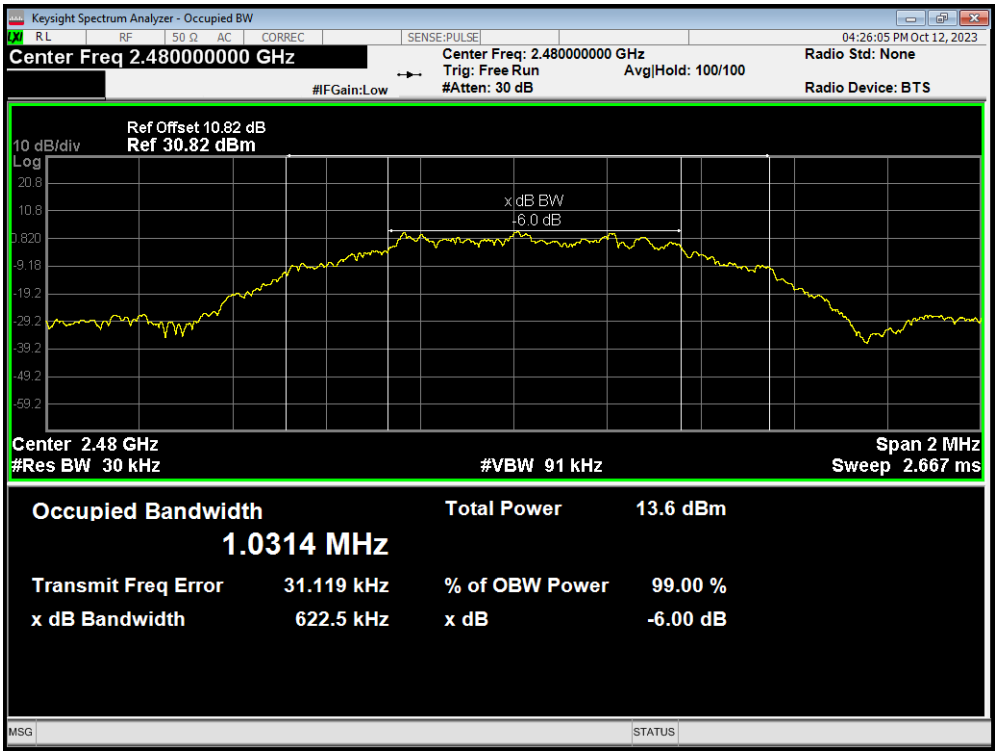
OBW Bluetooth LE(S=2) 2402MHz



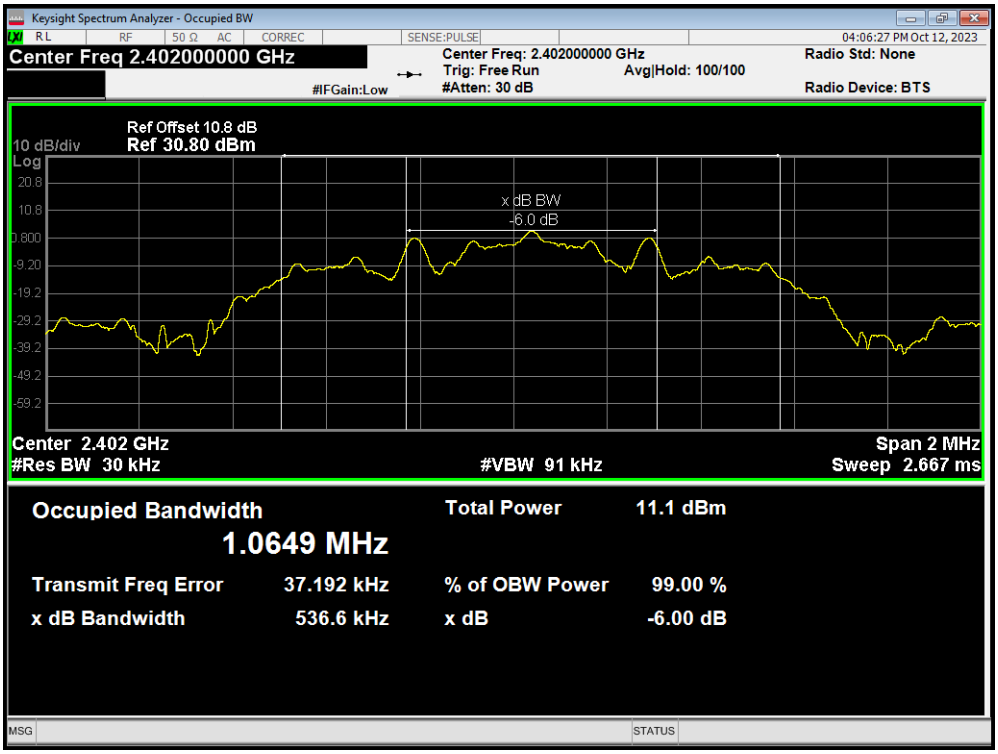
OBW Bluetooth LE(S=2) 2440MHz



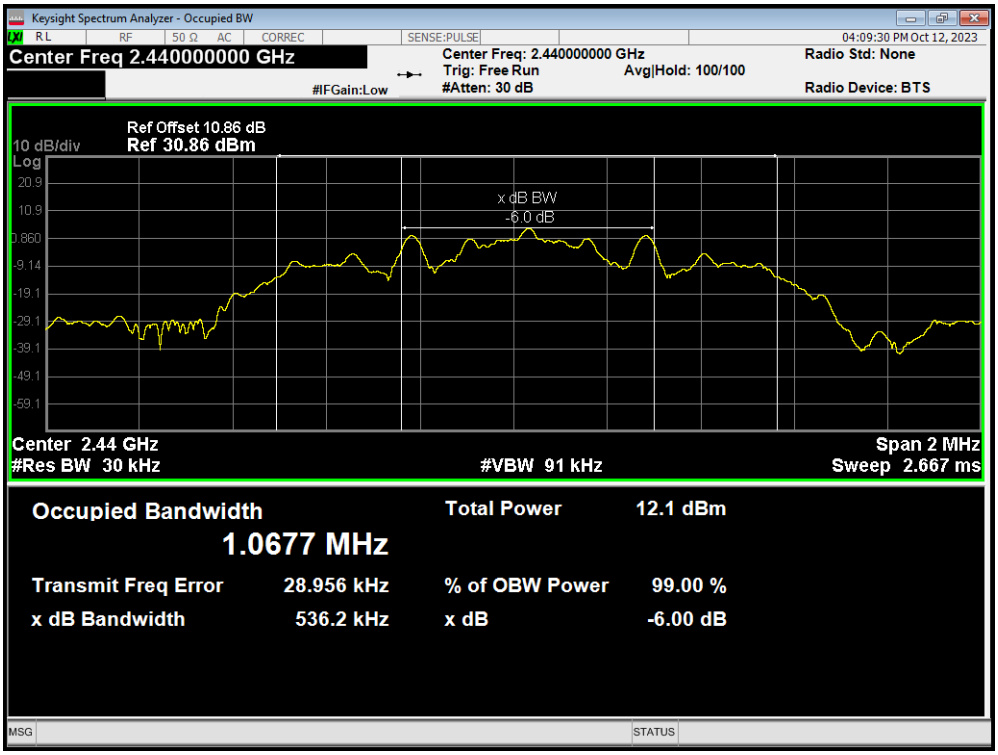
OBW Bluetooth LE(S=2) 2480MHz



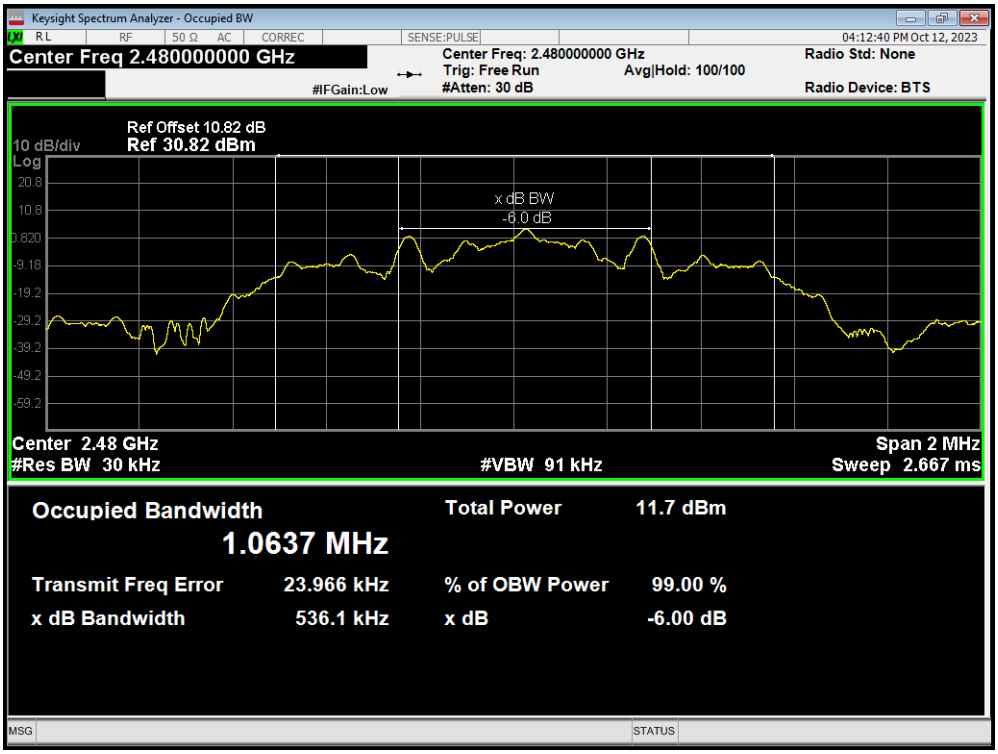
OBW Bluetooth LE(S=8) 2402MHz



OBW Bluetooth LE(S=8) 2440MHz

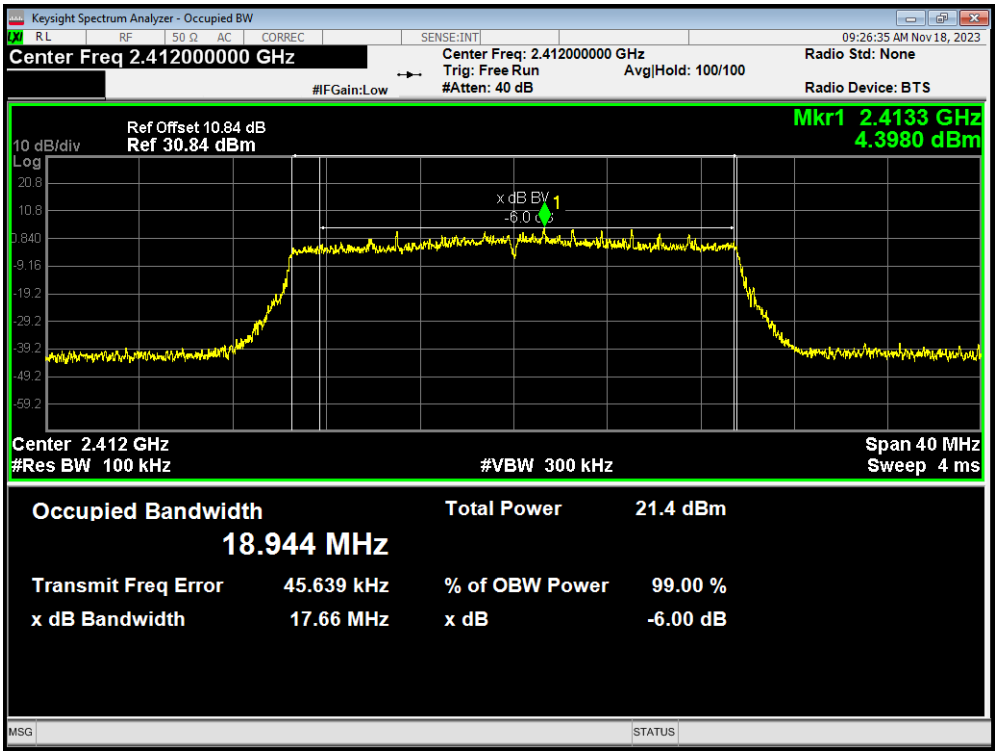


OBW Bluetooth LE(S=8) 2480MHz

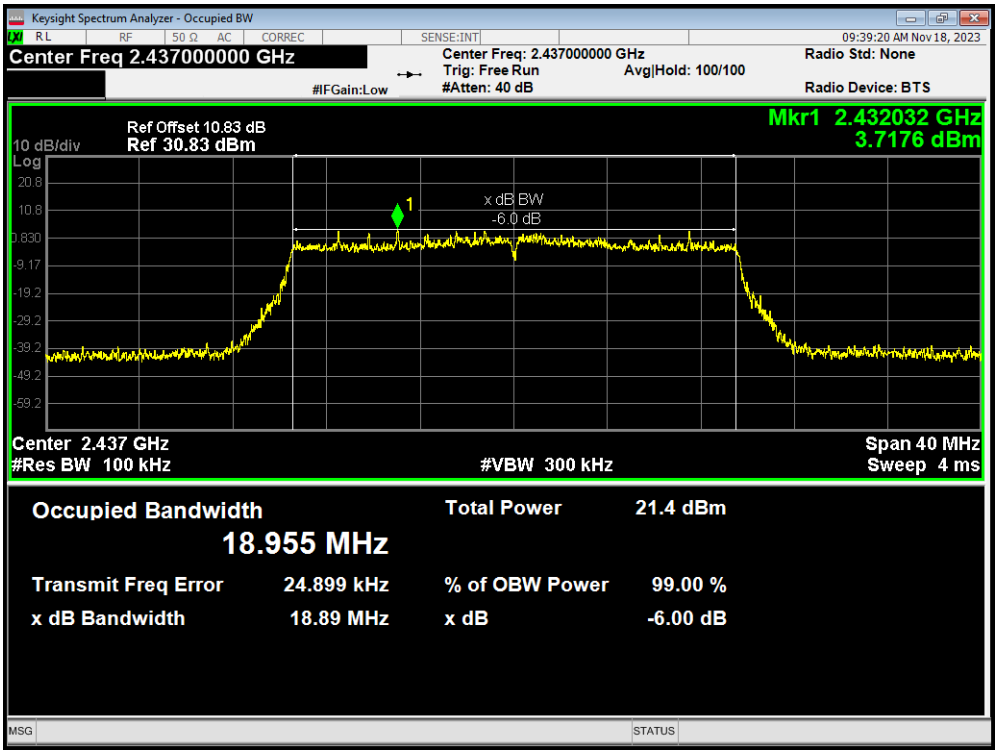


6 dB bandwidth

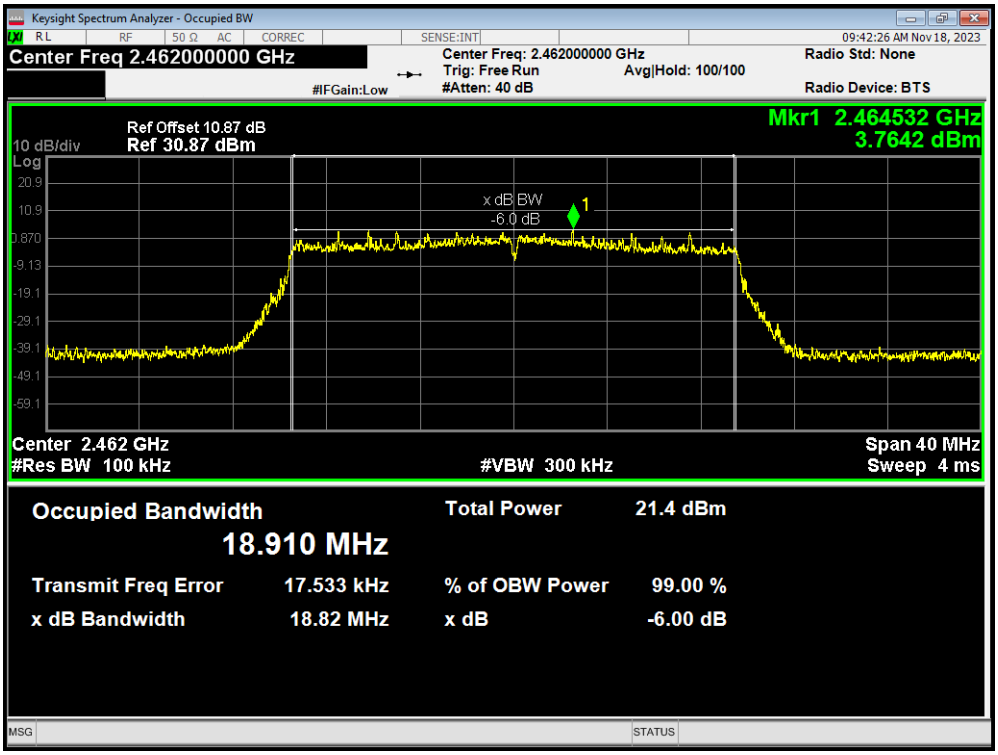
-6dB Bandwidth 802.11ax(HE20) 2412MHz



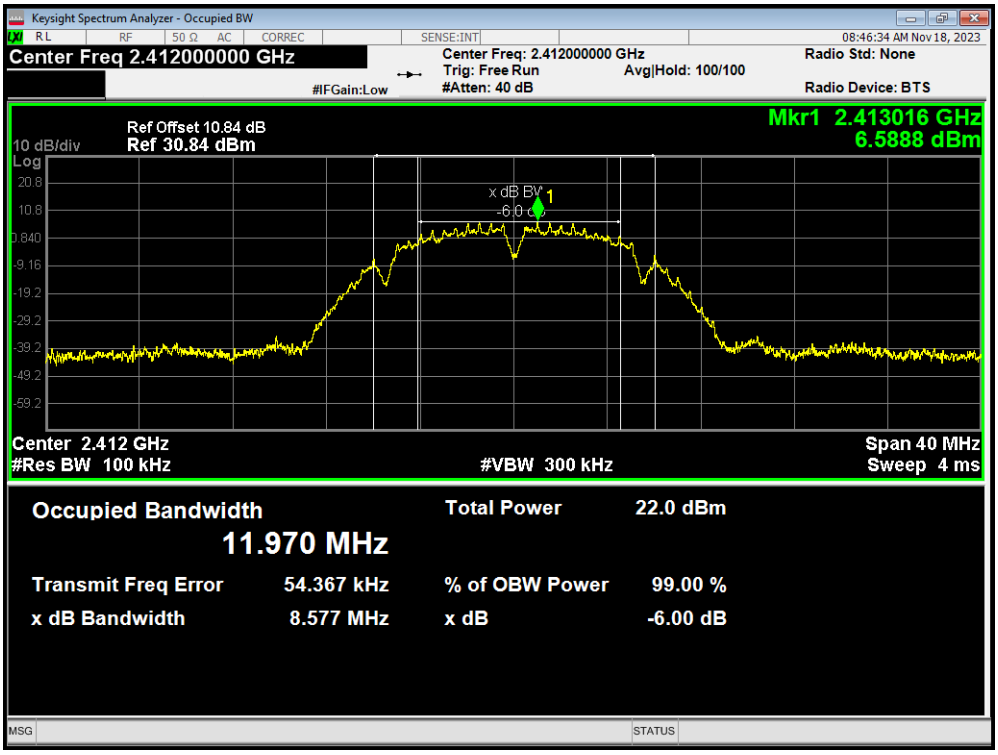
-6dB Bandwidth 802.11ax(HE20) 2437MHz



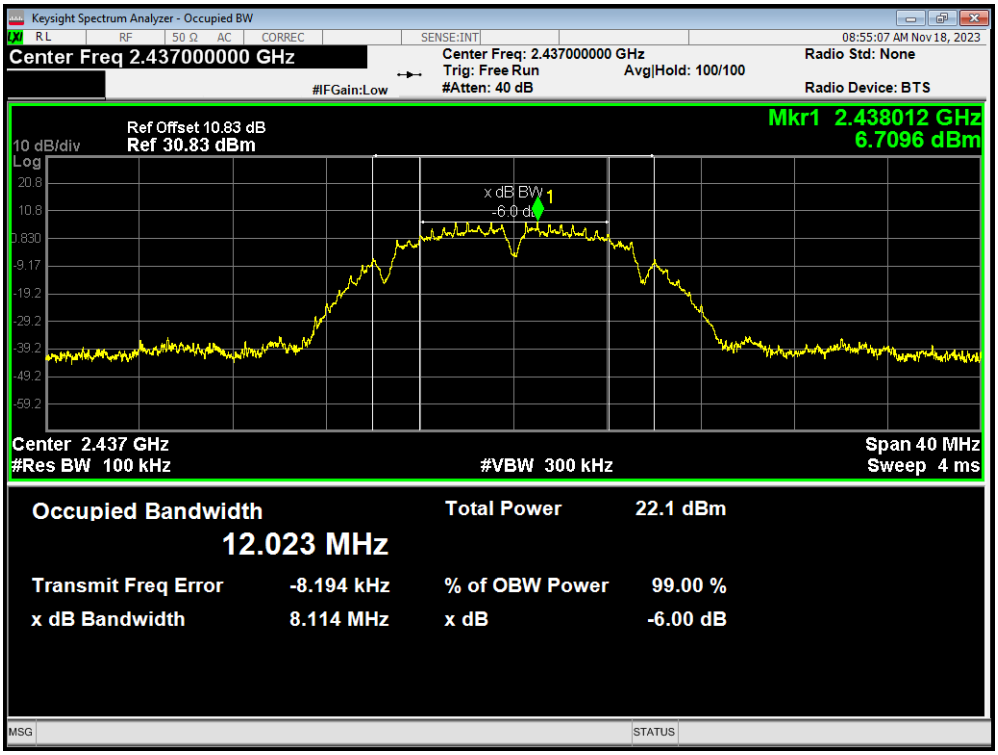
-6dB Bandwidth 802.11ax(HE20) 2462MHz



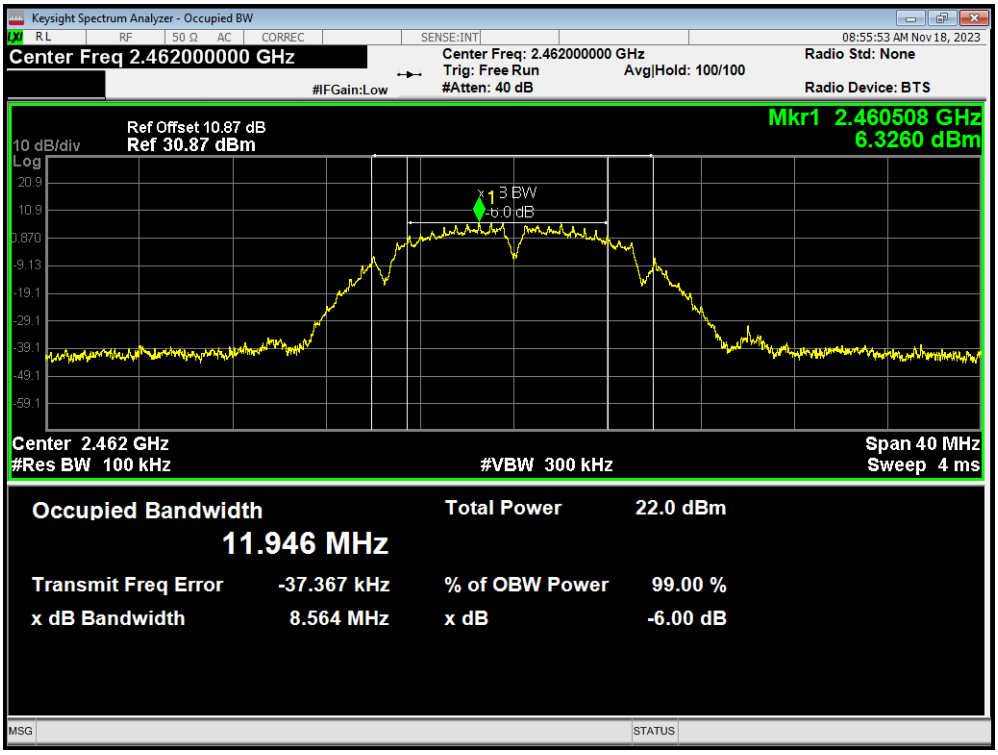
-6dB Bandwidth 802.11b 2412MHz



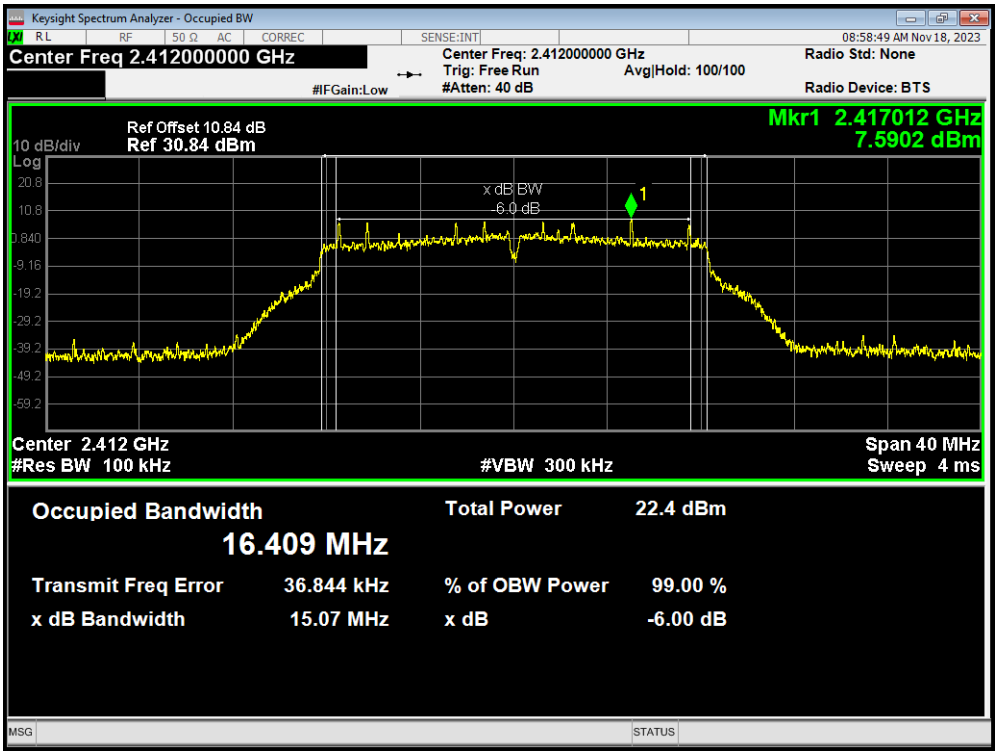
-6dB Bandwidth 802.11b 2437MHz



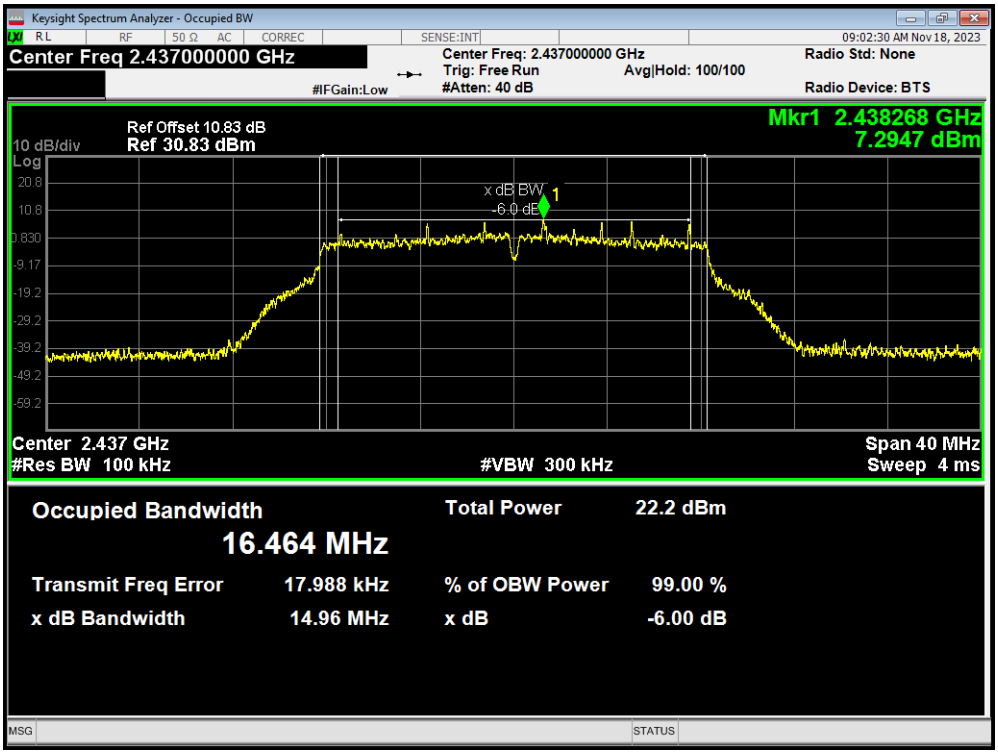
-6dB Bandwidth 802.11b 2462MHz



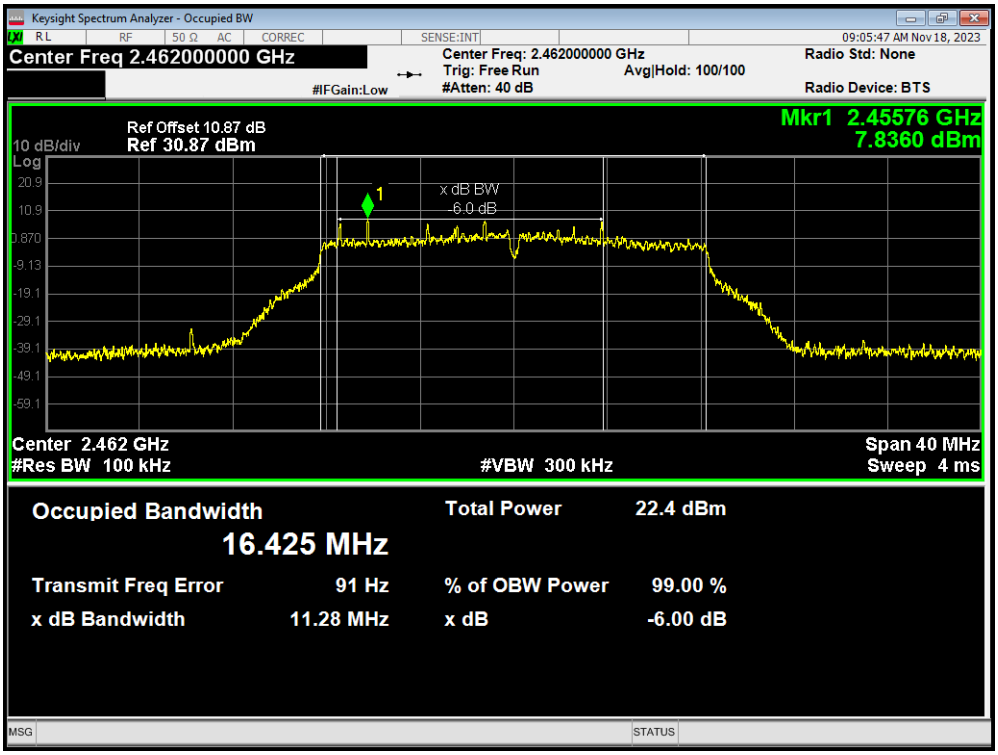
-6dB Bandwidth 802.11g 2412MHz



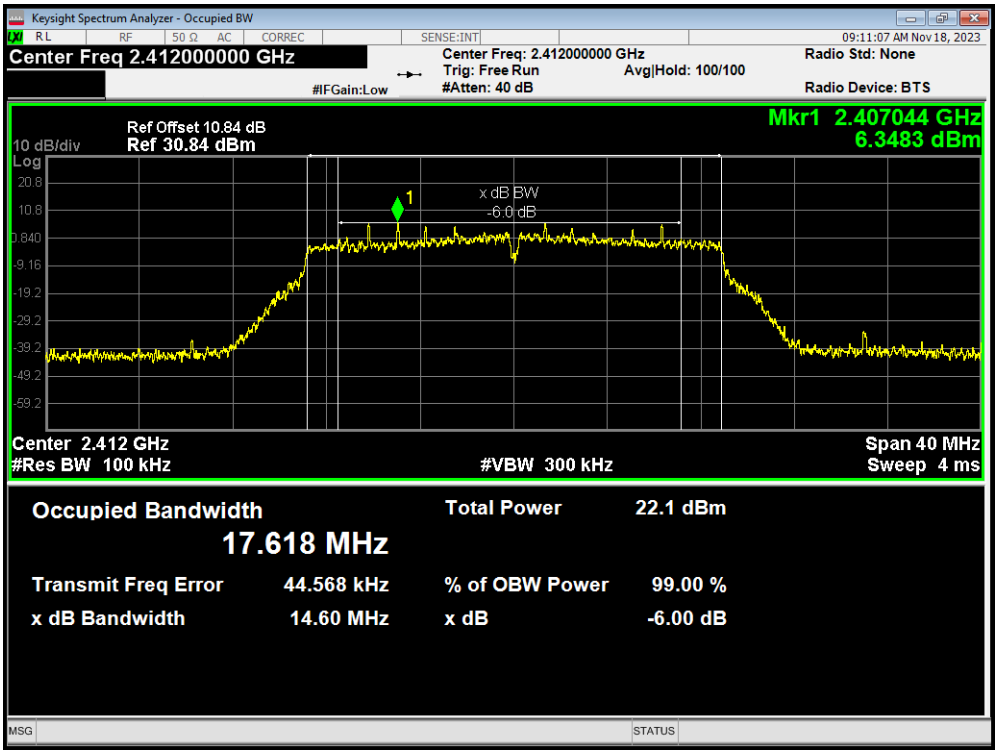
-6dB Bandwidth 802.11g 2437MHz



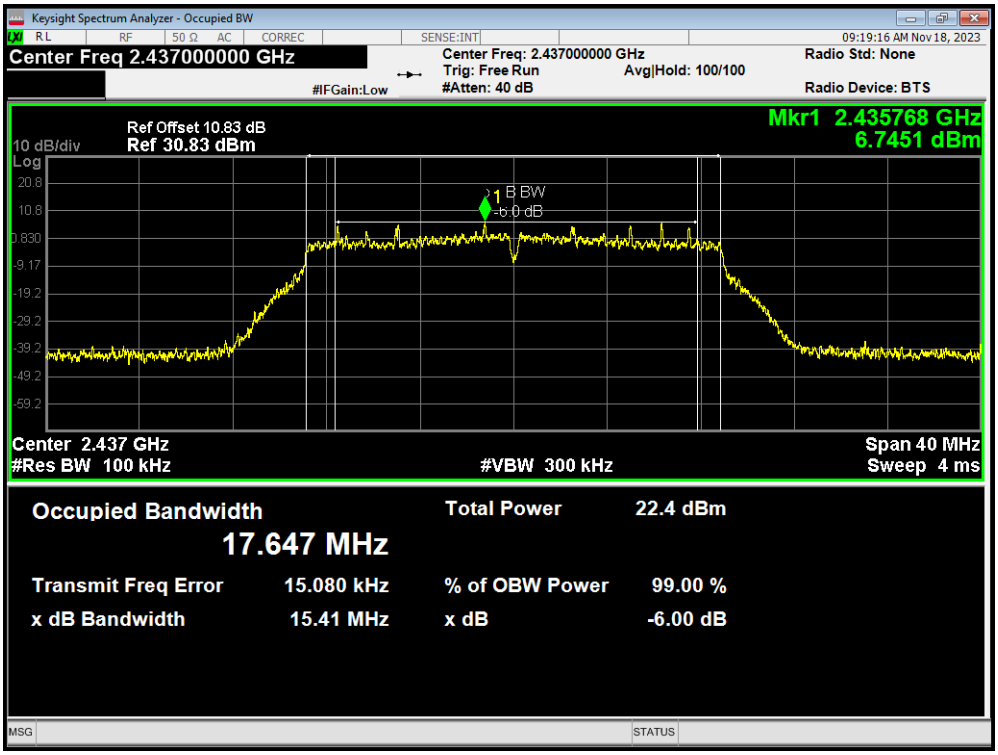
-6dB Bandwidth 802.11g 2462MHz



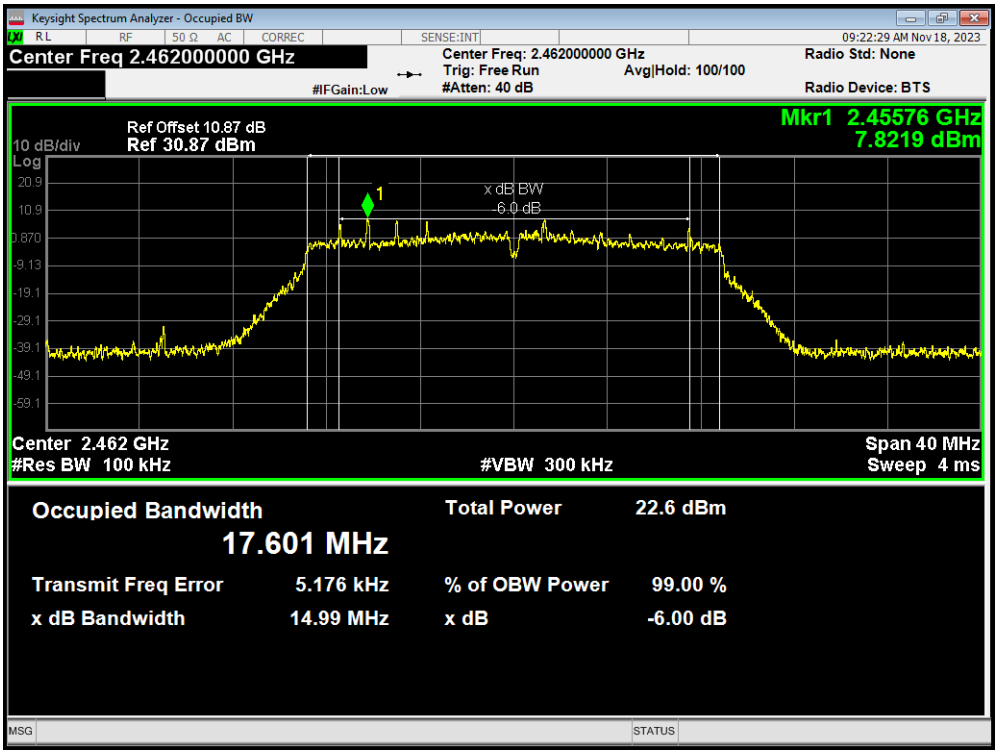
-6dB Bandwidth 802.11n(HT20) 2412MHz



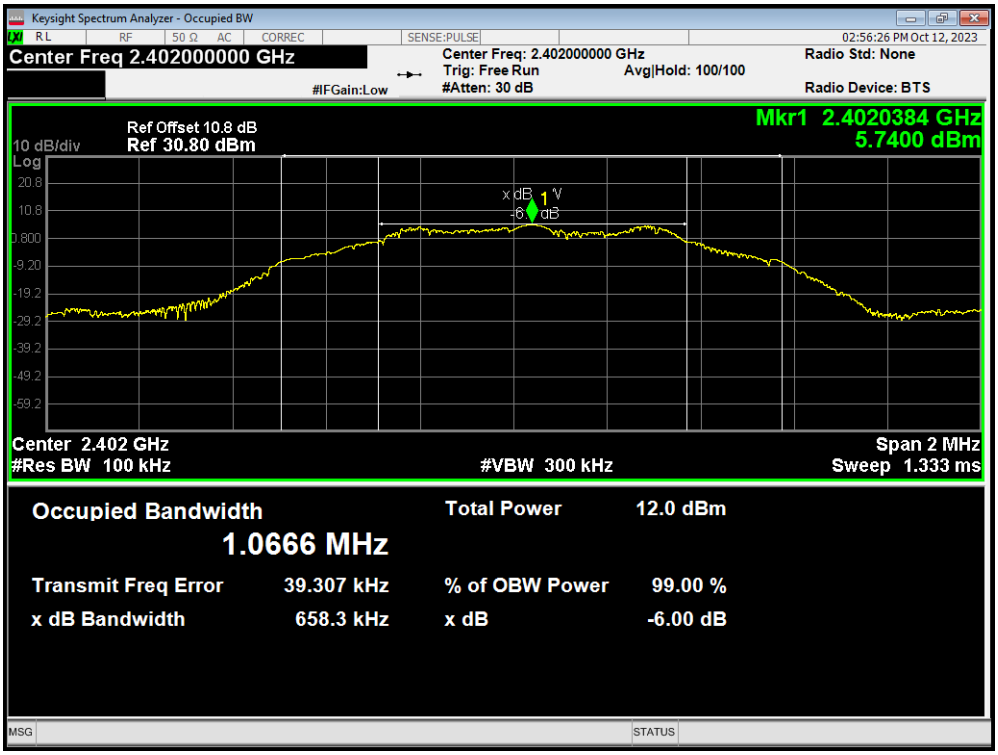
-6dB Bandwidth 802.11n(HT20) 2437MHz



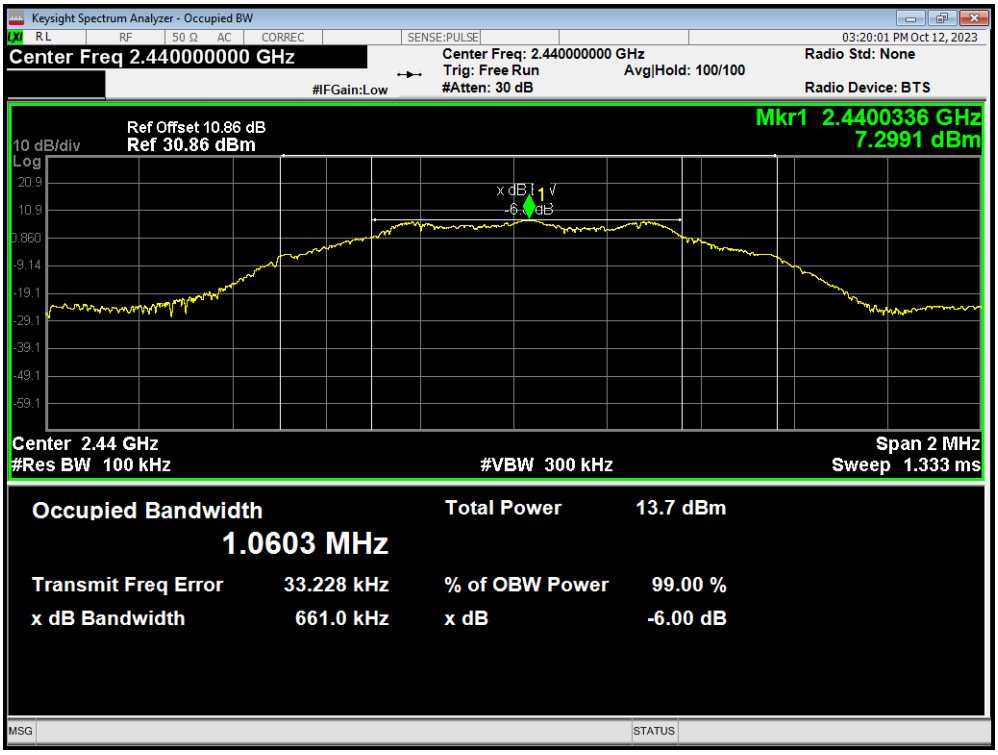
-6dB Bandwidth 802.11n(HT20) 2462MHz



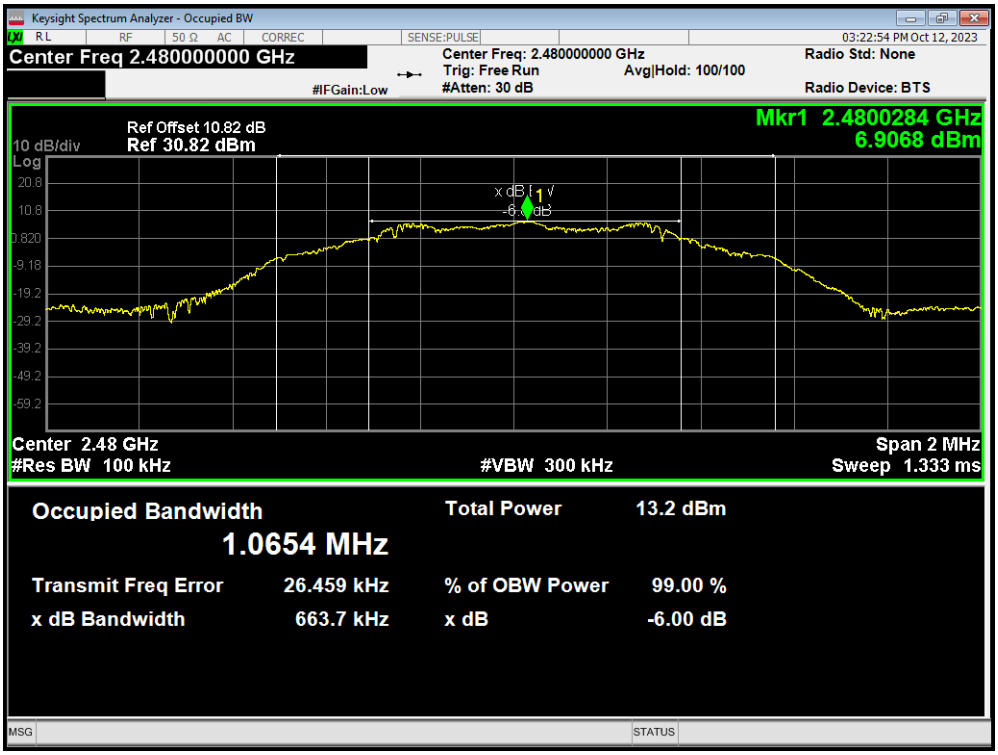
-6dB Bandwidth Bluetooth LE(1M)2402MHz



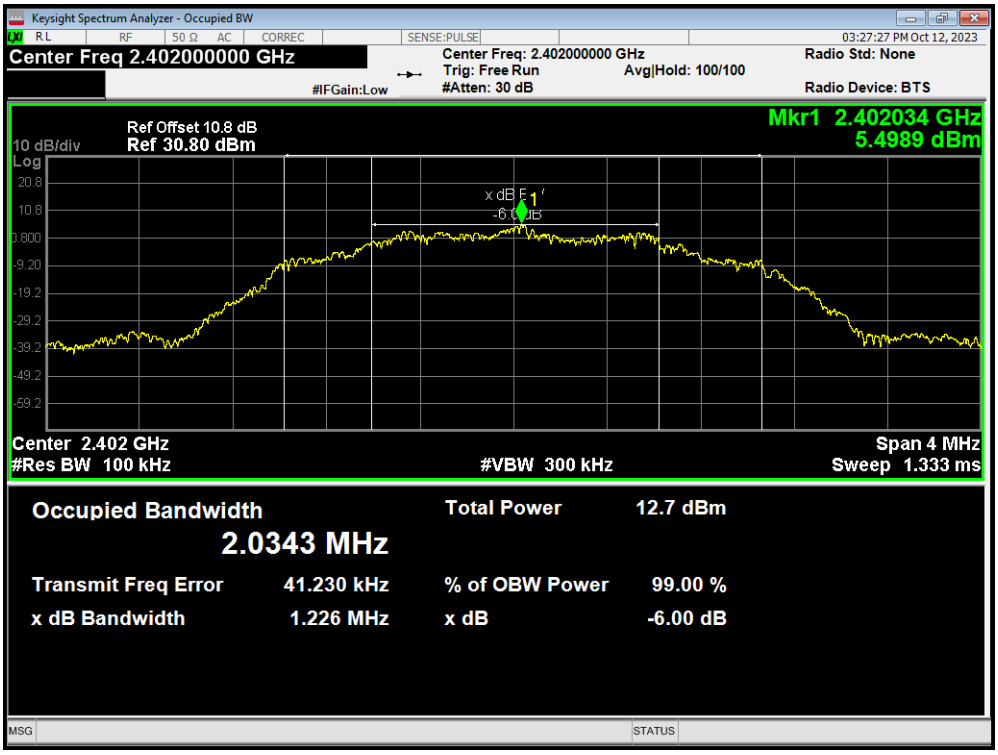
-6dB Bandwidth Bluetooth LE(1M)2440MHz



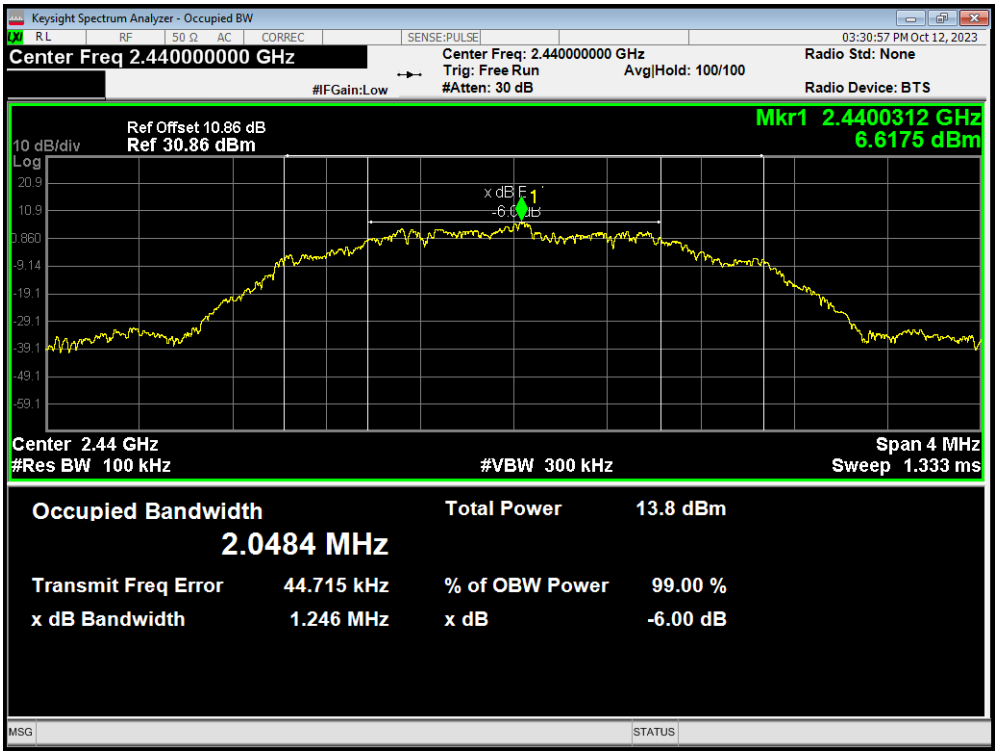
-6dB Bandwidth Bluetooth LE(1M)2480MHz



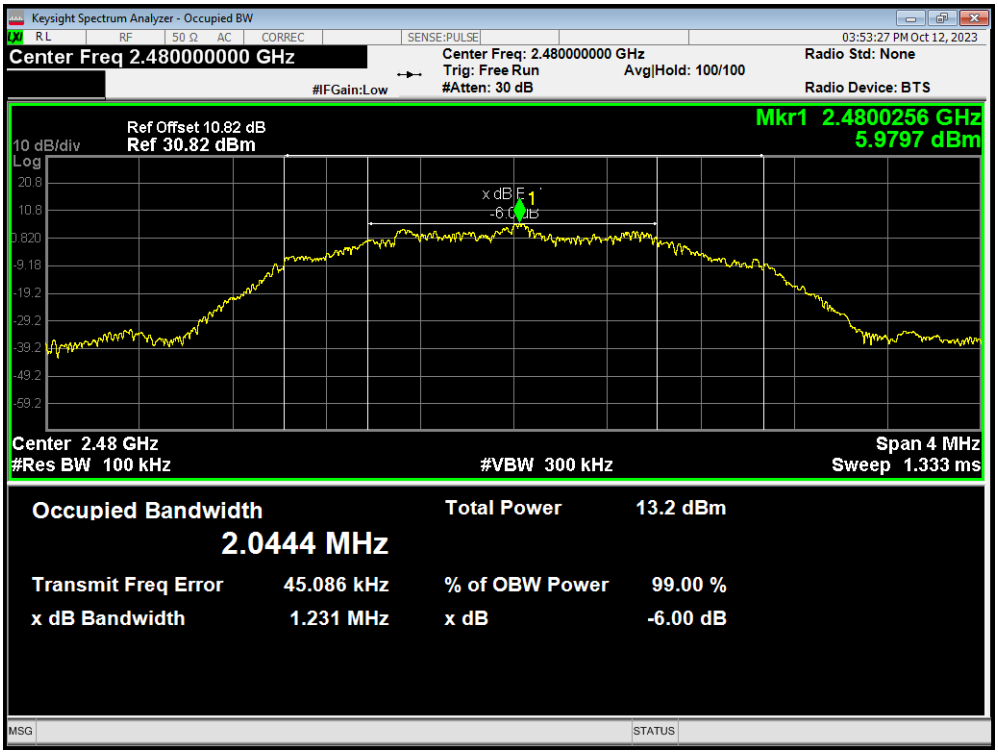
-6dB Bandwidth Bluetooth LE(2M) 2402MHz



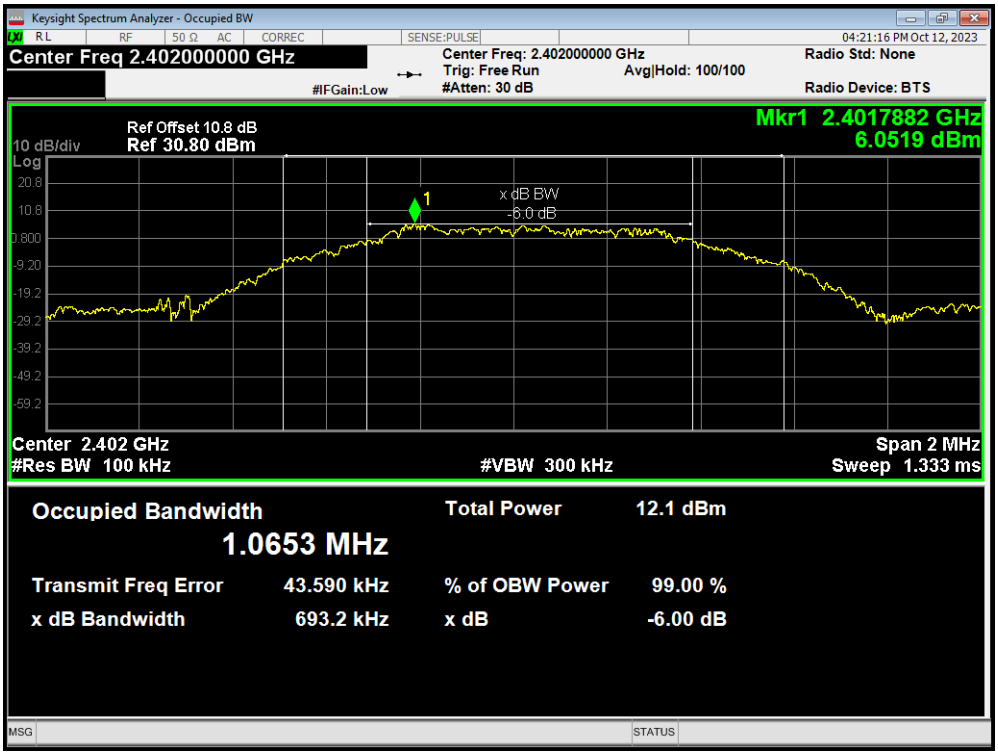
-6dB Bandwidth Bluetooth LE(2M) 2440MHz



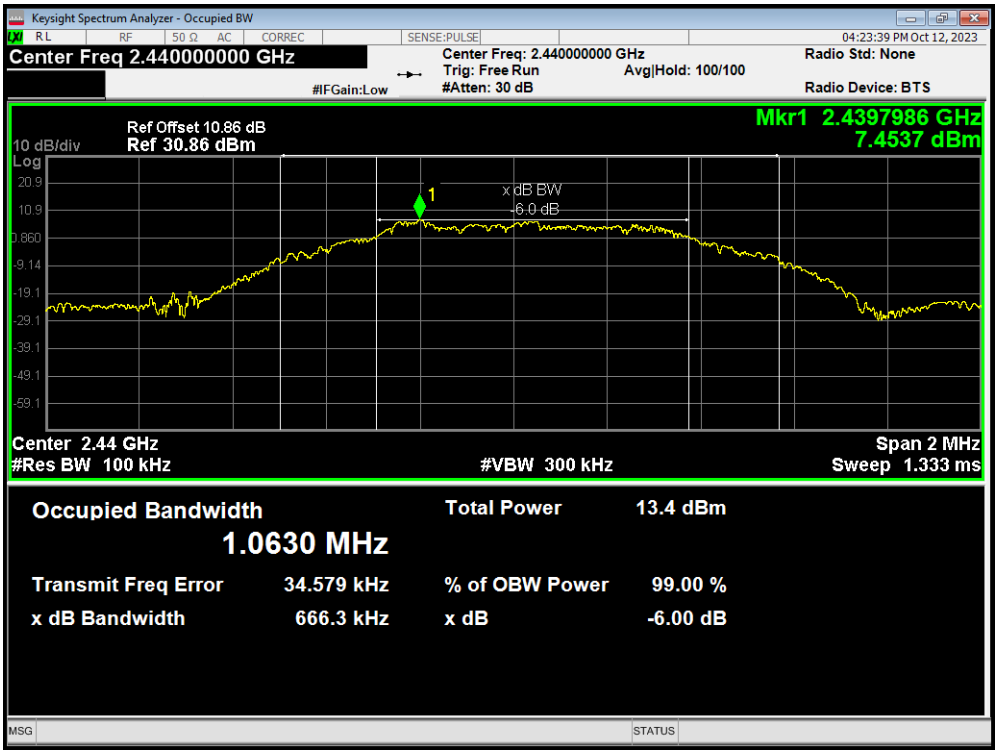
-6dB Bandwidth Bluetooth LE(2M) 2480MHz



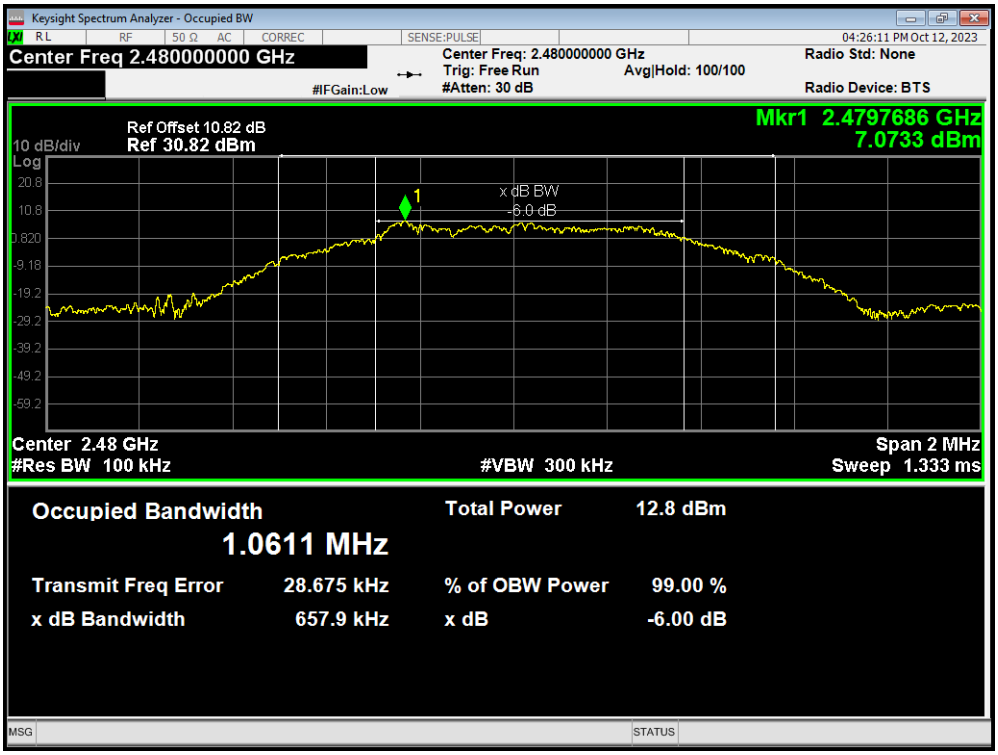
-6dB Bandwidth Bluetooth LE(S=2) 2402MHz



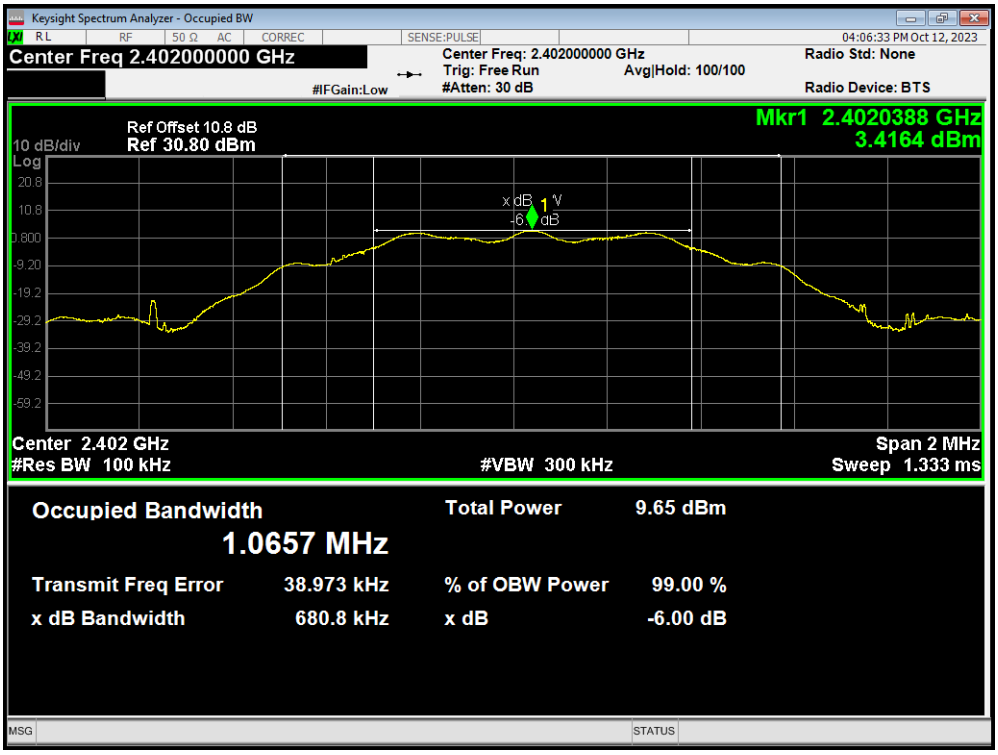
-6dB Bandwidth Bluetooth LE(S=2) 2440MHz



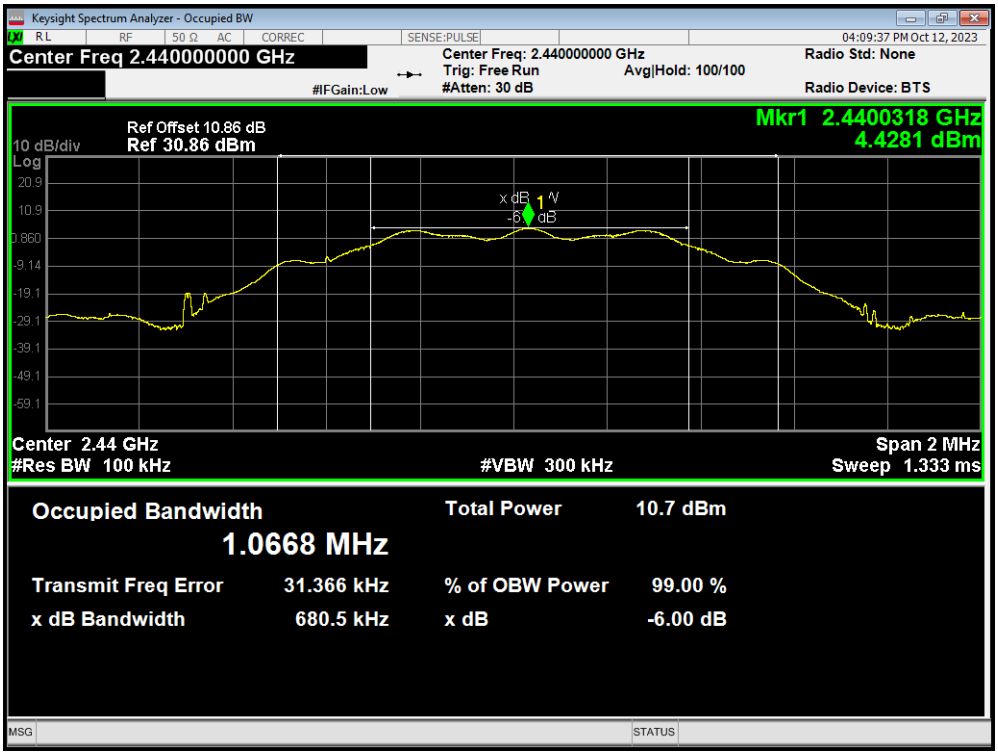
-6dB Bandwidth Bluetooth LE(S=2) 2480MHz



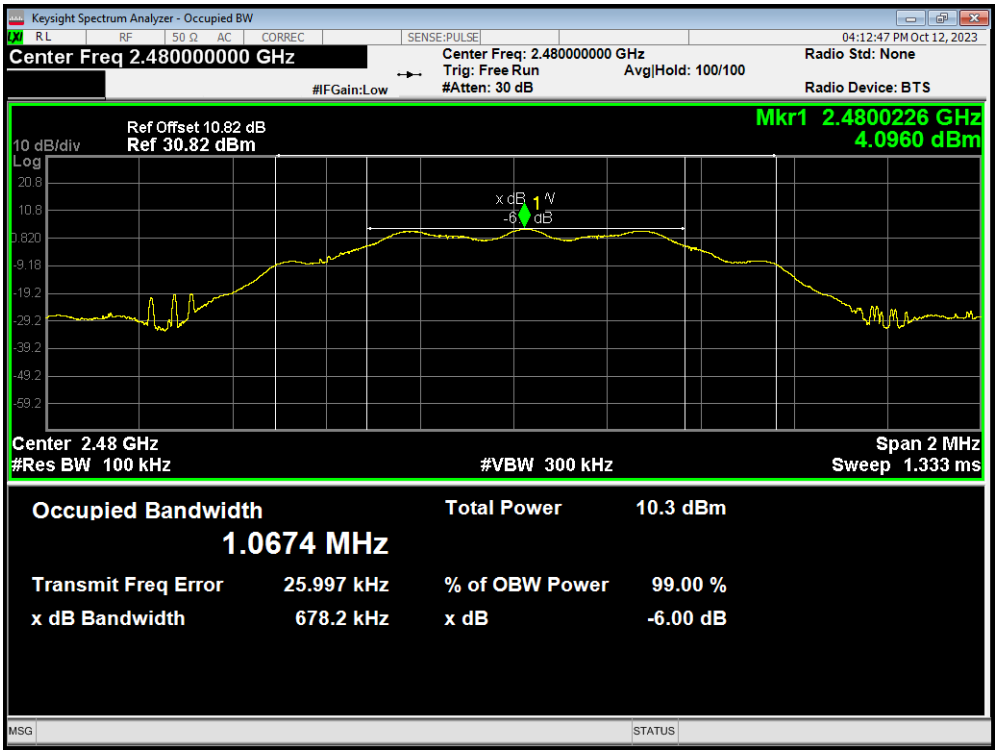
-6dB Bandwidth Bluetooth LE(S=8) 2402MHz



-6dB Bandwidth Bluetooth LE(S=8) 2440MHz



-6dB Bandwidth Bluetooth LE(S=8) 2480MHz



5.3. Band Edge

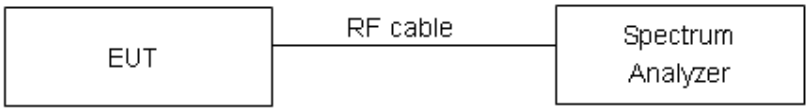
Ambient Condition

Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable the band edge of the lowest and highest channels were measured. The peak detector is used and RBW is set to 100 kHz and VBW is set to 300 kHz on spectrum analyzer. Spectrum analyzer plots are included on the following pages.

Test Setup



Limits

Rule Part 15.247(d) specifies that “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.”

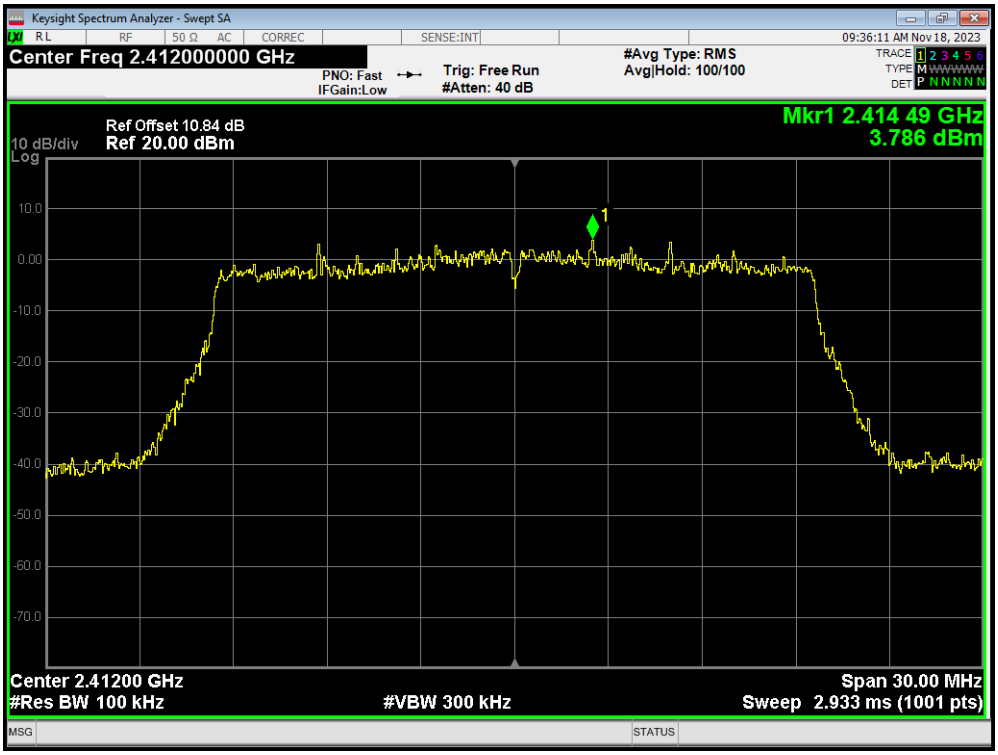
Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 1.96.

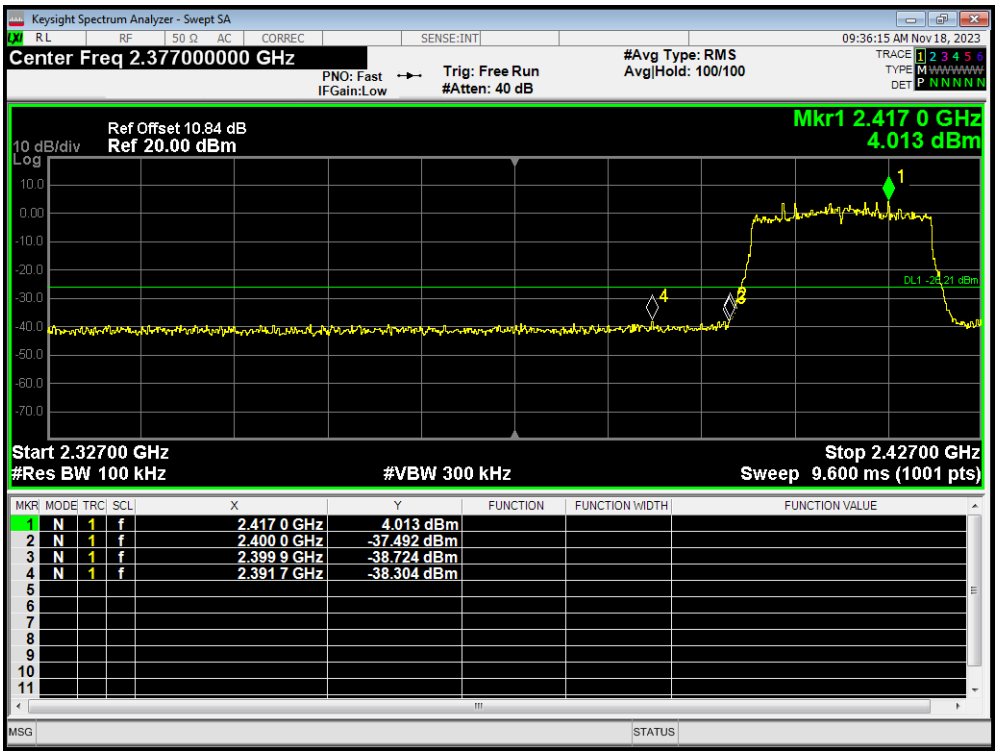
Frequency	Uncertainty
2GHz-3GHz	1.407 dB

Test Results: PASS

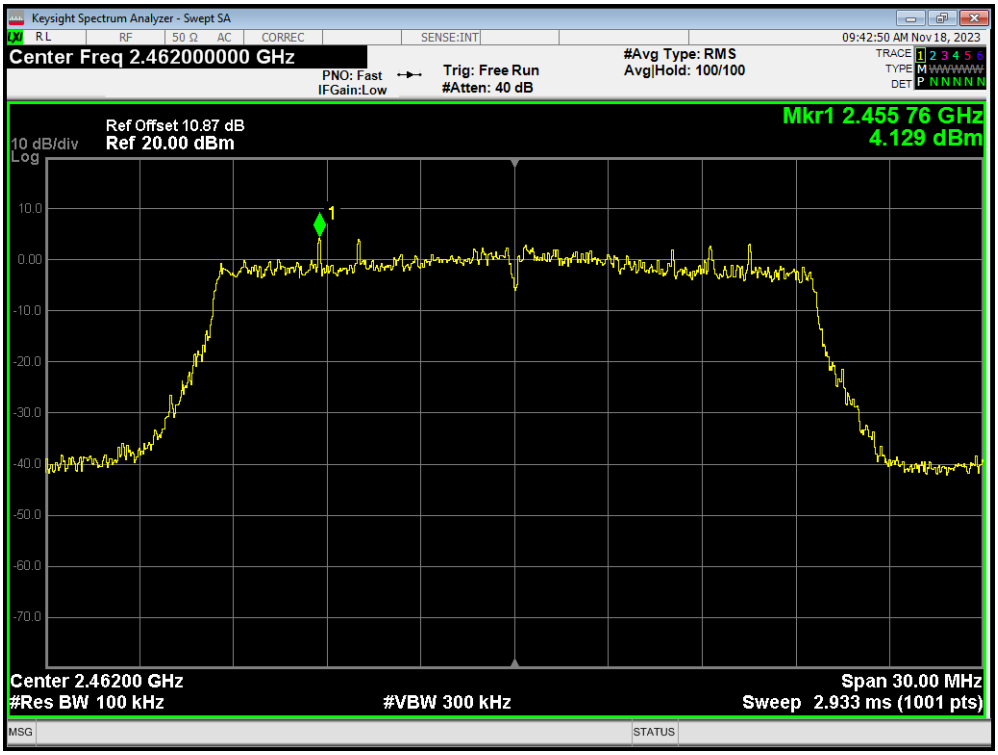
Band Edge 802.11ax(HE20) 2412MHz Ref



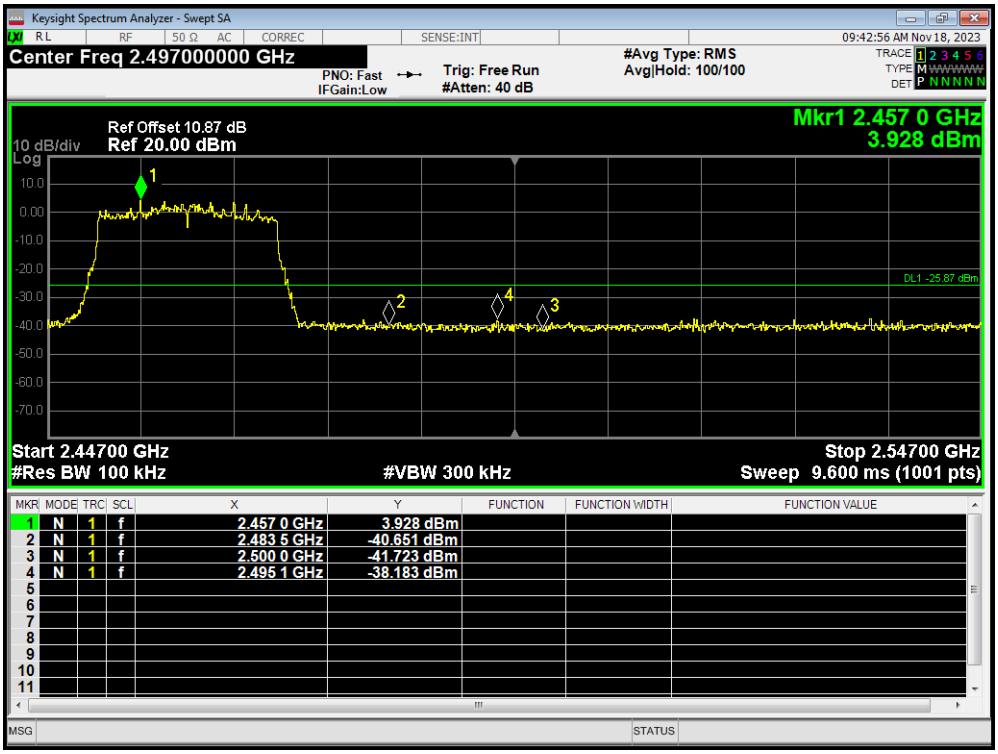
Band Edge 802.11ax(HE20) 2412MHz Emission



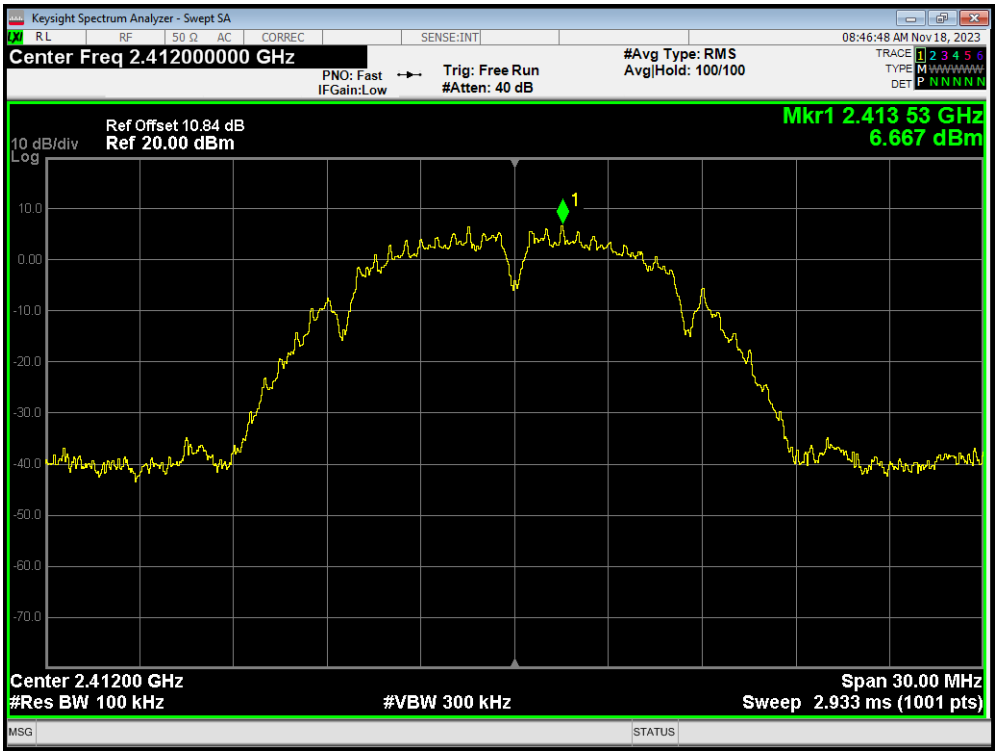
Band Edge 802.11ax(HE20) 2462MHz Ref



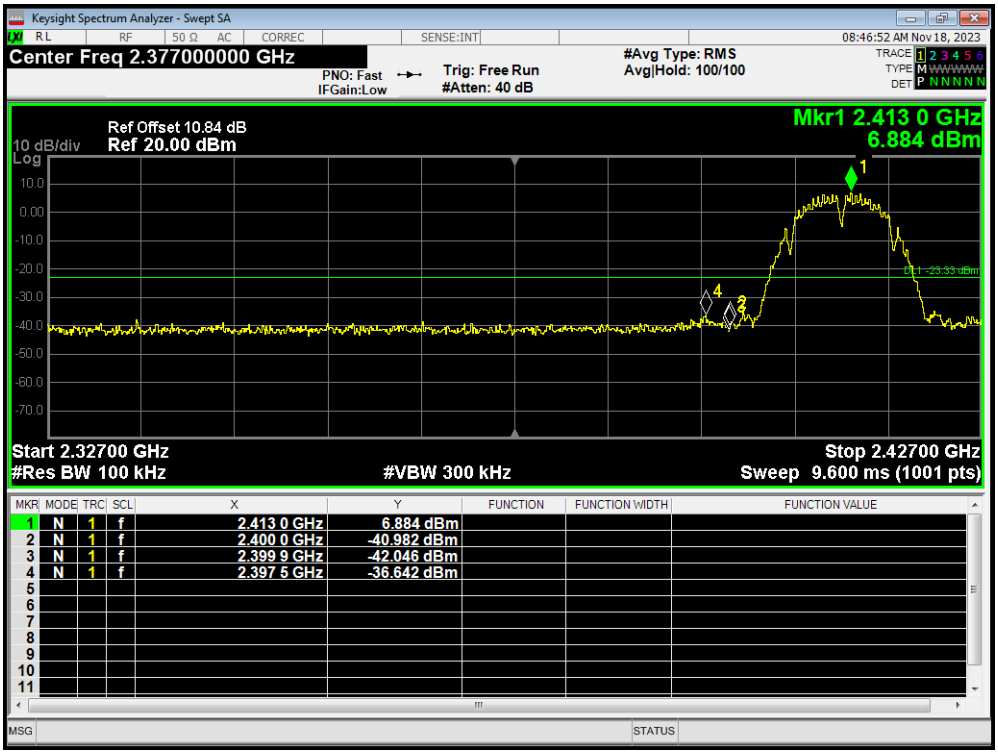
Band Edge 802.11ax(HE20) 2462MHz Emission



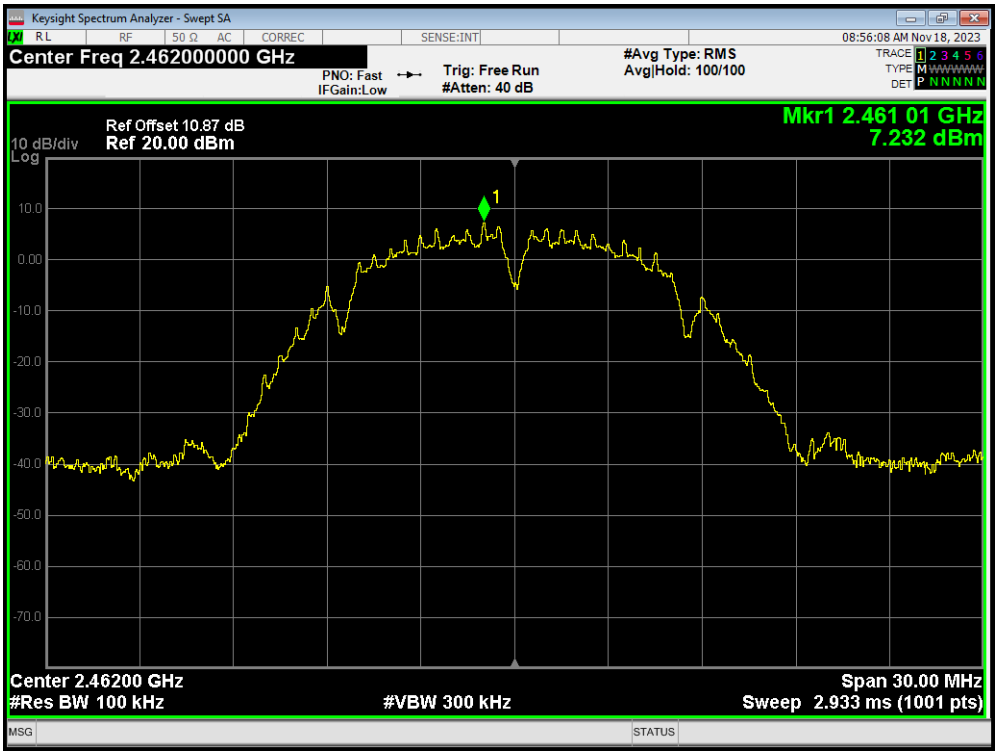
Band Edge 802.11b 2412MHz Ref



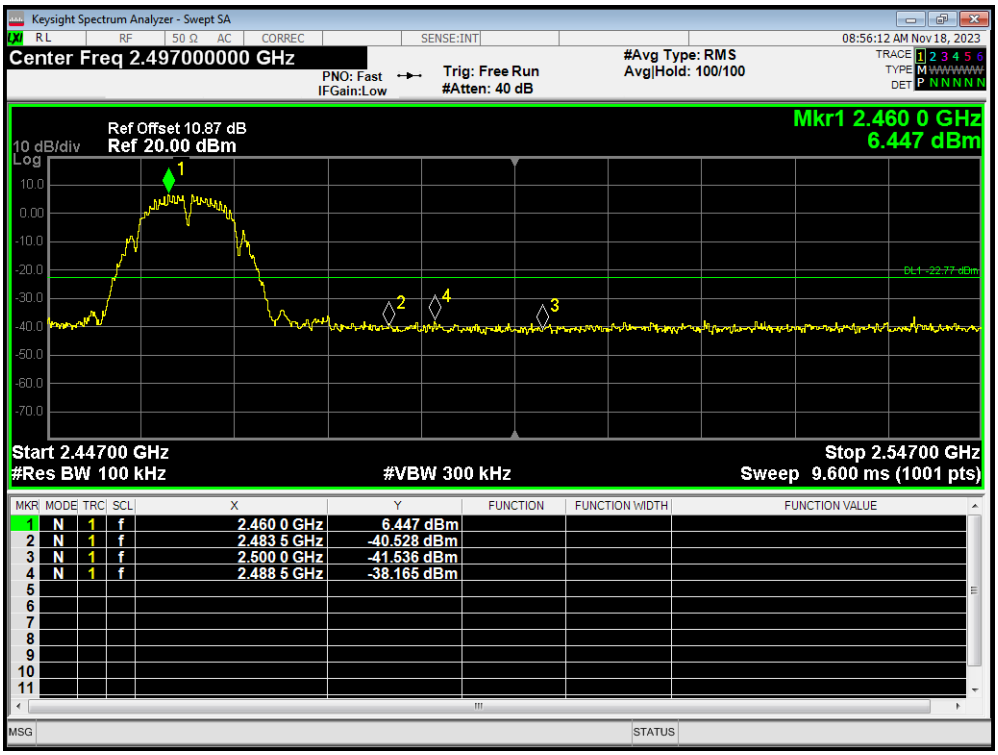
Band Edge 802.11b 2412MHz Emission



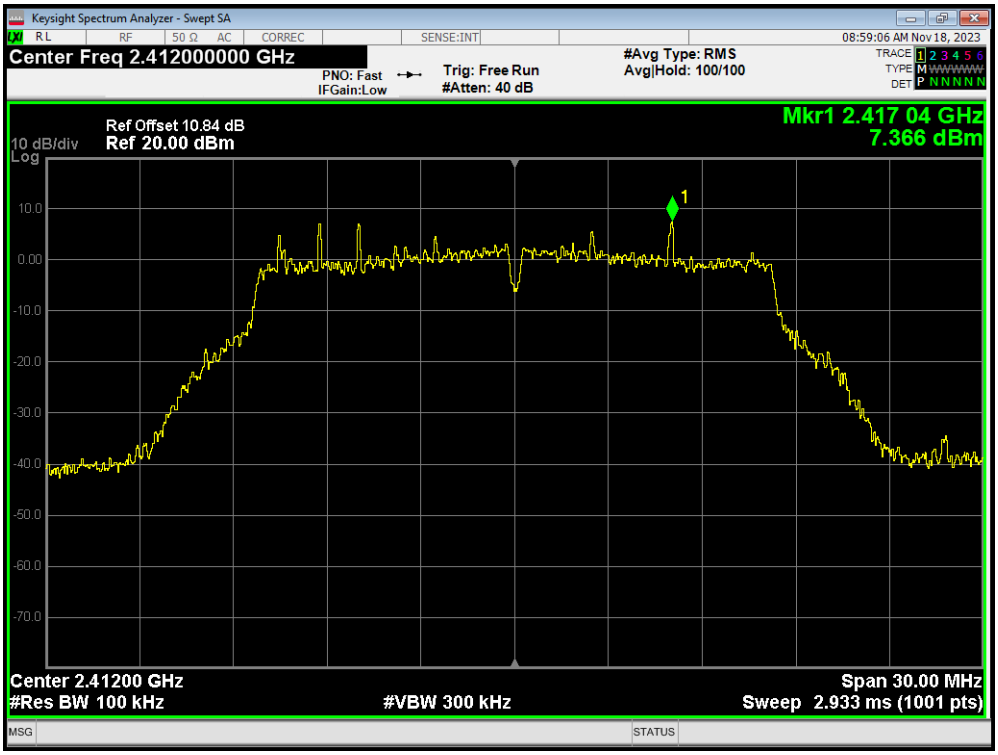
Band Edge 802.11b 2462MHz Ref



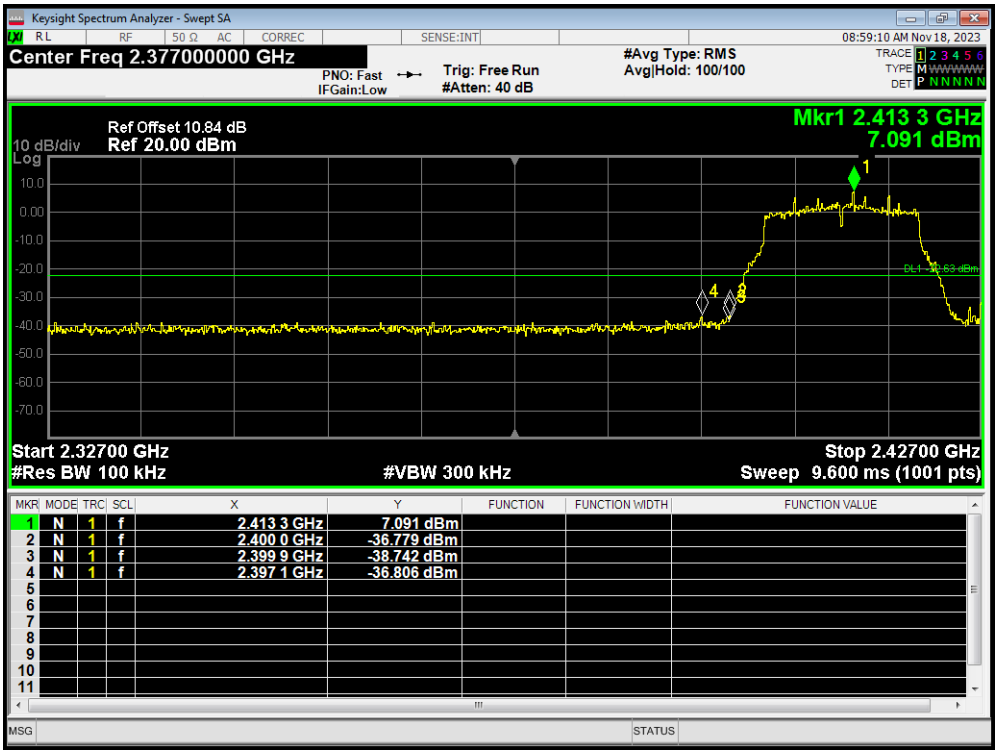
Band Edge 802.11b 2462MHz Emission



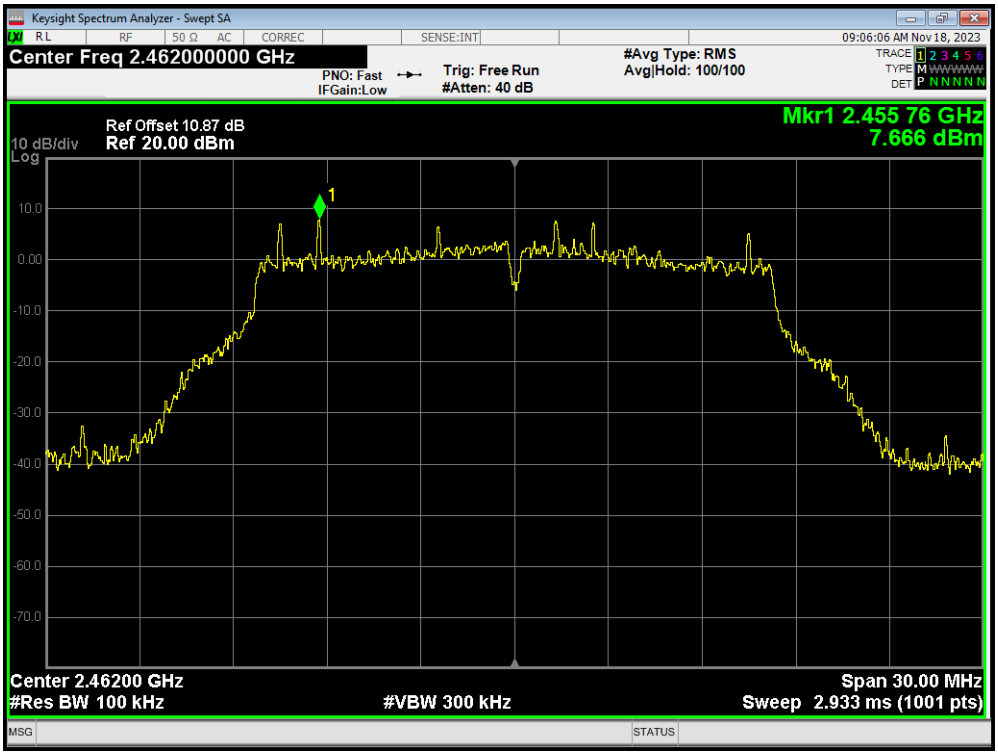
Band Edge 802.11g 2412MHz Ref



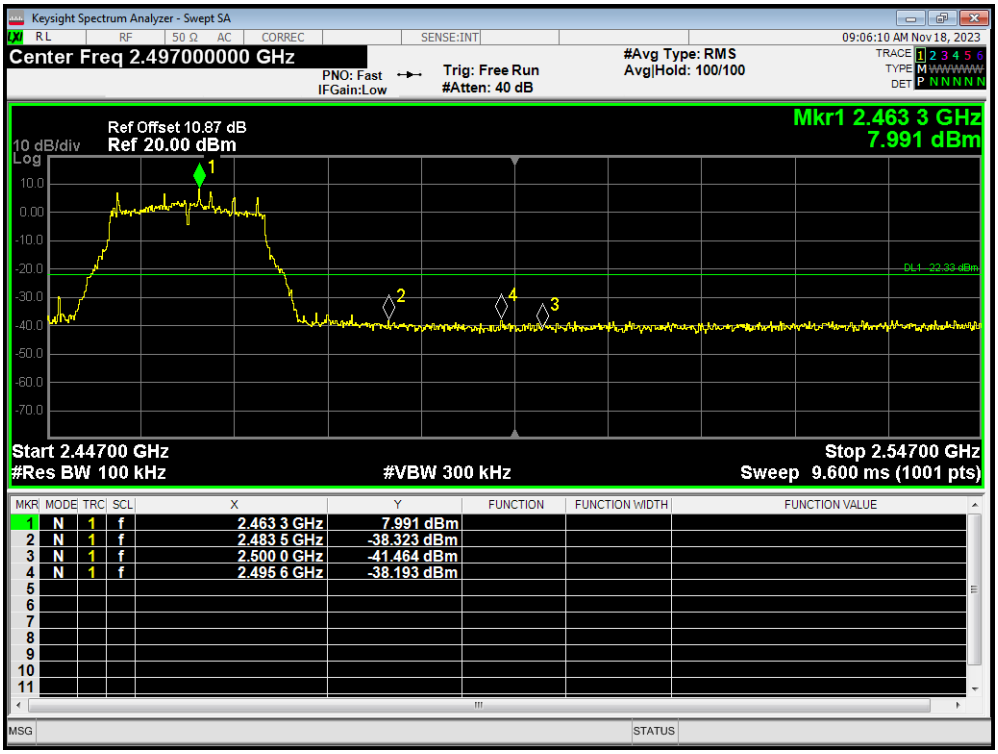
Band Edge 802.11g 2412MHz Emission



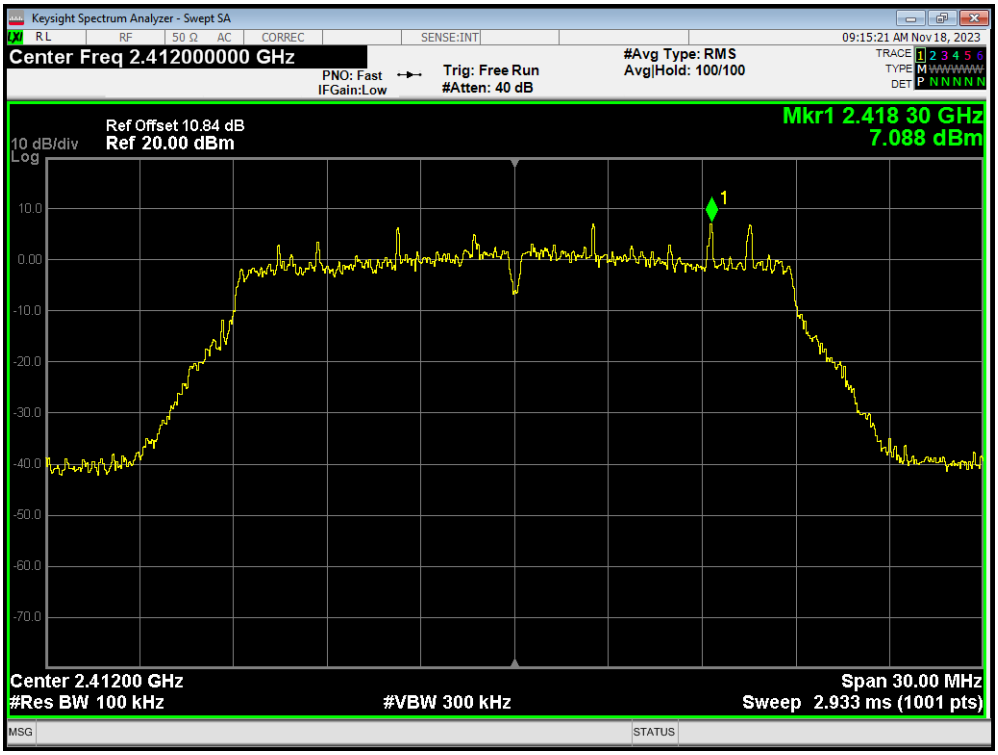
Band Edge 802.11g 2462MHz Ref



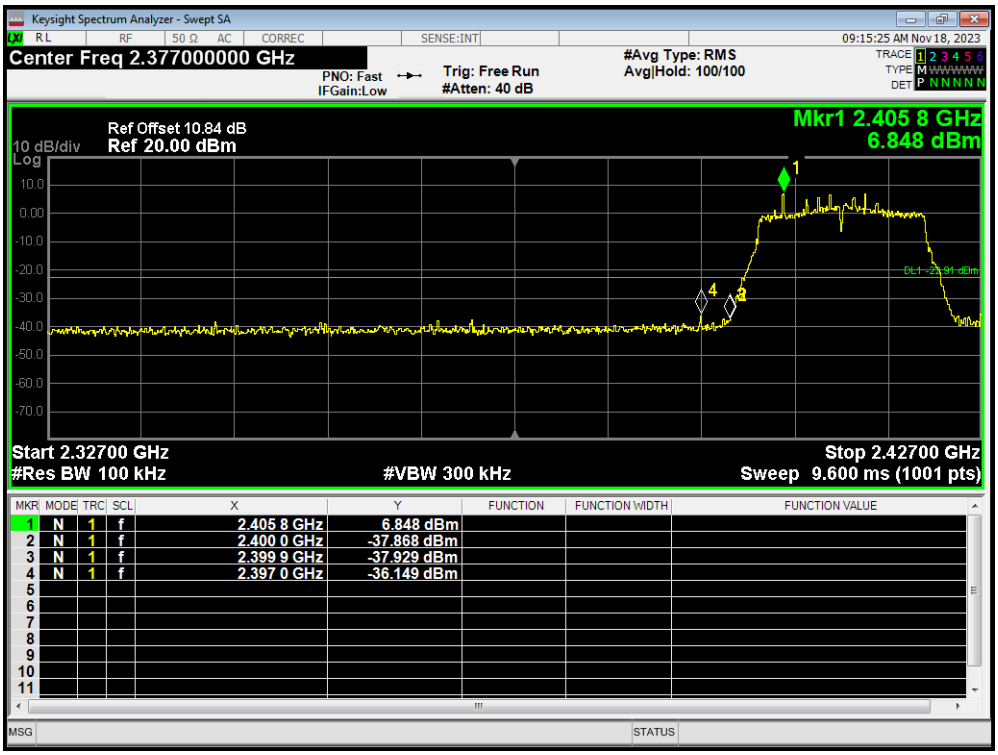
Band Edge 802.11g 2462MHz Emission



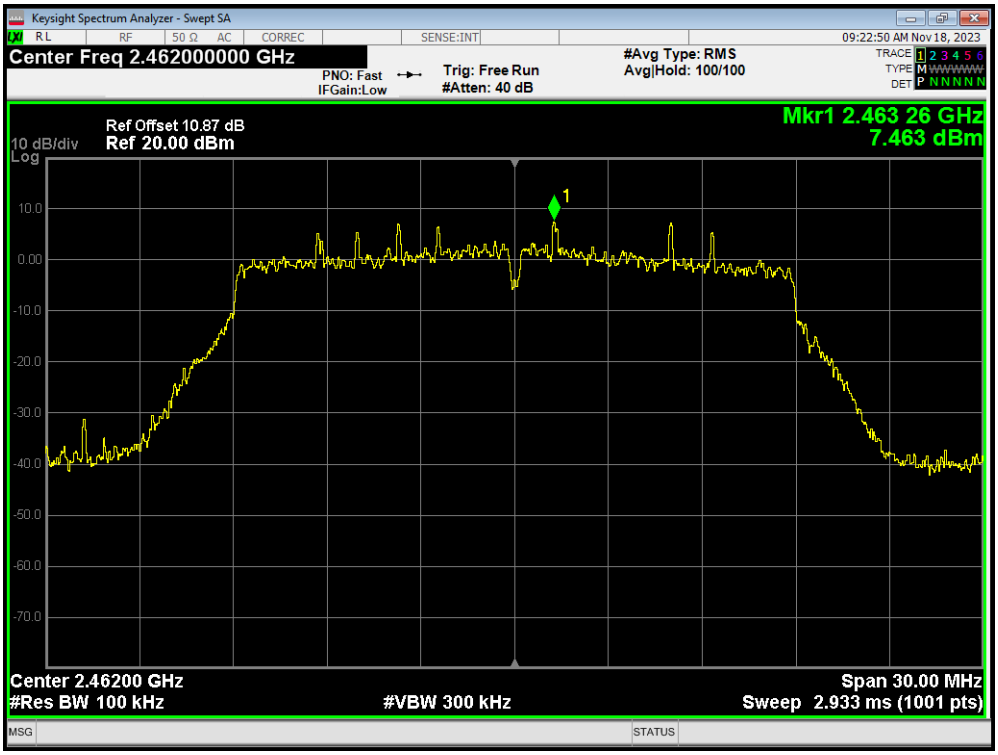
Band Edge 802.11n(HT20) 2412MHz Ref



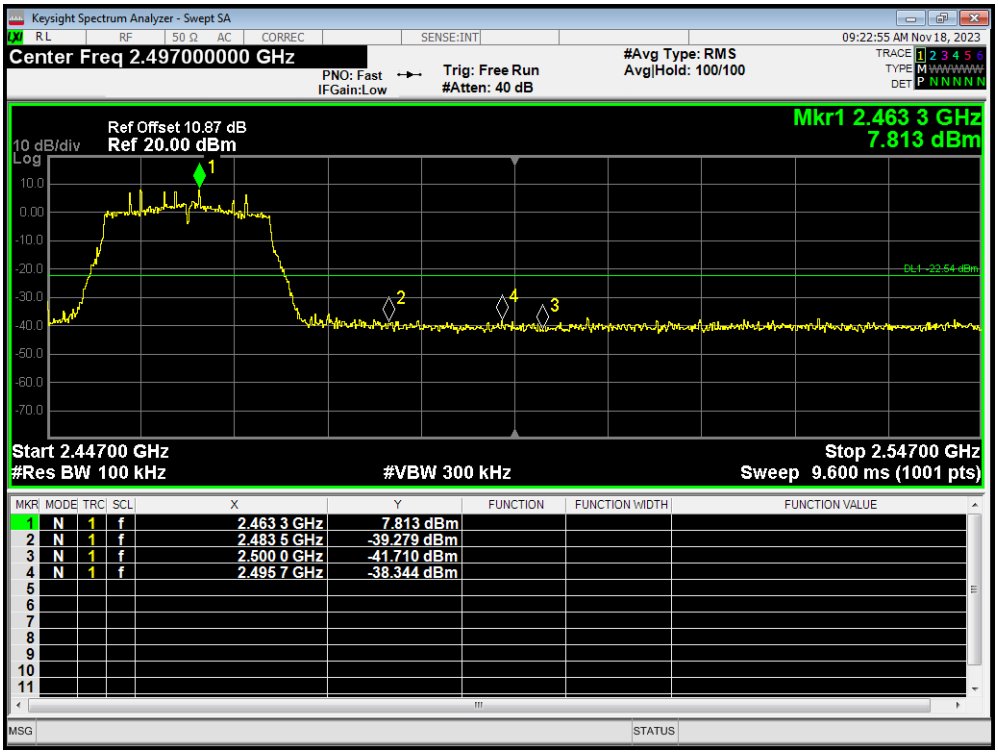
Band Edge 802.11n(HT20) 2412MHz Emission



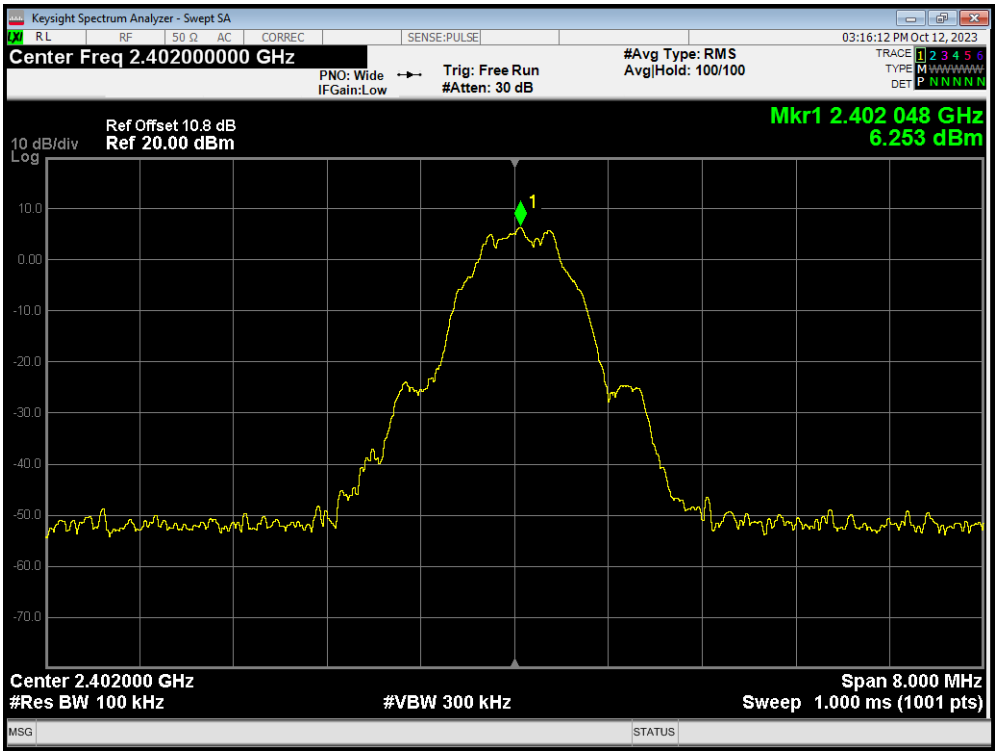
Band Edge 802.11n(HT20) 2462MHz Ref



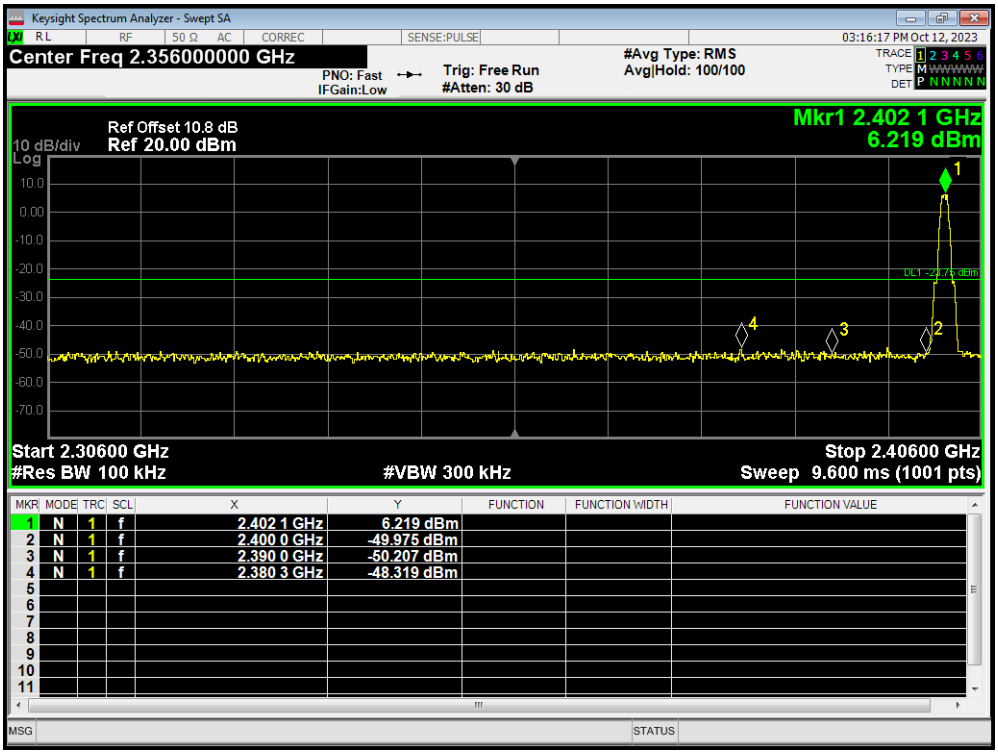
Band Edge 802.11n(HT20) 2462MHz Emission



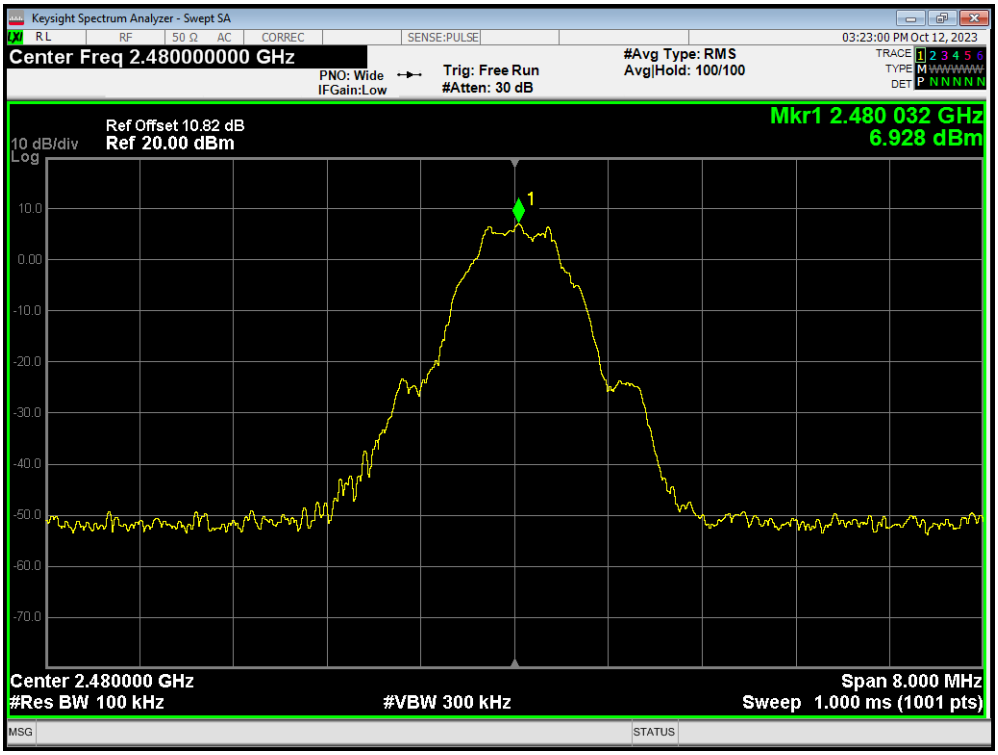
Band Edge Bluetooth LE(1M)2402MHz Ref



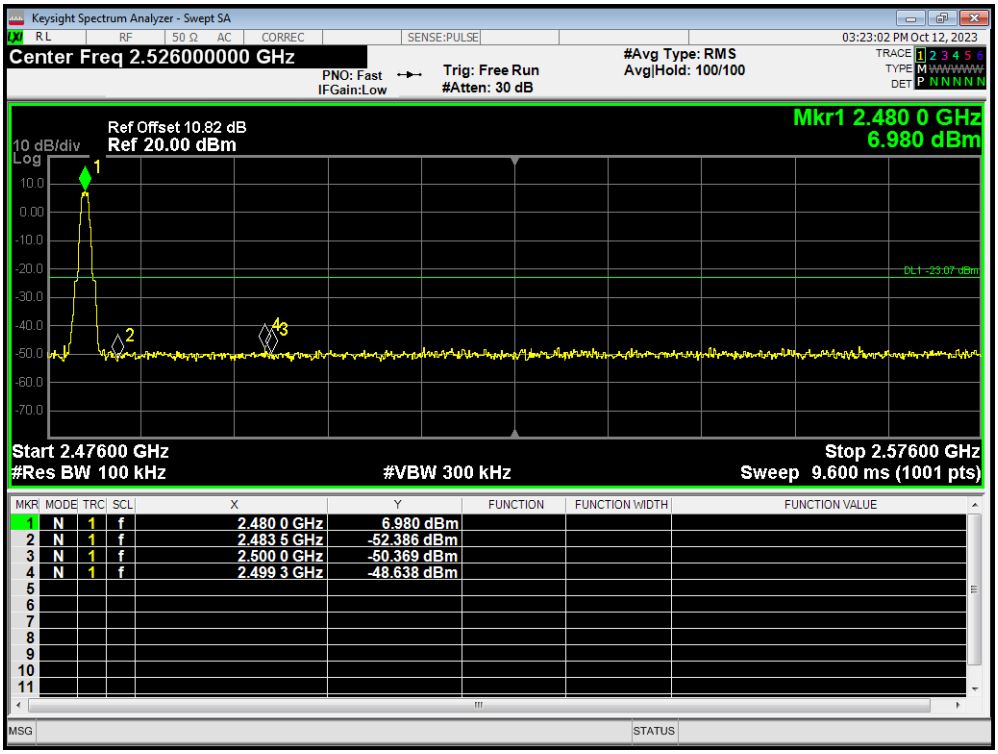
Band Edge Bluetooth LE(1M)2402MHz Emission



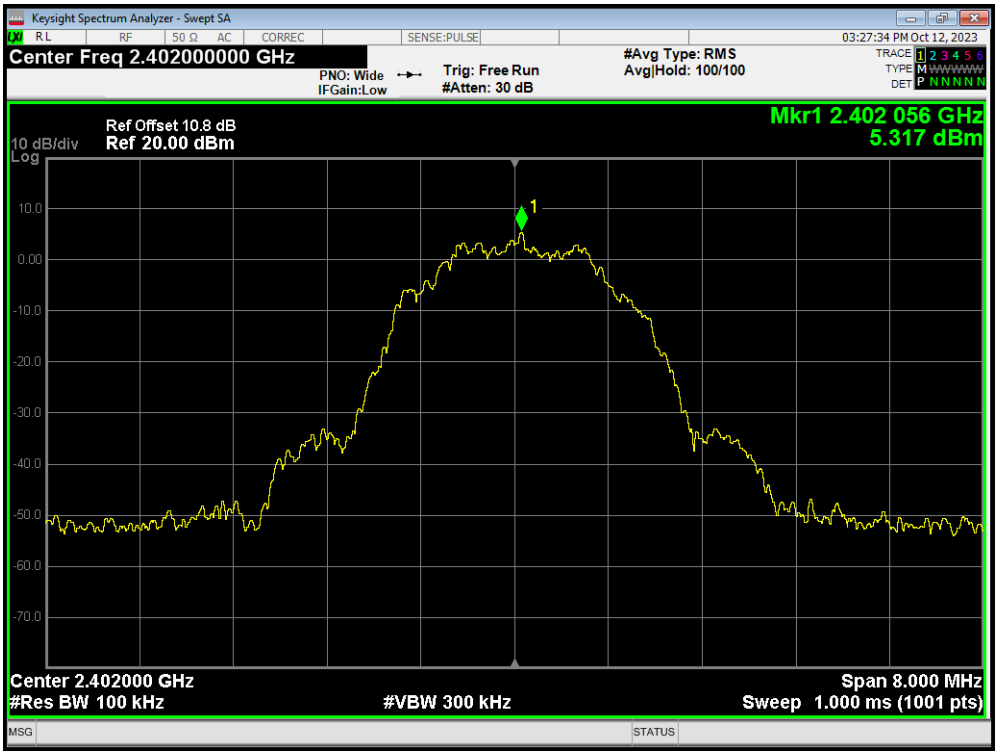
Band Edge Bluetooth LE(1M)2480MHz Ref



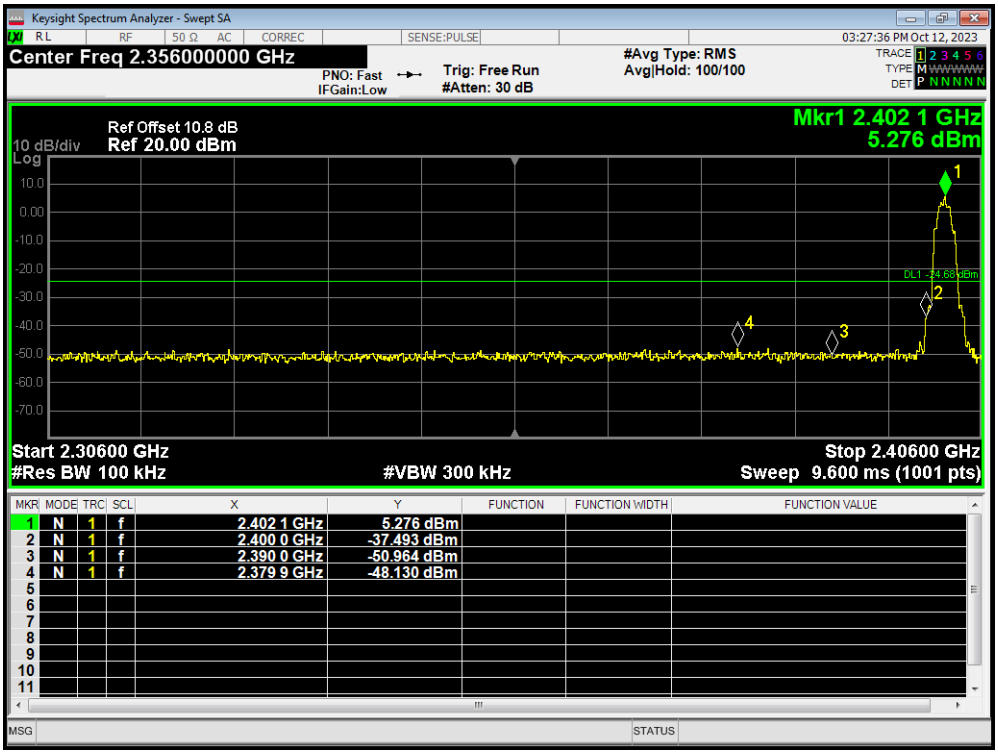
Band Edge Bluetooth LE(1M)2480MHz Emission



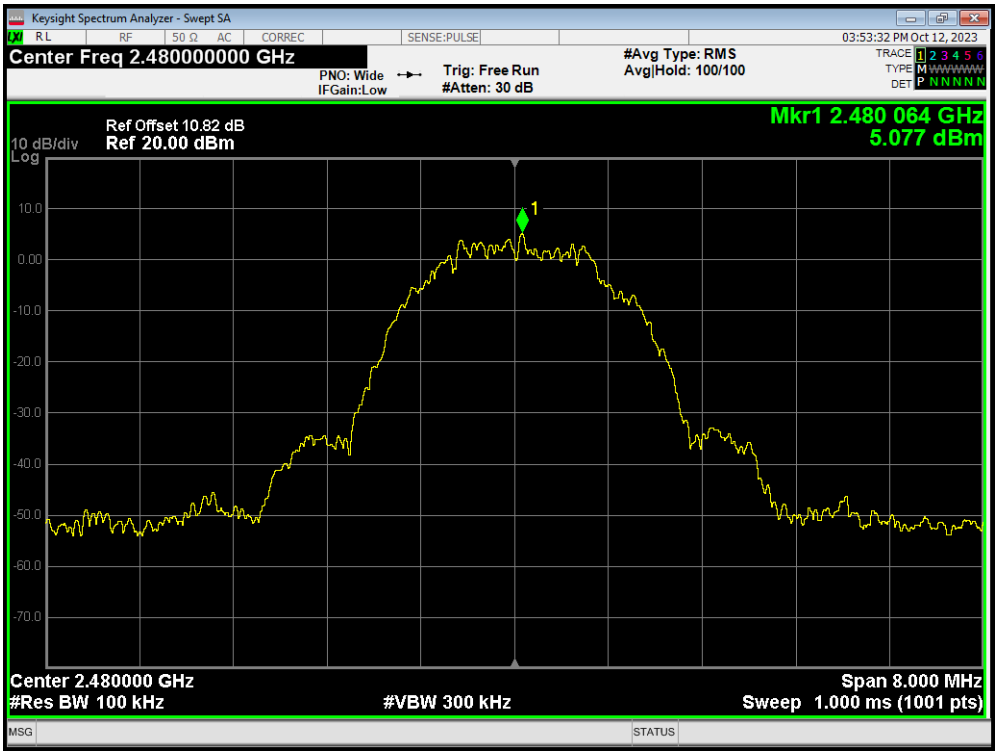
Band Edge Bluetooth LE(2M) 2402MHz Ref



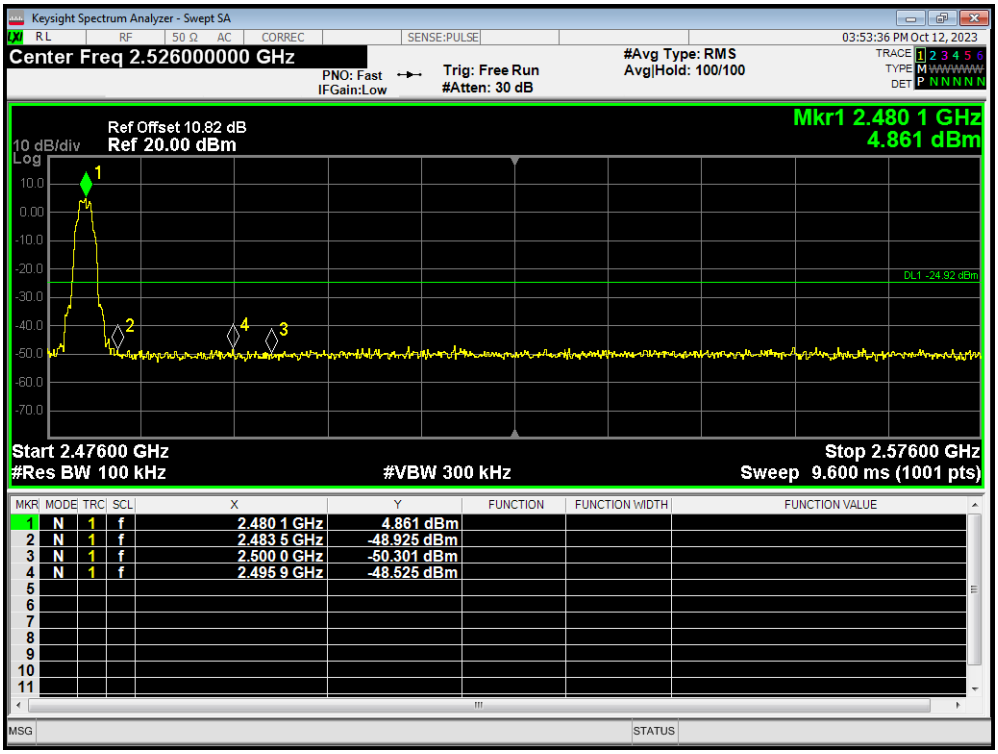
Band Edge Bluetooth LE(2M) 2402MHz Emission



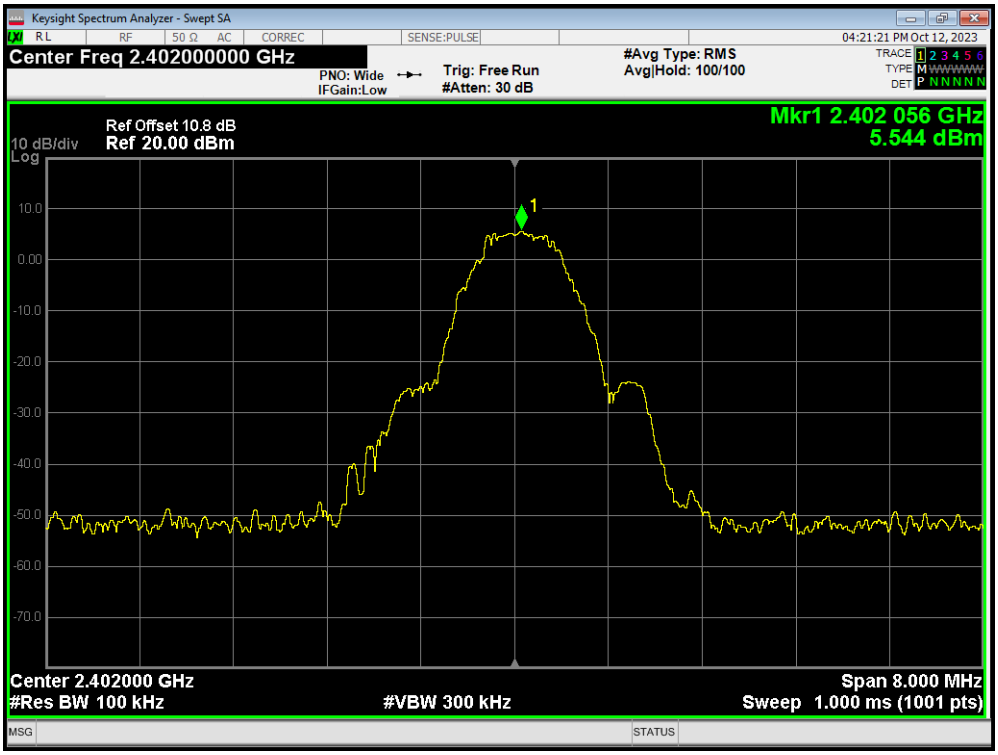
Band Edge Bluetooth LE(2M) 2480MHz Ref



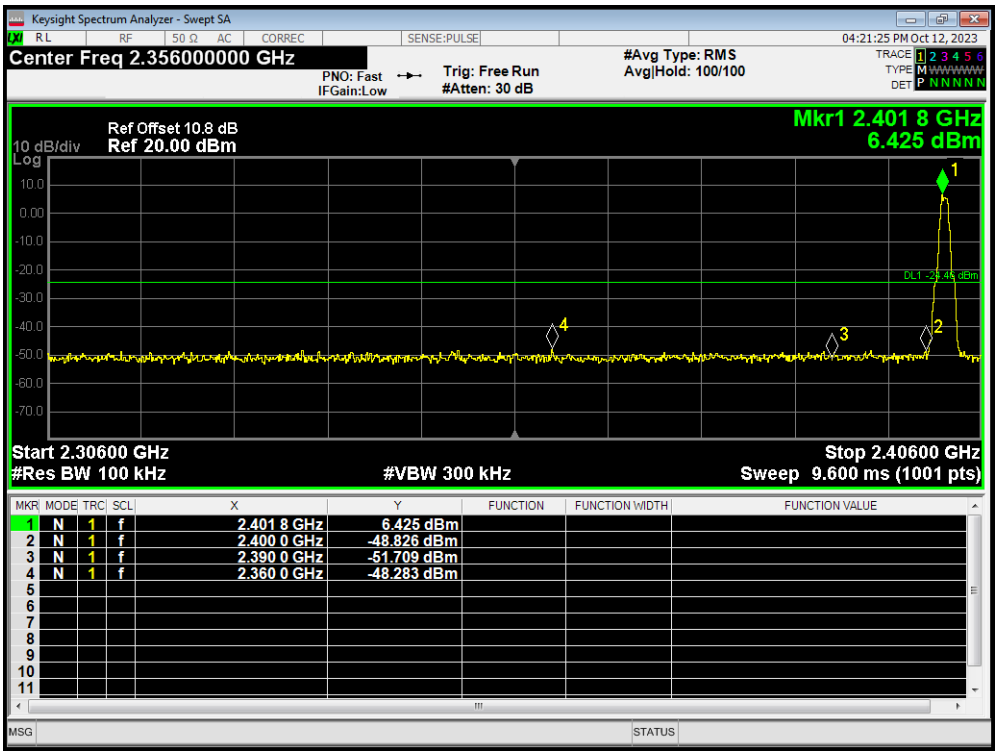
Band Edge Bluetooth LE(2M) 2480MHz Emission



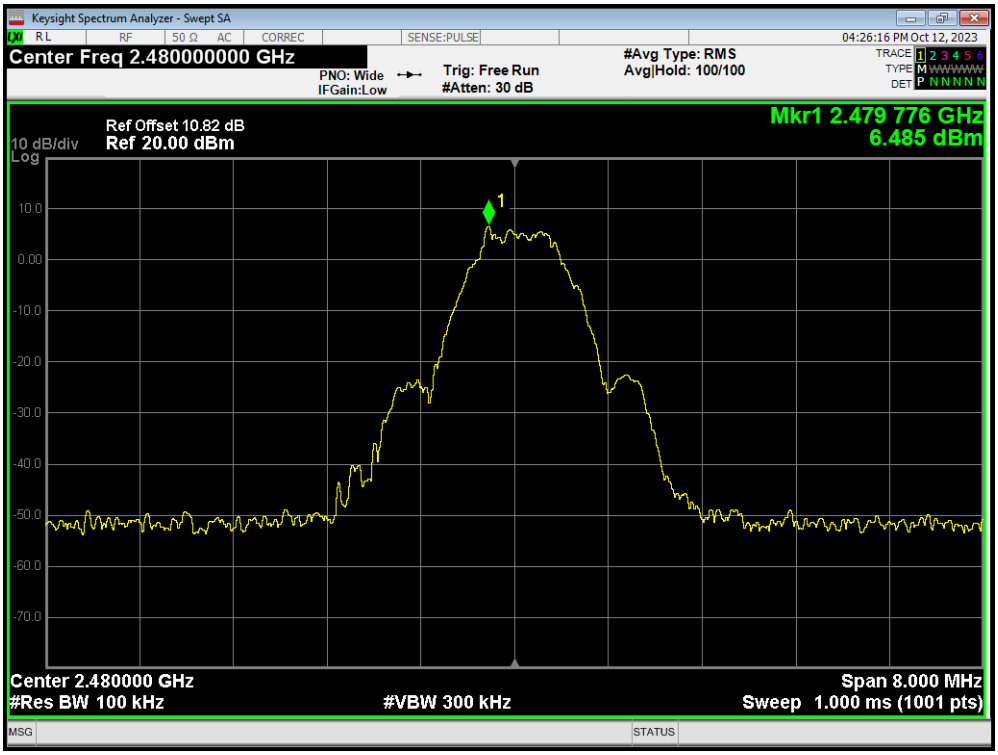
Band Edge Bluetooth LE(S=2) 2402MHz Ref



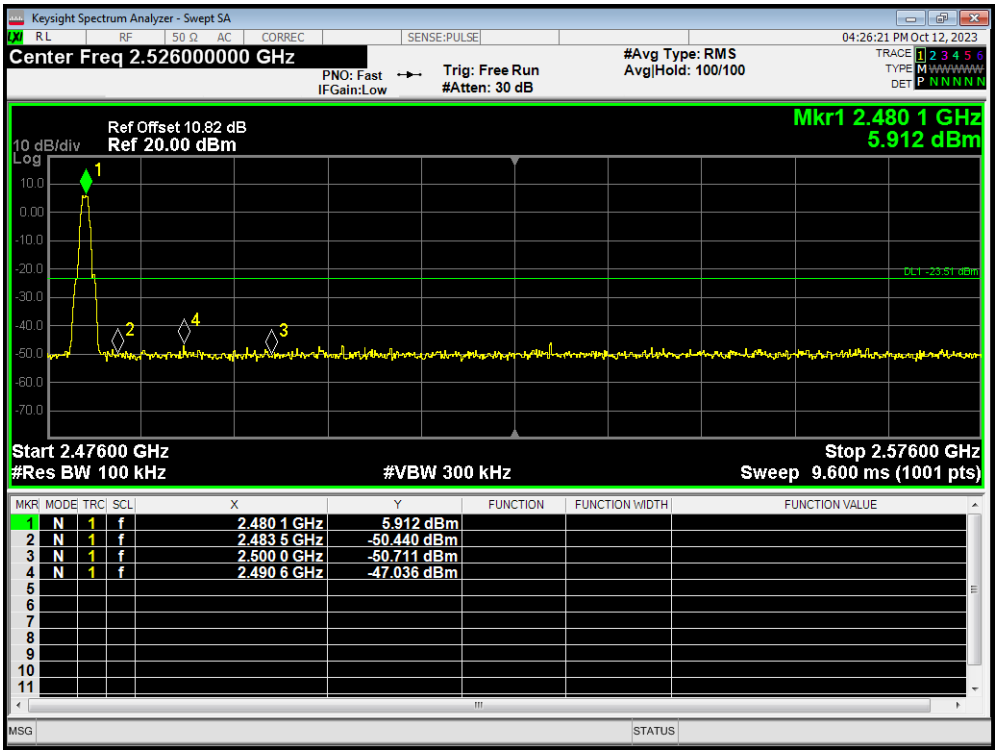
Band Edge Bluetooth LE(S=2) 2402MHz Emission



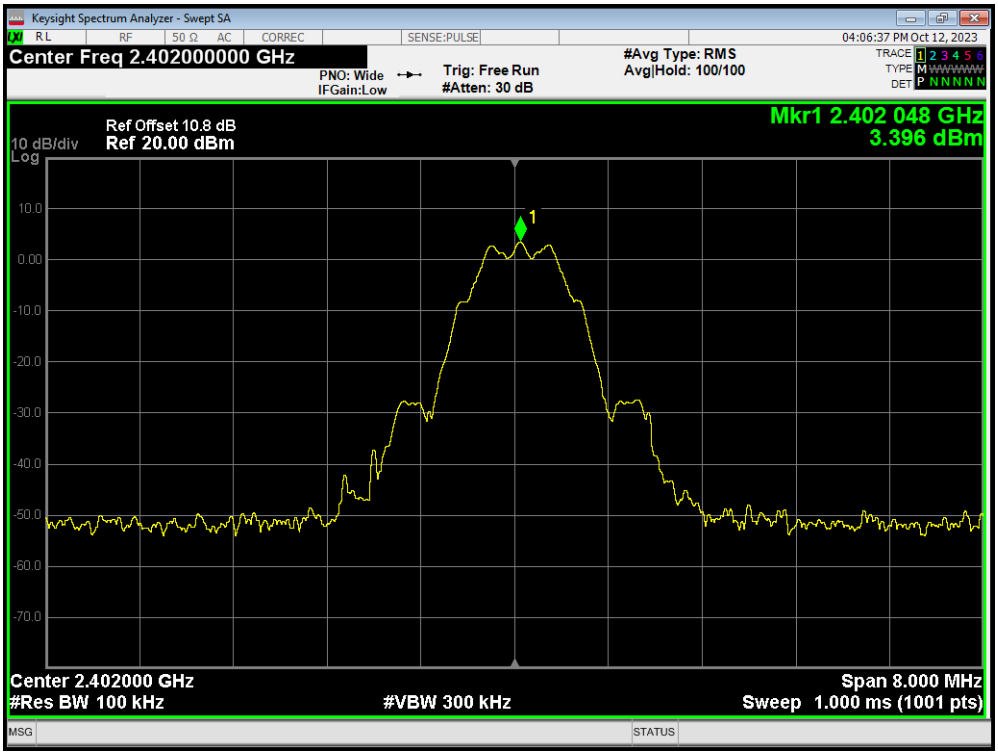
Band Edge Bluetooth LE(S=2) 2480MHz Ref



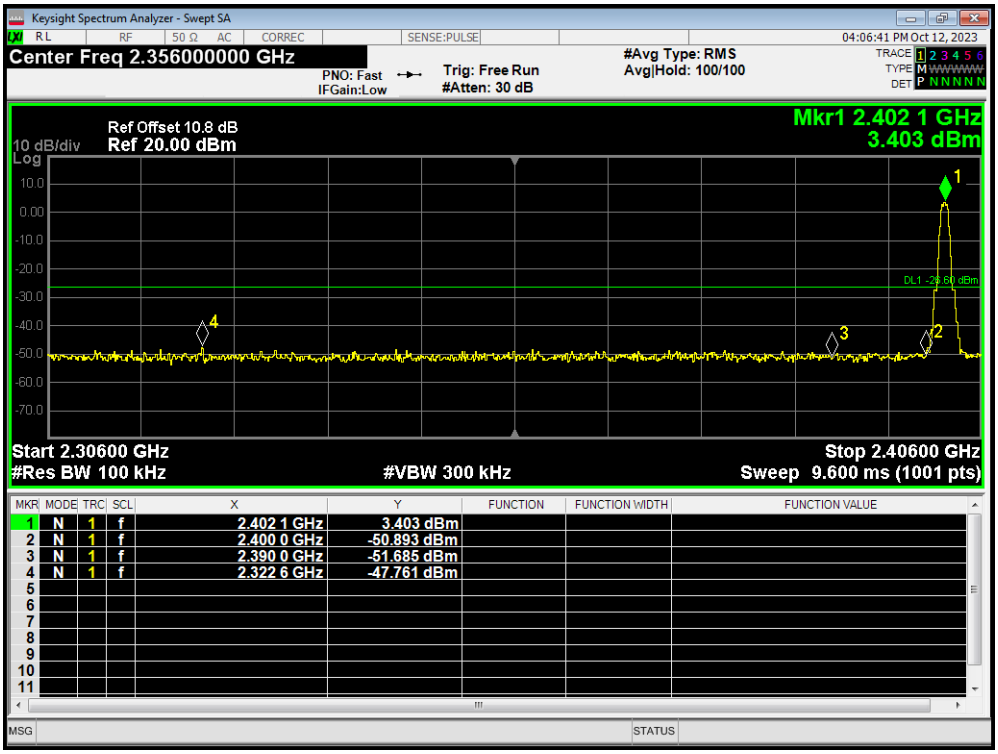
Band Edge Bluetooth LE(S=2) 2480MHz Emission



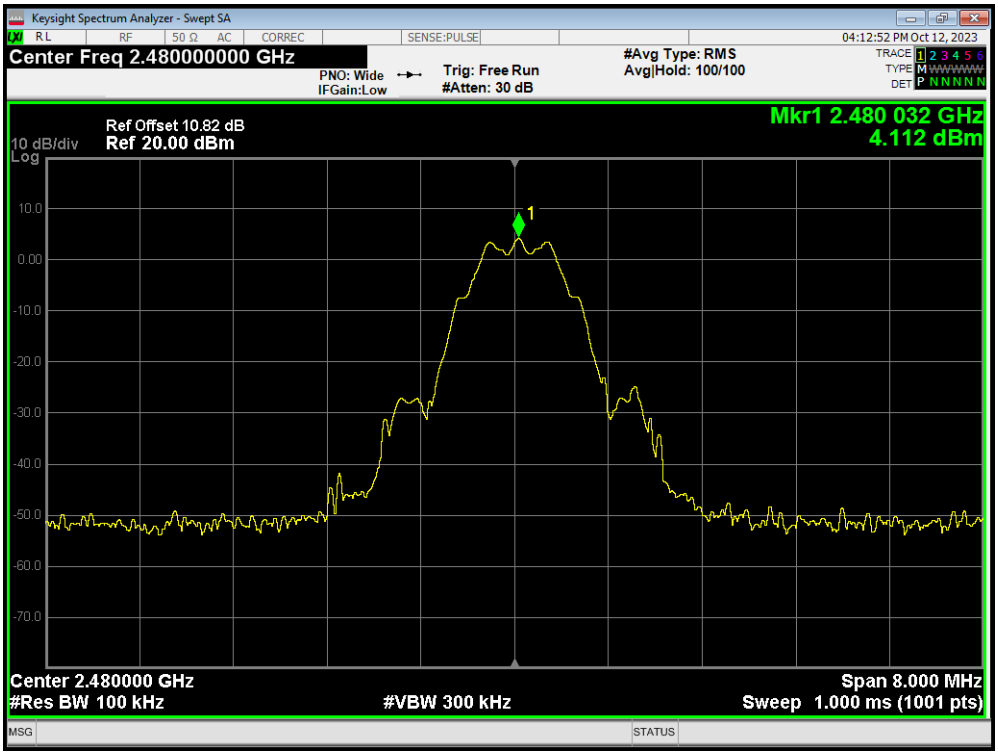
Band Edge Bluetooth LE(S=8) 2402MHz Ref



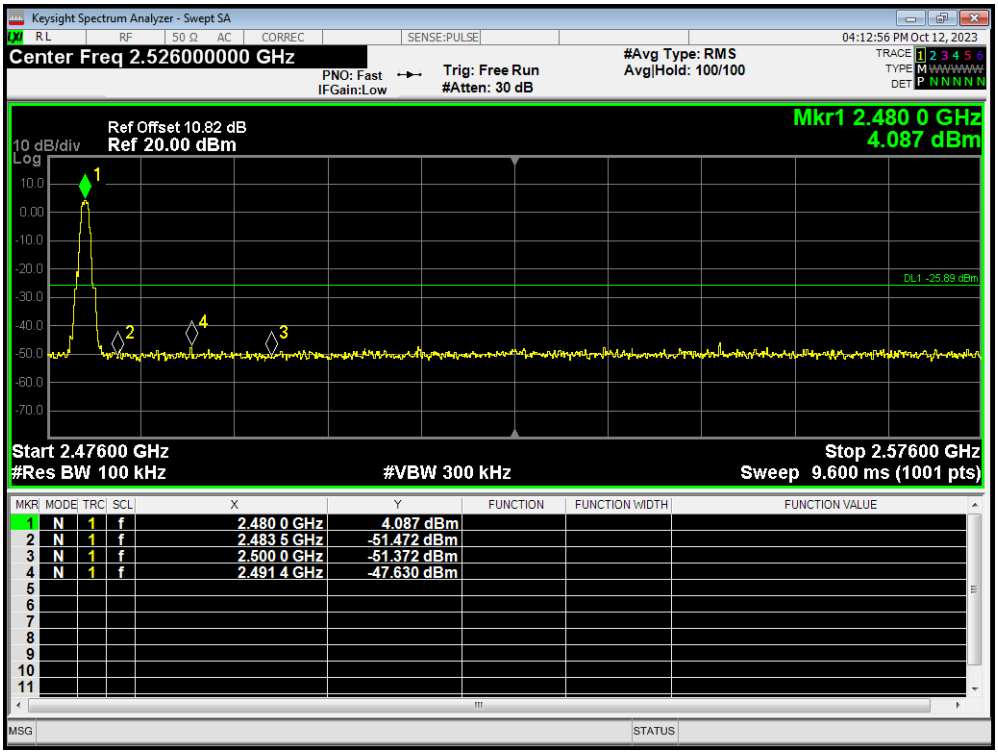
Band Edge Bluetooth LE(S=8) 2402MHz Emission



Band Edge Bluetooth LE(S=8) 2480MHz Ref



Band Edge Bluetooth LE(S=8) 2480MHz Emission



5.4. Power Spectral Density

Ambient Condition

Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

Method of Measurement

During the process of the testing, The EUT was connected to Spectrum Analyzer with a known loss. The EUT is max power transmission with proper modulation.

Method AVGPSD-1 was used for this test.

a) Set instrument center frequency to DTS channel center frequency

b) Set span to at least 1.5 times the OBW

c) Set RBW to:3kHz≤RBW≤100kHz

d) Set VBW≥[3x RBW]

e) Detector=power averaging (rms) or sample detector (when rms not available)

f) Ensure that the number of measurement points in the sweep ≥ [2 X span/RBW]

g) Sweep time auto couple

h) Employ trace averaging (rms) mode over a minimum of 100 traces

i) Use the peak marker function to determine the maximum amplitude level.

j) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced)

Method AVGPSD-2 was used for this test.

a) Measure the duty cycle (D)of the transmitter output signal as described in 11.6

b) Set instrument center frequency to DTS channel center frequency

c) Set span to at least 1.5 times the OBW

d) Set RBW to:3kHz≤RBW≤100kHz

e) Set VBW≥[3x RBW]

f) Detector= power averaging (rms) or sample detector (when rms not available)

g) Ensure that the number of measurement points in the sweep ≥ [2 X span/RBW]

h) Sweep time =auto couple

i) Do not use sweep triggering; allow sweep to "free run”

j) Employ trace averaging (rms) mode over a minimum of 100 traces

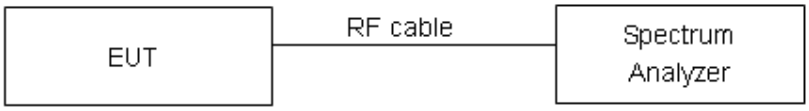
k) Use the peak marker function to determine the maximum amplitude level

l) Add [10 log(1/ D)], where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time

m) If measured value exceeds requirement specified by regulatory agency then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced)

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

Test setup



Limits

Rule Part 15.247(e) specifies that" For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. ''

Limits	≤ 8 dBm / 3kHz

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 0.75dB.

Test Results:

Test Mode	Carrier frequency (MHz))/ Channel	Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
Bluetooth (Low Energy) (1M)	2402/CH0	-11.93	-9.90	8	PASS
	2440/CH19	-11.12	-9.09	8	PASS
	2480/CH39	-11.35	-9.32	8	PASS
Bluetooth (Low Energy) (2M)	2402/CH0	-16.81	-11.77	8	PASS
	2440/CH19	-16.32	-11.28	8	PASS
	2480/CH39	-16.57	-11.53	8	PASS
Bluetooth (Low Energy) (S=2)	2402/CH0	-7.90	-5.41	8	PASS
	2440/CH19	-6.49	-4.00	8	PASS
	2480/CH39	-6.74	-4.25	8	PASS
Bluetooth (Low Energy) (S=8)	2402/CH0	-1.07	-0.24	8	PASS
	2440/CH19	-0.54	0.29	8	PASS
	2480/CH39	-1.08	-0.25	8	PASS
Note: Power Spectral Density =Read Value + Duty cycle correction factor					

SISO Antenna 1

Test Mode	Carrier frequency (MHz))/ Channel	Read Value (dBm / 30kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
802.11b	2412/CH 1	-6.43	-16.43	8	PASS
	2437/CH 6	-6.20	-16.20	8	PASS
	2462/CH11	-5.94	-15.94	8	PASS
802.11g	2412/CH 1	-7.10	-16.81	8	PASS
	2437/CH 6	-6.73	-16.44	8	PASS
	2462/CH11	-6.63	-16.34	8	PASS
802.11n HT20	2412/CH 1	-7.18	-16.86	8	PASS
	2437/CH 6	-7.34	-17.02	8	PASS
	2462/CH11	-7.34	-17.02	8	PASS
802.11ax HE20	2412/CH 1	-9.64	-19.24	8	PASS
	2437/CH 6	-9.64	-19.24	8	PASS
	2462/CH11	-9.72	-19.32	8	PASS
Note: Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3/30)					

SISO Antenna 2

Test Mode	Carrier frequency (MHz))/ Channel	Read Value (dBm / 30kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
802.11b	2412/CH 1	-6.45	-16.45	8	PASS
	2437/CH 6	-7.66	-17.66	8	PASS
	2462/CH11	-6.92	-16.92	8	PASS
802.11g	2412/CH 1	-7.22	-16.93	8	PASS
	2437/CH 6	-8.50	-18.21	8	PASS
	2462/CH11	-7.36	-17.07	8	PASS
802.11n HT20	2412/CH 1	-7.60	-17.28	8	PASS
	2437/CH 6	-9.26	-18.94	8	PASS
	2462/CH11	-7.86	-17.54	8	PASS
802.11ax HE20	2412/CH 1	-9.59	-19.19	8	PASS
	2437/CH 6	-11.02	-20.62	8	PASS
	2462/CH11	-10.51	-20.11	8	PASS
Note: Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3/30)					

MIMO

Test Mode	Carrier frequency (MHz))/ Channel	Power Spectral Density				Total PSD	Limit (dBm / 3kHz)	Conclusion
		Antenna 1		Antenna 2				
		Read Value (dBm / 30kHz)	Power Spectral Density (dBm / 3kHz)	Read Value (dBm / 30kHz)	Power Spectral Density (dBm / 3kHz)	(dBm / 3kHz)		
802.11n HT20	2412/CH 1	-7.21	-16.89	-7.85	-17.53	-14.19	8	PASS
	2437/CH 6	-8.21	-17.89	-8.91	-18.59	-15.22	8	PASS
	2462/CH11	-7.12	-16.80	-8.23	-17.91	-14.31	8	PASS
802.11ax HE20	2412/CH 1	-8.78	-18.38	-9.91	-19.51	-15.90	8	PASS
	2437/CH 6	-10.03	-19.63	-9.86	-19.46	-16.53	8	PASS
	2462/CH11	-9.08	-18.68	-9.71	-19.31	-15.97	8	PASS

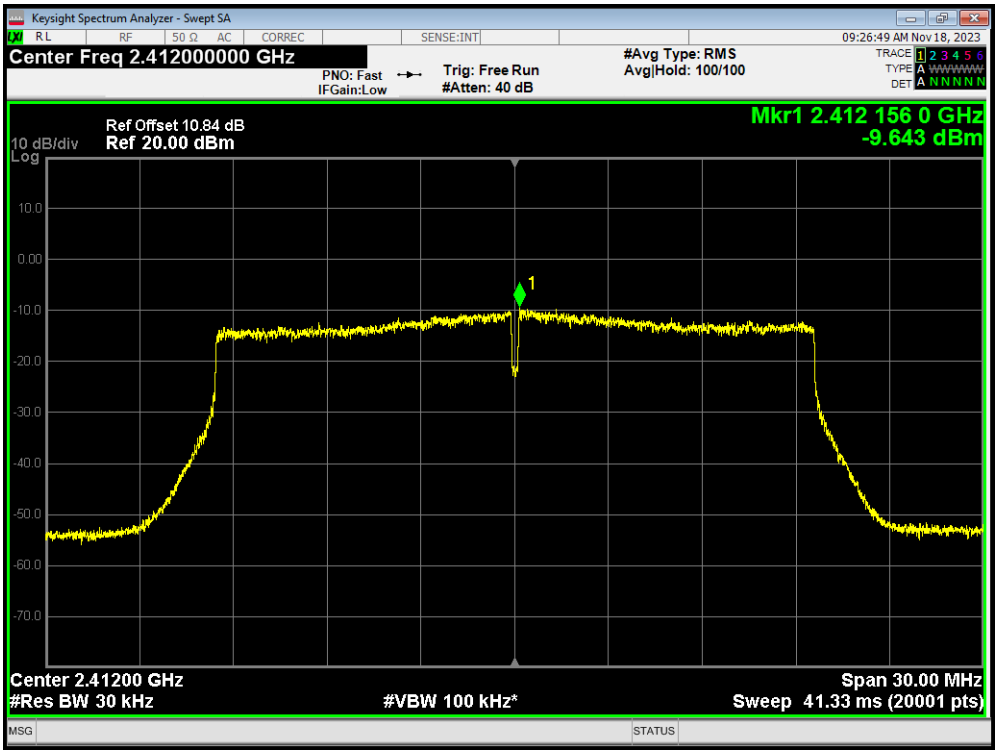
Note: 1.Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3/30)

2. For Total PSD, according to KDB 662911 D01 Multiple Transmitter Output v02r01 2)a),the power spectral density=$10\log(10^{(\text{PSD antenna1 in dBm/10})}+10^{(\text{PSD antenna2 in dBm/10})})$

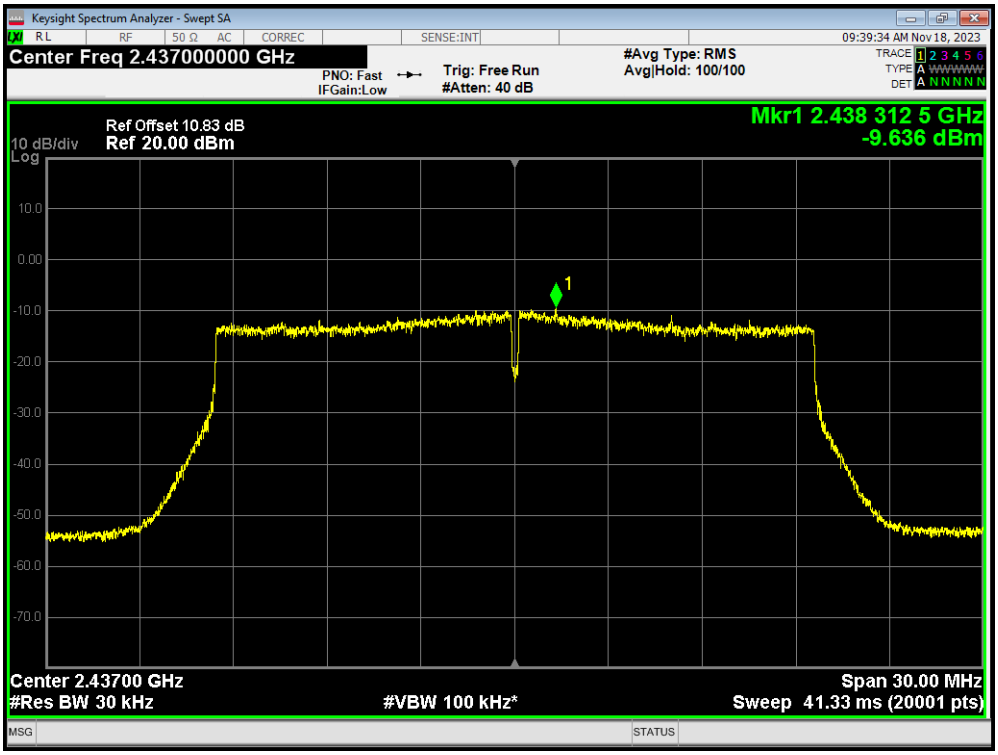
3. According to KDB 662911 D01 Multiple Transmitter Output v02r01 F)2)f)(i): If all antennas have the same gain, Directional gain = G_{ANT} + Array Gain. For PSD measurements on all devices, Array Gain=10log(Nant/Nss)dB, so directional gain=G_{ANT}+Array Gain=(-0.1)+10log(2/1)=2.91 <6dBi. So the PSD limit is 8 dBm

SISO Antenna 1

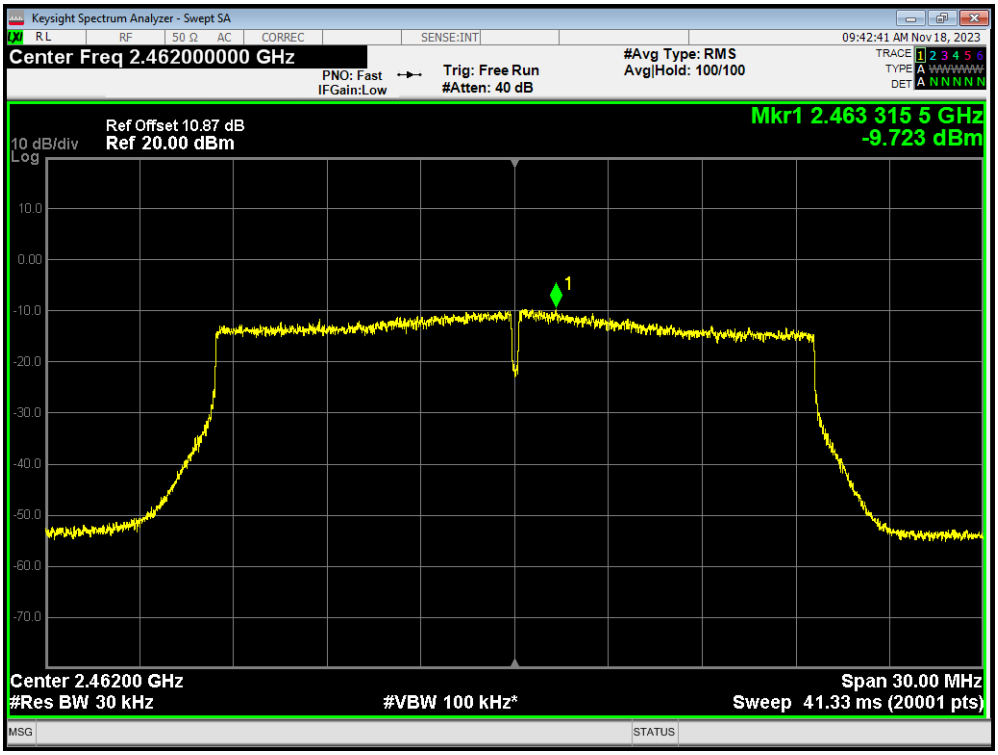
PSD 802.11ax(HE20) 2412MHz



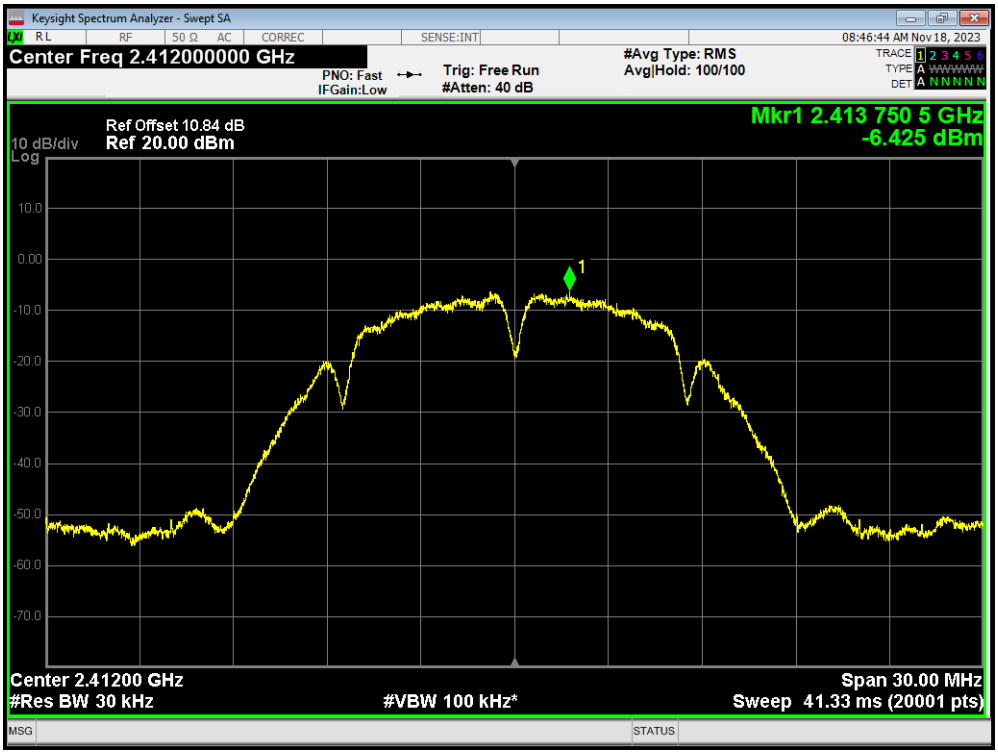
PSD 802.11ax(HE20) 2437MHz



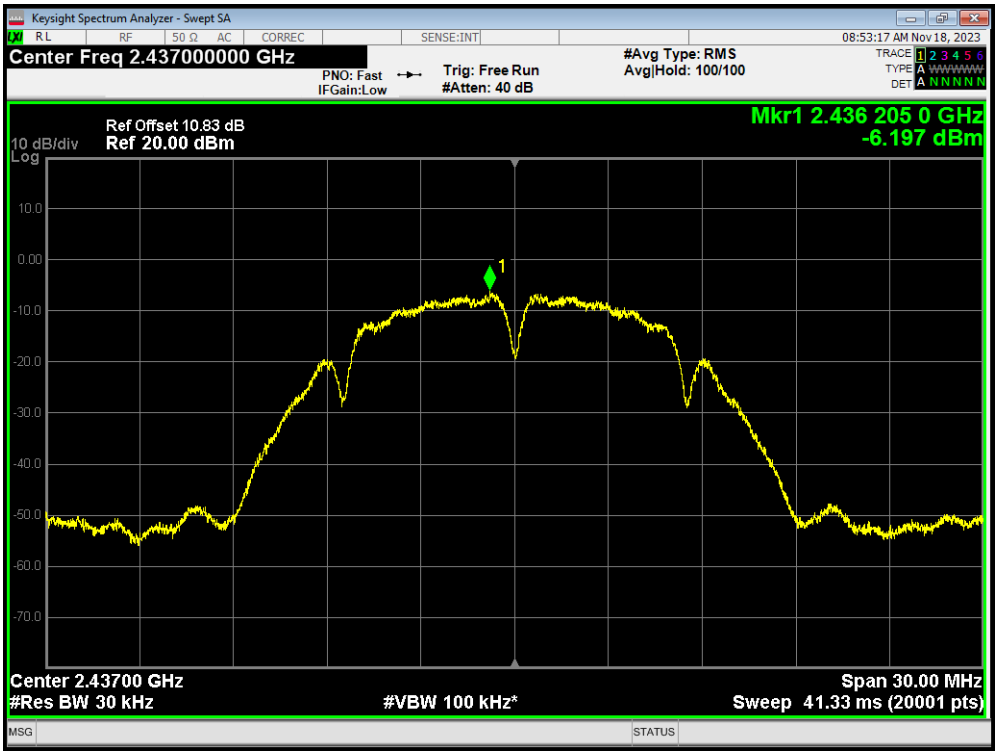
PSD 802.11ax(HE20) 2462MHz



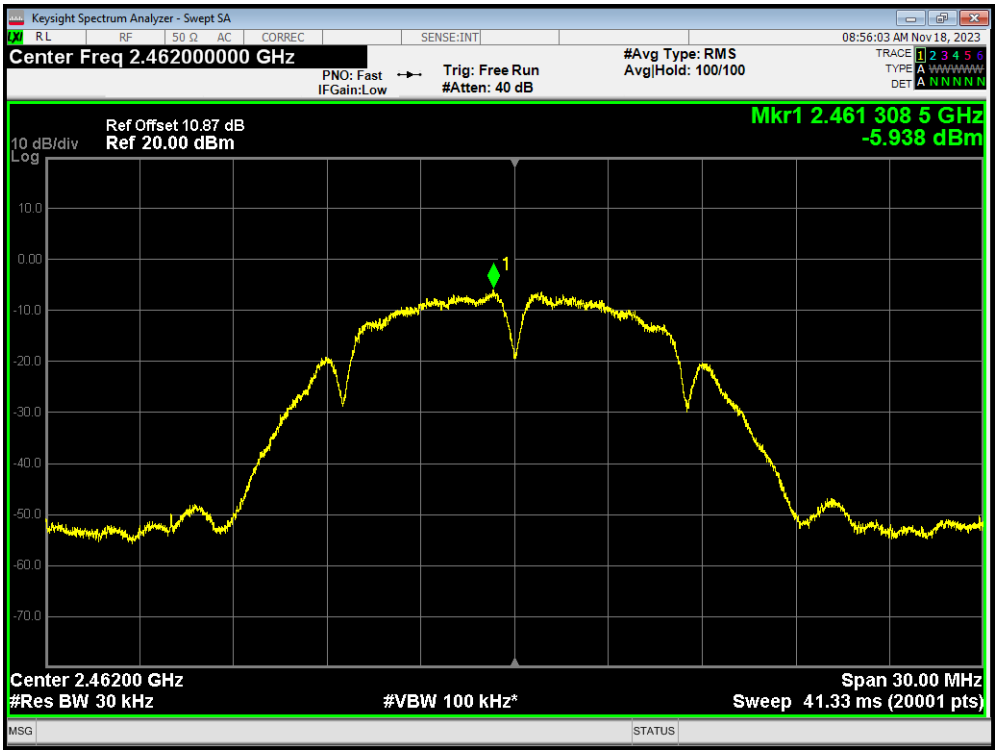
PSD 802.11b 2412MHz



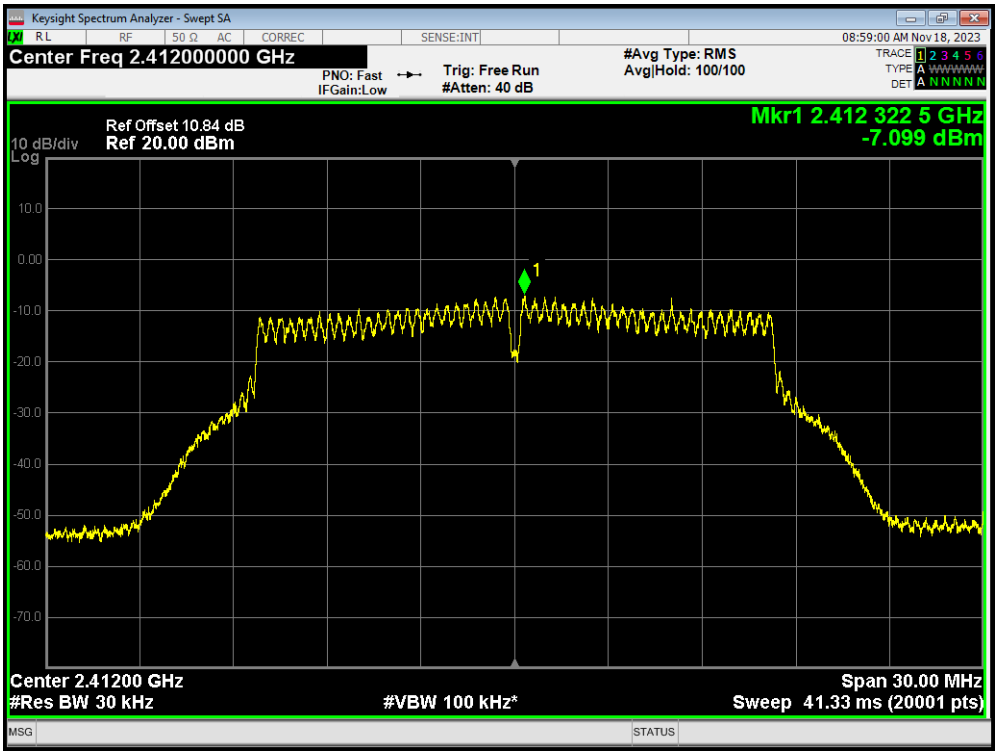
PSD 802.11b 2437MHz



PSD 802.11b 2462MHz



PSD 802.11g 2412MHz



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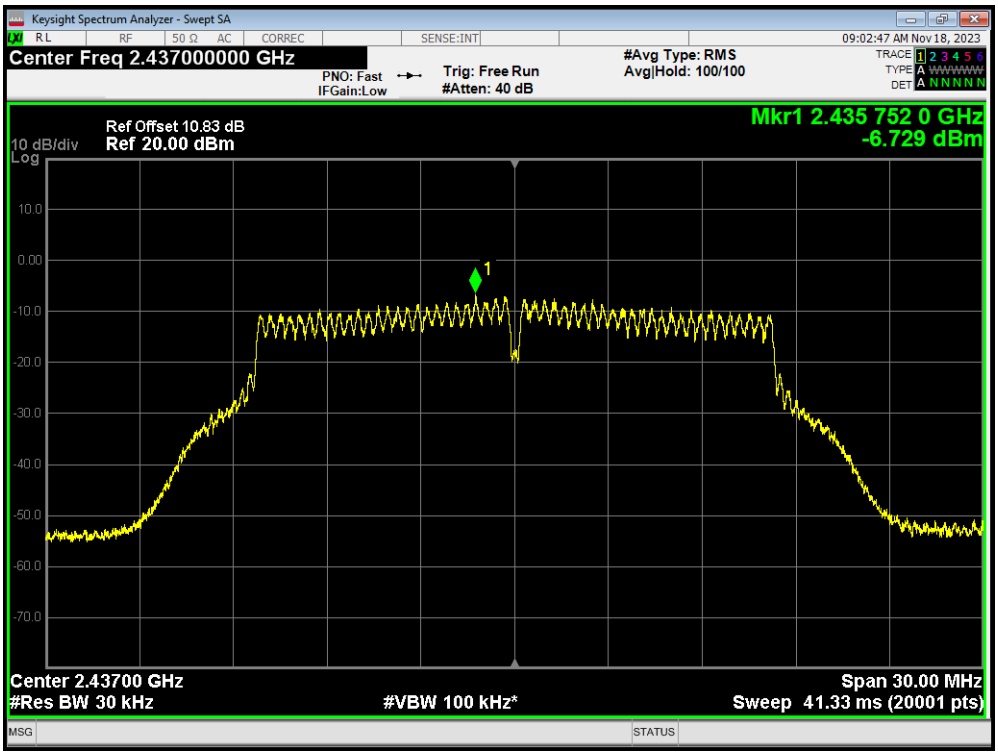

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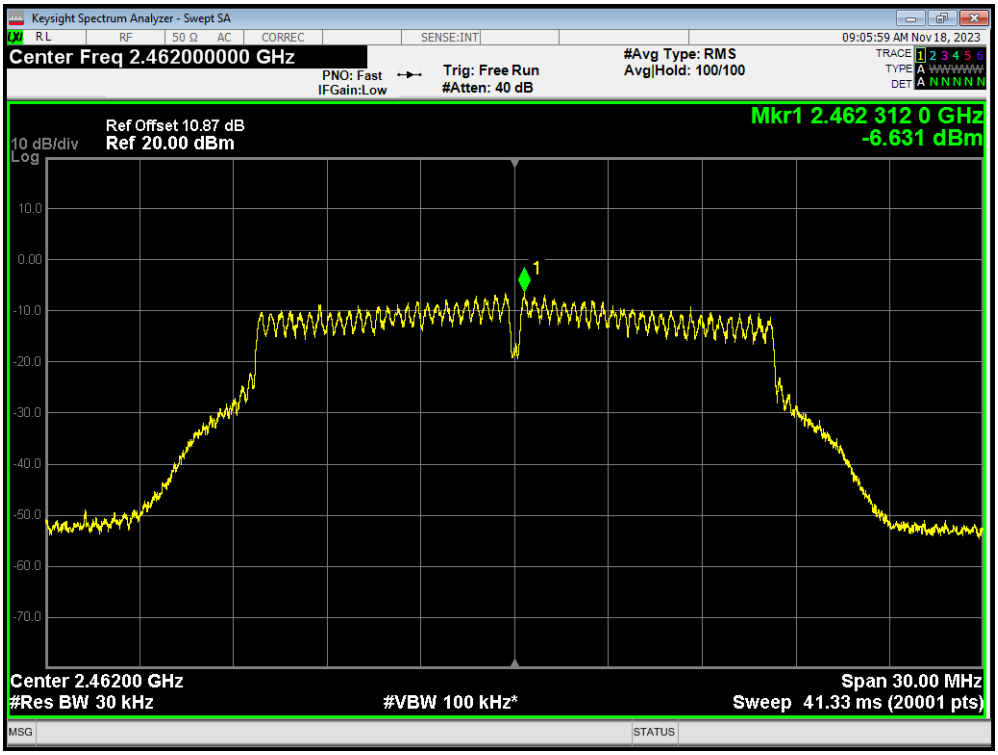
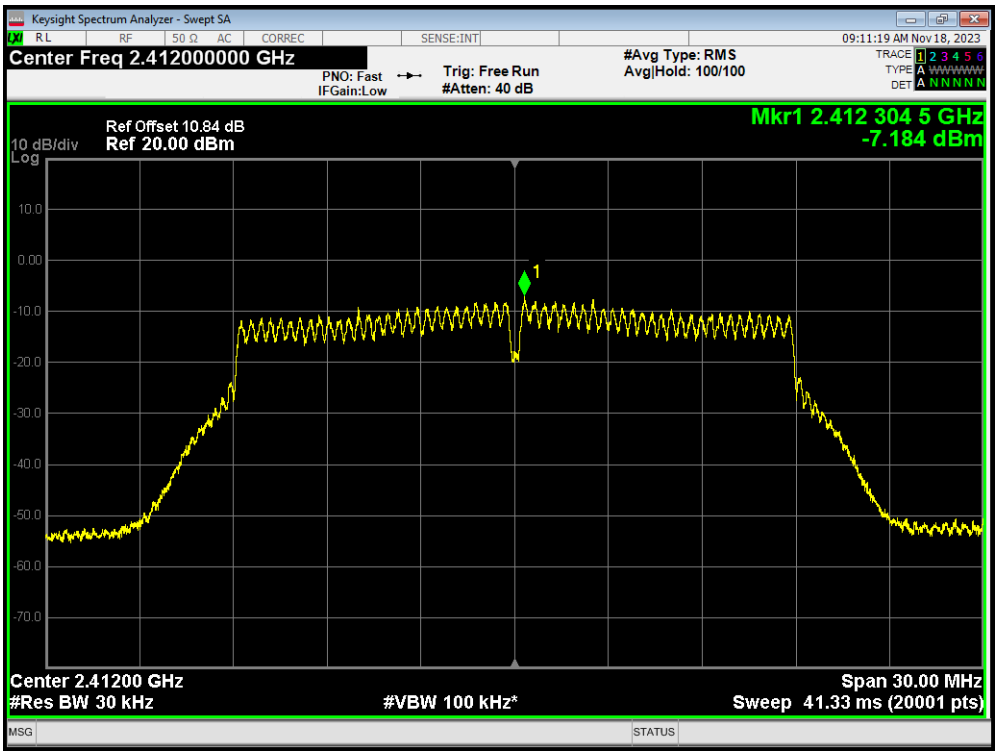


PSD 802.11n(HT20) 2412MHz



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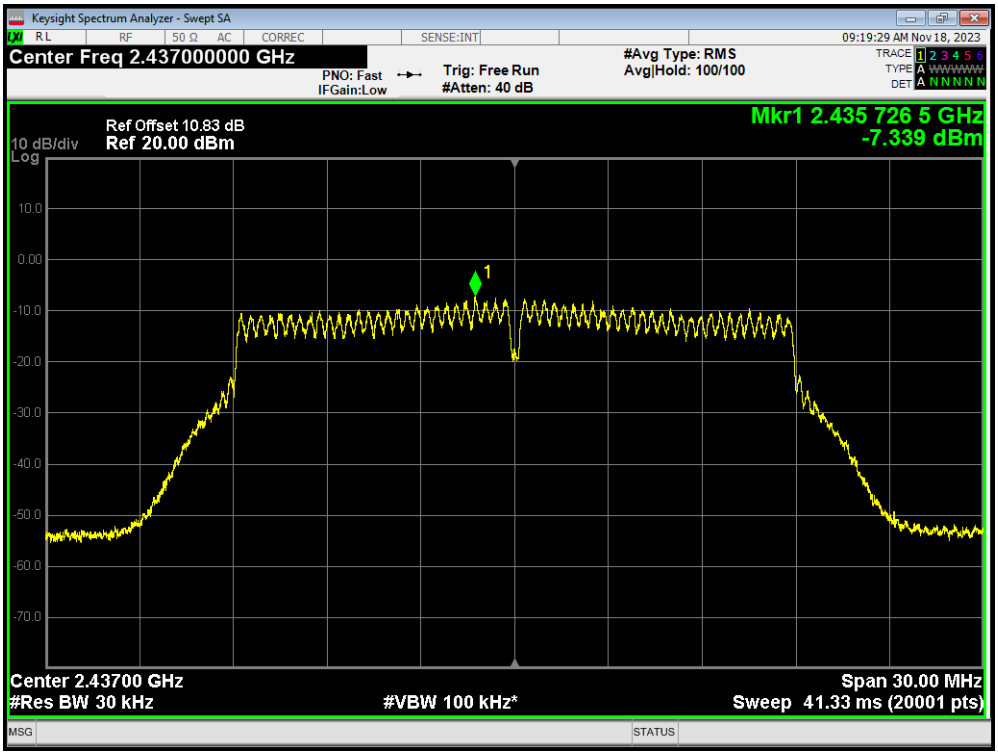

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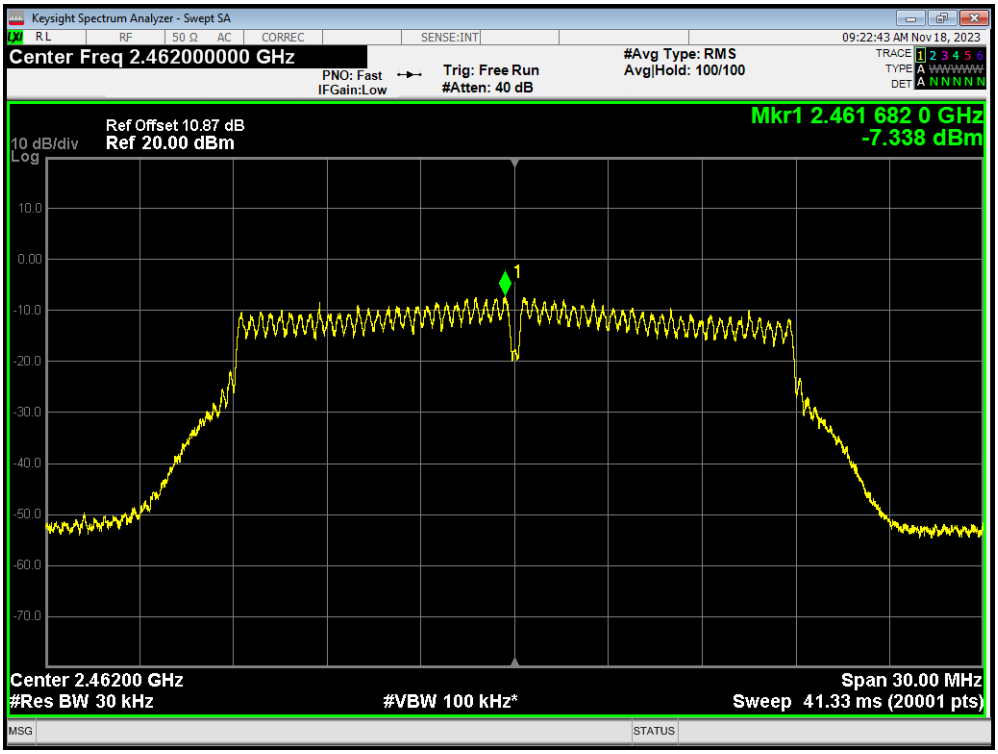
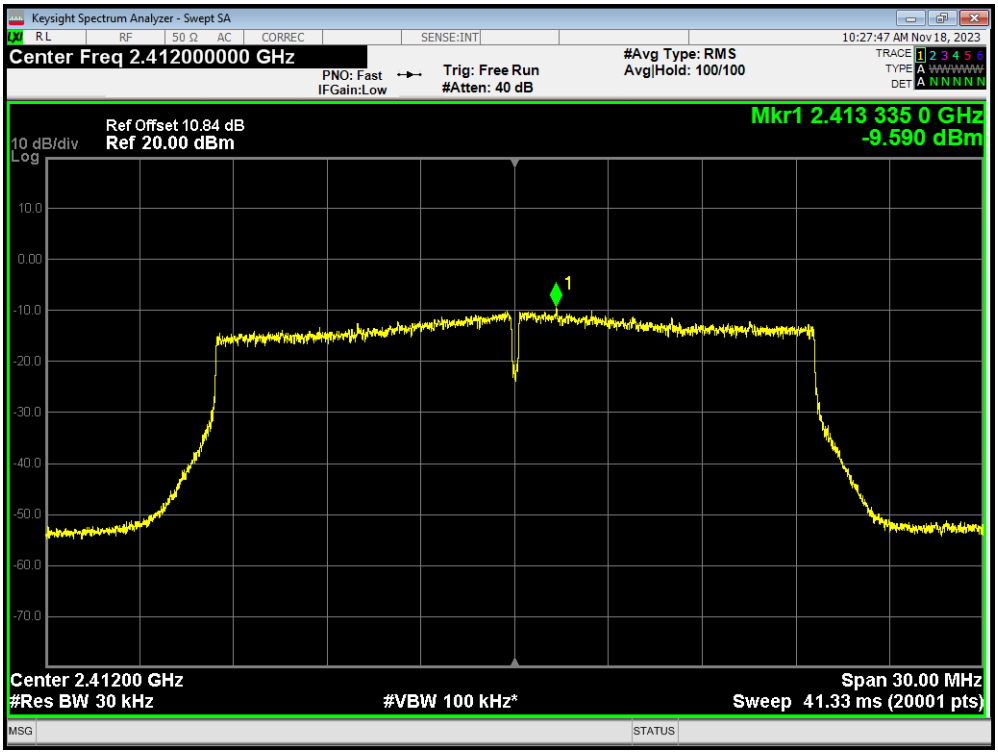
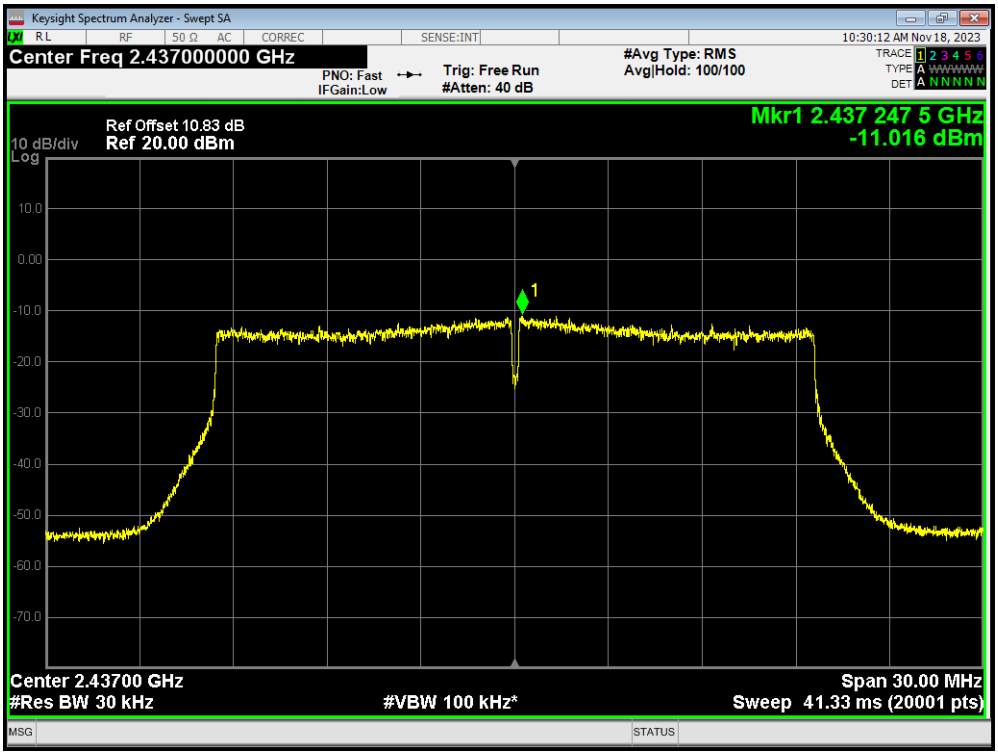


SISO Antenna 2

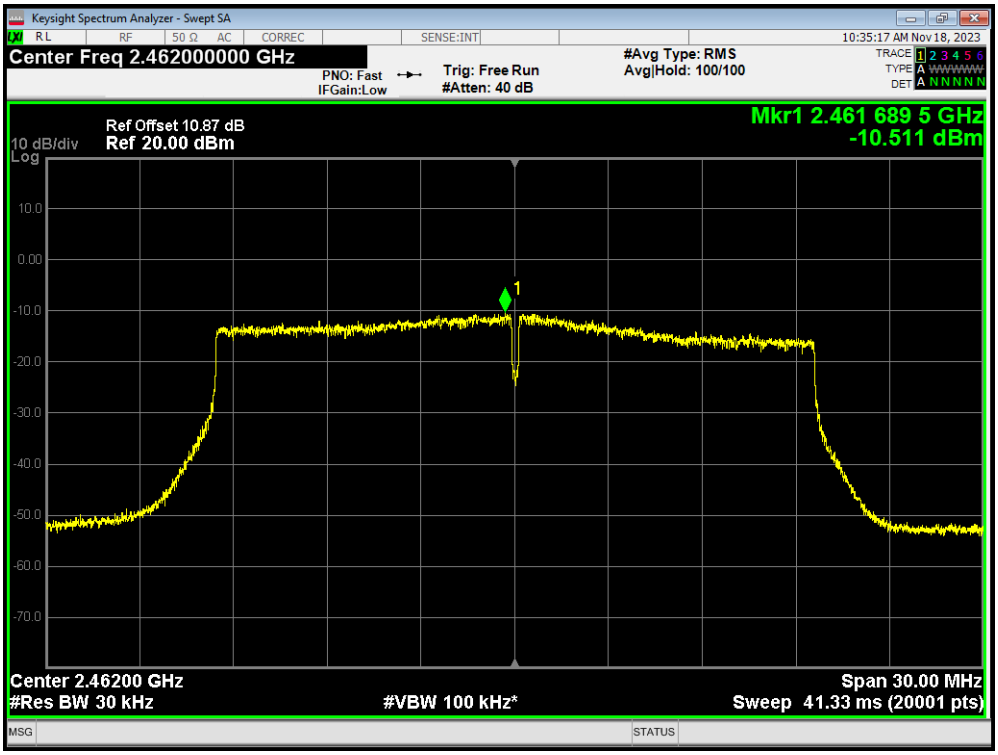
PSD 802.11ax(HE20) 2412MHz



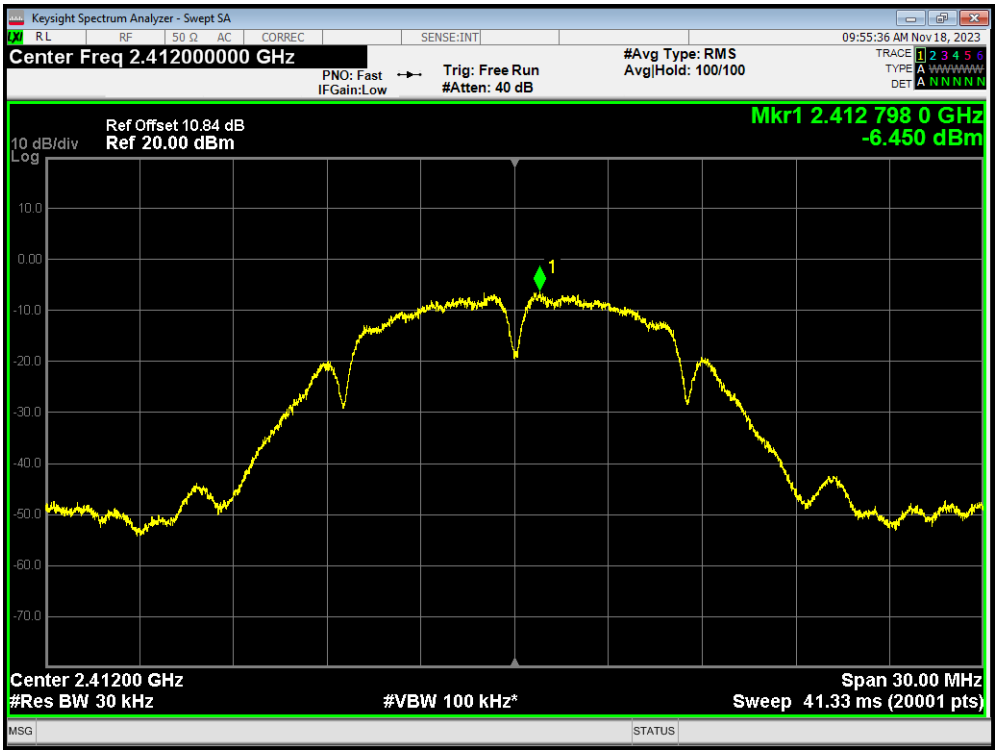
PSD 802.11ax(HE20) 2437MHz



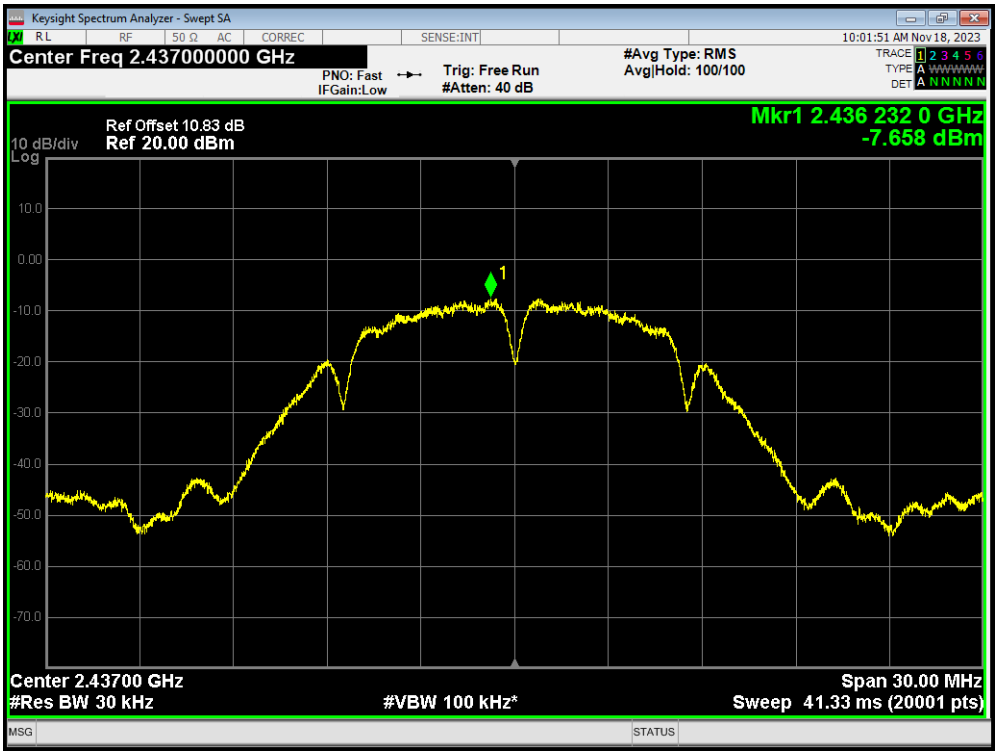
PSD 802.11ax(HE20) 2462MHz



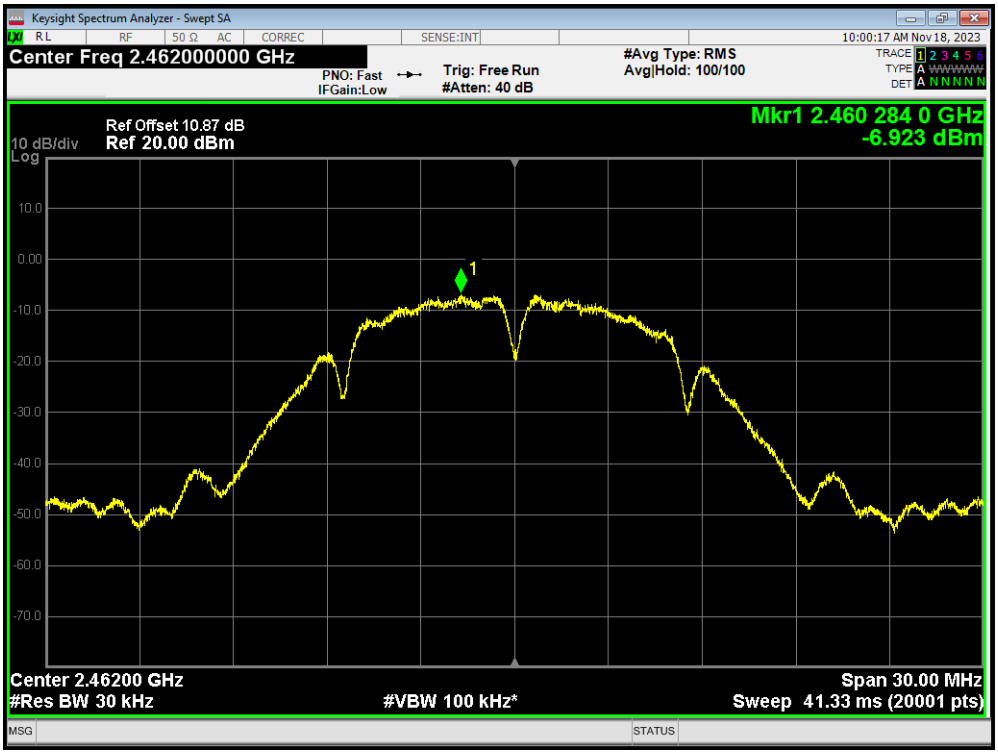
PSD 802.11b 2412MHz



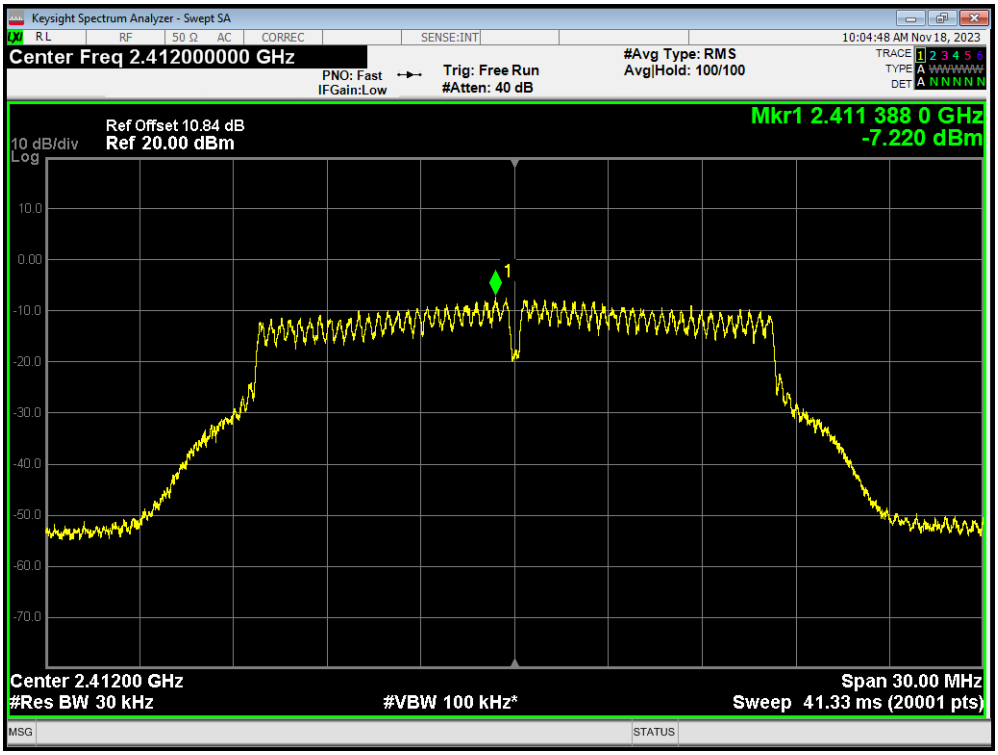
PSD 802.11b 2437MHz



PSD 802.11b 2462MHz



PSD 802.11g 2412MHz



PSD 802.11g 2437MHz