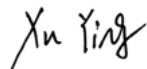


RF TEST REPORT

Applicant	Quectel Wireless Solutions Company Limited
FCC ID	XMR202309AF55C
Product	Wi-Fi & Bluetooth Module
Brand	Quectel
Model	AF55C
Report No.	R2308A0966-R1V2
Issue Date	December 15, 2023

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC CFR47 Part 15C (2022)**. 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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Approved by: Xu Kai

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Version	Revision Description	Issue Date
Rev.0	Initial issue of report.	December 8, 2023
Rev.1	Update information.	December 12, 2023
Rev.2	Update information.	December 15, 2023
Note: This revised report (Report No.: R2308A0966-R1V2) supersedes and replaces the previously issued report (Report No.: R2308A0966-R1V1). Please discard or destroy the previously issued report and dispose of it accordingly.		

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 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.			

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 **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)

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)

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

1.3. Testing Location

Company: TA Technology (Shanghai) Co., Ltd.
Address: Building 3, No.145, Jintang Rd, Pudong Shanghai, P.R.China
City: Shanghai
Post code: 201201
Country: P. R. China
Contact: Xu Kai
Telephone: +86-021-50791141/2/3
Fax: +86-021-50791141/2/3-8000
Website: <http://www.ta-shanghai.com>
E-mail: xukai@ta-shanghai.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	R1.0
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 (2022) 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

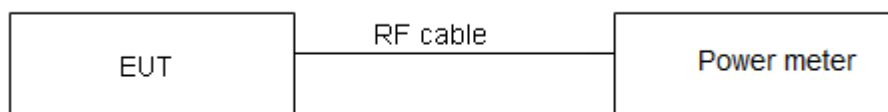
Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

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	$\leq 1W$ (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 = $G_{\text{ANT}} + \text{Array Gain}$,

For power measurements on IEEE 802.11 devices,

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

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

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

So directional gain = $G_{\text{ANT}} + \text{Array Gain} = (-0.1) + 0 = -0.1 \text{ dBi} < 6 \text{ dBi}$. 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

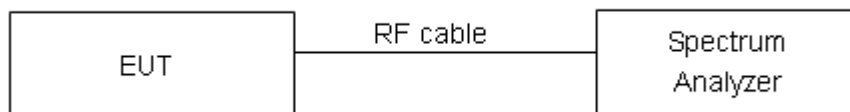
Temperature	Relative humidity
20°C ~ 25°C	45% ~ 50%

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

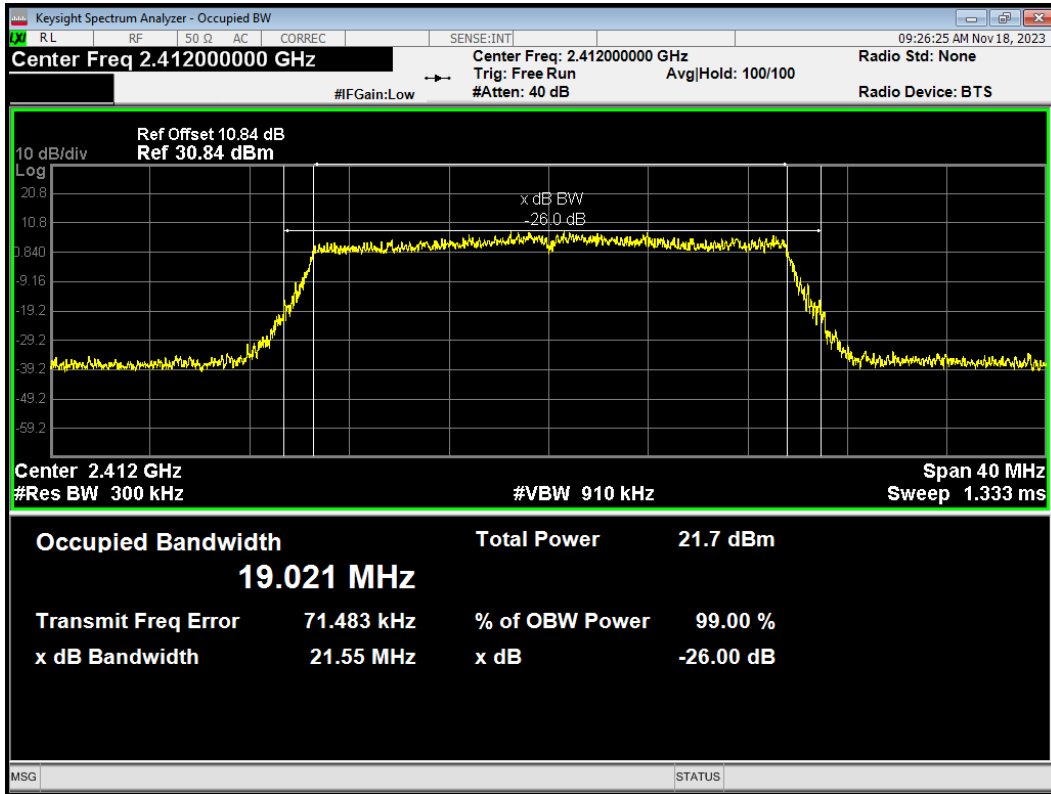
The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 2$, $U = 936$ Hz.

Test Results:

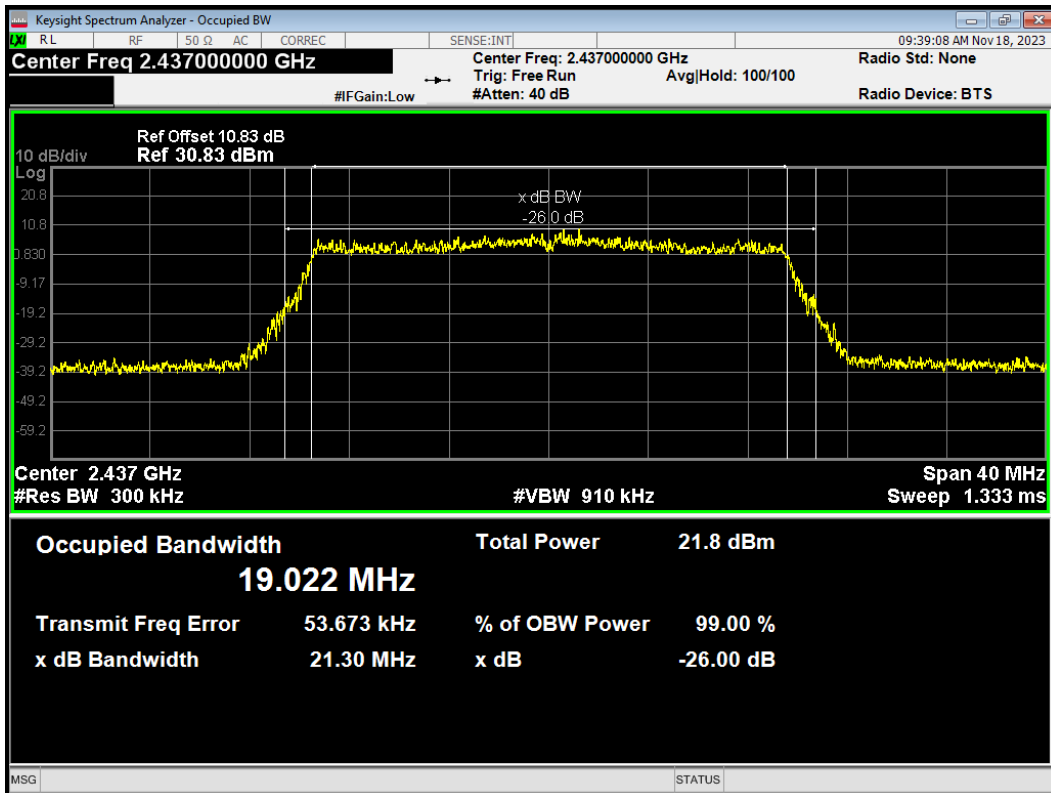
Test Mode	Carrier frequency (MHz)	99% bandwidth (MHz)	Minimum 6 dB bandwidth (MHz)	Limit (kHz)	Conclusion
802.11b	2412	12.010	8.577	500	PASS
	2437	12.051	8.114	500	PASS
	2462	11.990	8.564	500	PASS
802.11g	2412	16.761	15.066	500	PASS
	2437	16.804	14.964	500	PASS
	2462	16.707	11.283	500	PASS
802.11n HT20	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

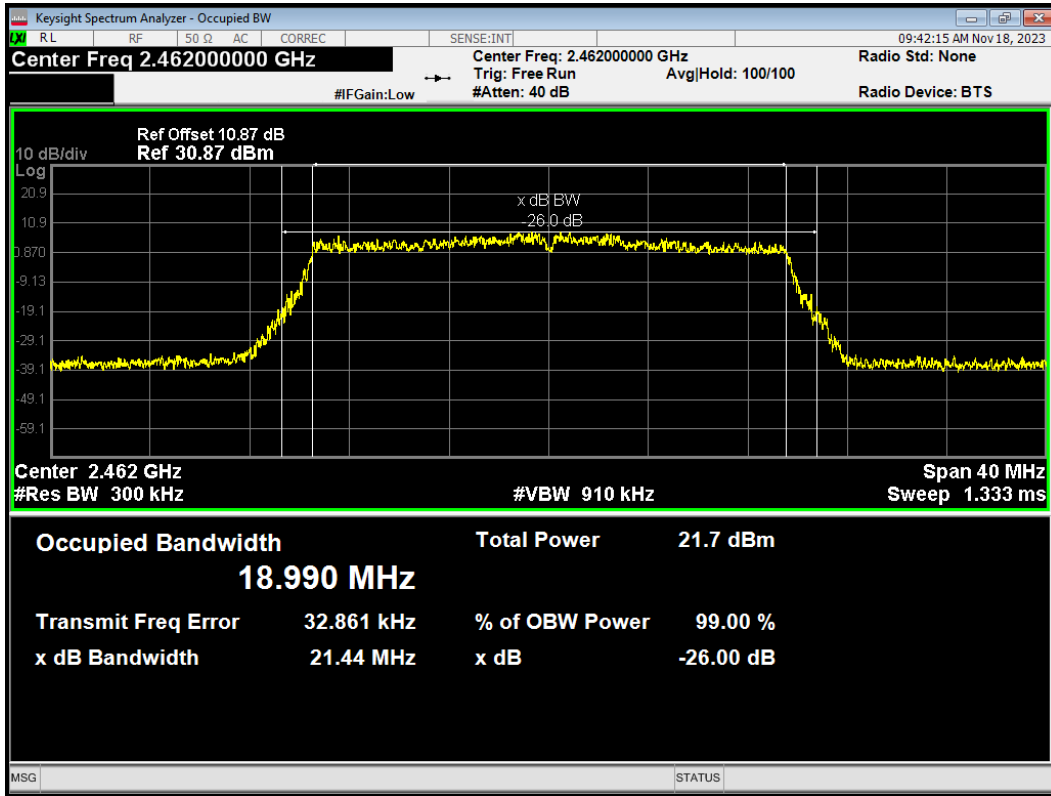
OBW 802.11ax(HE20) 2412MHz



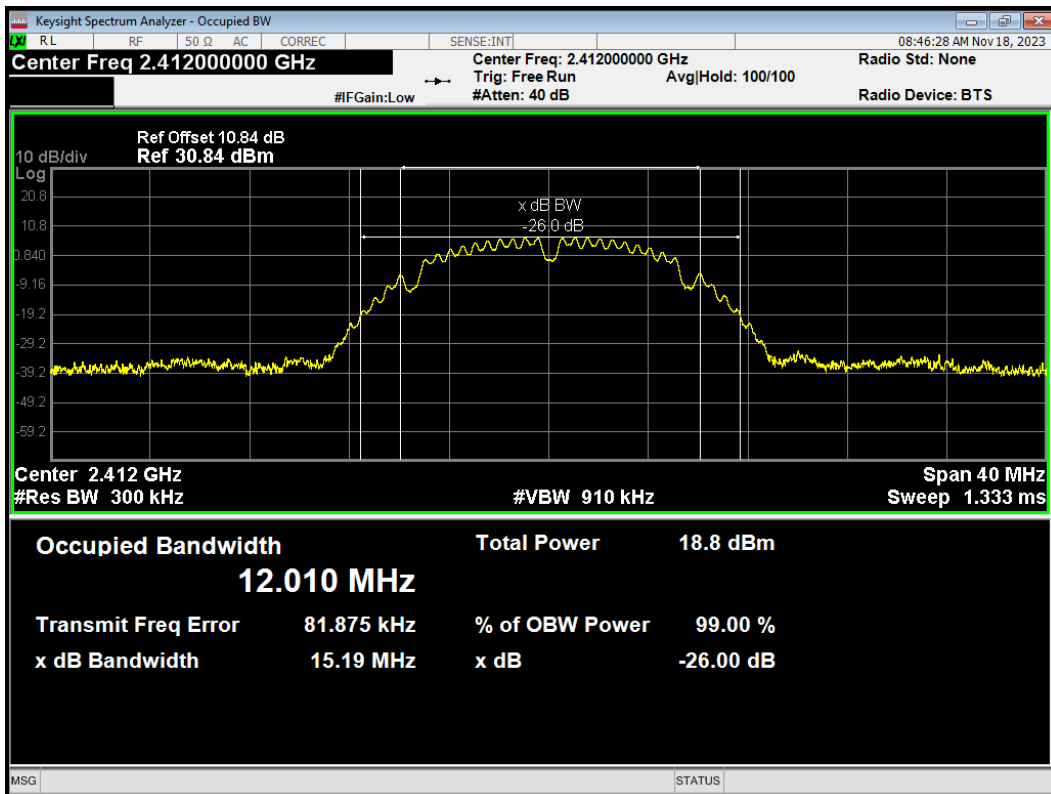
OBW 802.11ax(HE20) 2437MHz



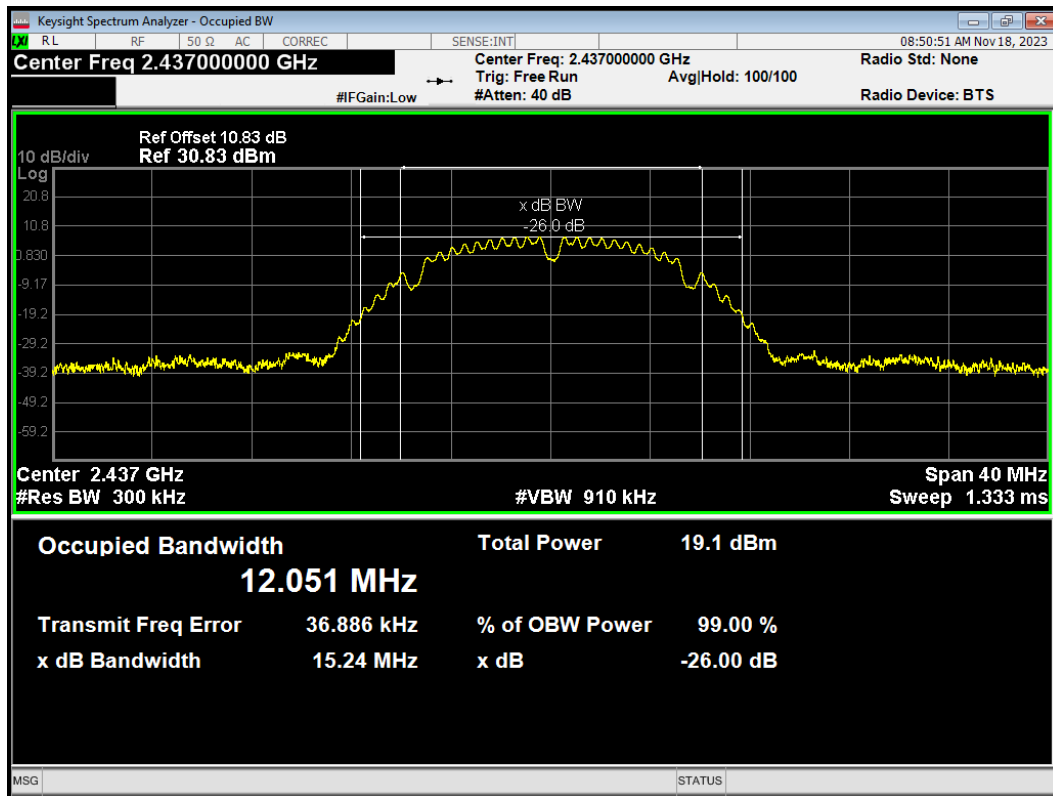
OBW 802.11ax(HE20) 2462MHz



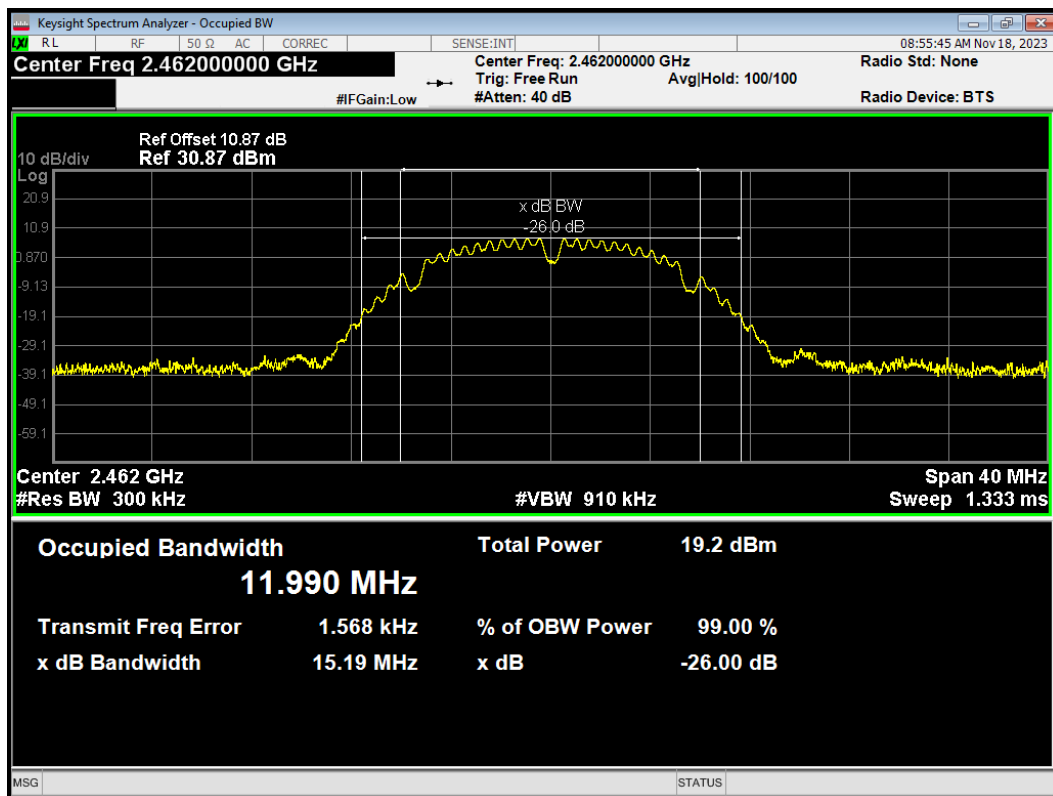
OBW 802.11b 2412MHz



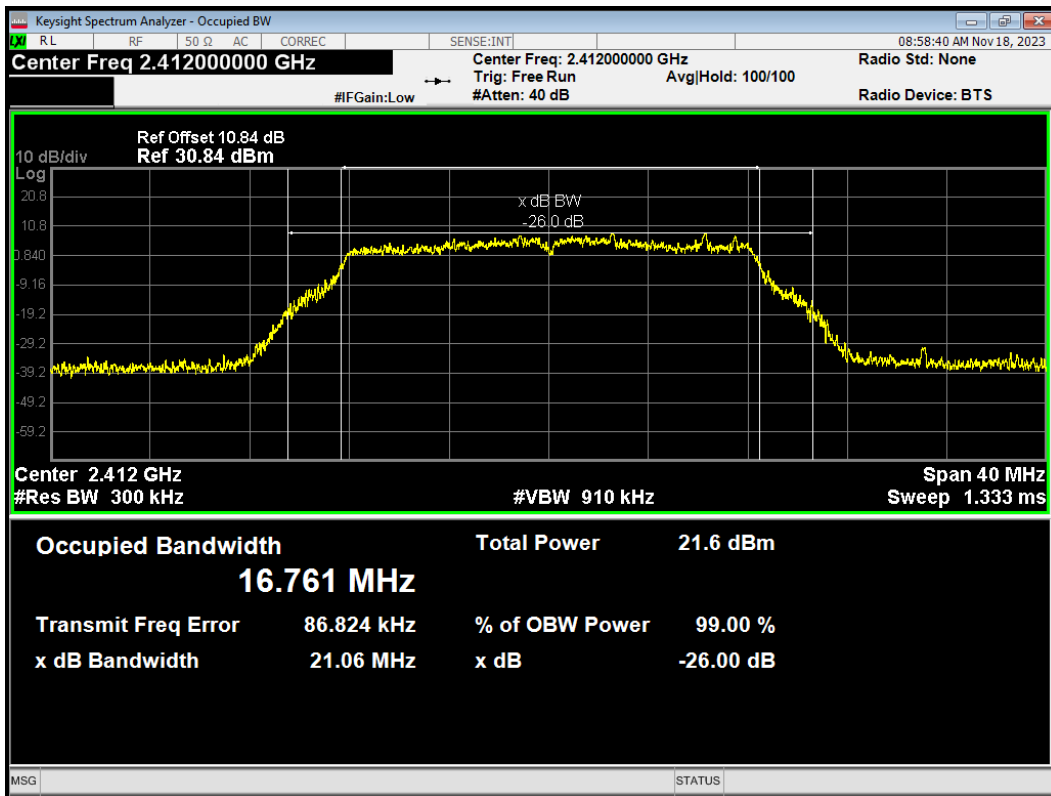
OBW 802.11b 2437MHz



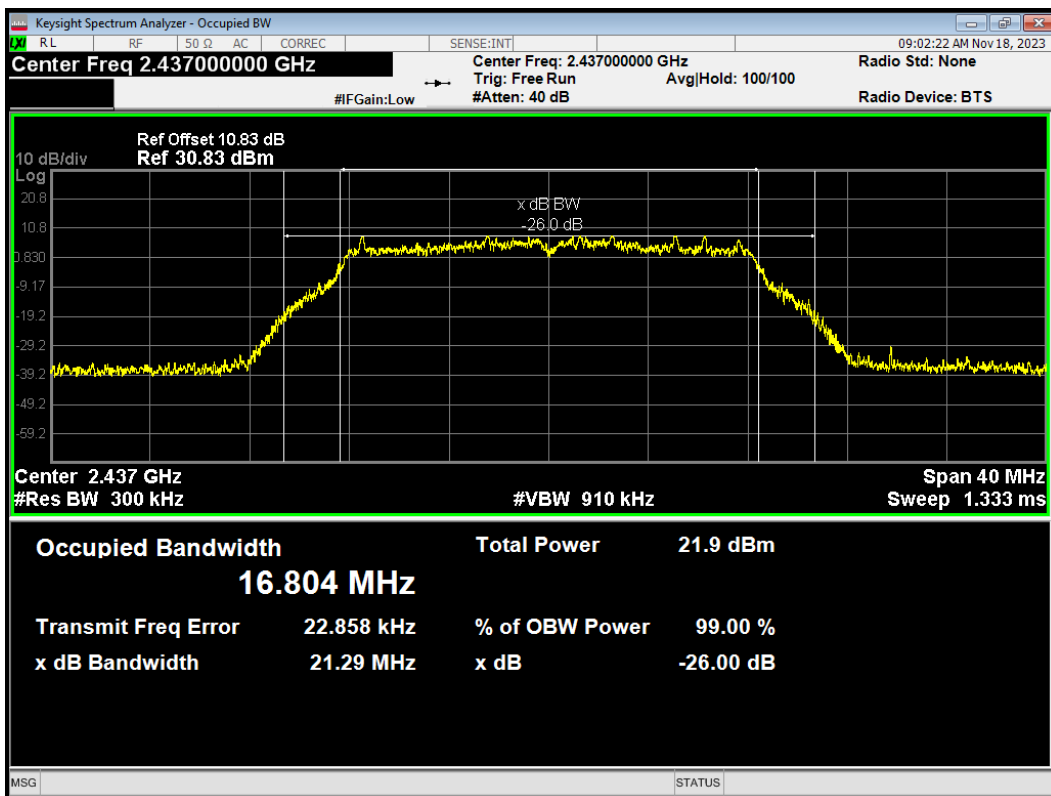
OBW 802.11b 2462MHz



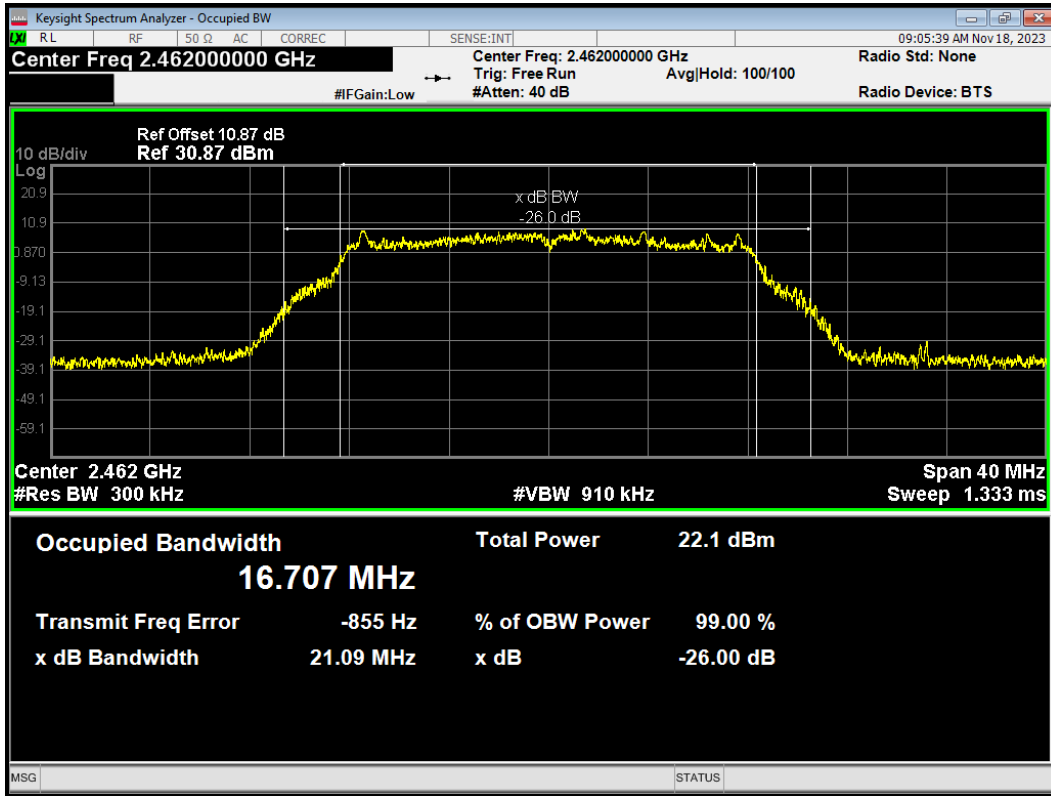
OBW 802.11g 2412MHz



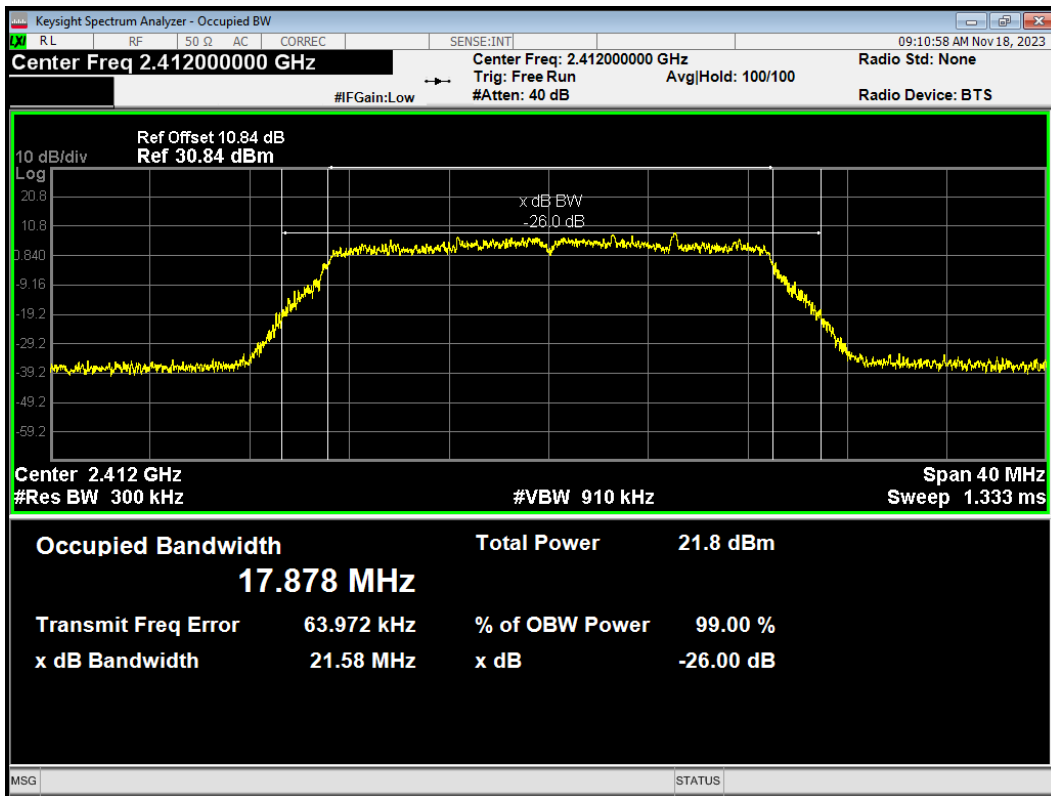
OBW 802.11g 2437MHz



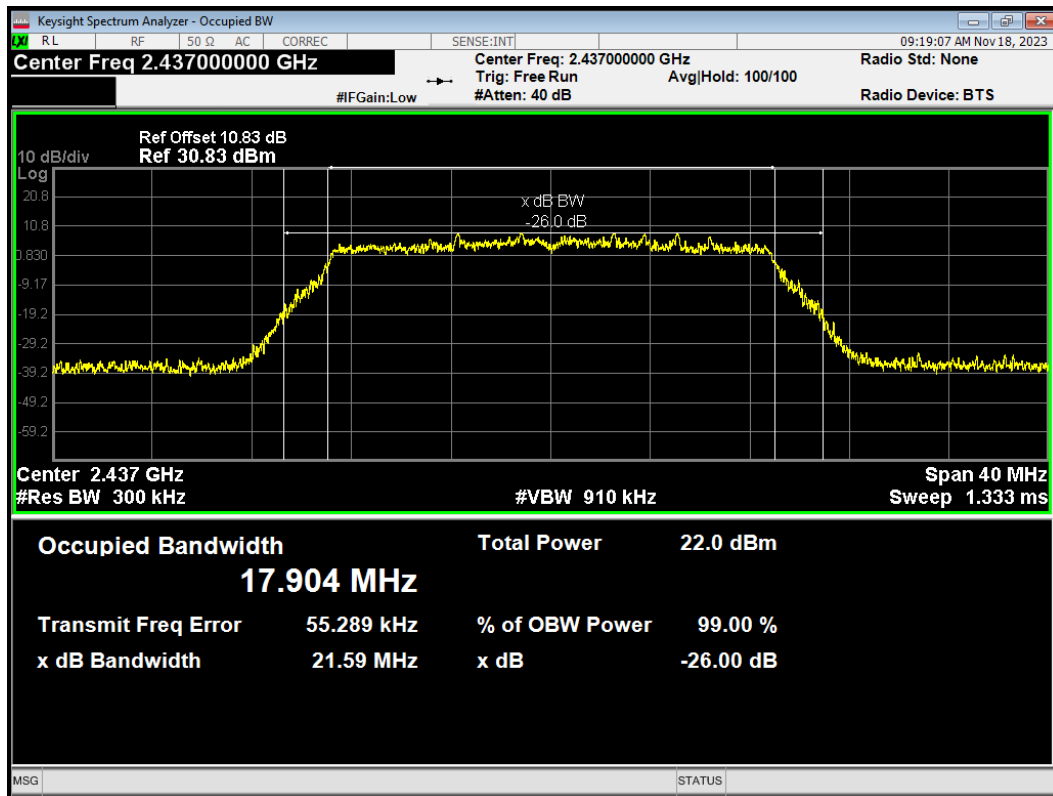
OBW 802.11g 2462MHz



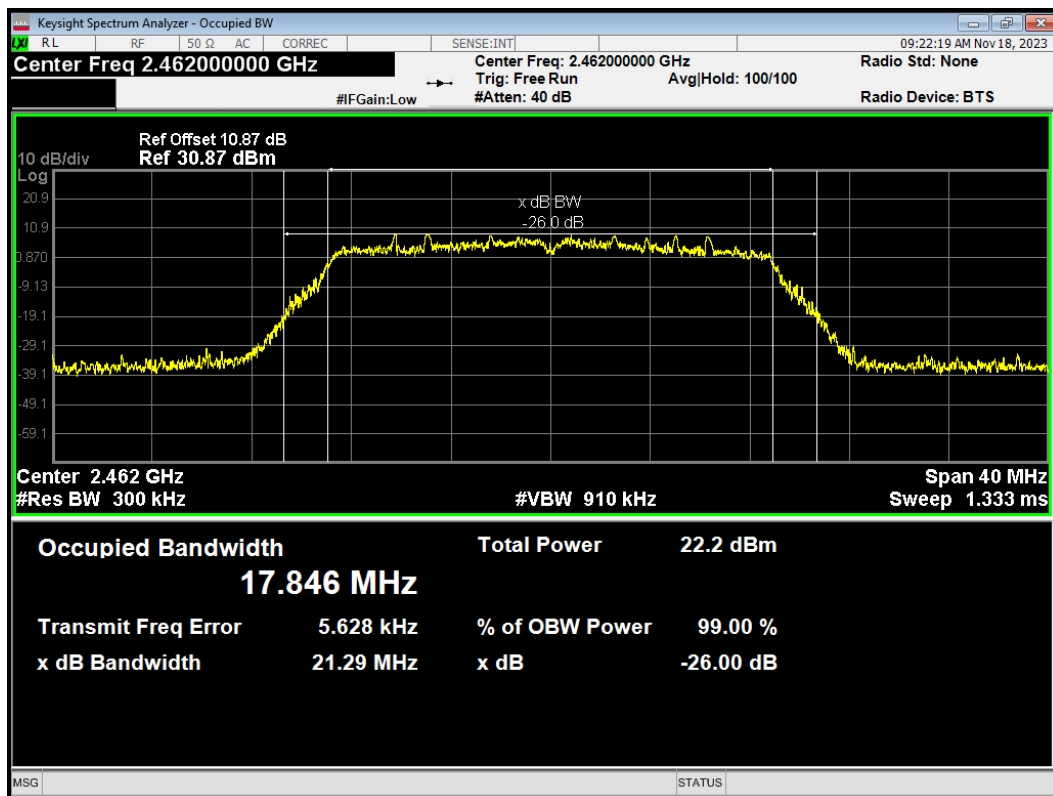
OBW 802.11n(HT20) 2412MHz



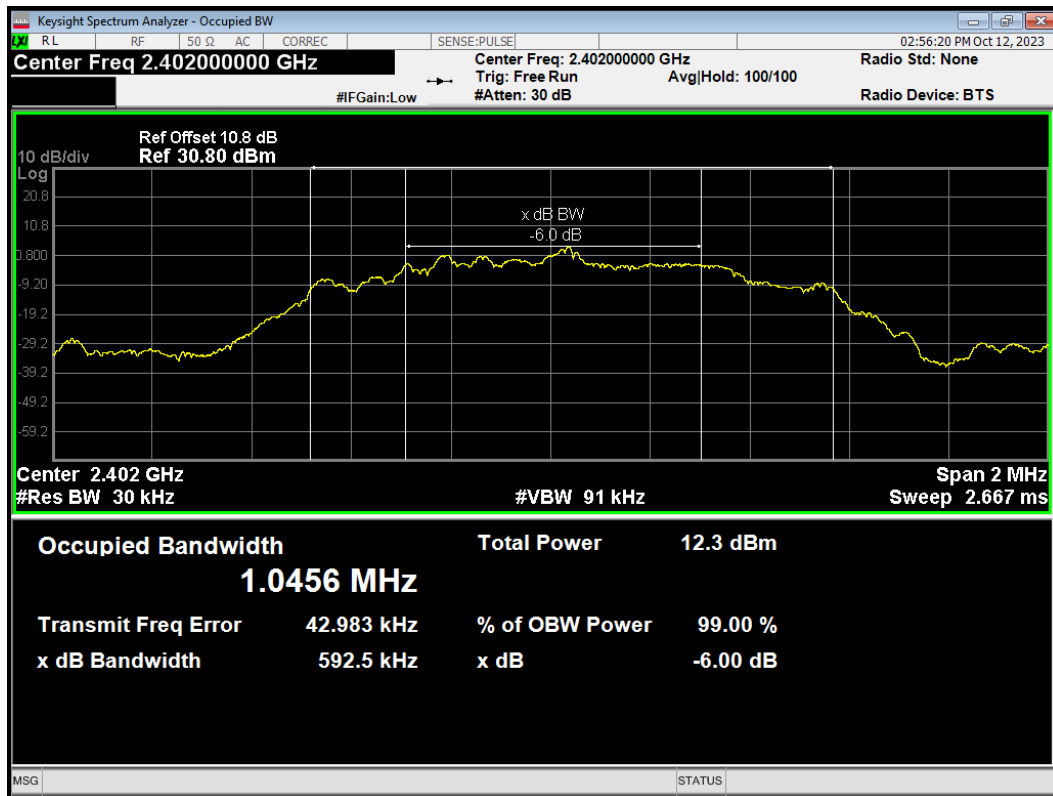
OBW 802.11n(HT20) 2437MHz



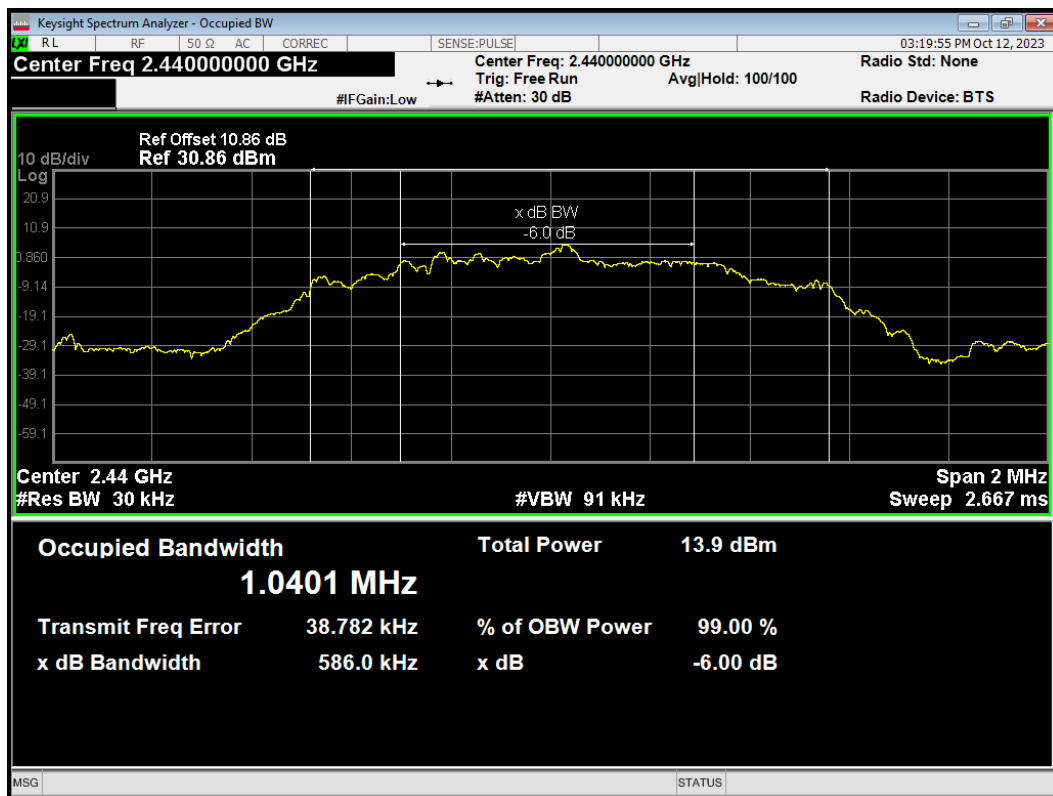
OBW 802.11n(HT20) 2462MHz



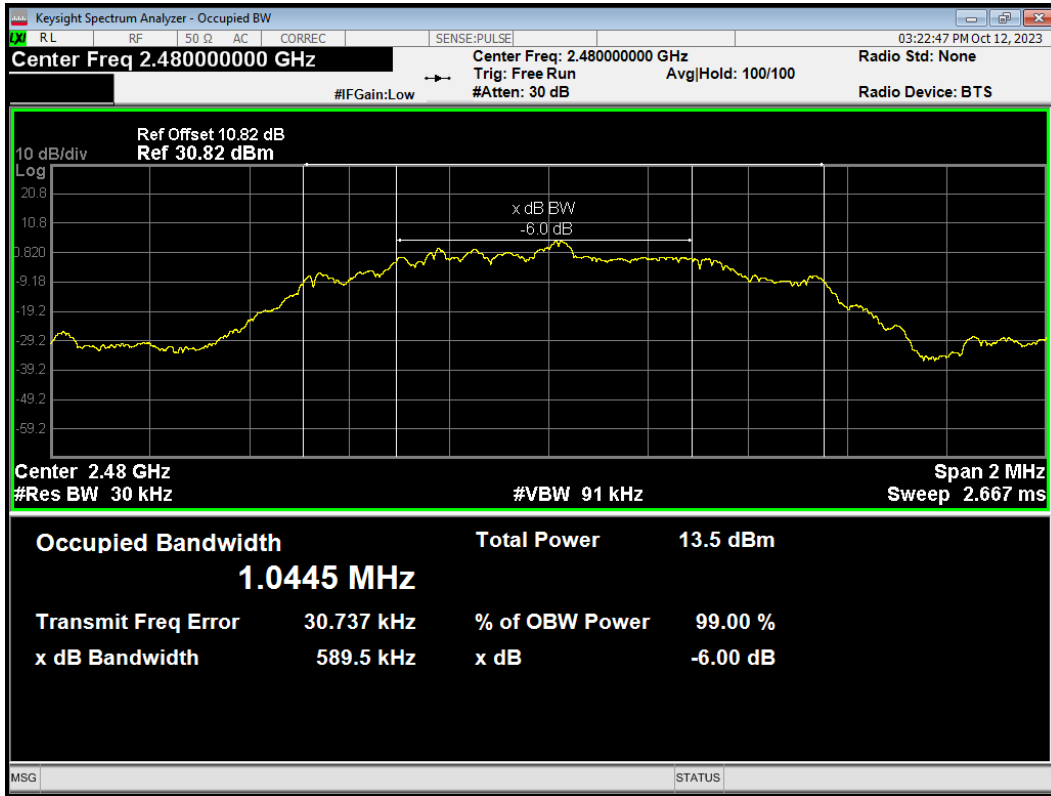
OBW Bluetooth LE(1M)2402MHz



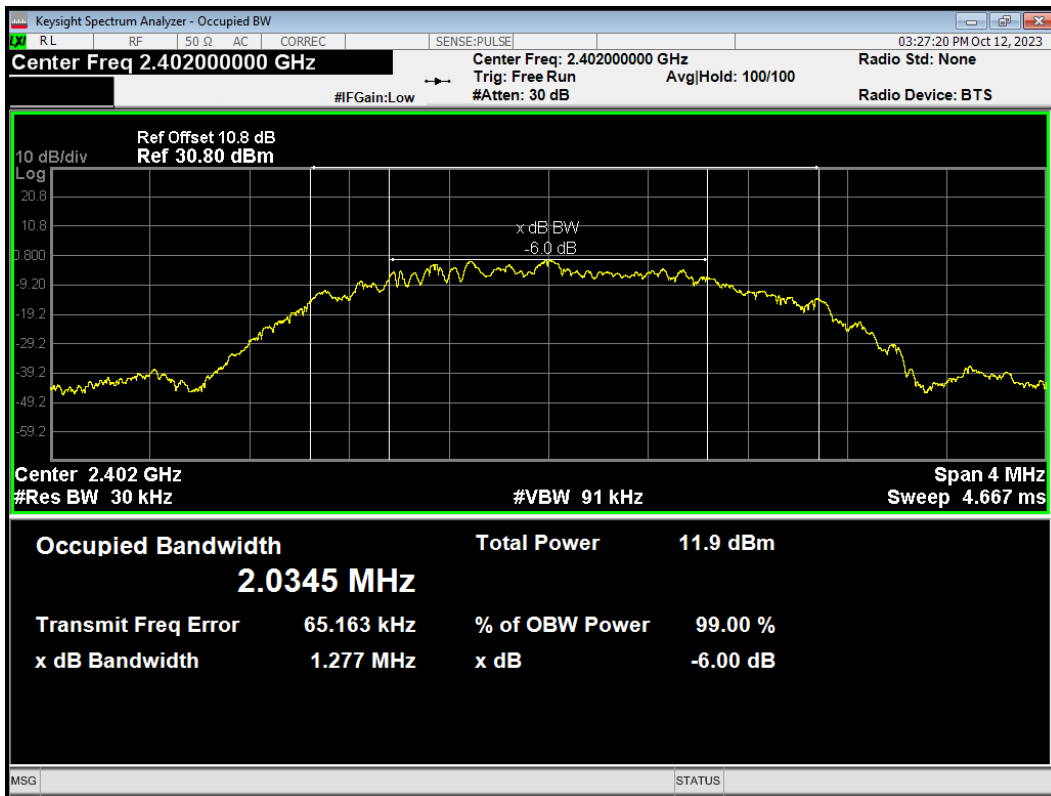
OBW Bluetooth LE(1M)2440MHz



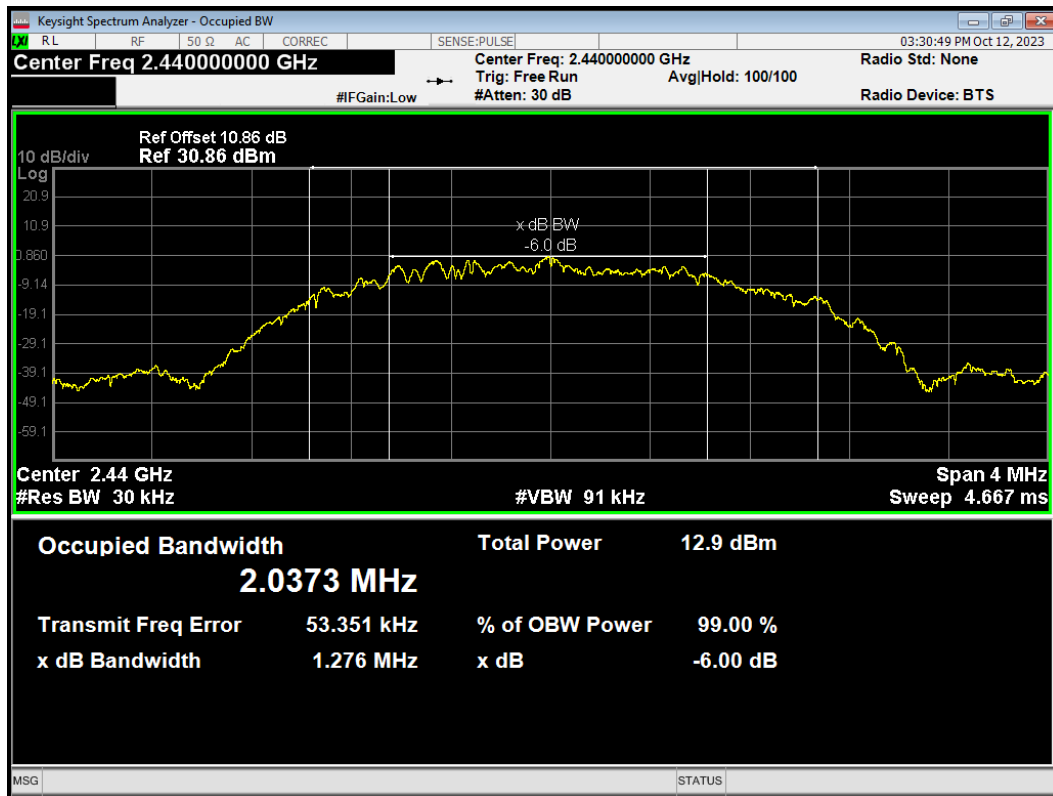
OBW Bluetooth LE(1M)2480MHz



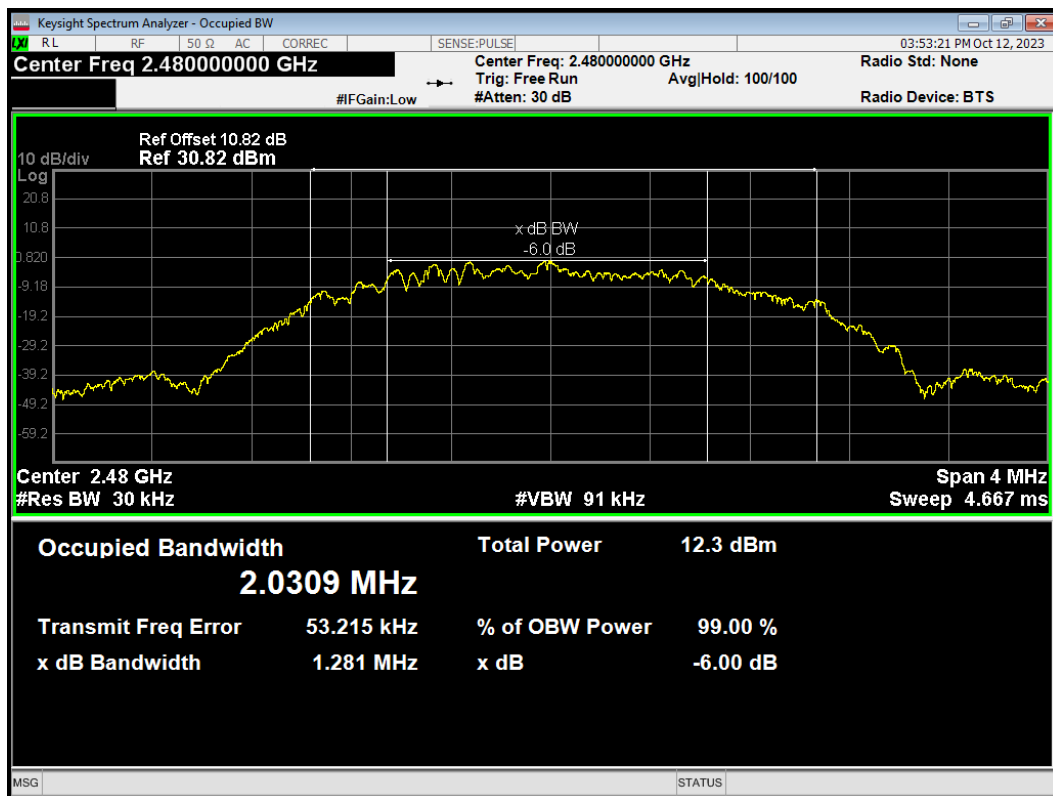
OBW Bluetooth LE(2M) 2402MHz



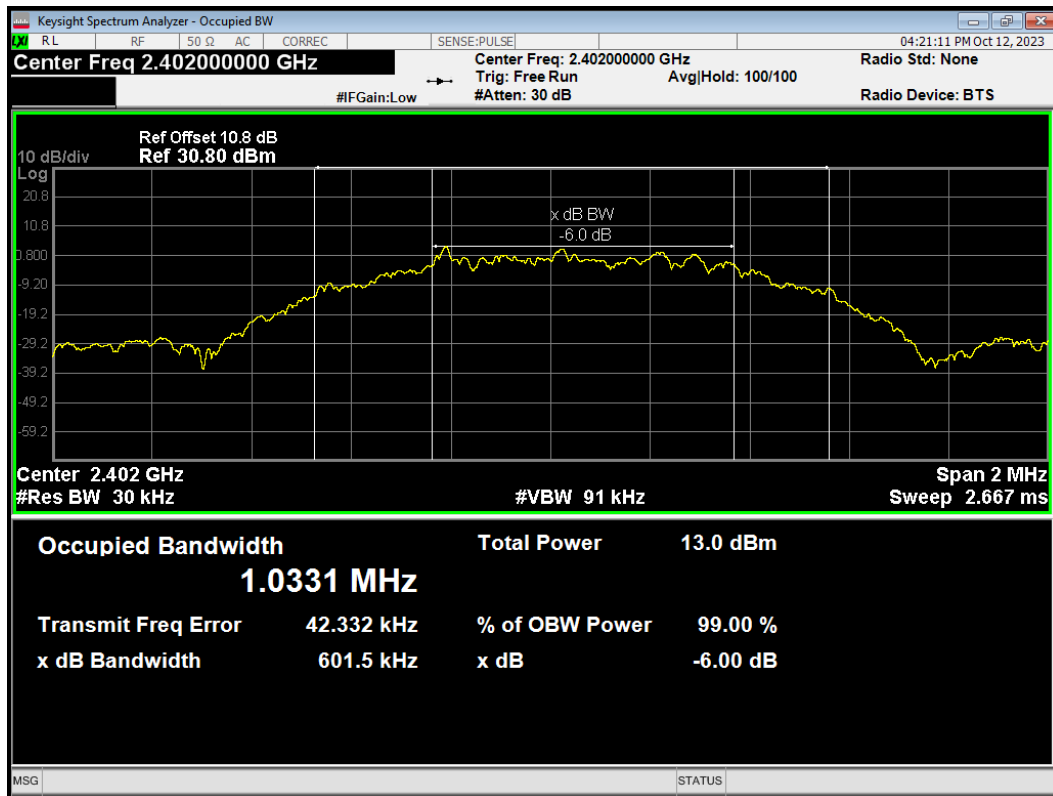
OBW Bluetooth LE(2M) 2440MHz



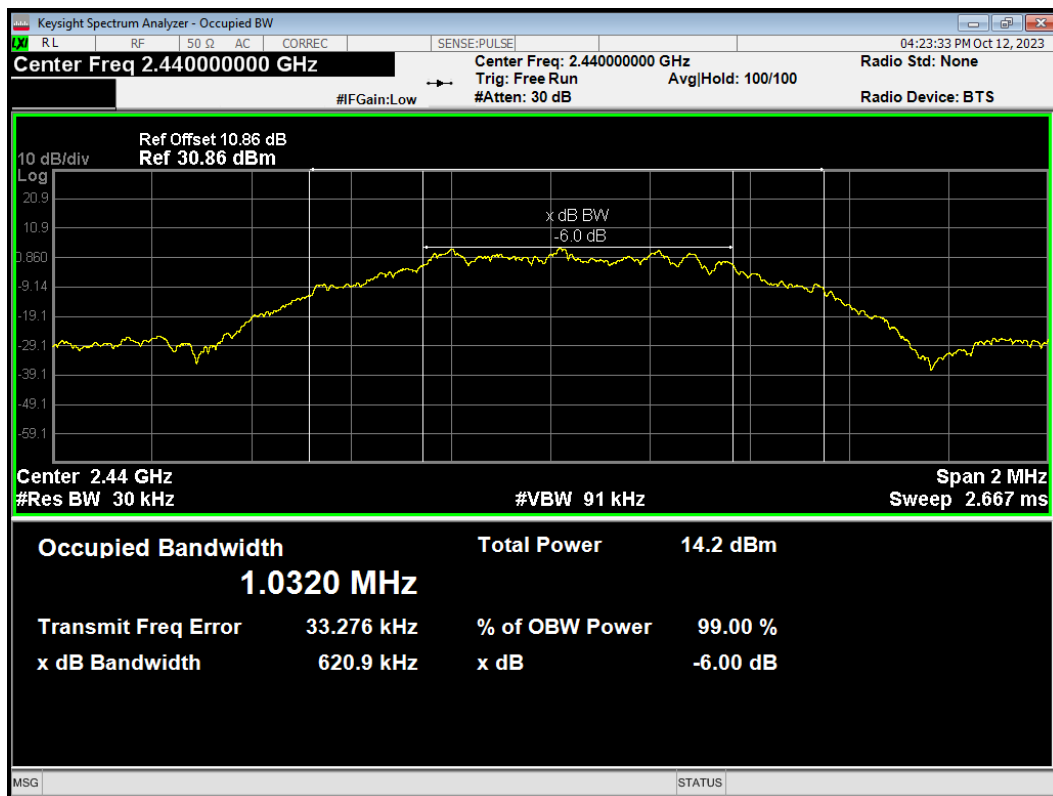
OBW Bluetooth LE(2M) 2480MHz



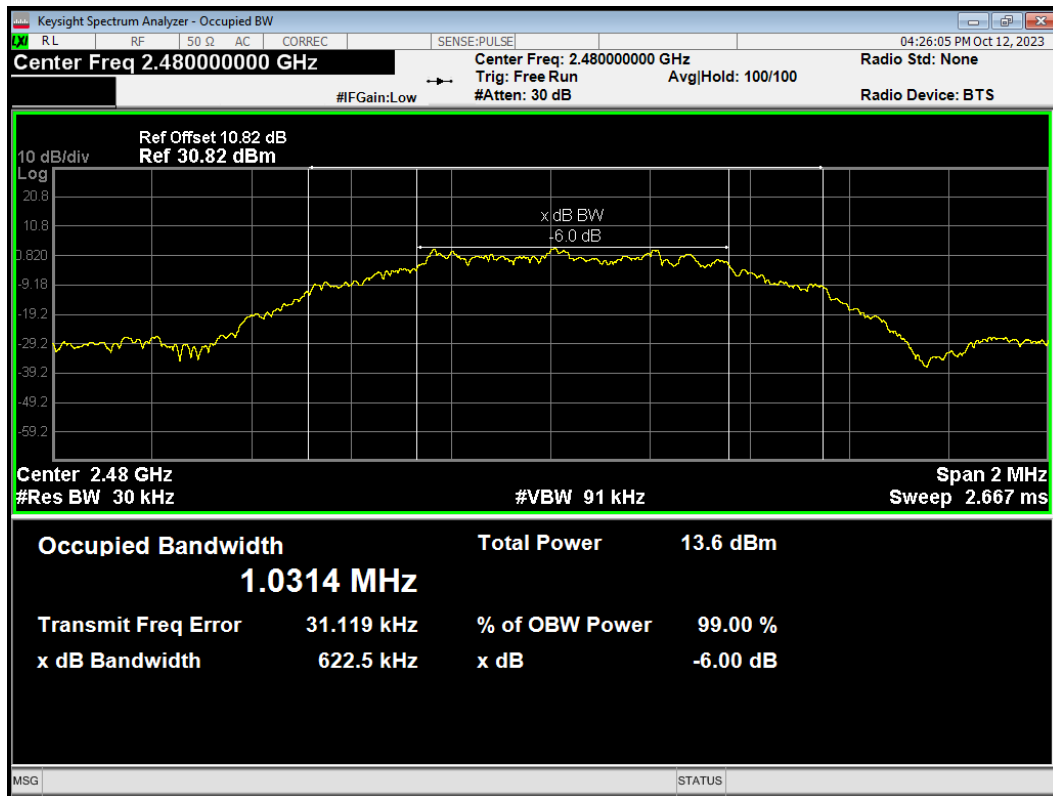
OBW Bluetooth LE(S=2) 2402MHz



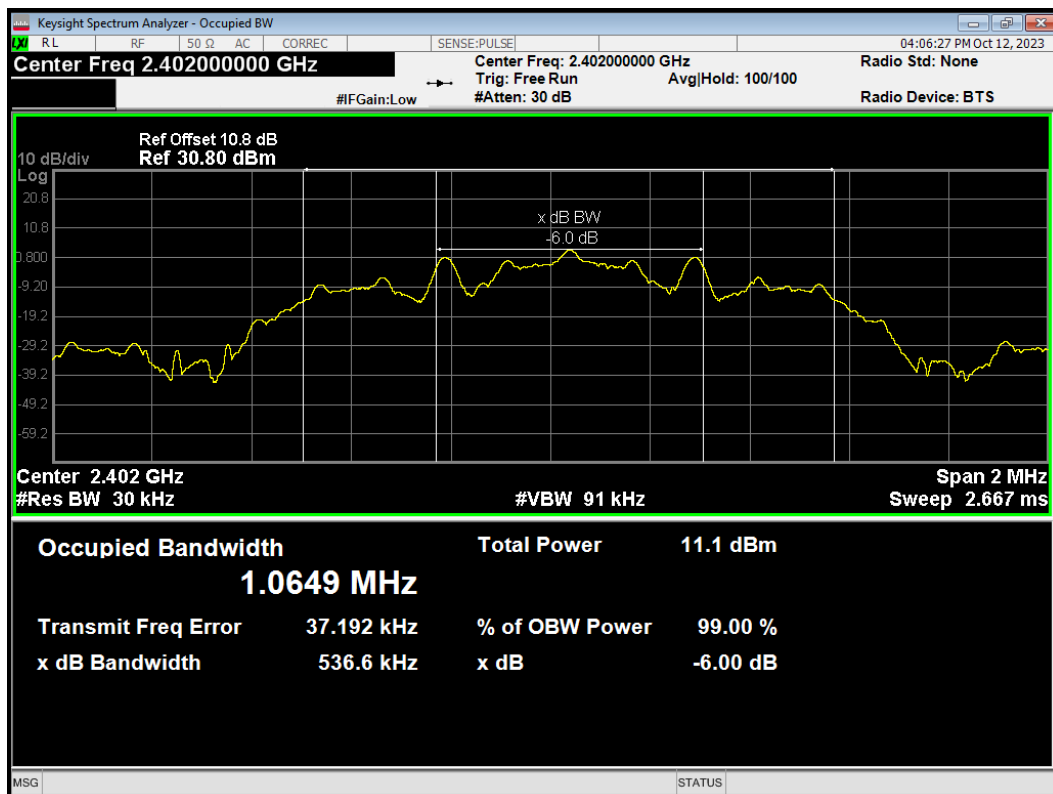
OBW Bluetooth LE(S=2) 2440MHz



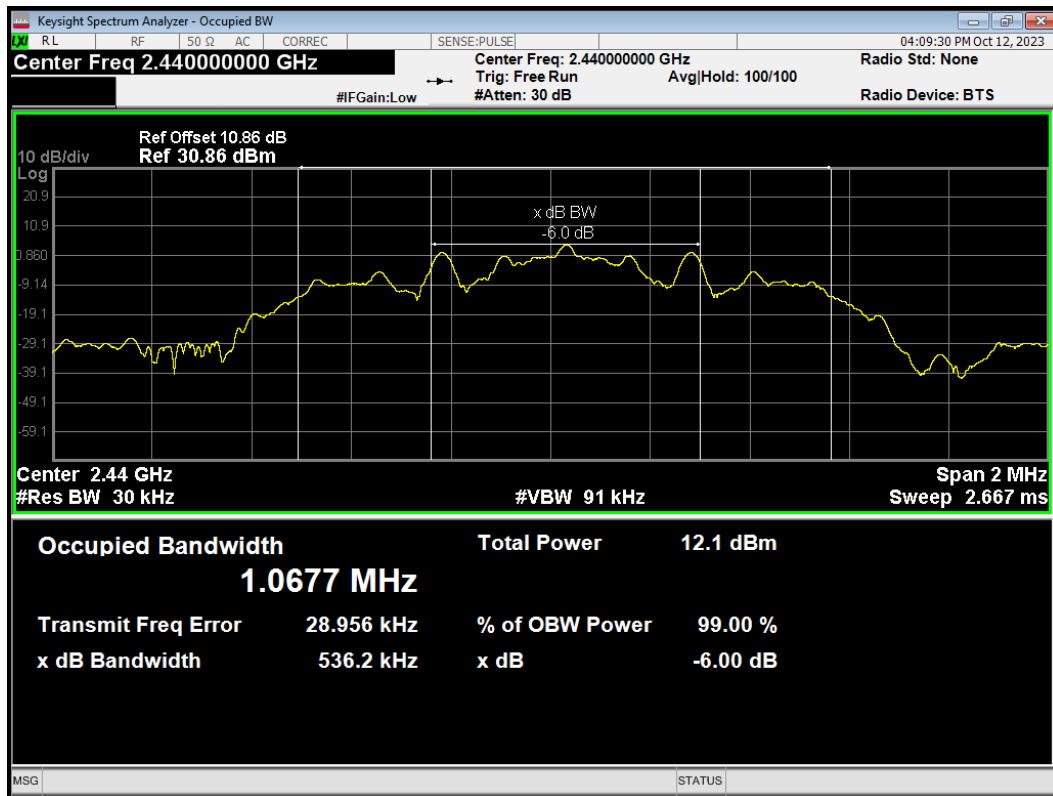
OBW Bluetooth LE(S=2) 2480MHz



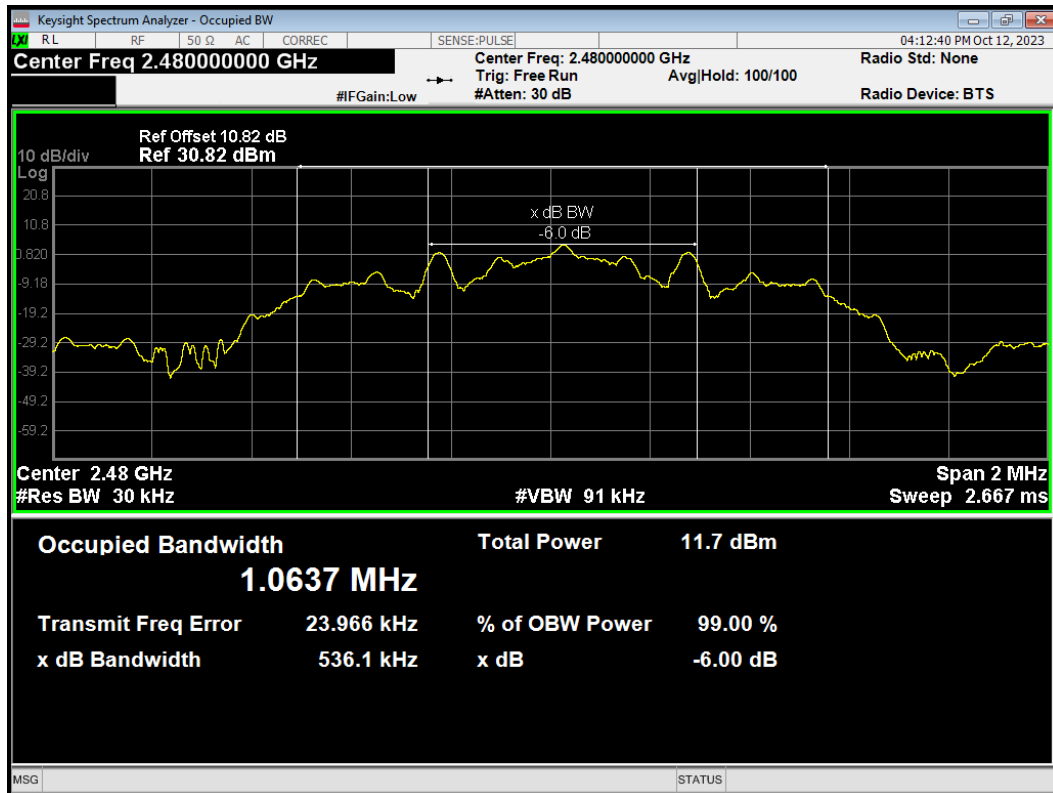
OBW Bluetooth LE(S=8) 2402MHz



OBW Bluetooth LE(S=8) 2440MHz

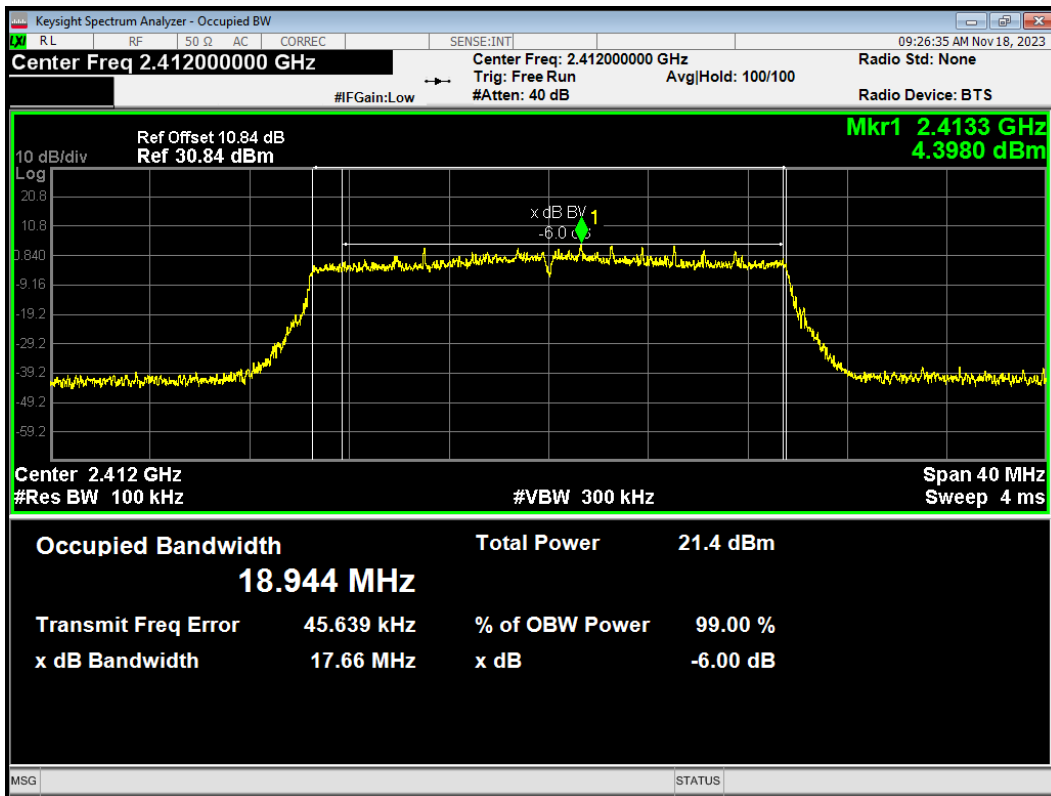


OBW Bluetooth LE(S=8) 2480MHz

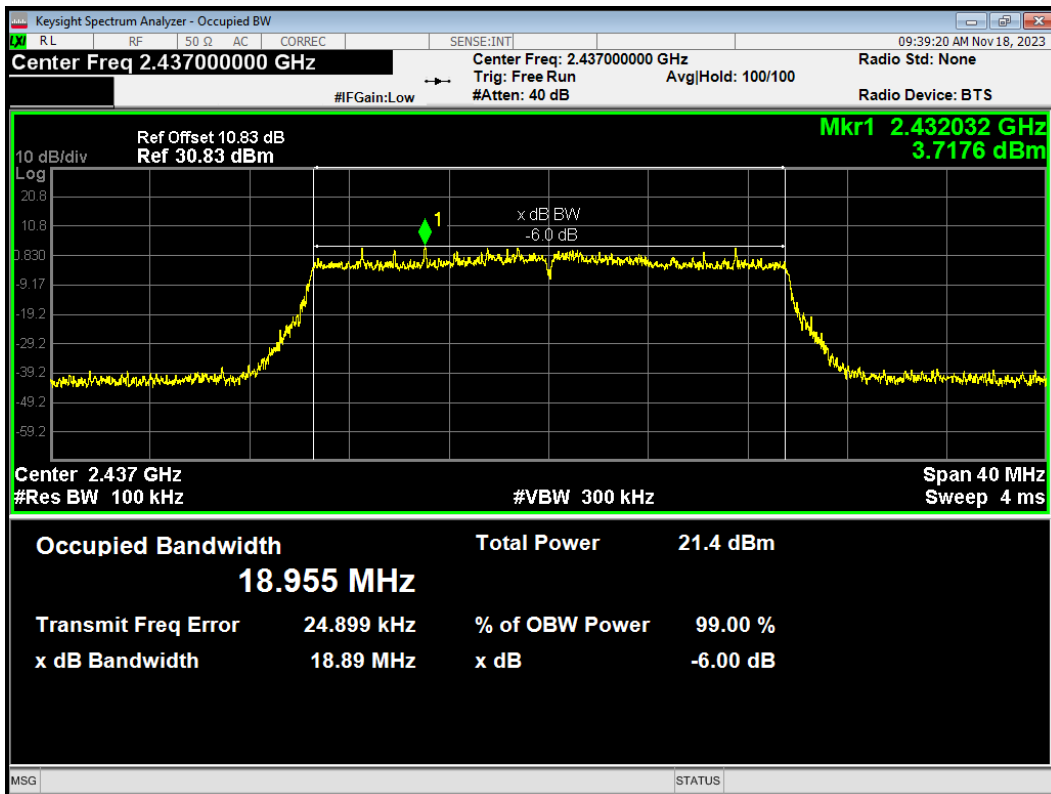


6 dB bandwidth

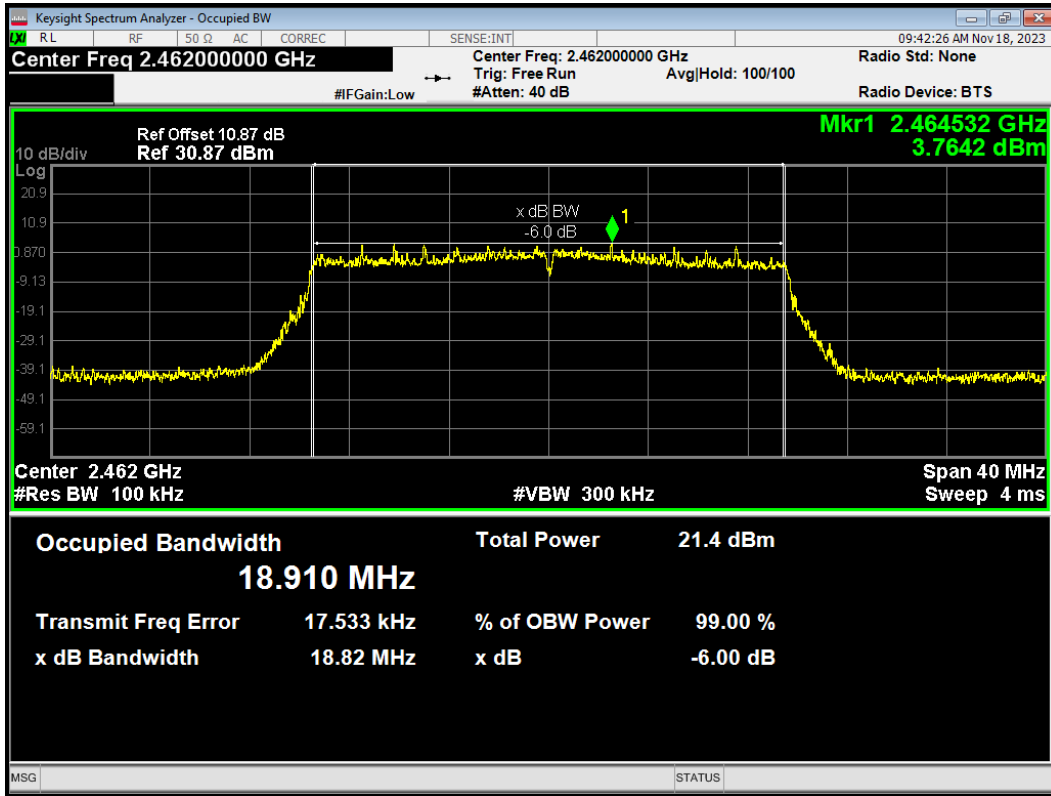
-6dB Bandwidth 802.11ax(HE20) 2412MHz



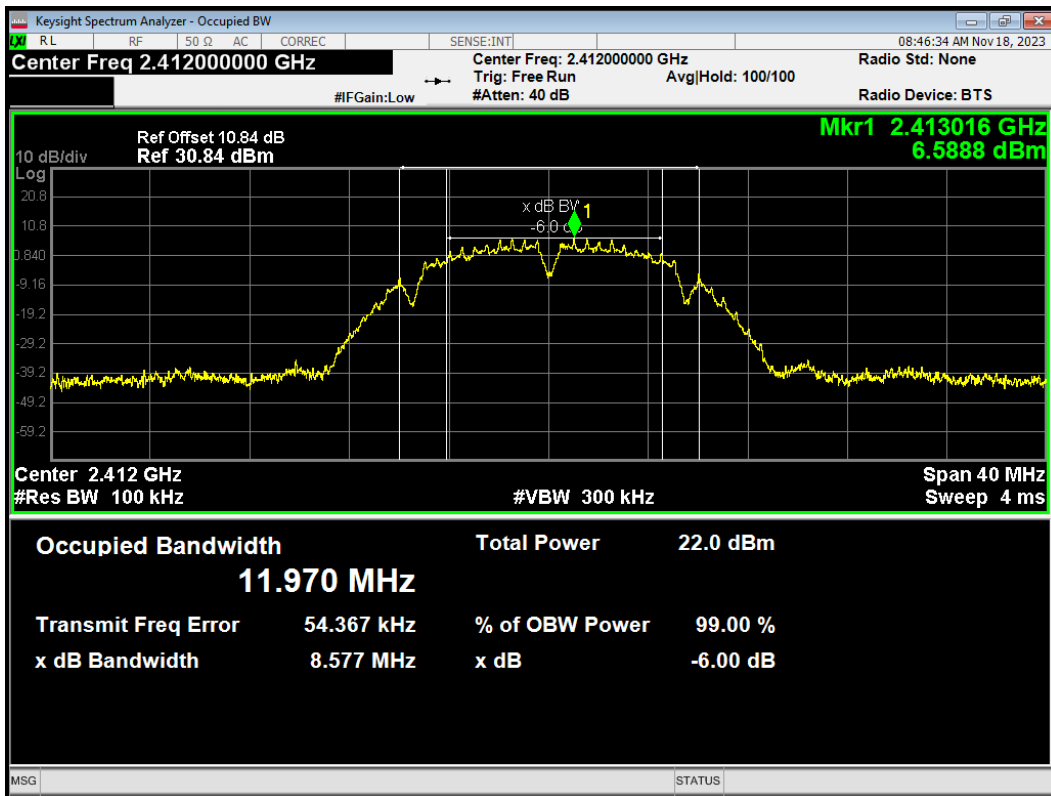
-6dB Bandwidth 802.11ax(HE20) 2437MHz



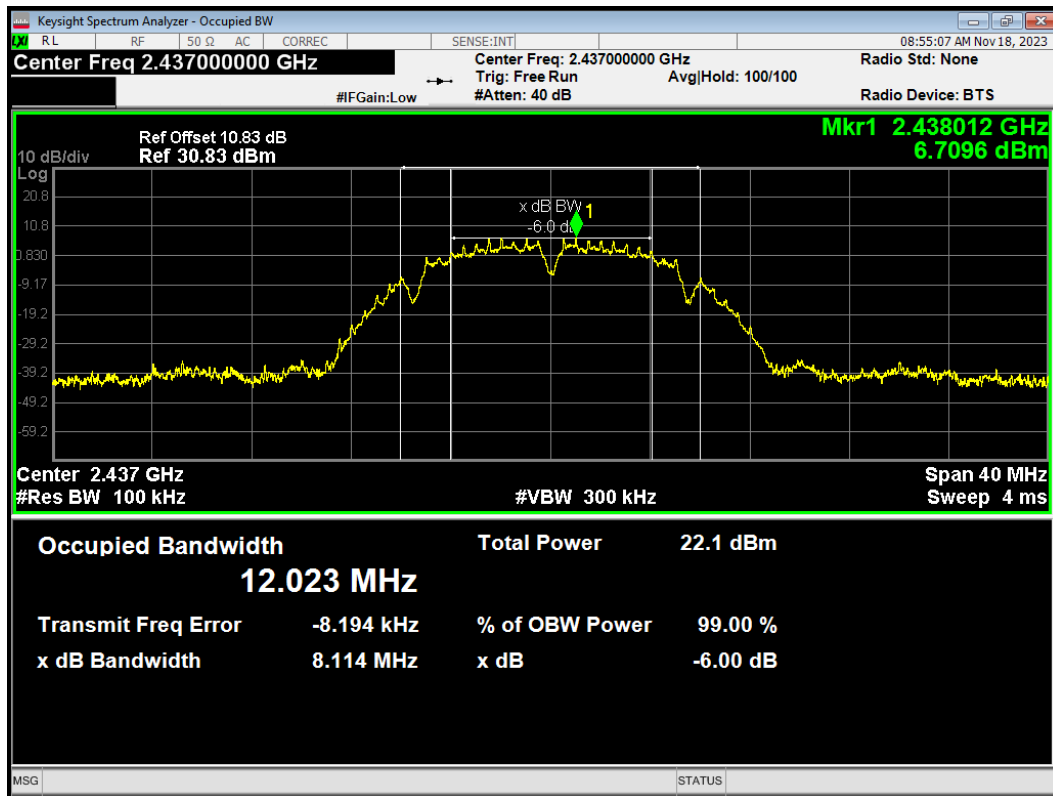
-6dB Bandwidth 802.11ax(HE20) 2462MHz



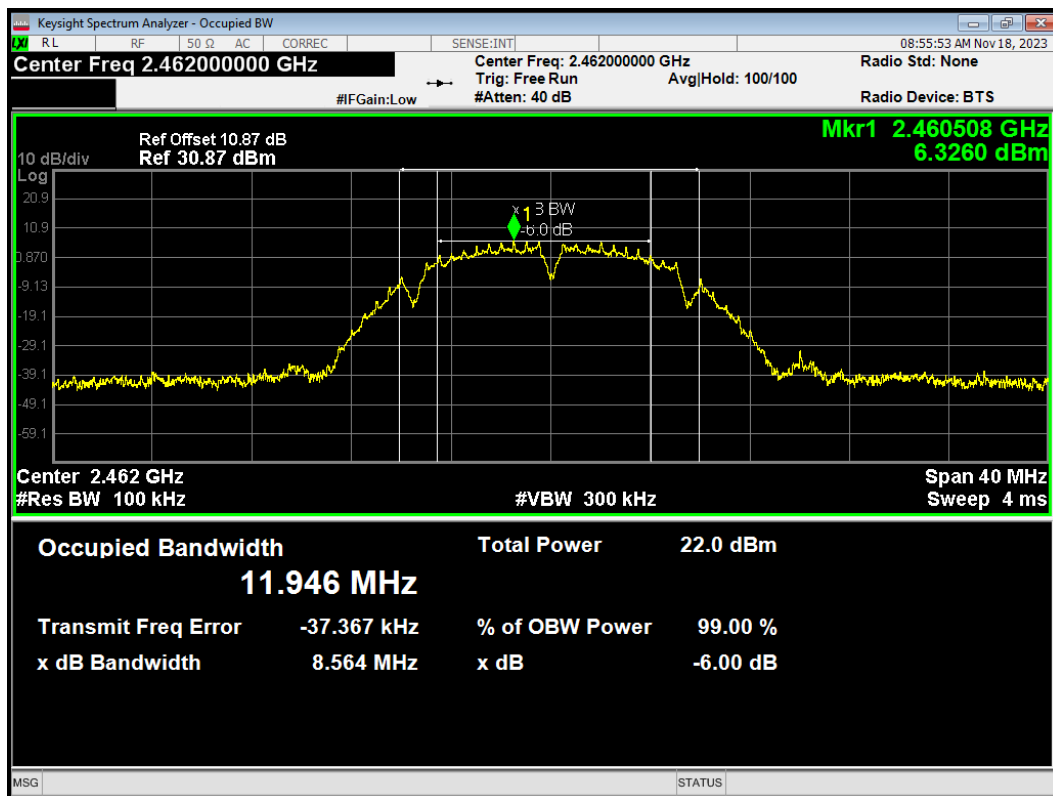
-6dB Bandwidth 802.11b 2412MHz



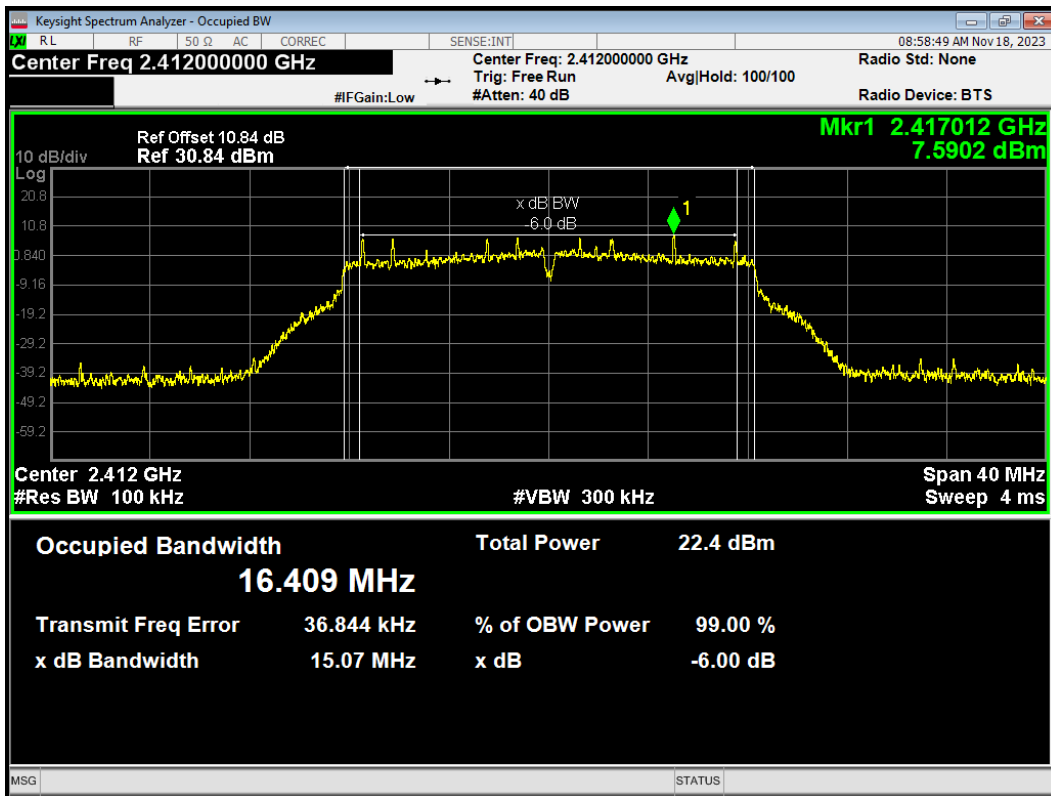
-6dB Bandwidth 802.11b 2437MHz



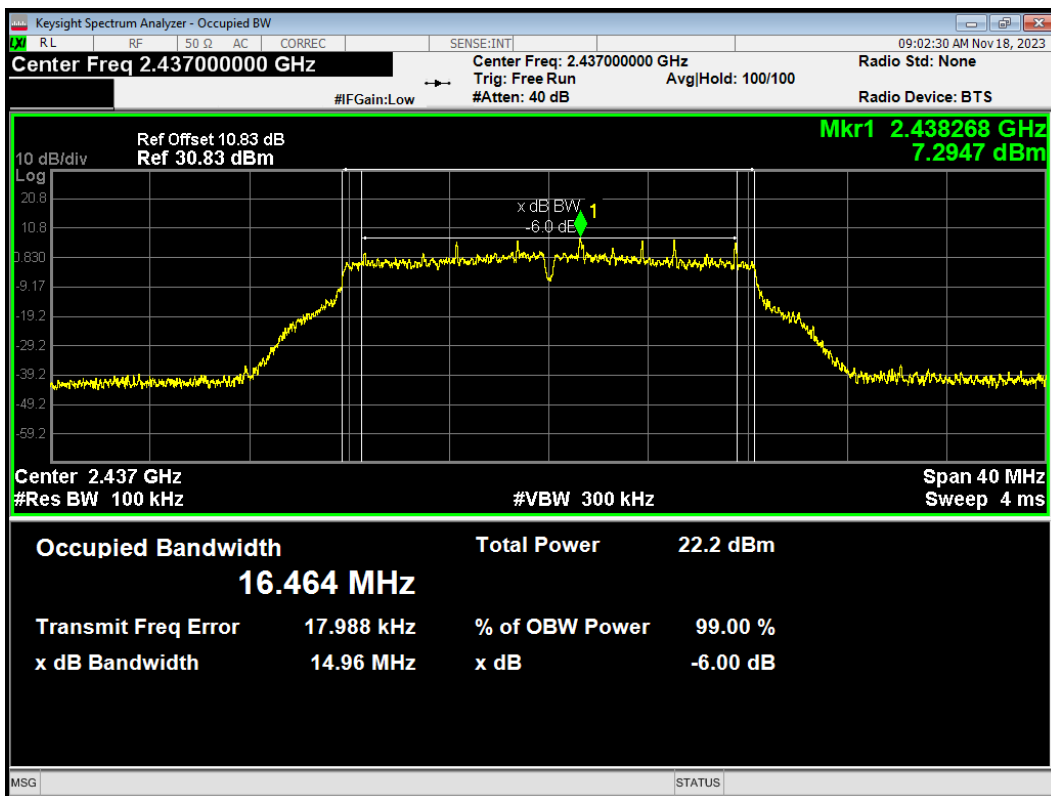
-6dB Bandwidth 802.11b 2462MHz



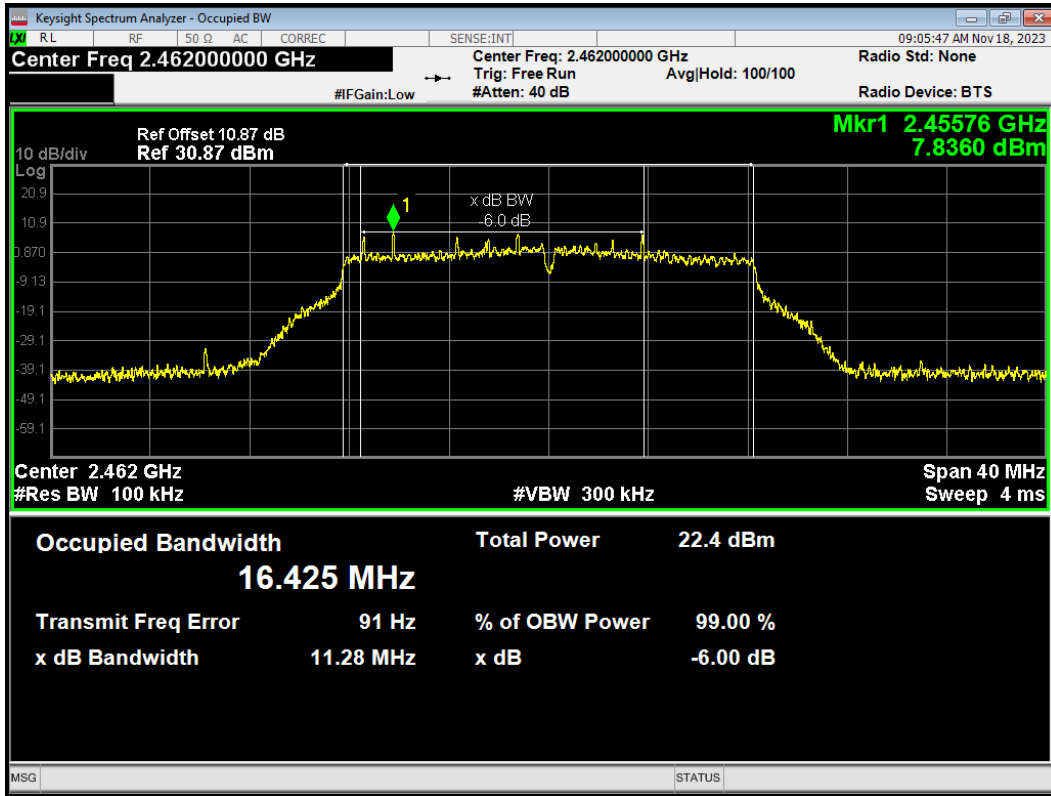
-6dB Bandwidth 802.11g 2412MHz



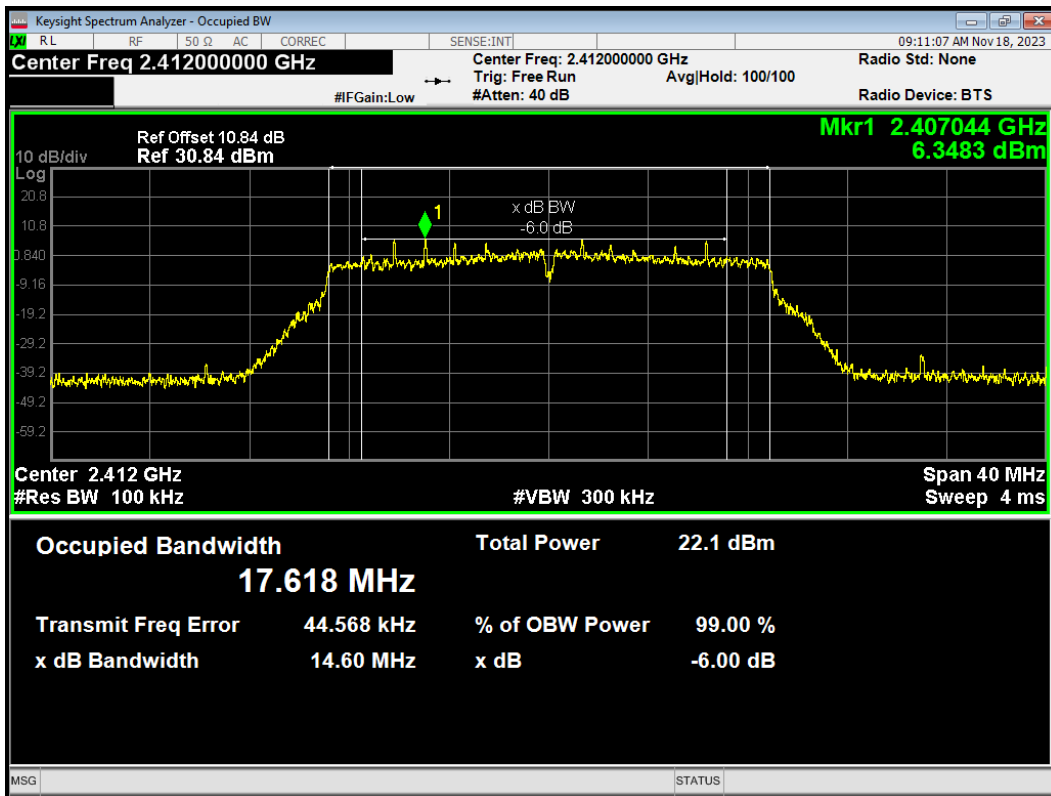
-6dB Bandwidth 802.11g 2437MHz



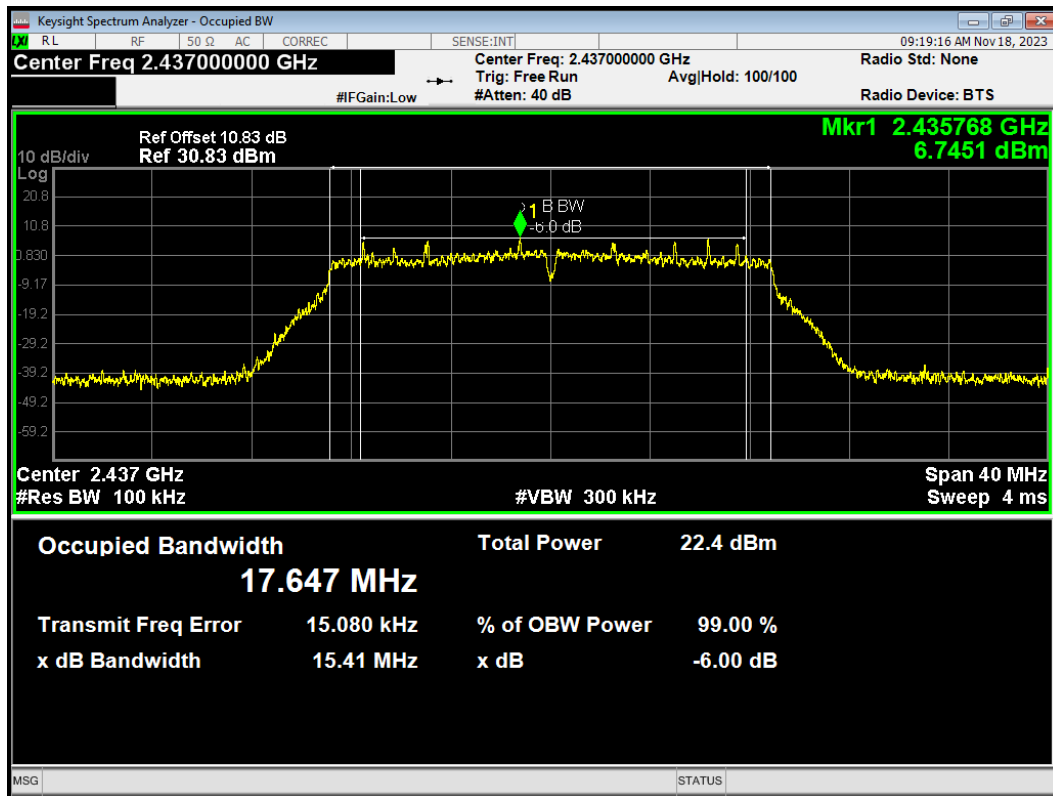
-6dB Bandwidth 802.11g 2462MHz



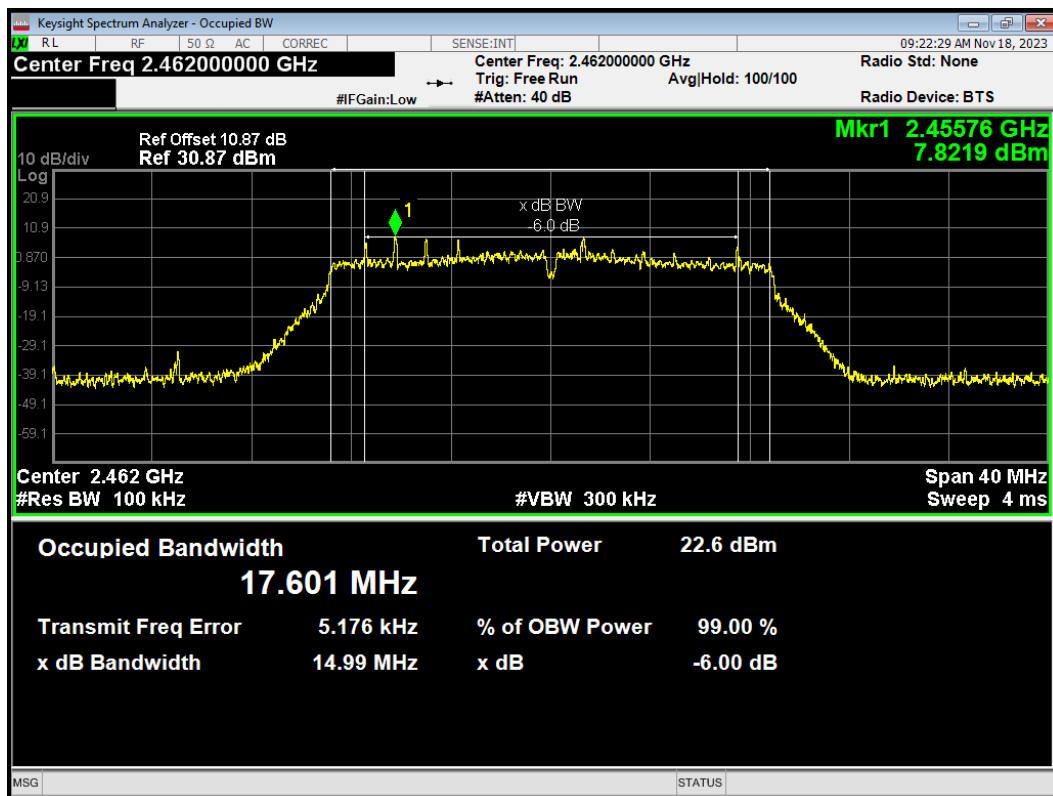
-6dB Bandwidth 802.11n(HT20) 2412MHz



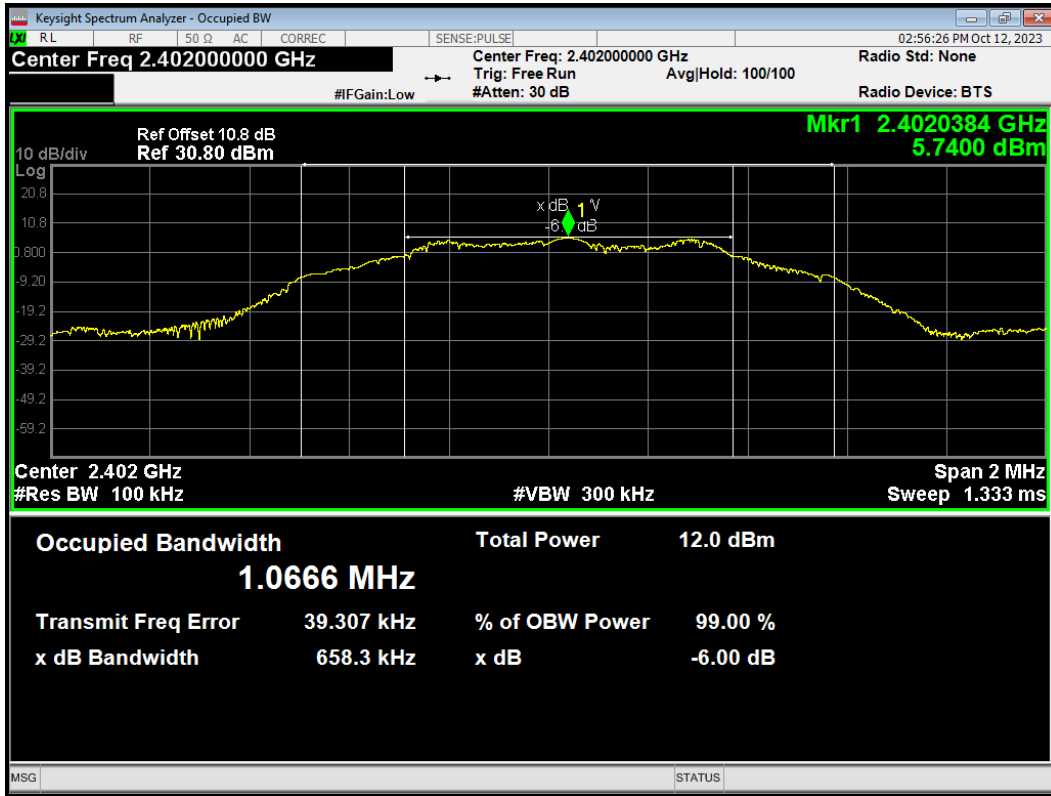
-6dB Bandwidth 802.11n(HT20) 2437MHz



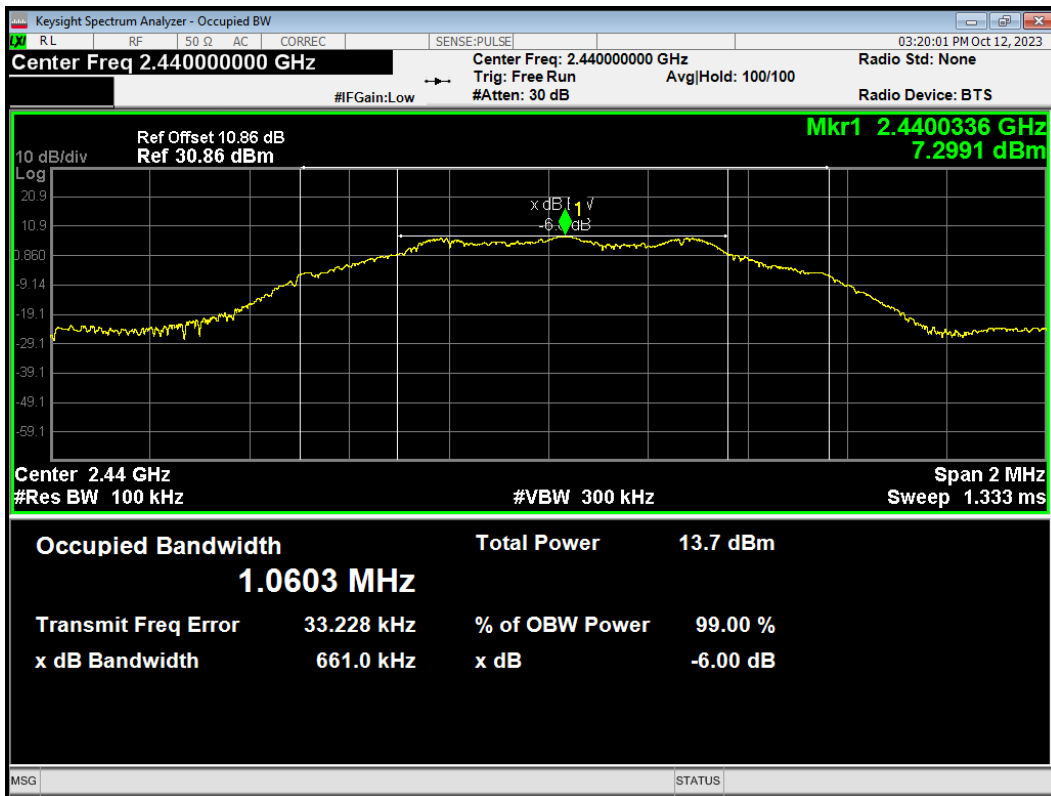
-6dB Bandwidth 802.11n(HT20) 2462MHz



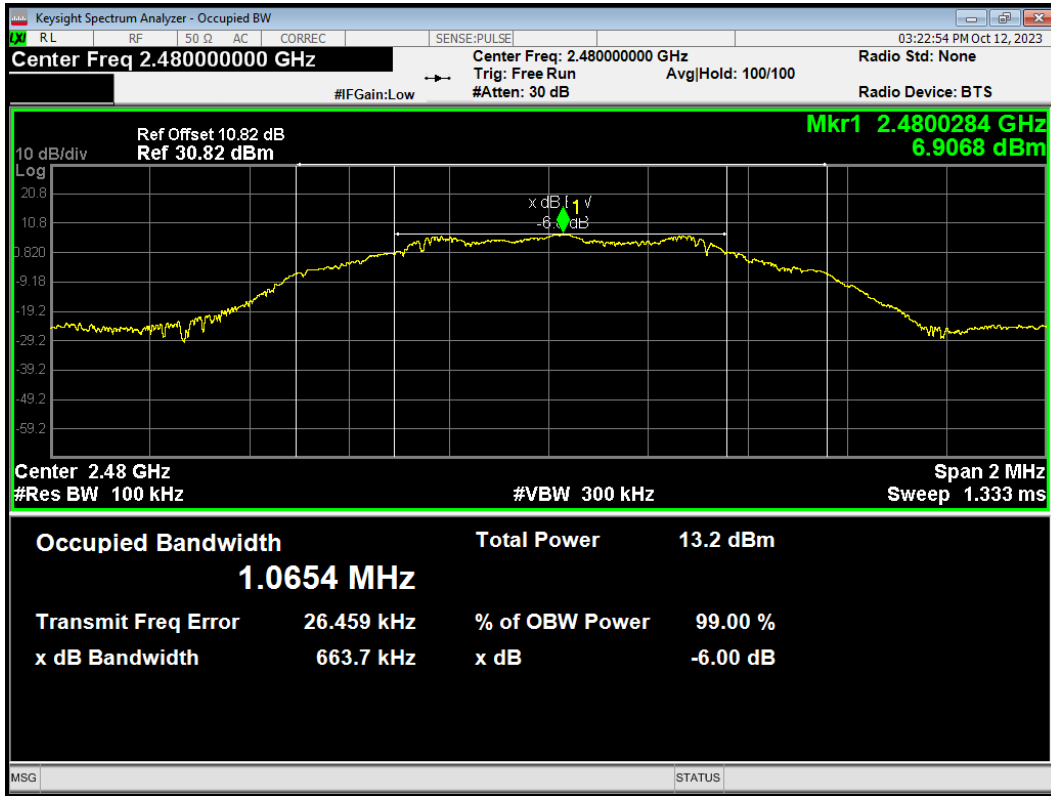
-6dB Bandwidth Bluetooth LE(1M)2402MHz



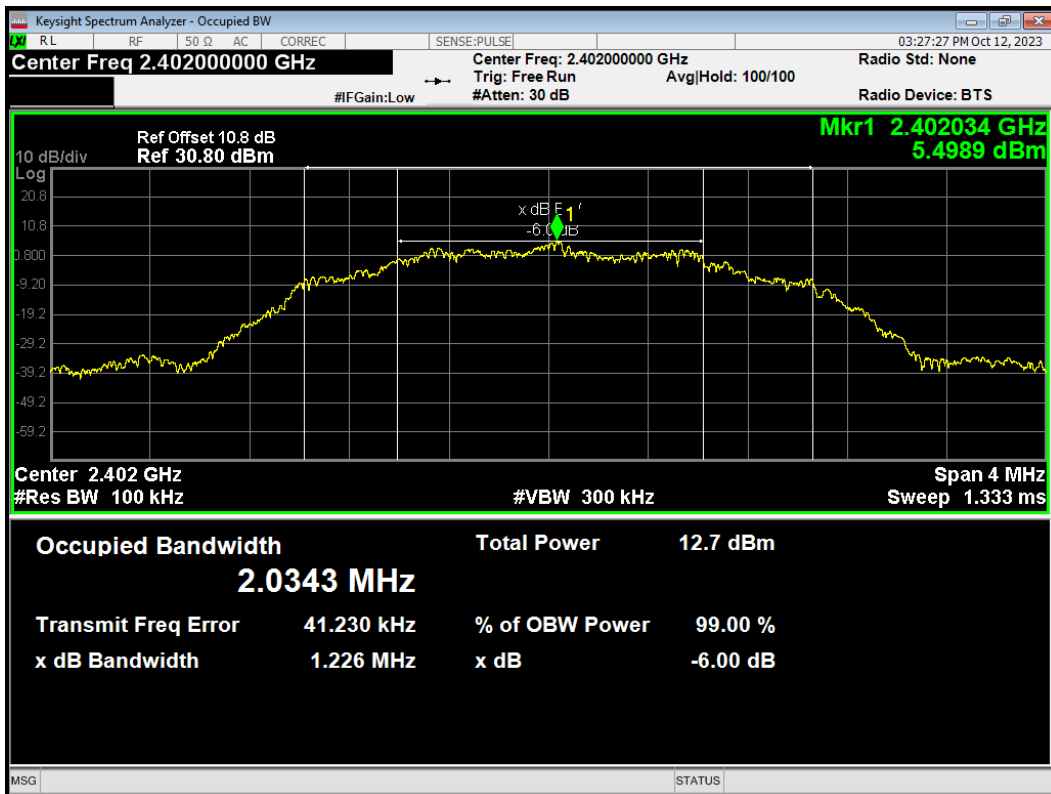
-6dB Bandwidth Bluetooth LE(1M)2440MHz



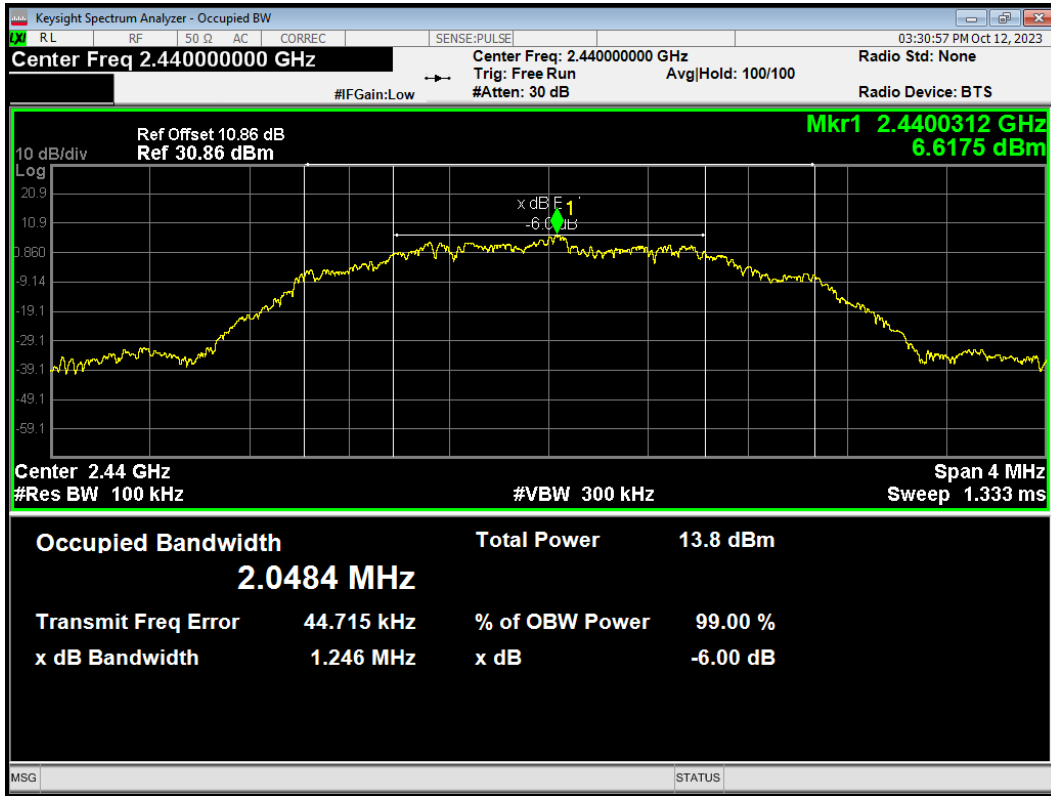
-6dB Bandwidth Bluetooth LE(1M)2480MHz



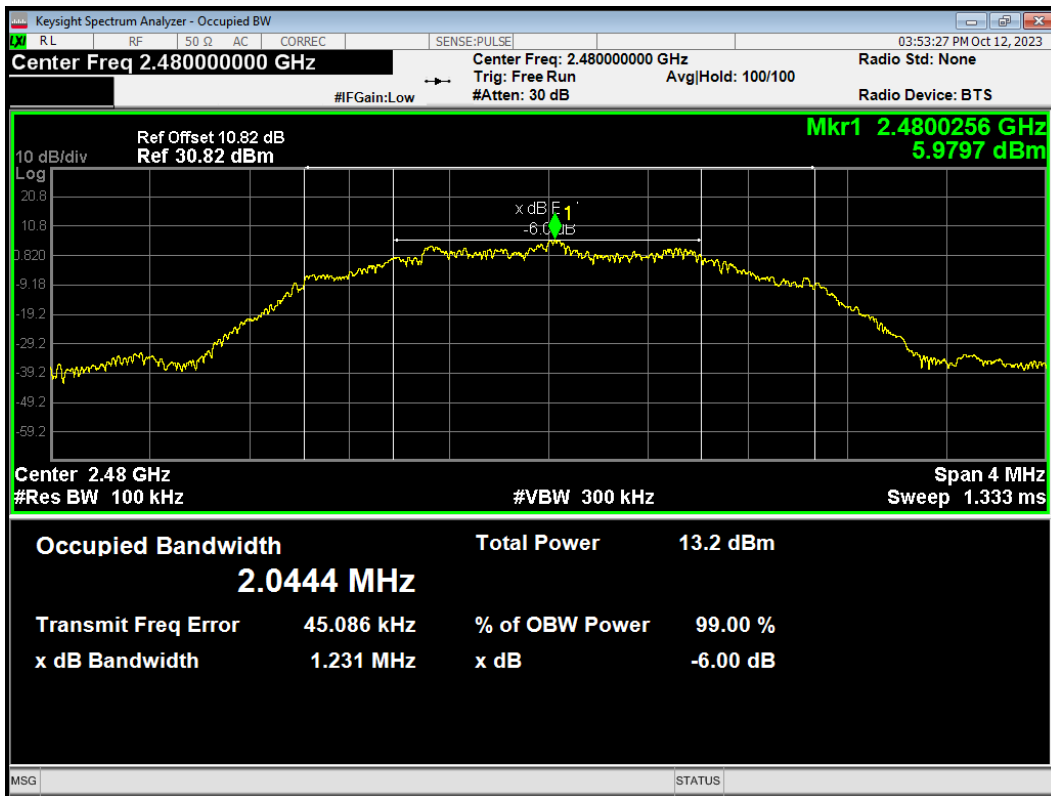
-6dB Bandwidth Bluetooth LE(2M) 2402MHz



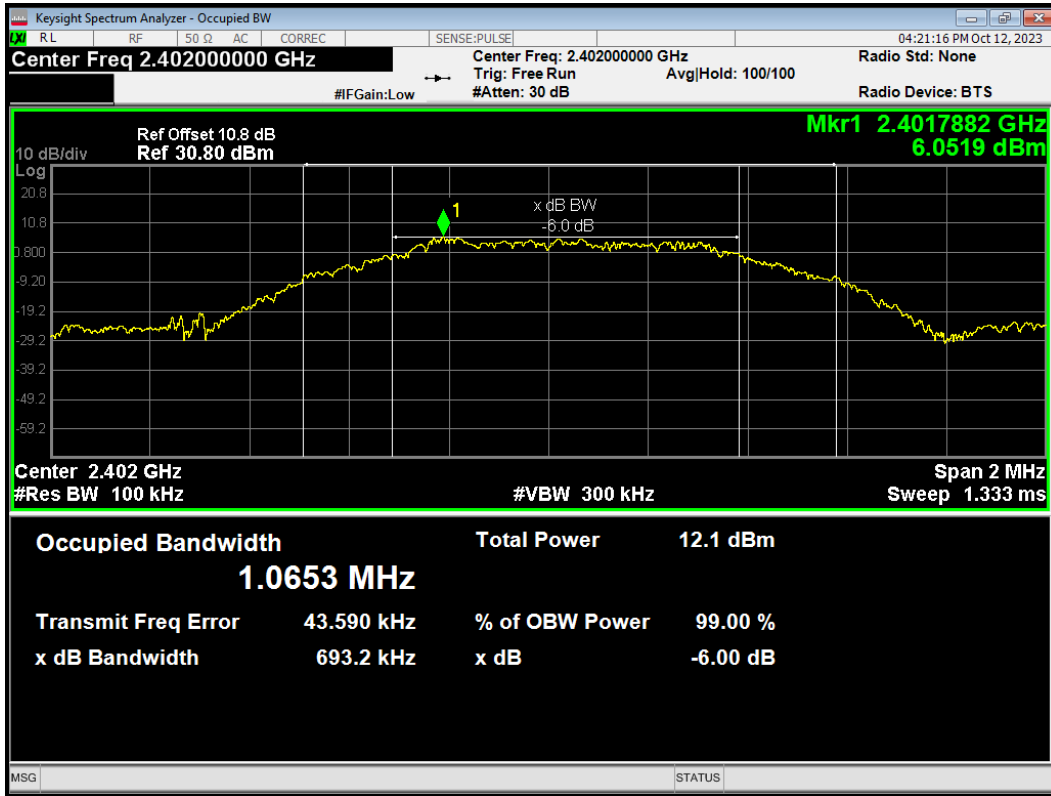
-6dB Bandwidth Bluetooth LE(2M) 2440MHz



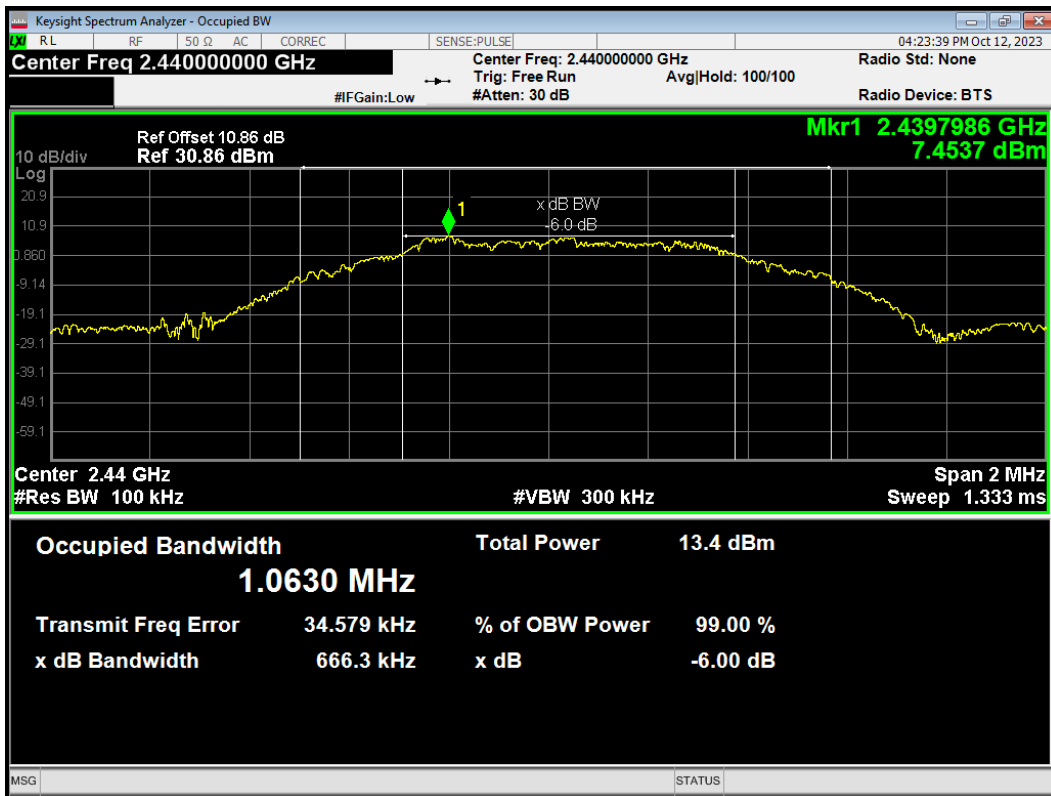
-6dB Bandwidth Bluetooth LE(2M) 2480MHz



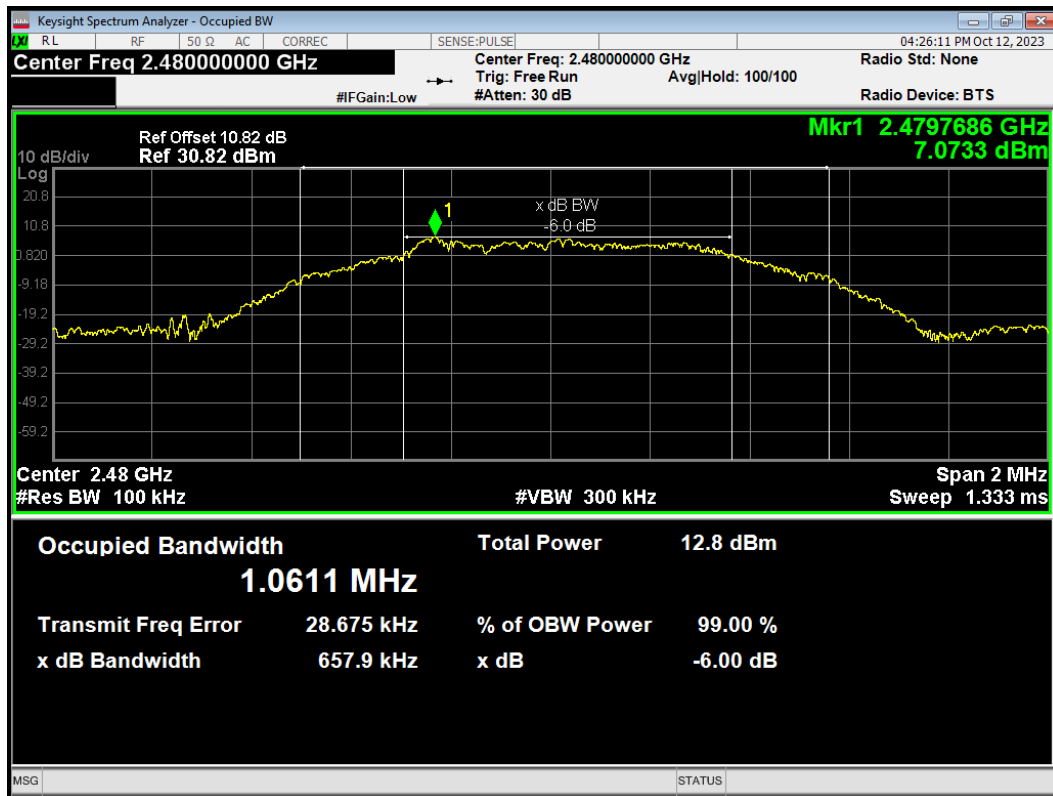
-6dB Bandwidth Bluetooth LE(S=2) 2402MHz



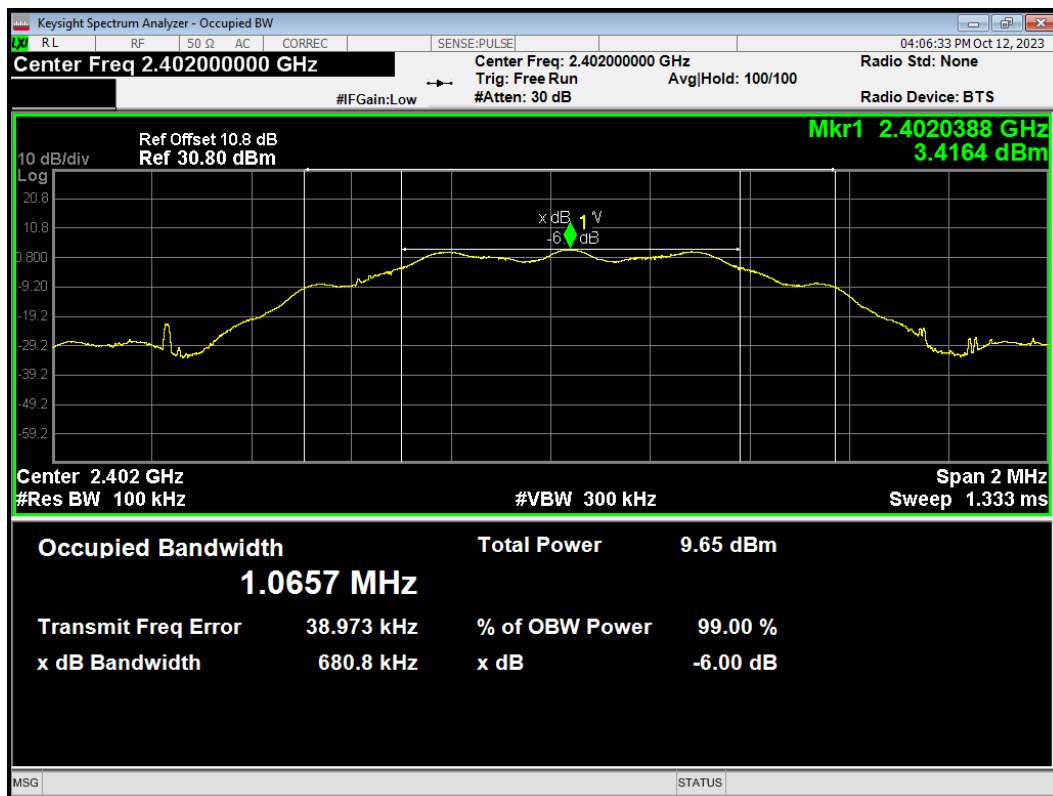
-6dB Bandwidth Bluetooth LE(S=2) 2440MHz



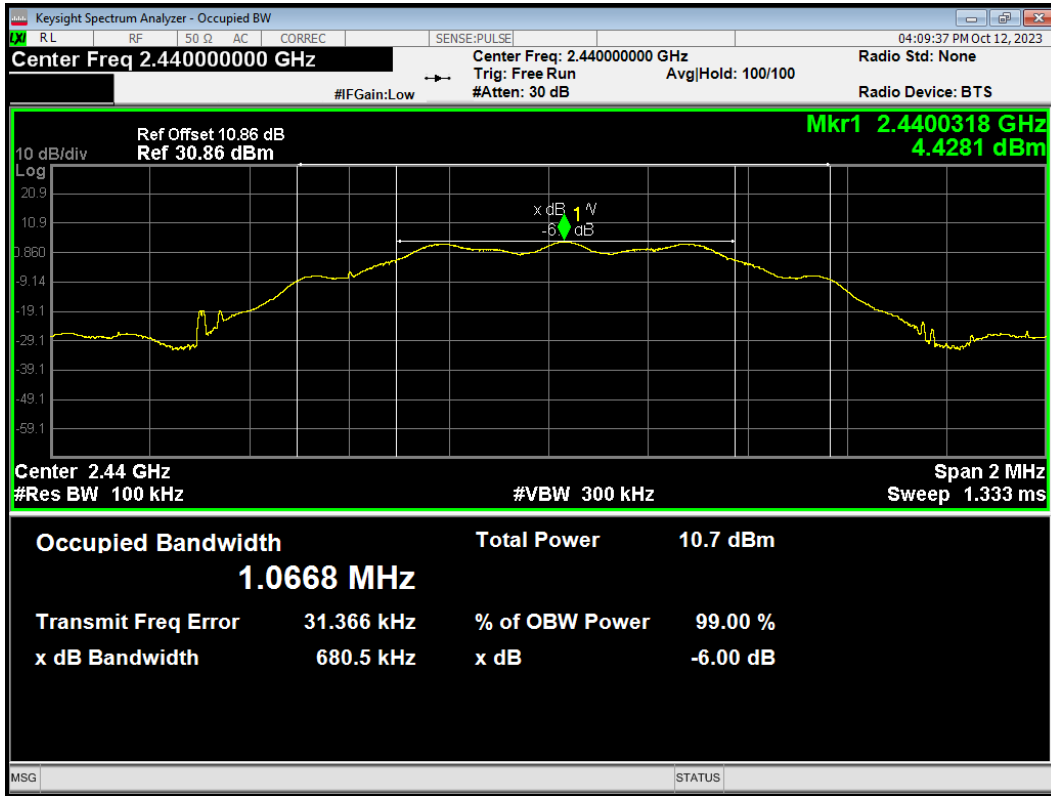
-6dB Bandwidth Bluetooth LE(S=2) 2480MHz



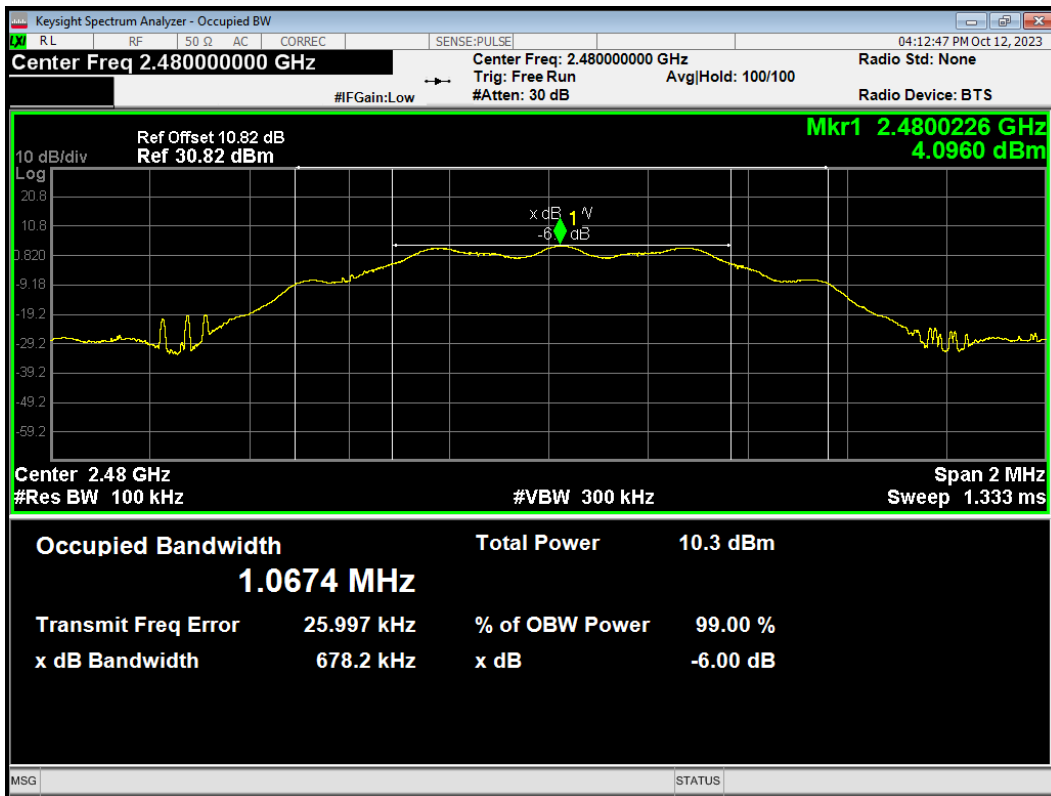
-6dB Bandwidth Bluetooth LE(S=8) 2402MHz



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



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



5.3. Band Edge

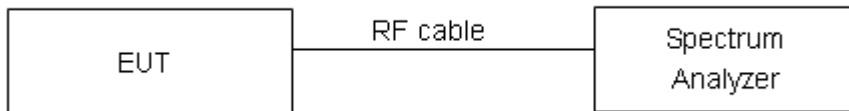
Ambient Condition

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.”

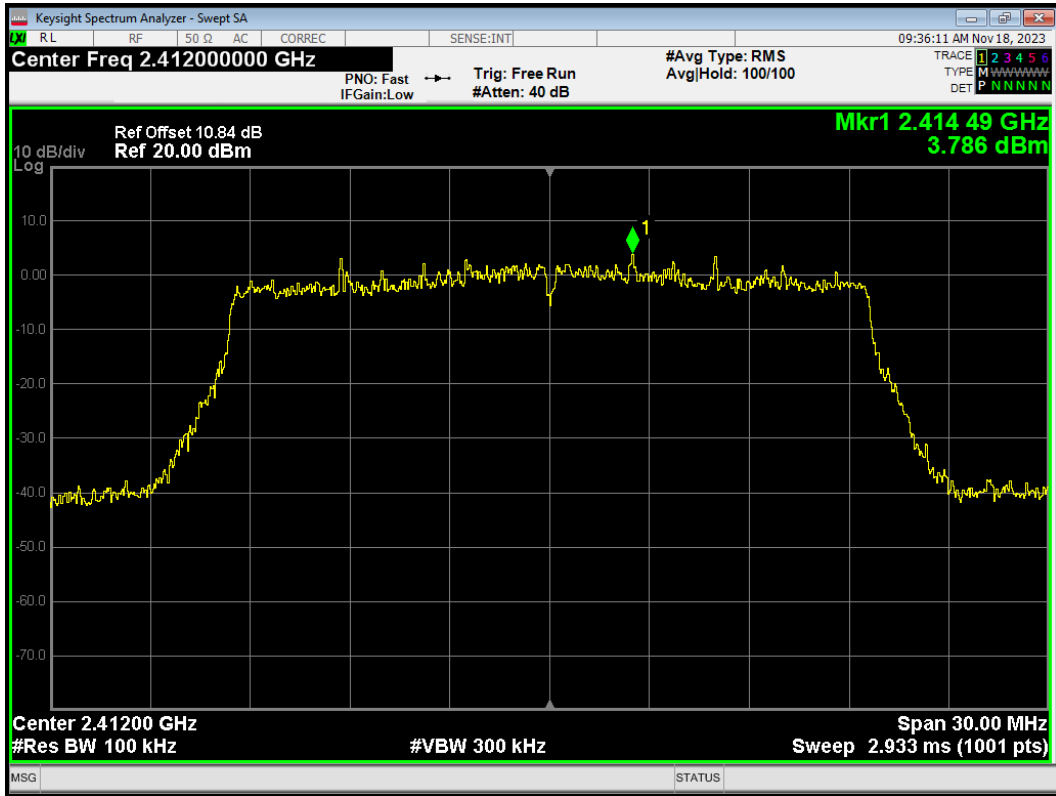
Measurement Uncertainty

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

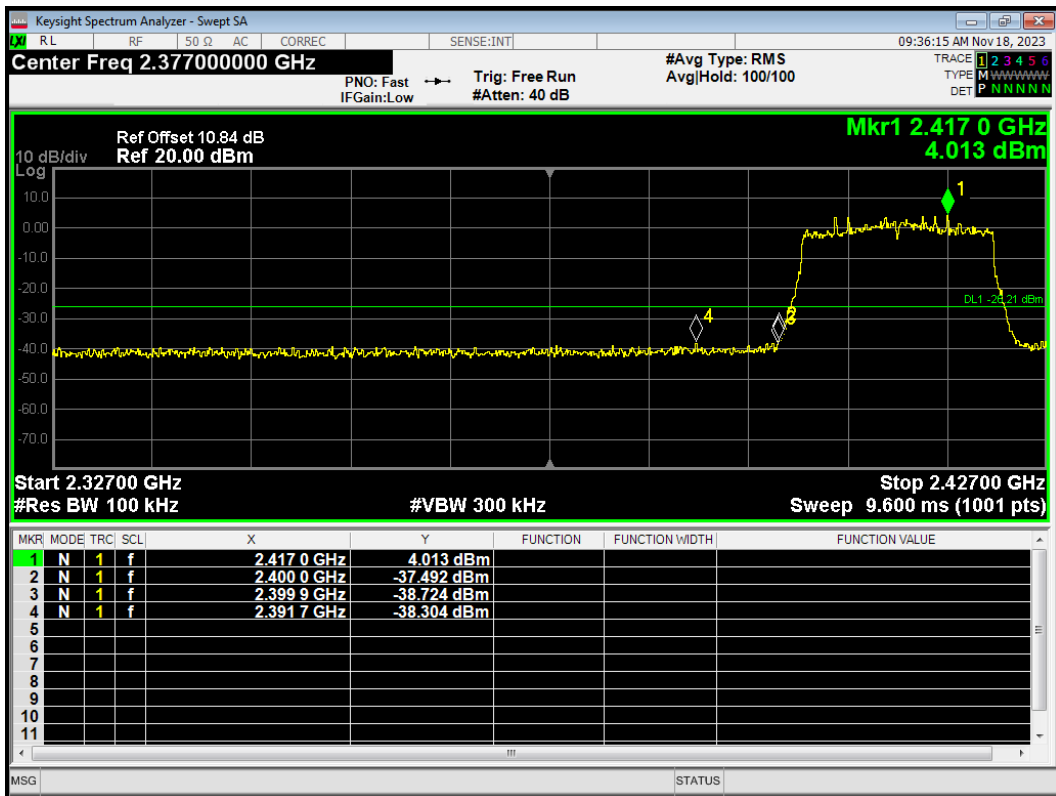
Frequency	Uncertainty
2GHz-3GHz	1.407 dB

Test Results: PASS

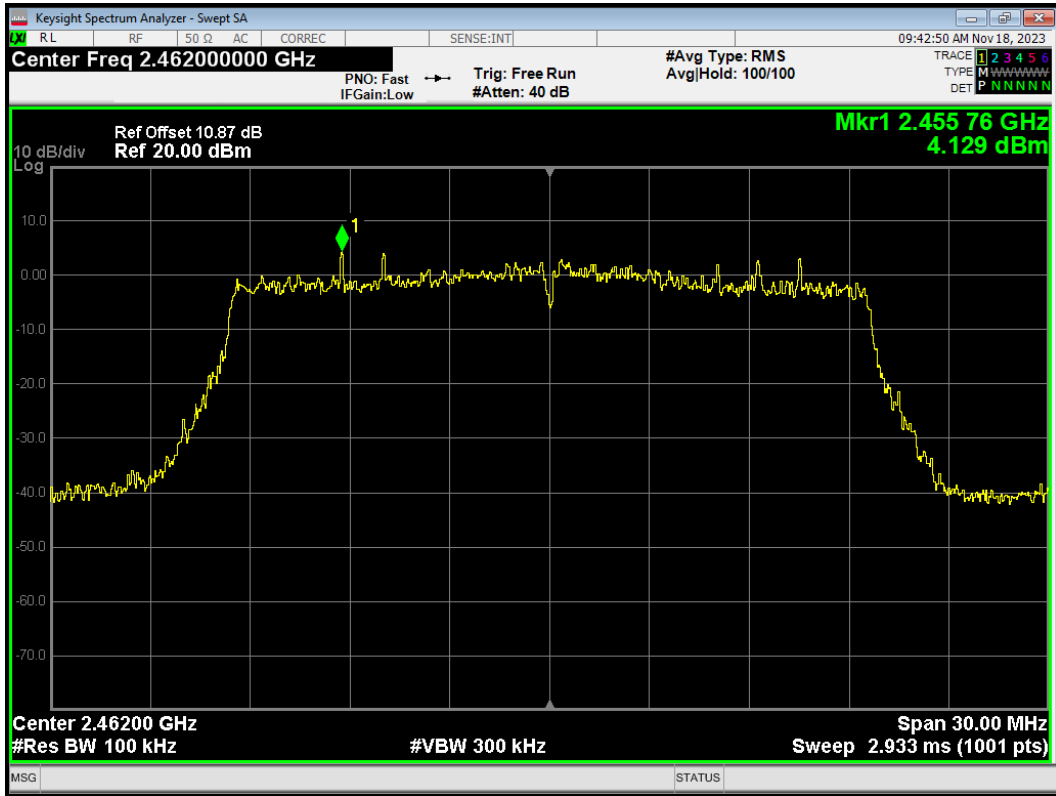
Band Edge 802.11ax(HE20) 2412MHz Ref



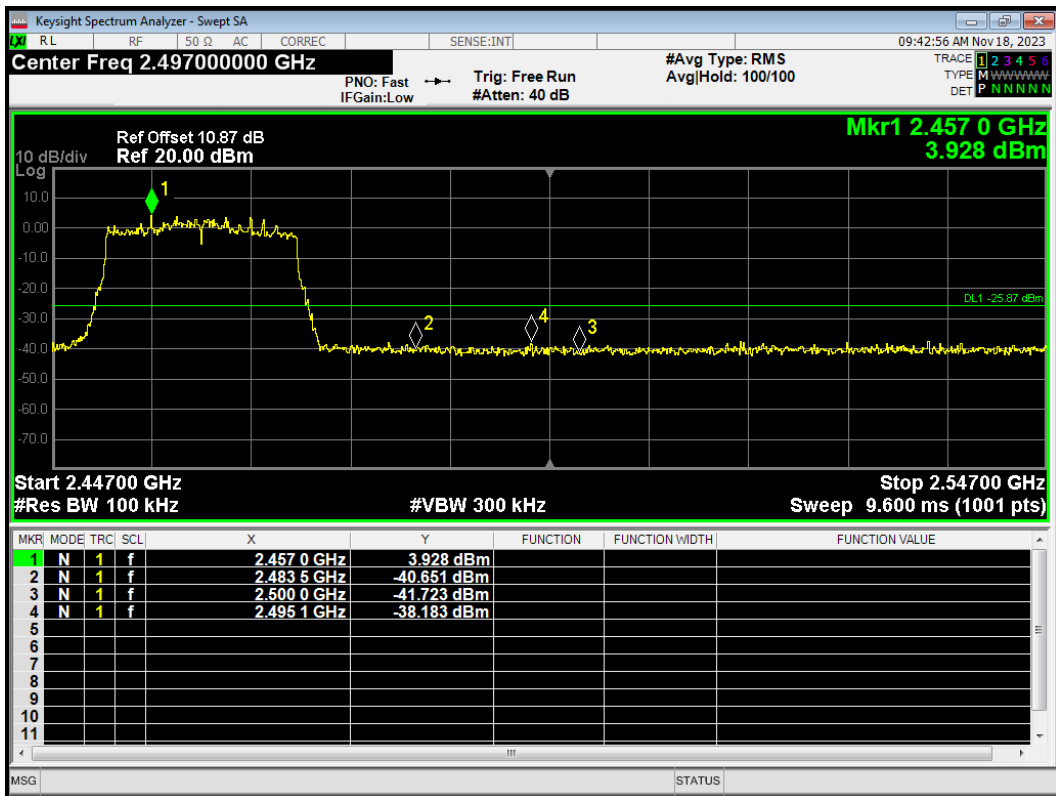
Band Edge 802.11ax(HE20) 2412MHz Emission



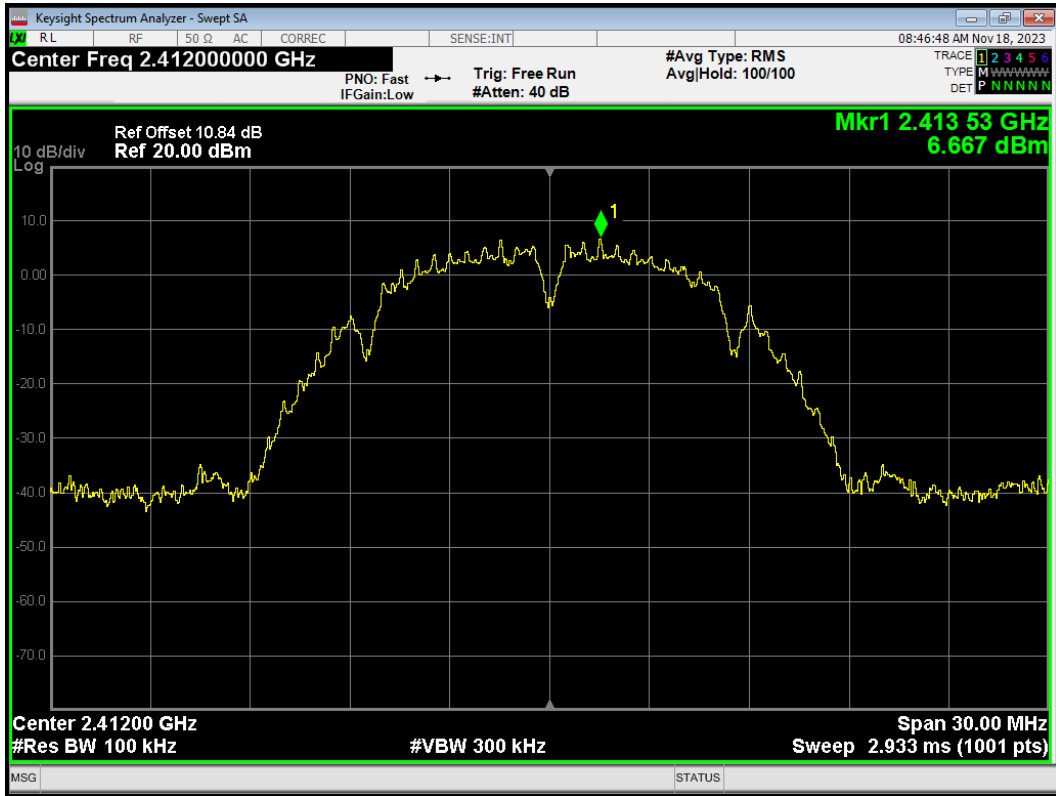
Band Edge 802.11ax(HE20) 2462MHz Ref



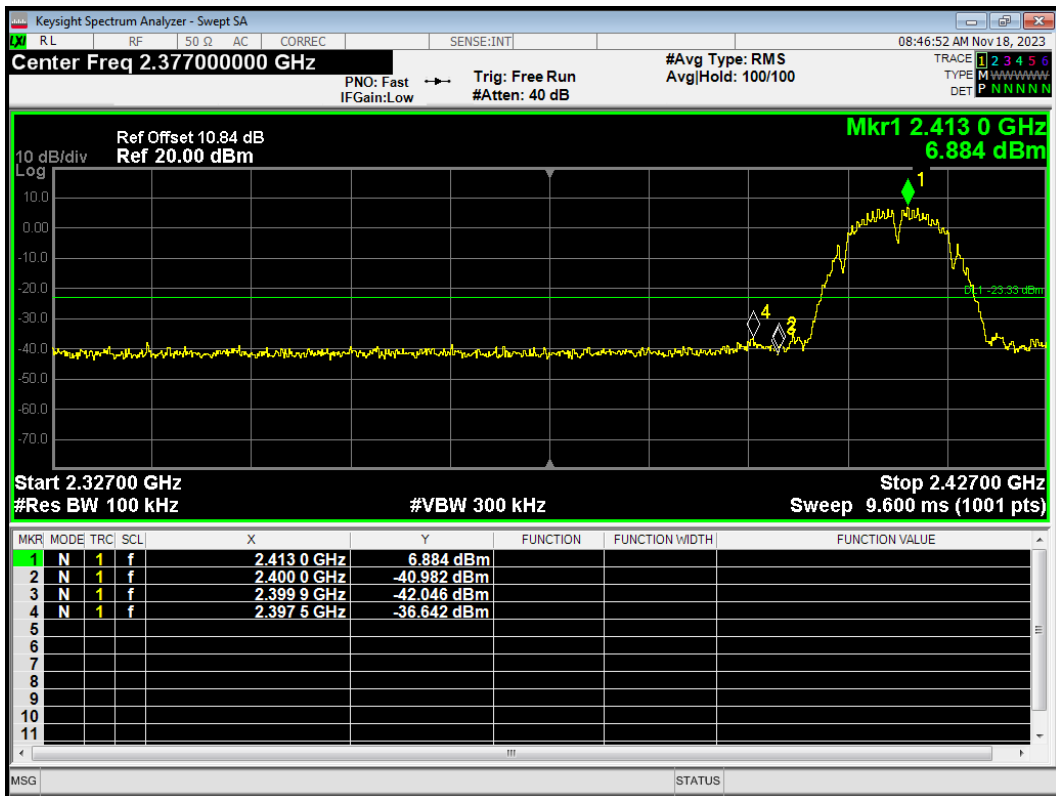
Band Edge 802.11ax(HE20) 2462MHz Emission



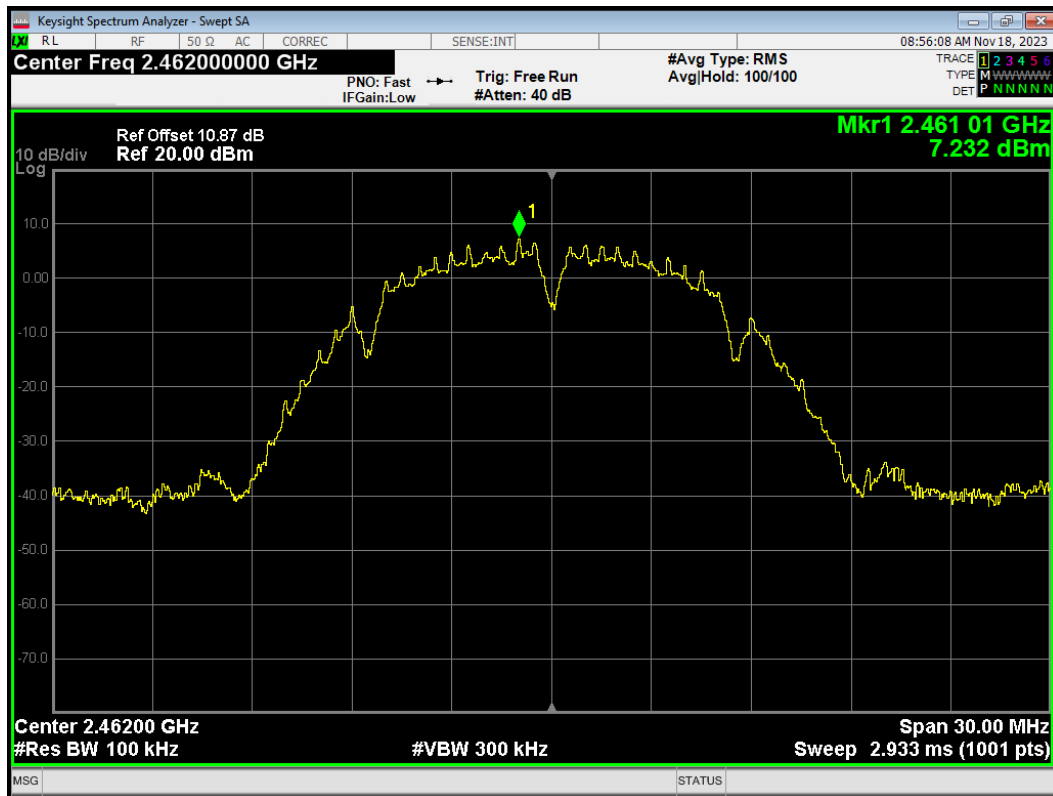
Band Edge 802.11b 2412MHz Ref



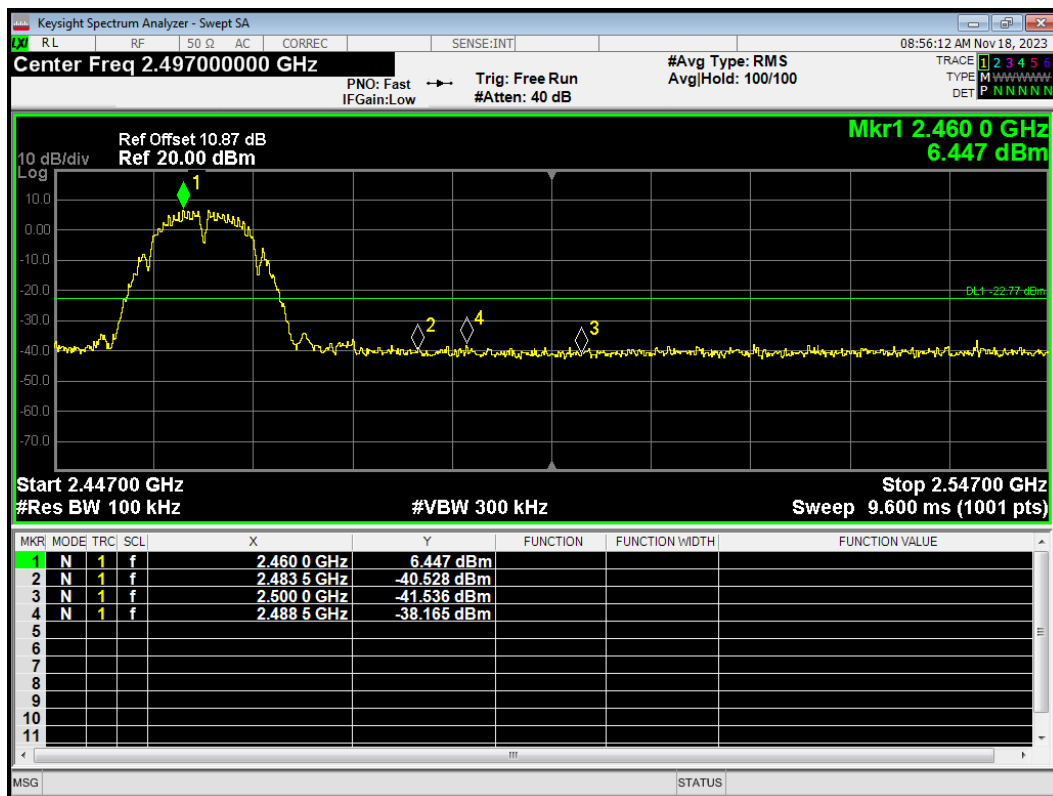
Band Edge 802.11b 2412MHz Emission



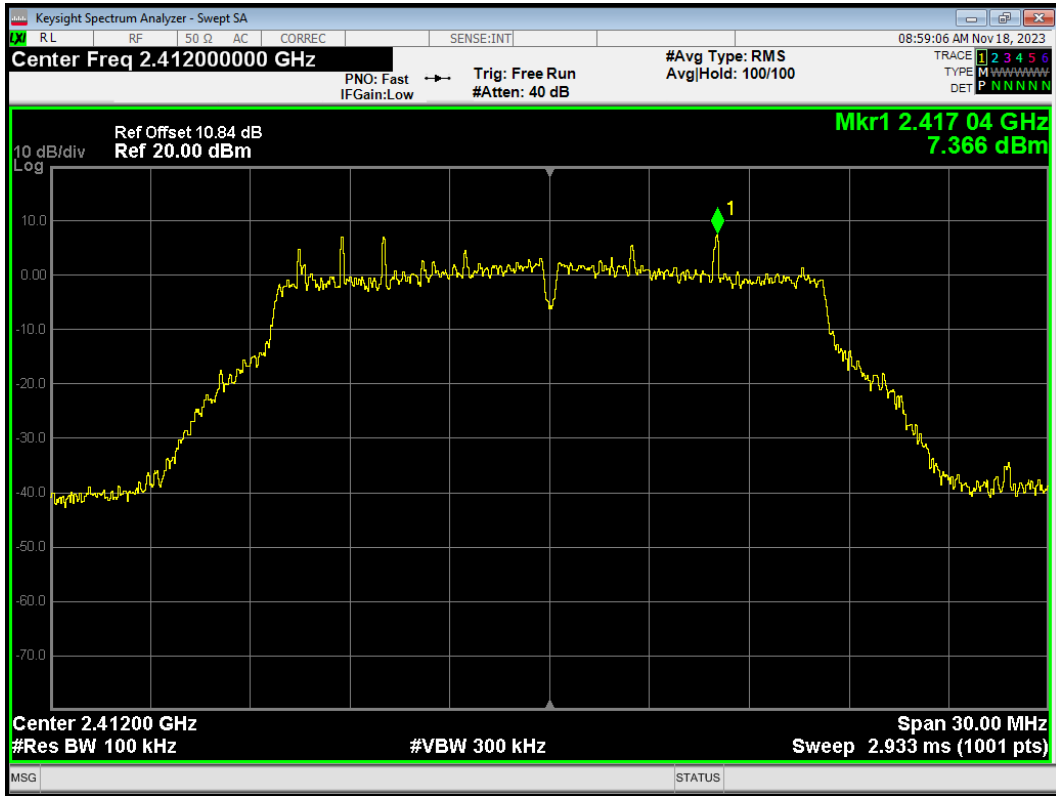
Band Edge 802.11b 2462MHz Ref



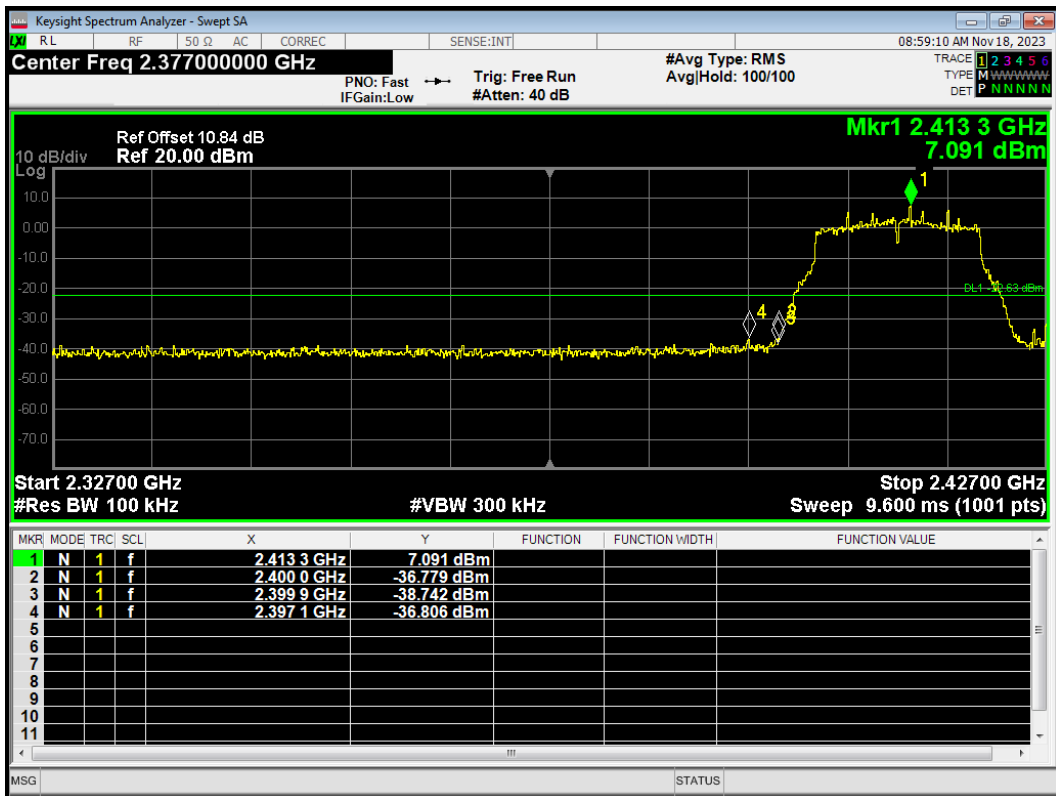
Band Edge 802.11b 2462MHz Emission



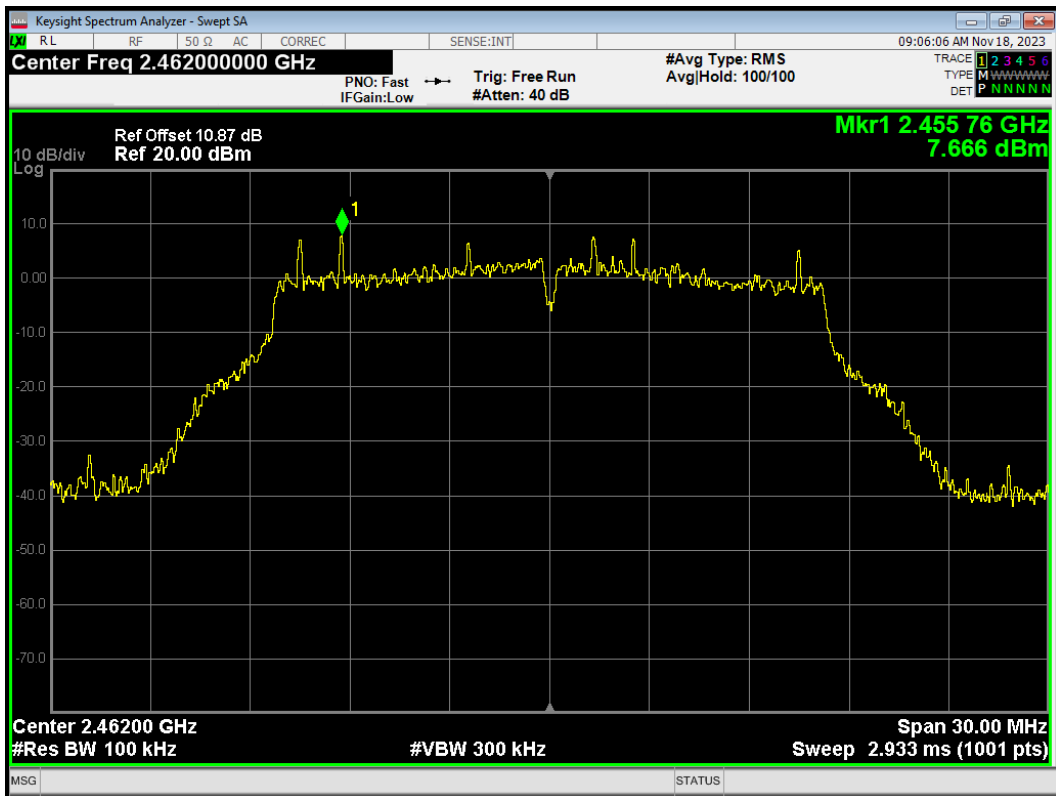
Band Edge 802.11g 2412MHz Ref



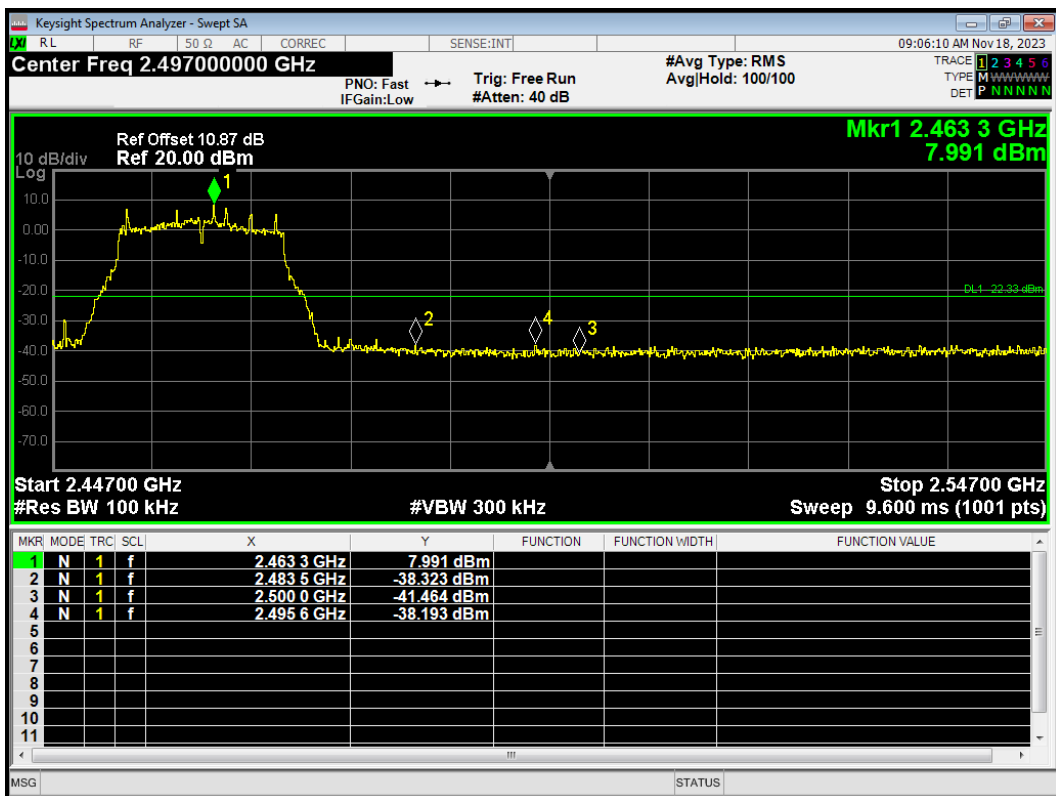
Band Edge 802.11g 2412MHz Emission



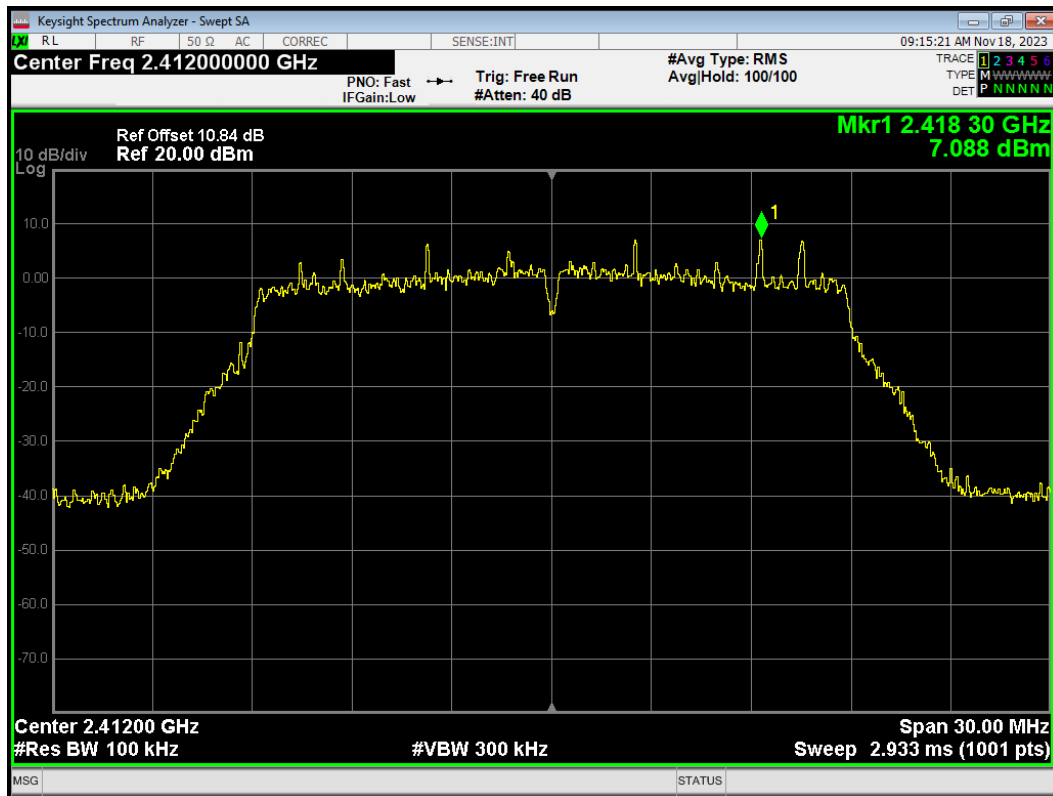
Band Edge 802.11g 2462MHz Ref



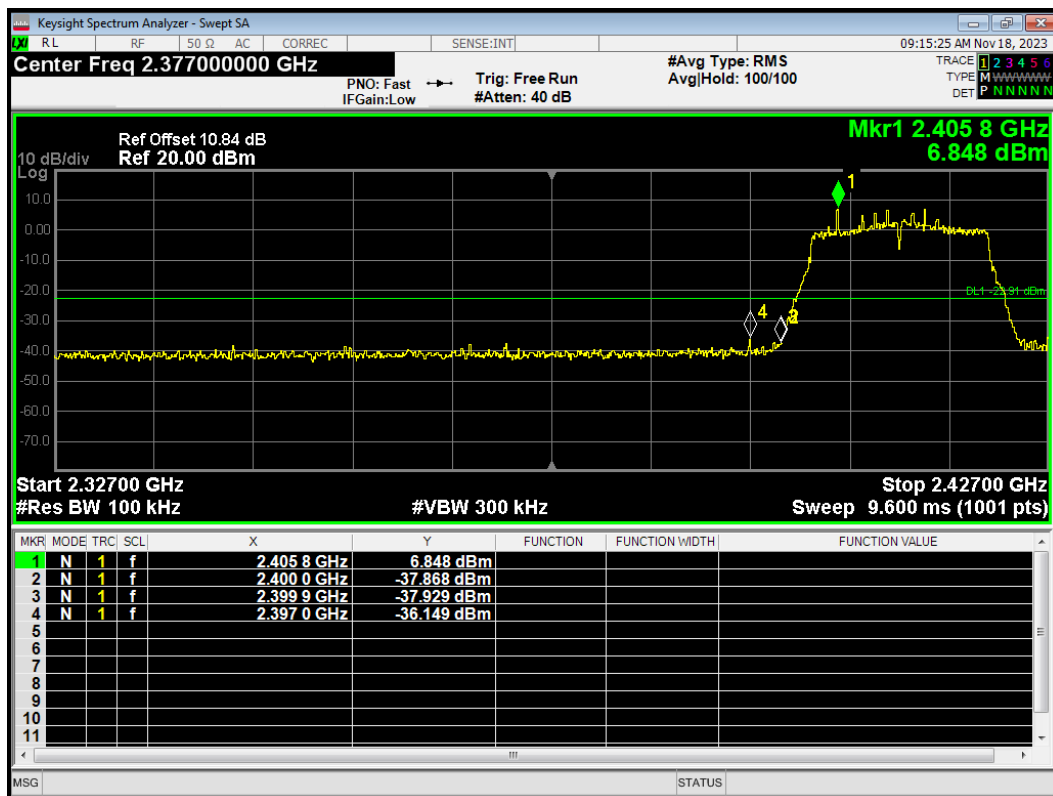
Band Edge 802.11g 2462MHz Emission



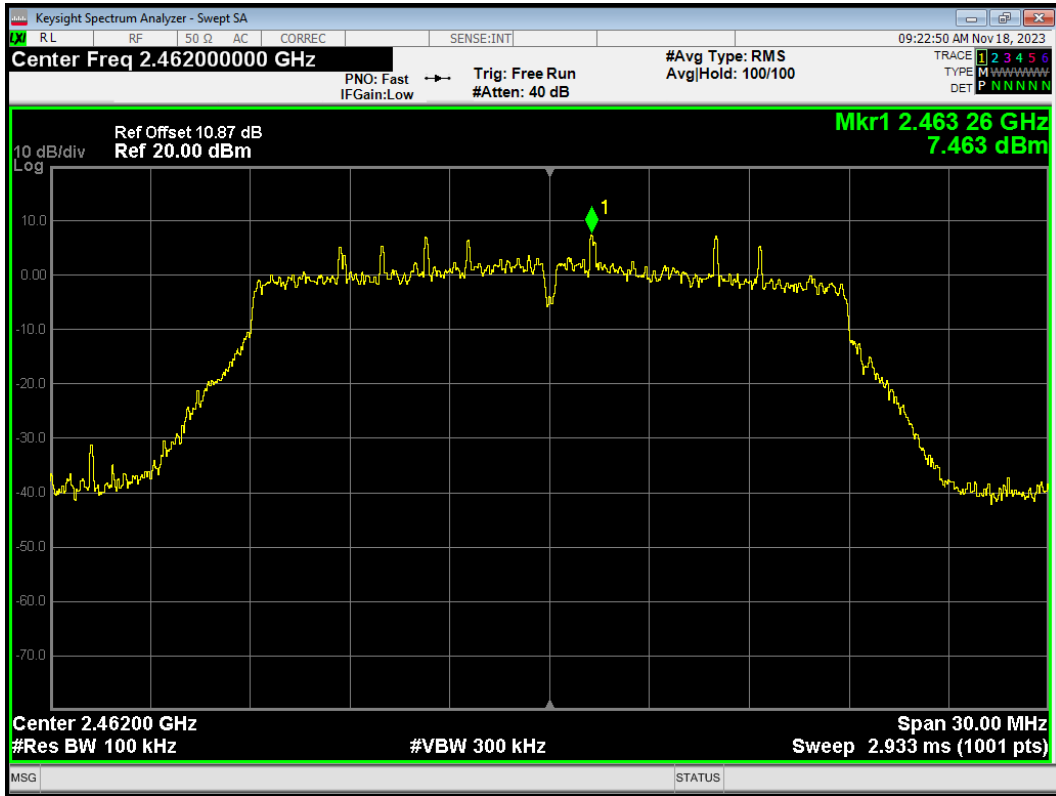
Band Edge 802.11n(HT20) 2412MHz Ref



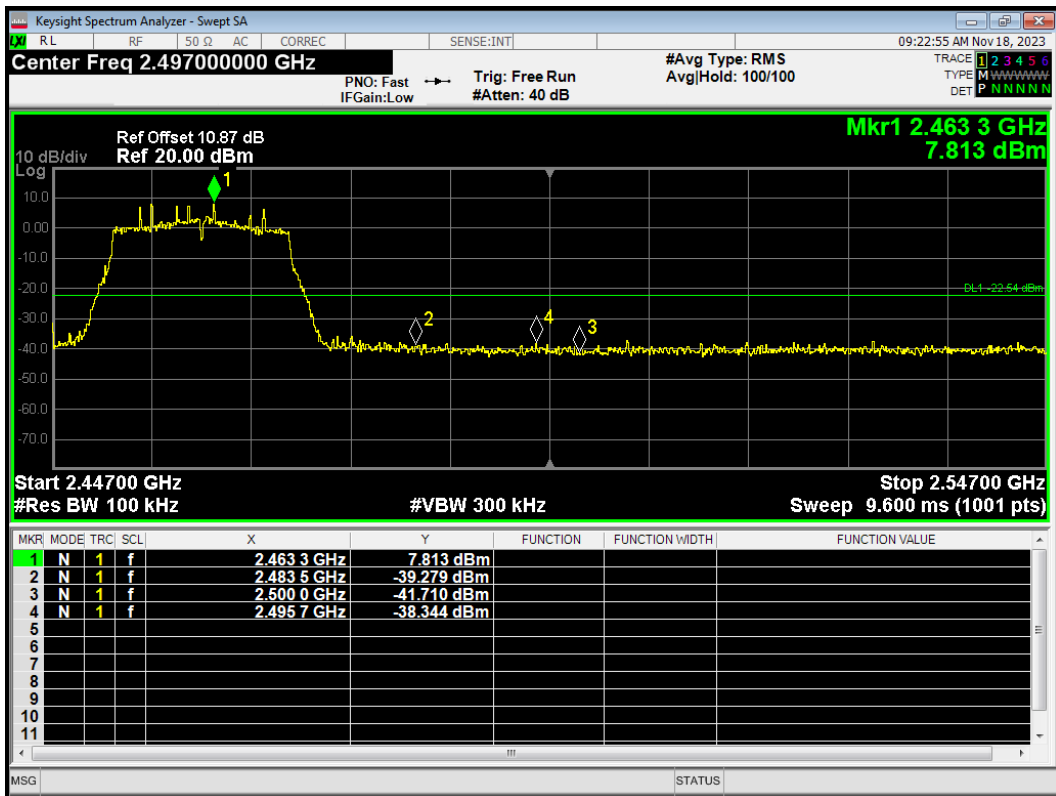
Band Edge 802.11n(HT20) 2412MHz Emission



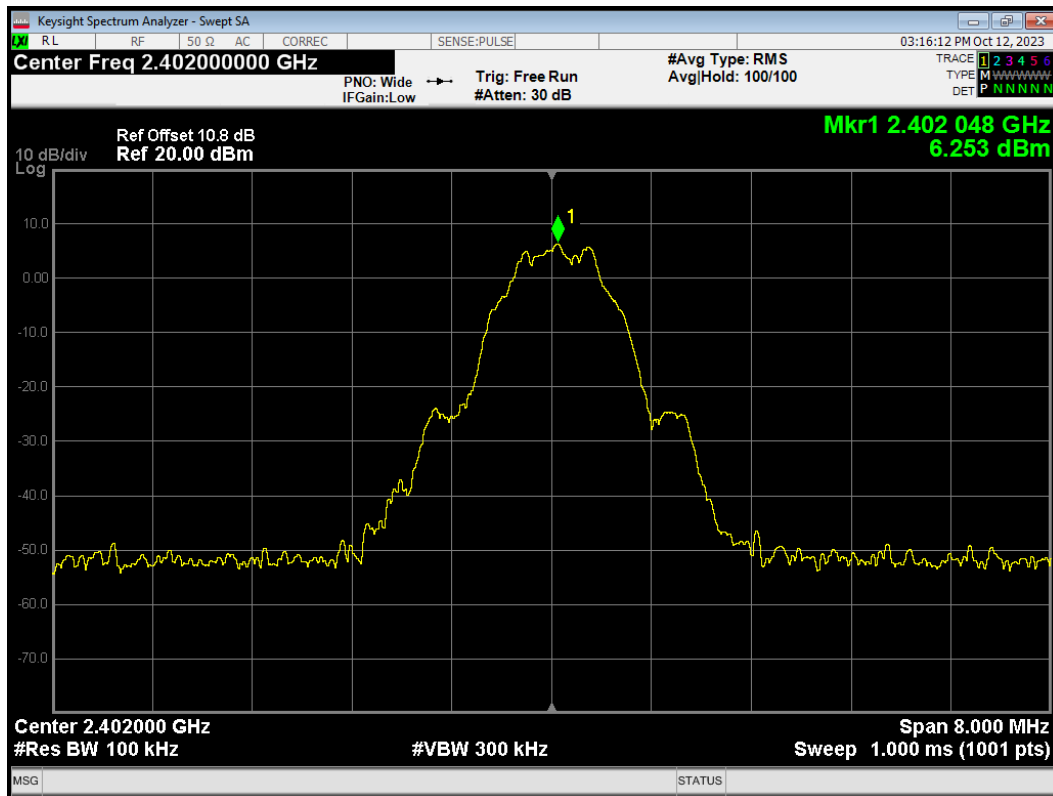
Band Edge 802.11n(HT20) 2462MHz Ref



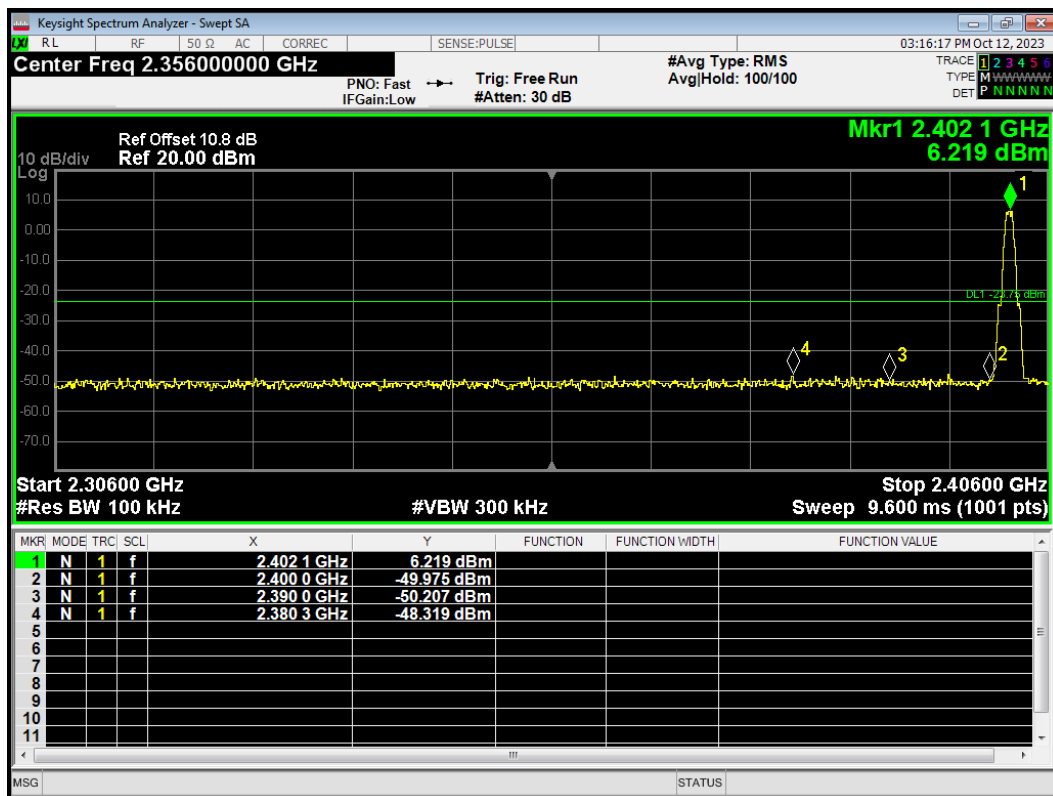
Band Edge 802.11n(HT20) 2462MHz Emission



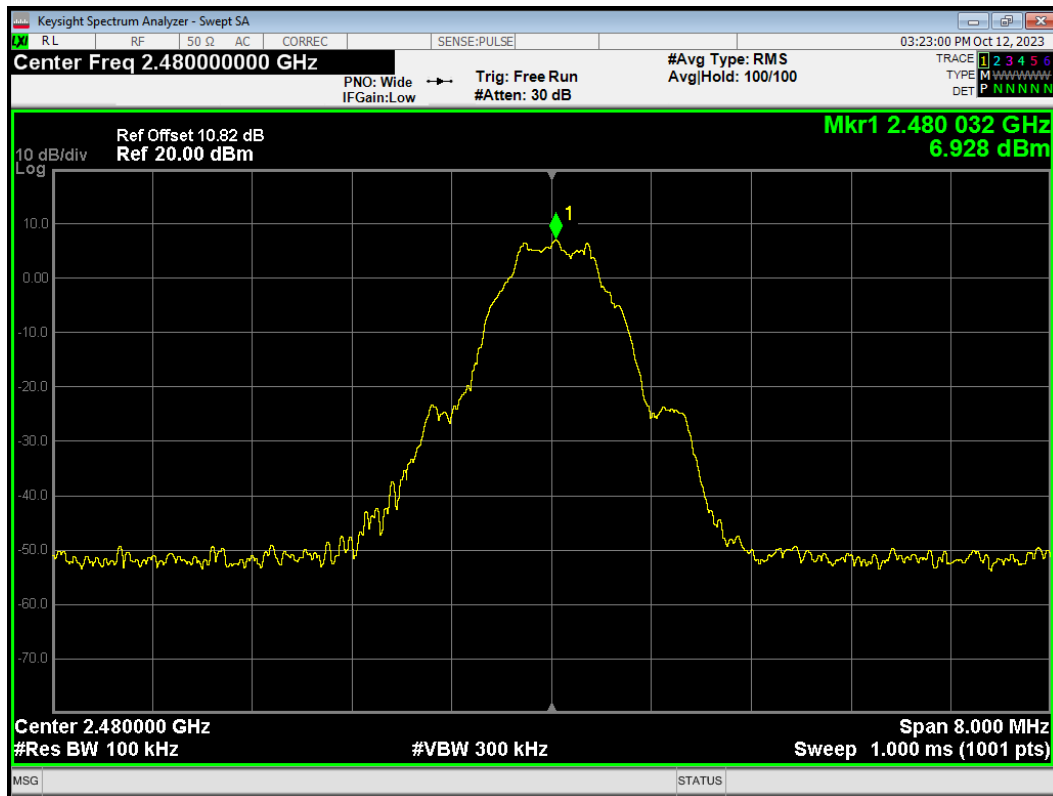
Band Edge Bluetooth LE(1M)2402MHz Ref



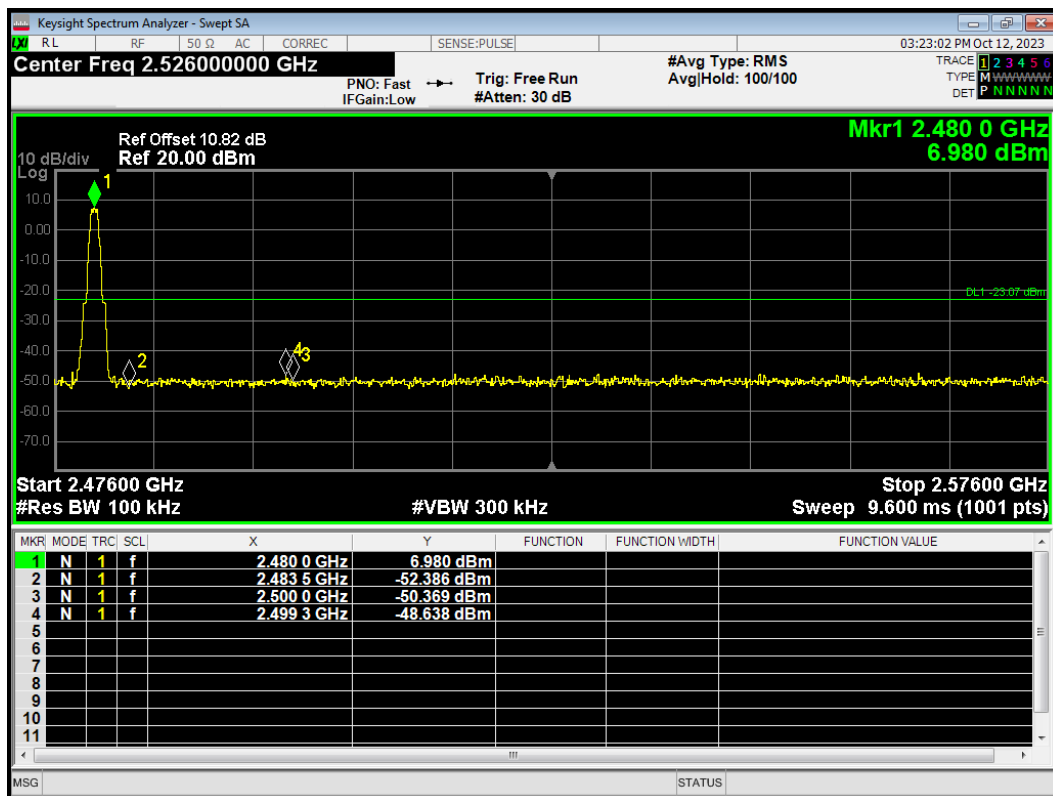
Band Edge Bluetooth LE(1M)2402MHz Emission



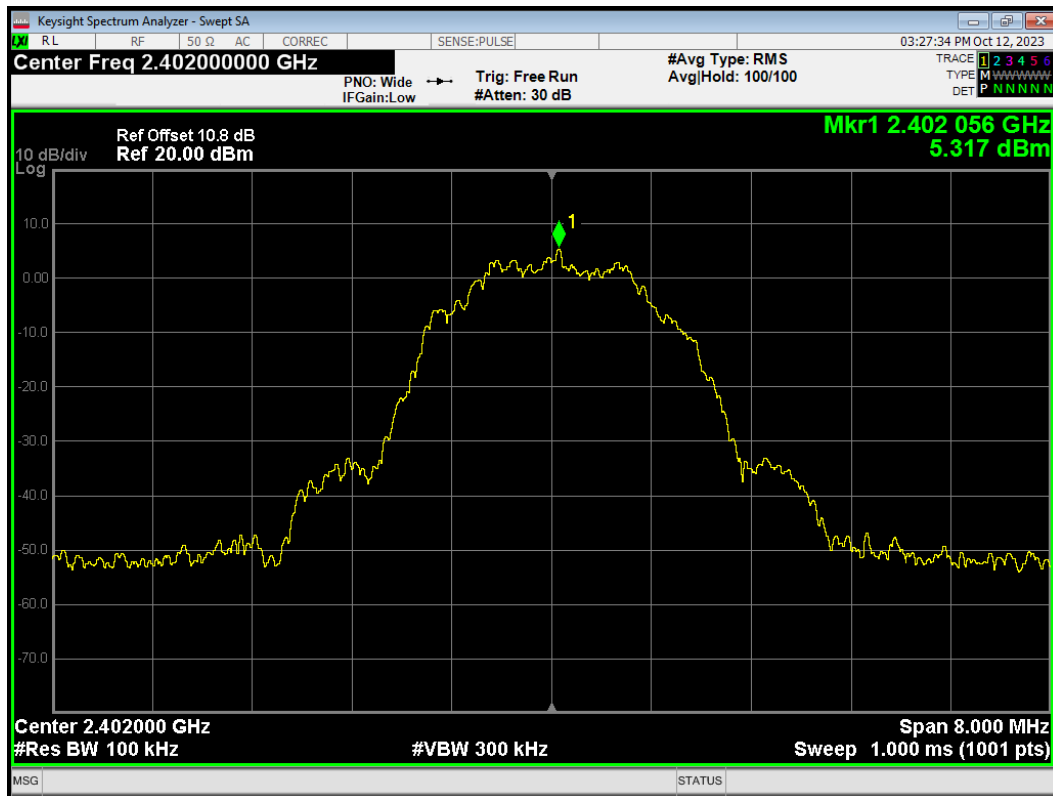
Band Edge Bluetooth LE(1M)2480MHz Ref



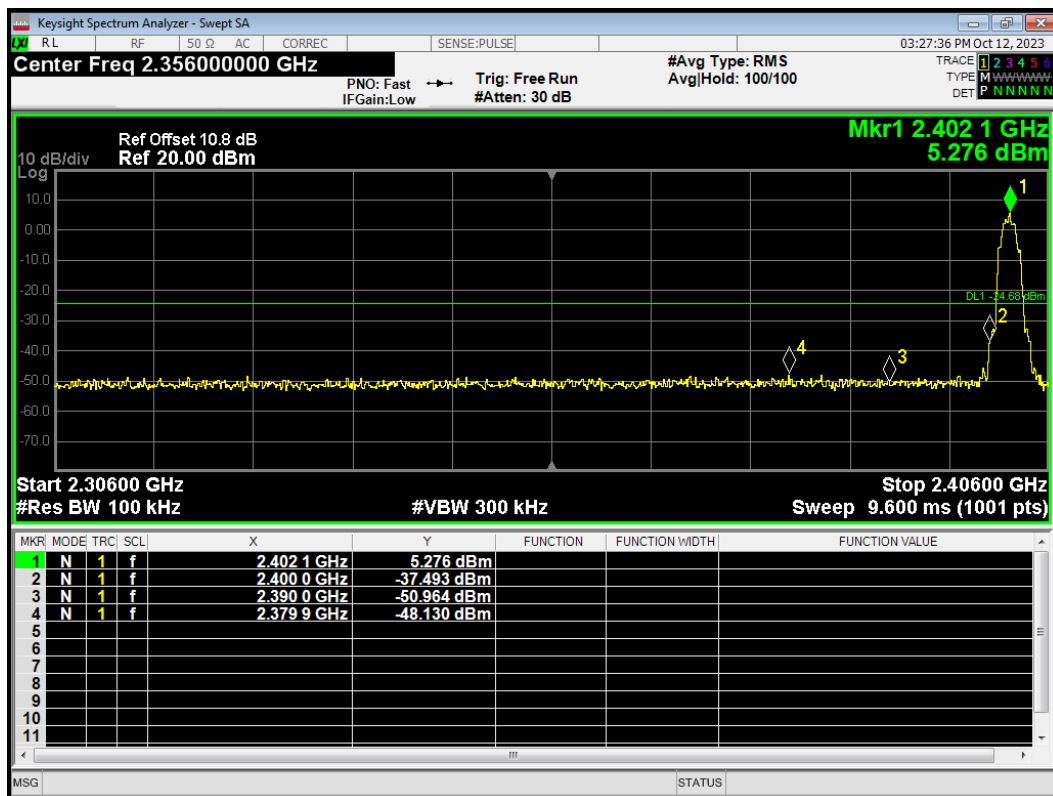
Band Edge Bluetooth LE(1M)2480MHz Emission



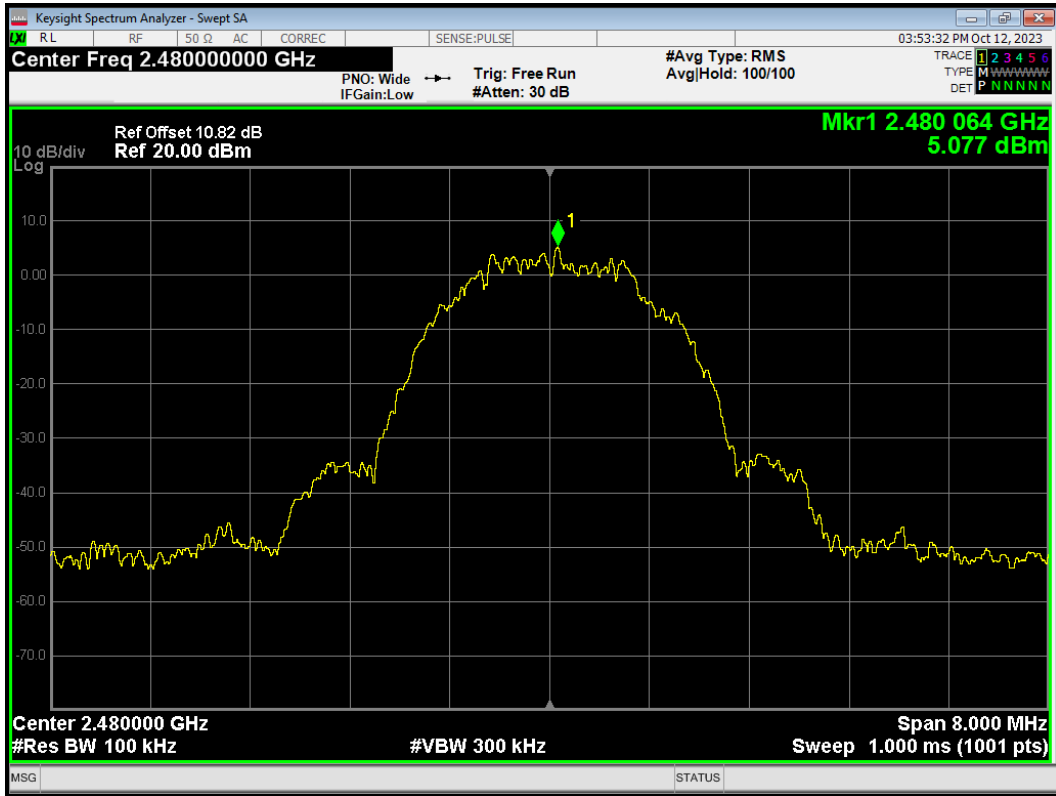
Band Edge Bluetooth LE(2M) 2402MHz Ref



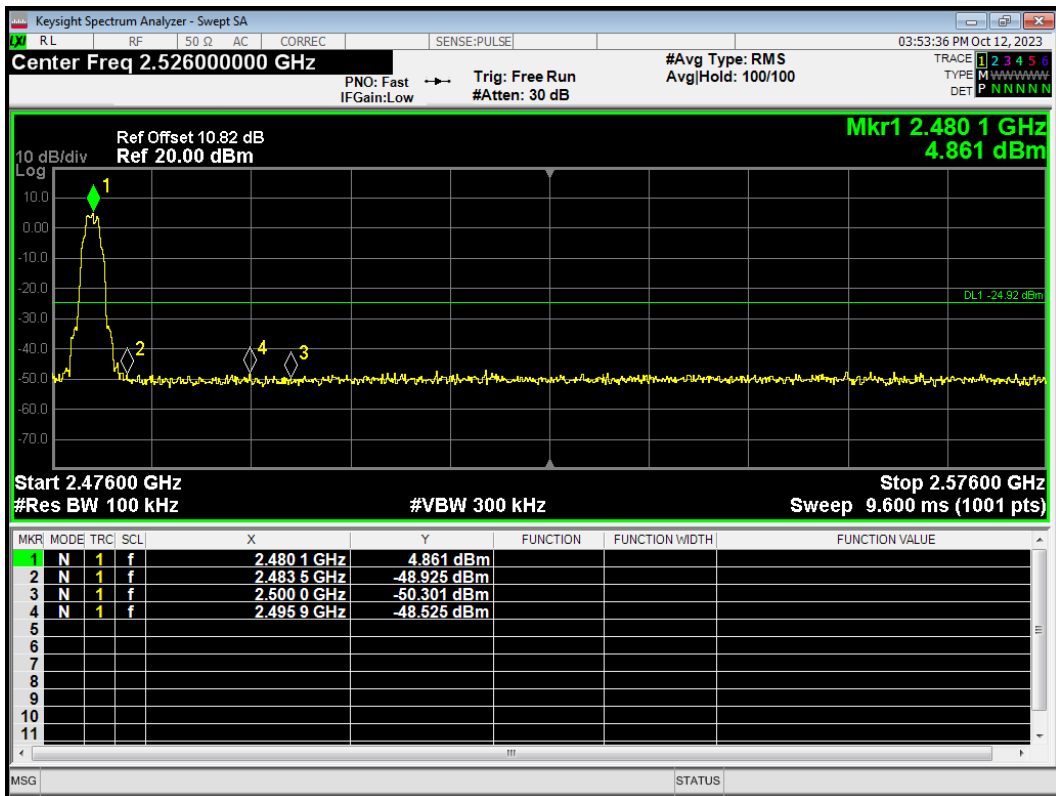
Band Edge Bluetooth LE(2M) 2402MHz Emission



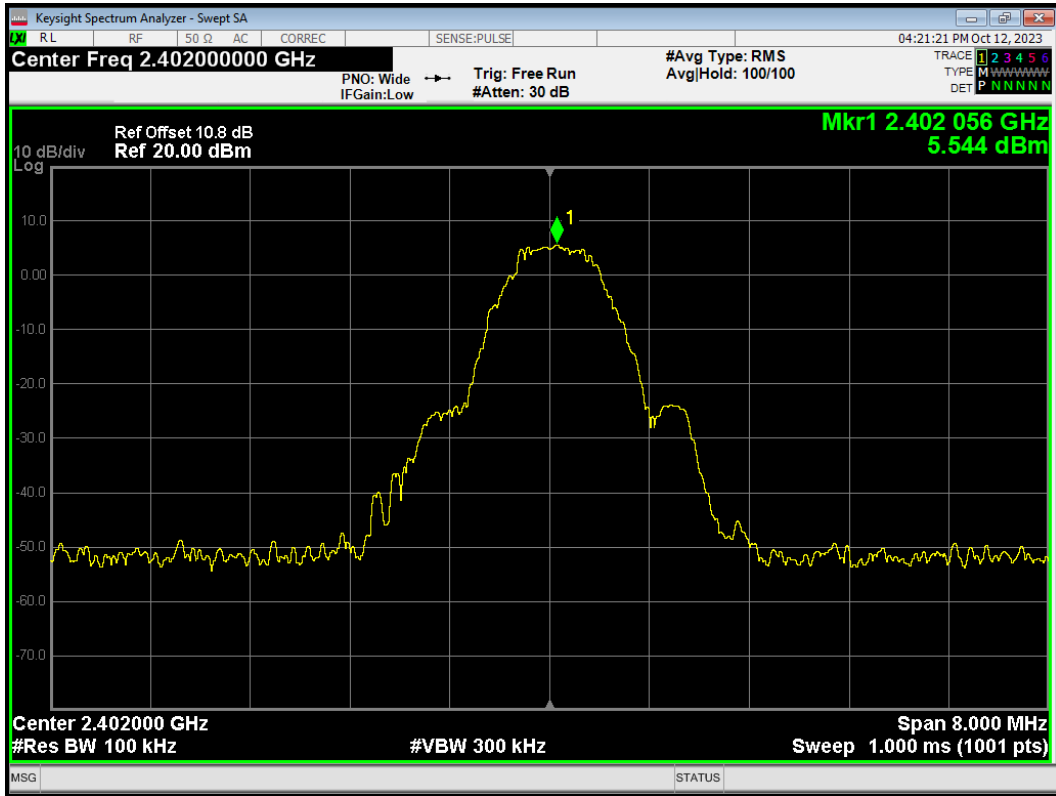
Band Edge Bluetooth LE(2M) 2480MHz Ref



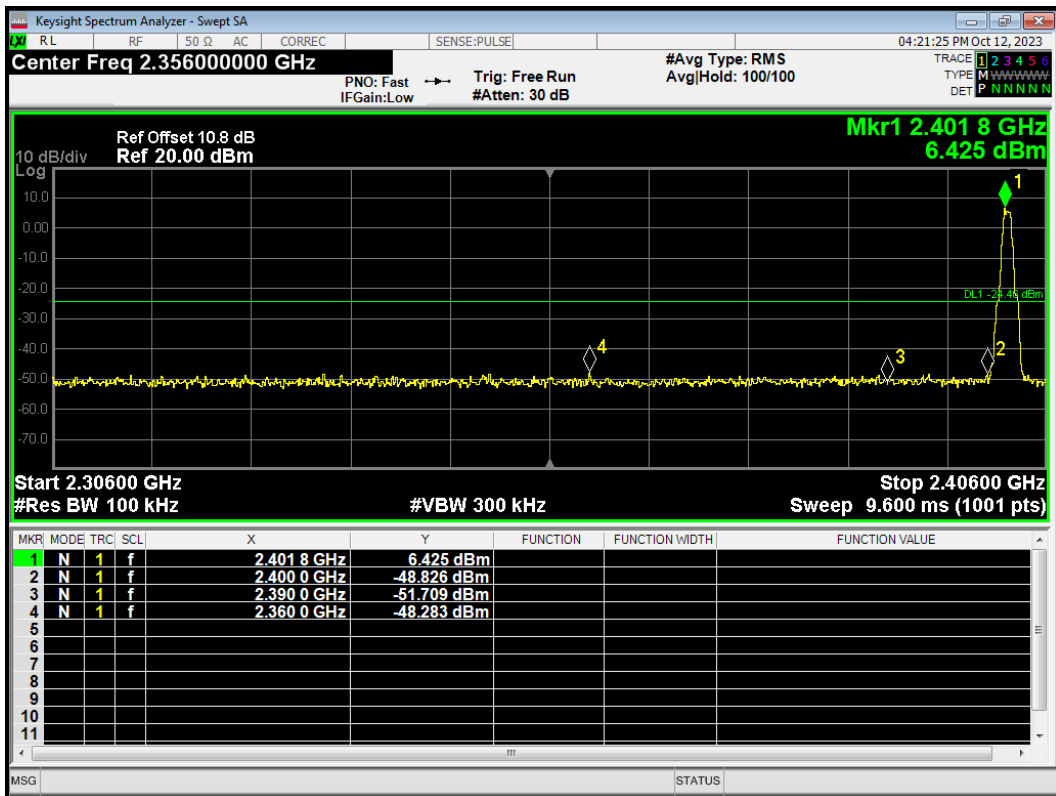
Band Edge Bluetooth LE(2M) 2480MHz Emission



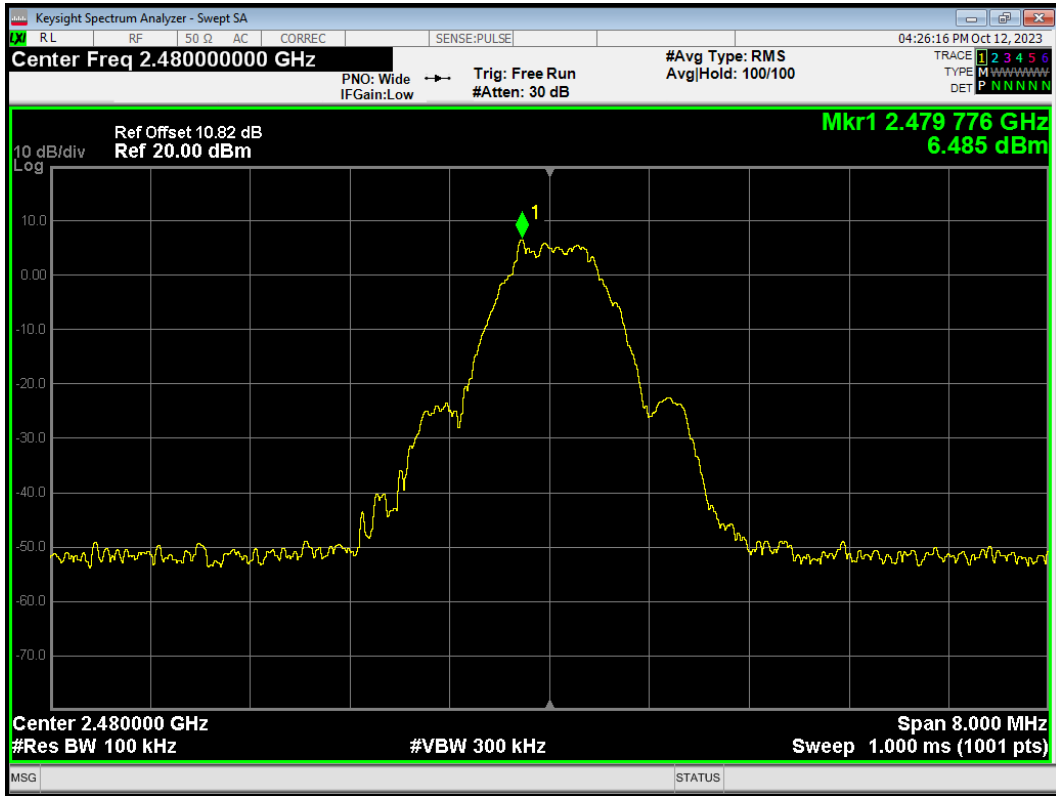
Band Edge Bluetooth LE(S=2) 2402MHz Ref



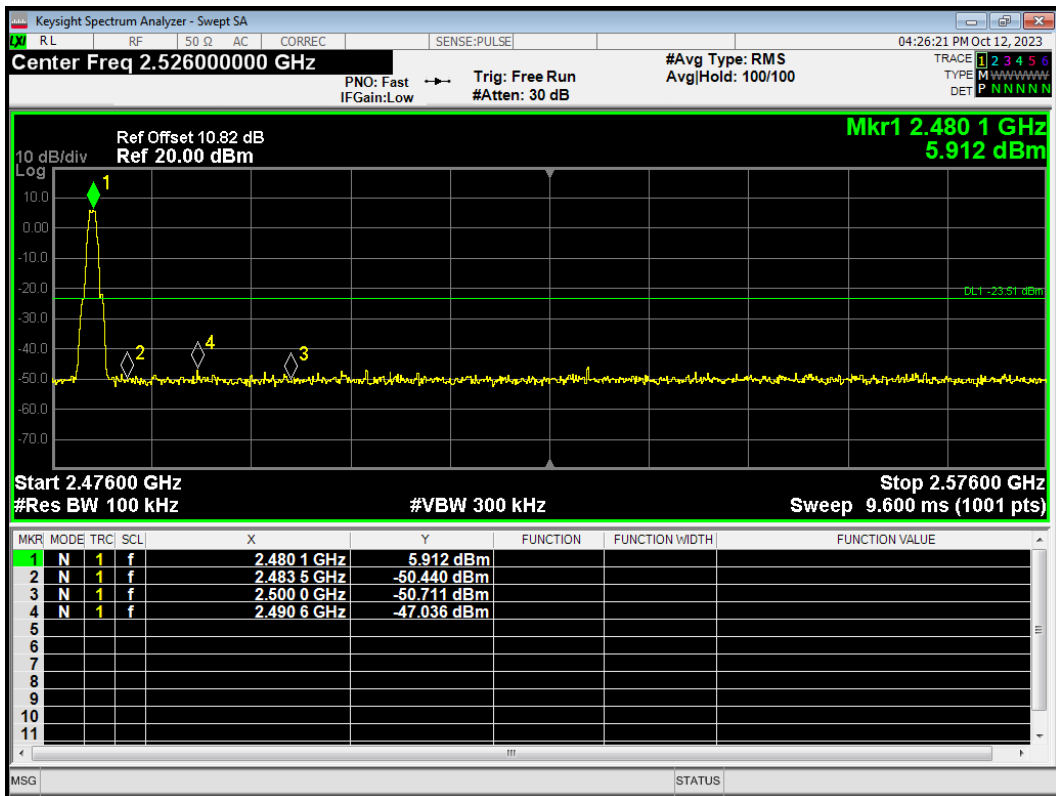
Band Edge Bluetooth LE(S=2) 2402MHz Emission



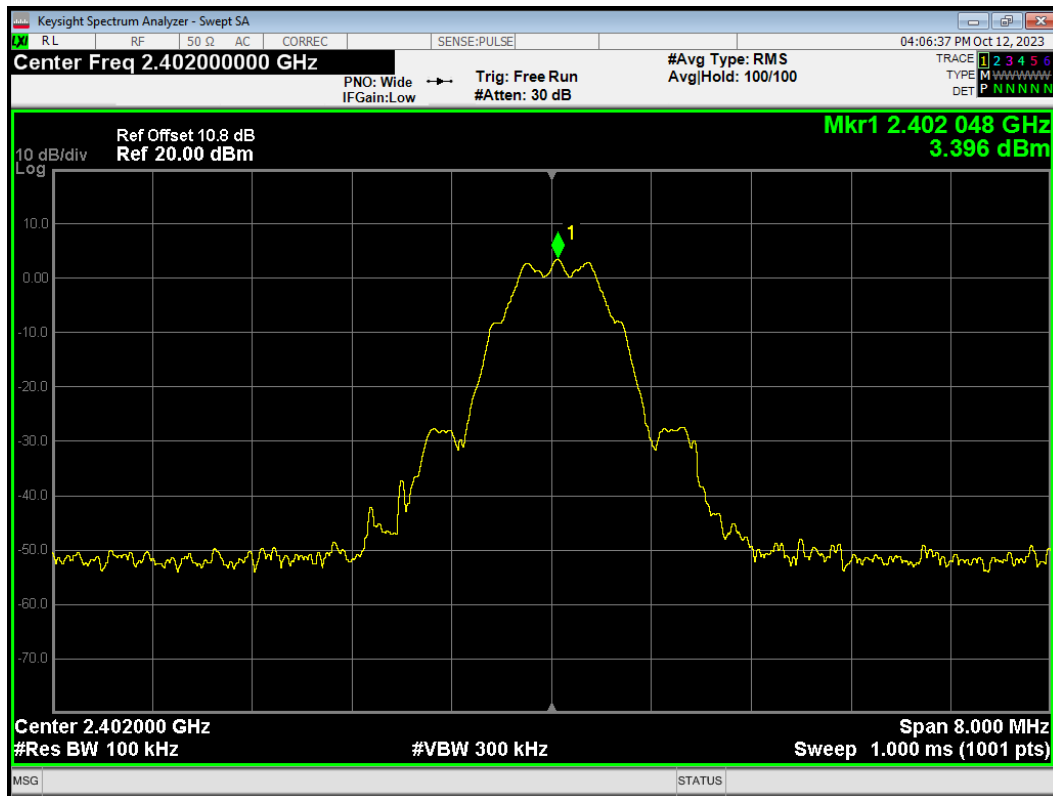
Band Edge Bluetooth LE(S=2) 2480MHz Ref



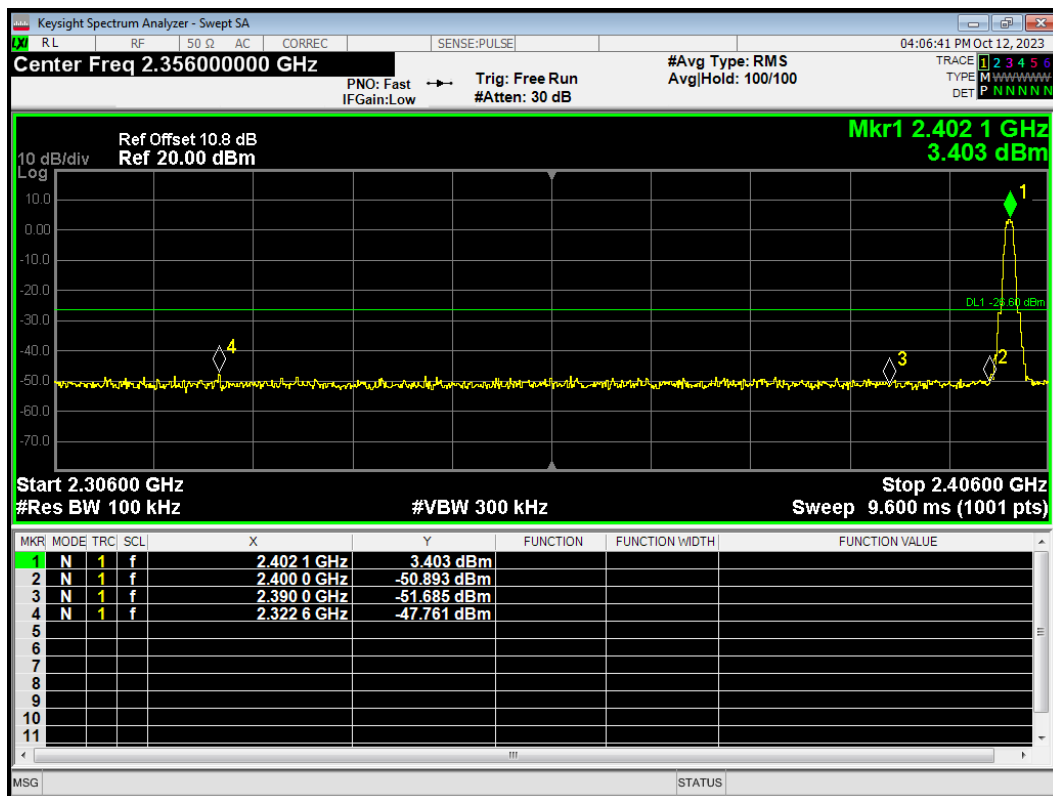
Band Edge Bluetooth LE(S=2) 2480MHz Emission



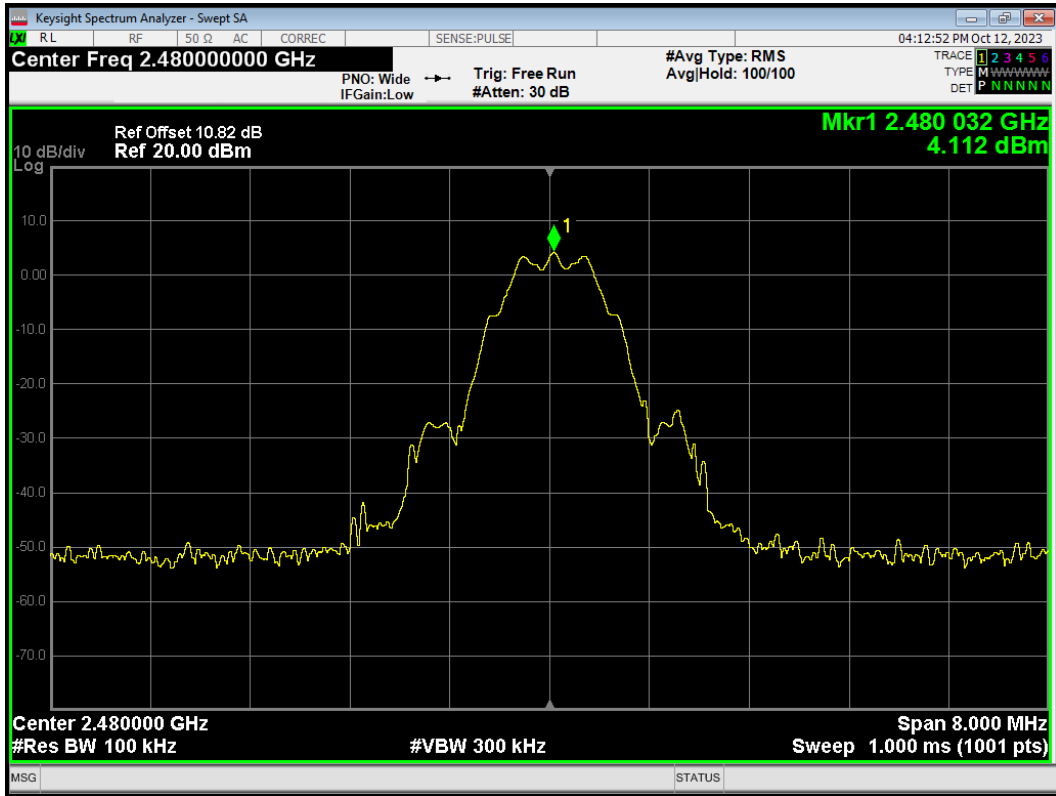
Band Edge Bluetooth LE(S=8) 2402MHz Ref



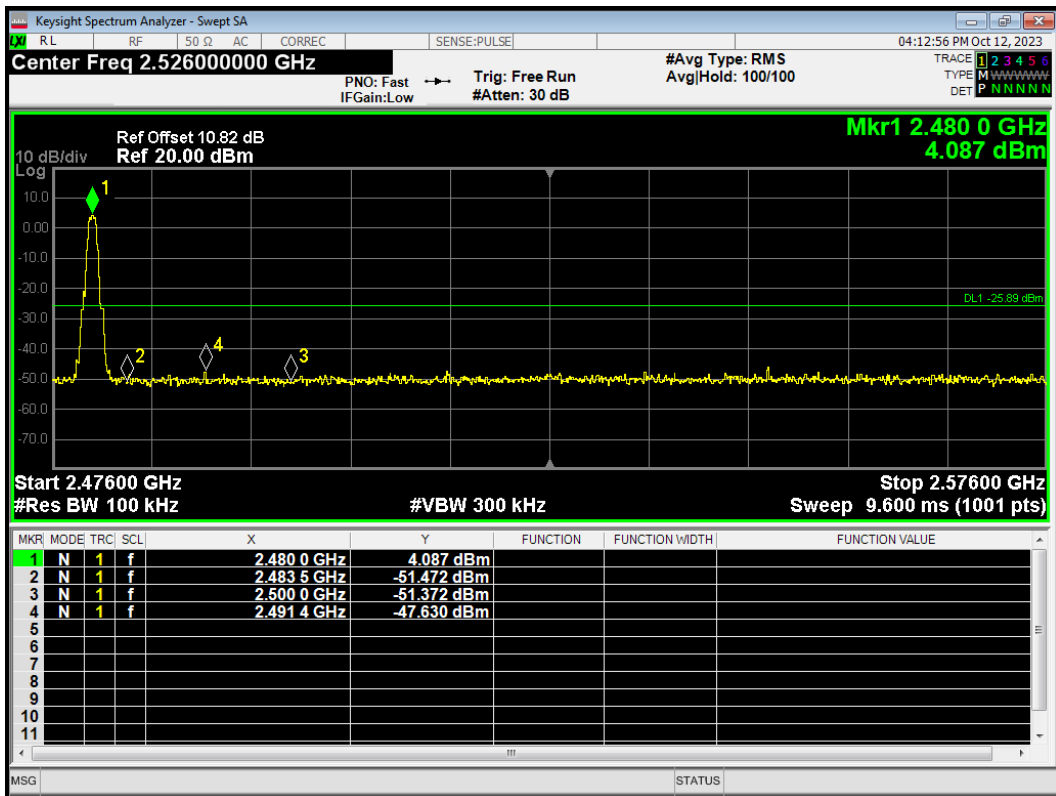
Band Edge Bluetooth LE(S=8) 2402MHz Emission



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: $3\text{kHz} \leq \text{RBW} \leq 100\text{kHz}$
- d) Set $\text{VBW} \geq [3 \times \text{RBW}]$
- e) Detector=power averaging (rms) or sample detector (when rms not available)
- f) Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span}/\text{RBW}]$
- 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.

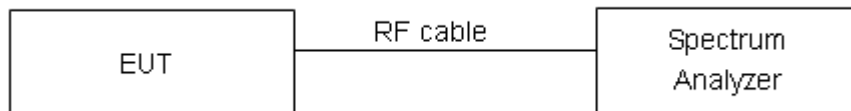
- a) Measure the duty cycle (D)of the transmitter output signal as described in 11.6
- b) Set instrument center frequency to DTS channel center frequency
- c) Set span to at least 1.5 times the OBW
- d) Set RBW to: $3\text{kHz} \leq \text{RBW} \leq 100\text{kHz}$
- e) Set $\text{VBW} \geq [3 \times \text{RBW}]$
- f) Detector= power averaging (rms) or sample detector (when rms not available)
- g) Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span}/\text{RBW}]$
- 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	$\leq 8 \text{ dBm} / 3\text{kHz}$
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Measurement Uncertainty

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

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)

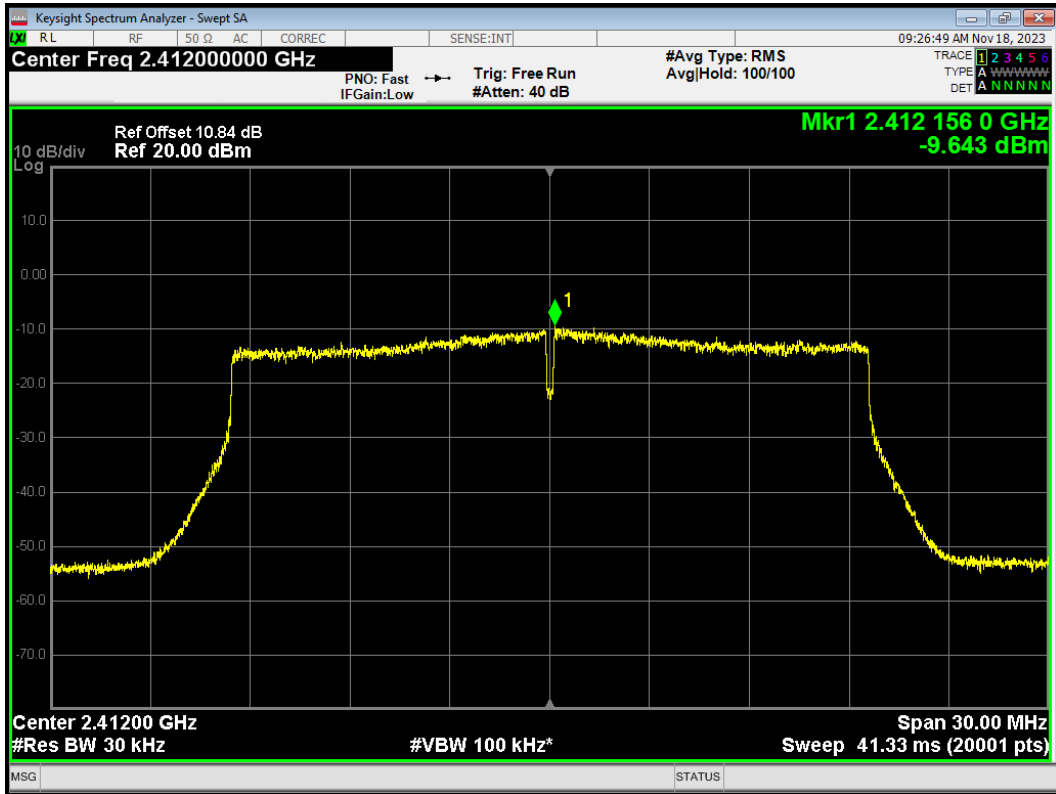
MIMO

Test Mode	Carrier frequency (MHz) / Channel	Power Spectral Density				Total PSD (dBm / 3kHz)	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)			
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

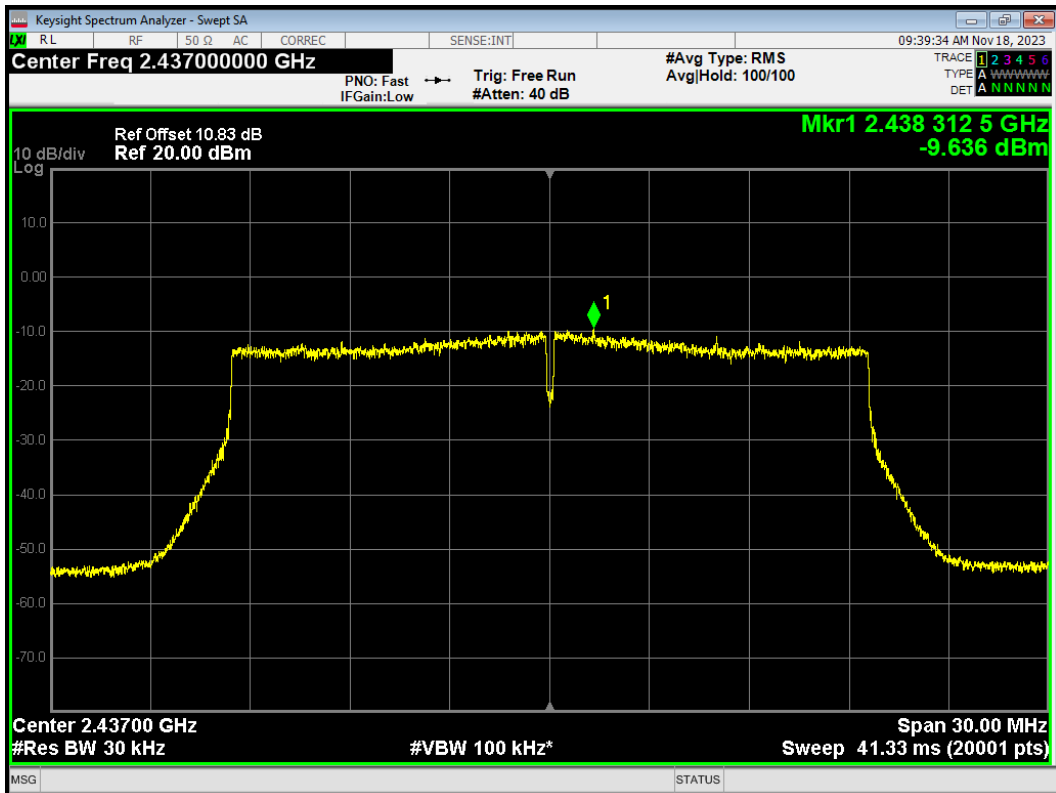
Note: 1. Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3/30)
2. For Total PSD, according to KDB 662911 D01 Multiple Transmitter Output v02r01 2)a), the power spectral density= $10\log(10^{(PSD_{antenna1} \text{ in dBm}/10)} + 10^{(PSD_{antenna2} \text{ in dBm}/10)})$
3. According to KDB 662911 D01 Multiple Transmitter Output v02r01 F)2)f)(i): If all antennas have the same gain, Directional gain = $G_{ANT} + \text{Array Gain}$. For PSD measurements on all devices, Array Gain= $10\log(N_{ant}/N_{ss})\text{dB}$, so directional gain= $G_{ANT} + \text{Array Gain} = (-0.1) + 10\log(2/1) = 2.91 < 6\text{dBi}$. So the PSD limit is 8 dBm

SISO Antenna 1

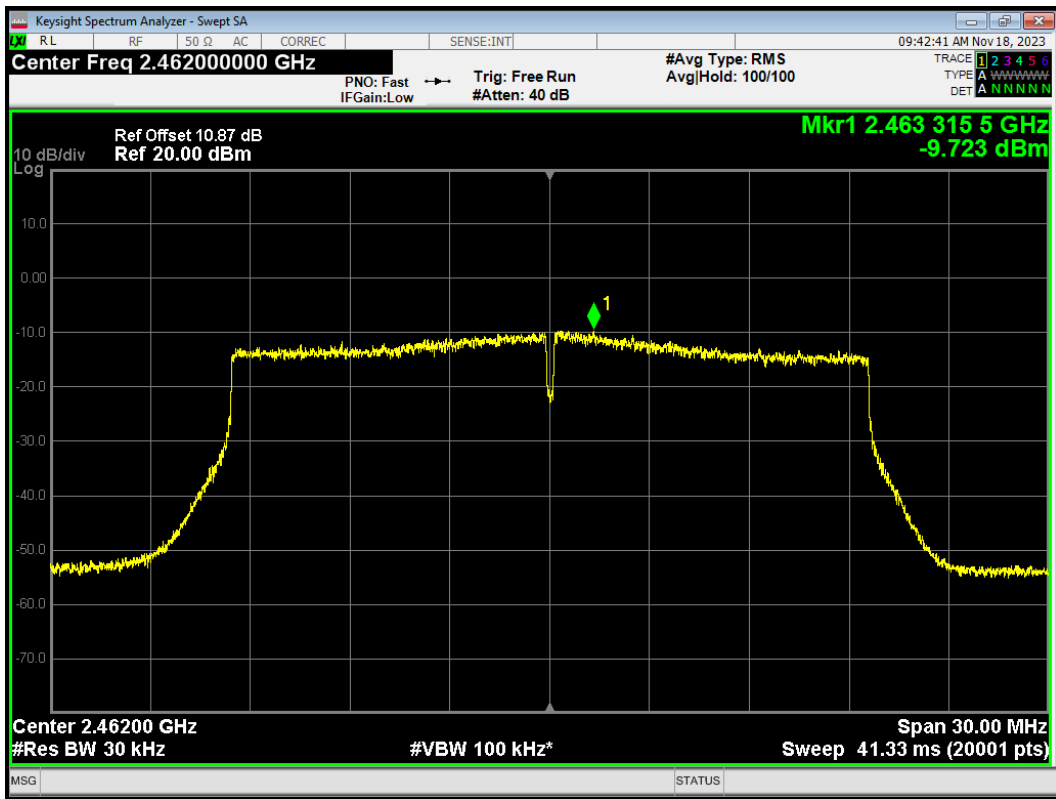
PSD 802.11ax(HE20) 2412MHz



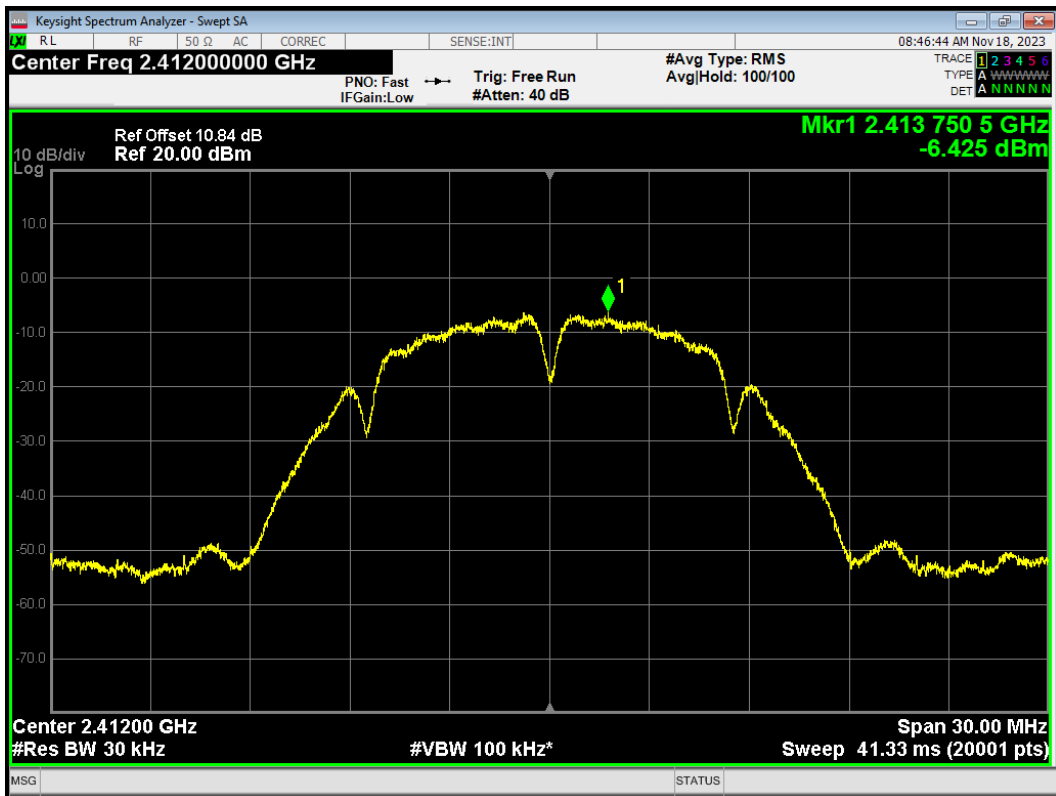
PSD 802.11ax(HE20) 2437MHz



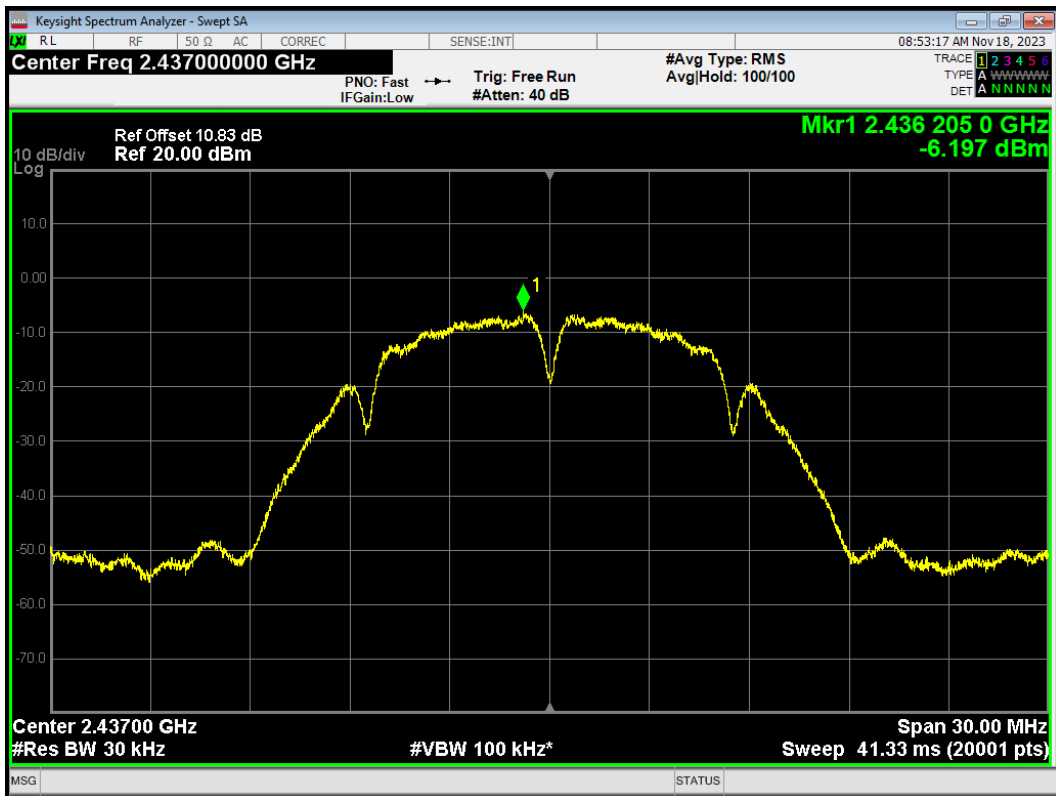
PSD 802.11ax(HE20) 2462MHz



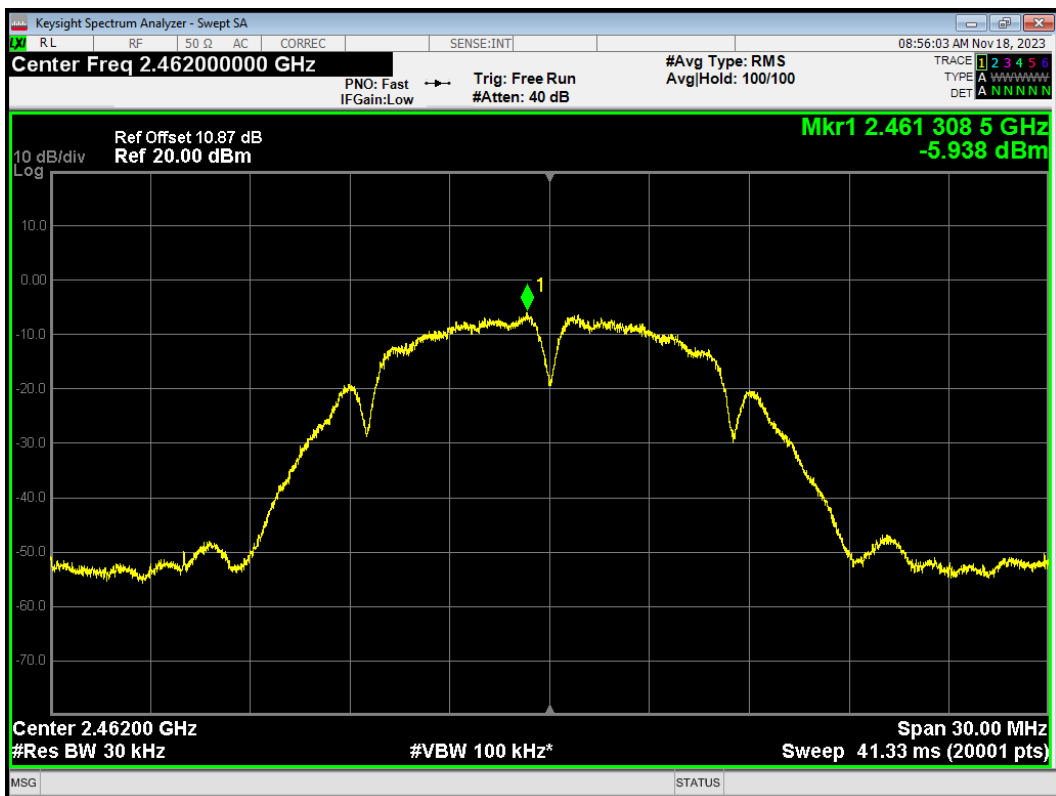
PSD 802.11b 2412MHz



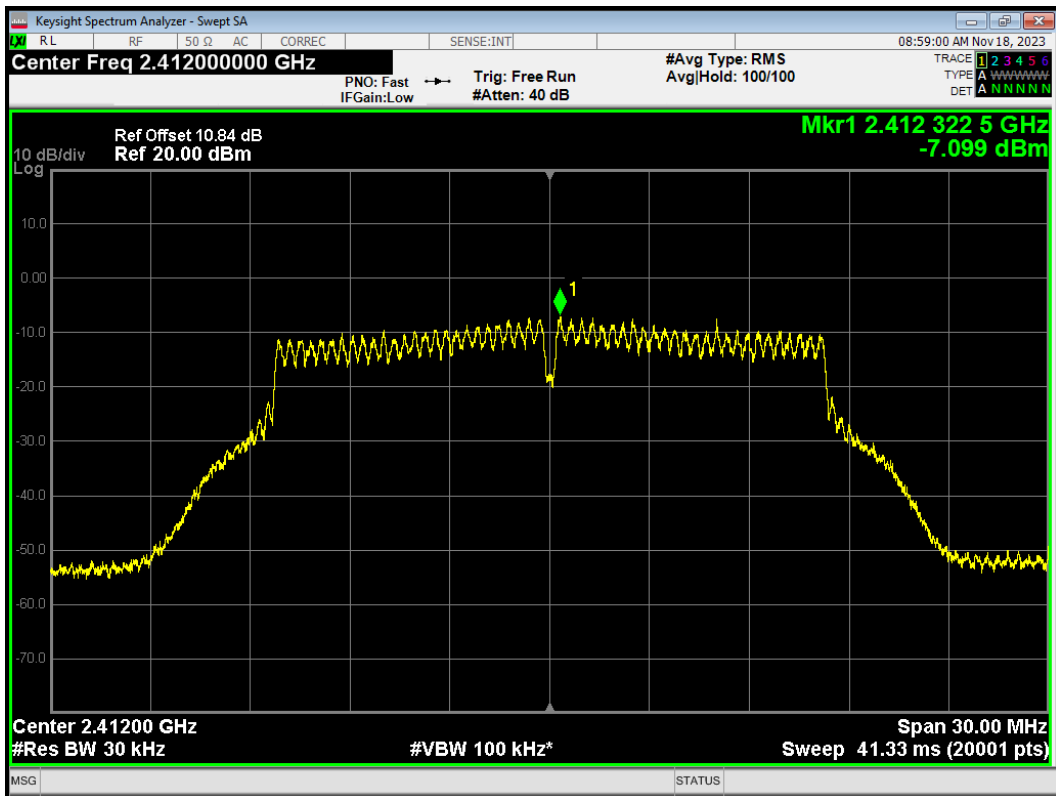
PSD 802.11b 2437MHz



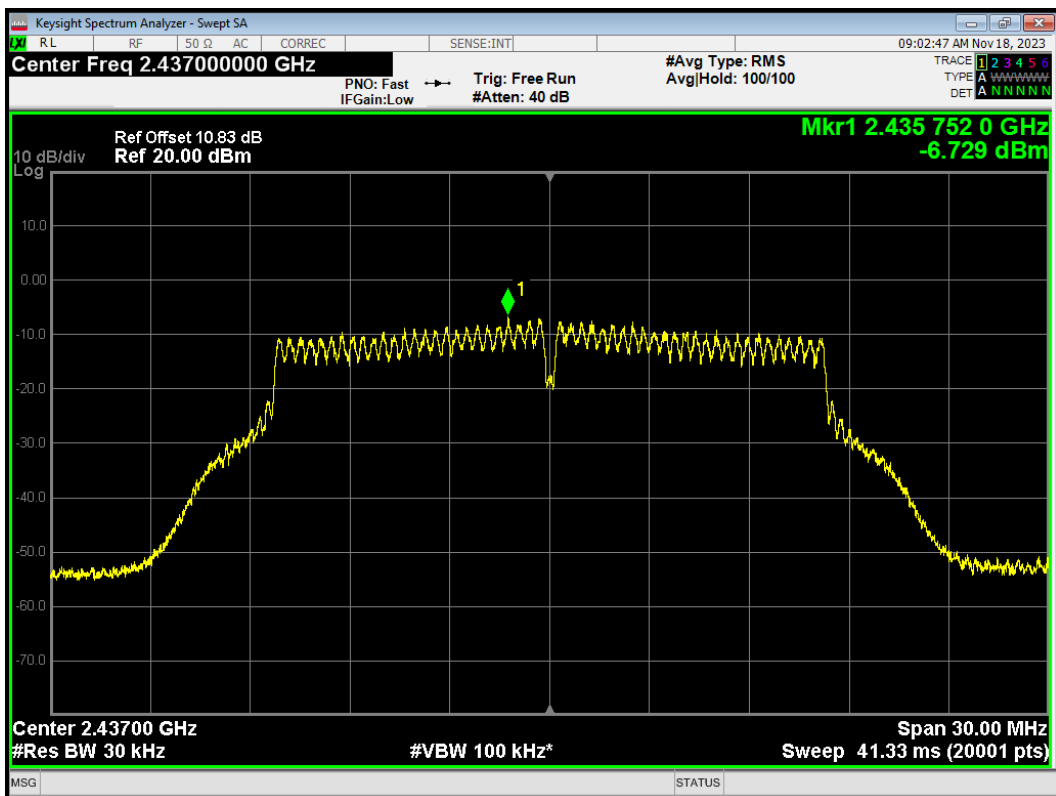
PSD 802.11b 2462MHz



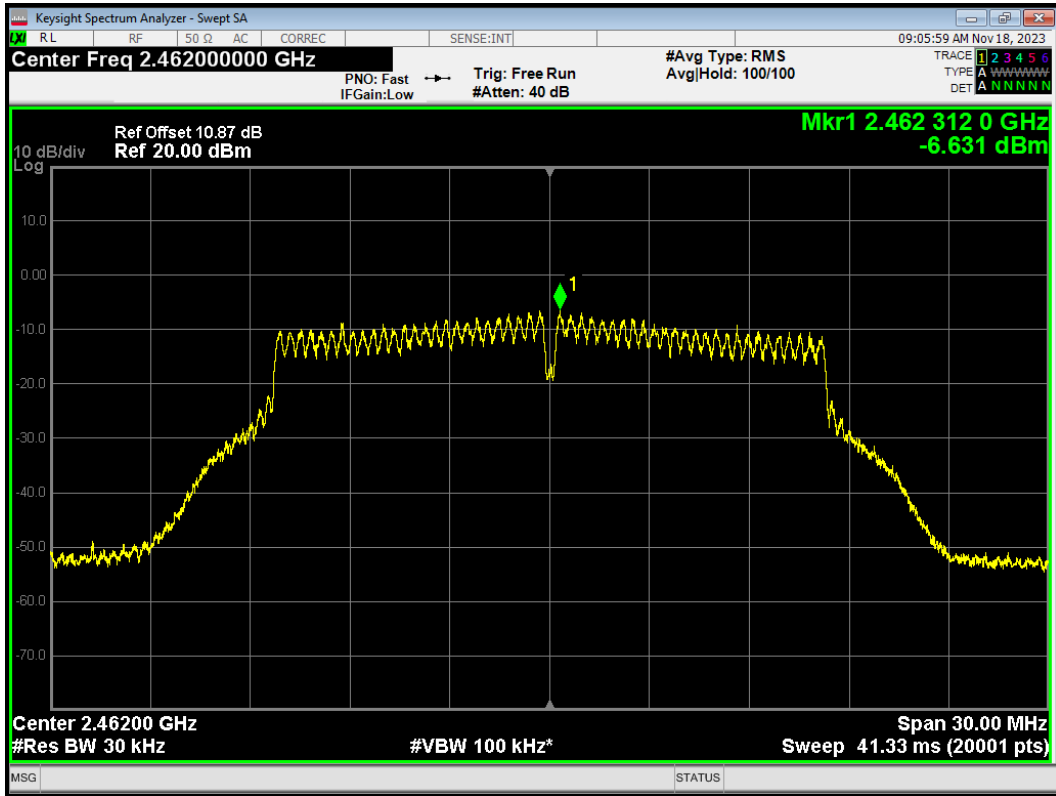
PSD 802.11g 2412MHz



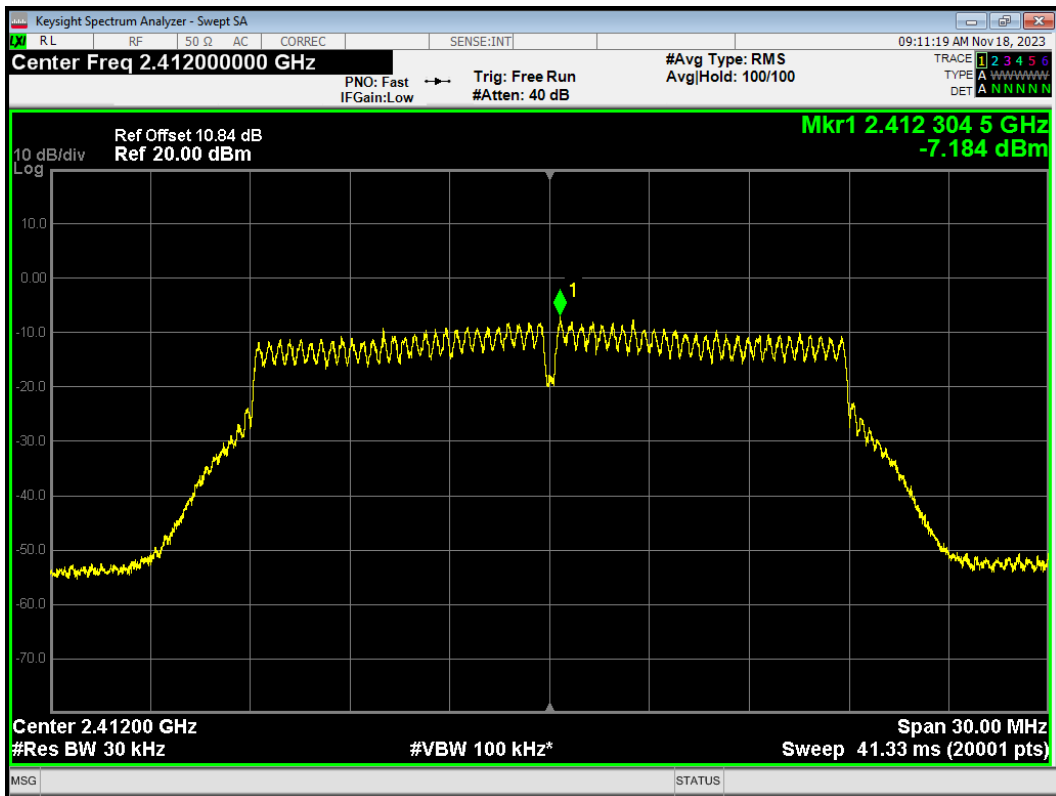
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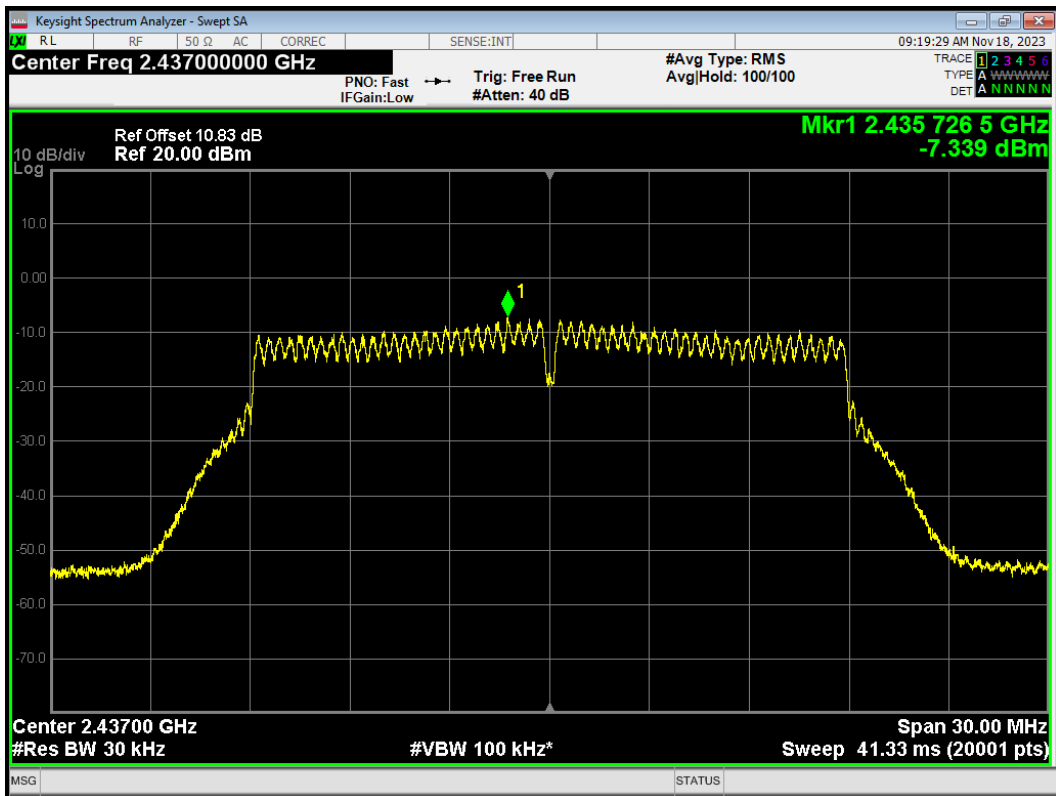
PSD 802.11g 2462MHz



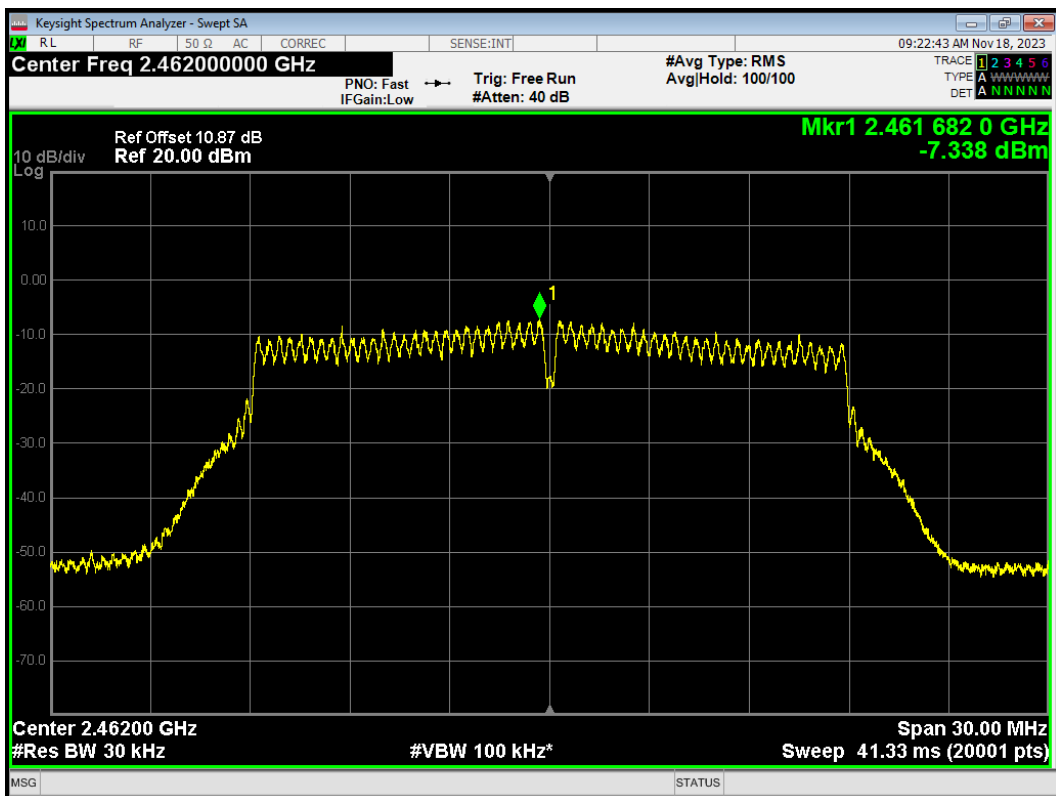
PSD 802.11n(HT20) 2412MHz



PSD 802.11n(HT20) 2437MHz

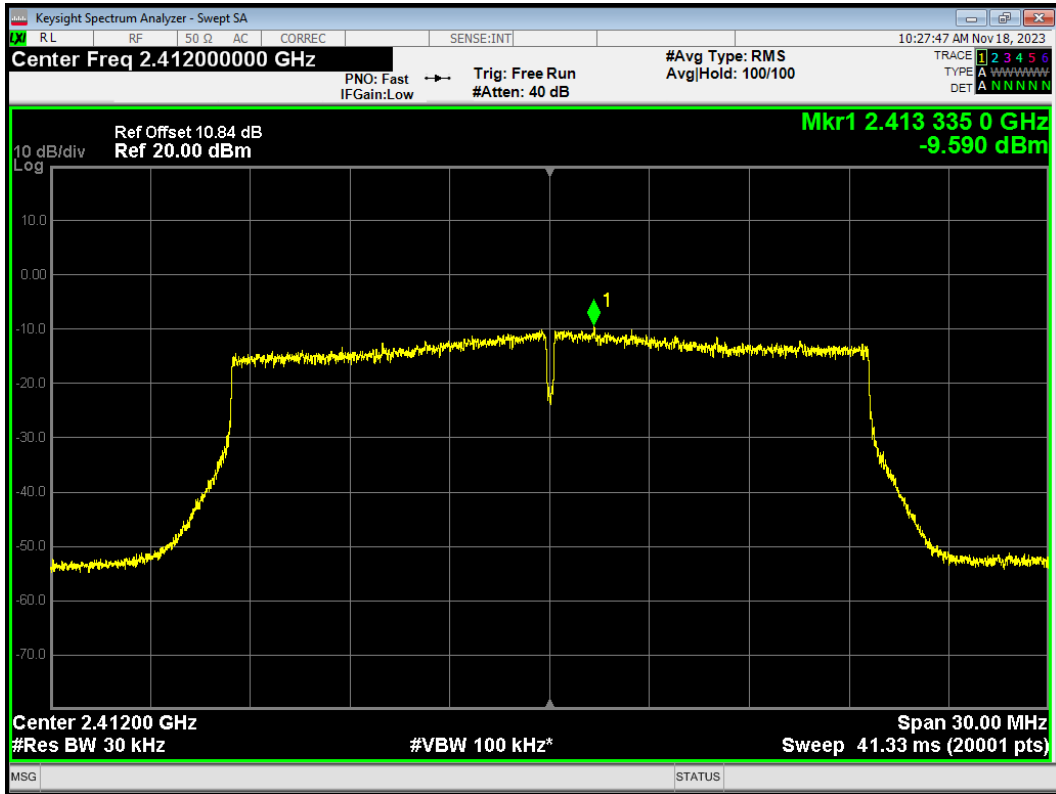


PSD 802.11n(HT20) 2462MHz

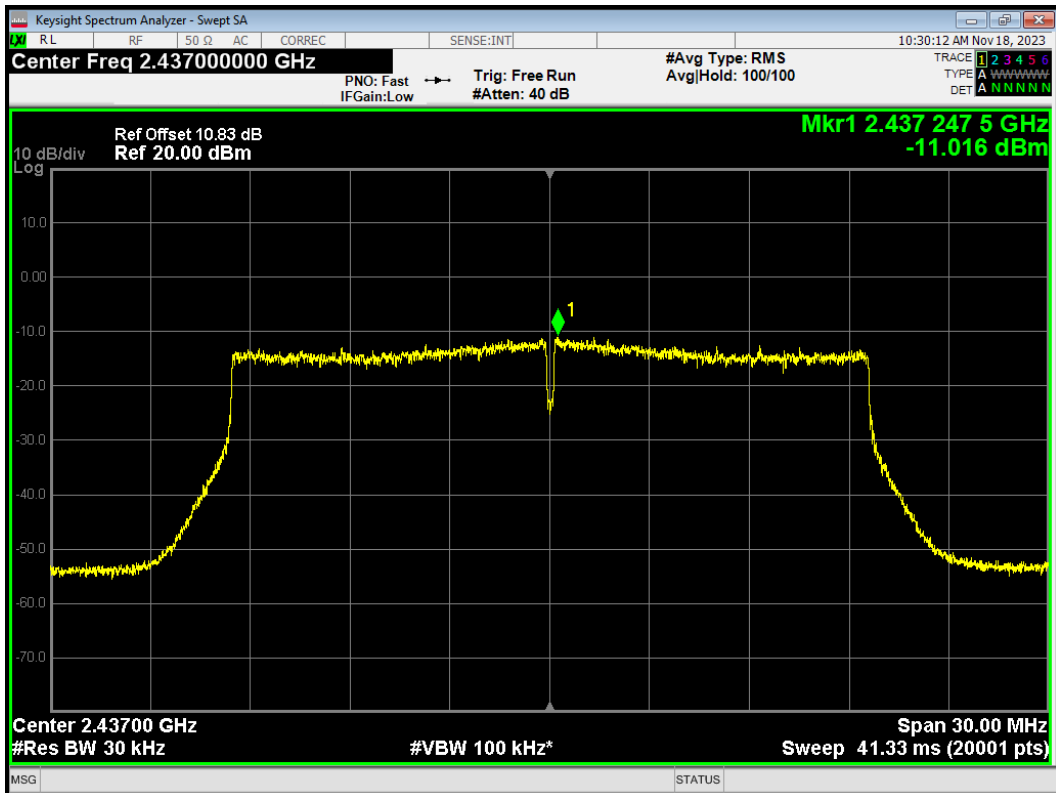


SISO Antenna 2

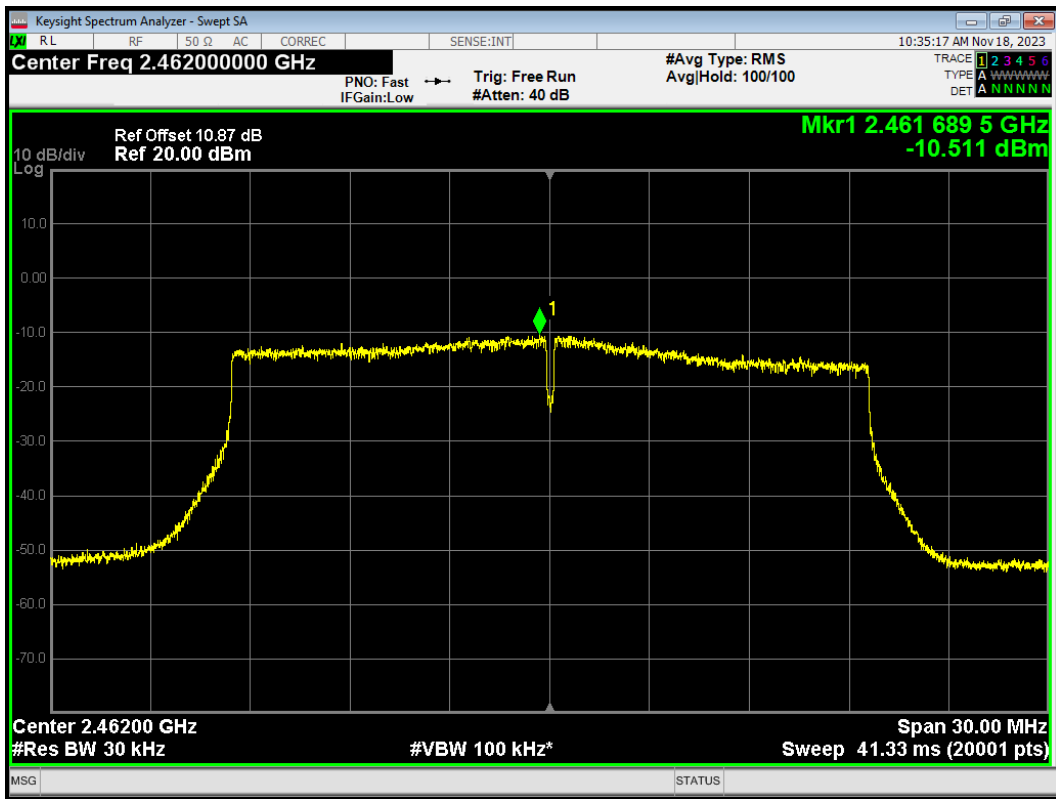
PSD 802.11ax(HE20) 2412MHz



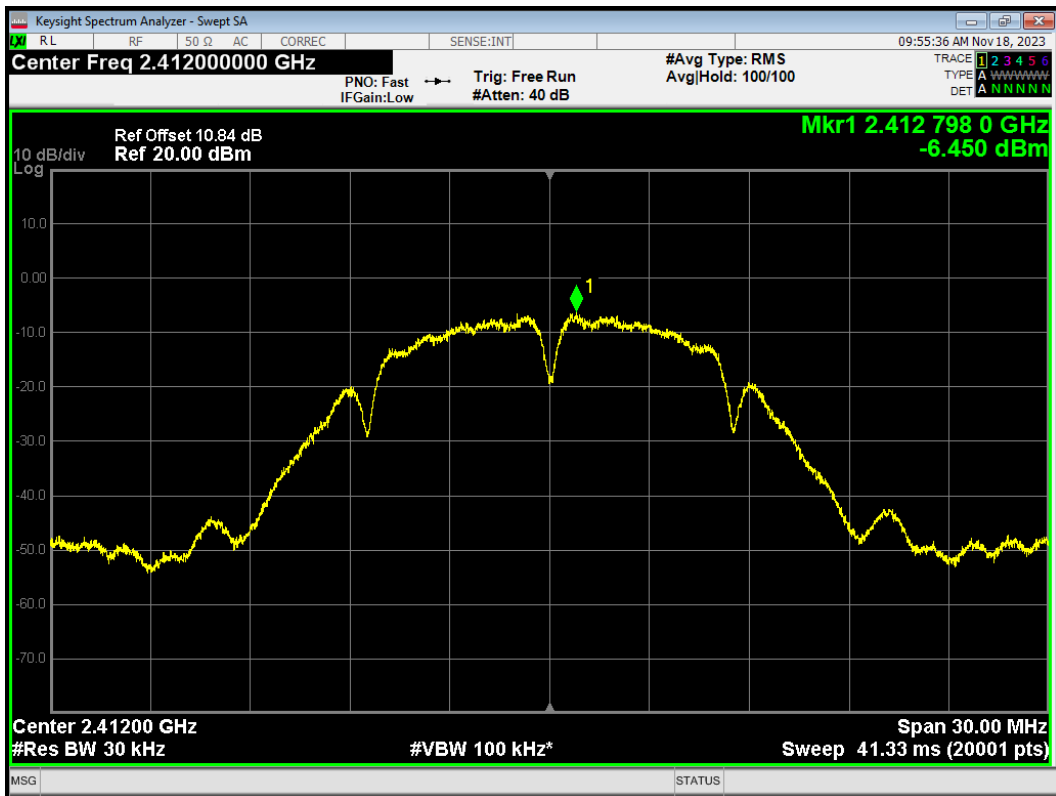
PSD 802.11ax(HE20) 2437MHz



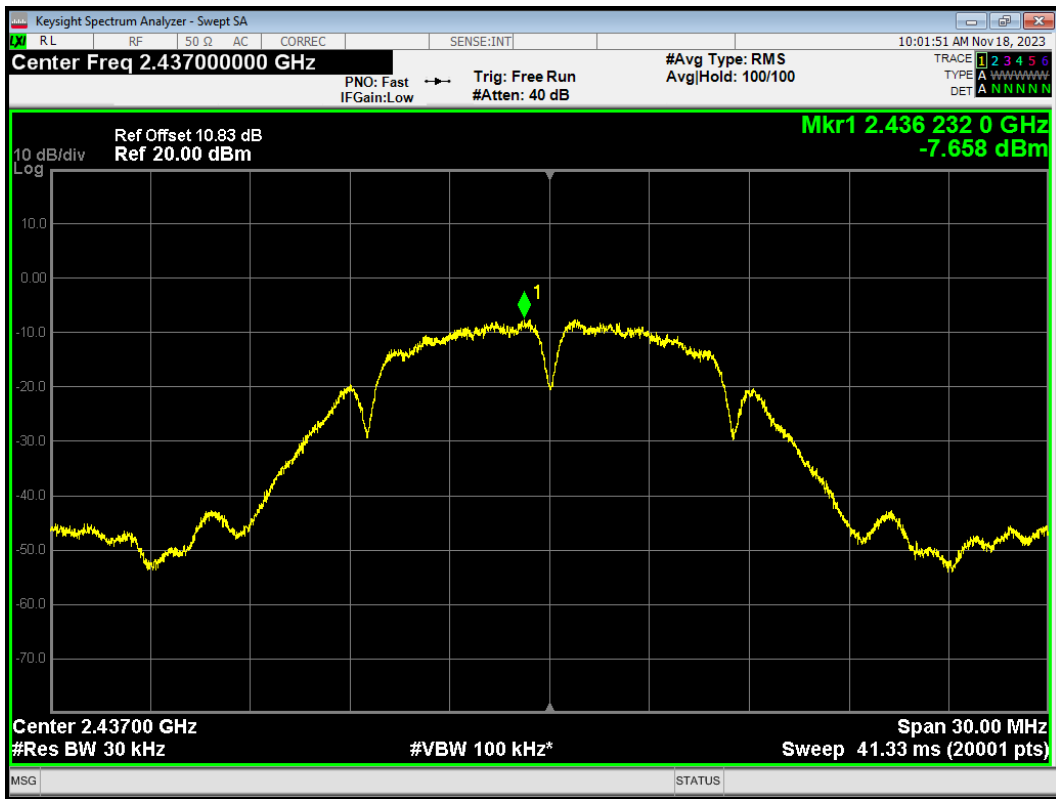
PSD 802.11ax(HE20) 2462MHz



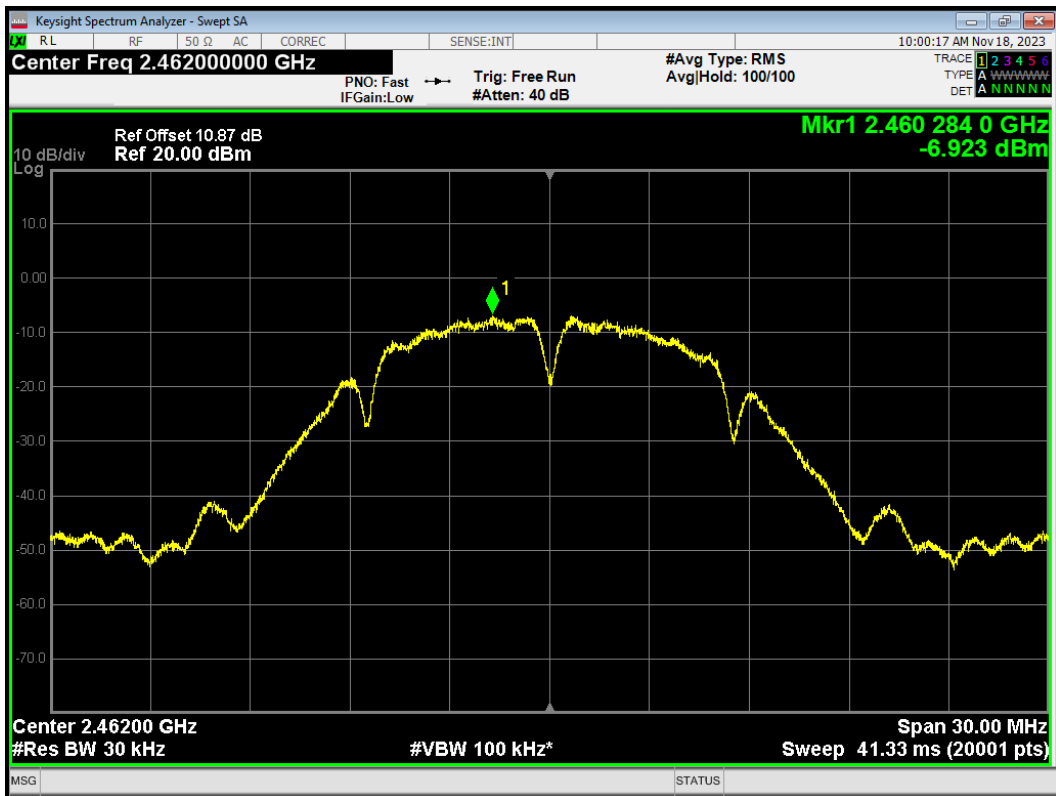
PSD 802.11b 2412MHz



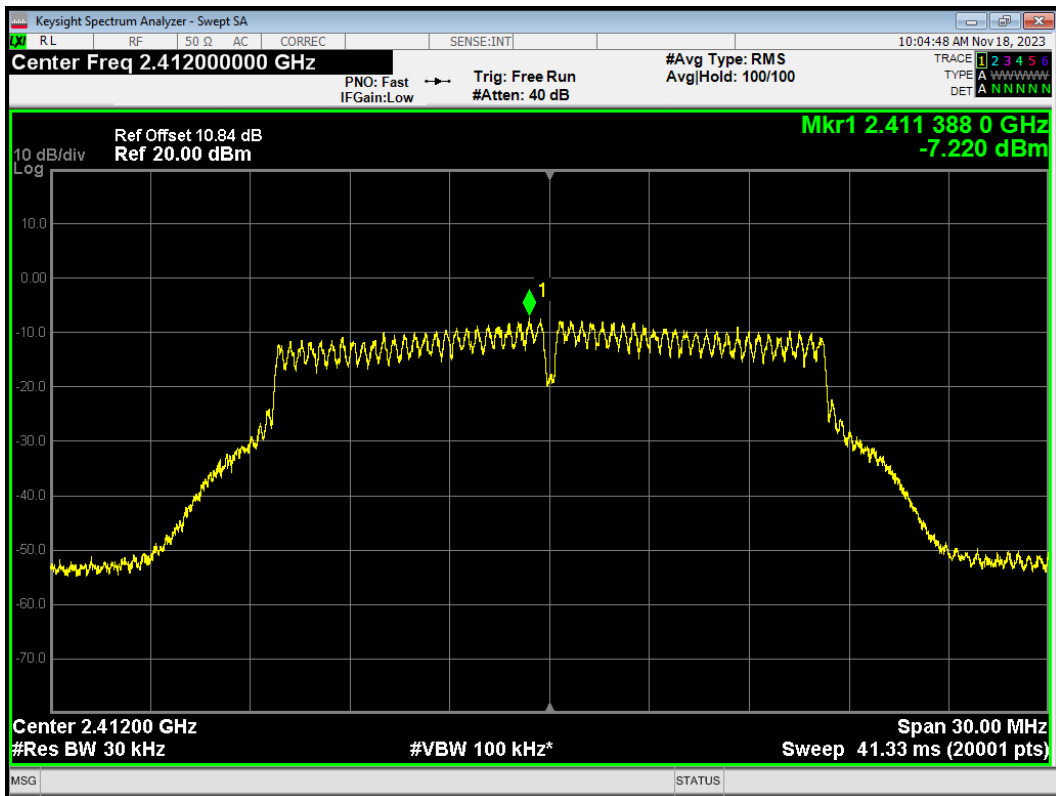
PSD 802.11b 2437MHz



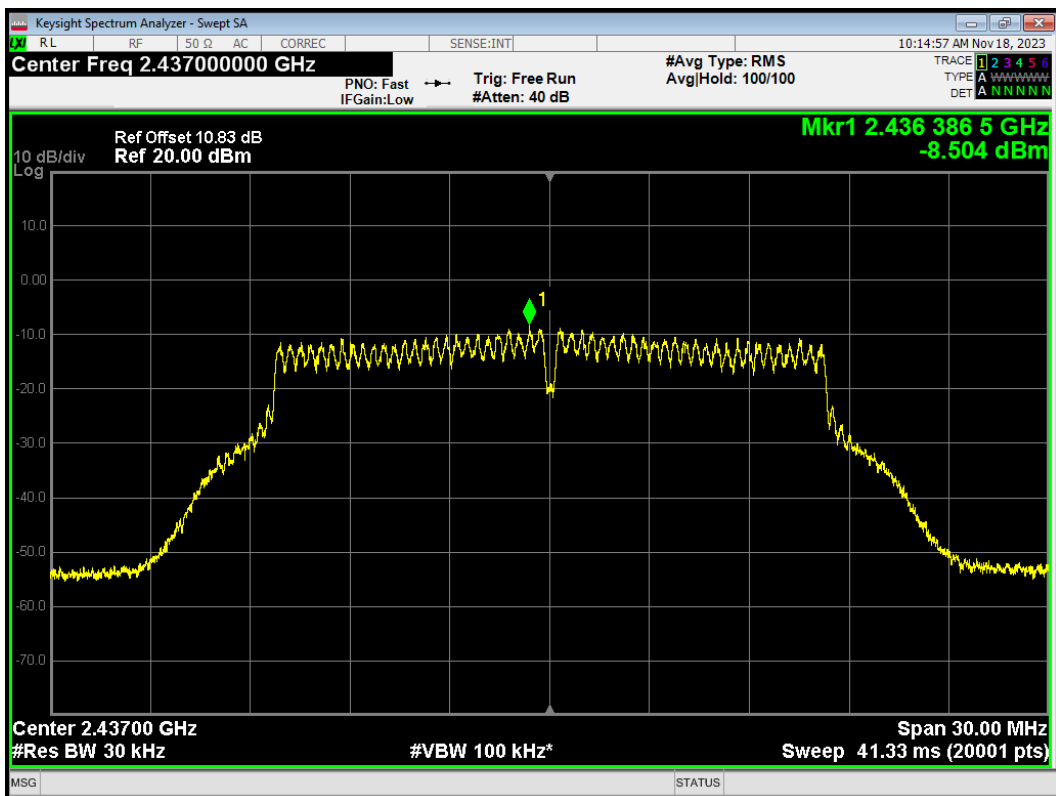
PSD 802.11b 2462MHz



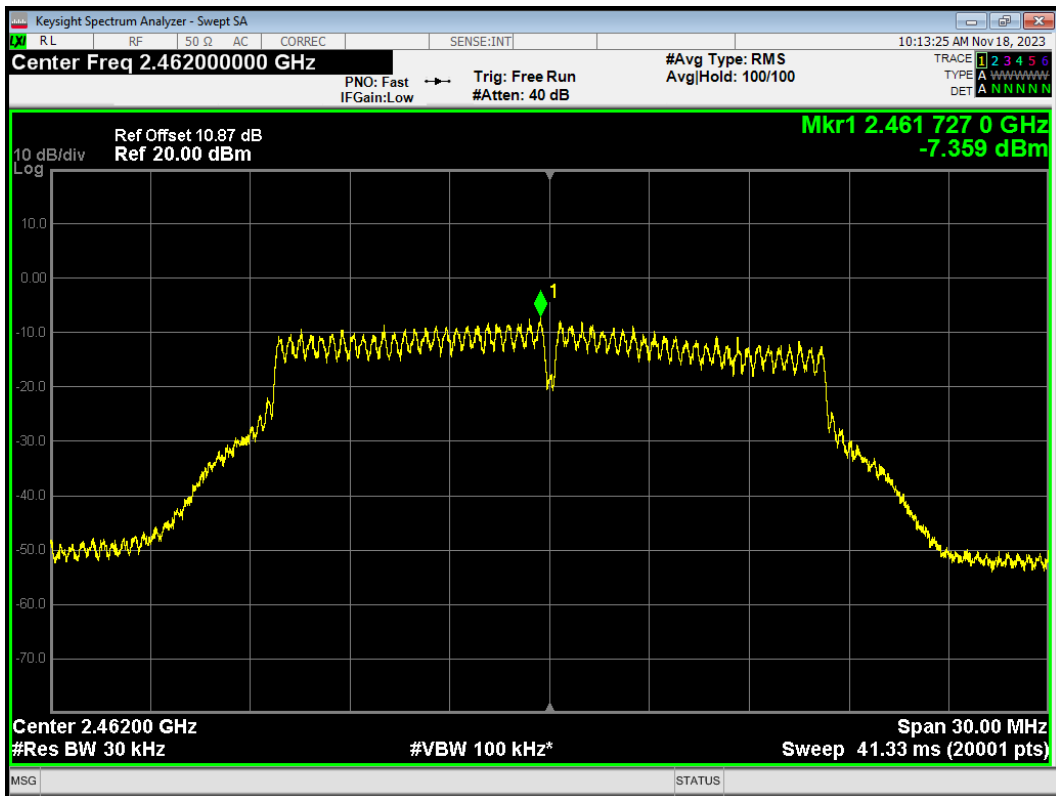
PSD 802.11g 2412MHz



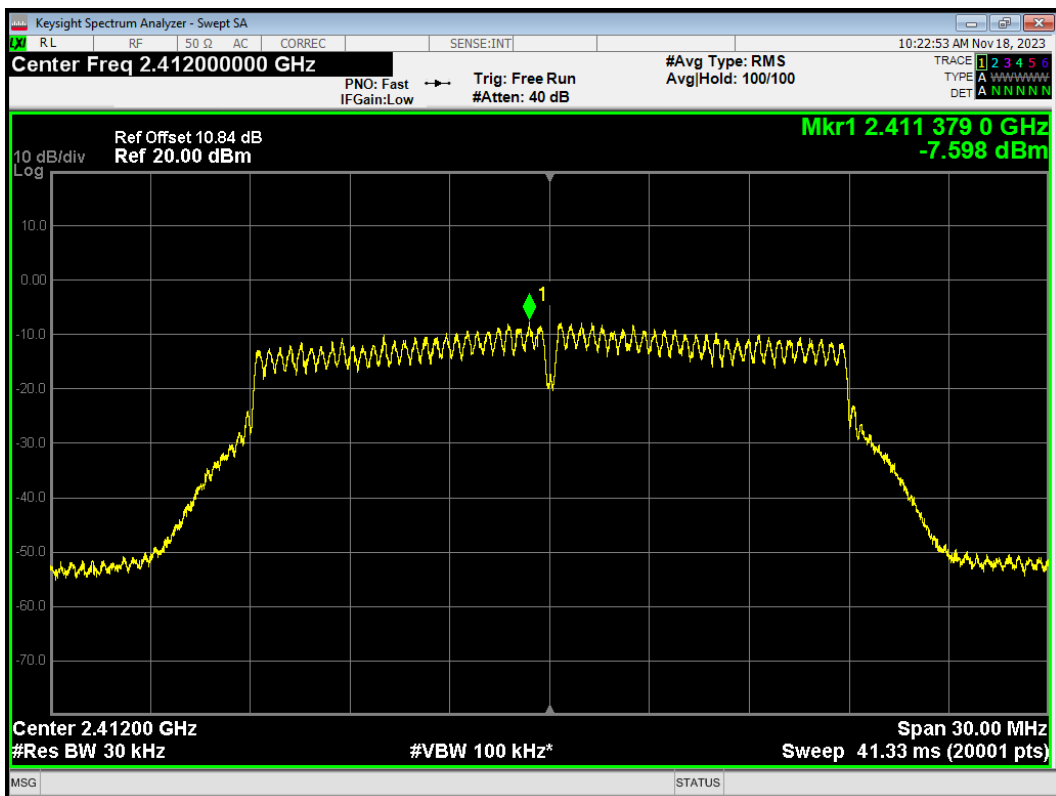
PSD 802.11g 2437MHz



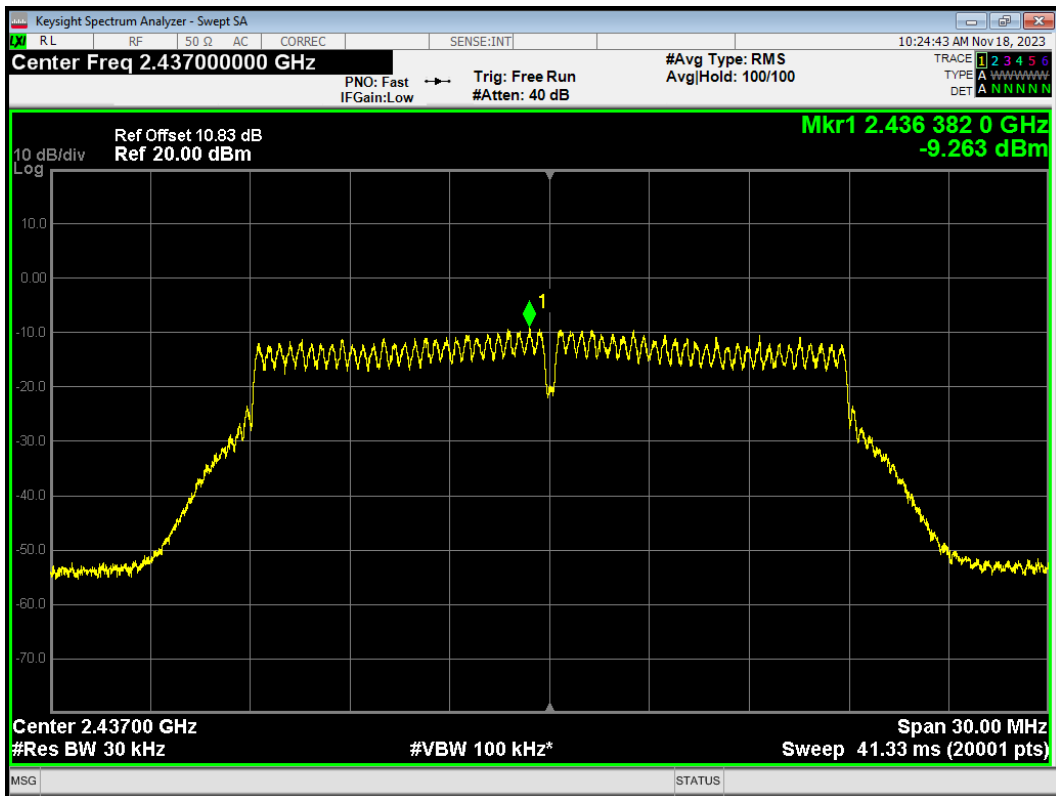
PSD 802.11g 2462MHz



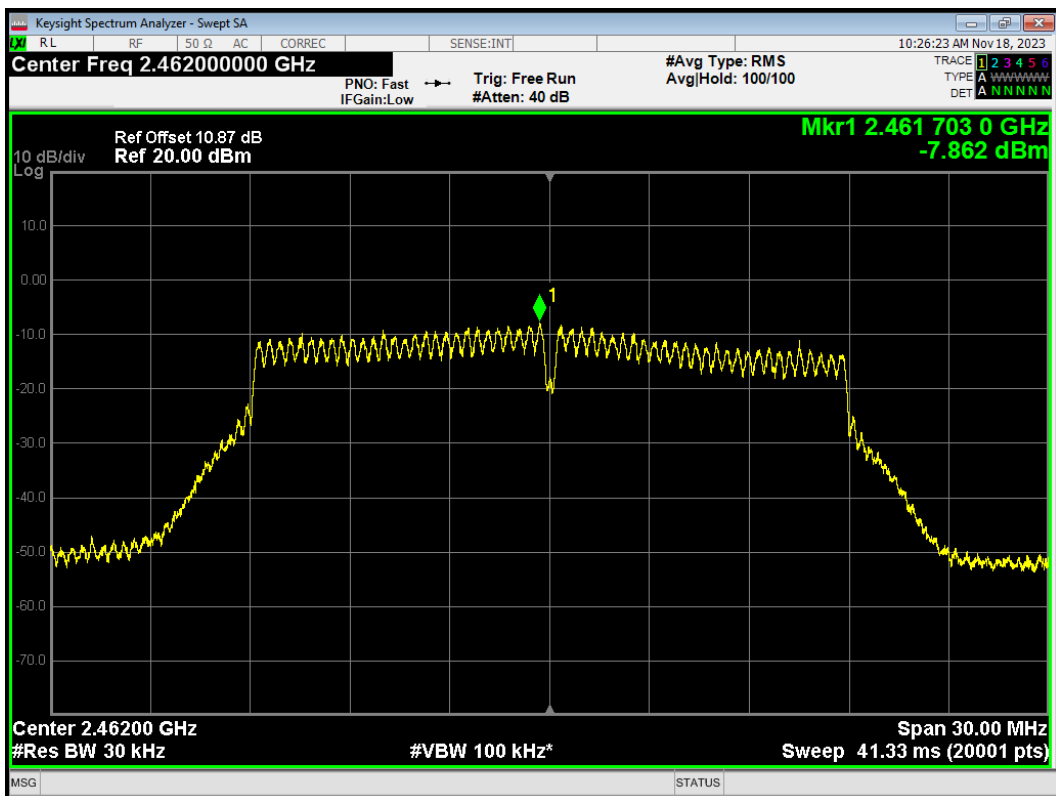
PSD 802.11n(HT20) 2412MHz



PSD 802.11n(HT20) 2437MHz

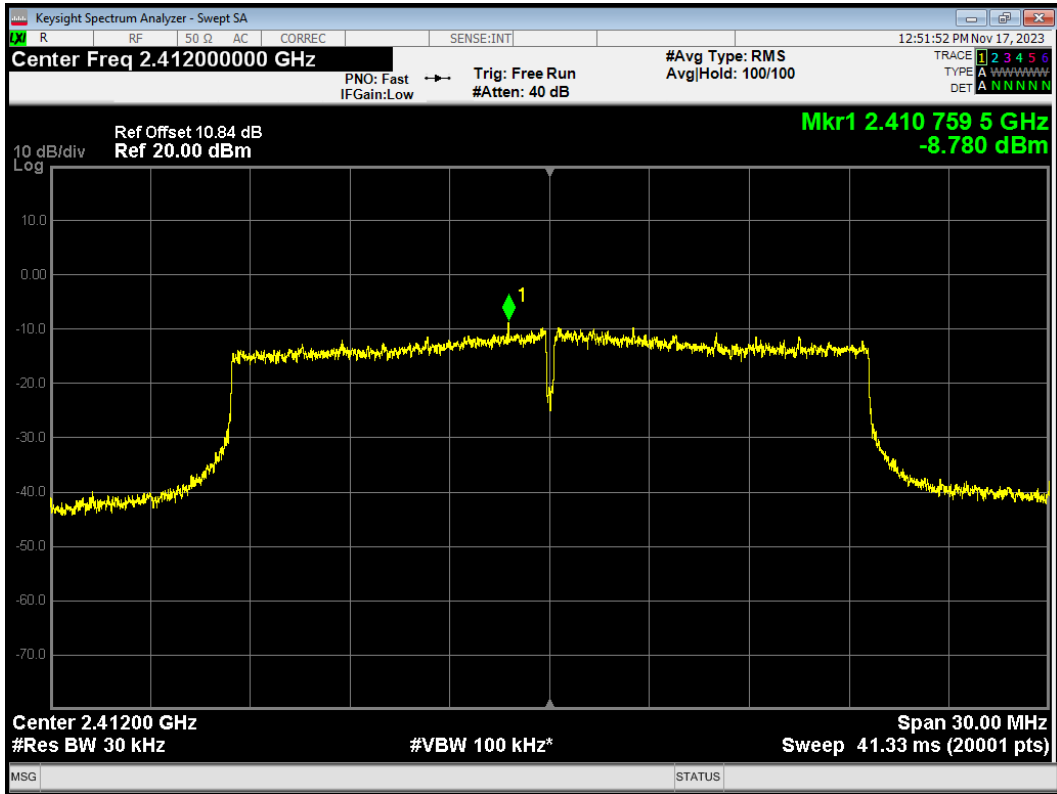


PSD 802.11n(HT20) 2462MHz

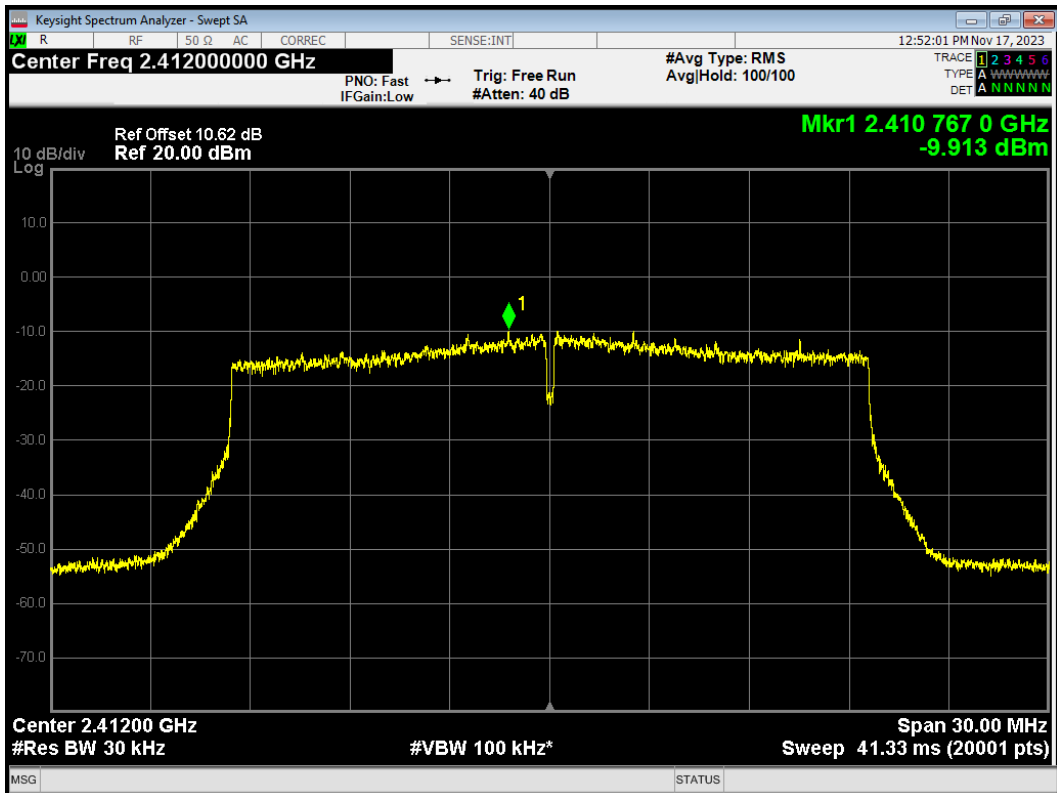


MIMO

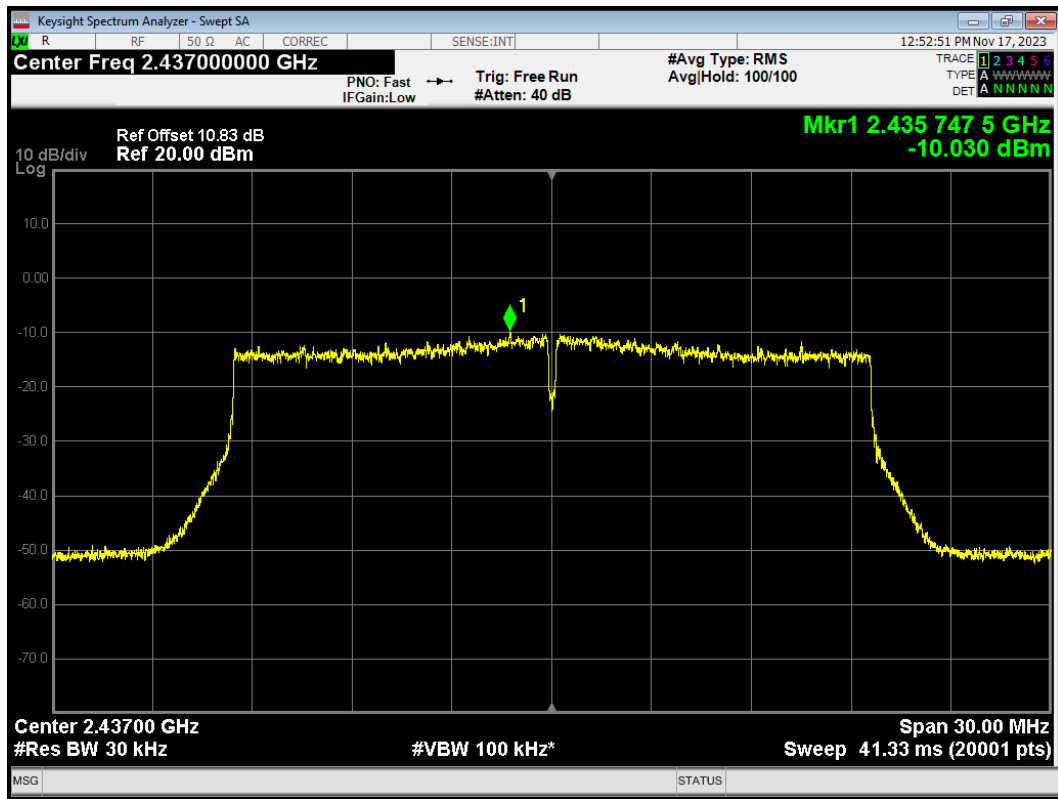
PSD 802.11ax(HE20) 2412MHz Ant1



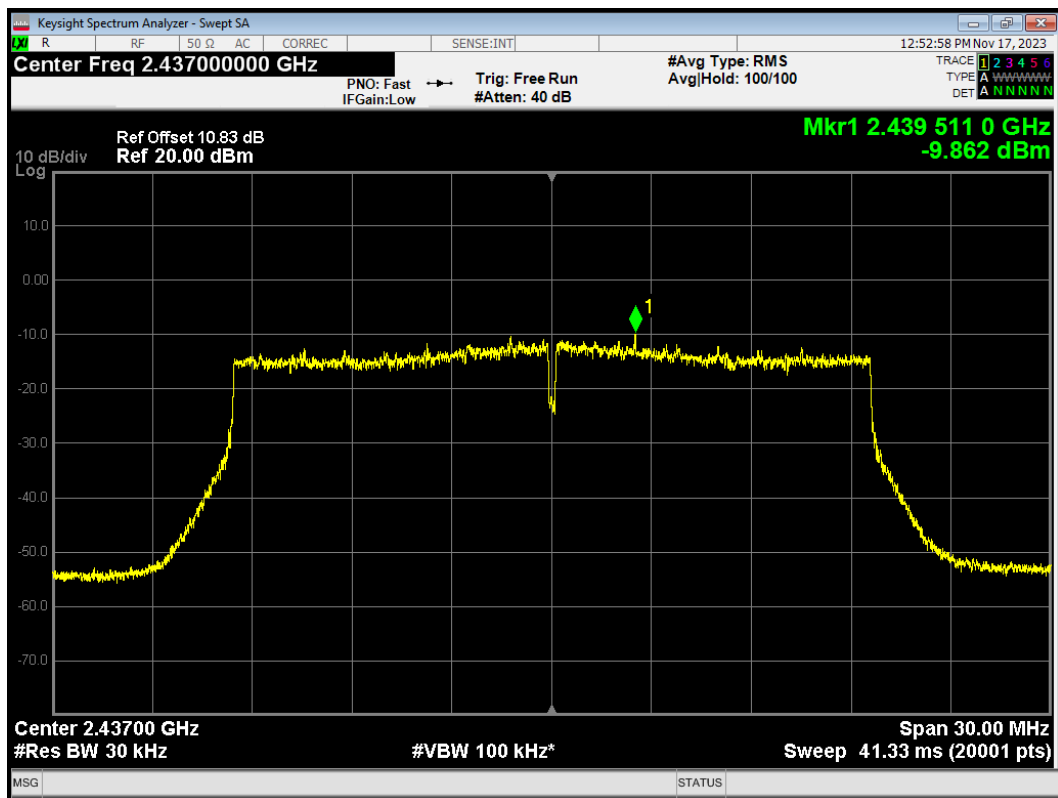
PSD 802.11ax(HE20) 2412MHz Ant2



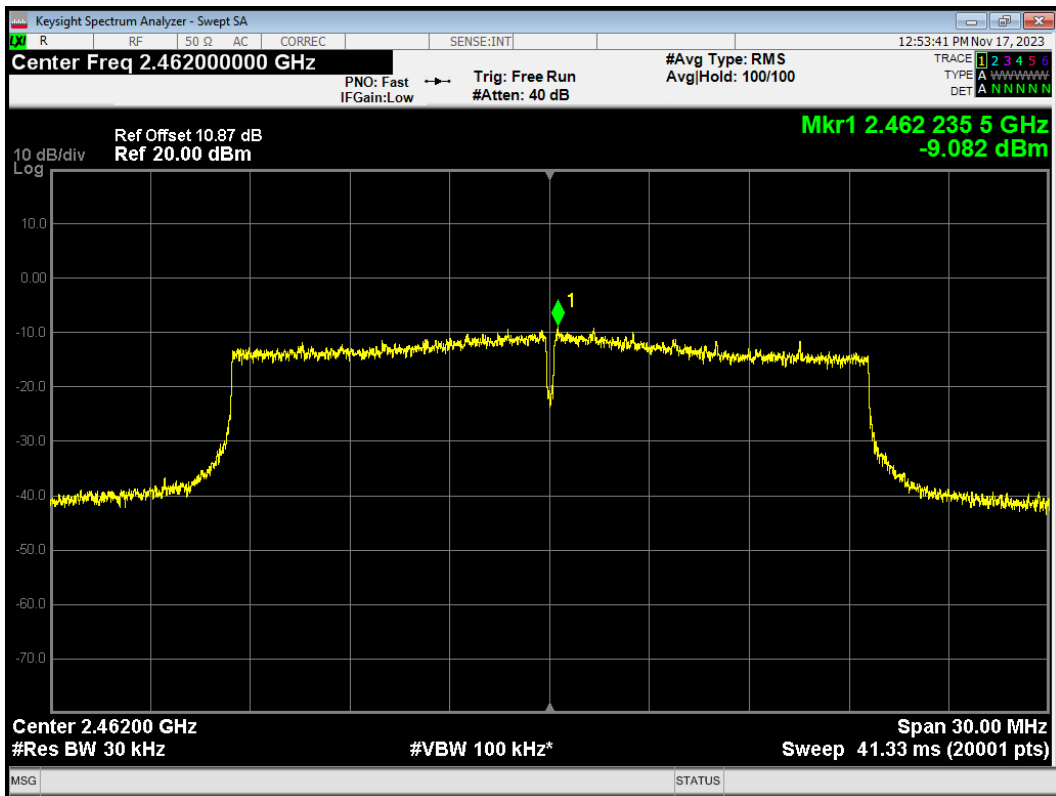
PSD 802.11ax(HE20) 2437MHz Ant1



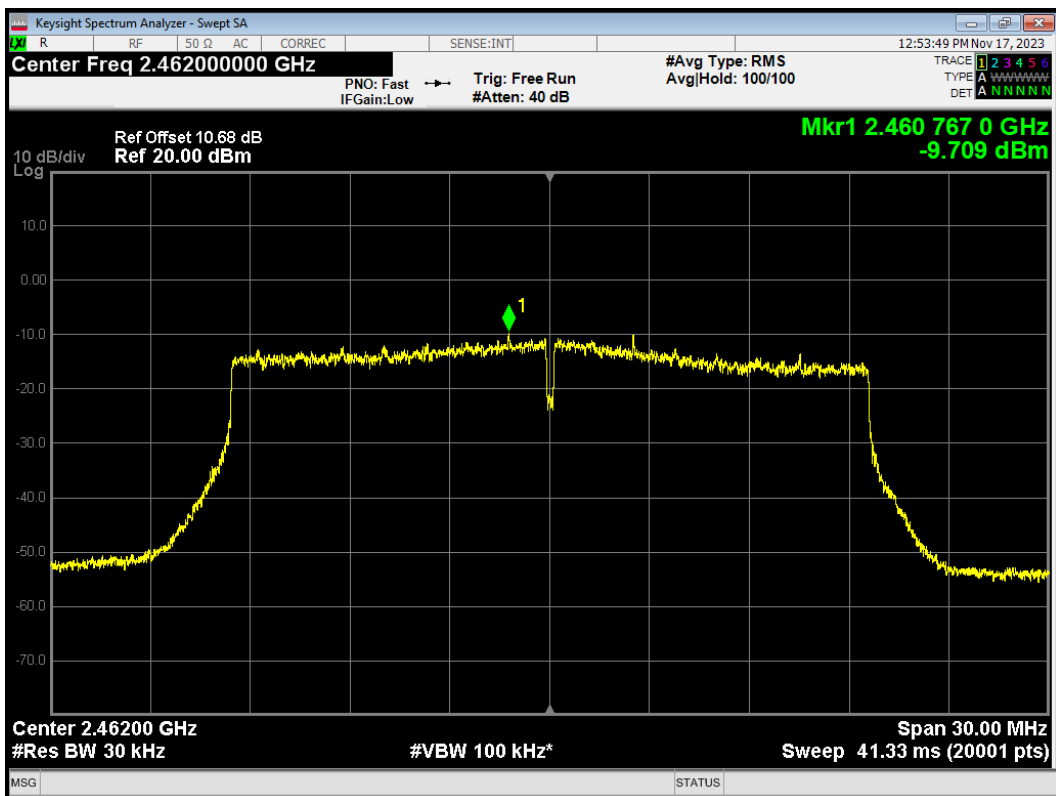
PSD 802.11ax(HE20) 2437MHz Ant2



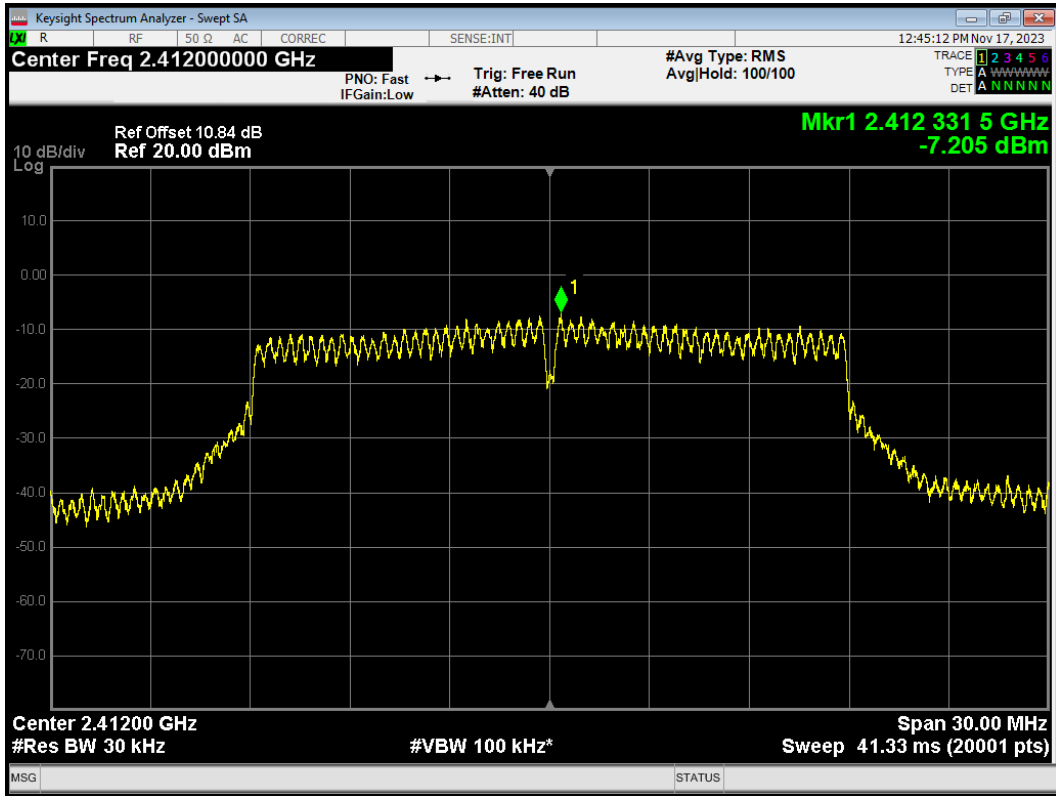
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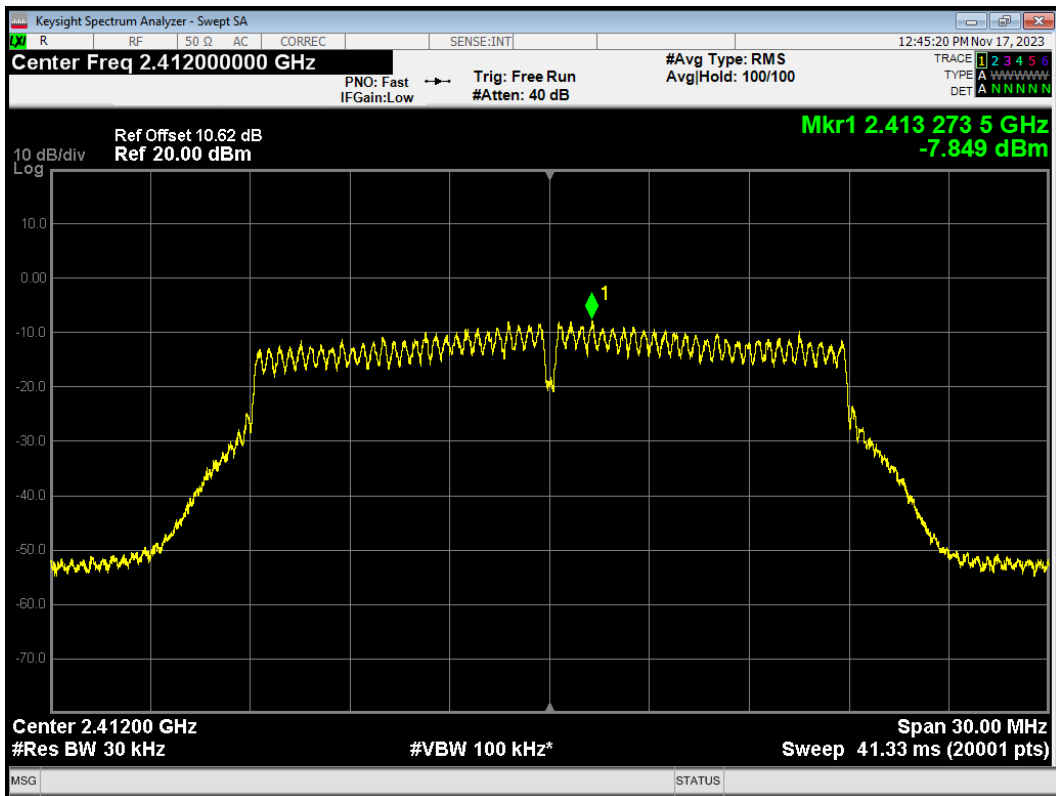
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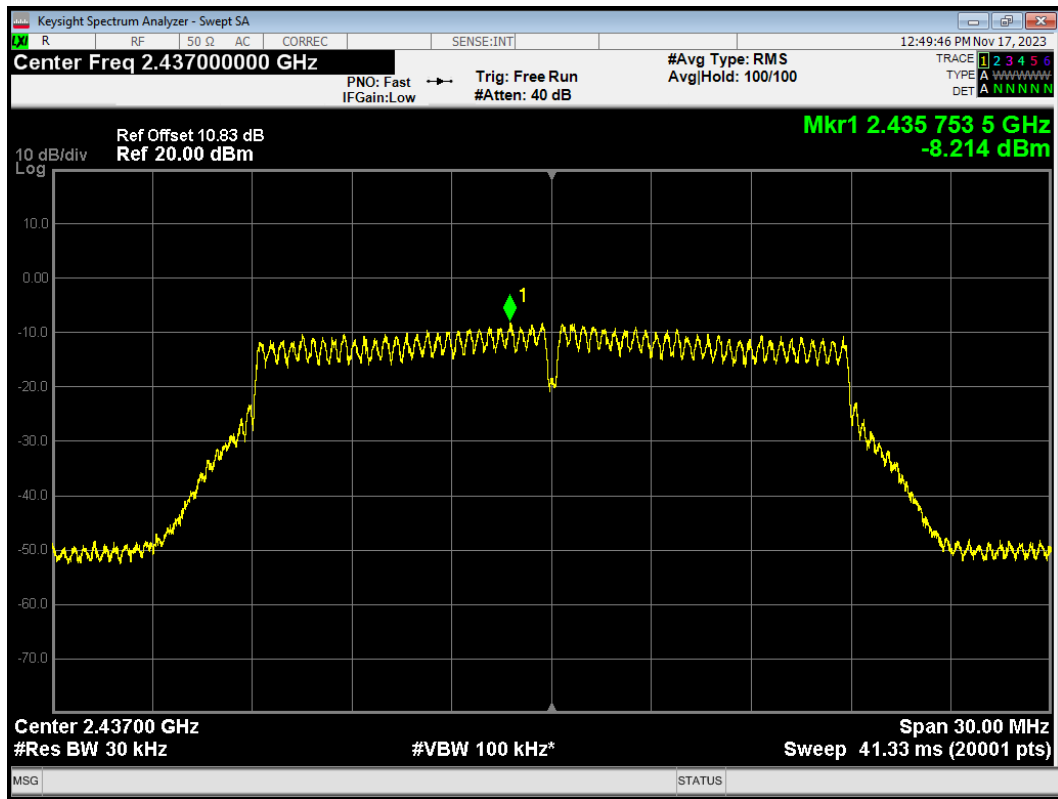
PSD 802.11n(HT20) 2412MHz Ant1



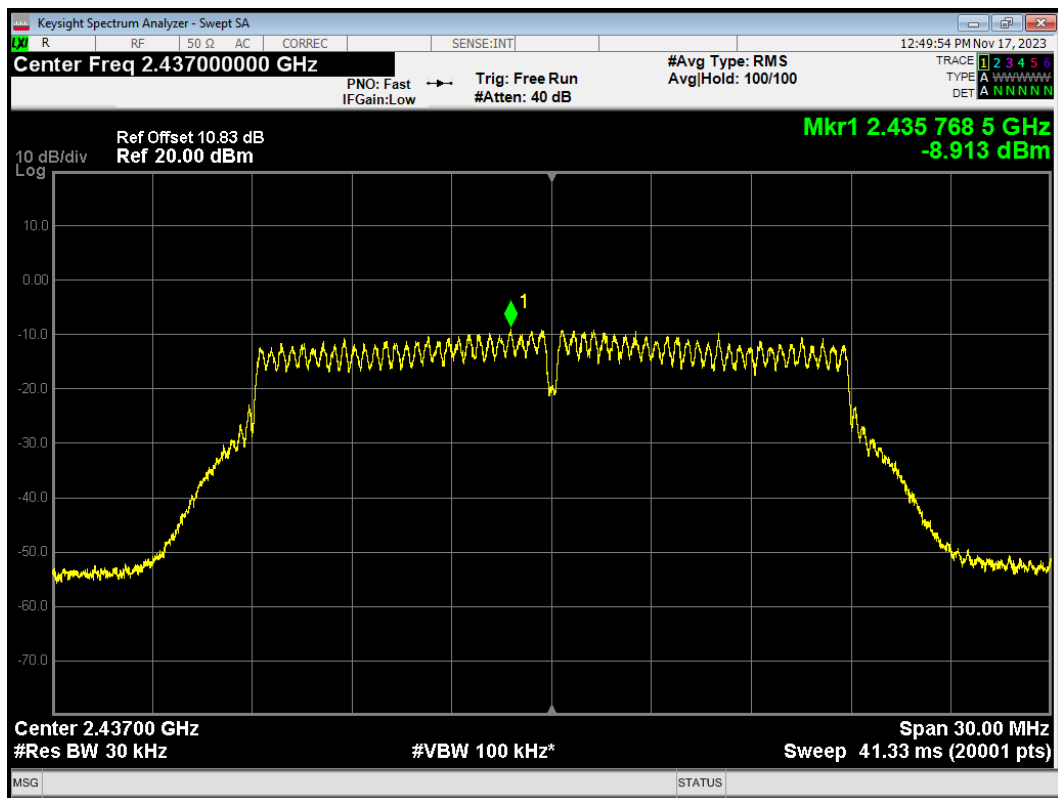
PSD 802.11n(HT20) 2412MHz Ant2



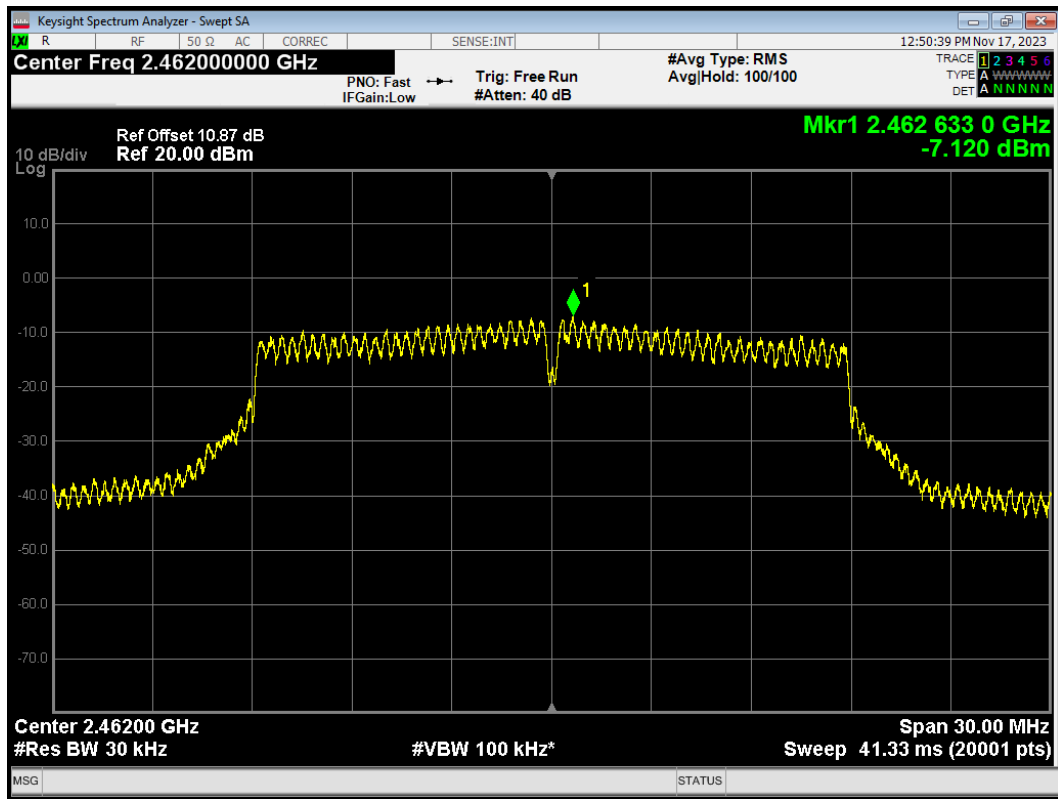
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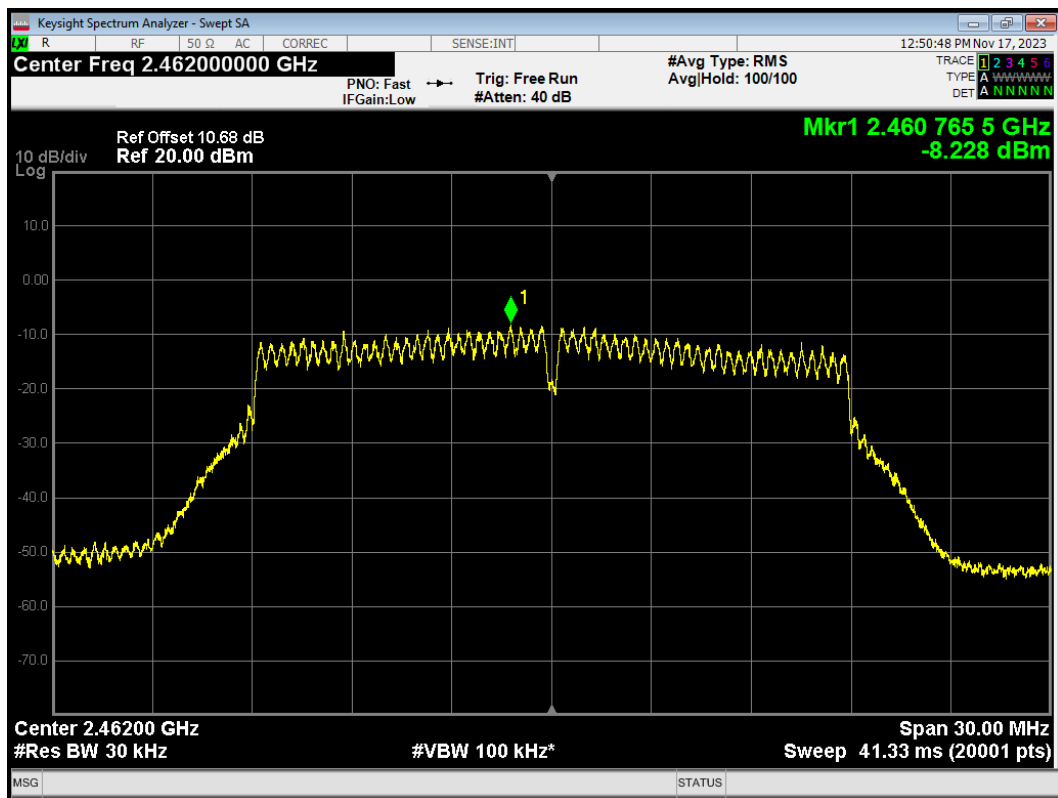
PSD 802.11n(HT20) 2437MHz Ant2



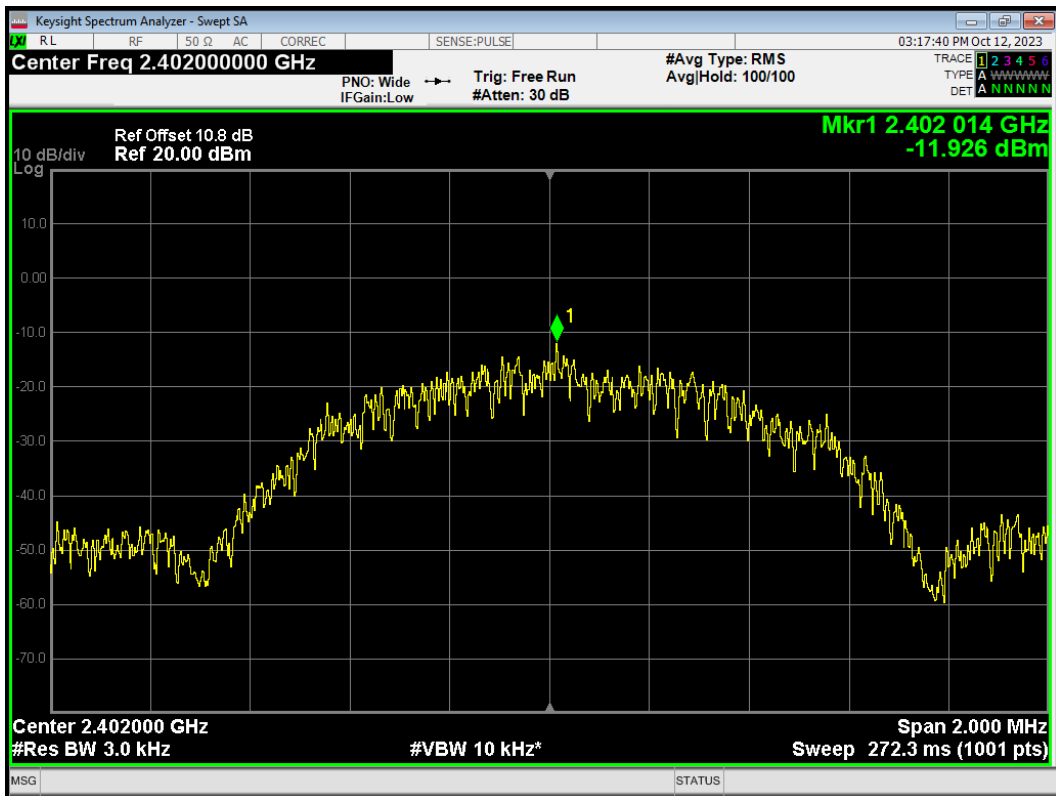
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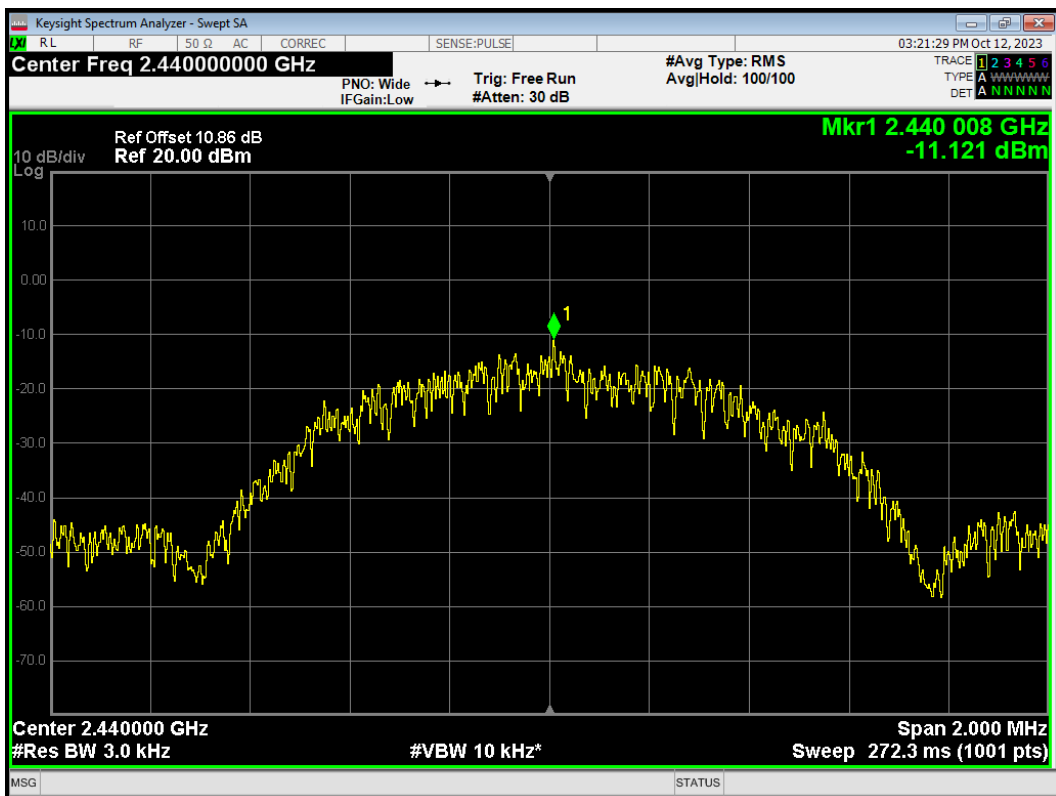
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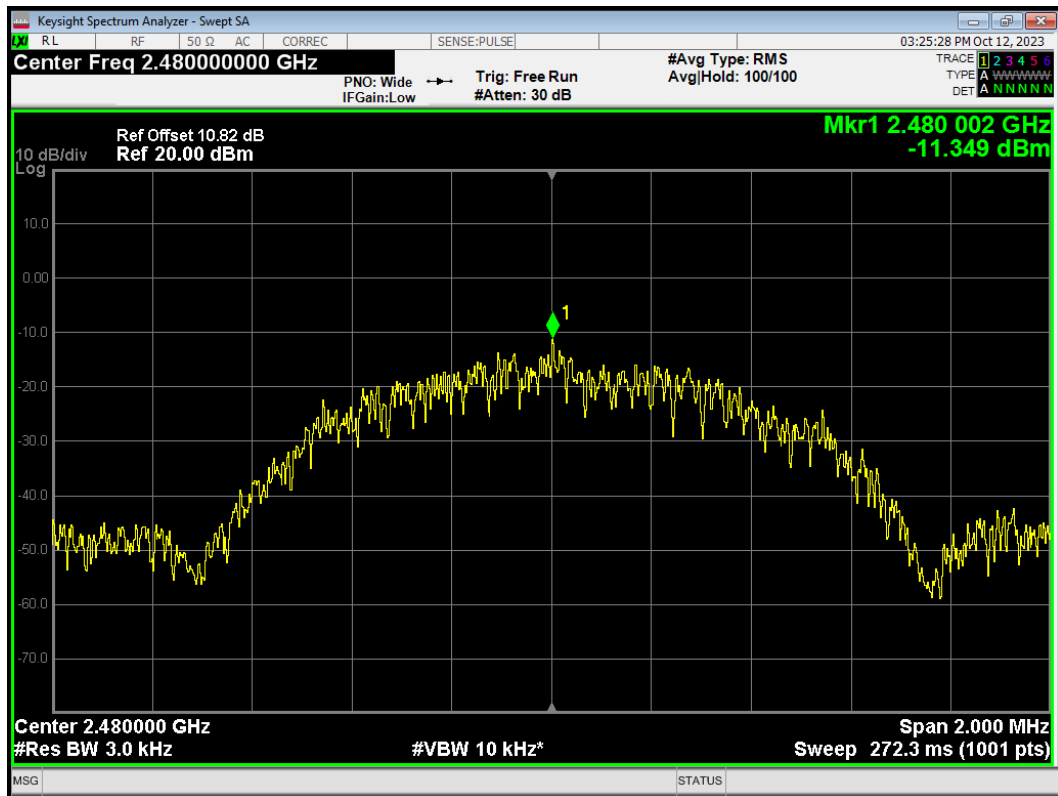
PSD Bluetooth LE(1M)2402MHz



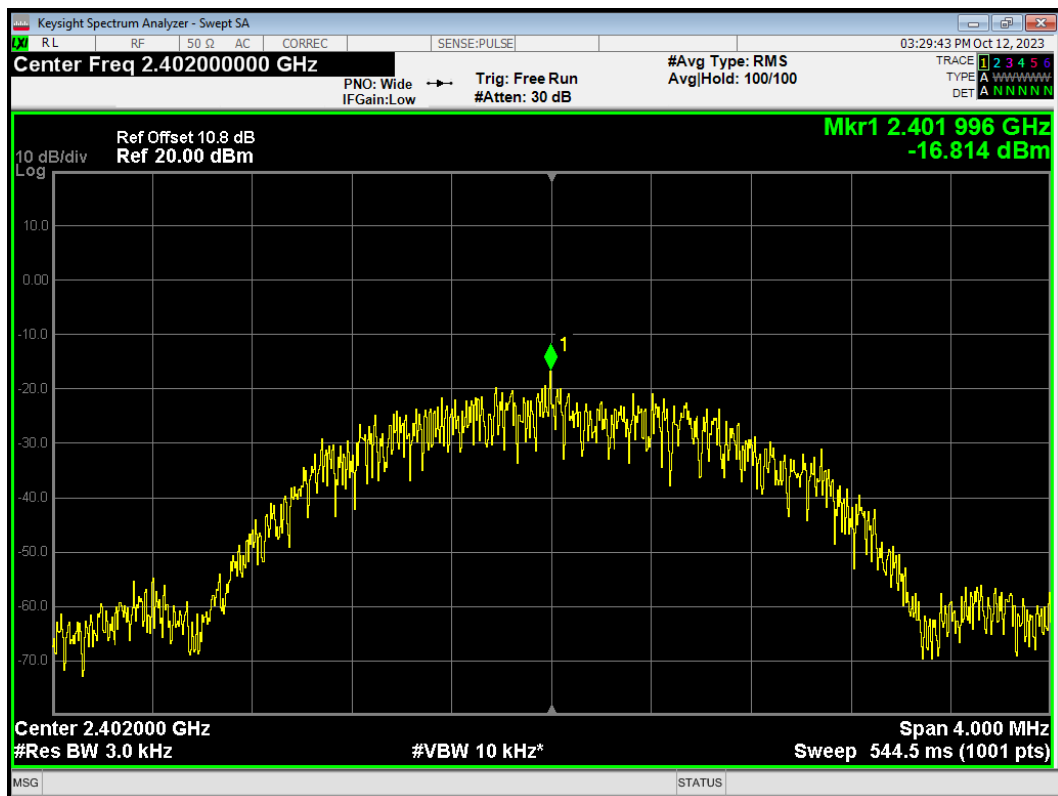
PSD Bluetooth LE(1M)2440MHz



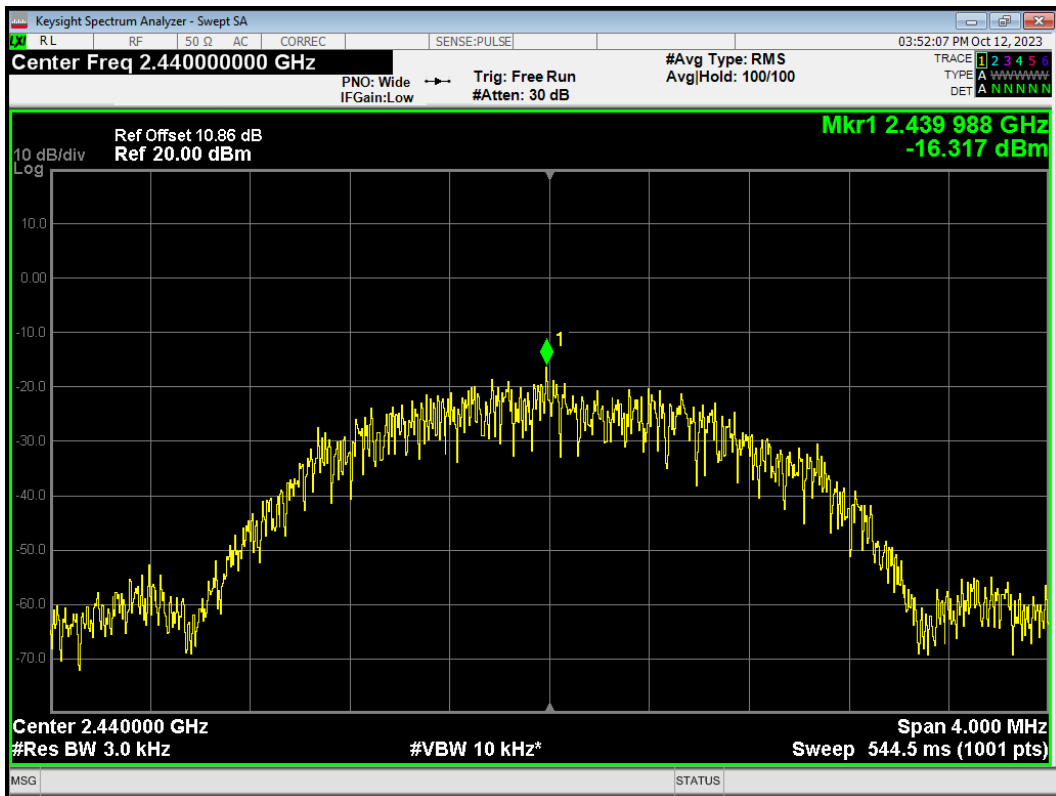
PSD Bluetooth LE(1M)2480MHz



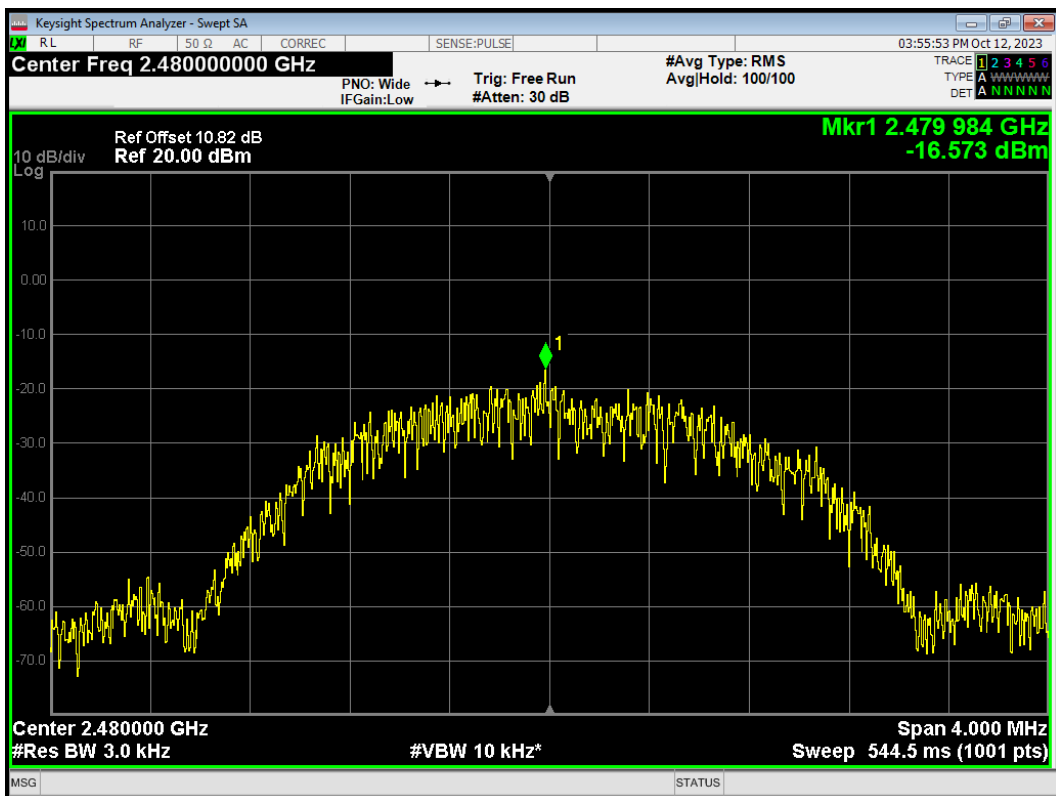
PSD Bluetooth LE(2M) 2402MHz



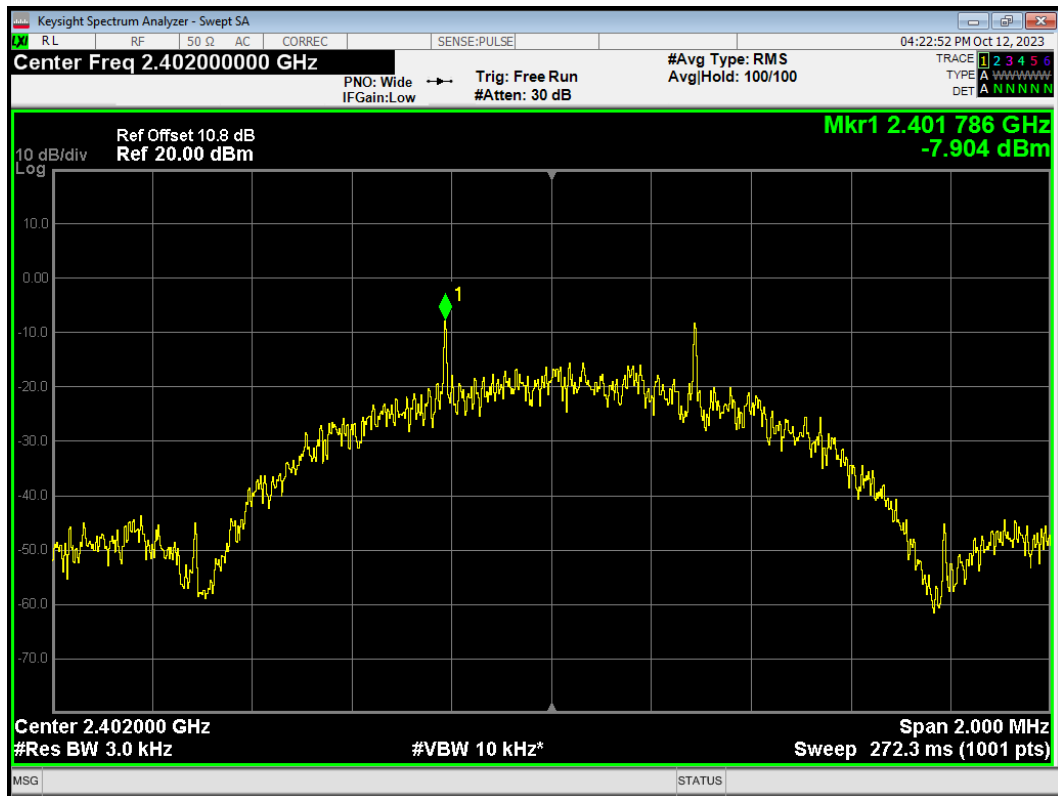
PSD Bluetooth LE(2M) 2440MHz



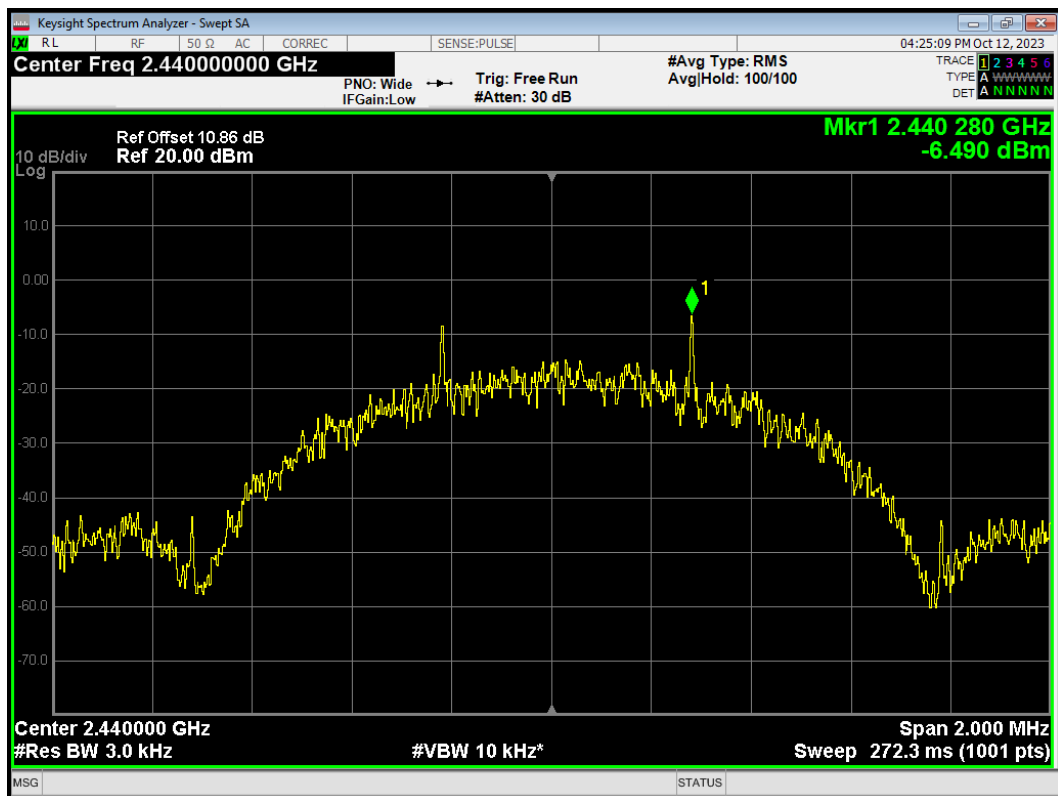
PSD Bluetooth LE(2M) 2480MHz



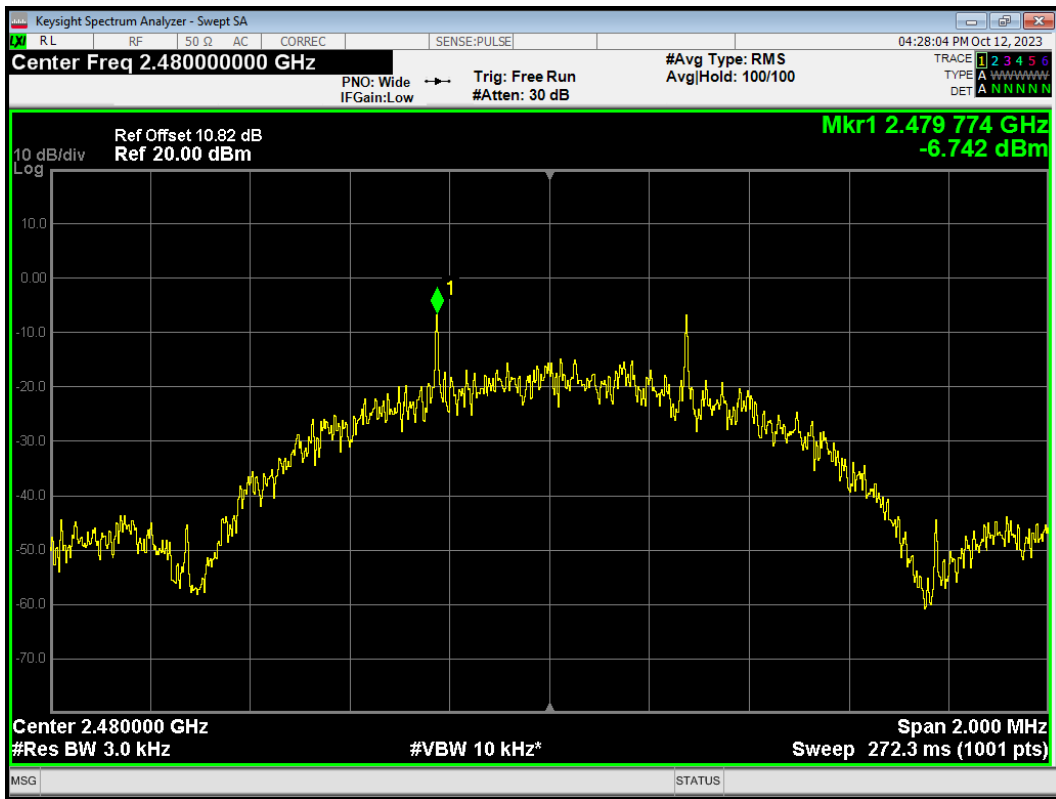
PSD Bluetooth LE(S=2) 2402MHz



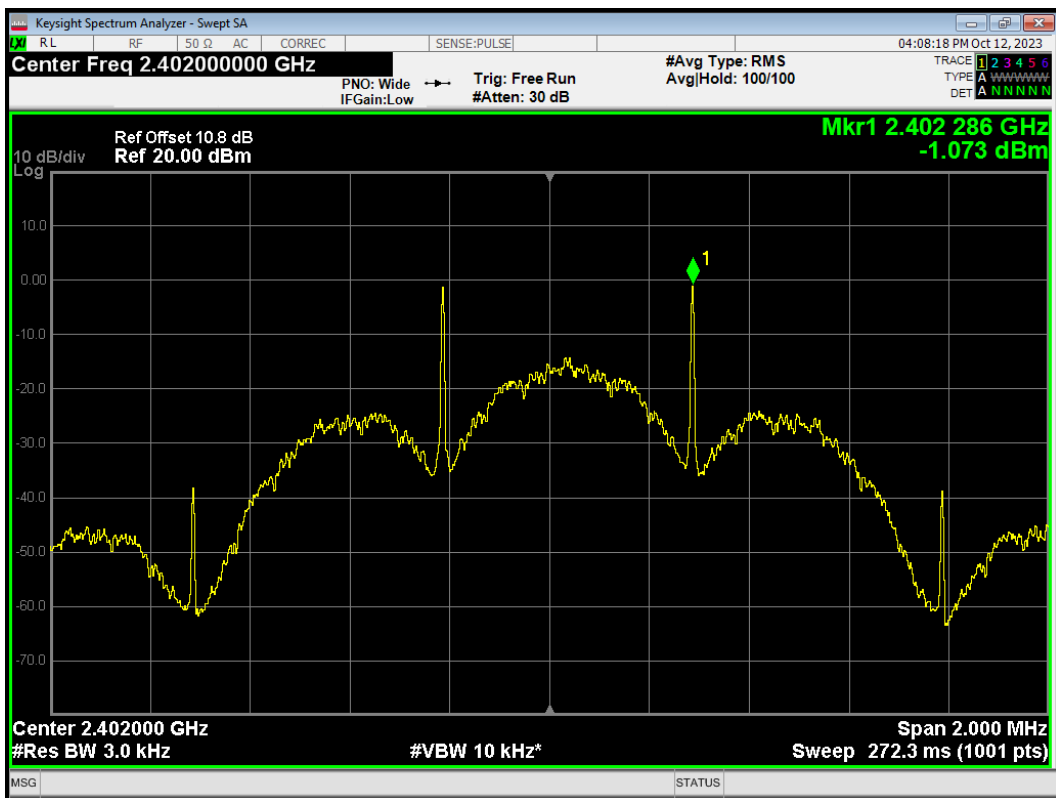
PSD Bluetooth LE(S=2) 2440MHz



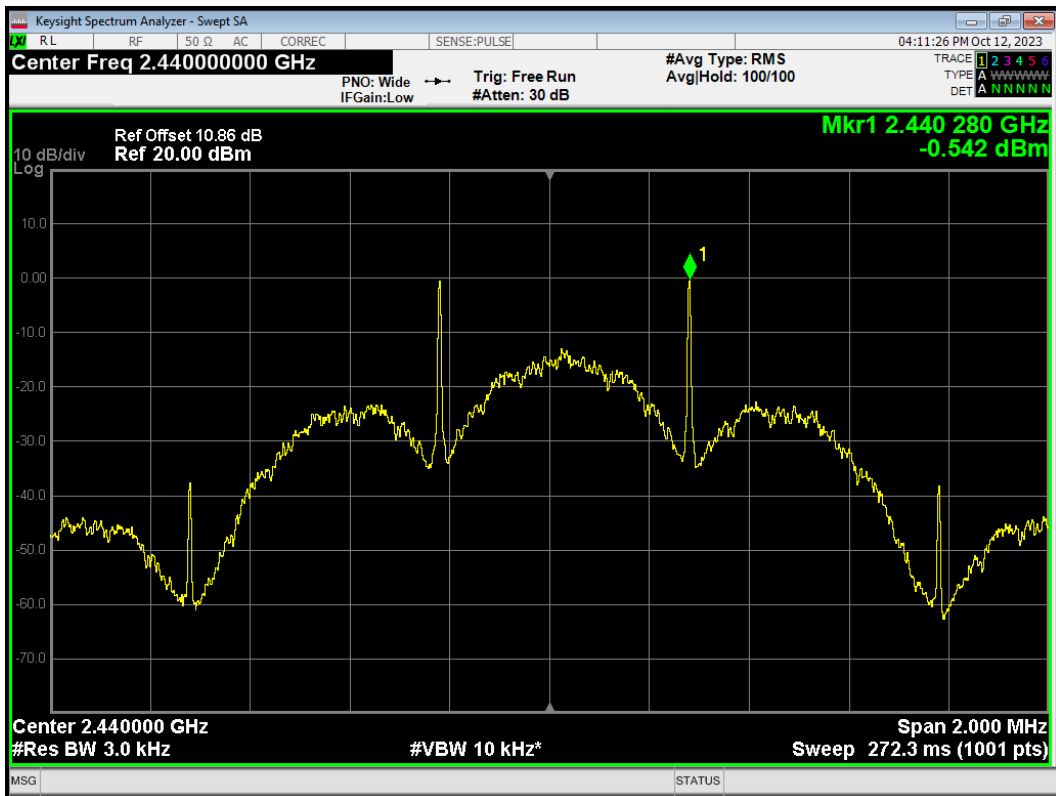
PSD Bluetooth LE(S=2) 2480MHz



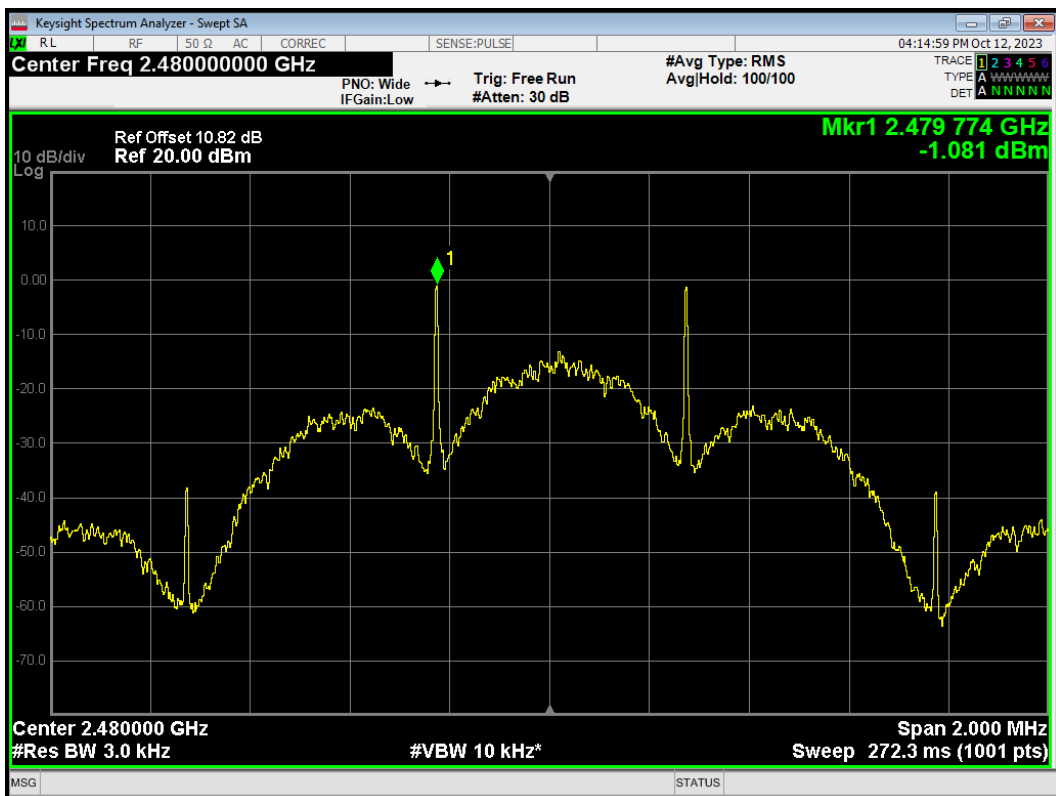
PSD Bluetooth LE(S=8) 2402MHz



PSD Bluetooth LE(S=8) 2440MHz



PSD Bluetooth LE(S=8) 2480MHz



5.5. Spurious RF Conducted Emissions

Ambient Condition

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

Method of Measurement

The EUT was connected to the spectrum analyzer with a known loss. The spectrum analyzer scans from 30MHz to the 10th harmonic of the carrier. The peak detector is used. Set RBW to 100 kHz and VBW to 300 kHz, Sweep is set to ATUO.

The test is in transmitting mode.

Test Setup



Limits

Rule Part 15.247(d) pacifies 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. ”

Test Mode	Carrier frequency (MHz)	Reference value (dBm)	Limit
802.11b	2412	6.560	-23.44
	2437	6.820	-23.18
	2462	6.700	-23.30
802.11g	2412	7.220	-22.78
	2437	7.580	-22.42
	2462	7.450	-22.55
802.11n HT20	2412	6.620	-23.38
	2437	7.130	-22.87
	2462	7.150	-22.85
802.11ax HE20	2412	4.240	-25.76
	2437	3.870	-26.13
	2462	3.870	-26.13

Bluetooth (Low Energy) (1M)	2402	6.220	-23.78
	2440	7.310	-22.69
	2480	6.910	-23.09
Bluetooth (Low Energy) (2M)	2402	5.490	-24.51
	2440	6.320	-23.68
	2480	5.920	-24.08
Bluetooth (Low Energy) (S=2)	2402	6.500	-23.50
	2440	7.550	-22.45
	2480	7.090	-22.91
Bluetooth (Low Energy) (S=8)	2402	3.420	-26.58
	2440	4.410	-25.59
	2480	4.070	-25.93

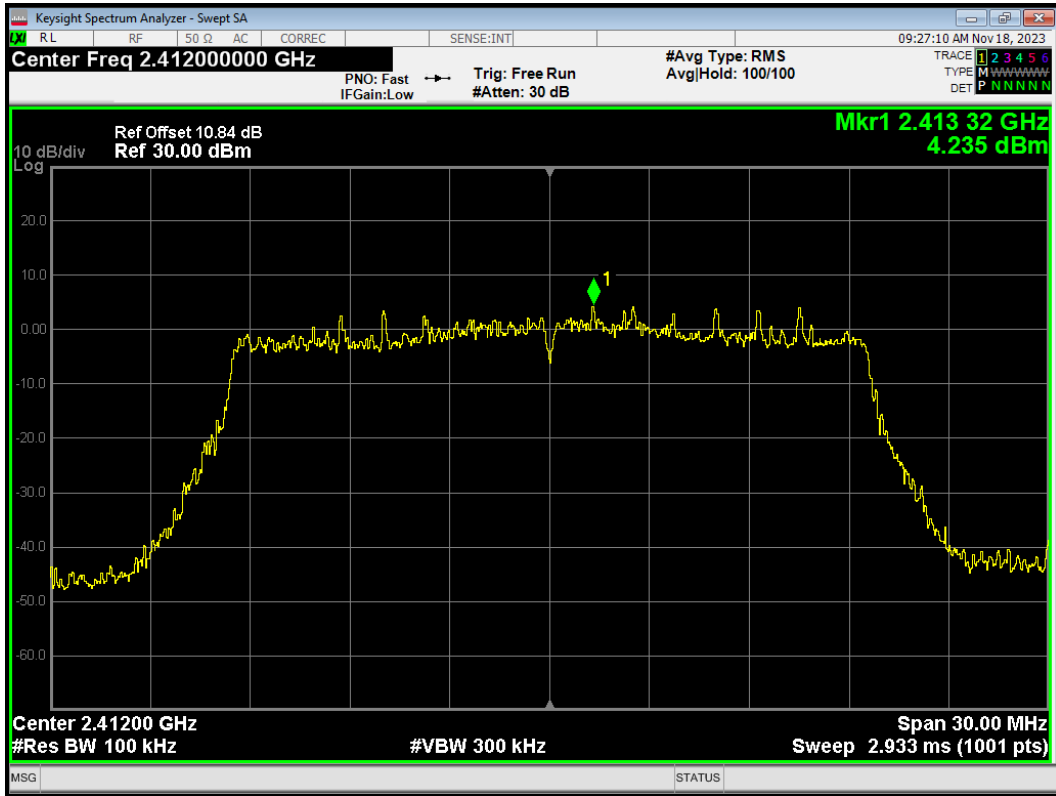
Measurement Uncertainty

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

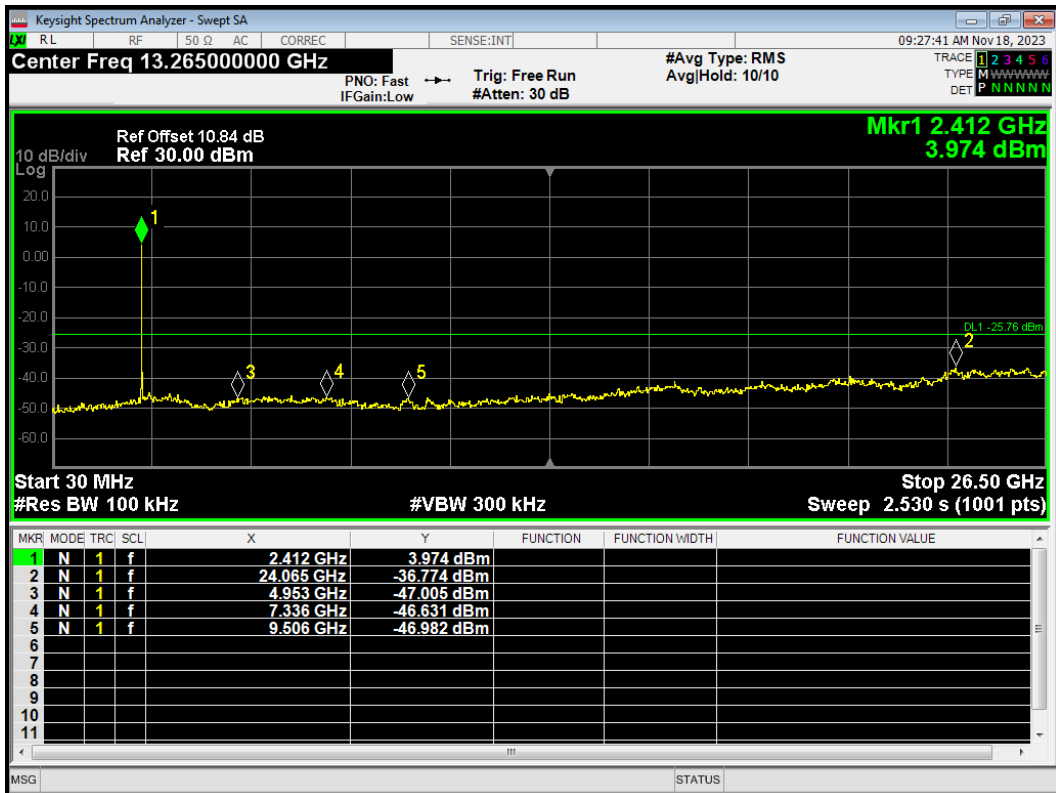
Frequency	Uncertainty
100kHz-2GHz	0.684 dB
2GHz-26GHz	1.407 dB

Test Results:

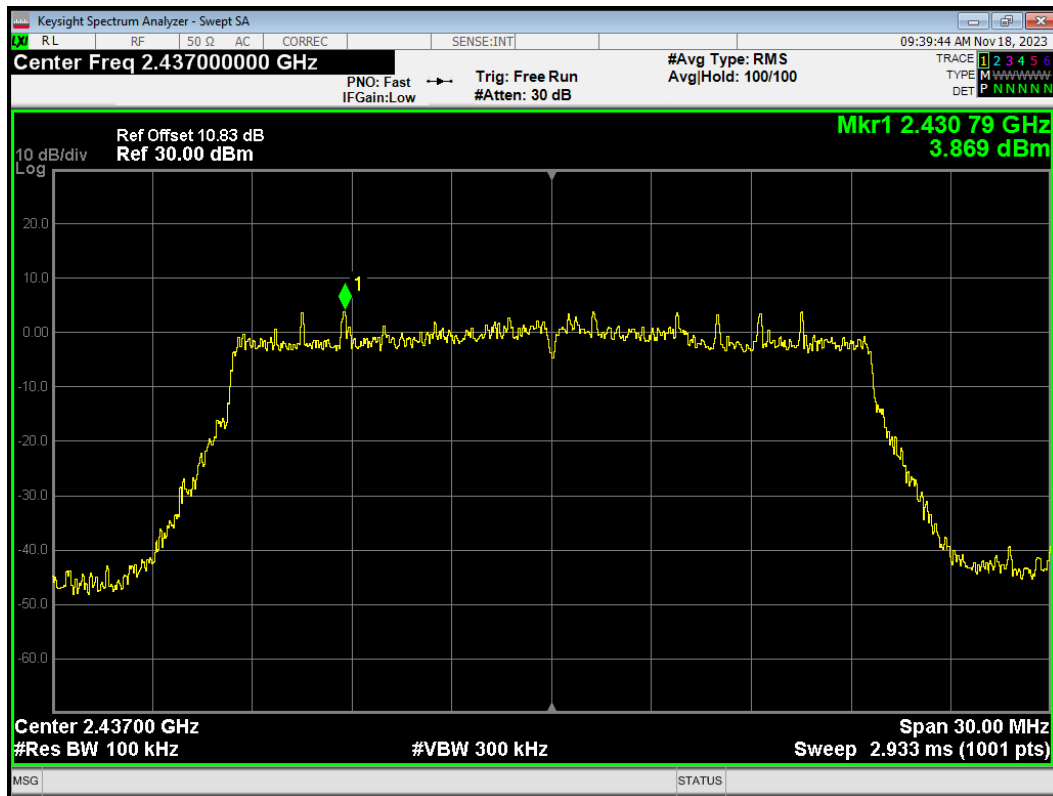
Tx. Spurious 802.11ax(HE20) 2412MHz Ref



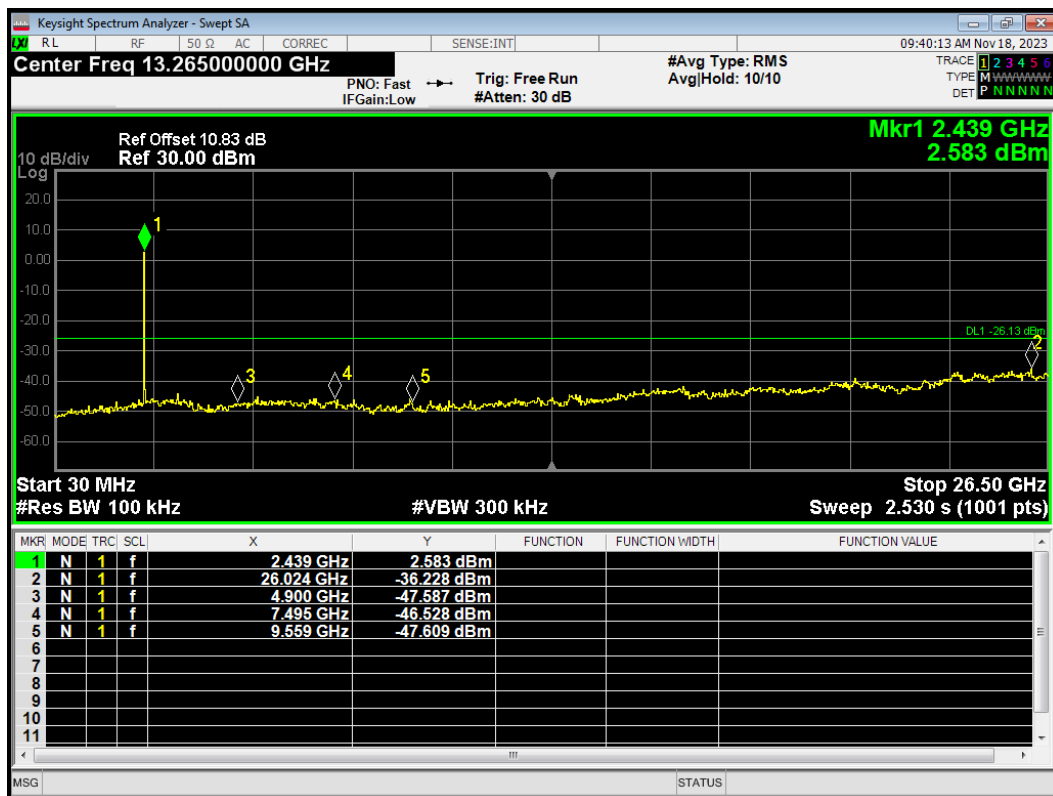
Tx. Spurious 802.11ax(HE20) 2412MHz Emission



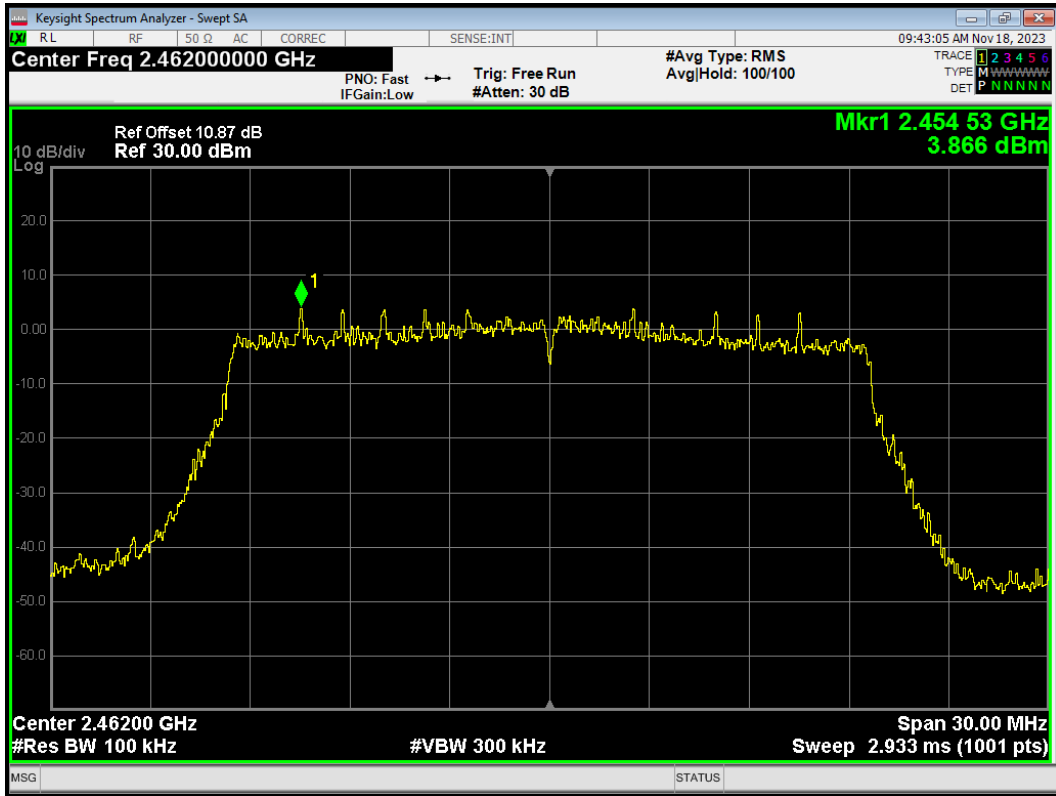
Tx. Spurious 802.11ax(HE20) 2437MHz Ref



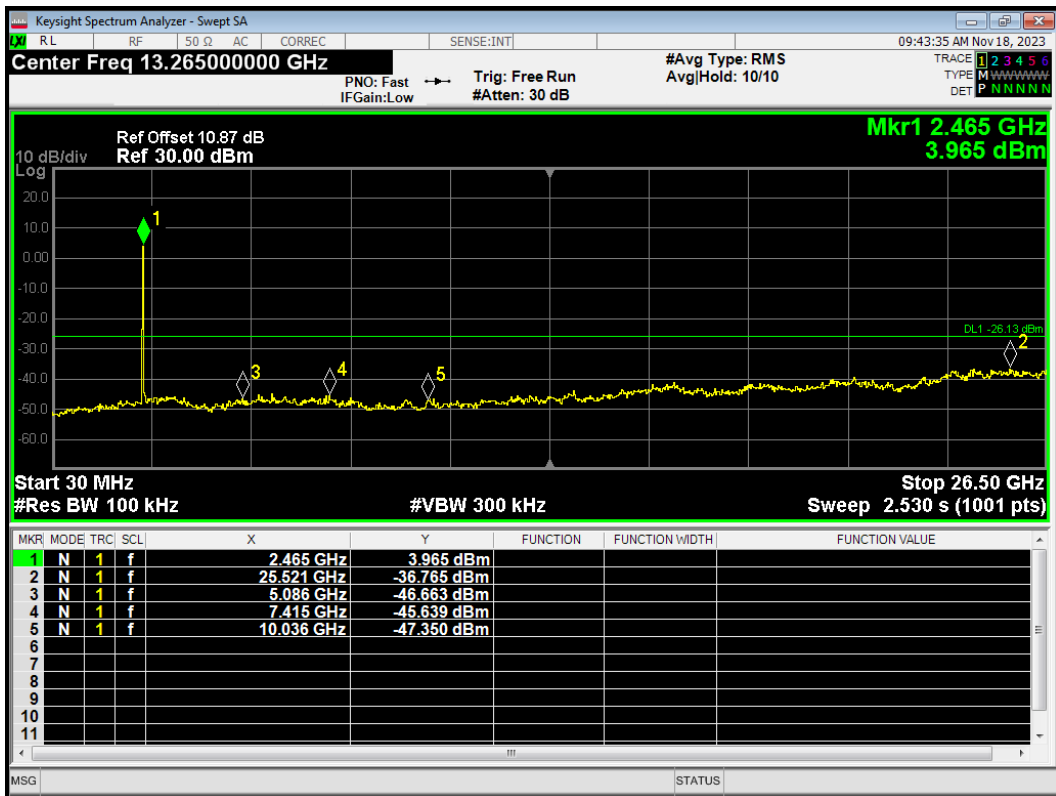
Tx. Spurious 802.11ax(HE20) 2437MHz Emission



Tx. Spurious 802.11ax(HE20) 2462MHz Ref



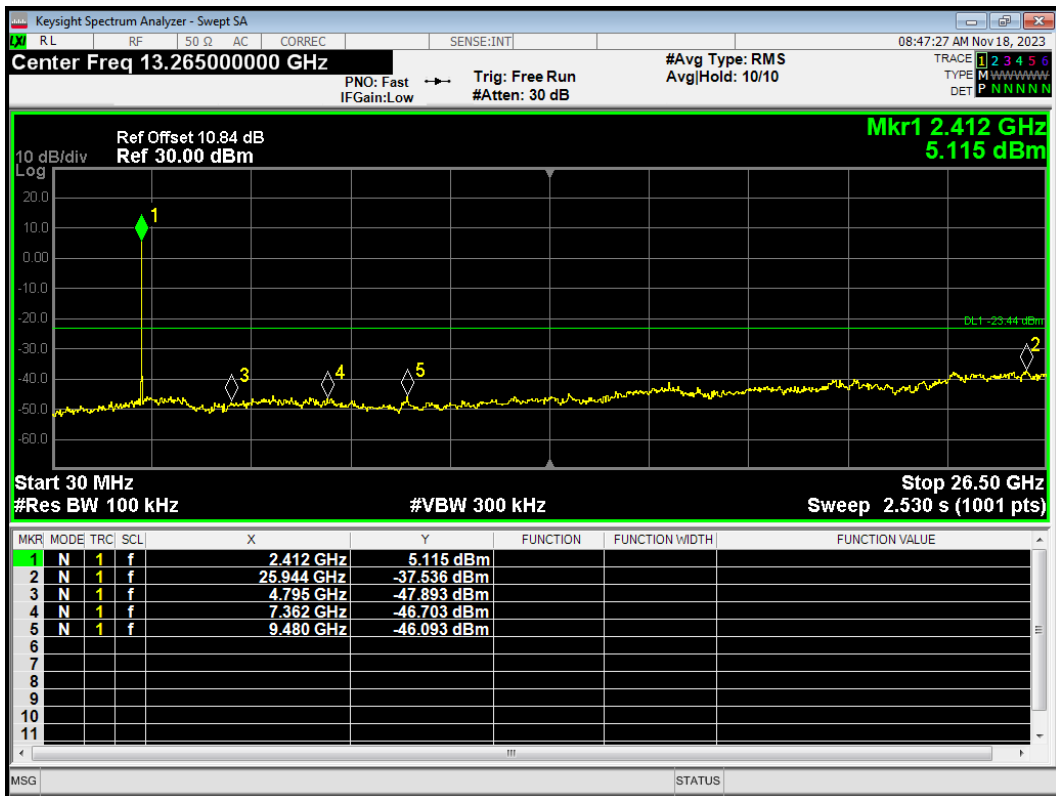
Tx. Spurious 802.11ax(HE20) 2462MHz Emission



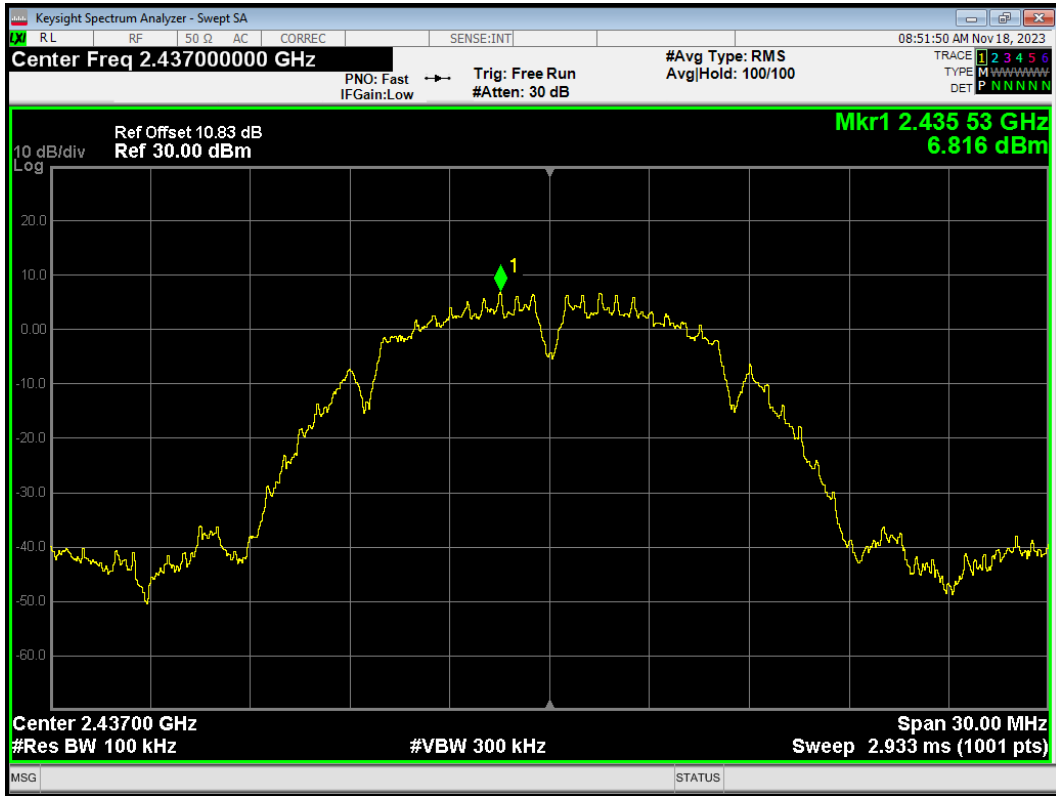
Tx. Spurious 802.11b 2412MHz Ref



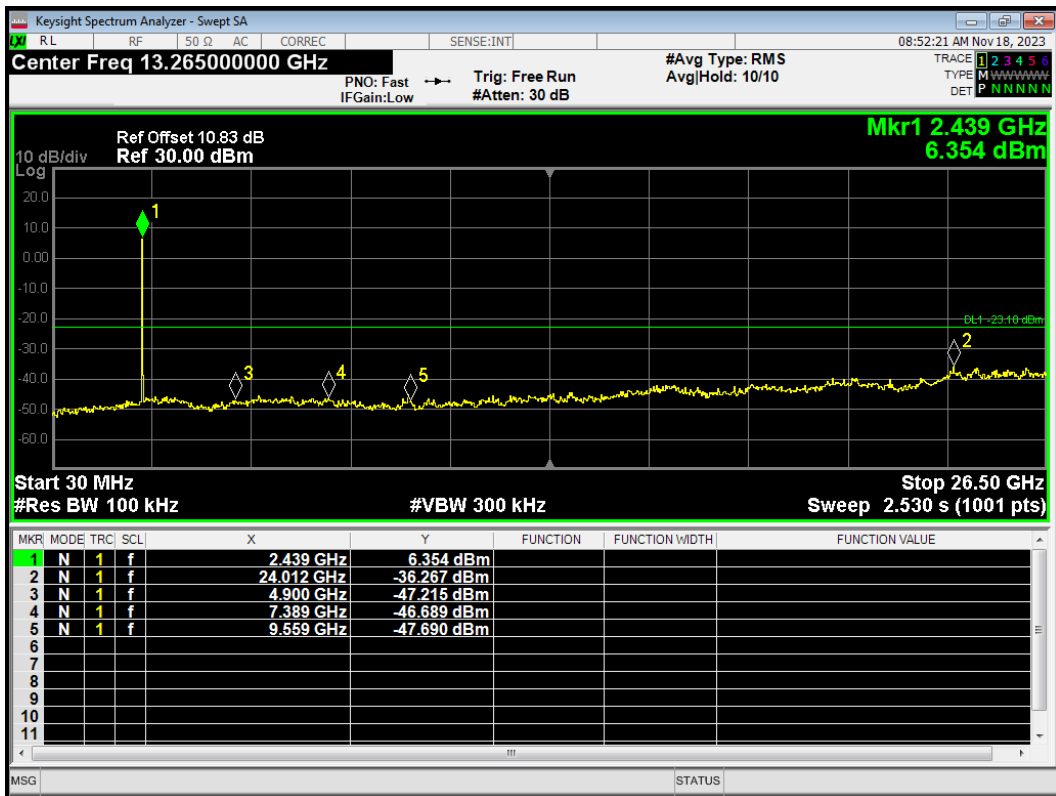
Tx. Spurious 802.11b 2412MHz Emission



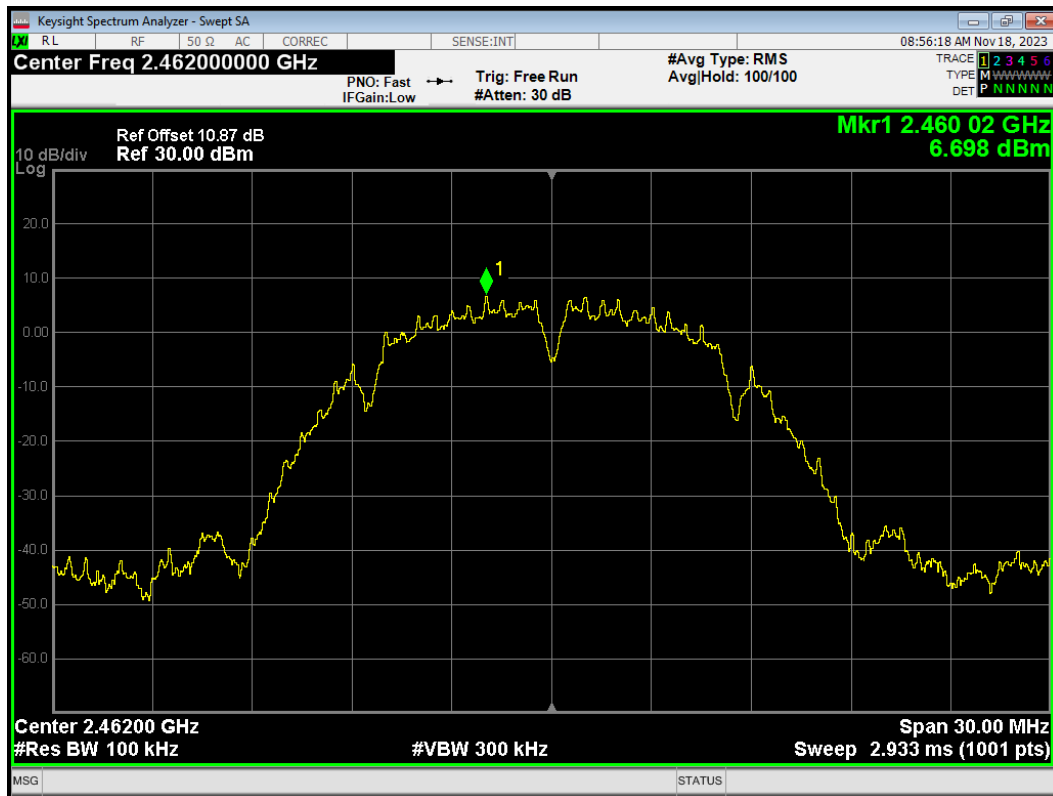
Tx. Spurious 802.11b 2437MHz Ref



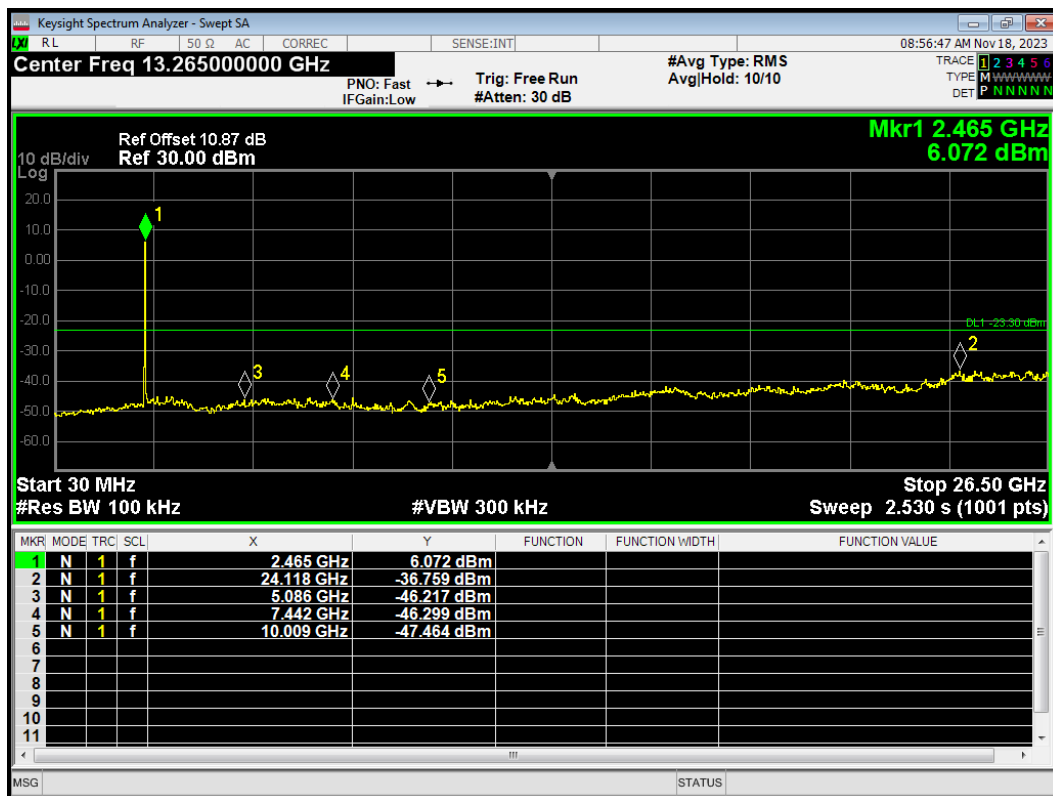
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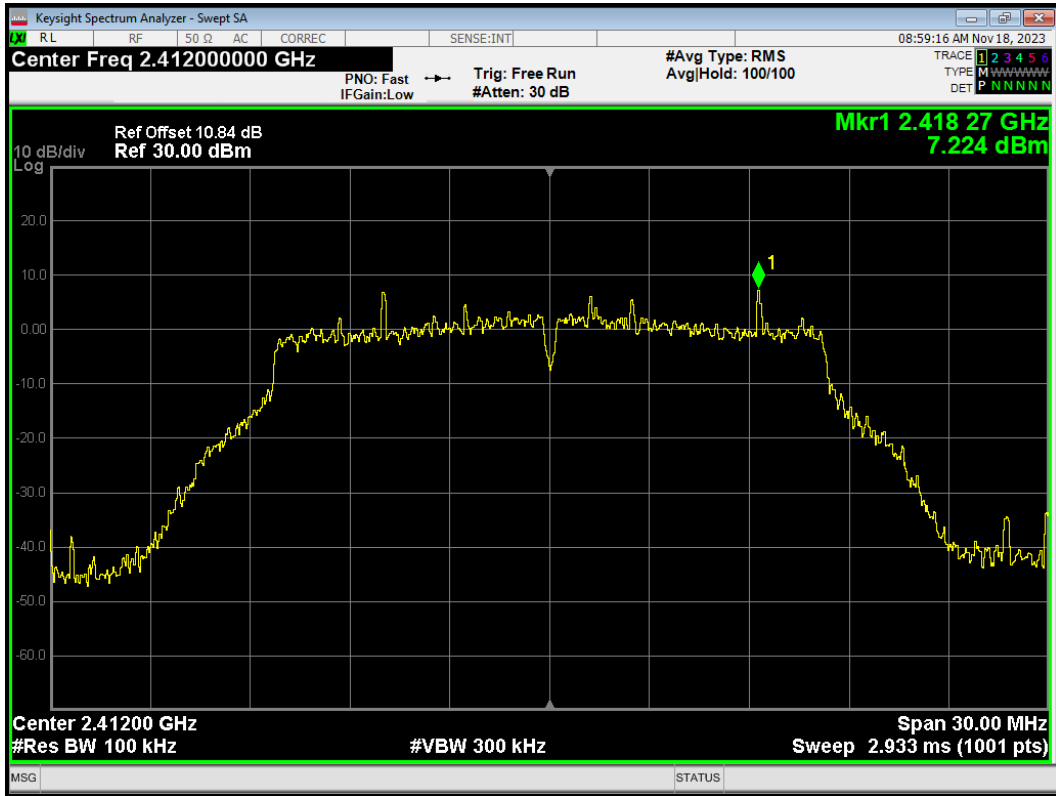
Tx. Spurious 802.11b 2462MHz Ref



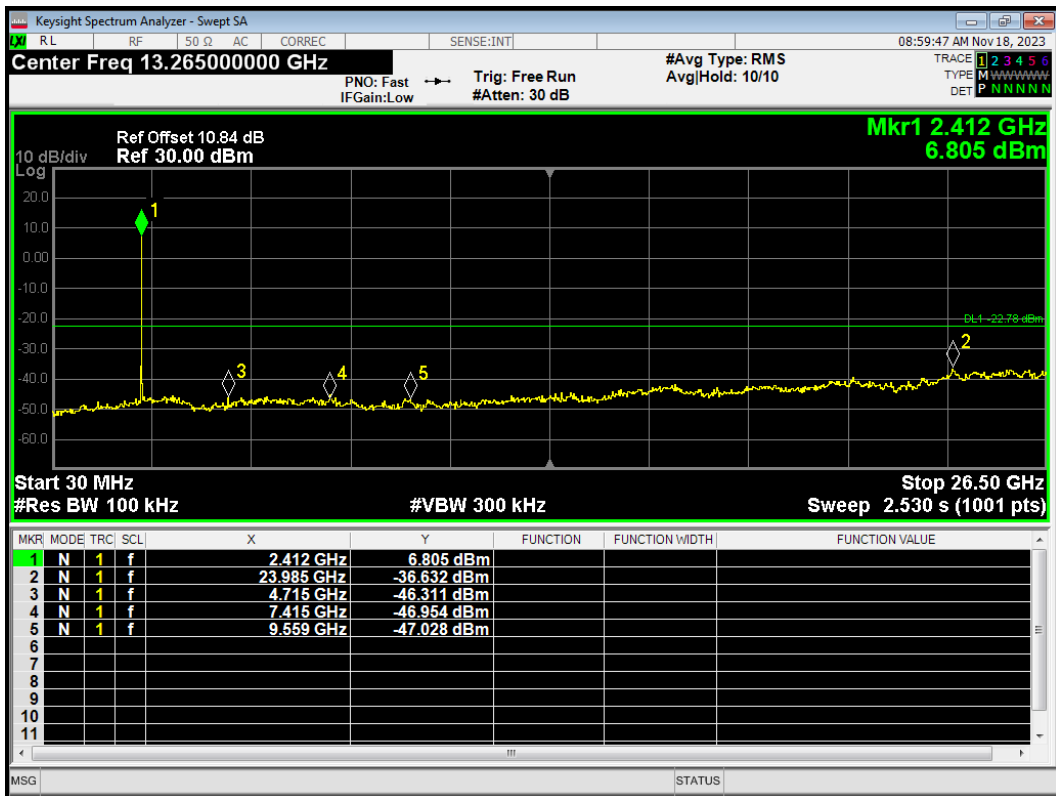
Tx. Spurious 802.11b 2462MHz Emission



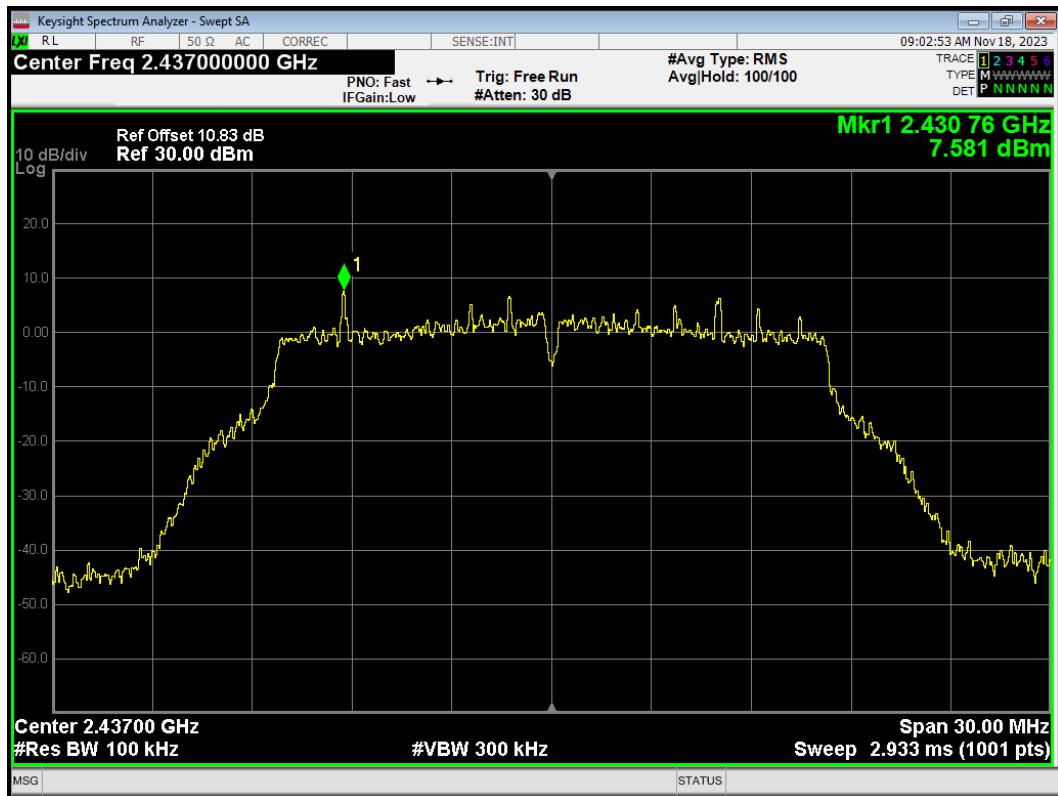
Tx. Spurious 802.11g 2412MHz Ref



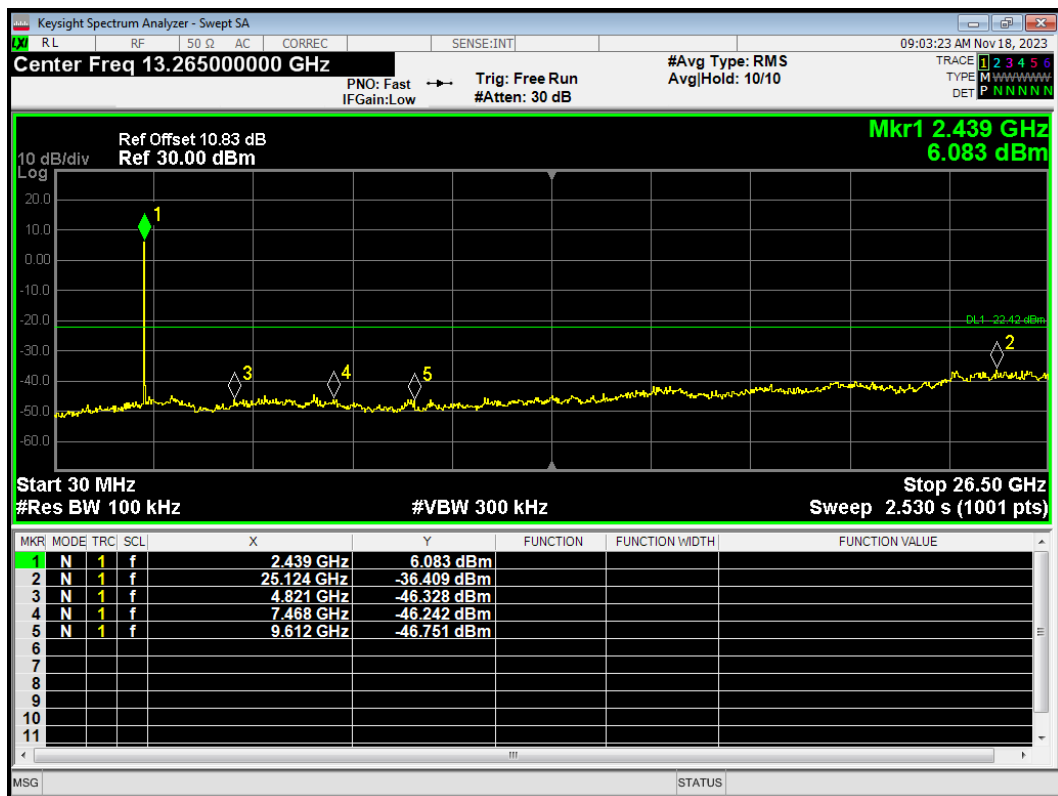
Tx. Spurious 802.11g 2412MHz Emission



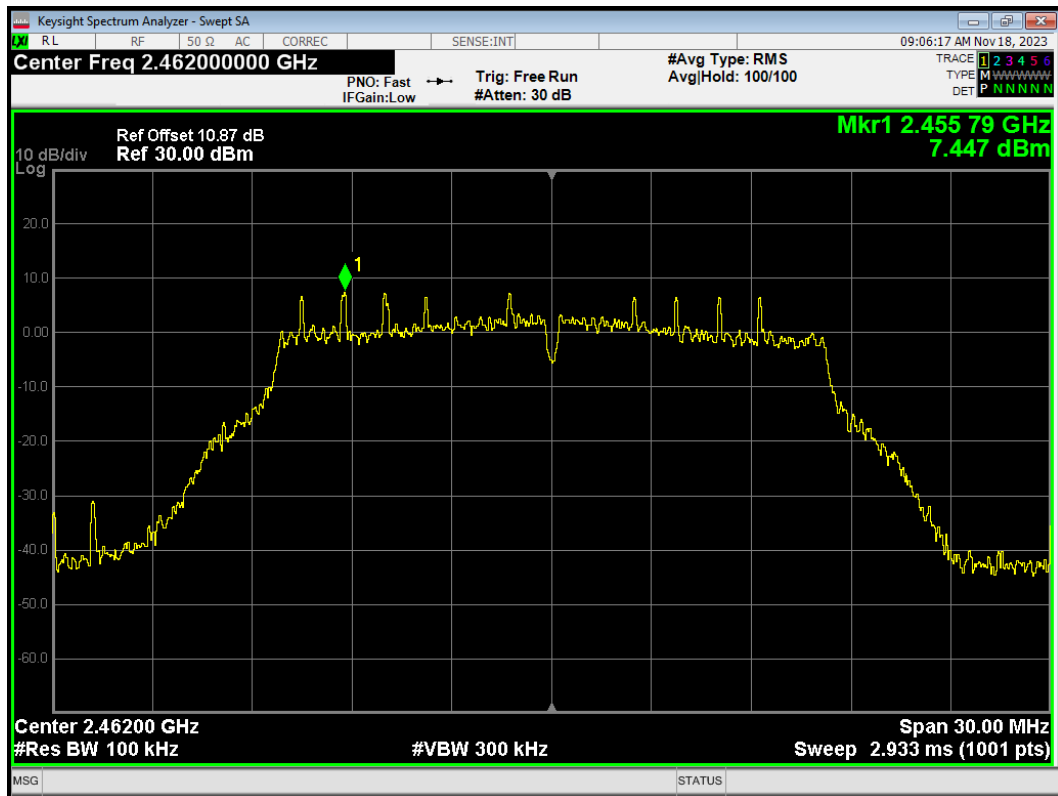
Tx. Spurious 802.11g 2437MHz Ref



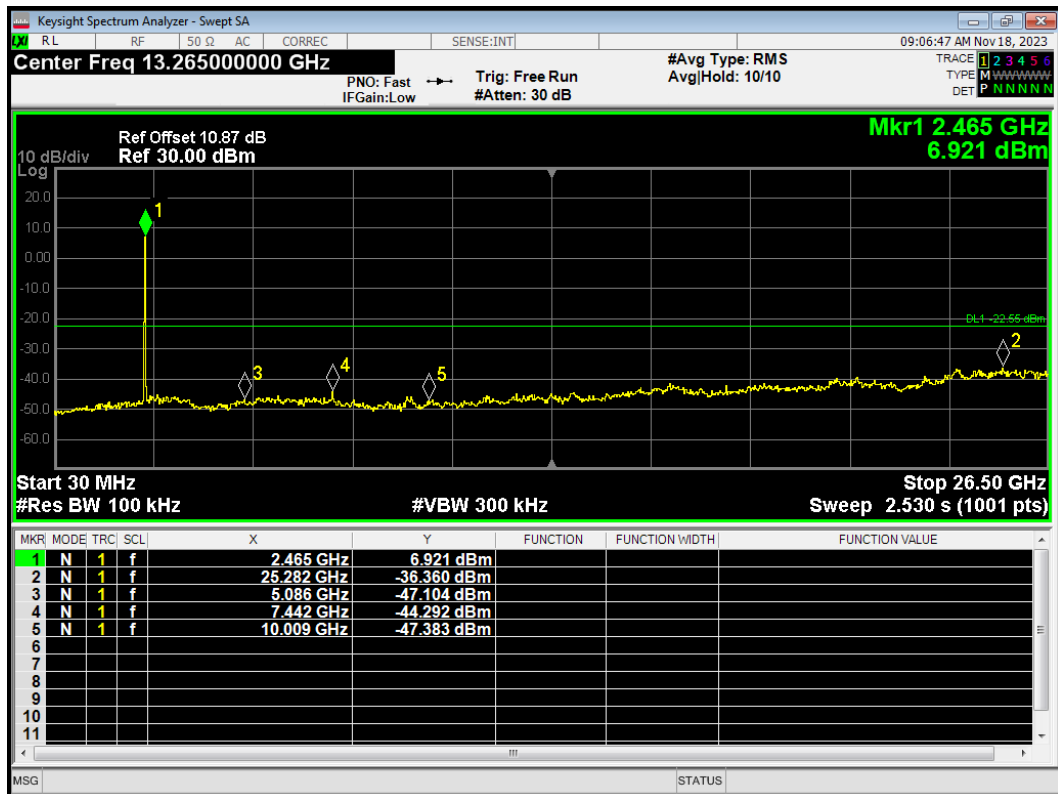
Tx. Spurious 802.11g 2437MHz Emission



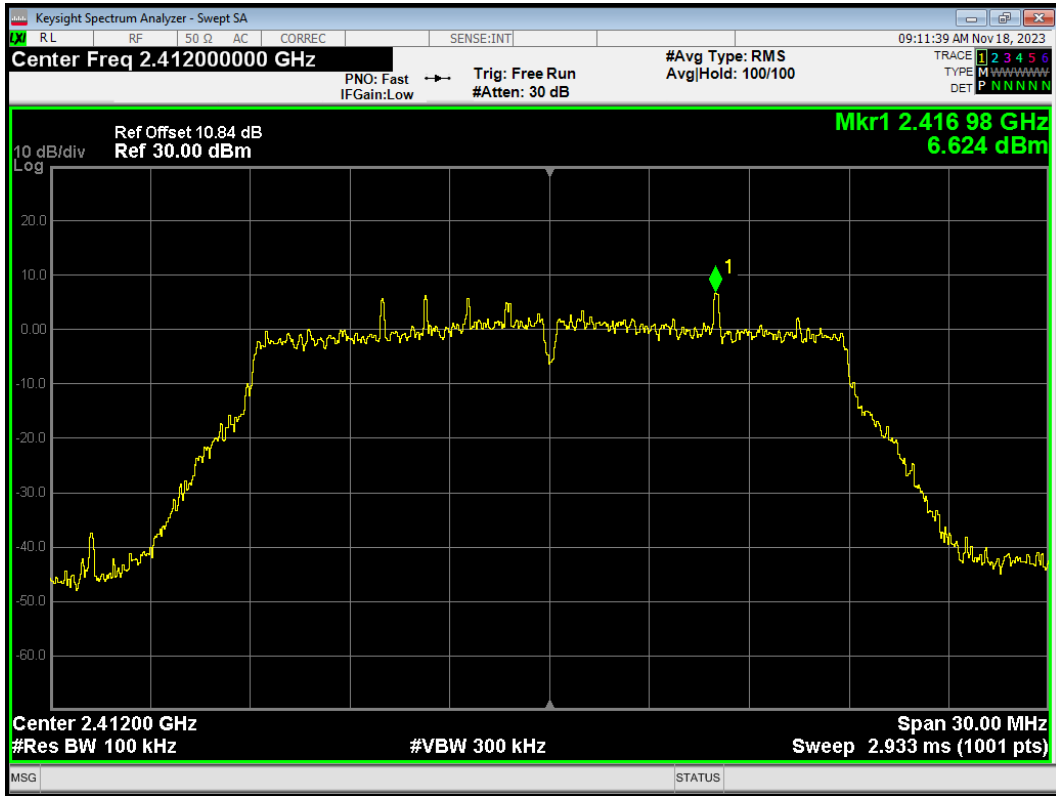
Tx. Spurious 802.11g 2462MHz Ref



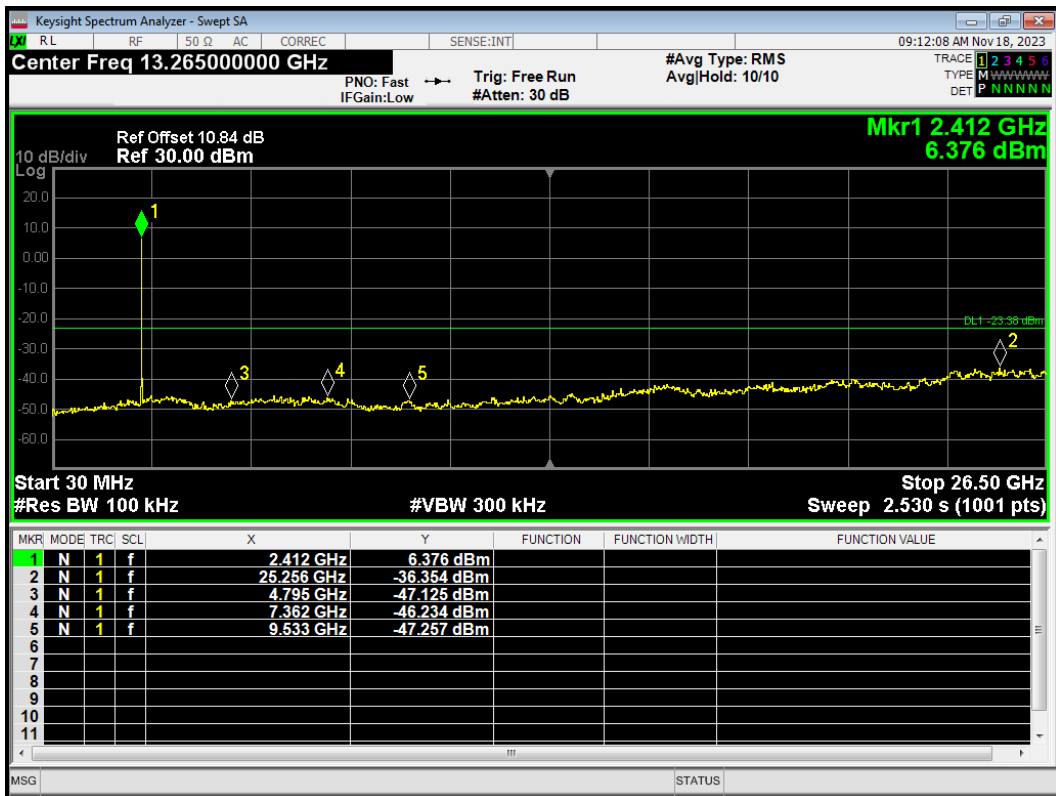
Tx. Spurious 802.11g 2462MHz Emission



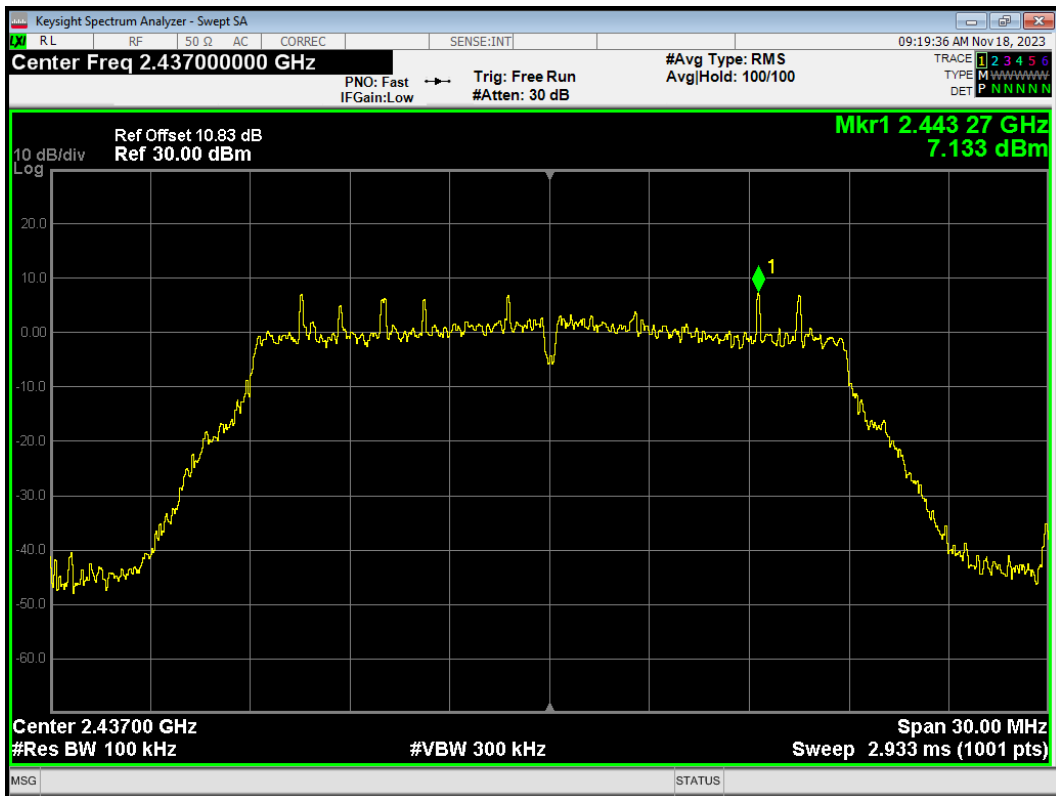
Tx. Spurious 802.11n(HT20) 2412MHz Ref



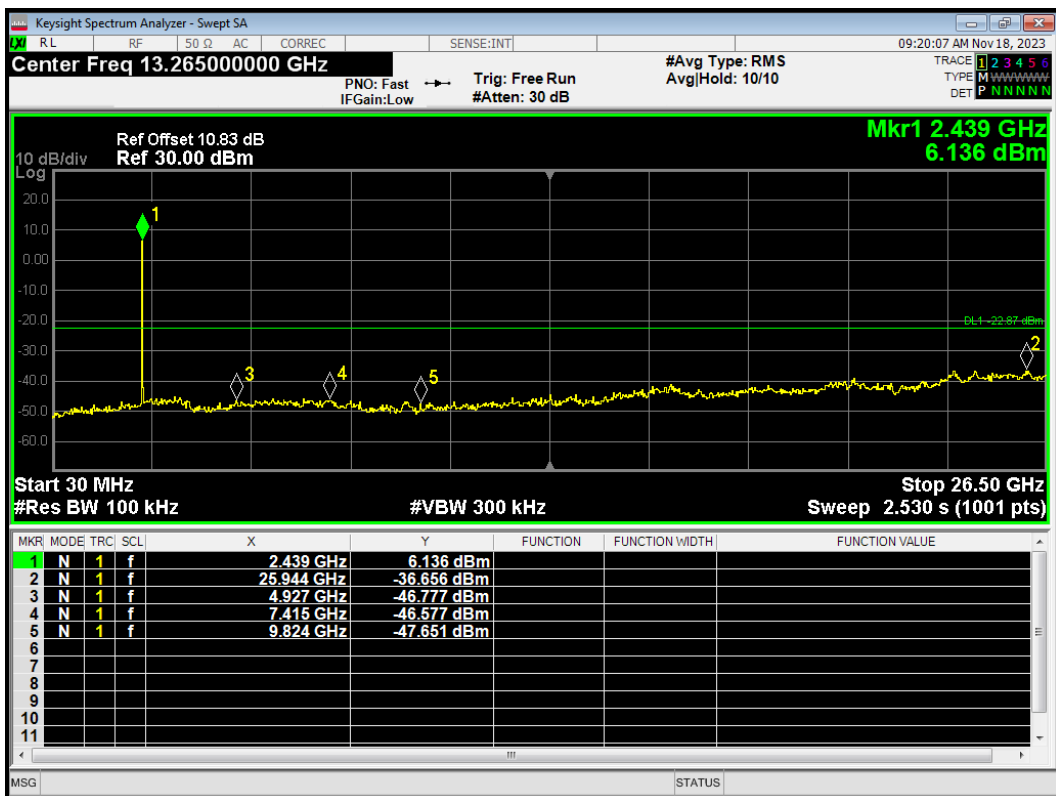
Tx. Spurious 802.11n(HT20) 2412MHz Emission



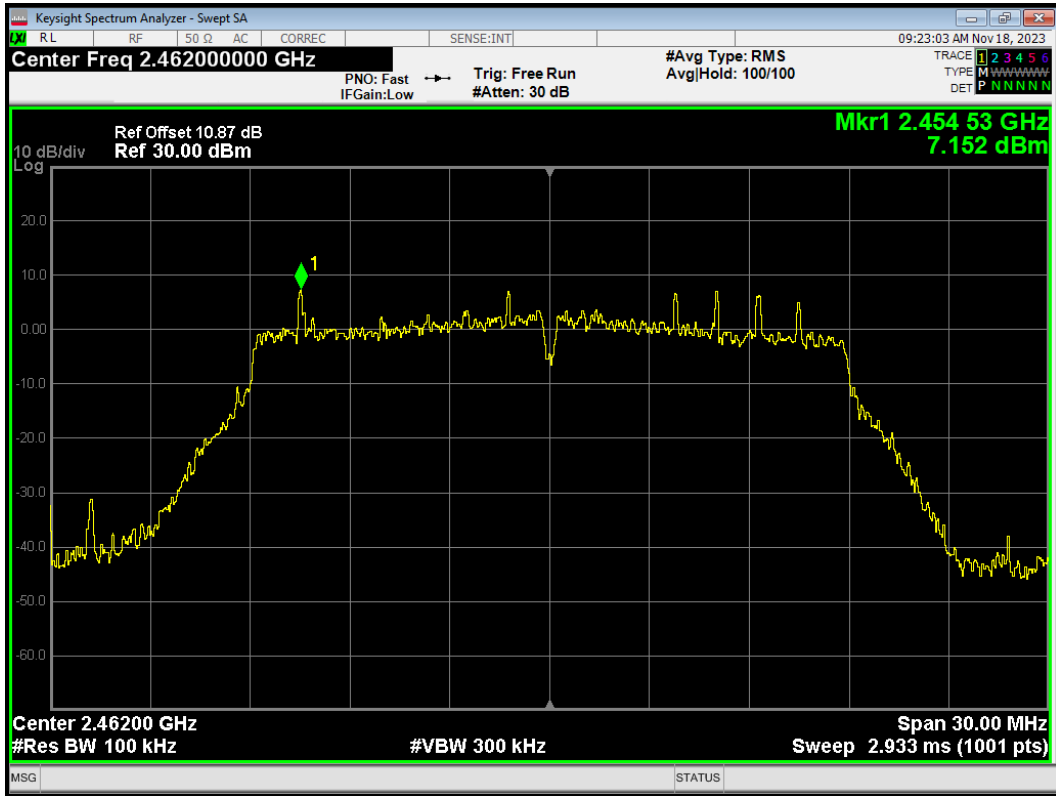
Tx. Spurious 802.11n(HT20) 2437MHz Ref



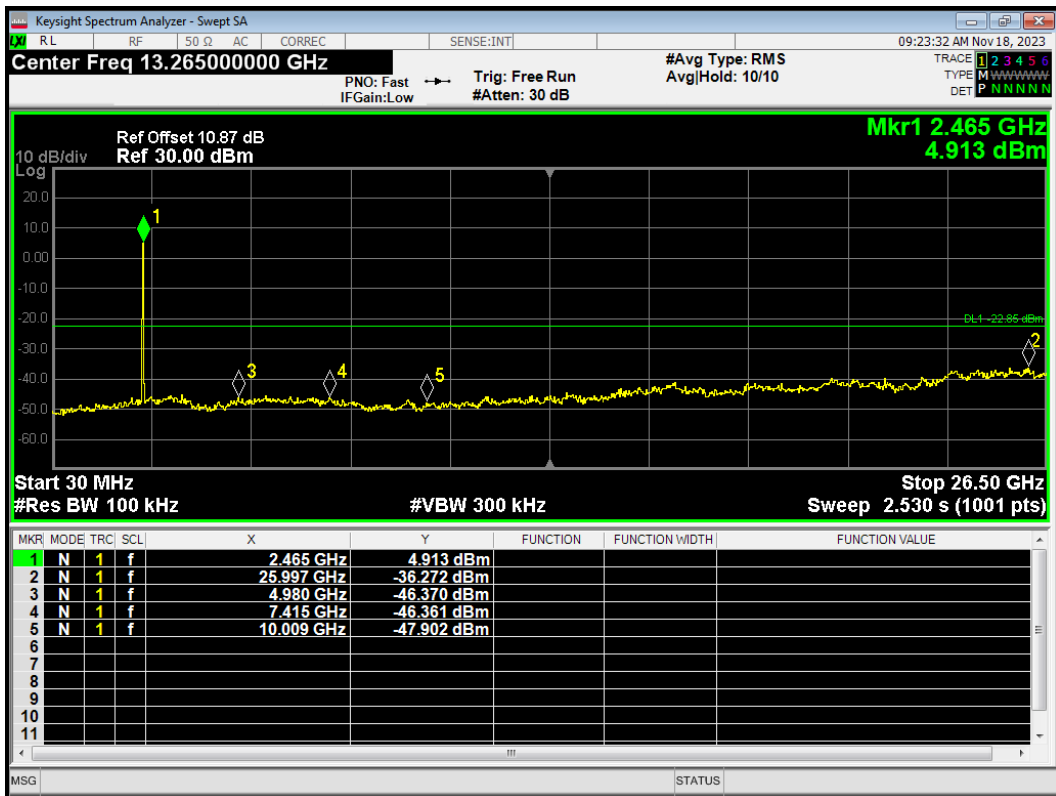
Tx. Spurious 802.11n(HT20) 2437MHz Emission



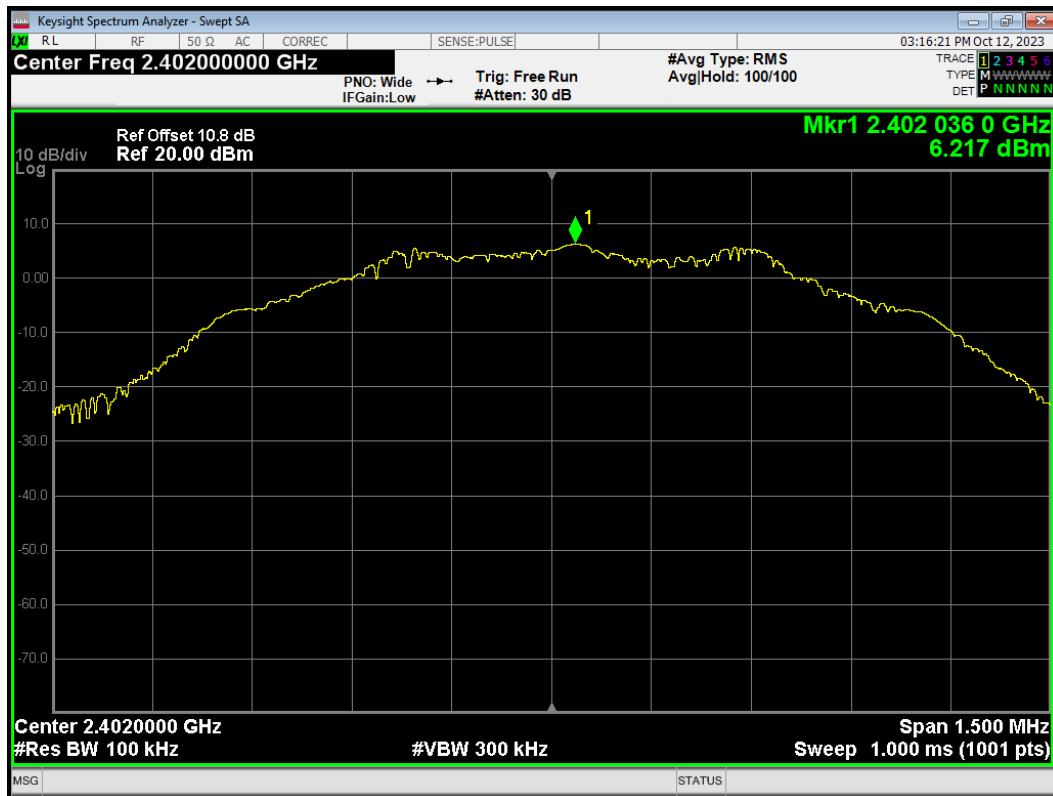
Tx. Spurious 802.11n(HT20) 2462MHz Ref



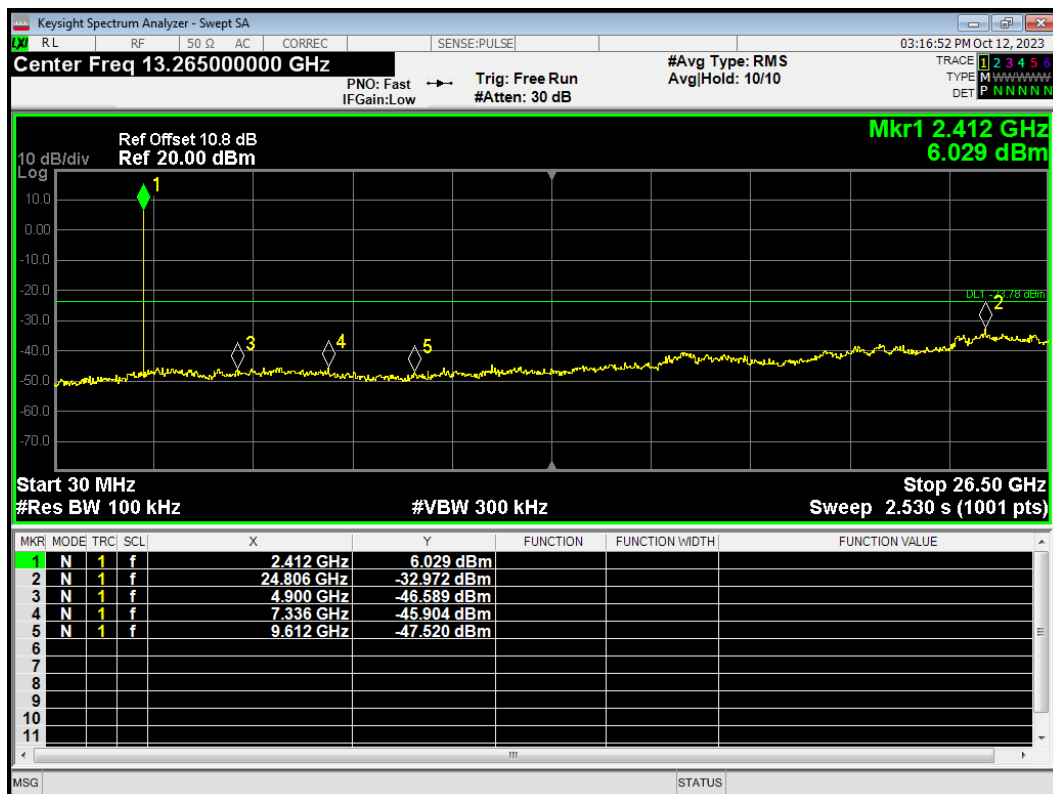
Tx. Spurious 802.11n(HT20) 2462MHz Emission



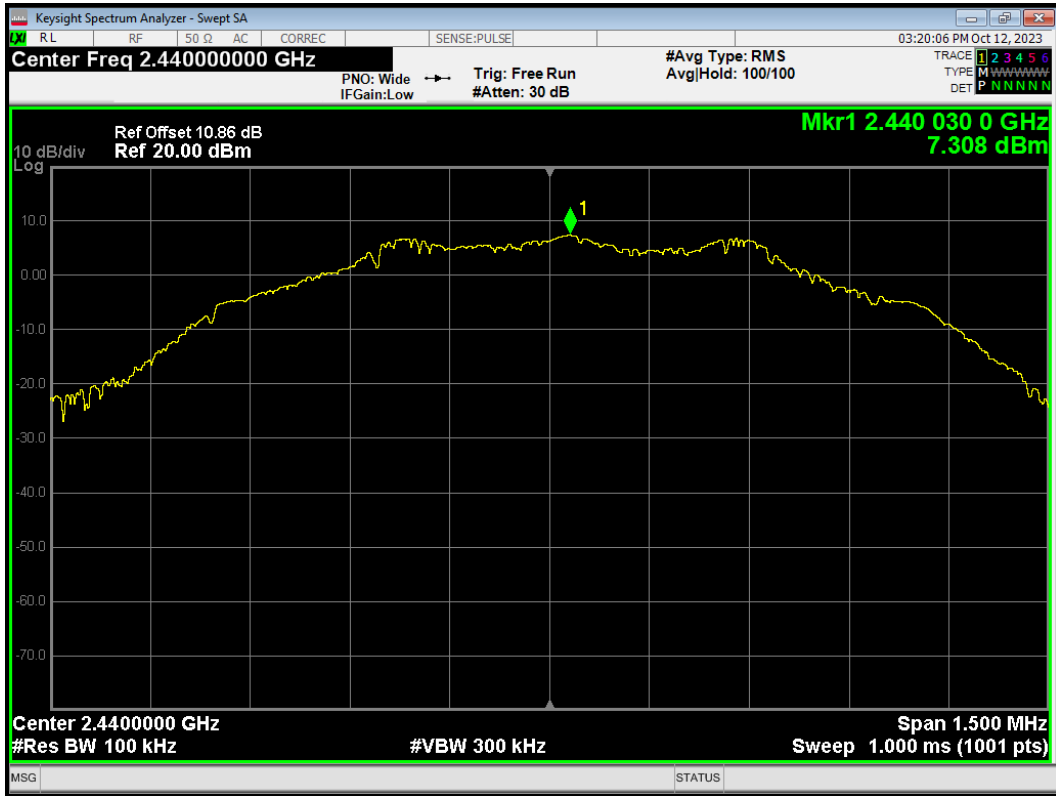
Tx. Spurious Bluetooth LE(1M)2402MHz Ref



Tx. Spurious Bluetooth LE(1M)2402MHz Emission



Tx. Spurious Bluetooth LE(1M)2440MHz Ref



Tx. Spurious Bluetooth LE(1M)2440MHz Emission

