

RF TEST REPORT

Applicant Quectel Wireless Solutions Co., Ltd.

FCC ID XMR202302AF31G

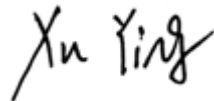
Product Wi-Fi & Bluetooth Module

Model AF31G

Report No. R2211A1014-R1V2

Issue Date June 9, 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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| Version | Revision description | Issue Date |
|---|-------------------------------|----------------|
| Rev.0 | Initial issue of report. | April 28, 2023 |
| Rev.1 | Update the image on page 148. | May 24, 2023 |
| Rev.2 | Update data. | June 9, 2023 |
| Note: This revised report (Report No.: R2211A1014-R1V2) supersedes and replaces the previously issued report (Report No.: R2211A1014-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 6.7 | 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: February 16, 2023 ~ April 6, 2023 and June 7, 2023 ~ June 9, 2023 Date of Sample Received: February 15, 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
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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 Co., Ltd. |
| Applicant address | Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233 |
| Manufacturer | Quectel Wireless Solutions Co., Ltd. |
| 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 | AF31G |
| SN | E1C22KA19000889 |
| Hardware Version | R1.0 |
| Software Version | NA |
| Power Supply | External power supply |
| Antenna Type | External Antenna |
| Antenna Connector | A permanently attached antenna (meet with the standard FCC Part 15.203 requirement) |
| Directional Gain | For Power: 4.35 dBi For PSD: 7.36dBi |
| additional beamforming gain | NA |
| Operating Frequency Range(s) | 802.11b/g/n(HT20): 2412 ~ 2462 MHz 802.11n(HT40): 2422 ~ 2452 MHz Bluetooth LE V5.0: 2402 ~2480 MHz |
| Modulation Type | 802.11b: DSSS 802.11g/n(HT20/HT40): OFDM Bluetooth LE: GFSK |
| Max. Output Power | Wi-Fi 2.4G: 19.34 dBm Bluetooth LE: 3.60dBm |
| Auxiliary test equipment | |
| Antenna | Manufacturer |
| | Model |
| | Antenna Gain |
| | Antenna Gain |
| | FOXCONN |
| | ACE-Antenna |
| | Antenna 1: 3.67 dBi |
| | Antenna 2: 4.35 dBi |
| | Bluetooth LE: 3.67 dBi |

Note: 1. The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.

2. The antenna gain is provided by the manufacturer.

3. The antenna is for testing only and will not be sold with the equipment

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 (H 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 LE | 1Mbps |

| Test Mode | Data Rate | | |
|--------------|-----------|-----------|----------|
| | Antenna 1 | Antenna 2 | CDD/MIMO |
| 802.11b | 1 Mbps | 1 Mbps | 1 Mbps |
| 802.11g | 6 Mbps | 6 Mbps | 6 Mbps |
| 802.11n HT20 | MCS0 | MCS0 | MCS8 |
| 802.11n HT40 | MCS0 | MCS0 | MCS8 |

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

| Test Cases | Antenna 1 | Antenna 2 | CDD/MIMO |
|---------------------------------|-----------|-----------|----------|
| Maximum output power | O | O | O |
| 6dB Bandwidth | -- | -- | O |
| Band Edge | -- | -- | O |
| Power Spectral Density | O | O | O |
| Spurious RF Conducted Emissions | -- | -- | O |
| Unwanted Emissions | -- | -- | O |
| Conducted Emission | -- | -- | 802.11g |
| Note: "O": test all bands | | | |

5. Test Case Results

5.1. Maximum output power

Ambient Condition

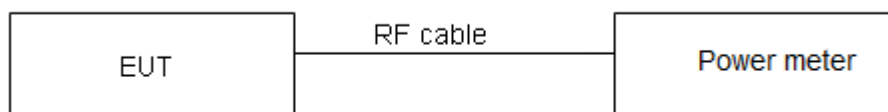
| Temperature | Relative humidity | Pressure |
|-------------|-------------------|----------|
| 23°C ~25°C | 45%~50% | 101.5kPa |

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 | $\leq 1\text{W}$ (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

| Power Index | | | | | |
|-------------|---------|---------|--------------|---------|--------------|
| Channel | 802.11b | 802.11g | 802.11n HT20 | Channel | 802.11n HT40 |
| CH1 | 17 | 14 | 12 | CH3 | 6 |
| CH2 | -- | 17 | 17 | CH4 | 8 |
| CH6 | 17 | 17 | 17 | CH5 | 10 |
| CH9 | -- | 17 | 17 | CH6 | 13 |
| CH10 | -- | 16 | 16 | CH7 | 9 |
| CH11 | 17 | 13 | 12 | CH8 | 8 |
| -- | -- | -- | -- | CH9 | 7 |

| Test Mode | Duty cycle | Duty cycle correction Factor(dB) |
|--|------------|----------------------------------|
| 802.11b | 0.976 | 0.11 |
| 802.11g | 0.974 | 0.11 |
| 802.11n HT20 | 0.978 | 0.10 |
| 802.11n HT40 | 0.955 | 0.20 |
| Note: when Duty cycle ≥ 0.98 , Duty cycle correction Factor not required. | | |

| Test Mode | Duty cycle | Duty cycle correction Factor(dB) |
|--|------------|----------------------------------|
| Bluetooth LE | 0.654 | 1.847 |
| Note: when Duty cycle ≥ 0.98 , Duty cycle correction Factor not required. | | |

| Test Mode | Carrier frequency (MHz) / Channel | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|--------------|-----------------------------------|------------------------------|--------------------------------------|-------------|------------|
| Bluetooth LE | 2402/CH0 | 0.61 | 2.46 | 30 | PASS |
| | 2440/CH19 | 1.75 | 3.60 | 30 | PASS |
| | 2480/CH39 | 1.06 | 2.91 | 30 | PASS |

SISO ANT1

| Test Mode | Carrier frequency (MHz))/ Channel | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|---|------------------------------------|------------------------------|--------------------------------------|-------------|------------|
| 802.11b | 2412/CH1 | 15.90 | 16.00 | 30 | PASS |
| | 2437/CH6 | 16.37 | 16.48 | 30 | PASS |
| | 2462/CH11 | 15.58 | 15.68 | 30 | PASS |
| 802.11g | 2412/CH1 | 12.78 | 12.89 | 30 | PASS |
| | 2417/CH2 | 16.18 | 16.29 | 30 | PASS |
| | 2437/CH6 | 16.32 | 16.43 | 30 | PASS |
| | 2452/CH9 | 16.20 | 16.31 | 30 | PASS |
| | 2457/CH10 | 15.02 | 15.13 | 30 | PASS |
| | 2462/CH11 | 11.92 | 12.03 | 30 | PASS |
| 802.11n HT20 | 2412/CH1 | 10.22 | 10.32 | 30 | PASS |
| | 2417/CH2 | 15.96 | 16.06 | 30 | PASS |
| | 2437/CH6 | 16.00 | 16.10 | 30 | PASS |
| | 2452/CH9 | 15.99 | 16.09 | 30 | PASS |
| | 2457/CH10 | 14.76 | 14.86 | 30 | PASS |
| | 2462/CH11 | 10.70 | 10.80 | 30 | PASS |
| 802.11n HT40 | 2422/CH3 | 4.79 | 4.99 | 30 | PASS |
| | 2427/CH4 | 7.14 | 7.34 | 30 | PASS |
| | 2432/CH5 | 9.08 | 9.28 | 30 | PASS |
| | 2437/CH6 | 15.64 | 15.84 | 30 | PASS |
| | 2442/CH7 | 8.29 | 8.49 | 30 | PASS |
| | 2447/CH8 | 7.36 | 7.56 | 30 | PASS |
| | 2452/CH9 | 6.41 | 6.61 | 30 | PASS |
| Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | |

SISO ANT2

| Test Mode | Carrier frequency (MHz) \ Channel | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|---|-----------------------------------|------------------------------|--------------------------------------|-------------|------------|
| 802.11b | 2412/CH1 | 16.61 | 16.72 | 30 | PASS |
| | 2437/CH6 | 16.07 | 16.17 | 30 | PASS |
| | 2462/CH11 | 16.02 | 16.13 | 30 | PASS |
| 802.11g | 2412/CH1 | 13.71 | 13.83 | 30 | PASS |
| | 2417/CH2 | 16.82 | 16.93 | 30 | PASS |
| | 2437/CH6 | 16.02 | 16.13 | 30 | PASS |
| | 2452/CH9 | 16.14 | 16.25 | 30 | PASS |
| | 2457/CH10 | 15.03 | 15.14 | 30 | PASS |
| | 2462/CH11 | 12.32 | 12.43 | 30 | PASS |
| 802.11n HT20 | 2412/CH1 | 11.39 | 11.49 | 30 | PASS |
| | 2417/CH2 | 16.50 | 16.60 | 30 | PASS |
| | 2437/CH6 | 15.74 | 15.84 | 30 | PASS |
| | 2452/CH9 | 15.84 | 15.94 | 30 | PASS |
| | 2457/CH10 | 14.81 | 14.91 | 30 | PASS |
| | 2462/CH11 | 11.05 | 11.14 | 30 | PASS |
| 802.11n HT40 | 2422/CH3 | 6.24 | 6.44 | 30 | PASS |
| | 2427/CH4 | 8.55 | 8.75 | 30 | PASS |
| | 2432/CH5 | 10.43 | 10.63 | 30 | PASS |
| | 2437/CH6 | 12.79 | 12.99 | 30 | PASS |
| | 2442/CH7 | 9.11 | 9.31 | 30 | PASS |
| | 2447/CH8 | 8.37 | 8.57 | 30 | PASS |
| | 2452/CH9 | 6.73 | 6.93 | 30 | PASS |
| Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | |

CDD/MIMO

| Network Standards | Carrier frequency (MHz) | Output Power (dBm) | | | | Total Power (dBm) | Limit (dBm) | Concl usion |
|-------------------|-------------------------|------------------------------|--------------------------------------|------------------------------|--------------------------------------|-------------------|-------------|----------------|
| | | Antenna 1 | | Antenna 2 | | | | |
| | | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | | | |
| 802.11b | 2412/CH1 | 15.83 | 15.94 | 16.59 | 16.70 | 19.34 | 30 | PASS |
| | 2437/CH6 | 16.27 | 16.38 | 16.03 | 16.14 | 19.27 | 30 | PASS |
| | 2462/CH11 | 15.47 | 15.58 | 15.92 | 16.03 | 18.82 | 30 | PASS |
| 802.11g | 2412/CH1 | 12.90 | 13.00 | 13.86 | 13.97 | 16.52 | 30 | PASS |
| | 2417/CH2 | 16.26 | 16.37 | 16.89 | 17.00 | 19.70 | 30 | PASS |
| | 2437/CH6 | 16.14 | 16.25 | 15.94 | 16.04 | 19.16 | 30 | PASS |
| | 2452/CH9 | 16.15 | 16.26 | 16.02 | 16.12 | 19.20 | 30 | PASS |
| | 2457/CH10 | 14.94 | 15.05 | 15.04 | 15.15 | 18.11 | 30 | PASS |
| | 2462/CH11 | 11.93 | 12.03 | 12.35 | 12.46 | 15.26 | 30 | PASS |
| 802.11n HT20 | 2412/CH1 | 11.60 | 11.70 | 11.59 | 11.69 | 14.70 | 30 | PASS |
| | 2417/CH2 | 16.02 | 16.22 | 16.66 | 16.76 | 19.51 | 30 | PASS |
| | 2437/CH6 | 15.87 | 15.87 | 15.71 | 15.81 | 18.85 | 30 | PASS |
| | 2452/CH9 | 15.87 | 15.87 | 15.78 | 15.88 | 18.88 | 30 | PASS |
| | 2457/CH10 | 14.72 | 14.72 | 14.78 | 14.87 | 17.81 | 30 | PASS |
| | 2462/CH11 | 10.76 | 10.85 | 11.18 | 11.28 | 14.08 | 30 | PASS |
| 802.11n HT40 | 2422/CH3 | 5.03 | 5.23 | 6.26 | 6.46 | 8.90 | 30 | PASS |
| | 2427/CH4 | 7.58 | 7.78 | 8.71 | 8.91 | 11.39 | 30 | PASS |
| | 2432/CH5 | 9.76 | 9.96 | 10.66 | 10.86 | 13.45 | 30 | PASS |
| | 2437/CH6 | 13.04 | 13.24 | 13.04 | 13.24 | 16.25 | 30 | PASS |
| | 2442/CH7 | 8.66 | 8.86 | 8.99 | 9.19 | 12.04 | 30 | PASS |
| | 2447/CH8 | 8.43 | 8.63 | 8.07 | 8.27 | 11.47 | 30 | PASS |
| | 2452/CH9 | 6.57 | 6.77 | 6.60 | 6.80 | 9.80 | 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. The manufacturer declared the $N_{ss}=1$. According to KDB 662911 D01 Multiple Transmitter Output v02r01 F)2)f(ii): If antenna gains are not equal, the user may use either of the following methods to calculate directional gain, provided that each transmit antenna is driven by only one spatial stream: Directional gain may be calculated by using the formulas applicable to equal gain antennas with G_{ANT} set equal to the gain of the antenna having the highest gain.

Directional gain = $G_{ANT\ MAX} + \text{Array Gain}$,

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 = $G_{ANT\ MAX} + \text{Array Gain} = 4.35 + 0 = 4.35$ dBi < 6dBi. So the power limit is 30dBm

5.2. 99% Bandwidth and 6dB Bandwidth

Ambient Condition

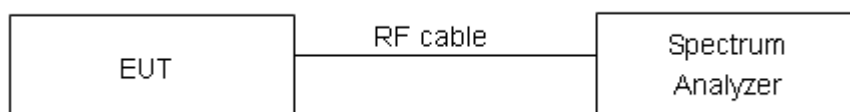
| Temperature | Relative humidity | Pressure |
|-------------|-------------------|----------|
| 23°C ~25°C | 45%~50% | 101.5kPa |

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

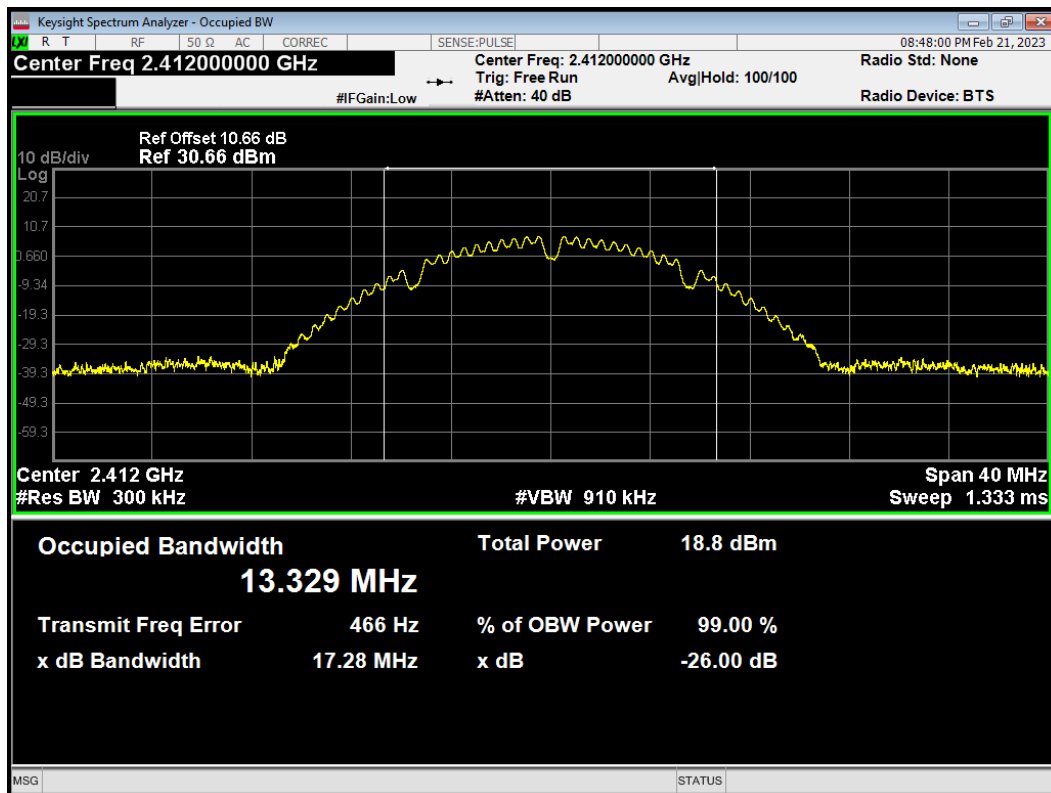
The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 2$, $U = 936$ Hz.

Test Results:

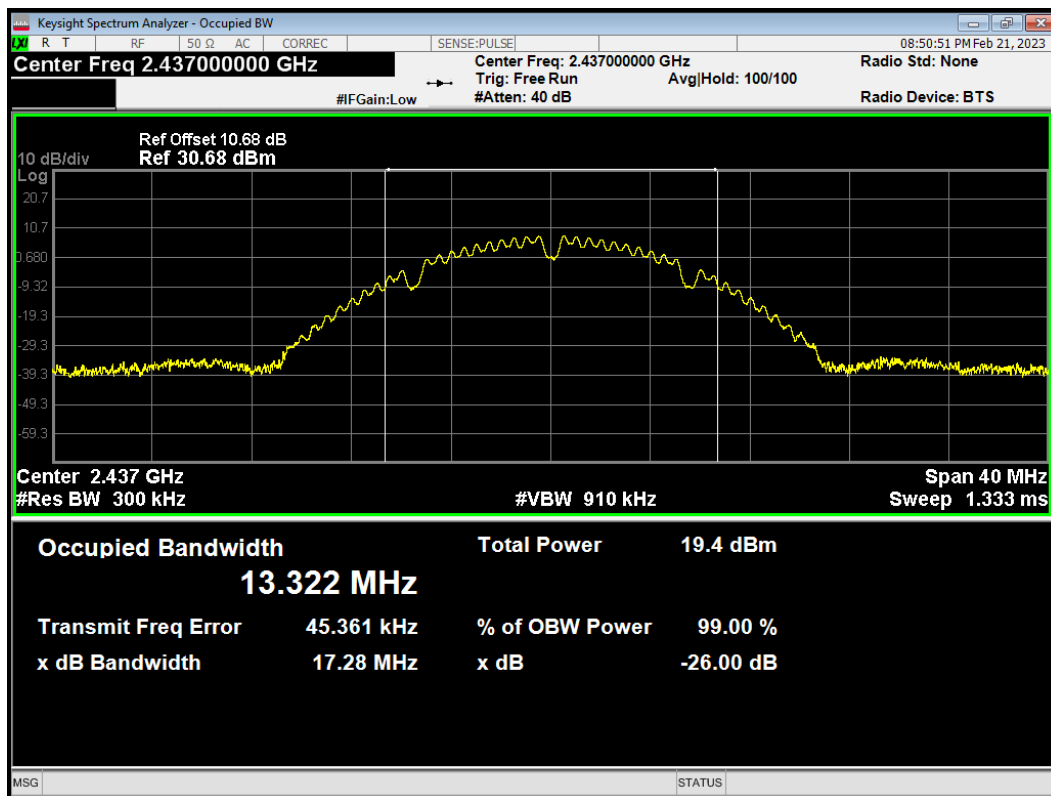
| Test Mode | Carrier frequency (MHz) | 99% bandwidth (MHz) | Minimum 6 dB bandwidth (MHz) | Limit (kHz) | Conclusion |
|-----------------|-------------------------|---------------------|------------------------------|-------------|------------|
| 802.11b | 2412 | 13.329 | 7.572 | 500 | PASS |
| | 2437 | 13.322 | 8.075 | 500 | PASS |
| | 2462 | 13.254 | 8.070 | 500 | PASS |
| 802.11g | 2412 | 16.321 | 16.313 | 500 | PASS |
| | 2417 | 16.293 | 15.805 | 500 | PASS |
| | 2437 | 16.322 | 15.548 | 500 | PASS |
| | 2452 | 16.279 | 15.026 | 500 | PASS |
| | 2457 | 16.285 | 13.979 | 500 | PASS |
| | 2462 | 16.338 | 15.445 | 500 | PASS |
| 802.11n HT20 | 2412 | 17.452 | 15.001 | 500 | PASS |
| | 2417 | 17.443 | 17.087 | 500 | PASS |
| | 2437 | 17.450 | 15.072 | 500 | PASS |
| | 2452 | 17.403 | 15.799 | 500 | PASS |
| | 2457 | 17.410 | 14.766 | 500 | PASS |
| | 2462 | 17.458 | 13.253 | 500 | PASS |
| 802.11n HT40 | 2422 | 35.994 | 34.972 | 500 | PASS |
| | 2427 | 35.934 | 32.552 | 500 | PASS |
| | 2432 | 35.975 | 31.589 | 500 | PASS |
| | 2437 | 35.867 | 35.089 | 500 | PASS |
| | 2442 | 35.842 | 32.937 | 500 | PASS |
| | 2447 | 35.863 | 35.102 | 500 | PASS |
| | 2452 | 35.820 | 28.776 | 500 | PASS |
| Bluetooth LE | 2402 | 1.066 | 0.664 | 500 | PASS |
| | 2440 | 1.065 | 0.660 | 500 | PASS |
| | 2480 | 1.056 | 0.670 | 500 | PASS |

99%bandwidth

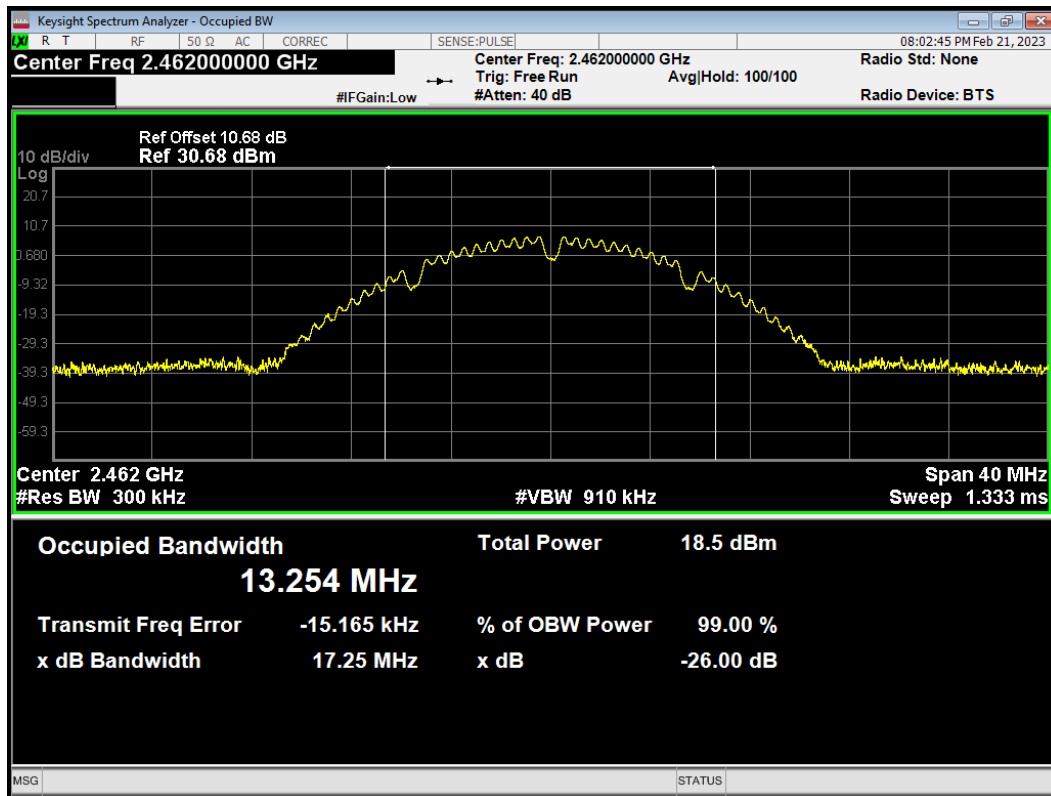
OBW 802.11b 2412MHz



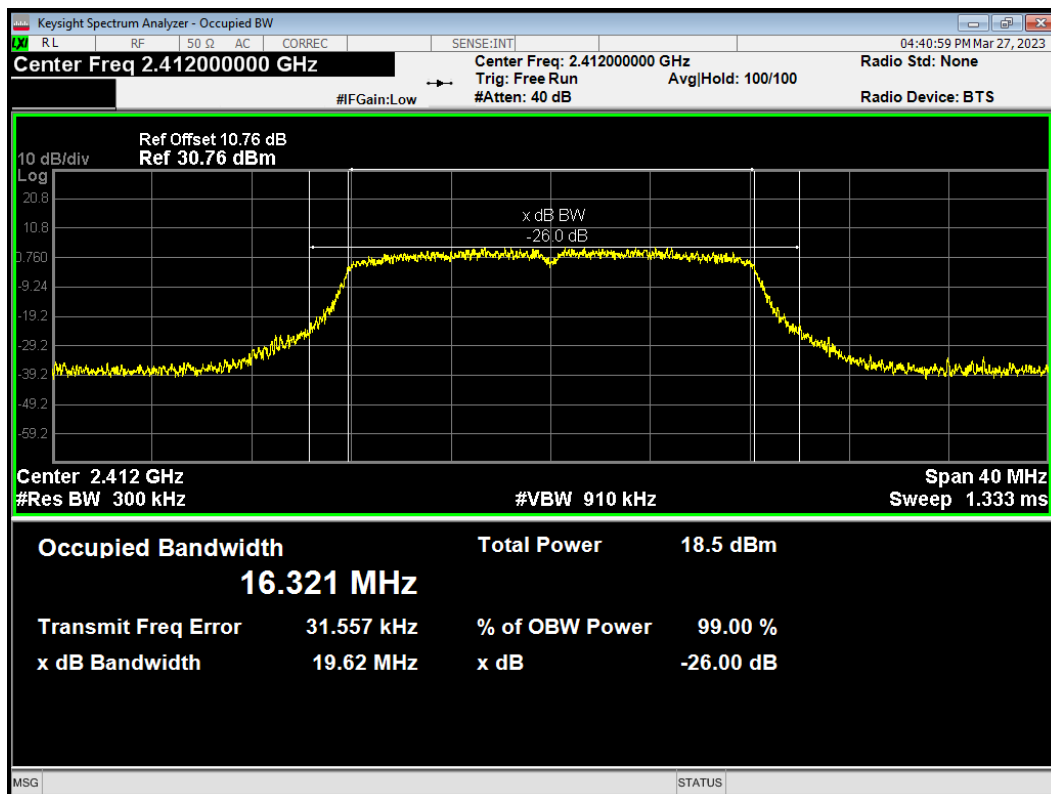
OBW 802.11b 2437MHz



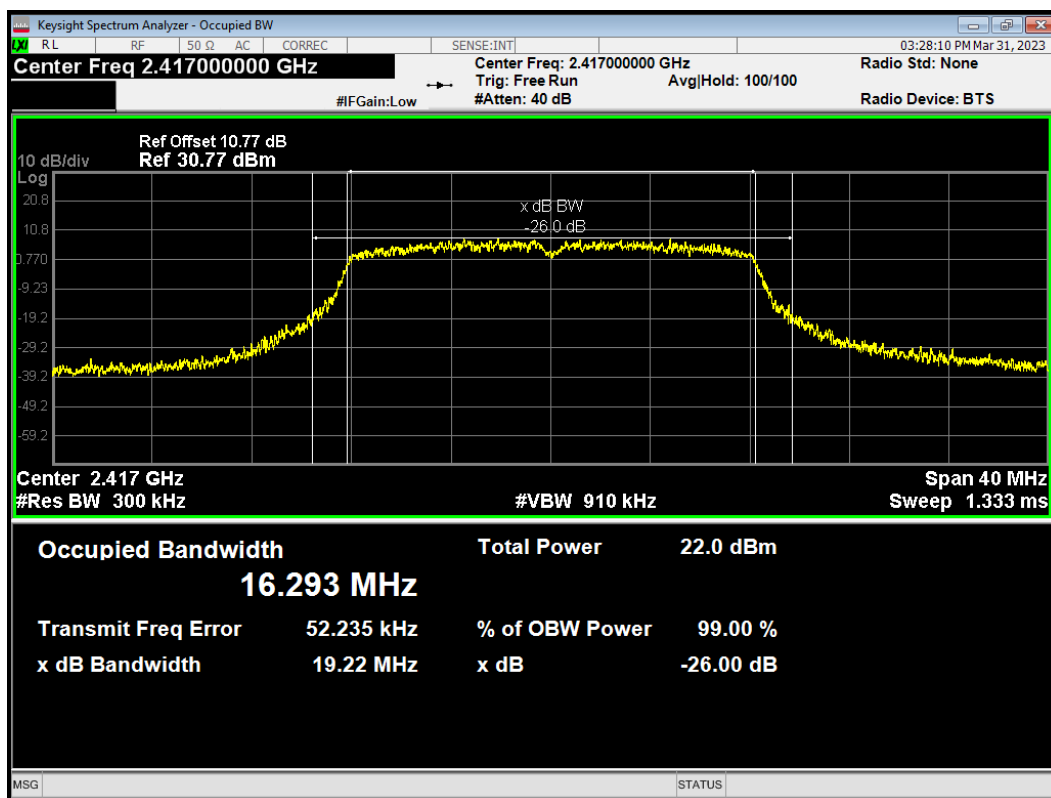
OBW 802.11b 2462MHz



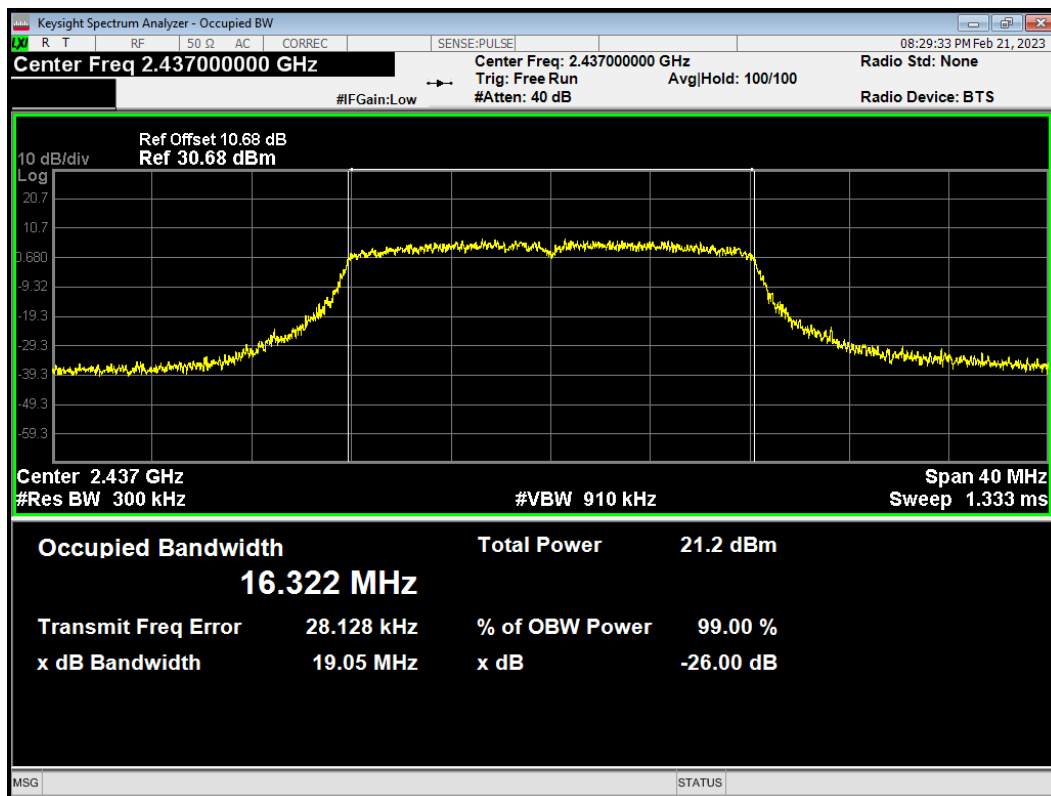
OBW 802.11g 2412MHz



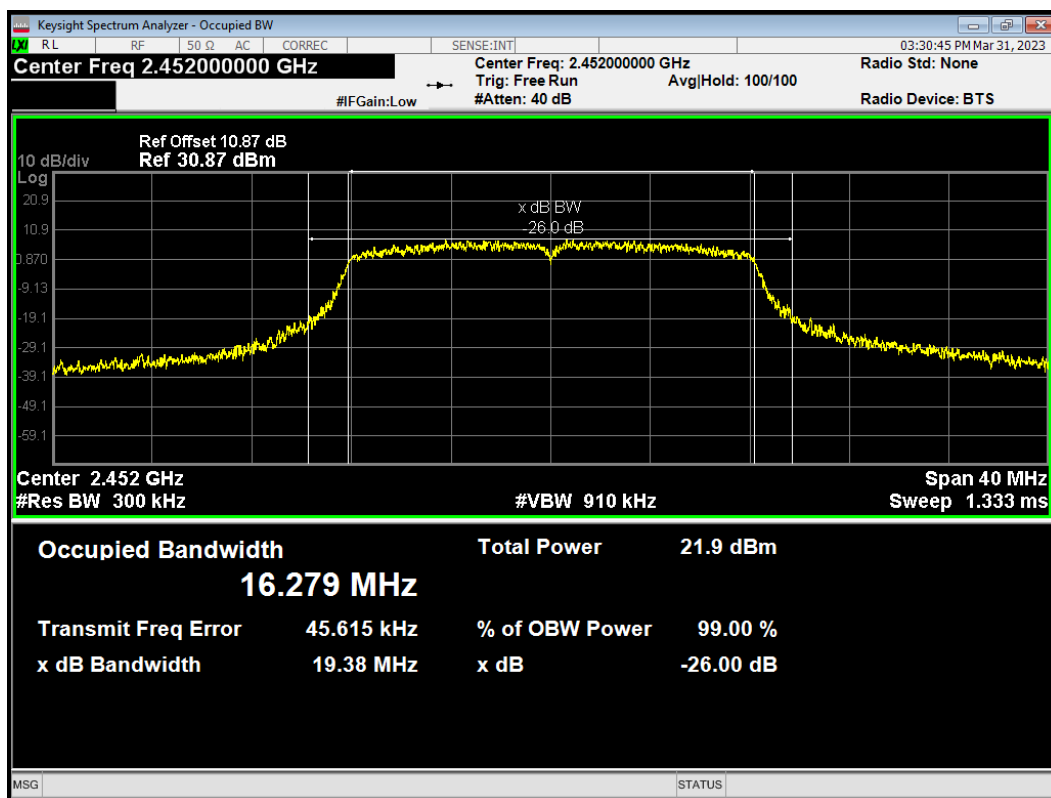
OBW 802.11g 2417MHz



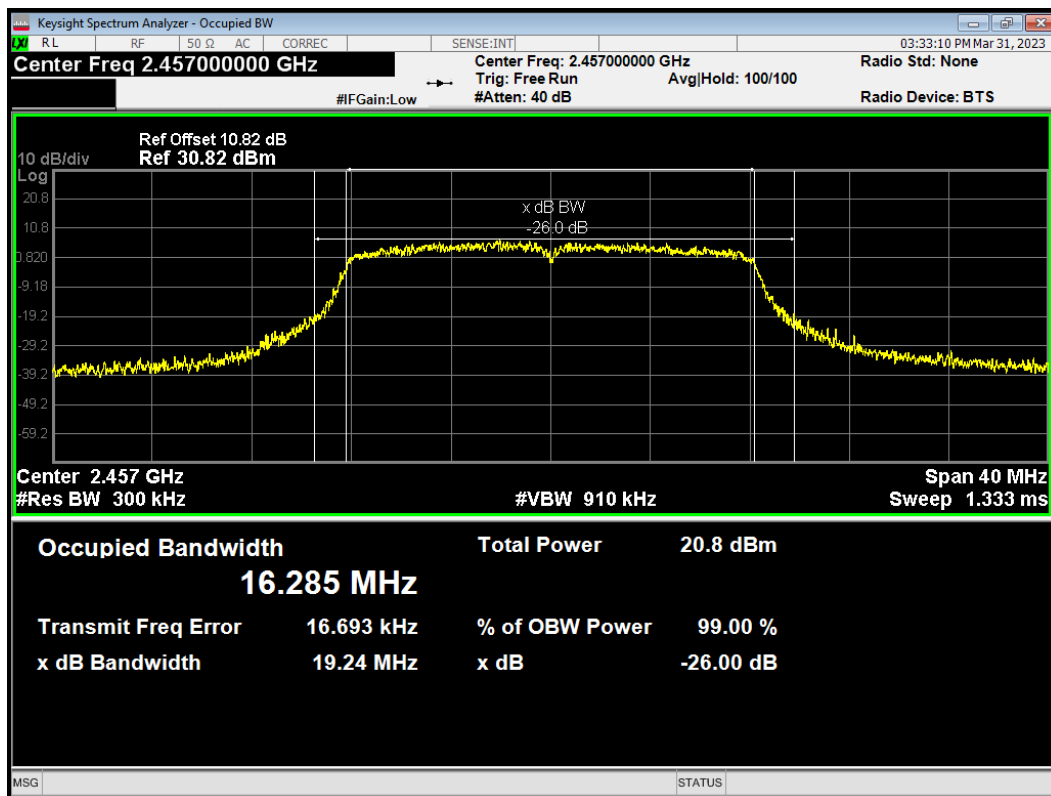
OBW 802.11g 2437MHz



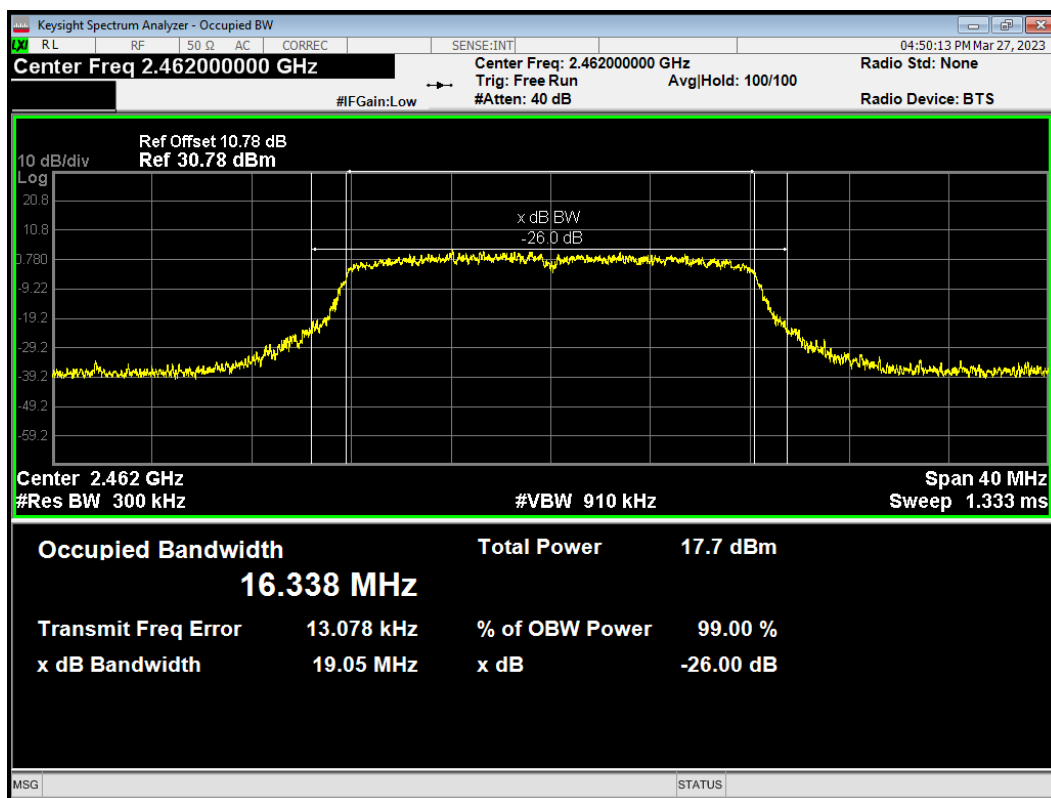
OBW 802.11g 2452MHz



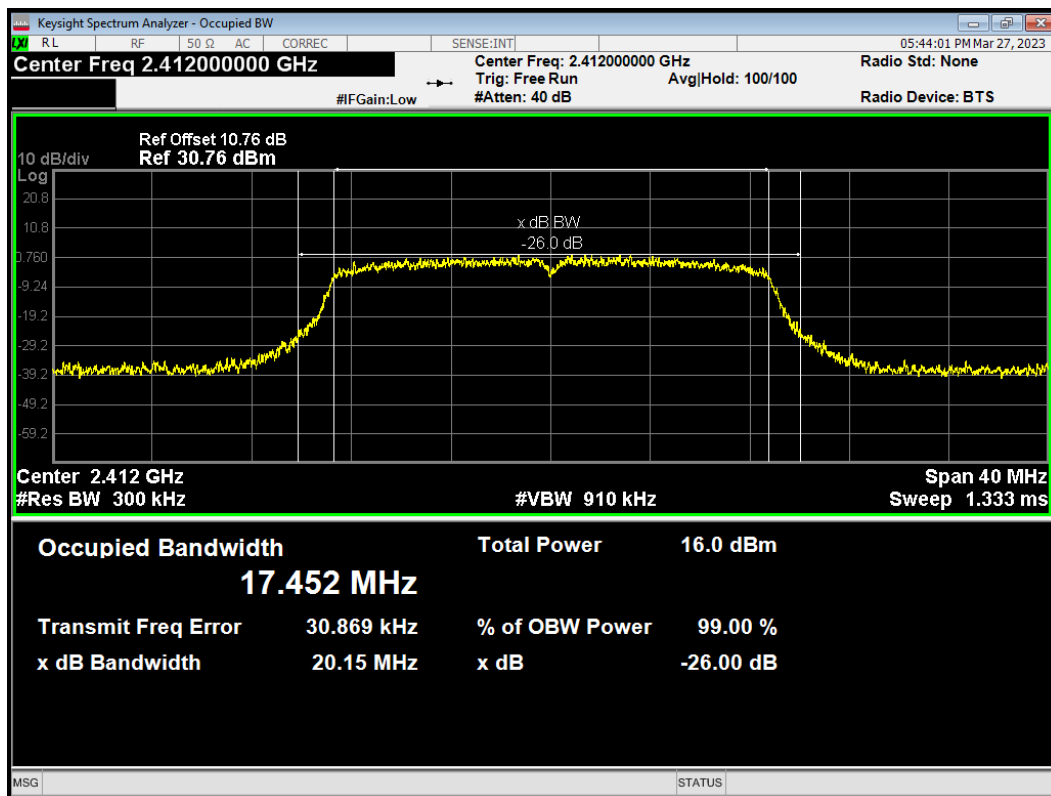
OBW 802.11g 2457MHz



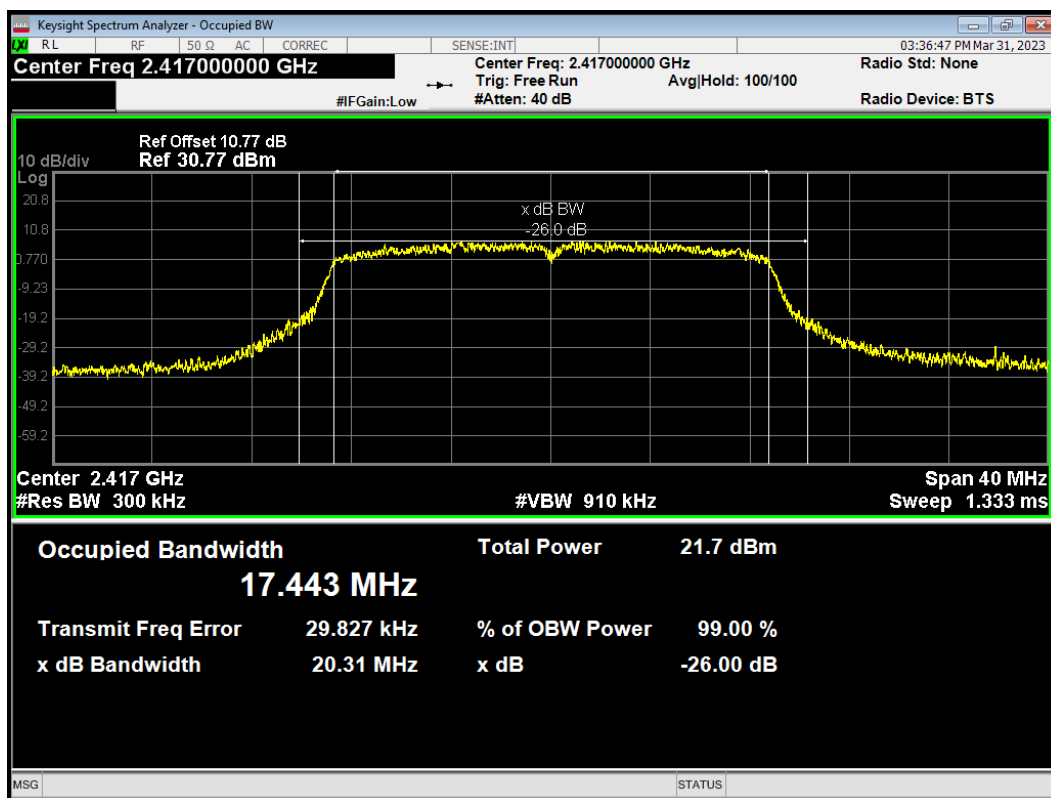
OBW 802.11g 2462MHz



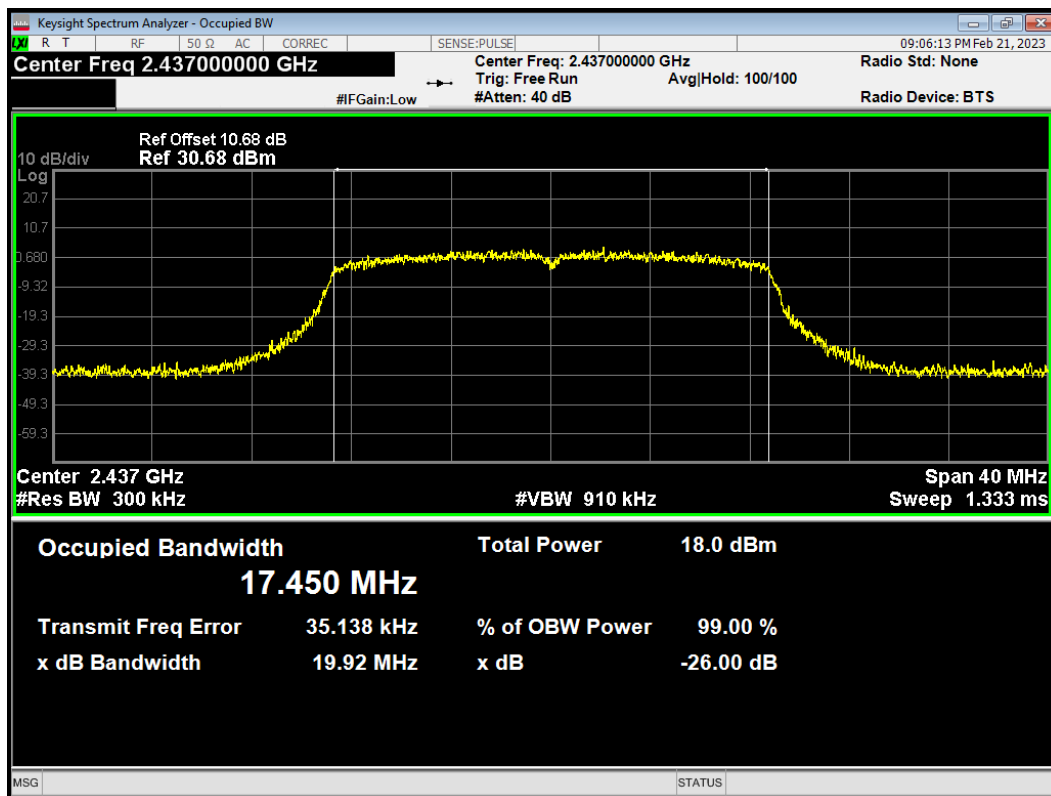
OBW 802.11n(HT20) 2412MHz



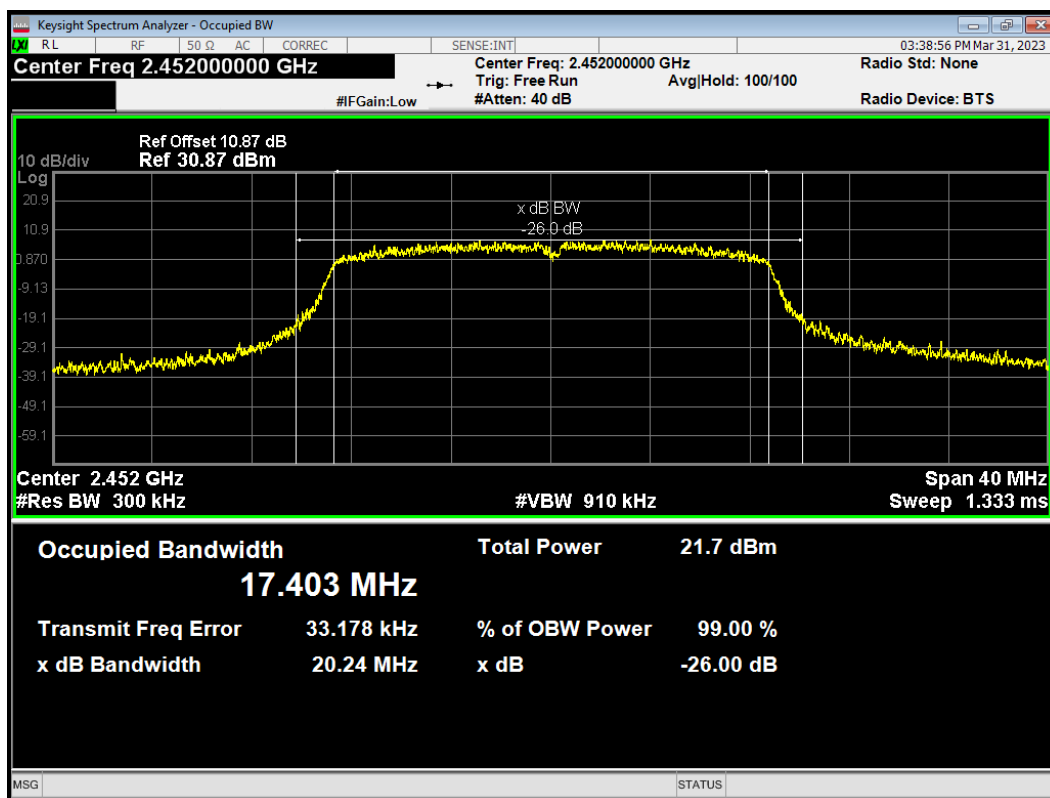
OBW 802.11n(HT20) 2417MHz



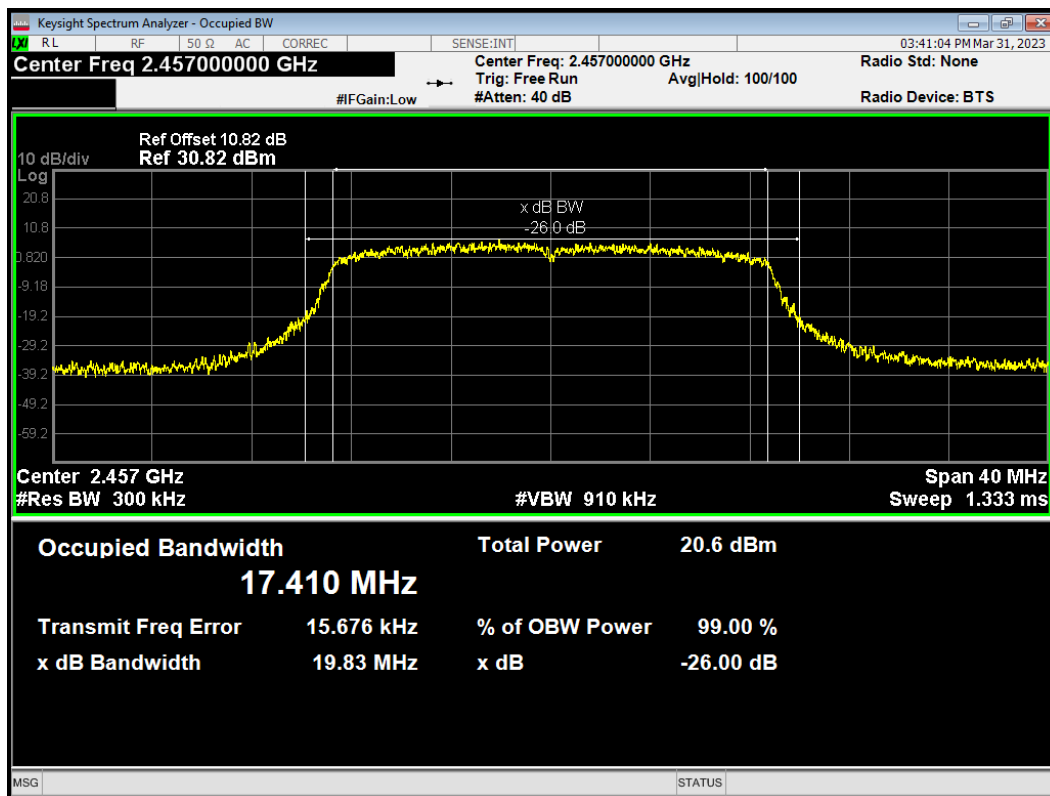
OBW 802.11n(HT20) 2437MHz



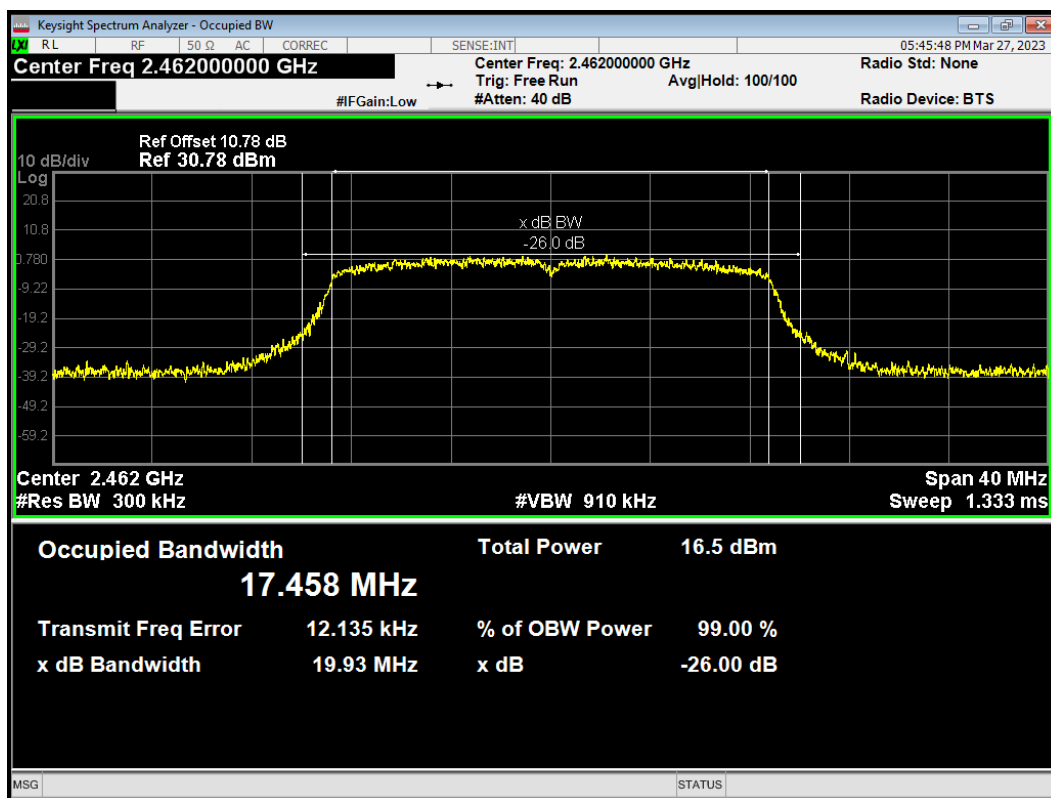
OBW 802.11n(HT20) 2452MHz



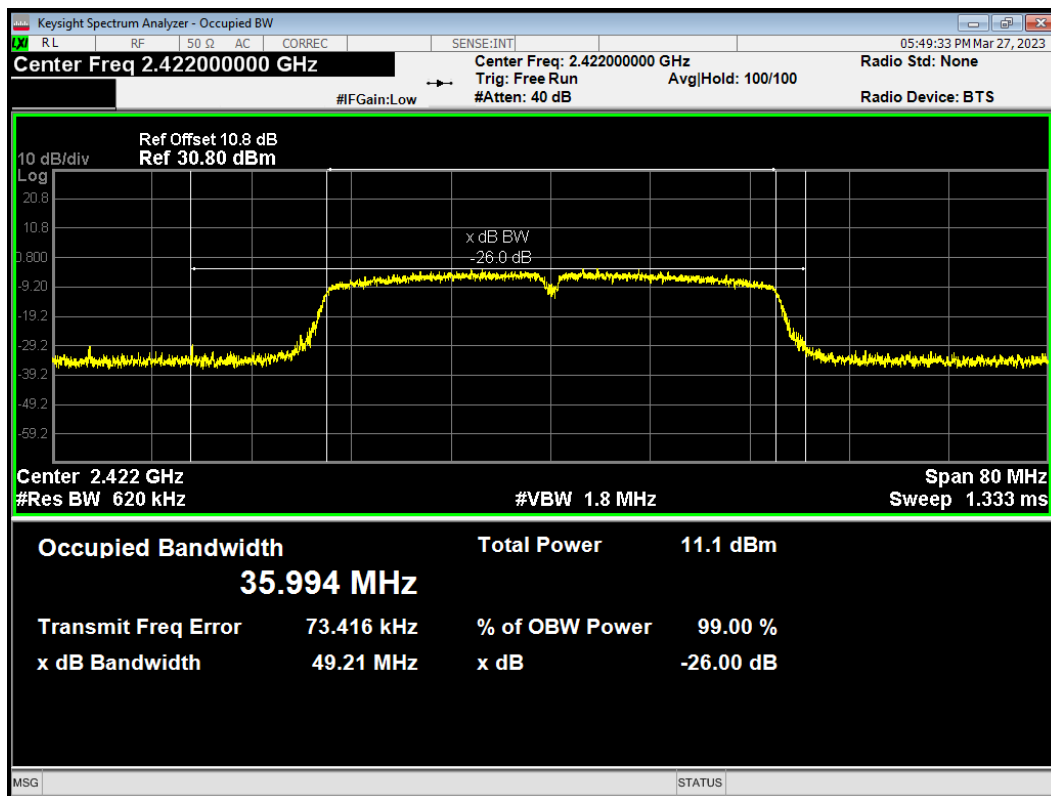
OBW 802.11n(HT20) 2457MHz



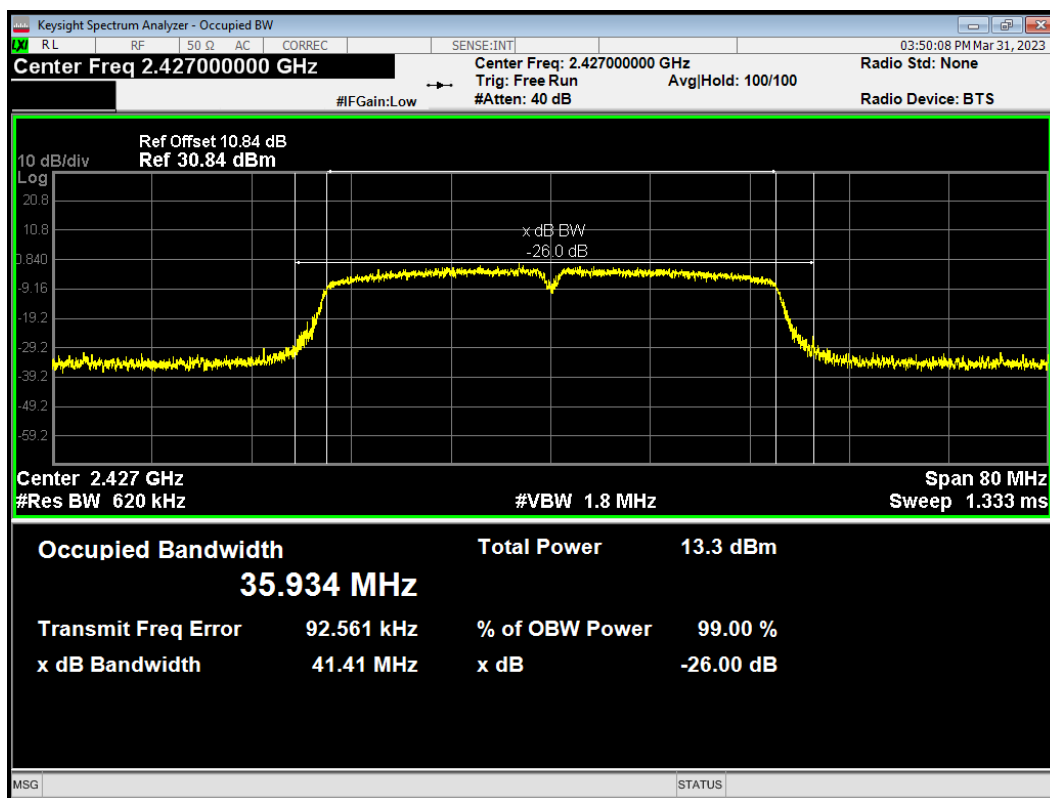
OBW 802.11n(HT20) 2462MHz



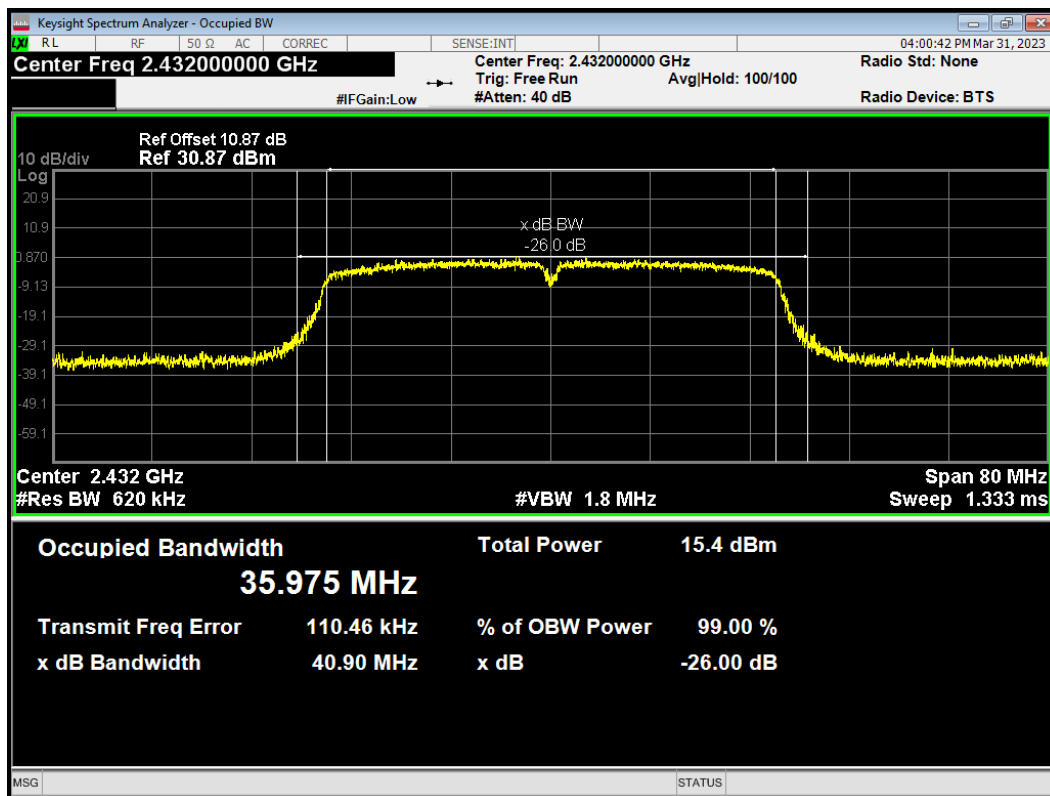
OBW 802.11n(HT40) 2422MHz



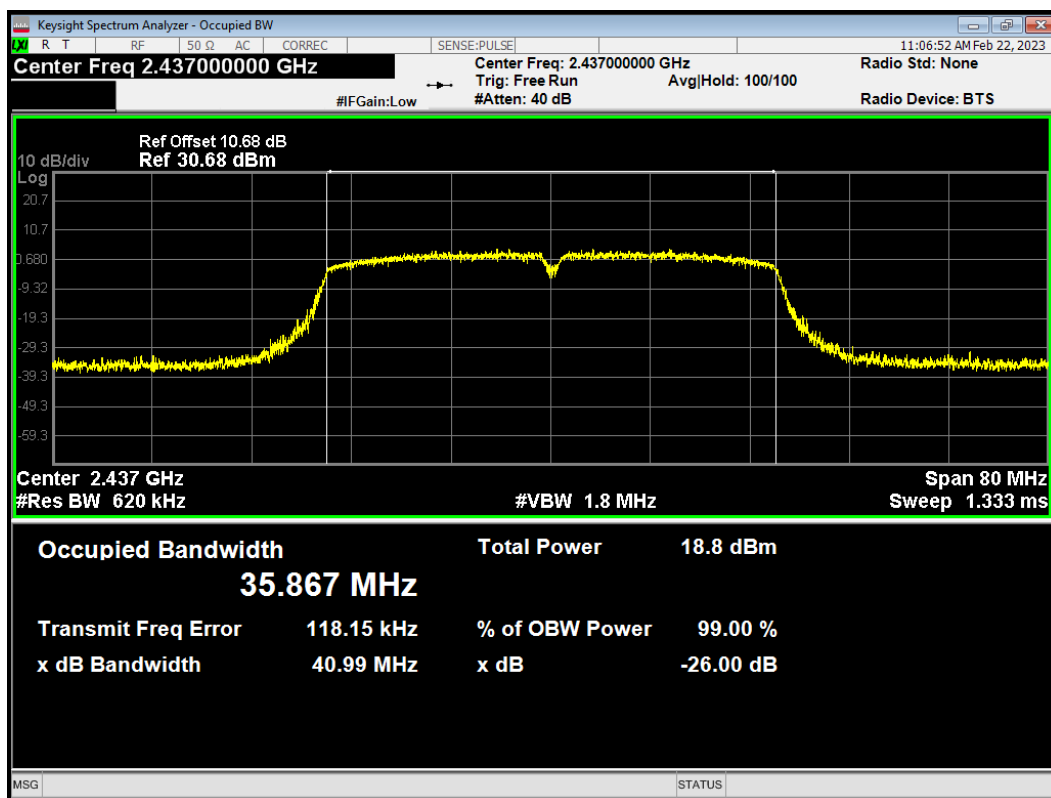
OBW 802.11n(HT40) 2427MHz



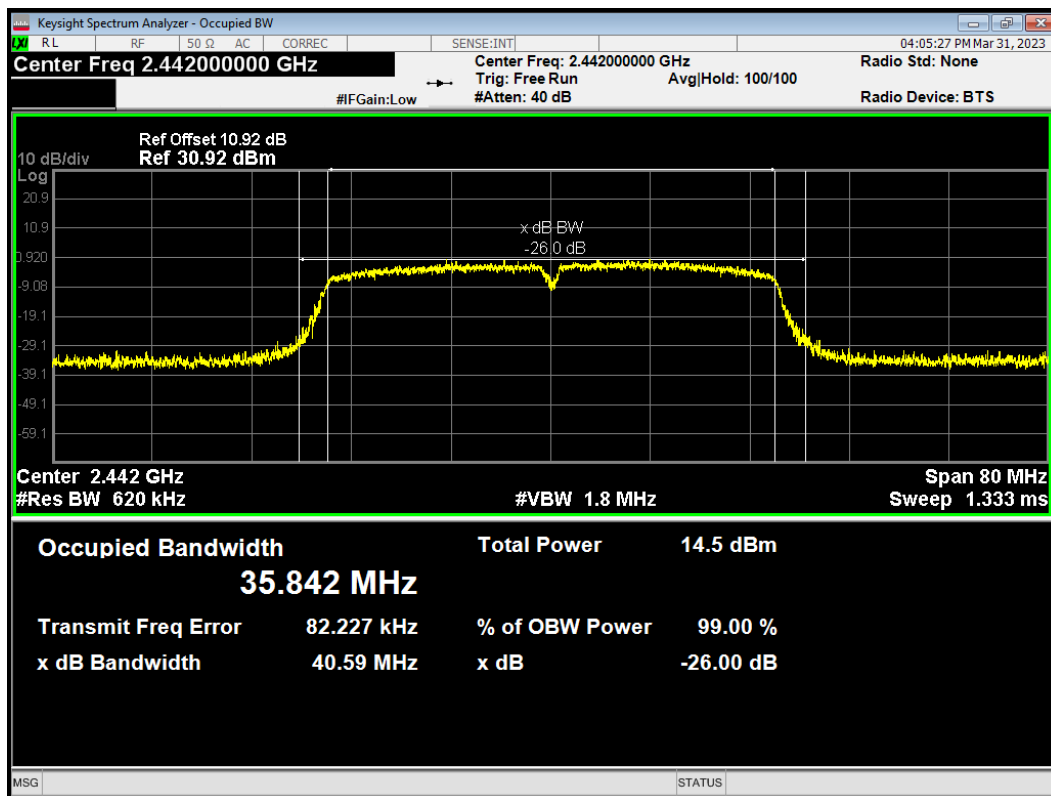
OBW 802.11n(HT40) 2432MHz



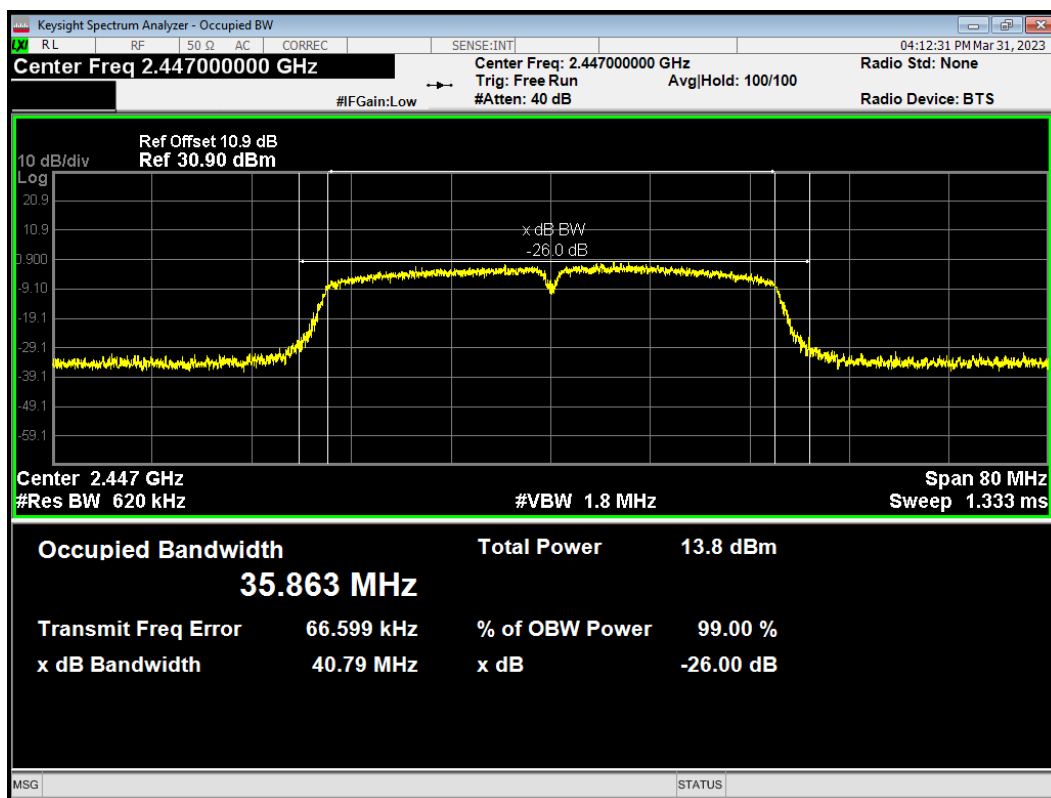
OBW 802.11n(HT40) 2437MHz



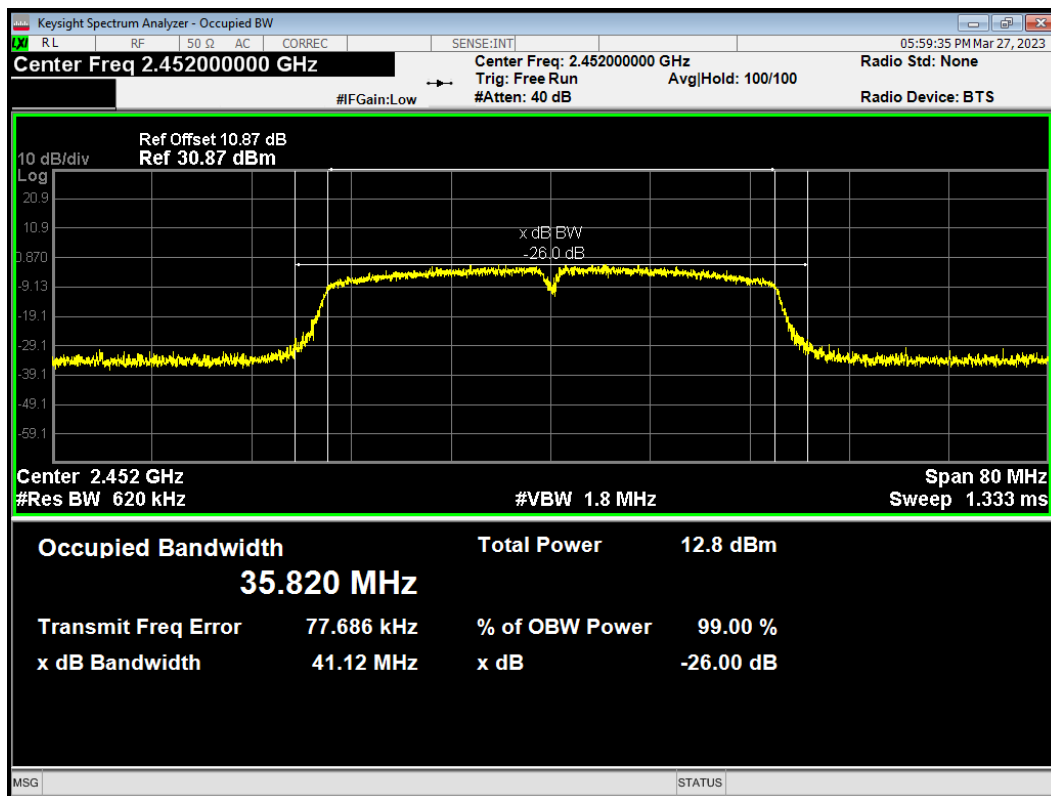
OBW 802.11n(HT40) 2442MHz



OBW 802.11n(HT40) 2447MHz

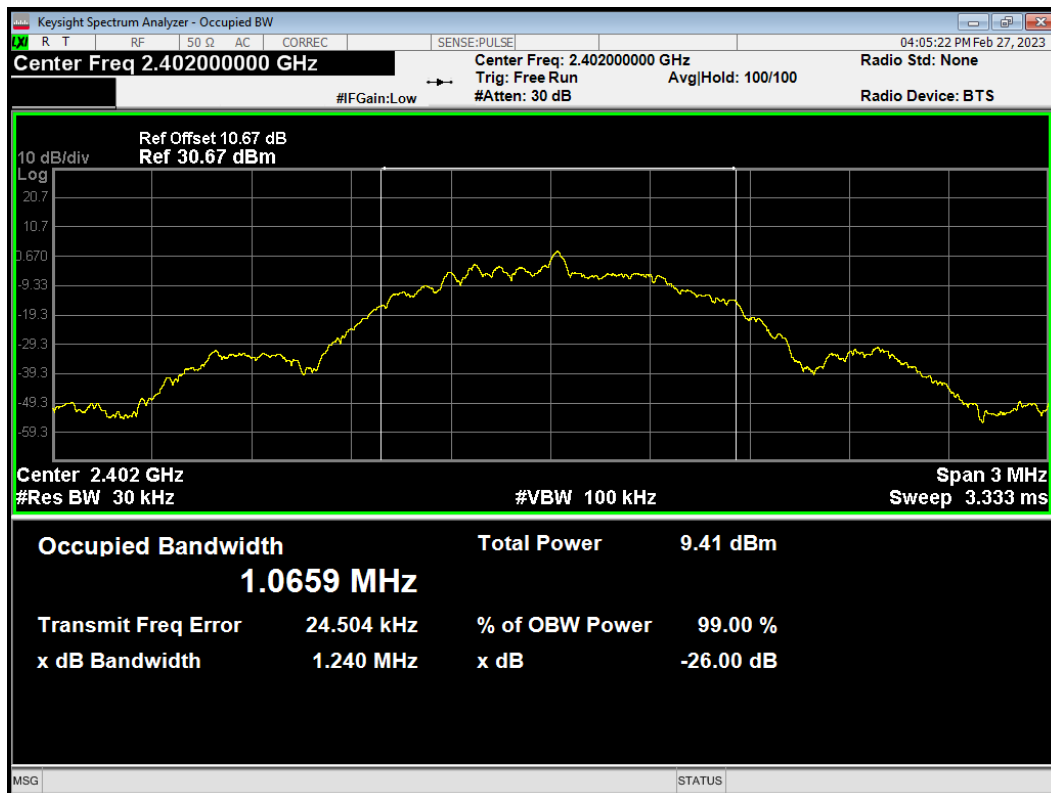


OBW 802.11n(HT40) 2452MHz



Bluetooth LE

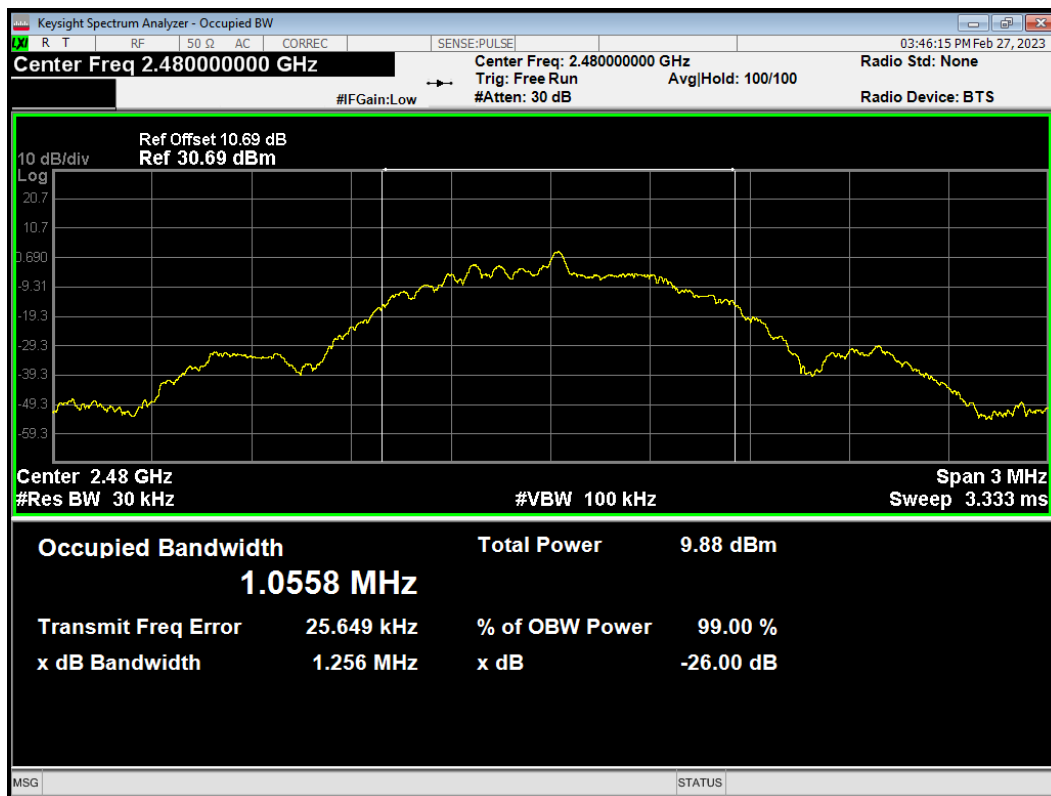
OBW Bluetooth LE 2402MHz



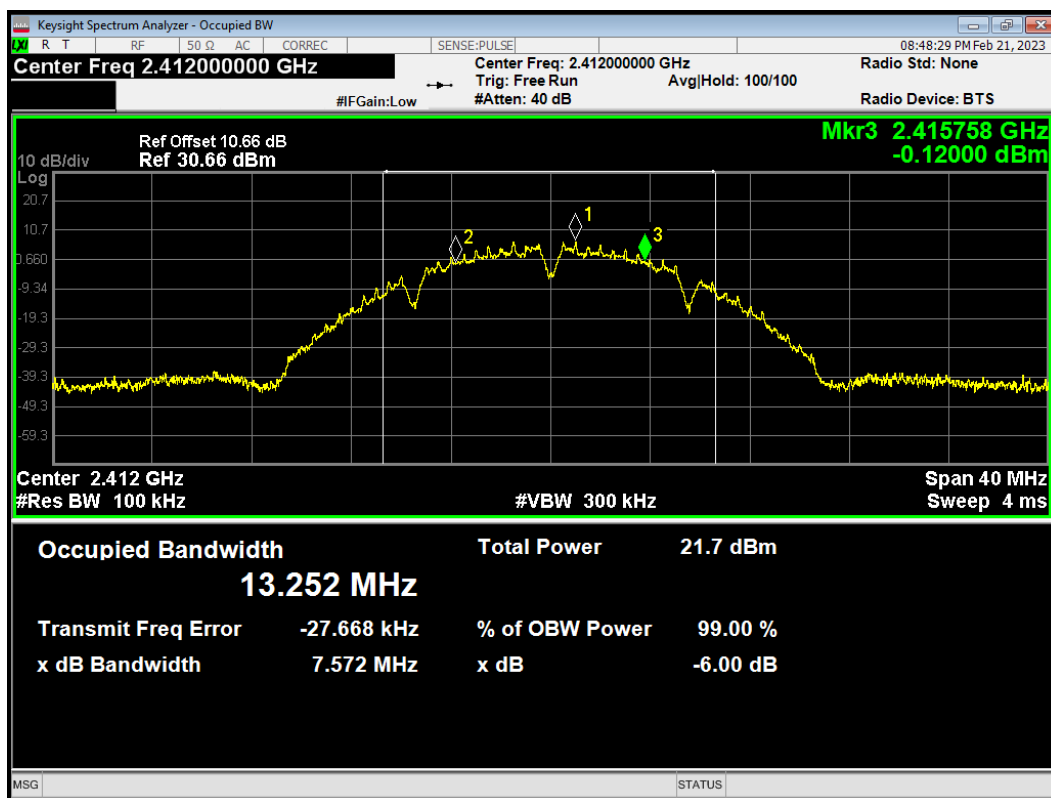
OBW Bluetooth LE 2440MHz



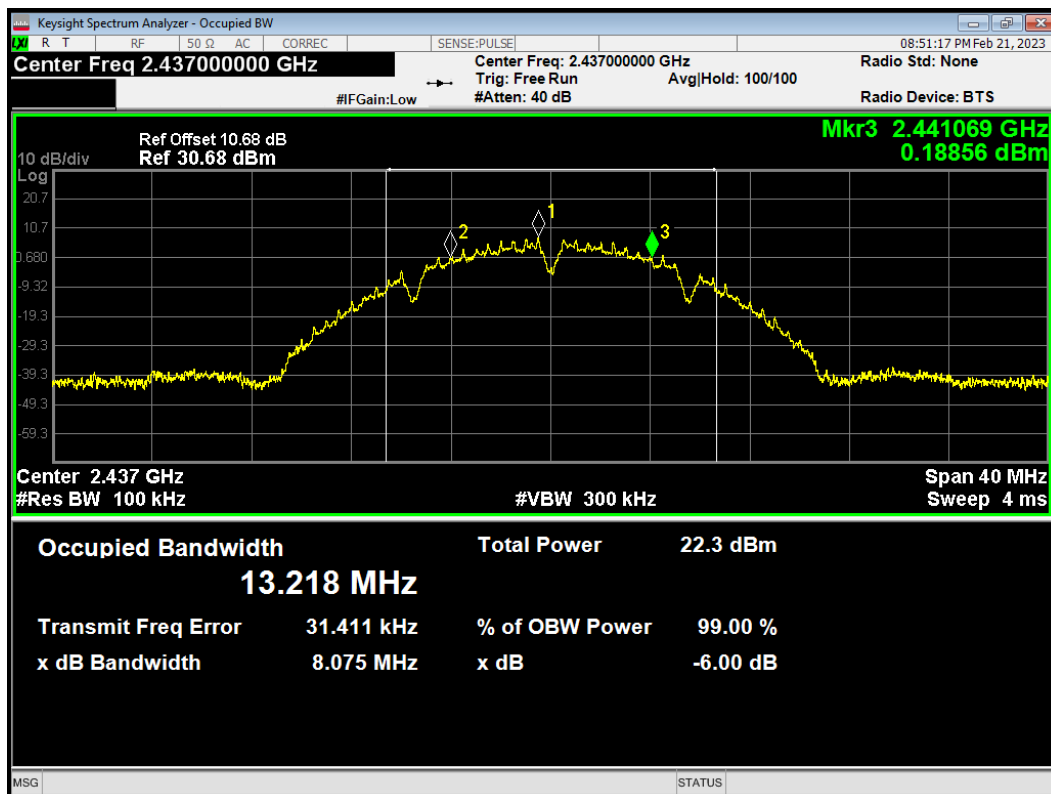
OBW Bluetooth LE 2480MHz



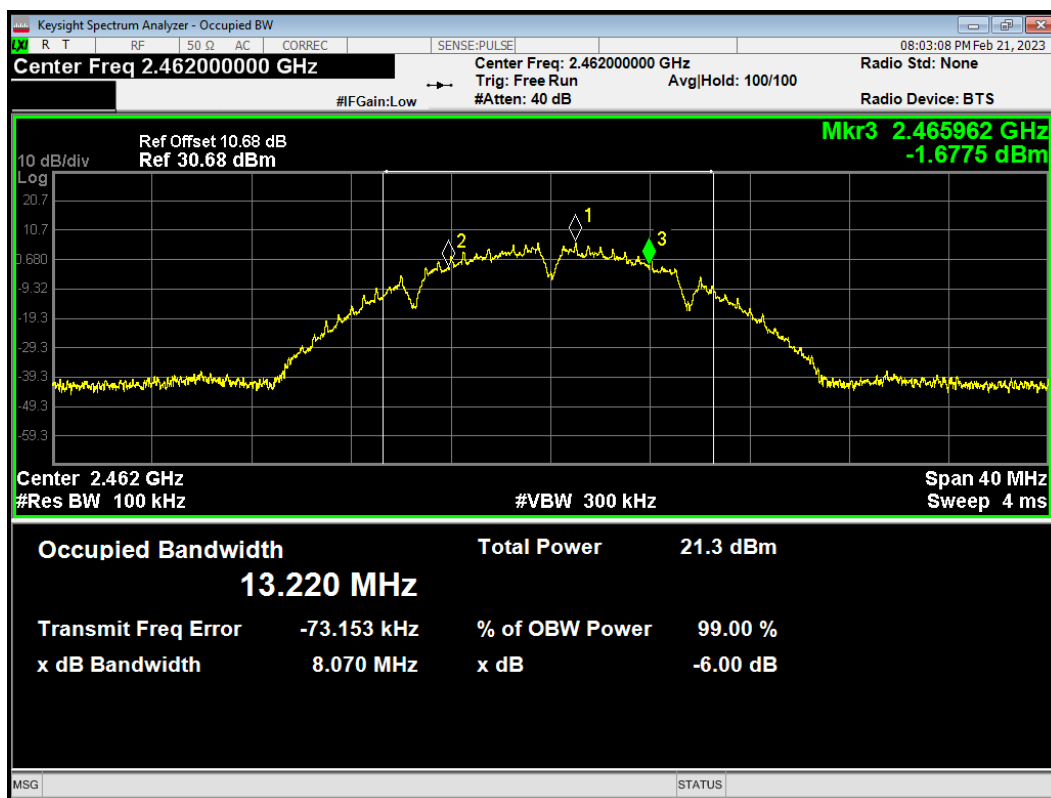
-6dB Bandwidth 802.11b 2412MHz



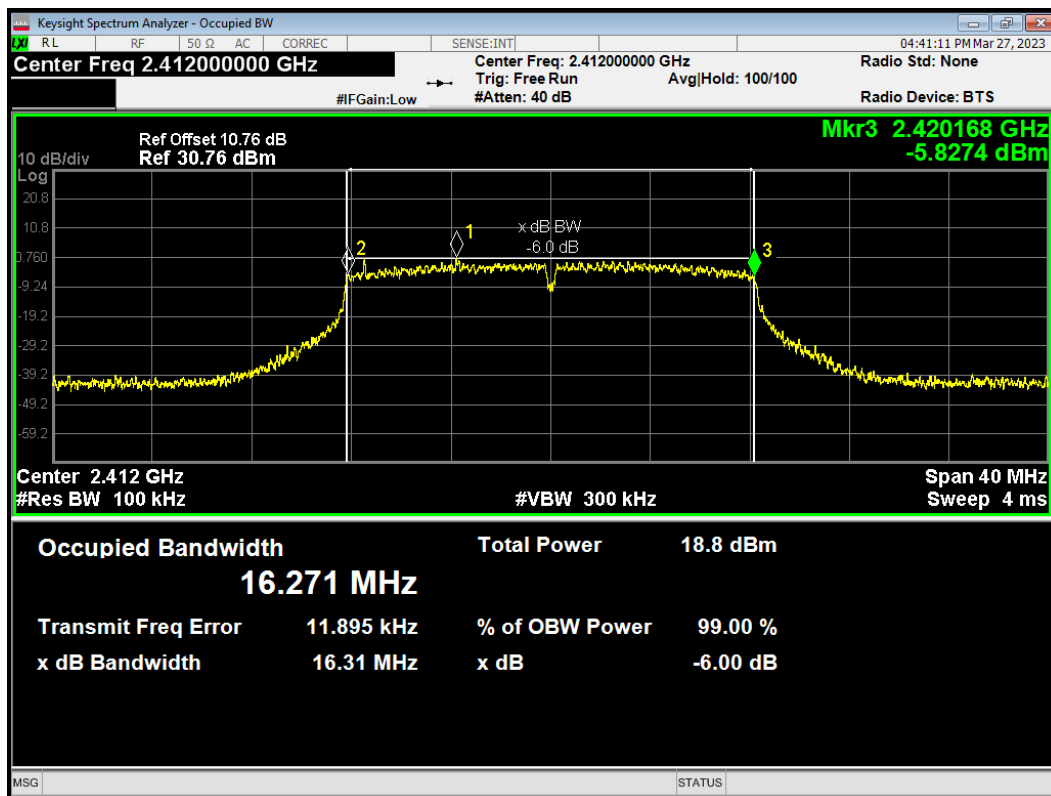
-6dB Bandwidth 802.11b 2437MHz



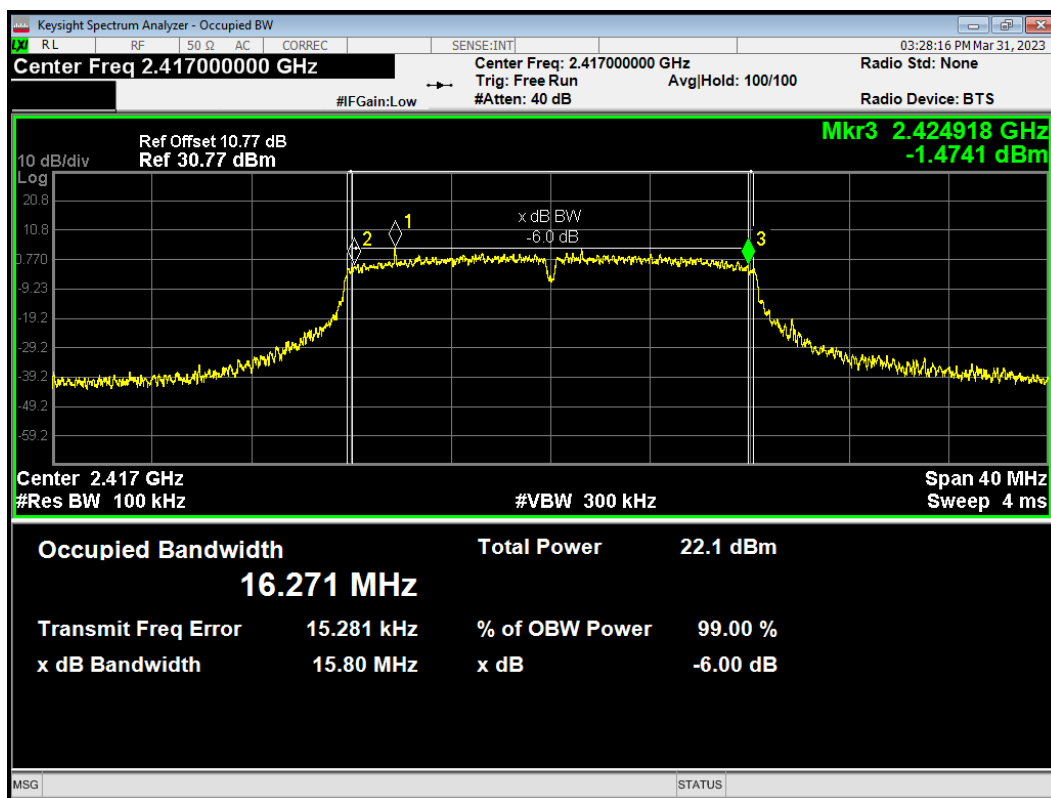
-6dB Bandwidth 802.11b 2462MHz



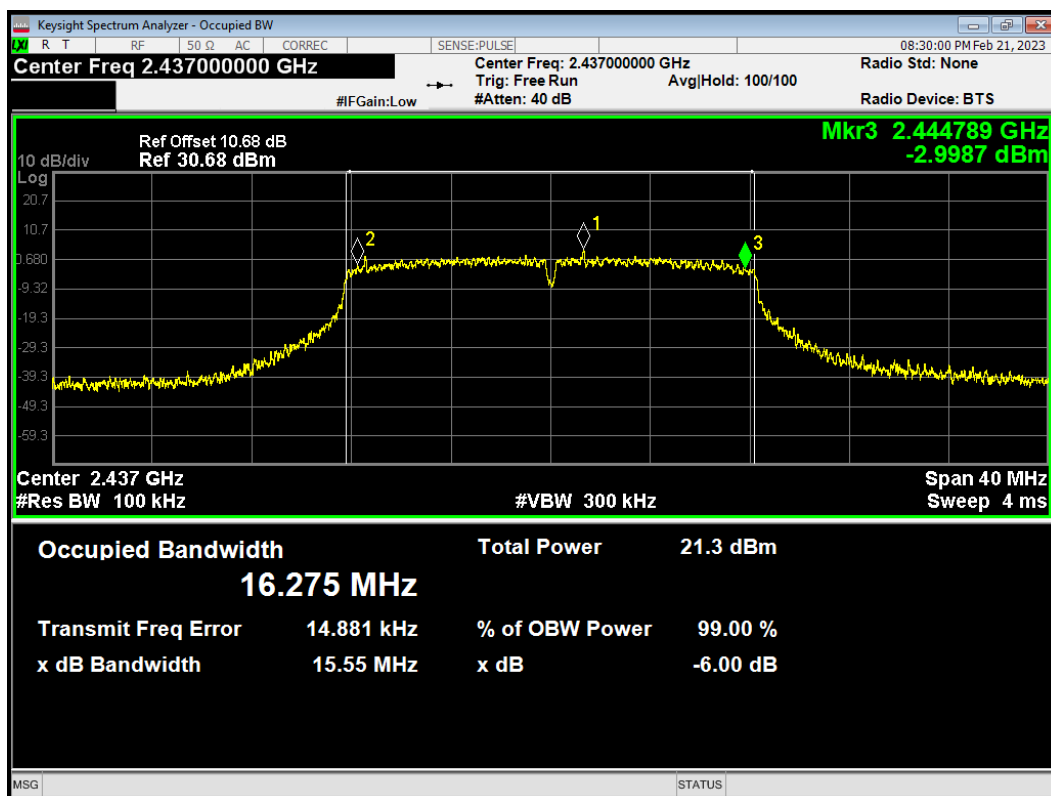
-6dB Bandwidth 802.11g 2412MHz



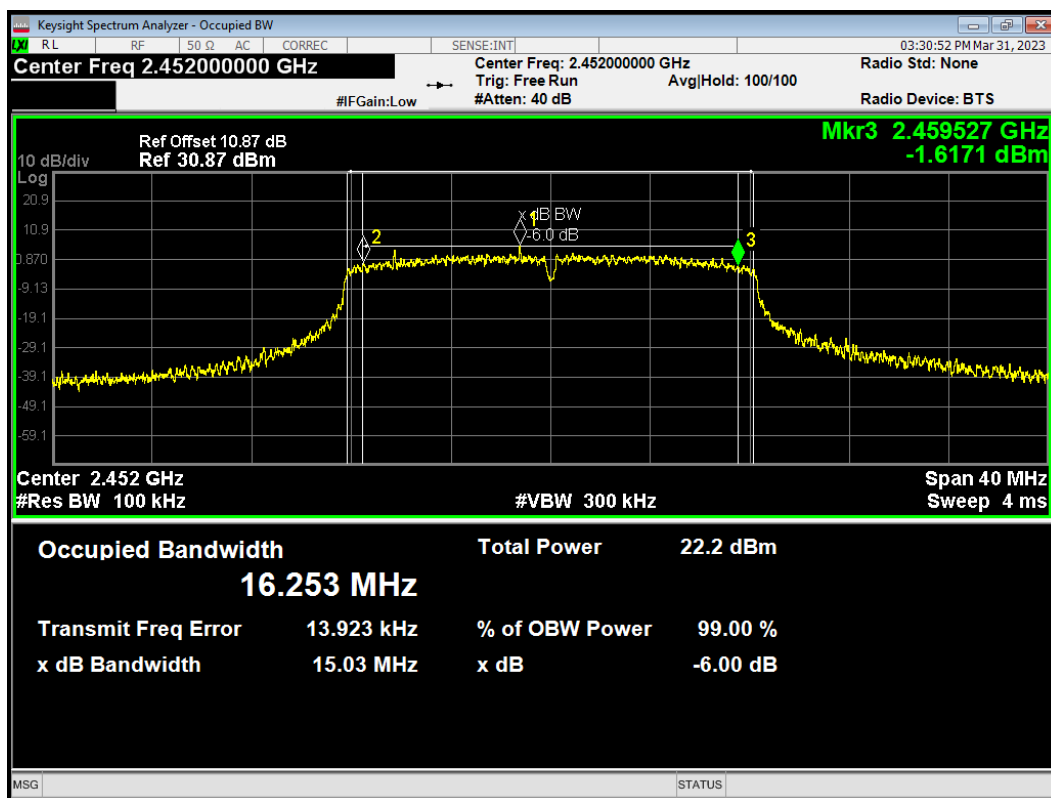
-6dB Bandwidth 802.11g 2417MHz



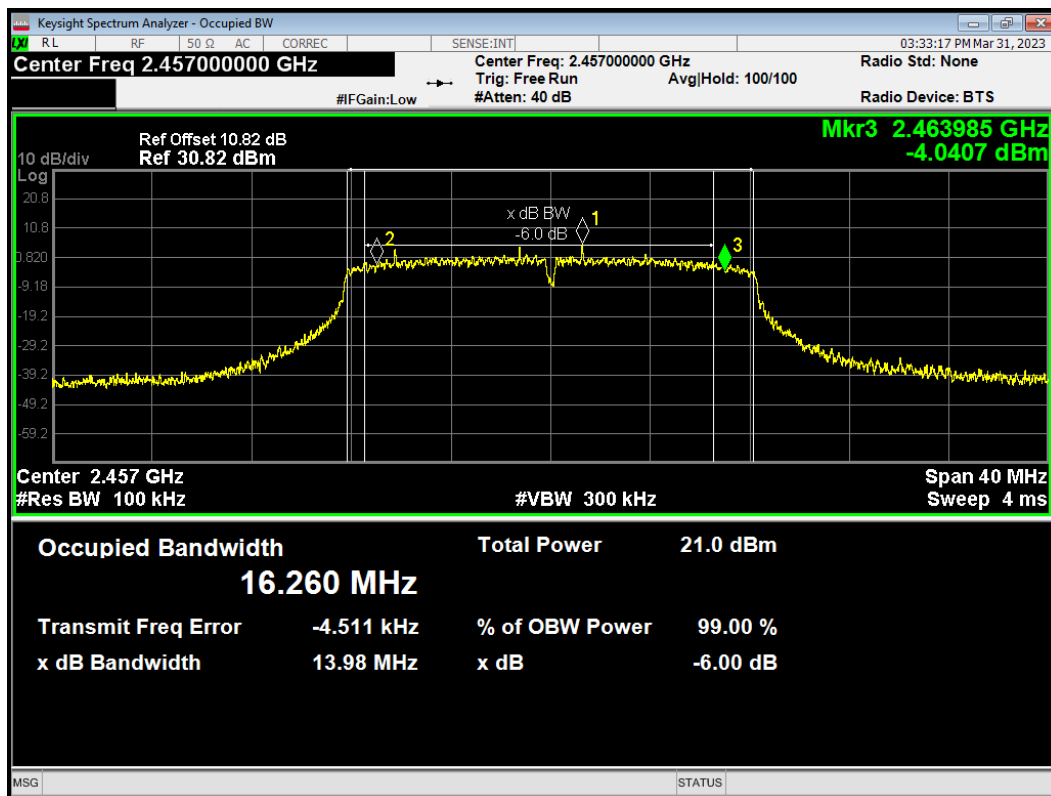
-6dB Bandwidth 802.11g 2437MHz



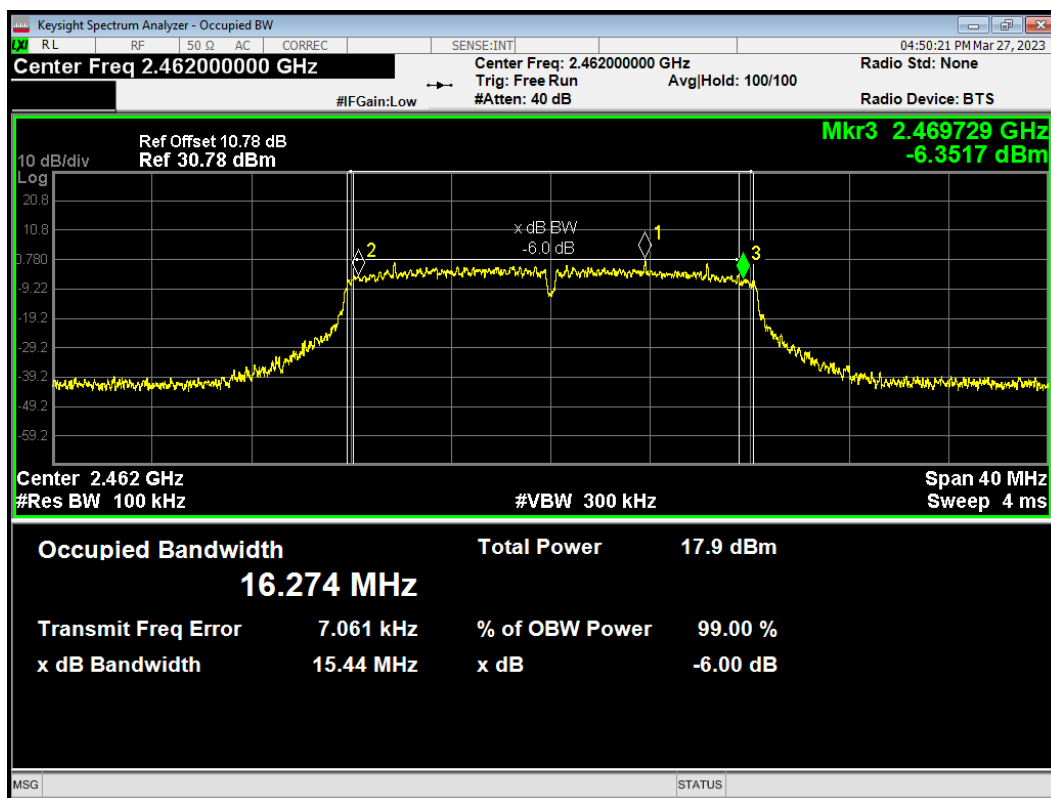
-6dB Bandwidth 802.11g 2452MHz



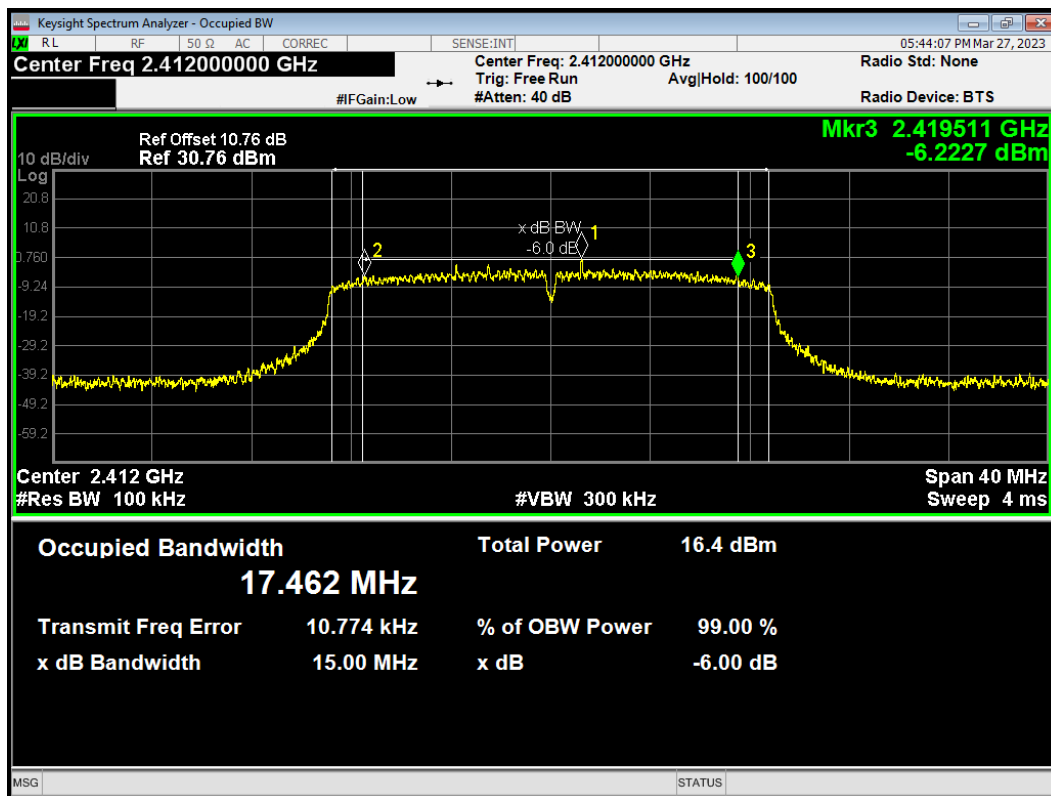
-6dB Bandwidth 802.11g 2457MHz



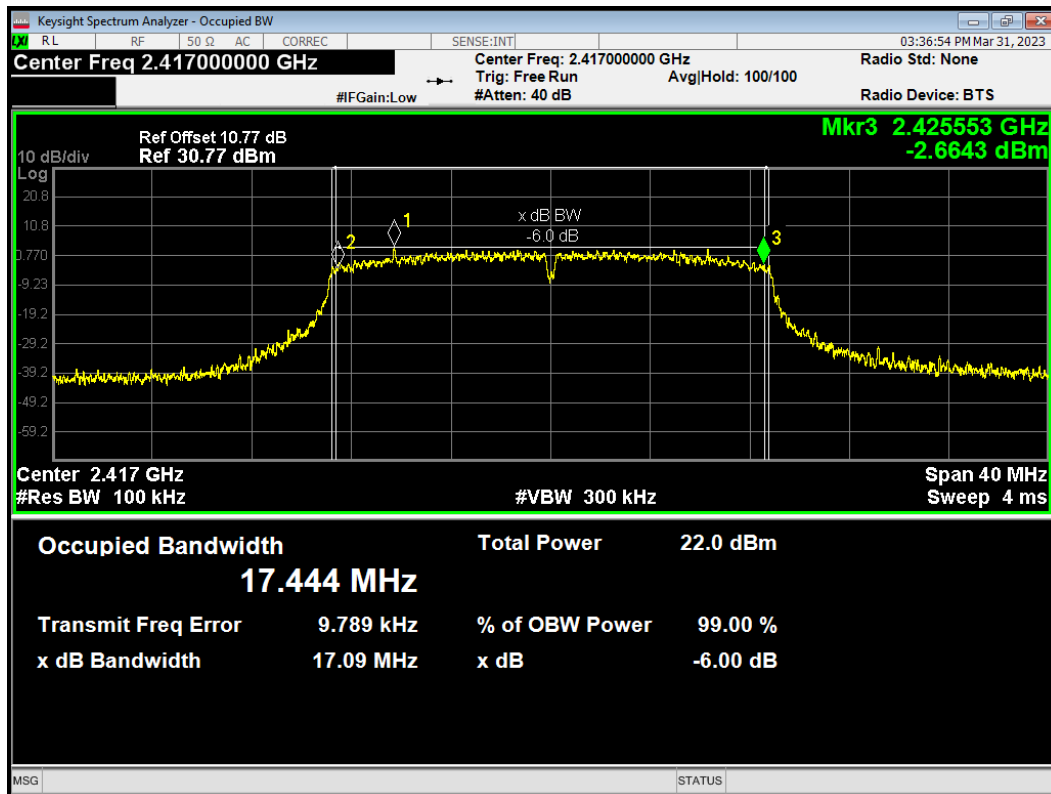
-6dB Bandwidth 802.11g 2462MHz



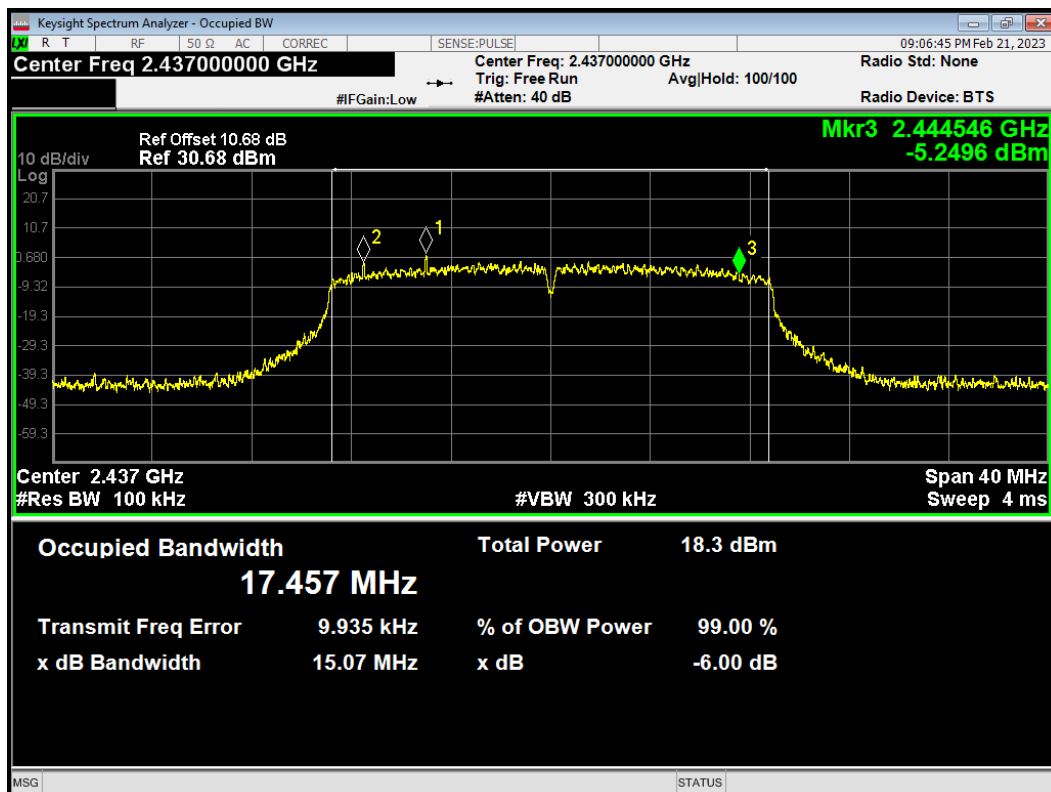
-6dB Bandwidth 802.11n(HT20) 2412MHz



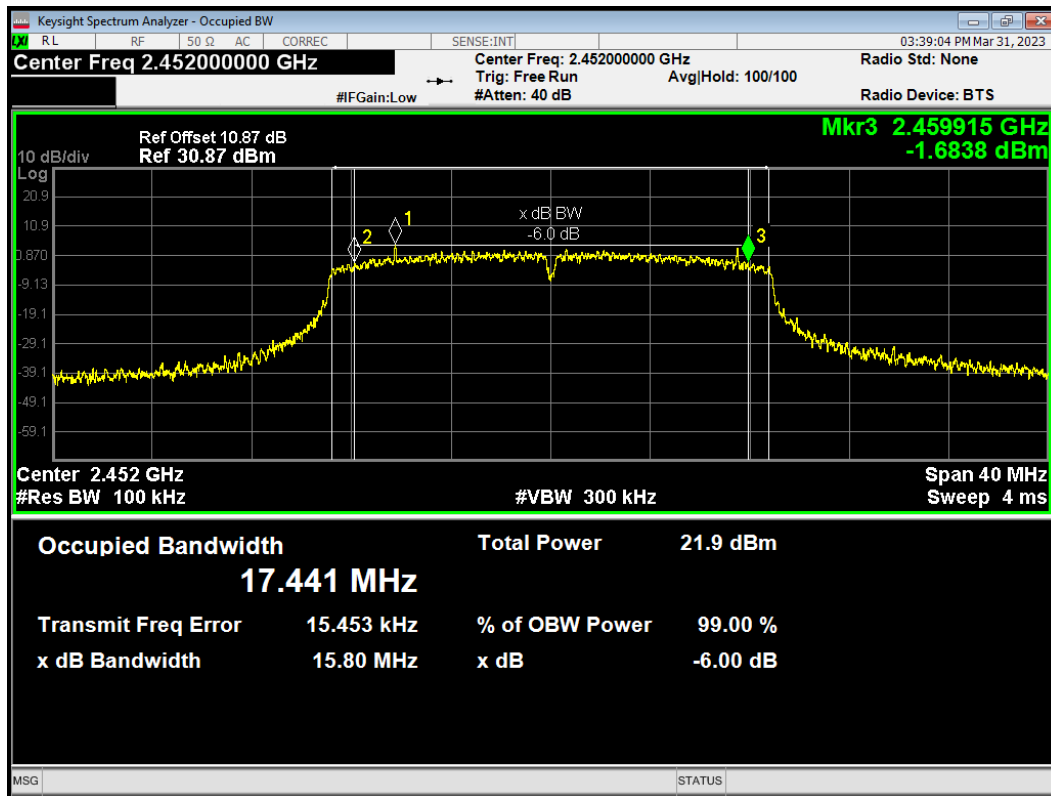
-6dB Bandwidth 802.11n(HT20) 2417MHz



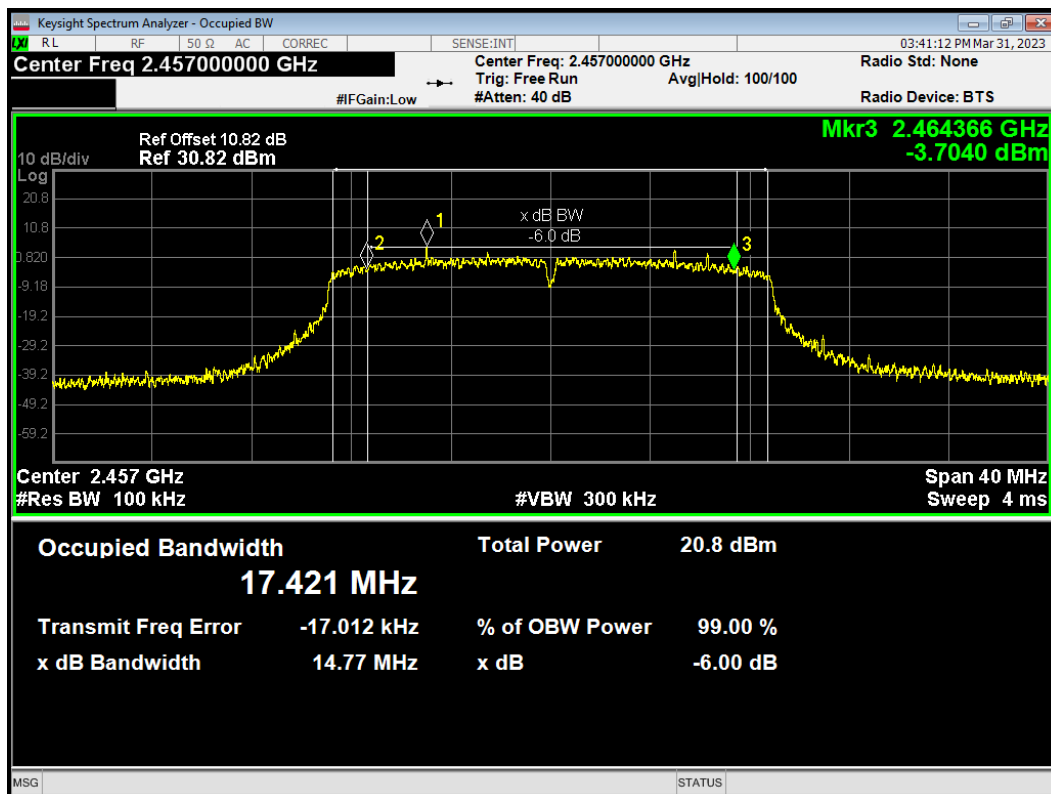
-6dB Bandwidth 802.11n(HT20) 2437MHz



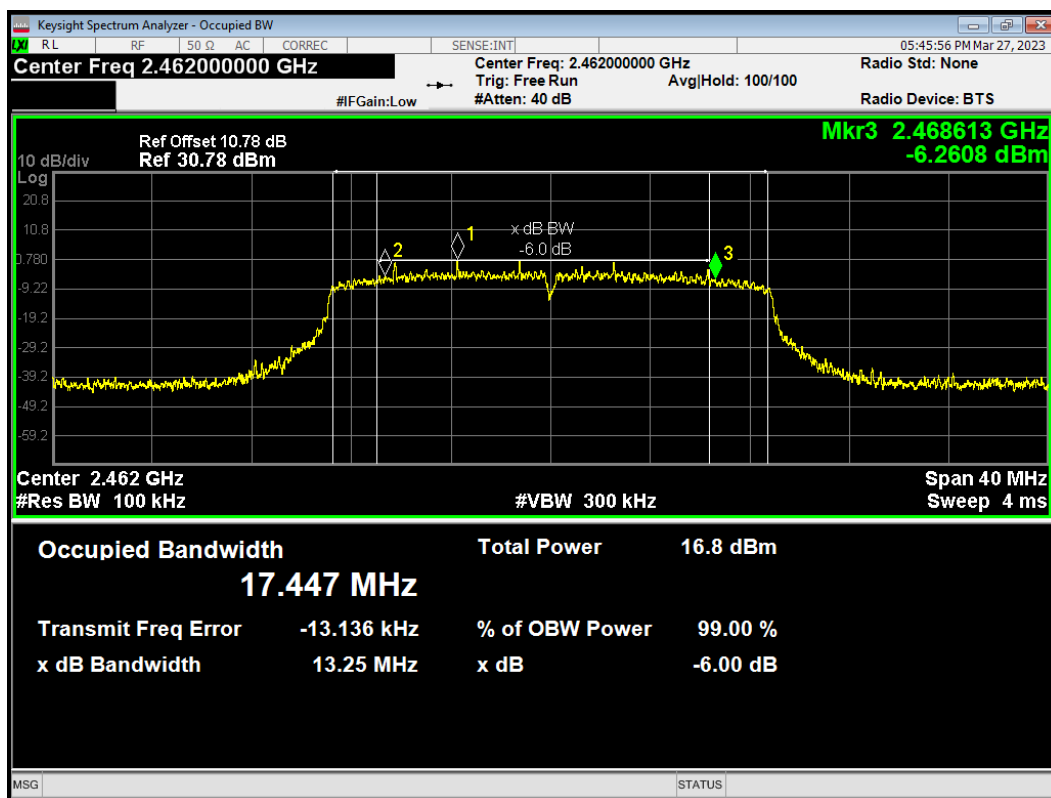
-6dB Bandwidth 802.11n(HT20) 2452MHz



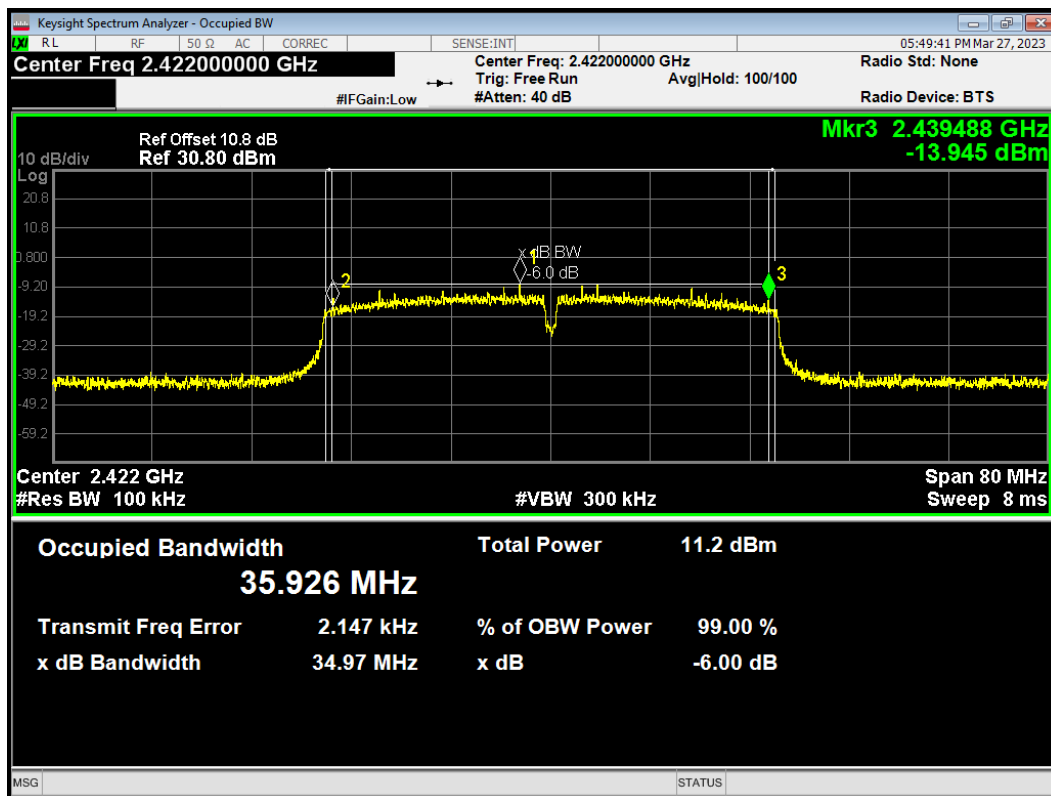
-6dB Bandwidth 802.11n(HT20) 2457MHz



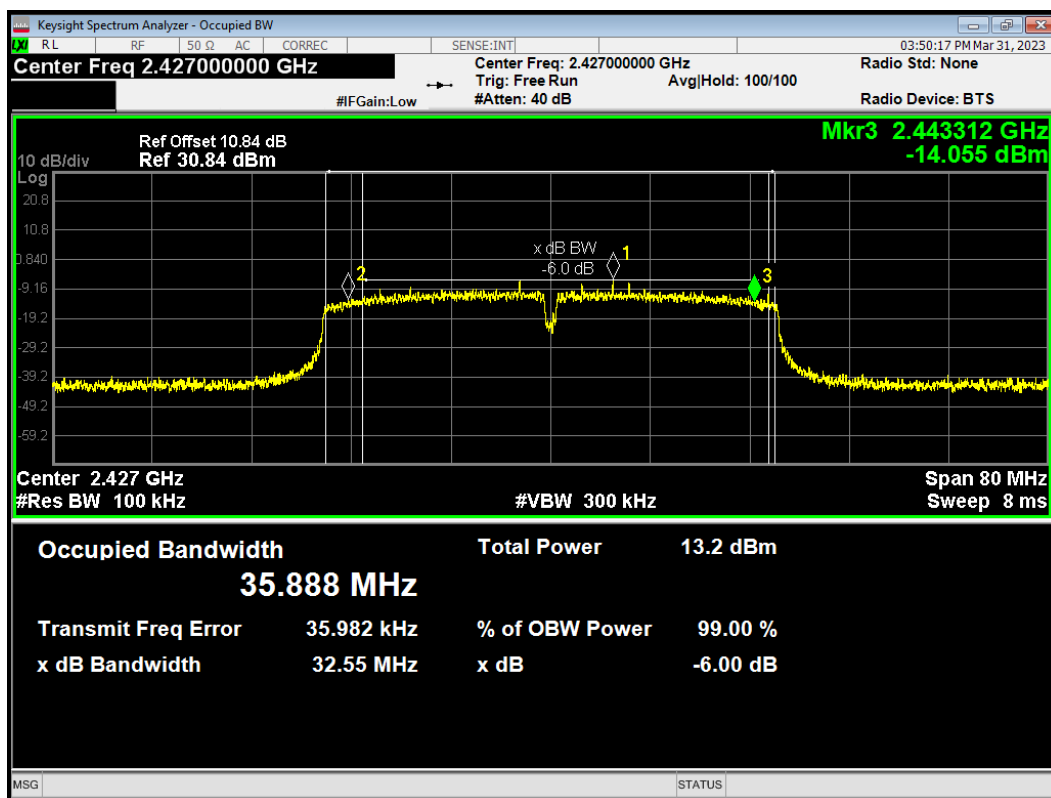
-6dB Bandwidth 802.11n(HT20) 2462MHz



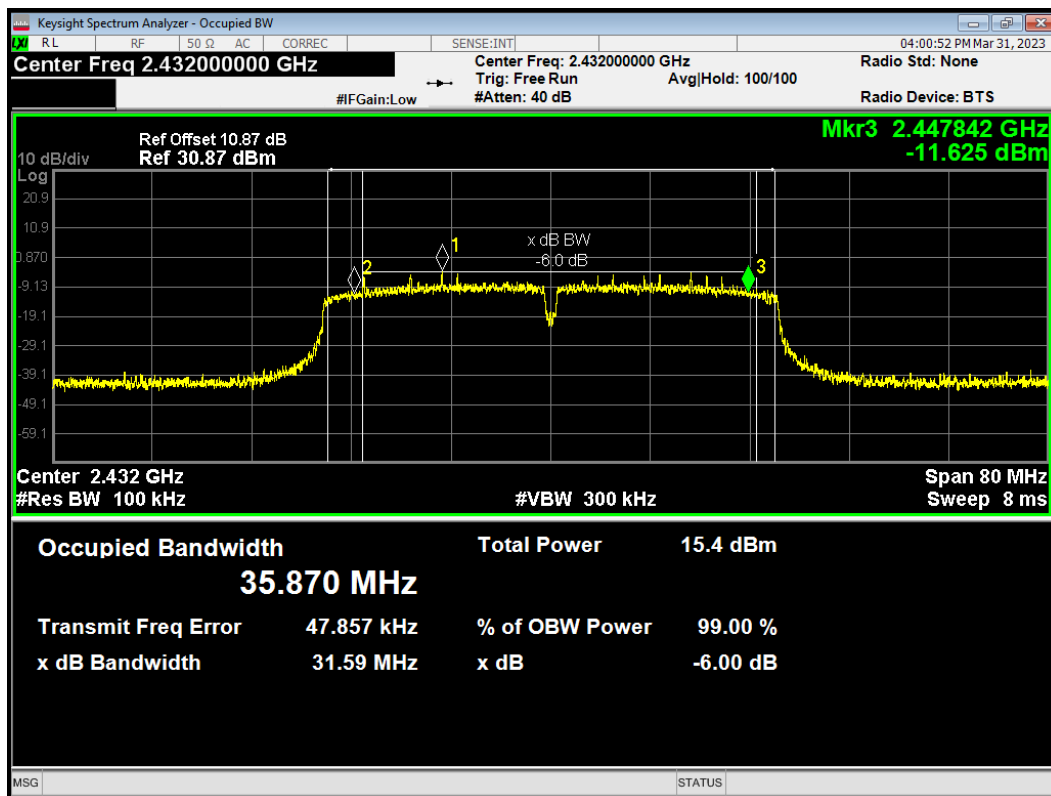
-6dB Bandwidth 802.11n(HT40) 2422MHz



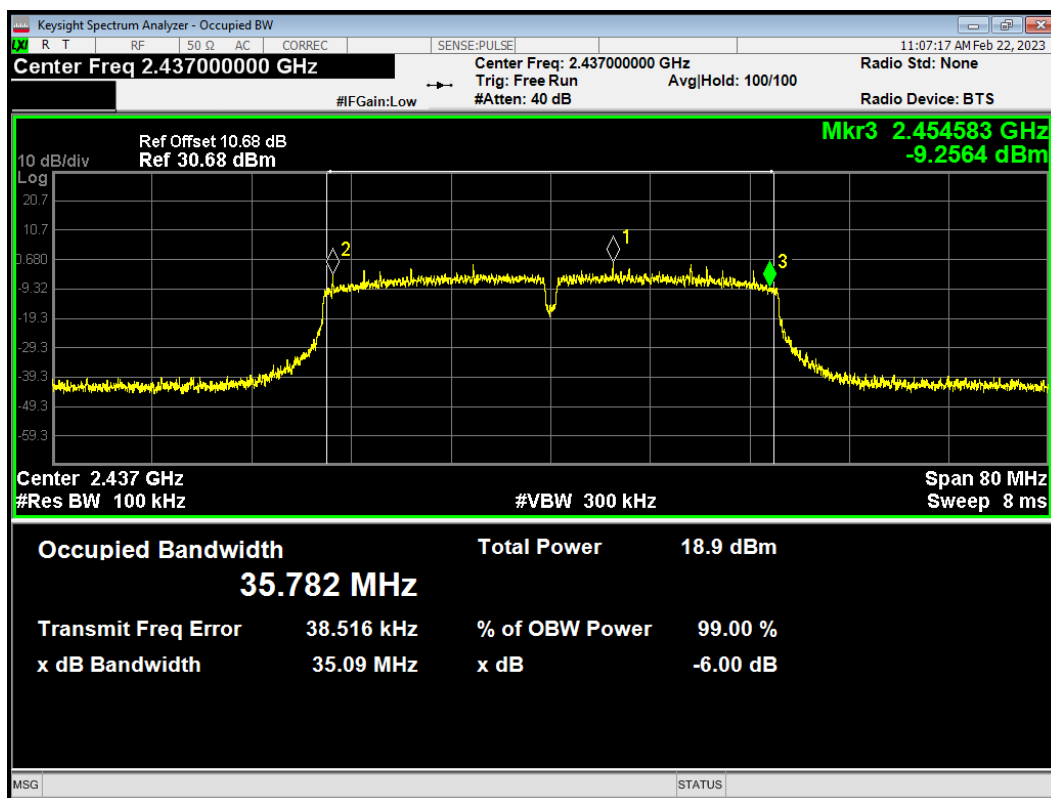
-6dB Bandwidth 802.11n(HT40) 2427MHz



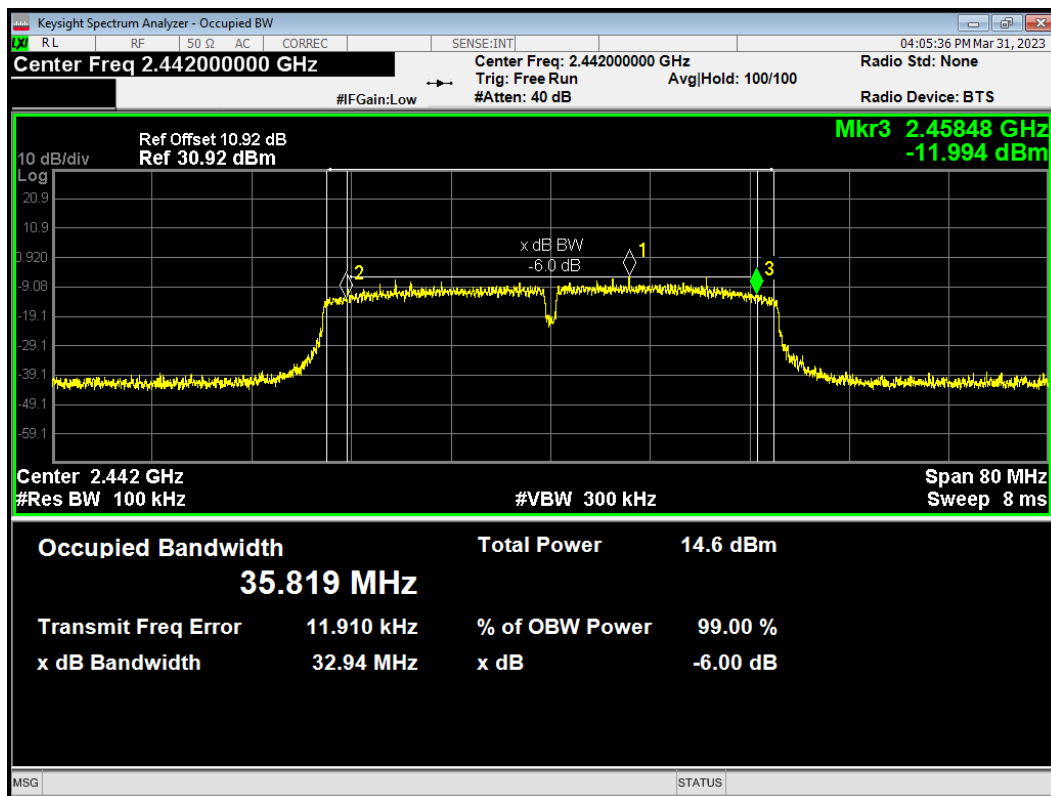
-6dB Bandwidth 802.11n(HT40) 2432MHz



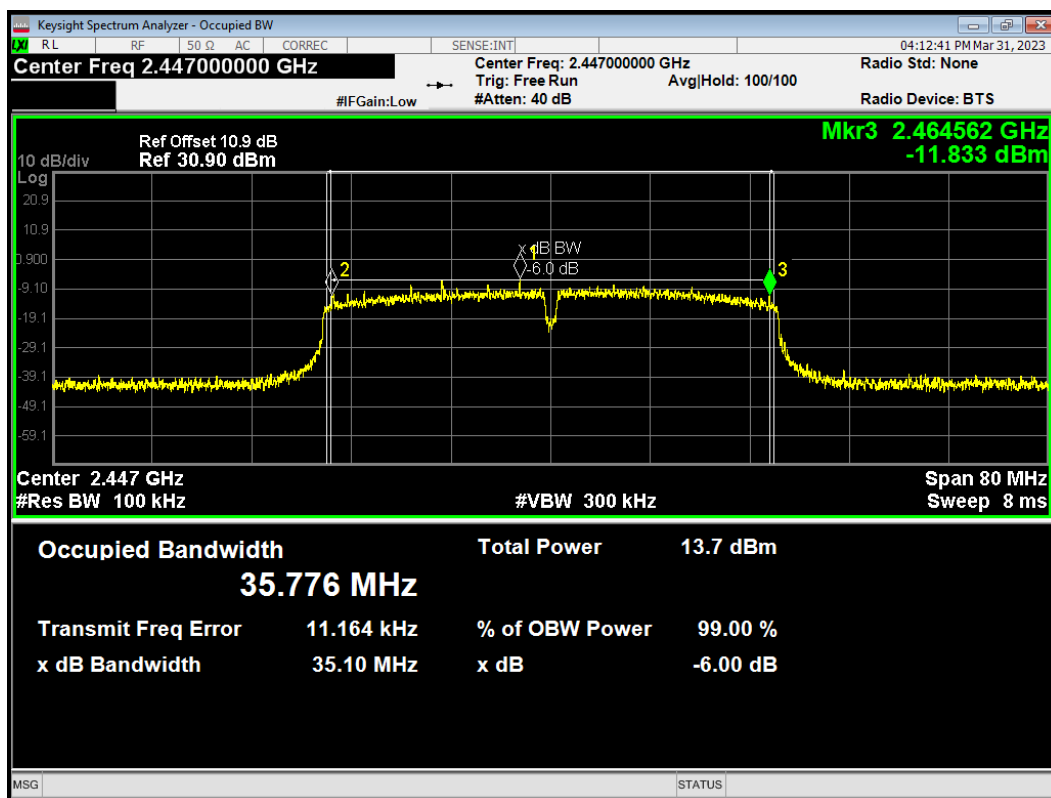
-6dB Bandwidth 802.11n(HT40) 2437MHz



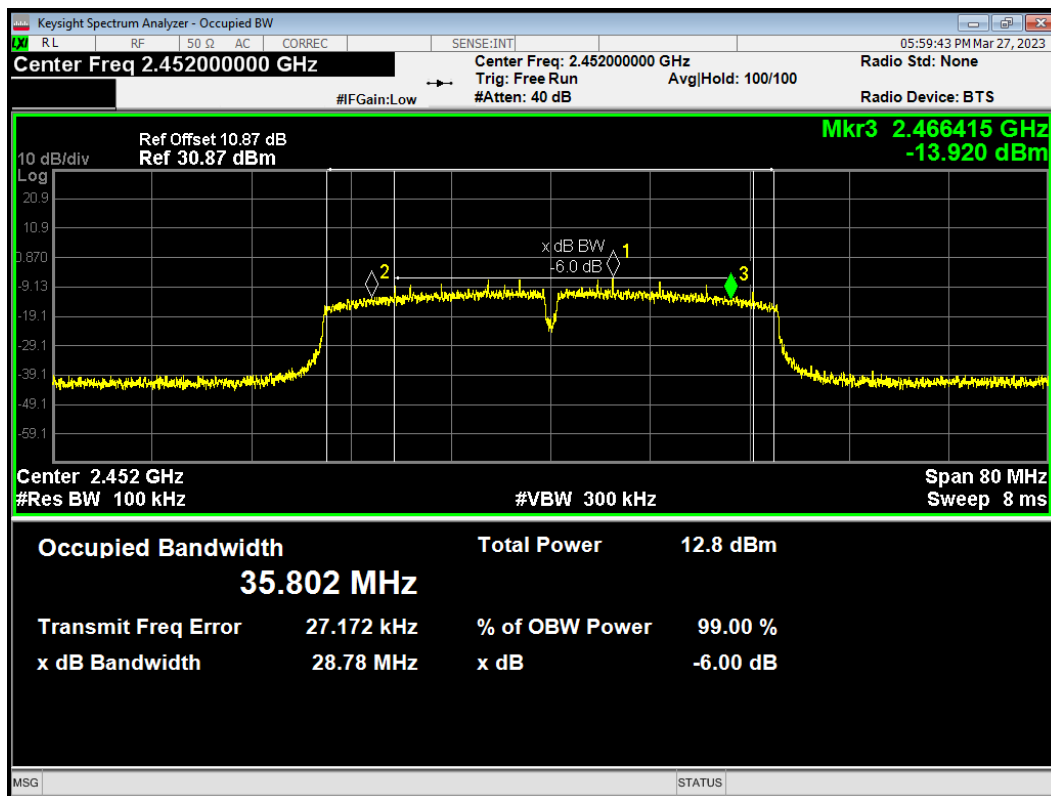
-6dB Bandwidth 802.11n(HT40) 2442MHz



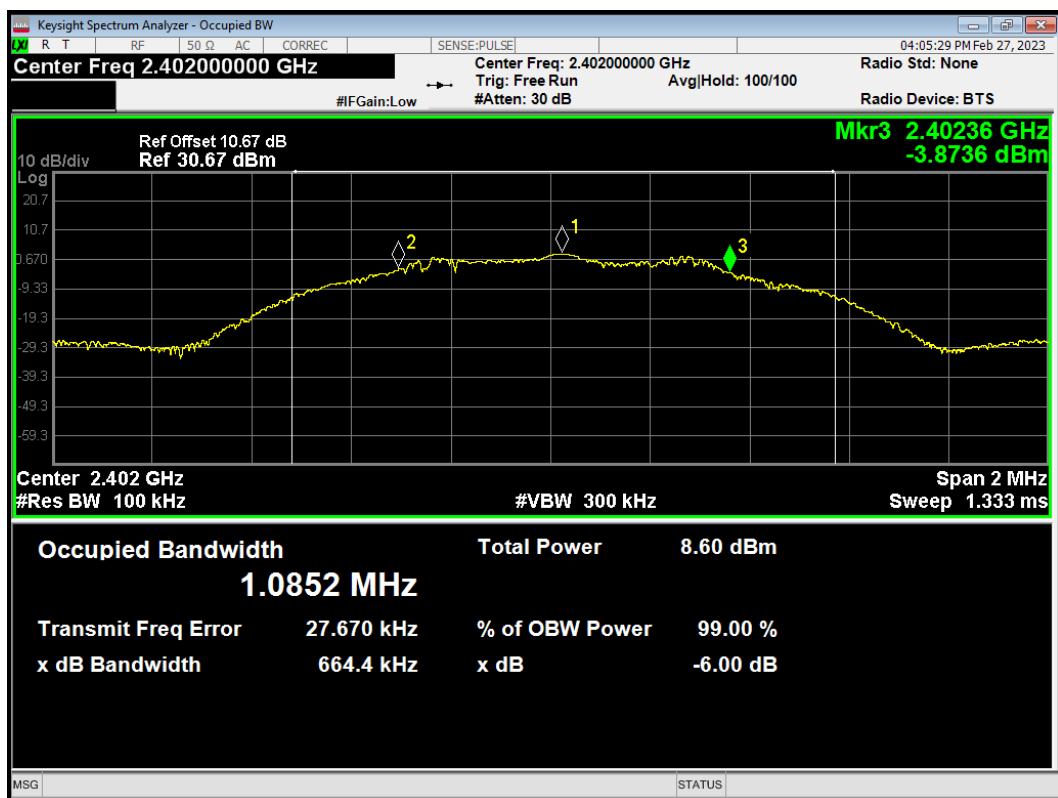
-6dB Bandwidth 802.11n(HT40) 2447MHz



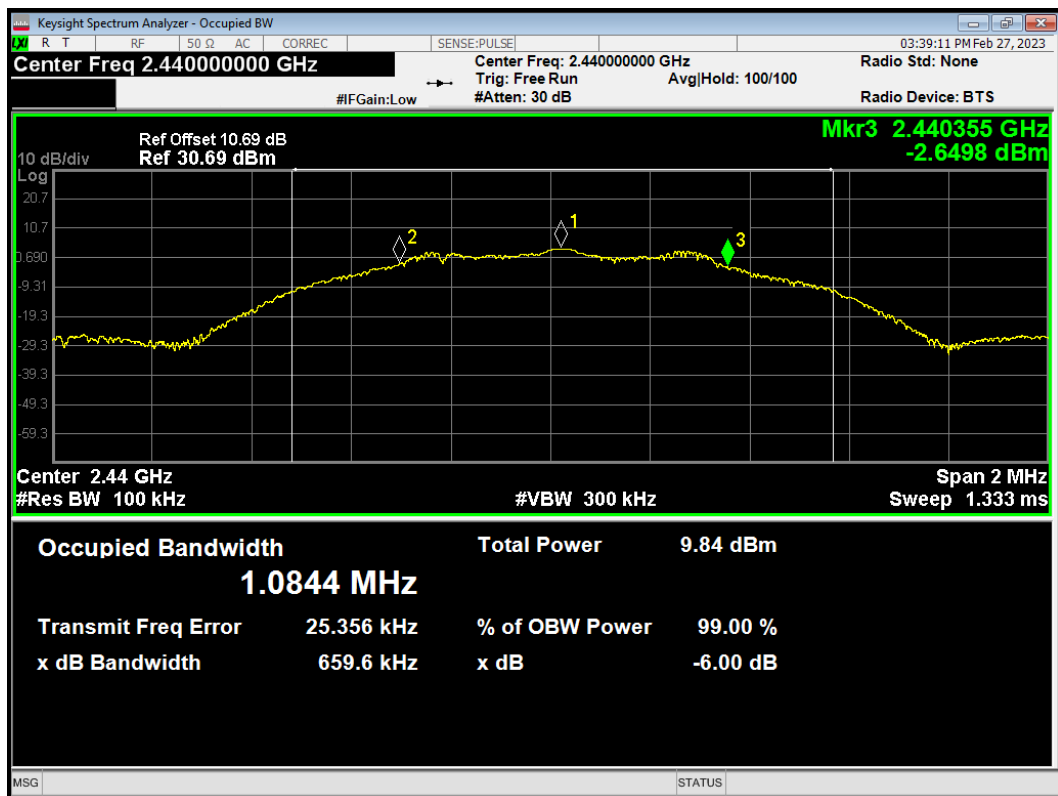
-6dB Bandwidth 802.11n(HT40) 2452MHz



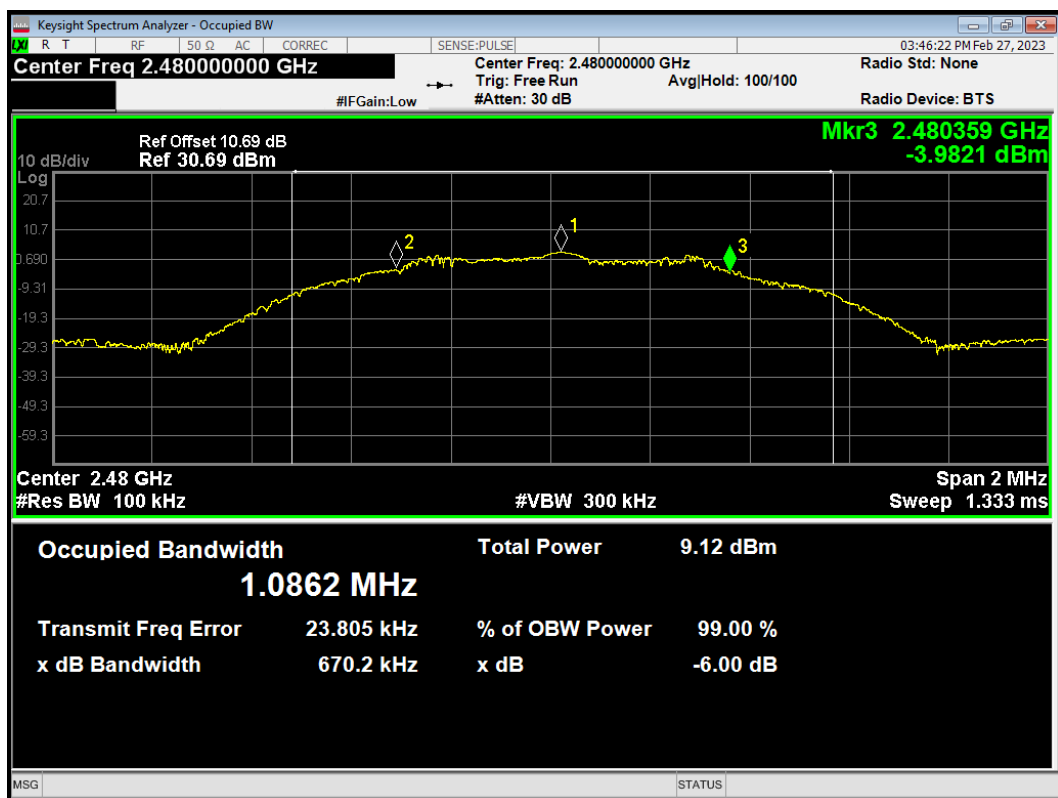
-6dB Bandwidth Bluetooth LE 2402MHz



-6dB Bandwidth Bluetooth LE 2440MHz



-6dB Bandwidth Bluetooth LE 2480MHz



5.3. Band Edge

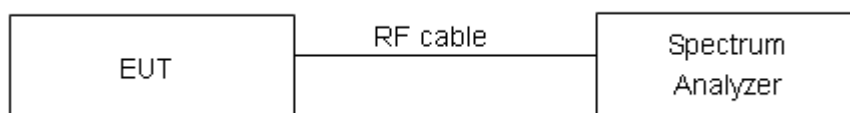
Ambient Condition

| Temperature | Relative humidity | Pressure |
|-------------|-------------------|----------|
| 23°C ~25°C | 45%~50% | 101.5kPa |

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.”

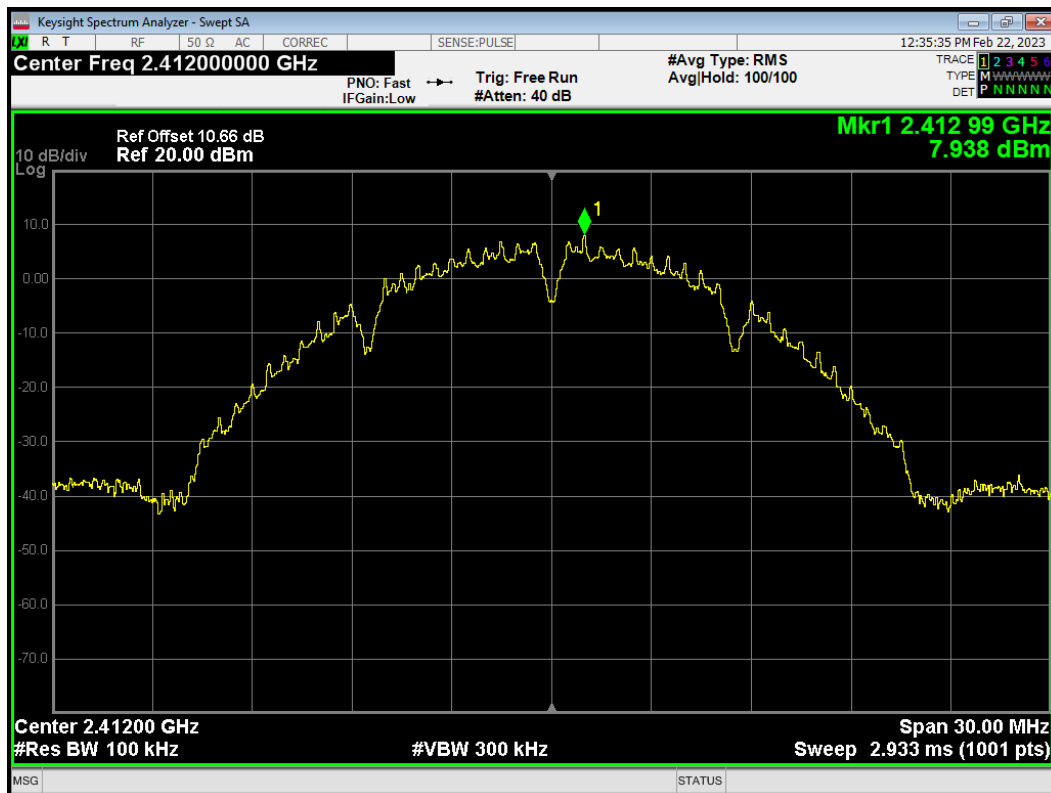
Measurement Uncertainty

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

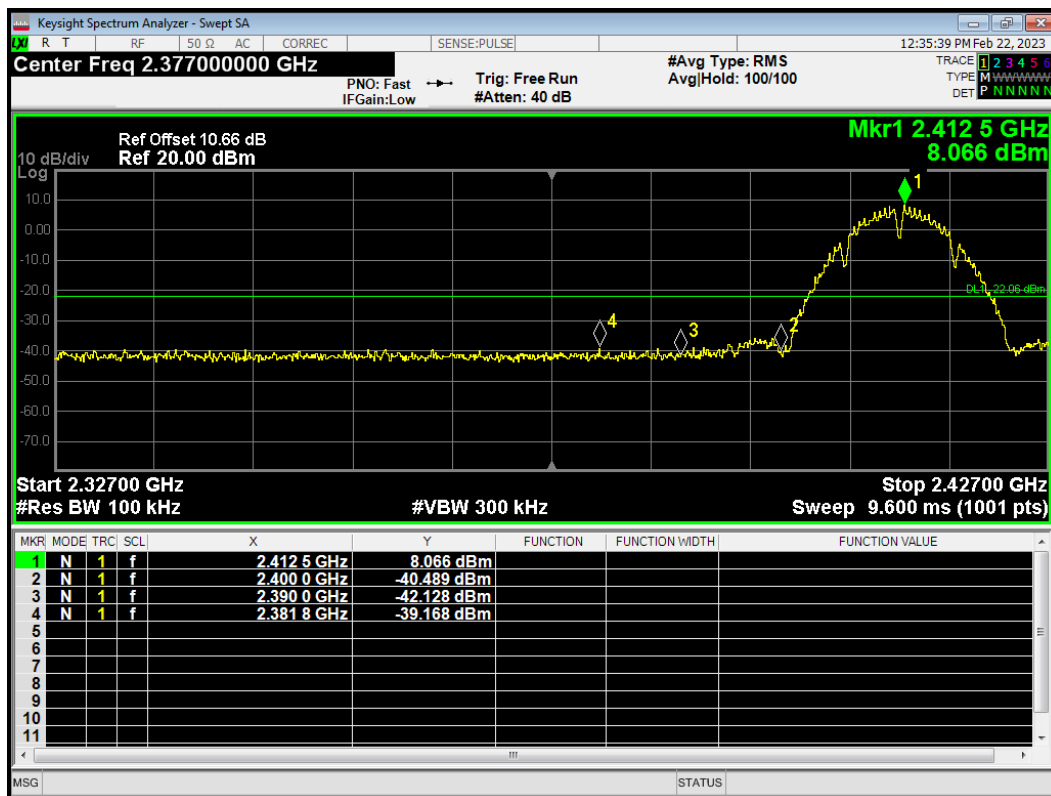
| Frequency | Uncertainty |
|-----------|-------------|
| 2GHz-3GHz | 1.407 dB |

Test Results: PASS

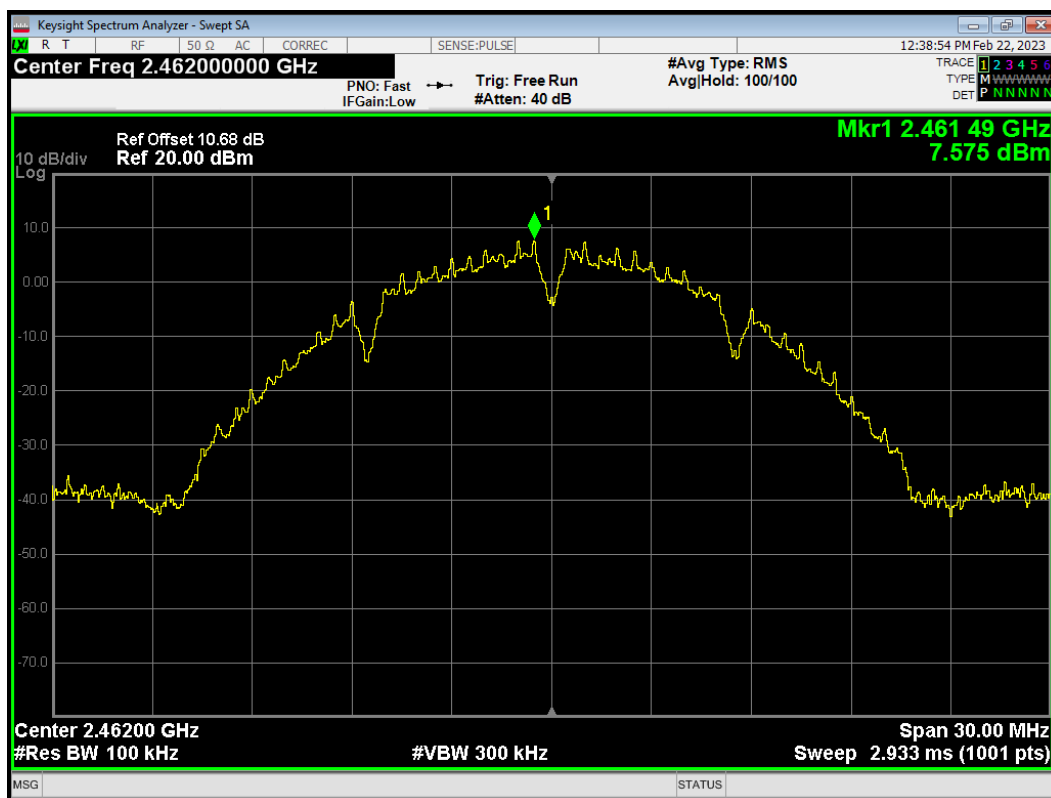
Band Edge 802.11b 2412MHz Ref



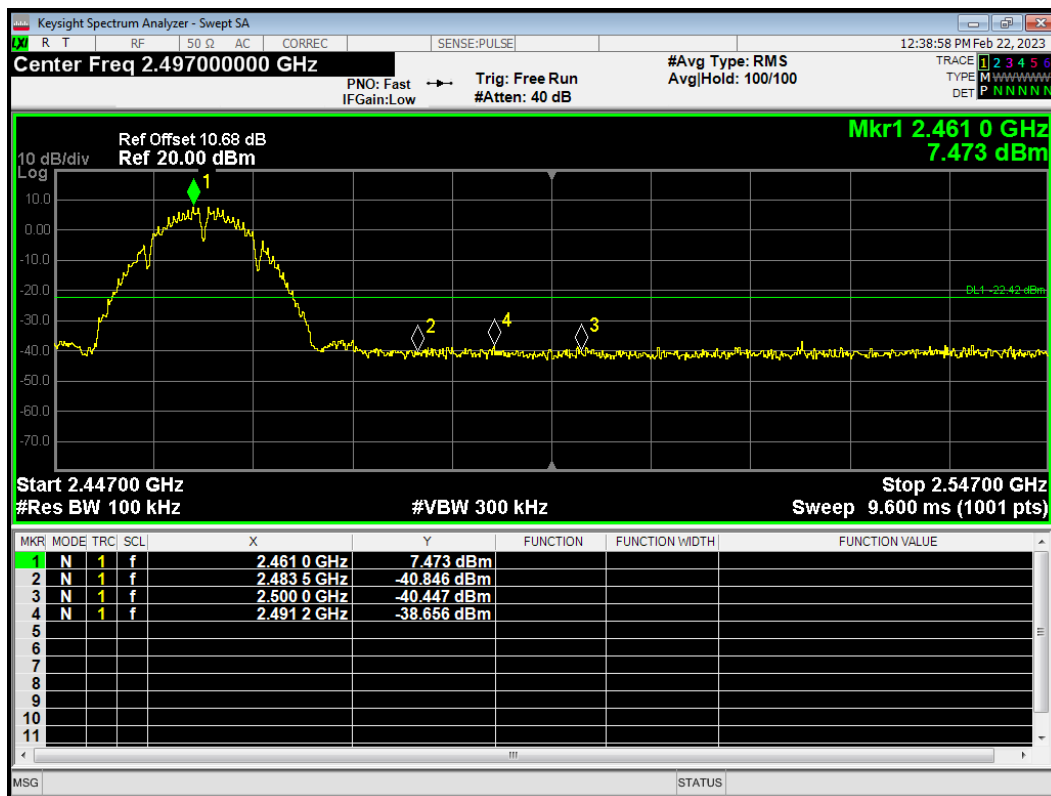
Band Edge 802.11b 2412MHz Emission



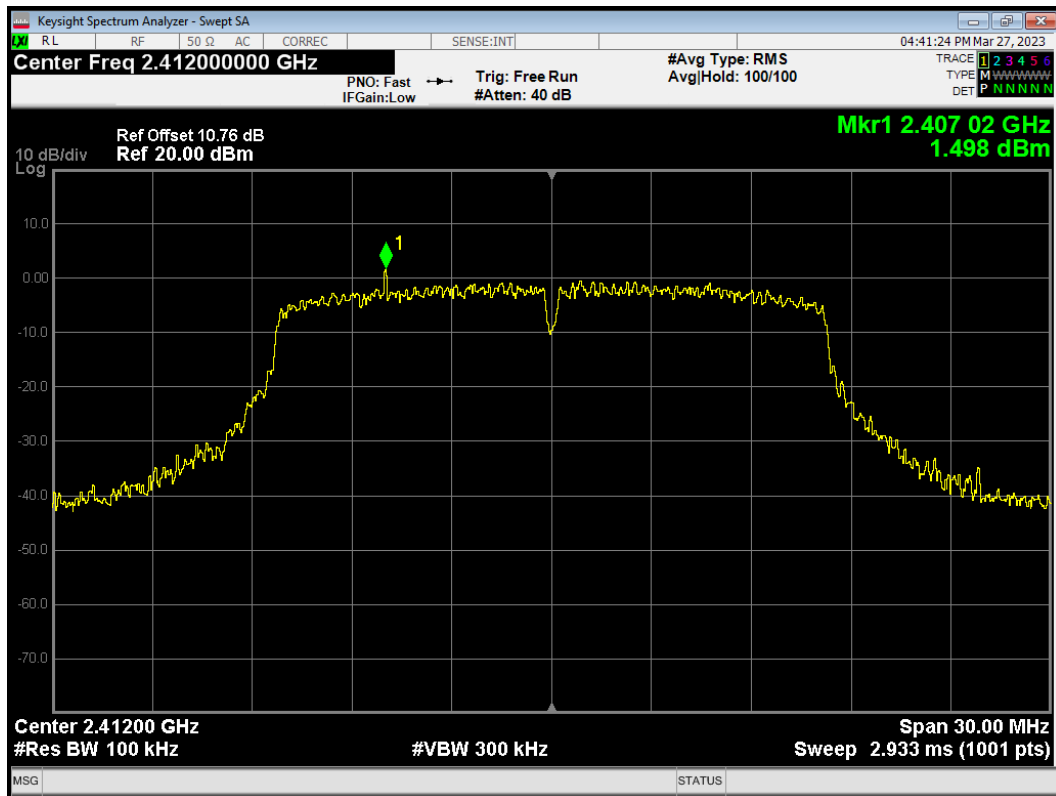
Band Edge 802.11b 2462MHz Ref



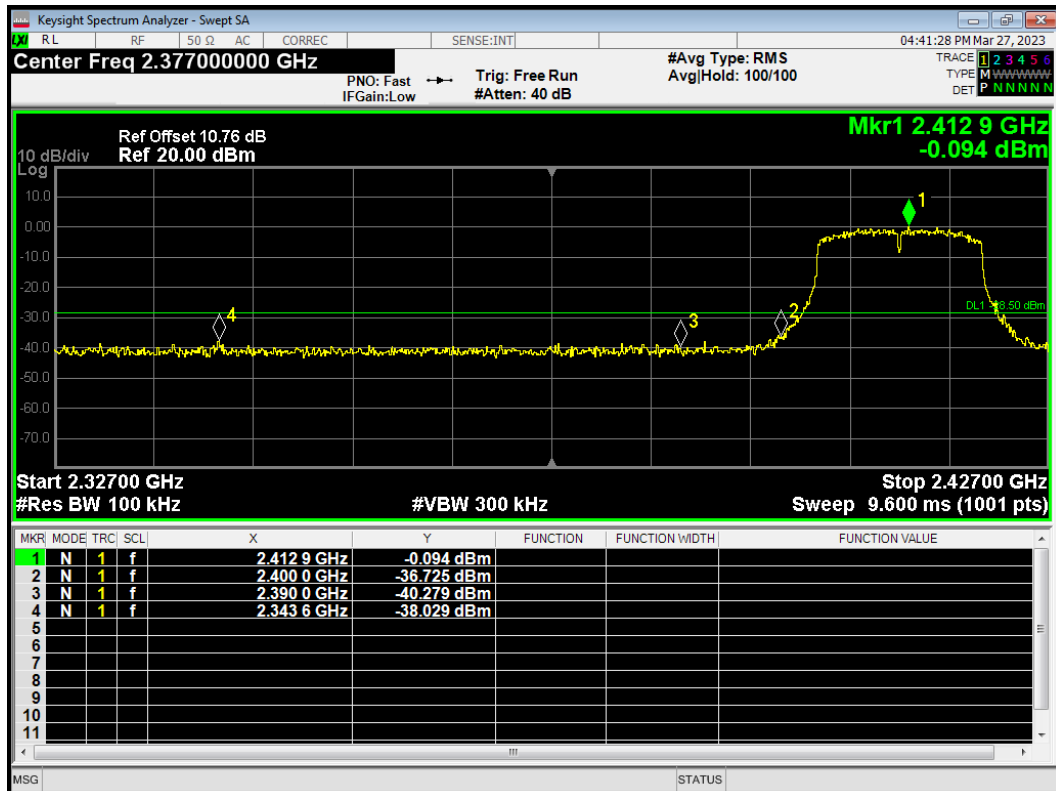
Band Edge 802.11b 2462MHz Emission



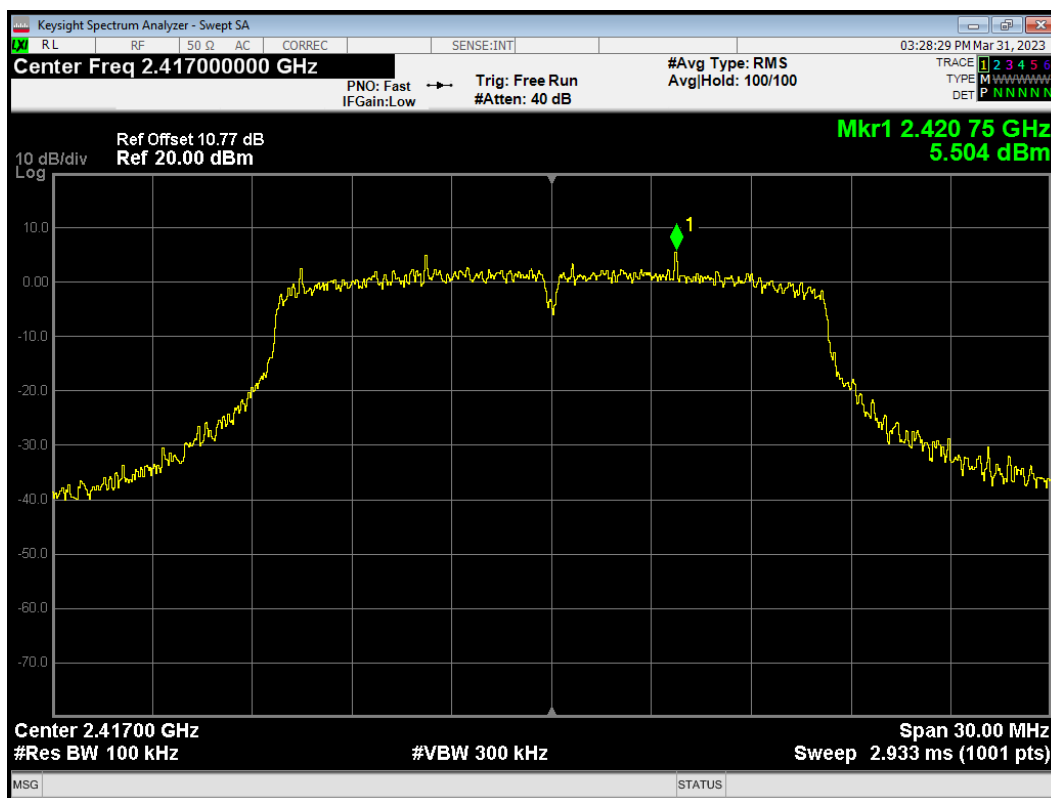
Band Edge 802.11g 2412MHz Ref



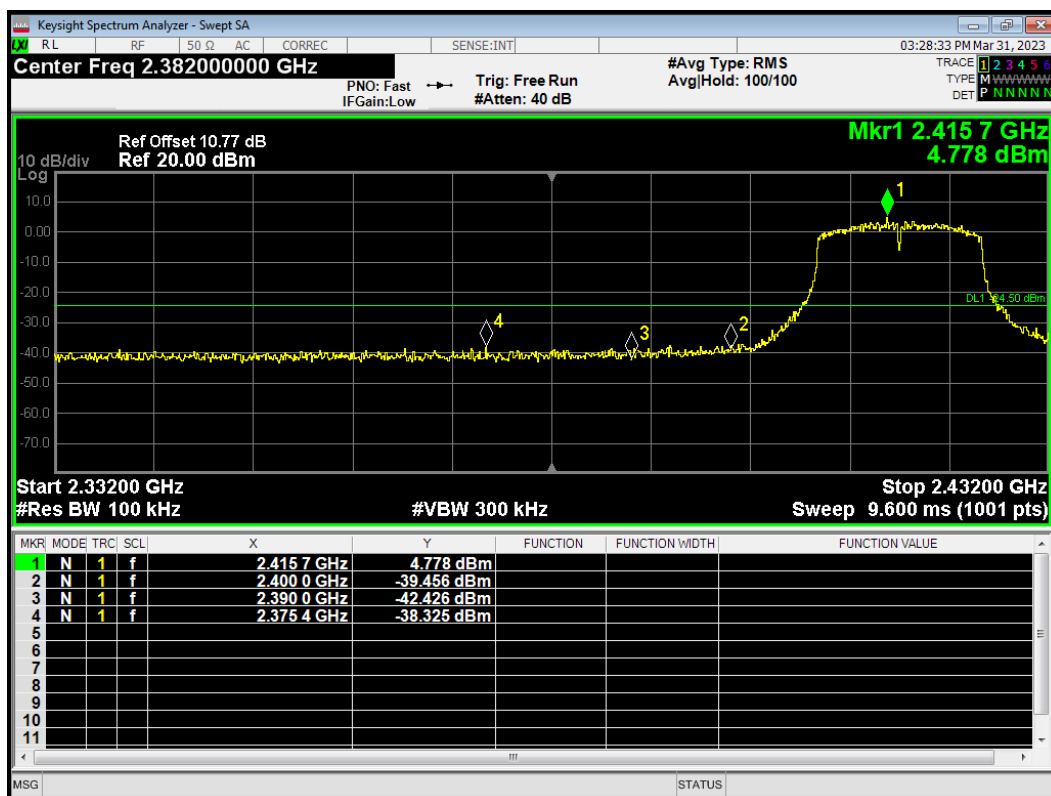
Band Edge 802.11g 2412MHz Emission



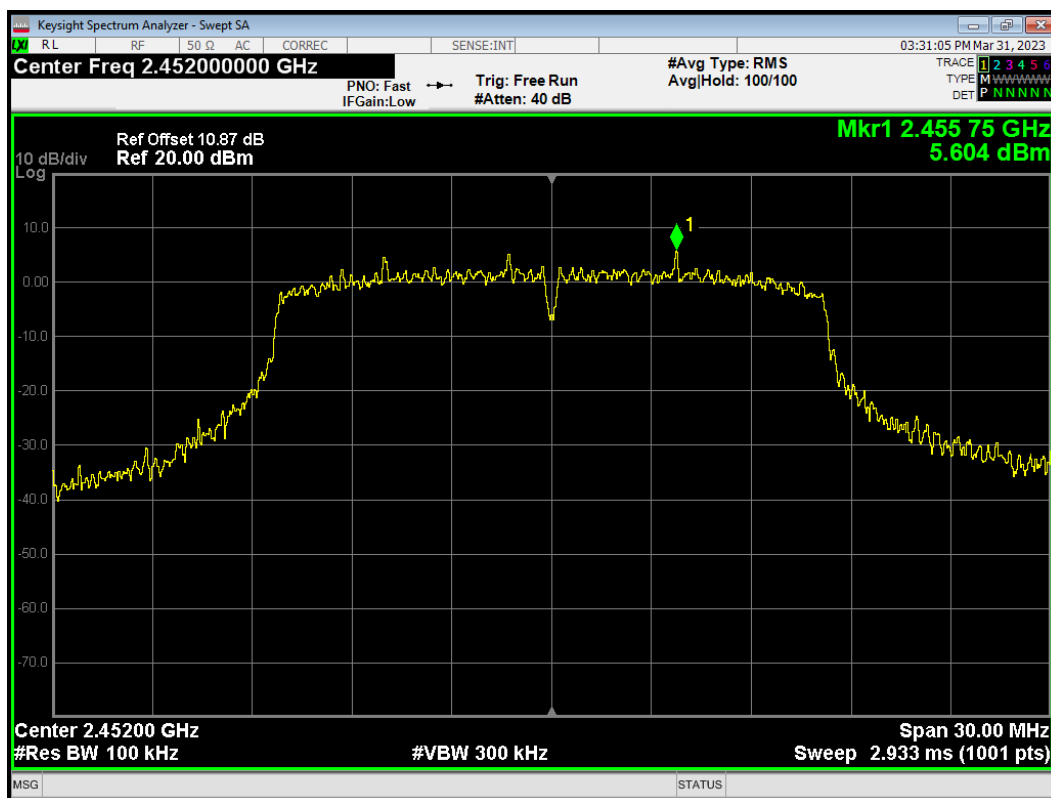
Band Edge 802.11g 2417MHz Ref



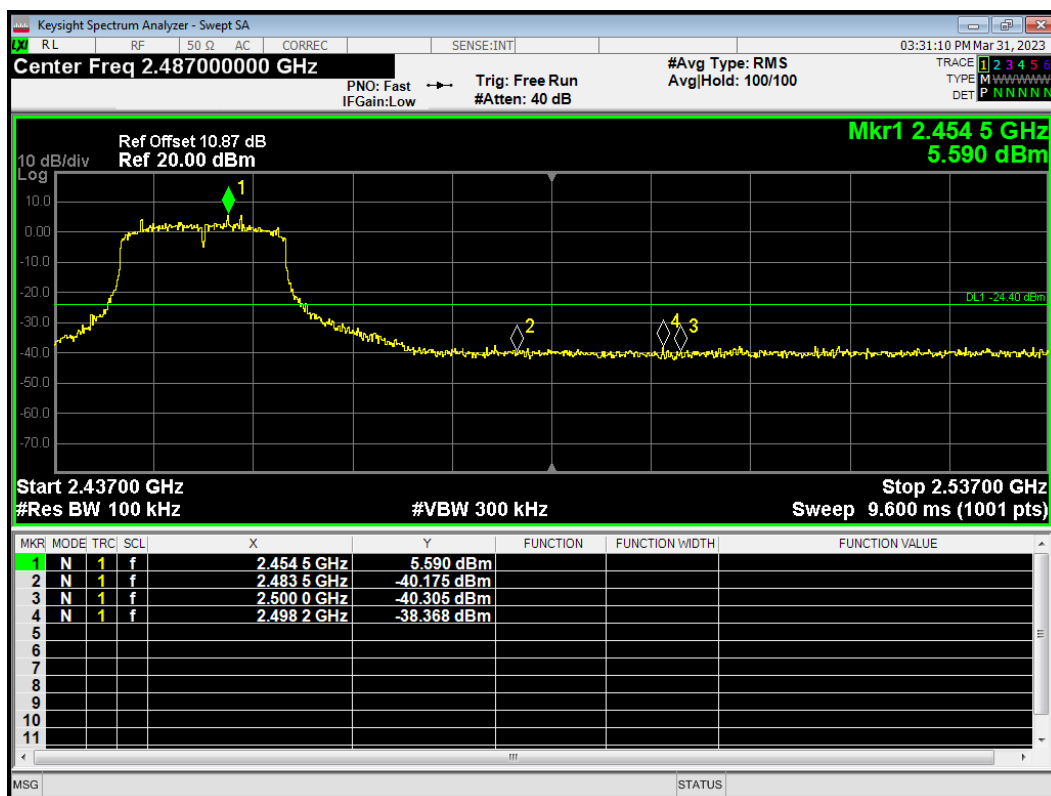
Band Edge 802.11g 2417MHz Emission



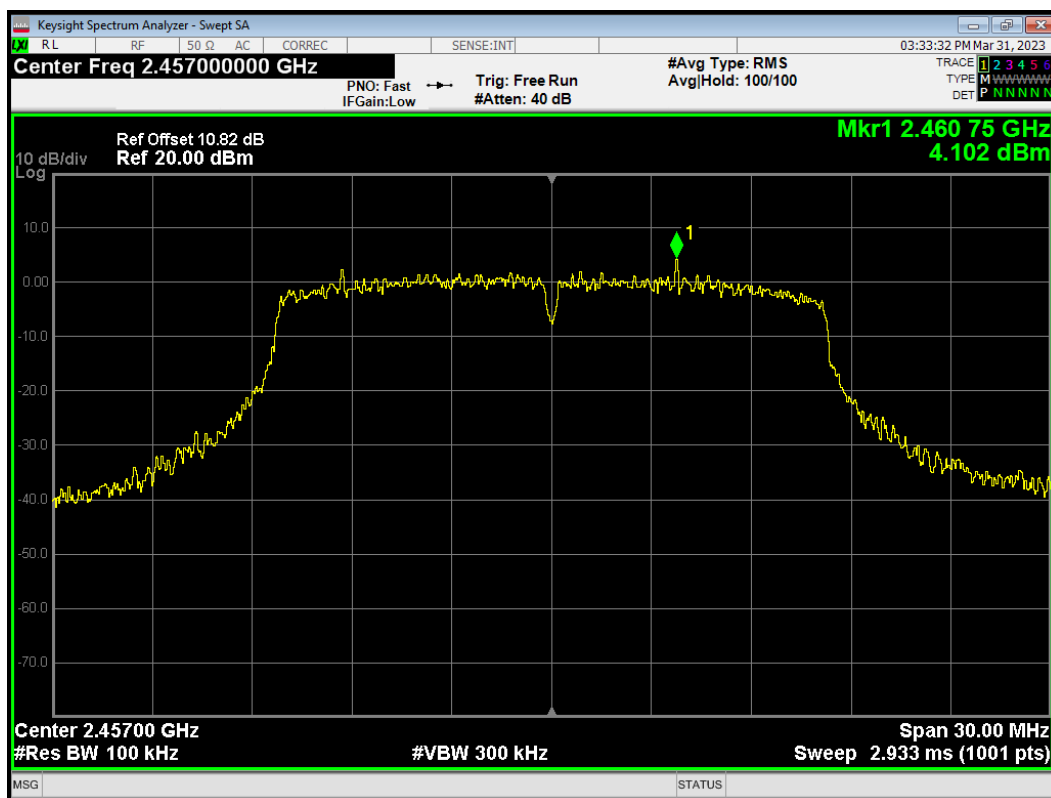
Band Edge 802.11g 2452MHz Ref



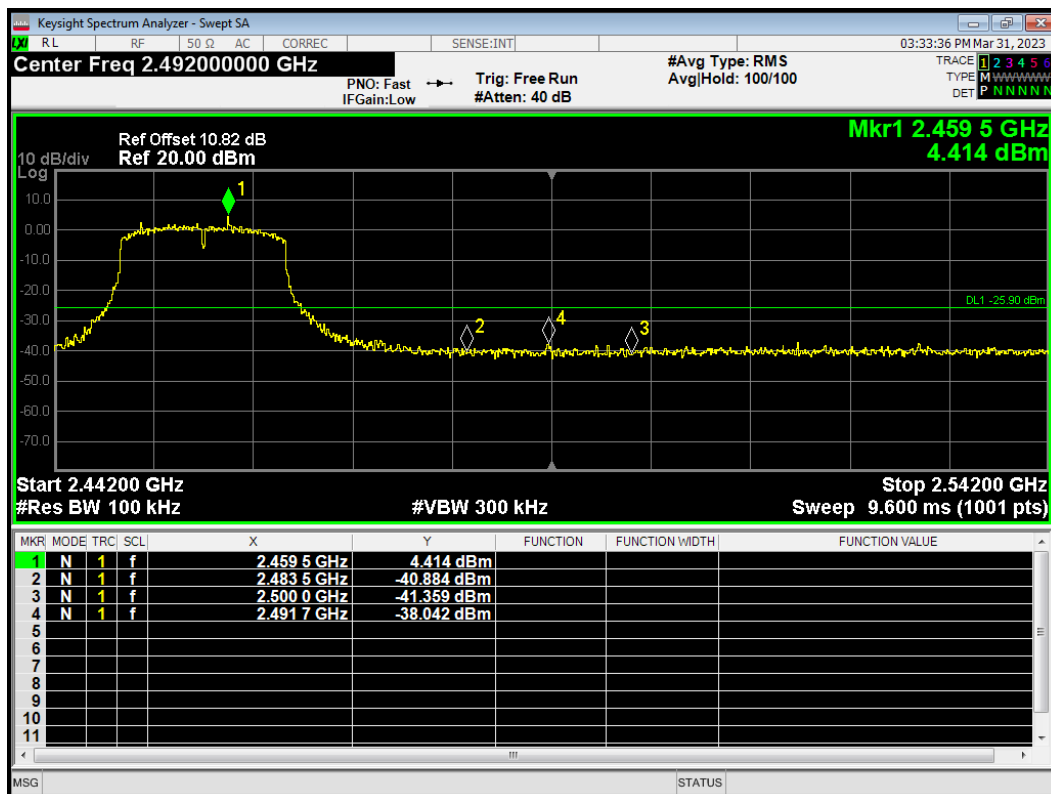
Band Edge 802.11g 2452MHz Emission



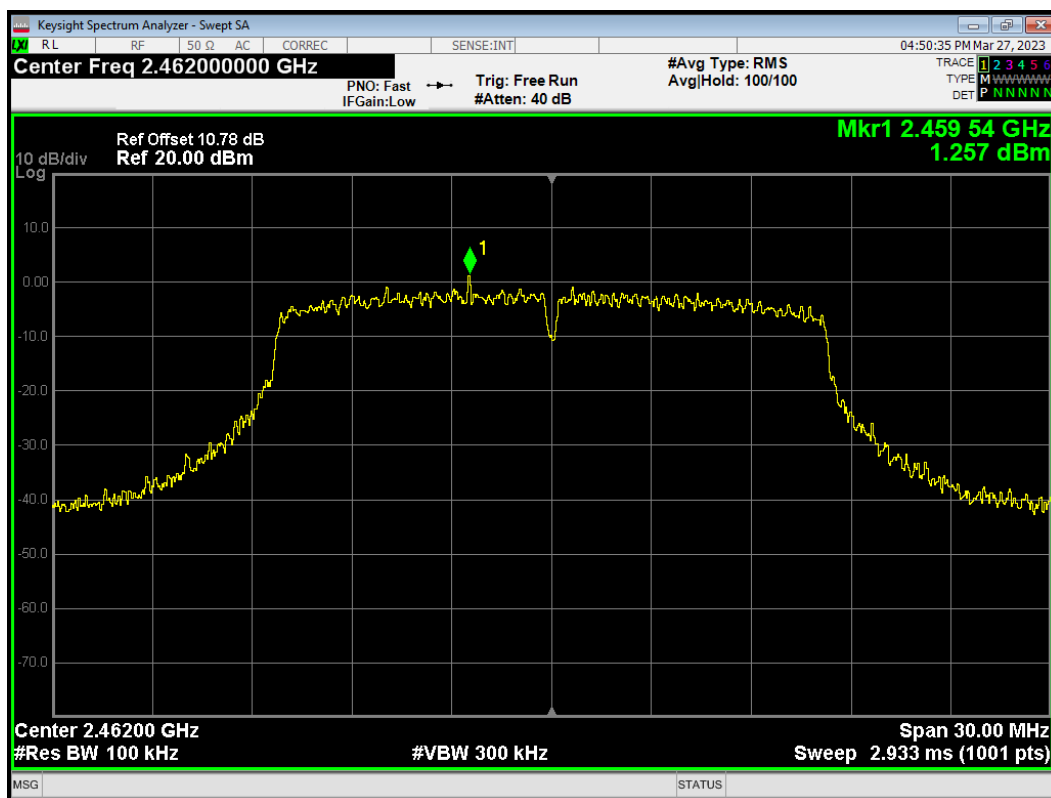
Band Edge 802.11g 2457MHz Ref



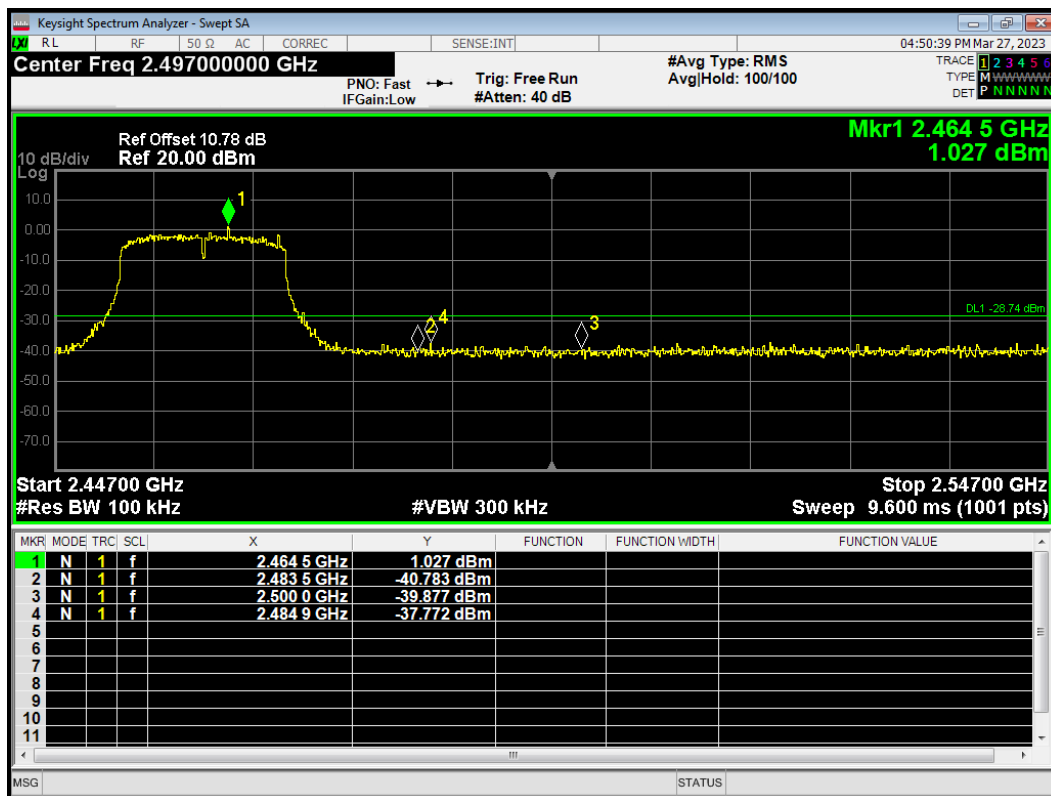
Band Edge 802.11g 2457MHz Emission



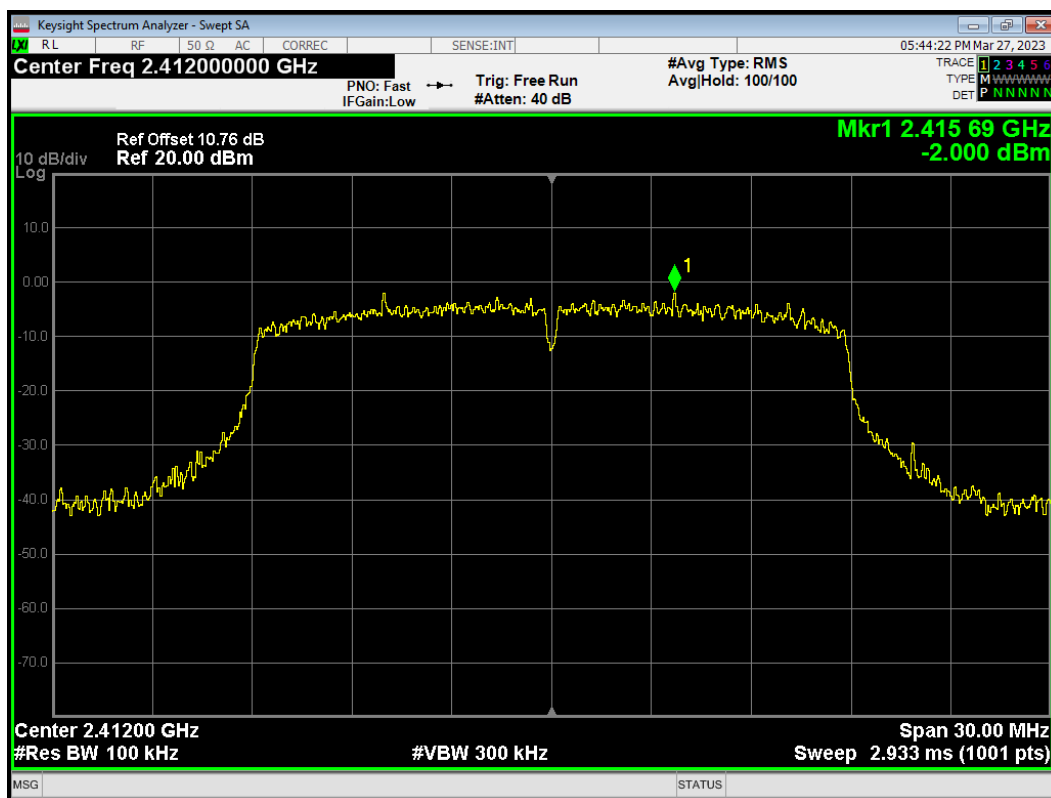
Band Edge 802.11g 2462MHz Ref



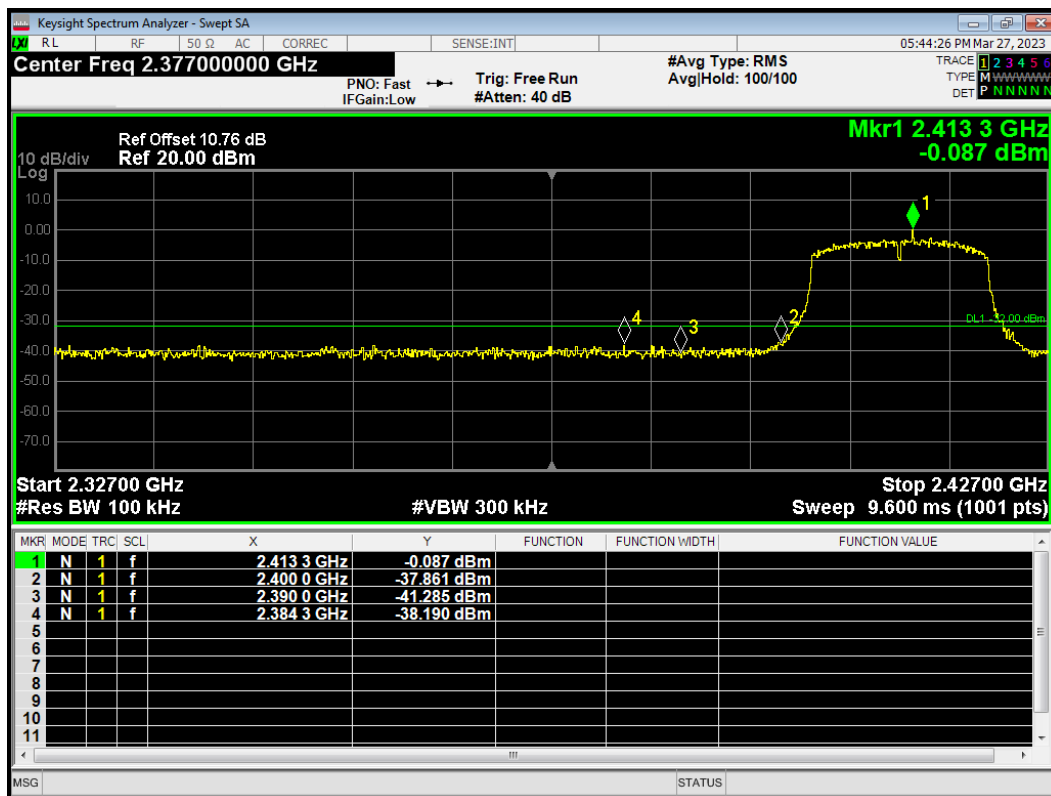
Band Edge 802.11g 2462MHz Emission



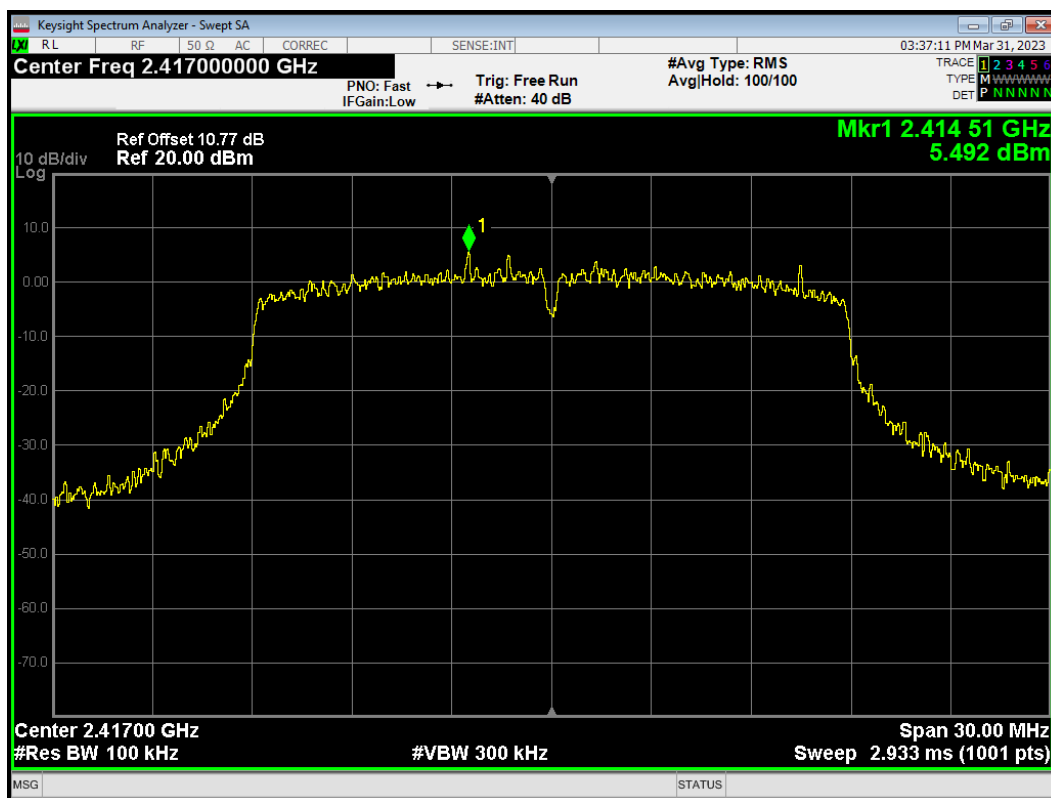
Band Edge 802.11n(HT20) 2412MHz Ref



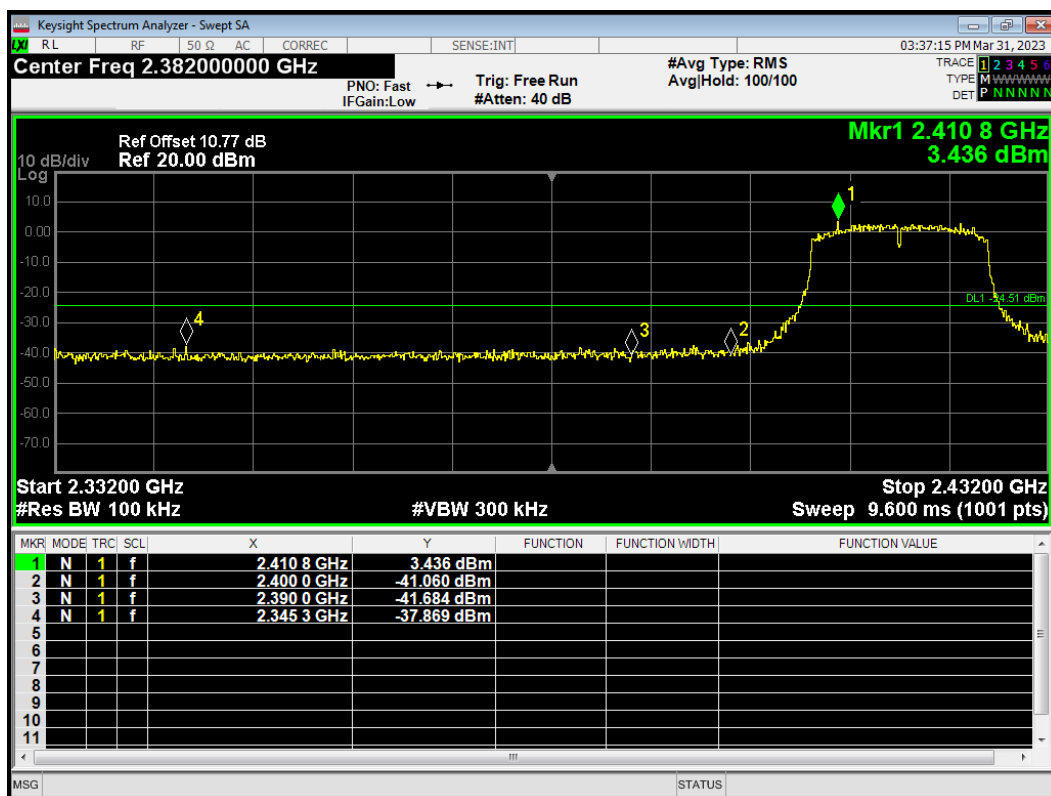
Band Edge 802.11n(HT20) 2412MHz Emission



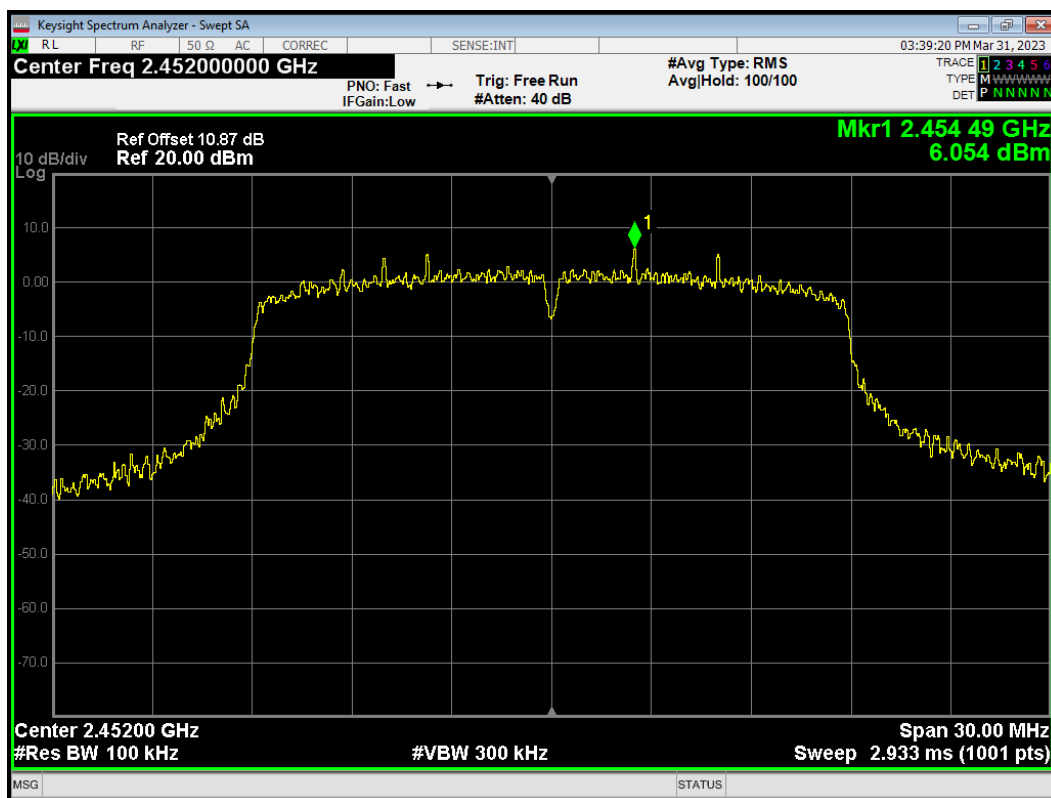
Band Edge 802.11n(HT20) 2417MHz Ref



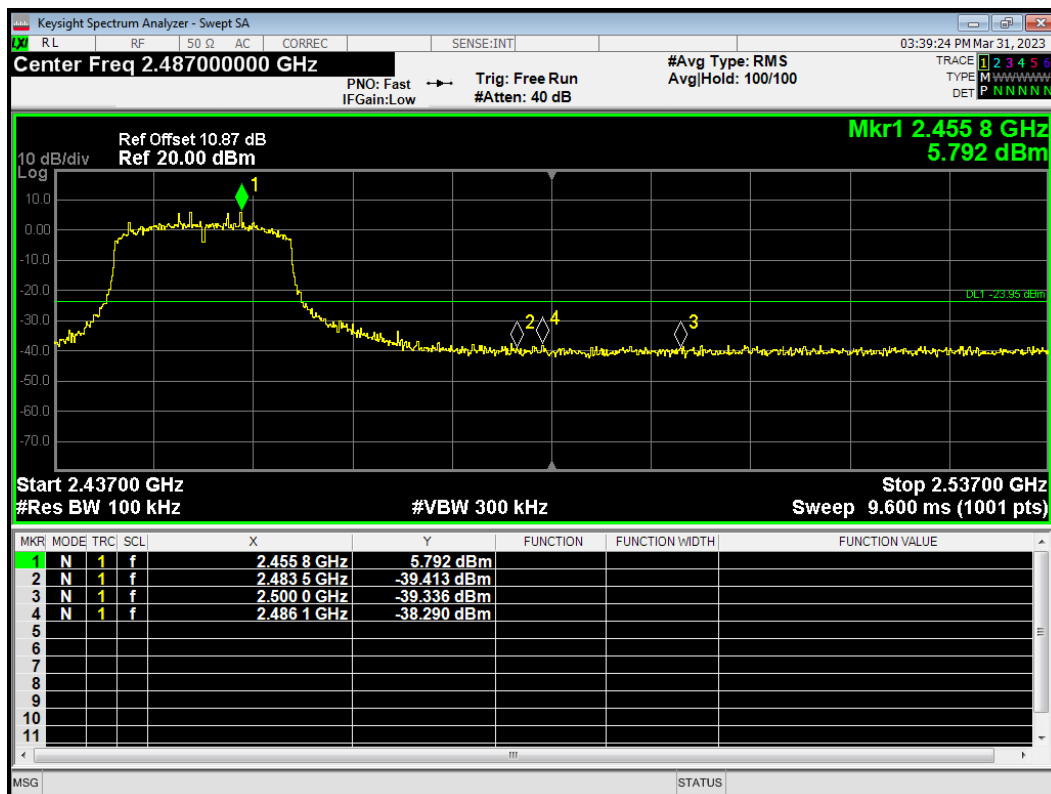
Band Edge 802.11n(HT20) 2417MHz Emission



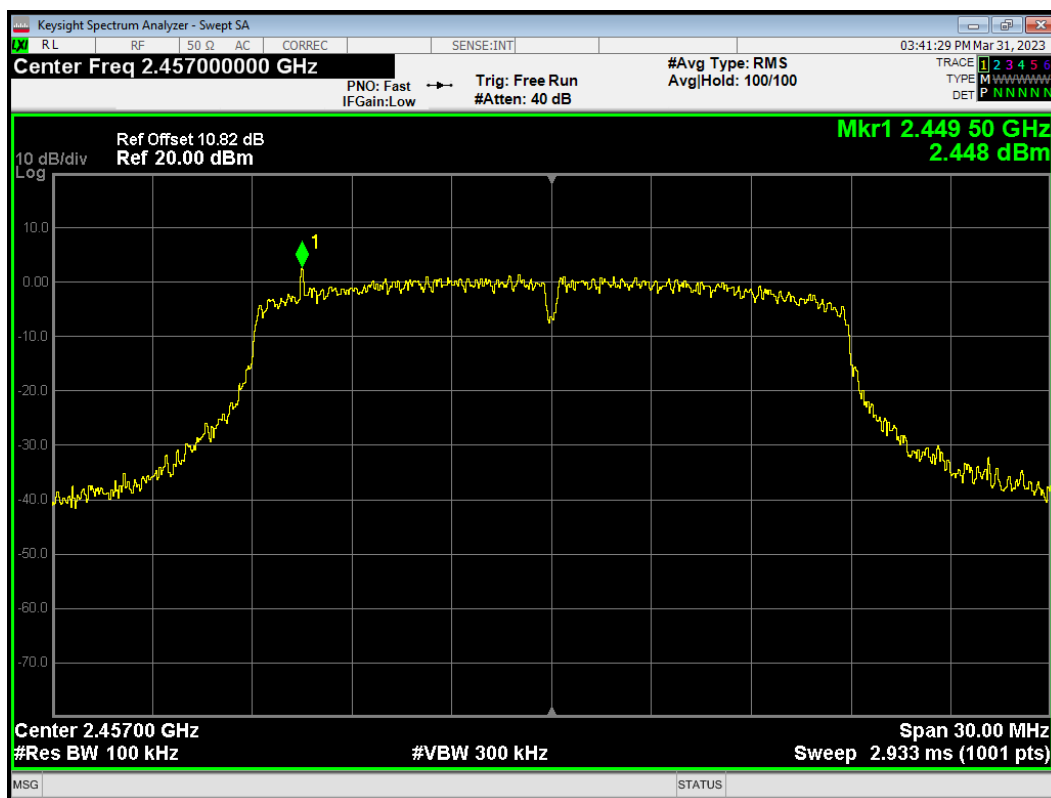
Band Edge 802.11n(HT20) 2452MHz Ref



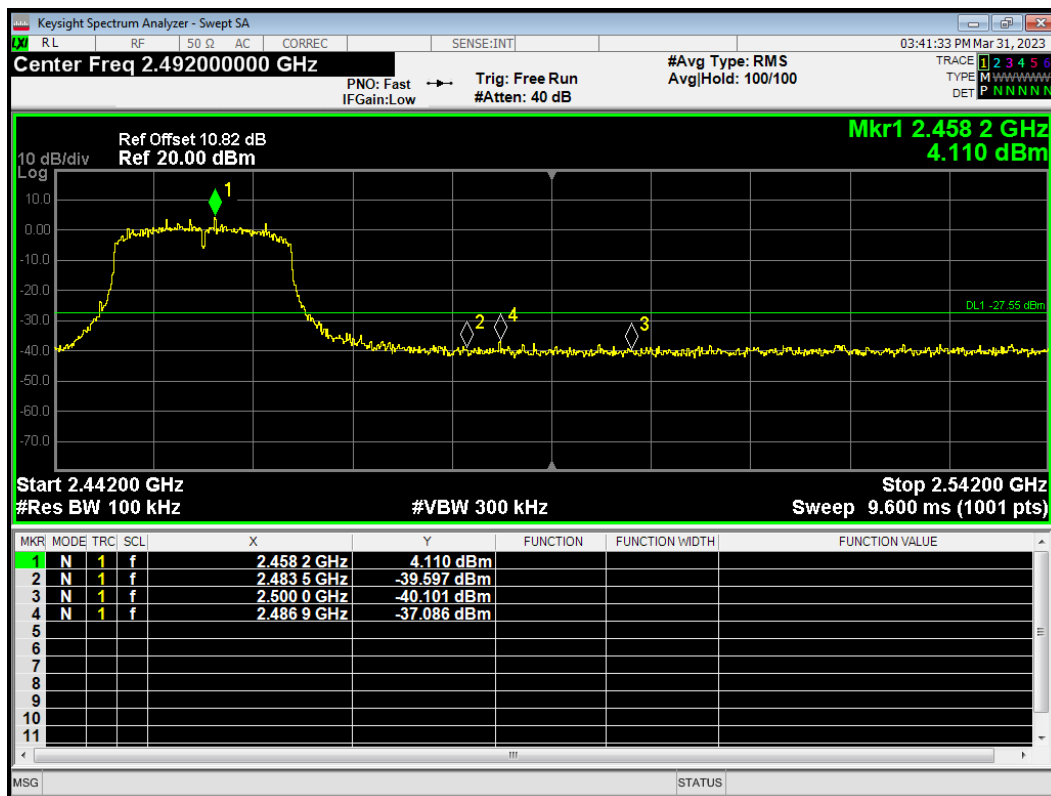
Band Edge 802.11n(HT20) 2452MHz Emission



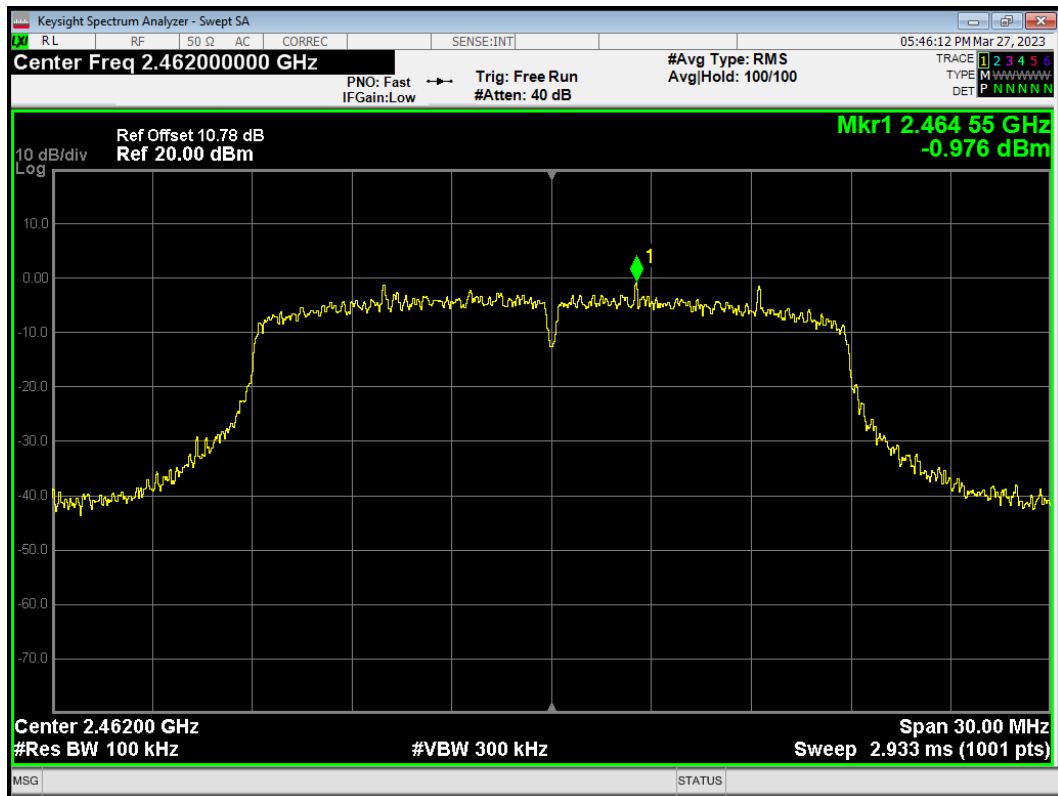
Band Edge 802.11n(HT20) 2457MHz Ref



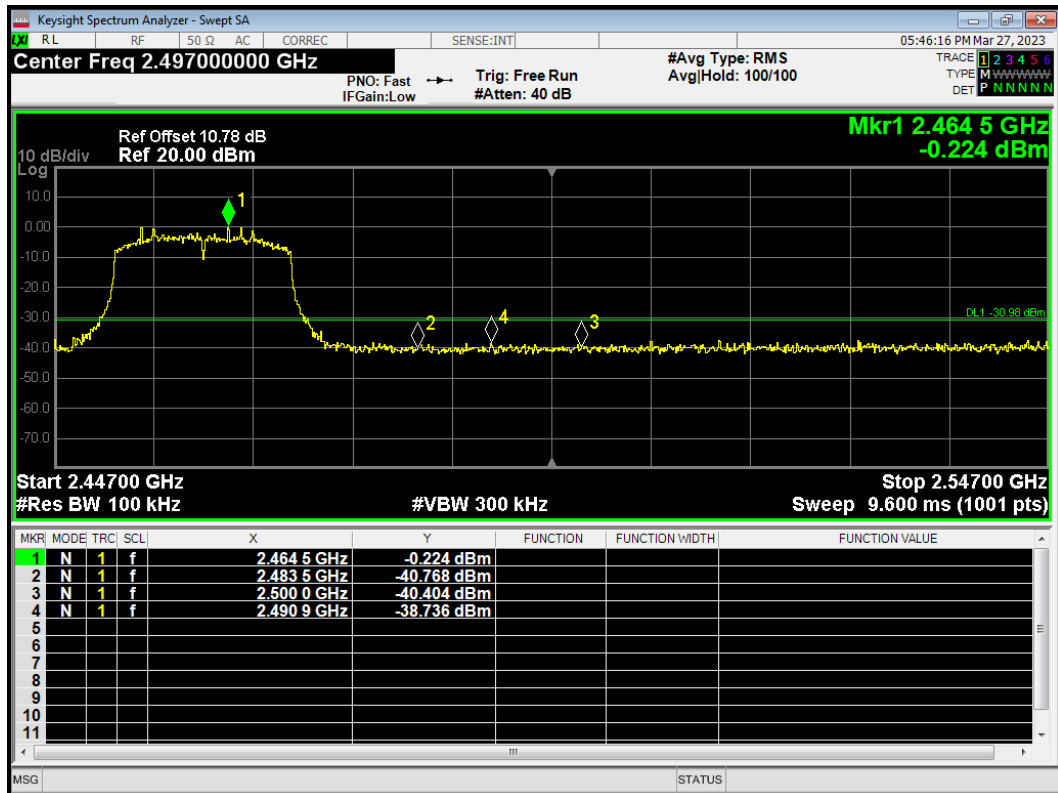
Band Edge 802.11n(HT20) 2457MHz Emission



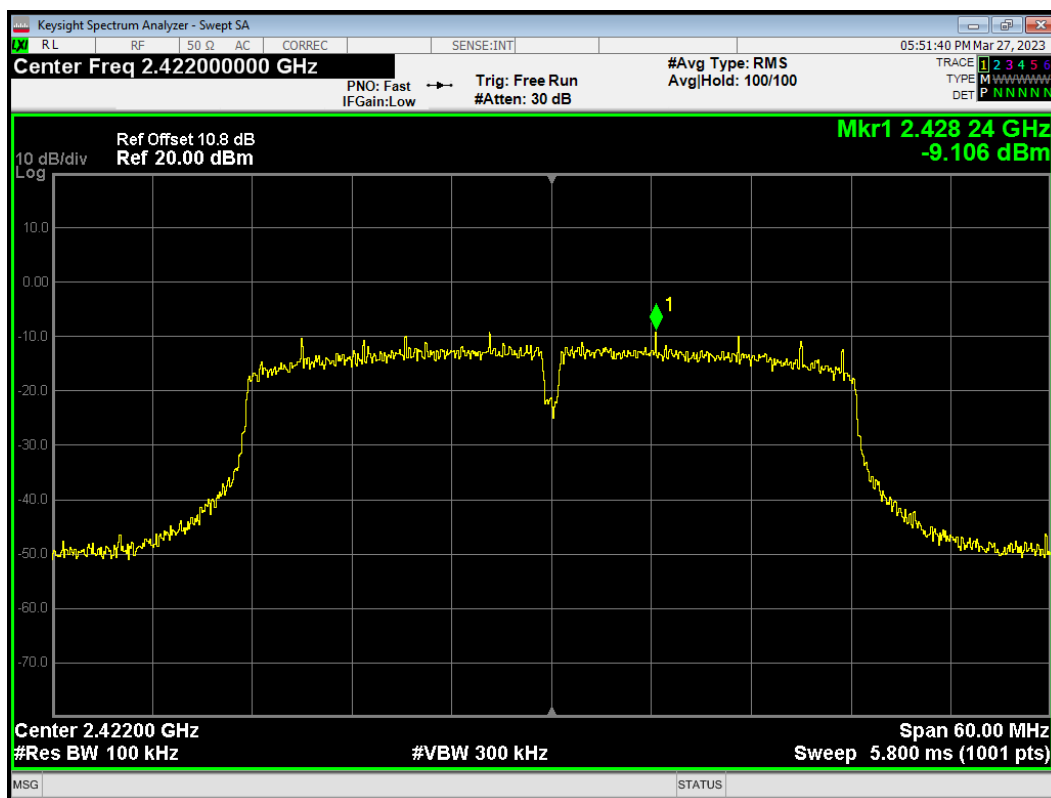
Band Edge 802.11n(HT20) 2462MHz Ref



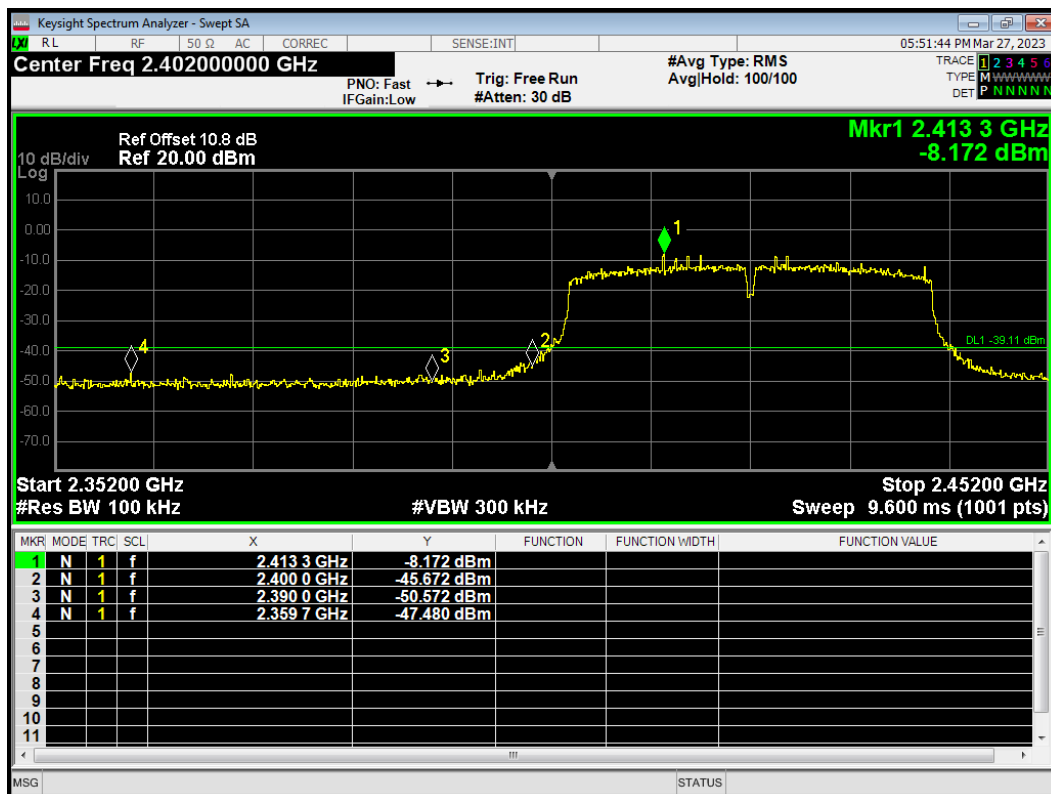
Band Edge 802.11n(HT20) 2462MHz Emission



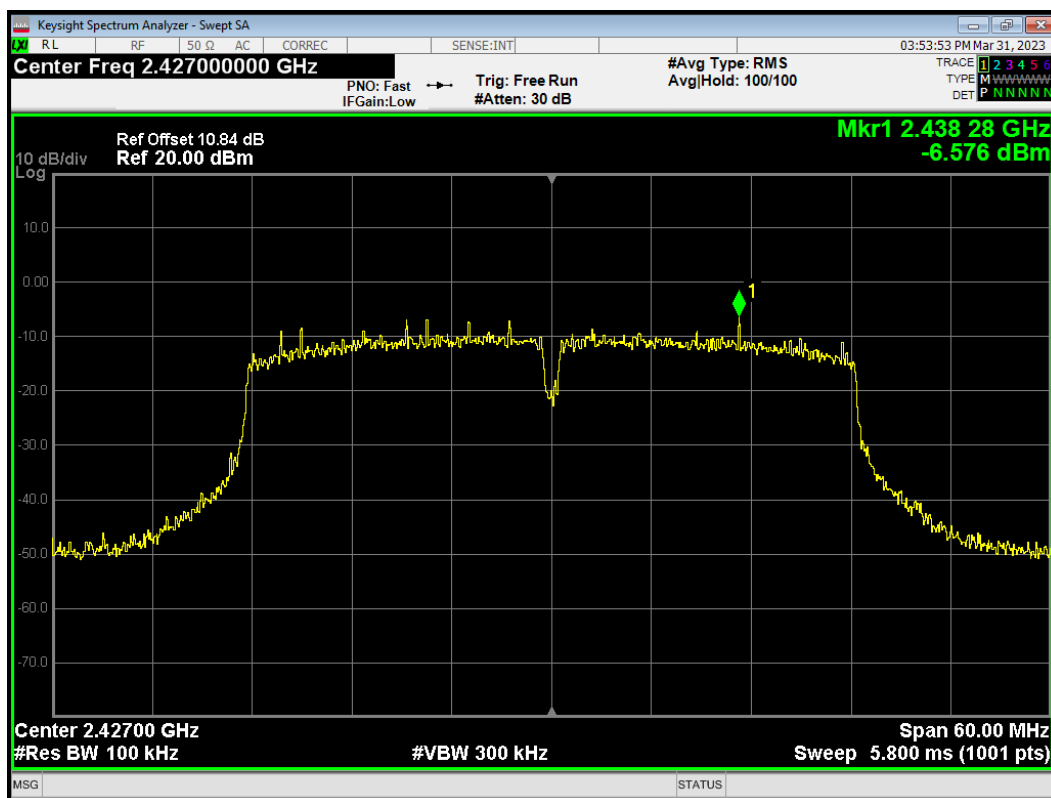
Band Edge 802.11n(HT40) 2422MHz Ref



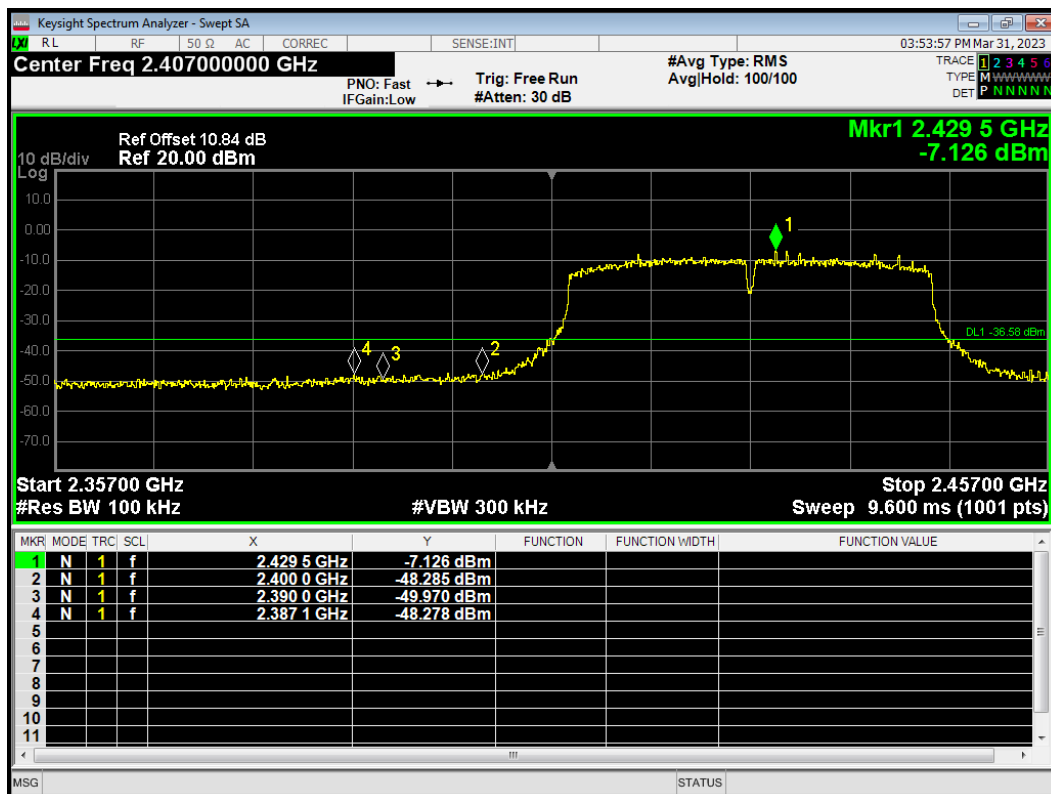
Band Edge 802.11n(HT40) 2422MHz Emission



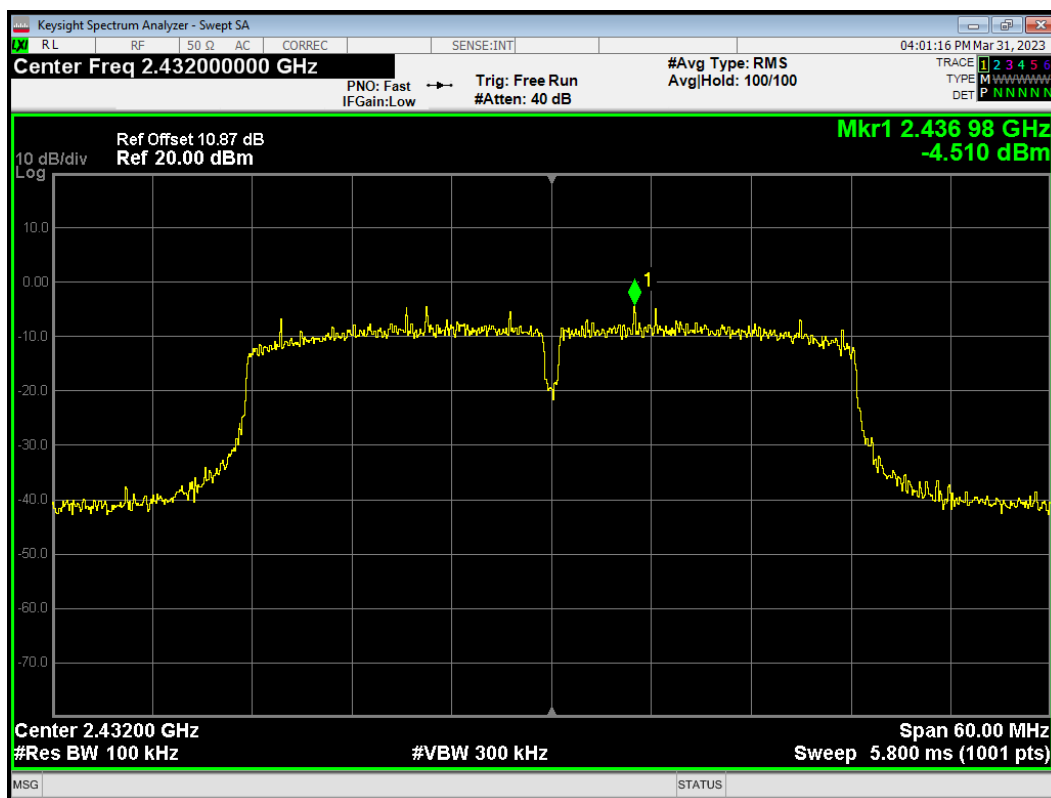
Band Edge 802.11n(HT40) 2427MHz Ref



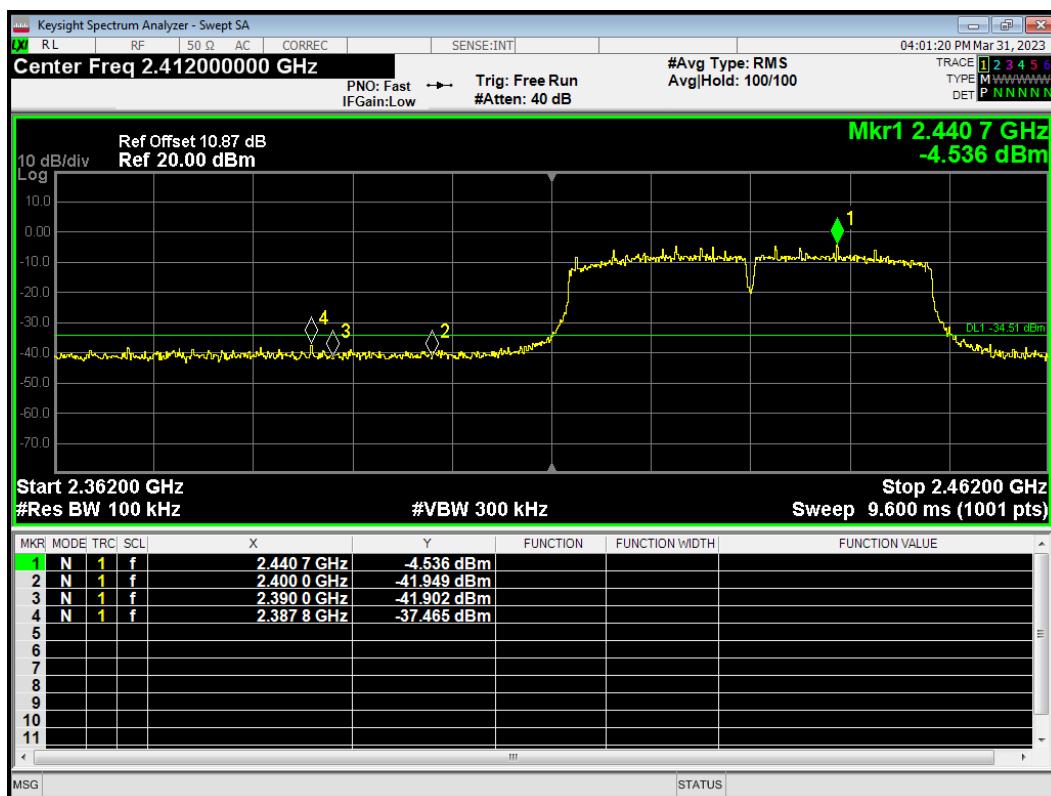
Band Edge 802.11n(HT40) 2427MHz Emission



Band Edge 802.11n(HT40) 2432MHz Ref



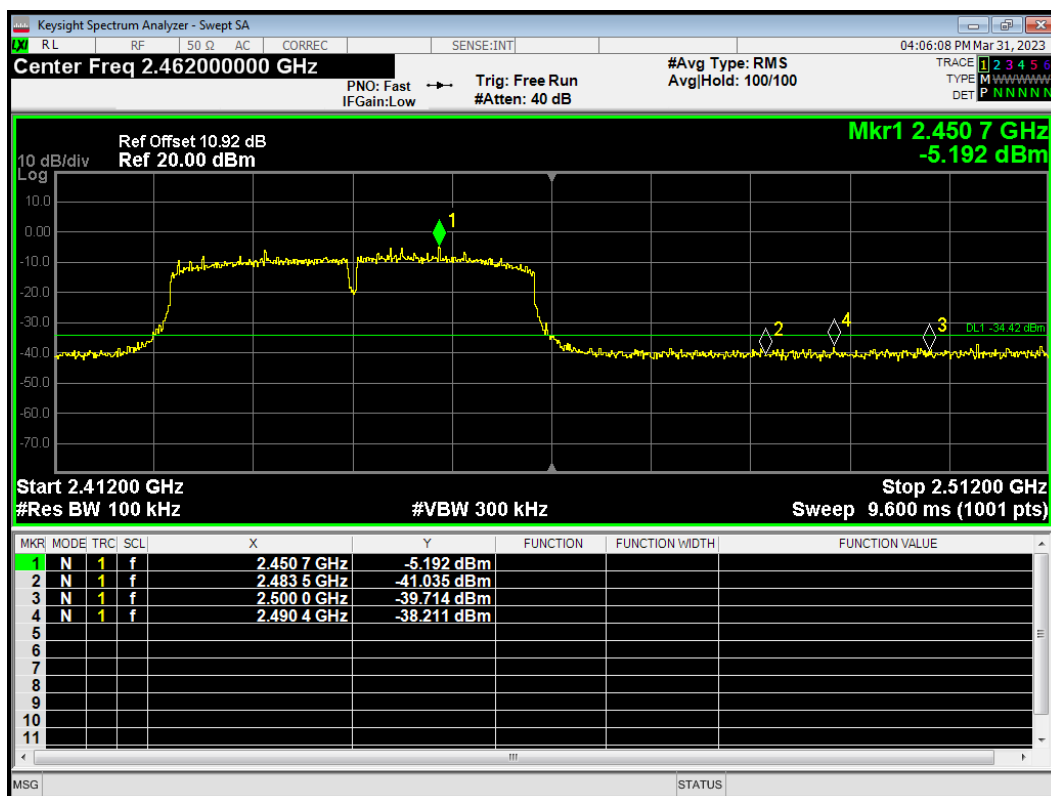
Band Edge 802.11n(HT40) 2432MHz Emission



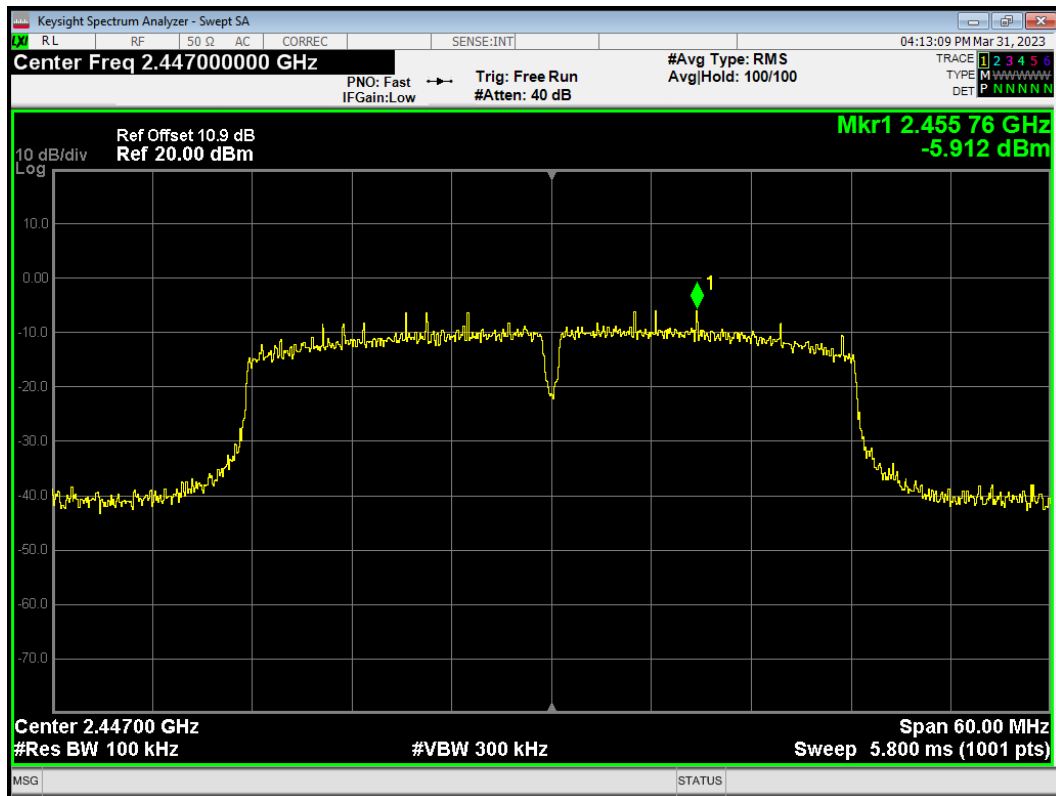
Band Edge 802.11n(HT40) 2442MHz Ref



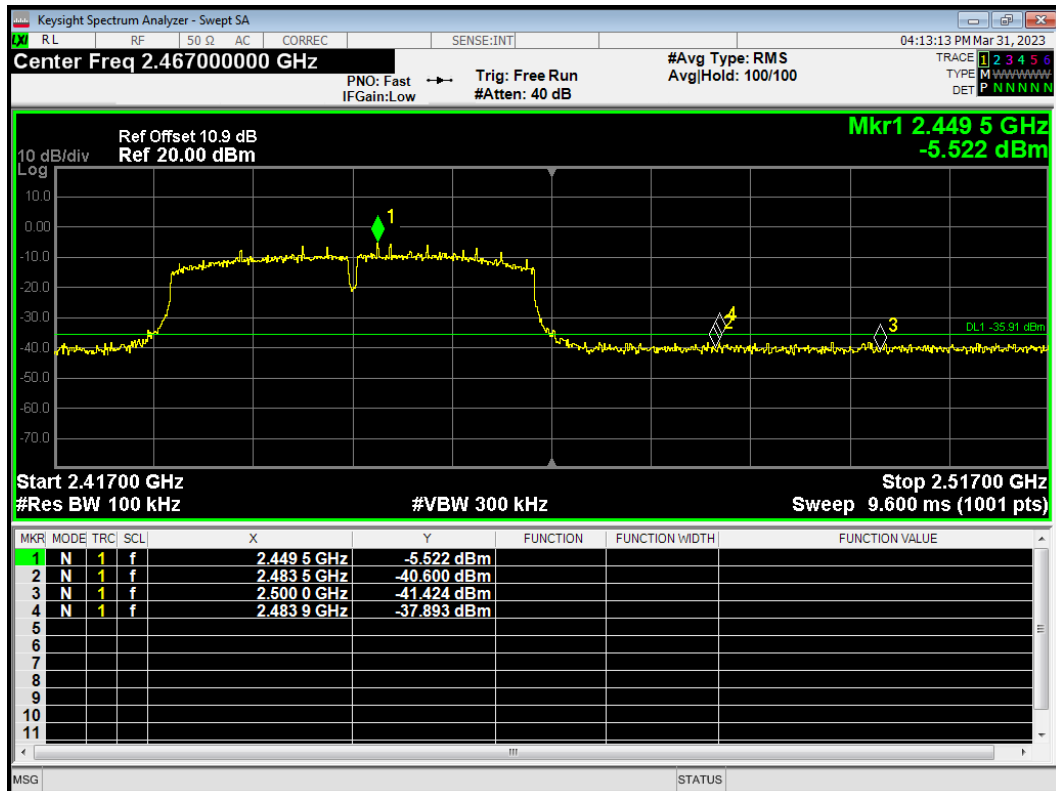
Band Edge 802.11n(HT40) 2442MHz Emission



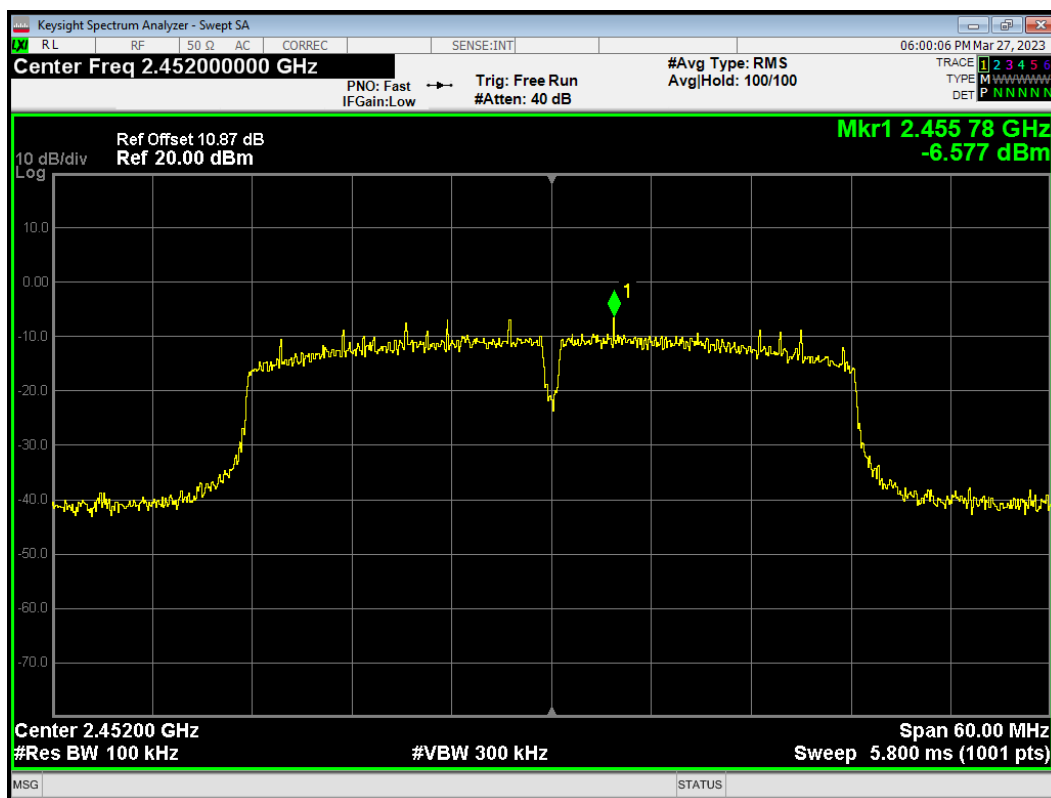
Band Edge 802.11n(HT40) 2447MHz Ref



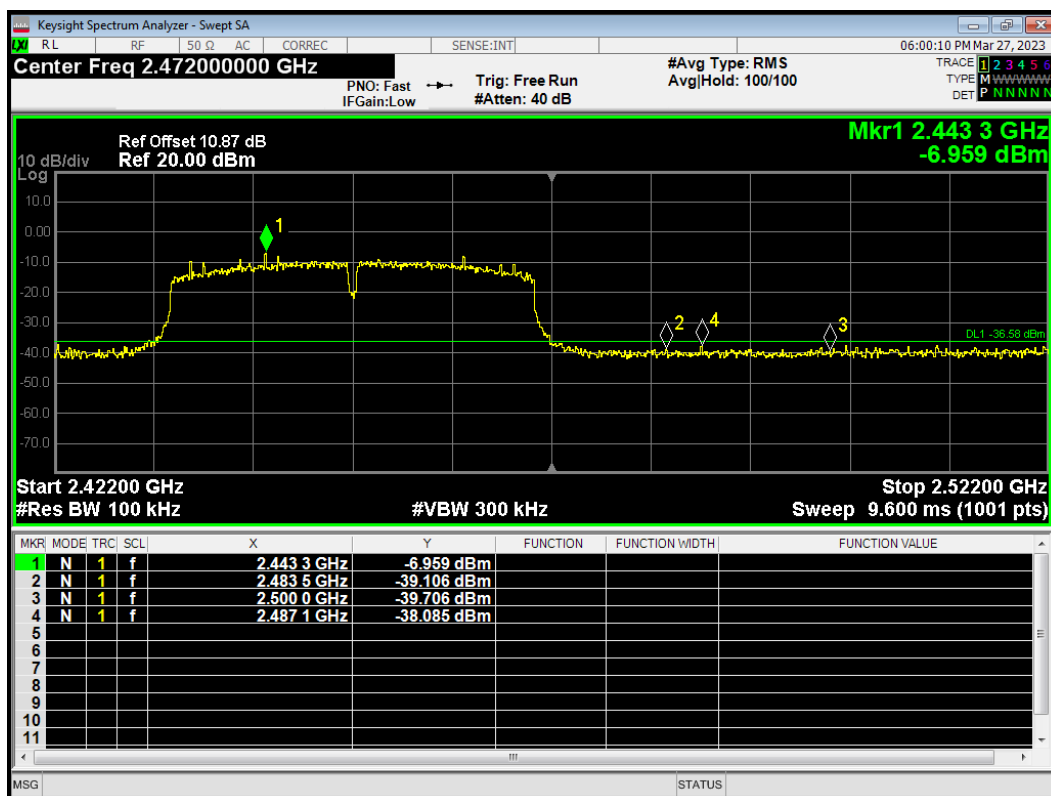
Band Edge 802.11n(HT40) 2447MHz Emission



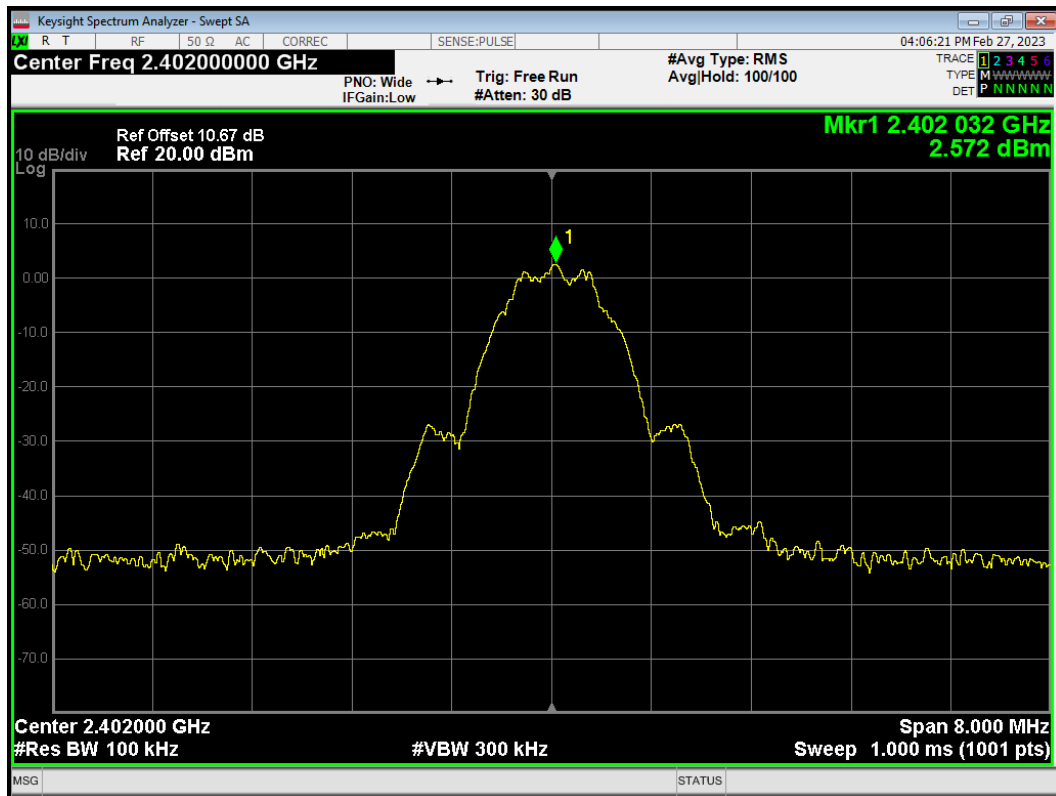
Band Edge 802.11n(HT40) 2452MHz Ref



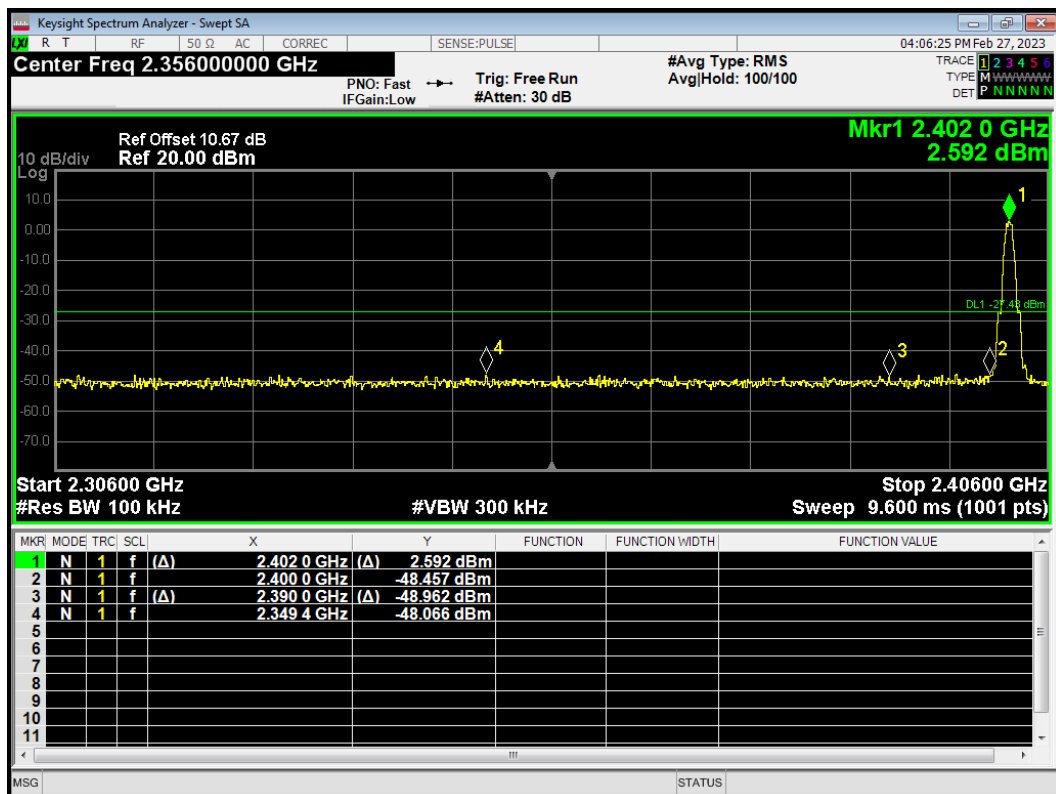
Band Edge 802.11n(HT40) 2452MHz Emission



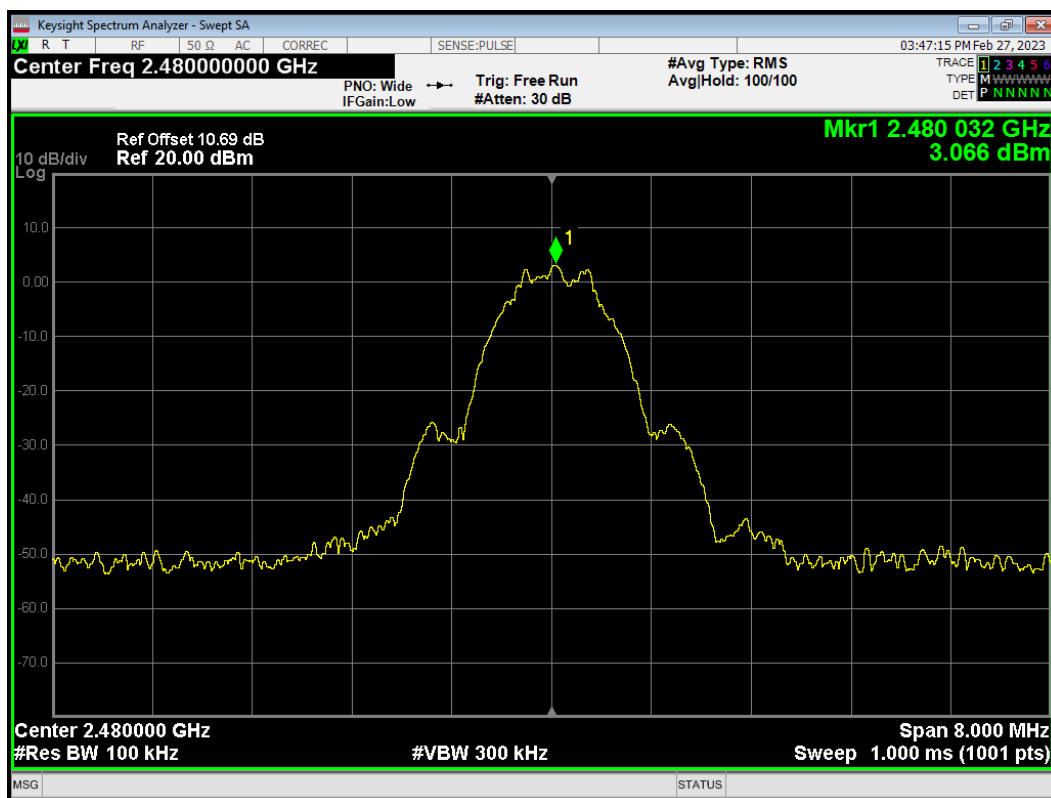
Band Edge Bluetooth LE 2402MHz Ref



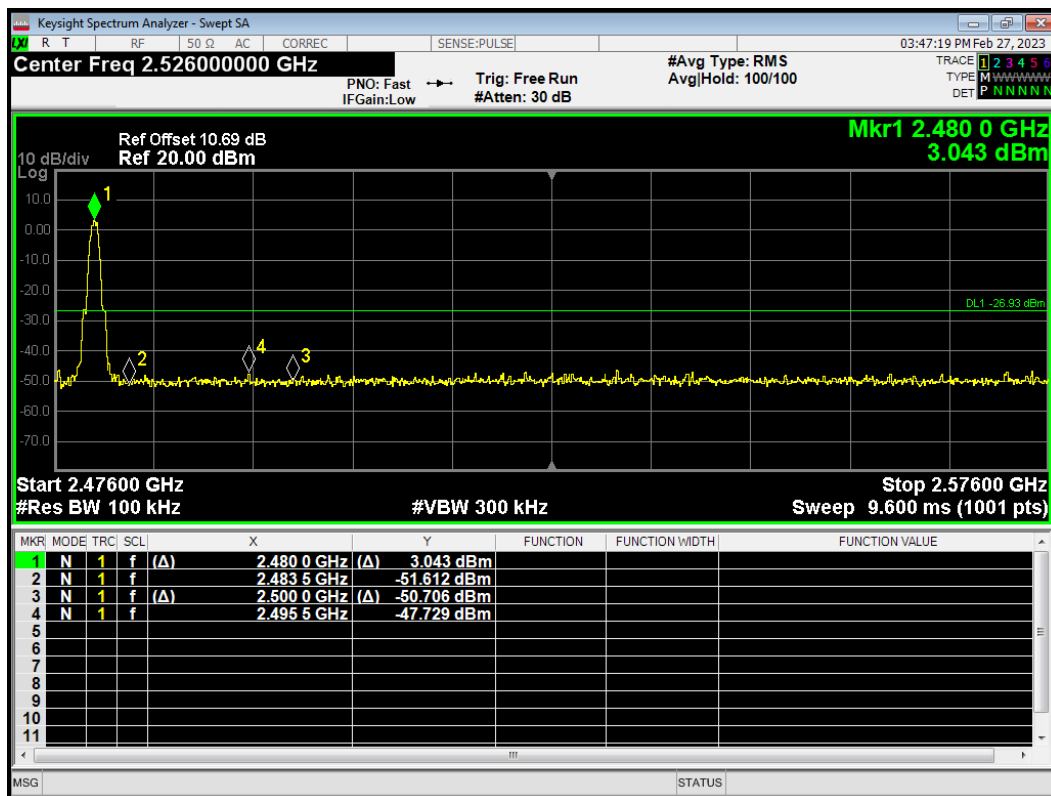
Band Edge Bluetooth LE 2402MHz Emission



Band Edge Bluetooth LE 2480MHz Ref



Band Edge Bluetooth LE 2480MHz Emission



5.4. Power Spectral Density

Ambient Condition

| Temperature | Relative humidity | Pressure |
|-------------|-------------------|----------|
| 23°C ~25°C | 45%~50% | 101.5kPa |

Method of Measurement

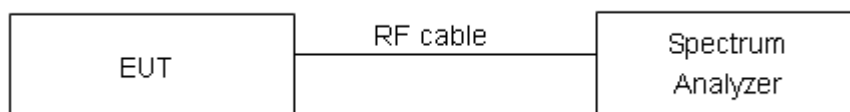
During the process of the testing, The EUT was connected to Spectrum Analyzer with a known loss. The EUT is max power transmission with proper modulation.

Method AVGPSD-2 was used for this test.

- Measure the duty cycle (D) of the transmitter output signal as described in 11.6
- Set instrument center frequency to DTS channel center frequency
- Set span to at least 1.5 times the OBW
- Set RBW to: $3\text{kHz} \leq \text{RBW} \leq 100\text{Kh}$
- Set VBW $\geq [3 \times \text{RBW}]$
- Detector= power averaging (rms) or sample detector (when rms not available)
- Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span}/\text{RBW}]$
- Sweep time =auto couple
- Do not use sweep triggering; allow sweep to "free run"
- Employ trace averaging (rms) mode over a minimum of 100 traces
- Use the peak marker function to determine the maximum amplitude level
- 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
- 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 | $\leq 8 \text{ dBm} / 3\text{kHz}$ |
|--------|------------------------------------|

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 | Channel Number | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|----------------|-------------------------|-------------------------------------|--------------------|------------|
| Bluetooth LE | 2402/CH0 | -16.77 | -14.92 | 8 | PASS |
| | 2440/CH19 | -16.17 | -14.32 | 8 | PASS |
| | 2480/CH39 | -16.47 | -14.62 | 8 | PASS |
| Note: Power Spectral Density =Read Value+Duty cycle correction factor | | | | | |

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| Test Mode | Channel Number | Read Value (dBm / 30kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|----------------|--------------------------|-------------------------------------|--------------------|------------|
| 802.11b | 2412/CH1 | -4.90 | -14.79 | 8 | PASS |
| | 2437/CH6 | -4.92 | -14.81 | 8 | PASS |
| | 2462/CH11 | -5.53 | -15.42 | 8 | PASS |
| 802.11g | 2412/CH1 | -11.35 | -21.24 | 8 | PASS |
| | 2417/CH2 | -7.82 | -17.71 | 8 | PASS |
| | 2437/CH6 | -7.67 | -17.56 | 8 | PASS |
| | 2452/CH9 | -7.06 | -16.95 | 8 | PASS |
| | 2457/CH10 | -8.90 | -18.79 | 8 | PASS |
| | 2462/CH11 | -12.11 | -22.00 | 8 | PASS |
| 802.11n HT20 | 2412/CH1 | -13.44 | -23.34 | 8 | PASS |
| | 2417/CH2 | -8.07 | -17.97 | 8 | PASS |
| | 2437/CH6 | -7.78 | -17.68 | 8 | PASS |
| | 2452/CH9 | -7.87 | -17.77 | 8 | PASS |
| | 2457/CH10 | -8.82 | -18.72 | 8 | PASS |
| | 2462/CH11 | -13.06 | -22.96 | 8 | PASS |
| 802.11n HT40 | 2422/CH3 | -21.90 | -31.70 | 8 | PASS |
| | 2427/CH4 | -19.88 | -29.68 | 8 | PASS |
| | 2432/CH5 | -18.30 | -28.10 | 8 | PASS |
| | 2437/CH6 | -11.56 | -21.36 | 8 | PASS |
| | 2442/CH7 | -18.52 | -28.32 | 8 | PASS |
| | 2447/CH8 | -19.32 | -29.12 | 8 | PASS |
| | 2452/CH9 | -20.33 | -30.13 | 8 | PASS |
| Note: Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3 / 30) | | | | | |

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| Test Mode | Channel Number | Read Value (dBm / 30kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|----------------|--------------------------|-------------------------------------|--------------------|------------|
| 802.11b | 2412/CH1 | -4.73 | -14.62 | 8 | PASS |
| | 2437/CH6 | -4.97 | -14.86 | 8 | PASS |
| | 2462/CH11 | -5.00 | -14.89 | 8 | PASS |
| 802.11g | 2412/CH1 | -10.12 | -20.01 | 8 | PASS |
| | 2417/CH2 | -7.08 | -16.97 | 8 | PASS |
| | 2437/CH6 | -7.78 | -17.67 | 8 | PASS |
| | 2452/CH9 | -7.86 | -17.75 | 8 | PASS |
| | 2457/CH10 | -8.48 | -18.37 | 8 | PASS |
| | 2462/CH11 | -11.69 | -21.58 | 8 | PASS |
| 802.11n HT20 | 2412/CH1 | -12.24 | -22.14 | 8 | PASS |
| | 2417/CH2 | -7.41 | -17.31 | 8 | PASS |
| | 2437/CH6 | -8.19 | -18.09 | 8 | PASS |
| | 2452/CH9 | -7.98 | -17.88 | 8 | PASS |
| | 2457/CH10 | -9.04 | -18.94 | 8 | PASS |
| | 2462/CH11 | -12.82 | -22.72 | 8 | PASS |
| 802.11n HT40 | 2422/CH3 | -20.33 | -30.13 | 8 | PASS |
| | 2427/CH4 | -18.63 | -28.43 | 8 | PASS |
| | 2432/CH5 | -16.90 | -26.70 | 8 | PASS |
| | 2437/CH6 | -14.30 | -24.10 | 8 | PASS |
| | 2442/CH7 | -17.45 | -27.25 | 8 | PASS |
| | 2447/CH8 | -18.37 | -28.17 | 8 | PASS |
| | 2452/CH9 | -19.70 | -29.50 | 8 | PASS |
| Note: Power Spectral Density (dBm/3kHz) =Read Value+Duty cycle correction factor + 10*log10(3 / 30) | | | | | |

CDD/MIMO

| Test Mode | Channel Number | 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) | | | |
| 802.11b | 2412/CH1 | -5.45 | -15.34 | -5.02 | -14.91 | -12.11 | 6.64 | PASS |
| | 2437/CH6 | -4.52 | -14.41 | -5.26 | -15.15 | -11.76 | 6.64 | PASS |
| | 2462/CH11 | -5.75 | -15.64 | -5.21 | -15.10 | -12.35 | 6.64 | PASS |
| 802.11g | 2412/CH1 | -11.17 | -21.06 | -10.06 | -19.95 | -17.46 | 6.64 | PASS |
| | 2417/CH2 | -7.72 | -17.61 | -6.76 | -16.65 | -14.10 | 6.64 | PASS |
| | 2437/CH6 | -8.01 | -17.90 | -8.08 | -17.97 | -14.93 | 6.64 | PASS |
| | 2452/CH9 | -7.68 | -17.57 | -7.96 | -17.85 | -14.70 | 6.64 | PASS |
| | 2457/CH10 | -8.97 | -18.86 | -8.85 | -18.74 | -15.79 | 6.64 | PASS |
| | 2462/CH11 | -11.89 | -21.78 | -11.73 | -21.62 | -18.69 | 6.64 | PASS |
| 802.11n HT20 | 2412/CH1 | -12.98 | -22.88 | -12.53 | -22.43 | -19.64 | 6.64 | PASS |
| | 2417/CH2 | -7.60 | -17.50 | -7.34 | -17.24 | -14.36 | 6.64 | PASS |
| | 2437/CH6 | -8.32 | -18.22 | -8.32 | -18.22 | -15.21 | 6.64 | PASS |
| | 2452/CH9 | -7.71 | -17.61 | -8.15 | -18.05 | -14.82 | 6.64 | PASS |
| | 2457/CH10 | -8.95 | -18.85 | -9.06 | -18.96 | -15.90 | 6.64 | PASS |
| | 2462/CH11 | -13.30 | -23.20 | -12.92 | -22.82 | -20.00 | 6.64 | PASS |
| 802.11n HT40 | 2422/CH3 | -20.93 | -30.73 | -20.72 | -30.52 | -27.61 | 6.64 | PASS |
| | 2427/CH4 | -19.55 | -29.35 | -18.53 | -28.33 | -25.80 | 6.64 | PASS |
| | 2432/CH5 | -17.59 | -27.39 | -16.62 | -26.42 | -23.87 | 6.64 | PASS |
| | 2437/CH6 | -13.93 | -23.73 | -13.89 | -23.69 | -20.70 | 6.64 | PASS |
| | 2442/CH7 | -18.32 | -28.12 | -17.77 | -27.57 | -24.83 | 6.64 | PASS |
| | 2447/CH8 | -17.91 | -27.71 | -18.92 | -28.72 | -25.17 | 6.64 | PASS |
| | 2452/CH9 | -20.16 | -29.96 | -19.95 | -29.75 | -26.84 | 6.64 | 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= $10\log(10^{(PSD \text{ antenna1 in dBm}/10)} + 10^{(PSD \text{ antenna2 in dBm}/10)})$

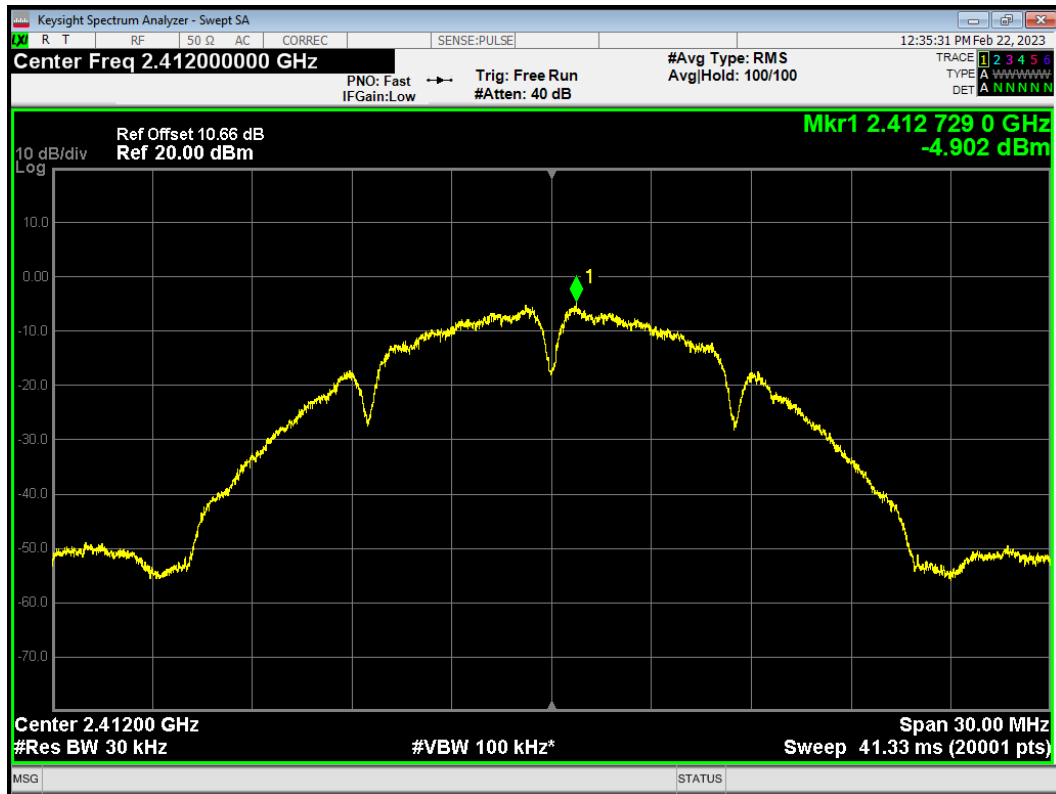
3. The manufacturer declared the $N_{ss}=1$. According to KDB 662911 D01 Multiple Transmitter Output v02r01 F)2)f)(ii): If antenna gains are not equal, the user may use either of the following methods to calculate directional gain, provided that each transmit antenna is driven by only one spatial stream: Directional gain may be calculated by using the formulas applicable to equal gain antennas with G_{ANT} set equal to the gain of the antenna having the highest gain.

Directional gain = $G_{ANT \text{ MAX}}$ + Array Gain. For PSD measurements on all devices, Array Gain= $10\log(N_{ant}/N_{ss})$ dB, so directional gain= $G_{ANT \text{ MAX}}$ +Array Gain= $4.35+10\log(2/1)=7.36 > 6$ dB.

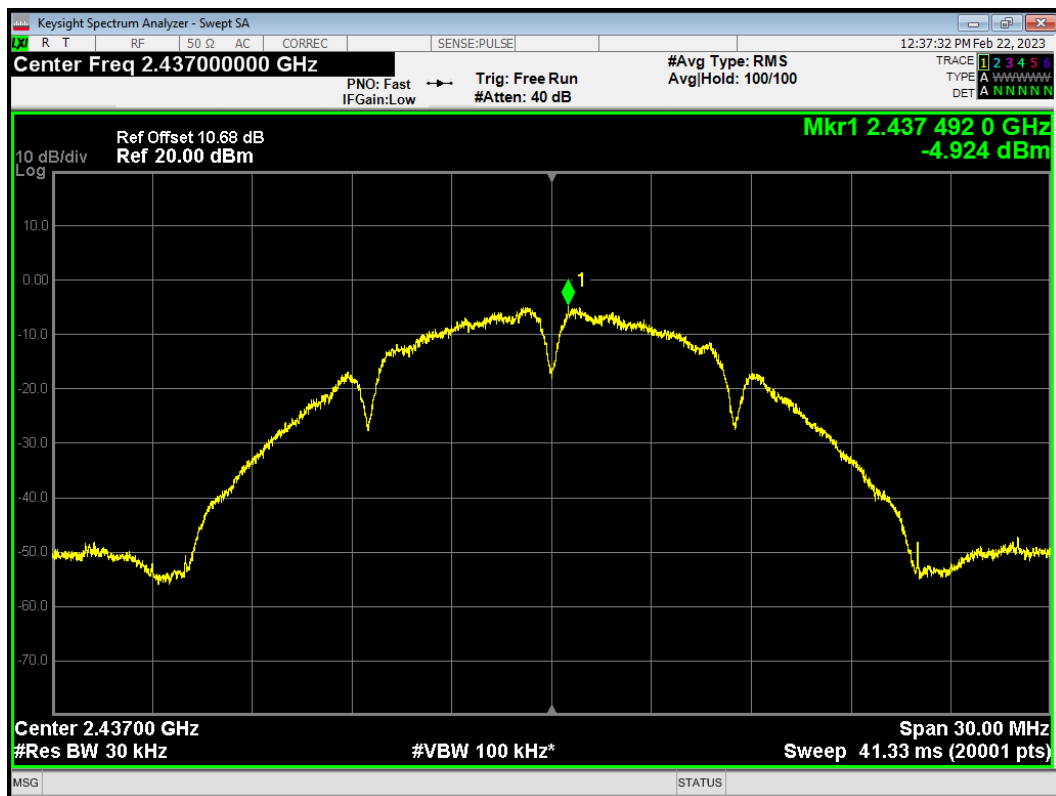
So the PSD limit is $8+6-\text{MAX}(6, \text{directional gain})$ dBm=6.64 dBm

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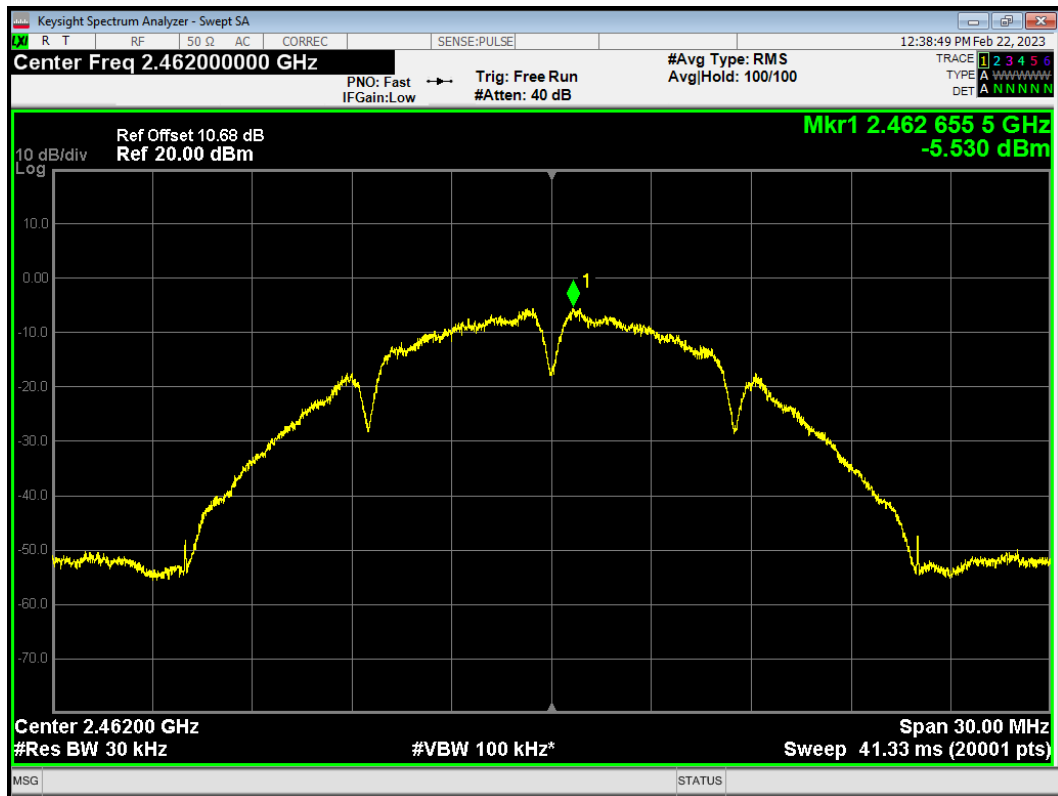
PSD 802.11b 2412MHz



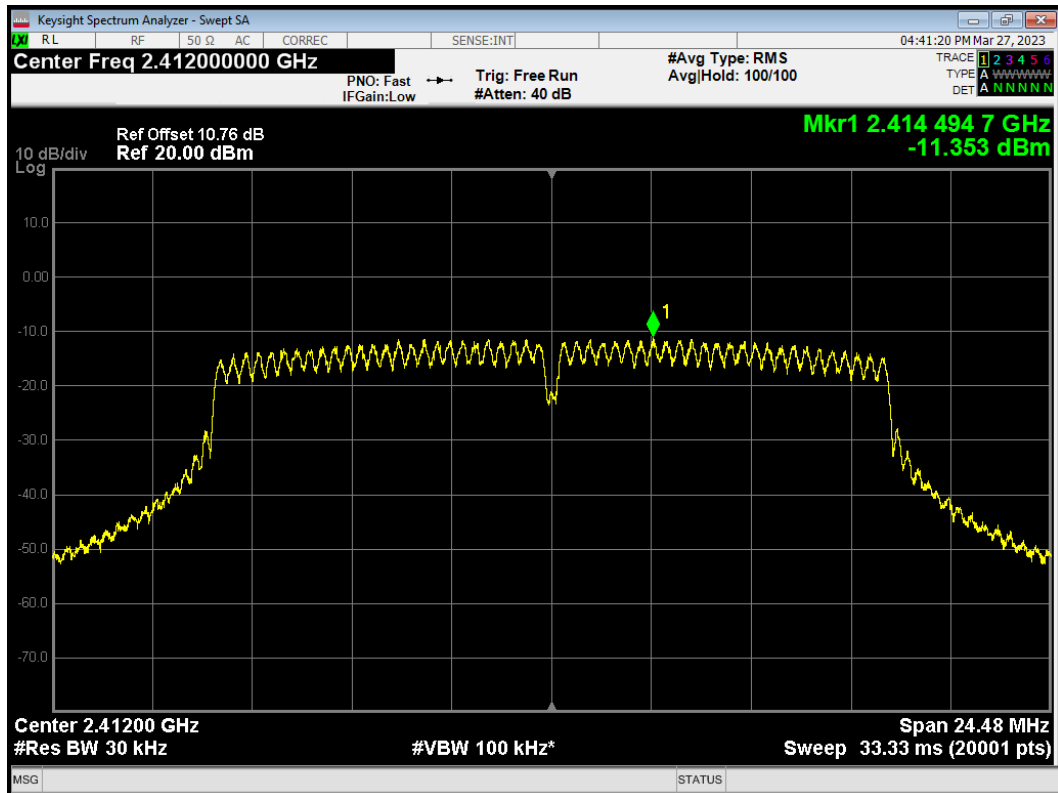
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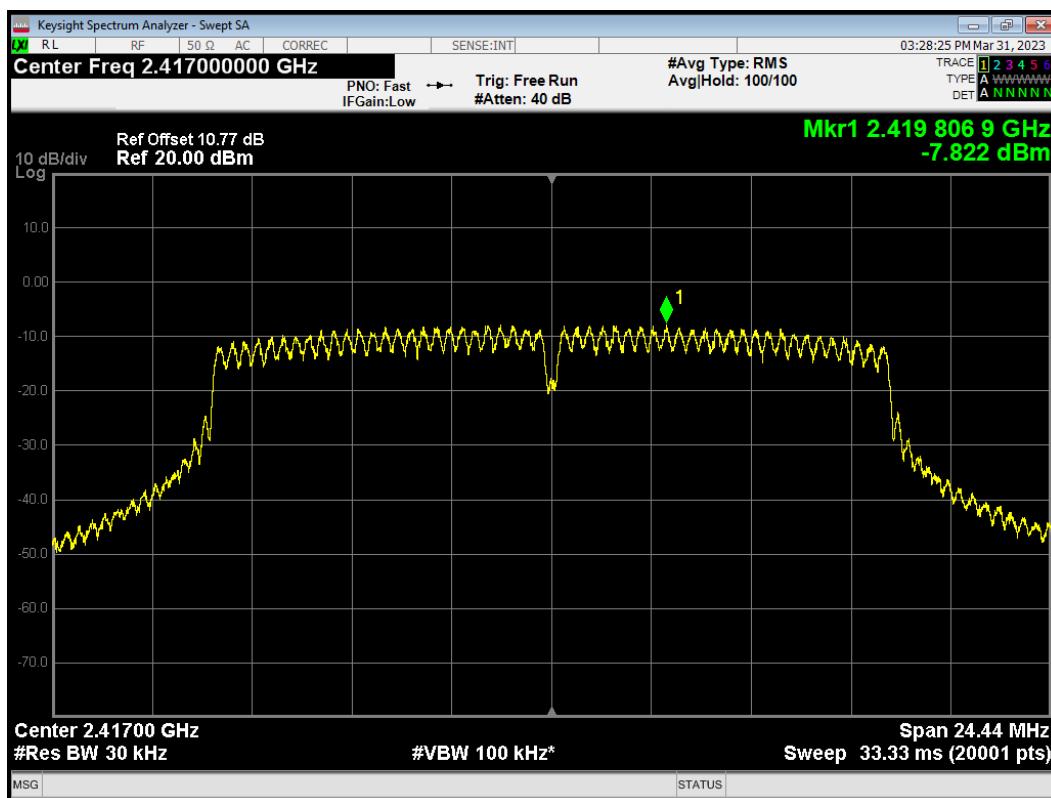
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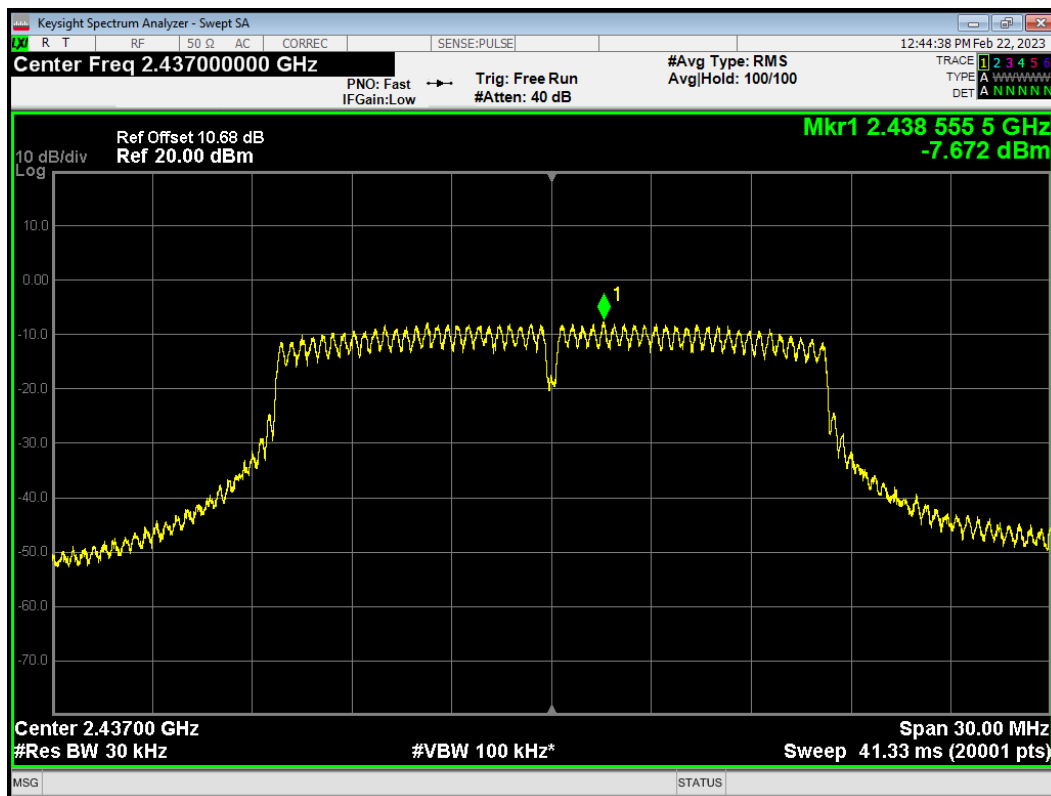
PSD 802.11g 2412MHz



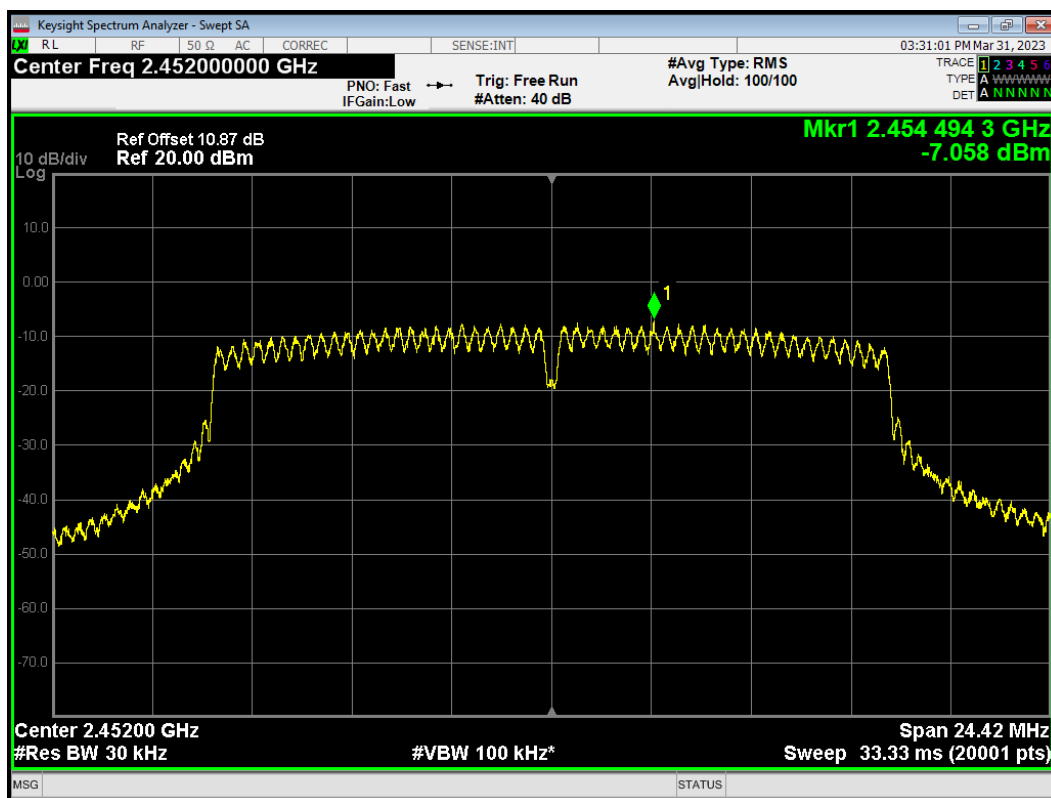
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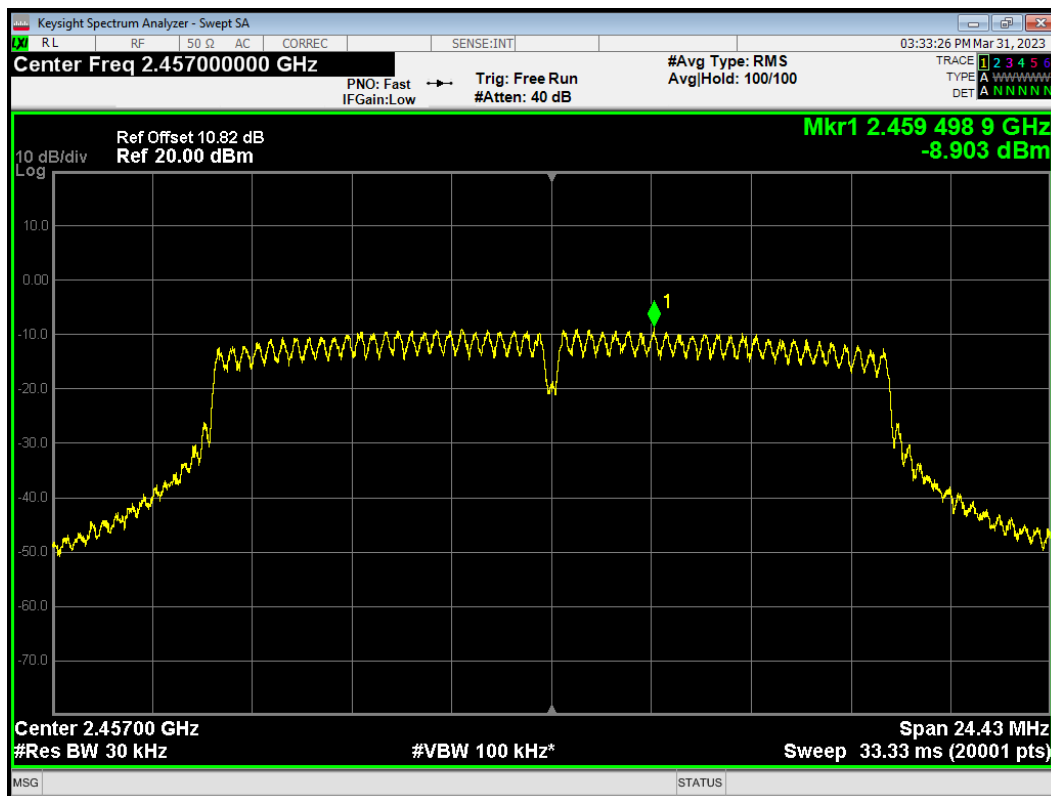
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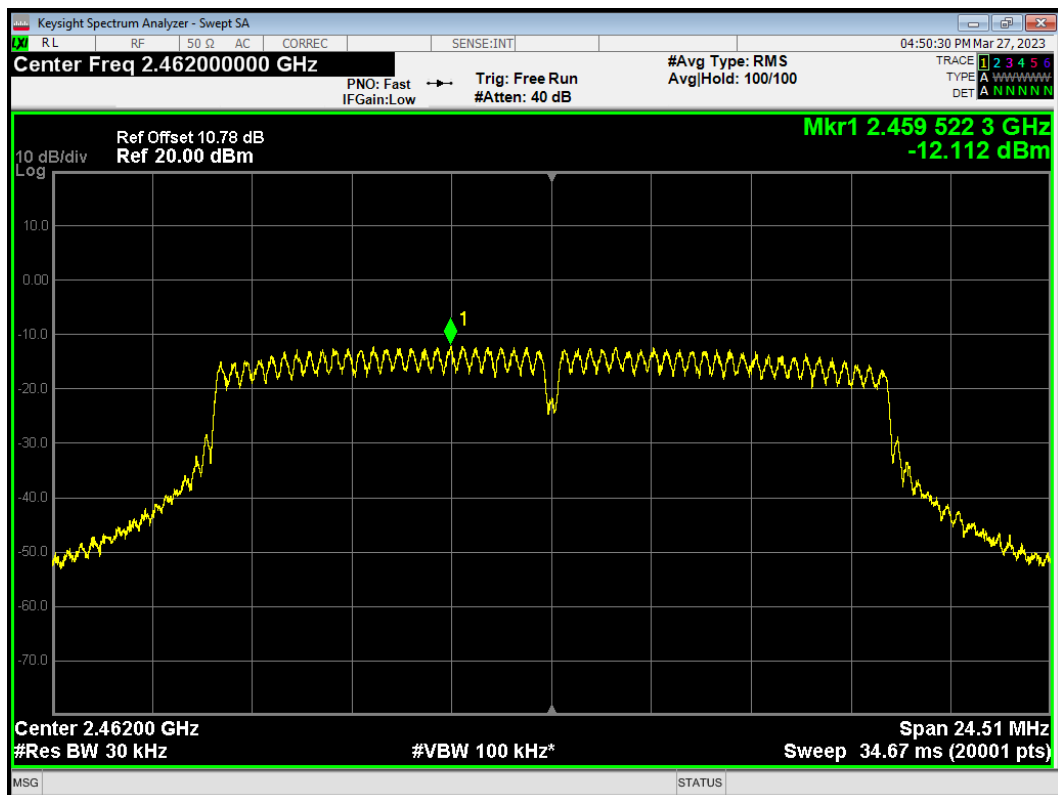
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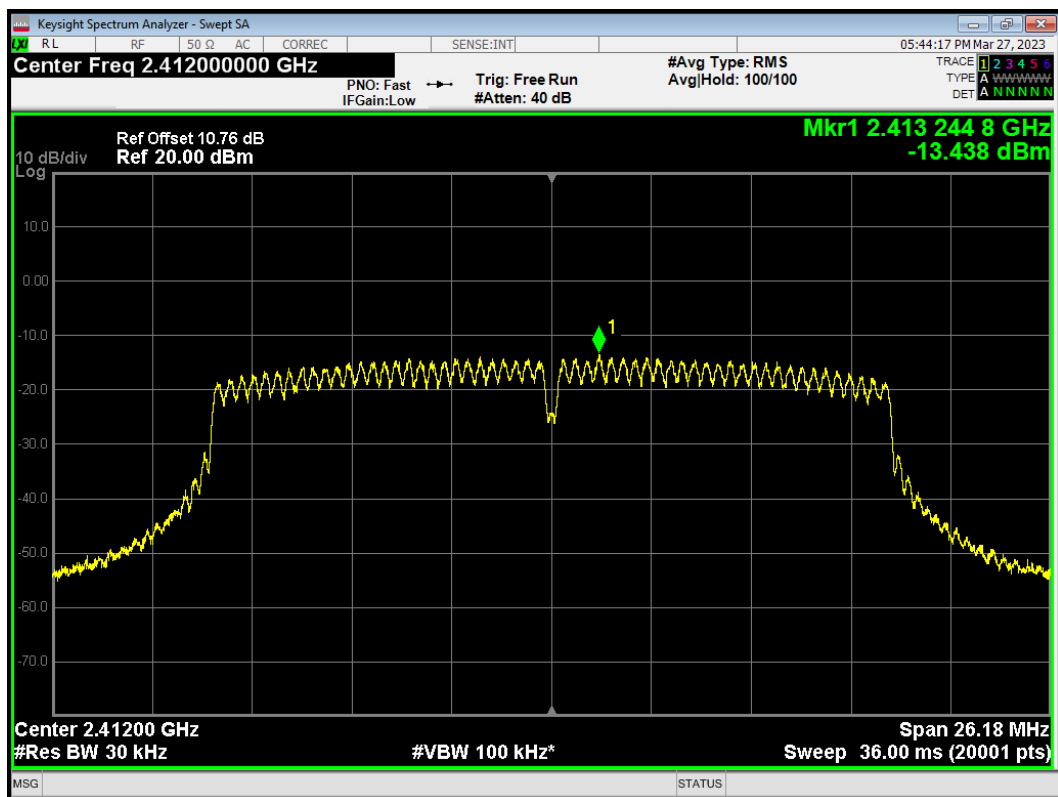
PSD 802.11g 2457MHz



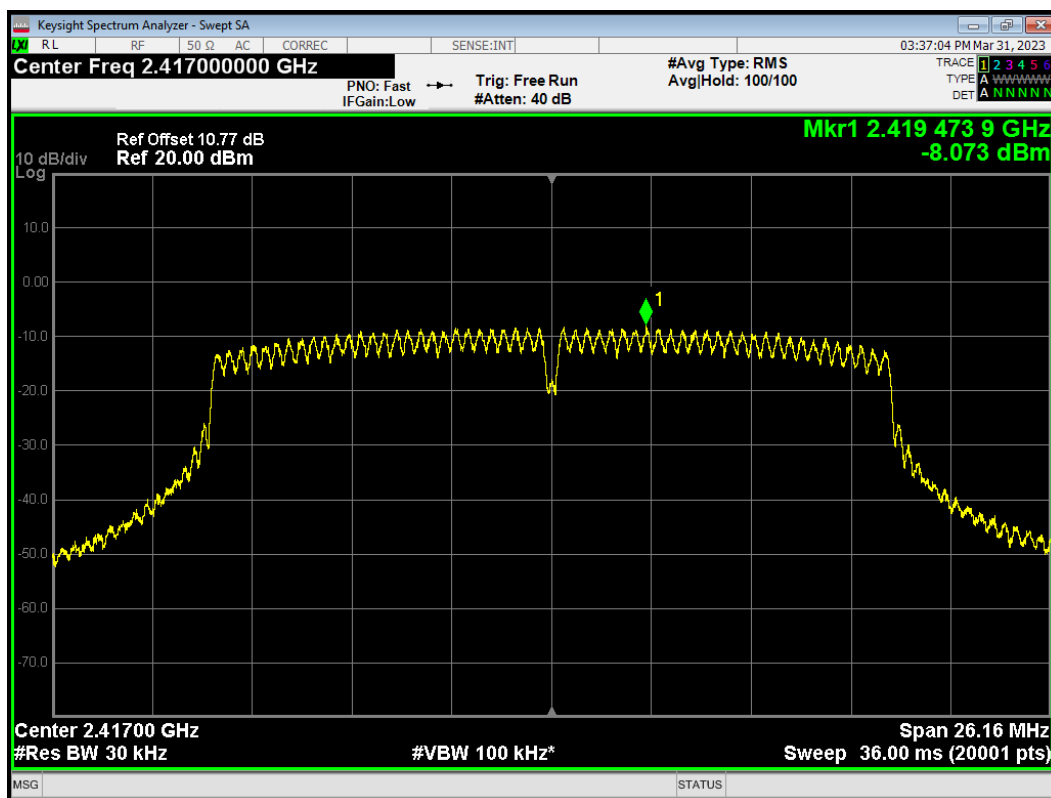
PSD 802.11g 2462MHz



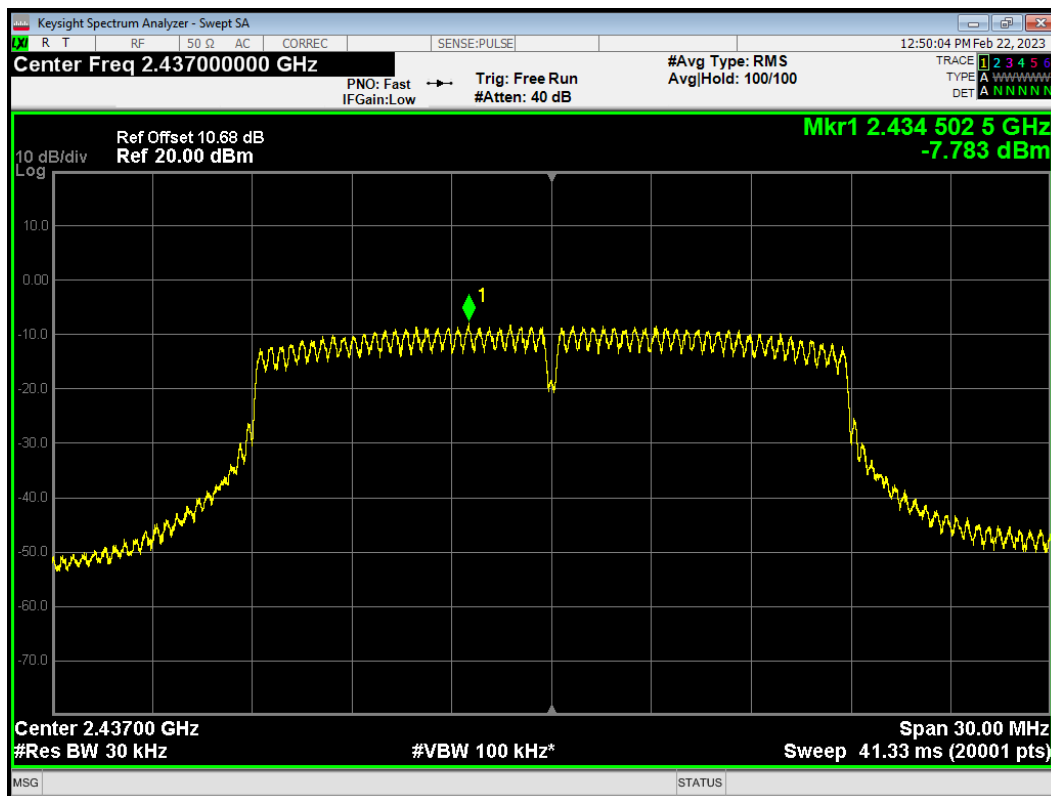
PSD 802.11n(HT20) 2412MHz



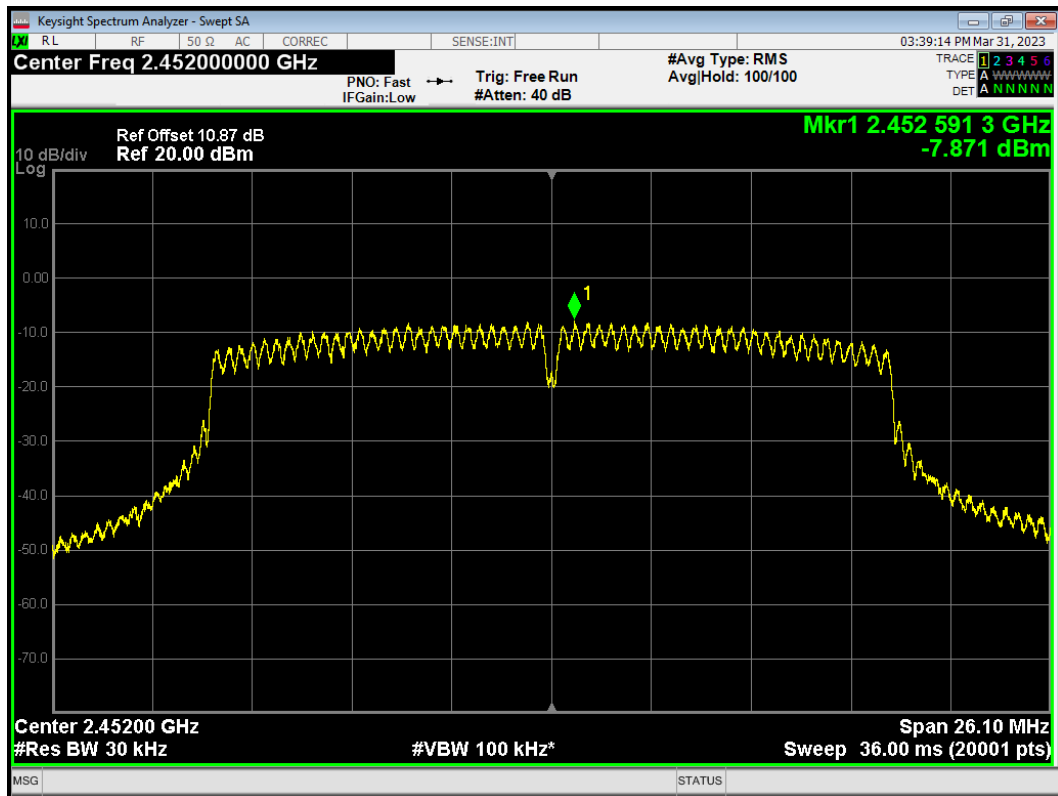
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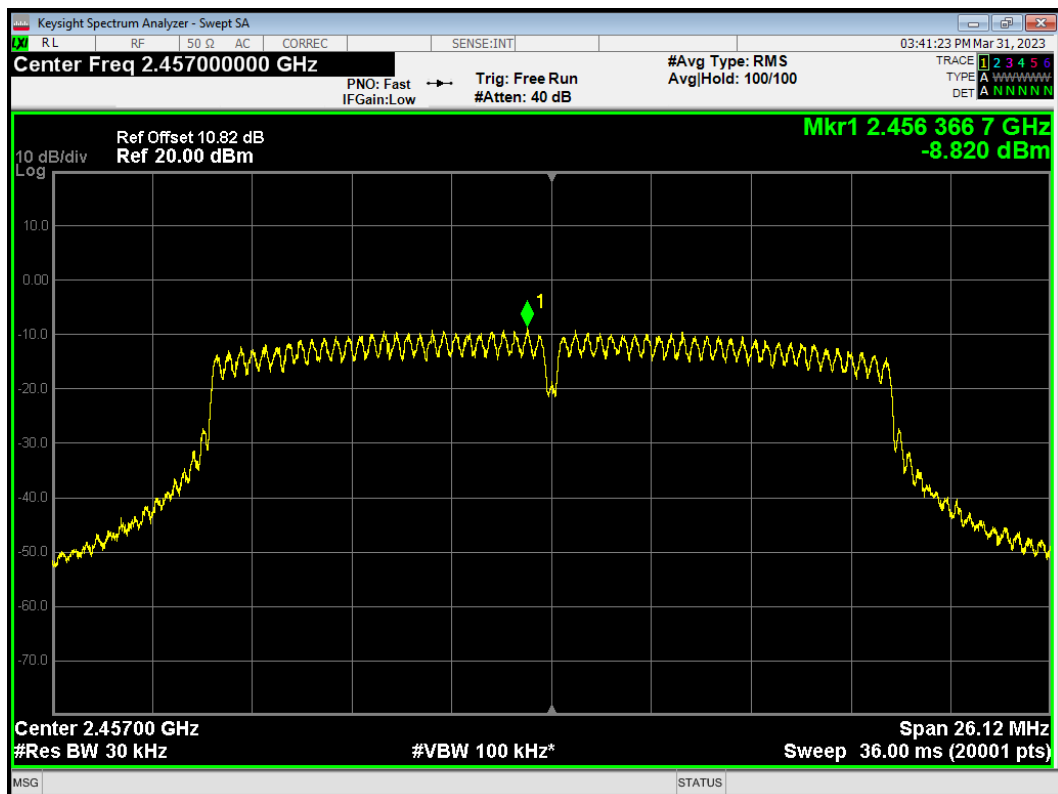
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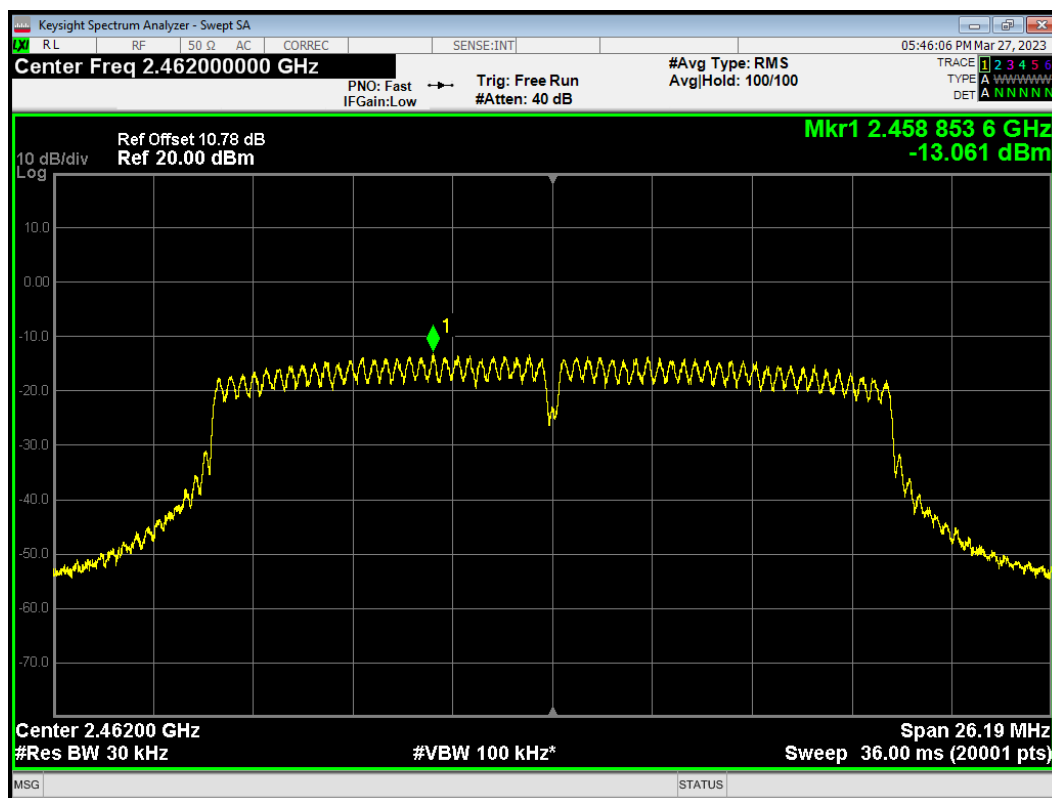
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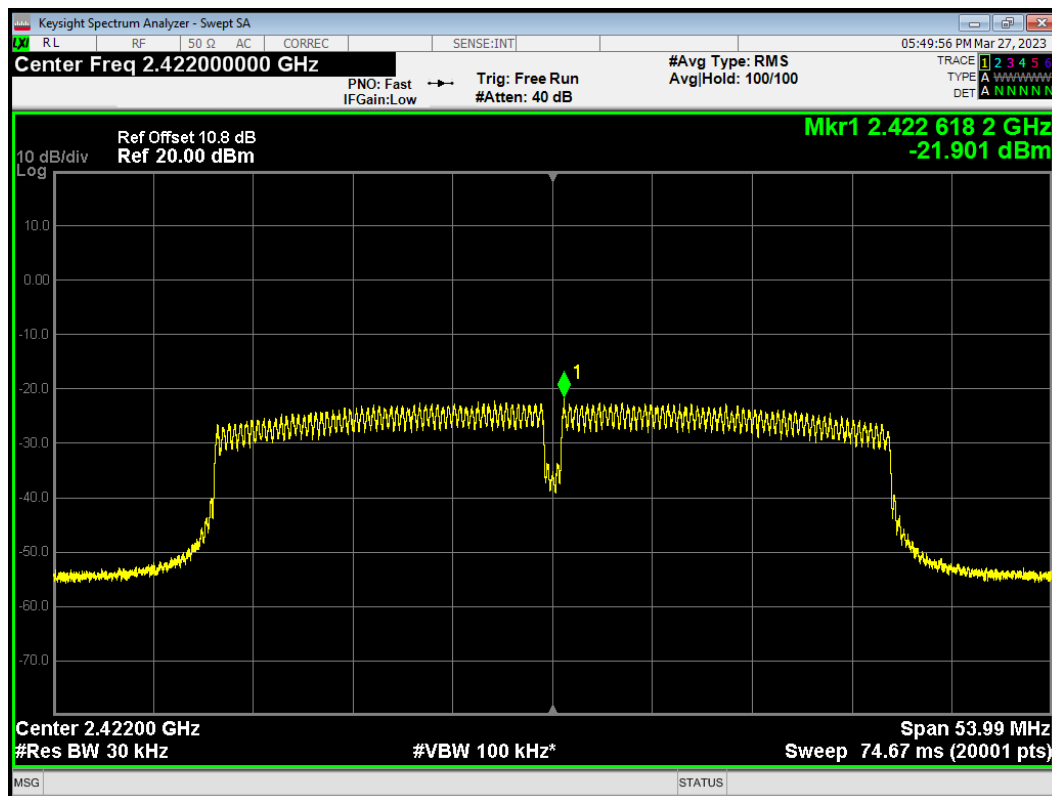
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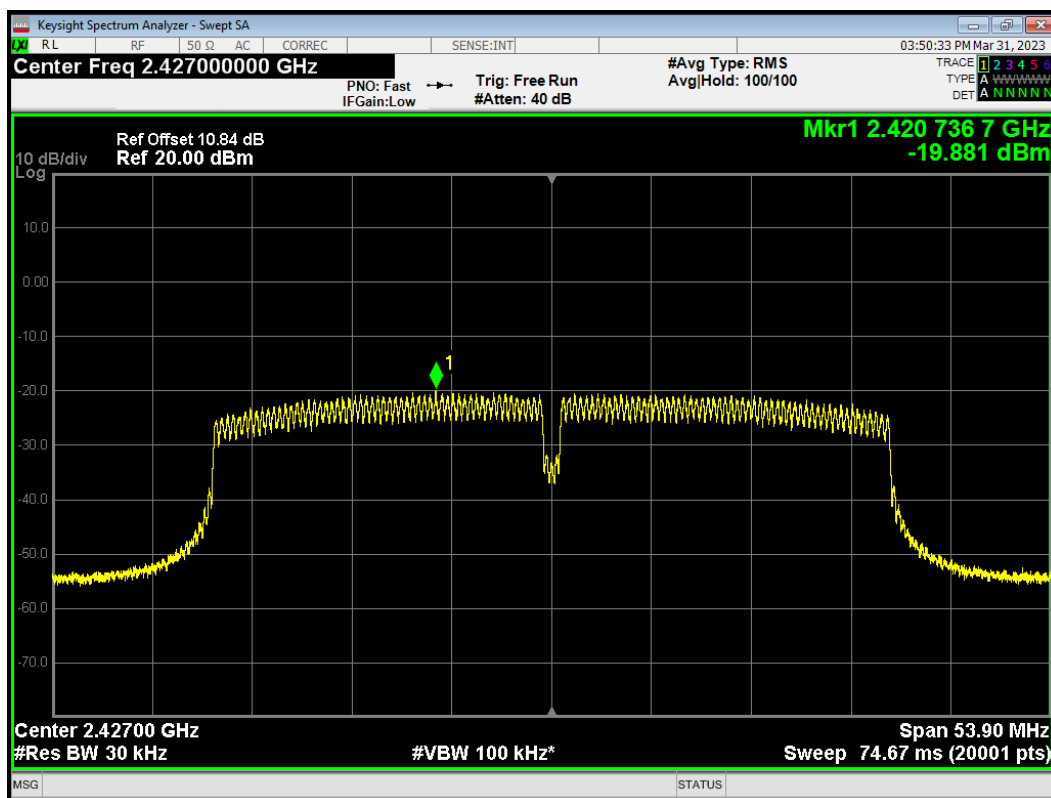
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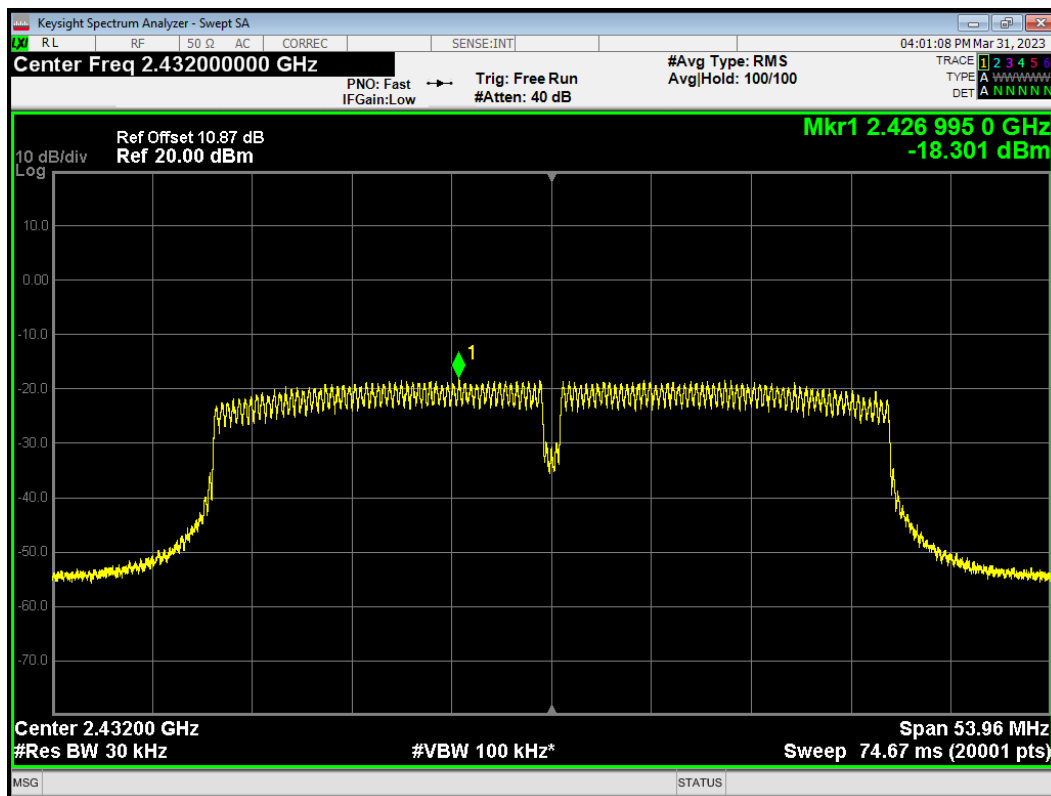
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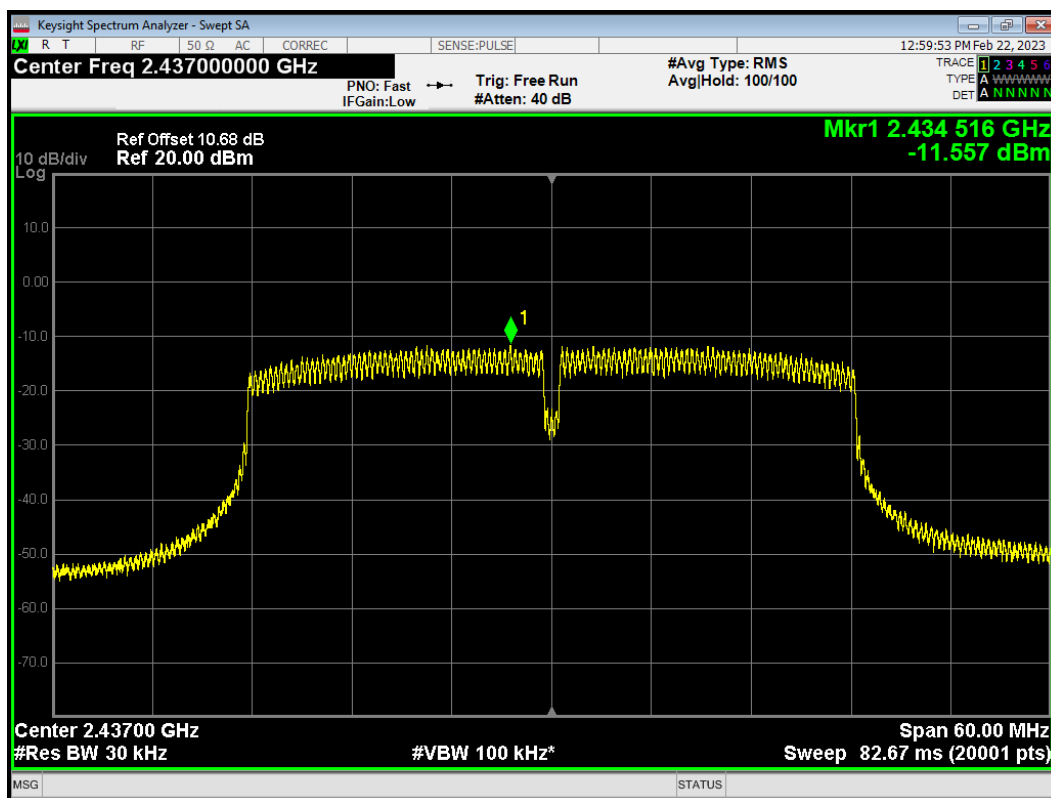
PSD 802.11n(HT40) 2427MHz



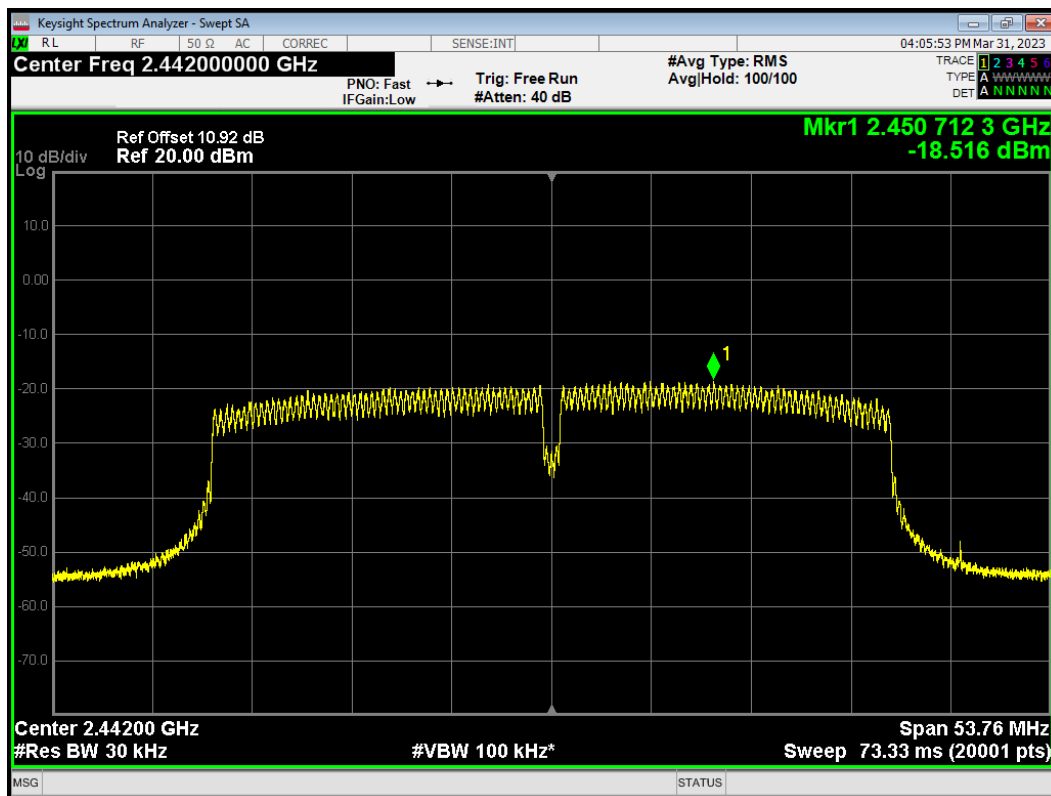
PSD 802.11n(HT40) 2432MHz



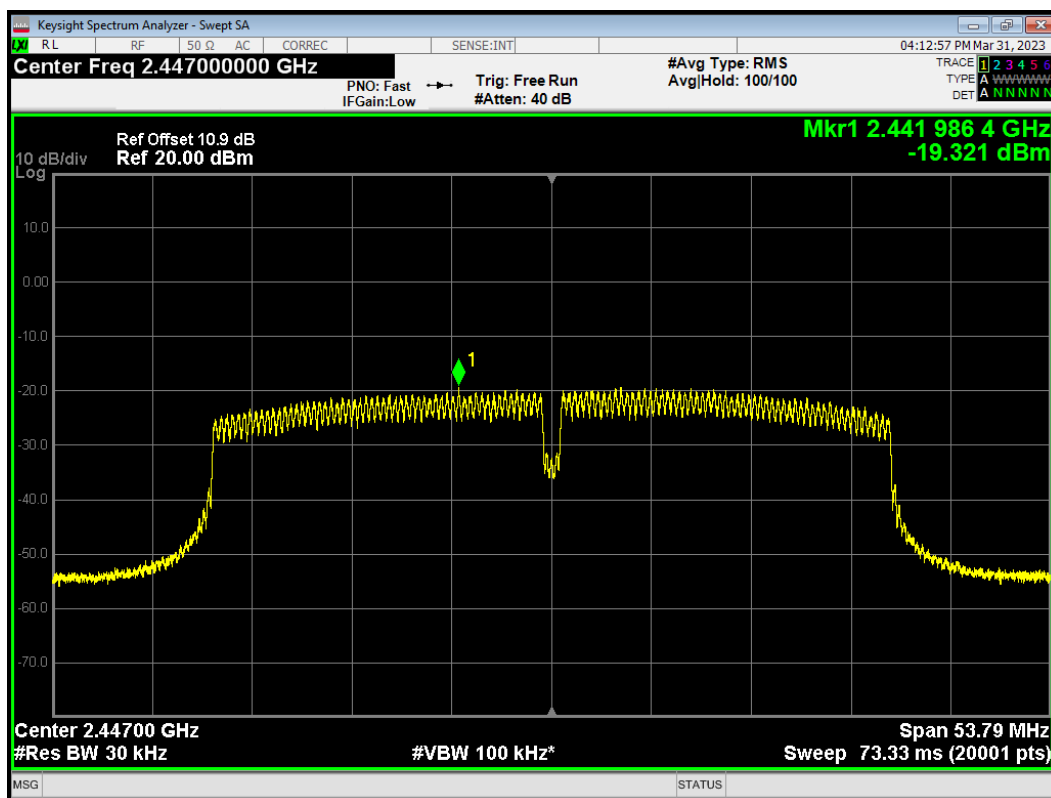
PSD 802.11n(HT40) 2437MHz



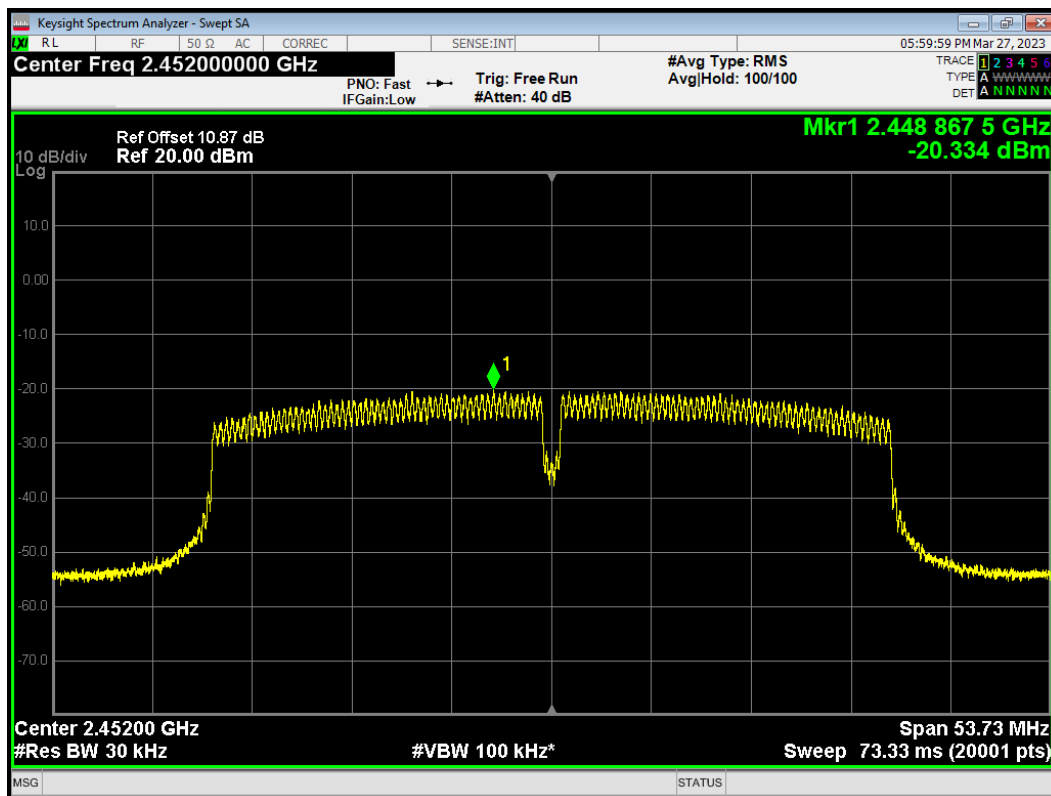
PSD 802.11n(HT40) 2442MHz



PSD 802.11n(HT40) 2447MHz

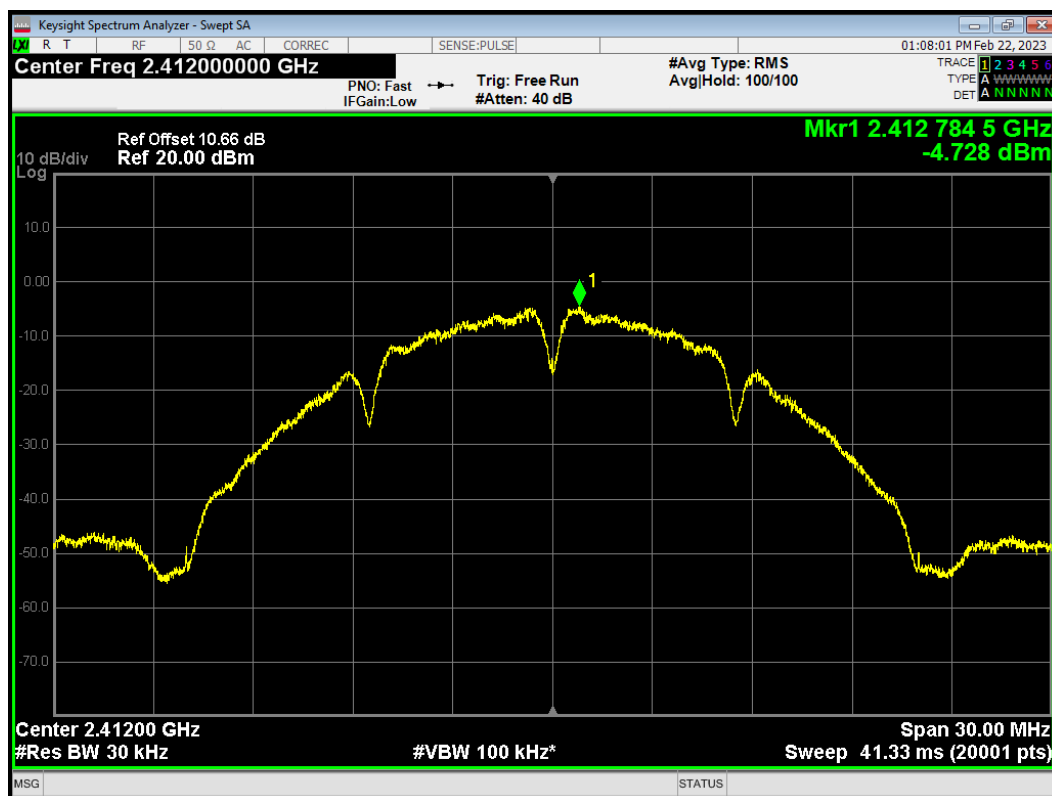


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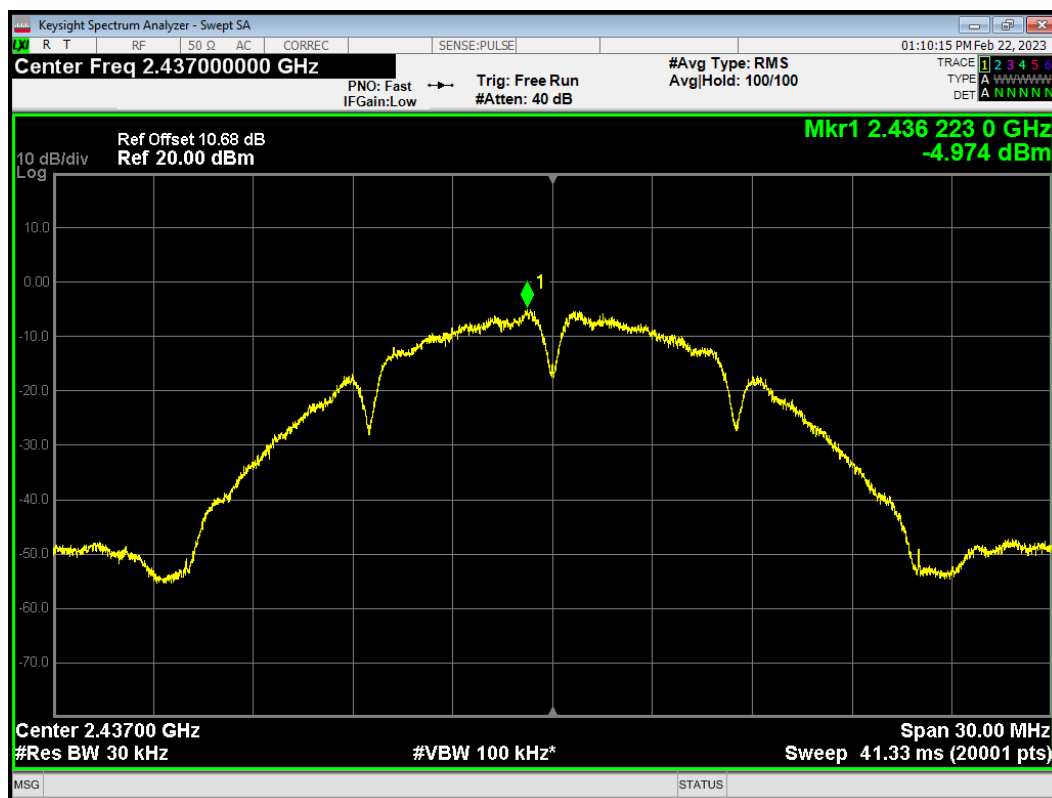


SISO ANT2

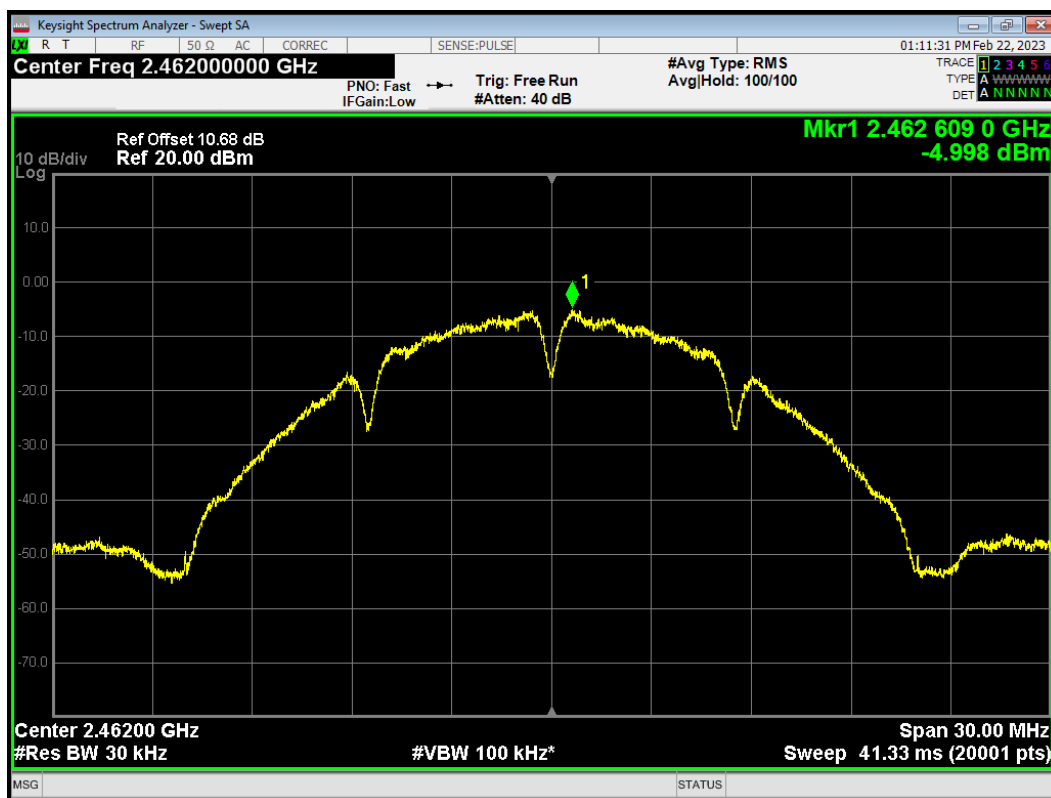
PSD 802.11b 2412MHz



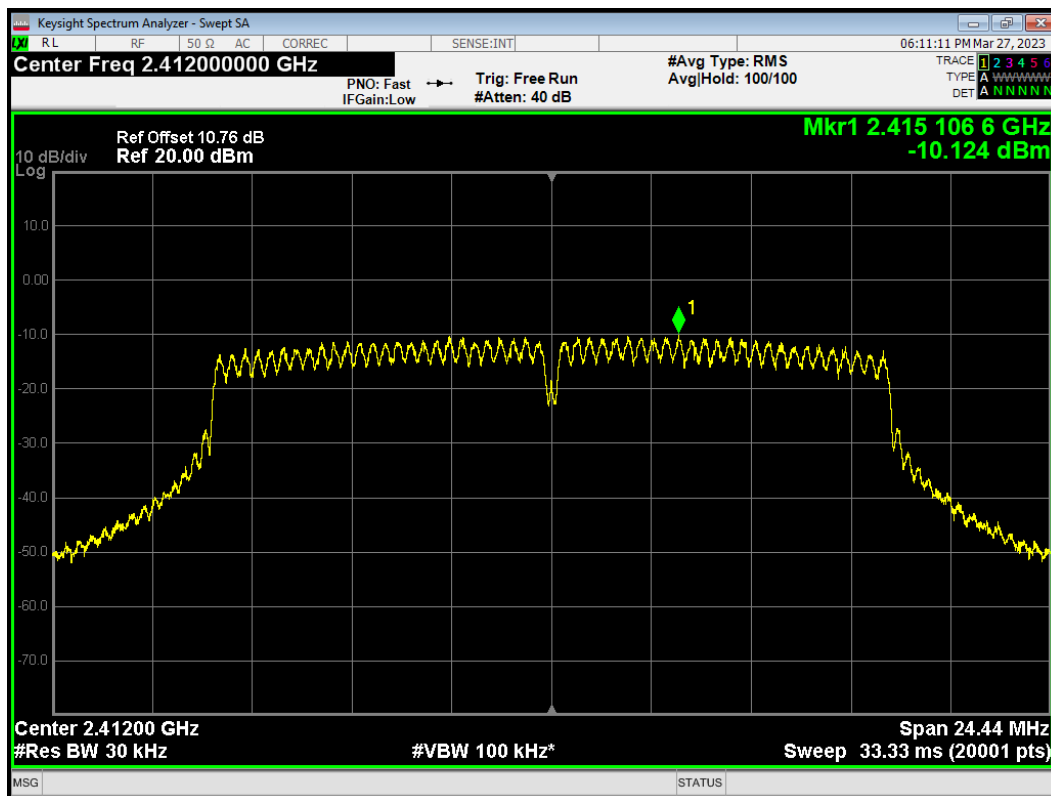
PSD 802.11b 2437MHz



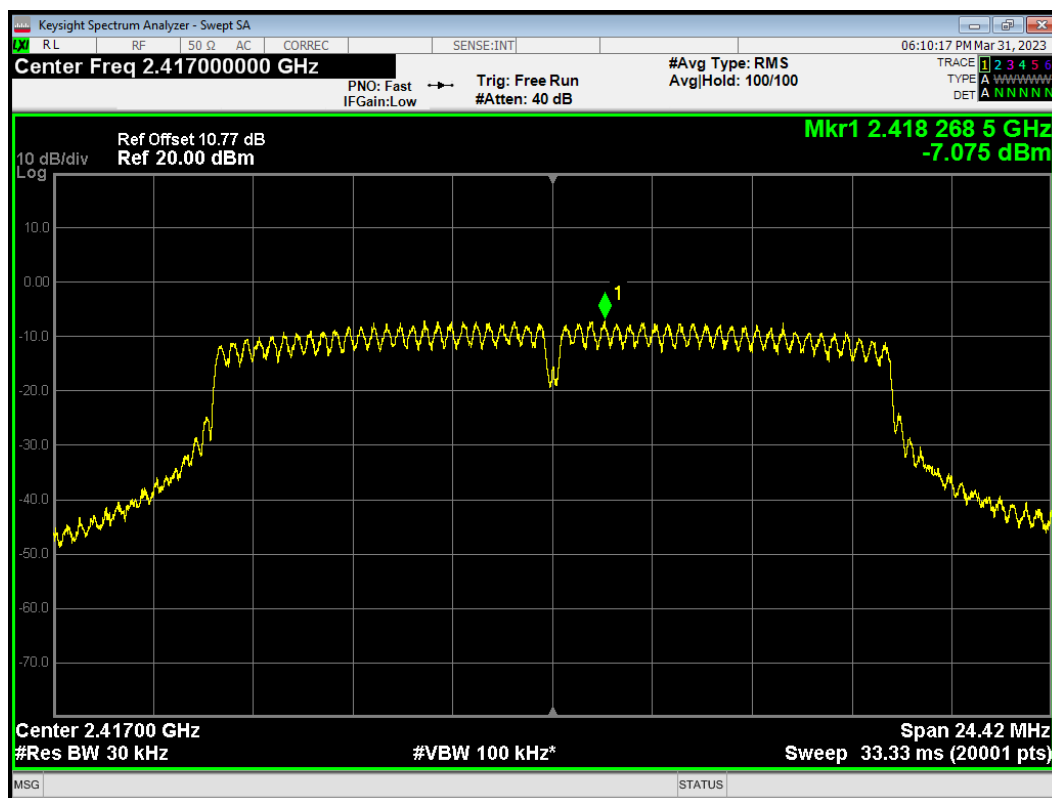
PSD 802.11b 2462MHz



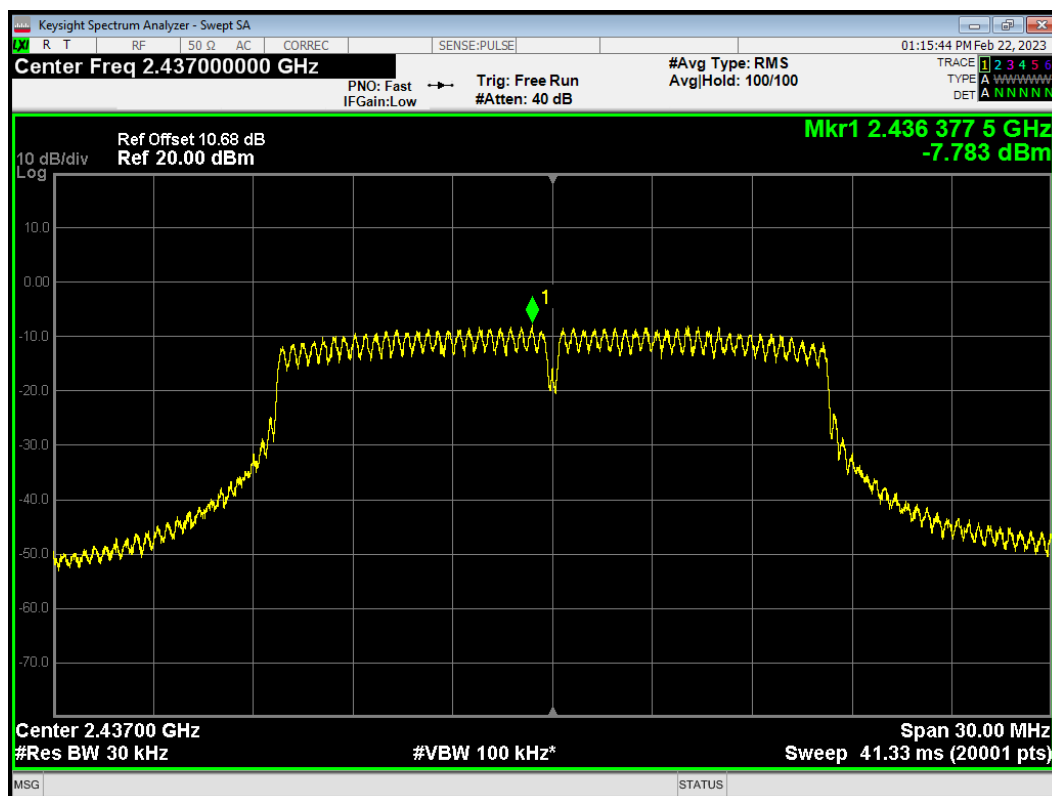
PSD 802.11g 2412MHz



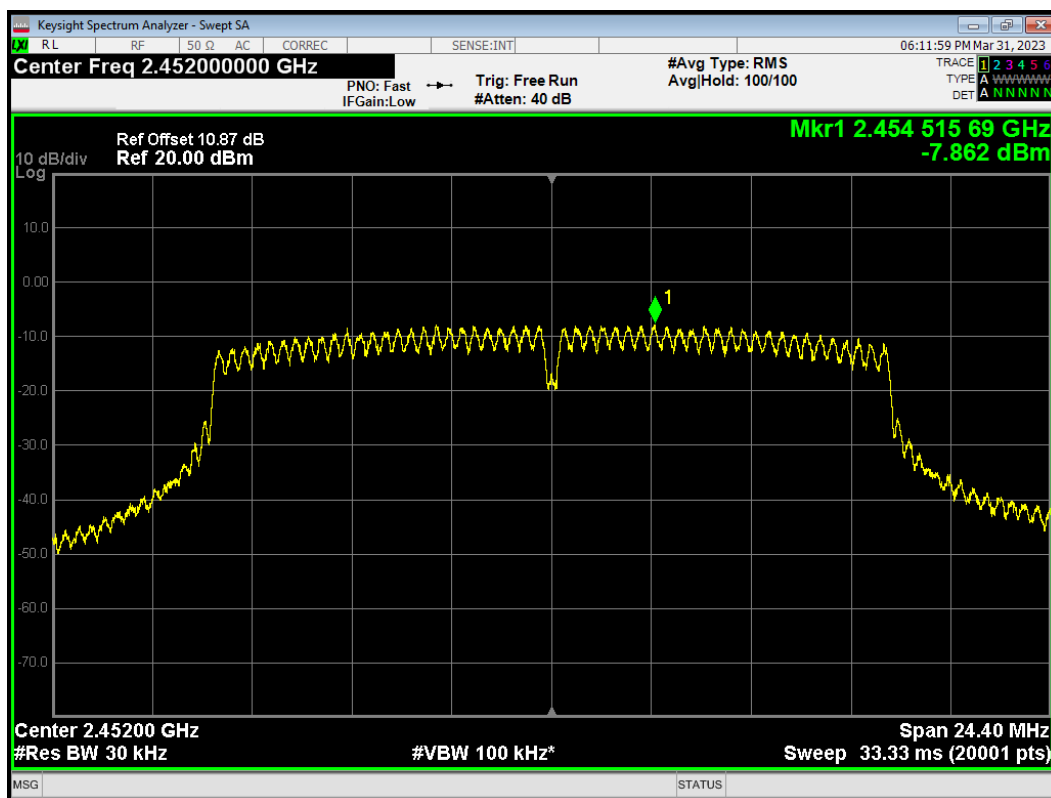
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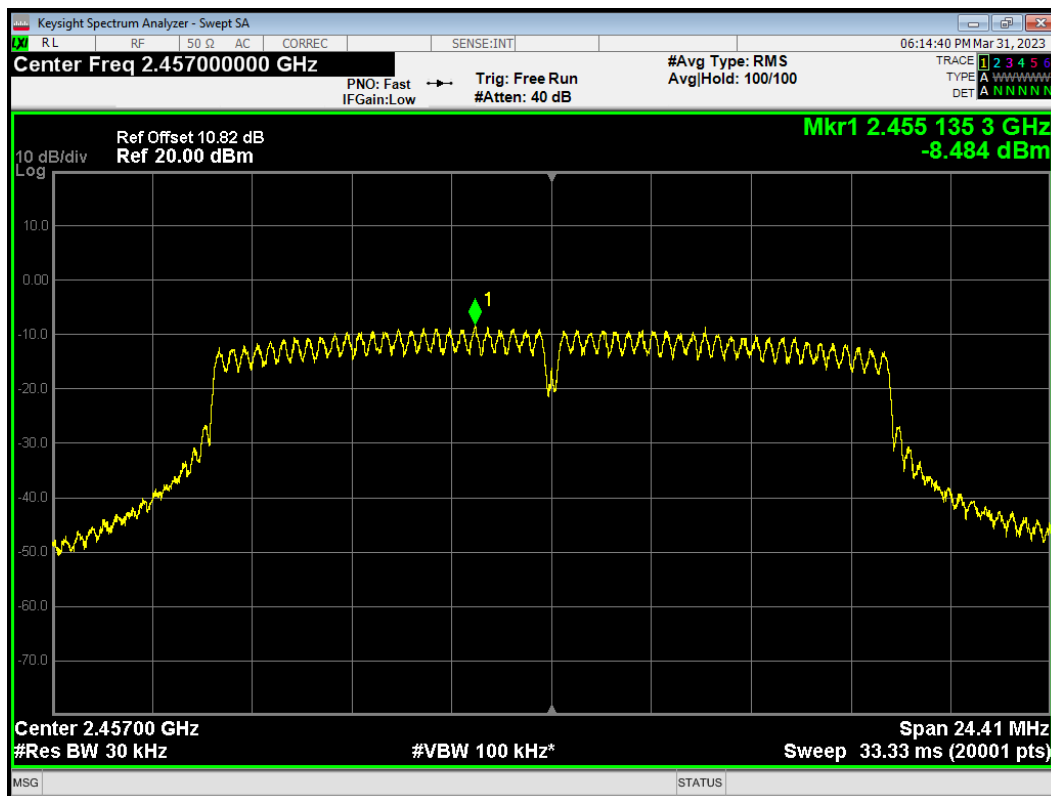
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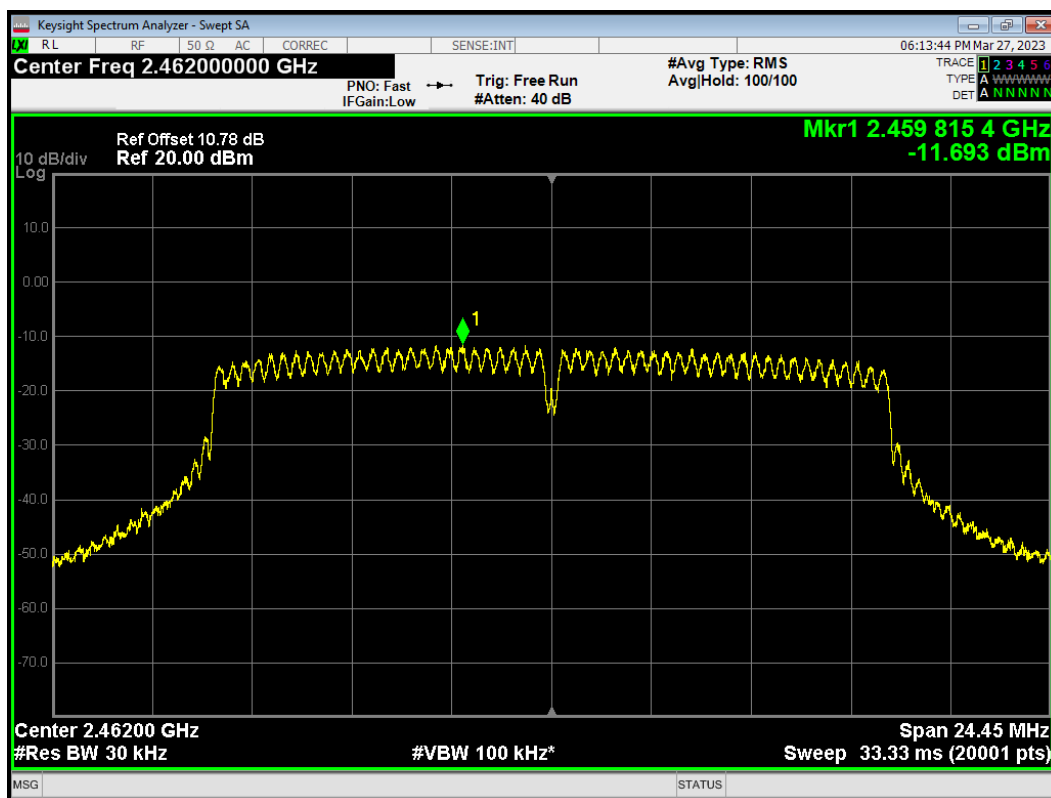
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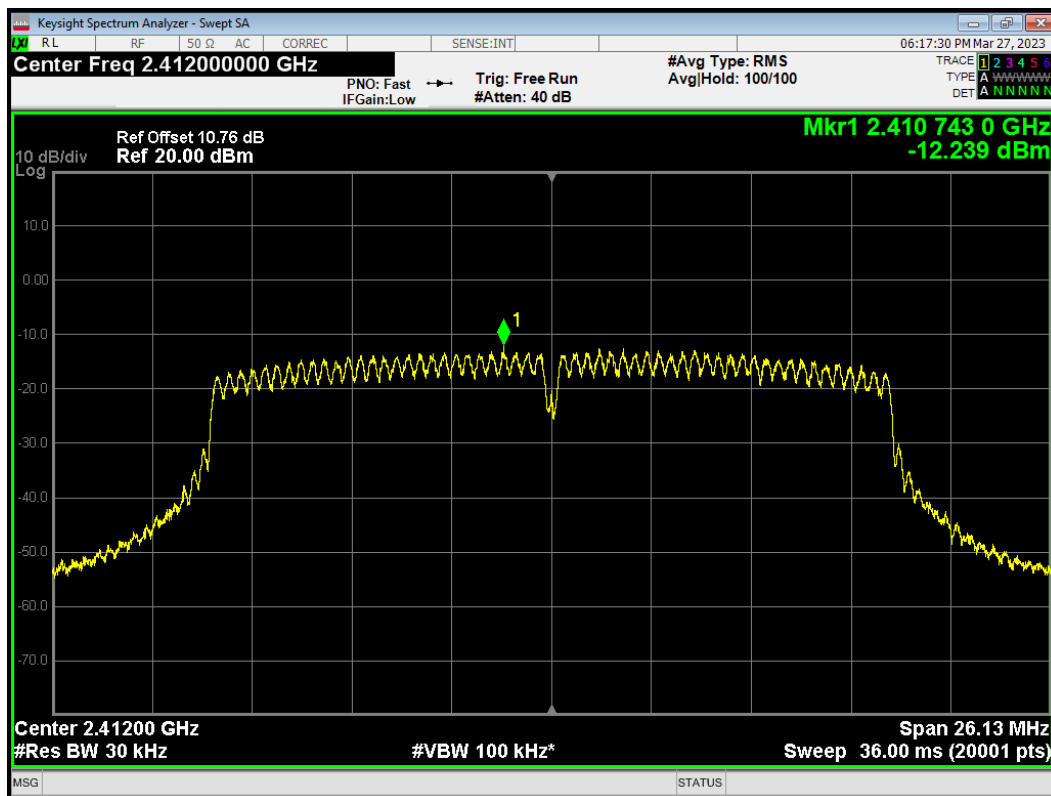
PSD 802.11g 2457MHz



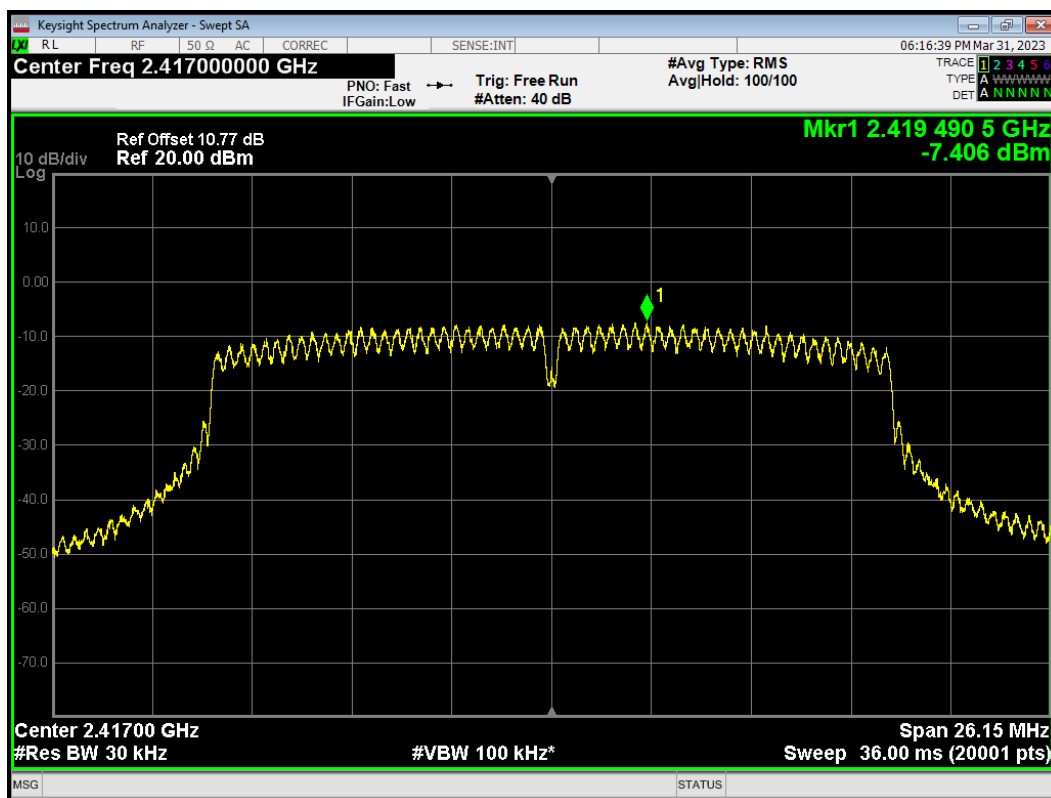
PSD 802.11g 2462MHz



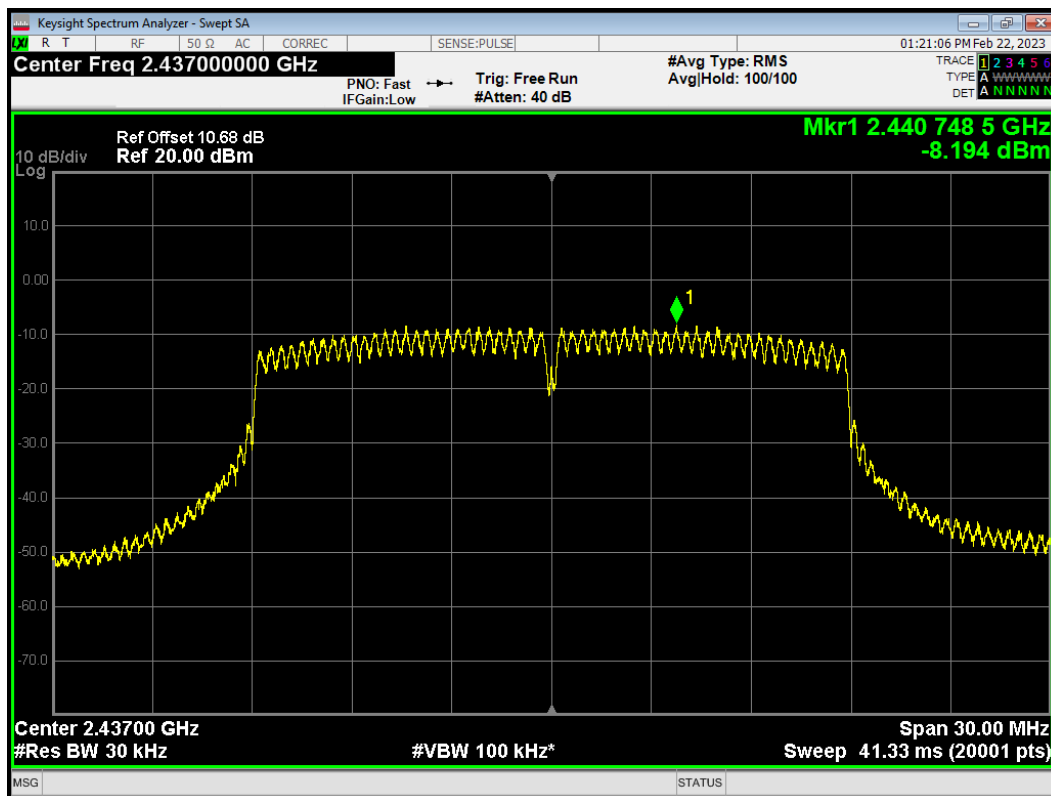
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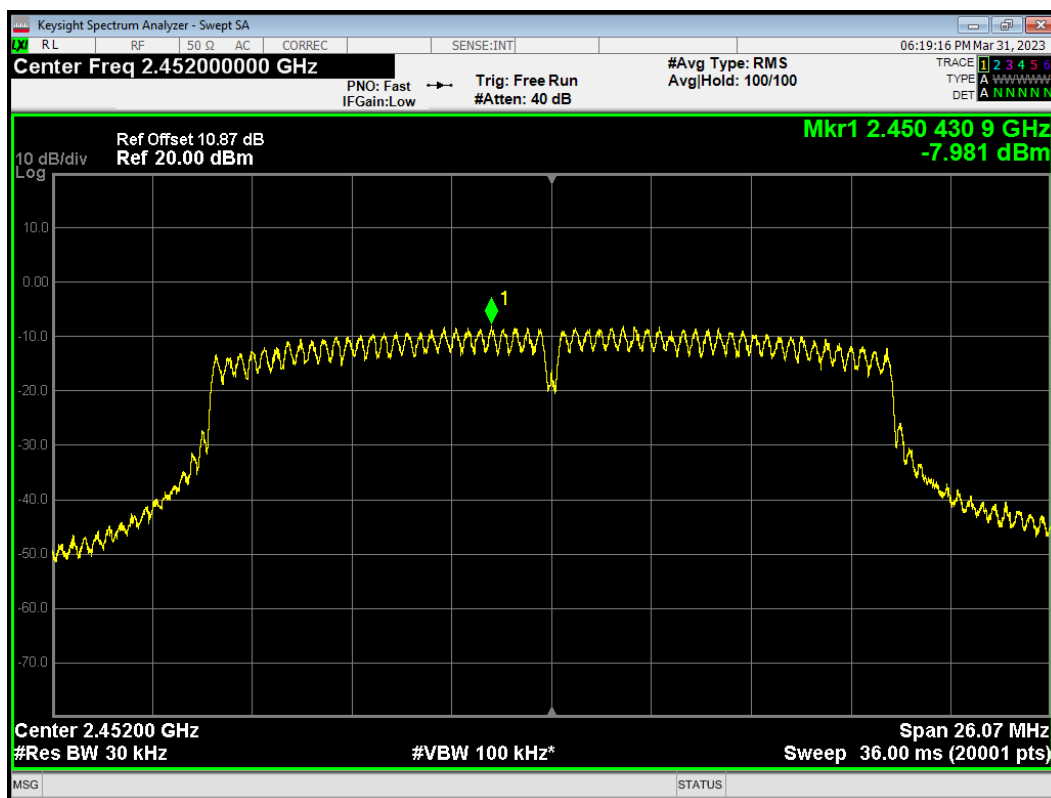
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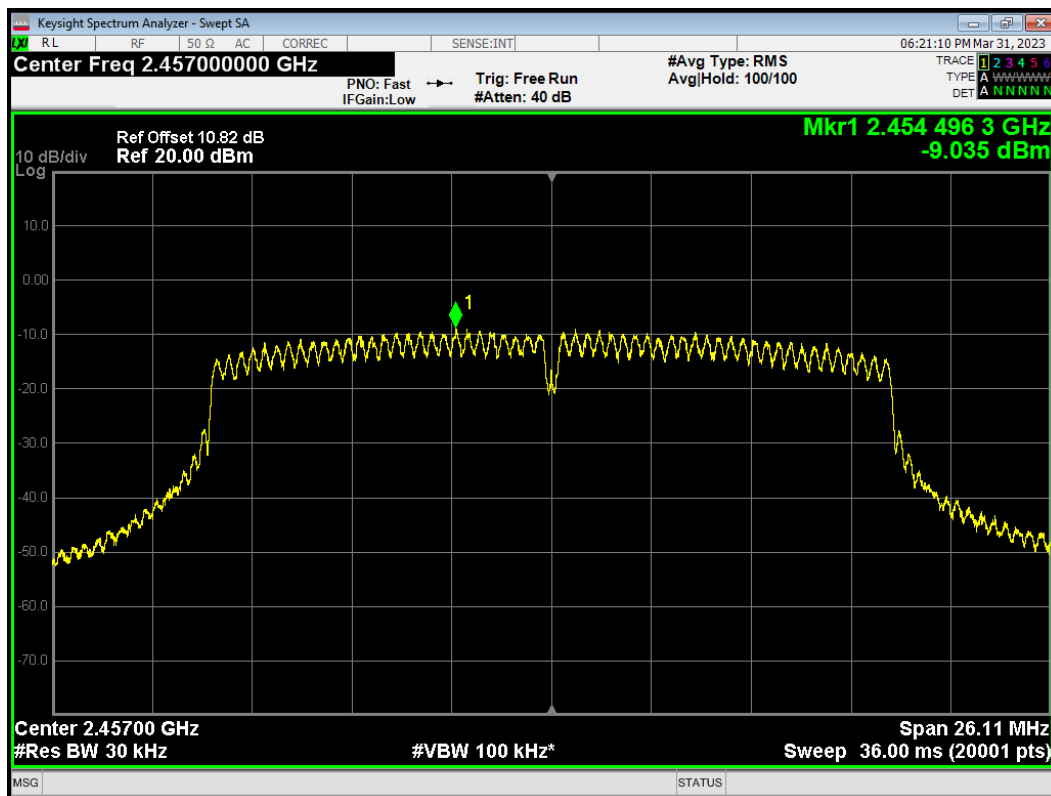
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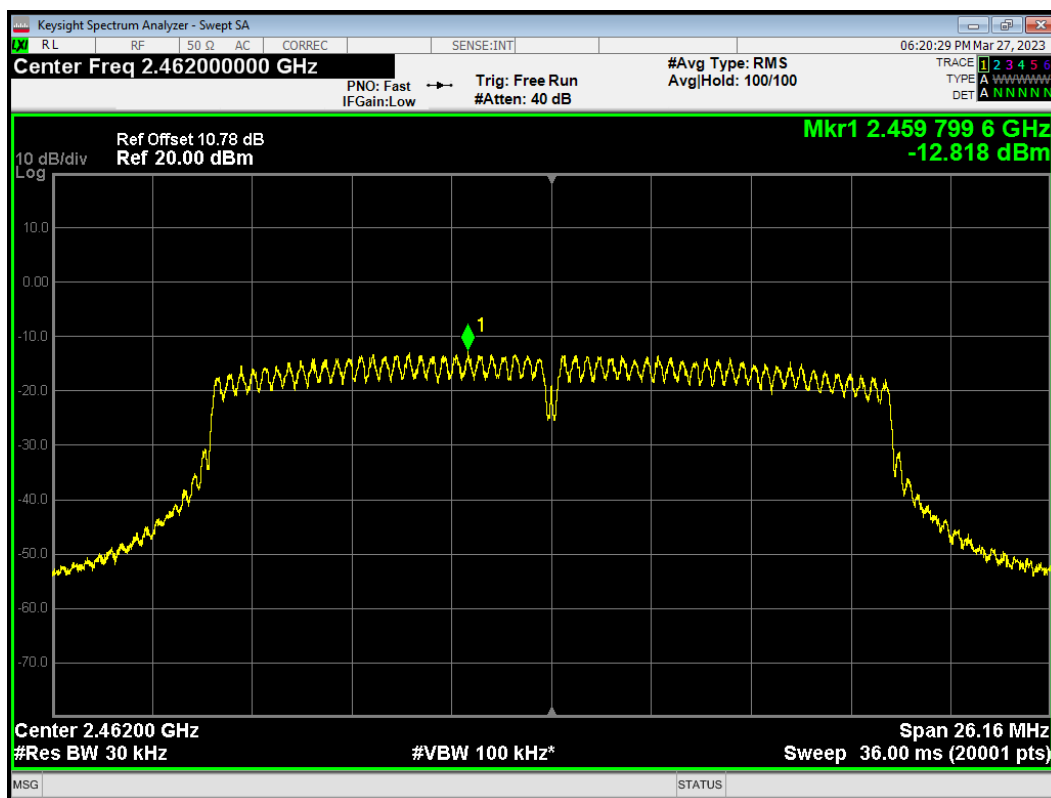
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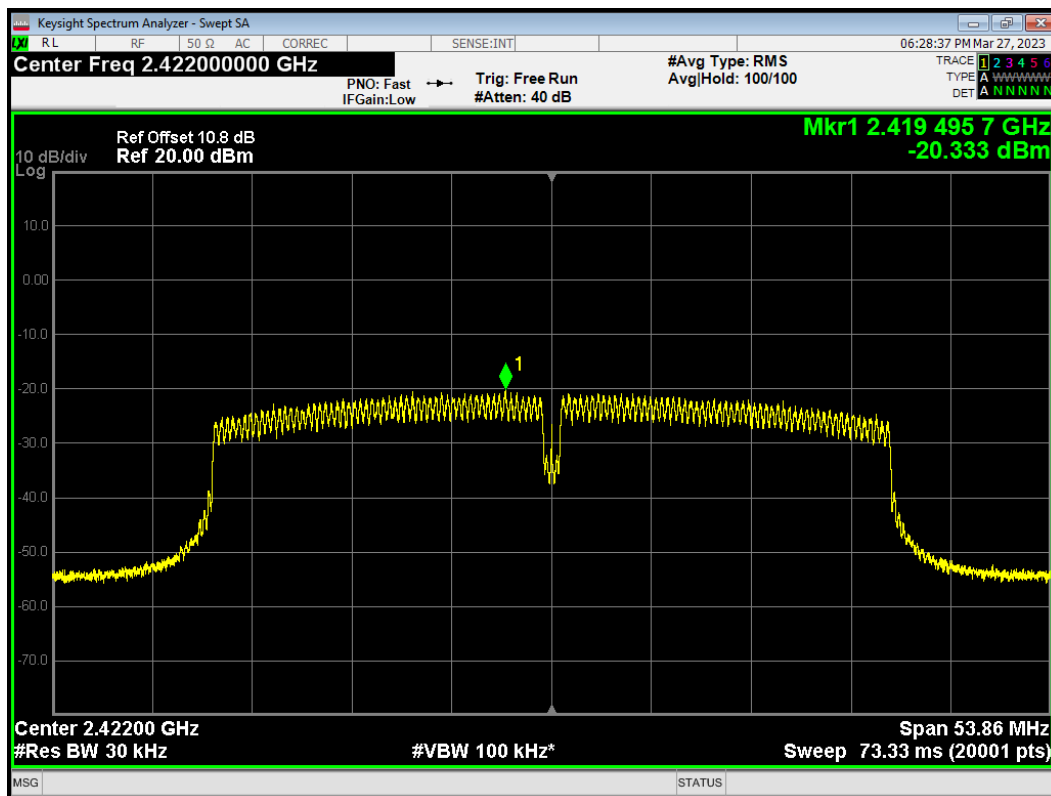
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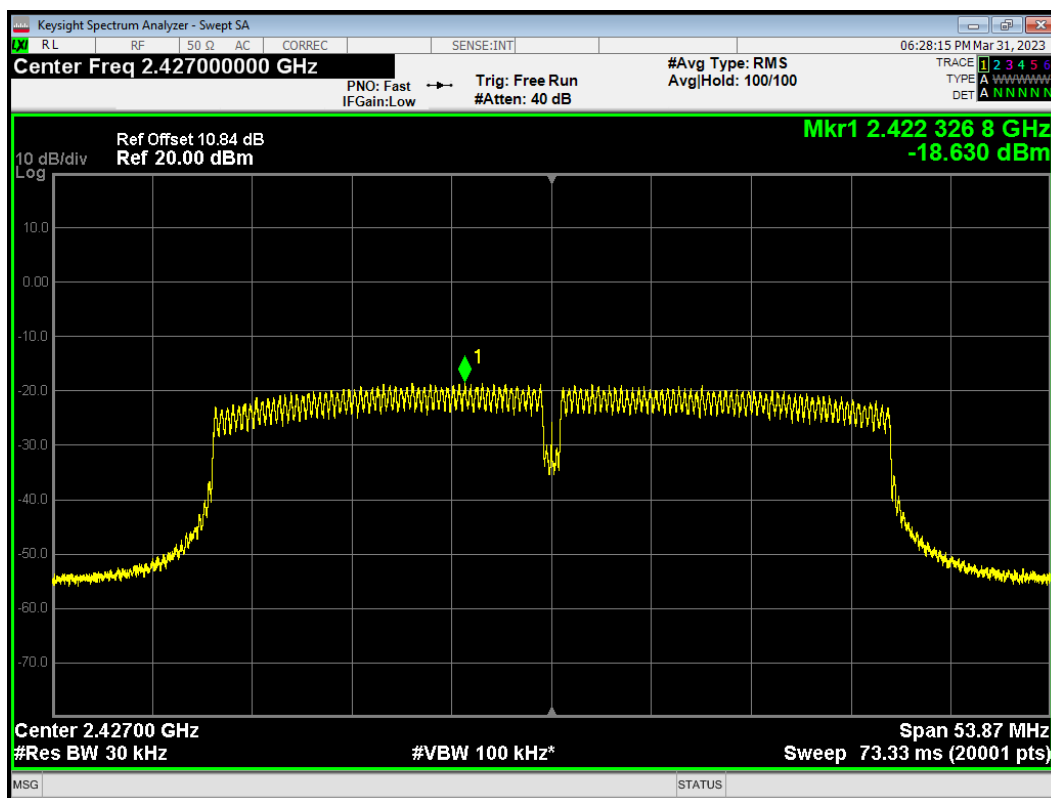
PSD 802.11n(HT20) 2462MHz



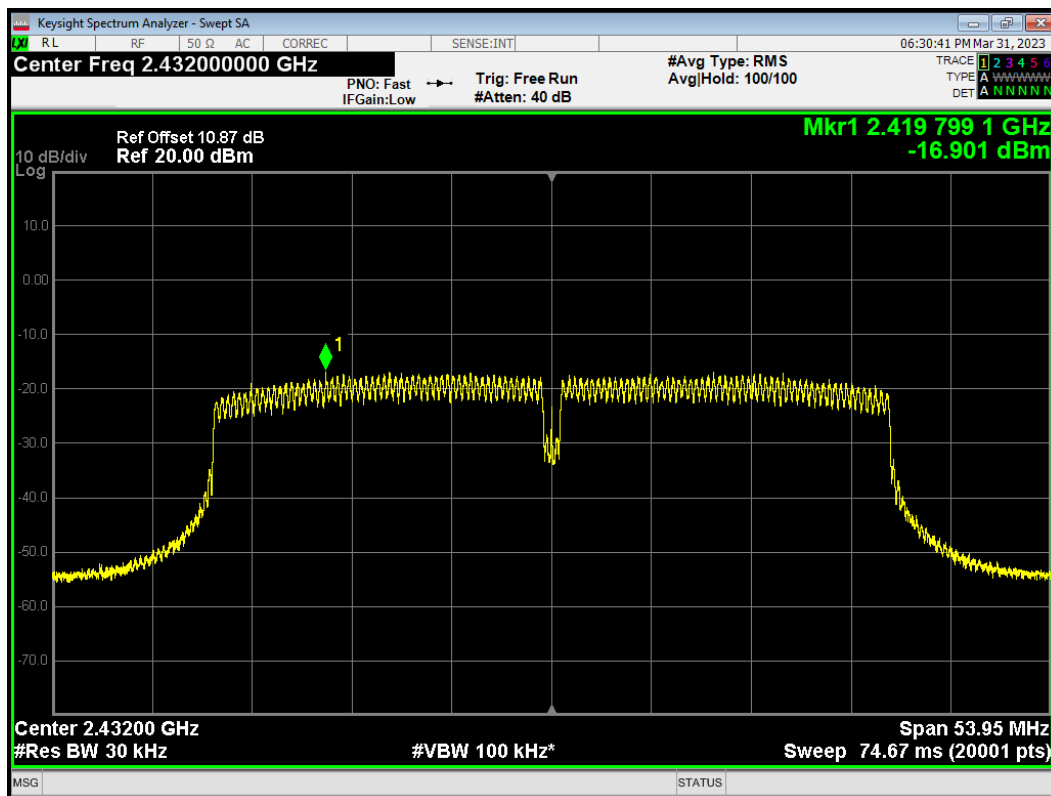
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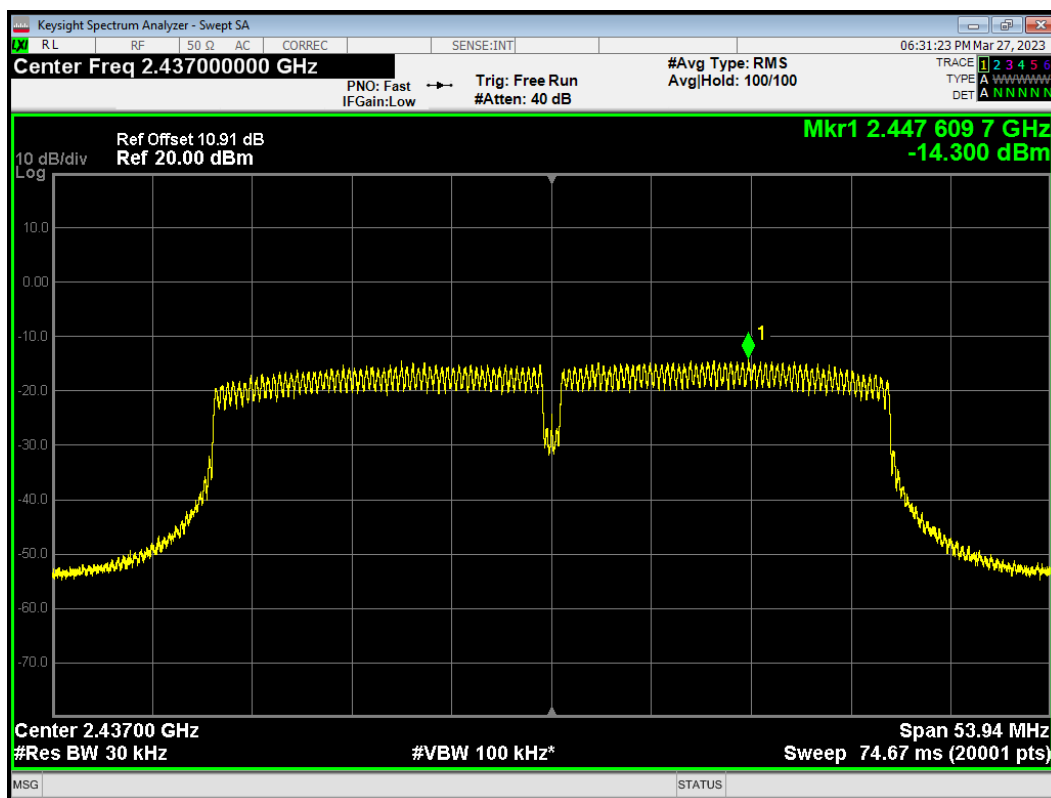
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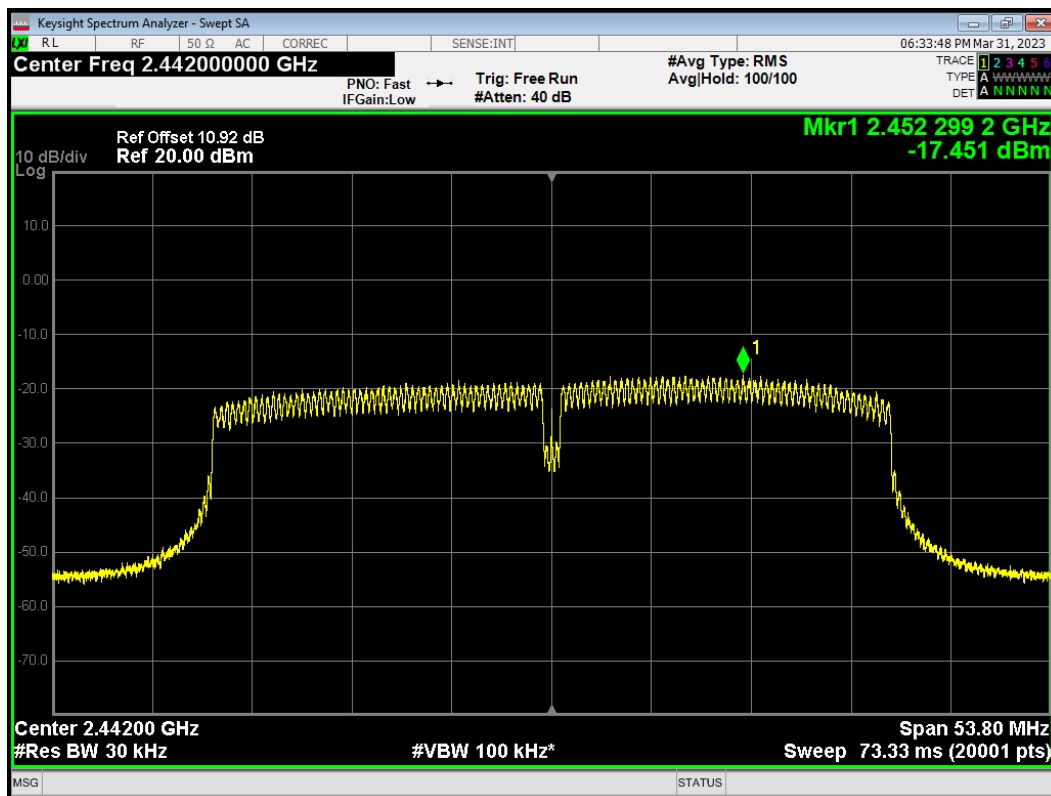
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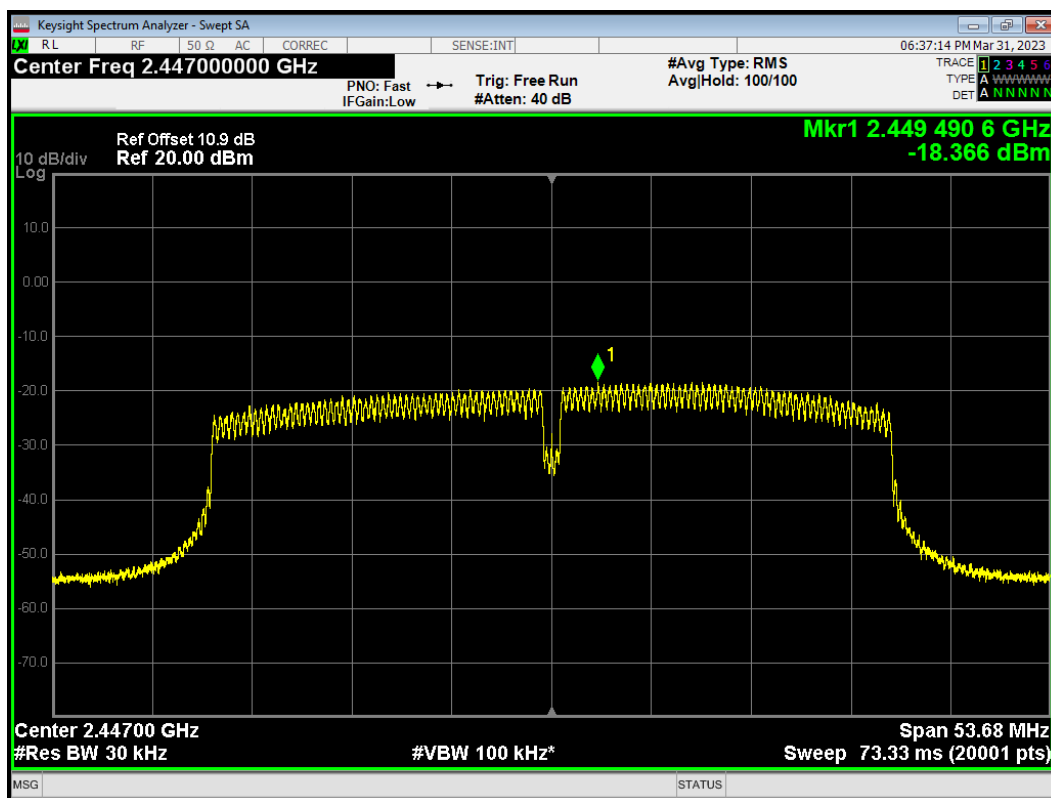
PSD 802.11n(HT40) 2437MHz



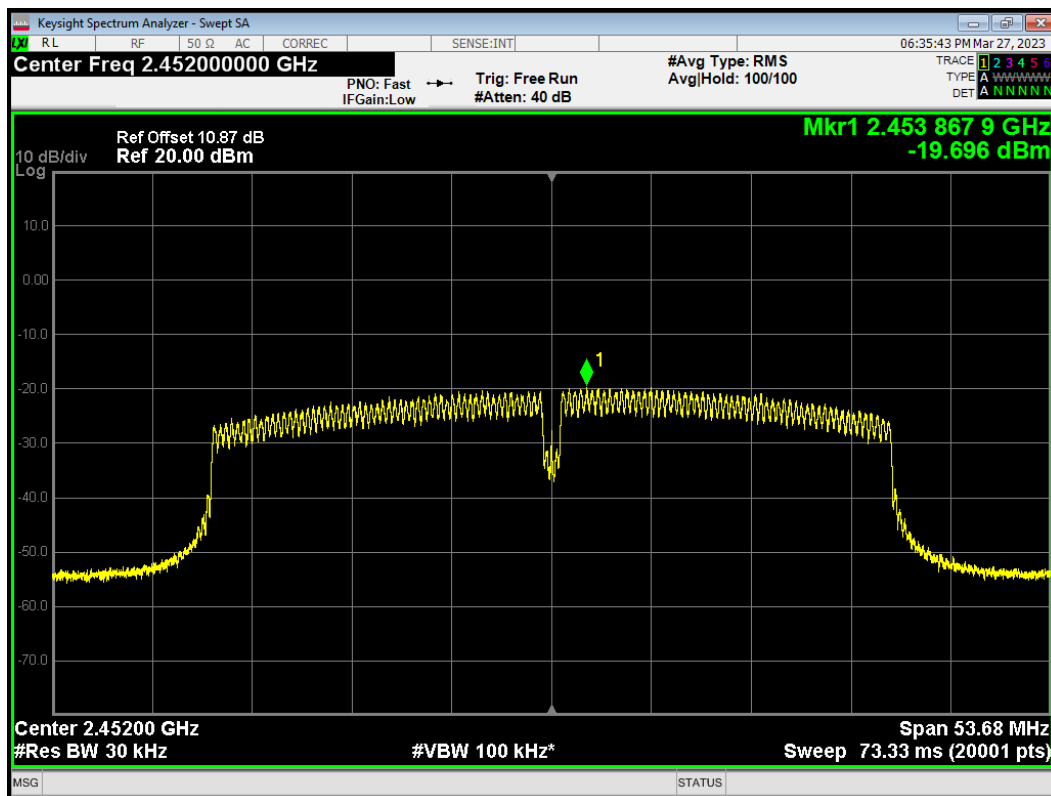
PSD 802.11n(HT40) 2442MHz



PSD 802.11n(HT40) 2447MHz

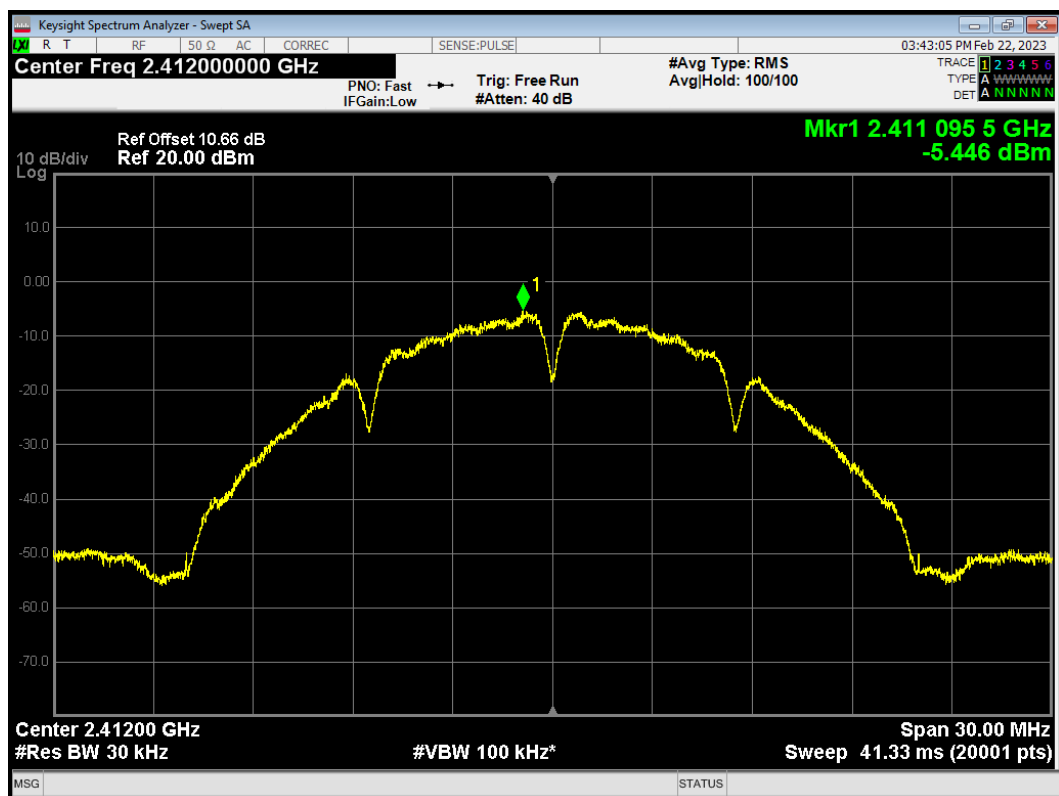


PSD 802.11n(HT40) 2452MHz

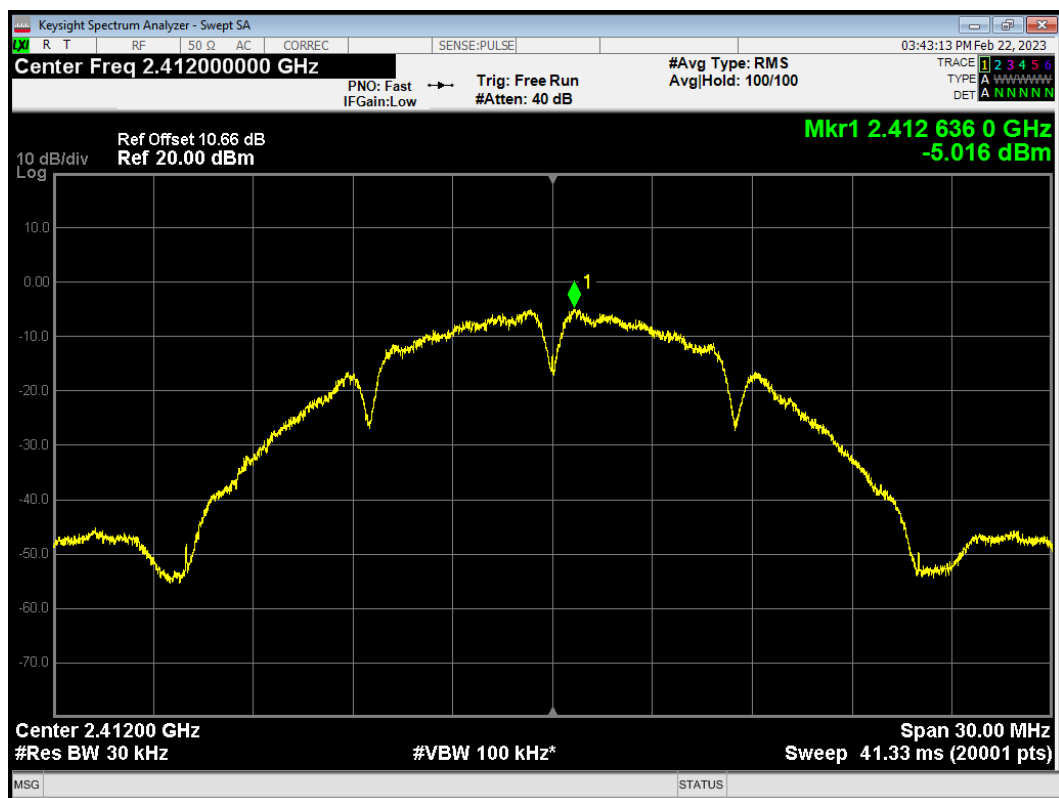


CDD/MIMO

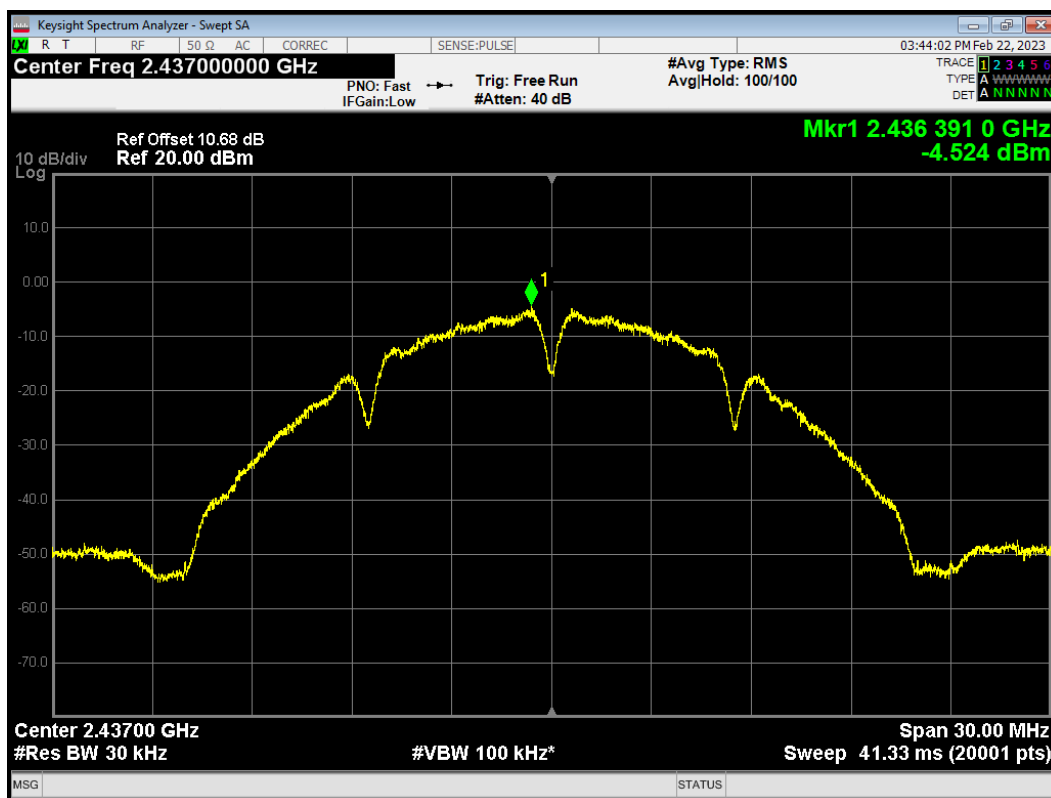
PSD 802.11b 2412MHz



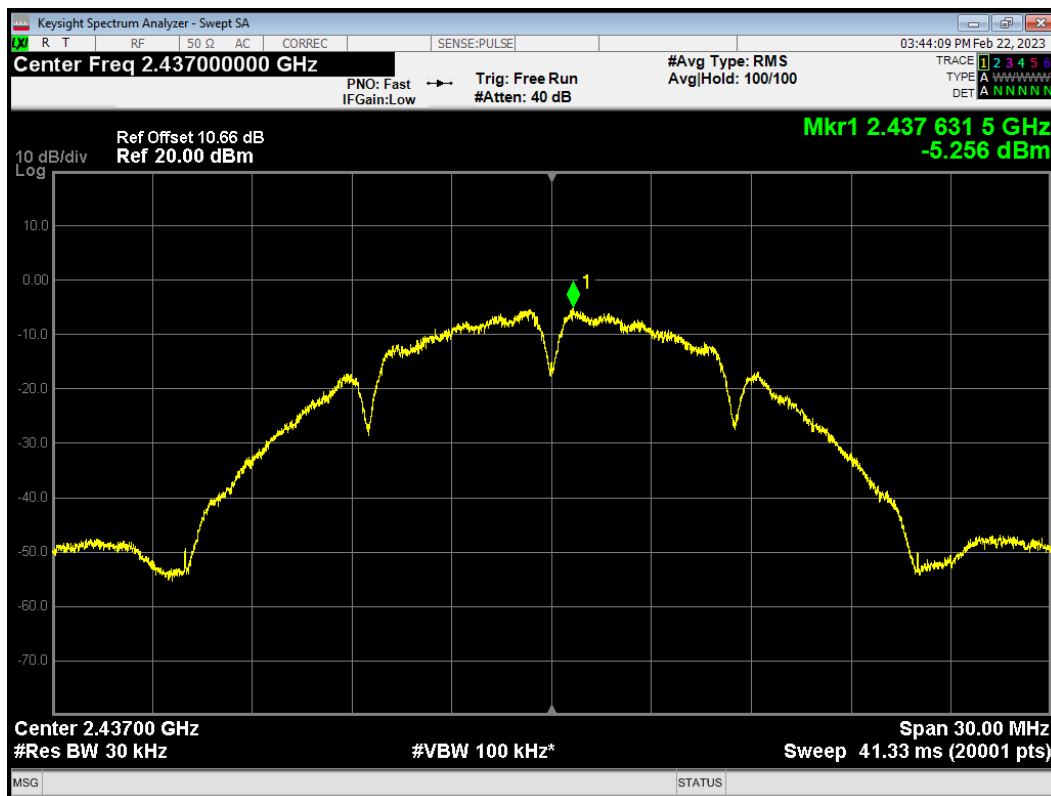
PSD 802.11b 2412MHz Ant2



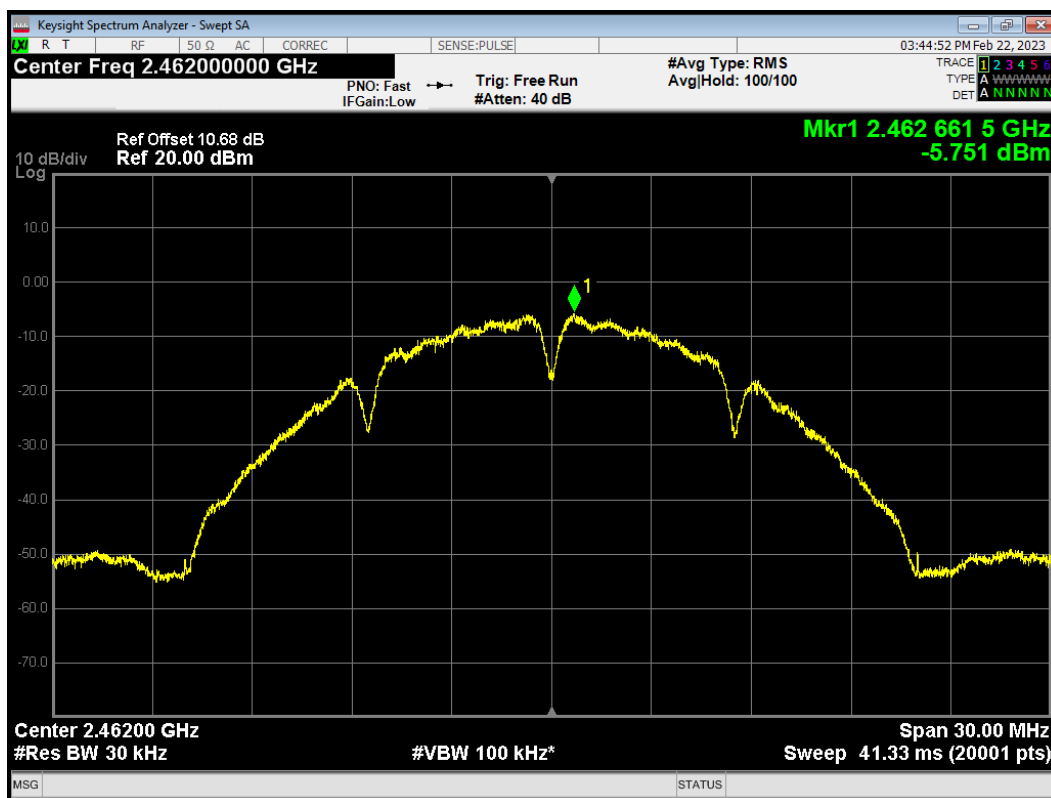
PSD 802.11b 2437MHz



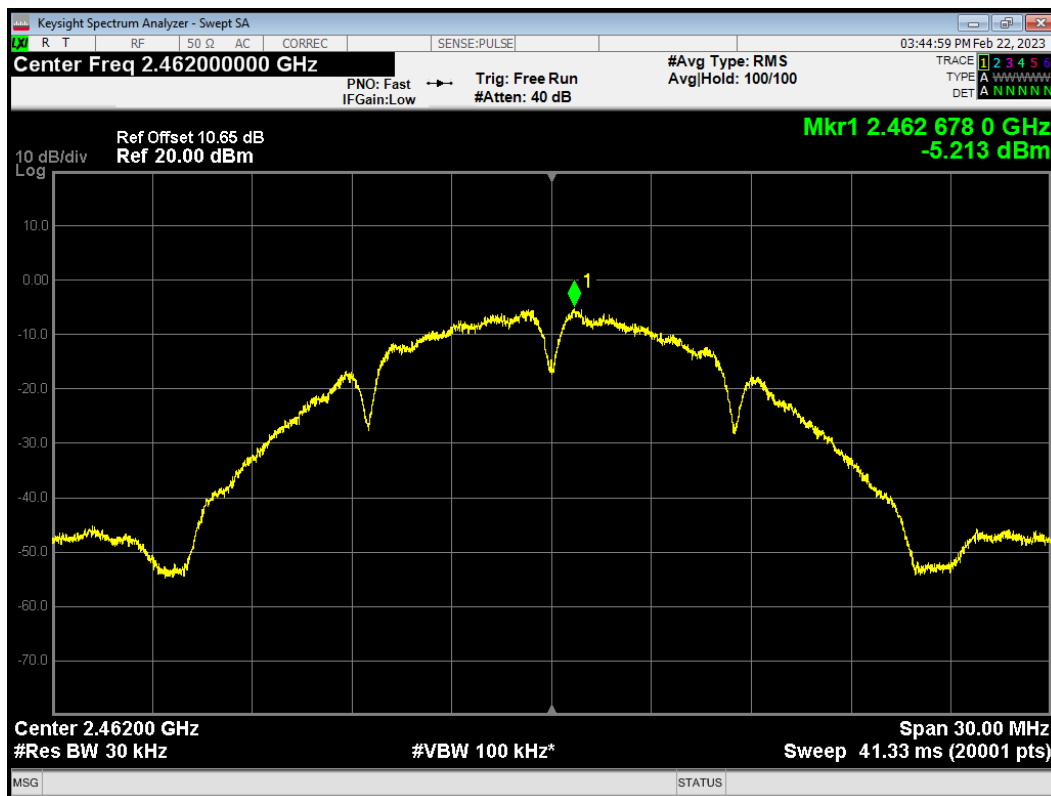
PSD 802.11b 2437MHz Ant2



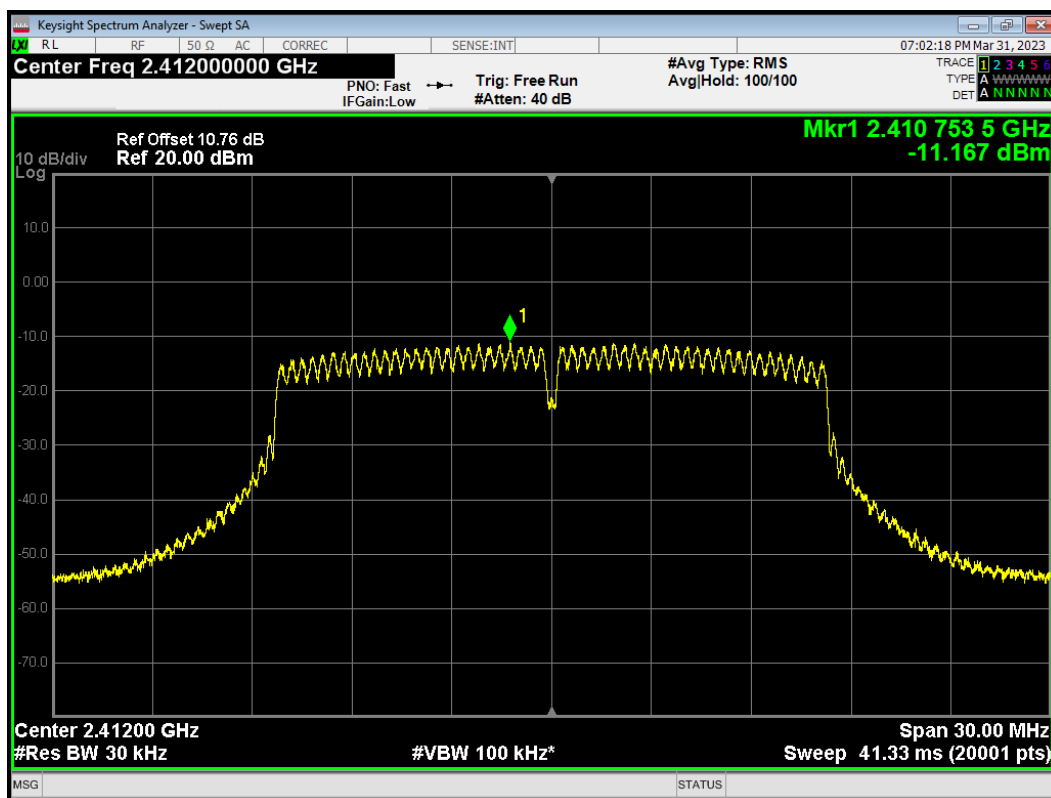
PSD 802.11b 2462MHz



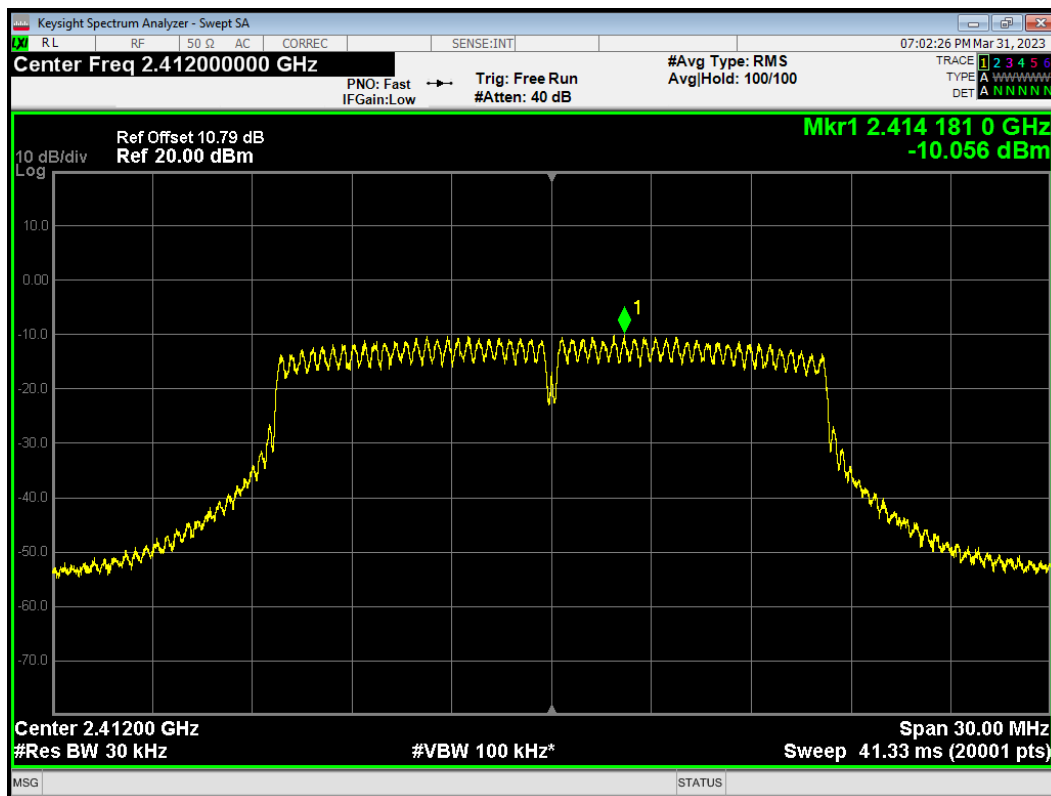
PSD 802.11b 2462MHz Ant2



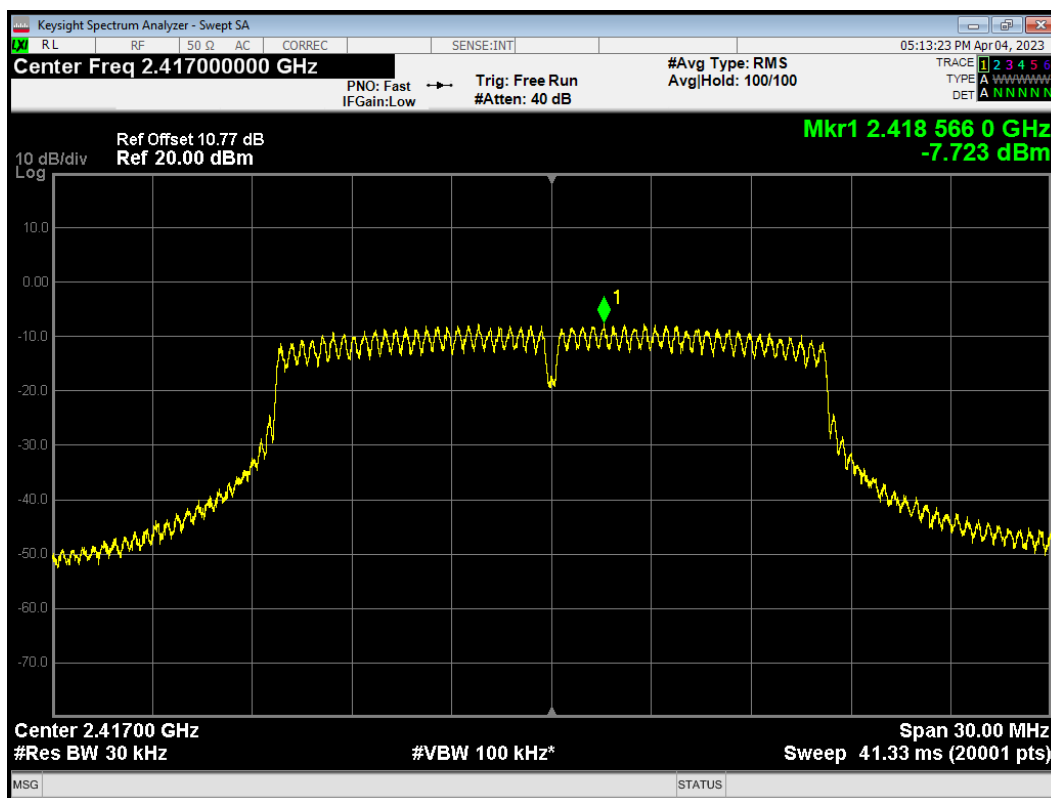
PSD 802.11g 2412MHz



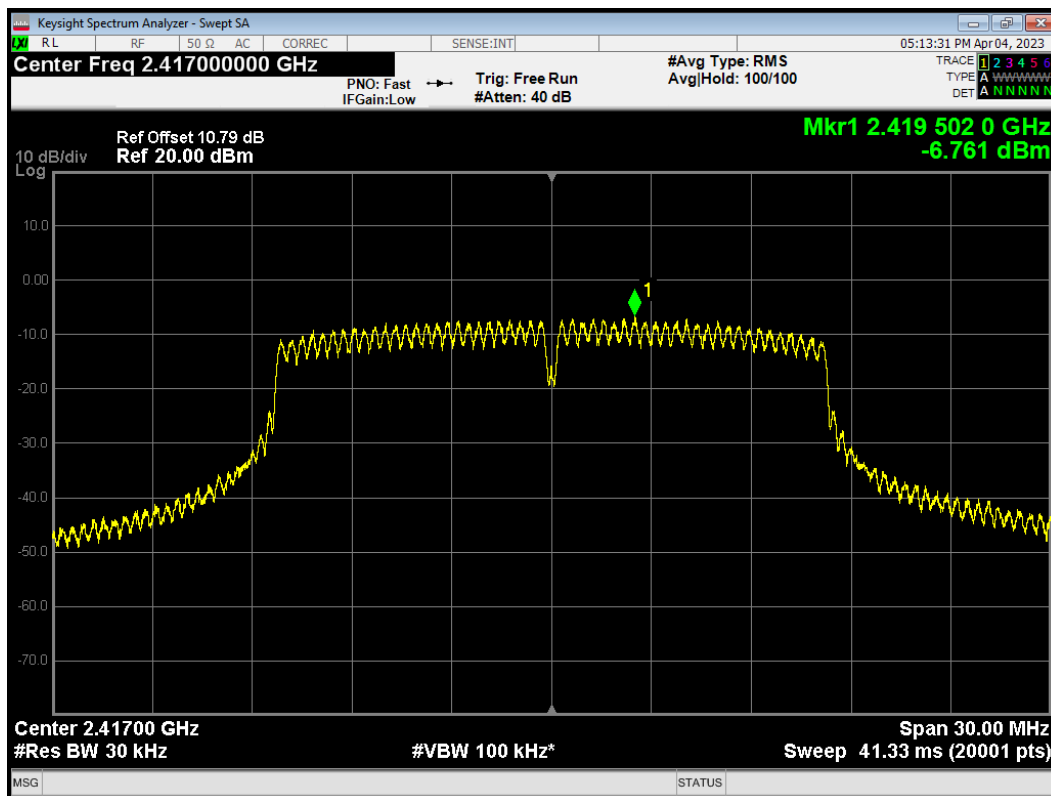
PSD 802.11g 2412MHz Ant2



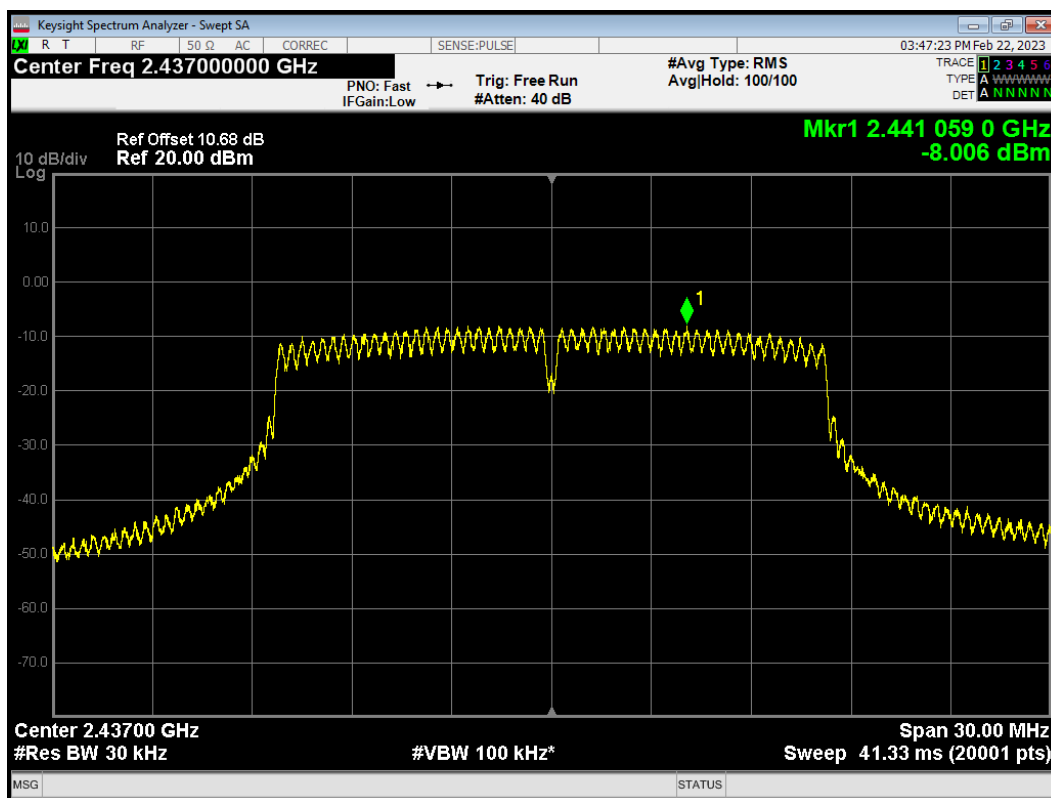
PSD 802.11g 2417MHz



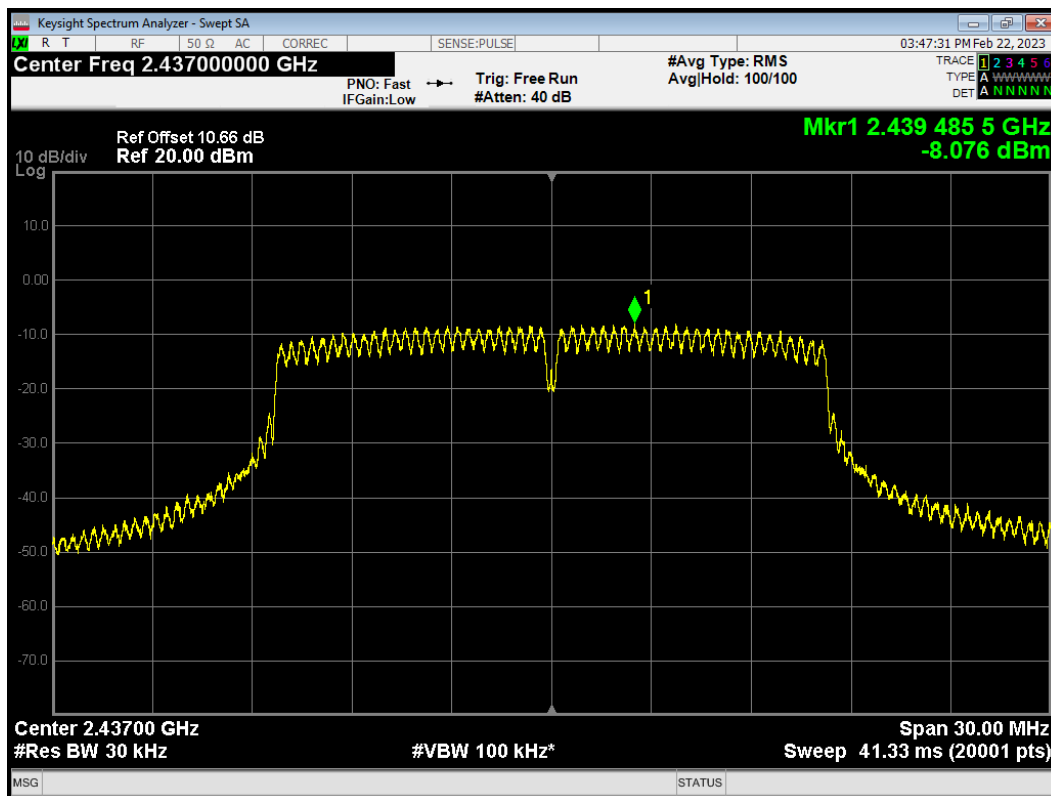
PSD 802.11g 2417MHz Ant2



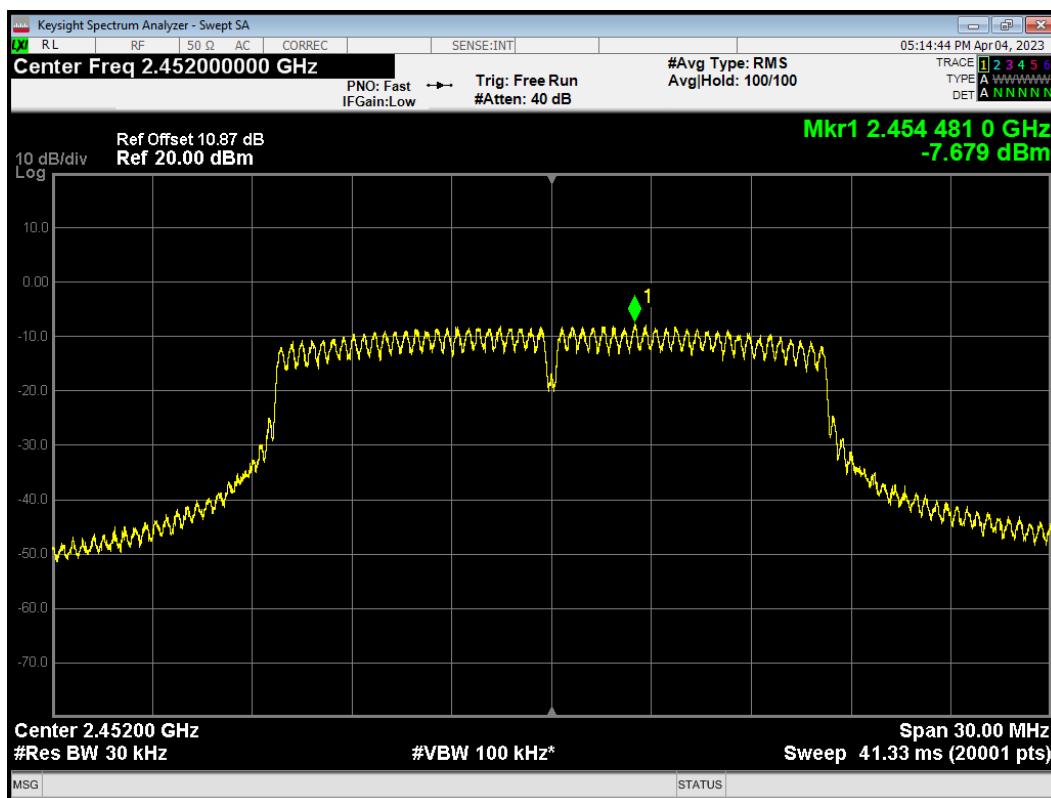
PSD 802.11g 2437MHz



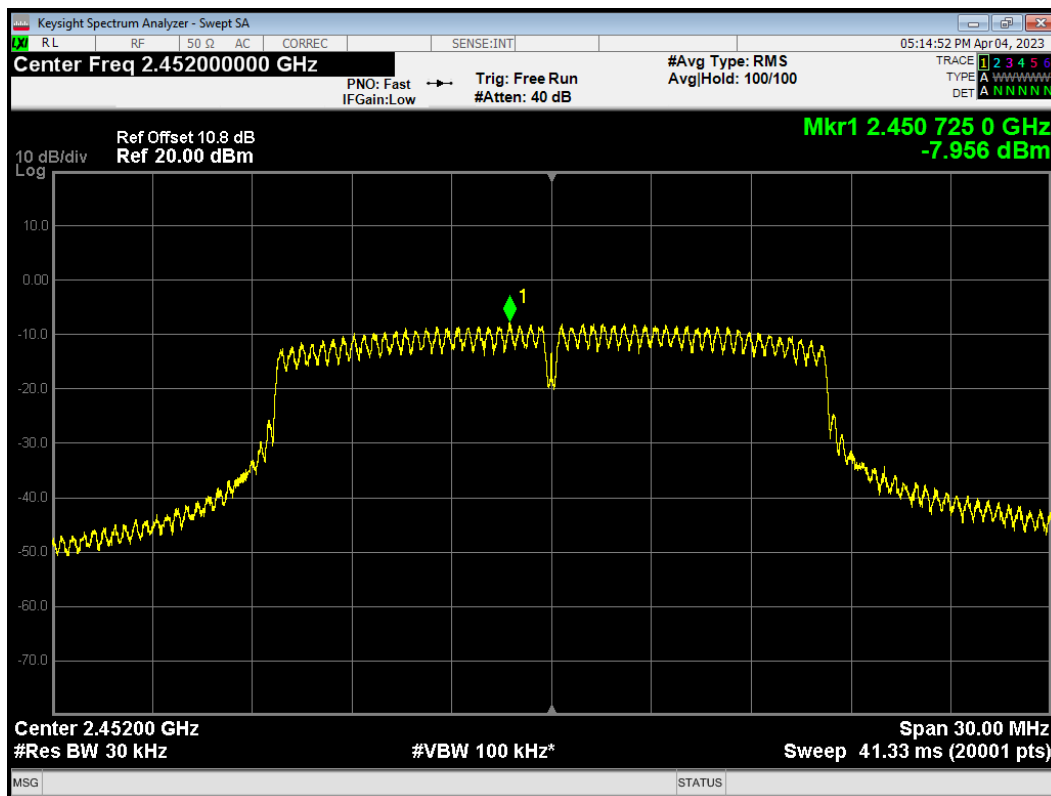
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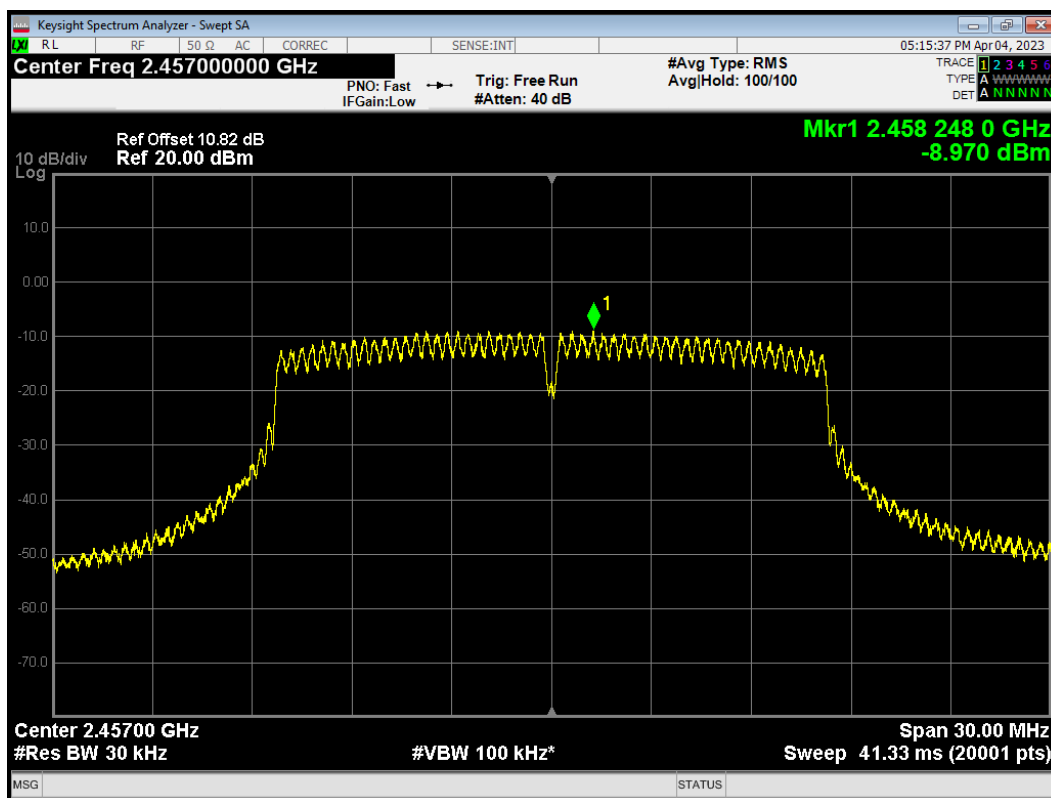
PSD 802.11g 2452MHz



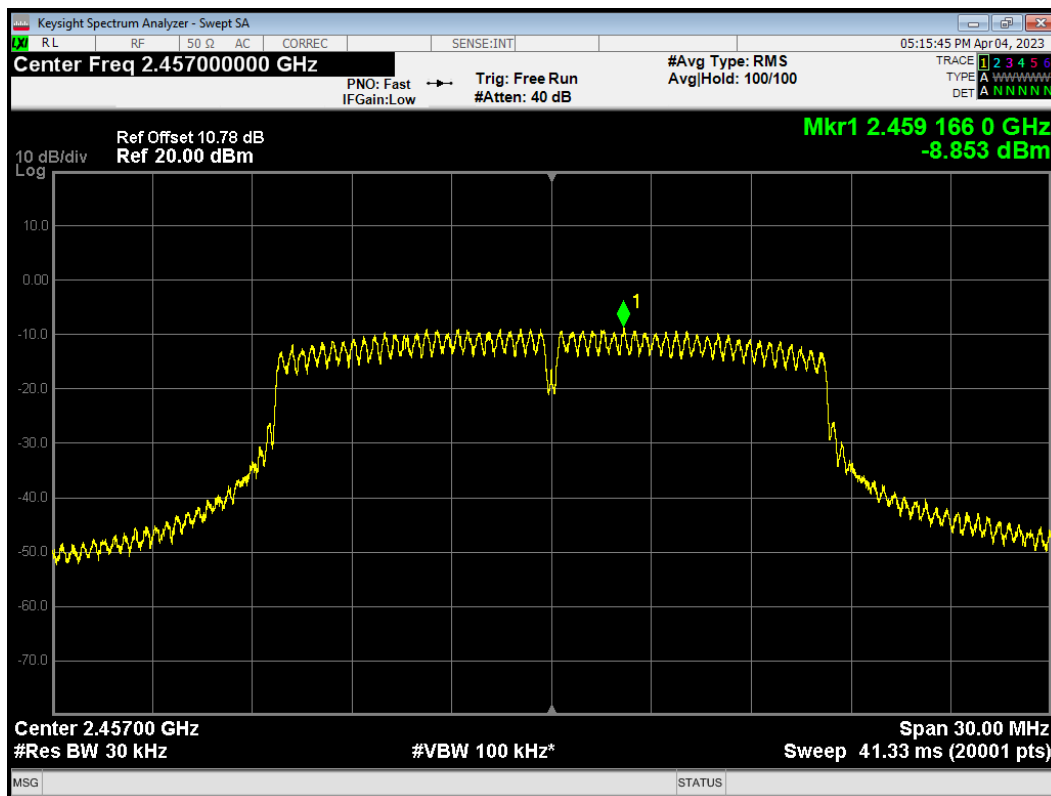
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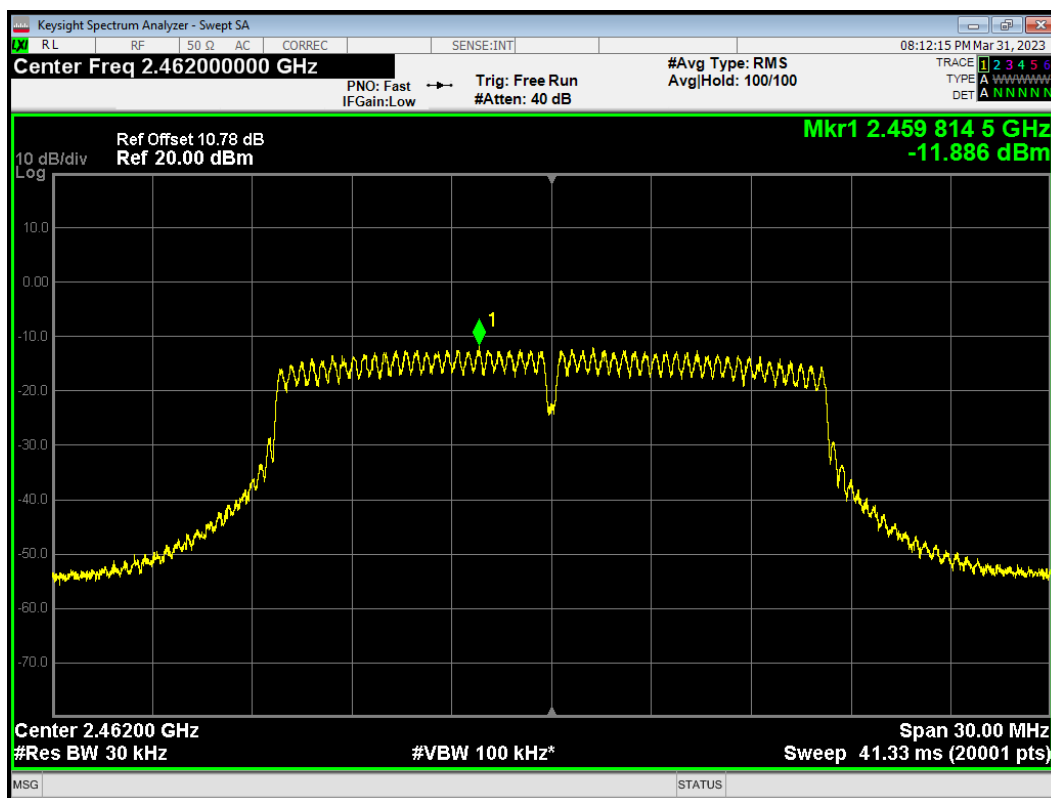
PSD 802.11g 2457MHz



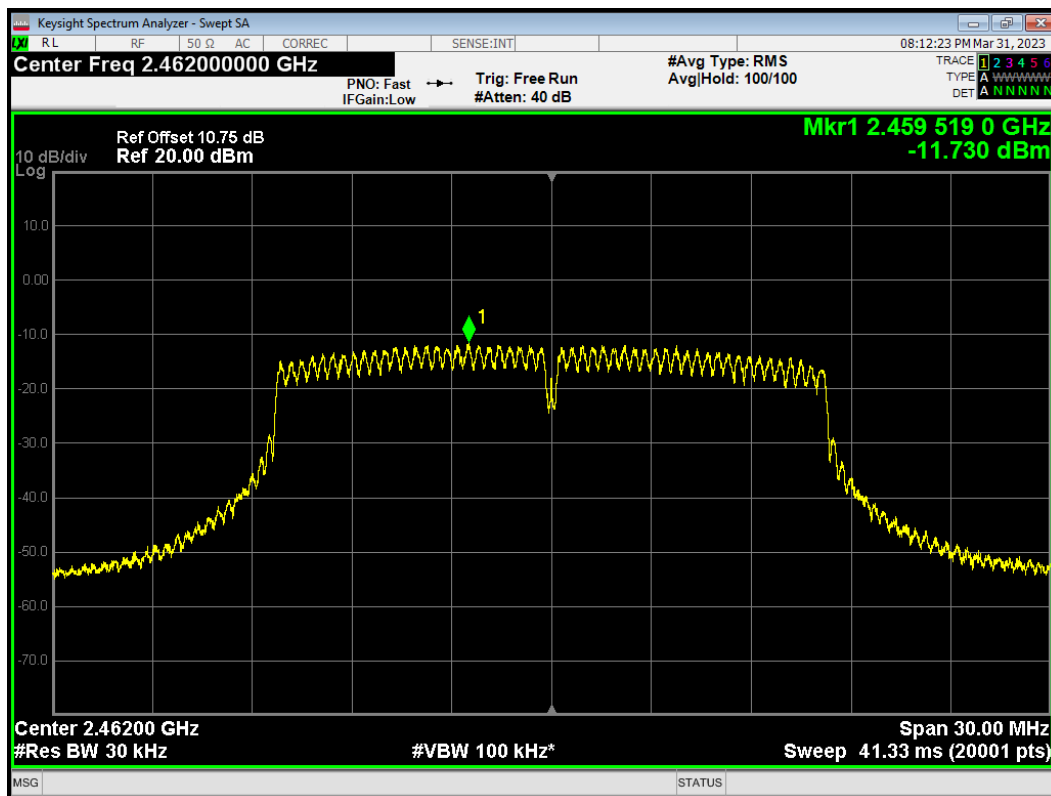
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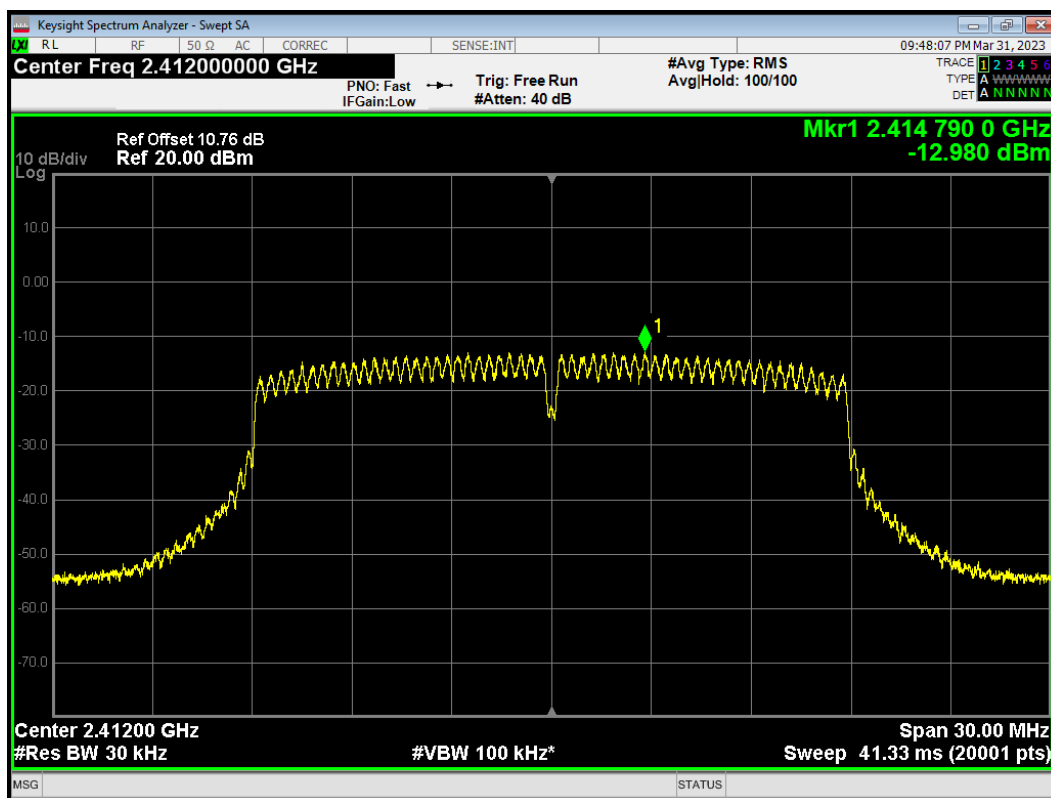
PSD 802.11g 2462MHz



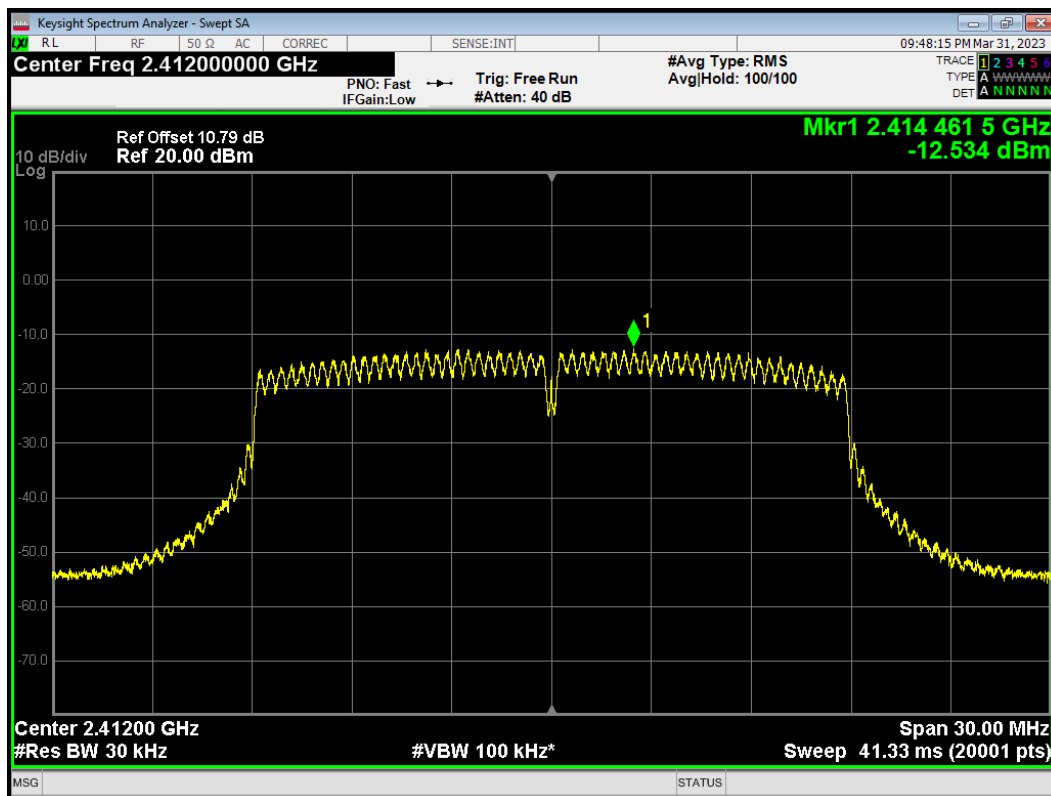
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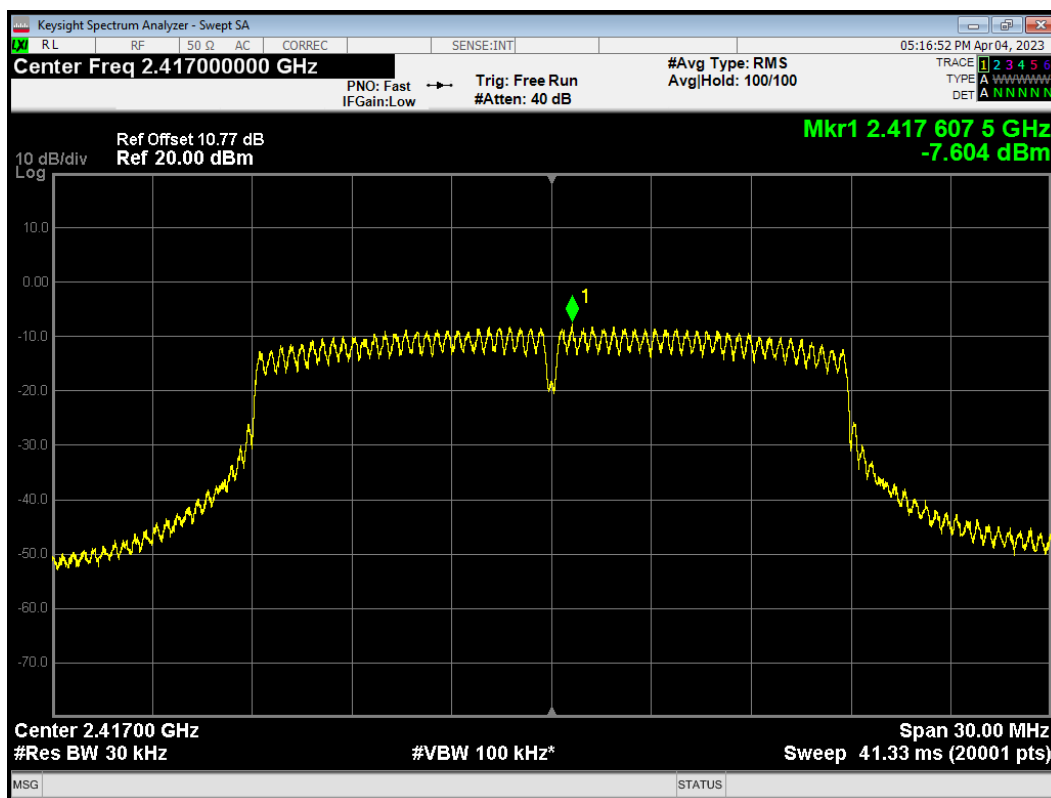
PSD 802.11n(HT20) 2412MHz



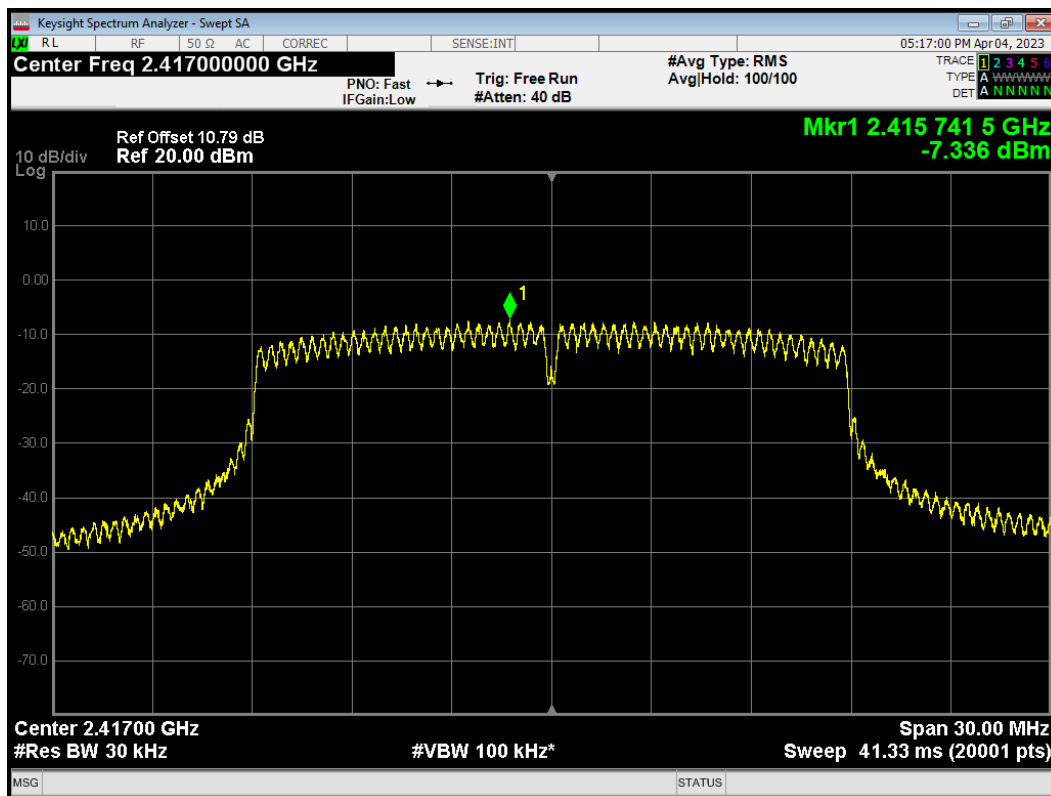
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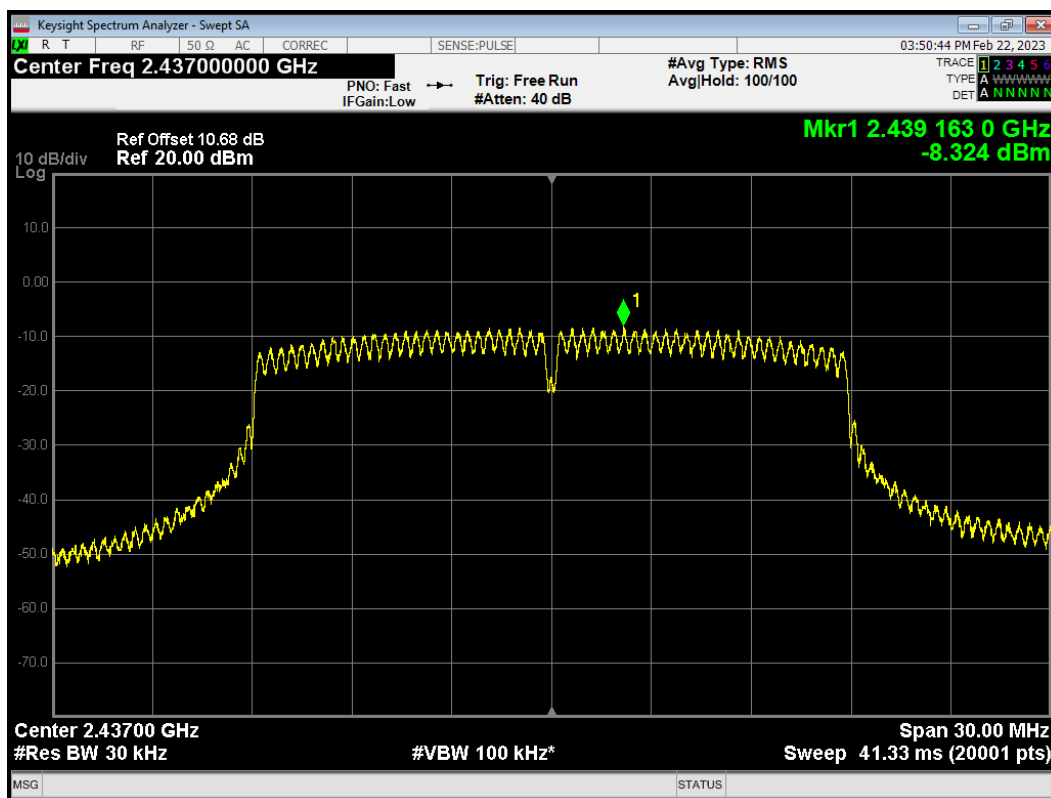
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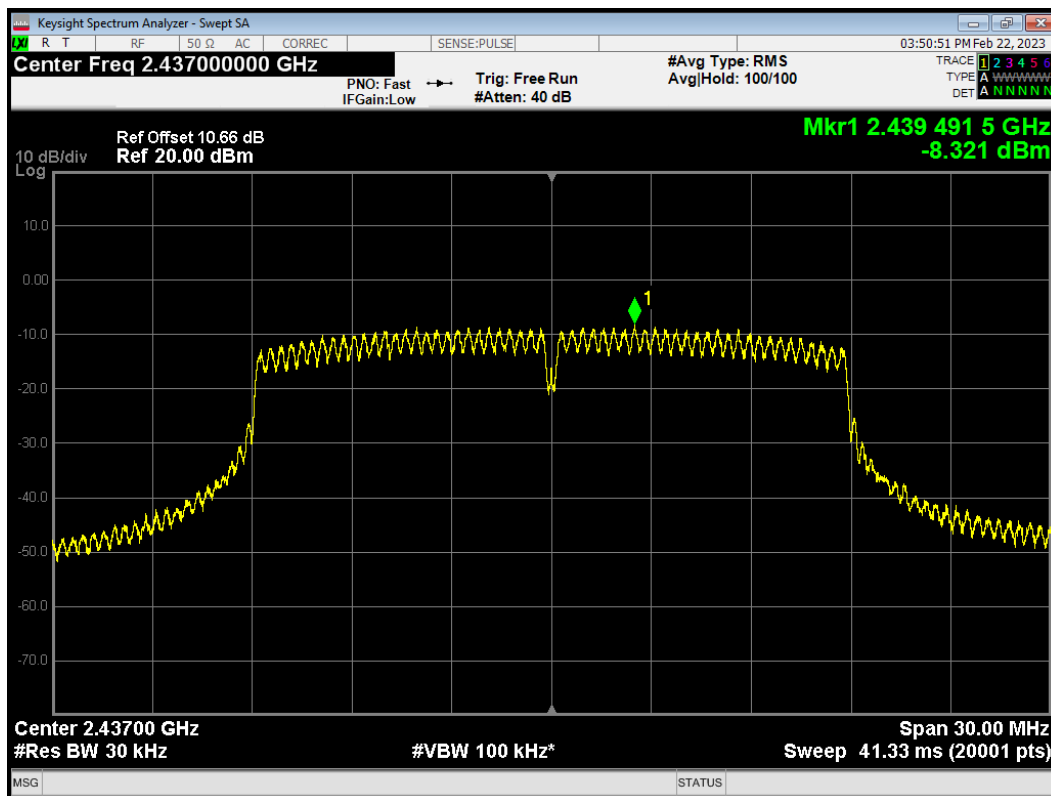
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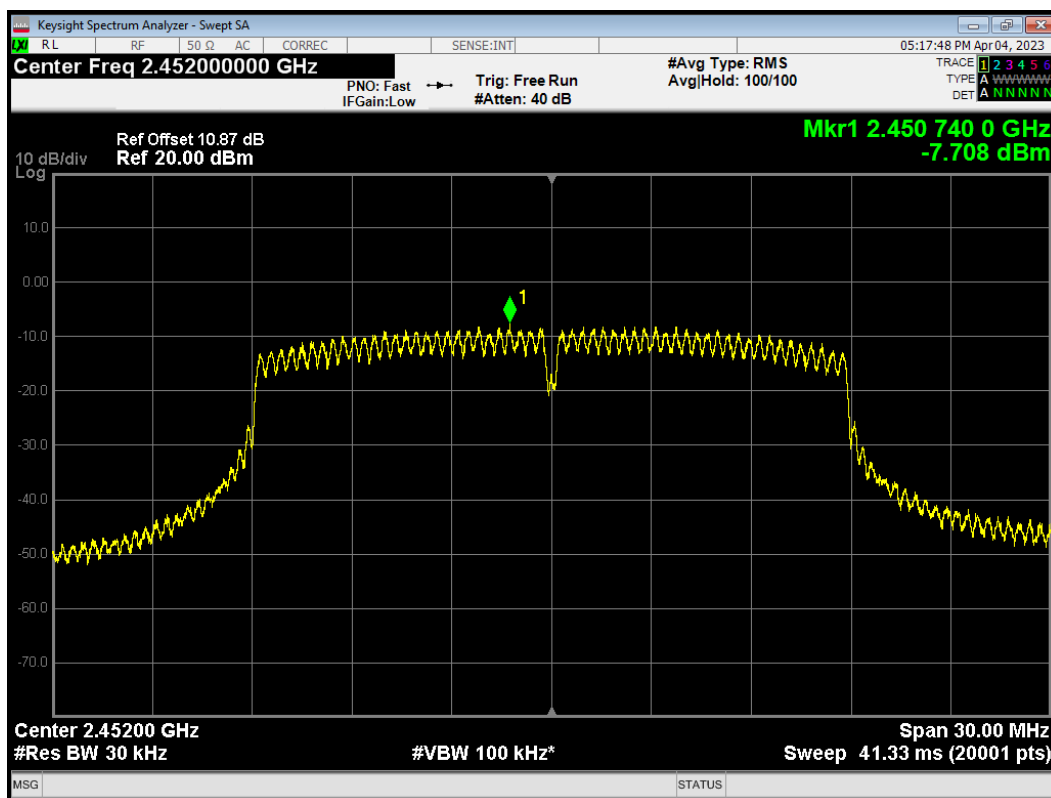
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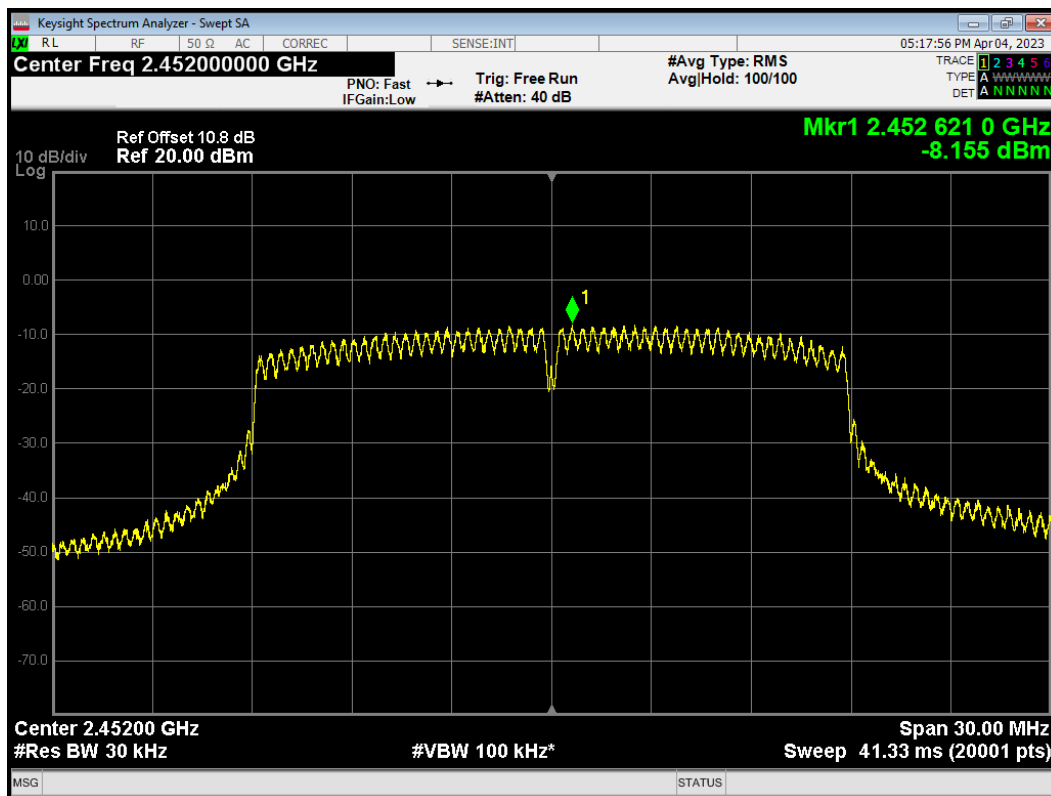
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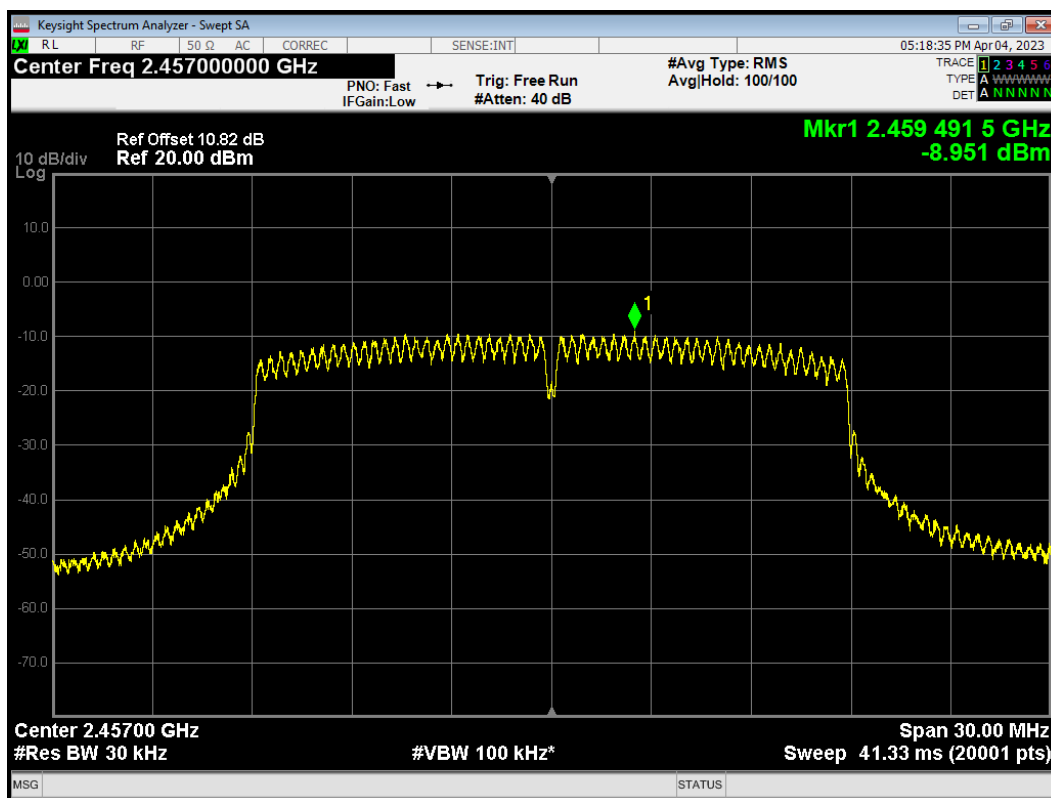
PSD 802.11n(HT20) 2452MHz



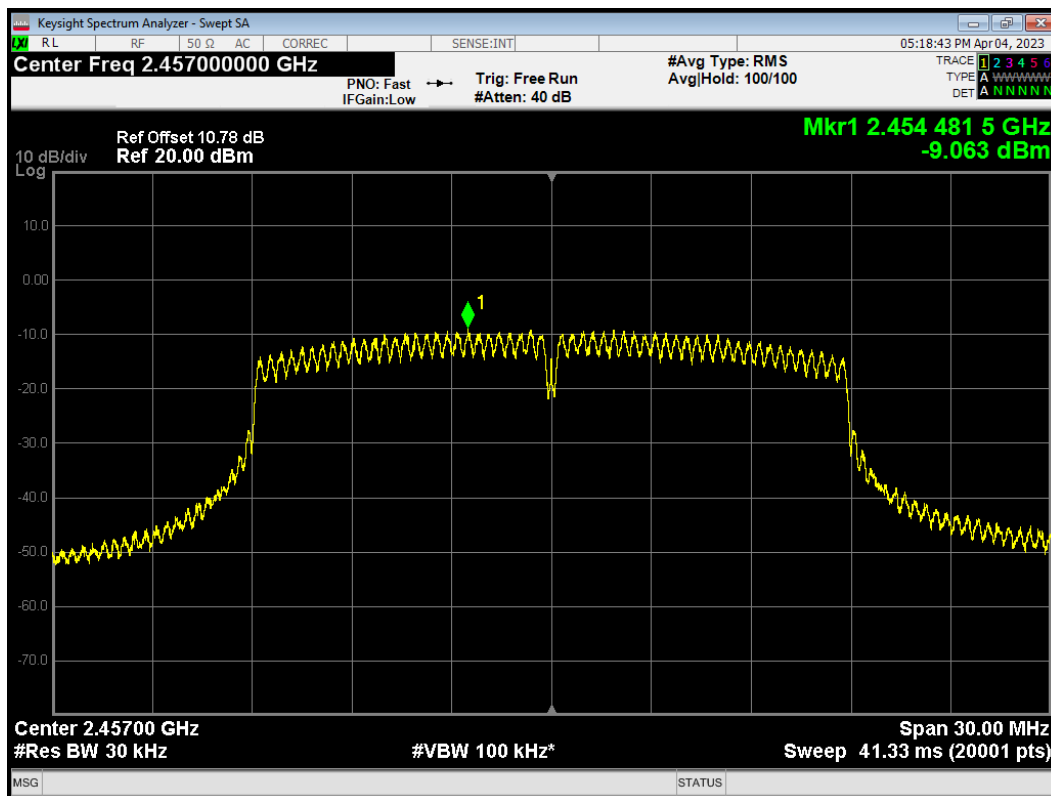
PSD 802.11n(HT20) 2452MHz Ant2



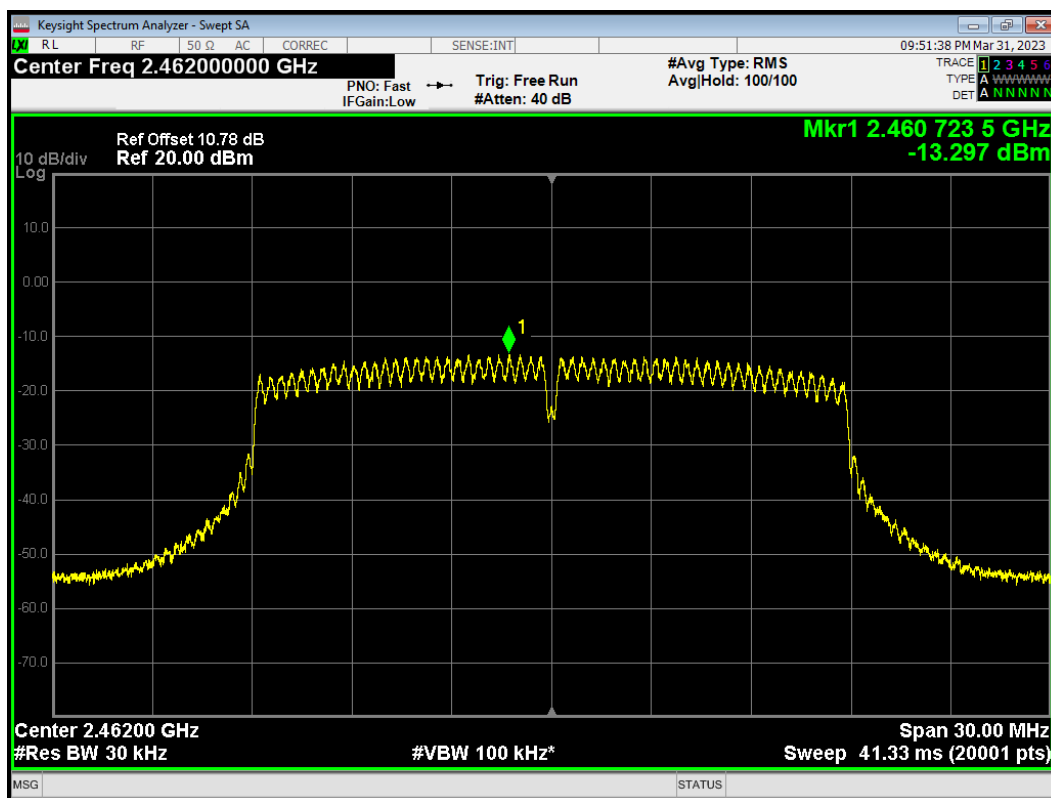
PSD 802.11n(HT20) 2457MHz



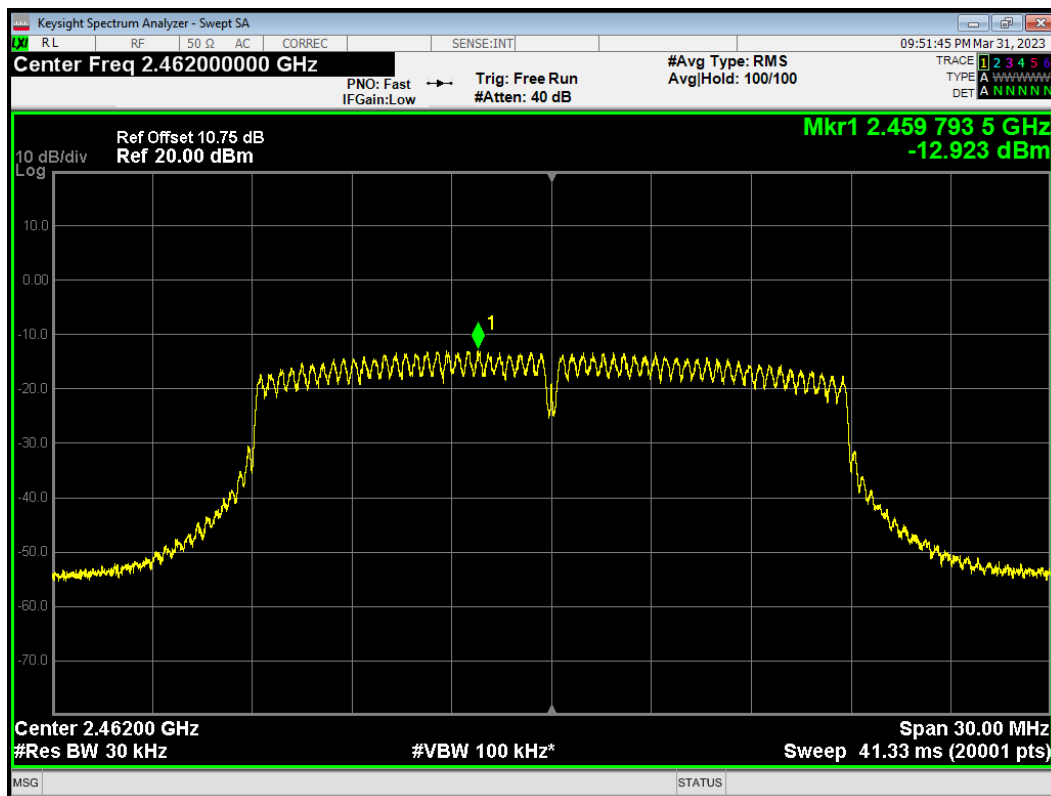
PSD 802.11n(HT20) 2457MHz Ant2



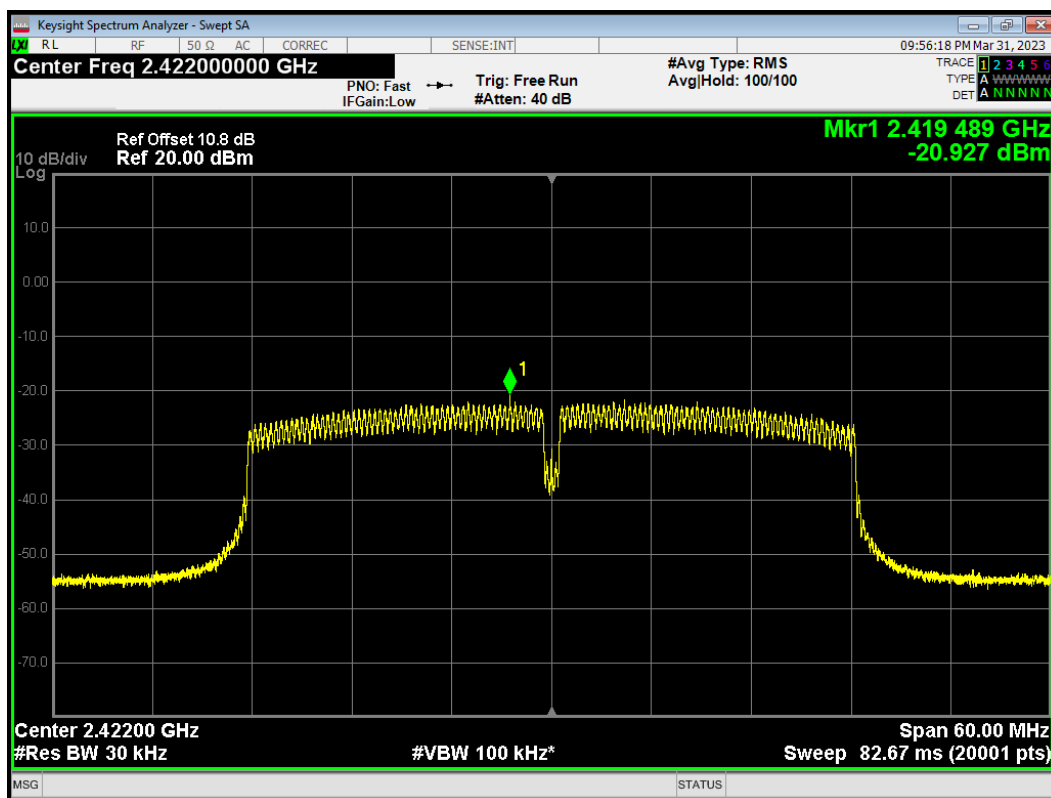
PSD 802.11n(HT20) 2462MHz



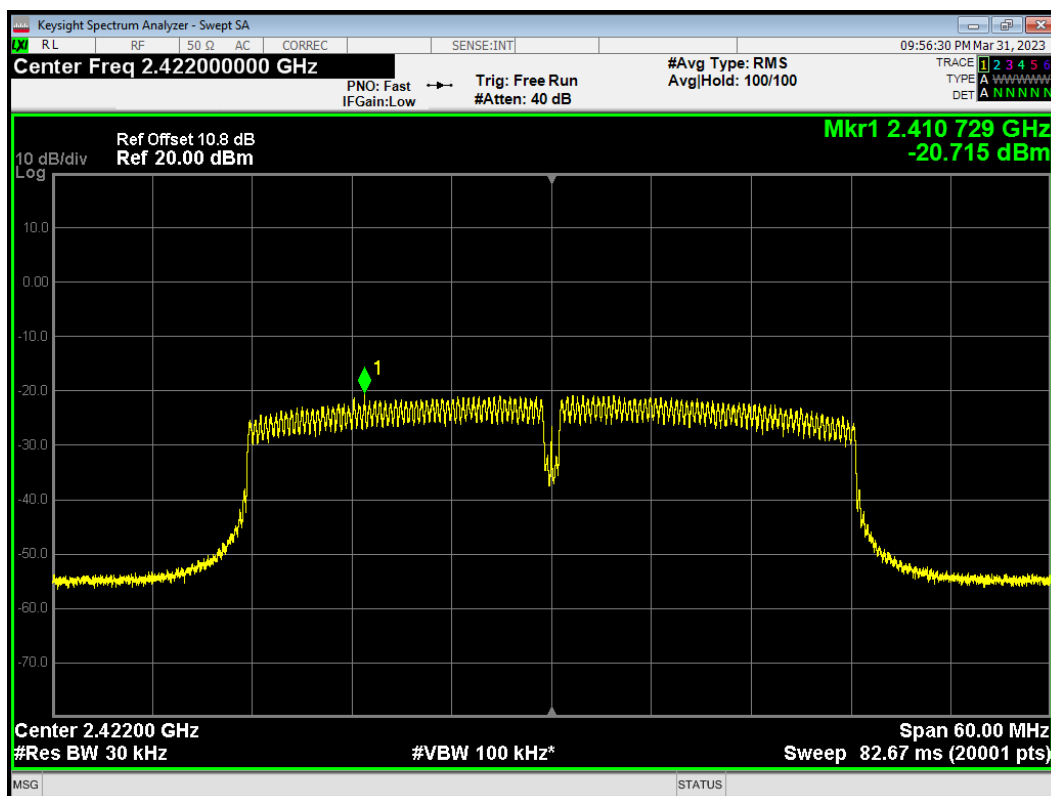
PSD 802.11n(HT20) 2462MHz Ant2



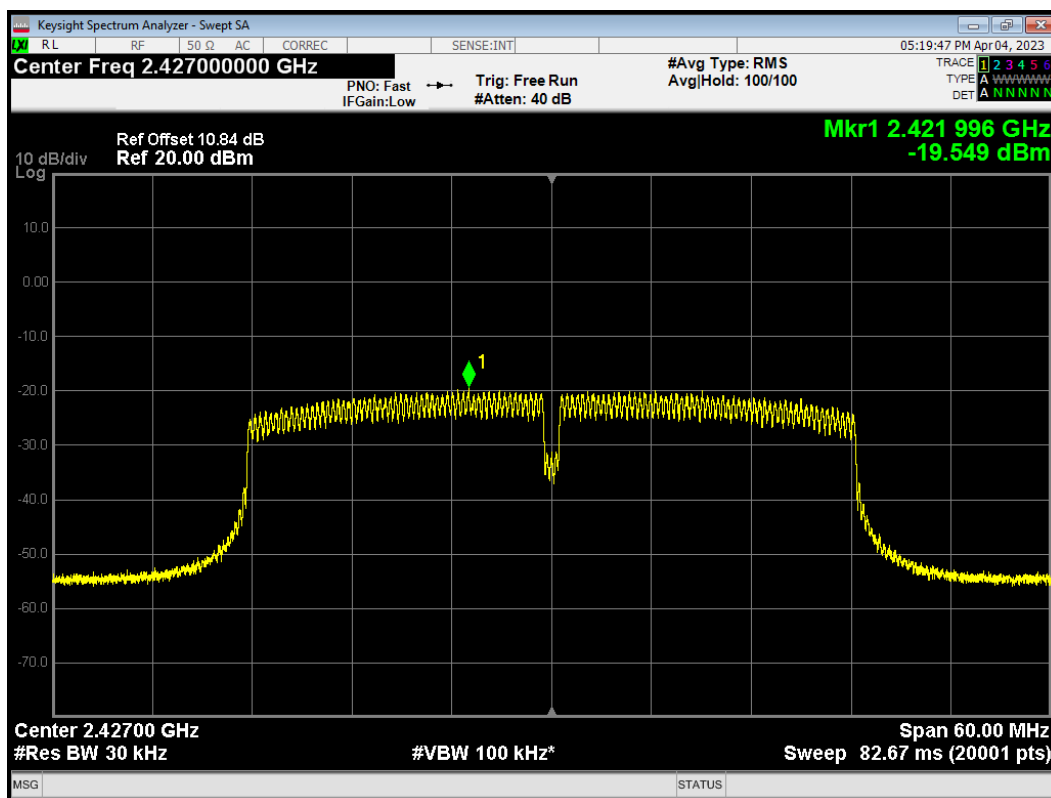
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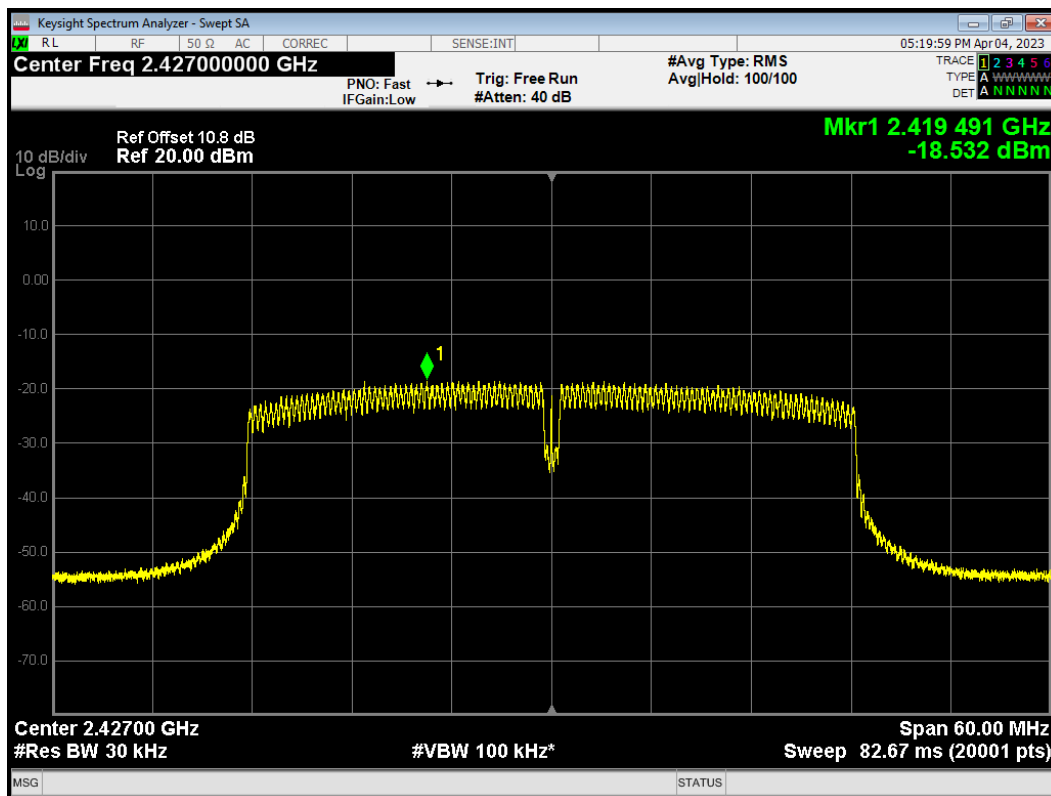
PSD 802.11n(HT40) 2422MHz Ant2



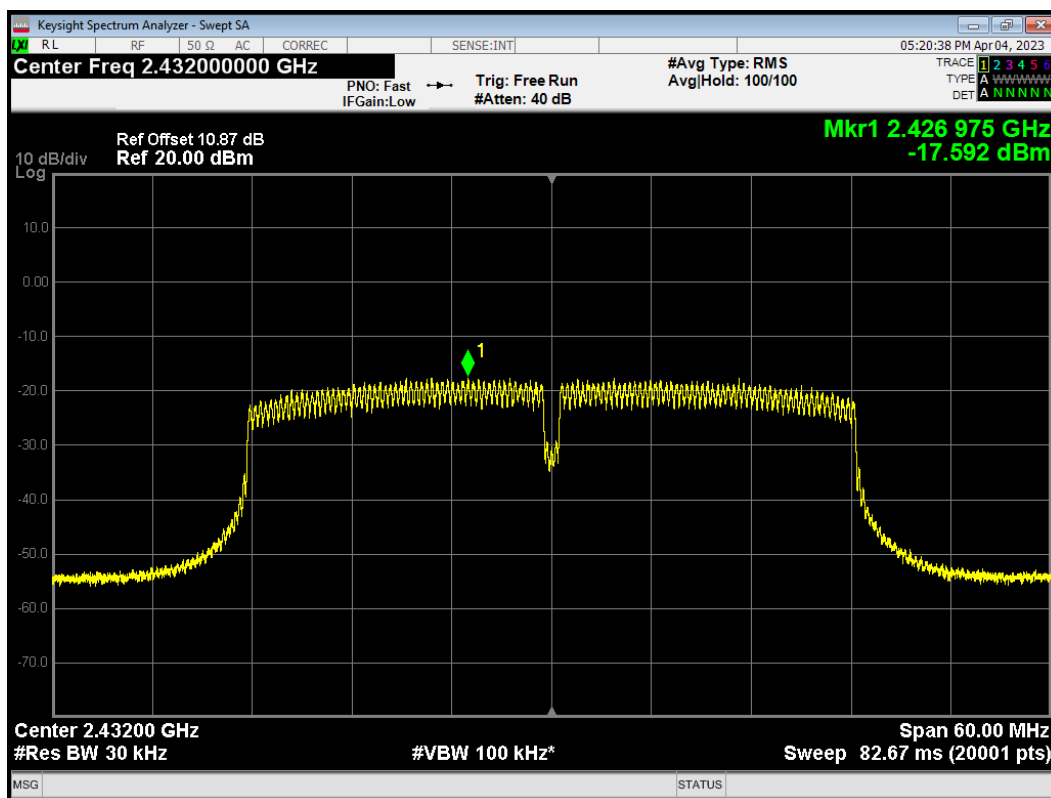
PSD 802.11n(HT40) 2427MHz



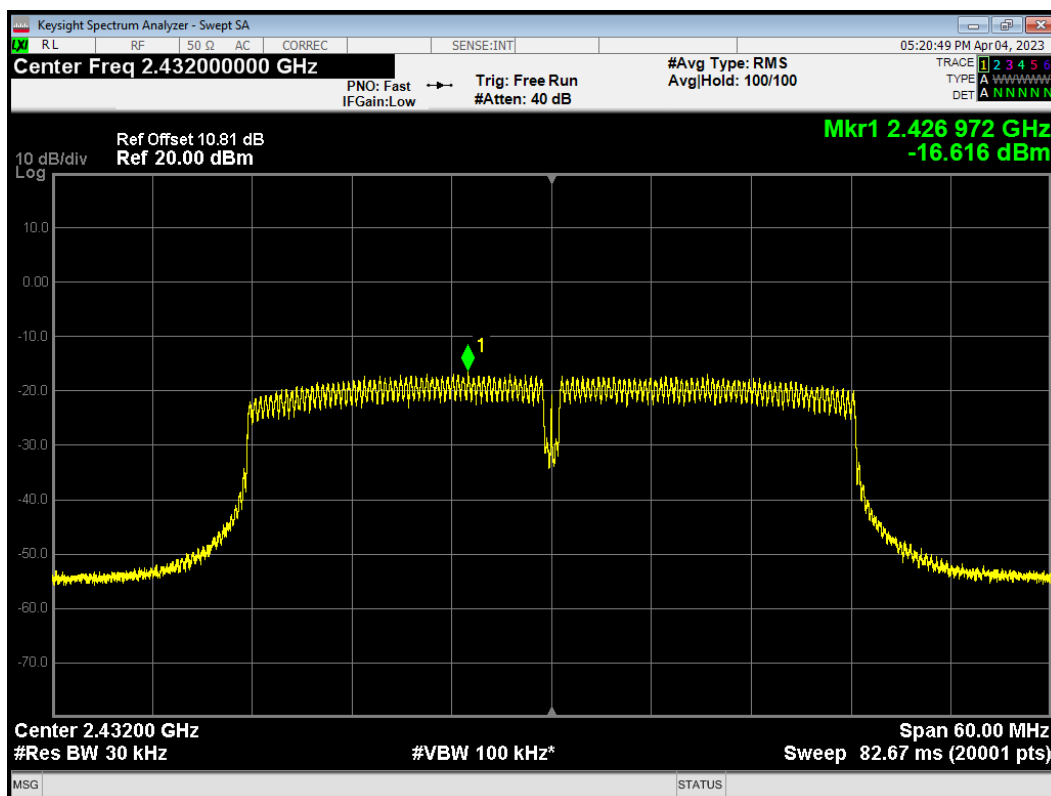
PSD 802.11n(HT40) 2427MHz Ant2



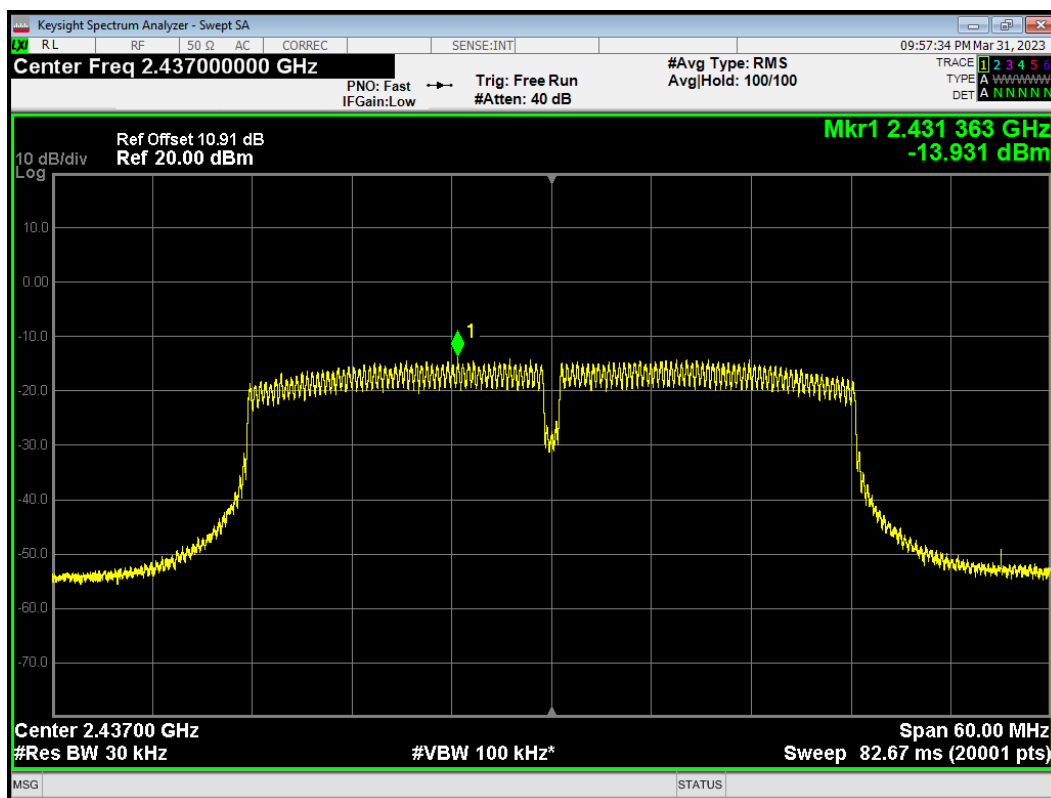
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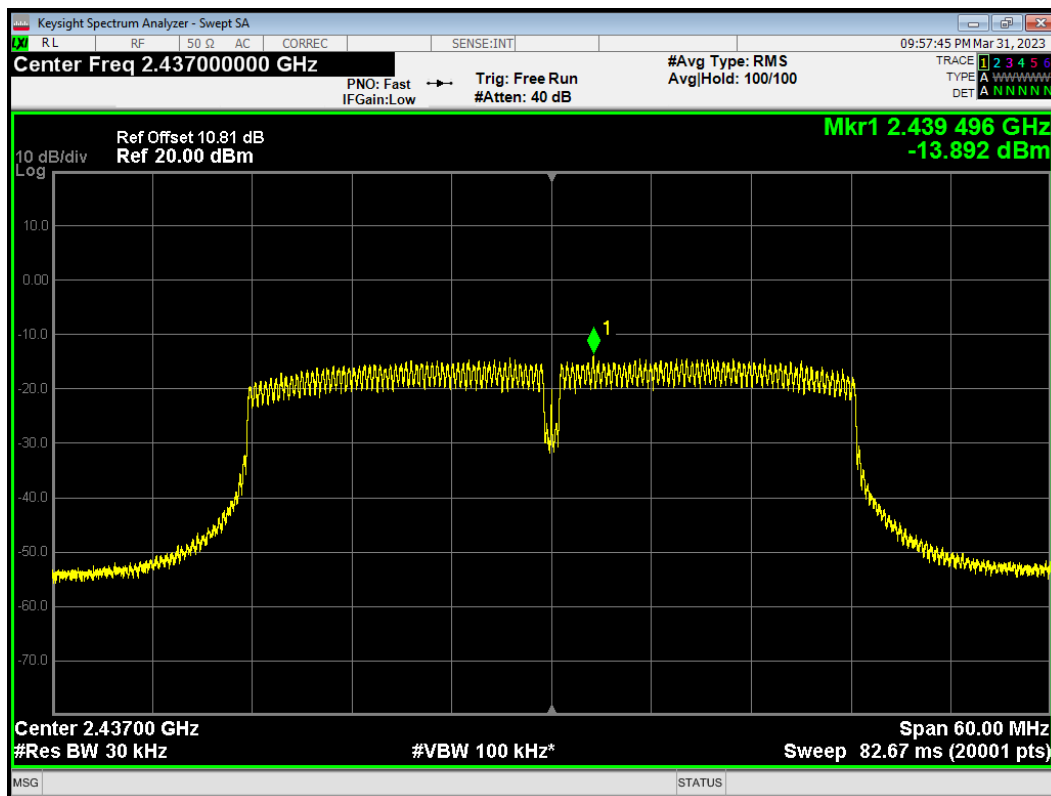
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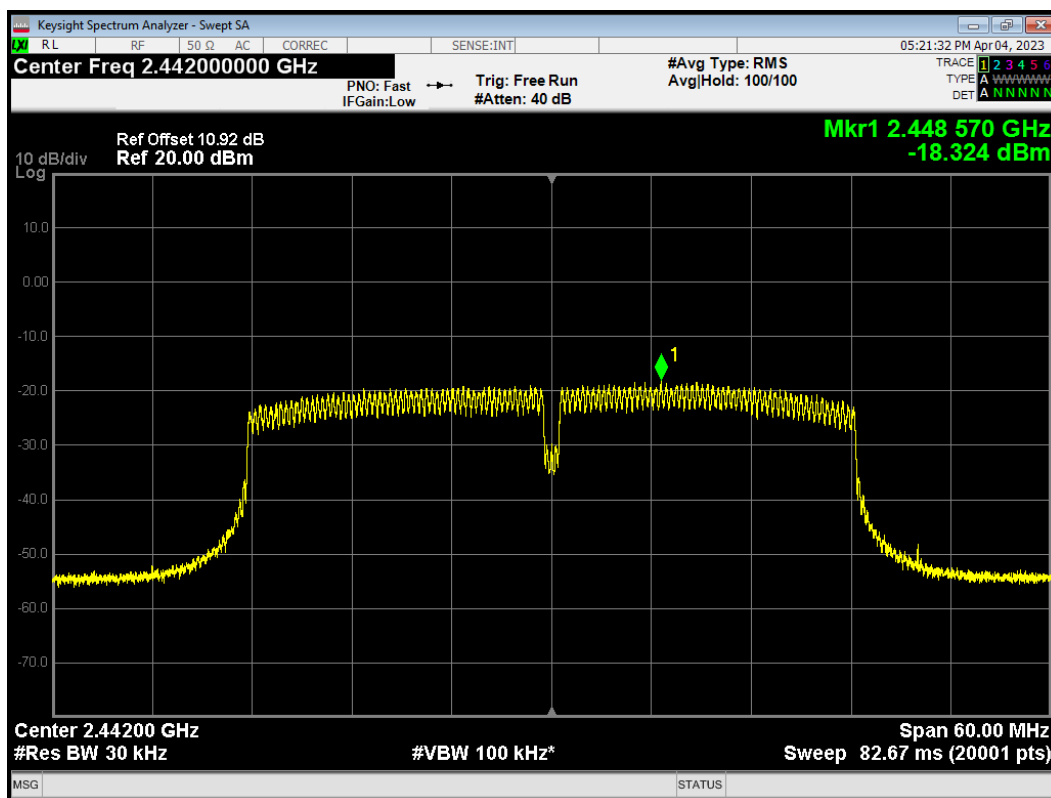
PSD 802.11n(HT40) 2437MHz



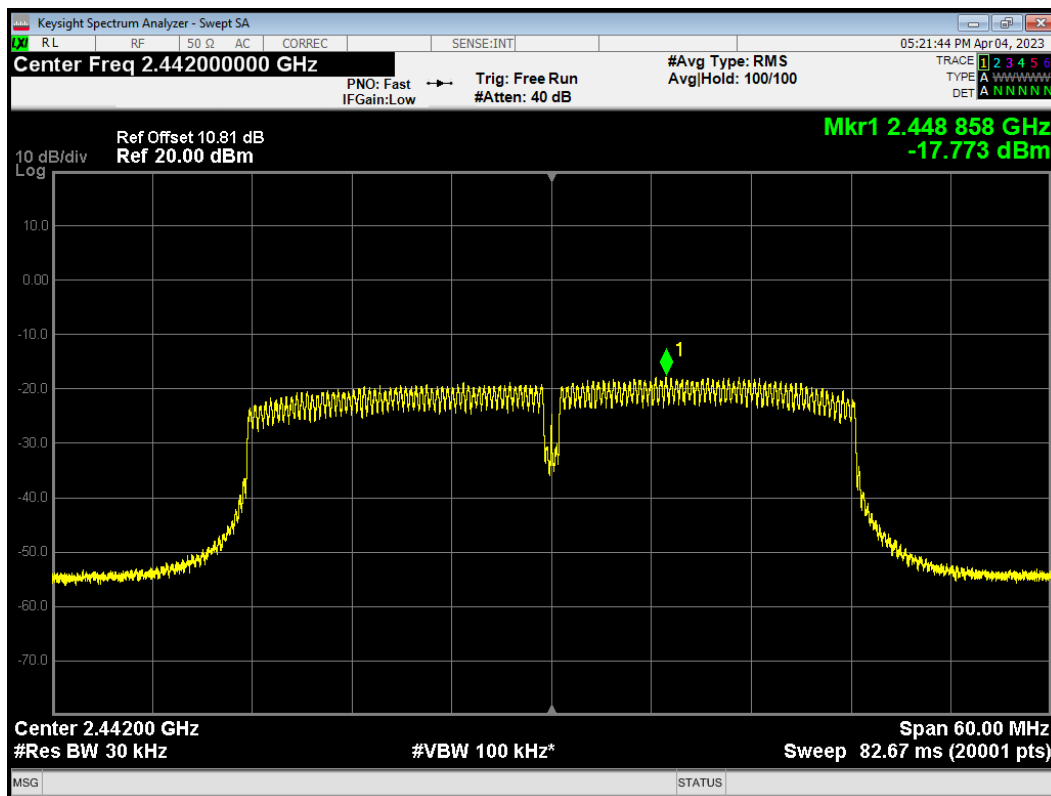
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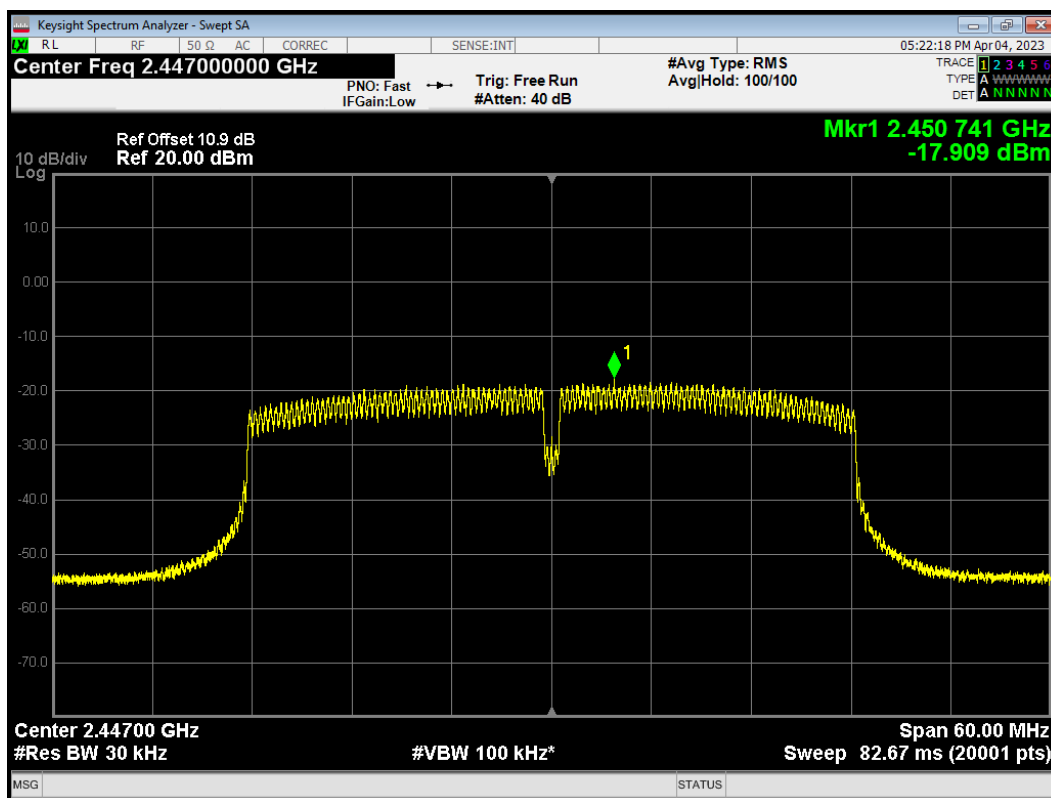
PSD 802.11n(HT40) 2442MHz



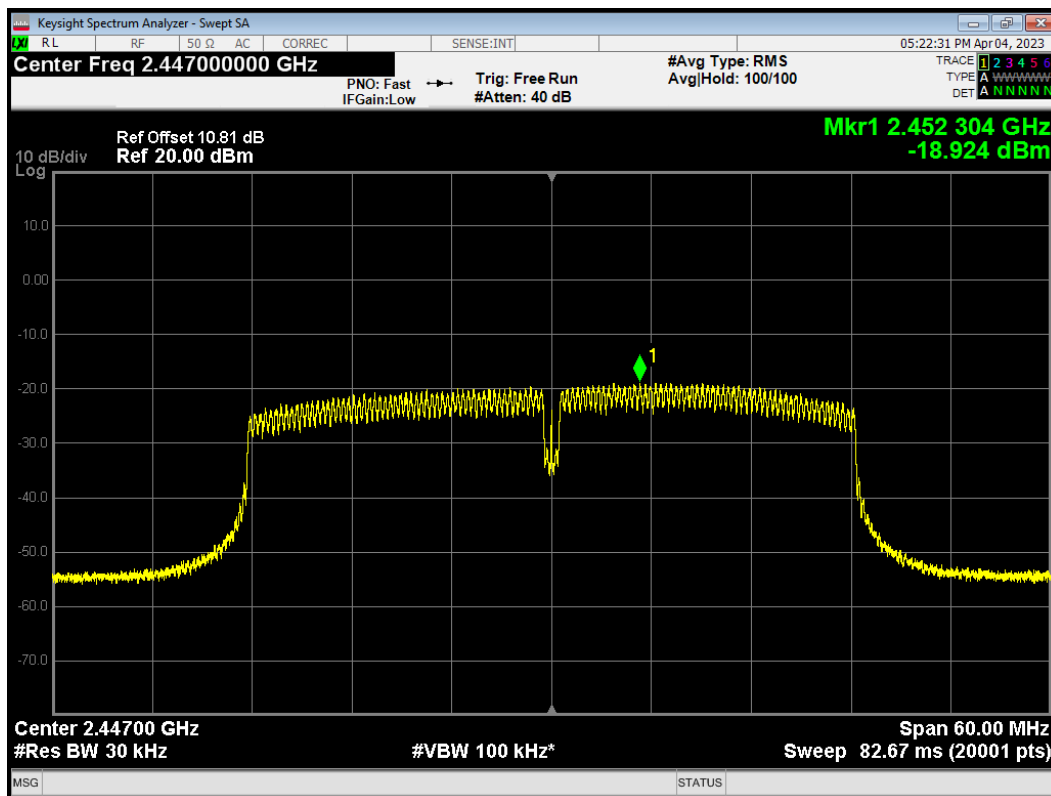
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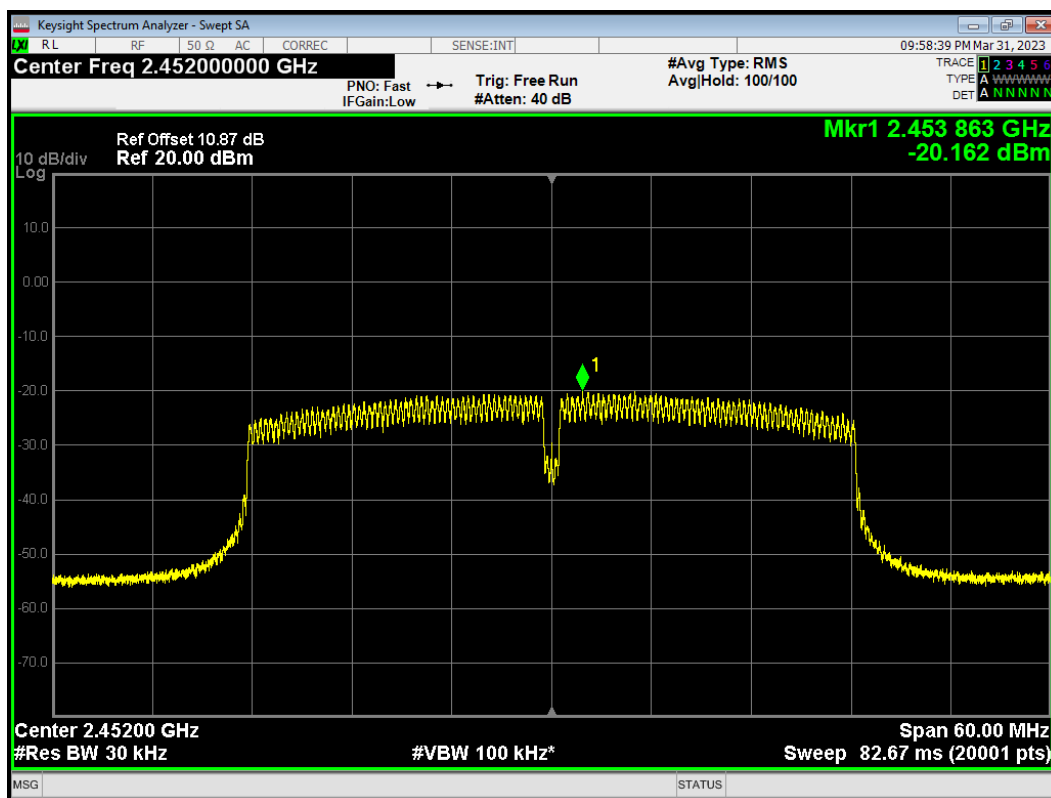
PSD 802.11n(HT40) 2447MHz



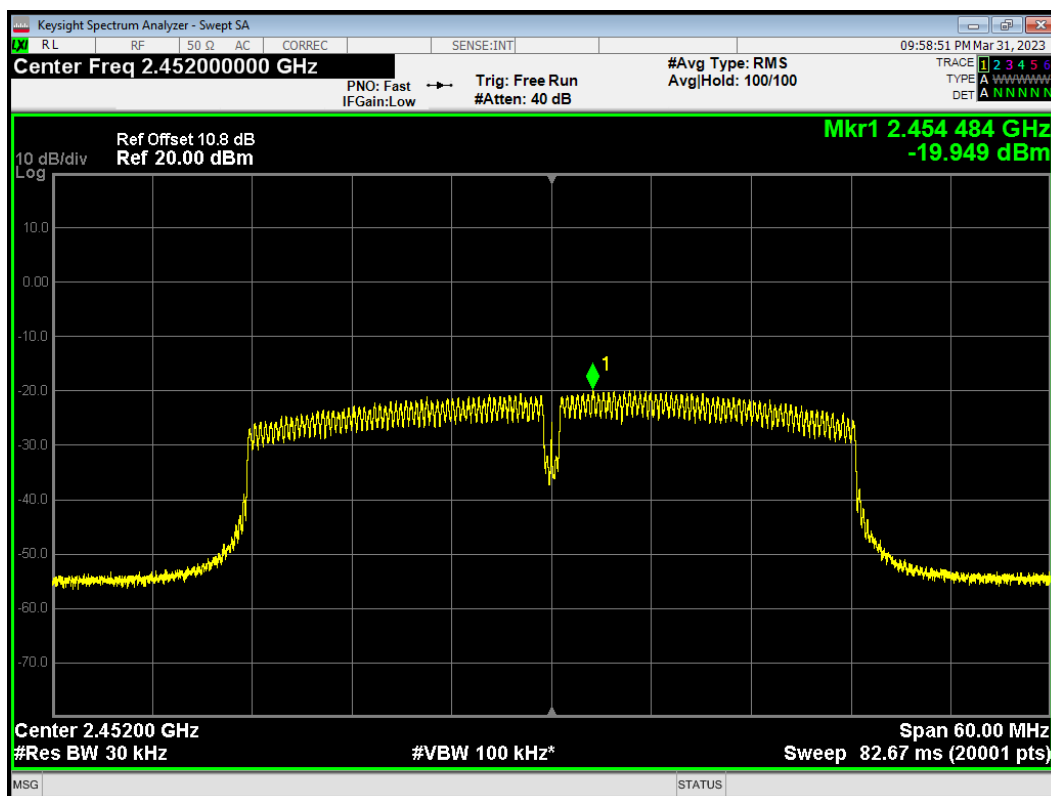
PSD 802.11n(HT40) 2447MHz Ant2



PSD 802.11n(HT40) 2452MHz

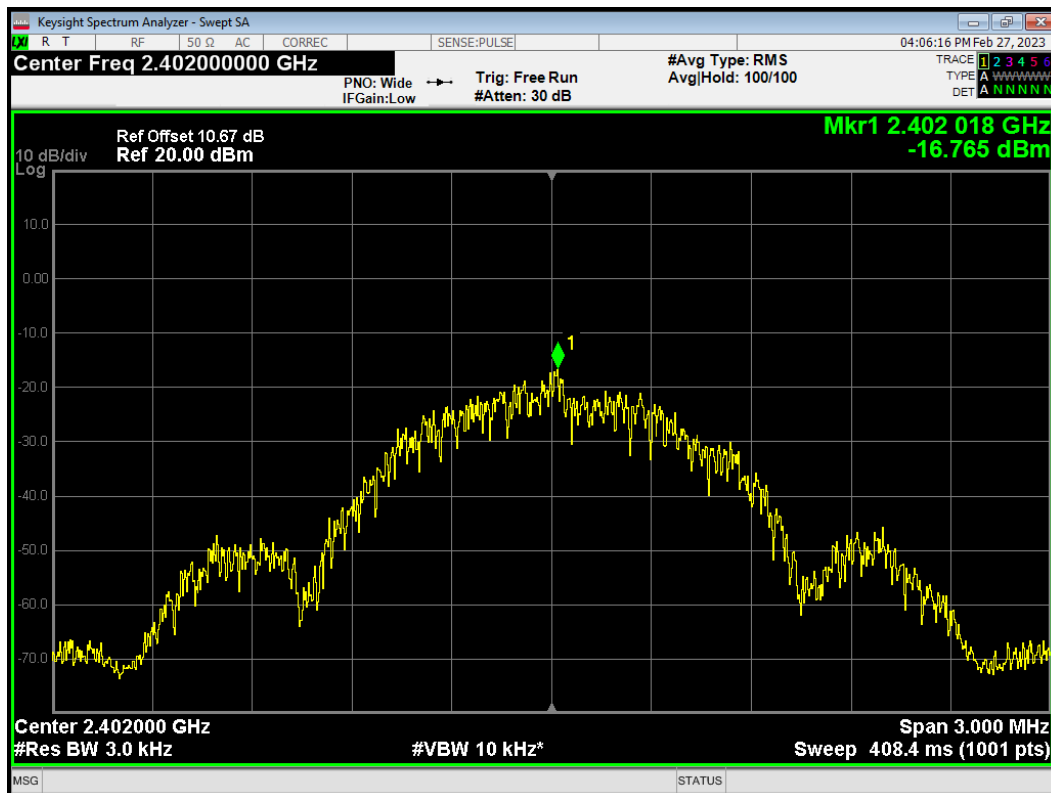


PSD 802.11n(HT40) 2452MHz Ant2

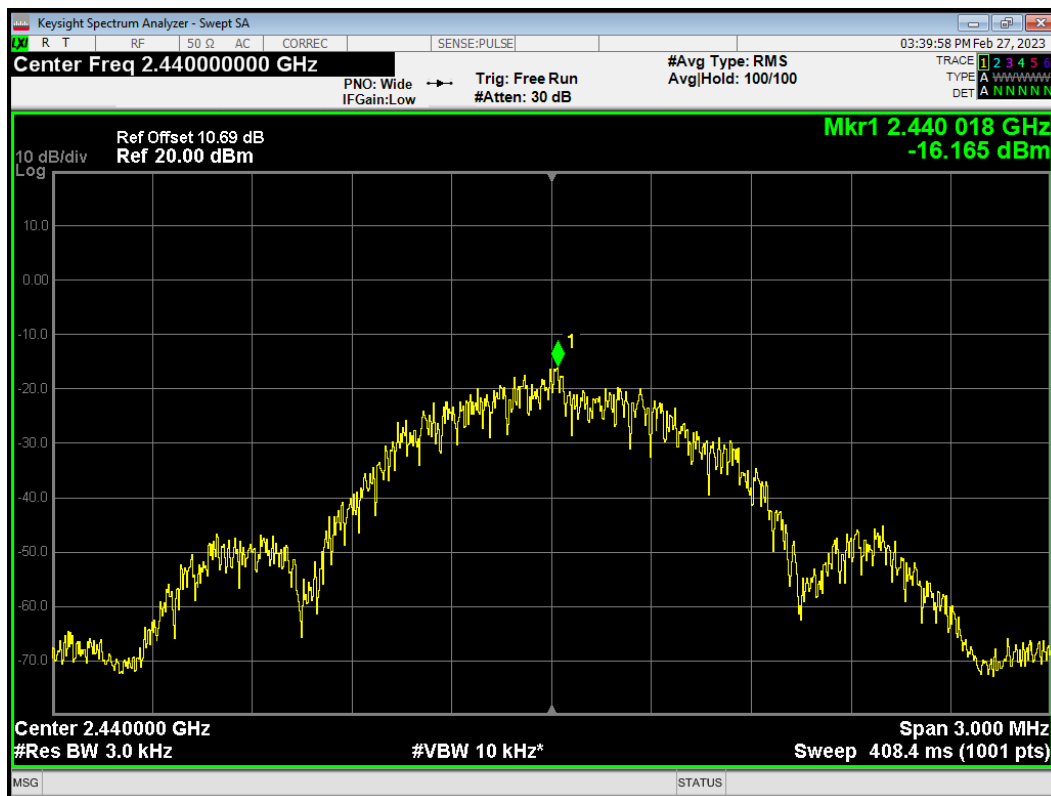


Bluetooth LE

PSD Bluetooth LE 2402MHz



PSD Bluetooth LE 2440MHz



PSD Bluetooth LE 2480MHz

