

Test Report

HELEM2301000056-3



INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C AND ISED CANADA REQUIREMENTS

Equipment Under Test: PTT Voice Responder

Model: APTT2

Type: APTT2-0001-00

Trademark: AINA

Manufacturer/Customer: AINA Wireless Finland Oy
Joensuunkatu 7 G
FI-24100, Salo
Finland

FCC Rule Part: §15.247

IC Rule Part: RSS-247, Issue 2, 2017

RSS-GEN Issue 5 Amendment 2, 2021

KDB: 558074 D01 15.247 Meas Guidance v05r02
Guidance for Compliance Measurements on Digital Transmission
Systems, Frequency Hopping Spread Spectrum System, and Hybrid
System Devices Operating Under §15.247 of the FCC rules (April 2, 2019)

Date: 28 March 2023

Issued by: A handwritten signature in blue ink, appearing to read 'Henri Mäki'.

Henri Mäki
Testing Engineer

Date: 28 March 2023

Checked by: A handwritten signature in blue ink, appearing to read 'Rauno Repo'.

Rauno Repo
Senior EMC Specialist

Table of Contents**TABLE OF CONTENTS**

| | |
|---|----|
| TABLE OF CONTENTS | 2 |
| GENERAL REMARKS | 3 |
| Disclaimer | 3 |
| RELEASE HISTORY..... | 4 |
| PRODUCT DESCRIPTION | 5 |
| Equipment Under Test | 5 |
| General Description | 5 |
| Samples and Modifications..... | 5 |
| Ratings and declarations..... | 5 |
| Ports and Cables | 6 |
| Peripherals | 6 |
| SUMMARY OF TESTING | 7 |
| EUT Test Conditions during Testing | 8 |
| Test Facility..... | 9 |
| TEST RESULTS | 10 |
| Antenna Requirement | 10 |
| AC Power-Line Conducted Emissions | 11 |
| 20 dB Bandwidth..... | 13 |
| Occupied Bandwidth 99% | 17 |
| Carrier Frequency Separation | 21 |
| Number of Hopping Channels | 23 |
| Average Time of Occupancy | 25 |
| Maximum Peak Conducted Output Power | 29 |
| Unwanted Emissions (conducted) | 33 |
| Unwanted Emissions (radiated)..... | 43 |
| TEST EQUIPMENT | 53 |
| AC Power-Line Conducted Emissions | 53 |
| Conducted RF Tests | 53 |
| Unwanted Emissions (radiated)..... | 53 |

GENERAL REMARKS**Disclaimer**

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 30 days only.

RELEASE HISTORY

| Version | Changes | Issued |
|---------|-----------------|---------------|
| 1.0 | Initial release | 28 March 2023 |

PRODUCT DESCRIPTION

Equipment Under Test

Equipment Under Test: PTT Voice Responder
Trademark: AINA
Model: APTT2
Type: APTT2-0001-00
Serial no: Sample 1: AW8230400038
Sample 2: AW8230400014
FCC ID: -
IC: -
Radio module or chip: Qualcomm QCC3044 (Dual-Mode Bluetooth, version 5.2)

General Description

The equipment under test is a push-to-talk voice responder. The equipment includes Bluetooth radio and a passive NFC tag, USB-C port and proprietary charging pins for charging, and 3.5 mm audio jack for headset. This test report contains the results for Bluetooth Classic.

Classification

| | |
|--|-------------------------------------|
| Fixed device | <input type="checkbox"/> |
| Mobile Device (Human body distance > 20cm) | <input checked="" type="checkbox"/> |
| Portable Device (Human body distance < 20cm) | <input checked="" type="checkbox"/> |

Samples and Modifications

| No. | Name | Description |
|-----|------------|---|
| 1 | APTT19A44F | Normal sample. Used for radiated tests. |
| 2 | APTT19A47D | Temporary antenna connector was soldered to replace original antenna. Used for conducted tests. |

Ratings and declarations

| | |
|------------------------------|--|
| Operating frequency range: | 2402-2480 MHz |
| Nominal channel bandwidth: | 1 MHz |
| Number of channels: | 79 |
| Channel separation: | 1 MHz |
| Transmission technique: | FHSS |
| Modulation: | GFSK, $\pi/4$ -DQPSK, 8DPSK |
| Data rate: | 1, 2, 3 Mbps |
| Antenna type: | Integral ceramic chip |
| Antenna gain: | +0.5 dBi |
| Antenna count: | 1 |
| EUT dimensions: | Height: 88 mm Width: 77 mm Length: 22 mm |
| Power requirements: | 3.7 VDC (rechargeable lithium-ion battery) |
| Operating temperature range: | -30...+60 °C |

Ports and Cables

| Cable / Port | Description |
|-------------------|---|
| USB-C | Used for charging and configuring the EUT during testing. |
| Charging pins | Not used during testing. |
| 3.5 mm audio jack | Connected to the peripheral headset during testing. |

Peripherals

| Peripheral | Description / Usage |
|------------|---|
| Charger | Celly SPT-104 (TC1USBC20WWH). Used for charging the EUT during AC Power-Line Conducted Emissions testing. |
| Headset | Connected to the audio jack of the EUT during testing. |
| Laptop | Lenovo ThinkPad T470p. Configuring and charging the EUT. |

The peripherals were provided by the customer.

SUMMARY OF TESTING

| Test Specification | Description of Test | Result |
|-------------------------------------|-------------------------------------|-------------|
| §15.203 | Antenna Requirement | PASS |
| §15.207 / RSS-Gen 8.8 | AC Power-Line Conducted Emissions | PASS |
| §15.247(a)(1) / RSS-247 5.1 a) | 20 dB Bandwidth | PASS |
| RSS-Gen 6.7 | Occupied Bandwidth 99 % | PASS |
| §15.247(a)(1) / RSS-247 5.1 a) | Carrier Frequency Separation | PASS |
| §15.247(a)(1)(iii) / RSS-247 5.1 d) | Number of Hopping Channels | PASS |
| §15.247(a)(1)(iii) / RSS-247 5.1 d) | Average Time of Occupancy | PASS |
| §15.247(b)(1) / RSS-247 5.4 d) | Maximum Peak Conducted Output Power | PASS |
| §15.247(d) / RSS-247 5.5 | Unwanted Emissions | PASS |

The decision rule applied for the tests results stated in this test report is according to the requirements of section 1.3 of ANSI C63.10-2013.

EUT Test Conditions during Testing

The radio was configured with a software provided by the customer (CSR BlueTest3). Normal modulation and maximum transmit power was used during the tests.

Conducted RF tests were performed with an automated Rohde & Schwarz TS8997 measurement system. The EUT was connected to the measurement system with a coaxial cable and was configured and charged with the peripheral laptop via USB-C port.

Radiated tests were performed in a semi-anechoic chamber with a measurement distance of 3 meters. During measurements above 1 GHz absorbers were placed on the floor. The EUT was connected to the peripheral headset and was configured and charged with the peripheral laptop via USB-C port. Radiated tests were performed only using the 1 Mbps data rate.

During AC Power-Line Conducted Emissions test the EUT was connected to the peripheral headset and was charged with the peripheral charger. Normal Bluetooth connection was established with the peripheral laptop.



Figure 1: Test setup block diagram (conducted RF tests)

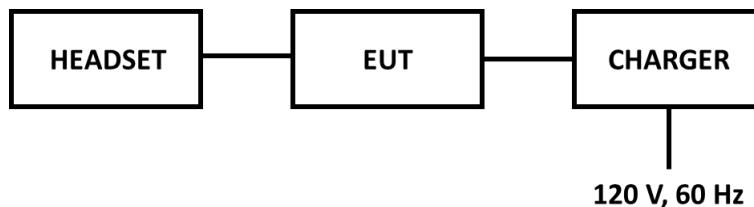


Figure 2: Test setup block diagram (AC Power-Line Conducted Emissions)



Figure 3: Test setup block diagram (radiated tests)

Table 1: Test frequencies and settings

| Data Rate | Packet Type | Payload | Channels | Frequency [MHz] |
|-----------|-------------|------------|-----------|------------------|
| 1 Mbps | DH5 | 339 bytes | 0, 39, 78 | 2402, 2441, 2480 |
| 2 Mbps | 2-DH5 | 679 bytes | 0, 39, 78 | 2402, 2441, 2480 |
| 3 Mbps | 3-DH5 | 1021 bytes | 0, 39, 78 | 2402, 2441, 2480 |

Test Facility

| | |
|--|---|
| Testing Laboratory / address: FCC designation number: F10002 ISED CAB identifier: T004 | SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND |
| Test Site: | <input type="checkbox"/> K10LAB, ISED Canada registration number: 8708A-1 <input checked="" type="checkbox"/> K5LAB, ISED Canada registration number: 8708A-2 <input type="checkbox"/> T10LAB |

TEST RESULTS**Antenna Requirement**

Standard: FCC Rule §15.203
Tested by: HEM
Date: 9 March 2023

FCC §15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

| Specification | Requirement (at least one of the following shall be applied) | Conclusion |
|---------------|---|-------------|
| §15.203 | <ol style="list-style-type: none">1. Permanently attached antenna2. Unique coupling to the intentional radiator3. Professionally installed radio. The installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded. | PASS |
| Note | Option 1 is used | |

AC Power-Line Conducted Emissions

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 3 March 2023
Temperature: 23 °C
Humidity: 33 %RH
Measurement uncertainty: ± 2.9 dB, level of confidence 95 % (k = 2)
Test result: **PASS**

FCC §15.207**RSS-Gen clause 8.8**

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in §15.207(a) and RSS-Gen clause 8.8, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

For equipment that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the equipment.

The emissions are measured with a LISN from 150 kHz to 30 MHz with a resolution bandwidth of 9 kHz using peak and average detectors.

The correction factor in the final result table contains the sum of the transducers (LISN + cables). The result value is the measured value corrected with the correction factor.

Test results

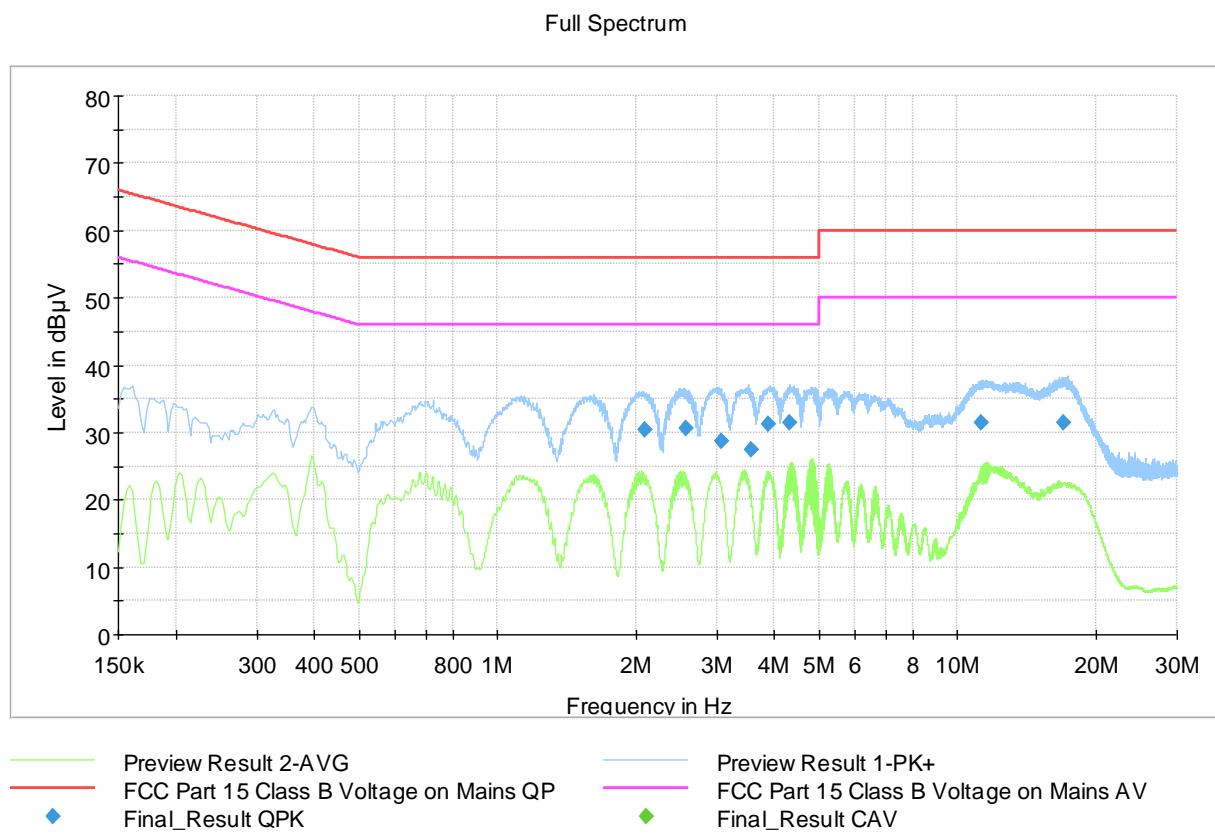


Figure 4: AC Power-Line Conducted Emissions

Table 2: Test results for AC Power-Line Conducted Emissions

| Frequency (MHz) | QuasiPeak (dBμV) | CAverage (dBμV) | Limit (dBμV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Corr. (dB) |
|-----------------|------------------|-----------------|--------------|-------------|-----------------|-----------------|------|------------|
| 2.098750 | 30.48 | --- | 56.00 | 25.52 | 15 x 1000.0 | 9.000 | L1 | 9.9 |
| 2.572750 | 30.51 | --- | 56.00 | 25.49 | 15 x 1000.0 | 9.000 | L1 | 9.9 |
| 3.063500 | 28.73 | --- | 56.00 | 27.27 | 15 x 1000.0 | 9.000 | L1 | 9.9 |
| 3.553750 | 27.39 | --- | 56.00 | 28.61 | 15 x 1000.0 | 9.000 | L1 | 9.9 |
| 3.888250 | 31.17 | --- | 56.00 | 24.83 | 15 x 1000.0 | 9.000 | L1 | 9.9 |
| 4.328500 | 31.50 | --- | 56.00 | 24.50 | 15 x 1000.0 | 9.000 | L1 | 10.0 |
| 11.295000 | 31.49 | --- | 60.00 | 28.51 | 15 x 1000.0 | 9.000 | N | 10.3 |
| 17.032250 | 31.36 | --- | 60.00 | 28.64 | 15 x 1000.0 | 9.000 | L1 | 10.4 |

20 dB Bandwidth

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Test result: **PASS**

**FCC §15.247(a)(1)
RSS-247 clause 5.1 a)**

The 20 dB bandwidth is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emissions is attenuated 20 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emissions.

Test results**Table 3:** Test results for 20 dB Bandwidth

| Data Rate | Frequency [MHz] | 20 dB BW [kHz] | Limit [kHz] | Result |
|-----------|-----------------|----------------|-------------|-------------|
| 1 Mbps | 2402 | 930.000 | - | PASS |
| | 2441 | 925.000 | | PASS |
| | 2480 | 925.000 | | PASS |
| 2 Mbps | 2402 | 1325.000 | - | PASS |
| | 2441 | 1325.000 | | PASS |
| | 2480 | 1325.000 | | PASS |
| 3 Mbps | 2402 | 1280.000 | - | PASS |
| | 2441 | 1280.000 | | PASS |
| | 2480 | 1280.000 | | PASS |

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|------------|
| Span | 2.000 MHz |
| RBW | 10.000 kHz |
| VBW | 30.000 kHz |
| Sweep Points | 400 |
| Sweep Time | 189.648 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweep Type | FFT |
| Preamp | off |
| Stable | 5 / 5 |

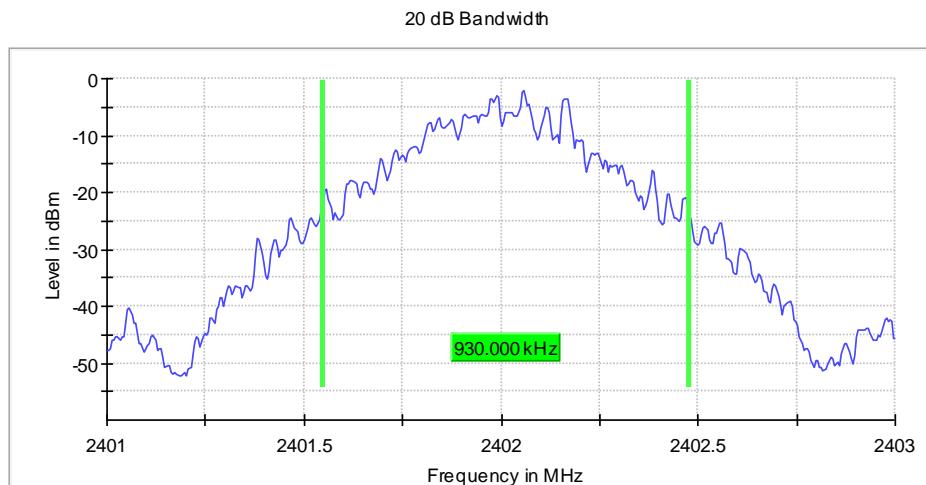


Figure 5: 20 dB Bandwidth (1 Mbps, TX 2402 MHz)

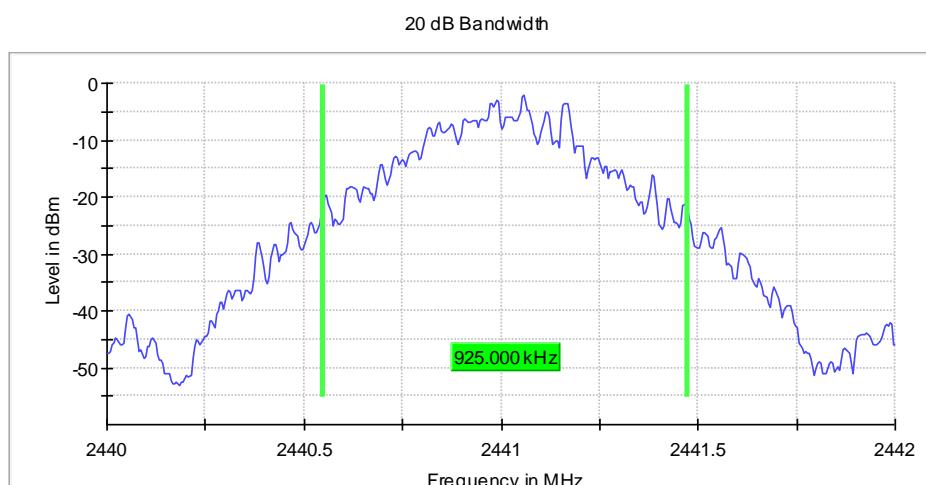


Figure 6: 20 dB Bandwidth (1 Mbps, TX 2441 MHz)

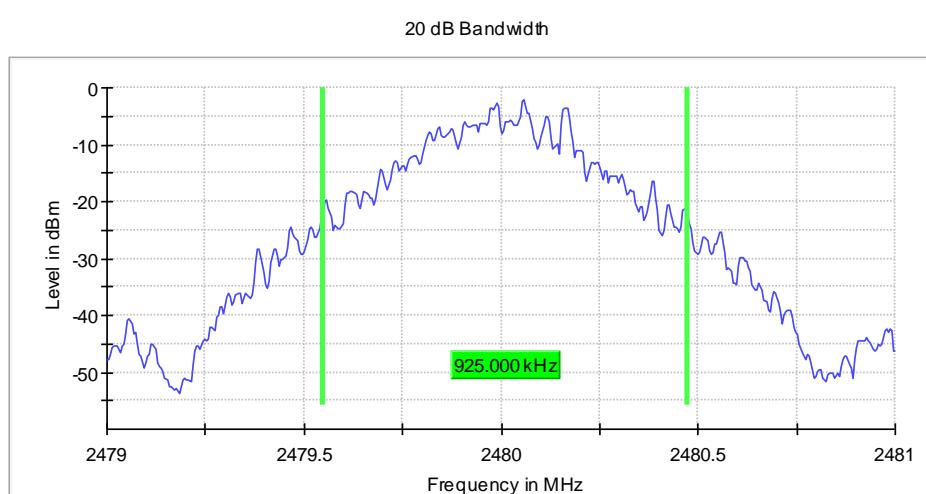


Figure 7: 20 dB Bandwidth (1 Mbps, TX 2480 MHz)

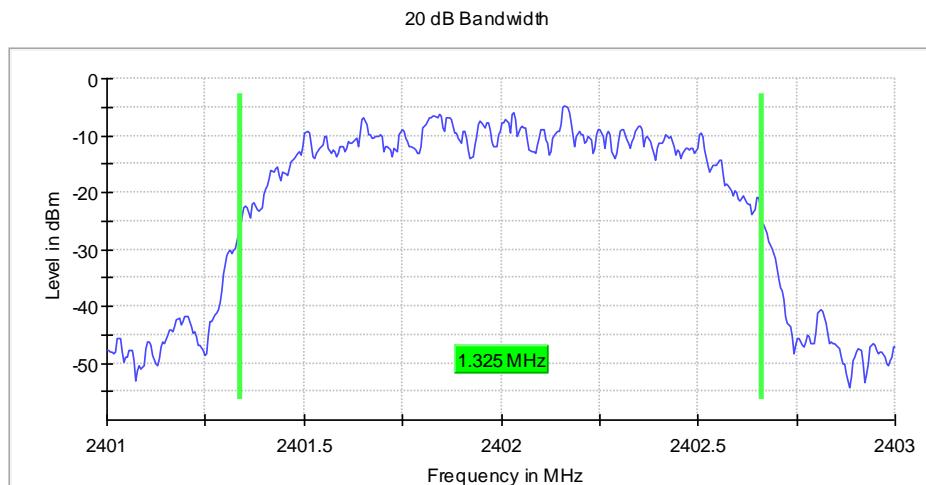


Figure 8: 20 dB Bandwidth (2 Mbps, TX 2402 MHz)

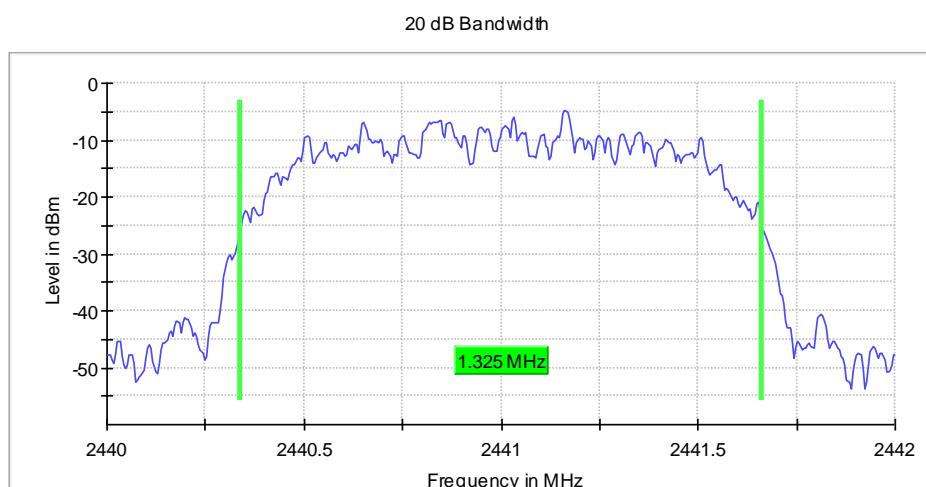


Figure 9: 20 dB Bandwidth (2 Mbps, TX 2441 MHz)

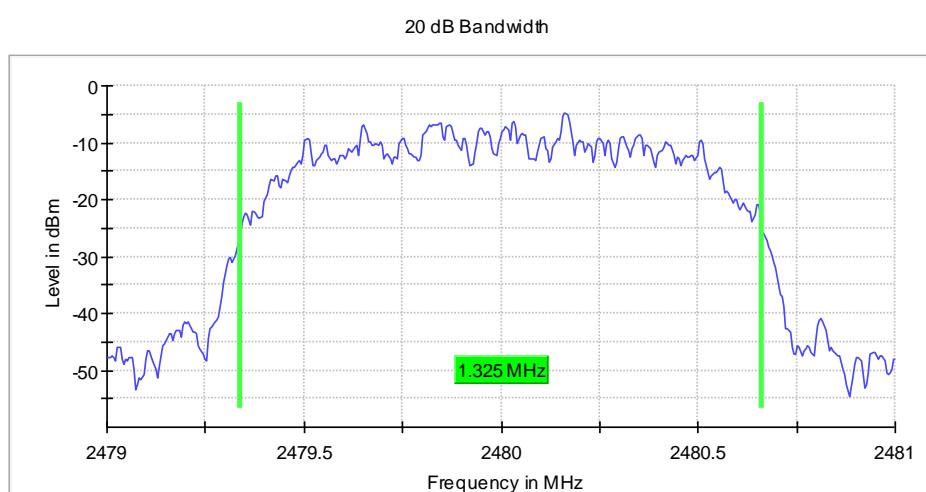


Figure 10: 20 dB Bandwidth (2 Mbps, TX 2480 MHz)

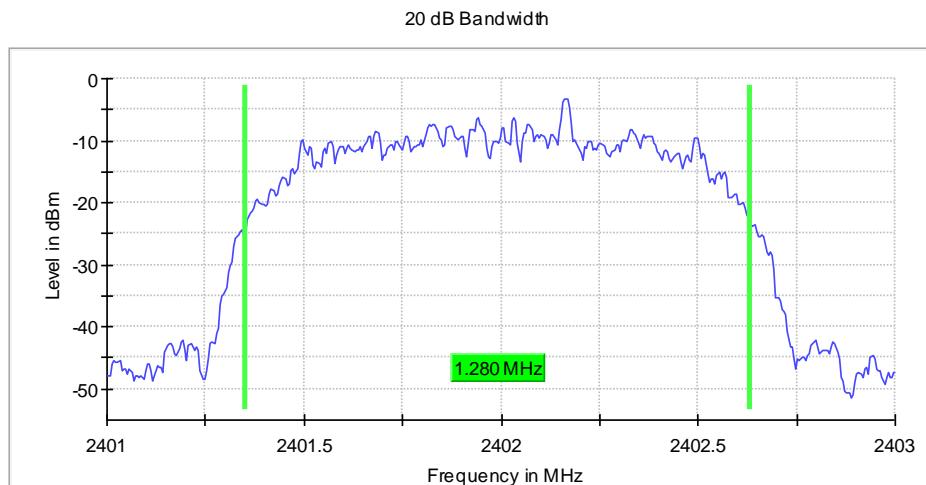


Figure 11: 20 dB Bandwidth (3 Mbps, TX 2402 MHz)

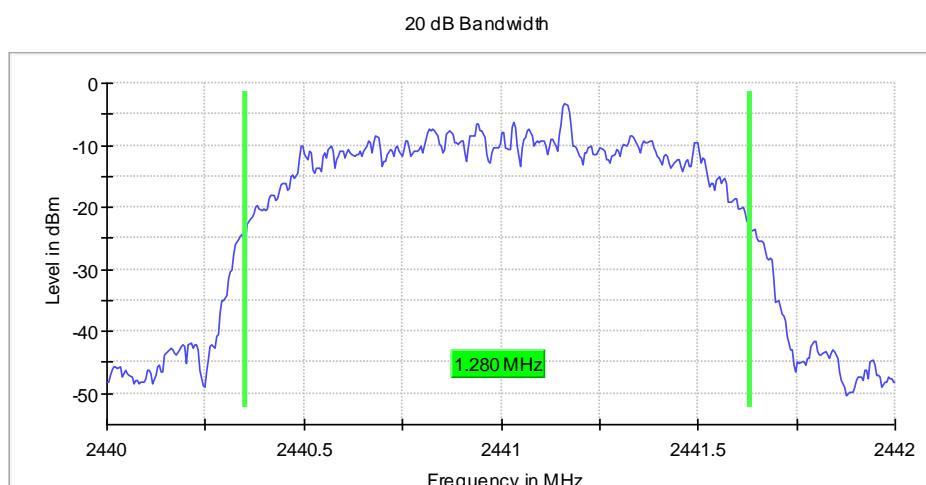


Figure 12: 20 dB Bandwidth (3 Mbps, TX 2441 MHz)

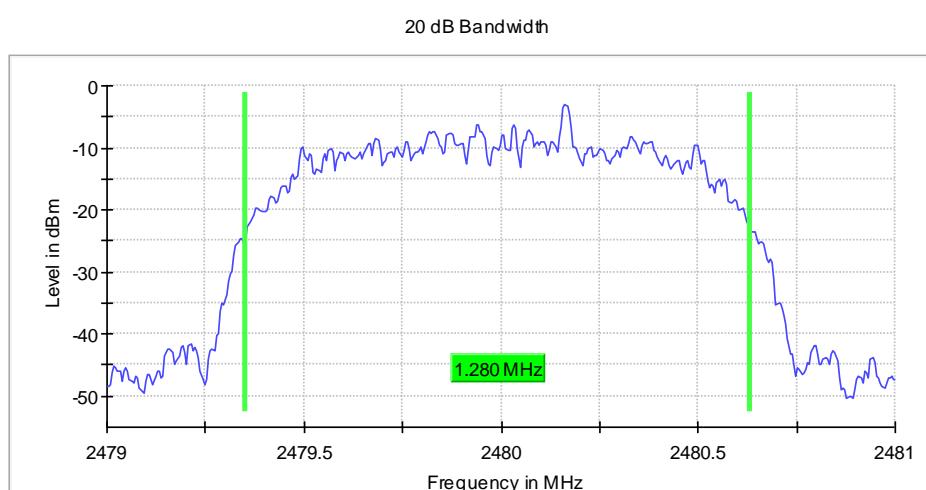


Figure 13: 20 dB Bandwidth (3 Mbps, TX 2480 MHz)

Occupied Bandwidth 99%

Standard: RSS-Gen
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Test result: **PASS**

RSS-Gen clause 6.7

The occupied bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental emission is contained.

Test results**Table 4:** Test results for Occupied Bandwidth 99%

| Data Rate | Frequency [MHz] | OBW 99% [kHz] | Limit [kHz] | Result |
|-----------|-----------------|---------------|-------------|-------------|
| 1 Mbps | 2402 | 865.000 | - | PASS |
| | 2441 | 865.000 | | PASS |
| | 2480 | 860.000 | | PASS |
| 2 Mbps | 2402 | 1180.000 | - | PASS |
| | 2441 | 1180.000 | | PASS |
| | 2480 | 1180.000 | | PASS |
| 3 Mbps | 2402 | 1190.000 | - | PASS |
| | 2441 | 1190.000 | | PASS |
| | 2480 | 1185.000 | | PASS |

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|------------|
| Span | 2.000 MHz |
| RBW | 10.000 kHz |
| VBW | 30.000 kHz |
| Sweep Points | 400 |
| Sweep Time | 189.648 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweep Type | FFT |
| Preamp | off |

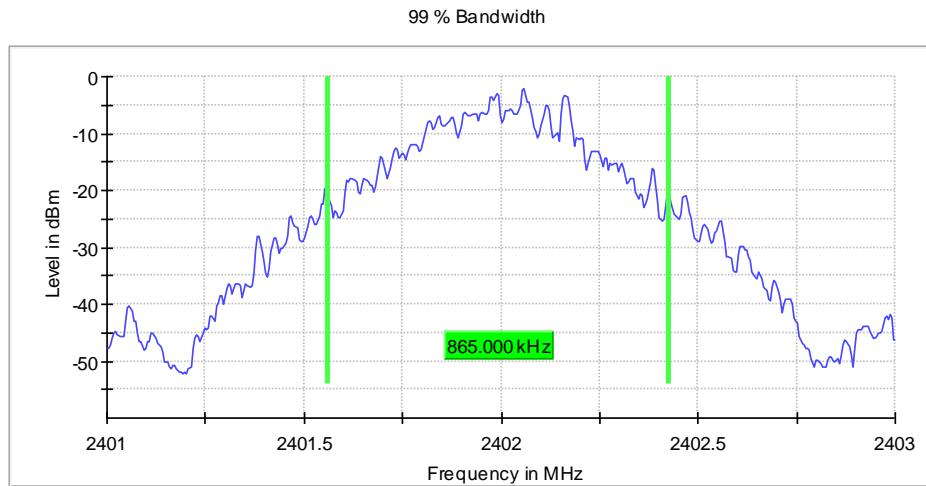
Occupied Bandwidth 99%

Figure 14: Occupied Bandwidth 99% (1 Mbps, TX 2402 MHz)

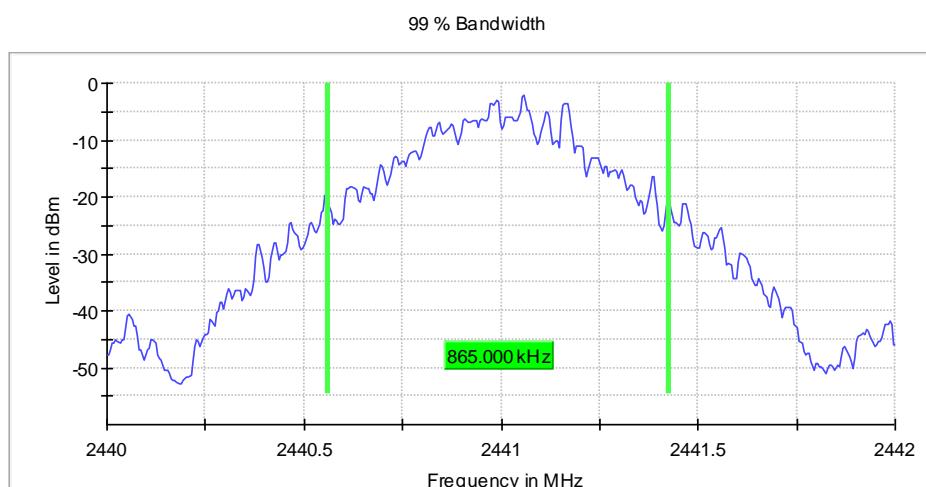


Figure 15: Occupied Bandwidth 99% (1 Mbps, TX 2441 MHz)

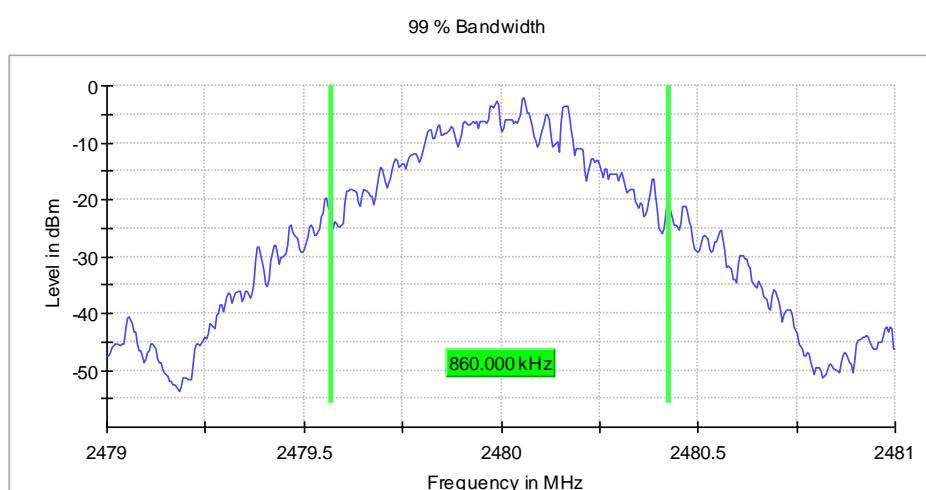


Figure 16: Occupied Bandwidth 99% (1 Mbps, TX 2480 MHz)

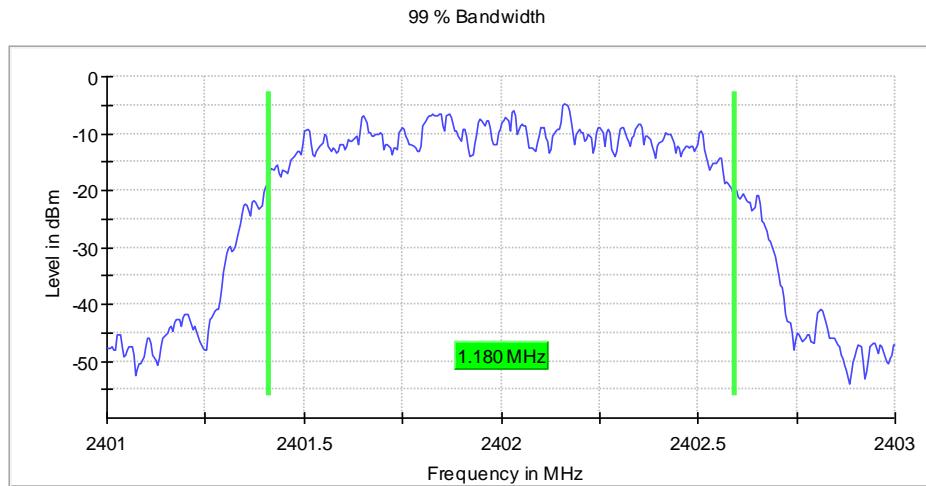
Occupied Bandwidth 99%

Figure 17: Occupied Bandwidth 99% (2 Mbps, TX 2402 MHz)

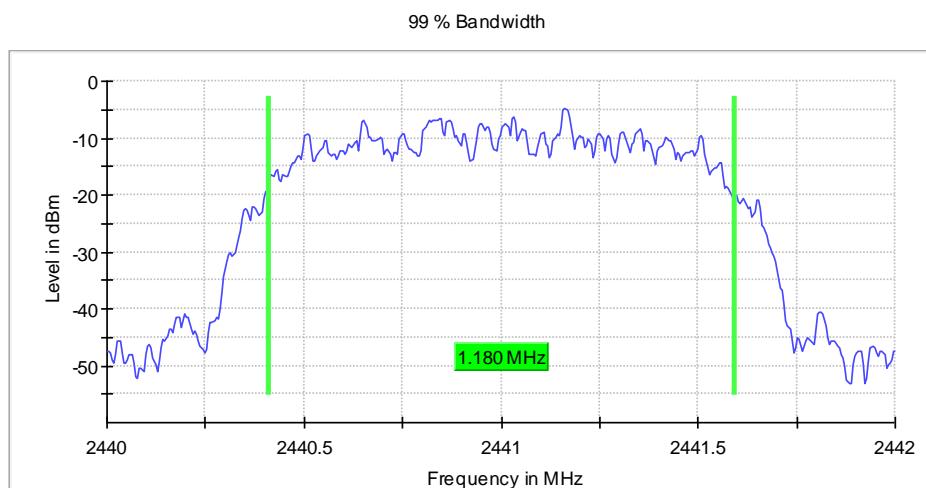


Figure 18: Occupied Bandwidth 99% (2 Mbps, TX 2441 MHz)

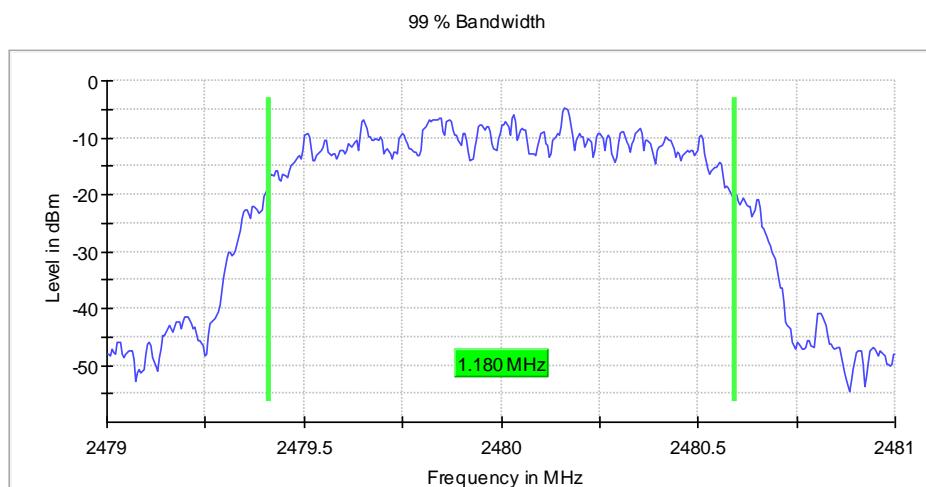


Figure 19: Occupied Bandwidth 99% (2 Mbps, TX 2480 MHz)

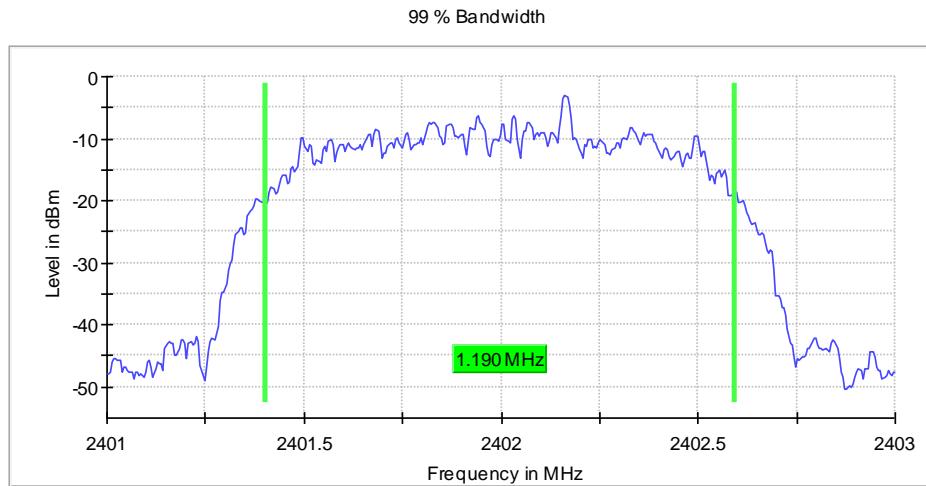
Occupied Bandwidth 99%

Figure 20: Occupied Bandwidth 99% (3 Mbps, TX 2402 MHz)

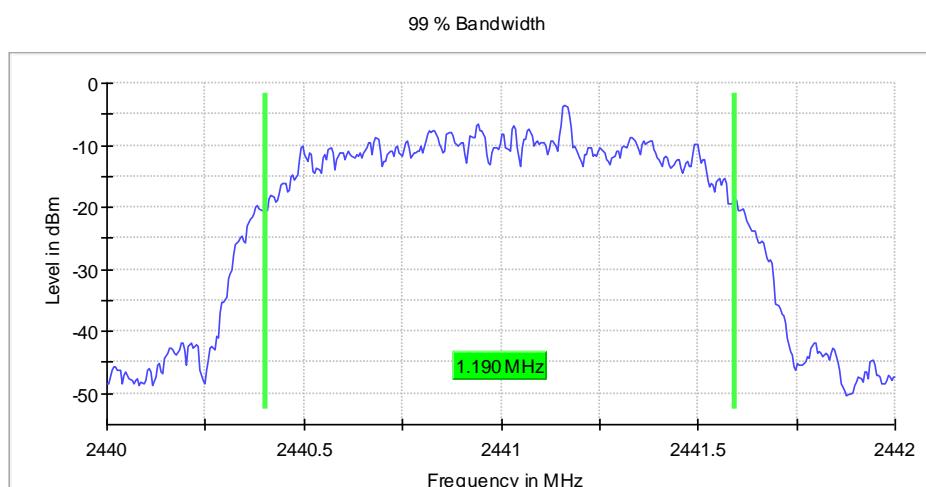


Figure 21: Occupied Bandwidth 99% (3 Mbps, TX 2441 MHz)

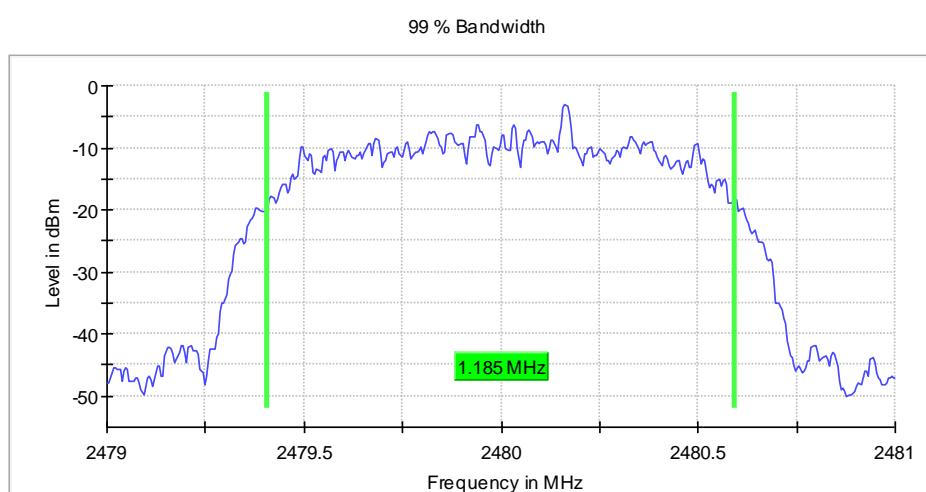


Figure 22: Occupied Bandwidth 99% (3 Mbps, TX 2480 MHz)

Carrier Frequency Separation

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Test result: **PASS**

FCC §15.247(a)(1) RSS-247 clause 5.1 a)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Test results

Table 5: Test results for Carrier Frequency Separation

| Data Rate | Separation [MHz] | Limit [MHz] | Result |
|-----------|------------------|---------------------|-------------|
| 1 Mbps | 1.009900 | 2/3 * 1.190 = 0.793 | PASS |

Note: the test was performed only with 1 Mbps data rate. The limit is based on the 20 dB Bandwidth result of 3 Mbps data rate (the widest bandwidth). The highest measured output power is approximately 4.5 mW

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|-------------|
| Start Frequency | 2.40100 GHz |
| Stop Frequency | 2.40400 GHz |
| Span | 3.000 MHz |
| RBW | 300.000 kHz |
| VBW | 300.000 kHz |
| Sweep Points | 101 |
| Sweep Time | 1.000 ms |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweep Type | Sweep |
| Preamp | off |

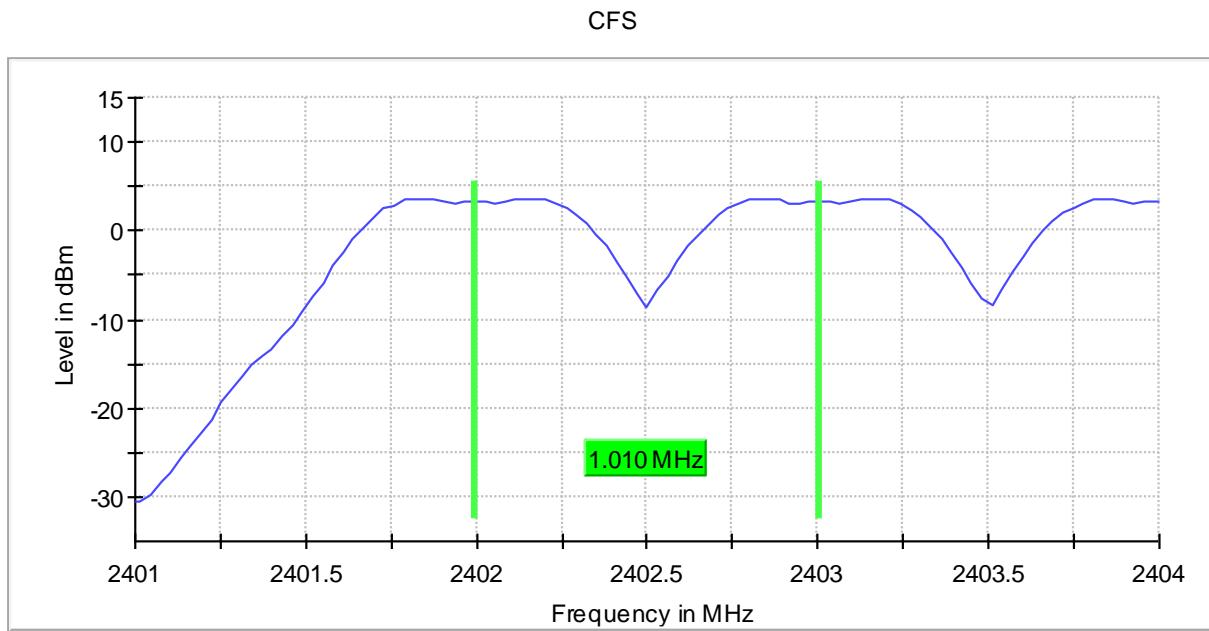


Figure 23: Carrier Frequency Separation (1 Mbps)

Number of Hopping Channels

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Test result: **PASS**

FCC §15.247(a)(1)(iii)
RSS-247 clause 5.1 d)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

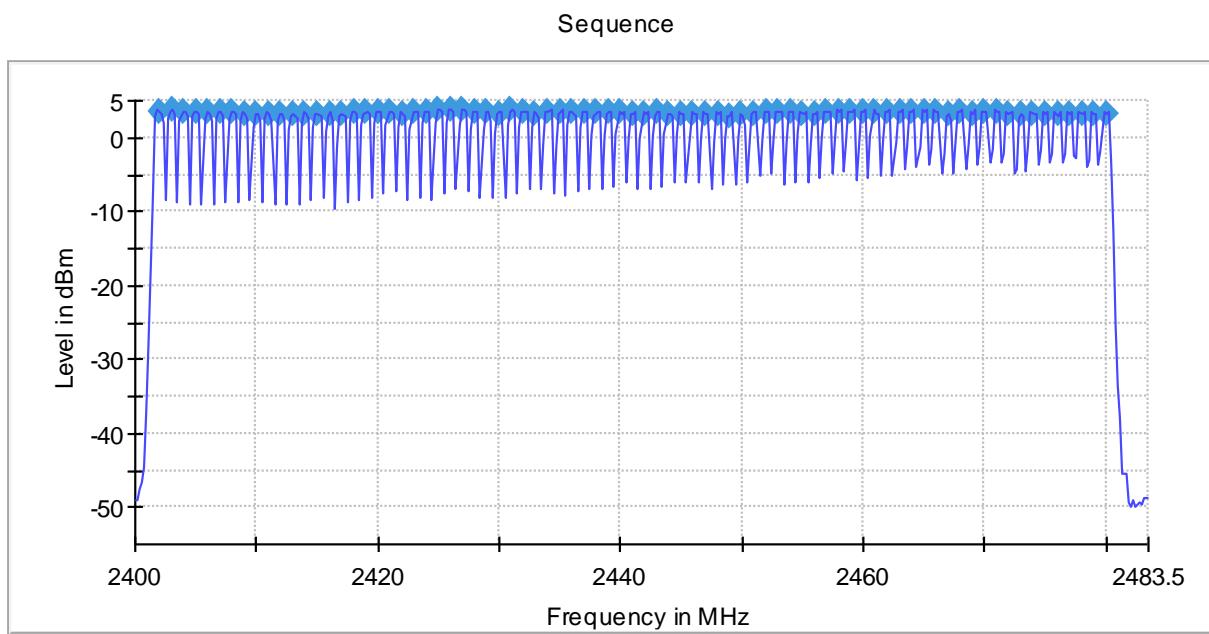
Test results**Table 6:** Test results for Number of Hopping Channels

| Data Rate | Channels | Limit | Result |
|-----------|----------|-------|-------------|
| 1 Mbps | 79 | 15 | PASS |

Note: the test was performed only with 1 Mbps data rate.

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|-------------|
| Start Frequency | 2.40000 GHz |
| Stop Frequency | 2.48350 GHz |
| Span | 83.500 MHz |
| RBW | 200.000 kHz |
| VBW | 200.000 kHz |
| Sweep Points | 418 |
| Sweep Time | 47.405 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweep Type | FFT |
| Preamp | off |

Number of Hopping Channels**Figure 24:** Number of Hopping Channels

Average Time of Occupancy

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Test result: **PASS**

FCC §15.247(a)(1)(iii)
RSS-247 clause 5.1 d)

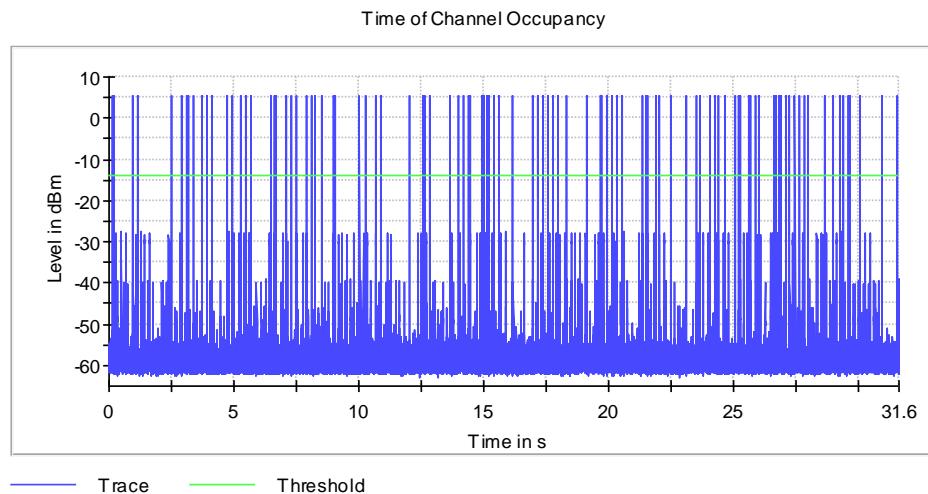
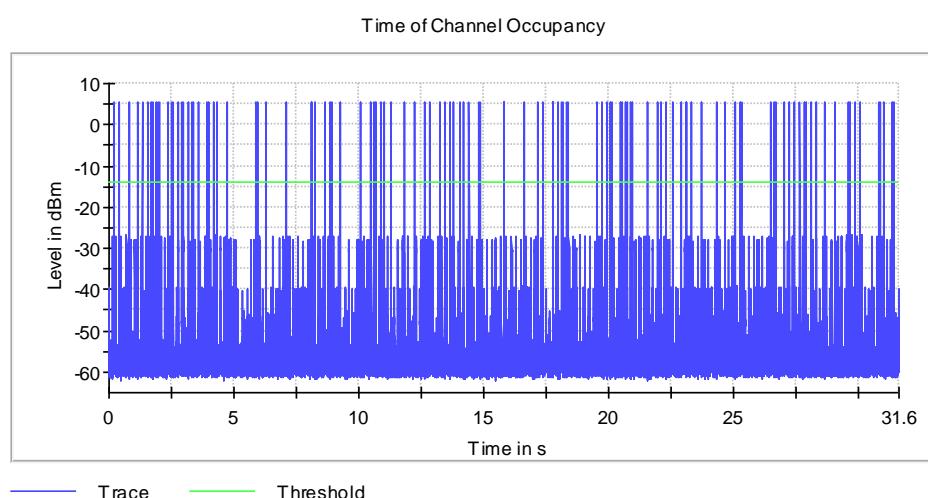
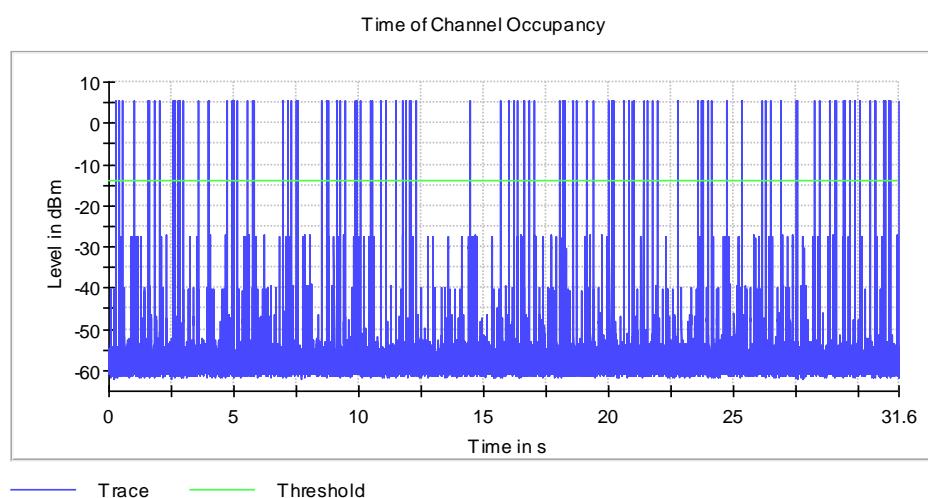
The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

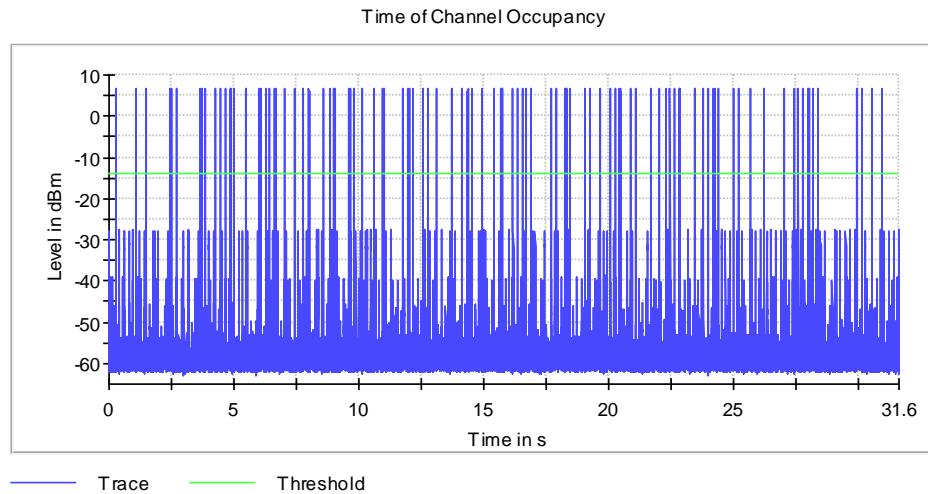
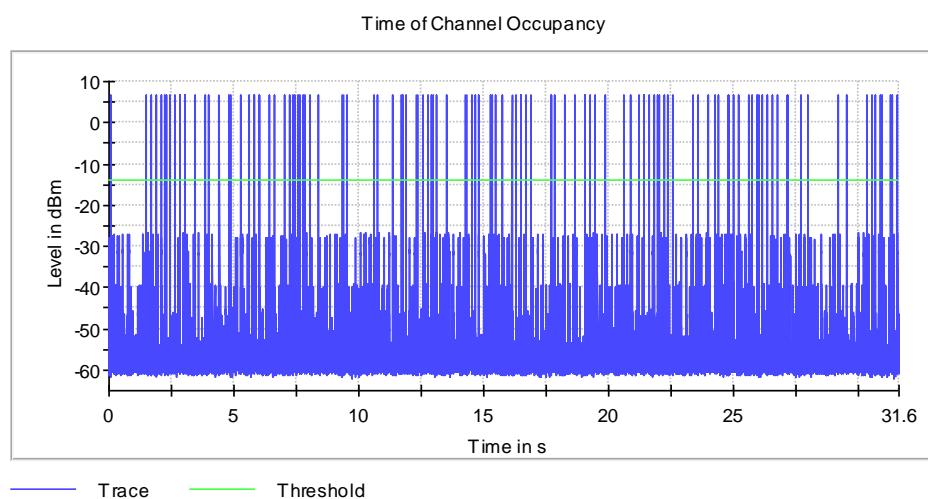
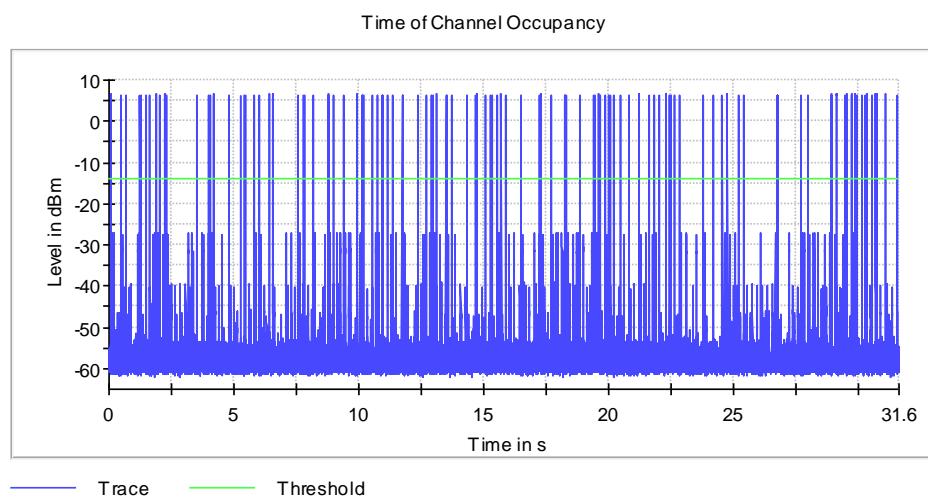
Test results**Table 7:** Test results for Average Time of Occupancy

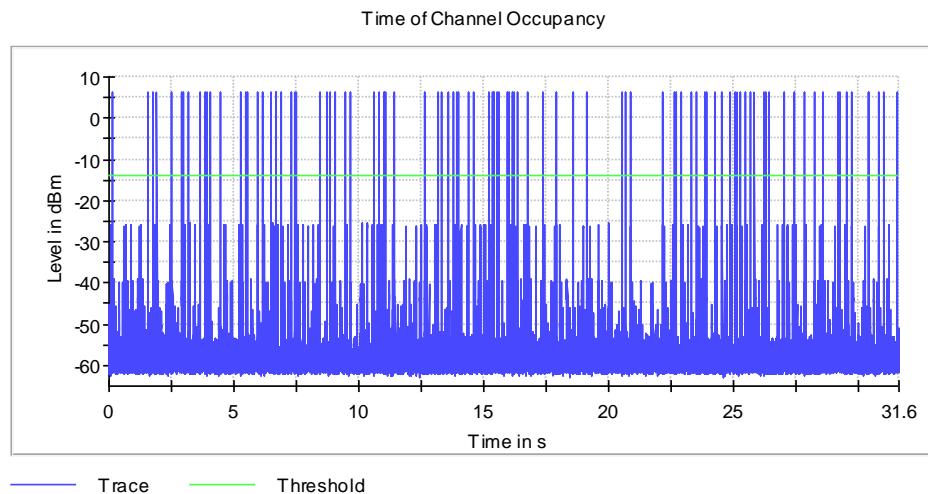
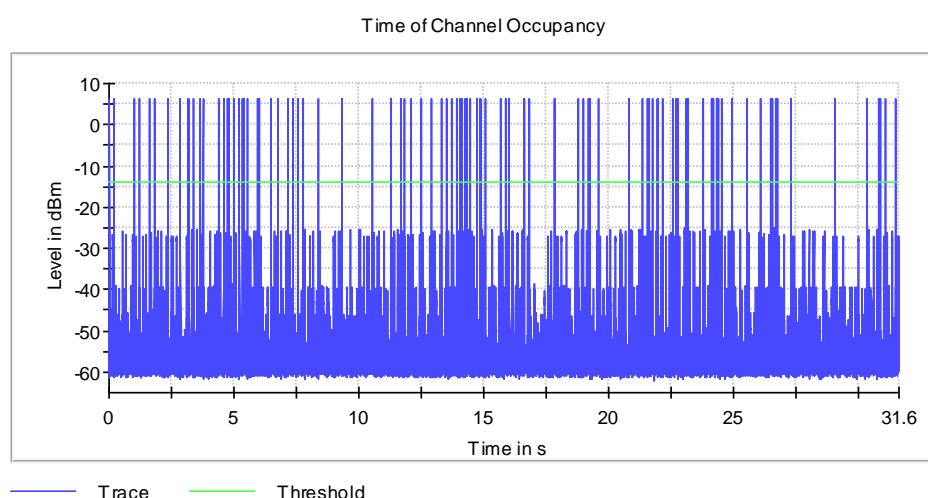
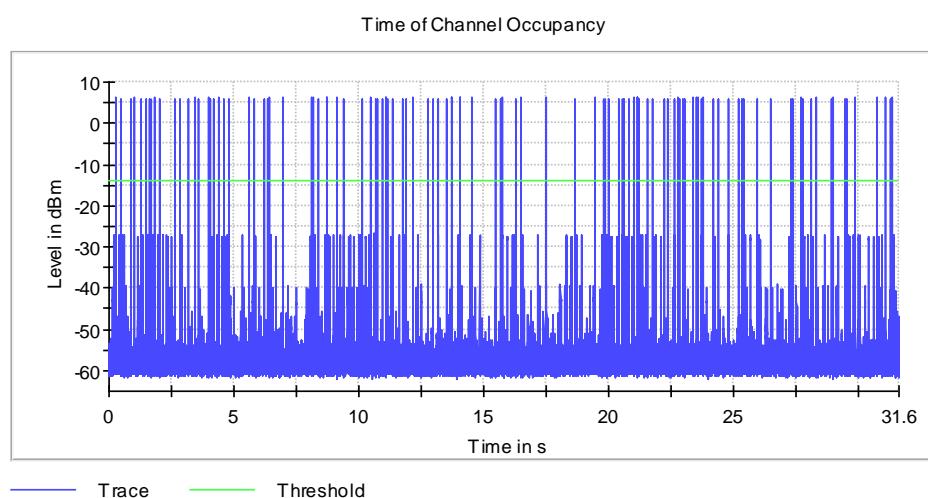
| Data Rate | Frequency [MHz] | Total Time [ms] | Limit [ms] | Result |
|-----------|-----------------|-----------------|----------------------------|-------------|
| 1 Mbps | 2402 | 298.630 | 400 ms within 31.6 s | PASS |
| | 2441 | 316.000 | | PASS |
| | 2480 | 304.440 | | PASS |
| 2 Mbps | 2402 | 289.740 | 400 ms within 31.6 s | PASS |
| | 2441 | 344.810 | | PASS |
| | 2480 | 318.680 | | PASS |
| 3 Mbps | 2402 | 284.220 | 400 ms within 31.6 s | PASS |
| | 2441 | 287.100 | | PASS |
| | 2480 | 304.530 | | PASS |

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|-------------|
| Span | Zero Span |
| RBW | 500.000 kHz |
| VBW | 1.000 MHz |
| Sweep Points | 30001 |
| Sweep Time | 31.600 s |
| Reference Level | -10.000 dBm |
| Attenuation | 0.000 dB |
| Detector | MaxPeak |
| Filter | Channel |
| Trace Mode | Clear Write |
| Sweep Type | Sweep |
| Preamp | off |
| Trigger | External |
| Trigger Offset | 0.000 s |

Average Time of Occupancy**Figure 25:** Average Time of Occupancy (1 Mbps, TX 2402 MHz)**Figure 26:** Average Time of Occupancy (1 Mbps, TX 2441 MHz)**Figure 27:** Average Time of Occupancy (1 Mbps, TX 2480 MHz)

Average Time of Occupancy**Figure 28:** Average Time of Occupancy (2 Mbps, TX 2402 MHz)**Figure 29:** Average Time of Occupancy (2 Mbps, TX 2441 MHz)**Figure 30:** Average Time of Occupancy (2 Mbps, TX 2480 MHz)

Average Time of Occupancy**Figure 31:** Average Time of Occupancy (3 Mbps, TX 2402 MHz)**Figure 32:** Average Time of Occupancy (3 Mbps, TX 2441 MHz)**Figure 33:** Average Time of Occupancy (3 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Measurement uncertainty: ± 2.87dB, level of confidence 95 % (k = 2)
Test result: **PASS**

**FCC §15.247(b)(1)
RSS-247 clause 5.4 b)**

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, the maximum peak conducted output power of the intentional radiated shall not exceed 1 W (30 dBm). For all other frequency hopping systems in the 2400-2483.5 MHz band the limit is 0.125 watts (21 dBm). The conducted output power limit is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test results**Table 8:** Test results for Maximum Peak Conducted Output Power

| Data Rate | Frequency [MHz] | Output Power [dBm] | Limit [dBm] | Result |
|-----------|-----------------|--------------------|-------------|-------------|
| 1 Mbps | 2402 | 3.9 | 21.0 | PASS |
| | 2441 | 3.7 | | PASS |
| | 2480 | 3.7 | | PASS |
| 2 Mbps | 2402 | 5.9 | 21.0 | PASS |
| | 2441 | 6.0 | | PASS |
| | 2480 | 5.9 | | PASS |
| 3 Mbps | 2402 | 6.5 | 21.0 | PASS |
| | 2441 | 6.5 | | PASS |
| | 2480 | 6.5 | | PASS |

Note: the limit 125 mW (21.0 dBm) was used in order to satisfy the Carrier Frequency Separation requirements.

The conducted measurement was performed with a spectrum analyzer using the following settings:

| Setting | Value |
|-----------------|------------|
| Span | 6.000 MHz |
| RBW | 2.000 MHz |
| VBW | 10.000 MHz |
| Sweep Points | 101 |
| Sweep Time | 953.450 ns |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweep Type | FFT |
| Preamp | off |

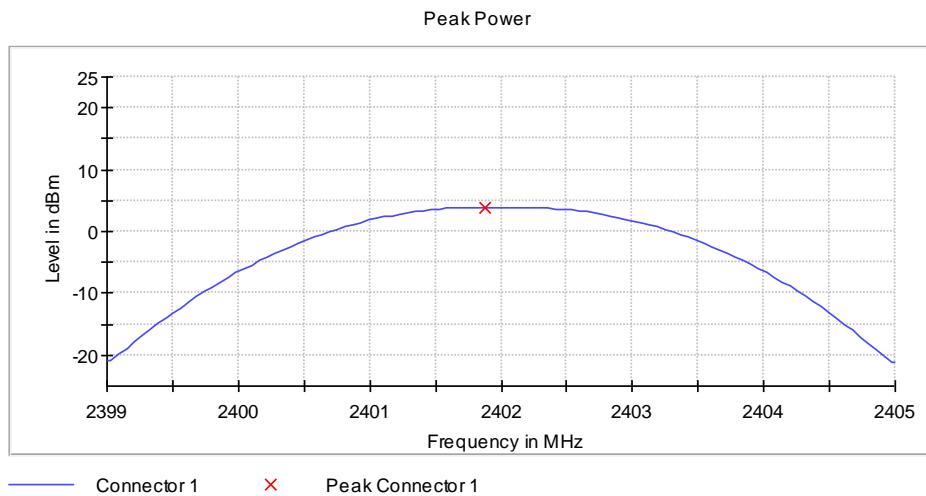
Maximum Peak Conducted Output Power

Figure 34: Maximum Peak Conducted Output Power (1 Mbps, TX 2402 MHz)

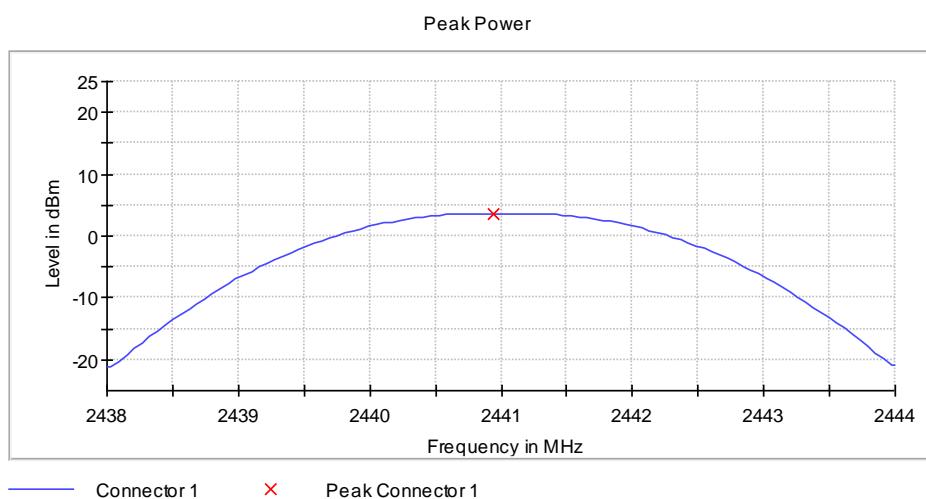


Figure 35: Maximum Peak Conducted Output Power (1 Mbps, TX 2441 MHz)

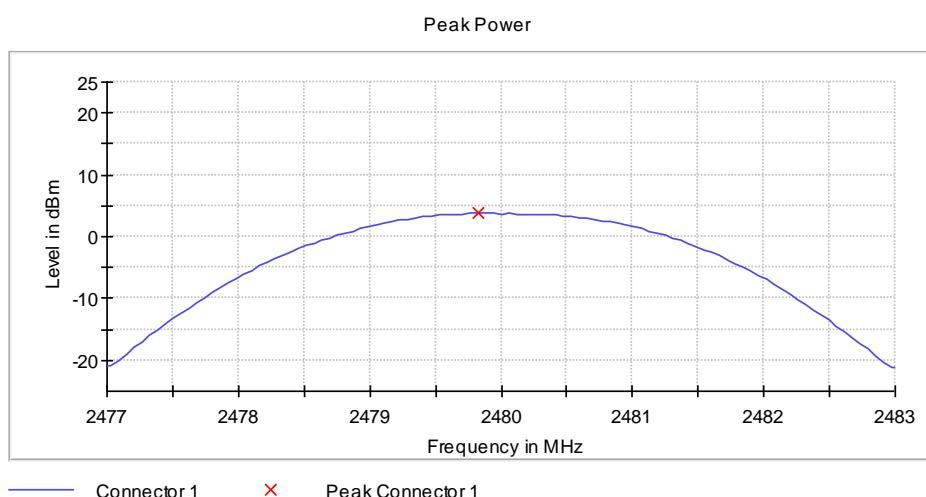
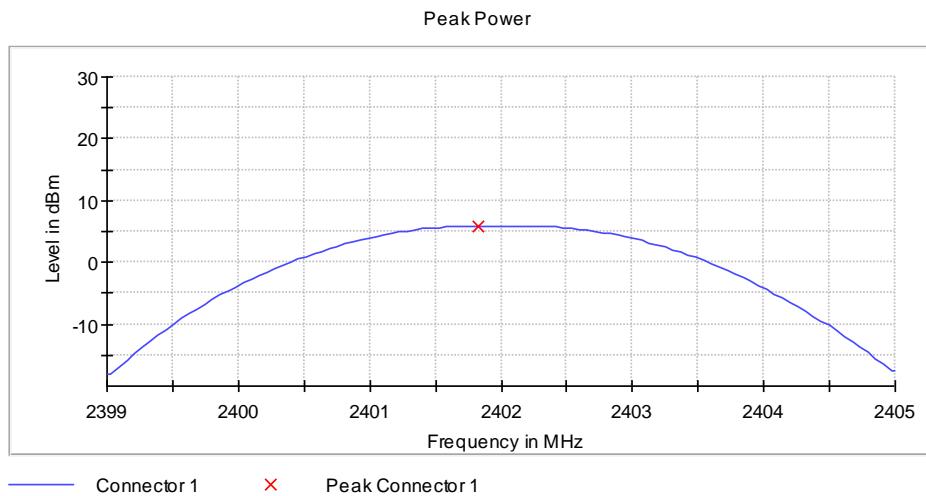
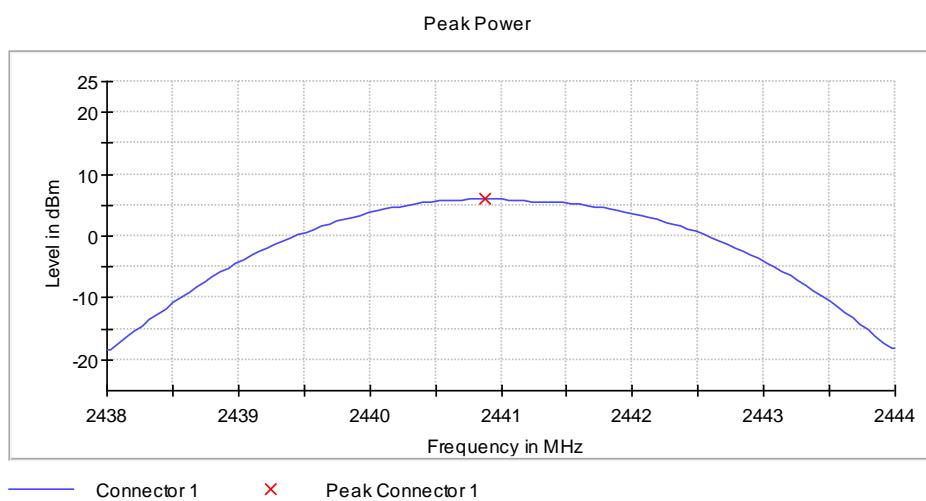
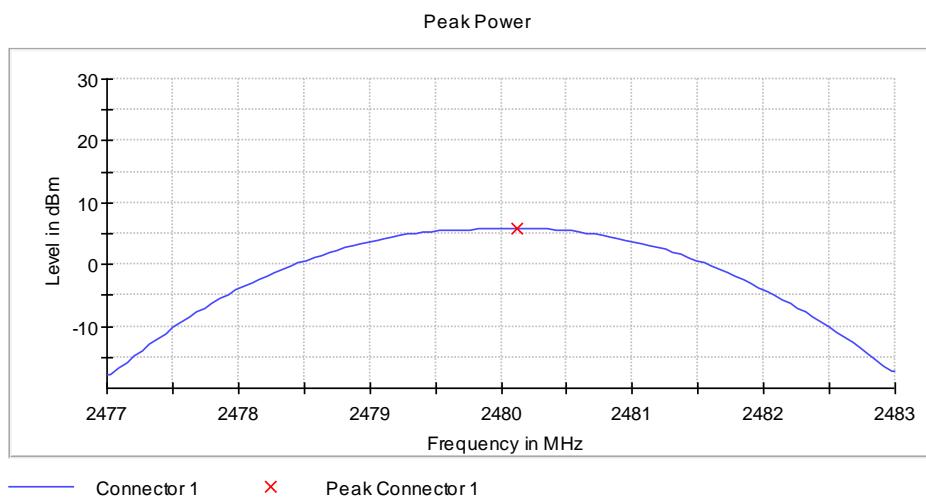
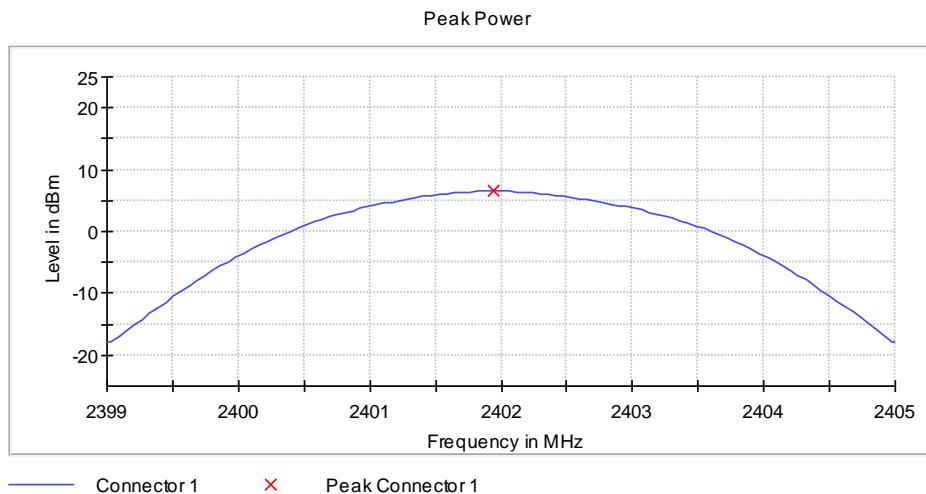
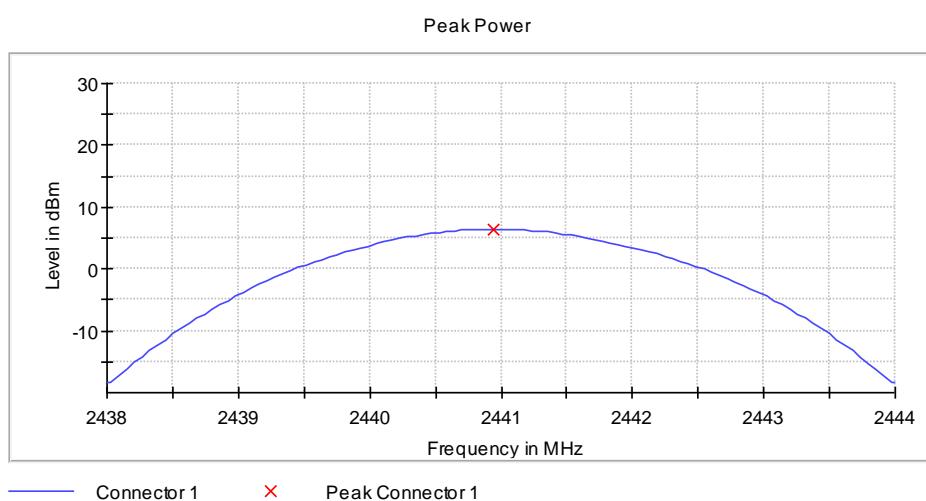
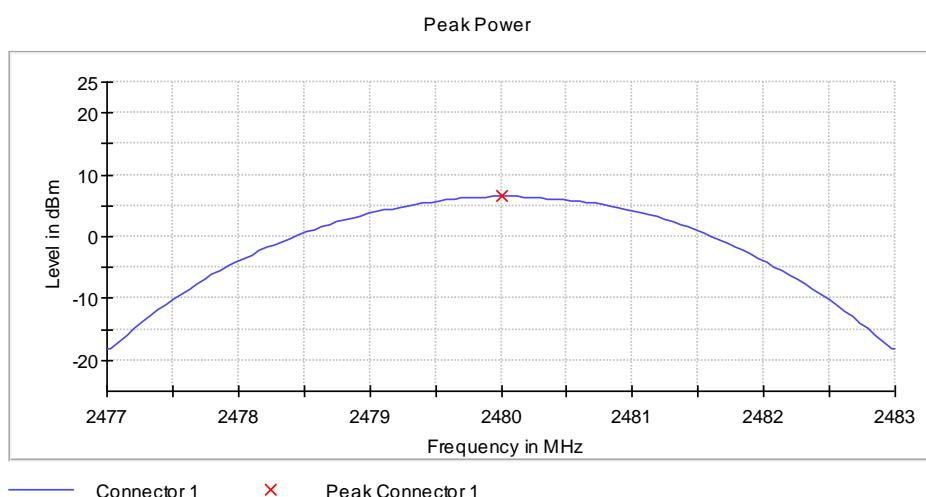


Figure 36: Maximum Peak Conducted Output Power (1 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power**Figure 37:** Maximum Peak Conducted Output Power (2 Mbps, TX 2402 MHz)**Figure 38:** Maximum Peak Conducted Output Power (2 Mbps, TX 2441 MHz)**Figure 39:** Maximum Peak Conducted Output Power (2 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power**Figure 40:** Maximum Peak Conducted Output Power (3 Mbps, TX 2402 MHz)**Figure 41:** Maximum Peak Conducted Output Power (3 Mbps, TX 2441 MHz)**Figure 42:** Maximum Peak Conducted Output Power (3 Mbps, TX 2480 MHz)

Unwanted Emissions (conducted)

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 9 March 2023
Temperature: 22 °C
Humidity: 16 %RH
Measurement uncertainty: ± 2.87 dB, level of confidence 95 % (k = 2)
Test result: **PASS**

**FCC §15.247(d)
RSS-247 clause 5.5**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.

Unwanted Emissions (conducted)

Test results

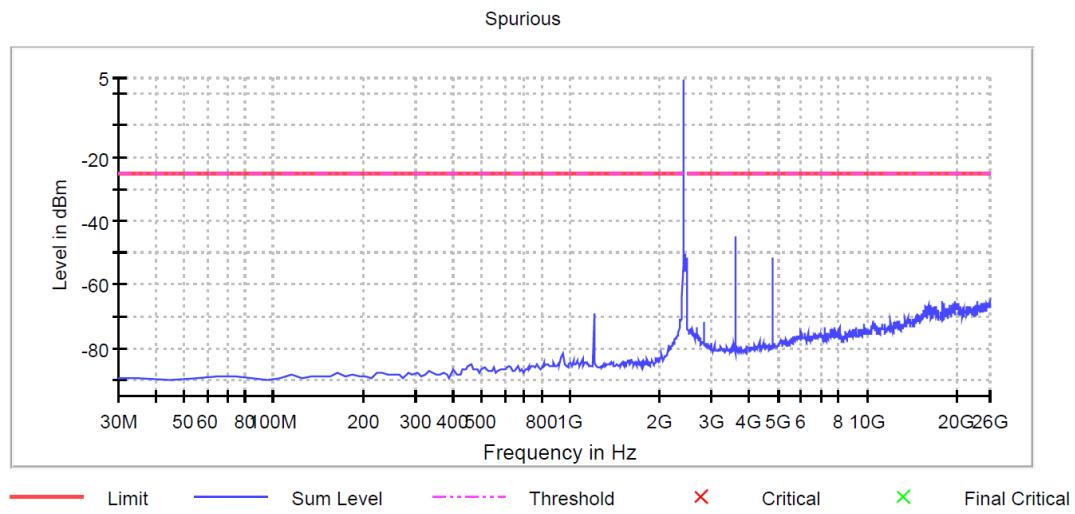


Figure 43: Unwanted Emissions, conducted (1 Mbps, TX 2402 MHz)

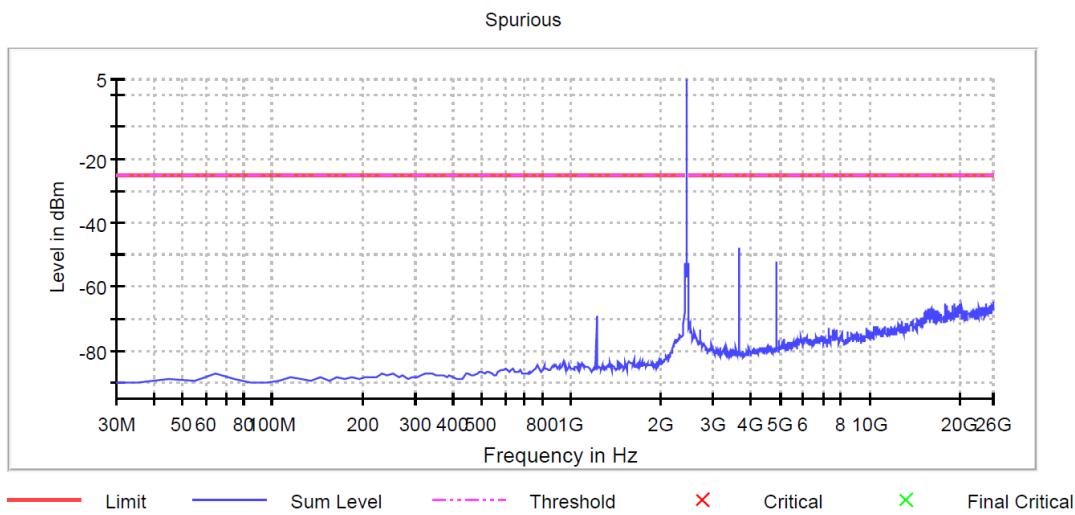


Figure 44: Unwanted Emissions, conducted (1 Mbps, TX 2441 MHz)

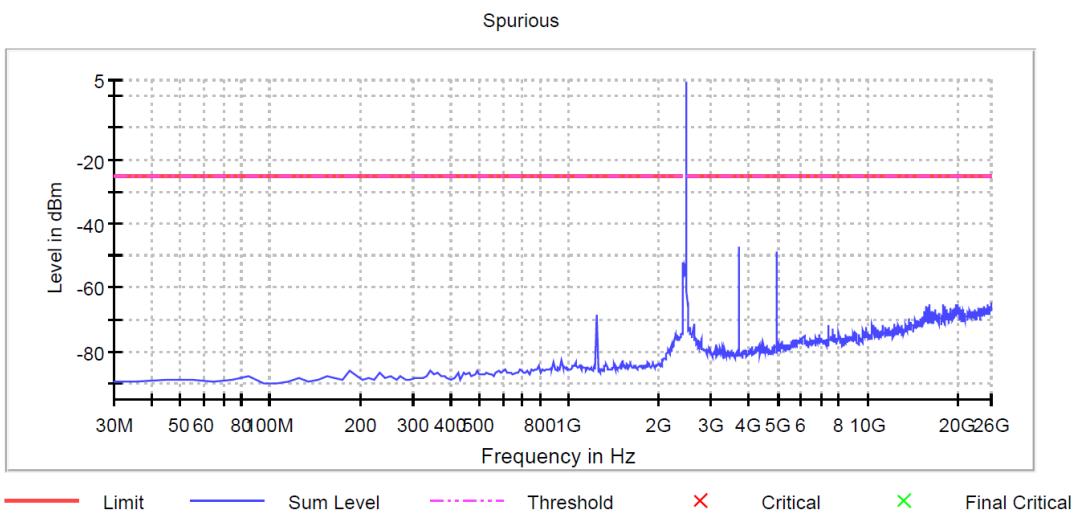


Figure 45: Unwanted Emissions, conducted (1 Mbps, TX 2480 MHz)

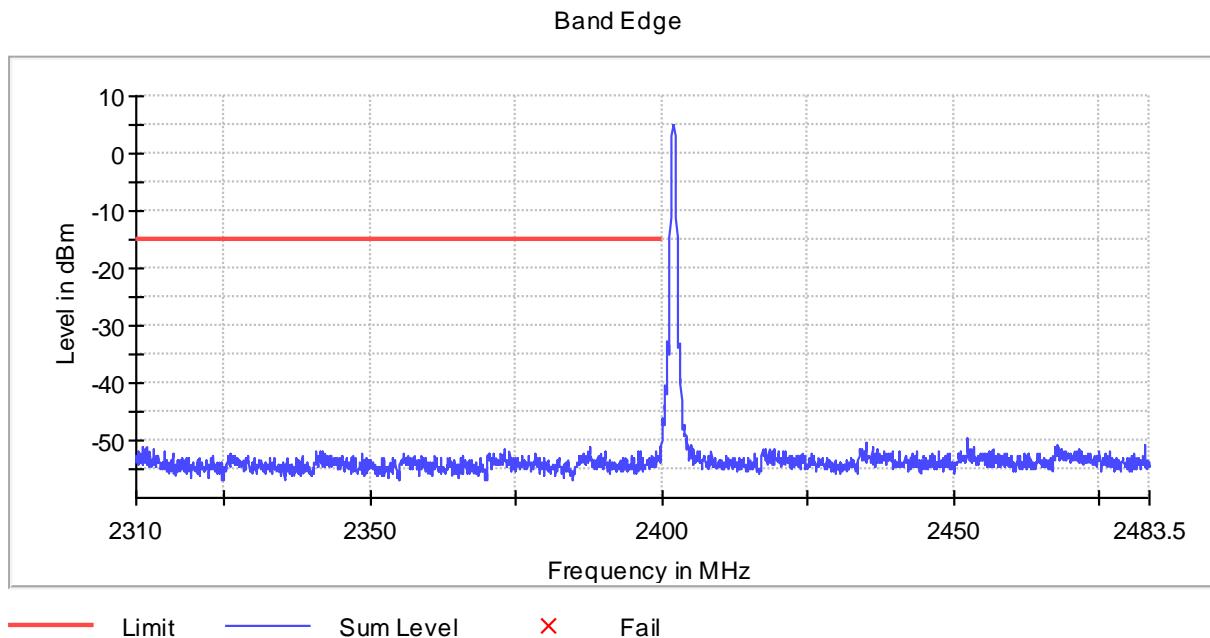


Figure 46: Lower Band-Edge, conducted (1 Mbps, TX 2402 MHz)

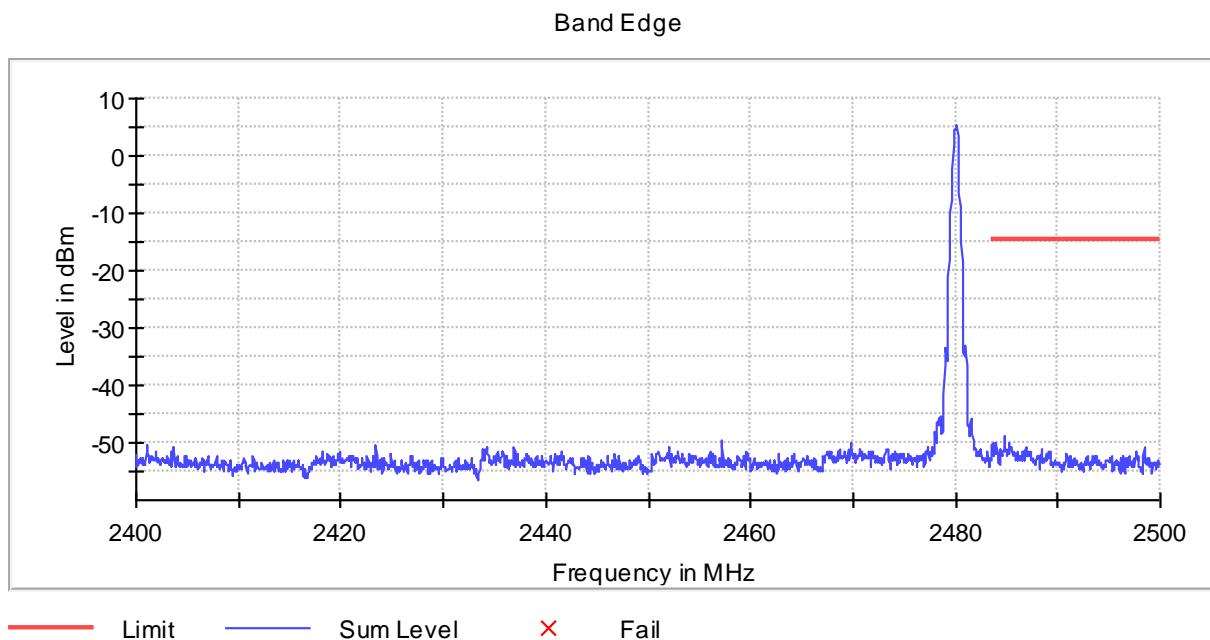


Figure 47: Upper Band-Edge, conducted (1 Mbps, TX 2480 MHz)

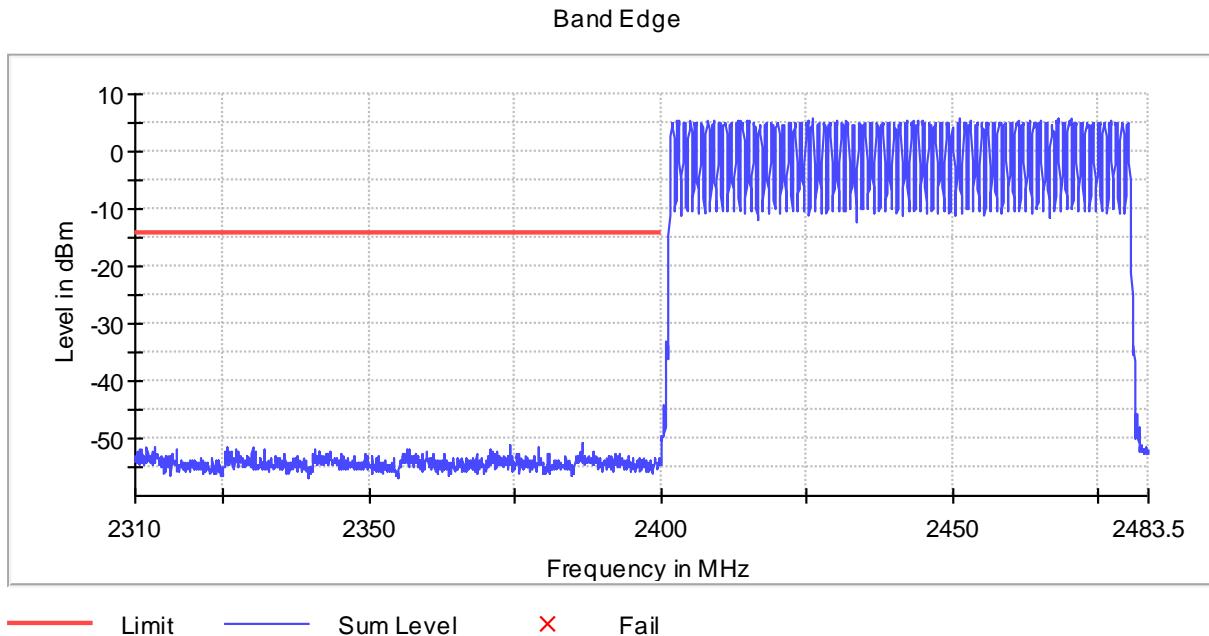


Figure 48: Lower Band-Edge, conducted (1 Mbps, hopping mode)

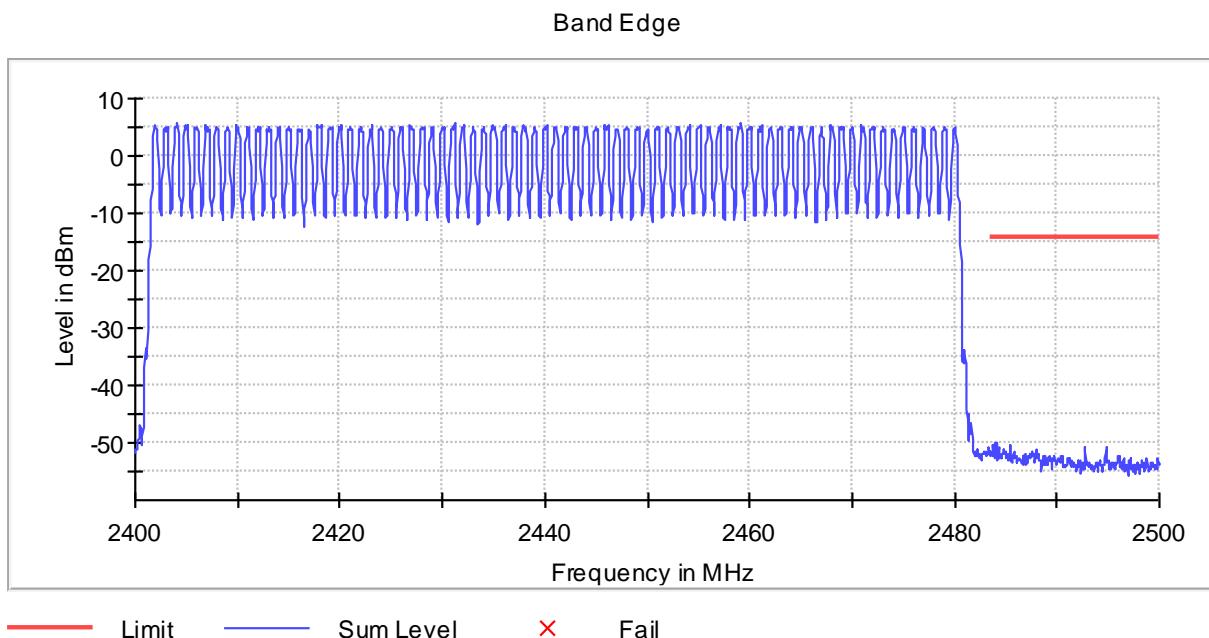


Figure 49: Upper Band-Edge, conducted (1 Mbps, hopping mode)

Unwanted Emissions (conducted)

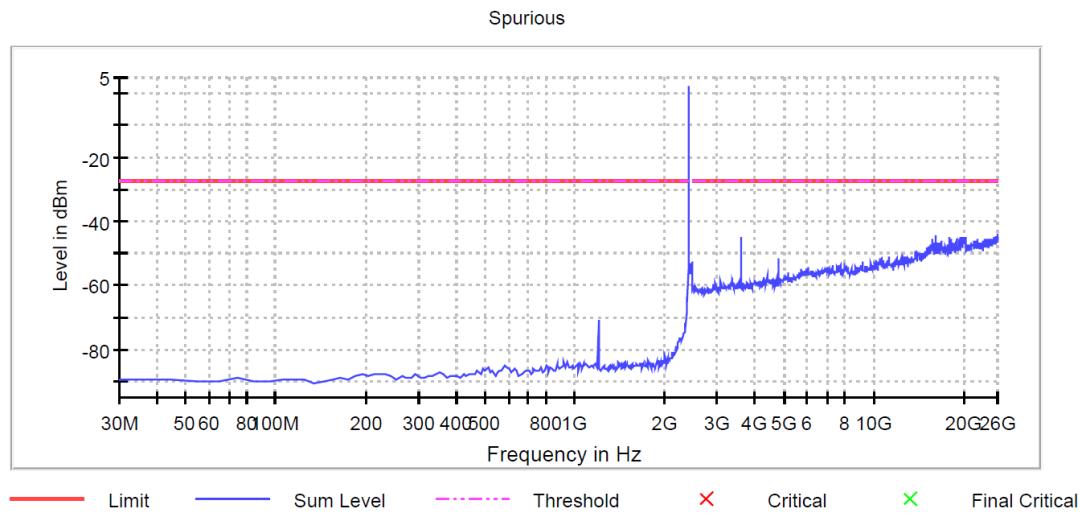


Figure 50: Unwanted Emissions, conducted (2 Mbps, TX 2402 MHz)

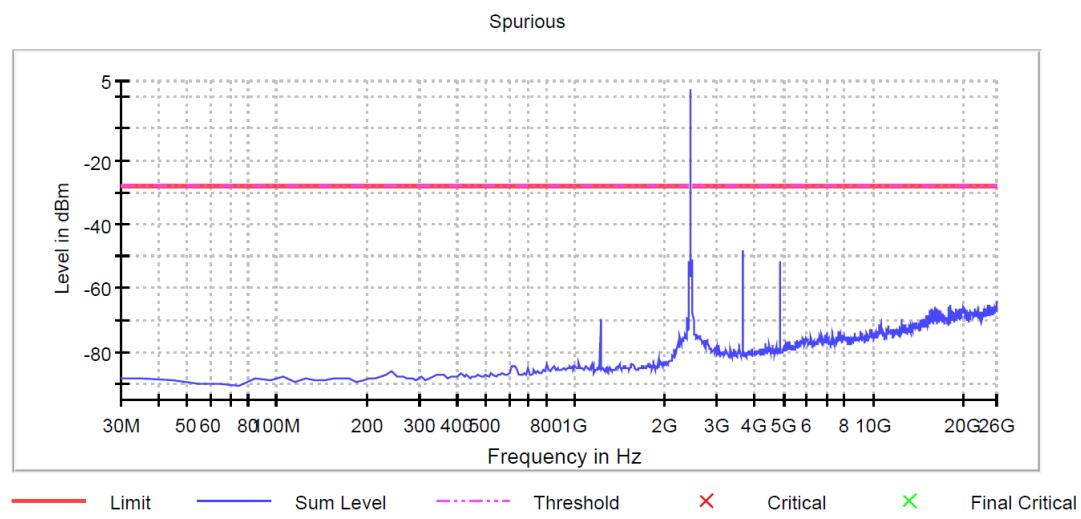


Figure 51: Unwanted Emissions, conducted (2 Mbps, TX 2441 MHz)

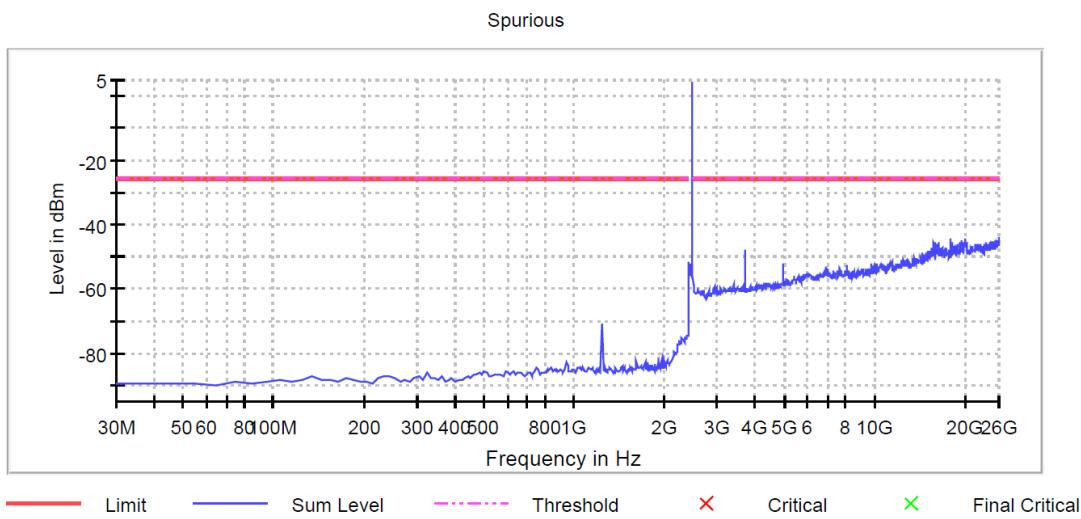


Figure 52: Unwanted Emissions, conducted (2 Mbps, TX 2480 MHz)

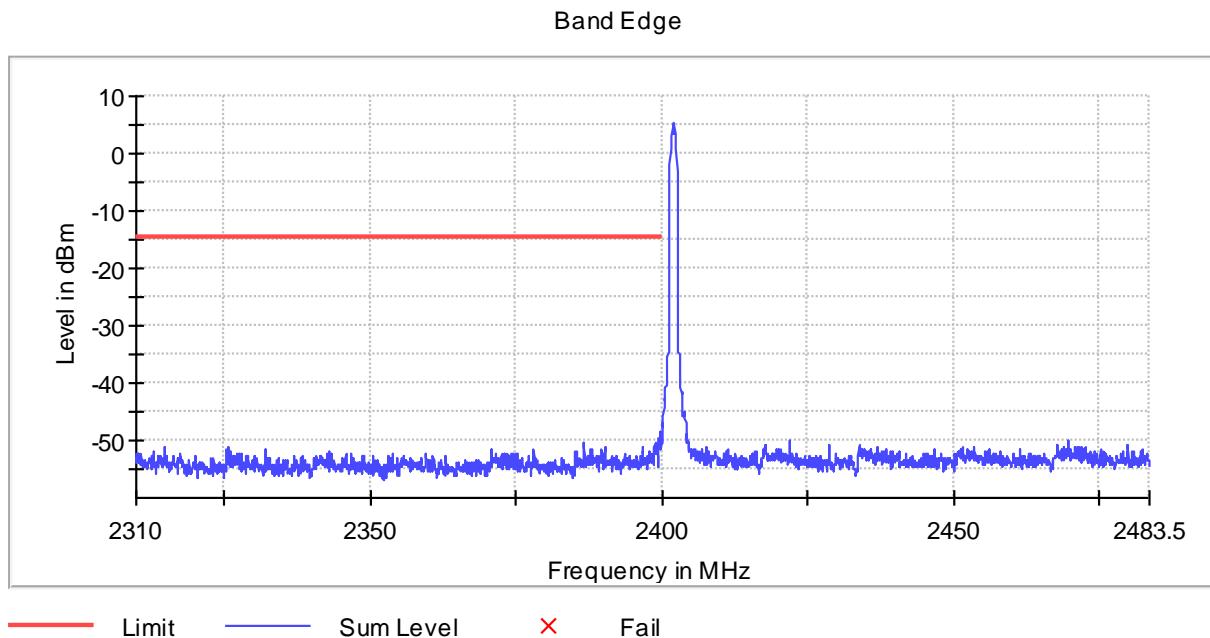
Unwanted Emissions (conducted)

Figure 53: Lower Band-Edge, conducted (2 Mbps, TX 2402 MHz)

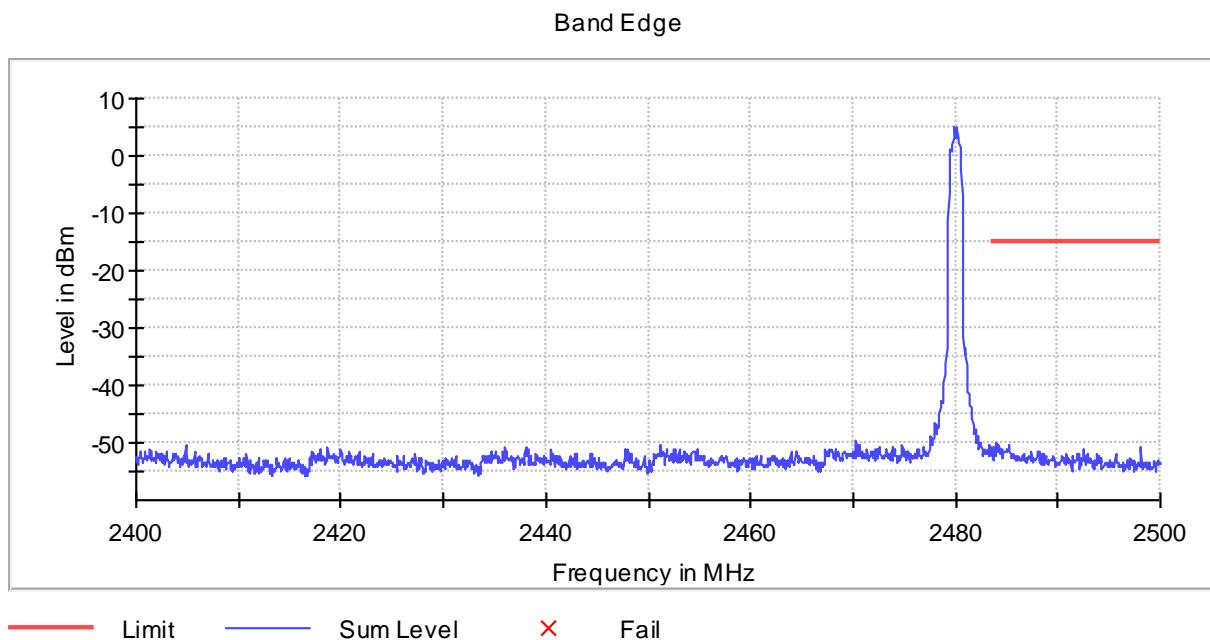


Figure 54: Upper Band-Edge, conducted (2 Mbps, TX 2480 MHz)

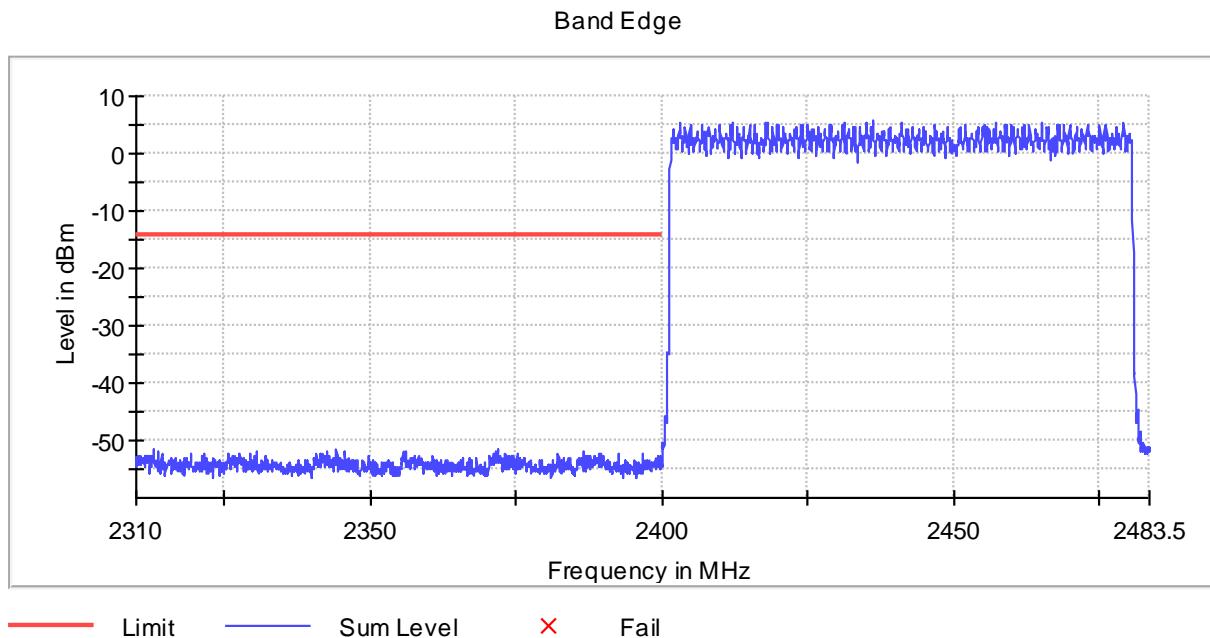


Figure 55: Lower Band-Edge, conducted (2 Mbps, hopping mode)

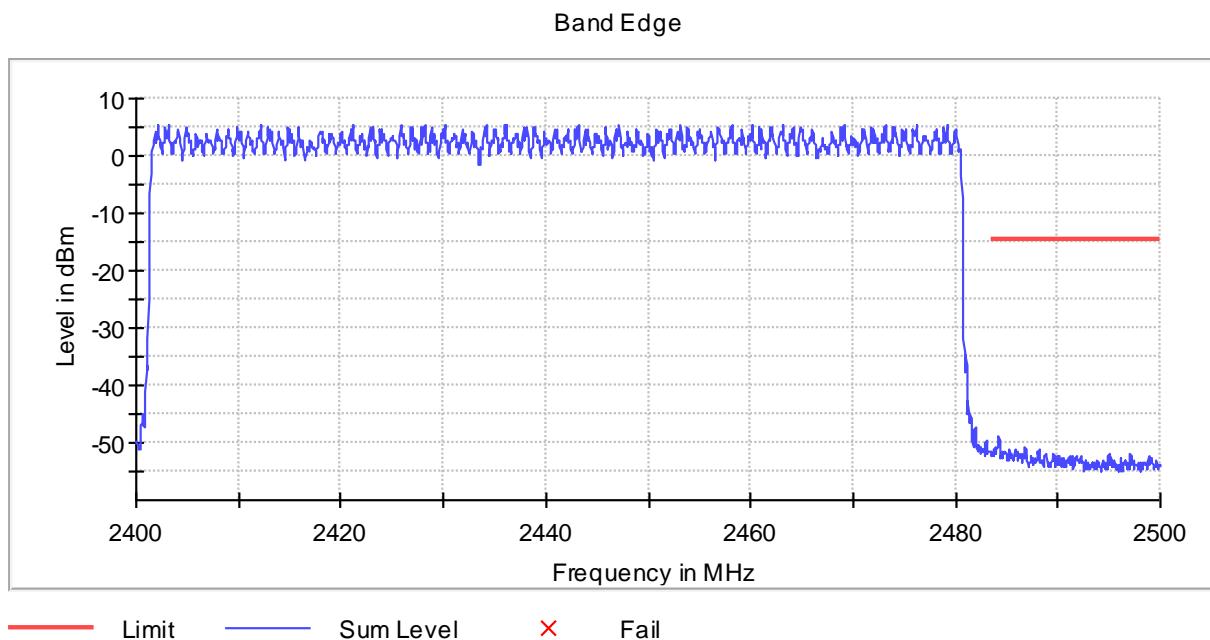
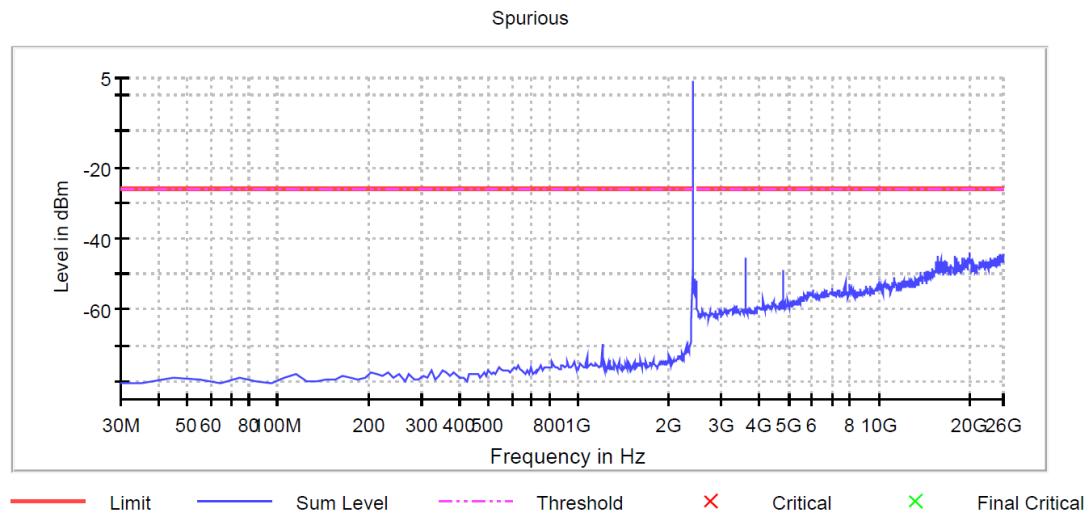
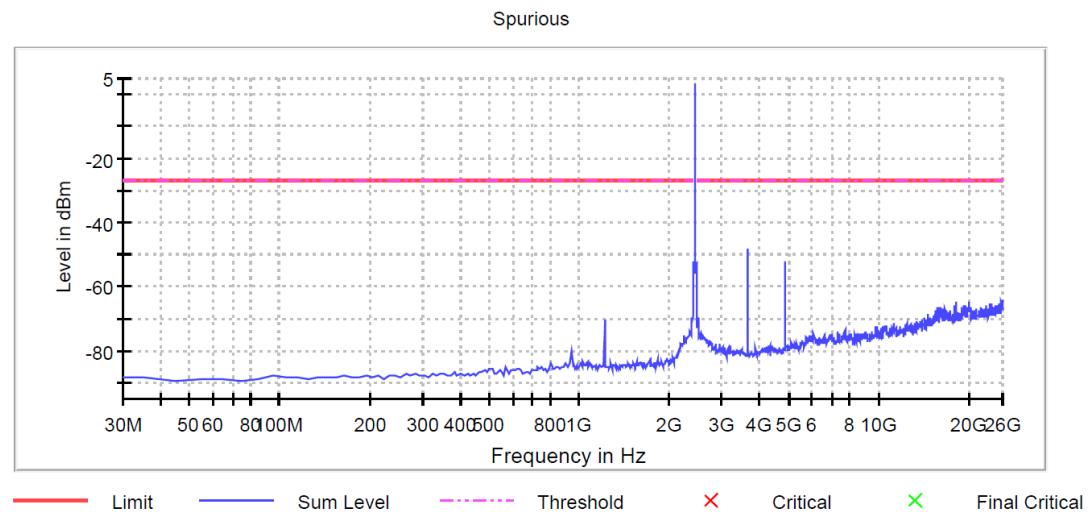
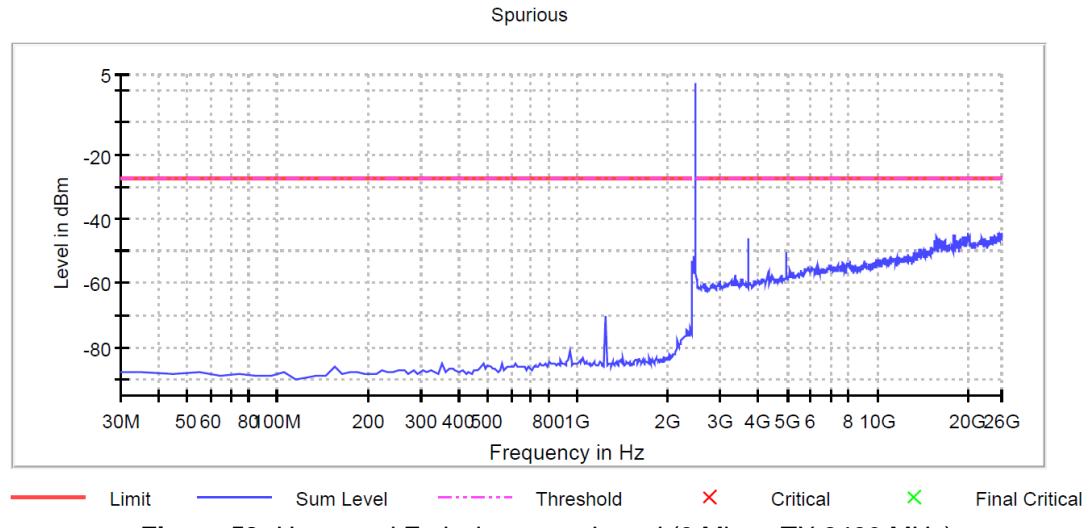


Figure 56: Upper Band-Edge, conducted (2 Mbps, hopping mode)

Unwanted Emissions (conducted)**Figure 57:** Unwanted Emissions, conducted (3 Mbps, TX 2402 MHz)**Figure 58:** Unwanted Emissions, conducted (3 Mbps, TX 2441 MHz)**Figure 59:** Unwanted Emissions, conducted (3 Mbps, TX 2480 MHz)

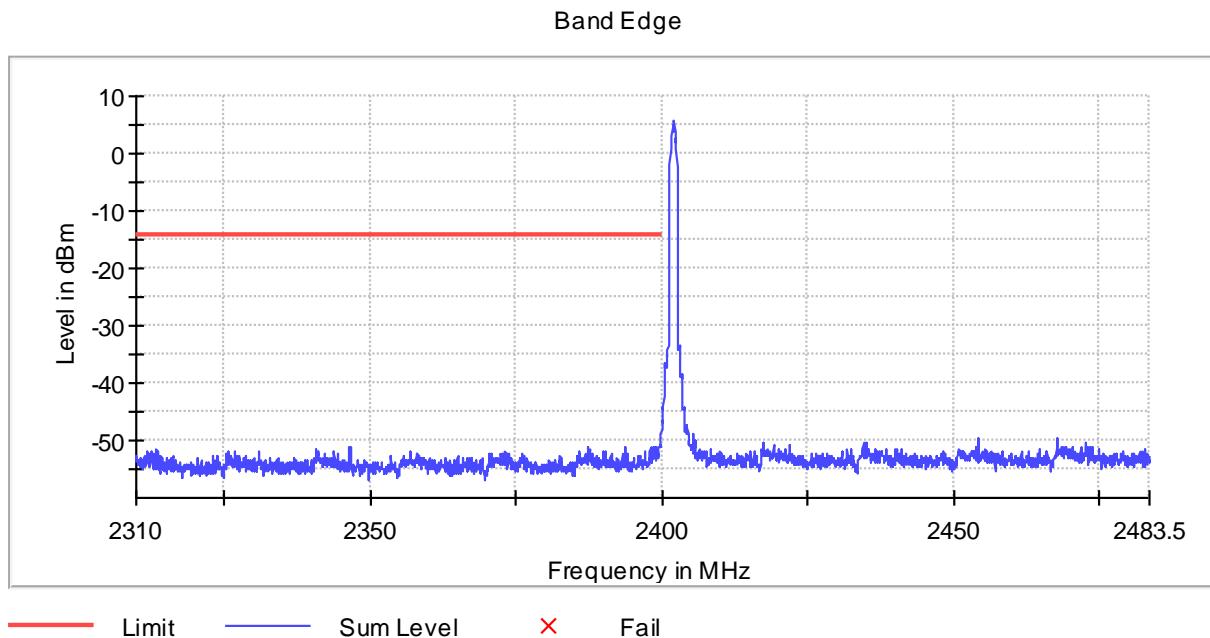
Unwanted Emissions (conducted)

Figure 60: Lower Band-Edge, conducted (3 Mbps, TX 2402 MHz)

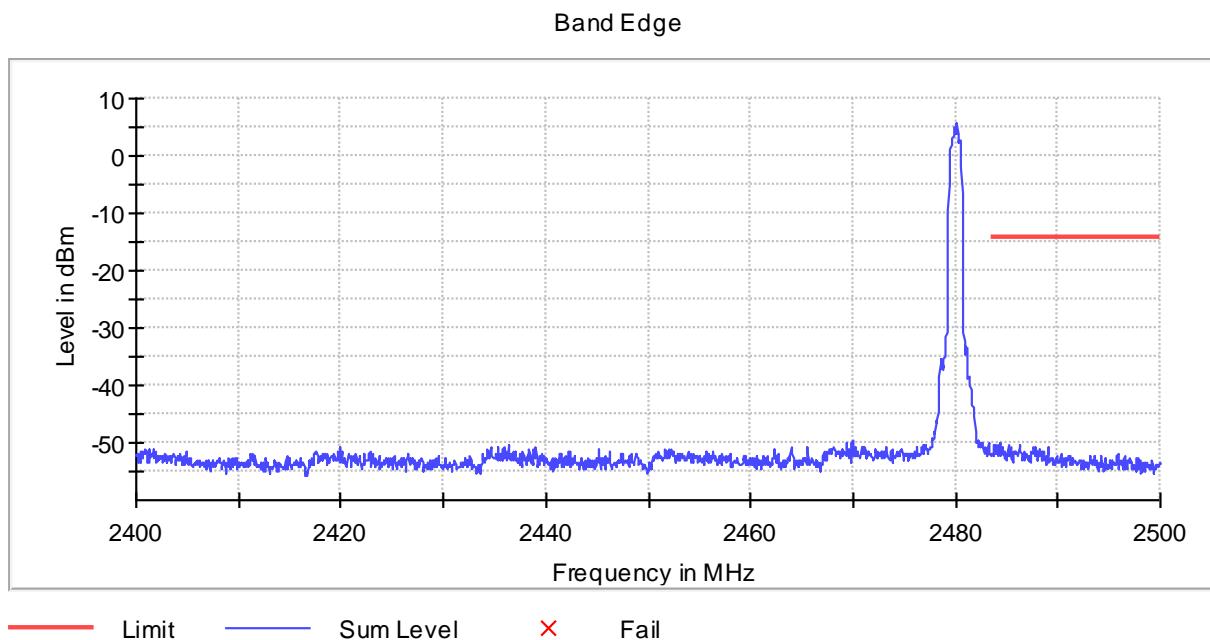


Figure 61: Upper Band-Edge, conducted (3 Mbps, TX 2480 MHz)

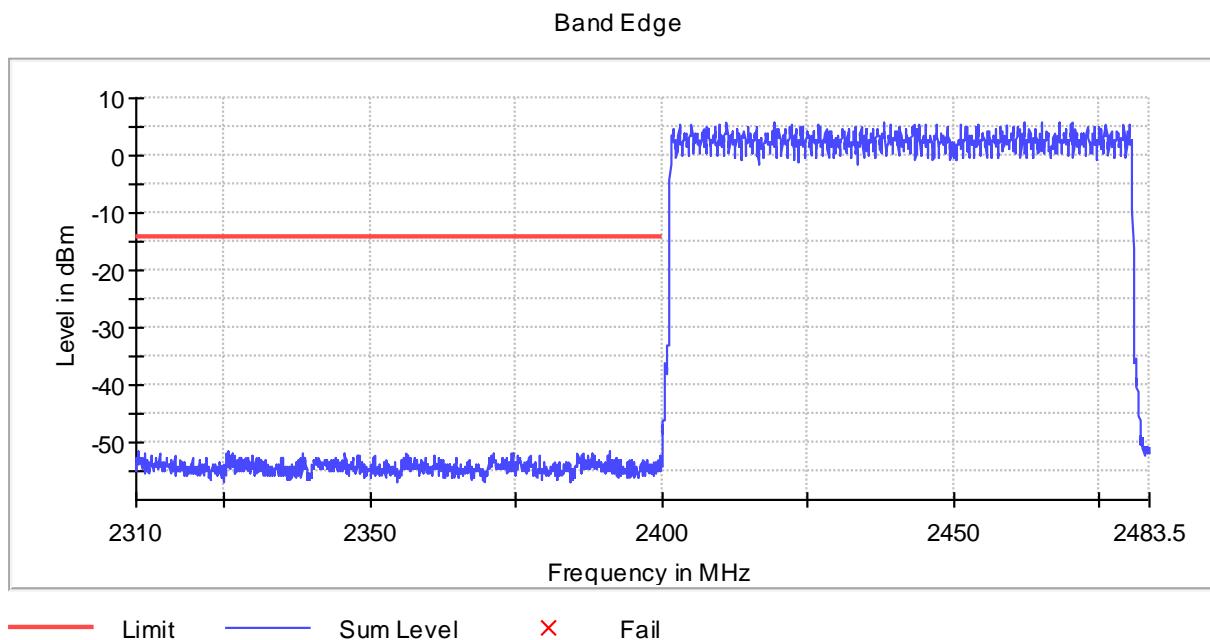


Figure 62: Lower Band-Edge, conducted (3 Mbps, hopping mode)

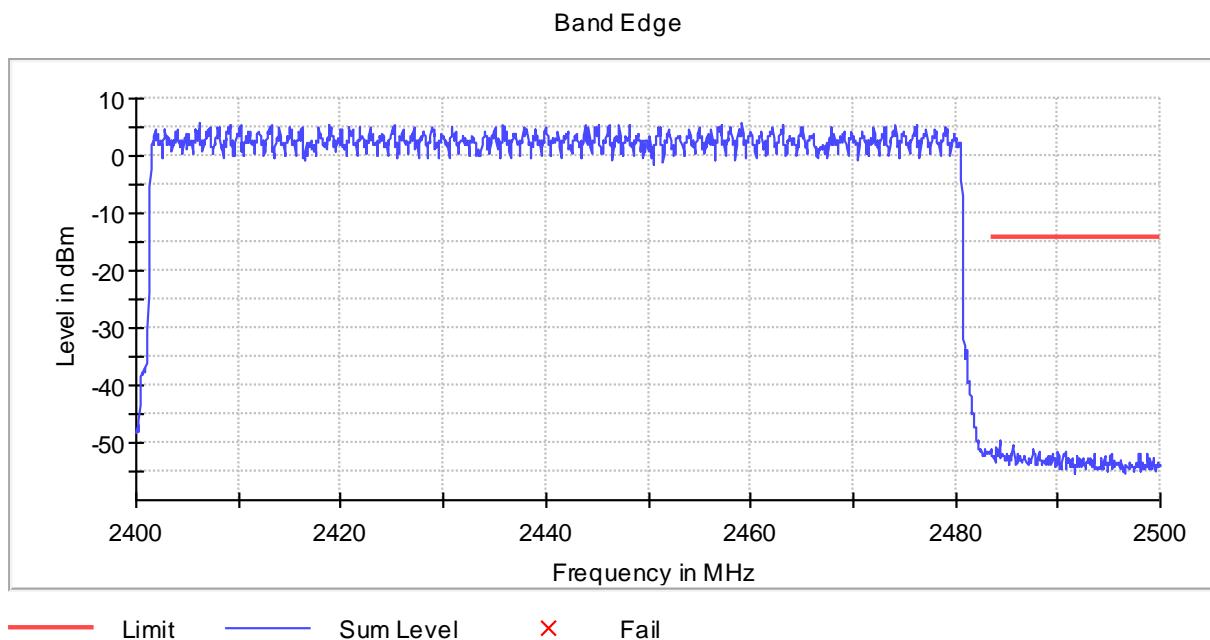


Figure 63: Upper Band-Edge, conducted (3 Mbps, hopping mode)

Unwanted Emissions (radiated)

Standard: ANSI C63.10-2013
Tested by: HEM, HAM
Date: 28 February 2023 1 March 2023
Temperature: 24 °C 23 °C
Humidity: 33 %RH 32 %RH
Measurement uncertainty: ± 4.51 dB, level of confidence 95 % (k = 2)
Test result: **PASS**

**FCC §15.247(d)
RSS-247 clause 5.5**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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. Attenuation below the general limits specified in §15.209(a) and RSS-Gen clause 8.9 is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a) and RSS-Gen clause 8.10, must also comply with the radiated emission limits specified in §15.209(a) and RSS-Gen clause 8.9.

Investigative measurements were performed in order to find the worst-case orientation for the EUT. The final measurements were performed in the worst-case orientation.

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables). The result value is the measured value corrected with the correction factor.

The measurements were performed using the 1 Mbps data rate.

Test results (1 Mbps, TX 2402 MHz)

Table 9: Test results with quasi-peak detector (1 Mbps, TX 2402 MHz)

| Frequency (MHz) | QuasiPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 0.623000 | -9.89 | 31.72 | 41.61 | 15 x 1000.0 | 9.000 | 0.0 *) | V | 342.0 | -20.4 |
| 209.255000 | 16.27 | 43.50 | 27.23 | 15 x 1000.0 | 120.000 | 146.0 | V | 243.0 | 15.2 |
| 219.935000 | 16.05 | 46.00 | 29.95 | 15 x 1000.0 | 120.000 | 136.0 | V | 244.0 | 15.5 |

*) Measurement loop antenna angle

Table 10: Test results with peak detector (1 Mbps, TX 2402 MHz)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 2400.000000 | 51.73 | 72.57 | 20.84 | 15 x 1000.0 | 1000.000 | 154.0 | V | 99.0 | 13.7 |
| 2401.900000 | 92.57 | --- | --- | 15 x 1000.0 | 1000.000 | 182.0 | V | 256.0 | 13.7 |
| 4803.700000 | 47.82 | 73.98 | 26.16 | 15 x 1000.0 | 1000.000 | 264.0 | H | 258.0 | 7.4 |
| 18869.400000 | 52.45 | 73.98 | 21.53 | 15 x 1000.0 | 1000.000 | 276.0 | V | 88.0 | 8.1 |

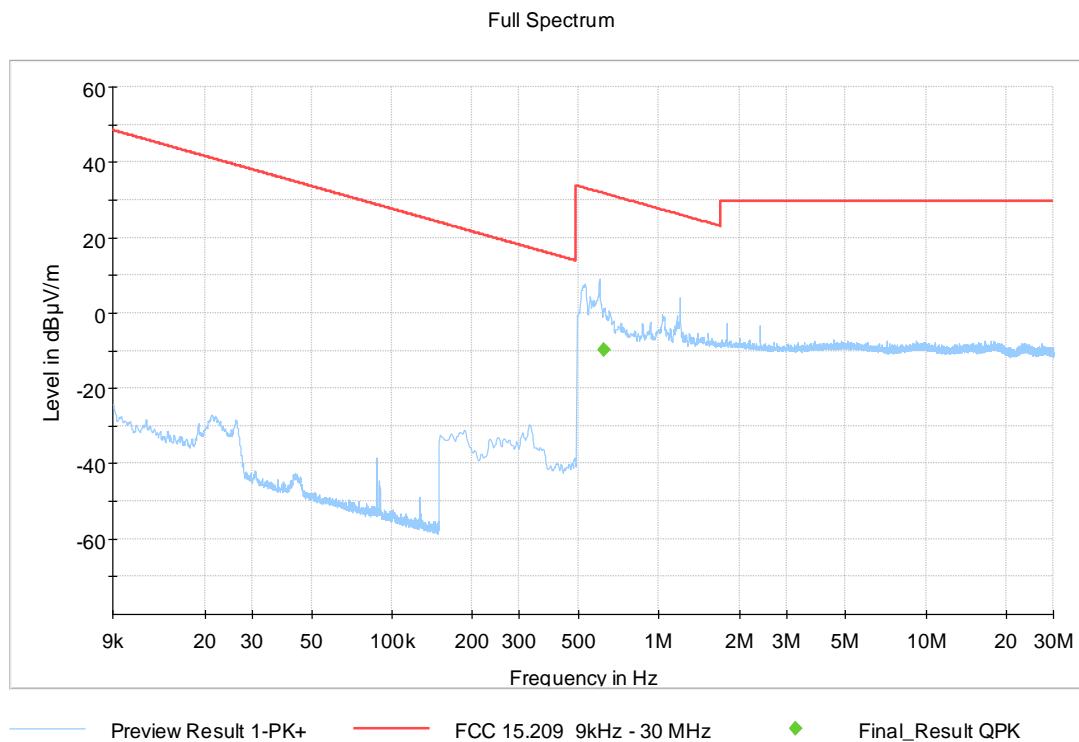


Figure 64: Unwanted Emissions, radiated 9 kHz – 30 MHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

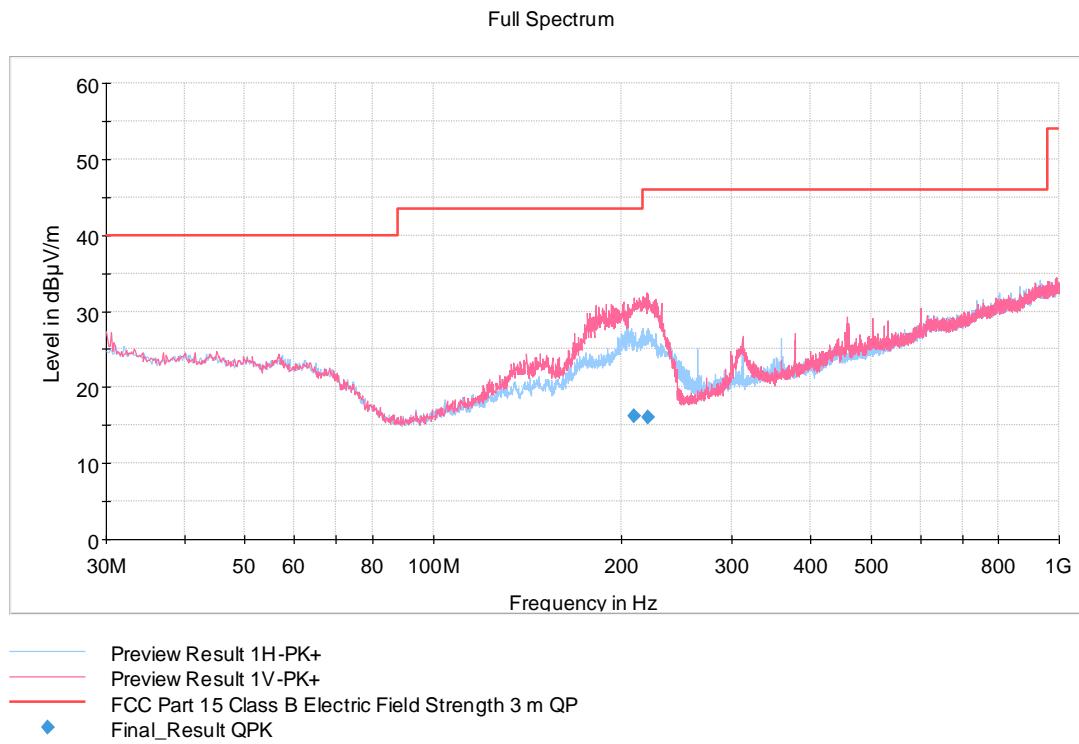


Figure 65: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2402 MHz)

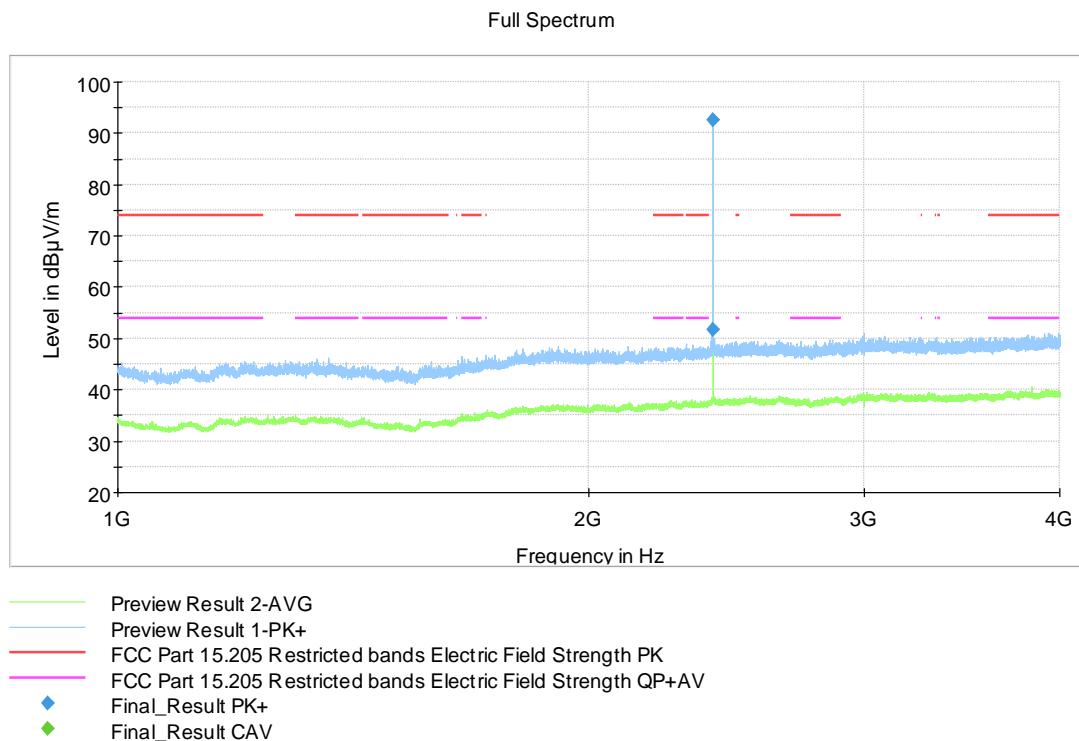


Figure 66: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2402 MHz)

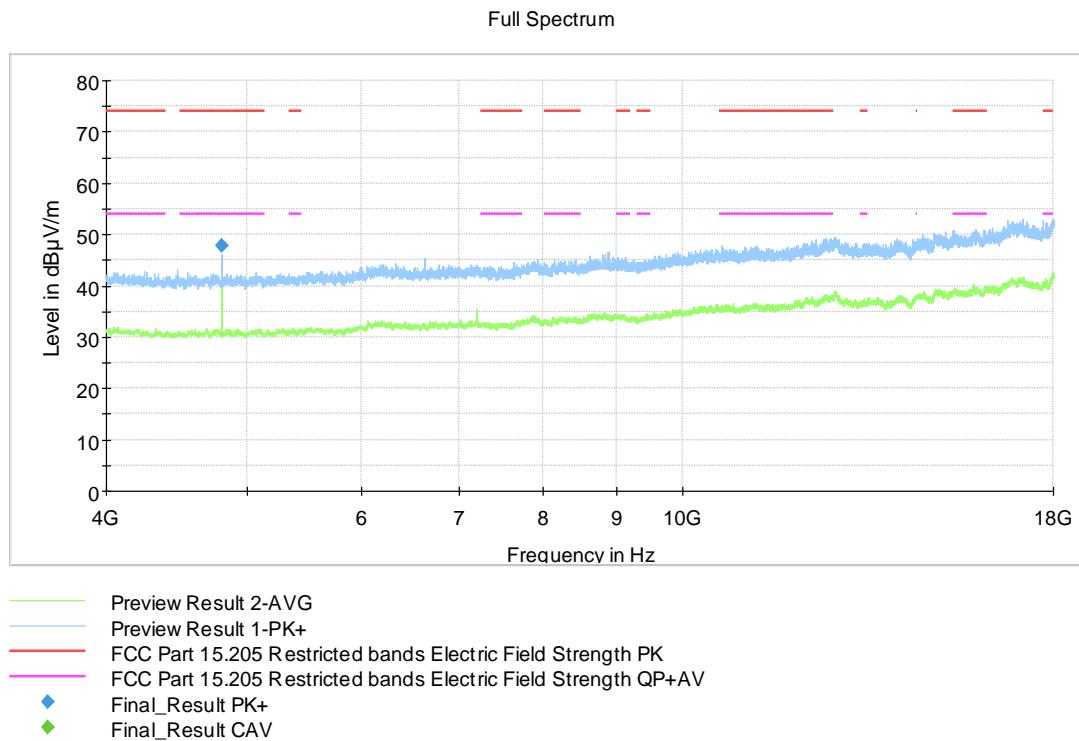


Figure 67: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2402 MHz)

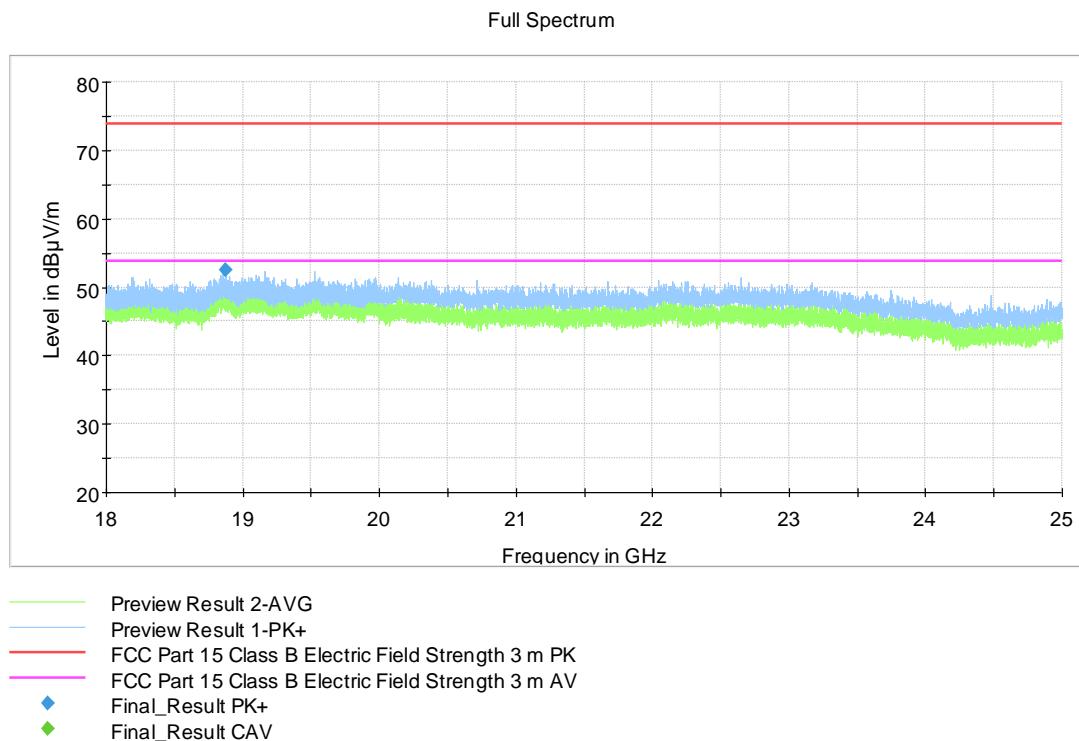


Figure 68: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2402 MHz)

Test results (1 Mbps, TX 2441 MHz)

Table 11: Test results with peak detector (1 Mbps, TX 2441 MHz)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 2441.100000 | 90.06 | --- | --- | 15 x 1000.0 | 1000.000 | 149.0 | V | 90.0 | 13.7 |
| 4881.900000 | 47.48 | 73.98 | 26.50 | 15 x 1000.0 | 1000.000 | 253.0 | H | 260.0 | 7.6 |

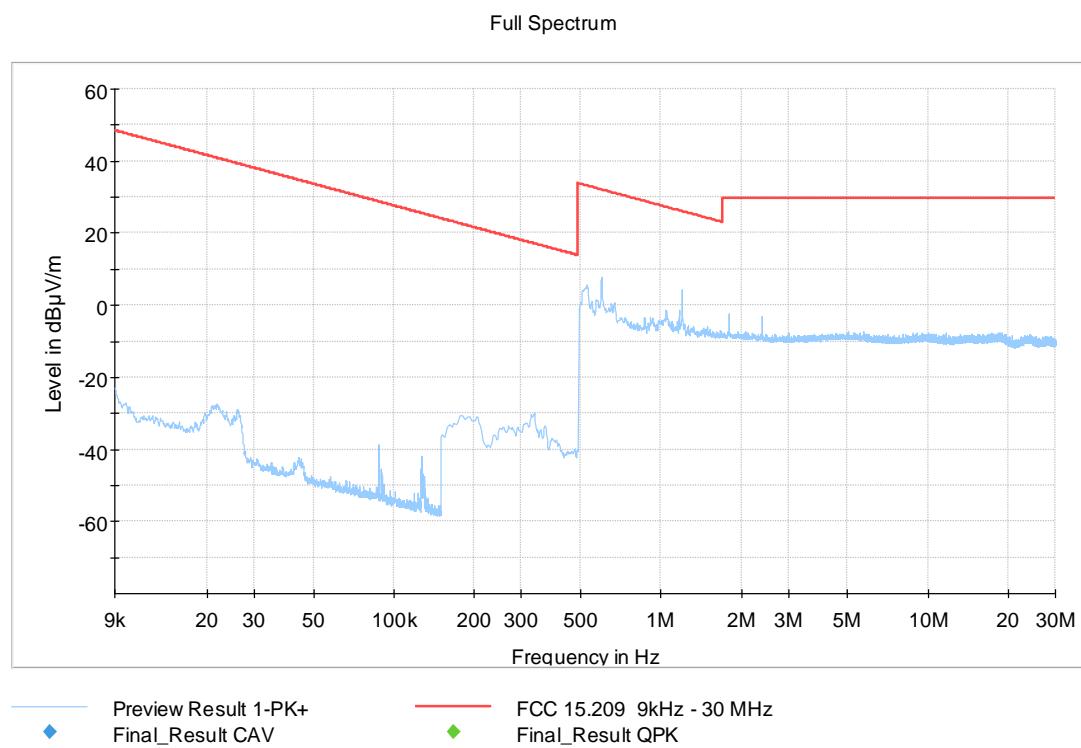


Figure 69: Unwanted Emissions, radiated 9 kHz – 30 MHz (1 Mbps, TX 2441 MHz)

Unwanted Emissions (radiated)

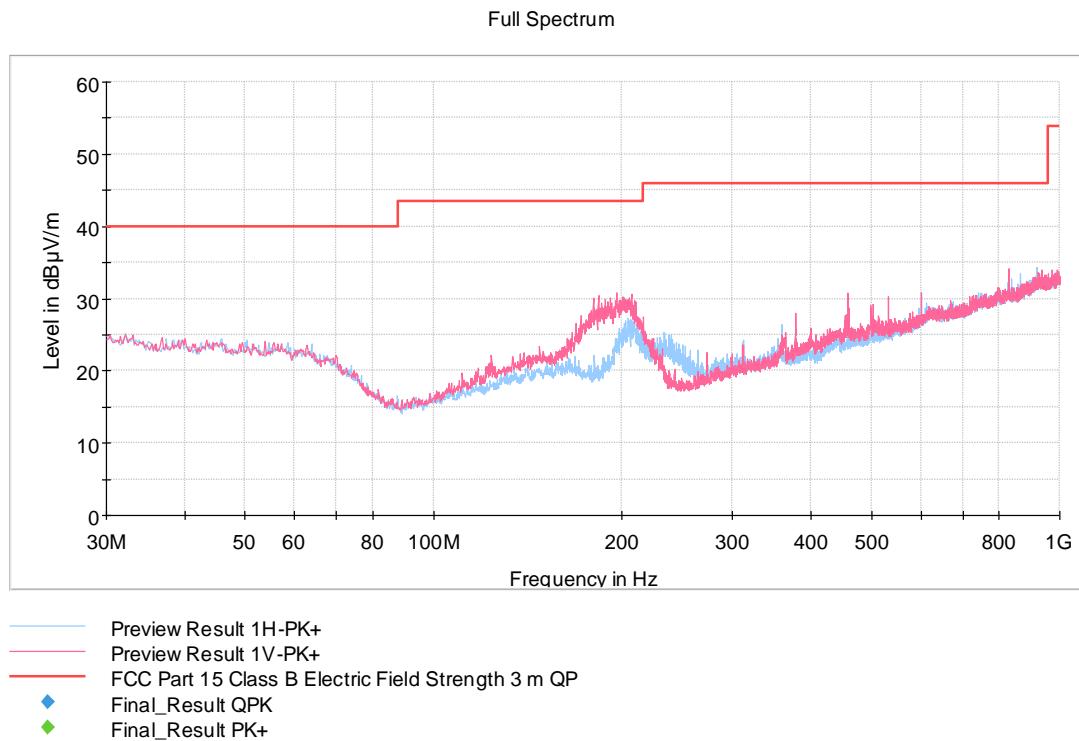


Figure 70: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2441 MHz)

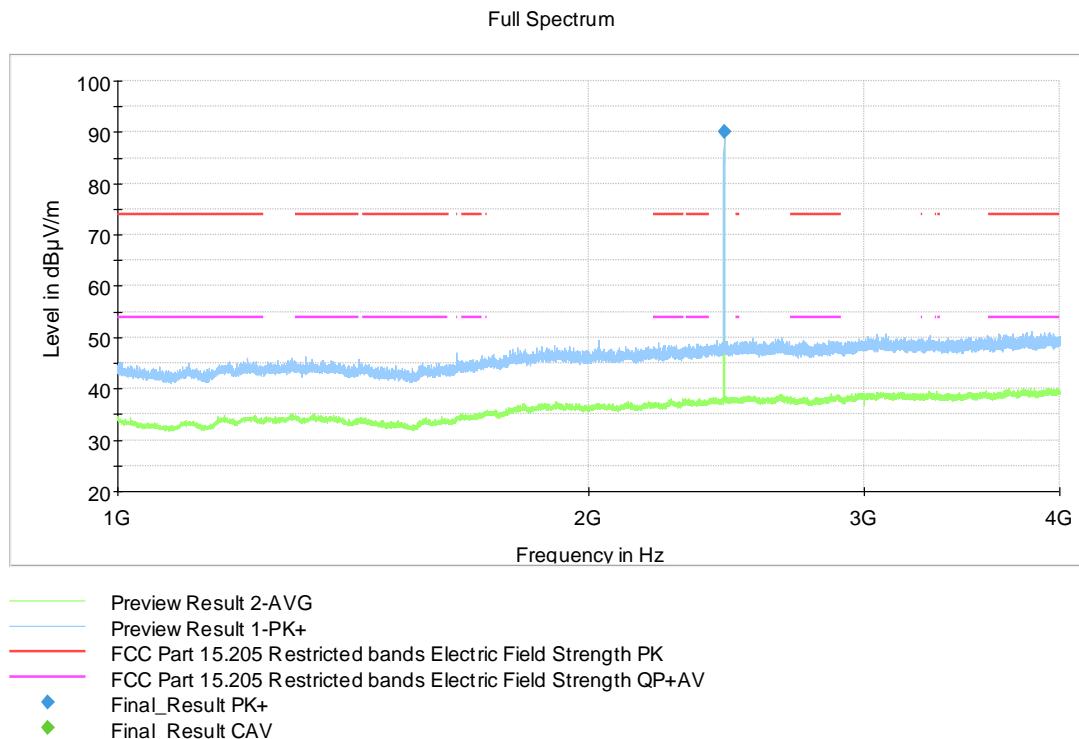


Figure 71: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2441 MHz)

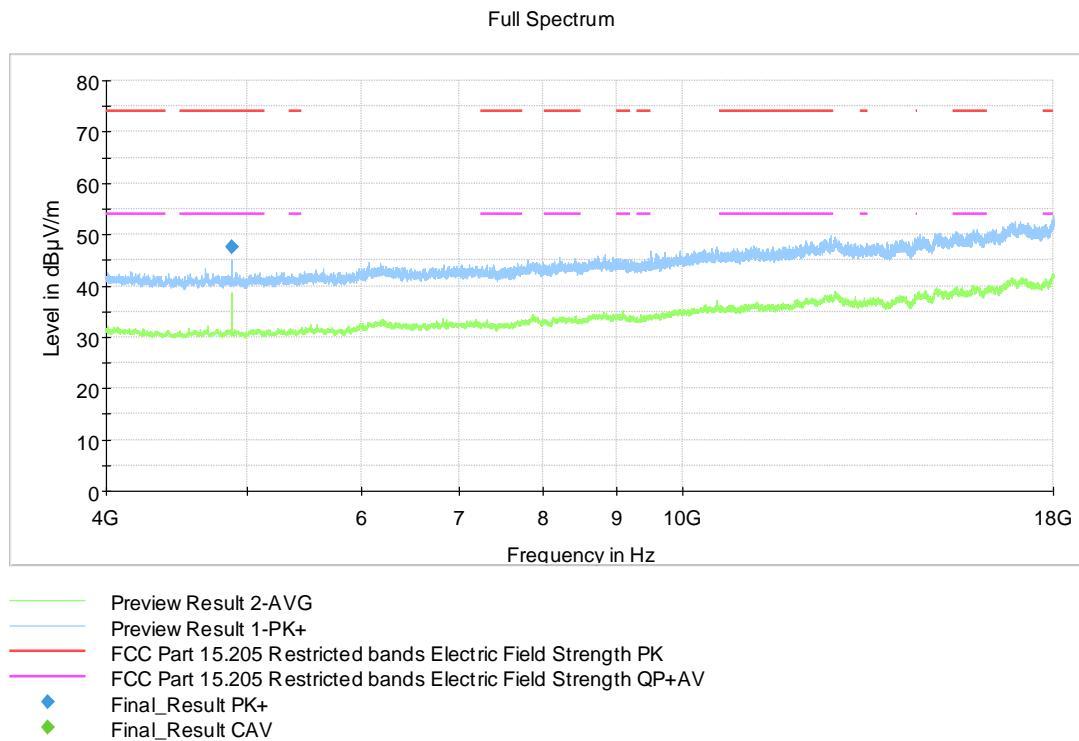


Figure 72: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2441 MHz)

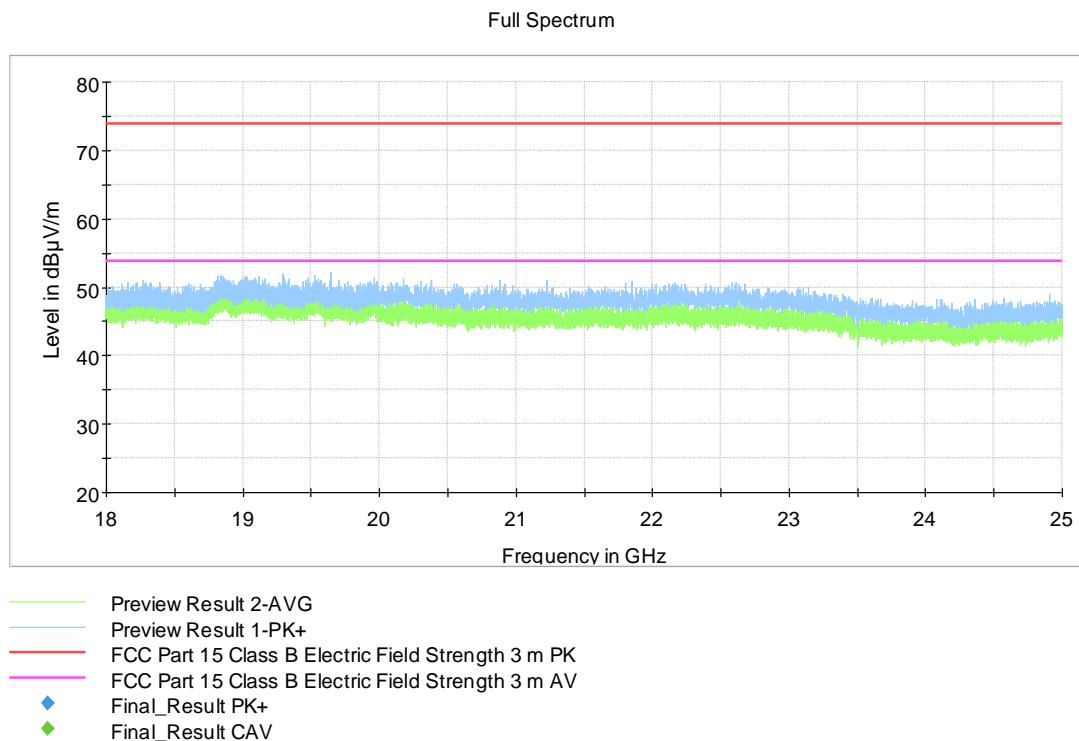


Figure 73: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2441 MHz)

Test results (1 Mbps, TX 2480 MHz)

Table 12: Test results with quasi-peak detector (1 Mbps, TX 2480 MHz)

| Frequency (MHz) | QuasiPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 0.603000 | 2.63 | 32.00 | 29.37 | 15 x 1000.0 | 9.000 | 90.0 *) | V | 257.0 | -20.4 |
| 1.199750 | -0.90 | 26.04 | 26.94 | 15 x 1000.0 | 9.000 | 90.0 *) | V | 294.0 | -20.5 |
| 1.802250 | -9.96 | 29.50 | 39.46 | 15 x 1000.0 | 9.000 | 90.0 *) | V | 256.0 | -20.4 |
| 202.225000 | 22.60 | 43.50 | 20.90 | 15 x 1000.0 | 120.000 | 105.0 | V | 11.0 | 15.2 |
| 206.685000 | 19.19 | 43.50 | 24.31 | 15 x 1000.0 | 120.000 | 175.0 | H | 350.0 | 15.2 |
| 232.845000 | 18.23 | 46.00 | 27.77 | 15 x 1000.0 | 120.000 | 105.0 | H | 251.0 | 16.5 |
| 360.215000 | 17.60 | 46.00 | 28.40 | 15 x 1000.0 | 120.000 | 163.0 | H | 137.0 | 21.0 |
| 503.975000 | 25.86 | 46.00 | 20.14 | 15 x 1000.0 | 120.000 | 100.0 | V | 282.0 | 24.6 |
| 599.975000 | 24.38 | 46.00 | 21.62 | 15 x 1000.0 | 120.000 | 378.0 | H | 68.0 | 26.8 |

*) Measurement loop antenna angle

Table 13: Test results with peak detector (1 Mbps, TX 2480 MHz)

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 2479.850000 | 91.57 | --- | --- | 15 x 1000.0 | 1000.000 | 231.0 | V | 93.0 | 13.7 |
| 2483.500000 | 50.02 | 73.98 | 23.96 | 15 x 1000.0 | 1000.000 | 378.0 | V | 318.0 | 13.8 |
| 4959.700000 | 46.19 | 73.98 | 27.79 | 15 x 1000.0 | 1000.000 | 247.0 | H | 240.0 | 7.4 |

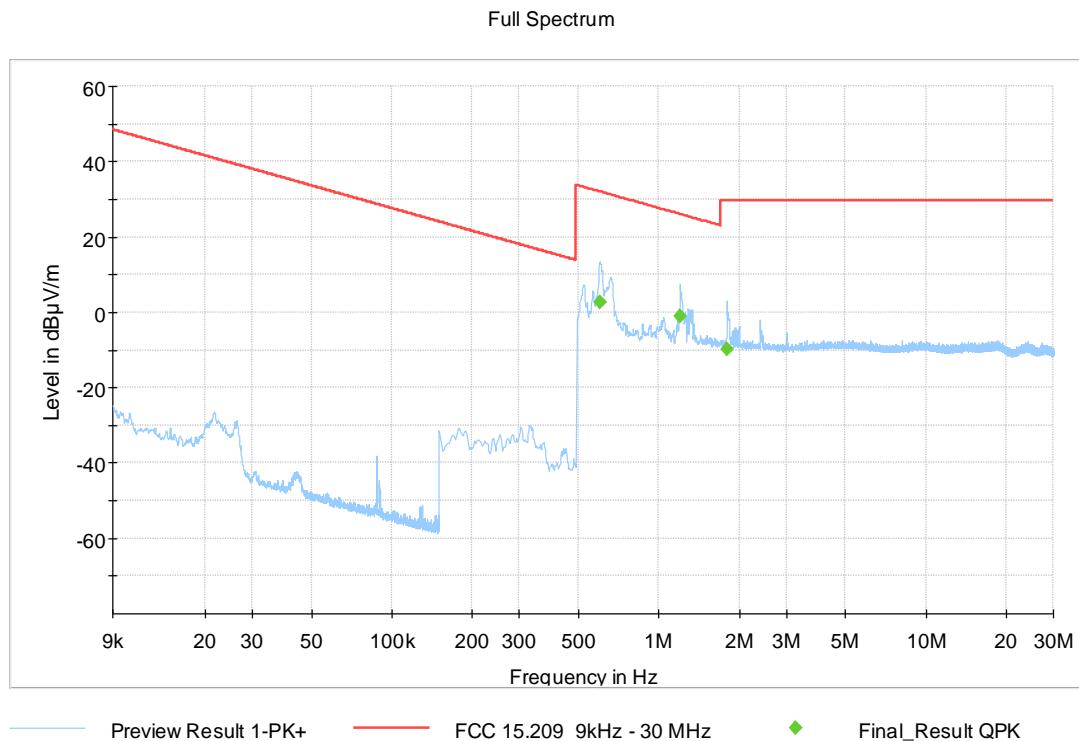


Figure 74: Unwanted Emissions, radiated 9 kHz – 30 MHz (1 Mbps, TX 2480 MHz)

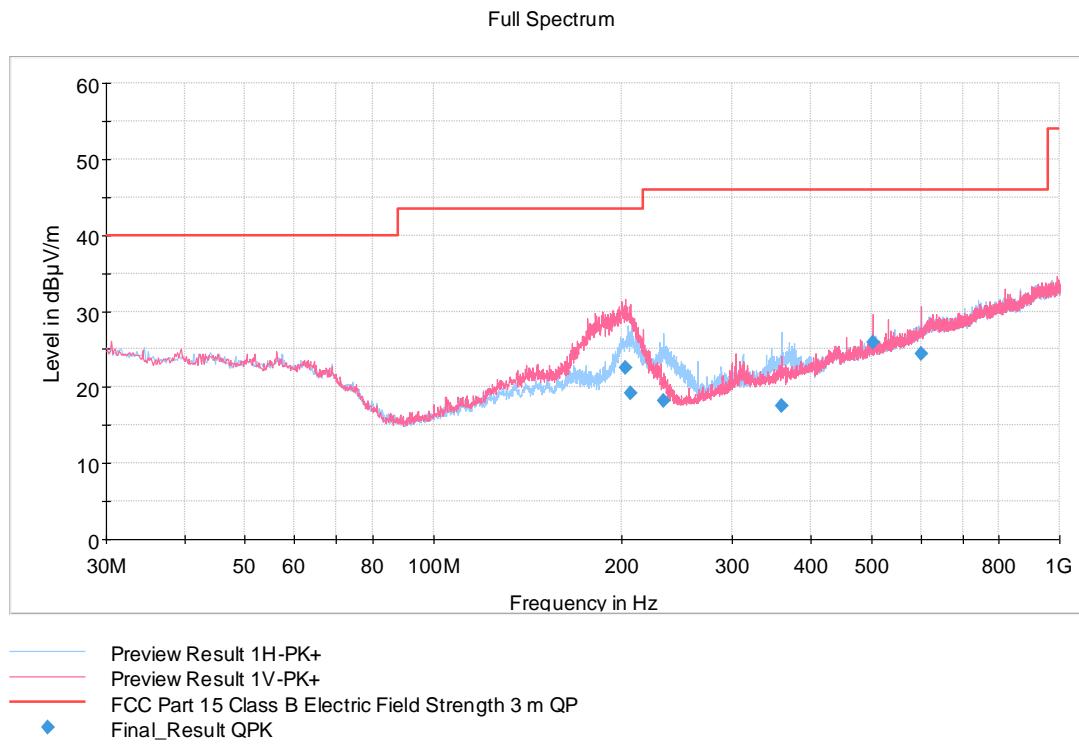


Figure 75: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2480 MHz)

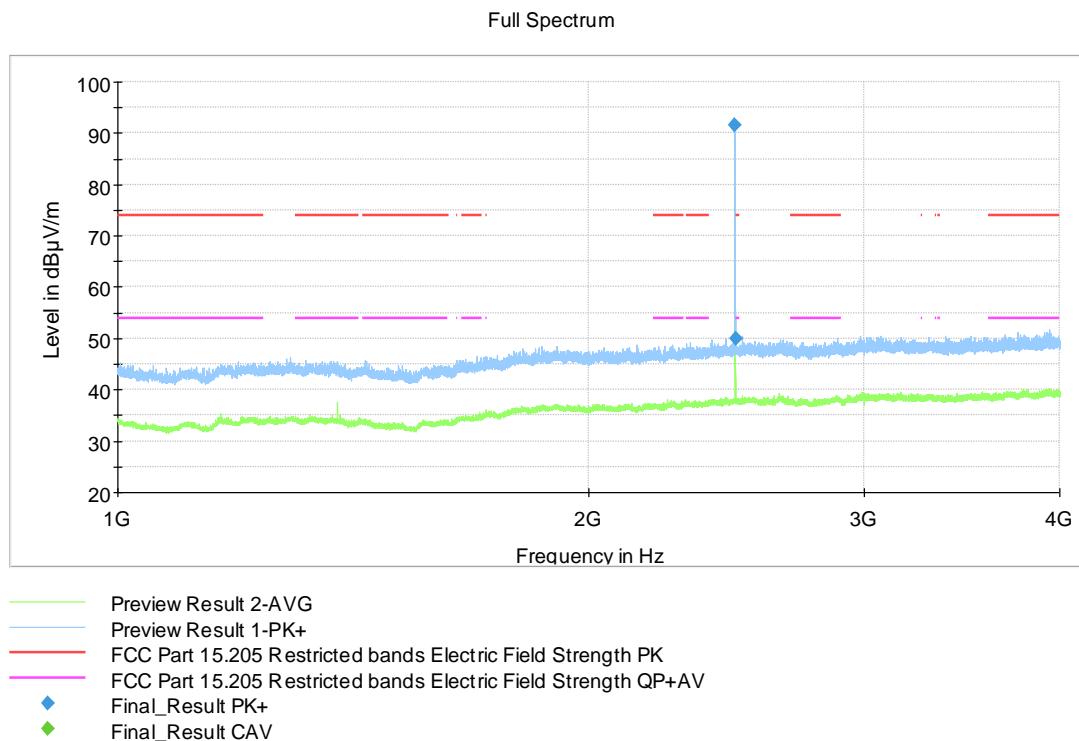


Figure 76: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2480 MHz)

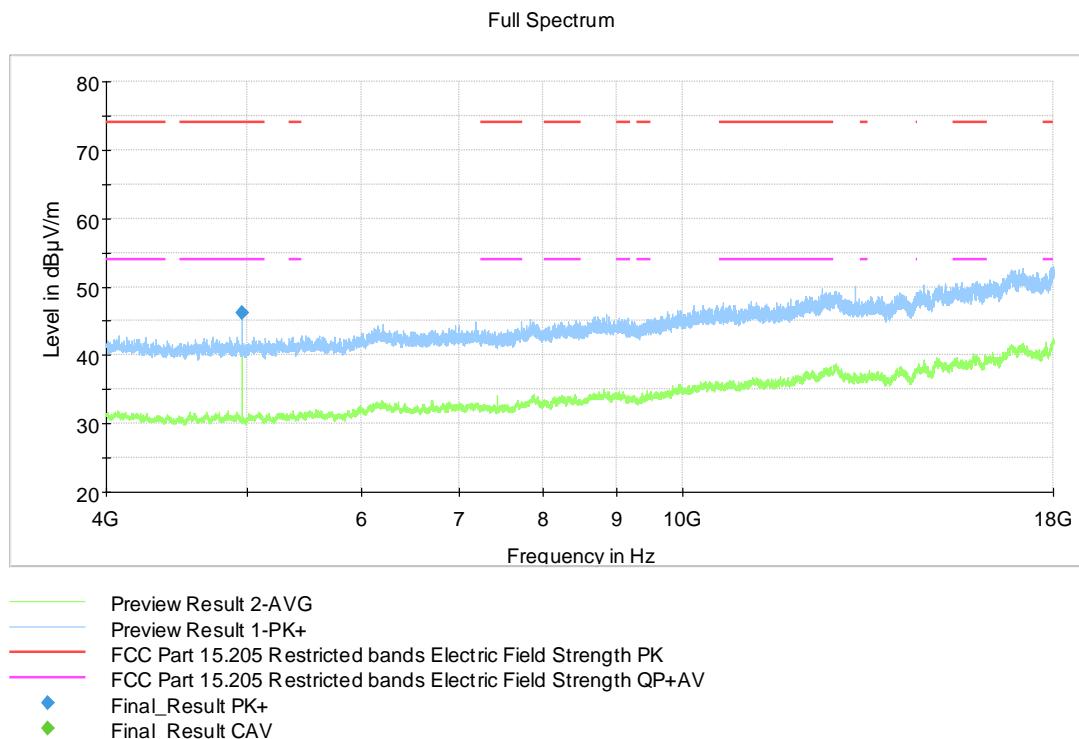


Figure 77: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2480 MHz)

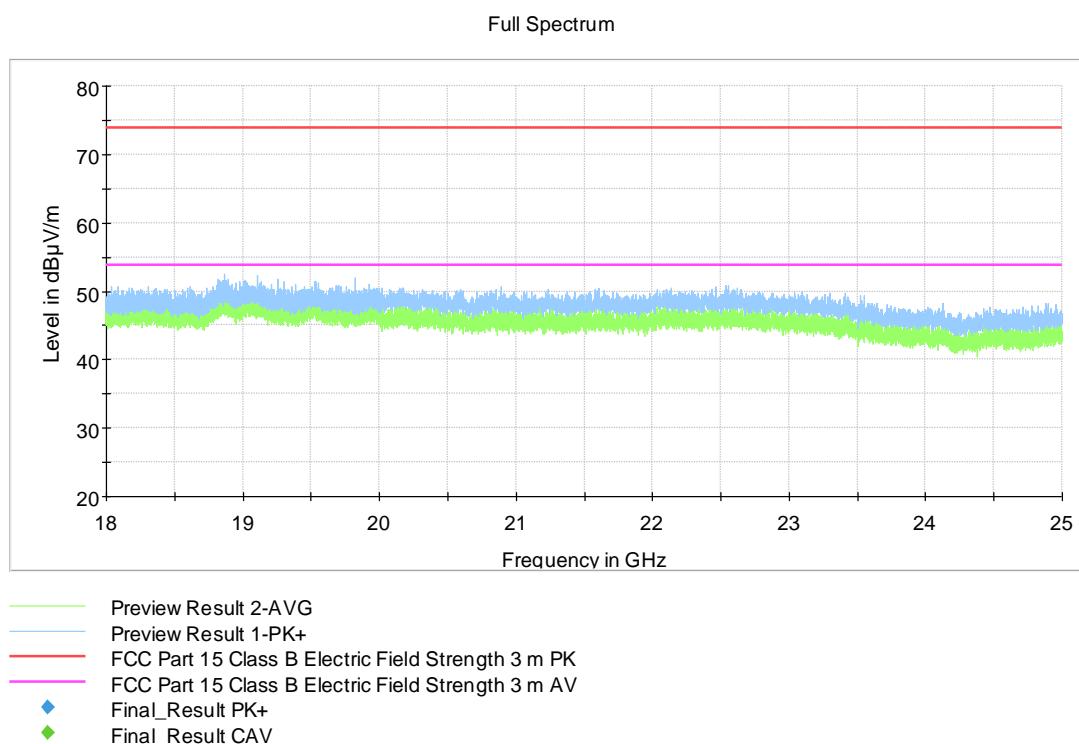


Figure 78: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2480 MHz)

TEST EQUIPMENT**AC Power-Line Conducted Emissions**

| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
|-------------------|-------------------|--------------|------------|------------|------------|
| EMI TEST RECEIVER | ROHDE & SCHWARZ | ESW26 | inv. 10679 | 2022-06-20 | 2023-06-20 |
| LISN | ROHDE & SCHWARZ | ENV216 | inv. 9611 | 2023-02-01 | 2024-02-01 |
| POWER SUPPLY | CALIFORNIA INSTR. | 15003i-400/3 | inv. 9486 | - | - |
| TEST SOFTWARE | ROHDE & SCHWARZ | EMC-32 | - | - | - |

Conducted RF Tests

| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
|-------------------|-----------------|------------|------------|------------|------------|
| OSP-B157W 8 PORT | ROHDE & SCHWARZ | OSP-B157W8 | inv. 10883 | 2022-06-17 | 2023-06-17 |
| OSP BASE UNIT | ROHDE & SCHWARZ | OSP 120 | inv. 10882 | 2022-06-20 | 2023-06-20 |
| SPECTRUM ANALYZER | ROHDE & SCHWARZ | FSV40 | inv. 10881 | 2022-06-21 | 2023-06-21 |
| TEST SOFTWARE | ROHDE & SCHWARZ | WMS32 | - | - | - |

Unwanted Emissions (radiated)

| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
|-----------------------------|-----------------|-----------------------|------------|------------|------------|
| ANTENNA | EMCO | 3160-09 | inv. 7294 | 2023-02-23 | 2024-02-23 |
| ANTENNA | EMCO | 3117 | inv. 7293 | 2022-06-16 | 2024-06-16 |
| ANTENNA | ROHDE & SCHWARZ | HFH2-Z2 , 335.4711.52 | inv. 8013 | 2022-10-25 | 2024-10-25 |
| ANTENNA | SCHWARZBECK | VULB 9168 | inv. 8911 | 2022-11-29 | 2024-11-29 |
| ANTENNA MAST | MATURO | TAM 4.0E | inv. 10181 | NCR | NCR |
| ATTENUATOR | PASTERNACK | 10 dB, DC-40 GHz | sn. A1 | 2021-04-20 | 2023-04-20 |
| ATTENUATOR | PASTERNACK | PE 7004-4 (4dB) | inv. 10126 | 2021-03-30 | 2023-03-30 |
| EMI TEST RECEIVER | ROHDE & SCHWARZ | ESW26 | inv. 10679 | 2022-06-20 | 2023-06-20 |
| FILTER | WAINWRIGHT | WHKX4.0/18G-10SS | inv. 10403 | 2023-01-09 | 2025-01-09 |
| MAST & TURNTABLE CONTROLLER | MATURO | NCD | inv. 10183 | NCR | NCR |
| RF PREAMPLIFIER | CIAO | CA1840-5019 | inv. 10593 | 2022-09-21 | 2023-09-21 |
| RF PREAMPLIFIER | CIAO | CA118-3123 | inv. 10278 | 2022-09-21 | 2023-09-21 |
| TEST SOFTWARE | ROHDE & SCHWARZ | EMC32 | - | - | - |
| TURNTABLE | MATURO | DS430 UPGRADED | inv. 10182 | NCR | NCR |

NCR = No Calibration Required

END OF REPORT