

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

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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	☐
Mobile Device (Human body distance > 20cm)	☒
Portable Device (Human body distance < 20cm)	☒

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

Product Description**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)

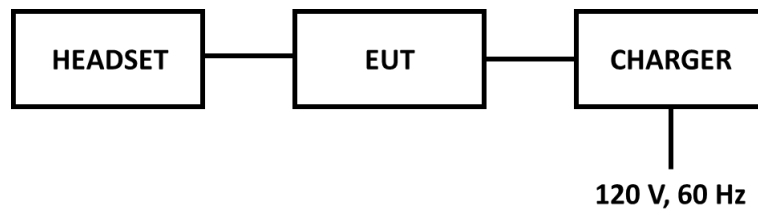


Figure 2: Test setup block diagram (AC Power-Line Conducted Emissions)



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

Summary of Testing

Test Facility

Testing Laboratory / address: FCC designation number: FI0002 ISED CAB identifier: T004	SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND
Test Site:	☐ K10LAB, ISED Canada registration number: 8708A-1 ☒ K5LAB, ISED Canada registration number: 8708A-2 ☐ 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	1. Permanently attached antenna 2. Unique coupling to the intentional radiator 3. 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 µH/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.

AC Power-Line Conducted Emissions

Test results

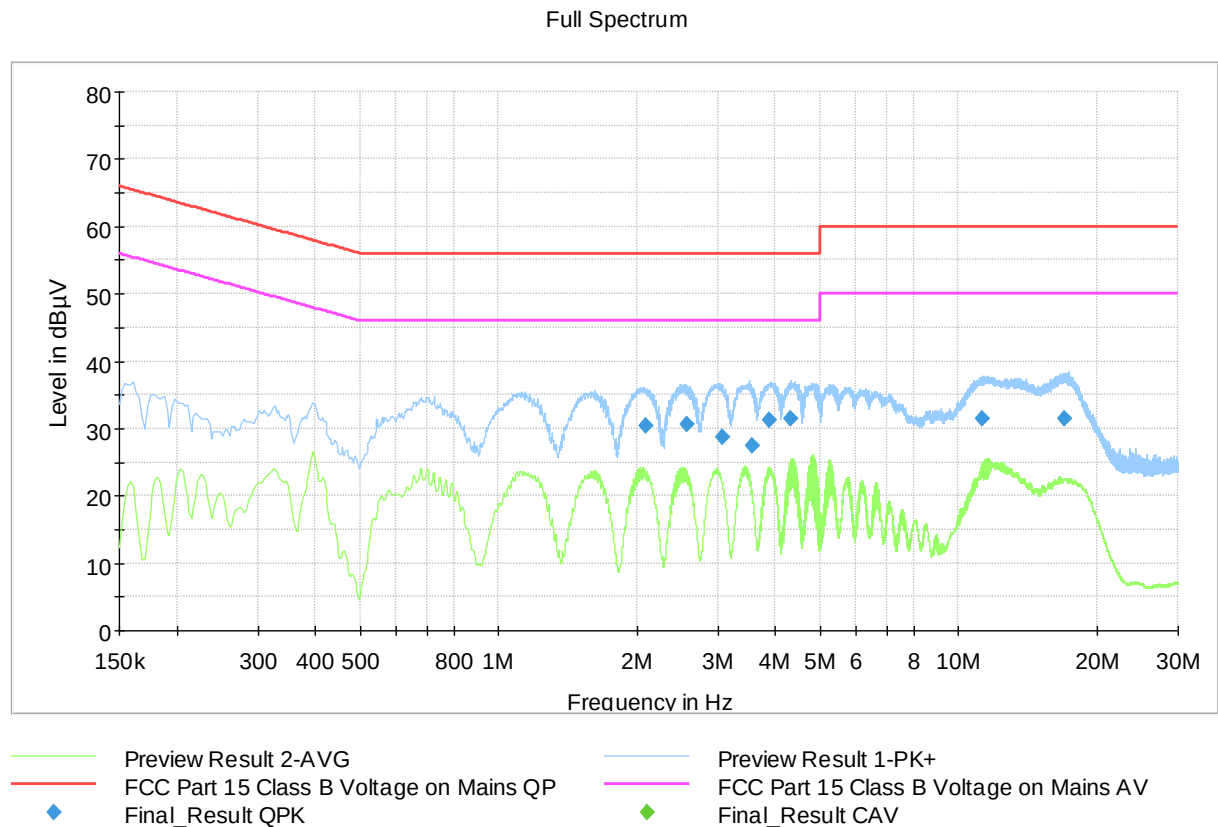


Figure 4: AC Power-Line Conducted Emissions

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

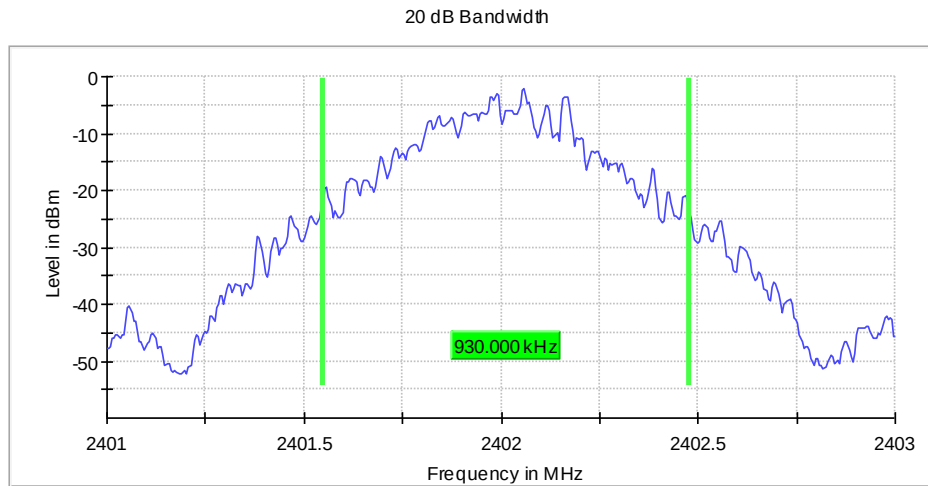


Figure 5: 20 dB Bandwidth (1 Mbps, TX 2402 MHz)

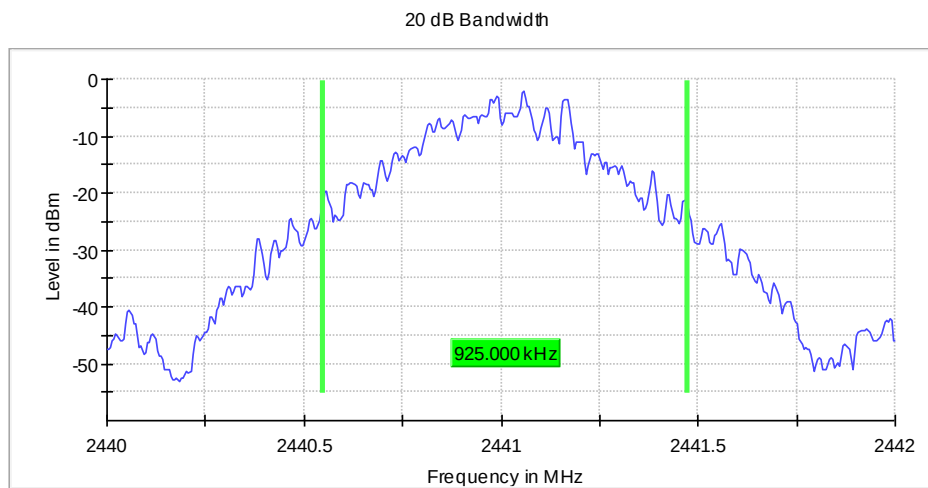


Figure 6: 20 dB Bandwidth (1 Mbps, TX 2441 MHz)

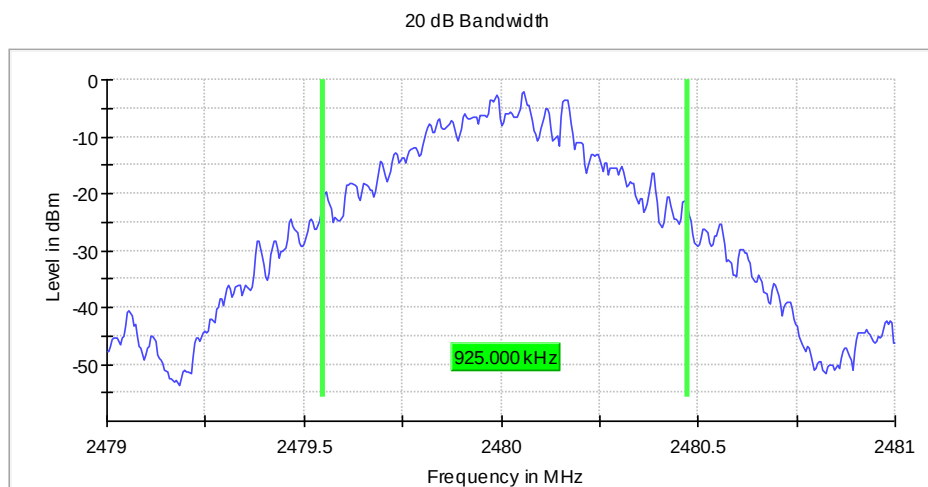


Figure 7: 20 dB Bandwidth (1 Mbps, TX 2480 MHz)

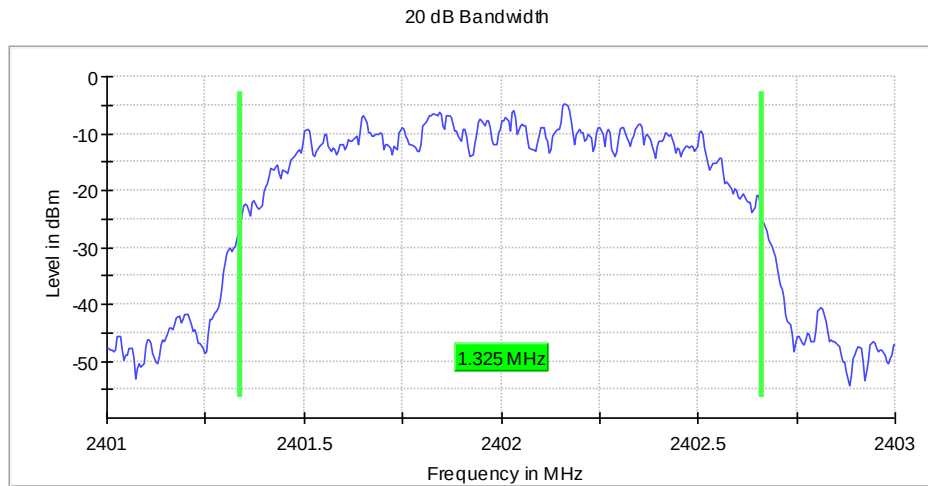


Figure 8: 20 dB Bandwidth (2 Mbps, TX 2402 MHz)

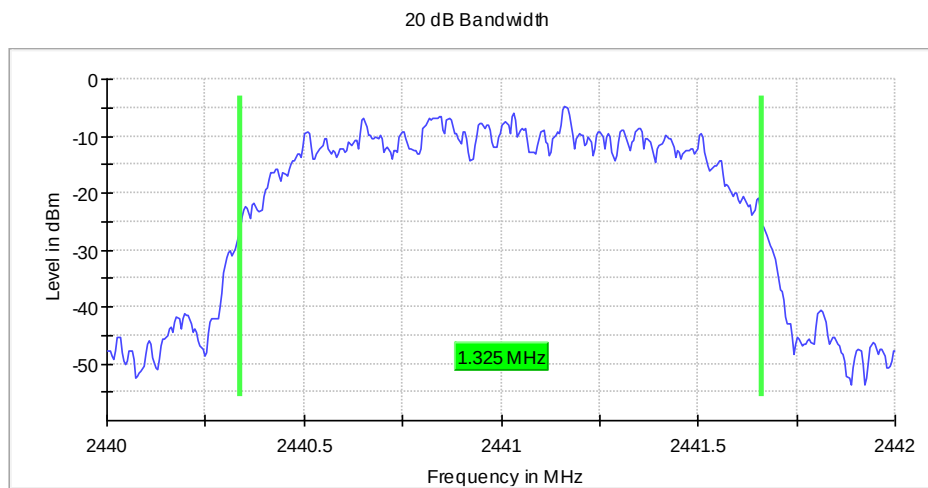


Figure 9: 20 dB Bandwidth (2 Mbps, TX 2441 MHz)

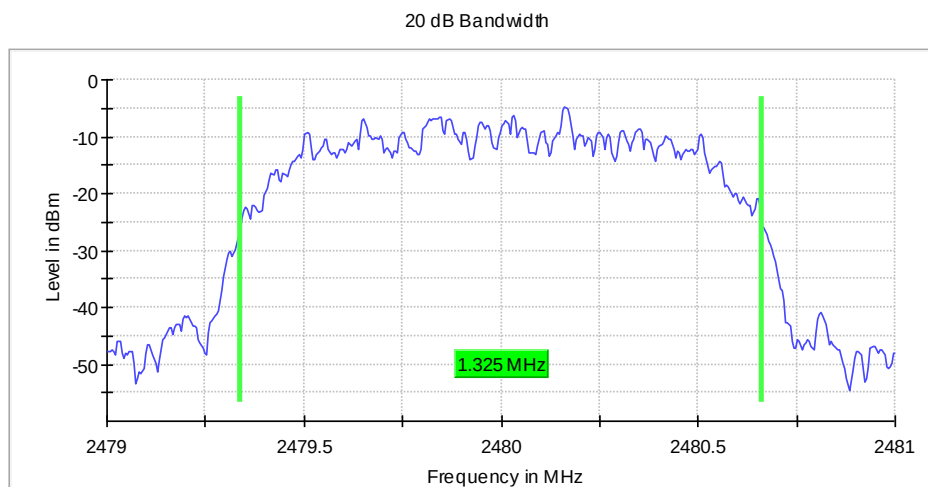


Figure 10: 20 dB Bandwidth (2 Mbps, TX 2480 MHz)

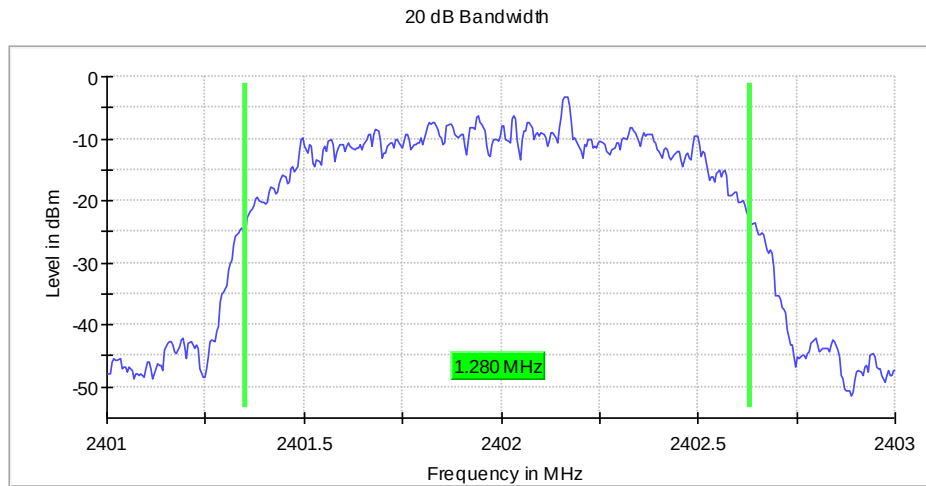


Figure 11: 20 dB Bandwidth (3 Mbps, TX 2402 MHz)

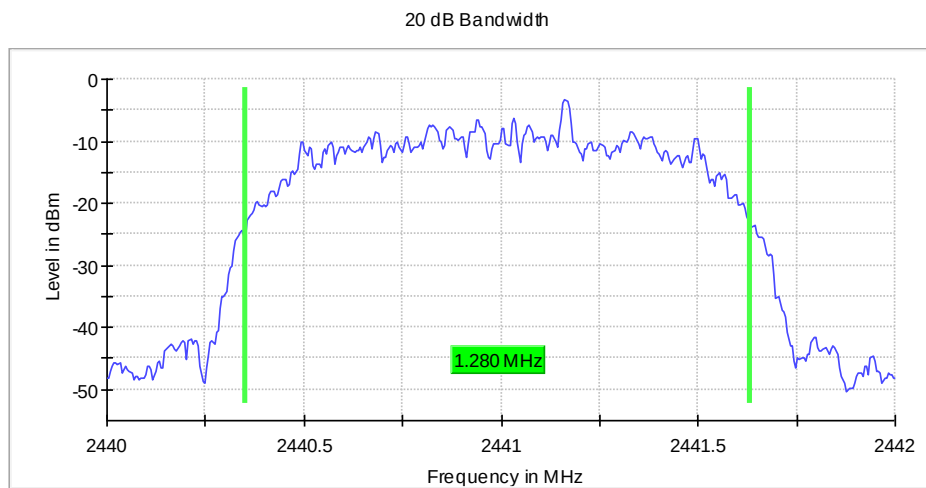


Figure 12: 20 dB Bandwidth (3 Mbps, TX 2441 MHz)

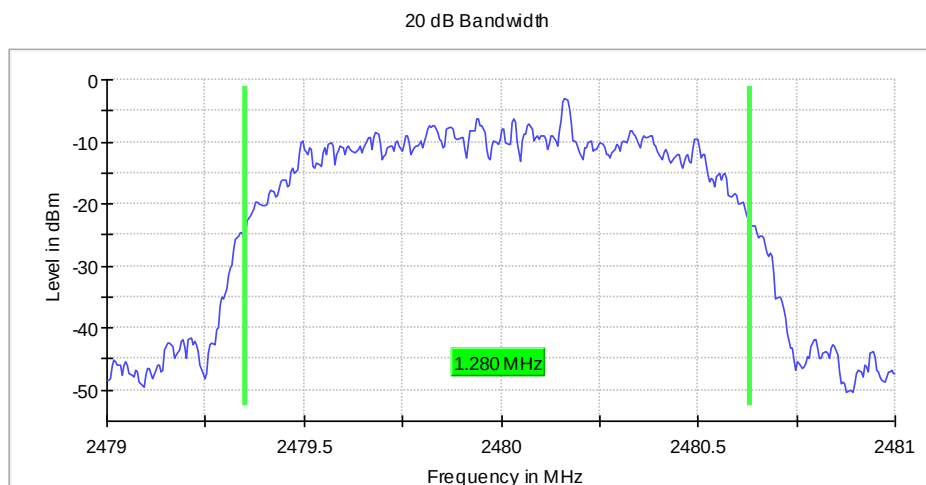


Figure 13: 20 dB Bandwidth (3 Mbps, TX 2480 MHz)

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
Preamplifier	off

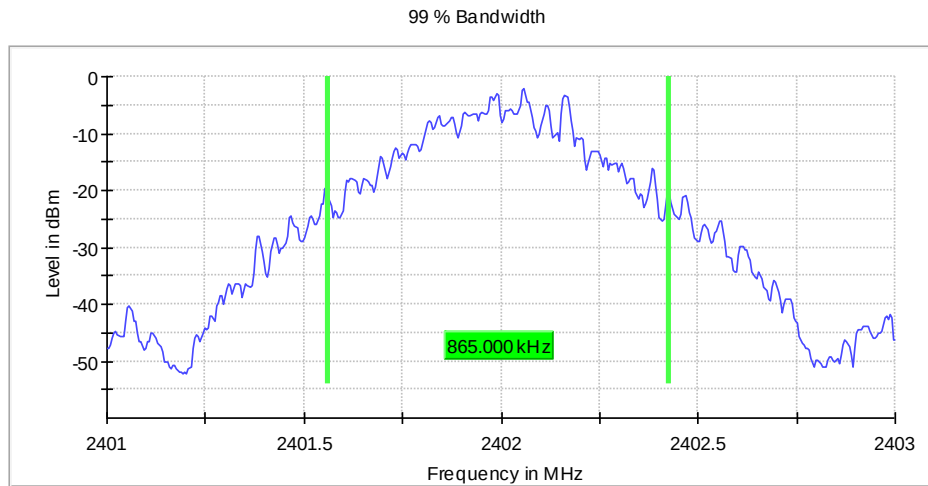


Figure 14: Occupied Bandwidth 99% (1 Mbps, TX 2402 MHz)

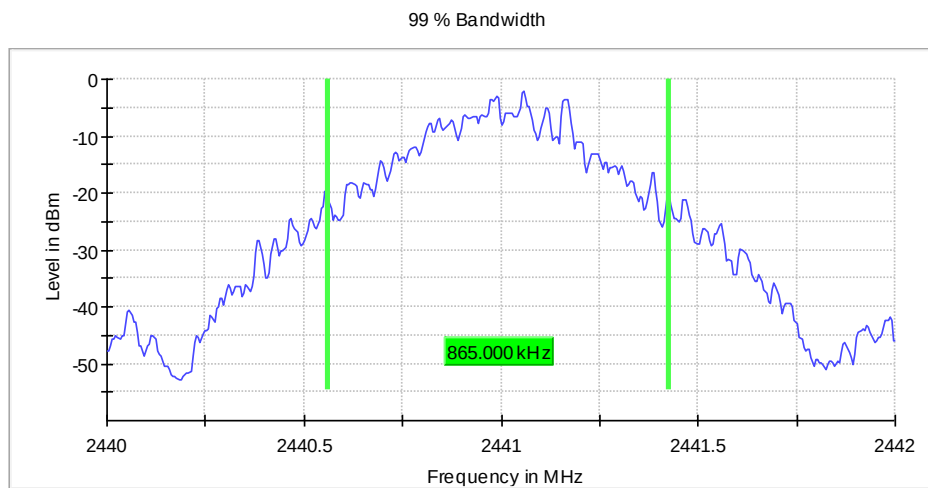


Figure 15: Occupied Bandwidth 99% (1 Mbps, TX 2441 MHz)

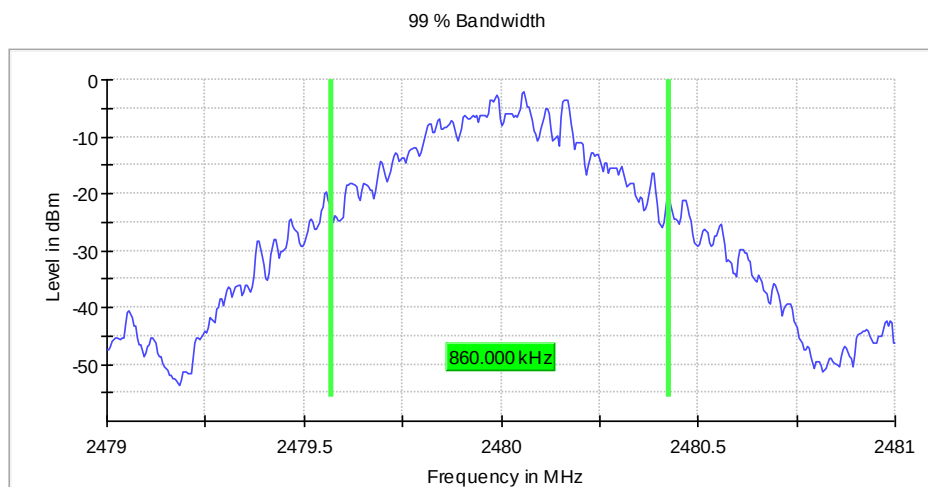


Figure 16: Occupied Bandwidth 99% (1 Mbps, TX 2480 MHz)

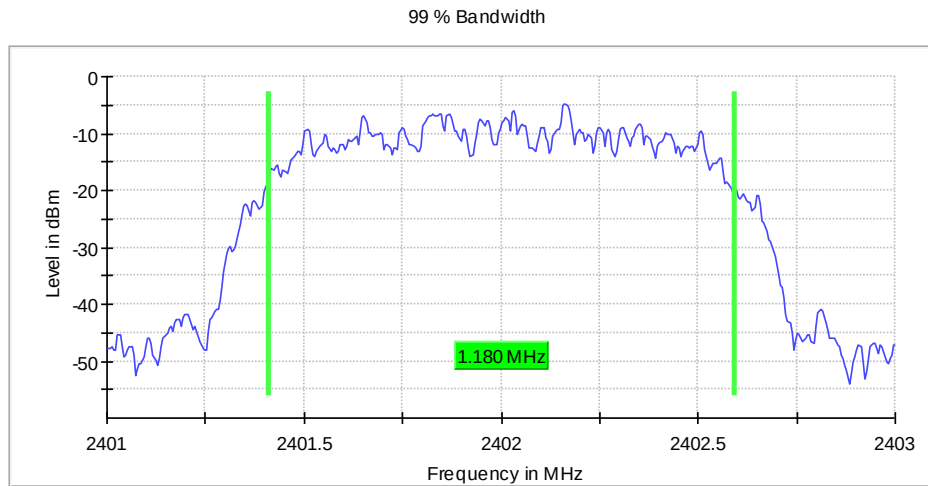


Figure 17: Occupied Bandwidth 99% (2 Mbps, TX 2402 MHz)

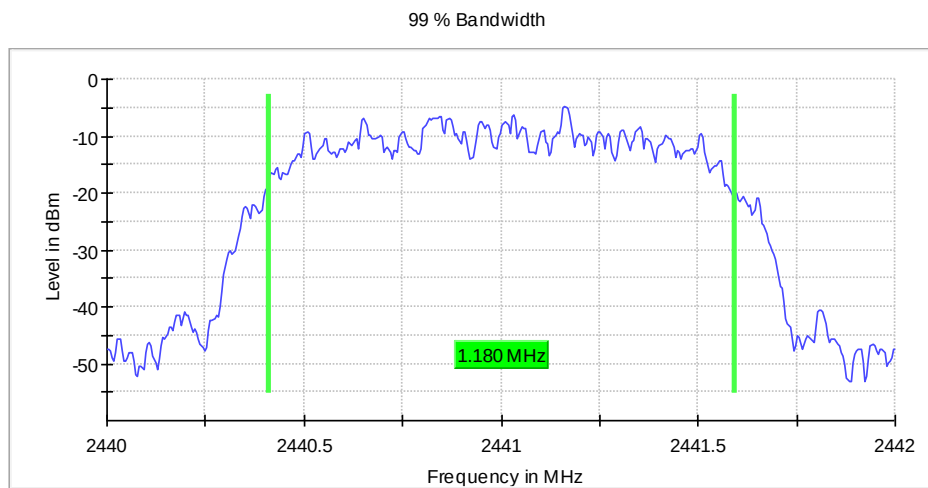


Figure 18: Occupied Bandwidth 99% (2 Mbps, TX 2441 MHz)

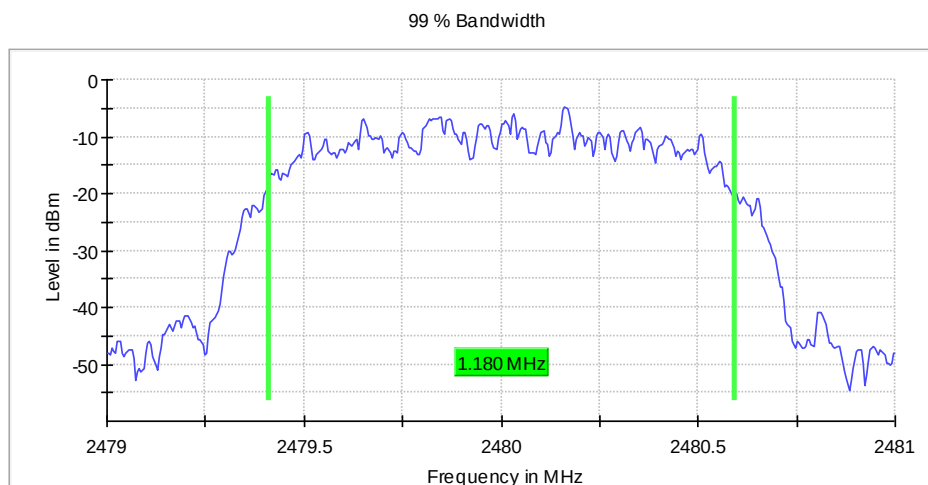


Figure 19: Occupied Bandwidth 99% (2 Mbps, TX 2480 MHz)

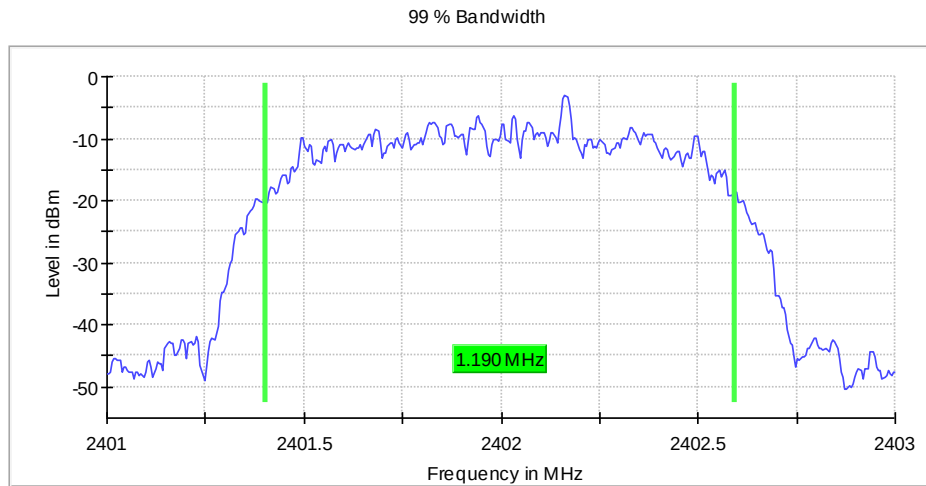


Figure 20: Occupied Bandwidth 99% (3 Mbps, TX 2402 MHz)

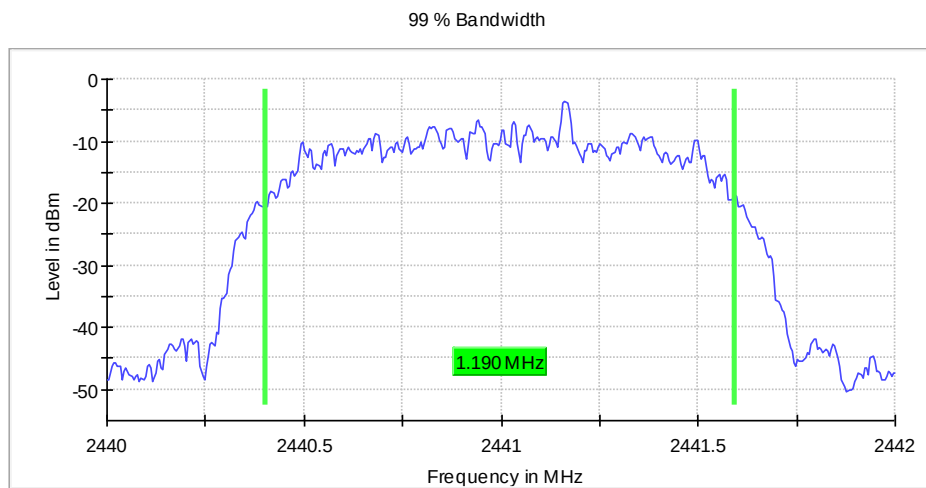


Figure 21: Occupied Bandwidth 99% (3 Mbps, TX 2441 MHz)

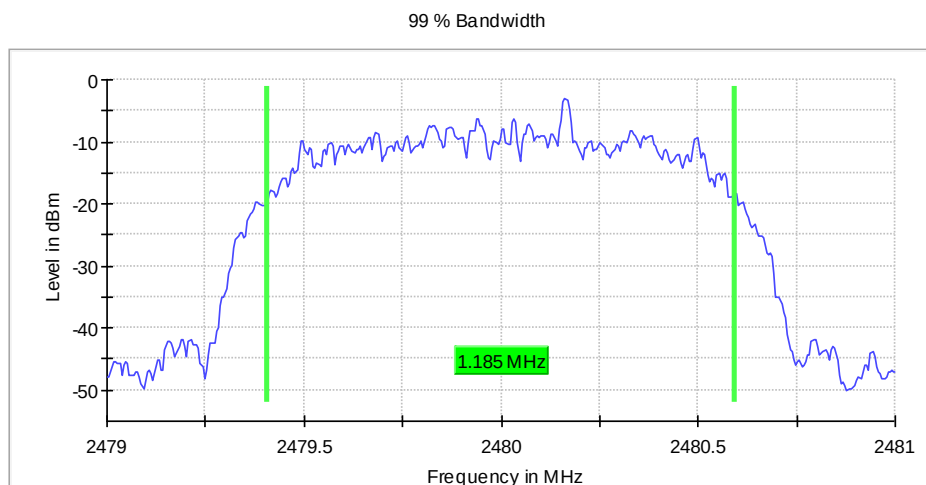


Figure 22: Occupied Bandwidth 99% (3 Mbps, TX 2480 MHz)

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

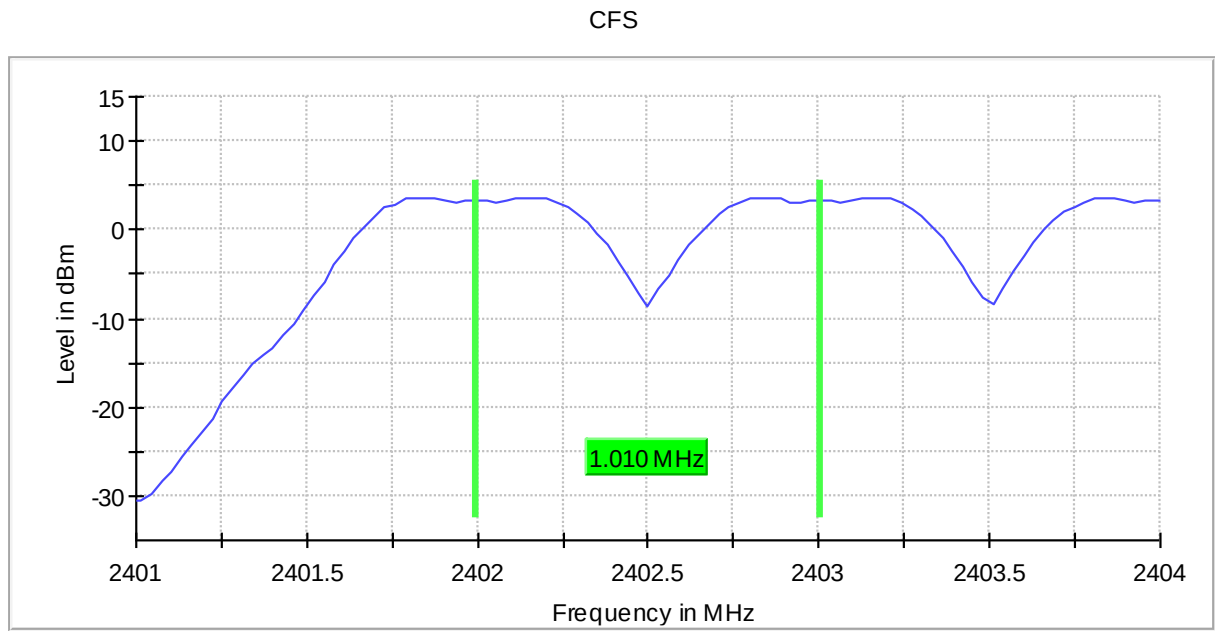


Figure 23: Carrier Frequency Separation (1 Mbps)

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

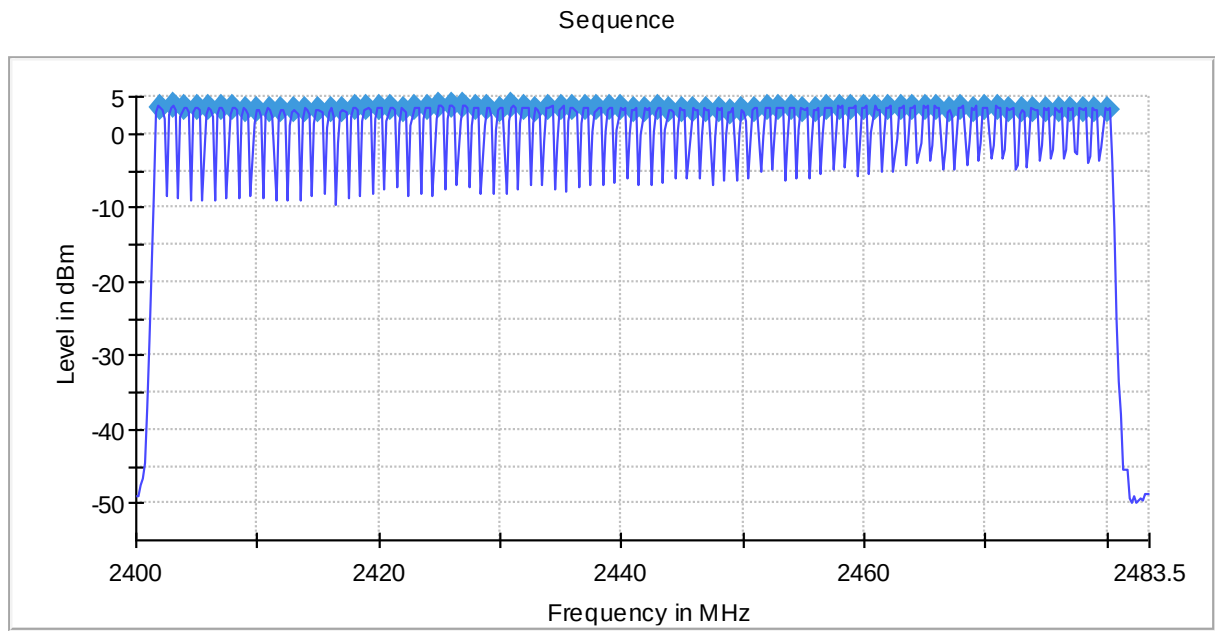


Figure 24: Number of Hopping Channels

Average Time of Occupancy**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		PASS
	2441	344.810		PASS
	2480	318.680		PASS
3 Mbps	2402	284.220		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
Preamplifier	off
Trigger	External
Trigger Offset	0.000 s

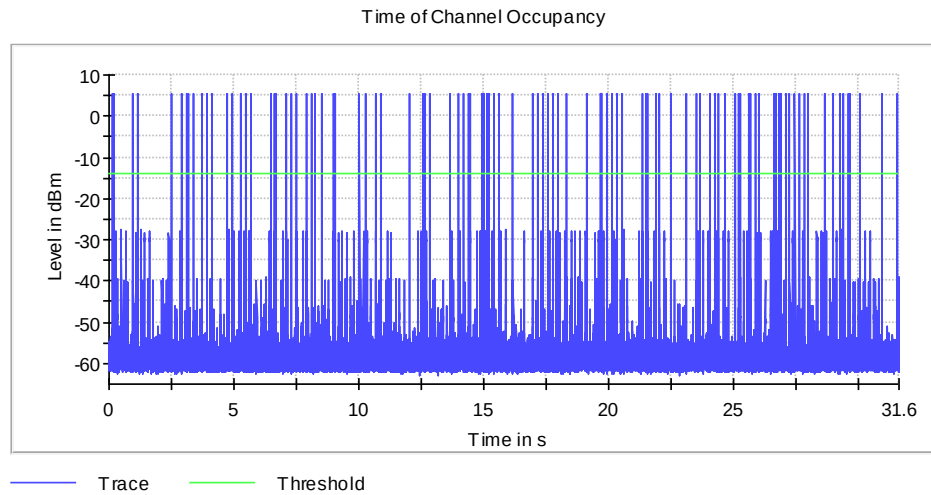


Figure 25: Average Time of Occupancy (1 Mbps, TX 2402 MHz)

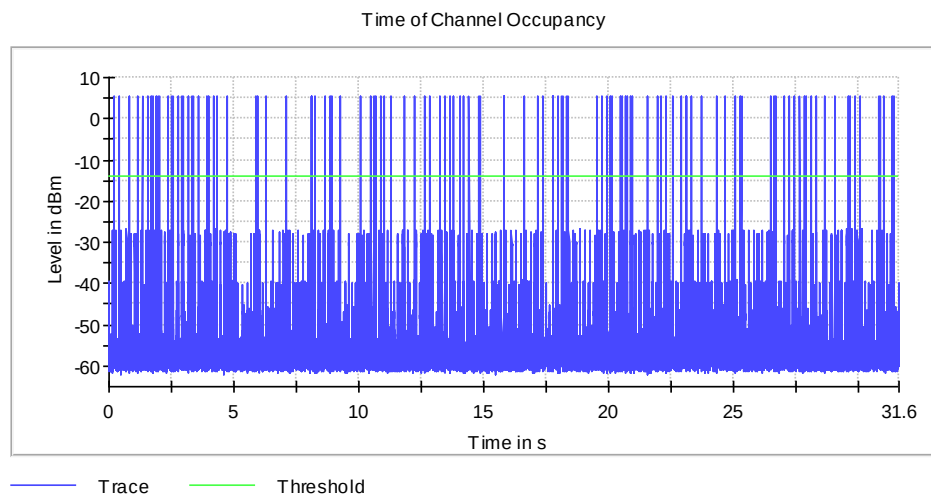


Figure 26: Average Time of Occupancy (1 Mbps, TX 2441 MHz)

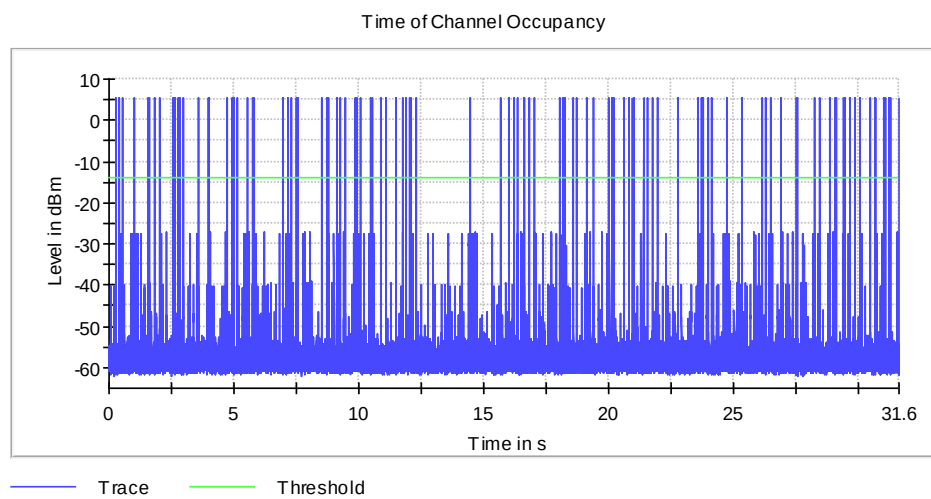


Figure 27: Average Time of Occupancy (1 Mbps, TX 2480 MHz)

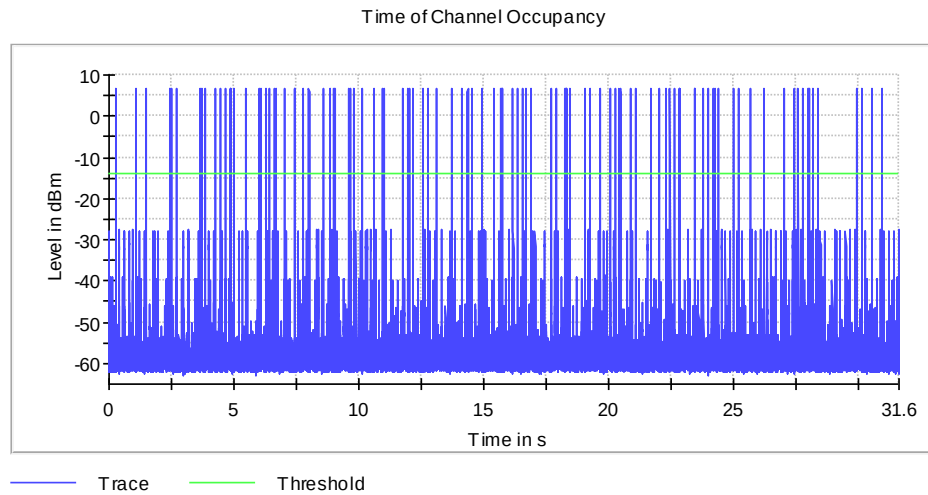


Figure 28: Average Time of Occupancy (2 Mbps, TX 2402 MHz)

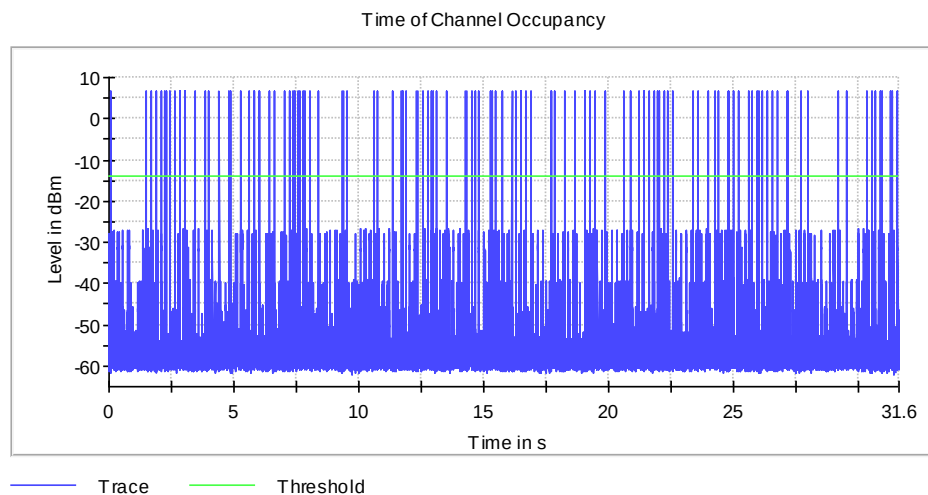


Figure 29: Average Time of Occupancy (2 Mbps, TX 2441 MHz)

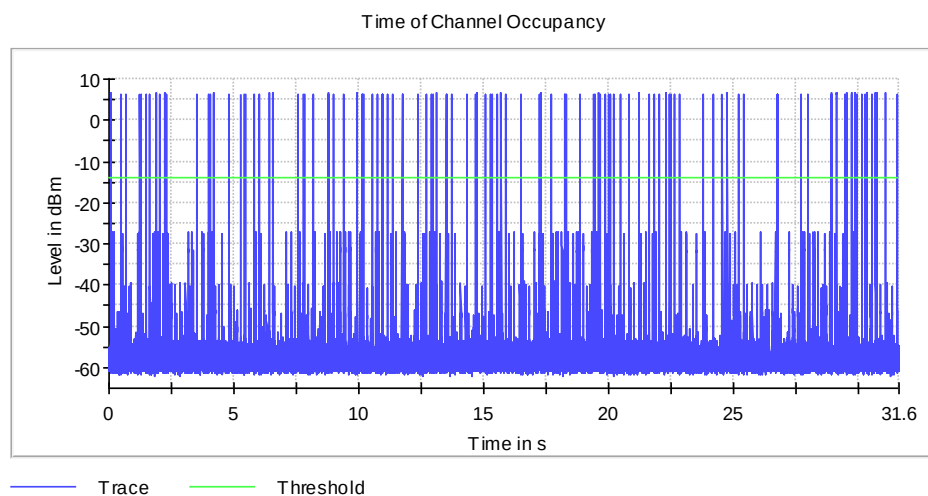


Figure 30: Average Time of Occupancy (2 Mbps, TX 2480 MHz)

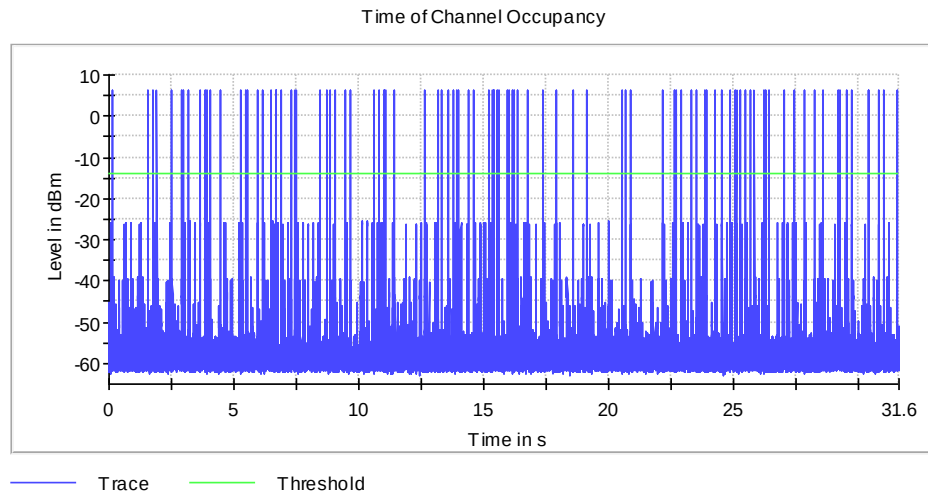


Figure 31: Average Time of Occupancy (3 Mbps, TX 2402 MHz)

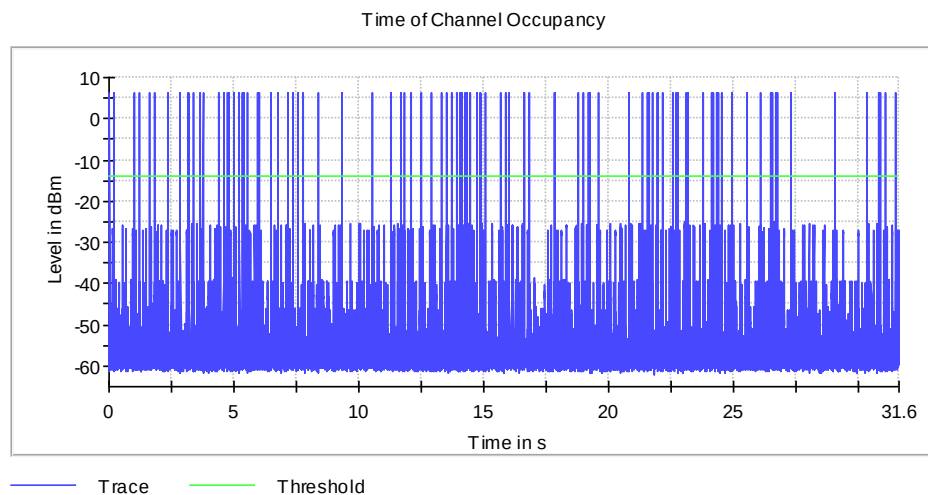


Figure 32: Average Time of Occupancy (3 Mbps, TX 2441 MHz)

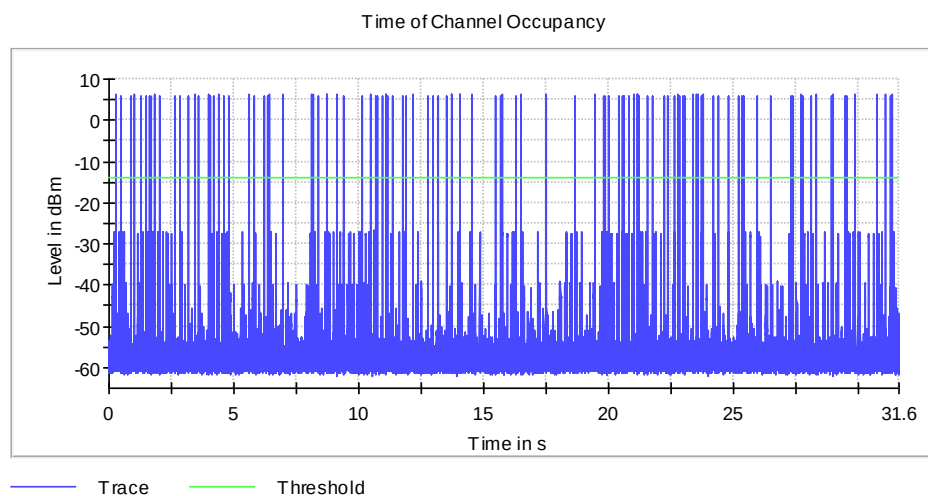


Figure 33: Average Time of Occupancy (3 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power**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: $\pm 2.87\text{dB}$, 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		PASS
	2441	6.0		PASS
	2480	5.9		PASS
3 Mbps	2402	6.5		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

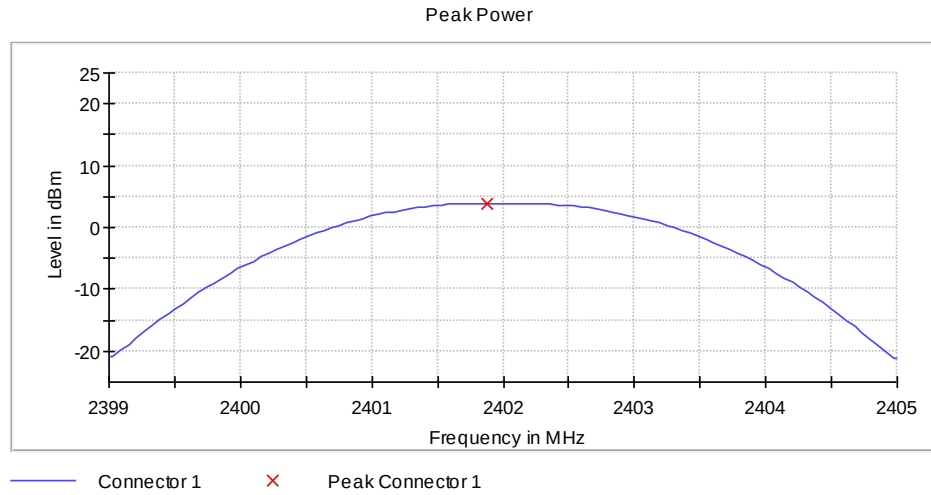


Figure 34: Maximum Peak Conducted Output Power (1 Mbps, TX 2402 MHz)

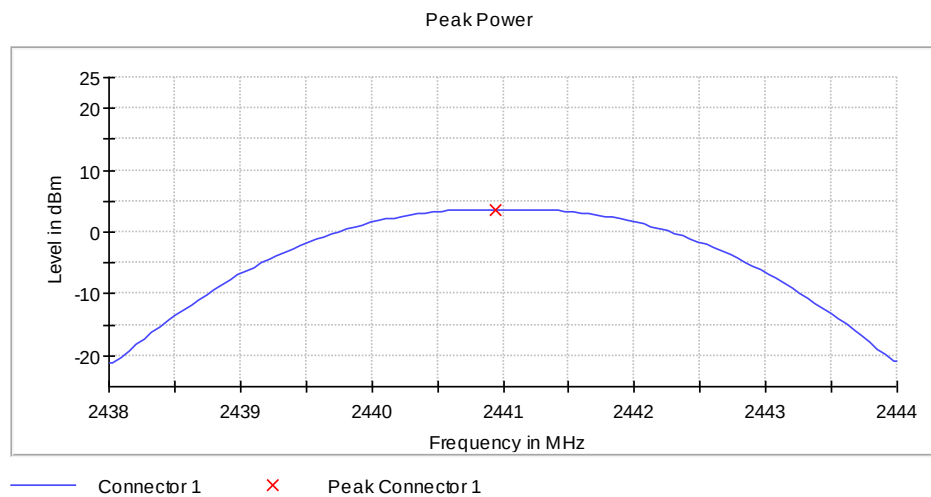


Figure 35: Maximum Peak Conducted Output Power (1 Mbps, TX 2441 MHz)

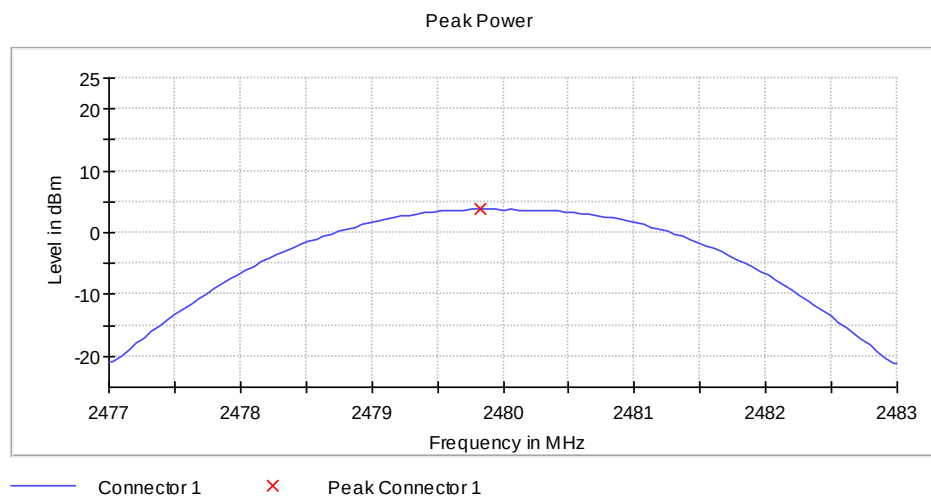


Figure 36: Maximum Peak Conducted Output Power (1 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power

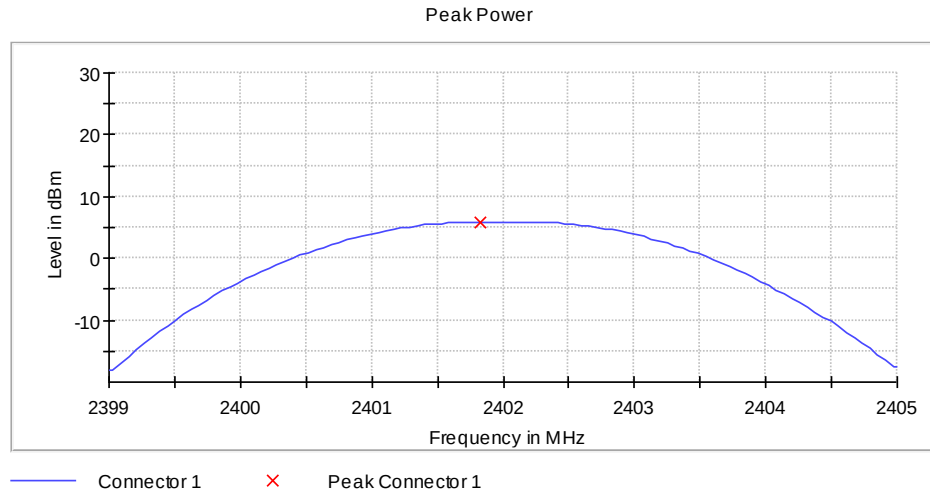


Figure 37: Maximum Peak Conducted Output Power (2 Mbps, TX 2402 MHz)

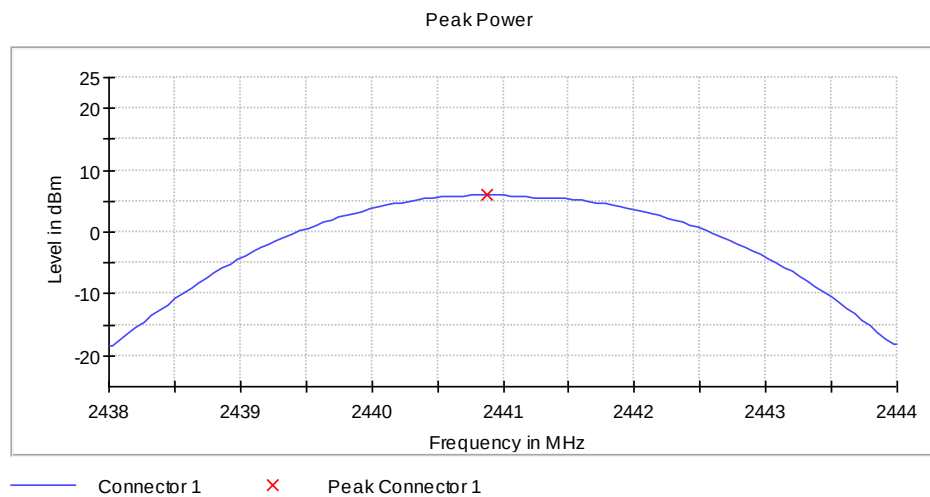


Figure 38: Maximum Peak Conducted Output Power (2 Mbps, TX 2441 MHz)

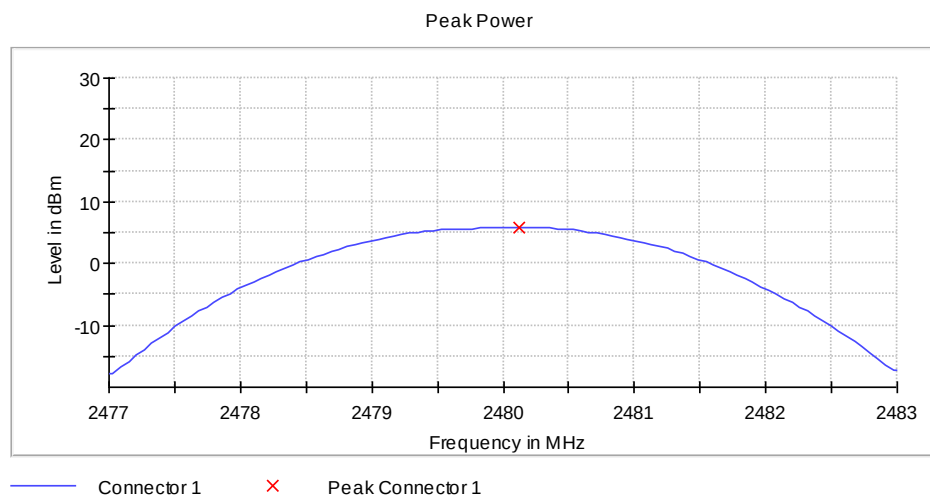


Figure 39: Maximum Peak Conducted Output Power (2 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power

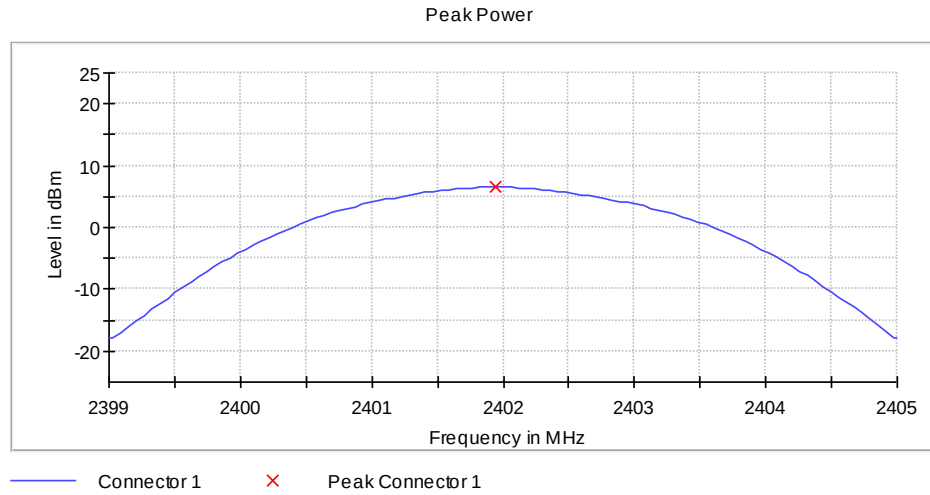


Figure 40: Maximum Peak Conducted Output Power (3 Mbps, TX 2402 MHz)

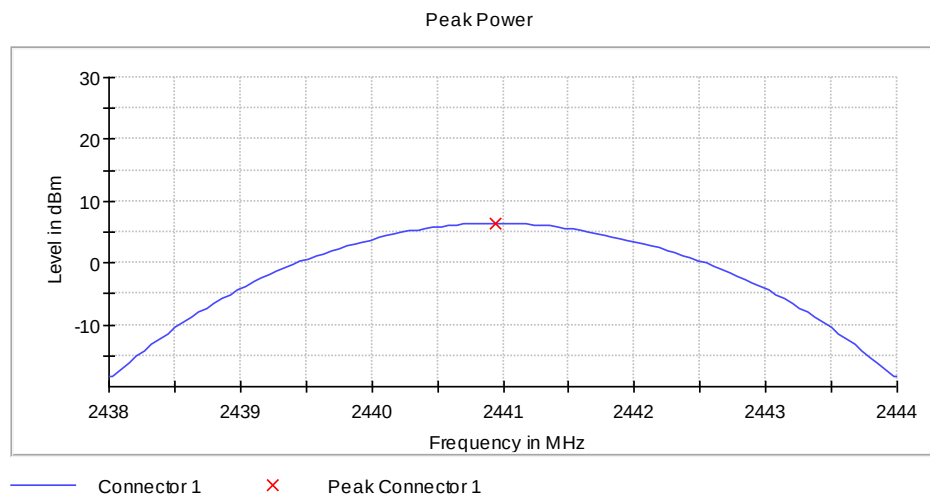


Figure 41: Maximum Peak Conducted Output Power (3 Mbps, TX 2441 MHz)

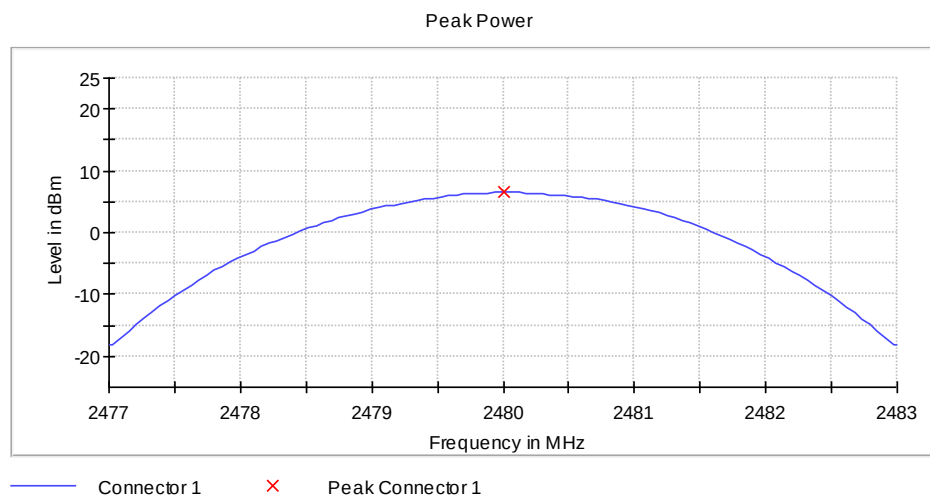


Figure 42: Maximum Peak Conducted Output Power (3 Mbps, TX 2480 MHz)

Unwanted Emissions (conducted)

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

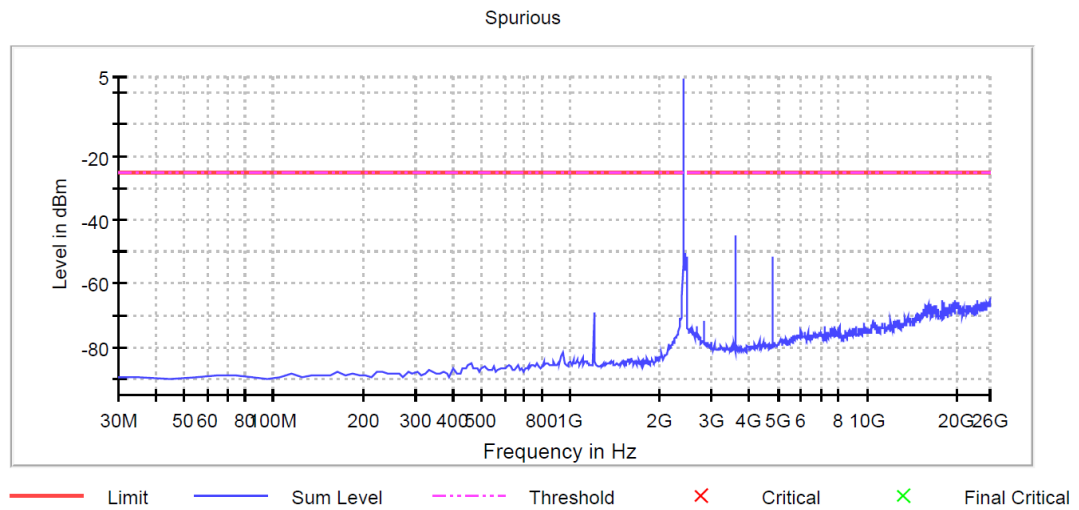


Figure 43: Unwanted Emissions, conducted (1 Mbps, TX 2402 MHz)

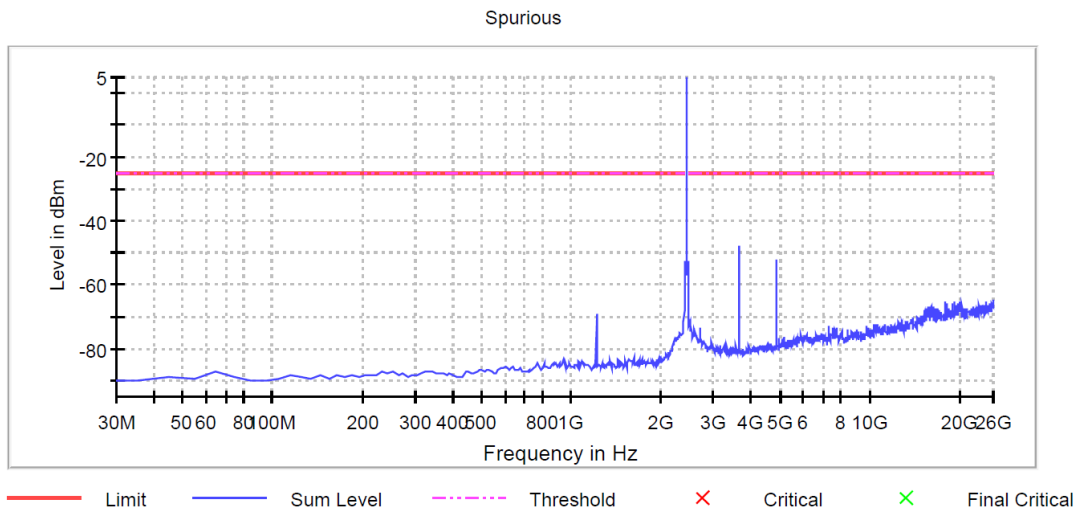


Figure 44: Unwanted Emissions, conducted (1 Mbps, TX 2441 MHz)

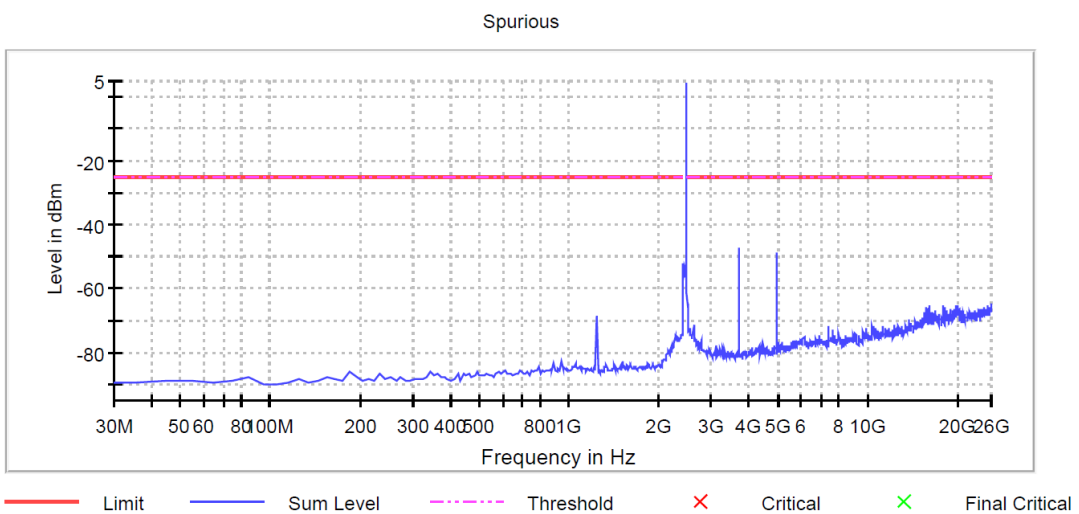


Figure 45: Unwanted Emissions, conducted (1 Mbps, TX 2480 MHz)

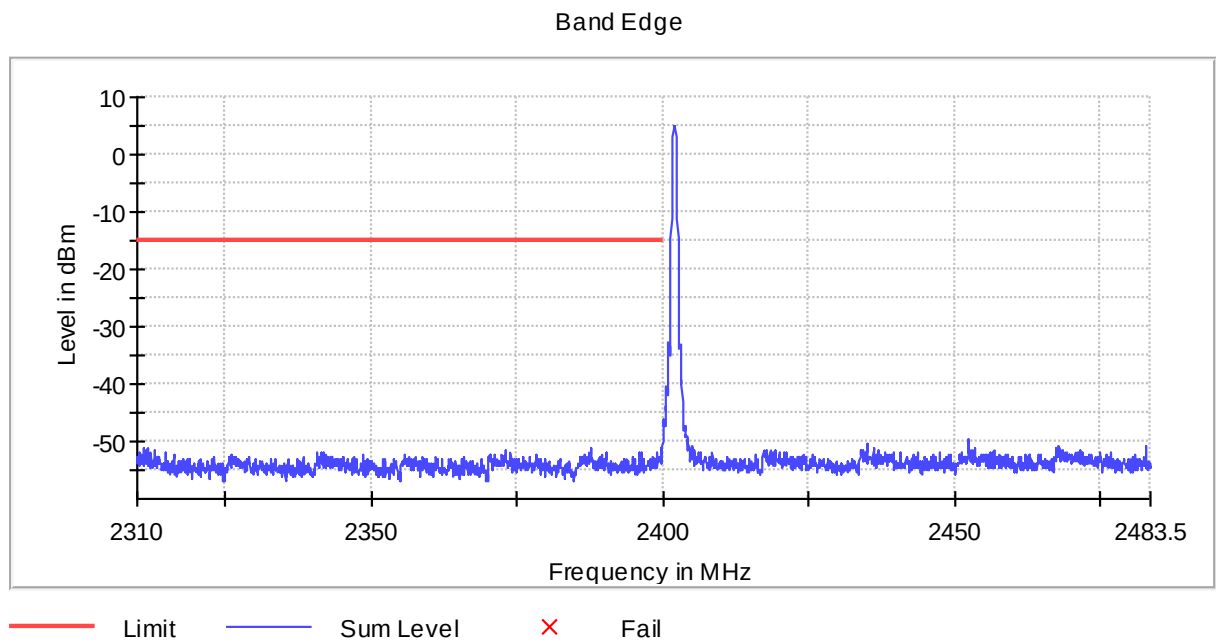


Figure 46: Lower Band-Edge, conducted (1 Mbps, TX 2402 MHz)

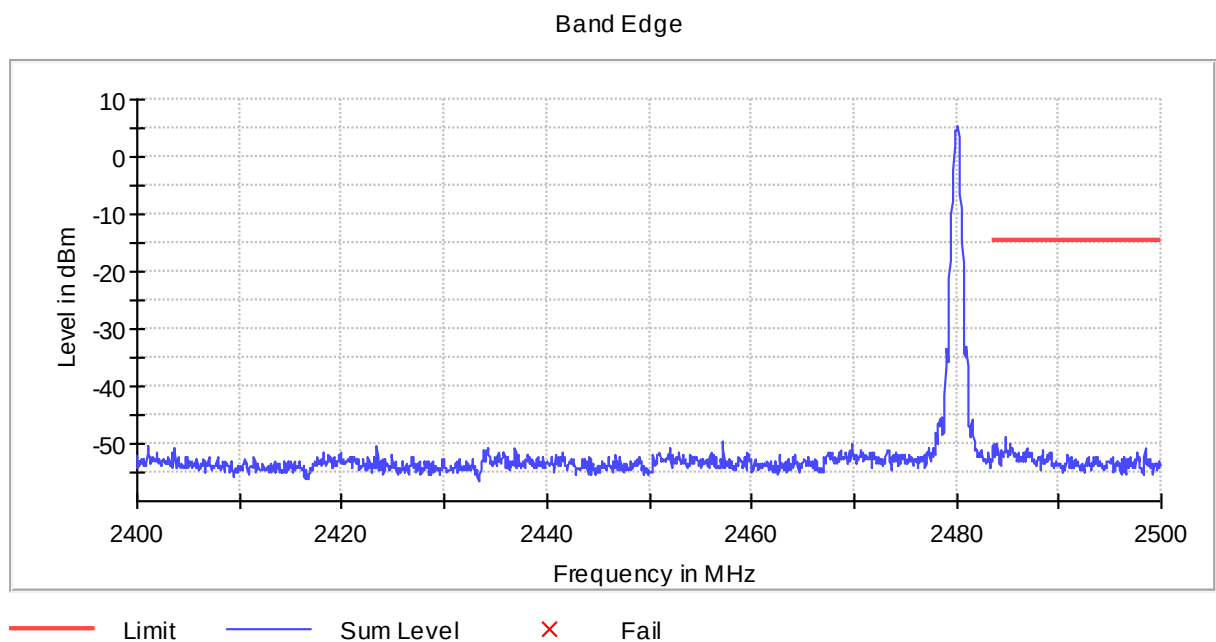


Figure 47: Upper Band-Edge, conducted (1 Mbps, TX 2480 MHz)

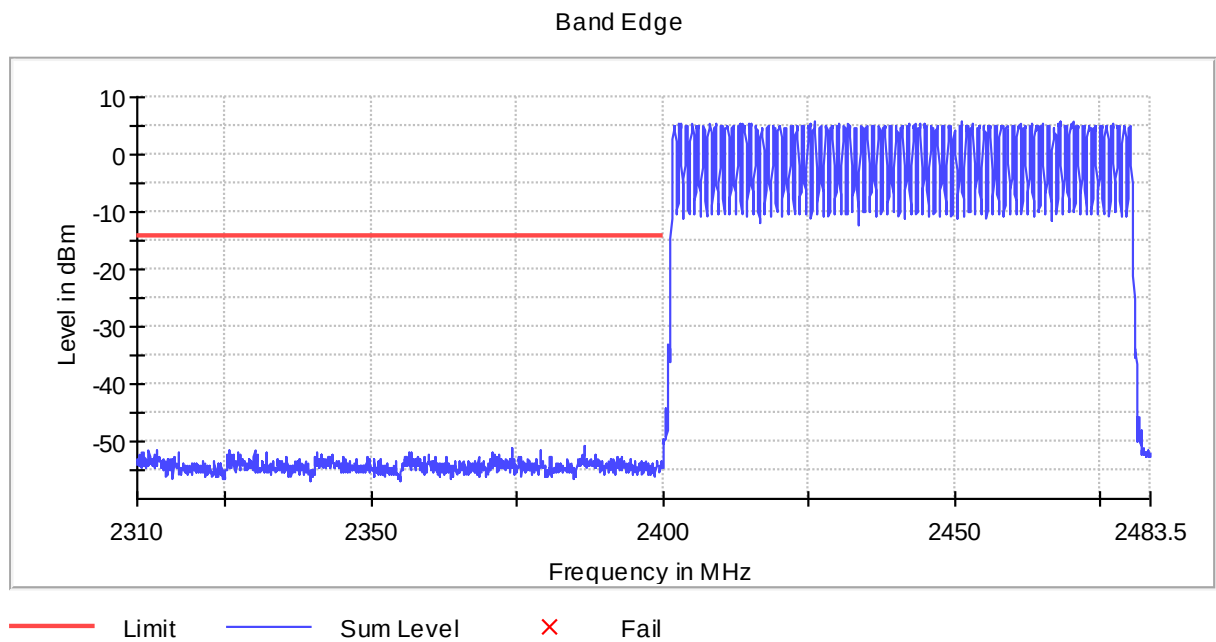


Figure 48: Lower Band-Edge, conducted (1 Mbps, hopping mode)

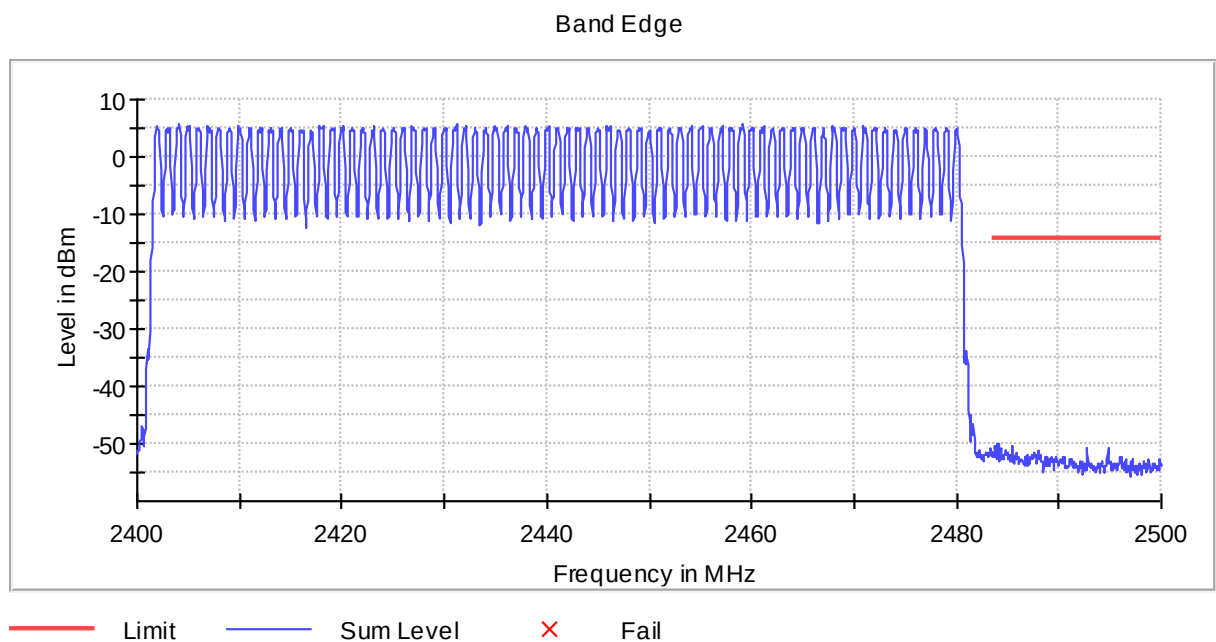


Figure 49: Upper Band-Edge, conducted (1 Mbps, hopping mode)

Unwanted Emissions (conducted)

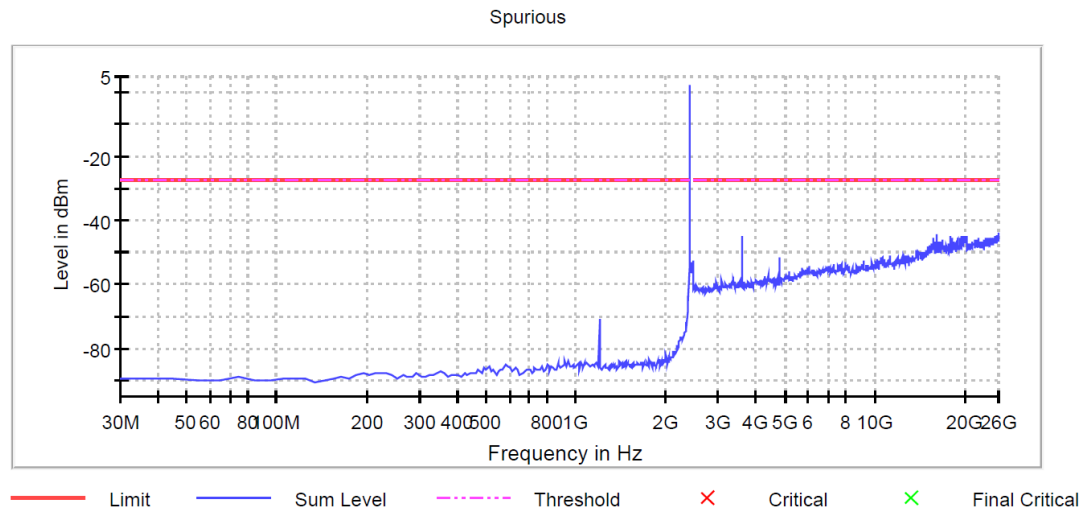


Figure 50: Unwanted Emissions, conducted (2 Mbps, TX 2402 MHz)

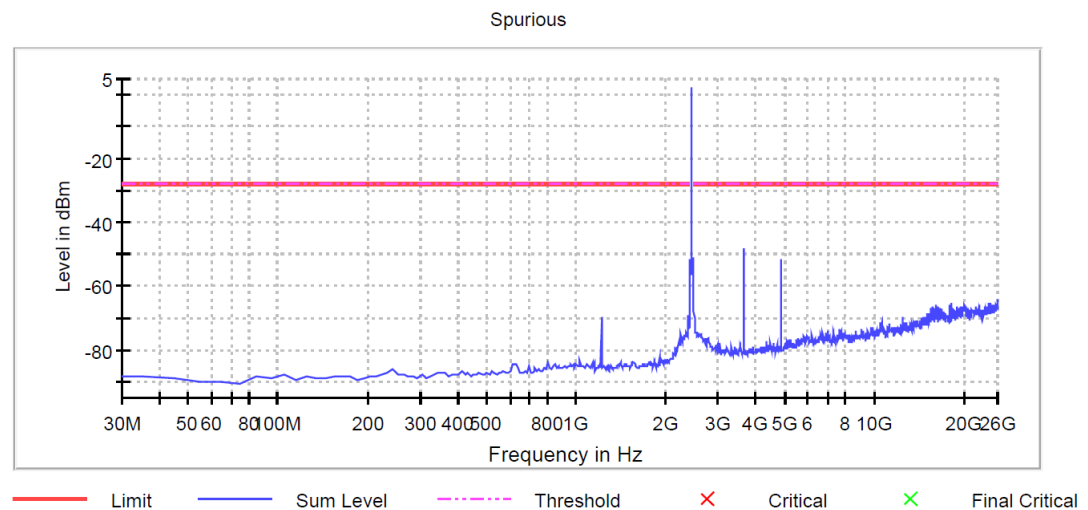


Figure 51: Unwanted Emissions, conducted (2 Mbps, TX 2441 MHz)

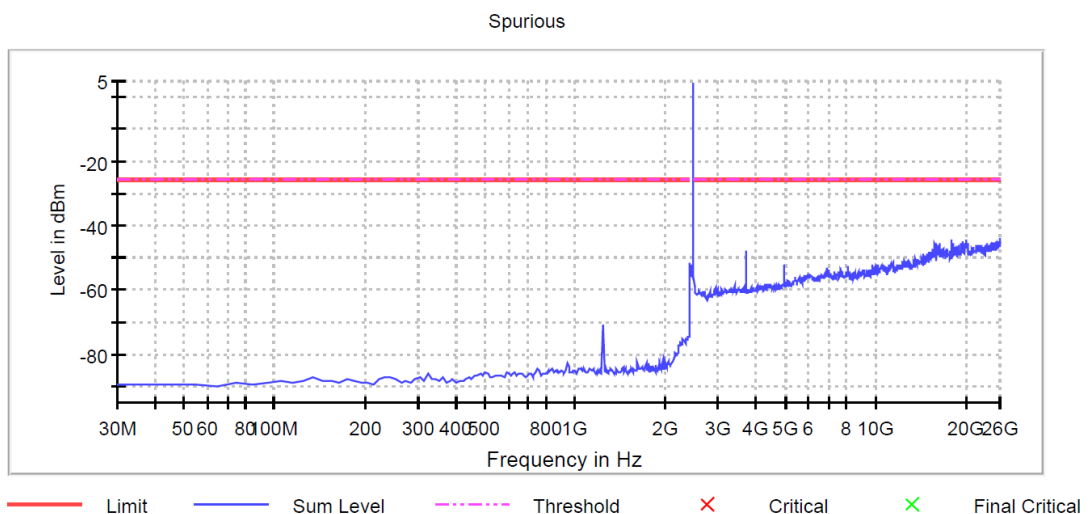


Figure 52: Unwanted Emissions, conducted (2 Mbps, TX 2480 MHz)

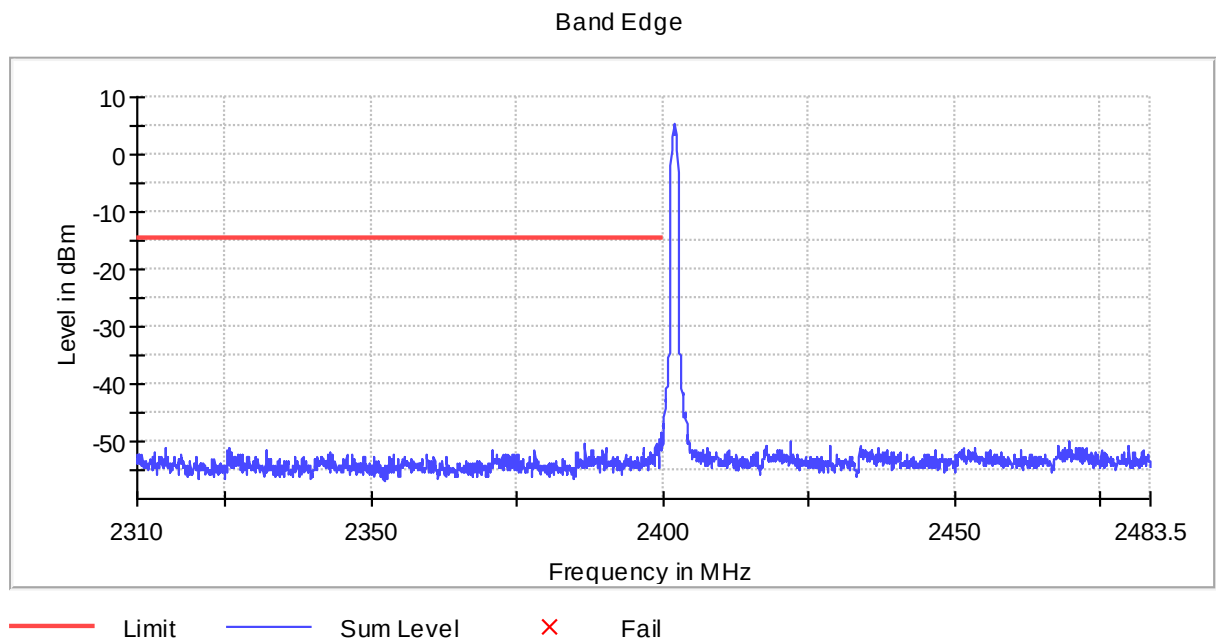


Figure 53: Lower Band-Edge, conducted (2 Mbps, TX 2402 MHz)

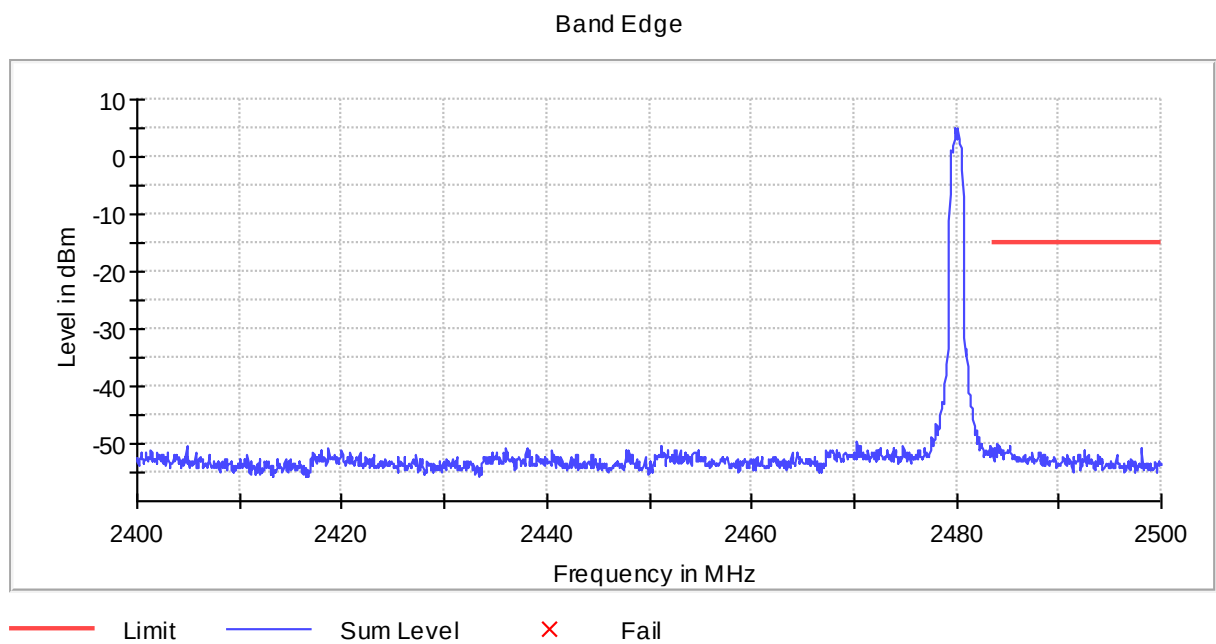


Figure 54: Upper Band-Edge, conducted (2 Mbps, TX 2480 MHz)

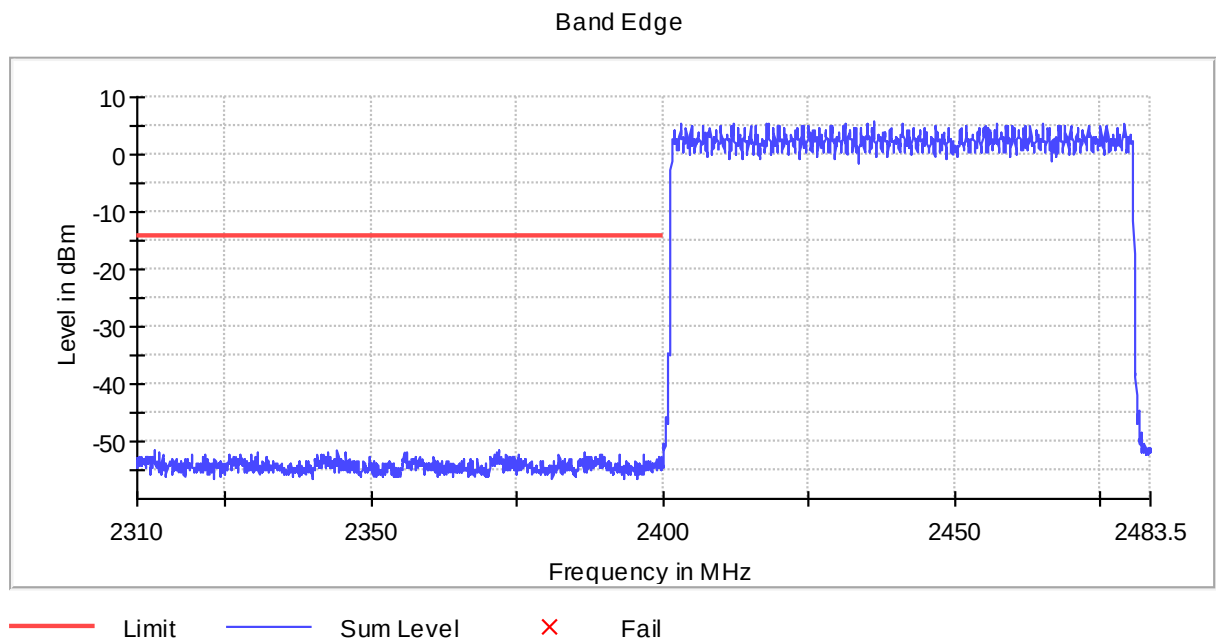


Figure 55: Lower Band-Edge, conducted (2 Mbps, hopping mode)

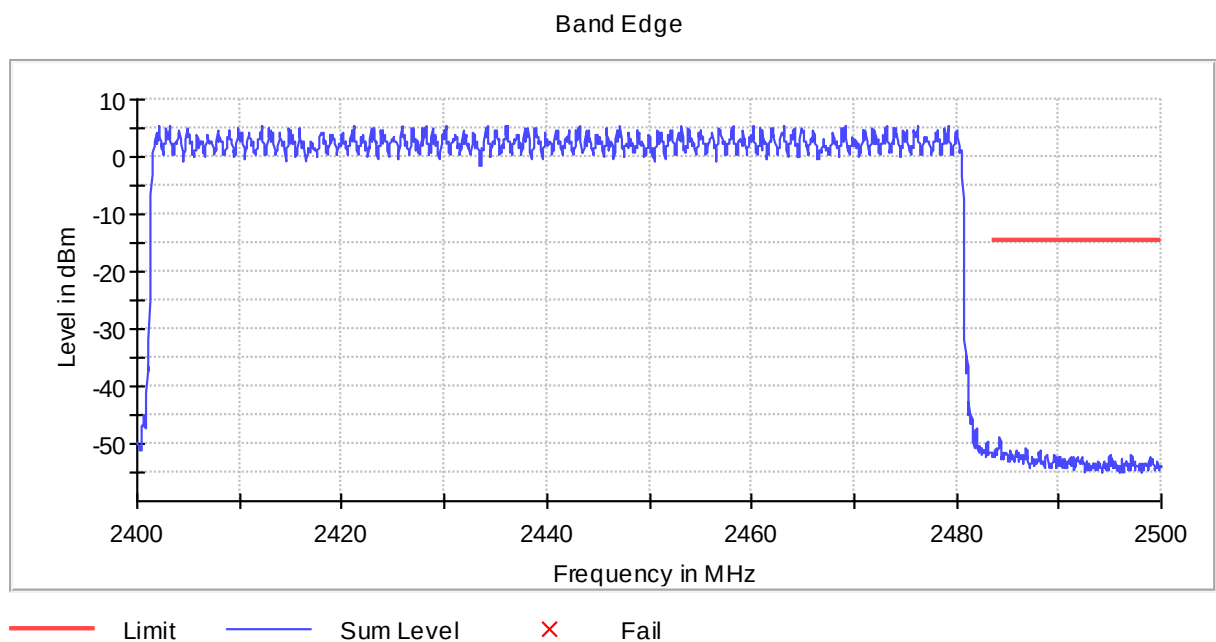


Figure 56: Upper Band-Edge, conducted (2 Mbps, hopping mode)

Unwanted Emissions (conducted)

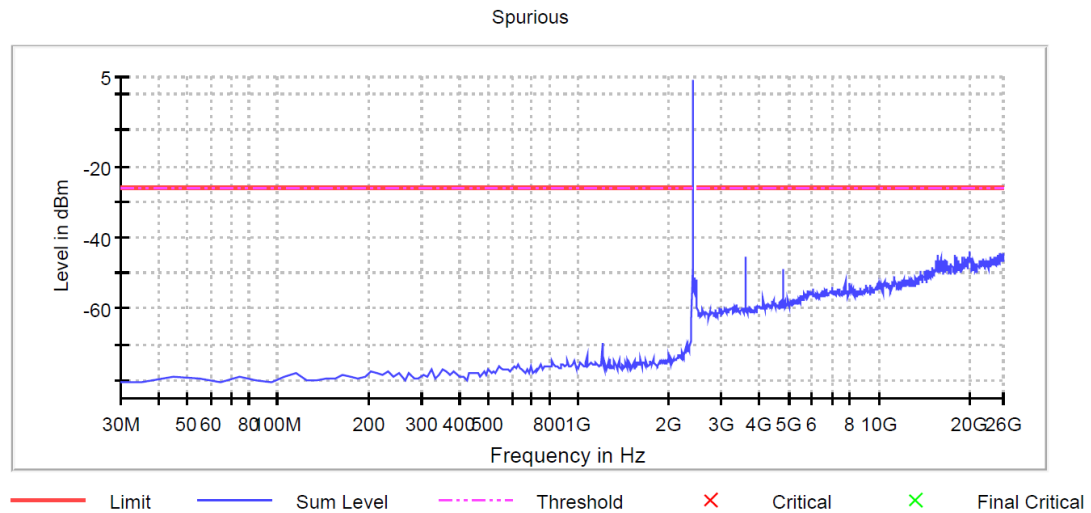


Figure 57: Unwanted Emissions, conducted (3 Mbps, TX 2402 MHz)

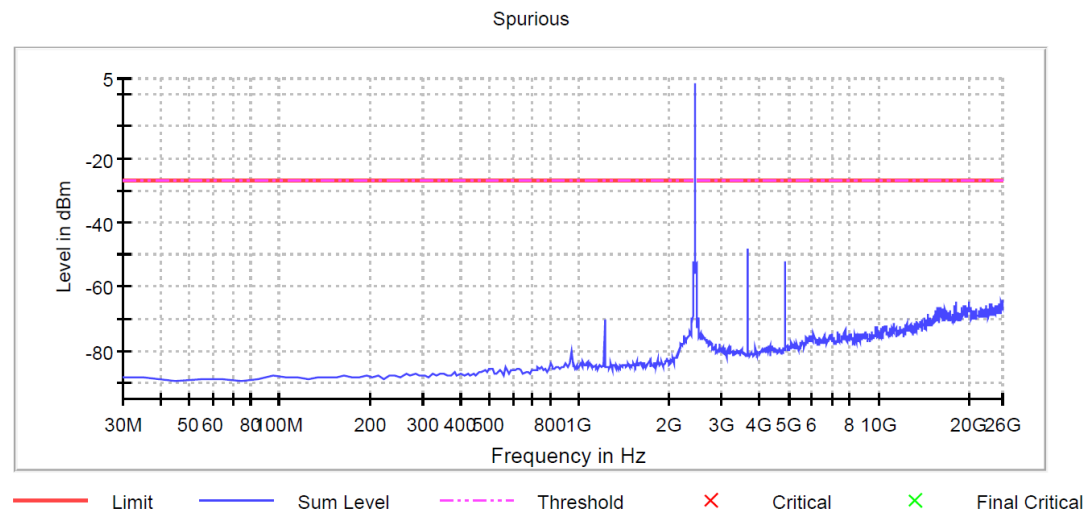


Figure 58: Unwanted Emissions, conducted (3 Mbps, TX 2441 MHz)

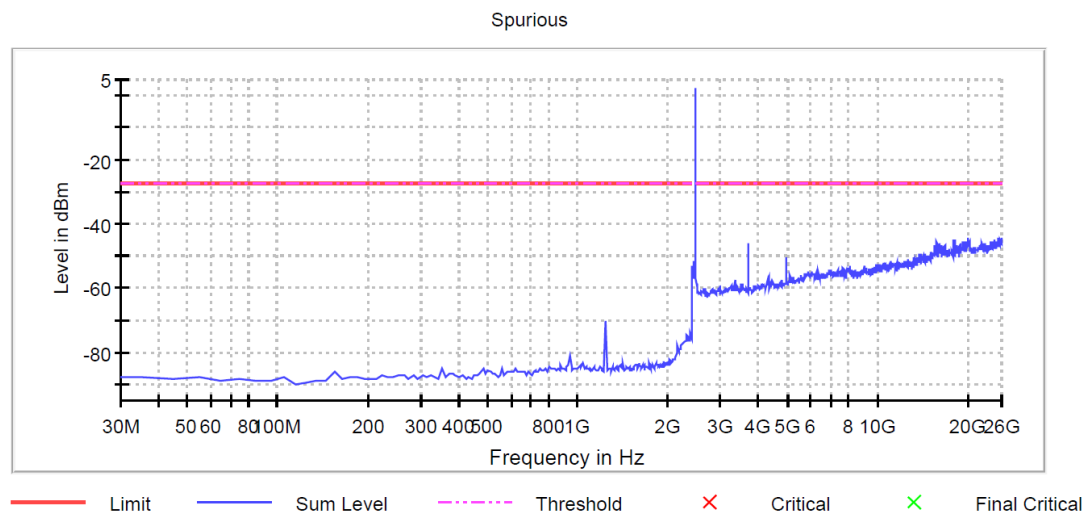


Figure 59: Unwanted Emissions, conducted (3 Mbps, TX 2480 MHz)

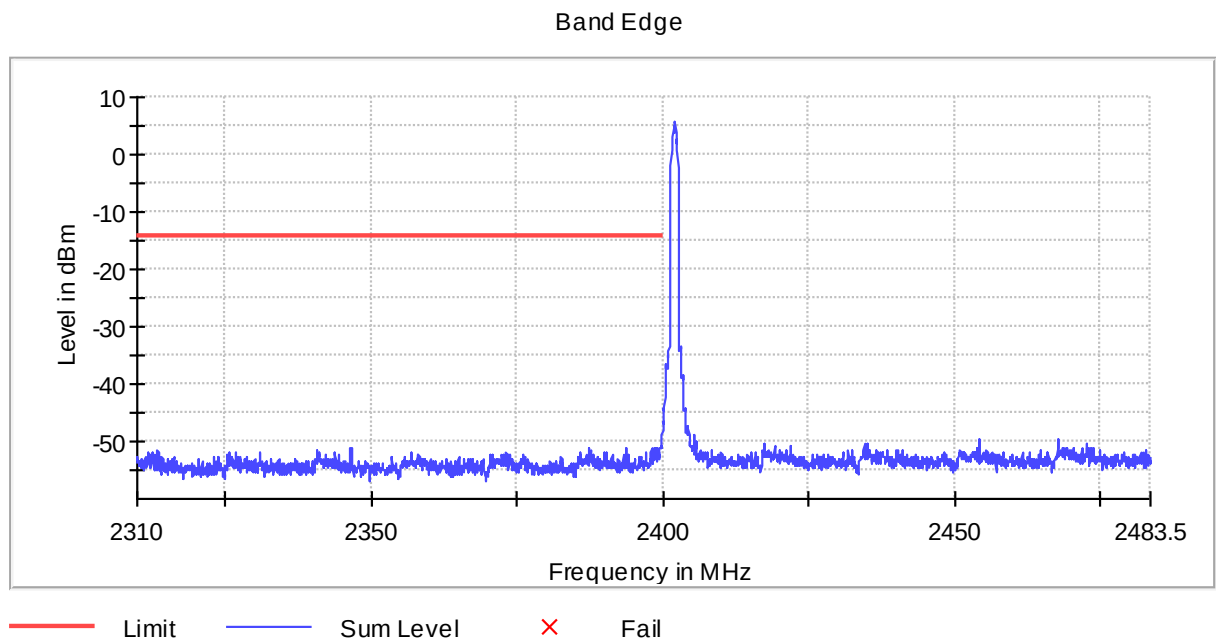


Figure 60: Lower Band-Edge, conducted (3 Mbps, TX 2402 MHz)

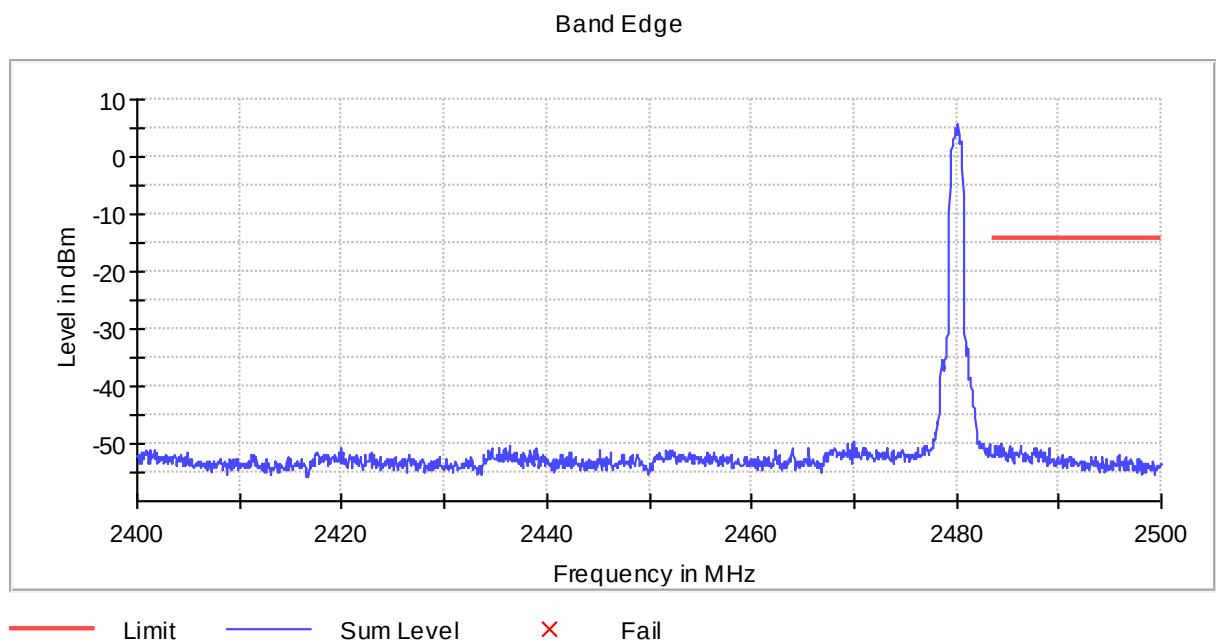


Figure 61: Upper Band-Edge, conducted (3 Mbps, TX 2480 MHz)

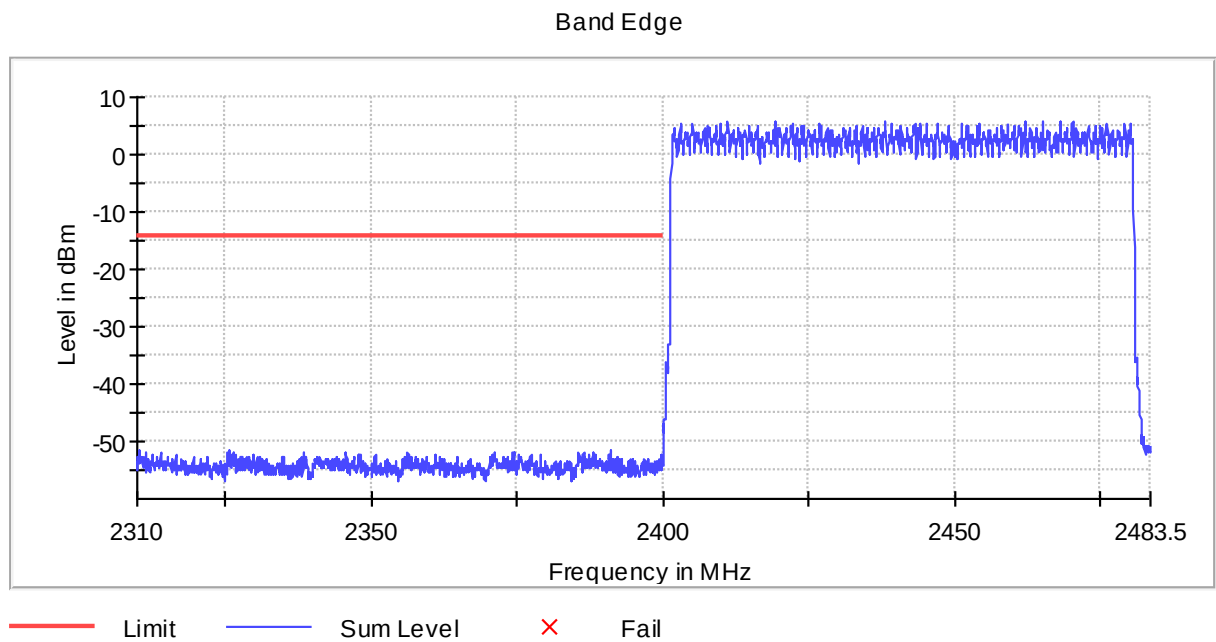


Figure 62: Lower Band-Edge, conducted (3 Mbps, hopping mode)

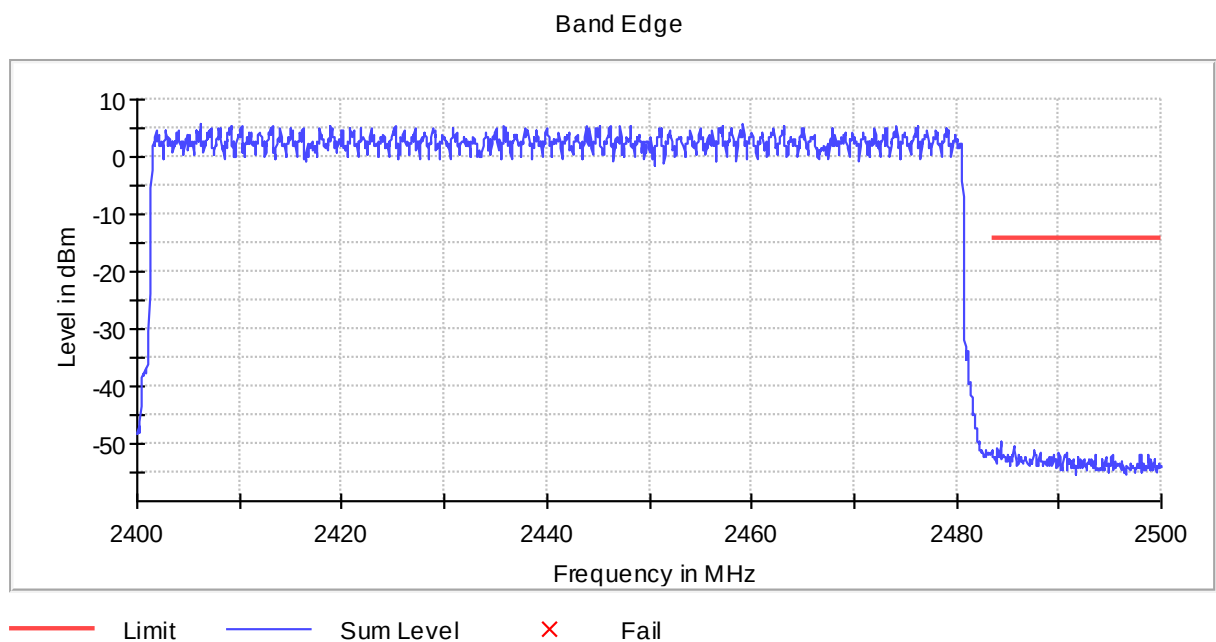


Figure 63: Upper Band-Edge, conducted (3 Mbps, hopping mode)

Unwanted Emissions (radiated)**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.

Unwanted Emissions (radiated)

Test results (1 Mbps, TX 2402 MHz)

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

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/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 (dBμV/m)	Limit (dBμV/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

Full Spectrum

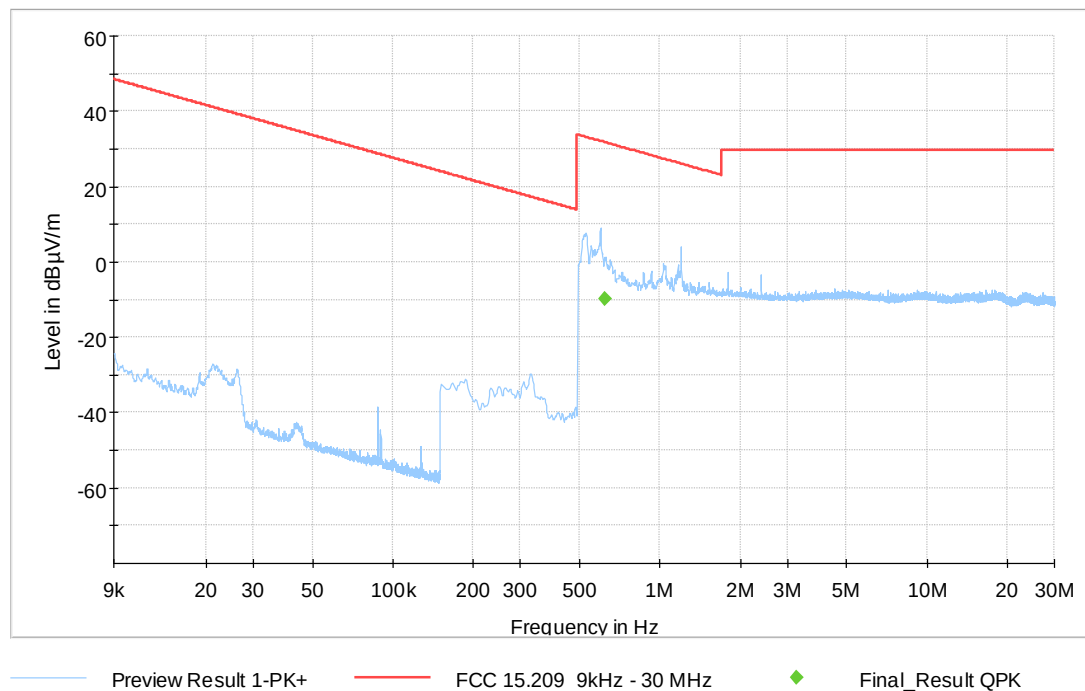


Figure 64: Unwanted Emissions, radiated 9 kHz – 30 MHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

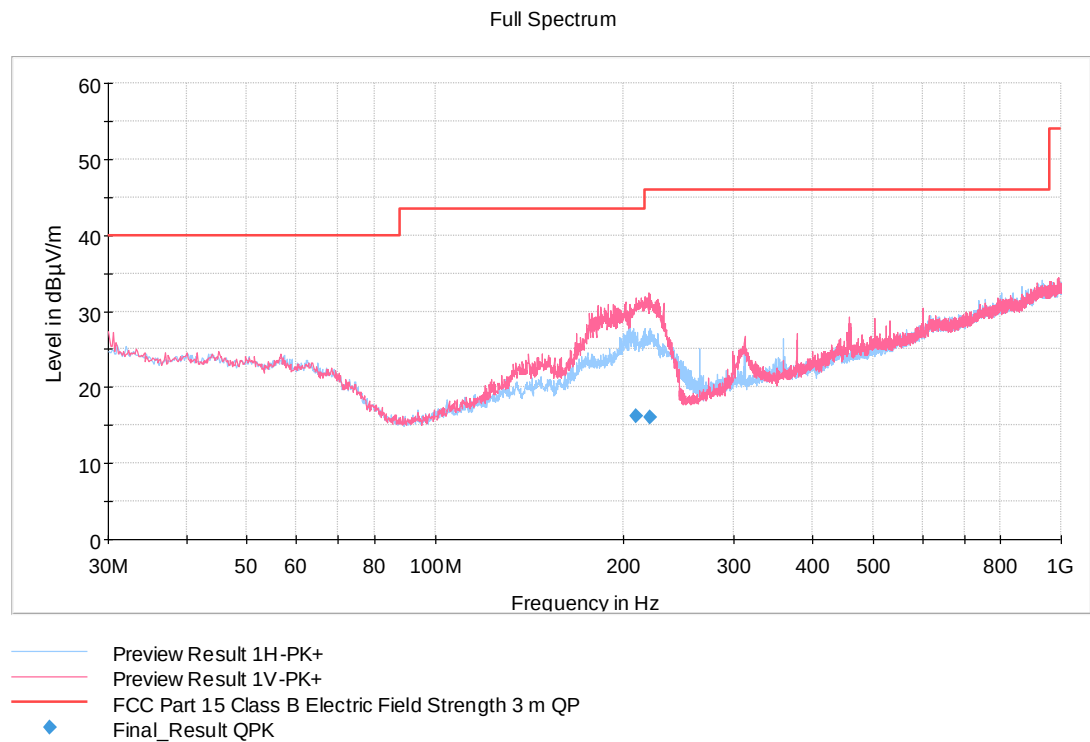


Figure 65: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2402 MHz)

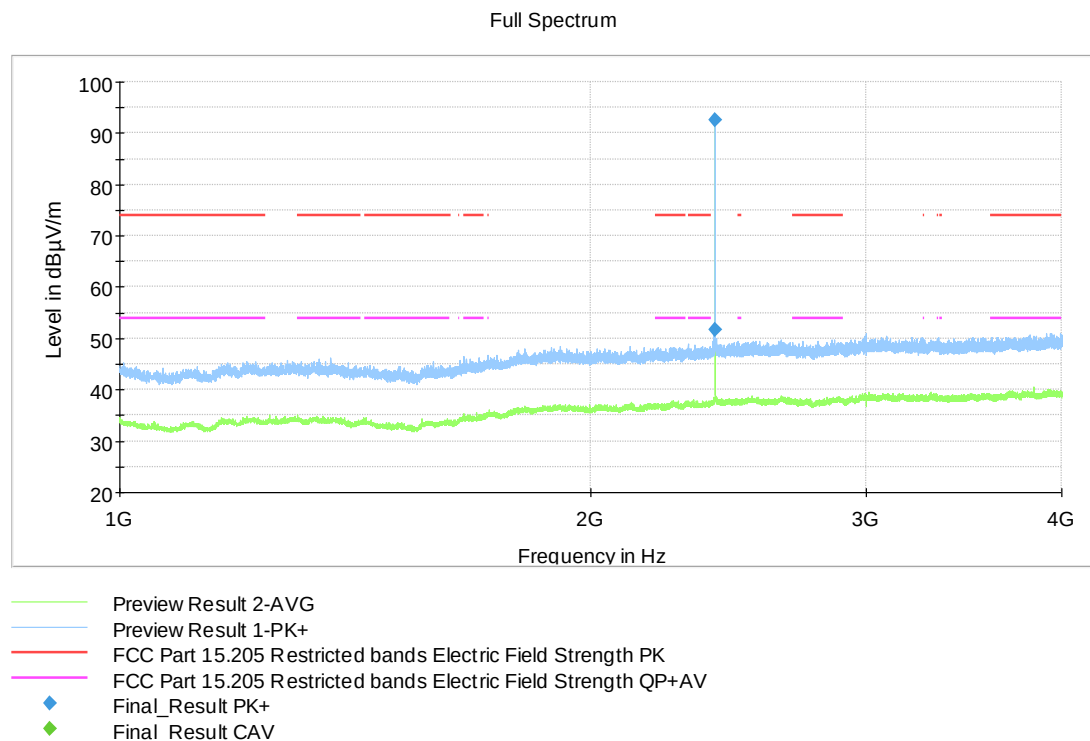


Figure 66: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

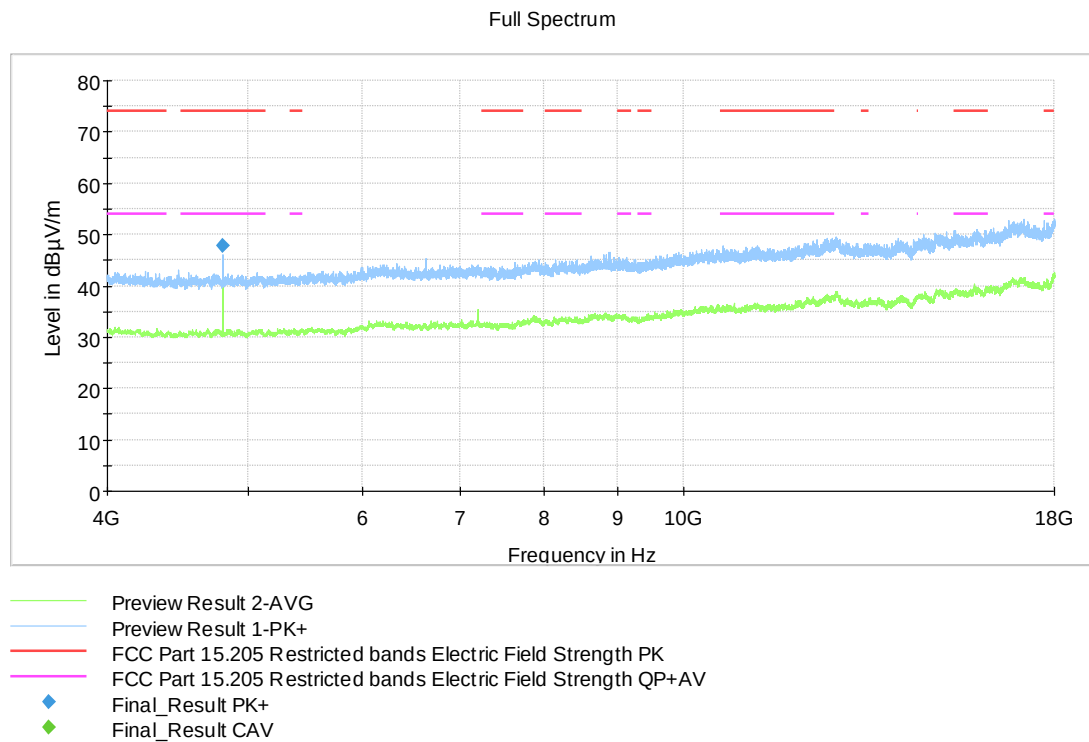


Figure 67: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2402 MHz)

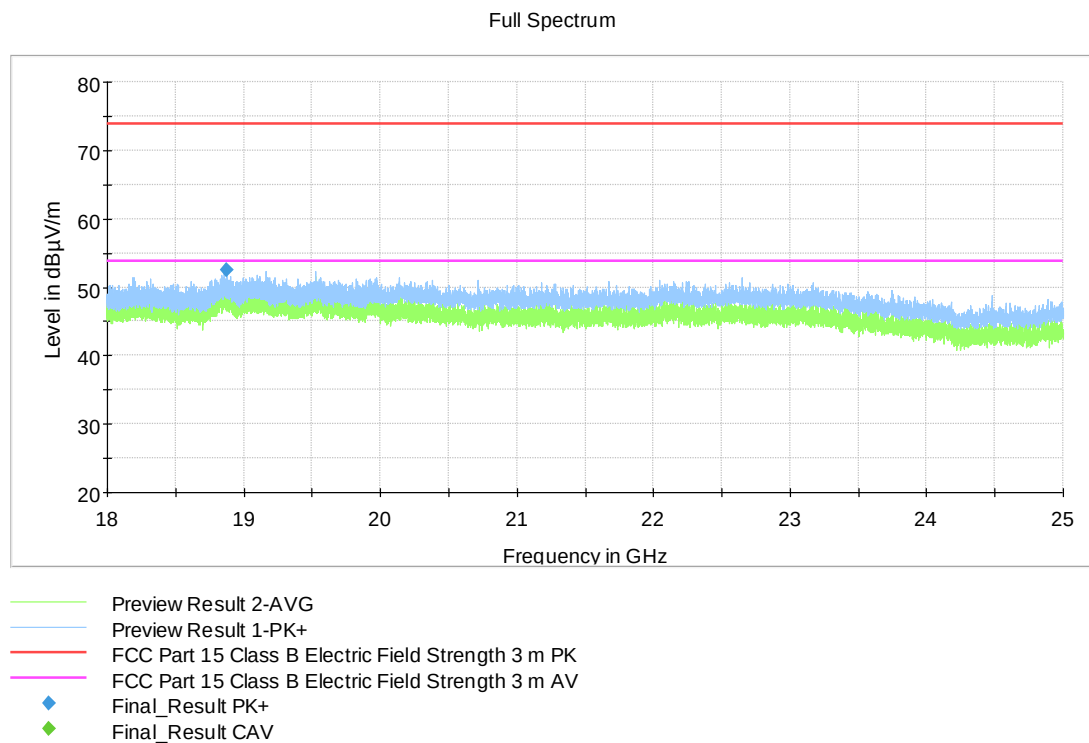


Figure 68: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

Test results (1 Mbps, TX 2441 MHz)

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

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/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

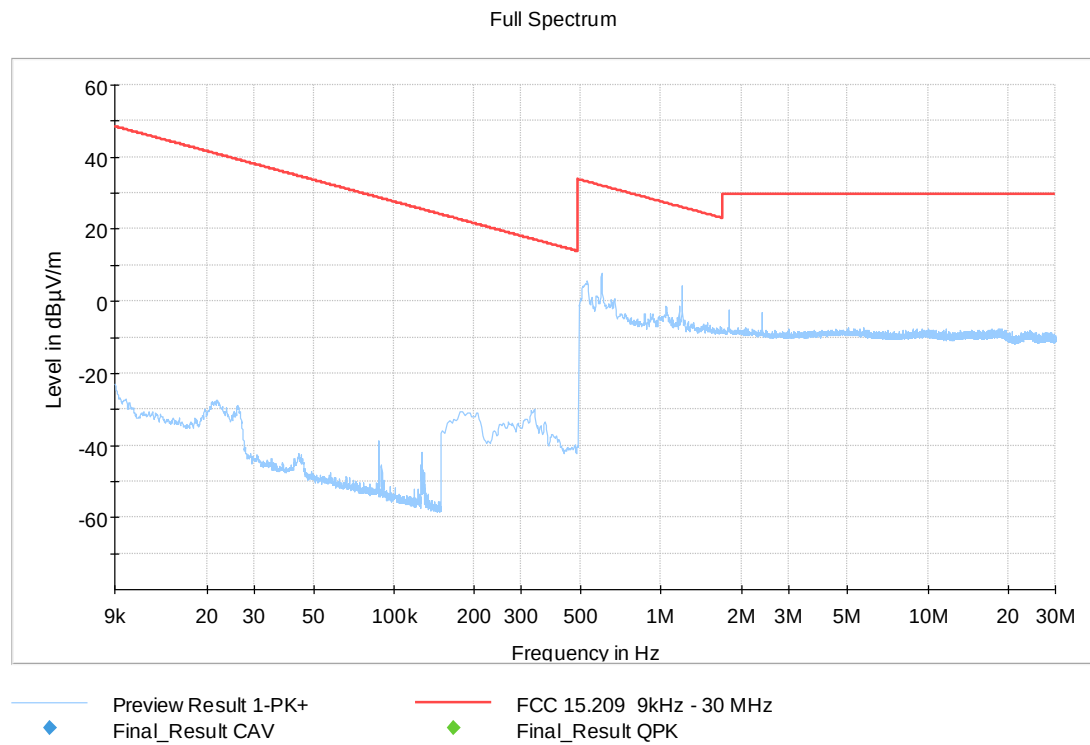


Figure 69: Unwanted Emissions, radiated 9 kHz – 30 MHz (1 Mbps, TX 2441 MHz)

Unwanted Emissions (radiated)

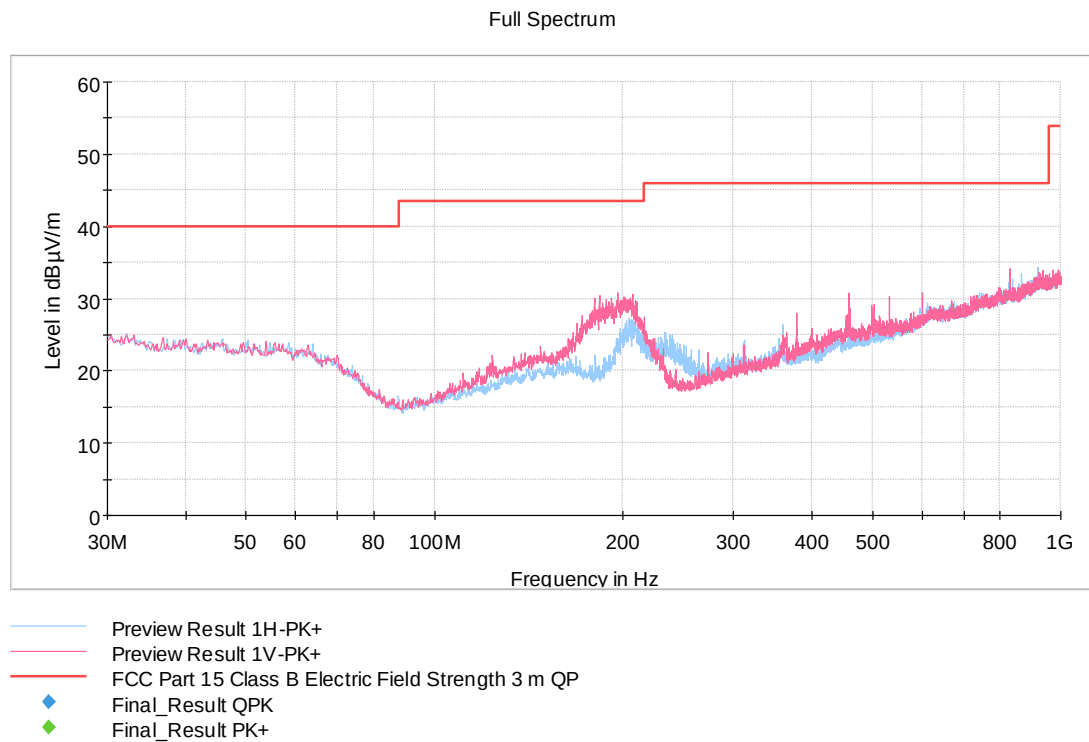


Figure 70: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2441 MHz)

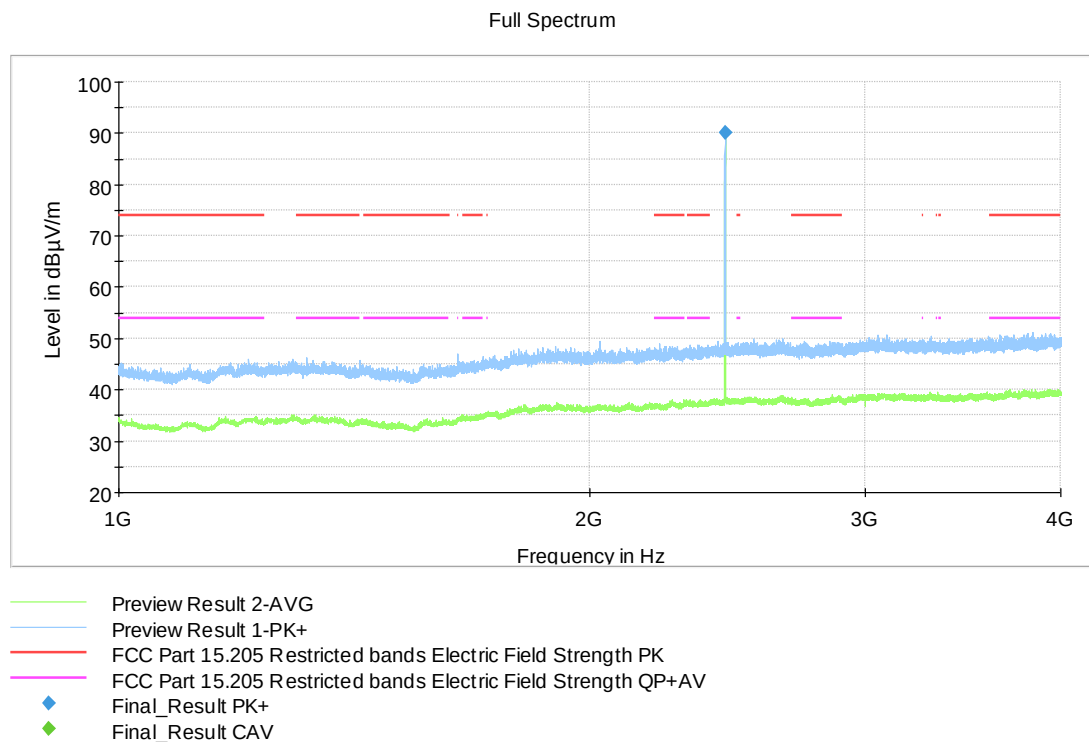


Figure 71: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2441 MHz)

Unwanted Emissions (radiated)

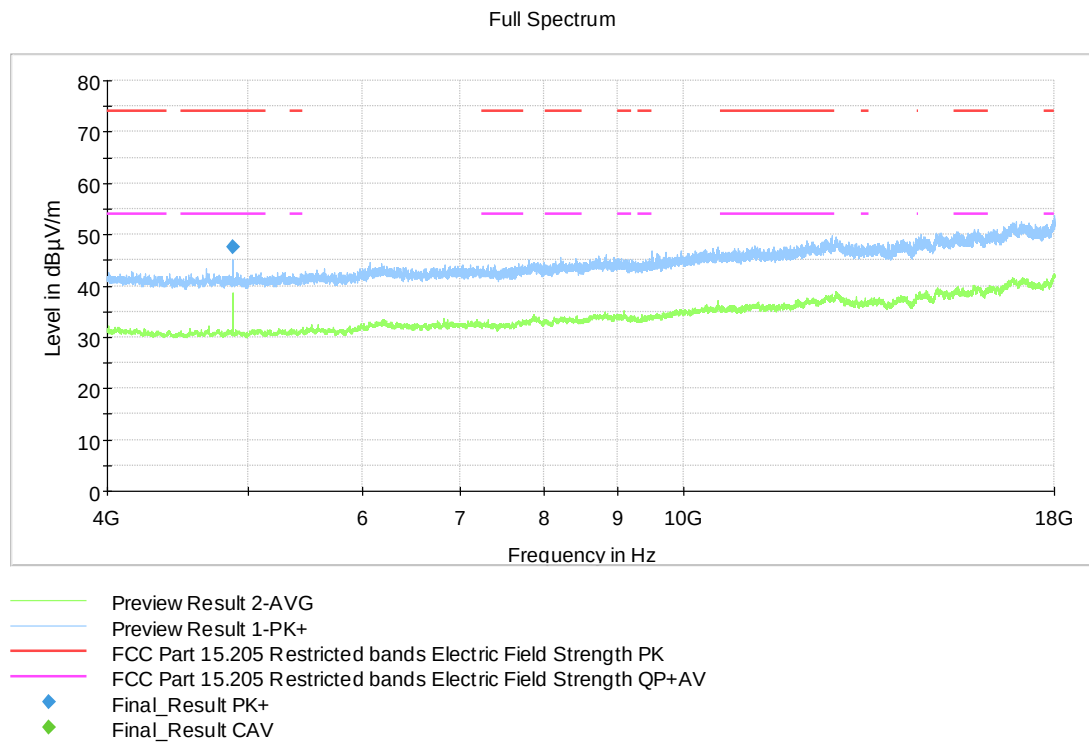


Figure 72: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2441 MHz)

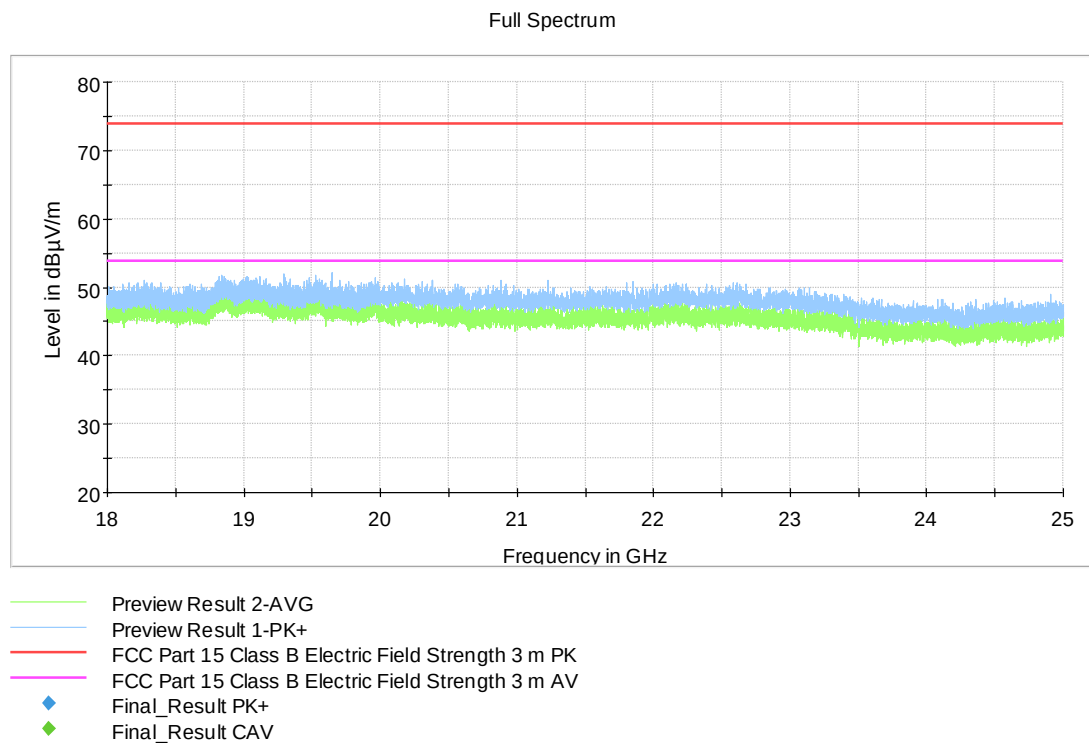


Figure 73: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2441 MHz)

Unwanted Emissions (radiated)

Test results (1 Mbps, TX 2480 MHz)

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

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/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 (dBμV/m)	Limit (dBμV/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)

Unwanted Emissions (radiated)

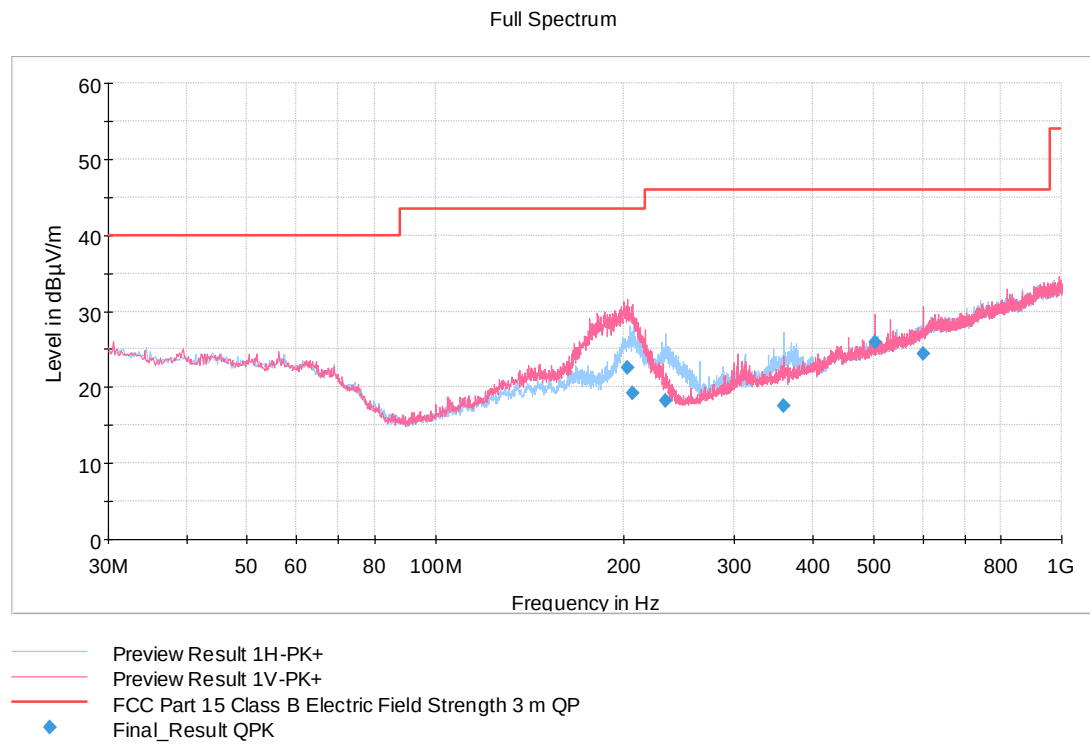


Figure 75: Unwanted Emissions, radiated 30 – 1000 MHz (1 Mbps, TX 2480 MHz)

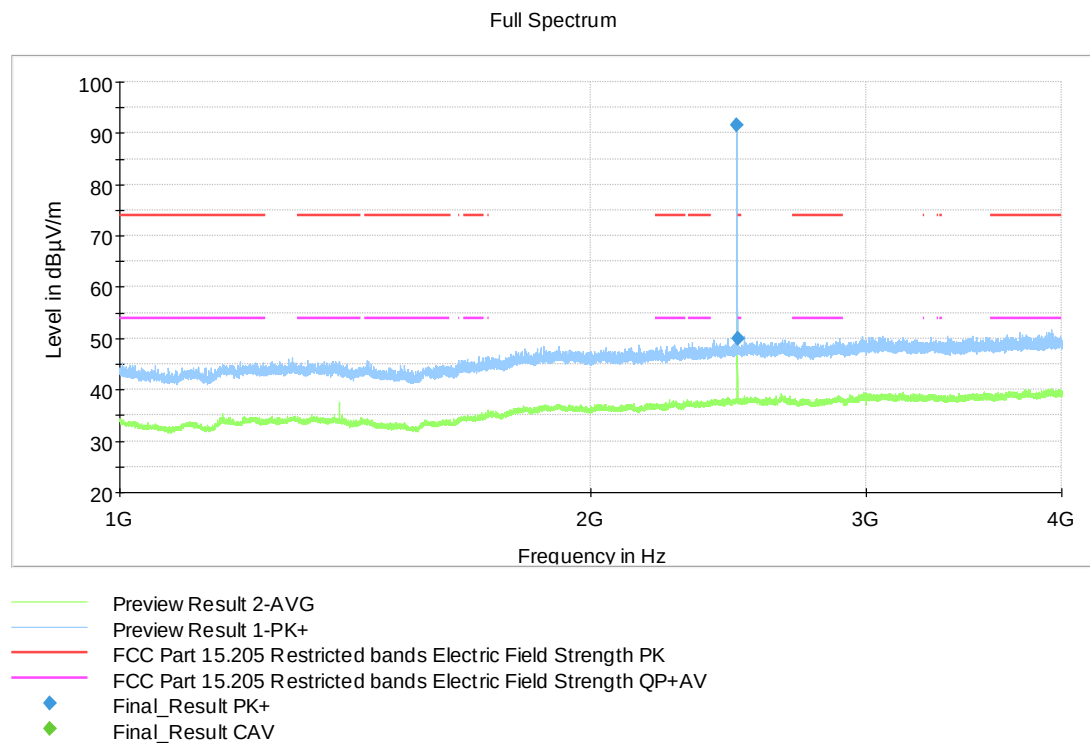


Figure 76: Unwanted Emissions, radiated 1 – 4 GHz (1 Mbps, TX 2480 MHz)

Unwanted Emissions (radiated)

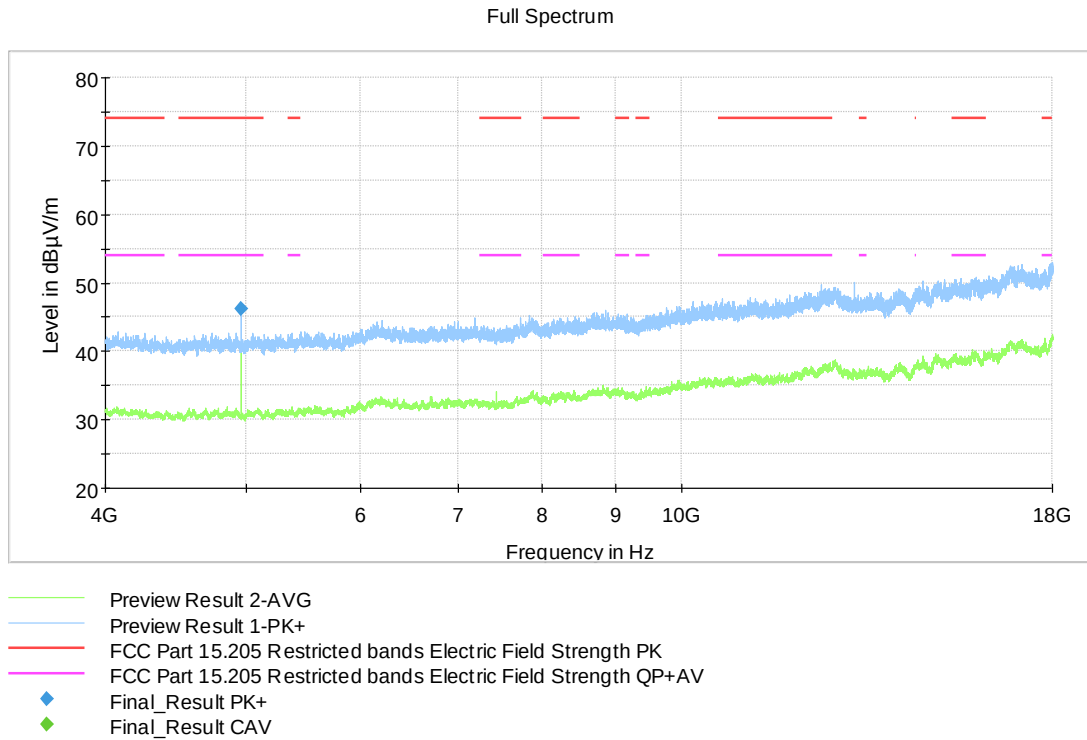


Figure 77: Unwanted Emissions, radiated 4 – 18 GHz (1 Mbps, TX 2480 MHz)

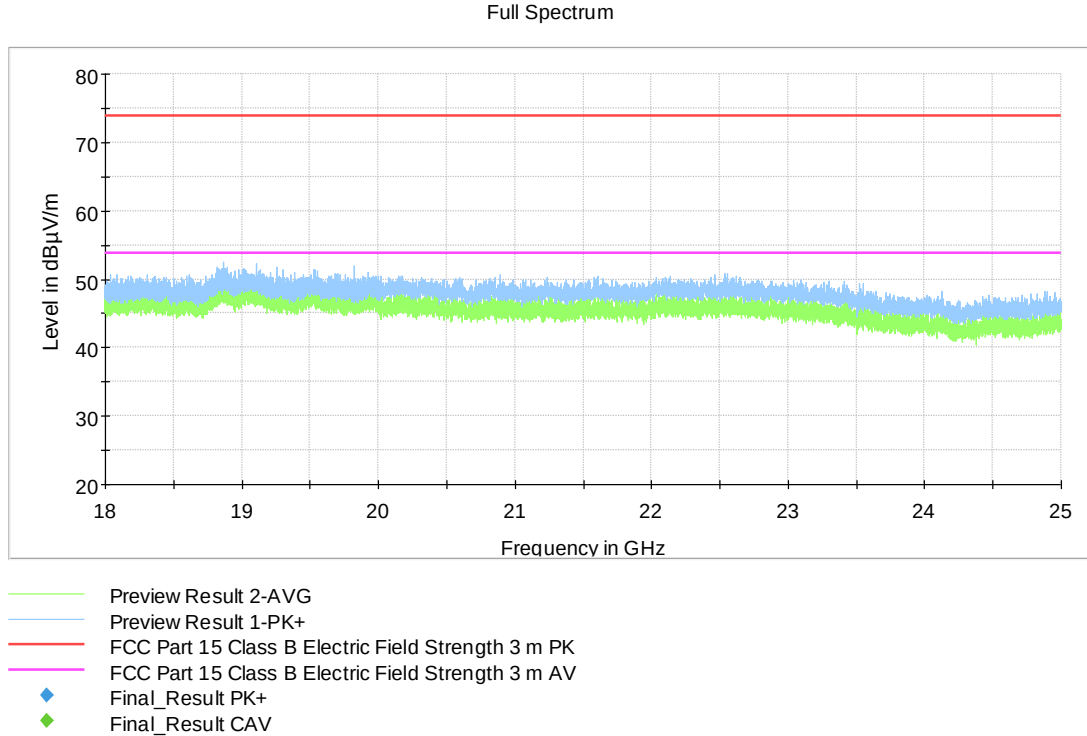


Figure 78: Unwanted Emissions, radiated 18 – 25 GHz (1 Mbps, TX 2480 MHz)

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	PASTERNAK	10 dB, DC-40 GHz	sn. A1	2021-04-20	2023-04-20
ATTENUATOR	PASTERNAK	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