

Test Report

HELEM2304000149-1



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

Equipment Under Test: Virtual Reality Headset

Model: HS-10A

Manufacturer: Varjo Technologies Oy
Vuorikatu 20
FI-00100 Helsinki
Finland

Customer: Varjo Technologies Oy
Vuorikatu 20
FI-00100 Helsinki
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: 12 October 2023

Issued by: 
Henri Mäki
Testing Engineer

Date: 12 October 2023

Checked by: 
Rauno Repo
Senior EMC Specialist

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GENERAL REMARKS

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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	12 October 2023

PRODUCT DESCRIPTION

Equipment Under Test

Equipment Under Test: Virtual Reality Headset
Model: HS-10A
Type: -
Trademark: VARJO
Serial no: -
FCC ID: 2AROD-005
IC: 24483-005
Radio module or chip: Nordic Semiconductor nRF52840-QIAA-F-R

General Description

The equipment under test is a virtual reality headset including a Nordic Semiconductor nRF52840 RF chip with a proprietary protocol for controller connection. The EUT connects to a PC with a 5 m USB-C and 5 m DisplayPort cables.

Classification

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

Samples and Modifications

No.	Name	Description
1	Conducted	Conducted sample is the main PCB of the device, where an SMA cable has been inserted to the sub miniature coaxial switch redirecting the RF output from the antenna to the SMA port.
2	Radiated	Normal sample configured with test software. Used during radiated tests and AC Power-Line Conducted Emissions test

Ratings and declarations

Operating frequency range:	2402 – 2480 MHz
Nominal channel bandwidth:	2 MHz
Number of channels:	40
Channel separation:	2 MHz
Transmission technique:	DSSS
Modulation:	GFSK
Data rate:	1 Mbps, 2 Mbps
Antenna type:	Integral inverted L antenna
Antenna gain:	+2.8829 dBi
Antenna count:	1
EUT dimensions:	Height: 150...185 mm Width: 200 mm Length: 330...400 mm
Power requirements:	15 VDC
Operating temperature range:	+10...+35 °C

Ports and Cables

Cable / Port	Description
DisplayPort	Connected to the peripheral laptop during AC Power-Line Conducted Emissions measurement and radiated tests
USB-C	Connected to the peripheral headset adapter

Peripherals

Peripheral	Description / Usage
Laptop	Razer Blade RZ09-0330, configuring the EUT
Headset adapter	Power supply and data communication
AC/DC power supply	Razer RC30-024801, power supply to laptop
AC/DC power supply	Power supply to headset adapter

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)(2) / RSS-247 5.2 a)	6 dB Bandwidth	PASS
RSS-Gen 6.7	Occupied Bandwidth 99 %	PASS
§15.247(b)(3) / RSS-247 5.4 d)	Maximum Peak Conducted Output Power	PASS
§15.247(d) / RSS-247 5.5	Unwanted Emissions	PASS
§15.247(e) / RSS-247 5.2 b)	Power Spectral Density	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 (nRF Connect v4.1.2), using the Direct Test Mode v2.1.0 application with the following settings:

- Transmit power 4 dBm
- Physical layer LE 1Mbps or LE 2Mbps
- Packet type PRBS9
- Packet length 40 bytes

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.

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.

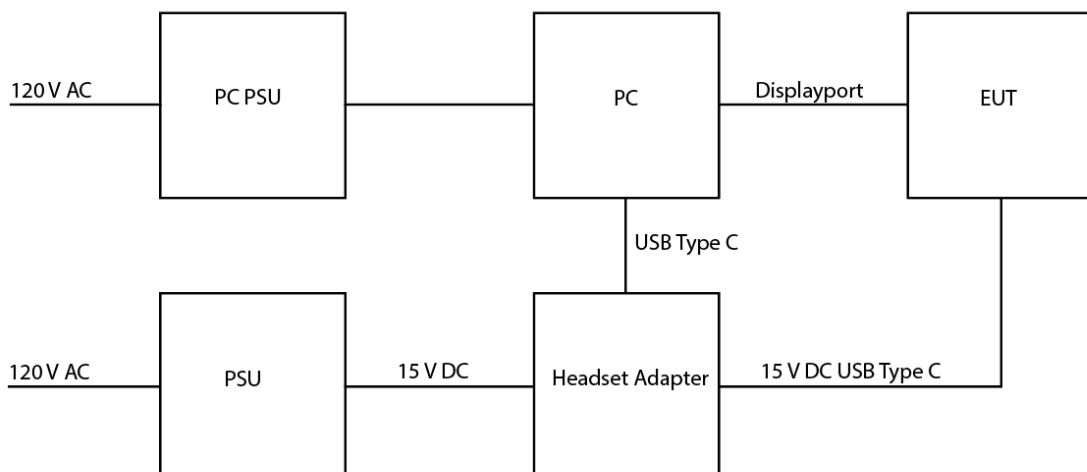


Figure 1: Test setup block diagram

Table 1: Test frequencies and settings

Data rate	Channel	Frequency [MHz]
1 Mbps	37	2402
	17	2440
	39	2480
2 Mbps	0	2404
	17	2440
	36	2478

Note: Channels 0 and 36 are the lowest and highest supported by 2 Mbps data rate.

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 §15.203
Tested by: HEM
Date: 28 June 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:	28 June 2023
Temperature:	23 °C
Humidity:	52 %RH
Measurement uncertainty:	± 2.9 dB, level of confidence 95 % (k = 2)
Test result:	PASS

FCC §15.207(a)
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

Full Spectrum

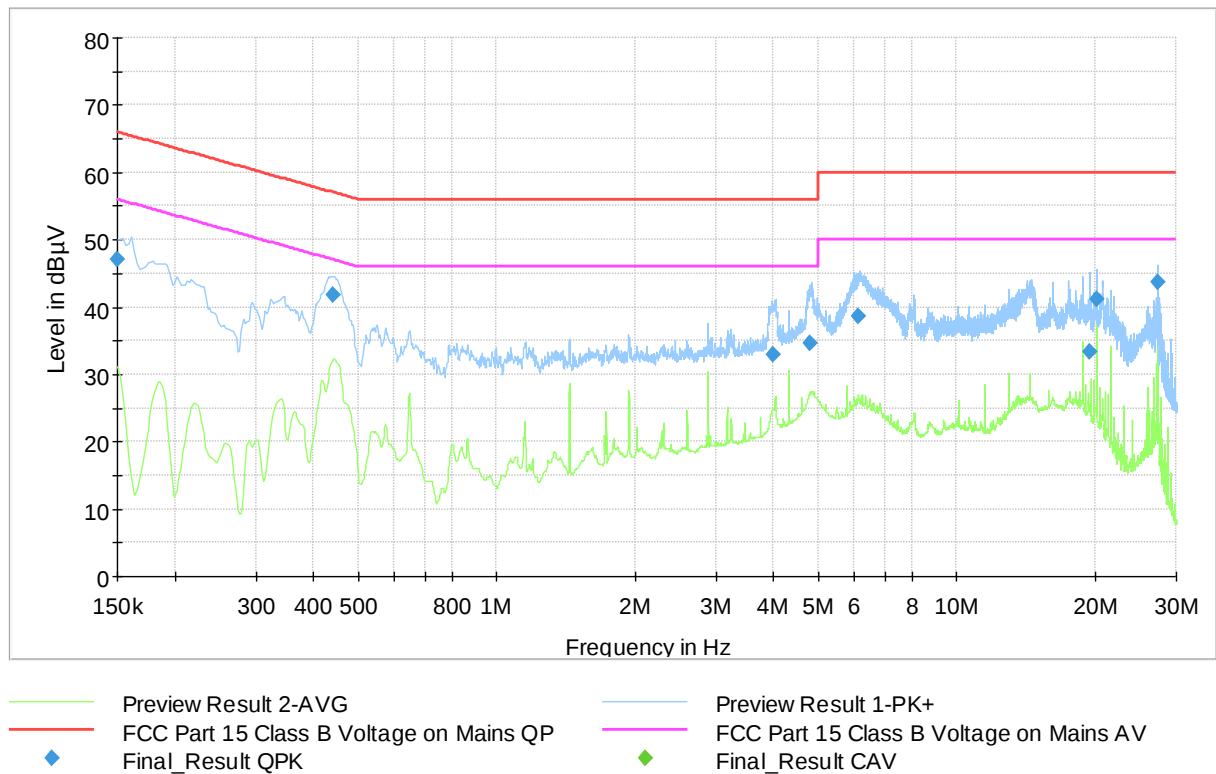


Figure 2: AC Power-Line Conducted Emissions

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)
0.150000	47.05	---	66.00	18.95	15 x 1000.0	9.000	L1	9.7
0.441500	41.89	---	57.03	15.14	15 x 1000.0	9.000	L1	9.7
4.000000	32.87	---	56.00	23.13	15 x 1000.0	9.000	L1	10.0
4.815000	34.56	---	56.00	21.44	15 x 1000.0	9.000	L1	10.0
6.116000	38.64	---	60.00	21.36	15 x 1000.0	9.000	N	10.1
19.399500	33.32	---	60.00	26.68	15 x 1000.0	9.000	L1	10.5
20.174000	41.25	---	60.00	18.75	15 x 1000.0	9.000	L1	10.4
27.364750	43.67	---	60.00	16.33	15 x 1000.0	9.000	L1	10.7

6 dB Bandwidth

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 10 October 2023
Temperature: 23 °C
Humidity: 33 %RH
Test result: **PASS**

FCC §15.247(a)(2) RSS-247 clause 5.2 a)

The 6 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 6 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.

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test results

Table 3: Test results for 6 dB Bandwidth

Data Rate	Frequency [MHz]	6 dB BW [kHz]	Limit [kHz]	Result
1 Mbps	2402	0.712872	≥ 500	PASS
	2440	0.732674		PASS
	2480	0.732674		PASS
2 Mbps	2404	1.188118		PASS
	2440	1.188118		PASS
	2478	1.188118		PASS

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

Setting	Value
Span	2.000 / 4.000 MHz
RBW	100.000 kHz
VBW	300.000 kHz
Sweep Points	101
Sweep Time	18.938 µs
Reference Level	0.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
Trace Mode	Max Hold
Sweep Type	FFT
Preamp	off

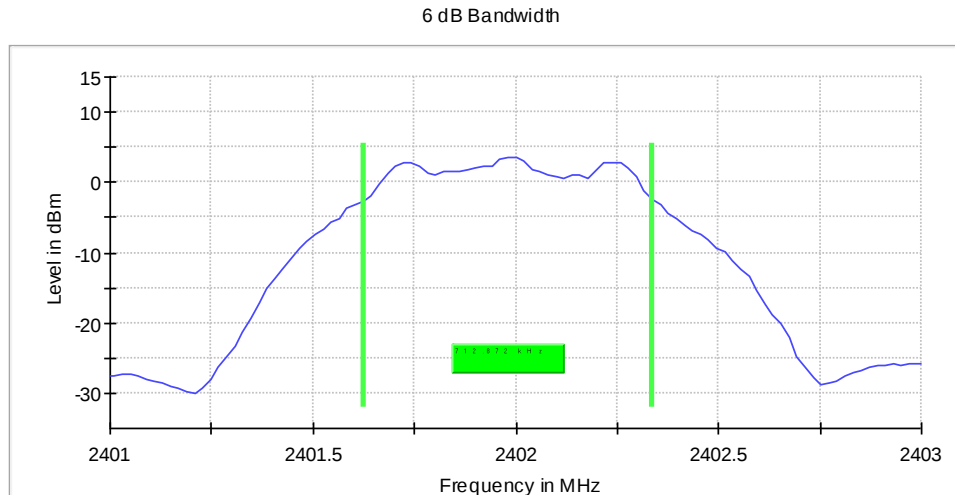


Figure 3: 6 dB Bandwidth (1 Mbps, TX 2402 MHz)

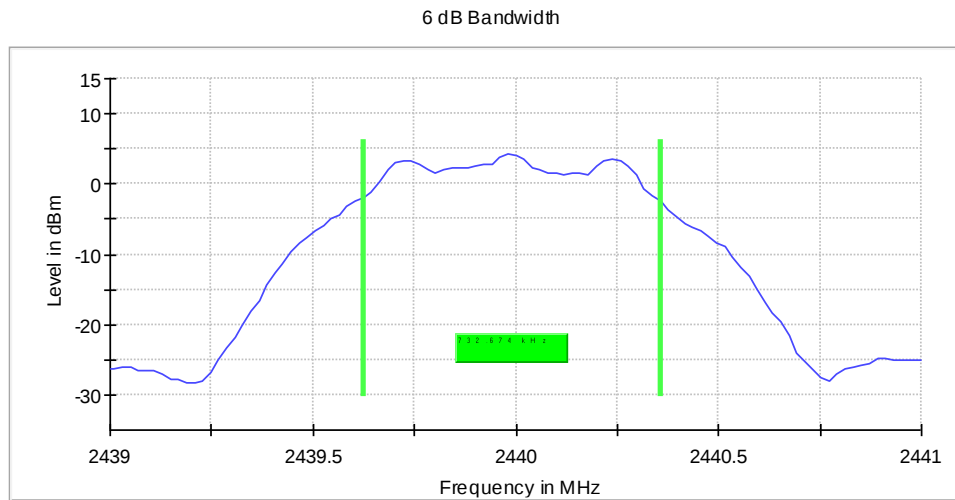


Figure 4: 6 dB Bandwidth (1 Mbps, TX 2440 MHz)

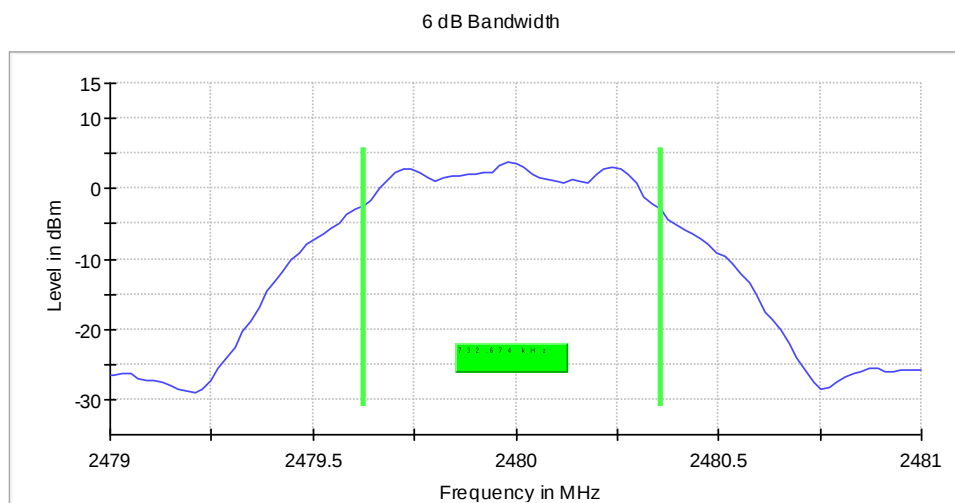


Figure 5: 6 dB Bandwidth (1 Mbps, TX 2480 MHz)

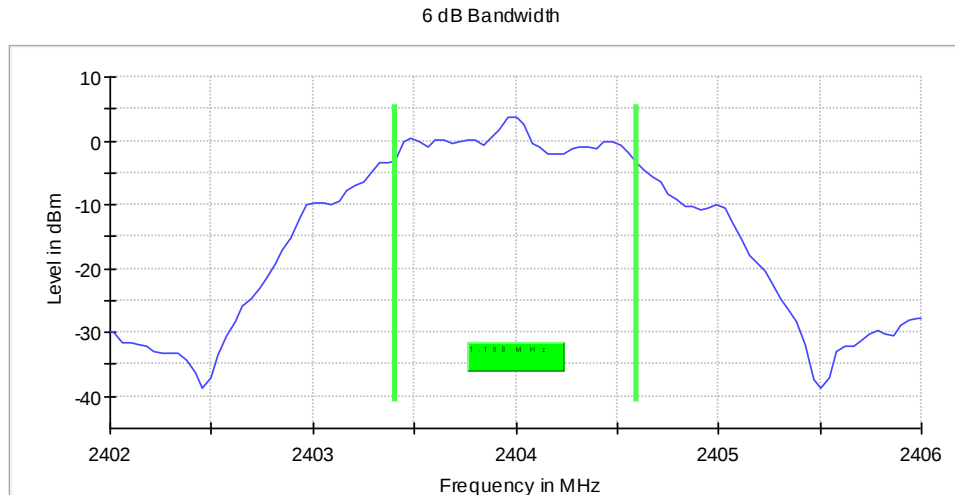


Figure 6: 6 dB Bandwidth (2 Mbps, TX 2404 MHz)

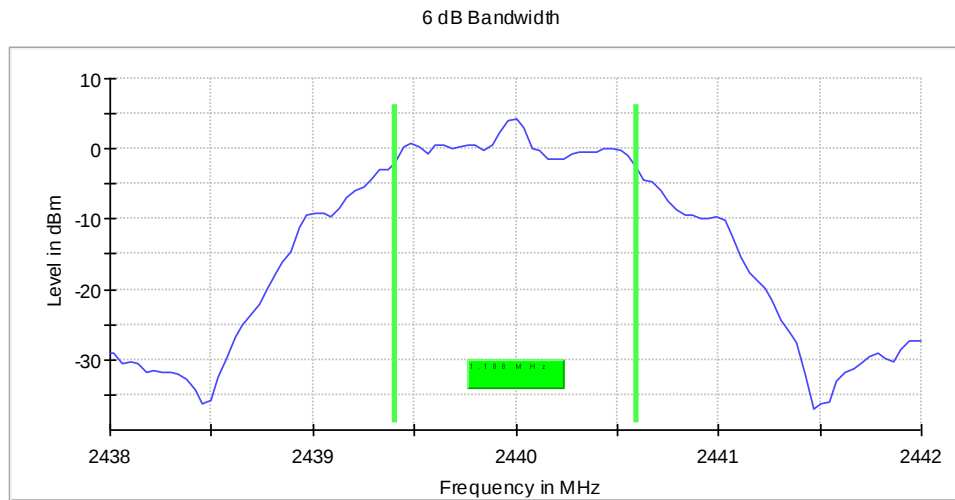


Figure 7: 6 dB Bandwidth (2 Mbps, TX 2440 MHz)

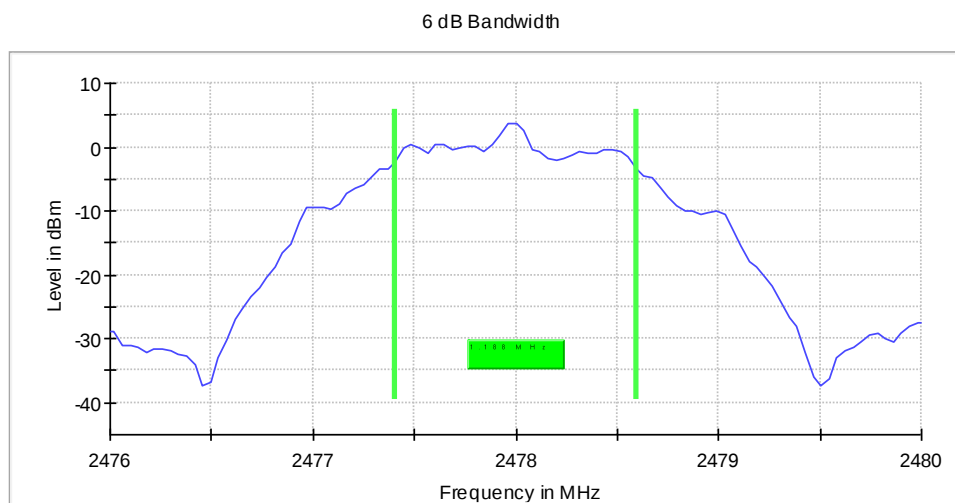


Figure 8: 6 dB Bandwidth (2 Mbps, TX 2478 MHz)

Occupied Bandwidth 99 %

Standard: RSS-Gen
Tested by: HEM
Date: 10 October 2023
Temperature: 23 °C
Humidity: 33 %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% [MHz]	Limit [kHz]	Result
1 Mbps	2402	1.045000	-	PASS
	2440	1.055000		PASS
	2480	1.050000		PASS
2 Mbps	2404	2.030000		PASS
	2440	2.040000		PASS
	2478	2.040000		PASS

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

Setting	Value
Span	2.000 / 4.000 MHz
RBW	10.000 / 20.000 kHz
VBW	30.000 / 100.000 kHz
Sweep Points	400
Sweep Time	189.648 / 94.824 µs
Reference Level	0.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
Trace Mode	Max Hold
Sweep Type	FFT
Preamp	off

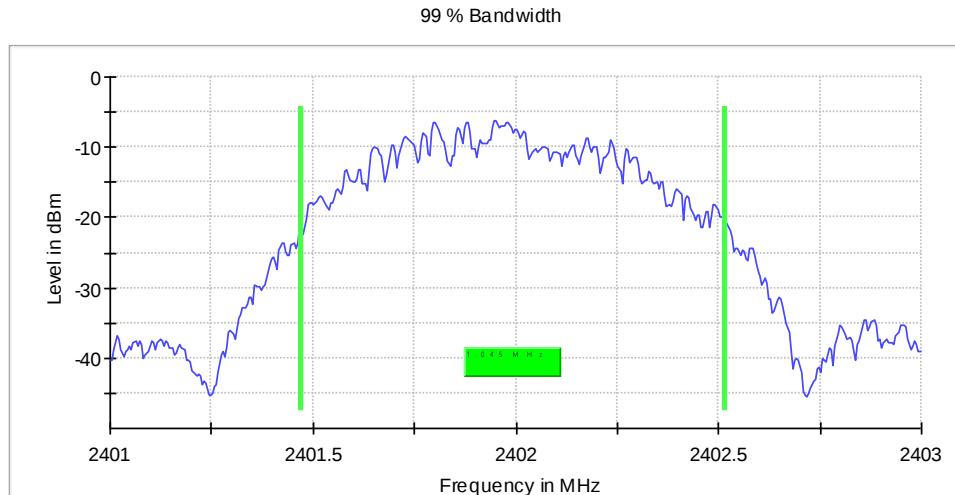


Figure 9: Occupied Bandwidth 99 % (1 Mbps, TX 2402 MHz)

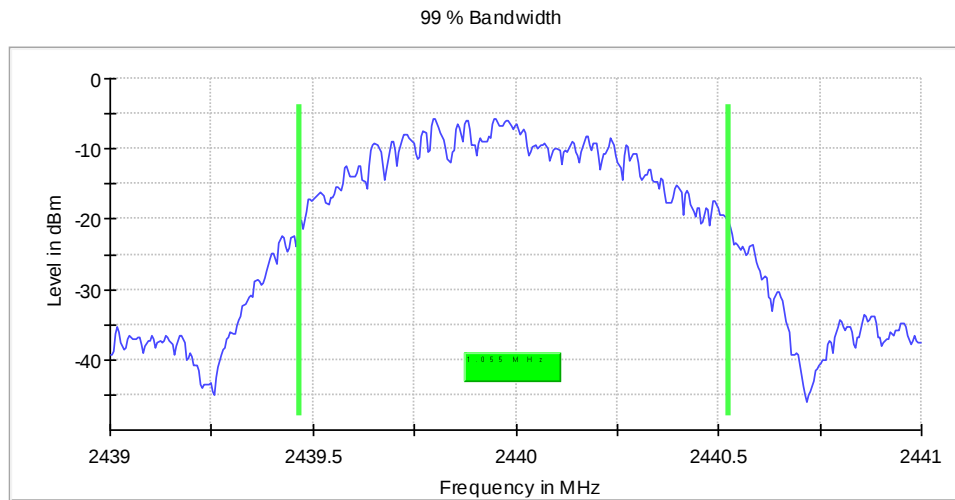


Figure 10: Occupied Bandwidth 99 % (1 Mbps, TX 2440 MHz)

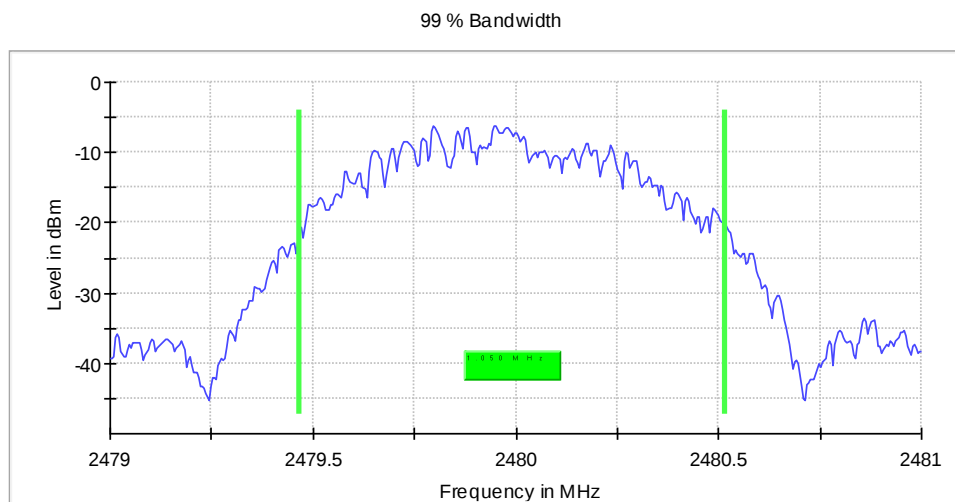


Figure 11: Occupied Bandwidth 99 % (1 Mbps, TX 2480 MHz)

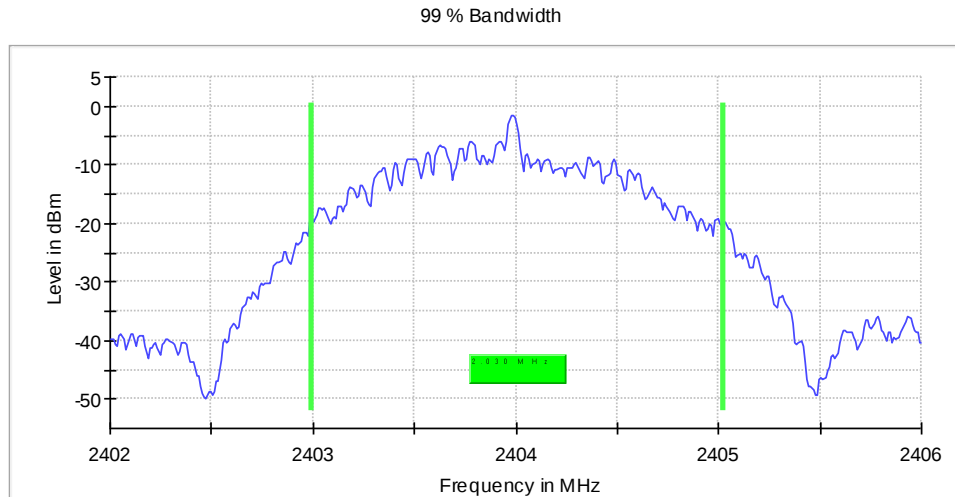


Figure 12: Occupied Bandwidth 99 % (2 Mbps, TX 2404 MHz)

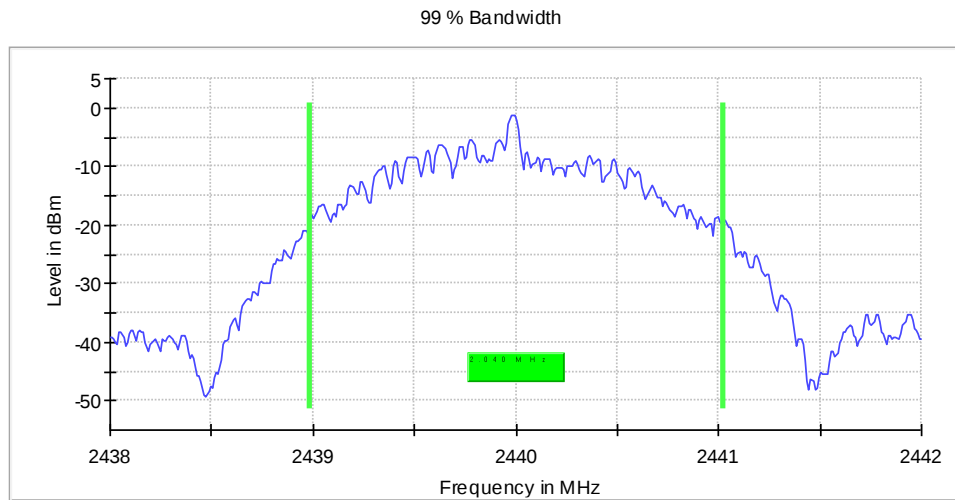


Figure 13: Occupied Bandwidth 99 % (2 Mbps, TX 2440 MHz)

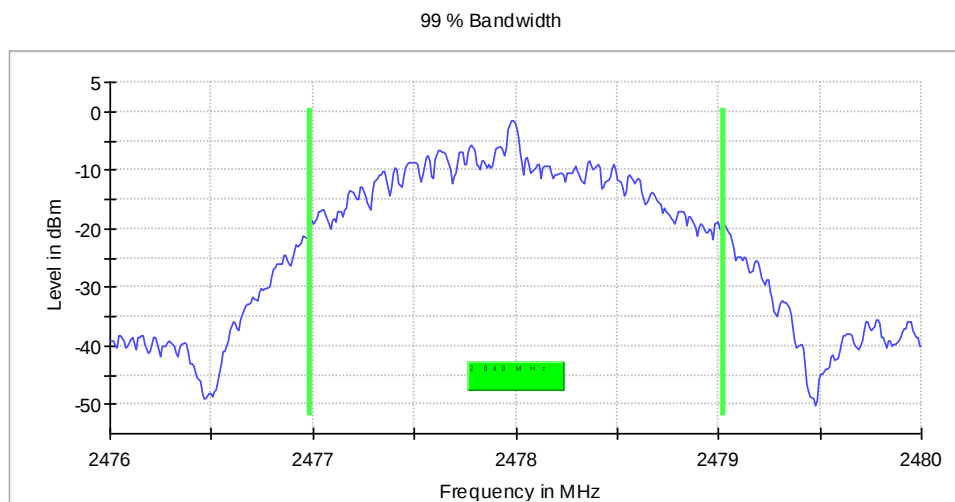


Figure 14: Occupied Bandwidth 99 % (2 Mbps, TX 2478 MHz)

Maximum Peak Conducted Output Power**Maximum Peak Conducted Output Power**

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 10 October 2023
Temperature: 23 °C
Humidity: 33 %RH
Measurement uncertainty: $\pm 2.87\text{dB}$, level of confidence 95 % ($k = 2$)
Test result: **PASS**

FCC §15.247(b)(3)
RSS-247 clause 5.4 d)

For systems using digital modulation in the 2400-2483.5 MHz band the maximum peak conducted output power of the intentional radiated shall not exceed 1 W (30 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 5:** Test results for Maximum Peak Conducted Output Power

Data Rate	Frequency [MHz]	Output Power [dBm]	Limit [dBm]	Result
1 Mbps	2402	3.8	30	PASS
	2440	4.3		PASS
	2480	3.9		PASS
2 Mbps	2404	3.9		PASS
	2440	4.3		PASS
	2478	4.0		PASS

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

Setting	Value
Span	3.000...9.000 MHz
RBW	1.000...3.000 MHz
VBW	3.000...10.000 MHz
Sweep Points	101
Sweep Time	0.953...1.907 μs
Reference Level	10.000 dBm
Attenuation	30.000 dB
Detector	MaxPeak
Trace Mode	Max Hold
Sweep Type	FFT
Preamp	off

Maximum Peak Conducted Output Power

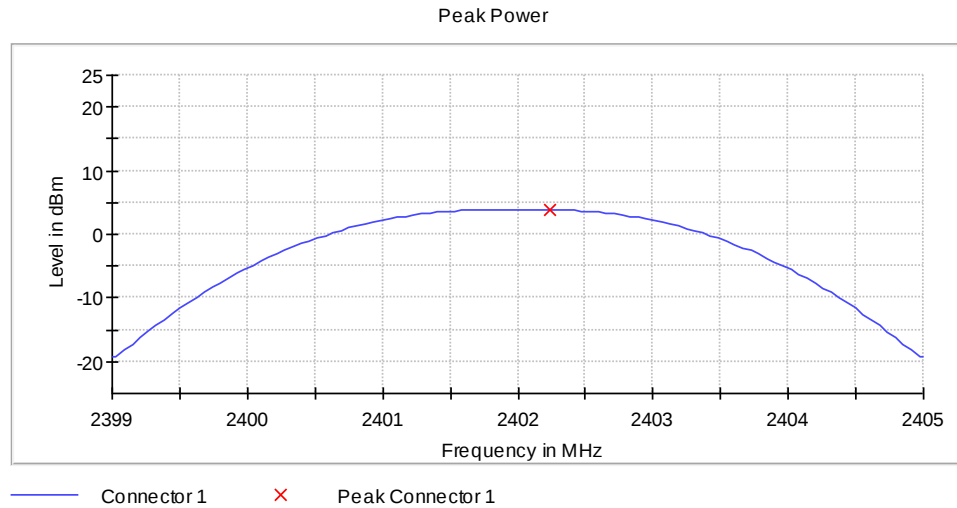


Figure 15: Maximum Peak Conducted Output Power (1 Mbps, TX 2402 MHz)

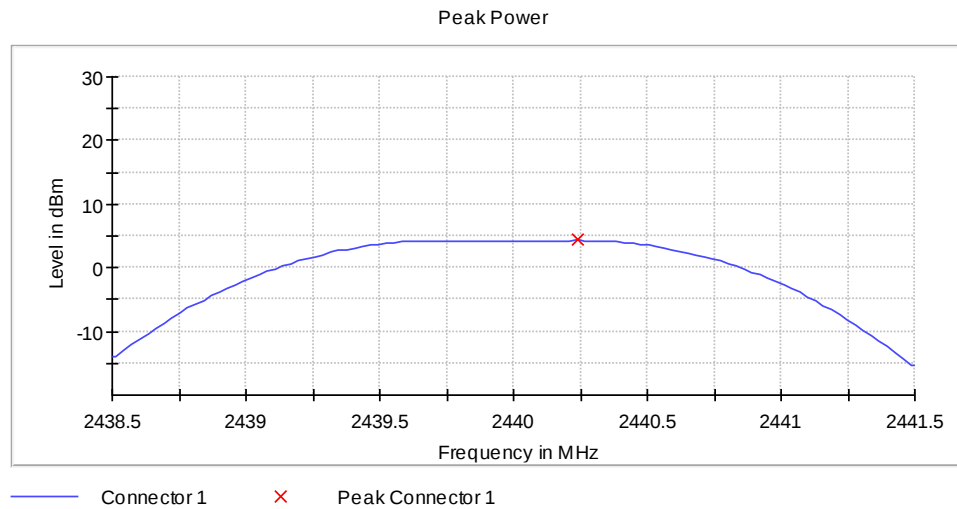


Figure 16: Maximum Peak Conducted Output Power (1 Mbps, TX 2440 MHz)

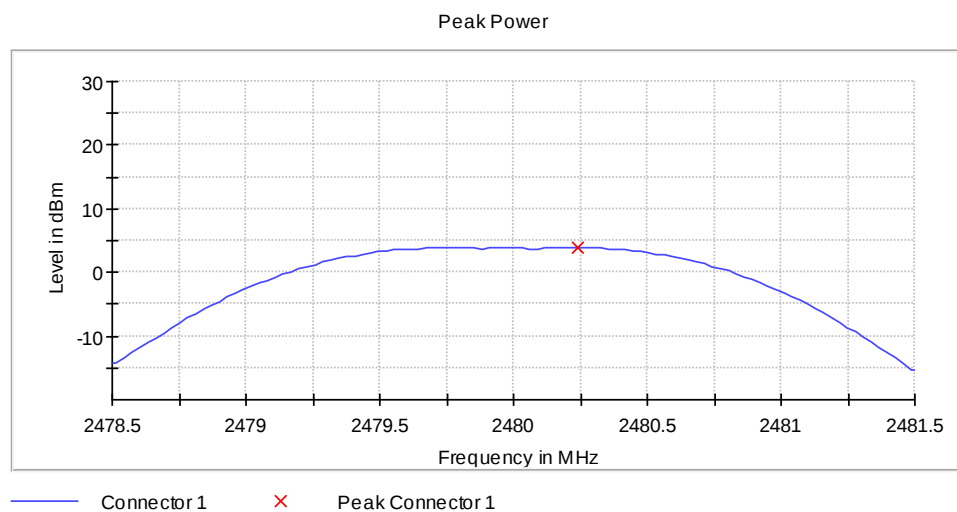


Figure 17: Maximum Peak Conducted Output Power (1 Mbps, TX 2480 MHz)

Maximum Peak Conducted Output Power

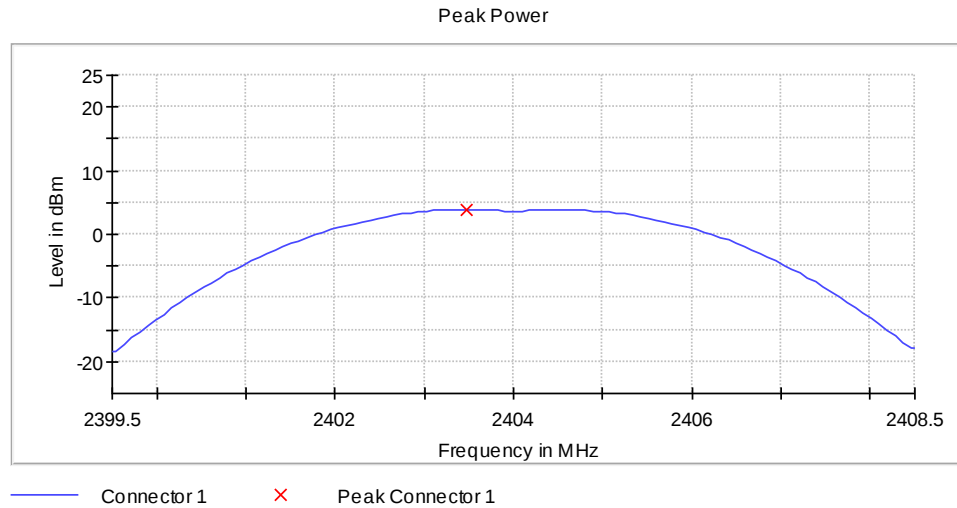


Figure 18: Maximum Peak Conducted Output Power (2 Mbps, TX 2404 MHz)

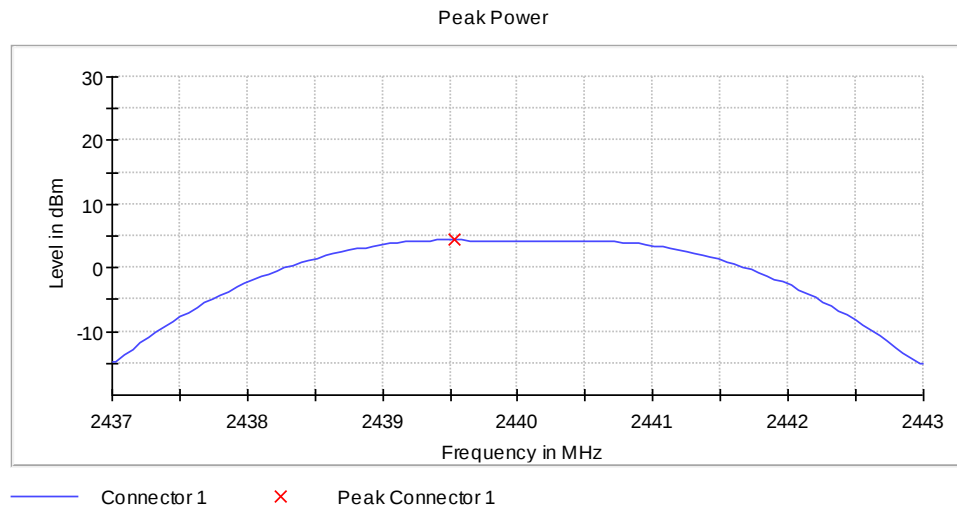


Figure 19: Maximum Peak Conducted Output Power (2 Mbps, TX 2440 MHz)

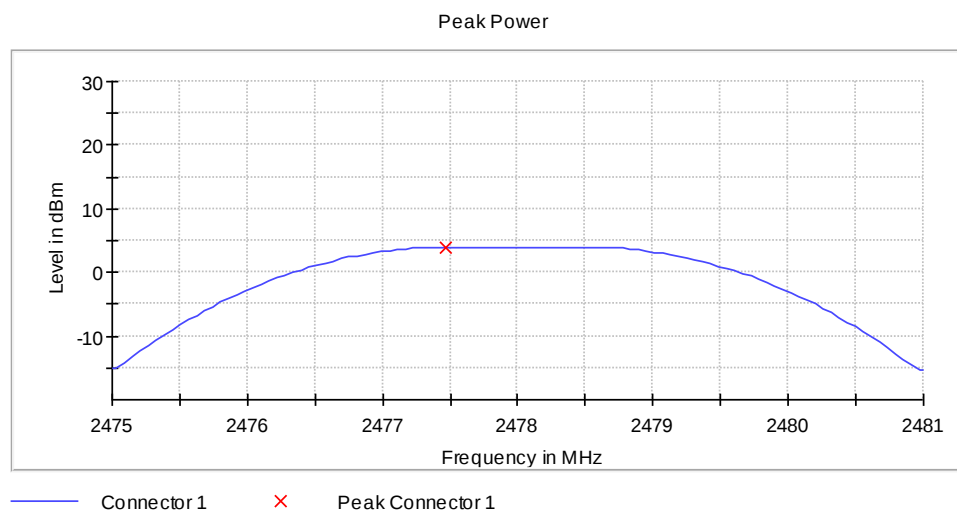


Figure 20: Maximum Peak Conducted Output Power (2 Mbps, TX 2478 MHz)

Unwanted Emissions (conducted)

Unwanted Emissions (conducted)

Standard:	ANSI C63.10-2013
Tested by:	HEM
Date:	10 October 2023
Temperature:	23 °C
Humidity:	33 %RH
Measurement uncertainty:	± 2.87dB, 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 digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

Unwanted Emissions (conducted)

Test results

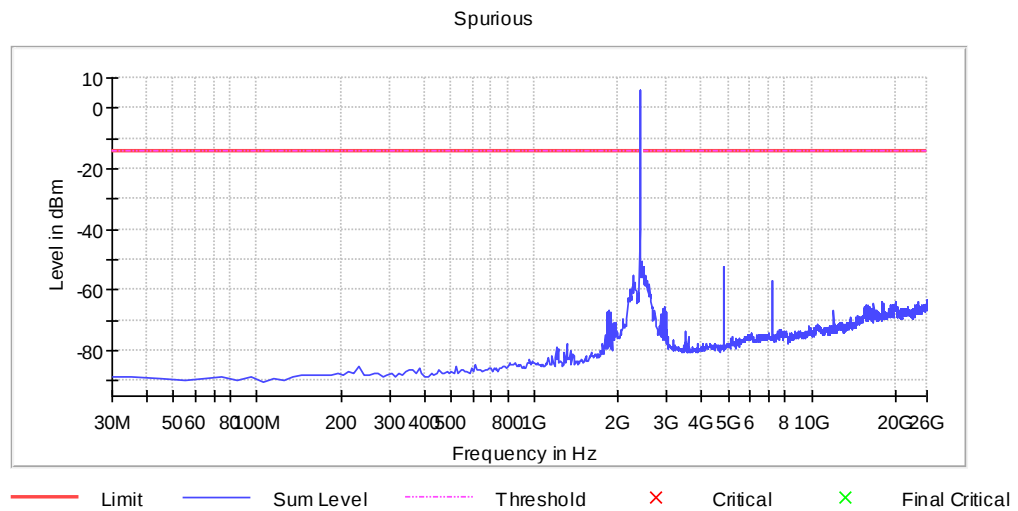


Figure 21: Unwanted emissions, conducted (1 Mbps, TX 2402 MHz)

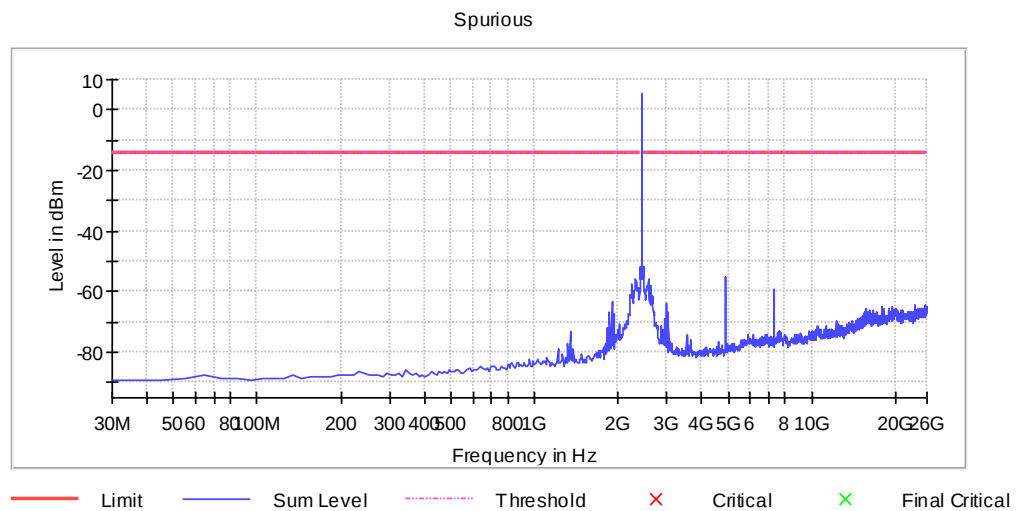


Figure 22: Unwanted emissions, conducted (1 Mbps, TX 2440 MHz)

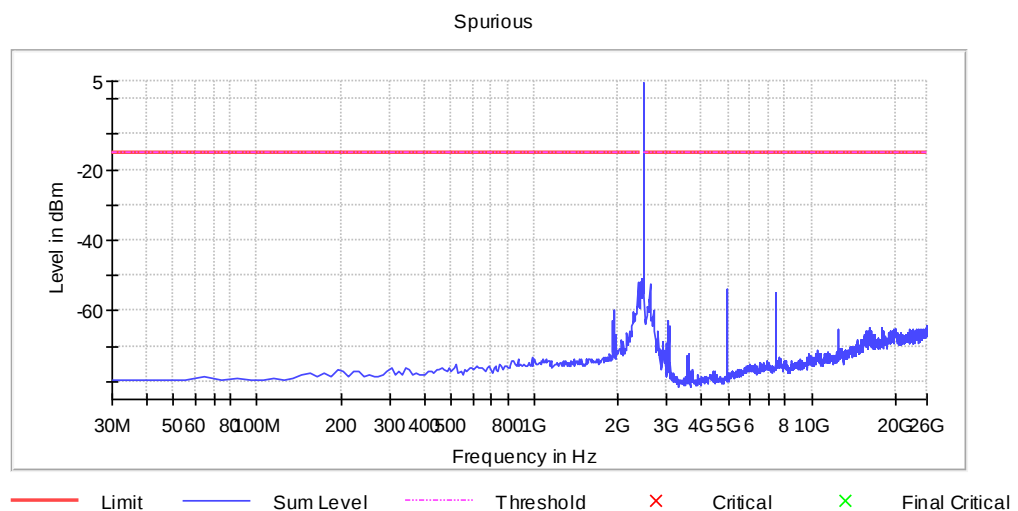


Figure 23: Unwanted emissions, conducted (1 Mbps, TX 2480 MHz)

Unwanted Emissions (conducted)

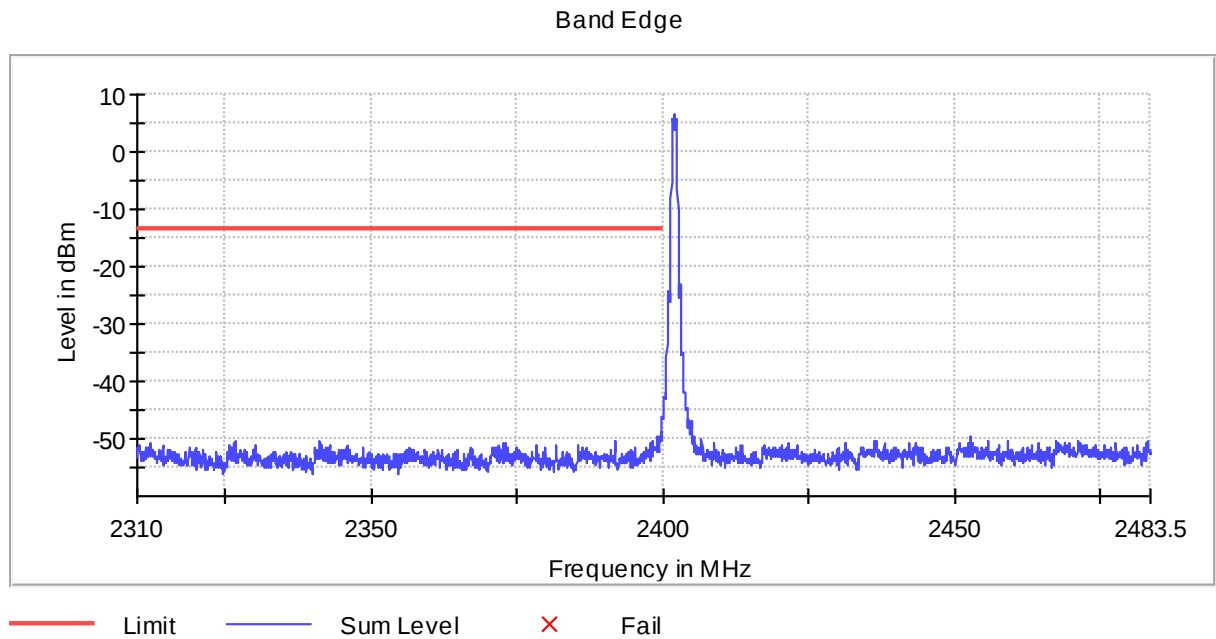


Figure 24: Lower band-edge, conducted (1 Mbps, TX 2402 MHz)

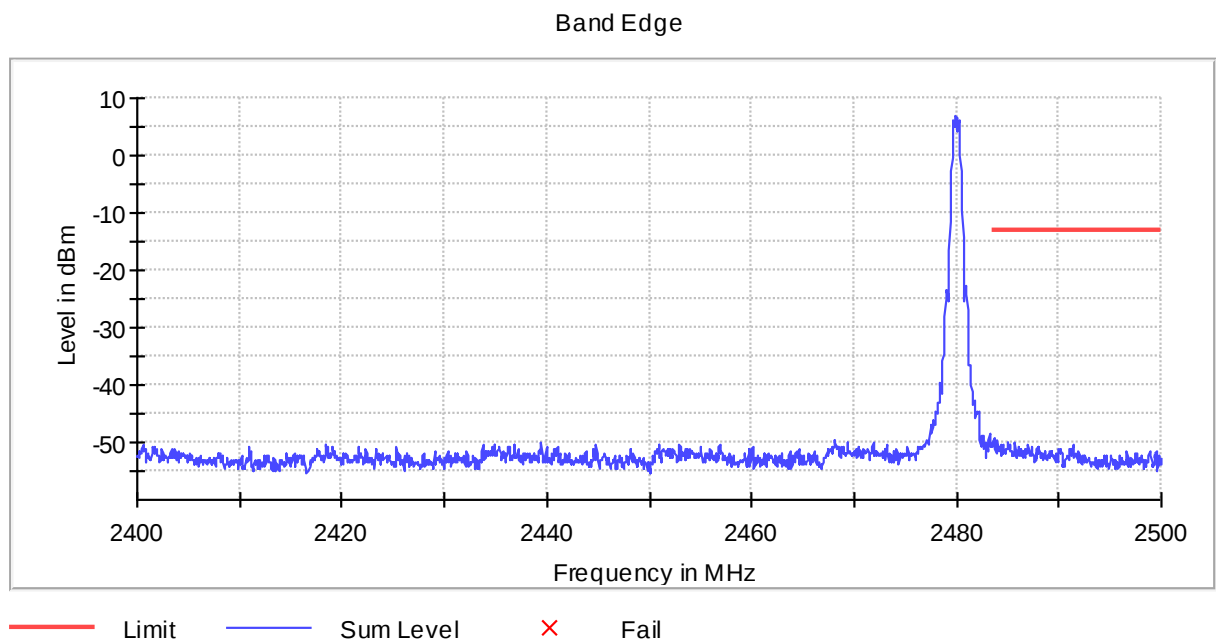


Figure 25: Upper band-edge, conducted (1 Mbps, TX 2480 MHz)

Unwanted Emissions (conducted)

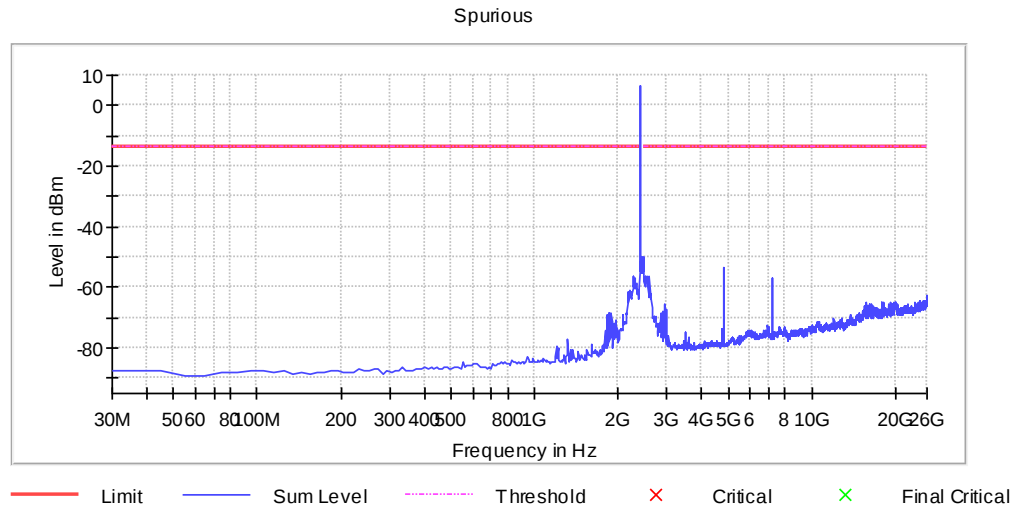


Figure 26: Unwanted emissions, conducted (2 Mbps, TX 2404 MHz)

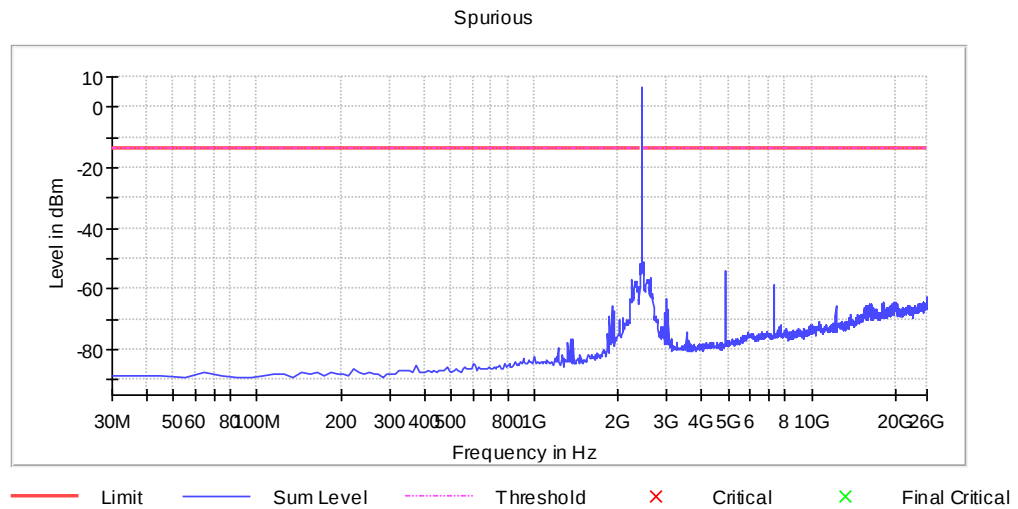


Figure 27: Unwanted emissions, conducted (2 Mbps, TX 2440 MHz)

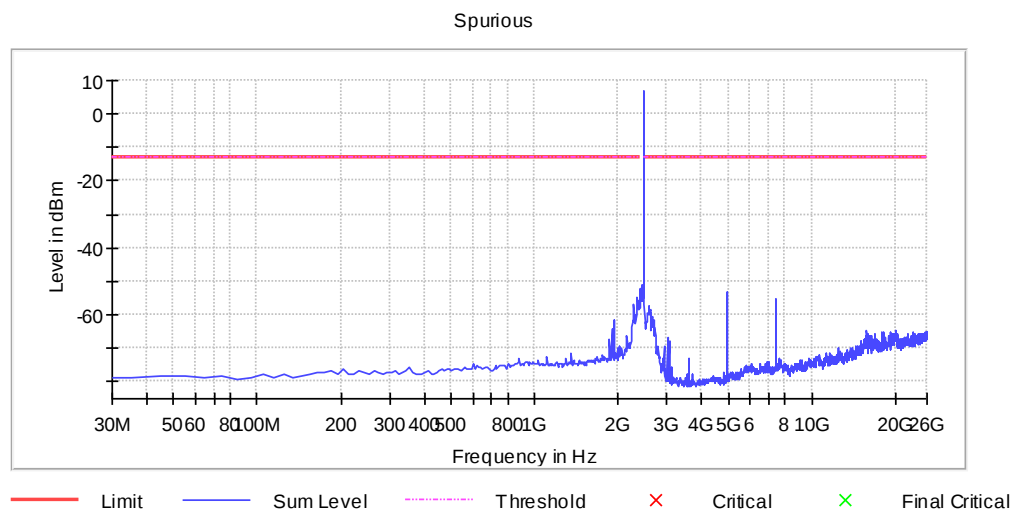


Figure 28: Unwanted emissions, conducted (2 Mbps, TX 2478 MHz)

Unwanted Emissions (conducted)

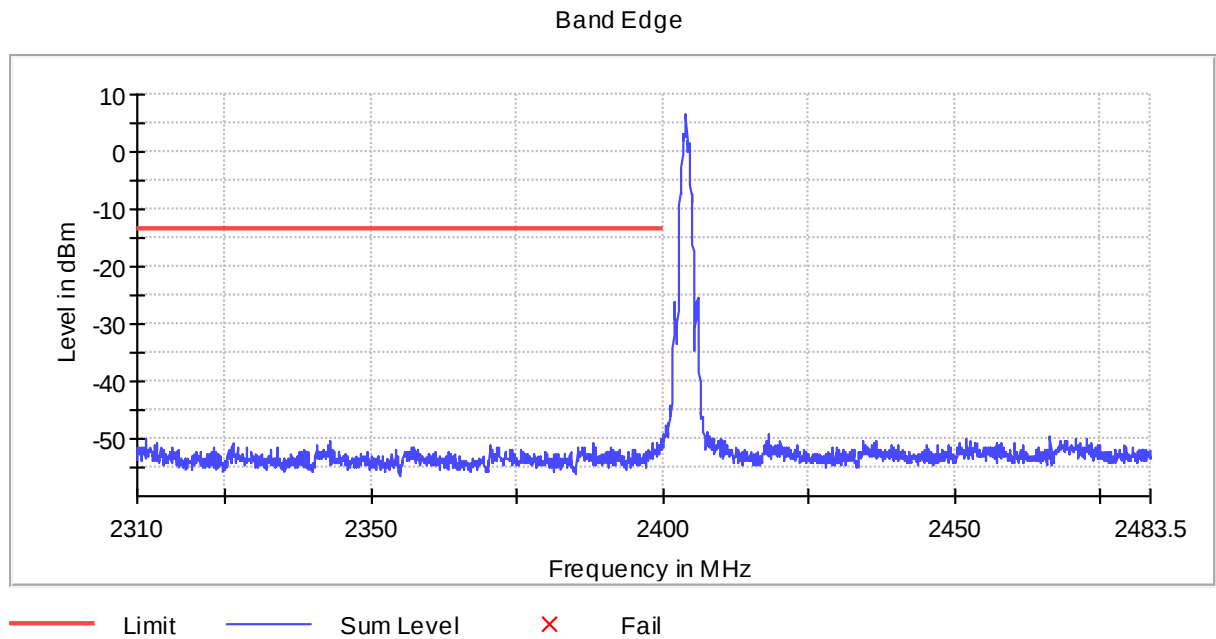


Figure 29: Lower band-edge, conducted (2 Mbps, TX 2404 MHz)

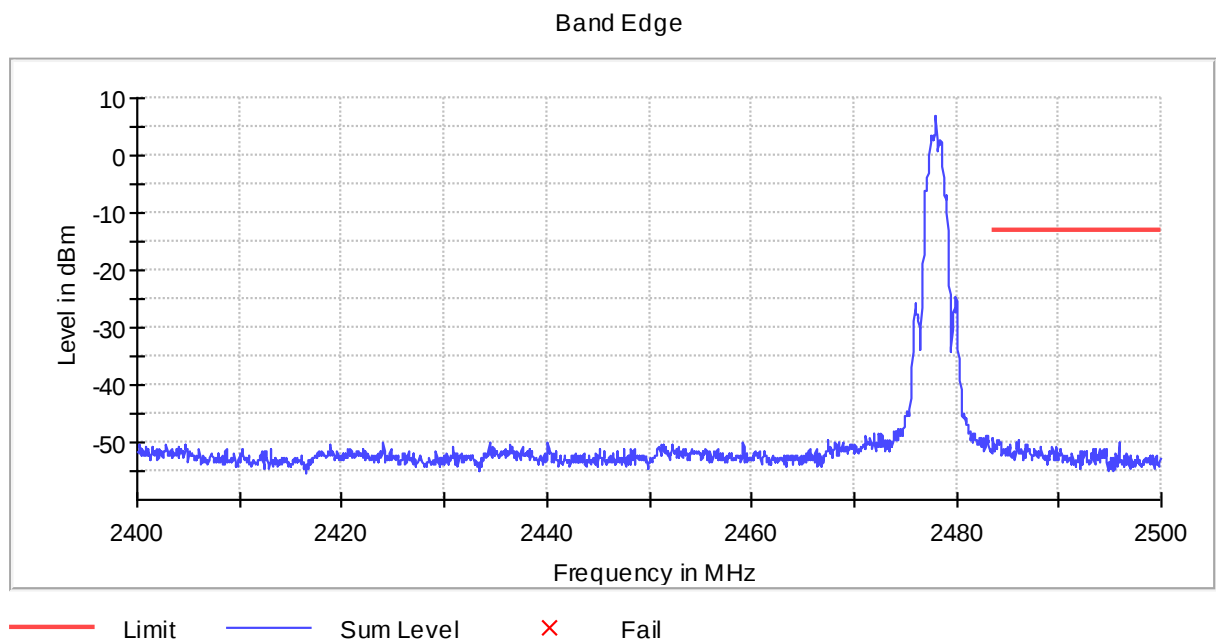


Figure 30: Upper band-edge, conducted (2 Mbps, TX 2478 MHz)

Unwanted Emissions (radiated)**Unwanted Emissions (radiated)**

Standard:	ANSI C63.10-2013	
Tested by:	HEM	LAS
Date:	23 August 2023	24 August 2023
Temperature:	23 °C	22 °C
Humidity:	55 %RH	57 %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 digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. 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.

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 6: 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)
74.805000	28.22	40.00	11.78	15 x 1000.0	120.000	395.0	H	25.0	14.8
120.465000	23.44	43.52	20.08	15 x 1000.0	120.000	105.0	V	282.0	15.8
173.005000	28.45	43.52	15.07	15 x 1000.0	120.000	142.0	V	338.0	17.6
259.175000	26.04	46.02	19.98	15 x 1000.0	120.000	118.0	H	225.0	17.9
334.955000	24.73	46.02	21.29	15 x 1000.0	120.000	111.0	H	158.0	20.5

Table 7: Test results with average detector (1 Mbps, TX 2402 MHz)

Frequency (MHz)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
12151.700000	35.53	54.00	18.47	15 x 1000.0	1000.000	224.0	H	70.0	17.8

Table 8: 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	63.46	75.23 *)	11.77	15 x 1000.0	1000.000	220.0	H	70.0	13.7
2402.000000	95.23	---	---	15 x 1000.0	1000.000	171.0	H	74.0	13.7
4804.400000	44.01	74.00	29.99	15 x 1000.0	1000.000	246.0	V	95.0	7.4
12152.100000	68.77	74.00	5.23	15 x 1000.0	1000.000	138.0	H	106.0	17.8

*) -20 dBc

Unwanted Emissions (radiated)

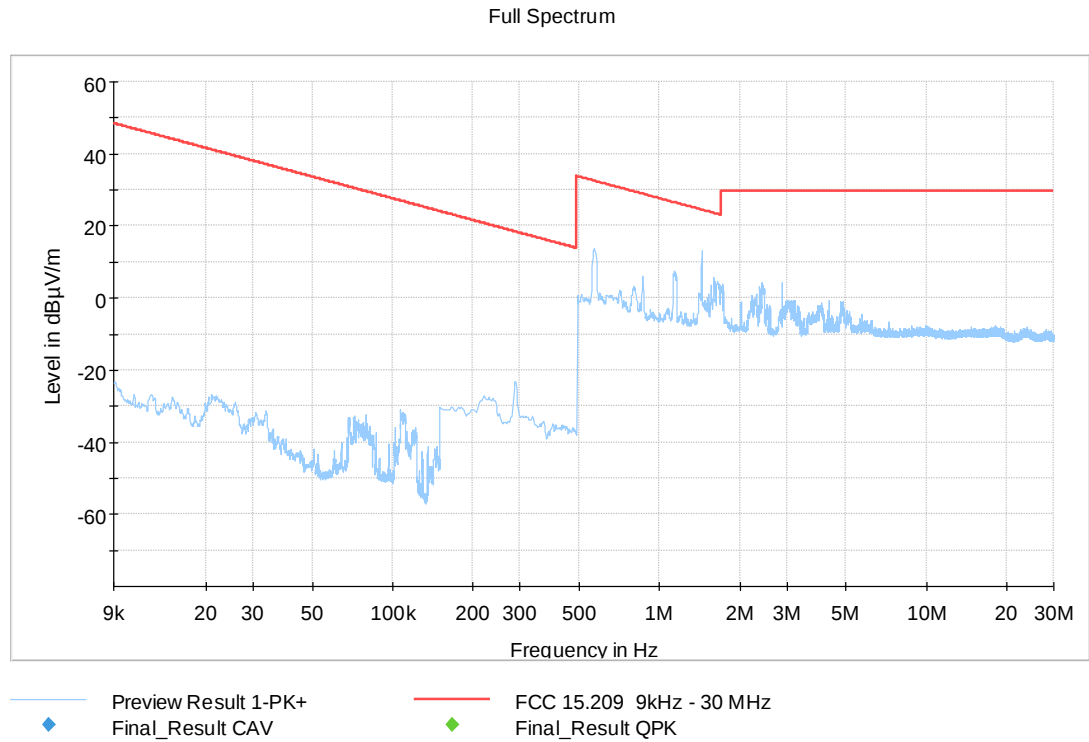


Figure 31: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coaxial (1 Mbps, TX 2402 MHz)

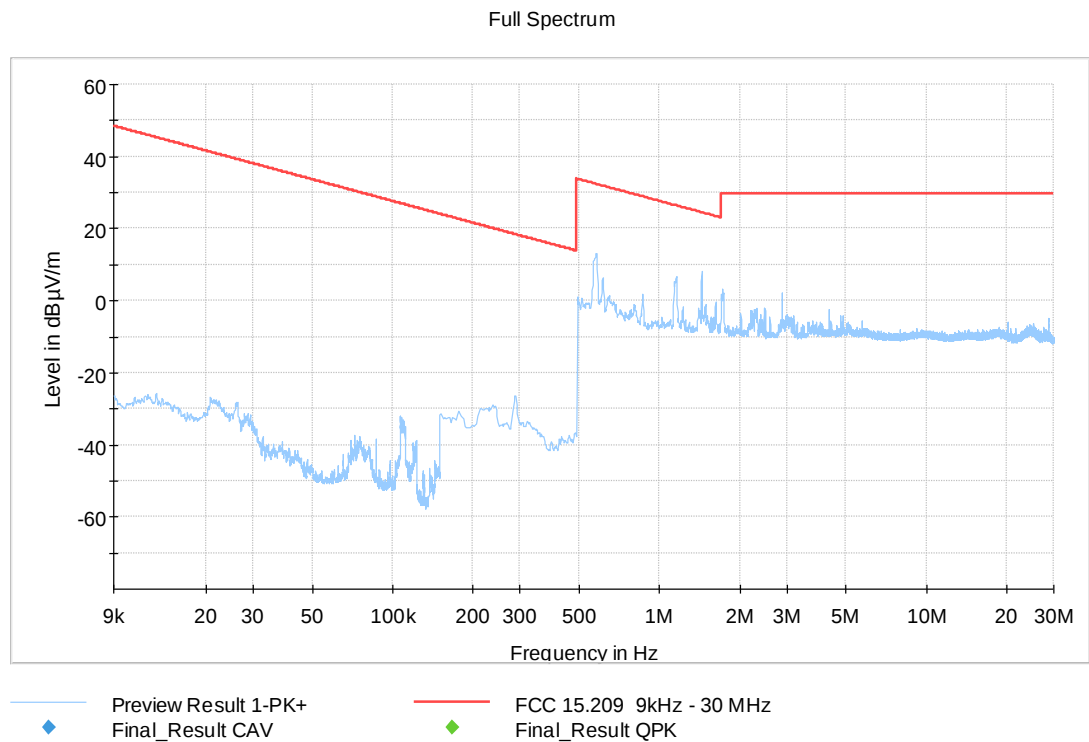


Figure 32: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coplanar (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

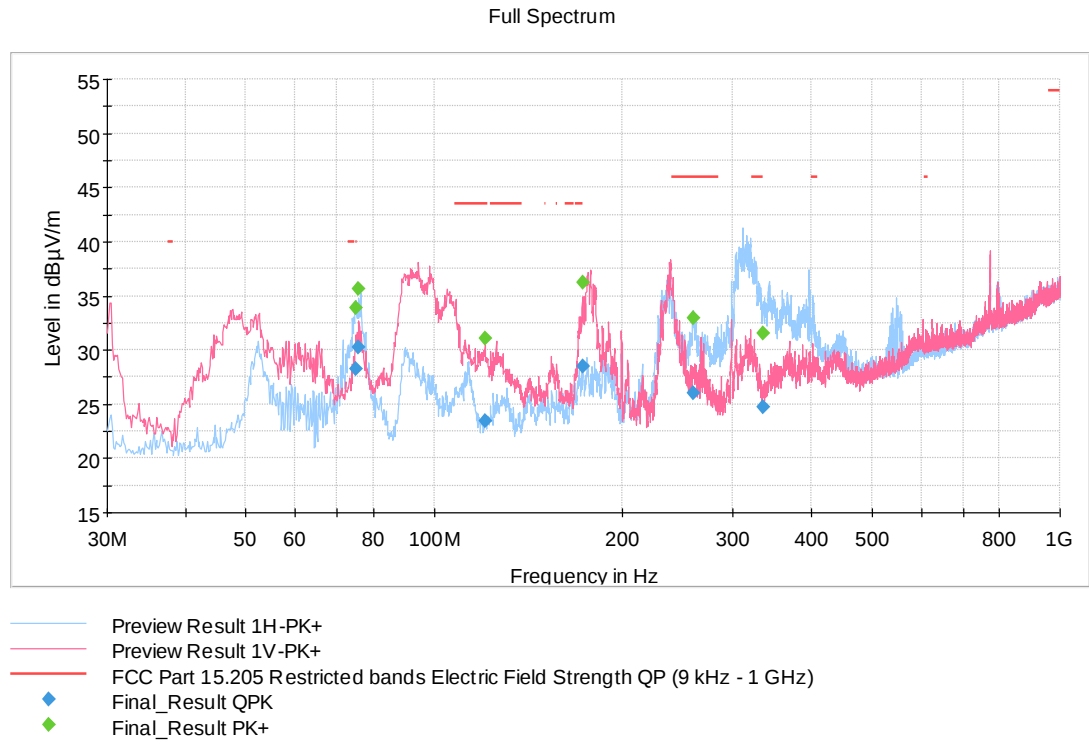


Figure 33: Unwanted emissions 30 - 1000 MHz (1 Mbps, TX 2402 MHz)

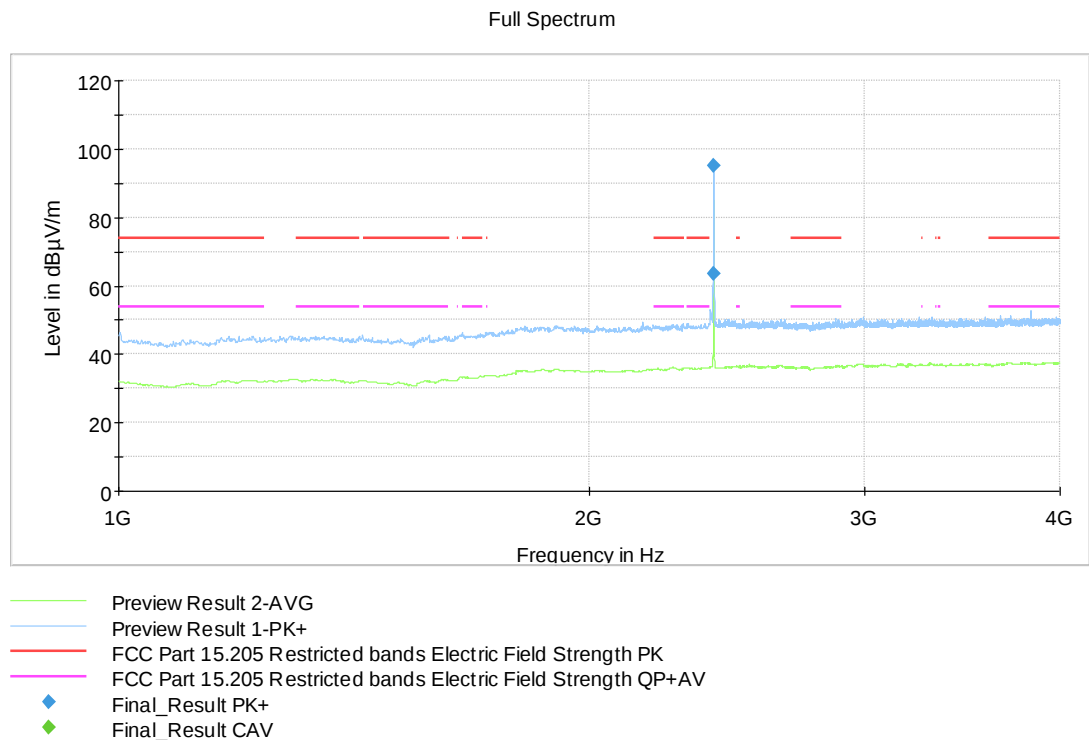


Figure 34: Unwanted emissions 1 - 4 GHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

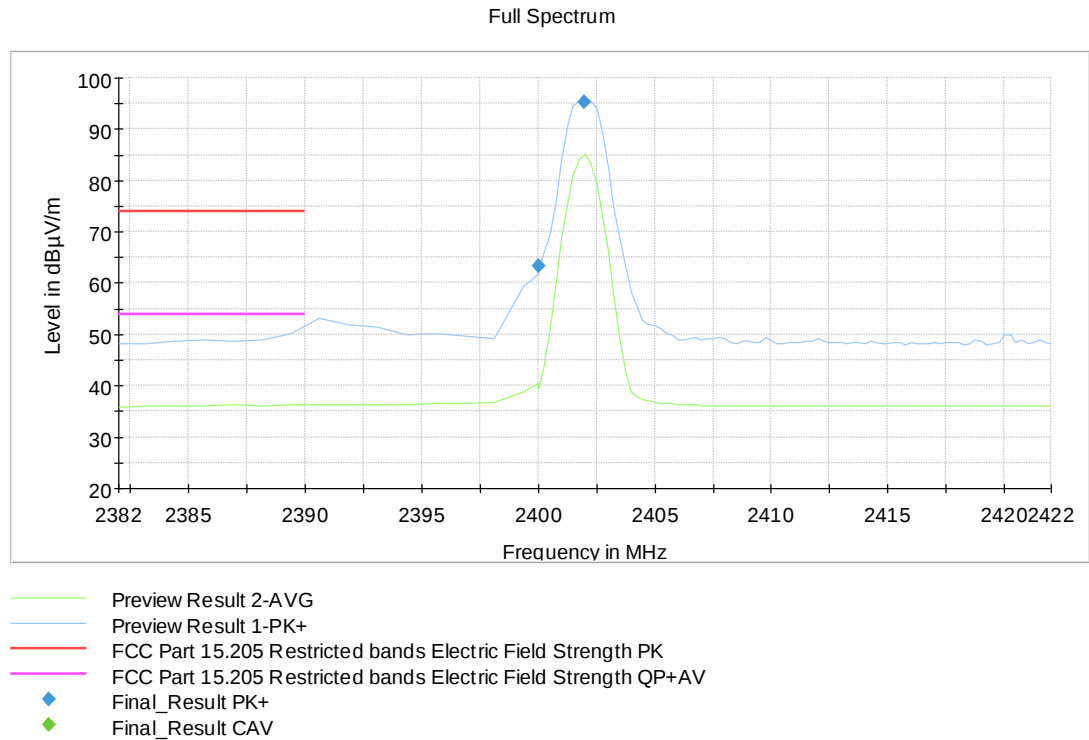


Figure 35: Lower band-edge (1 Mbps, TX 2402 MHz)

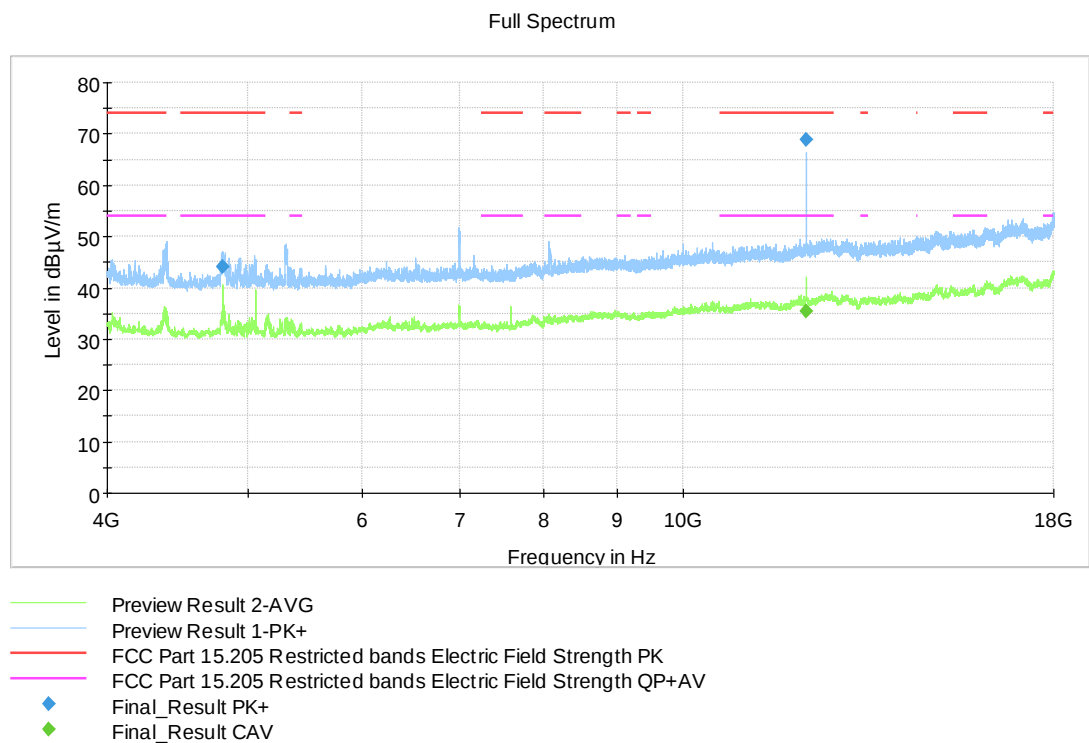


Figure 36: Unwanted emissions 4 - 18 GHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

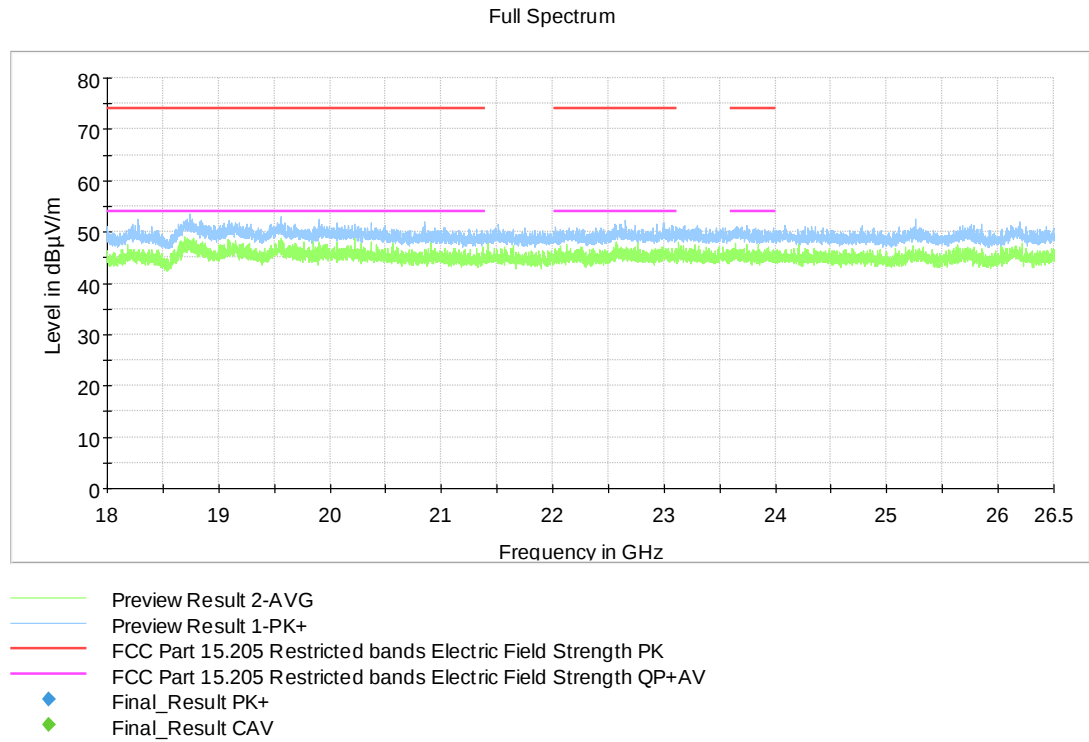


Figure 37: Unwanted emissions 18 - 26.5 GHz (1 Mbps, TX 2402 MHz)

Unwanted Emissions (radiated)

Test results (1 Mbps, TX 2440 MHz)

Table 9: Test results with quasi-peak detector (1 Mbps, TX 2440 MHz)

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
74.835000	25.89	40.00	14.11	15 x 1000.0	120.000	240.0	H	203.0	14.8
165.405000	20.97	43.52	22.55	15 x 1000.0	120.000	118.0	V	311.0	18.2
173.175000	29.26	43.52	14.26	15 x 1000.0	120.000	127.0	V	337.0	17.6
268.945000	28.43	46.02	17.59	15 x 1000.0	120.000	124.0	H	51.0	18.4
608.555000	22.57	46.02	23.45	15 x 1000.0	120.000	121.0	V	3.0	27.0

Table 10: Test results with average detector (1 Mbps, TX 2440 MHz)

Frequency (MHz)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
8084.000000	32.41	54.00	21.59	15 x 1000.0	1000.000	100.0	V	116.0	10.9
12143.300000	35.39	54.00	18.61	15 x 1000.0	1000.000	216.0	H	113.0	17.7

Table 11: Test results with peak detector (1 Mbps, TX 2440 MHz)

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2440.250000	94.99	---	---	15 x 1000.0	1000.000	175.0	V	2.0	13.6
4880.500000	46.34	74.00	27.66	15 x 1000.0	1000.000	177.0	V	103.0	7.6
8077.800000	61.16	74.00	12.84	15 x 1000.0	1000.000	138.0	V	299.0	11.0
12141.100000	62.87	74.00	11.13	15 x 1000.0	1000.000	100.0	H	16.0	17.7

Unwanted Emissions (radiated)

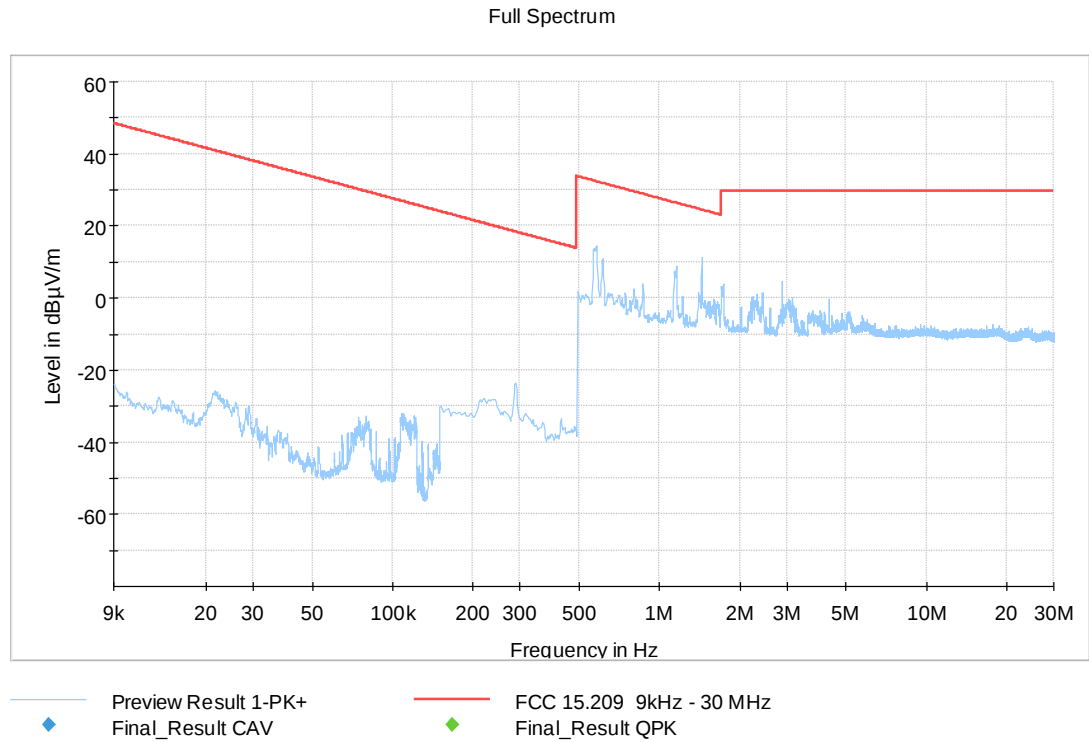


Figure 38: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coaxial (1 Mbps, TX 2440 MHz)

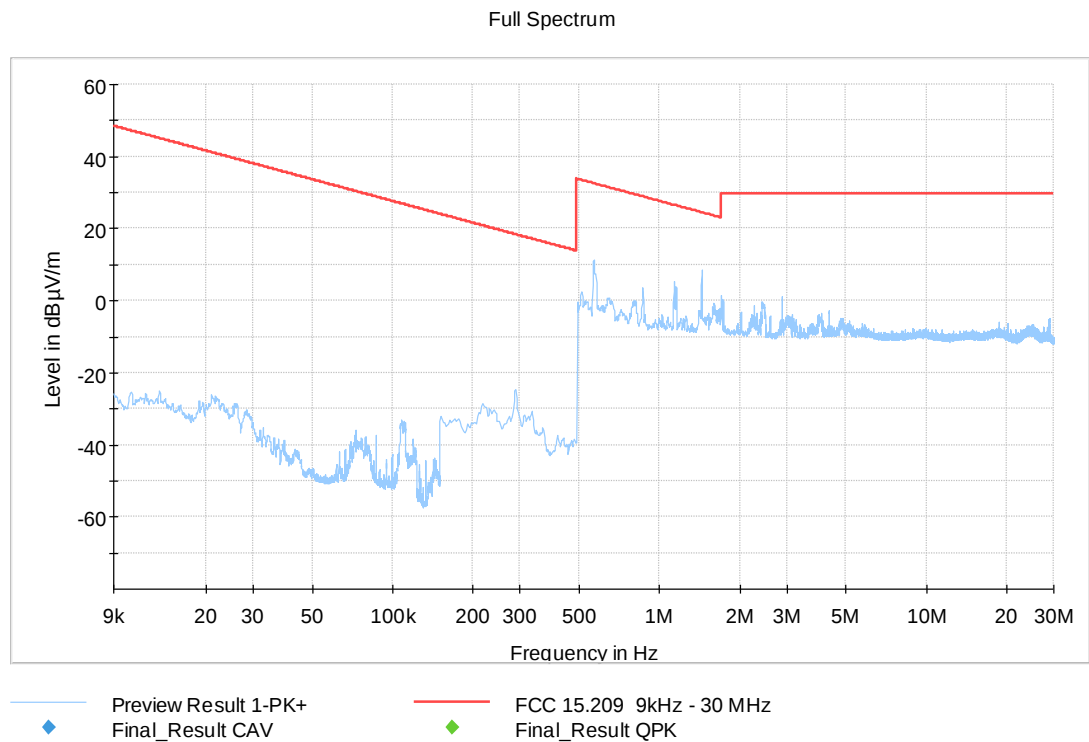


Figure 39: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coplanar (1 Mbps, TX 2440 MHz)

Unwanted Emissions (radiated)

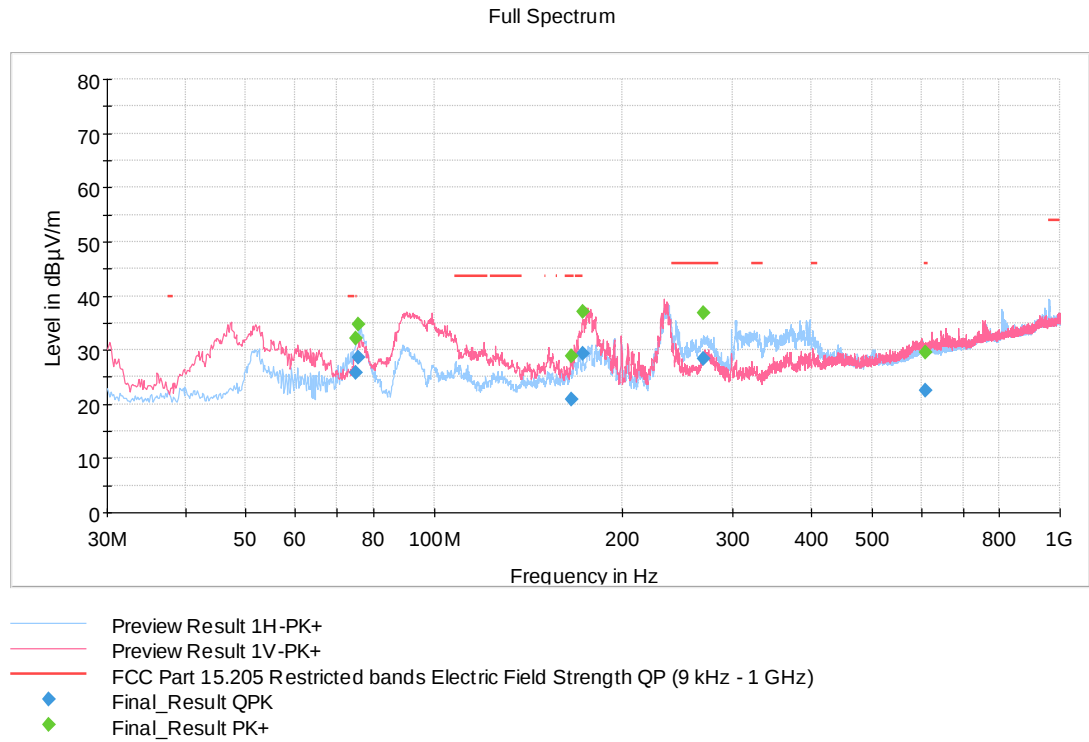


Figure 40: Unwanted emissions 30 - 1000 MHz (1 Mbps, TX 2440 MHz)

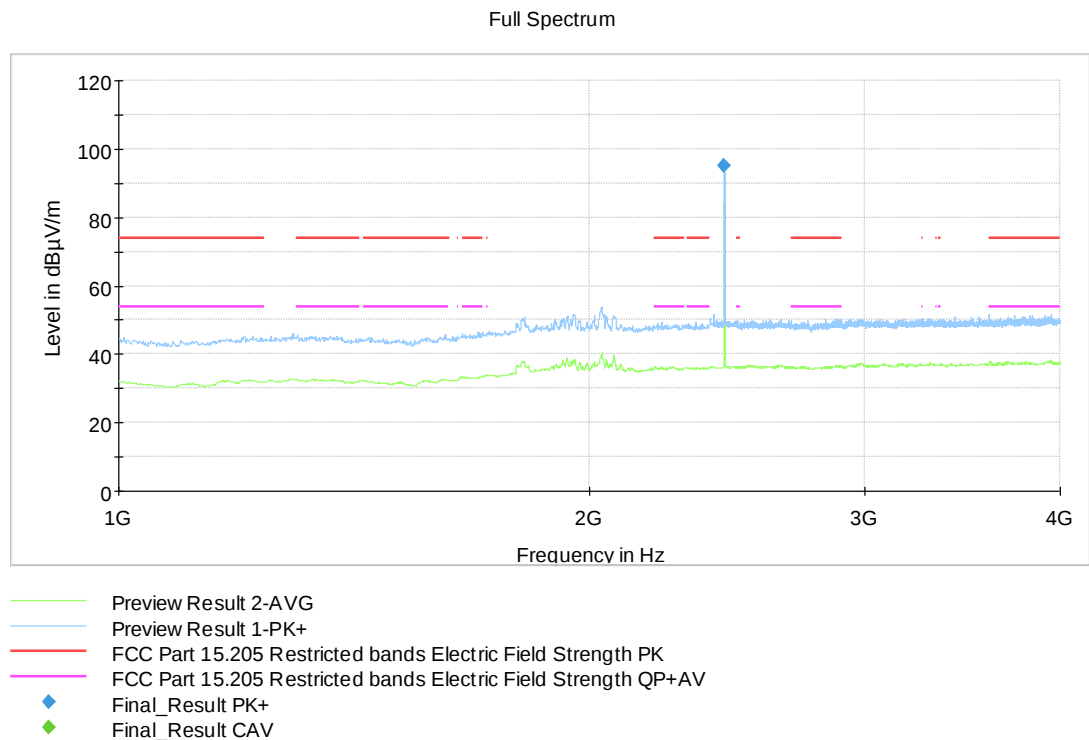


Figure 41: Unwanted emissions 1 - 4 GHz (1 Mbps, TX 2440 MHz)

Unwanted Emissions (radiated)

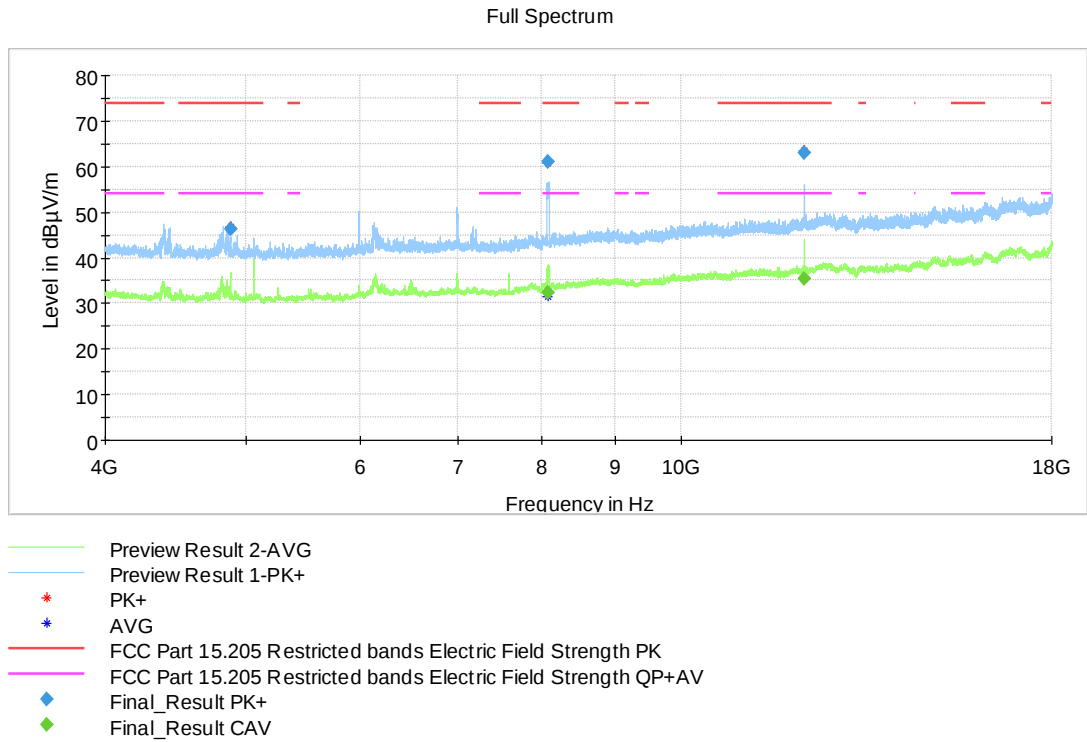


Figure 42: Unwanted emissions 4 - 18 GHz (1 Mbps, TX 2440 MHz)

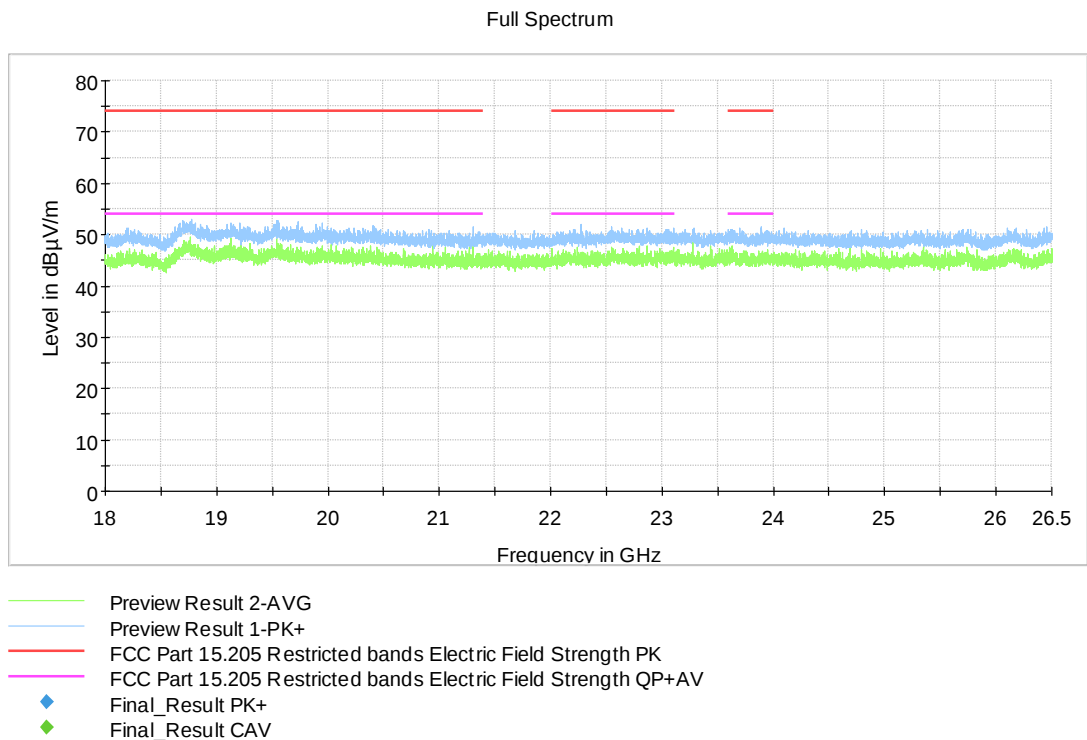


Figure 43: Unwanted emissions 18 - 26.5 GHz (1 Mbps, TX 2440 MHz)

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)
0.568500	12.35	32.51	20.16	15 x 1000.0	9.000	coax *)	V	180.0	-20.4
1.136500	5.80	26.51	20.71	15 x 1000.0	9.000	coax *)	V	180.0	-20.5
1.438750	10.61	24.47	13.86	15 x 1000.0	9.000	coax *)	V	267.0	-20.5
1.735250	-0.79	29.50	30.29	15 x 1000.0	9.000	coax *)	V	204.0	-20.4
121.625000	21.76	43.52	21.76	15 x 1000.0	120.000	121.0	V	264.0	15.9
172.965000	29.62	43.52	13.90	15 x 1000.0	120.000	118.0	V	285.0	17.6
266.255000	27.47	46.02	18.55	15 x 1000.0	120.000	127.0	H	80.0	18.3
612.505000	22.74	46.02	23.28	15 x 1000.0	120.000	108.0	V	176.0	27.1

*) Measurement loop antenna in coaxial orientation

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

Frequency (MHz)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
5064.900000	40.21	54.00	13.79	15 x 1000.0	1000.000	224.0	V	154.0	7.6
7597.500000	37.10	54.00	16.90	15 x 1000.0	1000.000	162.0	V	182.0	10.4
18711.150000	40.56	54.00	13.44	15 x 1000.0	1000.000	221.0	V	194.0	8.0

Table 14: 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)
2480.200000	96.02	---	---	15 x 1000.0	1000.000	152.0	V	348.0	13.7
2483.500000	53.45	74.00	20.55	15 x 1000.0	1000.000	228.0	V	15.0	13.7
4960.400000	46.17	74.00	27.83	15 x 1000.0	1000.000	131.0	H	147.0	7.4
18737.600000	54.29	74.00	19.71	15 x 1000.0	1000.000	130.0	V	123.0	8.2

Unwanted Emissions (radiated)

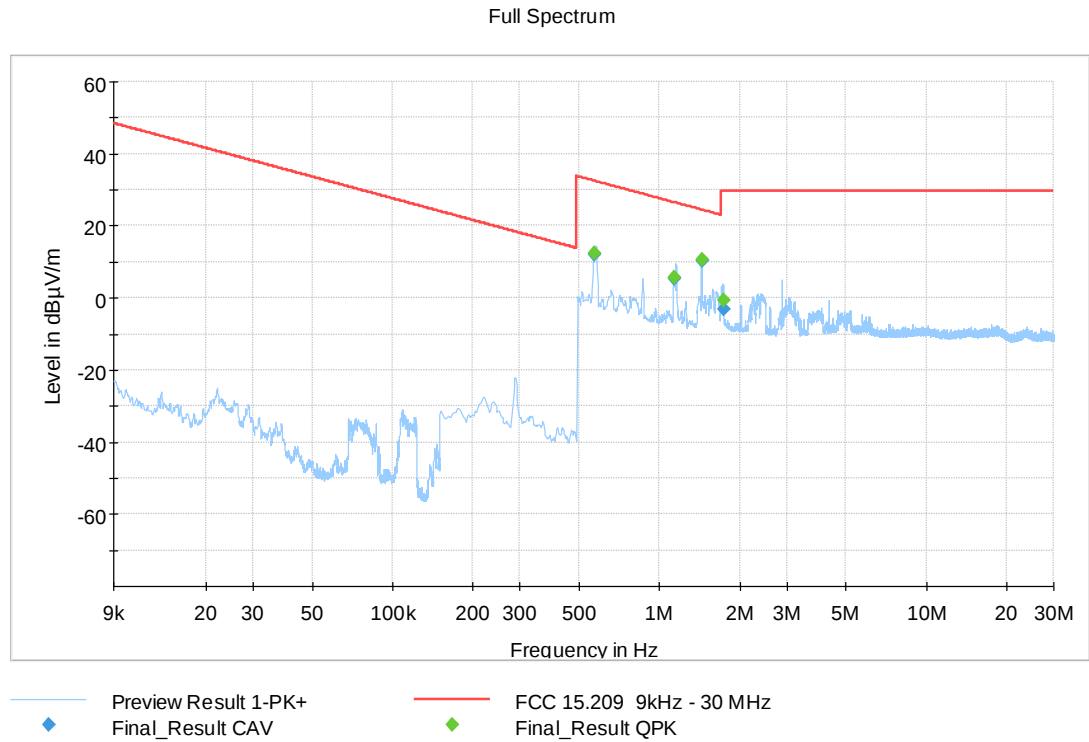


Figure 44: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coaxial (1 Mbps, TX 2480 MHz)

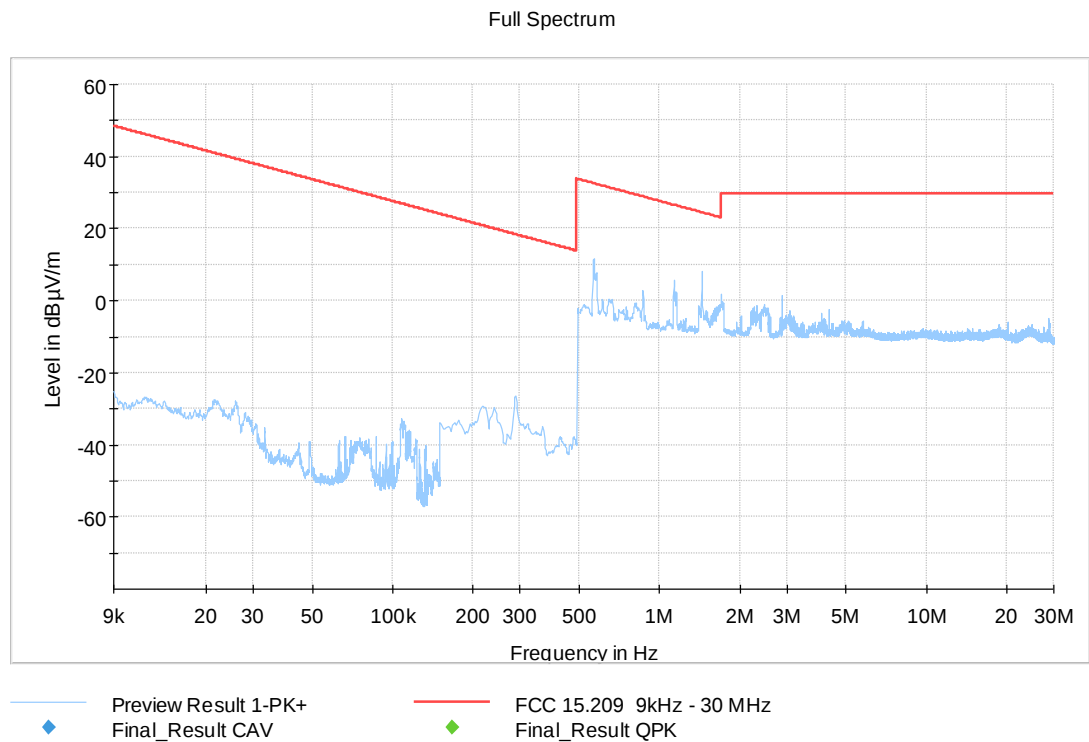


Figure 45: Unwanted emissions 9 kHz - 30 MHz, meas. loop antenna coplanar (1 Mbps, TX 2480 MHz)

Unwanted Emissions (radiated)

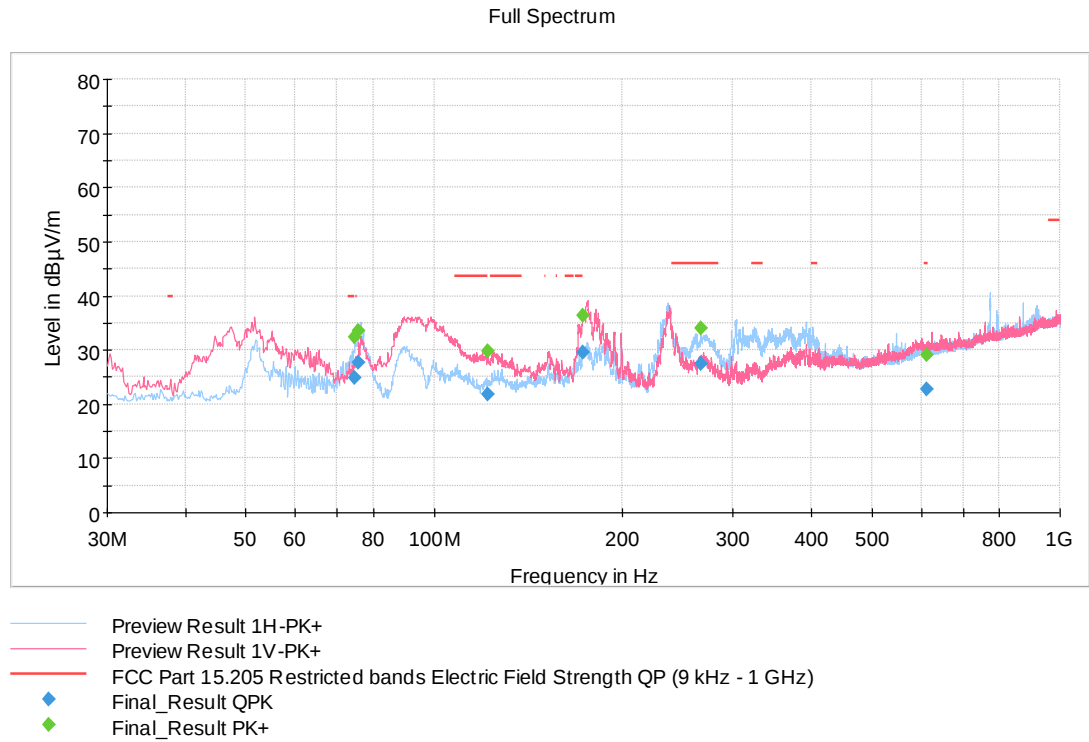


Figure 46: Unwanted emissions 30 - 1000 MHz (1 Mbps, TX 2480 MHz)

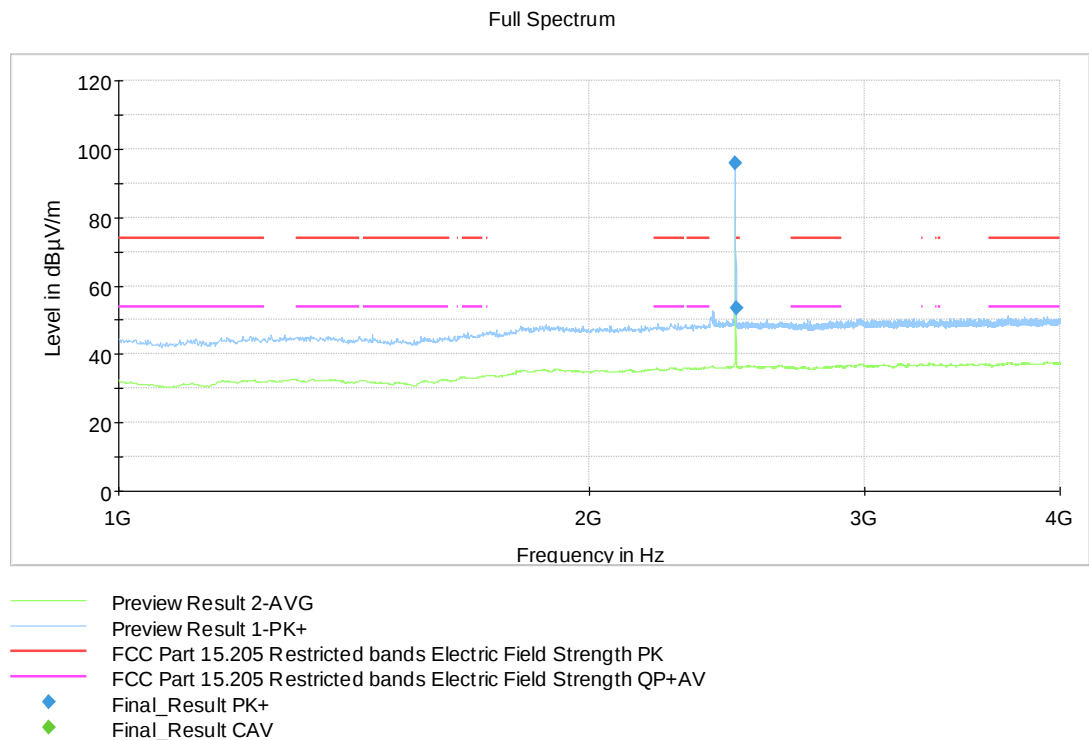


Figure 47: Unwanted emissions 1 - 4 GHz (1 Mbps, TX 2480 MHz)

Unwanted Emissions (radiated)

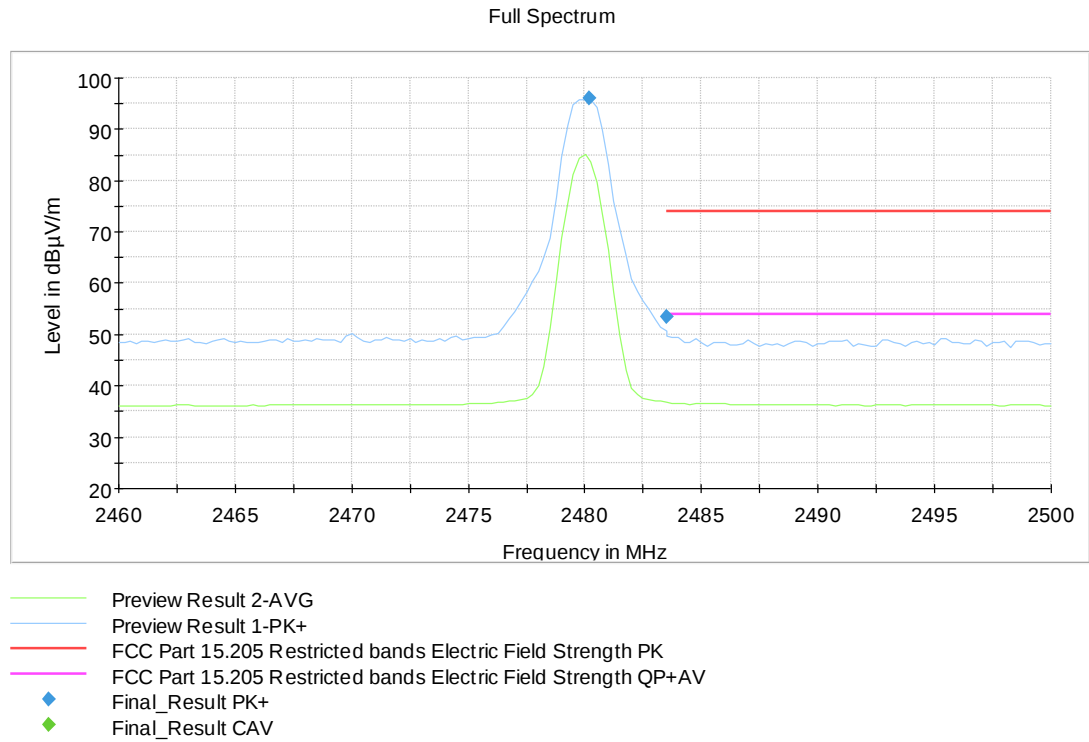


Figure 48: Upper band-edge (1 Mbps, TX 2480 MHz)

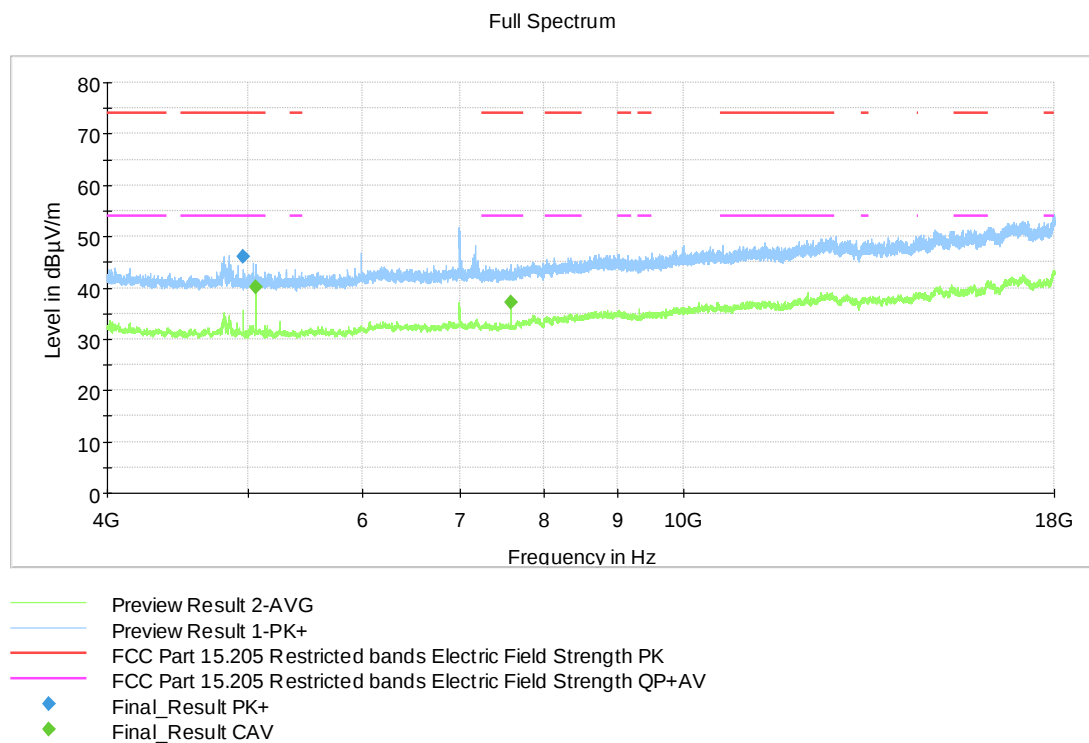


Figure 49: Unwanted emissions 4 - 18 GHz (1 Mbps, TX 2480 MHz)

Unwanted Emissions (radiated)

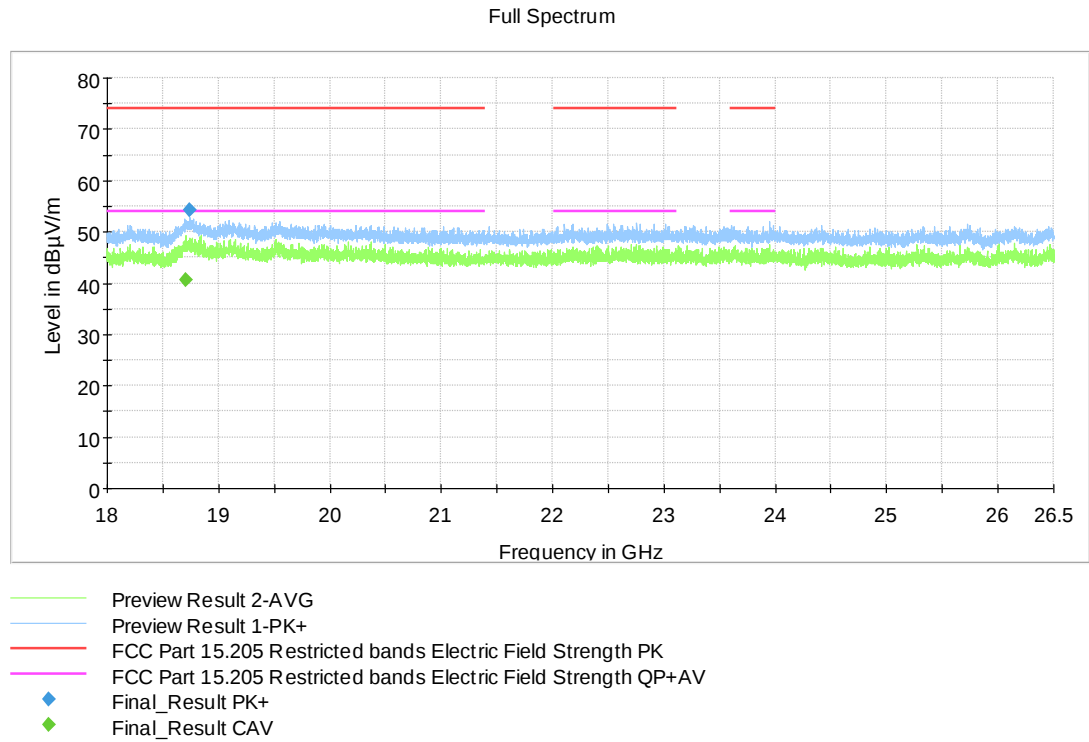


Figure 50: Unwanted emissions 18 - 26.5 GHz (1 Mbps, TX 2480 MHz)

Power Spectral Density

Standard: ANSI C63.10-2013
Tested by: HEM
Date: 10 October 2023
Temperature: 23 °C
Humidity: 33 %RH
Test result: **PASS**

FCC §15.247(e)
RSS-247 clause 5.2 b)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test results

Table 15: Test results for Power Spectral Density

Data Rate	Frequency [MHz]	PSD [dBm/10 kHz]	Limit [dBm/3 kHz]	Result
1 Mbps	2402	-6.068	≤ 8	PASS
	2440	-5.460		PASS
	2480	-5.944		PASS
2 Mbps	2404	-6.188		PASS
	2440	-5.750		PASS
	2478	-6.160		PASS

Note: Compliance was determined in a 10 kHz band.

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

Setting	Value
Span	1.500 / 3.000 MHz
RBW	10.000 kHz
VBW	30.000 kHz
Sweep Points	300 / 600
Sweep Time	1.500 / 3.000 ms
Reference Level	0.000 dBm
Attenuation	20.000 dB
Detector	MaxPeak
Trace Mode	Max Hold
Sweep Type	Sweep
Preamp	off

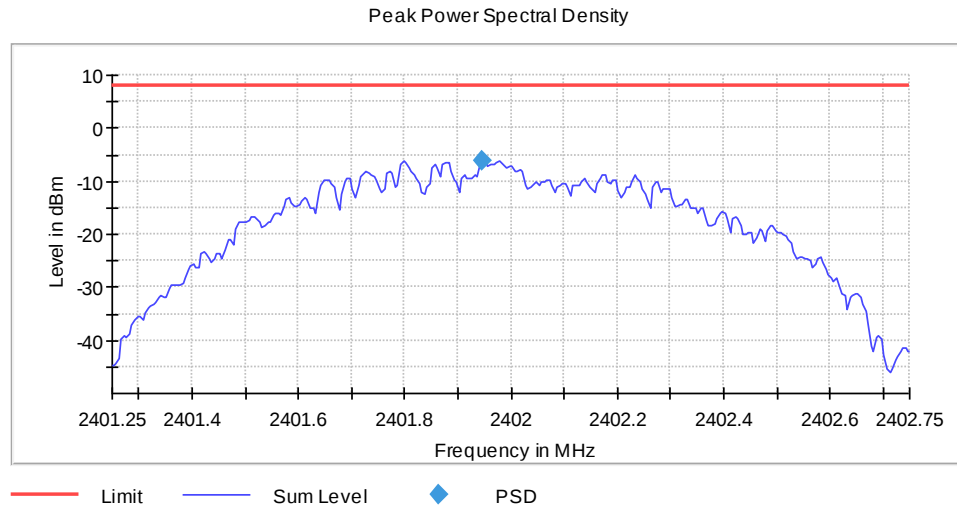


Figure 51: Power Spectral Density (1 Mbps, TX 2402 MHz)

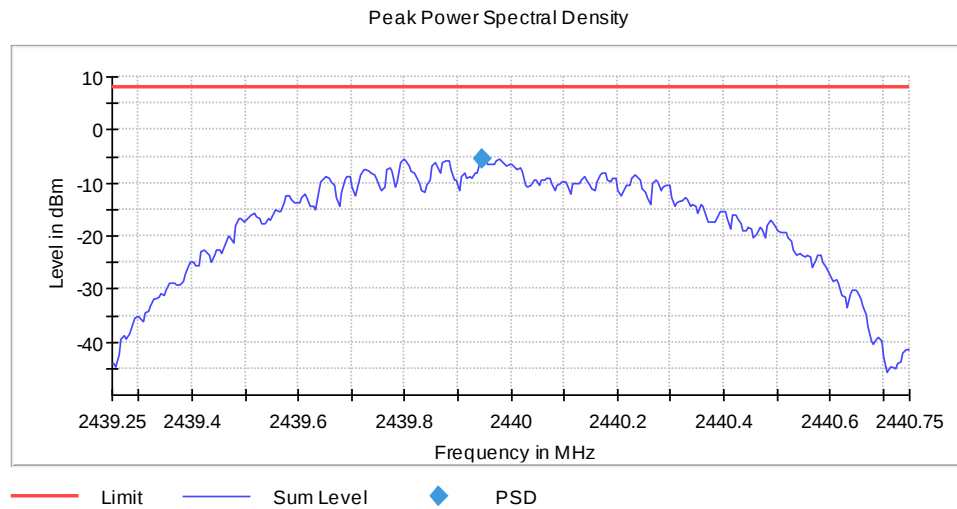


Figure 52: Power Spectral Density (1 Mbps, TX 2440 MHz)

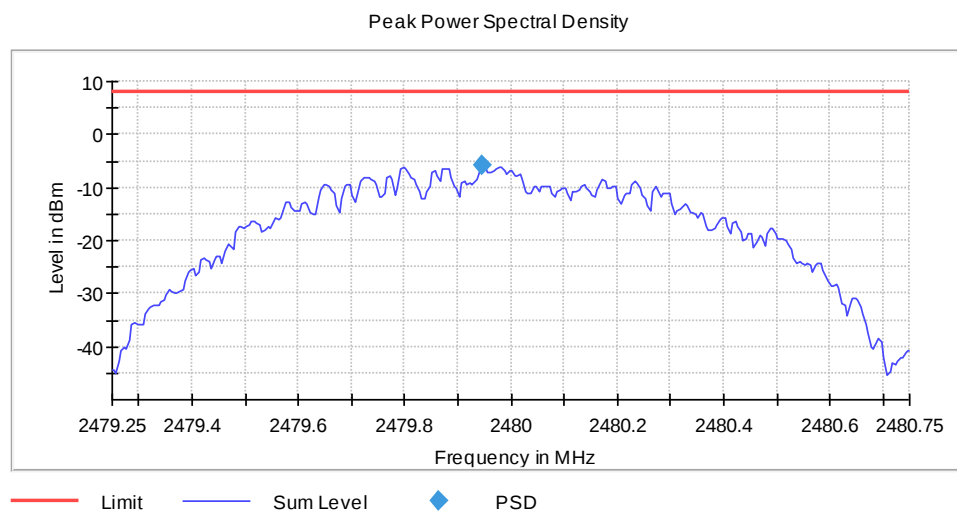


Figure 53: Power Spectral Density (1 Mbps, TX 2480 MHz)

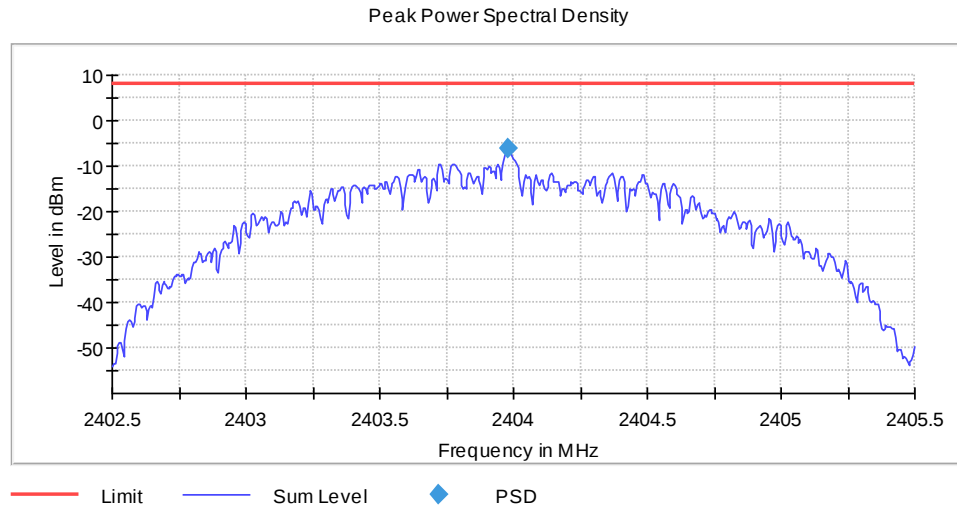


Figure 54: Power Spectral Density (2 Mbps, TX 2404 MHz)

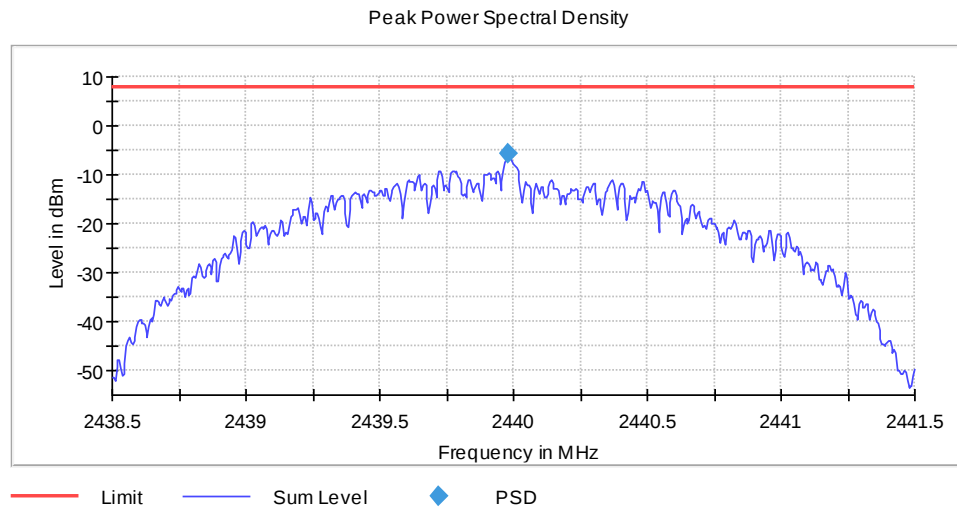


Figure 55: Power Spectral Density (2 Mbps, TX 2440 MHz)

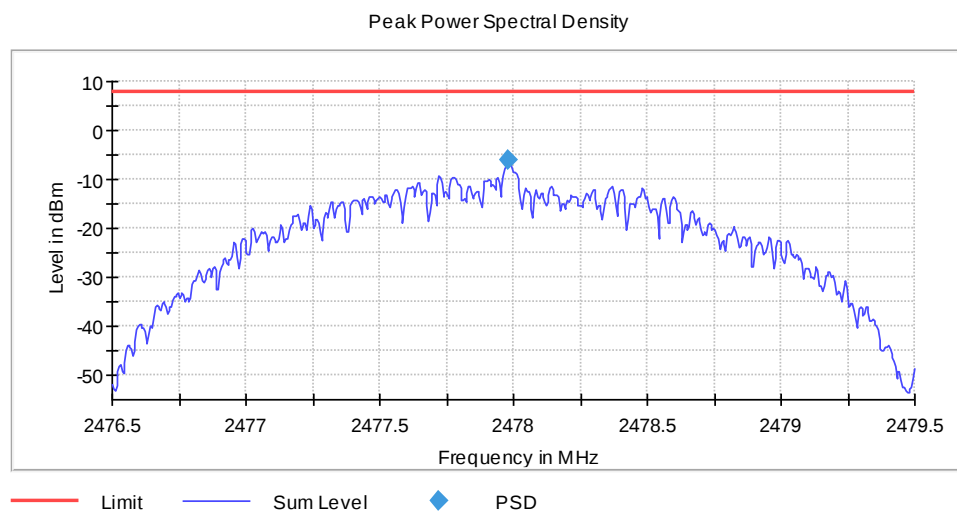


Figure 56: Power Spectral Density (2 Mbps, TX 2478 MHz)

TEST EQUIPMENT

AC Power-Line Conducted Emissions

Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv. 10670	2023-06-19	2024-06-18
LISN	ROHDE & SCHWARZ	ENV216	inv. 9611	2023-02-01	2024-02-01
LISN	ROHDE & SCHWARZ	ESH3-Z5	inv. 8019	2023-05-23	2024-05-23
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv. 7826	NCR	NCR
TEMPERATURE/ HUMIDITY SENSOR	EDS	OW-ENV-TH, K5 SAC	inv. 10517	2022-10-27	2023-10-27
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-

Conducted RF tests

Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
BASE MODULE	ROHDE & SCHWARZ	OSP-B157W8	inv. 10883	2023-07-03	2024-07-02
EQUIPMENT RACK	ROHDE & SCHWARZ	TS97-RA	inv. 9291	NCR	NCR
EXTENSION MODULE	ROHDE & SCHWARZ	OSP-B157WX	inv. 10884	2023-07-03	2024-07-02
SPECTRUM ANALYZER	ROHDE & SCHWARZ	FSV40	inv. 10881	2023-06-16	2024-06-16
SWITCH UNIT FOR EXTENSION MODULE	ROHDE & SCHWARZ	OSP120	inv. 9289	2023-07-03	2024-07-02
SWITCH UNIT FOR BASE MODULE	ROHDE & SCHWARZ	OSP120	inv. 10882	2023-07-03	2024-07-02

Unwanted Emissions (radiated)

Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
ANTENNA	EMCO	3160-09, emi 18-26.5GHz	inv. 7294	2023-02-23	2024-02-23
ANTENNA	EMCO	3117, emi 1-18GHz	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	2023-03-20	2025-03-20
ATTENUATOR	PASTERNAK	PE 7004-4 (4dB)	inv. 10126	2023-03-13	2024-03-13
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv. 10670	2023-06-19	2024-06-18
FILTER	WAINWRIGHT	HP, WHKX4.0/18G-10SS	inv. 10403	2023-01-09	2025-01-09
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv. 10183	NCR	NCR
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv. 7826	NCR	NCR
RF PREAMPLIFIER	CIAO	CA118-3123	inv. 10278	2022-09-15	2023-09-15
RF PREAMPLIFIER	CIAO	CA1840-5019	inv. 10593	2022-09-15	2023-09-15
TEMPERATURE/ HUMIDITY SENSOR	EDS	OW-ENV-TH, K5 SAC	inv. 10517	2022-10-27	2023-10-27
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
TURNTABLE	MATURO	DS430 UPGRADED	inv. 10182	NCR	NCR

NCR = No Calibration Required

END OF REPORT