Deutsche Akkreditierungsstelle D-PL-21375-01-00

INGENIEURBÜRO LENHARDT

Bundesnetzagentur

BNetzA-CAB-21/21-21

Test Report

Test report no.: 23048689-34084-0
Date of issue: 2023-11-13

Test result: The test item **- passed - and complies** with below listed standards.

Applicant

InnoSenT GmbH

Manufacturer

Same as applicant

Test Item

IMD-2002

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices, Subpart C -
§15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz

RSS-210, Issue 10 (2019-12)
Licence-Exempt Radio Apparatus: Category I Equipment

RSS-Gen, Issue 5 (2018-04)
General Requirements for Compliance of Radio Apparatus

Tested by (name, function, signature)	*Karsten Geraldy* *Senior Lab Manager RF*	signature
Approved by (name, function, signature)	*Andreas Bender* *Deputy Managing Director*	signature

Applicant and Test item details	
Applicant	InnoSenT GmbH Am Roedertor 30 97499, Donnersdorf, Germany Phone: +49-9528-9518-0
Manufacturer	Same as applicant
Test item description	24 GHz field disturbance sensor
Model/Type reference	IMD-2002
FCC ID	UXS-IMD-2002
IC	6902A-IMD2002
HMN	N/A
PMN	IMD-2002
HVIN	IMD-2002
FVIN	N/A
Frequency	24.00 GHz – 24.25 GHz
Antenna	Integrated planar patch antenna
Power supply	3.25 V – 3.35 V DC (5V DC via USB interface)
Temperature range	-30 °C – +80 °C

Disclaimer and Notes

The content of this report relates to the mentioned test sample(s) only.
IBL-Lab GmbH does not take samples. The samples used for testing are provided by the applicant.
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The last valid version is available at TAMSys®.
Signatures are done electronically, if signer does not match stated signer, it is signed per order.
Information supplied by the applicant can affect the validity of results. The data is marked accordingly.

Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

Decision rule:
Decision rule based on simple acceptance without guard bands, binary statement, based on mutually agreed uncertainty tolerances with expansion factor k=2 according to ILAC-G8:09/2019

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2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: https://ib-lenhardt.com/ E-Mail: info@ib-lenhardt.com
Accreditation / Designation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Attachment to the accreditation certificate D-PL-21375-01-00 ○ Electronics ○ Electromagnetic Compatibility ○ Radio ○ Electromagnetic Compatibility and Telecommunication (FCC requirements) ○ Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards ○ Automotive EMC Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement. • Designations ○ FCC Testing Laboratory Designation Number DE0024 ○ ISED ISED Company Number 27156 Testing Laboratory CAB Identifier DE0020 ○ Kraftfahrt-Bundesamt KBA-P 00120-23
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2023-09-12
Start – End of tests	2023-11-06 – 2023-11-09

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision history

-0 Initial Version

2.6 Further documents

List of further applicable documents belonging to the present test report:
– no additional documents –

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75% r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V AC ± 5%

3.2 Normal and extreme test conditions

	minimum	nominal	maximum
Temperature	-20 °C	20 °C	50 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	-/- V DC	5.0 V DC via USB	-/- V DC

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	**Description**
FCC 47 CFR Part 15	Radio Frequency Devices, Subpart C - §15.249 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz
RSS-210, Issue 10 (2019-12)	Licence-Exempt Radio Apparatus: Category I Equipment
RSS-Gen, Issue 5 (2018-04)	General Requirements for Compliance of Radio Apparatus

Reference	**Description**
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

24 GHz field disturbance sensor

5.2 Description of test item

Model name*	IMD-2002
Serial number*	00001408
Hardware status*	IMD-2002_2_3.3_2V2
Software status*	N/A

*: as declared by applicant

5.3 Technical data of test item

Operational frequency band*	24.00 GHz – 24.25 GHz
Operational carrier frequencies*	f1 = 24.156 GHz; f2 = 24.169 GHz; f3 = 24.181 GHz; f4 = 24.193 GHz; f5 = 24.205 GHz; f6 = 24.217 GHz; f7 = 24.229 GHz; f8 = 24.241 GHz
Type of radio transmission*	Modulated carrier
Modulation type*	FSK
Number of channels*	1
Channel bandwidth*	~5 MHz
Duty cycle*	100%
Antenna*	Integrated planar patch antenna
Antenna gain*	10 dBi
Power supply*	3.25 V – 3.35 V DC (5V DC via USB interface)
Temperature range*	-30 °C – +80 °C

*: as declared by applicant

5.4 Additional information

Model differences	-/-
Ancillaries tested with	-/-
Additional equipment used for testing	-/-

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15

Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§2.1049 RSS-Gen, 6.7	Occupied bandwidth (99% bandwidth)	Normal	3.525 MHz	P
§15.215(c) RSS-Gen, 6.11	Transmitter frequency stability	Normal/Extreme		P
§15.249(a) RSS-210,B.10	Field strength of emissions (wanted signal)	Normal	107.5 dBµV/m (PK) 101.4 dBµV/m (AVG)	P
§15.249(d) RSS-210,B.10	Field strength of emissions (spurious & harmonics)	Normal	< limit	P
§15.207 RSS-Gen, 8.8	AC conducted emissions	Normal	< limit	P

Notes

FCC's Millimeter Wave Test Procedures:
I. A radiated method of measurements in order to demonstrate compliance with the various regulatory requirements has been chosen in consideration of test equipment availability and the limitations of many external harmonic mixers. A conducted method of measurement could be employed if EUT and mixer waveguides both are accessible and of the same type (WG number) and if waveguide sections and transitions can be found. Another potential problem is that the peak power output may exceed the +20 dBm input power limit of many commercially available mixers. For these reasons a radiated method is preferred.

Comments and observations

Following pages show requirements and references of FCC Part 15 only. Same tests are also applicable and valid for RSS-210/RSS-Gen, with clauses given in the table above.

7 TEST RESULTS

7.1 Occupied bandwidth

Description

§2.1049 Measurements required: Occupied bandwidth.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

Limits

The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the frequency band.

Test procedure

ANSI C63.10, 6.9.3

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Step a) through step c) might require iteration to adjust within the specified range.

e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Note

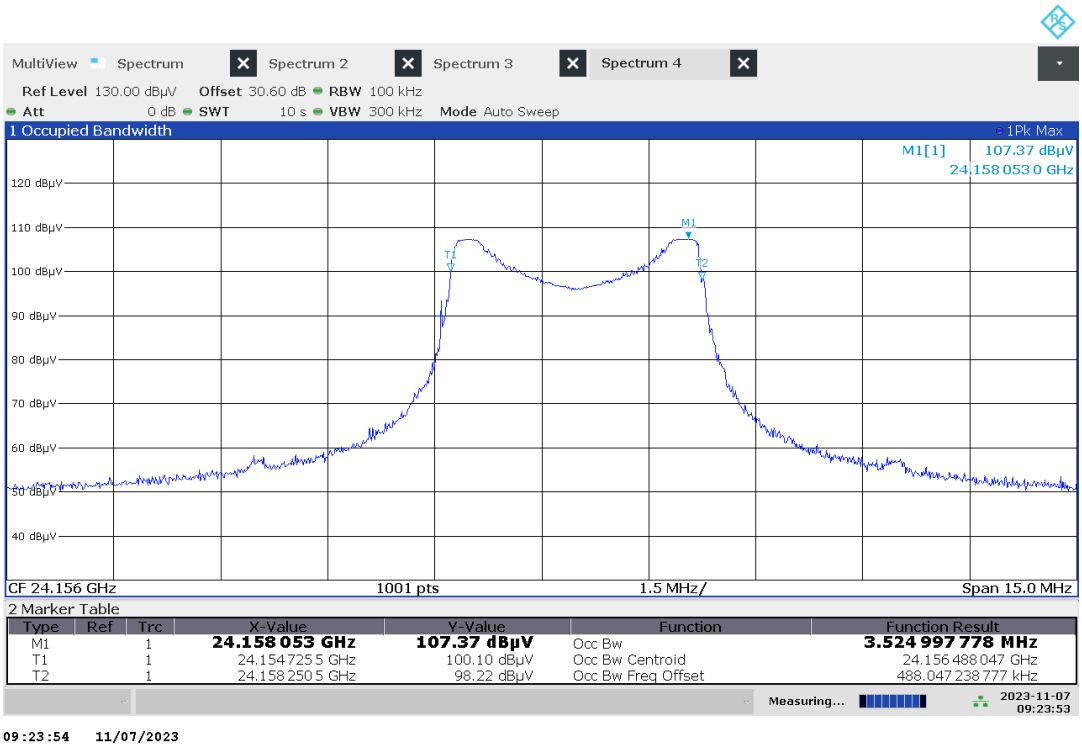
Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak detector will represent the worst-case results (see ANSI C63.10).

Test setup: 8.3 (test distance correction factor of 20dB/decade is already considered in the plots / result table)

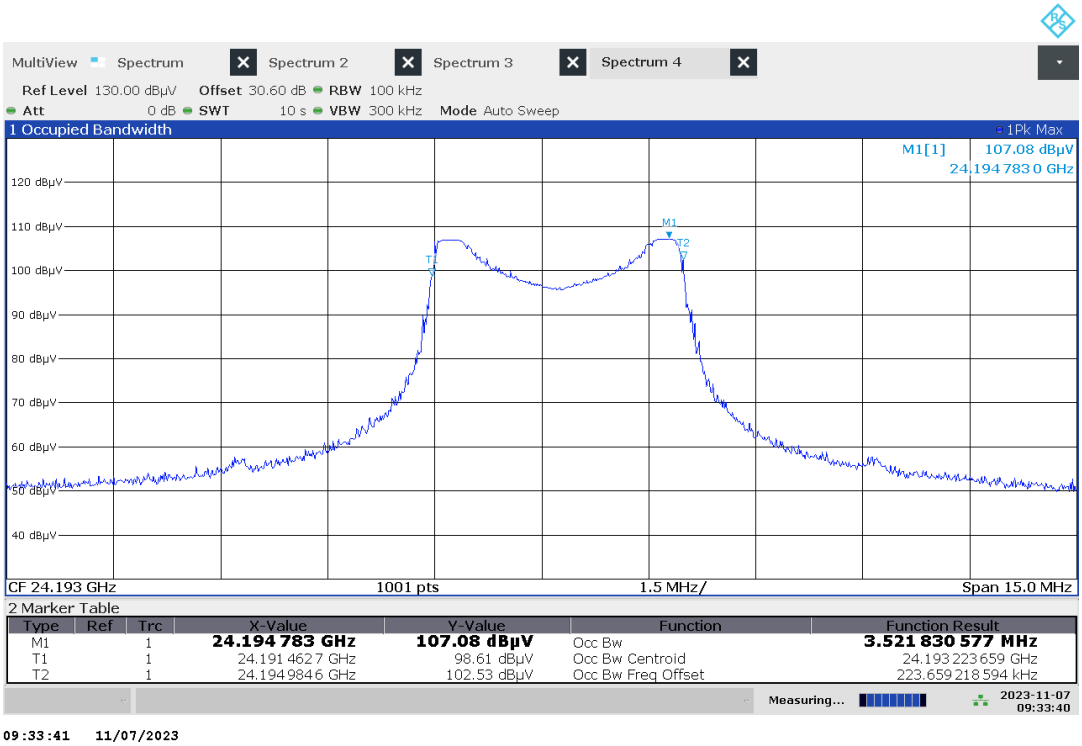
Test results:

EUT mode	Test distance	f_L [GHz]	f_H [GHz]	99% OBW [MHz]
f1	1 m	24.1547	24.1582	3.525
f4	1 m	24.1914	24.1950	3.521
f8	1 m	24.2397	24.2431	3.403

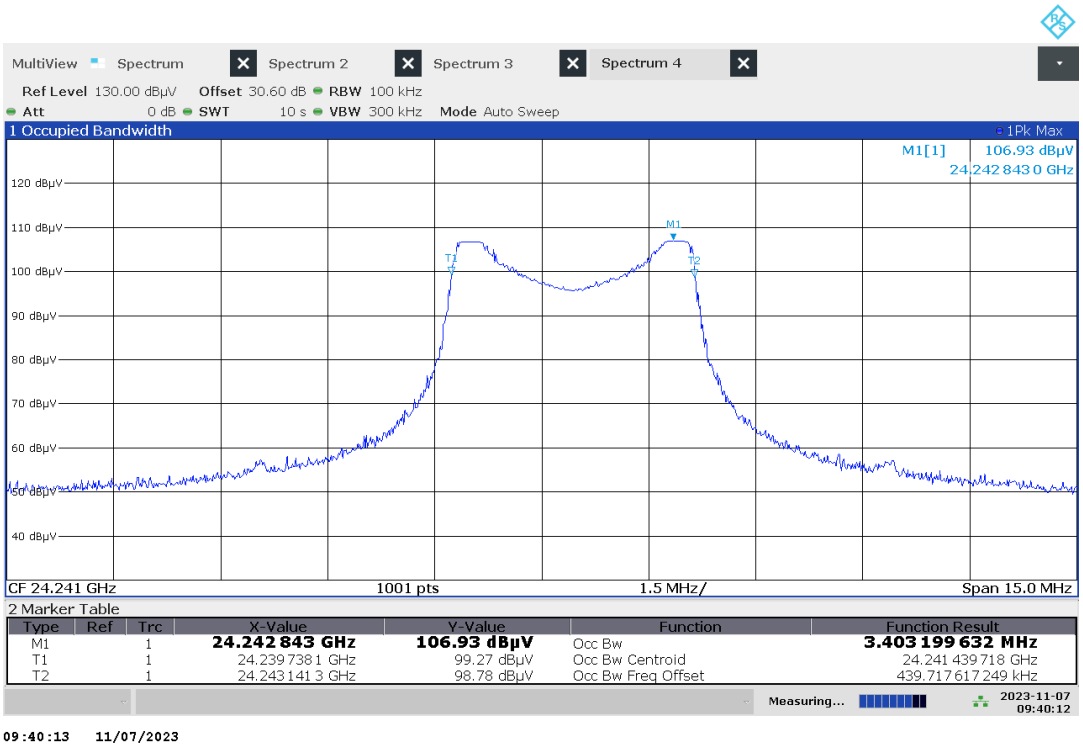
Plot no. 1: 99% OBW, Peak detector, f1



Plot no. 2: 99% OBW, Peak detector, f4



Plot no. 3: 99% OBW, Peak detector, f8



7.2 Transmitter frequency stability

Description

§15.215 (c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Limits

The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the frequency band.

Test procedure

ANSI C63.10, 6.9.2

A dBc bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are −6 dB, −20 dB, and −26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this subclause, the ratio is designated by "−xx dB." The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the "−xx dB" bandwidth; other requirements might specify that the "−xx dB" bandwidth be entirely contained within the authorized or designated frequency band.

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.
b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be at least three times RBW, unless otherwise specified by the applicable requirement.
c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.6.2.
d) Steps a) through c) might require iteration to adjust within the specified tolerances.
e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −99% OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
f) Set detection mode to peak and trace mode to max-hold.
g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).
h) Determine the "−xx dB down amplitude" using [(reference value) - xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.
i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "−xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value, then it shall be as close as possible to this value. The dBc bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "−xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The dBc bandwidth shall be reported by providing spectral plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Note
Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak detector will represent the worst-case results (see ANSI C63.10).

Test setup: 6.3 (EUT placed in climatic chamber)

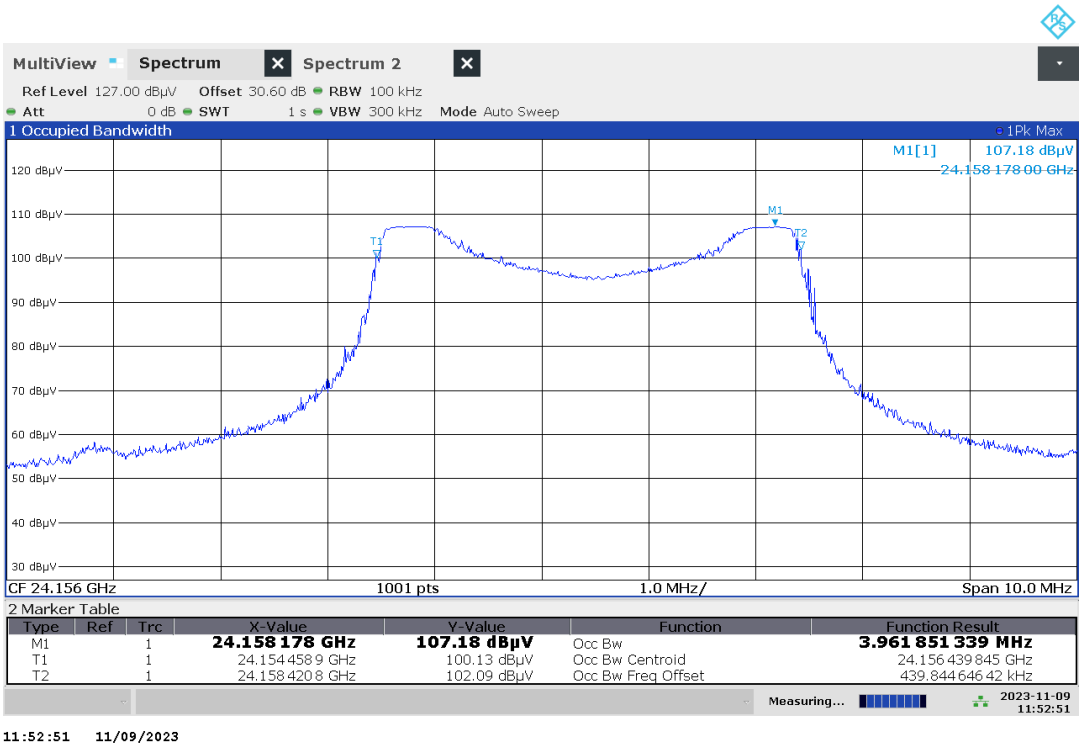
Test results:

EUT mode	Temperature / Voltage	f_L [GHz]	f_H [GHz]	99% OBW [MHz]
f1	50 °C / V_{nom}	24.1545	24.1594	**3.962**
f1	40 °C / V_{nom}	**24.1544**	24.1580	3.543
f1	30 °C / V_{nom}	24.1546	24.1581	3.511
f1	20 °C / $V_{mim - max}$	24.1549	24.1585	3.623
f1	10 °C / V_{nom}	24.1549	24.1586	3.692
f1	0 °C / V_{nom}	24.1549	24.1586	3.720
f1	-10 °C / V_{nom}	24.1556	24.1590	3.485
f1	-20 °C / V_{nom}	24.1551	24.1586	3.475
f8	50 °C / V_{nom}	24.2394	24.2431	3.691
f8	40 °C / V_{nom}	24.2394	24.2432	3.741
f8	30 °C / V_{nom}	24.2395	24.2430	3.513
f8	20 °C / $V_{mim - max}$	24.2400	24.2434	3.440
f8	10 °C / V_{nom}	24.2397	24.2432	3.520
f8	0 °C / V_{nom}	24.2400	24.2436	3.636
f8	-10 °C / V_{nom}	24.2404	**24.2437**	3.341
f8	-20 °C / V_{nom}	24.2400	24.2435	3.447

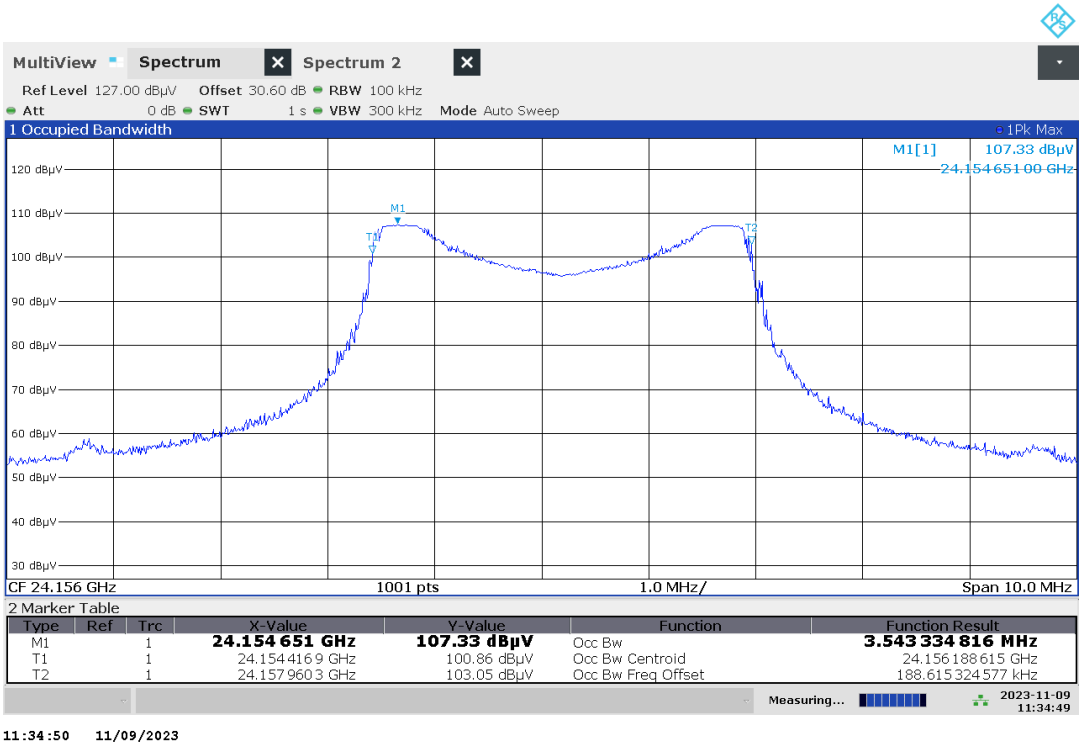
With voltage variation

Input voltage variation does not affect the transmitted signal (see plots for ambient/normal temperature).

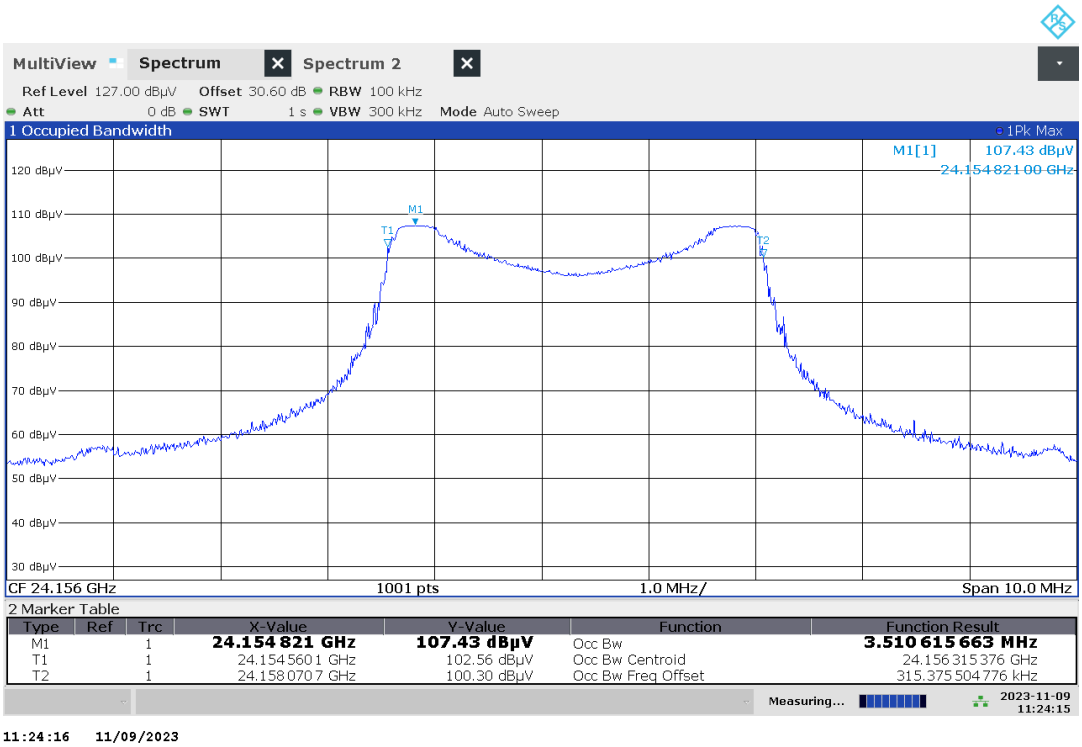
Plot no. 4: 99% OBW, f1, Peak detector, 50 °C



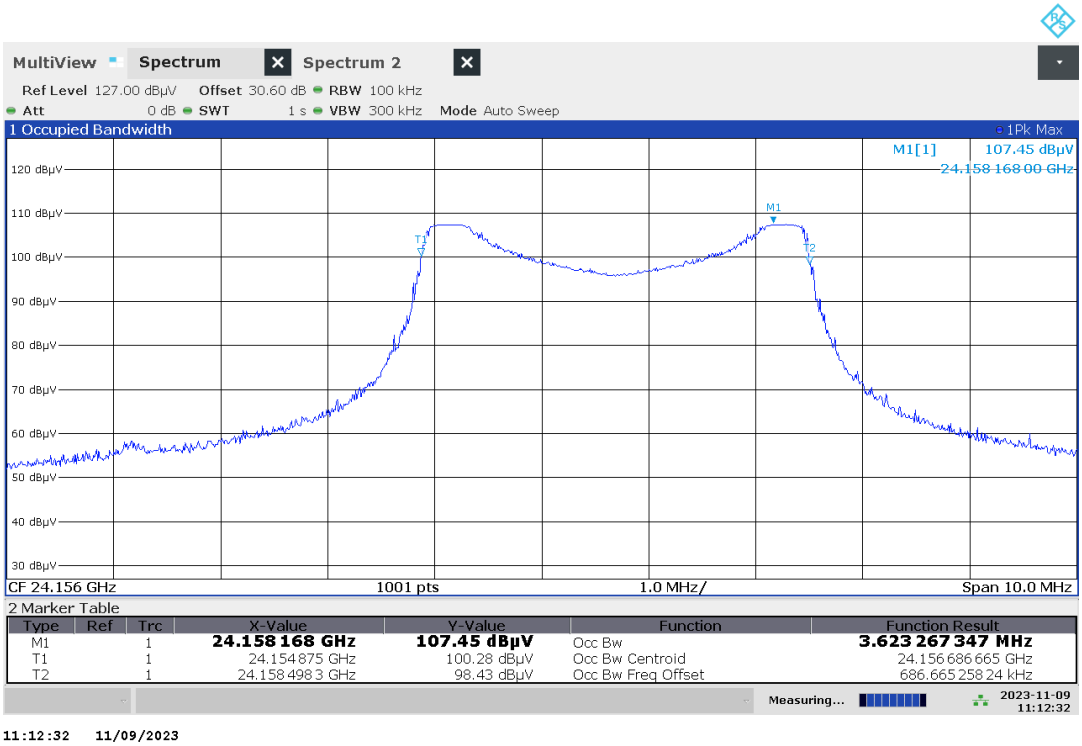
Plot no. 5: 99% OBW, f1, Peak detector, 40 °C



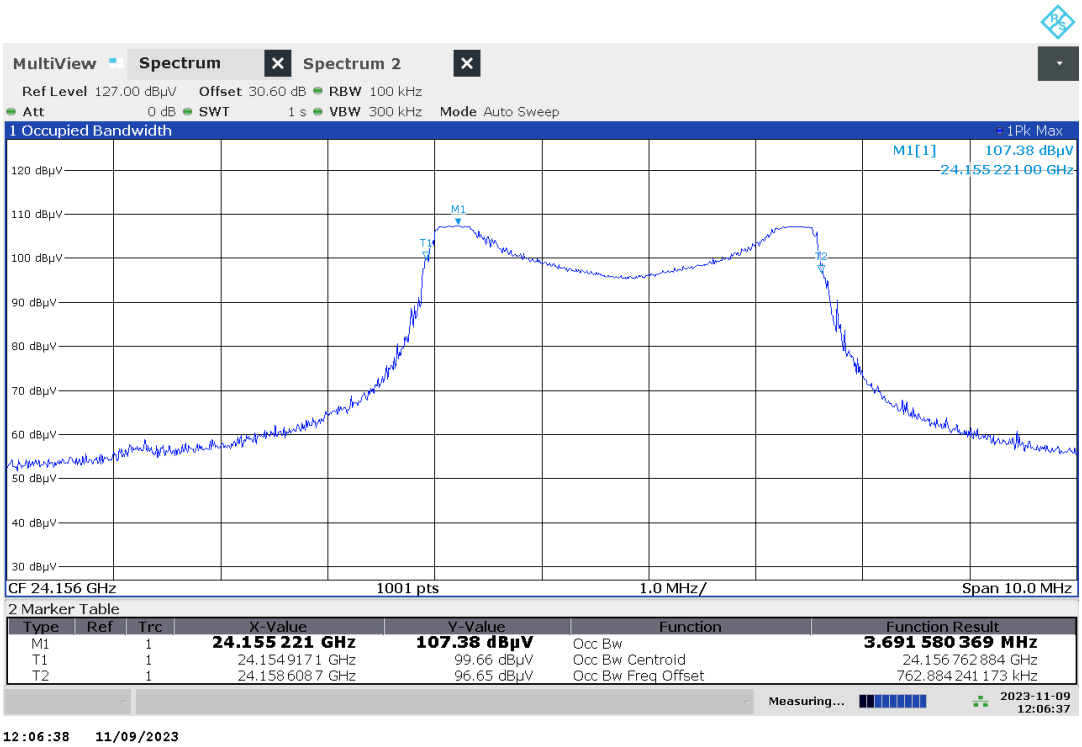
Plot no. 6: 99% OBW, f1, Peak detector, 30 °C



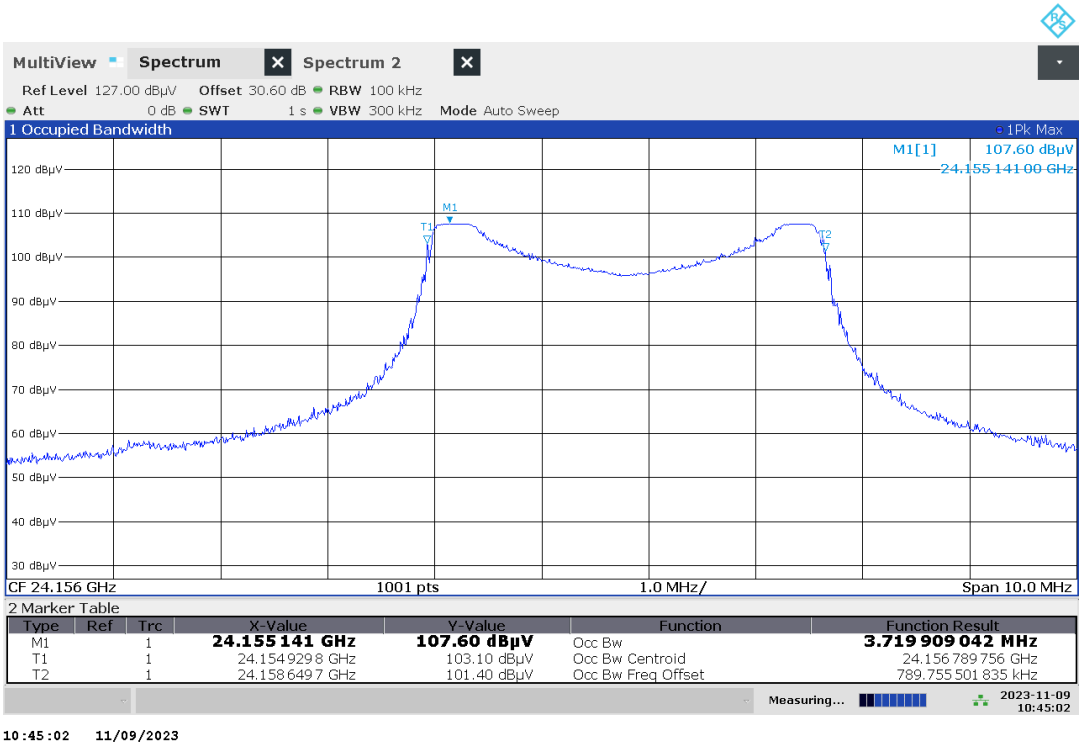
Plot no. 7: 99% OBW, f1, Peak detector, 20 °C



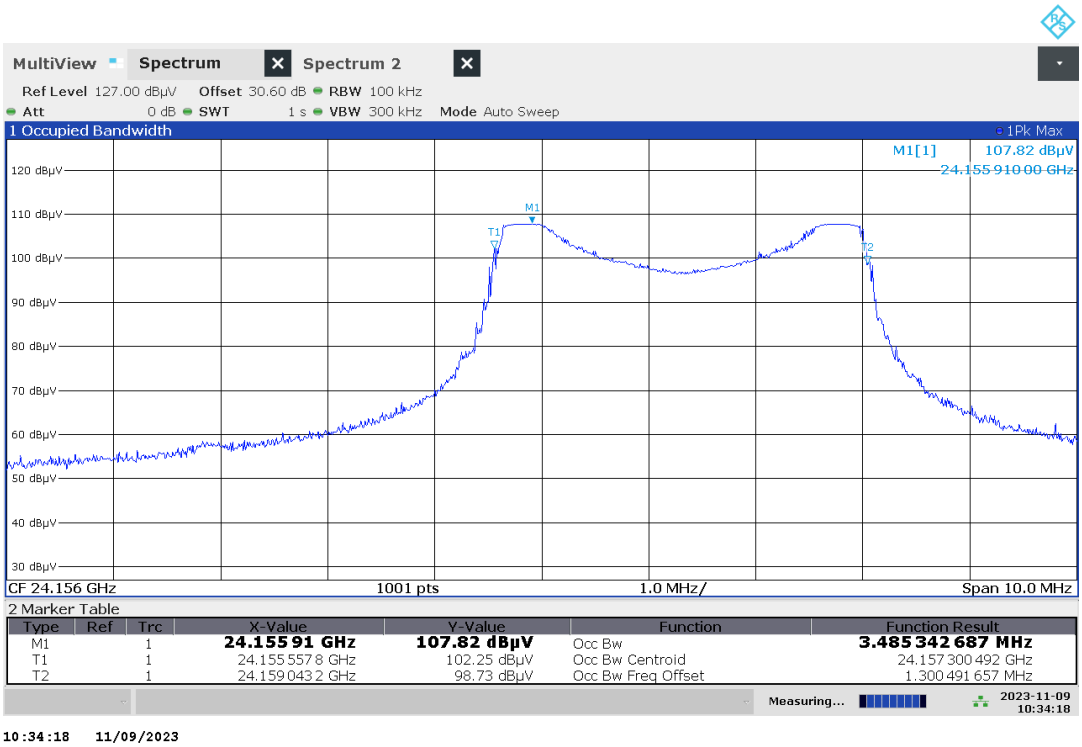
Plot no. 8: 99% OBW, f1, Peak detector, 10 °C



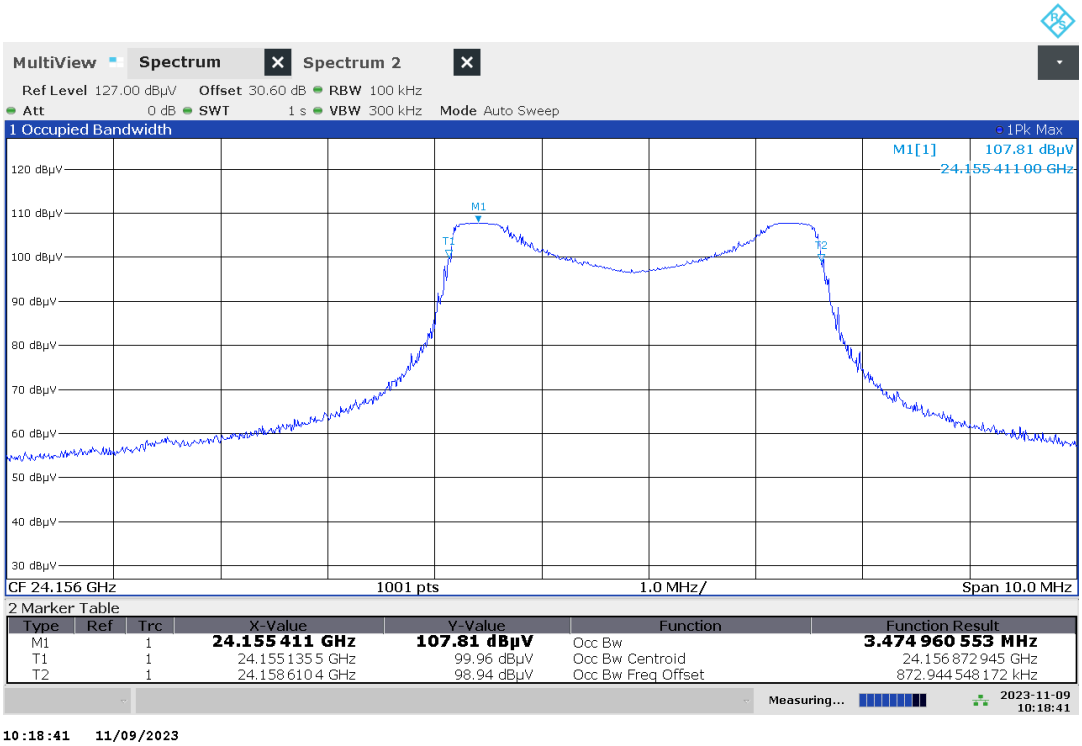
Plot no. 9: 99% OBW, f1, Peak detector, 0 °C



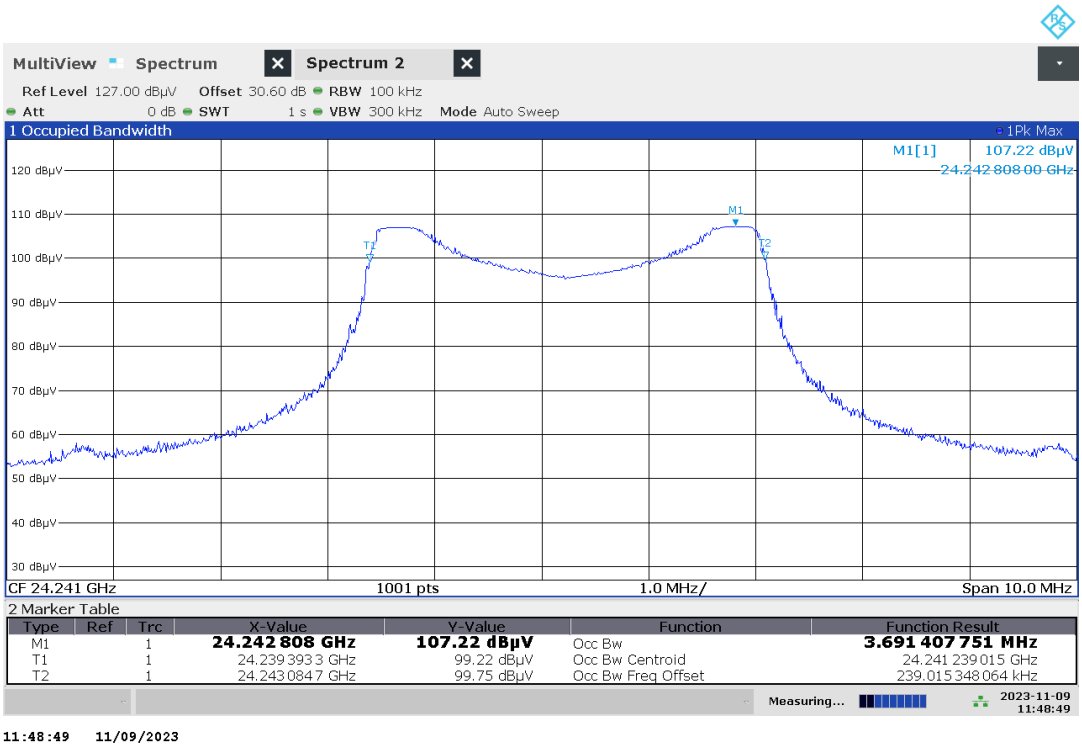
Plot no. 10: 99% OBW, f1, Peak detector, -10 °C



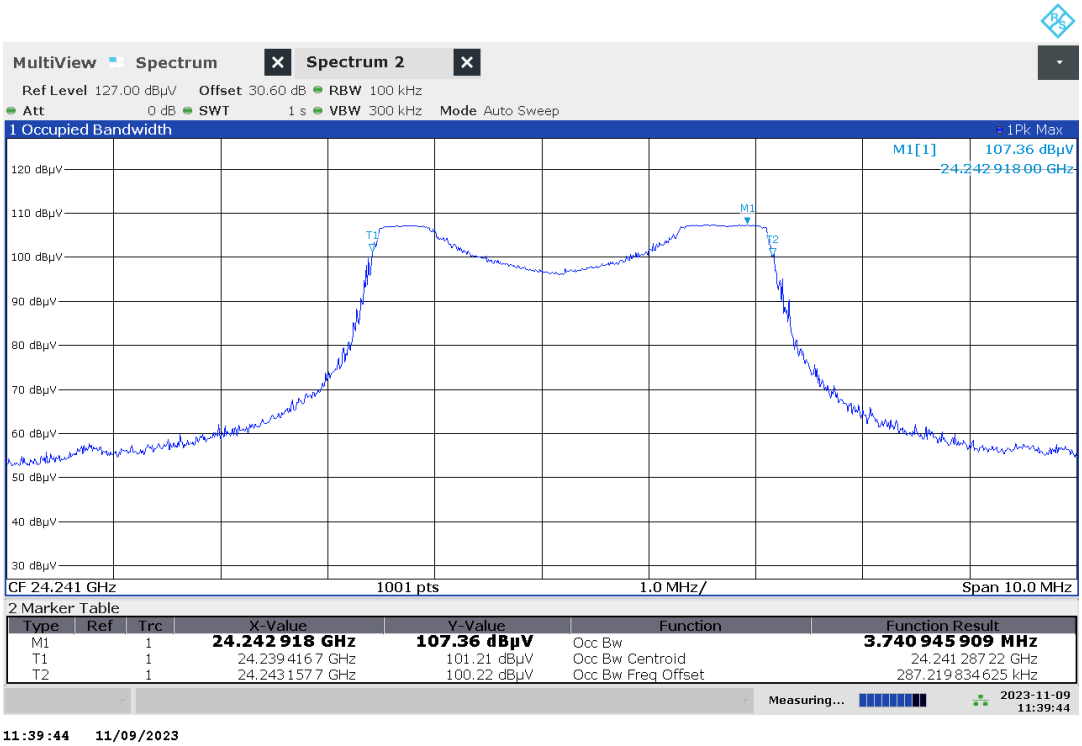
Plot no. 11: 99% OBW, f1, Peak detector, -20 °C



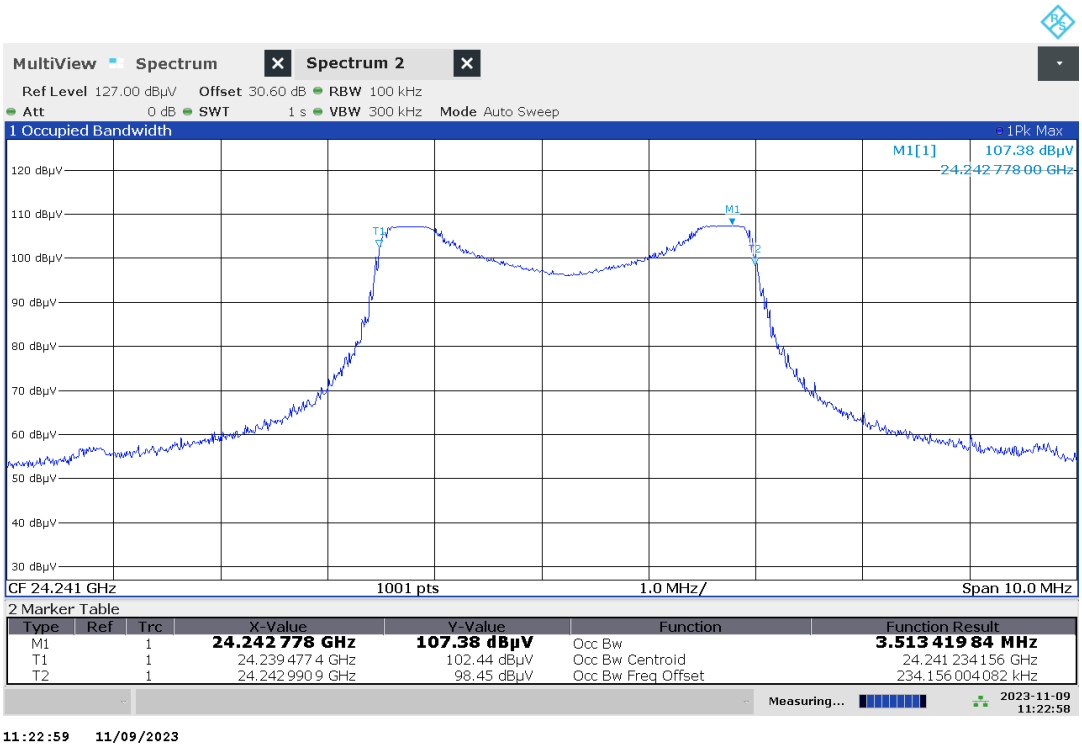
Plot no. 12: 99% OBW, f8, Peak detector, 50 °C



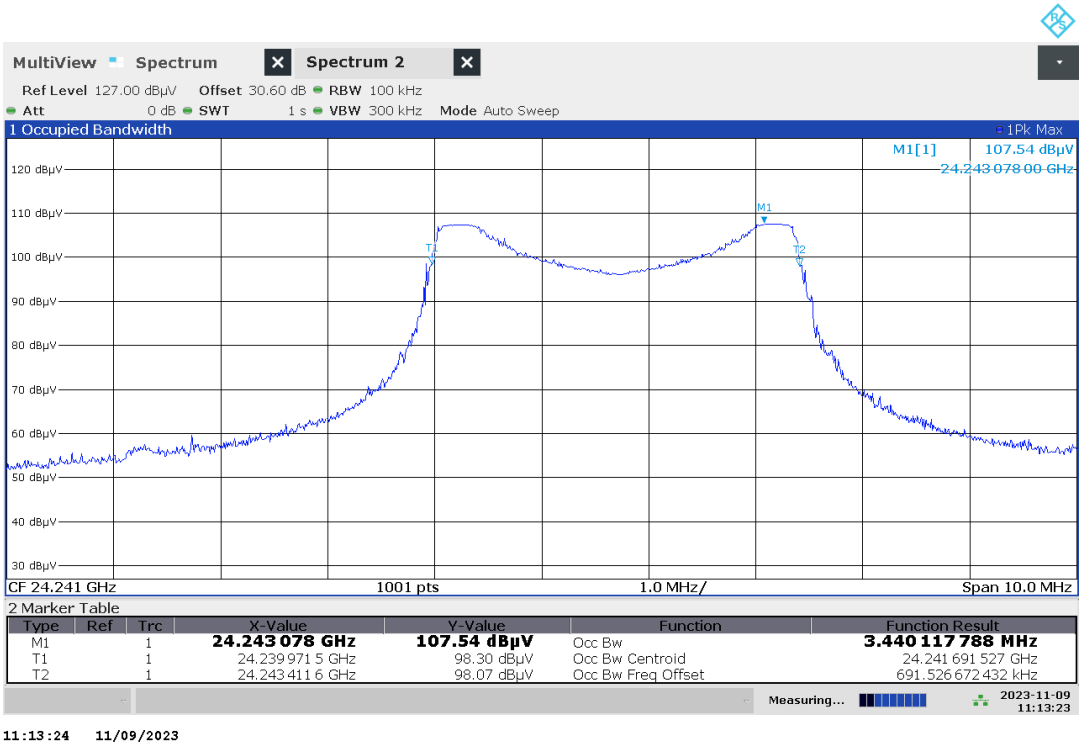
Plot no. 13: 99% OBW, f8, Peak detector, 40 °C



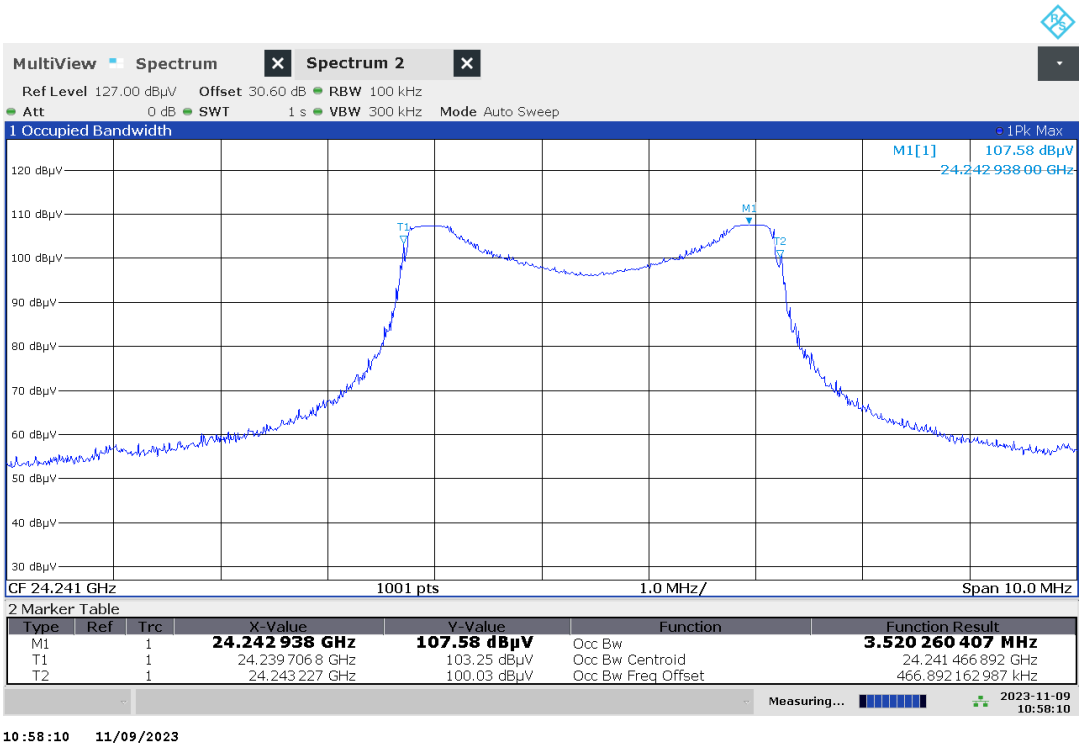
Plot no. 14: 99% OBW, f8, Peak detector, 30 °C



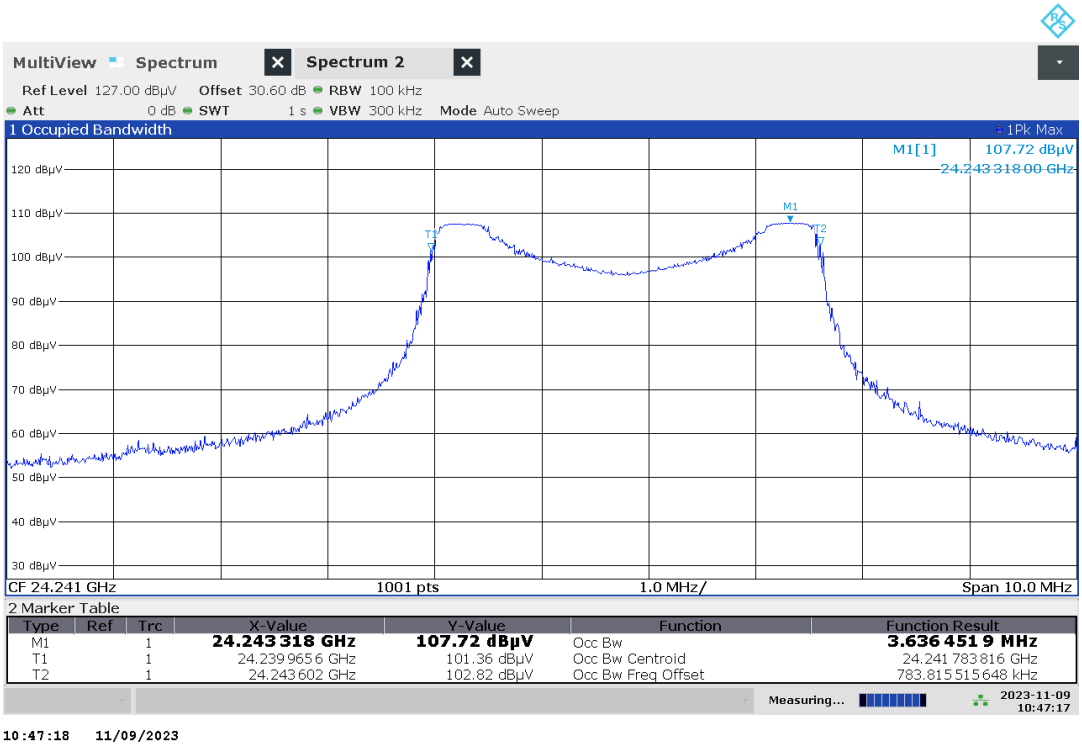
Plot no. 15: 99% OBW, f8, Peak detector, 20 °C



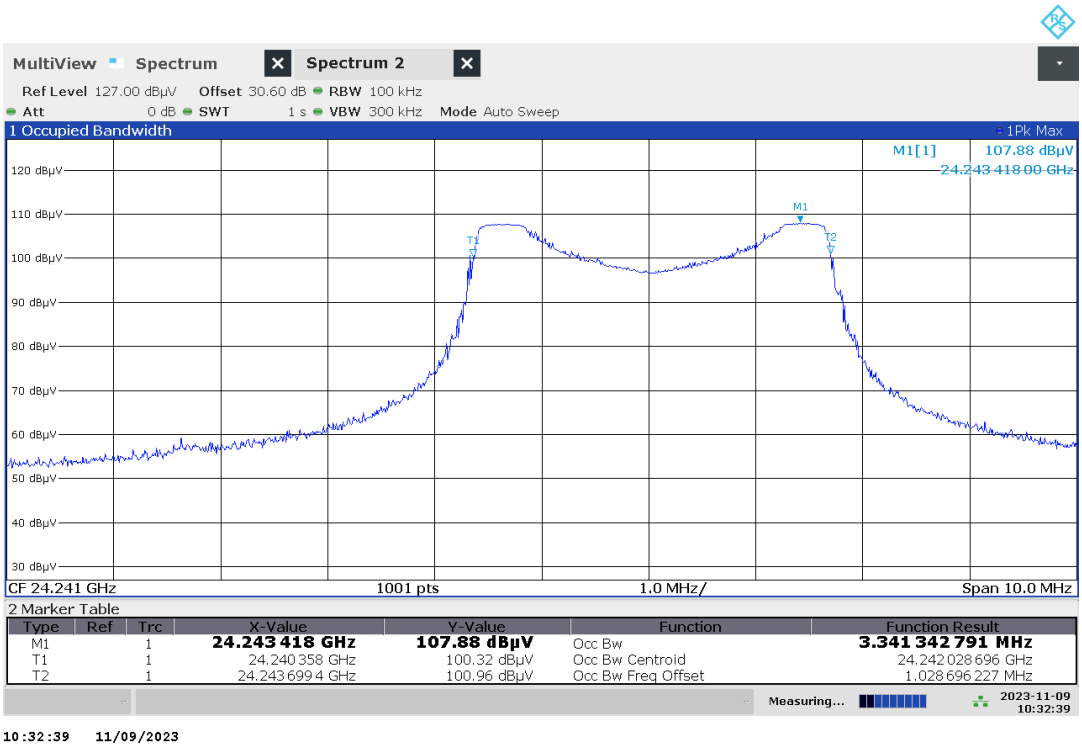
Plot no. 16: 99% OBW, f8, Peak detector, 10 °C



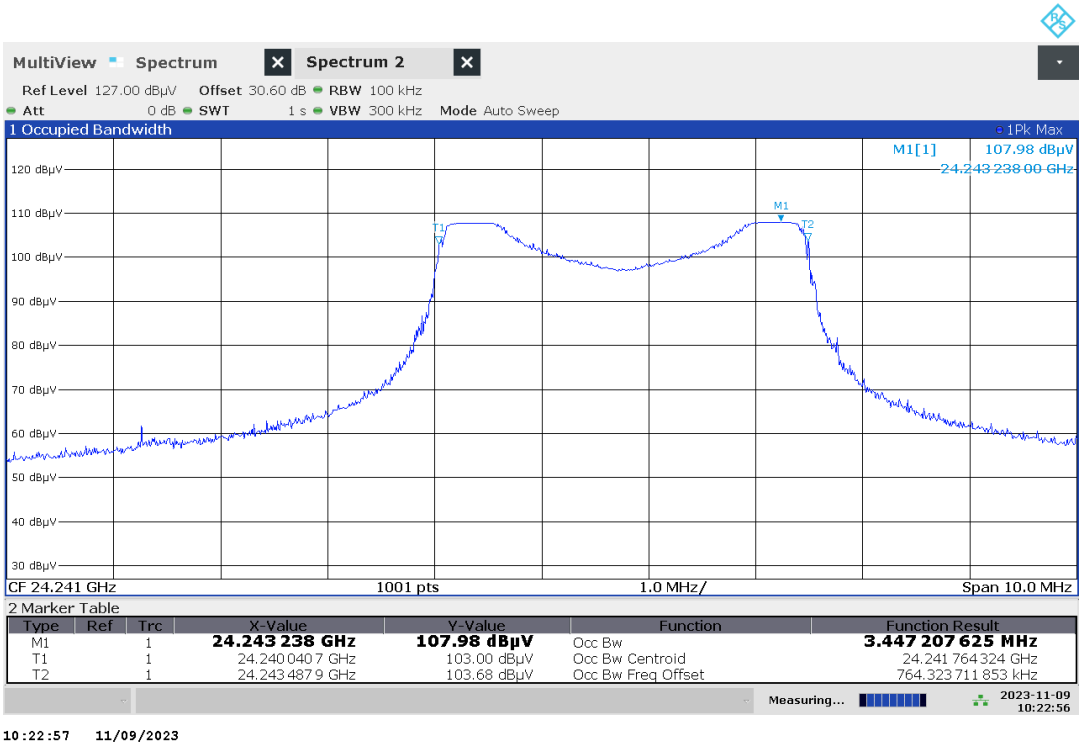
Plot no. 17: 99% OBW, f8, Peak detector, 0 °C



Plot no. 18: 99% OBW, f8, Peak detector, -10 °C



Plot no. 19: 99% OBW, f8, Peak detector, -20 °C



7.3 Field strength of emissions (wanted signal)

Description / Limits

§15.249 (a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental	Field strength of harmonics
902 – 928 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
2400 – 2483.5 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
5725 – 5875 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
24.00 – 24.25 GHz	250 mV/m (108 dBµV/m)	2500 µV/m (68 dBµV/m)

§15.249 (c) Field strength limits are specified at a distance of 3 meters.

Test procedure

§15.31 (c) Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

§15.31 (m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range	Number of frequencies	Location
< 1MHz bandwidth	1	middle
1 – 10 MHz bandwidth	2	1 near bottom and 1 near top
> 10 MHz bandwidth	3	1 near bottom / middle / top

§15.35 (b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g.,see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

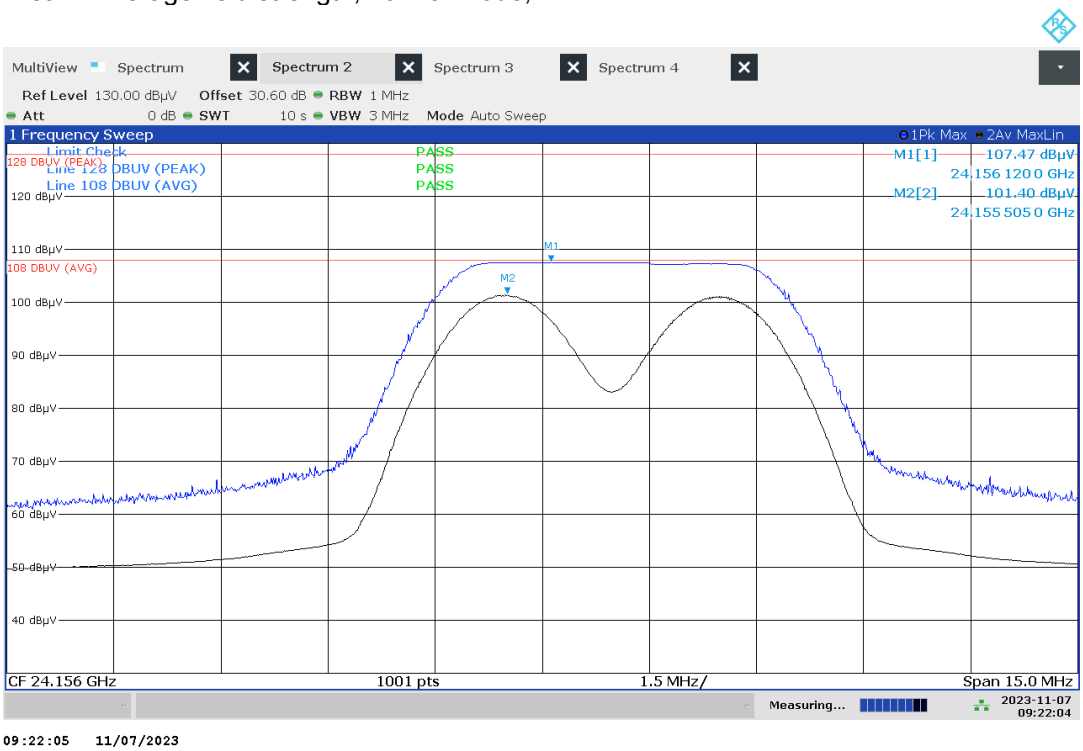
§15.35 (c) Unless otherwise specified, e.g., §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Test setup: 8.3 (test distance correction factor of 20dB/decade is already considered in the plots / result table)

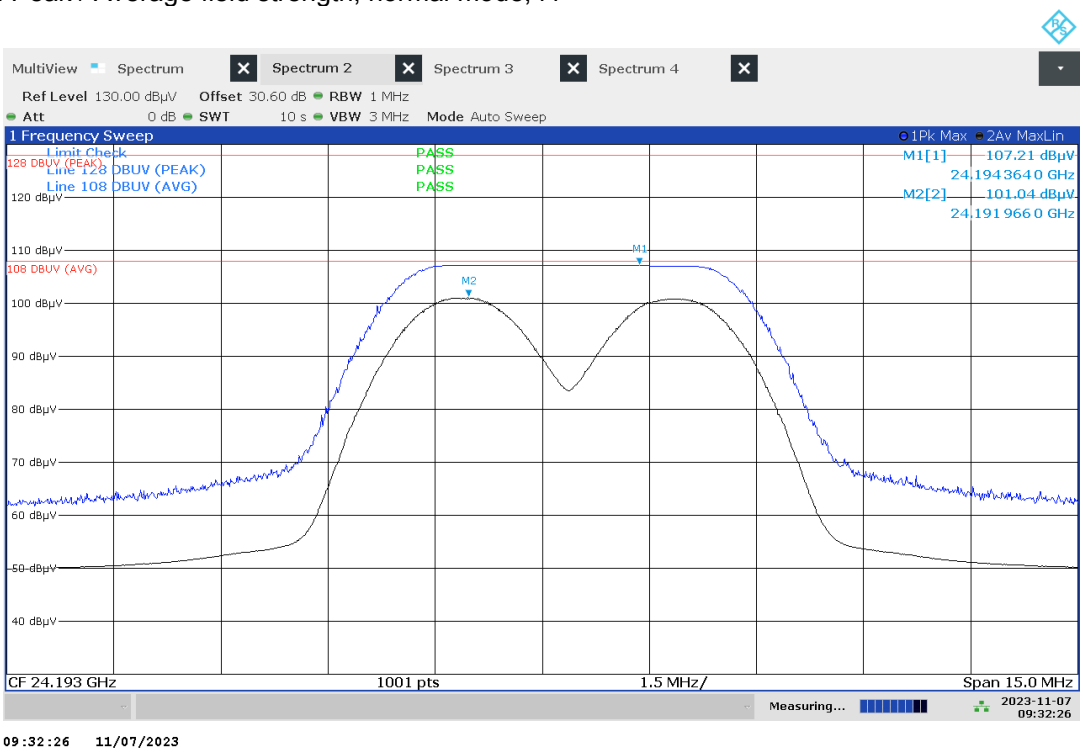
Test results

EUT mode	EUT	Test distance	AVG field strength [dBµV/m]	PK field strength [dBµV/m]
Normal	f1	1 m	107.5	101.4
Normal	f4	1 m	107.2	101.0
Normal	f8	1 m	107.0	100.9

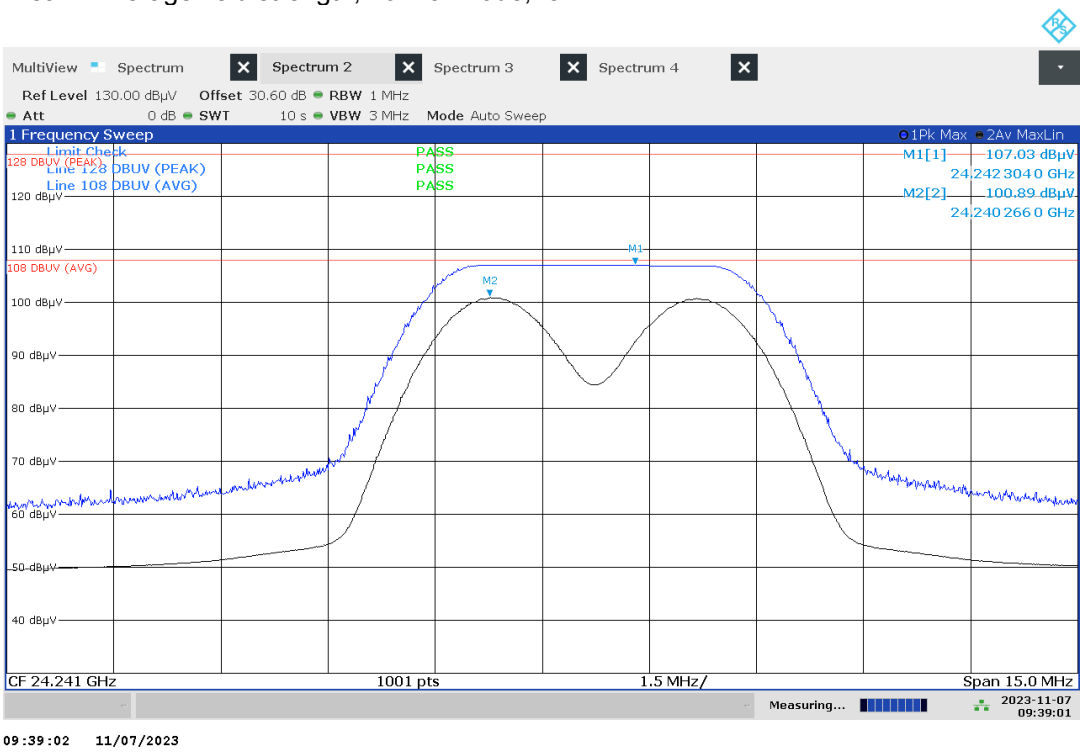
Plot no. 20: Peak / Average field strength, normal mode, f1



Plot no. 21: Peak / Average field strength, normal mode, f4



Plot no. 22: Peak / Average field strength, normal mode, f8



7.4 Field strength of emissions (spurious and harmonics)

Description / Limits

§15.249 (a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency	Field strength of fundamental	Field strength of harmonics
902 – 928 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
2400 – 2483.5 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
5725 – 5875 MHz	50 mV/m (94 dBµV/m)	500 µV/m (54 dBµV/m)
24.00 – 24.25 GHz	250 mV/m (108 dBµV/m)	2500 µV/m (68 dBµV/m)

§15.249 (c) Field strength limits are specified at a distance of 3 meters.

§15.249 (d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation:

Frequency	Field Strength	Measurement distance
0.009 – 0.490 MHz	2400/F[kHz] µV/m	300 m
0.490 – 1.705 MHz	24000/F[kHz] µV/m	30 m
1.705 – 30.0 MHz	30.0 µV/m / 29.5 dBµV/m	30 m
30 – 88 MHz	100 µV/m / 40.0 dBµV/m	3 m
88 – 216 MHz	150 µV/m / 43.5 dBµV/m	3 m
216 – 960 MHz	200 µV/m / 46.0 dBµV/m	3 m
960 – 100 000 MHz	500 µV/m / 54.0 dBµV/m	3 m

§15.249 (e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

Test procedure

§15.31 (c) Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

§15.31 (m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range	Number of frequencies	Location
< 1MHz bandwidth	1	middle
1 – 10 MHz bandwidth	2	1 near bottom and 1 near top
> 10 MHz bandwidth	3	1 near bottom / middle / top

§15.35 (b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g.,see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

§15.35 (c) Unless otherwise specified, e.g., §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Calculation of the far field distance (Rayleigh distance):

The aperture dimensions of these horn antennas shall be small enough so that the measurement distance in meters is equal to or greater than the Rayleigh distance (i.e. $R_m = 2D^2 / \lambda$), where D is the largest linear dimension (i.e. width or height) of the antenna aperture in m and λ is the free-space wavelength in meters at the frequency of measurement.

Antenna type	Frequency range [GHz]	D [m]	Highest frequency in use [GHz]	Far field distance R_m [m]
20240-20	17.6 – 26.7	0.0520	26.5	0.478
22240-20	26.4 – 40.1	0.0342	40	0.312
23240-20	33.0 – 50.1	0.0280	50	0.261
24240-20	39.3 – 59.7	0.0230	60	0.212
25240-20	49.9 – 75.8	0.0185	75	0.171
26240-20	60.5 – 91.5	0.0150	90	0.135
27240-20	73.8 – 112	0.0124	110	0.113

Typical test distances

Up to 18 GHz: 3.00 m
18 – 40 GHz: 1.00 m
40 – 60 GHz: 0.50 m
60 – 90 GHz: 0.30 m
90 – 100 GHz: 0.20 m
In-band / OOB: 1.00 m

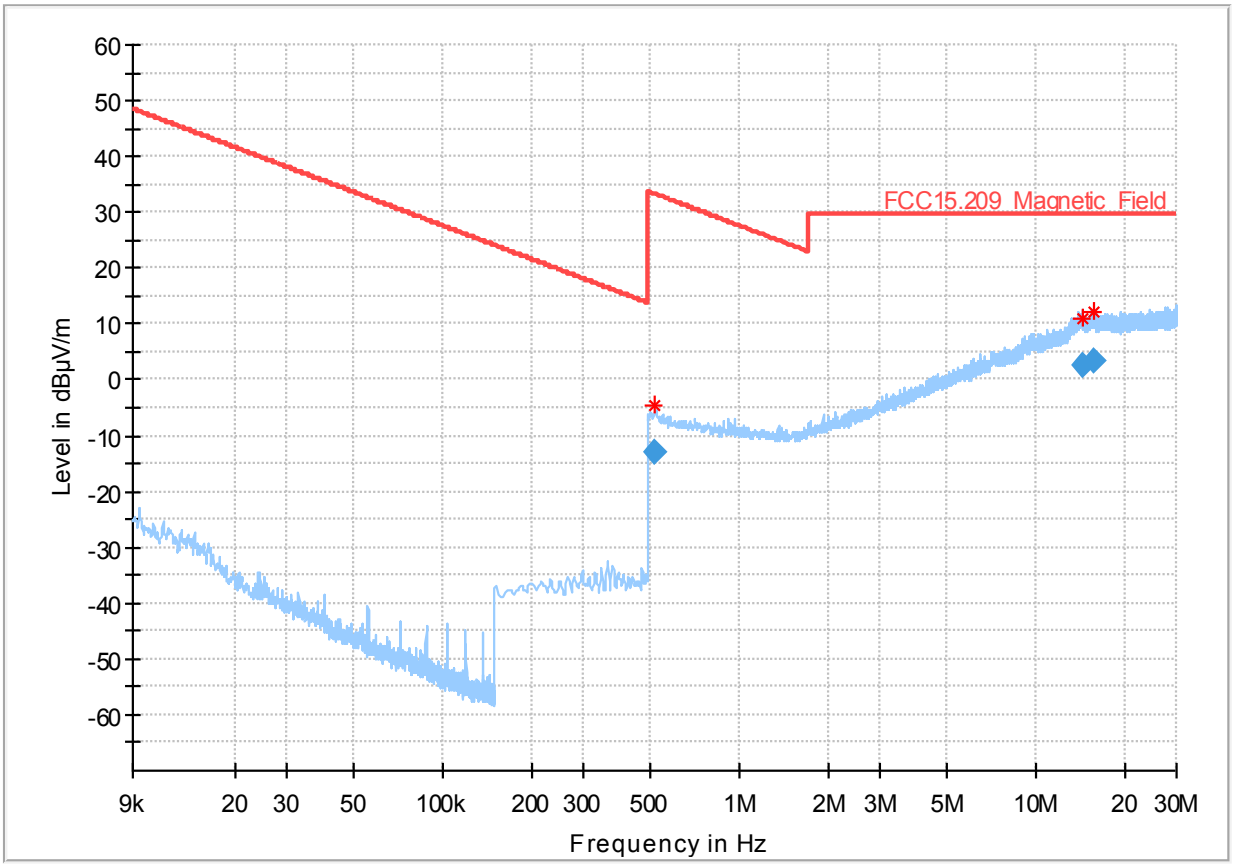
Test setup: 8.1 – 8.4

Test distance correction factor of 20dB/decade is already considered in the plots / result table.

Test results:

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]

Plot no. 23: radiated emissions 9 kHz – 30 MHz, loop antenna, f1



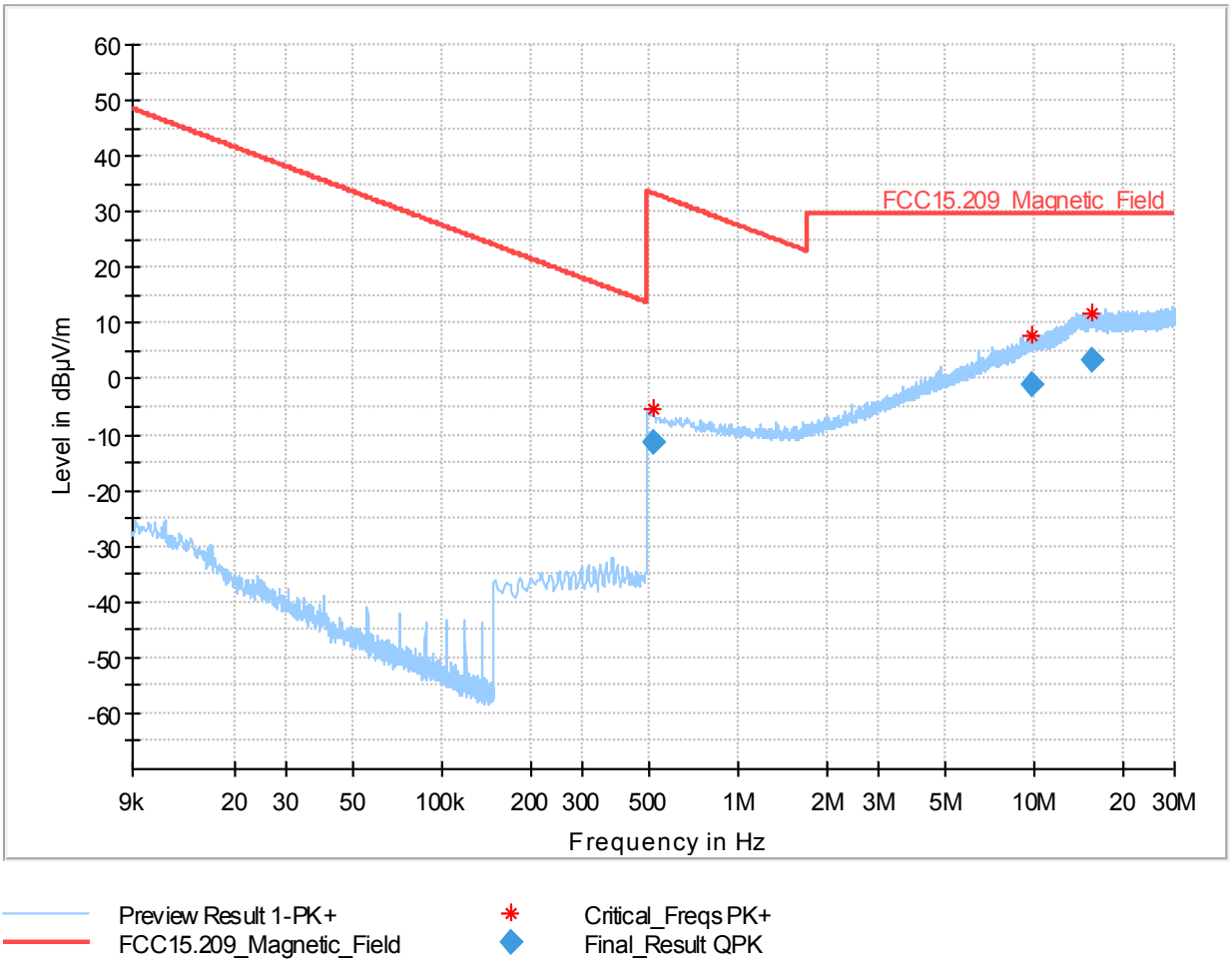
Preview Result 1-PK+
FCC15.209_Magnetic_Field
Critical_Freqs PK+
Final_Result QPK

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.523500	-12.85	33.23	46.08	100.0	9.000	V	30.0	-19.6
14.415000	2.47	29.54	27.07	100.0	9.000	V	165.0	-0.3
15.796500	3.24	29.54	26.30	100.0	9.000	V	255.0	0.4

Note:
The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y - 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-GEN Table 6 limit as it has to the 15.209(a) limit.
(Certification & Engineering Bureau, Q&A on Certification Procedures and Requirements, TCB Workshop April 2020, Nicolas DesMarais, 2020-04-09 - ISED Q&A - DesMarais.pdf)

Plot no. 24: radiated emissions 9 kHz – 30 MHz, loop antenna, f4

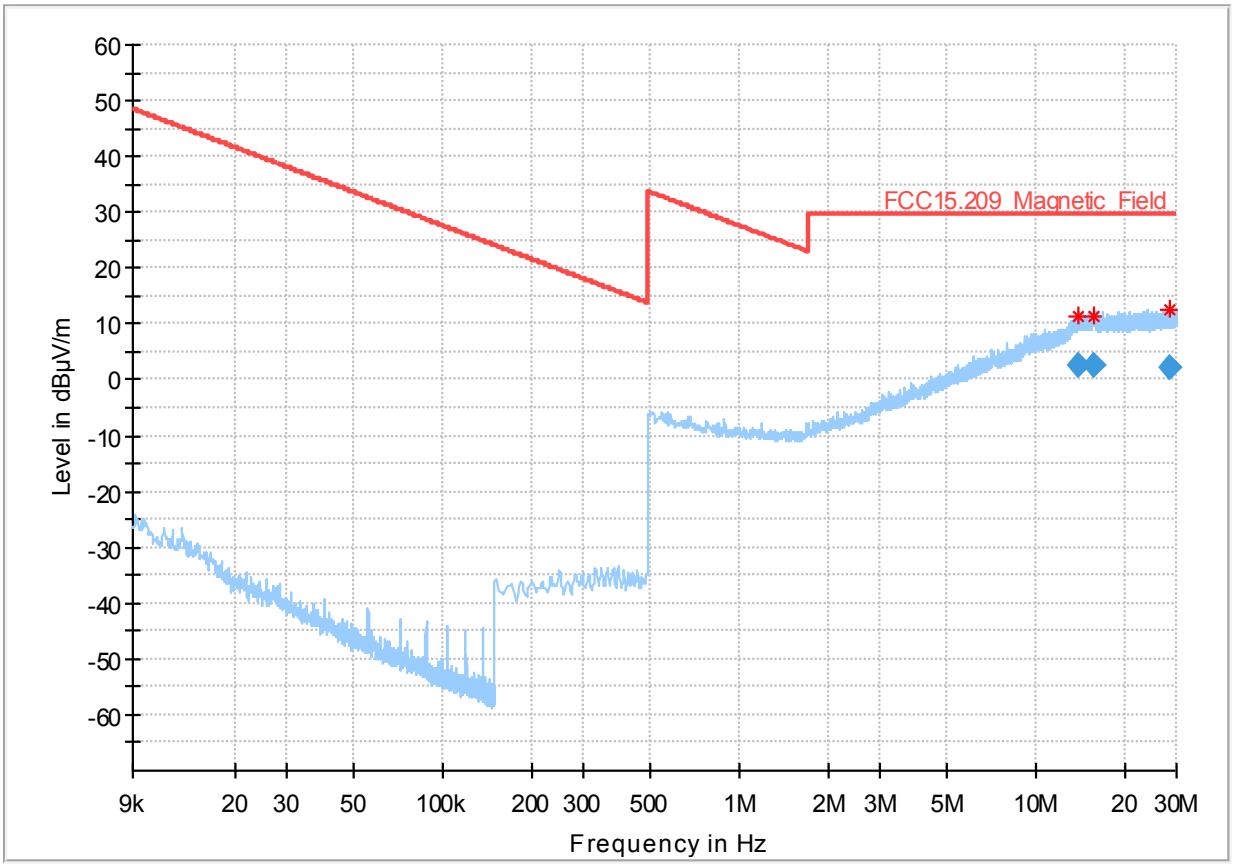


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.519000	-11.53	33.30	44.83	100.0	9.000	V	-10.0	-19.6
9.876750	-1.13	29.54	30.67	100.0	9.000	V	210.0	-3.5
15.787500	3.33	29.54	26.21	100.0	9.000	V	30.0	0.4

Note:
The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y - 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-GEN Table 6 limit as it has to the 15.209(a) limit.
(Certification & Engineering Bureau, Q&A on Certification Procedures and Requirements, TCB Workshop April 2020, Nicolas DesMarais, 2020-04-09 - ISED Q&A - DesMarais.pdf)

Plot no. 25: radiated emissions 9 kHz – 30 MHz, loop antenna, f8

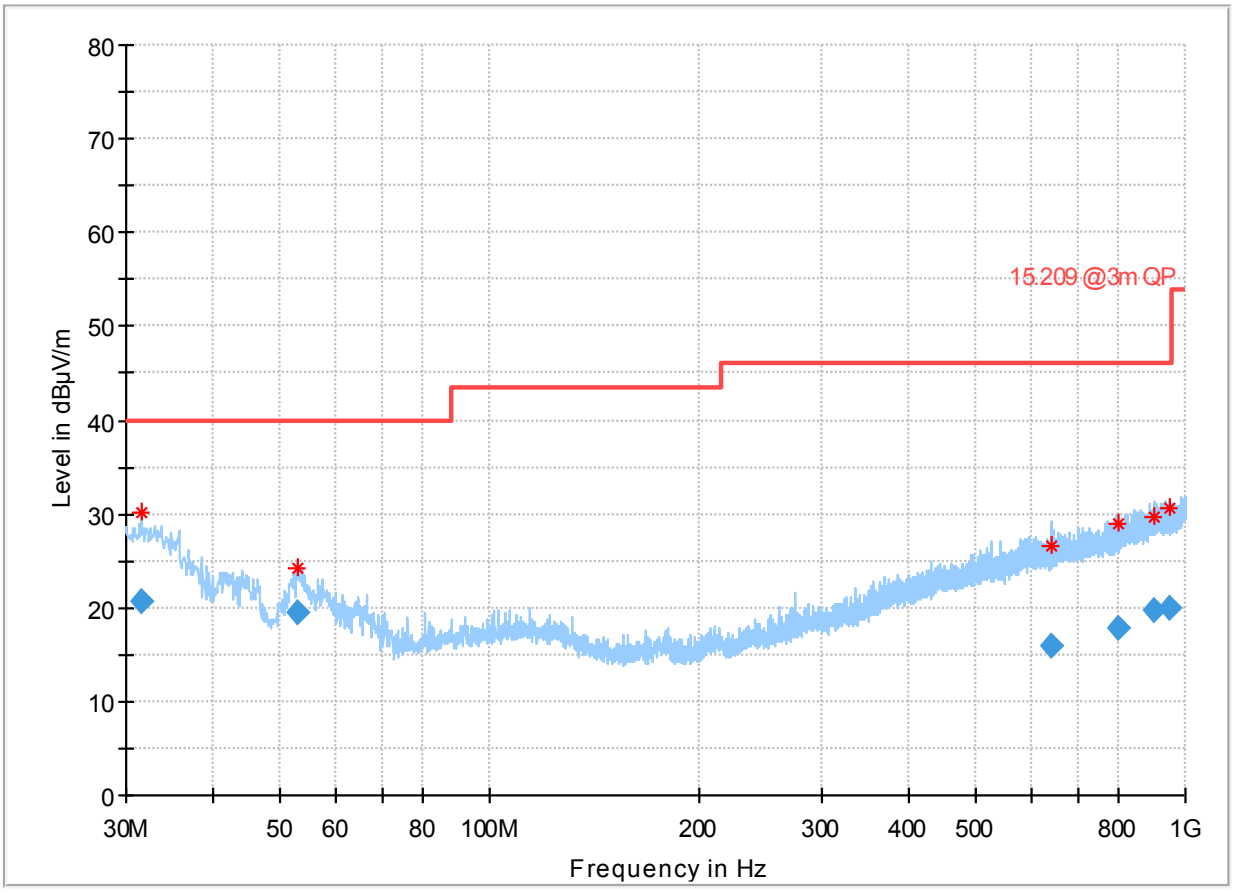


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
13.956000	2.51	29.54	27.03	100.0	9.000	V	-10.0	-0.6
15.929250	2.59	29.54	26.95	100.0	9.000	V	260.0	0.5
28.344750	2.05	29.54	27.49	100.0	9.000	V	165.0	0.8

Note:
The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y - 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-GEN Table 6 limit as it has to the 15.209(a) limit.
(Certification & Engineering Bureau, Q&A on Certification Procedures and Requirements, TCB Workshop April 2020, Nicolas DesMarais, 2020-04-09 - ISED Q&A - DesMarais.pdf)

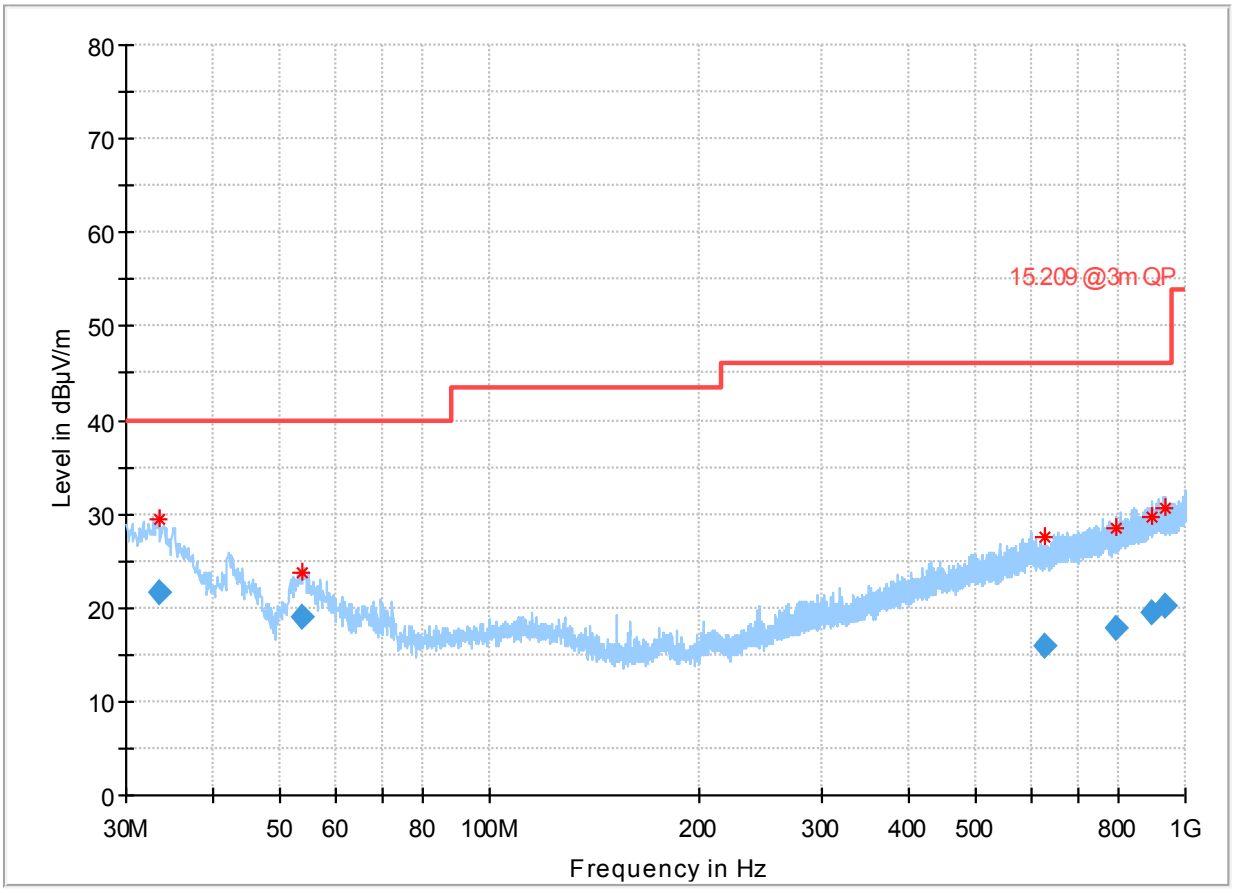
Plot no. 26: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f1



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
31.552000	20.55	40.00	19.45	100.0	120.000	103.0	V	357.0
53.072000	19.47	40.00	20.53	100.0	120.000	104.0	V	354.0
640.936000	15.86	46.00	30.14	100.0	120.000	148.0	V	203.0
798.637000	17.88	46.00	28.12	100.0	120.000	147.0	H	182.0
901.718000	19.70	46.00	26.30	100.0	120.000	136.0	H	122.0
947.897000	19.90	46.00	26.10	100.0	120.000	103.0	V	195.0

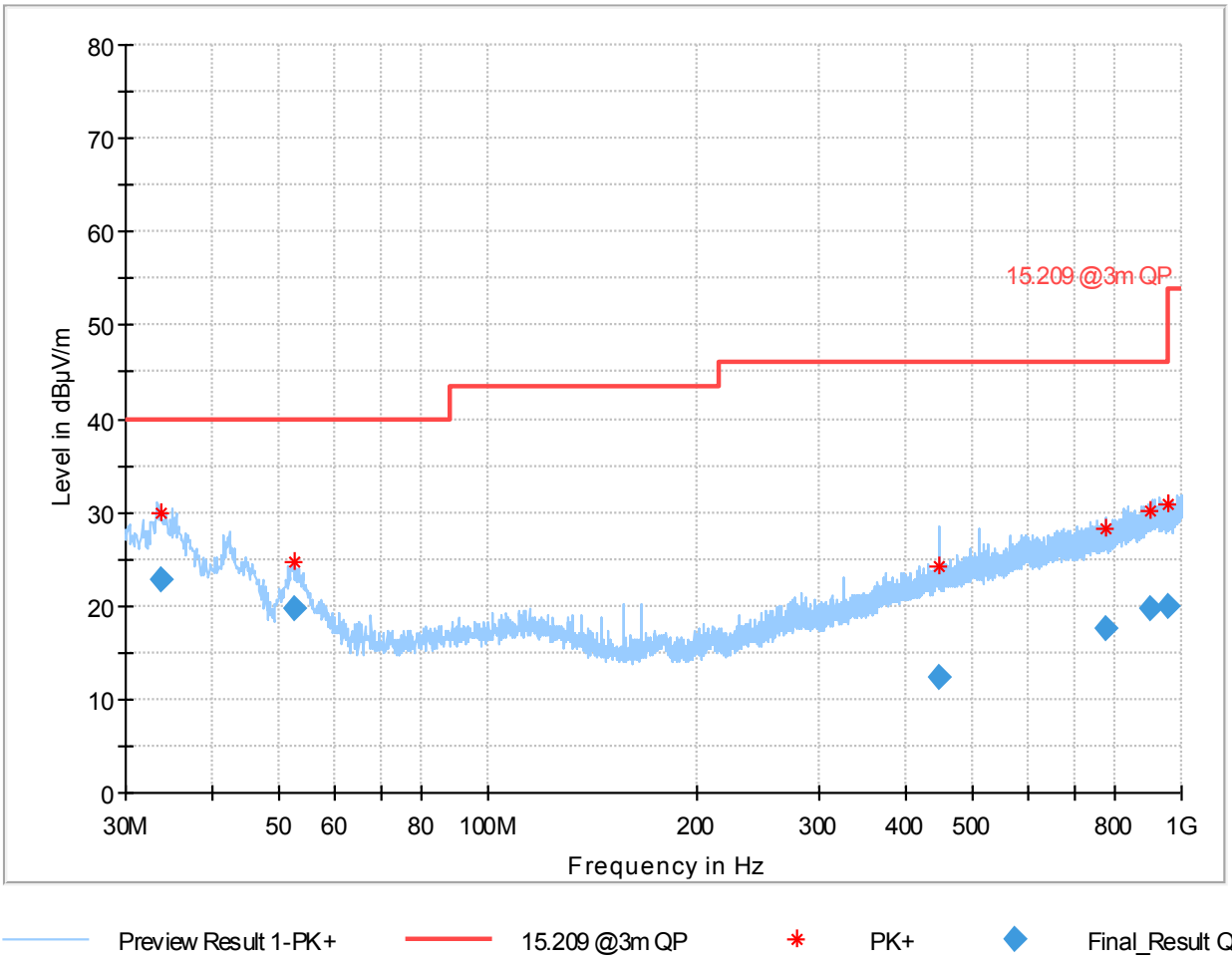
Plot no. 27: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f4



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
33.395000	21.55	40.00	18.45	100.0	120.000	100.0	V	73.0
53.763000	19.02	40.00	20.98	100.0	120.000	103.0	V	227.0
625.883000	15.99	46.00	30.01	100.0	120.000	253.0	V	105.0
797.508000	17.81	46.00	28.19	100.0	120.000	325.0	H	93.0
892.459000	19.37	46.00	26.63	100.0	120.000	287.0	H	34.0
932.814000	20.17	46.00	25.83	100.0	120.000	103.0	V	182.0

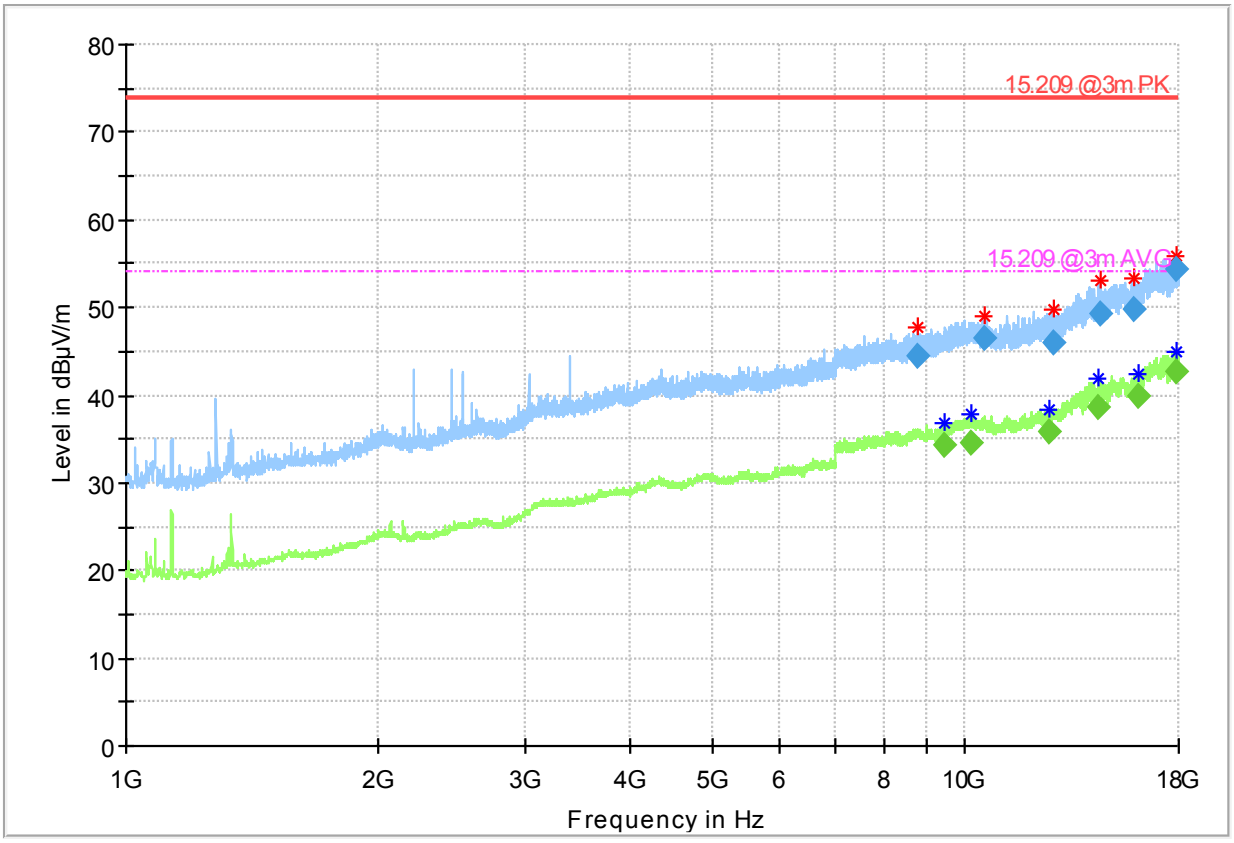
Plot no. 28: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f8



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
33.778000	22.86	40.00	17.14	100.0	120.000	103.0	V	-20.0
52.677000	19.61	40.00	20.39	100.0	120.000	100.0	V	311.0
447.920000	12.41	46.00	33.59	100.0	120.000	119.0	V	240.0
778.216000	17.68	46.00	28.32	100.0	120.000	103.0	V	246.0
900.201000	19.80	46.00	26.20	100.0	120.000	146.0	H	245.0
958.500000	20.03	46.00	25.97	100.0	120.000	148.0	H	204.0

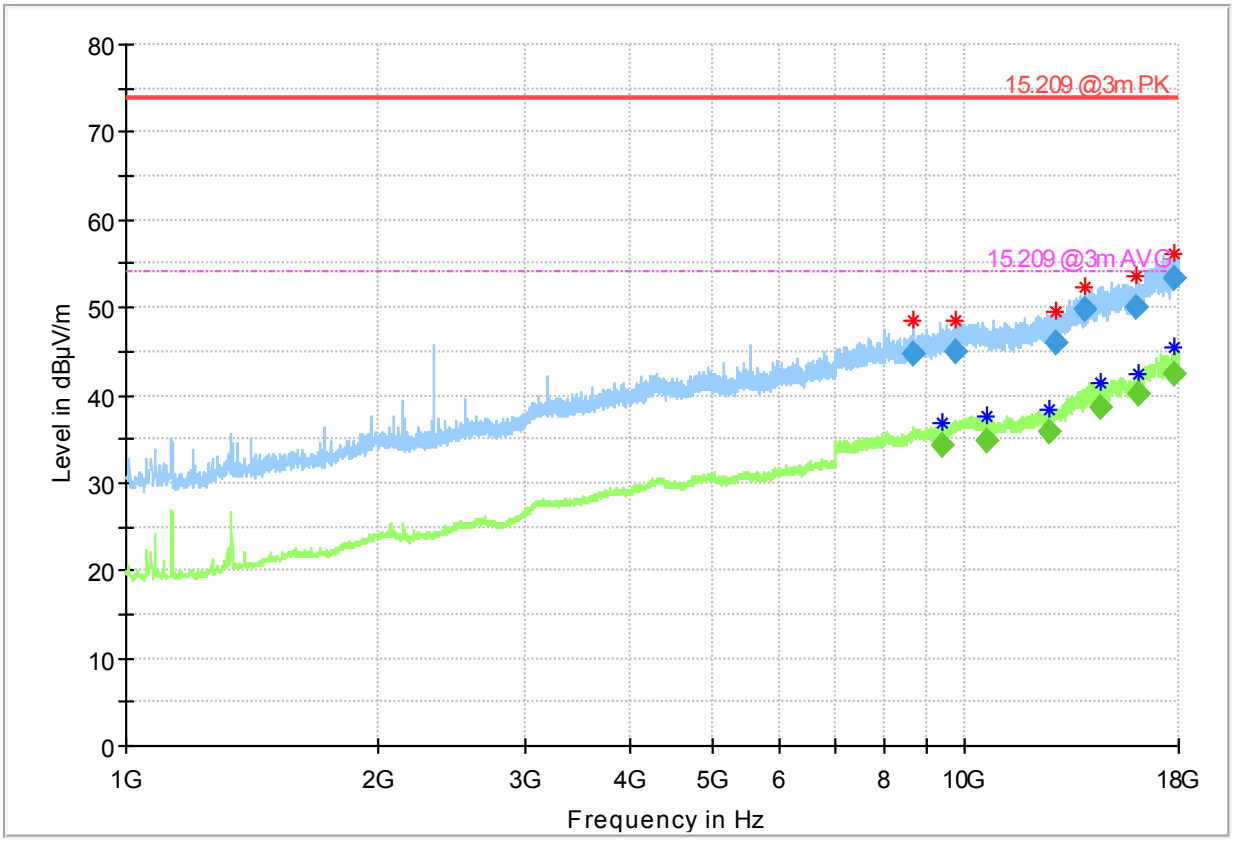
Plot no. 29: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, f1



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8814.146667	44.52	---	74.00	29.48	100.0	1000.000	150.0	H
9471.125833	---	34.19	54.00	19.81	100.0	1000.000	150.0	V
10171.664166	---	34.51	54.00	19.49	100.0	1000.000	150.0	H
10570.444167	46.48	---	74.00	27.52	100.0	1000.000	150.0	V
12647.522500	---	35.83	54.00	18.17	100.0	1000.000	150.0	H
12794.021666	45.96	---	74.00	28.04	100.0	1000.000	150.0	V
14479.339167	---	38.62	54.00	15.38	100.0	1000.000	150.0	H
14552.730000	49.22	---	74.00	24.78	100.0	1000.000	150.0	V
15913.969167	49.88	---	74.00	24.12	100.0	1000.000	150.0	H
16136.408333	---	39.87	54.00	14.13	100.0	1000.000	150.0	H
17866.253333	---	42.55	54.00	11.45	100.0	1000.000	150.0	H
17900.071667	54.32	---	74.00	19.68	100.0	1000.000	150.0	H

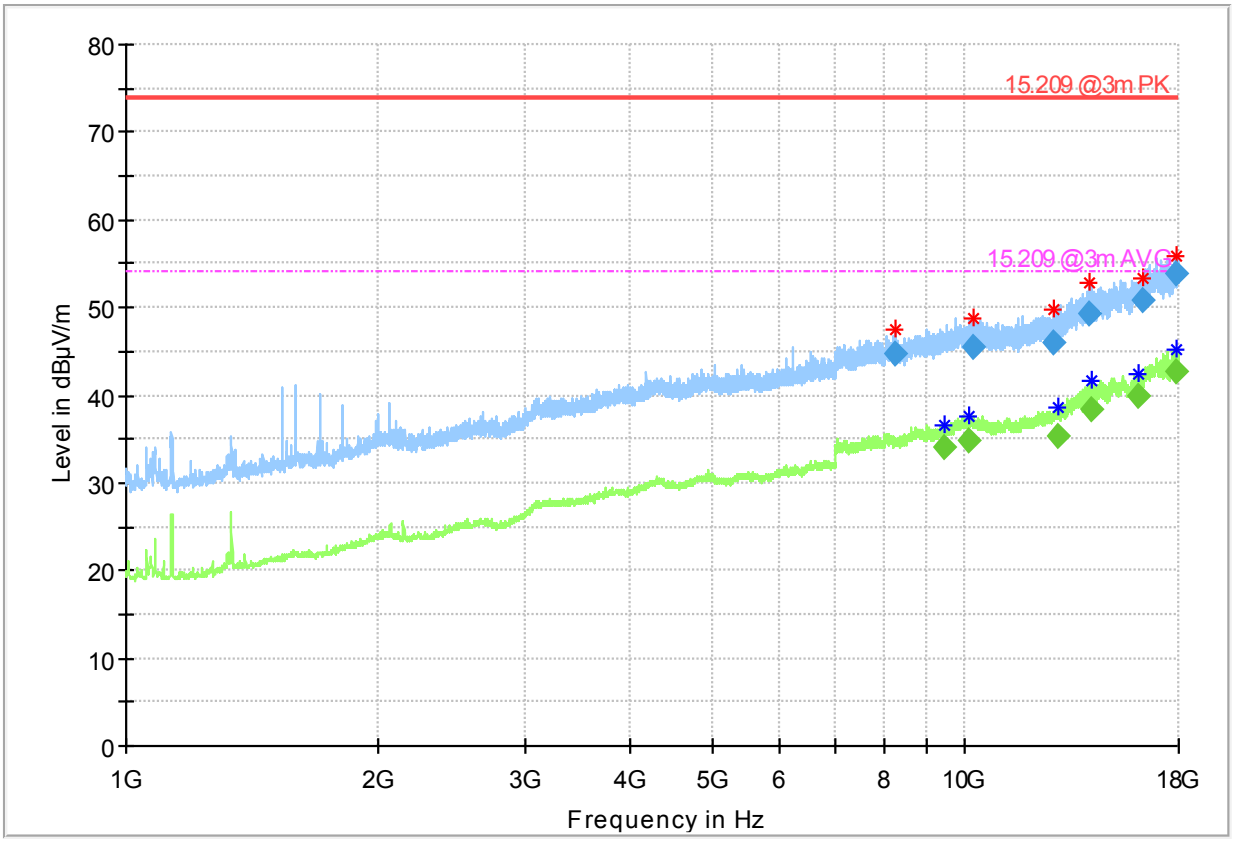
Plot no. 30: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, f4



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8696.089167	44.79	---	74.00	29.21	100.0	1000.000	150.0	V
9430.323334	---	34.39	54.00	19.61	100.0	1000.000	150.0	V
9778.792500	44.97	---	74.00	29.03	100.0	1000.000	150.0	V
10603.716667	---	34.85	54.00	19.15	100.0	1000.000	150.0	H
12645.243333	---	35.86	54.00	18.14	100.0	1000.000	150.0	V
12868.210000	46.00	---	74.00	28.00	100.0	1000.000	150.0	V
13883.224166	49.80	---	74.00	24.20	100.0	1000.000	150.0	H
14546.019166	---	38.60	54.00	15.40	100.0	1000.000	150.0	V
16046.536666	50.07	---	74.00	23.93	100.0	1000.000	150.0	V
16141.285000	---	40.10	54.00	13.90	100.0	1000.000	150.0	V
17795.535000	---	42.35	54.00	11.65	100.0	1000.000	150.0	V
17835.091666	53.45	---	74.00	20.55	100.0	1000.000	150.0	V

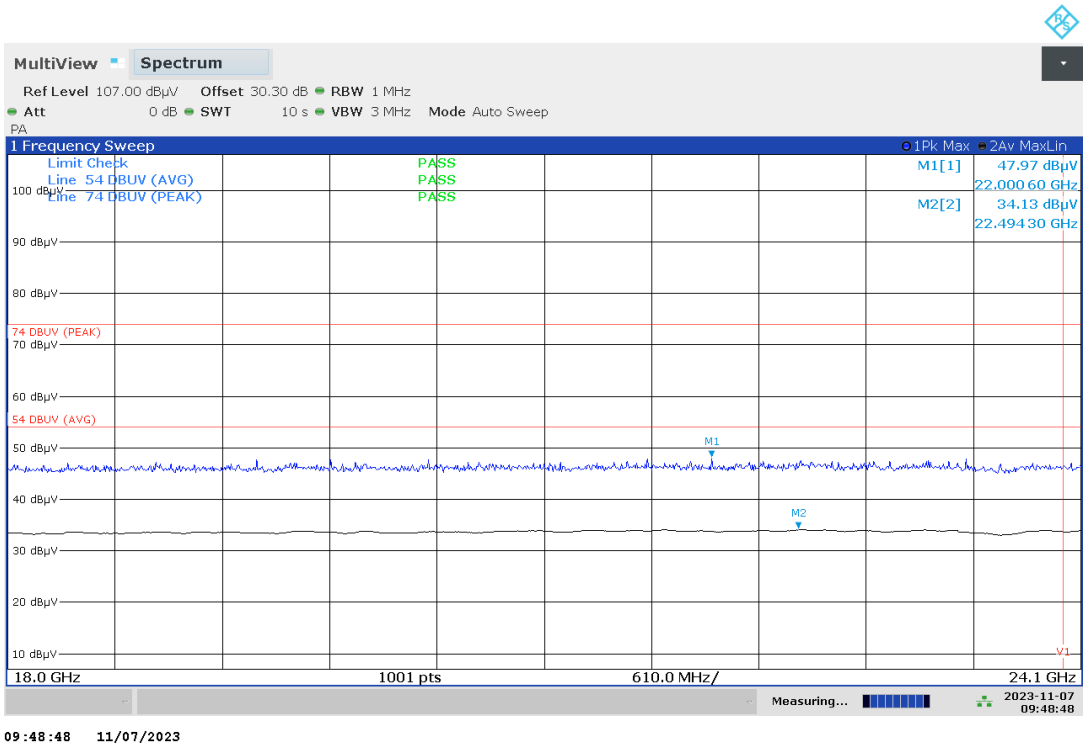
Plot no. 31: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, f8



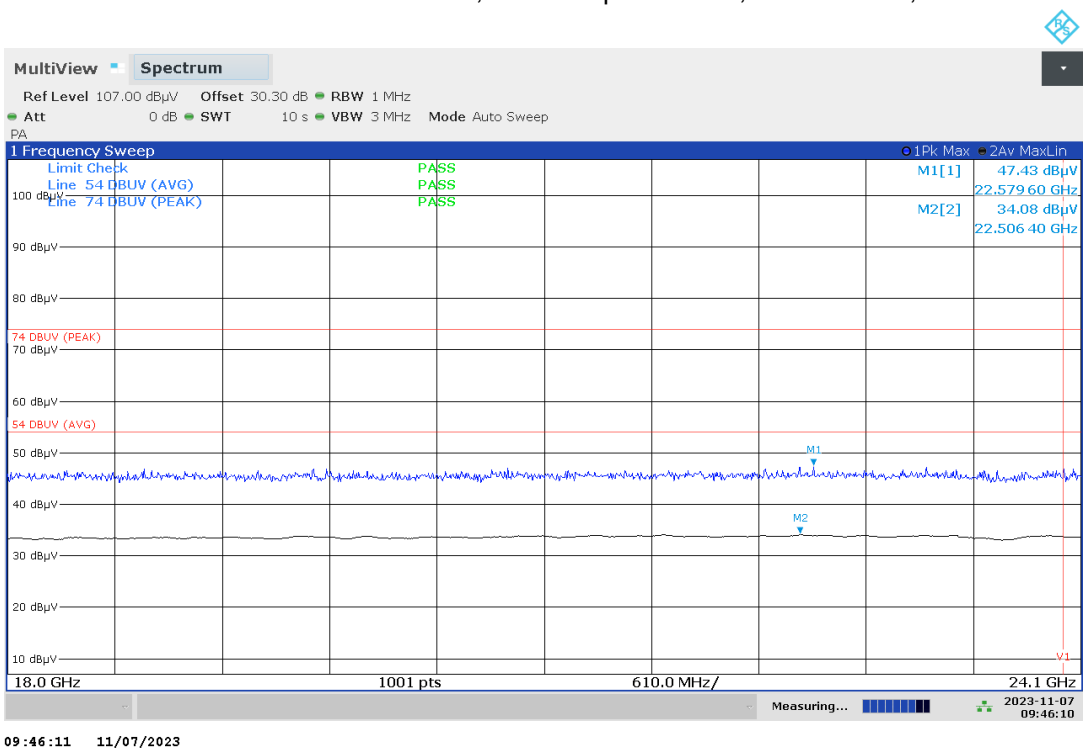
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8286.398334	44.74	---	74.00	29.26	100.0	1000.000	150.0	V
9440.109167	---	34.14	54.00	19.86	100.0	1000.000	150.0	H
10135.456667	---	34.69	54.00	19.31	100.0	1000.000	150.0	H
10272.354167	45.46	---	74.00	28.54	100.0	1000.000	150.0	H
12787.379166	46.07	---	74.00	27.93	100.0	1000.000	150.0	V
12894.769167	---	35.37	54.00	18.63	100.0	1000.000	150.0	H
14116.695000	49.22	---	74.00	24.78	100.0	1000.000	150.0	H
14176.669167	---	38.47	54.00	15.53	100.0	1000.000	150.0	V
16152.829166	---	39.84	54.00	14.16	100.0	1000.000	150.0	V
16279.700000	50.75	---	74.00	23.25	100.0	1000.000	150.0	V
17901.331666	---	42.70	54.00	11.30	100.0	1000.000	150.0	H
17906.524167	53.92	---	74.00	20.08	100.0	1000.000	150.0	H

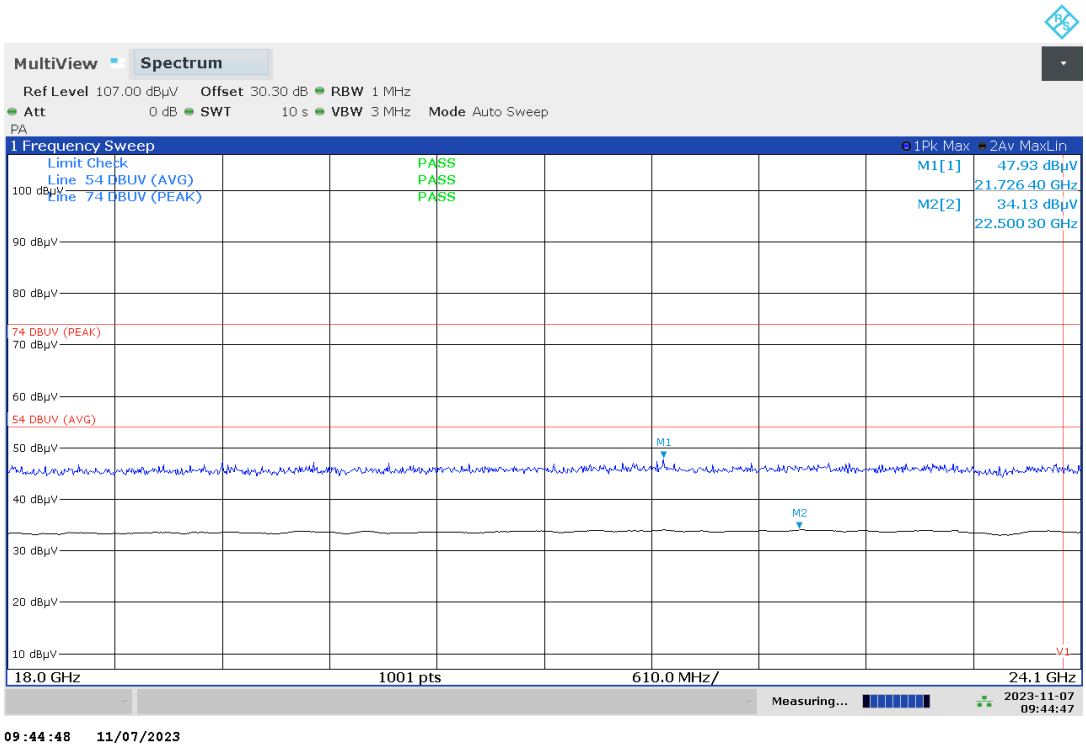
Plot no. 32: radiated emissions 18 GHz – 24.1 GHz, hor./vert. polarization, normal mode, f1



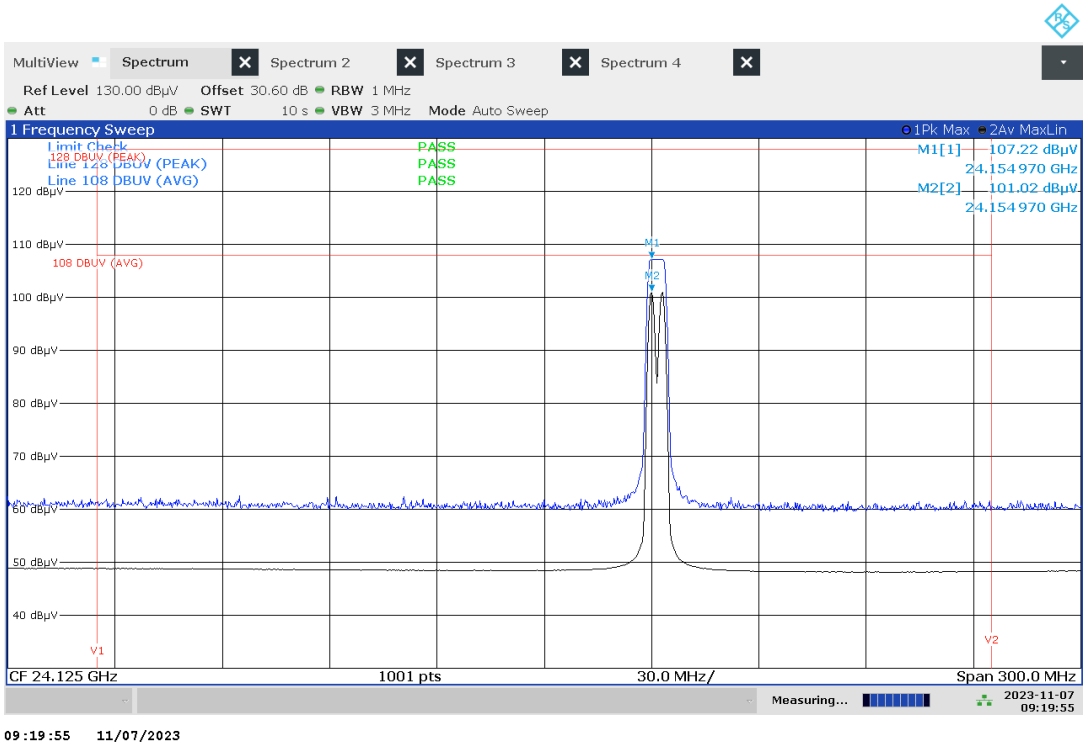
Plot no. 33: radiated emissions 18 GHz – 24.1 GHz, hor./vert. polarization, normal mode, f4



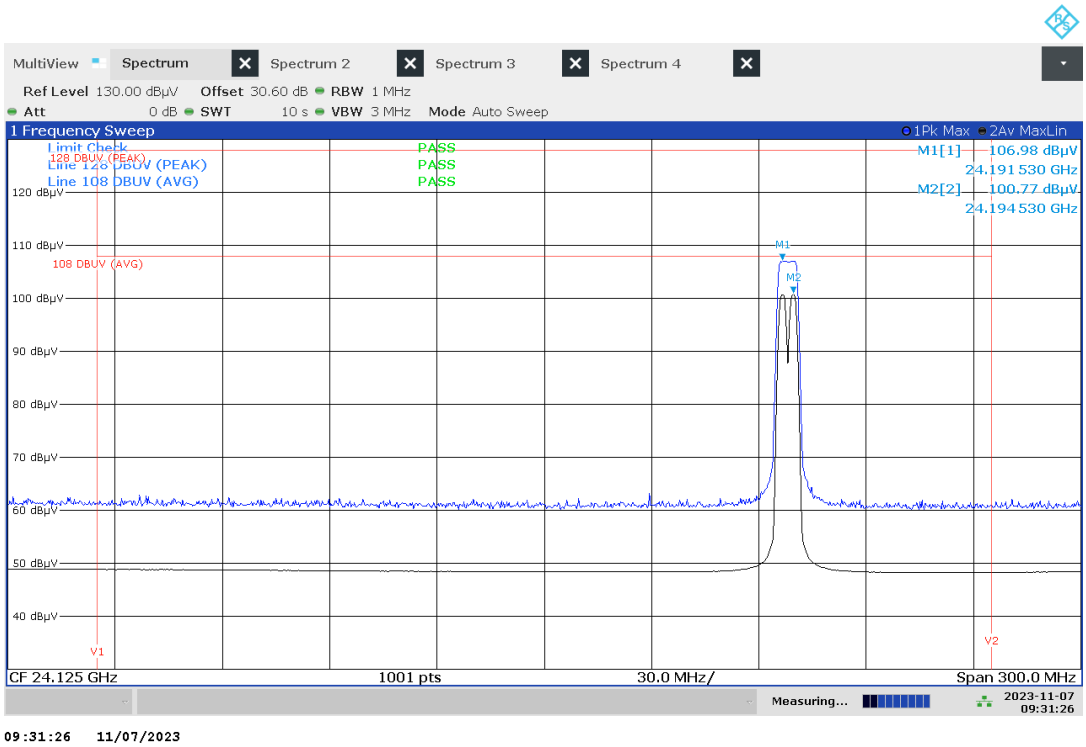
Plot no. 34: radiated emissions 18 GHz – 24.1 GHz, hor./vert. polarization, normal mode, f8



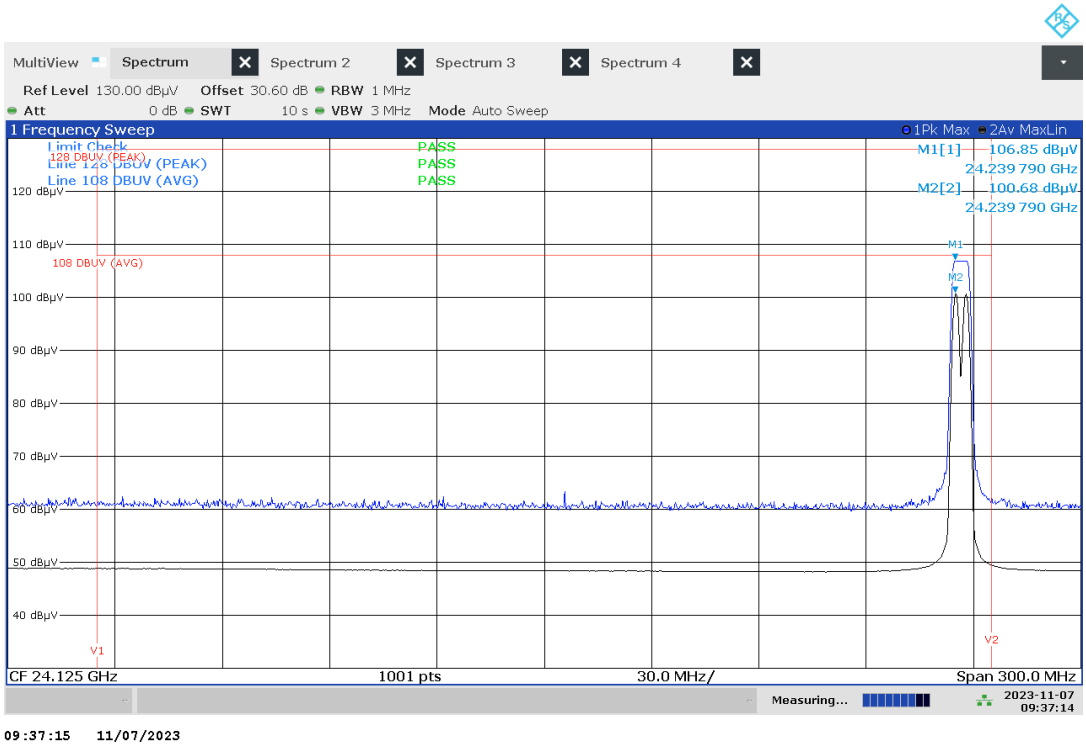
Plot no. 35: band edge compliance 24 GHz – 24.25 GHz, hor./vert. polarization, normal mode, f1



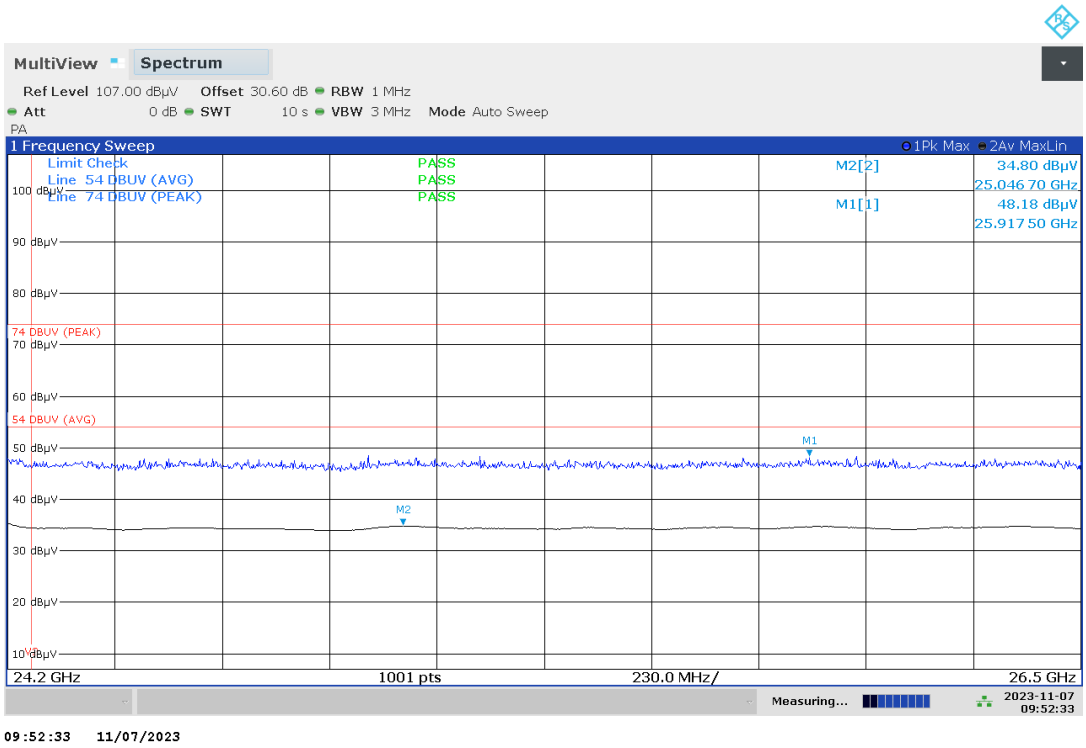
Plot no. 36: band edge compliance 24 GHz – 24.25 GHz, hor./vert. polarization, normal mode, f4



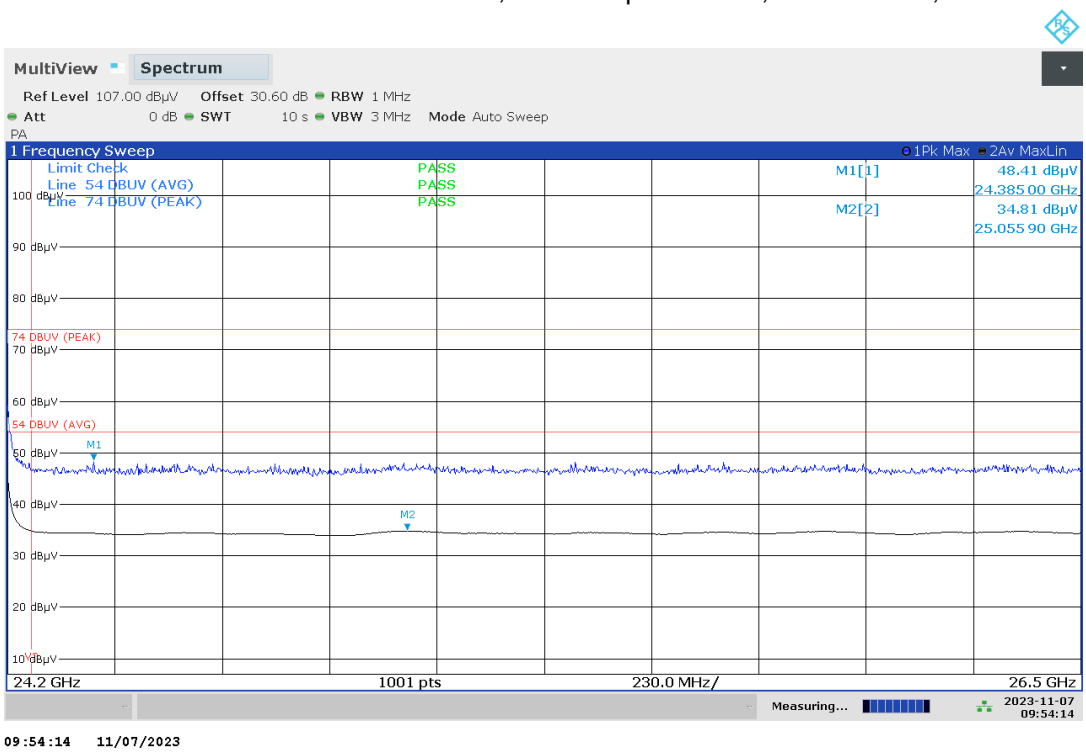
Plot no. 37: band edge compliance 24 GHz – 24.25 GHz, hor./vert. polarization, normal mode, f8



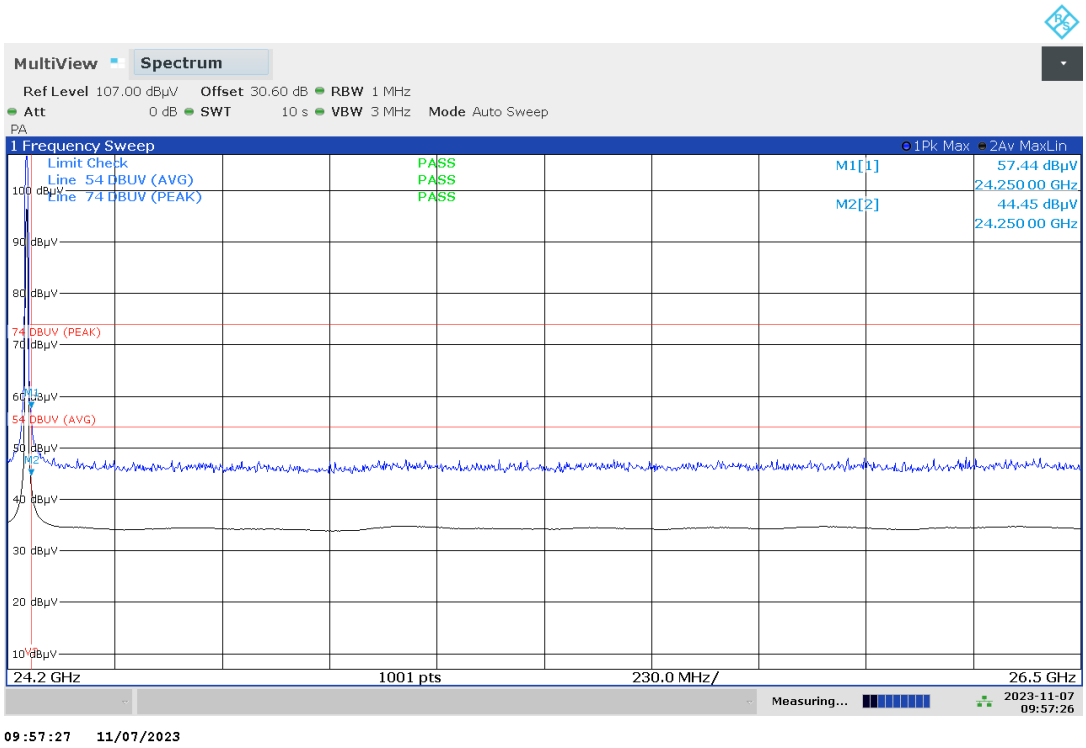
Plot no. 38: radiated emissions 24.2 GHz – 26.5 GHz, hor./vert. polarization, normal mode, f1



Plot no. 39: radiated emissions 24.2 GHz – 26.5 GHz, hor./vert. polarization, normal mode, f4



Plot no. 40: radiated emissions 24.2 GHz – 26.5 GHz, hor./vert. polarization, normal mode, f8



Plot no. 41: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, normal mode, f1 & f4 & f8