DAkkS Deutsche Akkreditierungsstelle D-PL-21375-01-00

LENHARDT WORLDWIDE | TESTING | CERTIFICATION

Bundesnetzagentur BNetzA-CAB-21/21-21

Test Report

Test report no.: 23089057-35993-1
Date of issue: 2024-02-09

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

Applicant
RFbeam Microwave GmbH

Manufacturer
RFbeam Microwave GmbH

Test Item
K-LD2-FLK

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

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

Applicant and Test item details	
Applicant	RFbeam Microwave GmbH Schuppisstrasse 7 9016, St. Gallen, Switzerland Fon: +41 71 245 33 80
Manufacturer	RFbeam Microwave GmbH Schuppisstrasse 7 9016, St. Gallen, Switzerland
Test item description	24 GHz field disturbance sensor
Model/Type reference	K-LD2-FLK
Standard specific information	
FCC ID	2ASYV-K-LD2-FLK
Frequency	24.05 GHz – 24.25 GHz
Antenna	PCB antenna
Power supply	3.2 – 5.5 V DC
Temperature range	-40 °C – +85 °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	2024-02-06
Start – End of tests	2024-02-06 – 2024-02-08

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS) – the measured value is below the acceptance limit, AL = TL
Test sample does not meet the requirements	F (FAIL) – the measured value is above the acceptance limit, AL = TL
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

-1 Revision: Plot No. 46 replaced / corrected

This test report 23089057-35993-1 replaces the previous test report 23089057-35993-0.
Utilisation, publication and control of previous report editions is under applicant's responsibility.

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	-40 °C	20 °C	+85 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	3.2 V DC	3.3 V DC	5.5 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

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*	K-LD2-FLK
Serial number*	#1
Hardware status*	B
Software status*	01

*: as declared by applicant

5.3 Technical data of test item

Operational frequency band*	24.05 GHz – 24.25 GHz
Operational carrier frequency*	f1 = 24.080 GHz, f2 = 24.108 GHz, f3 = 24.136 GHz, f4 = 24.164 GHz, f5 = 24.192 GHz, f6 = 24.220 GHz
Type of radio transmission*	Modulated carrier
Modulation type*	Pulsed CW
Number of channels*	6
Channel bandwidth*	<10 MHz
Duty cycle*	~4.5 %
Antenna*	PCB antenna
Power supply*	3.2 – 5.5 V DC
Temperature range*	-40 °C – +85 °C

*: as declared by applicant

5.4 Additional information

Model differences	– none –
Ancillaries tested with	evaluation board
Additional equipment used for testing	notebook with special test software for setting up the test frequencies low / mid / high

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15

Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§2.1049	Occupied bandwidth (99% bandwidth)	Normal	5.1 MHz	**- PASS -**
§15.215(c)	Transmitter frequency stability	Normal/Extreme	within band	**- PASS -**
§15.249(a)	Field strength of emissions (wanted signal)	Normal	PK: 106.0 dBµV AVG: 78.5 dBµV	**- PASS -**
§15.249(d)	Field strength of emissions (spurious & harmonics)	Normal	< limit	**- PASS -**
§15.207	AC conducted emissions	Normal	< limit	**- PASS -**

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.

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).

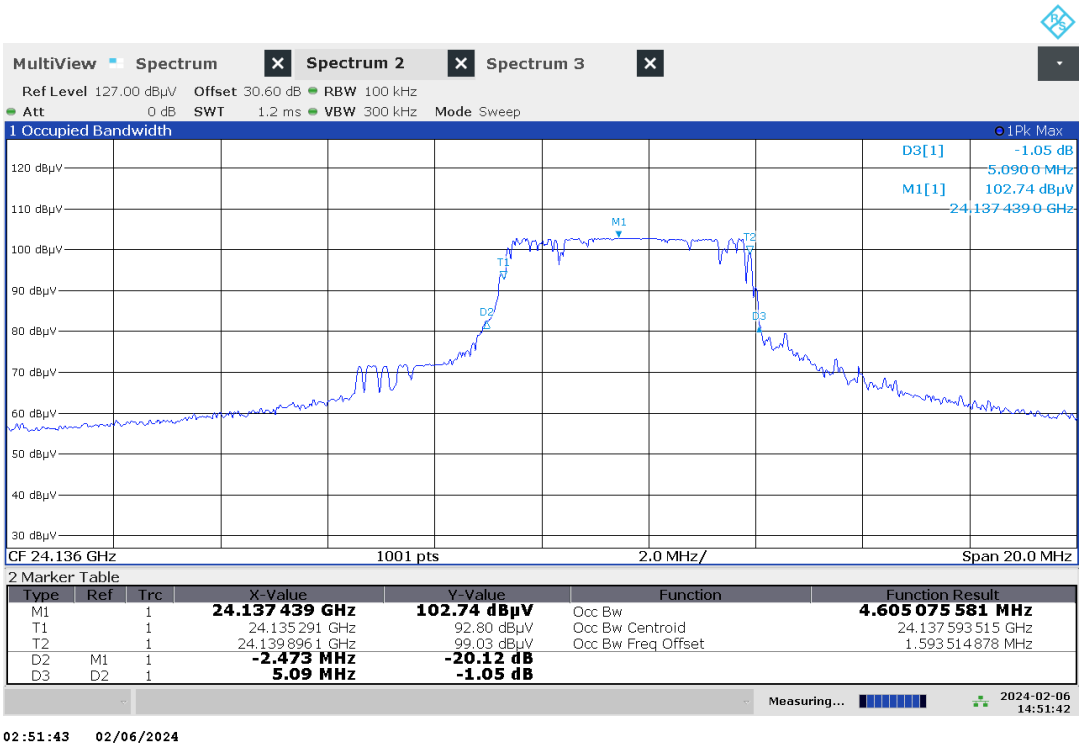
Test setup: 8.3 (test distance correction factor of 20dB/decade is already considered in the plots / result table)

Test results:

EUT mode	Test distance	f_L [GHz]	f_H [GHz]	99% OBW [MHz]
f_{low}	1 m	24.0797	24.0848	5.083
f_{mid}	1 m	24.1353	24.1399	4.605
f_{high}	1 m	24.2200	24.2239	3.886

Plot no. 1: 99% OBW, Peak detector, f_{low}

Plot no. 2: 99% OBW, Peak detector, f_{mid}



Plot no. 3: 99% OBW, Peak detector, f_{high}

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 (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

For showing compliance the 99% occupied bandwidth is tested.

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).

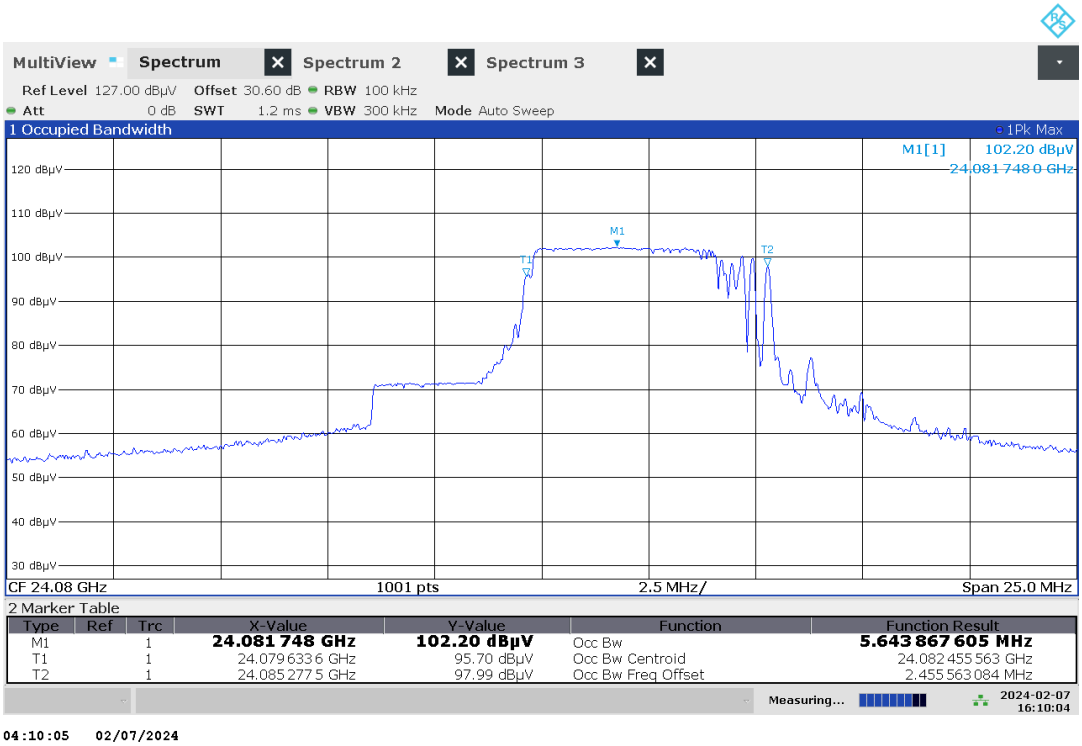
Test setup: 8.3 (EUT placed in climatic chamber)

Test results:

EUT mode	Temperature / Voltage	f_L [GHz]	f_H [GHz]	99% OBW [MHz]
f1	85 °C / V_{nom}	24.0796	24.0853	5.644
f1	70 °C / V_{nom}	**24.0788**	24.0846	5.763
f1	60 °C / V_{nom}	24.0796	24.0844	4.759
f1	50 °C / V_{nom}	24.0796	24.0841	4.553
f1	40 °C / V_{nom}	24.0798	24.0839	4.083
f1	30 °C / V_{nom}	24.0792	24.0848	5.530
f1	20 °C / $V_{mim - max}$	24.0799	24.0841	4.175
f1	10 °C / V_{nom}	24.0799	24.0841	4.176
f1	0 °C / V_{nom}	24.0802	24.0842	4.034
f1	-10 °C / V_{nom}	24.0799	24.0842	4.230
f1	-20 °C / V_{nom}	24.0806	24.0840	3.395
f1	-30 °C / V_{nom}	24.0801	24.0840	3.837
f1	-40 °C / V_{nom}	24.0793	24.0847	5.403
f6	85 °C / V_{nom}	24.2204	**24.2254**	5.053
f6	70 °C / V_{nom}	24.2203	24.2246	4.306
f6	60 °C / V_{nom}	24.2202	24.2249	4.726
f6	50 °C / V_{nom}	24.2196	24.2248	5.152
f6	40 °C / V_{nom}	24.2196	24.2244	4.854
f6	30 °C / V_{nom}	24.2195	24.2240	4.560
f6	20 °C / $V_{mim - max}$	24.2196	24.2246	5.013
f6	10 °C / V_{nom}	24.2198	24.2245	4.716
f6	0 °C / V_{nom}	24.2201	24.2239	3.823
f6	-10 °C / V_{nom}	24.2203	24.2246	4.308
f6	-20 °C / V_{nom}	24.2217	24.2239	2.224
f6	-30 °C / V_{nom}	24.2201	24.2243	4.118
f6	-40 °C / V_{nom}	24.2198	24.2242	4.324

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

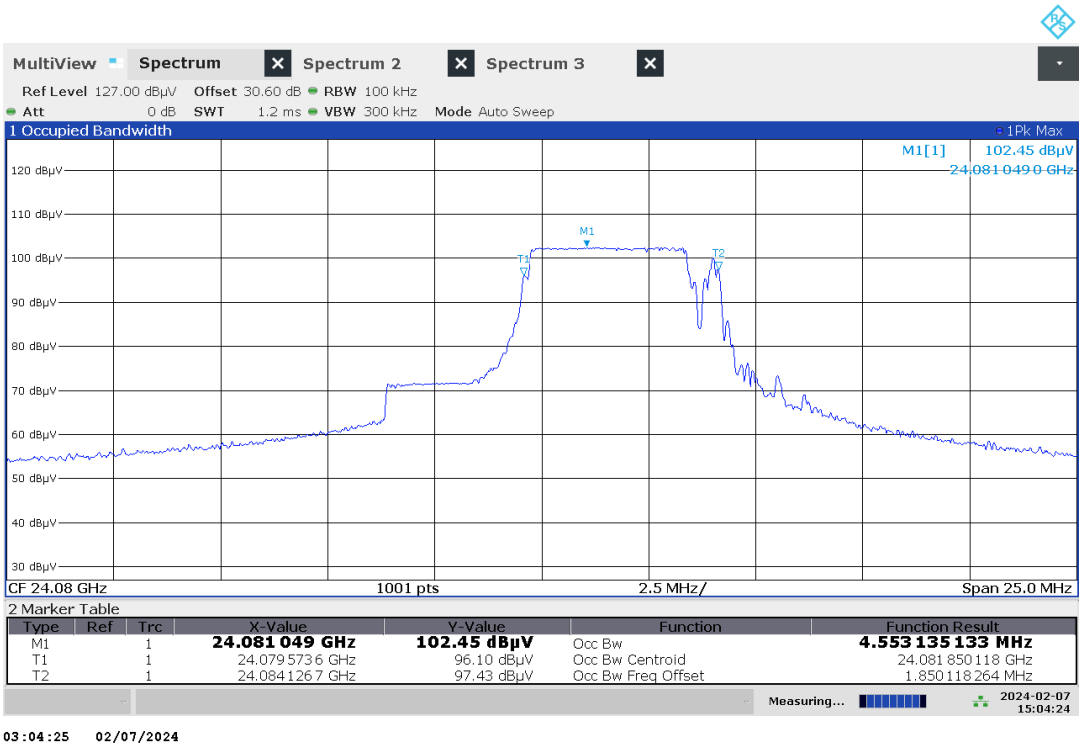
Plot no. 4: 99% OBW, f_{low}, Peak detector, 85 °C



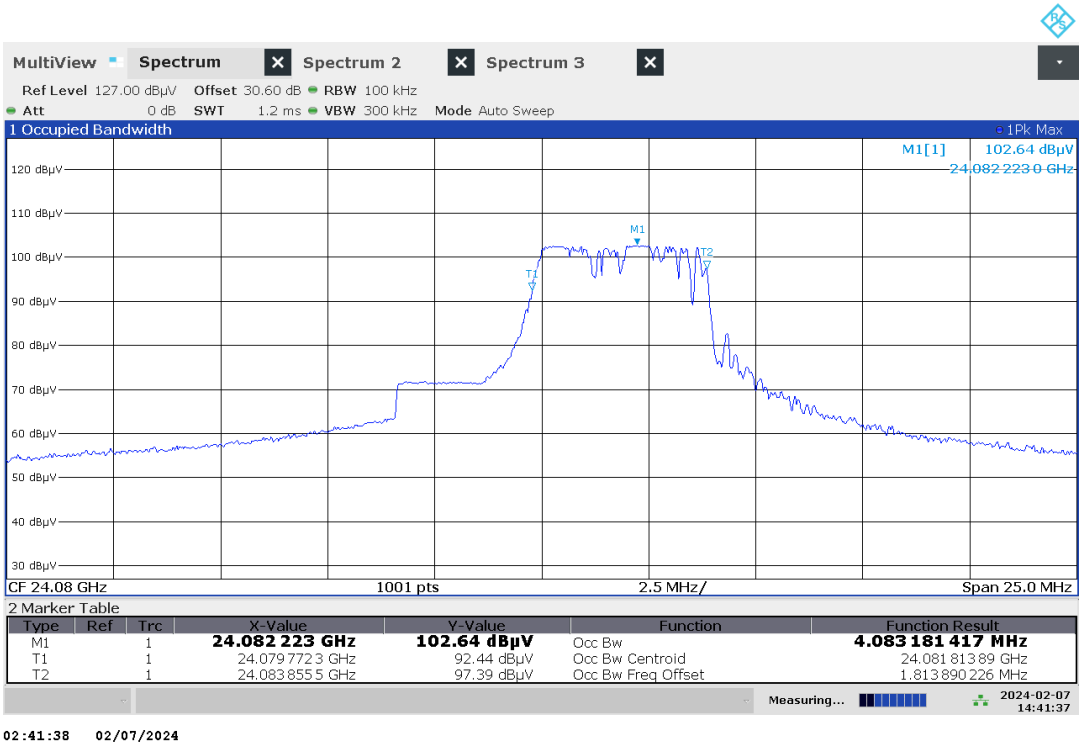
Plot no. 5: 99% OBW, f_{low}, Peak detector, 70 °C

Plot no. 6: 99% OBW, f_{low}, Peak detector, 60 °C

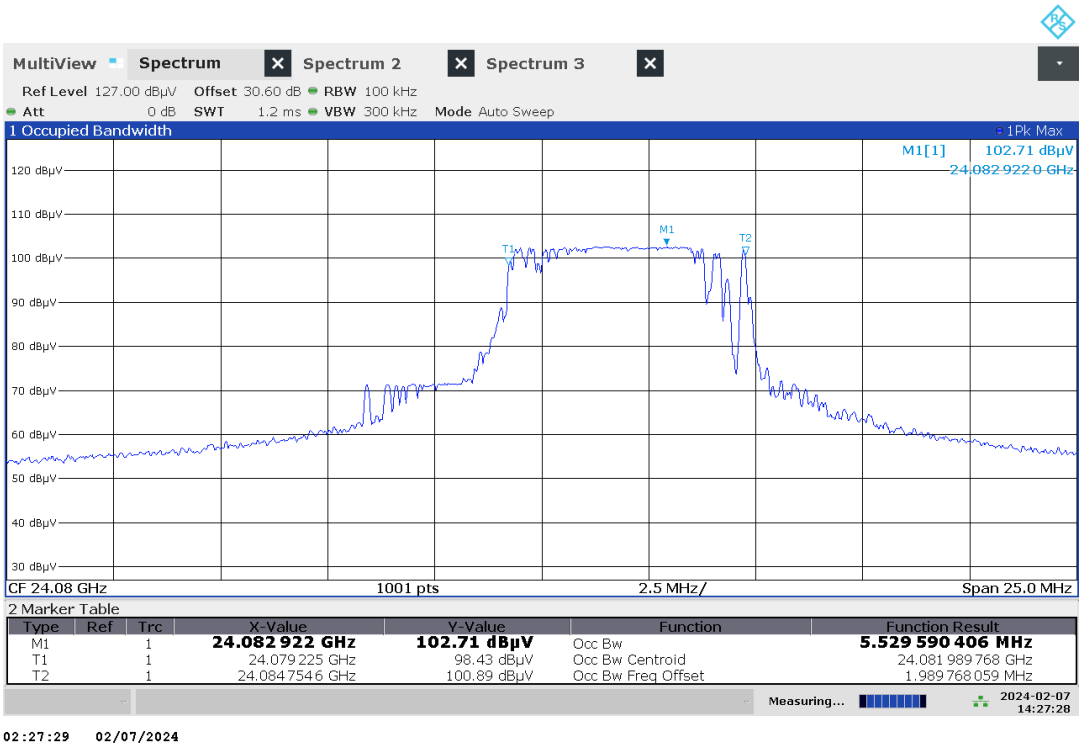
Plot no. 7: 99% OBW, f_{low}, Peak detector, 50 °C



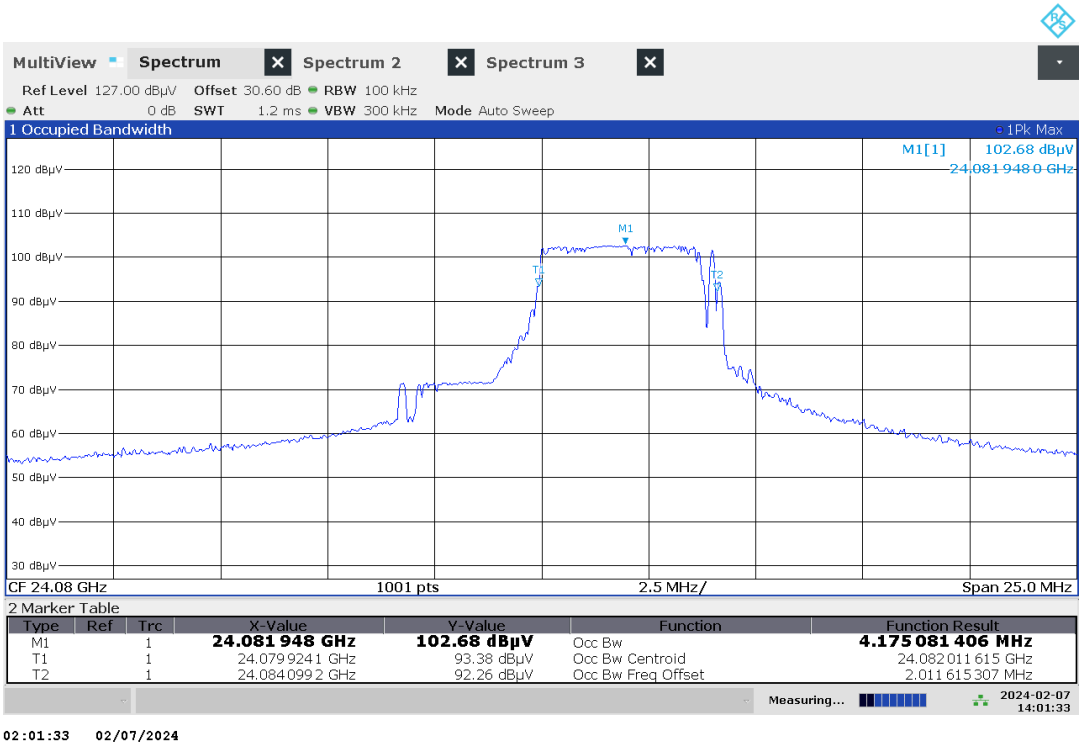
Plot no. 8: 99% OBW, f_{low}, Peak detector, 40 °C



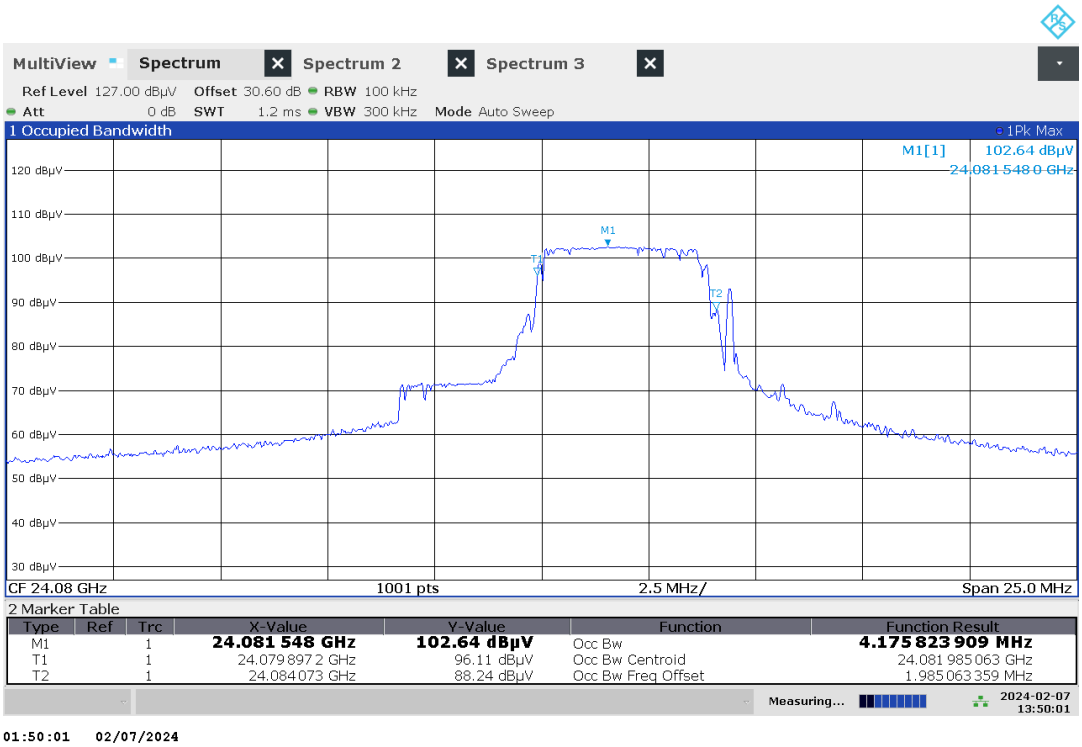
Plot no. 9: 99% OBW, f_{low}, Peak detector, 30 °C



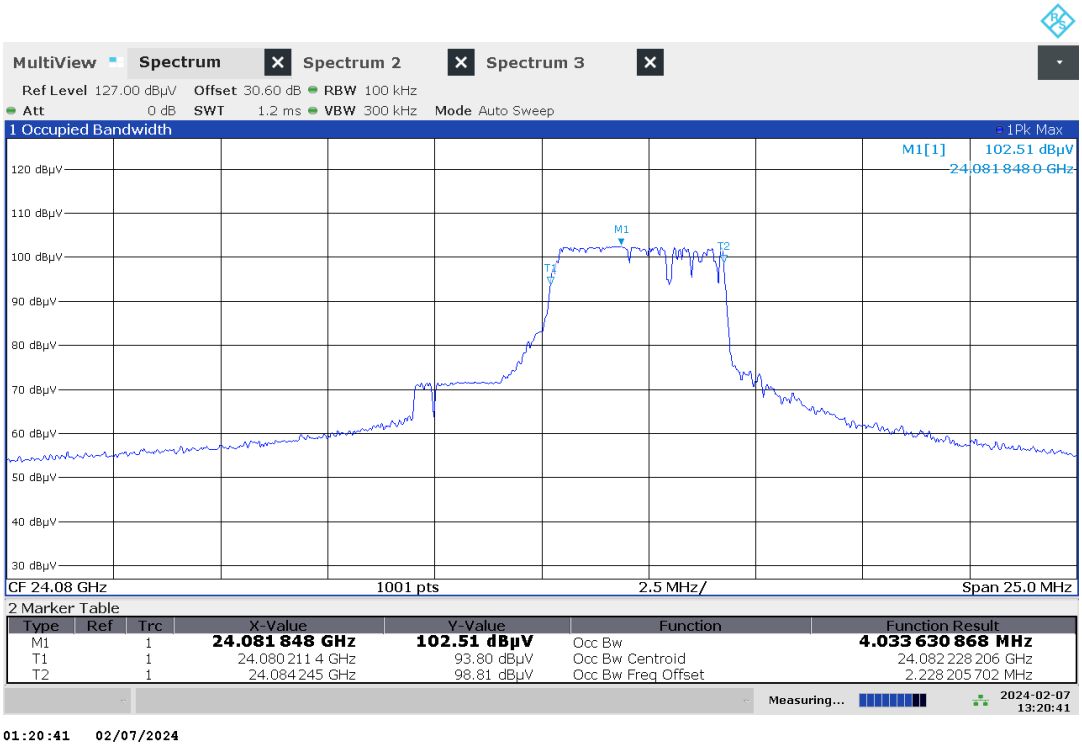
Plot no. 10: 99% OBW, f_{low}, Peak detector, 20 °C, V_{min} - V_{max}



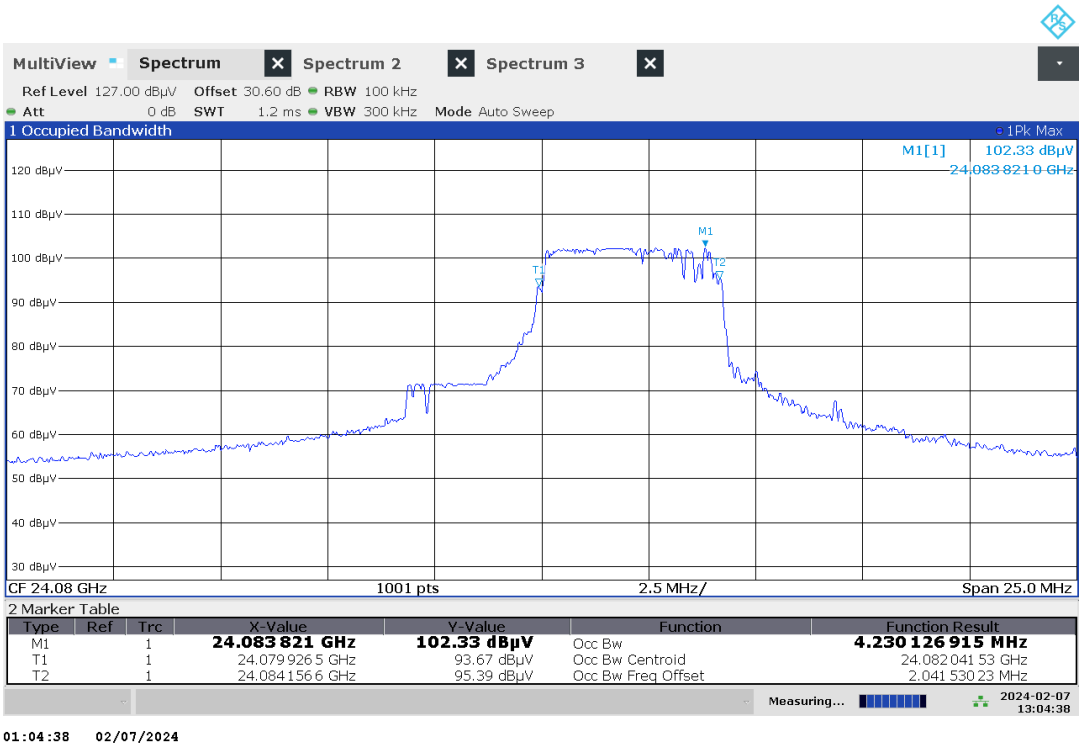
Plot no. 11: 99% OBW, f_{low}, Peak detector, 10 °C



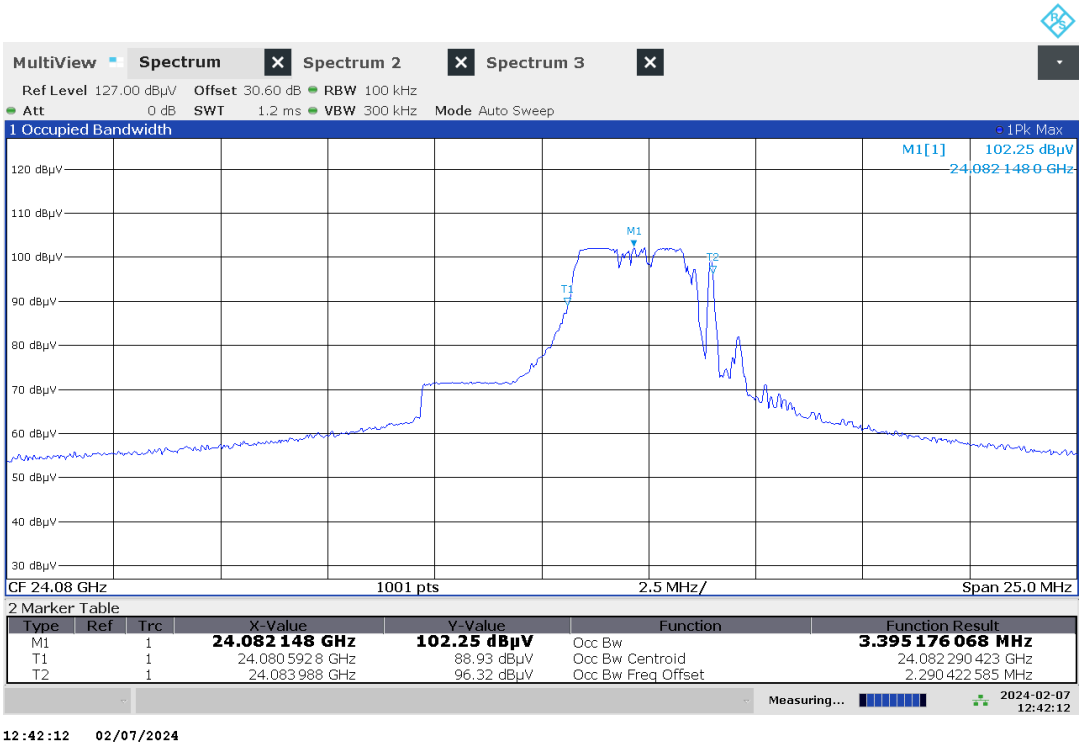
Plot no. 12: 99% OBW, f_{low}, Peak detector, 0 °C



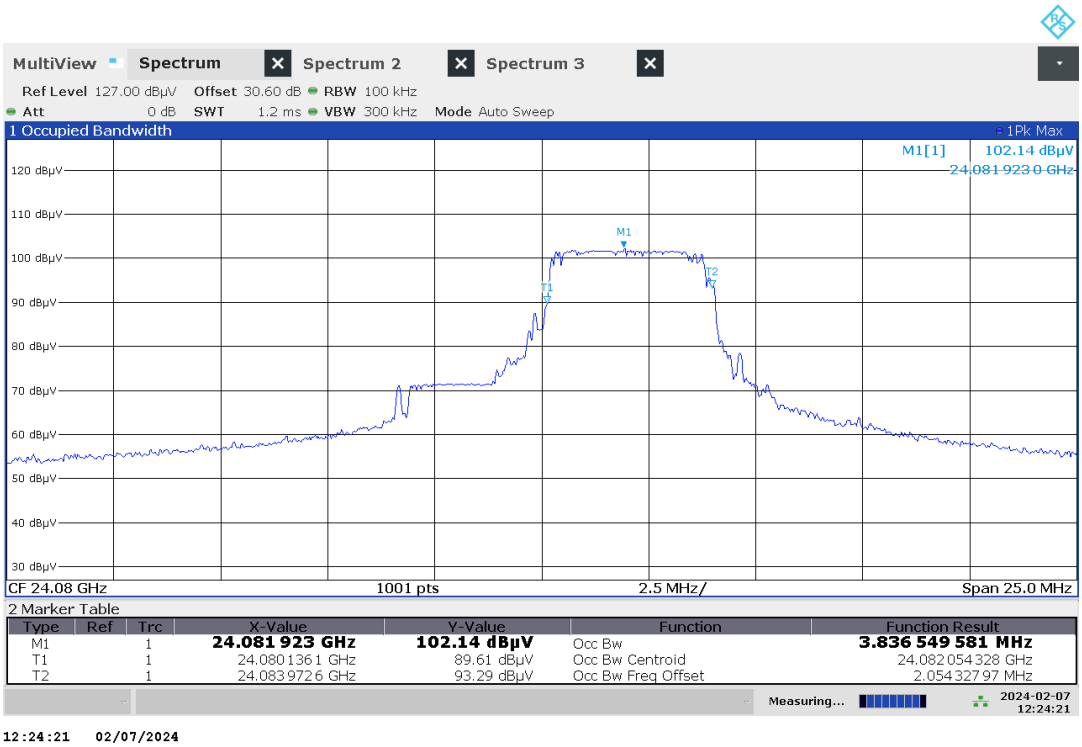
Plot no. 13: 99% OBW, f_{low}, Peak detector, -10 °C



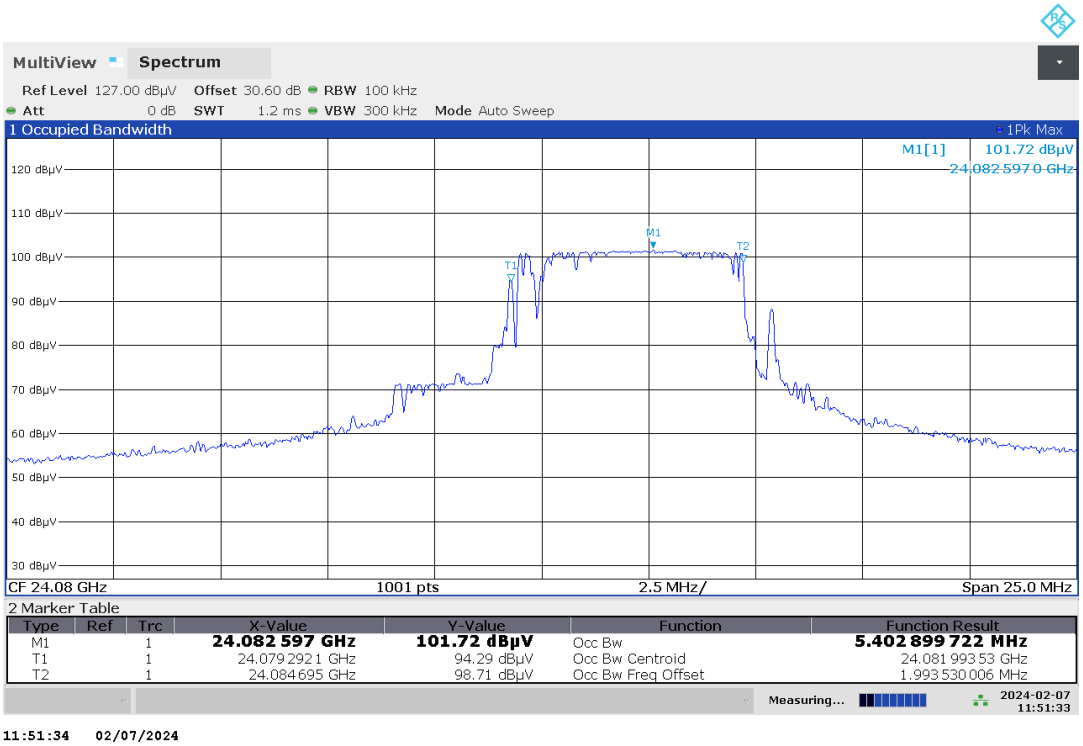
Plot no. 14: 99% OBW, f_{low}, Peak detector, -20 °C



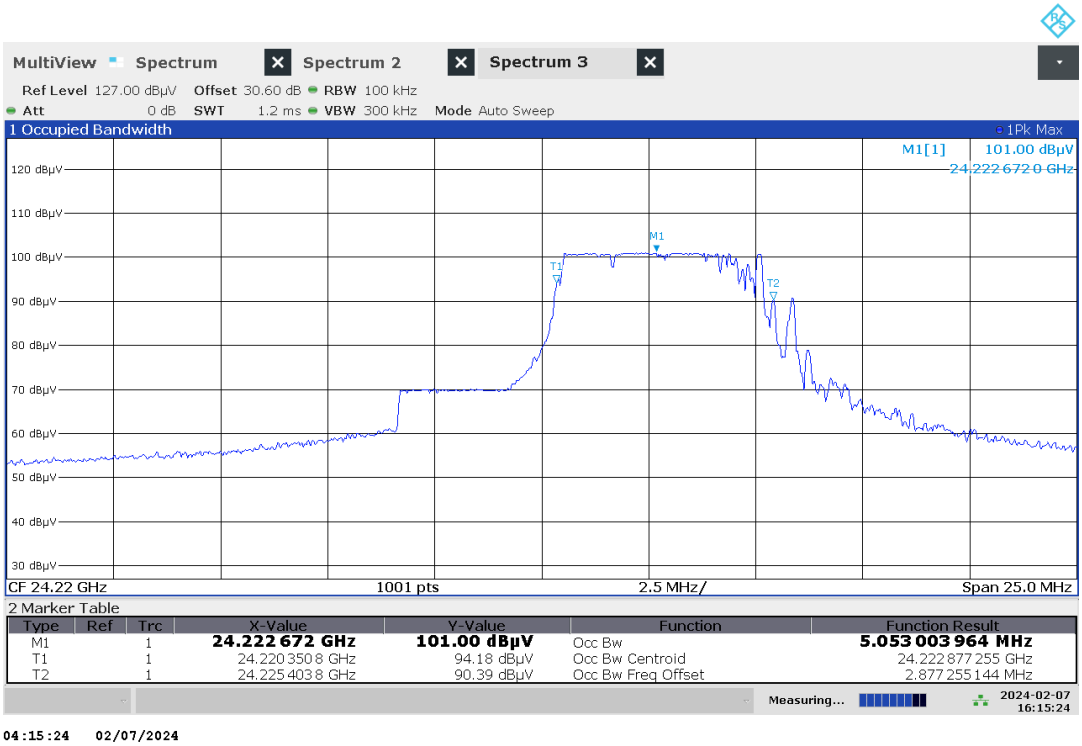
Plot no. 15: 99% OBW, f_{low}, Peak detector, -30 °C



Plot no. 16: 99% OBW, f_{low}, Peak detector, -40 °C



Plot no. 17: 99% OBW, f_{high}, Peak detector, 85 °C

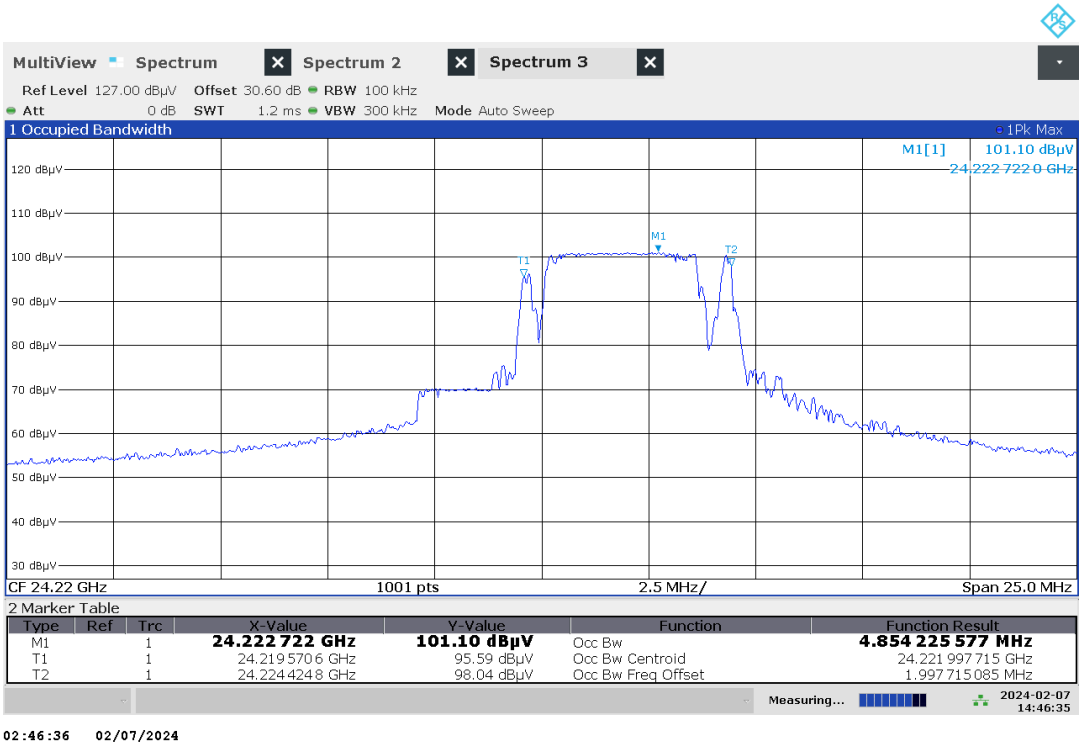


Plot no. 18: 99% OBW, f_{high}, Peak detector, 70 °C

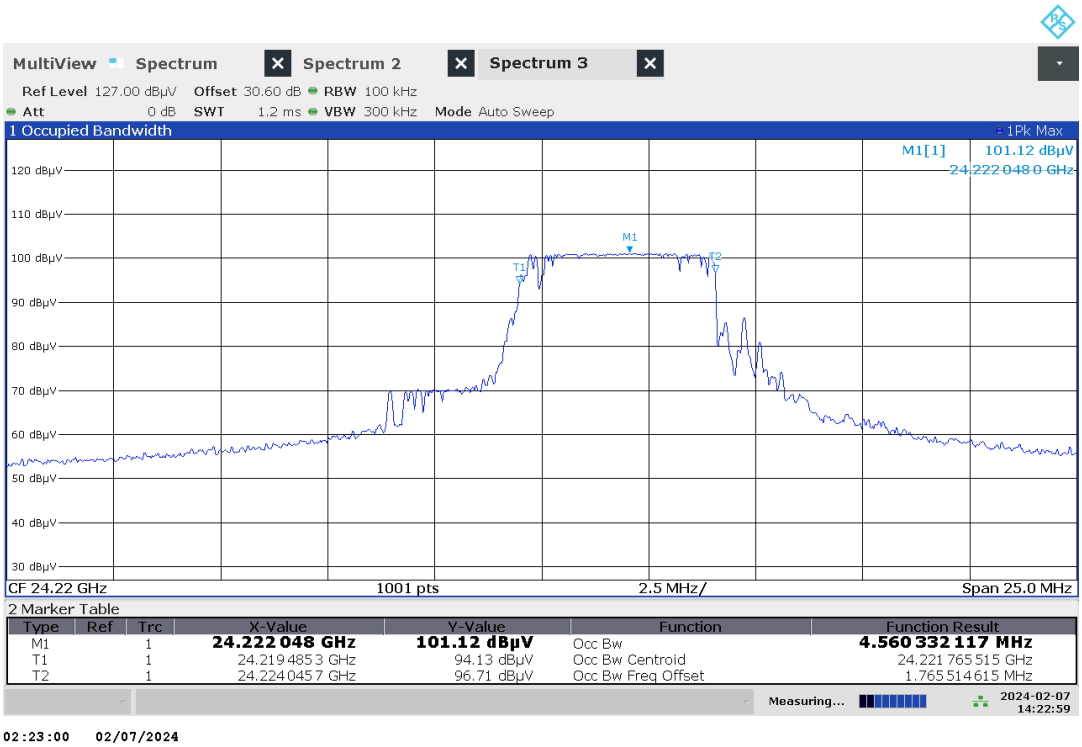
Plot no. 19: 99% OBW, f_{high}, Peak detector, 60 °C

Plot no. 20: 99% OBW, f_{high}, Peak detector, 50 °C

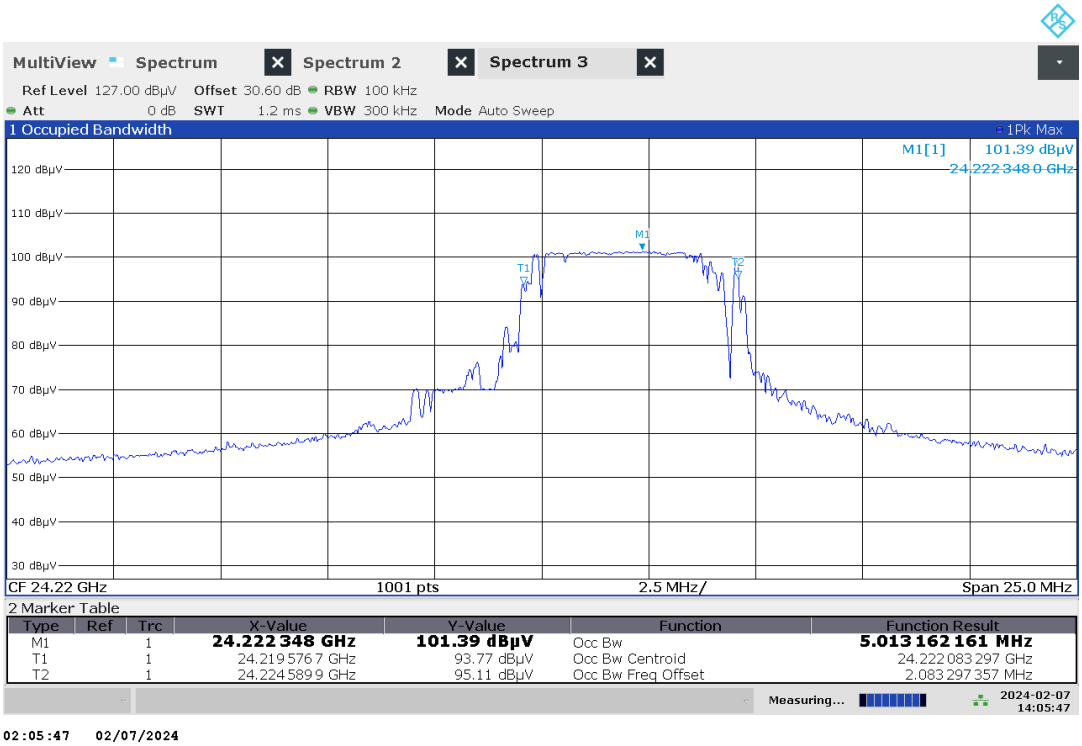
Plot no. 21: 99% OBW, f_{high}, Peak detector, 40 °C



Plot no. 22: 99% OBW, f_{high}, Peak detector, 30 °C

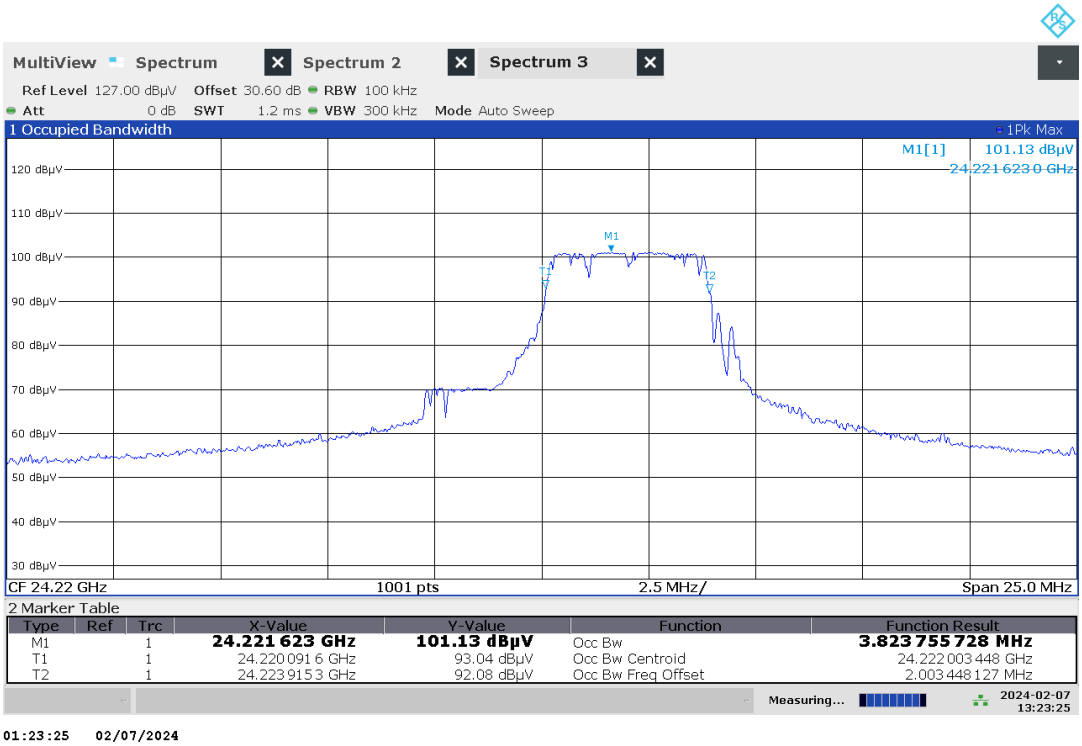


Plot no. 23: 99% OBW, f_{high}, Peak detector, 20 °C, V_{min} - V_{max}



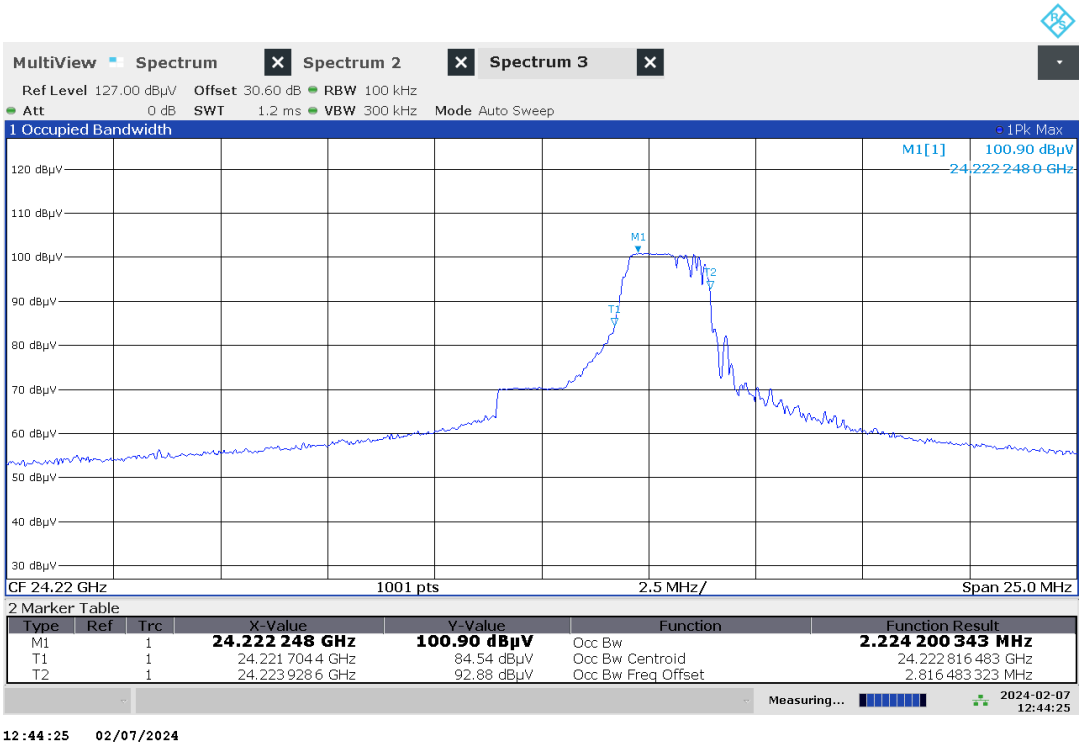
Plot no. 24: 99% OBW, f_{high}, Peak detector, 10 °C

Plot no. 25: 99% OBW, f_{high}, Peak detector, 0 °C

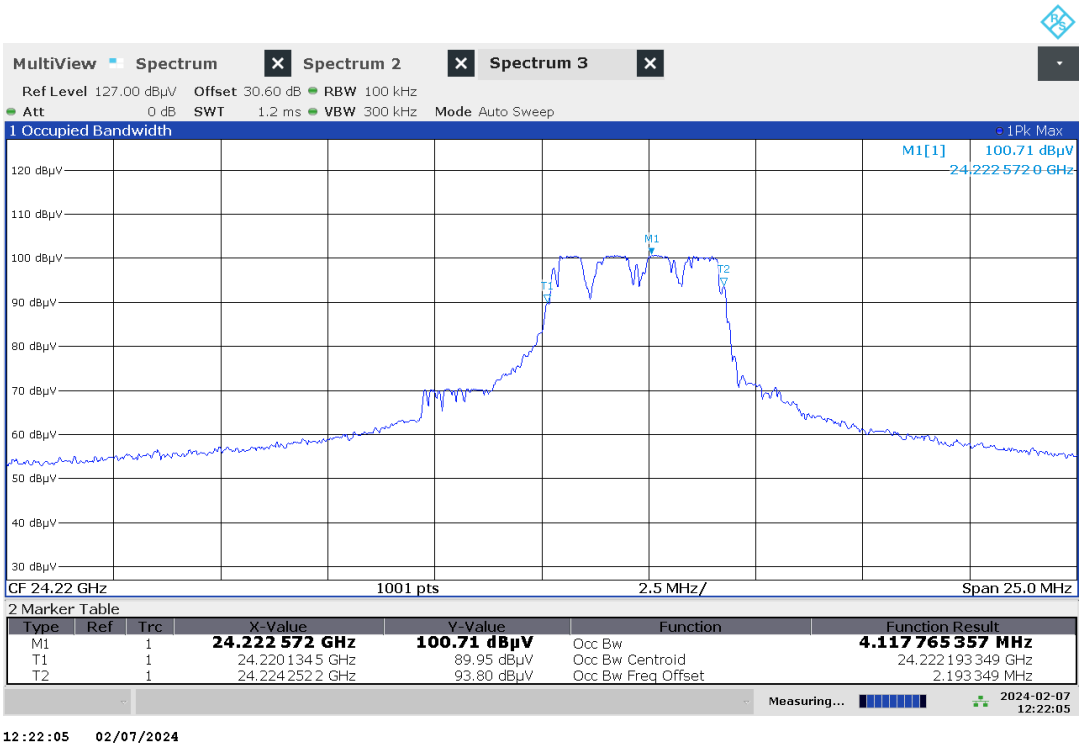


Plot no. 26: 99% OBW, f_{high}, Peak detector, -10 °C

Plot no. 27: 99% OBW, f_{high}, Peak detector, -20 °C



Plot no. 28: 99% OBW, f_{high}, Peak detector, -30 °C



Plot no. 29: 99% OBW, f_{high}, Peak detector, -40 °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.

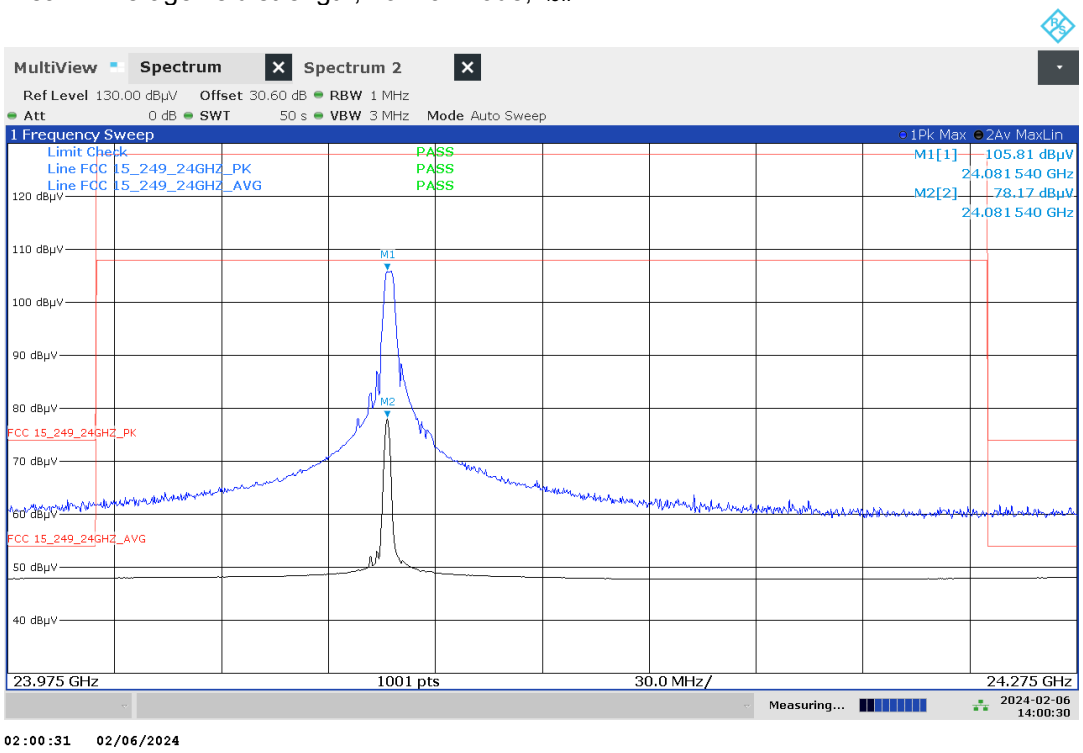
§15.35 (c) Unless otherwise specified, e.g., §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including 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)

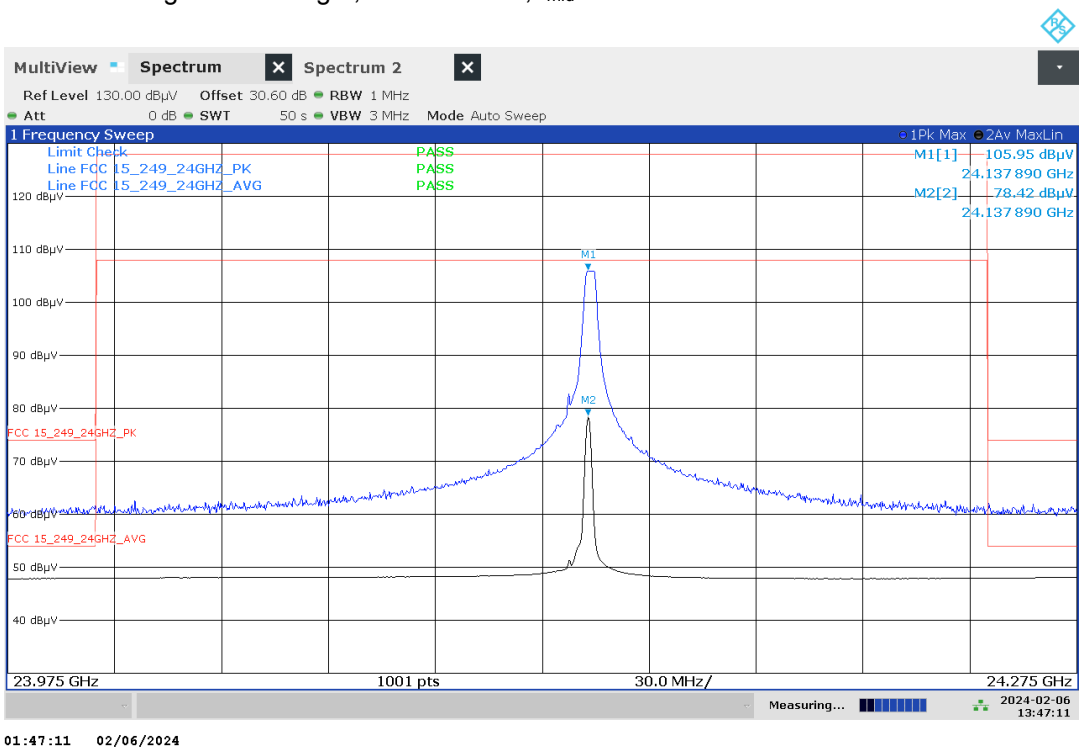
Test results

EUT mode	EUT	Test distance	AVG field strength [dBµV/m]	PK field strength [dBµV/m]
f_{low}	MOD1	1 m	78.2	105.8
f_{mid}	MOD1	1 m	78.4	106.0
f_{high}	MOD1	1 m	78.5	106.0

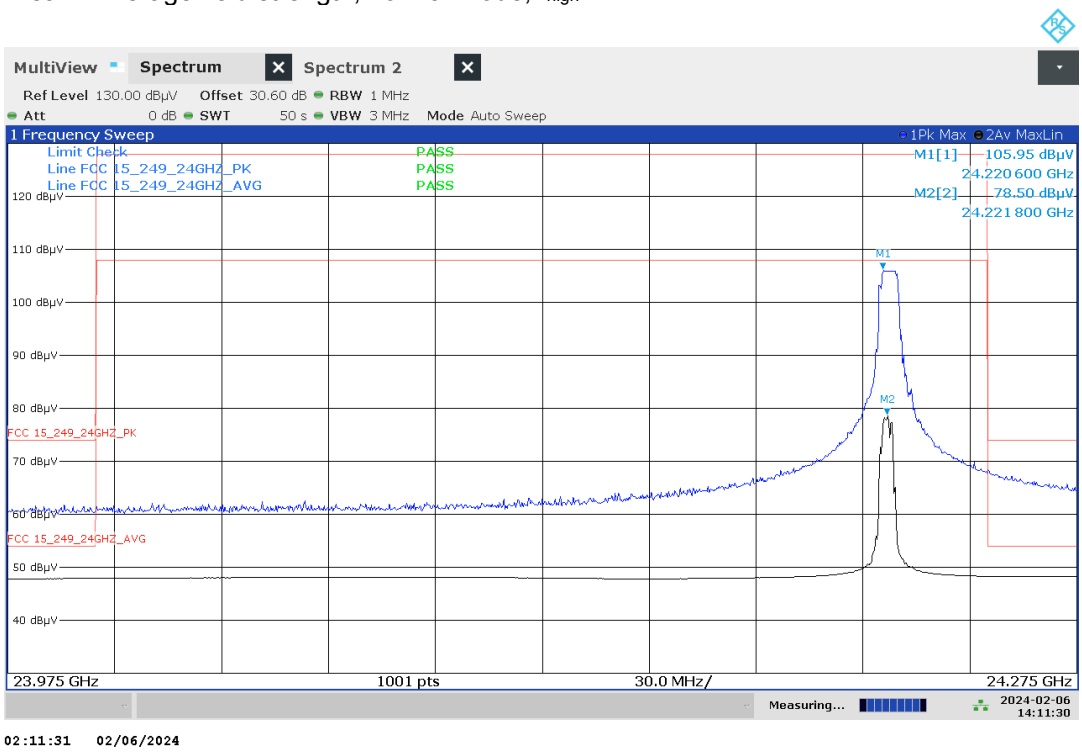
Plot no. 30: Peak / Average field strength, normal mode, f_{low}



Plot no. 31: Peak / Average field strength, normal mode, f_{mid}



Plot no. 32: Peak / Average field strength, normal mode, f_{high}



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	18.0 – 26.5	0.0520	26.5	0.478
22240-20	26.5 – 40.0	0.0342	40	0.312
23240-20	33.0 – 50.0	0.0280	50	0.261
24240-20	40.0 – 60.0	0.0230	60	0.212
25240-20	50.0 – 75.0	0.0185	75	0.171
26240-20	60.0 – 90.0	0.0150	90	0.135
27240-20	75.0 – 110	0.0124	100	0.113

Typical test distances

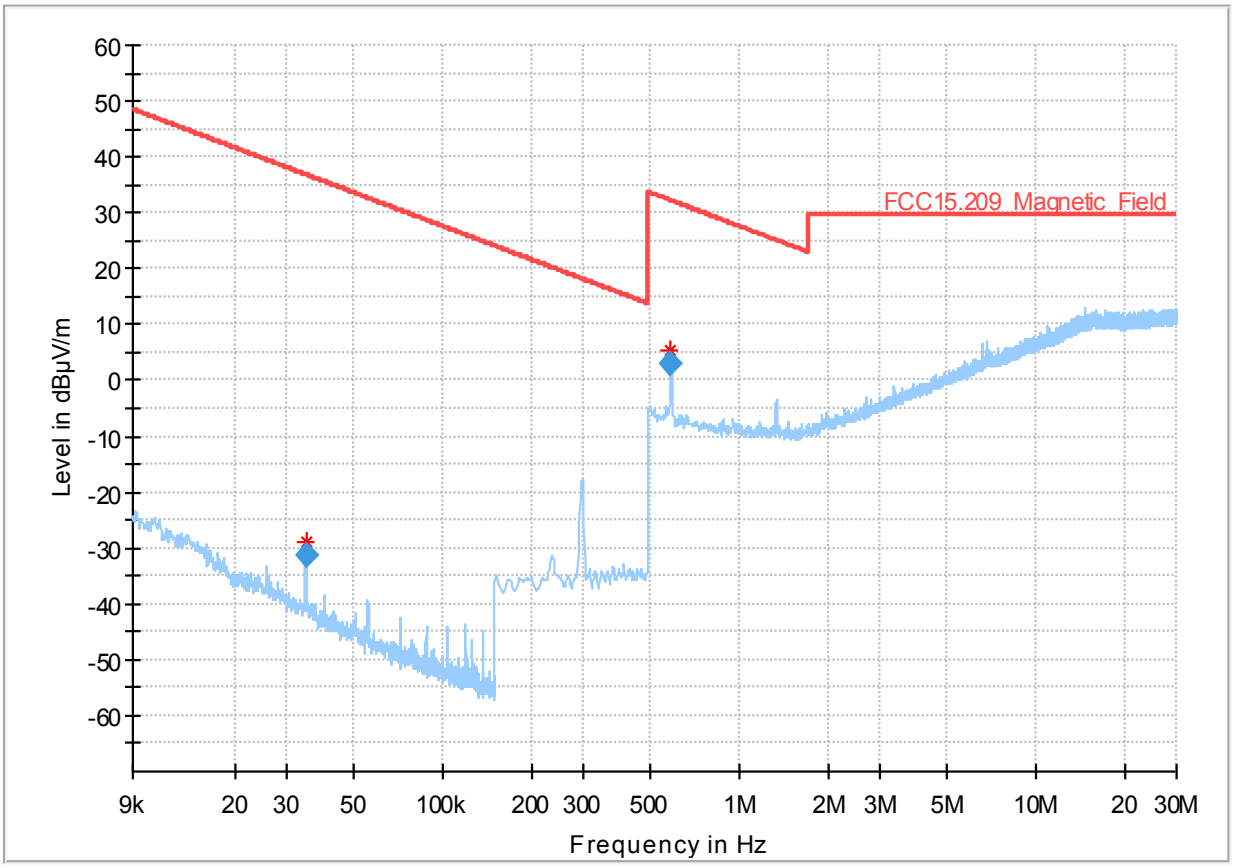
Up to 18 GHz:	3.00 m
18 – 40 GHz:	1.0 m
40 – 90 GHz:	0.5m
90 – 100 GHz:	0.3 m
In-band / OOB:	1m

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]
No critical peaks found. Please refer to plots.						

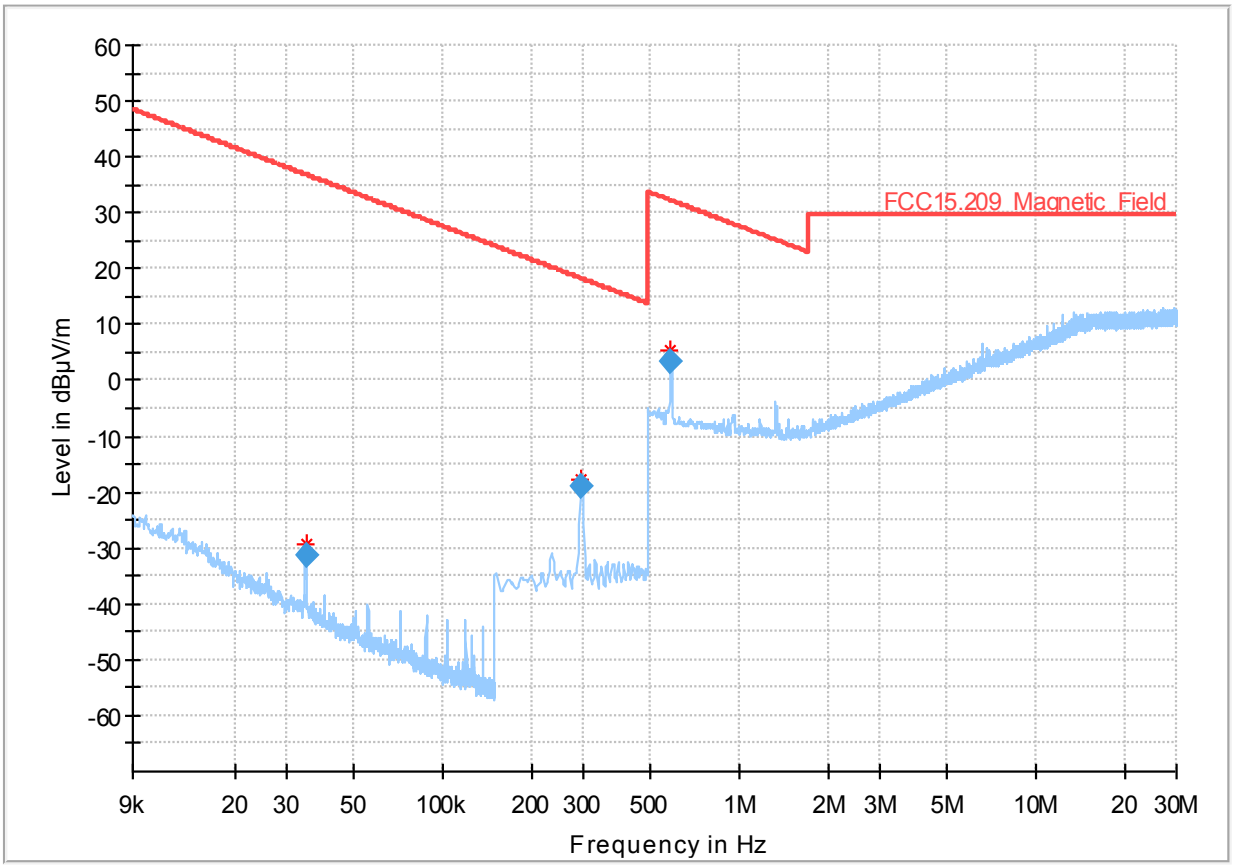
Plot no. 33: radiated emissions 9 kHz – 30 MHz, loop antenna, f_{low}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.034550	-31.39	36.83	68.22	100.0	0.200	V	60.0	-59.2
0.591000	3.17	32.18	29.01	100.0	9.000	V	-5.0	-19.6

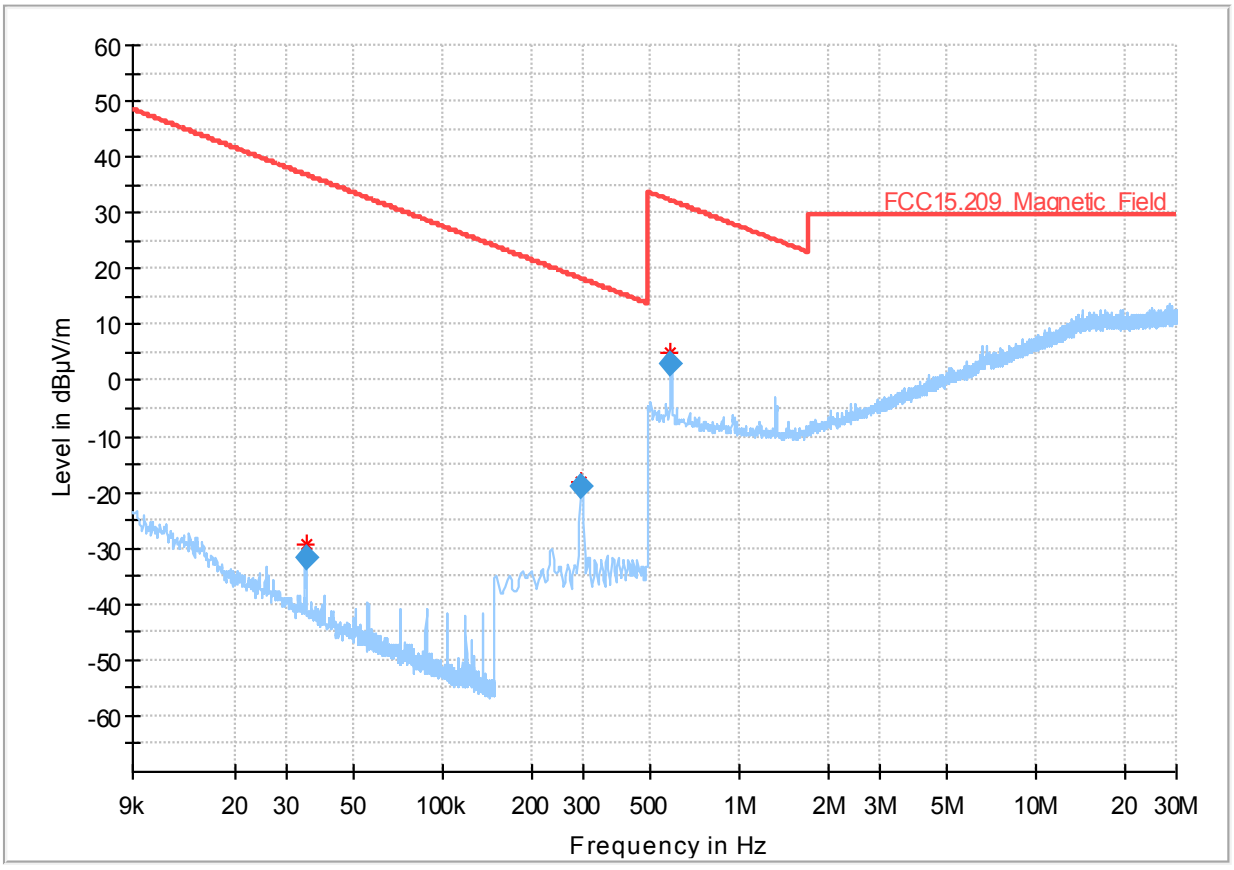
Plot no. 34: radiated emissions 9 kHz – 30 MHz, loop antenna, f_{mid}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.034550	-31.47	36.83	68.30	100.0	0.200	V	7.0	-59.2
0.294000	-18.91	18.24	37.15	100.0	9.000	V	120.0	-54.3
0.591000	3.18	32.18	29.00	100.0	9.000	V	120.0	-19.6

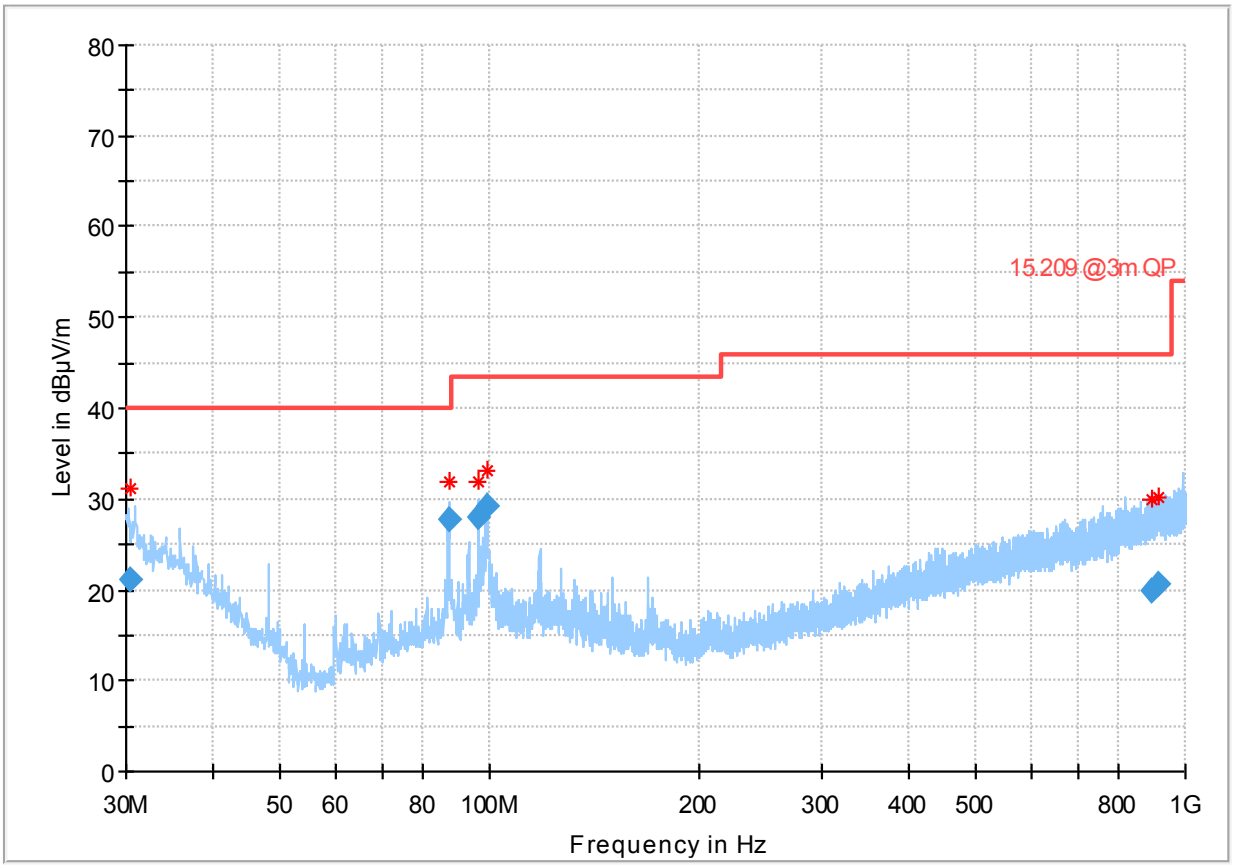
Plot no. 35: radiated emissions 9 kHz – 30 MHz, loop antenna, f_{high}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.034550	-31.79	36.83	68.62	100.0	0.200	V	120.0	-59.2
0.294000	-18.86	18.24	37.10	100.0	9.000	V	80.0	-54.3
0.591000	3.17	32.18	29.01	100.0	9.000	V	71.0	-19.6

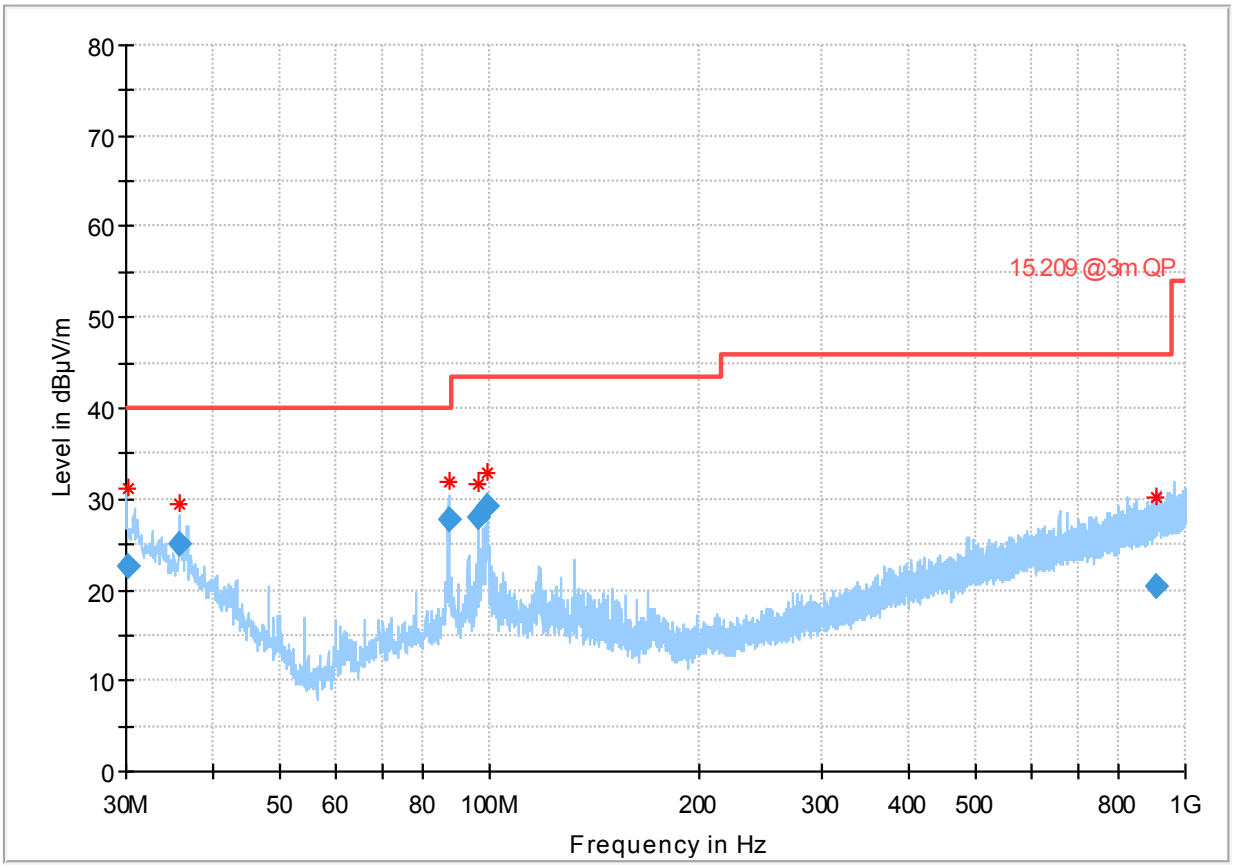
Plot no. 36: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f_{low}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.423000	21.17	40.00	18.83	100.0	120.000	100.0	V	39.0
87.211500	27.63	40.00	12.37	100.0	120.000	103.0	V	329.0
96.232500	28.06	43.50	15.44	100.0	120.000	301.0	H	228.0
99.239500	29.24	43.50	14.26	100.0	120.000	298.0	H	134.0
897.089500	19.77	46.00	26.23	100.0	120.000	350.0	V	301.0
917.215000	20.53	46.00	25.47	100.0	120.000	350.0	H	263.0

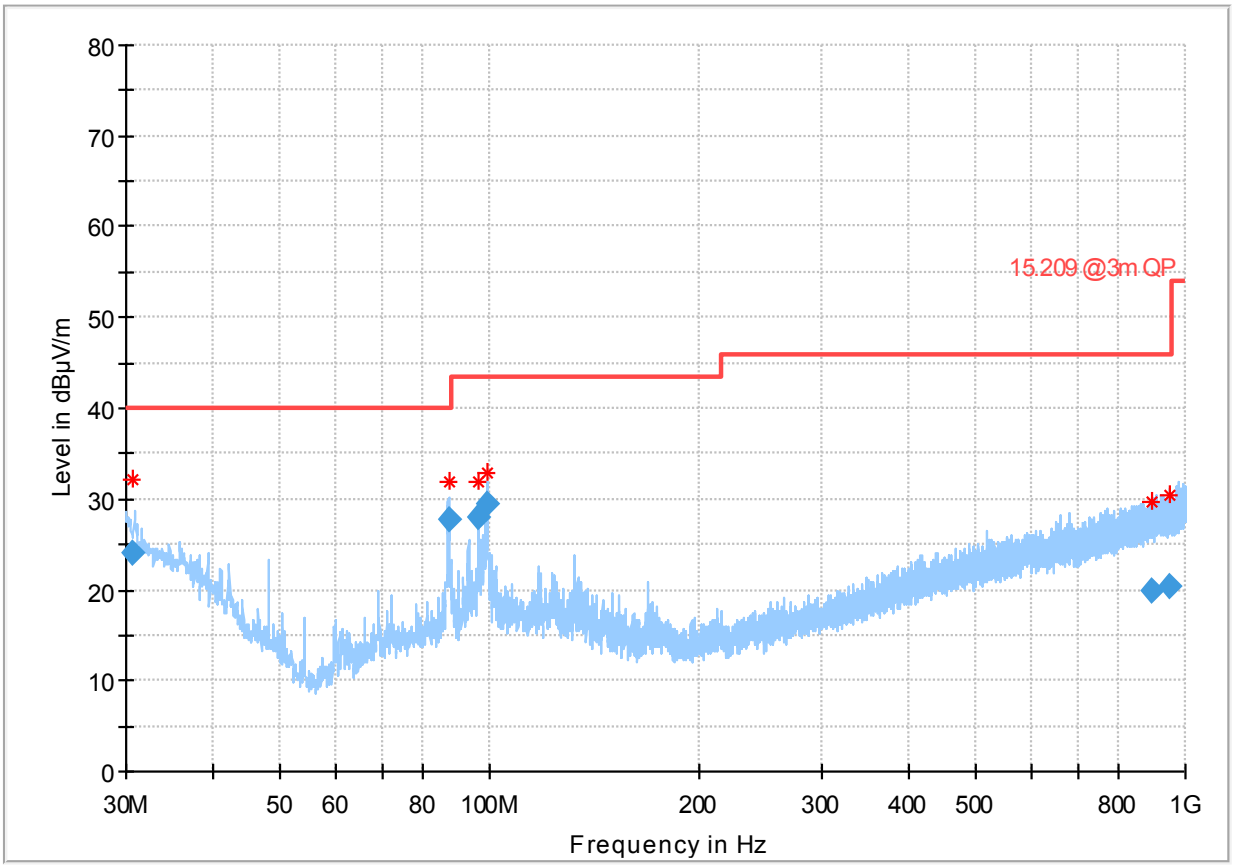
Plot no. 37: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f_{mid}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.180000	22.61	40.00	17.39	100.0	120.000	100.0	V	257.0
35.868500	24.97	40.00	15.03	100.0	120.000	100.0	V	10.0
87.211500	27.73	40.00	12.27	100.0	120.000	103.0	V	319.0
96.232500	28.08	43.50	15.42	100.0	120.000	282.0	H	109.0
99.239500	29.23	43.50	14.27	100.0	120.000	287.0	H	8.0
908.714000	20.28	46.00	25.72	100.0	120.000	320.0	V	320.0

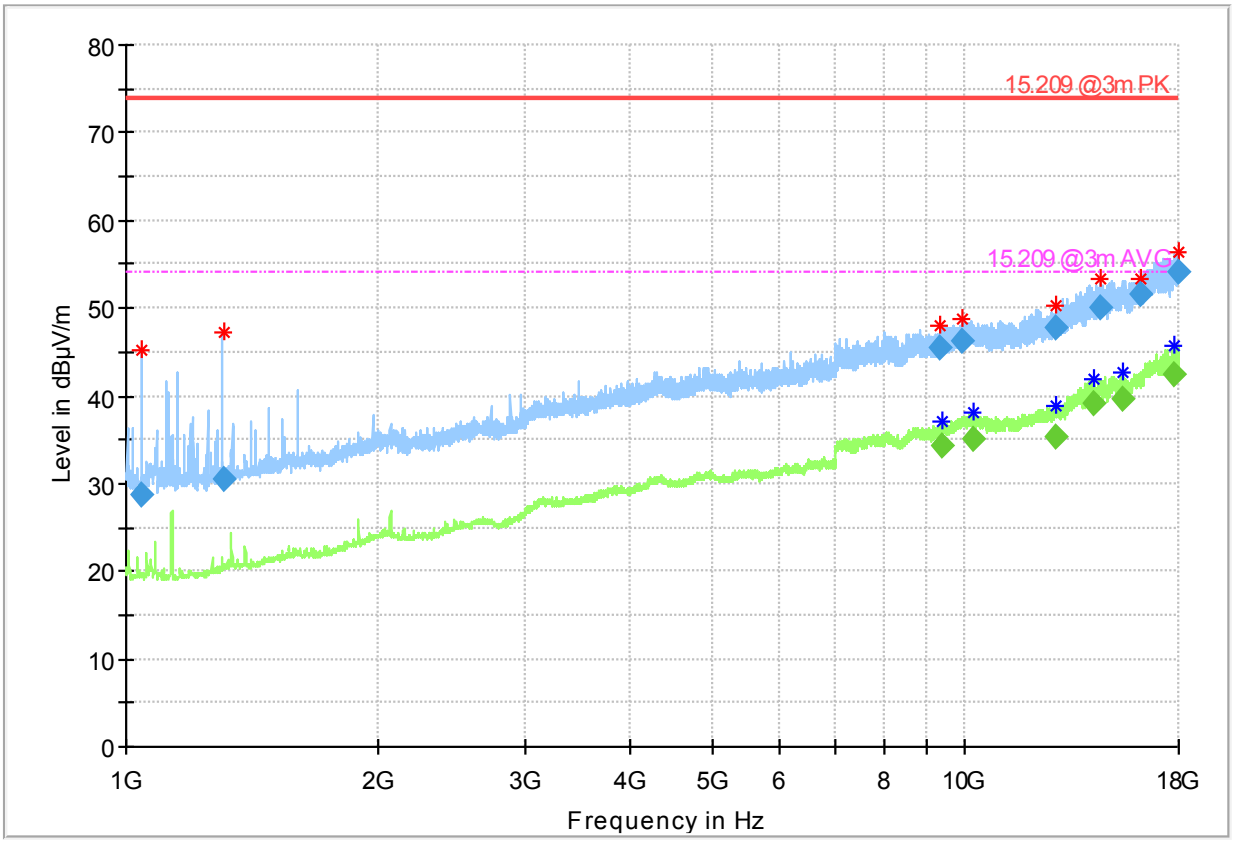
Plot no. 38: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f_{high}



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.603000	24.09	40.00	15.91	100.0	120.000	100.0	H	214.0
87.211500	27.74	40.00	12.26	100.0	120.000	100.0	V	59.0
96.232500	28.09	43.50	15.41	100.0	120.000	266.0	H	136.0
99.239500	29.35	43.50	14.15	100.0	120.000	303.0	H	112.0
895.434000	19.78	46.00	26.22	100.0	120.000	345.0	V	181.0
950.742500	20.26	46.00	25.74	100.0	120.000	119.0	H	268.0

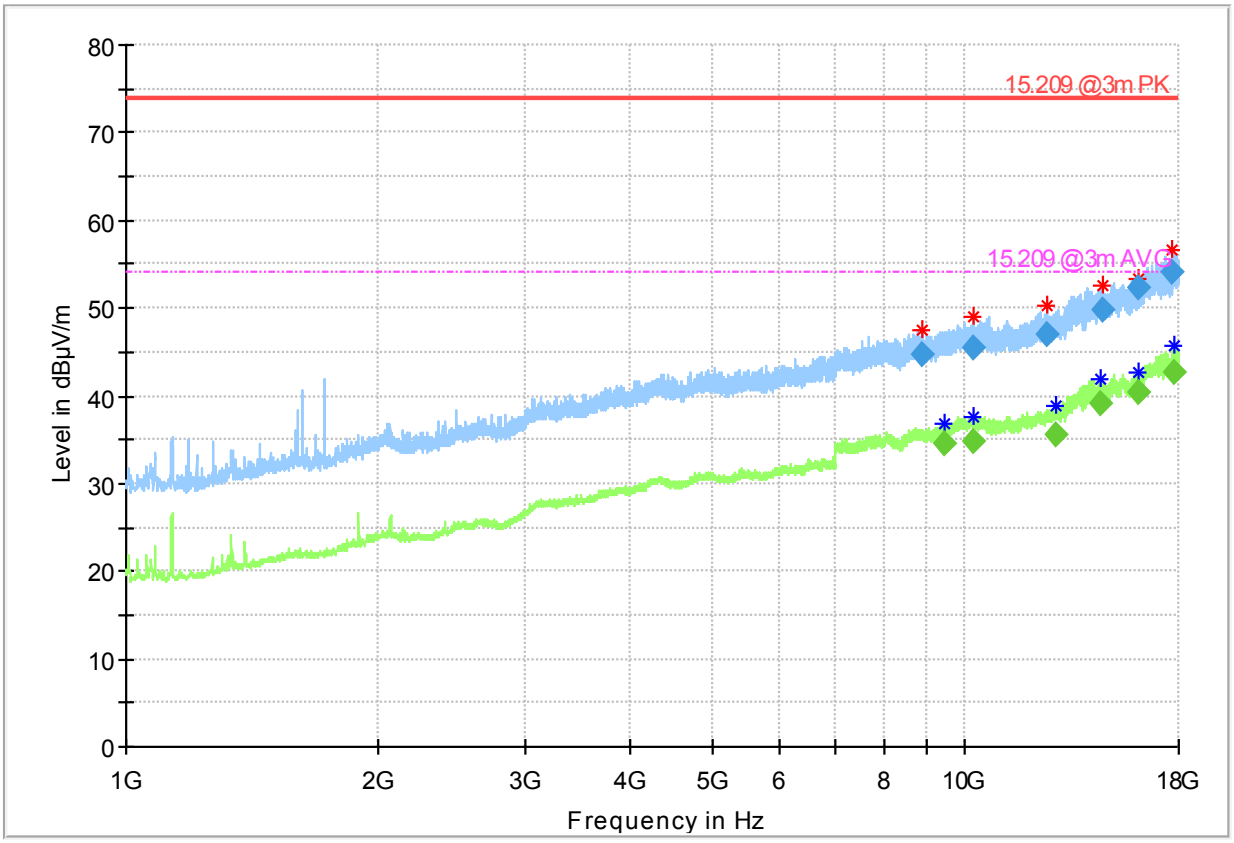
Plot no. 39: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, f_{low}



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
1044.436667	28.75	---	74.00	45.25	100.0	1000.000	150.0	H
1305.338333	30.51	---	74.00	43.49	100.0	1000.000	150.0	H
9372.225833	45.42	---	74.00	28.58	100.0	1000.000	150.0	V
9420.941666	---	34.25	54.00	19.75	100.0	1000.000	150.0	H
9918.179166	46.20	---	74.00	27.80	100.0	1000.000	150.0	H
10234.416667	---	34.92	54.00	19.08	100.0	1000.000	150.0	V
12833.963334	---	35.33	54.00	18.67	100.0	1000.000	150.0	V
12855.595833	47.65	---	74.00	26.35	100.0	1000.000	150.0	V
14242.322500	---	39.04	54.00	14.96	100.0	1000.000	150.0	H
14545.876666	49.92	---	74.00	24.08	100.0	1000.000	150.0	H
15425.039167	---	39.57	54.00	14.43	100.0	1000.000	150.0	V
16221.880833	51.49	---	74.00	22.51	100.0	1000.000	150.0	V
17828.478333	---	42.53	54.00	11.47	100.0	1000.000	150.0	H
17970.380000	54.08	---	74.00	19.92	100.0	1000.000	150.0	H

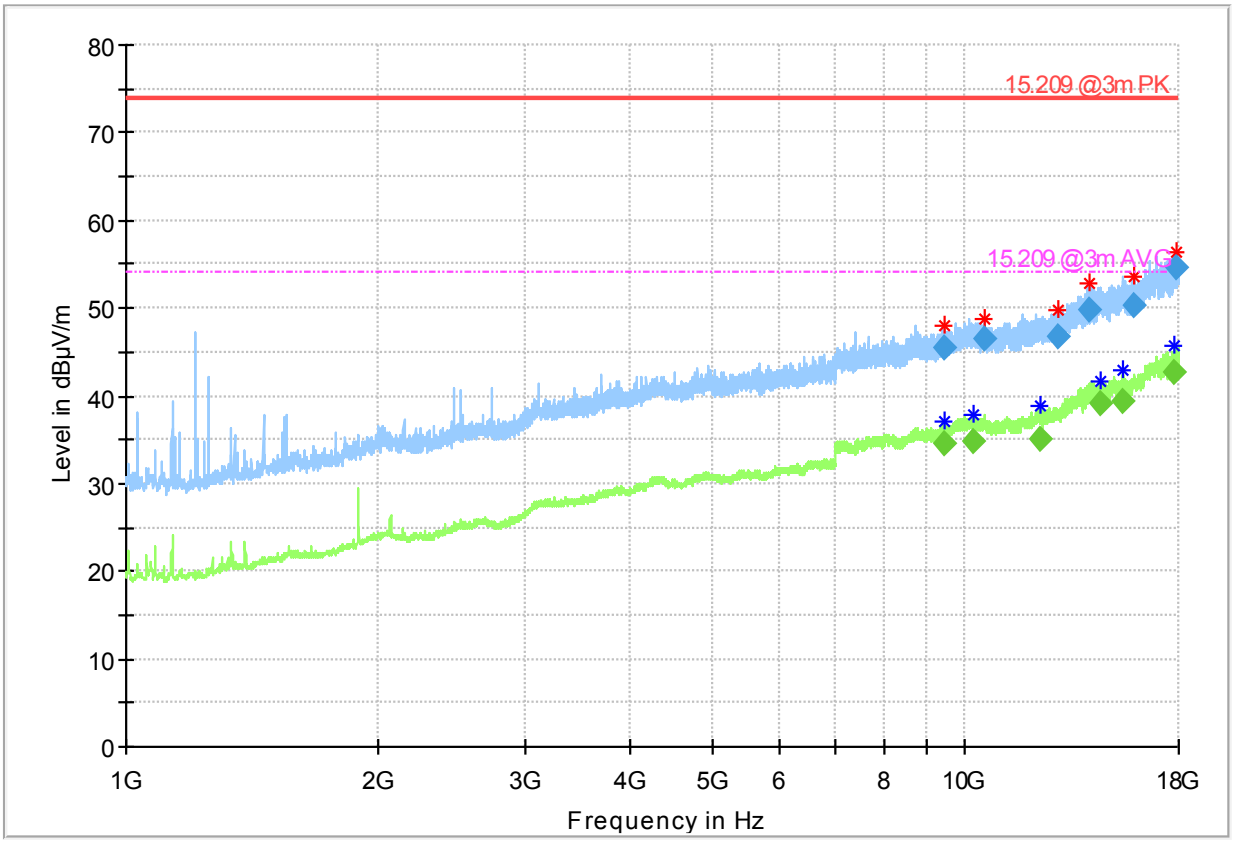
Plot no. 40: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f_{mid}



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8901.653333	44.62	---	74.00	29.38	100.0	1000.000	150.0	H
9439.819167	---	34.51	54.00	19.49	100.0	1000.000	150.0	H
10235.326667	---	34.84	54.00	19.16	100.0	1000.000	150.0	V
10258.061667	45.56	---	74.00	28.44	100.0	1000.000	150.0	V
12548.366667	47.05	---	74.00	26.95	100.0	1000.000	150.0	H
12849.585834	---	35.49	54.00	18.51	100.0	1000.000	150.0	V
14544.720000	---	39.14	54.00	14.86	100.0	1000.000	150.0	H
14583.640833	49.74	---	74.00	24.26	100.0	1000.000	150.0	V
16110.575000	52.38	---	74.00	21.62	100.0	1000.000	150.0	V
16143.895833	---	40.43	54.00	13.57	100.0	1000.000	150.0	H
17701.310834	54.00	---	74.00	20.00	100.0	1000.000	150.0	V
17800.580000	---	42.65	54.00	11.35	100.0	1000.000	150.0	V

Plot no. 41: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, f_{high}

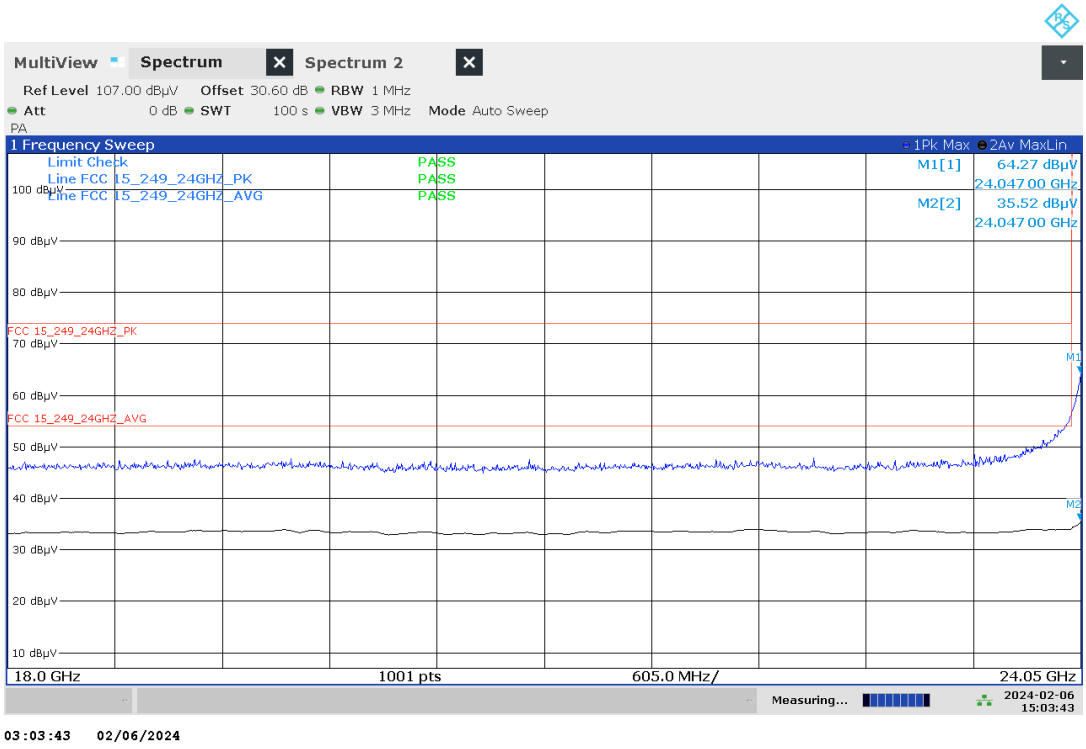


Preview Result 2-AVG
Critical_Freqs PK+
Final_Result PK+
Preview Result 1-PK+
15.209 @3m PK
Final_Result RMS
Critical_Freqs AVG
15.209 @3m AVG

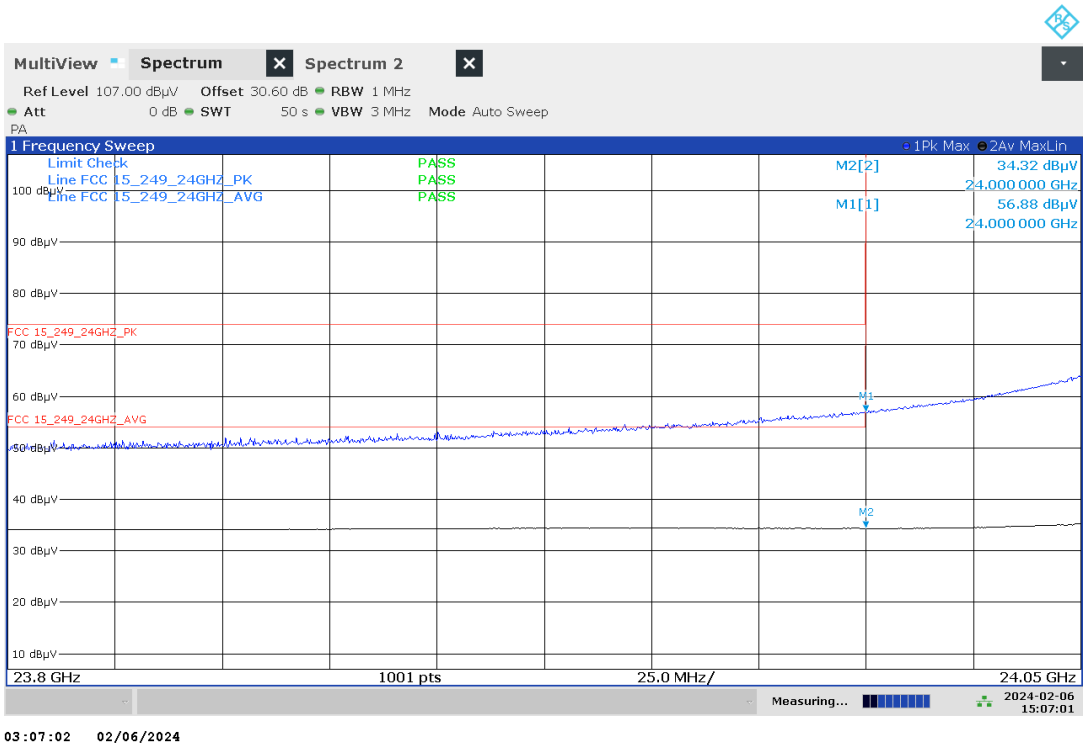
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
9439.275000	---	34.50	54.00	19.50	100.0	1000.000	150.0	V
9468.291666	45.46	---	74.00	28.54	100.0	1000.000	150.0	H
10234.614167	---	34.86	54.00	19.14	100.0	1000.000	150.0	H
10593.754166	46.59	---	74.00	27.41	100.0	1000.000	150.0	H
12315.195000	---	35.17	54.00	18.83	100.0	1000.000	150.0	V
12900.013334	46.85	---	74.00	27.15	100.0	1000.000	150.0	V
14080.014167	49.76	---	74.00	24.24	100.0	1000.000	150.0	V
14545.349167	---	39.23	54.00	14.77	100.0	1000.000	150.0	H
15420.206667	---	39.45	54.00	14.55	100.0	1000.000	150.0	V
15952.265833	50.27	---	74.00	23.73	100.0	1000.000	150.0	H
17799.996667	---	42.67	54.00	11.33	100.0	1000.000	150.0	H
17901.894166	54.53	---	74.00	19.47	100.0	1000.000	150.0	H

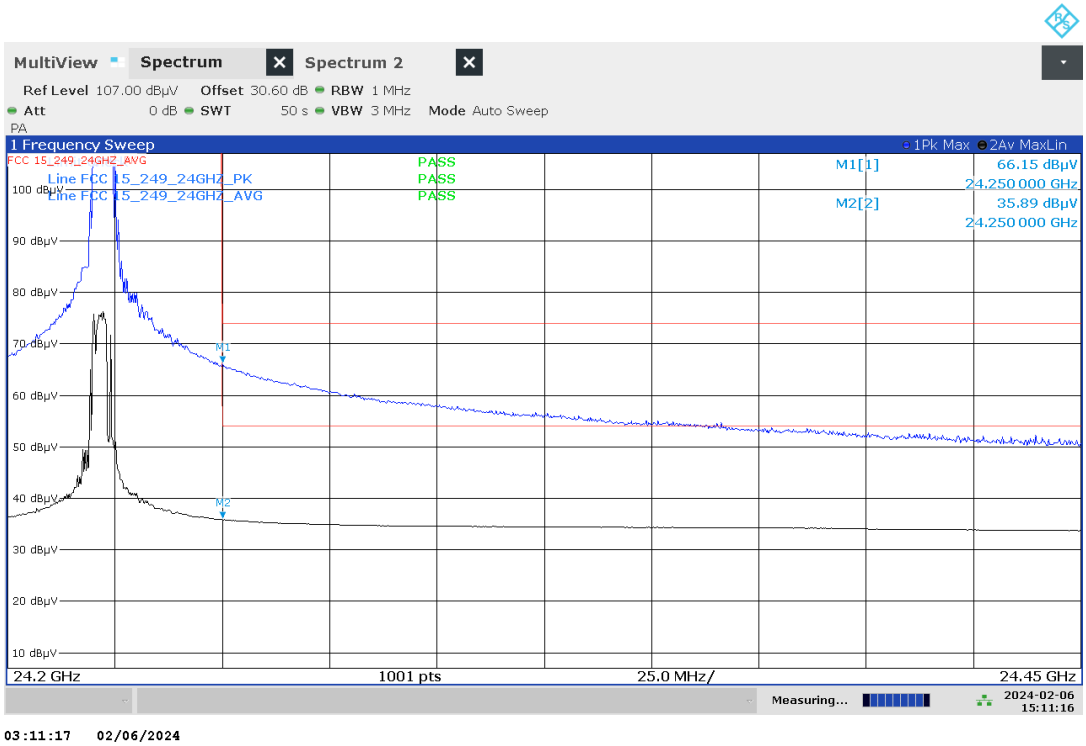
Plot no. 42: radiated emissions 18 GHz – 24 GHz, hor./vert. polarization, normal mode, f_{low} / f_{mid} / f_{high}



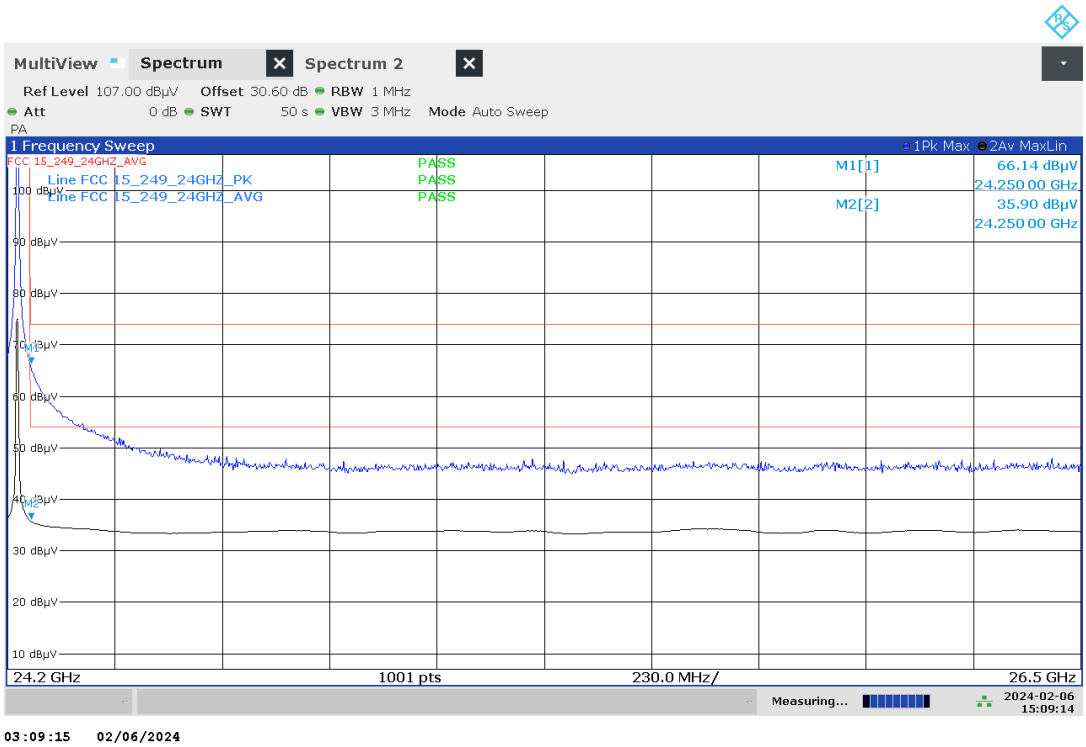
Plot no. 43: band edge compliance 24 GHz, hor./vert. polarization, normal mode, f_{low}



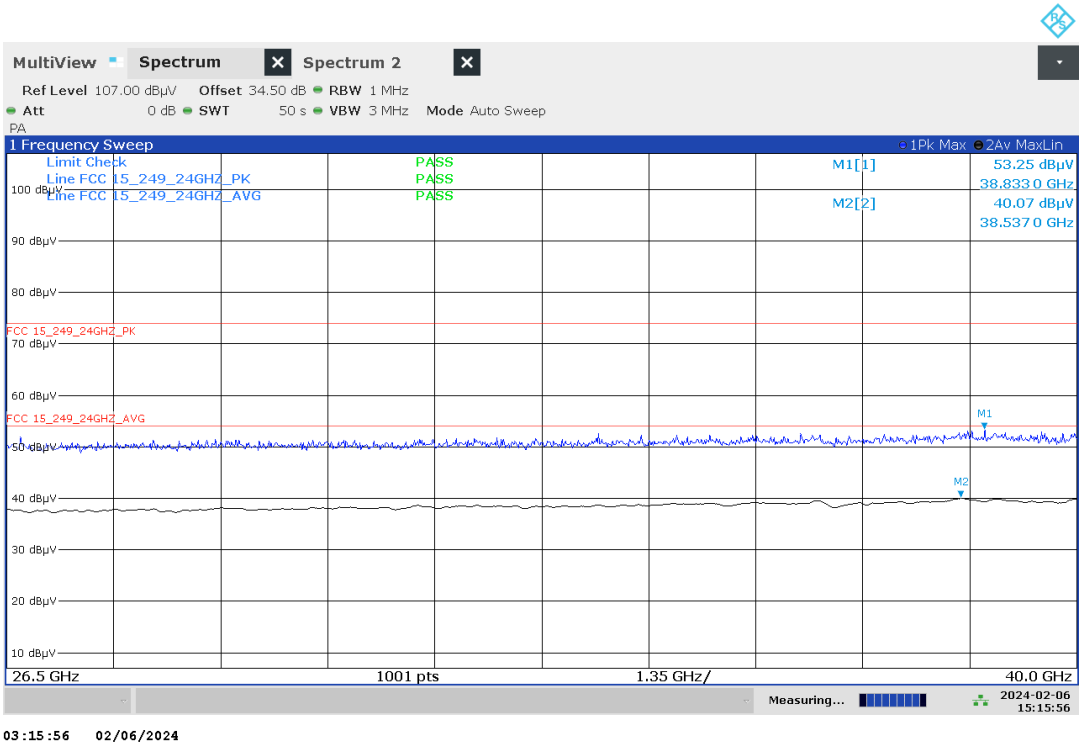
Plot no. 44: band edge compliance 24.25 GHz, hor./vert. polarization, normal mode, f_{high}



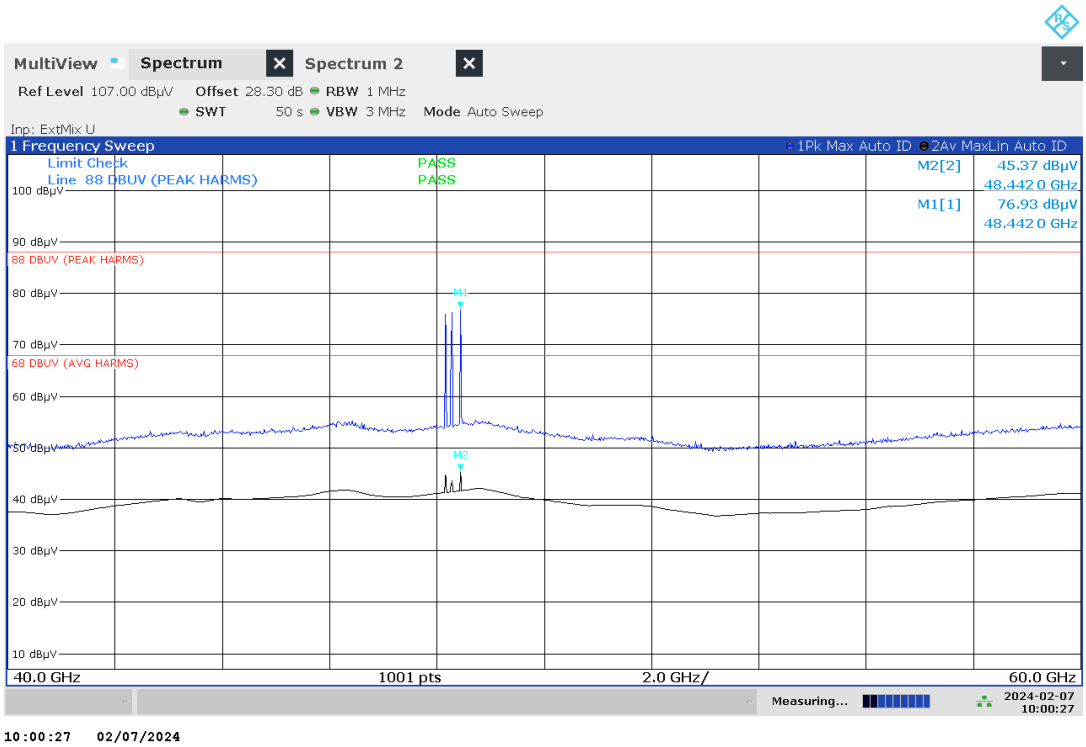
Plot no. 45: radiated emissions 24.25 GHz – 26.5 GHz, hor./vert. polarization, normal mode, f_{low} / f_{mid} / f_{high}



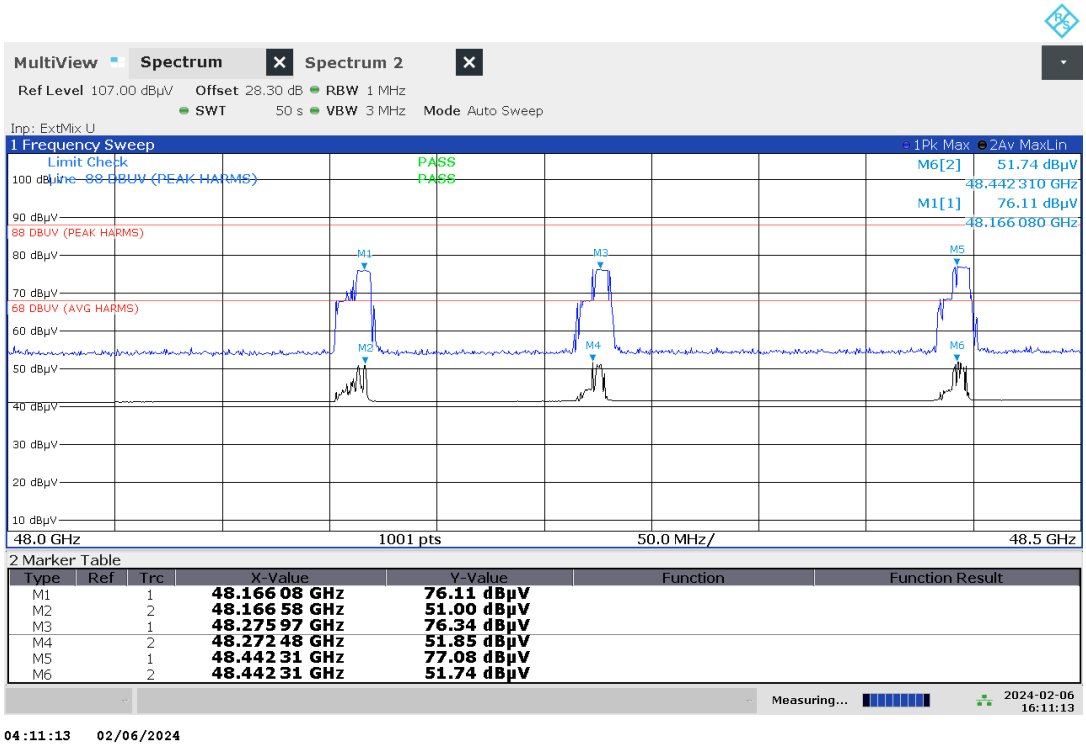
Plot no. 46: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, normal mode, f_{low} / f_{mid} / f_{high}



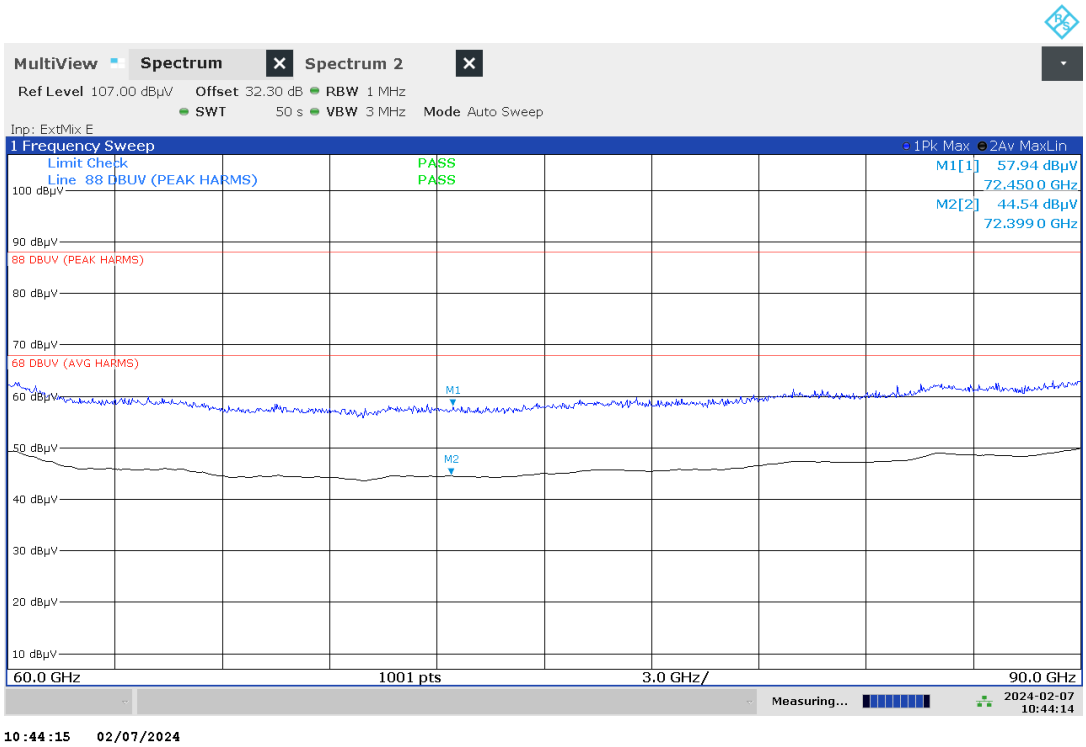
Plot no. 47: radiated emissions 40 GHz – 60 GHz, hor./vert. polarization, normal operation, f_{low} / f_{mid} / f_{high}



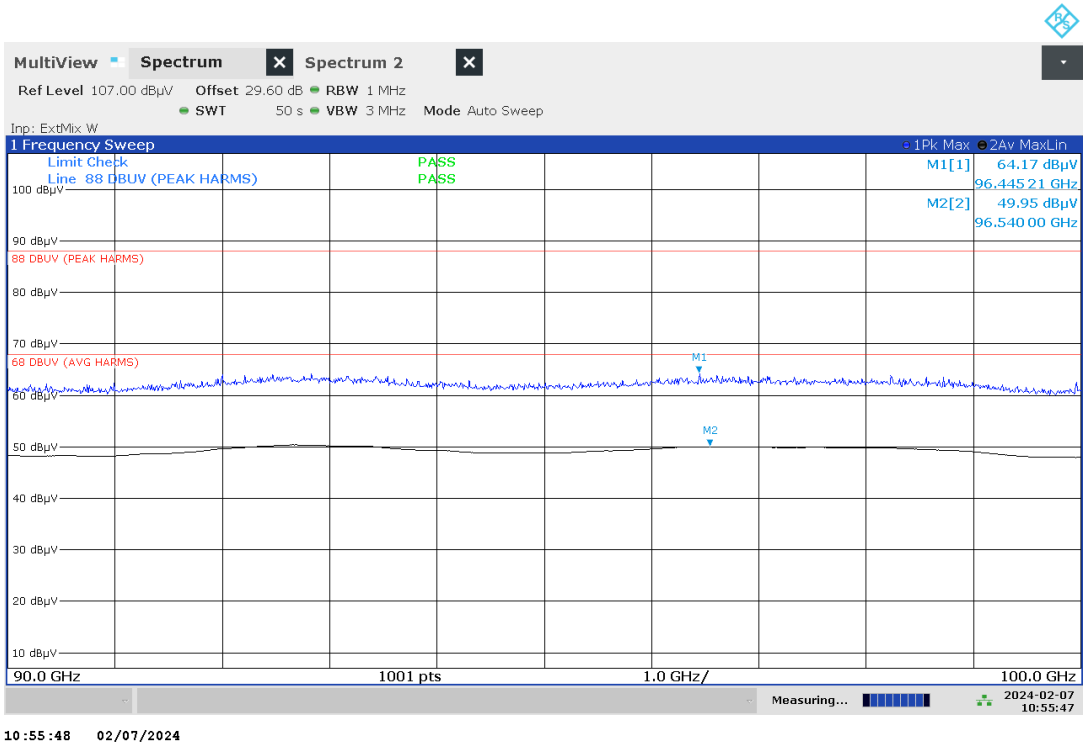
Plot no. 48: radiated emissions 48.3 GHz range (2nd harmonic), hor./vert. polarization, normal mode, f_{low} / f_{mid} / f_{high}



Plot no. 49: radiated emissions 60 GHz – 90 GHz, hor./vert. polarization, normal mode, f_{low} / f_{mid} / f_{high}



Plot no. 50: radiated emissions 90 GHz – 100 GHz, hor./vert. polarization, f_{low} / f_{mid} / f_{high}



7.5 AC Conducted Emissions

Description / Limits

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for 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 the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission [MHz]	Conducted limit [dBµV]	
	Quasi-Peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5.0	56	46
5.0 – 30	60	50
*Decreases with the logarithm of the frequency.		

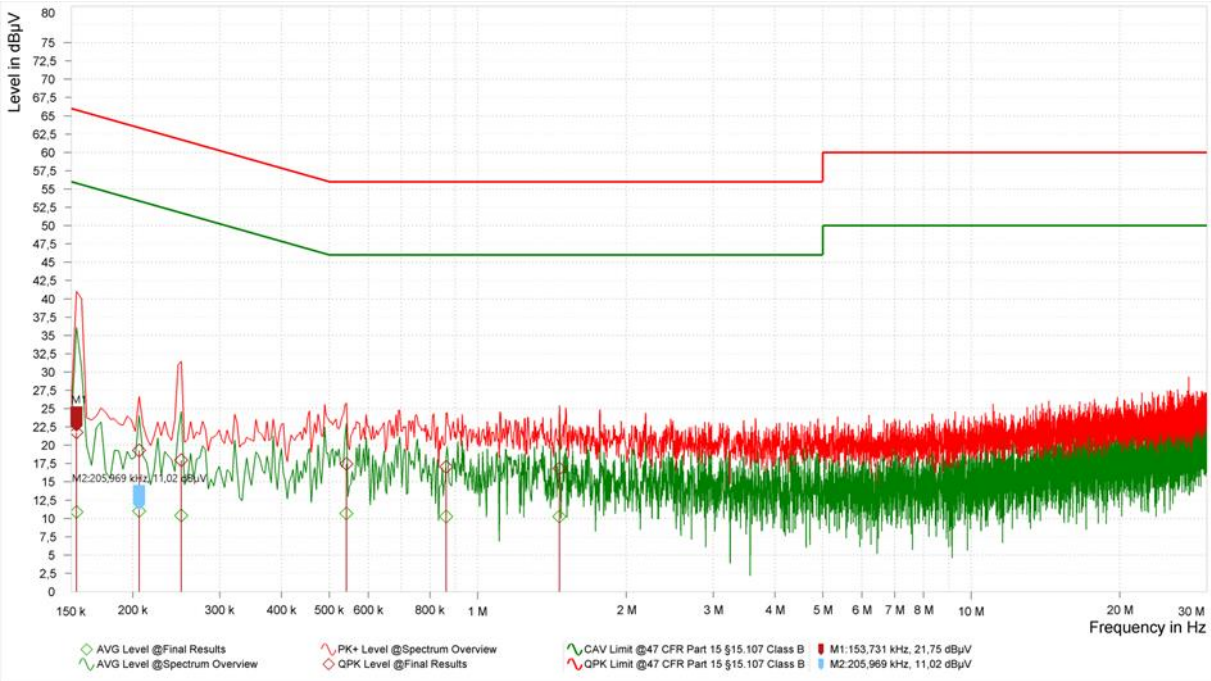
§15.207 (c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

Test setup: see 8.5

Test results

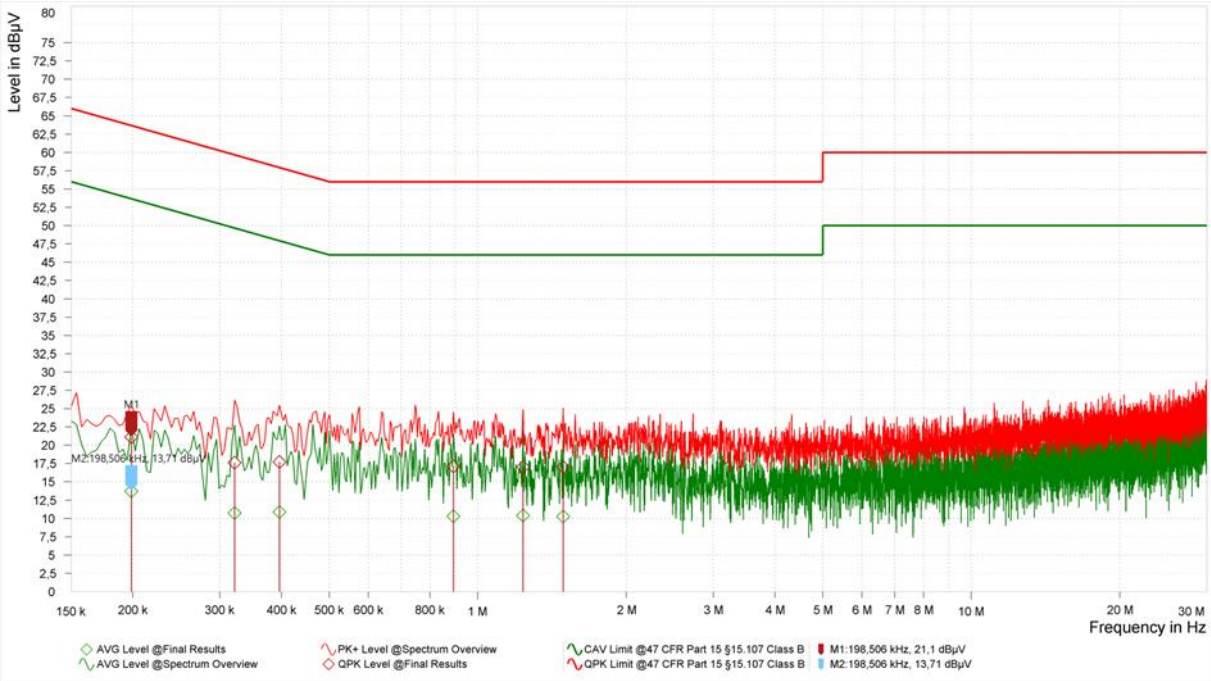
See next pages!

Plot no. 51: conducted emissions, line L1



Rg	Frequenc y [MHz]	QPK Level [dBµV]	QPK Limit [dBµV]	QPK Margin [dB]	AVG Level [dBµV]	AVG: CAV Limit [dBµV]	AVG Margin [dB]	Correctio n [dB]	Line	Meas. BW [kHz]	Meas. Time [s]
1	0,154	21,75	65,80	44,04	10,88	55,80	44,91	10,64	L1	9,000	15,000
1	0,206	19,29	63,37	44,08	11,02	53,37	42,35	9,85	L1	9,000	15,000
1	0,251	17,96	61,73	43,77	10,41	51,73	41,32	9,71	L1	9,000	15,000
1	0,542	17,43	56,00	38,57	10,66	46,00	35,34	10,07	L1	9,000	15,000
1	0,863	17,03	56,00	38,97	10,25	46,00	35,75	9,95	L1	9,000	15,000
1	1,463	16,83	56,00	39,17	10,27	46,00	35,73	9,87	L1	9,000	15,000

Plot no. 52: conducted emissions, neutral N



Rg	Frequency [MHz]	QPK Level [dBµV]	QPK Limit [dBµV]	QPK Margin [dB]	AVG Level [dBµV]	AVG: CAV Limit [dBµV]	AVG Margin [dB]	Correction [dB]	Line	Meas. BW [kHz]	Meas. Time [s]
1	0,199	21,10	63,67	42,57	13,71	53,67	39,96	9,88	N	9,000	15,000
1	0,322	17,62	59,66	42,05	10,74	49,66	38,93	9,90	N	9,000	15,000
1	0,396	17,72	57,93	40,21	10,86	47,93	37,07	10,05	N	9,000	15,000
1	0,893	17,10	56,00	38,90	10,30	46,00	35,70	9,95	N	9,000	15,000
1	1,236	17,03	56,00	38,97	10,38	46,00	35,62	9,90	N	9,000	15,000
1	1,490	17,02	56,00	38,98	10,27	46,00	35,73	9,88	N	9,000	15,000

8 Test Setup Description

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Cyclic chamber inspections and range calibrations are performed. Where possible, RF generating and signalling equipment as well as measuring receivers and analysers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

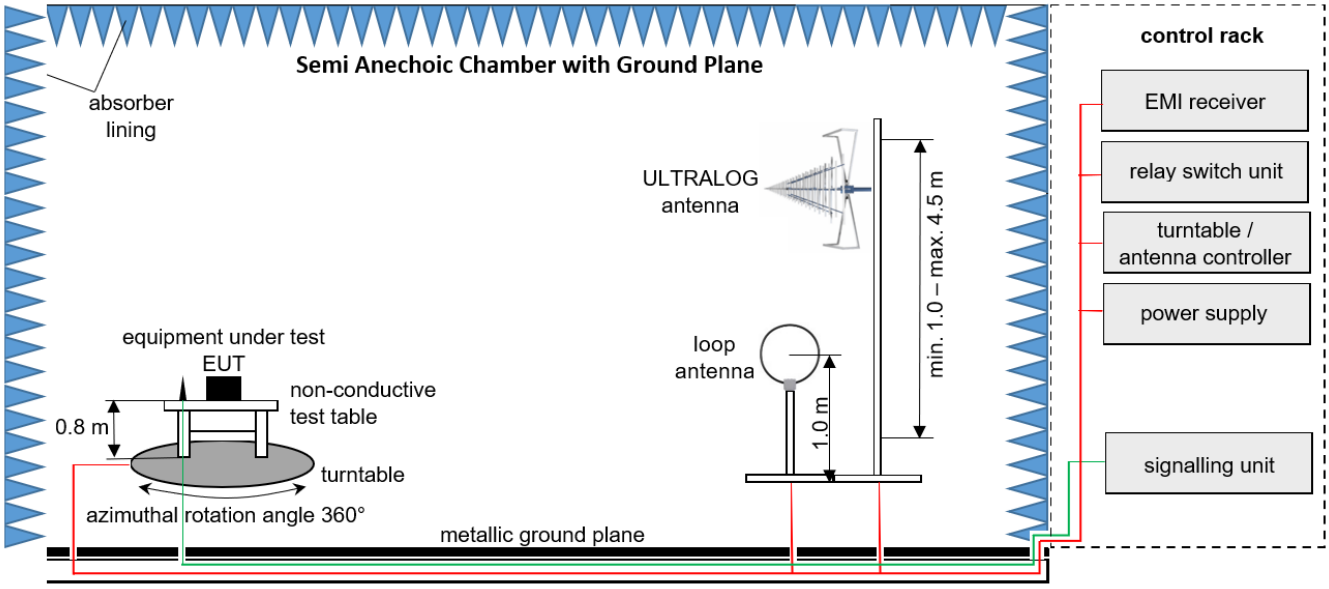
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Kind of calibration (abbreviations):

C = calibrated
CM = cyclic maintenance
NR = not required
L = locked

8.1 Semi Anechoic Chamber with Ground Plane

Radiated measurements are performed in vertical and horizontal plane in the frequency range 30 MHz to 1 GHz in a Semi Anechoic Chamber with a metallic ground plane. The EUT is positioned on a non-conductive test table with a height of 0.80 m above the metallic ground plane that covers the whole chamber. The receiving antennas conform to specification ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. These antennas can be moved over the height range between 1.0 m and 4.5 m in order to search for maximum field strength emitted from the EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by a spectrum analyzer where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: ULTRALOG antenna at 3 m; loop antenna at 3 m
EMC32 software version: 11.20.00

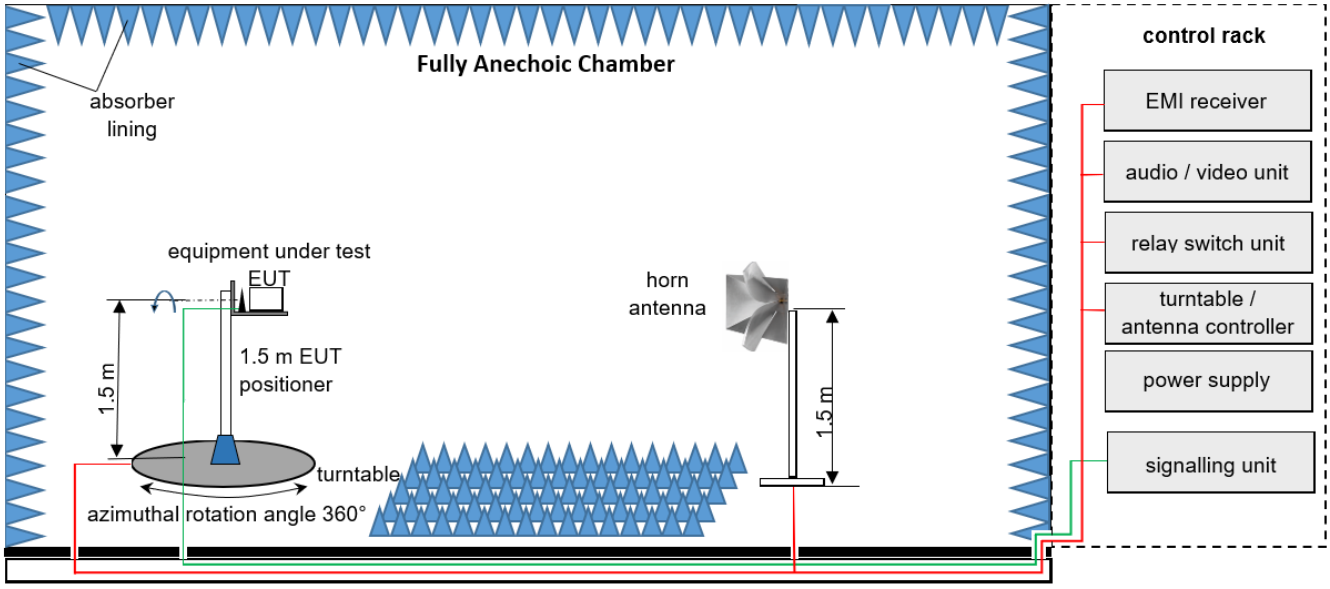
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Rohde & Schwarz	IN 600	101554	LAB000824	NR	–
2	Antenna	Rohde & Schwarz	HL562E	102173	LAB000673	C	2022-10-17 → 36M → 2025-10-17
3	Power Supply	Chroma	61602		LAB000507	NR	–
4	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
5	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
6	Antenna Mast	Berlebach	Tripod HFH2-Z8 & -Z9	101762	LAB000292	NR	–
7	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
8	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
9	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2023-07-04 → 12M → 2024-07-04
10	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	C	2022-01-31 → 36M → 2025-01-31
11	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
12	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
13	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
14	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
15	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
16	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
17	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
18	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2023-05-15 → 36M → 2026-05-15
19	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2022-12-22 → 36M → 2025-12-22
20	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–
21	Antenna	Rohde & Schwarz	HFH2-Z2E	100954	LAB000108	C	2023-05-05 → 36M → 2026-05-05

8.2 Fully Anechoic Chamber



Measurement distance: horn antenna at 3 m
EMC32 software version: 11.20.00

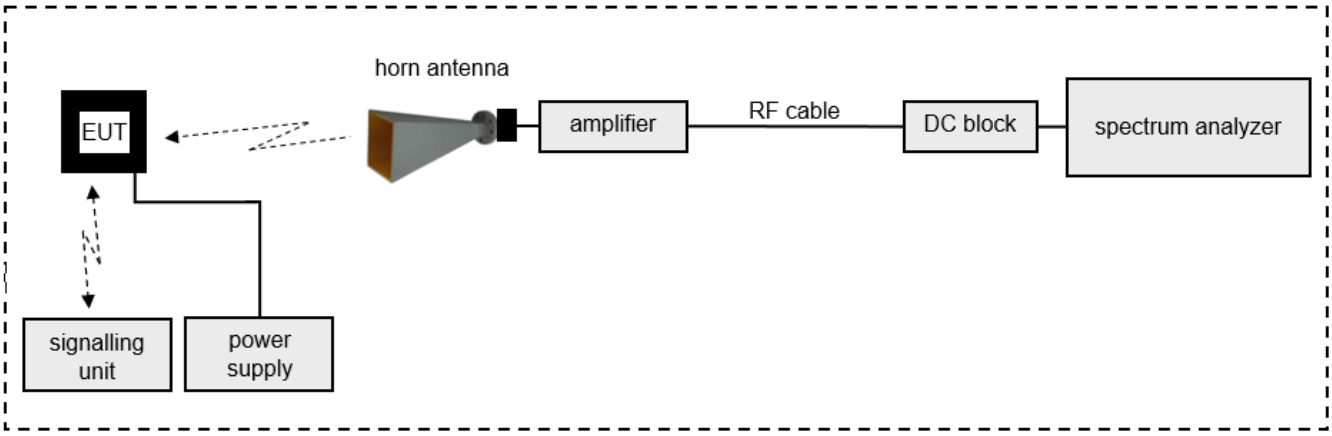
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

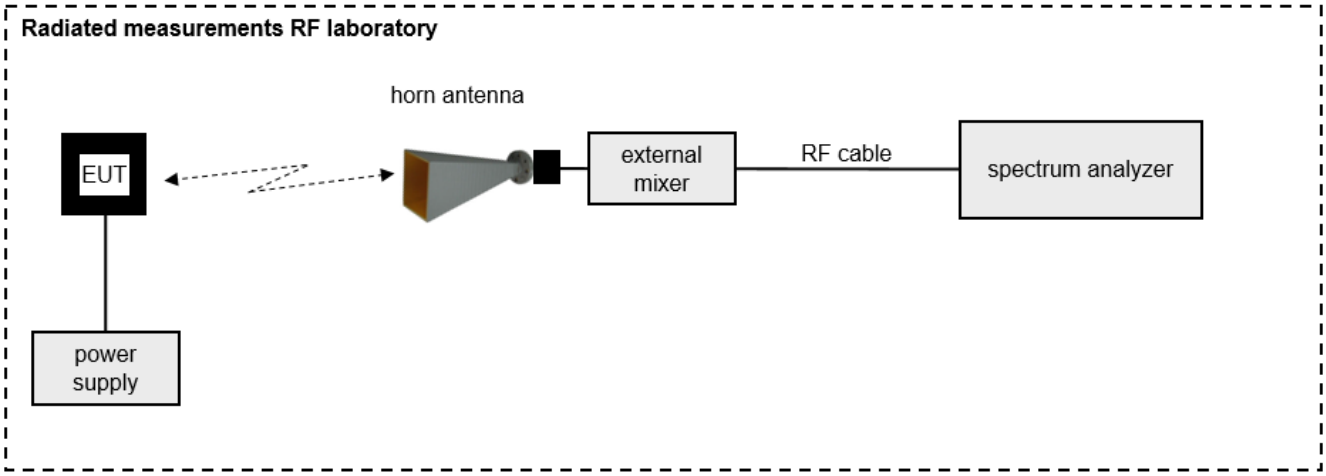
List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Rohde & Schwarz	IN 600	101554	LAB000824	NR	–
2	Antenna	Rohde & Schwarz	HL562E	102173	LAB000673	C	2022-10-17 → 36M → 2025-10-17
3	Power Supply	Chroma	61602		LAB000507	NR	–
4	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
5	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
6	Antenna Mast	Berlebach	Tripod HFH2-Z8 & -Z9	101762	LAB000292	NR	–
7	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
8	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
9	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2023-07-04 → 12M → 2024-07-04
10	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	C	2022-01-31 → 36M → 2025-01-31
11	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
12	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
13	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
14	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
15	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
16	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
17	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
18	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2023-05-15 → 36M → 2026-05-15
19	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2022-12-22 → 36M → 2025-12-22
20	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–
21	Antenna	Rohde & Schwarz	HFH2-Z2E	100954	LAB000108	C	2023-05-05 → 36M → 2026-05-05

8.3 Radiated measurements > 18 GHz



8.4 Radiated measurements > 50 GHz



Measurement distance: horn antenna e.g. 50 cm

FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

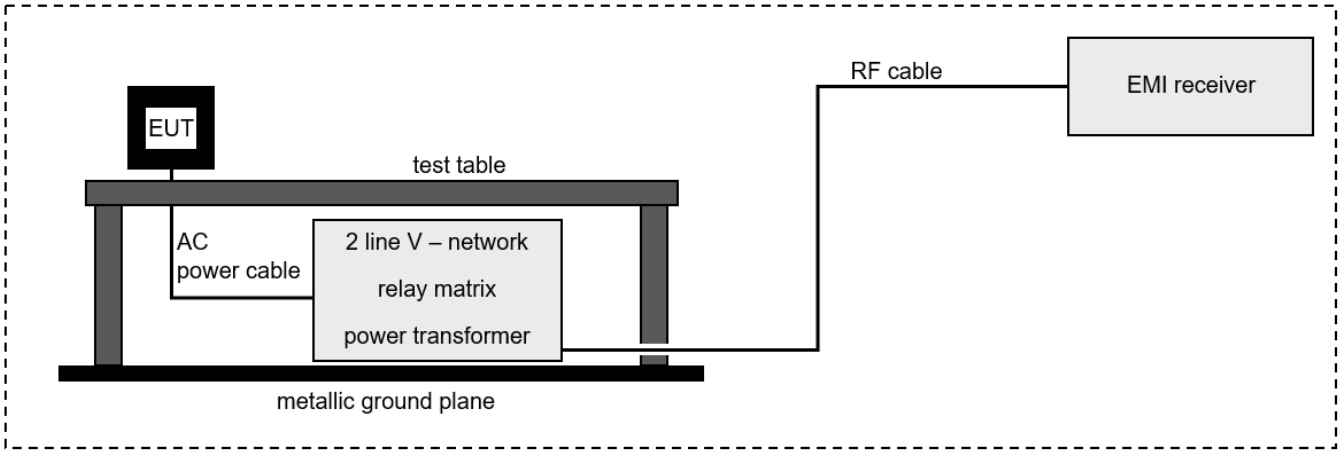
Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

Note: conversion loss of mixer is already included in analyzer value.

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Harmonic Mixer	Rohde & Schwarz	FS-Z060	101350	LAB000375	C	2023-04-13 → 12M → 2024-04-13
2	Test table	innco systems GmbH	PT0707-RH light	–	LAB000303	–	–
3	Spectrum Analyser	Rohde & Schwarz	FSW43	101391	LAB000289	NR	2023-06-02 → 12M → 2024-06-02
4	Power Supply	Elektro-Automatik GmbH & Co. KG	PS 2042-10 B	2878350263	LAB000190	NR	–
5	WG-Coax-Adapter	Flann Microwave Ltd	23373-TF30 UG383/U	273385	LAB000185	CM	–
6	WG-Coax-Adapter	Flann Microwave Ltd	22093-TF30 UG599/U	273263	LAB000183	CM	–
7	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273374	LAB000181	CM	–
8	Coaxial Cable	Huber & Suhner	SF101/1.0m	503989/1	LAB000163	CM	2023-07-17 → 12M → 2024-07-17
9	Coaxial Cable	Rosenberger	LU7-022-1000	34	LAB000154	NR	–
10	Coaxial Cable	Rosenberger	LU7-022-1000	33	LAB000153	NR	–
11	Antenna	Flann Microwave Ltd	27240-20	273367	LAB000137	CM	2023-08-24 → 36M → 2024-08-24
12	Antenna	Flann Microwave Ltd	25240-20	272860	LAB000133	CM	2023-08-24 → 36M → 2024-08-24
13	Antenna	Flann Microwave Ltd	23240-20	273431	LAB000131	CM	2023-08-24 → 36M → 2024-08-24
14	Antenna	Flann Microwave Ltd	22240-20	270448	LAB000130	CM	2023-07-17 → 12M → 2024-07-17
15	Antenna	Flann Microwave Ltd	20240-20	266402	LAB000127	CM	2023-07-17 → 12M → 2024-07-17
16	Harmonic Mixer	Rohde & Schwarz	FS-Z110	102000	LAB000114	C	2023-05-02 → 12M → 2024-05-02
17	Harmonic Mixer	Rohde & Schwarz	FS-Z090	102020	LAB000113	C	2023-04-06 → 12M → 2024-04-06
18	Antenna Mast	Schwarzbeck Mess-Elektronik OHG	AM 9104	99	LAB000109	NR	–
19	Climatic Chamber	CTS GmbH	T-65/50	204002	LAB000110	CM	2023-05-11 → 12M → 2024-05-11

8.5 AC conducted emissions



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	EMI Test Receiver	Rohde & Schwarz	EPL1000	100921	LAB000873	C	2023-12-06 → 36M → 2026-12-06
2	Shielded room	Albatross Projects GmbH	Sputnik 1 (Schirmkabine)		LAB000257	NR	–
3	Open Switch and Control Platform	Rohde & Schwarz	OSP-B200S2	101443	LAB000239	NR	–
4	Two-Line V-Network	Rohde & Schwarz	ENV216	102597	LAB000220	C	2023-11-07 → 24M → 2025-11-07

9 MEASUREMENT PROCEDURES

9.1 Radiated spurious emissions from 9 kHz to 30 MHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- For each turntable position the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated with special 3D adapter set to find maximum level of emissions.
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade of distance in the region closer than λ in m divided by 2π (i.e., λ/2π), and at 20 dB/decade of distance beyond that, using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the limit line of corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.2 Radiated spurious emissions from 30 MHz to 1 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable position / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.3 Radiated spurious emissions from 1 GHz to 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable position / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

9.4 Radiated spurious emissions above 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- EUT is powered on and set into operation.
- Test distance depends on EUT size and test antenna size (farfield conditions shall be met).

Pre-scan

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and for different polarizations of the antenna.

Final measurement

- Significant emissions found during the pre-scan will be maximized, i.e. position and antenna orientation causing the highest emissions with Peak and RMS detector
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C63.4 / C63.10).
- Final plot showing measurement data, levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit is recorded.

Note

- In case of measurements with external harmonic mixers (e.g. above 50 GHz) special care is taken to avoid possible overloading of the external mixer's input.
- As external harmonic mixers may generate false images, care is taken to ensure that any emission measured by the spectrum analyzer is indeed radiated from the EUT and not internally generated by the external harmonic mixer. Signal identification feature of spectrum analyzer is used to eliminate/reduce images of the external harmonic mixer.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.10

10 MEASUREMENT UNCERTAINTIES

Radio frequency	≤ ± 10 ppm
Radiated emission	≤ ± 6 dB
Temperature	≤ ± 1 °C
Humidity	≤ ± 5 %
DC and low frequency voltages	≤ ± 3 %

The indicated expanded measurement uncertainty corresponds to the standard measurement uncertainty for the measurement results multiplied by the coverage factor k = 2. It was determined in accordance with EA-4/02 M:2013. The true value is located in the corresponding interval with a probability of 95 %.