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

INGENIEURBÜRO LENHARDT

Bundesnetzagentur

BNetzA-CAB-21/21-21

Test Report

Test report no.: 22097841-29046-0
Date of issue: 2023-10-09

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

Applicant
Veoneer US, LLC

Manufacturer
Veoneer US, LLC

Test Item
60ICSG10V0

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices, Subpart C -
§15.255 Operation within the bands 57-71GHz

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

Company: IBL-Lab GmbH · Heinrich-Hertz-Allee 7-10 · 66386 St. Ingbert · Germany · **Tel:** +49 6894 38938-0 · **Fax:** +49 6894 38938-99
Company Register: 105151, Amtsgericht Saarbrücken
URL: www.ib-lenhardt.com · **E-Mail:** info@ib-lenhardt.com

Applicant and Test item details

Applicant	Veoneer US, LLC 26360 American Drive MI 48034, Southfield, MI 48034, USA Phone: +1 801 612 5555
Manufacturer	Veoneer US, LLC 26360 American Drive MI 48034, Southfield, MI 48034, USA
Test item description	60 GHz ICS Radar Sensor
Model/Type reference	60ICSG10V0
FCC ID	WU860ICSG10V0
Frequency	60 GHz to 64 GHz
Antenna	integrated patch antenna
Power supply	8.0 to 16.0 V DC
Temperature range	-40 °C to +85 °C

Disclaimer and Notes

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	2023-08-28
Start – End of tests	2023-08-28 – 2023-10-09

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	8.0 V DC	13.2 V DC	16.0 V DC

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	**Description**
FCC 47 CFR Part 15	Radio Frequency Devices, Subpart C - §15.255 Operation within the bands 57-71GHz

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

60 GHz ICS Radar Sensor

5.2 Description of test item

Model name*	60ICSG10V0
Serial number*	Normal: 00847 CW Low: 00577 CW Mid: 00797 CW High: 00846
Hardware status*	ICS1.0
Software status*	R255_51_19D26_109

*: as declared by applicant

5.3 Technical data of test item

Operational frequency band*	60 GHz to 64 GHz
Type of radio transmission*	modulated carrier
Modulation type*	FMCW
Number of channels*	1
Channel bandwidth*	<4 GHz
Channel spacing*	N/A
Receiver category*	N/A
Receiver bandwidth*	N/A
Duty cycle*	<10%
Antenna*	integrated patch antenna
Rated RF output power*	11 dBm
Power supply*	8.0 to 16.0 V DC
Temperature range*	-40 °C to +85 °C

*: as declared by applicant

5.4 Additional information

Model differences	Applicant provided 4 samples for testing: - 1x normal sample (FMCW) - 1x CW Low: FMCW stopped at the lower end of the band in use - 1x CW Mid: FMCW stopped in the middle of the band in use - 1x CW High: FMCW stopped at the upper end of the band in use according to requirements as listed in FCC Part 15.31(c)
Additional application considerations to test a component or sub-assembly	N/A
Ancillaries tested with	N/A
Additional equipment used for testing	N/A

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15

Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§15.255(e) / §2.1049	Occupied bandwidth (99% / 6dB / 10dB / 20dB)	Normal	3.72 GHz	P
§15.255(c)	Radiated EIRP	Normal	9.6 dBm Peak 1.0 dBm AVG	P
§15.215(c) / §15.255(f)	Transmitter frequency stability	Normal/Extreme	-/-	P
§15.255(d) / §15.209(a)	Field strength of emissions (spurious & harmonics)	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

-/-

7 TEST RESULTS

7.1 Occupied bandwidth (§2.1049)

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 57-71GHz frequency band.

FCC §15.255 (e)(2):

For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

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

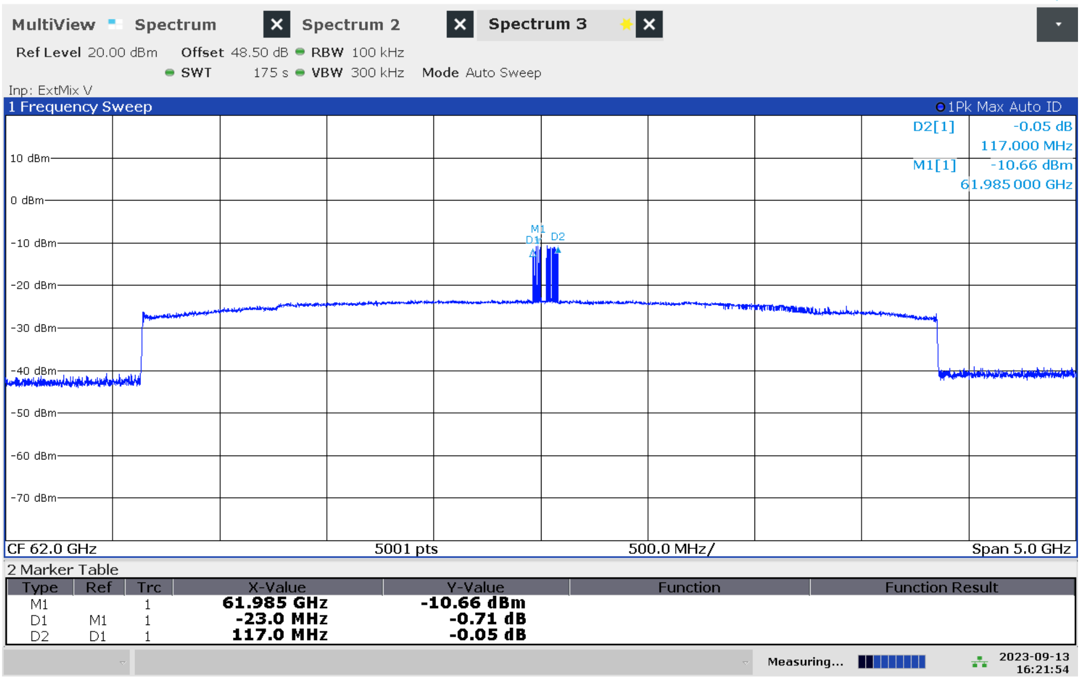
Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak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

Test setup: 8.4

Test results					
EUT mode	**Test conditions**	**RBW**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [GHz]**
Normal mode	Normal - 99%	40 MHz	60.1402	63.8589	**3.7186**
Normal mode	Normal - 6dB	100 kHz	61.9620	62.0790	0.1170
Normal mode		1 MHz	61.9690	62.0780	0.1090
Normal mode		10 MHz	60.1344	63.8547	**3.7203**
Normal mode	Normal - 10dB	100 kHz	61.9610	62.0800	0.1190
Normal mode		1 MHz	61.9600	62.0770	0.1170
Normal mode		10 MHz	60.1304	63.8597	3.7293
Normal mode	Normal - 20dB	100 kHz	63.9176	67.6299	3.7123
Normal mode		1 MHz	63.9446	67.6589	3.7143
Normal mode		10 MHz	63.9306	67.6828	3.7522

Plot no. 1: 99 % bandwidth, 40 MHz RBW

Plot no. 2: 6 dB bandwidth measured with 100 kHz RBW as given by §15.255 (e)(2)



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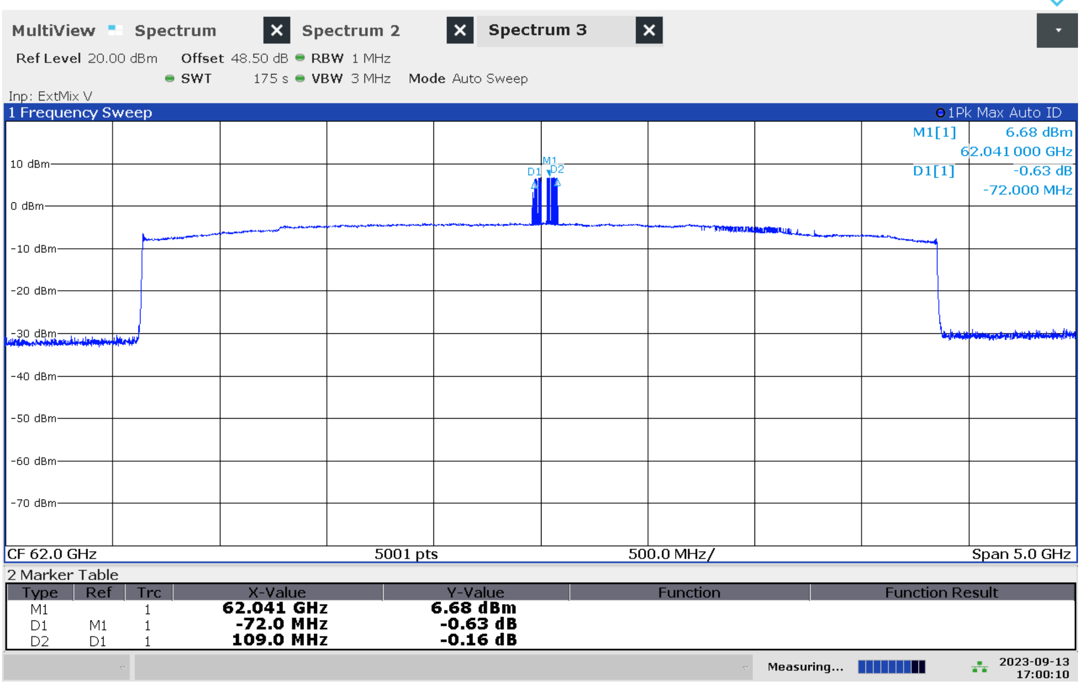
Note:
The 6 dB Bandwidth does not cover the full spectrum due to an uneven power spectral density and is therefore deemed insufficient, alternative measurements were made as worst-case considerations:

Plot no. 3: 6 dB bandwidth measured with 1 MHz RBW (alternative measurement)



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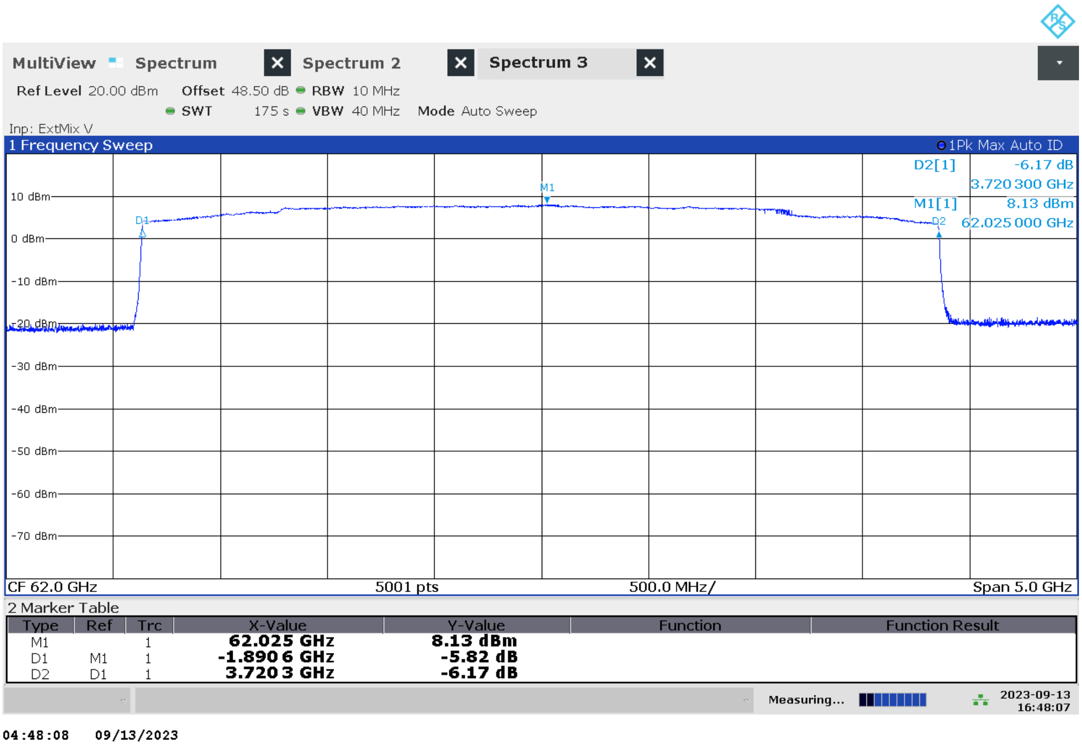
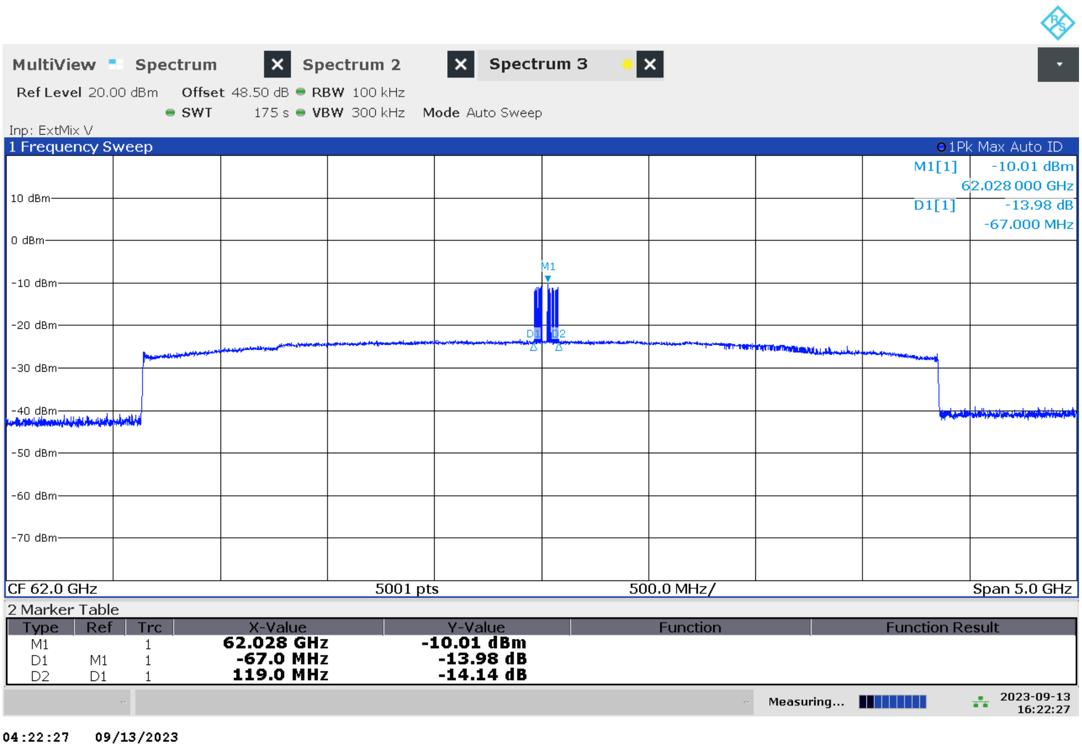
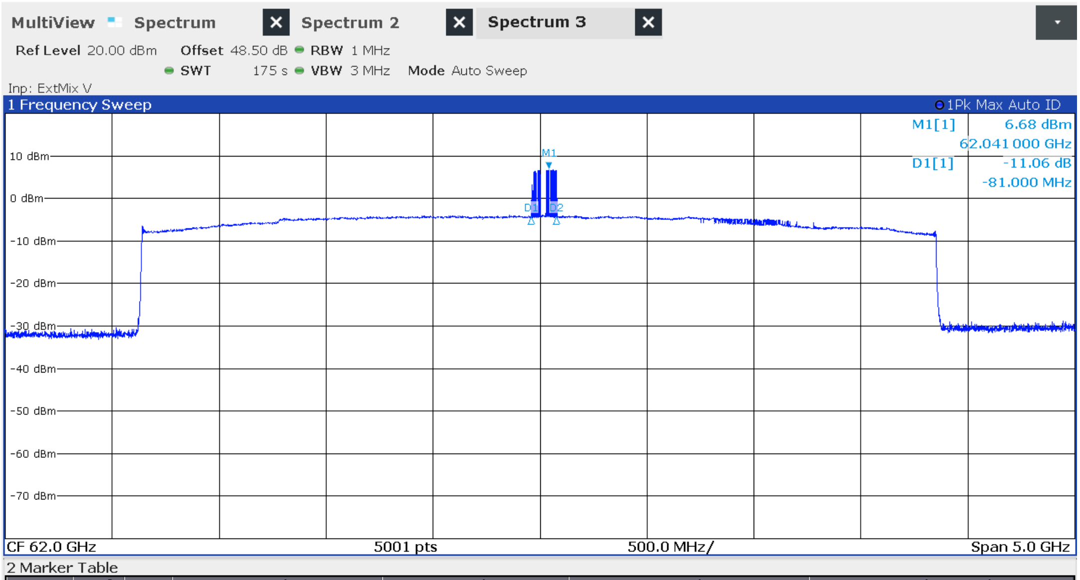
Plot no. 4: 6 dB bandwidth measured with 10 MHz RBW (alternative measurement)



Plot no. 5: 10 dB bandwidth measured with 100 kHz RBW (alternative measurement)



Plot no. 6: 10 dB bandwidth measured with 1 MHz RBW (alternative measurement)



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	62.041 GHz	6.68 dBm		
D1	M1	1	-81.0 MHz	-11.06 dB		
D2	D1	1	117.0 MHz	-10.96 dB		

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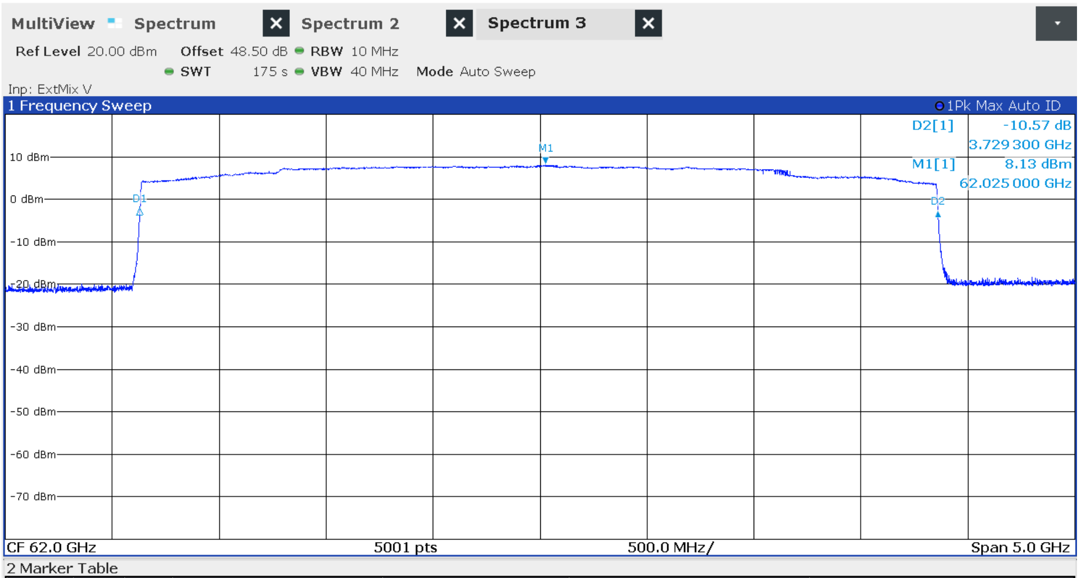
Plot no. 7: 10 dB bandwidth measured with 10 MHz RBW (alternative measurement)



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	62.025 GHz	8.13 dBm		
D1	M1	1	-1.894 6 GHz	-10.09 dB		
D2	D1	1	3.729 3 GHz	-10.57 dB		

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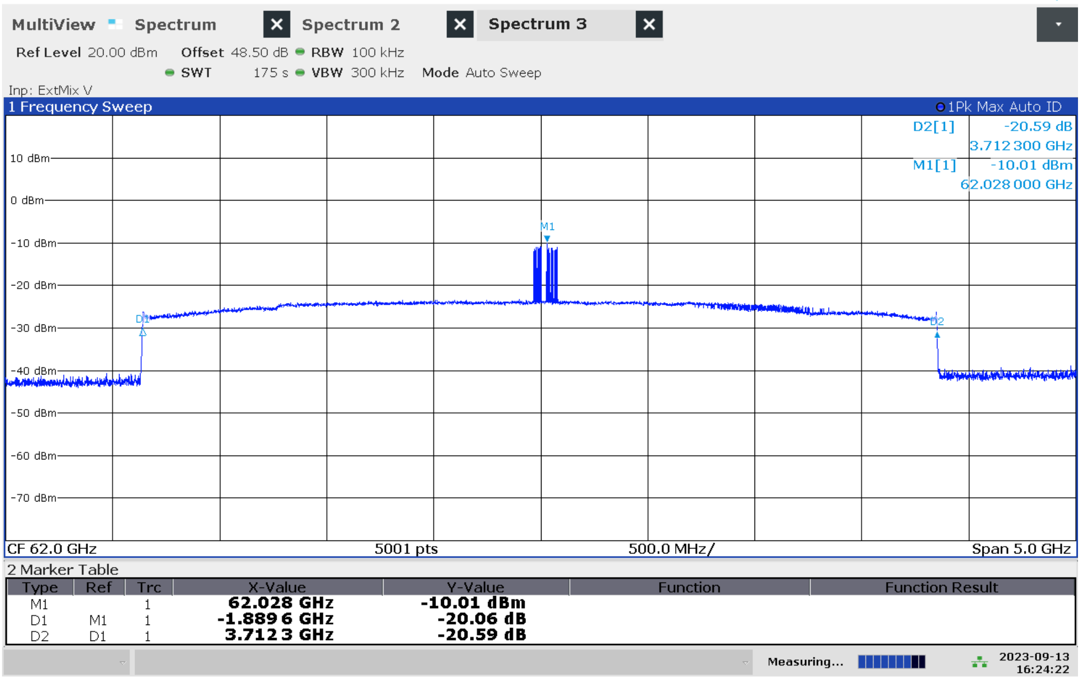
Plot no. 8: 20 dB bandwidth measured with 100 kHz RBW (alternative measurement)



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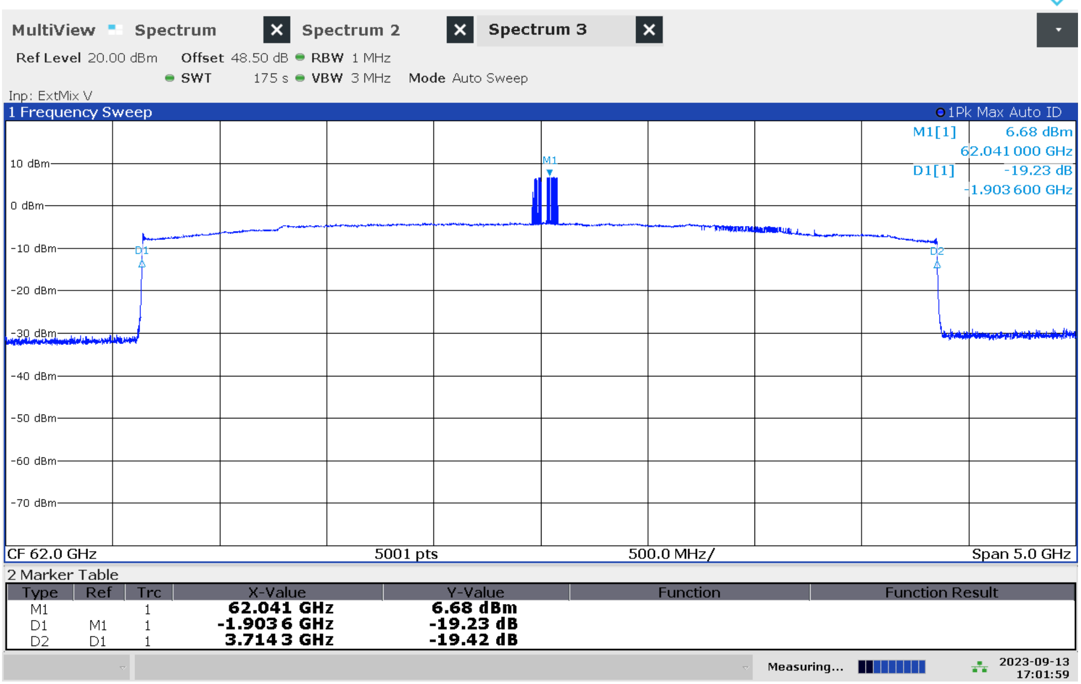
Plot no. 9: 20 dB bandwidth measured with 1 MHz RBW (alternative measurement)



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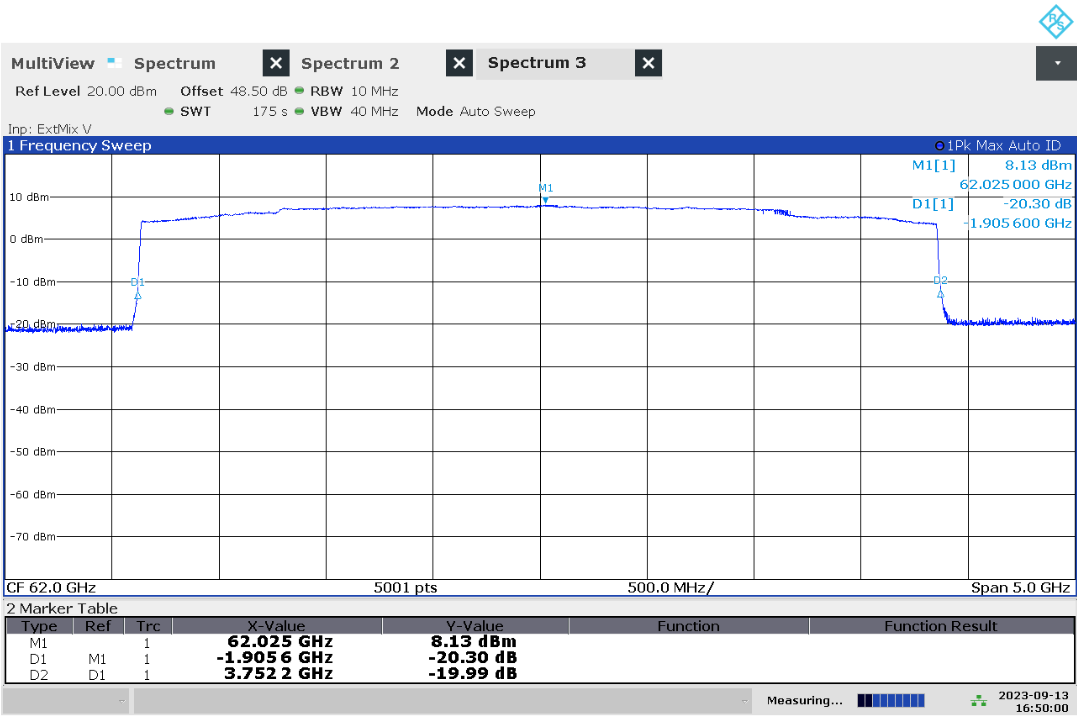
Plot no. 10: 20 dB bandwidth measured with 10 MHz RBW (alternative measurement)



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7.2 Radiated EIRP

Description / Limits

§ 15.255 (c) (2)

Field disturbance sensors/radars shall not exceed −10 dBm peak conducted output power and 10 dBm peak EIRP except that field disturbance sensors/radars that limit their operation to all or part of the specified frequency band may operate without being subject to a transmitter conducted output power limit if they operate in compliance with paragraph (b)(3) of this section or with one or more of the provisions below:

(i) 57.0–59.4 GHz:
the peak EIRP level shall not exceed 20 dBm for indoor operation or 30 dBm for outdoor operation;

(ii) 57.0–61.56 GHz:
the peak EIRP shall not exceed 3 dBm except that the peak EIRP shall not exceed 20 dBm if the sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds;

(iii) 57.0–64.0 GHz:

(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;

(B) The peak EIRP shall not exceed 20 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds when operated outdoors:

(1) As part of a temporary or permanently fixed application; or

(2) When being used in vehicular applications to perform specific tasks of moving something or someone, except for in-cabin applications;

(iv) A field disturbance sensor may operate in any of the modes in the above sub-sections so long as the device operates in only one mode at any time and does so for at least 33 milliseconds before switching to another mode.

Test procedure

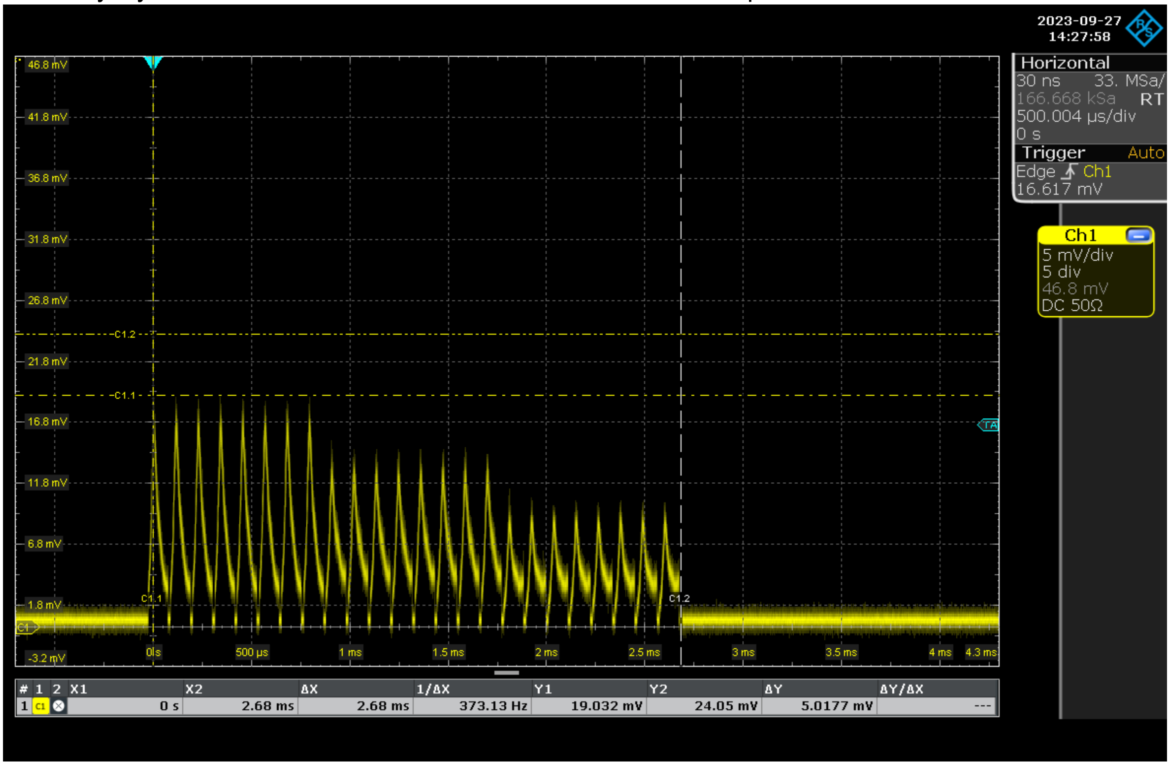
According to ANSI C63.10, 9.11 Measurement of the fundamental emission using an RF detector and substitution.

Test setup: 8.5

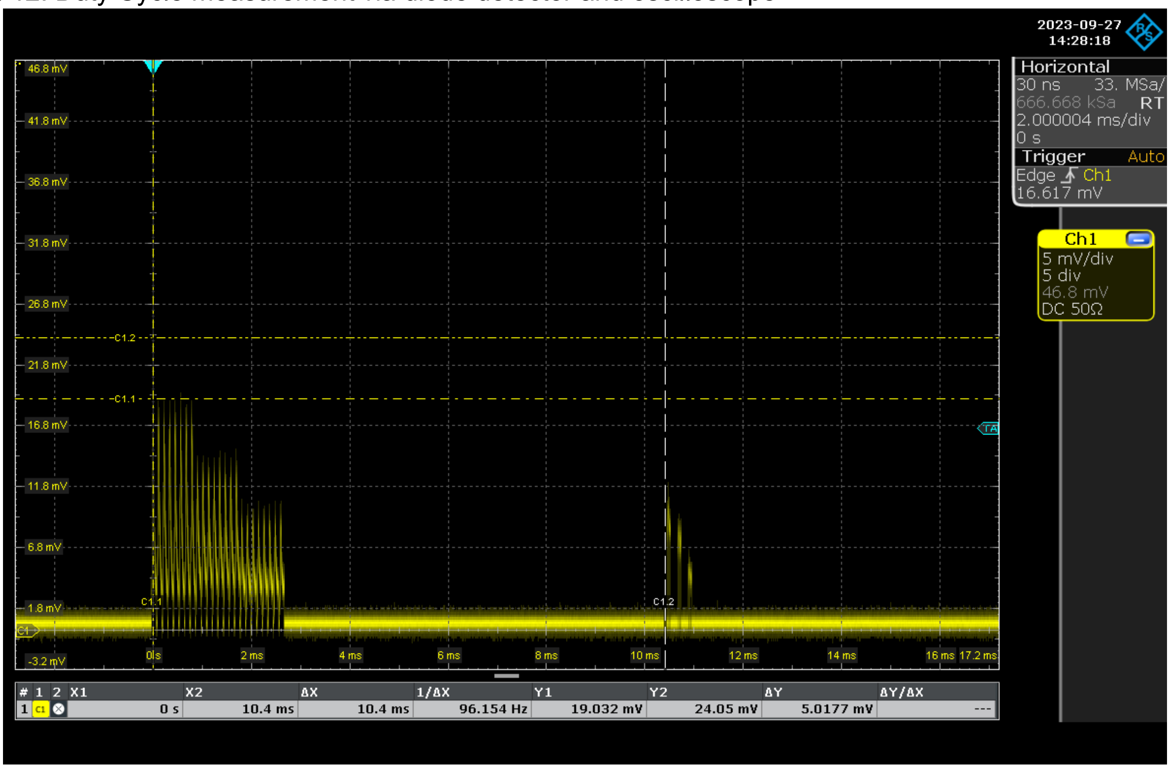
Test results:

EUT mode	Temperature / Voltage	Peak Power [dBm]	Mean Power [dBm]	On time [ms]	Off time [ms]	Cycle [ms]	Duty Cycle [%]
Normal operation	T_{nom} / V_{nom}	9.6	1.0	3.26	30.02	33.28	9.8

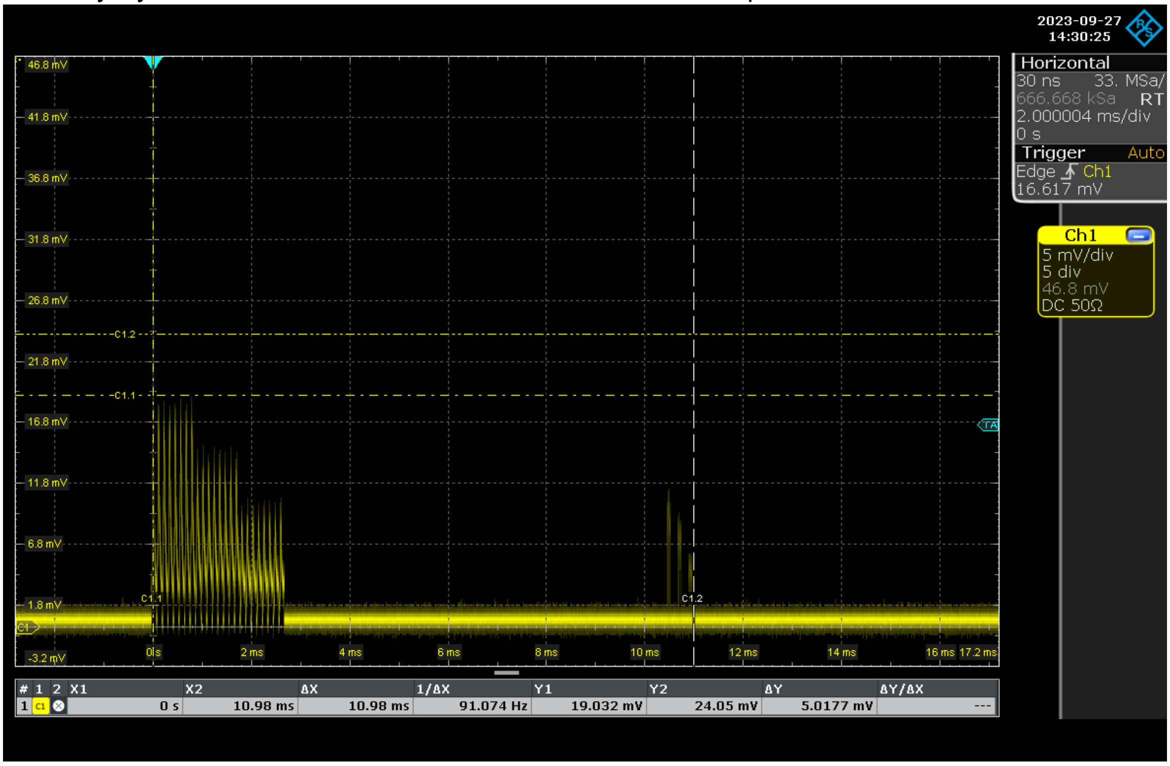
Plot no. 11: Duty Cycle measurement via diode detector and oscilloscope



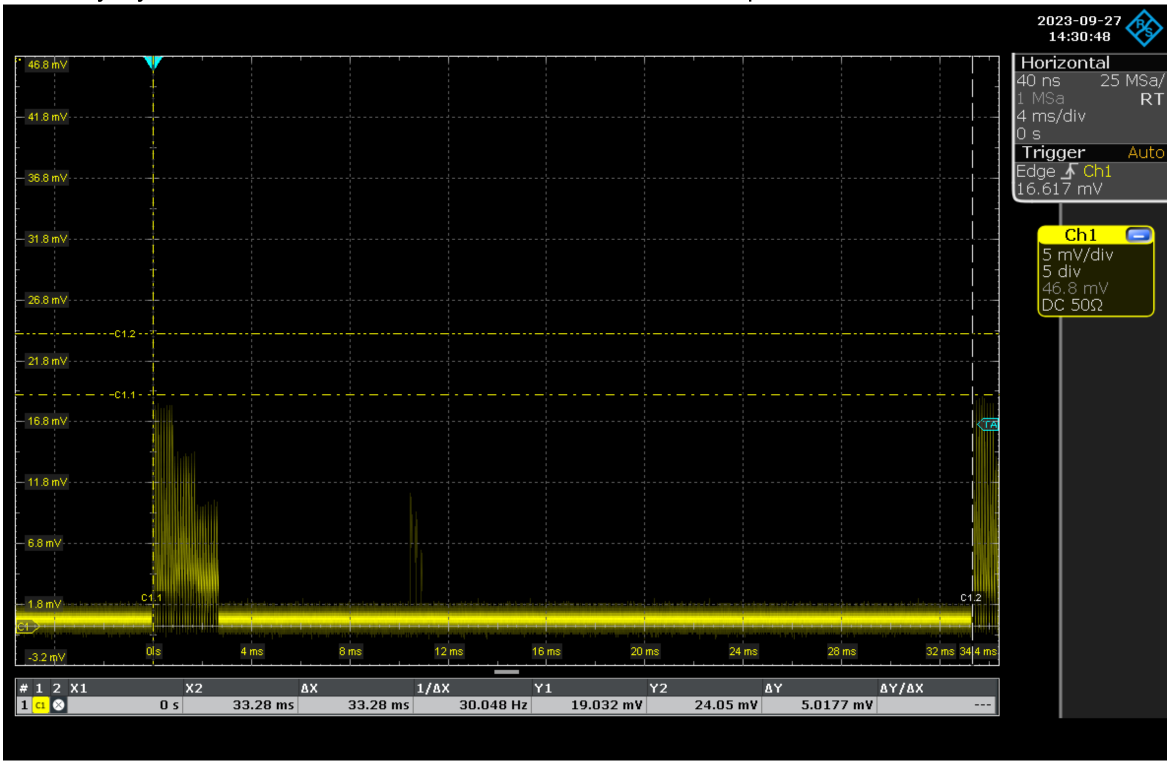
Plot no. 12: Duty Cycle measurement via diode detector and oscilloscope



Plot no. 13: Duty Cycle measurement via diode detector and oscilloscope



Plot no. 14: Duty Cycle measurement via diode detector and oscilloscope



7.3 Frequency stability (§2.1055 & §15.255(f))

Description

§2.1055 Measurements required: Frequency stability.

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From −30° to + 50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

Limits

§15.255 Operation within the band 57-71 GHz:

(f) Frequency stability. Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

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.

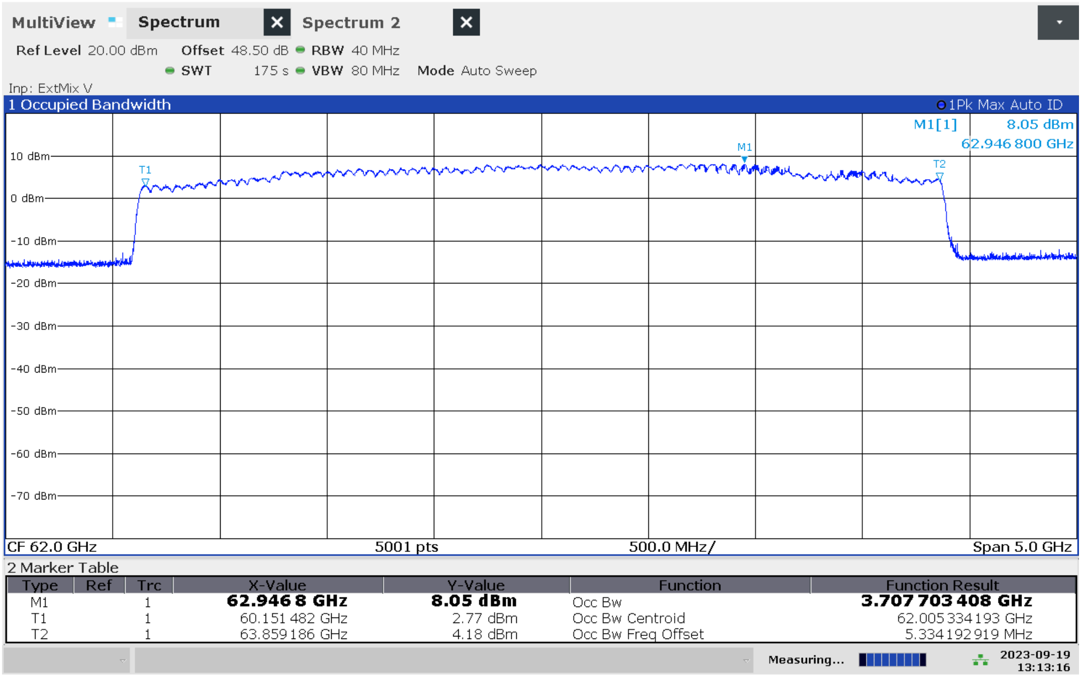
f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

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).

Test setup: 8.6				
Test results under normal and extreme test conditions:				
EUT mode	**Test conditions**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [MHz]**
Normal operation	-40 °C	60.151	63.859	3.7077
Normal operation	-30 °C	60.147	63.859	3.7121
Normal operation	-20 °C	60.144	63.860	3.7158
Normal operation	-10 °C	60.143	63.860	3.7164
Normal operation	0 °C	60.143	63.855	3.7121
Normal operation	10 °C	60.141	63.856	3.7152
Normal operation	20 °C / $V_{(min – max)}$	60.140	63.859	3.7186
Normal operation	30 °C	60.139	63.852	3.7125
Normal operation	40 °C	60.138	63.858	3.7196
Normal operation	50 °C	60.142	63.850	3.7081
Normal operation	85 °C	60.134	63.852	3.7172
Voltage variation				
Input voltage variation does not affect the transmitted signal (see plots for ambient/normal temperature).				

Plot no. 15: 99% OBW, Peak detector, -40 °C



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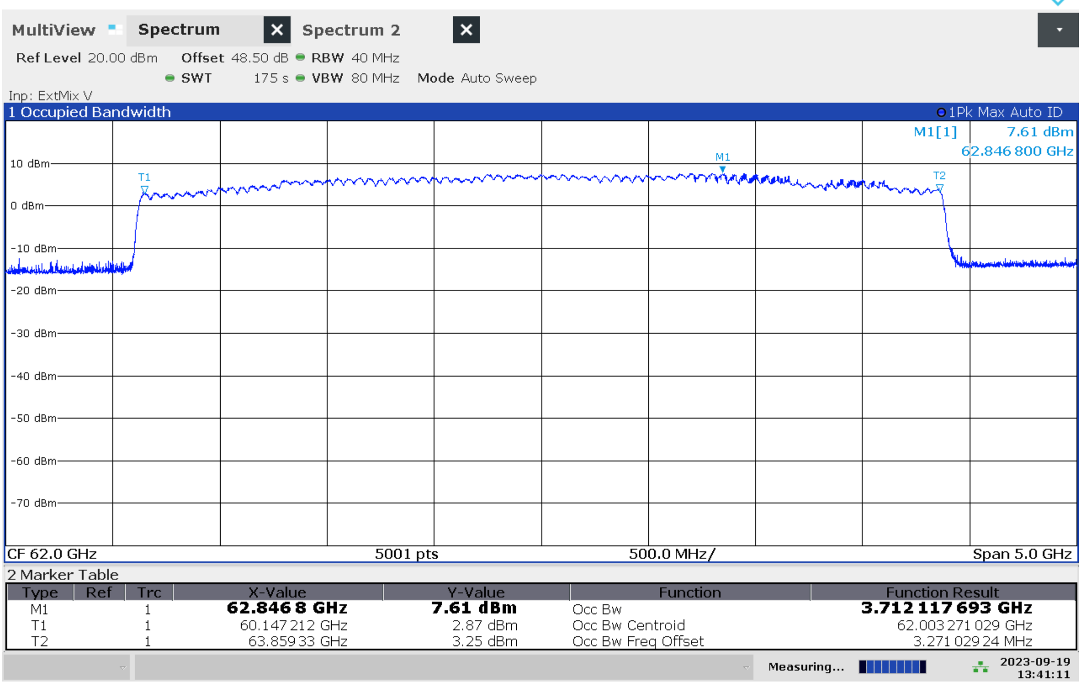
Plot no. 16: 99% OBW, Peak detector, -30 °C



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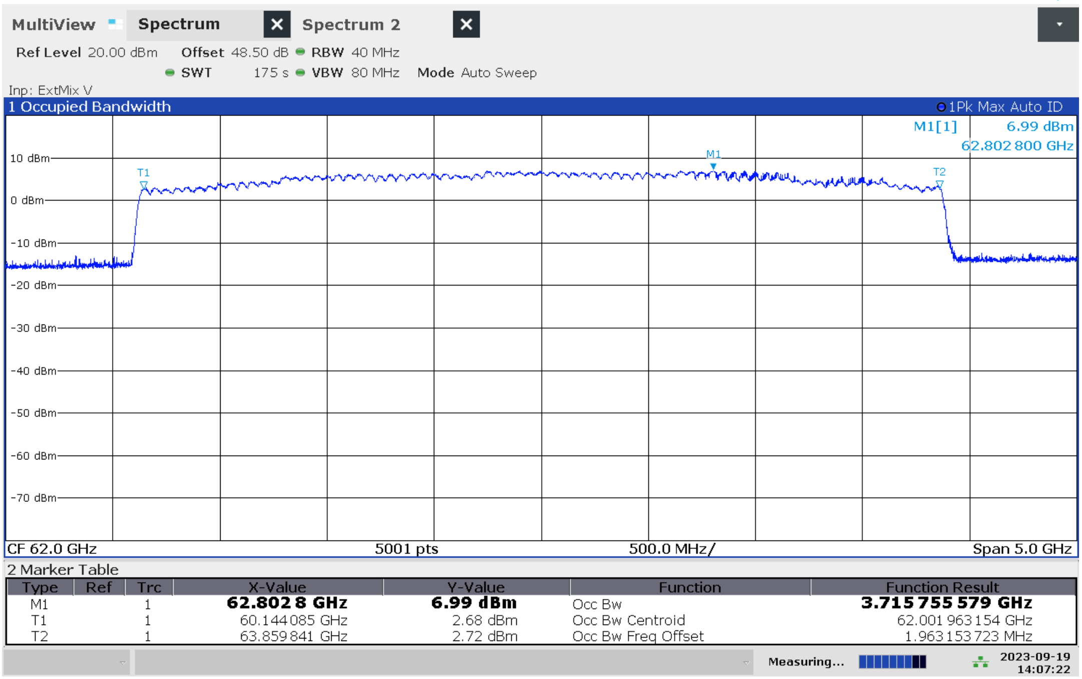
Plot no. 17: 99% OBW, Peak detector, -20 °C



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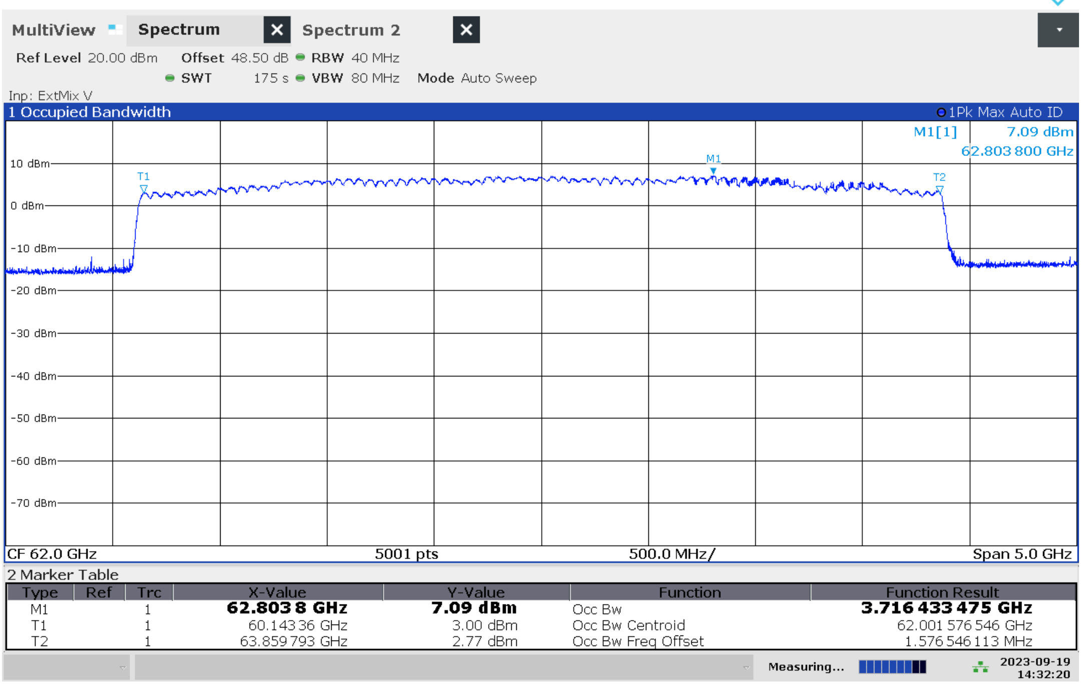
Plot no. 18: 99% OBW, Peak detector, -10 °C



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Plot no. 19: 99% OBW, Peak detector, +0 °C

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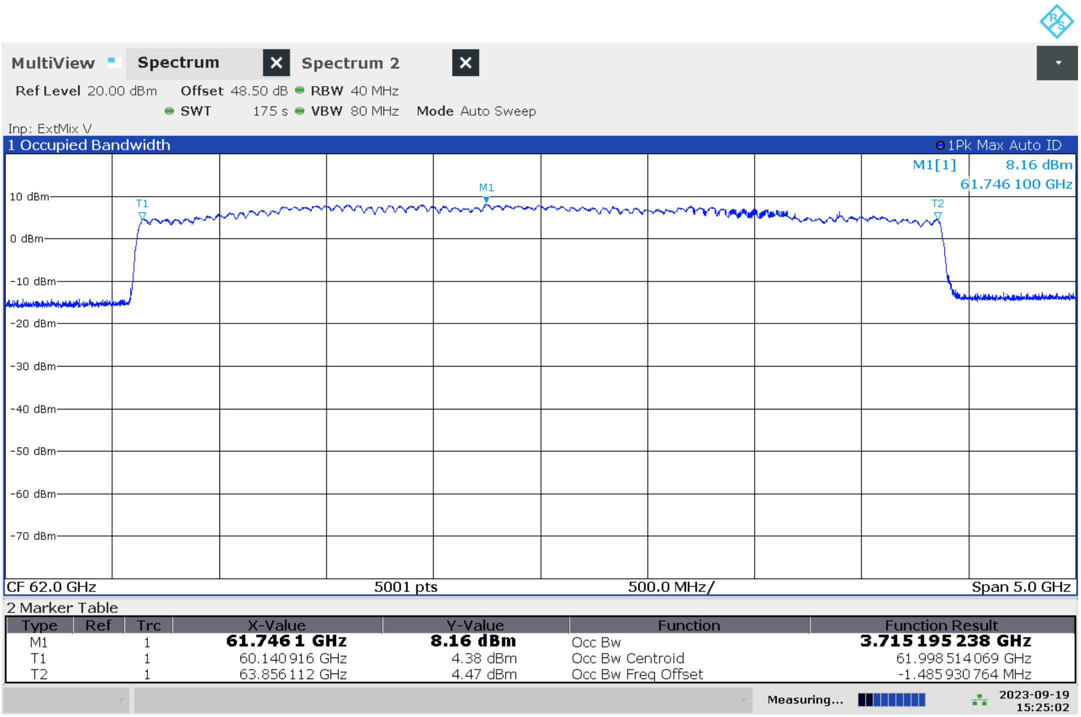
Plot no. 20: 99% OBW, Peak detector, +10 °C



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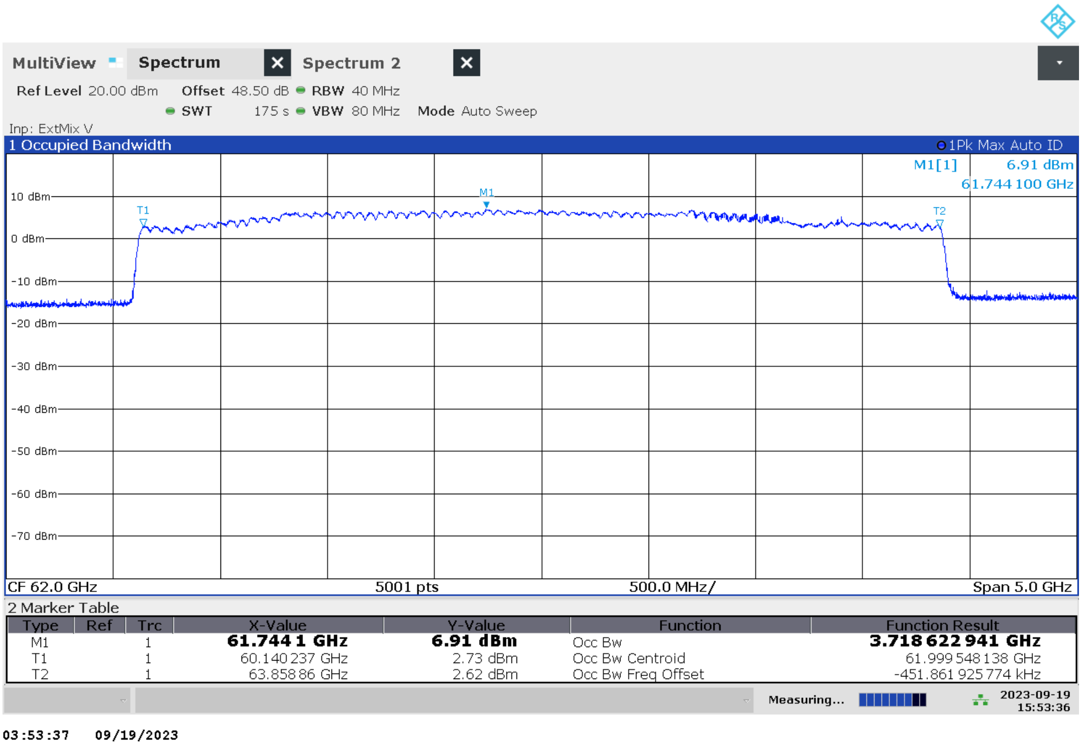
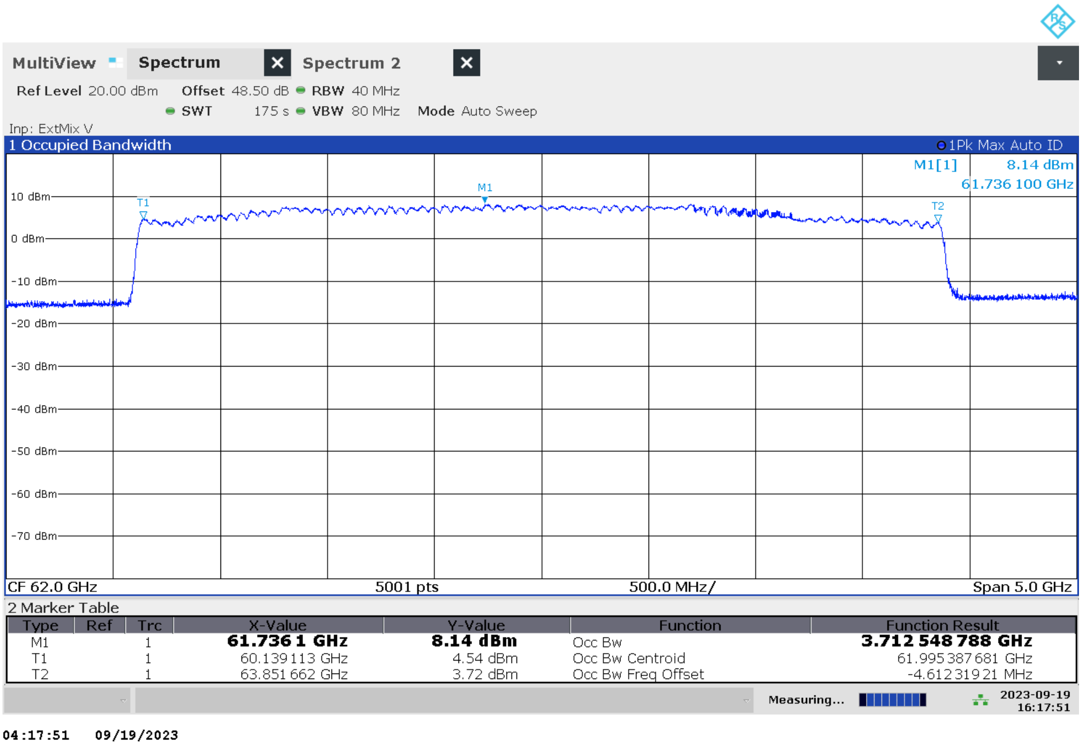
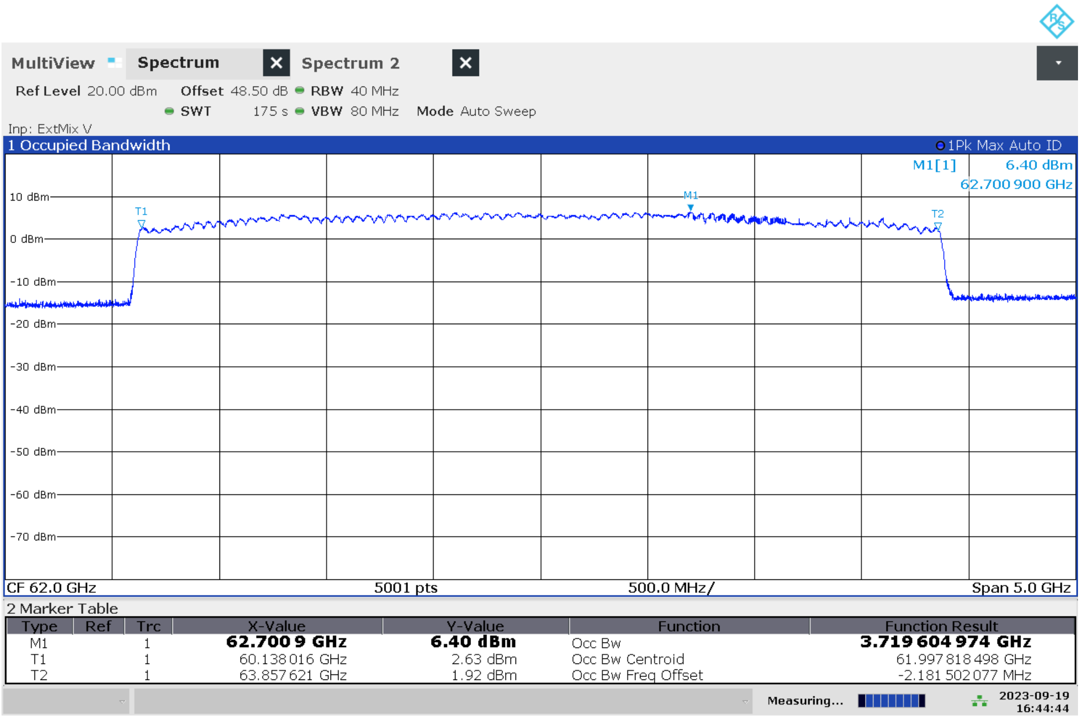
Plot no. 21: 99% OBW, Peak detector, +20 °C, $V_{(min - max)}$



Plot no. 22: 99% OBW, Peak detector, +30 °C

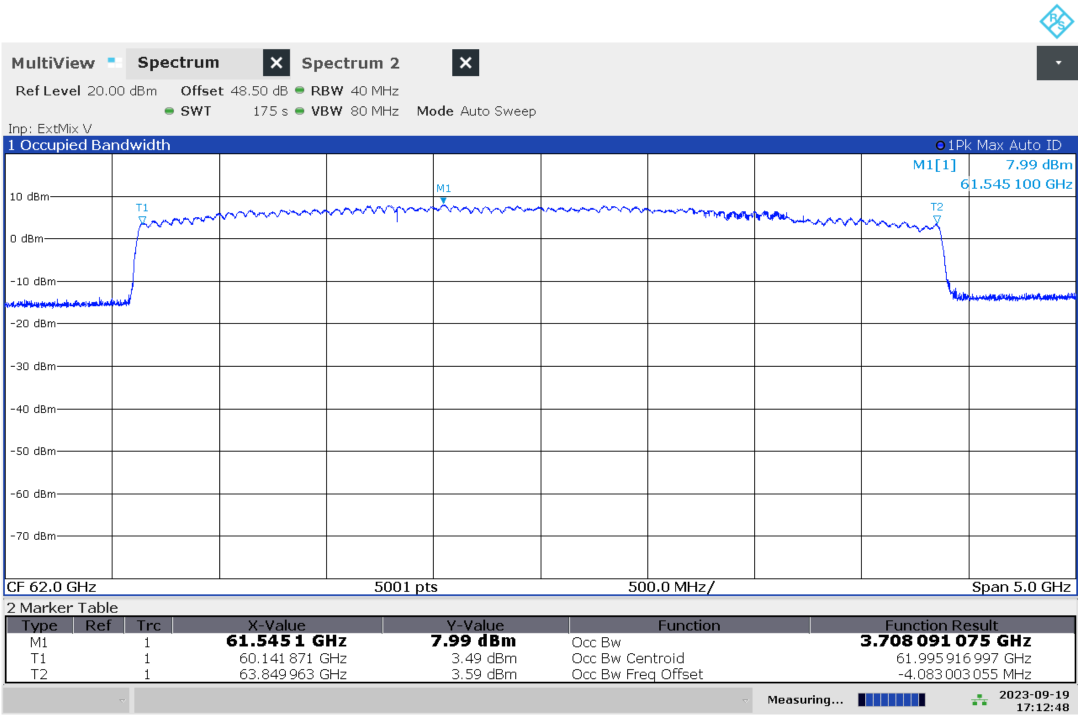


Plot no. 23: 99% OBW, Peak detector, +40 °C



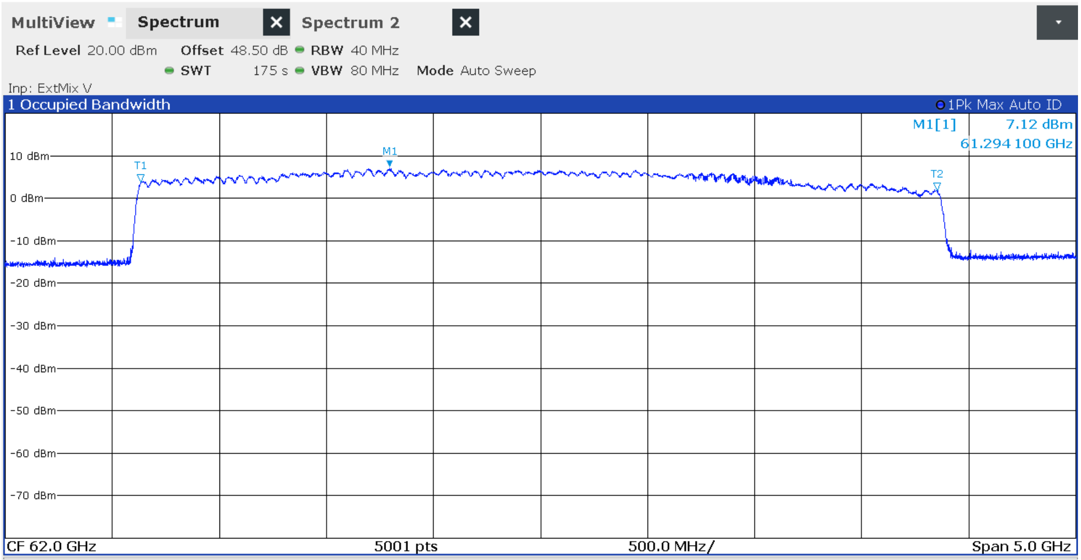
04:44:45 09/19/2023

Plot no. 24: 99% OBW, Peak detector, +50 °C



05:12:49 09/19/2023

Plot no. 25: 99% OBW, Peak detector, +85 °C



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**61.294 1 GHz**	**7.12 dBm**	Occ Bw	**3.717 248 81 GHz**
T1		1	60.134 291 GHz	3.73 dBm	Occ Bw Centroid	61.992 915 717 GHz
T2		1	63.851 54 GHz	1.75 dBm	Occ Bw Freq Offset	-7.084 283 093 MHz

Measuring... 2023-09-19 17:52:51

05:52:51 09/19/2023

7.4 Field strength of emissions (spurious and harmonics)

Description / Limits

§15.255 (d) (1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

§15.255 (d) (2)

Radiated emissions below 40 GHz shall not exceed the general limits in § 15.209.:

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

§15.255 (d) (3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters.

§15.255 (d) (4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

Limit of Waiver:

30 MHz – 200 GHz: -51.3 dBm

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	110	0.113
28240-20	90.0 – 140	0.0100	140	0.093
29240-20	110 – 170	0.0085	170	0.082
30240-20	140 – 220	0.0068	220	0.068

Used test distances

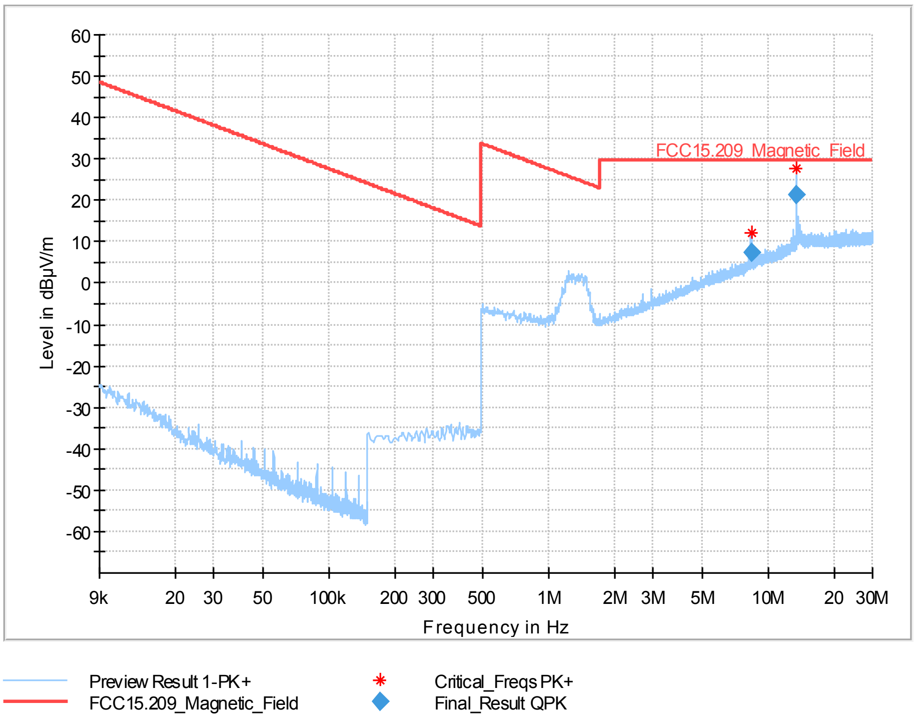
Up to 18 GHz:	3.00 m
18 – 40 GHz:	1.0 m
40 – 50 GHz:	1.0 m
50 – 75 GHz:	0.5 m
75 – 110 GHz:	0.25 m
110 – 220 GHz:	0.15 m
in-band:	1.0 m

Test setup: 8.1 – 8.4

Test results:

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
No critical emissions found, please refer to plots.						

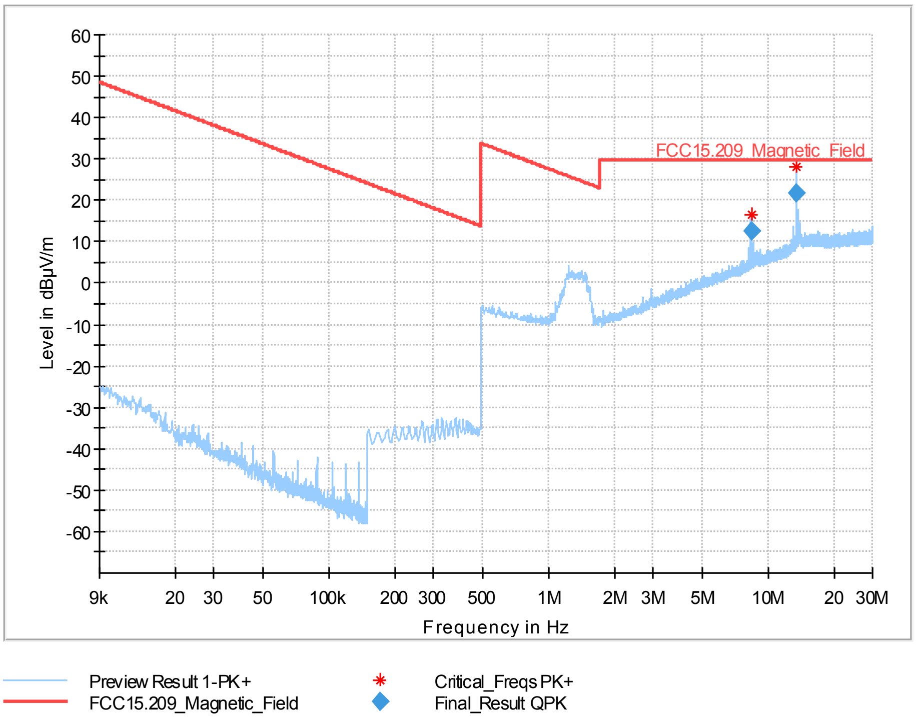
Plot no. 26: radiated emissions 9 kHz – 30 MHz, loop antenna, CW Low



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
8.391750	7.45	29.54	22.09	100.0	9.000	V	15.0	-5.1
13.560000	21.25	29.54	8.29	100.0	9.000	V	241.0	-0.9

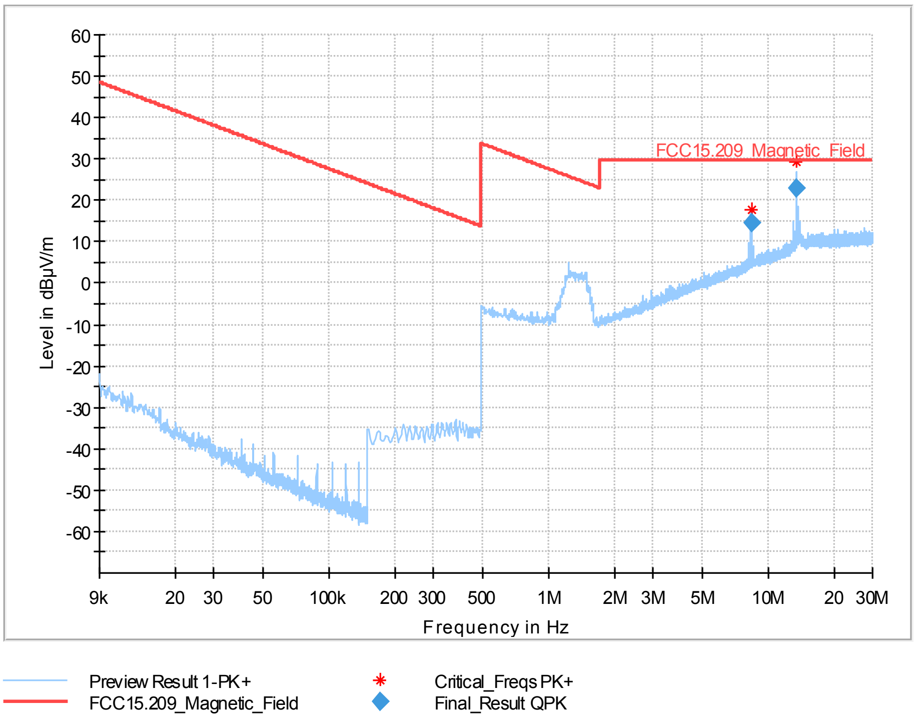
Plot no. 27: radiated emissions 9 kHz – 30 MHz, loop antenna, CW Mid



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
8.391750	12.73	29.54	16.81	100.0	9.000	V	210.0	-5.1
13.560000	21.60	29.54	7.94	100.0	9.000	V	331.0	-0.9

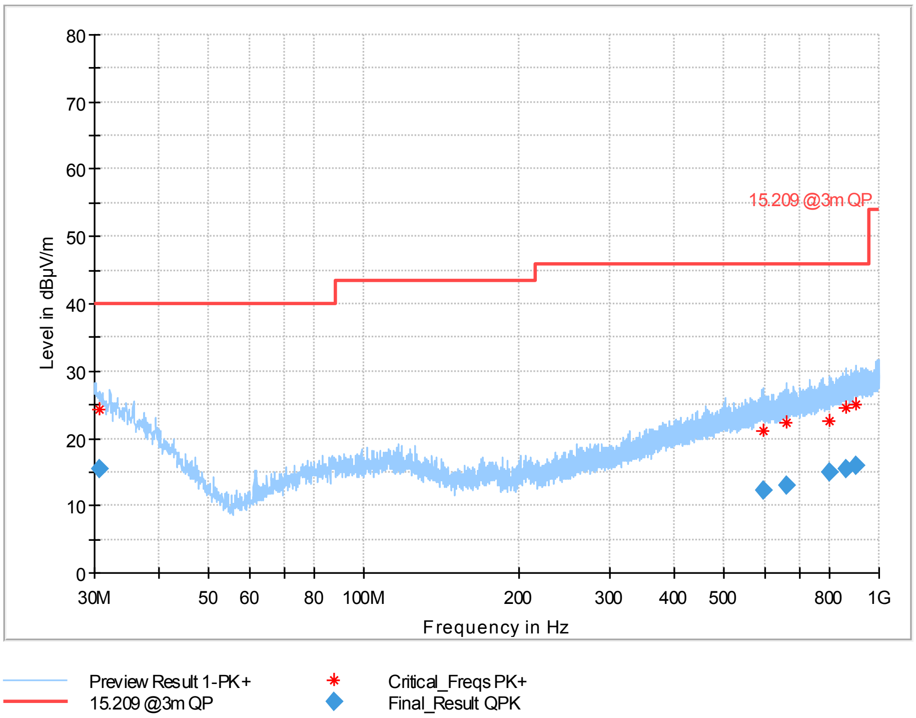
Plot no. 28: radiated emissions 9 kHz – 30 MHz, loop antenna, CW High



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
8.391750	14.36	29.54	15.18	100.0	9.000	V	60.0	-5.1
13.560000	22.82	29.54	6.72	100.0	9.000	V	127.0	-0.9

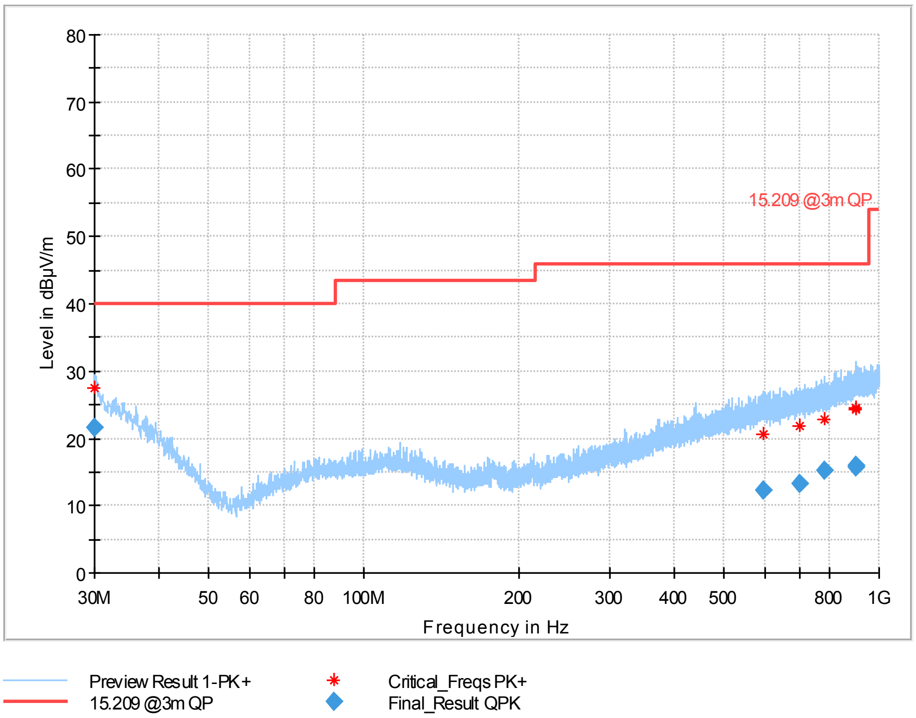
Plot no. 29: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, CW Low



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.597000	15.44	40.00	24.56	100.0	120.000	298.0	V	198.0
597.107500	12.19	46.00	33.81	100.0	120.000	277.0	H	-5.0
661.749000	12.97	46.00	33.03	100.0	120.000	266.0	H	345.0
800.131500	14.96	46.00	31.04	100.0	120.000	131.0	H	185.0
865.417000	15.49	46.00	30.51	100.0	120.000	150.0	H	190.0
904.519500	15.88	46.00	30.12	100.0	120.000	119.0	V	20.0

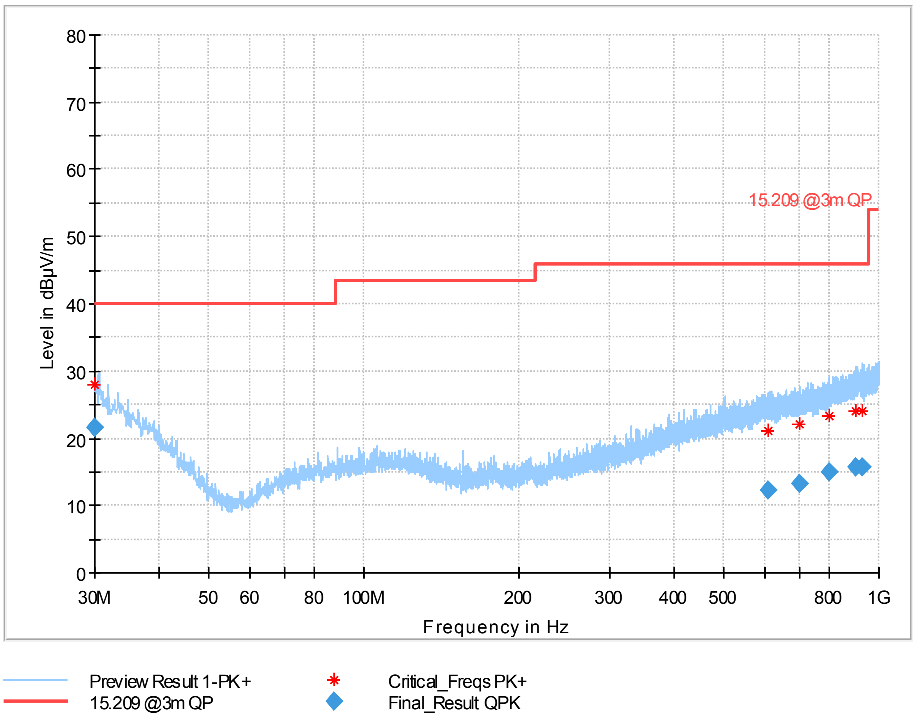
Plot no. 30: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, CW Mid



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.000000	21.71	40.00	18.29	100.0	120.000	100.0	V	274.0
596.897500	12.24	46.00	33.76	100.0	120.000	150.0	H	140.0
699.892500	13.22	46.00	32.78	100.0	120.000	100.0	H	-12.0
786.340000	15.11	46.00	30.89	100.0	120.000	150.0	V	201.0
899.574000	15.67	46.00	30.33	100.0	120.000	350.0	V	265.0
903.417500	15.89	46.00	30.11	100.0	120.000	116.0	H	202.0

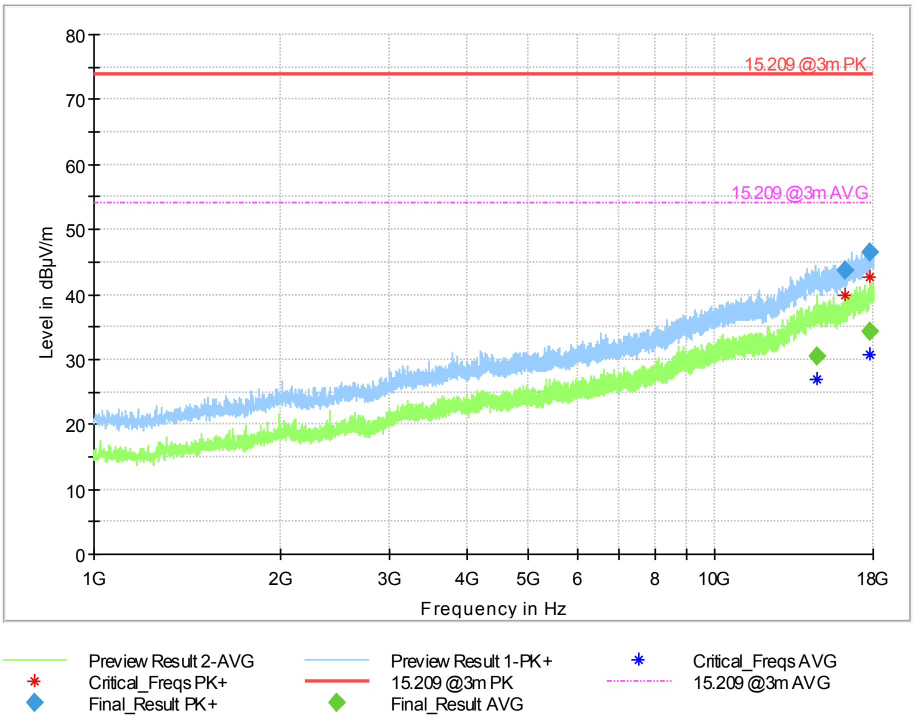
Plot no. 31: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization, CW High



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.082000	21.58	40.00	18.42	100.0	120.000	100.0	V	192.0
607.767000	12.17	46.00	33.83	100.0	120.000	150.0	H	236.0
701.130000	13.36	46.00	32.64	100.0	120.000	266.0	V	117.0
800.315000	14.91	46.00	31.09	100.0	120.000	103.0	V	303.0
900.537000	15.61	46.00	30.39	100.0	120.000	284.0	H	265.0
929.519000	15.82	46.00	30.18	100.0	120.000	104.0	H	175.0

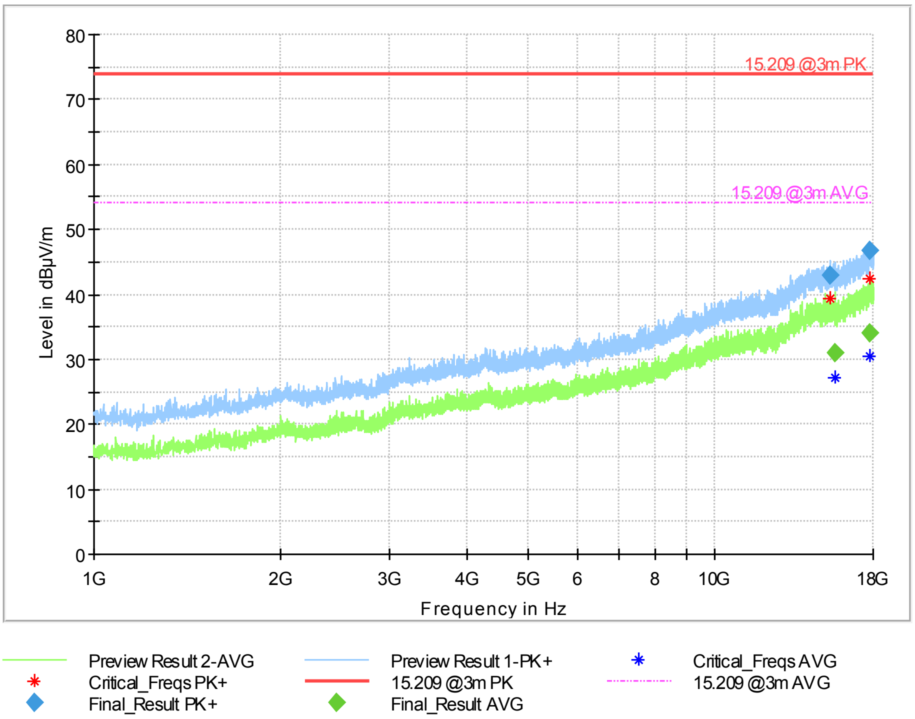
Plot no. 32: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, CW Low



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
14584.500000	---	30.59	54.00	23.41	100.0	1000.000	150.0	H
16237.336111	43.72	---	74.00	30.28	100.0	1000.000	150.0	H
17798.833333	46.43	---	74.00	27.57	100.0	1000.000	150.0	V
17806.583333	---	34.24	54.00	19.76	100.0	1000.000	150.0	V

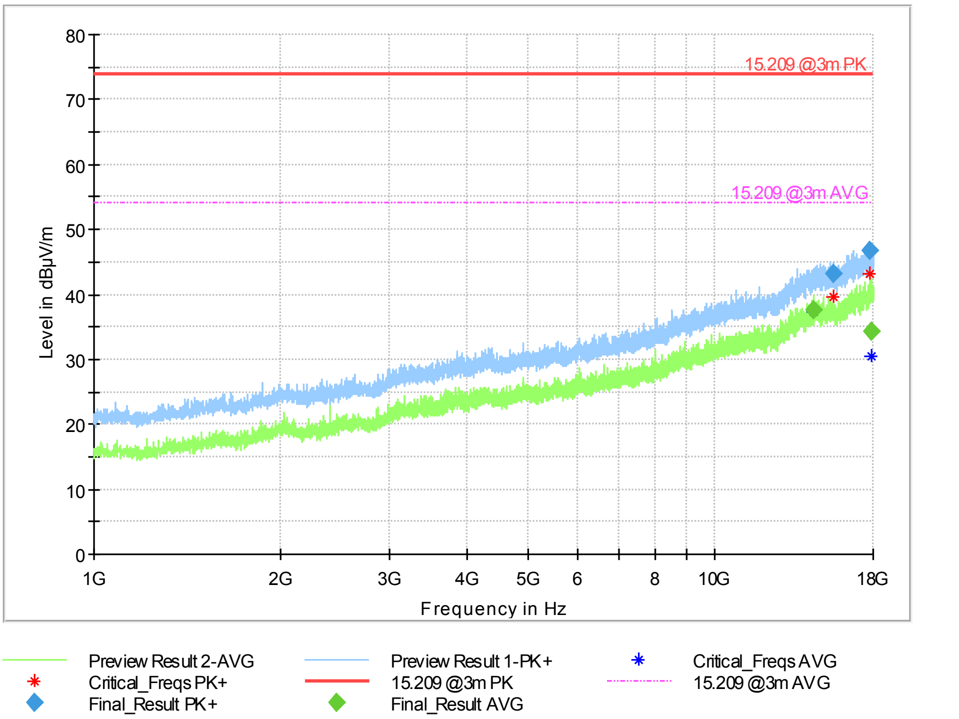
Plot no. 33: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, CW Mid



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
15382.000000	42.88	---	74.00	31.12	100.0	1000.000	150.0	H
15593.000000	---	30.90	54.00	23.10	100.0	1000.000	150.0	H
17775.041667	---	33.97	54.00	20.03	100.0	1000.000	150.0	H
17783.333333	46.72	---	74.00	27.28	100.0	1000.000	150.0	V

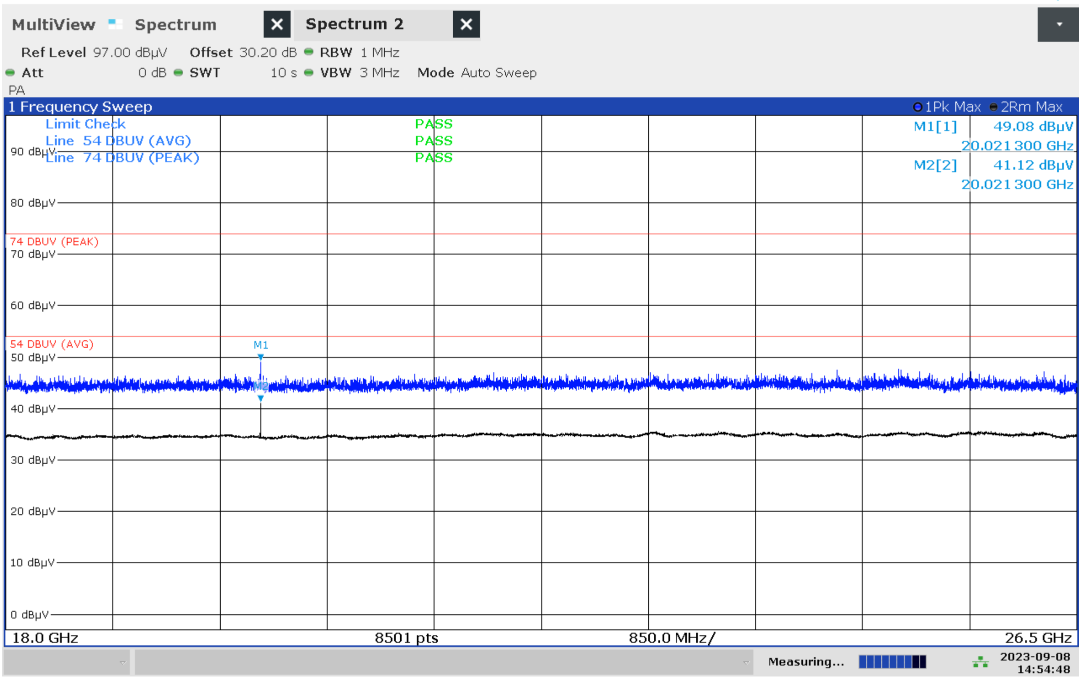
Plot no. 34: radiated emissions 1 GHz – 18 GHz, hor./vert. polarization, CW High



Final_Result

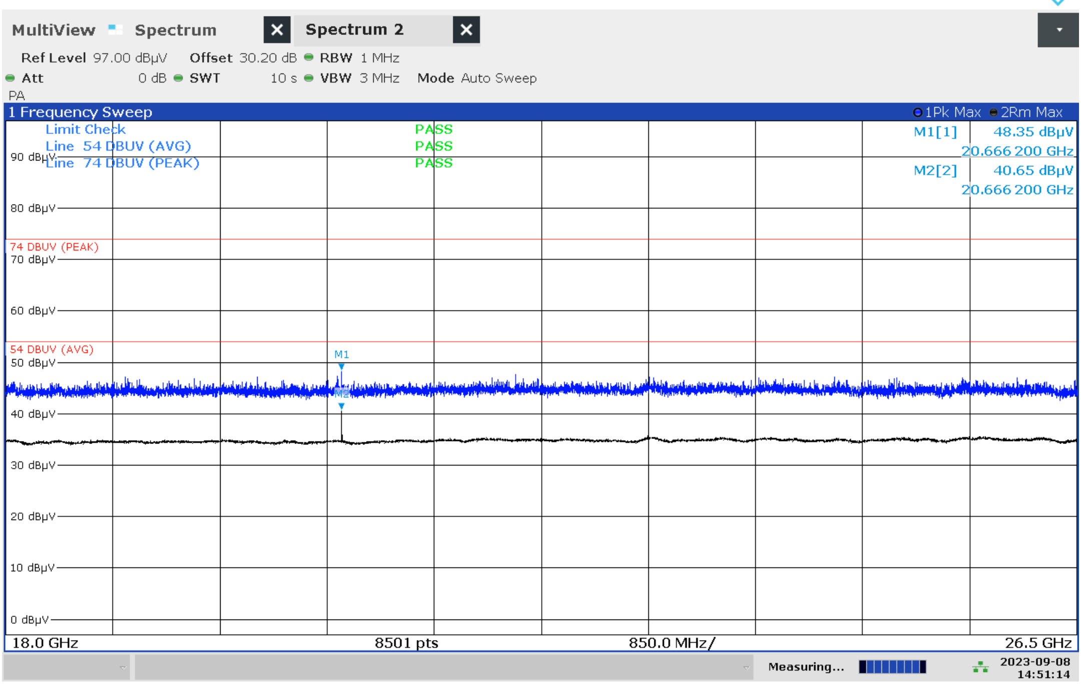
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
14399.477778	---	37.60	54.00	16.40	100.0	1000.000	150.0	H
15520.877778	43.18	---	74.00	30.82	100.0	1000.000	150.0	H
17827.166667	46.85	---	74.00	27.15	100.0	1000.000	150.0	V
17839.488889	---	34.23	54.00	19.77	100.0	1000.000	150.0	H

Plot no. 35: radiated emissions 18 GHz – 26.5 GHz, hor./vert. polarization, CW Low



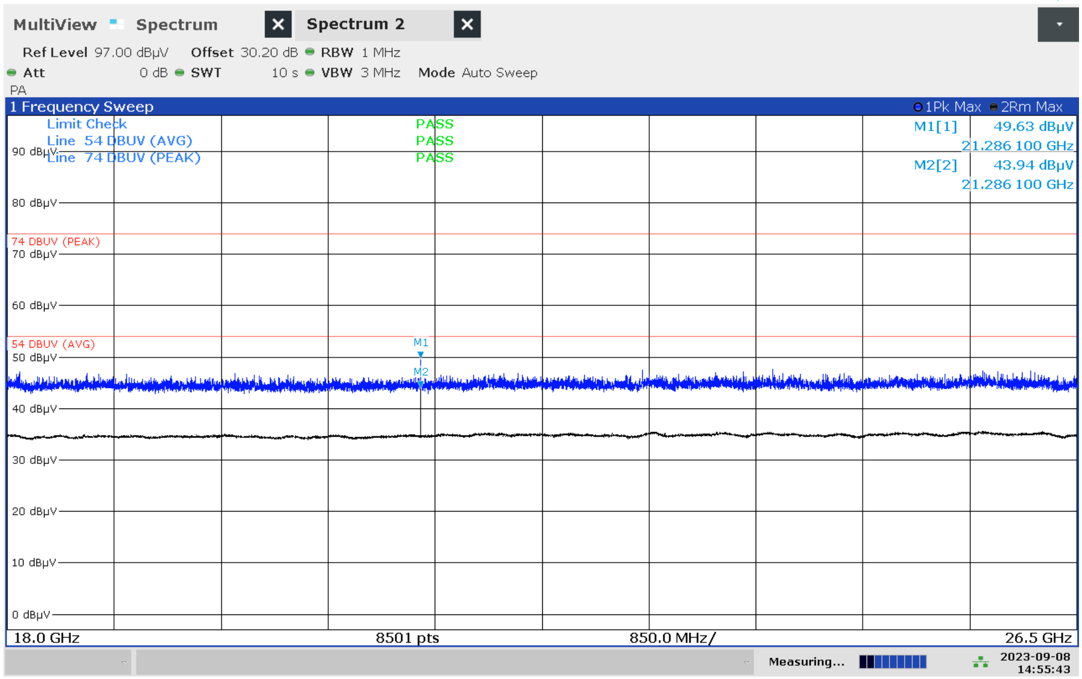
02:54:48 09/08/2023

Plot no. 36: radiated emissions 18 GHz – 26.5 GHz, hor./vert. polarization, CW Mid



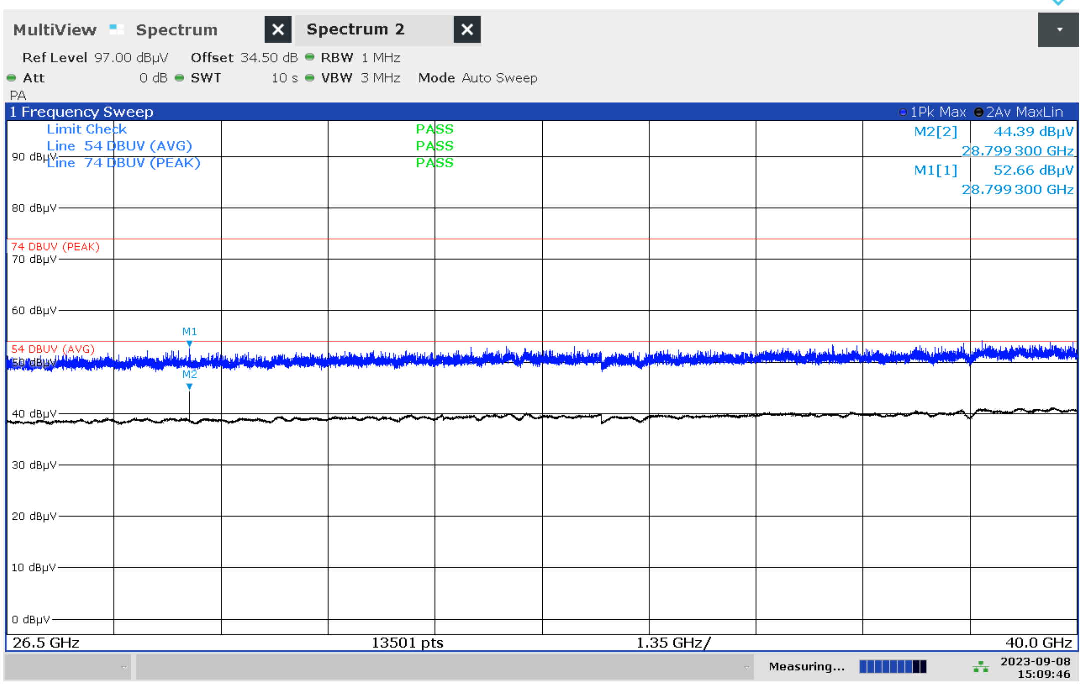
02:51:15 09/08/2023

Plot no. 37: radiated emissions 18 GHz – 26.5 GHz, hor./vert. polarization, CW High



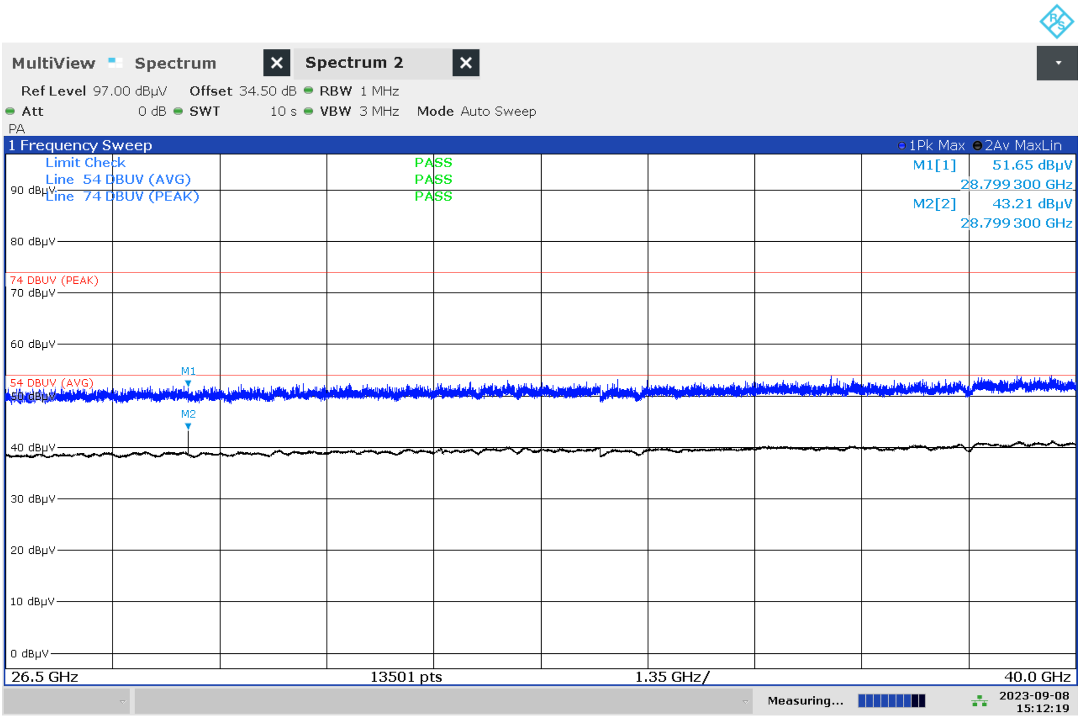
02:55:43 09/08/2023

Plot no. 38: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, CW Low



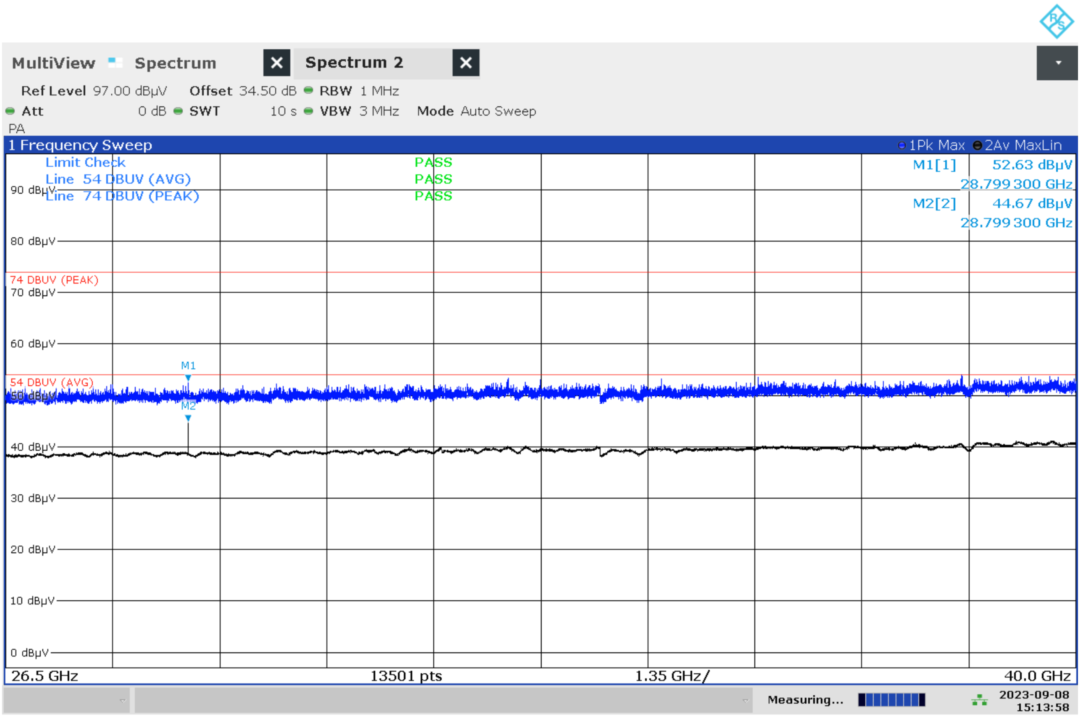
03:09:46 09/08/2023

Plot no. 39: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, CW Mid



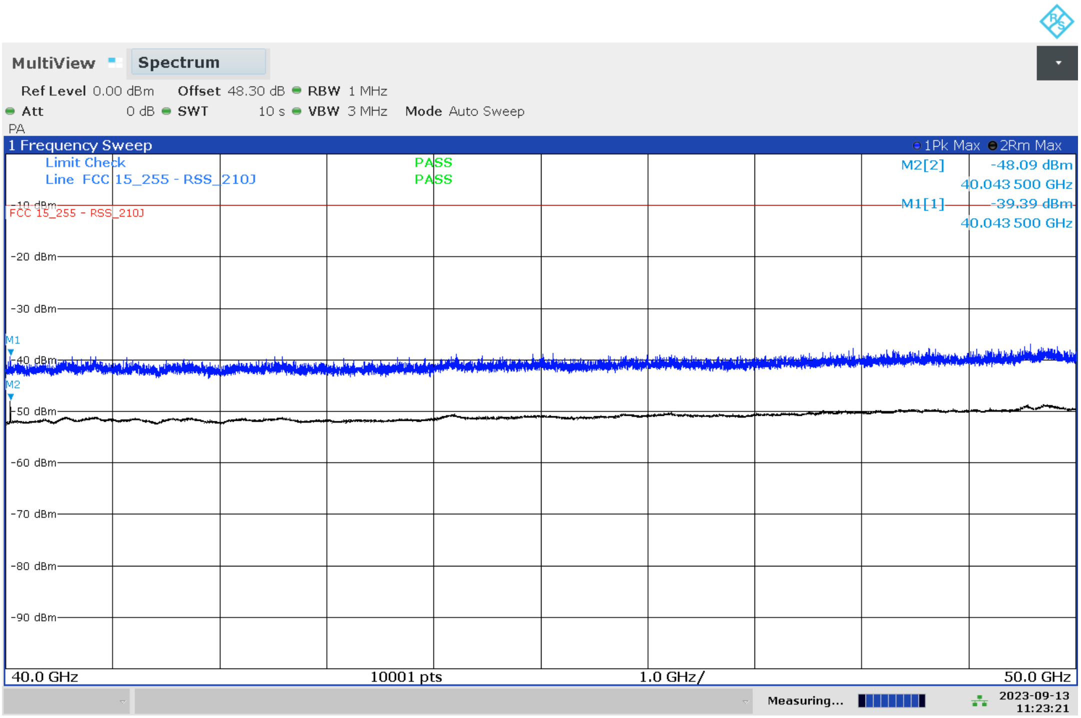
03:12:19 09/08/2023

Plot no. 40: radiated emissions 26.5 GHz – 40 GHz, hor./vert. polarization, CW High



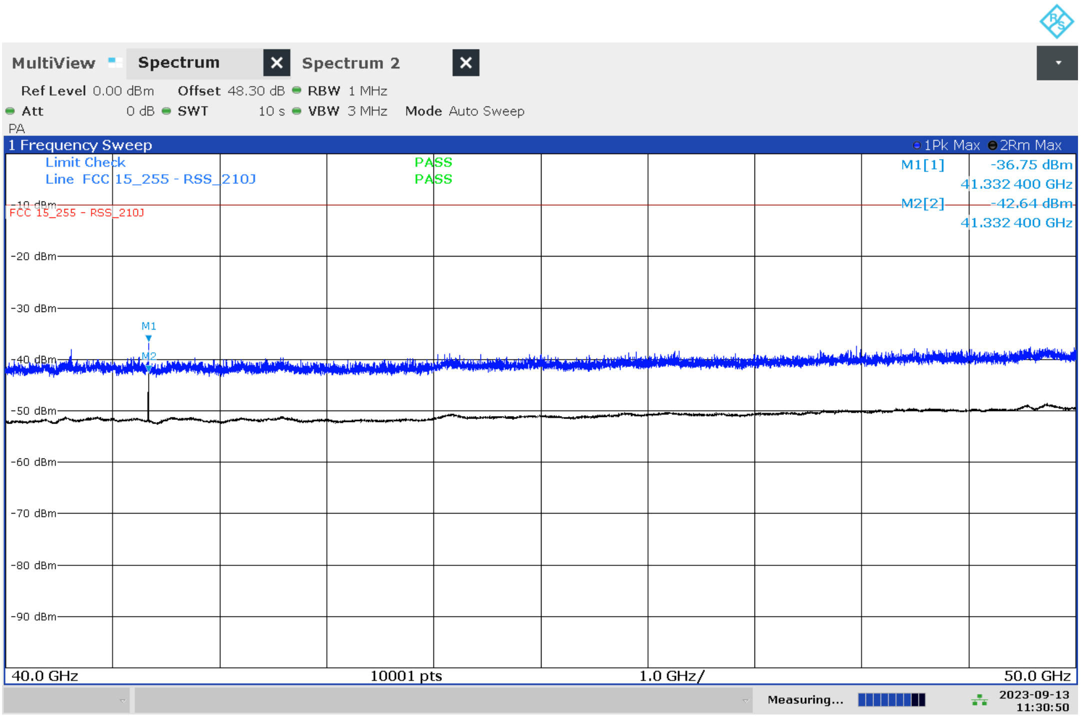
03:13:59 09/08/2023

Plot no. 41: radiated emissions 40 GHz – 50 GHz, hor./vert. polarization, CW Low



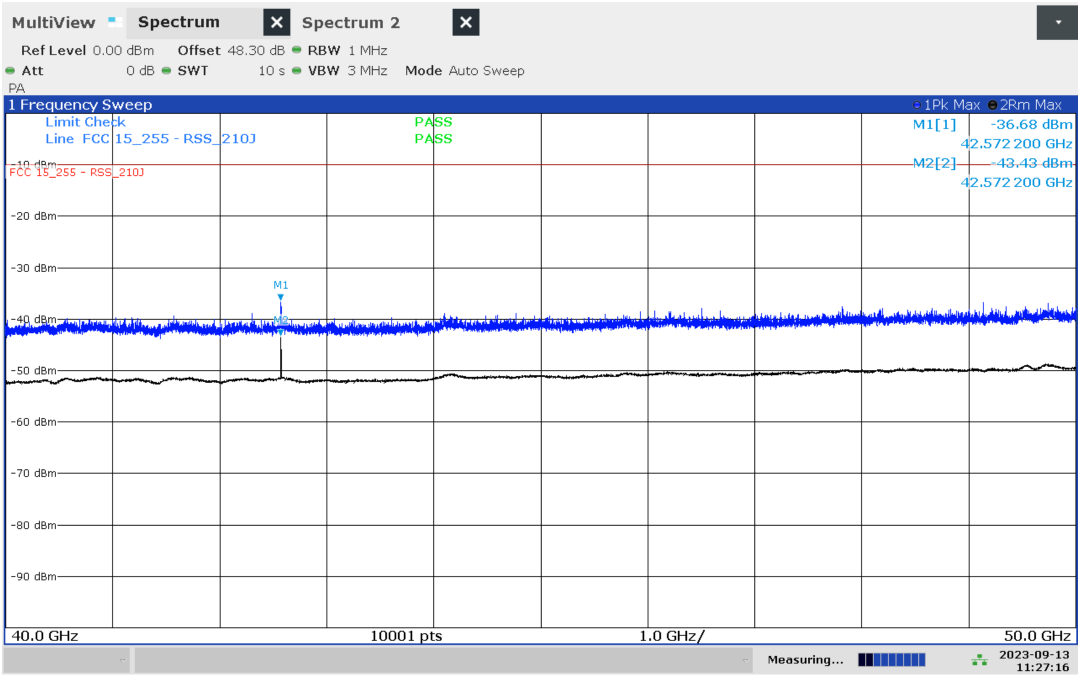
11:23:21 09/13/2023

Plot no. 42: radiated emissions 40 GHz – 50 GHz, hor./vert. polarization, CW Mid



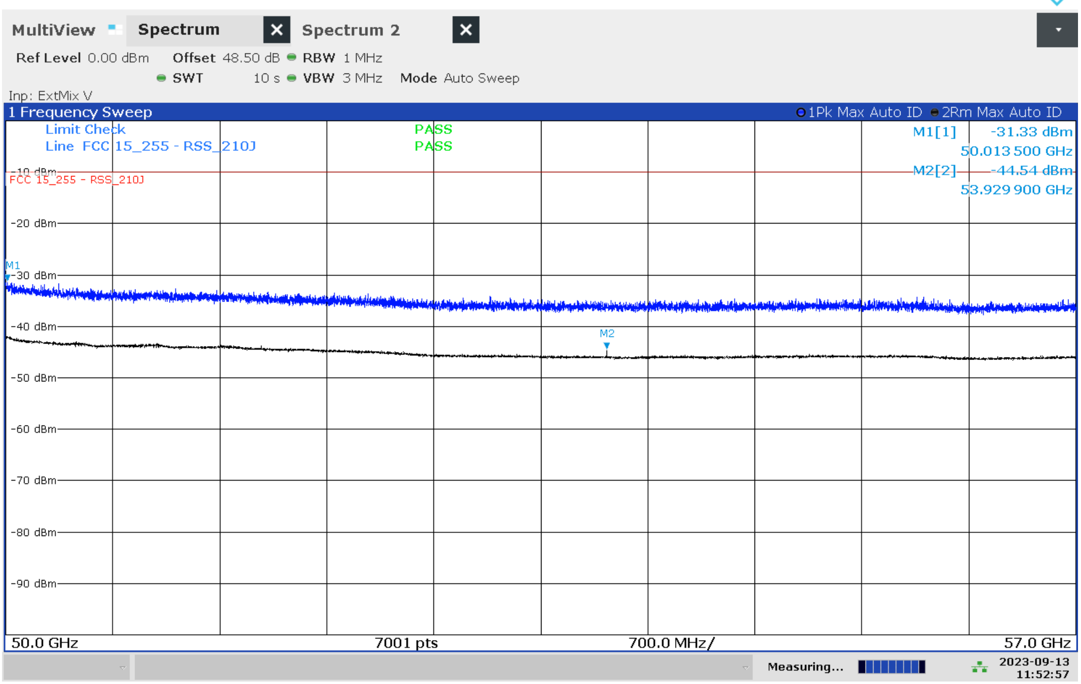
11:30:50 09/13/2023

Plot no. 43: radiated emissions 40 GHz – 50 GHz, hor./vert. polarization, CW High



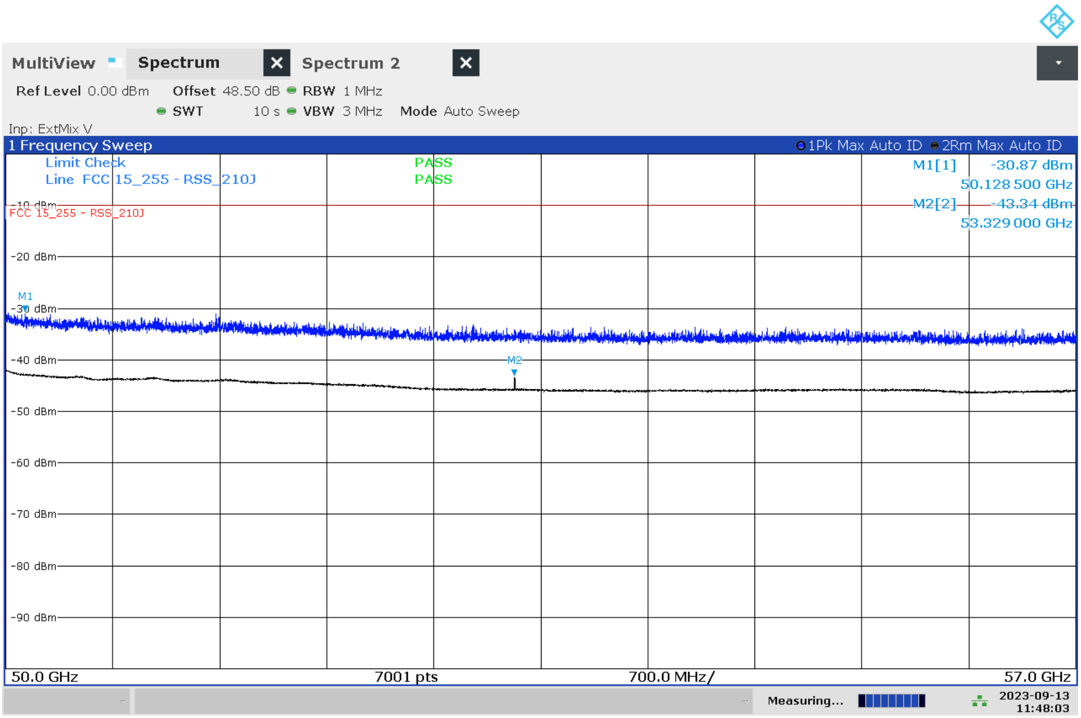
11:27:16 09/13/2023

Plot no. 44: radiated emissions 50 GHz – 57 GHz, hor./vert. polarization, CW Low



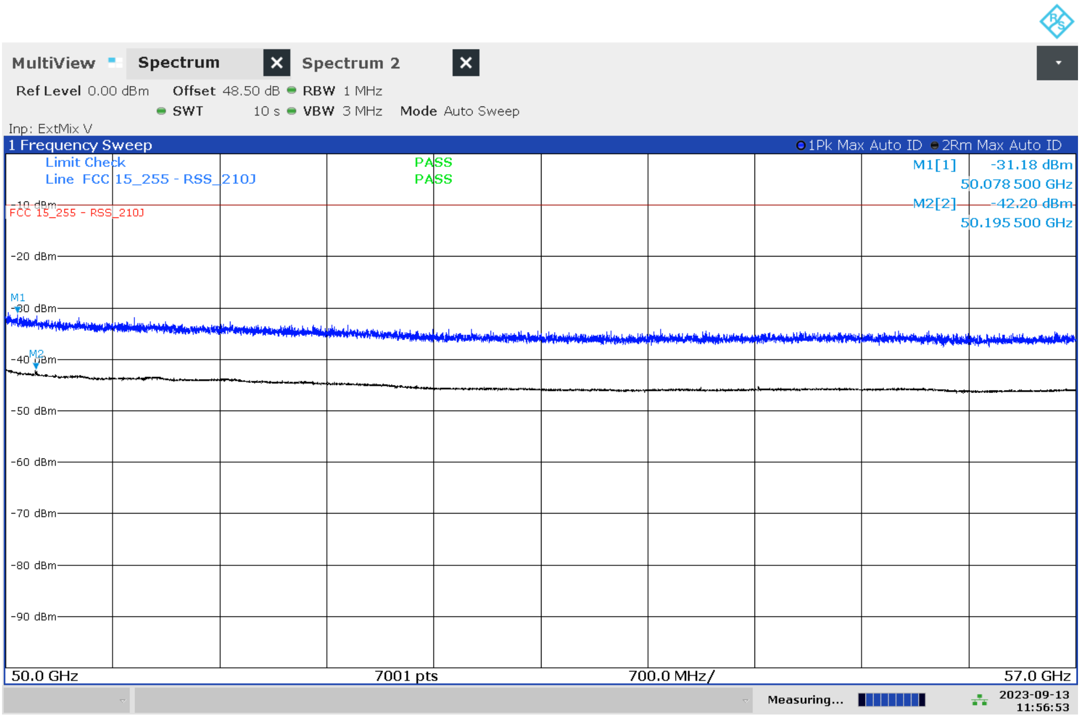
11:52:57 09/13/2023

Plot no. 45: radiated emissions 50 GHz – 57 GHz, hor./vert. polarization, CW Mid



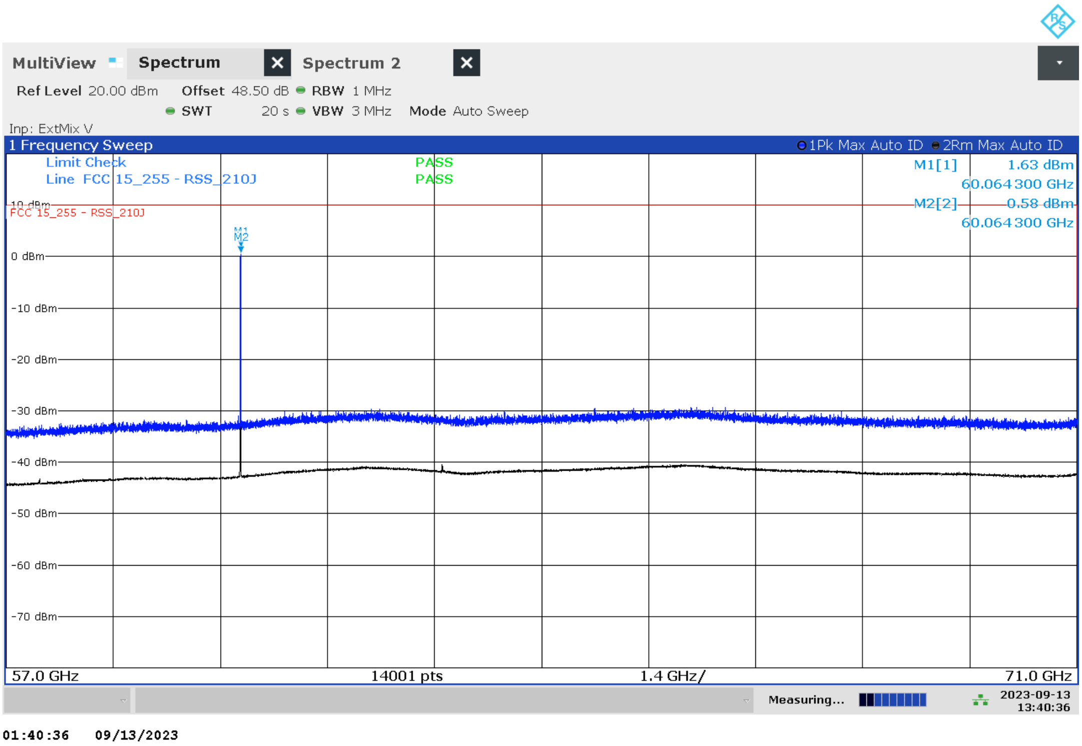
11:48:03 09/13/2023

Plot no. 46: radiated emissions 50 GHz – 57 GHz, hor./vert. polarization, CW High

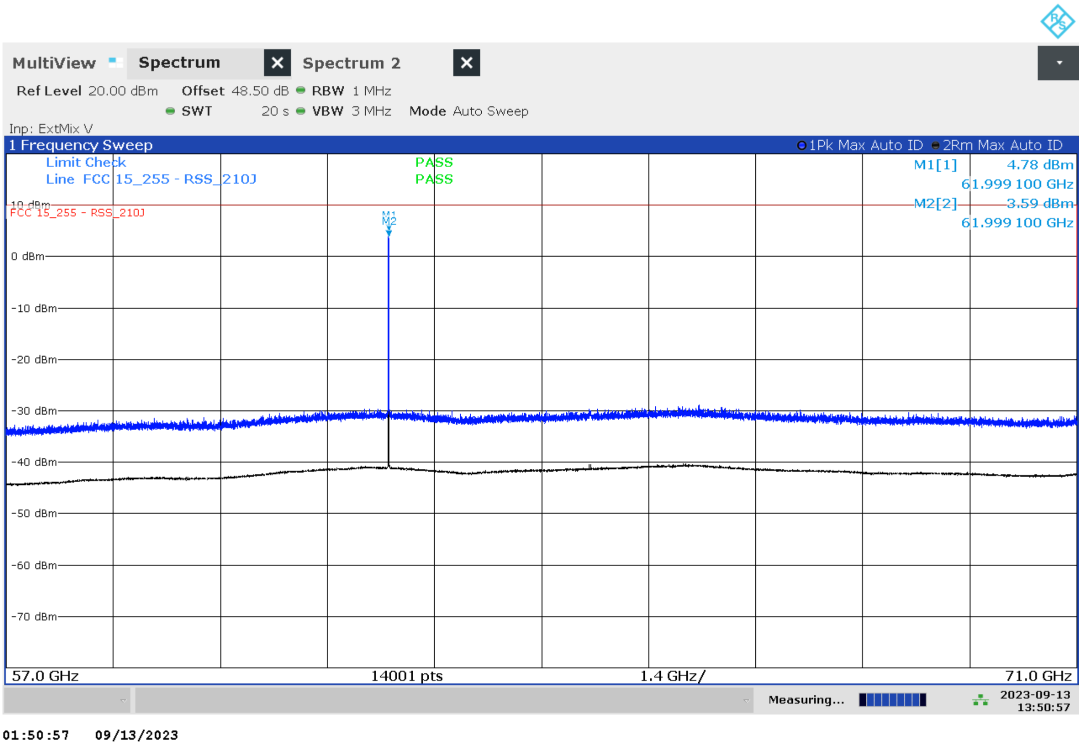


11:56:54 09/13/2023

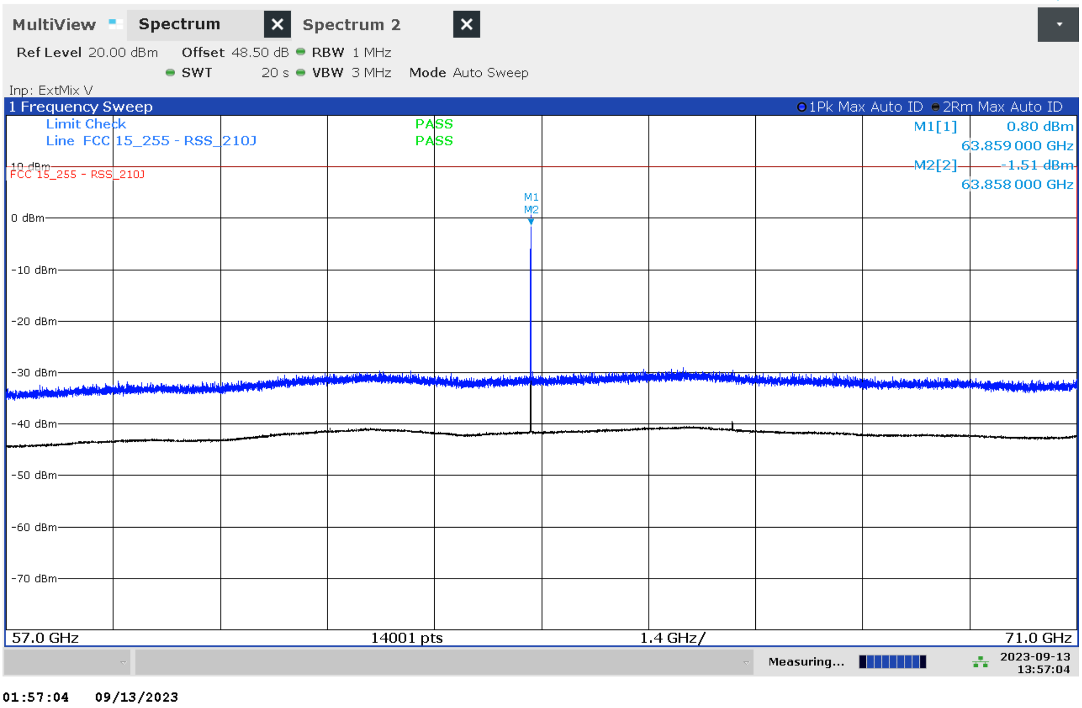
Plot no. 47: radiated emissions 57 GHz – 71 GHz, hor./vert. polarization, CW Low



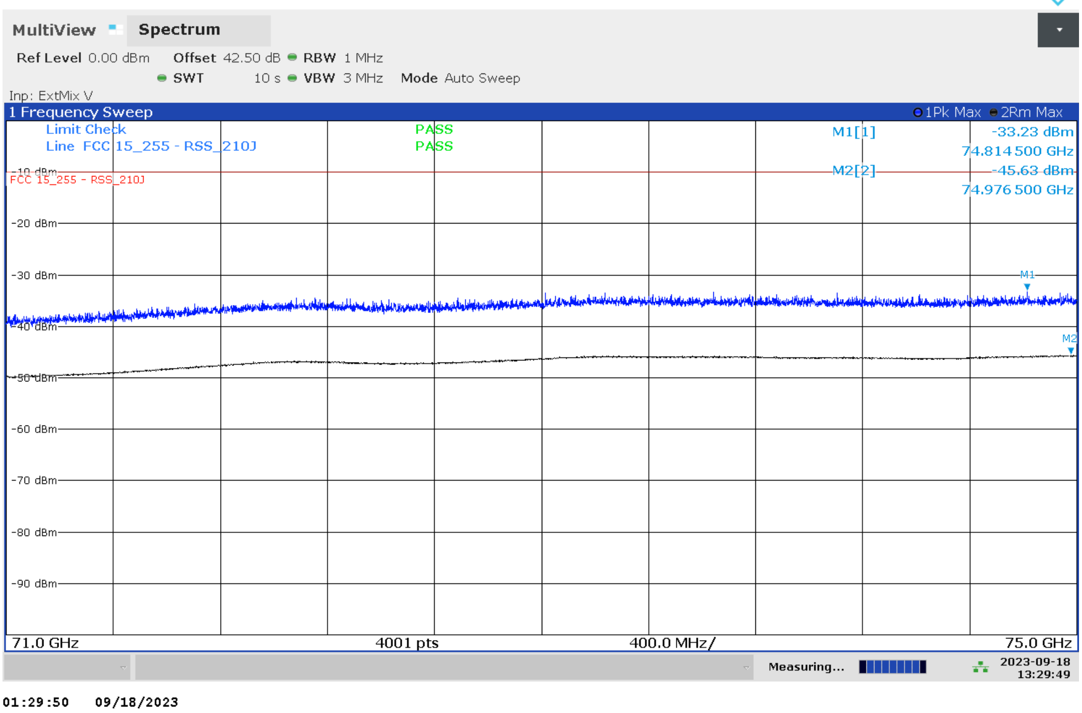
Plot no. 48: radiated emissions 57 GHz – 71 GHz, hor./vert. polarization, CW Mid



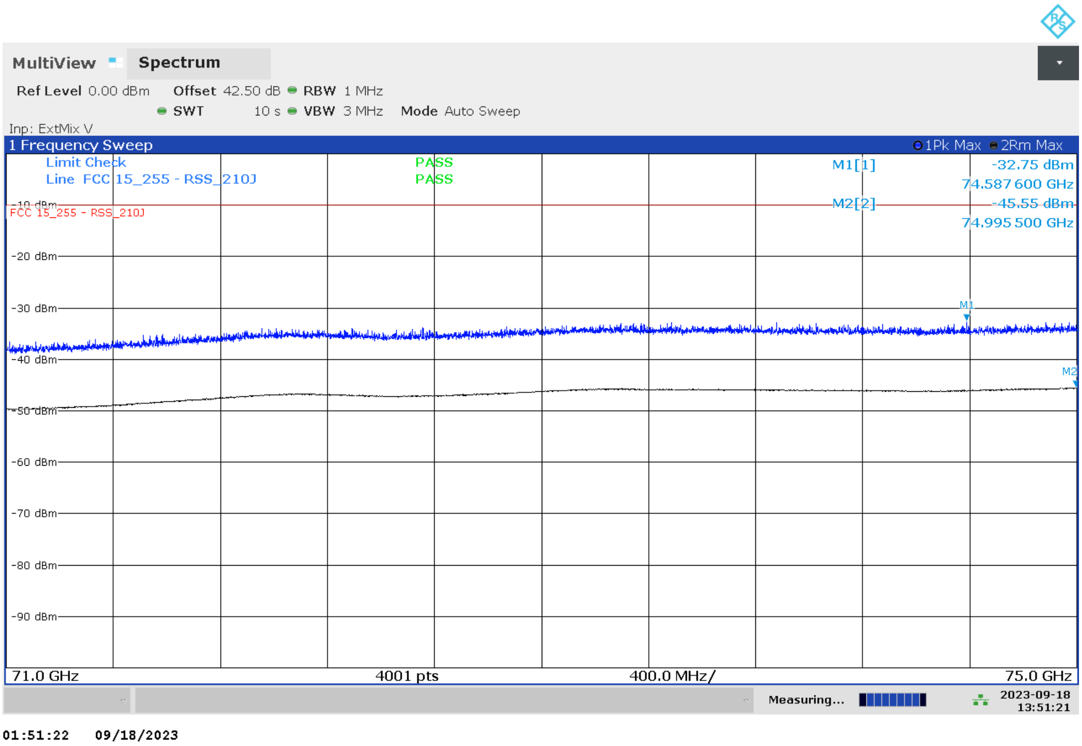
Plot no. 49: radiated emissions 50 GHz – 75 GHz, hor./vert. polarization, CW High



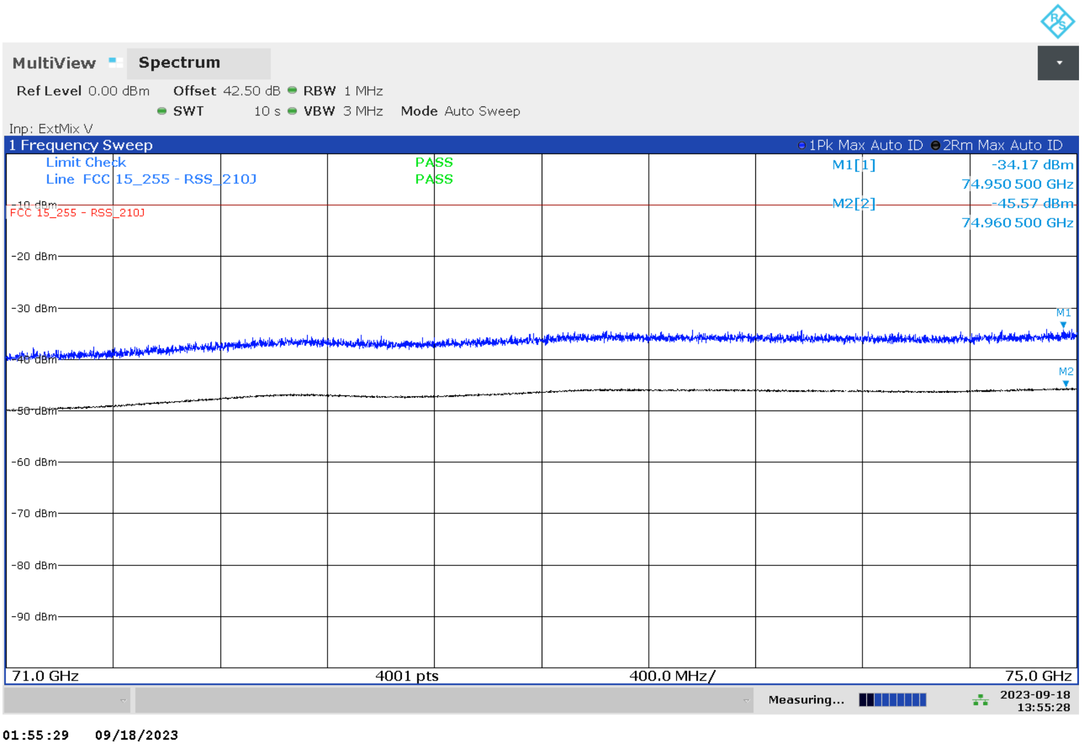
Plot no. 50: radiated emissions 71 GHz – 75 GHz, hor./vert. polarization, CW Low



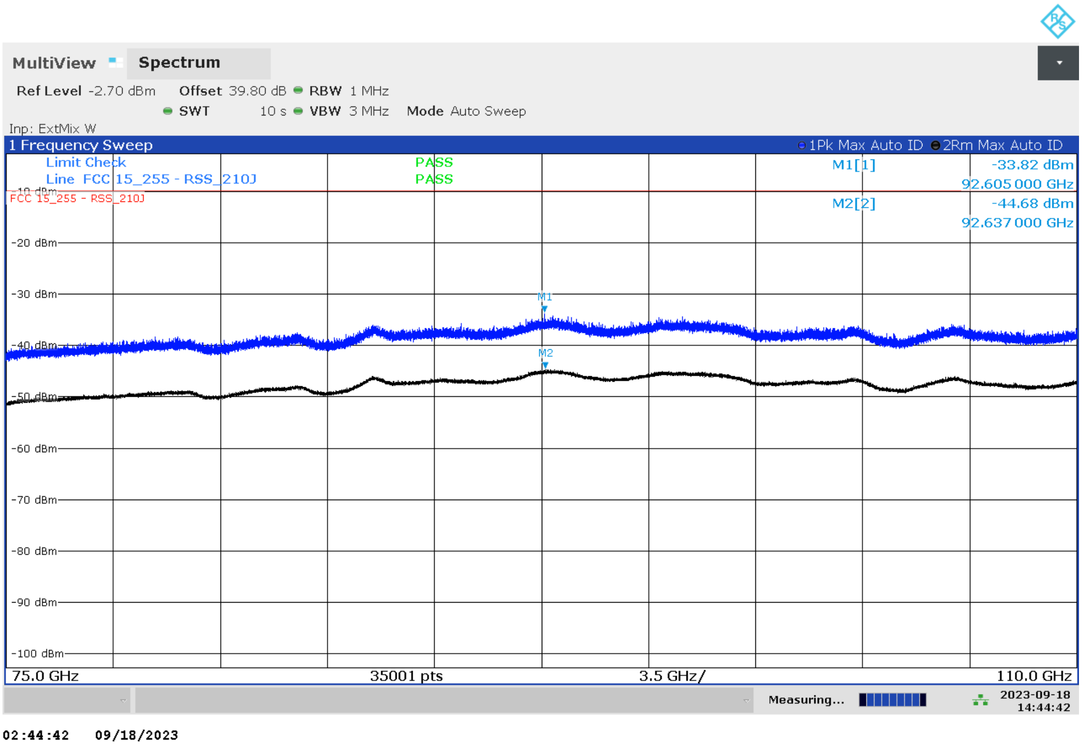
Plot no. 51: radiated emissions 71 GHz – 75 GHz, hor./vert. polarization, CW Low



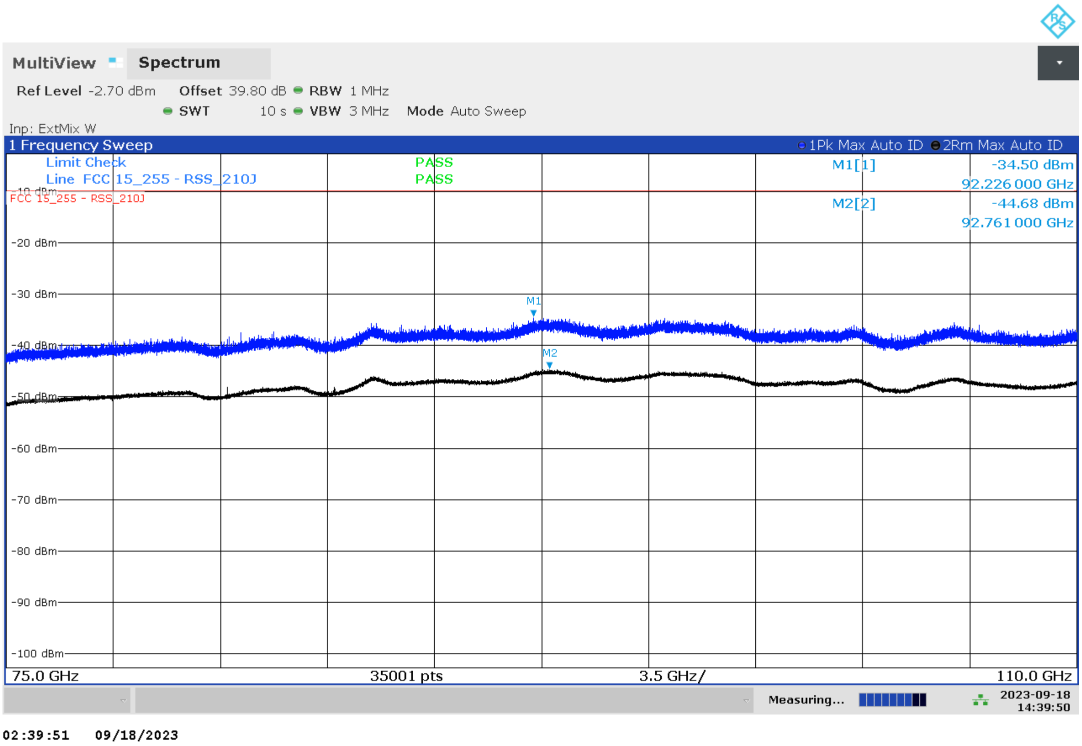
Plot no. 52: radiated emissions 71 GHz – 75 GHz, hor./vert. polarization, CW Low



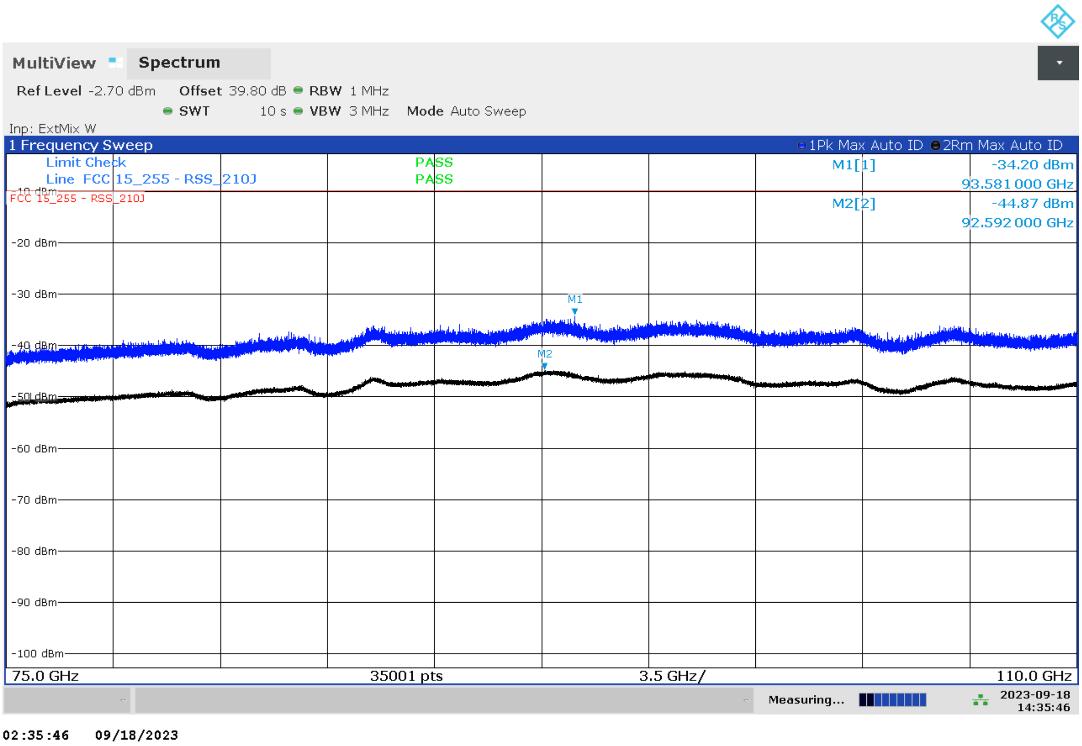
Plot no. 53: radiated emissions 75 GHz – 110 GHz, hor./vert. polarization, CW Low



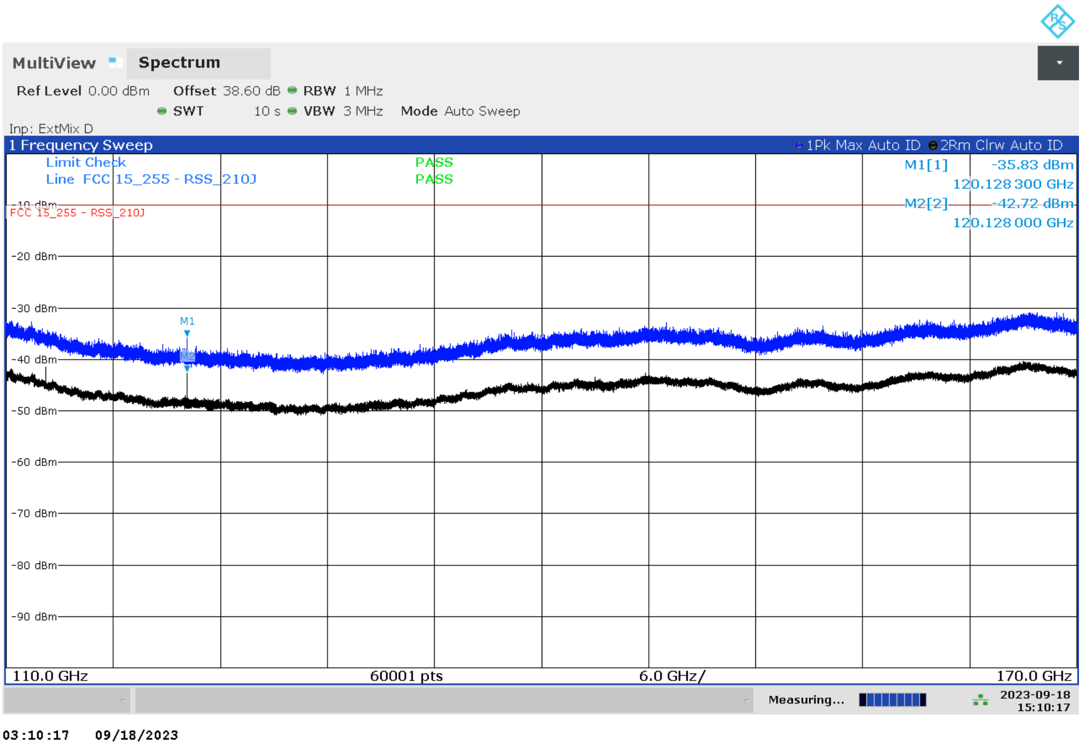
Plot no. 54: radiated emissions 75 GHz – 110 GHz, hor./vert. polarization, CW Mid



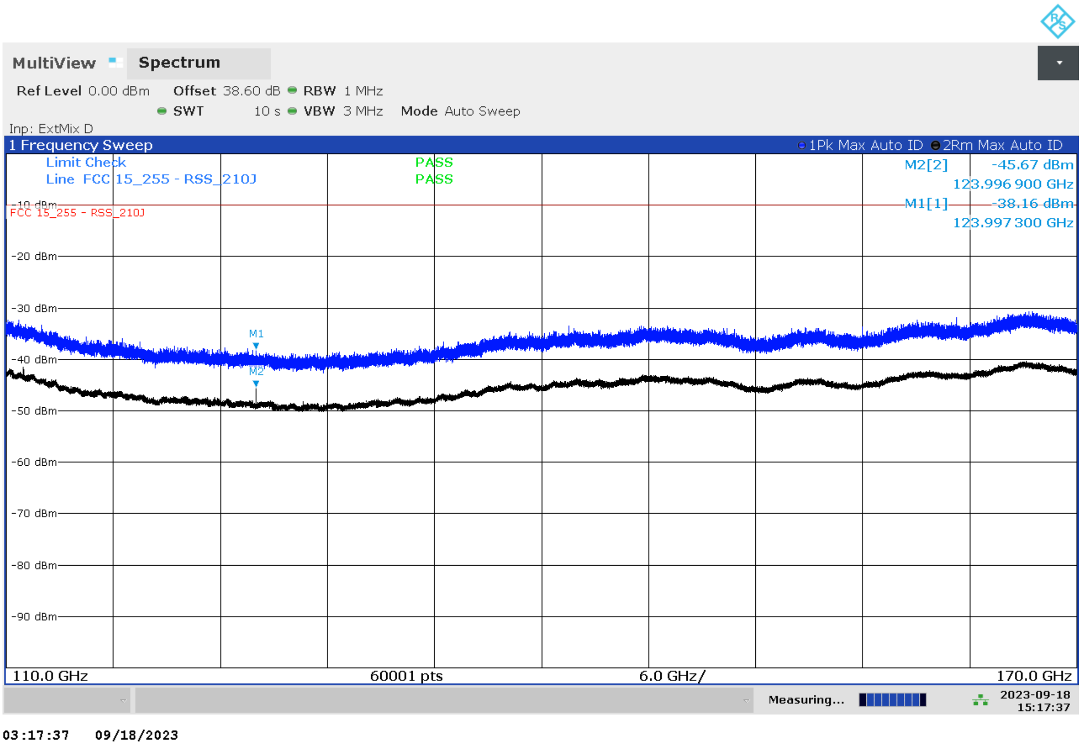
Plot no. 55: radiated emissions 75 GHz – 110 GHz, hor./vert. polarization, CW High



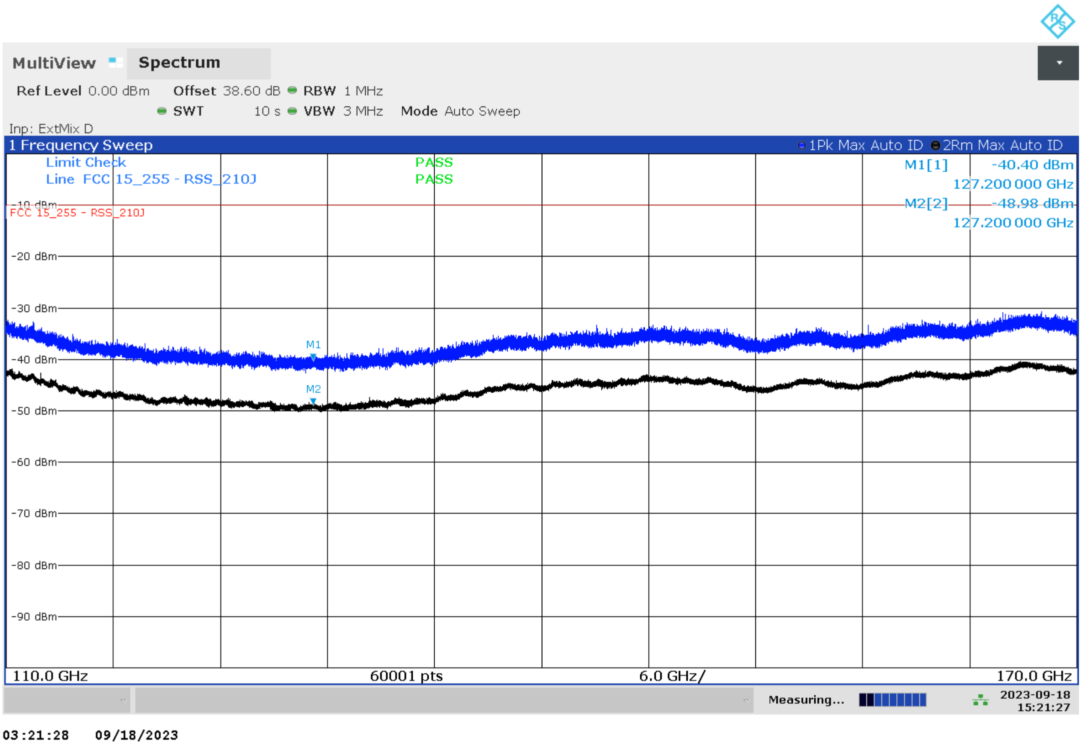
Plot no. 56: radiated emissions 110 GHz – 170 GHz, hor./vert. polarization, CW Low



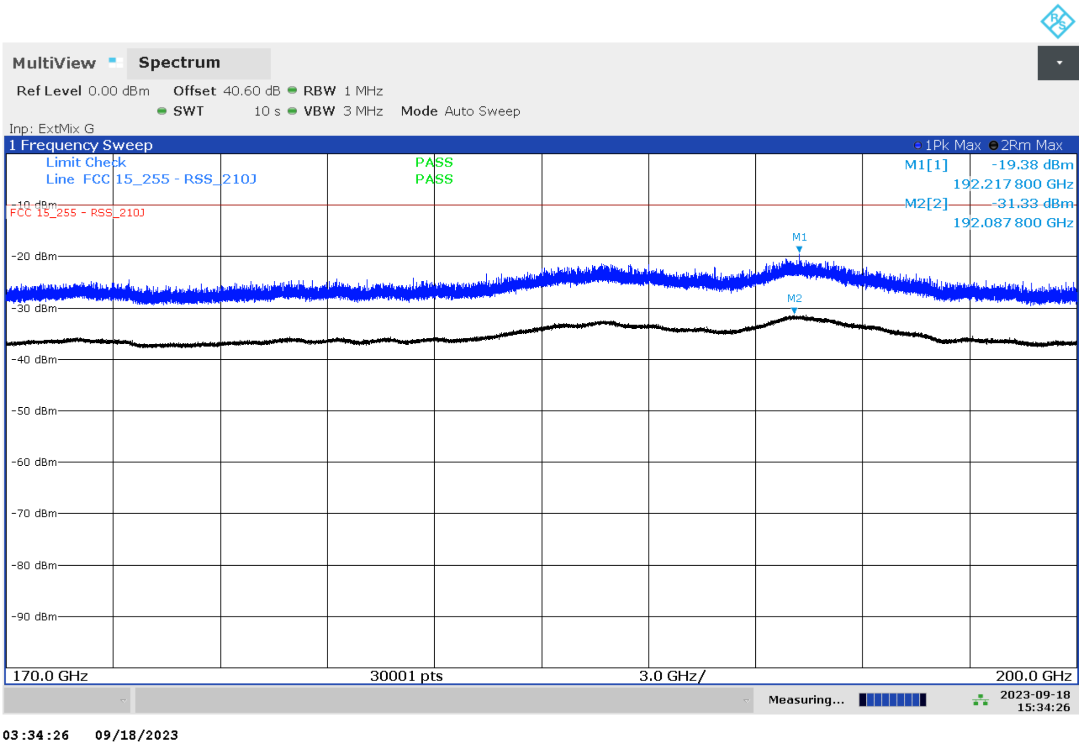
Plot no. 57: radiated emissions 110 GHz – 170 GHz, hor./vert. polarization, CW Mid



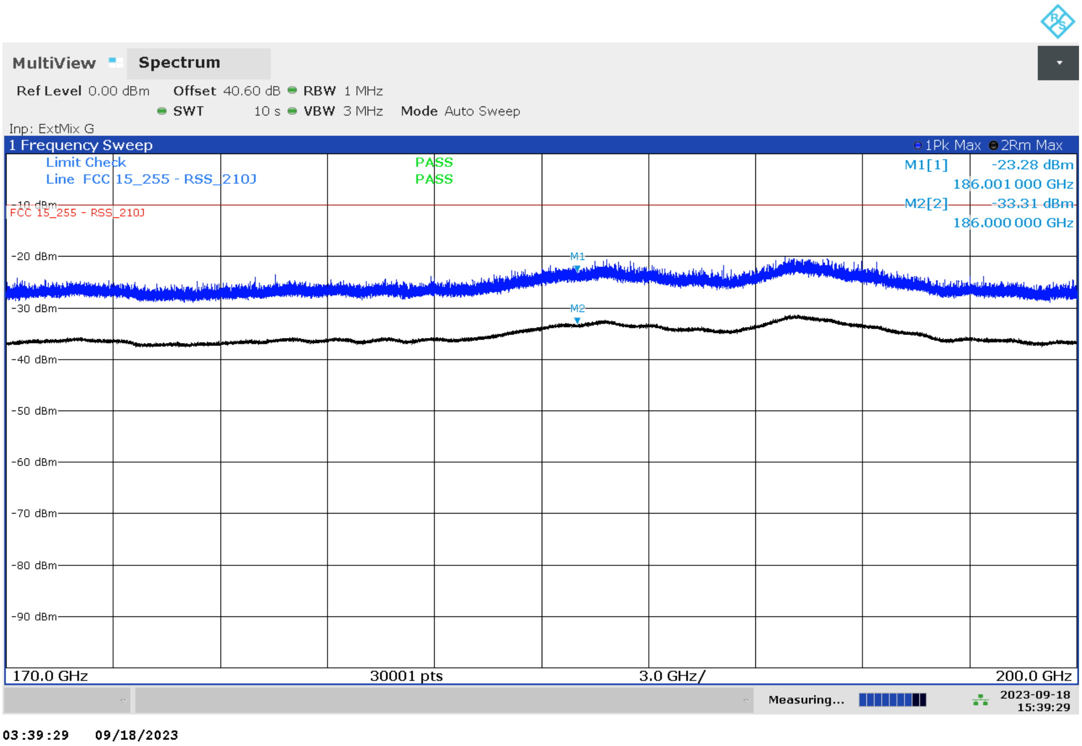
Plot no. 58: radiated emissions 110 GHz – 170 GHz, hor./vert. polarization, CW High



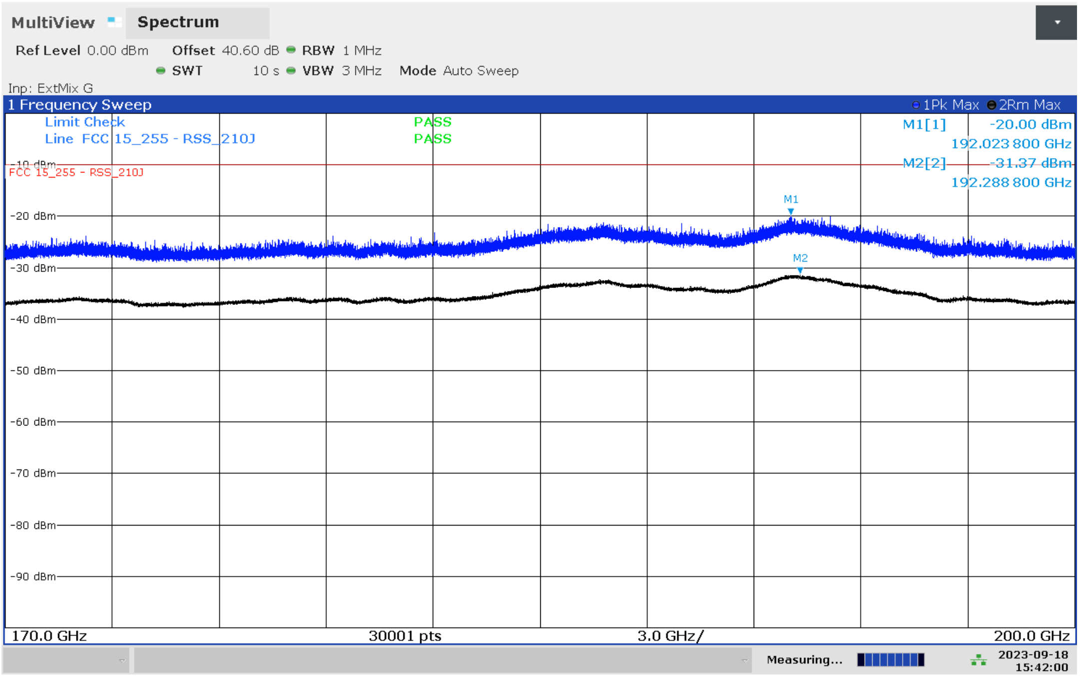
Plot no. 59: radiated emissions 170 GHz – 200 GHz, hor./vert. polarization, CW Low



Plot no. 60: radiated emissions 170 GHz – 200 GHz, hor./vert. polarization, CW Mid



Plot no. 61: radiated emissions 170 GHz – 200 GHz, hor./vert. polarization, CW High

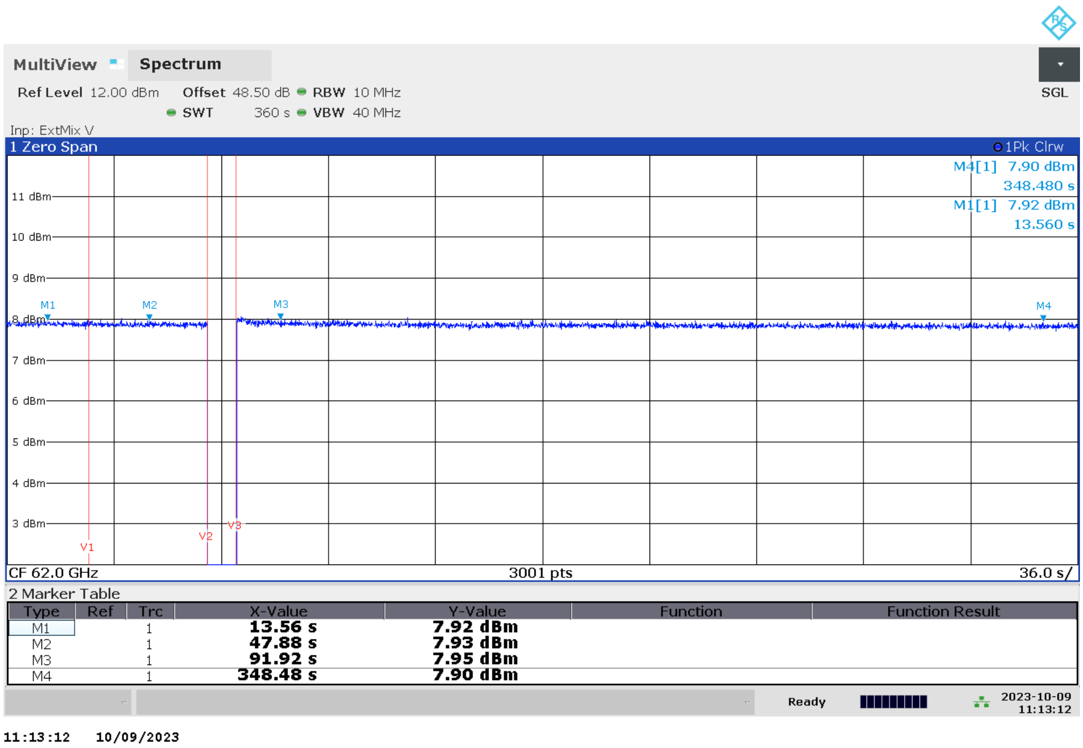


03:42:00 09/18/2023

7.5 Additional Measurement according to customer requirements (informative)

EUT is placed on a non-conductive table. PSD measurement is done on a representative distance, i.e. ≥ far field). Another EUT (“Interferer”) is placed on another non-conductive support, facing towards the EUT with its emitting side to the EUT and functioning as an in-band interferer. EUT’s peak power spectral density is measured, while it is exposed to the interferer signal.

Plot no. 62: Peak PSD vs. time (verification in time domain)



Note:
EUT is transmitting its signal. At vertical line V1 Interferer is powered on and functioning as an in-band interferer. At V2 EUT is powered off for a few seconds, then turned on again (V3). No change in power spectral density was observed while interfered by a similar radar sensor. Observation time is set to 360 s.

Test results:
No changes in EUT’s power spectral density detected during active interference.

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).

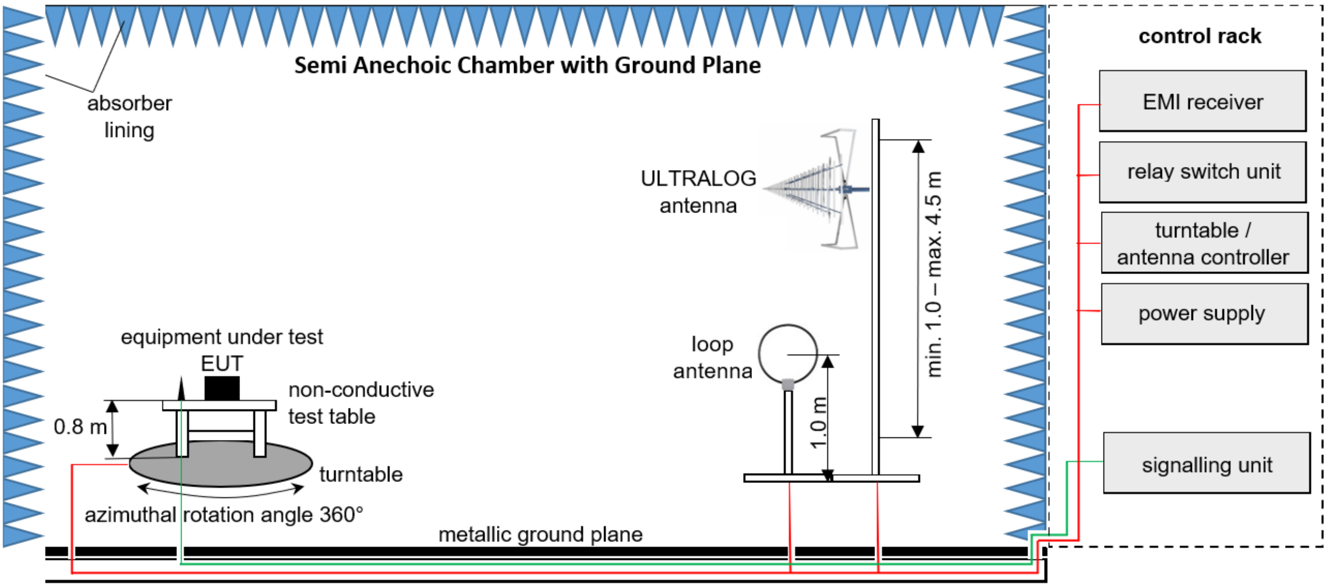
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

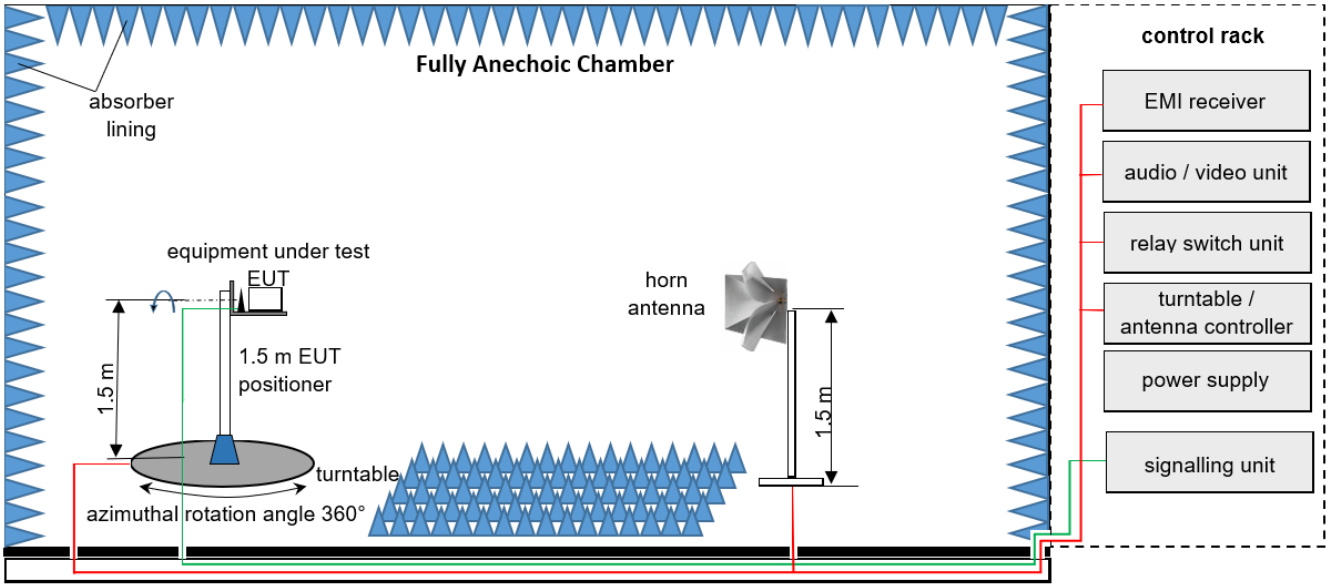
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	101126	LAB000684	NR	–
2	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
3	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
4	Power Supply	Chroma	61604	616040005416	LAB000285	NR	–
5	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
6	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
7	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2023-07-04 → 12M → 2024-07-04
8	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	C	2022-01-31 → 36M → 2025-01-31
9	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
10	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
11	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
12	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
13	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
14	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
15	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
16	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2023-05-15 → 36M → 2026-05-15
17	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2022-12-22 → 36M → 2025-12-22
18	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–
19	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2023-06-13 → 36M → 2026-06-13
20	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2023-04-05 → 36M → 2026-04-05
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

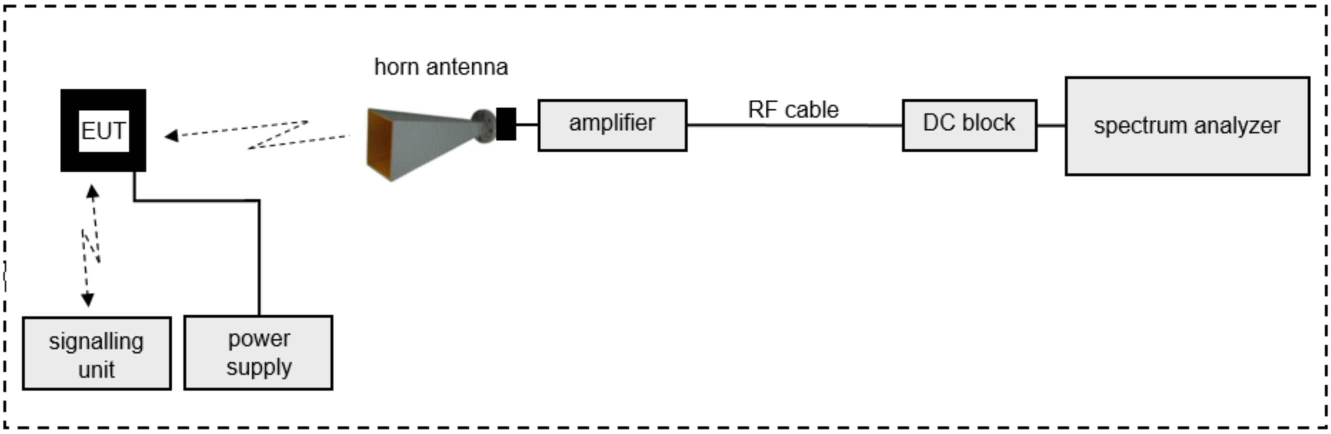
ROP = AV + D - G
(ROP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
ROP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 µW)

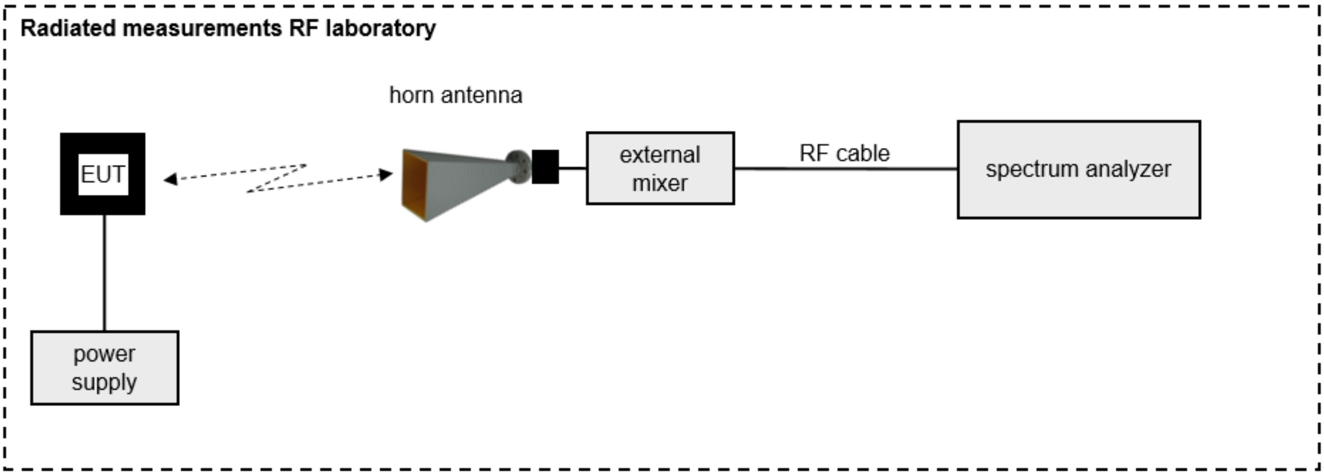
List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Rohde & Schwarz	IN 600	101126	LAB000684	NR	–
2	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
3	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
4	Power Supply	Chroma	61604	616040005416	LAB000285	NR	–
5	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
6	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
7	EMI Test Receiver	Rohde & Schwarz	ESW26	101481	LAB000236	C	2023-07-04 → 12M → 2024-07-04
8	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	C	2022-01-31 → 36M → 2025-01-31
9	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
10	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
11	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
12	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
13	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
14	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
15	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
16	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2023-05-15 → 36M → 2026-05-15
17	Antenna	Rohde & Schwarz	HL562E	102005	LAB000150	C	2022-12-22 → 36M → 2025-12-22
18	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–
19	Antenna	Rohde & Schwarz	HF907	102898	LAB000124	C	2023-06-13 → 36M → 2026-06-13
20	Antenna	Rohde & Schwarz	HL562E	102001	LAB000123	C	2023-04-05 → 36M → 2026-04-05
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



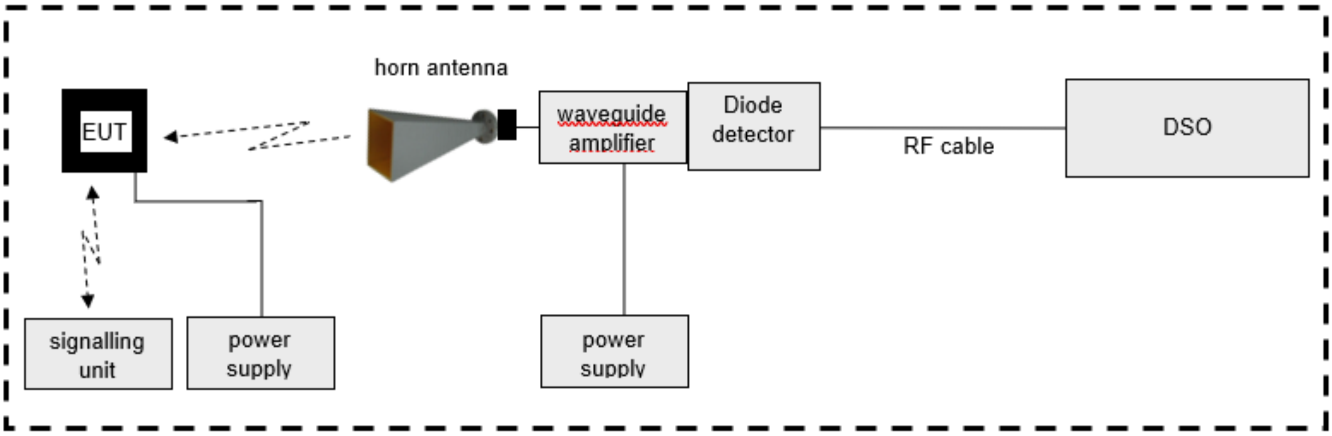
Measurement distance: Horn antenna e.g. 10 cm @ 170 GHz

ROP = AV + D - PA - G
(ROP-rad. output power; AV-analyzer value; PA preamplifier; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
ROP [dBm] = -72.63 [dBm] + 57.05 [dB] - 26.4 [dB] - 20.02 [dBi] = -62 [dBm]

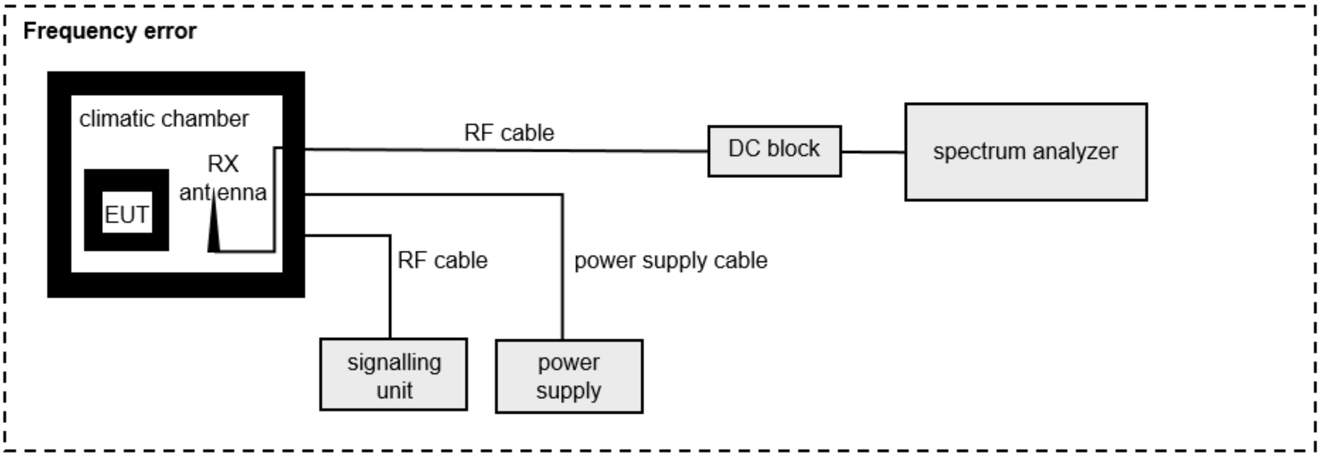
Note: Conversion loss of mixer, as well as above mentioned values (e.g. PA, D, G) are already included in analyzer value, due to corresponding transducer file and given offset.
Values in plots are final measurement values.

8.5 Radiated measurements / substitution method for EIRP



*) waveguide amplifier depends on frequency range and signal-to-noise ratio

8.6 Radiated measurements under extreme conditions



List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Pre-Amplifier	RPG Radiometer Physics GmbH	V-LNA 50-75 20 5	200116	LAB000685	NR	–
2	Detector Diode	Eravant	SFD-503753-15SF-P1	13789-01	LAB000436	NR	–
3	Coaxial Cable	Huber & Suhner	ST18/48"	2575556	LAB000392	CM	2023-07-17 → 12M → 2024-07-17
4	Absorber	Telemeter Electronic	EPP 12	-	LAB000327	NR	–
5	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	NR	–
6	Filter (Coax/WG, LPF, HPF, Band)	TTE	10-WHPF-84.5-UG387	-	LAB000299	NR	–
7	Multiplier	Rohde & Schwarz	SMZ75	101307	LAB000270	NR	–
8	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
9	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350255	LAB000189	NR	–
10	WG-Coax-Adapter	Flann Microwave Ltd	23373-TF30 UG383/U	273384	LAB000184	CM	2023-08-24 → 36M → 2024-08-24
11	WG-Coax-Adapter	Flann Microwave Ltd	22093-TF30 UG599/U	273263	LAB000183	CM	2023-08-24 → 36M → 2024-08-24
12	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273373	LAB000180	CM	2023-08-24 → 36M → 2024-08-24
13	Antenna	Flann Microwave Ltd	30240-20	273390	LAB000178	CM	2023-08-24 → 36M → 2024-08-24
14	Oszilloscope	Rohde & Schwarz	RTE1204	300113	LAB000175	C	2023-05-19 → 36M → 2026-05-19
15	Coaxial Cable	Huber & Suhner	SF101/1.0m	503989/1	LAB000163	CM	2023-07-17 → 12M → 2024-07-17
16	Coaxial Cable	Rosenberger	LU7-022-1000	34	LAB000154	CM	2023-07-17 → 12M → 2024-07-17
17	Coaxial Cable	Rosenberger	LU7-022-1000	33	LAB000153	CM	2023-07-17 → 12M → 2024-07-17
18	Antenna	Flann Microwave Ltd	32240-20	273469	LAB000152	CM	2023-08-24 → 36M → 2024-08-24
19	WG-Coax-Adapter	Flann Microwave Ltd	25373-WF60	270484	LAB000142	CM	2023-08-24 → 36M → 2024-08-24
20	Antenna	Flann Microwave Ltd	29240-20	273382	LAB000139	CM	2023-08-24 → 36M → 2024-08-24
21	Antenna	Flann Microwave Ltd	27240-20	273367	LAB000137	CM	2023-08-24 → 36M → 2024-08-24
22	Antenna	Flann Microwave Ltd	26240-20	273417	LAB000135	CM	2023-08-24 → 36M → 2024-08-24
23	Antenna	Flann Microwave Ltd	25240-20	272861	LAB000134	CM	2023-08-24 → 36M → 2024-08-24
24	Antenna	Flann Microwave Ltd	25240-20	272860	LAB000133	CM	2023-08-24 → 36M → 2024-08-24
25	Antenna	Flann Microwave Ltd	23240-20	273431	LAB000131	CM	2023-08-24 → 36M → 2024-08-24
26	Antenna	Flann Microwave Ltd	22240-20	270448	LAB000130	CM	2023-07-17 → 12M → 2024-07-17
27	Antenna	Flann Microwave Ltd	20240-20	266402	LAB000127	CM	2023-07-17 → 12M → 2024-07-17
28	Harmonic Mixer	Rohde & Schwarz	FS-Z170	100996	LAB000126	C	2023-04-26 → 12M → 2024-04-26
29	Power Meter	Rohde & Schwarz	NRP110T	101151	LAB000119	C	2023-06-05 → 12M → 2024-06-05
30	Signal Generator	Rohde & Schwarz	SMA100B-50	103838	LAB000118	C	2021-06-30 → 36M → 2024-06-30
31	Harmonic Mixer	Rohde & Schwarz	FS-Z325	101015	LAB000117	C	2023-04-11 → 12M → 2024-04-11
32	Harmonic Mixer	Rohde & Schwarz	FS-Z220	101039	LAB000116	C	2023-04-06 → 12M → 2024-04-06
33	Harmonic Mixer	Rohde & Schwarz	FS-Z110	102000	LAB000114	C	2023-05-02 → 12M → 2024-05-02
34	Harmonic Mixer	Rohde & Schwarz	FS-Z090	102020	LAB000113	C	2023-04-06 → 12M → 2024-04-06
35	Harmonic Mixer	Rohde & Schwarz	FS-Z075	102015	LAB000112	C	2023-05-03 → 12M → 2024-05-03
36	Spectrum Analyser	Rohde & Schwarz	FSW50	101450	LAB000111	C	2023-07-26 → 12M → 2024-07-26
37	Climatic Chamber	CTS GmbH	T-65/50	204002	LAB000110	CM	2023-05-11 → 12M → 2024-05-11
38	Antenna Mast	Schwarzbeck Mess-Elektronik OHG	AM 9104	99	LAB000109	NR	–
39	Multimeter	Keysight	U1242B	MY59160009	LAB000016	C	2023-09-20 → 24M → 2024-09-20

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 / C63.26

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 / C63.26

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).
- For each turntable position and antenna polarisation 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 / C63.26

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 / C63.26).
- 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 / C63.26

9.5 Radiated measurements of wanted emission using RF detector

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).

Measurement

Step #1:

- EUT's wanted signal is measured with RF-detector and oscilloscope:
- The EUT is moved carefully to maximize the wanted emission as shown on oscilloscope.
- Record mean and peak voltages (V_{mean} and V_{peak}) from the oscilloscope (e.g. screen shot).
- Measurement distance to EUT: d_{EUT}
- EUT's duty cycle: DC

Step #2: Substitution measurement at EUT's center frequency with CW-signal generator at d_{EUT}

- Power-off and remove EUT from test scenery.
- Install unmodulated CW-signal generator (with frequency multiplier) at the exact EUT position.
- Set the frequency of the signal generator to the center of the EUT's frequency range.
- Adjust the power of the generator such that the oscilloscope indicates a voltage equal to the peak voltage as measured and recorded for the EUT (V_{peak}).
- Disconnect the test antenna from signal generator and measure the generator's output power without changing any settings with a wideband mm-wave power meter with a thermocouple detector or equivalent. Record the measured value as peak power ($V_{ref\ peak}$). Record antenna gain of test antenna.
- Repeat above substitution measurement for the mean voltage recorded in 2nd step and record the measured value as mean power ($V_{ref\ mean}$).

Step #3: Calculation of Peak EIRP:

- Antenna gain of used test antenna at EUT's center frequency: G_{test}
- Peak EIRP = $P_{ref\ peak} + G_{test}$

Step #4: Calculation of Mean EIRP:

- Mean EIRP = $P_{ref\ mean} + G_{test}$

Detailed requirements can be found in ANSI C63.10, 9.11

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 %.