

Test Report

Test report no.: 22107893-28773-0

Date of issue: 2022-12-20

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

Applicant

Kärcher SE & Co. KG

Manufacturer

Kärcher SE & Co. KG

Test Item

4.683-250.0

RF-Spectrum Testing according to:

FCC 47 CFR Part 15

Radio Frequency Devices (Subpart C)

RSS-210, Issue 10 (2019-12)

Licence-Exempt Radio Apparatus: Category I Equipment

RSS-Gen, Issue 5 (2018-04)

General Requirements for Compliance of Radio Apparatus

Tested by
(name, function, signature)

Karsten Gerdaldy
Lab Manager RF


signature

Approved by
(name, function, signature)

Andreas Bender
Deputy Managing Director


signature

Applicant and Test item details

| | |
|------------------------------|--|
| Applicant | Kärcher SE & Co. KG Friedrich-List-Str. 4 71364, Winnenden, Germany Phone: +49 7195 903-0 Fax: +49 7195 903-2805 |
| Manufacturer | Same as applicant |
| Test item description | RFID-Reader |
| Model/Type reference | 4.683-250.0 |
| | |
| FCC ID | ZP946832500999 |
| IC | 9752A-4683500999 |
| HMN | N/A |
| PMN | 46832500 |
| HVIN | 468325000304 |
| FVIN | 46832500000100 |
| Frequency | 13.56 MHz |
| Antenna | Integrated PCB antenna |
| Power supply | 18 V to 42 V DC via external AC/DC adapter |
| Temperature range | -20 °C to +70 °C |

Disclaimer and Notes

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

IBL-Lab GmbH does not take test samples. The samples used for testing are provided by the applicant.

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: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de |
| Accreditation | <p>The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018.</p> <p>Scope of testing and registration number:</p> <ul style="list-style-type: none"> Electronics, EMC, Radio D-PL-21375-01-01 Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-02 Testing Laboratory Designation Number DE0024 Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-03 ISED Company Number 27156 Testing Laboratory CAB Identifier DE0020 <p>Website DAkkS: https://www.dakks.de/</p> <p>The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement</p> |
| Testing location | IBL-Lab GmbH Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany |
| Date of receipt of test samples | 2022-11-14 |
| Start – End of tests | 2022-12-01 – 2022-12-15 |

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 / 50 Hz |

3.2 Normal and extreme test conditions

| | minimum | normal | maximum |
|-------------------|----------|-----------|----------|
| Temperature | -20 °C | 20 °C | +50 °C |
| Relative humidity | -/- | 45 % r.h. | -/- |
| Power supply | 100 V AC | 115 V AC | 130 V AC |

4 TEST STANDARDS AND REFERENCES

| Test standard (accredited) | Description |
|-----------------------------|--|
| FCC 47 CFR Part 15 | Radio Frequency Devices (Subpart C) |
| RSS-210, Issue 10 (2019-12) | Licence-Exempt Radio Apparatus: Category I Equipment |
| RSS-Gen, Issue 5 (2018-04) | General Requirements for Compliance of Radio Apparatus |

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

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

RFID-Reader

5.2 Description of test item

| | |
|------------------|-------------|
| Model name* | 4.683-250.0 |
| Serial number* | 03520200015 |
| PCB identifier* | 9061504 |
| Hardware status* | 03.04 |
| Software status* | V00.01.00 |

*: as declared by applicant

5.3 Technical data of test item

| | |
|-----------------------------|--------------------------------|
| Operational frequency* | 13.56 MHz |
| Operational frequency band* | 11.81 MHz – 15.31 MHz |
| Type of radio transmission* | CW carrier & modulated carrier |
| Modulation type* | ASK |
| Number of channels* | 1 |
| Channel bandwidth* | -/- |
| Channel spacing* | -/- |
| Antenna* | Integrated PCB antenna |
| Power supply* | 18 V to 42 V DC |
| Temperature range* | -20 °C to +70 °C |

*: as declared by applicant

5.4 Additional information

| | |
|---------------------------------------|------|
| Model differences | none |
| Ancillaries tested with | none |
| Additional equipment used for testing | none |

Equipment Under Test (EUT) is prepared by the applicant with special test software to produce a continuously operating carrier with cyclic modulation.

6 SUMMARY OF TEST RESULTS

Test specification

FCC 47 CFR Part 15
RSS-210, Issue 10 (2019-12) / RSS-Gen, Issue 5 (2018-04)

| Clause | Requirement / Test case | Test Conditions | Result / Remark | Verdict |
|--|--|-----------------|------------------------|---------|
| §15.225 (a) – (c) RSS-210, B.6 a | Field strength of emissions (transmitter spectrum mask) | Normal | 65.0 dBµV/m @3m | P |
| §15.225(d) / §15.209(a) // RSS-210, B.6 a RSS-Gen | Field strength of emissions (spurious & harmonics) | Normal | < limit | P |
| §15.225(e) RSS-210, B.6 b | Frequency tolerance | Extreme | < 0.004 % < 40 ppm | P |
| §15.207 RSS-Gen, 8.8 | Conducted limits | Normal | < limit | P |
| §15.215(c) RSS-Gen, 6.7 | 20 dB bandwidth Occupied bandwidth | Normal | 428.7 kHz 859.1 kHz | P |

Notes

– none –

Comments and observations

– none –

7 TEST RESULTS

7.1 Field strength of emissions (transmitter spectrum mask)

Description / Limits

§15.225

(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15848 microvolts/meter at 30 meters (84 dB μ V/m).

(b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters (50.5 dB μ V/m).

(c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters (40.5 dBV/m).

Test procedure

§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 (a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long at the same bandwidth as indicated for CISPR quasi-peak measurements are employed.

Test setup: see 8.1

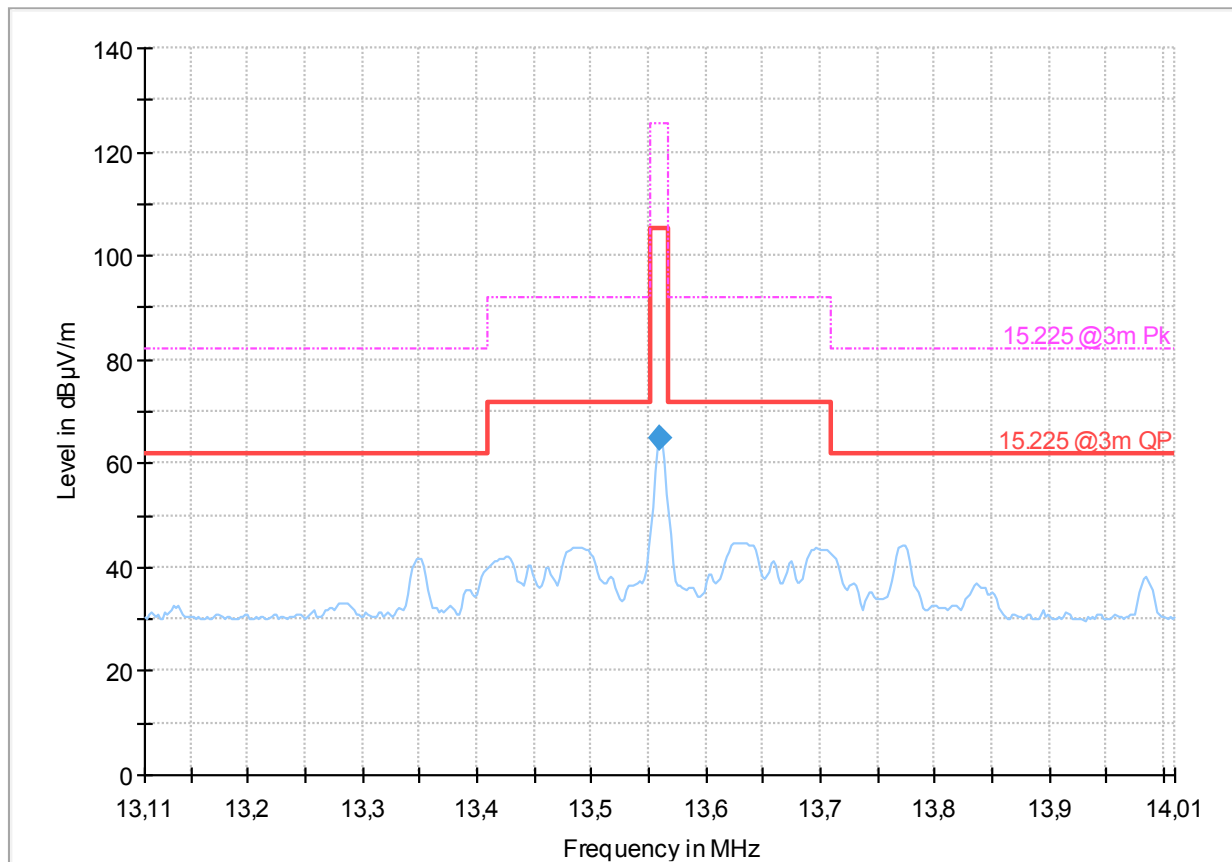
Test results

| Channel / Mode | Frequency [MHz] | Detector | Test distance [m] | Level [dB μ V/m] | Limit [dB μ V/m] | Margin [dB] |
|-----------------------|-----------------|----------|-------------------|----------------------|----------------------|-------------|
| Test mode with 25% DC | 13.56 | QP | 3 | 65.0 | 105.4 | 40.4 |
| | | | | | | |
| | | | | | | |

Note:

Testing was performed with high duty cycle for testing purpose (DC = 100 %)

Plot no. 1: Transmitter Spectrum Mask (TSM), loop antenna



— Preview Result 1-PK+ — 15.225 @3m Pk — 15.225 @3m QP
◆ Critical_Freqs PK+ Final_Result QPK

Final_Result

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-----|---------------|--------------|
| 13.560000 | 64.95 | 105.40 | 40.45 | 100.0 | 9.000 | H | 317.0 | 20.5 |

7.2 Field strength of emissions (spurious and harmonics)

Description / Limits

§15.225 (d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209:

| Frequency | Field Strength | Measurement distance |
|-------------------|--|----------------------|
| 0.009 – 0.490 MHz | 2400/F[kHz] $\mu\text{V/m}$ | 300 m |
| 0.490 – 1.705 MHz | 24000/F[kHz] $\mu\text{V/m}$ | 30 m |
| 1.705 – 30.0 MHz | 30.0 $\mu\text{V/m}$ / 29.5 dB $\mu\text{V/m}$ | 30 m |
| 30 – 88 MHz | 100 $\mu\text{V/m}$ / 40.0 dB $\mu\text{V/m}$ | 3 m |
| 88 – 216 MHz | 150 $\mu\text{V/m}$ / 43.5 dB $\mu\text{V/m}$ | 3 m |
| 216 – 960 MHz | 200 $\mu\text{V/m}$ / 46.0 dB $\mu\text{V/m}$ | 3 m |
| 960 – 100 000 MHz | 500 $\mu\text{V/m}$ / 54.0 dB $\mu\text{V/m}$ | 3 m |

Test procedure

§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 (a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long as the same bandwidth as indicated for CISPR quasi-peak measurements are employed.

Test setup: see 8.1

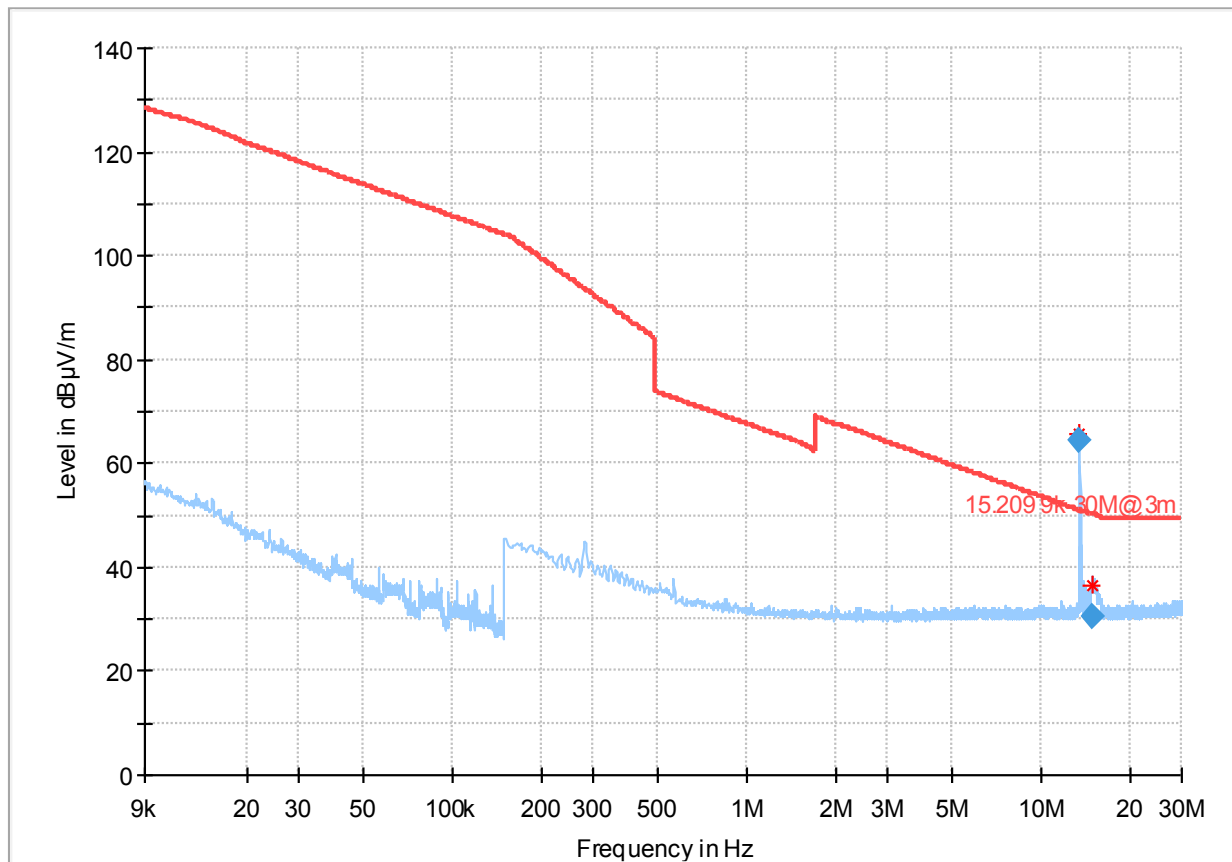
Test results

| Channel / Mode | Frequency [MHz] | Detector | Test distance [m] | Level [dB $\mu\text{V/m}$] | Limit [dB $\mu\text{V/m}$] | Margin [dB] |
|-----------------------|-----------------|----------|-------------------|-----------------------------|-----------------------------|-------------|
| Test mode with 25% DC | 13.560000 | QP | 3 | 61.9 | 105.4 | 43.5 |
| | 40.675000 | QP | 3 | 35.11 | 40.00 | 4.89 |
| | 54.225000 | QP | 3 | 36.78 | 40.00 | 3.22 |
| | 67.800000 | QP | 3 | 33.41 | 40.00 | 6.59 |
| | 116.87500 | QP | 3 | 28.33 | 43.50 | 15.17 |
| | 118.45000 | QP | 3 | 22.88 | 43.50 | 20.62 |
| | 244.07500 | QP | 3 | 36.20 | 46.00 | 9.80 |
| | 662.65000 | QP | 3 | 16.49 | 46.00 | 29.51 |
| | 668.55000 | QP | 3 | 15.82 | 46.00 | 30.18 |

Note:

Testing was performed with high duty cycle for testing purpose (DC = 100 %)

Plot no. 2: radiated emissions 9 kHz – 30 MHz, loop antenna



— Preview Result 1-PK+
— 15.209 9k-30M@3m

* Critical_Freqs PK+
◆ Final_Result QPK

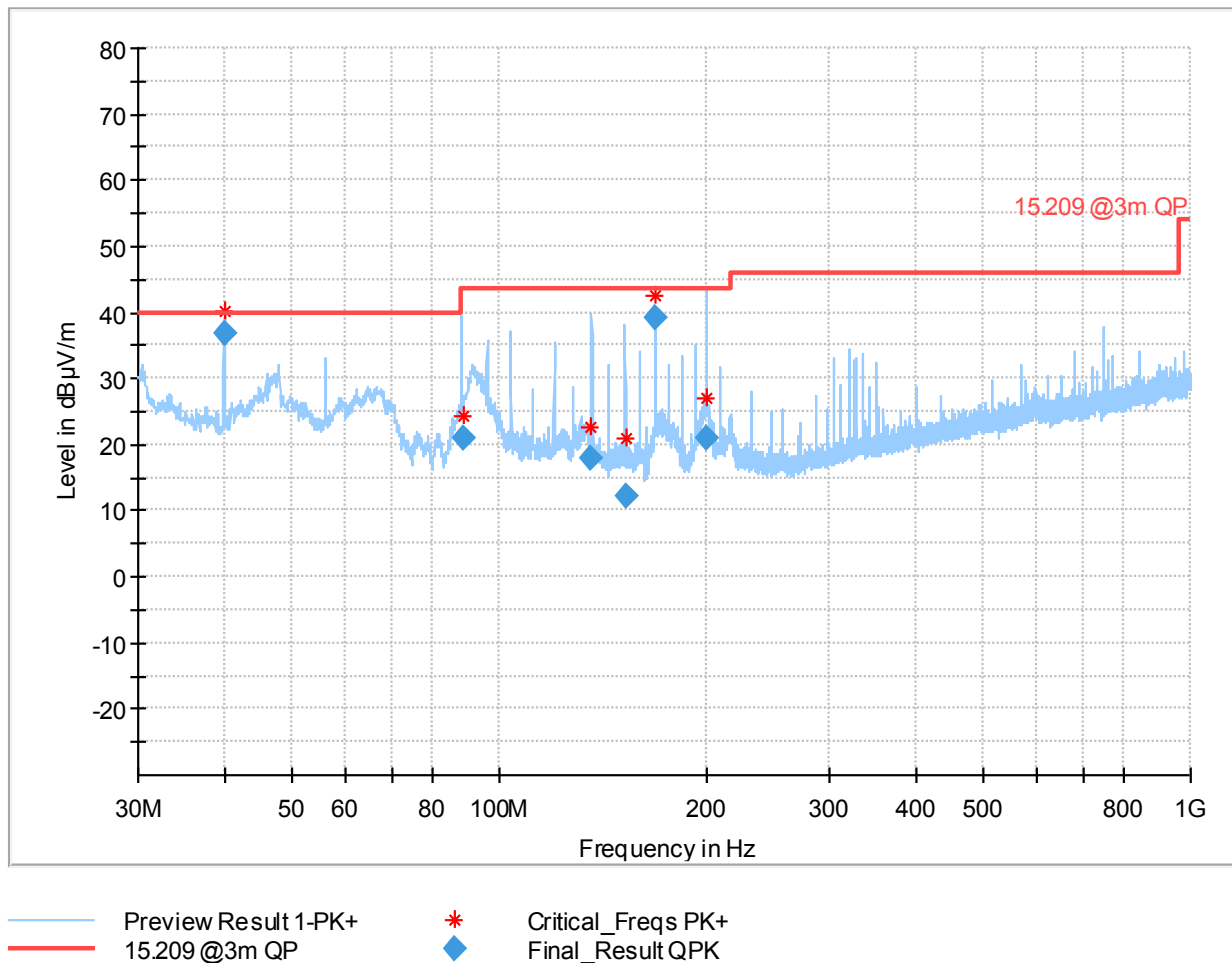
Final_Result

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-----|---------------|--------------|
| 13.560000 | 64.45 | 50.94 | -13.51 | 100.0 | 9.000 | H | 306.0 | 20.5 |
| 14.979750 | 30.52 | 50.07 | 19.55 | 100.0 | 9.000 | H | 285.0 | 20.4 |

Note:

Please see previous plot for transmitter spectrum mask (TSM)!

Plot no. 3: radiated emissions 30 MHz – 1 GHz, hor./vert. polarization



Final Result

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 39.991000 | 36.95 | 40.00 | 3.05 | 100.0 | 120.000 | 117.0 | H | 314.0 |
| 88.457500 | 20.97 | 43.50 | 22.53 | 100.0 | 120.000 | 117.0 | H | 213.0 |
| 135.621000 | 17.97 | 43.50 | 25.53 | 100.0 | 120.000 | 350.0 | H | 311.0 |
| 152.152500 | 12.32 | 43.50 | 31.18 | 100.0 | 120.000 | 150.0 | V | 147.0 |
| 168.007500 | 39.03 | 43.50 | 4.47 | 100.0 | 120.000 | 100.0 | H | 128.0 |
| 199.617500 | 20.91 | 43.50 | 22.59 | 100.0 | 120.000 | 277.0 | V | 224.0 |

7.3 Frequency tolerance

Description / Limits

§15.225 (e) The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to $+50$ degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

Test setup: see 8.3

Test results

| EUT mode | Test conditions | Declared frequency [MHz] | Measured frequency [MHz] | Deviation [%] | Deviation [ppm] |
|----------|-----------------|--------------------------|--------------------------|---------------|-----------------|
| Tx | -20 °C | 13.56 | 13.560529 | 0.0039 | 39.0 |
| Tx | $+20$ °C | 13.56 | 13.560446 | 0.0033 | 32.9 |
| Tx | $+50$ °C | 13.56 | 13.560269 | 0.0020 | 19.8 |

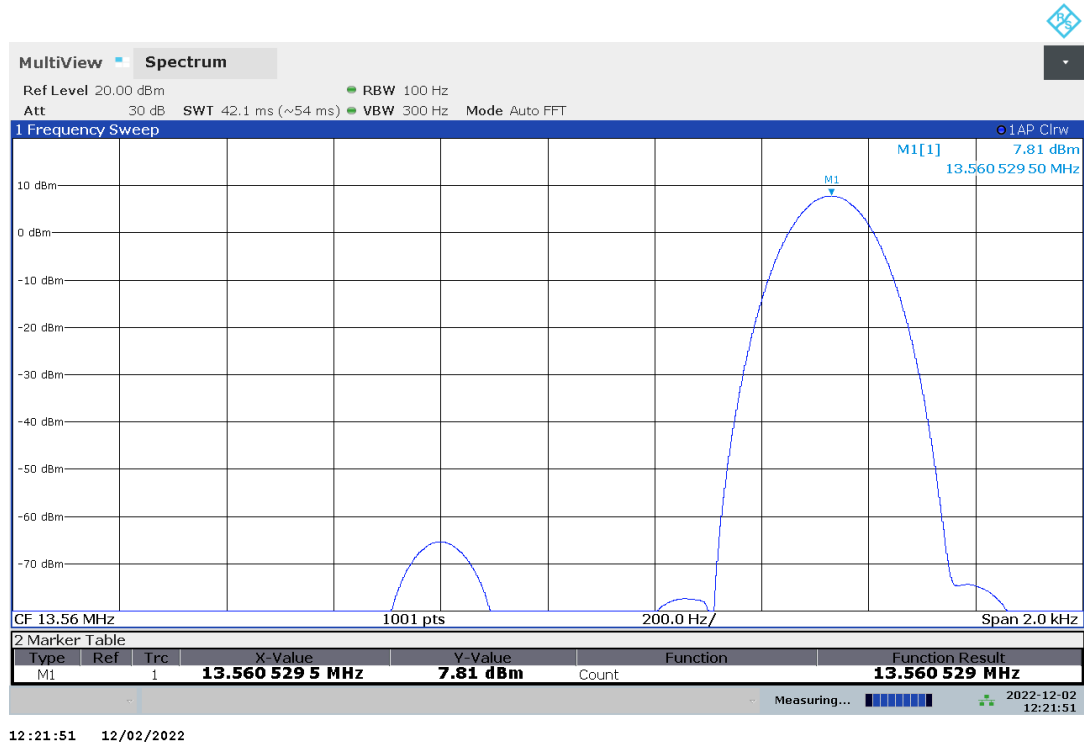
With voltage variation $\pm 15\%$ at normal temperature:

Input voltage variation of 115 V AC $\pm 15\%$ does not affect the transmitted signal.

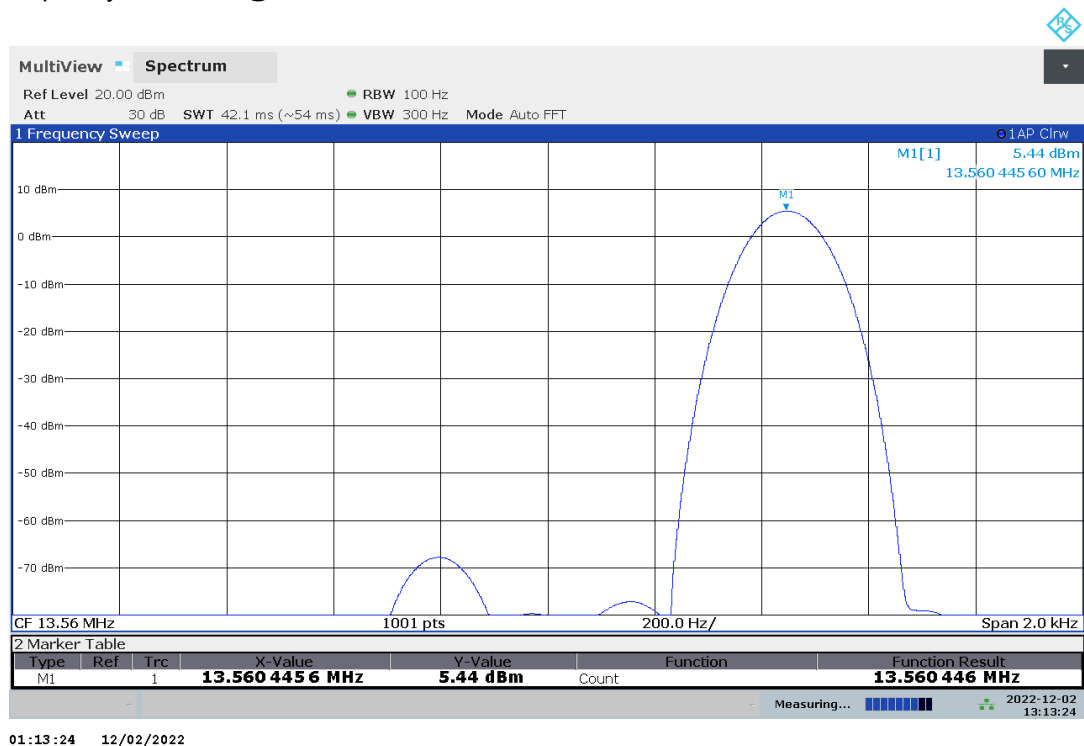
Note:

Testing was performed with high duty cycle for testing purpose (DC = 100 %)

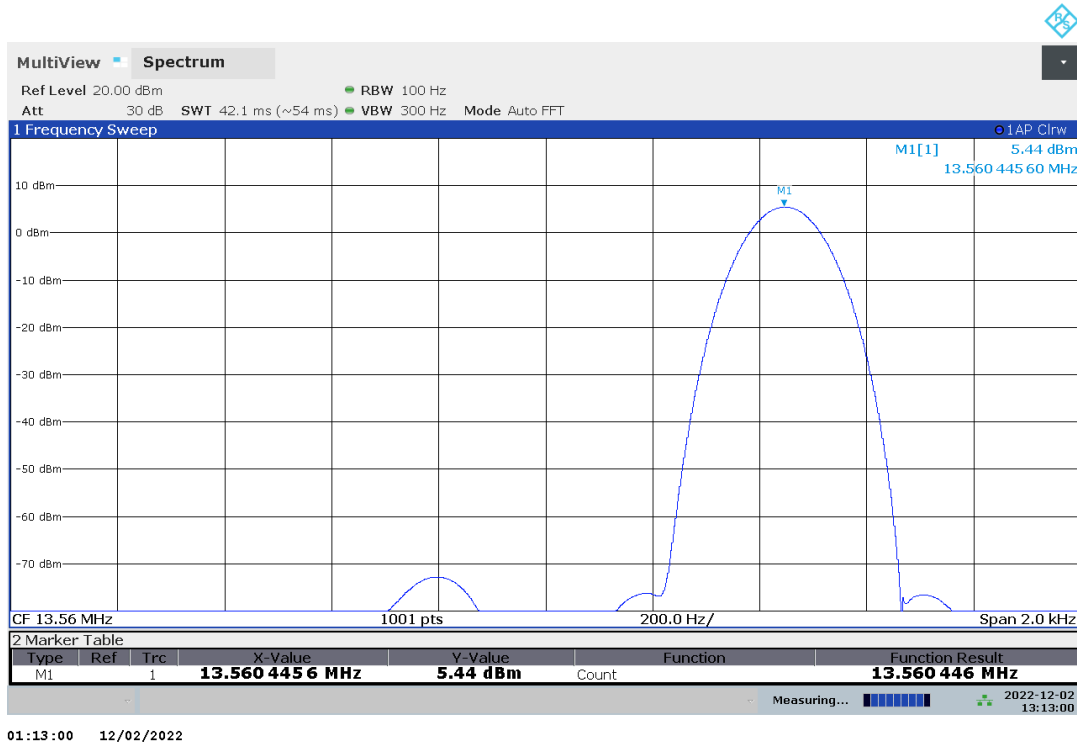
Plot no. 4: frequency tolerance @ -20 °C



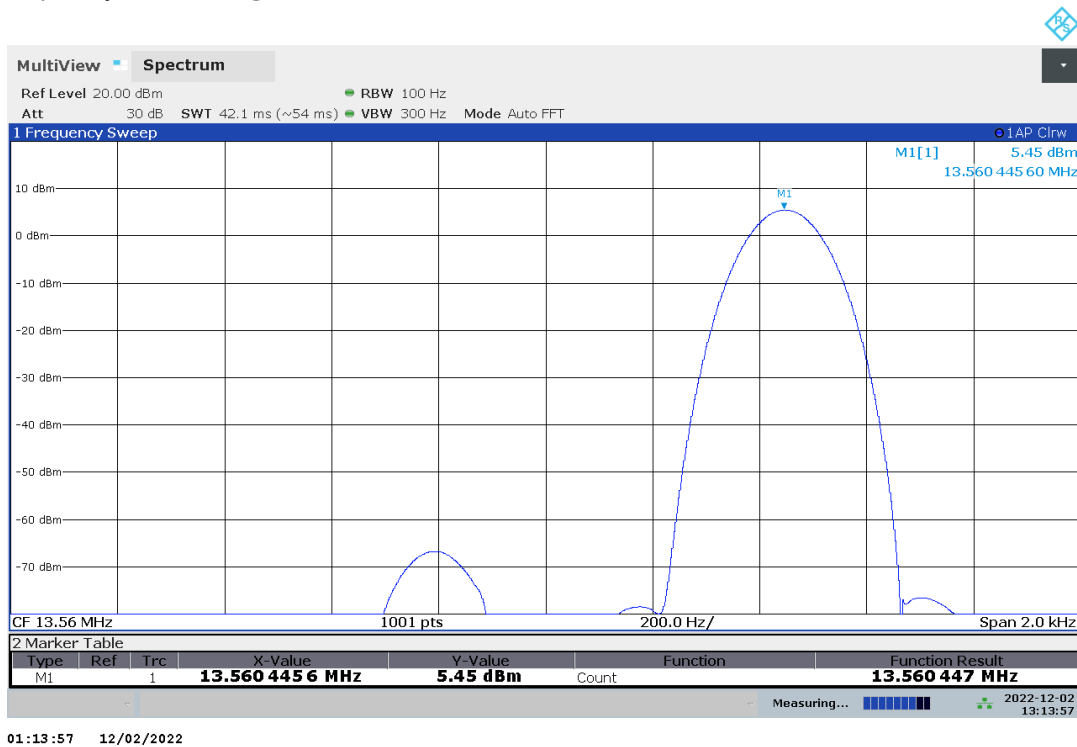
Plot no. 5: frequency tolerance @ +20 °C, Vmin



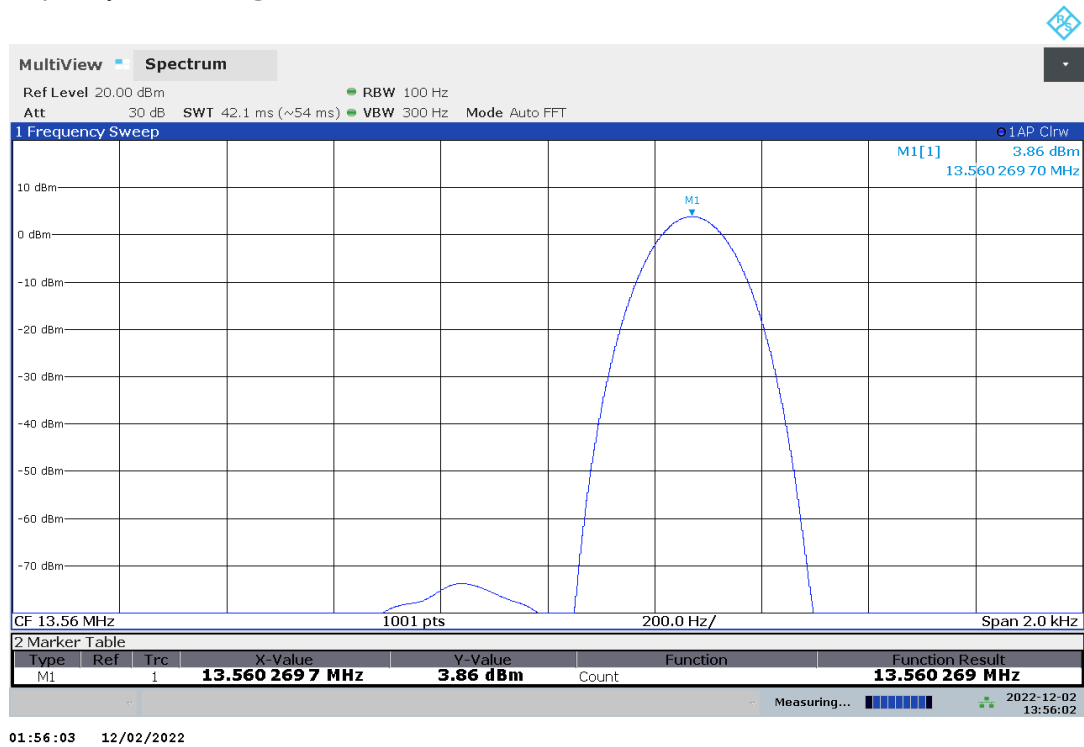
Plot no. 6: frequency tolerance @ +20 °C, Vnom



Plot no. 7: frequency tolerance @ +20 °C, Vmax



Plot no. 8: frequency tolerance @ +50 °C



7.4 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 μ H/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 [dB μ V] | |
|--------------------------------|------------------------------|-----------|
| | 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 8.2

Test results

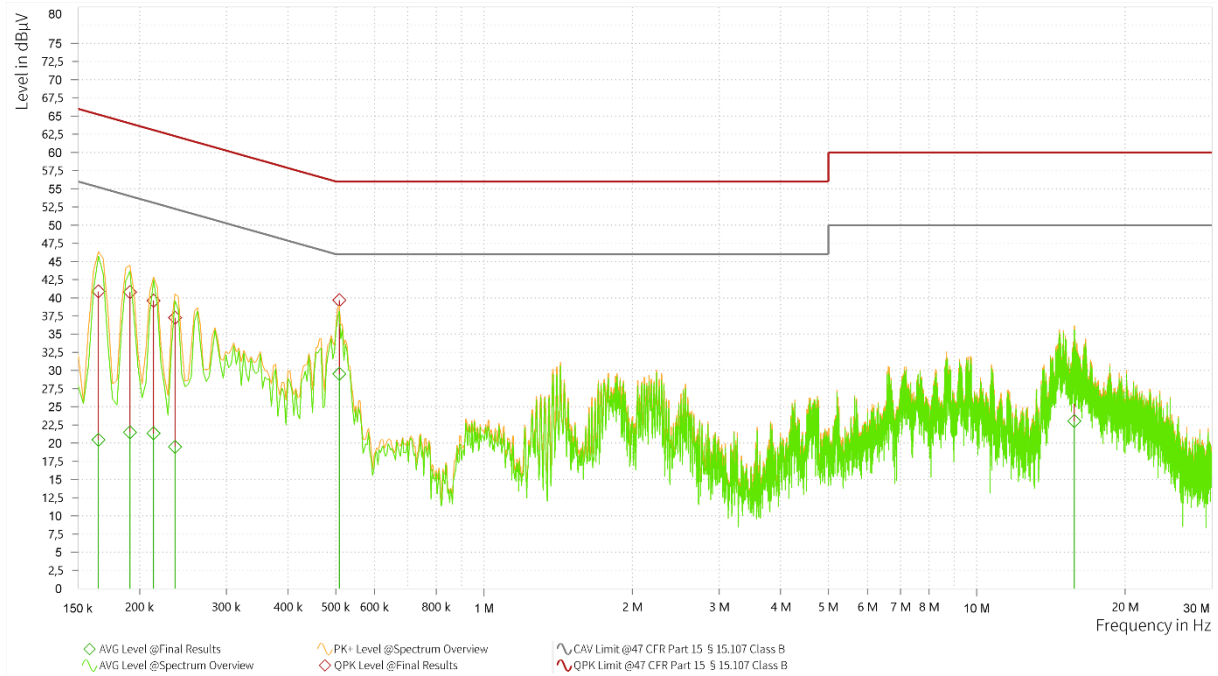
See next pages!

Note:

Testing was performed with high duty cycle for testing purpose (DC = 25 %)

Plot no. 9: conducted emissions, line L1

Spectrum Overview

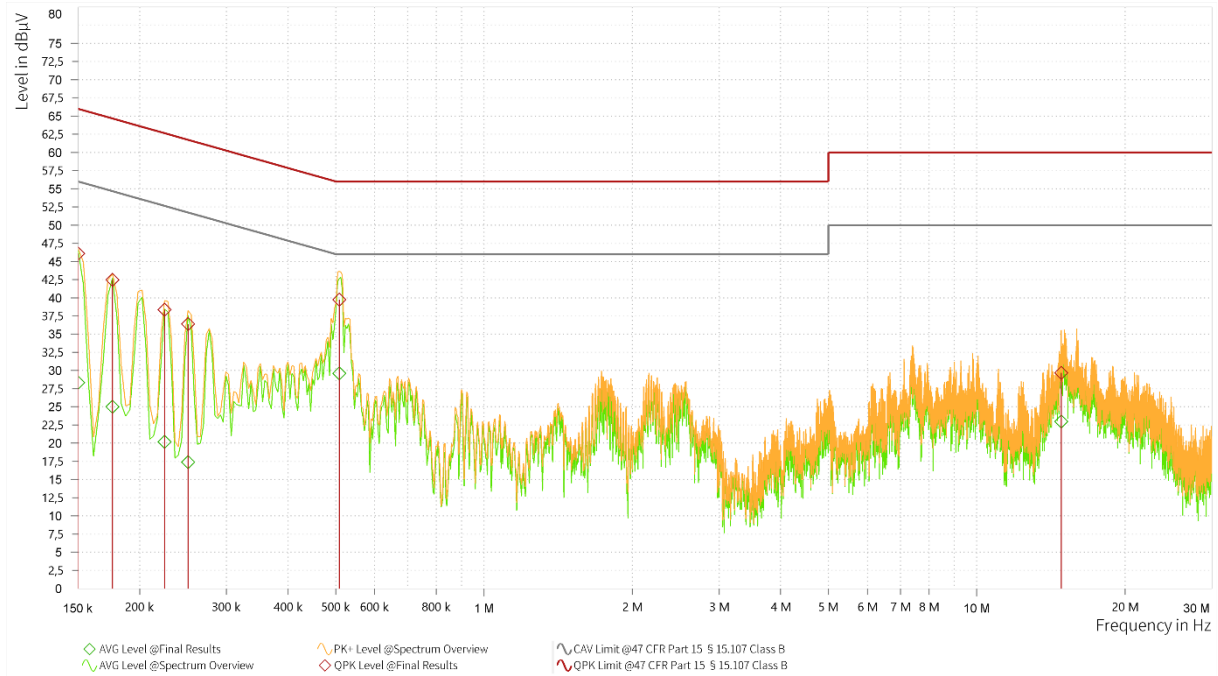


Final Results

| 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 [ms] | Time | Source | Comment |
|----|-----------------|------------------|------------------|-----------------|------------------|-----------------------|-----------------|-----------------|------|----------------|-----------------|----------|-----------------|---------|
| 1 | 0.165 | 40.86 | 65.21 | 24.35 | 20.47 | 55.21 | 34.74 | 10.16 | L1 | 9.000 | 15.000.000 | 11:54:49 | Critical Points | |
| 1 | 0.191 | 40.77 | 63.99 | 23.22 | 21.49 | 53.99 | 32.50 | 9.90 | L1 | 9.000 | 15.000.000 | 11:55:05 | Critical Points | |
| 1 | 0.213 | 39.62 | 63.07 | 23.45 | 21.36 | 53.07 | 31.71 | 9.83 | L1 | 9.000 | 15.000.000 | 11:55:22 | Critical Points | |
| 1 | 0.236 | 37.25 | 62.24 | 24.99 | 19.51 | 52.24 | 32.73 | 9.75 | L1 | 9.000 | 15.000.000 | 11:55:38 | Critical Points | |
| 1 | 0.508 | 39.66 | 56.00 | 16.34 | 29.52 | 46.00 | 16.48 | 10.08 | L1 | 9.000 | 15.000.000 | 11:55:55 | Critical Points | |
| 1 | 15.788 | 29.84 | 60.00 | 30.16 | 23.05 | 50.00 | 26.95 | 10.38 | L1 | 9.000 | 15.000.000 | 11:56:12 | Critical Points | |

Plot no. 10: conducted emissions, neutral N

Spectrum Overview



Final Results

| 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 [ms] | Time | Source | Comment |
|----|-----------------|------------------|------------------|-----------------|------------------|-----------------------|-----------------|-----------------|------|----------------|-----------------|----------|-----------------|---------|
| 1 | 0.150 | 46.08 | 66.00 | 19.92 | 28.31 | 56.00 | 27.69 | 10.79 | N | 9.000 | 15.000.000 | 11:58:06 | Critical Points | |
| 1 | 0.176 | 42.48 | 64.67 | 22.18 | 25.02 | 54.67 | 29.65 | 9.94 | N | 9.000 | 15.000.000 | 11:58:22 | Critical Points | |
| 1 | 0.225 | 38.36 | 62.65 | 24.29 | 20.16 | 52.65 | 32.48 | 9.79 | N | 9.000 | 15.000.000 | 11:58:39 | Critical Points | |
| 1 | 0.251 | 36.40 | 61.73 | 25.33 | 17.38 | 51.73 | 34.35 | 9.71 | N | 9.000 | 15.000.000 | 11:58:56 | Critical Points | |
| 1 | 0.508 | 39.73 | 56.00 | 16.27 | 29.59 | 46.00 | 16.41 | 10.08 | N | 9.000 | 15.000.000 | 11:59:12 | Critical Points | |
| 1 | 14.847 | 29.66 | 60.00 | 30.34 | 22.99 | 50.00 | 27.01 | 10.36 | N | 9.000 | 15.000.000 | 11:59:29 | Critical Points | |

7.5 20 dB bandwidth / occupied bandwidth

Description

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “x dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
- The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level 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, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

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:

- 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.
- 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.
- 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 $10 \log(\text{OBW/RBW})$ below the reference level. Specific guidance is given in 4.1.5.2.
- Step a) through step c) might require iteration to adjust within the specified range.
- 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.
- Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
- 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.
- 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 Parameters:

| | | | |
|--------------------------|------------------------------------|-----------------------------------|--|
| Detector | Pos-Peak (worst-case) | | |
| Trace-mode | Max Hold | | |
| Resolution bandwidth RBW | e.g. 10 kHz | | |
| Video bandwidth | ≥ RBW | | |
| Span | see plots | | |
| Sweep time | see plots | | |
| Measurement uncertainty | $\pm 1 \times 10^{-7}$ | | |
| Test environment | Normal | | |
| Test set-up | <input type="checkbox"/> Conducted | <input type="checkbox"/> Radiated | <input checked="" type="checkbox"/> Test Fixture |

Test Results:

| Channel | Min. Frequency F_L [MHz] | Max. frequency F_H [MHz] | 20 dB bandwidth [kHz] |
|---------|-------------------------------|-------------------------------|--------------------------|
| 1 | 13.3471 | 13.7758 | 428.7 |

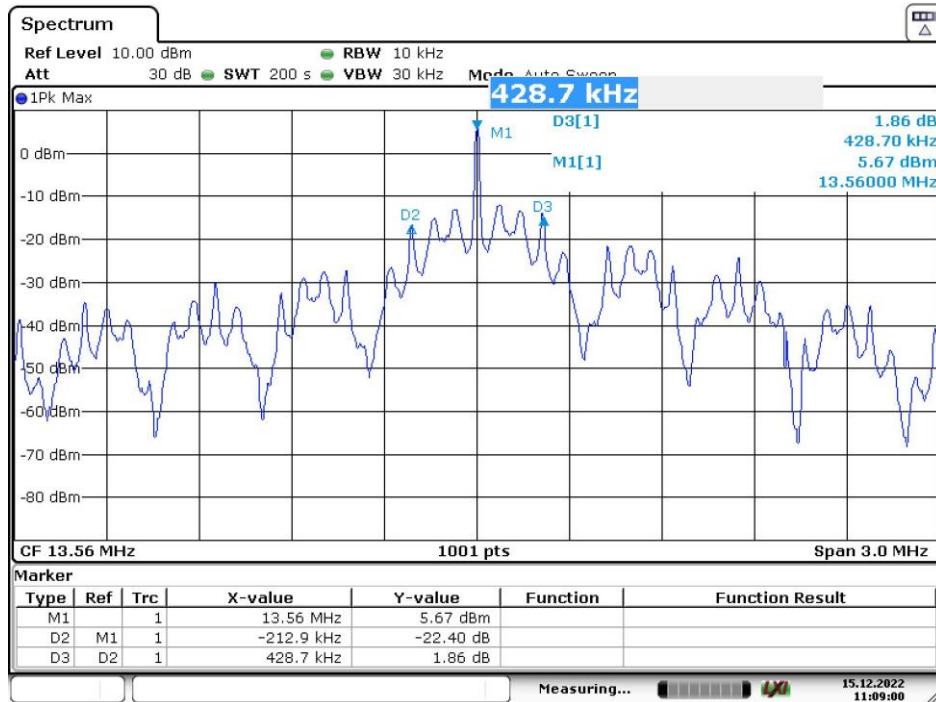
According to FCC Part 15.215 c)

| Channel | Min. Frequency F_L [MHz] | Max. frequency F_H [MHz] | Occupied bandwidth (99%) [kHz] |
|---------|-------------------------------|-------------------------------|-----------------------------------|
| 1 | 13.28028 | 14.13942 | 859.1 |

According to RSS-Gen, chapter 6.7

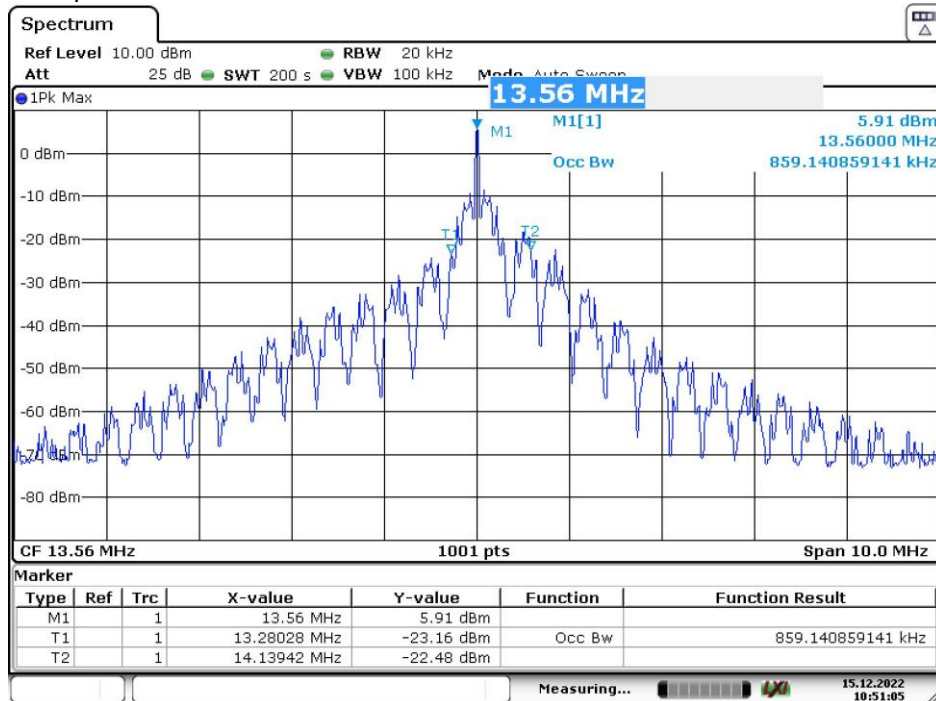
Where: F_L = is the lower edge of the 20 dB BW / OBW
 F_H = is the upper edge of the 20 dB BW / OBW

Plot No. 11: 20 dB bandwidth



Date: 15.DEC.2022 11:09:01

Plot No. 12: 99% Occupied Bandwidth



Date: 15.DEC.2022 10:51:05

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).

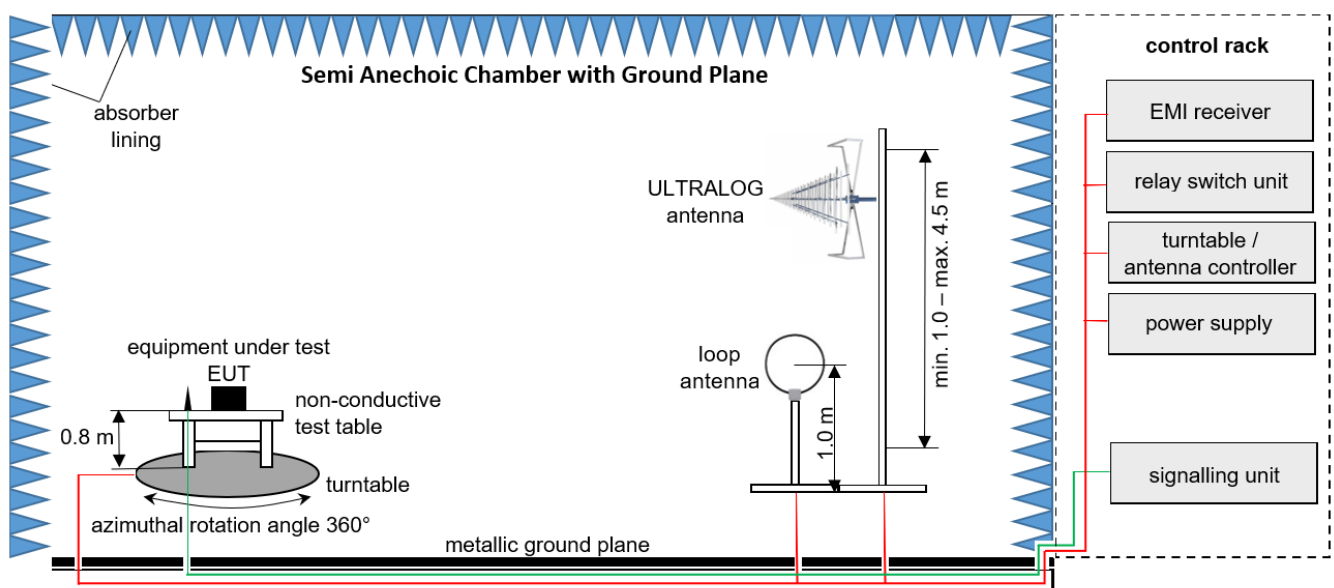
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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)

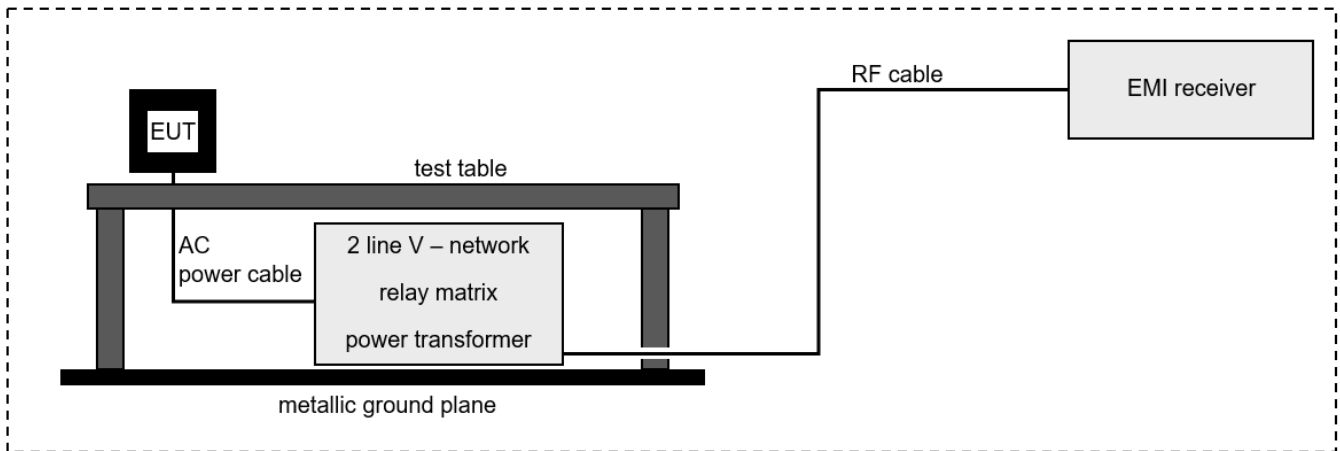
Example calculation:

$$FS [dB\mu V/m] = 12.35 [dB\mu V/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dB\mu V/m] \quad (35.69 \mu V/m)$$

List of test equipment used:

| No. | Equipment | Manufacturer | Type | Serial No. | IBL No. | Kind of Calibration | Last / Next Calibration |
|-----|------------------------------------|---------------------------------|--------------------------------|--------------|-----------|---------------------|-------------------------------|
| 1 | Power Supply | Elektro-Automatik GmbH & Co. KG | EA-PSI 9080-40 T | 2000230001 | LAB000313 | NR | – |
| 2 | Test table | innco systems GmbH | PT1208-080-RH | - | LAB000306 | NR | – |
| 3 | Power Supply | Chroma | 61604 | 616040005416 | LAB000285 | NR | – |
| 4 | Positioner | matur GmbH | TD 1.5-10KG | | LAB000258 | NR | – |
| 5 | Compressed Air | Implotex | 1-850-30 | - | LAB000256 | NR | – |
| 6 | EMI Test Receiver | Rohde & Schwarz | ESW26 | 101481 | LAB000236 | C | 2022-07-07 → 12M → 2023-07-07 |
| 7 | Semi/Fully Anechoic Chamber (SFAC) | Albatross Projects GmbH | Babylon 5 (SAC 5) | 20168.PR.B | LAB000235 | NR | 2020-07-23 → 36M → 2023-07-23 |
| 8 | Measurement Software | Rohde & Schwarz | EMC32 V11.20 | | LAB000226 | NR | – |
| 9 | Turntable | matur GmbH | TT2.0-2t | TT2.0-2t/921 | LAB000225 | NR | – |
| 10 | Antenna Mast | matur GmbH | CAM4.0-P | CAM4.0-P/316 | LAB000224 | NR | – |
| 11 | Antenna Mast | matur GmbH | BAM4.5-P | BAM4.5-P/272 | LAB000223 | NR | – |
| 12 | Controller | matur GmbH | FCU 3.0 | 10082 | LAB000222 | NR | – |
| 13 | Power Supply | Elektro-Automatik GmbH & Co. KG | EA-PS 2042-10 B | 2878350292 | LAB000191 | NR | – |
| 14 | Pre-Amplifier | Schwarzbeck Mess-Elektronik OHG | BBV 9718 C | 84 | LAB000169 | CM | 2022-05-31 → 12M → 2023-05-31 |
| 15 | Antenna | Rohde & Schwarz | HF907 | 102899 | LAB000151 | C | 2020-04-23 → 36M → 2023-04-23 |
| 16 | Antenna | Rohde & Schwarz | HL562E | 102005 | LAB000150 | C | 2020-07-05 → 36M → 2023-07-05 |
| 17 | Open Switch and Control Platform | Rohde & Schwarz | OSP200 Base Unit 2HU | 101748 | LAB000149 | NR | – |
| 18 | Antenna | Rohde & Schwarz | HF907 | 102898 | LAB000124 | C | 2020-04-23 → 36M → 2023-04-23 |
| 19 | Antenna | Rohde & Schwarz | HL562E | 102001 | LAB000123 | C | 2020-07-05 → 36M → 2023-07-05 |
| 20 | Antenna | Rohde & Schwarz | HFH2-Z2E - Active Loop Antenna | 100954 | LAB000108 | C | 2020-03-25 → 36M → 2023-03-25 |

8.2 AC conducted



$$FS = UR + CF + VC$$

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

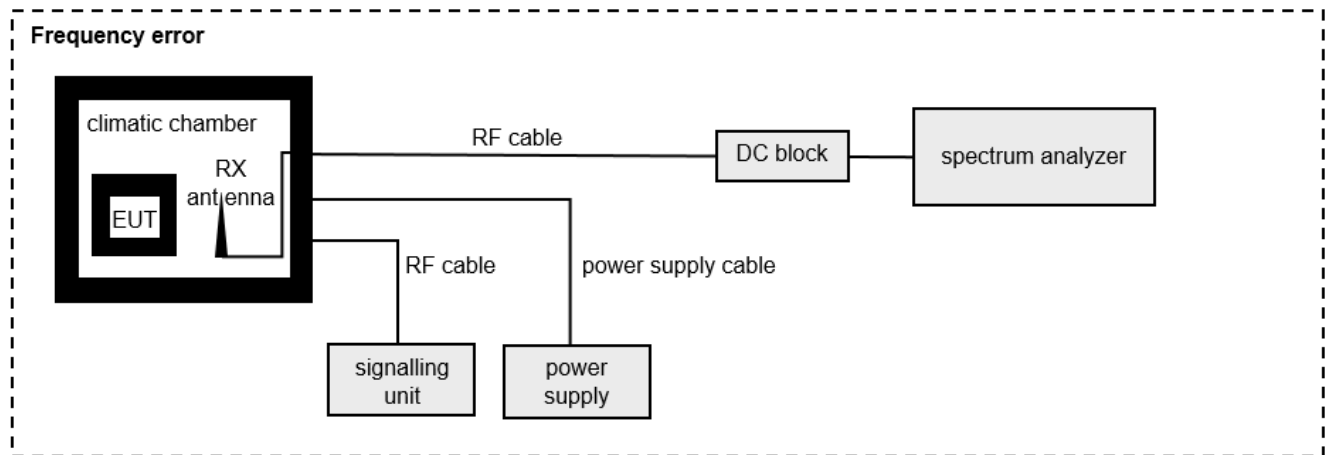
Example calculation:

$$FS [dB\mu V/m] = 37.62 [dB\mu V/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dB\mu V/m] (244.06 \mu V/m)$$

List of test equipment used:

| No. | Equipment | Manufacturer | Type | Serial No. | IBL No. | Kind of Calibration | Last / Next Calibration |
|-----|----------------------------------|-----------------|------------|--------------|-----------|---------------------|-------------------------------|
| 1 | Power Supply | Chroma | 61604 | 616040005416 | LAB000285 | NR | – |
| 2 | Open Switch and Control Platform | Rohde & Schwarz | OSP-B200S2 | 101443 | LAB000239 | NR | – |
| 3 | EMI Test Receiver | Rohde & Schwarz | ESW26 | 101481 | LAB000236 | C | 2022-07-07 → 12M → 2023-07-07 |
| 4 | Two-Line V-Network | Rohde & Schwarz | ENV216 | 102597 | LAB000220 | C | 2022-09-27 → 24M → 2023-09-27 |

8.3 Frequency error



List of test equipment used:

| No. | Equipment | Manufacturer | Type | Serial No. | IBL No. | Kind of Calibration | Last / Next Calibration |
|-----|-------------------|---------------------------------|-------------------|------------|-----------|---------------------|-------------------------------|
| 1 | Power Supply | Elektro-Automatik GmbH & Co. KG | EA-STT 2000B-4.5A | 2923010404 | LAB000362 | NR | – |
| 2 | Coaxial Cable | Huber & Suhner | ST18/48" | 2276454-01 | LAB000157 | CM | 2022-09-23 → 12M → 2023-09-23 |
| 3 | Spectrum Analyser | Rohde & Schwarz | FSW50 | 101450 | LAB000111 | C | 2022-07-28 → 12M → 2023-07-28 |
| 4 | Climatic Chamber | CTS GmbH | T-65/50 | 204002 | LAB000110 | CM | 2022-05-11 → 12M → 2023-05-11 |
| 5 | Loop antenna | IBL | – | – | – | NR | – |

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 315° in 45° steps.
- For each turntable step 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., $\lambda/2\pi$), 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 315° in 45° steps.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable step / 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., $\lambda/2\pi$), 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 | $\leq \pm 10$ ppm |
| Radiated emission | $\leq \pm 6$ dB |
| Temperature | $\leq \pm 1$ °C |
| Humidity | $\leq \pm 5$ % |
| DC and low frequency voltages | $\leq \pm 3$ % |

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-4/01 m:2013. The true value is located in the corresponding interval with a probability of 95 %.

End of Test Report
