Test Report

**Customer:**

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# RF test report

**180371-AU01+W01**

**DESKO GmbH**

**Keyboard with multiple card readers**

NEPTUN chrom

# EMV **TESTHAUS** GmbH

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## Accreditation:

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-12155-01-00

Registration number (FCC): 997268
Test Firm Type “accredited”: Valid until 2019-05-06
MRA US-EU, FCC designation number: DE0010
BnetzA-CAB-02/21-02/04 Valid until 2018-11-27

## Test Laboratory:

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Germany

The technical accuracy is guaranteed through the quality management of the
EMV **TESTHAUS** GmbH

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# 1 Test regulations

| | |
|---|---|
| 47 CFR Part 2: 10-2017 | Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC) |
| 47 CFR Part 15: 03-2017 | Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC) |
| ANSI C63.10:2013-06 | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| FCC KDB 174176 D01 June 3, 2015 | AC power-line conducted emissions Frequently Asked Questions |

# 2 Summary of test results

| Standard | Test result |
|---|---|
| 47 CFR Part 15,<br>sections 15.207 and 15.225 | Passed |

Straubing, May 18, 2018

Andreas Menacher
Test engineer
EMV **TESTHAUS** GmbH

Konrad Graßl
Head of EMC department
EMV **TESTHAUS** GmbH

# 3 Equipment under Test (EUT)

| | |
|---|---|
| Product type: | Keyboard with multiple card readers |
| Model Name: | NEPTUN chrom |
| Applicant: | DESKO GmbH |
| Manufacturer: | DESKO GmbH |
| Serial number: | Prototype NEPTUN chrom |
| FCC ID: | WTM-NEPTUN1 |
| Application frequency band: | 13.110 to 14.010 MHz |
| Frequency range: | 13.560 MHz |
| Operating frequency: | 13.560 MHz |
| Number of RF-channels: | 1 |
| Modulation: | ASK |
| Antenna connector: | ☒ permanent ☐ temporary ☐ none |
| Antenna types: | PCB antenna |
| | ☒ detachable ☐ not detachable |
| Maximum antenna gain: | N/A |
| Maximum conducted power: | N/A |
| Power supply: | 5.0 VDC ± 5 % |
| Temperature range: | 0℃ to +50℃ |

## 3.1 Photo documentation

For external photos of the EUT see annex B, for internal ones see annex C.
For photos taken during testing and including EUT-positions see annex A.

## 3.2 Short description of the EUT

EUT is a keyboard with internal RFID reader (13.56 MHz).

## 3.3 Operation mode

During the pre-tests it was observed that the “continuous-tag reading-mode” is the respective worst- case. Therefore this mode was selected for final testing. The device was configured by manufacturer to scan the RFID-Tag and send the data to the Test-PC.

The EUT was only tested in 3 orthogonal positions for the measurements from 9 kHz to 30 MHz. The normal position (position 1) of the EUT was used for all other measurements. This is documented in annex A.

## 3.4 Configuration

The following peripheral devices and interface cables were connected during the tests:

| Device | Model: | Serial or inventory no. |
|---|---|---|
| Keyboard with multiple card readers | NEPTUN chrom | Prototype NEPTUN chrom |
| Power Supply | GT-46200-2005-T3 | TR9CA4000YL4-N(R6B) |
| RFID tag | 13.56 MHz | ---- |
| Notebook | LIFEBOOK U772 | DSDA005103 |
| DC supply | Statron 3231.1 | E00017 |

## 3.5 Used cables

| Count | Description (type / lengths / remarks) | Serial no. |
|---|---|---|
| 1 | USB cable (2.2 m, shielded) | --- |

# 4 AC power line conducted emissions

## according to 47 CFR Part 15, section 15.207

## 4.1 Test location

| Description | Manufacturer | Inventory No. |
|---|---|---|
| Shielded room | Siemens - Matsushita | E00107 |

## 4.2 Test instruments

| | Description | Manufacturer | Inventory No. |
|---|---|---|---|
| ☒ | ESCS 30 | Rohde & Schwarz | E00003 |
| ☐ | ESU 26 | Rohde & Schwarz | W00002 |
| ☐ | ESCI | Rohde & Schwarz | E00001 |
| ☐ | ESH3-Z2 | Rohde & Schwarz | E00028 |
| ☒ | ESH2-Z5 | Rohde & Schwarz | E00004 |
| ☐ | ESH2-Z5 | Rohde & Schwarz | E00005 |
| ☒ | Cable set shielded room | Huber + Suhner | E00424 |

## 4.3 Limits

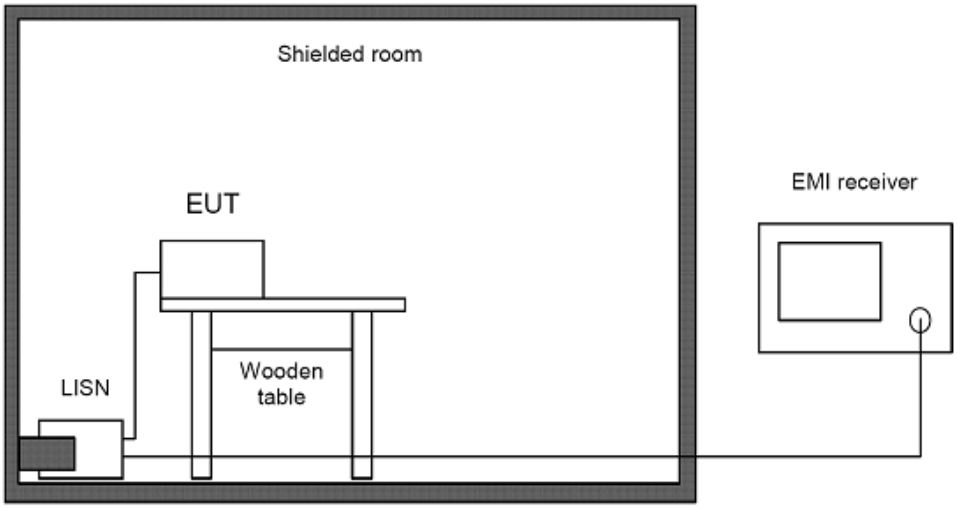
| Frequency [MHz] | Quasi-peak [dBµV] | Average [dBµV] |
|---|---|---|
| 0.15 – 0.5 | 66 – 56 | 56 – 46 |
| 0.5 – 5.0 | 56 | 46 |
| 5 – 30 | 60 | 50 |

## 4.4 Test procedure

1. The tests of conducted emission were carried out in a shielded room using a line impedance stabilization network (LISN) 50 µH/50 Ohms and an EMI test receiver.
2. The EMI test receiver was connected to the LISN and set to a measurement bandwidth of 9 kHz in the frequency range from 0.15 MHz to 30 MHz.
3. The EUT was placed on a wooden table and connected to the LISN.
4. To accelerate the measurement the detector of the EMI test receiver was set to peak and the whole frequency range form 0.15 MHz to 30 MHz was scanned.
5. After that all peaks values with less margin than 10 dB to quasi-peak limit or exceeding the limit were marked and re-measured with quasi-peak detector.
6. If after that all values are under the average limit no addition measurement is necessary. In case there are still values between quasi-peak and average limit then these values were re-measured with average detector.
7. These measurements were done on all power lines.

According to ANSI C63.10, section 6.2.2 testing of intentional radiators with detachable antennas shall be done with a dummy load otherwise the tests should be done with connected antenna and if adjustable fully extended.

## 4.5 Test setup

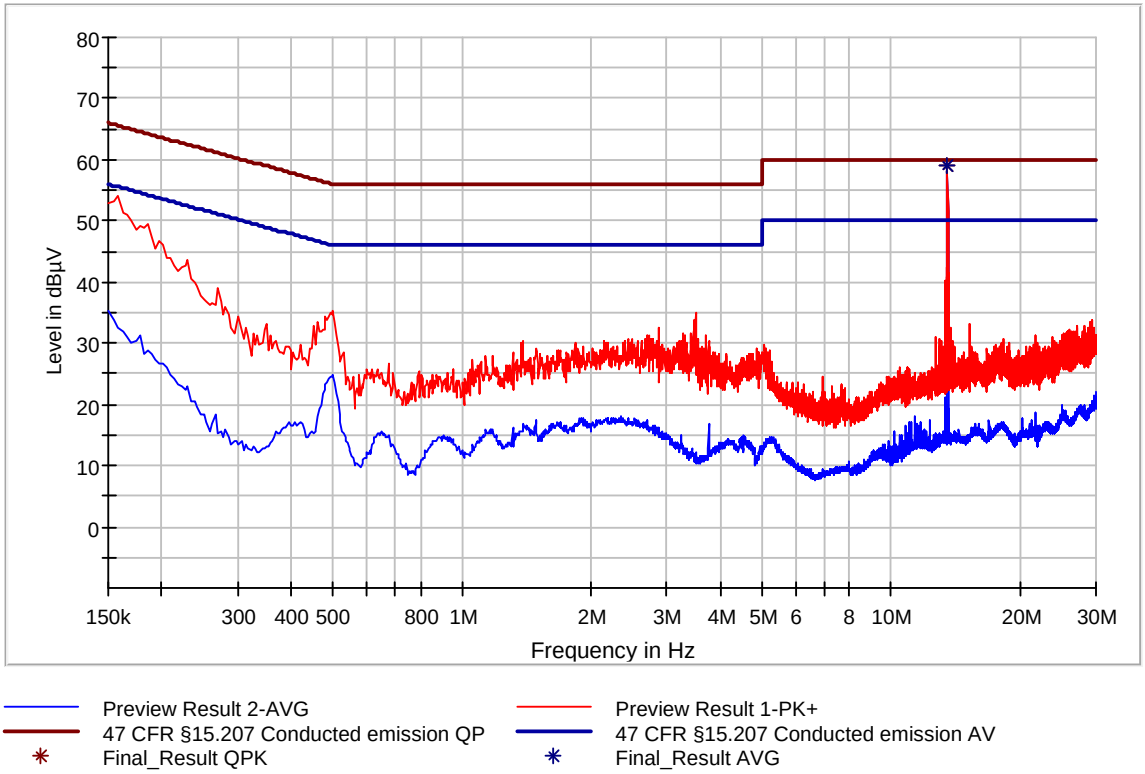



Picture 1: Outline of conducted emission test setup

Comments: All peripheral devices were additionally decoupled by means of a line stabilization network.

## 4.6 Test results

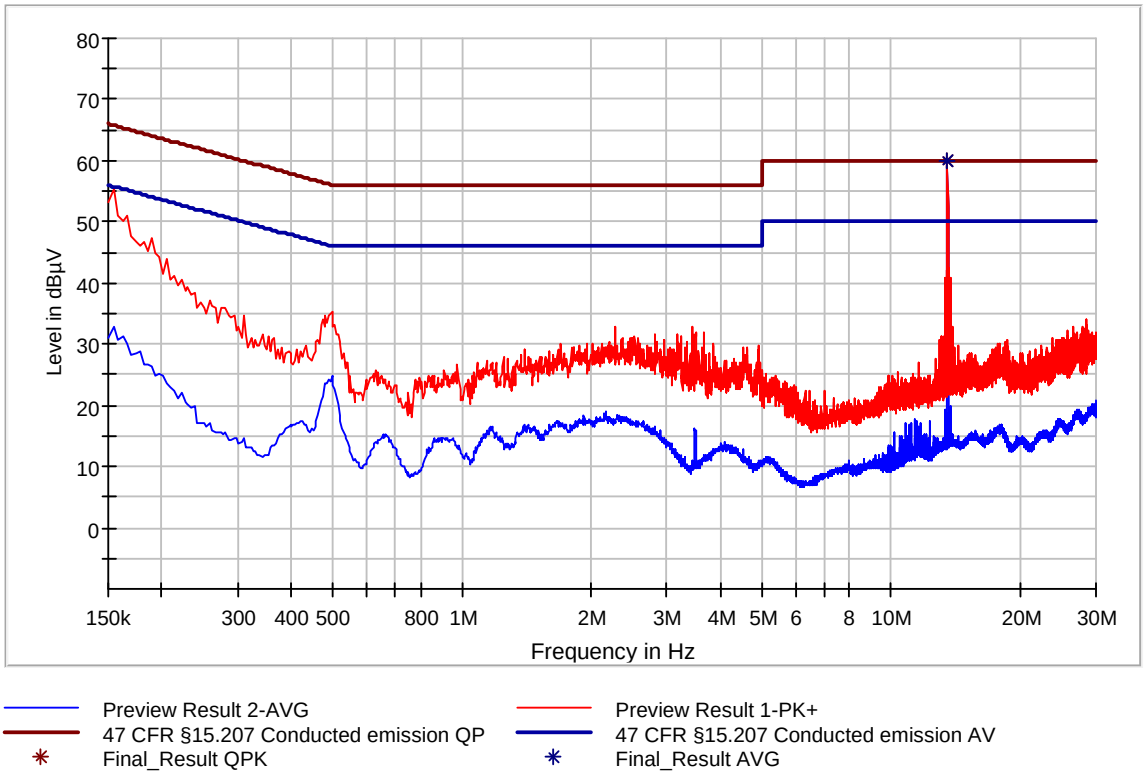
| | | | |
|---|---|---|---|
| Temperature: | 22℃ | Humidity: | 38% |
| Tested by: | Andreas Menacher | Test date: | 2018-05-02 |




Picture 2: Graphic - Conducted emission on mains, phase 1 (without termination)

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Line | PE |
|---|---|---|---|---|---|---|
| 13.561000 | --- | 59.08 | 50.00 | -9.08 | L1 | GND |
| 13.561000 | 58.92 | --- | 60.00 | 1.08 | L1 | GND |

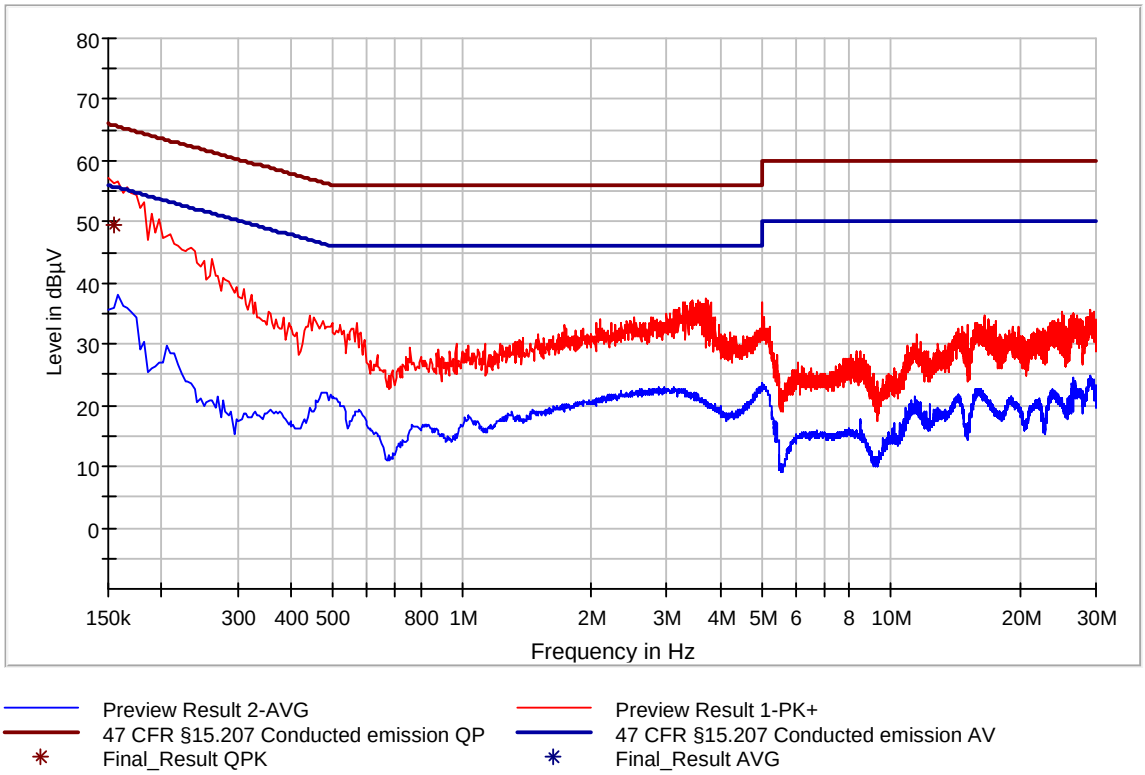
Picture 3: Table - Conducted emission on mains, phase 1 (without termination)




Picture 4: Graphic - Conducted emission on mains, neutral (without termination)

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Line | PE |
|---|---|---|---|---|---|---|
| 13.561000 | --- | 59.92 | 50.00 | -9.92 | N | GND |
| 13.561000 | 59.89 | --- | 60.00 | 0.11 | N | GND |

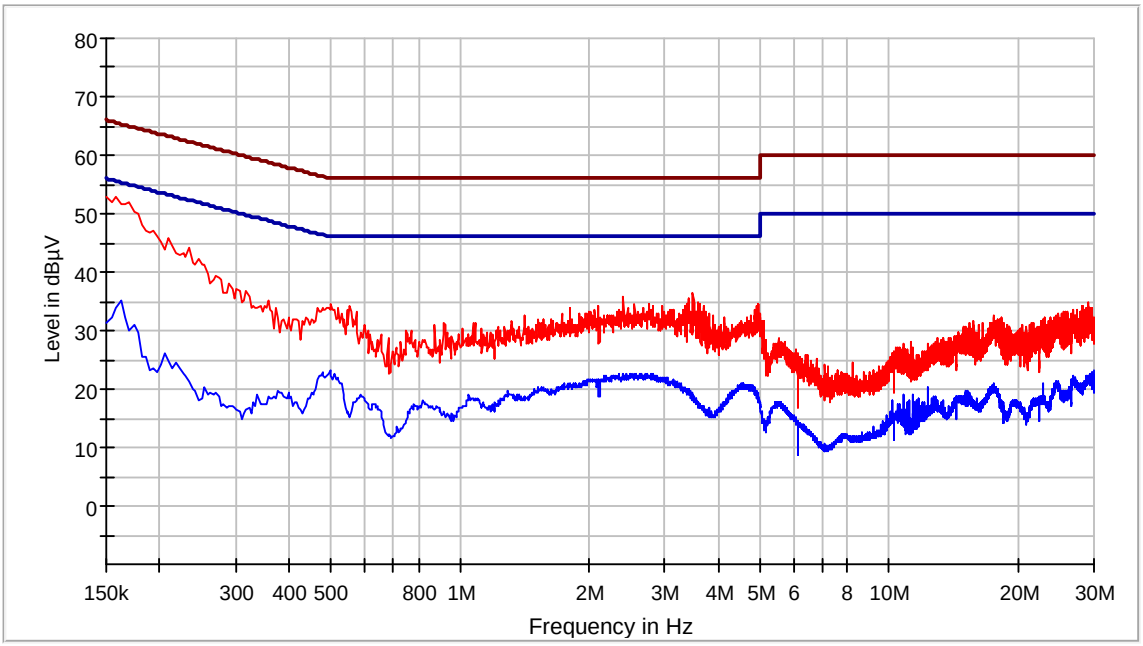
Picture 5: Table - Conducted emission on mains, neutral (without termination)




Picture 6: Graphic - Conducted emission on mains, phase L1 (with termination)

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Line | PE |
|---|---|---|---|---|---|---|
| 0.154000 | 49.61 | --- | 65.78 | 16.17 | L1 | GND |

Picture 7: Table - Conducted emission on mains, phase L1 (with termination)




Picture 8: Graphic - Conducted emission on mains, neutral (with termination)

# 5 Radiated emission measurement (<1 GHz)

**according to 47 CFR Part 15, section 15.205(a), 15.209(a), 15.225(a) to (e)**

## 5.1 Test Location

**Emission < 30 MHz**

☒ Scan with PK / AV detector in 3 m CDC.

☒ Final CISPR measurement with QP detector in 3 m OATS

**Emission > 30 MHz**

☒ Scan with QP detector in 3 m SAC.

☒ Final CISPR measurement with QP detector in 3 m SAC

## 5.2 Test instruments

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☒ | Compact Diagnostic Chamber (CDC) | VK041.0174 | Albatross Projects | E00026 |
| ☒ | Semi Anechoic Chamber (SAC) | --- | Albatross Projects | E00716 |
| ☒ | Open area test site | --- | EMV **TESTHAUS** GmbH | E00354 |
| ☒ | EMI test receiver (CDC / OATS) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☐ | EMI test receiver (SAC) | ESR 7 | Rohde & Schwarz | E00739 |
| ☒ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☐ | TRILOG broadband antenna (CDC) | VULB 9160 | Schwarzbeck | E00011 |
| ☐ | TRILOG broadband antenna (OATS) | VULB 9163 | Schwarzbeck | E00013 |
| ☒ | TRILOG broadband antenna (SAC) | VULB 9162 | Schwarzbeck | E00643 |
| ☒ | Loop Antenna | HFH2-Z2 | Rohde & Schwarz | E00060 |
| ☐ | Switch box | COSB 4-1-26 | Conformitas | W00091 |
| ☐ | Preamplifier | AMF-5D-00501800 | Parzich | W00089 |
| ☐ | Measurement software | E10 v1.4.12 | EMV TESTHAUS GmbH | E00443 |
| ☒ | Measurement software | EMC 32 | Rohde & Schwarz | --- |
| ☒ | Cable set SAC 3 m | --- | Huber + Suhner | E00434<br>E00755<br>E00320 |

## 5.3 Limits

The field strength of any emissions appearing outside of the 13.110 to 14.010 MHz band including spurious emissions falling into restricted bands as specified in 15.205(a) shall not exceed the general radiated emission limits as specified in 15.209.

| Frequency [MHz] | Field strength Fs [µV/m] | Field strength [dBµV/m] | Measurement distance d [m] |
|---|---|---|---|
| 0.009 – 0.490 | 266.6 – 4.9 | 48.5 – 13.8 | 300 |
| 0.490 – 1.705 | 48.98 – 14.08 | 33.8 – 22.97 | 30 |
| 1.705 – 30.0 | 30 | 29.54 | 30 |
| 30 – 88 | 100 | 40 | 3 |
| 88 – 216 | 150 | 43.5 | 3 |
| 216 - 960 | 200 | 46 | 3 |
| Above 960 | 500 | 54 | 3 |

As noted in 15.205(d)(7) devices according to 15.225 are exempt from complying with restricted band requirements for the 13.36 to 13.41 MHz band. Instead they have to comply with the limits as specified in 15.225 (a) to (d):

| Frequency [MHz] | Field strength Fs [µV/m] | Field strength [dBµV/m] | Measurement distance d [m] |
|---|---|---|---|
| 13.553 - 13.567 | 15,848 | 84 | 30 |
| 13.410 - 13.553 | 334 | 50.47 | 30 |
| 13.567 - 13.710 | 334 | 50.47 | 30 |
| 13.110 - 13.410 | 106 | 40.51 | 30 |
| 13.710 - 14.010 | 106 | 40.51 | 30 |
| f < 13.110 | according to limits in §15.209 | | |
| f > 14.010 | | | |

## 5.4 Test procedure

**Radiated emissions below 30 MHz**

1. For emissions below 30 MHz measurements are done using a loop antenna. Prescan is performed with peak detector and final measurements with quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 kHz where average detector applies. Antenna height is not changed during this test. Appropriate CISPR bandwidths of 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above are used.
2. EUT is configured according to ANSI C63.10. It is placed on the top of the turntable 0.8 meter above ground. The receiving antenna is placed 3 meters from the turntable. The test setup is placed inside a fully anechoic room (called “CDC”).
3. Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position
4. After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
5. With the test receiver set to the first frequency of the list, the EUT is rotated by ±45° around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
6. Step 5 is repeated for all other frequencies in the list.
7. Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission.

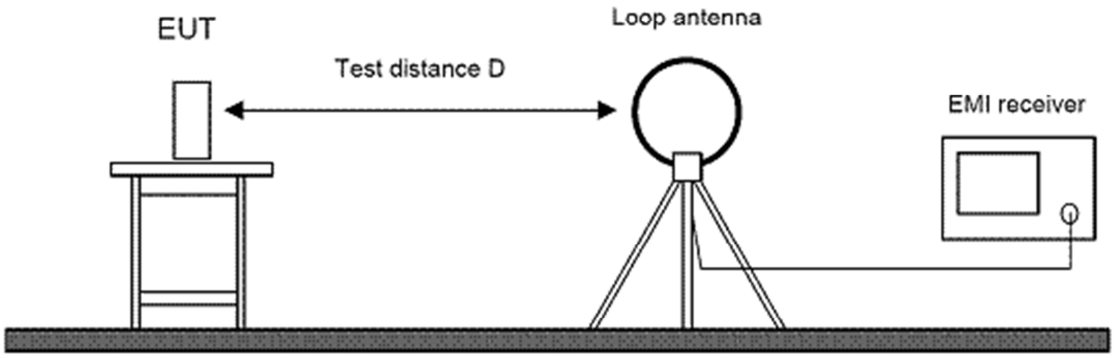
**Radiated emissions from 30 MHz to 1 GHz**

1. EUT is configured according to ANSI C63.10. It was placed on the top of the turntable 0.8 meter above ground. The receiving antenna is placed 3 meters from the turntable. The test setup was placed inside a semi-anechoic chamber (SAC).
2. EUT and all peripherals are powered on.
3. The broadband antenna is set to vertical polarization.
4. The table position is set to 0°.
5. The antenna height is set to 1 m.
6. The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
7. The antenna height is increased to 4 m in steps of 50 cm. At each height, step 6 is repeated.
8. The polarization of the measurement antenna is changed to horizontal.
9. The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step 6 is repeated.
10. The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps 5 to 9 are repeated.
11. After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.

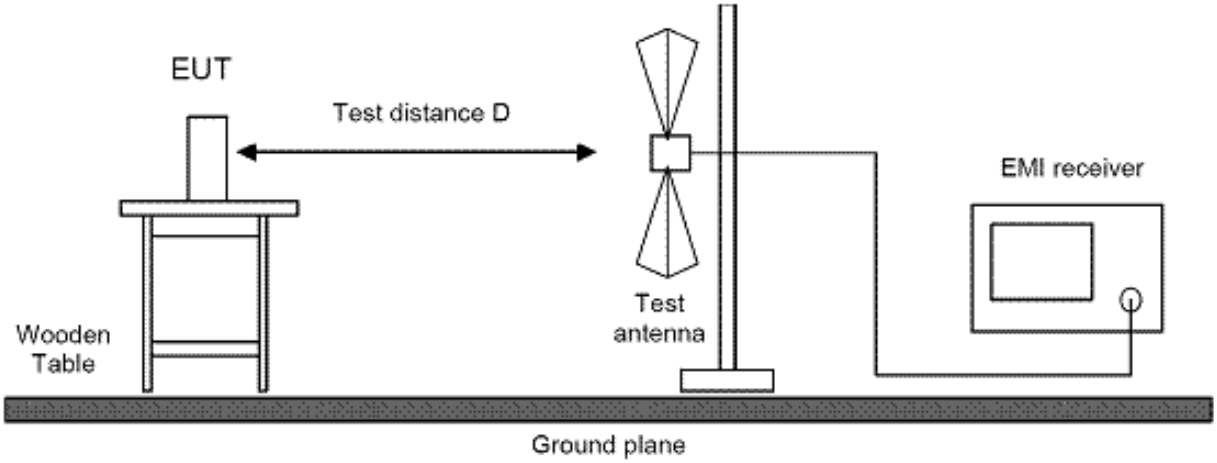
12. With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
13. The antenna is moved by ±50 cm around this height and the EUT is rotated by ±60° around this table position while measuring the emission level continuously.
14. For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
15. Steps 12 to 14 are repeated for all other frequencies in the list.

If the EUT may be used in various positions, steps 1 to 15 are repeated in two other orthogonal positions.

## 5.5 Test setup




Picture 9: Test setup for radiated emission measurement (< 30 MHz)




Picture 10: Test setup for radiated emission measurement (< 1 GHz)

## 5.6 Test deviation

There is no deviation from the standards referred to.

## 5.7 Test results

| | | | |
|---|---|---|---|
| Temperature: | 21℃ | Humidity: | 37% |
| Tested by: | Andreas Menacher | Test date: | 2018-05-03 |

# Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

$d_{near\ field}$ = 47.77 / $f_{MHz}$, or

$f_{MHz}$ = 47.77 / $d_{near\ field}$

The frequency $f_{MHz}$ at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

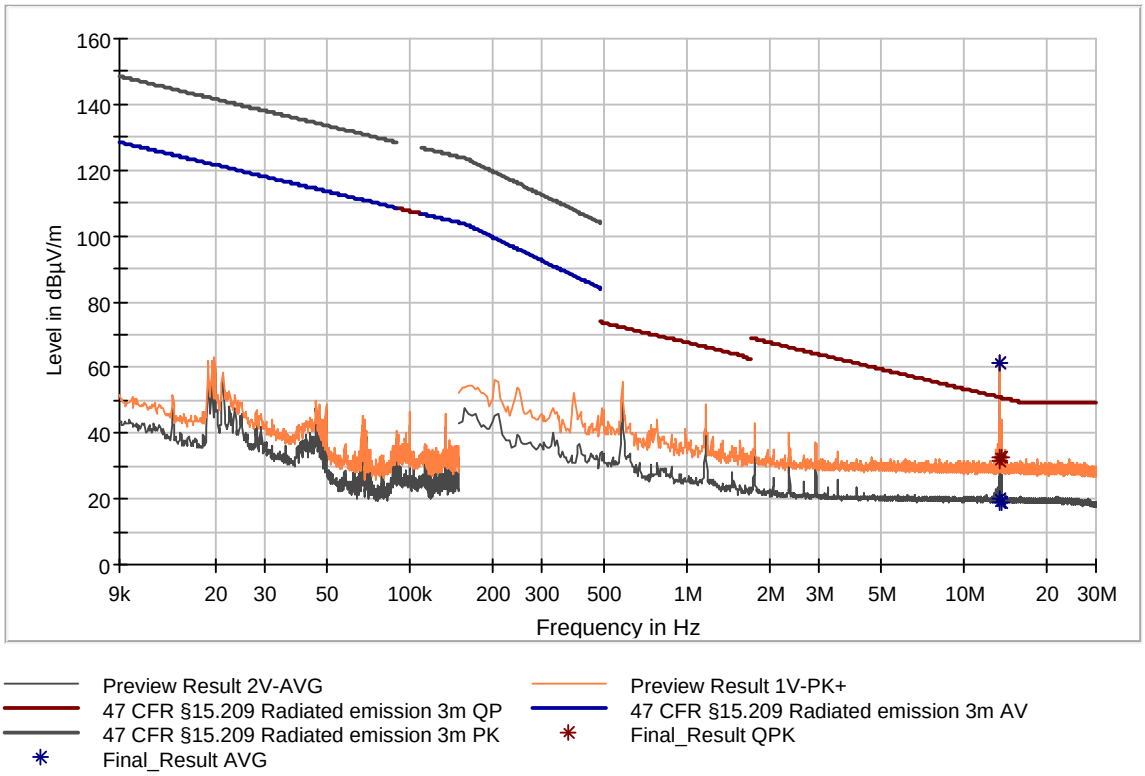
$f_{MHz}$(300 m) ≈ 0.159 MHz
$f_{MHz}$(30 m) ≈ 1.592 MHz
$f_{MHz}$(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = -40 log($d_{limit}$ / $d_{measure}$)
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log($d_{limit}$ / $d_{near\ field}$)
For f > 15.923 MHz:
Recalculation factor = -20 log($d_{limit}$ / $d_{measure}$)

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.

| *Frequency range* | *Step size* | *IF Bandwidth* | *Detector* | | *Measurement Time* | | *Preamplifier* |
|---|---|---|---|---|---|---|---|
| | | | *Prescan* | *Final scan* | *Prescan* | *Final scan* | |
| 9 kHz – 90 kHz | 80 Hz | 200 Hz | PK | AV | 1 ms | 1 s | off |
| 90 kHz – 110 kHz | 80 Hz | 200 Hz | PK | QPK | 1 ms | 1 s | off |
| 110 kHz – 150 kHz | 80 Hz | 200 Hz | PK | AV | 1 ms | 1 s | off |
| 150 kHz – 490 kHz | 4 kHz | 9 kHz | PK | AV | 1 ms | 1 s | off |
| 490 kHz – 30 MHz | 4 kHz | 9 kHz | PK | QPK | 1 ms | 1 s | off |

The following picture shows the worst-case-emissions for the spurious emissions at EUT-position 2, loop antenna parallel.




| **Frequency [MHz]** | **Measured value [dBµV/m]** | **Detector** | **Recalculation factor [dB]** | **Field strength [dBµV/m]** | **Limit [dBµV/m]** | **Margin** | **Result** |
|---|---|---|---|---|---|---|---|
| 13.447 | 20.08 | AV | -21.46 | -1.38 | --- | --- | Carrier |
| 13.447 | 31.38 | QP | -21.46 | 9.92 | 50.47 | 40.55 | Carrier |
| 13.483 | 19.02 | AV | -21.44 | -2.42 | --- | --- | Carrier |
| 13.483 | 32.52 | QP | -21.44 | 11.08 | 50.47 | 39.39 | Carrier |
| 13.560 | 61.27 | AV | -21.40 | 39.87 | --- | --- | Carrier |
| 13.560 | 61.55 | QP | -21.40 | 40.15 | 84.00 | 43.85 | Carrier |
| 13.659 | 18.98 | AV | -21.33 | -2.35 | --- | --- | Carrier |
| 13.659 | 32.88 | QP | -21.33 | 11.55 | 50.47 | 38.92 | Carrier |

Picture 11: Radiated emission 9 kHz – 30 MHz @ 3m distance

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

$d_{near\ field}$ = 47.77 / $f_{MHz}$

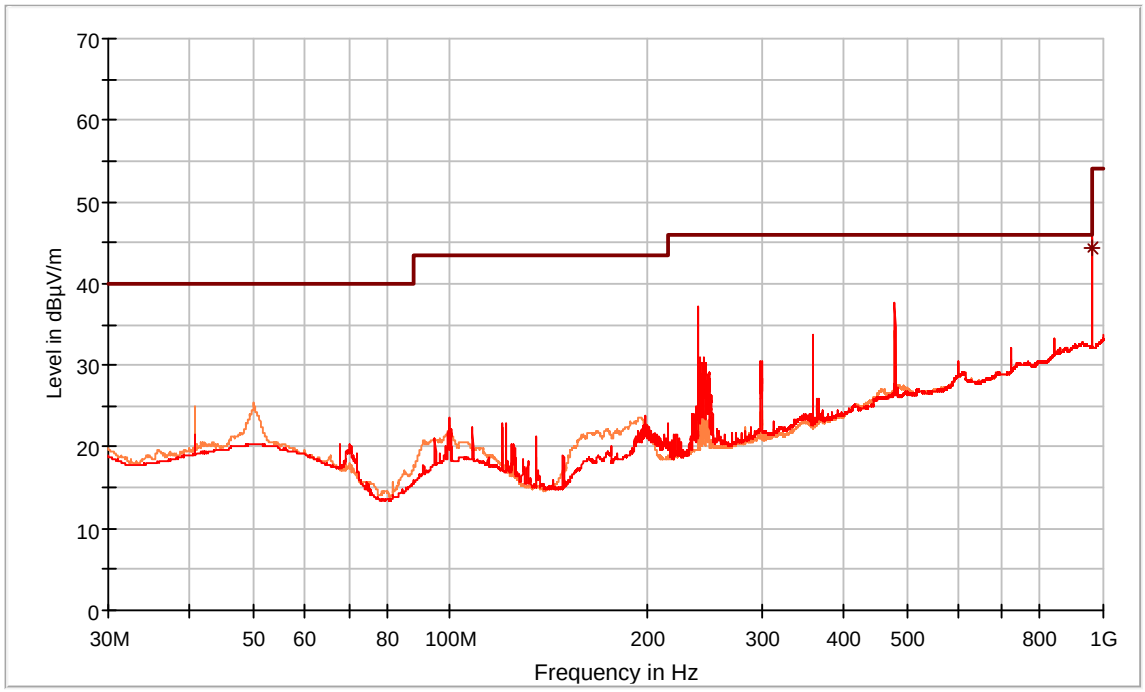
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log($d_{limit}$ / $d_{near\ field}$)

| $f_{MHz}$ [MHz] | $d_{near\ field}$ [m] | $d_{measure}$ [m] | $d_{limit}$ [m] | Recalculation factor [dB] |
|---|---|---|---|---|
| 13.447 | 3.552 | 3.0 | 30.0 | -21.46 |
| 13.483 | 3.542 | 3.0 | 30.0 | -21.44 |
| 13.560 | 3.552 | 3.0 | 30.0 | -21.40 |
| 13.659 | 3.497 | 3.0 | 30.0 | -21.33 |

# Radiated Emission Measurement 30 MHz - 1000 MHz

| *Frequency range* | *Polari-sation* | *Step size* | *IF Band-width* | *Detector* | | *Measurement Time* | | *Pre-amplifier* |
|---|---|---|---|---|---|---|---|---|
| | | | | *Prescan* | *Final scan* | *Prescan* | *Final scan* | |
| 30 MHz – 1 GHz | H / V | 50 kHz | 120 kHz | PK | QPK | 1 ms | 1 s | 20 dB |

The following pictures show the worst-case-emissions for EUT at normal positon.




| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Height (cm) | Pol | Azimuth (deg) |
|---|---|---|---|---|---|---|
| 959.970000 | 44.45 | 46.00 | 1.55 | 100.0 | H | 264.0 |

Picture 12: Radiated emission 30 MHz - 1000MHz @ 3m distance

# Spectrum Mask

## Test procedure

The EUT was placed in a fully anechoic chamber and the testing was performed in accordance with ANSI C63.10 and 47 CFR Part 15, section 15.225 (a) to (d). The measurement distance was 3 m. To find the closest margin of the spectrum to the limit mask adapted to the test distance the EUT was rotated by 360 degrees with detector of the test receiver set to peak. The loop antenna placed in a fixed height of 1 meter was rotated by 360 degrees to get the maximum of emission. In case of exceeding the limits the detector is switched to quasi peak for final testing in position of maximum emission.

## Test result

| | | | |
|---|---|---|---|
| Temperature: | 21℃ | Humidity: | 37% |
| Tested by: | Andreas Menacher | Test date: | 2018-05-03 |

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

$d_{near\ field}$ = 47.77 / $f_{MHz}$, or

$f_{MHz}$ = 47.77 / $d_{near\ field}$

The frequency $f_{MHz}$ at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

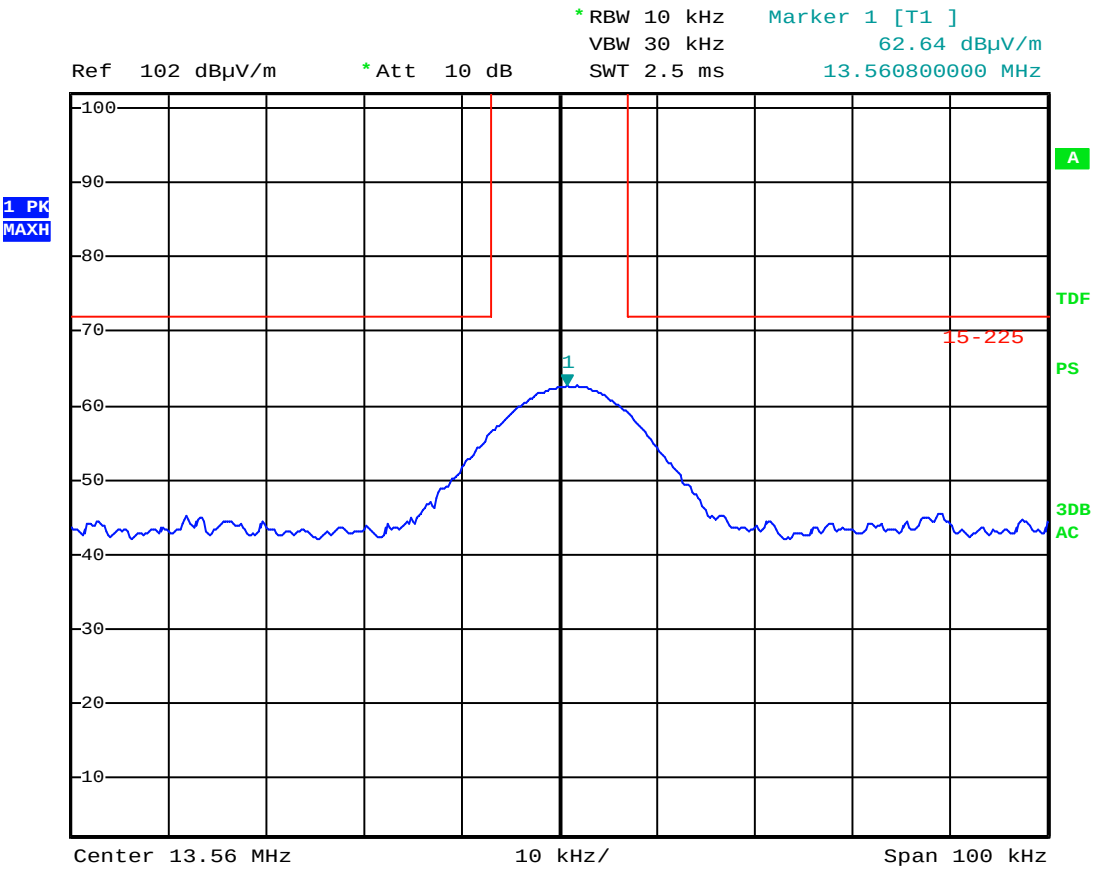
$f_{MHz}$(300 m) ≈ 0.159 MHz
$f_{MHz}$(30 m) ≈ 1.592 MHz
$f_{MHz}$(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.

| Frequency range | Step size | IF Bandwidth | Detector | | Measurement Time | | Preamplifier |
|---|---|---|---|---|---|---|---|
| | | | Prescan | Final scan | Prescan | Final scan | |
| 490 kHz – 30 MHz | 4 kHz | 9 kHz | PK | QPK | 1 ms | 1 s | off |

The following pictures show the worst-case-emissions for spectrum mask at EUT-position 2, loop antenna parallel.




Picture 13: Spectrum mask for 13.56 MHz @ 3m distance

| Frequency [MHz] | Measured value [dBµV/m] | Detector | Recalculation factor [dB] | Field strength [dBµV/m] | Limit [dBµV/m] | Margin [dB] | BW [kHz] |
|---|---|---|---|---|---|---|---|
| 13.560 | 62.64 | PK | -21.40 | 41.24 | 84.00 | 42.76 | 10 |

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

$d_{near\ field}$ = 47.77 / $f_{MHz}$

Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log($d_{limit}$ / $d_{near\ field}$)

| $f_{MHz}$ [MHz] | $d_{near\ field}$ [m] | $d_{measure}$ [m] | $d_{limit}$ [m] | Recalculation factor [dB] |
|---|---|---|---|---|
| 13.560 | 3.522 | 3.000 | 30.000 | -21.40 |

# 6 Radiated emission measurement (>1 GHz)

## according to 47 CFR Part 15, section 15.209(a)

This measurement needs not to be applied for the RFID part because

- the intentional radiator operates below 10 GHz and tenth harmonic of the highest fundamental frequency is lower than 1 GHz (see 47 CFR Part 15, section 15.33(a)(1), and RSS-Gen, section 6.13).

# 7 Carrier frequency stability

## according to CFR 47 Part 15, section 15.225(e)

## 7.1 Test Location

| | Description | Manufacturer | Inventory No. |
|---|---|---|---|
| ☐ | Climatic chamber VC 4100 | Vötsch Industrietechnik | C00014 |
| ☒ | Climatic chamber VC³ 4034 | Vötsch Industrietechnik | C00015 |

## 7.2 Test instruments

| | Description | Manufacturer | Inventory No. |
|---|---|---|---|
| ☐ | ESU 26 | Rohde & Schwarz | W00002 |
| ☒ | ESCI | Rohde & Schwarz | E00001 |
| ☒ | RF-R 400-1 | Langer EMV-Technik | E00270 |

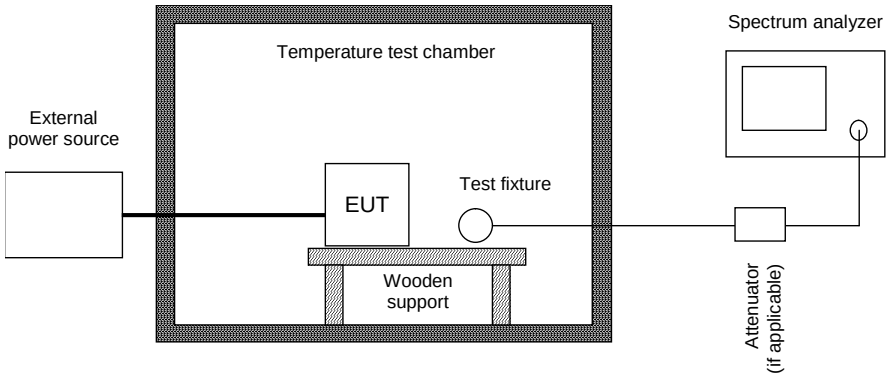
## 7.3 Limits

The frequency tolerance of the carrier signal shall be maintained within ±0.01% (100 ppm) 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. Alternatively, an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer.

## 7.4 Test procedure

1. If possible EUT is operating providing an unmodulated carrier. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to the shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.
   If an unmodulated carrier is not available a significant and stable point on the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1% of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance allowed is larger than the uncertainty of the measured frequency tolerance.
2. The carrier frequency is measured depending on the 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 an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer. Alternatively, tests shall be performed using a new battery.
3. The carrier frequency is measured over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage.

## 7.5 Test setup




Picture 14: Test setup for carrier frequency stability measurement

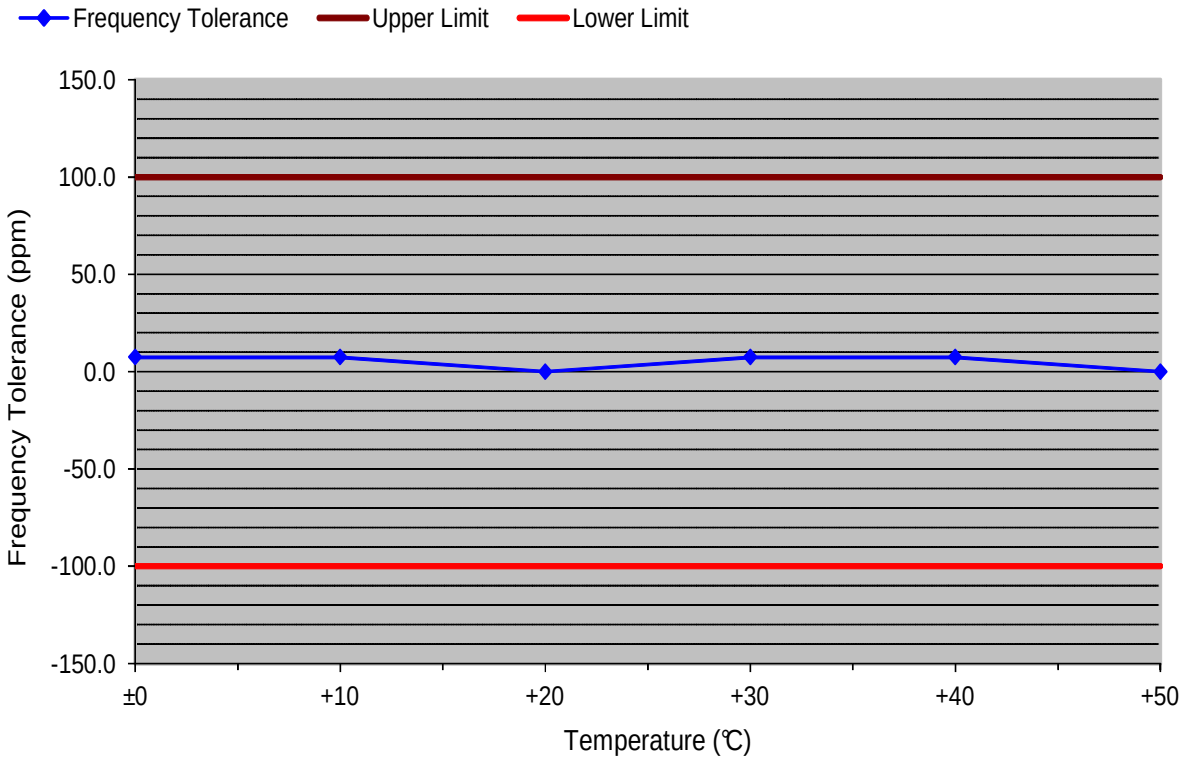
## 7.6 Test deviation

There is no deviation from the standards referred to.

## 7.7 Test result

| | | | |
|---|---|---|---|
| Temperature: | 21℃ | Humidity: | 37% |
| Tested by: | Andreas Menacher | Test date: | 2018-05-03 |

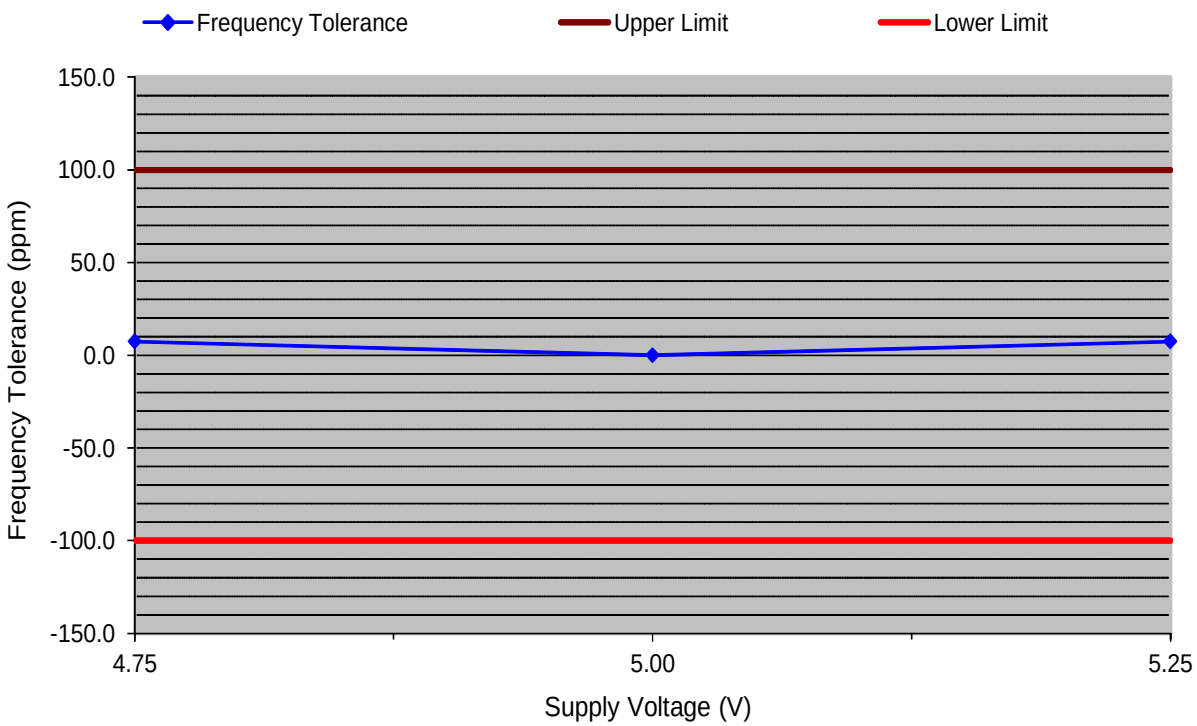
### Carrier frequency stability vs. temperature




| Supply voltage: | 5 V | Frequency under nominal conditions: | 13.561 MHz |
|---|---|---|---|

| Temperature (℃) | Frequency (MHz) | Frequency Tolerance (Hz) | Frequency Tolerance (ppm) | Upper Limit (ppm) | Lower Limit (ppm) | Margin (ppm) |
|---|---|---|---|---|---|---|
| ±0 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | 92.6 |
| +10 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | 92.6 |
| +20 | 13.561000 | 0 | 0.0 | +100.0 | -100.0 | 100.0 |
| +30 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | 92.6 |
| +40 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | 92.6 |
| +50 | 13.561000 | 0 | 0.0 | +100.0 | -100.0 | 100.0 |

## Carrier frequency stability vs. supply voltage




| | | | |
|---|---|---|---|
| Temperature: | +20 ℃ | Battery End Point: | Not applicable |
| Frequency under nominal conditions: | 13.561 MHz | | |

| Supply Voltage (V) | Frequency (MHz) | Frequency Tolerance (Hz) | Frequency Tolerance (ppm) | Upper Limit (ppm) | Lower Limit (ppm) | Margin (ppm) |
|---|---|---|---|---|---|---|
| 4.75 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | **92.6** |
| 5.00 | 13.561000 | 0 | 0.0 | +100.0 | -100.0 | 100.0 |
| 5.25 | 13.561100 | 100 | 7.4 | +100.0 | -100.0 | **92.6** |

# 8 Bandwidths

**according to CFR 47 Part 2, section 2.202(a)**

## 8.1 Test Location

See clause 5.1 on page 16.

## 8.2 Test instruments

See clause 0 on page 16.

## 8.3 Limits

The bandwidths are recorded only. There are no limits specified in CFR 47 Part 15, section 15.225

## 8.4 Test setup

See clause 5.5 on page 20.

## 8.5 Test deviation

There is no deviation from the standards referred to.

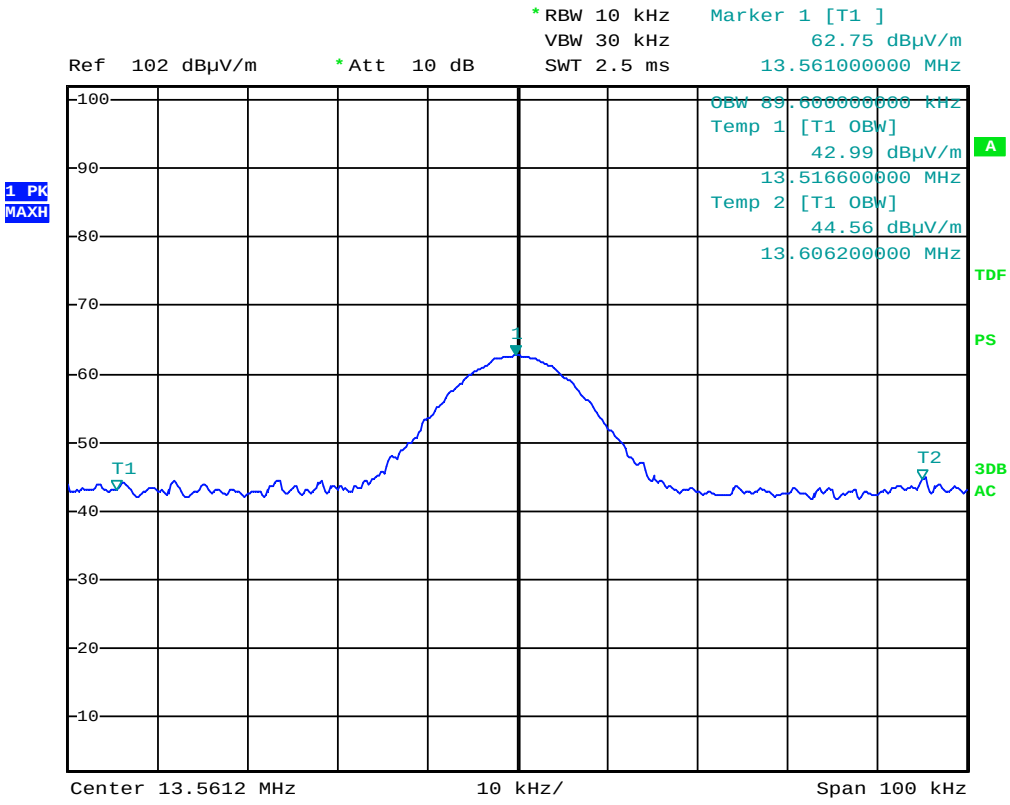
## 8.6 Test results

| | | | |
|---|---|---|---|
| Temperature: | 21℃ | Humidity: | 37% |
| Tested by: | Andreas Menacher | Test date: | 2018-05-03 |

# Occupied bandwidth (99 %)

## Test procedure

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured. The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used given that a peak or peak hold may produce a wider bandwidth than actual.
The trace data points are recovered and directly summed in linear 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. This frequency is recorded. The span between the two recorded frequencies is the occupied bandwidth. For this purpose the appropriate measurement function of the spectrum analyzer is used.



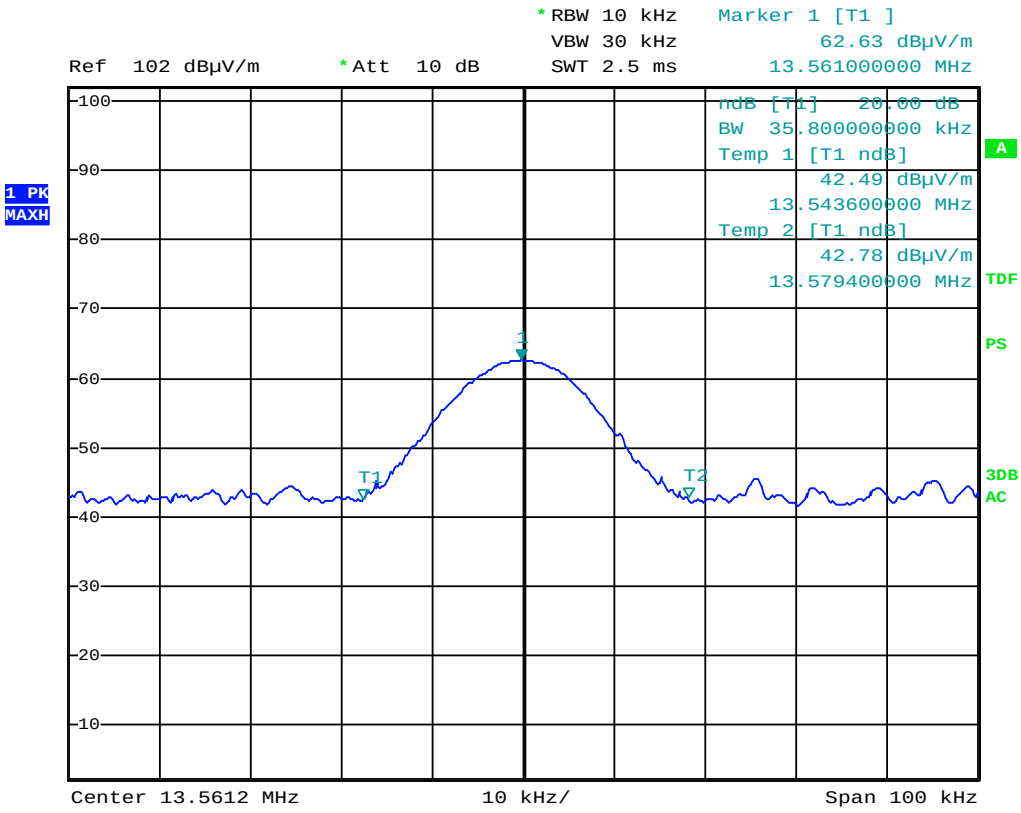

Picture 15: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 89.600 kHz

# -20 dB emission bandwidth

## Test procedure

Where indicated, the -20 dB emission bandwidth is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated 20 dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth equal to approximately 1.0% of the emission bandwidth.




Picture 16: -20 dB emission bandwidths

Measured -20 dB emission bandwidth: 35.800 kHz

| $f_{assigned}$ (MHz) | Index | $f_{-20dB}$ (MHz) | $\Delta f_T$ (kHz) | $\Delta f_U$ (kHz) | $f_{-20dB(T, U)}$ (MHz) | Limit (MHz) | Margin (kHz) | Result |
|---|---|---|---|---|---|---|---|---|
| 13.56100 | low | 13,543600 | 0.000 | 0.000 | 13.543600 | 13.110000 | 433.600 | Passed |
| | high | 13,579400 | 0.100 | 0.100 | 13.579600 | 14.010000 | 430.400 | Passed |
| | Bandwidth | 35.800 kHz | | | 36.000 kHz | | | |

with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 20 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = frequency in MHz where emission is at least 20 dB below the carrier, including offset caused by variations of temperature and supply voltage as recorded in clause 7.7

Measured -20 dB emission bandwidth:
At nominal conditions: 35.800 kHz
Including variations in temperature and supply voltage: 36.000 kHz

# 9 Equipment calibration status

| Description | Modell number | Serial number | Inventory number(s) | Last calibration | Next calibration |
|---|---|---|---|---|---|
| Test receiver | ESCI 3 | 100328 | E00552 | 2016-09 | 2018-09 |
| Test receiver | ESCS 30 | 825442/0002 | E00003 | 2016-04 | 2018-05[1] |
| Test receiver | ESR 7 | 101059 | E00739 | 2016-02 | 2019-02 |
| LISN | ESH2-Z5 | 893406/009 | E00005 | 2016-02 | 2019-02 |
| Loop antenna | HFH2-Z2 | 871398/0050 | E00060 | 2016-09 | 2018-09 |
| Broadband antenna | VULB 9162 | 9160-3050 | E00011 | 2018-03 | 2020-03 |
| Shielded room | P92007 | B83117C1109T211 | E00107 | N/A | |
| Compact diagnostic chamber (CDC) | VK041.0174 | D62128-A502-A69-2-0006 | E00026 | N/A | |
| Cable set shielded room | Cable no. 30 | --- | E00424 | 2016-07 | 2018-07 |
| Cable set CDC | Cables no. 37 and 38 | --- | E00459 E00460 | 2017-05 | 2019-05 |
| Cable set OATS 3 m | Cables no. 19, 34 and 36 | --- | E00453 E00456 E00458 | 2015-11 | 2018-11 |
| Cable set SAC 3 m | Cables no. 04, 52 and 12 | --- | E00434 E00755 E00320 | 2015-11 | 2018-11 |

Table 1: Equipment calibration status

Note 1: Expiration date of test firm accreditation for OATS and SAC:
FCC test firm type “accredited”: 2019-05

[1] Calibration valid until 2018-05-30.

# 10 Measurement uncertainty

| Description | Max. deviation | k= |
|---|---|---|
| Conducted emission AMN<br>(150 kHz to 30 MHz) | ± 3.4 dB | 2 |
| Radiated emission open field (3 m)<br>(9 kHz to 30 MHz)<br>(30 MHz to 300 MHz)<br>(300MHz to 1 GHz) | ± 4.8 dB<br>± 5.4 dB<br>± 5.9 dB | 2 |
| Radiated emission absorber chamber<br>(> 1000 MHz) | ± 4.5 dB | 2 |

Table 2: Measurement uncertainty

The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.

# 11 Revision History

| Date | Description | Person | Revision |
|---|---|---|---|
| 2018-05-18 | First edition | Andreas Menacher | 0 |