Test report

**Customer:**

HERMOS AG

Gartenstr. 19
95490 Mistelgau
GermanyTel.: +49 9279  991-0

# RF test report

**180412-AU01+W02**

**HERMOS AG**
**RFID-Reader**
**LFP USB Reader**

# EMV **TESTHAUS** GmbH

Gustav-Hertz-Straße 35
94315 Straubing
Germany
Tel.: +49 9421 56868-0
Fax: +49 9421 56868-100
Email: info@emv-testhaus.com

## Accreditation:

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

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:

EMV **TESTHAUS** GmbH
Gustav-Hertz-Straße 35
94315 Straubing
Germany

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

# Table of contents

# List of figures

# List of tables

# 1 Summary of test results

System type: RFID Reader

| *47 CFR part and section* | *Test* | *Page* | *Result* | *Note(s)* |
|---|---|---|---|---|
| 15.207 | AC power line conducted emissions<br>150 kHz to 30 MHz | 22 | Passed | --- |
| 2.202(a)<br>ANSI C63.10 | Occupied bandwidth (99 %) | 26 | For information only | --- |
| 15.205<br>(a) – (c) | Restricted bands of operation | 29 | Passed | --- |
| 15.209 | Radiated emissions<br>9 kHz to 10$^{th}$ harmonic | | | |
| | 9 kHz to 30 MHz | 32 | Passed | --- |
| | 30 MHz to 1 GHz | 36 | Passed | --- |
| | 1 GHz to 10$^{th}$ harmonic | | Not applicable | 1 |

*Notes (for information about EUT see clause 3):*

1 Not applicable if the 10$^{th}$ harmonic of the intentional transmitter is beyond 1 GHz (please see CFR 47 Part 15, section 15.33(a)(1), and RSS-Gen, section 6.13.

Straubing, July 19, 2018

Andreas Menacher
Test engineer
EMV **TESTHAUS** GmbH

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

# 2 Referenced publications

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

# 3 Equipment under test (EUT)

All Information in this clause is declared by customer.

## 3.1 General information

| | | | |
|---|---|---|---|
| Product type: | RFID-Reader | | |
| Model name: | LFP USB Reader | | |
| Serial number(s): | 1806HAG01858 | | |
| Applicant: | HERMOS AG | | |
| Manufacturer: | HERMOS AG | | |
| Version: | Hardware: | LFS_HLG_RevA | |
| | Software: | LFSHI1.0_FV02 | |
| Additional modifications: | Ferrite Würth **742 711 11** inside the grip on USB-cable. | | |
| FCC ID: | 2AP5OLFP | | |
| Power supply: | DC supply | | |
| | Nominal voltage: | 5.0V | |
| | Minimum voltage: | 4.75 V | |
| | Maximum voltage: | 5.50 V | |
| | Nominal frequency: | --- | |
| Temperature range: | 0 °C to +50 °C (customer defined) | | |
| Device type: | ☐ Portable | ☐ Mobile | ☒ Fixed |

## 3.2 Radio specifications

| | | | |
|---|---|---|---|
| System type: | RFID Reader | | |
| Application frequency band: | n/a | | |
| Frequency range used: | 120 kHz - 149 kHz | | |
| Operating frequencies: | 134 kHz | | |
| Short description: | The EUT is a RFID Reader operating at the frequency 134 kHz. | | |
| Number of RF channels | 1 | | |
| Modulation | ASK | | |
| Antenna: | Type: | Ferrite antenna | |
| | Gain: | n/a | |
| | Connector: | ☐ external | ☐ internal |
| | | ☐ temporary | ☒ none (integral antenna) |

## 3.3 Photo documentation

For external photos of the EUT see annex B, for internal ones see annex C.
Photos taken during testing including EUT positions can be found in annex A.

# 4 Test configuration and mode of operation

## 4.1 Test configuration

| *Device* | *Type designation* | *Serial or inventory no.* | *Manufacturer* |
|---|---|---|---|
| *EUT* | | | |
| RFID-Reader | LFP USB Reader | 1806HAG01858 | HERMOS AG |
| *Support equipment* | | | |
| PC[1] | ESPRIMO E900 | O00500 | Fujitsu |
| Monitor[1] | TFT B22T-7 Pro | O00857 | Fujitsu |
| Notebook[2] | LIFEBOOK U772 | O00632 | Fujitsu |
| Power supply of Notebook[2] | AC ADAPTER | A11-100P3A | Fujitsu Limited |
| USB2.0 Extender | Transmitter | UA0267 | LogiLink |
| USB 2.0 Extender | Receiver | UA0267 | LogiLink |

Table 1: Devices used for testing

## 4.2 Mode of operation

### 4.2.1 Test modes applied

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 activate the RFID reader for continuous transmission via RFID card.

[1] Only used for conducted emissions test.
[2] Was placed outside of test chambers.

# 5 Test procedures

## 5.1 General specifications

### 5.1.1 Test setups

Tabletop devices are placed on a non-conductive table with a height of 0.8 m. In case of AC power-line conducted emissions test, the rear of the EUT is located 40 cm to the vertical wall of the RF-shielded (screened) room which is used as vertical conducting plane. For radiated emission measurements above 1 GHz, tabletop devices are placed at a height of 1.5 m above the floor using a support made of styrene placed on top of the non-conductive table.

Floor-standing devices are placed either directly on the reference ground-plane or on insulating material (see clause 6.3.3 of ANSI C63.4-2014 for more details).

All other surfaces of tabletop or floor-standing EUTs are at least 80 cm from any other grounded conducting surface. This includes the case or cases of one or more LISNs when performing an AC power-line conducted emissions test.

Radiated emission measurements of equipment that can be used in multiple orientations (e.g. portable or handheld devices) are performed with the EUT in each of three orthogonal axis positions.

## 5.2 AC power line conducted emission

AC power-line conducted emissions are measured according to clause 6.2 of ANSI C63.10 over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network. The tests are performed in a shielded room.

If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements are made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.
For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter is used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

| *Frequency (f)* | *Measurement receiver bandwidth* | *Step size* | *Detector type* | | |
|---|---|---|---|---|---|
| | | | *Prescan* | *Prescan with FFT* | *Final scan* |
| 150 kHz ≤ f < 30 MHz | 9 kHz | ≤ 4.5 kHz | Peak, Average | Quasi-peak, Average | Quasi-peak, Average |

Table 2: Bandwidth and detector type for AC power-line conducted emissions test

The AC power-line conducted emissions test is performed in the following steps:

a) The EUT is arranged as tabletop or floor-standing equipment, as applicable, and connected to a line impedance stabilization network (LISN) with 50 µH / 50 Ω. If required, a second LISN of the same type and terminated by 50 Ω is used for peripheral devices. The EUT is switched on.
b) The measurement equipment is connected to the LISN for the EUT and set-up according to the specifications of the test (see table 2). At the LISN, the neutral line is selected to be tested.
c) The prescan is performed with both detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescan, but not for final scan.
d) When the prescan is completed, maximum levels with less margin than 10 dB or exceeding the limit are determined and collected in a list.
e) With the first frequency of the list selected, a frequency zoom over a range of ten times of the measurement receiver bandwidth around this frequency is performed. If the EUT has no significant drift in frequency, the frequency zoom can be skipped.
f) For final scan, the emission level is measured and the maximum is recorded.
g) Steps e) to f) are repeated for all other frequencies in the list. At least the six highest EUT emissions relative to the limit have to be recorded.
h) Steps c) to g) are repeated for all current-carrying conductors of all of the power cords of EUT, i.e. all phase and (if used) neutral line(s).

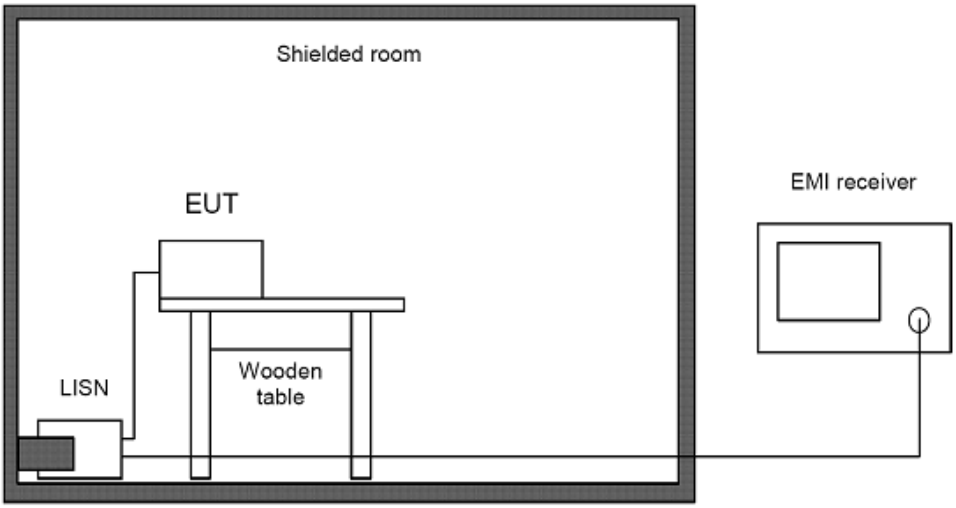


Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

## 5.3 Radiated emissions below 30 MHz

Radiated emissions below 30 MHz are measured according to clause 6.4 of ANSI C63.10 using an inductive shielded loop antenna. As this antenna measures the magnetic field only, its antenna factors are converted to electric field strength values assuming a free space impedance of 377 Ω as described in clause 4.3.1 of ANSI C63.10. This results in an additional correction of 51.53 dB.

According to clause 6.4.3 of ANSI C63.10, at frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the requirements. In this case, the results are extrapolated to the specified distance by using a recalculation factor determined according to one of the methods described in clause 6.4.4 of ANSI C63.10, provided that the maximum dimension of the device is equal to or less than 0.625 times the wavelength at the frequency being measured. As the minimum wavelength is 10 meters corresponding to the maximum frequency of 30 MHz, this requirement is fulfilled if the maximum dimension of the device is equal to or less than 6.25 meters.

Unless otherwise stated, the recalculation factor is determined according to clause 6.4.4.2 “Extrapolation from the measurement of a single point” of ANSI C63.10:

$d_{near\ field}$ = 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 to determine the recalculation factor:

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

Based on the test distances for the general radiated emission limits as specified in §15.209 of 47 CFR Part 15, the following formulas are used to determine the recalculation factor:

| *Frequency (f)* | $d_{limit}$ | $d_{measure}$ | *Formula for recalculation factor* |
|---|---|---|---|
| 9 kHz ≤ f ≤ 159 kHz<br>490 kHz < f ≤ 1.592 MHz | 300 m<br>30 m | 3 m | $-40 \log(d_{limit} / d_{measure})$ |
| 159 kHz < f ≤ 490 kHz<br>1.592 MHz < f ≤ 15.923 MHz | 300 m<br>30 m | 3 m | $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$ |
| f > 15.923 MHz | 30 m | 3 m | $-20 \log(d_{limit} / d_{measure})$ |

Table 3: Recalculation factors for extrapolation

Prescans for radiated measurements below 30 MHz are performed in a fully anechoic room (called “CDC”). The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 4.

| *Frequency (f)* | *Measurement receiver bandwidth* | *Step size* | *Detector type* | | |
|---|---|---|---|---|---|
| | | | *Prescan* | *Prescan with FFT* | *Final scan* |
| 9 kHz ≤ f < 150 kHz | 200 Hz | ≤ 100 Hz | Peak, Average | Peak Quasi-peak, Average | Peak Quasi-peak, Average |
| 150 kHz ≤ f < 30 MHz | 9 kHz | ≤ 4.5 kHz | Peak, Average | Peak Quasi-peak, Average | Peak Quasi-peak, Average |

Table 4: Bandwidth and detector type for radiated emissions test below 30 MHz

Prescans are performed with all detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans. If no limit is specified for certain detectors, final scan measurement with these detectors may be omitted.

The radiated emissions test below 30 MHz is performed in the following steps:

a) The loop antenna is positioned with its plane perpendicular to the ground with the lowest height of the antenna 1 m above the ground.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the loop antenna and set-up according to the specifications of the test (see table 4).
d) The EUT is turned to a position likely to get the maximum and the test antenna is rotated to detect the maximum of the fundamental in this EUT position.
e) 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.
f) After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
g) 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.
h) Step g) is repeated for all other frequencies in the list.
i) Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to i) are repeated in two other orthogonal positions. If the EUT may be used in one position only, steps a) to i) are repeated in one orthogonal position.

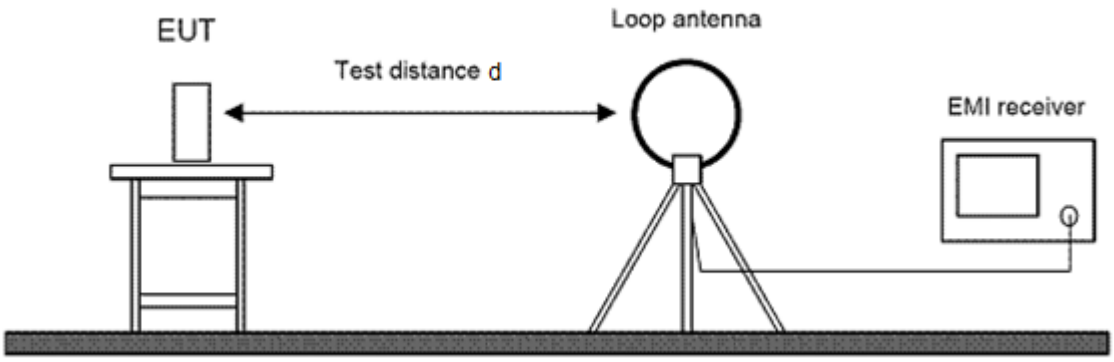


Figure 2: Setup for radiated emissions test below 30 MHz

## 5.4 Radiated emissions from 30 MHz to 1 GHz

Radiated emissions in the frequency range 30 MHz to 1 GHz are measured according to clause 6.5 of ANSI C63.10 using a semi-anechoic chamber (SAC) with a ground plane on the floor. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 5.

| *Frequency (f)* | *Measurement receiver bandwidth* | *Step size* | *Detector type* | | |
|---|---|---|---|---|---|
| | | | *Prescan* | *Prescan with FFT* | *Final scan* |
| 30 MHz ≤ f ≤ 1 GHz | 120 kHz | ≤ 60 kHz | Peak | Quasi-peak | Quasi-peak |

Table 5: Bandwidth and detector type for radiated emissions test from 30 MHz to 1 GHz

The measurement antenna is a combination of a biconical antenna and a logarithmic-periodic dipole array antenna. It is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and in a height between 1 m and 4 m above the ground plane.

If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The radiated emissions test from 30 MHz to 1 GHz is performed in the following steps:
a) The measurement antenna is oriented initially for vertical polarization.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 5).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.

f) 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.
g) The antenna height is increased to 4 m in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps e) to i) are repeated.
k) 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.
l) 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.
m) 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.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

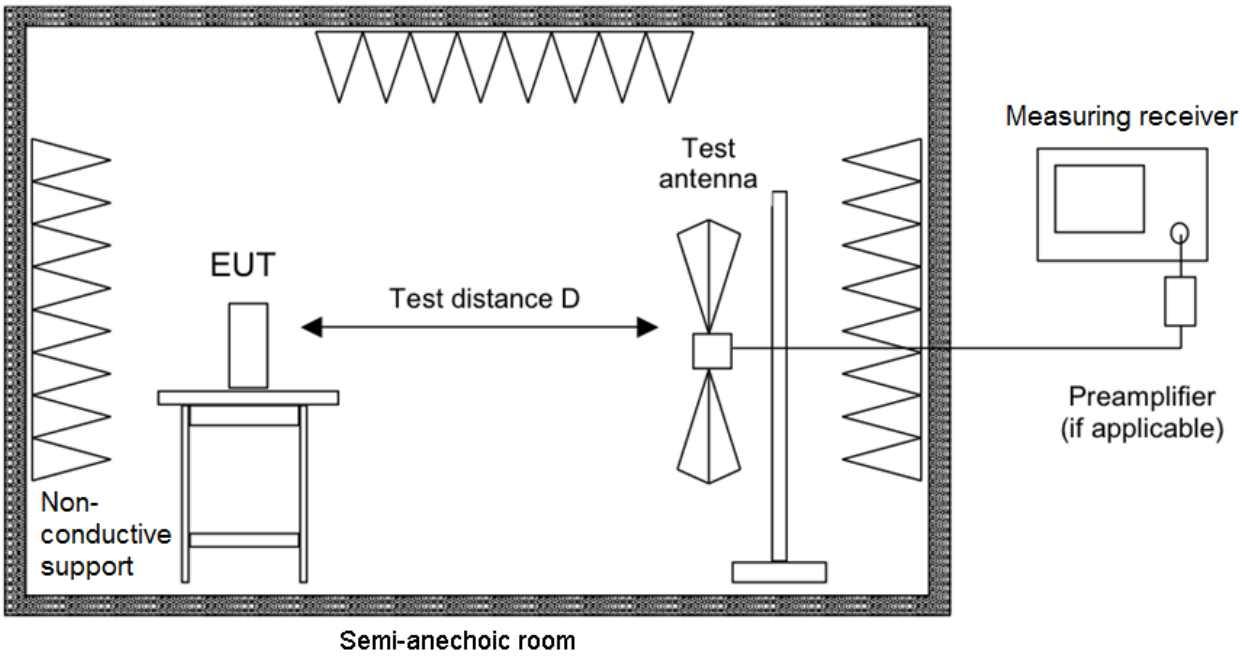


Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

## 5.5 Radiated emissions above 1 GHz

Radiated emissions above 1 GHz are measured according to clause 6.6 of ANSI C63.10 by conducting exploratory and final radiated emission tests. According to clause 6.6.4.1 of ANSI C63.10, measurements may be performed at a distance closer than that specified in the requirements. However, an attempt shall be made to avoid making final measurements in the near field of both the measurement antenna and the EUT.

For measurement of radiated emissions above 1 GHz, horn antennas are used.

### 5.5.1 Exploratory radiated emissions measurements

Exploratory radiated emissions above 1 GHz are measured in a semi-anechoic chamber with RF absorbing material on the floor or a fully anechoic room. They are performed by moving the receiving antenna over all sides of the EUT at a closer distance (e.g. 0.5 or 1 m) while observing the display of the test receiver to find the emissions to be re-tested during final radiated emission measurements.

According to clause 5.3.3 of ANSI C63.10, when performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade of distance (inverse of linear distance for field-strength measurements). To simplify testing and documentation, the limits are increased accordingly instead of decreasing the results.

The emissions of the EUT are displayed and recorded with an EMI test receiver operating in the spectrum analyzer mode using the settings as described in table 6.

| *Frequency (f)* | *Resolution bandwidth* | *Video bandwidth* | Sweep time | *Trace detector(s)* | *Trace mode(s)* | *Test* |
|---|---|---|---|---|---|---|
| f ≥ 1 GHz | 1 MHz | 3 MHz | AUTO | Max Peak, Average | Clear Write | Searching |
| | | | | | Max Hold | Recording |

Table 6: Bandwidth and trace settings for exploratory radiated emissions test above 1 GHz

If during exploratory radiated emissions measurements no levels to be re-tested are found, the final radiated emissions measurement may be omitted. In this case, the chart of the exploratory radiated emissions measurements has to be reported.

### 5.5.2 Final radiated emissions measurements

Final radiated emissions above 1 GHz are measured in a semi-anechoic chamber (SAC) with RF absorbing material on the floor between measurement antenna and EUT. The measurement

distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 7.

| *Frequency (f)* | *Measurement receiver bandwidth* | *Step size* | *Detector type* | |
|---|---|---|---|---|
| | | | *Prescan* | *Final scan* |
| f ≥ 1 GHz | 1 MHz | ≤ 500 kHz | Peak, Average | Peak, Average |

Table 7: Bandwidth and detector type for final radiated emissions test above 1 GHz

Prescans are performed with both detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The horn antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and to be moved in a scan height range between 1 m and the scan height upper range defined in clause 6.6.3.3 of ANSI C63.10. When the EUT is manipulated through three different orientations, the scan height upper range for the measurement antenna is limited to 2.5 m above the ground plane.or 0.5 m above the top of the EUT, whichever is higher. Otherwise, the scan height upper range is 4 m above the ground plane.
To keep the emission signal within the illumination area of the 3 dB beamwidth of the measurement antenna, the automatic tilt function of the antenna support device is used to point the antenna at an angle toward the source of the emission.

The final radiated emissions test above 1 GHz is performed in the following steps:
a) The measurement antenna is oriented initially for vertical polarization.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 7).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) 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.
g) The antenna height is increased to the scan height upper range in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from the scan height upper range to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 30°. At each table position, steps e) to i) are repeated.
k) 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.
l) 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.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±30° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.

o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

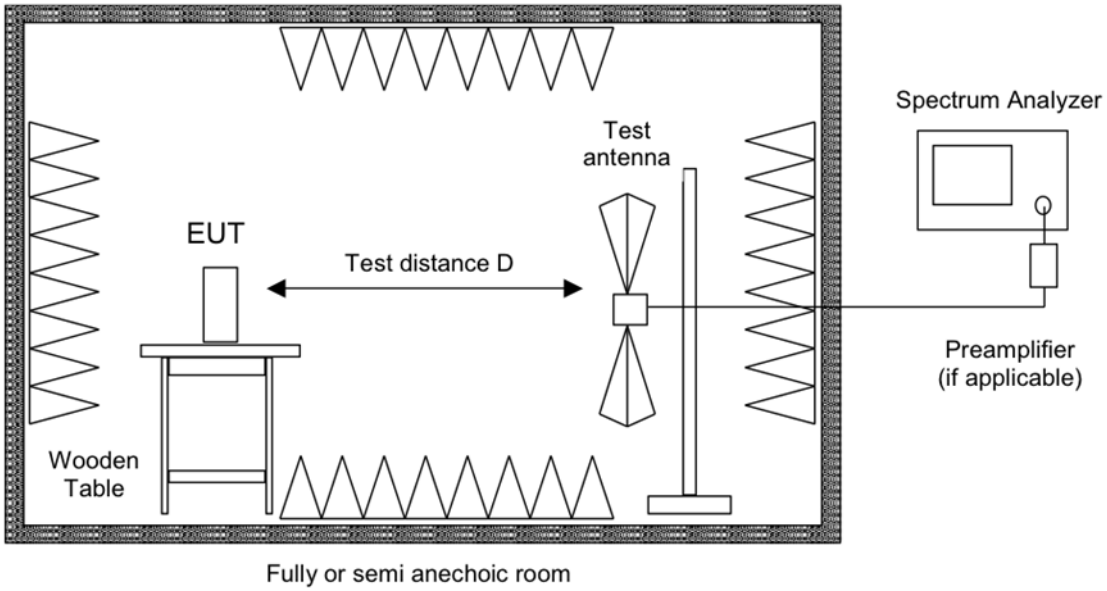


Figure 4: Setup for radiated emissions test above 1 GHz

## 5.6 Bandwidth measurements

### 5.6.1 99 % occupied bandwidth

The span of the spectrum analyzer is 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 resolution bandwidth is in the range of 1 % to 5 % of the occupied bandwidth and the video bandwidth is not smaller than three times the resolution bandwidth. Video averaging is not permitted.
If possible, the detector of the spectrum analyzer is set to “Sample”. However, if the device is not transmitting continuously, a peak, or peak hold is used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement).

To measure the 99 % emission bandwidth, the OBW function of the test receiver is used with the power bandwidth set to 99 %. This function indicates the lowest frequency (starting from the left side of the span) and the highest frequency (starting from the right side of the span) where 0.5% of

the total sum is reached. The difference between the two frequencies is the 99 % occupied bandwidth.

## 5.7 Restricted bands of operation

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 15.35. 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.

# 6 Test results

This clause gives details about the test results as collected in the summary of test results on page 6.

## 6.1 AC power line conducted emissions 150 kHz to 30 MHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.207
Reference(s): ANSI C63.10, clause 6.2

Result[3] ☒ Test passed ☐ Test not passed

### 6.1.1 Test equipment

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☒ | Shielded room | P92007 | Siemens Matsushita | E00107 |
| ☐ | EMI test receiver (CDC) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☒ | EMI test receiver (OATS) | ESCI 3 | Rohde & Schwarz | E00001 |
| ☐ | EMI test receiver | ESCS 30 | Rohde & Schwarz | E00003 |
| ☐ | EMI test receiver | ESR 7 | Rohde & Schwarz | E00739 |
| ☐ | EMI test receiver | ESU 26 | Rohde & Schwarz | W00002 |
| ☐ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☐ | Field probe | RF-R 400-1 | Langer EMV-Technik | E00270 |
| ☒ | Artificial mains network | ESH2-Z5 | Rohde & Schwarz | E00004 |
| ☒ | Artificial mains network | ESH2-Z5 | Rohde & Schwarz | E00005 |
| ☒ | Attenuator (10 dB) | 50FHB-010-10 | JFW Industries | E00471 |
| ☐ | Cable set CDC | RF cable(s) | Huber + Suhner | E00741<br>E00804 |
| ☐ | Test software | EMC32-EB (V10.35) | Rohde & Schwarz | E00777 |
| ☐ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E00778 |
| ☒ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E01073 |

[3] For information about measurement uncertainties see page 85.

### 6.1.2 Limits

As specified in section 15.209 of 47 CFR Part 15, the emissions from an intentional radiator shall not exceed the conducted limits as specified in table 8.

| *Frequency of emission [MHz]* | *Conducted limit* | |
|---|---|---|
| | *Quasi-peak [dBµV]* | *Average [dBµV]* |
| 0.15 – 0.5 | 66 to 56* | 56 to 46* |
| 0.5 – 5.0 | 56 | 46 |
| 5 – 30 | 60 | 50 |

Table 8: AC power-line conducted limits

* Decreases with the logarithm of the frequency.

### 6.1.3 Test procedure

AC power line conducted emissions are measured using the test procedure as described in clause 5.2.

Remark: The AC power line conducted emissions were measured at the AC-power input port of the PC. The nominal input supply was 120 V / 60 Hz.

## 6.1.4 Test results

| | | | |
|---|---|---|---|
| Performed by: | Andreas Menacher | Date(s) of test: | July 4, 2018 |
| Climatic conditions: | Ambient temperature<br>27 °C | Relative humidity<br>44 % | Barometric pressure<br>976 hPa |

| *Frequency range* | *Step size* | *IF Bandwidth* | *Detector* | | *Measurement Time* | | *Preamplifier* |
|---|---|---|---|---|---|---|---|
| | | | *Prescan* | *Final scan* | *Prescan* | *Final scan* | |
| 150 kHz – 30 MHz | ≤ 4.5 kHz | 9 kHz | PK, AV | QP, AV | 10 ms | 1 s | Off |

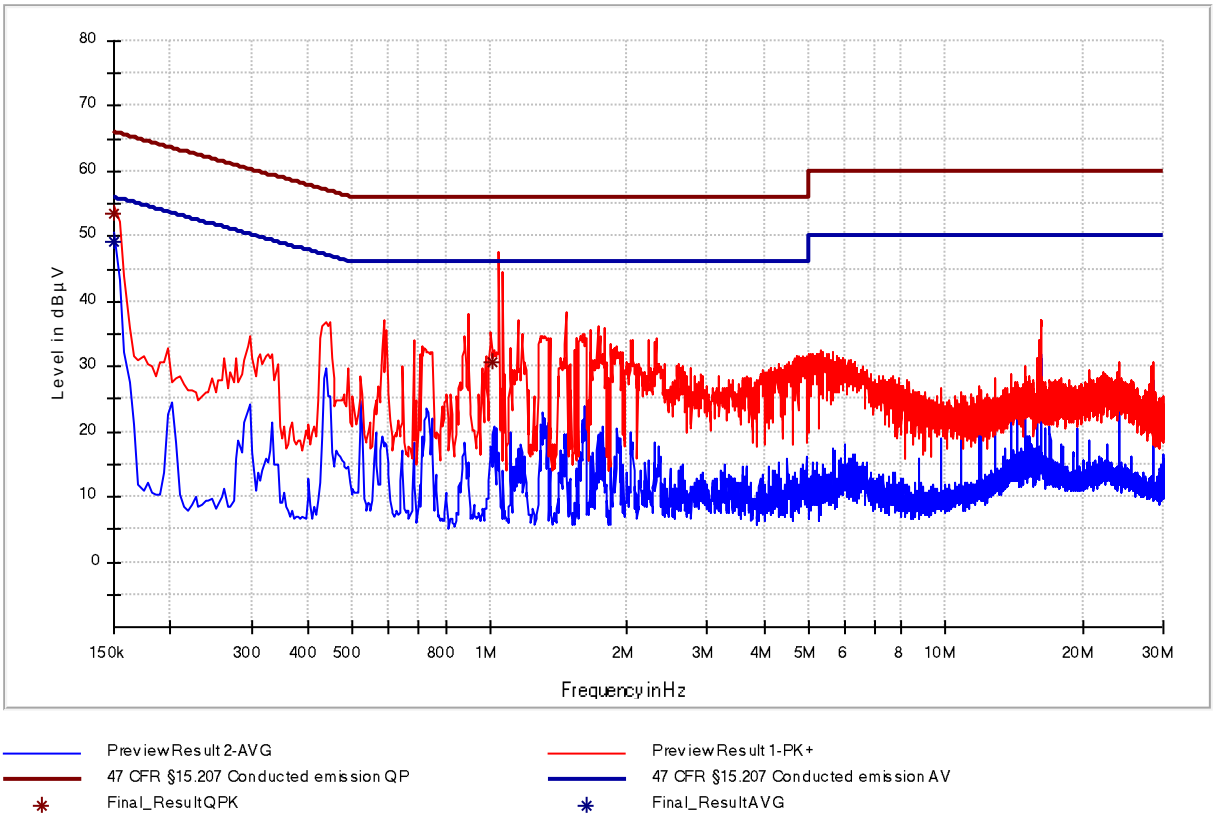


Figure 5: Chart of AC power-line conducted emissions test – phase L1

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Line | PE |
|---|---|---|---|---|---|---|
| 0.150000 | --- | 49.18 | 56.00 | 6.82 | L1 | GND |
| 0.150000 | 53.63 | --- | 66.00 | 12.37 | L1 | GND |
| 1.009000 | 30.57 | --- | 56.00 | 25.43 | L1 | GND |

Figure 6: Final results of AC power-line conducted emissions test – phase L1

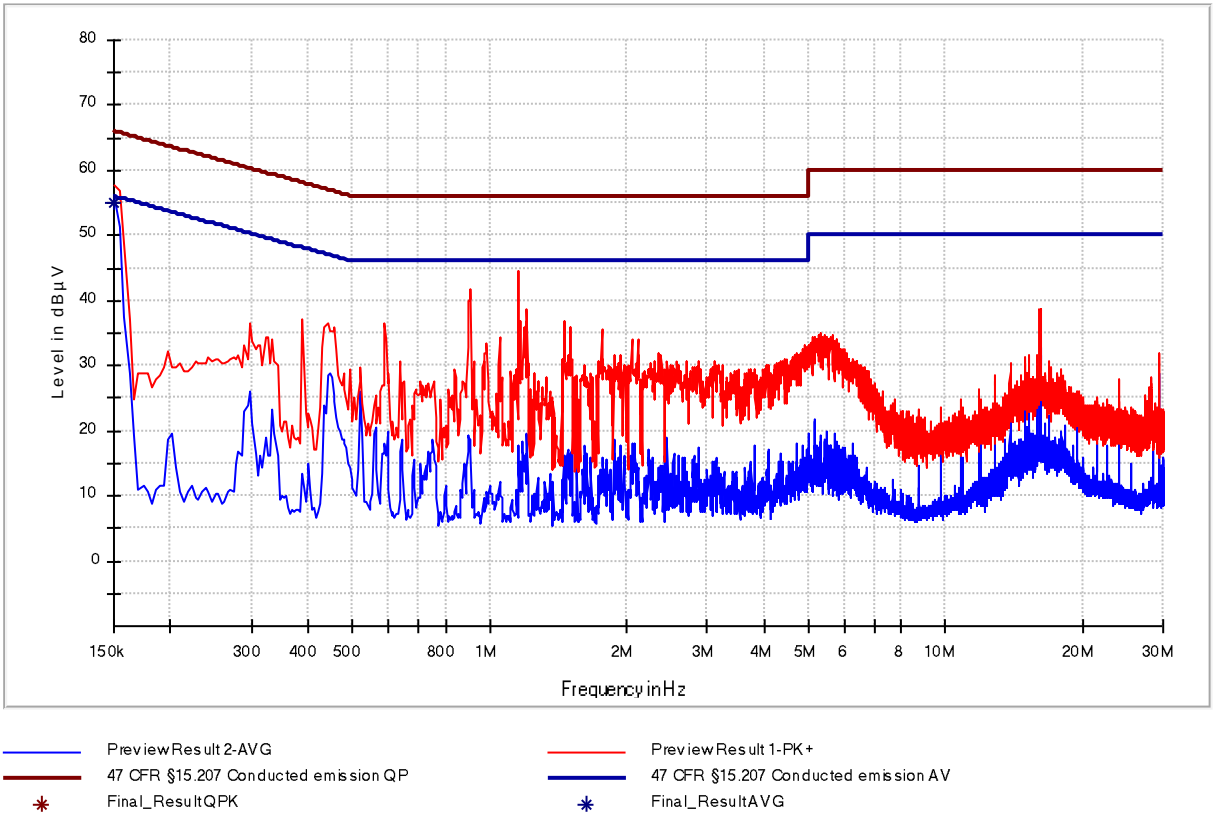


Figure 7: Chart of AC power-line conducted emissions test – phase N

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Line | PE |
|---|---|---|---|---|---|---|
| 0.150000 | --- | 55.04 | 56.00 | 0.96 | N | GND |

Figure 8: Final results of AC power-line conducted emissions test – phase N

## 6.2 Occupied bandwidth

Section(s) in 47 CFR Part 15: Requirement(s): 2.202(a)
Reference(s): ANSI C63.10, clause 6.9

| | | | |
|---|---|---|---|
| Performed by: | Andreas Menacher | Date(s) of test: | July 4, 2018 |
| Climatic conditions: | Ambient temperature<br>27 °C | Relative humidity<br>44 % | Barometric pressure<br>976 hPa |
| Result[4]: | ☒ Test passed | ☐ Test not passed | |

### 6.2.1 Test equipment

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☐ | EMI test receiver (CDC) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☒ | EMI test receiver (OATS) | ESCI 3 | Rohde & Schwarz | E00001 |
| ☐ | EMI test receiver | ESR 7 | Rohde & Schwarz | E00739 |
| ☐ | EMI test receiver | ESU 26 | Rohde & Schwarz | W00002 |
| ☐ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☒ | Field probe | RF-R 400-1 | Langer EMV-Technik | E00270 |

[4] For information about measurement uncertainties see page 76.

### 6.2.2 Limits

Although there is no limit specified, the occupied bandwidth has to be recorded and reported.

### 6.2.3 Test procedure

The occupied bandwidth is measured using the test procedure as described in clause 5.6.1 and referring to the

## 6.2.4 Test results

Final measurement was performed without tag, because this is the worst case.

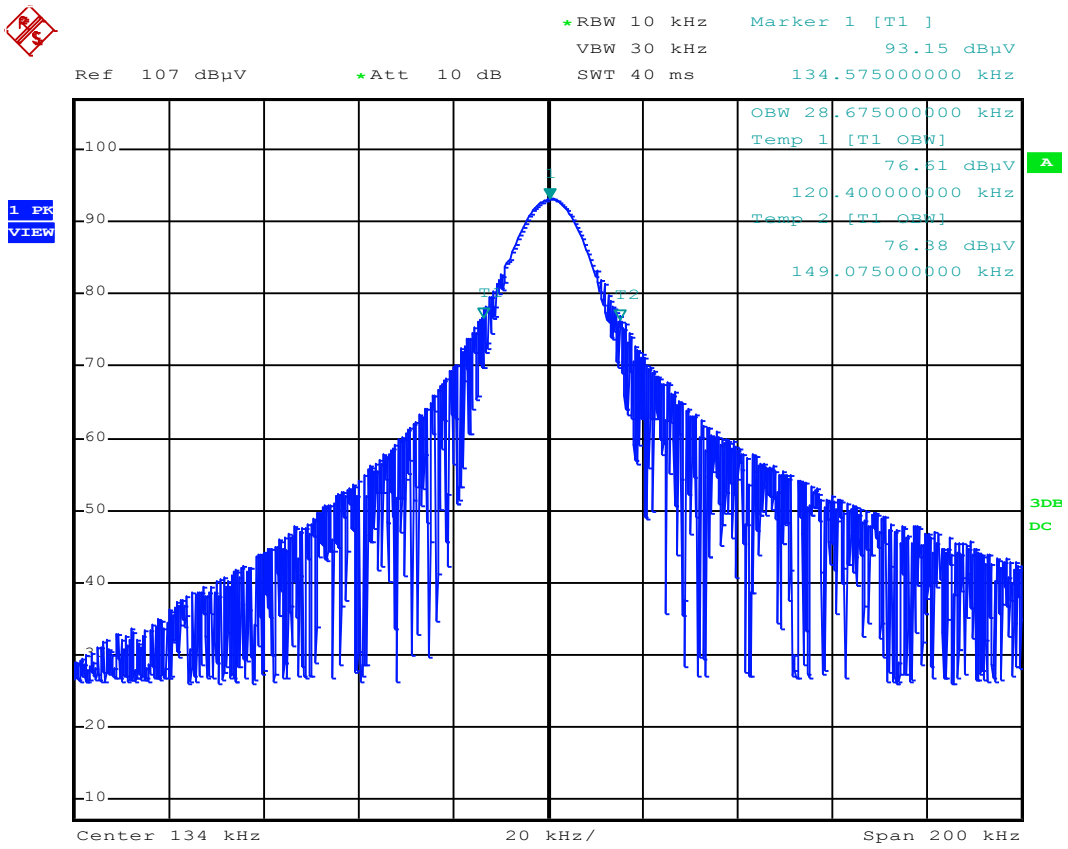


Figure 9: Chart of occupied bandwidth test

| *99% bandwidth* | *Band edge left* | | *Band edge right* | | *Result* |
|---|---|---|---|---|---|
| *[kHz]* | *Frequency [kHz]* | *Limit [MHz]* | *Frequency [MHz]* | *Limit [MHz]* | |
| 28.675 | 120.400 | --- | 149.075 | --- | Recorded |

Table 9: Results of occupied bandwidth test

## 6.3 Restricted band of operation from 0.090 MHz to 0.110 MHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.205(a)-(c)
Reference(s): ANSI C63.10, section 12.7.2

| | | | |
|---|---|---|---|
| Performed by: | Andreas Menacher | Date(s) of test: | July 4, 2018 |
| Climatic conditions: | Ambient temperature<br>27 °C | Relative humidity<br>44 % | Barometric pressure<br>976 hPa |
| Result[5]: | ☒ Test passed | ☐ Test not passed | |

### 6.3.1 Test equipment

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☒ | Compact Diagnostic Chamber (CDC) | VK041.0174 | Albatross Projects | E00026 |
| ☐ | Open area test site (OATS) | --- | EMV **TESTHAUS** | E00354 |
| ☐ | Semi-anechoic chamber (SAC) | SAC3 | Albatross Projects | E00716 |
| ☐ | EMI test receiver (CDC) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☐ | EMI test receiver (OATS) | ESCI 3 | Rohde & Schwarz | E00001 |
| ☒ | EMI test receiver | ESR 7 | Rohde & Schwarz | E00739 |
| ☐ | EMI test receiver | ESU 26 | Rohde & Schwarz | W00002 |
| ☐ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☐ | Field probe | RF-R 400-1 | Langer EMV-Technik | E00270 |
| ☒ | Loop antenna | HFH2-Z2 | Rohde & Schwarz | E00060 |
| ☐ | Cable set CDC | RF cable(s) | Huber + Suhner<br>AME HF-Technik<br>AME HF-Technik<br>Stabo | E00446<br>E00920<br>E00921<br>E01215 |
| ☐ | Test software | EMC32-EB (V10.35) | Rohde & Schwarz | E00777 |
| ☒ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E00778 |
| ☐ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E01073 |

[5] For information about measurement uncertainties see page 76.

### 6.3.2 Limits

As specified in section 15.205(a)-(c) of 47 CFR Part 15:

Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed above using the recalculation factor as described in clause 5.3.

### 6.3.3 Test procedure

The emission within the restricted band of operation from 0.090 MHz – 0.110 MHz is measured using the test procedure as described in clause 5.7.

## 6.3.4 Test results

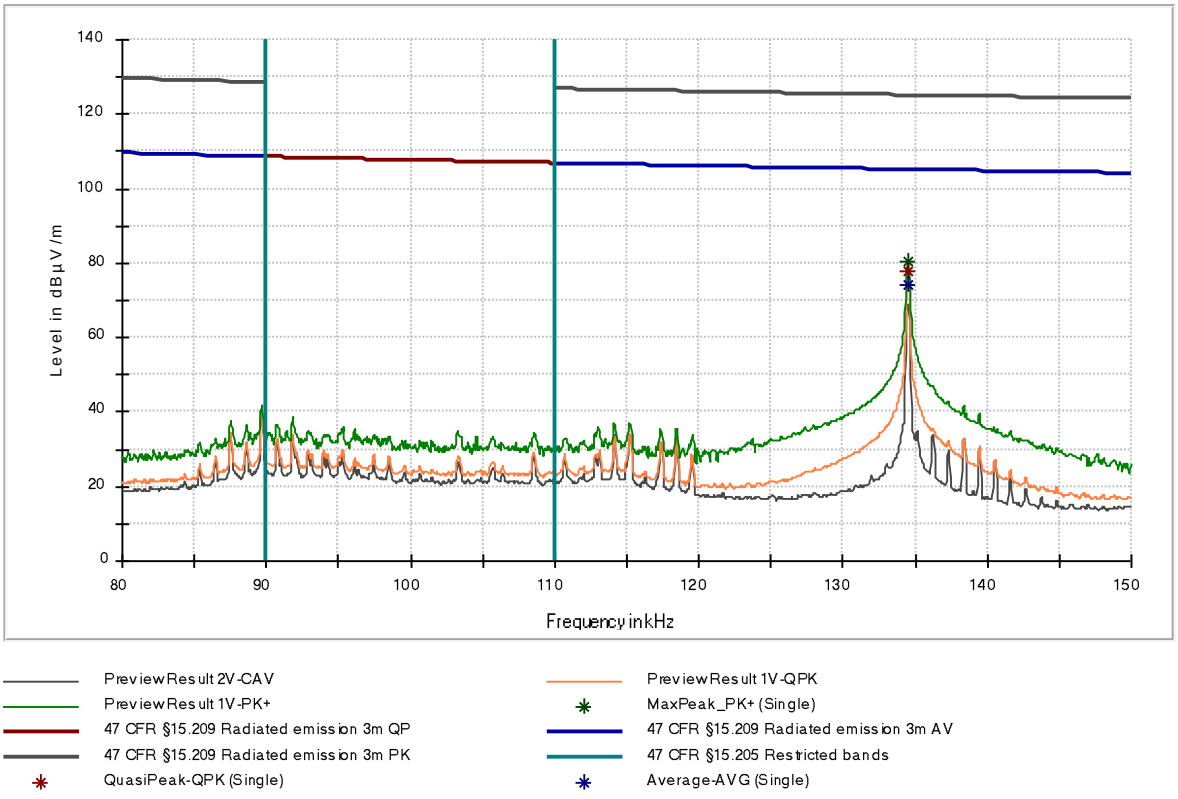


Figure 10: Restricted band of operation @ 3m distance

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

Recalculation factor = -40 log($d_{limit}$ / $d_{measure}$)

| $f_{MHz}$ [MHz] | $d_{measure}$ [m] | $d_{limit}$ [m] | Recalculation factor [dB] |
|---|---|---|---|
| 0.134 | 3.000 | 300.000 | -80 |

## 6.4 Radiated emissions

### 6.4.1 Emissions below 30 MHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.209
Reference(s): ANSI C63.10, clause 6.4

Result[6]: ☒ Test passed ☐ Test not passed

#### 6.4.1.1 Test equipment

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☒ | Compact Diagnostic Chamber (CDC) | VK041.0174 | Albatross Projects | E00026 |
| ☐ | Open area test site (OATS) | --- | EMV TESTHAUS | E00354 |
| ☐ | Semi-anechoic chamber (SAC) | SAC3 | Albatross Projects | E00716 |
| ☐ | EMI test receiver (CDC) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☐ | EMI test receiver (OATS) | ESCI 3 | Rohde & Schwarz | E00001 |
| ☒ | EMI test receiver | ESR 7 | Rohde & Schwarz | E00739 |
| ☐ | EMI test receiver | ESU 26 | Rohde & Schwarz | W00002 |
| ☐ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☐ | Field probe | RF-R 400-1 | Langer EMV-Technik | E00270 |
| ☒ | Loop antenna | HFH2-Z2 | Rohde & Schwarz | E00060 |
| ☐ | Cable set CDC | RF cable(s) | Huber + Suhner<br>AME HF-Technik<br>AME HF-Technik<br>Stabo | E00446<br>E00920<br>E00921<br>E01215 |
| ☐ | Test software | EMC32-EB (V10.35) | Rohde & Schwarz | E00777 |
| ☒ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E00778 |
| ☐ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E01073 |

[6] For information about measurement uncertainties see page 92.

### 6.4.1.2 Limits

| *Frequency* | *Field strength* | | *Measurement distance* |
|---|---|---|---|
| *[MHz]* | *[µV/m]* | *[dBµV/m]* | *[m]* |
| 0.009 – 0.490 | 2400/F(kHz)<br>(266.67 – 4.90) | 48.52 – 13.80 | 300 |
| 0.490 – 1.705 | 24000/F(kHz)<br>(48.98 – 14.08) | 33.80 – 22.97 | 30 |
| 1.705 – 30 | 30 | 29.54 | 30 |

Table 10: General radiated emission limits up to 30 MHz according to §15.209

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed in table 10 using the recalculation factor as described in clause 5.3.

### 6.4.1.3 Test procedure

The emissions below 30 MHz are measured using the

☒ test procedure for radiated measurements as described in clause 5.3.

## 6.4.1.4 Test results

| | | | |
|---|---|---|---|
| Performed by: | Andreas Menacher | Date(s) of test: | July 4, 2018 |
| Climatic conditions: | Ambient temperature 27°C | Relative humidity 44.0 % | Barometric pressure 976 hPa |
| Test distance: | ☒ 3 m | ☐ 10 m | ☐ ….. m |
| Antenna alignment: | ☒ in parallel | ☐ in line | ☐ angle ….. ° |
| EUT position[7]: | ☒ Position 1 | ☒ Position 2 | ☒ Position 3 |

| *Frequency range* | *Step size* | *IF Bandwidth* | *Detector* | | *Measurement Time* | | *Preamplifier* |
|---|---|---|---|---|---|---|---|
| | | | *Prescan* | *Final scan* | *Prescan* | *Final scan* | |
| 9 kHz – 150 kHz | 50 Hz | 200 Hz | QP, PK, CAV | QP, PK, AV | 2 s | 1 s | Off |
| 150 kHz – 30 MHz | 2.25 kHz | 9 kHz | QP, PK, CAV | QP, PK, AV | 2 s | 1 s | Off |

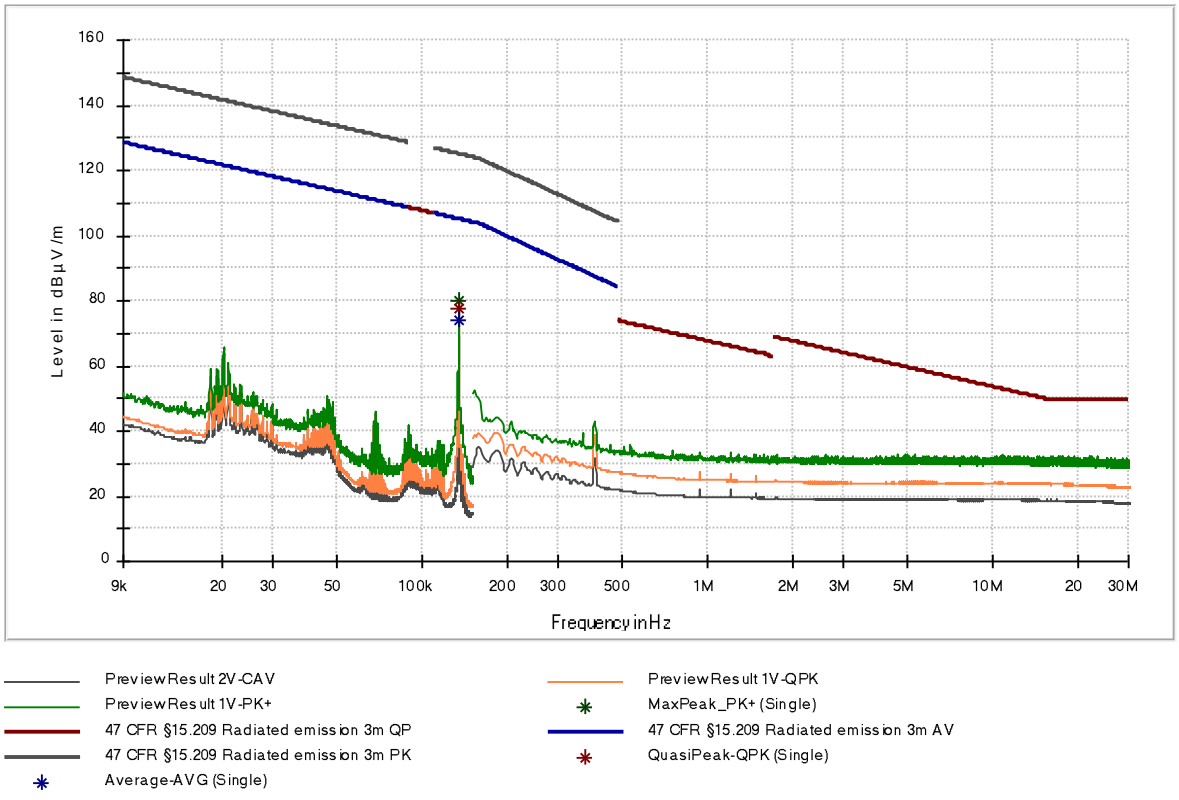


Figure 11: Chart of emissions test below 30 MHz without tag in position 2

[7] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

| Frequency [MHz] | Measured value [dBµV/m] | Detector | Recalculation factor [dB] | Field strength [dBµV/m] | Limit [dBµV/m] | Margin | Result |
|---|---|---|---|---|---|---|---|
| 0.13450 | 74.04 | AV | -80.0 | -5.96 | 25.05 | 31.01 | Pass |
| 0.13450 | 77.82 | QP | -80.0 | -2.18 | --- | --- | --- |
| 0.13450 | 80.25 | PK | -80.0 | 0.25 | 45.05 | 44.80 | Pass |

Table 11: Final results of emissions test below 30 MHz without tag in position 2

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

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

| $f_{MHz}$ [MHz] | $d_{measure}$ [m] | $d_{limit}$ [m] | Recalculation factor [dB] |
|---|---|---|---|
| 0.134 | 3.000 | 300.000 | -80 |

## 6.4.2 Emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.209
Reference(s): ANSI C63.10, clause 6.5

Result[8]: ☒ Test passed ☐ Test not passed

### 6.4.2.1 Test equipment

| | *Type* | *Designation* | *Manufacturer* | *Inventory no.* |
|---|---|---|---|---|
| ☒ | Semi-anechoic chamber (SAC) | SAC3 | Albatross Projects | E00716 |
| ☐ | Free space semi-anechoic chamber (FS-SAC) | FS-SAC | EMV **TESTHAUS** | E00100 |
| ☐ | EMI test receiver (CDC) | ESCI 3 | Rohde & Schwarz | E00552 |
| ☐ | EMI test receiver (OATS) | ESCI 3 | Rohde & Schwarz | E00001 |
| ☐ | EMI test receiver | ESR 7 | Rohde & Schwarz | E00739 |
| ☐ | EMI test receiver | ESU 26 | Rohde & Schwarz | W00002 |
| ☒ | EMI test receiver | ESW 44 | Rohde & Schwarz | E00895 |
| ☐ | Preamplifier (1 GHz - 18 GHz) | ALS05749 | Aldetec | W01007 |
| ☐ | TRILOG broadband antenna (CDC) | VULB 9160 | Schwarzbeck | E00011 |
| ☐ | TRILOG broadband antenna (OATS) | VULB 9163 | Schwarzbeck | E00013 |
| ☒ | TRILOG broadband antenna (SAC) | VULB 9162 | Schwarzbeck | E00643 |
| ☐ | Horn antenna | BBHA 9120D | Schwarzbeck | W00052 |
| ☐ | Horn antenna | BBHA 9170 | Schwarzbeck | W00054 |
| ☒ | Cable set SAC | RF cable(s) | Huber + Suhner | E00755<br>E01033<br>E01034 |
| ☐ | Cable set FS-SAC | RF cable(s) | Teledyne Reynolds<br>Huber + Suhner<br>Teledyne Reynolds | E00435<br>E00307<br>E00433 |
| ☒ | Test software | EMC32-EB (V10.35) | Rohde & Schwarz | E00777 |
| ☐ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E00778 |
| ☐ | Test software | EMC32-MEB (V10.35) | Rohde & Schwarz | E01073 |

[8] For information about measurement uncertainties see page 92.

### 6.4.2.2 Limits

| *Frequency* | *Field strength* | | *Measurement distance* |
|---|---|---|---|
| *[MHz]* | *[µV/m]* | *[dBµV/m]* | *[m]* |
| 30 – 88 | 100 | 40.00 | 3 |
| 88 – 216 | 150 | 43.52 | 3 |
| 216 - 960 | 200 | 46.02 | 3 |
| Above 960 | 500 | 53.98 | 3 |

Table 12: General radiated emission limits ≥ 30 MHz according to §15.209

### 6.4.2.3 Test procedure

The emissions from 30 MHz to 1 GHz are measured using the

☒ test procedure for radiated measurements as described in clause 5.4.

## 6.4.2.4 Test results

| | | | |
|---|---|---|---|
| Performed by: | Andreas Menacher | Date(s) of test: | July 3, 2018 |
| Climatic conditions: | Ambient temperature 26 °C | Relative humidity 42% | Barometric pressure 976 hPa |
| Test distance: | ☒ 3 m | ☐ 10 m | ☐ ….. m |
| EUT position[9]: | ☒ Position 1 | ☒ Position 2 | ☒ Position 3 |

| *Frequency range* | *Step size* | *IF Bandwidth* | *Detector* | | *Measurement Time* | | *Preamplifier* |
|---|---|---|---|---|---|---|---|
| | | | *Prescan* | *Final scan* | *Prescan* | *Final scan* | |
| 30 MHz – 1 GHz | 30 kHz | 120 kHz | QP | QP | 1 s | 1 s | 20 dB |

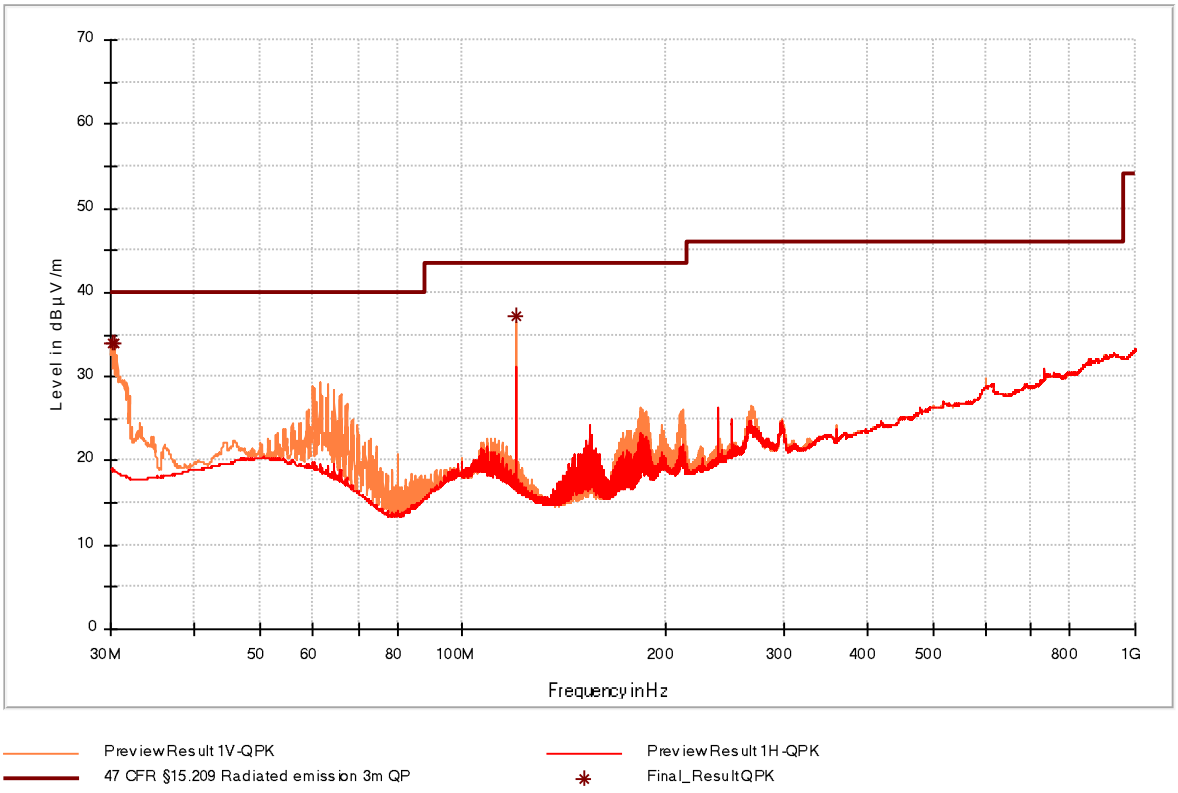


Figure 12: Chart of emissions test from 30 MHz to 1 GHz with tag in position 3

[9] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Height (cm) | Pol | Azimuth (deg) |
|---|---|---|---|---|---|---|
| 30.120000 | 34.03 | 40.00 | 5.97 | 100.0 | V | 153.0 |
| 30.390000 | 33.99 | 40.00 | 6.01 | 100.0 | V | 140.0 |
| 120.000000 | 37.27 | 43.50 | 6.23 | 100.0 | V | 205.0 |

Table 13: Final results of emissions test from 30 MHz to 1 GHz with tag in position 3

# 7 Equipment calibration status

| *Description* | *Modell number* | *Serial number* | *Inventory number(s)* | *Last calibration* | *Next calibration* |
|---|---|---|---|---|---|
| EMI test receiver | ESW44 | 101538 | E00895 | 2018-04 | 2019-04 |
| EMI test receiver | ESR7 | 101059 | E00739 | 2018-05 | 2019-05 |
| EMI test receiver | ESCI 3 | 100013 | E00001 | 2018-05 | 2020-05 |
| Loop antenna | HFH2-Z2 | 871398/0050 | E00060 | 2016-09 | 2018-09 |
| TRILOG broadband antenna (SAC3) | VULB 9162 | 9162-041 | E00643 | 2018-03 | 2021-03 |
| Magnetic field probe | RF-R 400-1 | 02.2030 | E00270 | N/A (see note 2) | |
| LISN | ESH2-Z5 | 881362/037 | E00004 | 2016-10 | 2018-10 |
| LISN | ESH2-Z5 | 893406/009 | E00005 | 2016-02 | 2018-08 |
| Shielded room | P92007 | B 83117 C 1109 T 211 | E00107 | N/A | |
| Compact diagnostic chamber (CDC) | VK041.0174 | D62128-A502-A69-2-0006 | E00026 | N/A | |
| Semi-anechoic chamber (SAC) | SAC3 | C62128-A520-A643-x-0006 | E00716 | 2018-03 | 2021-03 |
| Cable set CDC | RG214/U | --- | E00446 | 2018-04 | 2019-04 |
| | LCF12-50J | --- | E01215 | 2018-04 | 2019-04 |
| | LMR400 | 1718020006 | E00920 | 2018-01 | 2019-01 |
| | RG214 Hiflex | 171802007 | E00921 | 2018-01 | 2019-01 |
| Cable set of semi-anechoic chamber SAC3 | SF104EA/11PC35/11PC35/10000MM | 501347/4EA | E00755 | 2017-12 | 2018-12 |
| | SF104E/11PC35/11PC35/2000MM | 507410/4E | E01033 | 2017-12 | 2018-12 |
| | SF104E/11PC35/11PC35/2000MM | 507411/4E | E01034 | 2017-09 | 2018-09 |

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

Note 2: Used for relative measurements only (see test instruments for “Occupied bandwidth” clause 6.2)

# 8 Measurement uncertainties

| *Description* | *Uncertainty* | *k=* |
|---|---|---|
| AC power line conducted emission | ± 4.1 dB | 2 |
| Bandwidth tests | ± 2.0 % | |
| Radiated emissions in semi-anechoic chamber | | |
| 9 kHz to 30 MHz | ± 4.8 dB | 2 |
| 30 MHz to 300 MHz | ± 5.4 dB | 2 |
| 300MHz to 1 GHz | ± 4.7 dB | 2 |

Comment: 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.

Test related measurement uncertainties have to be taken into consideration when evaluating the test results. All used test instrument as well as the test accessories are calibrated at regular intervals.

# 9 Revision history

| *Revision* | *Date* | *Issued by* | *Description of modifications* |
|---|---|---|---|
| 0 | 2018-07-19 | Andreas Menacher | First edition |