

Radio Radio

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**Test report no.:**

240514-AU04+W02

**for:**

ELATEC GmbH  
RFID reader / writer  
TWN4 Secustos MU20

**according to:**

47 CFR Part 15, §15.225  
RSS-210



**Accreditation:**

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## 1 Summary of test results

System type: RFID Reader

47 CFR part and section	Test	Equivalent to IC radio standard(s)	Result	Note(s)	Page
15.207(a)	AC powerline conducted emissions	RSS-Gen, section 8.8	Passed	2	27
15.215(c)	20 dB bandwidth	---	Passed	---	32
---	Occupied bandwidth	RSS-Gen, section 6.7	Recorded	---	35
15.225 (a) – (c)	Operation within the band 13.110 MHz – 14.010 MHz	RSS-210 section B.6 (a) i to iii	Passed	---	37
15.225(e)	Carrier frequency stability	RSS-210, section B.6 (b)	Passed	---	41
15.225(d)	Emissions below 30 MHz outside the operating frequency band(s) specified	RSS-210, section B.6 (a) iv	Passed	---	45
15.225(d)	Spurious emissions from 30 MHz to 1 GHz	RSS-210, section B.6 (a) iv	Passed	---	52
15.225(d)	Spurious emissions above 1 GHz	RSS-210, section B.6 (a) iv	Passed	3, 4	58

Note(s):

- 1 For information about EUT see clause 3.
- 2 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.
- 3 Not applicable if the 10<sup>th</sup> harmonic of the intentional transmitter is below 1 GHz (please see 47 CFR Part 15, section 15.33(a)(1), and RSS-Gen, section 6.13.2(a))
- 4 According to 47 CFR Part 15, §15.33 (a)(5) and RSS-Gen, section 6.13.2 (d), the frequency range of investigation for the digital device shall be used if the range of investigation determined by the highest internal frequency of the digital device is higher than the 10<sup>th</sup> harmonic of the intentional radiator

Straubing, July 21, 2025



Tested by  
 Patricio Montenegro, M.Sc.-Ing.  
 Radio Test Engineer



Approved by  
 Konrad Graßl  
 Reviewer

## 2 Referenced publications

<i>Publication</i>	<i>Title</i>
CFR 47 Part 2 October 2024	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 October 2024	Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
ANSI C63.10 September 2020	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
RSS-Gen Issue 5 April 2018 Amendment 1 (March 2019) Amendment 2 (February 2021)	Spectrum Management and Telecommunications - Radio Standards Specification - General Requirements for Compliance of Radio Apparatus
RSS-210 Issue 11, June 25, 2024	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus: Category I Equipment

### 3 Equipment under test (EUT)

All Information in this clause is declared by customer.

#### 3.1 General information

Product type: RFID reader / writer  
Model name: TWN4 Secustos MU20  
Serial number(s): R2025235689  
Applicant: ELATEC GmbH  
Manufacturer: ELATEC GmbH  
Hardware version: PRODA  
Software version: B1.50/NKD4.70/CONT1.26/KPIBAVTQED/Beta 1  
Short description: EUT is a RFID reader / writer operating at the frequencies 125 kHz and 13.56 MHz. BLE is additionally integrated. In this test report only RFID working at 13.56 MHz is in consideration.  
Additional modifications: See 3.4  
FCC ID: WP5TWN4F32  
IC registration number: 7948A-TWN4F32  
Designation of emissions: 1K40K1D--  
Temperature range: -20 °C to +60 °C (customer defined)  
Device type:  Portable  Mobile  Fixed

### 3.2 Power supply

#### USB:

Power input characteristics:

Input power type:	DC
Nominal voltage:	5 V
Voltage range:	4.7 V – 5.8 V

#### RS-485:

Power input characteristics:

Input power type:	DC
Nominal voltage:	12 V
Voltage range:	6 V – 28 V

#### Wiegand:

Power input characteristics:

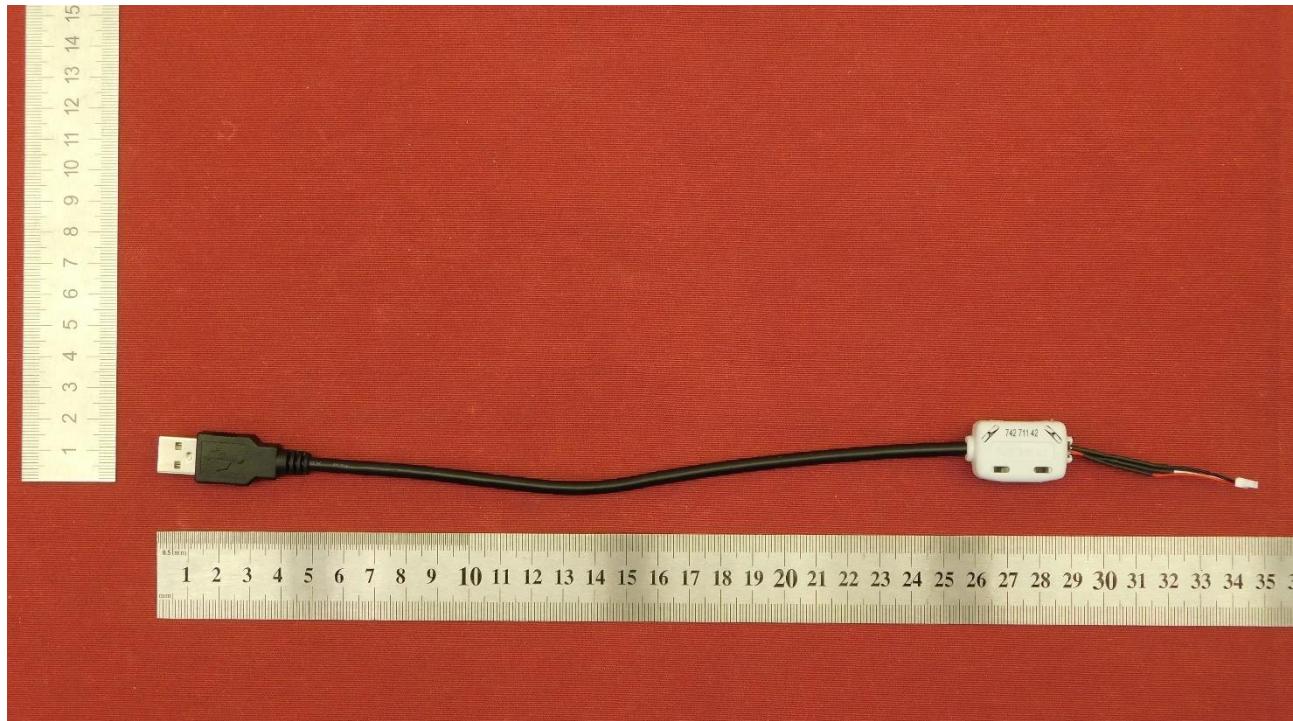
Input power type:	DC
Nominal voltage:	12 V
Voltage range:	6 V – 28 V

### 3.3 Radio specifications

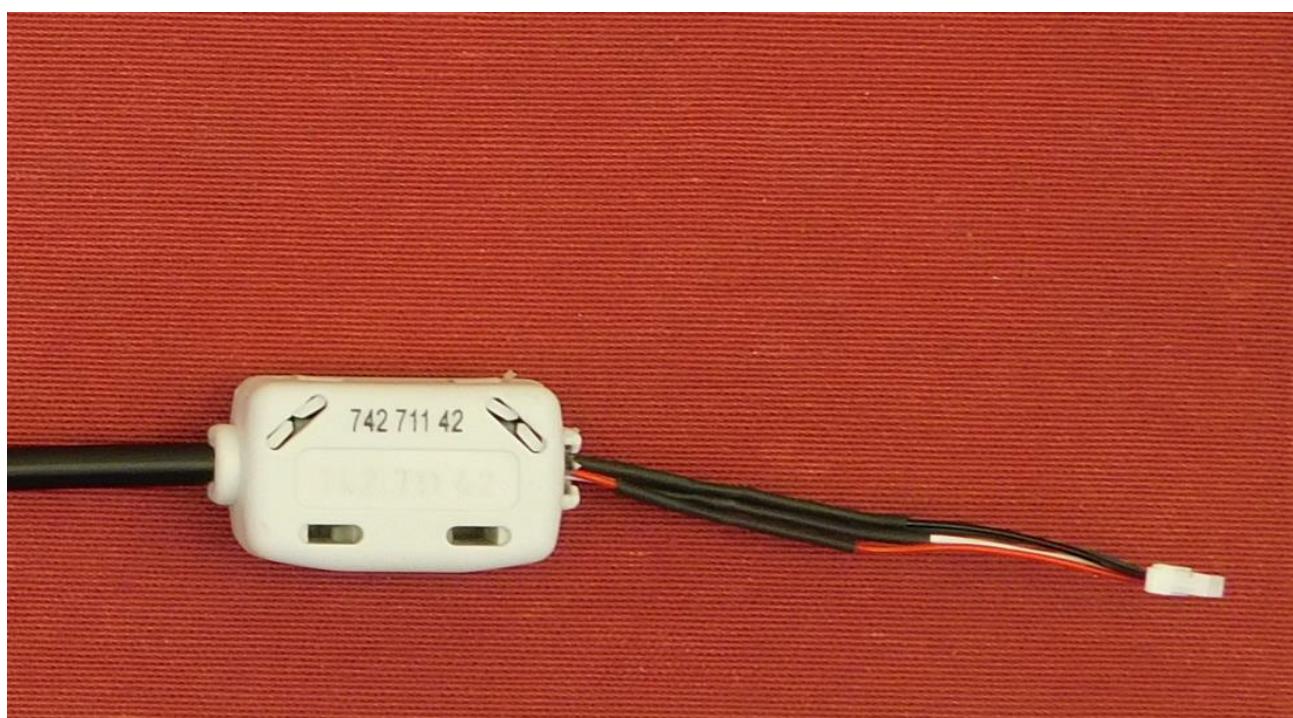
System type:	RFID Reader	
Application frequency band:	13.110 MHz – 14.010 MHz	
Operating frequencies:	13.56 MHz	
Number of RF channels	1	
Highest internal frequency:	2480 MHz (BLE)	
Modulation	ASK	
Antenna:	Type: Outer dimension: Inductance Width of wire Turns: Connector:	PCB antenna, 2 Layers 66.00 x 26 mm 1.25 $\mu$ H $\pm$ 5% 0.6 mm 3 <input type="checkbox"/> external <input type="checkbox"/> temporary
		<input type="checkbox"/> internal <input checked="" type="checkbox"/> none (integral antenna)

### 3.4 Equipment modifications (for USB mode only)

To achieve compliance with the regulations, the following modifications were made by a responsible employee of the manufacturer directly or via appropriate instructions:



Picture 1: Modification of EUT



Picture 2: Mounted ferrite

### 3.5 Photo documentation

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

## 4 Test configuration and mode of operation

### 4.1 Test configuration

Device	Type designation	Serial or inventory no.	Manufacturer
RFID reader / writer	TWN4 Secustos MU20	R2025235689	ELATEC GmbH

Table 1: EUT used for testing

Device	Type designation	Serial or inventory no.	Manufacturer
RFID tag	13.56 MHz	---	ELATEC GmbH
Laptop	Latitude 3410	9BDY103	DELL
Power supply for laptop	LA65NS2-01	---	DELL
USB cable	---	---	---
USB to serial adapter	DA-70157	---	DIGITUS
Wiegand adapter	SFCT-T4PM-A-100	---	ELATEC GmbH
Laboratory power supply	3231.1	E00017	Statron

Table 2: Support equipment used for testing

### 4.2 Mode of operation

#### This applies to all modes:

- By means of the test software "AppBlaster V4.05.04" the EUT was set in continuous interrogation mode at 13.56 MHz.

#### USB mode:

- The device was powered by a laptop via USB.
- With the exemption of the tests under extreme conditions all tests were performed with a supply voltage of 5 V (normal USB connection to the laptop).

#### RS-485 mode:

- The EUT was connected via an RS-485 cable and a serial to USB adapter to a laptop and in addition to a DC power supply.
- All tests were performed with a supply voltage of 12 V.

#### Wiegand mode:

- The EUT was connected to a Wiegand adapter which was powered by a DC power supply.
- All tests were performed with a supply voltage of 12 V.

## 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 6.2.3 of ANSI C63.10-2020 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 3: Bandwidth and detector type for AC power-line conducted emissions test

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

- 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 3). 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).

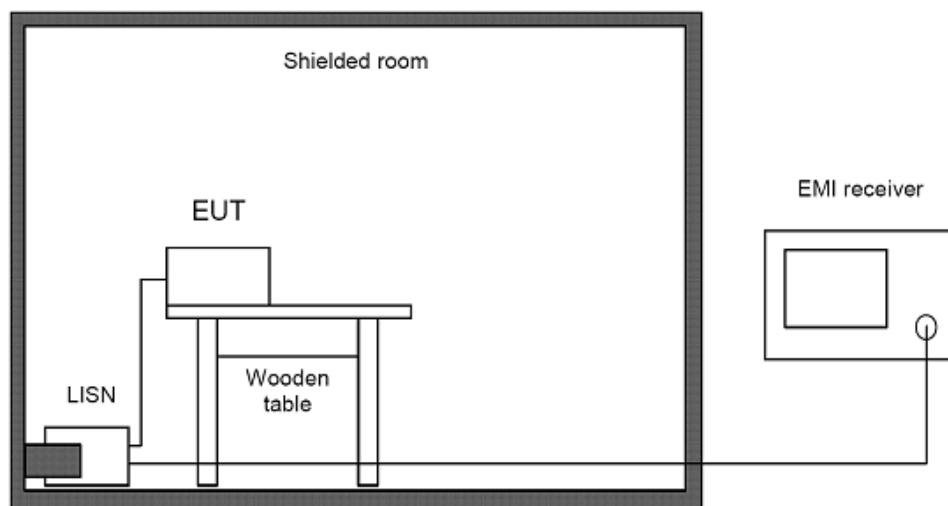


Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

Phase	Frequency (MHz)	Reading value (dB $\mu$ V)	AMN correction (dB)	Cable attenuation + 10 dB attenuator (dB)	Correction factor (Corr.) (dB)	Level (dB $\mu$ V)
L 1	10	10	0.6	10.9	11.5	21.5
N	10	10	1.0	10.9	11.9	21.9

Table 4: Sample calculation

Correction factor = Artificial mains network correction + Cable attenuation + 10 dB

Level = Reading value + Correction factor = 10 dB $\mu$ V + 11.5 dB = 21.5 dB $\mu$ V

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.

### 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  $377 \Omega$  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:

$$\begin{aligned} d_{\text{near field}} &= 47.77 / f_{\text{MHz}}, \text{ or} \\ f_{\text{MHz}} &= 47.77 / d_{\text{near field}} \end{aligned}$$

The frequency  $f_{\text{MHz}}$  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:

$$\begin{aligned} f_{\text{MHz}}(300 \text{ m}) &\approx 0.159 \text{ MHz} \\ f_{\text{MHz}}(30 \text{ m}) &\approx 1.592 \text{ MHz} \\ f_{\text{MHz}}(3 \text{ m}) &\approx 15.923 \text{ MHz} \end{aligned}$$

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

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

Table 5: Recalculation factors for extrapolation

The radiated measurements below 30 MHz are performed in a semi-anechoic chamber (called "SAC). The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 6.

Frequency (f)	Measurement receiver bandwidth	Step size	Detector type
9 kHz $\leq$ f $<$ 150 kHz	200 Hz	$\leq 100 \text{ Hz}$	Peak Quasi-peak Average
150 kHz $\leq$ f $<$ 30 MHz	9 kHz	$\leq 4.5 \text{ kHz}$	Peak Quasi-peak Average

Table 6: Bandwidth and detector type for radiated emissions test below 30 MHz

Frequency (MHz)	Reading value (dB $\mu$ V)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dB $\mu$ V/m)
10	20.00	19.59	0.33	19.92	39.92

Table 7: Sample calculation

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 20 dB $\mu$ V + 19.92 dB = 39.92 dB $\mu$ V/m

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:

### 5.3.1 Automatic test method

- 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 6).
- d) The table position is set to 0°. The table step is defined as 20°.
- e) The loop antenna is aligned along the test axis (in line).
- f) Then the EUT is rotated in a horizontal plane through 360° in steps as defined in step d). 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.
- g) The loop antenna is aligned orthogonal to the test axis (parallel).
- h) Then the EUT is rotated in a horizontal plane through 360° in steps as defined in step d). 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.
- i) After the last prescan, the significant maximum emissions, the antenna position and their table positions are determined and collected in a list.
- j) For maximization, the EUT is rotated clockwise and counterclockwise by the table step as defined in step d) while measuring the emission level continuously.
- k) The worst case positions of the table and the maximum emission levels are recorded.
- l) Steps j) to k) are repeated for all other frequencies in the list.

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

### 5.3.2 Manual test method

- 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 6).
- d) The table position is set to 0°.
- e) The loop antenna is aligned along the test axis (in line).
- f) Then the EUT is rotated in a horizontal plane through 360° continuously. The scan table method in receiver mode of the measurement instrument is used for pre-measurements. The max hold function is used. The significant maximum emissions are determined and collected in a list.
- g) The loop antenna is aligned orthogonal to the test axis (parallel).
- h) Then the EUT is rotated in a horizontal plane through 360° continuously. The scan table method in receiver mode of the measurement instrument is used for pre-measurements. The max hold function is used. The significant maximum emissions are determined and collected in a list.
- i) Final scan: the test receiver is set in the bargraph max hold function and is set to the first frequency of the list, the EUT is rotated by 360° while measuring the emission level continuously. The worst-case table position and the maximum emission level is recorded.
- j) Step i) is repeated for all other frequencies in the list.

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

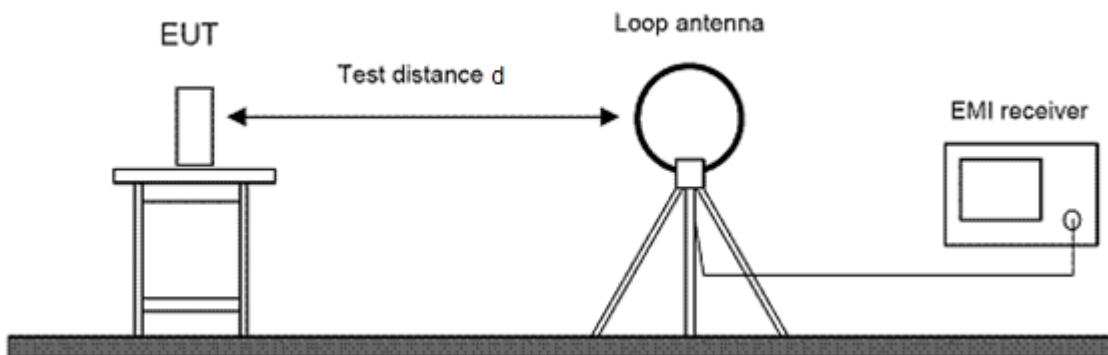


Figure 2: Setup for radiated emissions test below 30 MHz

## 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 8.

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

Frequency (MHz)	Reading value (dB $\mu$ V)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dB $\mu$ V/m)
100	30.00	11.71	1.06	12.77	42.77

Table 9: Sample calculation

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 30 dB $\mu$ V + 12.77 dB = 42.77 dB $\mu$ V/m

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:

#### 5.4.1 Automatic test method

- 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 8).
- d) The table position is set to 0°. The table step is defined as 20°.
- e) The antenna height is set to 1 m. The antenna step is defined as 50 cm.
- 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 antenna steps as defined in step e). 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 antenna steps as defined in step e). At each height, step f) is repeated.
- j) The EUT is rotated in a horizontal plane through 360° in table steps as defined in step d). 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) For maximization, the antenna is moved up and down by the antenna step as defined in step e) and the EUT is rotated clockwise and counterclockwise by the table step as defined in step d) while measuring the emission level continuously.
- n) The worst-case positions of antenna and table and the maximum emission level are recorded.
- o) Steps l) to n) are repeated for all other frequencies in the list.

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

#### 5.4.2 Manual test method

- 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 8).
- 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 while the EUT is rotated in a horizontal plane through 360° continuously. The measurement is performed with peak detector and max hold.
- 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) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna are determined and collected in a list.
- k) For the final scan the test receiver is set to the first frequency of the list. By using the bargraph max hold function of the measurement receiver the emission in consideration is maximised by rotating the EUT in the horizontal plane through 360° and moving the antenna from 1 m to 4 m.
- l) The worst-case positions of antenna and table and the maximum emission level are recorded.
- m) Steps k) to l) are repeated for all other frequencies in the list.

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

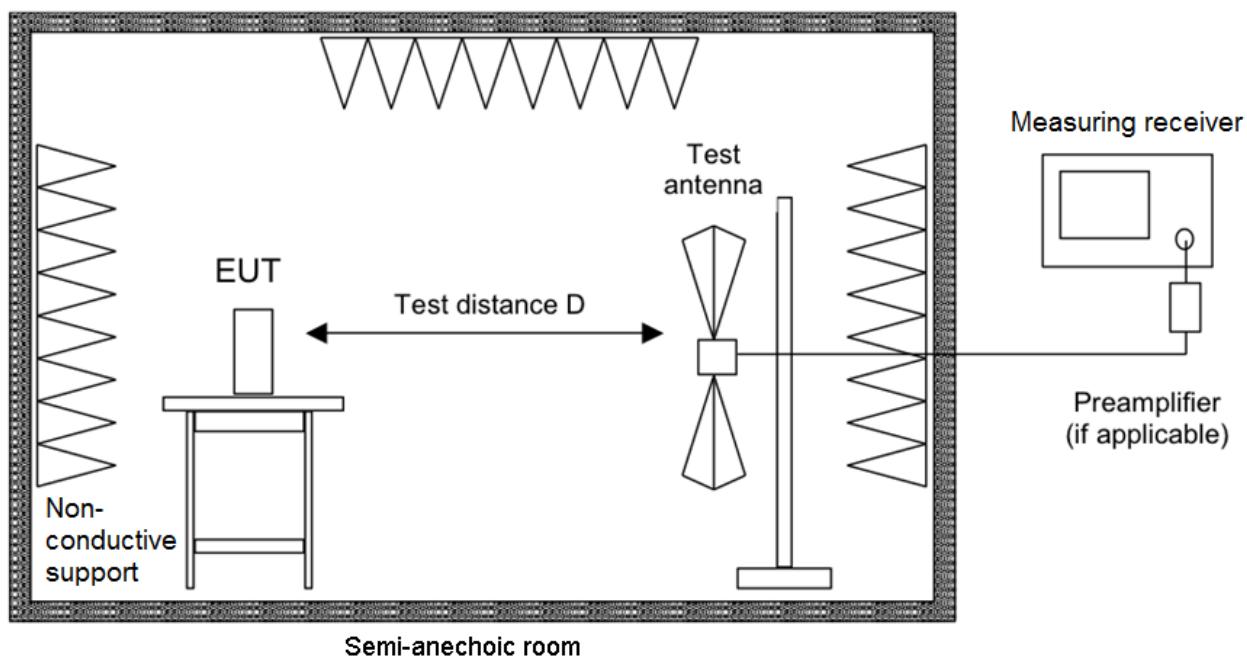


Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

## 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.

Test chamber	Frequency (MHz)	Reading value (dB $\mu$ V)	Antenna correction (dB/m)	Correction pre-amplifier (dB)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dB $\mu$ V/m)
SAC3	2400	50.00	27.76	-47.91	5.24	-14.91	35.08
FS-SAC	2400	50.00	27.76	-34.57	3.51	-3.30	46.70

Table 10: Sample calculation

Correction factor = Antenna correction + Correction pre-amplifier + Cable attenuation

SAC3:

Level = Reading value + Correction factor = 50.00 dB $\mu$ V - 14.92 dB/m = 35.08 dB $\mu$ V/m

FS-SAC:

Level = Reading value + Correction factor = 50.00 dB $\mu$ V - 3.30 dB/m = 46.70 dB $\mu$ V/m

### 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 11.

Frequency (f)	Resolution bandwidth	Video bandwidth	Sweep time	Trace detector(s)
f ≥ 1 GHz	1 MHz	3 MHz	AUTO	Max Peak, Average

Table 11: 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 the semi-anechoic chamber (SAC3) or Free space semi-anechoic chamber (FS-SAC) with RF absorbing material on the floor between measurement antenna and EUT. The measurement distance is 3 meters in the semi-anechoic chamber (SAC3) or 1.5 m in the Free space semi-anechoic chamber (FS-SAC). The emissions of the EUT are recorded with an EMI test receiver configured as described in table 12.

Frequency (f)	Measurement receiver bandwidth	Step size	Detector type	
			Prescan	Final scan
$f \geq 1 \text{ GHz}$	1 MHz	$\leq 500 \text{ kHz}$	Peak, Average	Peak, Average

Table 12: 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:

### 5.5.2.1 Automatic measurement method

- 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 12).
- d) The table position is set to 0°. The table step is defined as 20°.
- e) The antenna height is set to 1 m. The antenna step is defined as 50 cm.
- 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 antenna steps as defined in step e). 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 antenna steps as defined in step e). At each height, step f) is repeated.
- j) The EUT is rotated in a horizontal plane through 360° in table steps as defined in step d). 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) For maximization, the antenna is moved up and down by the antenna step as defined in step e) and the EUT is rotated clockwise and counterclockwise by the table step as defined in step d) while measuring the emission level continuously.
- n) The worst-case positions of antenna and table and the maximum emission level are recorded.
- o) Steps l) to n) are repeated for all other frequencies in the list.

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

### 5.5.2.2 Manual measurement method

- 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 12).
- 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 while the EUT is rotated in a horizontal plane through 360° continuously. The measurement is performed with peak detector and max hold.
- 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) After the last prescan, the significant maximum emissions with their polarizations are determined and collected in a list.
- k) For the final scan the test receiver is set to the first frequency of the list. By using the bargraph max hold function of the measurement receiver the emission in consideration is maximised by rotating the EUT in the horizontal plane through 360° and moving the antenna from 1 m to 4 m (2.5 m).
- l) The worst-case positions of antenna and table and the maximum emission level are recorded.
- m) Steps k) to l) are repeated for all other frequencies in the list.

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

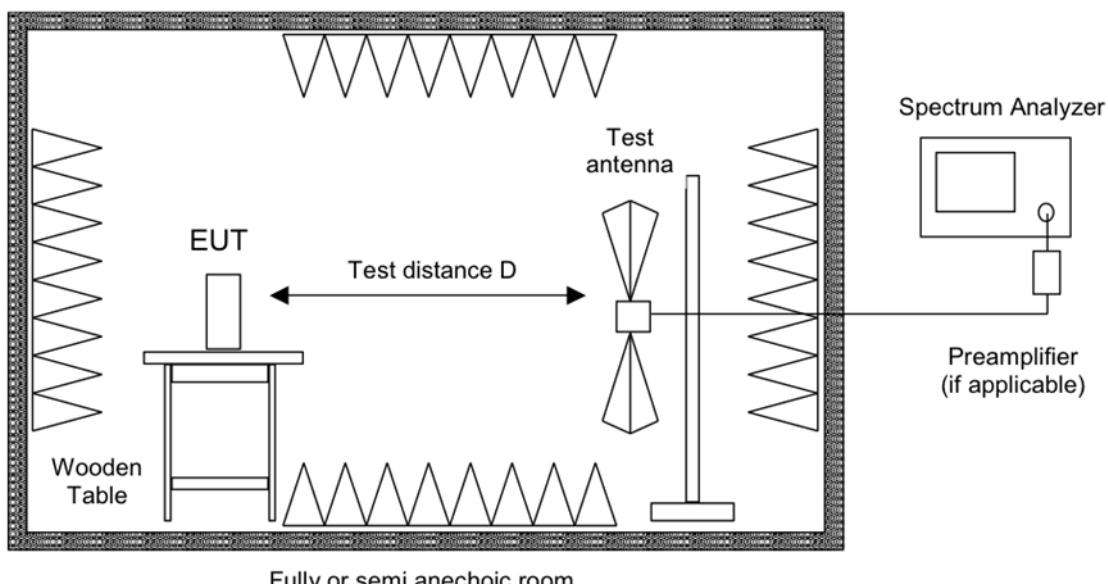


Figure 4: Setup for radiated emissions test above 1 GHz

## 5.6 Bandwidth measurements

### 5.6.1 20 dB bandwidth of the emission

The 20 dB bandwidth of the emission is measured according to clause 6.9.2 of ANSI C63.10 as the width of the spectral envelope of the modulated signal, at an amplitude level reduced by a ratio of 20 dB down from the reference value.

The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer is between two times and five times the 20 dB bandwidth. The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1 % to 5 % of the 20 dB bandwidth and the video bandwidth (VBW) shall be approximately three times RBW.

The reference level of the instrument is set 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  $[10 \log (20 \text{ dB bandwidth}/\text{RBW})]$  below the reference level.

### 5.6.2 99 % occupied bandwidth

According to section 6.7 of RSS-Gen, the occupied bandwidth (OBW) is defined as the 99 % emission 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 Carrier frequency stability

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 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.

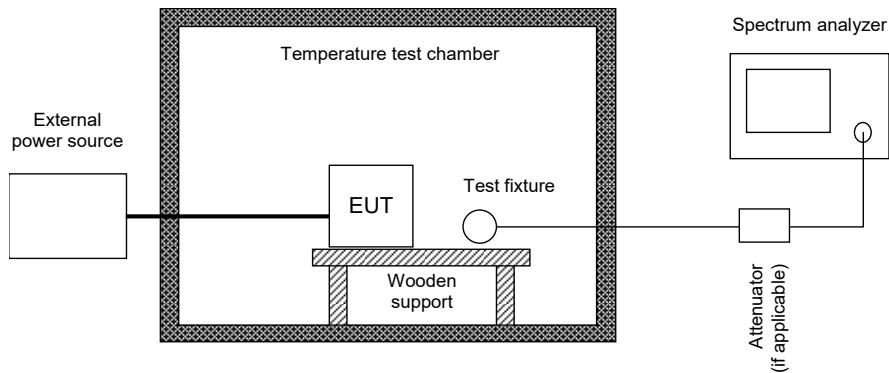


Figure 5: Test setup for carrier frequency stability measurement

## 6 Test results

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

For information about measurement uncertainties see page 64.

The climatic conditions are recorded during the tests. It is ensured that the climatic conditions are within the following ranges:

<i>Ambient temperature</i>	<i>Ambient humidity</i>	<i>Ambient pressure</i>
15°C to 35°C	30 % to 75 %	86 kPa to 106 kPa

## 6.1 AC powerline conducted emissions

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.207(a) ANSI C63.10, clause 6.2
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-Gen, section 8.8 ANSI C63.10, clause 6.2

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	June 5, 2025
Result:	<input checked="" type="checkbox"/> Test passed	<input type="checkbox"/> Test not passed	

### 6.1.1 Test equipment

Description	Designation	Manufacturer	Inventory number(s)	Last check	Next check	Check type
Shielded room	P92007	S+M Components	E00107	---	---	N/A
EMI test receiver	ESR7	Rohde & Schwarz	E01549	2024-08-16	2025-08-16	C
Attenuator (10 dB)	HFP 50	Trilithic	E00355	2024-06-18	2025-12-18	V
Artificial mains network (AMN) with artificial hand connection	ENV432	Rohde & Schwarz	E01733	2024-12-19	2025-12-19	C
Cable set no. 1 for shielded room	RG 223/U	Huber & Suhner	E00741	2024-06-18	2025-12-18	V
	RG 223/U	Huber & Suhner	E00804	2024-06-18	2025-12-18	V
Test software	ELEKTRA ELEMI-EAS (V5.11)	Rohde & Schwarz	E01777	---	---	N/A

#### Note(s)

1. C = Calibration
2. V = Verification

## 6.1.2 Limits

According to §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  $\mu$ 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.

According to §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.

According to RSS-Gen, section 8.8:

Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in of the following table, as measured using a 50  $\mu$ H / 50  $\Omega$  line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in the following table shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The lower limit applies at the boundary between the frequency ranges. The device used to power the EUT shall be representative of typical applications.

Frequency of emission (MHz)	Conducted limit (dB $\mu$ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

Table 13: Limits for AC powerline conducted emissions according to § 15.207 and RSS-Gen

\*Decreases with the logarithm of the frequency

### 6.1.3 Test procedure

The AC powerline conducted emissions are measured using the test procedure as described in clause 5.2.

### 6.1.4 Test results

Note(s):

1. The test was performed at 120 V and 60 Hz.

#### 6.1.4.1 USB mode

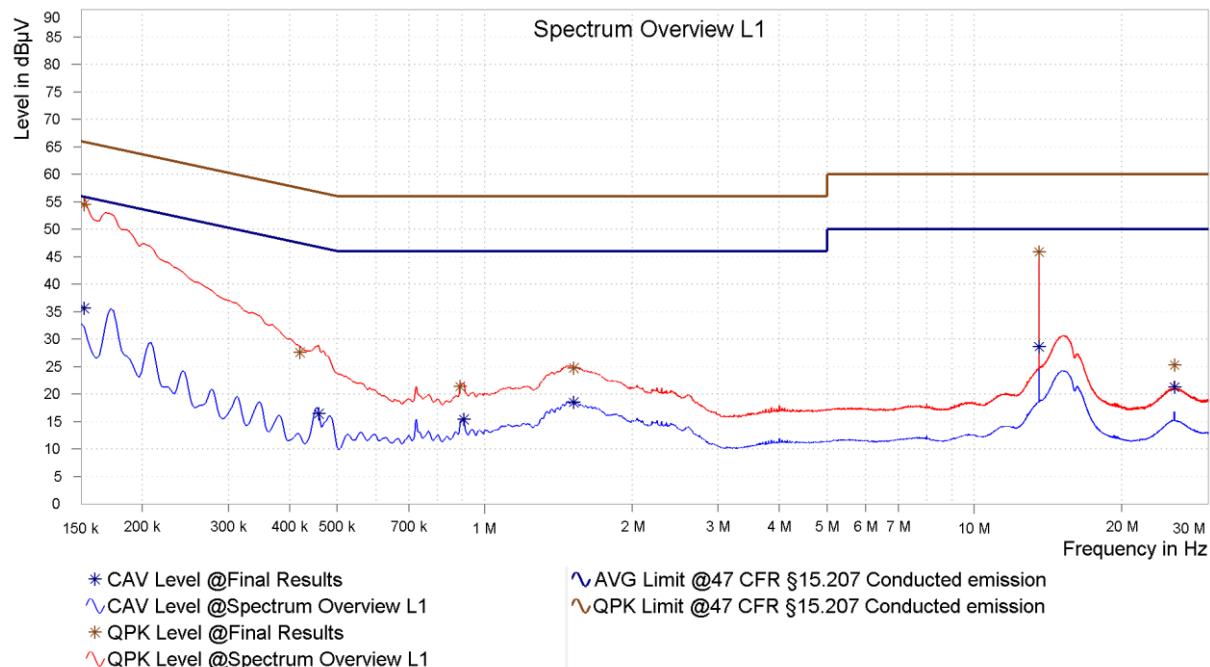


Figure 6: Chart of AC powerline conducted emissions on L1

Freq. (MHz)	QP level (dB $\mu$ V)	QP limit (dB $\mu$ V)	QP margin (dB)	CAV level (dB $\mu$ V)	CAV limit (dB $\mu$ V)	CAV margin (dB)	Corr. (dB)	Line	Result
0.152	54.5	65.9	11.4	---	---	---	20.3	L1	Passed
0.152	---	---	---	35.7	55.9	20.2	20.3	L1	Passed
0.420	27.5	57.5	30.0	---	---	---	20.3	L1	Passed
0.458	---	---	---	16.4	46.7	30.3	20.3	L1	Passed
0.893	21.4	56.0	34.6	---	---	---	20.3	L1	Passed
0.906	---	---	---	15.4	46.0	30.6	20.3	L1	Passed
1.518	24.8	56.0	31.2	---	---	---	20.3	L1	Passed
1.520	---	---	---	18.5	46.0	27.5	20.3	L1	Passed
13.560	45.9	60.0	14.1	---	---	---	20.9	L1	Passed
13.560	---	---	---	28.6	50.0	21.4	20.9	L1	Passed
25.600	25.3	60.0	34.7	---	---	---	21.3	L1	Passed
25.600	---	---	---	21.3	50.0	28.7	21.3	L1	Passed

Table 14: Results of AC powerline conducted emissions on L1

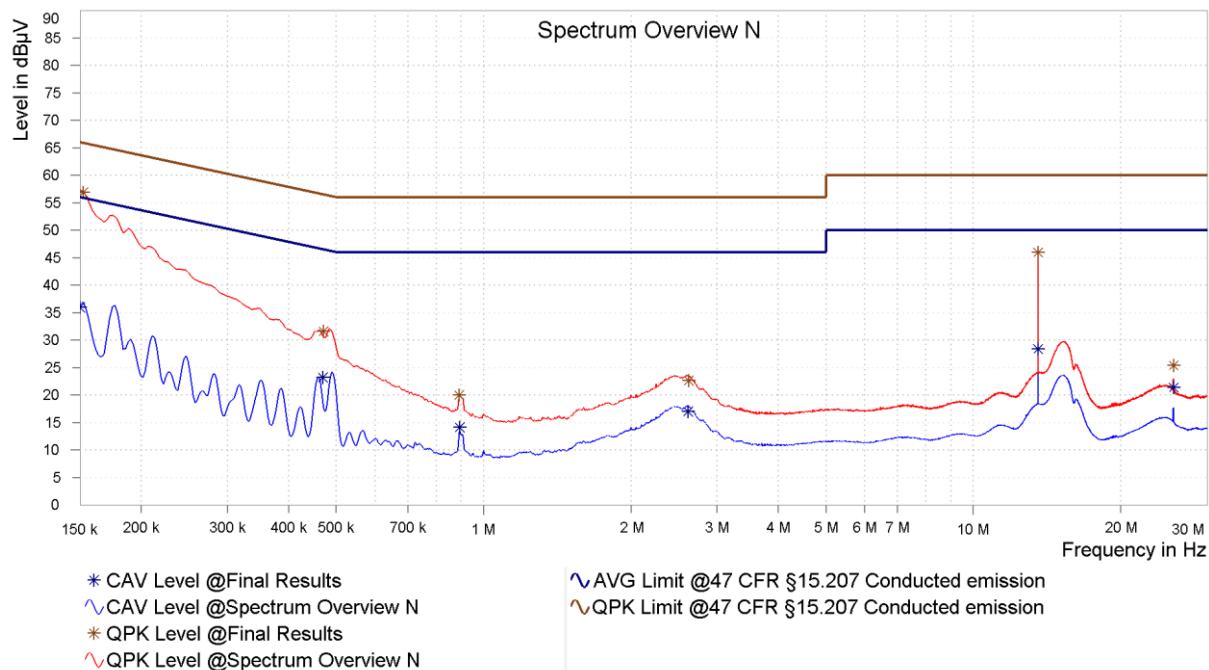


Figure 7: Chart of AC powerline conducted emissions on N

Freq. (MHz)	QP level (dB $\mu$ V)	QP limit (dB $\mu$ V)	QP margin (dB)	CAV level (dB $\mu$ V)	CAV limit (dB $\mu$ V)	CAV margin (dB)	Corr. (dB)	Line	Result
0.150	---	---	---	36.0	56.0	20.0	20.3	N	Passed
0.152	56.9	65.9	9.0	---	---	---	20.3	N	Passed
0.470	---	---	---	23.2	46.5	23.3	20.3	N	Passed
0.472	31.6	56.5	24.9	---	---	---	20.3	N	Passed
0.893	20.0	56.0	36.0	---	---	---	20.3	N	Passed
0.895	---	---	---	14.2	46.0	31.8	20.3	N	Passed
2.614	---	---	---	17.1	46.0	28.9	20.4	N	Passed
2.621	22.6	56.0	33.4	---	---	---	20.4	N	Passed
13.560	45.9	60.0	14.1	---	---	---	21.1	N	Passed
13.560	---	---	---	28.5	50.0	21.5	21.1	N	Passed
25.600	25.4	60.0	34.6	---	---	---	21.8	N	Passed
25.600	---	---	---	21.4	50.0	28.6	21.8	N	Passed

Table 15: Results of AC powerline conducted emissions on N

## 6.2 20 dB bandwidth

Section(s) in 47 CFR Part 15:

Requirement(s):

Reference(s):

15.215(c)

ANSI C63.10 , clause 6.9

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Performed by: Patricio Montenegro, Date(s) of test: May 15, 2025  
M.Sc.-Ing.

Result:  Test passed  Test not passed

---

### 6.2.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
EMI test receiver	ESU26	Rohde & Schwarz	W00002	2024-08-09	2025-08-09	C
RF field probe set	RF2	LANGER EMV-Technik	E00270	See note 1		N/A

Note(s)

- Only used for relative measurements.
- C = Calibration

### 6.2.2 Limits

According to §15.215(c):

Intentional radiators operating under the alternative provisions to the general emission limits must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

### 6.2.3 Test procedure

The 20 dB bandwidth is measured using the conducted measurement procedure using a test fixture with the analyzer settings as described in clause 5.6.1 at normal conditions.

Any required results for maximum 20 dB bandwidth under extreme conditions are obtained by addition and subtraction of the upper and lower frequency error results (see clause 6.5.4) to each bandwidth measurement obtained in this test.

## 6.2.4 Test results

### 6.2.4.1 USB mode

Note(s):

1. Pre-measurements were performed to declare the worst-case which is documented below.

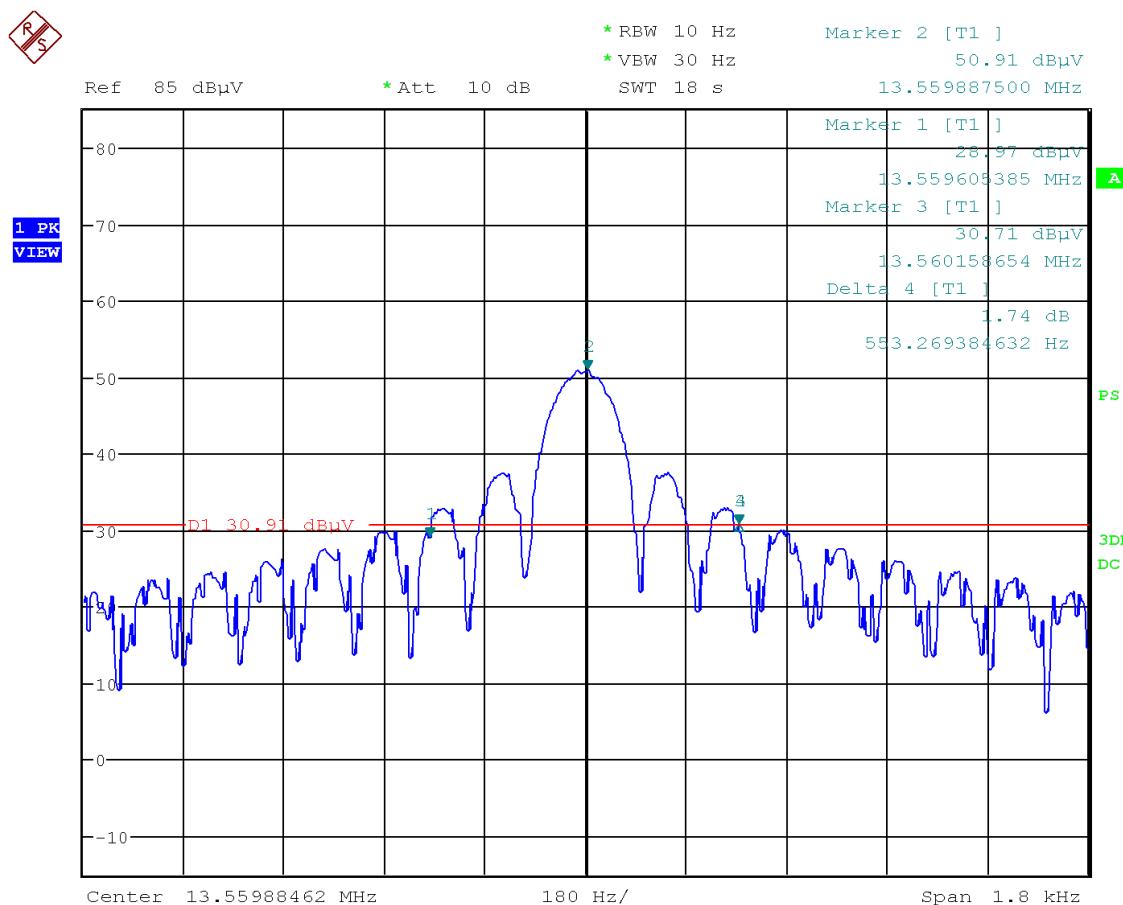


Figure 8: Chart of 20 dB bandwidth tests at normal conditions, without tag

20 dB bandwidth (kHz)	Band edge left		Band edge right		Result
	Frequency (MHz)	Limit (MHz)	Frequency (MHz)	Limit (MHz)	
0.553	13.559605	>13.553000	13.560158	<13.5670000	Passed

Table 16: Results of 20 dB bandwidth tests at normal conditions, without tag

$f_{\text{assigned}}$ (MHz)	<i>Index</i>	$f_{-20dB}$ (MHz)	$\Delta f_T$ (kHz)	$\Delta f_U$ (kHz)	$f_{-20dB(T, U)}$ (MHz)	<i>Limit</i> (MHz)	<i>Margin</i> (kHz)	<i>Result</i>
13.560000	low	13.559605	-0.160	0.000	13.559445	>13.553000	6.445	Passed
	high	13.560158	0.080	0.000	13.560238	<13.567000	6.762	Passed
	Bandwidth	0.553 kHz			0.793 kHz			

Table 17: Results of 20 dB bandwidth tests at extreme conditions, with tag

with:

- $f_{-20dB(\text{low})}$  = lower frequency in MHz where emission is at least 20 dB below the carrier at normal conditions
- $f_{-20dB(\text{high})}$  = upper frequency in MHz where emission is at least 20 dB below the carrier at normal conditions
- $f_{\text{assigned}}$  = assigned frequency in MHz
- $\Delta f_{T(\text{low})}$  = maximum absolute value of negative frequency offset to frequency at normal conditions caused by temperature variation in kHz
- $\Delta f_{T(\text{high})}$  = maximum absolute value of positive frequency offset to frequency at normal conditions caused by temperature variation in kHz
- $\Delta f_{U(\text{low})}$  = maximum absolute value of negative frequency offset to frequency at normal conditions caused by voltage variation in kHz
- $\Delta f_{U(\text{high})}$  = maximum absolute value of positive frequency offset to frequency at normal 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 6.5.4

Measured -20 dB emission bandwidth:

At nominal conditions: 0.553 kHz

Including variations in temperature and supply voltage: 0.793 kHz

### 6.3 Occupied bandwidth

Section(s) in RSS: Requirement(s): RSS-Gen, section 6.7  
Reference(s): ANSI C63.10, clause 6.9

Performed by: Patricio Montenegro, Date(s) of test: May 15, 2025  
M.Sc.-Ing.

Result:  Recorded  Not recorded

#### 6.3.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
EMI test receiver	ESU26	Rohde & Schwarz	W00002	2024-08-09	2025-08-09	C
RF field probe set	RF2	LANGER EMV-Technik	E00270	See note 1		N/A

##### Note(s)

3. Only used for relative measurements.
4. C = Calibration

#### 6.3.2 Limits

According to 2.1049(i):

Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

According to RSS-Gen, section 6.7:

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

#### 6.3.3 Test procedure

Occupied bandwidth is measured using the

- radiated measurement procedure with the analyzer settings as described in clause 5.6.2.
- conducted measurement procedure using a test fixture with the analyzer settings as described in clause 5.6.2.

### 6.3.4 Test results

Note(s):

1. Pre-measurements were performed to declare the worst-case which is documented below.

#### 6.3.4.1 USB mode

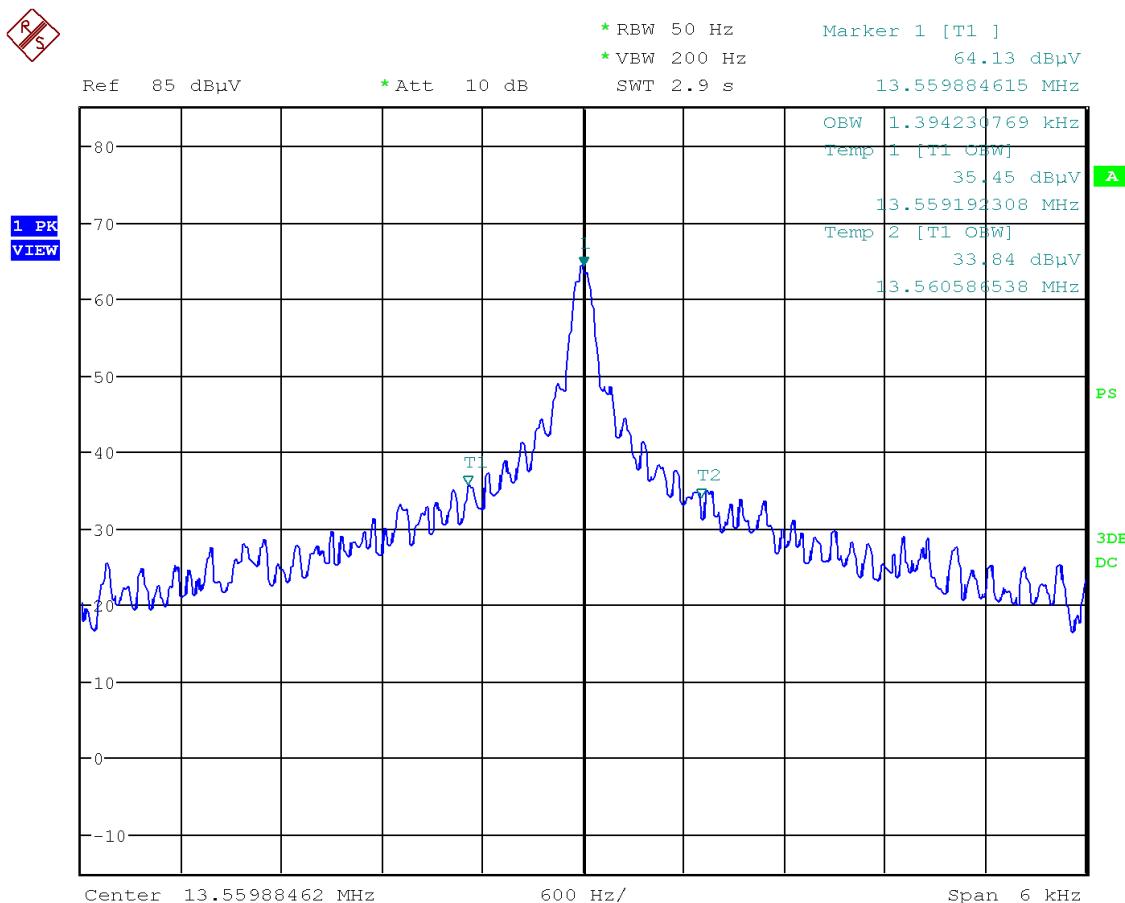


Figure 9: Chart of occupied bandwidth test, without tag

Lower frequency of bandwidth (MHz)	Upper frequency of bandwidth (MHz)	Occupied bandwidth (kHz)	Result
13.55919	13.56059	1.40	Recorded

Table 18: Results of occupied bandwidth test, without tag

## 6.4 Operation within the band 13.110 MHz – 14.010 MHz

Section(s) in 47 CFR Part 15:

Requirement(s):

15.225 (a)-(c)

Reference(s):

ANSI C63.10, section 6.4

Section(s) in RSS:

Requirement(s):

RSS-210, section B.6 (a) i to iii

Reference(s):

ANSI C63.10, section 6.4

Performed by:

Patricio Montenegro,  
M.Sc.-Ing.

Date(s) of test:

May 22, 2025

Result:

Test passed

Test not passed

### 6.4.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716	2023-01-03	2026-01-03	V
EMI test receiver	ESW26	Rohde & Schwarz	E01775	2025-02-28	2026-02-28	C
Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060	2024-11-28	2025-11-28	C
Cable set no. 1 for semi-anechoic chamber SAC3 (9 kHz to 30 MHz)	RG 223/U - 350cm	AME HF-Technik	E01527	2024-08-06	2026-02-06	V
	RG 214/U - 500cm	AME HF-Technik	E01736	2024-03-14	2025-09-14	V

Note(s)

1. C = Calibration
2. V = Verification

#### 6.4.2 Limits

According to § 15.225(a)-(c):

The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15848 microvolts/meter at 30 meters.

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.

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.

According to RSS-210 section B.6 (a) i to iii:

The field strength of any emissions shall not exceed the following limits:

- i. 15.848 mV/m (84 dB $\mu$ V/m) at 30 m, within the band 13.553-13.567 MHz
- ii. 334  $\mu$ V/m (50.5 dB $\mu$ V/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz
- iii. 106  $\mu$ V/m (40.5 dB $\mu$ V/m) at 30 m, within the bands 13.110-13.410 MHz and 13.710-14.010 MHz

In case of measurements that 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.

#### 6.4.3 Test procedure

The emission within the band 13.110 MHz – 14.010 MHz is measured using the

- manual measurement procedure as described in clause 5.3.
- automatic measurement procedure as described in clause 5.3.

#### 6.4.4 Test results

Test distance:	<input checked="" type="checkbox"/> 3 m		
Antenna alignment:	<input type="checkbox"/> in parallel	<input checked="" type="checkbox"/> in line	
EUT position:	<input type="checkbox"/> Position X	<input checked="" type="checkbox"/> Position Y	<input type="checkbox"/> Position Z

Note(s):

1. Pre-measurements were performed to declare the worst-case which is documented below.
2. The chart shows the calculated limit at 3 m.

##### 6.4.4.1 USB mode



Figure 10: Chart of emission within the band 13.110 MHz to 14.010 MHz, EUT in position Y, without tag, antenna in line at 3 m distance

<i>Freq. (MHz)</i>	<i>EUT Pos.</i>	<i>Det.</i>	<i>Field strength (dB<math>\mu</math>V/m at 3 m)</i>	<i>Rec. factor</i>	<i>Calc. field strength (dB<math>\mu</math>V/ m)</i>	<i>at dist. (m)</i>	<i>Limit (dB<math>\mu</math>V/ m)</i>	<i>at dist. (m)</i>	<i>Mar. (dB)</i>	<i>Pol</i>	<i>Azim. (deg)</i>	<i>Corr. (dB/m)</i>	<i>Res</i>
13.560	Y	QP	49.7	-21.4	28.3	30	84.0	30	55.7	I	91	19.7	P

Table 19: Results of emission within the band 13.110 MHz to 14.010 MHz, without tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Rec. factor</i>	Recalculation factor
<i>Calc.</i>	Calculated
<i>at dis</i>	at distance
<i>Mar.</i>	Margin
<i>Pol.</i>	= Polarization of the measurement antenna
I	Polarization of the measurement antenna in line
O	Polarization of the measurement antenna parallel
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	Result
P	Passed
Np	Not passed

## 6.5 Carrier frequency stability

Section(s) in 47 CFR Part 15: Requirement(s): 15.225(e)  
 Reference(s): ANSI C63.10, section 6.8

Section(s) in RSS: Requirement(s): RSS-210, annex B6 (b)  
 Reference(s): RSS-Gen, section 6.11

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Performed by: Patricio Montenegro, Date(s) of test: May 27, 2025  
 M.Sc.-Ing.

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Result:  Test passed  Test not passed

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### 6.5.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
EMI test receiver	ESU26	Rohde & Schwarz	W00002	2024-08-09	2025-08-09	C
Multimeter	METRAHit 2+	GMC-I Gossen-Metrawatt	W01452	2024-09-17	2025-09-17	C
Climatic chamber (340 l)	VC³ 4034	Vötsch Industrietechnik	C00015	See note 6		C
Universal IAQ instrument	testo 400	Testo SE & Co. KGaA	SEB01701	24.09.2024	24.09.2025	C
Thermoelectric couple (type K)	368	Testo SE & Co. KGaA	SEB01703	26.09.2024	26.09.2025	C
Laboratory power supply	3231.1	Statron	E00017	See note 1		N/A
USB measurement box	---	---	SEB01231	See note 2		N/A
RF field probe set	RF2	LANGER EMV-Technik	E00270	See note 3		N/A

Note(s):

1. The power supply is not calibrated, the level was set using a calibrated multimeter.
2. The USB measurement box is not calibrated, it's only used as breakout box to supply power to the USB port.
3. Only used for relative measurements.
4. C = Calibration
5. V = Verification
6. The climatic chamber is not calibrated, the temperature is measured by using the calibrated listed Universal IAQ instrument.

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## 6.5.2 Limits

According to §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. 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.

According to RSS-210 section B.6 (b):

The carrier frequency stability shall not exceed  $\pm 100$  ppm.

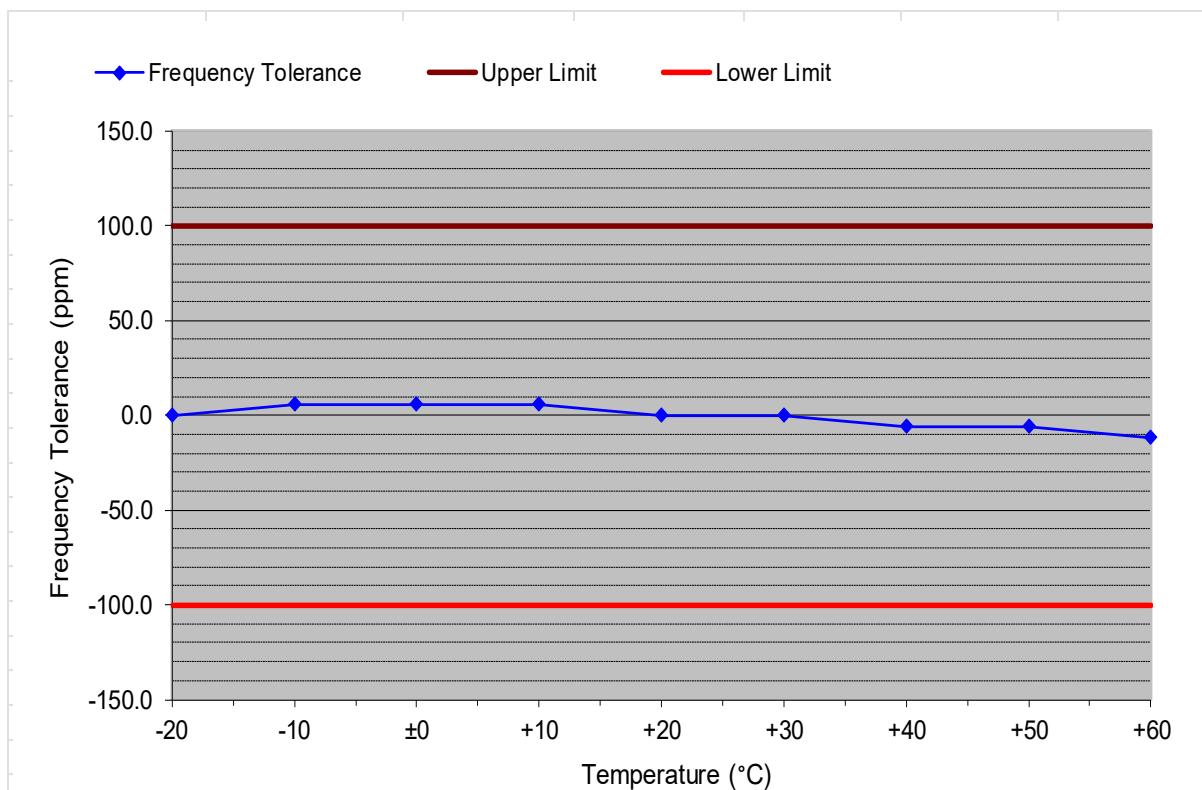
## 6.5.3 Test procedure

The carrier frequency stability is measured using the test procedure as described in clause 5.7.

## 6.5.4 Test results

### 6.5.4.1 USB mode

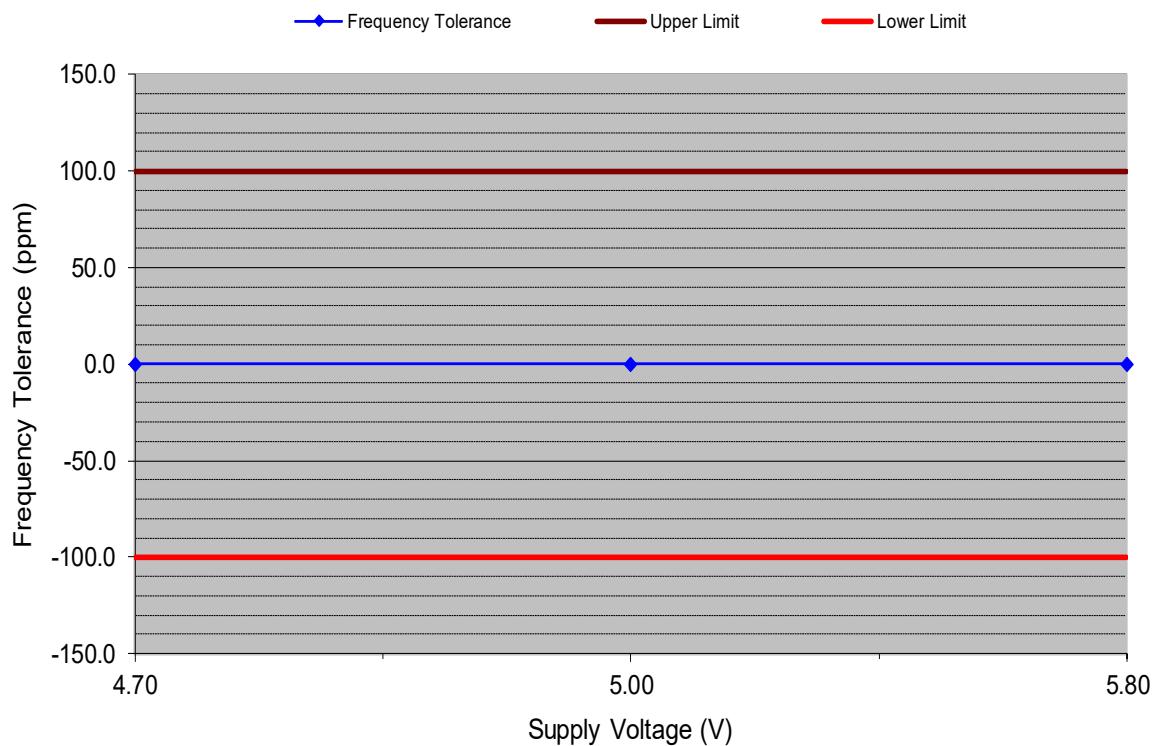
#### Carrier frequency stability vs. temperature



Supply voltage:		5 V	Frequency under nominal conditions:			13.55991987 MHz
Temperature (°C)	Frequency (MHz)	Frequency (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13.559920	0	0.0	+100.0	-100.0	100.0
-10	13.560000	80	5.9	+100.0	-100.0	94.1
±0	13.560000	80	5.9	+100.0	-100.0	94.1
+10	13.560000	80	5.9	+100.0	-100.0	94.1
+20	13.559920	0	0.0	+100.0	-100.0	100.0
+30	13.559920	0	0.0	+100.0	-100.0	100.0
+40	13.559840	-80	-5.9	+100.0	-100.0	94.1
+50	13.559840	-80	-5.9	+100.0	-100.0	94.1
+60	13.559760	-160	-11.8	+100.0	-100.0	88.2

Result: Passed

## Carrier frequency stability vs. supply voltage



Temperature: +20 °C  
Frequency under normal conditions: 13.559920 MHz

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
4.70	13.559920	0	0.0	+100.0	-100.0	100.0
5.00	13.559920	0	0.0	+100.0	-100.0	100.0
5.80	13.559920	0	0.0	+100.0	-100.0	100.0

Result: Passed

## 6.6 Emissions below 30 MHz outside the operating frequency band(s) specified

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.225 (d) ANSI C63.10, clause 6.4
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section B.6 (a) iv ANSI C63.10, clause 6.4

Performed by:	Patrício Montenegro, M.Sc.-Ing.	Date of test:	May 22, 2025
Result:	<input checked="" type="checkbox"/> Test passed	<input type="checkbox"/> Test not passed	

### 6.6.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716	2023-01-03	2026-01-03	V
EMI test receiver	ESW26	Rohde & Schwarz	E01775	2025-02-28	2026-02-28	C
Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060	2024-11-28	2025-11-28	C
Cable set no. 1 for semi-anechoic chamber SAC3 (9 kHz to 30 MHz)	RG 223/U - 350cm	AME HF-Technik	E01527	2024-08-06	2026-02-06	V
	RG 214/U - 500cm	AME HF-Technik	E01736	2024-03-14	2025-09-14	V
Test software	ELEKTRA ELEMI-EAS (V5.11)	Rohde & Schwarz	E01776	---	---	N/A

#### Note(s)

1. C = Calibration
2. V = Verification

## 6.6.2 Limits

According to §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 (MHz)	Field strength ( $\mu$ V/m)	Field strength ( $dB\mu$ V/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz) (266.67 – 4.90)	48.52 – 13.80	300
0.490 – 1.705	24000/F(kHz) (48.98 – 14.08)	33.80 – 22.97	30
1.705 – 30	30	29.54	30

Table 20: General radiated emission limits up to 30 MHz according to §15.209

According to RSS-210, section B.6 (a) iv:

RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz.

Frequency (MHz)	Field strength ( $\mu$ A/m)	Field strength ( $dB\mu$ A/m)	Measurement distance (m)
0.009 – 0.490	6.37/F(kHz) (0.708 – 0.013)	-2.999 – -37.721	300
0.490 – 1.705	63.7/F(kHz) (0.13 – 0.037)	-17.721 – -28.636	30
1.705 – 30	0.08	-21.94	30

Table 21: General radiated emission limits up to 30 MHz according to section 8.9 of RSS-Gen

In case of measurements that 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 20 and Table 21, using the recalculation factor as described in clause 5.3.

## 6.6.3 Test procedure

The radiated emissions below 30 MHz are measured using the

- manual measurement procedure as described in clause 5.3.
- automatic measurement procedure as described in clause 5.3.

## 6.6.4 Test results

Test distance:	<input checked="" type="checkbox"/> 3 m		
Antenna alignment:	<input checked="" type="checkbox"/> in parallel (O)	<input checked="" type="checkbox"/> in line (I)	
EUT position:	<input checked="" type="checkbox"/> Position X	<input checked="" type="checkbox"/> Position Y	<input type="checkbox"/> Position Z

### Note(s):

1. Pre-measurements were performed to declare the worst-case which is documented below.
2. Apart from the documented emissions, all other emissions were greater than 20 dB below the limit.
3. The operation frequency at 13.56 MHz is not in consideration in this test.
4. The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-Gen section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377 Ohms. For example, the measurement at frequency X kHz resulted in a level of Y dBuV/m, which is equivalent to  $Y - 51.5 = Z$  dBuA/m, which has the same margin, W dB, to the corresponding RSS-Gen limit as it has to 15.209(a) limit.

### 6.6.4.1 USB mode

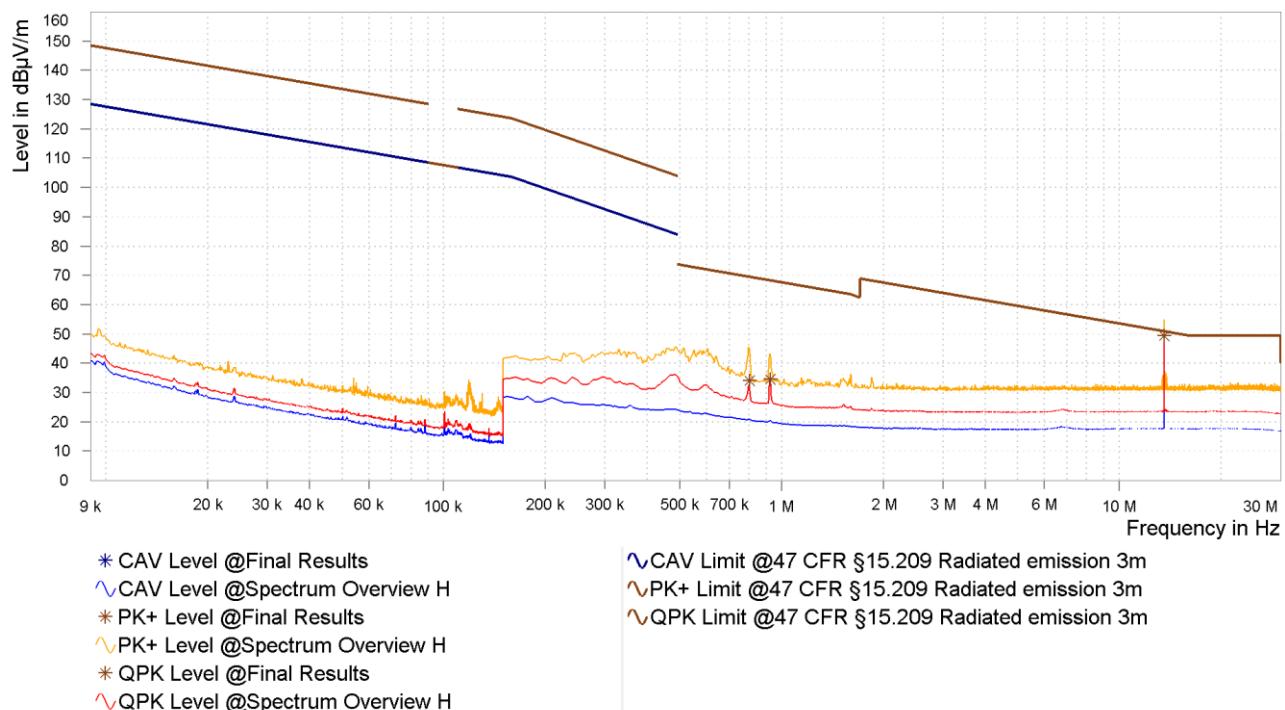


Figure 11: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization in line, without tag

<i>Freq. (MHz)</i>	<i>EUT Pos.</i>	<i>Det</i>	<i>Field strength (dB<math>\mu</math>V/m at 3 m)</i>	<i>Rec. factor</i>	<i>Calc. field strength (dB<math>\mu</math>V/ m)</i>	<i>at dist . (m)</i>	<i>Limit (dB<math>\mu</math>V/ m)</i>	<i>at dist. (m)</i>	<i>Mar. (dB)</i>	<i>Pol</i>	<i>Azim. (deg)</i>	<i>Corr. (dB/m)</i>	<i>Res</i>
0.803	Y	QP	38.6	-40.0	-1.4	30	29.5	30	30.9	I	94	19.6	P
0.924	Y	QP	34.7	-40.0	-5.3	30	28.3	30	33.6	I	97	19.6	P

Table 22: Final results of radiated emissions test below 30 MHz according to § 15.209, without tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Rec. factor</i>	= Recalculation factor
<i>Calc.</i>	= Calculated
<i>at dis</i>	= at distance
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
I	= Polarization of the measurement antenna in line
O	= Polarization of the measurement antenna parallel
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
P	= Passed
Np	= Not passed

<i>Freq. (MHz)</i>	<i>EUT Pos.</i>	<i>De t.</i>	<i>Calc. field strength (dB<math>\mu</math>A/m at 3 m)</i>	<i>Rec. factor</i>	<i>Calc. field strength (dB<math>\mu</math>A/ m)</i>	<i>at dist. (m)</i>	<i>Limit (dB<math>\mu</math>A/ m)</i>	<i>at dist. (m)</i>	<i>Mar. (dB)</i>	<i>Pol</i>	<i>Azim. (deg)</i>	<i>Corr. (dB/m)</i>	<i>Res</i>
0.803	Y	QP	-12.9	-40.0	-52.9	30	-22.0	30	30.9	I	94	-31.9	P
0.924	Y	QP	-16.8	-40.0	-56.8	30	-23.2	30	33.6	I	97	-31.9	P

Table 23: Final results of radiated emissions test below 30 MHz according to RSS-210, without tag

Note:

1. The calculated magnetic field strength (dB $\mu$ A/m at 3 m) is the measured electric field strength (dB $\mu$ V/m at 3 m) minus 51.5 dB.

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Rec. factor</i>	= Recalculation factor
<i>Calc.</i>	= Calculated
<i>at dis</i>	= at distance
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
I	= Polarization of the measurement antenna in line
O	= Polarization of the measurement antenna parallel
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
P	= Passed
Np	= Not passed

#### 6.6.4.2 RS-485 mode

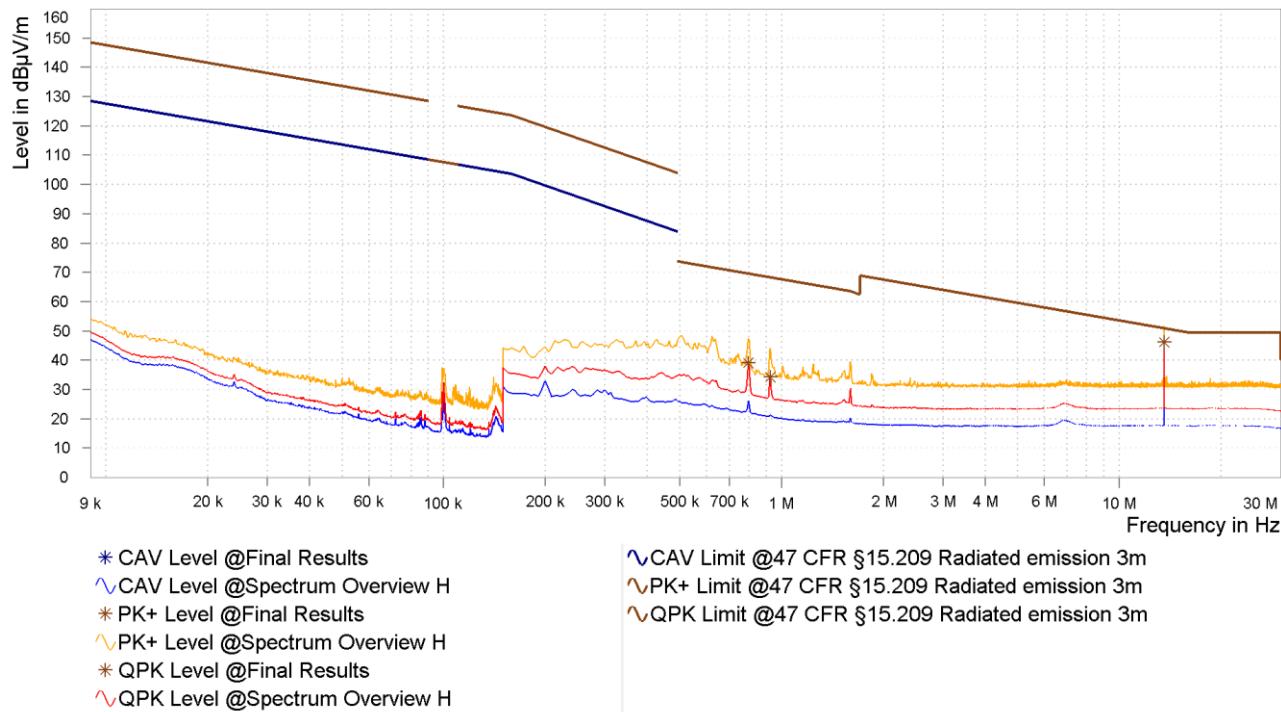


Figure 12: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization parallel, without tag

<i>Freq. (MHz)</i>	<i>EUT T Po s.</i>	<i>Det</i>	<i>Field strength (dB<math>\mu</math>V/m at 3 m)</i>	<i>Rec. factor</i>	<i>Calc. field strength (dB<math>\mu</math>V/ m)</i>	<i>at dist. (m)</i>	<i>Limit (dB<math>\mu</math>V/ m)</i>	<i>at dist. (m)</i>	<i>Mar. (dB)</i>	<i>Pol</i>	<i>Azim. (deg)</i>	<i>Corr. (dB/m)</i>	<i>Res</i>
0.798	Y	QP	36.7	-40.0	-3.3	30	29.6	30	32.9	O	160	19.6	P
0.924	Y	QP	35.4	-40.0	-4.6	30	28.3	30	32.9	O	158	19.6	P

Table 24: Final results of radiated emissions test below 30 MHz according to § 15.209, without tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Rec. factor</i>	= Recalculation factor
<i>Calc.</i>	= Calculated
<i>at dis</i>	= at distance
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
I	= Polarization of the measurement antenna in line
O	= Polarization of the measurement antenna parallel
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
P	= Passed
Np	= Not passed

<i>Freq. (MHz)</i>	<i>EUT Pos.</i>	<i>De t.</i>	<i>Calc. field strength (dB<math>\mu</math>A/m at 3 m)</i>	<i>Rec. factor</i>	<i>Calc. field strength (dB<math>\mu</math>A/ m)</i>	<i>at dist. (m)</i>	<i>Limit (dB<math>\mu</math>A/ m)</i>	<i>at dist. (m)</i>	<i>Mar. (dB)</i>	<i>Pol</i>	<i>Azim. (deg)</i>	<i>Corr. (dB/m)</i>	<i>Res</i>
0.798	Y	QP	-14.8	-40.0	-54.8	30	-21.9	30	32.9	O	160	-31.9	P
0.924	Y	QP	-16.1	-40.0	-56.1	30	-23.2	30	32.9	O	158	-31.9	P

Table 25: Final results of radiated emissions test below 30 MHz according to RSS-210, without tag

Note:

2. The calculated magnetic field strength (dB $\mu$ A/m at 3 m) is the measured electric field strength (dB $\mu$ V/m at 3 m) minus 51.5 dB.

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Rec. factor</i>	= Recalculation factor
<i>Calc.</i>	= Calculated
<i>at dis</i>	= at distance
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
I	= Polarization of the measurement antenna in line
O	= Polarization of the measurement antenna parallel
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
P	= Passed
Np	= Not passed

#### 6.6.4.3 Wiegand mode

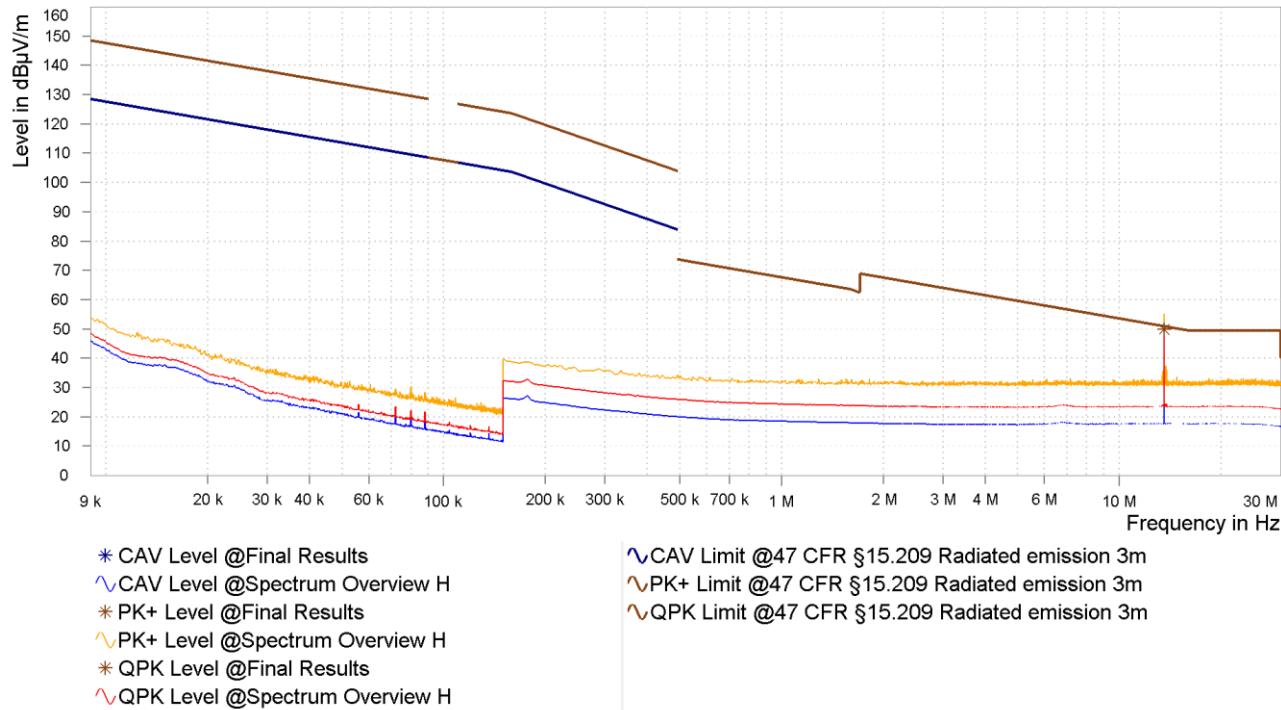


Figure 13: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization in line, without tag

## 6.7 Spurious emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.225 (d) ANSI C63.10, clause 6.5
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section B.6 (a) iv ANSI C63.10, clause 6.5

Performed by:	Patrício Montenegro, M.Sc.-Ing.	Date of test:	May 16, 2025 May 21, 2025
Result:	<input checked="" type="checkbox"/> Test passed <input type="checkbox"/> Test not passed		

### 6.7.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716	2023-01-03	2026-01-03	V
EMI test receiver	ESW26	Rohde & Schwarz	E01775	2025-02-28	2026-02-28	C
TRILOG broadband antenna	VULB 9162	Schwarzbeck Mess-Elektronik	E00643	2024-04-17	2027-04-17	C
Cable set no. 2 for semi-anechoic chamber SAC3 (30 MHz to 18 GHz)	S04272B - 200cm SF104E/11PC3 5/11PC35/2000 MM SF104EA/11PC 35/11PC35/100 00MM	AME HF-Technik Huber & Suhner Huber & Suhner	E01285 E01435 E01439	2024-08-22 2024-08-21 2024-05-06	2026-02-22 2026-02-21 2025-11-06	V V V
Test software	ELEKTRA ELEMI-EAS (V5.11)	Rohde & Schwarz	E01776	---	---	N/A

#### Note(s)

1. C = Calibration
2. V = Verification

## 6.7.2 Limits

According to §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.

According to RSS-210, section B.6 (a) iv:

RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz.

<i>Frequency (MHz)</i>	<i>Field strength (<math>\mu</math>V/m)</i>	<i>Field strength (dB<math>\mu</math>V/m)</i>	<i>Measurement distance (m)</i>
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 26: General radiated emission limits  $\geq$  30 MHz according to §15.209 and RSS-Gen

## 6.7.3 Test procedure

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

- manual measurement procedure as described in clause 5.4.
- automatic measurement procedure as described in clause 5.4.

## 6.7.4 Test results

Test distance:	<input checked="" type="checkbox"/> 3 m		
Polarization:	<input checked="" type="checkbox"/> horizontal	<input checked="" type="checkbox"/> vertical	
EUT position:	<input type="checkbox"/> Position X	<input checked="" type="checkbox"/> Position Y	<input type="checkbox"/> Position Z

### Note(s):

1. Pre-measurements were performed to declare the worst-case which is documented below.

### 6.7.4.1 USB mode

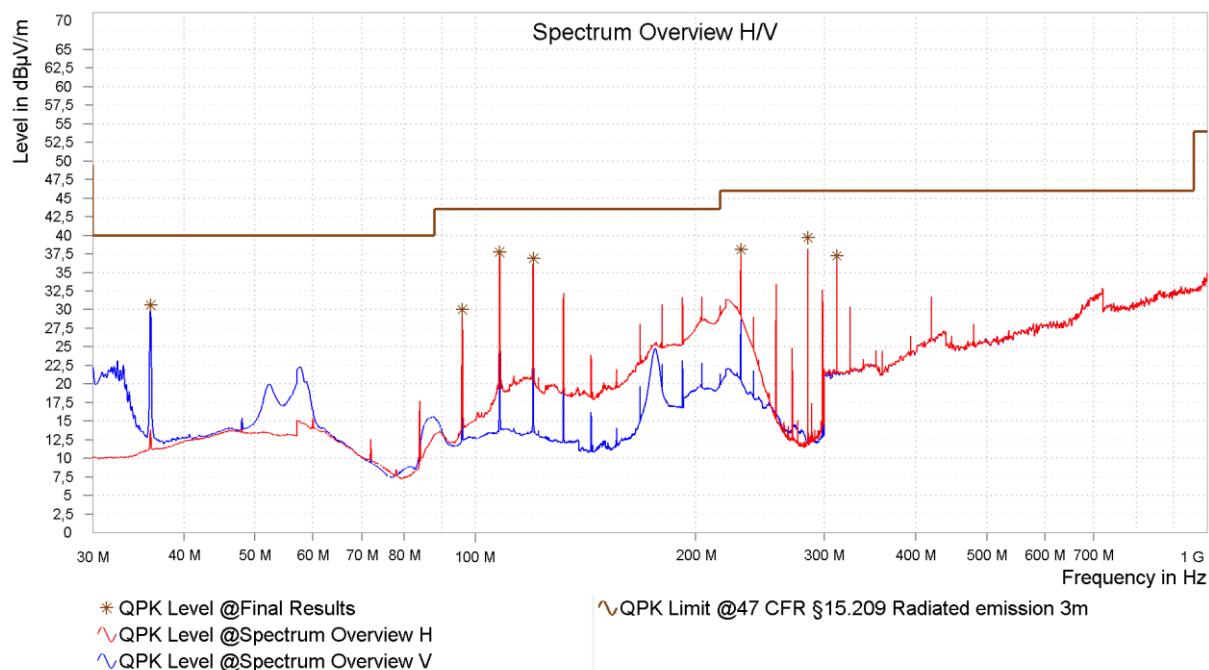


Figure 14: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, antenna polarization horizontal and vertical, with tag

Freq. (MHz)	EUT Pos.	QP Field strength (dB $\mu$ V/m at 3 m)	QP Limit (dB $\mu$ V/m) at 3 m	QP Margin (dB)	Corr. (dB/m)	Pol.	Azim. (deg)	Height (m)	Result
36.000	Y	30.7	40.0	9.3	12	V	100	1.00	Passed
96.000	Y	30.1	43.5	13.4	12	H	168	3.18	Passed
108.000	Y	37.7	43.5	5.8	13	H	180	2.68	Passed
120.000	Y	36.9	43.5	6.6	11	H	19	2.81	Passed
230.520	Y	38.1	46.0	7.9	13	H	7	1.24	Passed
284.760	Y	39.8	46.0	6.2	15	H	158	1.00	Passed
311.880	Y	37.2	46.0	8.8	15	H	7	1.02	Passed

Table 27: Results of radiated emissions test from 30 MHz to 1 GHz, with tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Det.</i>	= Detector
<i>Pol.</i>	= Polarization of the measurement antenna
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor

#### 6.7.4.2 RS-485 mode

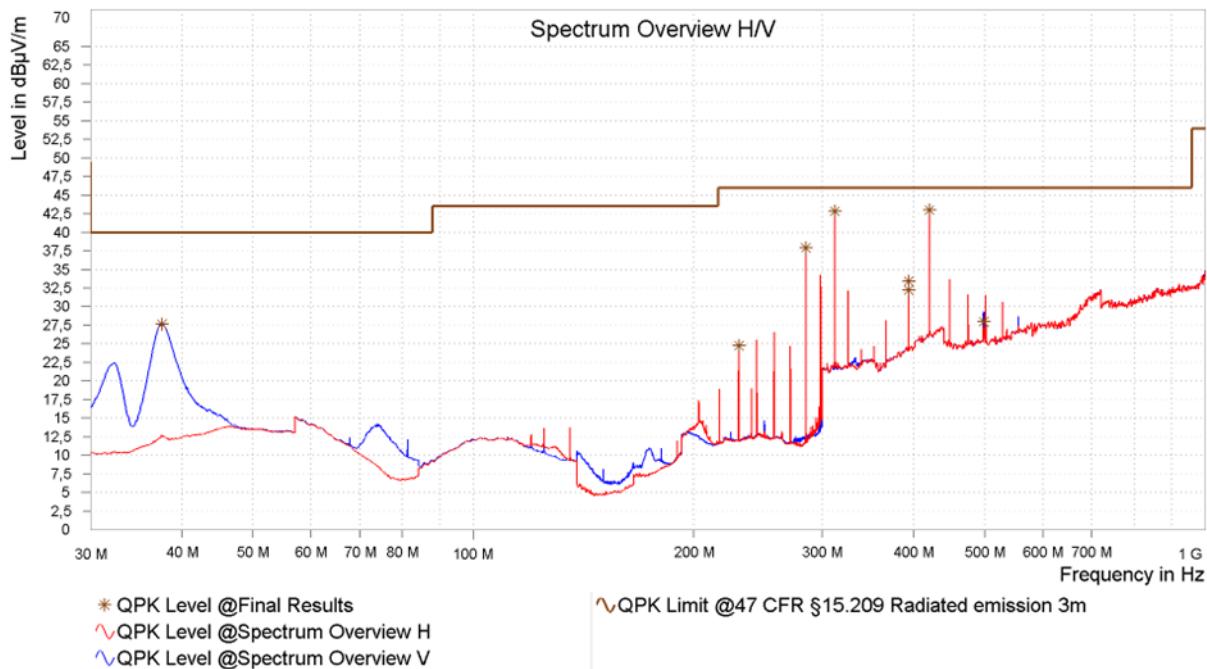


Figure 15: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, antenna polarization horizontal and vertical, with tag

Freq. (MHz)	EUT Pos.	QP Field strength (dB $\mu$ V/m at 3 m)	QP Limit (dB $\mu$ V/m) at 3 m	QP Margin (dB)	Corr. (dB/m)	Pol.	Azim. (deg)	Height (m)	Result
37.560	Y	27.7	40.0	12.3	13	V	243	1.01	Passed
230.520	Y	24.7	46.0	21.3	13	H	233	1.22	Passed
284.760	Y	38.0	46.0	8.0	15	H	237	1.00	Passed
311.880	Y	42.8	46.0	3.2	15	H	239	1.00	Passed
393.240	Y	32.3	46.0	13.7	18	V	165	1.03	Passed
393.240	Y	33.4	46.0	12.6	18	H	237	1.00	Passed
420.360	Y	43.0	46.0	3.0	18	H	233	2.10	Passed
497.820	Y	28.0	46.0	18.0	20	V	61	1.06	Passed

Table 28: Results of radiated emissions test from 30 MHz to 1 GHz, with tag

with:  
 Freq. = Frequency  
 EUT Pos. = EUT Position  
 Det. = Detector  
 Pol. = Polarization of the measurement antenna  
 Azim. (deg) = Azimuth (degree)  
 Corr. = Correction factor

#### 6.7.4.3 Wiegand mode

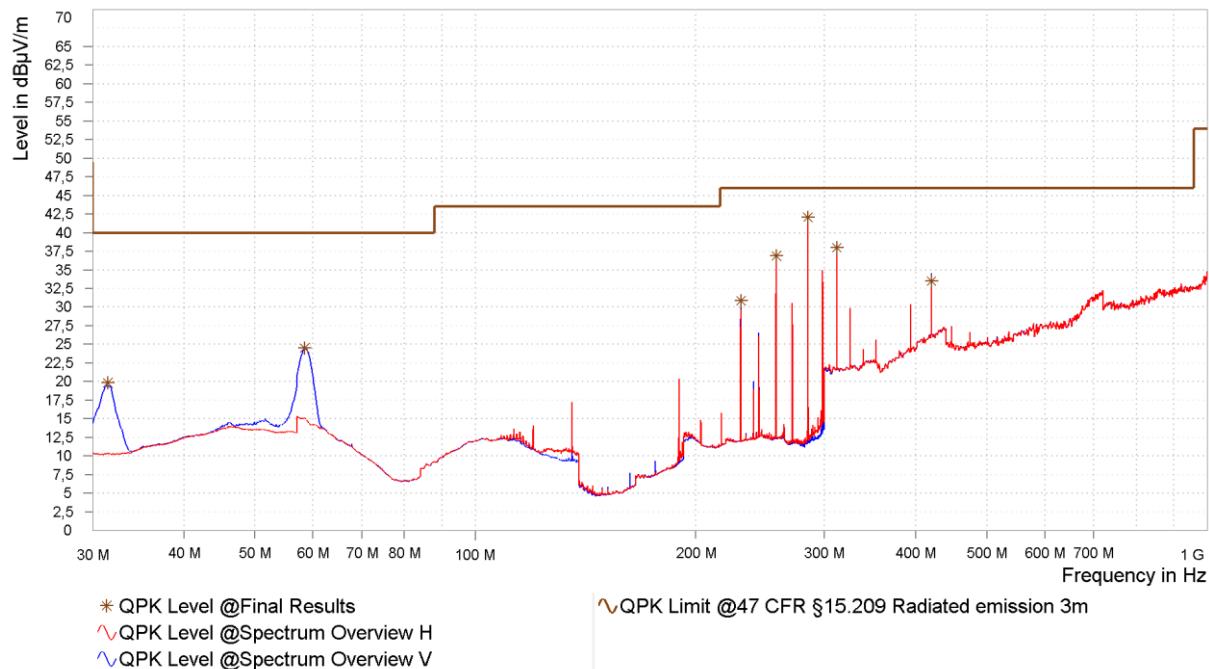


Figure 16: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, antenna polarization horizontal and vertical, with tag

Freq. (MHz)	EUT Pos.	QP Field strength ( $\text{dB}\mu\text{V}/\text{m}$ at 3 m)	QP Limit ( $\text{dB}\mu\text{V}/\text{m}$ at 3 m)	QP Margin (dB)	Corr. (dB/m)	Pol.	Azim. (deg)	Height (m)	Result
31.440	Y	19.9	40.0	20.1	11	V	302	1.00	Passed
58.440	Y	24.5	40.0	15.5	14	V	-6	1.03	Passed
230.520	Y	30.9	46.0	15.1	13	V	181	1.01	Passed
257.640	Y	36.9	46.0	9.1	15	H	116	1.00	Passed
284.760	Y	42.1	46.0	3.9	15	H	122	1.00	Passed
311.880	Y	38.0	46.0	8.0	15	H	123	1.00	Passed
420.360	Y	33.5	46.0	12.5	18	V	290	1.27	Passed

Table 29: Results of radiated emissions test from 30 MHz to 1 GHz, with tag

with:  
 Freq. = Frequency  
 EUT Pos. = EUT Position  
 Det. = Detector  
 Pol. = Polarization of the measurement antenna  
 Azim. (deg) = Azimuth (degree)  
 Corr. = Correction factor

## 6.8 Spurious emissions above 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.225 (d) ANSI C63.10, clause 6.6
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section B.6 (a) iv ANSI C63.10, clause 6.6

Performed by:	Patrício Montenegro, M.Sc.-Ing.	Date of test:	May 26, 2025 June 12, 2025
Result:	<input checked="" type="checkbox"/> Test passed <input type="checkbox"/> Test not passed		

### 6.8.1 Test equipment

Description	Designation	Manufacturer	Inventory number	Last check	Next check	Check type
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716	2023-01-03	2026-01-03	V
EMI test receiver	ESW26	Rohde & Schwarz	E01775	2025-02-28	2026-02-28	C
Preamplifier (1 GHz to 18 GHz)	ALS05749	Aldetec	W01007	2025-06-12	2026-06-12	V
Double ridged broadband horn antenna	BBHA 9120D	Schwarzbeck Mess-Elektronik	W00053	2022-09-27	2025-09-27	C
Cable set anechoic chamber (FS-SAC) (1 GHz to 26.5 GHz)	262-0942-1500	Teledyne Storm Microwave	E00435	2024-02-19	2025-08-19	V
	SF104EA/11PC 35/11PC35/500 0MM	Huber & Suhner	E01438	2025-06-11	2026-12-11	V
	262-0942-1500	Teledyne Storm Microwave	E00433	2024-02-19	2025-08-19	V
Test software	ELEKTRA ELEMI-EAS (V5.11)	Rohde & Schwarz	E01776	---	---	N/A

#### Note(s)

1. C = Calibration
2. V = Verification

## 6.8.2 Limits

According to §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.

According to RSS-210, section B.6 (a) iv:

RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz.

<i>Frequency (MHz)</i>	<i>Field strength (<math>\mu</math>V/m)</i>	<i>(dB<math>\mu</math>V/m)</i>	<i>Measurement distance (m)</i>
Above 960	500	54	3

Table 30: General radiated emission limits above 960 MHz according to §15.209 and RSS-Gen

## 6.8.3 Test procedure

The radiated emissions above 1 GHz are measured using the

- manual measurement procedure as described in clause 5.5.
- automatic measurement procedure as described in clause 5.5.

## 6.8.4 Test results

Test distance:	Exploratory tests:	<input type="checkbox"/> 1 m	<input type="checkbox"/> 0.5 m
	Final tests:	<input checked="" type="checkbox"/> 3 m	<input type="checkbox"/> 1.5 m
Polarization:	<input checked="" type="checkbox"/> horizontal	<input checked="" type="checkbox"/> vertical	
EUT position:	<input type="checkbox"/> Position X	<input checked="" type="checkbox"/> Position Y	<input type="checkbox"/> Position Z

### Note(s):

- 1 Pre-measurements were performed to declare the worst case which is documented below.
- 2 Apart from the documented emissions, all other emissions were greater than 20 dB below the limit.

### 6.8.4.1 USB mode

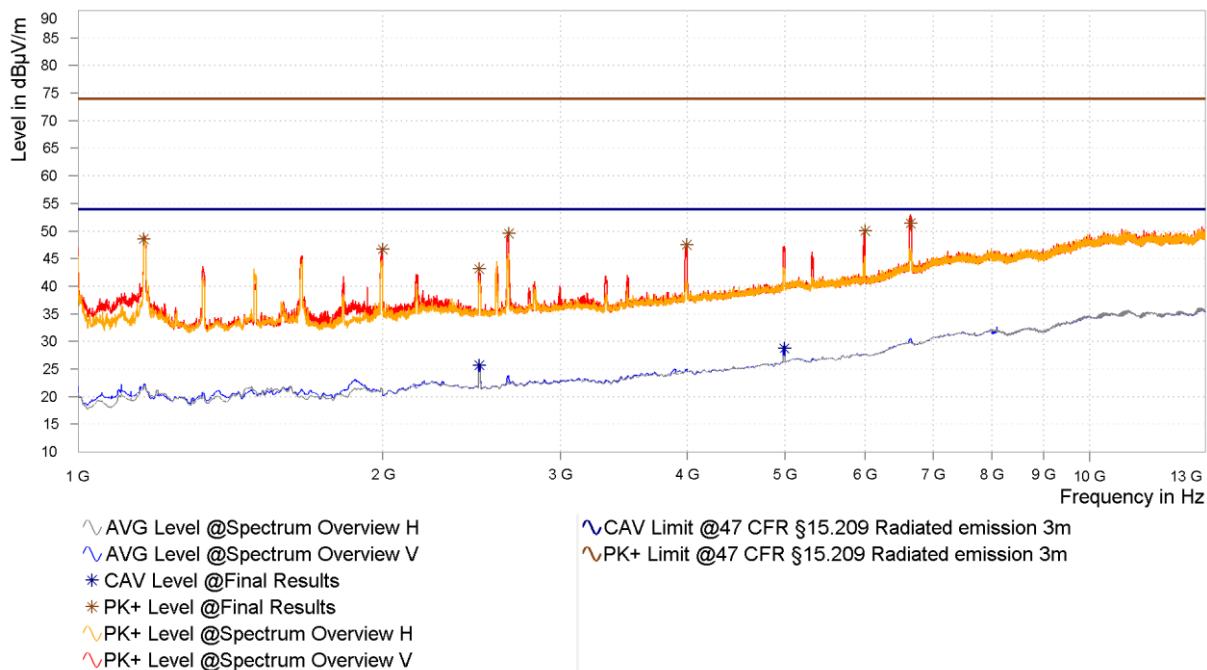


Figure 17: Chart of emissions test from 1 GHz to 13 GHz, EUT position Y, antenna polarization vertical and horizontal, with tag

<i>Freq. (MHz)</i>	<i>EUT Pos.</i>	<i>Pk level (dB<math>\mu</math>V/ m) at 3 m</i>	<i>Pk limit (dB<math>\mu</math>V/ m) at 3 m</i>	<i>Pk Mar. (dB)</i>	<i>AV level (dB<math>\mu</math>V/ m) at 3 m</i>	<i>AV limit (dB<math>\mu</math>V/ m) at 3 m</i>	<i>AV Mar. (dB)</i>	<i>Corr. (dB/m)</i>	<i>Pol.</i>	<i>Azim. (deg)</i>	<i>Height (m)</i>	<i>Res.</i>
1161.00	Y	48.5	74.0	25.5	---	---	---	-18.4	V	186	3.65	P
2000.00	Y	46.7	74.0	27.3	---	---	---	-16.3	V	233	1.67	P
2490.00	Y	43.2	74.0	30.8	---	---	---	-14.2	V	147	2	P
2491.00	Y	---	---	---	25.7	54.0	28.3	-14.2	V	149	2.63	P
2666.50	Y	49.6	74.0	24.4	---	---	---	-13.6	V	183	1.49	P
3994.00	Y	47.5	74.0	26.5	---	---	---	-9.0	V	266	1.18	P
4991.50	Y	---	---	---	28.8	54.0	25.2	-6.1	V	152	2.51	P
5996.50	Y	50.0	74.0	24.0	---	---	---	-4.1	V	100	1.67	P
6651.50	Y	51.5	74.0	22.5	---	---	---	-2.2	V	182	1	P

Table 31: Results of radiated emissions test &gt; 1 GHz, with tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
P	= Passed
Np	= Not passed

#### 6.8.4.2 RS-485 mode

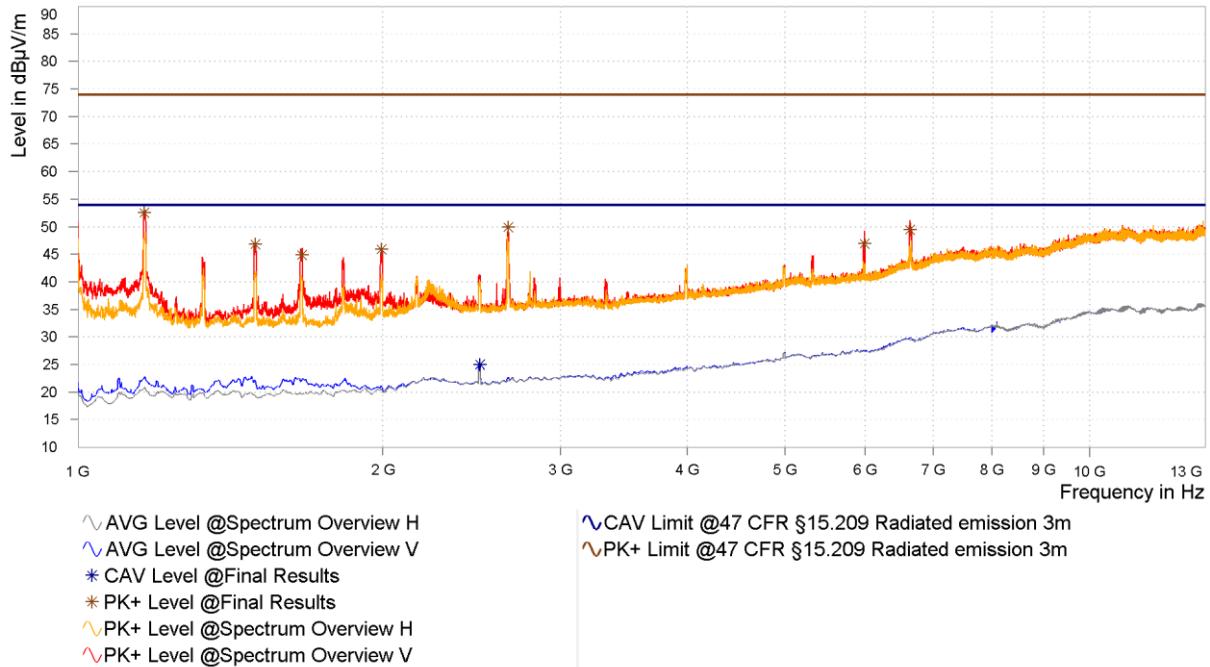


Figure 18: Chart of emissions test from 1 GHz to 13 GHz, EUT position Y, antenna polarization vertical and horizontal, with tag

Freq. (MHz)	EUT Pos.	Pk level (dB $\mu$ V/m) at 3 m	Pk limit (dB $\mu$ V/m) at 3 m	Pk Mar. (dB)	AV level (dB $\mu$ V/m) at 3 m	AV limit (dB $\mu$ V/m) at 3 m	AV Mar. (dB)	Corr. (dB/m)	Pol.	Azim. (deg)	Height (m)	Res.
1163.00	Y	52.6	74.0	21.4	---	---	---	-18.4	V	179	2.47	P
1497.00	Y	46.9	74.0	27.1	---	---	---	-18.0	V	-5	1.68	P
1663.50	Y	45.0	74.0	29.0	---	---	---	-18.1	V	326	2.98	P
1994.00	Y	45.9	74.0	28.1	---	---	---	-16.3	V	45	1.37	P
2493.50	Y	---	---	---	25.0	54.0	29.0	-14.2	V	149	1.55	P
2660.50	Y	49.9	74.0	24.1	---	---	---	-13.7	V	213	2.2	P
5987.50	Y	47.0	74.0	27.0	---	---	---	-4.1	V	327	1.29	P
6643.50	Y	49.5	74.0	24.5	---	---	---	-2.2	V	182	1.9	P

Table 32: Results of radiated emissions test > 1 GHz, with tag

with:

<i>Freq.</i>	= Frequency
<i>EUT Pos.</i>	= EUT Position
<i>Mar.</i>	= Margin
<i>Pol.</i>	= Polarization of the measurement antenna
<i>Azim. (deg)</i>	= Azimuth (degree)
<i>Corr.</i>	= Correction factor
<i>Res.</i>	= Result
<i>P</i>	= Passed
<i>Np</i>	= Not passed

#### 6.8.4.3 Wiegand mode

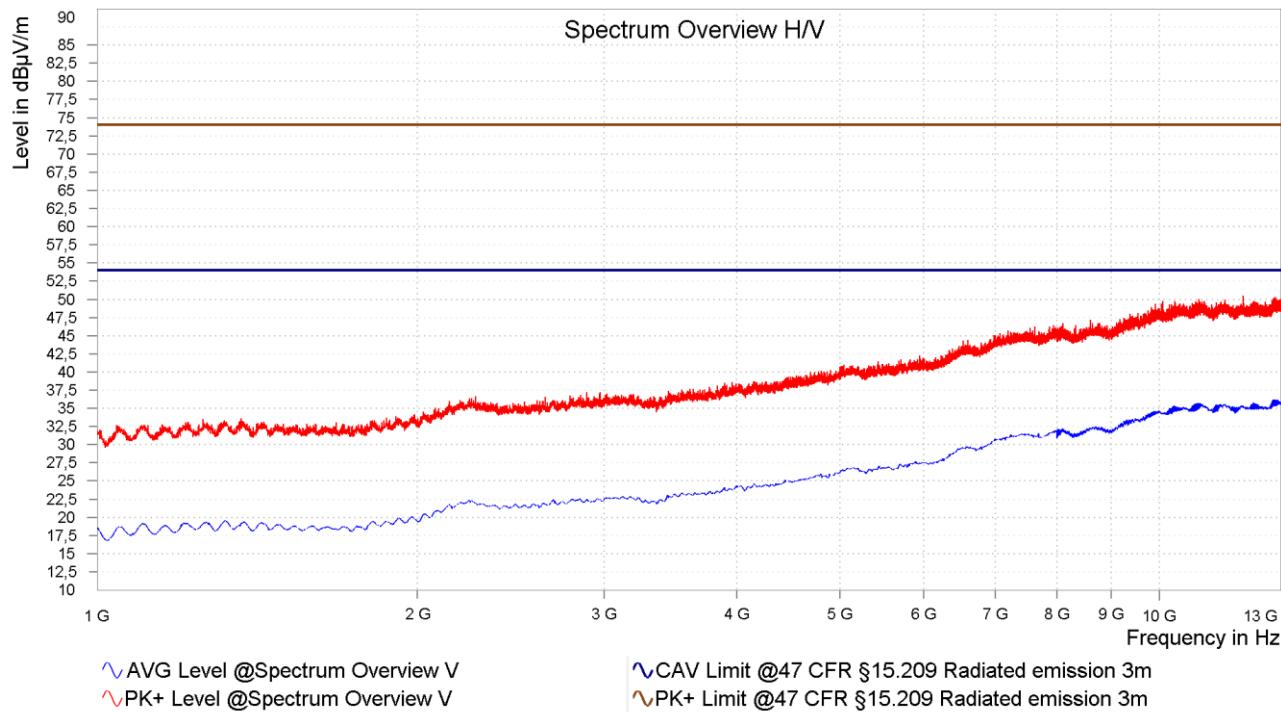


Figure 19: Chart of emissions test from 1 GHz to 13 GHz, EUT position Y, antenna polarization vertical, without tag

## 7 Measurement uncertainties

Description	Uncertainty	$U_{Limit}$	Note(s)	$k=$
AC power line conducted emission	$\pm 3.0$ dB	$\pm 3.4$ dB	2b), 3b)	2
Carrier frequency stability	$\pm 0.1$ ppm	$\pm 0.5$ ppm	2a), 3d)	2
Bandwidth tests	$\pm 2.0$ %	$\pm 5$ %	2a), 3a)	2
Radiated emissions				
from 9 kHz to 30 MHz	$\pm 3.8$ dB	$\pm 4.0$ dB	2b), 3b)	2
from 30 MHz to 1 GHz	$\pm 6.1$ dB	$\pm 6.3$ dB	2b), 3b)	2
from 1 GHz to 6 GHz	$\pm 4.6$ dB	$\pm 5.2$ dB	2b), 3b)	2
from 6 GHz to 18 GHz	$\pm 5.0$ dB	$\pm 5.5$ dB	2b), 3b)	2
from 18 GHz to 26.5 GHz	$\pm 5.4$ dB	$\pm 6.0$ dB	2b), 3c)	2
from 26.5 GHz to 40 GHz	$\pm 6.2$ dB	$\pm 6.5$ dB	2b), 3c)	2

### Note(s):

- 1 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.
- 2 The values of the measurement uncertainty as listed above are calculated according to
  - a) ETSI TR 100 028-1 V1.4.1 and ETSI TR 100 028-2 V1.4.1
  - b) CISPR 16-4-2:2011-06 + A1:2014-02 + A2:2018-08
- 3 The limits for the measurement uncertainty as listed above are
  - a) derived from ETSI EN 300 328 V2.1.1
  - b) equal to  $U_{CISPR}$  taken from CISPR 16-4-2:2011-06 + A1:2014-02 + A2:2018-08
  - c) defined by the test laboratory
- 4 Simple acceptance is applied as the decision rule while keeping the specified limits ( $U_{Limit}$ ) for the expanded measurement uncertainty (i.e. Test Uncertainty Ratio  $TUR \geq 1:1$ ). That means, compliance is based on the recorded level by the lab irrespective of the expanded measurement uncertainty value but with a limitation to it. For details on simple acceptance and the level of risk (such as false accept, false reject and false statistical assumptions) associated with this decision rule see ISO/IEC Guide 98-4:2012 and ILAC G8:09/2019 "Guidelines on Decision Rules and Statements of Conformity" ("Binary Statement for Simple Acceptance Rule" according to clause 4.2.1).
- 5 All used test instruments as well as the test accessories are calibrated at regular intervals.

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**8 Revision history**

<i>Revision</i>	<i>Date</i>	<i>Issued by</i>	<i>Description of modifications</i>
0	2025-07-21	Patricio Montenegro, M.Sc.-Ing.	First edition

Template: RF\_15.225\_RSS-210\_V1.14