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Test report no.:

250049-AU01+W01

for:

HERMOS AG

HFMux16 Transponder Reader

HF WIP - Regal 16x RFID

according to:

47 CFR Part 15, §15.225

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

Accreditation:

Deutsche Akkreditierungsstelle D-PL-12155-01-00

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Department of Innovation, Science and Economic Development Canada (ISED)
as a recognized testing laboratory
CAB identifier: DE0011
Company number: 3472A

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The technical accuracy is guaranteed through the quality management of Element Materials Technology Straubing GmbH.

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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	25
15.215(c)	20 dB bandwidth	---	Passed	---	32
15.225 (a) – (c)	Operation within the band 13.110 MHz – 14.010 MHz	RSS-210 section B.6 (a) i to iii	Passed	---	36
15.225(e)	Carrier frequency stability	RSS-210, section B.6 (b)	Passed	---	40
15.225(d)	Emissions below 30 MHz outside the operating frequency band(s) specified	RSS-210, section B.6 (a) iv	Passed	---	44
15.225(d)	Spurious emissions from 30 MHz to 1 GHz	RSS-210, section B.6 (a) iv	Passed	---	48
15.225(d)	Spurious emissions above 1 GHz	RSS-210, section B.6 (a) iv	Not applicable	3, 4	---

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 10th 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 10th harmonic of the intentional radiator

Straubing, June 10, 2025

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

Approved by
Konrad Graßl
Reviewer

2 Referenced publications

Publication	*Title*
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:	HFMux16 Transponder Reader		
Model name:	HF WIP - Regal 16x RFID		
Serial number(s):	2502HAG36916		
Applicant:	HERMOS AG		
Manufacturer:	HERMOS AG		
Hardware version:	HF_MUX16_RevD, 2.13.129		
Software version:	STM32_HF16x_DE13_AppV1802		
Short description:	EUT is a RFID reader operating at the frequency 13.56 MHz.		
Additional modifications:	None		
FCC ID:	2AP5OHFMUX16		
Power supply:	DC supply via PoE		
	Nominal voltage:	48 V	
	Minimum voltage:	43 V	
	Maximum voltage:	56 V	
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:	13.110 MHz – 14.010 MHz		
Operating frequencies:	13.56 MHz		
Number of RF channels	1		
Highest internal frequency:	100 MHz		
Modulation	ASK		
Antenna:	Type:	PCB antenna with C-Network	
	Outer dimension:	85 x 54 mm	
	Inductance	0.5 µH	
	Width of wire	1.1 mm	
	Turns:	2	
	Connector:	☒ external	☐ internal
		☐ temporary	☐ none (integral antenna)

3.3 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*
HFMux16 Transponder Reader	HF WIP - Regal 16x RFID	2502HAG36916	HERMOS AG

Table 1: EUT used for testing

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RFID tag	13.56 MHz	---	HERMOS AG
AC power adapter	524179	31182718308	INTELLINET

Table 2: Support equipment used for testing

4.2 Mode of operation

- The EUT was in continuous interrogation mode at 13.56 MHz.
- A green LED indicated the correct reading of the RFID tag.
- During the tests in the climate chamber the EUT was powered via a PoE injector by two in series connected laboratory power supplies, for the rest of the tests the EUT was powered via PoE.
- As declared by the manufacturer the EUT has 16 identical antenna ports. Premeasurements were performed to determine the worse case, resulting on the antenna port 1.
- The tests were performed on the antenna port 1.

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:
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 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).

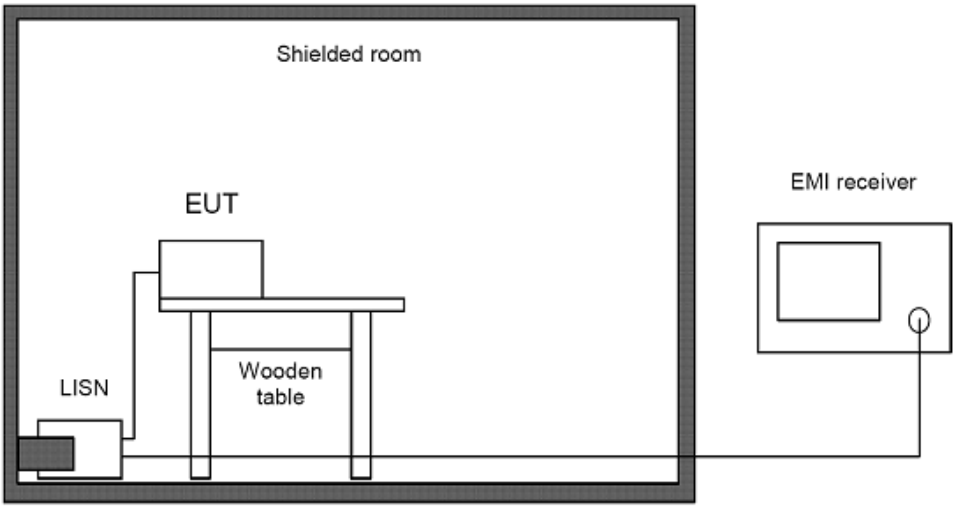


Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

Phase	*Frequency (MHz)*	*Reading value (dBµV)*	*AMN correction (dB)*	*Cable attenuation + 10 dB attenuator (dB)*	*Correction factor (Corr.) (dB)*	*Level (dBµV)*
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 = Artifical mains network correction + Cable attenuation + 10 dB

Level = Reading value + Correction factor = 10 dBµV + 11.5 dB = 21.5 dBµV

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 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 or RSS-Gen, 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 490 kHz < f ≤ 1.592 MHz	300 m 30 m	3 m	$-40 \log(d_{limit} / d_{measure})$
159 kHz < f ≤ 490 kHz 1.592 MHz < f ≤ 15.923 MHz	300 m 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 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 ≤ f < 150 kHz	200 Hz	≤ 100 Hz	Peak Quasi-peak Average
150 kHz ≤ f < 30 MHz	9 kHz	≤ 4.5 kHz	Peak Quasi-peak Average

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

Frequency (MHz)	*Reading value (dBµV)*	*Antenna correction (dB/m)*	*Cable attenuation (dB)*	*Correction factor (Corr.) (dB)*	*Level (dBµV/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 dBµV + 19.92 dB = 39.92 dBµV/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.

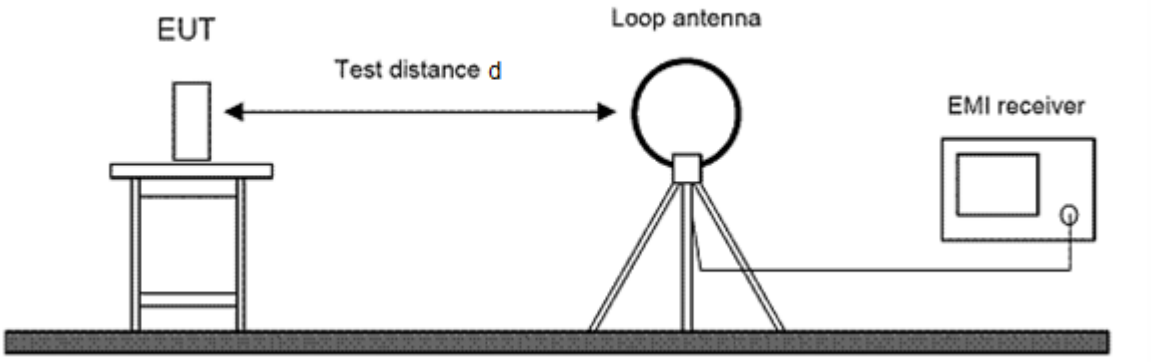


Figure 2: Setup for radiated emissions test below 30 MHz

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 (dBµV)*	*Antenna correction (dB/m)*	*Cable attenuation (dB)*	*Correction factor (Corr.) (dB)*	*Level (dBµV/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 dBµV + 12.77 dB = 42.77 dBµV/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.

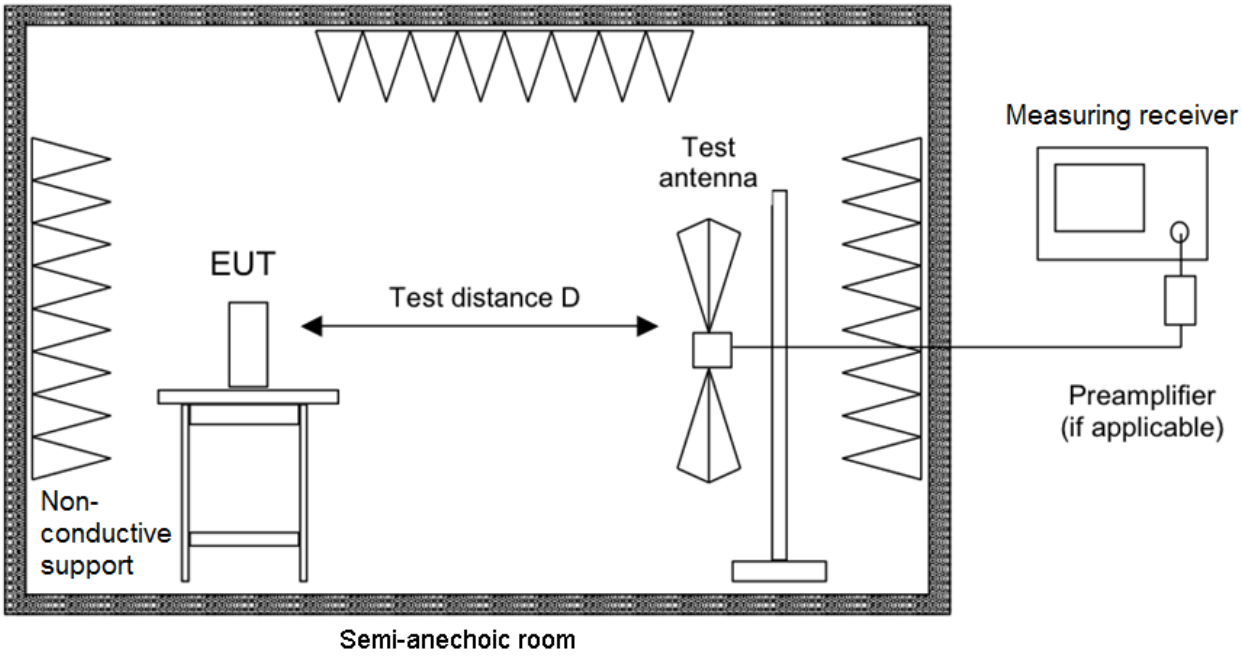


Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

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 (dBµV)*	*Antenna correction (dB/m)*	*Correction pre-amplifier (dB)*	*Cable attenuation (dB)*	*Correction factor (Corr.) (dB)*	*Level (dBµV/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 dBµV - 14.92 dB/m = 35.08 dBµV/m

FS-SAC:
Level = Reading value + Correction factor = 50.00 dBµV - 3.30 dB/m = 46.70 dBµV/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 ≥ 1 GHz	1 MHz	≤ 500 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.

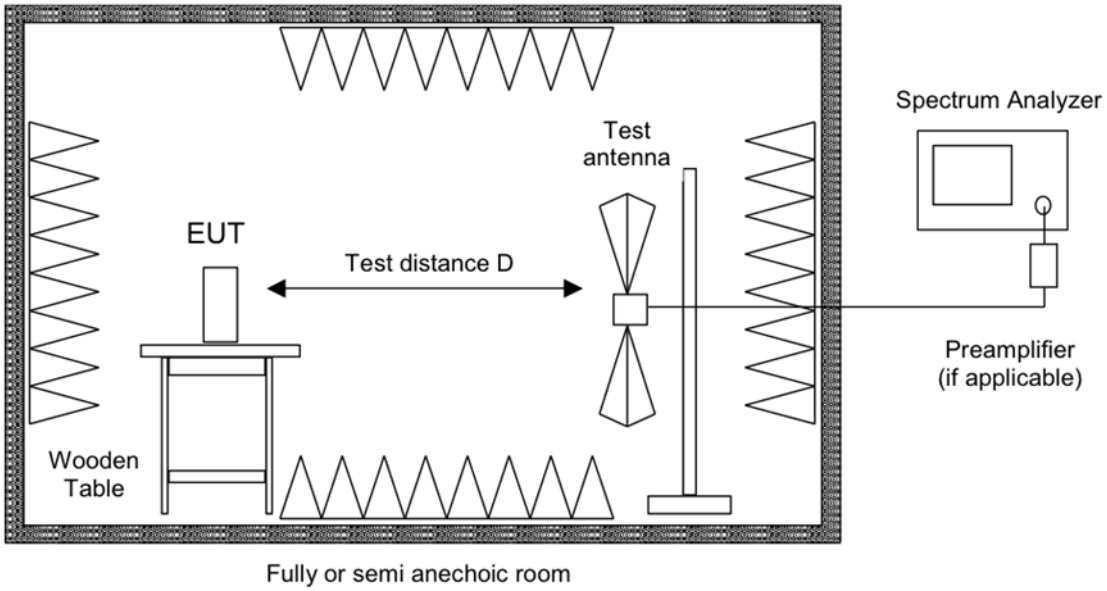


Figure 4: Setup for radiated emissions test above 1 GHz

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 dB bandwidth/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.

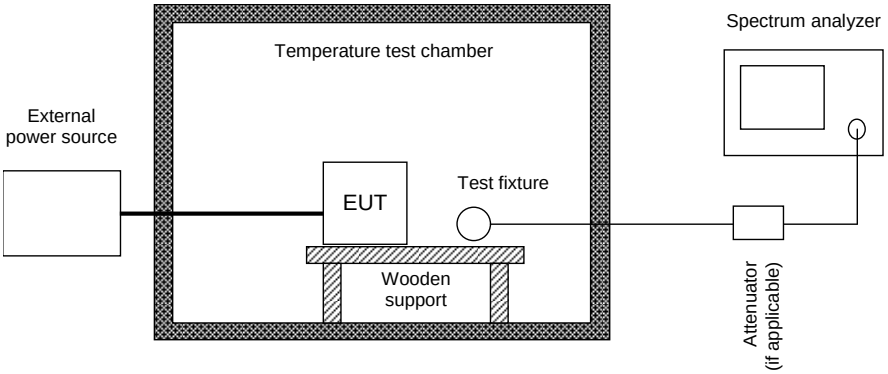


Figure 5: Test setup for carrier frequency stability measurement

6 Test results

This clause gives details about the test results as collected in the summary of test results on page 5.

For information about measurement uncertainties see page 52.

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

Ambient temperature	*Ambient humidity*	*Ambient pressure*
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):	15.207(a)
	Reference(s):	ANSI C63.10, clause 6.2
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 8.8
	Reference(s):	ANSI C63.10, clause 6.2

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	May 5, 2025
Result:	☒ Test passed	☐ 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
Attenuator (20 dB)	CA-SMAMF-20-18-5W-RDD	TACTRON ELEKTRONIK & Co.KG	W01727	2024-05-17	2025-11-17	VDT
Artificial mains network (AMN) with artificial hand connection	ENV432	Rohde & Schwarz	E01733	2024-12-19	2025-12-18	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
3. VDT = Verification during test

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 µH / 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 µH / 50 Ω 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 (dBµV)*	
	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.

Note(s)
1. According to KDB 174176 D01 Line Conducted FAQ v01r01 the intentional operator which operates below 30 MHz was first measured with the antenna connected to determine compliance with section 15.207 and RSS-Gen limits outside the transmitter´s fundamental emission band and then the antenna was replaced by a dummy load and the test was repeated to show compliance with section 15.207 and RSS-Gen limits within the transmitter´s fundamental emission band.

6.1.4 Test results

Note(s):
1. The test was performed at 120 V and 60 Hz.

Mode 1: Loop antenna of the EUT is connected to the output of the RF chip (normal sample).

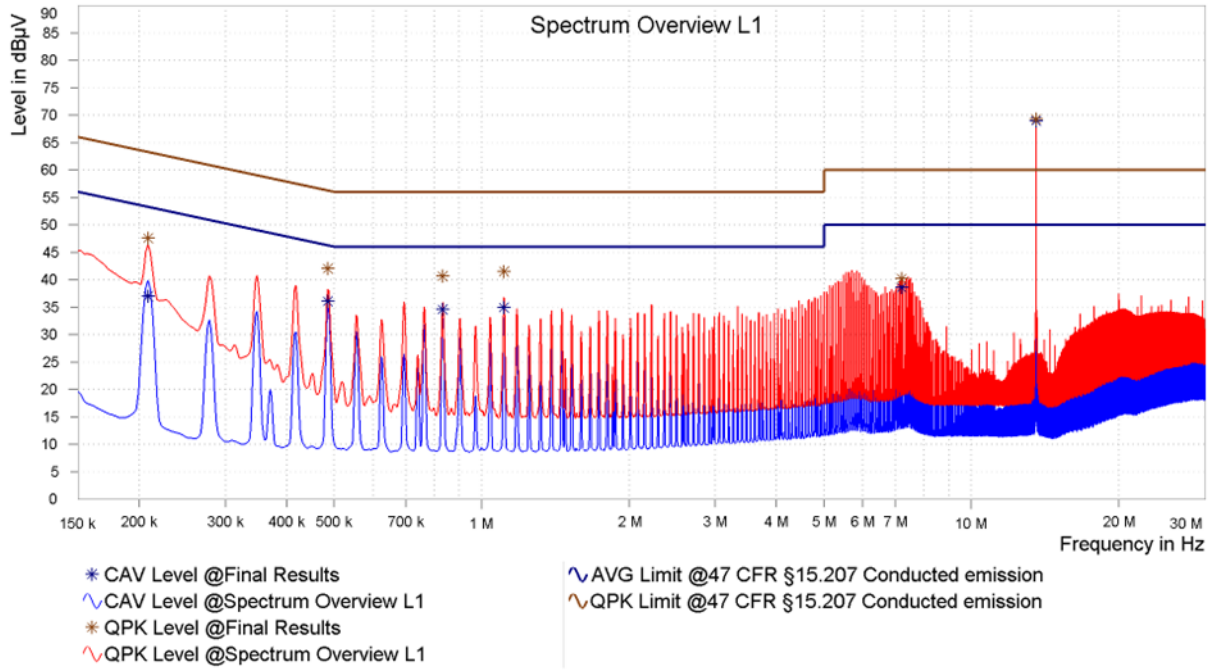


Figure 6: Chart of AC powerline conducted emissions on L1

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Line*	*PE*	*Corr. (dB)*	*Result*
0.209	47.6	---	63.3	15.7	L1	GND	20.3	Passed
0.209	---	37.1	53.3	16.2	L1	GND	20.3	Passed
0.485	42.1	---	56.3	14.2	L1	GND	20.3	Passed
0.485	---	36.1	46.3	10.2	L1	GND	20.3	Passed
0.832	40.6	---	56.0	15.4	L1	GND	20.3	Passed
0.832	---	34.6	46.0	11.5	L1	GND	20.3	Passed
1.111	41.6	---	56.0	14.5	L1	GND	20.3	Passed
1.111	---	35.0	46.0	11.0	L1	GND	20.3	Passed
7.215	40.2	---	60.0	19.8	L1	GND	20.6	Passed
7.217	---	38.6	50.0	11.4	L1	GND	20.6	Passed
13.560	69.4	---	60.0	-9.4	L1	GND	20.9	Not passed
13.560	---	69.0	50.0	-19.0	L1	GND	20.9	Not passed

Table 14: Results of AC powerline conducted emissions on L1

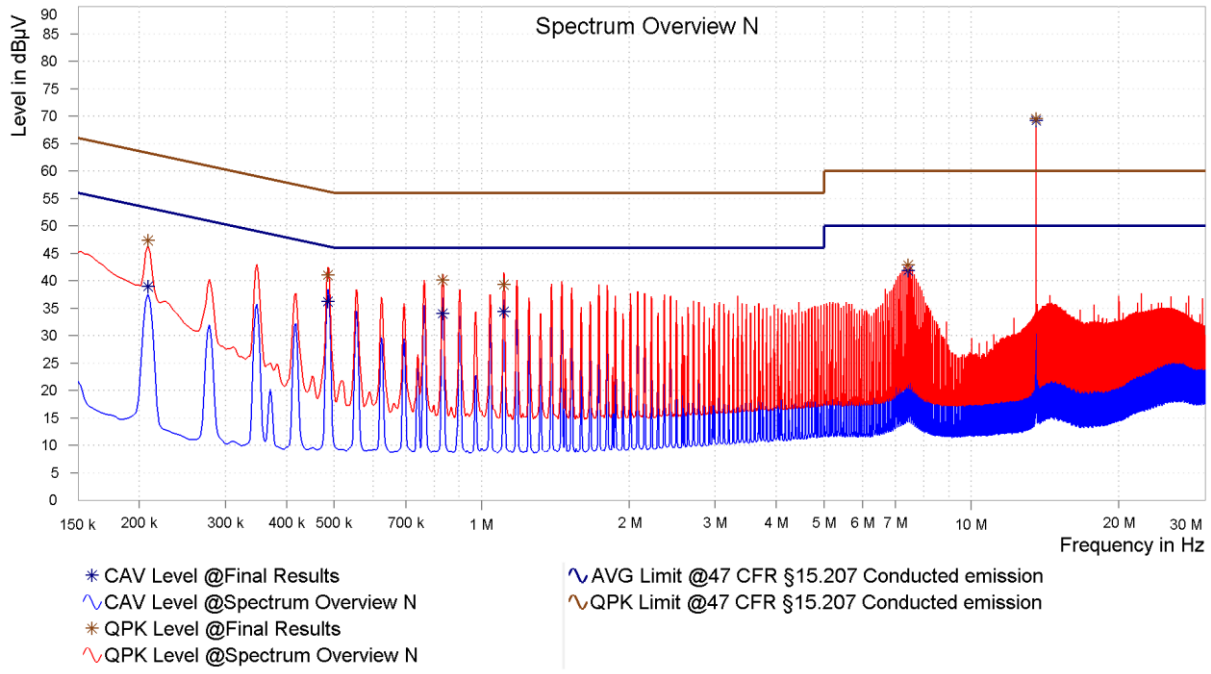


Figure 7: Chart of AC powerline conducted emissions on N

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Line*	*PE*	*Corr. (dB)*	*Result*
0.209	47.4	---	63.3	15.9	N	GND	20.3	Passed
0.209	---	39.0	53.3	14.3	N	GND	20.3	Passed
0.485	41.0	---	56.3	15.2	N	GND	20.3	Passed
0.485	---	36.2	46.3	10.0	N	GND	20.3	Passed
0.832	40.1	---	56.0	15.9	N	GND	20.3	Passed
0.832	---	34.0	46.0	12.0	N	GND	20.3	Passed
1.111	39.4	---	56.0	16.6	N	GND	20.3	Passed
1.111	---	34.4	46.0	11.6	N	GND	20.3	Passed
7.427	42.9	---	60.0	17.1	N	GND	20.7	Passed
7.427	---	41.9	50.0	8.1	N	GND	20.7	Passed
13.560	69.5	---	60.0	-9.5	N	GND	21.1	Not passed
13.560	---	69.2	50.0	-19.2	N	GND	20.9	Not passed

Table 15: Results of AC powerline conducted emissions on N

Note:
1. The test result is negative at the operation frequency. This test was repeated in mode 2.

Mode 2: Loop antenna of the EUT is disconnected and the output of the RF chip is terminated with a dummy load (according to note 1 in clause 7.1.3)

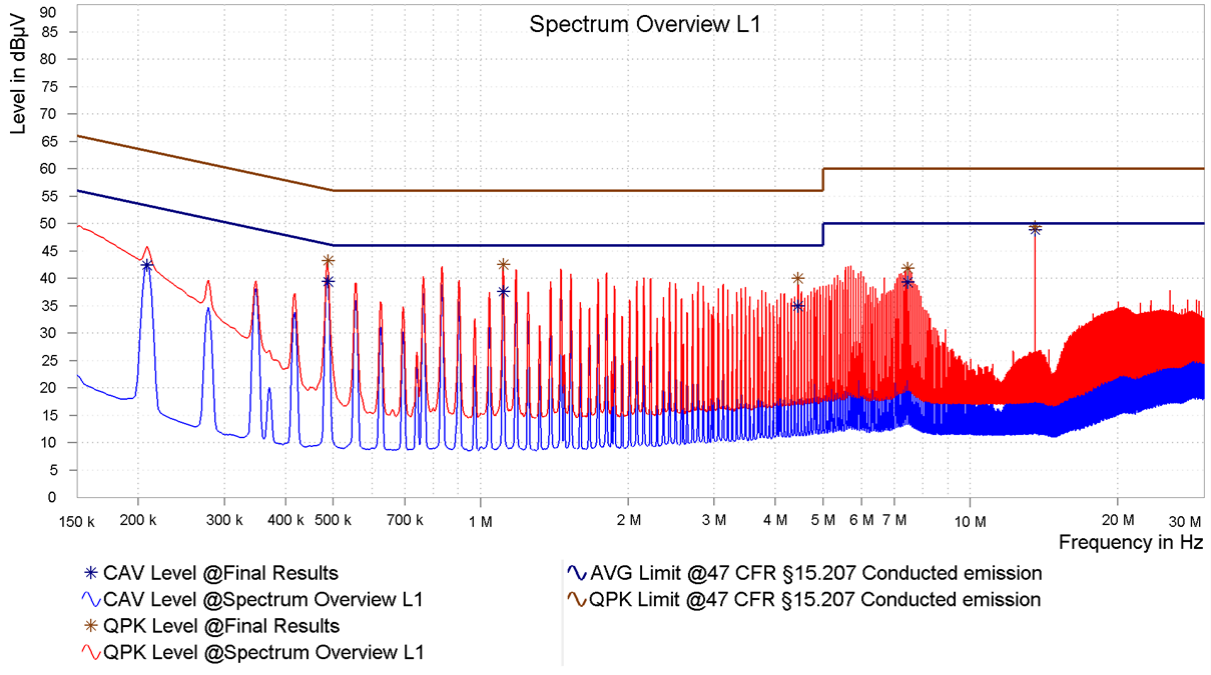


Figure 8: Chart of AC powerline conducted emissions on L1

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Line*	*PE*	*Corr. (dB)*	*Result*
0.164	45.3	---	65.3	20.0	L1	GND	20.25	Passed
0.209	---	42.4	55.3	12.9	L1	GND	20.25	Passed
0.488	43.2	---	56.2	13.1	L1	GND	20.25	Passed
0.488	---	39.4	46.2	6.8	L1	GND	20.25	Passed
1.113	42.5	---	56.0	13.5	L1	GND	20.3	Passed
1.113	---	37.6	46.0	8.4	L1	GND	20.3	Passed
4.450	40.1	---	56.0	16.0	L1	GND	20.5	Passed
4.450	---	34.9	46.0	11.1	L1	GND	20.5	Passed
7.440	41.9	---	60.0	18.2	L1	GND	20.64	Passed
7.440	---	39.4	50.0	10.6	L1	GND	20.64	Passed
13.560	49.4	---	60.0	10.6	L1	GND	20.91	Passed
13.560	---	48.9	50.0	1.2	L1	GND	20.91	Passed
0.164	45.3	---	65.3	20.0	L1	GND	20.25	Passed

Table 16: Results of AC powerline conducted emissions on L1

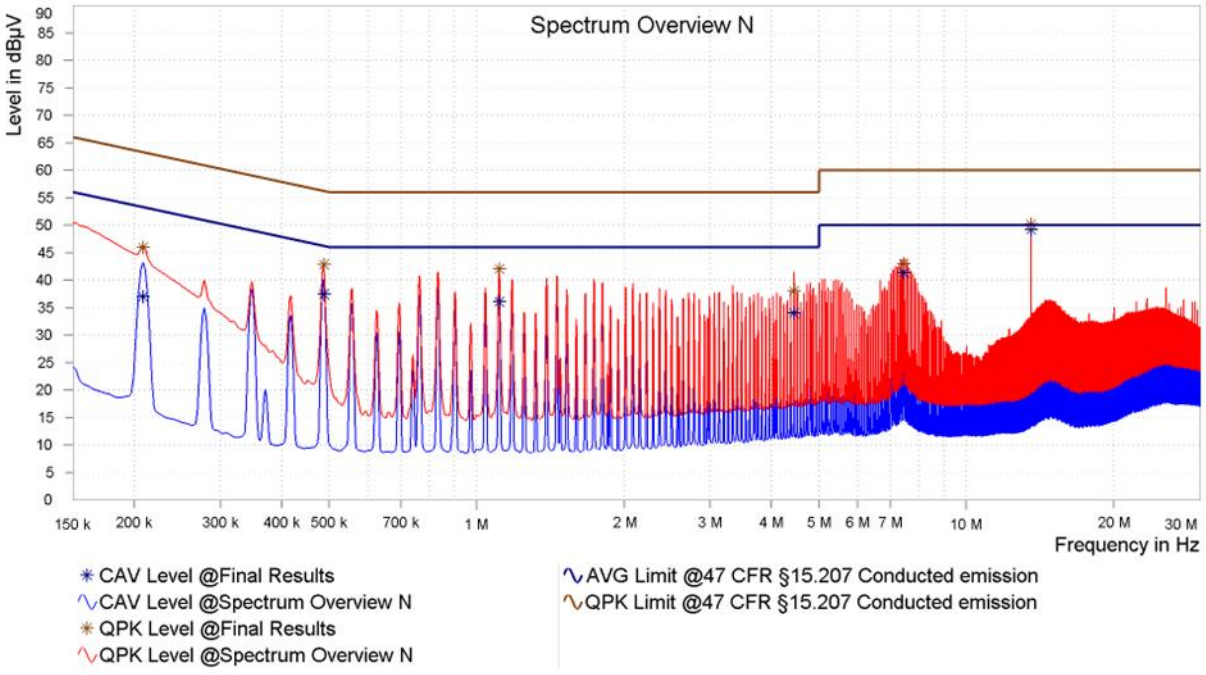


Figure 9: Chart of AC powerline conducted emissions on N

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Line*	*PE*	*Corr. (dB)*	*Result*
0.209	46.0	---	63.3	17.3	N	GND	20.3	Passed
0.209	---	37.0	53.3	16.3	N	GND	20.3	Passed
0.488	42.8	---	56.2	13.4	N	GND	20.3	Passed
0.488	---	37.5	46.2	8.7	N	GND	20.3	Passed
1.113	42.1	---	56.0	13.9	N	GND	20.3	Passed
1.113	---	36.1	46.0	9.9	N	GND	20.3	Passed
4.448	38.0	---	56.0	18.0	N	GND	20.5	Passed
4.448	---	34.0	46.0	12.0	N	GND	20.5	Passed
7.440	43.0	---	60.0	17.0	N	GND	20.7	Passed
7.440	---	41.4	50.0	8.6	N	GND	20.7	Passed
13.560	50.2	---	60.0	9.8	N	GND	21.1	Passed
13.560	---	49.2	50.0	0.8	N	GND	20.9	Passed

Table 17: Results of AC powerline conducted emissions on N

6.2 20 dB bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s):	15.215(c)	
	Reference(s):	ANSI C63.10 , clause 6.9	

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date(s) of test:	April 25, 2025
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	ESW44	Rohde & Schwarz	E00895	2025-01-09	2026-01-09	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	2024-04-26	2025-04-26	C
Laboratory power supply	3231.1	Statron	E01236	See note 1		N/A
Laboratory power supply	3252.1	Statron	E00016	See note 1		N/A
RF field probe set	RF2	LANGER EMV-Technik	E00270	See note 2		N/A
PoE injector	---	---	---	See note 3		N/A

Note(s)
1. The power supply is not calibrated, the level was set using a calibrated multimeter.
2. Only used for relative measurements.
3. Only used as breakout to supply power to the RJ45 port
4. 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 6.4.4) to each bandwidth measurement obtained in this test.

6.2.4 Test results

Note(s):
1. Pre-measurements were performed to declare the worst-case which is documented below.

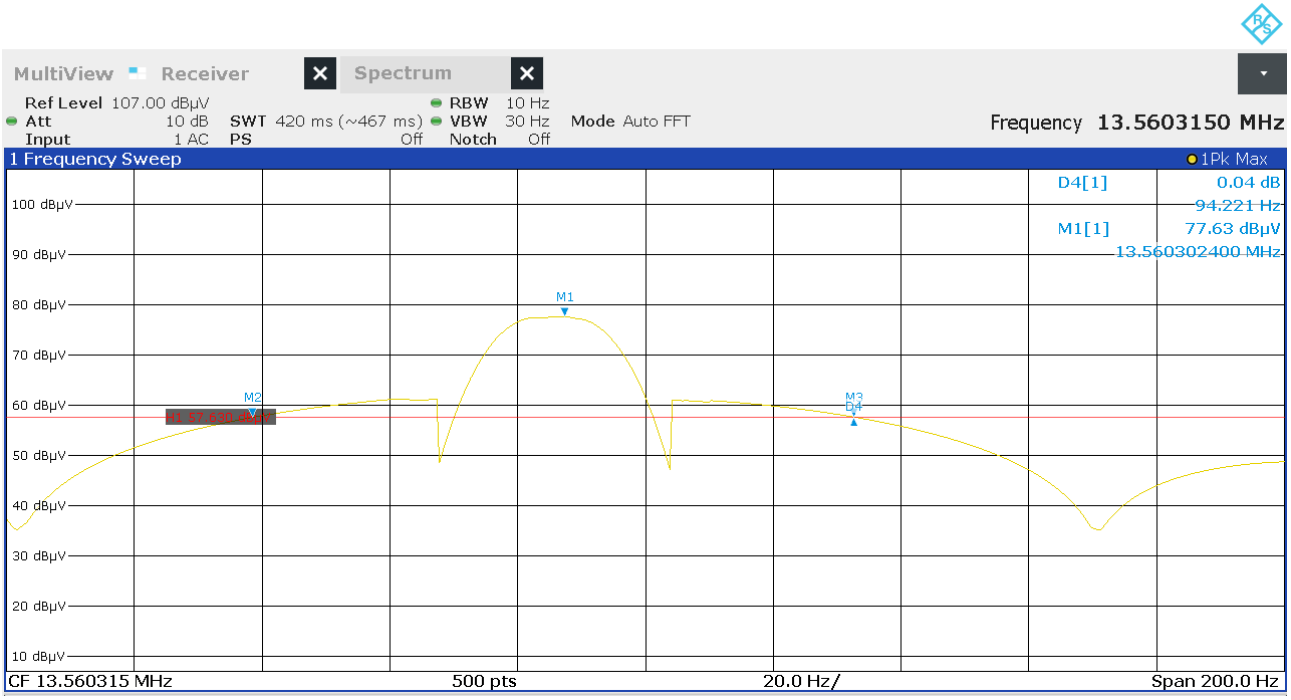


Figure 10: Chart of 20 dB bandwidth tests at normal conditions, with tag

20 dB bandwidth	*Band edge left*		*Band edge right*		*Result*
(kHz)	*Frequency (MHz)*	*Limit (MHz)*	*Frequency (MHz)*	*Limit (MHz)*	
0.094	13.560253	>13.553000	13.560347	<13.5670000	Passed

Table 18: Results of 20 dB bandwidth tests at normal conditions, with tag

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.560253	0.000	0.000	13.560253	>13.553000	7.253	Passed
	high	13.560347	0.020	0.000	13.560367	<13.567000	6.633	Passed
	Bandwidth	0.094 kHz			0.114 kHz			

Table 19: Results of 20 dB bandwidth tests at extreme conditions, with tag

with:
- $f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier at normal conditions
- $f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 20 dB below the carrier at normal conditions
- $f_{assigned}$ = assigned frequency in MHz
- $\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at normal conditions caused by temperature variation in kHz
- $\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at normal conditions caused by temperature variation in kHz
- $\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at normal conditions caused by voltage variation in kHz
- $\Delta f_{U(high)}$ = 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 6.4.4

Measured -20 dB emission bandwidth:
At nominal conditions: 0.094 kHz
Including variations in temperature and supply voltage: 0.114 kHz

6.3 Operation within the band 13.110 MHz – 14.010 MHz

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.225 (a)-(c) ANSI C63.10, section 6.4
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section B.6 (a) i to iii ANSI C63.10, section 6.4

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date(s) of test:	April 29, 2025
Result:	☒ Test passed	☐ Test not passed	

6.3.1 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

6.3.2 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 dBµV/m) at 30 m, within the band 13.553-13.567 MHz
ii. 334 µV/m (50.5 dBµV/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz
iii.106 µV/m (40.5 dBµV/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.

6.3.3 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 clause 5.3.

6.3.4 Test results

Test distance:	☒ 3 m		
Antenna alignment:	☒ in parallel	☒ in line	
EUT position:	☒ Position X	☒ Position Y	☒ 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.

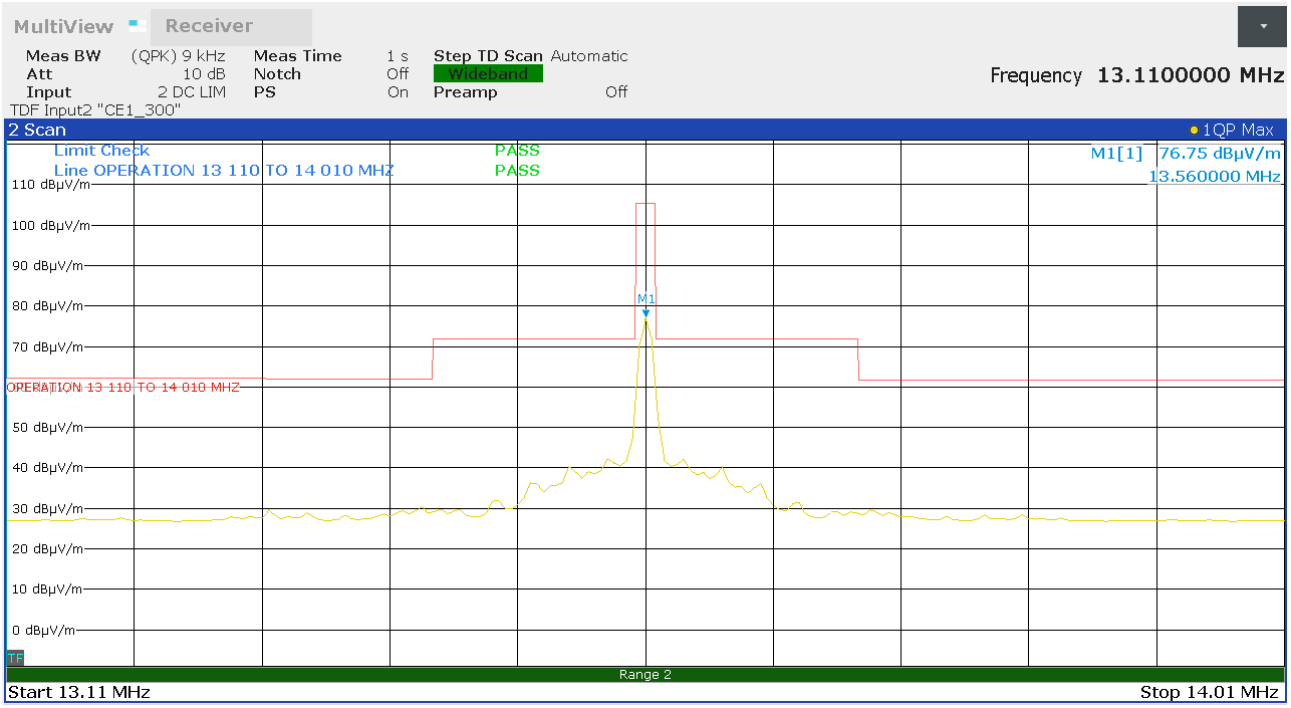


Figure 11: Chart of emission within the band 13.110 MHz to 14.010 MHz, EUT in position Y, without tag, antenna parallel at 3 m distance

Freq. (MHz)	*EUT Pos.*	*Det.*	*Field strength (dBµV/m at 3 m)*	*Rec. factor*	*Calc. field strength (dBµV/ m)*	*at dist. (m)*	*Limit (dBµV/ m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
13.560	Y	QP	76.8	-21.4	55.4	30	84.0	30	28.6	O	355	19.5	P

Table 20: Results of emission within the band 13.110 MHz to 14.010 MHz, without tag

with:

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

6.4 Carrier frequency stability

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.225(e) ANSI C63.10, section 6.8
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, annex B6 (b) RSS-Gen, section 6.11

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date(s) of test:	April 25, 2025
Result:	☒ Test passed	☐ Test not passed	

6.4.1 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	2024-04-26	2025-04-26	C
Laboratory power supply	3231.1	Statron	E00017	See note 1		N/A
Laboratory power supply	3231.1	Statron	E00528	See note 1		N/A
RF field probe set	RF2	LANGER EMV-Technik	E00270	See note 2		N/A
PoE injector	---	---	---	See note 3		N/A

Note(s):
1. The power supply is not calibrated, the level was set using a calibrated multimeter.
2. Only used for relative measurements.
3. Only used as breakout to supply power to the RJ45 port
4. C = Calibration

6.4.2 Limits

According to §15.225 (e):
The frequency tolerance of the carrier signal shall be maintained within ±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.

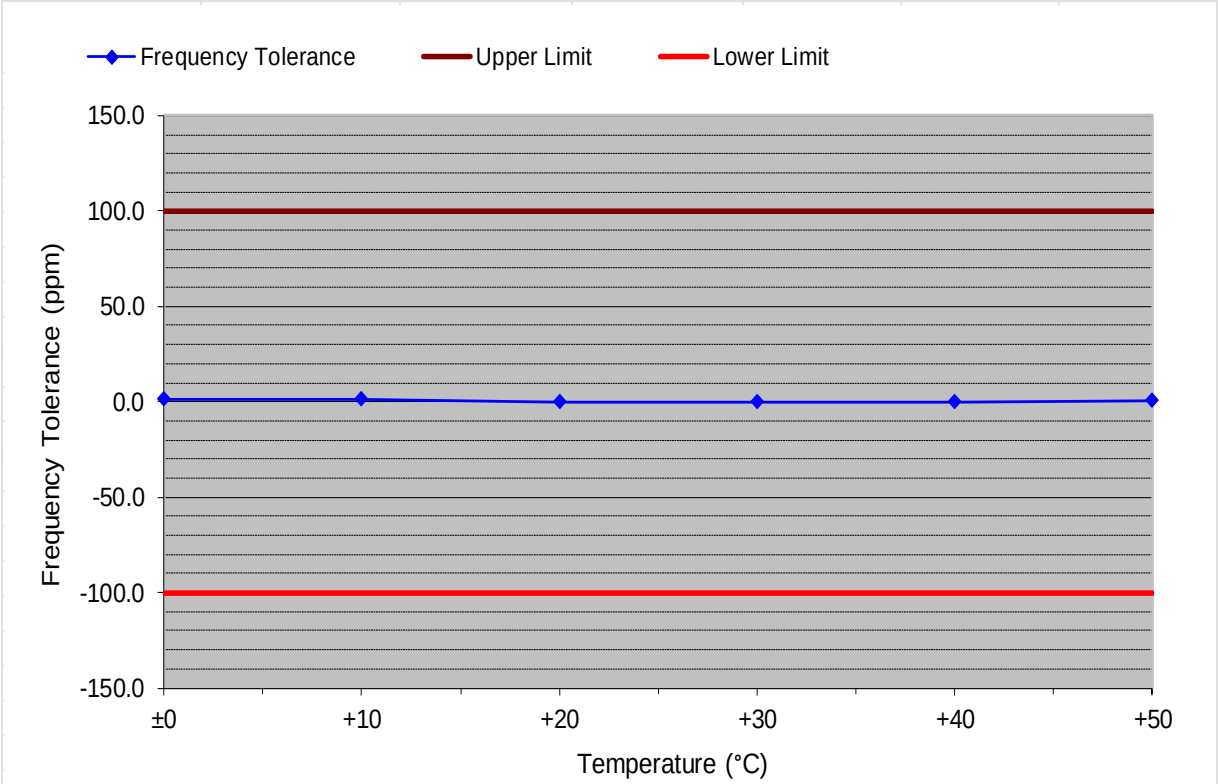
According to RSS-210 section B.6 (b):
The carrier frequency stability shall not exceed ±100 ppm.

6.4.3 Test procedure

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

6.4.4 Test results

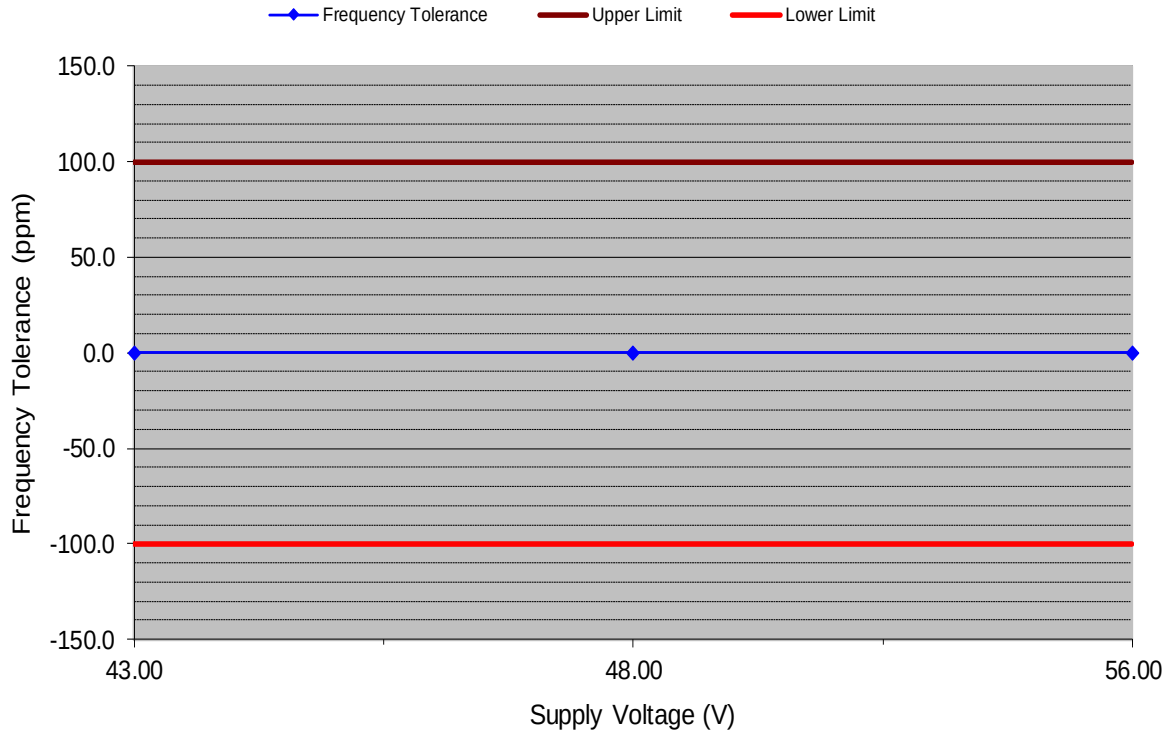
Carrier frequency stability vs. temperature



Supply voltage:	48 V	Frequency under nominal conditions:			13.56015 MHz
Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	(ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
±0	13.56017	20	1.5	+100.0	-100.0	**98.5**
+10	13.56017	20	1.5	+100.0	-100.0	**98.5**
+20	13.56015	0	0.0	+100.0	-100.0	100.0
+30	13.56015	0	0.0	+100.0	-100.0	100.0
+40	13.56015	0	0.0	+100.0	-100.0	100.0
+50	13.56016	10	0.7	+100.0	-100.0	99.3

Result: Passed

Carrier frequency stability vs. supply voltage



Temperature:	+20 °C	Battery End Point:	43.00 V
Frequency under nominal conditions:	13.56015 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
43.00	13.560150	0	0.0	+100.0	-100.0	100.0
48.00	13.560150	0	0.0	+100.0	-100.0	100.0
56.00	13.560150	0	0.0	+100.0	-100.0	100.0

Result: Passed

6.5 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:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	April 28, 2025
Result:	☒ Test passed	☐ Test not passed	

6.5.1 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

6.5.2 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	*Field strength*		*Measurement distance*
(MHz)	*(µV/m)*	*(dBµV/m)*	*(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 21: 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	*Field strength*		*Measurement distance*
(MHz)	*(µA/m)*	*(dBµA/m)*	*(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 22: 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 21 and Table 22, using the recalculation factor as described in clause 5.3.

6.5.3 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.

6.5.4 Test results

Test distance:	☐ 3 m		
Antenna alignment:	☒ in parallel (O)	☒ in line (I)	
EUT position:	☒ Position X	☒ Position Y	☒ 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.

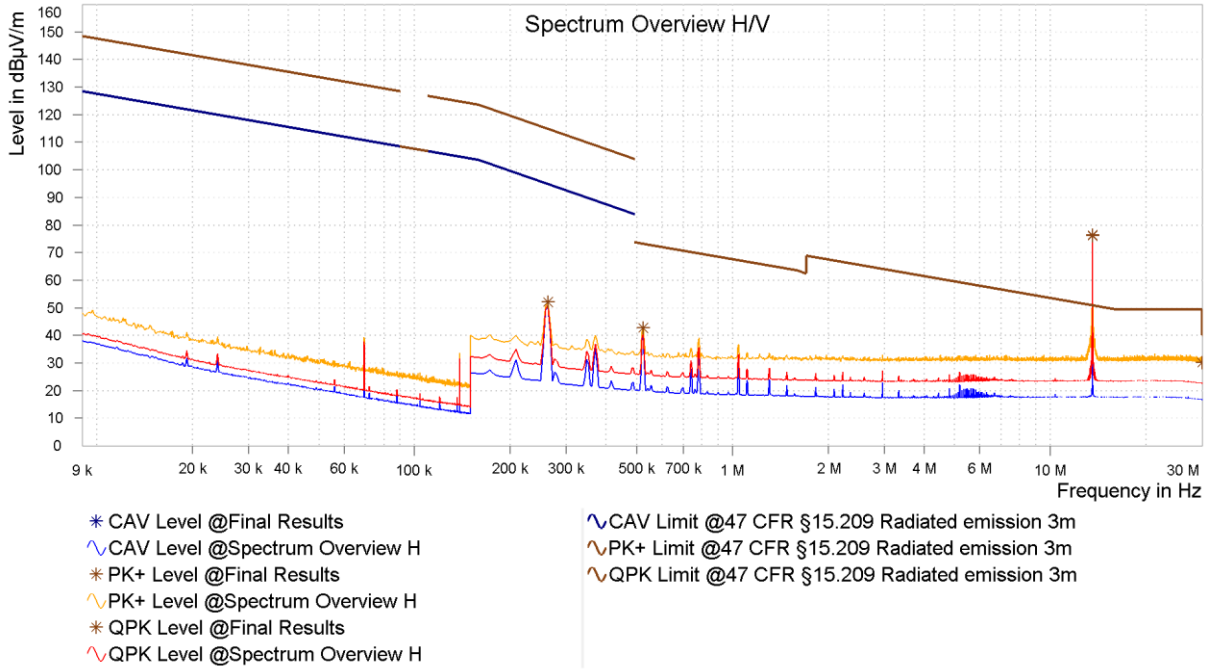


Figure 12: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization parallel, without tag

Freq. (MHz)	*EUT Pos.*	*Det*	*Field strength (dBµV/m at 3 m)*	*Rec. factor*	*Calc. field strength (dBµV/m)*	*at dist. (m)*	*Limit (dBµV/m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.263	Y	Pk	52.2	-75.6	-23.4	300	39.2	300	20.7	O	167	19.5	P
0.263	Y	AV	51.1	-75.6	-24.5	300	19.2	300	43.7	O	167	19.5	P
0.524	Y	QP	40.7	-40.0	0.7	30	33.2	30	32.5	O	167	19.5	P

Table 23: Final results of radiated emissions test below 30 MHz according to § 15.209, without tag

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

6.6 Spurious emissions from 30 MHz to 1 GHz

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

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	April 29, 2025
Result:	☒ Test passed	☐ 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
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	AME HF-Technik	E01285	2024-08-22	2026-02-22	V
	SF104E/11PC35/11PC35/2000MM	Huber & Suhner	E01435	2024-08-21	2026-02-21	V
	SF104EA/11PC35/11PC35/10000MM	Huber & Suhner	E01439	2024-05-06	2025-11-06	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.

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	*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 24: General radiated emission limits ≥ 30 MHz according to §15.209 and RSS-Gen

6.6.3 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.

6.6.4 Test results

Test distance:	☒ 3 m		
Polarization:	☒ horizontal	☒ vertical	
EUT position:	☒ Position X	☒ Position Y	☒ Position Z

Note(s):
1. Pre-measurements were performed to declare the worst-case which is documented below.

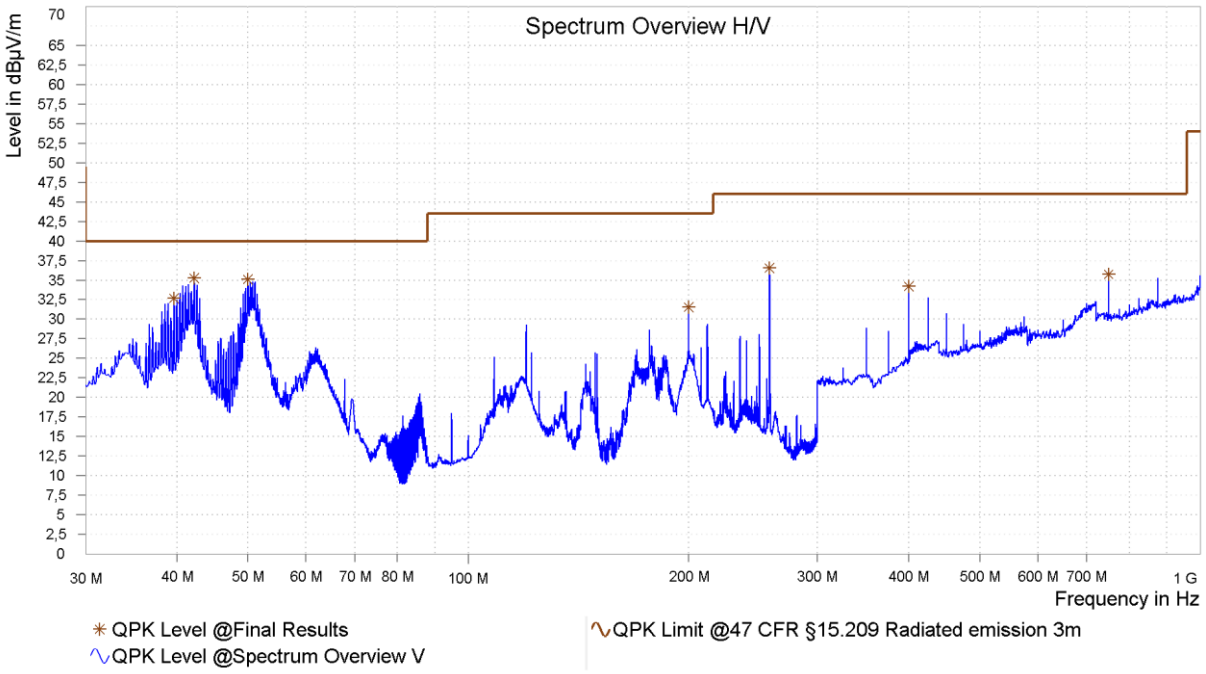


Figure 13: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, antenna polarization vertical, with tag

Freq. (MHz)	*EUT Pos.*	*Det.*	*Field strength (dBµV/m at 3 m)*	*Limit (dBµV/m) at 3 m*	*Margin (dB)*	*Height (cm)*	*Pol.*	*Azim. (deg)*	*Corr. (dB/m)*	*Result*
39.600	Y	QP	32.7	40.0	7.3	1.0	V	290.0	13.3	Passed
42.240	Y	QP	35.3	40.0	4.7	1.0	V	299.0	14.0	Passed
49.980	Y	QP	35.1	40.0	4.9	1.0	V	295.0	14.7	Passed
199.980	Y	QP	31.6	43.5	11.9	2.3	V	231.0	13.3	Passed
258.060	Y	QP	36.6	46.0	9.4	1.7	V	25.0	14.6	Passed
400.020	Y	QP	34.2	46.0	11.8	1.1	V	165.0	17.7	Passed
750.000	Y	QP	35.7	46.0	10.3	1.4	V	251.0	24.0	Passed

Table 25: 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

7 Measurement uncertainties

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

8 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2025-06-10	Patricio Montenegro, M.Sc.-Ing.	First edition

Template: RF_15.225_RSS-210_V1.13