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Applicant:

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Test report no.:

240514-AU02+W01

for:

ELATEC GmbH
RFID reader / writer
TWN4 Secustos SG30

according to:

47 CFR Part 15, §15.209
RSS-210

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

Accreditation:

FCC test firm accreditation expiration date: 2025-09-19
MRA US-EU, FCC designation number: DE0010
Test firm registration number: 997268
FCC Registration Number (FRN): 0032245045
BNetzA-CAB-02/21-02/7 Valid until 2028-11-26

Recognized until 2027-03-18 by the
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 power line conducted emissions 150 kHz to 30 MHz	RSS-Gen, section 8.8	Passed	2	25
---	Occupied bandwidth	RSS-Gen, section 6.7	Recorded	---	30
15.209(a)	Radiated emissions below 30 MHz	RSS-210 section 8.3	Passed	---	32
15.209(a)	Radiated emissions from 30 MHz to 1 GHz	RSS-210 section 8.3	Passed	---	40
15.209(a)	Radiated emissions > 1 GHz	RSS-210 section 8.3	Passed	3, 4	46

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, April 29, 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 June 2013	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 SG30
Serial number(s):	R2025125683
Applicant:	ELATEC GmbH
Manufacturer:	ELATEC GmbH
Hardware version:	PRODA
Software version:	CONT1.26, Mode 4 (125 kHz)
Firmware version:	4.70
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 125 kHz is in consideration.
Additional modifications:	See clause 3.4
FCC ID:	WP5TWN4F31
IC registration number:	7948A-TWN4F31
Designation of emissions:	335HK1D--
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

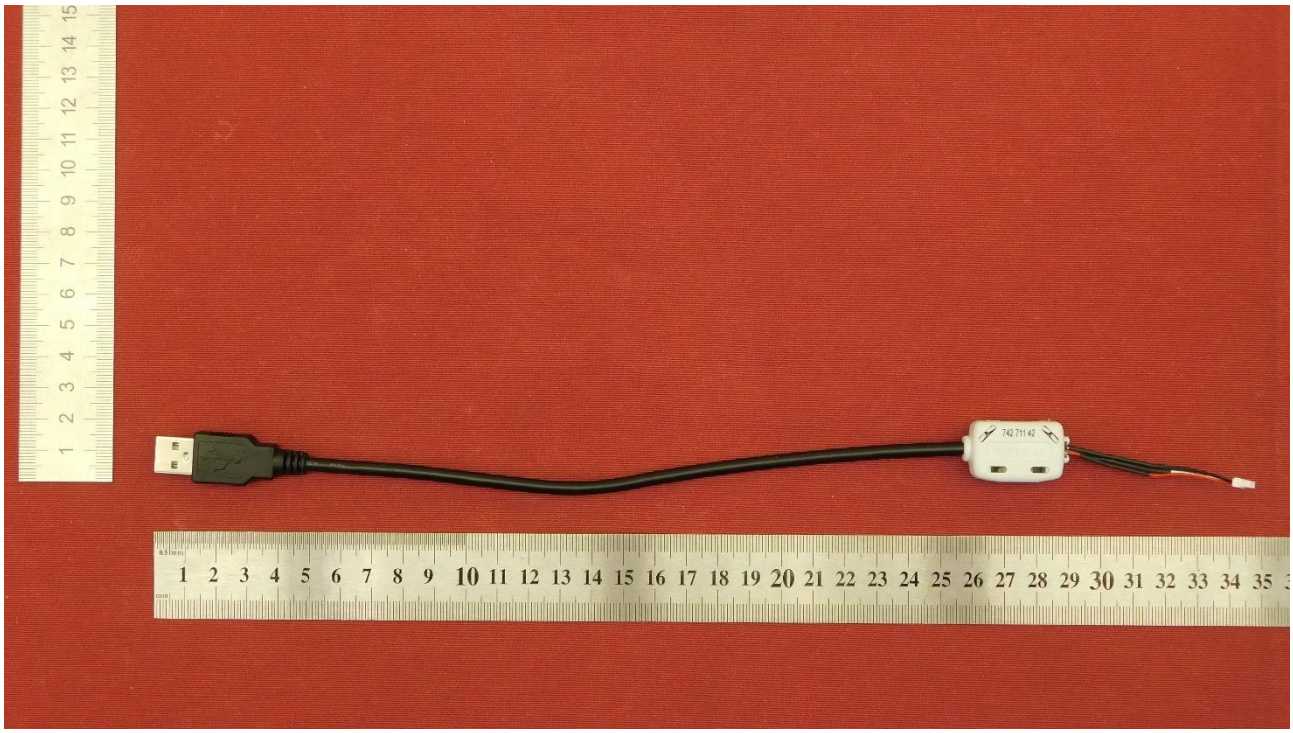
3.3 Radio specifications

System type:	RFID Reader		
Application frequency band:	n/a		
Operating frequencies:	125 kHz		
Number of RF channels	1		
Highest internal frequency:	2480 MHz (BLE)		
Modulation	ASK		
Antenna:	Type:	Magnetic loop	
	Inductance:	490 µH ± 5%	
	Diameter of wire:	0.11 mm	
	Turns:	135, max 140	
	Connector:	☐ external	☐ internal
		☐ temporary	☒ none (integral antenna)

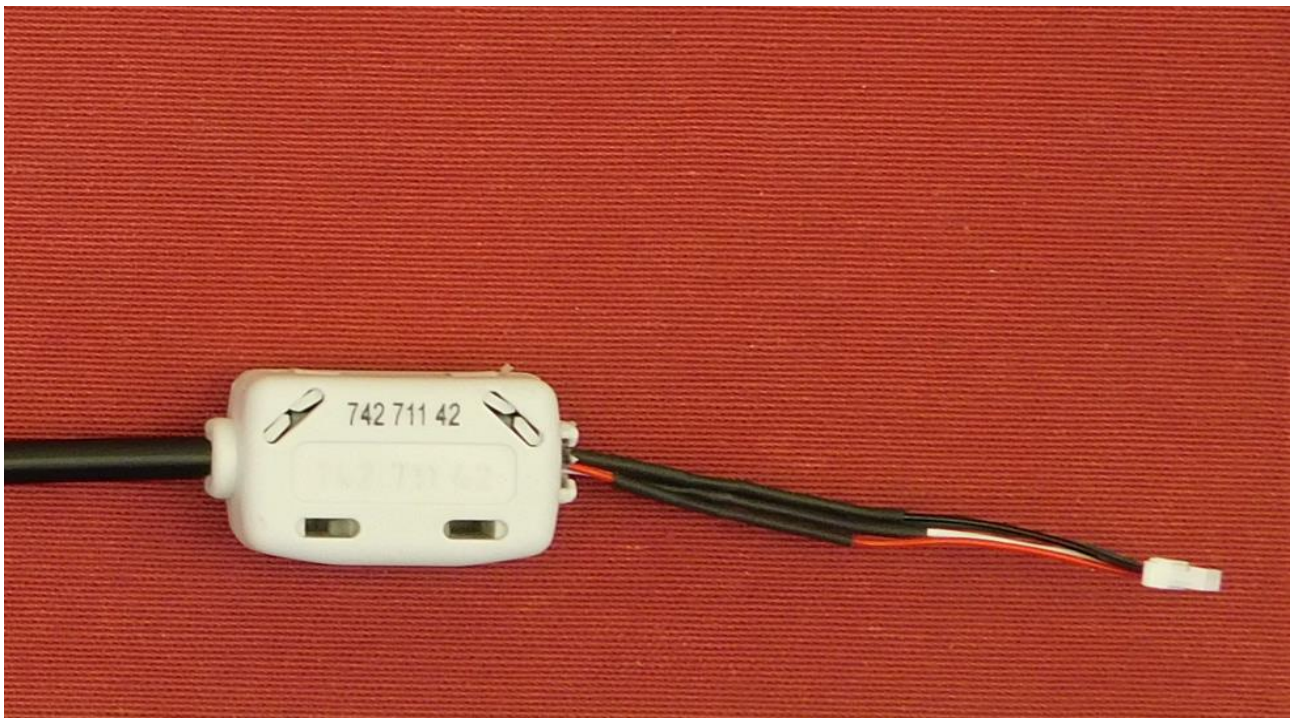
3.4 Equipment modifications (for USB mode only)

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

- For USB mode, a short USB cable with ~35 cm and a ferrite of the manufacturer Würth with the part number 742 711 42 was necessary for radiated emissions measurement (30 MHz - 1 GHz) to comply with the limits. This modification was used for all tests in USB mode.



Picture 1: USB cable with mounted ferrite



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 SG30	R2025125683	ELATEC GmbH

Table 1: EUT used for testing

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RFID tag	125 kHz	---	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 125 kHz.

USB mode:

- The device was powered by a laptop via USB.
- 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 C63.10-2013 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).

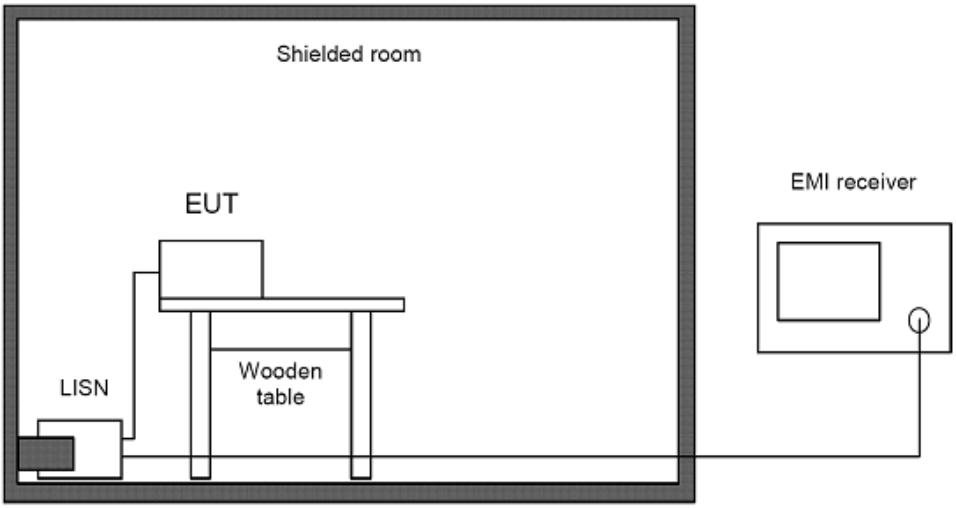


Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

Phase	*Frequency (MHz)*	*Reading value (dBµV)*	*AMN correction (dB)*	*Cable attenuation + 10 dB attenuator (dB)*	*Correction factor (Corr.) (dB)*	*Level (dBµV/m)*
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.

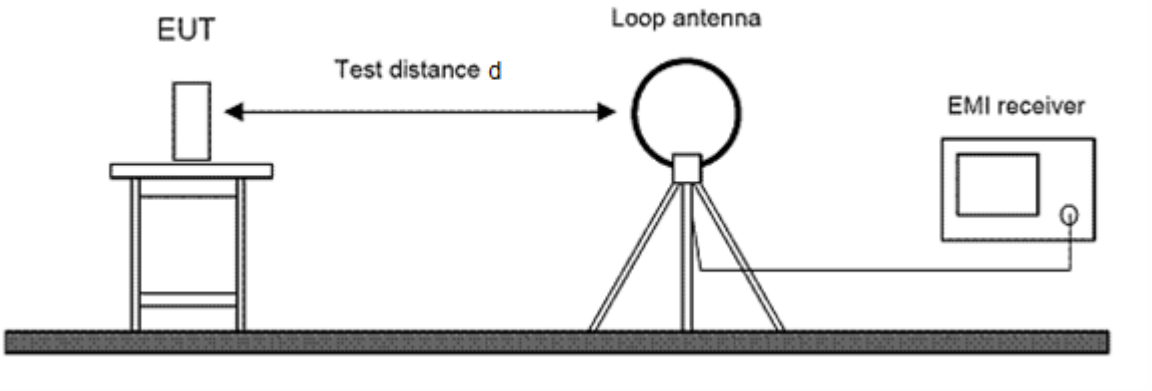


Figure 2: Setup for radiated emissions test below 30 MHz

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.

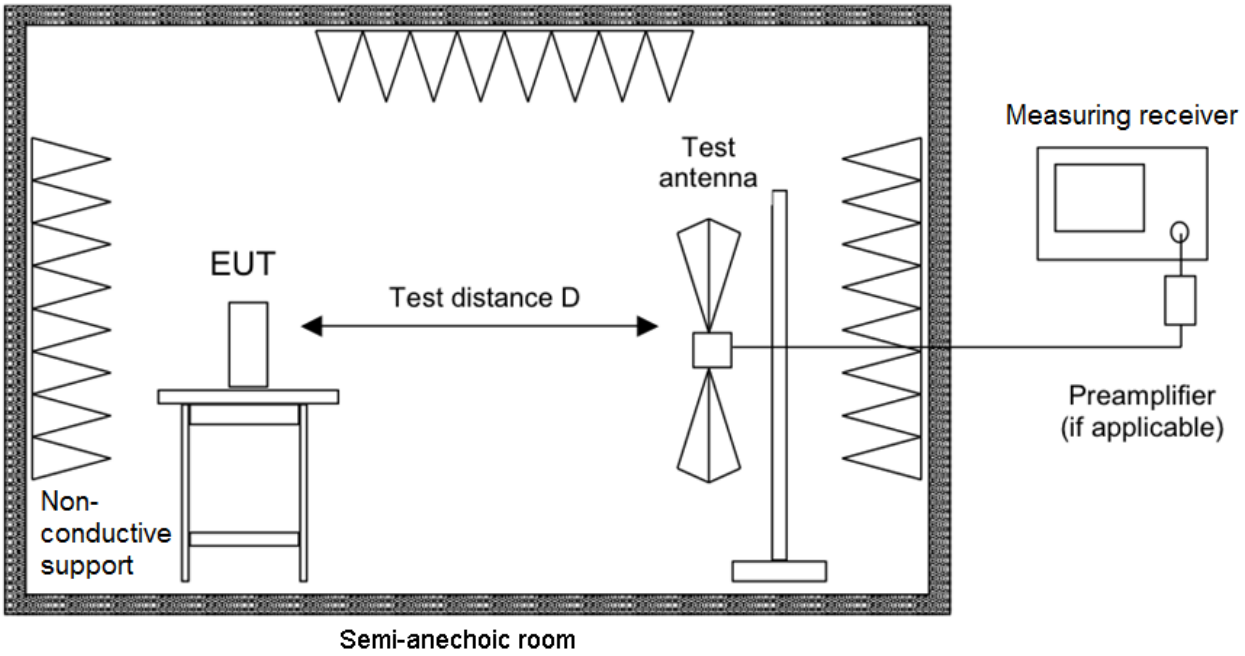


Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

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	-14.92	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.

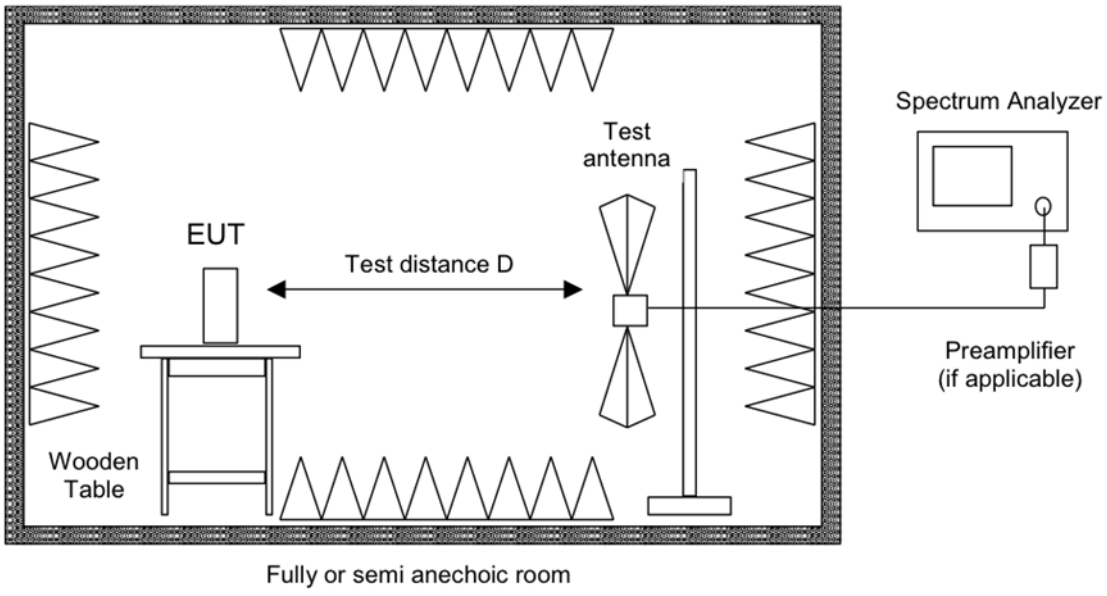


Figure 4: Setup for radiated emissions test above 1 GHz

5.6 Bandwidth measurements

5.6.1 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.

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 53.

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 power line conducted emissions 150 kHz to 30 MHz

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:	Christian Kiermeier	Date of test:	February 18, 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
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	EMC32-EB (V10.60.20)	Rohde & Schwarz	E00777	---	---	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 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	*Conducted limit (dBµV)*	
(MHz)	*Quasi-peak*	*Average*
0.15-0.5	66.0 to 56.0*	56.0 to 46.0*
0.5-5	56.0	46.0
5-30	60.0	50.0

Table 13: Limits for AC powerline conducted emissions according to § 15.207(a) and RSS-Gen, section 8.8

*Decreases with the logarithm of the frequency

6.1.3 Test procedure

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

6.1.4 Test results

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

6.1.4.1 USB mode

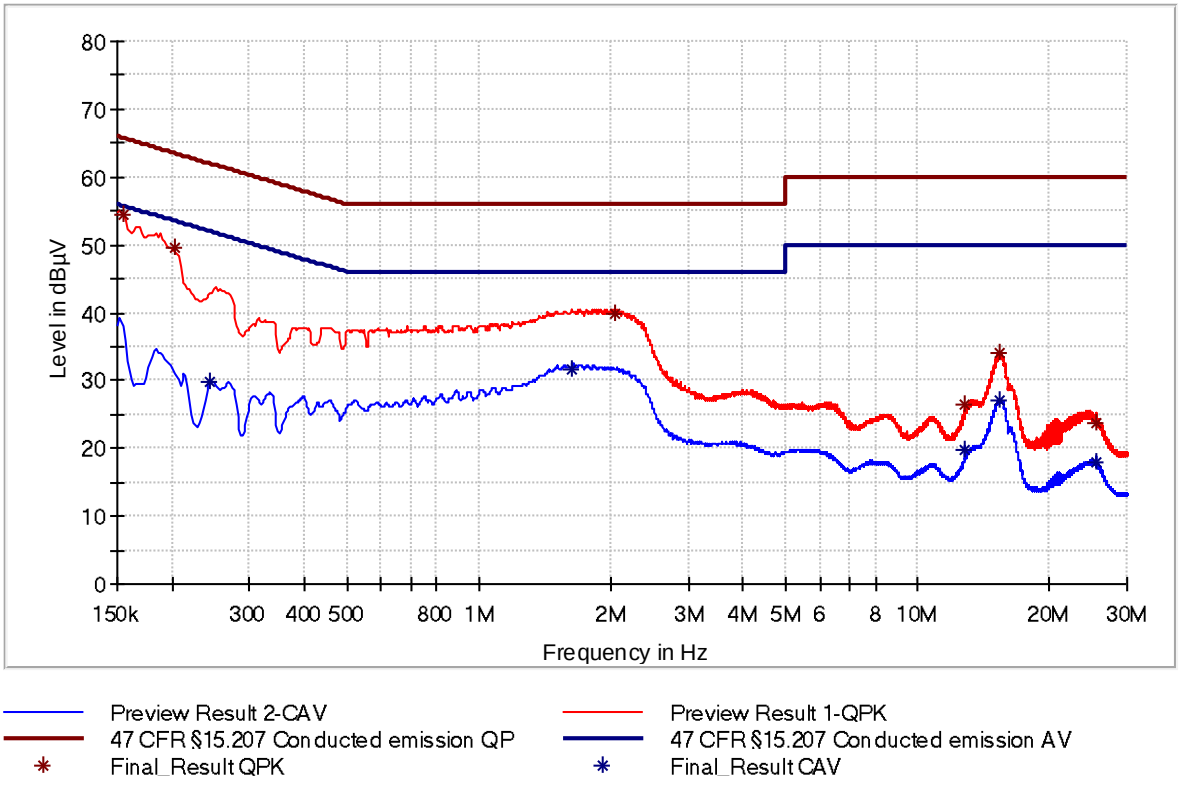


Figure 5: Chart of AC powerline conducted emissions on L1

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE	Corr. (dB)	Result
0.155	54.6	---	65.8	11.2	L1	GND	20.3	Passed
0.204	49.5	---	63.5	14.0	L1	GND	20.3	Passed
0.245	---	29.8	51.9	22.1	L1	GND	20.2	Passed
1.633	---	31.7	46.0	14.3	L1	GND	20.3	Passed
2.051	39.9	---	56.0	16.1	L1	GND	20.4	Passed
12.800	26.4	---	60.0	33.6	L1	GND	20.9	Passed
12.800	---	19.7	50.0	30.3	L1	GND	20.9	Passed
15.367	---	27	50.0	23.0	L1	GND	21.0	Passed
15.389	33.9	---	60.0	26.1	L1	GND	21.0	Passed
25.600	---	17.9	50.0	32.1	L1	GND	21.3	Passed
25.600	23.8	---	60.0	36.2	L1	GND	21.3	Passed

Table 14: Results of AC powerline conducted emissions on L1

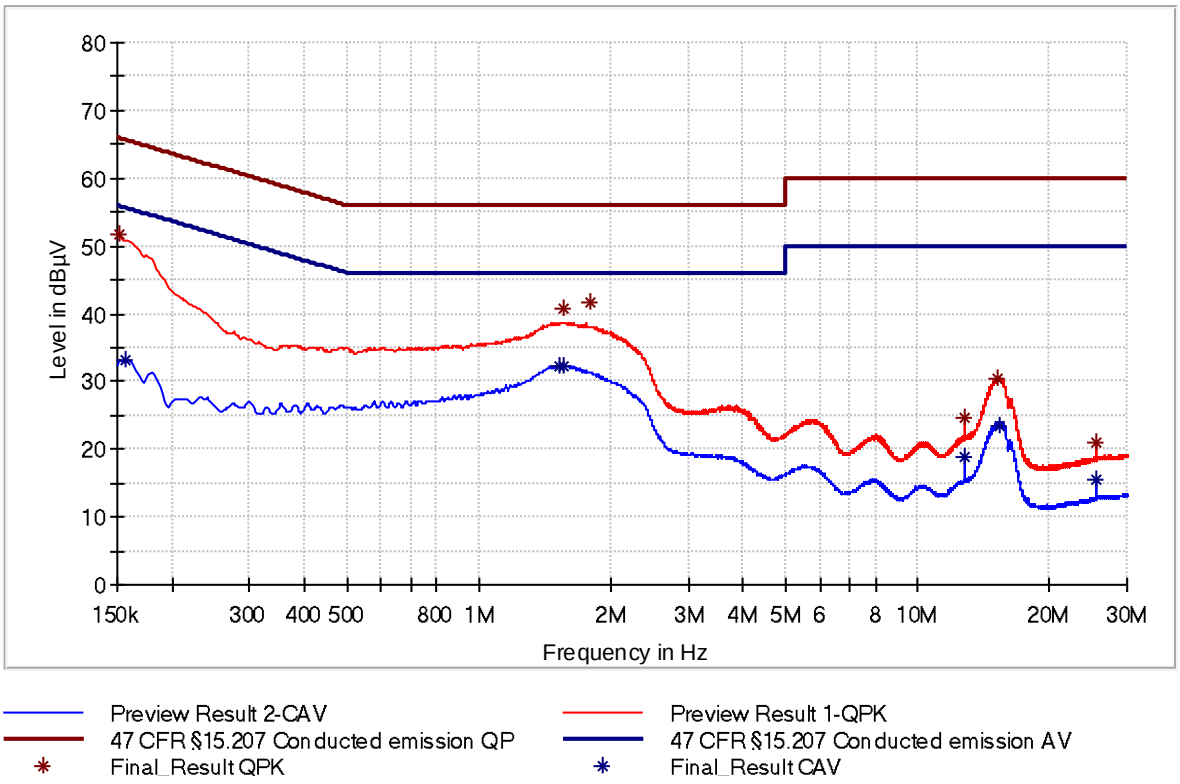


Figure 6: Chart of AC powerline conducted emissions on N

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Line*	*PE*	*Corr. (dB)*	*Result*
0.152	51.8	---	65.9	14.1	N	GND	20.2	Passed
0.157	---	33.3	55.6	22.3	N	GND	20.3	Passed
1.529	---	32.2	46.0	13.8	N	GND	20.3	Passed
1.561	40.6	---	56.0	15.4	N	GND	20.3	Passed
1.568	---	32.1	46.0	13.9	N	GND	20.3	Passed
1.790	41.6	---	56.0	14.4	N	GND	20.4	Passed
12.800	24.7	---	60.0	35.3	N	GND	21.1	Passed
12.800	---	18.9	50.0	31.1	N	GND	21.1	Passed
15.203	30.5	---	60.0	29.5	N	GND	21.2	Passed
15.419	---	23.4	50.0	26.6	N	GND	21.2	Passed
25.600	---	15.5	50.0	34.5	N	GND	21.7	Passed
25.600	21.0	---	60.0	39.0	N	GND	21.7	Passed

Table 15: Results of AC powerline conducted emissions on N

6.2 Occupied bandwidth

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

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	February 24, 2025
Result:	☒ Result recorded	☐ Result not recorded	

6.2.1 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	ESR7	Rohde & Schwarz	E00739	2024-03-08	2025-03-08	C
Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060	2024-11-28	2025-11-28	C
Cable set no. 1 for semi-anechoic chamber SAC3	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

Note(s)
1. C = Calibration
2. V = Verification

6.2.2 Limits

According to RSS-Gen, section 6.7:
There is no limit specified, the occupied bandwidth has to be recorded and reported.

6.2.3 Test procedure

Occupied bandwidth is measured using the
☒ radiated measurement procedure with the analyzer settings as described in clause 5.6.1.
☐ conducted measurement procedure using a test fixture with the analyzer settings as described in clause 5.6.1.

6.2.4 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.

6.2.4.1 USB mode

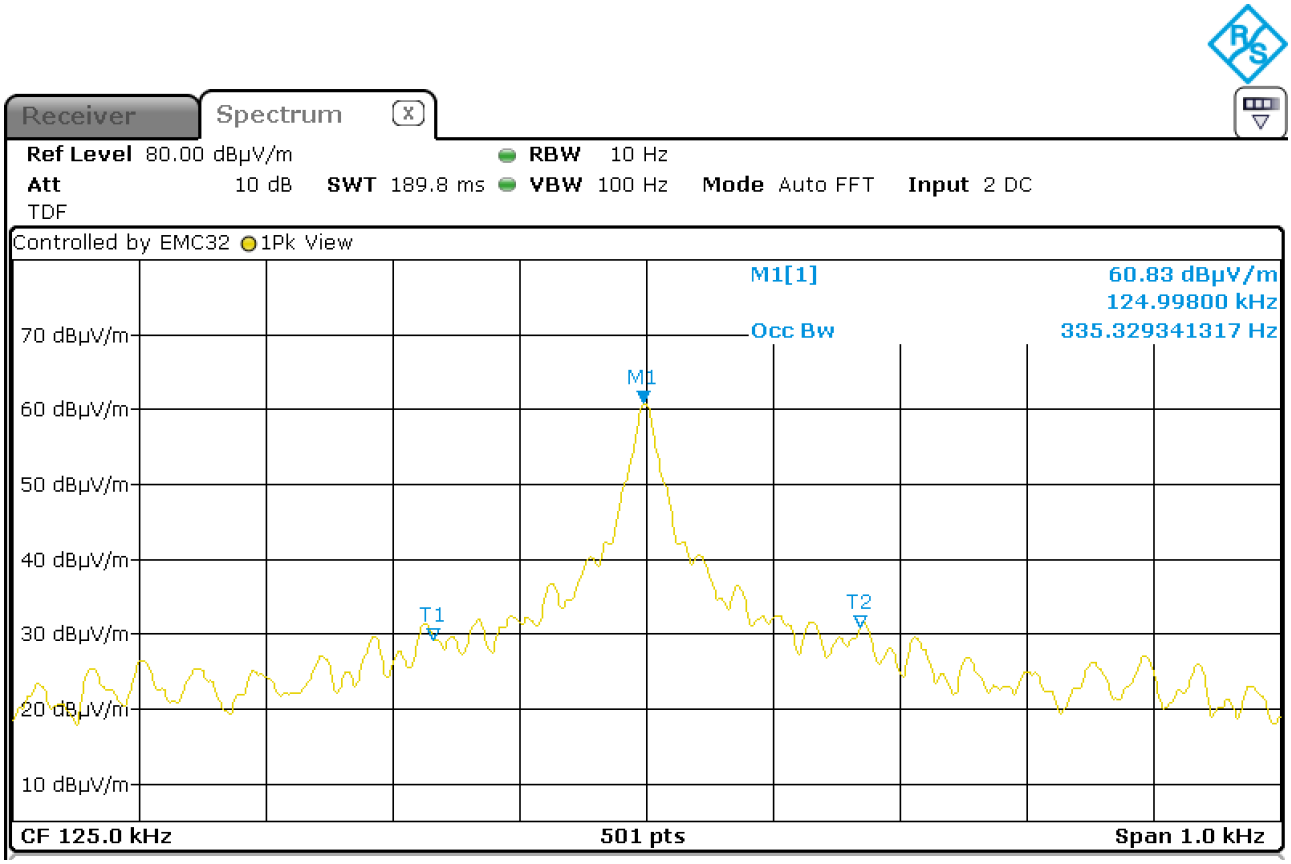


Figure 7: Chart of occupied bandwidth test, without tag

Lower frequency of bandwidth (kHz)	*Upper frequency of bandwidth (kHz)*	*Occupied bandwidth (kHz)*	*Result*
124.832	125.167	0.335	Recorded

Table 16: Results of occupied bandwidth test, without tag

6.3 Radiated emissions below 30 MHz

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.209(a) ANSI C63.10, clause 6.4
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section 8.3 ANSI C63.10, clause 6.4

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	February 21, 2025 February 24, 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	ESR7	Rohde & Schwarz	E00739	2024-03-08	2025-03-08	C
Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060	2024-11-28	2025-11-28	C
Cable set no. 1 for semi-anechoic chamber SAC3	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	EMC32-MEB (V10.60.20)	Rohde & Schwarz	E01073	---	---	N/A

Note(s)
1. C = Calibration
2. V = Verification

6.3.2 Limits

According to § 15.209(a):
Except as provided elsewhere in subpart 15.209 the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency	*Field strength*		*Measurement distance*
(MHz)	*(µV/m)*	*(dBµV/m)*	*(m)*
0.009 – 0.490	2400/F(kHz) (266.67 – 4.90)	48.5 – 13.8	300
0.490 – 1.705	24000/F(kHz) (48.98 – 14.08)	33.8 – 23.0	30
1.705 – 30	30	29.5	30

Table 17: General radiated emission limits up to 30 MHz according to §15.209

According to section 8.3 of RSS-210:
Transmitters whose wanted and unwanted emissions fall within the general field strength limits specified in RSS-Gen may operate licence-exempt in any of the frequency bands, other than the restricted frequency bands listed in RSS-Gen and the TV bands 54-72 MHz, 76-88 MHz, 174-216 MHz and 470-602 MHz, and shall be certified under RSS-210. Under no circumstances shall the level of any unwanted emissions exceed the level of the fundamental emissions.

Frequency	*Field strength*		*Measurement distance*
(MHz)	*(µA/m)*	*(dBµA/m)*	*(m)*
0.009 – 0.490	6.37/F(kHz) (0.708 – 0.013)	-3.0 – -37.7	300
0.490 – 1.705	63.7/F(kHz) (0.130 – 0.037)	-17.7 – -28.6	30
1.705 – 30	0.08	-21.9	30

Table 18: 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 17 and Table 18, using the recalculation factor as described in clause 5.3.

6.3.3 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.

6.3.4 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 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.

6.3.4.1 USB mode

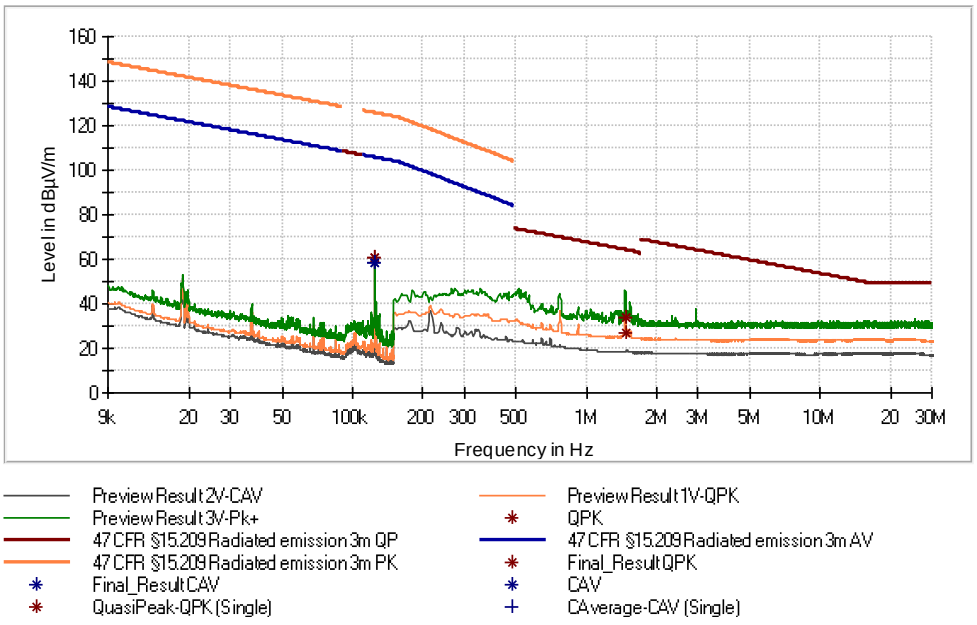


Figure 8: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization parallel, without tag

Freq. (MHz)	*EUT Pos.*	*Det*	*FS at 3 m*	*Rec. Factor (dB)*	*Calc. field strength (dBµV/ m)*	*at dist. (m)*	*Limit (dBµV/ m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	Pk	61.5	-80.0	-18.5	300	45.7	300	64.2	O	180	19.6	P
0.125	Y	AV	58.5	-80.0	-21.5	300	25.7	300	47.2	O	180	19.6	P
1.466	Y	QP	33.6	-40.0	-6.4	30	24.3	30	30.7	O	137	19.6	P

Table 19: Final results of radiated emissions test below 30 MHz according to § 15.209, without tag

with:
Freq. = Frequency
EUT Pos. = EUT Position
Det = Detector
FS at 3 m = Field strength (dBµV/m at 3 m)
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

Freq. (MHz)	*EUT Pos.*	*Det.*	*Calc. field strength (dBµA/m at 3 m)*	*Rec. Factor (dB)*	*Calc. field strength (dBµA/ m)*	*at dist. (m)*	*Limit (dBµA/ m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	Pk	10.0	-80.00	-70.0	300	-5.8	300	64.2	O	180	-31.9	P
0.125	Y	AV	7.0	-80.00	-73.0	300	-25.8	300	47.2	O	180	-31.9	P
1.466	Y	QP	-17.9	-40.00	-57.9	30	-27.2	30	30.7	O	137	-31.9	P

Table 20: Final results of radiated emissions test below 30 MHz according to RSS-210, without tag

Note:
1. The calculated field strength (dBµA/m at 3 m) is the measured field strength (dBµV/m at 3 m) minus 51.5 dB.

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

6.3.4.2 RS-485 mode

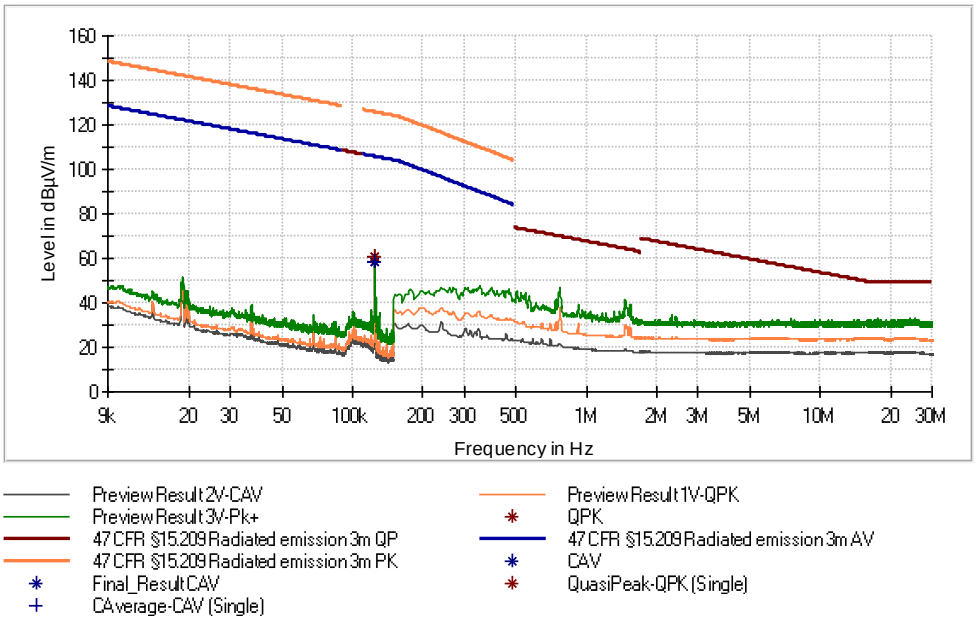


Figure 9: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization parallel, without tag

Freq. (MHz)	*EUT Pos.*	*Det*	*FS at 3 m*	*Rec. Factor (dB)*	*Calc. field strength (dBµV/m)*	*at dist. (m)*	*Limit (dBµV/m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	Pk	61.8	-80.0	-18.2	300	45.7	300	63.9	O	180	19.6	P
0.125	Y	AV	58.7	-80.0	-21.3	300	25.7	300	47.0	O	180	19.6	P

Table 21: Final results of radiated emissions test below 30 MHz according to § 15.209, without tag

with:
Freq. = Frequency
EUT Pos. = EUT Position
Det = Detector
FS at 3 m = Field strength (dBµV/m at 3 m)
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

Freq. (MHz)	*EUT Pos.*	*Det.*	*Calc. field strength (dBµA/m at 3 m)*	*Rec. Factor (dB)*	*Calc. field strength (dBµA/ m)*	*at dist. (m)*	*Limit (dBµA/ m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	PK	10.3	-80.00	-69.7	300	-5.8	300	63.9	O	180	-31.9	P
0.125	Y	AV	7.2	-80.00	-72.8	300	-25.8	300	47.0	O	180	-31.9	P

Table 22: Final results of radiated emissions test below 30 MHz according to RSS-210, without tag

Note:
2. The calculated field strength (dBµA/m at 3 m) is the measured field strength (dBµV/m at 3 m) minus 51.5 dB.

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

6.3.4.3 Wiegand mode

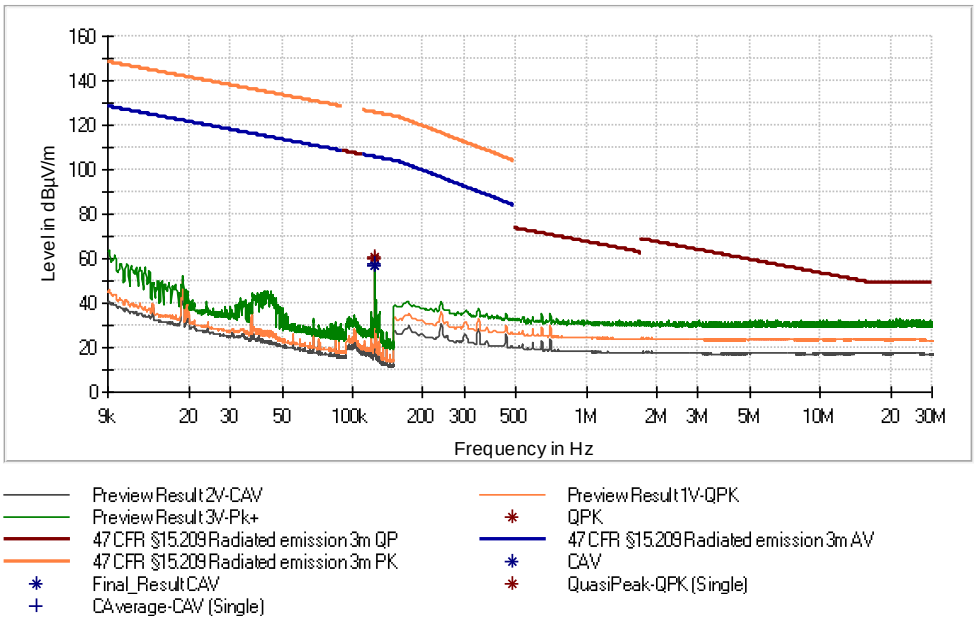


Figure 10: Chart of radiated emissions test below 30 MHz, EUT position Y, antenna polarization parallel, without tag

Freq. (MHz)	*EUT Pos.*	*Det*	*FS at 3 m*	*Rec. Factor (dB)*	*Calc. field strength (dBµV/m)*	*at dist. (m)*	*Limit (dBµV/m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	Pk	61.3	-80.0	-18.7	300	45.7	300	64.4	O	180	19.6	P
0.125	Y	AV	57.1	-80.0	-22.9	300	25.7	300	48.6	O	180	19.6	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
FS at 3 m		Field strength (dBµV/m at 3 m)
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

Freq. (MHz)	*EUT Pos.*	*Det.*	*Calc. field strength (dBµA/m at 3 m)*	*Rec. Factor (dB)*	*Calc. field strength (dBµA/ m)*	*at dist. (m)*	*Limit (dBµA/ m)*	*at dist. (m)*	*Mar. (dB)*	*Pol*	*Azim. (deg)*	*Corr. (dB/m)*	*Res*
0.125	Y	Pk	9.8	-80.00	-70.2	300	-5.8	300	64.4	O	180	-31.9	P
0.125	Y	AV	5.6	-80.00	-74.4	300	-25.8	300	48.6	O	180	-31.9	P

Table 24: Final results of radiated emissions test below 30 MHz according to RSS-210, without tag

Note:
1. The calculated field strength (dBµA/m at 3 m) is the measured field strength (dBµV/m at 3 m) minus 51.5 dB.

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 Radiated emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.209(a)
	Reference(s):	ANSI C63.10, clause 6.5
Section(s) in RSS:	Requirement(s):	RSS-210, section 8.3
	Reference(s):	ANSI C63.10, clause 6.5

Performed by:	Christian Kiermeier	Date of test:	February 18, 2025 March 4, 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	ESW44	Rohde & Schwarz	E00895	2025-01-09	2026-01-09	C
TRILOG broadband antenna	VULB 9162	Schwarzbeck Mess-Elektronik	E00643	2024-04-17	2027-04-17	C
Cable set no. 1 for semi-anechoic chamber SAC3	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	EMC32-MEB (V10.60.20)	Rohde & Schwarz	E01073	---	---	N/A

Note(s)
1. C = Calibration
2. V = Verification

6.4.2 Limits

According to § 15.209(a):
Except as provided elsewhere in subpart 15.209 the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

According to section 8.3 of RSS-210:
Transmitters whose wanted and unwanted emissions fall within the general field strength limits specified in RSS-Gen may operate licence-exempt in any of the frequency bands, other than the restricted frequency bands listed in RSS-Gen and the TV bands 54-72 MHz, 76-88 MHz, 174-216 MHz and 470-602 MHz, and shall be certified under RSS-210. Under no circumstances shall the level of any unwanted emissions exceed the level of the fundamental emissions.

Frequency	*Field strength*		*Measurement distance*
(MHz)	*(µV/m)*	*(dBµV/m)*	*(m)*
30 – 88	100	40.0	3
88 – 216	150	43.5	3
216 - 960	200	46.0	3
Above 960	500	54.0	3

Table 25: General radiated emission limits ≥ 30 MHz according to §15.209 and RSS-Gen

6.4.3 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.

6.4.4 Test results

Test distance:	☒ 3 m	☐ ….. 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.
2. Apart from the documented emissions, all other emissions were greater than 20 dB below the limit.

6.4.4.1 USB mode

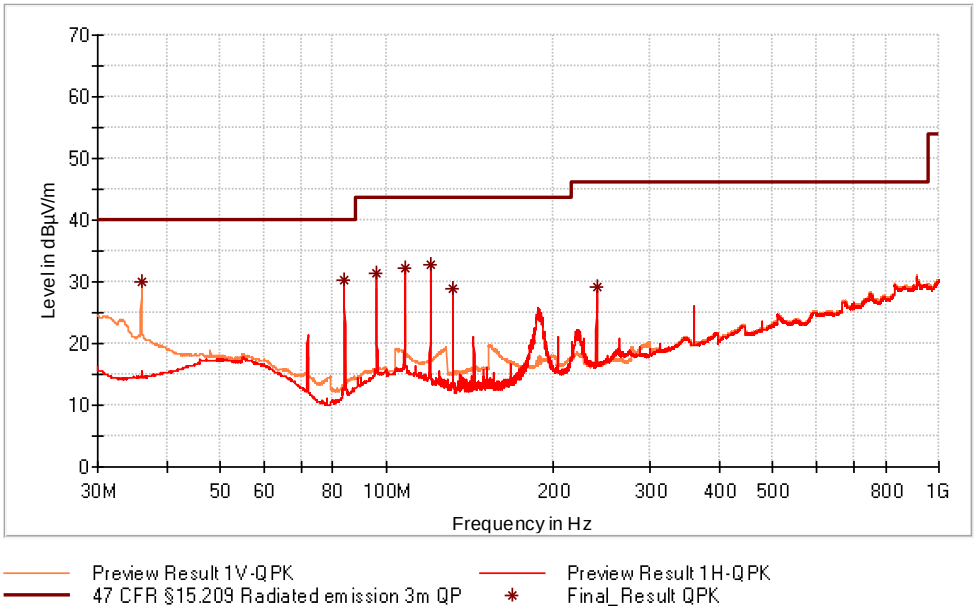


Figure 11: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, with tag, antenna horizontal and vertical

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*
36.000	Y	QP	30.1	40.0	9.9	100.0	V	60.0	12.0	Passed
84.000	Y	QP	30.2	40.0	9.8	207.0	H	248.0	8.6	Passed
96.000	Y	QP	31.3	43.5	12.2	308.0	H	249.0	12.3	Passed
108.000	Y	QP	32.2	43.5	11.3	268.0	H	75.0	12.7	Passed
120.000	Y	QP	32.9	43.5	10.6	276.0	H	85.0	10.9	Passed
132.000	Y	QP	28.8	43.5	14.7	169.0	H	249.0	9.5	Passed
240.000	Y	QP	29.1	46.0	16.9	113.0	H	103.0	13.9	Passed

Table 26: 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

6.4.4.2 RS-485 mode

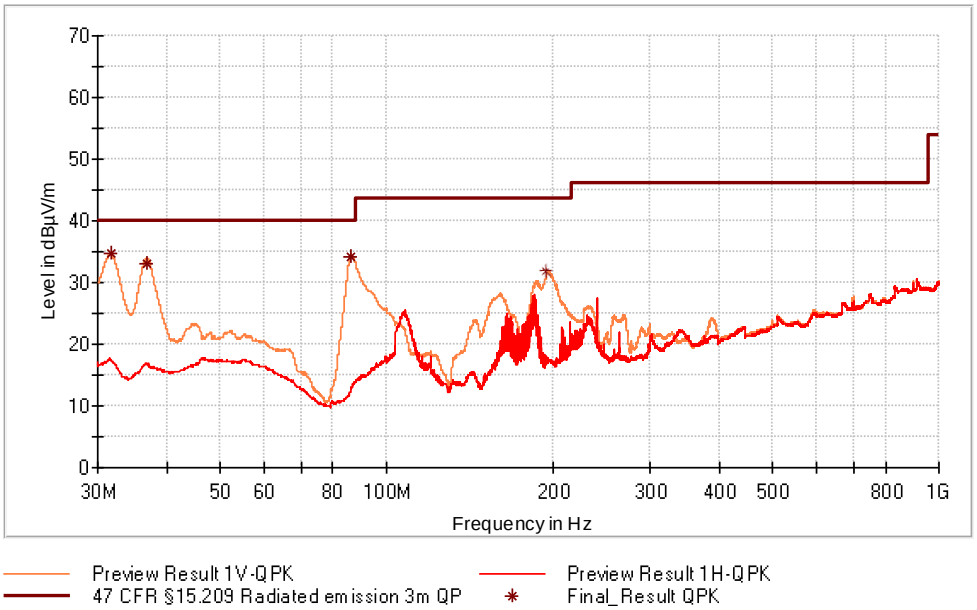


Figure 12: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, with tag, antenna horizontal and vertical

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*
31.680	Y	QP	34.7	40.0	5.3	135.0	V	0.0	10.7	Passed
36.930	Y	QP	33.1	40.0	6.9	157.0	V	18.0	12.4	Passed
86.400	Y	QP	34.2	40.0	5.8	158.0	V	27.0	9.4	Passed
196.92	Y	QP	31.4	43.5	12.1	150	V	0.0	13.2	Passed

Table 27: 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

6.4.4.3 Wiegand mode

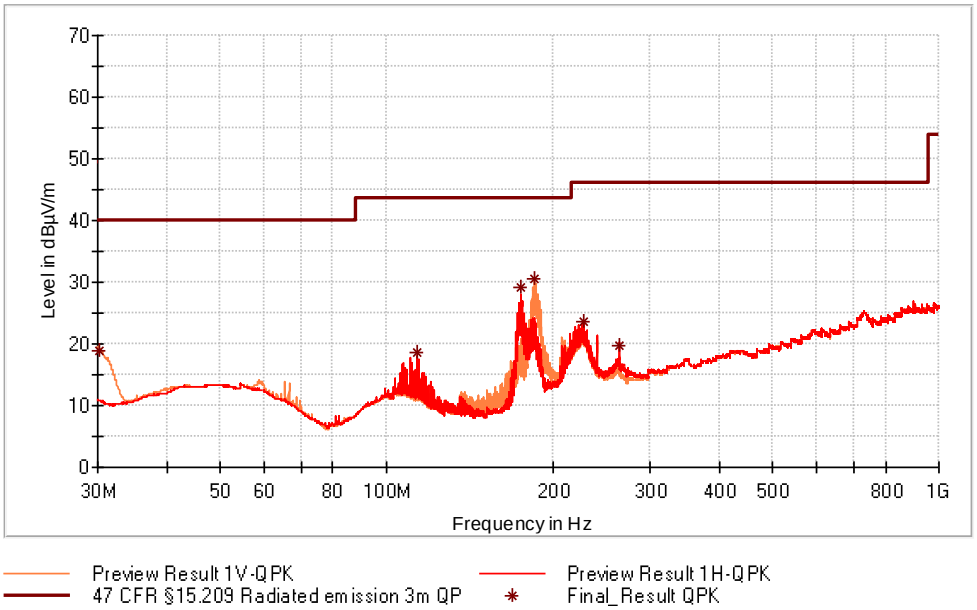


Figure 13: Chart of radiated emissions test from 30 MHz to 1 GHz, EUT position Y, with tag, antenna horizontal and vertical

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*
30.270	Y	QP	18.9	40.0	21.1	100.0	V	0.0	10.9	Passed
113.550	Y	QP	18.5	43.5	25.0	269.0	H	257.0	12.0	Passed
174.720	Y	QP	29.2	43.5	14.3	168.0	H	86.0	10.4	Passed
185.610	Y	QP	30.5	43.5	13.0	100.0	V	129.0	11.4	Passed
227.100	Y	QP	23.7	46.0	22.3	124.0	H	240.0	13.3	Passed
264.000	Y	QP	19.8	46.0	26.2	100.0	H	232.0	14.5	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

6.5 Radiated emissions > 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	15.209(a) ANSI C63.10, clause 6.6
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-210, section 8.3 ANSI C63.10, clause 6.6

Performed by:	Patricio Montenegro, M.Sc.-Ing.	Date of test:	February 25, 2025 February 26, 2025 February 27, 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	ESW44	Rohde & Schwarz	E00895	2025-01-09	2026-01-09	C
Preamplifier (1 GHz to 18 GHz)	ALS05749	Aldetec	W01007	2024-06-17	2025-06-17	V
Double ridged broadband horn antenna	BBHA 9120D	Schwarzbeck Mess-Elektronik	W00053	2022-09-27	2025-09-27	C
Cable set no. 1 for semi-anechoic chamber SAC3 (9 kHz 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	EMC32-MEB (V10.60.20)	Rohde & Schwarz	E01073	---	---	N/A

Note(s)
1. C = Calibration
2. V = Verification

6.5.2 Limits

According to § 15.209(a):

Except as provided elsewhere in subpart 15.209 the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

According to section 8.3 of RSS-210:
Transmitters whose wanted and unwanted emissions fall within the general field strength limits specified in RSS-Gen may operate licence-exempt in any of the frequency bands, other than the restricted frequency bands listed in RSS-Gen and the TV bands 54-72 MHz, 76-88 MHz, 174-216 MHz and 470-602 MHz, and shall be certified under RSS-210. Under no circumstances shall the level of any unwanted emissions exceed the level of the fundamental emissions.

Frequency	*Field strength*		*Measurement distance*
(MHz)	*(µV/m)*	*(dBµV/m)*	*(m)*
Above 960	500	54.0	3

Table 29: General radiated emission limits above 960 MHz according to §15.209 and RSS-Gen

6.5.3 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.

6.5.4 Test results

Test distance:	Exploratory tests: Final tests:	☐ 1 m ☒ 3 m	☐ 0.5 m ☐ 1.5 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. The table results show the final measurements of the emissions detected in the pre-measurements which are shown in this test report.
2 Apart from the documented emissions, all other emissions were greater than 20 dB below the limit.

6.5.4.1 USB mode

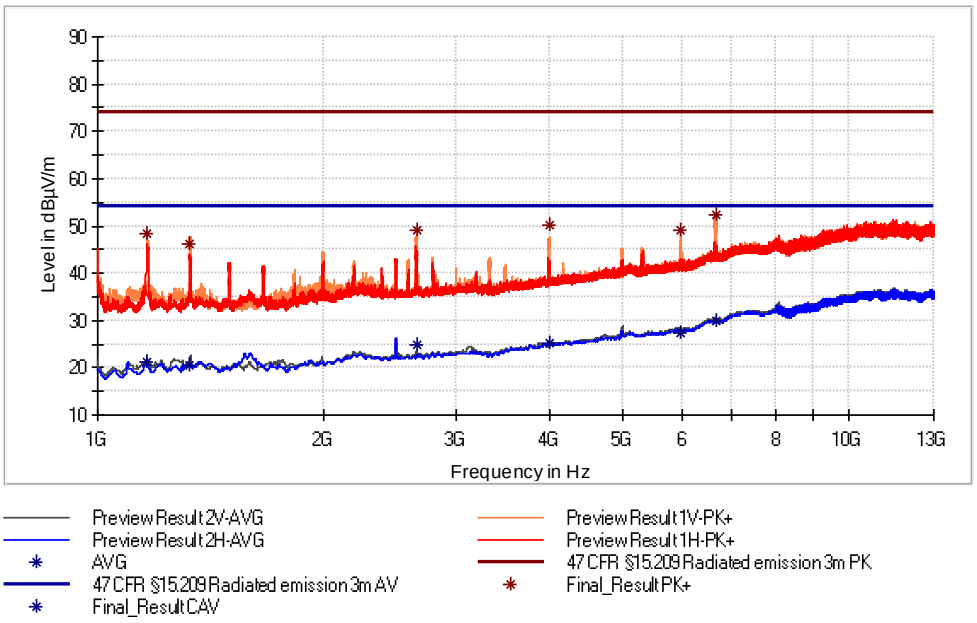


Figure 14: Chart of radiated emissions pre-measurement from 1 GHz to 12.5 GHz, EUT position Y, with tag, antenna polarization horizontal and vertical

Freq. (MHz)	*EUT Pos.*	*Det.*	*Level (dBµV/m) at 3 m*	*Average limit (dBµV/m) at 3 m*	*Mar. (dB)*	*Peak limit (dBµV/m) at 3 m*	*Mar. (dB)*	*Height (cm)*	*Pol.*	*Azim. (deg)*	*Corr. (dB/m)*	*Res.*
1164.000	Y	AV	21.2	54.0	32.8	---	---	161	V	207	-18.4	P
1164.000	Y	Pk	48.4	---	---	74.0	25.6	161	V	207	-18.4	P
1327.000	Y	Pk	46.4	---	---	74.0	27.6	133	V	0	-17.9	P
1327.000	Y	AV	20.6	54.0	33.4	---	---	133	V	0	-17.9	P
2664.000	Y	AV	24.7	54.0	29.3	---	---	195	V	116	-13.6	P
2664.000	Y	Pk	49.3	---	---	74.0	24.7	195	V	116	-13.6	P
4000.000	Y	Pk	50.3	---	---	74.0	23.7	104	V	122	-8.9	P
4000.000	Y	AV	25.2	54.0	28.8	---	---	104	V	122	-8.9	P
5984.750	Y	AV	27.4	54.0	26.6	---	---	100	V	261	-4.1	P
5984.750	Y	Pk	49.1	---	---	74.0	24.9	100	V	261	-4.1	P
6655.500	Y	AV	29.7	54.0	24.3	---	---	100	V	316	-2.2	P
6655.500	Y	Pk	52.4	---	---	74.0	21.6	100	V	316	-2.2	P

Table 30: Results of radiated emissions test > 1 GHz, with tag

with:
Freq. = Frequency
EUT Pos. = EUT Position
Det. = Detector
Mar. = Margin
Pol. = Polarization of the measurement antenna
Azim. (deg) = Azimuth (degree)
Corr. = Correction factor
Res. = Result
P = Passed
Np = Not passed

6.5.4.2 RS-485 mode

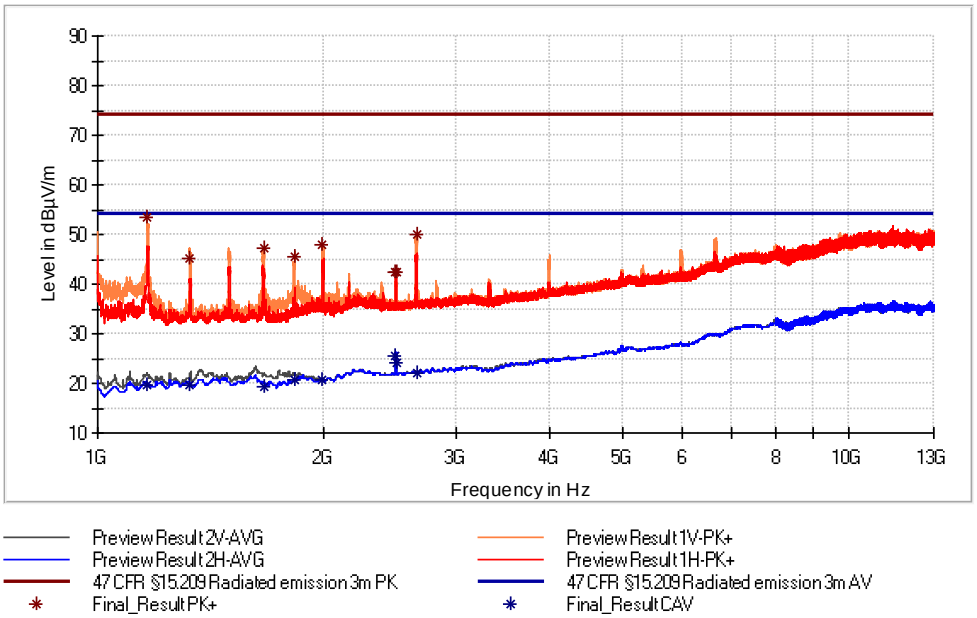


Figure 15: Chart of radiated emissions pre-measurement from 1 GHz to 12.5 GHz, EUT position X, with tag, antenna polarization horizontal and vertical

Freq. (MHz)	*EUT Pos.*	*Det.*	*Level (dBµV/m) at 3 m*	*Average limit (dBµV/m) at 3 m*	*Mar. (dB)*	*Peak limit (dBµV/m) at 3 m*	*Mar. (dB)*	*Height (cm)*	*Pol.*	*Azim. (deg)*	*Corr. (dB/m)*	*Res.*
1161.250	Y	Pk	53.4	---	---	74.0	20.6	250	V	188	-18.3	P
1161.250	Y	AV	19.6	54.0	34.4	---	---	250	V	188	-18.3	P
1327.500	Y	Pk	45.3	---	---	74.0	28.7	270	V	160	-17.9	P
1327.500	Y	AV	19.6	54.0	34.4	---	---	270	V	160	-17.9	P
1664.500	Y	Pk	47.3	---	---	74.0	26.7	381	V	123	-18.1	P
1664.500	Y	AV	19.3	54.0	34.7	---	---	381	V	123	-18.1	P
1832.250	Y	Pk	45.5	---	---	74.0	28.5	238	V	327	-17.3	P
1832.250	Y	AV	20.8	54.0	33.2	---	---	238	V	327	-17.3	P
1991.500	Y	AV	20.9	54.0	33.1	---	---	277	V	48	-16.3	P
1991.500	Y	Pk	48.1	---	---	74.0	25.9	277	V	48	-16.3	P
2496.000	Y	AV	25.5	54.0	28.5	---	---	200	H	88	-14.1	P
2496.000	Y	Pk	42.6	---	---	74.0	31.4	200	H	88	-14.1	P
2500.000	Y	Pk	42.5	---	---	74.0	31.5	171	H	87	-14.1	P
2500.000	Y	AV	24.0	54.0	30.0	---	---	171	H	87	-14.1	P
2665.250	Y	Pk	50.1	---	---	74.0	24.0	273	V	208	-13.6	P
2665.250	Y	AV	21.9	54.0	32.1	---	---	273	V	208	-13.6	P

Table 31: Results of radiated emissions test > 1 GHz, with tag

with:
Freq. = Frequency
EUT Pos. = EUT Position
Det. = Detector
Mar. = Margin
Pol. = Polarization of the measurement antenna
Azim. (deg) = Azimuth (degree)
Corr. = Correction factor
Res. = Result
P = Passed
Np = Not passed

6.5.4.3 Wiegand mode

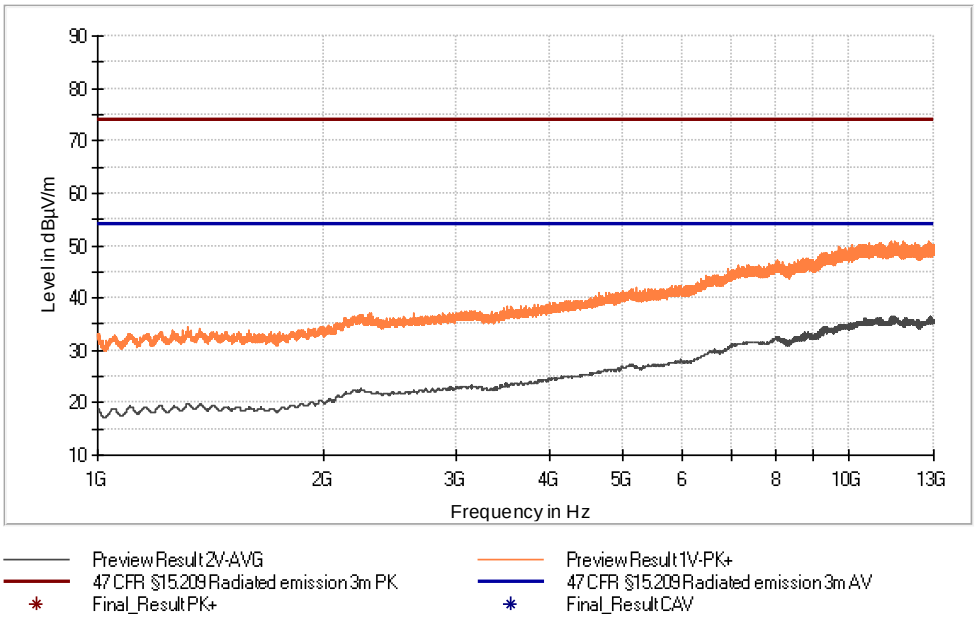


Figure 16: Chart of radiated emissions pre-measurement from 1 GHz to 12.5 GHz, EUT position Y, with tag, antenna polarization vertical

7 Measurement uncertainties

Description	*Uncertainty*	U_{Limit}	*Note(s)*	*k=*
AC power line conducted emission	± 3.0 dB	± 3.4 dB	2b), 3b)	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	2025-04-29	Patricio Montenegro, M.Sc.-Ing.	First edition

Template: RF_15.209_RSS-210_V1.12