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Radio Radio Radio Radio Radio Radio Radio Radio Radio Radio Radio

Applicant:

Elatec GmbH

Zeppelinstraße 1

82178 Puchheim

Tel.: +49 89 5529961-0

Test report no.:

200739-AU01+W01

for:

Elatec GmbH

RFID reader / writer module

TWN4 MultiTech 3C M

according to:

15.209 (partly)

RSS-210 (partly)

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12155-01-04

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12155-01-03

Accreditation:

FCC test firm accreditation expiration date: 2021-05-30
MRA US-EU, FCC designation number: DE0010
FCC registration number: 97268
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Department of Innovation, Science and Economic Development Canada (ISED)
as a recognized testing laboratory
CAB identifier: DE0011
Company number: 3472A

Location of Testing:

Element Materials Technology Straubing GmbH
Tel.: +49 9421 56868-0
Fax: +49 9421 56868-100
Email: info.straubing@element.com
Gustav-Hertz-Straße 35
94315 Straubing, Germany

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

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1 General remark

The EUT is only certified with USB interface. Additionally, a CAN interface is intended, so the tests in this test report are only partly tests with the CAN interface.

2 Summary of test results

System type: RFID Reader

47 CFR part and section	*Test*	*Equivalent to IC radio standard(s)*	*Page*	*Result*	*Note(s)*
15.207(a)	AC power line conducted emissions 150 kHz to 30 MHz	RSS-Gen, section 8.8	24	Passed	1
15.209(a)	Radiated emissions below 30 MHz	RSS-210 section 7.3	30	Passed	---
15.209(a)	Radiated emissions from 30 MHz to 1 GHz	RSS-210 section 7.3	35	Passed	---

Note(s) (for information about EUT see clause 4):

1 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.

Straubing, July 15, 2021

Jennifer Riedel B. Eng.
Radio Test Engineer

Konrad Graßl
Department Manager Radio

3 Referenced publications

Publication	*Title*
CFR 47 Part 2 October 2020	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 2020	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 5March 2019	Spectrum Management and Telecommunications - Radio Standards Specification - General Requirements for Compliance of Radio Apparatus
RSS-210 Issue 10, December 2019	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

4 Equipment under test (EUT)

All Information in this clause is declared by customer.

4.1 General information

Product type:	RFID reader / writer module		
Model name:	TWN4 MultiTech 3C M		
Serial number(s):	2021215960		
Applicant:	Elatec GmbH		
Manufacturer:	Elatec GmbH		
Version:	Hardware:	B	
	Software:	B1.09/NBF4.01/CANT1.00/P	
Additional modifications:	None		
FCC ID:	WP5TWN4F4		
IC registration number:	7948A-TWN4F4		
Power supply:	DC supply		
	Nominal voltage:	5 V	
Temperature range:	-20 °C to +50 °C (customer defined)		
Device type:	☐ Portable	☐ Mobile	☒ Fixed

4.2 Radio specifications

System type:	RFID Reader		
Application frequency band:	n/a		
Operating frequencies:	125 kHz 134.2 kHz		
Short description:	The EUT is a RFID reader / writer module operating at the frequencies 125 kHz and 134.2 kHz. Furthermore, the EUT employs the frequency 13.56 MHz which is in consideration in another test report..		
Number of RF channels	3 (see short description for more information)		
Highest internal frequency:	120 MHz		
Modulation	ASK		
Antenna:	Type: Connector:	Loop antenna ☐ external ☐ temporary	☐ internal ☒ none (integral antenna)

4.3 Photo documentation

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

5 Test configuration and mode of operation

5.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RFID reader / writer module	TWN4 MultiTech 3C M	2021215960	Elatec GmbH

Table 1: EUT used for testing

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RFID-tag	125 kHz	---	Elatec GmbH
RFID-tag	134.2 kHz	---	Elatec GmbH
Laptop	Lifebook A531	E001053	FUJITSU
Power supply for laptop	AC adapter	E001053	FUJITSU
Power supply	3231.1	E01235	Statron
USB/CAN interface	CPC-USB/ARM7-GTI	0006421	EMS Dr. Thomas Wünsche
Power supply for EUT (see note 1)	C176U3	SEB01258	Hycell

Table 2: Support equipment used for testing

Port	*Classification*	*Cable type*	*Note*
DC power port	DC power	Unshielded	
CAN interface	Signal/control	Unshielded	
USB connector	Signal/control	Shielded	2

Table 3: Ports of EUT

Note(s):
1 The power supply was only used for AC power line conducted emissions 150 kHz to 30 MHz.
2 Only CAN interface was tested.

5.2 Mode of operation

5.2.1 Test software used for all tests

The EUT was DC powered and set into continuously reading the tag. The reading of the tag was shown on the laptop via CAN interface.

6 Test procedures

6.1 General specifications

6.1.1 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.

6.2 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 4: 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 4). 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).

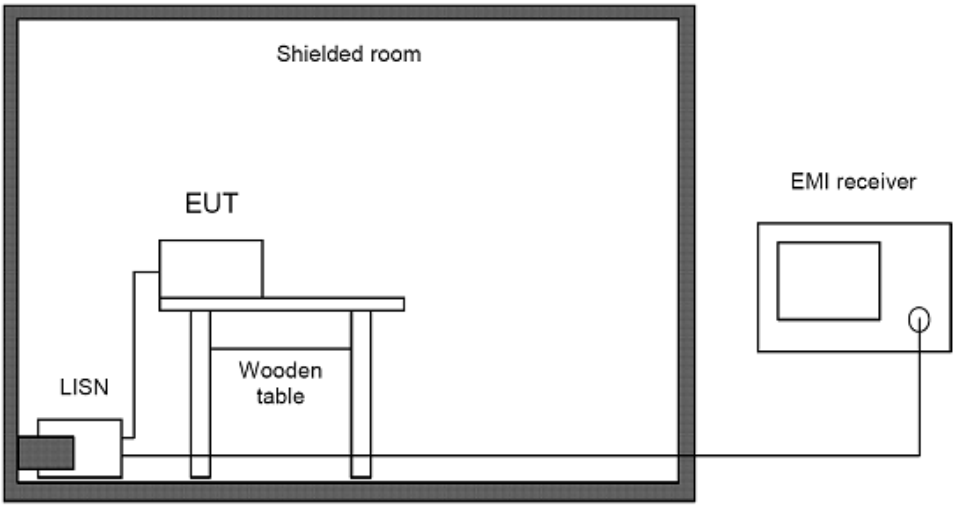

Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

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 5: 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.

6.3 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 6: Recalculation factors for extrapolation

Prescans for radiated measurements below 30 MHz are performed in a fully anechoic room (called “CDC”). The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 7.

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

Table 7: 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 8: 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:

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 7).
d) The EUT is turned to a position likely to get the maximum and the test antenna is rotated to detect the maximum of the fundamental in this EUT position.
e) Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position.
f) After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
g) With the test receiver set to the first frequency of the list, the EUT is rotated by ±45° around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
h) Step g) is repeated for all other frequencies in the list.
i) Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

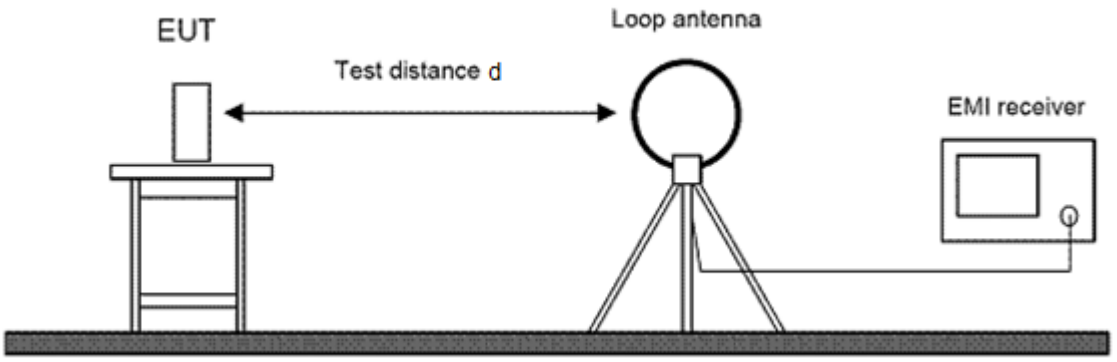

Figure 2: Setup for radiated emissions test below 30 MHz

6.4 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 9.

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 9: 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 10: 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:

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 9).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
g) The antenna height is increased to 4 m in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±60° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

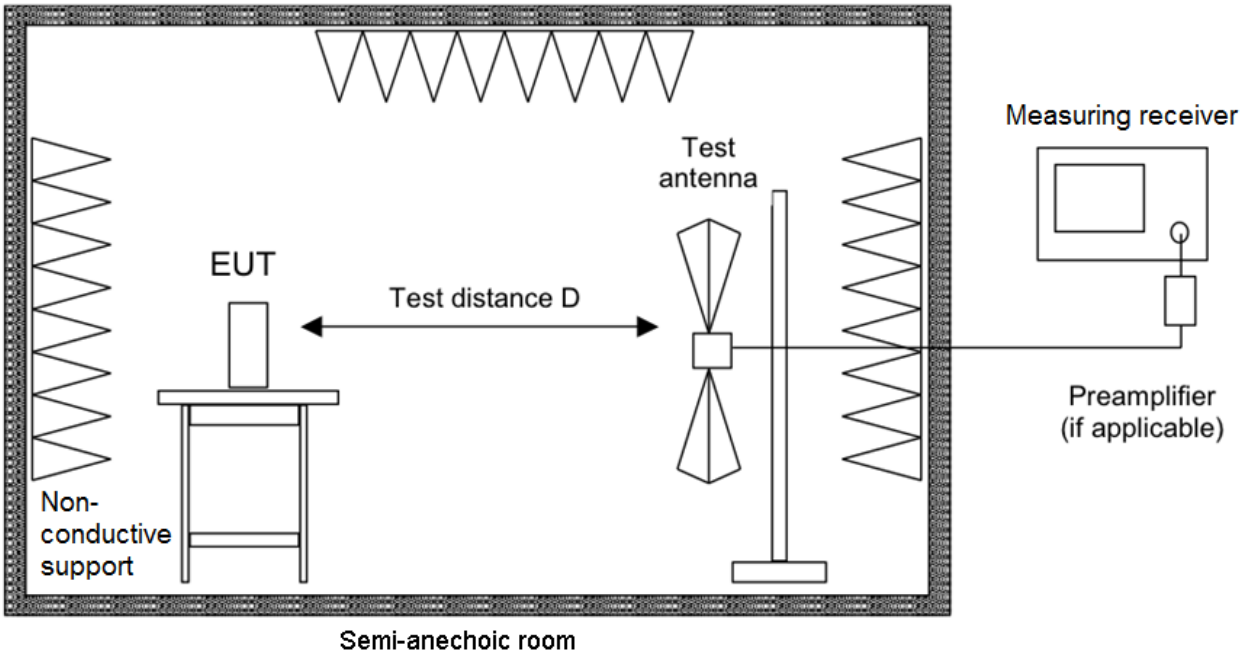

Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

6.5 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 11: 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

6.5.1 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 12.

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

Table 12: 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.

6.5.2 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 13.

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

Table 13: Bandwidth and detector type for final radiated emissions test above 1 GHz

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

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

The final radiated emissions test above 1 GHz is performed in the following steps:

a) The measurement antenna is oriented initially for vertical polarization.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 13).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
    g) The antenna height is increased to the scan height upper range in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from the scan height upper range to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 30°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±30° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

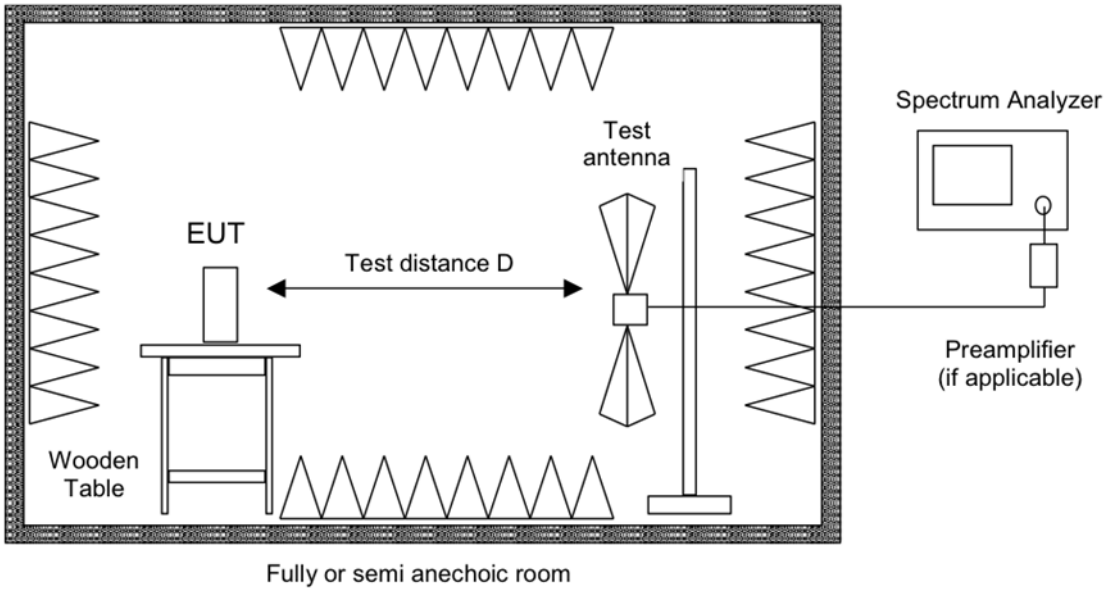

Figure 4: Setup for radiated emissions test above 1 GHz

6.6 Bandwidth measurements

6.6.1 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.

6.6.2 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.

6.7 Restricted bands of operation

The EUT was placed in a fully anechoic chamber and the testing was performed in accordance with ANSI C63.10 and 47 CFR Part 15, section 15.35. The measurement distance was 3 m. To find the closest margin of the spectrum to the limit mask adapted to the test distance the EUT was rotated by 360 degrees with detector of the test receiver set to peak. The loop antenna placed in a fixed height of 1 meter was rotated by 360 degrees to get the maximum of emission. In case of exceeding the limits the detector is switched to quasi peak for final testing in position of maximum emission.

7 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 40.

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

7.1 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:	Jennifer Riedel B. Eng.	Date of test:	July 7, 2021
Result:	☒ Test passed	☐ Test not passed	

7.1.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Shielded room	P92007	Siemens Matsushita	E00107
EMI test receiver	ESR 7	Rohde & Schwarz	E01549
Artificial mains network	ESH2-Z5	Rohde & Schwarz	E00004
Attenuator (10 dB)	50FHB-010-10	JFW Industries	E00471
Cable set shielded room	RG 223/U RG 223/U	AME HF-Technik AME HF-Technik	E00741 E00804
Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777

7.1.2 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 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 table 9, 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 table 9 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 14: Limits for AC powerline conducted emissions § 15.207(a) and RSS-Gen, section 8.8

*Decreases with the logarithm of the frequency

7.1.3 Test procedure

AC power line conducted emissions are measured using the test procedure as described in clause 6.2.

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.

7.1.4 Test results

Note(s):
1 No assessable emissions were detected.

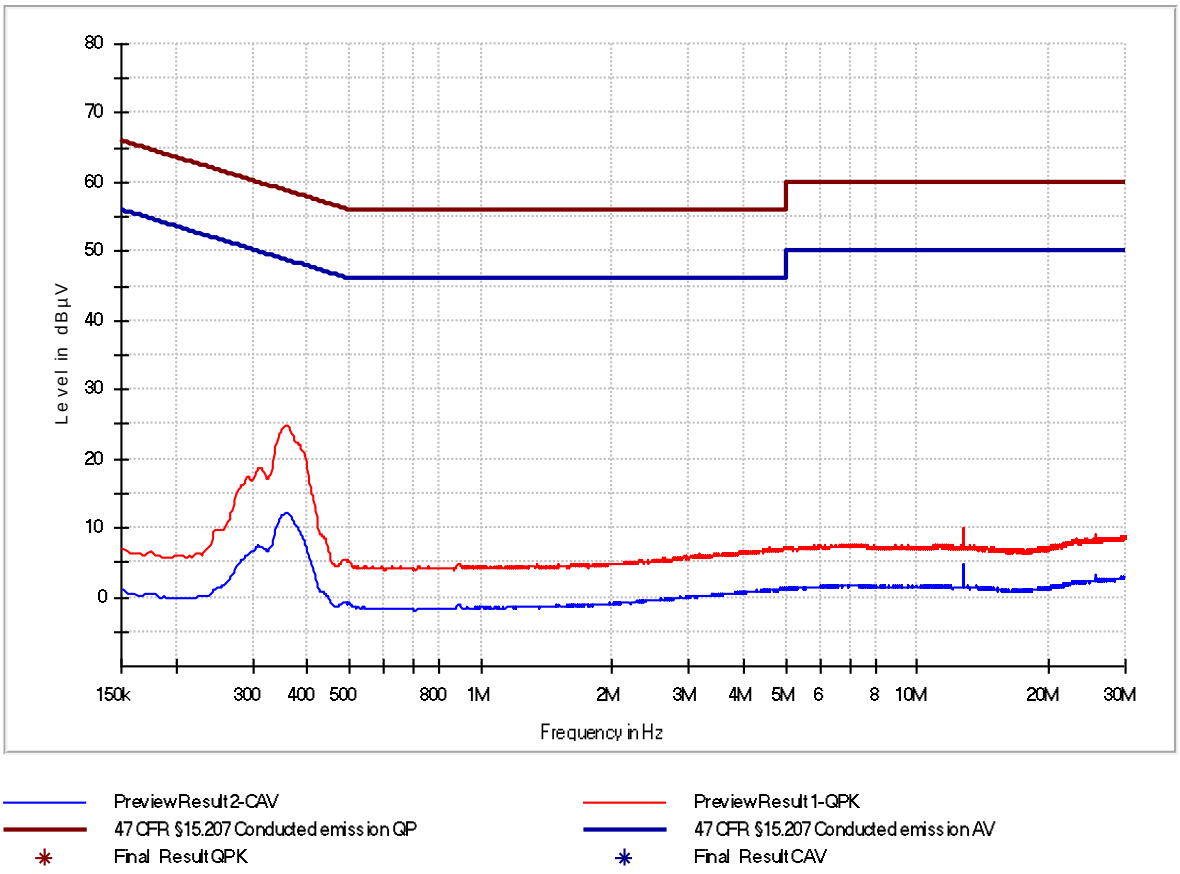

Figure 5: Chart of AC power-line conducted emissions test of 125 kHz – phase L1

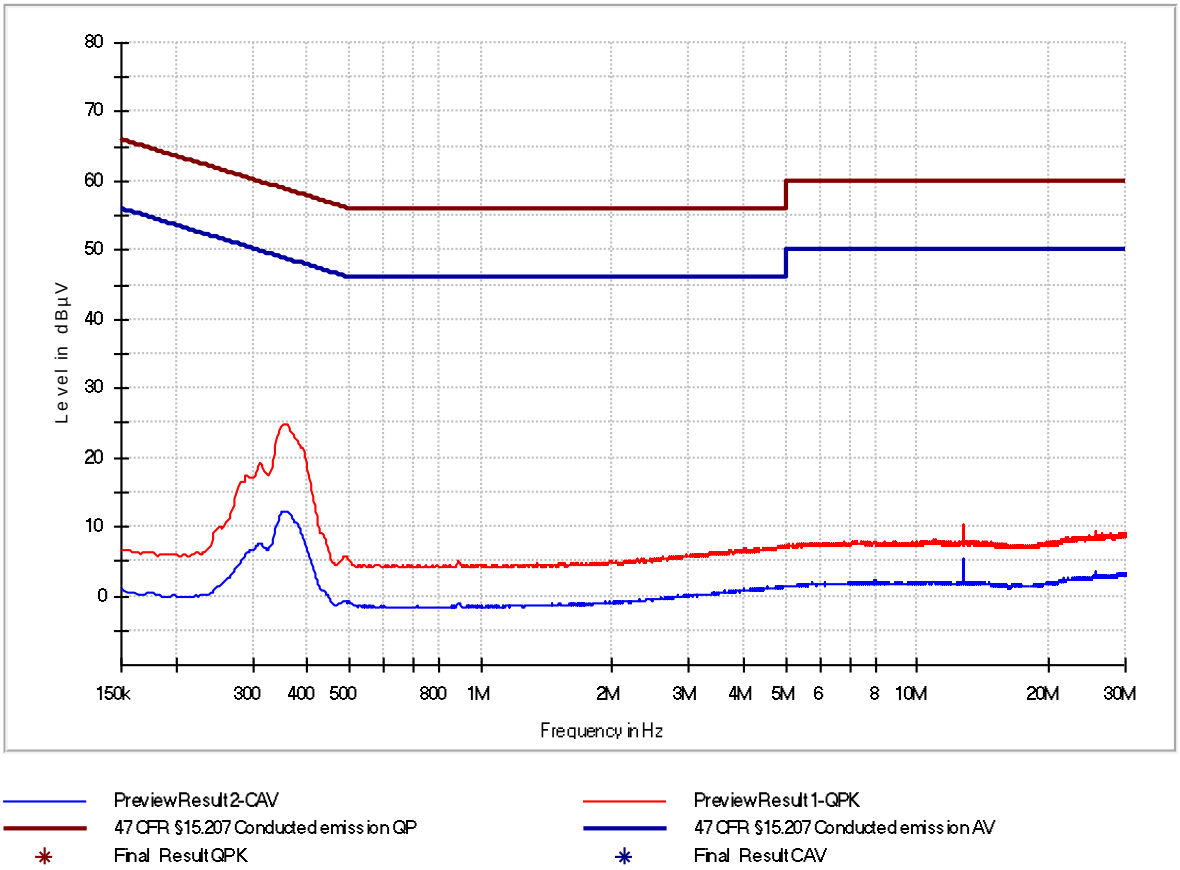

Figure 6: Chart of AC power-line conducted emissions test of 125 kHz – phase N

Note(s):
1 No assessable emissions were detected.

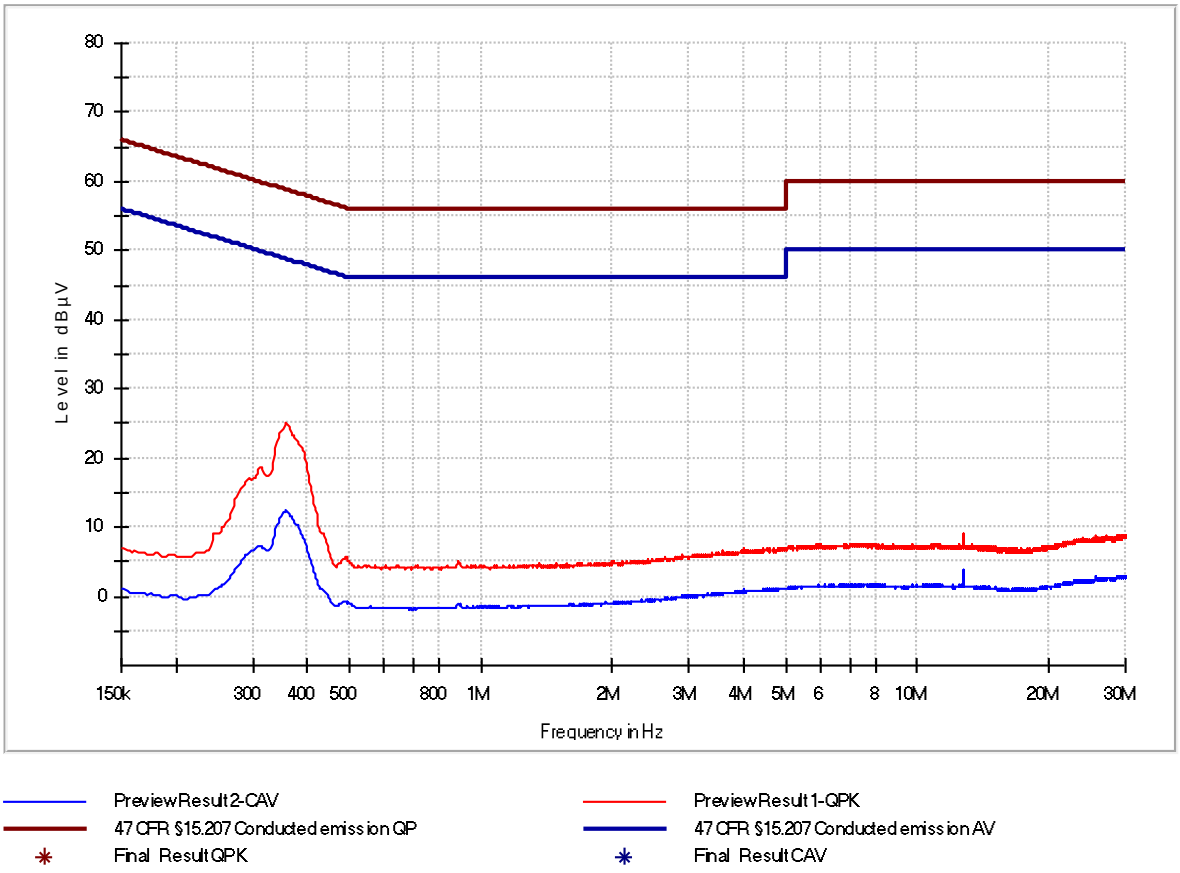

Figure 7: Chart of AC power-line conducted emissions test of 134.2 kHz – phase L1

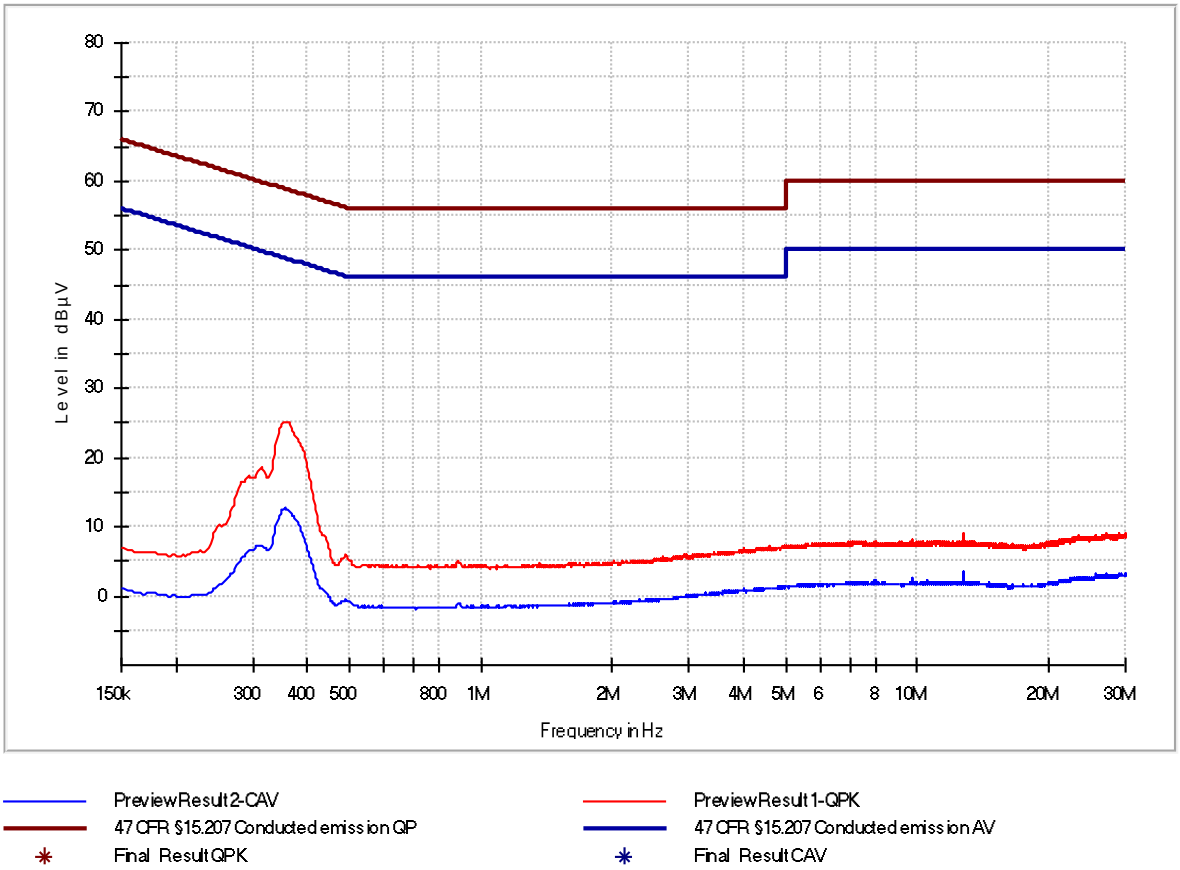

Figure 8: Chart of AC power-line conducted emissions test of 134.2 kHz – phase N

7.2 Radiated emissions below 30 MHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.209(a)
	Reference(s):	ANSI C63.10, clause 6.4
Section(s) in RSS:	Requirement(s):	RSS-210, section 7.3
	Reference(s):	ANSI C63.10, clause 6.4

Performed by:	Jennifer Riedel B. Eng.	Date of test:	June 11, 2021
Result:	☒ Test passed	☐ Test not passed	

7.2.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
EMI test receiver	ESW 44	Rohde & Schwarz	E00895
Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
Cable set CDC	RF cable(s)	Huber + Suhner AME HF-Technik AME HF-Technik Stabo	E00446 E00920 E00921 E01215
Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777

7.2.2 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)	48.52 – 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 15: General radiated emission limits up to 30 MHz according to §15.209

According to section 7.3 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)	-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 16: General radiated emission limits up to 30 MHz according to RSS Gen, section 8.9

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed in table 15 and Table 16, using the recalculation factor as described in clause Radiated emissions below 30 MHz.

7.2.3 Test procedure

The emissions below 30 MHz are measured using the test procedure for radiated measurements as described in clause Radiated emissions below 30 MHz.

7.2.4 Test results

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

Note(s):
1. Premeasurements were performed to declare the worst-case which is documented below.
2. 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.

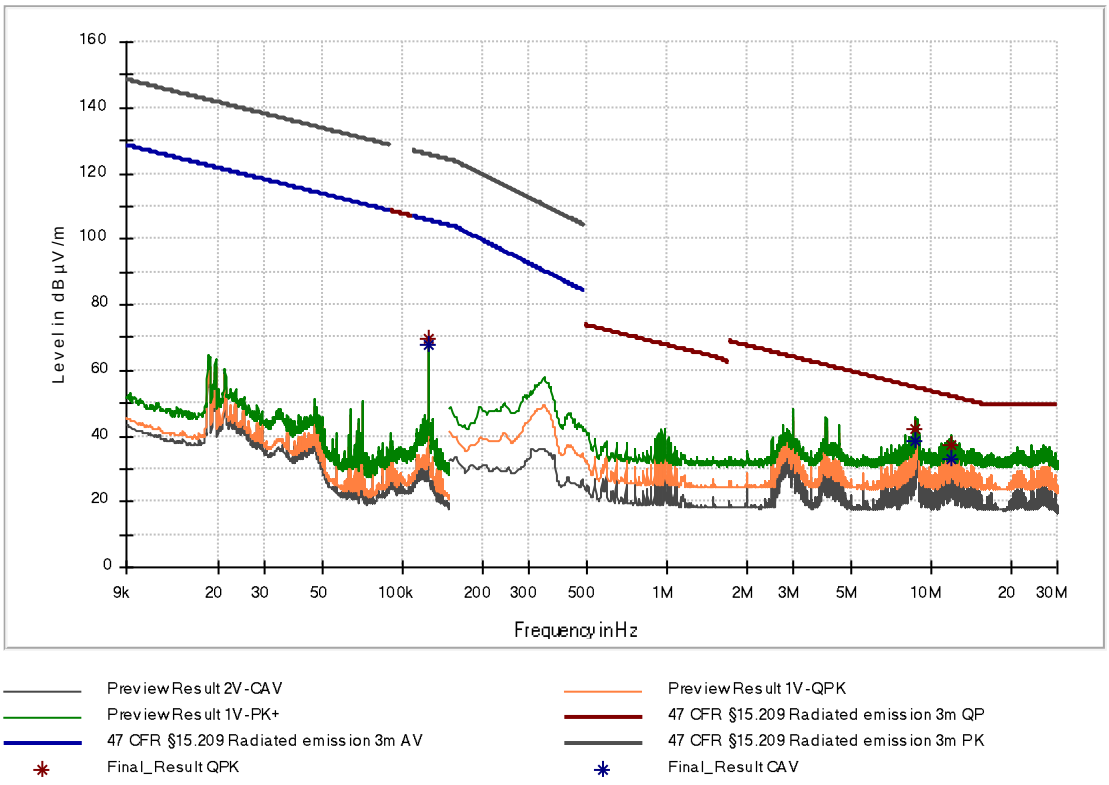

Figure 9: Chart of emissions test below 30 MHz of 125 kHz, EUT position Y, without tag, antenna in line at 3 m

Frequency (MHz)	*Measured value (dBµV/m) at 3 m*	*Recalculation factor (dB)*	*Field strength (dBµV/m) at 300 m*	*Limit (dBµV/m) at 300 m*	*Margin (dB)*	*Detector*	*Azimuth (deg)*	*Result*
0.125000	71.06	-82.10	-11.04	45.67	56.71	PK	179.0	Pass
0.125000	67.72	-80.00	-12.28	25.67	37.95	AV	179.0	Pass
8.760750	42.29	-25.19	17.10	29.54	12.44	QP	151.0	Pass

Table 17: Final results of emission below 30 MHz of 125 kHz, EUT position Y, without tag, antenna in line according to § 15.209

Frequency (MHz)	Measured value (dBµA/m) at 3 m	Recalculation factor (dB)	Field strength (dBµA/m) at 300 m	Limit (dBµA/m) at 300 m	Margin (dB)	Detector	Azimuth (deg)	Result
0.125000	19.56	-82.10	-61.54	-6.44	55.50	PK	179.0	Pass
0.125000	16.22	-80.00	-63.78	-25.83	37.95	AV	179.0	Pass
8.760750	-9.21	-25.19	-34.40	-21.96	12.44	QP	151.0	Pass

Table 18: Final results of emission below 30 MHz of 125 kHz, EUT position Y, without tag, antenna in line according to RSS-210

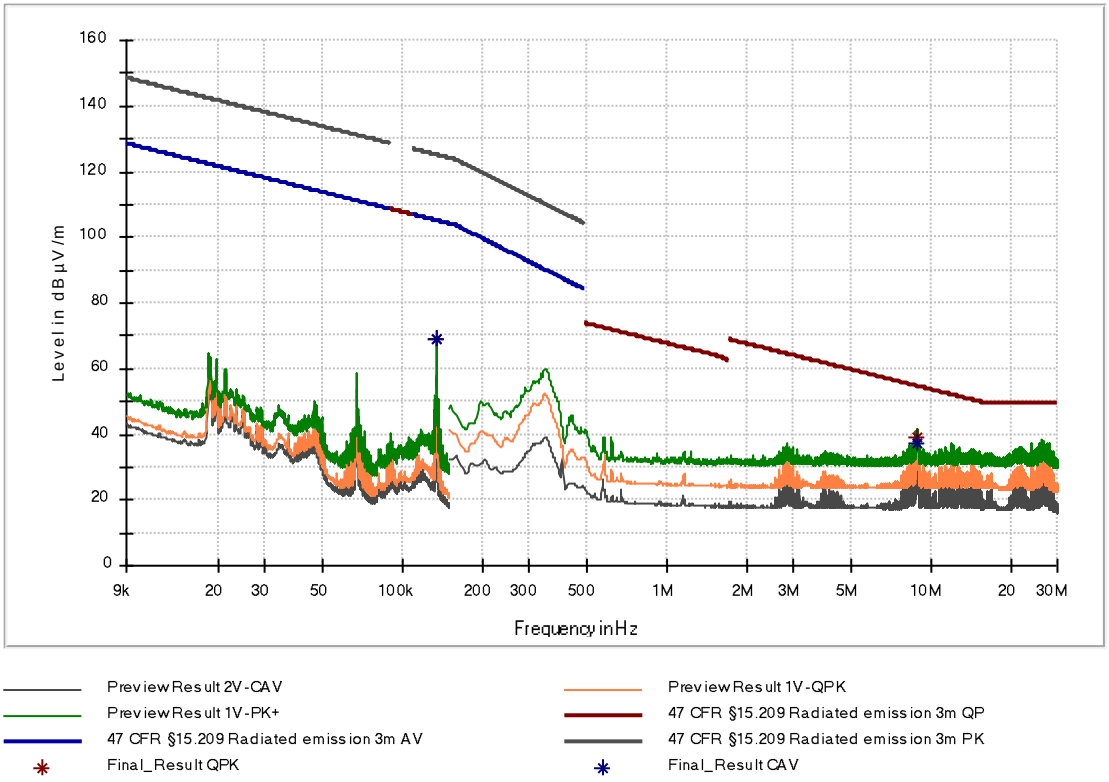

Figure 10: Chart of emissions test below 30 MHz of 134.2 kHz, EUT position Y, without tag, antenna in line at 3 m

Frequency (MHz)	*Measured value (dBµV/m) at 3 m*	*Recalculation factor (dB)*	*Field strength (dBµV/m) at 300 m*	*Limit (dBµV/m) at 300 m*	*Margin (dB)*	*Detector*	*Azimuth (deg)*	*Result*
0.134200	71.15	-81.49	-10.34	45.05	55.38	PK	164.0	Pass
0.134200	68.90	-80.00	-11.10	25.05	36.15	AV	164.0	Pass
8.839500	39.02	-25.11	13.91	29.54	15.63	QP	161.0	Pass

Table 19: Final results of emission below 30 MHz of 134.2 kHz, EUT position Y, without tag, antenna in line according to § 15.209

Frequency (MHz)	*Measured value (dBµA/m) at 3 m*	*Recalculation factor (dB)*	*Field strength (dBµA/m) at 300 m*	*Limit (dBµA/m) at 300 m*	*Margin (dB)*	*Detector*	*Azimuth (deg)*	*Result*
0.134200	19.65	-81.49	-61.84	-6.45	55.38	PK	164.0	Pass
0.134200	17.40	-80.00	-62.60	-26.45	36.15	AV	164.0	Pass
8.839500	-12.48	-25.11	-37.59	-21.96	15.63	QP	161.0	Pass

Table 20: Final results of emission below 30 MHz of 134.2 kHz, EUT position Y, without tag, antenna in line according to RSS-210

7.3 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 7.3
	Reference(s):	ANSI C63.10, clause 6.5

Performed by:	Jennifer Riedel B. Eng.	Date of test:	June 21, 2021
Result:	☒ Test passed	☐ Test not passed	

7.3.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
EMI test receiver	ESW 44	Rohde & Schwarz	E00895
TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

7.3.2 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:

According to section 7.3 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	40.00	3
88 – 216	150	43.52	3
216 - 960	200	46.02	3
Above 960	500	53.98	3

Table 21: General radiated emission limits ≥ 30 MHz according to §15.209 and RSS-Gen

7.3.3 Test procedure

The emissions from 30 MHz to 1 GHz are measured using the test procedure for radiated measurements as described in clause 6.4.

7.3.4 Test results

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

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

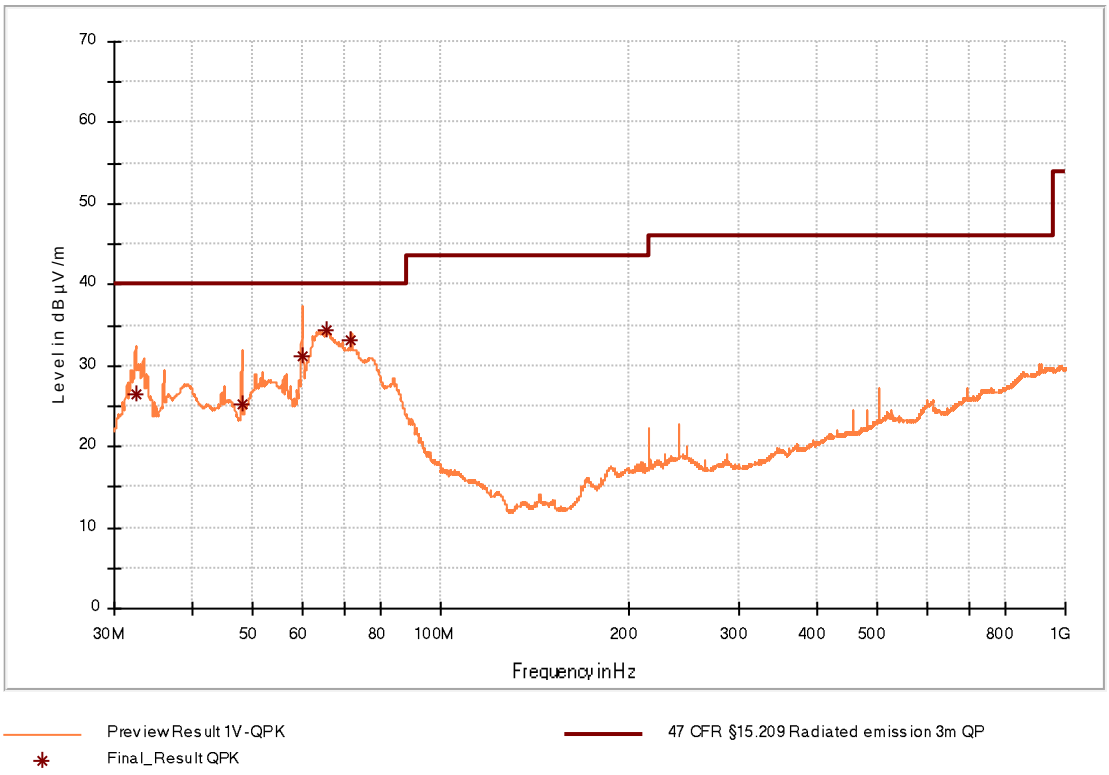

Figure 11: Chart of emissions test from 30 MHz to 1 GHz of 125 kHz, EUT position Z, without tag, antenna vertical, at 3 m

Frequency (MHz)	*Measured value QuasiPeak (dBµV/m) at 3m*	*Limit (dBµV/m) at 3m*	*Margin (dB)*	*Height (cm)*	*Polarization*	*Azimuth (deg)*	*Result*
32.430000	26.42	40.00	13.58	100.0	V	240.0	Passed
48.060000	25.19	40.00	14.81	151.0	V	240.0	Passed
60.000000	31.21	40.00	8.79	100.0	V	179.0	Passed
65.700000	34.43	40.00	5.57	100.0	V	176.0	Passed
71.880000	33.21	40.00	6.79	123.0	V	187.0	Passed

Table 22: Final results of emissions test from 30 MHz to 1 GHz of 125 kHz, EUT position Z, without tag, at 3 m

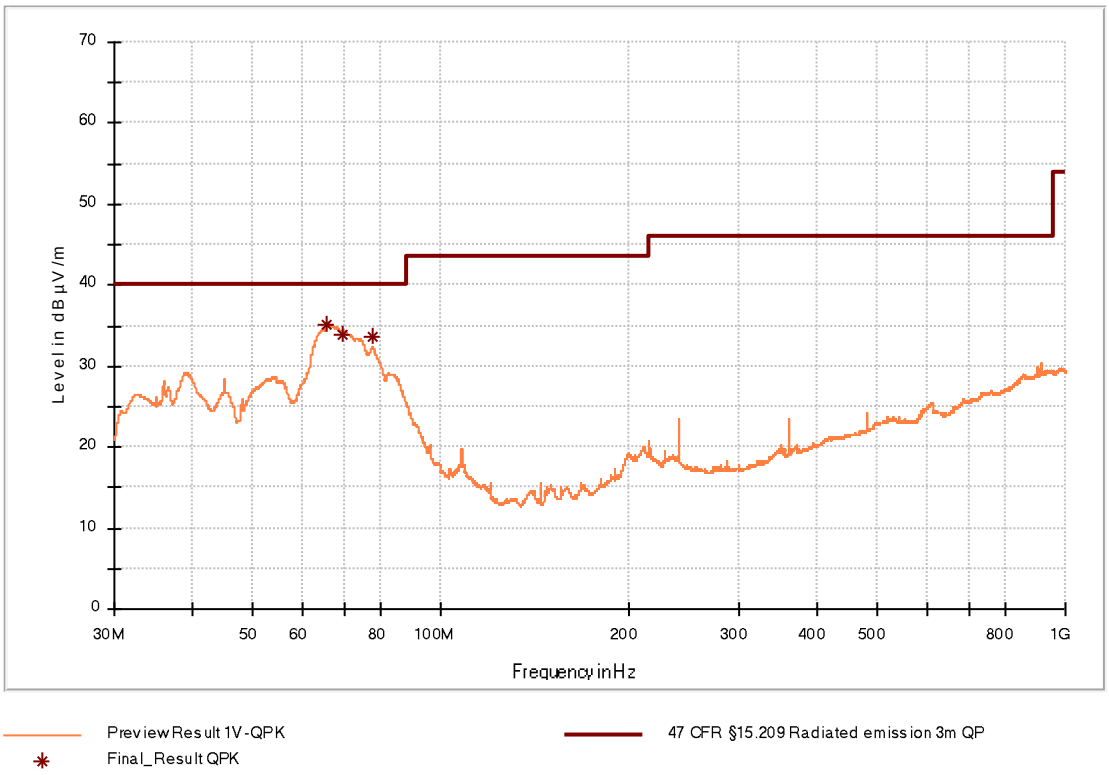

Figure 12: Chart of emissions test from 30 MHz to 1 GHz of 134.2 kHz, EUT position Z, without tag, antenna vertical, at 3 m

Frequency (MHz)	*Measured value QuasiPeak (dBµV/m) at 3m*	*Limit (dBµV/m) at 3m*	*Margin (dB)*	*Height (cm)*	*Polarization*	*Azimuth (deg)*	*Result*
65.820000	35.05	40.00	4.95	100.0	V	180.0	Passed
69.630000	33.81	40.00	6.19	123.0	V	206.0	Passed
77.730000	33.58	40.00	6.42	150.0	V	121.0	Passed

Table 23: Final results of emissions test from 30 MHz to 1 GHz of 134.2 kHz, EUT position Z, without tag, at 3 m

8 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2020-08	2022-08
EMI test receiver	ESU26	100026	W00002	2020-06	2022-06
EMI test receiver	ESR7	101059	E00739	2019-08	2021-08
EMI test receiver	ESR7	102170	E01549	2021-05	2023-05
EMI test receiver	ESCI3	100328	E00552	2020-10	2022-10
EMI test receiver	ESCI3	100013	E00001	2020-05	2022-05
Preamplifier (1 GHz - 18 GHz)	BBV 9718 B	00032	W01325	2020-09	2021-10
Preamplifier (18 GHz - 40 GHz)	BBV 9721	43	W01350	2020-11	2021-11
Preamplifier (1 GHz - 18 GHz)	ALS05749	001	W01007	2021-01	2022-01
Loop antenna	HFH2-Z2	871398/0050	E00060	2020-10	2022-10
LISN	ESH2-Z5	881362/037	E00004	Note 1	
LISN	ESH2-Z5	893406/009	E00005	2020-10	2022-10
Field probe	RF-R 400-1	02-2030	E00270	Note 2	
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2021-03	2024-03
Horn antenna	BBHA 9120D	9120D-592	W00053	2020-04	2023-04
Horn antenna	BBHA 9170	9170-332	W00055	2020-04	2023-04
Shielded room	P92007	B 83117 C 1109 T 211	E00107	N/A	
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69-2-0006	E00026	N/A	
Semi-anechoic chamber (SAC) with floor absorbers	FS-SAC	---	E00100	2021-03	2024-03
Semi-anechoic chamber (SAC)	SAC3	C62128-A520-A643-x-0006	E00716	2021-03	2024-03
Cable set CDC	RG214/U	---	E00446	2021-04	2022-04
	LCF12-50J	---	E01215	2021-04	2022-04
	LMR400	1718020006	E00920	2021-01	2022-01
	RG214 Hiflex	171802007	E00921	2021-01	2022-01
Cable set anechoic chamber	262-0942-1500	005	E00435	2020-10	2021-10
	SF104EA/2x11PC35-42/5m	11144/4EA	E00307	2020-12	2021-12
	262-0942-1500	003	E00433	2020-10	2021-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2020-12	2021-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01035	2020-12	2021-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2020-09	2021-09

Note(s)
1. Only used for decoupling of support equipment.
2. Only used for relative measurements.

9 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.

5 All used test instruments as well as the test accessories are calibrated at regular intervals.

10 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2021-07-15	Jennifer Riedel B. Eng.	First edition

Template: RF_15.209_RSS-210_V1.3