Test report

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Test report no.:

200143-AU01+W06

for:

Elatec GmbH
RFID reader / writer
TWN4 Palon Compact LEGIC

according to:

15.225

RSS-210

EMV TESTHAUS

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

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

Accreditation:

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Recognized on March 14th, 2019 by the
Department of Innovation, Science and Economic Development (ISED) Canada
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CAB identifier: DE0011
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The technical accuracy is guaranteed through the quality management of the EMV **TESTHAUS** 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)*	*Page*	*Result*	*Note(s)*
15.207	AC power line conducted emissions 150 kHz to 30 MHz	RSS-210, section 3.1 RSS-Gen, section 8.8	26	Passed	1
15.215(c)	20 dB bandwidth	---	33	Passed	
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	RSS-Gen, section 6.7	36	Passed	
15.225 (a) – (d)	Operation within the band 13.110 – 14.010 MHz	RSS-210 section B.6	38	Passed	
15.225(e)	Carrier frequency stability	RSS-210, section B.6 RSS-Gen, section 6.11	41	Passed	
15.209	Emissions outside the operating frequency band(s) specified 9 kHz to 2 GHz	RSS-Gen, section 6.13 RSS-Gen, section 8.9			
	9 kHz to 30 MHz		44	Passed	---
	30 MHz to 1 GHz		50	Passed	---
	1 GHz to 2 GHz		55	Passed	2,3

Notes (for information about EUT see clause 3):

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.

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

3 According to 47 CFR Part 15, §15.33, 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, March 30, 2020

Andreas Menacher
Test engineer
EMV **TESTHAUS** GmbH

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

2 Referenced publications

Publication	*Title*
CFR 47 Part 2 November 2019	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 November 2019	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 March 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

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 Palon Compact LEGIC		
Serial number(s):	2020081224		
Applicant:	Elatec GmbH		
Manufacturer:	Elatec GmbH		
Version:	Hardware:	T4W2-B01C7-PRODC	
	Software:	B1.08/NKB3.12/STD2.02/B/BT1.07EL	
Additional modifications:	None		
FCC ID:	WP5TWN4F11		
IC registration number:	7948A-TWN4F11		
Power supply:	DC supply		
USB:	Nominal voltage:	5.00 V	
	Minimum voltage:	4.30 V	
	Maximum voltage:	5.50V	
RS-485 / RS-232:	Nominal voltage:	12.00 V	
	Minimum voltage:	9.00 V	
	Maximum voltage:	30.00 V	
Temperature range:	-25 °C to +80 °C (customer defined)		
Device type:	☐ Portable	☐ Mobile	☒ Fixed

3.2 Radio specifications

System type:	RFID Reader		
Application frequency band:	13.110 MHz – 14.010 MHz		
Operating frequency:	13.56 MHz		
Short description:	The EUT is a RFID Reader which is operating at the frequencies 125 kHz and 13.56 MHz. Only the frequency 13.56 MHz is in consideration in this test report.		
Number of RF channels	1		
Highest internal frequency:	120 MHz		
Modulation	ASK		
Antenna:	Type:	PCB antenna	
	Connector:	☐ external	☐ internal
		☐ temporary	☒ none (integral antenna)

3.3 Photo documentation

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

4 Test configuration and mode of operation

4.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
EUT			
RFID reader / writer	TWN4 Palon Compact LEGIC	2020081224	Elatec GmbH
Support equipment			
RFID-tag	Keyfob 13.56 MHz	---	---
Laptop	Lifebook U772	O00632	FUJITSU
Power supply for laptop	AC adapter	O00632	FUJITSU
Power supply	3231.1	E01235	Statron
Adapter + wiring	Serial to USB	0219	ASSMANN Electronic
Adapter + wiring	RS-485 to USB	V0331	---
USB cable	Micro USB – USB A	---	---
USB measurement box	USB measurement box	SEB01231	EMV Testhaus

Table 1: Devices used for testing

Port	*Classification*	*Cable type*	*Note*
DC power	DC power	Unshielded	
RS-485	Signal control	Unshielded	
RS-232	Signal control	Unshielded	
USB	DC power / signal control	Shielded	
Clock-Data / Wiegand	Signal control	Unshielded	

Table 2: Ports of EUT

4.2 Mode of operation

4.2.1 Test software used for all tests

Test software “TWN4_NKx322_CAPC107_Continuous_Mode3_BLE(CH0)_13.56MHz.bix” was used for all tests in this test report.

4.2.2 Test modes applied

The EUT was forced via customer test software to search permanent for 13.56 MHz tags.

Then the tag ID was sent to a notebook via USB, RS-485 or RS-232 interface.

Parallel to this the protocols Clock/Data and Wigand were sent successively and permanent at the respective port.

The spurious emission measurements from 9 kHz – 30 MHz, 30 MHz – 1 GHz and 1 GHz – 2 GHz were performed with each of the interfaces active.

All other measurements in this test report were performed with the USB interface.

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).

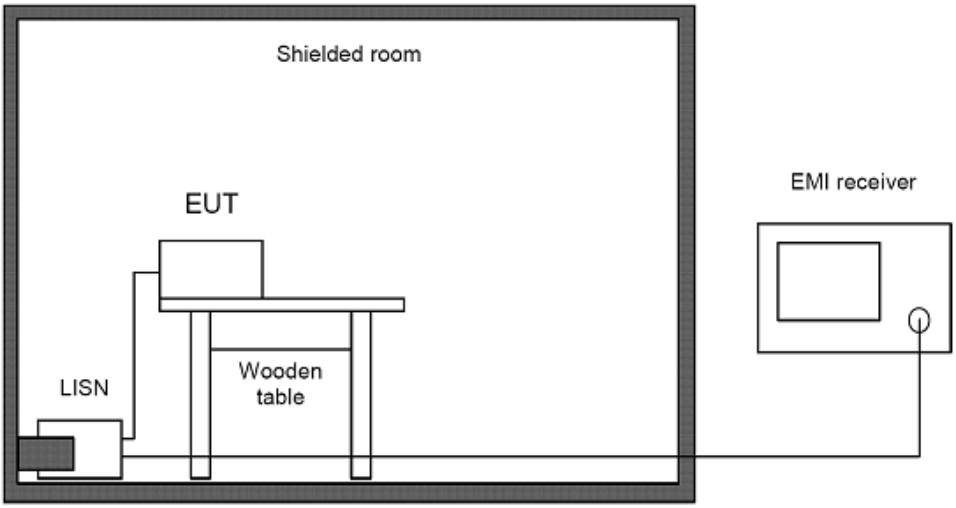


Figure 1: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

5.3 Radiated emissions below 30 MHz

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

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

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

$d_{near\ field}$ = 47.77 / f_{MHz}, or
f_{MHz} = 47.77 / $d_{near\ field}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula to determine the recalculation factor:

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

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

Frequency (f)	d_{limit}	$d_{measure}$	*Formula for recalculation factor*
9 kHz ≤ f ≤ 159 kHz 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 4: 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 5.

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

Sample calculation:

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

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 20 dBµV + 19.92 dB/m = 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 5).
d) The EUT is turned to a position likely to get the maximum and the test antenna is rotated to detect the maximum of the fundamental in this EUT position.
e) Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position.
f) After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
g) With the test receiver set to the first frequency of the list, the EUT is rotated by ±45° around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
h) Step g) is repeated for all other frequencies in the list.
i) Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission. At least, frequency and level of the six highest emissions relative to the

limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

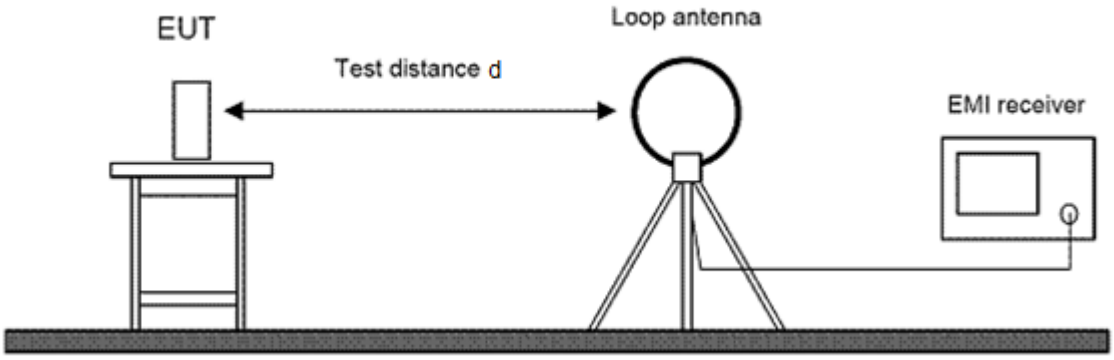


Figure 2: Setup for radiated emissions test below 30 MHz

5.4 Radiated emissions from 30 MHz to 1 GHz

Radiated emissions in the frequency range 30 MHz to 1 GHz are measured according to clause 6.5 of ANSI C63.10 using a semi-anechoic chamber (SAC) with a ground plane on the floor. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 6.

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

Sample calculation:

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

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 30 dBµV + 12.77 dB/m = 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 6).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
g) The antenna height is increased to 4 m in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±60° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

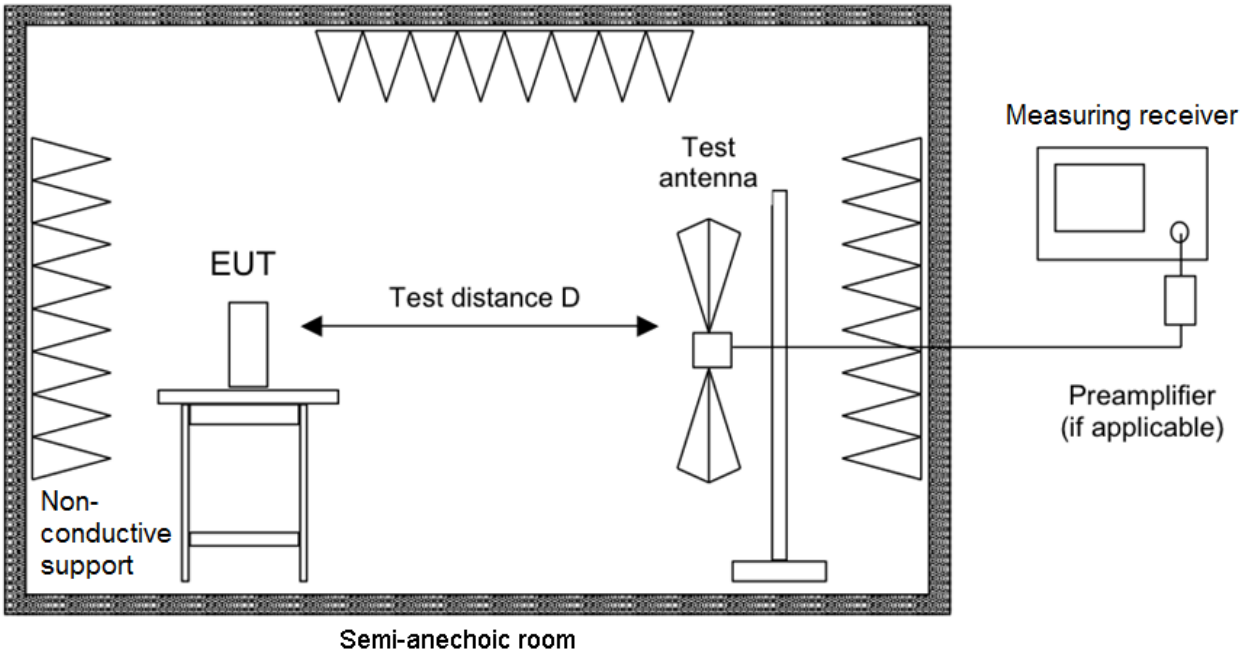


Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

5.5 Radiated emissions above 1 GHz

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

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

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Correction pre-amplifier (dB)	Cable attenuation (dB)	Correction factor (Corr.) (dB/m)	Level (dBµV/m)
2400	50.00	27.76	-47.91	5.24	-14.92	35.08

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

Level = Reading value + Correction factor = 50.00 dBµV - 14.92 dB/m = 35.08 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 7.

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

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

5.5.2 Final radiated emissions measurements

Final radiated emissions above 1 GHz are measured in a semi-anechoic chamber (SAC) with RF absorbing material on the floor between measurement antenna and EUT. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 8.

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

Table 8: 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 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. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
g) The antenna height is increased to the scan height upper range in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.

i) The antenna height is decreased from the scan height upper range to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 30°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±30° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

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

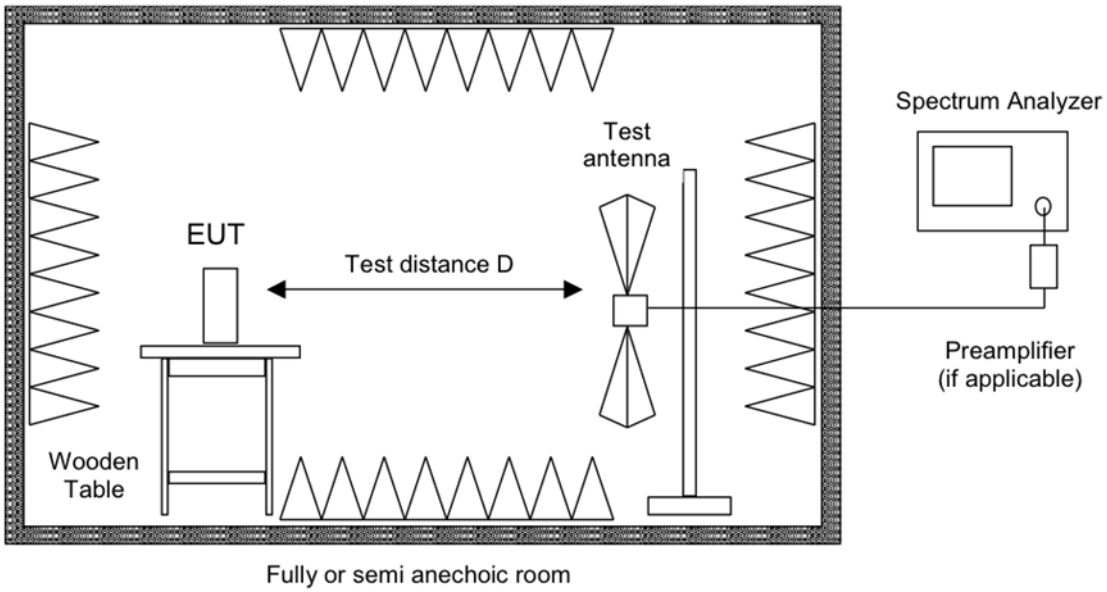


Figure 4: Setup for radiated emissions test above 1 GHz

5.6 Bandwidth measurements

5.6.1 20 dB bandwidth of the emission

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

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

The reference level of the instrument is set as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (20 dB bandwidth/RBW)] below the reference level.

5.6.2 99 % occupied bandwidth

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

The span of the spectrum analyzer is set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
The resolution bandwidth is in the range of 1 % to 5 % of the occupied bandwidth and the video bandwidth is not smaller than three times the resolution bandwidth. Video averaging is not permitted.
If possible, the detector of the spectrum analyzer is set to “Sample”. However, if the device is not transmitting continuously, a peak, or peak hold is used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement).

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

5.7 Operation within the band 13.110 MHz - 14.010 MHz

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 15.225 (a) to (d). 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.

5.8 Carrier frequency stability

1. If possible EUT is operating providing an unmodulated carrier. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to the shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance. If an unmodulated carrier is not available a significant and stable point on the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1% of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance allowed is larger than the uncertainty of the measured frequency tolerance.
2. The carrier frequency is measured depending on the variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C.
   For battery operated equipment an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer. Alternatively, tests shall be performed using a new battery.
3. The carrier frequency is measured over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage.

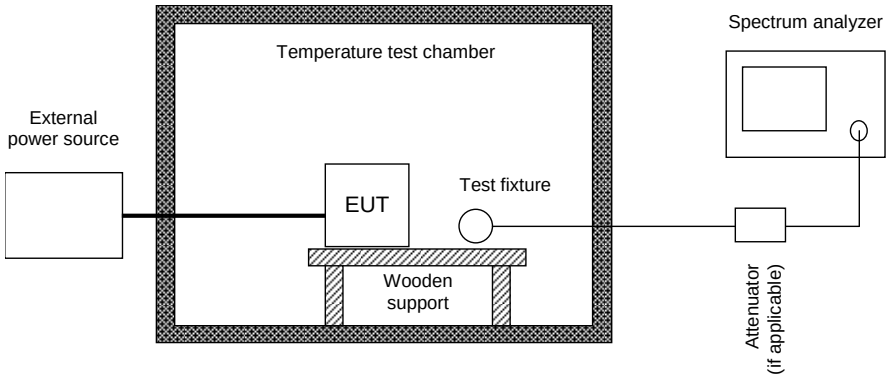


Figure 5: Test setup for carrier frequency stability measurement

6 Test results

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

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

Ambient temperature	*Ambient humidity*	*Ambient pressure*
15°C to 35°C	30 % to 75 %	86 kPa to 106 kPa

6.1 AC powerline conducted emissions

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

Performed by:	Andreas Menacher	Date of test:	March 27, 2020

Result[1]: ☒ Test passed ☐ Test not passed

6.1.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Shielded room	P92007	Siemens – Matsushita	E00107
EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
Line impedance stabilization network	ESH2-Z5	Rohde & Schwarz	E00005
Cable set shielded room	RF cable(s)	Huber + Suhner	E00424
Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777

[1] For information about measurement uncertainties see page 53.

6.1.2 Limits

For intentional radiators that are 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 Table 9.

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 9: Limits for AC powerline conducted emissions

*Decreases with the logarithm of the frequency

6.1.3 Test procedure

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

Remark: 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 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 limits within the transmitter´s fundamental emission band.

6.1.4 Test results

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

Note: The notebook was powered with 120 V / 60 Hz.

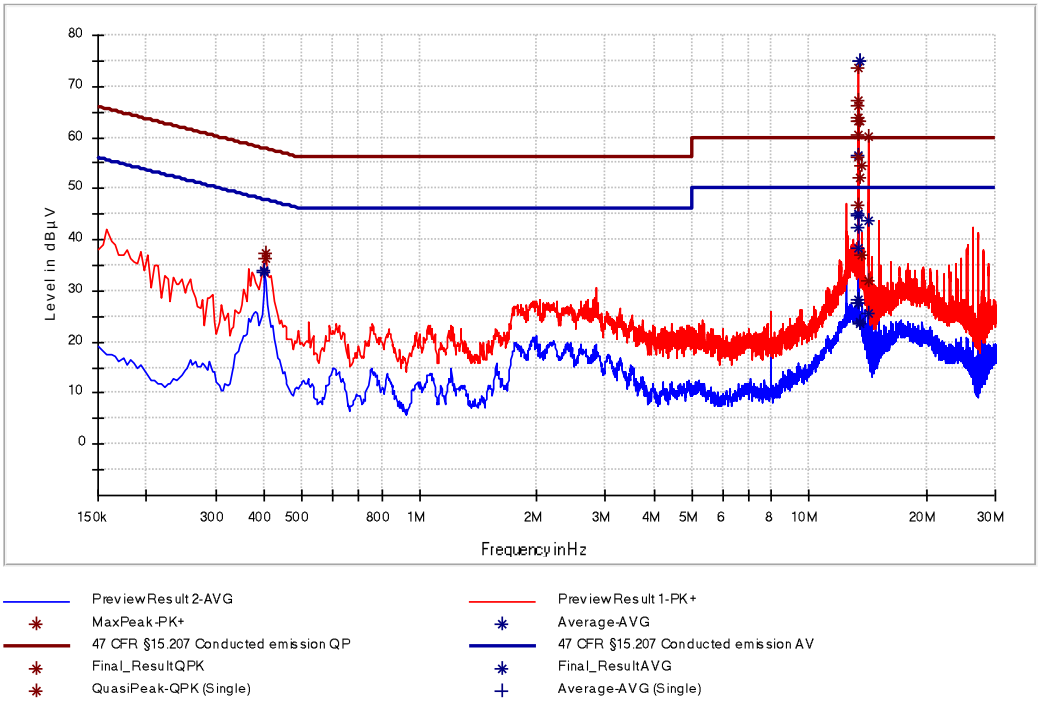


Figure 6: Chart of AC powerline conducted emissions on L1 – without termination

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE	Result
0.401000	---	33.97	47.83	13.86	L1	GND	Pass
0.405000	36.36	---	57.75	21.39	L1	GND	Pass
13.297000	---	27.46	50.00	22.54	L1	GND	Pass
13.325000	---	28.19	50.00	21.81	L1	GND	Pass
13.349000	67.37	---	60.00	-7.37	L1	GND	Pass
13.349000	---	38.44	50.00	11.56	L1	GND	Pass
13.560000	87.83	---	60.00	-27.83	L1	GND	Pass
13.560000	---	75.09	50.00	-25.09	L1	GND	Pass
13.357000	---	27.45	50.00	22.55	L1	GND	Pass
13.389000	46.74	---	60.00	13.26	L1	GND	Pass
13.425000	56.04	---	60.00	3.96	L1	GND	Pass
13.431000	51.98	---	60.00	8.02	L1	GND	Pass
13.553000	---	23.68	50.00	26.32	L1	GND	Pass
13.577000	54.39	---	60.00	5.61	L1	GND	Pass
14.169000	---	25.55	50.00	24.45	L1	GND	Pass
14.169000	31.98	---	60.00	28.02	L1	GND	Pass

Table 10: Results of AC powerline conducted emissions on L1 – without termination

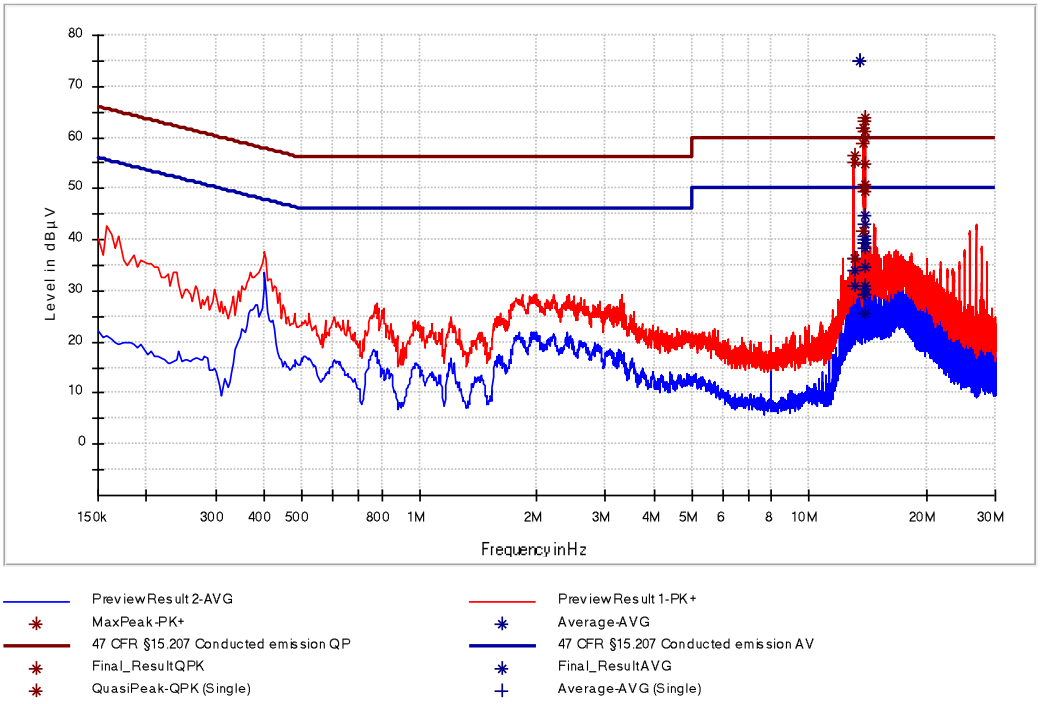


Figure 7: Chart of AC powerline conducted emissions on N – without termination

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE	Result
13.045000	---	31.01	50.00	18.99	N	GND	Pass
13.045000	36.19	---	60.00	23.81	N	GND	Pass
13.833000	50.09	---	60.00	9.91	N	GND	Pass
13.841000	41.60	---	60.00	18.40	N	GND	Pass
13.855000	---	30.31	50.00	19.69	N	GND	Pass
13.857000	---	31.12	50.00	18.88	N	GND	Pass
13.857000	50.08	---	60.00	9.92	N	GND	Pass
13.883000	---	29.44	50.00	20.56	N	GND	Pass
13.883000	50.75	---	60.00	9.25	N	GND	Pass
13.889000	---	34.58	50.00	15.42	N	GND	Pass
13.889000	49.33	---	60.00	10.67	N	GND	Pass
13.901000	---	25.73	50.00	24.27	N	GND	Pass
13.850000	---	29.33	50.00	20.67	N	GND	Pass
13.850000	54.89	---	60.00	5.11	N	GND	Pass
13.560000	---	75.02	50.00	-25.02	N	GND	Pass
13.560000	87.65	---	60.00	-27.65	N	GND	Pass

Table 11: Results of AC powerline conducted emissions on N – without termination

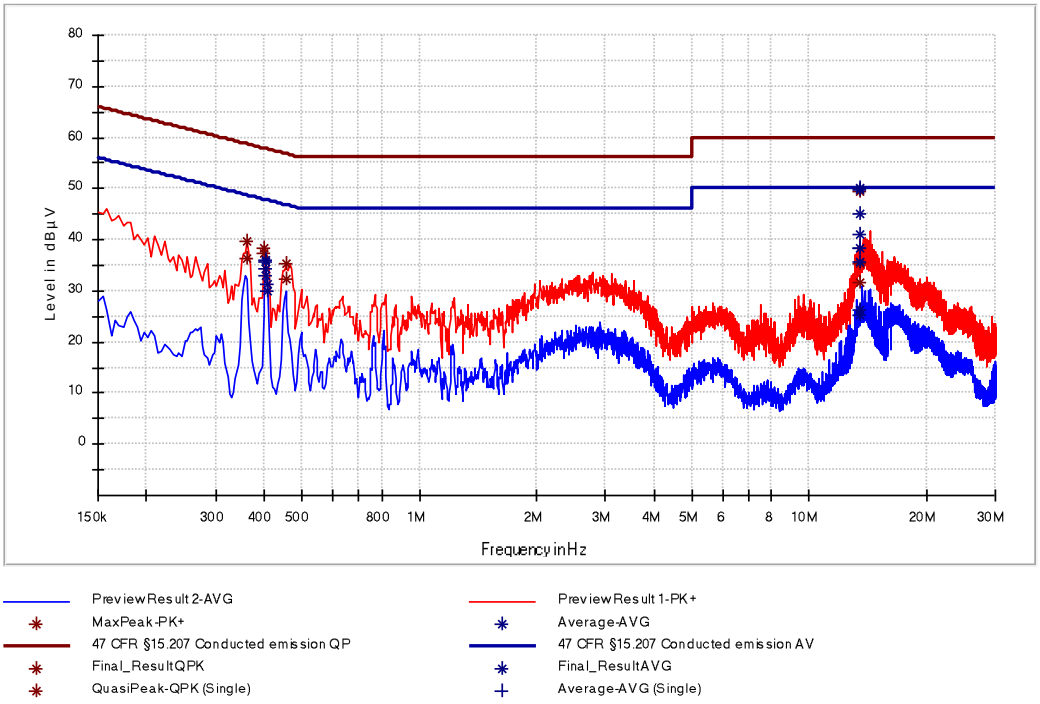


Figure 8: Chart of AC powerline conducted emissions on L1 – with termination

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE	Result
0.361000	36.38	---	58.71	22.33	L1	GND	Pass
0.401000	37.25	---	57.83	20.58	L1	GND	Pass
0.403000	---	35.64	47.79	12.15	L1	GND	Pass
0.405000	---	35.84	47.75	11.91	L1	GND	Pass
0.409000	---	31.22	47.67	16.45	L1	GND	Pass
0.457000	32.17	---	56.75	24.58	L1	GND	Pass
13.517000	---	26.29	50.00	23.71	L1	GND	Pass
13.533000	31.59	---	60.00	28.41	L1	GND	Pass
13.560000	49.42	---	60.00	10.58	L1	GND	Pass
13.560000	---	35.62	50.00	14.38	L1	GND	Pass

Table 12: Results of AC powerline conducted emissions on L1 – with termination

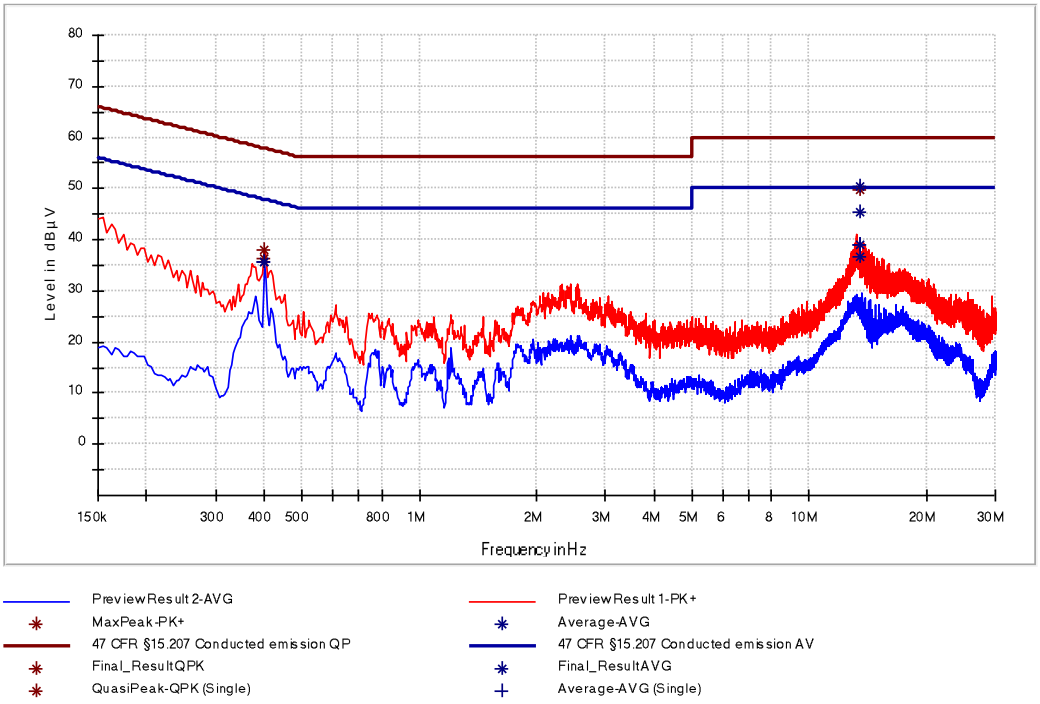


Figure 9: Chart of AC powerline conducted emissions on N – with termination

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE	Result
0.401000	---	35.58	47.83	12.25	N	GND	Pass
0.401000	36.45	---	57.83	21.38	N	GND	Pass
13.560000	49.85	---	60.00	10.15	N	GND	Pass
13.560000	---	36.69	50.00	13.31	N	GND	Pass

Table 13: Results of AC powerline conducted emissions on N – with termination

6.2 20 dB bandwidth

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

Performed by:	Andreas Menacher	Date(s) of test:	March 12, 2020
Result[2]:	☒ Test passed	☐ Test not passed	

6.2.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
Field probe	RF-R 400-1	Langer EMV-Technik	E00270

6.2.2 Limits

According to §15.215(c), intentional radiators operating under the alternative provisions to the general emission limits must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

6.2.3 Test procedure

The 20 dB bandwidth is measured using the test procedure as described in clause 5.6.1.

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

6.2.4 Test results

Remark: The 20 dB bandwidth measurement was performed with tag, because this was the worst case.

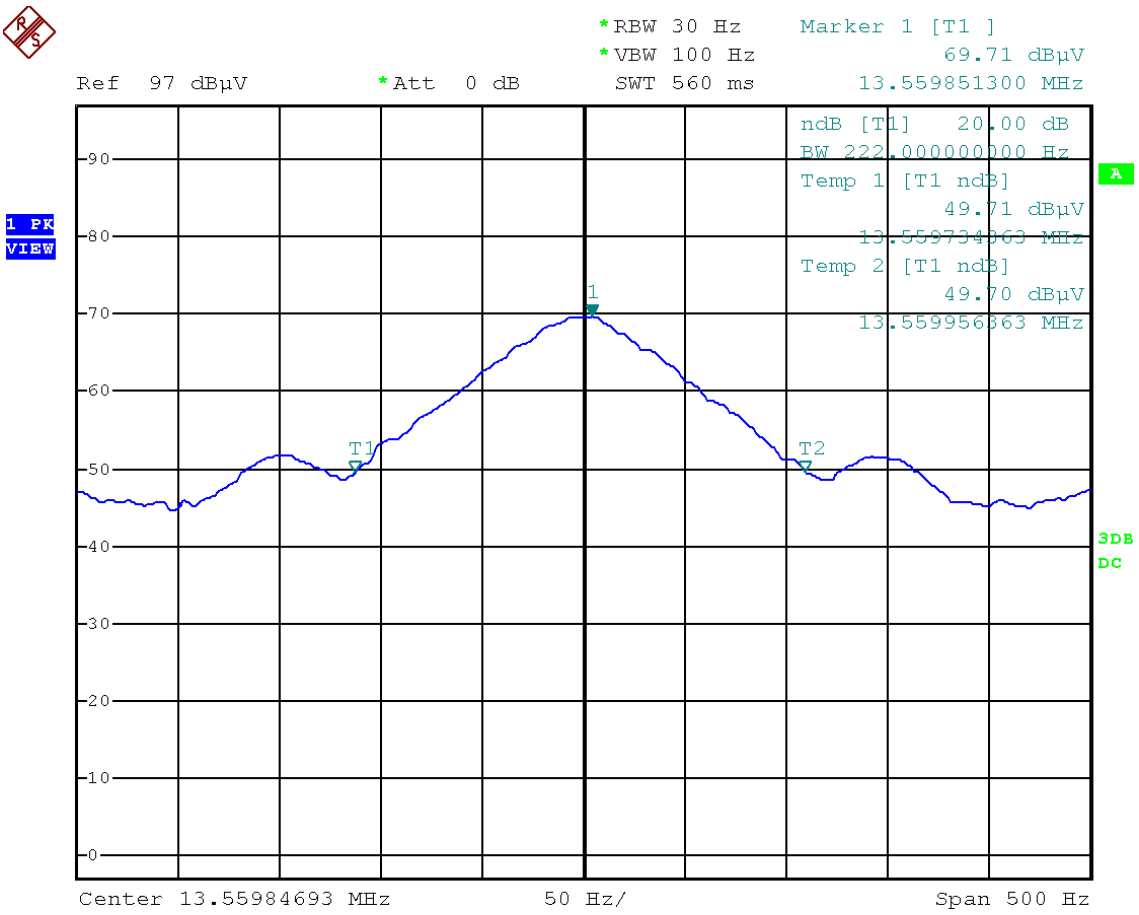


Figure 10: Chart of 20 dB bandwidth tests

20 dB bandwidth	*Band edge left*		*Band edge right*		*Result*
[kHz]	*Frequency [MHz]*	*Limit [MHz]*	*Frequency [MHz]*	*Limit [MHz]*	
0.222	13.559734	13.553000	13.559956	13.5670000	Passed

Table 14: Results of 20 dB bandwidth tests

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.559851	low	13. 559734	0.140	0.073	13.559521	13.553000	6.521	Passed
	high	13. 559956	0.048	---	13.560004	13.567000	6.996	Passed
	Bandwidth	0.222 kHz			0.483 kHz			

with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 20 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = frequency in MHz where emission is at least 20 dB below the carrier, including offset caused by variations of temperature and supply voltage as recorded in clause 5.8

Measured -20 dB emission bandwidth:
At nominal conditions: 0.222 kHz
Including variations in temperature and supply voltage: 0.483 kHz

6.3 Occupied bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s):	2.202(a)
	Reference(s):	ANSI C63.10, clause 6.9
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 6.7
	Reference(s):	ANSI C63.10, clause 6.9

Performed by:	Andreas Menacher	Date(s) of test:	March 12, 2020
Result[3]:	☒ Test passed	☐ Test not passed	

6.3.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
Field probe	RF-R 400-1	Langer EMV-Technik	E00270

6.3.2 Limits

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

6.3.3 Test procedure

The occupied bandwidth is measured using the test procedure as described in clause 5.6.2.

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

6.3.4 Test results

Note: The occupied bandwidth measurement was performed without tag, because this was the worst case.

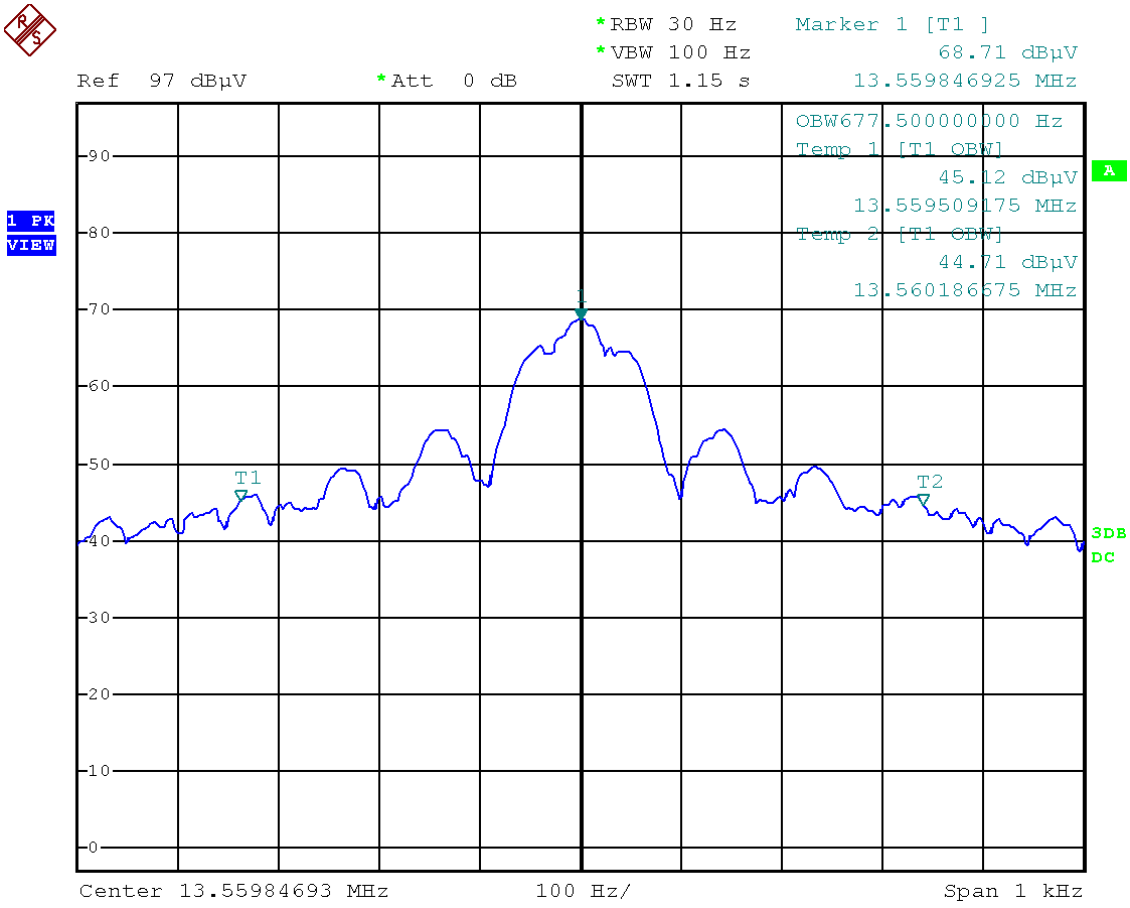


Figure 11: Chart of occupied bandwidth test

99% bandwidth [kHz]	*Band edge left Frequency [MHz]*	*Band edge right Frequency [MHz]*	*Result*
0.677	13.559509	13.560186	Recorded

Table 15: Results of occupied bandwidth test

6.4 Operation within the band 13.110 MHz – 14.010 MHz

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

Performed by:	Andreas Menacher	Date(s) of test:	March 19, 2020
Result[4]:	☒ Test passed	☐ Test not passed	

6.4.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
EMI test receiver	ESR 7	Rohde & Schwarz	E00739
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-MEB (V10.35)	Rohde & Schwarz	E00778

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

6.4.2 Limits

As specified in section 15.225(a)-(d) of 47 CFR Part 15:

The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15.848 microvolts/meter at 30 meters.

Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

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

6.4.3 Test procedure

The emission within the band 13.110 MHz – 14.010 MHz is measured using the test procedure as described in clause 5.7.

6.4.4 Test results

Notes:

The final measurement was performed with tag.

Only the worst case is shown: EUT in position X, antenna in line.

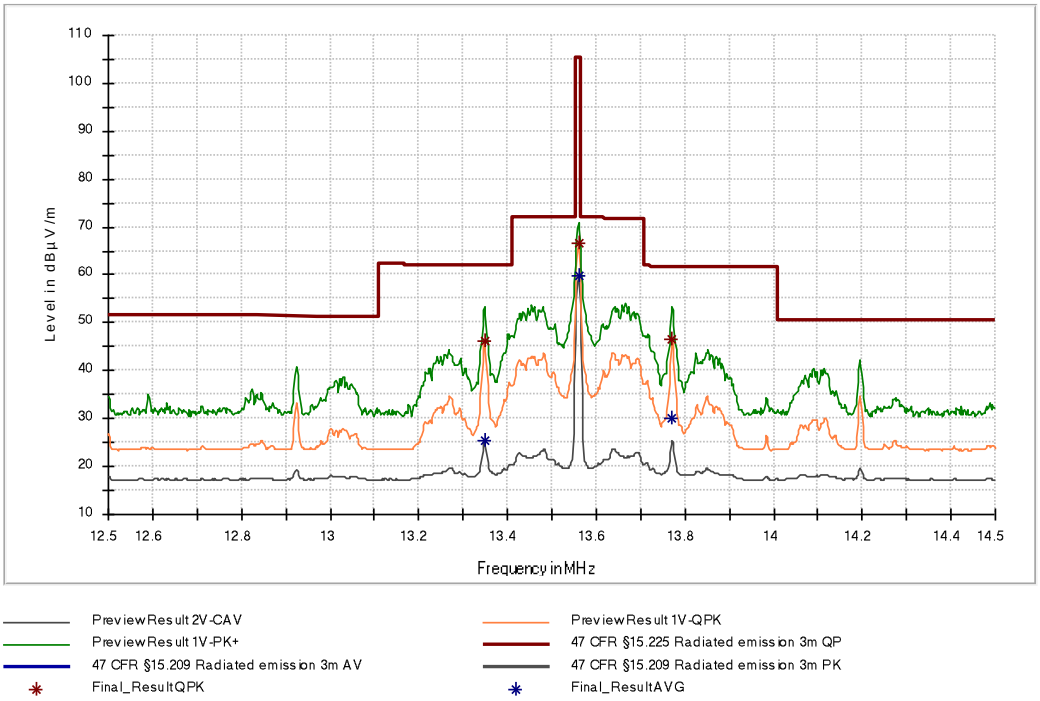


Figure 12: Chart of emission within the band 13.110 MHz to 14.010 MHz at 3m distance

Frequency [MHz]	Measured value [dBµV/m] at 3 m	Recalculation factor [dB]	Field strength [dBµV/m] at 30 m	Limit [dBµV/m] at 30 m	Margin [dB]	Detector	BW [kHz]
13.348500	46.20	-21.53	24.67	40.51	15.84	QP	10
13.560000	66.55	-21.40	45.15	84.00	38.84	QP	10
13.771500	46.47	-21.26	25.21	40.51	15.30	QP	10

Table 16: Results of emission within the band 13.110 MHz to 14.010 MHz

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

6.5 Carrier frequency stability

Section(s) in 47 CFR Part 15:	Requirement(s):	15.225(e)
	Reference(s):	15.225(e)
Section(s) in RSS:	Requirement(s):	RSS-210, annex B6, RSS-Gen, section 6.11
	Reference(s):	RSS-Gen, section 6.11

Performed by:	Andreas Menacher	Date(s) of test:	March 23, 2020
Result[5]:	☒ Test passed	☐ Test not passed	

6.5.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Climatic chamber 340 l	VC³ 4034	Vötsch Industrietechnik	C00015
EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
Field probe	RF-R 400-1	Langer EMV-Technik	E00270

6.5.2 Limits

The frequency tolerance of the carrier signal shall be maintained within ±0.01% (100 ppm) of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C.
For battery operated equipment, the equipment tests shall be performed using a new battery. Alternatively, an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer.

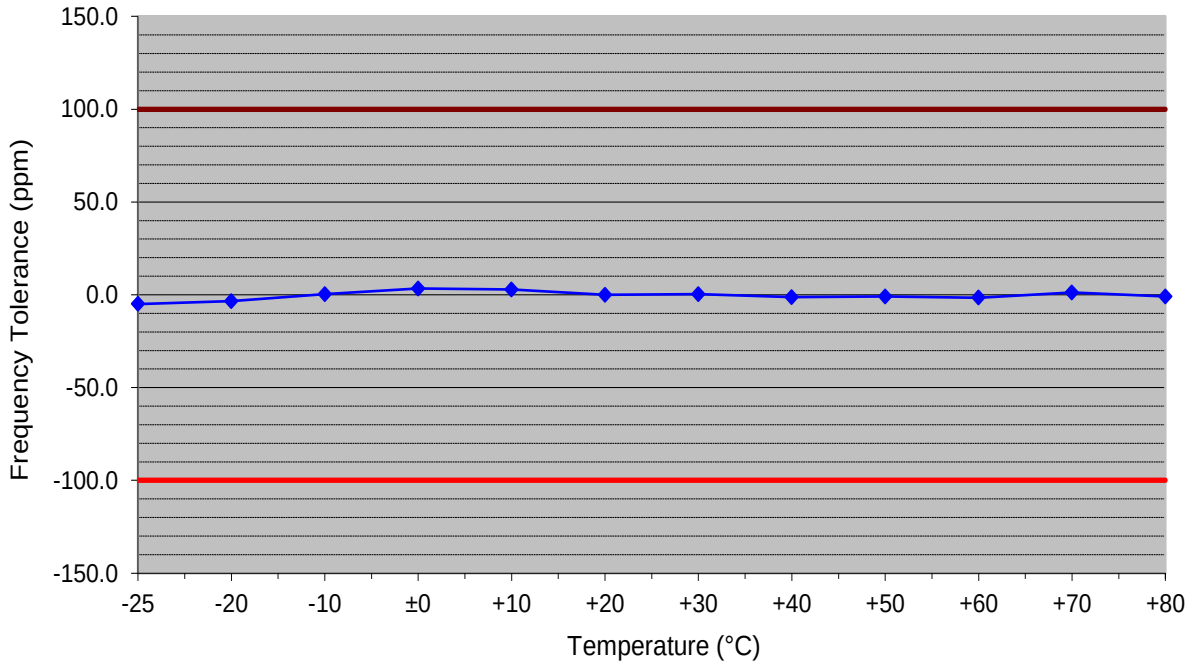
6.5.3 Test procedure

The carrier frequency stability is measured using the test procedure as described in clause 5.8.

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

6.5.4 Test results

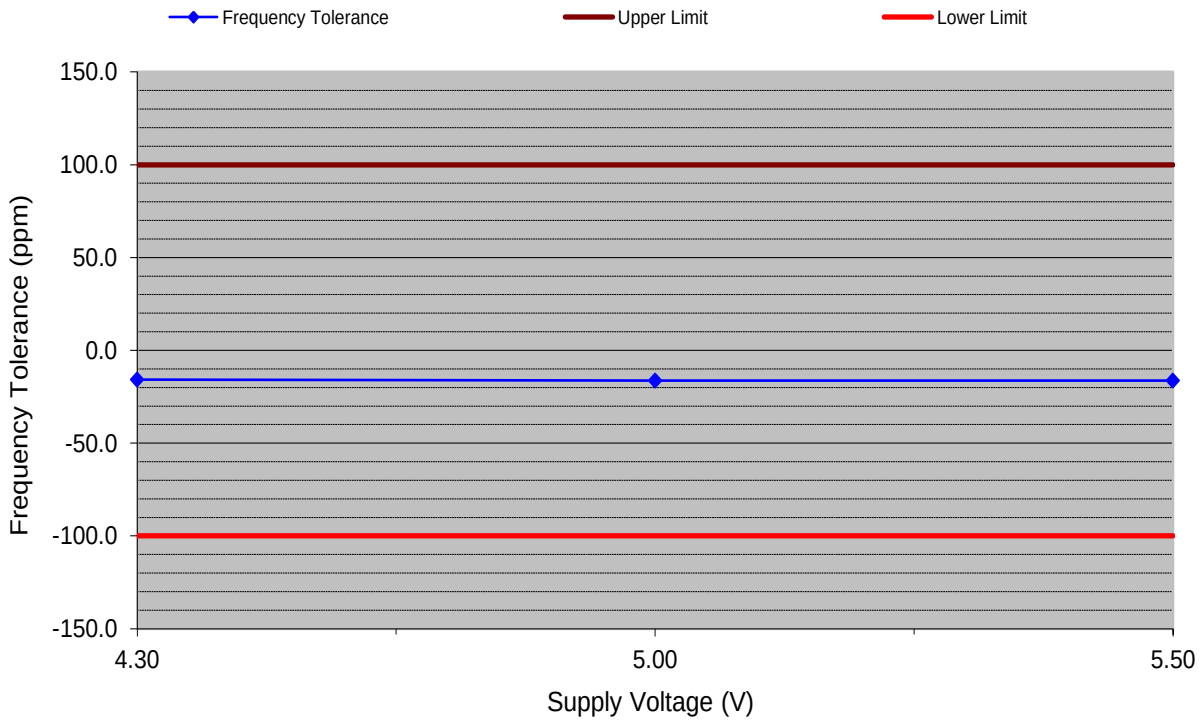
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13.559778 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	(ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-25	13.559711	-67	-4.9	+100.0	-100.0	**95.1**
-20	13.559731	-47	-3.5	+100.0	-100.0	96.5
-10	13.559782	4	0.3	+100.0	-100.0	99.7
±0	13.559824	46	3.4	+100.0	-100.0	96.6
+10	13.559816	38	2.8	+100.0	-100.0	97.2
+20	13.559778	0	0.0	+100.0	-100.0	100.0
+30	13.559782	4	0.3	+100.0	-100.0	99.7
+40	13.559761	-17	-1.3	+100.0	-100.0	98.7
+50	13.559765	-13	-1.0	+100.0	-100.0	99.0
+60	13.559757	-21	-1.5	+100.0	-100.0	98.5
+70	13.559795	17	1.3	+100.0	-100.0	98.7
+80	13.559899	-13	-1.0	+100.0	-100.0	99.0

Carrier frequency stability vs. supply voltage



Temperature:	+20 °C	Battery End Point:	4.20 V
Frequency under nominal conditions:	13.56 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
4.30	13.559786	-214	-15.8	+100.0	-100.0	84.2
5.00	13.559778	-222	-16.4	+100.0	-100.0	83.6
5.50	13.559778	-222	-16.4	+100.0	-100.0	83.6

6.6 Emissions outside the operating frequency band(s) specified

6.6.1 Emissions below 30 MHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.209
	Reference(s):	ANSI C63.10, clause 6.4
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.4

Performed by:	Andreas Menacher	Date of test:	March 19, 2020
Result[6]:	☒ Test passed	☐ Test not passed	

6.6.1.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
EMI test receiver	ESR 7	Rohde & Schwarz	E00739
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-MEB (V10.35)	Rohde & Schwarz	E00778

[6] For information about measurement uncertainties see page 53.

6.6.1.2 Limits

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

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 18: General radiated emission limits up to 30 MHz according to RSS Gen

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

6.6.1.3 Test procedure

The emissions below 30 MHz are measured using the

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

6.6.1.4 Test results

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

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

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

Note 2: No assessable emissions could be detected.

Note 3: The emission at 13.560000 MHz is the operating frequency of the EUT and is not under consideration in this test.

Note 4: The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-Gen section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377 Ohms. For example, the measurement at frequency X kHz resulted in a level of Y dBuV/m, which is equivalent to Y – 51.5 = Z dBuA/m, which has the same margin, W dB, to the corresponding RSS-Gen Table 6 limit as it has to 15.209(a) limit.

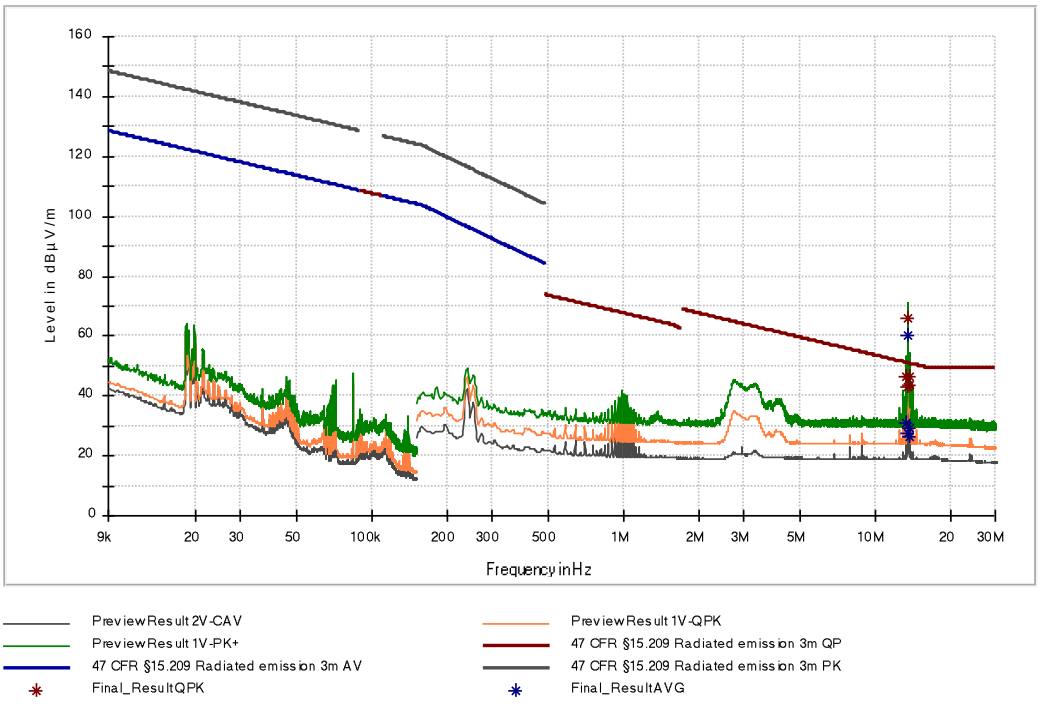


Figure 13: Chart of emissions test below 30 MHz, EUT position X, with tag, antenna in line at 3 m with active RS-485 interface

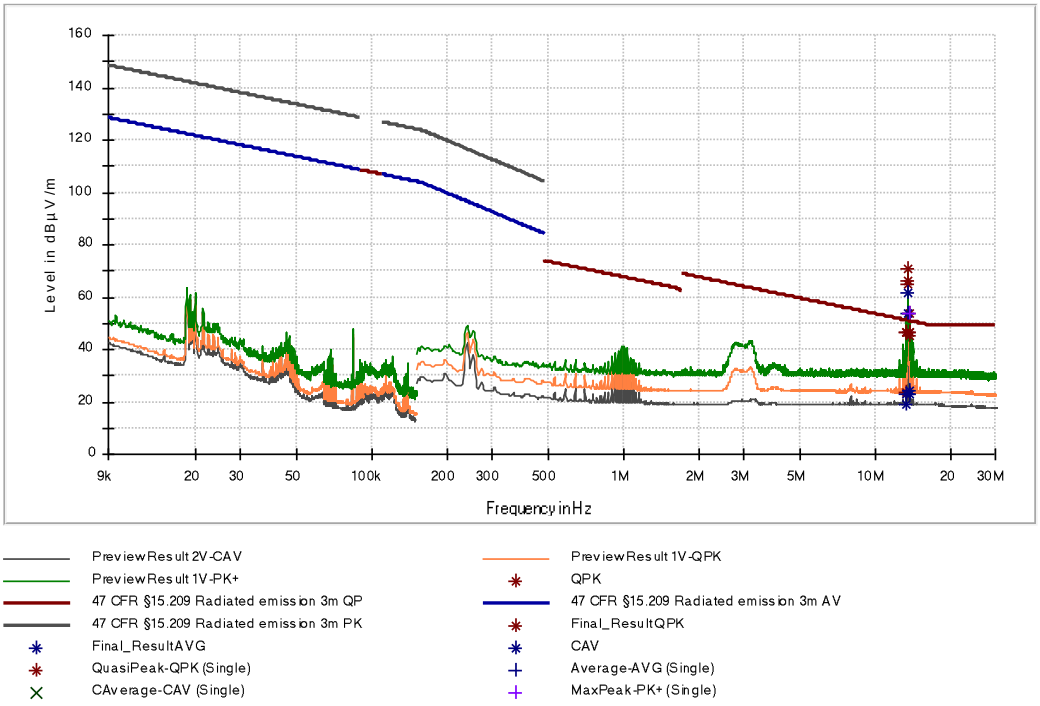


Figure 14: Chart of emissions test below 30 MHz, EUT position Y, with tag, antenna in line at 3 m with active RS-232 interface

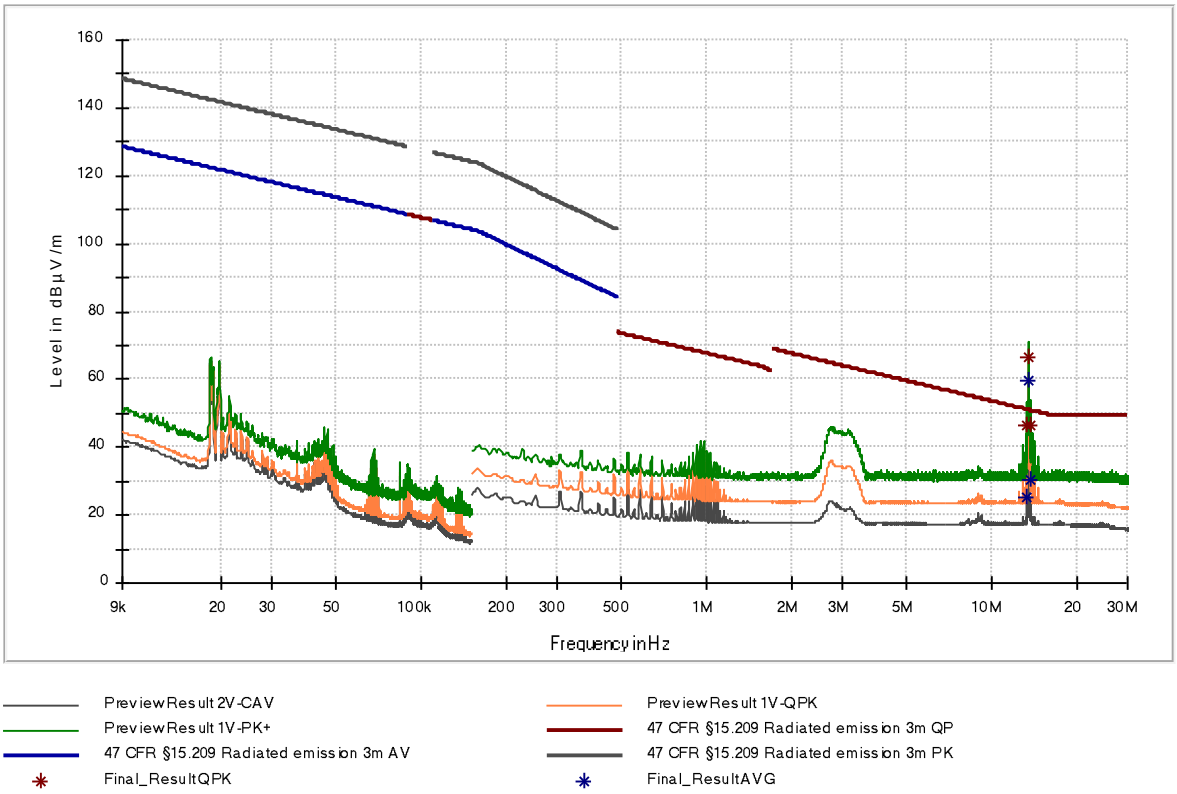


Figure 15: Chart of emissions test below 30 MHz, EUT position X, with tag, antenna in line at 3 m with active USB interface

6.6.2 Emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.209
	Reference(s):	ANSI C63.10, clause 6.5
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.5

Performed by:	Andreas Menacher	Date of test:	March 13, 2020
Result[7]:	☒ Test passed	☐ Test not passed	

6.6.2.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Semi-anechoic chamber with floor absorbers	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	E00778

[7] For information about measurement uncertainties see page 53.

6.6.2.2 Limits

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

Table 19: General radiated emission limits ≥ 30 MHz according to §15.209

6.6.2.3 Test procedure

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

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

6.6.2.4 Test results

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

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

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

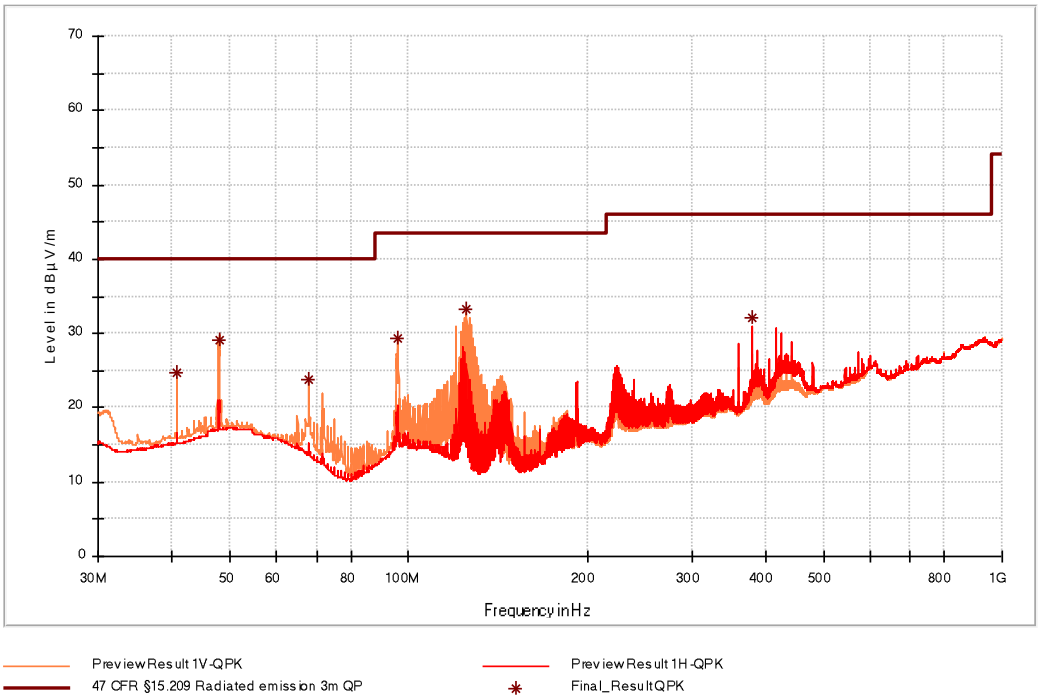


Figure 16: Chart of emissions test from 30 MHz to 1 GHz, EUT positon X, with tag at 3 m with active RS-485 interface

Frequency (MHz)	Measured value QuasiPeak (dBµV/m) at 3m	Limit (dBµV/m) at 3m	Margin (dB)	Height (cm)	Polarization	Azimuth (deg)	Result
40.680000	24.82	40.00	15.18	100.0	V	86.0	Pass
48.000000	29.02	40.00	10.98	112.0	V	0.0	Pass
67.800000	23.75	40.00	16.25	100.0	V	102.0	Pass
96.000000	29.42	43.50	14.08	100.0	V	83.0	Pass
125.430000	33.17	43.50	10.33	100.0	V	146.0	Pass
378.480000	32.08	46.00	13.92	101.0	H	240.0	Pass

Table 20: Final results of emissions test from 30 MHz to 1 GHz, EUT positon X, with tag at 3 m with active RS-485 interface

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

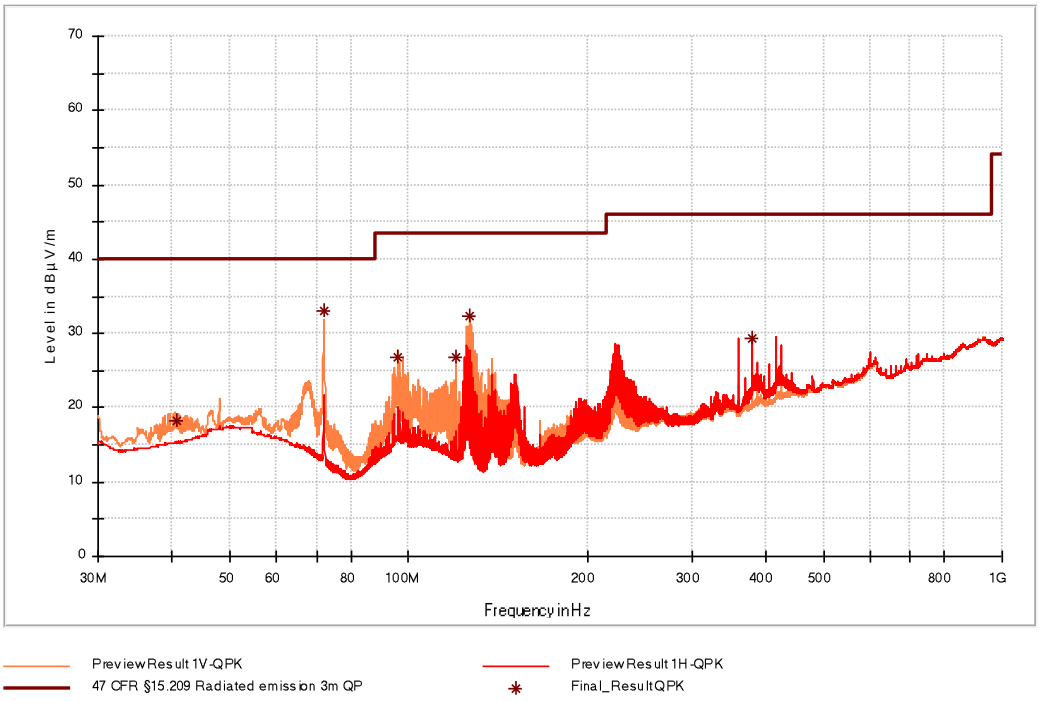


Figure 17: Chart of emissions test from 30 MHz to 1 GHz, EUT positon X, without tag at 3 m with active RS-232 interface

Frequency (MHz)	Measured value QuasiPeak (dBµV/m) at 3m	Limit (dBµV/m) at 3m	Margin (dB)	Height (cm)	Polarization	Azimuth (deg)	Result
40.680000	18.28	40.00	21.72	100.0	V	58.0	Pass
72.000000	32.93	40.00	7.07	100.0	V	162.0	Pass
95.820000	26.69	43.50	16.81	101.0	V	116.0	Pass
120.000000	26.78	43.50	16.72	102.0	V	179.0	Pass
126.420000	32.31	43.50	11.19	103.0	V	137.0	Pass
378.480000	29.38	46.00	16.62	100.0	H	240.0	Pass

Table 21: Final results of emissions test from 30 MHz to 1 GHz, EUT positon X, without tag at 3 m with active RS-232 interface

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

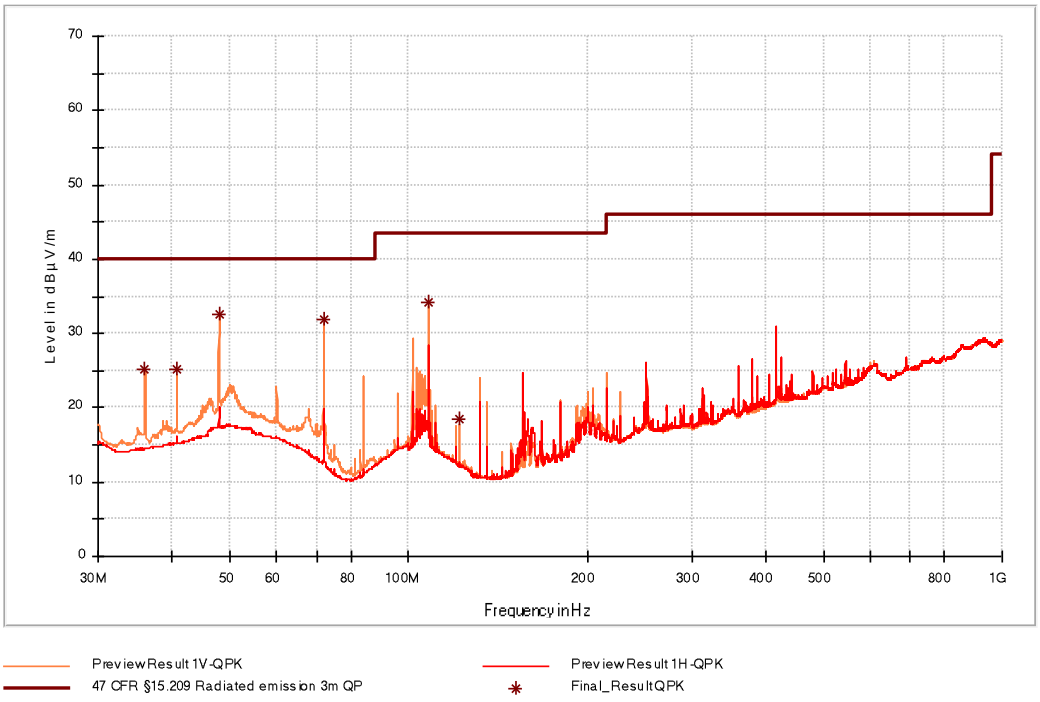


Figure 18: Chart of emissions test from 30 MHz to 1 GHz, EUT positon Y, with tag at 3 m with active USB interface

Frequency (MHz)	Measured value QuasiPeak (dBµV/m) at 3m	Limit (dBµV/m) at 3m	Margin (dB)	Height (cm)	Polarization	Azimuth (deg)	Result
36.000000	25.14	40.00	14.86	100.0	V	0.0	Pass
40.680000	25.11	40.00	14.89	100.0	V	263.0	Pass
48.000000	32.57	40.00	7.43	112.0	V	0.0	Pass
72.000000	31.87	40.00	8.13	100.0	V	179.0	Pass
108.000000	34.20	43.50	9.30	100.0	V	152.0	Pass
122.040000	18.40	43.50	25.10	100.0	V	135.0	Pass

Table 22: Final results of emissions test from 30 MHz to 1 GHz, EUT positon Y, with tag at 3 m with active USB interface

6.6.3 Emissions from 1 GHz to 2 GHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.209
	Reference(s):	ANSI C63.10., clause 6.6
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.6

Performed by:	Andreas Menacher	Date of test:	March 20, 2020
Result[8]:	☒ Test passed	☐ Test not passed	

6.6.3.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
EMI test receiver	ESW 44	Rohde & Schwarz	E00895
Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
Horn antenna	BBHA 9120D	Schwarzbeck	W00052
Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[8] For information about measurement uncertainties see page 53.

6.6.3.2 Limits

Frequency	*Field strength*		*Measurement distance*
[MHz]	*[µV/m]*	*[dBµV/m]*	*[m]*
Above 960	500	53.98	3

Table 23: General radiated emission limits above 960 MHz according to §15.209

6.6.3.3 Test procedure

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

☒ test procedure for radiated measurements as described in clause 5.5.

6.6.3.4 Test results

Test distance:	Final tests:	☒ 3 m	☐ 1 m
EUT position:	☒ Position 1	☒ Position 2	☒ Position 3

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Pre-amplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
1 GHz – 2 GHz	250 kHz	1 MHz	PK + AV	PK + AV	1.5 s	0.1 s	External

Note 1: Premeasurements were performed to declare the worst-case which is documented below.
Note 2: No assessable emissions could be detected.

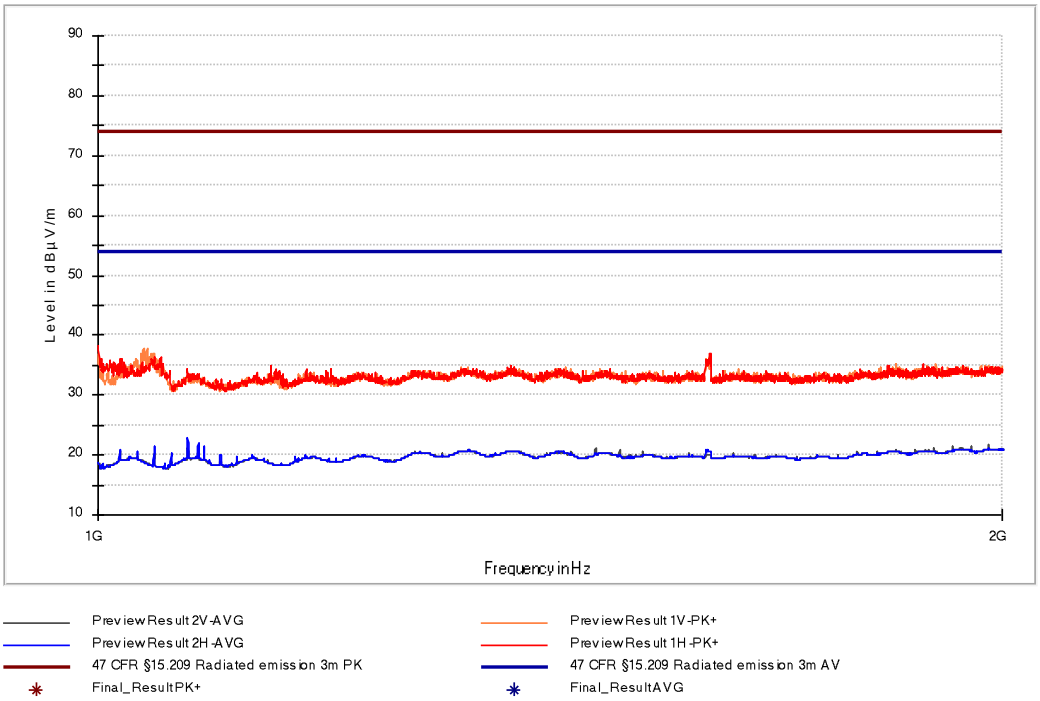


Figure 19: Chart of emissions test from 1 GHz to 2 GHz, EUT positon X, with tag, with active RS-485 interface

Note 1: Premeasurements were performed to declare the worst-case which is documented below.
Note 2: No assessable emissions could be detected.

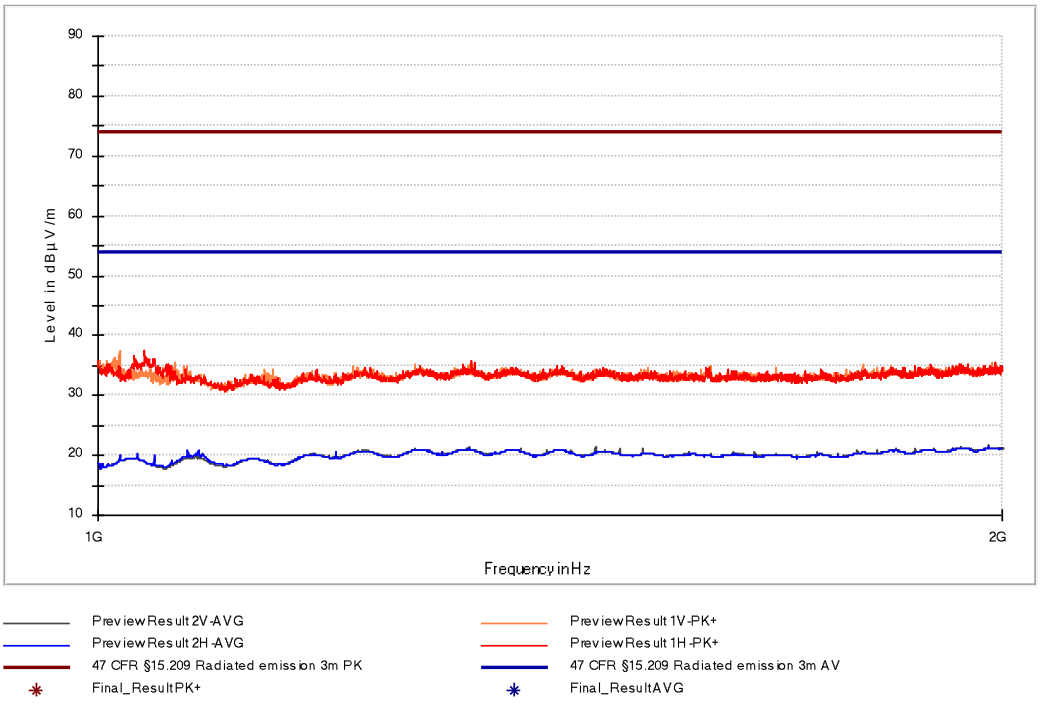


Figure 20: Chart of emissions test from 1 GHz to 2 GHz, EUT position X, without tag, with active RS-232 interface

Note 1: Premeasurements were performed to declare the worst-case which is documented below.
Note 2: No assessable emissions could be detected.

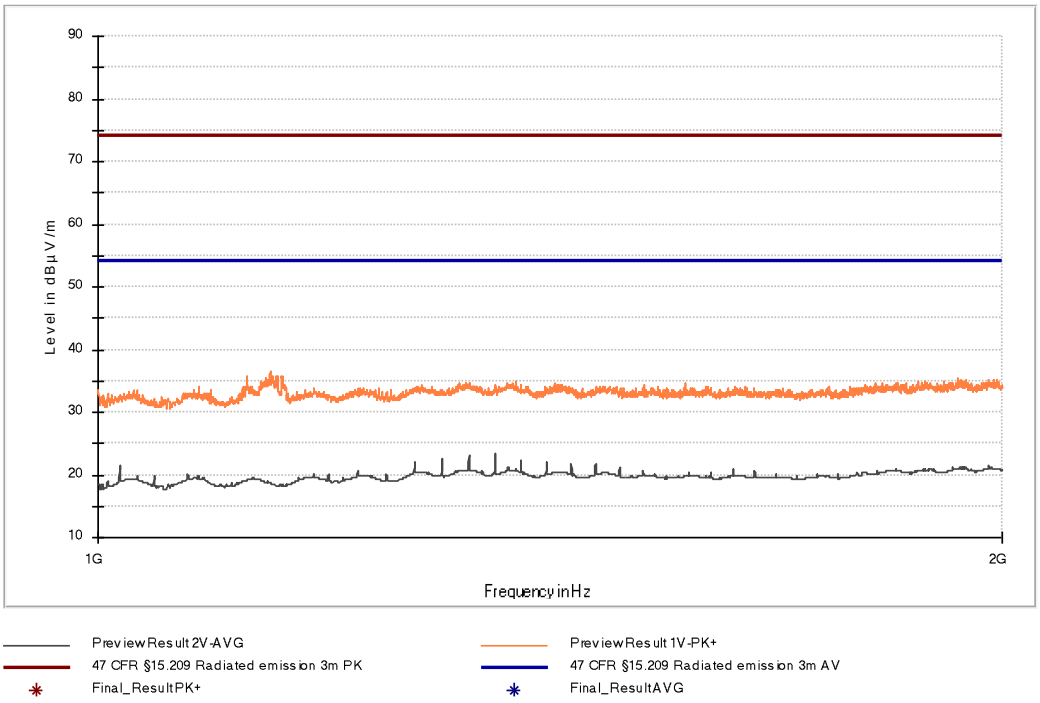


Figure 21: Chart of emissions test from 1 GHz to 2 GHz, EUT position X, without tag, antenna in vertical polarization, with active USB interface

7 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2019-07	2020-07
EMI test receiver	ESR7	101059	E00739	2018-08	2020-08
EMI test receiver	ESCI	100328	E00552	2018-10	2020-10
EMI test receiver	ESCI	100013	E00001	2018-05	2020-05
Preamplifier (1 GHz - 18 GHz)	ALS05749	001	W01007	2018-10	2020-03
Loop antenna	HFH2-Z2	871398/0050	E00060	2018-10	2020-10
LISN	ESH2-Z5	893406/009	E00005	2018-10	2020-10
Field probe	RF-R 400-1	02-2030	E00270	see Note 1	
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2018-07	2021-07
Horn antenna	BBHA 9120D	9120D-592	W00052	2017-04	2020-04
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	2018-03	2021-03
Semi-anechoic chamber (SAC)	SAC3	C62128-A520-A643-x-0006	E00716	2018-03	2021-03
Cable set CDC	RG214/U	---	E00446	2018-04	2020-04
	LCF12-50J	---	E01215	2018-04	2020-04
	LMR400	1718020006	E00920	2018-01	2020-01
	RG214 Hiflex	171802007	E00921	2018-01	2020-01
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2019-08	2020-08
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01035	2019-08	2020-08
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2019-08	2020-08

Note 1: Only used for relative measurements (clause 6.1, 6.3 and 6.5).

8 Measurement uncertainties

Description	*Uncertainty*	*k=*
AC power line conducted emission	± 4.1 dB	2
Carrier frequency separation Number of hopping frequencies Time of occupancy (dwell time)	± 5.0 %	2
Bandwidth tests	± 2.0 %	
Maximum conducted output power (conducted)	± 1.5 dB	
Power spectral density (conducted)	± 2.9 dB	
Conducted spurious emissions	± 2.9 dB	
Radiated emissions in semi-anechoic chamber		
9 kHz to 30 MHz	± 4.8 dB	2
30 MHz to 300 MHz	± 5.4 dB	2
300MHz to 1 GHz	± 4.7 dB	2
Radiated emissions in semi-anechoic chamber with RF absorbing material on the floor or fully anechoic room		
1 GHz to 25 GHz	± 4.5 dB	2

Comment: The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.

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

9 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2020-03-30	Andreas Menacher	First edition