Test report

Customer:

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RF test report

170713-AU02+W01

Mühlbauer GmbH & Co. KG

UHF Reader

Impinj Indy R2000

EMV TESTHAUS

ilac-MRA

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

EMV **TESTHAUS** GmbH

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Accreditation:

Test Firm Type “accredited”: Valid until 2019-06-05
MRA US-EU, FCC designation number: DE0010
BnetzA-CAB-02/21-02/5 Valid until 2023-11-26

Recognized on March 14th, 2019 by the
Department of Innovation, Science and Economic Development (ISED) Canada
as a wireless testing laboratory
CAB identifier: DE0011

Test laboratory:

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The technical accuracy is guaranteed through the quality management of
EMV **TESTHAUS** GmbH.

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1 Summary of test results

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15.249(a)	Field strength of the fundamental wave	27	Passed	---
15.249(a)	Spurious emissions (magnetic field) 9 kHz – 30 MHz	29	Passed	---
15.249(a)	Spurious emissions radiated (electrical field) 30 MHz – 10th harmonic	29	Passed	---
15.215(c)	20 dB bandwidth	45	Passed	---

Straubing, May 29, 2019

Jennifer Riedel
Test engineer
EMV **TESTHAUS** GmbH

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

2 Referenced publications

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A – General (May, 2019)	
Part 15, Subpart A, Section 15.31	Measurement Standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements
Part 15, Subpart A, Section 15.35	Measurement detector functions and bandwidths
FCC Rules and Regulations Part 15, Subpart C – Intentional Radiators (May, 2019)	
Part 15, Subpart C, Section 15.203	Antenna Requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.215	Additional provisions to the general radiated emission limitations.
Part 15, Subpart C, Section 15.249	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz
ANSI C63.10: 2013	Procedures for Compliance Testing of Unlicensed Wireless Devices

3 Equipment under test (EUT)

Product type:	UHF reader	
Model name:	Indy 2k UHF Reader	
Serial number(s):	Serial prototype	
Applicant:	Mühlbauer GmbH & Co. KG	
Manufacturer:	Mühlbauer GmbH & Co. KG	
Version:	Hardware: Software:	Rev. A 2.06.00
Additional modifications:	None	
Short description:	The EUT is a UHF reader working in the frequency band from 902 MHz to 928 MHz.	
FCC ID:	2AT8S61065822	
Frequency range:	902-928 MHz	
Operating frequencies:	902.25 MHz to 927.75 MHz	
Channel spacing:	300 kHz	
Number of RF channels:	85	
System type:	UHF/RFID reader	
Modulation type(s):	PR-ASK	
Antenna type(s):	Mini-Guardrail antenna	
Antenna gain(s):	-20 dBi	
Power supply:	DC supply	
	Nominal voltage: Minimum voltage: Maximum voltage:	24.00 V 17.00 V 32.00 V
Device type:	☐ Portable ☐ Mobile	☒ Fixed

Number of RF channels	Channel no.	Operating frequency	Channel spacing	Modulation
85	1	902.25 MHz	300 kHz	PR-ASK
	35	912.85 MHz	300 kHz	PR-ASK
	85	927.75 MHz	300 kHz	PR-ASK

Table 1: Radio specifications of EUT

4 Test configuration and mode of operation

4.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
EUT			
UHF reader	Impinj Indy R2000	---	Mühlbauer GmbH & Co. KG
Reader antenna	Mini-Guardrail ILT Antenna	IPJ-A0303-000	Impinj
Support equipment			
Power supply for EUT	Switching adapter	DSA-60W-20 1	CUI INC
Tag	865 to 954	3034257BF7194E40C15 23632	Mühlbauer GmbH & Co. KG
Notebook	LIFEBOOK U772	O00632	FUJITSU
Power supply for notebook	A11-100P3A	O00632	FUJITSU

Table 2: Devices used for testing

Port	*Classification (see note 1)*	*Cable type*	*Cable length*		*Note*
			used	*maximum*	
U.FL antenna ports	Signal/control	Unshielded	0.5 m	---	
Power supply	DC power connected to dedicated AC/DC power supply	Shielded	1.50 m	---	
RS232 connector	Signal/control	Shielded	1.85 m		2

Table 3: Ports of EUT and appropriate cables[1]

Notes:
1 Ports of EUT are classified as “AC power”, “DC power”, “DC power connected to dedicated AC/DC power supply”, “Signal/control” or “Wired network”.
2 The RS232 connector is used for configuration only.

[1] As specified by manufacturer.

4.2 Mode of operation

4.2.1 Test software used for all tests

The test software “Reader V44b” is part of the firmware of the EUT. It is controlled by RS232 connection. The required test mode can be selected by selecting the appropriate parameters in the test program, as shown in Figure 1.

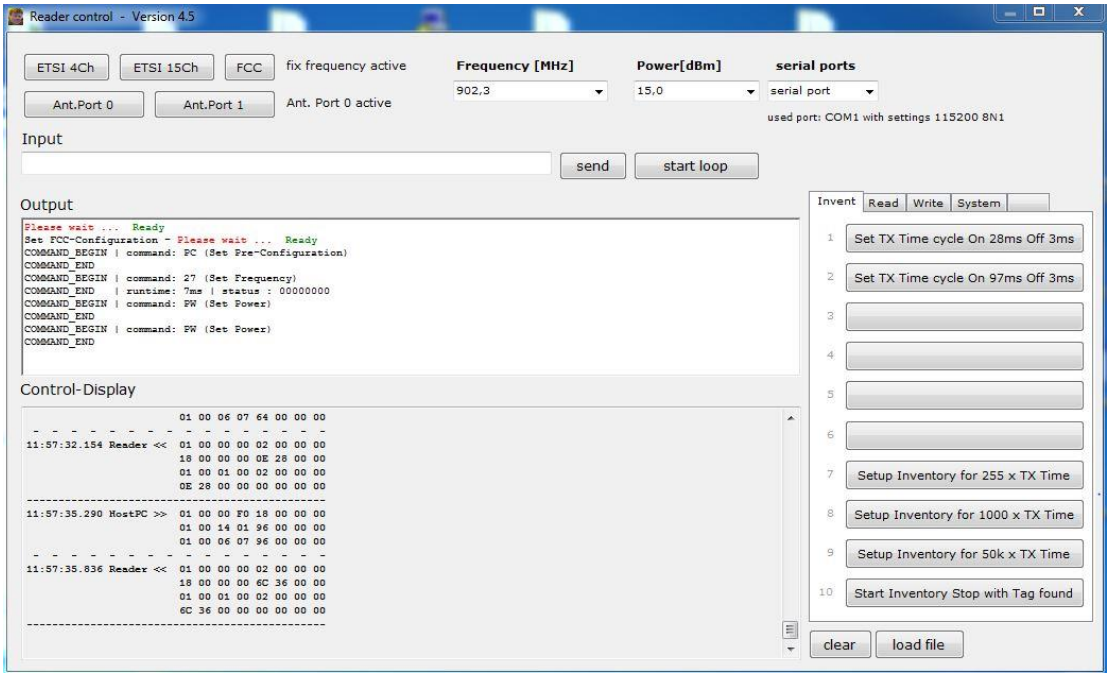


Figure 1: Setting of the required test mode

The following parameters can be selected in the appropriate menu:

- Antenna port 0 or 1
- Frequency (902.3 MHz to 927.9 MHz)
- Power (0 dBm to 15 dBm)
- Duty Cycle (Set TX Time cycle On 97 ms off 3 ms)
- Setup Inventory for 50k x TX Time

After setting the values pressing “Start Inventory Stop with Tag found” starts the transmitting.

For reading the tag, the button “Start Access Read” in the tab “Read” can be pressed.

Note: For the tests the power setting 15 dBm was used as declared by the manufacturer.

4.2.2 Test modes applied

For the measurements the frequencies 902.3 MHz, 912.9 MHz and 927.9 MHz were set. The power setting was 15 dBm. For further details see clause 4.2.1.

5 Measurement Procedures

5.1 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).

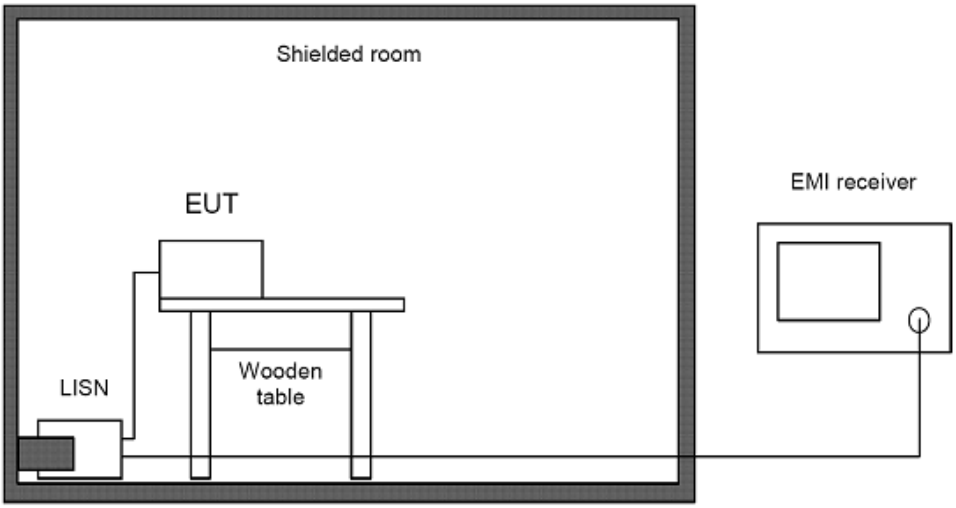


Figure 2: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

5.2 20 dB bandwidth

The 20 dB bandwidth test method refers to section 6.9.2 of ANSI C63.10 and shall be as follows:

Spectrum analyzer settings:
Spectrum analyzer center frequency = nominal EUT channel center frequency
Span = between two times and five times the OBW
IF filter bandwidth (3 dB RBW) = between 1 % to 5 % of the OBW
VBW ≥ 3 x RBW
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/RBW) dB above peak of spectral envelope

Measure the maximum width of the emission that is constrained by the frequencies associated with the two markers (upper and lower frequencies) that are at or slightly below the 20 dB down amplitude relative to the maximum level measured in the fundamental emission.
If possible, use the automatic bandwidth measurement capability of the spectrum analyzer using the X dB bandwidth mode with X set to 20 dB. Submit this plot(s).
The 20 dB bandwidth is the frequency difference between the two markers.

For test setup see clause 5.5.

5.3 Occupied bandwidth (99%)

The occupied bandwidth test method refers to section 6.9.3 of ANSI C63.10 and shall be as follows.

Spectrum analyzer settings:
Span = between 1.5 times and 5.0 times of the OBW, centered on a channel
RBW ≥ in the range of 1% to 5% of the OBW
VBW ≥ approximately three times the RBW
Sweep time = auto coupled
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/RBW) dB above peak of spectral envelope

Use the 99% power bandwidth function of the spectrum analyzer and report the measured bandwidth.

For test setup see clause 5.5.

5.4 Spurious radiated emissions 9 kHz to 10th harmonic

For test setup and test method see clause 5.5.

5.5 Radiated emissions

5.5.1 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 5: 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 6.

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 6: 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)	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 = 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 6).
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.

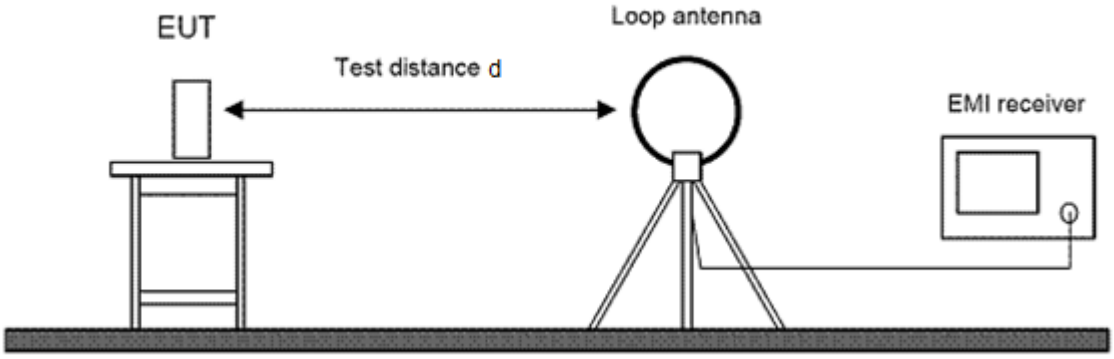


Figure 3: Setup for radiated emissions test below 30 MHz

5.5.2 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 7.

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 7: 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)	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 = 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 7).
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.

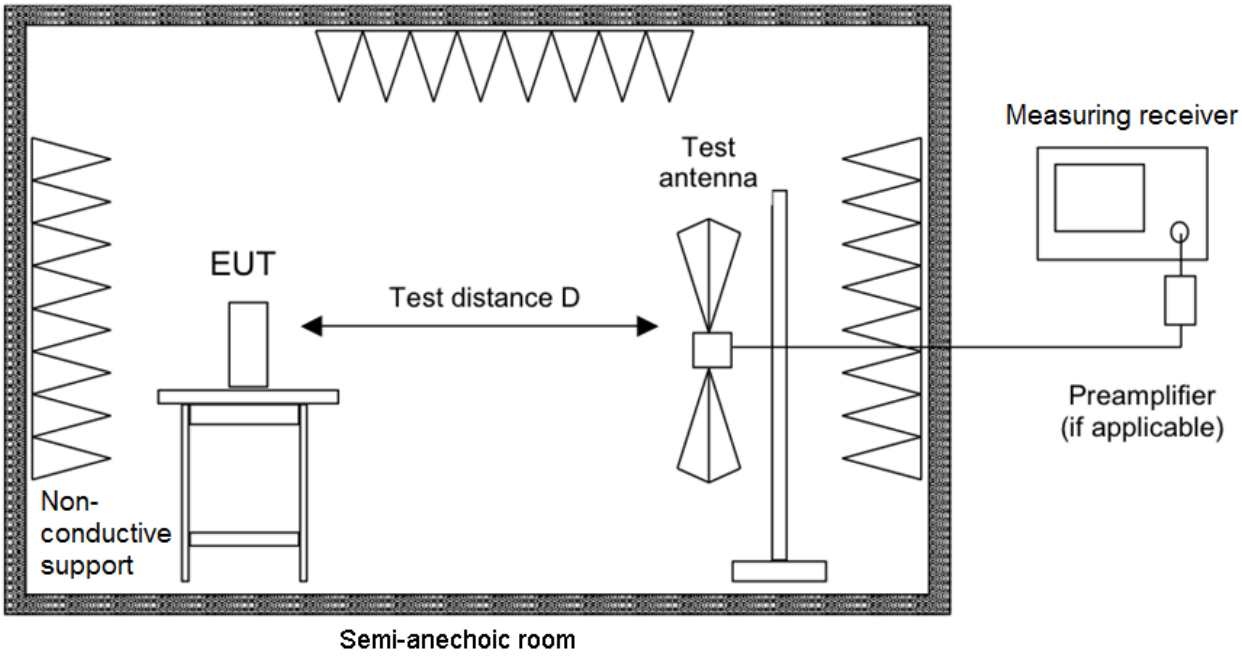


Figure 4: Setup for radiated emissions test from 30 MHz to 1 GHz

5.5.3 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)	Level (dBµV/m)
2400	50.00	27.76	-34.57	3.51	-3.30	46.70

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

Level = Reading value + Correction factor = 50.00 dBµV – 3.30 dB = 46.70 dBµV/m

5.5.3.1 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 8.

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 8: 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.

5.5.3.2 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 9.

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

Table 9: 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 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 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.

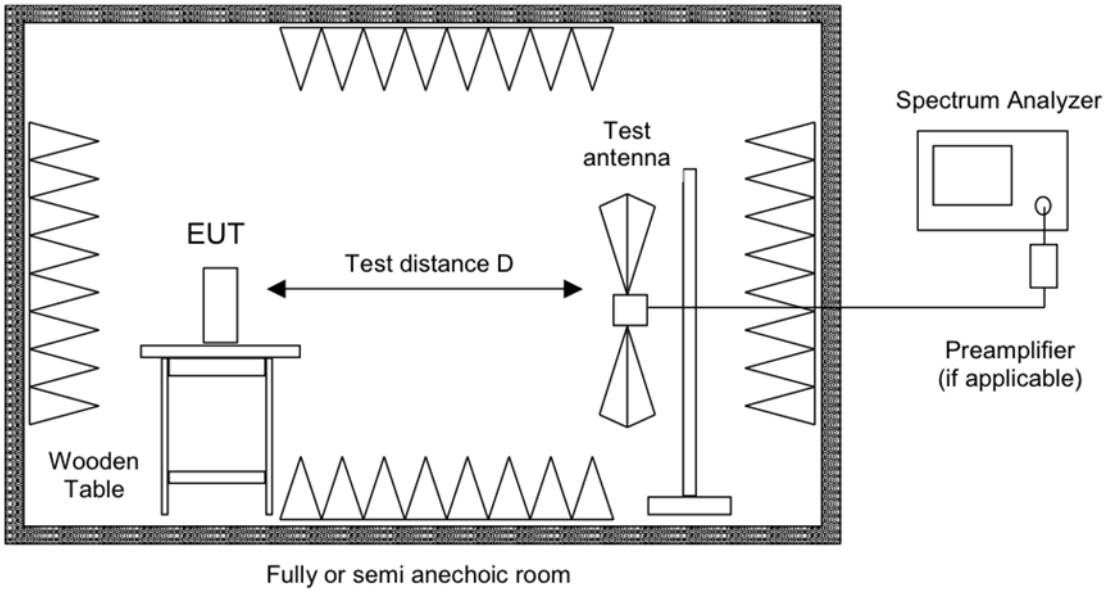


Figure 5: Setup for radiated emissions test above 1 GHz

6 Test results

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

6.1 AC powerline conducted emissions

47 CFR part and section: 15.207(a)

Measurement procedure See 5.1

Result[2]: ☒ 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	E00004
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

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 10.

Frequency of emission (MHz)	*Conducted limit (dBµV)*	
	Quasi-peak	*Average*
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

Table 10: Limits for AC powerline conducted emissions

*Decreases with the logarithm of the frequency

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

6.1.3 Test results

Performed by:	Jennifer Riedel	Date of test:	May 15, 2019

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

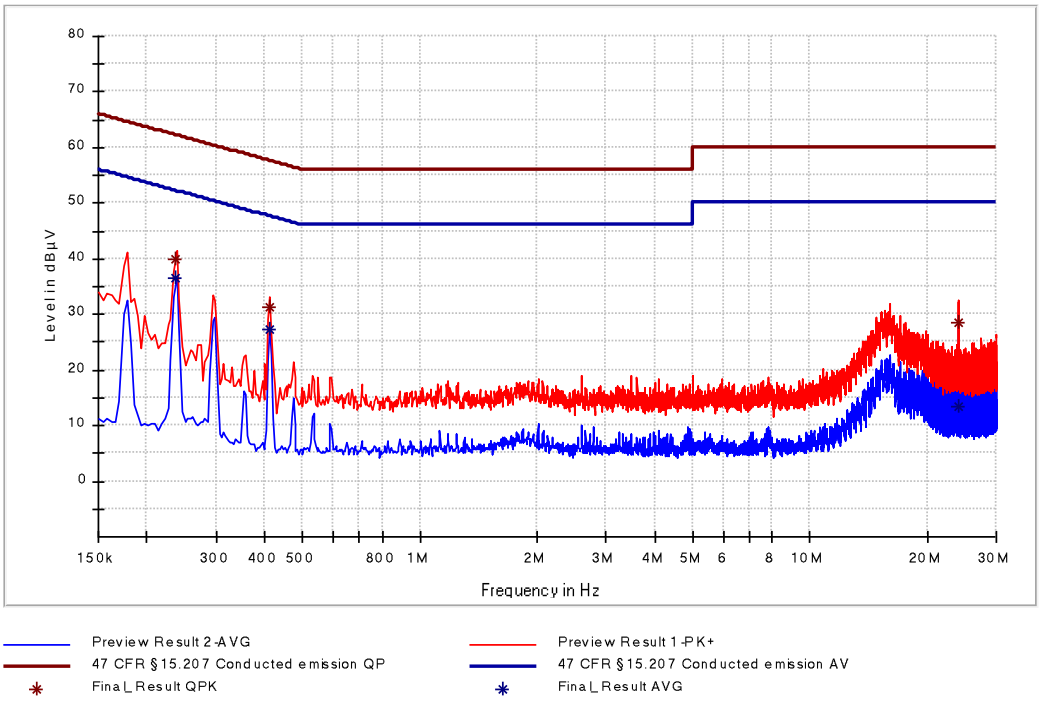


Figure 6: Chart of AC powerline conducted emissions on L1

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
0.237000	---	36.46	52.20	15.74	L1	GND
0.237000	40.07	---	62.20	22.13	L1	GND
0.413000	---	27.22	47.59	20.37	L1	GND
0.413000	31.36	---	57.59	26.23	L1	GND
23.953000	---	13.28	50.00	36.72	L1	GND
23.993000	28.64	---	60.00	31.36	L1	GND

Table 11: Results of AC powerline conducted emissions on L1

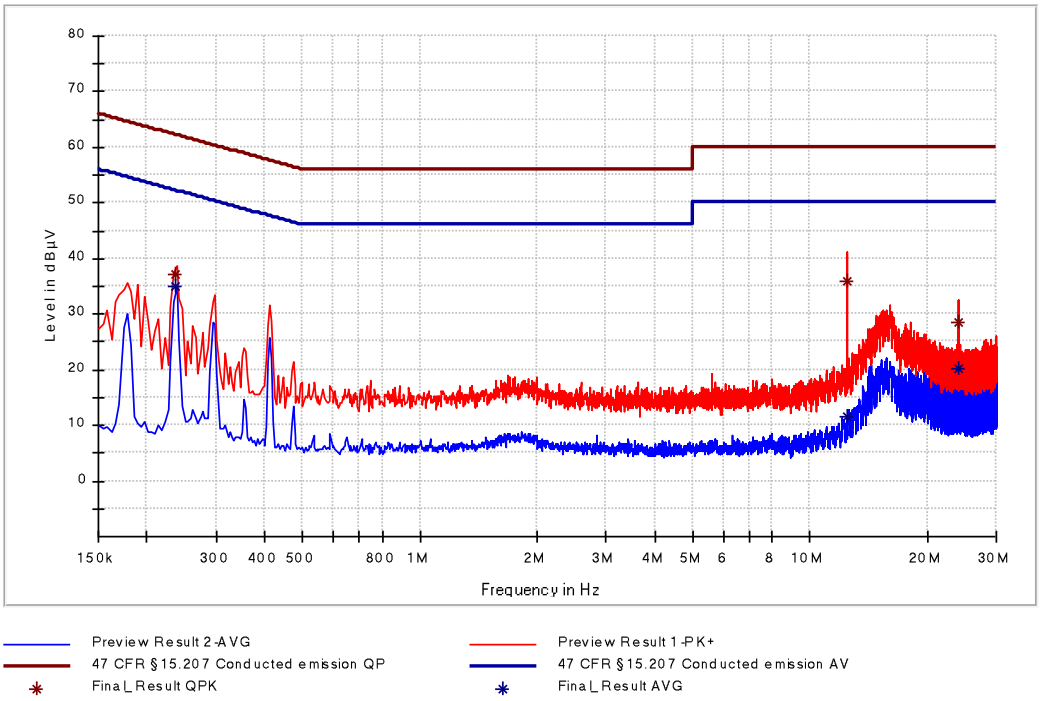


Figure 7: Chart of AC powerline conducted emissions on N

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
0.237000	---	35.03	52.20	17.17	N	GND
0.237000	37.09	---	62.20	25.11	N	GND
23.985000	---	20.12	50.00	29.88	N	GND
24.013000	28.43	---	60.00	31.57	N	GND
12.426000	35.98	---	60.00	24.02	N	GND
12.426000	---	11.70	50.00	38.30	N	GND

Table 12: Results of AC powerline conducted emissions on N

6.2 Field strength of fundamental wave

47 CFR part and section: 15.249(a)

Measurement procedure: See 5.4

Result ☒ Test passed ☐ Test not passed

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open Area Test Site (OATS)	---	EMV **TESTHAUS**	E00354
☒	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☐	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☐	Preamplifier	ALS05749	MIWEKO	W01007
☐	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Measurement software	E10	ib comPLAN	E00443
☒	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.2.2 Limit according to 15.249(a)

Frequency [MHz]	Field strength Fs [mV/m]	Field strength [dBµV/m]	Measurement distance d [m]
902-928	50	94	3

6.2.3 Test Result

Performed by:	Jennifer Riedel	Date of test:	May 16, 2019

Note 1: Premeasurements have shown that the field strength of the fundamental wave is higher without tag. So only these results are listed in the table below.

Note 2: Premeasurements have shown that antenna port 0 is the worst case, so only the results of this antenna port are listed in the table below.

f [MHz]	Level QPK [dBµV/m]	Limit QPK [dBµV/m]	Margin [dB]
902.200	86.99	94	7.01
912.750	85.80	94	8.20
927.750	86.89	94	7.11

Table 13: Test results of field strength of fundamental wave

6.3 Spurious radiated emissions 9 kHz to 10th harmonic

47 CFR part and section: 15.249(a)

Measurement procedure: See 5.4

Result ☒ Test passed ☐ Test not passed

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open Area Test Site (OATS)	---	EMV **TESTHAUS**	E00354
☒	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☒	Preamplifier	BBV 9718 B	Schwarzbeck	W01325
☒	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Measurement software	E10	ib comPLAN	E00443
☒	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.3.2 Limits < 1 GHz

Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
0.009 – 0.490	266.6 – 4.9	48.5 – 13.8	300
0.490 – 1.705	48.98 – 14.08	33.8 – 22.97	30
1.705 – 30.0	30	29.54	30
30 – 88	100	40	3
88 – 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

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

$d_{near\ field}$ = 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 for determining the recalculation factor:

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

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.

6.3.3 Limits > 1 GHz

< 54 dBµV/m (average detector) inside restricted bands
< 74 dBµV/m (peak detector) inside restricted bands

6.3.4 Test results from 9 kHz to 30 MHz

Performed by:	Jennifer Riedel	Date of test:	May 14, 2019	
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ parallel	☒ in line	☐ angle: ….°	
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 – 90 kHz	100 Hz	200 Hz	PK	AV	100 ms	2 s	20 dB
90 kHz – 110 kHz	100 Hz	200 Hz	PK	QPK	100 ms	2 s	20 dB
110 kHz – 150 kHz	100 Hz	200 Hz	PK	AV	100 ms	2 s	20 dB
150 kHz – 490 kHz	4.5 kHz	9 kHz	PK	AV	100 ms	2 s	20 dB
490 kHz – 30 MHz	4.5 kHz	9 kHz	PK	QPK	100 ms	2 s	20 dB

Note 1: In this test report only the charts of the worst case positions and polarizations are shown. These are found through premeasurements.
Note 2: Premeasurements have shown that antenna port 0 is the worst case, so only the results of this antenna port are listed in the table below.

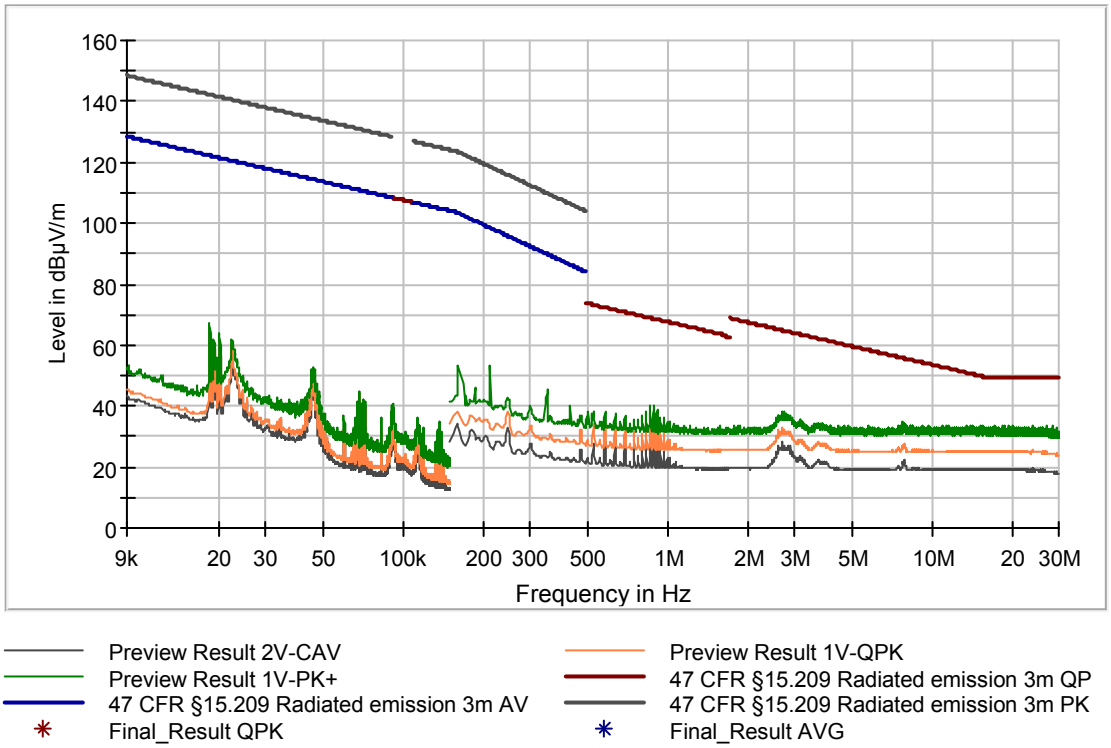


Figure 8: Chart of spurious radiated emission test 9 kHz - 30 MHz, 902.25 MHz in position X and in line

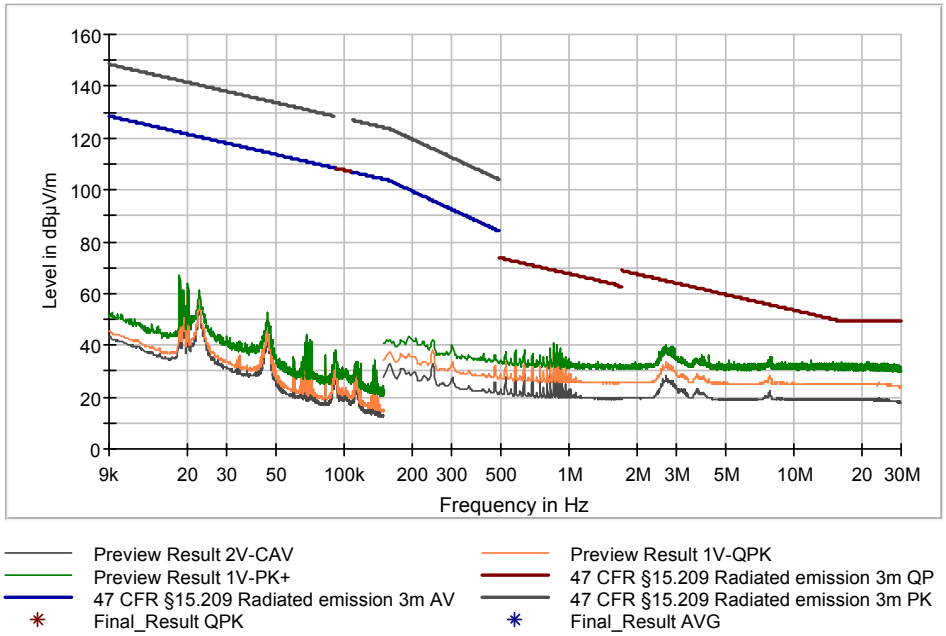


Figure 9: Chart of spurious radiated emission test 9 kHz - 30 MHz, 912.75 MHz in position X and in line

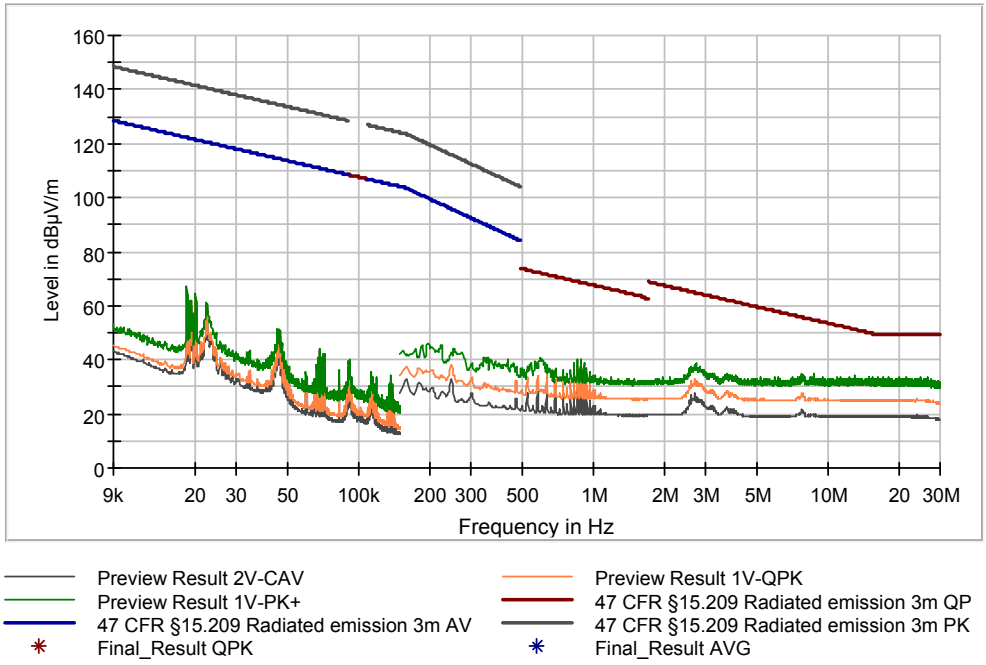


Figure 10: Chart of spurious radiated emission test 9 kHz - 30 MHz, 927.75 MHz in position X and in line

Note: No assessable emissions were detected.

6.3.5 Test results from 30 MHz to 1 GHz

Performed by:	Jennifer Riedel	Date of test:	May 16, 2019	
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☒ Position X	☒ Position Y	☒ Position Z	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
30 MHz – 1 GHz	50 kHz	120 kHz	PK	PK	Coupled	1 s	20 dB

Note 1: In this test report only the charts of the worst case positions and worst polarizations are shown. These are found through premeasurements
Note 2: Premeasurements have shown that the worst case is without tag, so only these results are shown in this clause.
Note 3: Premeasurements have shown that antenna port 0 is the worst case, so only the results of this antenna port are listed in the table below.

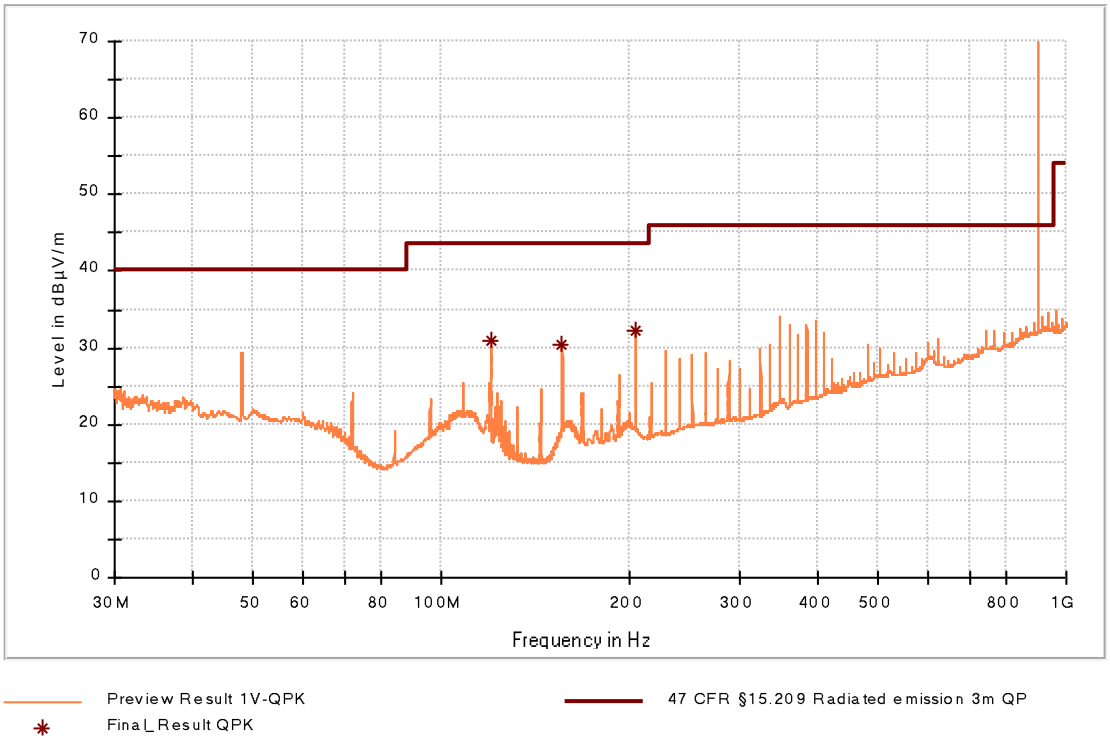


Figure 11: Chart of spurious radiated emission test 30 MHz - 1 GHz, 902.25 MHz in position Z

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
120.120000	30.93	43.50	12.57	1000.0	120.000	101.0	V	149.0	10.9
156.180000	30.33	43.50	13.17	1000.0	120.000	100.0	V	140.0	9.6
204.210000	32.15	43.50	11.35	1000.0	120.000	100.0	V	0.0	12.8

Table 14: Final result of spurious radiated emission test 30 MHz to 1 GHz, 902.25 MHz in position Z

Note: The emission from the fundamental (902.25 MHz) is not in consideration in this section but in section 6.2.

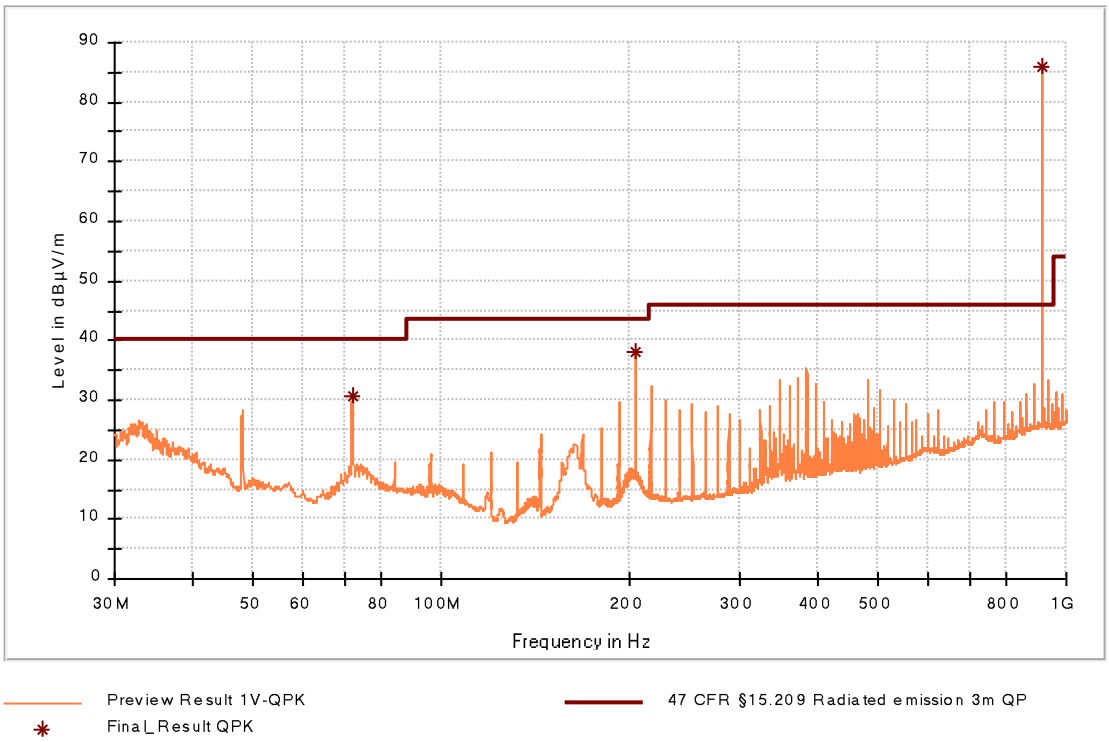


Figure 12: Chart of spurious radiated emission test 30 MHz - 1 GHz, 912.75 MHz in position Z

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
72.000000	30.84	40.00	9.16	1000.0	120.000	100.0	V	172.0	9.9
204.210000	38.20	43.50	5.30	1000.0	120.000	100.0	V	0.0	12.8

Table 15: Final result of spurious radiated emission test 30 MHz to 1 GHz, 912.75 MHz in position Z

Note: The emission from the fundamental (912.75 MHz) is not in consideration in this section but in section 6.2.

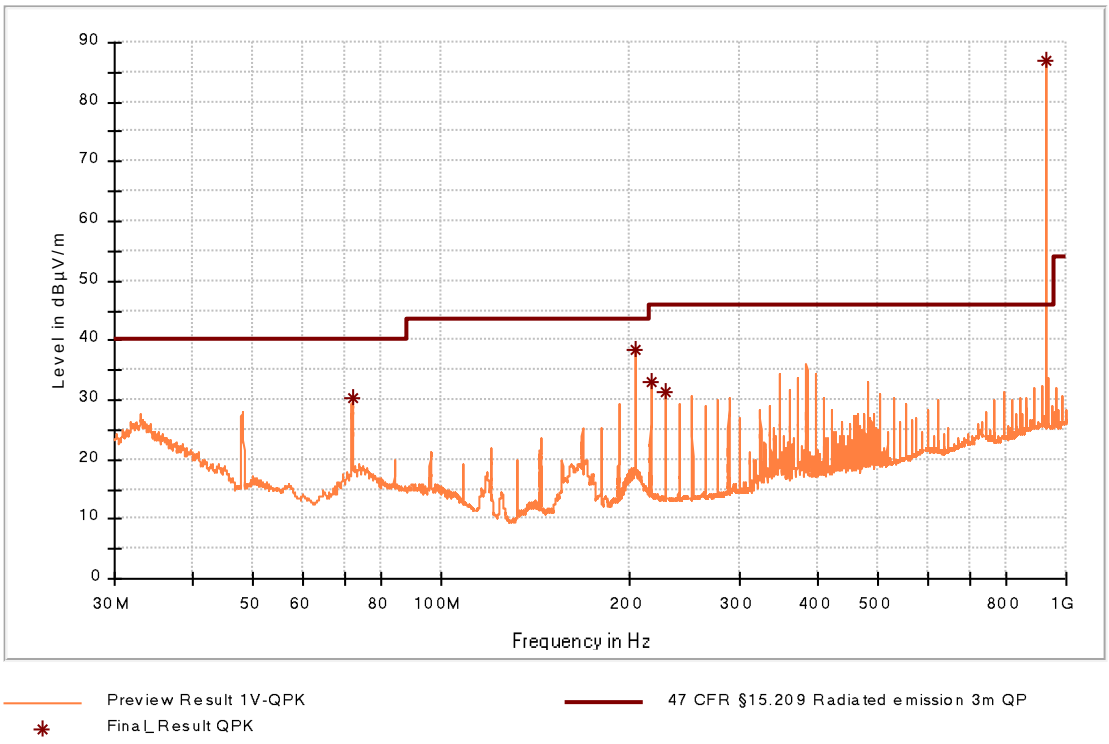


Figure 13: Chart of spurious radiated emission test 30 MHz - 1 GHz, 927.75 MHz in position Z

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
72.000000	30.45	40.00	9.55	1000.0	120.000	185.0	V	172.0	9.9
204.210000	38.30	43.50	5.20	1000.0	120.000	100.0	V	0.0	12.8
216.240000	33.11	46.00	12.89	1000.0	120.000	100.0	V	5.0	12.7
228.240000	31.31	46.00	14.69	1000.0	120.000	100.0	V	27.0	13.4

Table 16: Final result of spurious radiated emission test 30 MHz to 1 GHz, 927.75 MHz in position Z

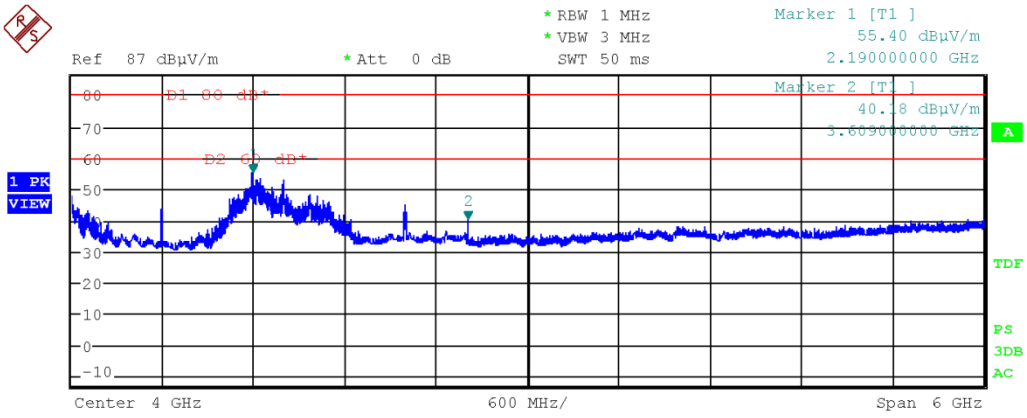
Note: The emission from the fundamental (927.75 MHz) is not in consideration in this section but in section 6.2.

6.3.7 Test results from 1 GHz to 10th harmonic

Performed by:	Jennifer Riedel	Date of test:	May 13, 2019	
Test distance:	Prescan:	☐ 1 m	☐ 3 m	☒ 1.5 m
	Final scan:	☐ 3 m	☐ 10 m	☒ 1.5 m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☒ Position 1	☒ Position 2	☒ Position 3	

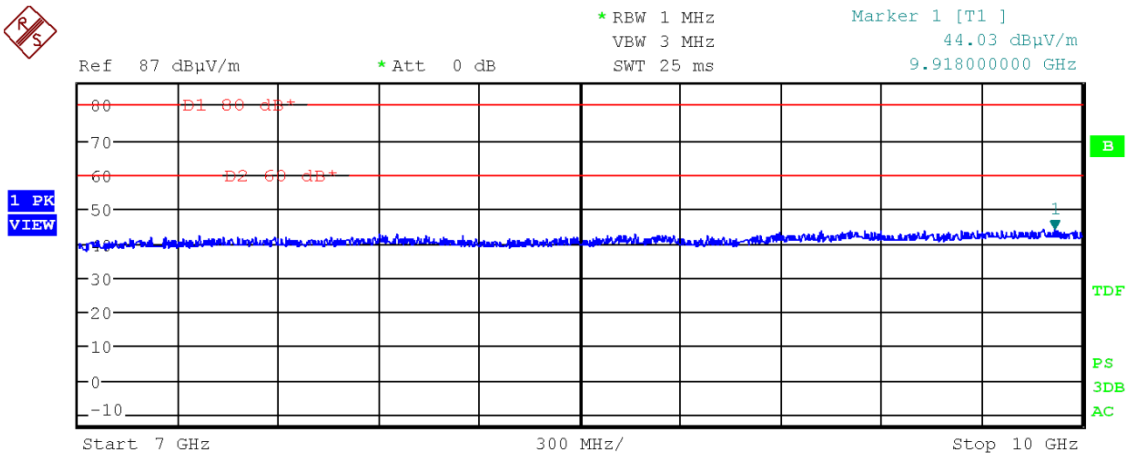
Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
1 GHz – 10 GHz	250 kHz	1 MHz	PK	PK	50 ms	1000 ms	30 dB
1 GHz – 10 GHz	250 kHz	1 MHz	AV	AV	50 ms	1000 ms	30 dB

Note 1: In this test report only the charts of the worst case positions are shown. These are found through premeasurements.
Note 2: Premeasurements have shown that the measurements with tag are the worst case, so only these results are shown in this clause.
Note 3: Premeasurements have shown that antenna port 0 is the worst case, so only the results of this antenna port are listed in the table below.
Note 4: The measurements from 1 GHz to 10 GHz are made at a measurement distance of 1.5 m. The limit lines for these tests are converted and calculated to the limit lines at a measurement distance of 3 m.



#	Frequency	Level	#	Frequency	Level
1	1.004000 GHz	47.82 dBµV	13	2.315500 GHz	50.63 dBµV
2	1.599500 GHz	43.81 dBµV	14	2.328000 GHz	49.39 dBµV
3	2.040500 GHz	47.09 dBµV	15	2.377500 GHz	48.13 dBµV
4	2.057500 GHz	46.68 dBµV	16	2.392500 GHz	53.05 dBµV
5	2.075000 GHz	47.33 dBµV	17	2.420500 GHz	48.22 dBµV
6	2.100500 GHz	48.31 dBµV	18	2.424000 GHz	47.21 dBµV
7	2.142000 GHz	49.42 dBµV	19	2.524500 GHz	45.49 dBµV
8	2.190000 GHz	55.40 dBµV	20	2.569500 GHz	48.34 dBµV
9	2.225500 GHz	53.13 dBµV	21	2.619000 GHz	47.75 dBµV
10	2.237500 GHz	52.16 dBµV	22	2.660500 GHz	46.51 dBµV
11	2.245000 GHz	53.22 dBµV	23	2.692000 GHz	45.73 dBµV
12	2.258000 GHz	51.28 dBµV	24	3.193500 GHz	44.92 dBµV

Figure 14: Chart of spurious radiated emission final test 1 GHz to 7 GHz, 902.25 MHz in position Z



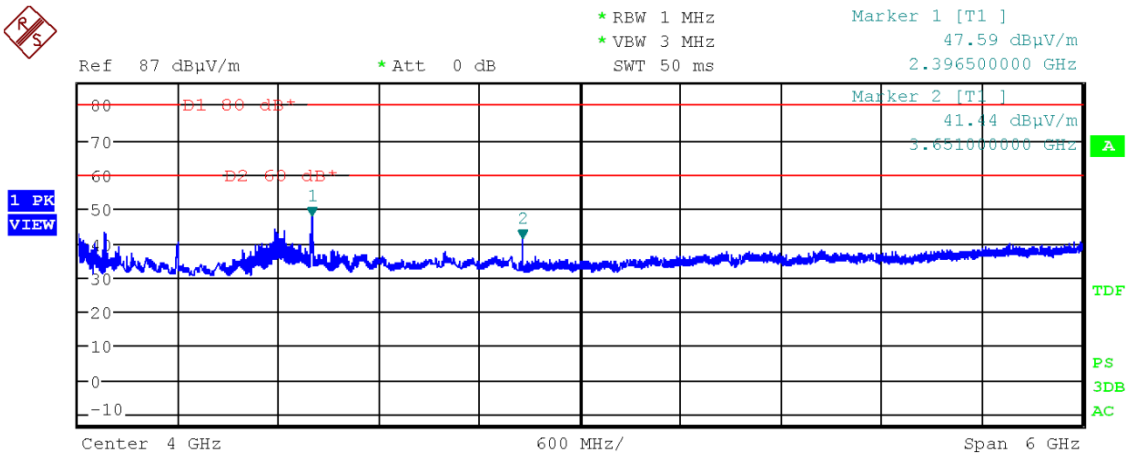
#	Frequency	Level
1	9.918000 GHz	44.03 dBµV

Figure 15: Chart of spurious radiated emission final test 7 GHz to 10 GHz, 902.25 MHz in position Z

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol
1004.000	47.82	---	80.00	32.18	50.0	1000.000	H
1599.500	43.81	---	80.00	36.19	50.0	1000.000	H
2040.500	47.09	---	80.00	32.91	50.0	1000.000	H
2057.500	46.68	---	80.00	33.32	50.0	1000.000	H
2075.000	47.33	---	80.00	32.67	50.0	1000.000	H
2100.500	48.31	---	80.00	31.69	50.0	1000.000	H
2142.000	49.42	---	80.00	30.58	50.0	1000.000	H
2190.000	55.40	---	80.00	24.60	50.0	1000.000	H
2225.500	53.13	---	80.00	26.87	50.0	1000.000	H
2237.500	52.16	---	80.00	27.84	50.0	1000.000	H
2245.000	53.22	---	80.00	26.78	50.0	1000.000	H
2258.000	51.28	---	80.00	28.72	50.0	1000.000	H
2315.500	50.63	---	80.00	29.37	50.0	1000.000	H
2328.000	49.39	---	80.00	30.61	50.0	1000.000	H
2377.500	48.13	---	80.00	31.87	50.0	1000.000	H
2392.500	53.05	---	80.00	26.95	50.0	1000.000	H
2420.500	48.22	---	80.00	31.78	50.0	1000.000	H
2424.000	47.21	---	80.00	32.79	50.0	1000.000	H
2524.500	45.49	---	80.00	34.51	50.0	1000.000	H
2569.500	48.34	---	80.00	31.66	50.0	1000.000	H
2619.000	47.75	---	80.00	32.25	50.0	1000.000	H
2660.500	46.51	---	80.00	33.49	50.0	1000.000	H
2692.000	45.73	---	80.00	34.27	50.0	1000.000	H
3193.500	44.92	---	80.00	35.08	50.0	1000.000	H
3609.000	40.18	---	80.00	39.82	50.0	1000.000	H
9918.000	44.03	---	80.00	35.97	50.0	1000.000	H

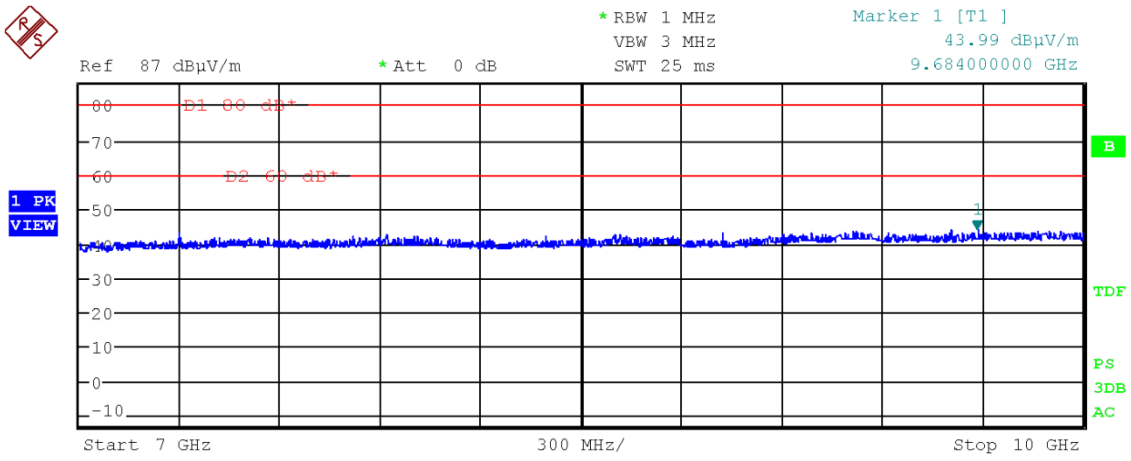
Table 17: Final result of spurious radiated emission test 1 GHz to 10th harmonic, 902.25 MHz

Note: According to ANSI C63.10-2013, clause 6.6.4.3 note 1 if the maximized peak measured value complies with the average limit, then it is unnecessary to perform an average measurement.



#	Frequency	Level	#	Frequency	Level
1	1.008500 GHz	42.51 dBµV	13	2.104000 GHz	39.80 dBµV
2	1.035500 GHz	40.63 dBµV	14	2.132000 GHz	39.56 dBµV
3	1.100500 GHz	39.63 dBµV	15	2.151000 GHz	40.00 dBµV
4	1.152500 GHz	37.89 dBµV	16	2.180500 GHz	43.84 dBµV
5	1.155500 GHz	43.00 dBµV	17	2.187500 GHz	42.98 dBµV
6	1.159000 GHz	40.96 dBµV	18	2.197000 GHz	42.54 dBµV
7	1.161500 GHz	41.53 dBµV	19	2.232000 GHz	43.35 dBµV
8	1.165000 GHz	42.63 dBµV	20	2.396500 GHz	47.59 dBµV
9	1.241500 GHz	38.98 dBµV	21	2.521000 GHz	37.93 dBµV
10	1.598000 GHz	40.28 dBµV	22	3.651000 GHz	41.44 dBµV
11	1.987500 GHz	37.87 dBµV	23	6.948500 GHz	40.38 dBµV
12	2.064000 GHz	39.28 dBµV			

Figure 16: Chart of spurious radiated emission final test 1 GHz to 7 GHz, 912.75 MHz in position Z



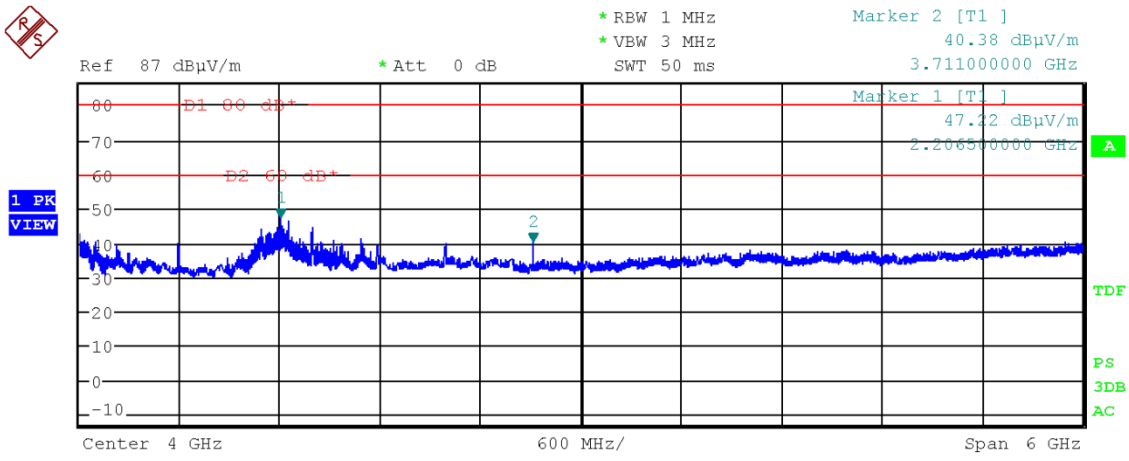
#	Frequency	Level
1	9.684000 GHz	43.99 dBµV

Figure 17: Chart of spurious radiated emission final test 7 GHz to 10 GHz, 912.75 MHz in position Z

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol
1008.500	42.51	---	80.00	37.49	50.0	1000.000	H
1035.500	40.63	---	80.00	39.37	50.0	1000.000	H
1100.500	39.63	---	80.00	40.37	50.0	1000.000	H
1152.500	37.89	---	80.00	42.11	50.0	1000.000	H
1155.500	43.00	---	80.00	37.00	50.0	1000.000	H
1159.000	40.96	---	80.00	39.04	50.0	1000.000	H
1161.500	41.53	---	80.00	38.47	50.0	1000.000	H
1165.000	42.63	---	80.00	37.37	50.0	1000.000	H
1241.500	38.98	---	80.00	41.02	50.0	1000.000	H
1598.000	40.28	---	80.00	39.72	50.0	1000.000	H
1987.500	37.87	---	80.00	42.13	50.0	1000.000	H
2064.000	39.28	---	80.00	40.72	50.0	1000.000	H
2104.000	39.80	---	80.00	40.20	50.0	1000.000	H
2132.000	39.56	---	80.00	40.44	50.0	1000.000	H
2151.000	40.00	---	80.00	40.00	50.0	1000.000	H
2180.500	43.84	---	80.00	36.16	50.0	1000.000	H
2187.500	42.98	---	80.00	37.02	50.0	1000.000	H
2197.000	42.54	---	80.00	37.46	50.0	1000.000	H
2232.000	43.35	---	80.00	36.65	50.0	1000.000	H
2396.500	47.59	---	80.00	32.41	50.0	1000.000	H
2521.000	37.93	---	80.00	42.07	50.0	1000.000	H
3651.000	41.44	---	80.00	38.56	50.0	1000.000	H
6948.500	40.38	---	80.00	39.62	50.0	1000.000	H
9684.000	43.99	---	80.00	36.01	50.0	1000.000	H

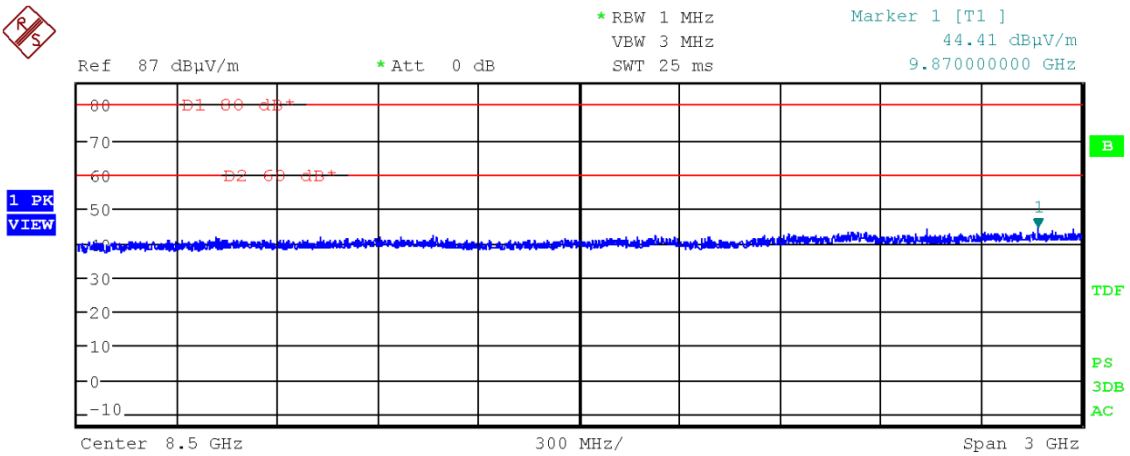
Table 18: Final result of spurious radiated emission test 1 GHz to 10th harmonic, 912.75 MHz

Note: According to ANSI C63.10-2013, clause 6.6.4.3 note 1 if the maximized peak measured value complies with the average limit, then it is unnecessary to perform an average measurement.



#	Frequency	Level	#	Frequency	Level
1	1.002000 GHz	42.62 dBµV	13	2.316000 GHz	41.07 dBµV
2	1.097500 GHz	40.51 dBµV	14	2.344000 GHz	40.47 dBµV
3	1.594000 GHz	39.59 dBµV	15	2.383000 GHz	41.79 dBµV
4	2.078000 GHz	41.88 dBµV	16	2.392000 GHz	43.14 dBµV
5	2.092000 GHz	44.08 dBµV	17	2.399500 GHz	44.59 dBµV
6	2.117000 GHz	42.06 dBµV	18	2.449000 GHz	40.12 dBµV
7	2.139500 GHz	42.94 dBµV	19	2.517000 GHz	40.61 dBµV
8	2.152000 GHz	42.86 dBµV	20	2.567000 GHz	39.87 dBµV
9	2.188000 GHz	44.32 dBµV	21	2.689000 GHz	41.19 dBµV
10	2.206500 GHz	47.22 dBµV	22	3.196500 GHz	39.80 dBµV
11	2.213500 GHz	45.19 dBµV	23	3.711000 GHz	40.38 dBµV
12	2.249000 GHz	46.47 dBµV	24	6.886500 GHz	40.39 dBµV

Figure 18: Chart of spurious radiated emission final test 1 GHz to 7 GHz, 927.75 MHz in position Z



#	Frequency	Level
1	9.870000 GHz	44.41 dBµV

Figure 19: Chart of spurious radiated emission final test 7 GHz to 10 GHz, 927.75 MHz in position Z

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol
1002.000	42.62	---	80.00	37.38	50.0	1000.000	H
1097.500	40.51	---	80.00	39.49	50.0	1000.000	H
1594.000	39.59	---	80.00	40.41	50.0	1000.000	H
2078.000	41.88	---	80.00	38.12	50.0	1000.000	H
2092.000	44.08	---	80.00	35.92	50.0	1000.000	H
2117.000	42.06	---	80.00	37.94	50.0	1000.000	H
2139.500	42.94	---	80.00	37.06	50.0	1000.000	H
2152.000	42.86	---	80.00	37.14	50.0	1000.000	H
2188.000	44.32	---	80.00	35.68	50.0	1000.000	H
2206.500	47.22	---	80.00	32.78	50.0	1000.000	H
2213.500	45.19	---	80.00	34.81	50.0	1000.000	H
2249.000	46.47	---	80.00	33.53	50.0	1000.000	H
2316.000	41.07	---	80.00	38.93	50.0	1000.000	H
2344.000	40.47	---	80.00	39.53	50.0	1000.000	H
2383.000	41.79	---	80.00	38.21	50.0	1000.000	H
2392.000	43.14	---	80.00	36.86	50.0	1000.000	H
2399.500	44.59	---	80.00	35.41	50.0	1000.000	H
2449.000	40.12	---	80.00	39.88	50.0	1000.000	H
2517.000	40.61	---	80.00	39.39	50.0	1000.000	H
2567.000	39.87	---	80.00	40.13	50.0	1000.000	H
2689.000	41.19	---	80.00	38.81	50.0	1000.000	H
3196.500	39.80	---	80.00	40.20	50.0	1000.000	H
3711.000	40.38	---	80.00	39.62	50.0	1000.000	H
6886.500	40.39	---	80.00	39.61	50.0	1000.000	H
9870.000	44.41	---	80.00	35.59	50.0	1000.000	H

Table 19: Final result of spurious radiated emission test 1 GHz to 10th harmonic, 927.75 MHz

Note: According to ANSI C63.10-2013, clause 6.6.4.3 note 1 if the maximized peak measured value complies with the average limit, then it is unnecessary to perform an average measurement.

6.4 20 dB bandwidth

47 CFR part and section: 15.215(c)

Measurement procedure (DTS): See 5.2

Result ☒ Test passed ☐ Test not passed

6.4.1 Test equipment

Type	*Designation*	*Manufacturer*	*Inventory no.*
☐ Laboratory environment	---	---	---
☒ Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒ EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐ EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒ Measuring antenna set	---	---	A00088

6.4.2 Limits according to FCC Part 15C Section 15.215(c):

Intentional radiators must be designed to ensure that the 20 dB bandwidth of the emission is contained within the frequency band designed in the rule section under which the equipment is operated.

6.4.3 Test results

Performed by:	Jennifer Ebner	Date of test:	August 10, 2018

Note 1: Premeasurements have shown that the tests with tag are the worst case, so only these results are shown in this clause.

Note 2: Premeasurements have shown that antenna port 0 is the worst case, so only the results of this antenna port are listed in the table below.

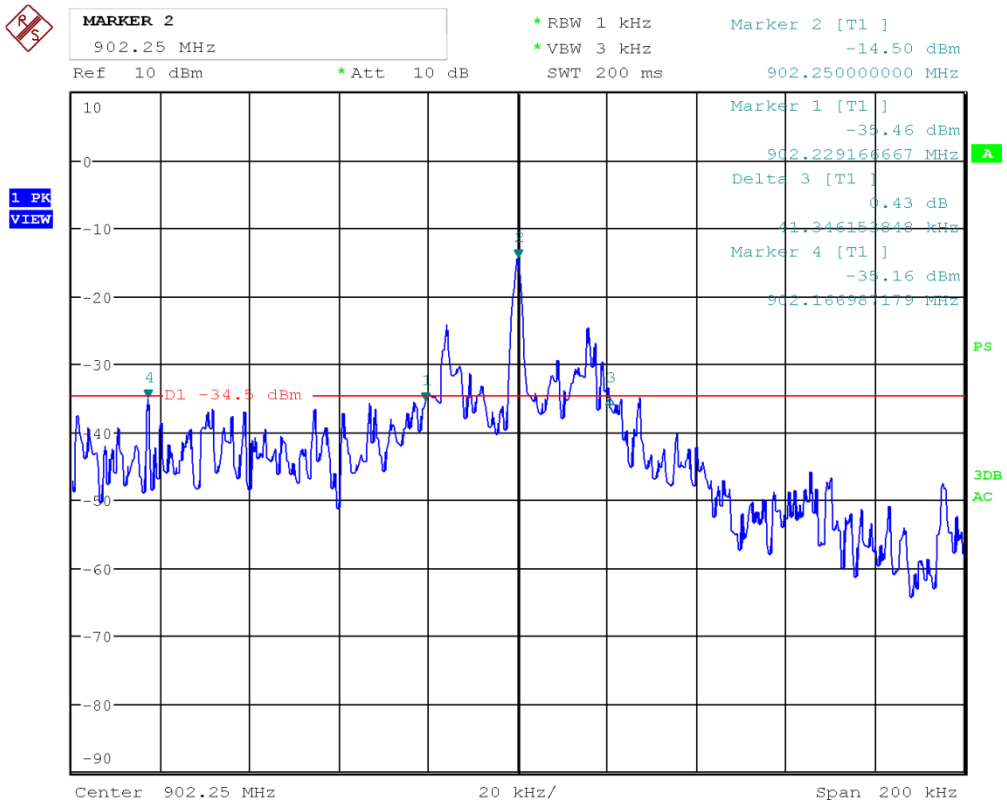


Figure 20: Chart of 20 dB bandwidth test, 902.25 MHz

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	Lowest band-edge [MHz]	f_{upper} [MHz]	Highest band-edge [MHz]	Result
902.250	41.346	902.229	902.000	902.270	928.000	Passed

Table 20: Final results of 20 dB bandwidth test, 902.25 MHz

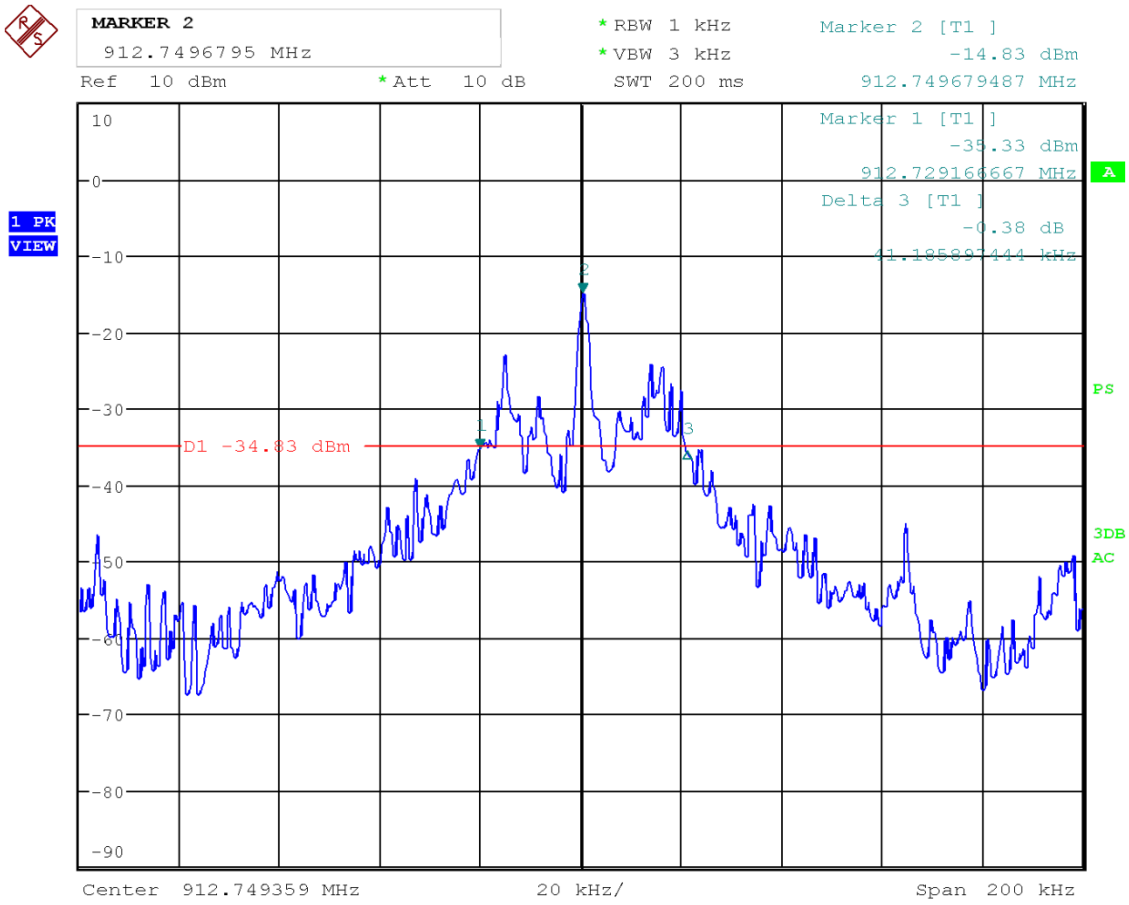


Figure 21: Chart of 20 dB bandwidth test, 912.75 MHz

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	Lowest band-edge [MHz]	f_{upper} [MHz]	Highest band-edge [MHz]	Result
912.750	41.186	912.729	902.000	912.770	928.000	Passed

Table 21: Final results of 20 dB bandwidth test, 912.75 MHz

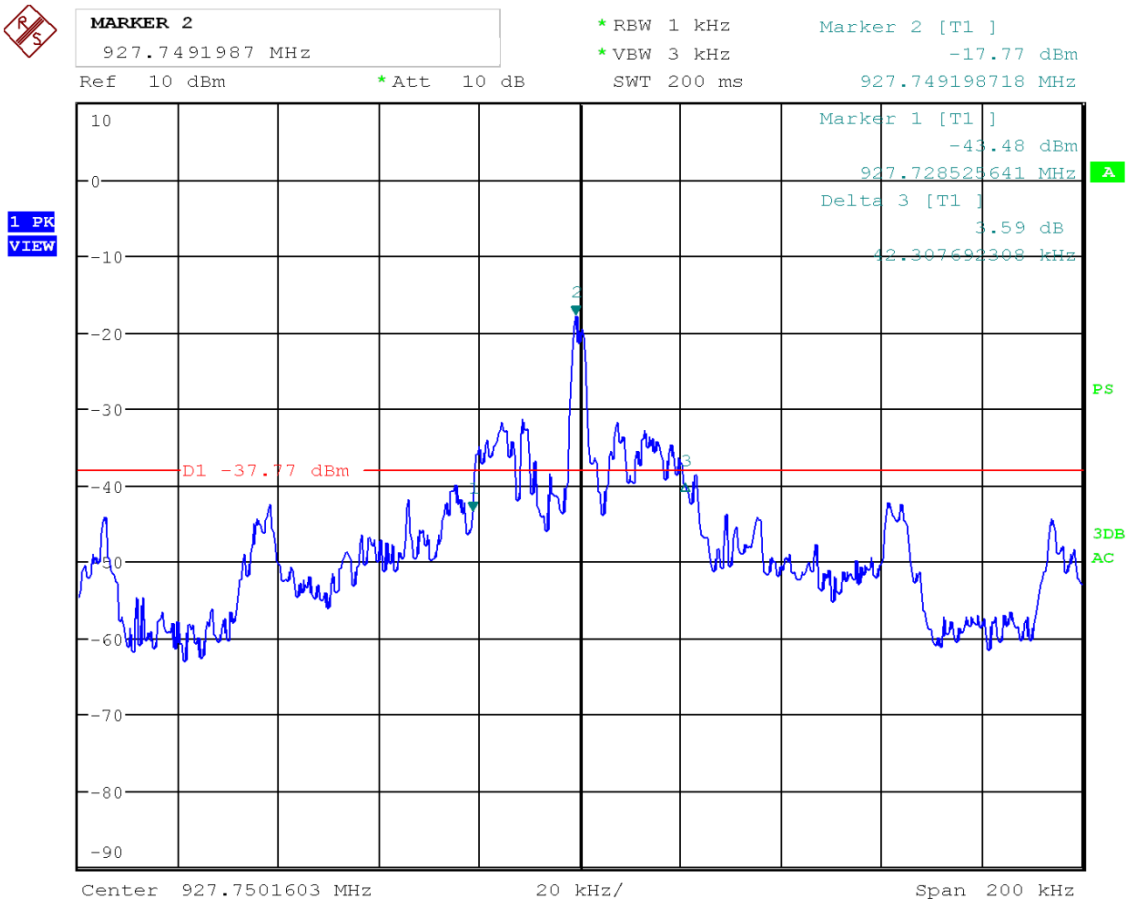


Figure 22: Chart of 20 dB bandwidth test, 927.75 MHz

f [MHz]	20dB-BW [kHz]	f_{lower} [MHz]	Lowest band-edge [MHz]	f_{upper} [MHz]	Highest band-edge [MHz]	Result
927.749	42.308	927.729	902.000	927.771	928.000	Passed

Table 22: Final results of 20 dB bandwidth test, 927.75 MHz

7 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2018-04	2020-04
EMI test receiver	ESR7	101059	E00739	2018-05	2020-05
EMI test receiver	ESU26	100026	W00002	2018-06	2020-06
Preamplifier (1 GHz - 18 GHz)	ALS05749	001	W01007	2019-01	2020-01
Preamplifier (0.5 GHz – 18 GHz)	BBV 9718 B	032	W01325	2018-09	2019-09
Loop antenna	HFH2-Z2	871398/0050	E00060	2018-10	2020-10
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2018-03	2021-03
Horn antenna	BBHA 9120D	9120D-592	W00052	2017-04	2020-04
Horn antenna	BBHA 9170	9170-332	W00054	2017-04	2020-04
LISN	ESH2-Z5	881362/037	E00004	see Note 2	
LISN	ESH2-Z5	893406/009	E00005	2018-10	2020-10
Measuring antenna set	---	---	A00088	N/A[1]	
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	2019-04	2020-04
	LCF12-50J	---	E01215	2019-04	2020-04
	LMR400	1718020006	E00920	2019-01	2020-01
	RG214 Hiflex	171802007	E00921	2019-01	2020-01
Cable set anechoic chamber	262-0942-1500	005	E00435	2019-10	2020-10
	SF104EA/2x11PC35-42/5m	11144/4EA	E00307	2018-12	2019-12
	262-0942-1500	003	E00433	2018-10	2019-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01033	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2018-09	2019-09

Table 23: Equipment calibration status

Note 1: Only used for relative measurements.
Note 2: Only used for decoupling of support equipment.

8 Measurement uncertainties

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	± 4.1 dB	2
Carrier frequency separation Number of hopping frequencies Time of occupancy (dwell time)	± 5.0 %	2
Bandwidth tests	± 2.0 %	2
Maximum conducted output power	± 1.5 dB	2
Power spectral density	± 3.0 dB	2
Spurious RF conducted emissions	± 3.0 dB	2
Radiated emission open field or semi-anechoic chamber 9 kHz to 30 MHz 30 MHz to 300 MHz 300MHz to 1 GHz	 ± 4.8 dB ± 5.4 dB ± 5.9 dB	2
Radiated emission anechoic chamber (> 1000 MHz)	± 4.5 dB	2

Table 24: Measurement uncertainty

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.

9 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2019-05-29	Jennifer Riedel	First edition

10 Additional documents

☒ Annex A: Pictures of test setup and EUT-positions
☒ Annex B: Pictures of EUT (external)
☒ Annex C: Pictures of EUT (internal)