Test report

Customer:

Ahrma Holding BV

Teugseweg 12
7418 AM Deventer
The Netherlands

RF test report

180014-AU01+W01

Ahrma Holding BV

Pallet tracker

SM2

EMV **TESTHAUS** GmbH

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Accreditation:

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

Test Firm Type “accredited”: Valid until 2019-05-06
MRA US-EU, FCC designation number: DE0010
BNetzA-CAB-02/21-02/04 Valid until 2018-11-27

Industry Canada test site numbers with registration expiry date:
3472A-1, expiring 2018-11-09
3472A-2, expiring 2018-11-12

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

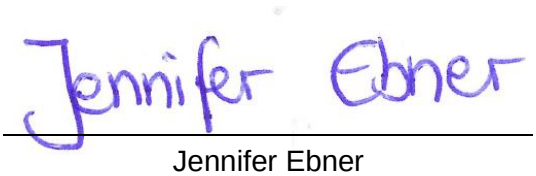
System type: Digital transmission system (DTS)

47 CFR part and section	*Test*	*Page*	*Result*	*Note(s)*
15.207	AC power line conducted emissions 150 kHz to 30 MHz	---	Not applicable	1
15.247(a)(1) KDB 558074, section 8	20 dB bandwidth	27	For information only	2
15.247(a)(2) KDB 558074, section 8	6 dB bandwidth	31	Passed	3
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	35	For reference only	3
15.247(b) KDB 558074, section 9	Maximum conducted output power	39	Passed	---
15.247(e) KDB 558074, section 10	Power spectral density	43	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Antenna-port conducted measurements	---	Not applicable	4
15.247(d) KDB 558074, section 13	Band-edge compliance	47	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Emissions outside the operating frequency band(s) specified 9 kHz to 10th harmonic			
	9 kHz to 30 MHz	53	Passed	---
	30 MHz to 1 GHz	57	Passed	---
	1 GHz to 10th harmonic	61	Passed	---
2.1091	RF exposure evaluation for mobile devices	70	Passed	---

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 For systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is regarded as the bandwidth of the emission and measuring the 20 dB bandwidth is not required.
3 For frequency hopping systems, measuring the 6 dB bandwidth (DTS bandwidth) is not required.
4 If antenna port conducted tests cannot be performed (e.g. for portable or handheld devices with integral antenna), then radiated tests are performed for demonstrating compliance to the conducted emission requirements (see “Spurious radiated emissions 9 kHz to 10th harmonic”).

Straubing, May 15, 2018



Jennifer Ebner
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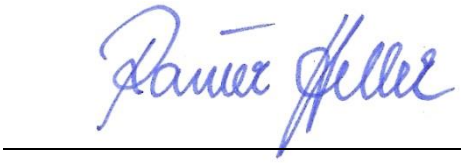

Rainer Heller
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2 Referenced publications

Publication	*Title*
CFR 47 Part 2 October 2017	Code of Federal Regulations, Title 47 (Telecommunication), Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)
CFR 47 Part 15 October 2017	Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
KDB Publication no. 412172 August 7, 2015	Guidelines for determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF transmitting system
KDB Publication no. 447498 October 23, 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
KDB Publication no. 558074 April 5, 2017	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
KDB Publication no. 662911 October 31, 2013	Emissions Testing of Transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc)
ANSI C63.10 June 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

3 Equipment under test (EUT)

All Information in this clause is declared by customer.

3.1 General information

Product type:	Pallet tracker	
Model name:	SM2	
Serial number(s):	04743699:	standard version with integral antenna (for radiated tests)
	04737224:	special version with temporary antenna connector for conducted tests (designed for test purposes only)
Applicant:	BM innovations GmbH	
Manufacturer:	Ahrma Holding BV	
Version:	Hardware:	BM-SM2 V1.1
	Software:	FW 0.5.23
Additional modifications:	None	
FCC ID:	2AHGQ-SM2	
Power supply:	Battery supply by primary lithium-thionyl chloride battery (1.20 Ah)	
	Nominal voltage:	3.6 V
	Minimum voltage:	2.5 V
	Maximum voltage:	3.8 V
	Nominal frequency:	---
Temperature range:	-10 °C to +60 °C (customer defined)	
Device type:	☐ Portable	☒ Mobile ☐ Fixed

3.2 Radio specifications

System type[1]:	Digital transmission system (DTS)	
Application frequency band:	2400.0 MHz - 2483.5 MHz	
Frequency range used:	2402.0 MHz - 2480.0 MHz	
Operating frequencies:	2402.0 MHz - 2480.0 MHz	
Short description:	The EUT is a RF device using Bluetooth Low Energy (BLE) technique in the 2.4 GHz band. It is tested as a digital transmission system (DTS).	
Antenna:	Type:	Planar inverted-F antenna (PIFA) mounted on printed board
	Gain:	0 dBi
	Connector:	☐ external ☐ internal ☐ temporary ☒ none (integral antenna)
		Note: Special version with temporary antenna connector is designed for test purposes only.

[1] "DTS" is the equipment class for digital transmission systems, "DSS" for all other Part 15 spread spectrum transmitters as used for equipment authorization system form 731.

Frequency range used:	2402 MHz to 2480 MHz
Number of RF channels:	40 (37 data channels, 3 advertising channels)
Channel spacing:	2 MHz
Modulation(s):	GFSK
Data rate(s):	1 Mbps

Channel no.	Operating frequency	Test(s) performed	Channel no.	Operating frequency	Test(s) performed
0	2402 MHz	☒	20	2442 MHz	☐
1	2404 MHz	☐	21	2444 MHz	☐
2	2406 MHz	☐	22	2446 MHz	☐
3	2408 MHz	☐	23	2448 MHz	☐
4	2410 MHz	☐	24	2450 MHz	☐
5	2412 MHz	☐	25	2452 MHz	☐
6	2414 MHz	☐	26	2454 MHz	☐
7	2416 MHz	☐	27	2456 MHz	☐
8	2418 MHz	☐	28	2458 MHz	☐
9	2420 MHz	☐	29	2460 MHz	☐
10	2422 MHz	☐	30	2462 MHz	☐
11	2424 MHz	☐	31	2464 MHz	☐
12	2426 MHz	☐	32	2466 MHz	☐
13	2428 MHz	☐	33	2468 MHz	☐
14	2430 MHz	☐	34	2470 MHz	☐
15	2432 MHz	☐	35	2472 MHz	☐
16	2434 MHz	☐	36	2474 MHz	☐
17	2436 MHz	☐	37	2476 MHz	☐
18	2438 MHz	☐	38	2478 MHz	☐
19	2440 MHz	☒	39	2480 MHz	☒

Table 1: Radio specifications of EUT

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			
Pallet tracker (for radiated tests)	SM2	04743699 MAC address: A0:E6:F8:48:62:13	Ahrma Holding BV
Pallet tracker (for conducted tests)	SM2	04737224 MAC address: A0:E6:F8:48:48:C8	Ahrma Holding BV
Support equipment			
Smartphone	HTC One mini	HT38YW107487	HTC
Power supply for smartphone	EP-TAG10EWE	DK1D921V S/B-E	Apple

Table 2: Devices used for testing

4.2 Mode of operation

4.2.1 Test software used for all tests

For all tests collected in this report, the app “BMI BLE Scan” provided by BM innovations is used. A short description of how to configure the EUT for TX mode issued by the manufacturer is shown below.

The test initiates different RF tests:

String to write: **Ch**, 0x00, 0x00, 0x00, **XX**, 0xAA, 0x51, 0x09

XX = **00** for BLE PHY level transmit Test in Direct Test mode
- The payload of every packet is fixed to 37 bytes
- The payload pattern is fixed to 0xAA

XX = **01** for continuous transmitter modem test using unmodulated carrier wave tone

XX = **02** to start a continuous transmitter direct test mode test using a modulated carrier wave and transmitting a byte packet of Pseudo-Random 9-bit data. A packet is transmitted on a different frequency (linearly stepping through all RF channels 0…39) every 625 us.

XX = **03** to start a continuous receiver modem test using a modulated carrier wave tone.

XX = **04** for BLE PHY level Transmit Test in Direct Test mode with whitener configured to TI Pseudo Number 9 (PN9). (NOTE: This test is not implemented in FW v.0.5.23)
- The payload of every packet is fixed to 37 bytes
- The payload pattern is fixed to 0xAA

Ch is the TX RF frequency 0…39 (00-27 in HEX), where F = 2402+ (**Ch***2 MHz).
The Transmit Test never ends (reset device or remove battery to stop it).

Steps to start:
1. Start App BMi BLE Scan on Android Phone
2. Connect with device (Shake it before)
3. Choose BMi Pallet Service
4. Choose Mode (Test Mode) – write HEX 01 – return
5. Choose Set-Up (Test Mode) – write HEX “String”

Example:

String to write: **Ch**, 0x00, 0x00, 0x00, **XX**, 0xAA, 0x51, 0x09
1300000000**01**AA5109 = unmodulated carrier at 2440 MHz

4.2.2 Test modes applied

For the measurements the testing mode “XX = 00” is used with the carrier frequency set to the appropriate channel using “Ch = 01”, “Ch = 19” or “Ch = 39”, as applicable. For further details see clause 4.2.1.

5 Test procedures

5.1 General specifications

5.1.1 Test setups

Tabletop devices are placed on a non-conductive table with a height of 0.8 m. In case of AC power-line conducted emissions test, the rear of the EUT is located 40 cm to the vertical wall of the RF-shielded (screened) room which is used as vertical conducting plane. For radiated emission measurements above 1 GHz, tabletop devices are placed at a height of 1.5 m above the floor using a support made of styrene placed on top of the non-conductive table.

Floor-standing devices are placed either directly on the reference ground-plane or on insulating material (see clause 6.3.3 of ANSI C63.4-2014 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.

5.1.2 Conversion to conducted test results

If test procedures described herein are based on the use of an antenna-port conducted test configuration, but the EUT cannot provide such a configuration (e.g., portable or handheld devices with integral antenna), radiated tests are performed for demonstrating compliance to the conducted requirements.

If a radiated test configuration has to be used, then the measured power or field strength levels are converted to equivalent conducted power levels for comparison to the applicable limit. For this purpose, at first the radiated field strength or power levels are converted to EIRP as described in annex G of ANSI C63.10 and KDB Publication 412172, document D01. The equivalent conducted power is then determined by subtracting the EUT transmit antenna gain from the EIRP (assuming logarithmic representation).

For devices utilizing multiple antenna technologies, KDB Publication 662911 applies.

5.2 Antenna-port conducted measurements

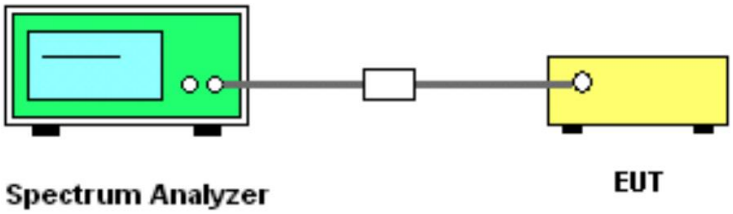

Figure 1: Setup for antenna-port conducted measurements

The RF signal of the EUT is measured conducted at the antenna port. In case of no permanent antenna connector available, a temporary antenna connector should be supplied by the manufacturer. The specific insertion loss of the signal path, which is matched to 50 Ohm, is determined. The test receiver is set to analyzer mode with pre-selector activated. The measurement readings on the test receiver are corrected by the signal path loss.

For frequency hopping systems (FHSS), the test equipment is configured according to Public Notice DA 00-705, for digital transmission systems (DTS) the settings as specified by KDB Publication 558074, document D01, are used.

If a radiated test configuration has to be used, conversion to conducted test results is performed according to clause 5.1.2.

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 3: 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 4.

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

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 4).

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.

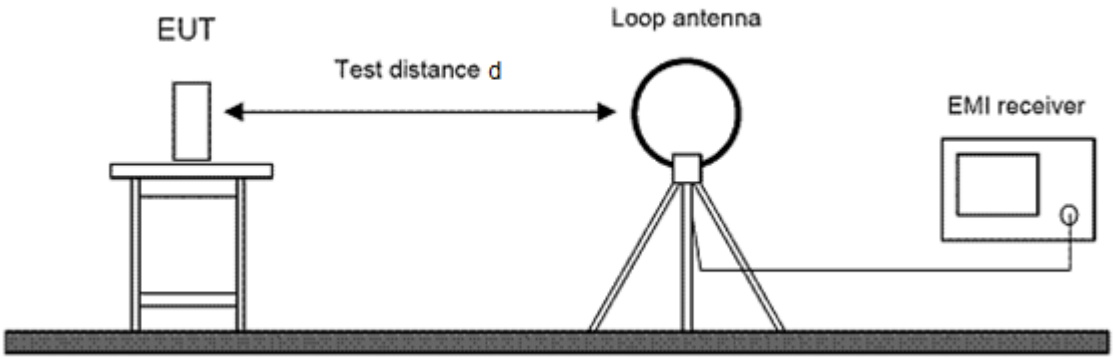

Figure 2: Setup for radiated emissions test below 30 MHz

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 5.

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

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 5).
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.

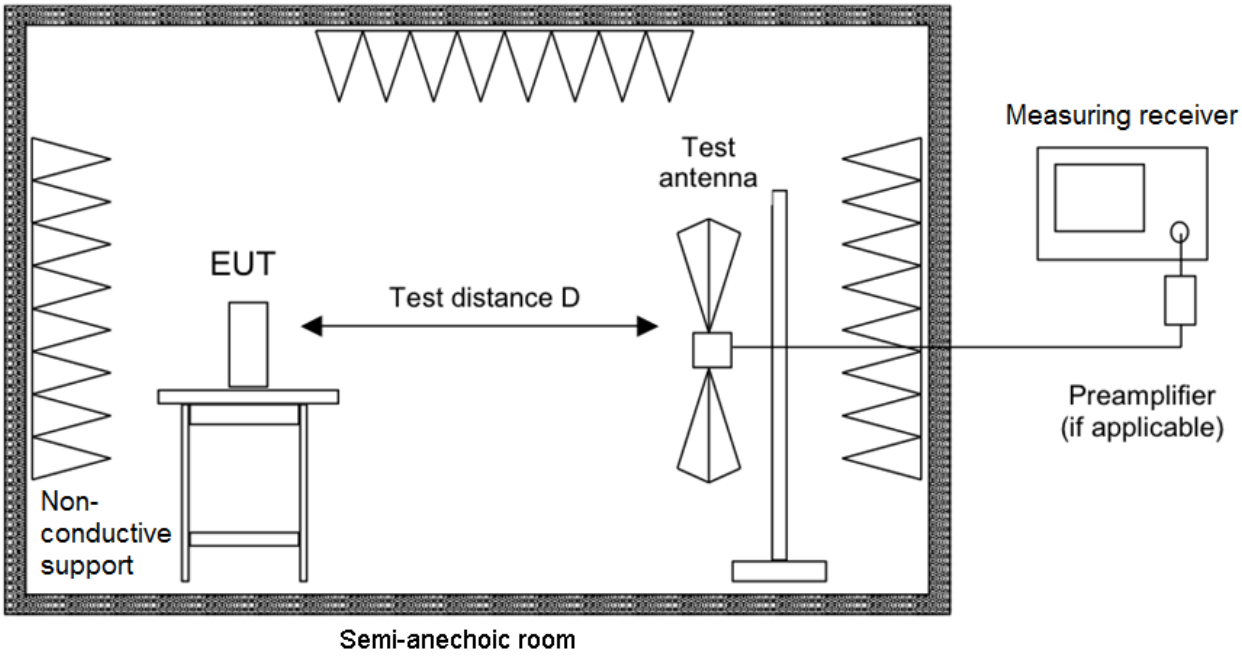

Figure 3: Setup for radiated emissions test from 30 MHz to 1 GHz

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.

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 6.

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 6: 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 7.

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

Table 7: 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 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 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.

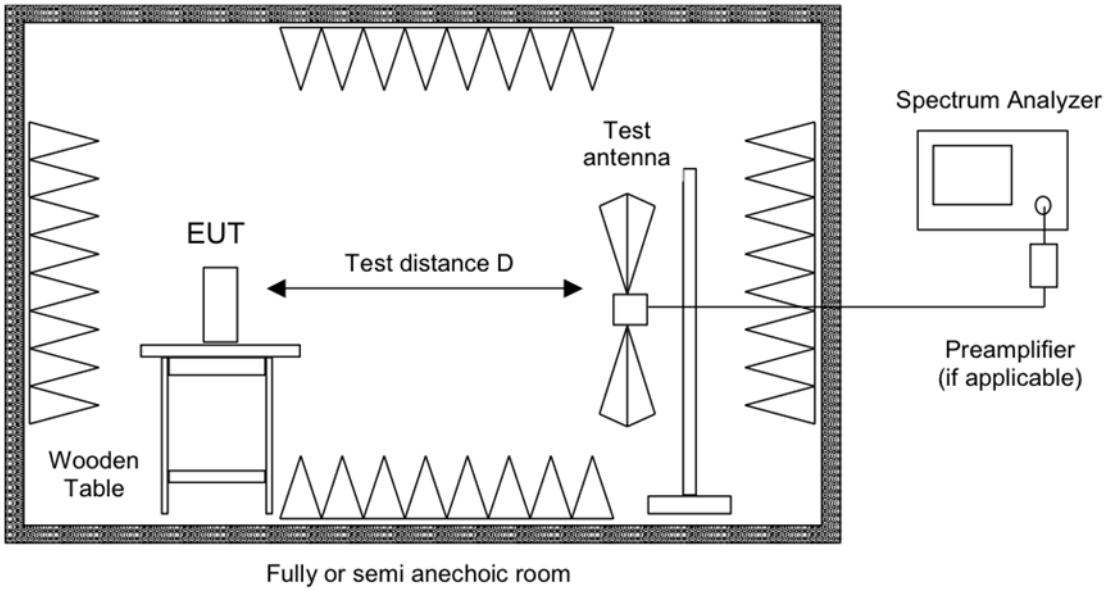

Figure 4: Setup for radiated emissions test above 1 GHz

5.6 Bandwidth measurements

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

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.

The 20 dB bandwidth of the emission is not required for digital transmission systems (DTS). For these systems, the 6 dB bandwidth applies.

5.6.2 6 dB bandwidth (DTS bandwidth)

The 6 dB bandwidth or DTS bandwidth is measured according to clause 8.0 of KDB Publication 558074, document D01, using the following settings:

a) Resolution bandwidth RBW = 100 kHz
b) Video bandwidth (VBW) ≥ 3 x RBW
c) Detector = Peak
d) Trace mode = max hold
e) Sweep = auto couple

After the trace is stabilized, the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

If using the automatic bandwidth measurement capability of the test instrument (6 dB down function), care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB. In addition, it has to be checked that this function delivers the two outermost amplitude points.

The 6 dB bandwidth is not required for frequency hopping systems (FHSS). For these systems the 20 dB bandwidth applies.

5.6.3 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 Maximum peak conducted output power

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

5.7.1 Frequency hopping systems (FHSS)

The maximum conducted output power test method for frequency hopping systems (FHSS) refers to section “Peak Output Power” of Public Notice DA 00-705.

The spectrum analyzer settings are as follows:

a) Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
b) RBW > the 20 dB bandwidth of the emission being measured
c) VBW ≥ RBW
d) Sweep time = auto coupled
e) Detector function = peak
f) Trace mode = max hold
g) Reference level = more than 10·log(OBW/RBW) dB above peak of spectral envelope

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the maximum peak conducted output power.

5.7.2 Digital transmission systems (DTS)

The maximum conducted output power test method for digital transmission systems (DTS) refers to section 9.1.1 of KDB Publication 558074, document D01.

The spectrum analyzer settings are as follows:

h) Span ≥ 3 x RBW, centered on a channel
i) RBW ≥ DTS bandwidth
j) VBW ≥ 3 x RBW
k) Sweep time = auto coupled
l) Detector function = peak
m) Trace mode = max hold
n) Reference level = more than 10·log(OBW/RBW) dB above peak of spectral envelope

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the maximum peak conducted output power.

5.8 Power spectral density

The power spectral density test method for DTS systems refers to section 10.2 of KDB Publication 558074, document D01.

The spectrum analyzer settings are as follows:

a) Span = 1.5 times the DTS bandwidth, centered on a channel
b) RBW: 3 kHz ≤ RBW ≤ 100 kHz
c) VBW ≥ 3 x RBW
d) Sweep time = auto coupled or ≥ span/RBW in seconds, whichever is greater
e) Detector function = peak
f) Trace mode = max hold
g) Reference level = more than 10·log(OBW/RBW) dB above peak of spectral envelope

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the power spectral density.

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

The power spectral density is required for digital transmission systems (DTS), only. It does not apply to frequency hopping systems (FHSS).

6 Test results

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

6.1 20 dB bandwidth

Section(s) in 47 CFR Part 15: Requirement(s): 15.215(c)
Reference(s): KDB 558074 D01, section 8

Performed by:	Jennifer Ebner	Date(s) of test:	March 15, 2018
Climatic conditions:	Ambient temperature 21.0 °C	Relative humidity 34.8% to 35.4%	Barometric pressure 974.5 to 975.2 hPa
Result[2]:	☒ Test passed	☐ Test not passed	

6.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[2] For information about measurement uncertainties see page 75.

6.1.1 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.

The specific rule section under which the equipment operates is §15.247. According to §15.247(a)(2), for systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is specified as the bandwidth of the emission. In this case, measuring the 20 dB bandwidth is not required.

6.1.2 Test procedure

The 20 dB bandwidth is measured using the test procedure as described in clause 5.6.1 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.5.

6.1.3 Test results

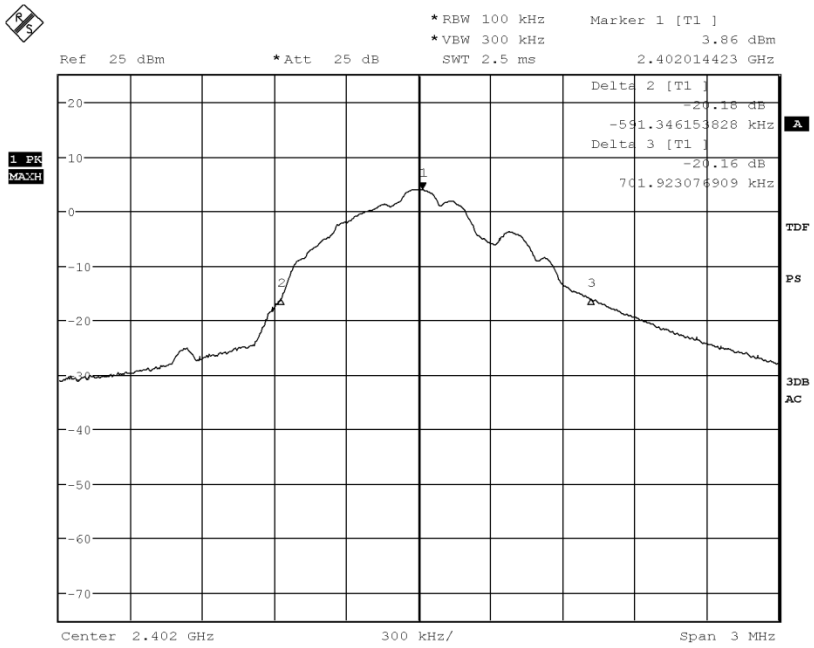

Figure 5: Chart of 20 dB bandwidth on channel 01

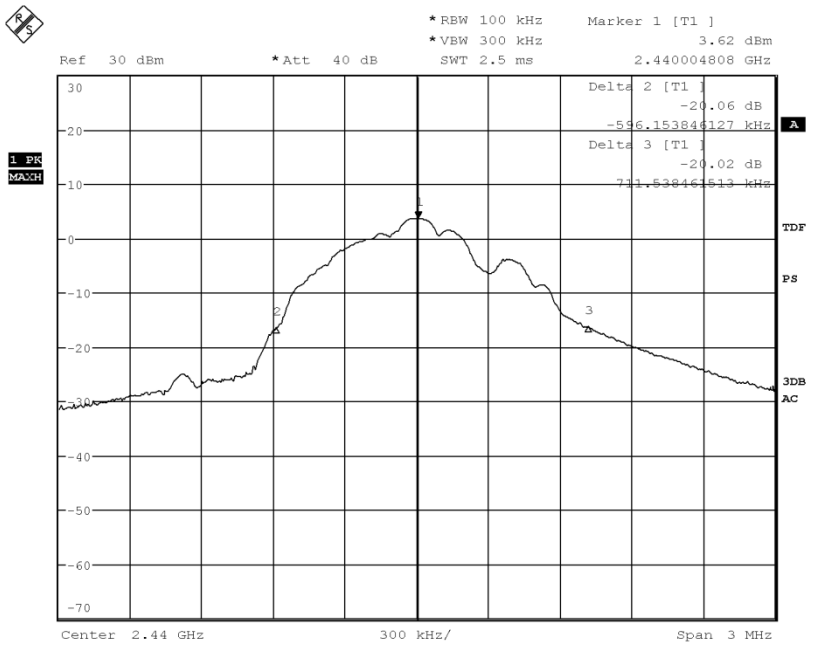

Figure 6: Chart of 20 dB bandwidth on channel 19

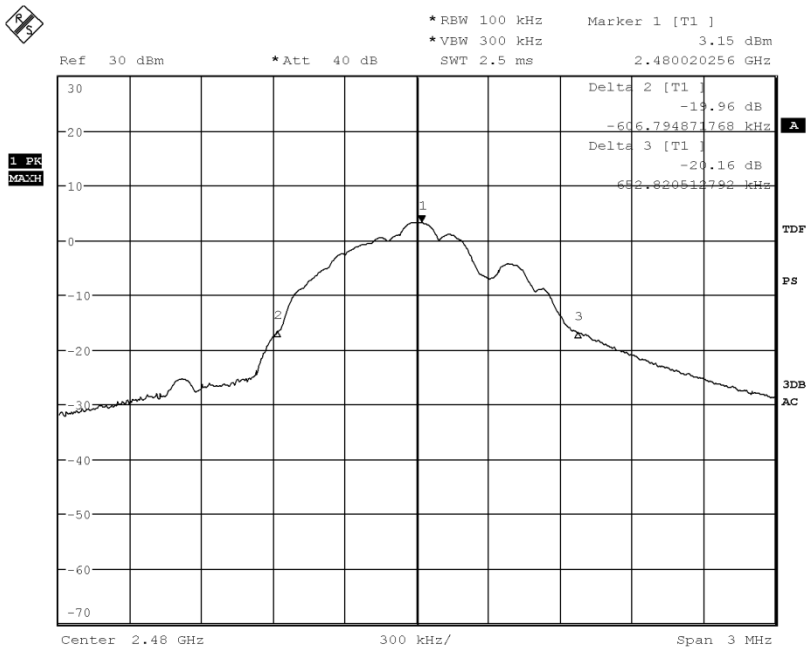

Figure 7: Chart of 20 dB bandwidth test on channel 39

Channel	*20 dB bandwidth*	*Band edge left*		*Band edge right*		*Result*[3]
	[kHz]	*Frequency [MHz]*	*Limit [MHz]*	*Frequency [MHz]*	*Limit [MHz]*	
01	1293.269	2401.423077	2400.0	2402.716346	2483.5	Recorded
19	1307.692	2439.408654	2400.0	2440.716346	2483.5	Recorded
39	1259.616	2479.413461	2400.0	2480.673077	2483.5	Recorded

Table 8: Results of 20 dB bandwidth tests

[3] For systems using digital modulation techniques (DTS), the 20 dB bandwidth is recorded for information only.

6.2 6 dB bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s):	15.215(c), 15.247(a)(2)	
	Reference(s):	KDB 558074 D01, section 8	

Performed by:	Jennifer Ebner	Date(s) of test:	March 15, 2018
Climatic conditions:	Ambient temperature 21.0 °C	Relative humidity 34.8% to 35.4%	Barometric pressure 974.5 to 975.2 hPa
Result[4]:	☒ Test passed	☐ Test not passed	

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[4] For information about measurement uncertainties see page 75.

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 bandwidth of the emission 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.

According to §15.247(a)(2), for systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is specified as the bandwidth of the emission. The minimum 6 dB bandwidth shall be at least 500 kHz.

Measuring the 6 dB bandwidth is not required for frequency hopping systems (FHSS). For these systems the 20 dB bandwidth applies.

6.2.3 Test procedure

The 6 dB bandwidth is measured using the test procedure as described in clause 5.6.2 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.5.

6.2.4 Test results

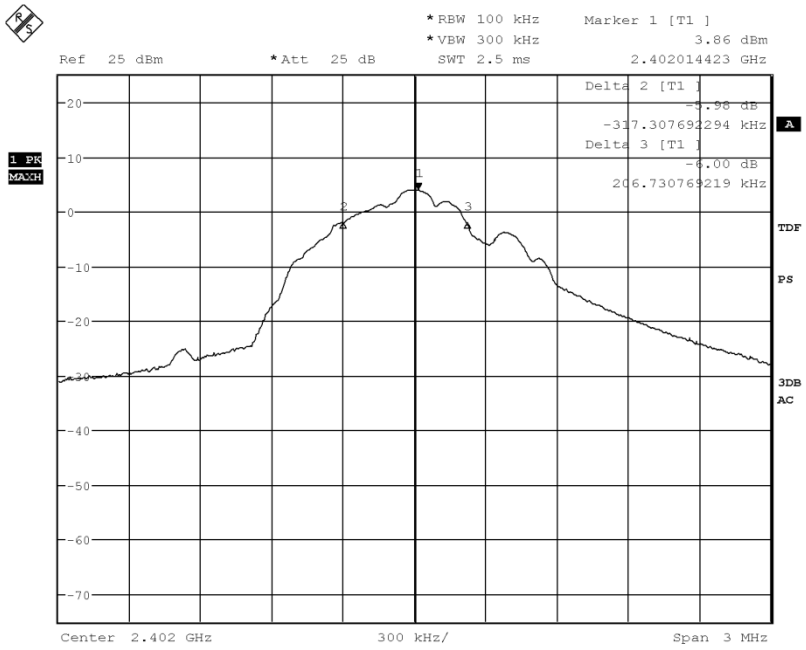

Figure 8: Chart of 6 dB bandwidth test on channel 01

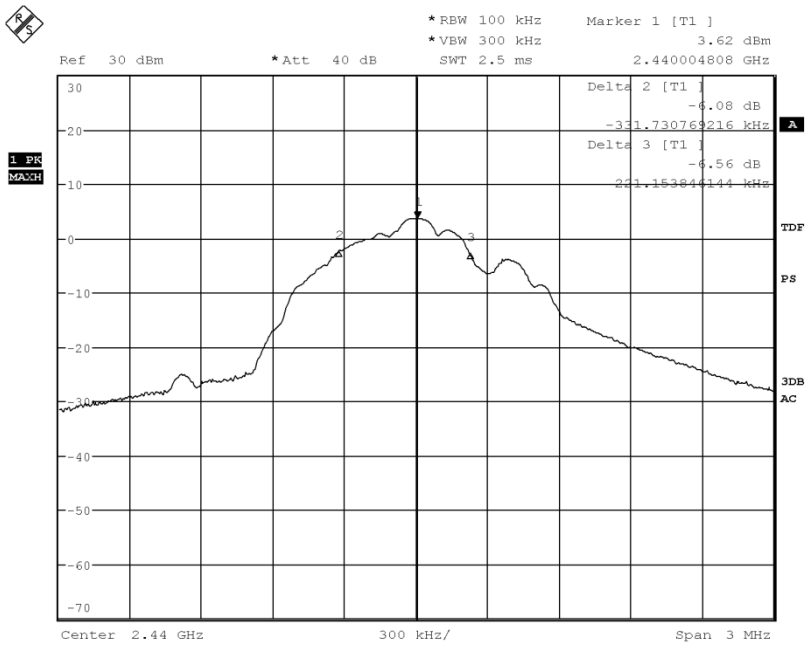

Figure 9: Chart of 6 dB bandwidth test on channel 19

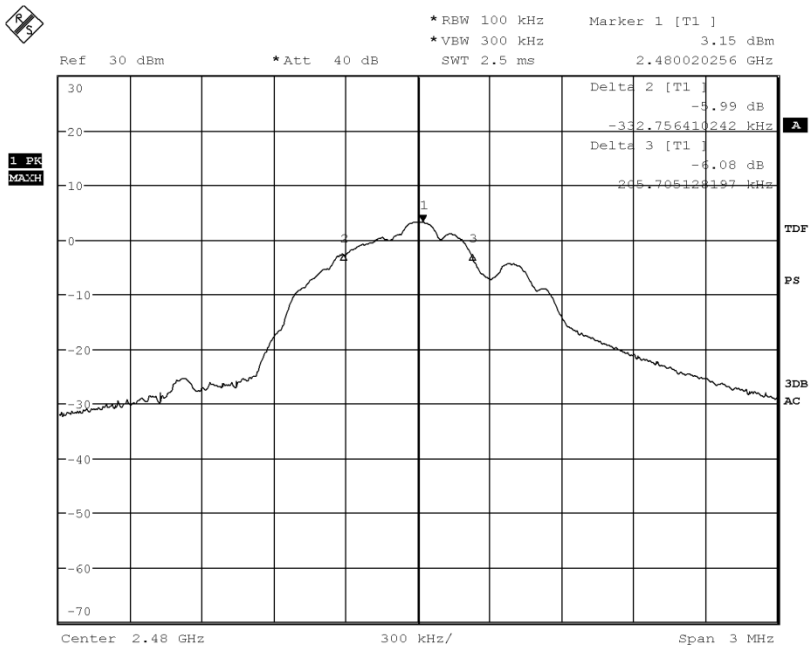

Figure 10: Chart of 6 dB bandwidth test on channel 39

Channel	*6 dB bandwidth*		*Band edge left*		*Band edge right*		*Result*
	Value [kHz]	*Limit [kHz]*	*Frequency [MHz]*	*Limit [MHz]*	*Frequency [MHz]*	*Limit [MHz]*	
01	524.039	≥ 500	2401.696692	2400.0	2402.221154	2483.5	Passed
19	552.885	≥ 500	2439.673077	2400.0	2440.225962	2483.5	Passed
39	538.461	≥ 500	2479.68750	2400.0	2480.225961	2483.5	Passed

Table 9: Results of 6 dB channel bandwidth test

6.3 Occupied bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s):	2.202(a), KDB 558074 D01, section 5.2	
	Reference(s):	ANSI C63.10, clause 6.9	

Performed by:	Jennifer Ebner	Date(s) of test:	March 15, 2018
Climatic conditions:	Ambient temperature 21.0 °C	Relative humidity 34.8% to 35.4%	Barometric pressure 974.5 to 975.2 hPa
Result[5]:	☒ Test passed	☐ Test not passed	

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[5] For information about measurement uncertainties see page 75.

6.3.2 Limits

According to section 5.2 of KDB Publication 558074, document D01, the 99 % occupied bandwidth is necessary for setting the proper reference level and input attenuation.

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 5.6.3 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.5.

6.3.4 Test results

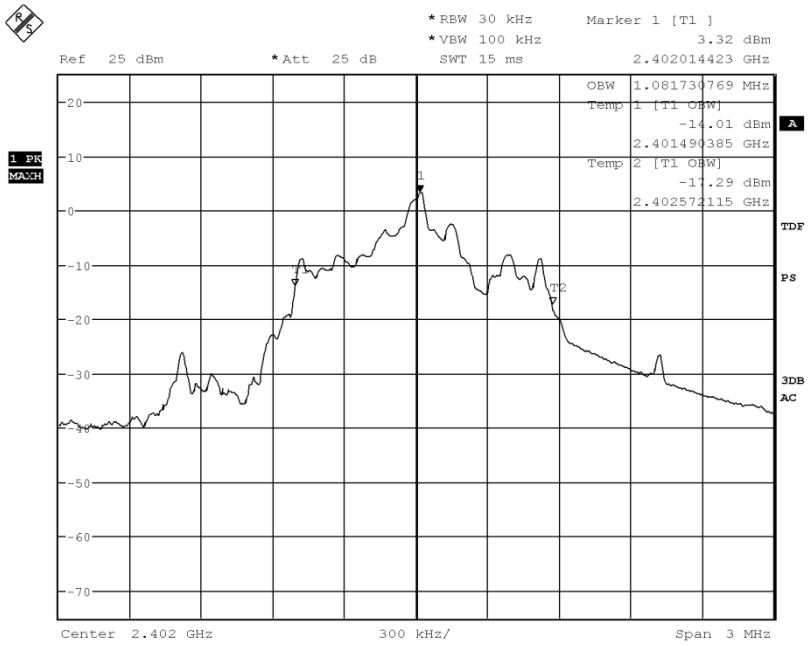

Figure 11: Chart of occupied bandwidth test on channel 01

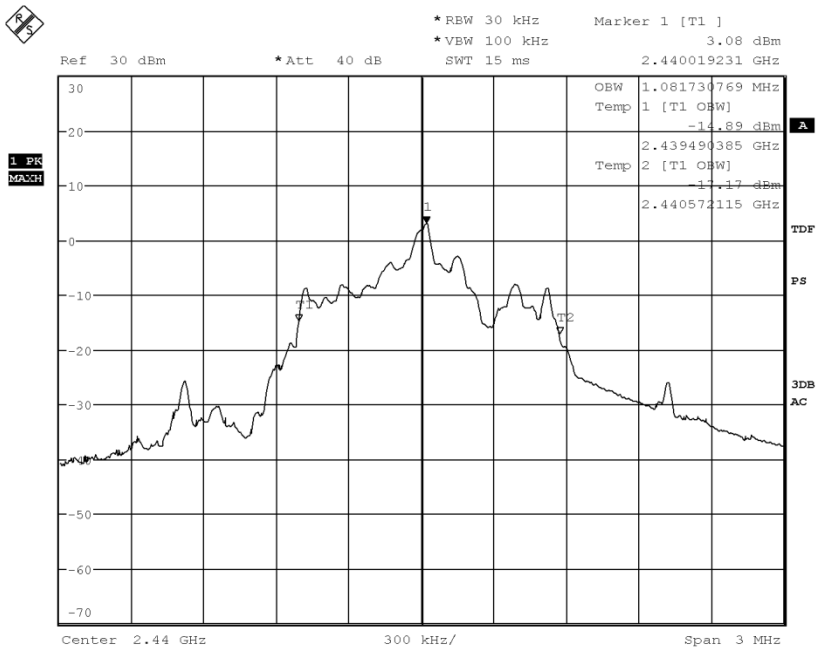

Figure 12: Chart of occupied bandwidth test on channel 19

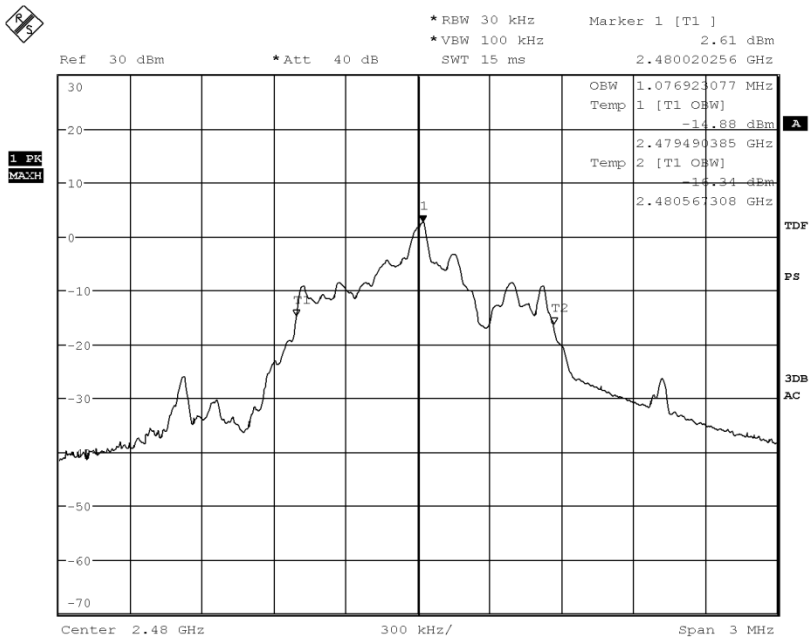

Figure 13: Chart of occupied bandwidth test on channel 39

Channel	*99 % occupied bandwidth [kHz]*	*Result*
01	1081.731	Recorded
19	1081.731	Recorded
39	1076.923	Recorded

Table 10: Results of occupied bandwidth test

6.4 Maximum peak conducted output power

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(b)
Reference(s): KDB 558074 D01, section 9

Performed by:	Jennifer Ebner	Date(s) of test:	March 15, 2018
Climatic conditions:	Ambient temperature 21.0 °C	Relative humidity 34.8% to 35.4%	Barometric pressure 974.5 to 975.2 hPa
Result[6]:	☒ Test passed	☐ Test not passed	

6.4.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[6] For information about measurement uncertainties see page 75.

6.4.2 Limits

As specified in section 15.247(b)(3) of 47 CFR Part 15, for systems using digital modulation (DTS), the maximum peak conducted output power of the intentional radiator shall not exceed 1 Watt (30 dBm).
This limit is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

6.4.3 Test procedure

The maximum peak conducted output power is measured using the test procedure as described in clause 5.7.2 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.5.

6.4.4 Test results

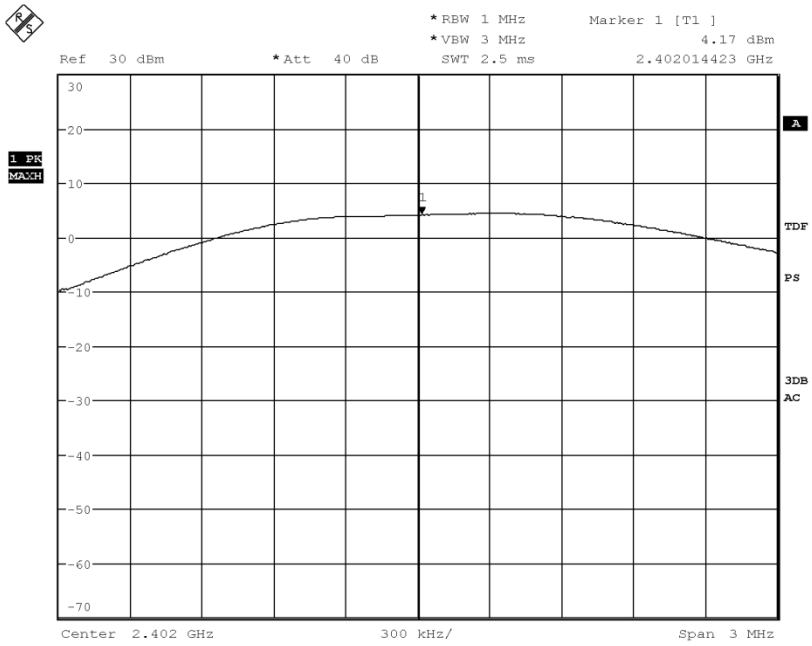

Figure 14: Chart of maximum peak conducted output power test on channel 01

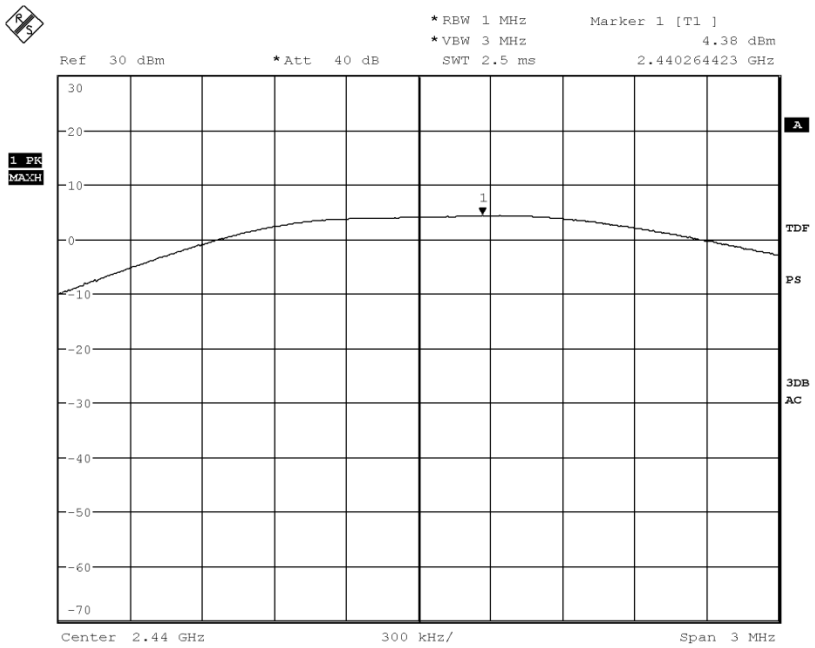

Figure 15: Chart of maximum peak conducted output power test on channel 19

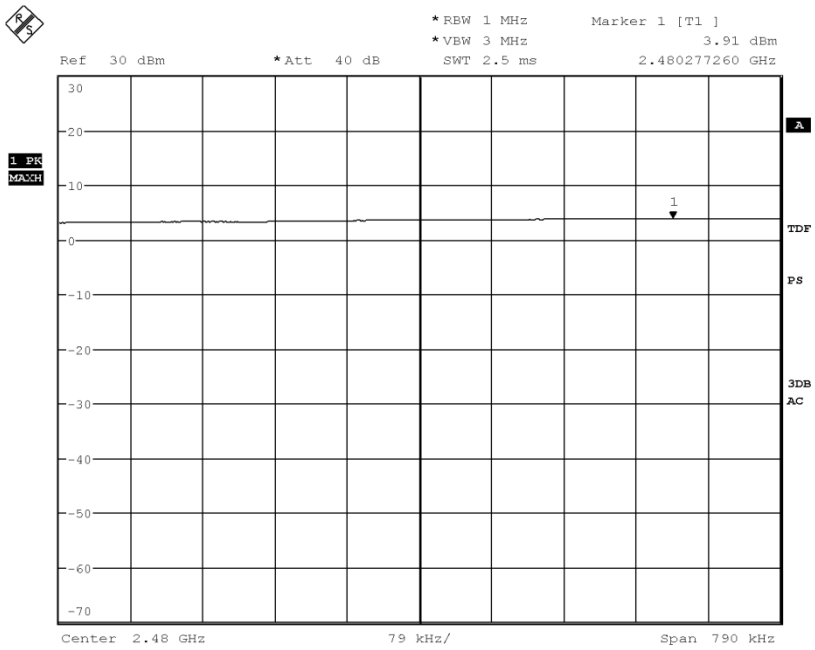

Figure 16: Chart of maximum peak conducted output power test on channel 39

Channel	*Frequency [MHz]*	*Maximum peak conducted output power [dBm]*	*Limit*[7]		*Margin [dB]*	*Results*
			[dBm]	*[W]*		
01	2402.337	4.17	30	1	25.83	Passed
19	2440.332	4.38	30	1	25.62	Passed
39	2480.250	3.91	30	1	26.09	Passed

Table 11: Results of maximum peak conducted output power test

[7] If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. For information about the EUT *see* clause 3.

6.5 Power spectral density

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(e)
Reference(s): KDB 558074 D01, section 10

Performed by:	Jennifer Ebner	Date(s) of test:	March 15, 2018
Climatic conditions:	Ambient temperature 21.0 °C	Relative humidity 34.8% to 35.4%	Barometric pressure 974.5 to 975.2 hPa
Result[8]:	☒ Test passed	☐ Test not passed	

6.5.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[8] For information about measurement uncertainties see page 75.

6.5.2 Limits

As specified in section 15.247(e) of 47 CFR Part 15, for digitally modulated systems (DTS), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

The same method of determining the conducted output power shall be used to determine the power spectral density.

For frequency hopping systems (FHSS), measuring the power spectral density is not applicable.

6.5.3 Test procedure

The power spectral density is measured using the test procedure as described in clause 5.8 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.5.

6.5.4 Test results

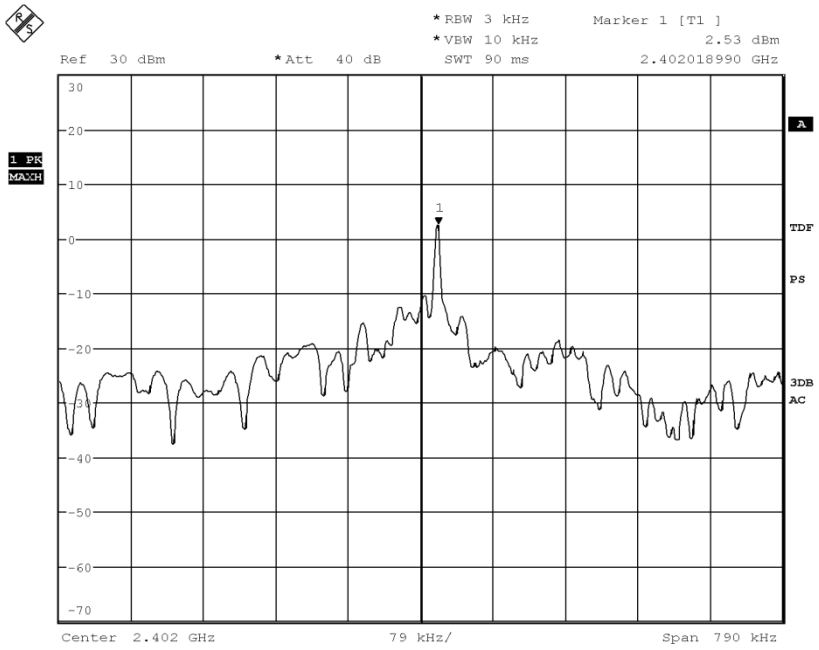

Figure 17: Chart of power spectral density test on channel 01

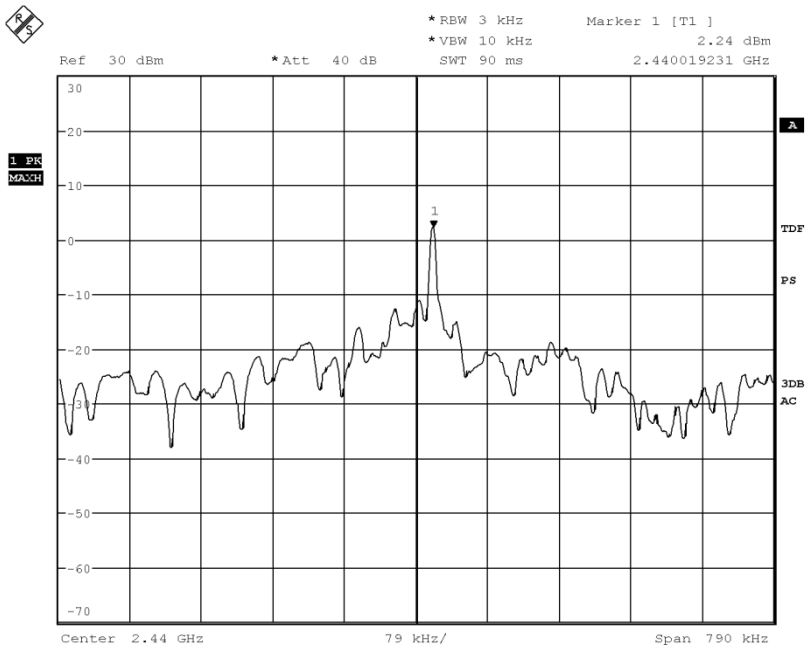

Figure 18: Chart of power spectral density test on channel 19

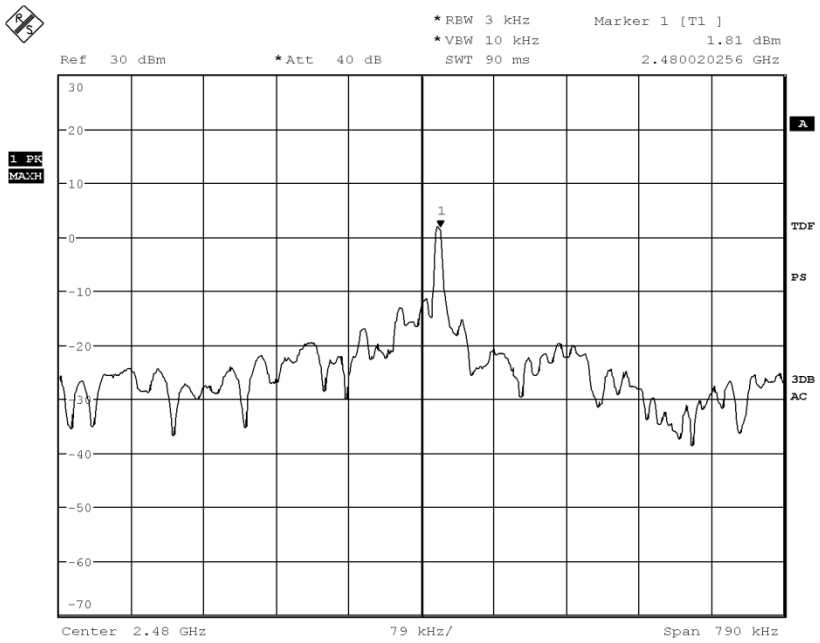

Figure 19: Chart of power spectral density test on channel 39

Channel	*Frequency [MHz]*	*Power spectral density [dBm]*	*Limit [dBm]*	*Margin [dB]*	*Results*
01	2402.019	2.53	8.00	5.47	Passed
19	2440.019	2.24	8.00	5.76	Passed
39	2480.020	1.81	8.00	6.19	Passed

Table 12: Results of power spectral density test

6.6 Band-edge measurements

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(d)
Reference(s): KDB 558074 D01, section 13

Result[9]: ☒ Test passed ☐ Test not passed

6.6.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☒	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☒	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[9] For information about measurement uncertainties see page 75.

6.6.2 Limits

Only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	above 38.6
13.36-13.41			

Table 13: Restricted bands of operation according to §15.205

According to §15.247(d), in any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands (see table 13) must also comply with the radiated emission limits specified in §15.209(a)

6.6.3 Test procedure

The band-edge measurements are performed using the

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.5.

6.6.4 Test results

Performed by:	Jennifer Ebner	Date(s) of test:	March 29, 2018
Climatic conditions:	Ambient temperature 23.6 °C	Relative humidity 26.9 %	Barometric pressure 969.0 hPa
Test distance:	☒ 3 m	☐ 10 m	☐ ….. m
EUT position:	☒ Position 1	☒ Position 2	☒ Position 3

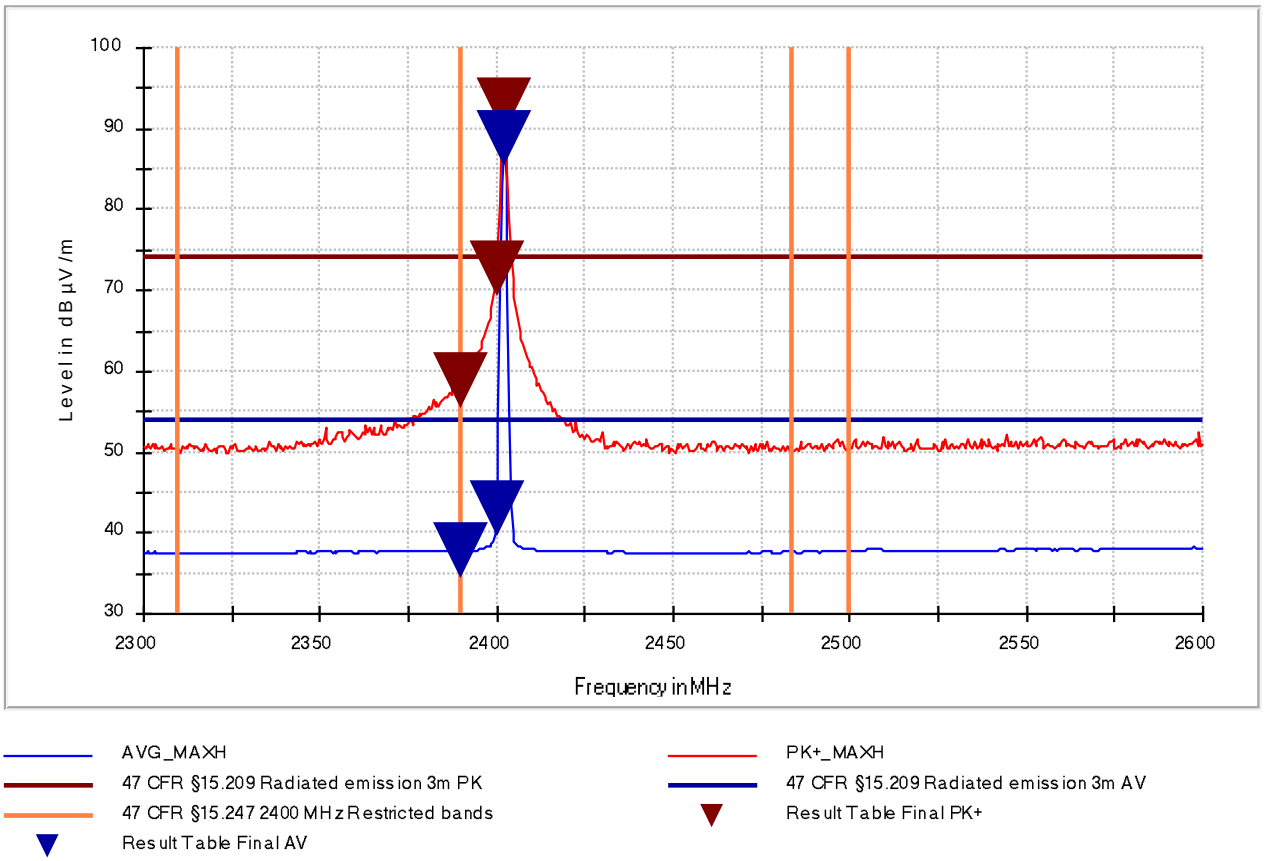

Figure 20: Chart of band-edge measurement on channel 01 in horizontal polarization

Frequency (MHz)	*EUT pos.*	*PK detector* Value (dBµV/m)	Limit (dBµV/m)	*AV detector* Value (dBµV/m)	Limit (dBµV/m)	*Height* (cm)	*Polarization*	*Azimuth* (deg)	*Corr.* (dB/m)	*Result*
2390.000	2	58.8	74.0	37.7	54.0	156.0	H	62.0	30.4	Passed
2400.000	2	72.6	-20 dBc	42.9	-20 dBc	156.0	H	62.0	30.4	Passed
2402.000	2	92.8	---	88.9	---	156.0	H	62.0	30.4	Passed

Table 14: Results of band-edge compliance test on channel 01 in horizontal polarization

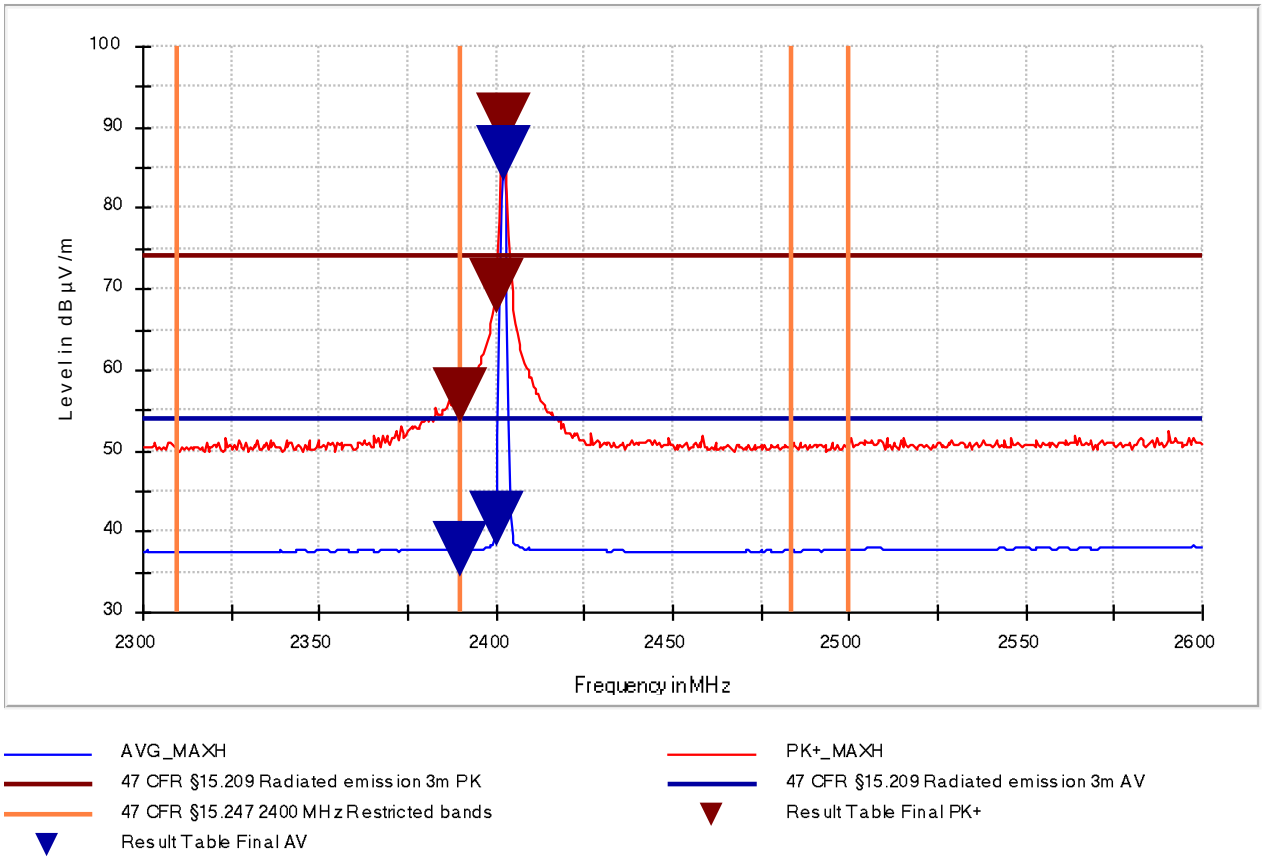

Figure 21: Chart of band-edge measurement on channel 01 in vertical polarization

Frequency (MHz)	*EUT pos.*	*PK detector*		*AV detector*		*Height* (cm)	*Polarization*	*Azimuth* (deg)	*Corr.* (dB/m)	*Result*
		Value (dBµV/m)	*Limit* (dBµV/m)	*Value* (dBµV/m)	*Limit* (dBµV/m)					
2390.000	2	56.7	74.0	37.7	54.0	172.0	V	313.0	30.4	Passed
2400.000	2	70.4	-20 dBc	41.5	-20 dBc	172.0	V	313.0	30.4	Passed
2402.000	2	90.7	---	86.7	---	172.0	V	313.0	30.4	Passed

Table 15: Results of band-edge compliance test on channel 01 in vertical polarization

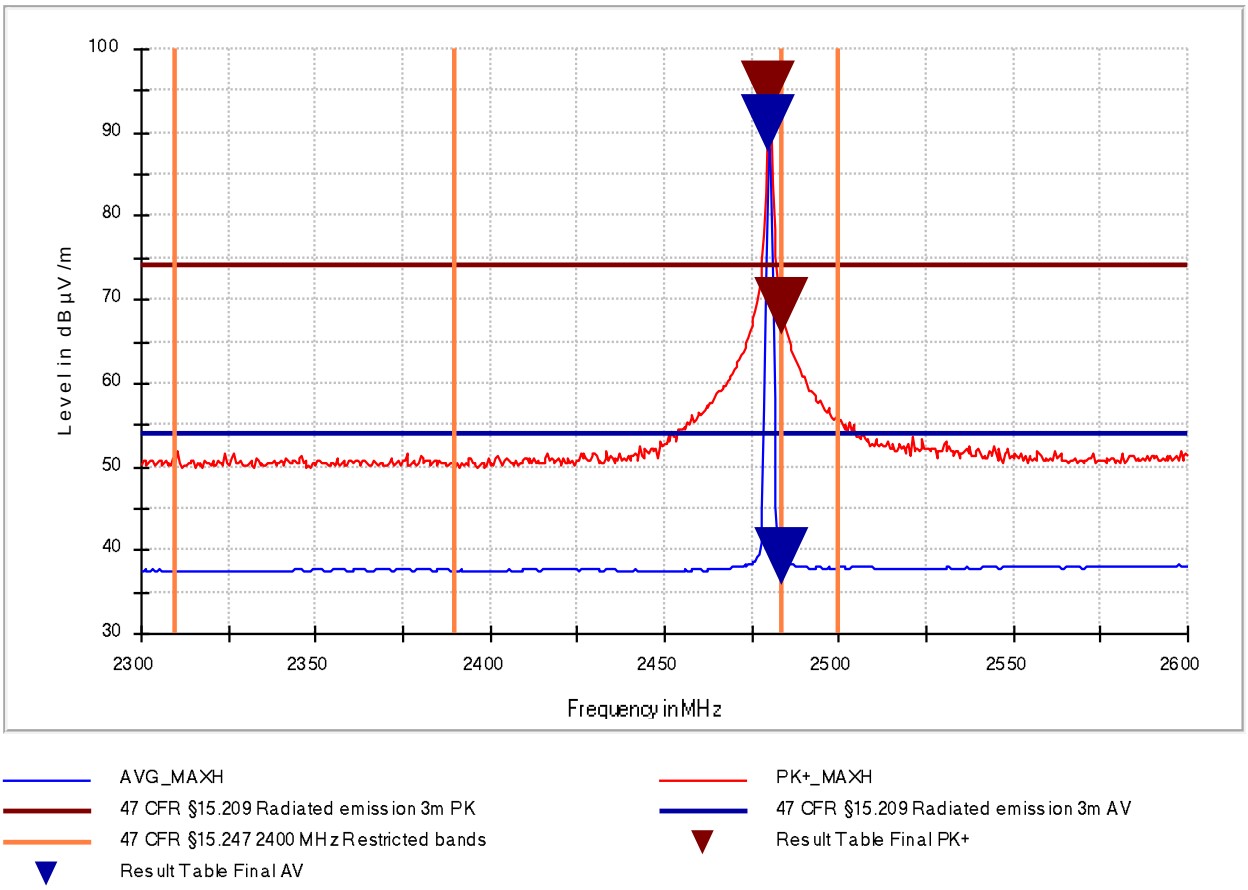

Figure 22: Chart of band-edge measurement on channel 39 in horizontal polarization

Frequency (MHz)	*EUT pos.*	*PK detector*		*AV detector*		*Height* (cm)	*Polari-zation*	*Azimuth* (deg)	*Corr.* (dB/m)	*Result*
		Value (dBµV/m)	*Limit* (dBµV/m)	*Value* (dBµV/m)	*Limit* (dBµV/m)					
2480.000	2	95.2	---	91.1	---	124.0	H	30.0	30.3	Passed
2483.500	2	69.3	74.0	39.2	54.0	124.0	H	30.0	30.3	Passed

Table 16: Results of band-edge compliance test on channel 39 in horizontal polarization

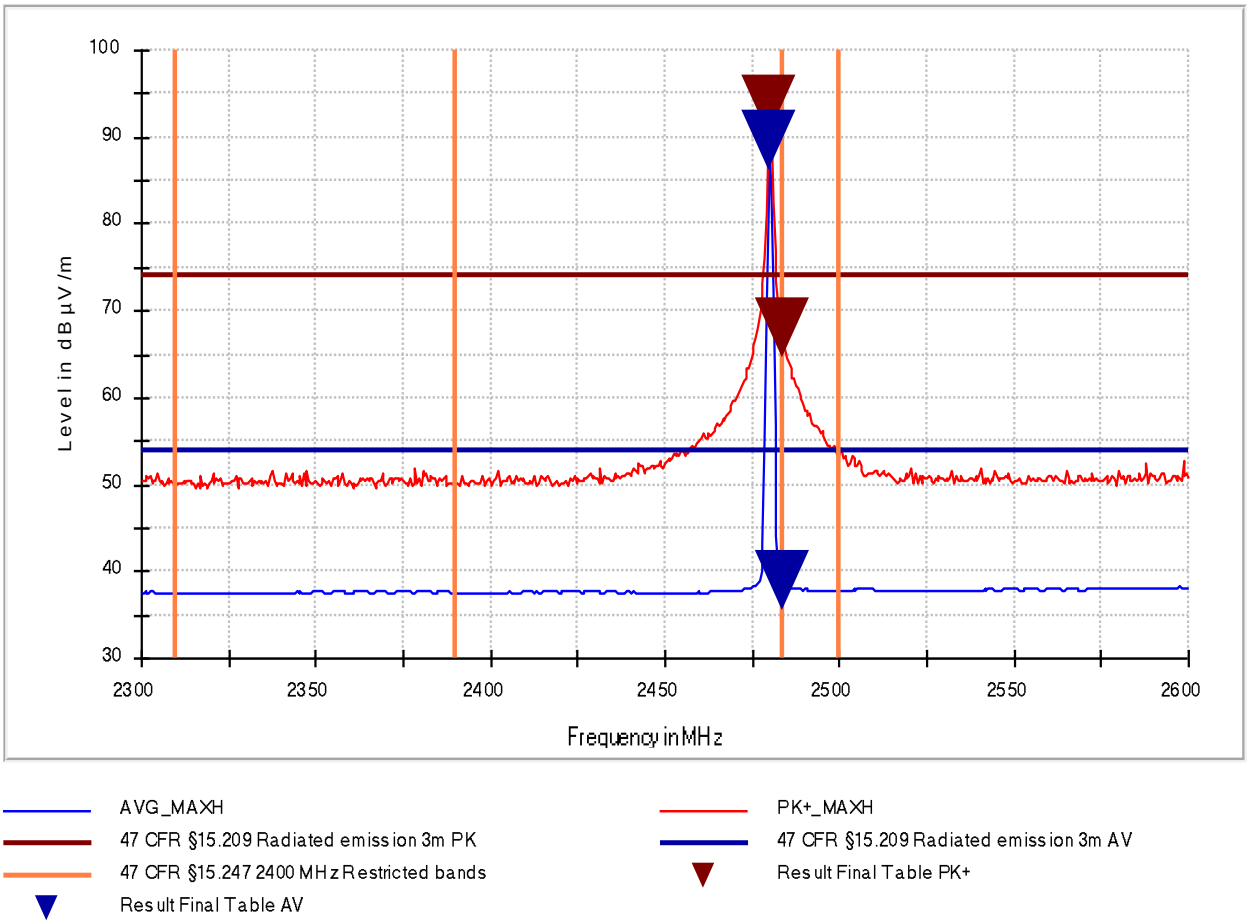

Figure 23: Chart of band-edge measurement on channel 39 in vertical polarization

Frequency (MHz)	*EUT pos.*	*PK detector* Value (dBµV/m)	Limit (dBµV/m)	*AV detector* Value (dBµV/m)	Limit (dBµV/m)	*Height* (cm)	*Polari-zation*	*Azimuth* (deg)	*Corr.* (dB/m)	*Result*
2480.000	2	93.5	---	89.5	---	192.0	V	317.0	30.3	Passed
2483.500	2	67.9	74.0	38.8	54.0	192.0	V	317.0	30.3	Passed

Table 17: Results of band-edge compliance test on channel 39 in vertical polarization

6.7 Emissions outside the operating frequency band(s) specified

6.7.1 Emissions below 30 MHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(d)
Reference(s): KDB 558074 D01, sections 11 and 12

Result[10]: ☒ Test passed ☐ Test not passed

6.7.1.1 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)	SAC3	Albatross Projects	E00716
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Field probe	RF-R 400-1	Langer EMV-Technik	E00270
☒	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	Cable set CDC	RF cable(s)	Huber + Suhner AME HF-Technik AME HF-Technik Stabo	E00446 E00920 E00921 E01215
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☒	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[10] For information about measurement uncertainties see page 75.

6.7.1.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands (see table 13) must also comply with the radiated emission limits specified in §15.209(a). For the frequency range 9 kHz to 30 MHz, these limits are shown in table 18.

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 18: General radiated emission limits up to 30 MHz according to §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 in table 18 using the recalculation factor as described in clause 5.3.

6.7.1.3 Test procedure

The emissions below 30 MHz are measured using the

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.3.

6.7.1.4 Test results

Performed by:	Jennifer Ebner	Date(s) of test:	March 12, 2018
Climatic conditions:	Ambient temperature 24.9 °C	Relative humidity 25.0 %	Barometric pressure 975.3 hPa
Test distance:	☒ 3 m	☐ 10 m	☐ ….. m
Antenna alignment:	☒ in parallel	☐ in line	☐ angle ….. °
EUT position[11]:	☒ Position 1	☒ Position 2	☒ Position 3

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	2 s	1 s	Off
150 kHz – 30 MHz	2.25 kHz	9 kHz	QP, PK, CAV	QP, PK, AV	2 s	1 s	Off

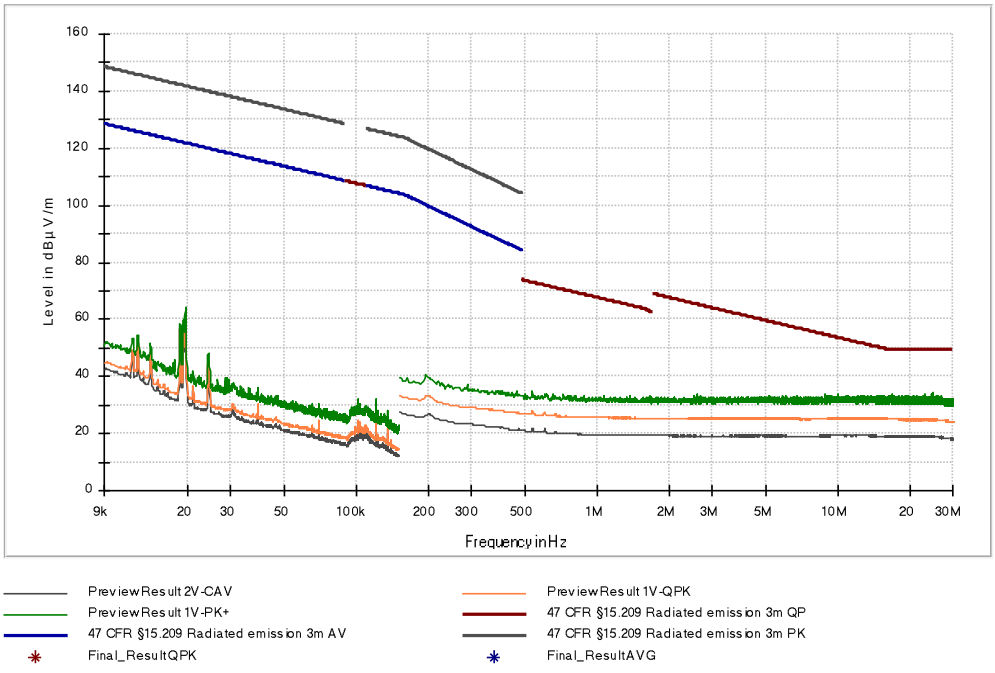

Figure 24: Chart of emissions test below 30 MHz on channel 01 in position 1

[11] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

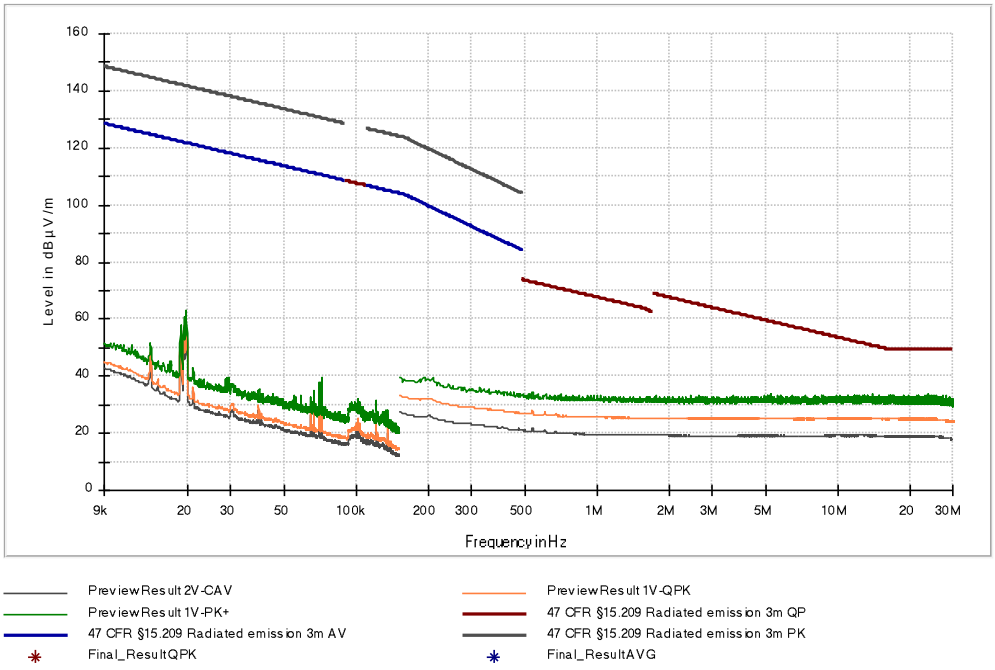

Figure 25: Chart of emissions test below 30 MHz on channel 19 in position 2

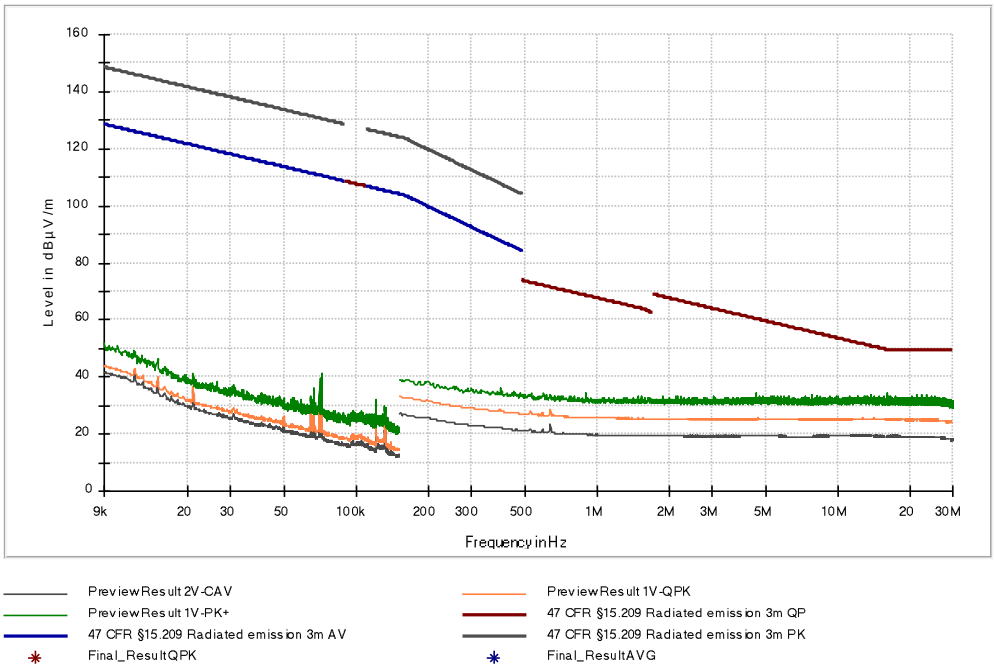

Figure 26: Chart of emissions test below 30 MHz on channel 39 in position 3

6.7.2 Emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(d)
Reference(s): KDB 558074 D01, sections 11 and 12

Result[12]: ☒ Test passed ☐ Test not passed

6.7.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☒	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☒	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[12] For information about measurement uncertainties see page 75.

6.7.2.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands (see table 13) must also comply with the radiated emission limits specified in §15.209(a). For frequencies equal to and above 30 MHz, these limits are shown in table 19.

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

6.7.2.3 Test procedure

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

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.4.

6.7.2.4 Test results

Performed by:	Jennifer Ebner	Date(s) of test:	March 21 to 23, 2018
Climatic conditions:	Ambient temperature 21.8 °C to 24.4 °C	Relative humidity 25.8 % to 32.1%	Barometric pressure 974.8 hPa to 976.3 hPa
Test distance:	☒ 3 m	☐ 10 m	☐ ….. m
EUT position[13]:	☒ Position 1	☒ Position 2	☒ Position 3

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

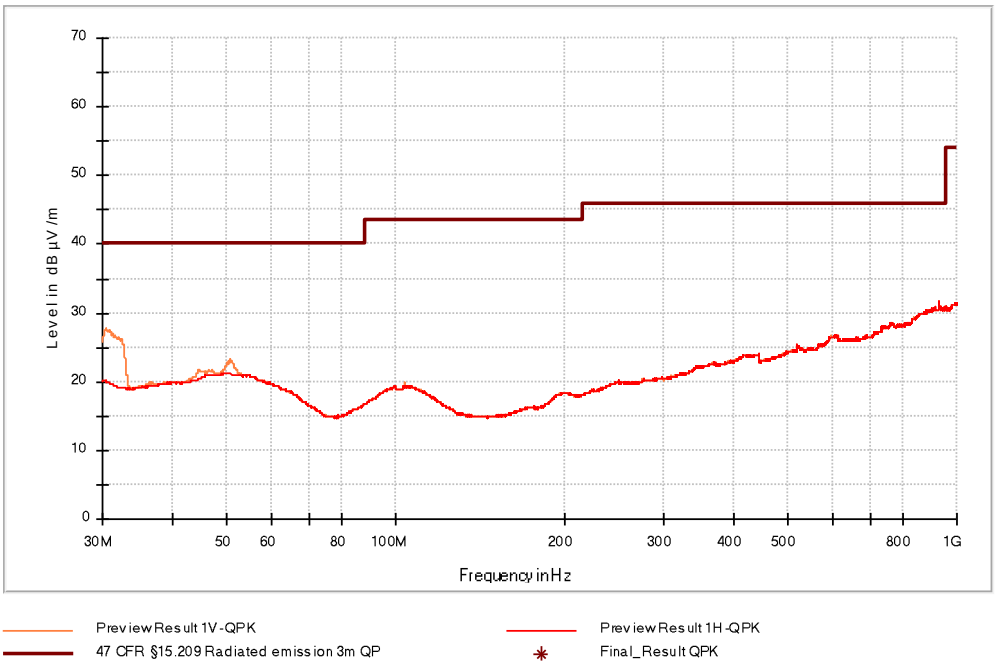

Figure 27: Chart of emissions test from 30 MHz to 1 GHz on channel 01 in position 2

[13] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

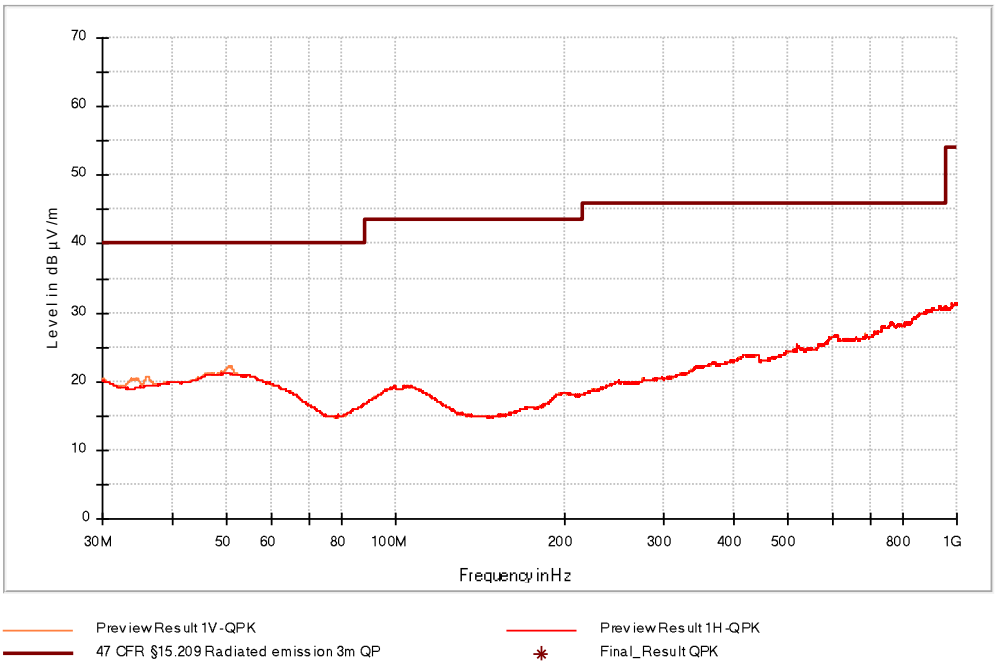

Figure 28: Chart of emissions test from 30 MHz to 1 GHz on channel 19 in position 2

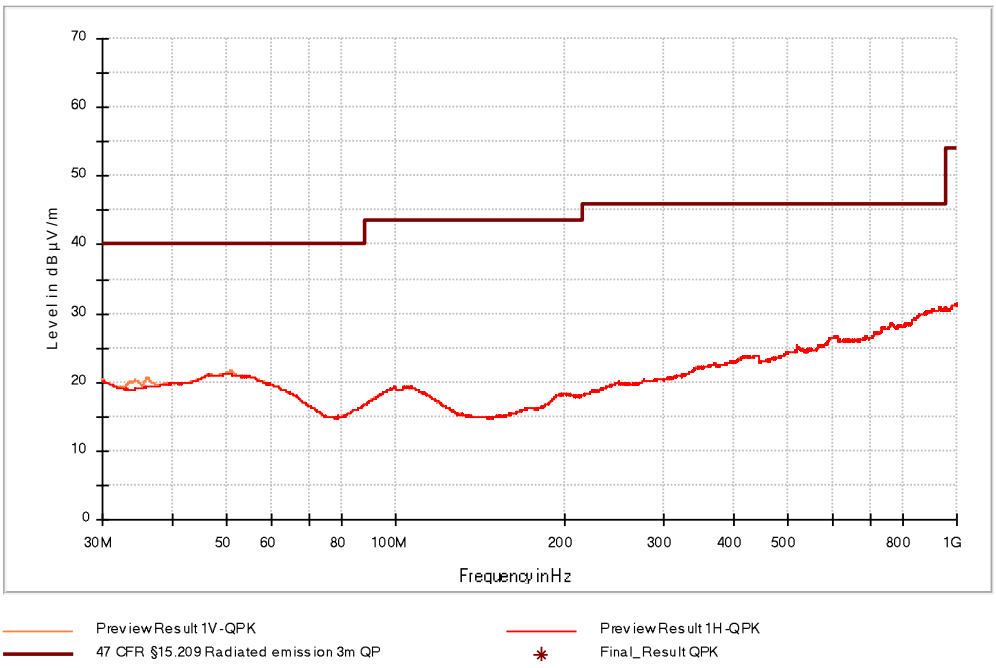

Figure 29: Chart of emissions test from 30 MHz to 1 GHz on channel 39 in position 2

6.7.3 Emissions from 1 GHz to 25 GHz (10th harmonic)

Section(s) in 47 CFR Part 15: Requirement(s): 15.247(d)
Reference(s): KDB 558074 D01, sections 11 and 12

Result[14]: ☒ Test passed ☐ Test not passed

6.7.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
	Notch filter	FSM-2450-85	Miteq	W00092
	Highpass filter	WHKX10-5850-6500-18000-40SS	Wainwright Instruments	W00699
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	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 9170	Schwarzbeck	W00054
☒	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☒	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[14] For information about measurement uncertainties see page 75.

6.7.3.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands (see table 13) must also comply with the radiated emission limits specified in §15.209(a). For frequencies above 960 MHz, these limits are shown in table 20.

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

Table 20: General radiated emission limits above 960 MHz according to §15.209

6.7.3.3 Test procedure

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

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.5.

6.7.3.4 Test results

Performed by:	Jennifer Ebner	Date(s) of test:	March 21 to 23, 2018
Climatic conditions:	Ambient temperature 21.8 °C to 24.4 °C	Relative humidity 25.8 % to 32.1%	Barometric pressure 974.8 hPa to 976.3 hPa
Test distance:	Exploratory tests: Final tests:	☐ 1 m ☒ 3 m	☒ 0.5 m ☐ 1 m
EUT position[15]:	☒ Position 1	☒ Position 2	☒ Position 3

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Pre-amplifier*	*Distance*
			Prescan	*Final scan*	*Prescan*	*Final scan*		
1 GHz – 7 GHz	250 kHz	1 MHz	PK + AV	PK + AV	1.5 s	0.1 s	External	3 m
7 GHz – 12.5 GHz	250 kHz	1 MHz	PK + AV	PK + AV	2 s	0.1 s	External	3 m

Frequency range	*Resolution bandwidth*	*Video bandwidth*	Sweep time	*Trace detector(s)*	*Trace mode(s)*	*Test*	*Pre-amplifier*	*Dis-tance*
12.5 GHz – 25 GHz	1 MHz	3 MHz	AUTO	Max Peak	Clear Write	Searching	20 dB[1]	0.5 m[2]
					Max Hold	Recording		

Note 1: The internal preamplifier of the measuring receiver ESW44 was used for the exploratory measurements from 12.5 GHz to 25 GHz.

Note 2: The exploratory measurements from 12.5 GHz to 25 GHz are made at a measurement distance of 0.5 m. The limit lines for these tests were converted and calculated from the limit lines at a measurement distance of 3m.

[15] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

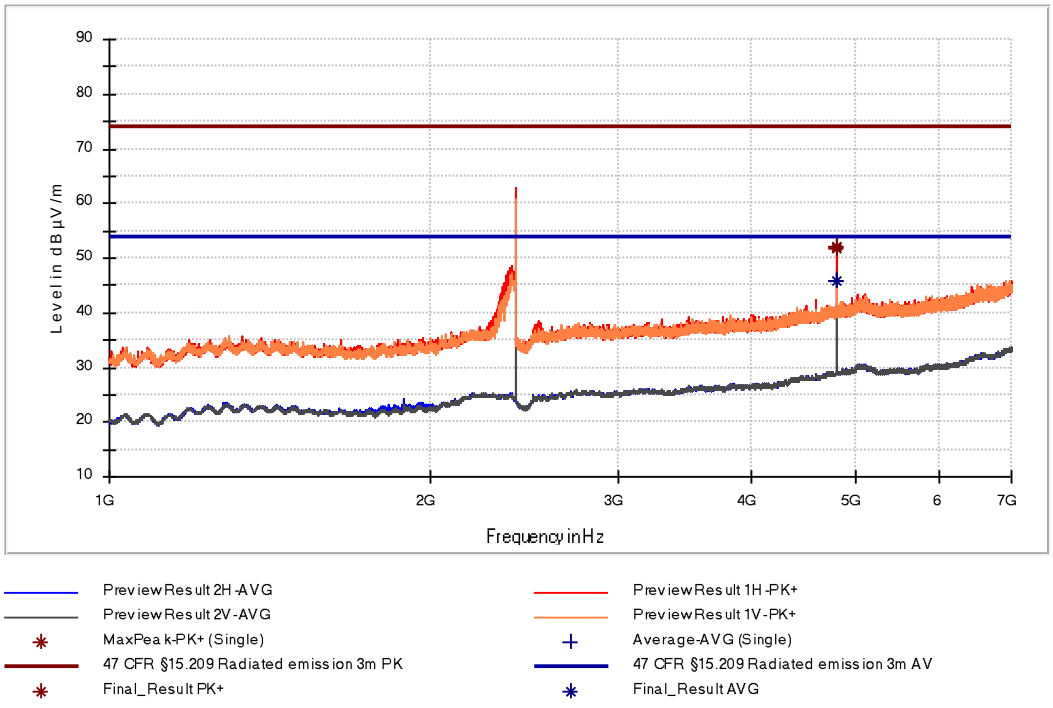

Figure 30: Chart of emissions test from 1 GHz to 7 GHz on channel 01 in position 2

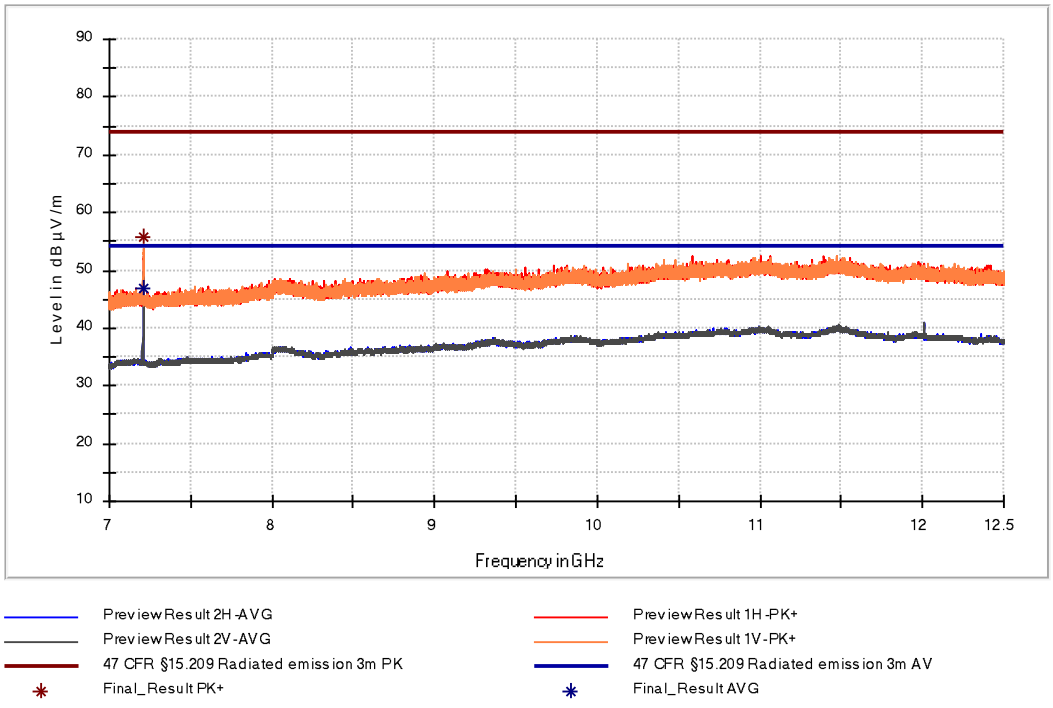

Figure 31: Chart of emissions test from 7 GHz to 12.5 GHz on channel 01 in position 2

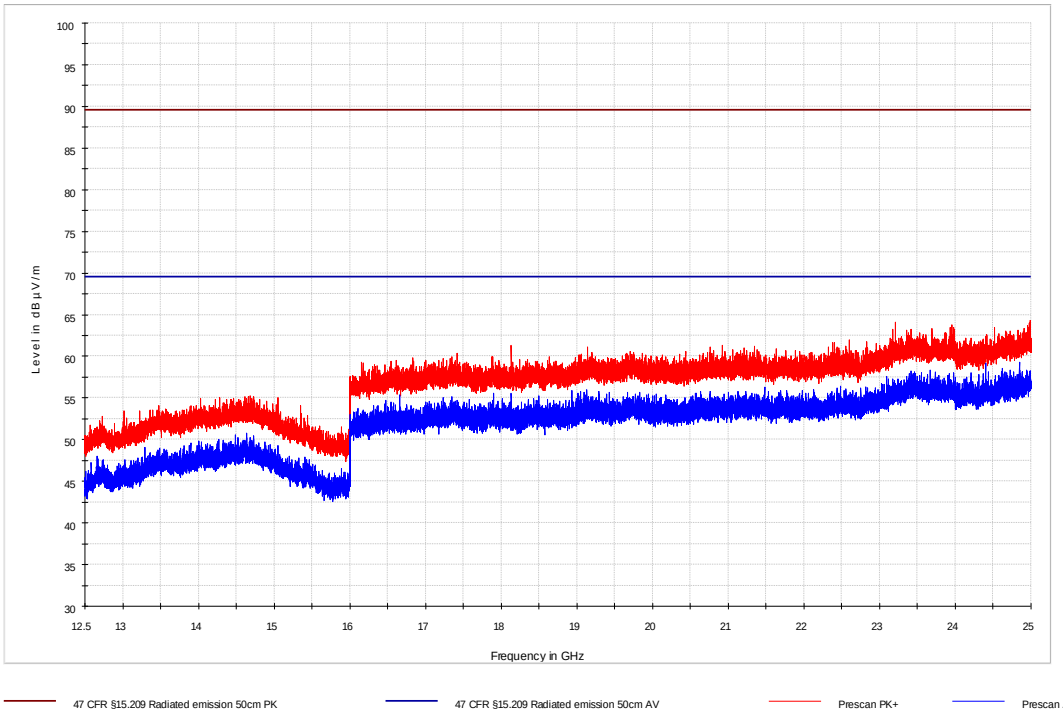

Figure 32: Chart of exploratory emissions test from 12.5 GHz to 25 GHz on channel 01 at 0.5 m

Frequency (MHz)	*EUT Pos.*	*Level (dBµV/m)*	*Detector*	*Limit (dBµV/m)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Height (cm)*	*Pol.*	*Azimuth (deg)*	*Corr. (dB/m)*
4804.034	2	51.81	PK	74.00	22.19	100.0	1000.000	100.0	H	178.0	-7.9
4804.034	2	45.89	AV	54.00	8.11	100.0	1000.000	100.0	H	178.0	-7.9
7206.018	2	55.89	PK	74.00	18.11	100.0	1000.000	280.0	V	189.0	-2.1
7206.018	2	47.01	AV	54.00	6.99	100.0	1000.000	280.0	V	189.0	-2.1

Table 21: Results of emissions test from 1 GHz to 25 GHz on channel 01 at 0.5 m

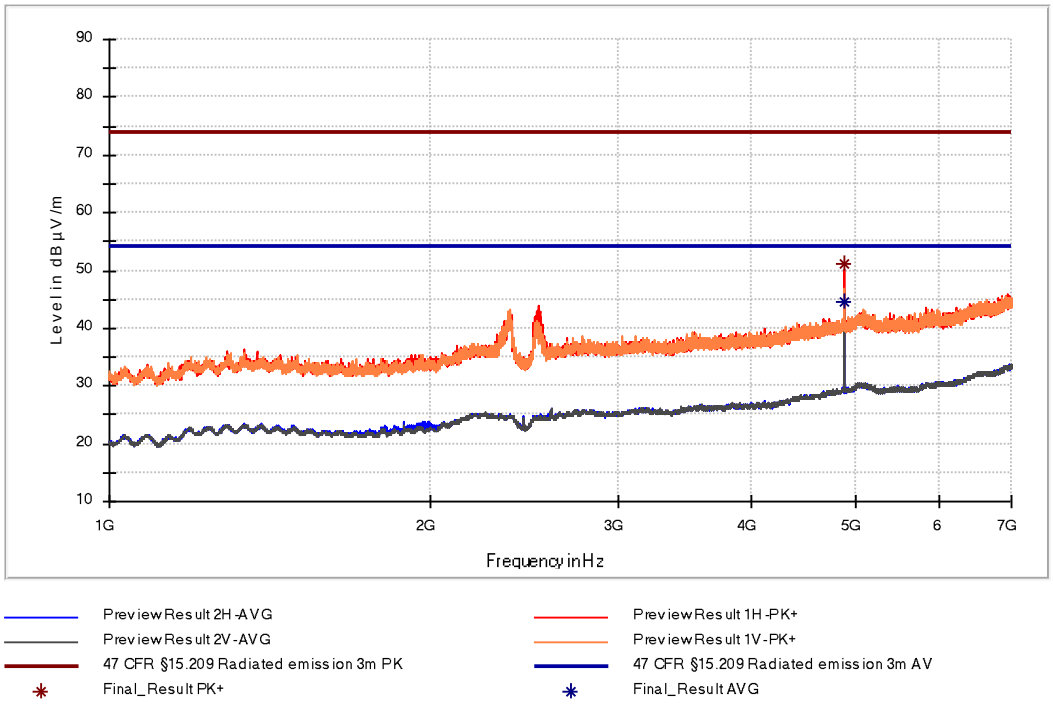

Figure 33: Chart of emissions test from 1 GHz to 7 GHz on channel 19 in position 2

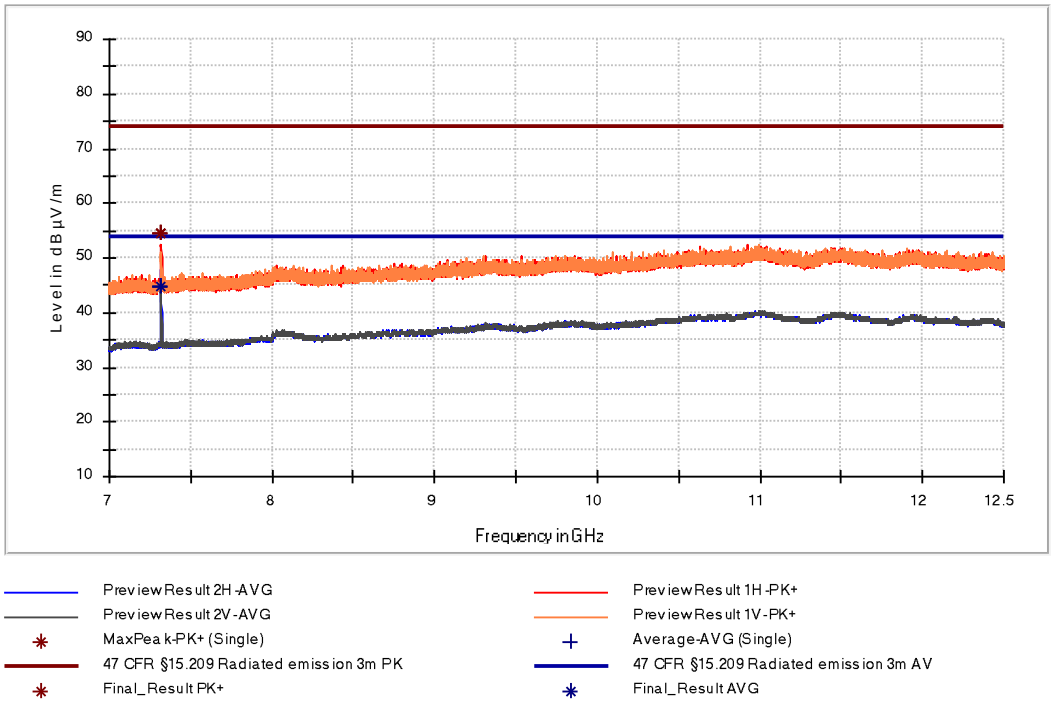

Figure 34: Chart of emissions test from 7 GHz to 12.5 GHz on channel 19 in position 2

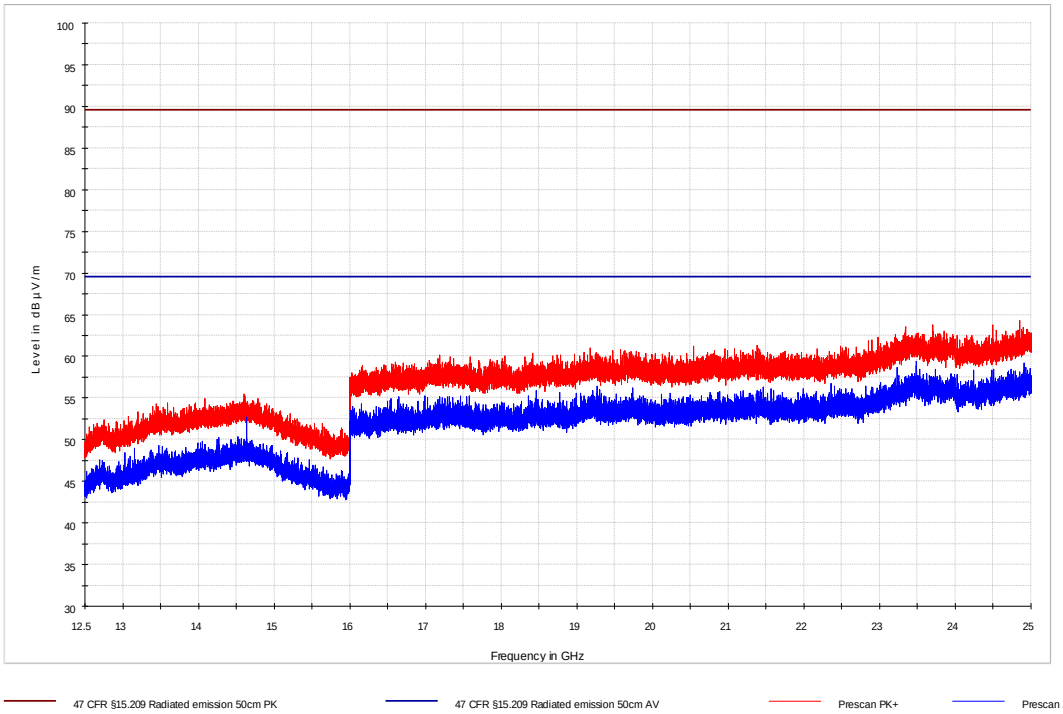

Figure 35: Chart of exploratory emissions test from 12.5 GHz to 25 GHz on channel 19 at 0.5 m

Frequency (MHz)	*EUT Pos.*	*Level (dBµV/m)*	*Detector*	*Limit (dBµV/m)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Height (cm)*	*Pol.*	*Azimuth (deg)*	*Corr. (dB/m)*
4880.000	2	51.13	PK	74.00	22.87	100.0	1000.000	272.0	H	9.0	-7.9
4880.000	2	44.67	AV	54.00	9.33	100.0	1000.000	272.0	H	9.0	-7.9
7320.000	2	54.53	PK	74.00	19.47	100.0	1000.000	262.0	H	233.0	-2.1
7320.000	2	44.79	AV	54.00	9.21	100.0	1000.000	262.0	H	233.0	-2.1

Table 22: Results of emissions test from 1 GHz to 25 GHz on channel 19 at 0.5 m

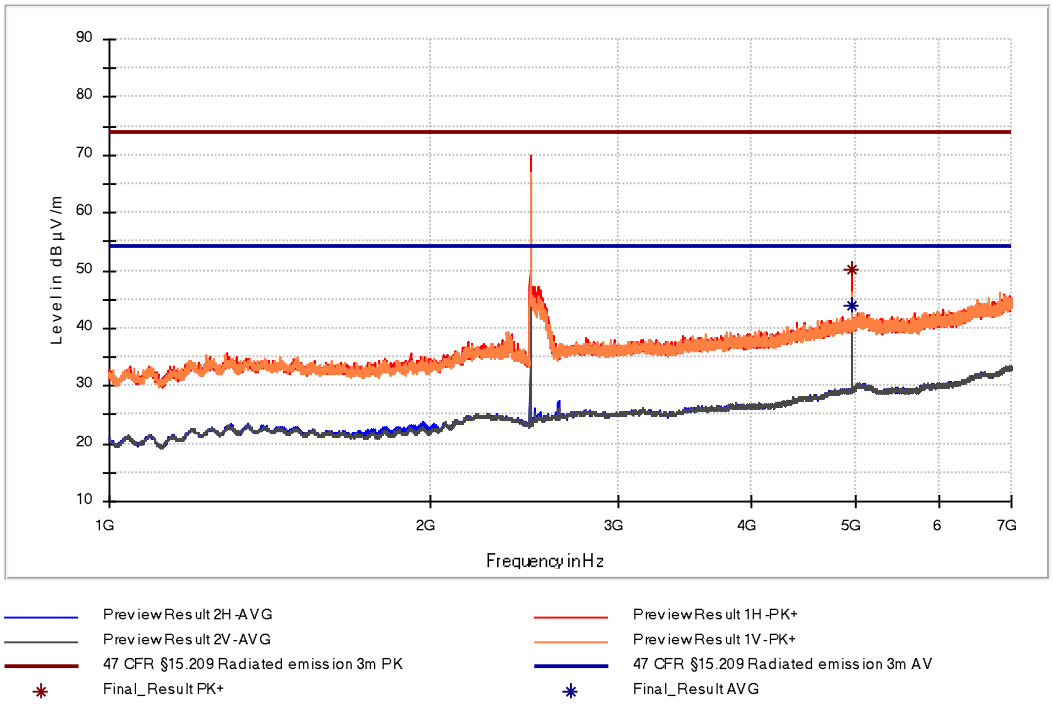

Figure 36: Chart of emissions test from 1 GHz to 7 GHz on channel 39 in position 2

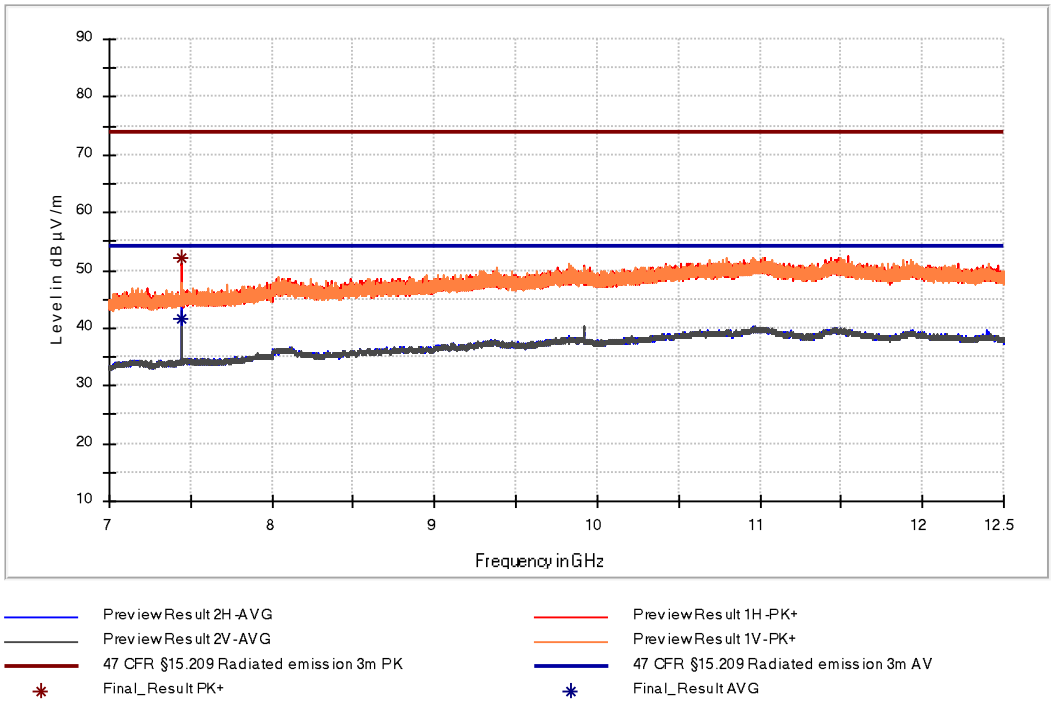

Figure 37: Chart of emissions test from 7 GHz to 12.5 GHz on channel 39 in position 2

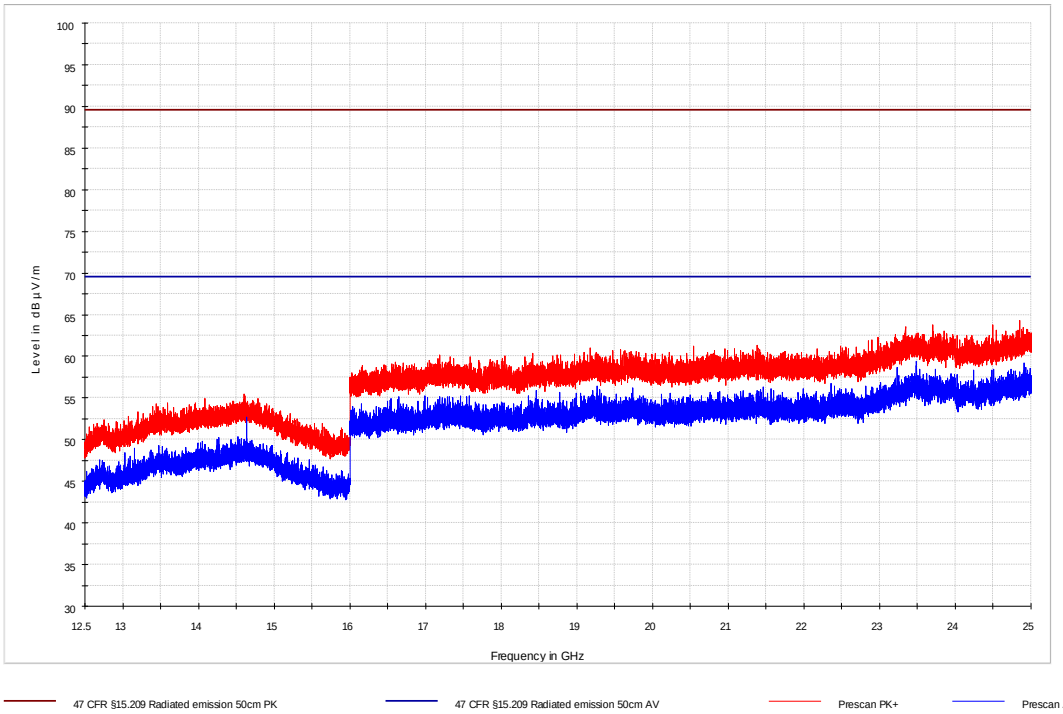

Figure 38: Chart of exploratory emissions test from 12.5 GHz to 25 GHz on channel 39 at 0.5 m

Frequency (MHz)	*EUT Pos.*	*Level (dBµV/m)*	*Detector*	*Limit (dBµV/m)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Height (cm)*	*Pol.*	*Azimuth (deg)*	*Corr. (dB/m)*
4960.036	2	50.31	PK	74.00	23.69	100.0	1000.000	100.0	H	182.0	-7.6
4960.036	2	43.90	AV	54.00	10.10	100.0	1000.000	100.0	H	182.0	-7.6
7440.061	2	52.03	PK	74.00	21.97	100.0	1000.000	102.0	H	189.0	-1.6
7440.061	2	41.63	AV	54.00	12.37	100.0	1000.000	102.0	H	189.0	-1.6

Table 23: Results of emissions test from 1 GHz to 25 GHz on channel 39 at 0.5 m

6.8 Radio frequency radiation exposure evaluation for mobile devices

Section(s) in 47 CFR Chapter I:	Requirement(s):	1.1310, 2.1093, 15.247(i)
	Reference(s):	KDB 447498 D01, section 7

Result:	☒ Test passed	☐ Test not passed

6.8.1 Data of equipment under test (EUT)

Antenna connector (see clause 3):	☐ permanent	☐ temporary	☒ none
Antenna detachable:	☐ yes	☒ no	
Tune-up function:	☐ yes	☒ no	

Maximum antenna gain (see clause 3):	logarithmic 0.0 dBi	numeric 1.0
Maximum conducted output power (see clause 6.4.4):	logarithmic 4.38 dBm	numeric 2.74 mW
Maximum equivalent isotropically radiated power:	logarithmic 4.38 dBm	numeric 2.74 mW
Maximum operation frequency (see clause 3):	2480.000 MHz	

6.8.2 Requirements

This estimation follows the general guidelines for RF Exposure according to KDB 447498.

As noted in §2.1091(b) a mobile device is defined as “a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a **separation distance of at least 20 centimeters** is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.”
According to §2.1091(c) the limits to be used for evaluation are defined in §1.1310.

As specified in §1.1310(d)(2) at operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE), derived from whole-body SAR limits and listed in Table 1 of §1.1310(e) may be used.

Table 24 below shows the limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3 - 3.0	614	1.63	*100	6
3.0 - 30	1842/f	4.89/f	*900/f2	6
30 - 300	61.4	0.163	1.0	6
300 - 1500			f/300	6
1500 - 100000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3 - 1.34	614	1.63	*100	30
1.34 - 30	824/f	2.19/f	$*180/f^2$	30
30 - 300	27.5	0.073	0.2	30
300 - 1500			f/1500	30
1500 - 100000			1.0	30

Table 24: Limits for maximum permissible exposure (MPE) according to table 1 of §1.1310(e)

Notes:
1. f = frequency in MHz.
2. * = Plane-wave equivalent power density.

6.8.3 Results

Separation distance: 20 cm

Worst case at channel 19 (2440 MHz):

EIRP = maximum peak conducted output power + gain = 4.38 dBm + 0 dBi = 4.38 dBm

Calculation according the worst case limit of §1.1310(e)

Channel frequency	P_{EIRP}	P	P	P_d	Limit P_d	Exposure ratio
(MHz)	(dBm)	(mW)	(W)	(mW/cm^2)	(mW/cm^2)	(%)
2440	4.38	2.742	0.002742	0.000545	1.00	0.054

6.8.4 Requirements for simultaneous transmission

There is only one integrated radio technology, therefore considerations about simultaneous transmissions are not applicable.

7 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2017-04	2018-04
EMI test receiver	ESU26	100026	W00002	2016-04	2018-06
EMI test receiver	ESR7	101059	E00739	2017-05	2018-05
Preamplifier (1 GHz - 18 GHz)	ALS05749	001	W01007	2018-01	2019-01
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
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
Notch filter	FSM-2450-85	E13646	W00092	N/A	
Highpass filter	WHKX10-5850-6500-18000-40SS	1	W00699	N/A	
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	2019-04
	LCF12-50J	---	E01215	2018-04	2019-04
	LMR400	1718020006	E00920	2018-01	2019-01
	RG214 Hiflex	171802007	E00921	2018-01	2019-01
Cable set anechoic chamber	262-0942-1500	005	E00435	2017-10	2018-10
	SF104EA/2x11PC35-42/5m	11144/4EA	E00307	2017-12	2018-12
	262-0942-1500	003	E00433	2017-10	2018-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2017-12	2018-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01033	2017-12	2018-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2017-09	2018-09

Note 1: Industry Canada (test sites number 3472A-1 and 3472A-2): 2018-11
Note 2: Expiration date of test firm accreditation for SAC:
FCC test firm type “accredited”: 2019-05

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	2018-05-15	Jennifer Ebner	First edition