

# Test report

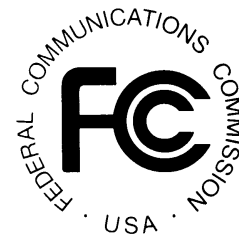
**Customer:**

CHIPOLO d.o.o.

Cesta 1.maja 83  
1430 Hrastnik  
Slovenia

## RF test report

160817-AU01+W02



Industry  
Canada Industrie  
Canada

**CHIPOLO d.o.o.**

**Bluetooth enabled item finder**

CPM6



The test result refers exclusively to the model tested.

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## Accreditation:



FCC facility registration number: 221458  
Test Firm Type "2.948 listed": Valid until 2017-04-22  
Test Firm Type "accredited": Valid until 2017-06-09  
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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# 1 Summary of test results

System type: Digital transmission system (DTS)

47 CFR part and section <sup>1</sup>	Test	Equivalent to IC radio standard(s)	Page	Result	Note(s)
15.207	AC power line conducted emissions 150 kHz to 30 MHz	RSS-Gen Issue 4, section 8.8	---	Not applicable	1
15.247(a)(1) KDB 558074, section 8	20 dB bandwidth	RSS-247 Issue 2, section 5.1(b)	20	Passed	---
15.247(a)(2) KDB 558074, section 8	6 dB bandwidth	RSS-247 Issue 2, section 5.2(a)	25	Passed	2
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	RSS-Gen Issue 4, section 6.6	30	For reference only	2
15.247(b) KDB 558074, section 9	Maximum conducted output power	RSS-Gen Issue 4, section 6.12 RSS-247 Issue 2, section 5.4	35	Passed	---
15.247(e) KDB 558074, section 10	Power spectral density	RSS-247 Issue 2, section 5.2(b)	40	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Antenna-port conducted measurements	RSS-247 Issue 2, section 5.5	---	Not applicable	3
15.247(d) KDB 558074, section 13	Band-edge compliance (radiated)	RSS-247 Issue 2, section 5.5	46	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Spurious radiated emissions 9 kHz to 10 <sup>th</sup> harmonic	RSS-Gen Issue 4, section 6.13 RSS-247 Issue 2, section 5.5	51	Passed	---
2.1093	RF radiation exposure evaluation for portable devices	RSS-Gen Issue 4, section 3.2 (exempted form SAR and RF evaluation)	70	Passed	---

**Notes:**

- 1 EUT is battery powered.
- 2 For systems using digital modulation techniques the 6 dB bandwidth (DTS bandwidth) is regarded as the occupied bandwidth.
- 3 Spurious radiated emissions 9 kHz to 10<sup>th</sup> harmonic performed.



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Straubing, April 3, 2017



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## 2 Referenced publications

<i>Publication</i>	<i>Title</i>
CFR 47 Part 2 October 2016	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 2016	Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
KDB Publication no. 447498 October 23, 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
KDB Publication no. 558074 April 8, 2016	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C63.10 June 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 4 November 2014	Spectrum Management and Telecommunications - Radio Standards Specification - General Requirements for Compliance of Radio Apparatus
RSS-102, Issue 5 March 2015	Spectrum Management and Telecommunications - Radio Standards Specification - Radio Frequency Exposure Compliance of Radiocommunications Apparatus
RSS-247, Issue 2 February 2017	Spectrum Management and Telecommunications Radio Standards Specification Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices



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### 3 Equipment under test (EUT)

Product type: Bluetooth enabled item finder

Model name: CPM6

Serial number(s): #1 (without housing, with artificial antenna connector)  
#2 (with housing, no artificial antenna connector)

Manufacturer: CHIPOLO d.o.o.

Version: Hardware: ---  
Software: ---

Additional modifications: None

FCC ID: 2AD85-CPM6

Application frequency band: 2400.00 MHz to 2483.50 MHz

Frequency range: 2402.00 MHz to 2480.00 MHz

Operating frequencies: 2402.00 MHz to 2480.00 MHz

Channel spacing: 2 MHz

Number of RF channels: 40

System type: Digital transmission system (DTS)

Modulation type(s): GFSK

Class of emission: F1D

Antenna type(s): PCB antenna

Antenna gain(s): approximately 0 dBi

Power supply: Battery supply  
Nominal voltage: 3.0 V  
Minimum voltage: 2.7 V  
Maximum voltage: 3.2 V  
Nominal frequency: ---

Temperature range: from -20 °C to +70°C

Device type:  Portable  Mobile  Fixed



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## 4 Test configuration and mode of operation

### 4.1 Test configuration

<i>Device</i>	<i>Type designation</i>	<i>Serial or inventory no.</i>	<i>Manufacturer</i>
Bluetooth enabled item finder	CPM6	#1	CHIPOLO d.o.o.
Bluetooth enabled item finder	CPM6	#2	CHIPOLO d.o.o.
Notebook	Lifebook A531	E00521	Fujitsu Siemens

Table 1: Devices used for testing

<i>Port</i>	<i>Classification</i>	<i>Cable type</i>	<i>Cable length</i>	
			<i>used</i>	<i>maximum<sup>1</sup></i>
USB (only for configuration of EUT)	signal/control	Shielded	1.0 m	----

Table 2: Ports of EUT and appropriate cables

### 4.2 Attenuation of test cable(s)

<i>Frequency (MHz)</i>	<i>Attenuation (dB).</i>
2402.0	3.31
2440.0	3.35
2480.0	3.30

Table 3: Attenuation of artificial antenna cable

### 4.3 Mode of operation

EUT was tested in following mode(s) of operation:

- Tx-mode, unmodulated
- Tx-mode, modulated -> PRBS9, data length 16
- Channels: 1 ( 2402 MHz )  
20 ( 2440 MHz )  
40 ( 2480 MHz )

Applied Software: DirectTestModes (Nordic)

<sup>1</sup> As specified by applicant



## 5 Measurement Procedures

### 5.1 20 dB bandwidth (DTS)

The 20 dB bandwidth test method for DTS systems shall be analog to the 6 dB bandwidth test method for DTS systems.

For test setup see clause 5.8.

### 5.2 6 dB bandwidth (DTS)

The 6 dB bandwidth (DTS bandwidth) test method for DTS systems refers to section 8.0 of KDB 558074 D01 and shall be as follows.

Spectrum analyzer settings:

Span = centered on a channel, wide enough to capture the whole channel

RBW = 100 kHz

VBW  $\geq 3 \times$  RBW

Sweep time = auto coupled

Detector function = peak

Trace mode = max hold

Reference level: more than  $10\log(\text{OBW}/\text{RBW})$  dB above peak of spectral envelope

Measure 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 possible, use the automatic bandwidth measurement capability of the spectrum analyzer using the X dB bandwidth mode with X set to 6 dB. Submit this plot(s).

For test setup see clause 5.8.



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### 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  $\geq$  in the range of 1% to 5% of the OBW

VBW  $\geq$  approximately three times the RBW

Sweep time = auto coupled

Detector function = peak

Trace mode = max hold

Reference level: more than  $10\log(\text{OBW}/\text{RBW})$  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 5.8.

### 5.4 Maximum conducted output power (DTS)

The maximum conducted output power test method for DTS systems refers to section 9.1.1 of KDB 558074 D01 and shall be as follows.

Spectrum analyzer settings:

Span  $\geq 3 \times$  RBW, centered on a channel

RBW  $\geq$  DTS bandwidth

VBW  $\geq 3 \times$  RBW

Sweep time = auto coupled

Detector function = peak

Trace mode = max hold

Reference level: more than  $10\log(\text{OBW}/\text{RBW})$  dB above peak of spectral envelope

Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the maximum conducted output power. Submit this plot(s).

For test setup see clause 5.8.



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## 5.5 Power spectral density

The power spectral density test method refers to section 10.2 of KDB 558074 D01 and shall be as follows.

Spectrum analyzer settings:

Span = 1.5 times the DTS bandwidth, centered on a channel

RBW:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$

VBW  $\geq 3 \times \text{RBW}$

Sweep time = auto coupled or  $\geq \text{span}/\text{RBW}$  in seconds, whichever is greater

Detector function = peak

Trace mode = max hold

Reference level: more than  $10\log(\text{OBW}/\text{RBW})$  dB above peak of spectral envelope

Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the power spectral density. Submit this plot(s).

For test setup see clause 5.8.

## 5.6 Band-edge compliance (radiated)

For test setup and test method see clause 5.9.

## 5.7 Spurious radiated emissions 9 kHz to 10<sup>th</sup> harmonic

For test setup and test method see clause 5.9.



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## 5.8 Conducted emissions at antenna connector

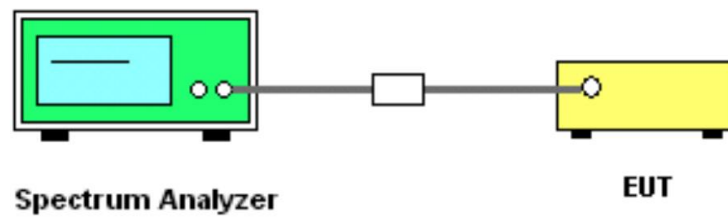


Figure 1: Setup for conducted emission test at antenna connector

The RF signal of the EUT is measured at the antenna connector. In case of no permanent antenna connector, a temporary antenna connector is supplied by the manufacturer. The specific insertion loss of the signal path, which is matched to 50 Ohm, is evaluated within a calibration. 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.

## 5.9 Radiated emissions

### 5.9.1 Radiated emissions below 30 MHz

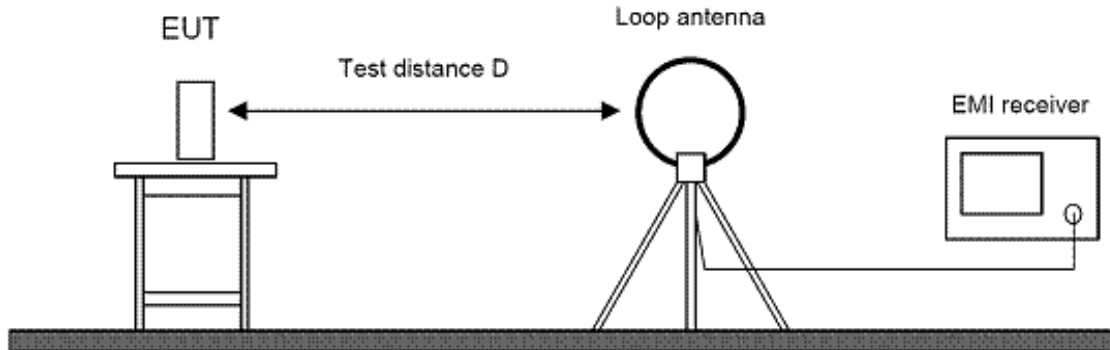


Figure 2: Setup for radiated emission test below 30 MHz

The test method for radiated emissions below 30 MHz refers to section 6.4 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The loop antenna is set in parallel with the antenna of the EUT.
4. The EMI receiver performs a scan from 9 kHz to 30 MHz with peak detector and measurement bandwidth set to 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above.
5. The turn table is rotated to 8 different positions ( $360^\circ / 8$ ).
6. The antenna is set in line with the antenna of the EUT and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS with 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz, where average detector applies.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The highest value for each frequency is recorded.

## 5.9.2 Radiated emissions from 30 MHz to 1 GHz

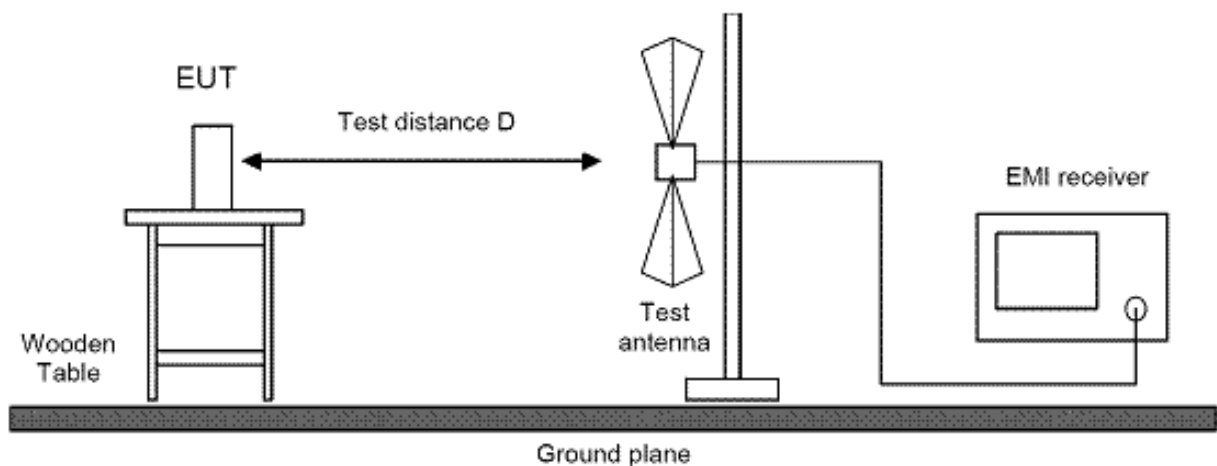


Figure 3: Setup for radiated emission test from 30 MHz to 1 GHz

The test method for radiated emissions from 30 MHz to 1 GHz refers to section 6.5 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The broadband antenna is set to vertical polarization.
4. The EMI receiver performs a scan from 30 MHz to 1000 MHz with peak detector and measurement bandwidth set to 120 kHz.
5. The turn table is rotated to 6 different positions ( $360^\circ / 6$ ).
6. The antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS at 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The height of the broadband receiving antenna is varied between 1 meter and 4 meters above ground to find the maximum emission field strength of both horizontal and vertical polarization.
10. The highest value for each frequency is recorded.



### 5.9.3 Radiated emissions from above 1 GHz

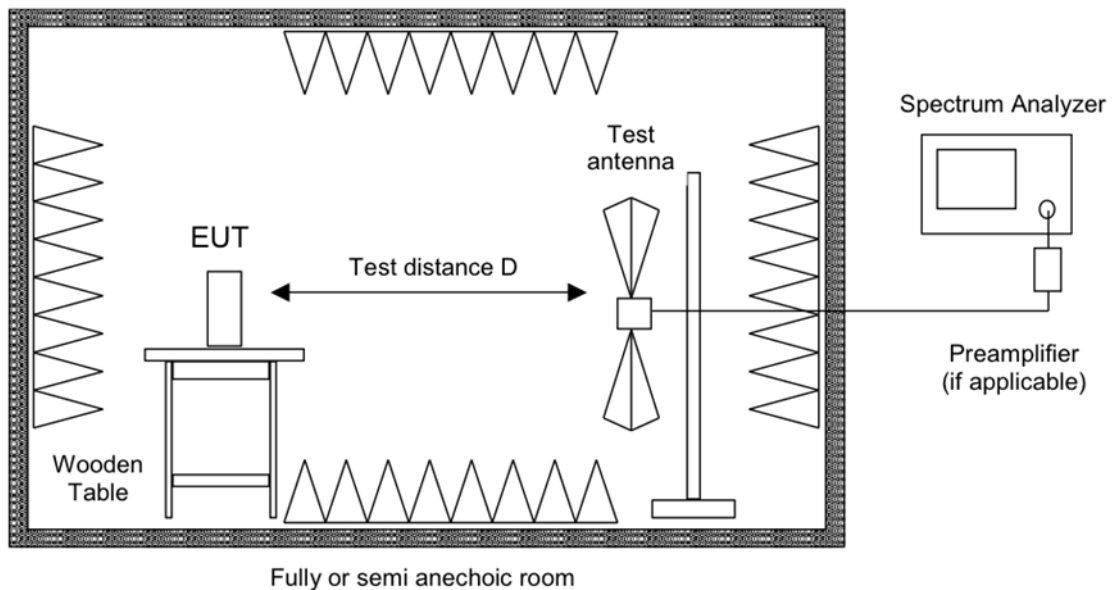


Figure 4: Setup for radiated emission test above 1 GHz

The test method for radiated emissions above 1 GHz refers to section 6.6 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 1.5 meter above ground. The test setup is placed inside a semi-anechoic chamber with RF absorbers on the floor.
2. EUT and all peripherals are powered on.
3. To identify the critical frequencies, extrapolatory radiated emission tests are performed at a closer distance than 3 meters (e.g. 1 meter). The critical frequencies found are noted.
4. For pre-scan the receiving antenna is located 3 meters from the EUT.
5. The broadband horn antenna is set to vertical polarization.
6. The EMI receiver performs a scan from 1 GHz to the 10<sup>th</sup> harmonic of the fundamental frequency with peak and average detector activated simultaneously and measurement bandwidth set to 1 MHz. The trace data is recorded using the max hold function.
7. The turntable is rotated in steps of 15°.
8. After a full turn by 360° the antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
9. After the scan all peak values over the limit or with less margin than 10 dB are marked. If critical frequencies recorded during extrapolatory radiated emission tests are not contained, they are added to this list.
10. Emission levels at listed frequencies are maximized by moving the turntable and varying the antenna height until maximum of emission is found.
11. The turntable is rotated by 360 degrees to determine the position of the highest radiation.

12. The height of the broadband receiving antenna is varied between 1 meter and the upper height above ground to find the maximum emission field strength of both horizontal and vertical polarization. For equipment that is tested in multiple orientations, the upper height is limited to 2.5 meters or 0.5 meters above the top of the EUT, whichever is higher. For all other equipment the upper height is 4 meters.
13. The highest value for each frequency is recorded.



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## 6 Test results

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



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## 6.1 20 dB bandwidth

47 CFR part and section: 15.247 (a)(1)  
Equivalent to IC radio standard(s) RSS-247 Issue 2, section 5.1(b)  
Measurement procedure (DTS): See 5.1

---

Performed by: Martin Müller Date of test: January 25, 2017

---

Result  Test passed  Test not passed

---

### 6.1.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Laboratory environment	---	---	---
<input type="checkbox"/> EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002



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## 6.1.2 Limits for digital transmission systems

None -> results recorded for information only.



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### 6.1.3 Test results

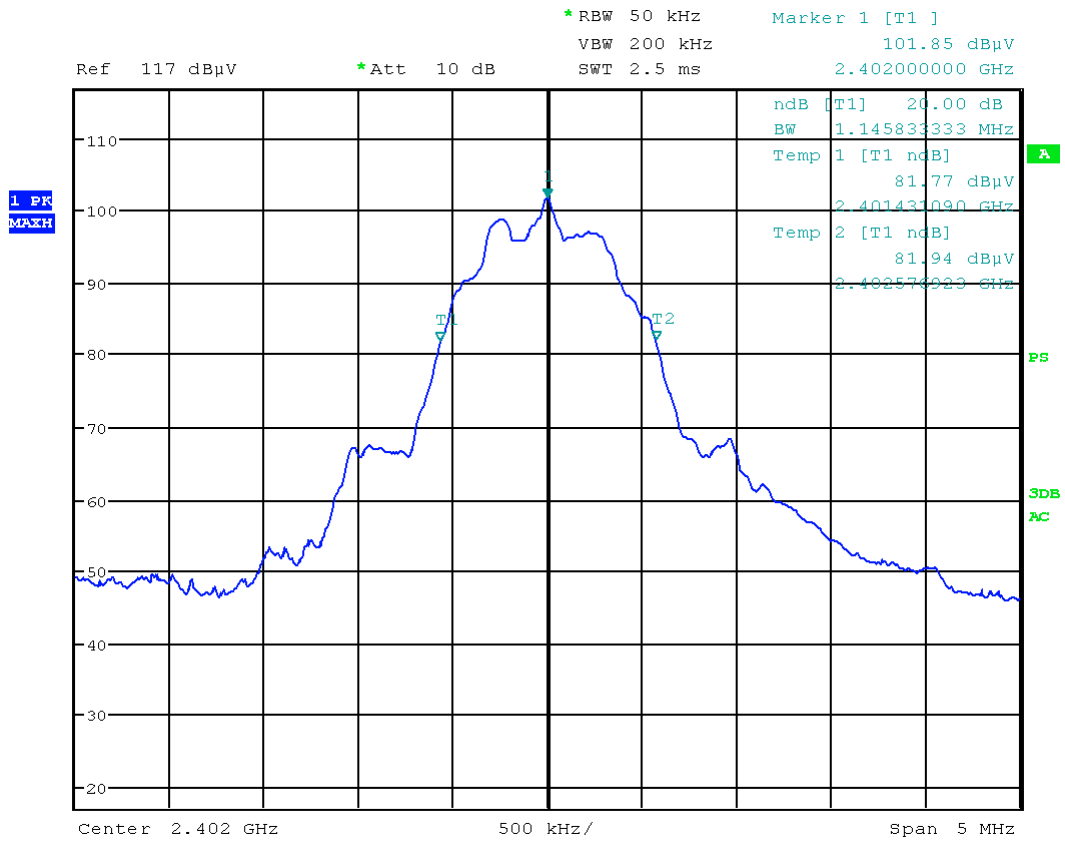


Figure 5: Chart of 20 dB bandwidth test, channel low



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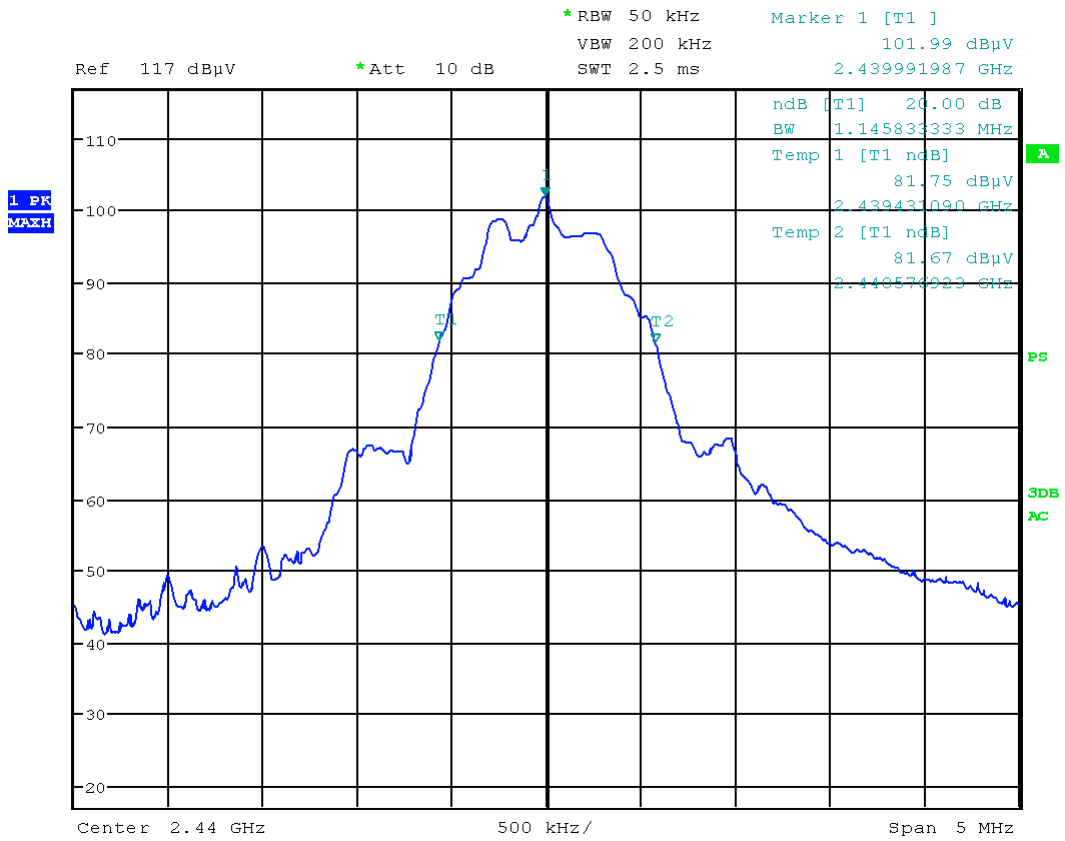


Figure 6: Chart of 20 dB bandwidth test, channel mid



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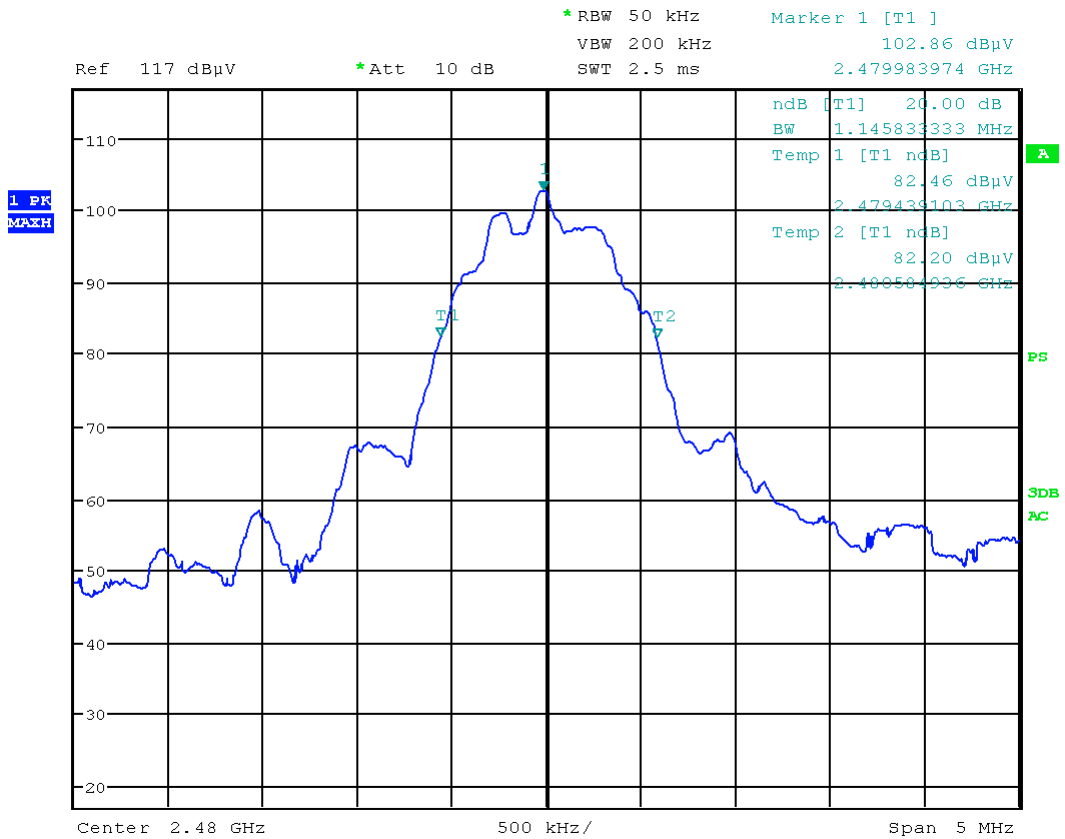


Figure 7: Chart of 20 dB bandwidth test, channel high

f [MHz]	20dB-BW [MHz]	f <sub>lower</sub> [MHz]	f <sub>upper</sub> [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2402.000	1.146	2401.431	2402.577	2400.0	2483.5	within band
2439.992	1.146	2439.431	2440.577	2400.0	2483.5	within band
2479.984	1.146	2479.439	2480.585	2400.0	2483.5	within band

Table 4: Final results of 20 dB bandwidth test



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## 6.2 6 dB bandwidth

47 CFR part and section: 15.247 (a)(2)  
Equivalent to IC radio standard(s) RSS-247 Issue 2, section 5.2(a)  
Measurement procedure (DTS): See 5.2

---

Performed by: Martin Müller Date of test: January 25, 2017

---

Result  Test passed  Test not passed

---

### 6.2.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Laboratory environment	---	---	---
<input type="checkbox"/> EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002



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## 6.2.2 Limits for digital transmission systems

The minimum 6 dB bandwidth shall be at least 500 kHz.

In addition the 6 dB bandwidth must be contained within the designated frequency band.



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## 6.2.3 Test results

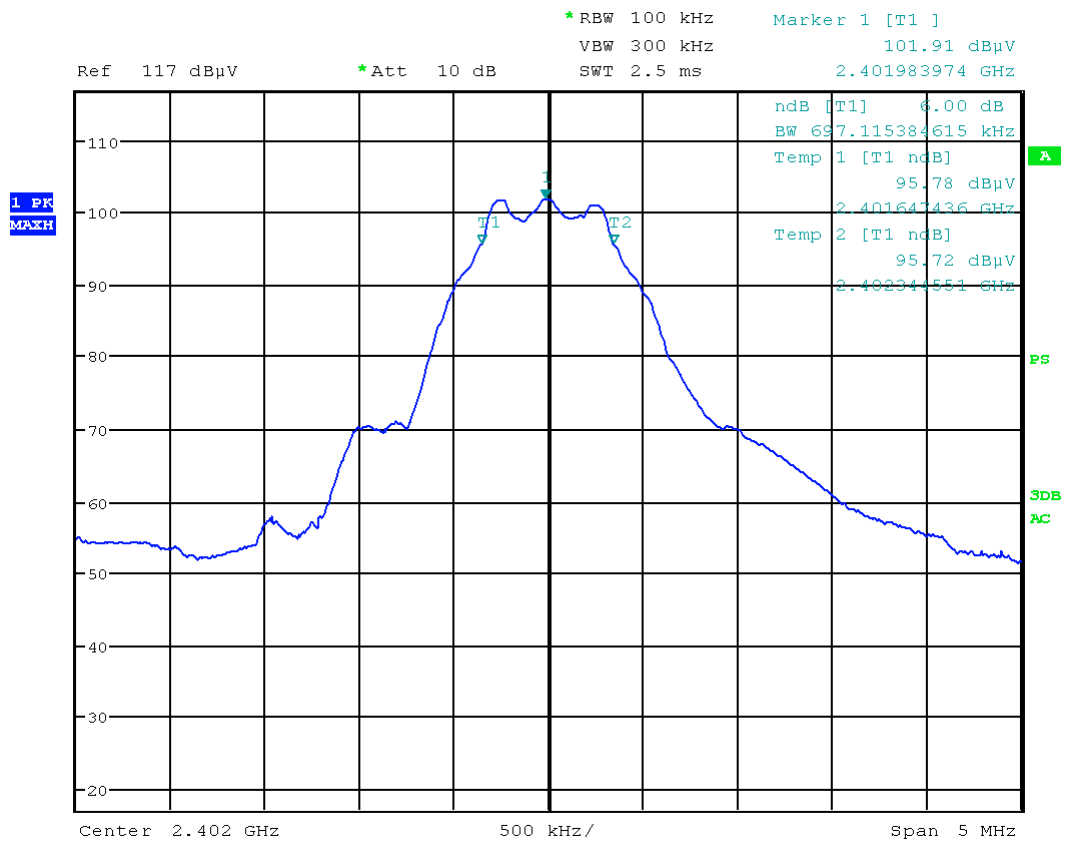


Figure 8: Chart of 6 dB bandwidth test, channel low

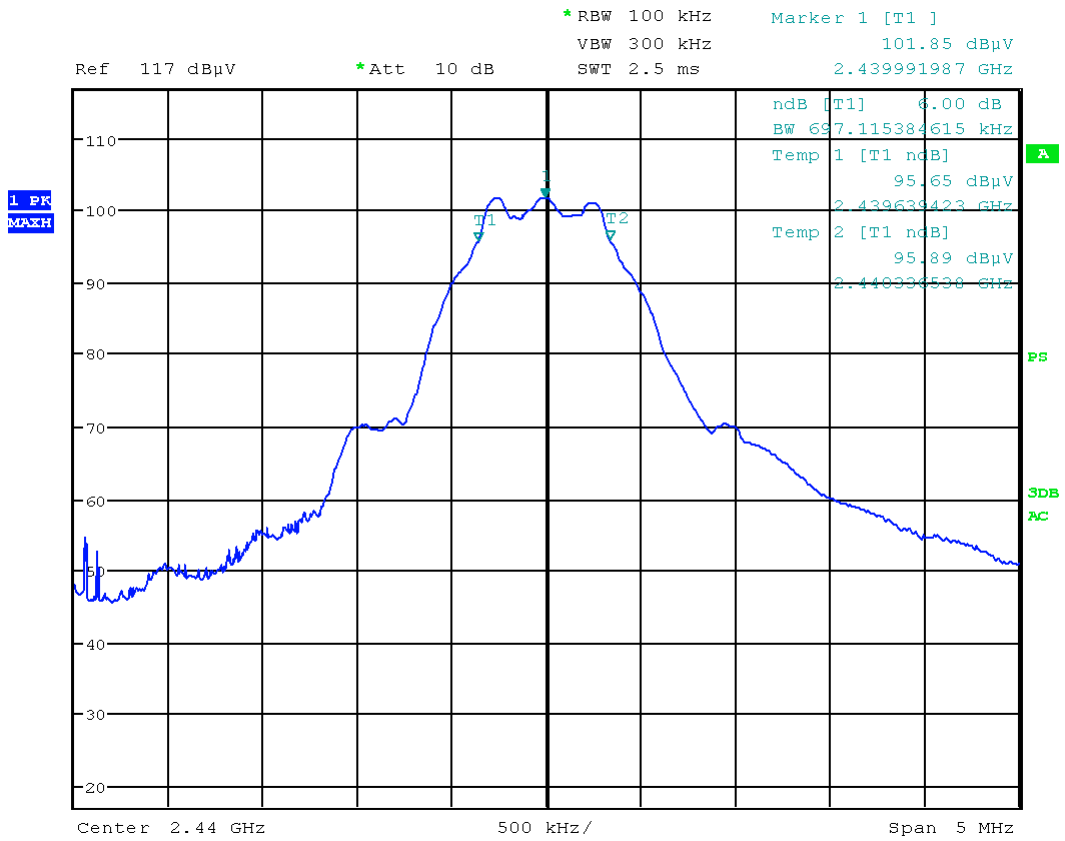


Figure 9: Chart of 6 dB bandwidth test, channel mid



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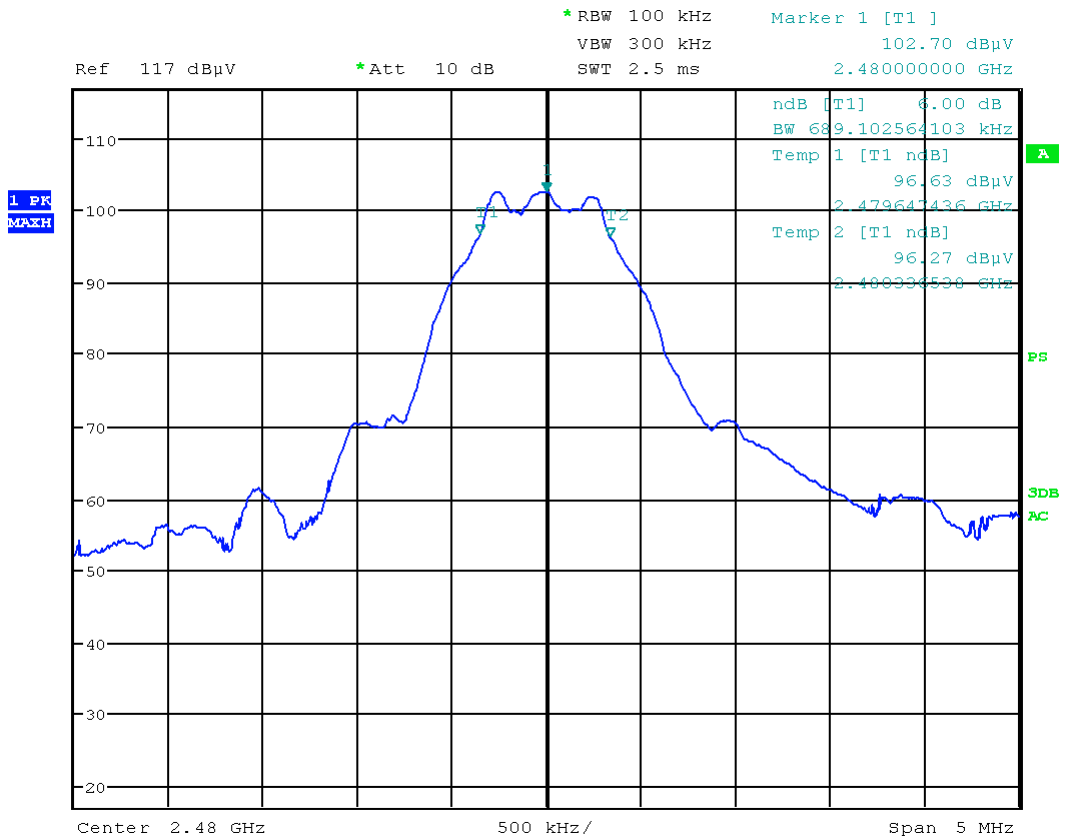


Figure 10: Chart of 6 dB bandwidth test, channel high

f [MHz]	6dB-BW [MHz]	f <sub>lower</sub> [MHz]	f <sub>upper</sub> [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2401.984	0.698	2401.647	2402.345	2400.0	2483.5	Pass
2439.992	0.698	2439.639	2440.337	2400.0	2483.5	Pass
2480.000	0.689	2479.648	2480.337	2400.0	2483.5	Pass

Table 5: Final results of 6 dB bandwidth test



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## 6.3 Occupied bandwidth

47 CFR part and section: 2.202 (a)  
Equivalent to IC radio standard(s) RSS-Gen Issue 4, section 6.6  
Measurement procedure: See 5.3

---

Performed by: Martin Müller Date of test: January 25, 2017

---

Result  Test passed  Test not passed

---

### 6.3.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Laboratory environment	---	---	---
<input type="checkbox"/> EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002



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### 6.3.2 Limits

None -> results recorded for setting the proper reference level.



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### 6.3.3 Test results

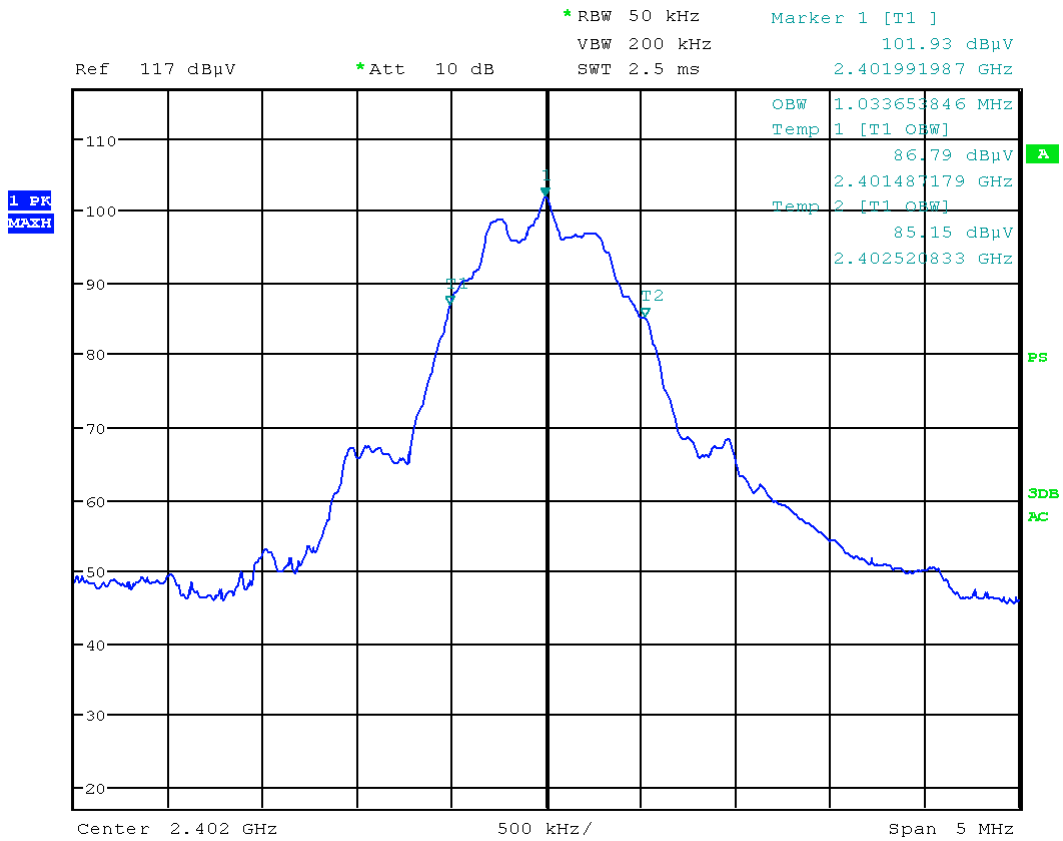


Figure 11: Chart of occupied bandwidth test, channel low



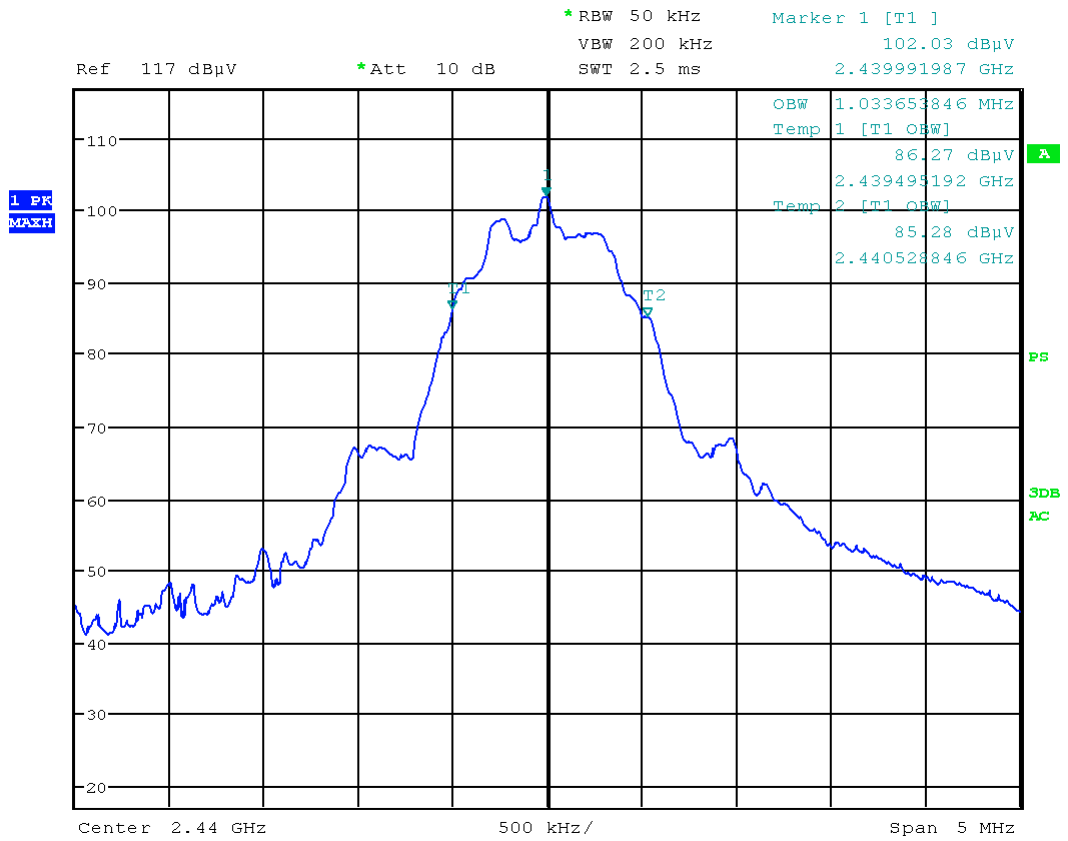


Figure 12: Chart of occupied bandwidth test, channel mid



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Figure 13: Chart of occupied bandwidth test, channel high

f [MHz]	Occ. BW [MHz]	f <sub>lower</sub> [MHz]	f <sub>upper</sub> [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2401.992	1.034	2401.487	2402.521	2400.0	2483.5	within band
2439.992	1.034	2439.495	2440.529	2400.0	2483.5	within band
2479.984	1.018	2479.495	2480.513	2400.0	2483.5	within band

Table 6: Final results of occupied bandwidth test



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## 6.4 Maximum conducted output power

47 CFR part and section: 15.247 (b)  
Equivalent to IC radio standard(s) RSS-Gen Issue 4, section 6.12  
RSS-247 Issue 2, section 5.4  
Measurement procedure (DTS): See 5.4

---

Performed by: Martin Müller Date of test: January 25, 2017

---

Result  Test passed  Test not passed

---

### 6.4.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Laboratory environment	---	---	---
<input type="checkbox"/> EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002



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## 6.4.2 Limits for digital transmission systems

1 watt (30 dBm).



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### 6.4.3 Test results

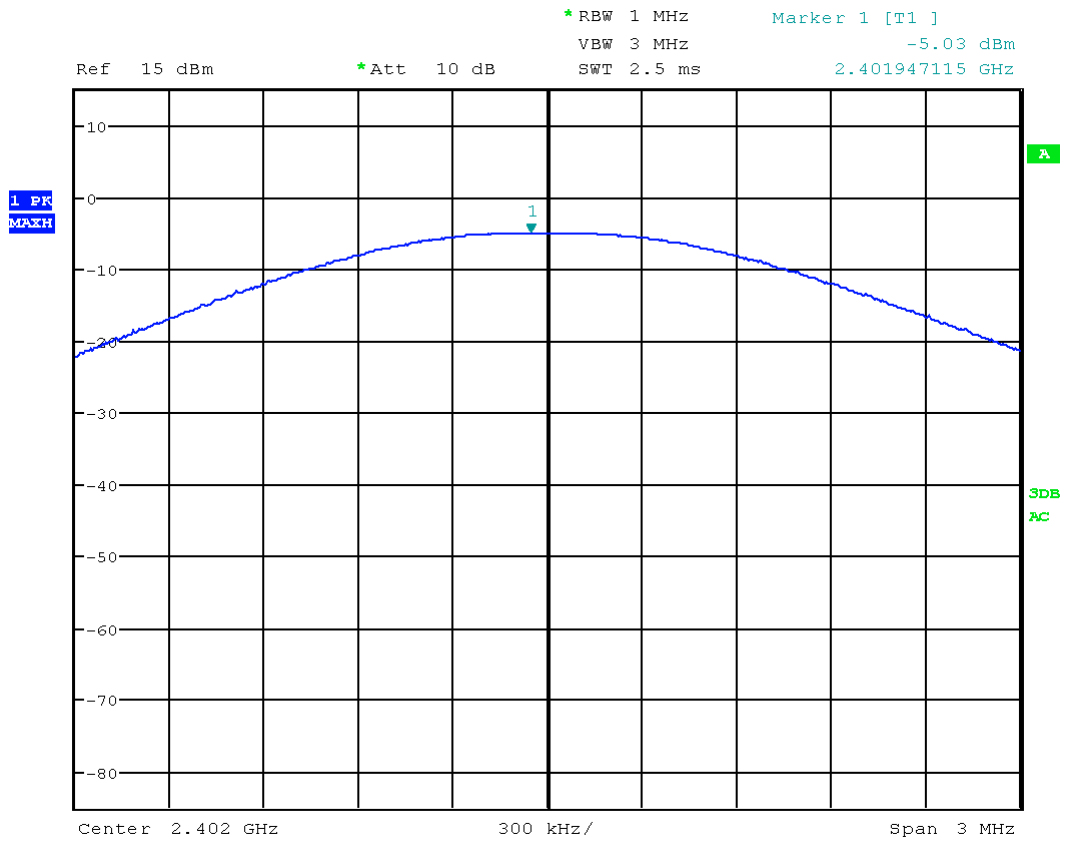


Figure 14: Chart of maximum conducted output power test, channel low

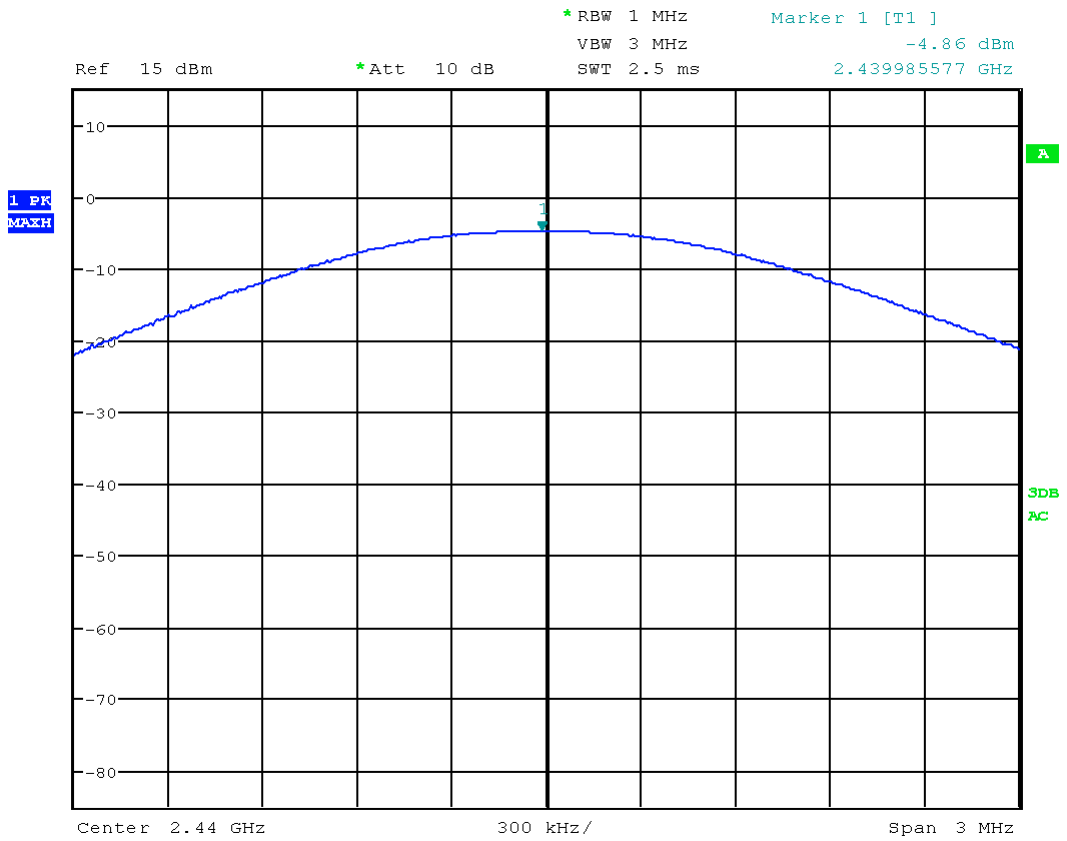


Figure 15: Chart of maximum conducted output power test, channel mid



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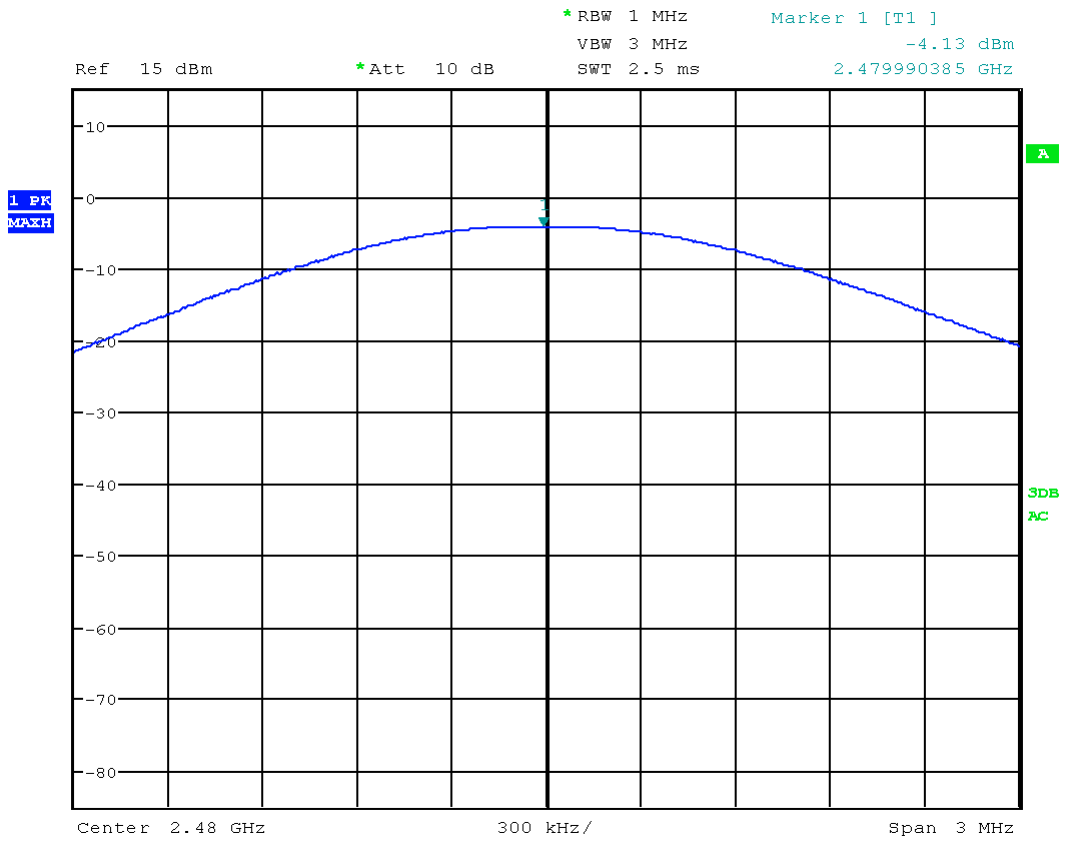


Figure 16: Chart of maximum conducted output power test, channel high

f [MHz]	P <sub>meas</sub> [dBm]	a <sub>testcable</sub> [dB]	Maximum conducted output power [dBm]	Limit [dBm]	Result
2401.947	-5.03	3.31	-1.72	30.0	Pass
2439.986	-4.86	3.35	-1.51	30.0	Pass
2479.990	-4.13	3.30	-0.83	30.0	Pass

Table 7: Final results of maximum conducted output power test



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## 6.5 Power spectral density

47 CFR part and section: 15.247 (e)  
Equivalent to IC radio standard(s) RSS-247 Issue 2, section 5.2(b)  
Measurement procedure: See 5.5

---

Performed by: Martin Müller Date of test: January 25, 2017

---

Result  Test passed  Test not passed

---

### 6.5.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Laboratory environment	---	---	---
<input type="checkbox"/> EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002



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## 6.5.2 Limits

For digitally modulated systems, 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.



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## 6.5.3 Test results

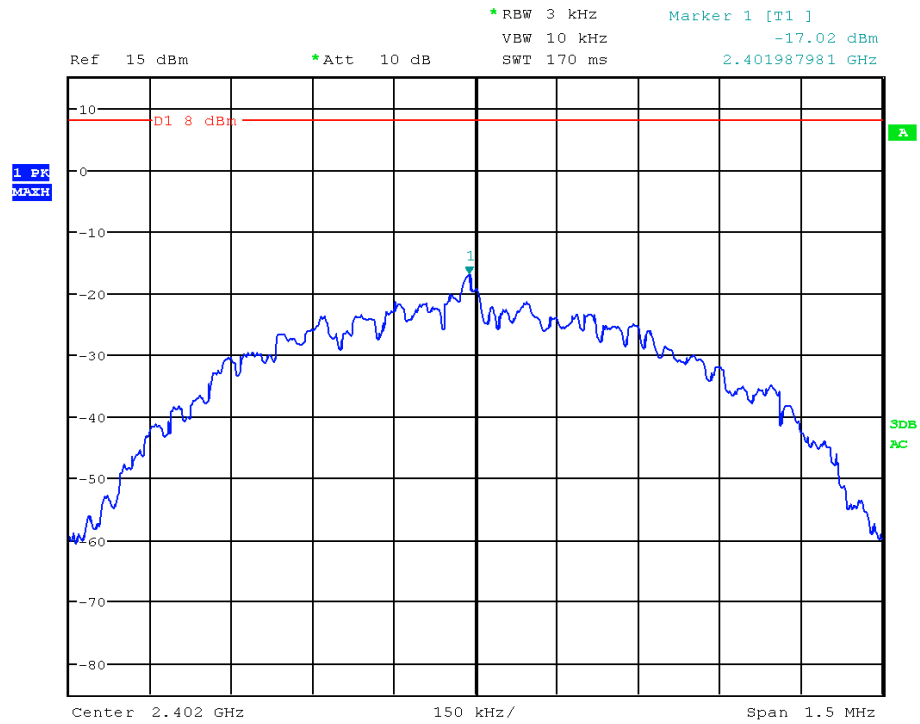


Figure 17: Chart of power spectral density test, channel low - complete carrier

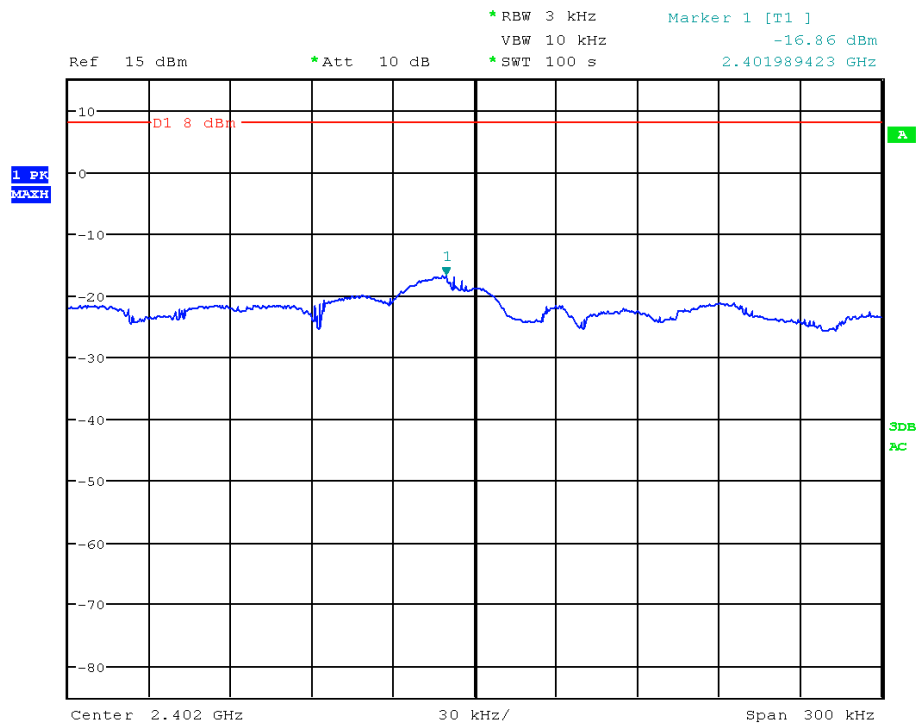


Figure 18: Chart of power spectral density test, channel low - zoom to maximum

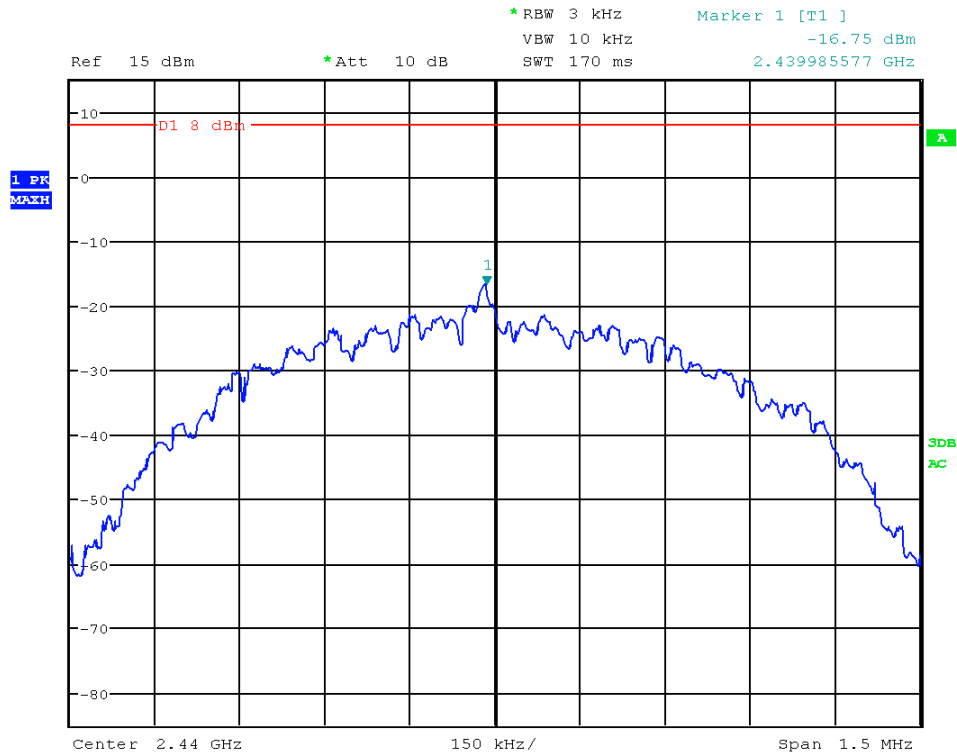


Figure 19: Chart of power spectral density test, channel mid - complete carrier

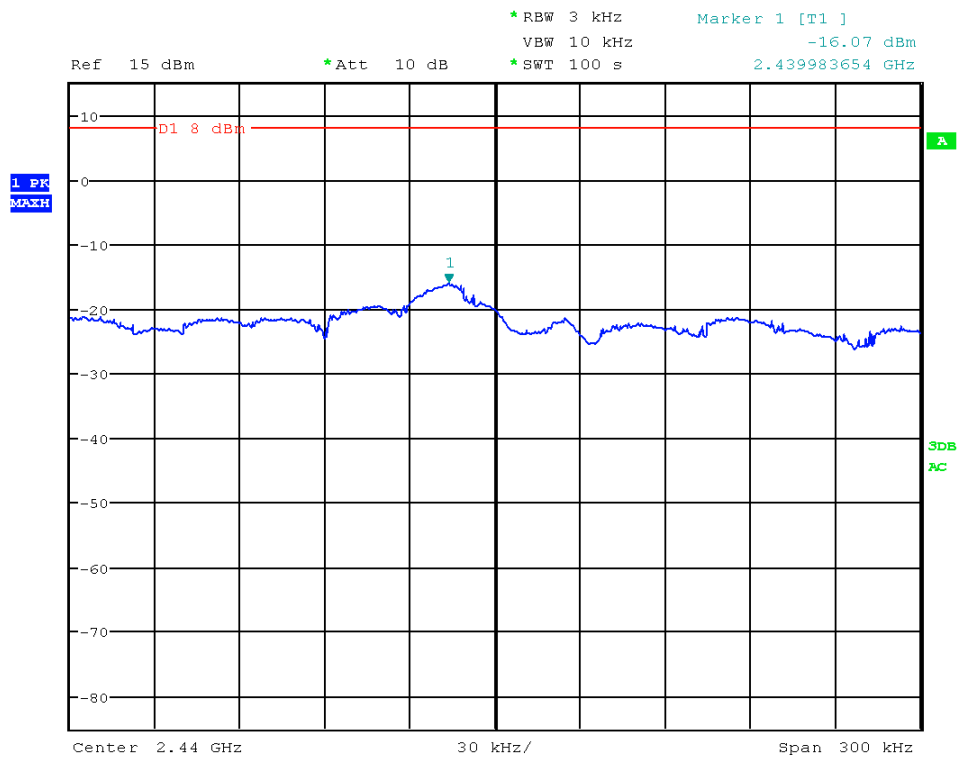


Figure 20: Chart of power spectral density test, channel mid - zoom to maximum



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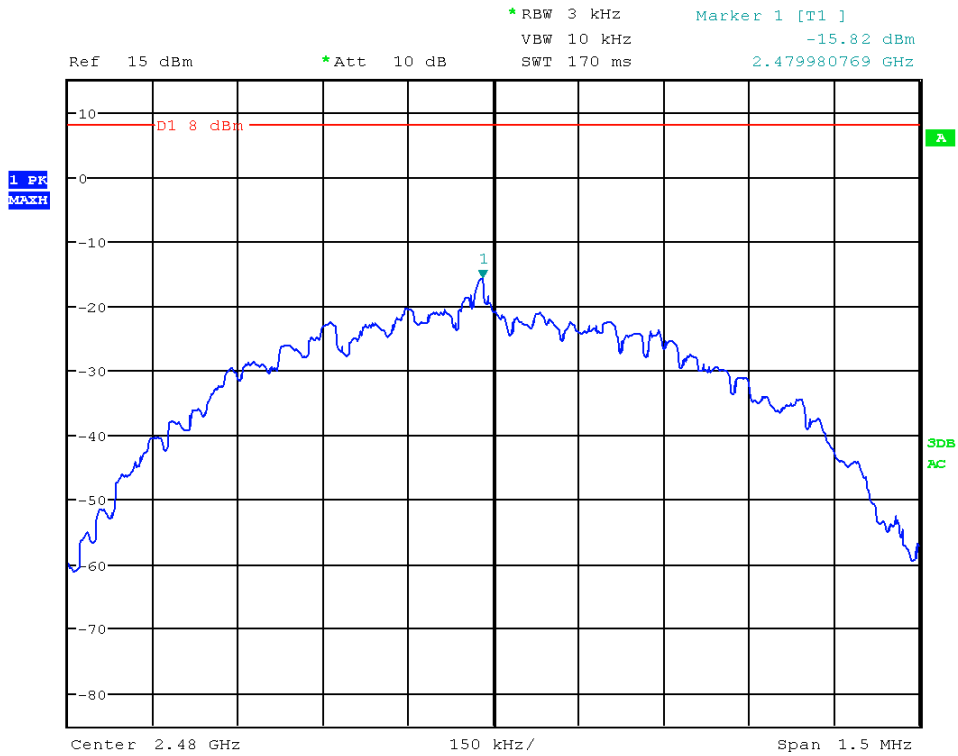


Figure 21: Chart of power spectral density test, channel high - complete carrier

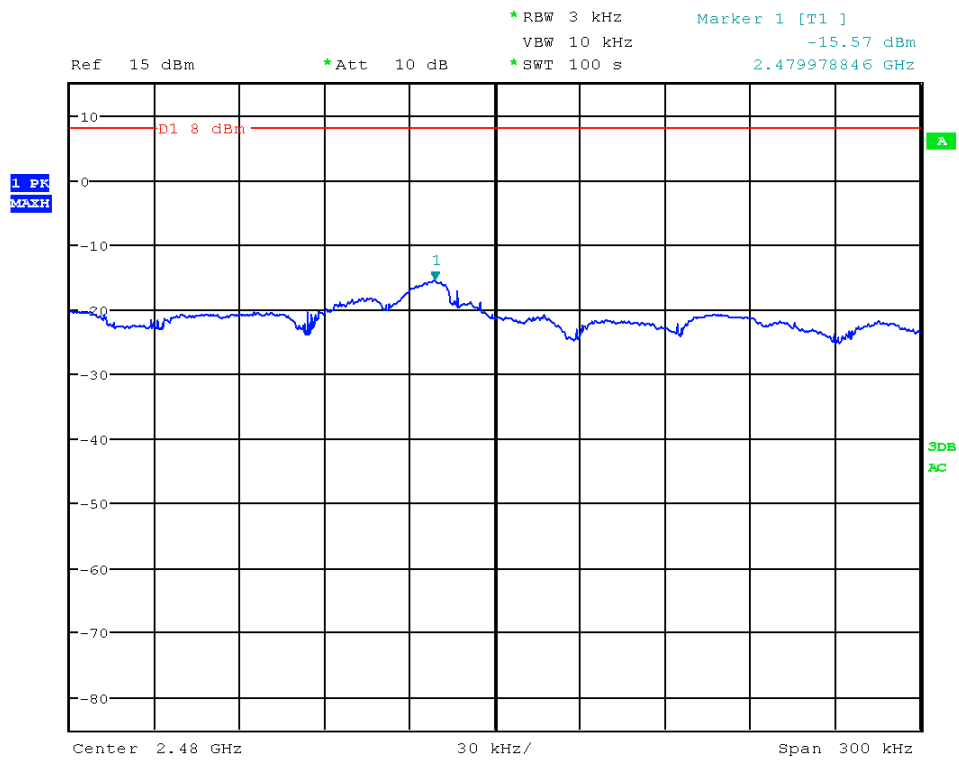


Figure 22: Chart of power spectral density test, channel high - zoom to maximum

f [MHz]	P <sub>meas</sub> [dBm]	a <sub>testcable</sub> [dB]	Power spectral density [dBm / 3 kHz]	Limit [dBm / 3 kHz]	Result
2401.989	-16.86	3.31	-13.55	8.0	Pass
2439.984	-16.07	3.35	-12.72	8.0	Pass
2479.979	-15.57	3.30	-12.27	8.0	Pass

Table 8: Final results of power spectral density test



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## 6.6 Band-edge compliance (radiated)

47 CFR part and section: 15.247 (d)  
 Equivalent to IC radio standard(s) RSS-247 Issue 2, section 5.5  
 Measurement procedure: See 5.6

Performed by: Martin Müller Date of test: March 13, 2017

Result  Test passed  Test not passed

### 6.6.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input type="checkbox"/> Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
<input type="checkbox"/> Open Area Test Site (OATS)	---	EMV <b>TESTHAUS</b> GmbH	E00354
<input type="checkbox"/> Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
<input checked="" type="checkbox"/> Anechoic Chamber (AC)	---	EMV <b>TESTHAUS</b> GmbH	E00100
<input type="checkbox"/> EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
<input type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/> EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
<input type="checkbox"/> EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
<input checked="" type="checkbox"/> EMI test receiver	ESW 44	Rohde & Schwarz	E00895
<input type="checkbox"/> Preamplifier	AMF-5D-00501800	Miteq	W00089
<input type="checkbox"/> Preamplifier	AMF-6F-16002650	Miteq	W00090
<input type="checkbox"/> Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/> TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
<input type="checkbox"/> TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
<input type="checkbox"/> TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
<input type="checkbox"/> Horn antenna	BBHA 9120D	Schwarzbeck	W00052
<input checked="" type="checkbox"/> Horn antenna	BBHA 9120D	Schwarzbeck	W00053
<input type="checkbox"/> Horn antenna	BBHA 9170	Schwarzbeck	W00055
<input type="checkbox"/> Measurement software	E10	ib comPLAN	E00443
<input type="checkbox"/> Measurement software	EMC 32	Rohde & Schwarz	E00777



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## 6.6.2 Limits

- < -20 dBc outside restricted bands
- < 54 dB $\mu$ V/m (average detector) inside restricted bands
- < 74 dB $\mu$ V/m (peak detector) inside restricted bands



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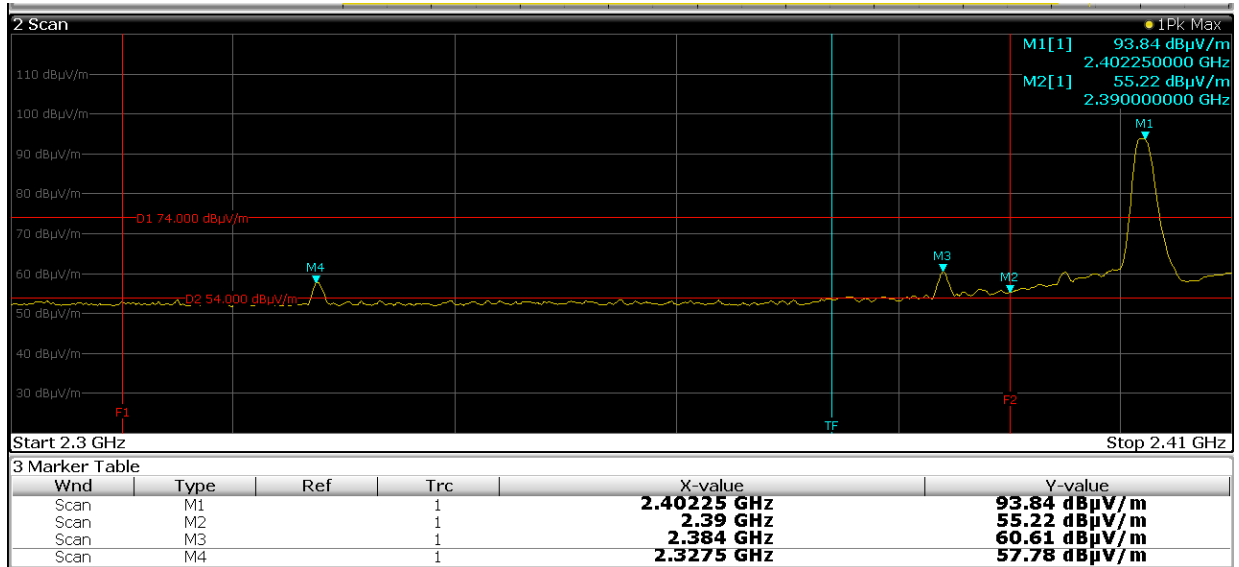


Figure 23: Chart of band edge compliance test, lower band edge - PK

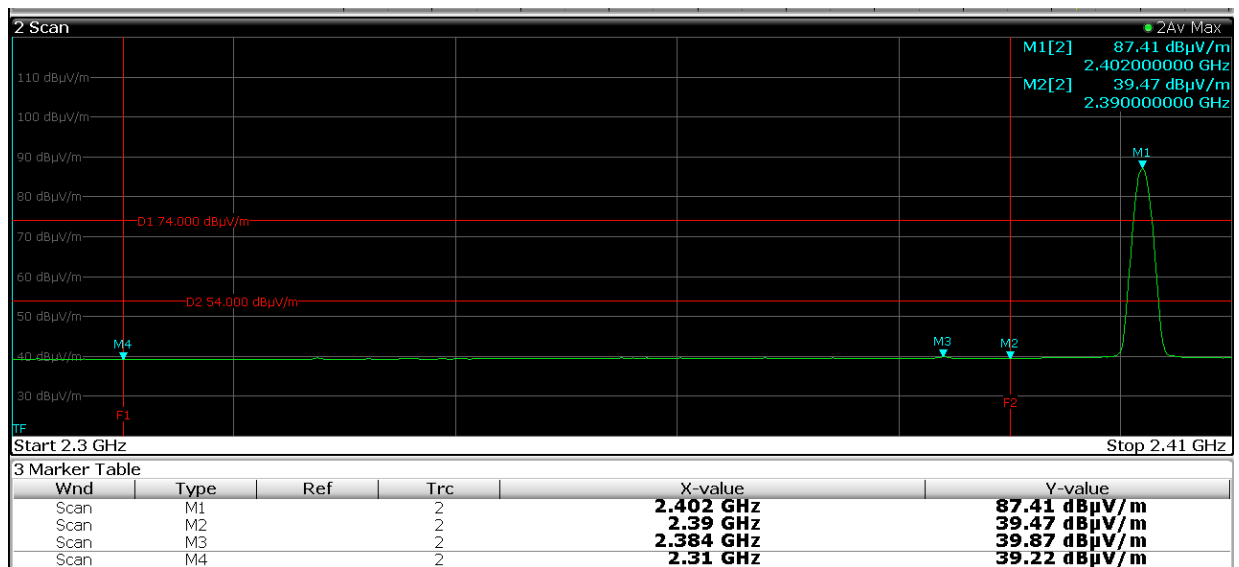


Figure 24: Chart of band edge compliance test, lower band edge - AV

f[MHz]	E <sub>meas</sub> [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2310.000	39.22	AV	Yes	54	Pass
2327.500	57.78	PK		74	Pass
2384.000	60.61	PK		74	Pass
2384.000	39.87	AV		54	Pass
2390.000	55.22	PK		74	Pass
2390.000	39.47	AV		54	Pass
2402.000	87.41	AV	No	----	Carrier
2402.250	93.84	PK		----	Carrier

Table 9: Final result of band edge compliance test, lower band edge



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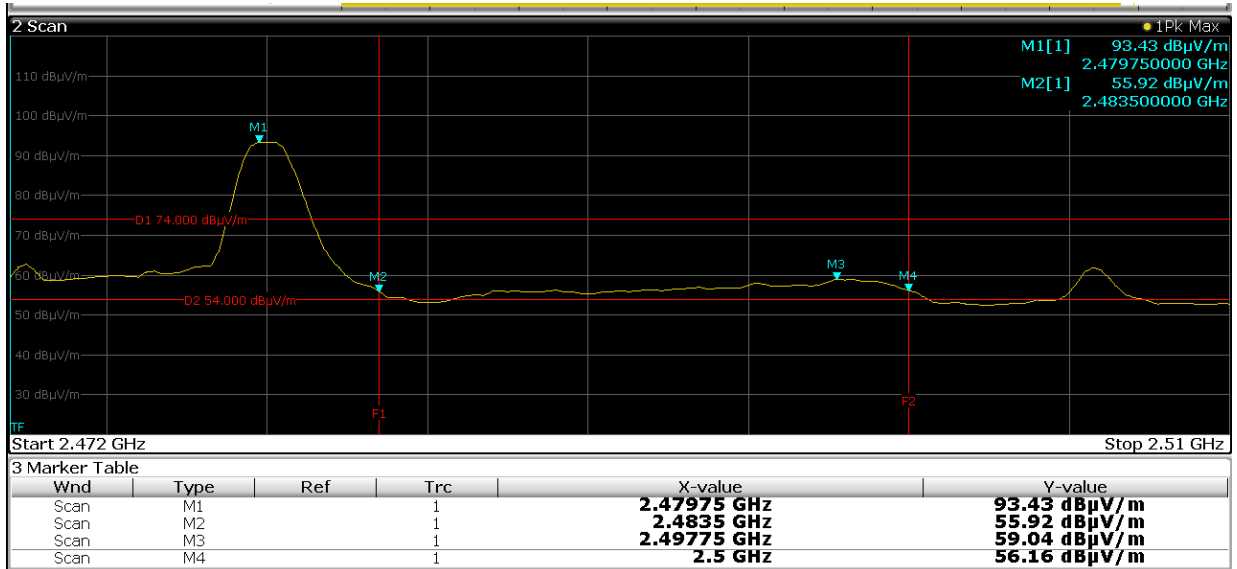


Figure 25: Chart of band edge compliance test, upper band edge - PK

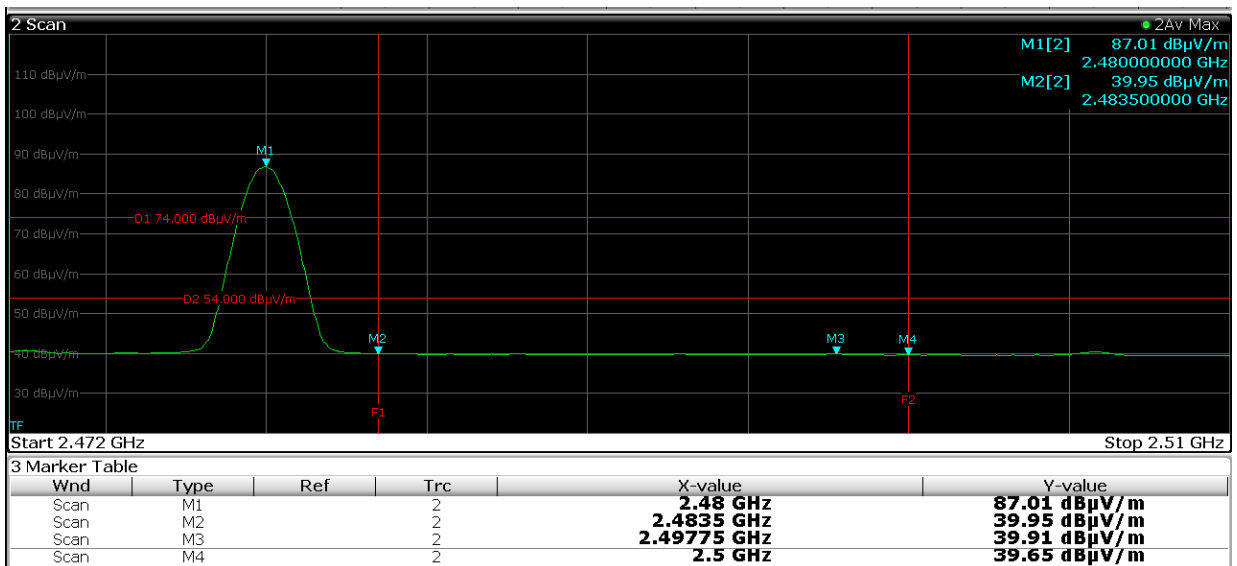


Figure 26: Chart of band edge compliance test, upper band edge - AV

f [MHz]	E <sub>meas</sub> [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2479.750	93.43	PK	No	----	Carrier
2480.000	87.01	AV		----	Carrier
2483.500	55.92	PK	Yes	74	Pass
2483.500	39.95	AV		54	Pass
2497.750	59.04	PK		74	Pass
2497.750	39.91	AV		54	Pass
2500.000	56.16	PK		74	Pass
2500.000	39.65	AV		54	Pass

Table 10: Final result of band edge compliance test, upper band edge



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## 6.7 Spurious radiated emissions 9 kHz to 10th harmonic

47 CFR part and section: 15.247 (d)  
 Equivalent to IC radio standard(s) RSS-Gen Issue 4, section 6.13  
 RSS-247 Issue 2, section 5.5  
 Measurement procedure: See 5.7

Performed by: Martin Müller Date of test: March 16, 2017

Result  Test passed  Test not passed

### 6.7.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
<input checked="" type="checkbox"/> Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
<input checked="" type="checkbox"/> Open Area Test Site (OATS)	---	EMV <b>TESTHAUS</b> GmbH	E00354
<input type="checkbox"/> Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
<input checked="" type="checkbox"/> Anechoic Chamber (AC)	---	EMV <b>TESTHAUS</b> GmbH	E00100
<input checked="" type="checkbox"/> EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/> EMI test receiver	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/> EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
<input checked="" type="checkbox"/> EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
<input checked="" type="checkbox"/> EMI test receiver	ESW 44	Rohde & Schwarz	E00895
<input type="checkbox"/> Preamplifier	AMF-5D-00501800	Miteq	W00089
<input checked="" type="checkbox"/> Preamplifier	AMF-6F-16002650	Miteq	W00090
<input checked="" type="checkbox"/> Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
<input checked="" type="checkbox"/> TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
<input checked="" type="checkbox"/> TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
<input type="checkbox"/> TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
<input type="checkbox"/> Horn antenna	BBHA 9120D	Schwarzbeck	W00052
<input checked="" type="checkbox"/> Horn antenna	BBHA 9120D	Schwarzbeck	W00053
<input checked="" type="checkbox"/> Horn antenna	BBHA 9170	Schwarzbeck	W00055
<input checked="" type="checkbox"/> Measurement software	E10	ib comPLAN	E00443
<input type="checkbox"/> Measurement software	EMC 32	Rohde & Schwarz	E00777



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## 6.7.2 Limits < 1 GHz

Frequency [MHz]	Field strength Fs [ $\mu\text{V}/\text{m}$ ]	Field strength [dB $\mu\text{V}/\text{m}$ ]	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”:

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

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

The frequency  $f_{\text{MHz}}$  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:

$$f_{\text{MHz}}(300 \text{ m}) \approx 0.159 \text{ MHz}$$

$$f_{\text{MHz}}(30 \text{ m}) \approx 1.592 \text{ MHz}$$

$$f_{\text{MHz}}(3 \text{ m}) \approx 15.923 \text{ MHz}$$

For  $9 \text{ kHz} \leq f \leq 159 \text{ kHz}$  and  $490 \text{ kHz} < f \leq 1.592 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{limit}} / d_{\text{measure}})$$

For  $159 \text{ kHz} < f \leq 490 \text{ kHz}$  and  $1.592 \text{ MHz} < f \leq 15.923 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$$

For  $f > 15.923 \text{ MHz}$ :

$$\text{Recalculation factor} = -20 \log(d_{\text{limit}} / d_{\text{measure}})$$

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.

## 6.7.3 Limits > 1 GHz

< -20 dBc outside restricted bands

< 54d B $\mu\text{V}/\text{m}$  (average detector) inside restricted bands

< 74d B $\mu\text{V}/\text{m}$  (peak detector) inside restricted bands



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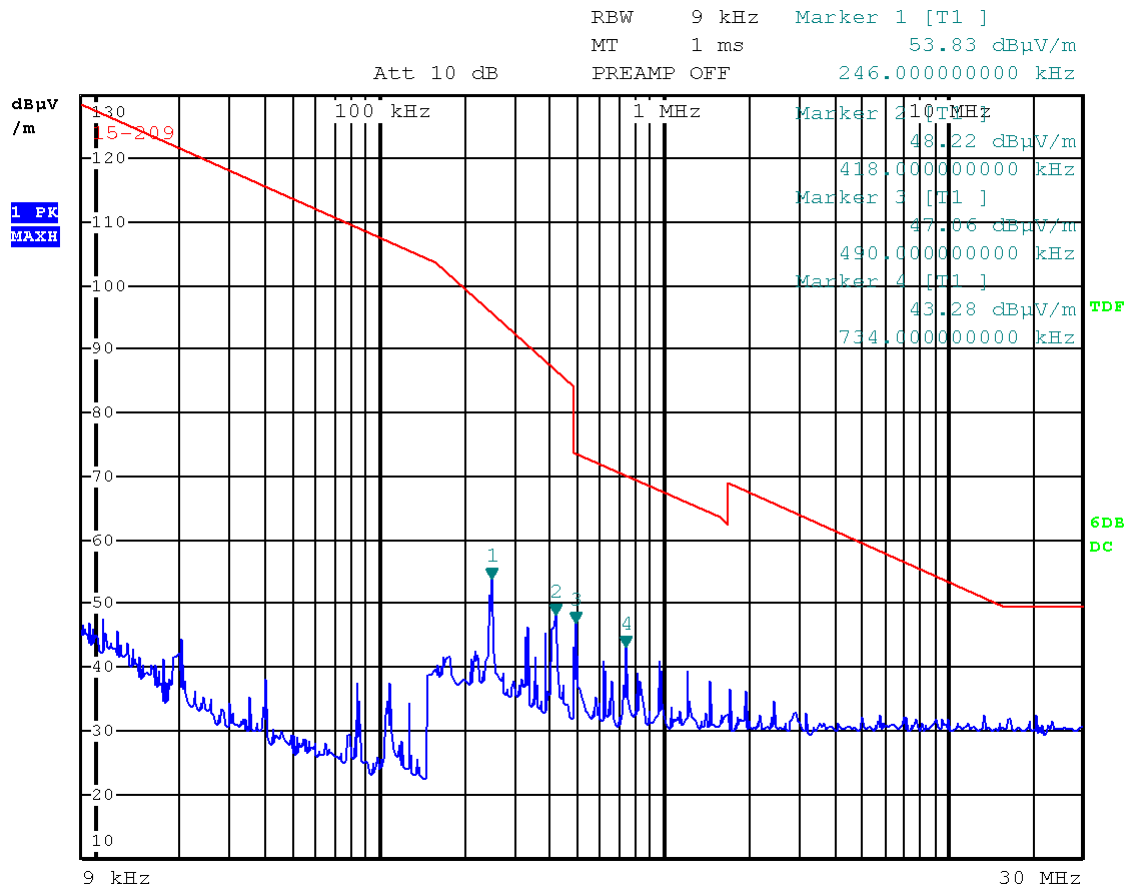


Figure 27: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel low



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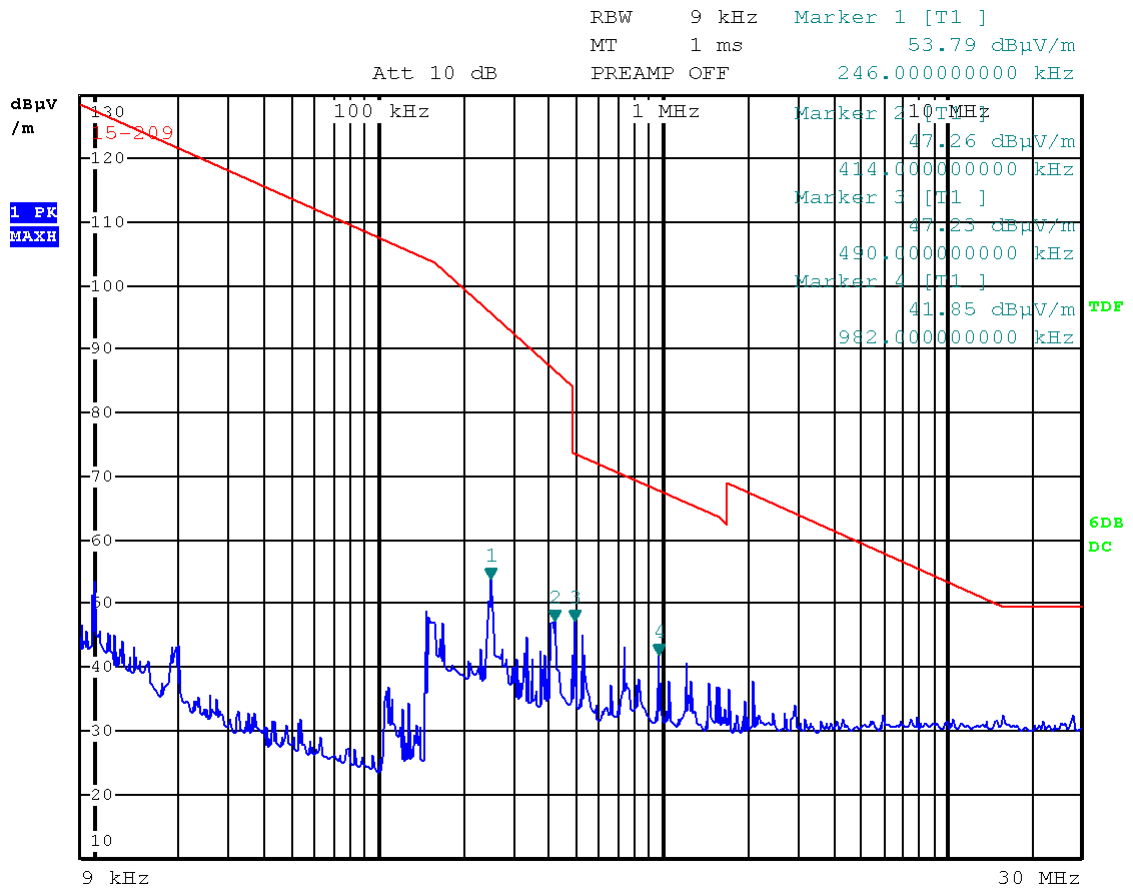


Figure 28: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel mid



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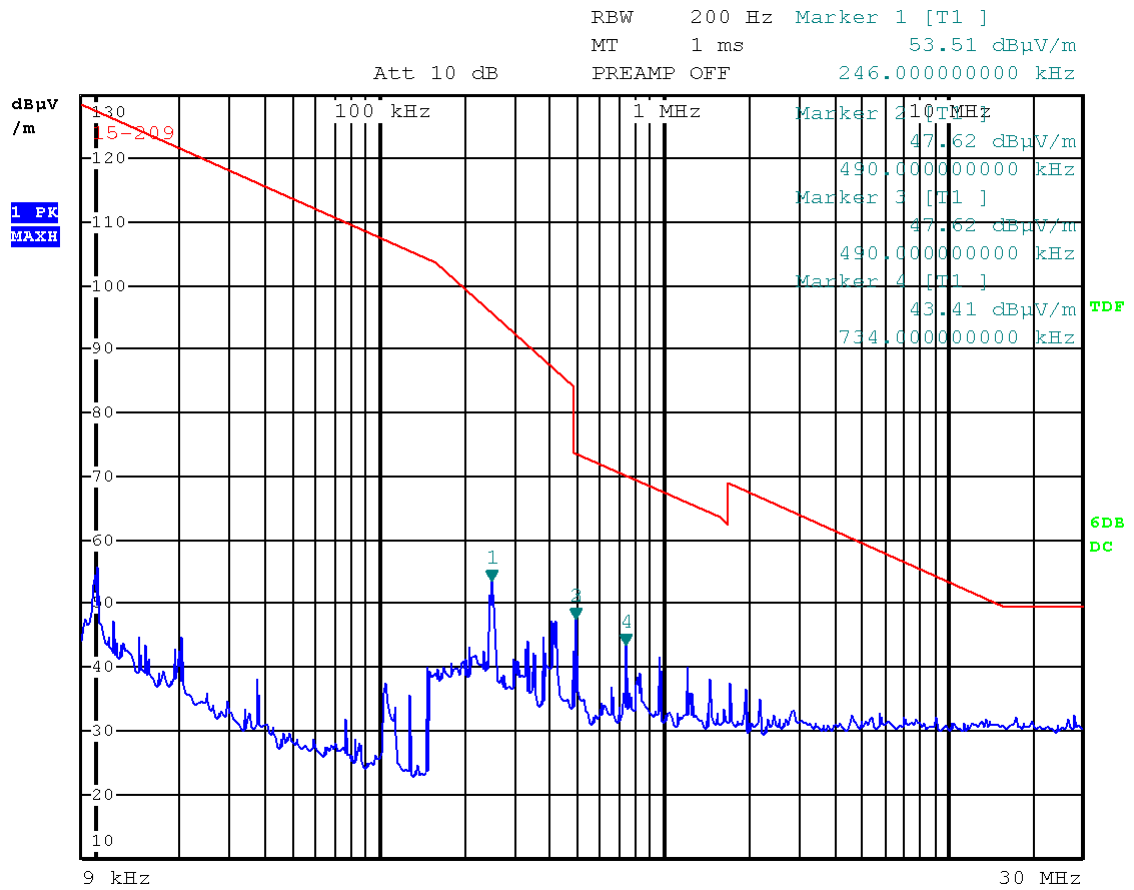


Figure 29: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel high



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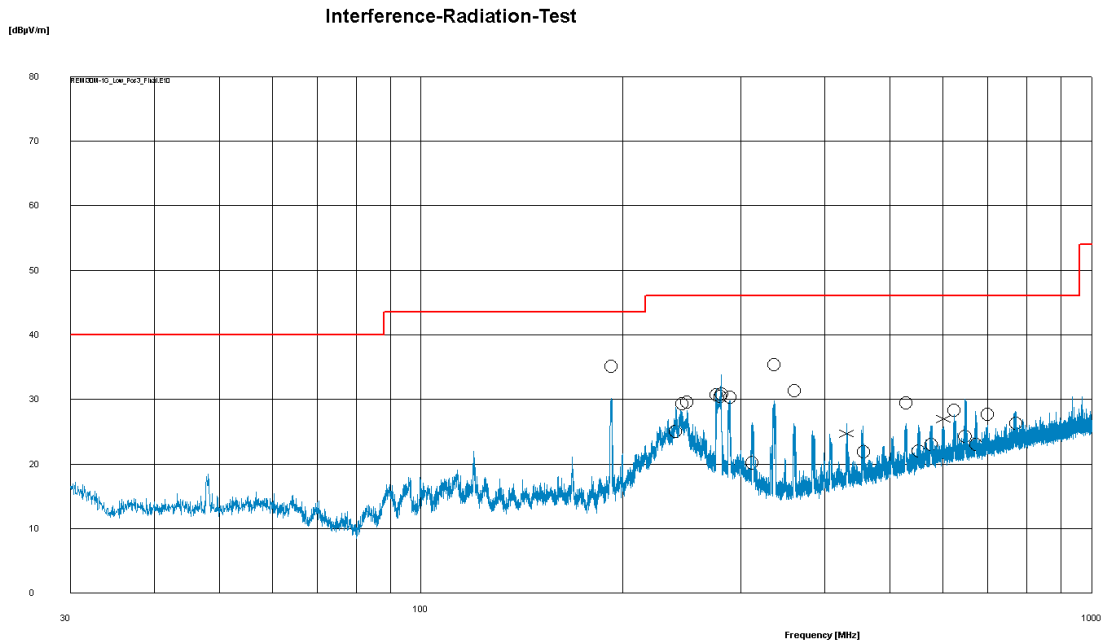


Figure 30: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel low

f [MHz]	E <sub>final</sub> [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
192.12	35.19	43.52	100	121	H	Pass
239.58	25.04	46.02	100	164	H	Pass
244.98	29.29	46.02	100	89	H	Pass
249.18	29.57	46.02	100	55	H	Pass
275.34	30.76	46.02	100	157	H	Pass
279.42	30.47	46.02	100	105	H	Pass
280.32	30.89	46.02	100	169	H	Pass
289.02	30.36	46.02	100	25	H	Pass
311.34	20.20	46.02	106	194	H	Pass
335.94	35.38	46.02	100	113	H	Pass
360.00	31.33	46.02	100	155	H	Pass
431.76	24.62	46.02	100	339	V	Pass
456.60	21.86	46.02	100	136	H	Pass
528.24	29.42	46.02	100	100	H	Pass
551.58	22.03	46.02	100	214	H	Pass
575.28	23.09	46.02	100	234	H	Pass
601.26	26.97	46.02	100	302	V	Pass
623.10	28.29	46.02	100	145	H	Pass
646.92	24.25	46.02	104	148	H	Pass
671.10	23.05	46.02	108	95	H	Pass
698.94	27.69	46.02	100	59	H	Pass
769.68	26.27	46.02	155	6	H	Pass

Table 11: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel low



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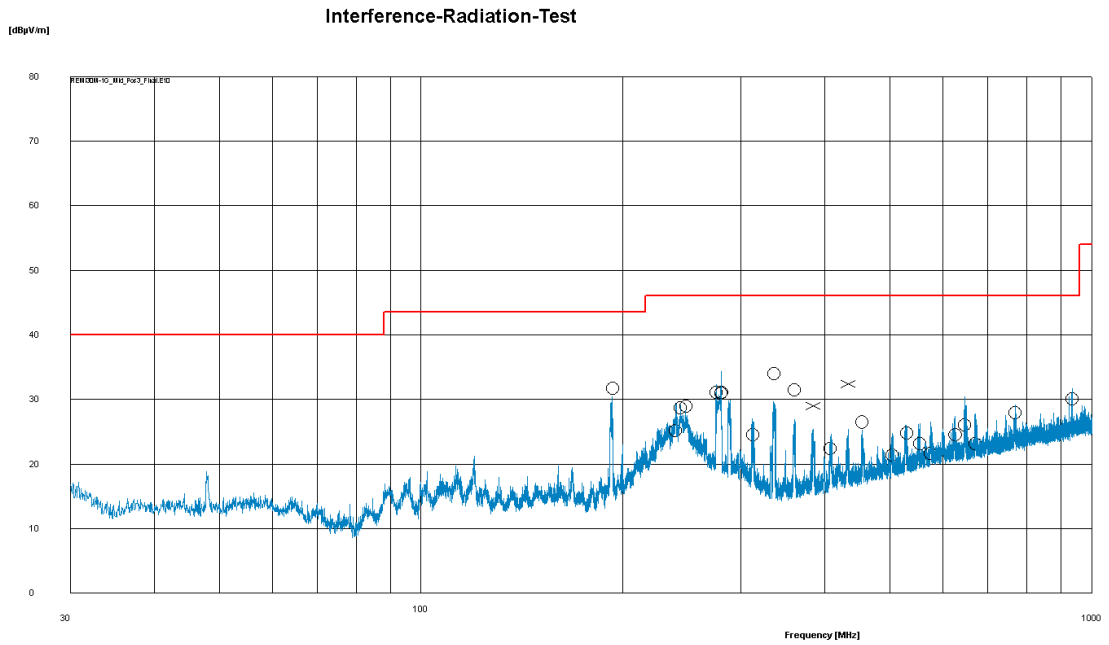


Figure 31: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel mid

f [MHz]	E <sub>final</sub> [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
192.90	31.74	43.52	100	126	H	Pass
239.46	25.17	46.02	100	66	H	Pass
243.66	28.68	46.02	100	100	H	Pass
248.16	28.91	46.02	100	58	H	Pass
275.34	31.10	46.02	100	159	H	Pass
279.78	30.96	46.02	100	154	H	Pass
280.32	31.10	46.02	100	157	H	Pass
311.94	24.52	46.02	100	308	H	Pass
335.64	33.96	46.02	100	131	H	Pass
360.06	31.45	46.02	100	154	H	Pass
384.06	28.96	46.02	100	31	V	Pass
407.64	22.37	46.02	100	275	H	Pass
433.20	32.33	46.02	100	58	V	Pass
454.14	26.51	46.02	213	260	H	Pass
503.70	21.37	46.02	100	116	H	Pass
529.62	24.78	46.02	100	97	H	Pass
553.98	23.15	46.02	136	224	H	Pass
574.68	21.64	46.02	397	218	H	Pass
625.56	24.59	46.02	100	49	H	Pass
646.68	26.07	46.02	362	145	H	Pass
670.32	23.20	46.02	181	167	H	Pass
769.26	27.99	46.02	136	37	H	Pass
934.74	30.06	46.02	100	87	H	Pass

Table 12: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel mid



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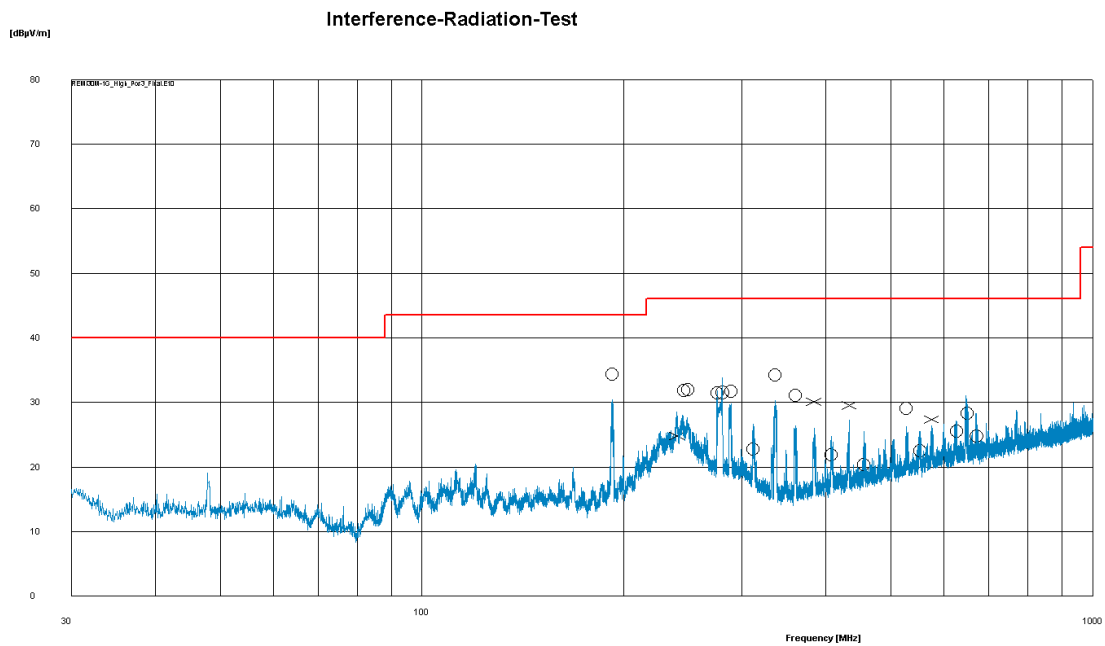


Figure 32: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel high

f [MHz]	E <sub>final</sub> [dBV/m]	Limit [dB $\mu$ V/m]	Height [cm]	TT [°]	Polarisation	Result
191.94	34.43	43.52	100	124	H	Pass
240.00	24.83	46.02	100	61	V	Pass
245.28	31.81	46.02	100	99	H	Pass
248.76	32.04	46.02	100	109	H	Pass
275.34	31.52	46.02	100	145	H	Pass
280.32	31.55	46.02	100	118	H	Pass
288.78	31.71	46.02	100	18	H	Pass
311.52	22.82	46.02	106	199	H	Pass
335.76	34.24	46.02	100	113	H	Pass
360.42	31.12	46.02	100	156	H	Pass
384.00	30.10	46.02	100	0	V	Pass
407.58	21.91	46.02	100	166	H	Pass
433.14	29.53	46.02	100	360	V	Pass
455.70	20.35	46.02	128	147	H	Pass
527.16	29.12	46.02	100	244	H	Pass
551.76	22.50	46.02	100	225	H	Pass
575.52	27.35	46.02	100	320	V	Pass
625.74	25.61	46.02	100	335	H	Pass
649.20	28.37	46.02	100	0	H	Pass
670.86	24.83	46.02	106	147	H	Pass

Table 13: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel high



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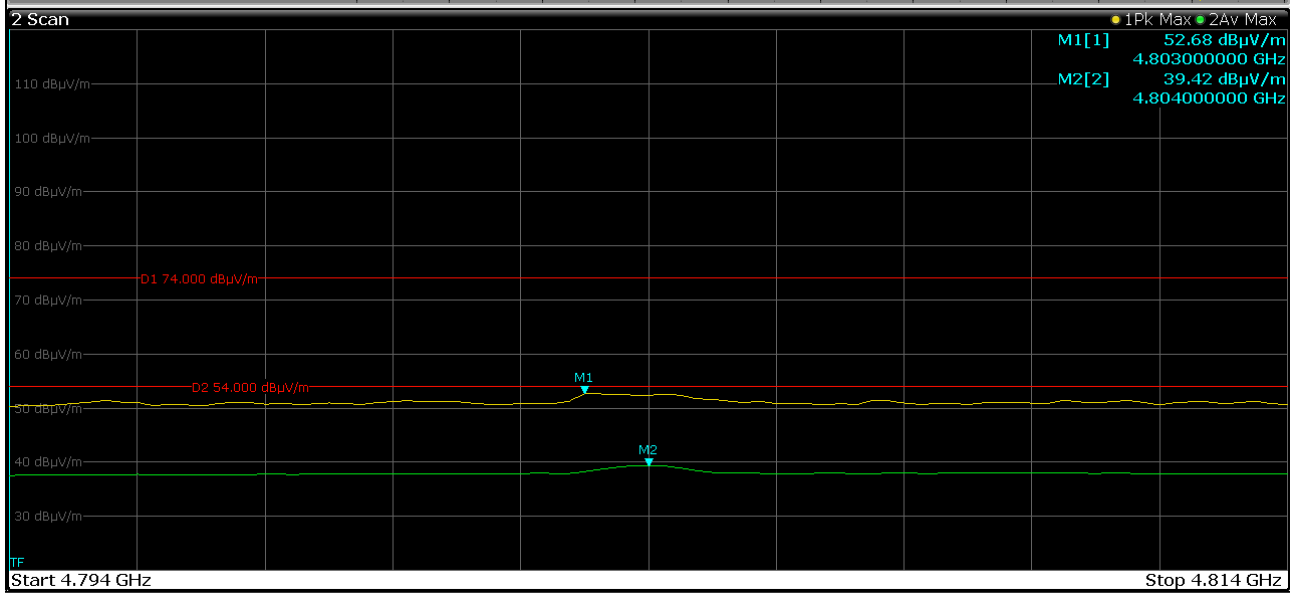


Figure 33: 1<sup>st</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel low

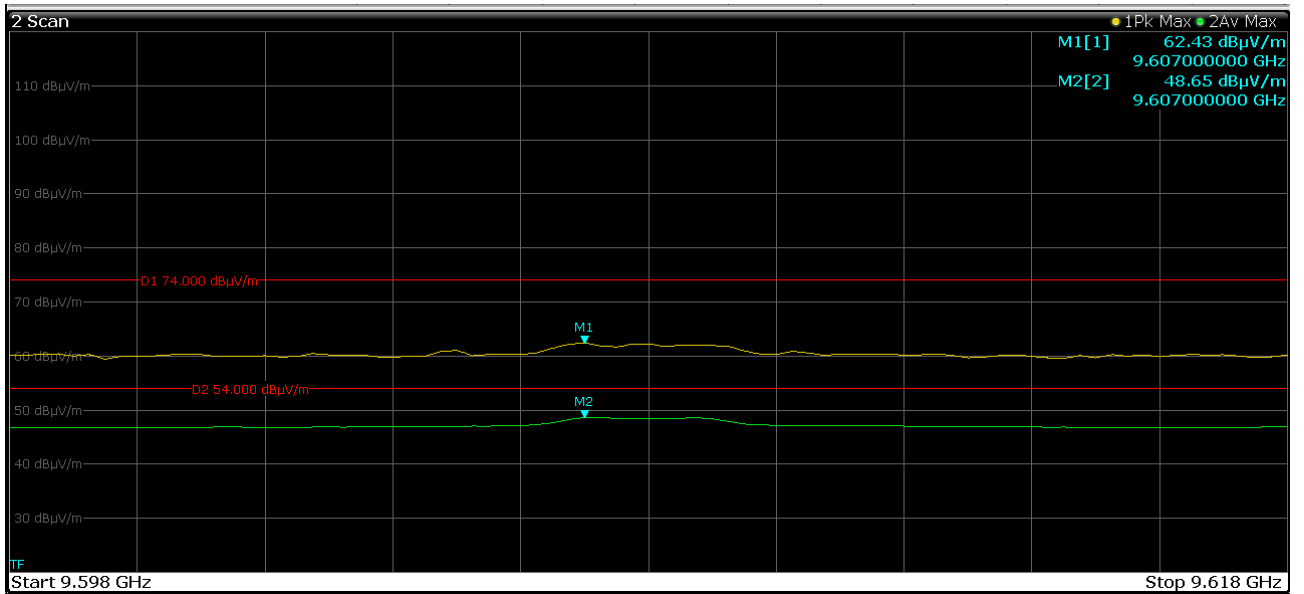


Figure 34: 2<sup>nd</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel low

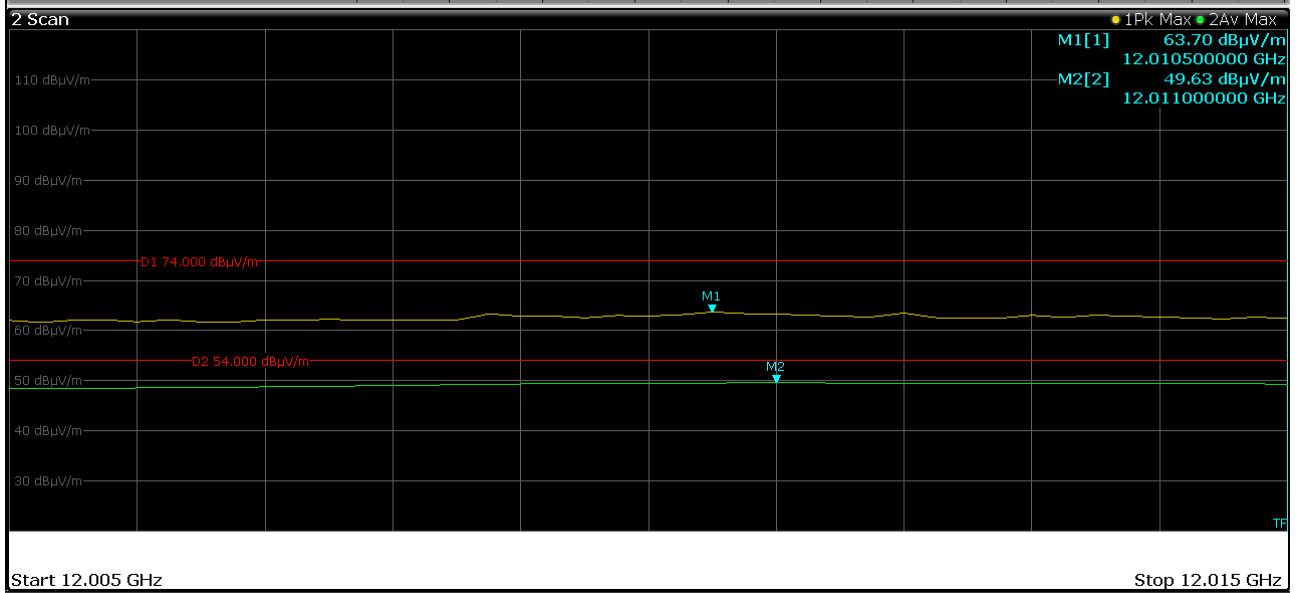


Figure 35: 3<sup>rd</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel low

Channel low									
f[GHz]	E <sub>meas</sub> [dBµV/m]	EUT-Pos	Polarization	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4023	93.84	3	H	34	145	PK	No	---	Carrier
2.4020	87.41					AV		---	Carrier
4.8030	52.68	3	H	152	143	PK	Yes	74	Pass
4.8040	39.42					AV		54	Pass
9.6070	62.43	3	H	71	139	PK	No	-20dBc	Pass
9.6070	48.65					AV		-20dBc	Pass
12.0105	63.70	3	H	25	163	PK	Yes	74	Pass
12.0110	49.63					AV		54	Pass

Table 14: Final result of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel low

Remark: For Carrier level see chapter 6.6



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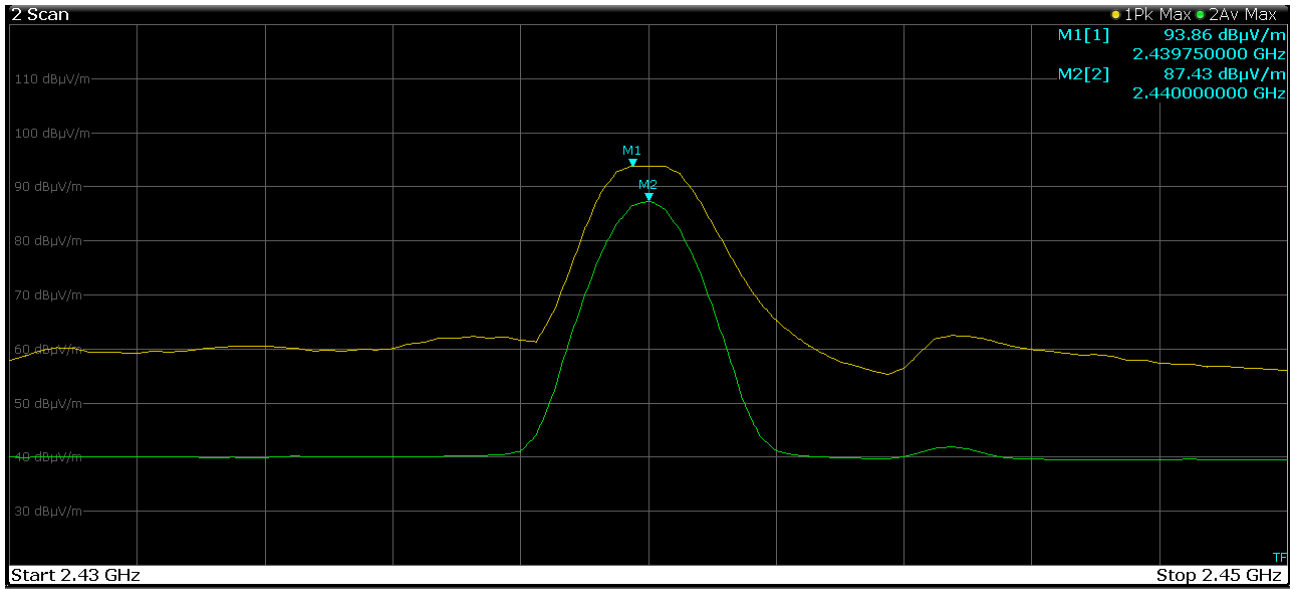


Figure 36: 1<sup>st</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel mid

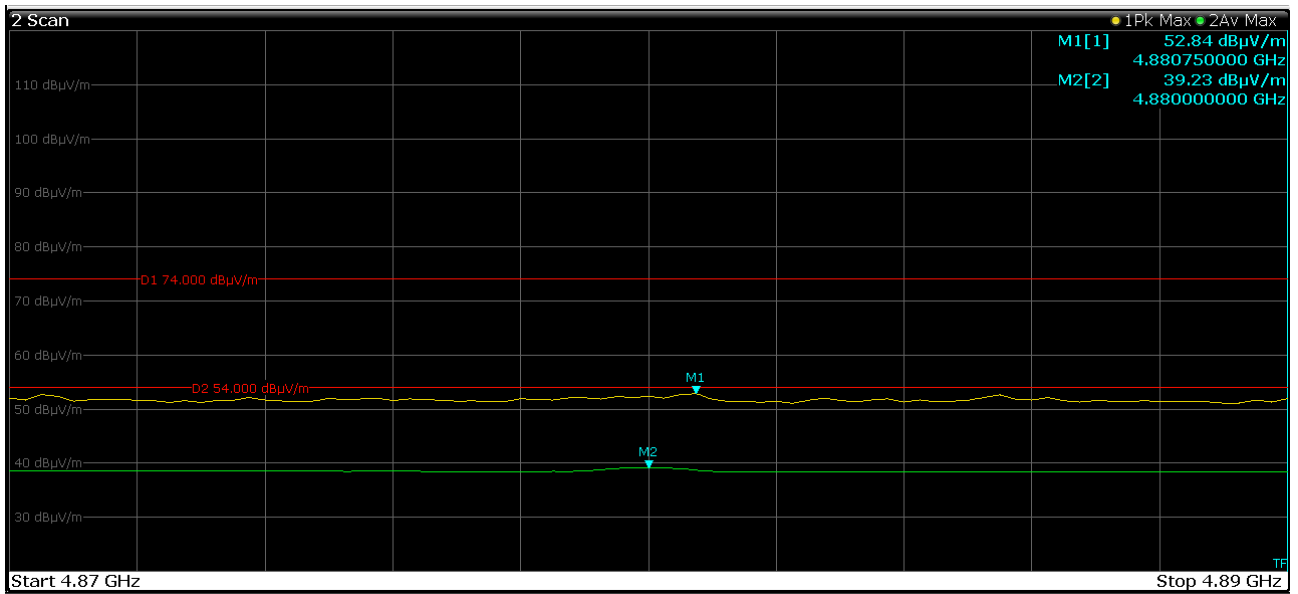


Figure 37: 2<sup>nd</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel mid

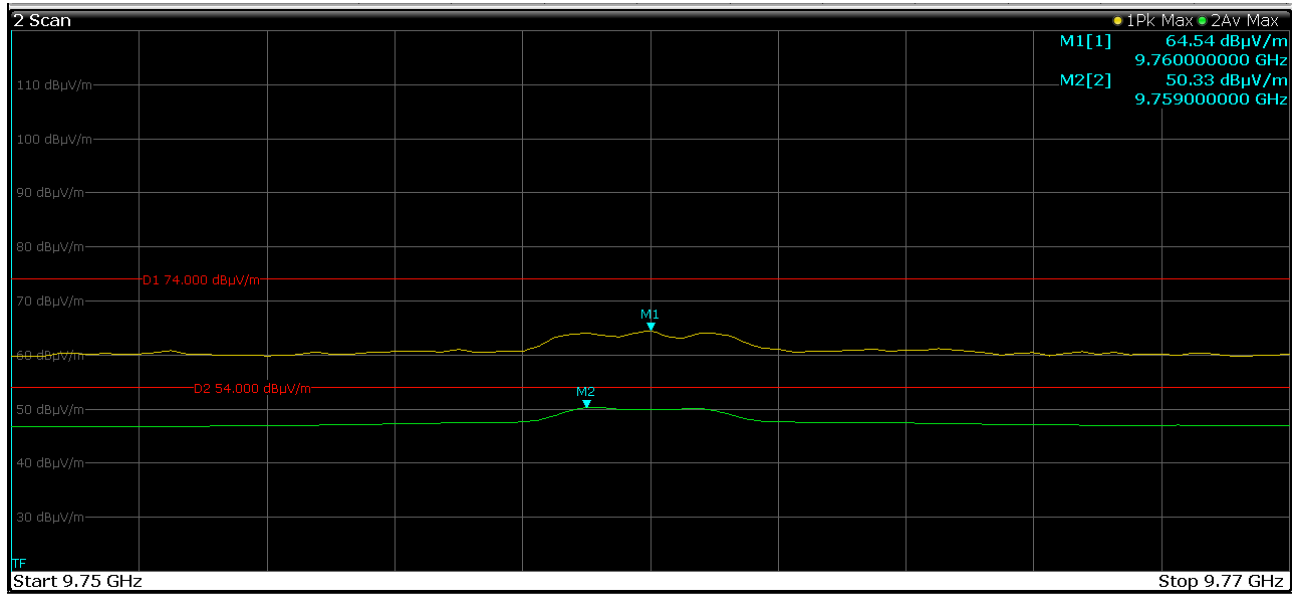


Figure 38: 3<sup>rd</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel mid

Channel mid									
f[GHz]	E <sub>meas</sub> [dBµV/m]	EUT-Pos	Polarization	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4398	93.86	3	H	36	151	PK	No	---	Carrier
2.4400	87.43					AV		---	Carrier
4.8808	52.84	3	H	145	149	PK	Yes	74	Pass
4.8800	39.23					AV		54	Pass
9.7600	64.54	3	H	80	162	PK	No	-20dBc	Pass
9.7590	50.33					AV		-20dBc	Pass

Table 15: Final result of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel mid



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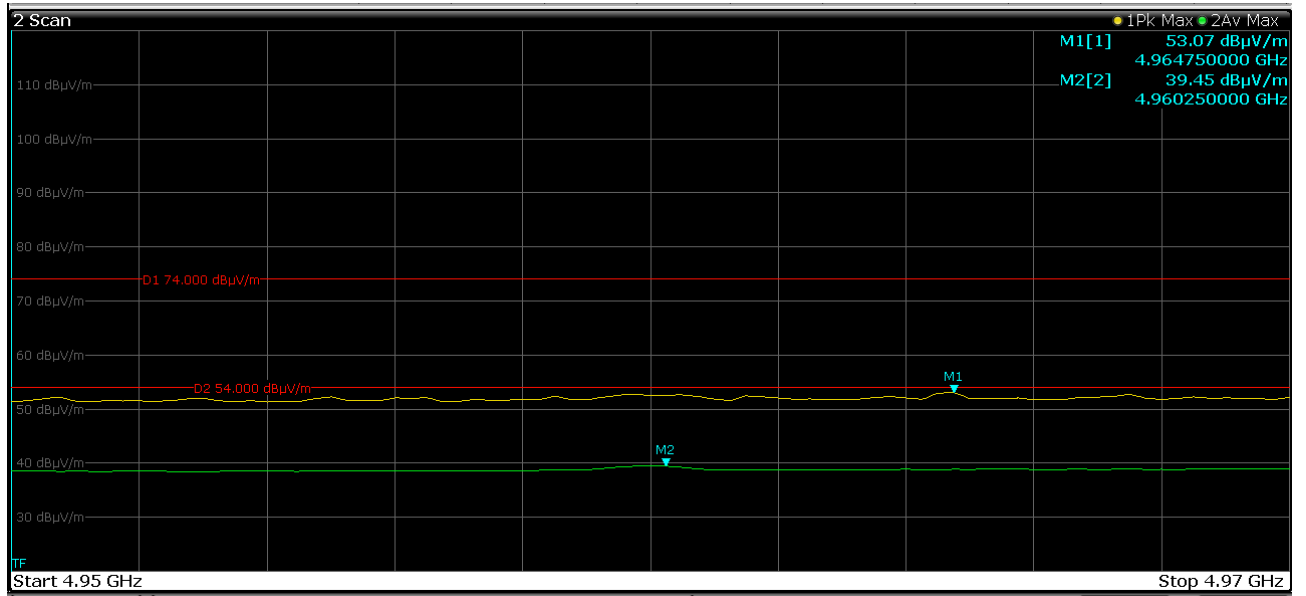


Figure 39: 1<sup>st</sup> Chart of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel high

Channel high									
f[GHz]	E <sub>meas</sub> [dBµV/m]	EUT-Pos	Polarization	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
4.9648	53.07	3	H	156	145	PK	Yes	74	Pass
4.9603	39.45					AV		54	Pass

Table 16: Final result of spurious radiated emission test 1 GHz to 10<sup>th</sup> harmonic, channel high



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## 6.8 Radio frequency radiation exposure evaluation for portable devices

Reference(s): 47 CFR Part 2, §2.1093  
KDB 447498 D01, section 4.3.1  
RSS Gen Issue 4, section 3.2  
RSS-102 Issue 5, section 2.5.1

---

Performed by:	Martin Müller	Date of test:	March 31, 2017
---------------	---------------	---------------	----------------

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Result:	<input checked="" type="checkbox"/> Test passed	<input type="checkbox"/> Test not passed
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---

### 6.8.1 Data of equipment under test (EUT)

Antenna connector (see clause 3):	<input type="checkbox"/> permanent	<input checked="" type="checkbox"/> temporary	<input type="checkbox"/> none
Antenna detachable:	<input type="checkbox"/> yes	<input checked="" type="checkbox"/> no	
Tune-up function:	<input type="checkbox"/> yes	<input checked="" type="checkbox"/> no	
Maximum antenna gain (see clause 3):	logarithmic 0.0 dBi	numeric 1.0	
Maximum conducted output power (see clause 6.4):	logarithmic -0.83 dBm	numeric 0.83 mW	
Maximum equivalent isotropically radiated power:	logarithmic -0.83 dBm	numeric 0.83 mW	
Maximum operation frequency (see clause 3):	2480.0 MHz		
Minimum test separation distance:	5 mm		

### 6.8.2 Requirements

To be excluded from SAR tests set out in 47 CFR Part 2, §2.1093, the limits of the general guidelines for RF Exposure as described in KDB 447498 D01, section 4.3.1, have to be kept. For 100 MHz to 6 GHz and test separation distances  $\leq 50$  mm, the 1 g and 10 g SAR test exclusion thresholds are determined by the following equation:



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$$\frac{P_{conducted}(mW) \cdot \sqrt{f(GHz)}}{d_{min}(mm)} \leq 3.0$$

with:  $P_{conducted}$  = source-based time-averaged maximum conducted output power in mW, adjusted for tune-up tolerance  
 $f$  = RF channel transmit frequency in GHz  
 $d_{min}$  = minimum test separation distance in mm determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander



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## 6.8.3 Results

### 6.8.3.1 Test results according to KDB 447498 D01

Calculation of minimum test separation distance:

$$\begin{aligned}\frac{P_{\text{conducted}}(\text{mW}) \cdot \sqrt{f(\text{GHz})}}{d_{\text{min}}(\text{mm})} &\leq 3.0 &\Leftrightarrow d_{\text{min}}(\text{mm}) &\geq \frac{P_{\text{conducted}}(\text{mW}) \cdot \sqrt{f(\text{GHz})}}{3.0} \\ & &\Leftrightarrow d_{\text{min}}(\text{mm}) &\geq \frac{1 \cdot \sqrt{2.48}}{3.0} \\ & &\Leftrightarrow d_{\text{min}}(\text{mm}) &\geq 0.525 \\ & &\Rightarrow d_{\text{min}}(\text{mm}) &= 0.6\end{aligned}$$

Final check:

$$\begin{aligned}\frac{P_{\text{conducted}}(\text{mW}) \cdot \sqrt{f(\text{GHz})}}{d_{\text{min}}(\text{mm})} &\leq 3.0 &\Leftrightarrow \frac{1 \cdot \sqrt{2.48}}{5} &\leq 3.0 \\ & &\Rightarrow 0.315 &\leq 3.0 \quad \checkmark\end{aligned}$$

Notes:

- 1 Power and distance are rounded to the nearest mW and mm before calculation.
- 2 The result is rounded to one decimal place for comparison



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## 7 Equipment calibration status

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Test receiver	ESCI 3	100013	E00001	2016-02	2018-02
Test receiver	ESCI 3	100328	E00552	2016-09	2018-09
Test receiver	ESCS 30	825442/0002	E00003	2016-04	2018-04
Test receiver	ESU 26	100026	W00002	2016-02	2018-02
Test receiver	ESR 7	101059	E00739	2016-04	2018-04
Test receiver	ESW 44	101538	E00895	2016-12	2018-12
Broadband horn antenna	BBHA 9120D	9120D-593	W00053	2016-03	2018-03
Broadband horn antenna	BBHA 9170	BBHA 9170	W00055	2016-03	2018-03
Preamplifier	AMF-5D-00501800-28-13P	1319793	W00089	2015-06	2017-06
Preamplifier	AMF-6F-16002650-25-10P	1317552	W00090	2015-06	2017-06
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9160	9160-3050	E00011	2015-09	2017-09
Broadband antenna	VULB 9163	9163-114	E00013	2015-09	2017-09
Shielded room	P92007	B83117C1109T211	E00107	N/A	
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69-2-0006	E00026	N/A	
Open area test site (OATS)	---	---	E00354	2015-10	2017-10
Semi anechoic chamber (SAC)	SAC3	C62128-A520-A643-x-0006	E00716	2015-09	2017-09
Climatic chamber 340 I	VC <sup>3</sup> 4034	58566123250010	C00015	2016-10	2018-10
Cable set shielded room	Cable no. 30	---	E00424	2016-07	2018-07
Cable set CDC	Cables no. 37 and 38	---	E00459 E00460	2015-05	2017-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2015-11	2017-11
Cable set SAC 3 m	Cables no. 57, 58 and 59	---	E00453 E00455 E00458	2015-10	2017-10

Table 17: Equipment calibration status



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Note 1: Expiration date of measurement facility registration (OATS) by  
- FCC (registration number 221458): 2017-04  
- Industry Canada (test sites number 3472A-1 and 3472A-2): 2018-11  
Note 2: Expiration date of test firm accreditation for OATS and SAC:  
FCC test firm type "accredited": 2017-06



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## 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 18: 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.



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## 9 Revision history

<i>Revision</i>	<i>Date</i>	<i>Issued by</i>	<i>Description of modifications</i>
0	2017-04-03	Martin Müller	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)



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