Test report

Customer:

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RF test report

160583-AU01+W02

Industry Canada Industrie Canada

DewertOkin GmbH

RF Remote Control

RF-TOUCH

The test result refers exclusively to the model tested.
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EMV **TESTHAUS** GmbH

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

EMV **TESTHAUS** GmbH

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Accreditation:

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

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:

EMV **TESTHAUS** GmbH
Gustav-Hertz-Straße 35
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Germany

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

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1 Summary of test results

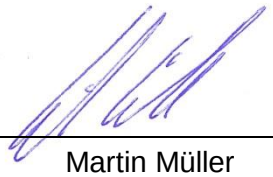
System type: Digital transmission system (DTS)

47 CFR part and section [1]	*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)	24	Passed	2
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	RSS-Gen Issue 4, section 6.6	28	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	32	Passed	---
15.247(e) KDB 558074, section 10	Power spectral density	RSS-247 Issue 2, section 5.2(b)	36	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	44	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Spurious radiated emissions 9 kHz to 10th 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)	69	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 10th harmonic performed.

Straubing, March 20, 2017



Martin Müller
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EMV **TESTHAUS** GmbH

Rainer Heller
Head of EMC / radio department
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2 Referenced publications

Publication	*Title*
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 Apperatus
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

3 Equipment under test (EUT)

Product type:	RF Remote Control	
Model name:	RF-TOUCH	
Serial number(s):	D123456 0001 -> for radiated tests D123456 0002 -> for conducted tests	
Applicant:	DewertOkin GmbH	
Manufacturer:	DewertOkin GmbH	
Version:	Hardware: Software:	--- ---
Additional modifications:	None	
FCC ID:	O3YRFTOUCH1089	
IC registration number:	10744A-RFTOUCH1089	
Application frequency band:	2400.0 MHz - 2483.5 MHz	
Frequency range:	2403.0 MHz - 2478.0 MHz	
Operating frequencies:	2403.0 MHz - 2478.0 MHz	
Channel spacing:	1 MHz	
Number of RF channels:	76	
System type:	Digital transmission system (DTS)	
Modulation type(s):	GFSK	
Class of emission:	F1D	
Antenna type(s):	PCB antenna (F-Antenna layouted)	
Antenna gain(s):	approximately 0 dBi	
Power supply:	Battery supply	
	Nominal voltage: Minimum voltage: Maximum voltage: Nominal frequency:	4.5 V --- --- ---
Temperature range:	0 °C to +40 °C	
Device type:	☒ Portable ☐ Mobile ☐ Fixed	

4 Test configuration and mode of operation

4.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RF Remote Control	RF-TOUCH	D123456 0001	DewertOkin GmbH
RF Remote Control	RF-TOUCH	D123456 0002	DewertOkin GmbH

Table 1: Devices used for testing

Port	*Classification*	*Cable type*	*Cable length*	
			used	*maximum*[1]
---	---	---	---	---

Table 2: Ports of EUT and appropriate cables

4.2 Attenuation of test cable(s)

Frequency (MHz)	*Attenuation (dB).*
2403.0	0.54
2440.0	0.55
2478.0	0.55

Table 3: Attenuation of test cable

4.3 Mode of operation

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

SRD mode

Channel low -> 2403.0 MHz (modulated / unmodulated)
Channel mid -> 2440.0 MHz (modulated / unmodulated)
Channel high -> 2478.0 MHz (modulated / unmodulated)

[1] 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 ≥ 3 x RBW
Sweep time = auto coupled
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/RBW) dB above peak of spectral envelope

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.

5.3 Occupied bandwidth (99%)

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

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

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

For test setup see clause 5.8.

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

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.

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 kHz ≤ RBW ≤ 100 kHz
VBW ≥ 3 x RBW
Sweep time = auto coupled or ≥ span/RBW in seconds, whichever is greater
Detector function = peak
Trace mode = max hold
Reference level: more than 10·log(OBW/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 10th harmonic

For test setup and test method see clause 5.9.

5.8 Conducted emissions at antenna connector

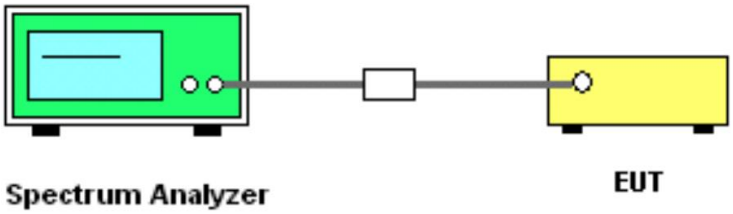


Figure 1: Setup for conducted emission test at antenna connector

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

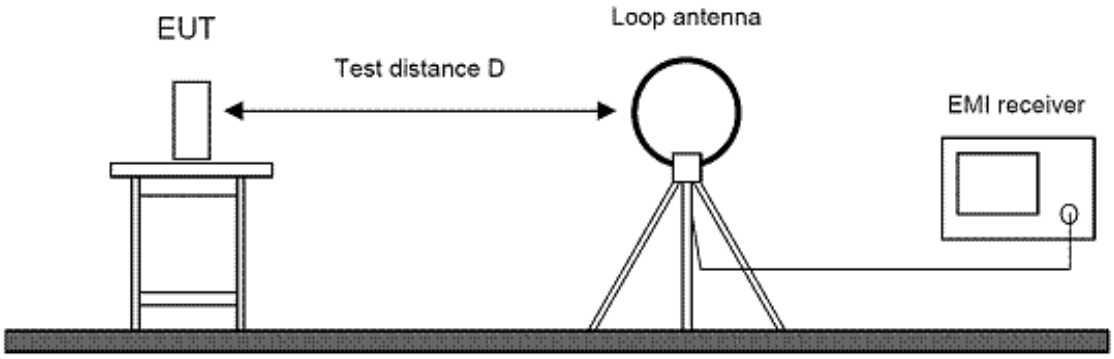


Figure 2: Setup for radiated emission test below 30 MHz

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° / 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

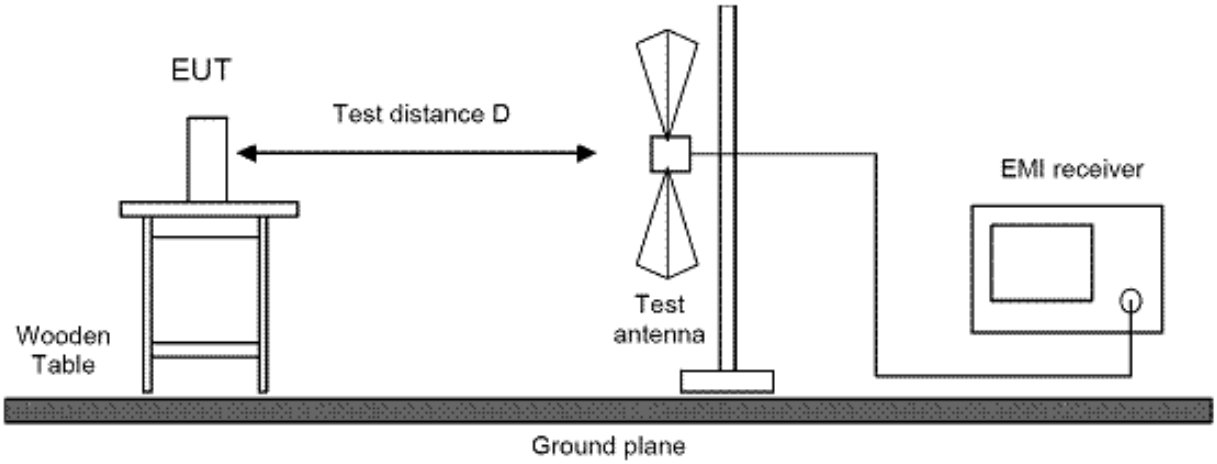


Figure 3: Setup for radiated emission test from 30 MHz to 1 GHz

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° / 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

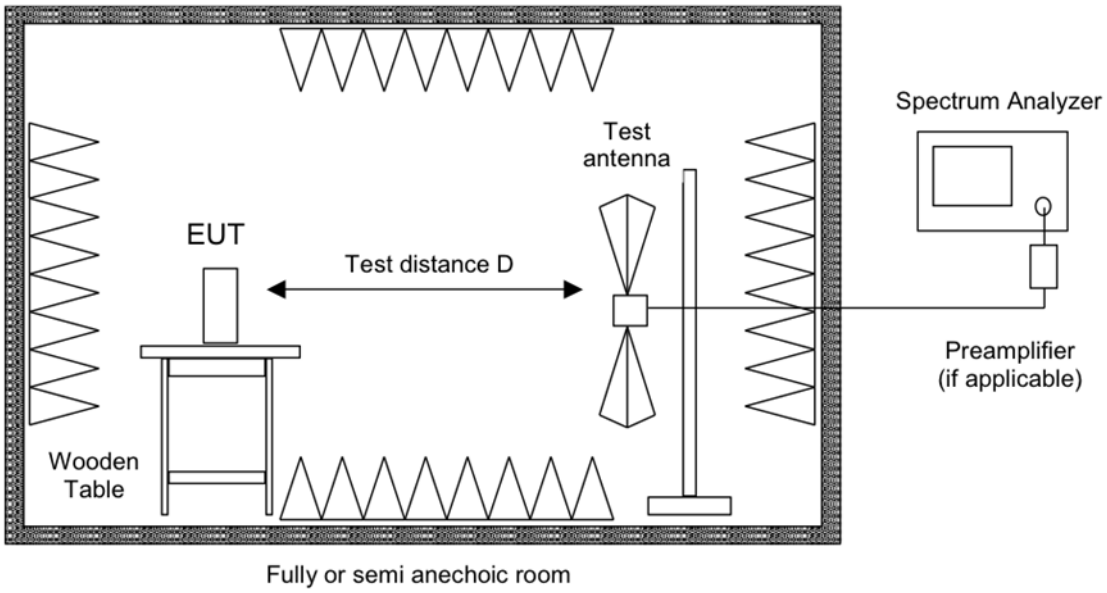


Figure 4: Setup for radiated emission test above 1 GHz

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 10th 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.

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

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:	See 5.1

Performed by:	Martin Müller	Date of test:	February 10, 2017
Result	☒ Test passed	☐ Test not passed	

6.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Laboratory environment	---	---	---
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002

6.1.2 Limits for digital transmission systems

None -> results recorded for information only.

6.1.3 Test results

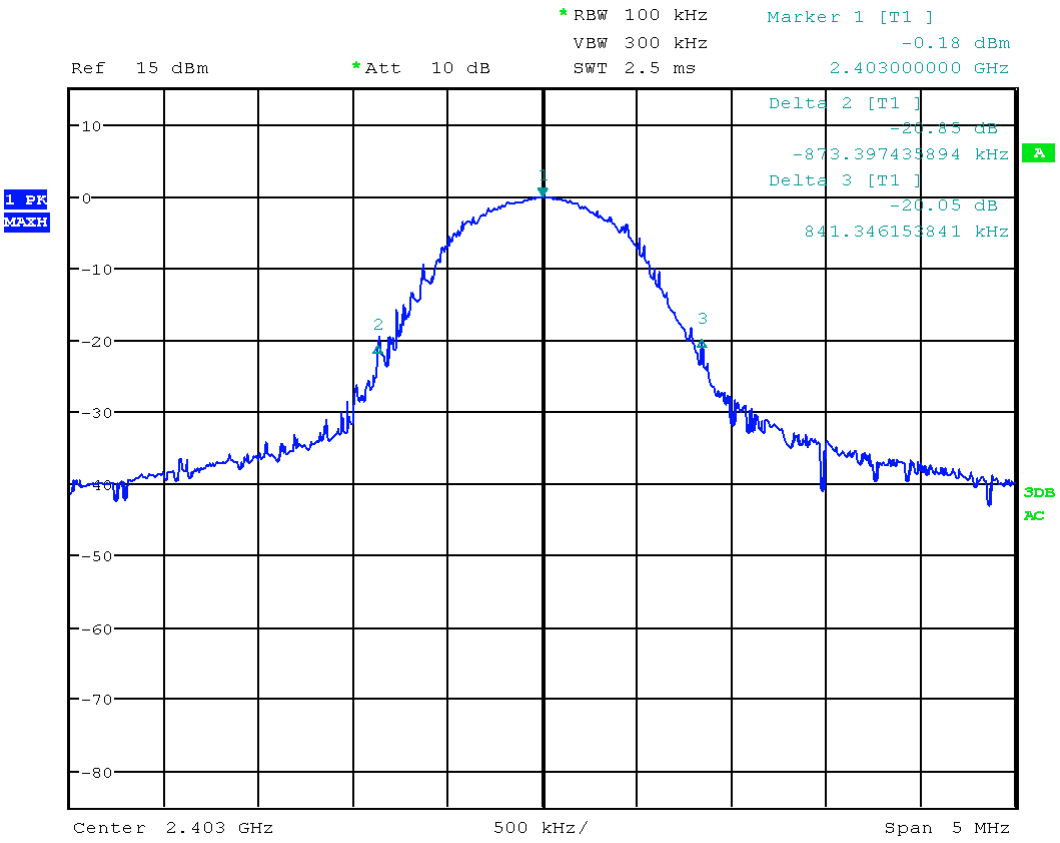


Figure 5: Chart of 20 dB bandwidth test, channel low

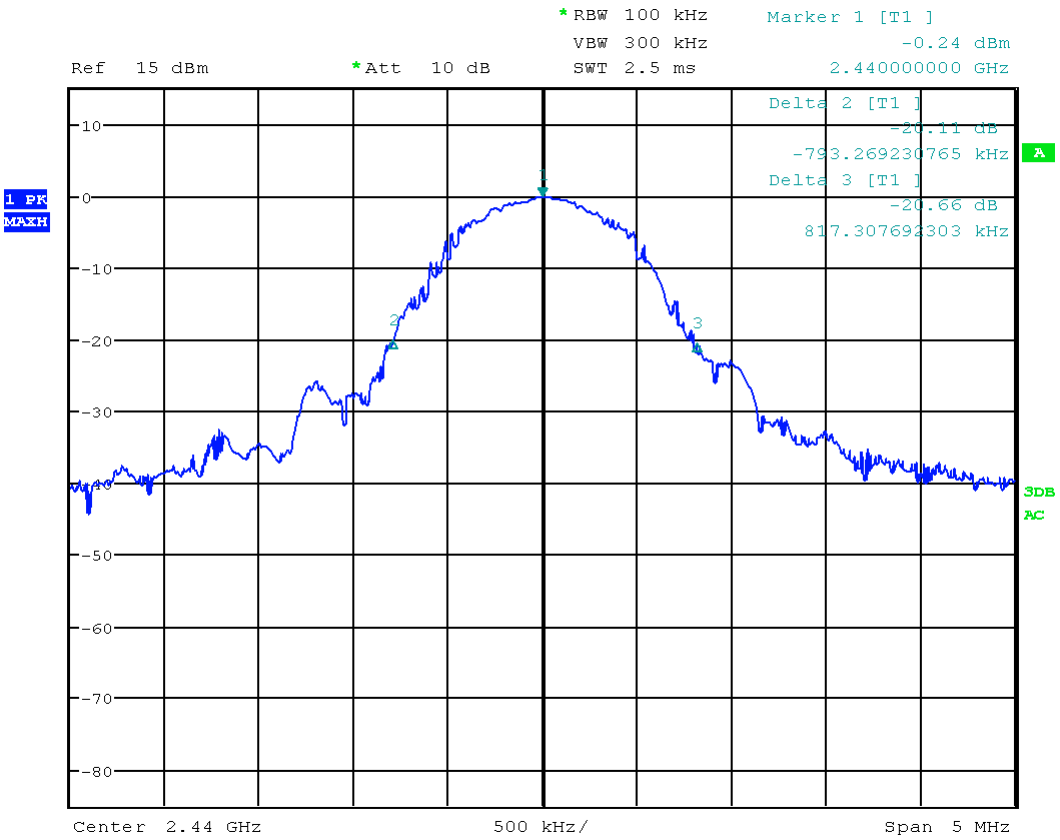


Figure 6: Chart of 20 dB bandwidth test, channel mid

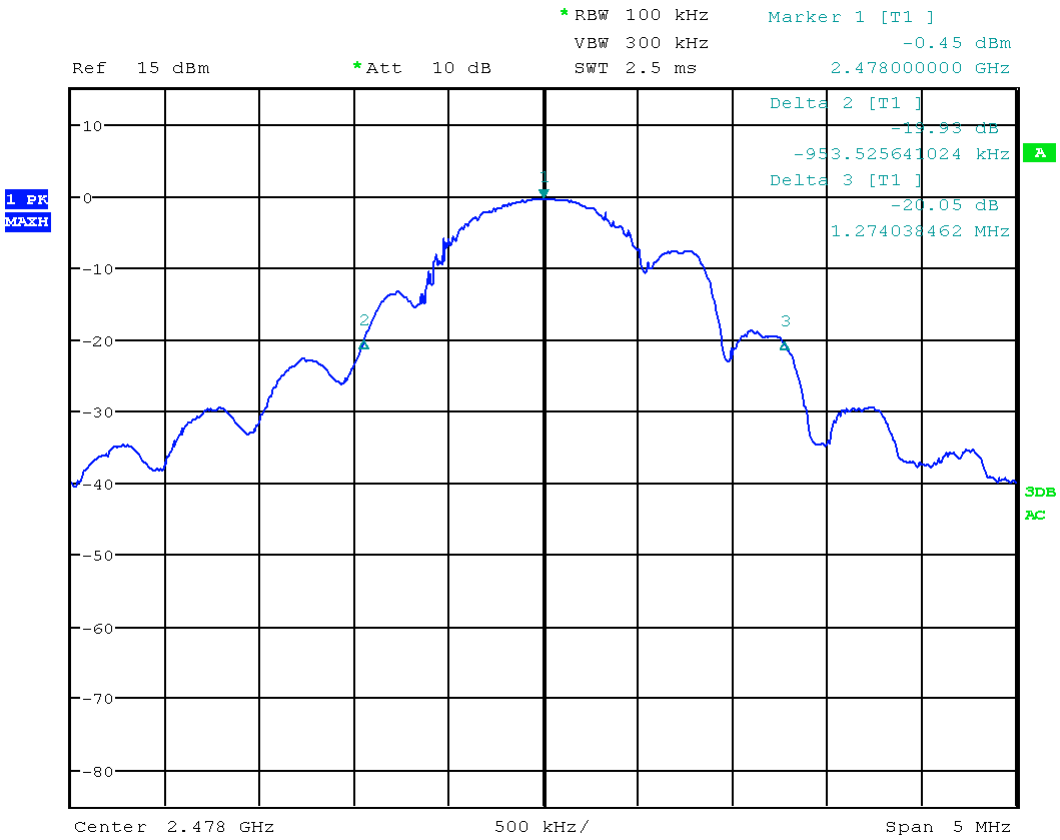


Figure 7: Chart of 20 dB bandwidth test, channel high

f [MHz]	20dB-BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2403.000	1.715	2402.126	2403.841	2400.0	2483.5	within band
2440.000	1.611	2439.206	2440.817	2400.0	2483.5	within band
2478.000	2.228	2477.046	2479.274	2400.0	2483.5	within band

Table 4: Final results of 20 dB bandwidth test

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:	See 5.2

Performed by:	Martin Müller	Date of test:	February 10, 2017
Result	☒ Test passed	☐ Test not passed	

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Laboratory environment	---	---	---
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002

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.

6.2.3 Test results

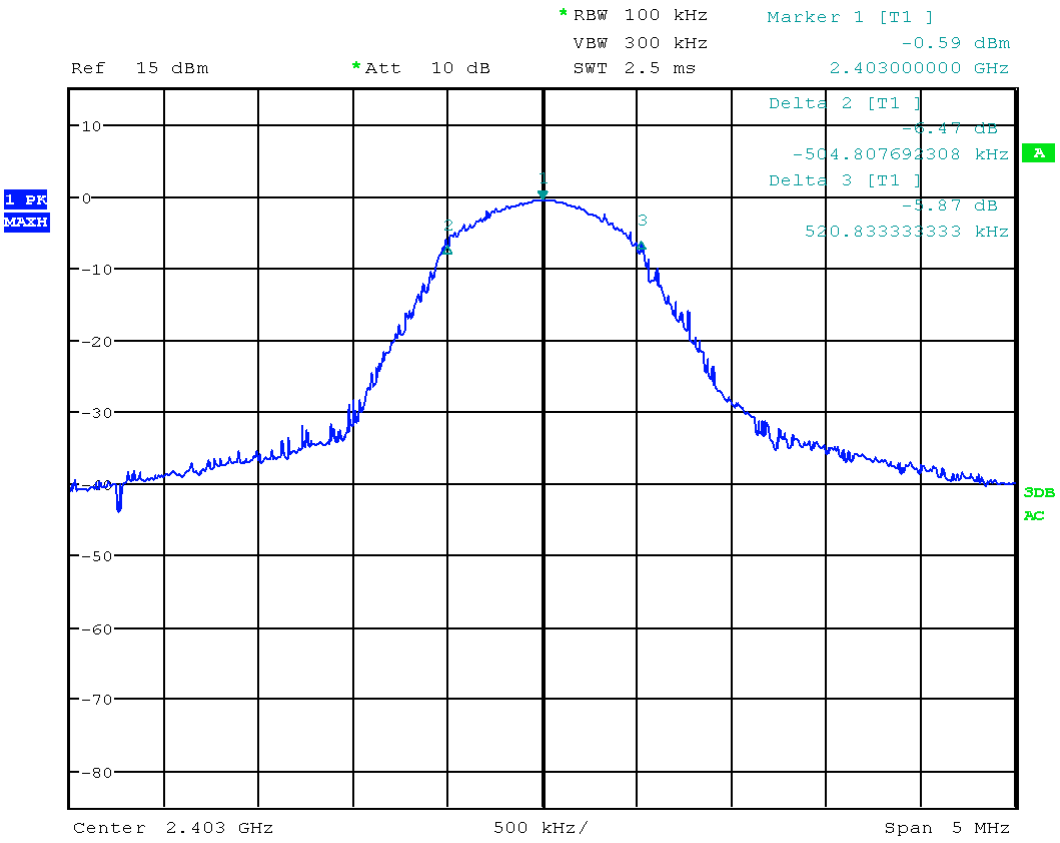


Figure 8: Chart of 6 dB bandwidth test, channel low

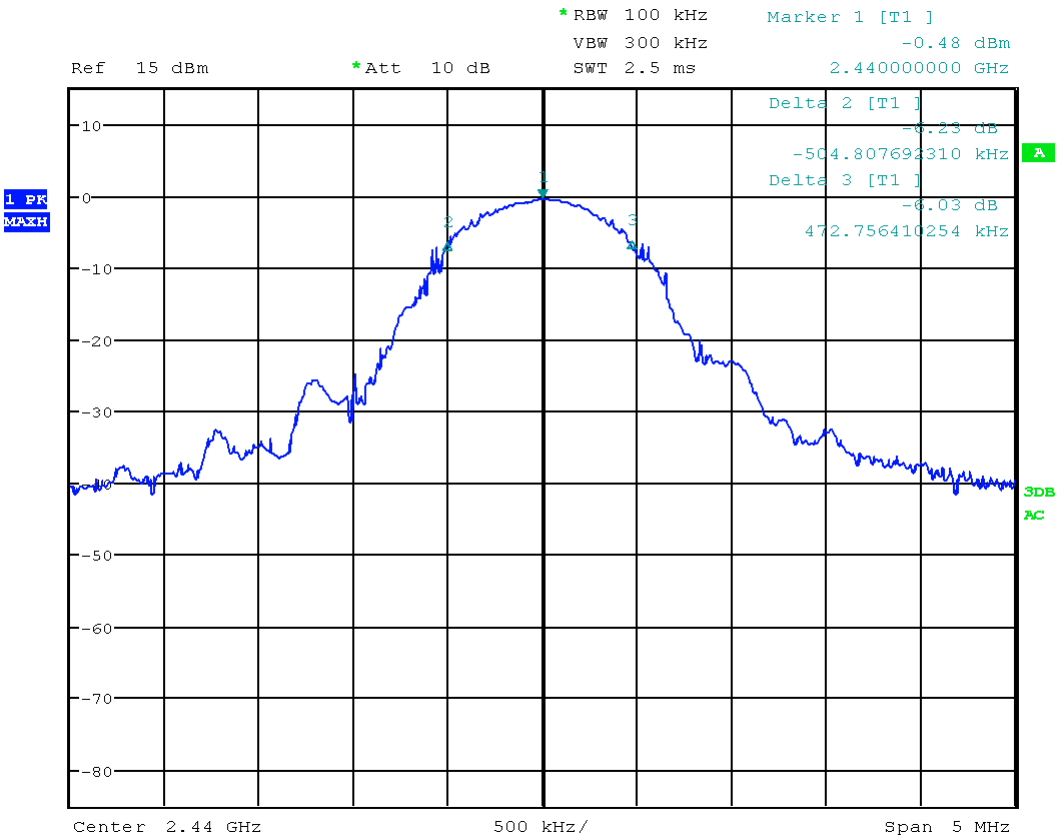


Figure 9: Chart of 6 dB bandwidth test, channel mid

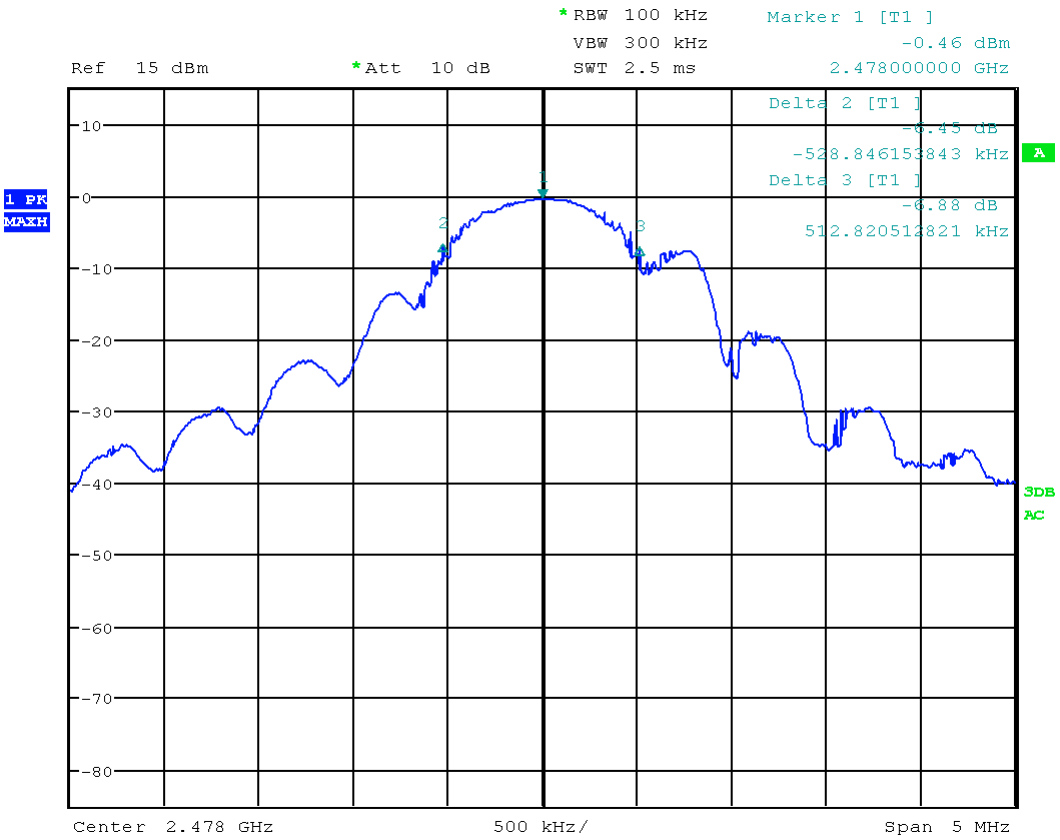


Figure 10: Chart of 6 dB bandwidth test, channel high

f [MHz]	6dB-BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2403.000	1.026	2402.495	2403.521	2400.0	2483.5	Pass
2440.000	0.978	2439.495	2440.473	2400.0	2483.5	Pass
2478.000	1.042	2477.471	2478.512	2400.0	2483.5	Pass

Table 5: Final results of 6 dB bandwidth test

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:	February 10, 2017
Result	☒ Test passed	☐ Test not passed	

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Laboratory environment	---	---	---
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002

6.3.2 Limits

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

6.3.3 Test results

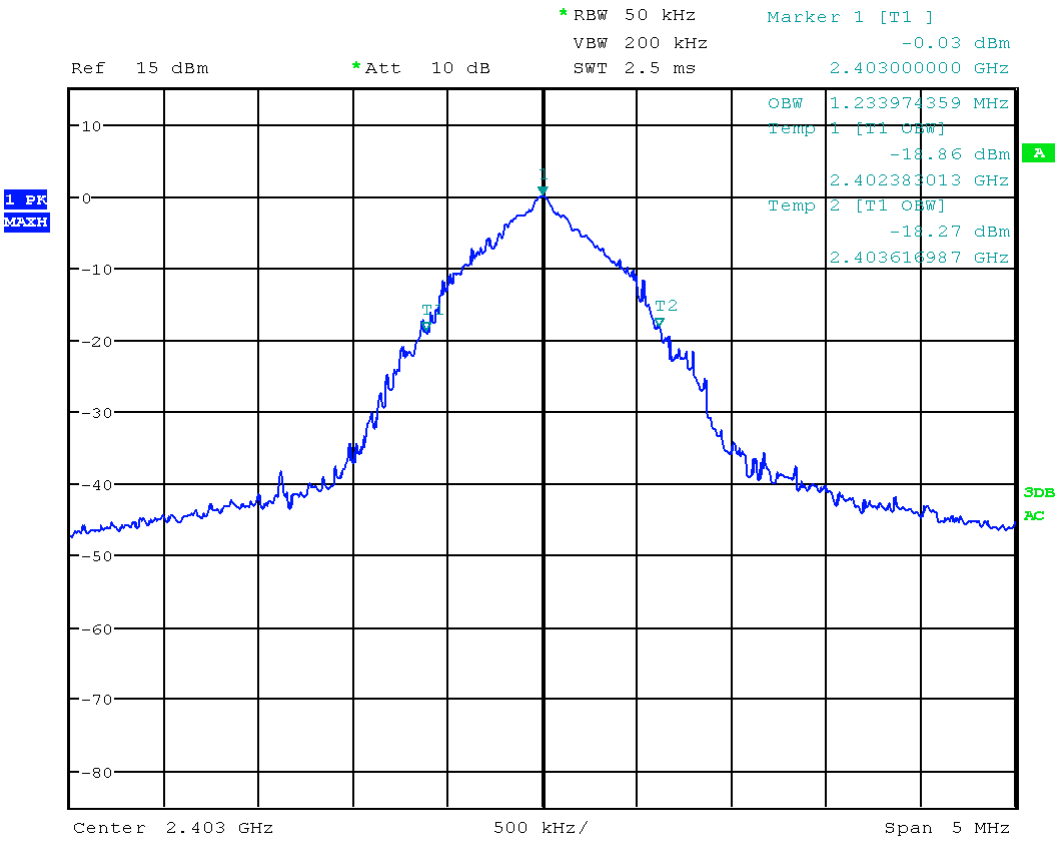


Figure 11: Chart of occupied bandwidth test, channel low

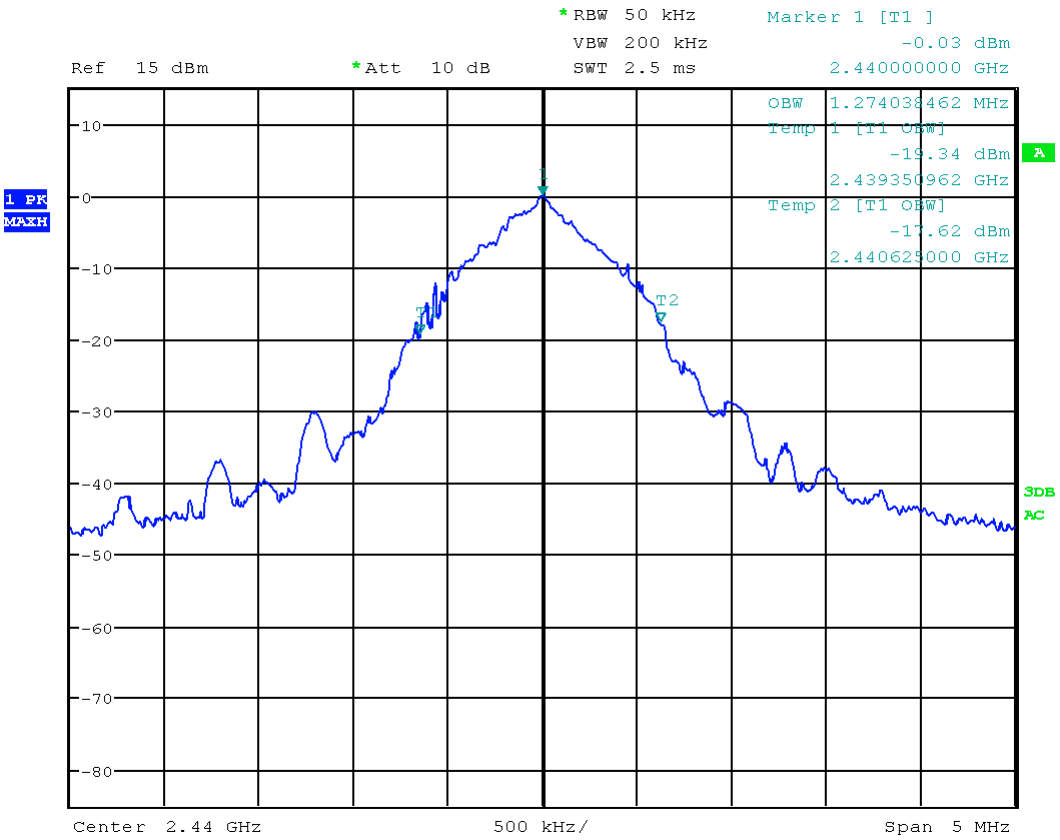


Figure 12: Chart of occupied bandwidth test, channel mid

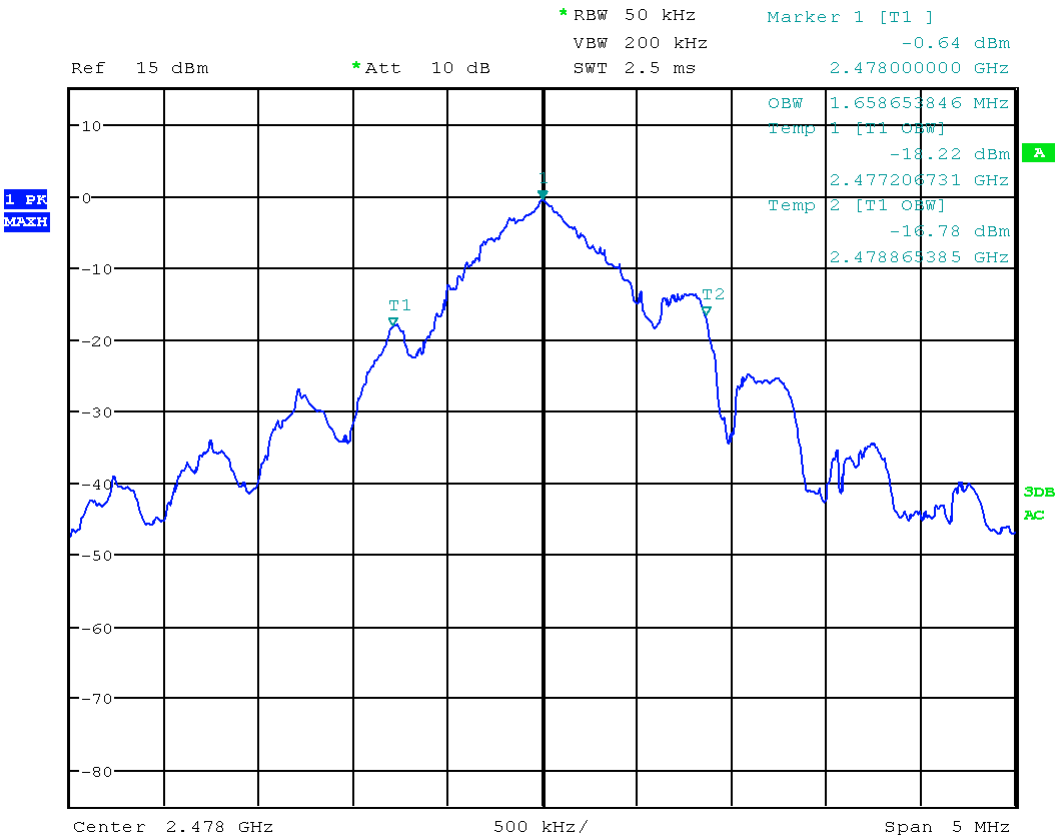


Figure 13: Chart of occupied bandwidth test, channel high

f [MHz]	Occ. BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2403.000	1.234	2402.383	2403.617	2400.0	2483.5	within band
2440.000	1.274	2439.351	2440.625	2400.0	2483.5	within band
2478.000	1.659	2477.206	2478.865	2400.0	2483.5	within band

Table 6: Final results of occupied bandwidth test

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:	See 5.4

Performed by:	Martin Müller	Date of test:	February 16, 2017
Result	☒ Test passed	☐ Test not passed	

6.4.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Laboratory environment	---	---	---
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002

6.4.2 Limits for digital transmission systems

1 watt (30 dBm)

6.4.3 Test results

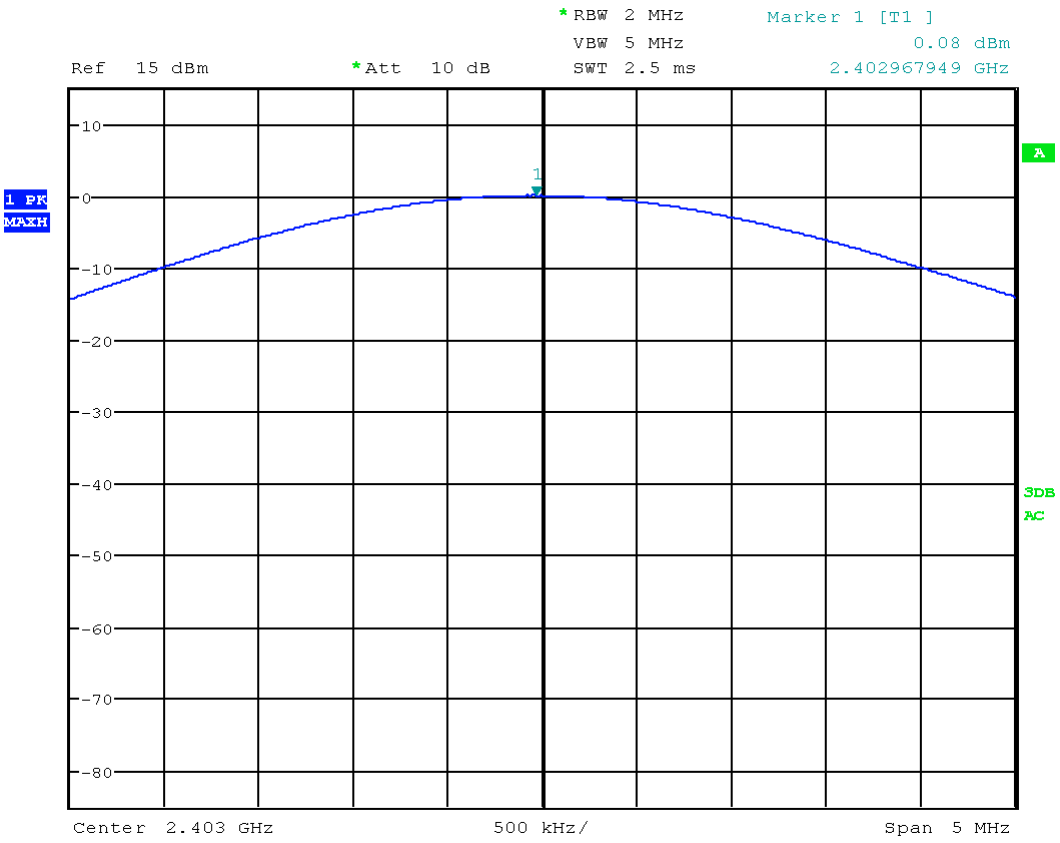


Figure 14: Chart of maximum conducted output power test, channel low

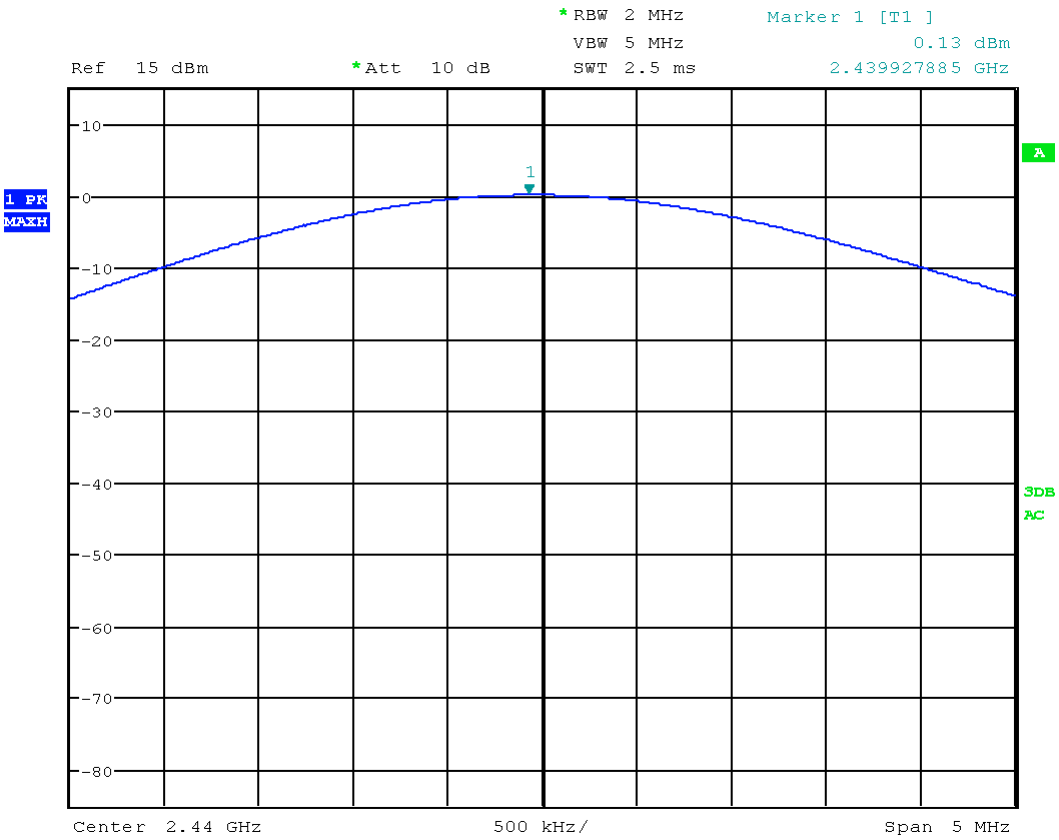


Figure 15: Chart of maximum conducted output power test, channel mid

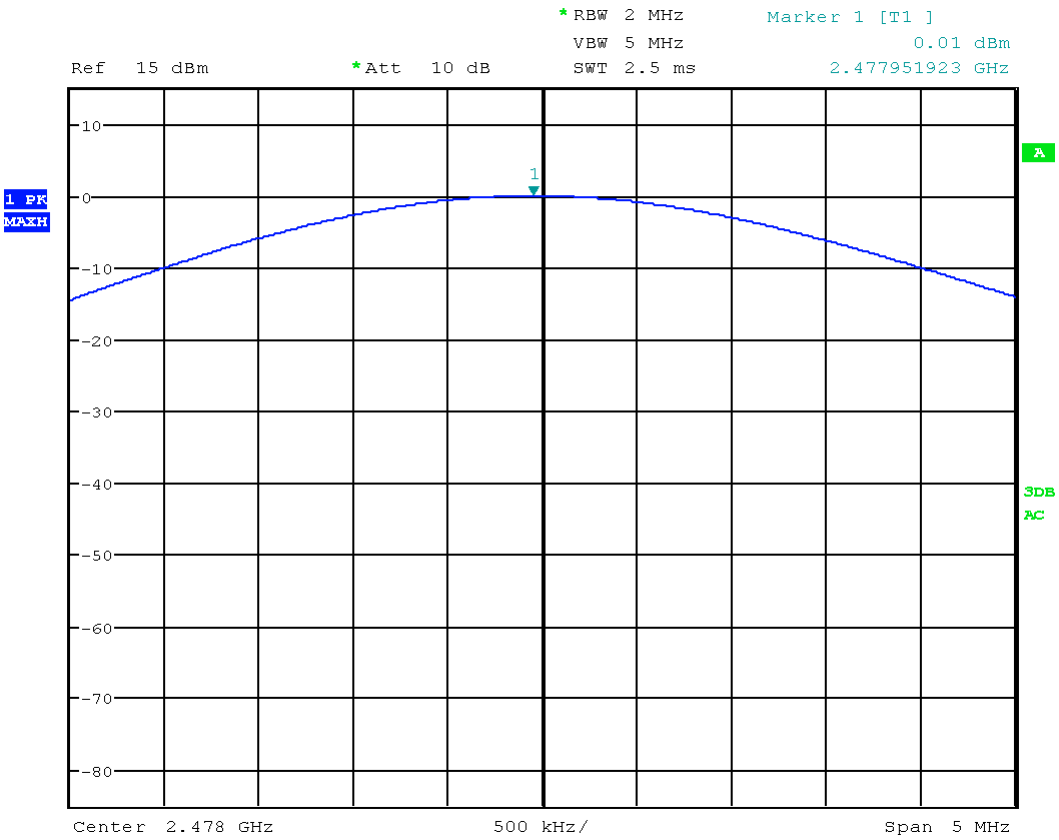


Figure 16: Chart of maximum conducted output power test, channel high

f [MHz]	P_{meas} [dBm]	$a_{testcable}$ [dB]	Maximum conducted output power [dBm]	Limit [dBm]	Result
2402.968	0.08	0.54	0.62	30.0	Pass
2439.928	0.13	0.55	0.68	30.0	Pass
2477.952	0.01	0.55	0.56	30.0	Pass

Table 7: Final results of maximum conducted output power test

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:	February 16, 2017
Result	☒ Test passed	☐ Test not passed	

6.5.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Laboratory environment	---	---	---
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002

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.

6.5.3 Test results

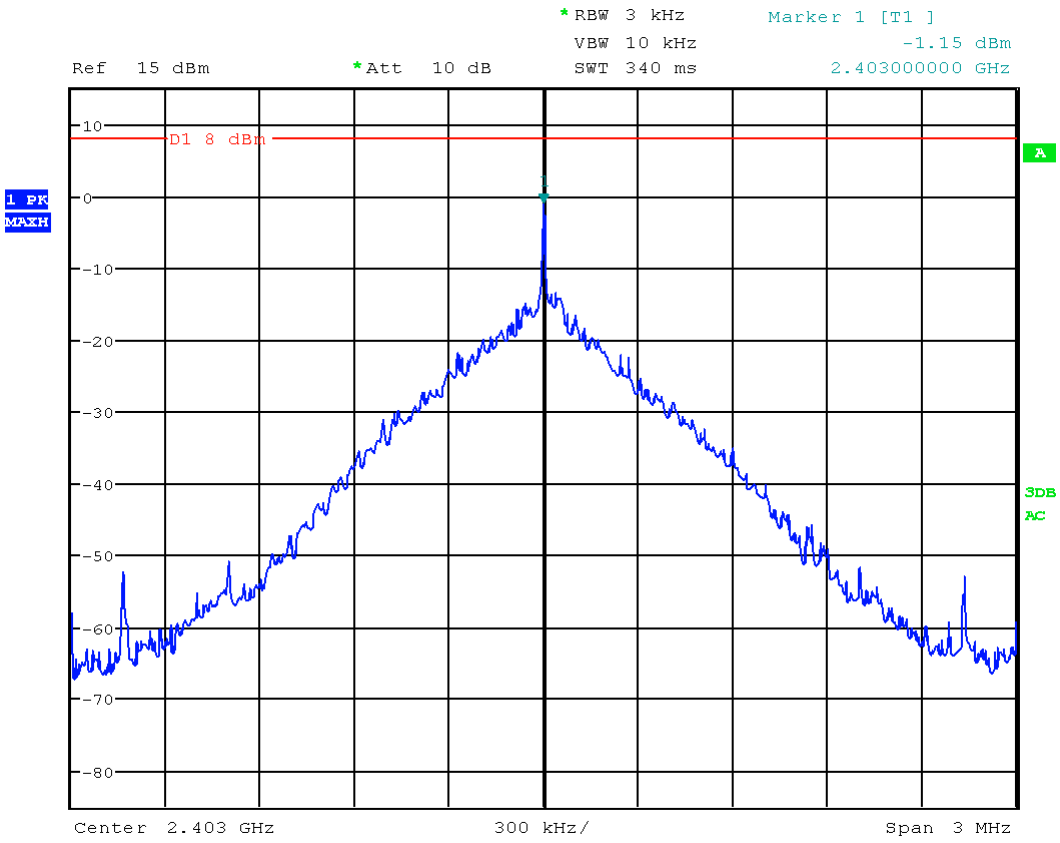


Figure 17: Chart of power spectral density test, channel low - complete carrier

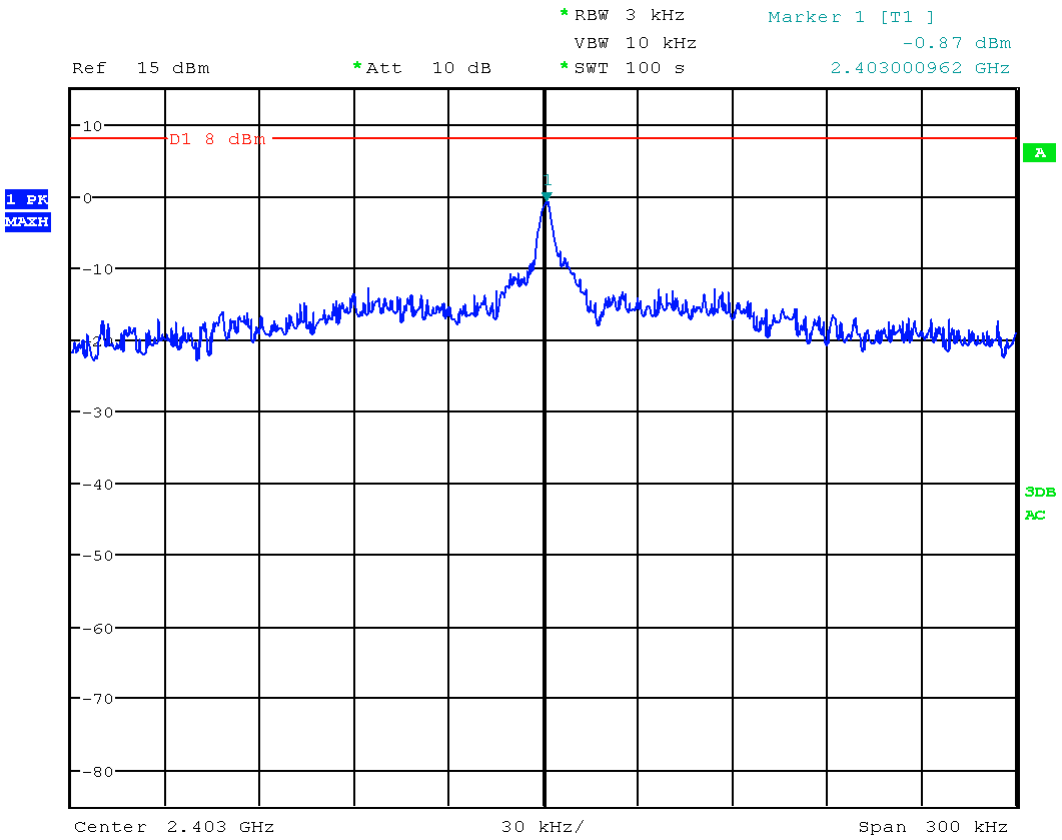


Figure 18: Chart of power spectral density test, channel low - zoom to maximum

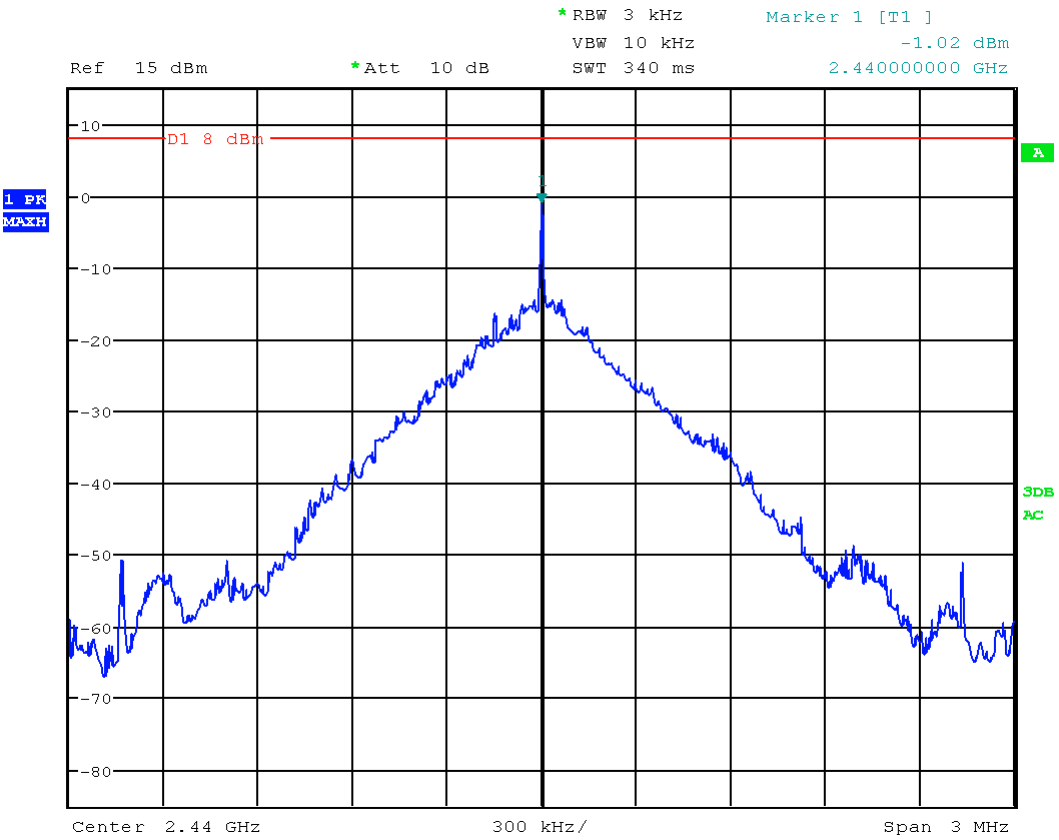


Figure 19: Chart of power spectral density test, channel mid - complete carrier

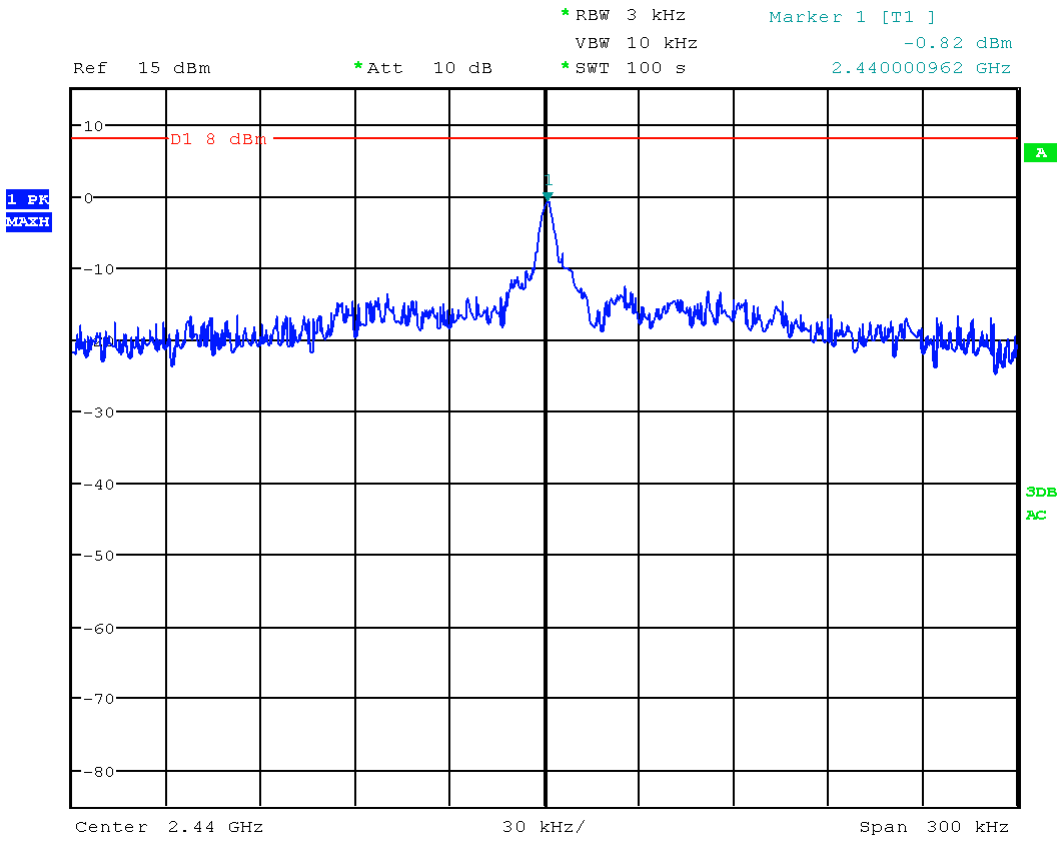


Figure 20: Chart of power spectral density test, channel mid - zoom to maximum

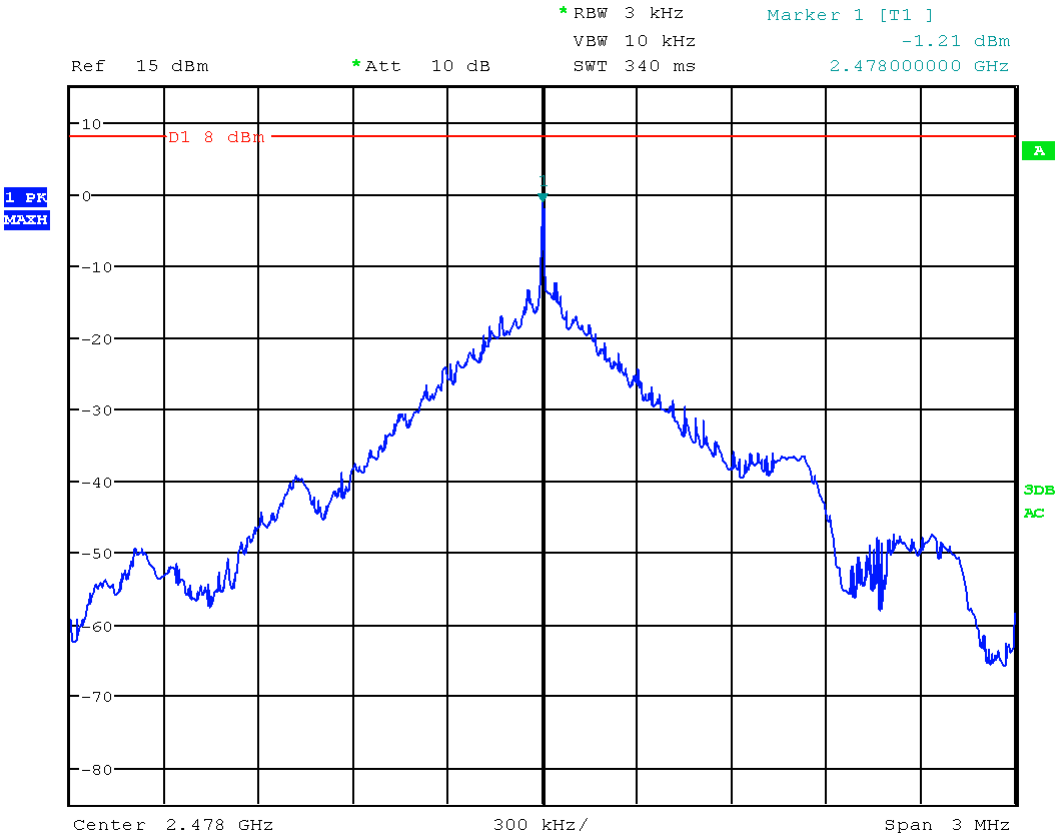


Figure 21: Chart of power spectral density test, channel high - complete carrier

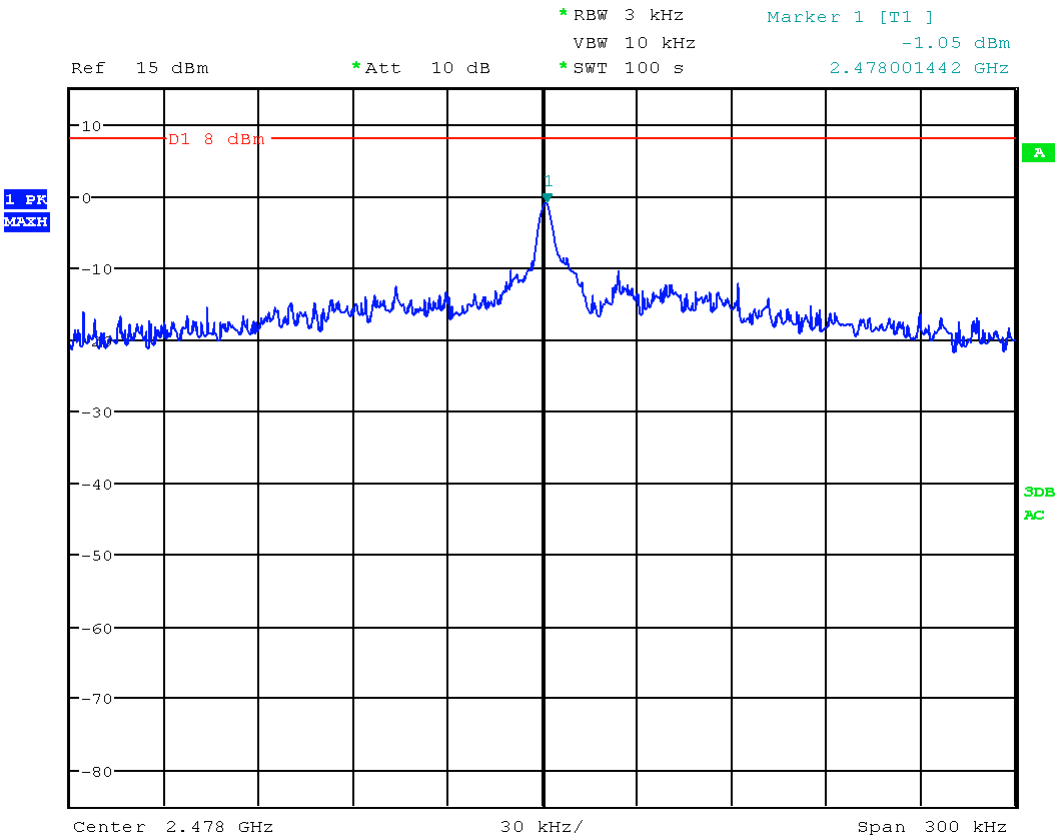


Figure 22: Chart of power spectral density test, channel high - zoom to maximum

f [MHz]	P_{meas} [dBm]	$a_{testcable}$ [dB]	Power spectral density [dBm / 3 kHz]	Limit [dBm / 3 kHz]	Result
2403.001	-0.87	0.54	-0.33	8.0	Pass
2440.001	-0.82	0.55	-0.27	8.0	Pass
2478.001	-1.05	0.55	-0.50	8.0	Pass

Table 8: Final results of power spectral density test

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:	February 16, 2017
Result	☒ Test passed	☐ Test not passed	

6.6.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open Area Test Site (OATS)	---	EMV **TESTHAUS** GmbH	E00354
☐	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS** GmbH	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☐	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	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 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00055
☐	Measurement software	E10	ib comPLAN	E00443
☐	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.6.2 Limits

< -20 dBc outside restricted bands
< 54 dBµV/m (average detector) inside restricted bands
< 74 dBµV/m (peak detector) inside restricted bands

6.6.3 Test results

Test distance:	Prescan:	☐ 1 m	☒ 3 m	☐ ….. m
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☐ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
2.30 GHz – 2.51 GHz	250 kHz	1 MHz	PK	PK	100 ms	100 ms	30 dB
2.30 GHz – 2.51 GHz	250 kHz	1 MHz	AV	AV	100 ms	100 ms	30 dB

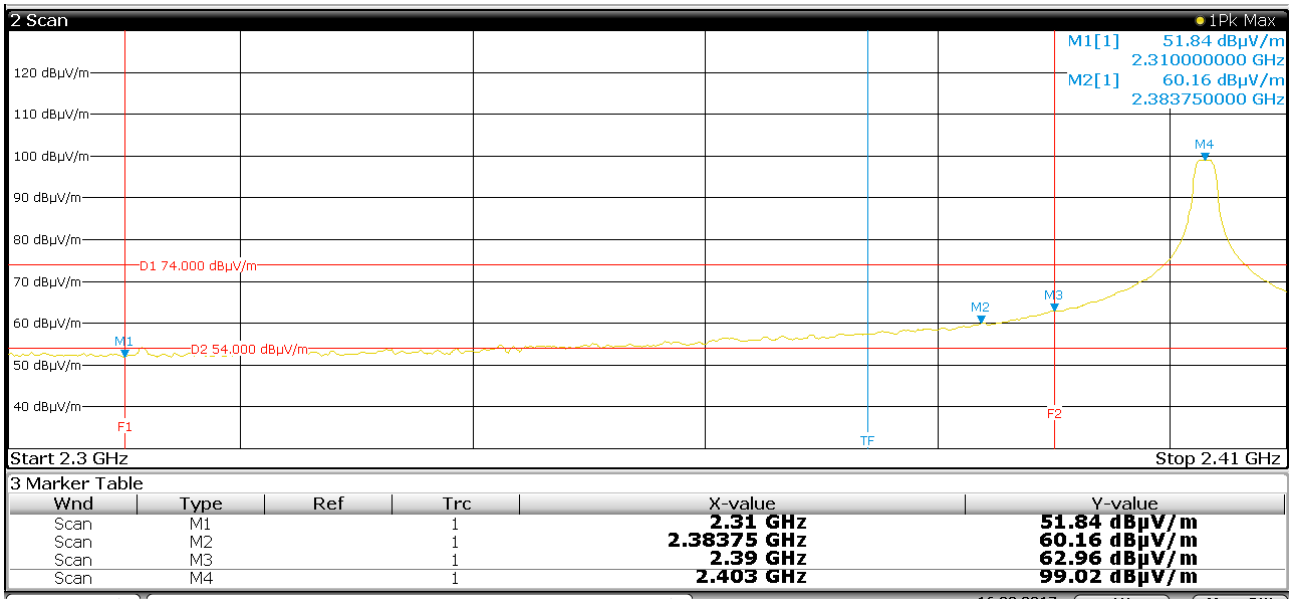


Figure 23: Chart of band edge compliance test, lower band edge - PK

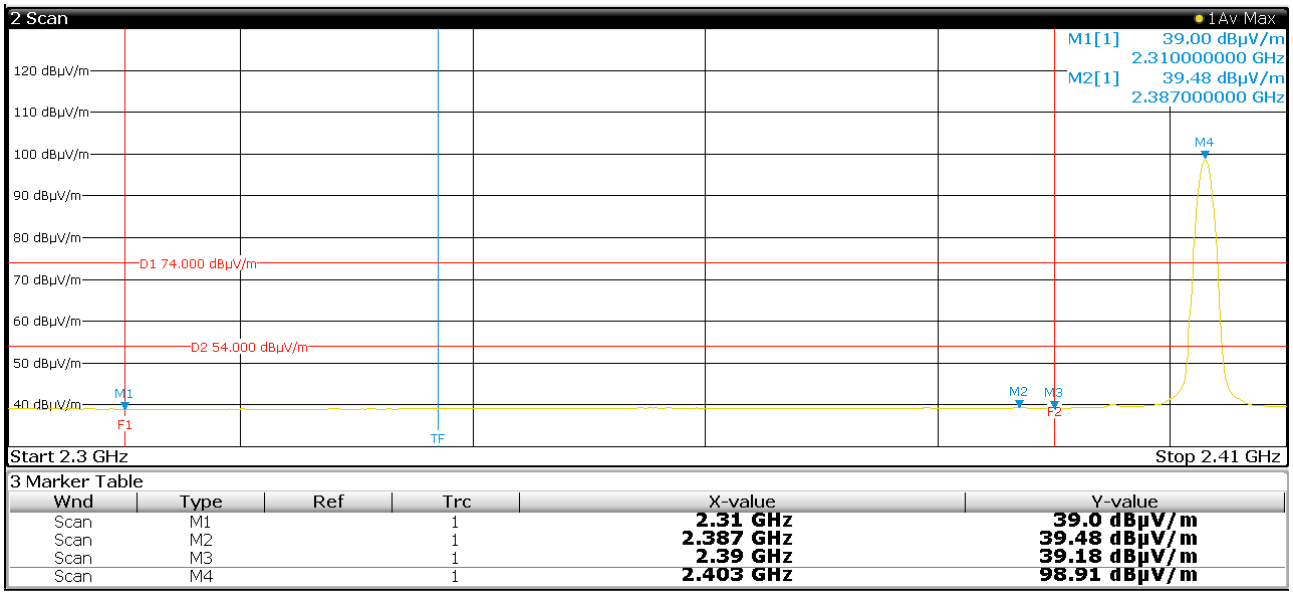
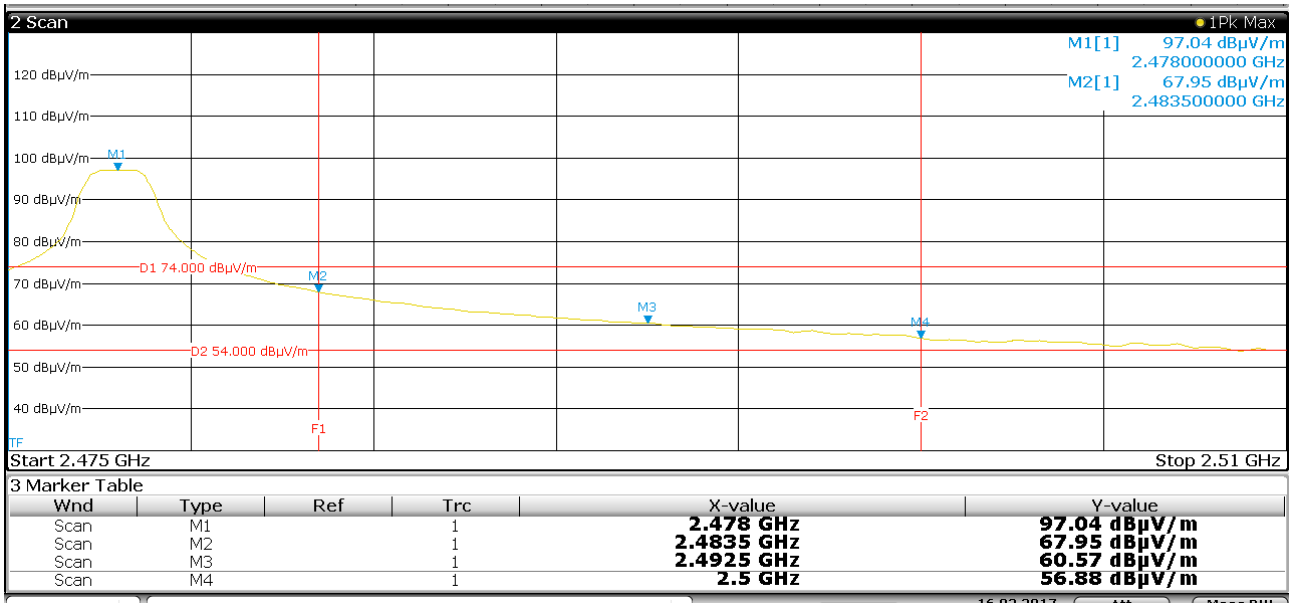


Figure 24: Chart of band edge compliance test, lower band edge - AV

f[MHz]	E_{meas} [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2310.000	51.84	PK	Yes	74	Pass
2310.000	39.00	AV		54	Pass
2383.750	60.16	PK		74	Pass
2387.000	39.48	AV		54	Pass
2390.000	62.96	PK		74	Pass
2390.000	39.18	AV		54	Pass
2403.000	99.02	PK	No	----	Carrier
2403.000	98.81	AV		----	Carrier

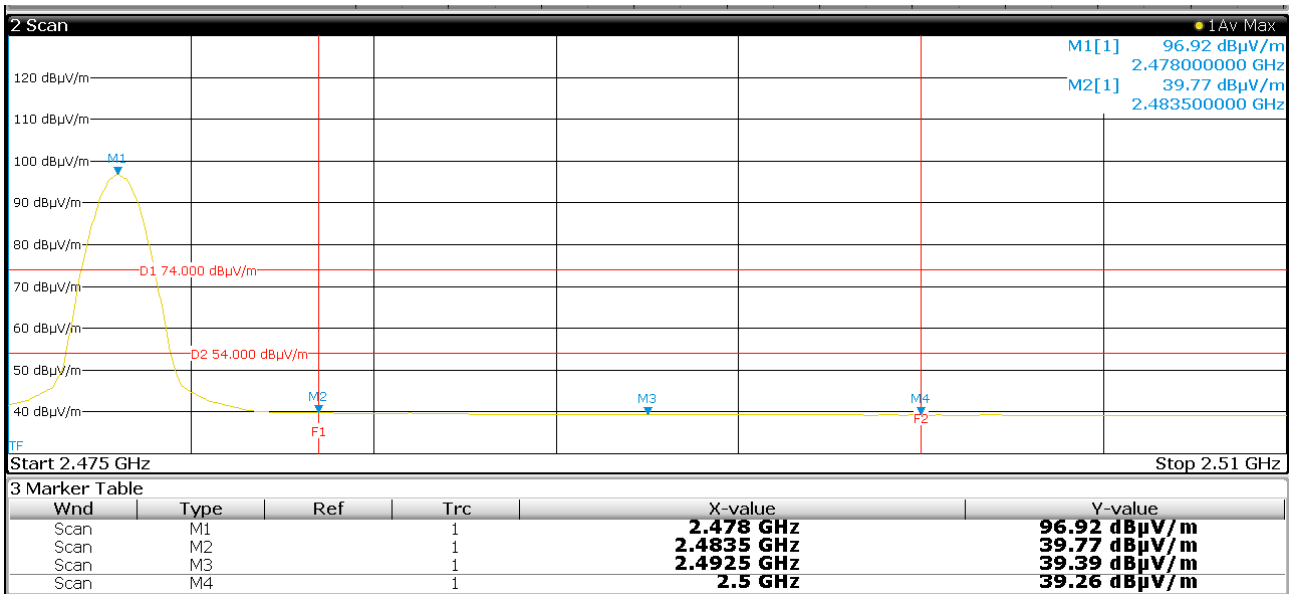
Table 9: Final result of band edge compliance test, lower band edge



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	2.478 GHz	97.04 dBµV/m
Scan	M2		1	2.4835 GHz	67.95 dBµV/m
Scan	M3		1	2.4925 GHz	60.57 dBµV/m
Scan	M4		1	2.5 GHz	56.88 dBµV/m

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



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	2.478 GHz	96.92 dBµV/m
Scan	M2		1	2.4835 GHz	39.77 dBµV/m
Scan	M3		1	2.4925 GHz	39.39 dBµV/m
Scan	M4		1	2.5 GHz	39.26 dBµV/m

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

f[MHz]	E_{meas} [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2478.000	97.04	PK	No	----	Carrier
2478.000	96.92	AV		----	Carrier
2483.500	67.95	PK	Yes	74	Pass
2483.500	39.77	AV		54	Pass
2492.500	60.57	PK		74	Pass
2492.500	39.39	AV		54	Pass
2500.000	56.88	PK		74	Pass
2500.000	39.26	AV		54	Pass

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

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 2, 2017
Result	☒ Test passed	☐ Test not passed	

6.7.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	Open Area Test Site (OATS)	---	EMV **TESTHAUS** GmbH	E00354
☐	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS** GmbH	E00100
☒	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☒	Preamplifier	AMF-6F-16002650	Miteq	W00090
☒	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☒	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 9120D	Schwarzbeck	W00053
☒	Horn antenna	BBHA 9170	Schwarzbeck	W00055
☒	Measurement software	E10	ib comPLAN	E00443
☐	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.7.2 Limits < 1 GHz

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

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

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

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

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

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

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

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

6.7.3 Limits > 1 GHz

< -20 dBc outside restricted bands
< 54d BµV/m (average detector) inside restricted bands
< 74d BµV/m (peak detector) inside restricted bands

6.7.4 Test results from 9 kHz to 30 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☐ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☐ Position 1	☐ Position 2	☒ Position 3	

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off

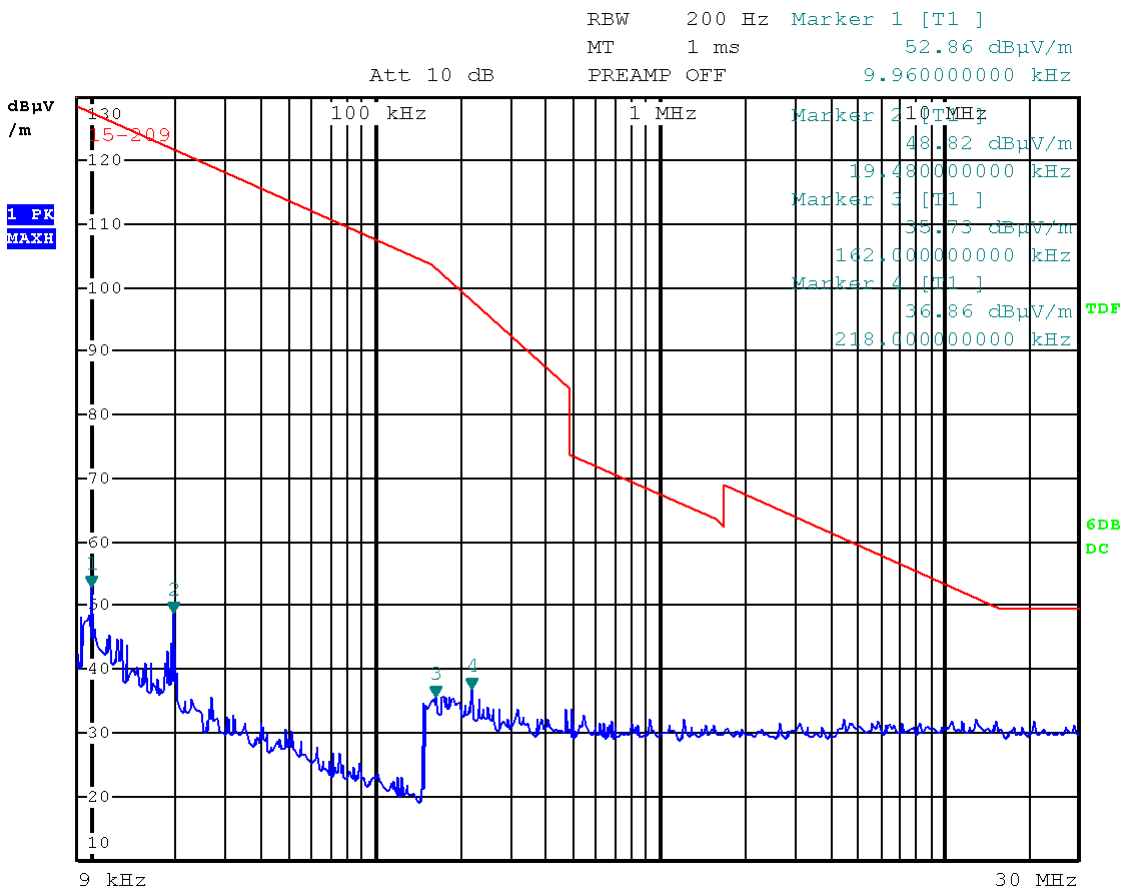


Figure 27: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel low

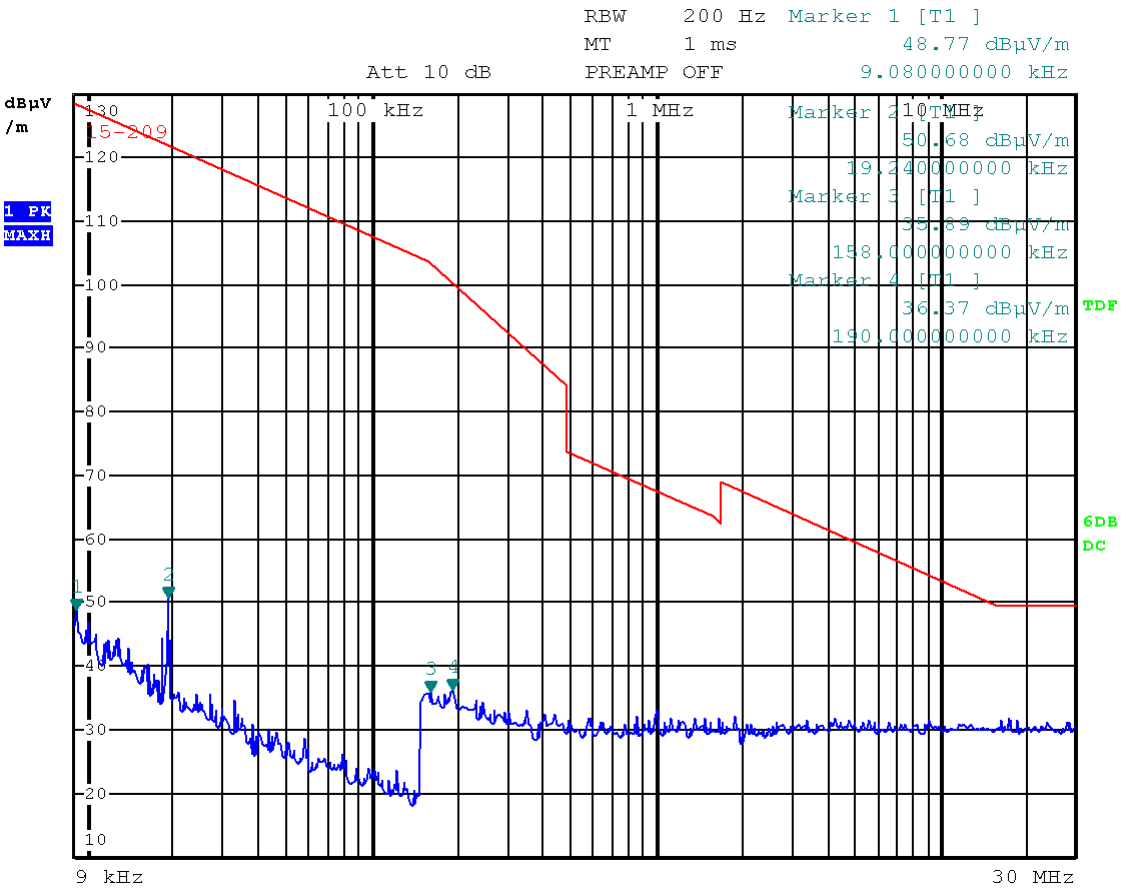


Figure 28: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel mid

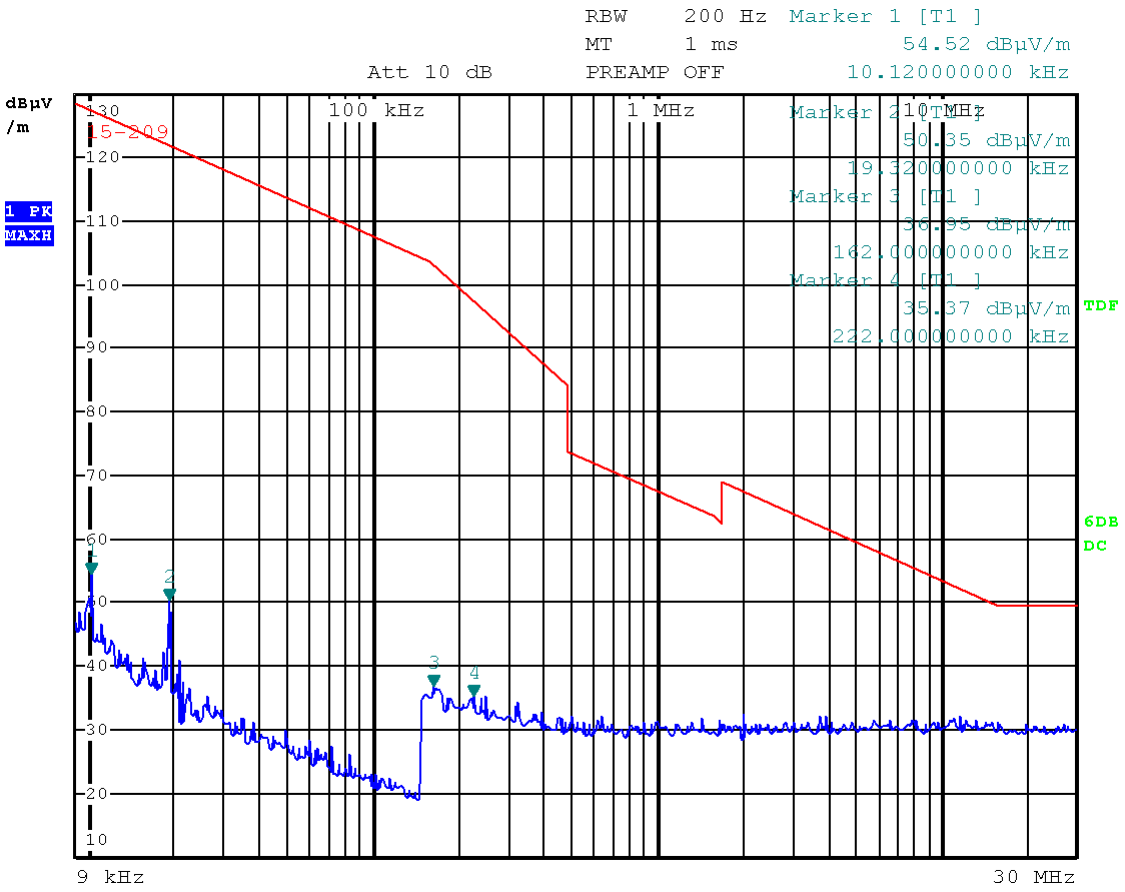


Figure 29: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel high

6.7.5 Test results from 30 MHz to 1 GHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☐ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☐ Position 2	☒ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
30 MHz – 1 GHz	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB

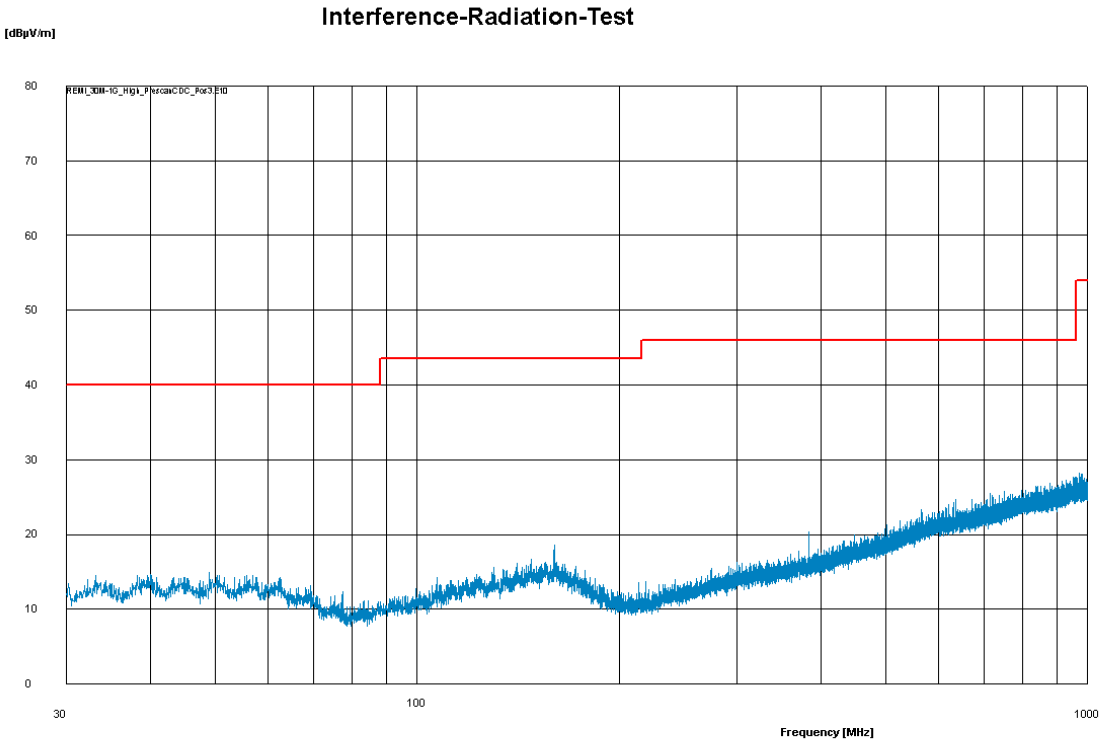


Figure 30: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel low

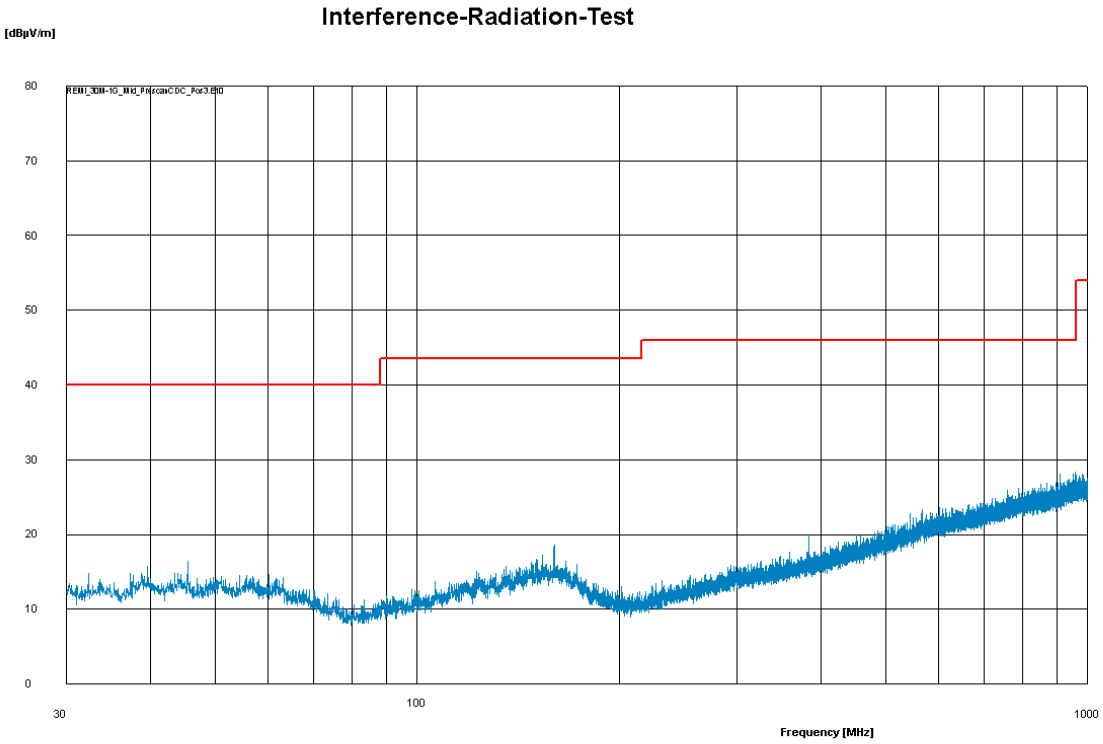


Figure 31: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel mid

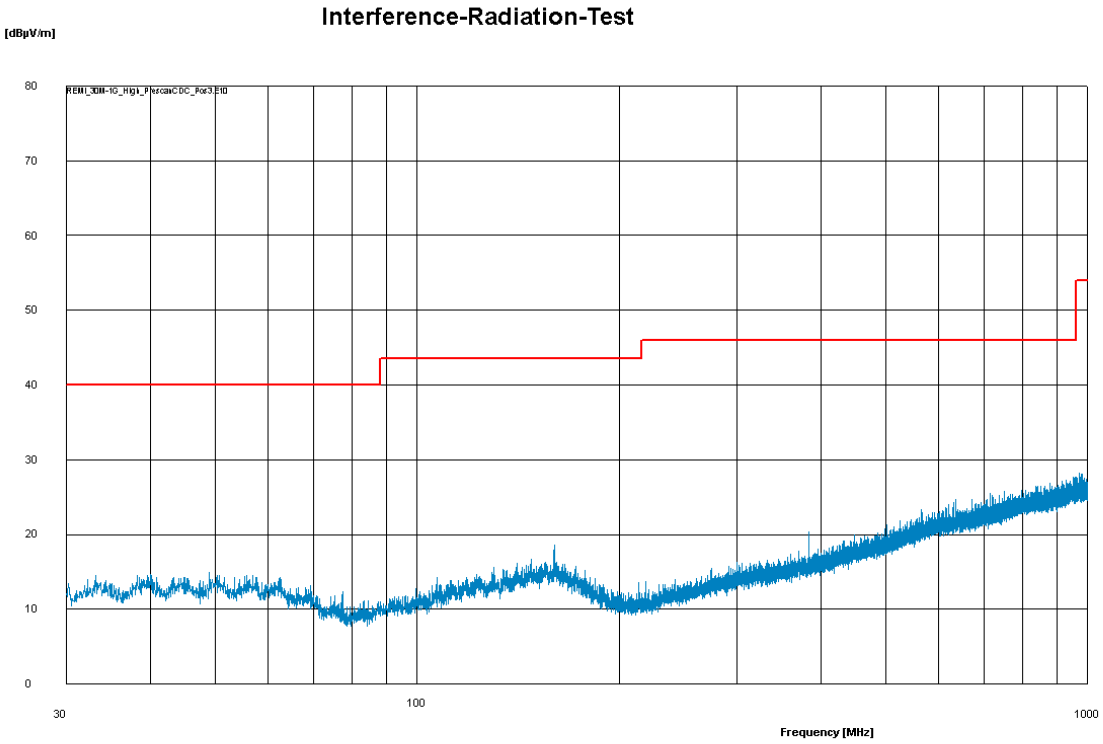


Figure 32: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel high

6.7.6 Test results from 1 GHz to 10th harmonic

Test distance:	Prescan:	☒ 1 m	☒ 3 m	☐ ….. m
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☒ Position 1	☒ Position 2	☒ Position 3	

Frequency range	*Step size*	*IF Band-width*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
1 GHz – 26 GHz	250 kHz	1 MHz	PK	PK	100 ms	100 ms	30 dB
1 GHz – 26 GHz	250 kHz	1 MHz	AV	AV	100 ms	100 ms	30 dB

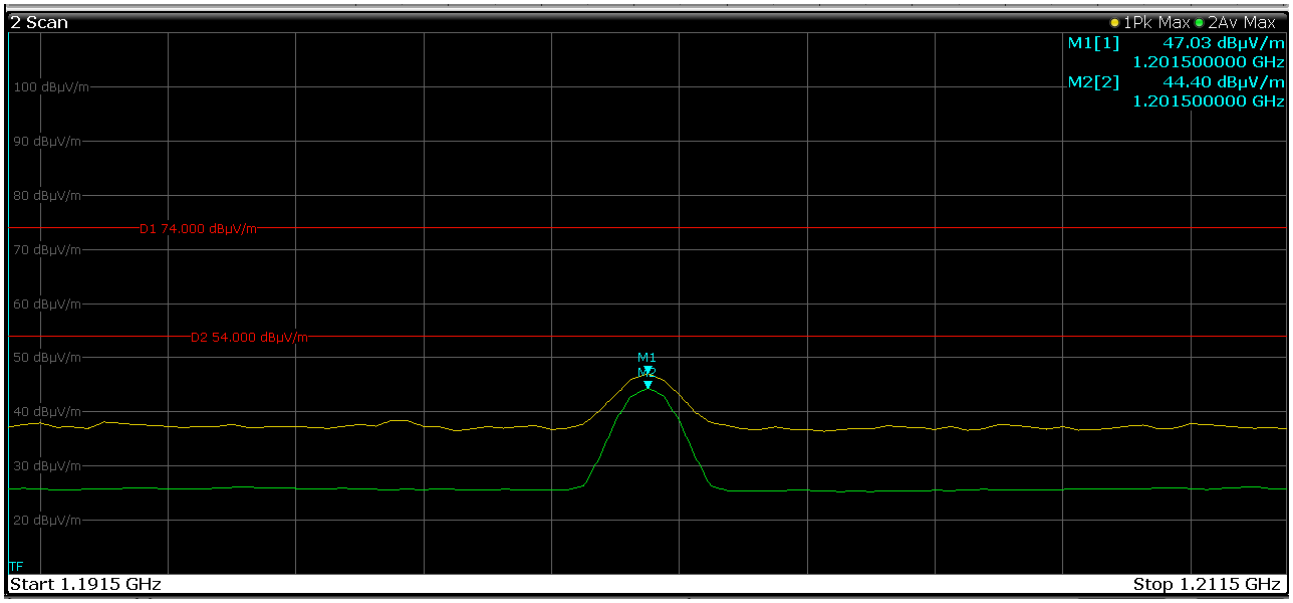


Figure 33: 1st Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel low

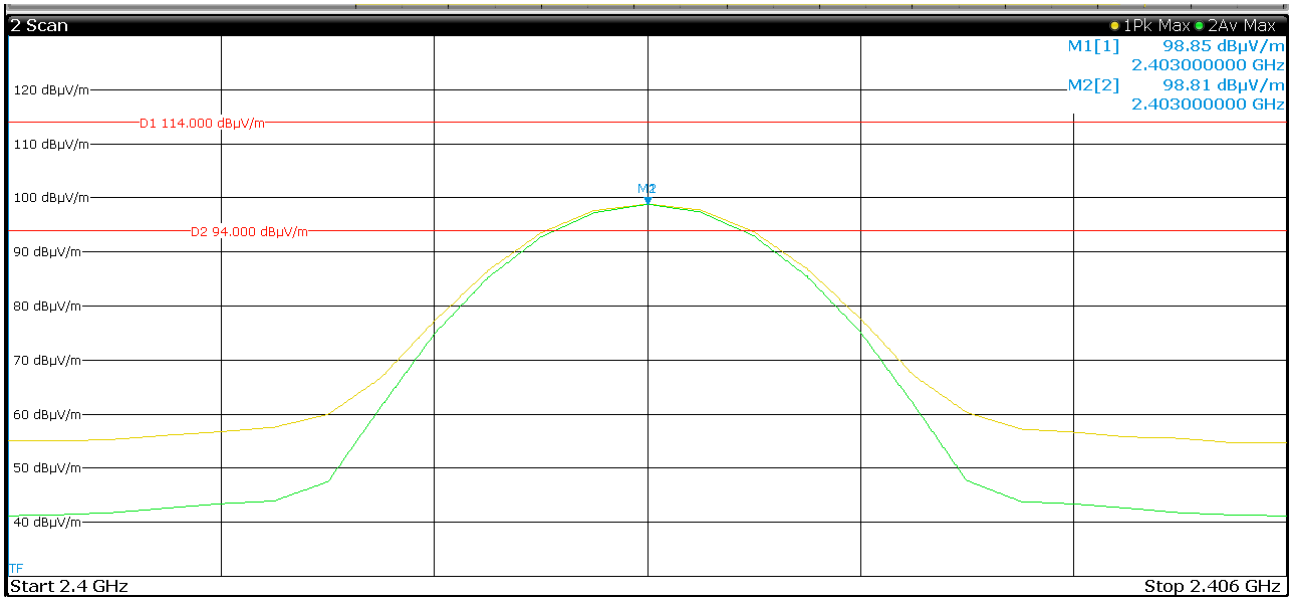


Figure 34: 2nd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel low

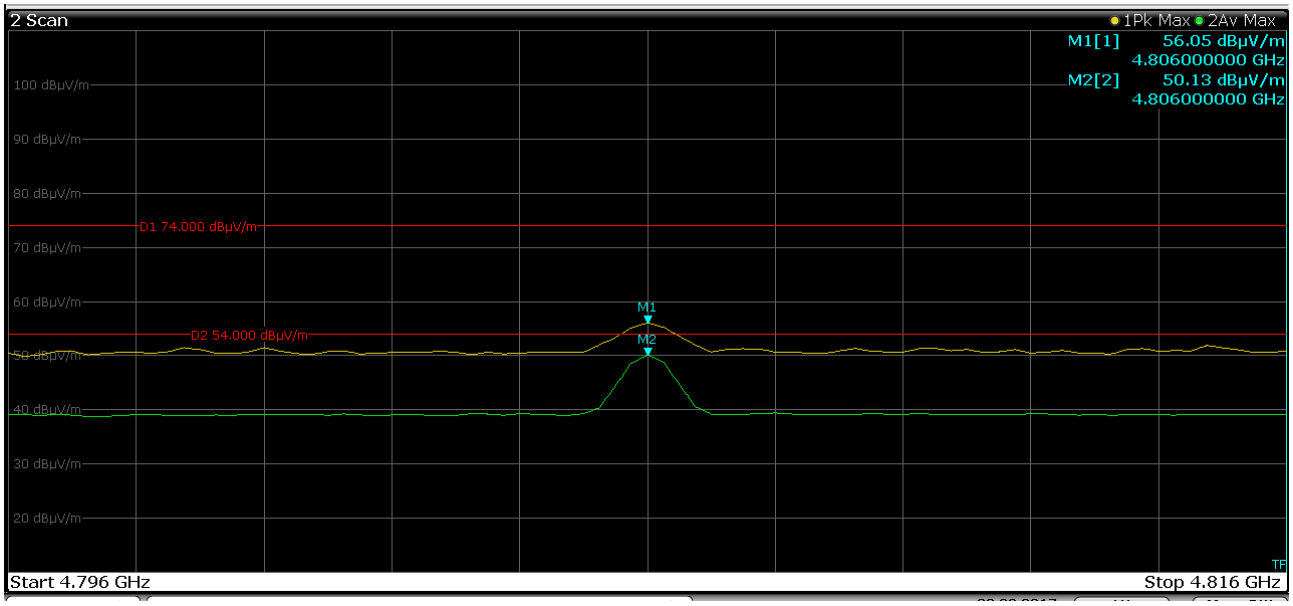


Figure 35: 3rd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel low

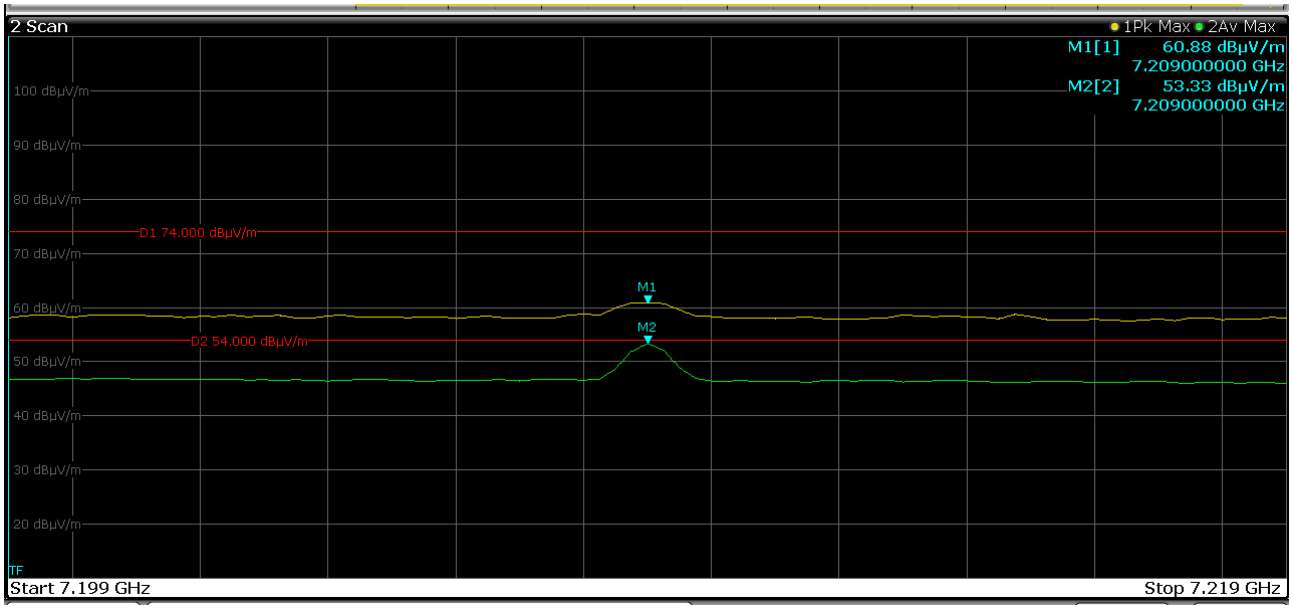


Figure 36: 4th Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel low

Channel low									
f[GHz]	**E_{meas} [dBµV/m]**	**EUT-Pos**	**Polari-zation**	**Table [°]**	**Height [cm]**	**Detector**	**Restr. Band**	**Limit [dBµV/m]**	**Result**
1.2015	47.03	2	H	181	145	PK	Yes	74	Pass
1.2015	44.40					AV		54	Pass
2.4030	98.85	2	H	190	148	PK	No	---	Carrier
2.4030	98.81					AV		---	Carrier
4.8060	56.05	1	H	152	172	PK	Yes	74	Pass
4.8060	50.13					AV		54	Pass
7.2090	60.88	3	H	71	173	PK	No	-20 dBc	Pass
7.2090	53.33					AV		-20 dBc	Pass

Table 11: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel low

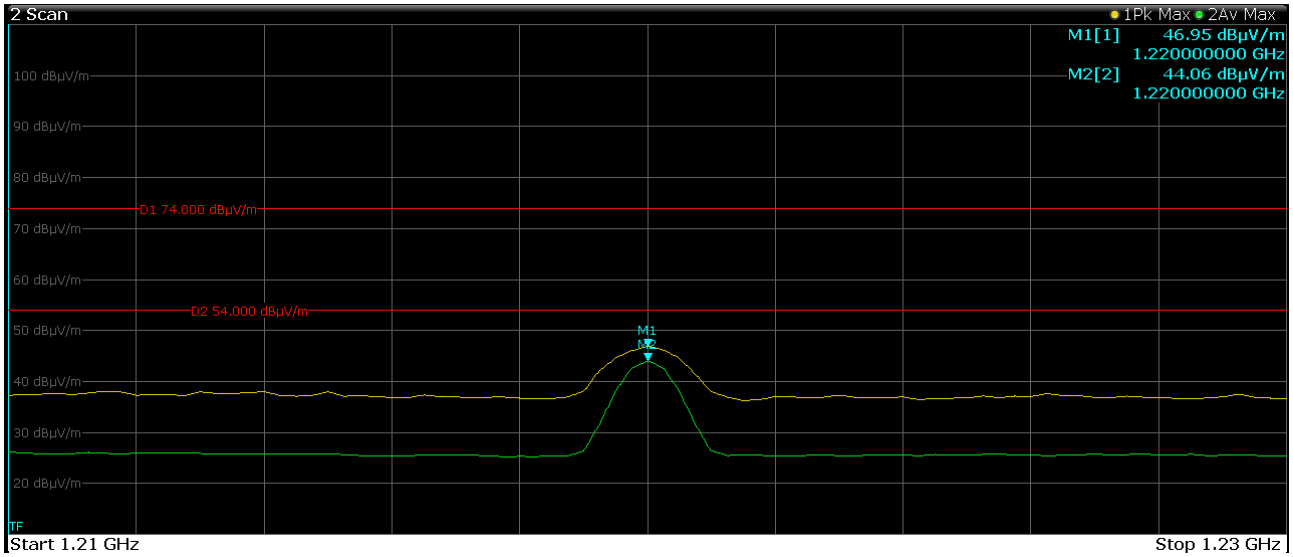


Figure 37: 1st Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel mid

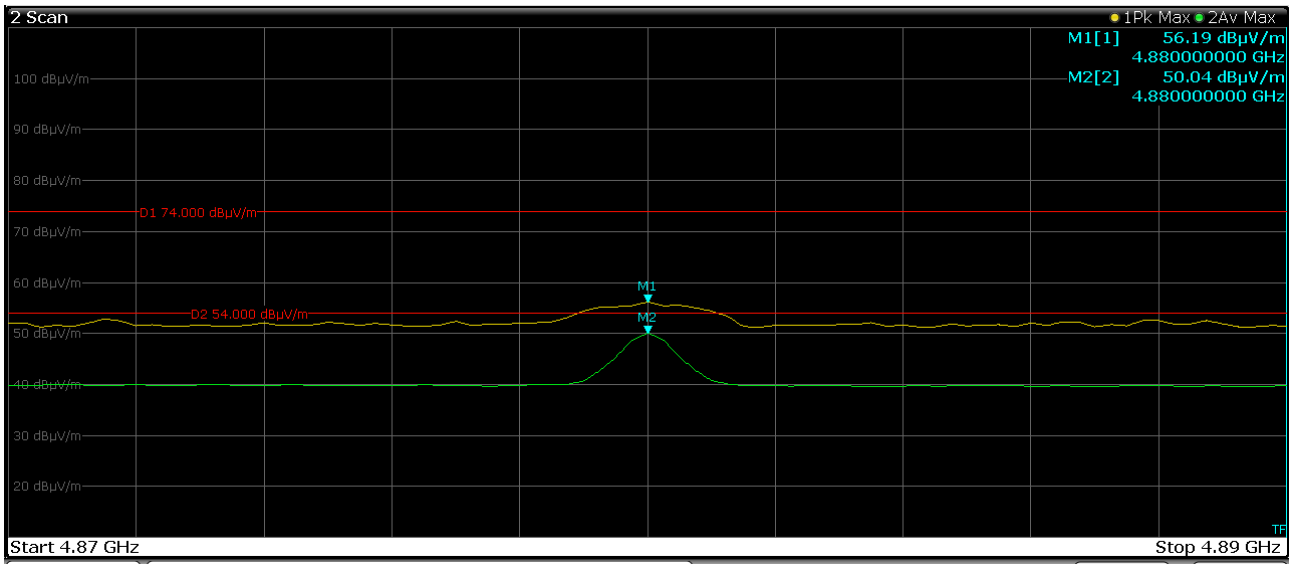


Figure 38: 2nd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel mid

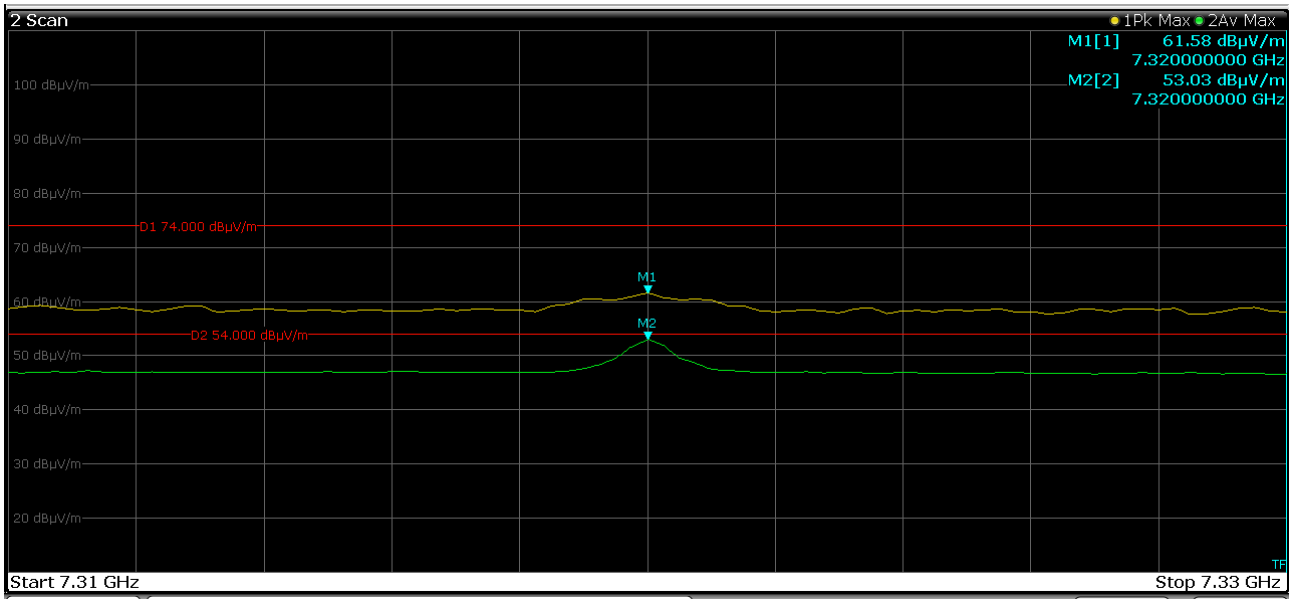


Figure 39: 3rd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel mid

Channel mid									
f[GHz]	**E_{meas} [dBµV/m]**	**EUT-Pos**	**Polari-zation**	**Table [°]**	**Height [cm]**	**Detector**	**Restr. Band**	**Limit [dBµV/m]**	**Result**
1.2200	46.95	2	H	172	185	PK	Yes	74	Pass
1.2200	44.06					AV		54	Pass
4.8800	56.19	1	H	154	176	PK	Yes	74	Pass
4.8800	50.04					AV		54	Pass
7.3200	61.58	3	H	67	175	PK	Yes	74	Pass
7.3200	53.03					AV		54	Pass

Table 12: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel mid

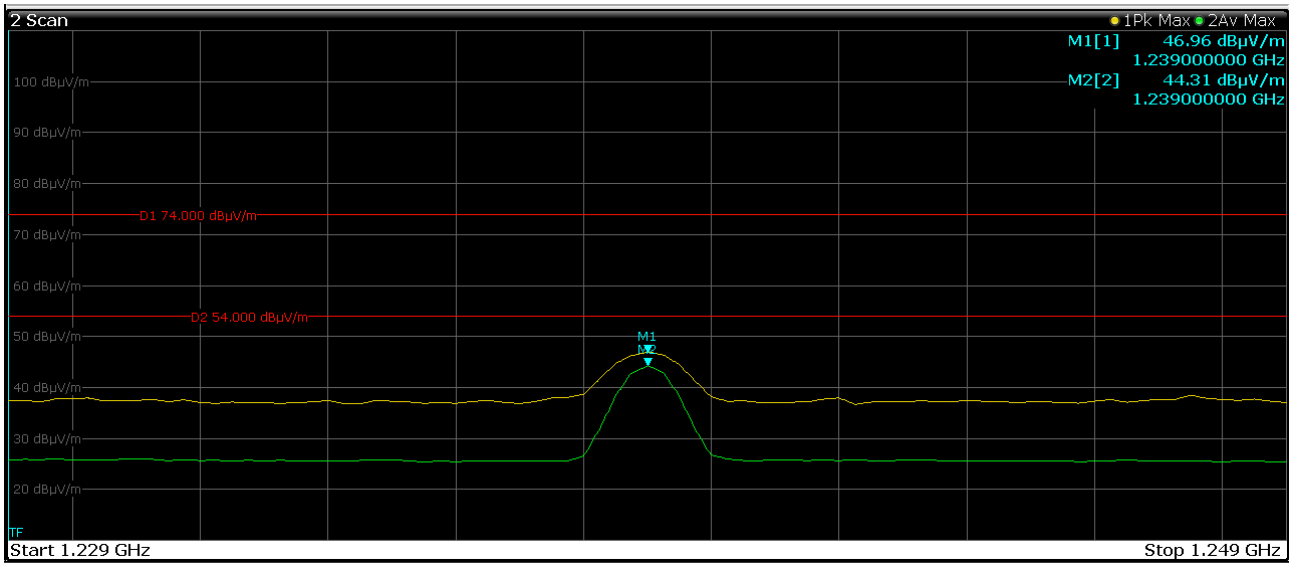


Figure 40: 1st Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel high

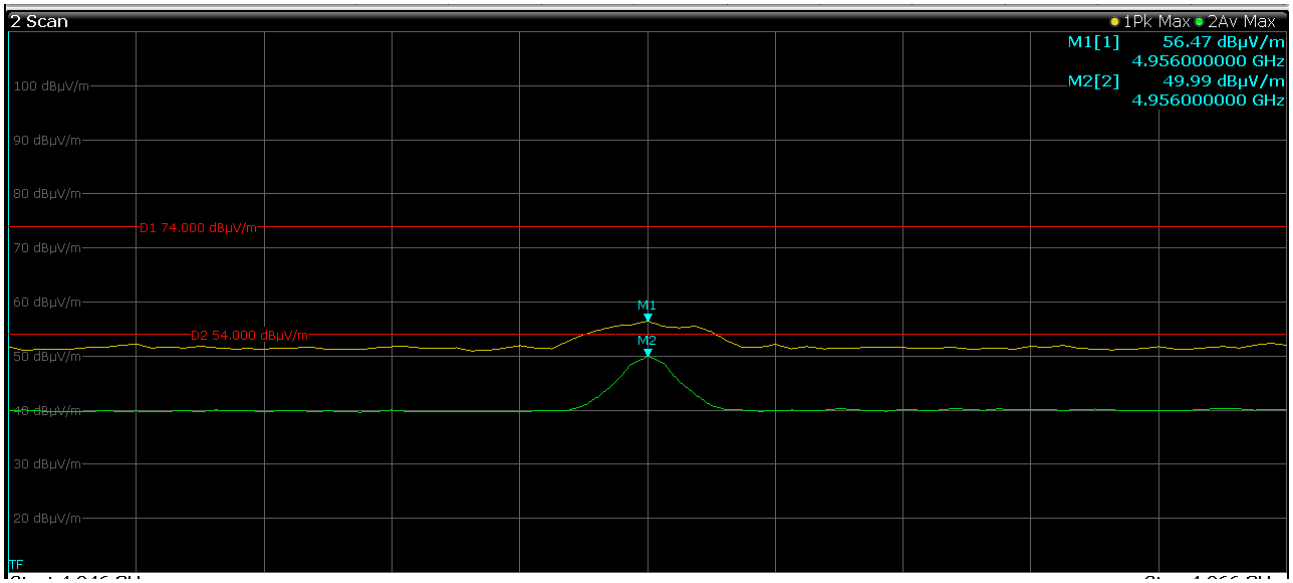


Figure 41: 2nd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel high

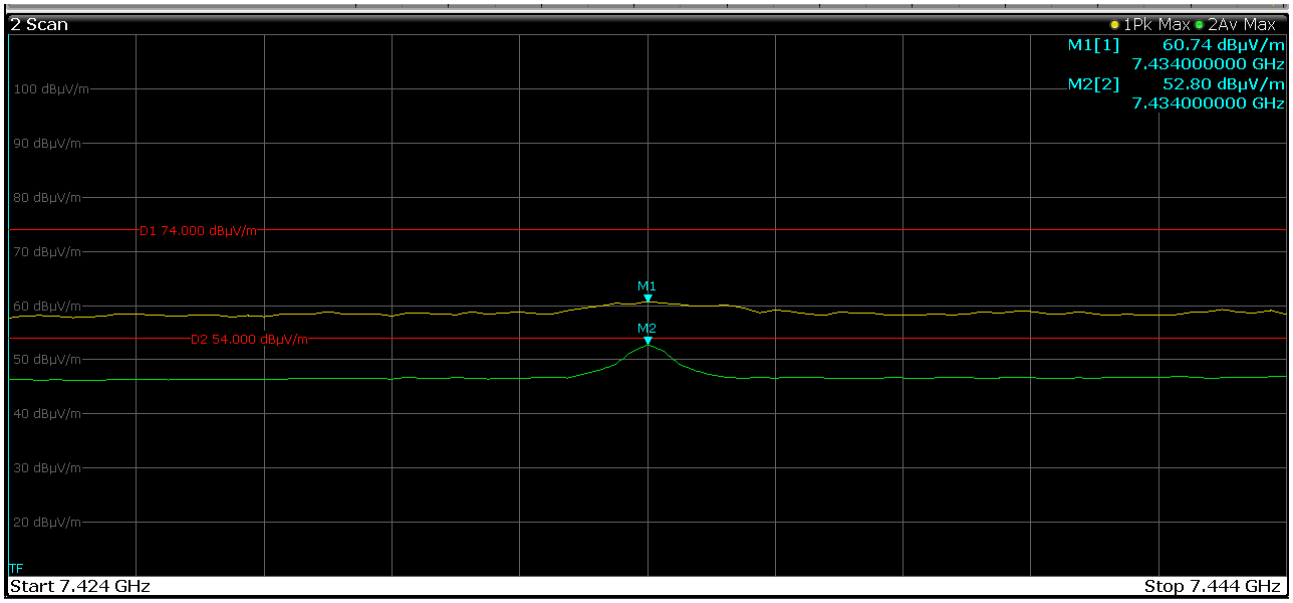


Figure 42: 3rd Chart of spurious radiated emission test 1 GHz to 10th harmonic, channel high

Channel high									
f[GHz]	**E_{meas} [dBµV/m]**	**EUT-Pos**	**Polari-zation**	**Table [°]**	**Height [cm]**	**Detector**	**Restr. Band**	**Limit [dBµV/m]**	**Result**
1.2390	46.96	2	H	189	157	PK	Yes	74	Pass
1.2390	44.31					AV		54	Pass
4.9560	56.47	2	H	213	171	PK	Yes	74	Pass
4.9560	49.99					AV		54	Pass
7.4340	60.74	3	H	68	155	PK	Yes	74	Pass
7.4340	52.80					AV		54	Pass

Table 13: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel high

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:	February 10, 2017
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):	logarithmic 0.68 dBm	numeric 1.17 mW	
Maximum equivalent isotropically radiated power:	logarithmic 0.68 dBm	numeric 1.17 mW	
Maximum operation frequency (see clause 3):	2478.000 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 ≤ 50 mm, the 1 g and 10 g SAR test exclusion thresholds are determined by the following equation:

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

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

According to RSS-102, section 2.5.1, SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in table 1 of RSS-102 (see table 14). Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power.

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW
Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Table 14: Limits for exemption from SAR evaluation

6.8.3 Results

6.8.3.1 Test results according to KDB 447498 D01

Calculation of minimum test separation distance:

$$\frac{P_{conducted}(mW)\cdot\sqrt{f(GHz)}}{d_{min}(mm)} \le 3.0 \quad \Leftrightarrow \quad d_{min}(mm) \ge \frac{P_{conducted}(mW)\cdot\sqrt{f(GHz)}}{3.0}$$

$$\Leftrightarrow \quad d_{min}(mm) \ge \frac{2\cdot\sqrt{2.478000}}{3.0}$$

$$\Leftrightarrow \quad d_{min}(mm) \ge 1.05$$

$$\Rightarrow \quad d_{min}(mm) = 5$$

Final check:

$$\frac{P_{conducted}(mW)\cdot\sqrt{f(GHz)}}{d_{min}(mm)} \le 3.0 \quad \Leftrightarrow \quad \frac{2\cdot\sqrt{2.478000}}{5} \le 3.0$$

$$\Leftrightarrow \quad 0.63 \le 3.0 \ \checkmark$$

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

6.8.3.2 Test results according to RSS-102

Calculation of exemption limit at maximum operation frequency using linear interpolation for the applicable separation distance:

$$P_{limit}(f) = P_{limit}(f_n) + \frac{f - f_n}{f_{n+1} - f_n} \cdot \left(P_{limit}(f_{n+1}) - P_{limit}(f_n)\right)$$

with:
$P_{limit}(f)$ = exemption limit at maximum operation frequency
$P_{limit}(f_n)$ = exemption limit at lower frequency listed in table closest to maximum operation frequency
$P_{limit}(f_{n+1})$ = exemption limit at upper frequency listed in table closest to maximum operation frequency
F = maximum operation frequency
f_n = lower frequency listed in table closest to maximum operation frequency
f_{n+1} = upper frequency listed in table closest to maximum operation frequency

$$P_{limit}(2478.000\ MHz) = 4\ mW + \frac{2478.000\ MHz - 2450\ MHz}{3500\ MHz - 2450\ MHz} \cdot (2\ mW - 4\ mW)$$

$$P_{limit}(2478.000\ MHz) = 3.94\ mW$$

As the maximum output power is defined as the higher level of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) it results in 1.17 mW which is below the exemption limit at maximum operation frequency.

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 l	VC³ 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 15: Equipment calibration status

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

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 16: Measurement uncertainty

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

9 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2017-03-07	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)