Test report

Customer:

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RF test report

170062-AU01+W01

Industry Canada Industrie Canada

DewertOkin GmbH

Control unit

CU170

(SRD mode)

EMV TESTHAUS

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

EMV **TESTHAUS** GmbH

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Germany
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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 2017-07-12
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
94315 Straubing
Germany

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

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1 Summary of test results

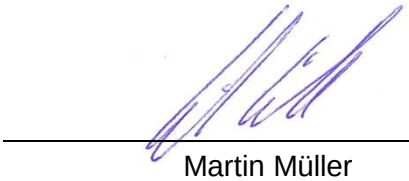
System type: Digital transmission system (DTS)

47 CFR part and section	*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	21	Passed	---
15.247(a)(1) KDB 558074, section 8	20 dB bandwidth	RSS-247 Issue 2, section 5.1(b)	26	Passed	---
15.247(a)(2) KDB 558074, section 8	6 dB bandwidth	RSS-247 Issue 2, section 5.2(a)	29	Passed	1
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	RSS-Gen Issue 4, section 6.6	32	For reference only	1
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)	38	Passed	---
15.247(d) KDB 558074, sections 11 & 12	Antenna-port conducted measurements	RSS-247 Issue 2, section 5.5	---	Not applicable	2
15.247(d) KDB 558074, section 13	Band-edge compliance (radiated)	RSS-247 Issue 2, section 5.5	43	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	49	Passed	---
2.1091	RF exposure evaluation for mobile devices	RSS-Gen Issue 4, section 3.2 (exempted form SAR and RF evaluation)	66	Passed	---

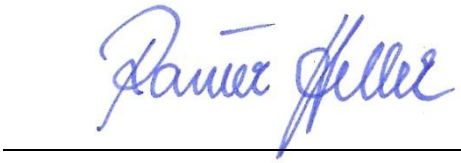
Notes:

1 For systems using digital modulation techniques the 6 dB bandwidth (DTS bandwidth) is regarded as the occupied bandwidth.
2 Spurious radiated emission tests 9 kHz to 10th harmonic performed.

Straubing, May 2, 2017



Martin Müller
Test engineer
EMV **TESTHAUS** GmbH



Rainer Heller
Head of EMC / radio department
EMV **TESTHAUS** GmbH

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. 412172 August 7, 2015	Guidelines for determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF transmitting system
KDB Publication no. 447498 October 23, 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
KDB Publication no. 558074 April 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:	Control unit	
Model name:	CU170	
Serial number(s):	123456 0007	
Applicant:	DewertOkin GmbH	
Manufacturer:	DewertOkin GmbH	
Version:	Hardware: Software:	---- ----
Additional modifications:	None	
FCC ID:	O3YCU170	
IC registration number:	10744A-CU170	
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 channels	
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:	DC supply	
	Nominal voltage: Minimum voltage: Maximum voltage: Nominal frequency:	24 V 24 V 29 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*
	EUT		
control unit	CU170	123456 0007	DewertOkin GmbH
	Peripheral devices		
Power supply EUT	PD12	Z56014285301601448	Phoenix Mecano
Notebook	Lifebook A531	E00521	Fujitsu
Power supply notebook	ADP-65JH AD	S26113-E557-V55-01	Fujitsu
AC power supply (120V / 60Hz)	61602	ABP000000730	Chroma ATE

Table 1: Devices used for testing

Port	*Classification*	*Cable type*	*Cable length*	
			used	*maximum*[1]
DC power	dc power	Shielded	1.5 m	---
USB (mounted for test purposes only)	signal/control	Shielded	1.5 m	---

Table 2: Ports of EUT and appropriate cables

4.2 Mode of operation

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

SRD mode

Channel 3 -> 2403.0 MHz (unmodulated)
Channel 40 -> 2440.0 MHz (unmodulated)
Channel 78 -> 2478.0 MHz (unmodulated)

Channel 3 -> 2403.0 MHz (modulated -> 1 Mbit/s)
Channel 40 -> 2440.0 MHz (modulated -> 1 Mbit/s)
Channel 78 -> 2478.0 MHz (modulated -> 1 Mbit/s)

Applied Software: HTerm 0.8.1(terminal software)

[1] As specified by applicant

5 Measurement Procedures

5.1 AC power line conducted emissions 150 kHz to 30 MHz

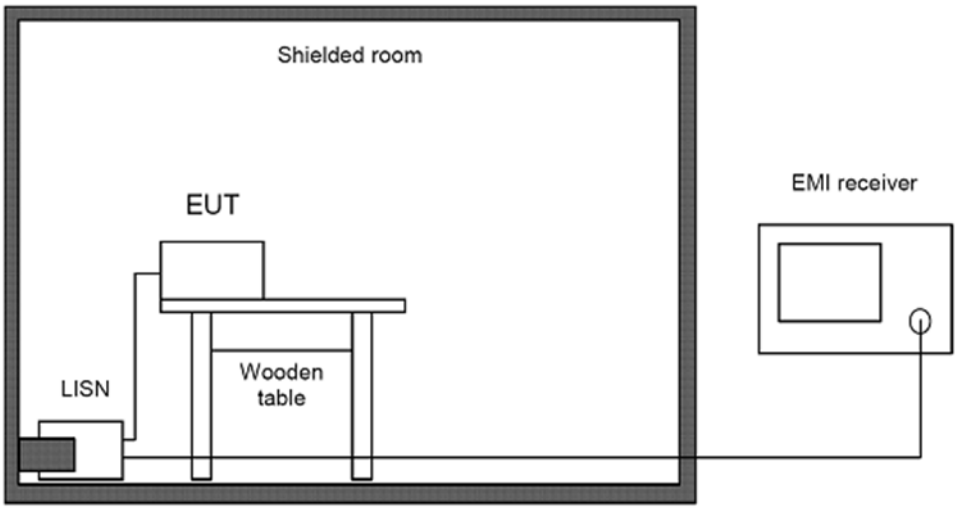


Figure 1: Test setup for AC power line conducted emissions 150 kHz to 30 MHz

The AC power line conducted emissions test method refers to section 6.2 of ANSI C63.10 and shall be as follows.
The tests of conducted emission is carried out in a shielded room using a line impedance stabilization network (LISN) 50 µH/50 Ohms and a EMI test receiver. The EMI test receiver is connected to the LISN and set to a measurement bandwidth of 9 kHz in the frequency range from 0.15 MHz to 30 MHz. The EUT is placed on a wooden table and connected to the LISN.
To accelerate the measurement the detector of the EMI test receiver is set to peak. A prescan is performed covering the whole frequency range from 0.15 MHz to 30 MHz. After that all peak values with less margin than 10 dB to quasi-peak limit or exceeding the limit are marked and re-measured with quasi-peak detector. If all values are below the average limit no additional measurement is necessary. In case of there are values between quasi-peak and average limit these values are re-measured using an average detector.
All peripheral devices are additionally decoupled by means of a line stabilization network.

5.2 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 5.10.

5.3 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).

In case of antenna-port conducted tests cannot be performed on an EUT (e.g., portable or handheld devices with integral antenna), then according to section 3.0 of KDB 558074 D01 radiated tests are performed for demonstrating compliance.

For test setup see clause 5.10.

5.4 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.

In case of antenna-port conducted tests cannot be performed on an EUT (e.g., portable or handheld devices with integral antenna), then according to section 3.0 of KDB 558074 D01 radiated tests are performed for demonstrating compliance.

For test setup see clause 5.10.

5.5 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).

In case of antenna-port conducted tests cannot be performed on an EUT (e.g., portable or handheld devices with integral antenna), then according to section 3.0 of KDB 558074 D01 radiated tests are performed for demonstrating compliance to the conducted emission requirements.
The radiated field strength or power level is then converted to EIRP according to annex G of ANSI C63.10. The equivalent conducted output power is then determined by subtracting the EUT transmit antenna gain from the EIRP (assuming logarithmic representation).

For test setup see clause 5.10.

5.6 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).

In case of antenna-port conducted tests cannot be performed on an EUT (e.g., portable or handheld devices with integral antenna), then according to section 3.0 of KDB 558074 D01 radiated tests are performed for demonstrating compliance to the conducted emission requirements.
The radiated field strength or power level is then converted to EIRP according to annex G of ANSI C63.10. The equivalent power spectral density is then determined by subtracting the EUT transmit antenna gain from the EIRP (assuming logarithmic representation).

For test setup see clause 5.10.

5.7 Band-edge compliance (radiated)

For test setup and test method see clause 5.10.

5.8 Spurious radiated emissions 9 kHz to 10th harmonic

For test setup and test method see clause 5.10.

5.9 Conducted emissions at antenna connector

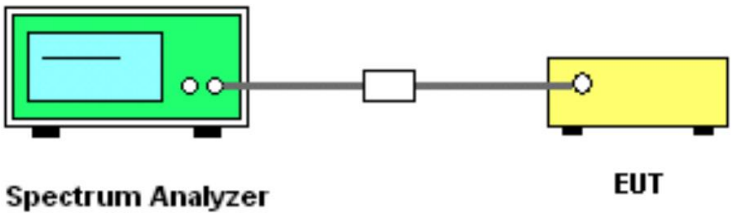


Figure 2: Setup for conducted emission test at antenna connector

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.

5.10 Radiated emissions

5.10.1 Radiated emissions below 30 MHz

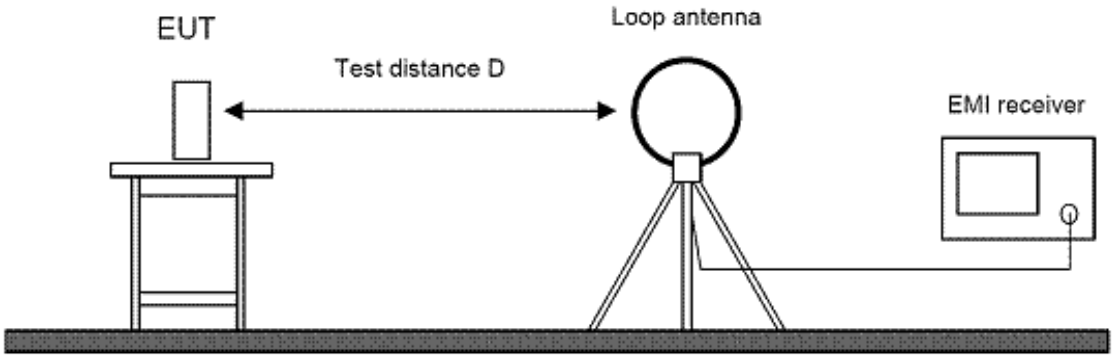


Figure 3: Setup for radiated emission test below 30 MHz

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.

5.10.2 Radiated emissions from 30 MHz to 1 GHz

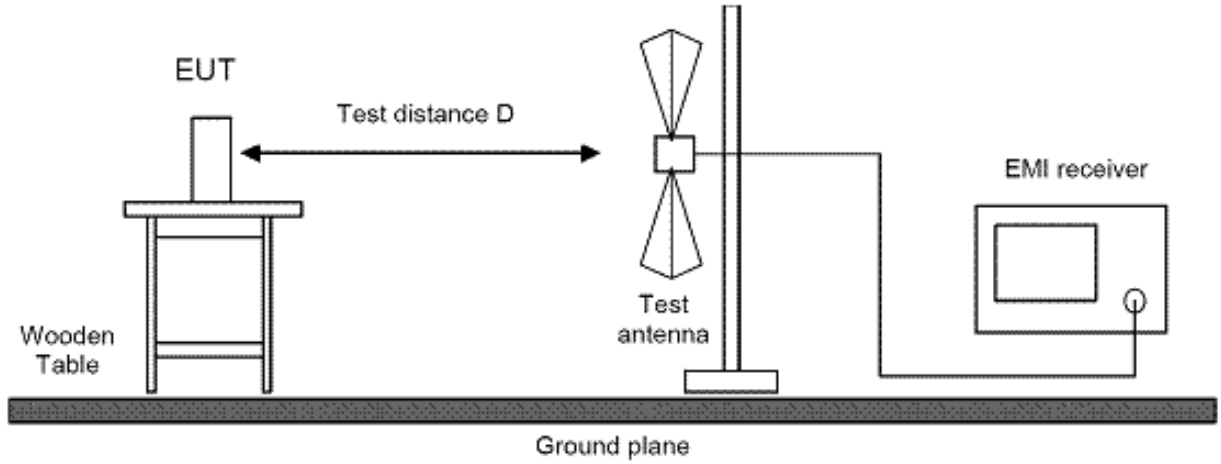


Figure 4: Setup for radiated emission test from 30 MHz to 1 GHz

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.

5.10.3 Radiated emissions above 1 GHz

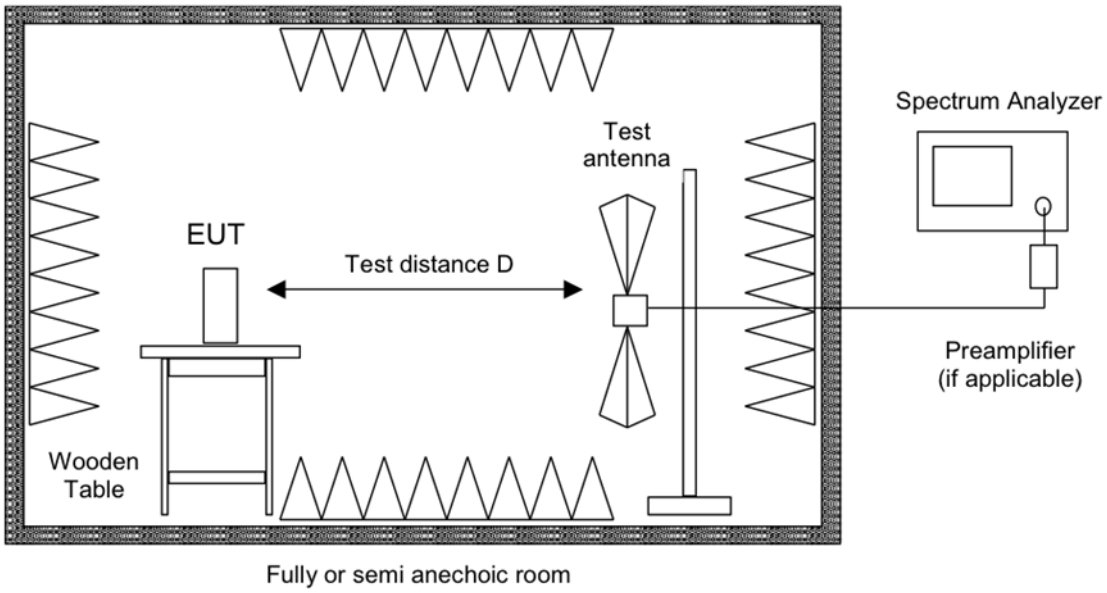


Figure 5: Setup for radiated emission test above 1 GHz

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 AC power line conducted emissions 150 kHz to 30 MHz

47 CFR part and section:	15.207
Equivalent to IC radio standard(s)	RSS-Gen Issue 4, section 8.8
Measurement procedure:	See 5.1

Performed by:	Martin Müller	Date of test:	April 13, 2017
Result	☒ Test passed	☐ Test not passed	

6.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Shielded room	P92007	Siemens Matsushita	E00107
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESCS 30	Rohde & Schwarz	E00003
☒	Artificial mains network	ESH2-Z5	Rohde & Schwarz	E00004
☒	Artificial mains network	ESH2-Z5	Rohde & Schwarz	E00005
☒	Attenuator (10 dB)	50FHB-010-10	JFW Industries	E00471
☒	Measurement software	E10	ib comPLAN	E00443

6.1.2 Limits

Frequency [MHz]	**Quasi-peak [dBµV]**	**Avarage [dBµV]**
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

6.1.3 Test results

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

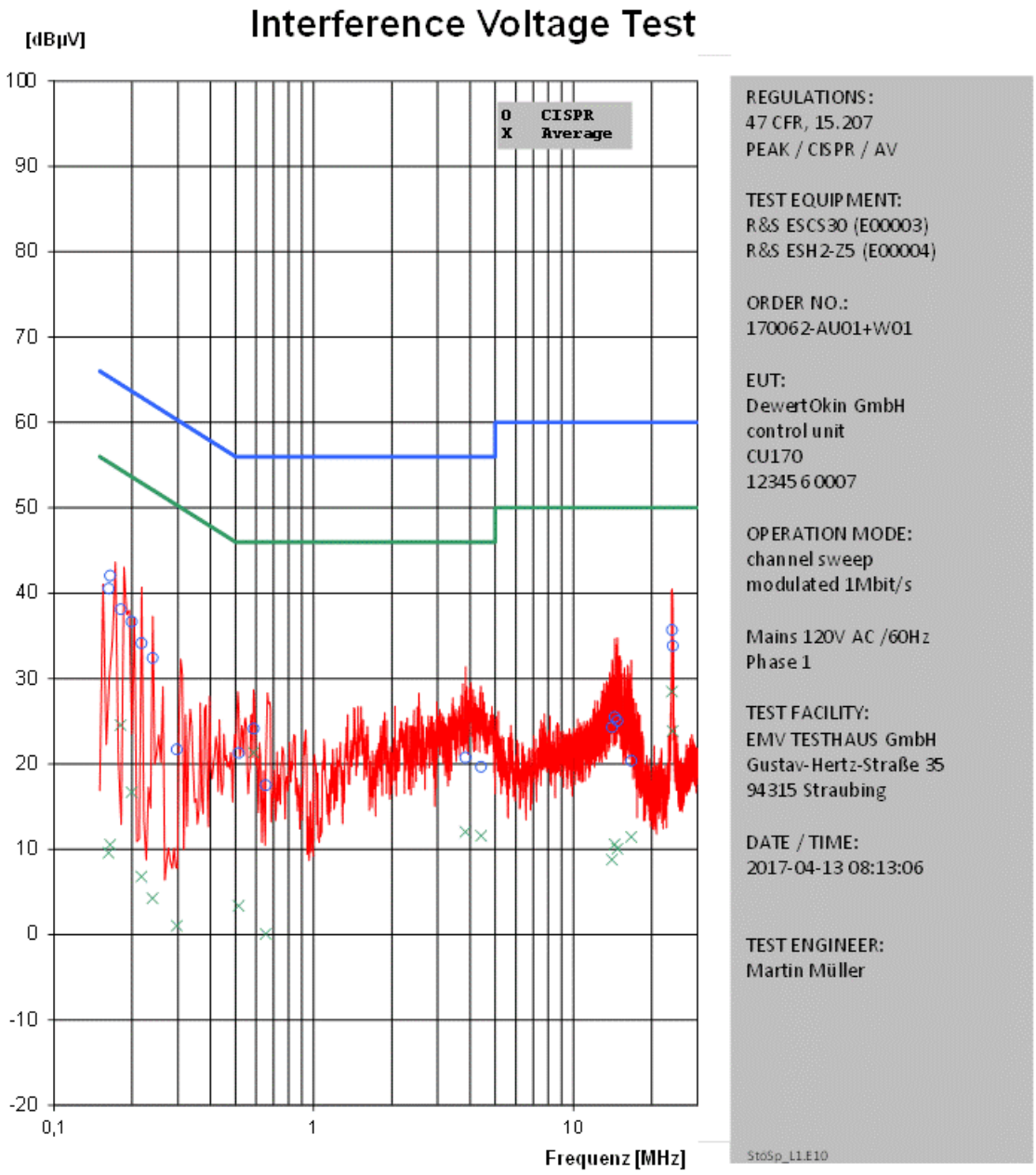


Figure 6: Chart of AC power line conducted emissions 150 kHz to 30 MHz – phase L1

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
0,16	42,1	65,2	23,2	10,5	55,2	44,7	0,0	
0,16	40,5	65,3	24,8	9,6	55,3	45,8	0,0	
0,18	38,1	64,4	26,3	24,5	54,4	29,9	0,0	
0,20	36,7	63,7	27,0	16,7	53,7	37,0	0,0	
0,22	34,1	62,9	28,8	6,8	52,9	46,1	0,0	
0,24	32,4	62,1	29,7	4,2	52,1	47,9	0,0	
0,30	21,7	60,3	38,6	1,0	50,3	49,3	0,0	
0,52	21,3	56,0	34,7	3,4	46,0	42,6	0,0	
0,59	24,1	56,0	31,9	21,3	46,0	24,7	0,0	
0,65	17,5	56,0	38,5	0,1	46,0	45,9	0,0	
3,84	20,8	56,0	35,3	12,0	46,0	34,0	0,0	
4,41	19,7	56,0	36,4	11,6	46,0	34,4	0,0	
14,08	24,3	60,0	35,7	8,8	50,0	41,2	0,0	
14,43	25,5	60,0	34,5	10,6	50,0	39,4	0,0	
14,77	25,0	60,0	35,0	10,1	50,0	40,0	0,0	
16,72	20,4	60,0	39,6	11,4	50,0	38,6	0,0	
23,98	35,7	60,0	24,3	28,5	50,0	21,5	0,0	
24,11	33,8	60,0	26,2	23,9	50,0	26,2	0,0	

Figure 7: Final results of AC power line conducted emissions 150 kHz to 30 MHz – phase L1

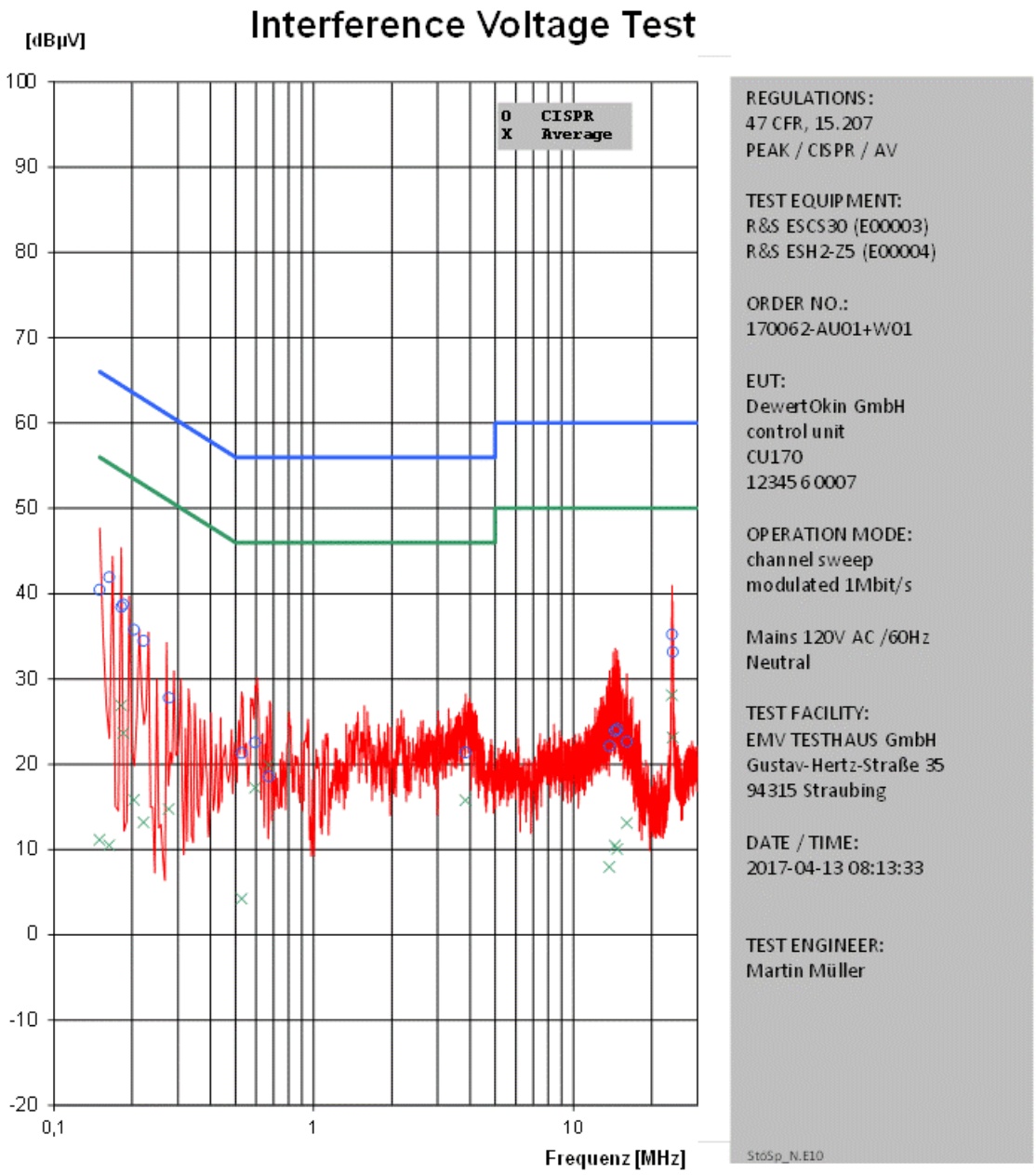


Figure 8: Chart of AC power line conducted emissions 150 kHz to 30 MHz – phase N

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
0,15	40,4	66,0	25,6	11,1	56,0	44,9	0,0	
0,16	41,9	65,3	23,4	10,5	55,3	44,8	0,0	
0,18	38,4	64,4	26,0	26,9	54,4	27,6	0,0	
0,19	38,7	64,3	25,5	23,6	54,3	30,6	0,0	
0,20	35,8	63,5	27,7	15,8	53,5	37,7	0,0	
0,22	34,5	62,8	28,3	13,2	52,8	39,6	0,0	
0,28	27,8	60,9	33,1	14,7	50,9	36,2	0,0	
0,53	21,3	56,0	34,7	4,2	46,0	41,8	0,0	
0,59	22,6	56,0	33,5	17,2	46,0	28,8	0,0	
0,67	18,6	56,0	37,5	19,9	46,0	26,1	0,0	
3,84	21,4	56,0	34,6	15,8	46,0	30,2	0,0	
13,77	22,1	60,0	37,9	8,0	50,0	42,1	0,0	
14,46	23,9	60,0	36,1	10,5	50,0	39,6	0,0	
14,75	24,1	60,0	35,9	10,1	50,0	40,0	0,0	
16,06	22,7	60,0	37,4	13,1	50,0	36,9	0,0	
23,98	35,2	60,0	24,8	28,1	50,0	21,9	0,0	
24,11	33,2	60,0	26,8	23,1	50,0	26,9	0,0	

Figure 9: Final results of AC power line conducted emissions 150 kHz to 30 MHz – phase N

6.2 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 5.2

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052

6.2.2 Limits for digital transmission systems

None -> results recorded for information only.

6.2.3 Test results

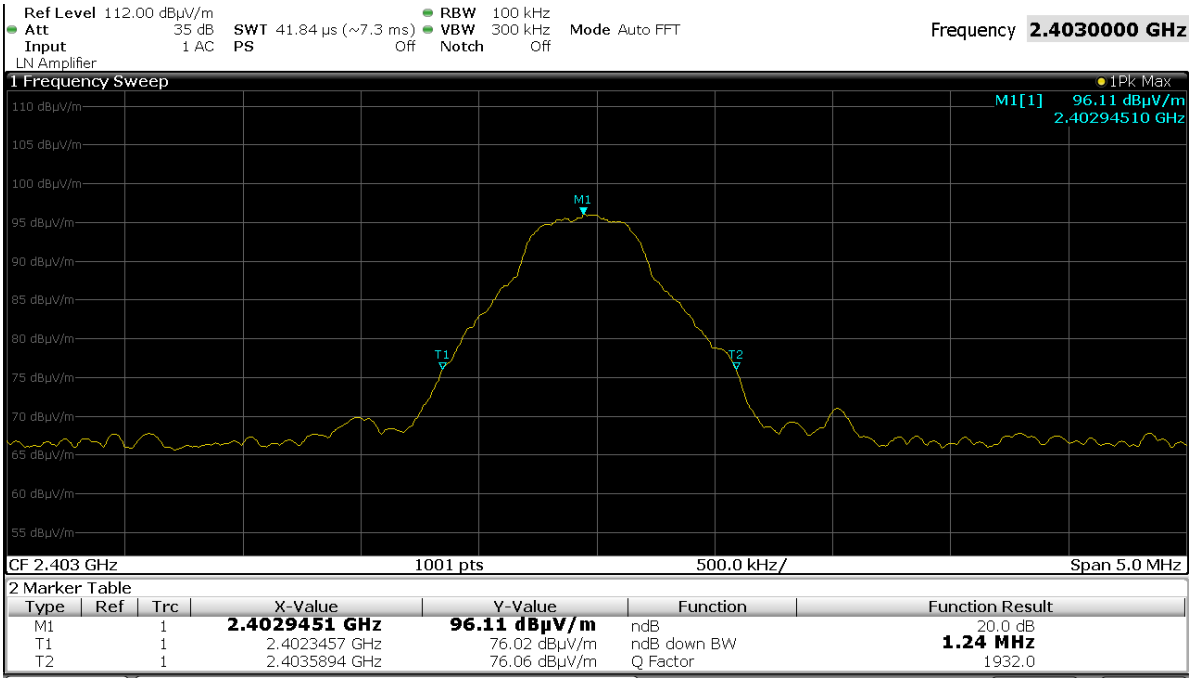


Figure 10: Chart of 20 dB bandwidth test, channel 3

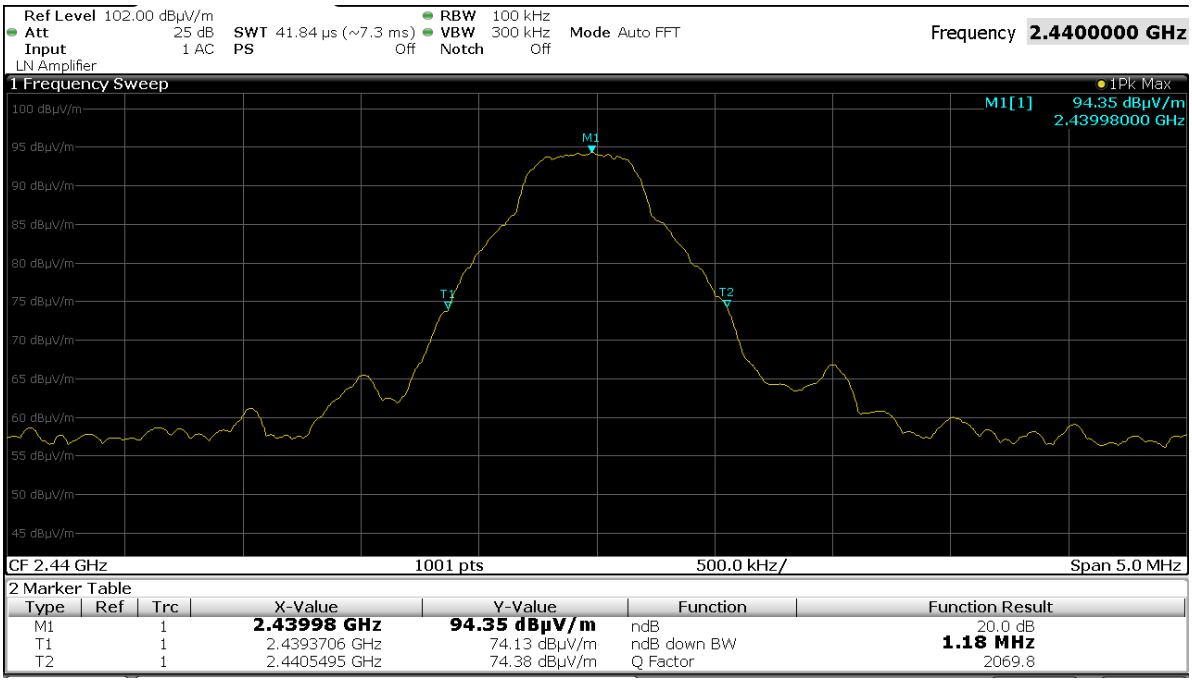


Figure 11: Chart of 20 dB bandwidth test, channel 40

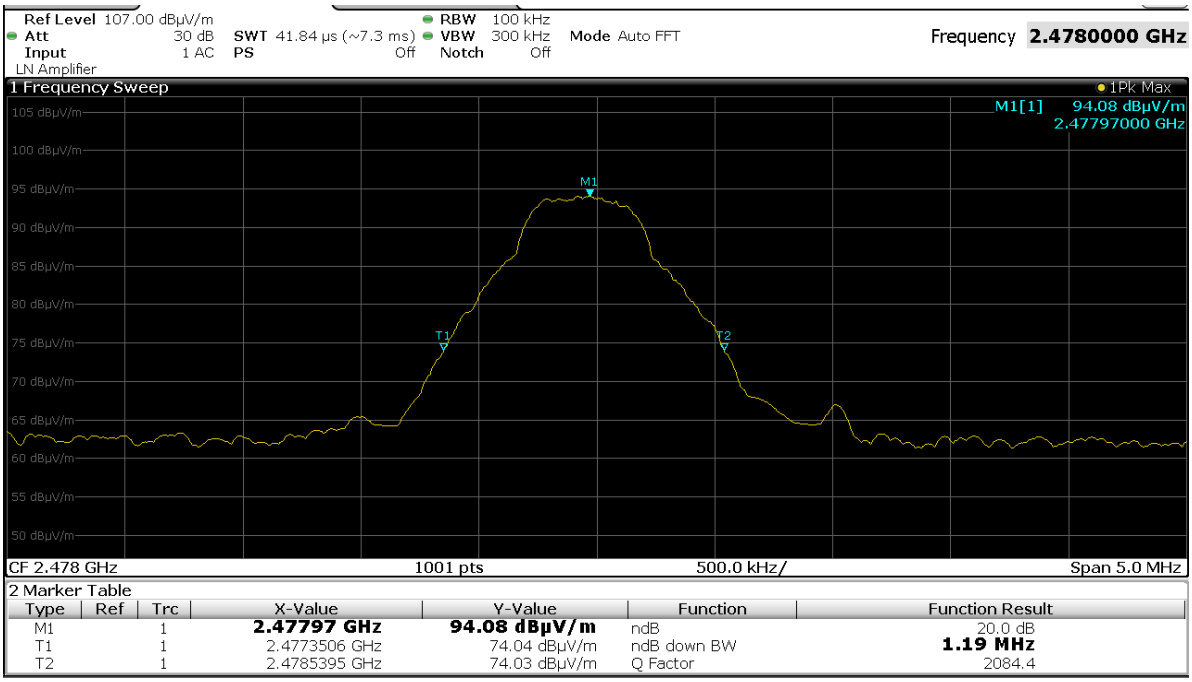


Figure 12: Chart of 20 dB bandwidth test, channel 78

f [MHz]	20dB-BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2402.945	1.243	2402.346	2403.589	2400.0	2483.5	within band
2439.980	1.179	2439.371	2440.550	2400.0	2483.5	within band
2477.970	1.189	2477.351	2478.540	2400.0	2483.5	within band

Table 3: Final results of 20 dB bandwidth test

6.3 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 5.3

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052

6.3.2 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.

6.3.3 Test results

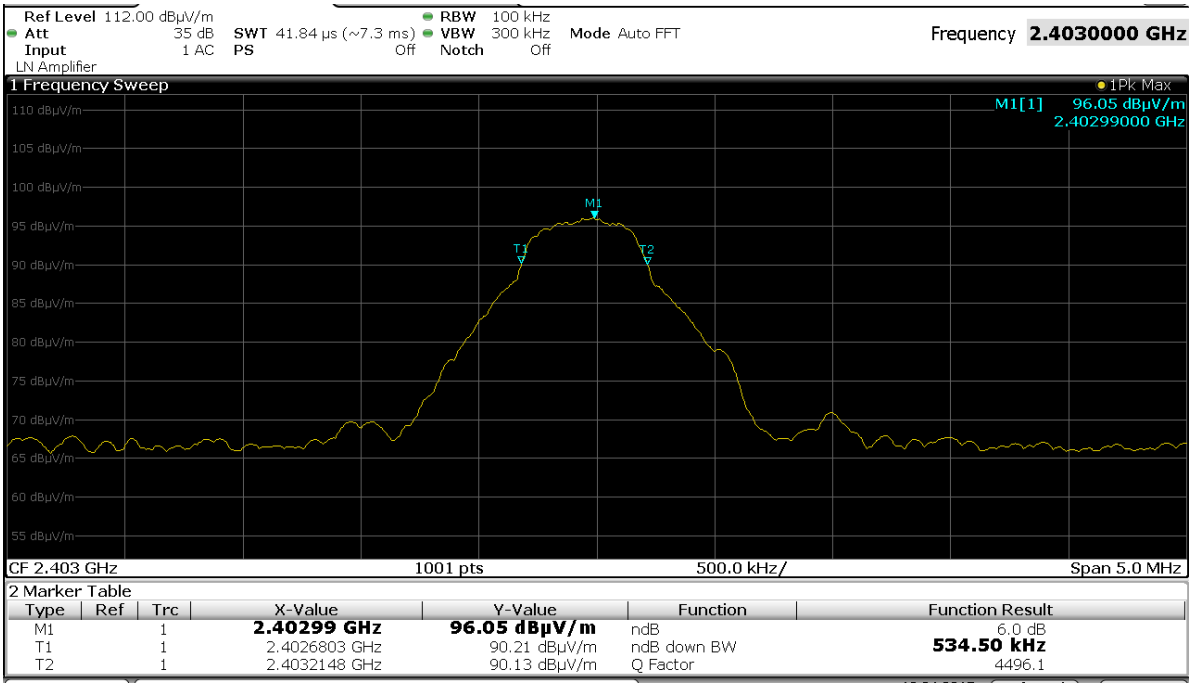


Figure 13: Chart of 6 dB bandwidth test, channel 3

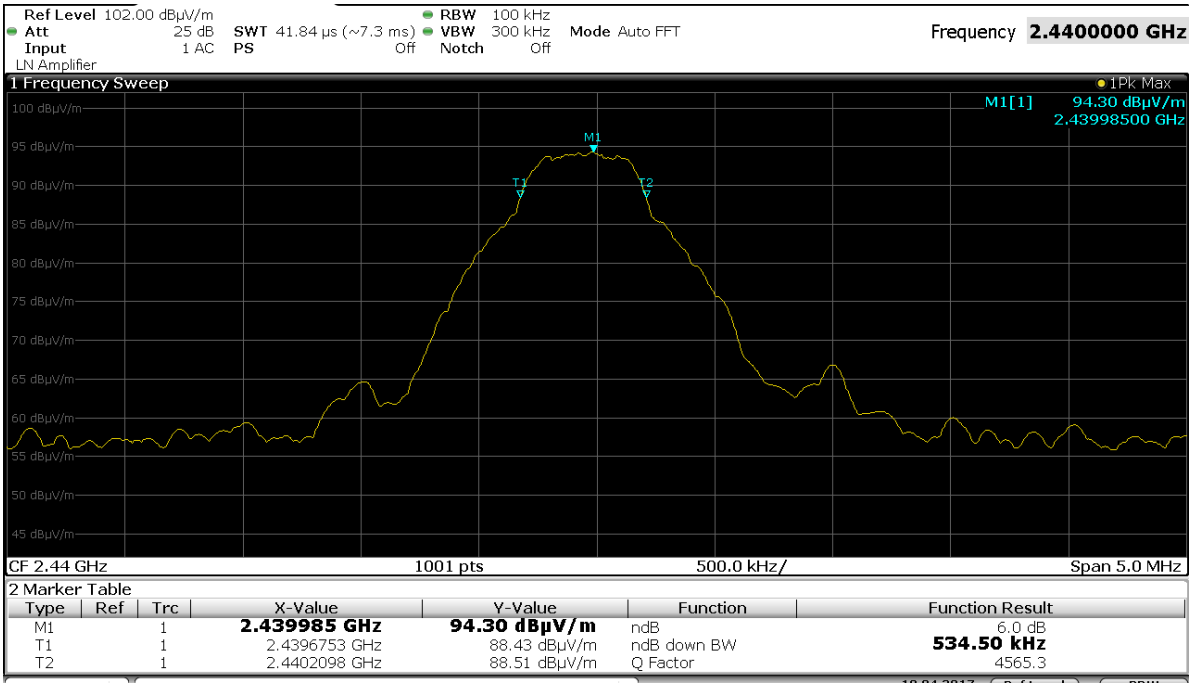


Figure 14: Chart of 6 dB bandwidth test, channel 40

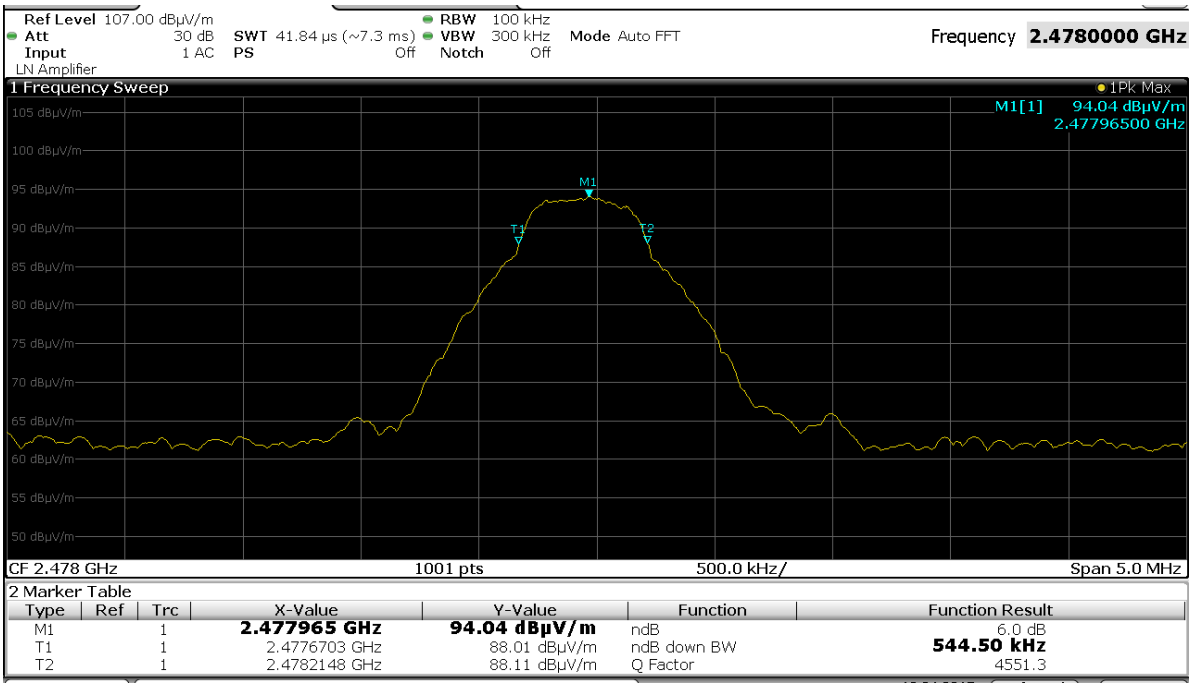


Figure 15: Chart of 6 dB bandwidth test, channel 78

f [MHz]	6dB-BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2402.990	0.535	2402.680	2403.215	2400.0	2483.5	Pass
2439.985	0.535	2439.675	2440.210	2400.0	2483.5	Pass
2477.965	0.545	2477.670	2478.215	2400.0	2483.5	Pass

Table 4: Final results of 6 dB bandwidth test

6.4 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 5.4

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.4.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052

6.4.2 Limits

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

6.4.3 Test results

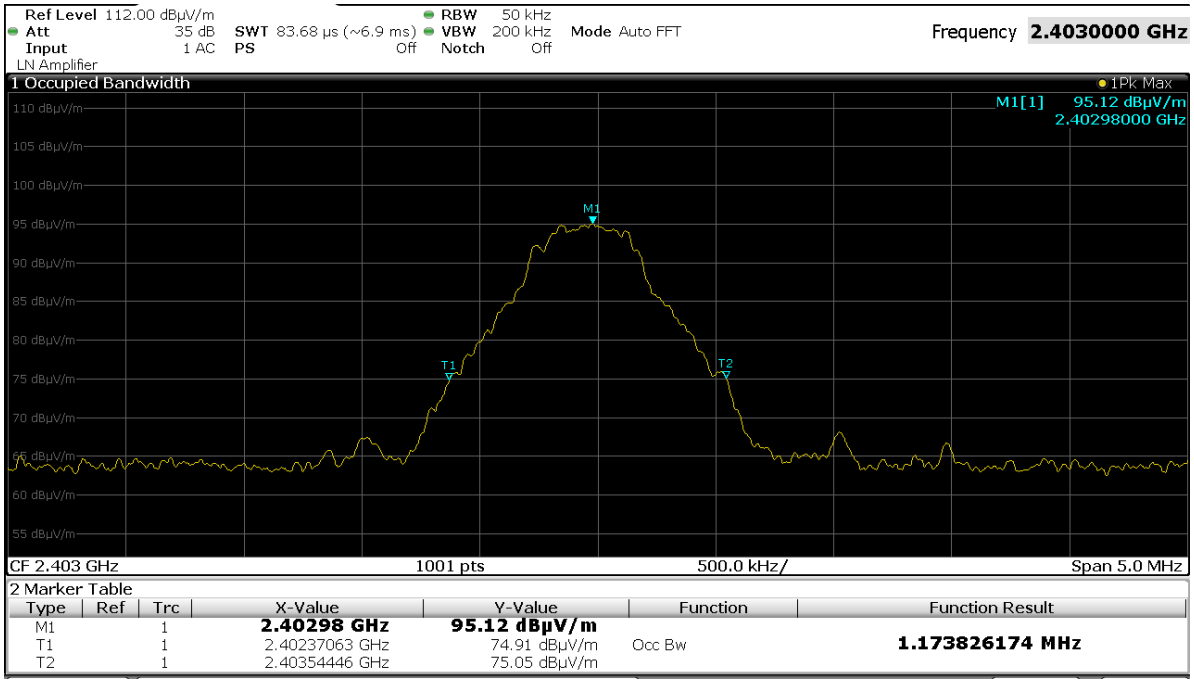


Figure 16: Chart of occupied bandwidth test, channel 3

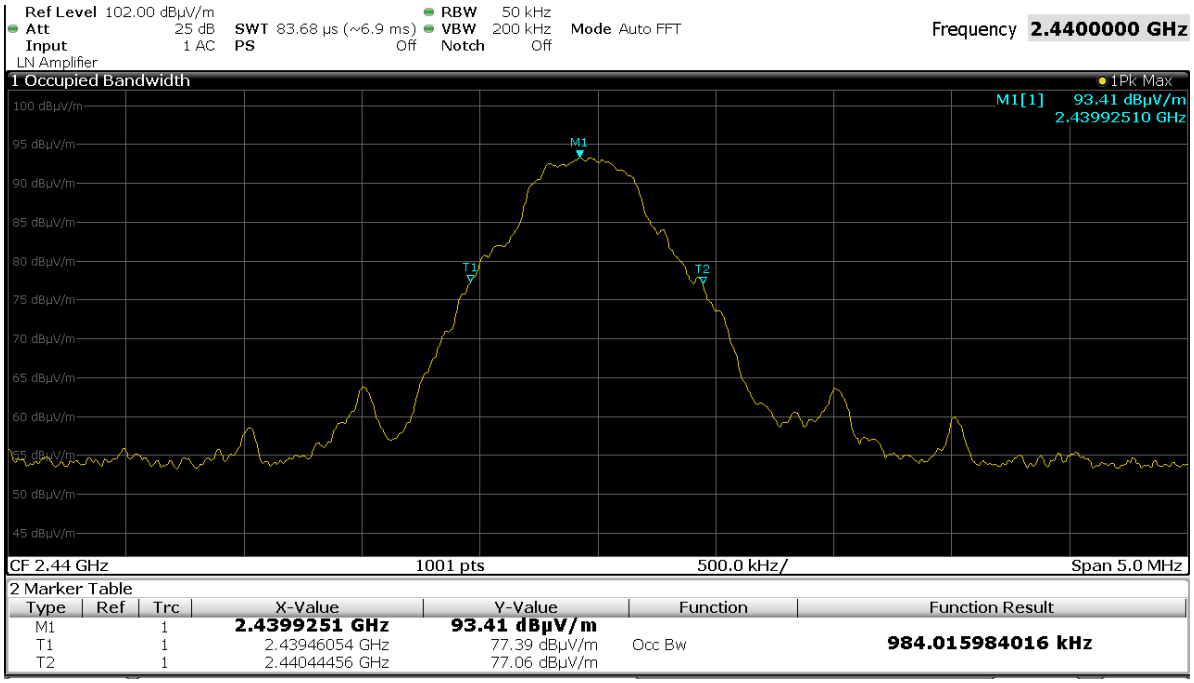


Figure 17: Chart of occupied bandwidth test, channel 40

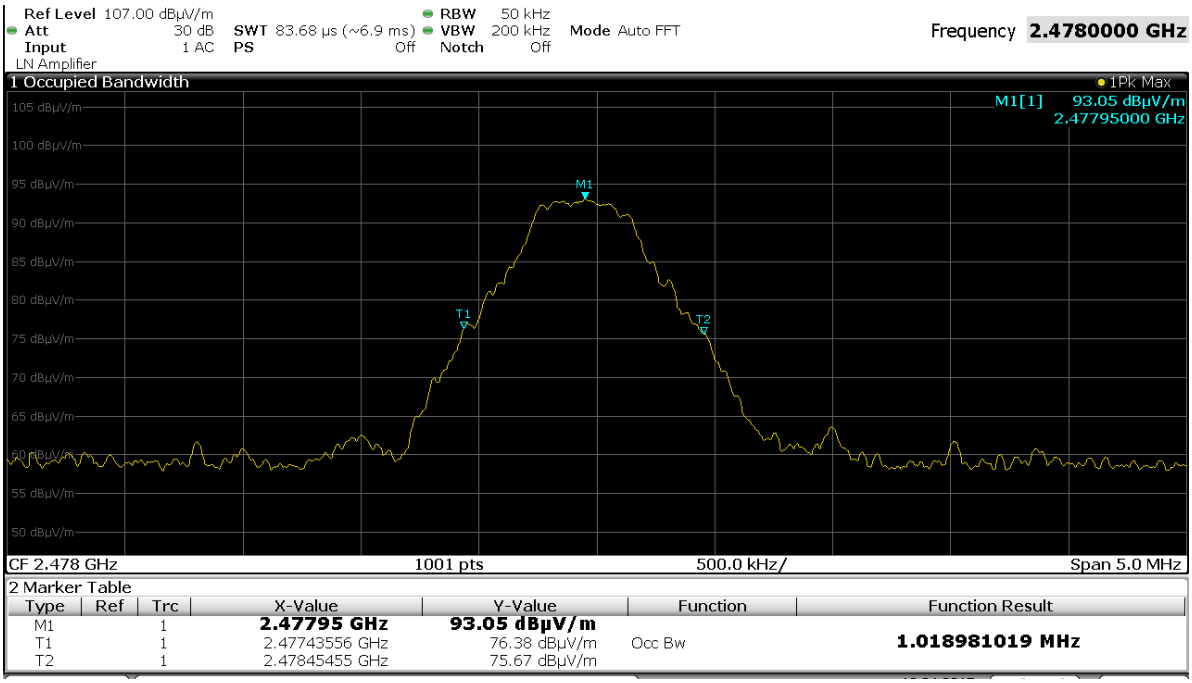


Figure 18: Chart of occupied bandwidth test, channel 78

f [MHz]	Occ. BW [MHz]	f_{lower} [MHz]	f_{upper} [MHz]	Lower band edge [MHz]	Upper band edge [MHz]	Result
2402.980	1.174	2402.371	2403.544	2400.0	2483.5	within band
2439.925	0.984	2439.461	2440.445	2400.0	2483.5	within band
2477.950	1.019	2477.436	2478.455	2400.0	2483.5	within band

Table 5: Final results of occupied bandwidth test

6.5 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 5.5

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.5.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052

6.5.2 Limits for digital transmission systems

1 watt (30 dBm).

6.5.3 Test results

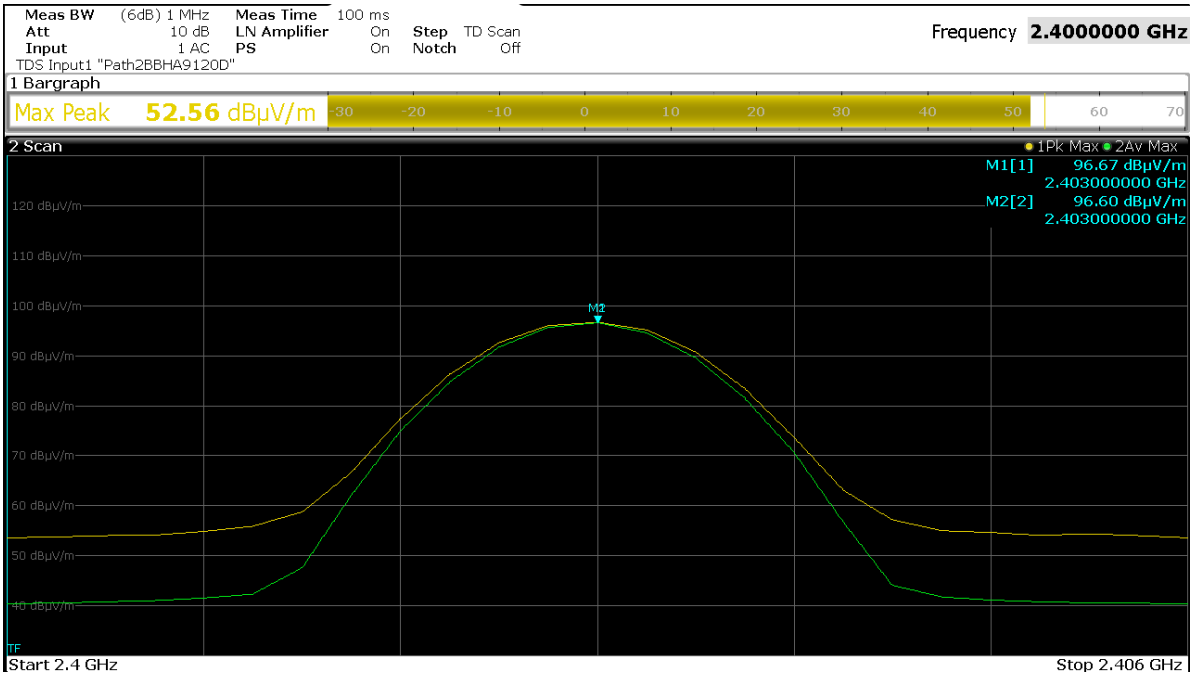


Figure 19: Chart of carrier electric field strength, channel 3

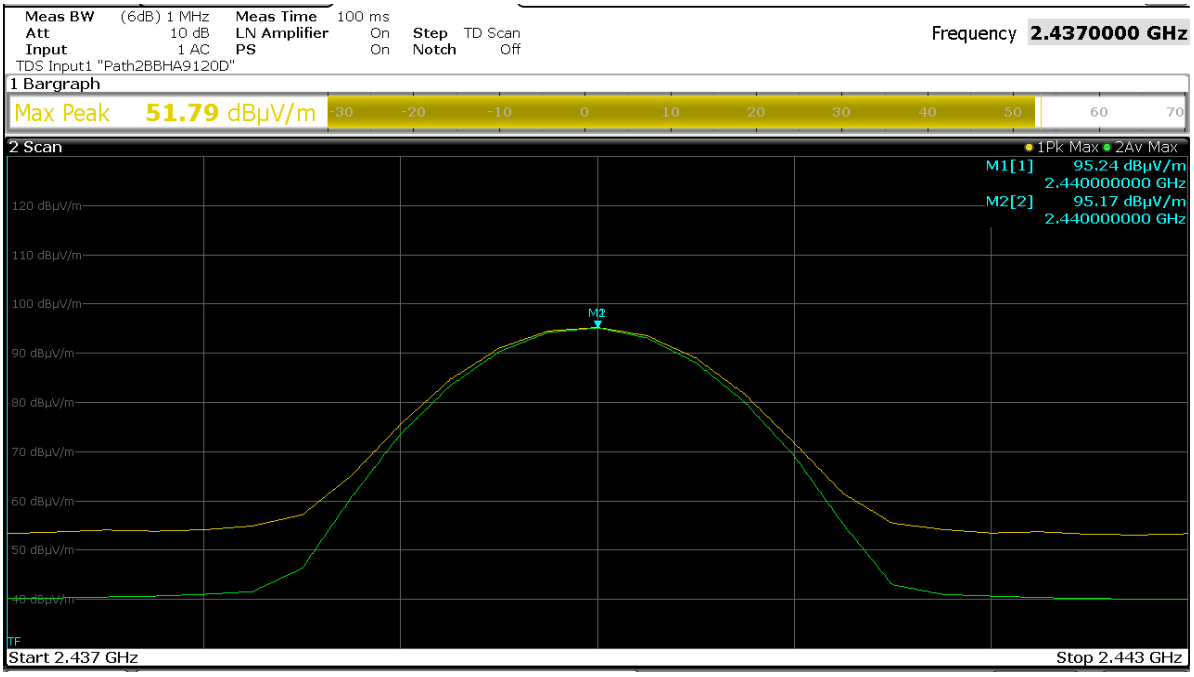


Figure 20: Chart of carrier electric field strength, channel 40

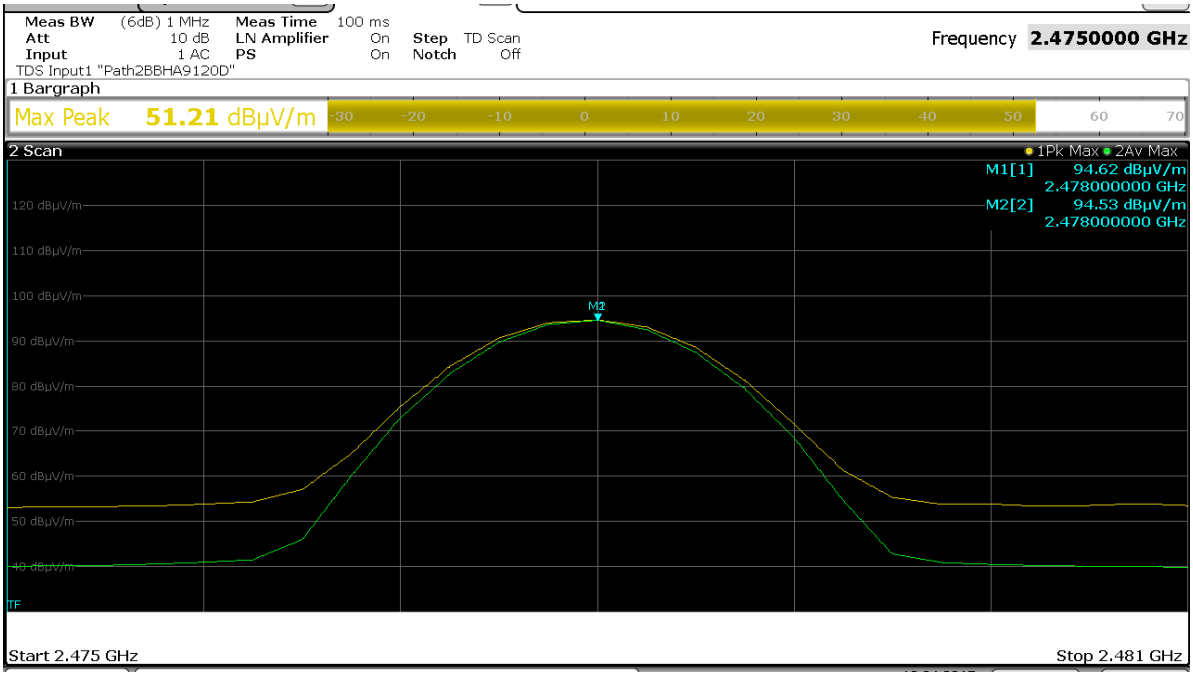


Figure 21: Chart of carrier electric field strength, channel 78

Calculation of EIRP according to ANSI C63.10, sections 11.3 and annex G with derived formula as noted in section 12.7.3:

EIRP[dBm] = E[dBµV/m] + 20·log($d_{measure}$[m]) - 104.77

With $d_{measure}$ = 3 m ⇒ EIRP[dBm] = E[dBµV/m] - 95.23

Calculation of "maximum conducted output power":

Maximum conducted output power[dBm] = EIRP[dBm] - g[dBi]

f [MHz]	E_{meas} [dBµV/m]	EUT position	Polari-zation	EIRP [dBm]	g [dBi]	Maximum conducted output power [dBm]	Limit [dBm]	Result
2403.000	96.67	1	H	1.44	0	1.44	30.0	Pass
2440.000	95.24	1	H	0.01	0	0.01	30.0	Pass
2478.000	94.62	1	H	-0.61	0	-0.61	30.0	Pass

Table 6: Final results of maximum conducted output power test

6.6 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 5.6

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.6.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Laboratory environment	---	---	---
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052

6.6.2 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.

6.6.3 Test results

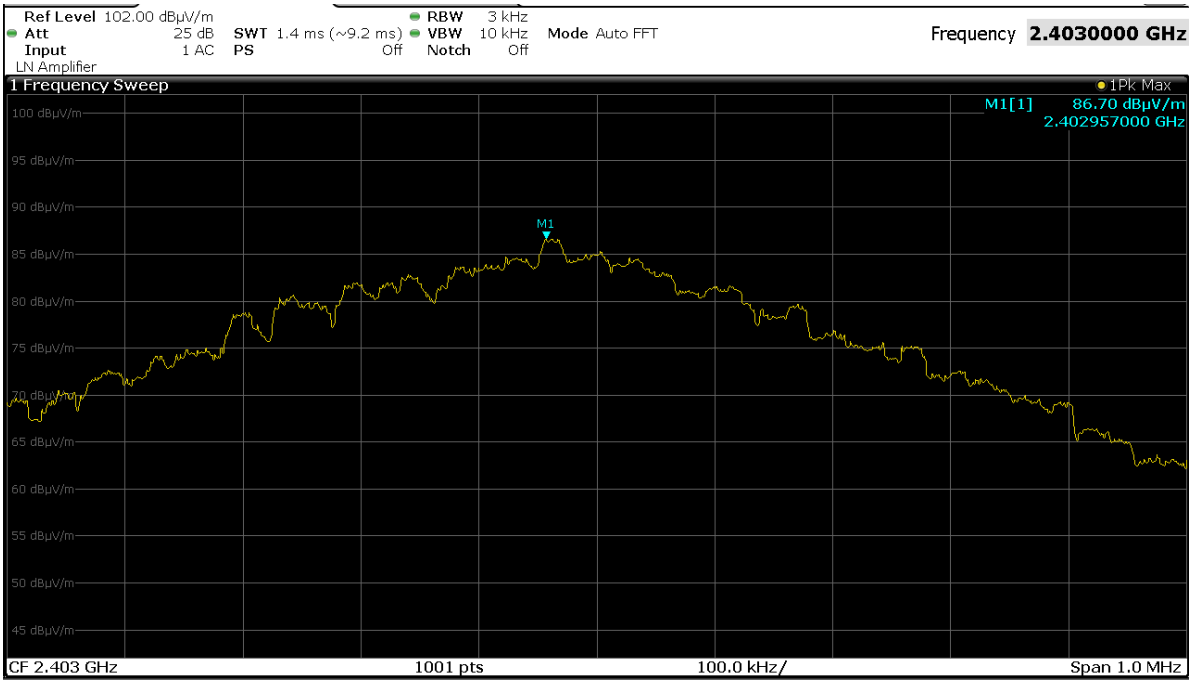


Figure 22: Chart of carrier electric field strength / 3 kHz, channel 3 - complete carrier

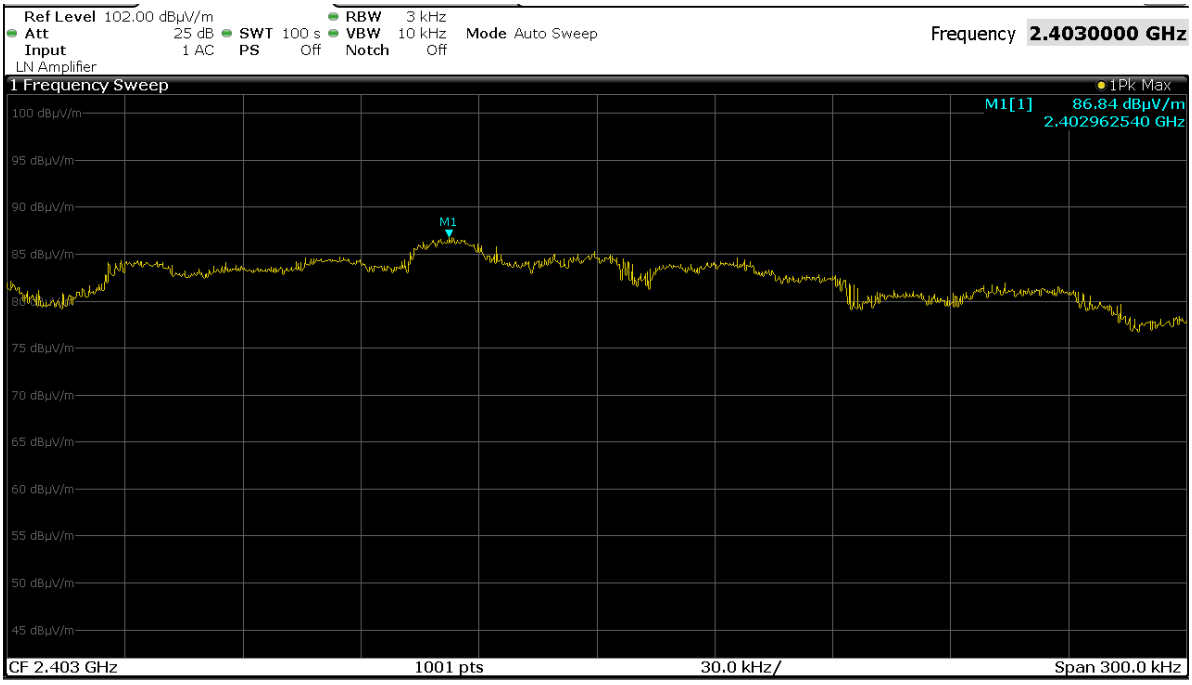


Figure 23: Chart of carrier electric field strength / 3 kHz, channel 3 - zoom to maximum

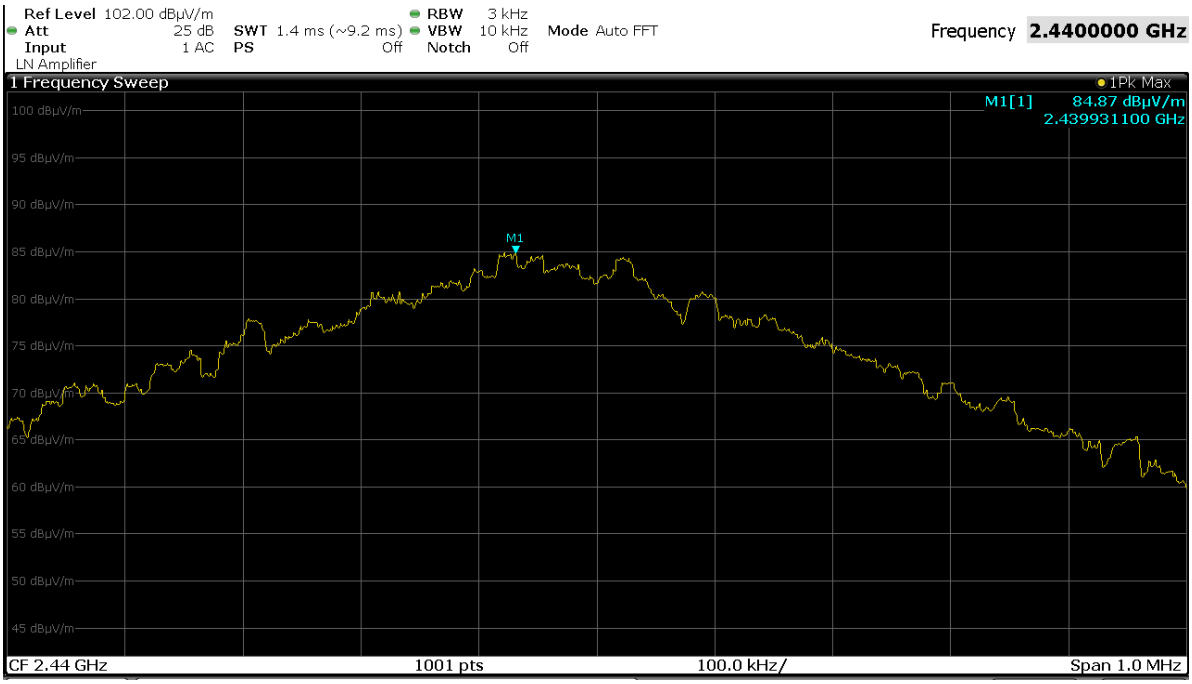


Figure 24: Chart of carrier electric field strength / 3 kHz, channel 40 - complete carrier

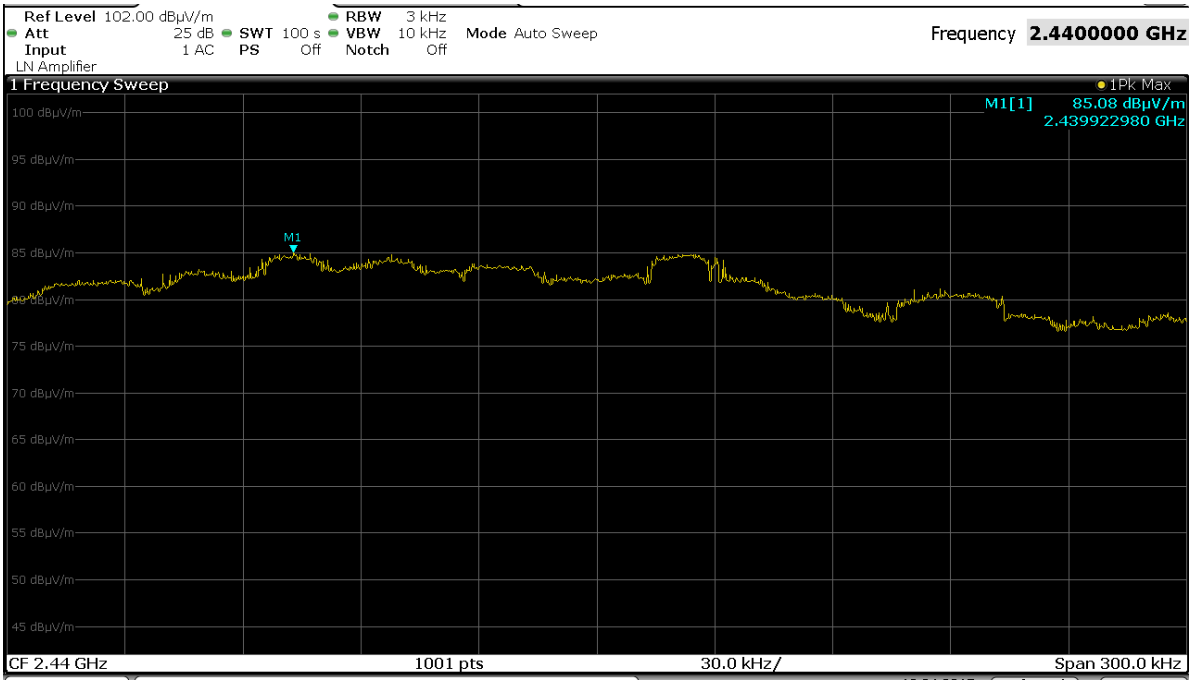


Figure 25: Chart of carrier electric field strength / 3 kHz, channel 40 - zoom to maximum

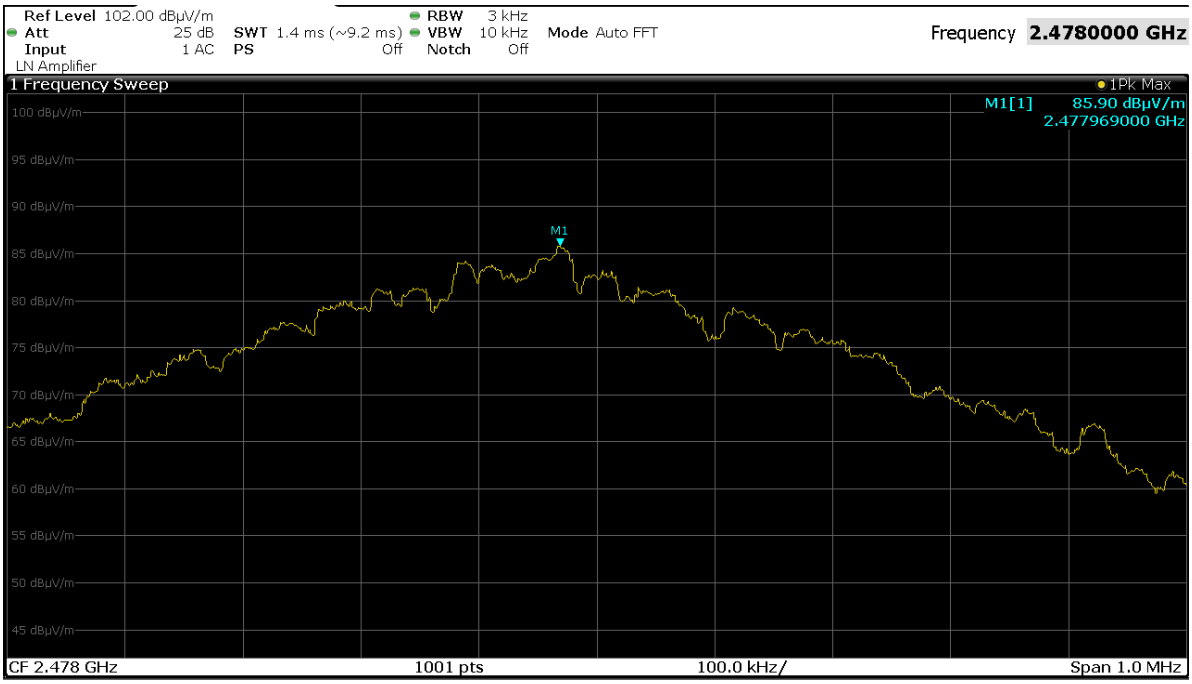


Figure 26: Chart of carrier electric field strength / 3 kHz, channel 78 - complete carrier

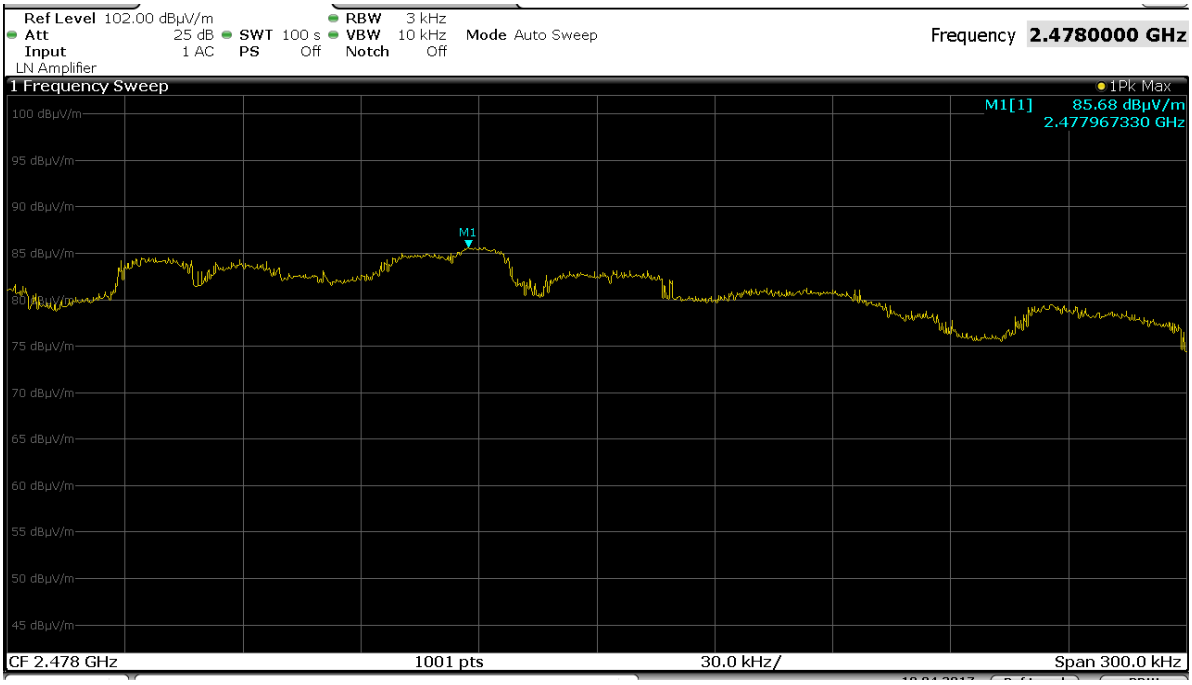


Figure 27: Chart of carrier electric field strength / 3 kHz, channel 78 - zoom to maximum

Calculation of EIRP according to ANSI C63.10, sections 11.3 and annex G with derived formula as noted in section 12.7.3:

EIRP[dBm] = E[dBµV/m] + 20·log($d_{measure}$[m]) - 104.77

With $d_{measure}$ = 3 m ⇒ EIRP[dBm] = E[dBµV/m] - 95.23

Calculation of " power spectral density":"

Power spectral density[dBm / 3 kHz] = EIRP[dBm] - g[dBi]

f [MHz]	E_{meas} [dBµV/m]	EUT position	Polari-zation	EIRP [dBm]	g [dBi]	Power spectral density [dBm / 3 kHz]	Limit [dBm / 3 kHz]	Result
2402.963	86.84	1	H	-8.39	0	-8.39	8.0	Pass
2439.923	85.08	1	H	-10.15	0	-10.15	8.0	Pass
2477.969	85.90	1	H	-9.33	0	-9.33	8.0	Pass

Table 7: Final results of power spectral density test

6.7 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 5.7

Performed by:	Martin Müller	Date of test:	April 21, 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**	E00354
☐	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☒	Anechoic Chamber (AC)	---	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier	AMF-5D-00501800	Miteq	W00089
☐	Preamplifier	AMF-6F-16002650	Miteq	W00090
☐	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	TRILOG broadband antenna (CDC)	VULB 9163	Schwarzbeck	E00012
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00053
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00055
☐	Measurement software	E10	ib comPLAN	E00443
☐	Measurement software	EMC 32	Rohde & Schwarz	E00777

6.7.2 Limits

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

6.7.3 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

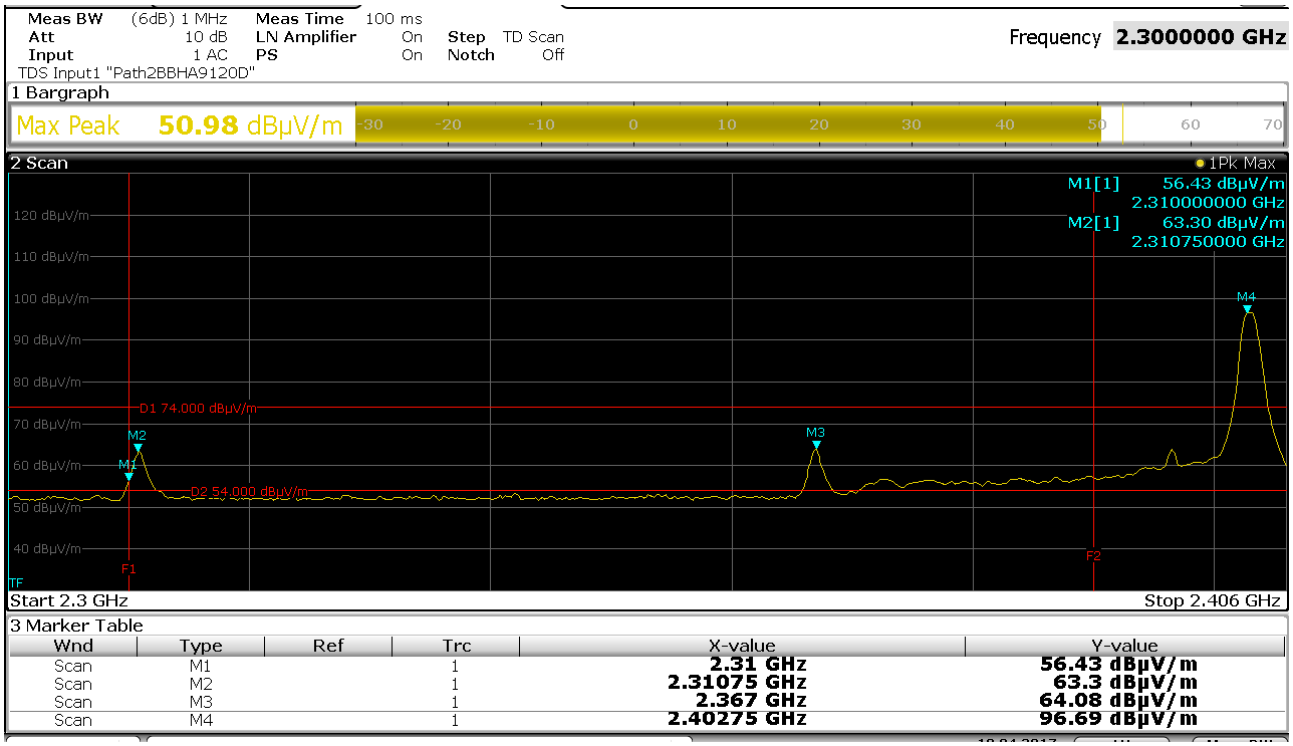


Figure 28: Chart of band edge compliance test, lower band edge - PK

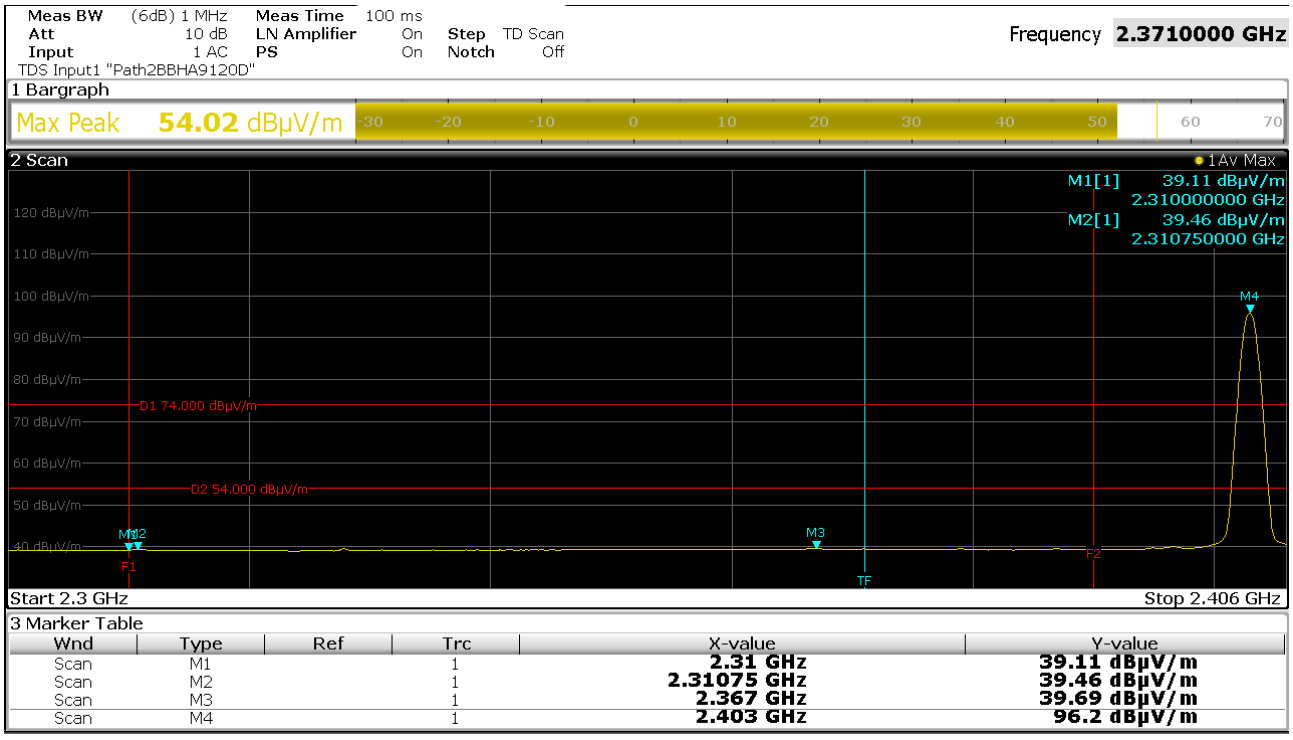


Figure 29: Chart of band edge compliance test, lower band edge - AV

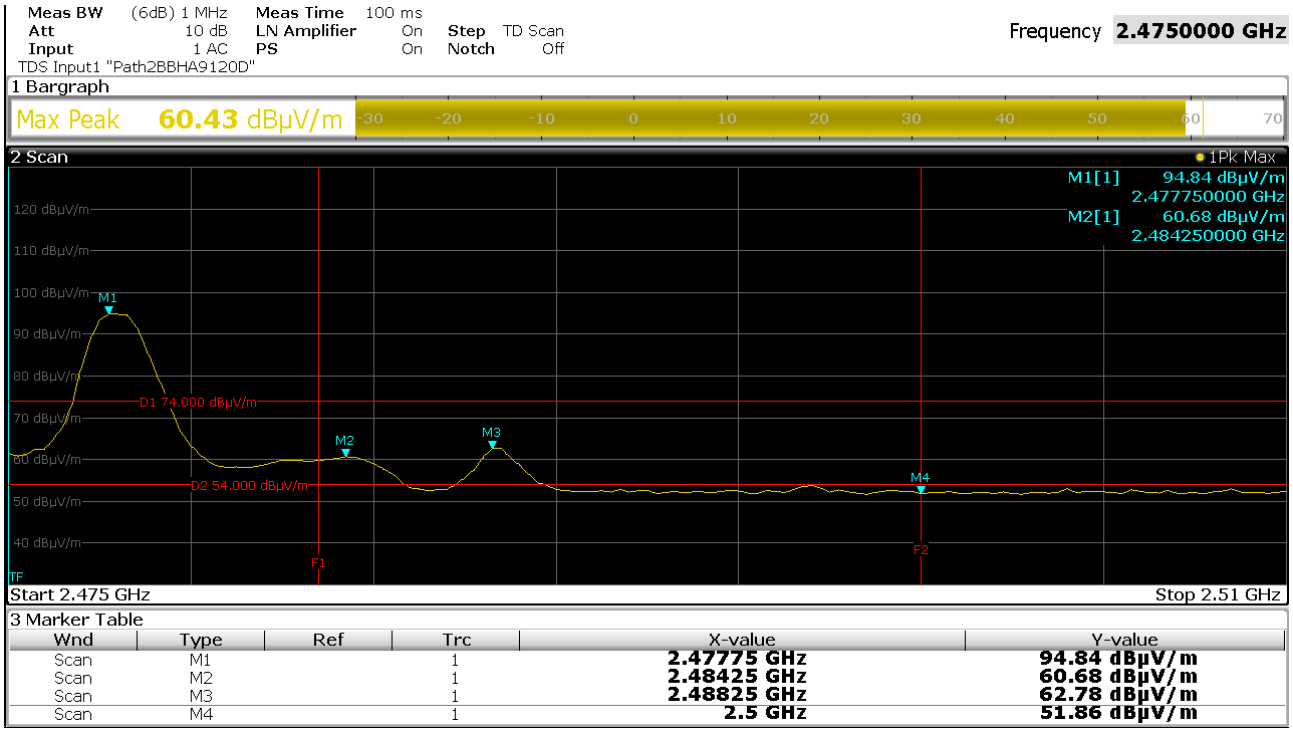


Figure 30: Chart of band edge compliance test, upper band edge - PK

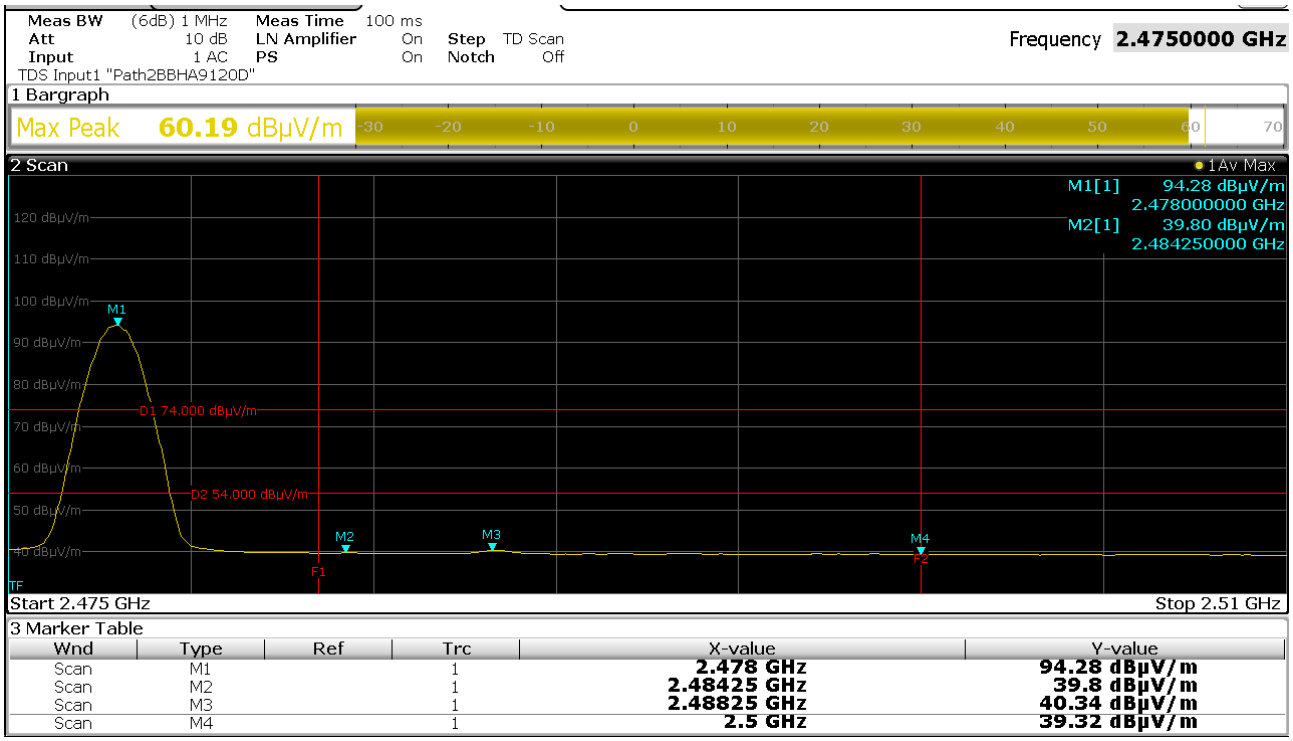


Figure 31: Chart of band edge compliance test, upper band edge - AV

f[MHz]	E_{meas} [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2310.000	56.43	PK	Yes	74	Pass
2310.000	39.11	AV		54	Pass
2310.750	63.30	PK		74	Pass
2310.750	39.46	AV		54	Pass
2367.000	64.08	PK		74	Pass
2367.000	39.69	AV		54	Pass
2402.750	96.69	PK	No	----	Carrier
2403.000	96.20	AV		----	Carrier

Table 8: Final result of band edge compliance test, lower band edge

f[MHz]	E_{meas} [dBµV/m]	Detector	Restricted Band	Limit [dBµV/m]	Result
2477.750	94.84	PK	No	----	Carrier
2478.000	94.28	AV		----	Carrier
2484.250	60.68	PK	Yes	74	Pass
2484.250	39.80	AV		54	Pass
2488.250	62.78	PK		74	Pass
2488.250	40.34	AV		54	Pass
2500.000	51.86	PK		74	Pass
2500.000	39.32	AV		54	Pass

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

6.8 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 5.8

Performed by:	Martin Müller	Date of test:	April 21, 2017
Result	☒ Test passed	☐ Test not passed	

6.8.1 Test equipment

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

6.8.2 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.

6.8.3 Limits > 1 GHz

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

6.8.4 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

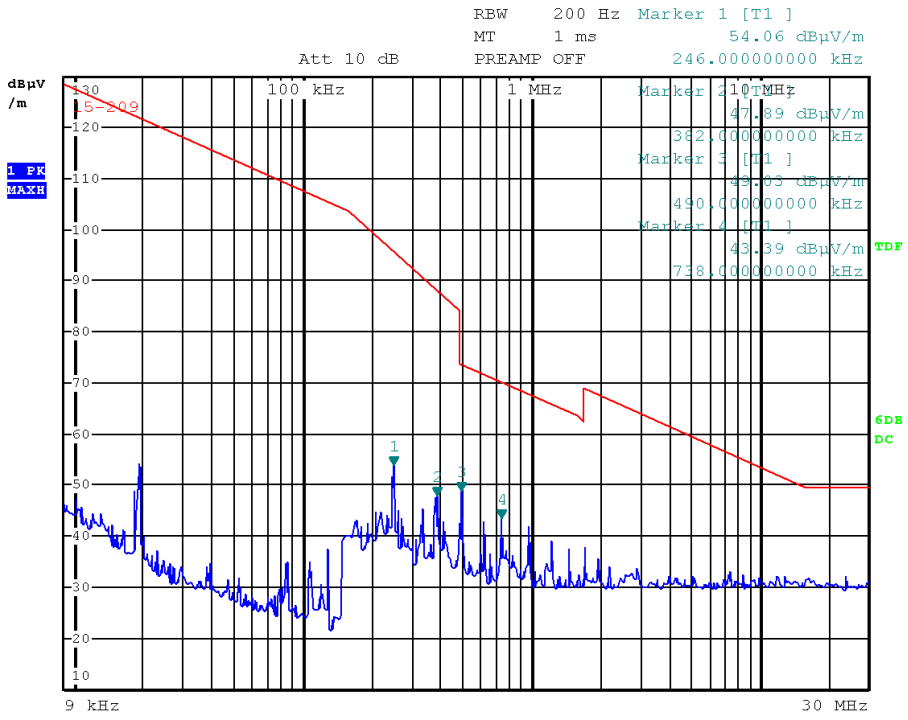


Figure 32: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel 3

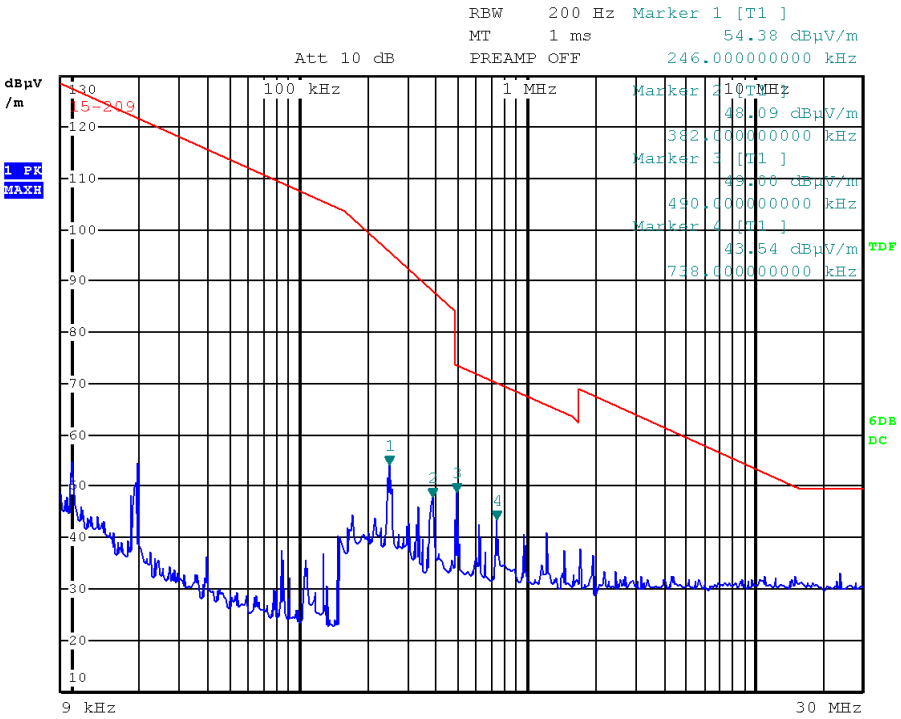


Figure 33: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel 40

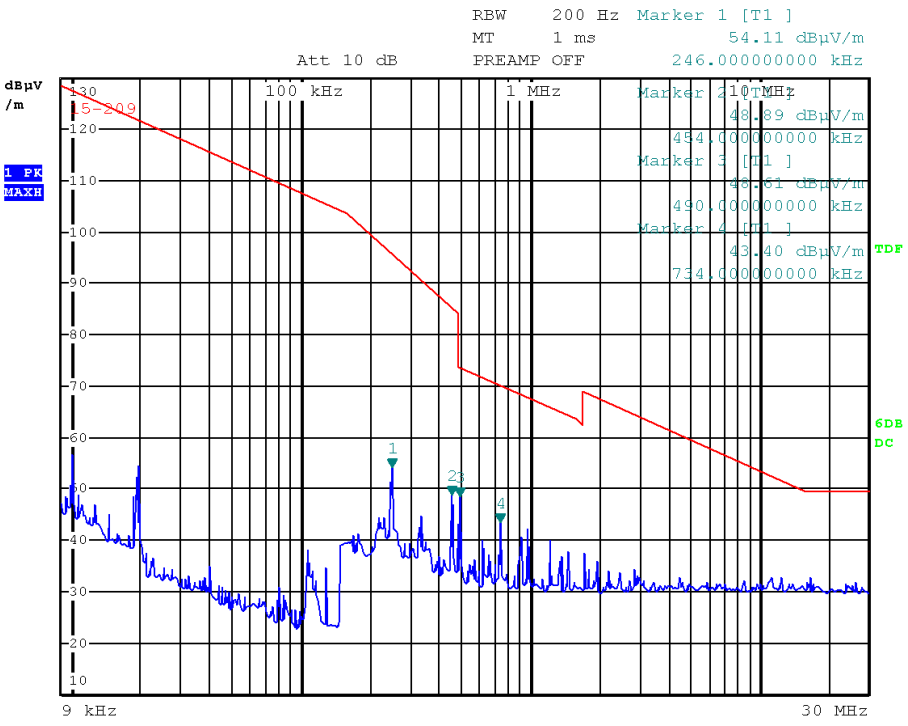


Figure 34: Chart of spurious radiated emission test 9 kHz - 30 MHz, channel 78

6.8.5 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

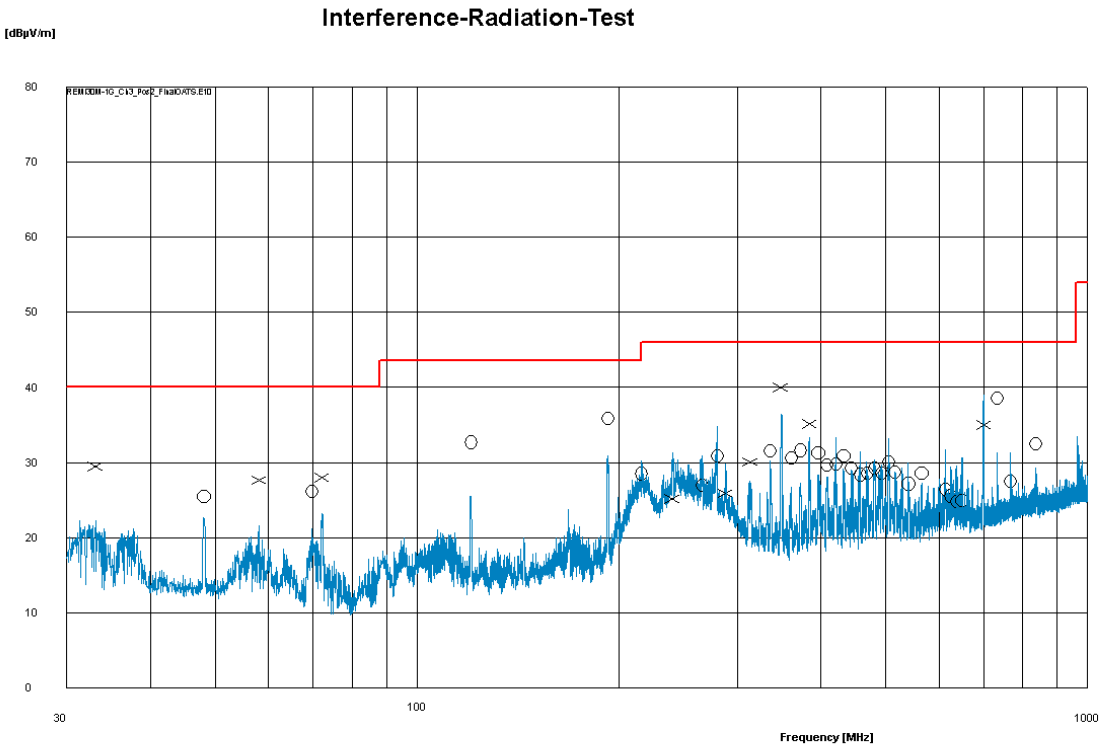


Figure 35: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 3

f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
33.12	29.46	40.00	100	16	V	Pass
48.06	25.54	40.00	100	360	H	Pass
58.14	27.66	40.00	100	185	V	Pass
69.72	26.17	40.00	100	29	H	Pass
72.06	27.99	40.00	100	61	V	Pass
120.18	32.72	43.52	100	82	H	Pass
192.42	35.93	43.52	100	87	H	Pass
216.12	28.55	46.02	100	83	H	Pass
240.06	25.20	46.02	100	281	V	Pass
266.34	27.00	46.02	100	48	H	Pass
279.84	30.90	46.02	100	44	H	Pass
288.24	25.90	46.02	100	7	V	Pass
313.68	30.09	46.02	100	27	V	Pass
336.00	31.58	46.02	100	165	H	Pass
348.54	39.98	46.02	118	20	V	Pass
360.90	30.59	46.02	100	167	H	Pass
372.78	31.64	46.02	100	176	H	Pass
384.84	35.13	46.02	100	359	V	Pass
396.24	31.36	46.02	100	253	H	Pass
408.78	29.64	46.02	100	245	H	Pass
420.60	29.84	46.02	100	241	H	Pass
432.24	30.94	46.02	100	246	H	Pass
444.00	29.29	46.02	100	230	H	Pass
457.62	28.40	46.02	100	234	H	Pass
468.72	28.63	46.02	100	46	H	Pass
480.00	29.25	46.02	100	51	H	Pass
493.20	28.63	46.02	100	38	H	Pass
505.44	30.06	46.02	100	40	H	Pass
515.94	28.78	46.02	100	34	H	Pass
540.06	27.20	46.02	100	38	H	Pass
565.20	28.57	46.02	100	121	H	Pass
613.14	26.41	46.02	100	12	H	Pass
624.54	25.59	46.02	100	170	H	Pass
637.38	24.86	46.02	100	0	H	Pass
649.74	24.99	46.02	100	35	H	Pass
699.78	35.01	46.02	100	40	V	Pass
732.42	38.54	46.02	107	8	H	Pass
766.62	27.50	46.02	100	47	H	Pass
836.34	32.51	46.02	100	87	H	Pass

Table 10: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel 3

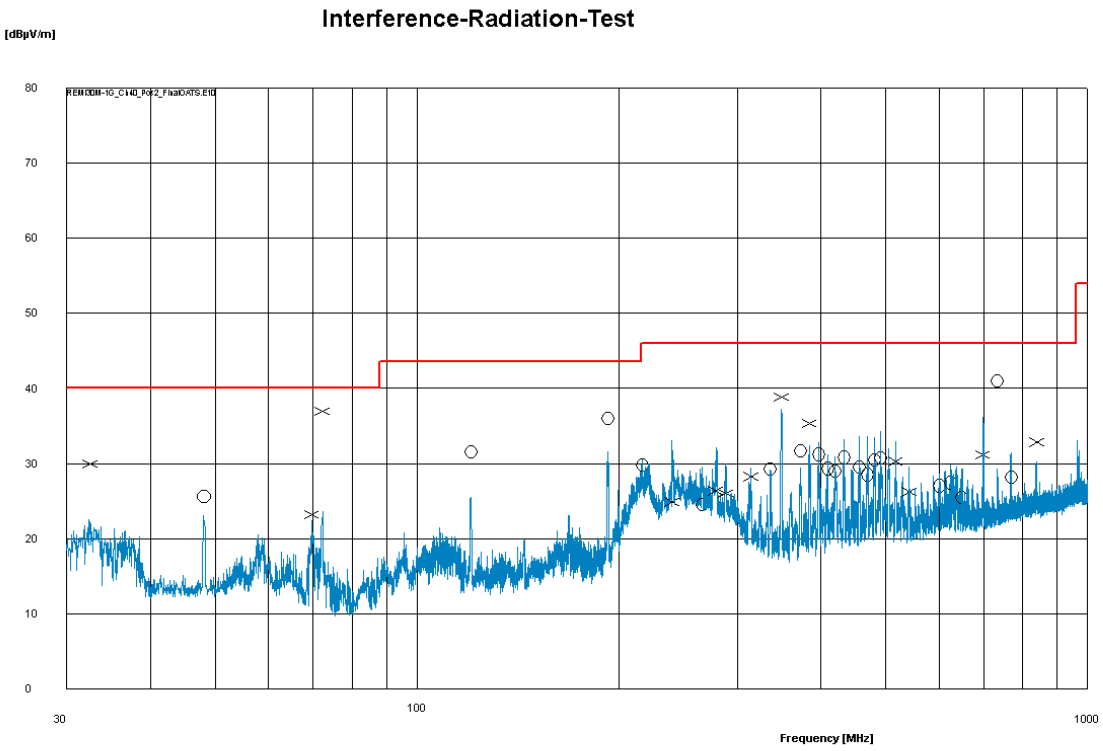


Figure 36: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 40

f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
32.52	29.96	40.00	100	81	H	Pass
48.06	25.60	40.00	100	89	H	Pass
69.60	23.21	40.00	120	292	V	Pass
72.24	36.95	40.00	100	117	H	Pass
120.42	31.55	43.52	100	38	V	Pass
192.42	36.06	43.52	100	6	V	Pass
216.30	29.86	46.02	100	31	V	Pass
240.00	24.93	46.02	100	167	H	Pass
265.62	24.58	46.02	100	12	V	Pass
278.82	26.37	46.02	100	165	H	Pass
288.54	26.03	46.02	100	0	V	Pass
314.82	28.28	46.02	100	254	H	Pass
335.88	29.26	46.02	100	242	H	Pass
349.86	38.87	46.02	100	254	H	Pass
372.78	31.68	46.02	100	235	H	Pass
384.84	35.34	46.02	100	241	H	Pass
396.66	31.23	46.02	100	45	H	Pass
409.08	29.35	46.02	100	43	H	Pass
419.82	29.05	46.02	152	37	H	Pass
432.90	30.84	46.02	100	352	V	Pass
456.72	29.59	46.02	100	354	V	Pass
469.26	28.54	46.02	100	138	H	Pass
480.84	30.51	46.02	100	7	H	Pass
491.40	30.74	46.02	100	41	H	Pass
517.08	30.26	46.02	100	35	V	Pass
542.04	26.28	46.02	370	134	H	Pass
600.24	27.06	46.02	100	49	H	Pass
624.66	27.47	46.02	100	25	V	Pass
648.72	25.50	46.02	100	81	H	Pass
698.10	31.17	46.02	100	89	H	Pass
731.82	41.07	46.02	120	292	V	Pass
769.74	28.23	46.02	100	117	H	Pass
839.76	32.84	46.02	100	38	V	Pass

Table 11: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel 40

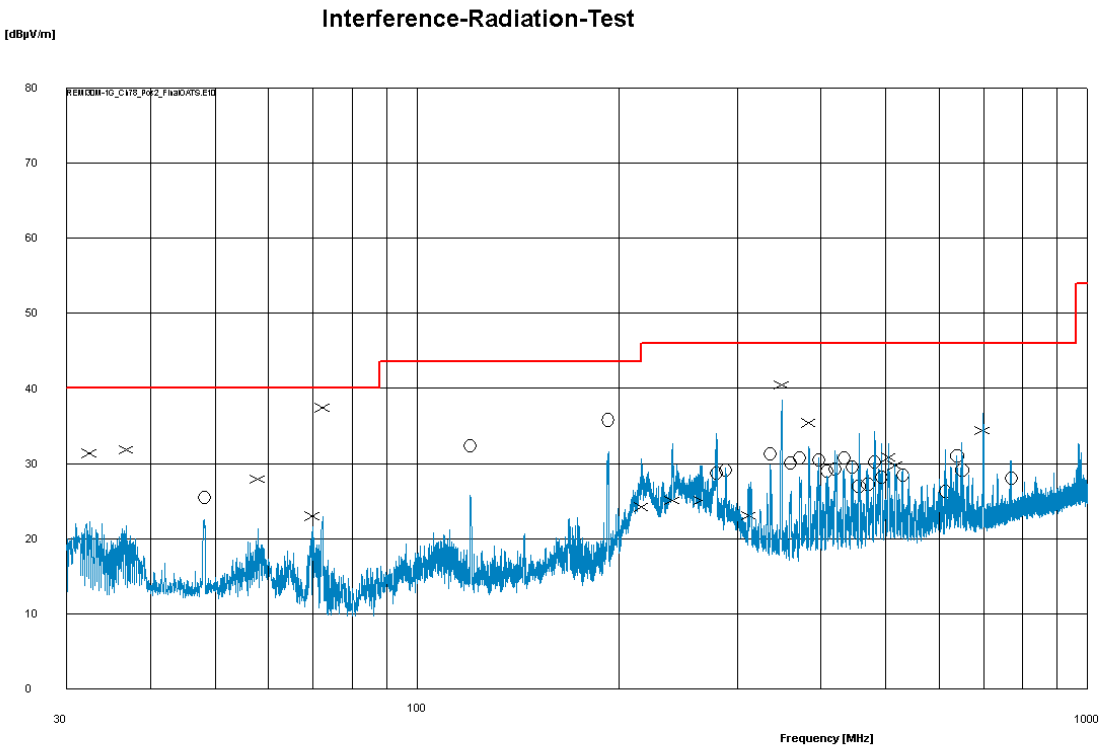


Figure 37: Chart of spurious radiated emission test 30 MHz - 1 GHz, channel 78

f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
32.46	31.38	40.00	100	334	V	Pass
36.84	31.83	40.00	100	64	V	Pass
48.12	25.47	40.00	100	355	H	Pass
57.84	27.92	40.00	100	185	V	Pass
69.78	23.00	40.00	100	360	V	Pass
72.24	37.47	40.00	106	58	V	Pass
120.00	32.41	43.52	100	92	H	Pass
192.24	35.82	43.52	101	98	H	Pass
216.00	24.23	43.52	100	324	V	Pass
240.06	25.10	46.02	103	304	V	Pass
265.56	25.13	46.02	100	37	V	Pass
279.18	28.79	46.02	100	214	H	Pass
287.82	29.15	46.02	100	22	H	Pass
312.18	23.11	46.02	100	8	V	Pass
336.06	31.34	46.02	100	165	H	Pass
349.86	40.46	46.02	112	16	V	Pass
360.00	30.12	46.02	100	174	H	Pass
371.94	30.83	46.02	100	163	H	Pass
383.40	35.43	46.02	100	1	V	Pass
397.26	30.51	46.02	100	255	H	Pass
408.24	29.07	46.02	100	245	H	Pass
420.24	29.27	46.02	100	250	H	Pass
432.66	30.80	46.02	100	237	H	Pass
444.84	29.57	46.02	100	239	H	Pass
455.52	27.04	46.02	100	234	H	Pass
469.92	27.22	46.02	100	47	H	Pass
481.38	30.21	46.02	100	37	H	Pass
492.00	28.26	46.02	100	38	H	Pass
504.90	30.81	46.02	100	348	V	Pass
515.94	29.73	46.02	100	360	V	Pass
529.50	28.46	46.02	336	76	H	Pass
613.20	26.36	46.02	100	13	H	Pass
638.40	31.06	46.02	359	127	H	Pass
649.62	29.20	46.02	100	1	H	Pass
696.96	34.40	46.02	100	41	V	Pass
769.74	28.12	46.02	100	46	H	Pass

Table 12: Final result of spurious radiated emission test 30 MHz - 1 GHz, channel 78

6.8.6 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 – 16 GHz	250 kHz	1 MHz	PK	PK	100 ms	100 ms	30 dB
1 GHz – 16 GHz	250 kHz	1 MHz	AV	AV	100 ms	100 ms	30 dB
16 GHz – 26 GHz	250 kHz	1 MHz	PK	PK	100 ms	100 ms	external
16 GHz – 26 GHz	250 kHz	1 MHz	AV	AV	100 ms	100 ms	external

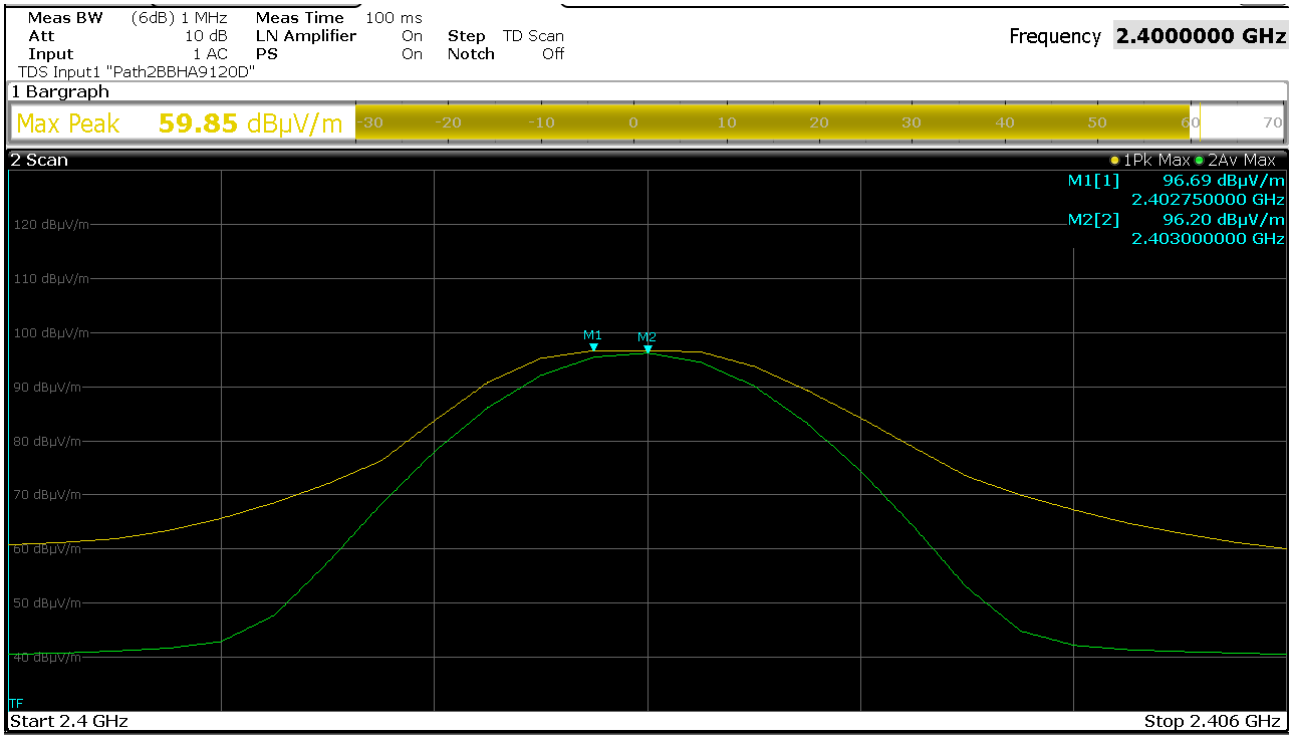


Figure 38: 1st Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 3

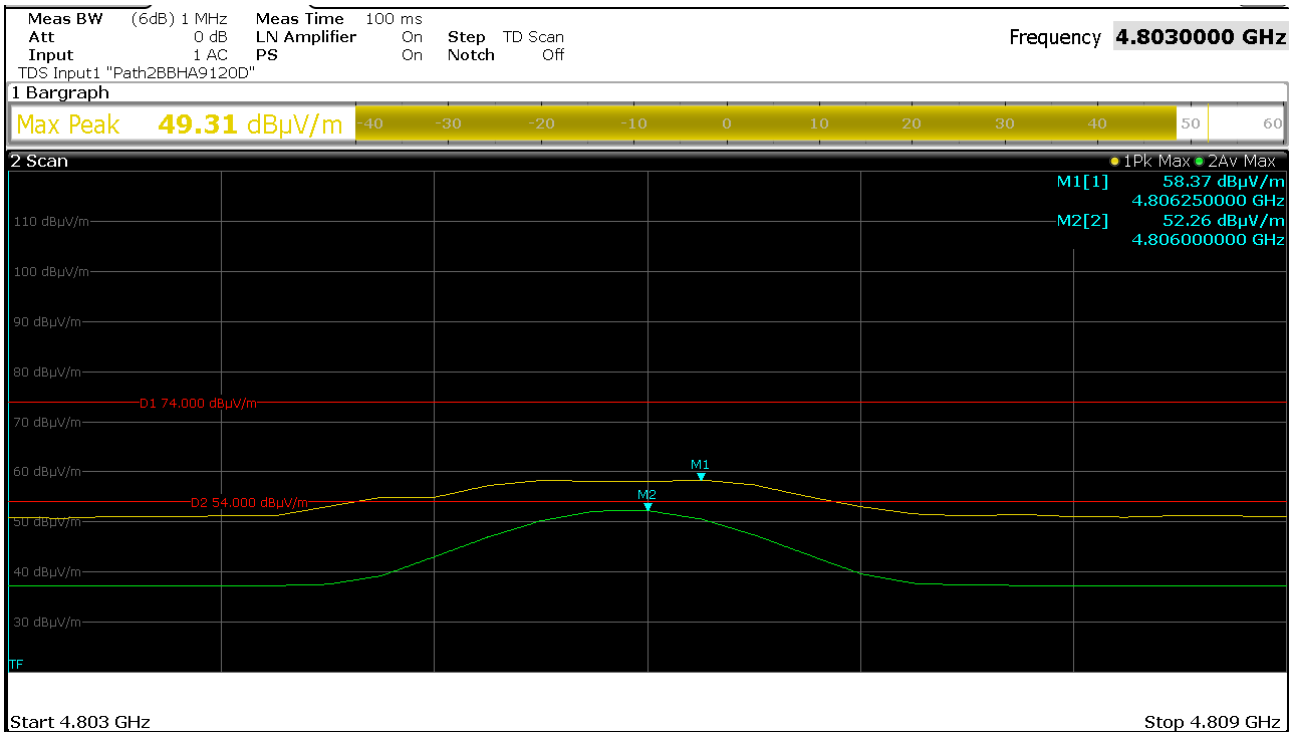


Figure 39: 2nd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 3

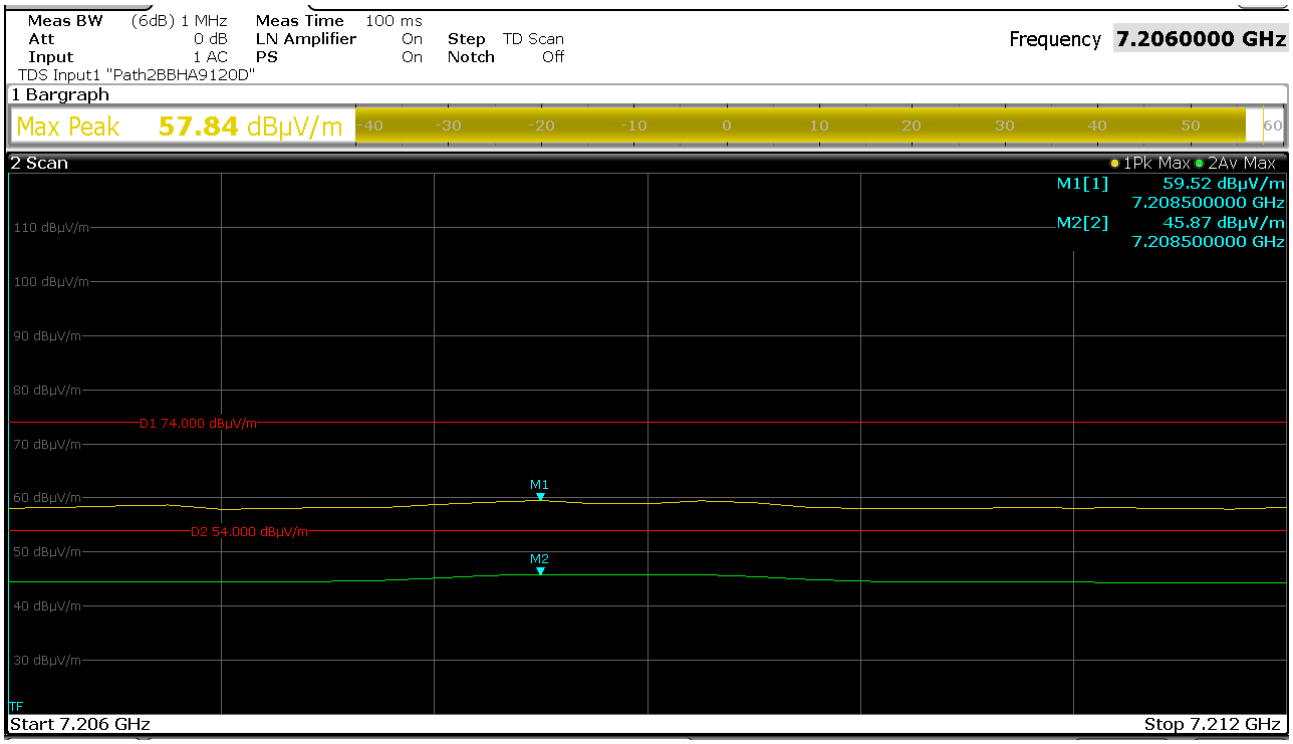


Figure 40: 3rd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 3

f[GHz]	E_{meas} [dBµV/m]	EUT-Pos	Polari-zation	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4028	96.69	1	H	343	148	PK	No	---	Carrier
2.4030	96.20					AV		---	Carrier
4.8063	58.37	2	V	347	119	PK	Yes	74	Pass
4.8060	52.26					AV		54	Pass
7.2085	59.52	2	V	304	185	PK	No	-20dBc	Pass
7.2085	45.87					AV		-20dBc	Pass

Table 13: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel 3

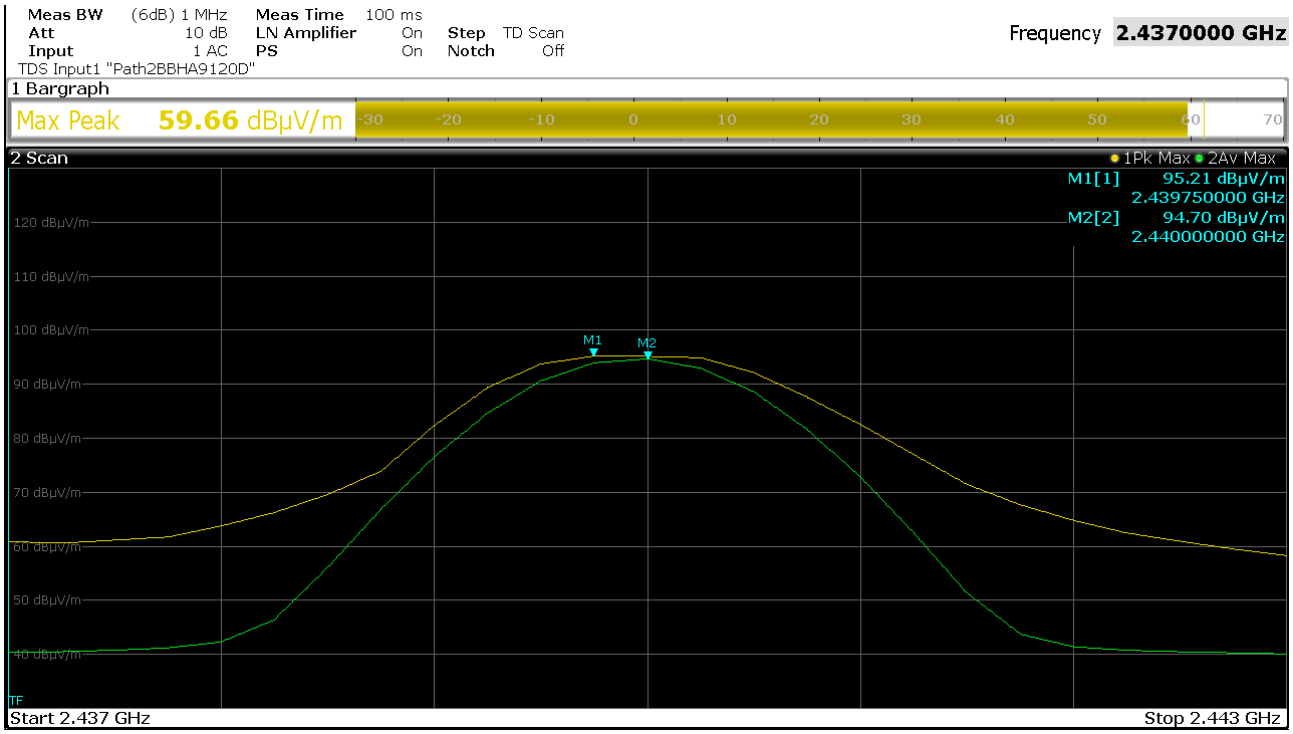


Figure 41: 1st Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 40

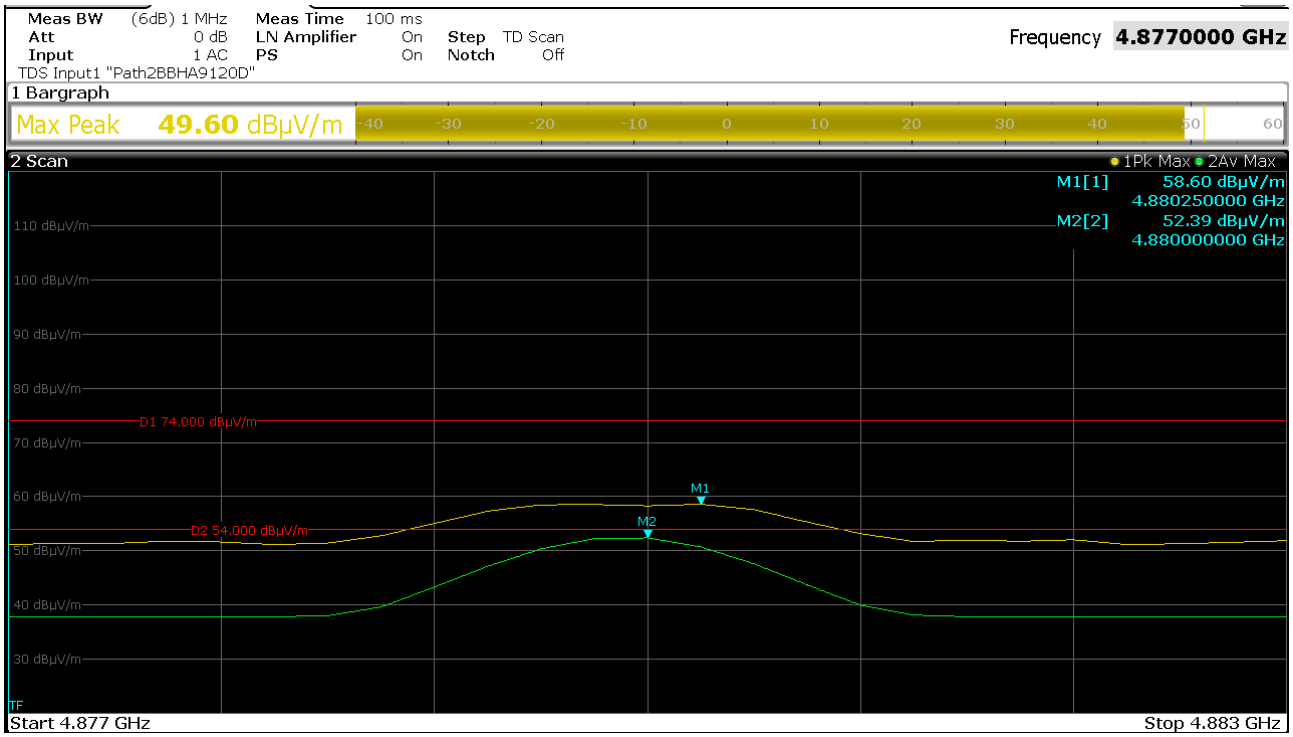


Figure 42: 2nd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 40

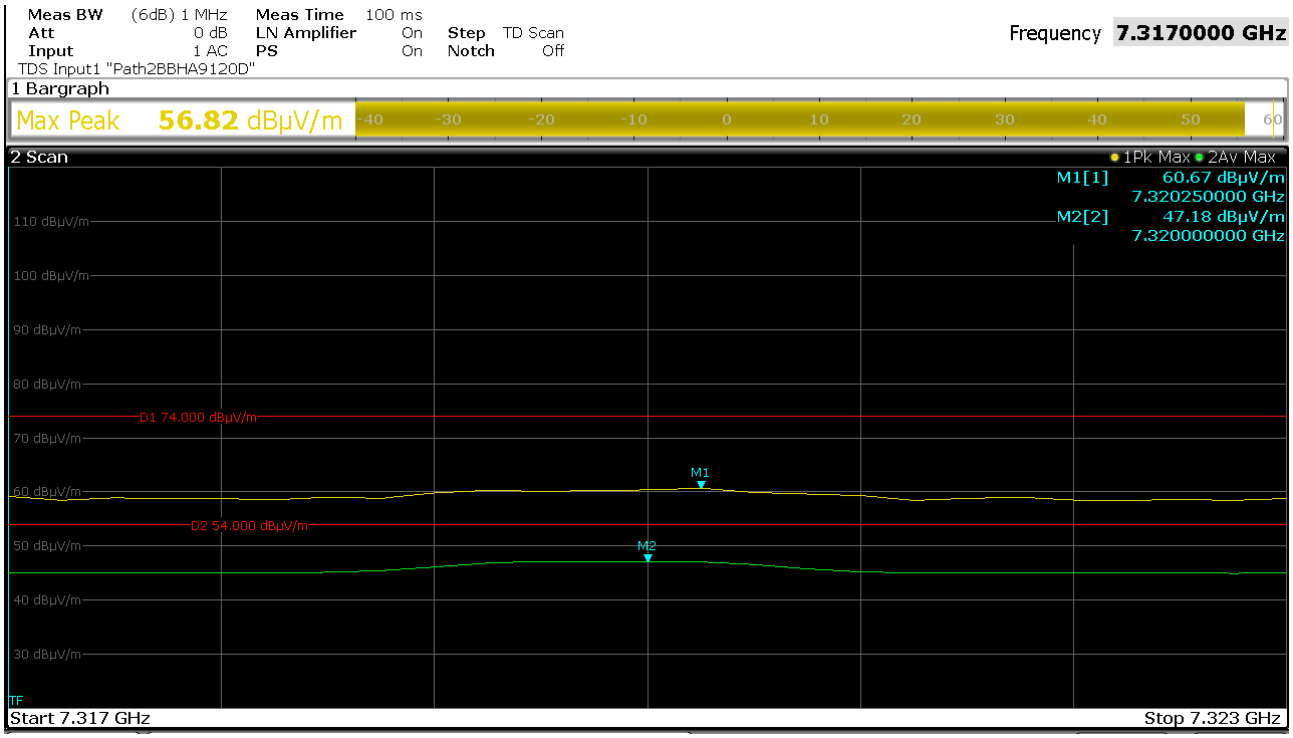


Figure 43: 3rd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 40

f[GHz]	E_{meas} [dBµV/m]	EUT-Pos	Polari-zation	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4398	95.21	1	H	341	171	PK	No	---	Carrier
2.4400	94.70					AV		---	Carrier
4.8803	58.60	2	V	55	155	PK	Yes	74	Pass
4.8800	52.39					AV		54	Pass
7.3203	60.67	2	V	35	181	PK	Yes	74	Pass
7.3200	47.18					AV		54	Pass

Table 14: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel 40

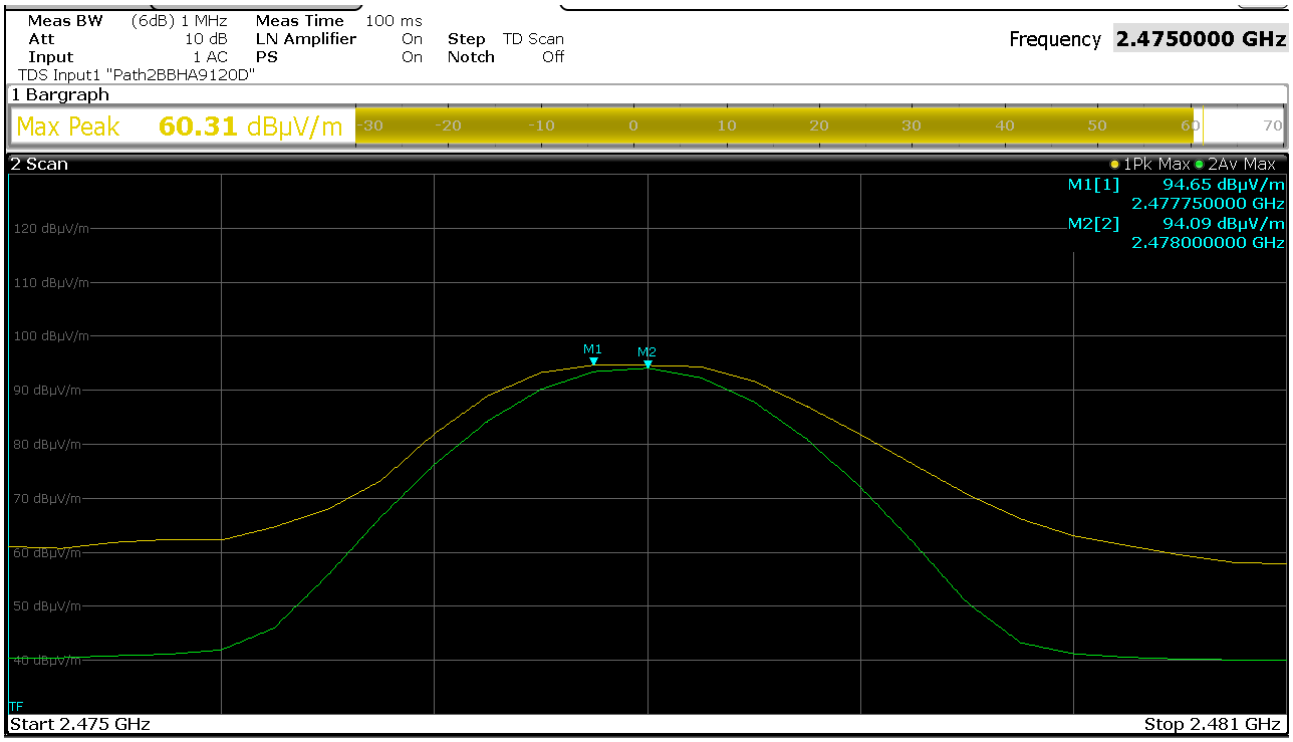


Figure 44: 1st Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 78

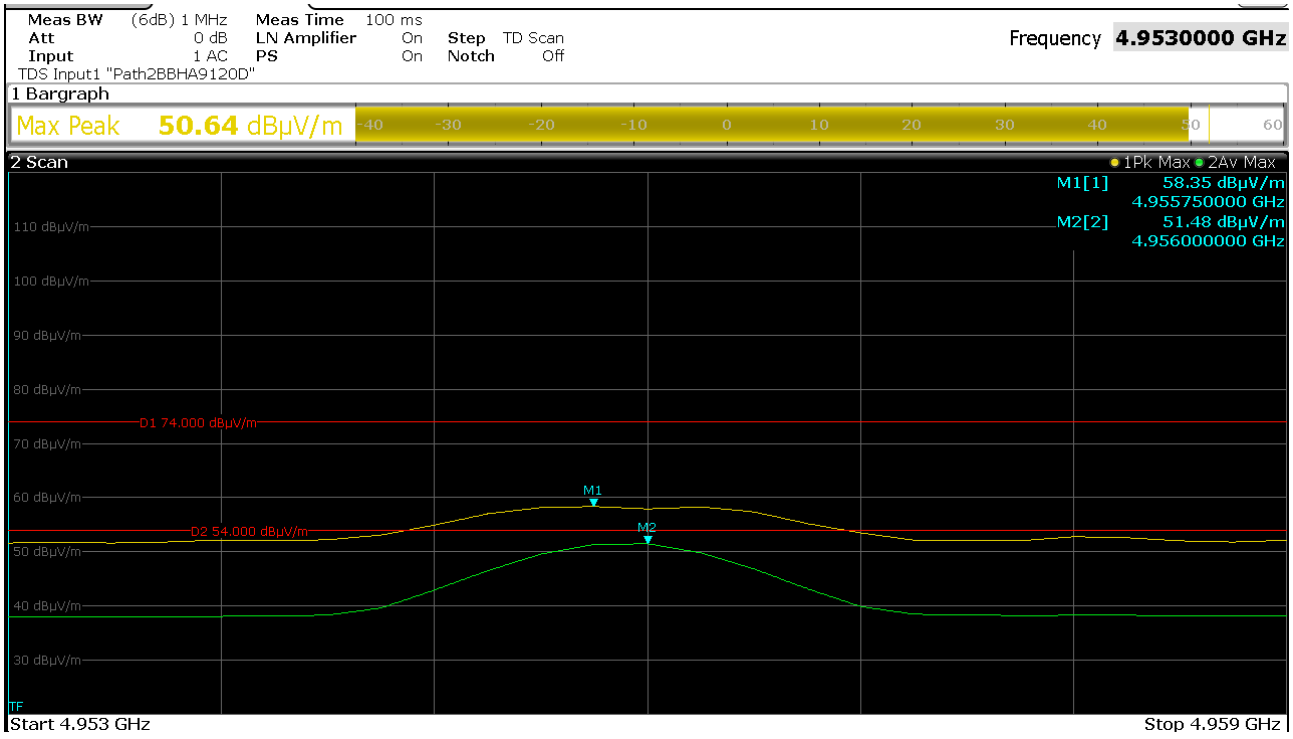


Figure 45: 2nd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 78

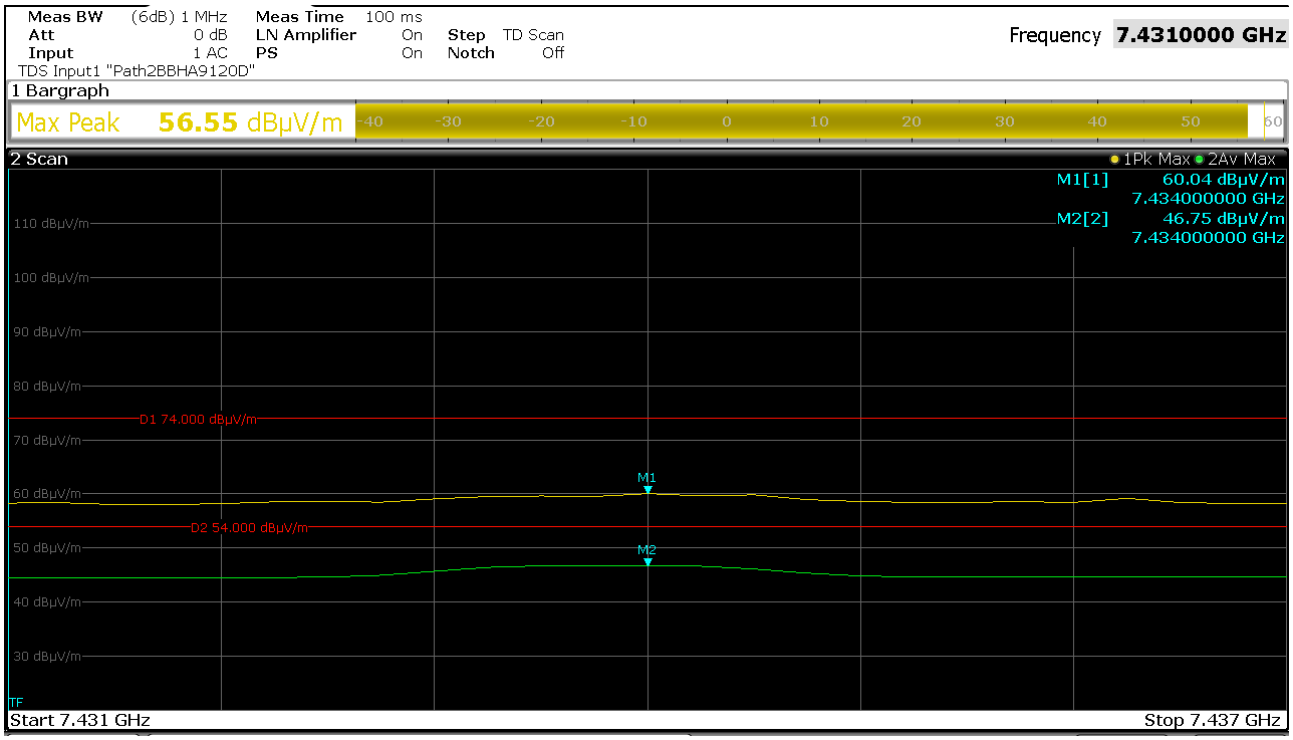


Figure 46: 3rd Chart of spurious radiated emission final test 1 GHz to 10th harmonic, channel 78

f[GHz]	E_{meas} [dBµV/m]	EUT-Pos	Polari-zation	Table [°]	Height [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4778	94.65	1	H	339	170	PK	No	---	Carrier
2.4780	94.09					AV		---	Carrier
4.9558	58.35	2	V	56	152	PK	Yes	74	Pass
4.9560	51.48					AV		54	Pass
7.4340	60.04	2	V	32	178	PK	Yes	74	Pass
7.4340	46.75					AV		54	Pass

Table 15: Final result of spurious radiated emission test 1 GHz to 10th harmonic, channel 78

6.9 Radio frequency radiation exposure evaluation for mobile devices

Reference(s): 47 CFR Part 2, §2.1091
KDB 447498 D01, section 7
RSS Gen Issue 4, section 3.2
RSS-102 Issue 5, section 2.5.2

Performed by:	Martin Müller	Date of test:	April 24, 2017
Result:	☒ Test passed	☐ Test not passed	

6.9.1 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 6.5):	logarithmic 1.44 dBm	numeric 1.39 mW	
Maximum equivalent isotropically radiated power:	logarithmic 1.44 dBm	numeric 1.39 mW	
Maximum operation frequency (see clause 3):	2478.000 MHz		

6.9.2 Requirements

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

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

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

Table 16 below shows the limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

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

Table 16: Limits for maximum permissible exposure (MPE) according to table 1 of §1.1310(e)

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

Appropriate RF Field Strength Limits for Devices Used by the General Public (Uncontroled Environment) can be found in table 4 of RSS-102, section 4:

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10	83	90	-	Instantaneous*
0.1-10	-	0.73/f	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619\ f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\ f^{0.5}$	$4.21 \times 10^{-4}\ f^{0.5}$	$6.67 \times 10^{-5}\ f$	$616000/f^{1.2}$
Note: f is frequency in MHz. *Based on nerve stimulation (NS). ** Based on specific absorption rate (SAR).				

Table 17: RF field strength limits according to table 4 of RSS-102

6.9.3 Results

Maximum peak value of electric field strength measured at 2402.8 MHz in a distance of 3 m:
$E_{meas}(3\ m)$ = 96.69 dBµV/m (see clause 6.8)

For far-field conditions wave impedance in free space is about 120·π Ω (51.5 dB). Therefore, magnetic field strength results in:
$H_{meas}(3\ m) = E_{meas}(3\ m)$ - 51.5 dB = 96.69 dBµV/m -51.5 dB = 45.19 dBµA/m

Worst case field strength is calculated for a separation distance of 20 centimeters.

Using an extrapolation factor of 20 dB/decade (~ r^{-1}) results in:
$E_{calc}(20\ cm)$ = 96.69 dBµV/m - 20 · log(0.2 m / 3 m) = 96.69 dBµV/m + 23.52 dB
E_{calc} (20 cm) = 120.21 dBµV/m = 1.024 V/m

Using an extrapolation factor of 20 dB/decade (~ r^{-1}) results in:
$H_{calc}(20\ cm)$ = 45.19 dBµA/m - 20 · log(0.2 m / 3 m) = 45.19 dBµA/m + 23.52 dB
$H_{calc}(20\ cm)$ = 68.71 dBµA/m = $2.726 \cdot 10^{-3}$ A/m

Worst case power density is calculated for a separation distance of 20 centimeters by using the respective field strengths as calculated above:

$S_{calc}(20\ cm) = E_{calc}(20\ cm) \cdot H_{calc}(20\ cm) = 1.024\ V/m \cdot \underline{2.726 \cdot 10^{-3}}\ A/m$
$S_{calc}(20cm) = \underline{0.0028\ W/m^2} = \underline{0.00028\ mW/cm^2}$

Comparing the calculated results to the limits for general population/uncontroled exposure at 2402.8 MHz shows that even with worst case calculation using peak values the limits are kept.

E-field			
E_{calc}(20 cm) (V/m)	Limit 47 CFR Par 1, §1.1310(e) (V/m)		Limit RSS-102, table 2 (V/m)
1.024	---		44.916
H-field			
H_{calc}(20 cm) (A/m)	Limit 47 CFR Par 1, §1.1310(e) (A/m)		Limit RSS-102, table 2 (A/m)
0.0028	---		0.119
Power density			
S_{calc}(20 cm) (mW/cm^2)	Limit 47 CFR Par 1, §1.1310(e) (mW/cm^2)	S_{calc}(20 cm) (W/m^2)	Limit RSS-102, table 2 (W/m^2)
0.00028	1.0	0.0028	5.352

Table 18: Calculated results @ 2402.8 MHz compared to RF field strength limits

6.9.4 Requirements for simultaneous transmission

According to customer, simultaneous transmission of SRD and BLE is not intended to be used. However, the following calculations show that MPE and RF field strength limits would be kept even with simultaneous transmission of SRD and BLE.

6.9.4.1 Requirements

As noted in KDB 447498 D01, section 7.2, simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

In case of simultaneous transmission the standalone results are used for calculation according to the following formulas:

$$\sum_{i=SRD}^{BLE} \frac{E_i}{E_{limit\ i}} \leq 1 \Leftrightarrow \frac{E_{SRD}(V/m)}{E_{limit\ SRD}(V/m)} + \frac{E_{BLE}(V/m)}{E_{limit\ BLE}(V/m)} \leq 1$$

$$\sum_{i=SRD}^{BLE} \frac{H_i}{H_{limit\ i}} \leq 1 \Leftrightarrow \frac{H_{SRD}(A/m)}{H_{limit\ SRD}(A/m)} + \frac{H_{BLE}(A/m)}{H_{limit\ BLE}(A/m)} \leq 1$$

$$\sum_{i=SRD}^{BLE} \frac{S_i}{S_{limit\ i}} \leq 1 \Leftrightarrow \frac{S_{SRD}(W/m^2)}{S_{limit\ SRD}(W/m^2)} + \frac{S_{BLE}(W/m^2)}{S_{limit\ BLE}(W/m^2)} \leq 1$$

Note: As for power density using the limit according to RSS-102, table 2, gives the worst case ratio, the values in W/m² are selected.

6.9.4.2 Results

With values for BLE mode taken from clause 6.9.3 of test report no. 170062-AU01+W02 the results are:

$$\frac{E_{SRD}(V/m)}{E_{limit\ SRD}(V/m)} + \frac{E_{BLE}(V/m)}{E_{limit\ BLE}(V/m)} = \frac{1.024\ V/m}{44.916\ V/m} + \frac{0.991\ V/m}{44.911\ V/m} \approx 0.045 \leq 1\ \checkmark$$

$$\frac{H_{SRD}(A/m)}{H_{limit\ SRD}(A/m)} + \frac{H_{BLE}(A/m)}{H_{limit\ BLE}(A/m)} = \frac{0.0028\ A/m}{0.119\ A/m} + \frac{0.0026\ A/m}{0.119\ A/m} \approx 0.045 \leq 1\ \checkmark$$

$$\frac{S_{SRD}(W/m^2)}{S_{limit\ SRD}(W/m^2)} + \frac{S_{BLE}(W/m^2)}{S_{limit\ BLE}(W/m^2)} = \frac{0.0028\ W/m^2}{5.352\ W/m^2} + \frac{0.0026\ W/m^2}{5.351\ W/m^2} \approx 0.001 \leq 1\ \checkmark$$

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	2016-02	2018-02
Test receiver	ESW 44	101538	E00895	2016-12	2018-12
Broadband horn antenna	BBHA 9120D	9120D-592	W00052	2017-04	2020-04
Broadband horn antenna	BBHA 9170	9170-332	W00054	2017-04	2020-04
Preamplifier	AMF-6F-16002650-25-10P	1317552	W00090	2015-06	2017-06
LISN	ESH2-Z5	881362/037	E00004	2016-10	2018-10
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9163	9163-228	E00012	2016-04	2019-04
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 19: Equipment calibration status

Note 1: Expiration date of measurement facility registration by
- FCC (registration number 221458): 2017-07
- 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 20: 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	2017-05-02	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)