Test Report

Customer:

Procter & Gamble Service GmbH

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RF Test Report

150111-AU01+W03

Industry Canada Industrie Canada

Procter & Gamble Service GmbH
electric toothbrush with BLE
3765

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
94315 Straubing
Germany

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

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1 Test regulations

47 CFR Part 2 October 2014	Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)
47 CFR Part 15 October 2014	Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
KDB Publication no. 558074 June 5, 2014	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
FCC KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
FCC KDB 447498 D01 February 7, 2014	Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies
RSS-Gen Issue 4, November 2014	General Requirements for Compliance of Radio Apparatus
RSS-102 Issue 5, March 2015	Radio Frequency Exposure Compliance of Radiocommunications Apperatus
RSS-247 Issue 1, May 2015	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.1 Cross reference of FCC and Industry Canada standards

47 CFR Part and Section	Test	Page	Equivalent to IC
15.207	AC power line conducted emissions 150 kHz to 30 MHz	see note 1	RSS-Gen Issue 4 section 8.8
15.247(a)(2) KDB 558074, section 8 15.215(c)	6 dB bandwidth	13	RSS-247 Issue 1, section 5.2
15.215(c)	20 dB bandwidth[1]	17	RSS-247 Issue 1, section 5.1 (1)
2.202(a)	Occupied bandwidth	21	RSS-Gen Issue 4, section 6.6
15.247(b) KDB 558074, section 9	Maximum peak conducted output power	25	RSS-Gen Issue 4, section 6.12 RSS-247 Issue 1, section 5.4
15.247(d)	Band-edge compliance	36	RSS-247 Issue 1, section 5.5
15.247(e) KDB 558074, section 10	Power spectral density	30	RSS-Gen Issue 4, section 6.12 RSS-247 Issue 1, section 5.2
15.247(d)	Spurious RF Conducted Emission	41	RSS-247 Issue 1, section 5.5
15.247(d)	Radiated emission 9 kHz to 10th harmonic	50 58	RSS-Gen Issue 4, section 6.13 RSS-247 Issue 1, section 5.5
2.1093	Radiofrequency radiation exposure evaluation: portable devices.	70	RSS-Gen Issue 4, section 3.2 Exempted from SAR and RF evaluation

Note 1: As described in user manual radio transmission is deactivated while handle is placed on plugged-in charger. Therefore charging mode is not subject to radio certification and AC power line conducted emissions test does not apply, although plugged-in charger and handle are put on the market together as electric toothbrush.
In addition, handle is sold with a charging travel case that also contains a charger. Using wireless power transfer, plugged-in charger and charging travel case have to be authorized separately.

1.2 Summary of test results

Standard	Test result
FCC 47 CFR Part 15, section 15.247	Passed
RSS-247 Issue 1 and RSS-Gen Issue 4	Passed

[1] For DTS equipment recorded for information only.

2 Equipment under Test (EUT)

Product type:	Electric toothbrush with BLE
Model Name:	3765
Manufacturer:	Procter & Gamble Service GmbH
Serial number(s):	Sample2: for radiated measurements Sample3 with temporary antenna connector for conducted measurements
FCC ID:	USQ3765
IC:	6856A-3765
Application frequency band:	2400 MHz to 2483.5 MHz
Frequency range:	2402MHz to 2480 MHz
Operating frequency:	2402MHz to 2480 MHz
Channel spacing [1)]:	2 MHz
Number of RF-channels [1)]:	40 (37 + 3 advertising channels)
Type of modulation [1)]:	DSSS (GFSK)
Antenna type [1)]:	PCB antenna, not detachable, g = -1.0 dBi
Antenna connectors:	None (temporary antenna connector for testing purposes only)
Antenna diversity:	☐ yes ☒no
Power supply [1) 2)]:	Battery supplied Nominal voltage: 3.7 V DC
Temperature range[1)]:	0°C to +50°C

1) As declared by manufacturer.
2) As described in user manual radio transmission is deactivated while handle is placed on plugged-in charger. Therefore charging mode is not subject to radio certification, although plugged-in charger and handle are put on the market together.
In addition, handle is sold with a charging travel case that also contains a charger.
Using wireless power transfer, plugged-in charger and charging travel case have to be authorized separately.

2.1 Photo documentation

For photos taken during testing see annex A.
For photos of the EUT see annex B.
For internal photos of the EUT see annex C.

2.2 Short description of the EUT

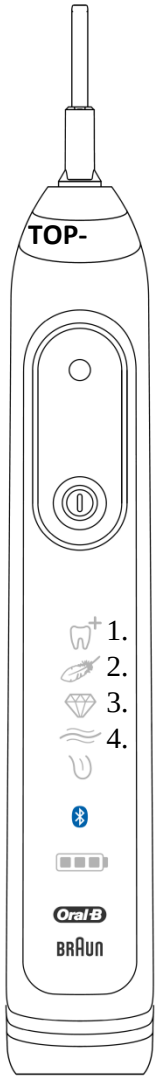
The EUT is a electric toothbrush that transmits data to e.g. a smart phone via BLE.

During pre-measurements it was investigated which EUT position is the respective worst-case.
The EUT positions are documented in annex A.

2.3 Operation mode

The EUT was set to the measured channels. Further the following adjustments were set:

Tx-mode: Channel low -> 2402 MHz
Channel mid -> 2440 MHz
Channel high -> 2480 MHz
continuous carrier, modulated, unmodulated



BUTTON-PRESSED	TOP-LED	MODE-LED	MODE
1	blue	1	BT TX Continous Wave (CW), 2402 MHz, 0 dBm
2	blue	2	BT TX Continous Wave (CW), 2440 MHz, 0 dBm
3	blue	3	BT TX Continous Wave (CW), 2480 MHz, 0 dBm
4	blue flashing	1	BT TX Modulated, 2402 MHz 0 dBm
5	blue flashing	2	BT TX Modulated, 2440 MHz 0 dBm
6	blue flashing	3	BT TX Modulated, 2480 MHz 0 dBm
7	off	**1**	BT RX On, 2402 MHz Standard gain
8	off	**2**	BT RX On, 2440 MHz Standard gain
9	off	**3**	BT RX On, 2480 MHz Standard gain
10			OFF
11	red	1	PROP TX Modulated, 2403 MHz
12	red	2	PROP TX Modulated, 2425 MHz
13	red	3	PROP TX Modulated, 2427 MHz
14	red	4	PROP TX Modulated, 2452 MHz
15			OFF

Reference point for all conducted measurements is plug of temporary antenna connector. Therefore all reading values were corrected by the attenuation of the test cable and the cable of the temporary antenna connector (see Table 1).

2.4 Configuration

The following peripheral devices and interface cables were connected during the tests:

Device	Model:	S/N
Electric toothbrush with proprietary mode	3765	Sample2 (for radiated measurements)
Electric toothbrush with proprietary mode	3765	Sample3 (for conducted measurements)
Charging device [1)]	Plus Voyager	97.533.685
AC power source[1)] 230V/50 Hz to 120V/60 Hz	Chroma 61602	E00633

Note 1: Only used for measurement "AC power line conducted emissions 150 kHz to 30 MHz".

Used cables

Count:	Description: (type / lengths / remarks)	Serial No
1	Adapter antenna cable (MMCX / SMA-connector) / 0.1m / coax / attenuation see Table 1	N/A

Channel	Frequency [GHz]	test cable attenuation [dB]	antenna cable attenuation [dB]	cable correction [dB]
Low	2.402	0.55	0.47	**1.02**
Mid	2.440	0.55	0.52	**1.07**
High	2.480	0.56	0.44	**1.00**

Table 1: Cable corrections

3 6 dB bandwidth

according to 47 CFR Part 15, sections 15.247(a) and 15.215(c), KDB Publication no. 558074, section 8

3.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

3.2 Test Instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

3.3 Limits

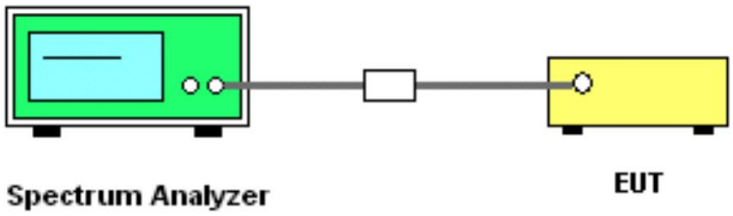
The minimum 6 dB bandwidth shall be at least 500 kHz and must be contained within the designated frequency band.

3.4 Test procedure

1. The test is performed in accordance with FCC KDB publication no. 558074
2. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
3. The unit was operated in continuous transmit mode with modulation.
4. The resolution bandwidth was set to 100 kHz with video bandwidth at least equal to three times the resolution bandwidth.

5. 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 were recorded.

3.5 Test setup



Picture 1: Test setup for 6 dB bandwidth measurement

3.6 Test deviation

There is no deviation with the original standard.

3.7 EUT operation during test

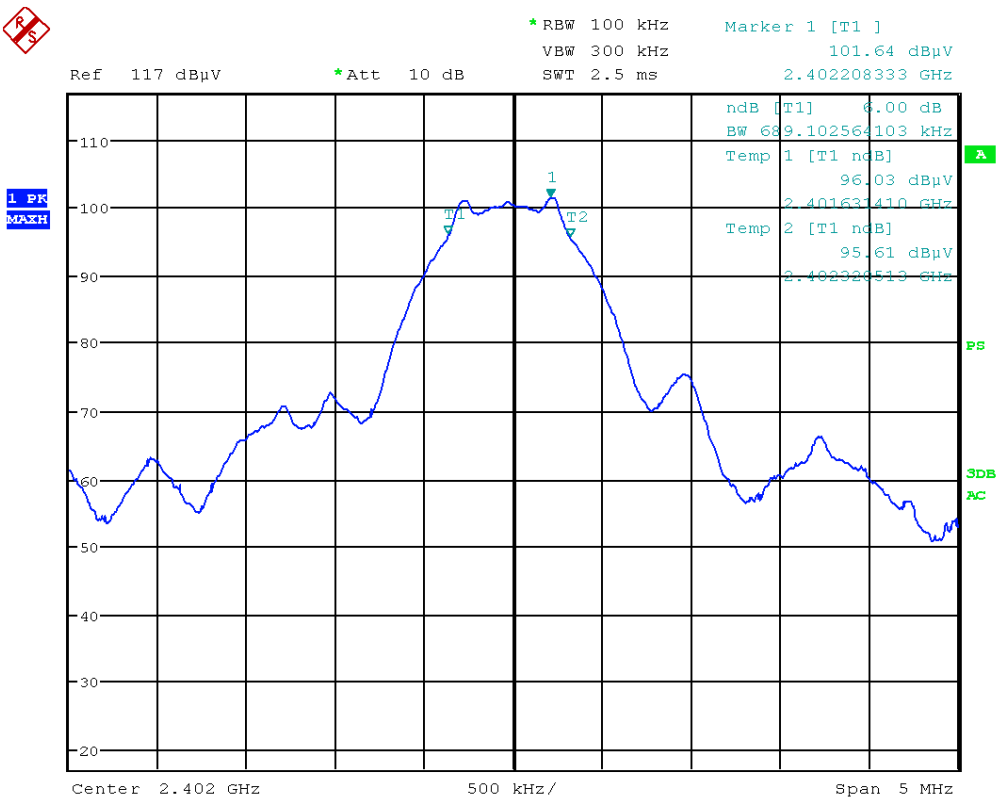
The EUT was programmed to be in continuously transmitting mode.

3.8 Test results

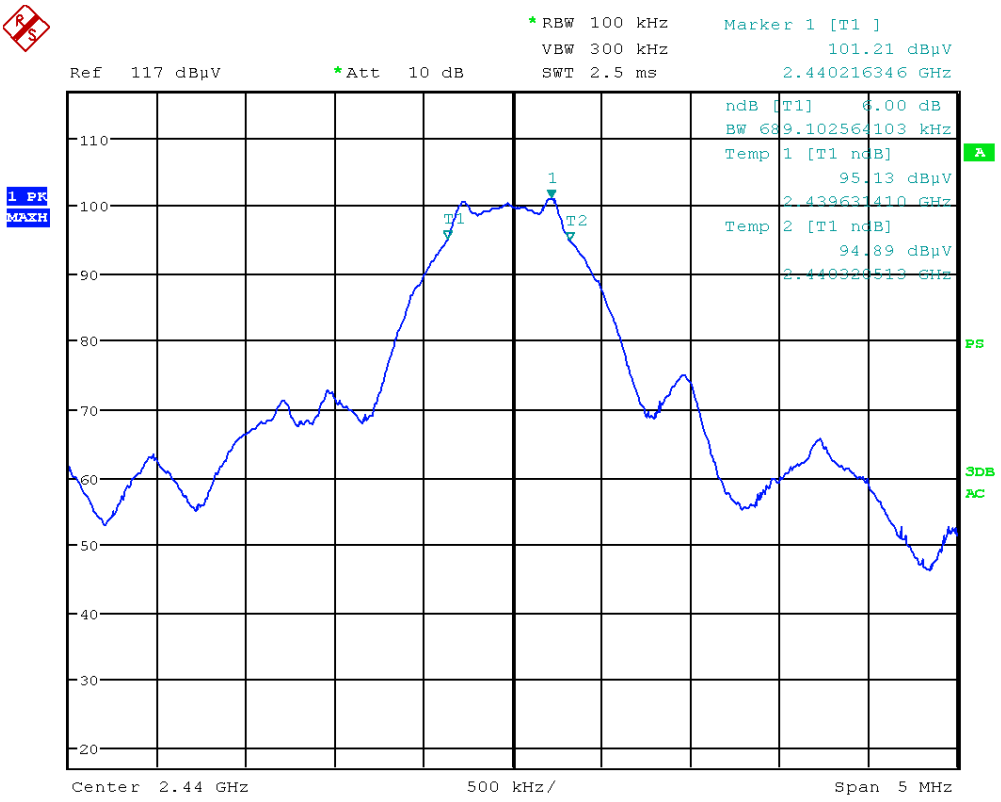
Temperature:	19°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-10-19

Designated frequency band: 2400 MHz to 2483.5 MHz

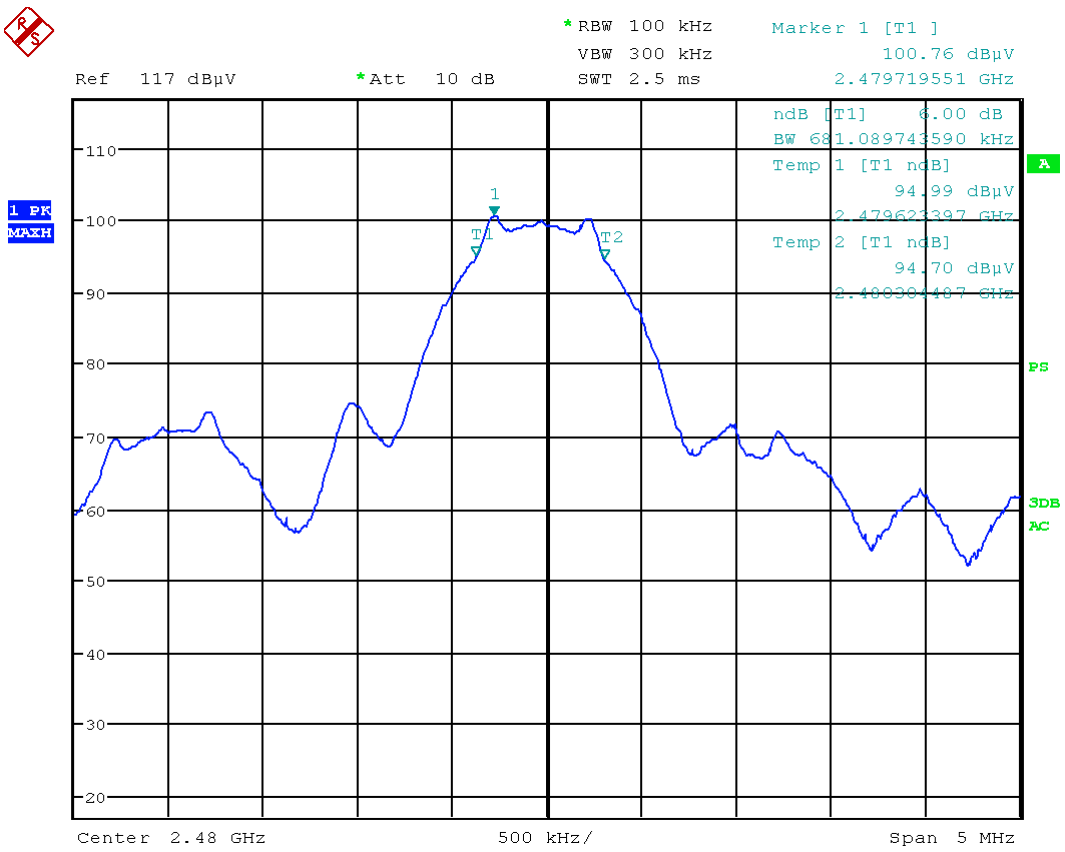
Channel	Frequency (GHz)			6 dB bandwidth (MHz)	Result
	peak	low	high		
Low	2.40221	2.40163	2.40232	0.68910	Pass
Mid	2.44022	2.43963	2.44032	0.68910	Pass
High	2.47972	2.47962	2.48030	0.6811	Pass



Picture 2: 6dB bandwidth, channel low



Picture 3: 6dB bandwidth, channel mid



Picture 4: 6dB bandwidth, channel high

4 20 dB bandwidth

according to 47 CFR Part 15, section 15.215(c)

4.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

4.2 Test Instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

4.3 Limits

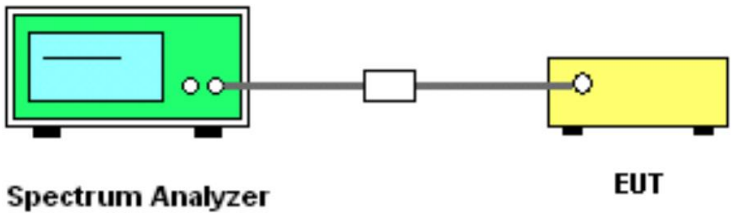
As not specified in the specific rule section the 20 dB bandwidth is measured and reported for information only.

4.4 Test procedure

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The unit was operated in continuous transmit mode with modulation.
3. The resolution bandwidth was set to equal or greater than 1.0% of the emission bandwidth with video bandwidth at least equal to resolution bandwidth.
4. 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 20 dB relative to the maximum level measured in the fundamental emission were recorded.

4.5 Test setup



Picture 5: Test setup for 20 dB bandwidth measurement

4.6 Test deviation

There is no deviation with the original standard.

4.7 EUT operation during test

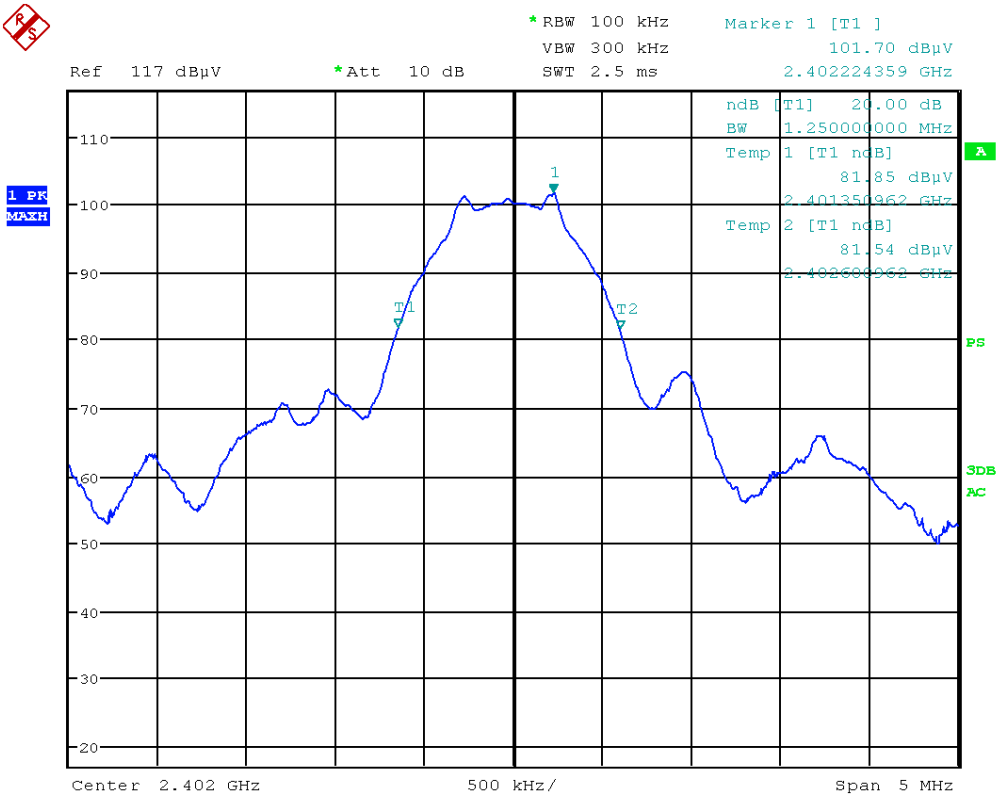
The EUT was programmed to be in continuously transmitting mode.

4.8 Test results

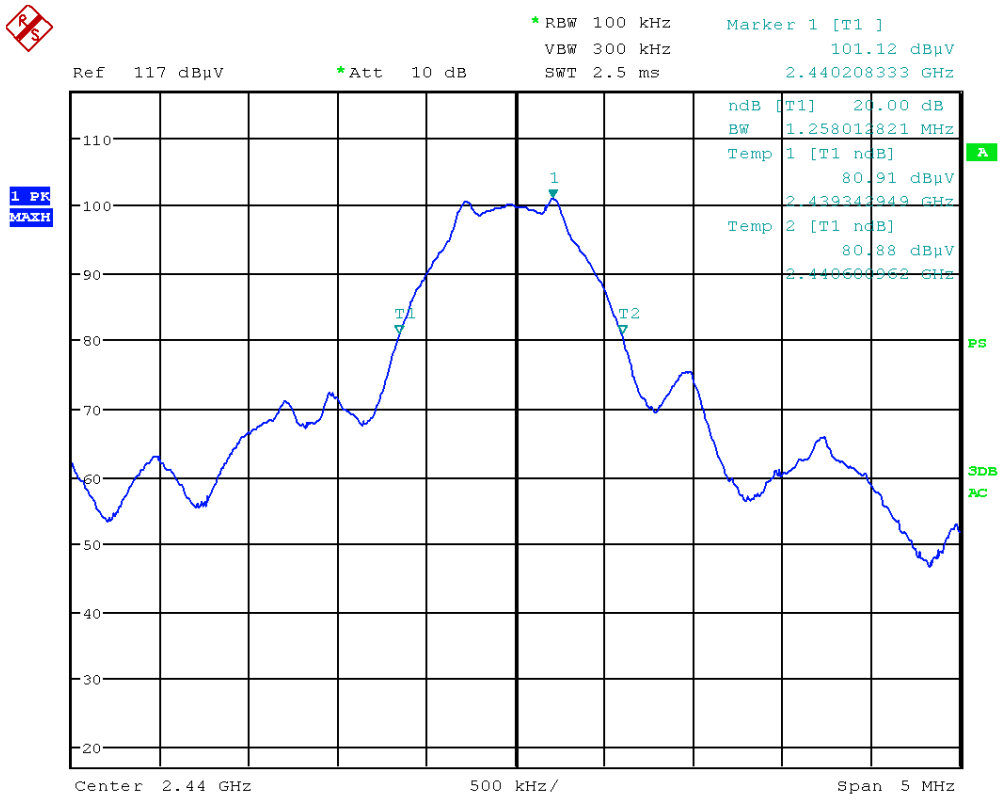
Temperature:	19°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-10-19

Designated frequency band: 2400 MHz to 2483.5 MHz

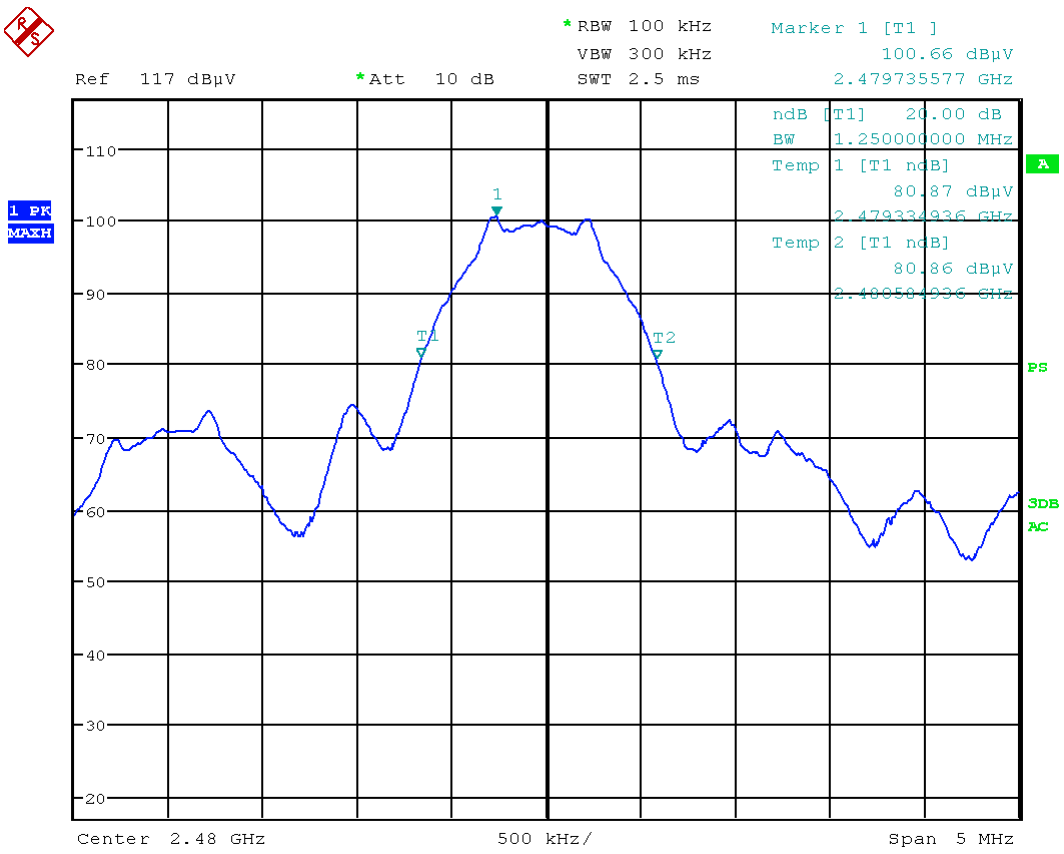
Channel	Frequency (GHz)			20 dB bandwidth (MHz)	Result
	peak	low	high		
Low	2.40222	2.40135	2.40260	1.25000	within band
Mid	2.44021	2.43934	2.44060	1.25801	within band
High	2.47974	2.47933	2.48058	1.25000	within band



Picture 6: 20dB bandwidth, channel low



Picture 7: 20dB bandwidth, channel mid



Picture 8: 20dB bandwidth, channel high

5 Occupied bandwidth

according to 47 CFR Part 2, section 2.202(a)

5.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

5.2 Test Instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

5.3 Limits

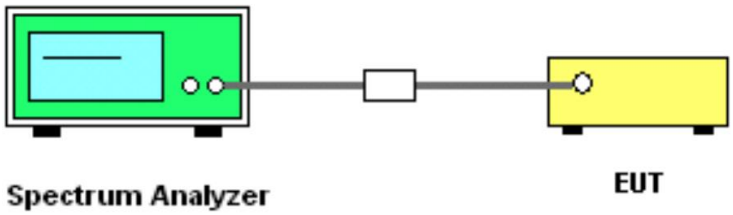
As not specified in the specific rule section the occupied bandwidth is measured and reported for information only.

5.4 Test procedure

1. The test is performed in accordance with 47 CFR Part 2, section 2.202(a)
2. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
3. The unit was operated in continuous transmit mode with modulation.
4. The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately three times the RBW.

5. The 99 % frequency bandwidth was measured so that, below its lower and above its upper frequency limits, the mean powers radiated were each equal to 0.5 percent of the total mean power radiated by a given emission.

5.5 Test setup



Picture 9: Test setup for occupied bandwidth measurement

5.6 Test deviation

There is no deviation with the original standard.

5.7 EUT operation during test

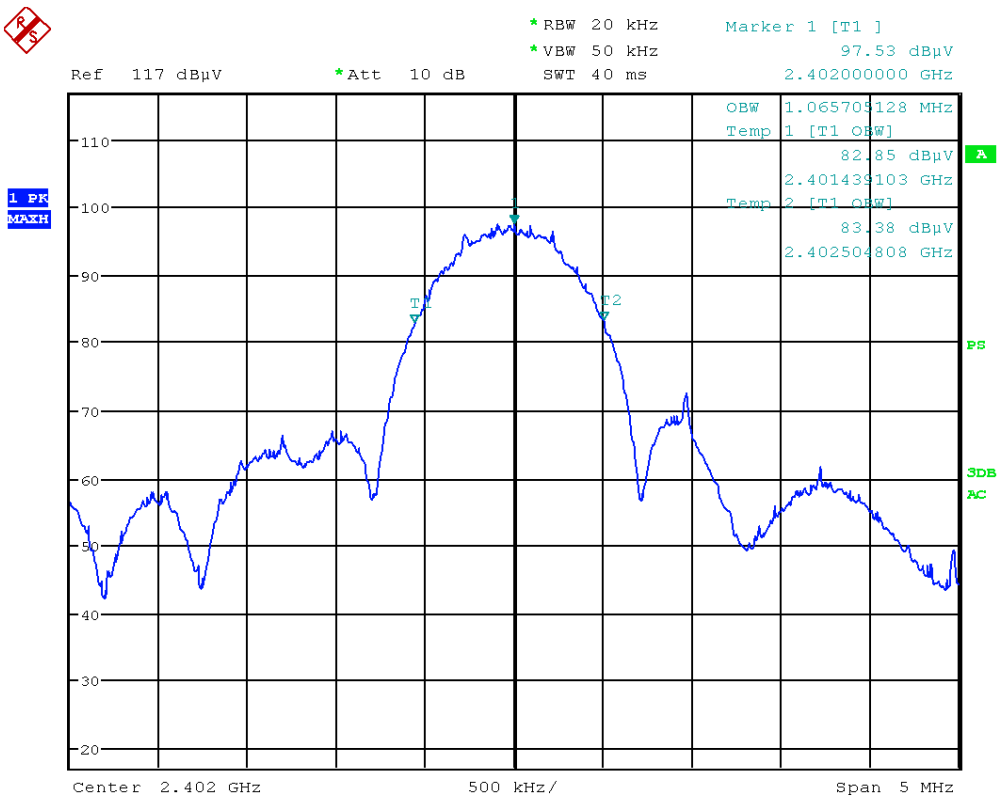
The EUT was programmed to be in continuously transmitting mode.

5.8 Test results

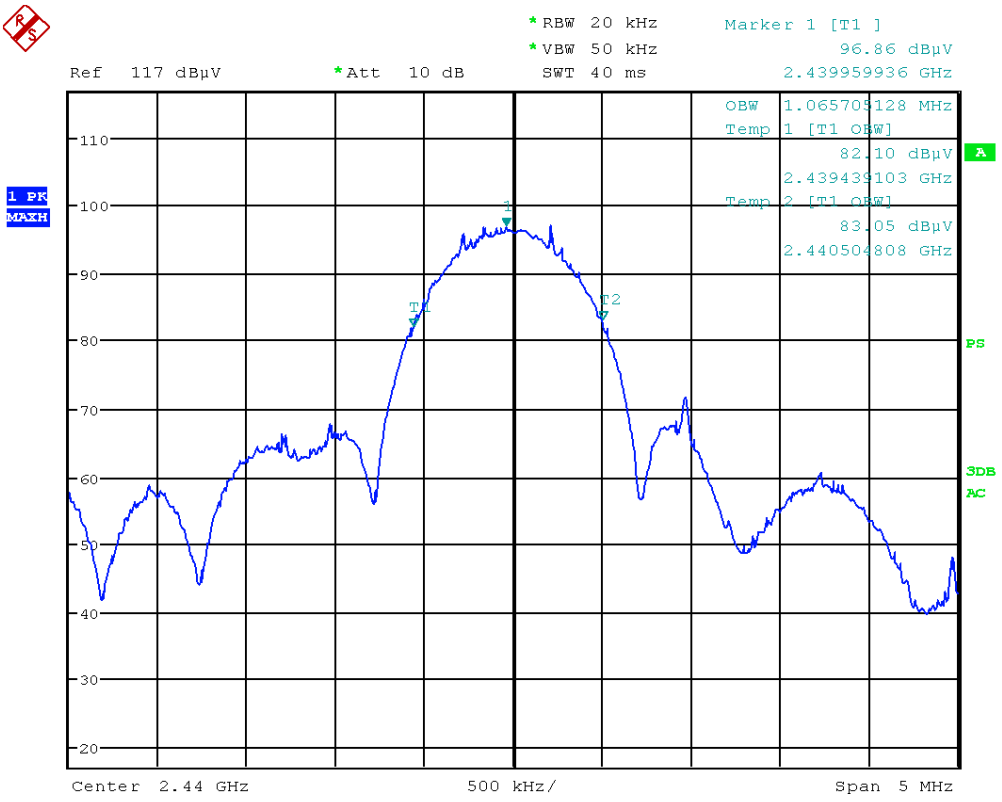
Temperature:	19°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-10-19

Designated frequency band: 2400 MHz to 2483.5 MHz

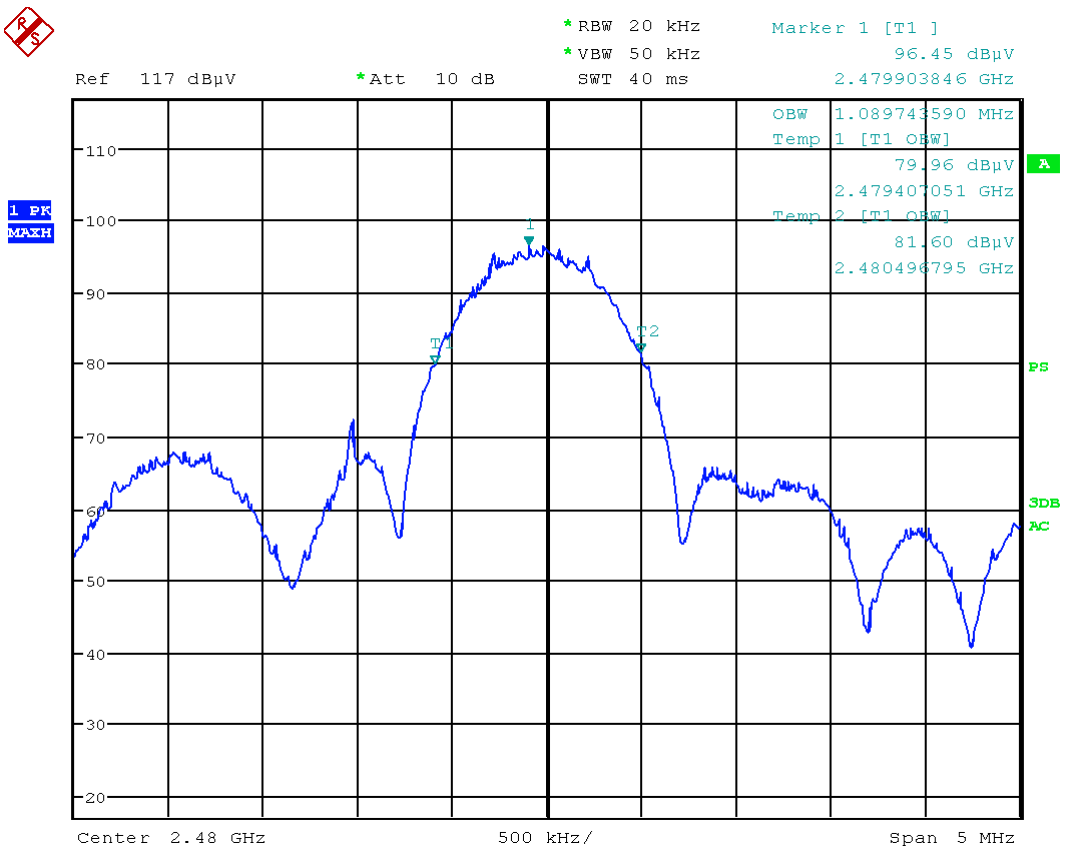
Channel	Frequency (GHz)			99 % bandwidth (MHz)	Result
	peak	low	high		
Low	2.40200	2.40144	2.40250	1.06571	within band
Mid	2.43996	2.43944	2.44050	1.06571	within band
High	2.47990	2.47941	2.48050	1.08974	within band



Picture 10: Occupied bandwidth, channel low



Picture 11: Occupied bandwidth, channel mid



Picture 12: Occupied bandwidth, channel high

6 Maximum peak conducted output power

according to 47 CFR Part 15, section 15.247(b), and KDB 558074, section 9

6.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

6.2 Test instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

6.3 Limits

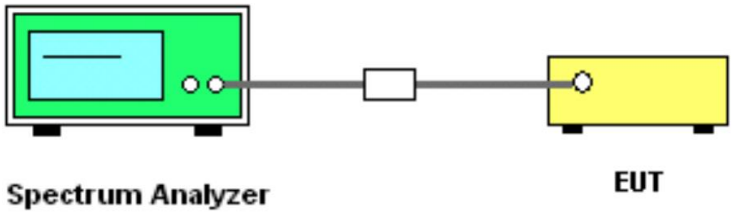
For systems using digital modulation: 1 Watt (30 dBm).

As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power.
Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level.
The conducted output power limit is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

6.4 Test procedure

1. The transmitter output (antenna port) was connected to the spectrum analyzer.
2. Test was performed in accordance with measurement of Digital Transmission Systems operating under Section 15.247 and FCC KDB publication no. 558074, section 9.1.1 with detector set to peak (max hold) and the following settings:
   a) RBW ≥ DTS bandwidth (6 dB bandwidth)
   b) VBW ≥ 3 × RBW.
   c) span ≥ 3 x RBW
   d) Sweep time = auto couple.

6.5 Test setup



Picture 13: Test setup for conducted output power measurement

6.6 Test deviation

There is no deviation with the original standard.

6.7 EUT operation during Test

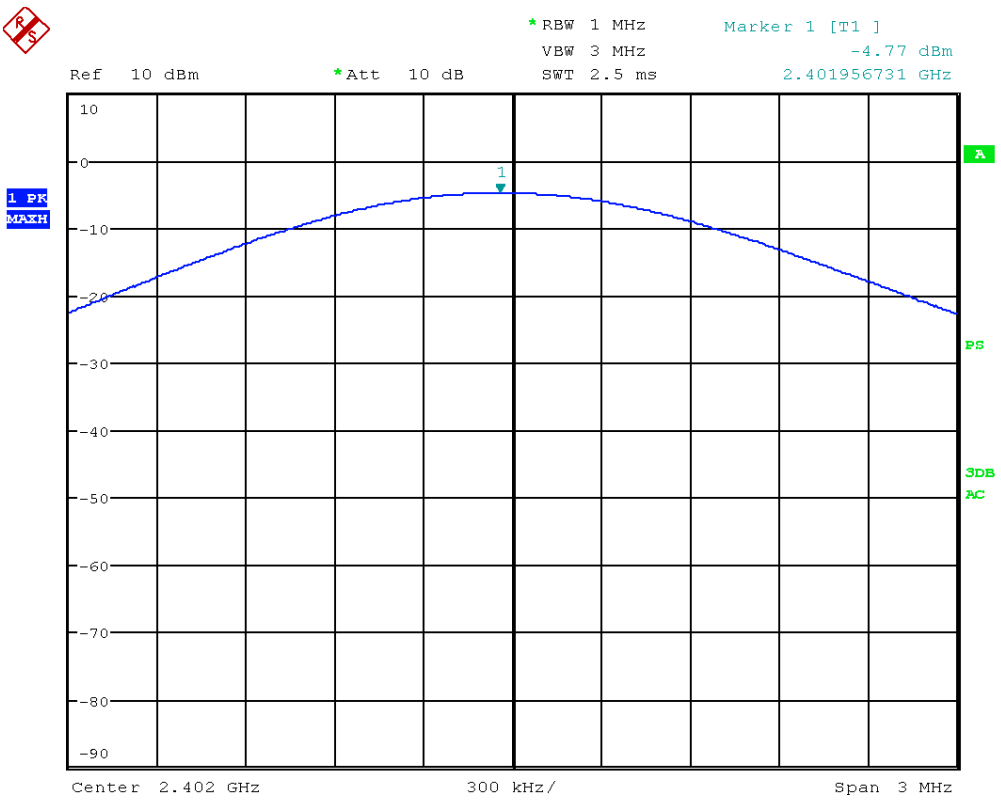
The EUT was programmed to be in continuously transmitting mode.

6.8 Test results

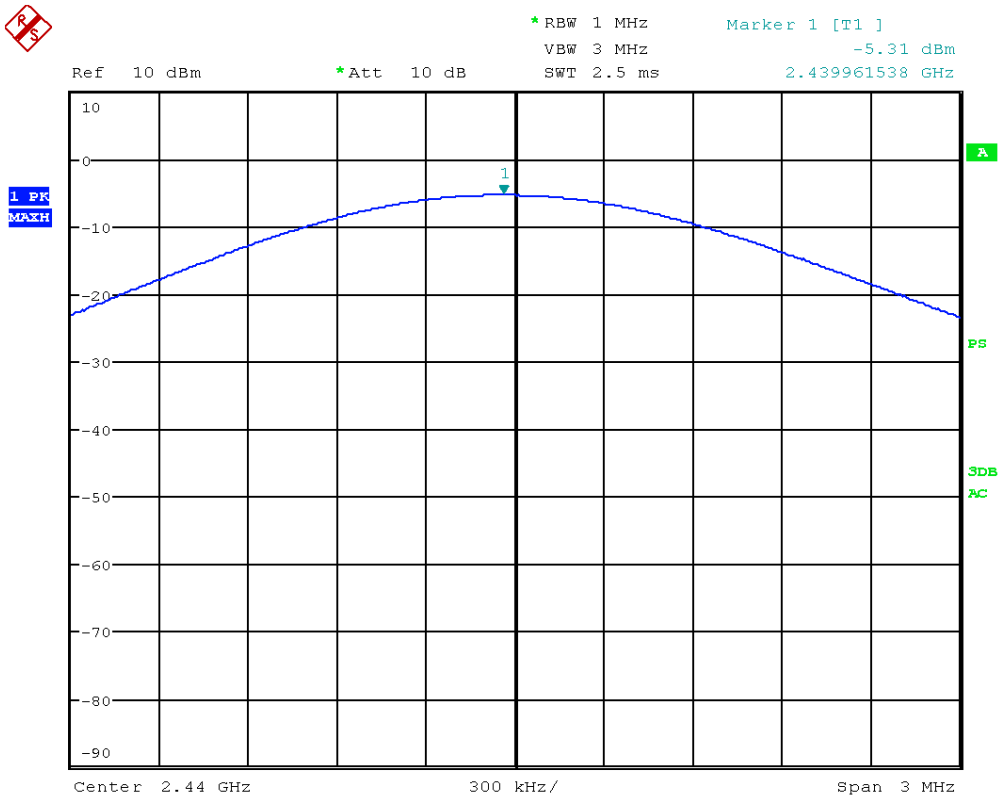
Temperature:	20°C	Humidity:	43%
Tested by:	M. Müller	Test date:	2015-10-20

Channel	Frequency (GHz)	Detector	Conducted power		Limit (dBm)	Result
			reading (dBm)	final (dBm)		
Low	2.40196	PK	-4.77	-3.75	30	Passed
Mid	2.43996	PK	-5.31	-4.24	30	Passed
High	2.47995	PK	-5.59	-4.59	30	Passed

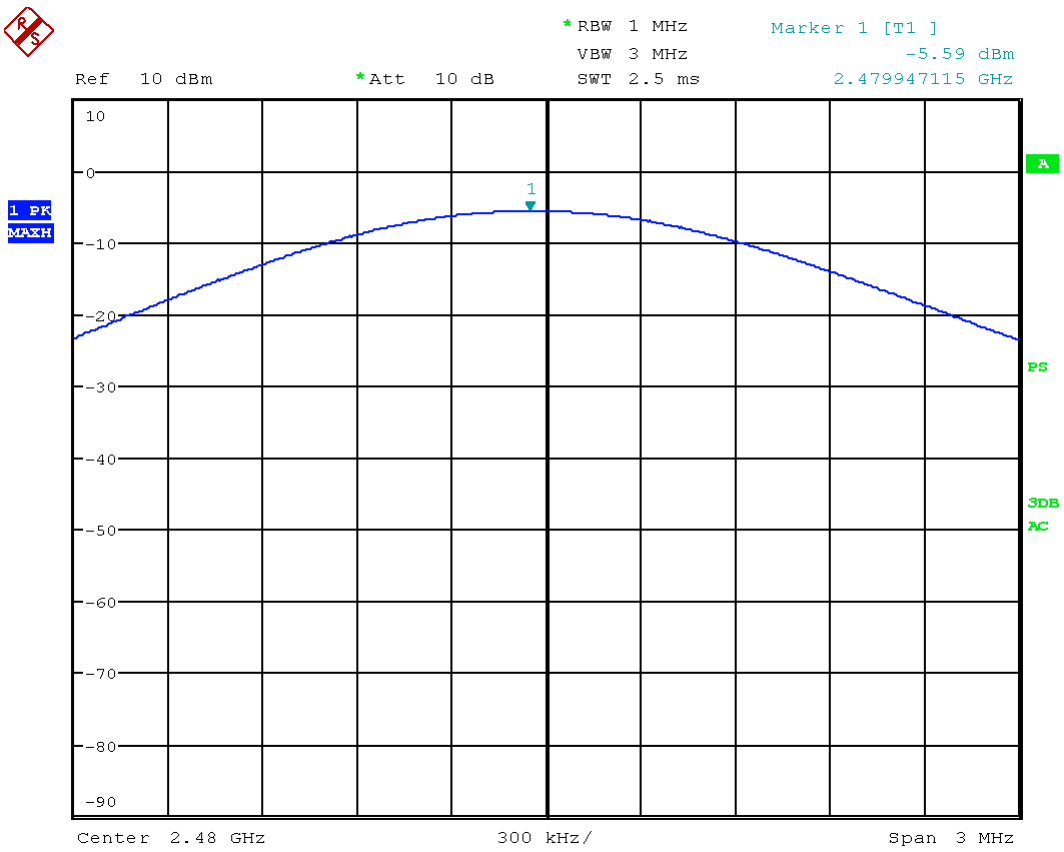
Comments: Final conducted power value is reading value + cable correction according to Table 1.



Picture 14: Conducted output power, channel low



Picture 15: Conducted output power, channel mid



Picture 16: Conducted output power, channel high

7 Power spectral density

according to 47 CFR Part 15, section 15.247(e), and KDB 558074, section 10

7.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

7.2 Test instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

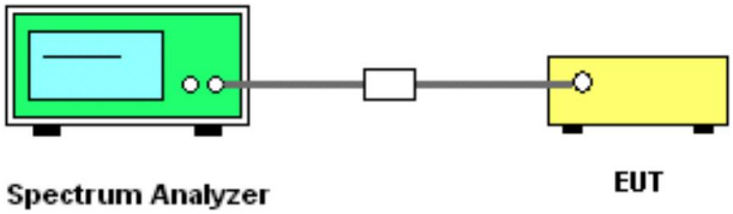
7.3 Limits

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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of section 15.247.
The same method of determining the conducted output power shall be used to determine the power spectral density.

7.4 Test procedure

1. The transmitter output (antenna port) was connected to the spectrum analyzer.
2. Test was performed in accordance with measurement of Digital Transmission Systems operating under Section 15.247 and FCC KDB publication no. 558074, section 10 with detector set to peak (max hold) and the following settings:
   a) span = 1.5 x DTS bandwidth (6 dB bandwidth)
   b) 3 kHz ≤ RBW ≤ 100 kHz
   c) VBW ≥ 3 × RBW.
   d) Sweep time = auto couple for prescans, ≥ span / RBW for final scan

7.5 Test setup



Picture 17: Test setup for power spectral density measurement

7.6 Test deviation

There is no deviation with the original standard.

7.7 EUT operation during Test

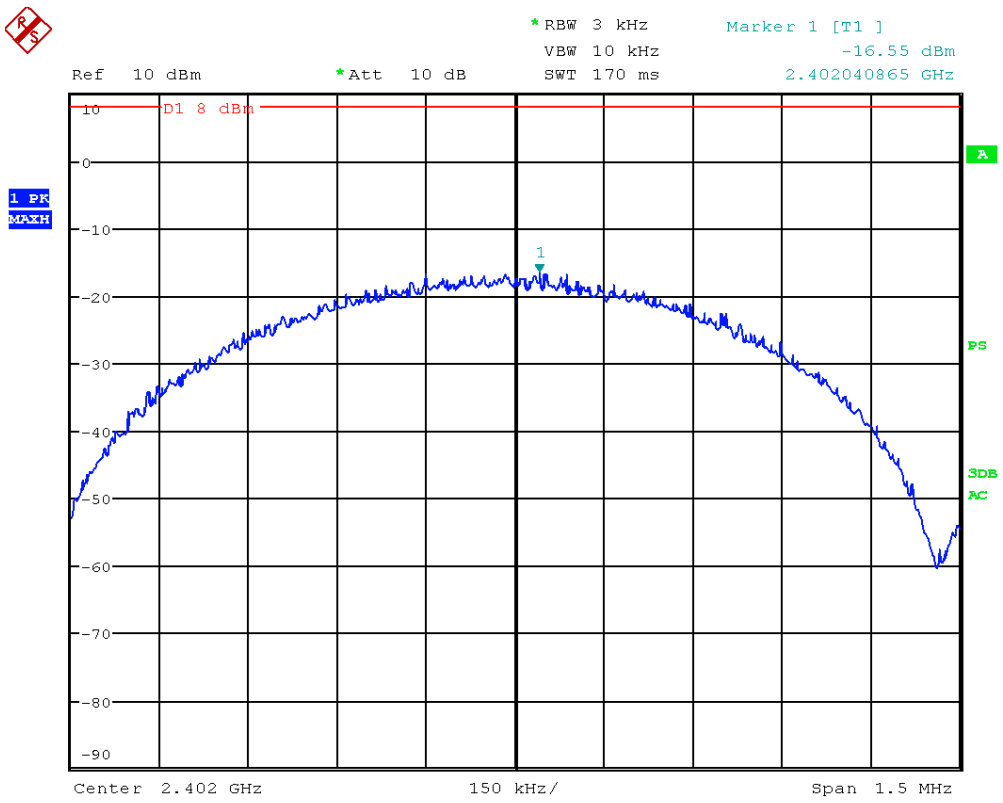
The EUT was programmed to be in continuously transmitting mode.

7.8 Test results

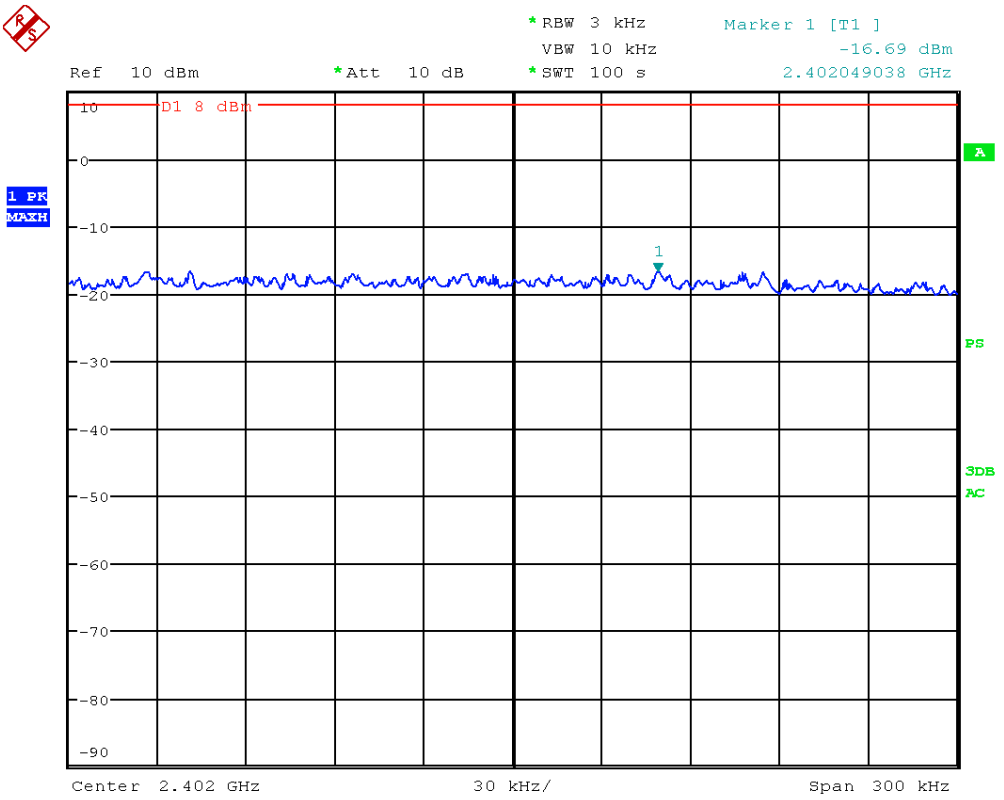
Temperature:	21°C	Humidity:	46%
Tested by:	M. Müller	Test date:	2015-10-20

Channel	Detector	Frequency (GHz)	PSD @ 3kHz RBW		Limit (dBm)	Result
			reading (dBm)	final (dBm)		
Low	PK	2.40205	-16.69	-15.67	8	Passed
Mid	PK	2.44005	-16.88	-15.81	8	Passed
High	PK	2.47993	-17.85	-16.85	8	Passed

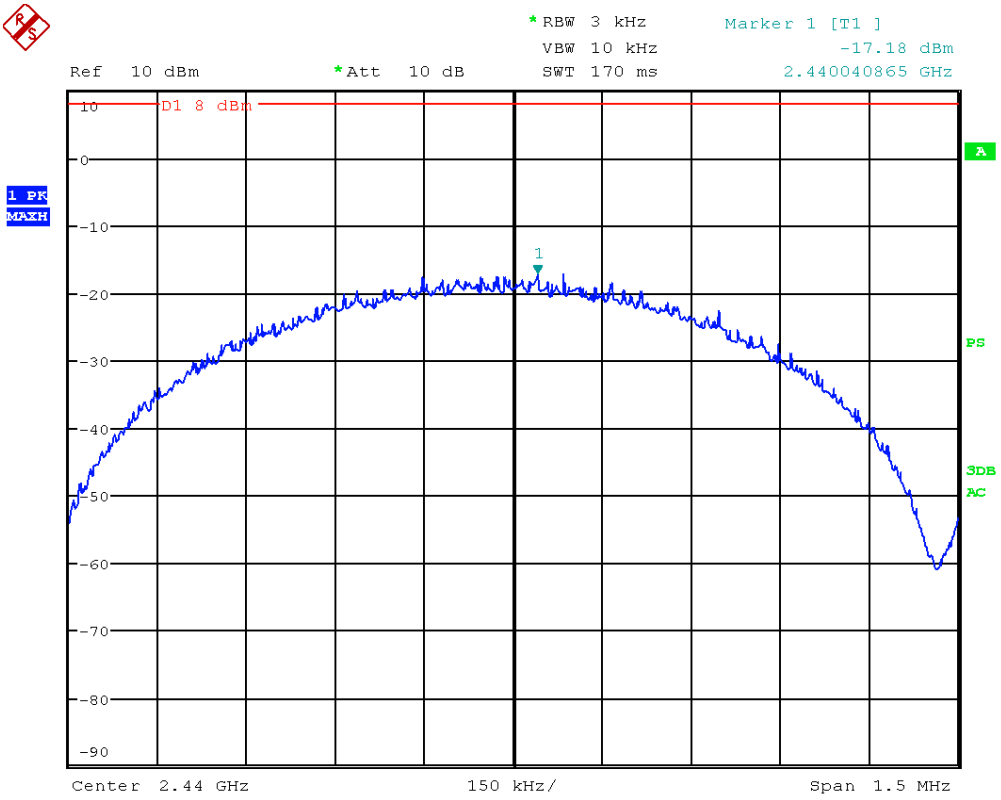
Comments: Final PSD value is reading value + cable correction according to Table 1.



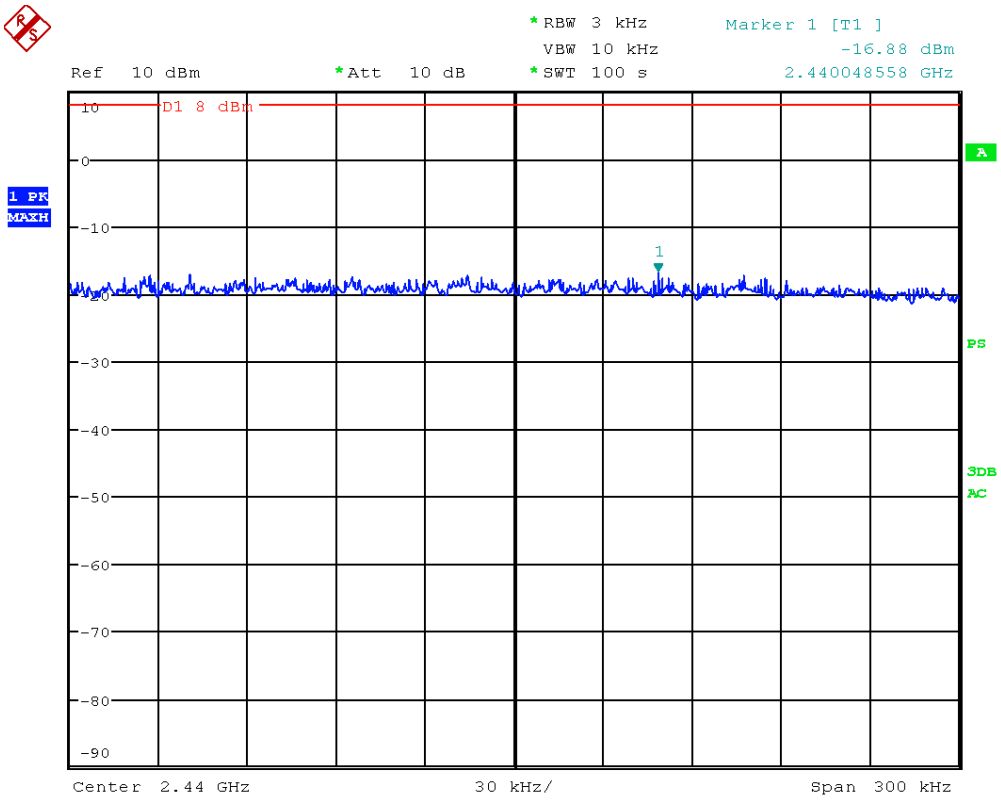
Picture 18: Power spectral density, channel low - complete carrier



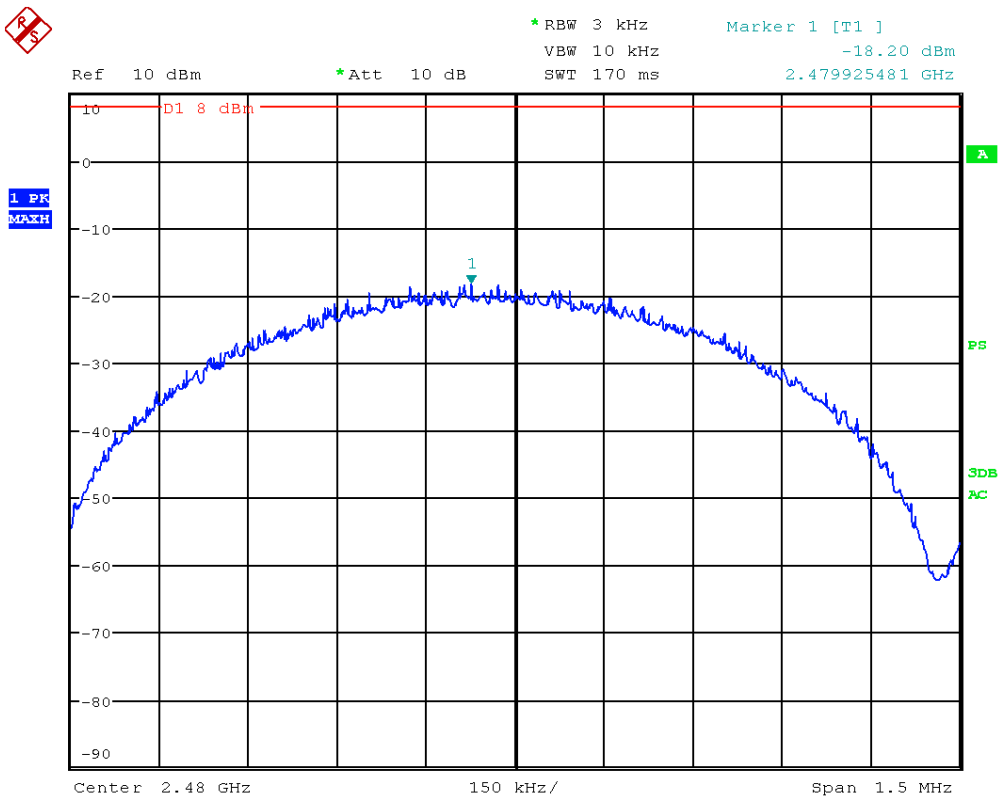
Picture 19: Power spectral density, channel low - zoom to maximum



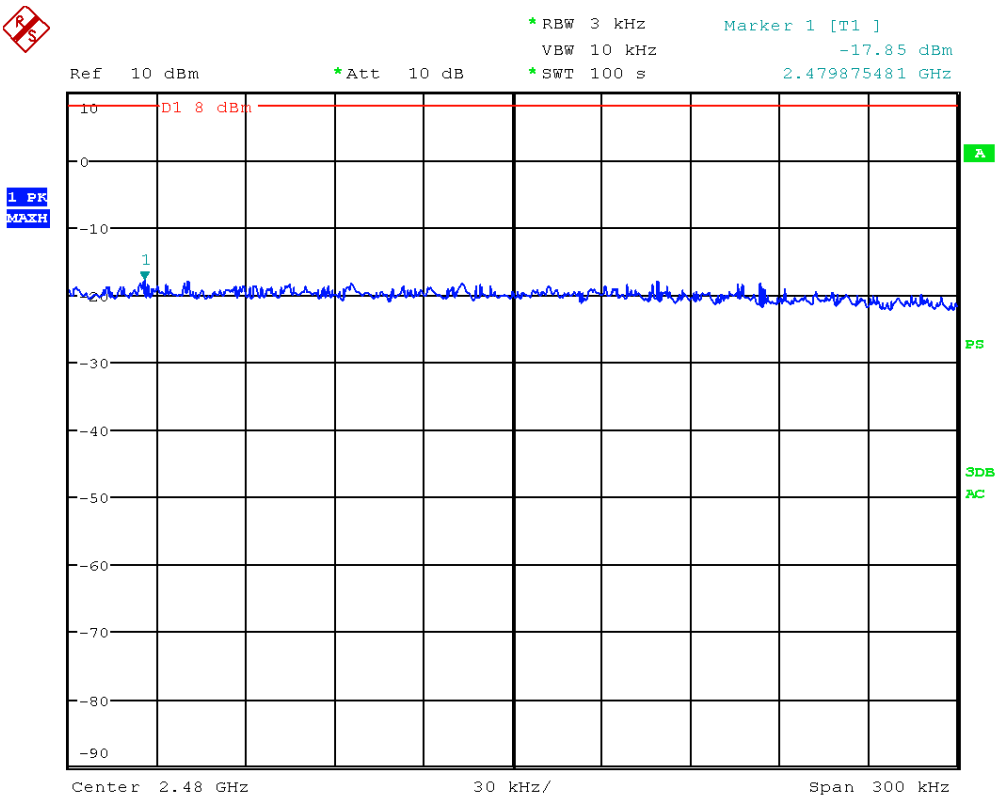
Picture 20: Power spectral density, channel mid - complete carrier



Picture 21: Power spectral density, channel mid - zoom to maximum



Picture 22: Power spectral density, channel high - complete carrier



Picture 23: Power spectral density, channel high - zoom to maximum

8 Band-edge compliance

according to 47 CFR Part 15, section 15.247(d)

8.1 Test location

Description	Manufacturer	Inventory No.
Anechoic chamber	EMV **TESTHAUS** GmbH	E00100

8.2 Test Instruments

	Description	Manufacturer	Inventory No.
☑	ESU26	Rohde & Schwarz	W00002
☑	AMF-5D-00501800-28-13P	Miteq	W00089
☐	AMF-6F-16002650-25-10P	Miteq	W00090
☑	BBHA 9170	Schwarzbeck	W00054
☐	BBHA 9170	Schwarzbeck	W00055
☐	COSB 4-1-26	Conformitas	W00091

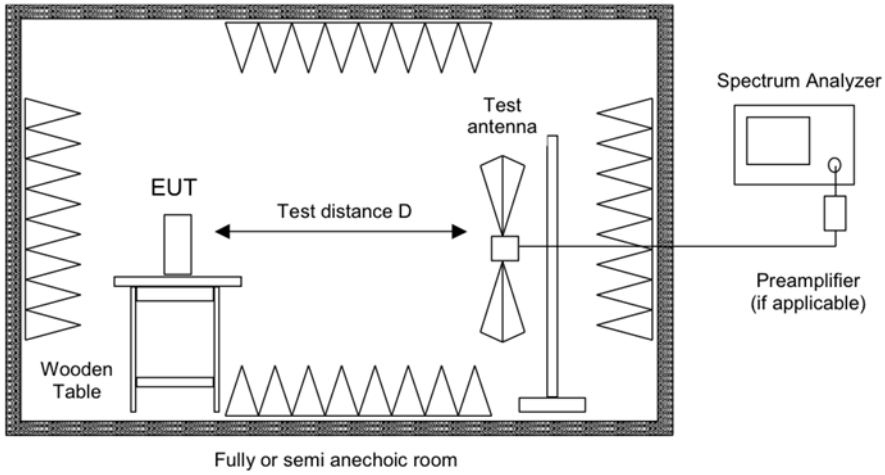
8.3 Limits

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

8.4 Test procedure

1. Configure the EUT according to ANSI C63.10. The EUT was placed on the top of the turntable 1.5 meter above ground. The receiving antenna was placed 3 meters from the turntable. The test setup was placed inside a fully anechoic chamber.
2. Power on the EUT and all peripherals.
3. Set frequency to lowest channel
4. Maximize radiated emission at band edges by moving turntable and antenna height with horizontal and vertical antenna polarization.
5. Record this trace(s) and set appropriate markers
6. Set frequency to highest channel
7. Repeat steps 4 and 5

8.5 Test setup



Picture 24: Test setup for band-edge compliance measurement

8.6 Test deviation

There is no deviation with the original standard.

8.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.
It was investigated that for this test EUT-position3 in combination with measurement-antenna polarised to horizontal is the respective worst-case.

8.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-10-29

f[GHz]	E_{meas} [dBµV/m]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.40230	90.80	PK	No	----	Carrier
2.40211	90.01	AV (1 kHz)		----	Carrier
2.39000	48.42	PK	Yes	74	Pass
2.39000	37.00	AV (1 kHz)		54	Pass
2.31000	39.93	PK	Yes	74	Pass
2.31000	28.02	AV (1 kHz)		54	Pass

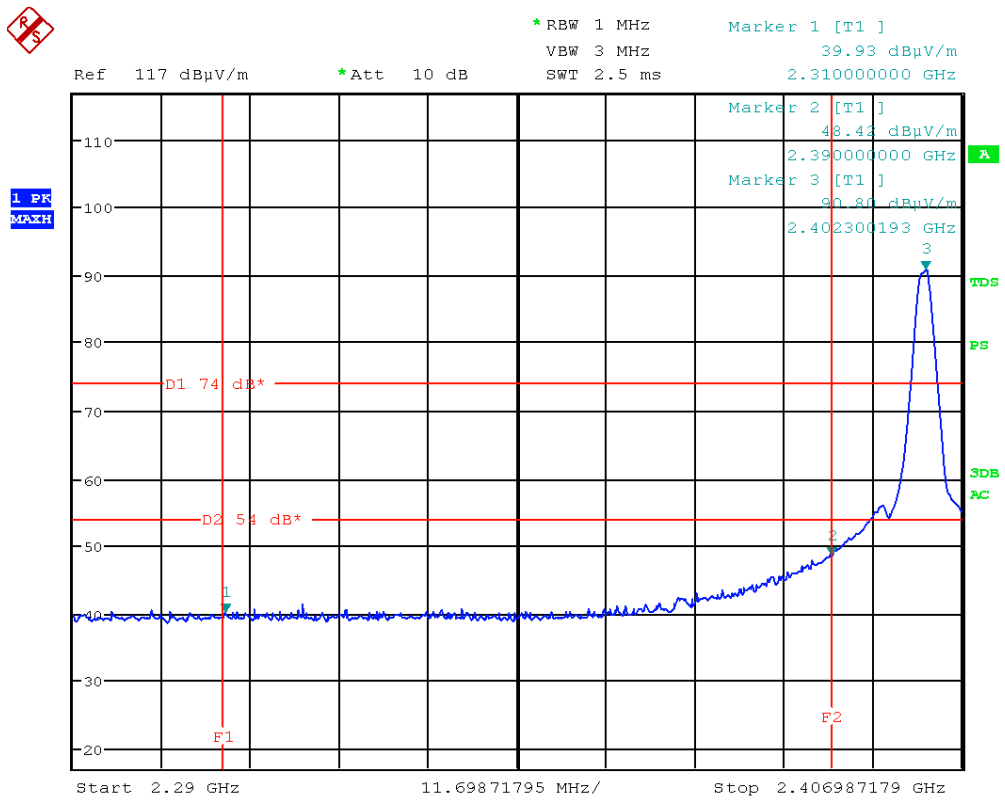
Picture 25: Band edge compliance – lower edge

Note: Frequency lines in charts are set to the edges of the restricted band closest to the carrier:
F1 = 2.3100 GHz
F2 = 2.3900 GHz

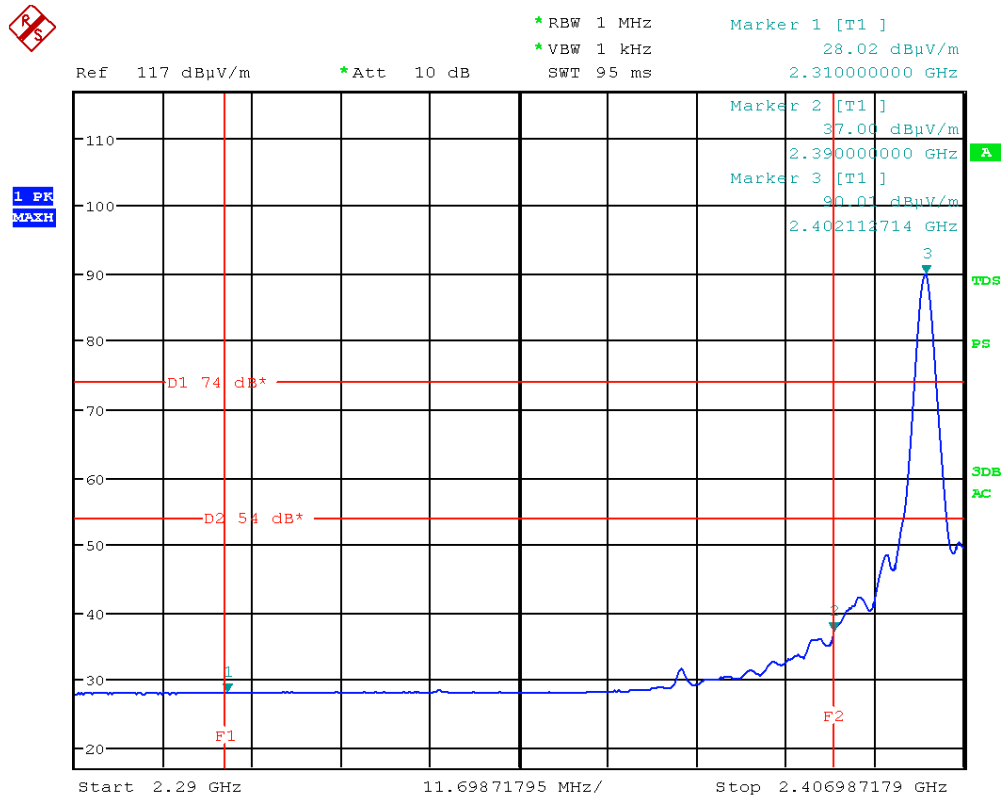
f[GHz]	E_{meas} [dBµV/m]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.47971	89.71	PK	No	----	Carrier
2.47994	88.80	AV (1 kHz)		----	Carrier
2.48350	55.48	PK	Yes	74	Pass
2.48350	47.27	AV (1 kHz)		54	Pass
2.50000	42.02	PK	Yes	74	Pass
2.50000	30.20	AV (1 kHz)		54	Pass

Picture 26: Band edge compliance – upper edge

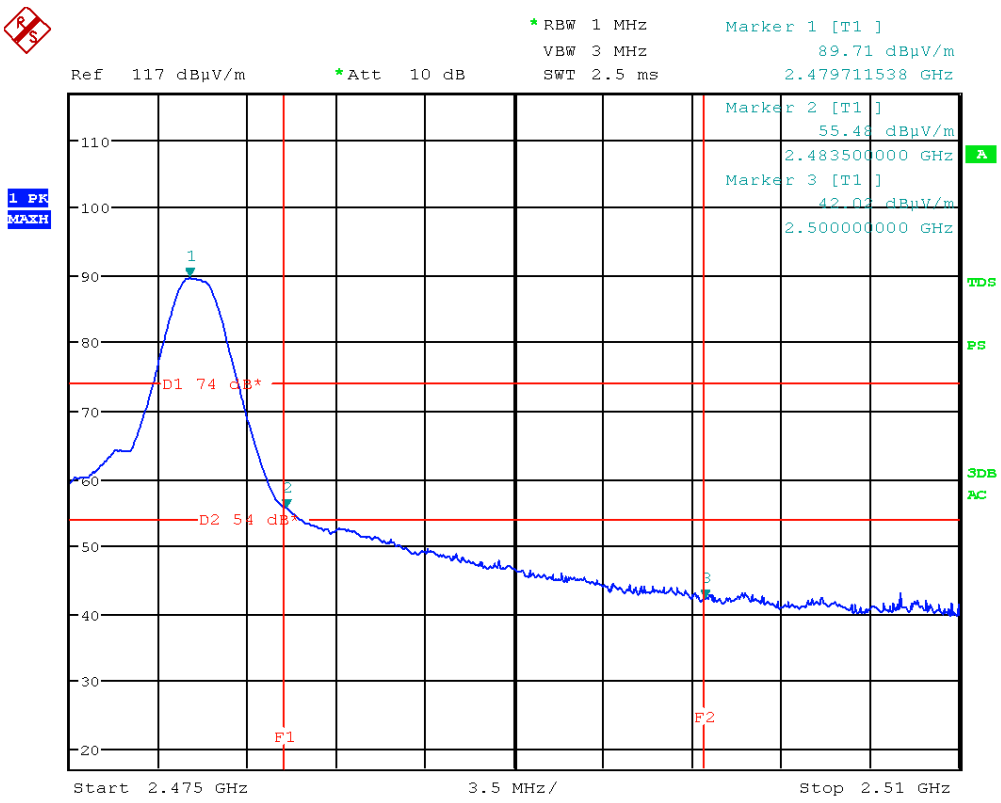
Note: Frequency lines in charts are set to the edges of the restricted band closest to the carrier:
F1 = 2.4835 GHz
F2 = 2.5000 GHz



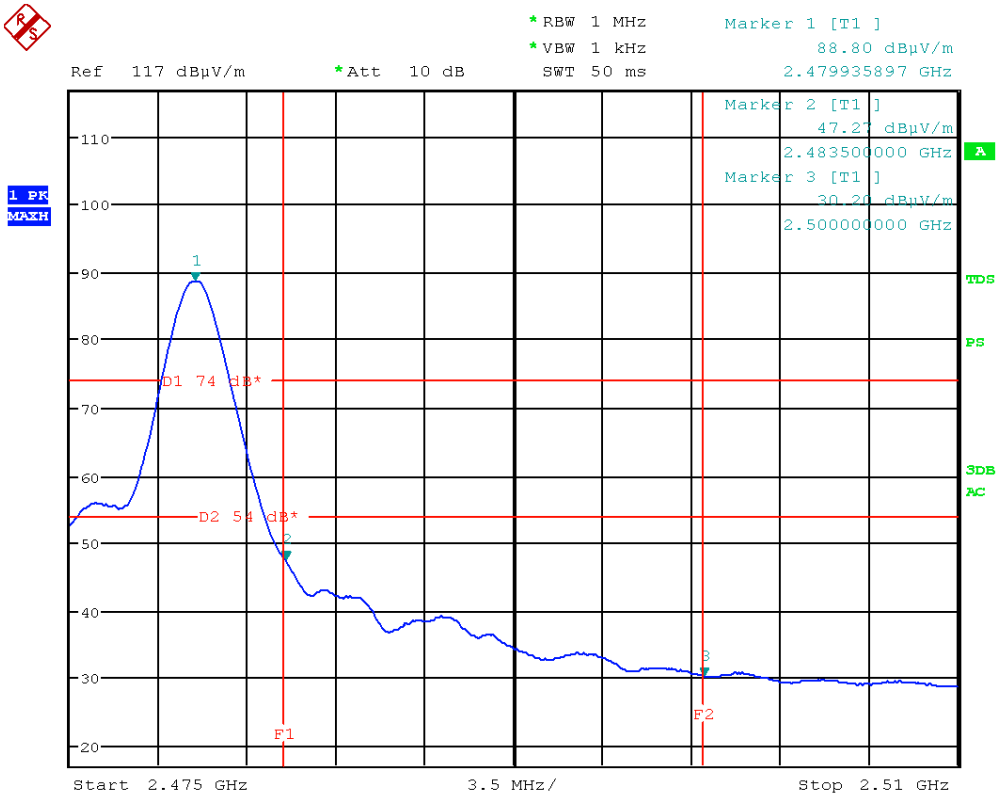
Picture 27: lower edge (PK)



Picture 28: lower edge (AV)



Picture 29: upper edge (PK)



Picture 30: upper edge (AV)

9 Spurious RF Conducted Emission

according to 47 CFR Part 15, section 15.247(d)

9.1 Test location

☑ Conducted measurement
☐ Scan with peak detector in 3 m CDC
☐ CISPR measurement with quasi peak detector on 10m open area test site.
☐ Measurement with peak detector on 3m open area test site

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site	EMV **TESTHAUS** GmbH	E00354

9.2 Test Instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30 (FF)	Rohde & Schwarz	E00003
☑	ESU 26	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	HFH2-Z2	Rohde & Schwarz	E00060
☐	VULB 9163 (FF)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011

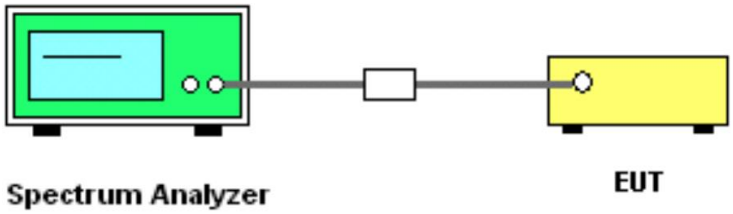
9.3 Limits

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

9.4 Test procedure

1. The test is performed in accordance with FCC KDB publication no. 558074.
2. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
3. The unit was operated in continuous transmit mode with modulation.
4. Minimum resolution bandwidths of 200 Hz for measurement frequencies below 150 kHz, 10 kHz between 150 kHz and 30 MHz, 100 kHz between 30 MHz and 1 GHz and 1 MHz above 1 GHz were used.
5. Measure the spectrum from the lowest frequency generated in the EUT up through the 10th harmonic.

9.5 Test setup



Picture 31: Test setup for conducted spurious emission measurement

9.6 Test deviation

There is no deviation with the original standard.

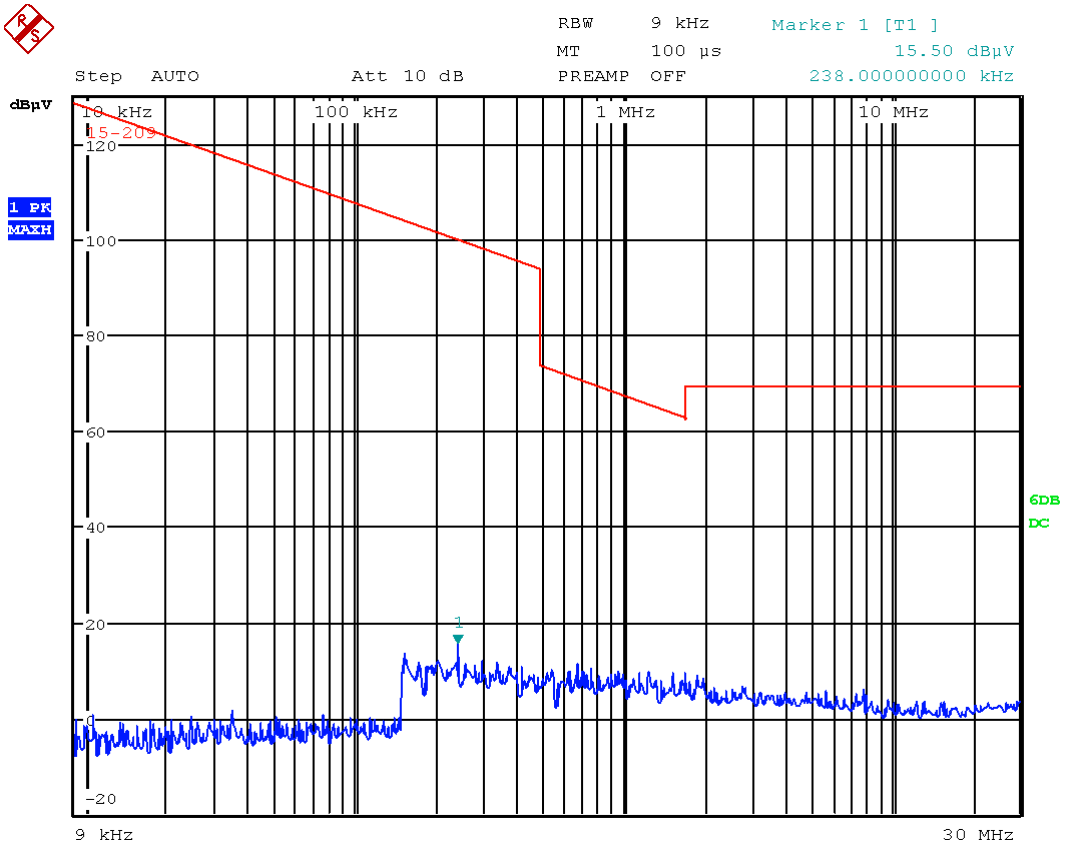
9.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

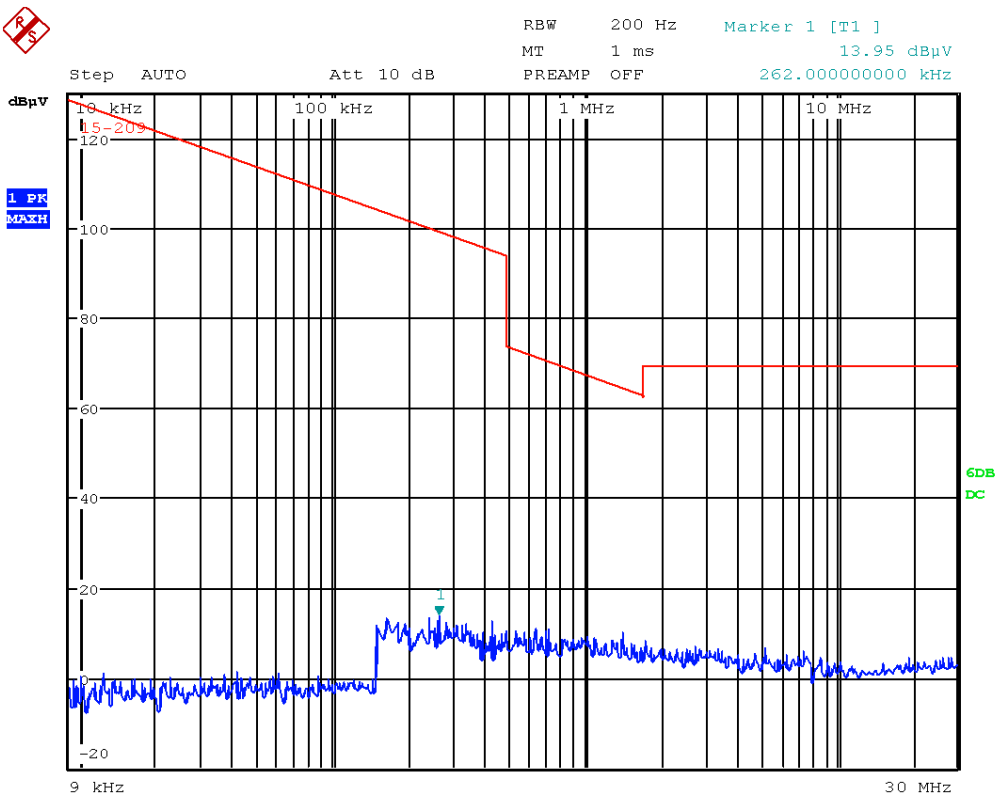
9.8 Test results

Temperature:	21°C	Humidity:	46%
Tested by:	M. Müller	Test date:	2015-10-20

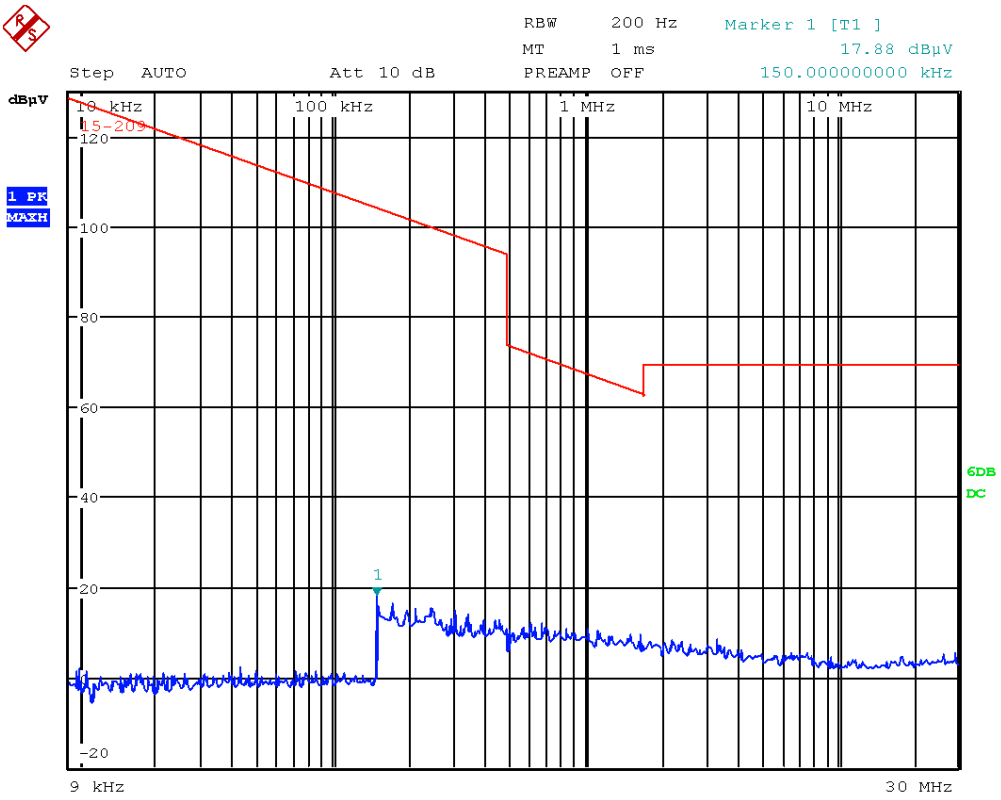
9.9 Test results 9 kHz – 30 MHz



Picture 32: spurious emission, channel low (9kHz - 30MHz)

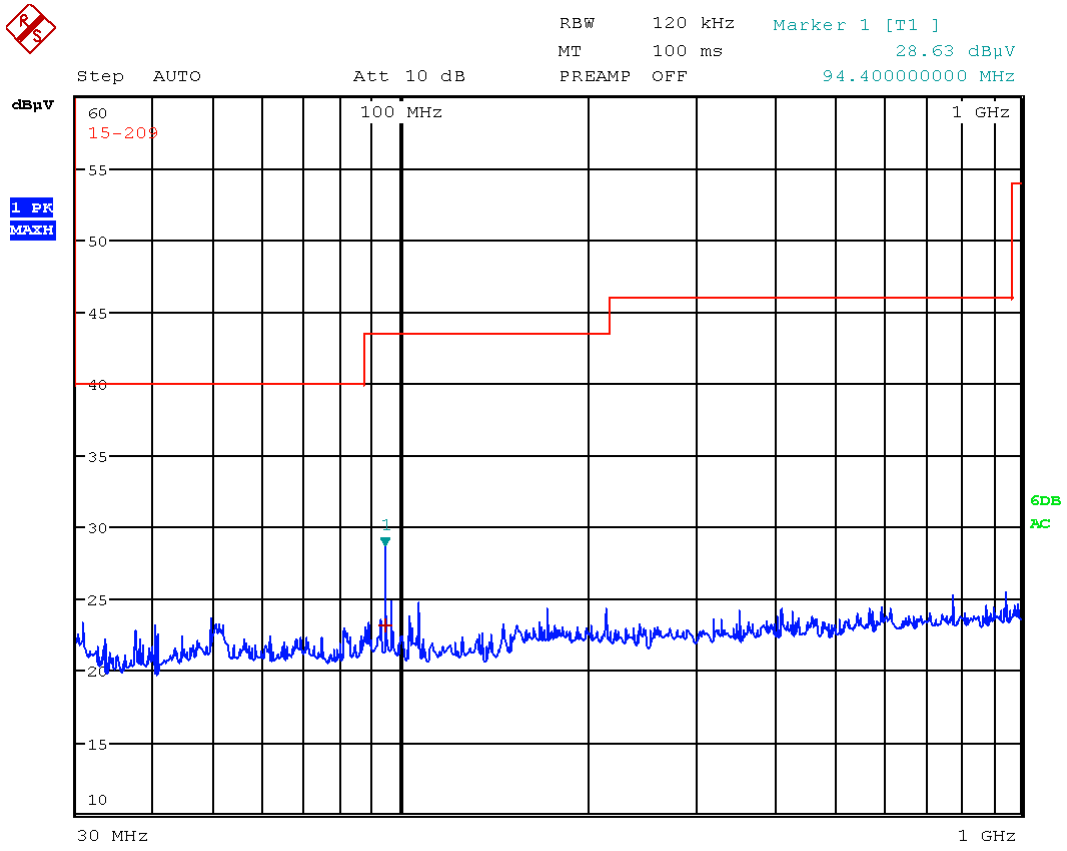


Picture 33: spurious emission, channel mid (9kHz - 30MHz)



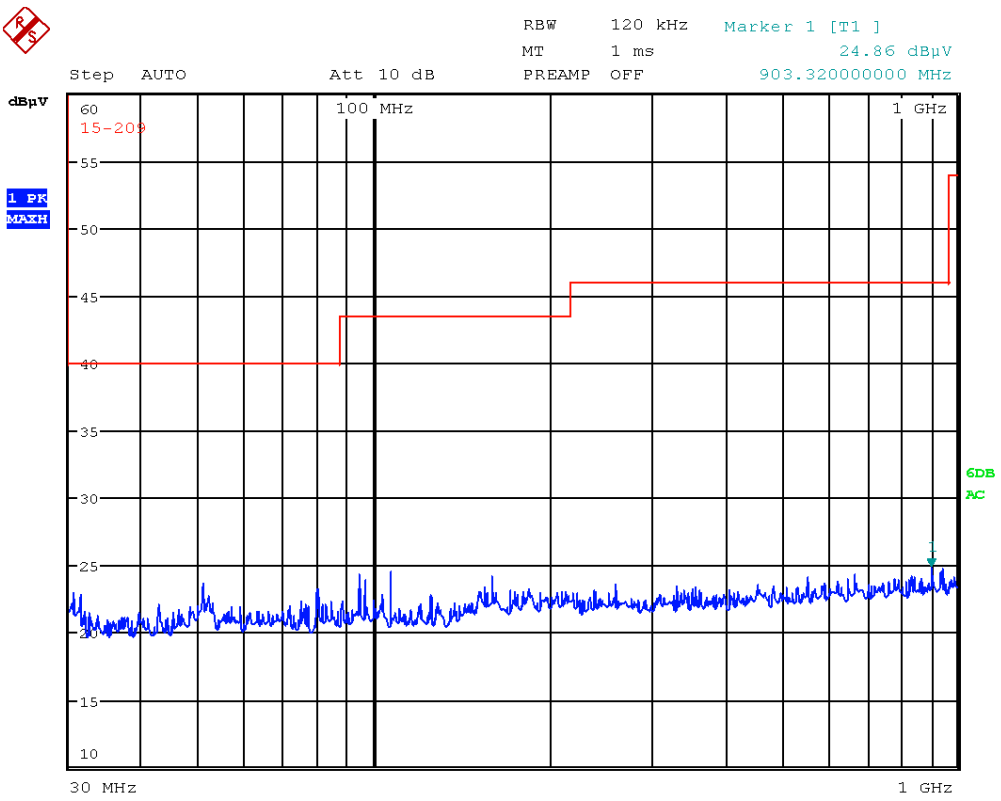
Picture 34: spurious emission, channel high (9kHz - 30MHz)

9.10 Test results 30 MHz – 1 GHz

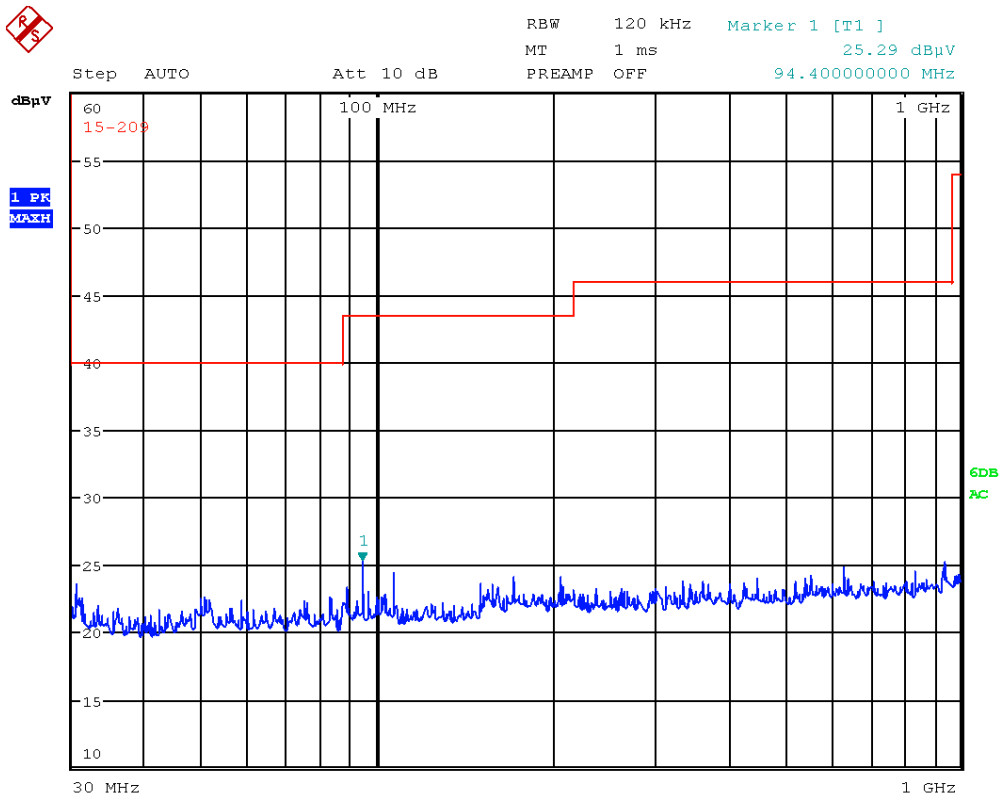


Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
1	94.400000000 MHz	23.22	Quasi Peak	-20.30

Picture 35: spurious emission, channel low (30MHz - 1GHz)

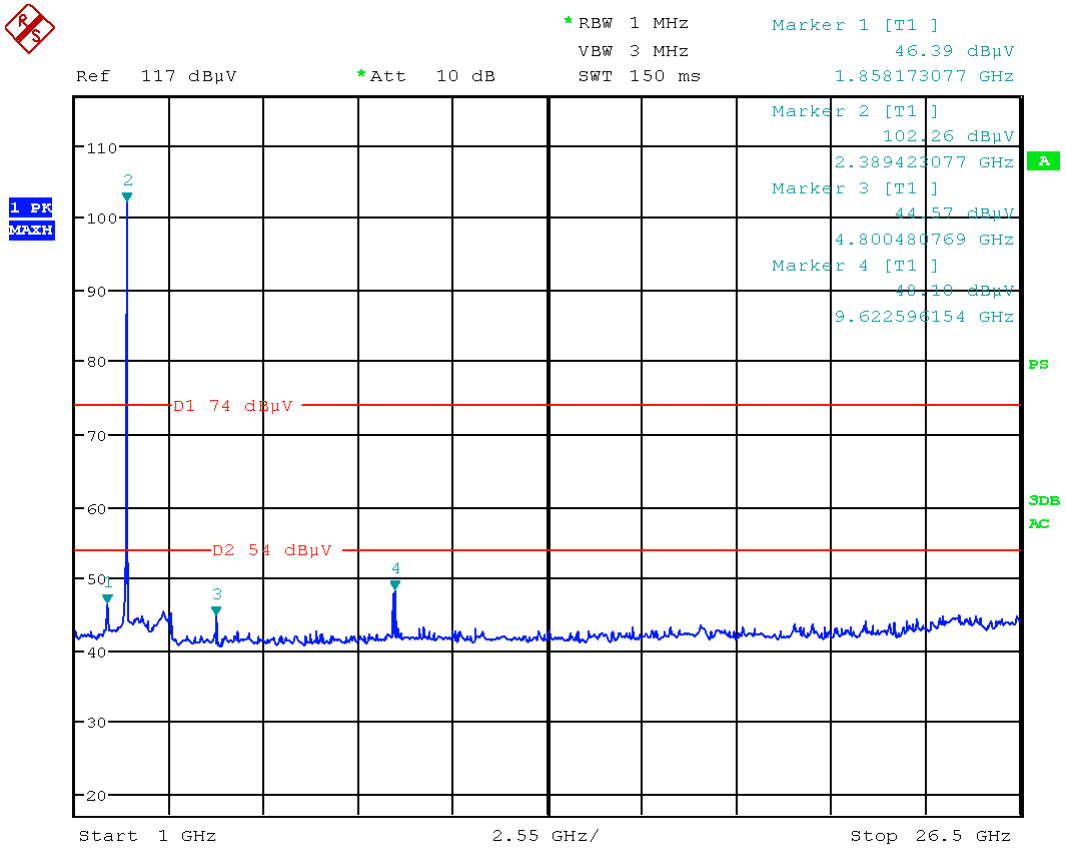


Picture 36: spurious emission, channel mid (30MHz - 1GHz)



Picture 37: spurious emission, channel high (30MHz - 1GHz)

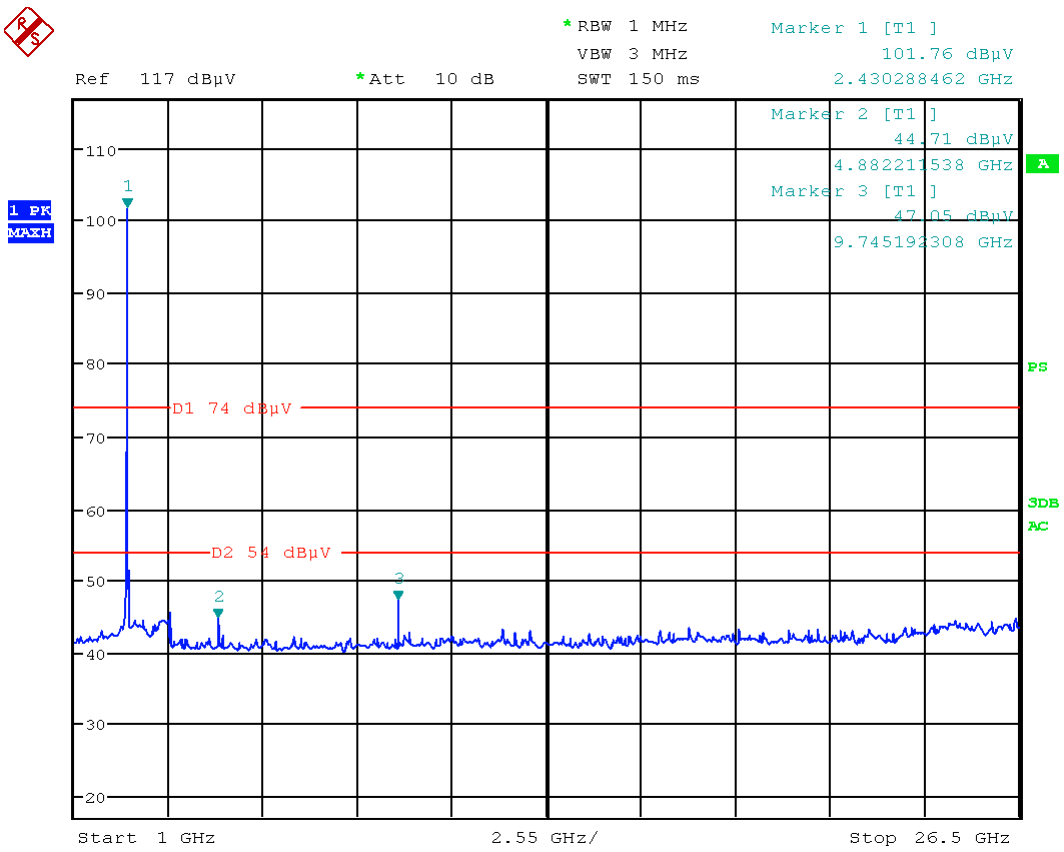
9.11 Test results 1 GHz – 26 GHz



Channel low							
f[GHz]	E_{meas} [dBµV]	Correction [dB]	Final [dBµV]	Detector	Restr. Band	Limit [dBµV]	Result
1.85817	46.39	0.96	47.35	PK	No	-20dBc	Pass
2.40197 [1)]	102.26	1.02	102.28	PK	No	----	Carrier
4.80048	44.57	1.29	45.86	PK	Yes	74	Pass
9.62260	48.10	1.72	49.82	PK	No	-20dBc	Pass

Picture 38: spurious emission, channel low (1GHz - 26 GHz)

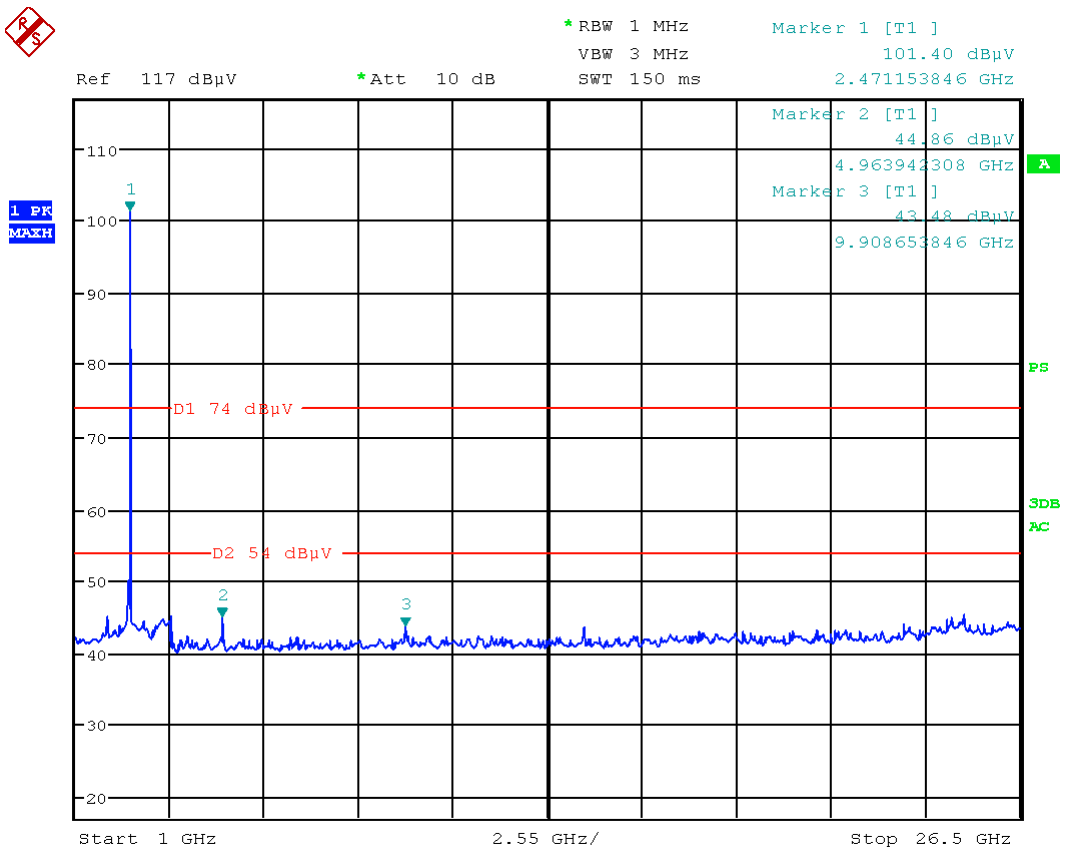
Note 1): Frequency of carrier in the picture above is not correct because of the frequency span (25.5 GHz). Corrected frequency according to picture 54.



Channel mid							
f[GHz]	E_{meas} [dBµV]	Correction [dB]	Final [dBµV]	Detector	Restr. Band	Limit [dBµV]	Result
2.43997 [1)]	101.76	1.07	102.83	PK	No	---	Carrier
4.88221	44.71	1.29	46.00	PK	Yes	74	Pass
9.74519	47.05	1.72	48.77	PK	No	-20dBc	Pass

Picture 39: spurious emission, channel mid (1GHz - 26 GHz)

Note 1): Frequency of carrier in the picture above is not correct because of the frequency span (25.5 GHz). Corrected frequency according to picture 58.



Channel high							
f[GHz]	E_{meas} [dBµV]	Correction [dB]	Final [dBµV]	Detector	Restr. Band	Limit [dBµV]	Result
2.47997 [1)]	101.40	1.00	102.40	PK	No	----	Carrier
4.96394	44.86	1.44	45.30	PK	Yes	74	Pass
9.90865	43.48	1.71	45.19	PK	No	-20dBc	Pass

Picture 40: spurious emission, channel high (1GHz - 26 GHz)

Note 1): Frequency of carrier in the picture above is not correct because of the frequency span (25.5 GHz). Corrected frequency according to picture 62.

10 Radiated emission measurement (<1 GHz)

according to 47 CFR Part 15, sections 15.205(a), 15.209(a), 15.247(d), and Public Notice DA 00-705

10.1 Test Location

☑ Scan with peak detector in 3 m CDC.

☑ Final CISPR measurement with quasi peak detector on 3 m open area test site.

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open site area	EMV **TESTHAUS** GmbH	E00354

10.2 Test instruments

	Description	Manufacturer	Inventory No.
☑	ESCS 30 (OATS)	Rohde & Schwarz	E00003
☐	ESU 26	Rohde & Schwarz	W00002
☑	ESCI (CDC)	Rohde & Schwarz	E00001
☑	VULB 9163 (OATS)	Schwarzbeck	E00013
☑	VULB 9160 (CDC)	Schwarzbeck	E00011
☑	HFH2-Z2	Rohde & Schwarz	E00060
☑	Feedline OATS	Huber & Suhner	200024

10.3 Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.
In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

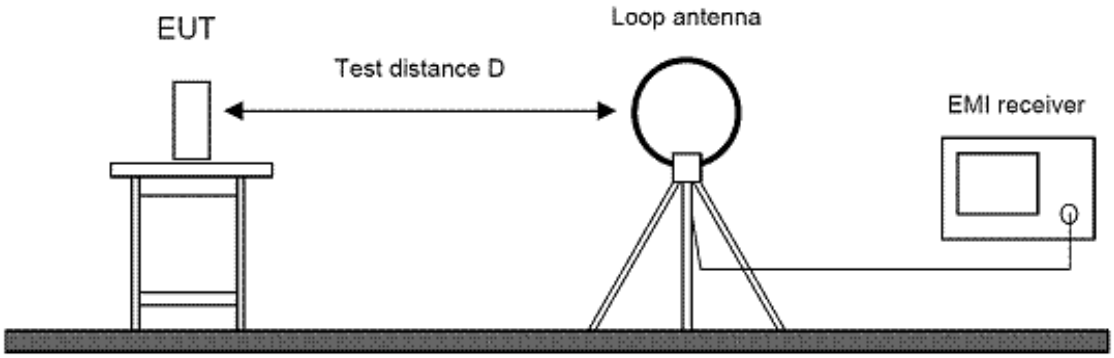
Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
0.009 – 0.490	266.6 – 4.9	48.5 – 13.8	300
0.490 – 1.705	48.98 – 14.08	33.8 – 22.97	30
1.705 – 30.0	30	29.54	30
30 – 88	100	40	3
88 – 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

10.4 Test procedure

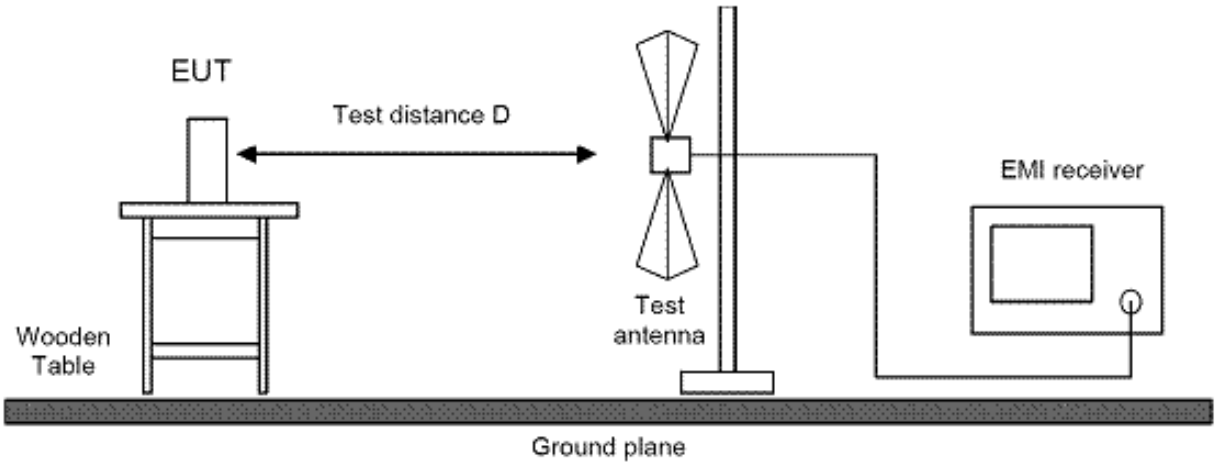
1. Configure the EUT according to ANSI C63.10. The EUT is placed on the top of the turntable 0.8 meter above ground. The receiving antenna is placed 3 meters from the turntable. For prescan measurements the test setup is placed inside a compact diagnostic chamber.
2. Power on the EUT and all peripherals.
3. The broadband antenna is set to vertical polarization.
4. The EMI receiver performes a scan from 9 kHz to 30 MHz or 30MHz to 1000MHz with the detector set to peak. Appropriate CISPR measurement bandwidths are used, i. e. 200 Hz for the frequency range 9 kHz to 150 kHz, 10 kHz for 150 kHz to 30 MHz and 120 kHz for 30MHz to 1000MHz.
5. The turn table is rotated to 6 different positions (360° / 6) and the antenna polarization is changed to horizontal.
6. Repeat the test procedure at step 4 and 5.
7. Then the test setup is placed in an OATS at 3 m distance and all peak values over or with less than 6dB margin to the limit are re-measured with quasi-peak detector (except for the frequency bands 9–90 kHz and 110–490 kHz where average detector is used). If the margin of all emissions recorded prescan in the compact diagnostic chamber is more than 6 dB no final test in OATS is performed.
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 one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization. The highest value is recorded.

10. For emissions below 30MHz, measurements are performed with a loop antenna. The antenna height is not changed during this test.

10.5 Test setup



Picture 41: Test setup for radiated emission measurement (< 30 MHz)



Picture 42: Test setup for radiated emission measurement (< 1 GHz)

10.6 Test deviation

There is no deviation with the original standard.

10.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

10.8 Test results

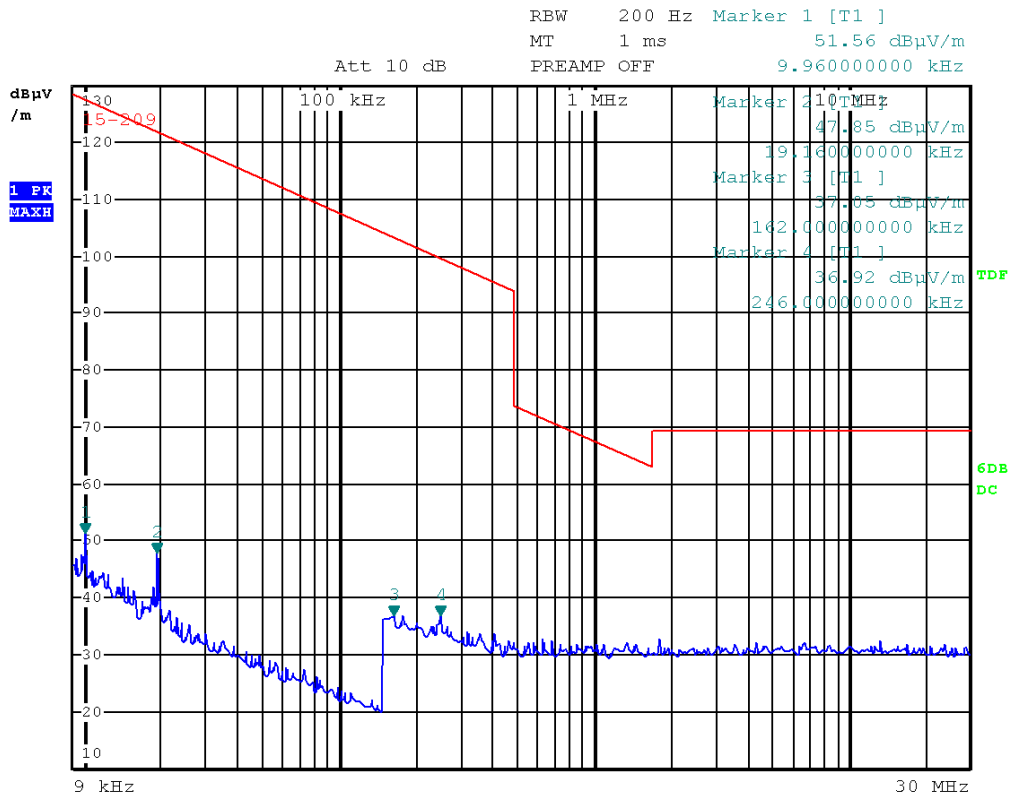
Transmit mode

Temperature:	22°C	Humidity:	46%
Tested by:	M. Müller	Test date:	2015-10-22

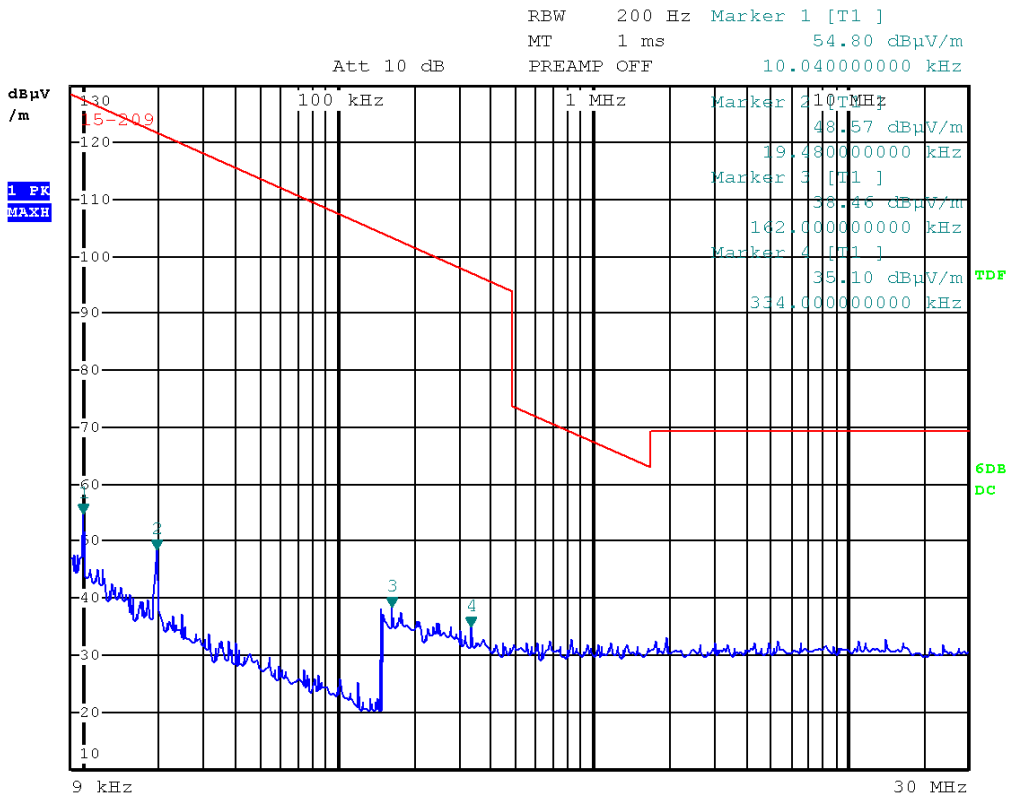
Radiated Emission Measurement 9 kHz – 30 MHz

Note:
Measured value = dBµV/m @ 3 m
Recalculation factor = 40 dB / decade
Recalculated value1 = dBµV/m @ 3 m - 40 dB = **dBµV/m @ 30 m**
Recalculated value2 = dBµV/m @ 30 m - 40 dB = **dBµV/m @ 300 m**

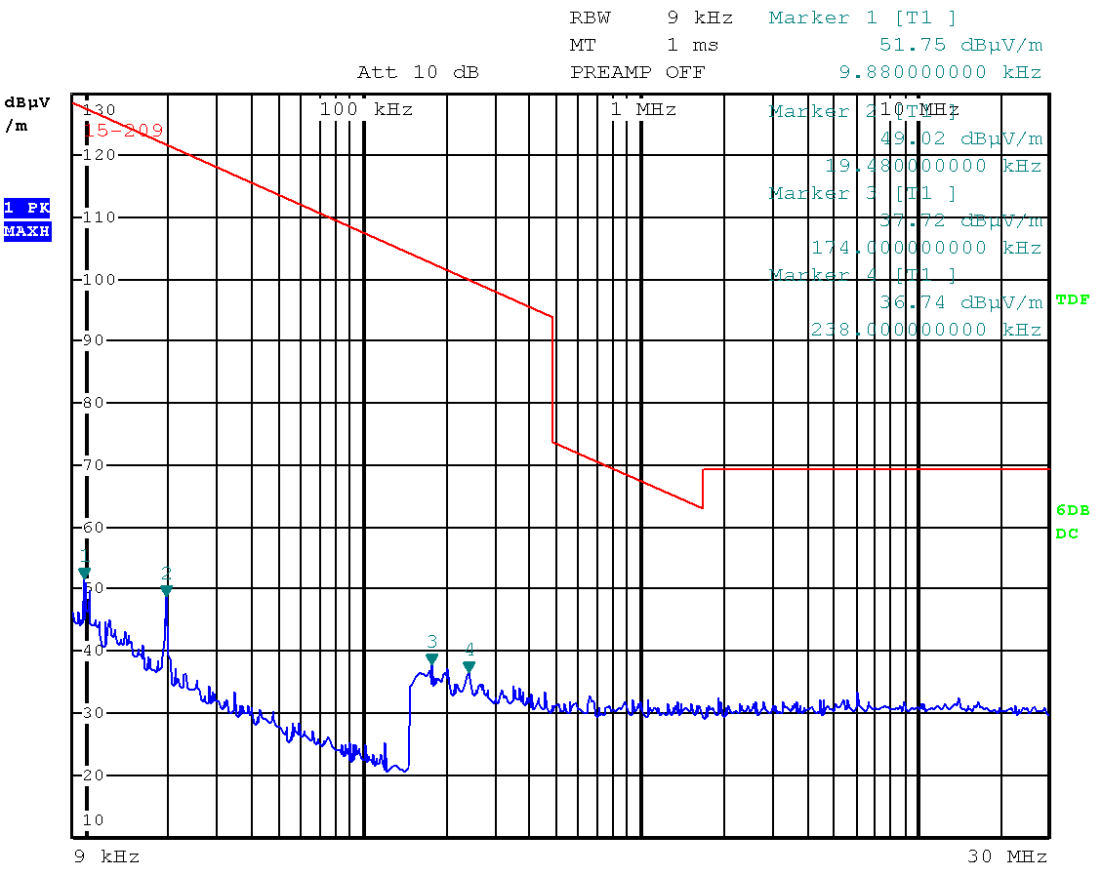
During pre-measurements it was investigated that for the radiated emission measurement from 9kHz to 30MHz the worst-case-position is EUT-position 1 in combination with the loop-antenna polarised to “I”.



Picture 43: Radiated emission 9 kHz – 30MHz (Channel low)



Picture 44: Radiated emission 9 kHz – 30MHz (Channel mid)



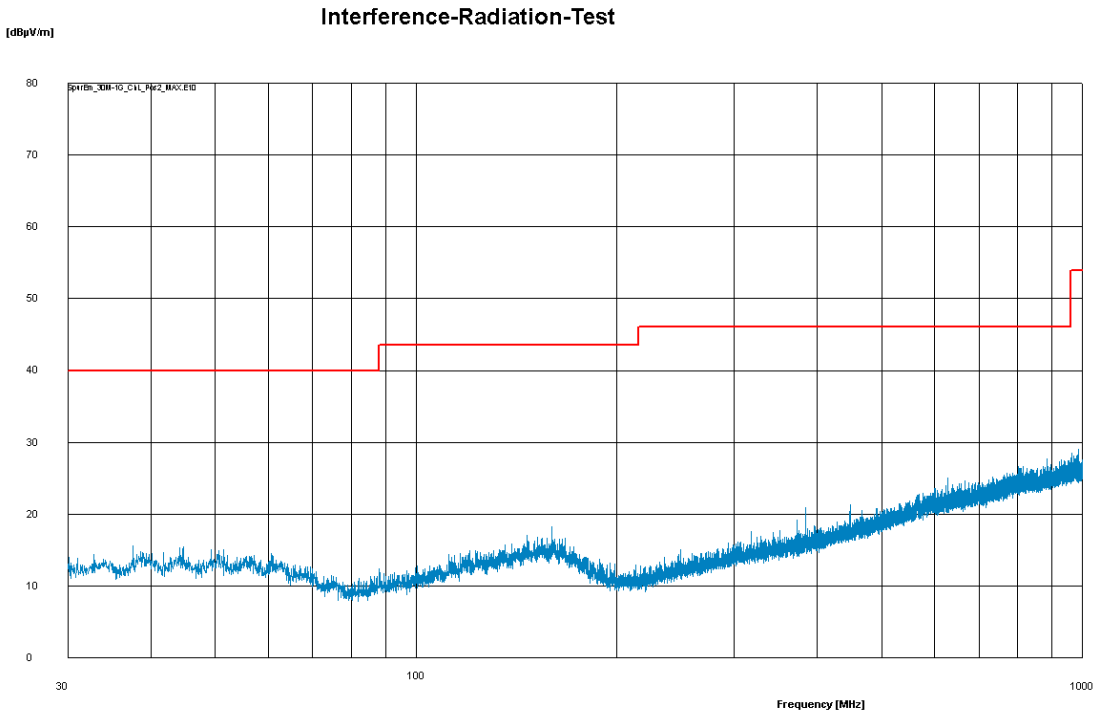
Picture 45: Radiated emission 9 kHz – 30MHz (Channel high)

Transmit mode

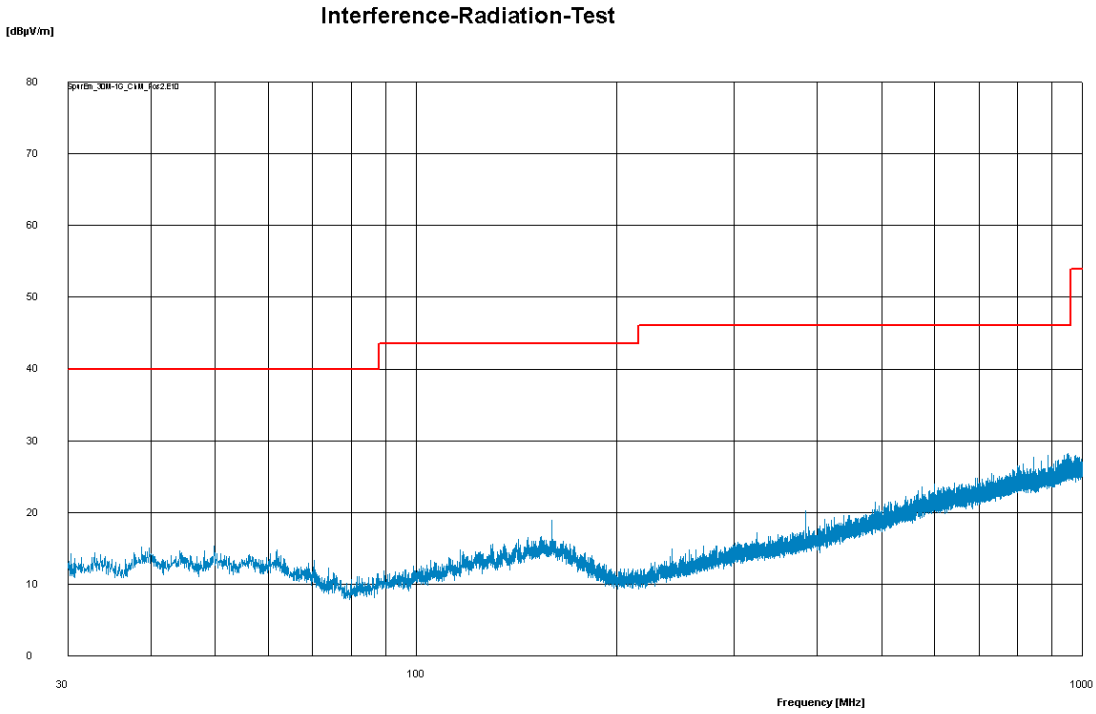
Temperature:	21°C	Humidity:	48%
Tested by:	M. Müller	Test date:	2015-10-22

Radiated Emission Measurement 30 MHz - 1 GHz

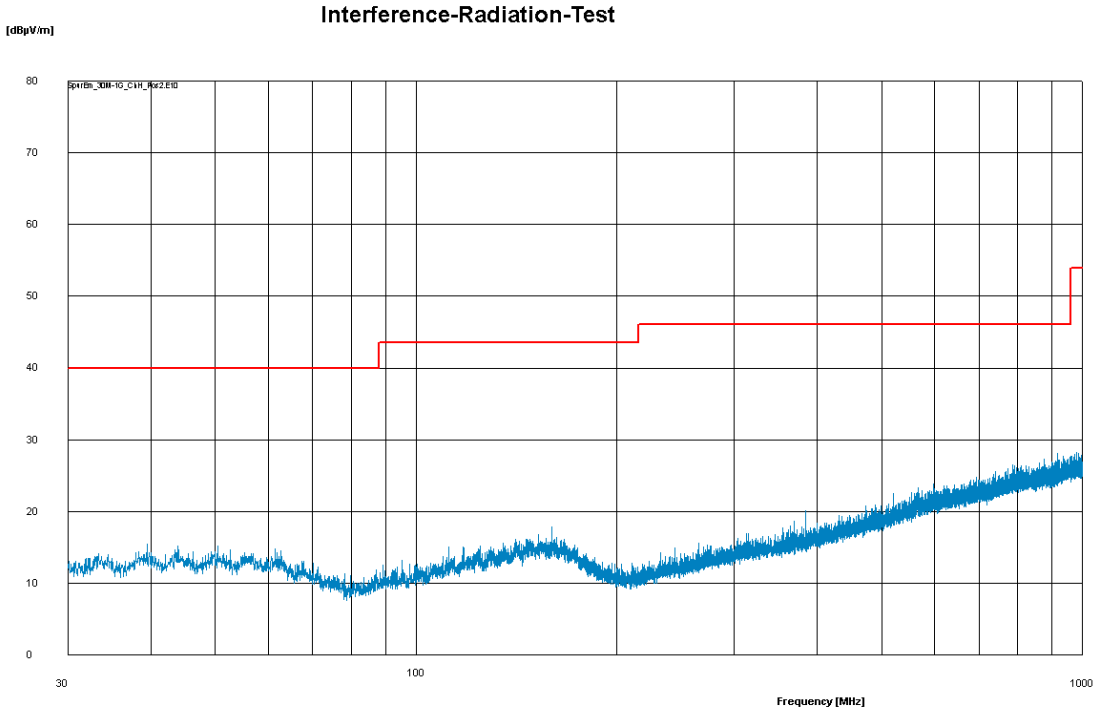
It was investigated that EUT position 2 is the respective worst-case.



Picture 46: Radiated emission 30 MHz – 1000MHz (Channel low)



Picture 47: Radiated emission 30 MHz – 1000MHz (Channel mid)



Picture 48: Radiated emission 30 MHz – 1000MHz (Channel high)

11 Radiated emission measurement (>1 GHz)

according to 47 CFR Part 15, sections 15.205(a), 15.209(a), 15.247(d), and Public Notice DA 00-705

11.1 Test location

☑ Scan with peak detector in 3 m anechoic chamber

☑ Final measurement with average and max peak detector.

Description	Manufacturer	Inventory No.
Anechoic chamber	EMV **TESTHAUS** GmbH	E00100

11.2 Test instruments

	Description	Manufacturer	Inventory No.
☑	ESU26	Rohde & Schwarz	W00002
☑	AMF-5D-00501800-28-13P	Miteq	W00089
☑	AMF-6F-16002650-25-10P	Miteq	W00090
☑	BBHA 9120D	Schwarzbeck	W00053
☑	BBHA 9170	Schwarzbeck	W00055
☐	COSB 4-1-26	Conformitas	W00091

11.3 Limits

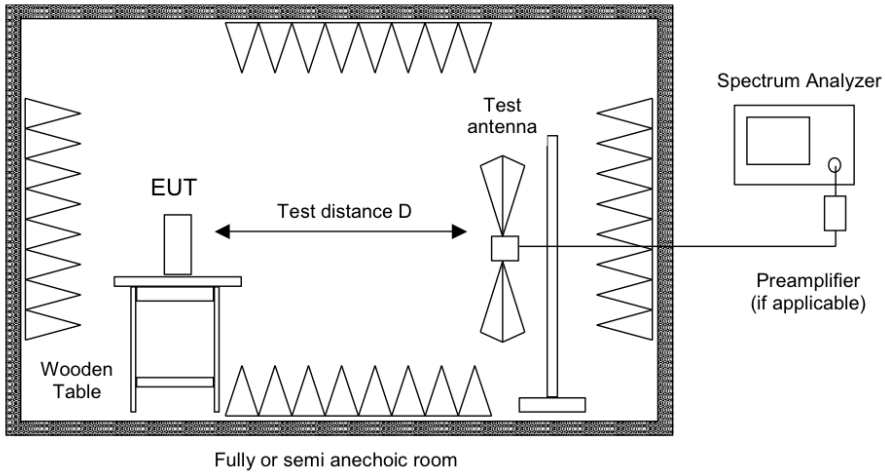
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
30 – 88	100	40	3
88 – 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

11.4 Test procedure

1. Configure the EUT according to ANSI C63.10. The EUT was placed on the top of the turntable 1.5 meter above ground. The receiving antenna was placed 3 meters from the turntable. The test setup was placed inside a fully anechoic chamber.
2. Power on the EUT and all peripherals.
3. The broadband antenna was set to vertical polarization.
4. The EMI receiver performed a scan from 1000 MHz to 10th harmonic of the fundamental frequency with the detector set to peak and the measurement bandwidth set to 1 MHz (VBW ≥ 3 MHz). The trace data was recorded with the receiver Max Hold function.
5. The turn table was rotated in intervals of 15°.
6. After a full 360°-turn the antenna polarization was changed to horizontal and the test was repeated at step 4 and 5.
7. After the scan suspicious frequencies were selected and maximized by moving turntable and variation of antenna height until maximum of emission was found.
8. Then the RBW was set to 1 MHz and the VBW was reduced to a minimum of 10 Hz (1 kHz by default) to get average values determined by video averaging.
9. The receiving antenna was set to vertical polarization.
10. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
11. The receiving antenna was then set to horizontal polarization and the measurement was repeated at step 9.
12. The highest recorded level was noted.

11.5 Test setup



Picture 49: Test setup for radiated emission measurement (> 1 GHz)

11.6 Test deviation

There is no deviation with the original standard.

11.7 EUT operation during test

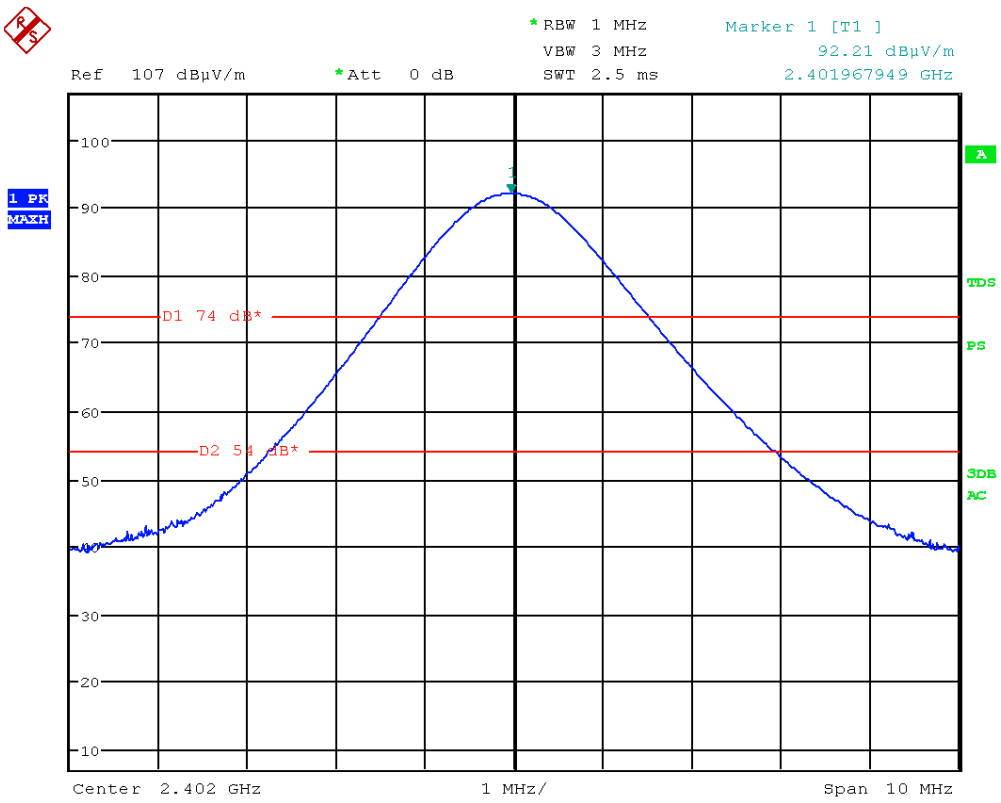
The EUT was programmed to be in continuously transmitting mode.
For these measurements it was investigated that EUT-position3 is the respective worst-case.

11.8 Test results

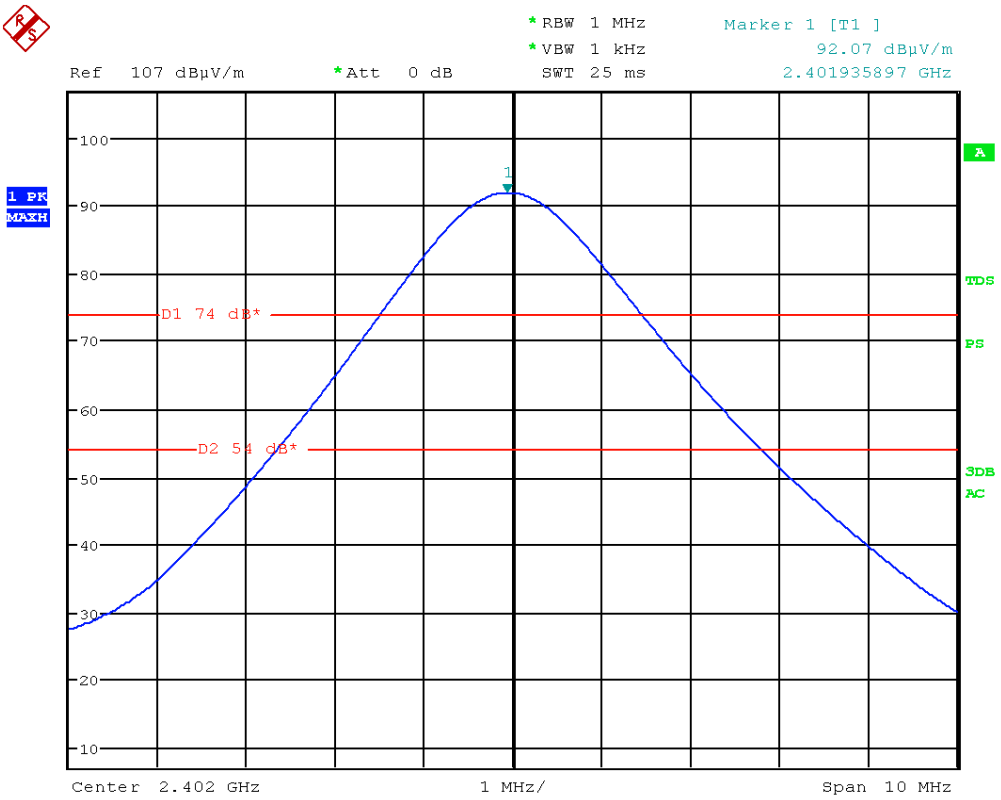
Temperature:	19°C	Humidity:	47%
Tested by:	M. Müller	Test date:	2015-10-29

Final Results:

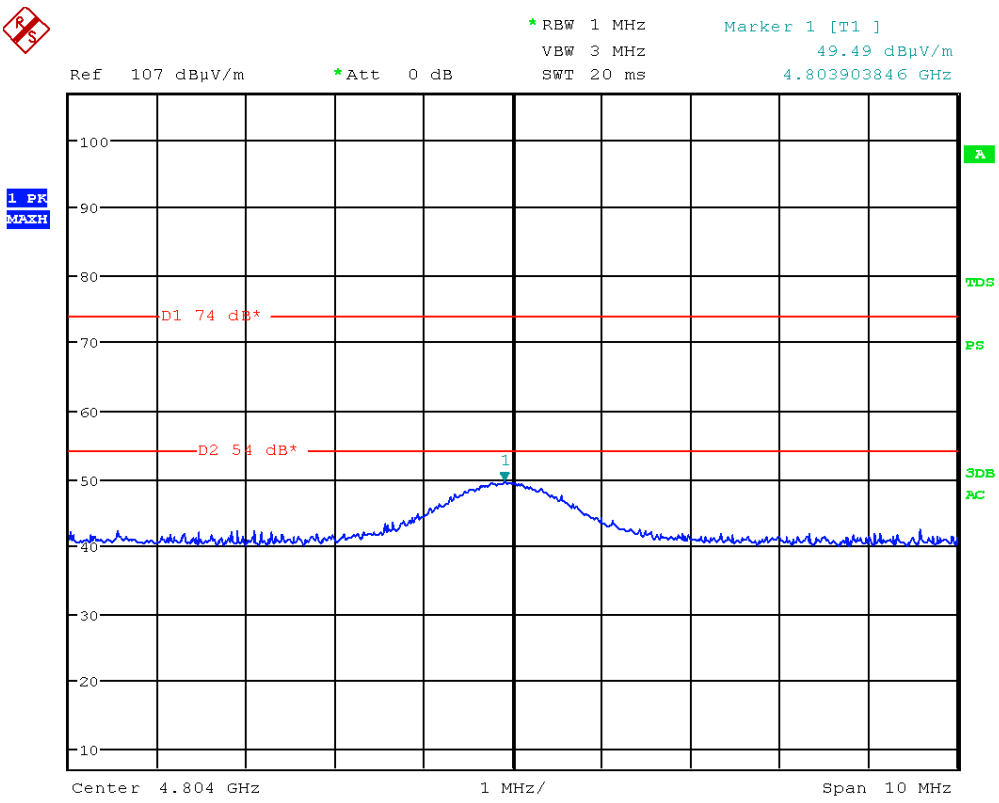
Channel low								
f[GHz]	E_{meas} [dBµV/m]	Ant	Turntable [°]	Hight [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.40197	92.21	H	5.8	190	PK	No	----	Carrier
2.40194	92.07				AV		----	Carrier
4.80390	49.49	H	25.1	156	PK	Yes	74	Pass
4.80392	45.81				AV		54	Pass



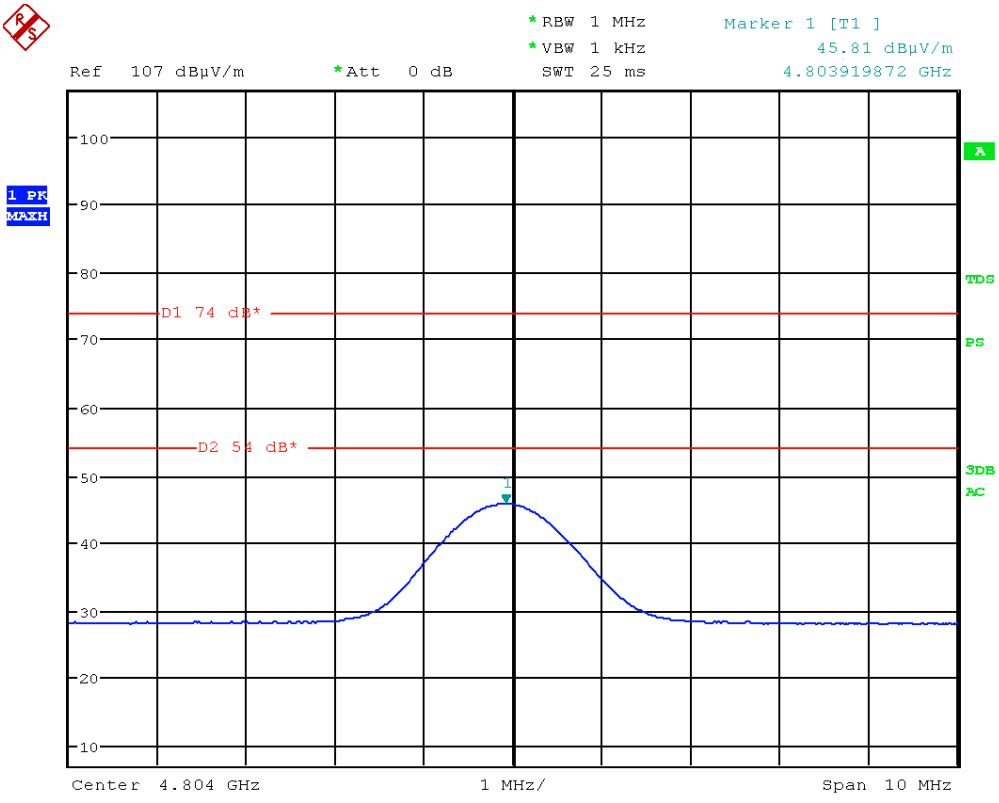
Picture 50: spurious emission, Channel low - PK



Picture 51: spurious emission, Channel low - AV

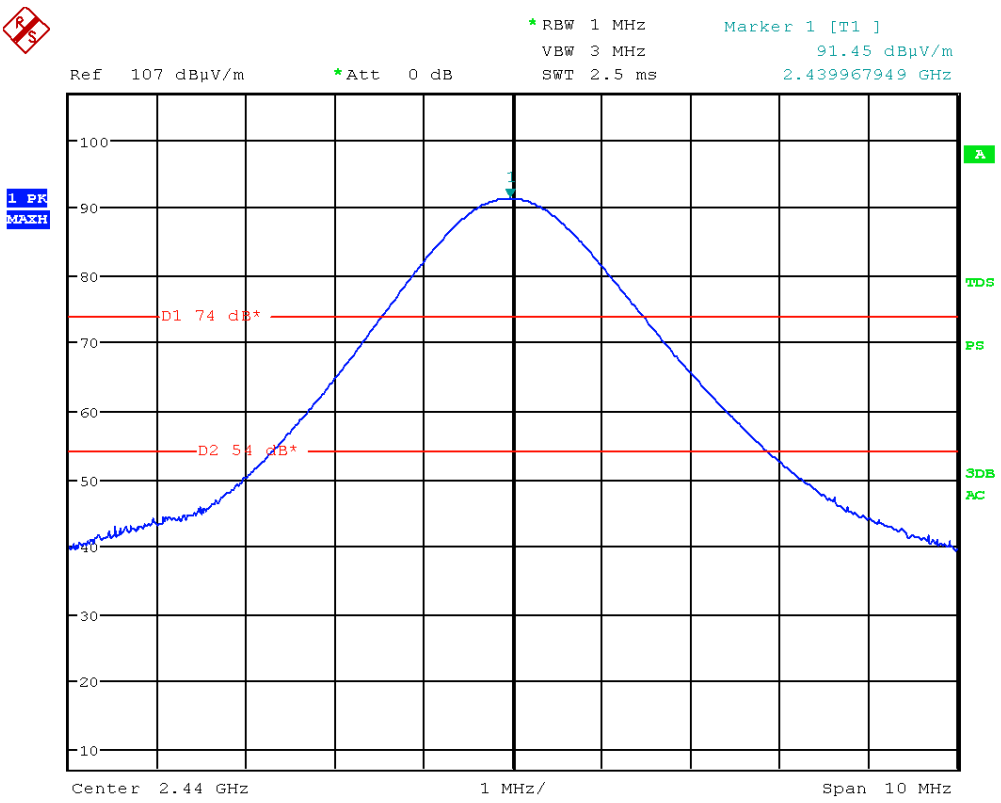


Picture 52: spurious emission, Channel low - PK

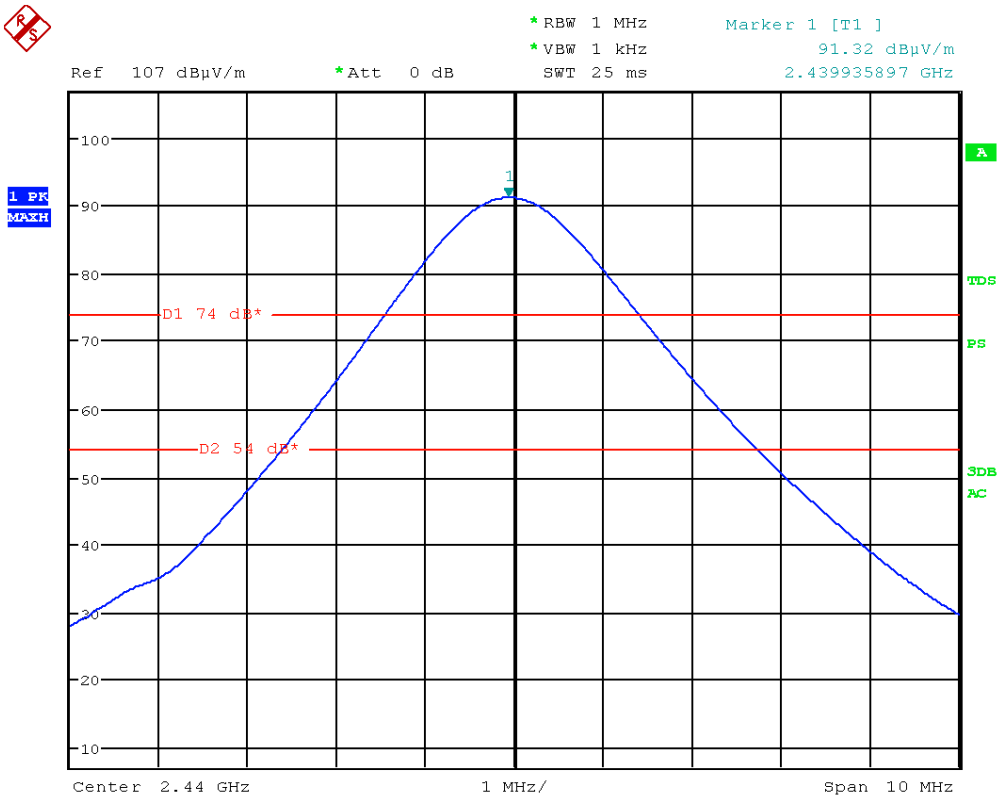


Picture 53: spurious emission, Channel low – AV

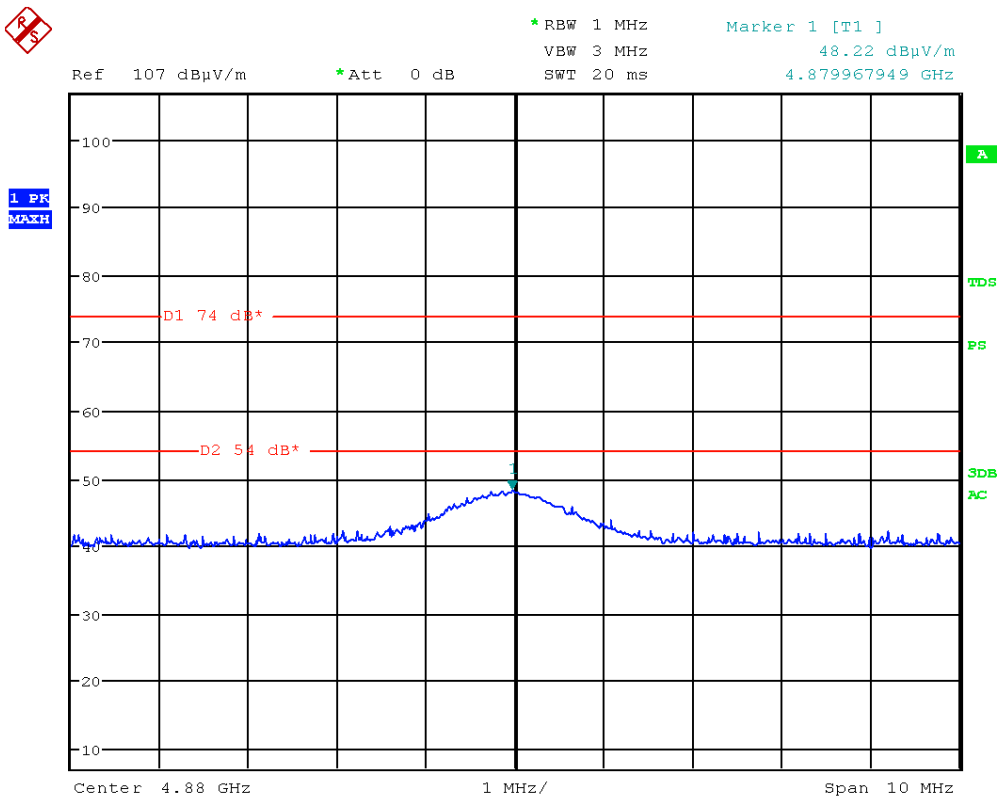
Channel mid								
f[GHz]	E_{meas} [dBµV/m]	Ant	Turntable [°]	Hight [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.43997	91.45	H	17.2	163	PK	No	----	Carrier
2.43994	91.32				AV		----	Carrier
4.87997	48.22	H	15.2	165	PK	Yes	74	Pass
4.87994	43.67				AV		54	Pass



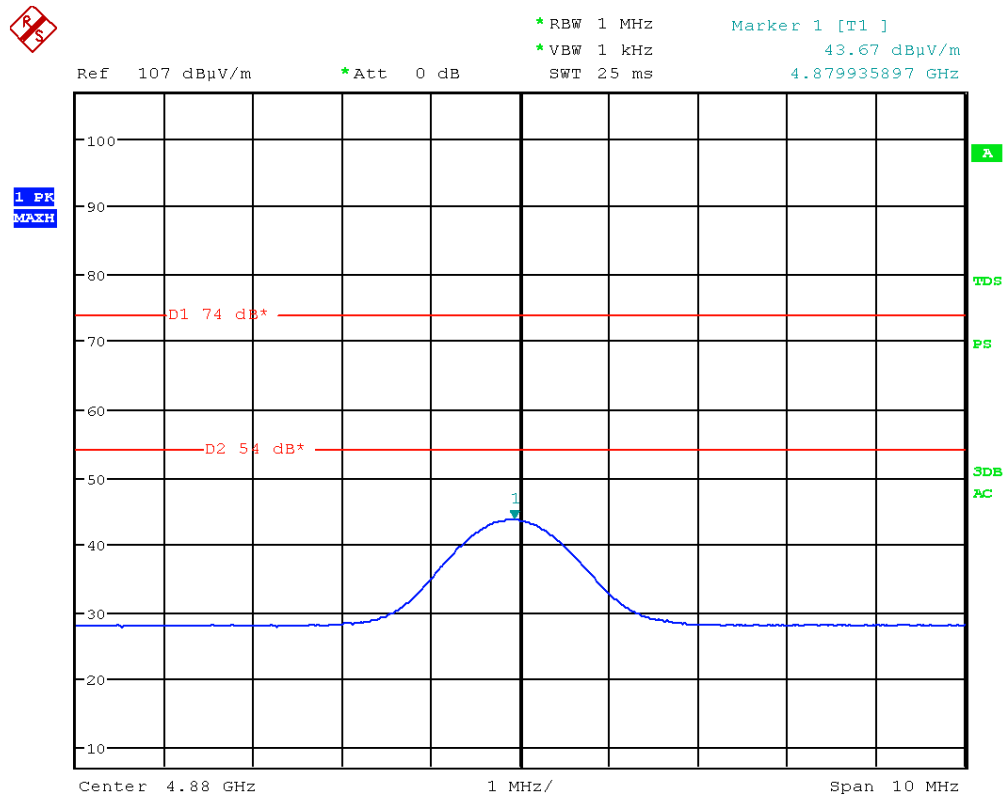
Picture 54: spurious emission, Channel mid - PK



Picture 55: spurious emission, Channel mid - AV

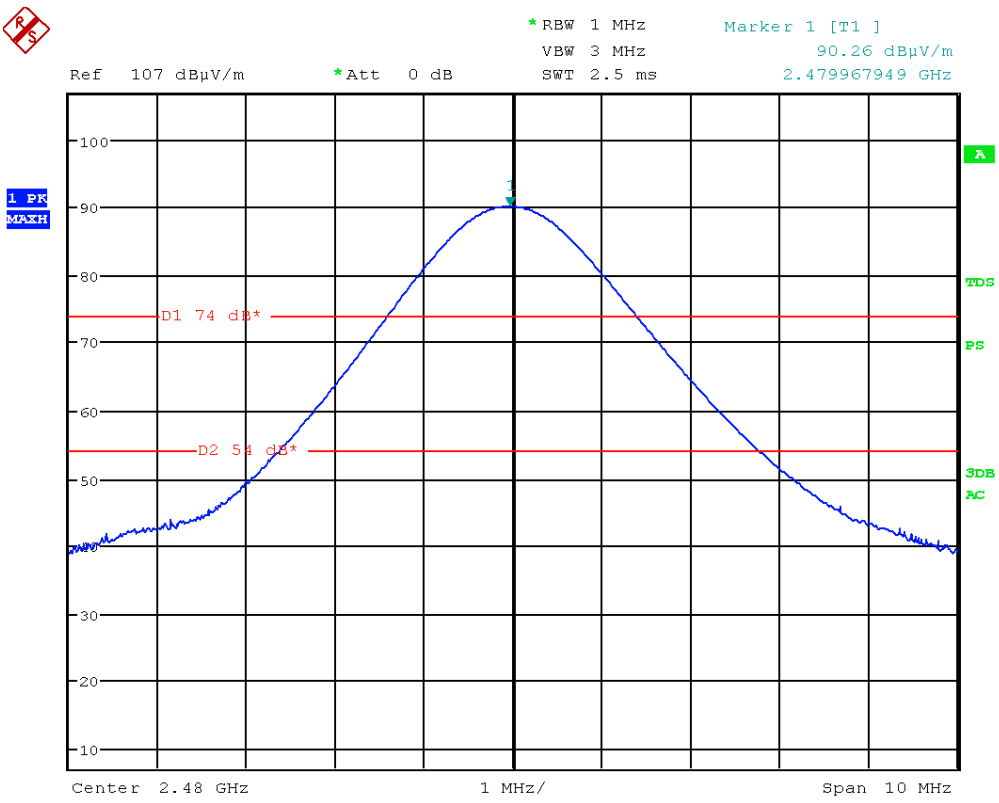


Picture 56: spurious emission, Channel mid - PK

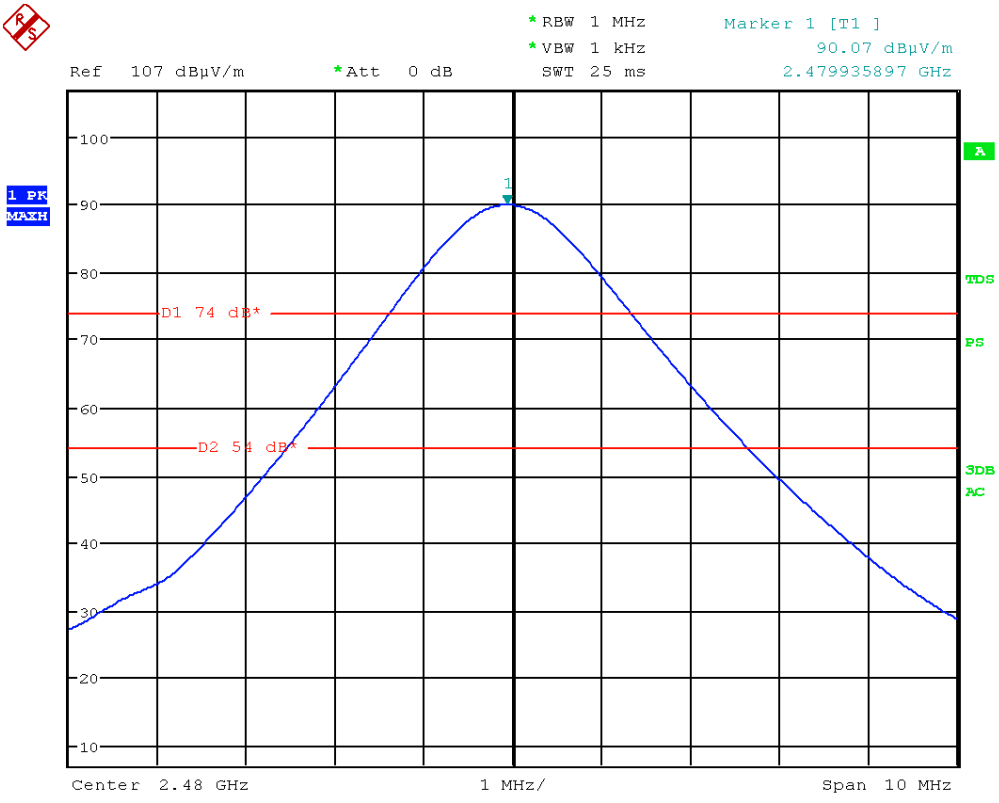


Picture 57: spurious emission, Channel mid – AV

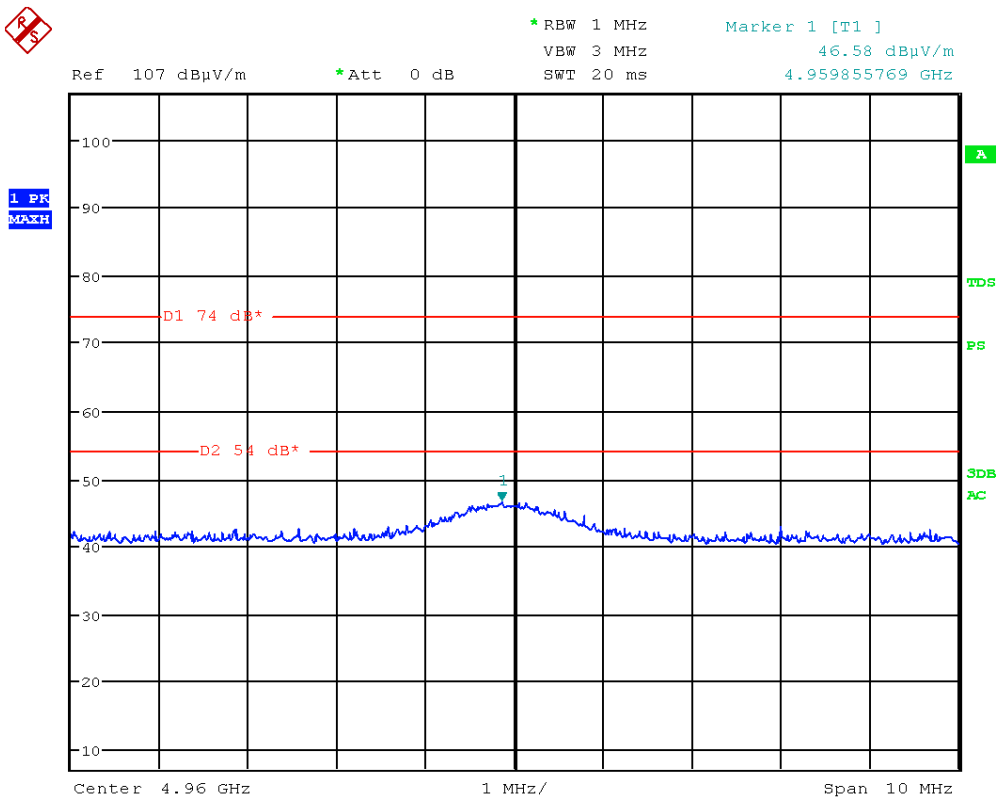
Channel high								
f[GHz]	E_{meas} [dBµV/m]	Ant	Turntable [°]	Hight [cm]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.47997	90.26	H	16.8	169	PK	No	----	Carrier
2.47994	90.07				AV		----	Carrier
4.95986	46.58	H	357.4	204	PK	Yes	74	Pass
4.95986	39.92				AV		54	Pass



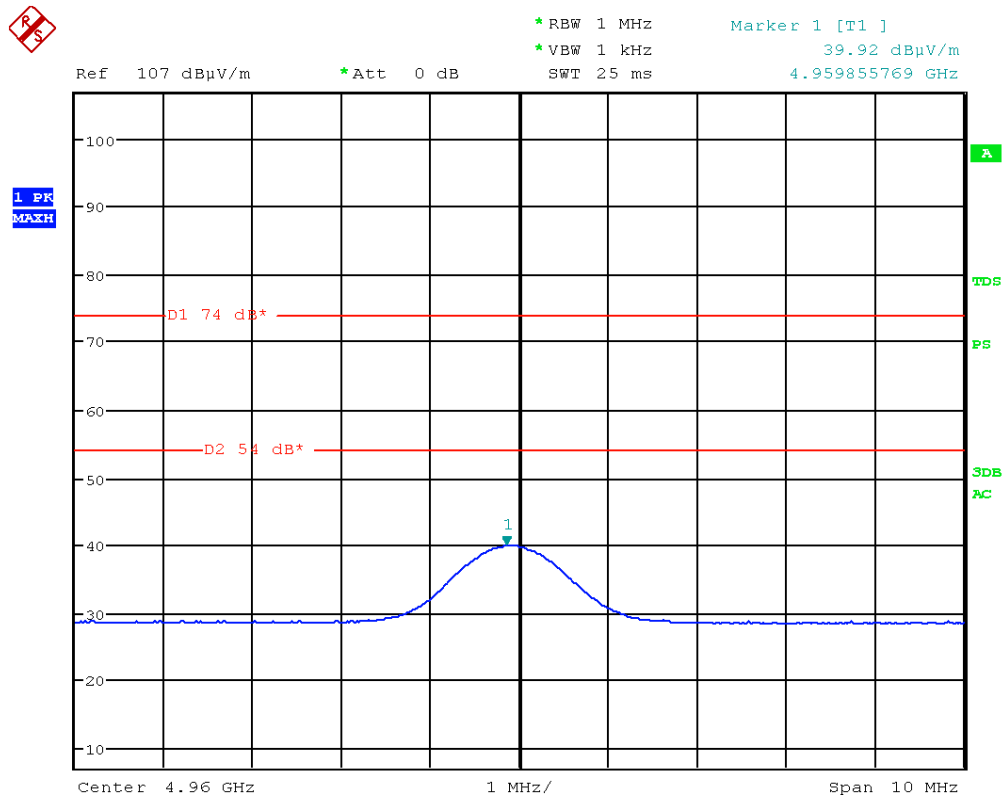
Picture 58: spurious emission, Channel high - PK



Picture 59: spurious emission, Channel high - AV



Picture 60: spurious emission, Channel high - PK



Picture 61: spurious emission, Channel high – AV

12 Radio frequency radiation exposure evaluation for mobile devices

according to 47 CFR Part 2, section 2.1093,
KDB 447498 D01, section 4.3.1,
RSS-Gen Issue 4, section 3.2, and RSS-102 Issue 5, section 2.5.1

12.1 Equipment data

Antenna detachable (see antenna specifications):	☐ yes	☒ no
Temporary antenna connector:	☒ yes	☐ no
Tune-up function:	☐ yes	☒ no
Antenna gain G referring to isotropic radiator:	-1.0 dBi Numeric gain:	0.794
Conducted output power CP (maximum):	-3.75 dBm Numeric power:	0.422 mW
Separation distance between user and transmitting device:	☒ R ≤ 20 cm	☐ R > 20 cm

12.2 SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm according to KDB 447498 D01 section 4.3.1 1):

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

Calculation: $\frac{0mW \times \sqrt{2.48}}{1mm} = 0 < 3.0$

12.3 Exemption Limits for SAR Evaluation according to RSS-102 Issue 5, section 2.5.1:

Limit according to table1:

Frequency (MHz)	Exemption Limits (mW) At separation distance of ≤5 mm
2450	4

13 Equipment calibration status

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Test receiver	ESU 26	100026	W00002	2014-02	2016-02
Test receiver	ESCI 3	100013	E00001	2013-12	2015-12
Test receiver	ESCI 3	100328	E00552	2014-07	2016-07
Test receiver	ESCS 30	825442/0002	E00003	2014-02	2016-02
Test receiver	ESCS 30	845552/0008	E00551	2014-01	2016-01
LISN	ESH2-Z5	881362/037	E00004	2015-06	2017-06
LISN	ESH2-Z5	893406/009	E00005	2014-01	2016-01
Loop antenna	HFH2-Z2	871398/0050	E00004	2014-07	2016-07
Broadband antenna	VULB 9163	9163-114	E00013	2015-09	2017-09
Broadband horn antenna	BBHA 9120D	9120D-593	W00053	2014-03	2016-03
Broadband horn antenna	BBHA 9170	9170-331	W00055	2014-03	2016-03
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	2016-10
Climatic chamber 340 l	VC³ 4034	58566123250010	C00015	2014-09	2016-09
Cable set shielded room	Cable no. 30	---	E00424	2015-07	2016-07
Cable set CDC	Cables no. 37 and 38	---	E00459 E00460	2015-05	2016-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2015-10	2016-10
Cable set OATS 10 m	Cables no. 19, 33 and 36	---	E00453 E00455 E00458	2015-10	2016-10
Cable set anechoic chamber 01	Cables no. 01, 09, 11 and 13	---	W00095 E00307 E00319 E00436	2015-04	2016-04

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Cable set anechoic chamber 02	Cables no. 01, 09, 12 and 14	---	W00095 E00307 E00320 E00437	2015-04	2016-04

Table 2: Equipment calibration status

Note: Expiry date of measurement facility registration by
- FCC (registration number 221458): 2017-04
- Industry Canada (test site numbers 3472A-1 and 3472A-2): 2018-11

14 Measurement uncertainty

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	± 4.0 dB	2
Radiated emission open field (30 MHz to 1 GHz)	± 4.5 dB	2
Radiated emission absorber chamber (> 1000 MHz)	± 5.4 dB	2

Table 3: Measurement uncertainty

Comment: The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. If k=2 the value of the measurements lies within the assigned range of values with a probability of 95 %.

15 Summary

The EMC Regulations according to the marked specifications are

☑ **KEPT**

The EUT does fulfill the general approval requirements mentioned.

☐ **NOT KEPT**

The EUT does not fulfill the general approval requirements mentioned.

Place, Date: Straubing, April 28th, 2015

Martin Müller	Rainer Heller
Test engineer	Head of EMC / radio department
EMV **TESTHAUS** GmbH	EMV **TESTHAUS** GmbH

16 Revision History

Date	Description	Person	Revision
2016-04-28	First edition	M. Müller	- - - -