Test Report

Customer:

Trimble Kaiserslautern GmbH

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RF test report

140494-AU01+W02

Trimble Kaiserslautern GmbH

RF module 2.4 GHz

TI RF AMP module

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

EMV **TESTHAUS** GmbH

Gustav-Hertz-Straße 35
94315 Straubing
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Fax: +49 9421 56868-100
Email: info@emv-testhaus.com

Accreditation:

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

FCC facility registration number: 221458
Test Firm Type “2.948 listed”: Valid until 2017-04-22
Test Firm Type “accredited”: Valid until 2015-06-11
MRA US-EU, FCC designation number: DE0010
BnetzA-CAB-02/21-02/04 Valid until 2018-11-27

Industry Canada test site number: 3472A-1
Registration expiry date: 2015-10-02

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

CFR 47 Part 2 October 2013	Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)
CFR 47 Part 15 October 2013	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
OET Bulletin 65 August 1997	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
ANSI C63.4 December 2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10 June 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen Issue 4, November 2014	General Requirements for Compliance of Radio Apparatus
RSS-102 Issue 4, March 2010, updated December 2010	Radio Frequency Exposure Compliance of Radiocommunications Apperatus
RSS-210 Issue 8, December 2010	Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment

1.1 Cross reference of FCC and Industry Canada standards

CFR 47 Part and Section	Test	Equivalent to IC
15.207	AC power line conducted emissions[1] 150 kHz to 30 MHz	RSS-Gen Issue 4 section 8.8
15.247(a)(2) KDB 558074, section 8	6 dB bandwidth	RSS-210 Issue 8, section A 8.2
15.247(a)(1)	20 dB bandwidth[2]	RSS-210 Issue 8, section A 8.1(a)
2.202(a)	Occupied bandwidth	RSS-Gen Issue 4, section 6.6
15.247(b) KDB 558074, section 9	Maximum peak conducted output power	RSS-Gen Issue 4, section 6.12 RSS-210 Issue 8, A 8.4
15.247(d)	Band-edge compliance	RSS-210 Issue 8, section A 8.5
15.247(e) KDB 558074, section 10	Power spectral density	RSS-210 Issue 8, section A 8.2
15.247(d)	Spurious RF Conducted Emission	RSS-210 Issue 8, section A 8.5
15.247(d)	Radiated emission 9 kHz to 10th harmonic	RSS-Gen Issue 4, section 6.13 RSS-210 Issue 8, section A 8.5
2.1091	Radio frequency radiation exposure evaluation for mobile devices	RSS-Gen Issue 4, section 3.2 Exempted from SAR and RF evaluation

[1] This test was not applied because EUT is powered by battery supplied remote control having no port to be connected to AC mains.
[2] For DTS equipment recorded for information only.

1.2 Summary of test results

Standard	Test result
FCC CFR 47 Part 15, section 15.247	Passed
RSS-210 Issue 8 Annex 8 with appropriate sections in RSS-Gen Issue 4	Passed

2 Equipment under Test (EUT)

Product type:	RF module 2.4 GHz
Model Name:	TI RF AMP module
Manufacturer:	Trimble Navigation Limited
Serial number(s):	sample no. 1: standard version sample no. 2: version with temporary antenna connector for conducted tests
FCC ID:	PWR-TK42RF
IC:	4131A-TK42RF
Application freq. band:	2400 MHz – 2483.5 MHz
Frequency range:	2405MHz – 2480 MHz
Operating frequency:	2405MHz – 2480 MHz
Channel spacing:	5 MHz
Number of RF-channels:	16
Type of modulation:	DSSS
Antenna type:	internal PCB antenna
Power supply:	Powered by battery supplied remote control Nominal voltage: 3.3 V DC
Temperature range:	-20°C to +50°C

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 RF module which uses the 2.4-GHz-band and which can be integrated in special industrial applications (e.g. remote controls).

During the 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: - with amplifier
- power level to 14 dBm
- transmitter interval to 10 ms

2.4 Configuration

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

Device	Model:	S/N
RF module 2.4 GHz	TI RF AMP module (standard version for radiated tests)	sample no. 1
RF module 2.4 GHz	TI RF AMP module (version with temporary antenna connector for conducted tests)	sample no. 2
Remote PCB	RC402N	sample no. 2
Remote control	RC402N	N/A
Power supply	Input 120V/60Hz /Output 0-30V DC Statron 3252.1	1201211
Multimeter	Gossen METRAhit 29S	E00099

Used cables

Numbers:	Description: (type / lengths / remarks)	Serial No
2	DC cable / 1.5m / unshielded	N/A
1	Antenna cable / 0.3m / shielded	N/A

3 AC power line conducted emissions

according to CFR 47 Part 15, section 15.207

3.1 Test location

Description	Manufacturer	Inventory No.
Shielded chamber	Siemens - Matsushita	E00107

3.2 Test instruments

	Description	Manufacturer	Inventory No.
☐	ESCS 30	Rohde & Schwarz	E00003
☐	ESCI	Rohde & Schwarz	E00001
☐	ESH3 Z2	Rohde & Schwarz	E00028
☐	ESH 2-Z5	Rohde & Schwarz	E00004
☐	ESH 2-Z5	Rohde & Schwarz	E00005

3.3 Limits

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

3.4 Test results

This test was not applied because EUT is powered by battery supplied remote control having no port to be connected to AC mains.

4 6 dB bandwidth

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

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

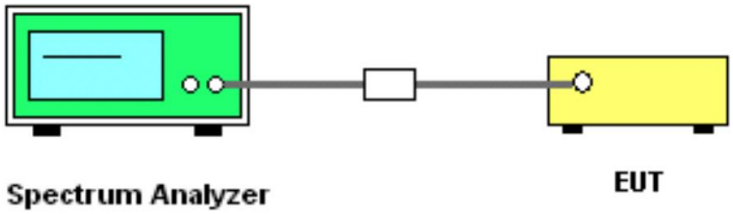
4.3 Limits

The minimum 6 dB bandwidth shall be at least 500kHz

4.4 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.

4.5 Test setup



Picture 1: Test setup for 6 dB bandwidth measurement

4.6 Test deviation

There is no deviation with the original standard.

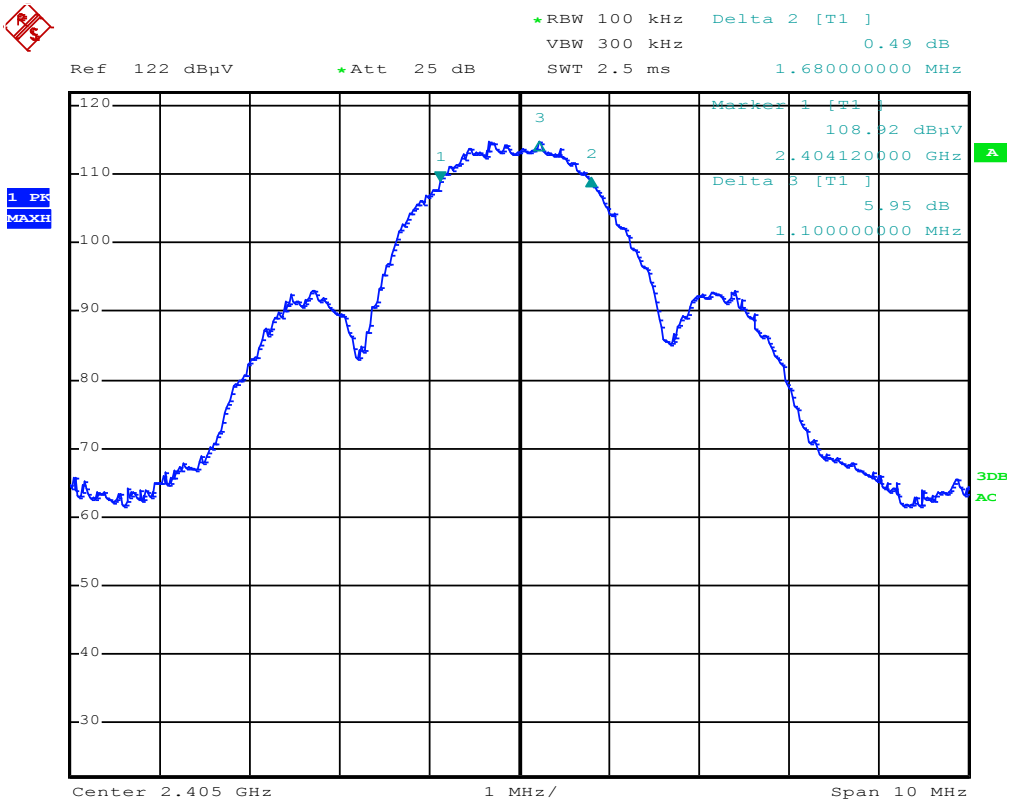
4.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

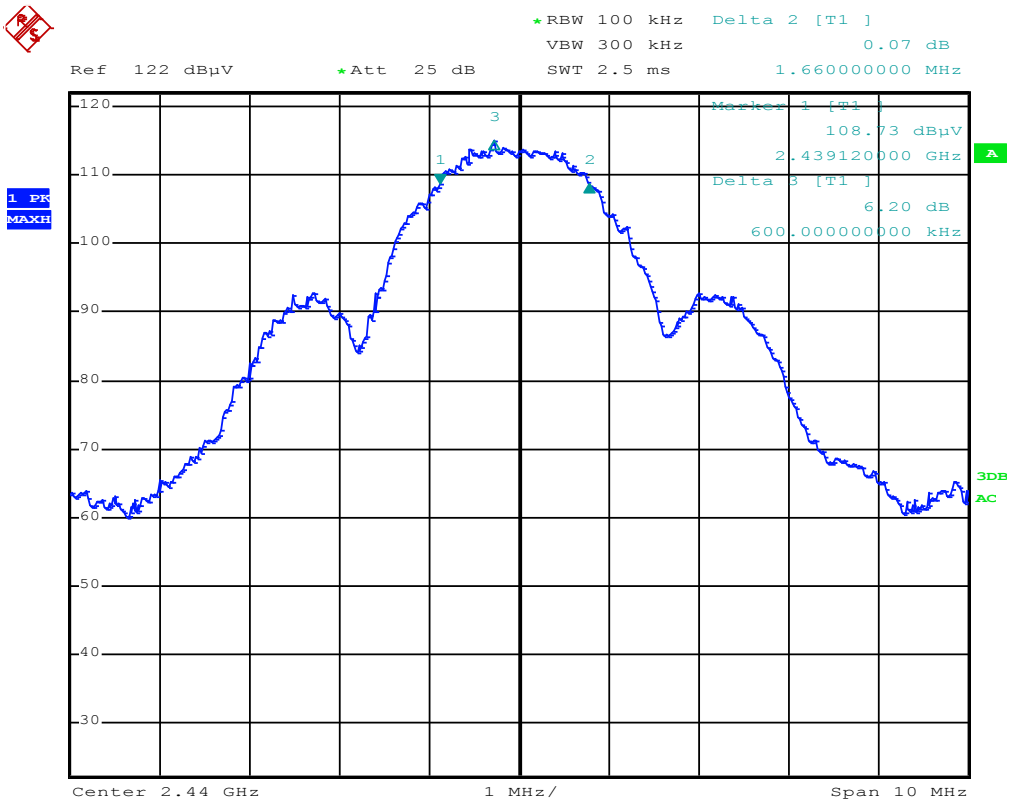
4.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

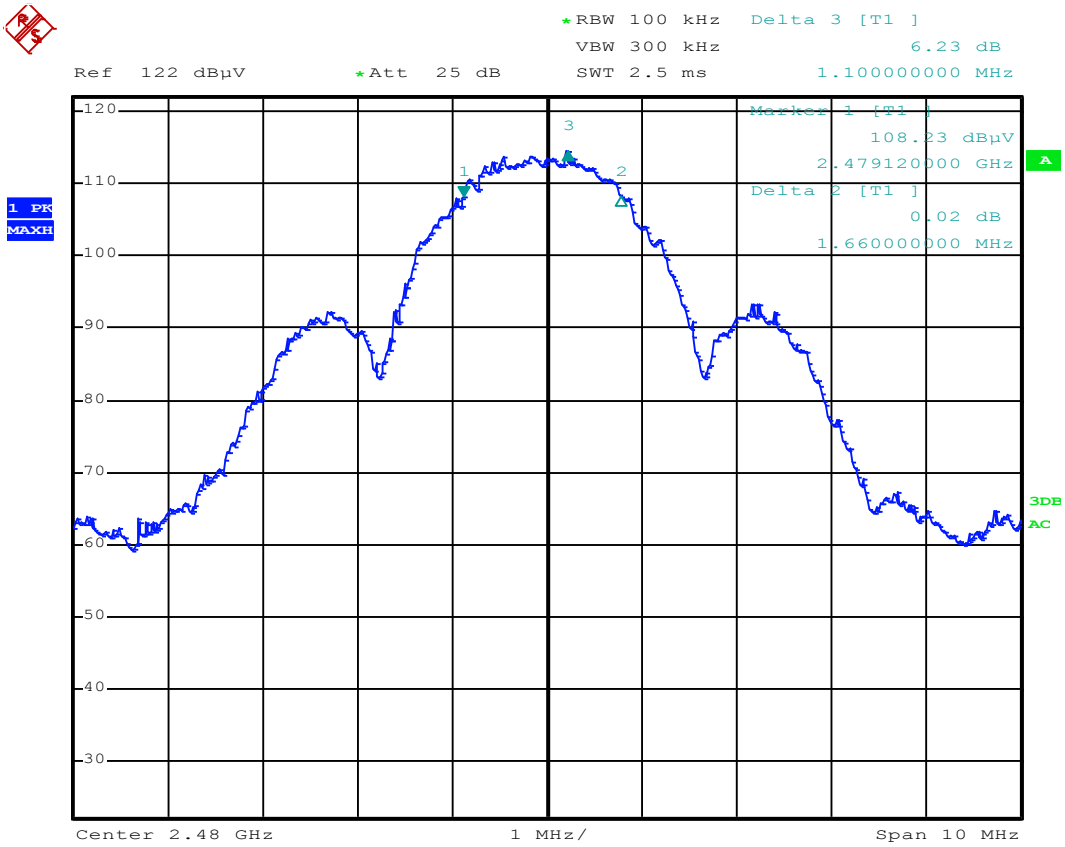
Channel	Frequency (GHz)	6 dB bandwidth (MHz)
11	2.405	1.680
18	2.440	1.660
26	2.480	1.660



Picture 2: 6dB bandwidth channel 11



Picture 3: 6dB bandwidth channel 18



Picture 4: 6dB bandwidth channel 26

5 20 dB bandwidth

according to CFR 47 Part 15, section 15.247(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

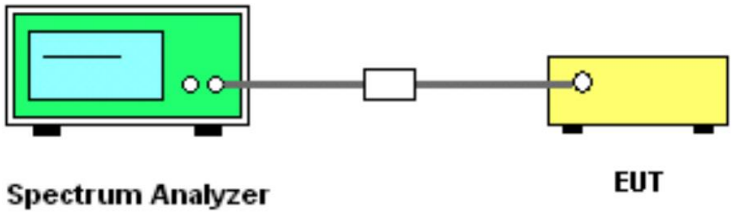
5.3 Limits

N/A

5.4 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.

5.5 Test setup



Picture 5: Test setup for 20 dB bandwidth measurement

5.6 Test deviation

There is no deviation with the original standard.

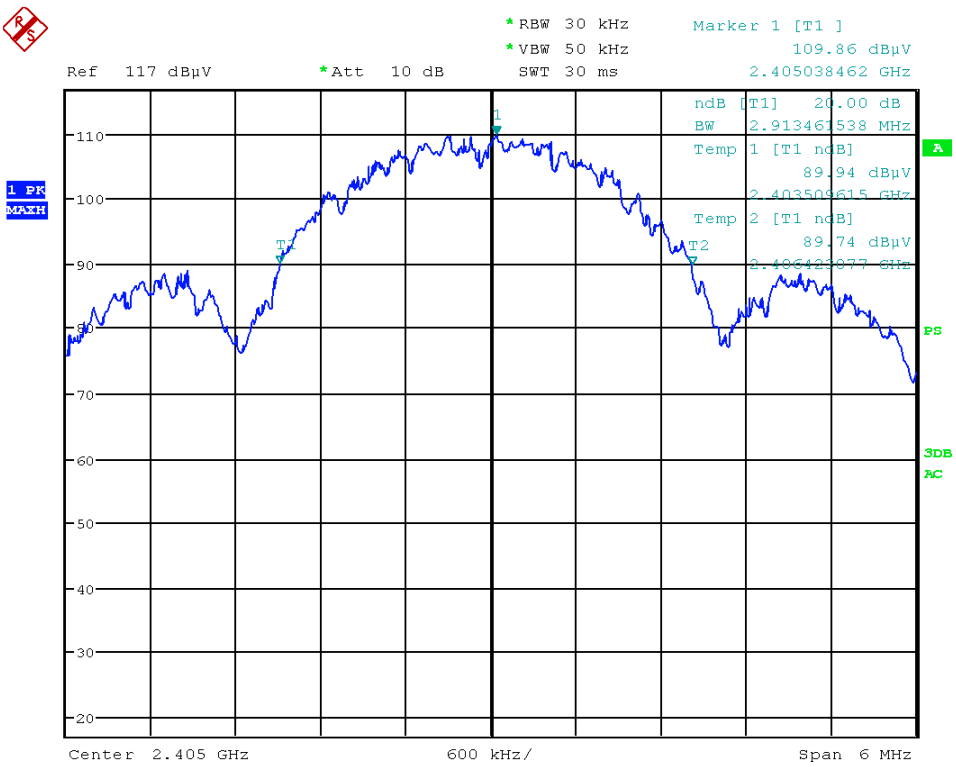
5.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

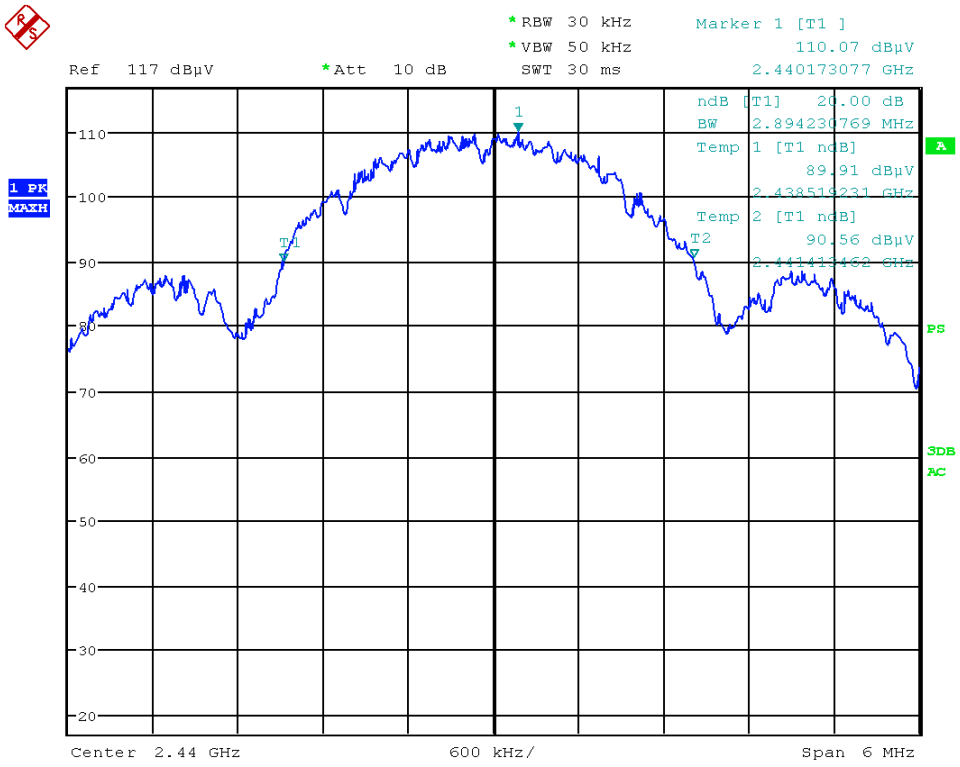
5.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

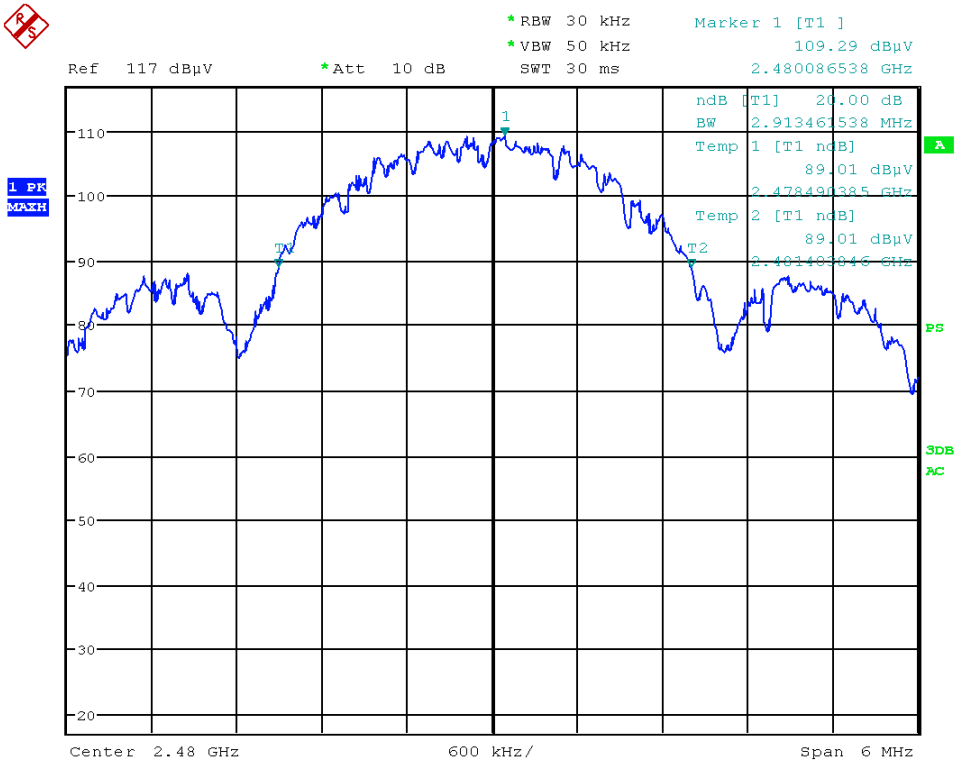
Channel	Frequency (GHz)	20 dB bandwidth (MHz)
11	2.405	2.9135
18	2.440	2.8942
26	2.480	2.9135



Picture 6: 20dB bandwidth channel 11



Picture 7: 20dB bandwidth channel 18



Picture 8: 20dB bandwidth channel 26

6 Occupied bandwidth

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

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

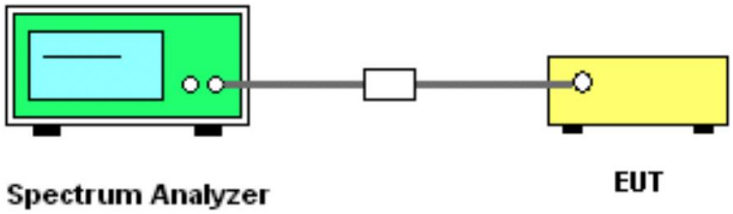
6.3 Limits

N/A

6.4 Test procedure

1. The test is performed in accordance with CFR 47 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.

6.5 Test setup



Picture 9: Test setup for occupied bandwidth measurement

6.6 Test deviation

There is no deviation with the original standard.

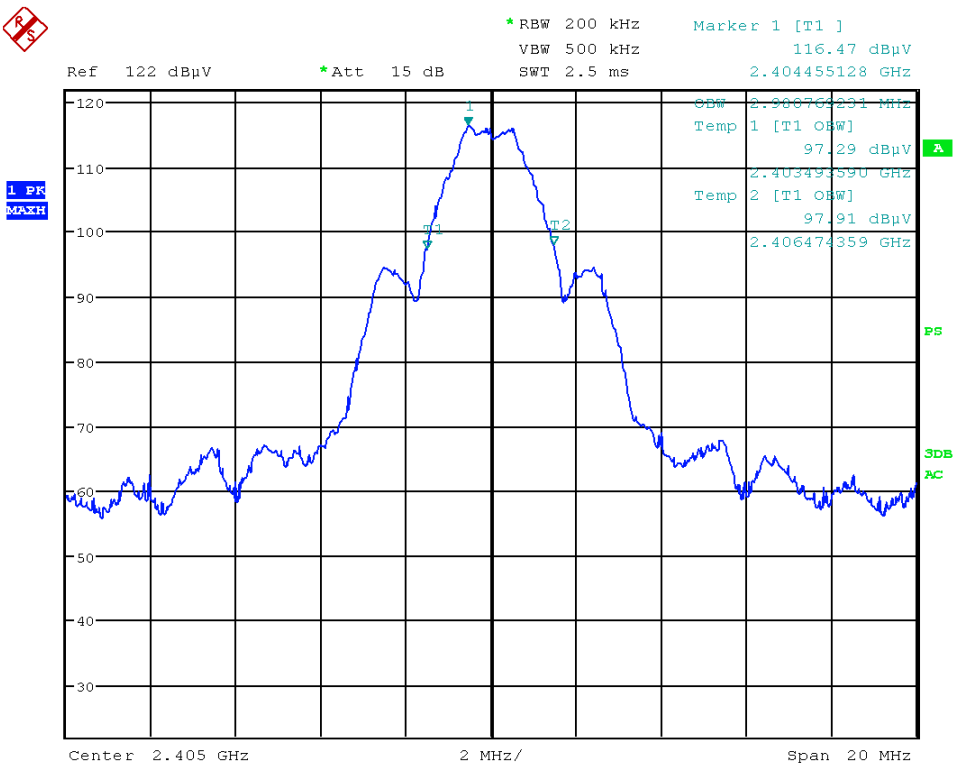
6.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

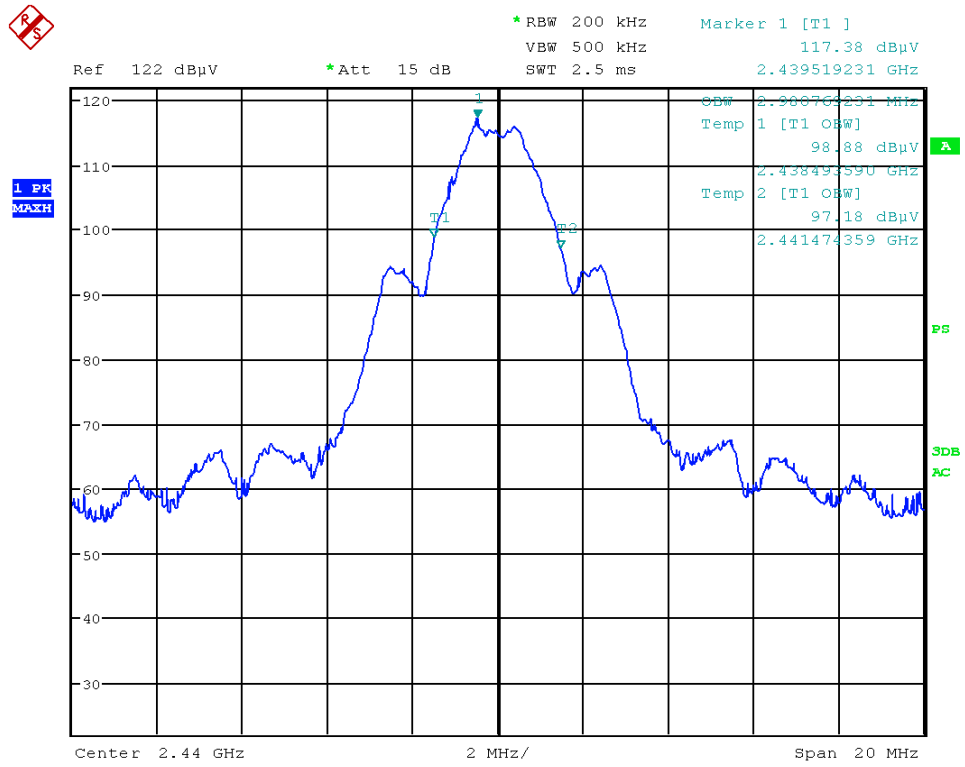
6.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

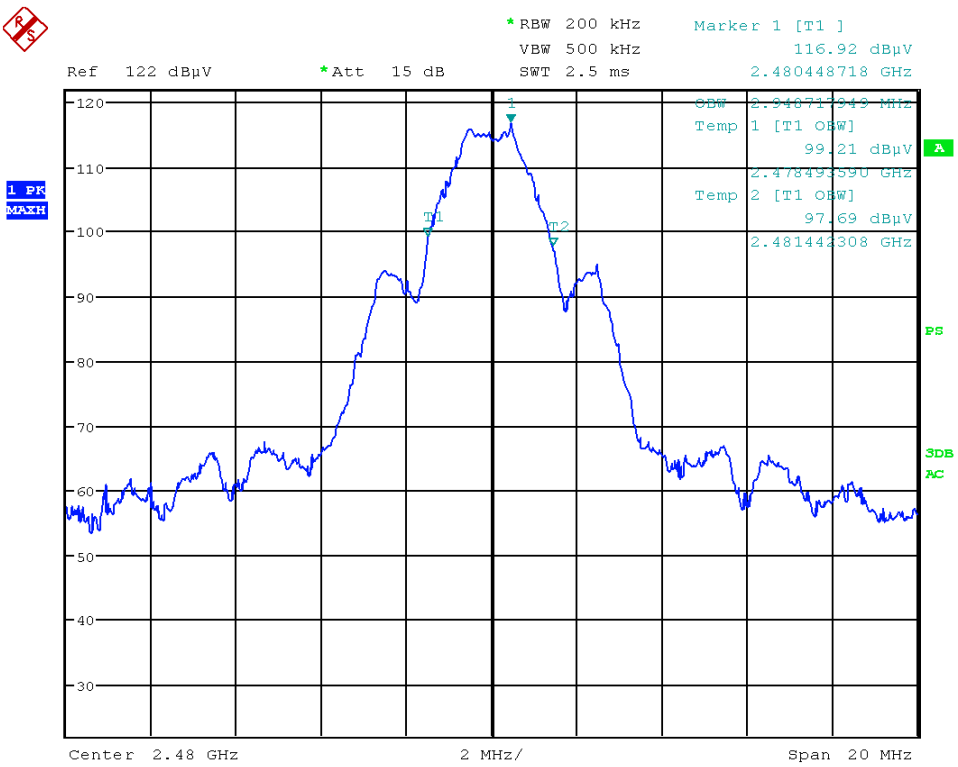
Channel	Frequency (GHz)	Occupied bandwidth (MHz)
11	2.405	2.9808
18	2.440	2.9808
26	2.480	2.9487



Picture 10: Occupied bandwidth channel 11



Picture 11: Occupied bandwidth channel 18



Picture 12: Occupied bandwidth channel 26

7 Maximum peak conducted output power

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

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

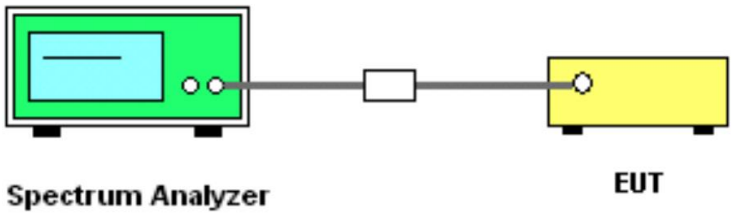
For systems using digital modulation: 1 Watt (30 dBm).

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.

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 9 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.

7.5 Test setup



Picture 13: Test setup for conducted output power measurement

7.6 Test deviation

There is no deviation with the original standard.

7.7 EUT operation during Test

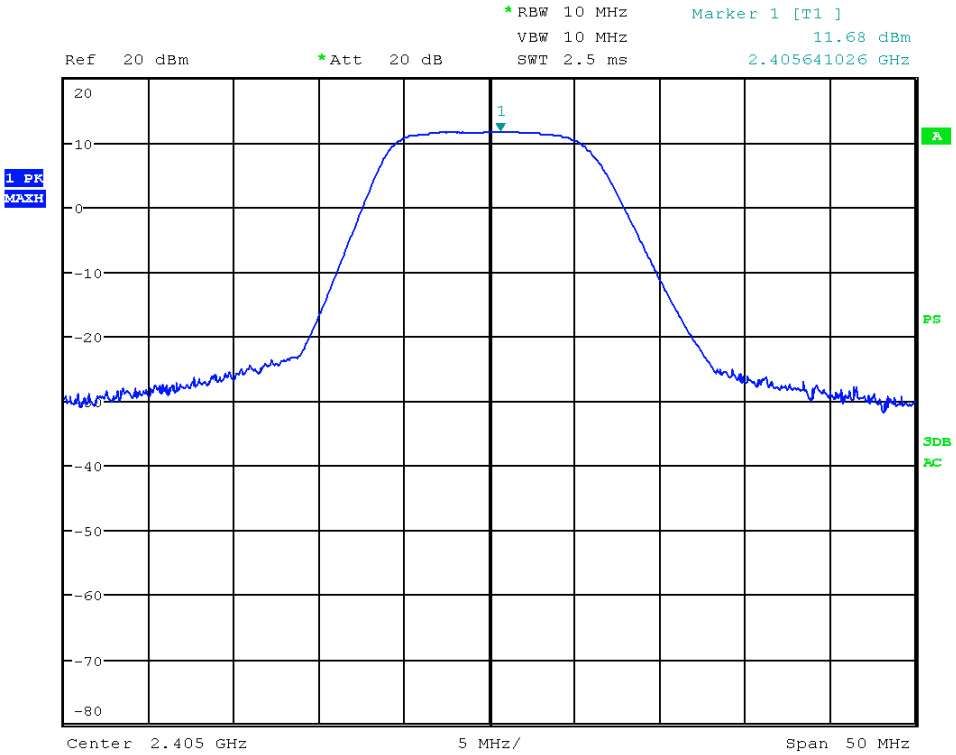
The EUT was programmed to be in continuously transmitting mode.

7.8 Test results

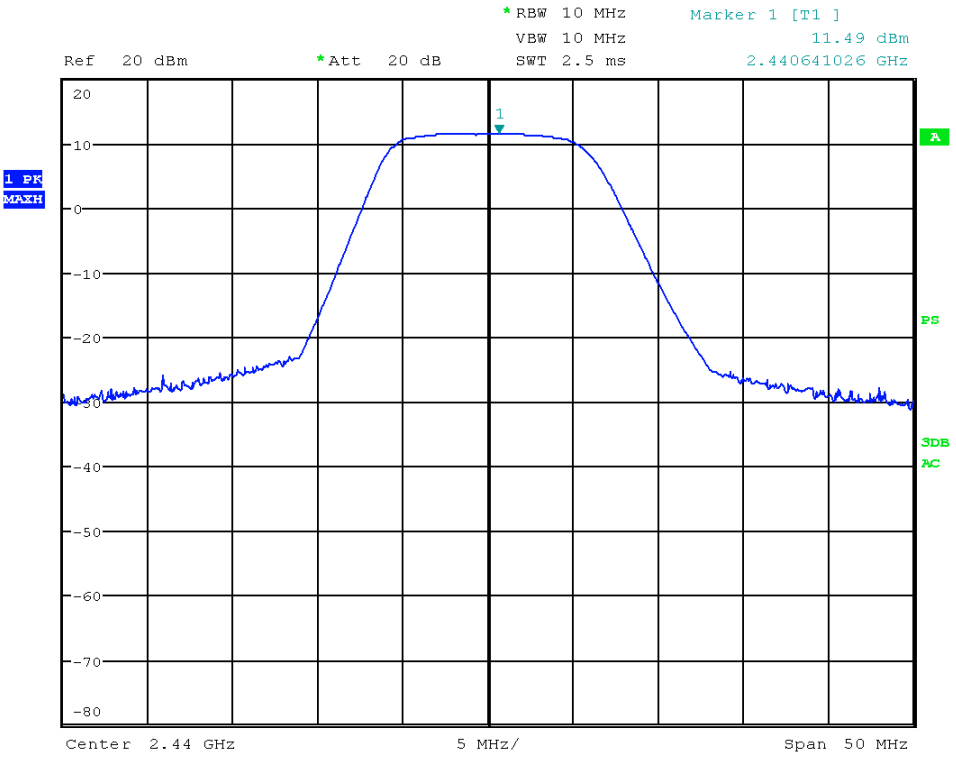
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

Channel	Frequency (GHz)	Detector	Conducted power (dBm)	Limit (dBm)	Result
11	2.405	PK	11.68	30	Passed
18	2.440	PK	11.49	30	Passed
26	2.480	PK	11.33	30	Passed

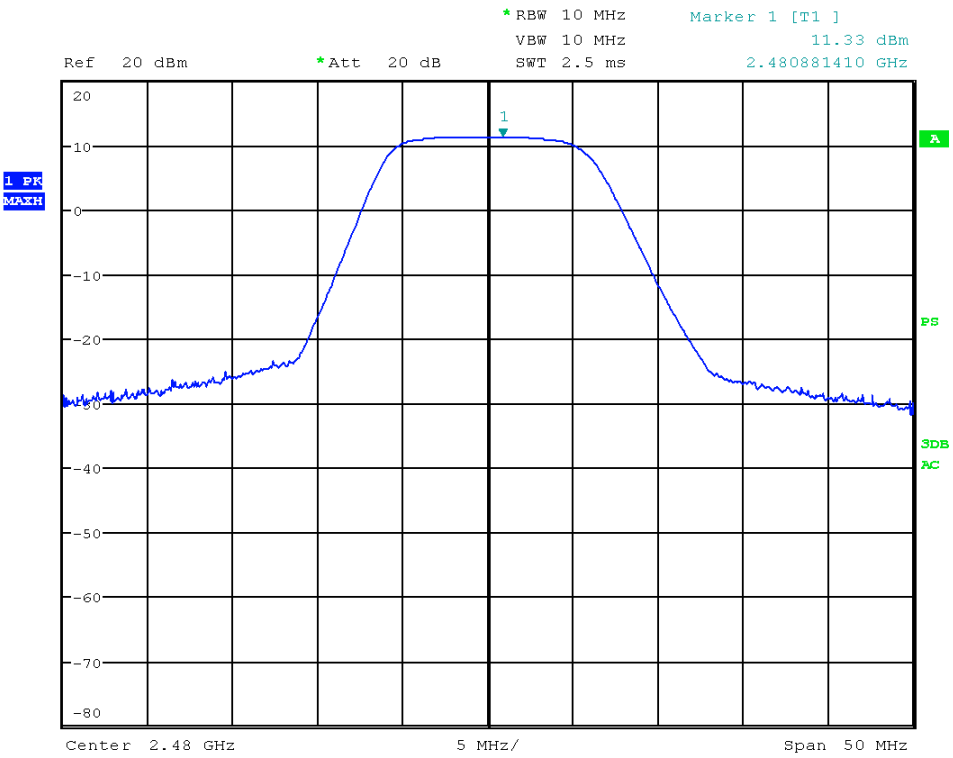
Comments: - none -



Picture 14: Conducted output power channel 11



Picture 15: Conducted output power channel 18



Picture 16: Conducted output power channel 26

8 Power spectral density

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

8.1 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

8.2 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

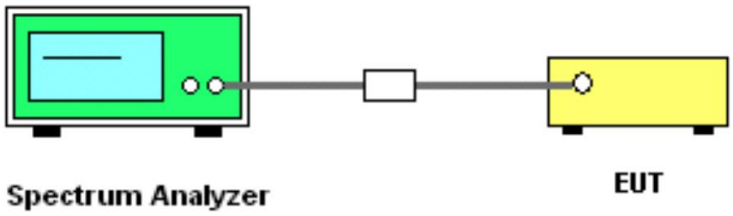
8.3 Limits

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.

8.4 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

8.5 Test setup



Picture 17: Test setup for power spectral density measurement

8.6 Test deviation

There is no deviation with the original standard.

8.7 EUT operation during Test

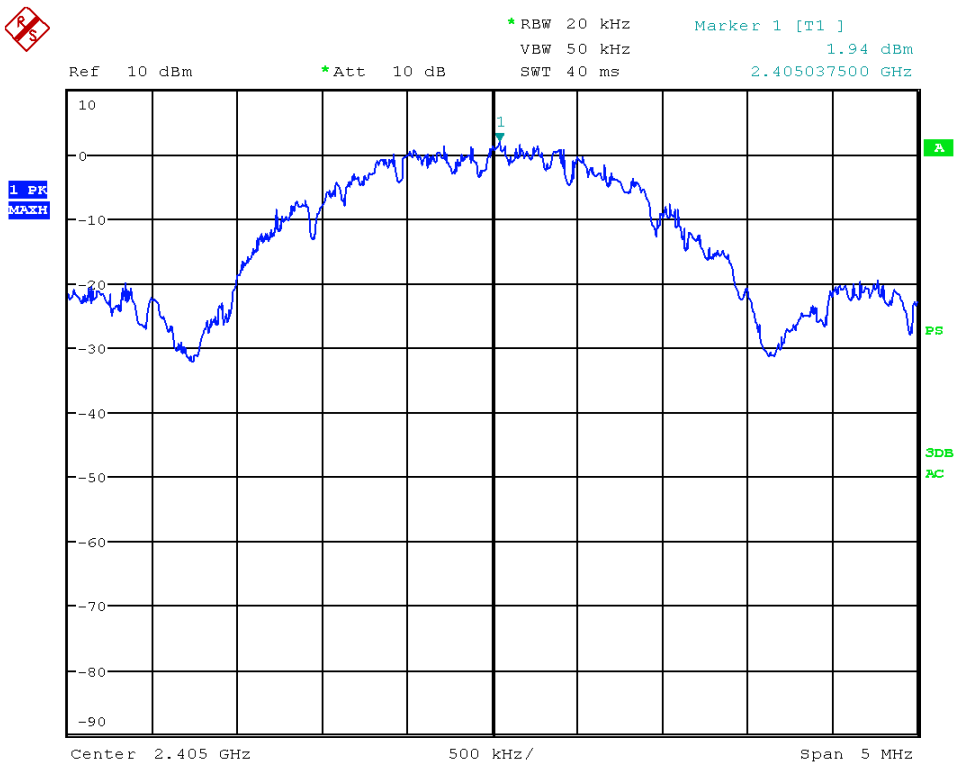
The EUT was programmed to be in continuously transmitting mode.

8.8 Test results

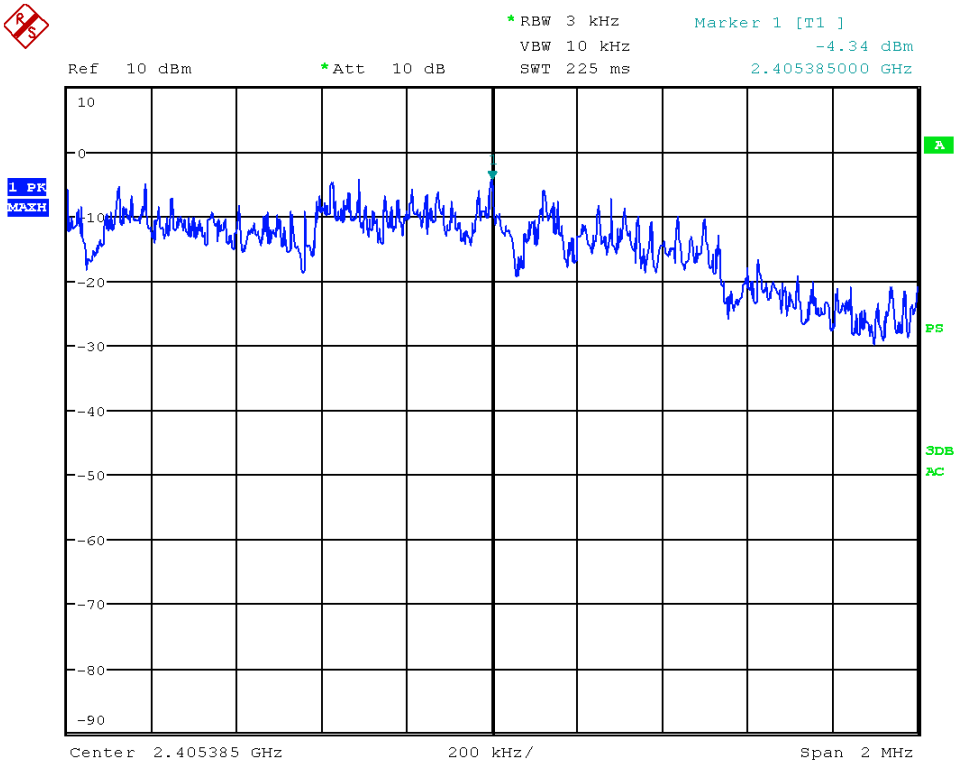
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

Channel	Detector	Frequency (GHz)	PSD @ 20kHz RBW (dBm)	Frequency (GHz)	PSD @ 3kHz RBW (dBm)	Limit (dBm)	Result
11	PK	2.40504	1.94	2.40501	-3.33	8	Passed
18	PK	2.44001	1.35	2.44007	-3.33	8	Passed
26	PK	2.48003	1.60	2.48007	-3.92	8	Passed

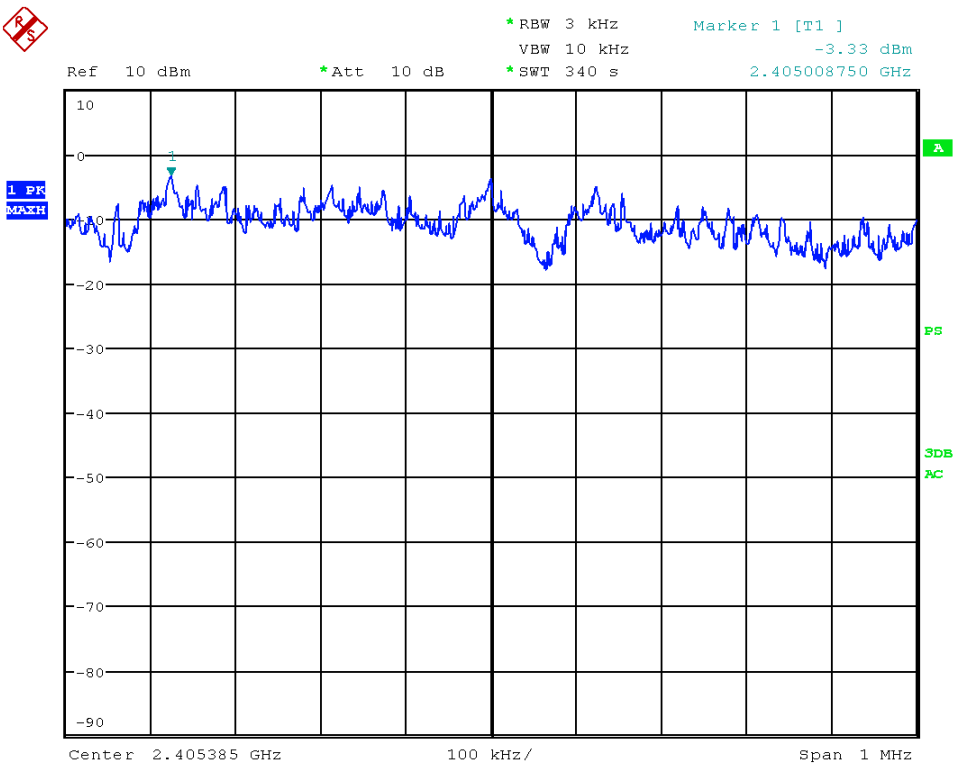
Comments: - none -



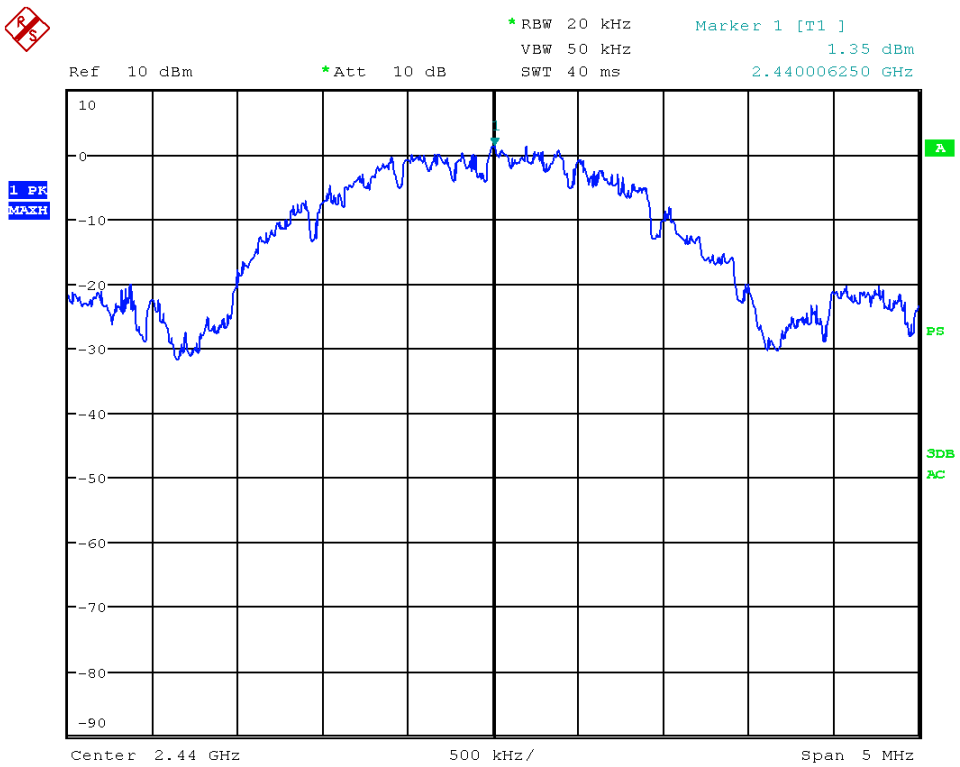
Picture 18: Power spectral density channel 11 - complete carrier



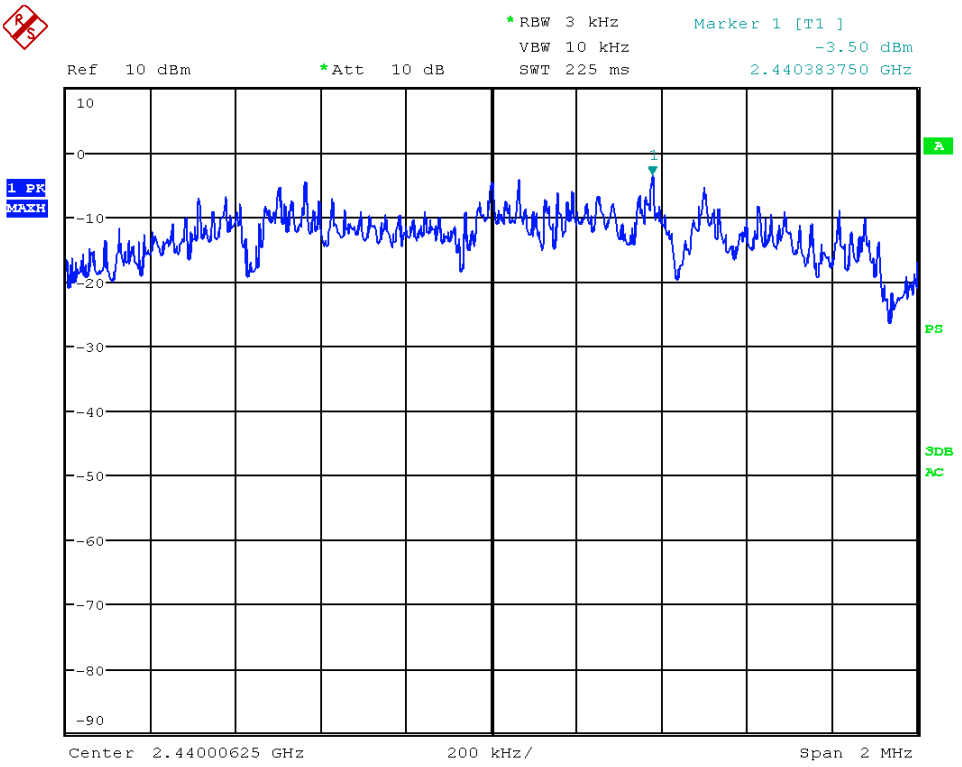
Picture 19: Power spectral density channel 11 - zoom1 to maximum



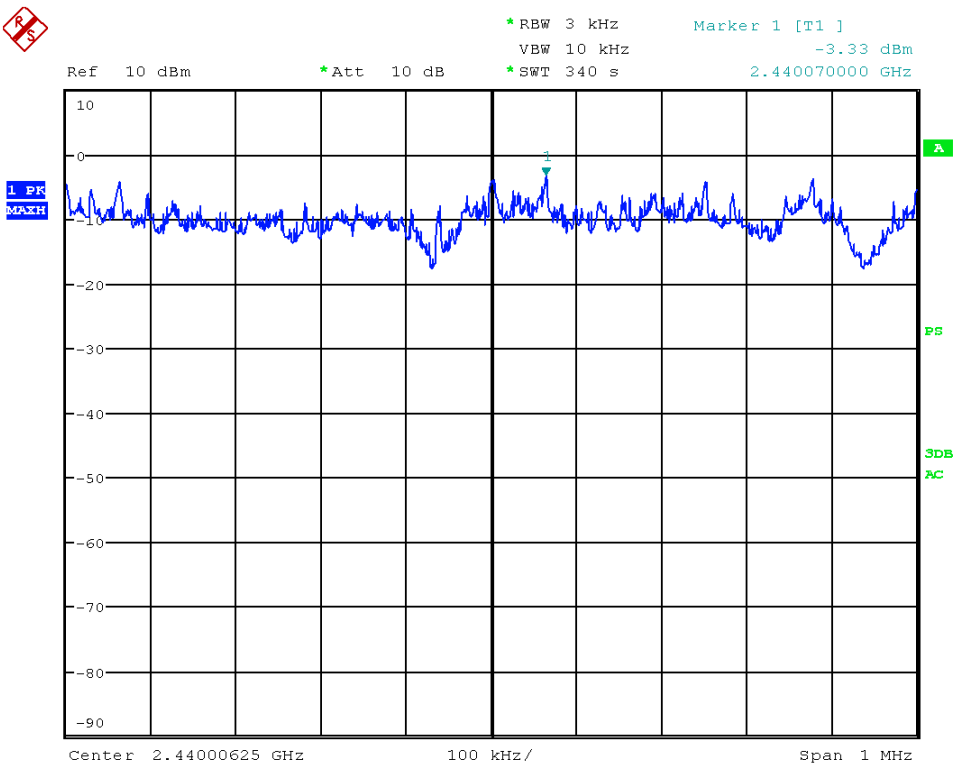
Picture 20: Power spectral density channel 11 - zoom2 to maximum



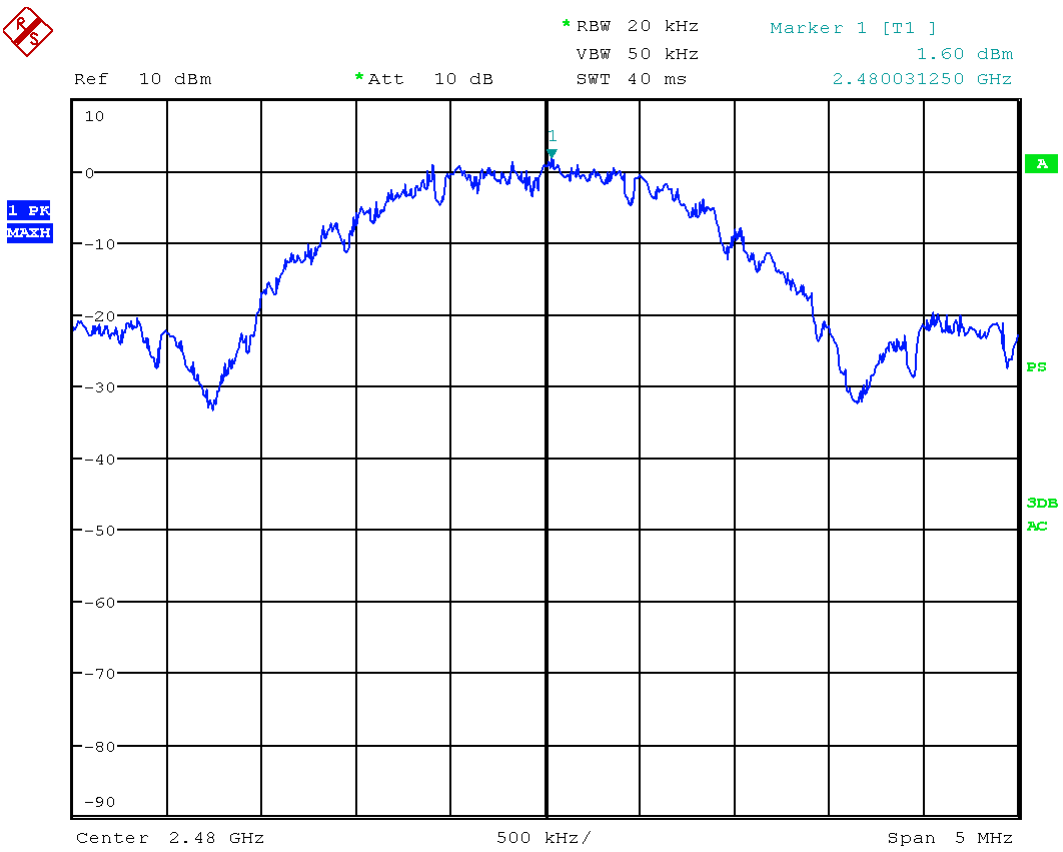
Picture 21: Power spectral density channel 18 - complete carrier



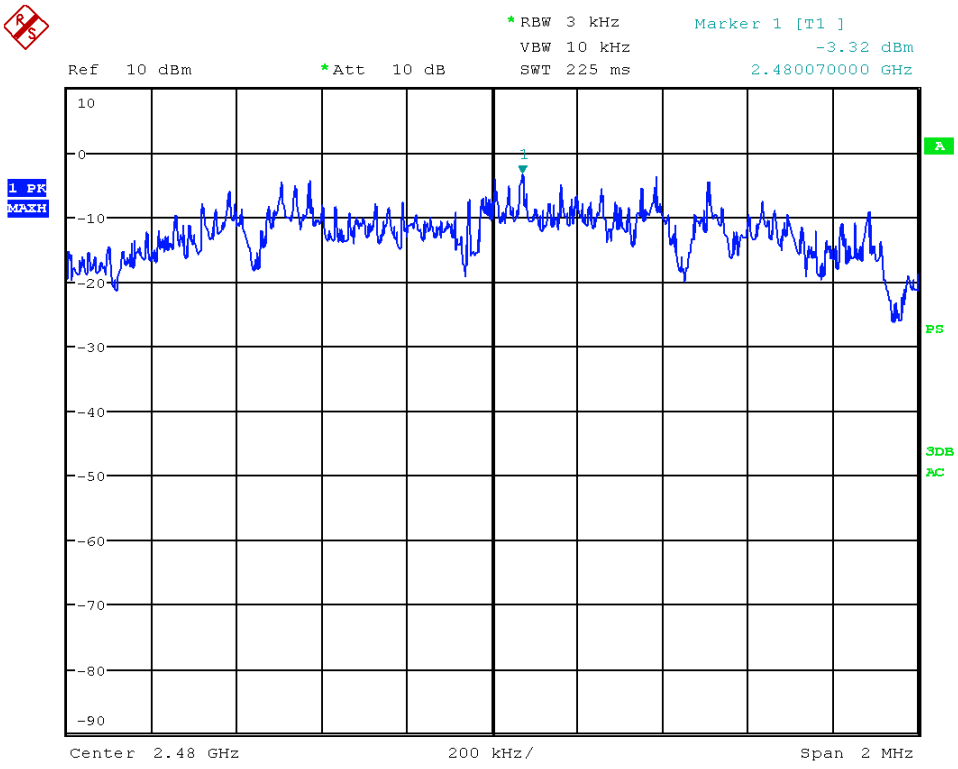
Picture 22: Power spectral density channel 18 - zoom1 to maximum



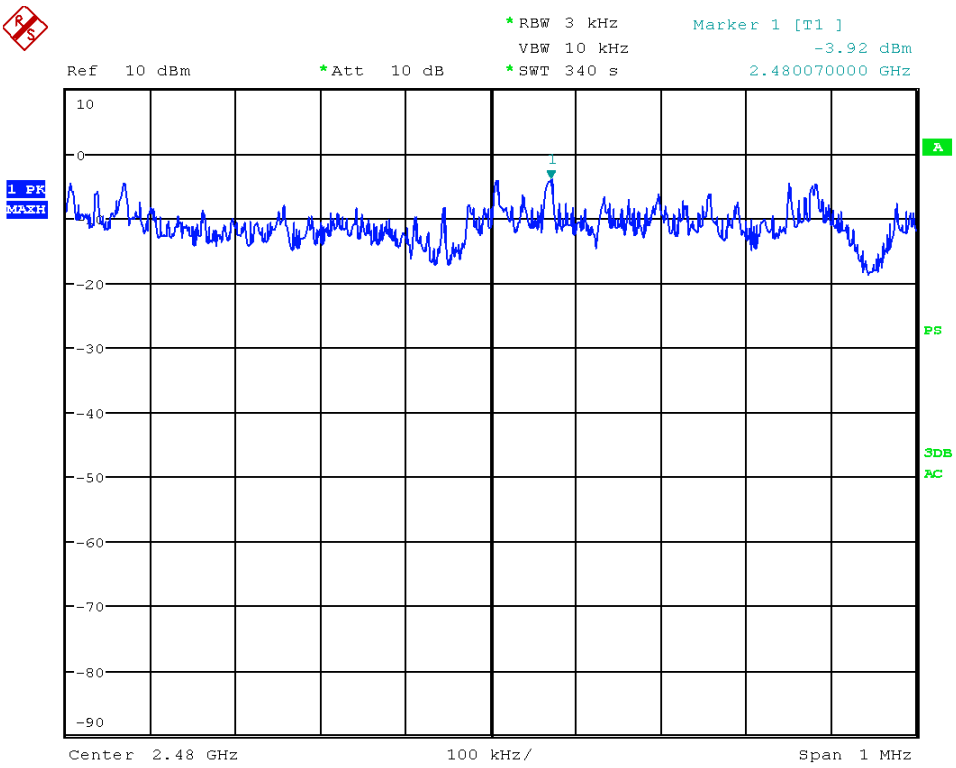
Picture 23: Power spectral density channel 18 - zoom2 to maximum



Picture 24: Power spectral density channel 26 - complete carrier



Picture 25: Power spectral density channel 26 - zoom1 to maximum



Picture 26: Power spectral density channel 26 - zoom2 to maximum

9 Band-edge compliance

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

9.1 Test location

☑ Scan with peak detector in 3 m CDC.

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

9.2 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

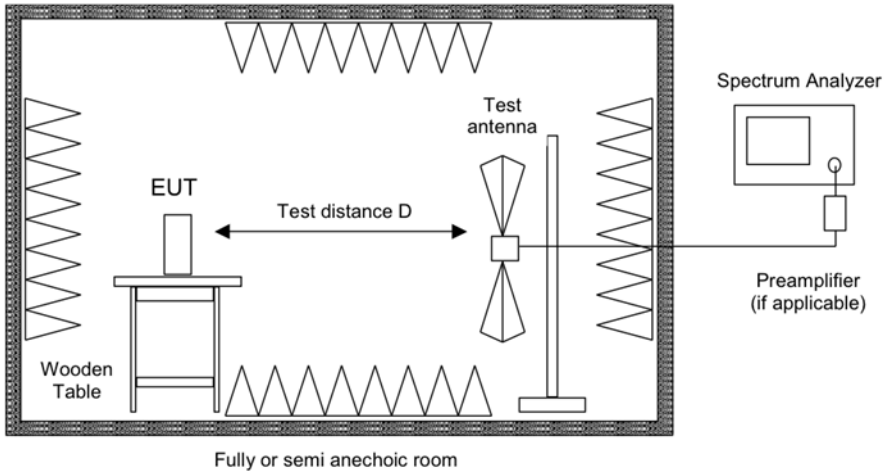
9.3 Limits

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

9.4 Test procedure

1. Configure the EUT according to ANSI C63.4. The EUT was placed on the top of the turntable 0.8 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

9.5 Test setup



Picture 27: Test setup for band-edge compliance measurement

9.6 Test deviation

There is no deviation with the original standard.

9.7 EUT operation during test

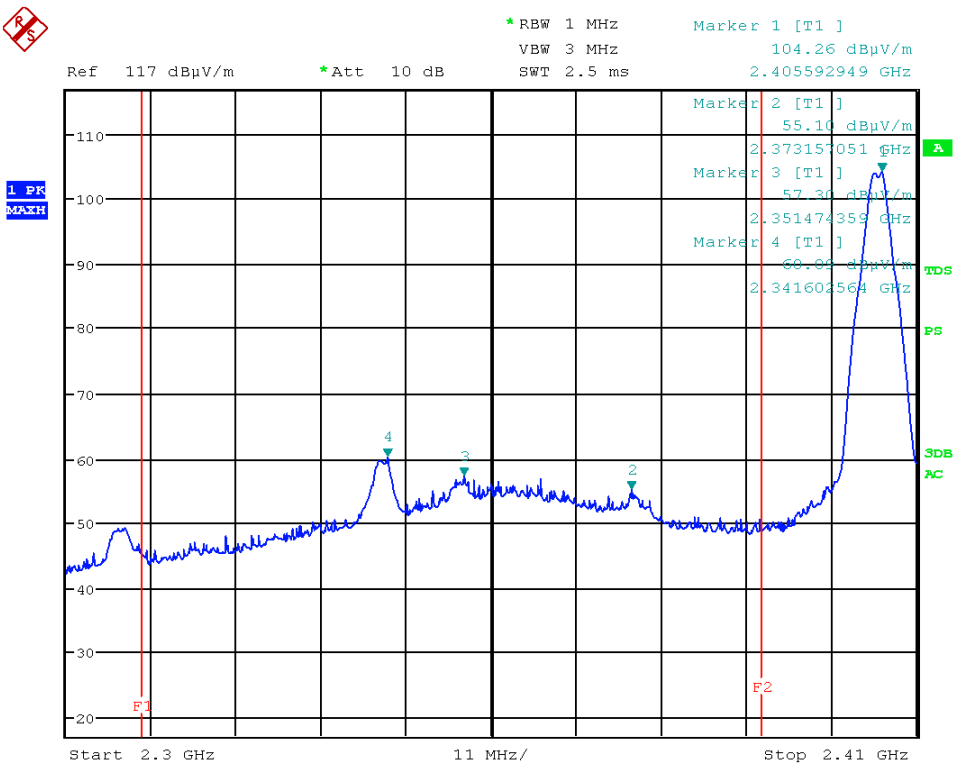
The EUT was programmed to be in continuously transmitting mode.

9.8 Test results

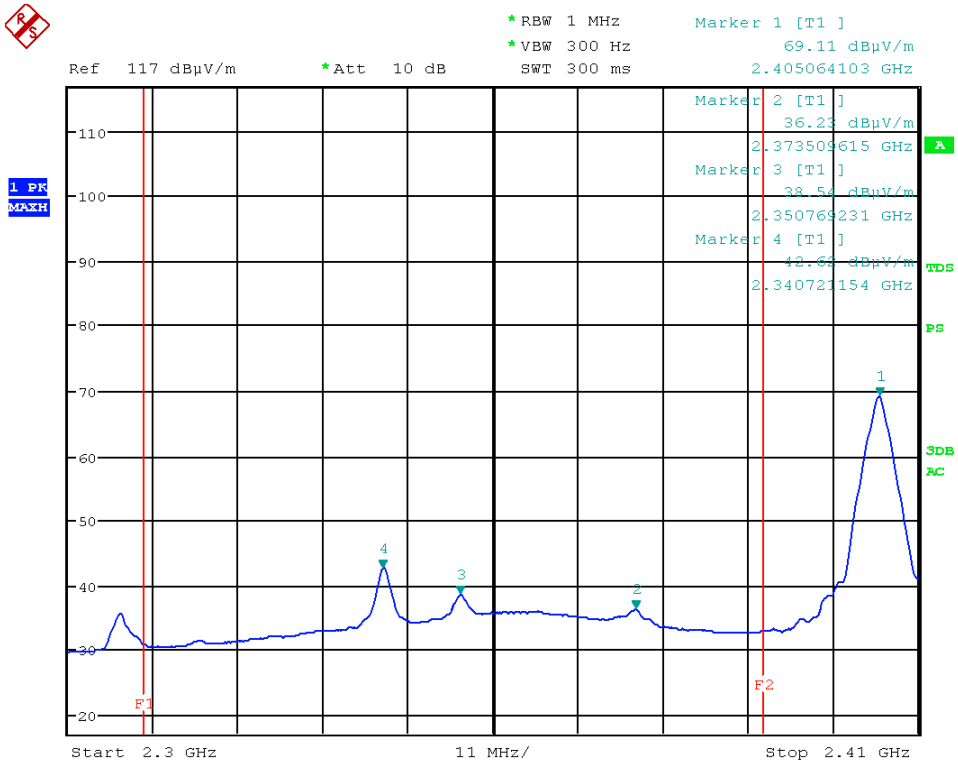
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-26

Frequency (GHz)	Detector	Reading value (dBµV/m)	Restricted Band	Limit (dBµV/m)	Result
2.3416	PK	60.09	Yes	74	Passed
2.3407	AV	42.62		54	Passed
2.3515	PK	57.30	Yes	74	Passed
2.3508	AV	38.54		54	Passed
2.3732	PK	55.10	Yes	74	Passed
2.3735	AV	36.23		54	Passed
2.4050	PK	104.26	No	- - -	Carrier
2.4050	AV	69.11		- - -	Carrier

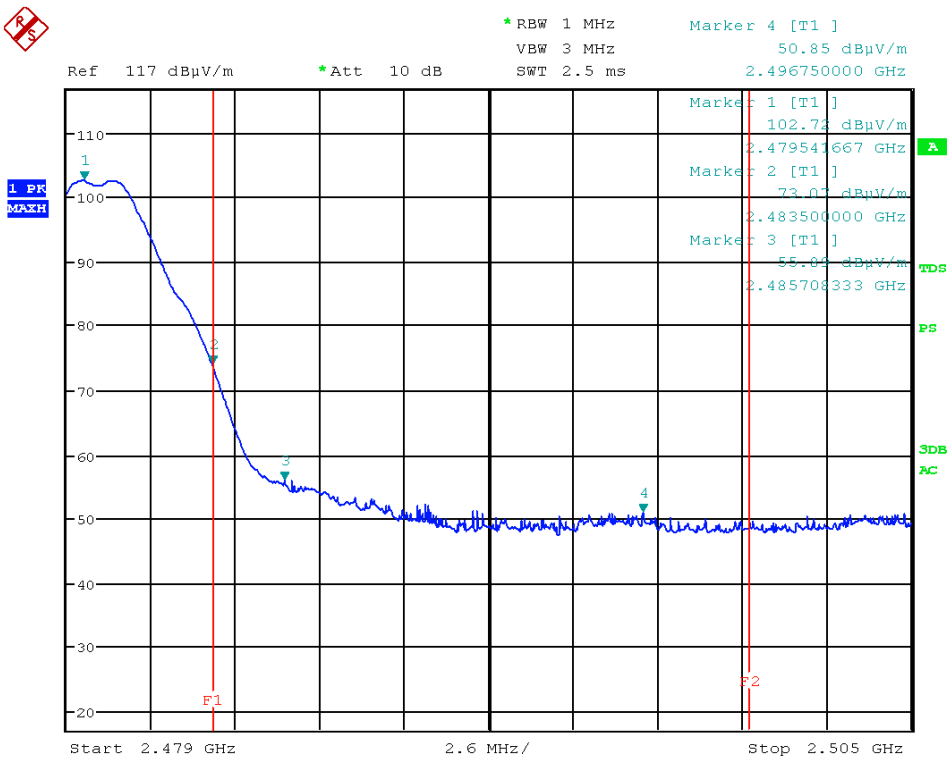
Frequency (GHz)	Detector	Reading value (dBµV/m)	Restricted Band	Limit (dBµV/m)	Result
2.4800	PK	102.72	No	- - -	Carrier
2.4800	AV	68.76		- - -	Carrier
2.4835	PK	73.07	Yes	74	Passed
2.4835	AV	47.50		54	Passed
2.4857	PK	55.09	Yes	74	Passed
2.4864	AV	38.04		54	Passed
2.4968	PK	50.85	Yes	74	Passed
2.4958	AV	33.76		54	Passed



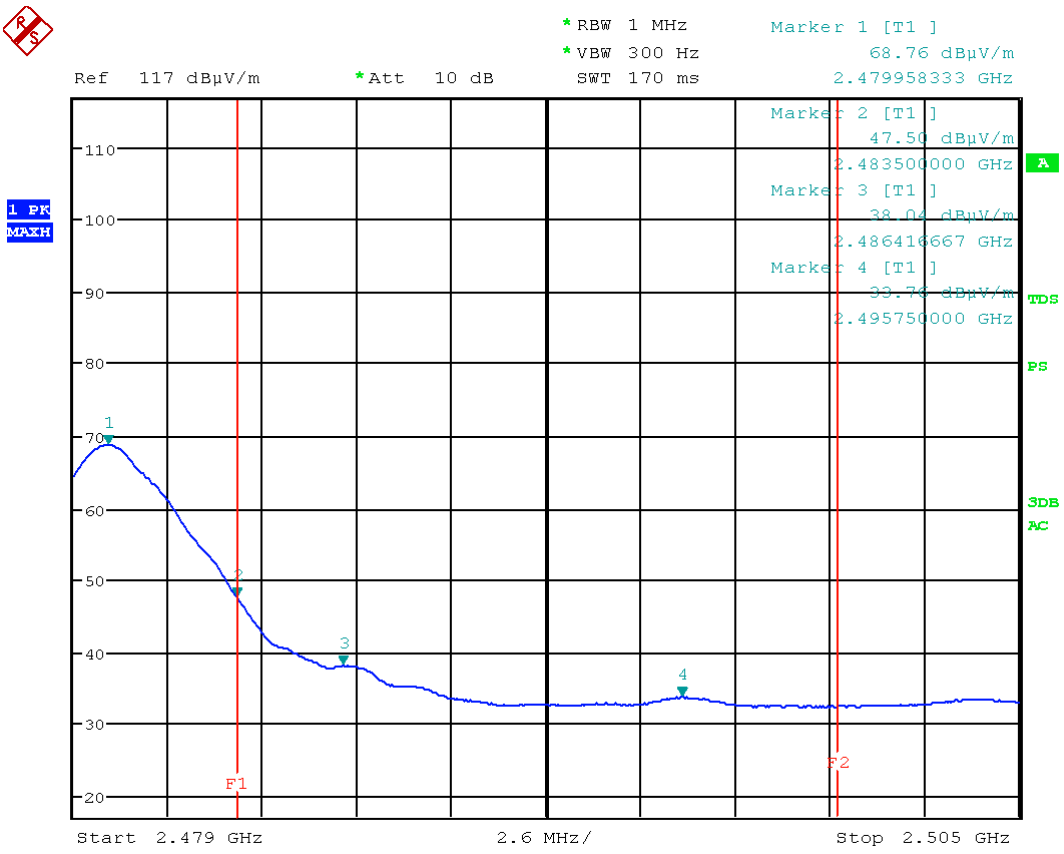
Picture 28: lower edge - PK



Picture 29: lower edge - AV



Picture 30: upper edge - PK



Picture 31: upper edge – AV

10 Spurious RF Conducted Emission

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

10.1 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

10.2 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

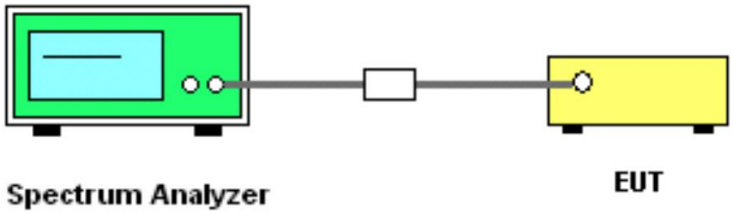
10.3 Limits

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

10.4 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.

10.5 Test setup



Picture 32: Test setup for conducted spurious emission measurement

10.6 Test deviation

There is no deviation with the original standard.

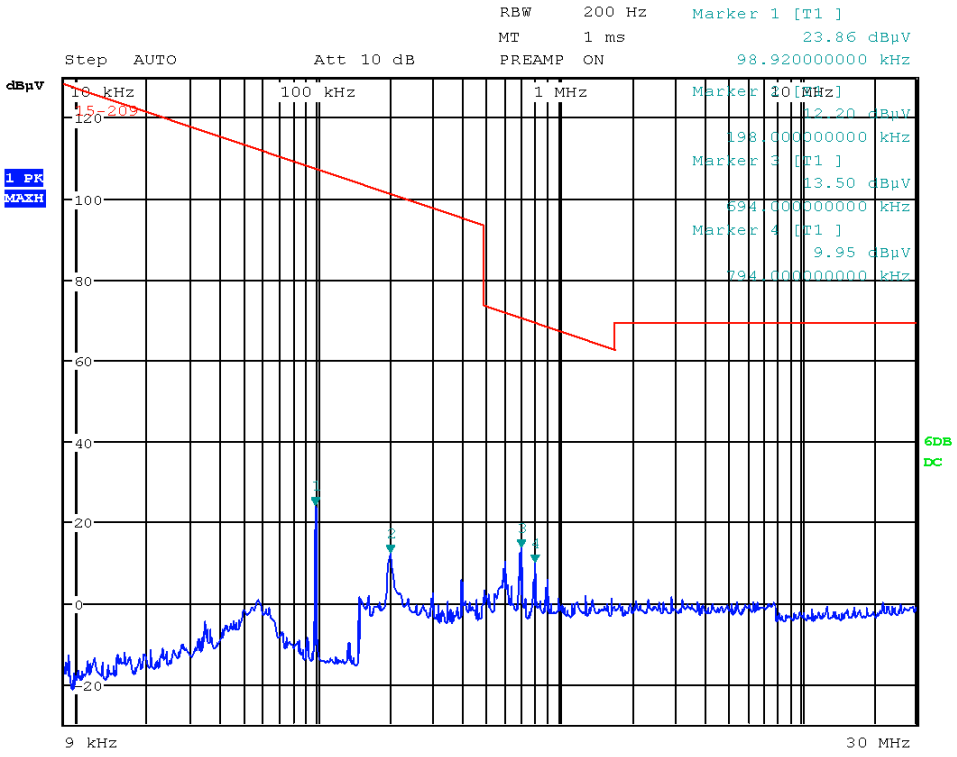
10.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

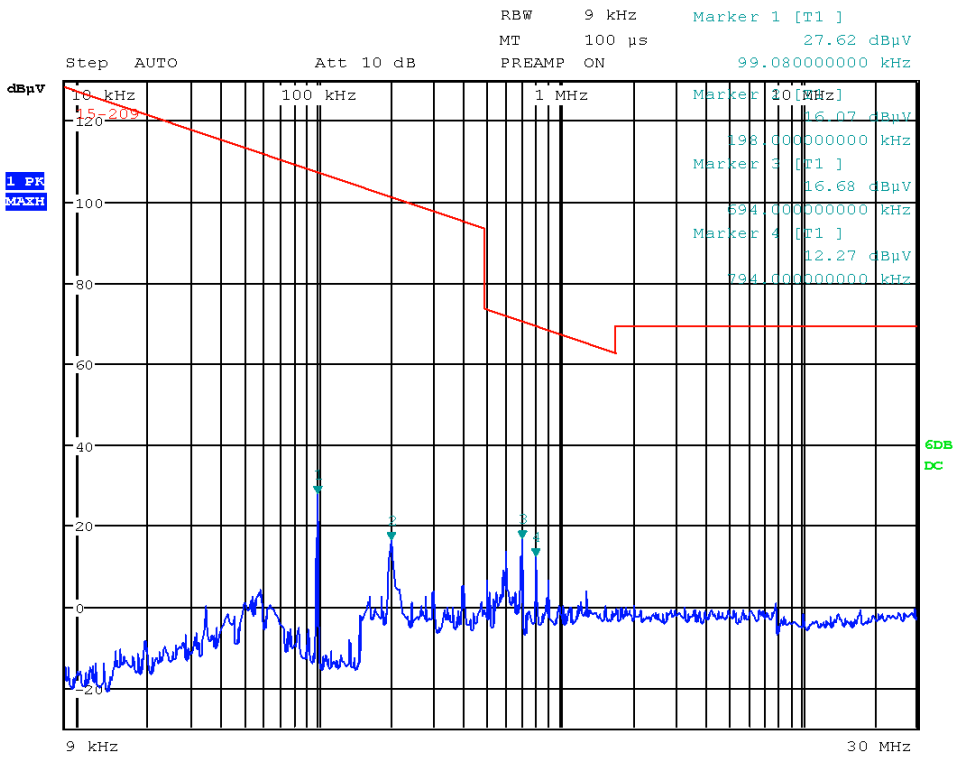
10.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-27

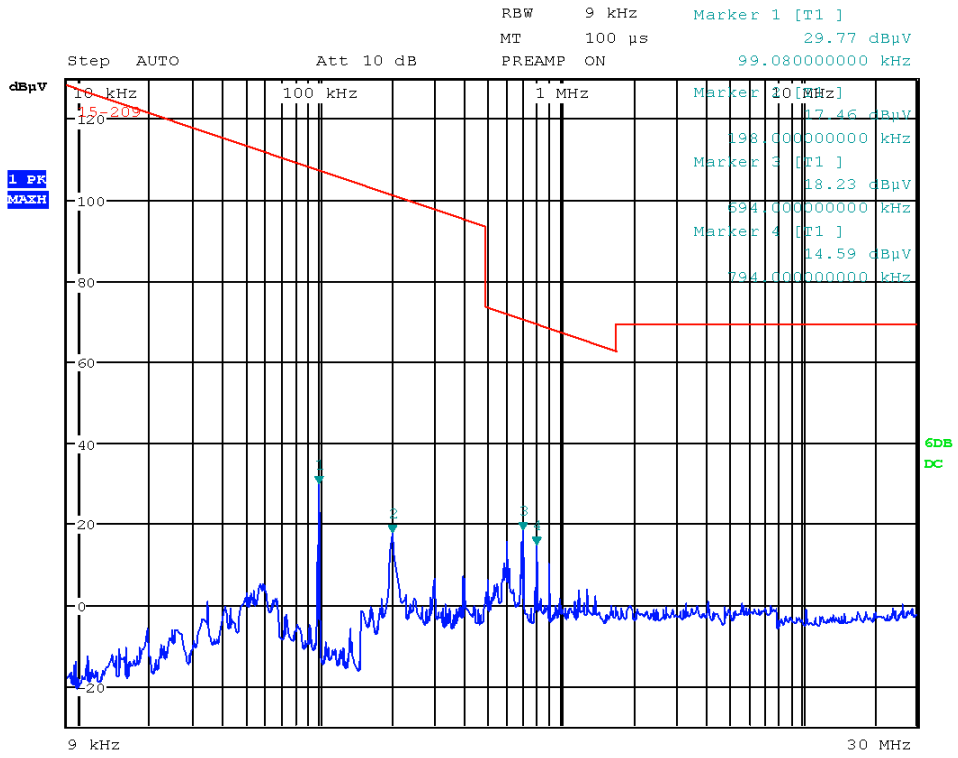
10.9 Test results 9 kHz – 30 MHz



Picture 33: spurious emission channel 11 (9kHz - 30MHz)

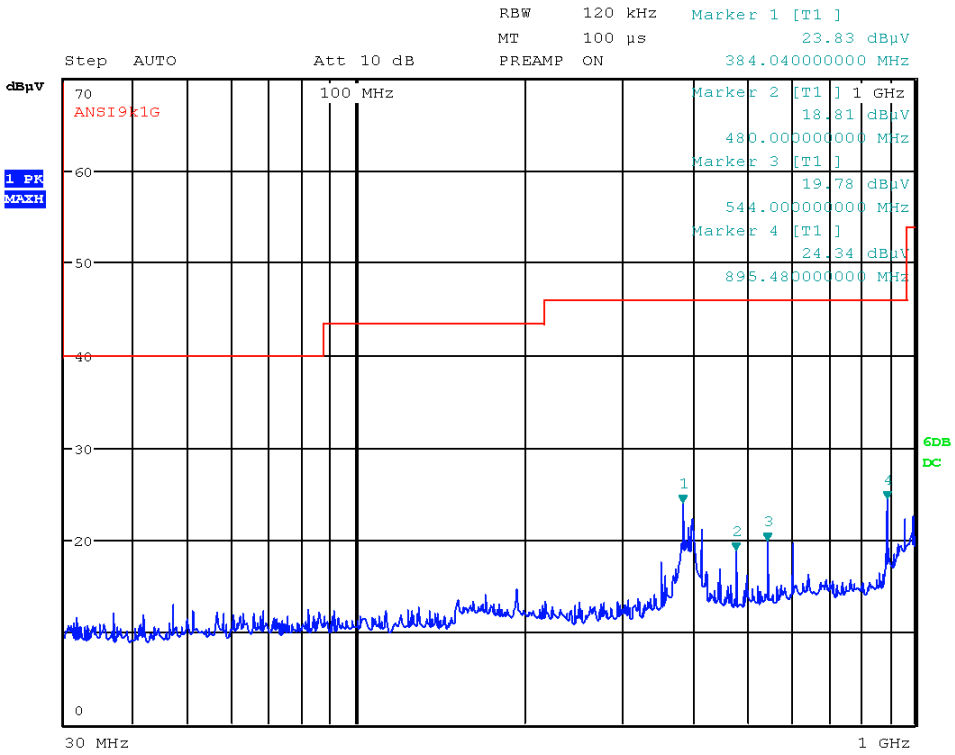


Picture 34: spurious emission channel 18 (9kHz - 30MHz)

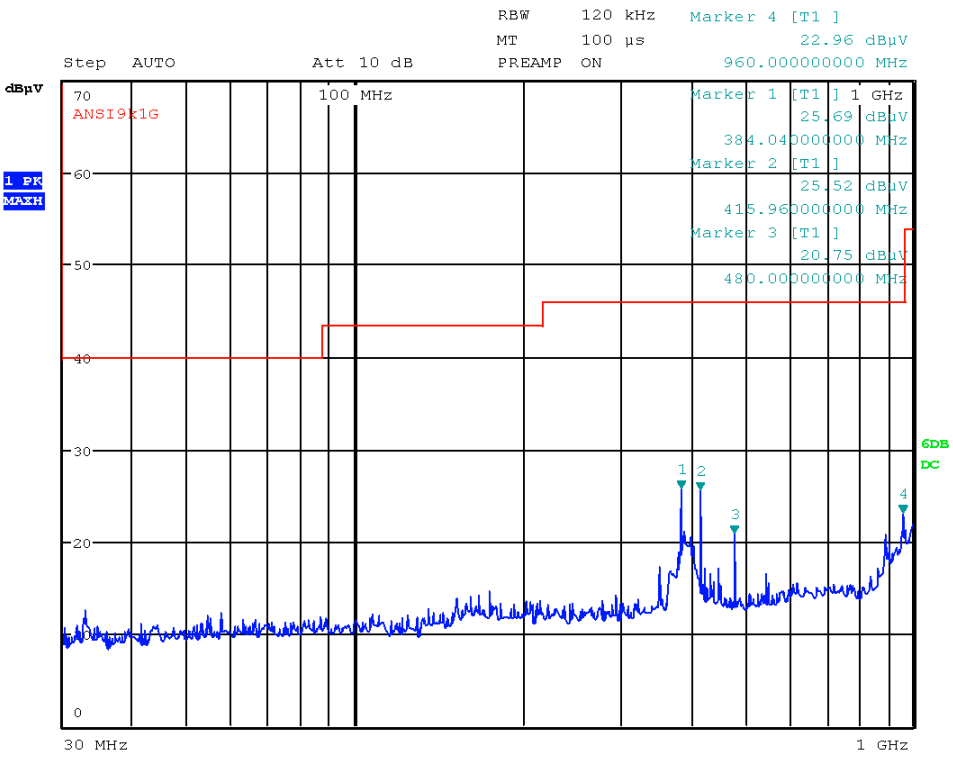


Picture 35: spurious emission channel 26 (9kHz - 30MHz)

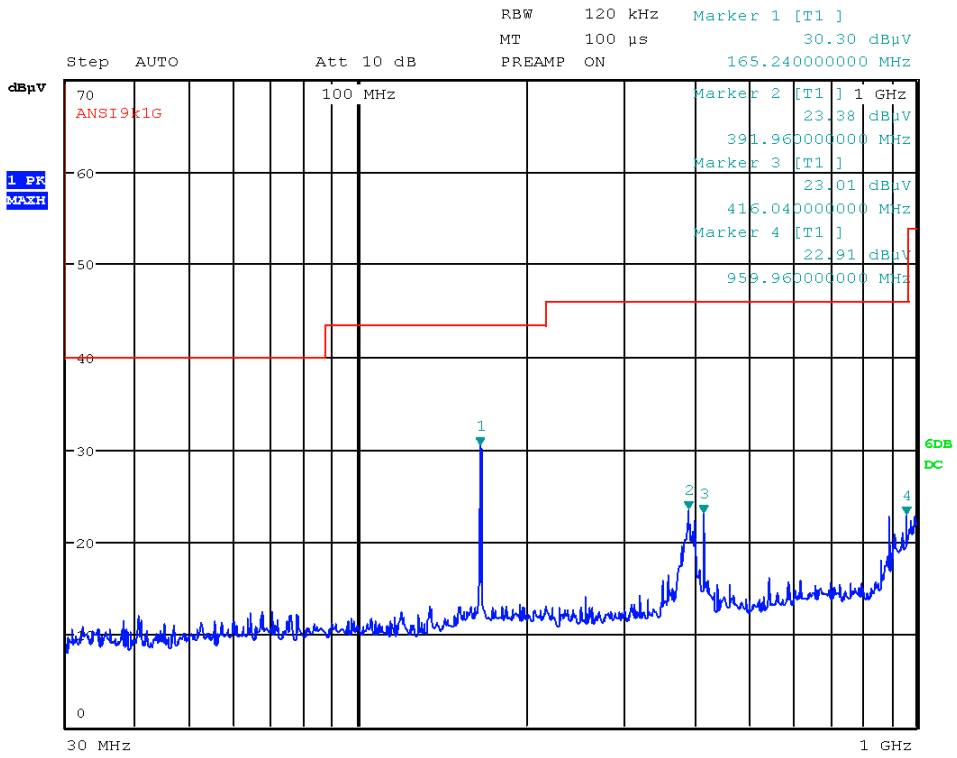
10.10 Test results 30 MHz – 1 GHz



Picture 36: spurious emission channel 11 (30MHz - 1GHz)

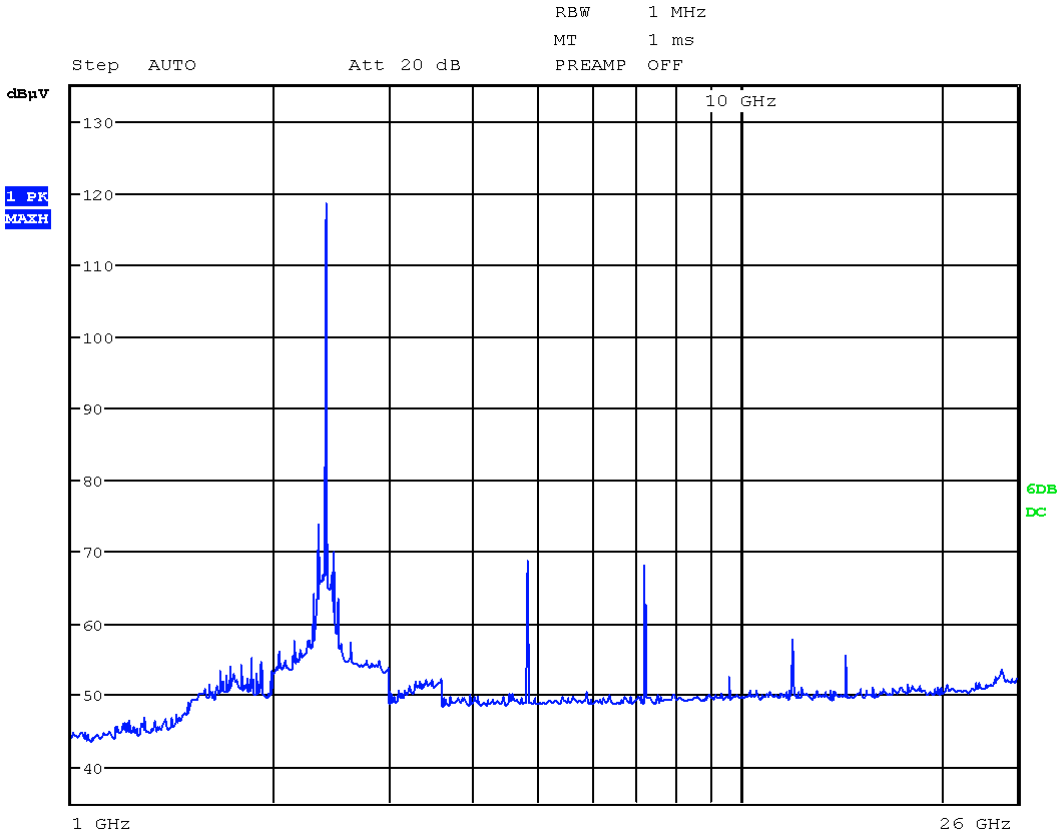


Picture 37: spurious emission channel 18 (30MHz - 1GHz)



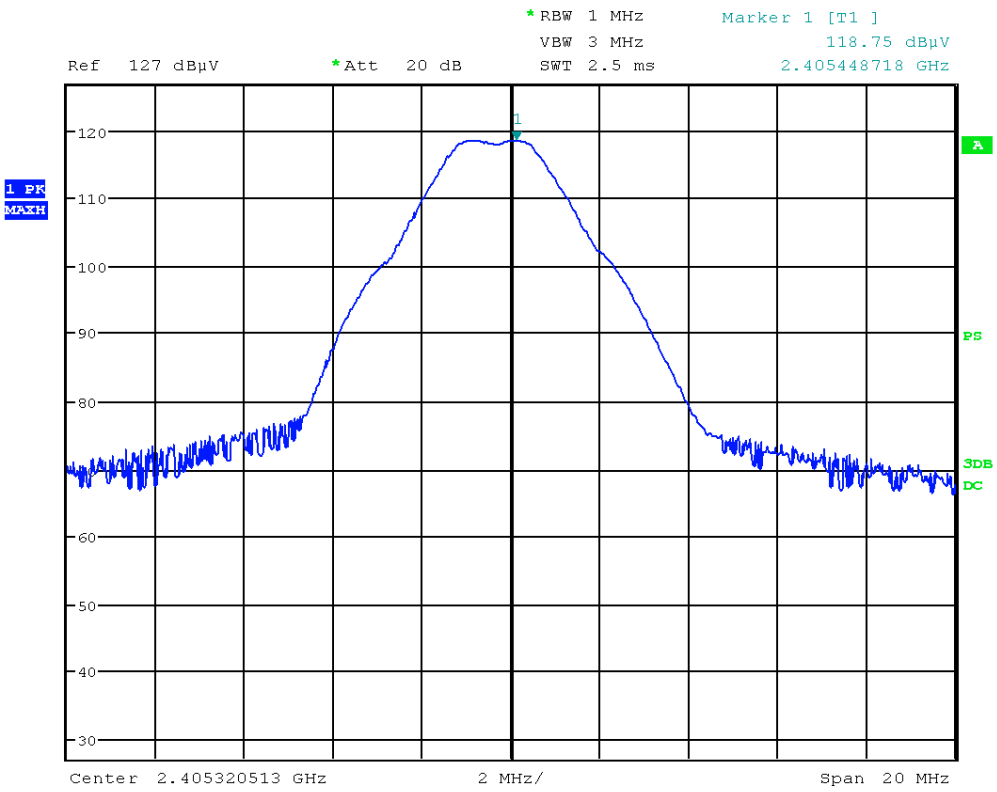
Picture 38: spurious emission channel 26 (30MHz - 1GHz)

10.11 Test results 1 GHz – 26 GHz

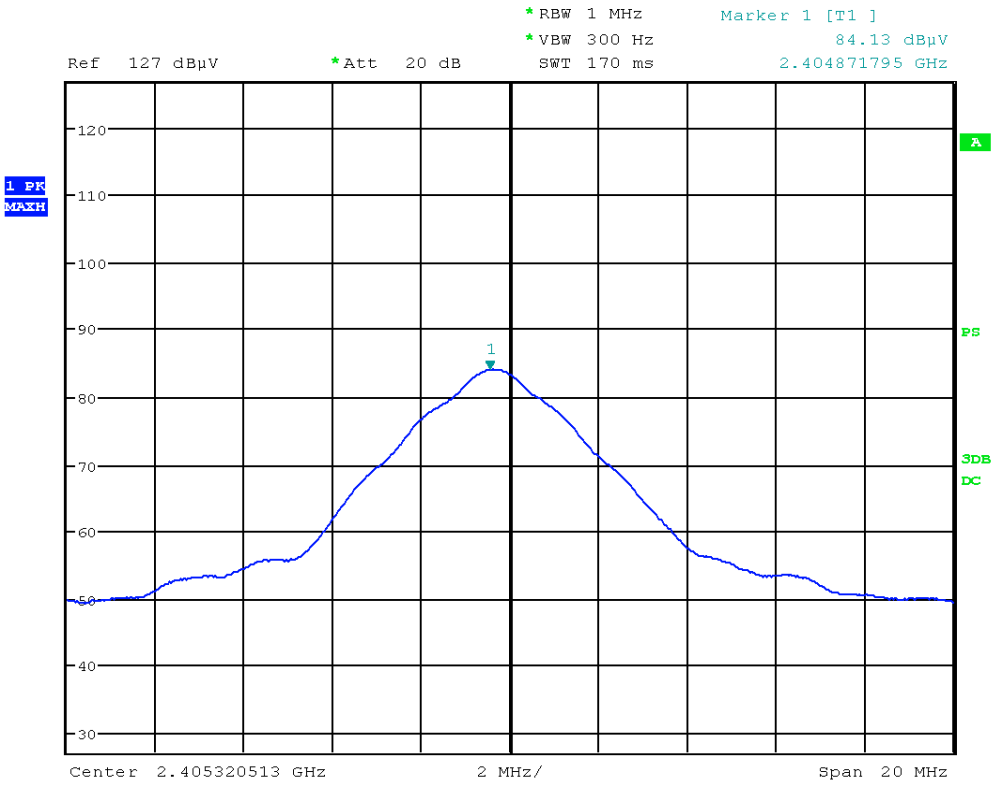


Frequency (GHz)	Reading (dBµV)	Detector	Limit (dBµV)	Restricted band	Result
Channel 11					
2.4050	118.75	PK	Carrier	No	Carrier
2.4050	84.13	AV	Carrier	No	Carrier
4.8100	70.23	PK	74	Yes	Passed
4.8100	52.99	AV	54	Yes	Passed
7.2150	69.49	PK	- 20dBc	No	Passed
7.2150	52.54	AV	- 20dBc	No	Passed
12.0250	58.05	PK	74	Yes	Passed
12.0250	40.77	AV	54	Yes	Passed
14.4300	56.10	PK	- 20dBc	No	Passed
14.4300	38.80	AV	- 20dBc	No	Passed

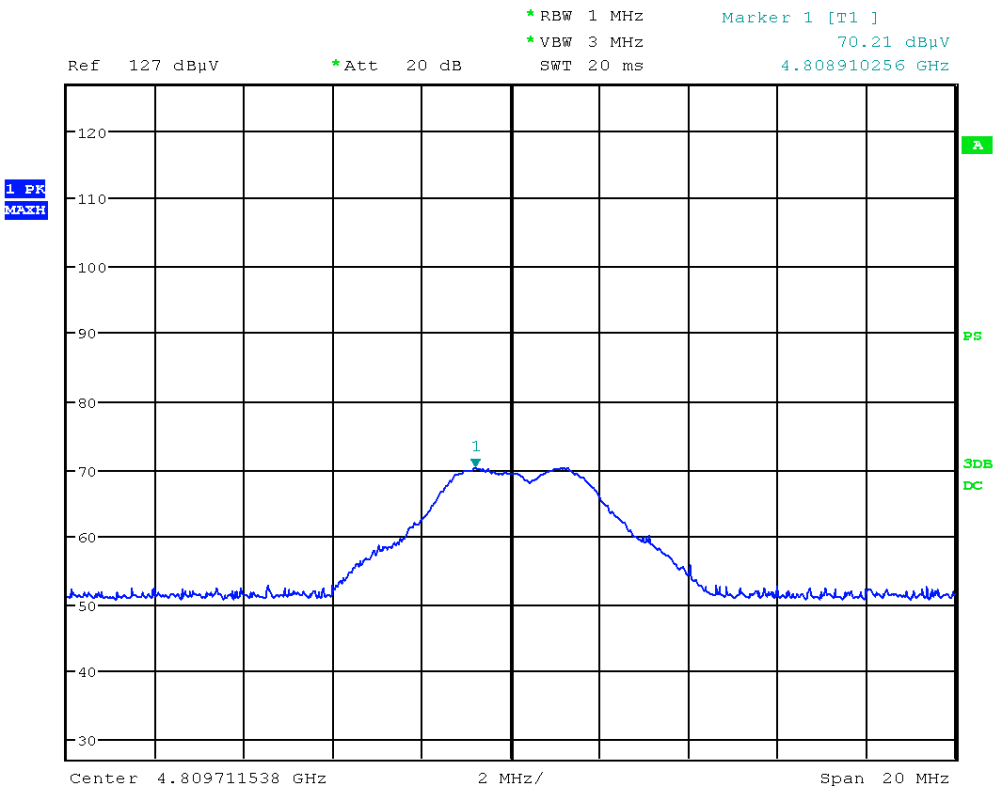
Picture 39: spurious emission channel 11 (1GHz - 26 GHz)



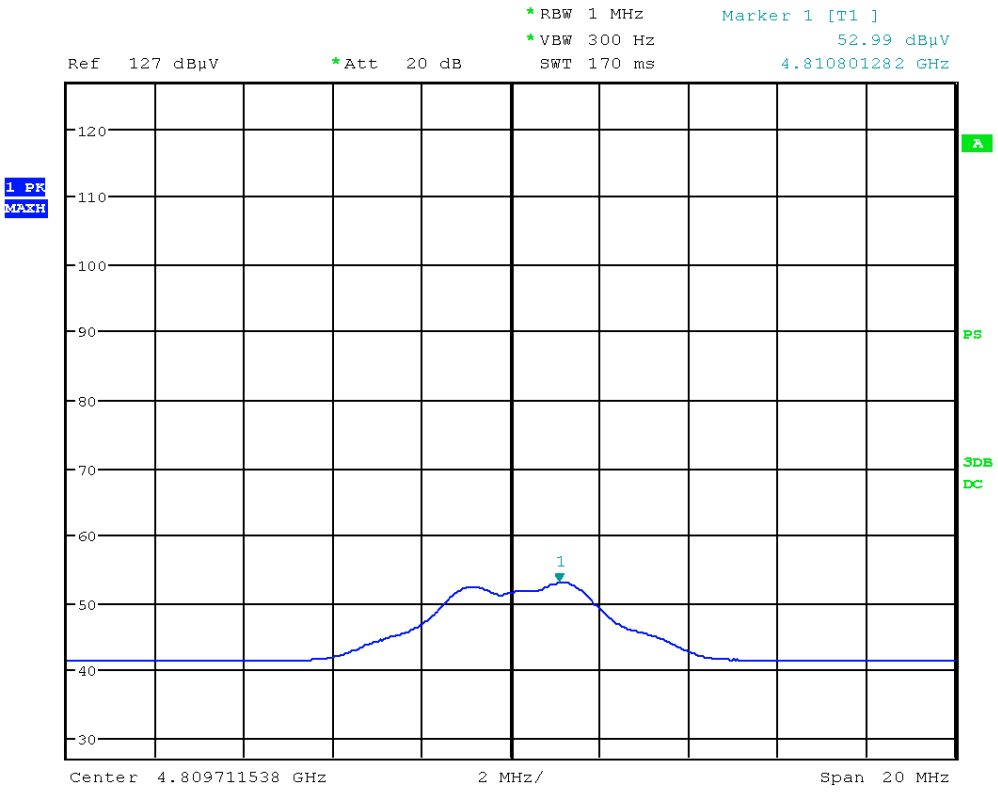
Picture 40: spurious emission channel 11 - PK



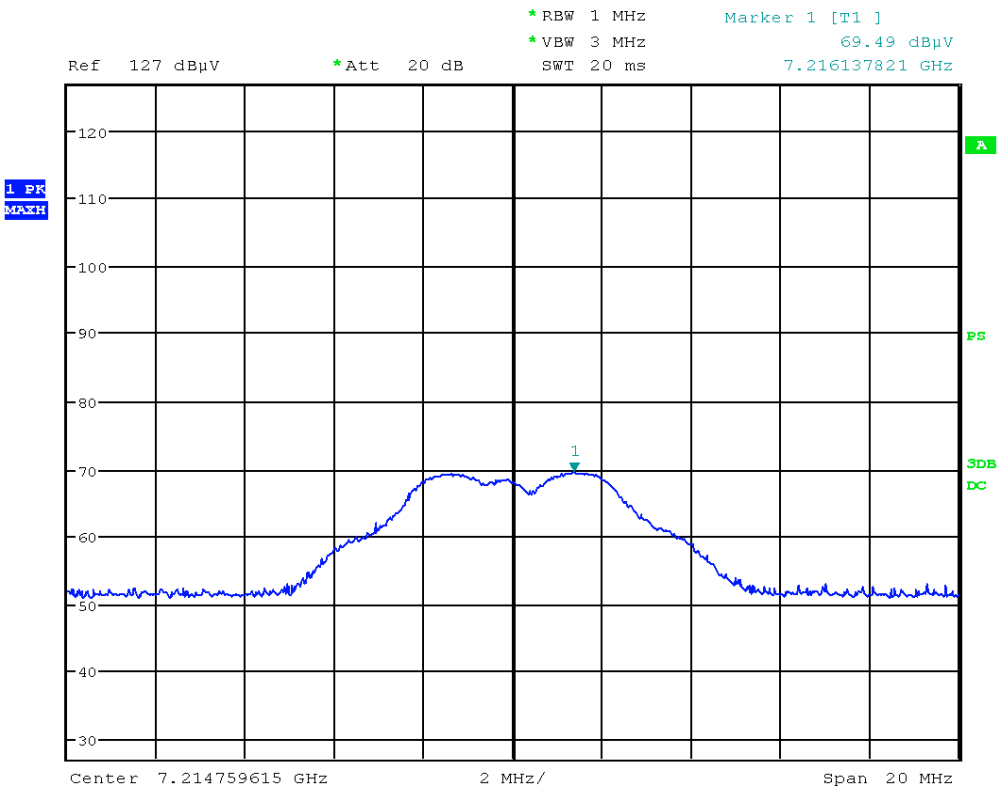
Picture 41: spurious emission channel 11 - AV



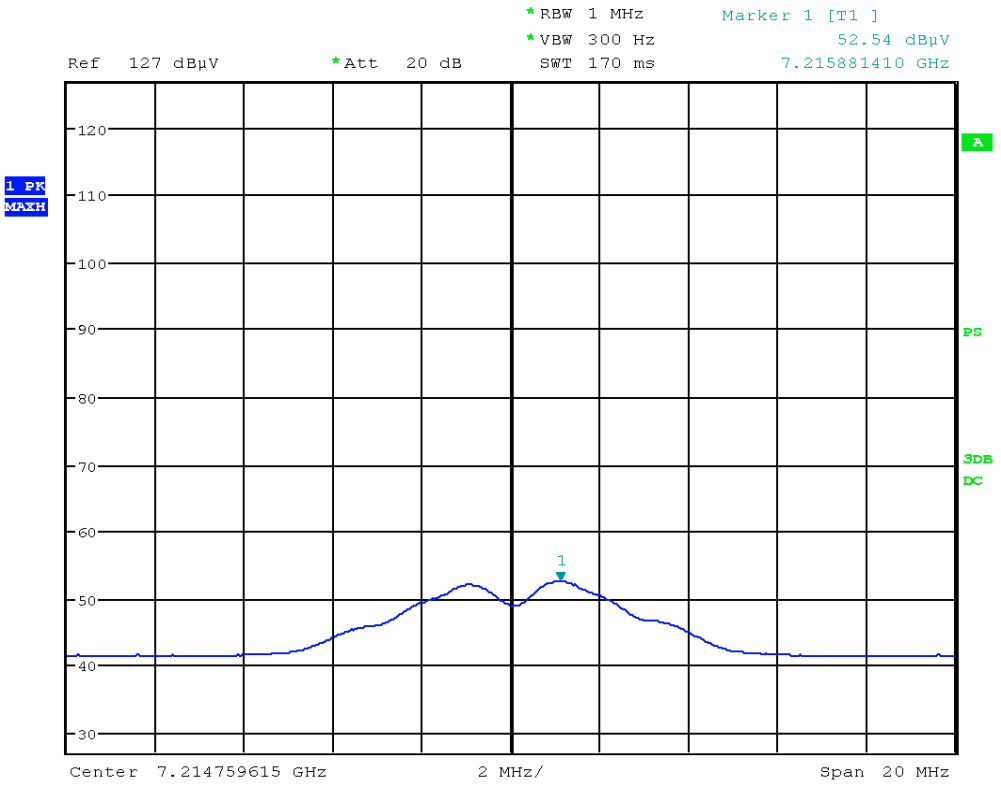
Picture 42: spurious emission channel 11 - PK



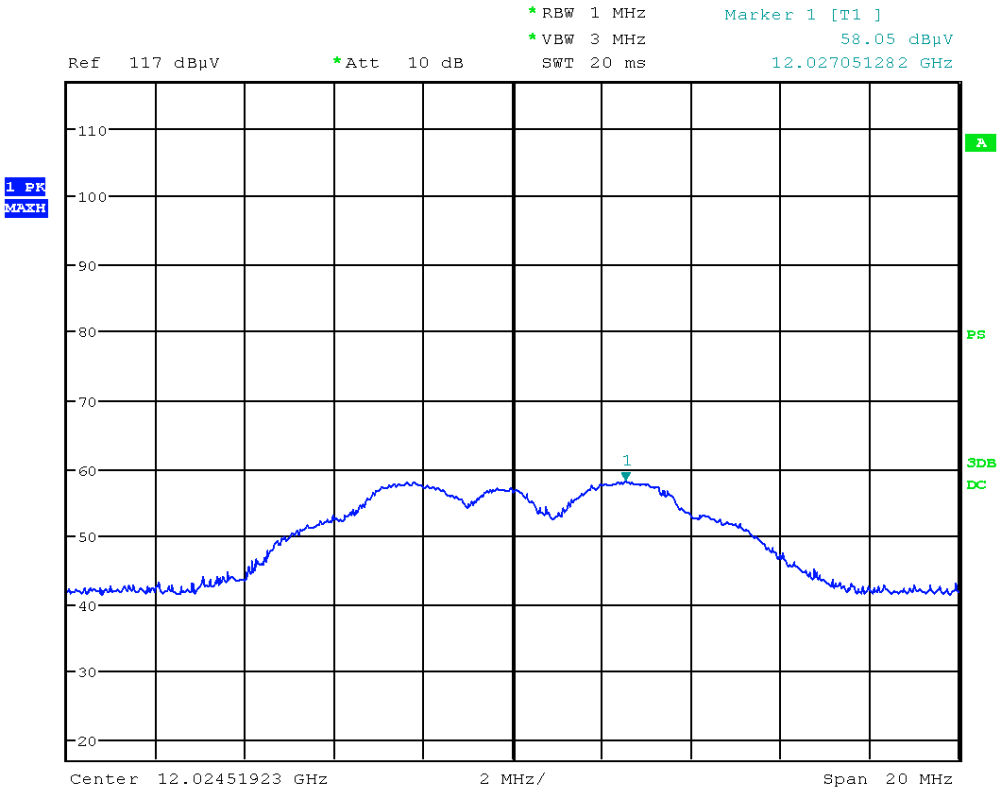
Picture 43: spurious emission channel 11 - AV



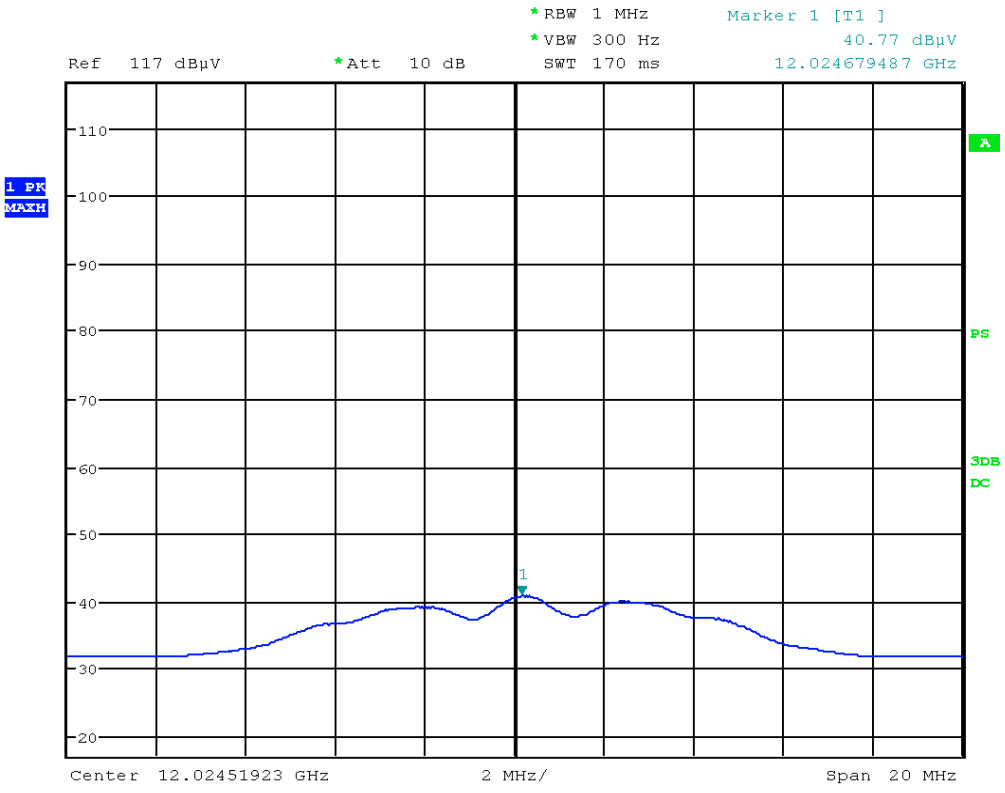
Picture 44: spurious emission channel 11 - PK



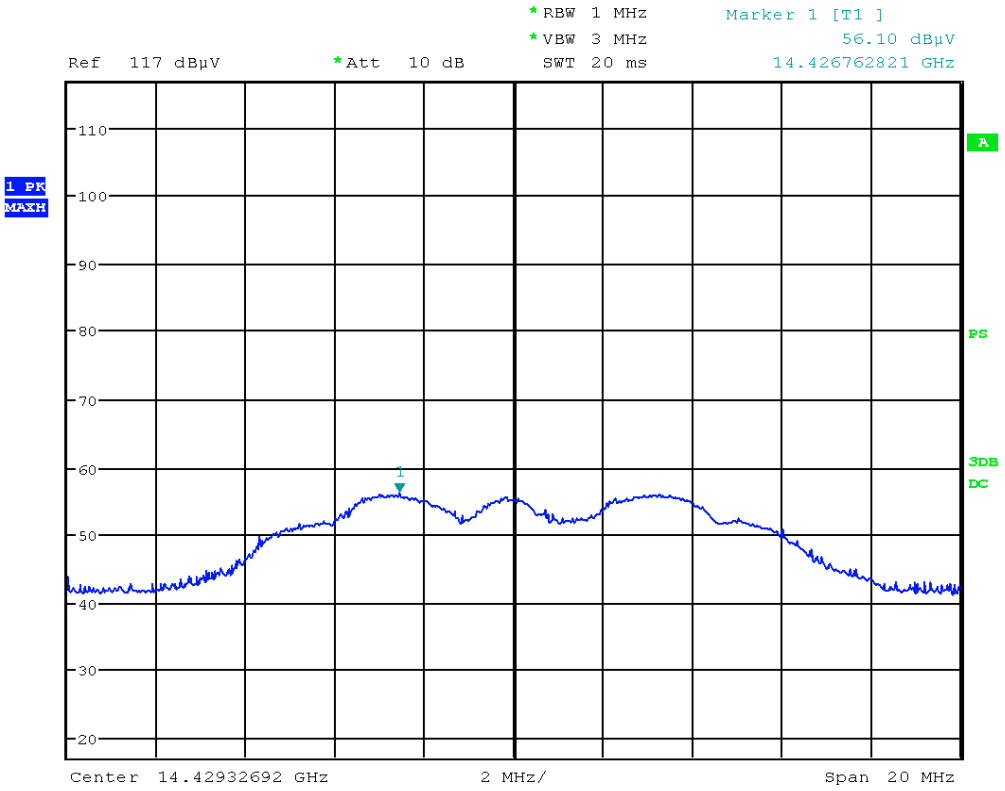
Picture 45: spurious emission channel 11 - AV



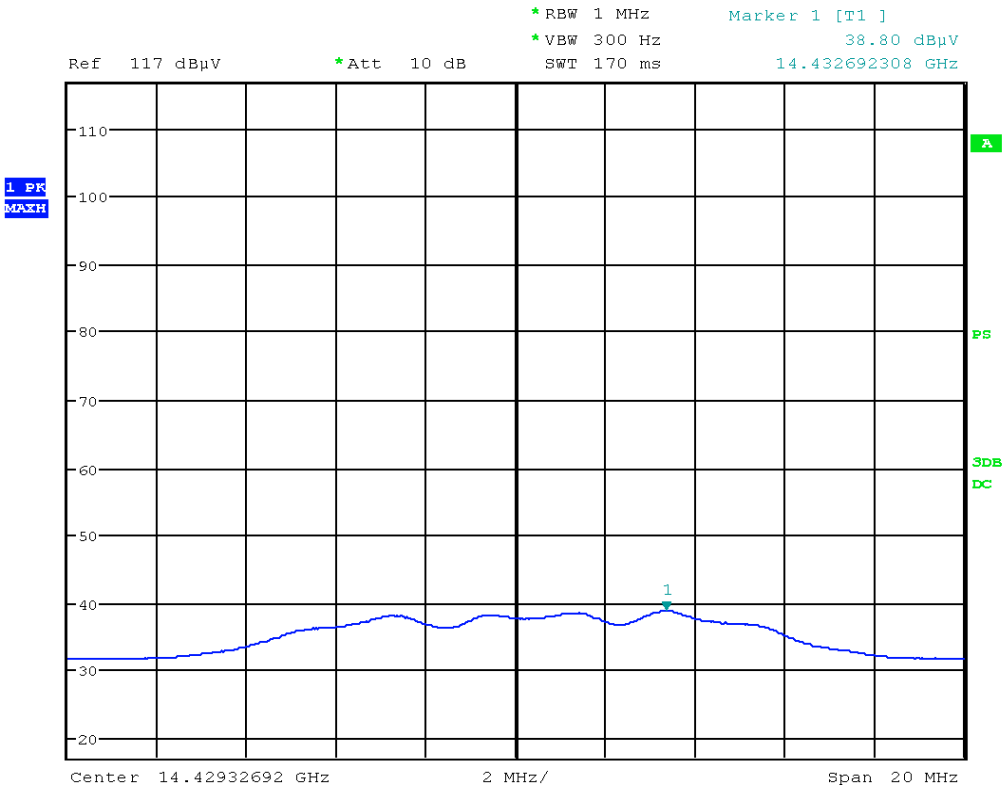
Picture 46: spurious emission channel 11 - PK



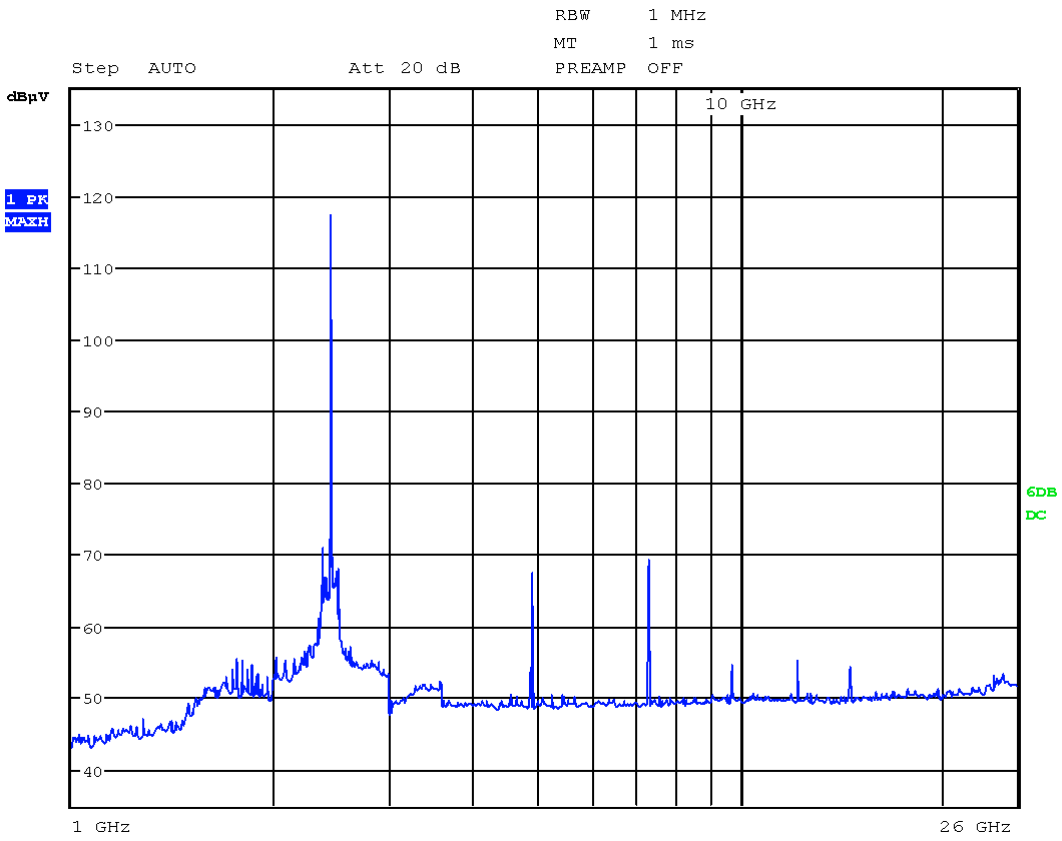
Picture 47: spurious emission channel 11 - AV



Picture 48: spurious emission channel 11 - PK

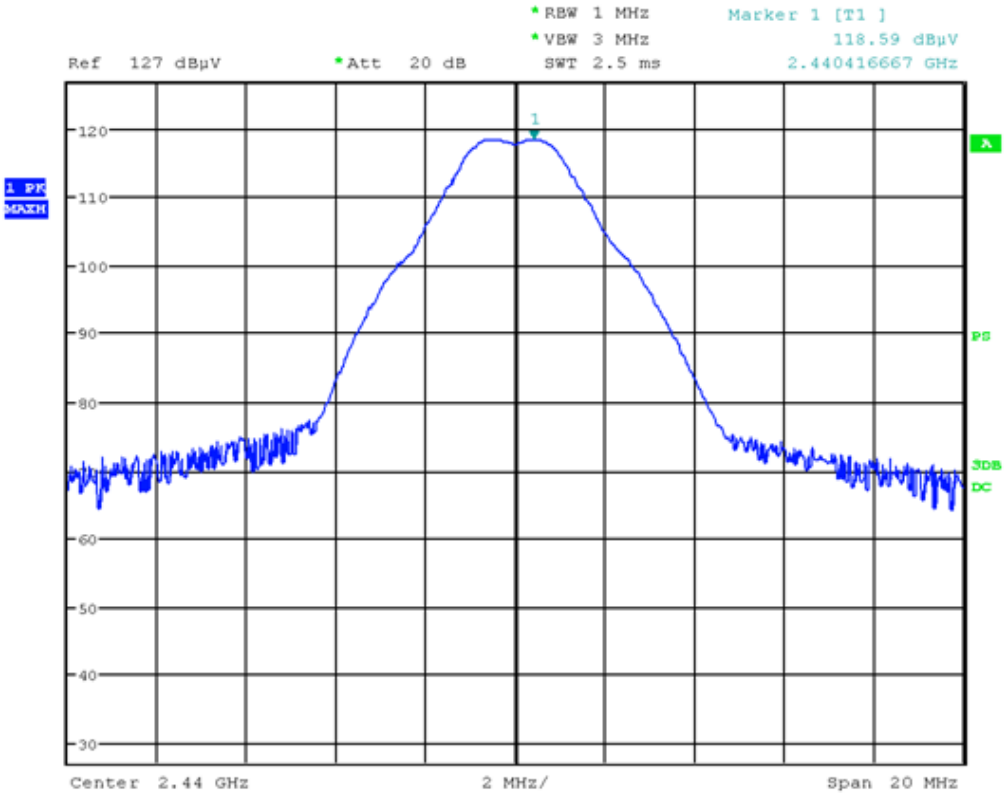


Picture 49: spurious emission channel 11 - AV

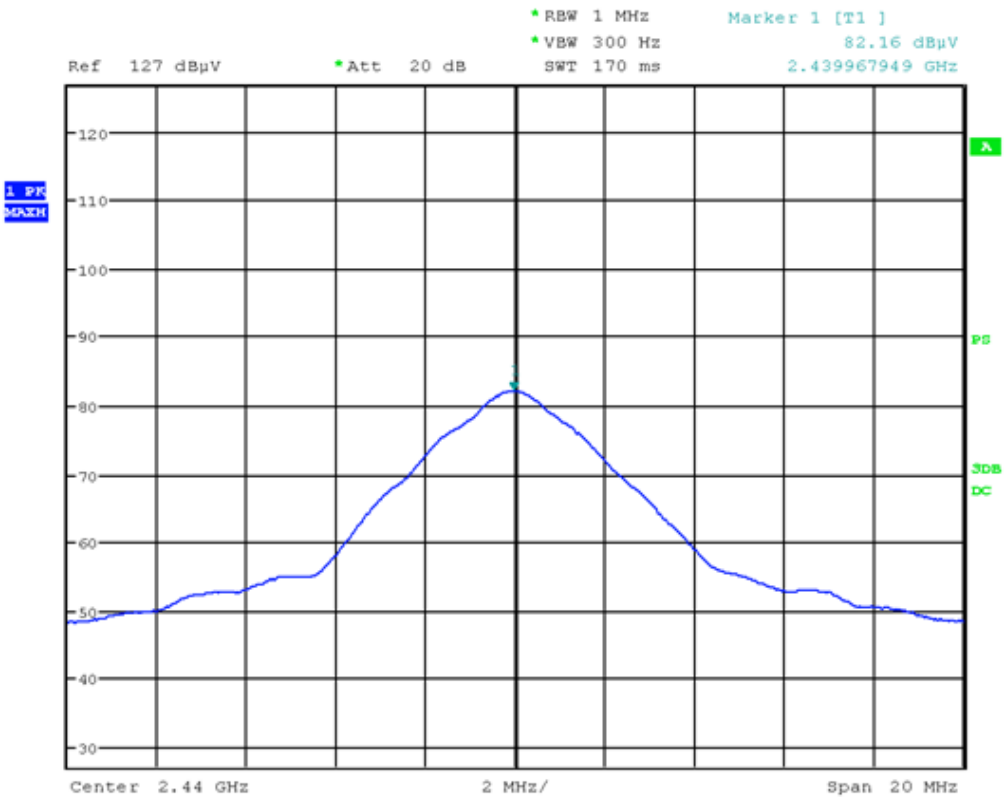


Frequency (GHz)	Reading (dBµV)	Detector	Limit (dBµV)	Restricted band	Result
Channel 18					
2.4404	118.59	PK	Carrier	No	Carrier
2.4400	82.16	AV	Carrier	No	Carrier
4.8790	68.22	PK	74	Yes	Passed
4.8808	48.39	AV	54	Yes	Passed
7.3212	70.19	PK	74	Yes	Passed
7.3208	48.85	AV	54	Yes	Passed
9.7618	52.43	PK	- 20dBc	No	Passed
9.7617	33.41	AV	- 20dBc	No	Passed
12.2021	55.41	PK	74	Yes	Passed
12.1998	35.12	AV	54	Yes	Passed
14.6369	53.86	PK	- 20dBc	No	Passed
14.6406	33.11	AV	- 20dBc	No	Passed

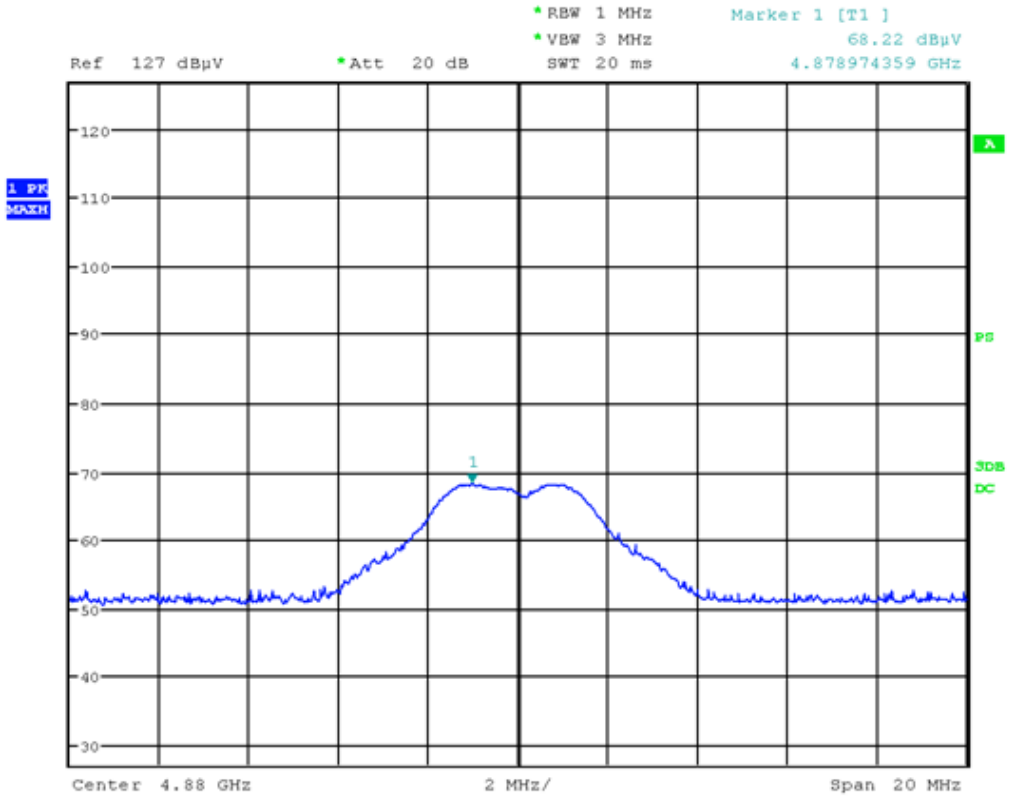
Picture 50: spurious emission channel 18 (1GHz - 26 GHz)



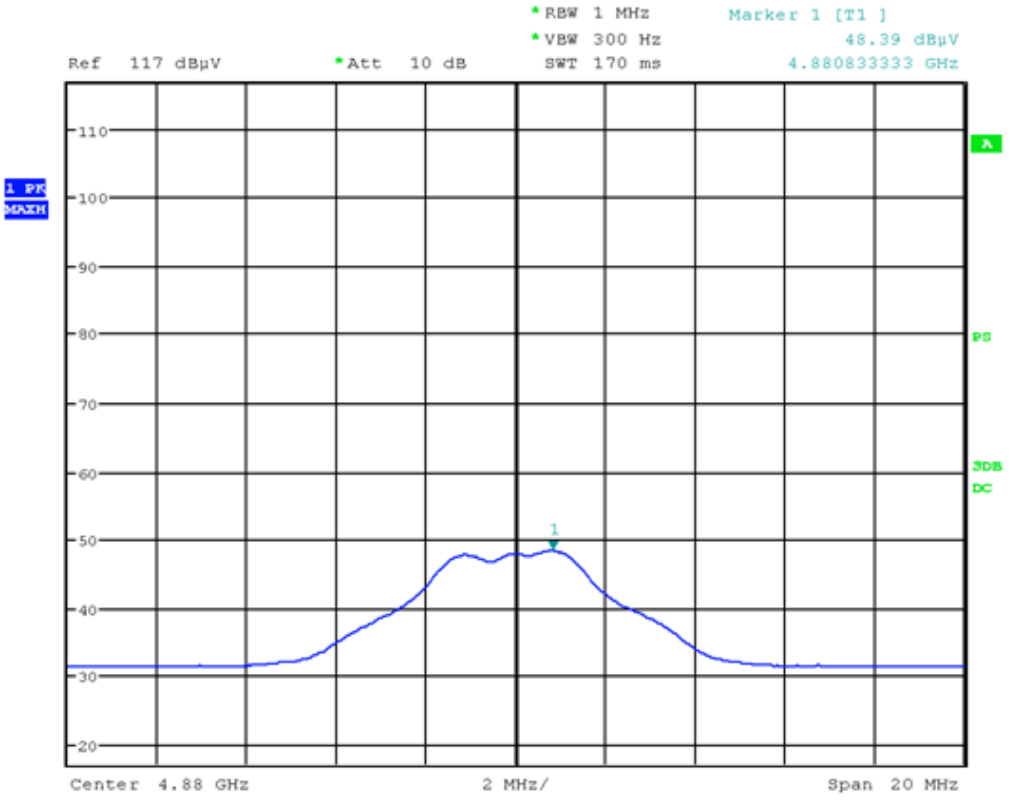
Picture 51: spurious emission channel 18 - PK



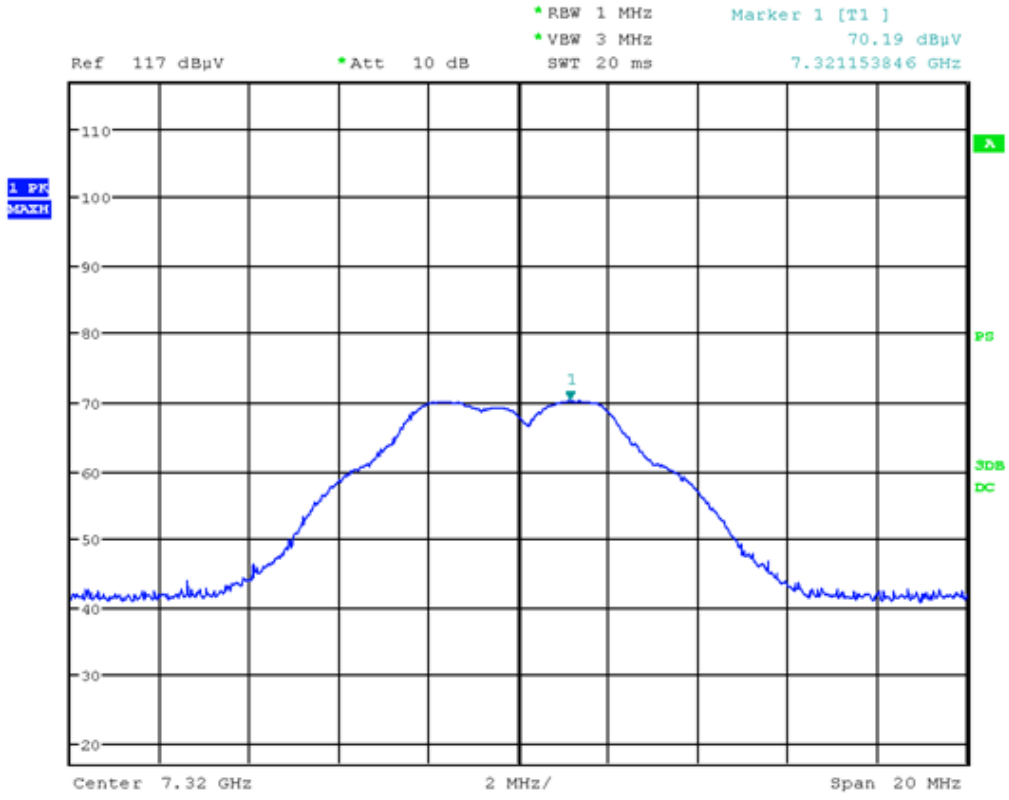
Picture 52: spurious emission channel 18 - AV



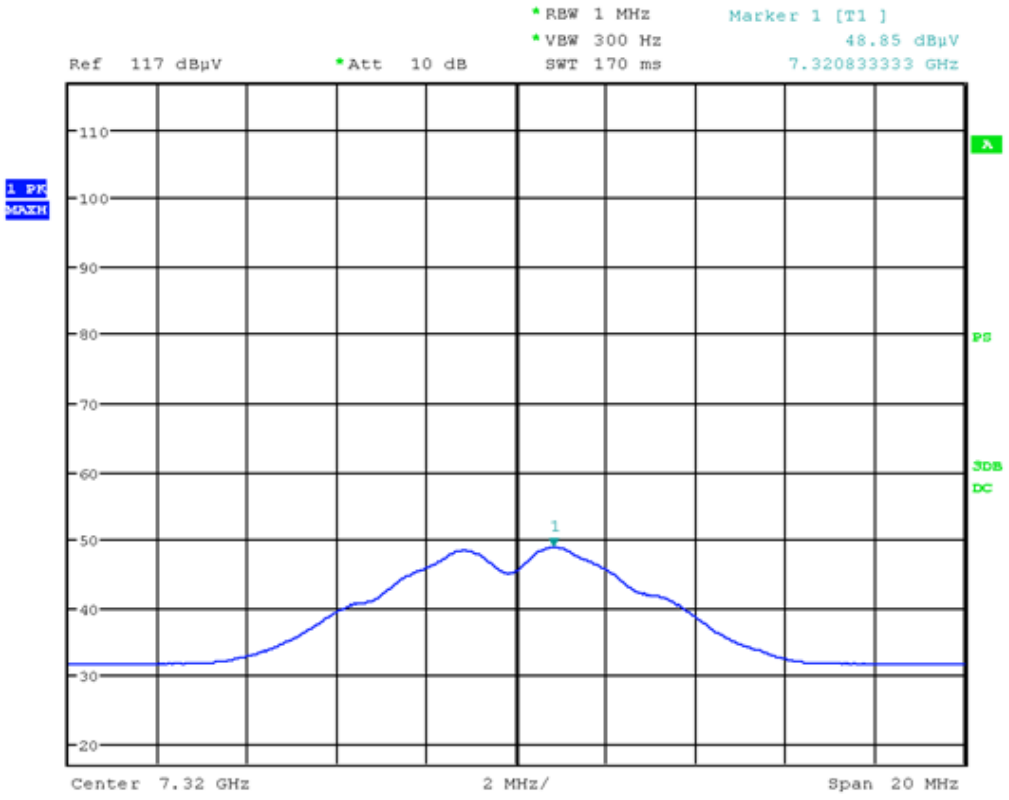
Picture 53: spurious emission channel 18 - PK



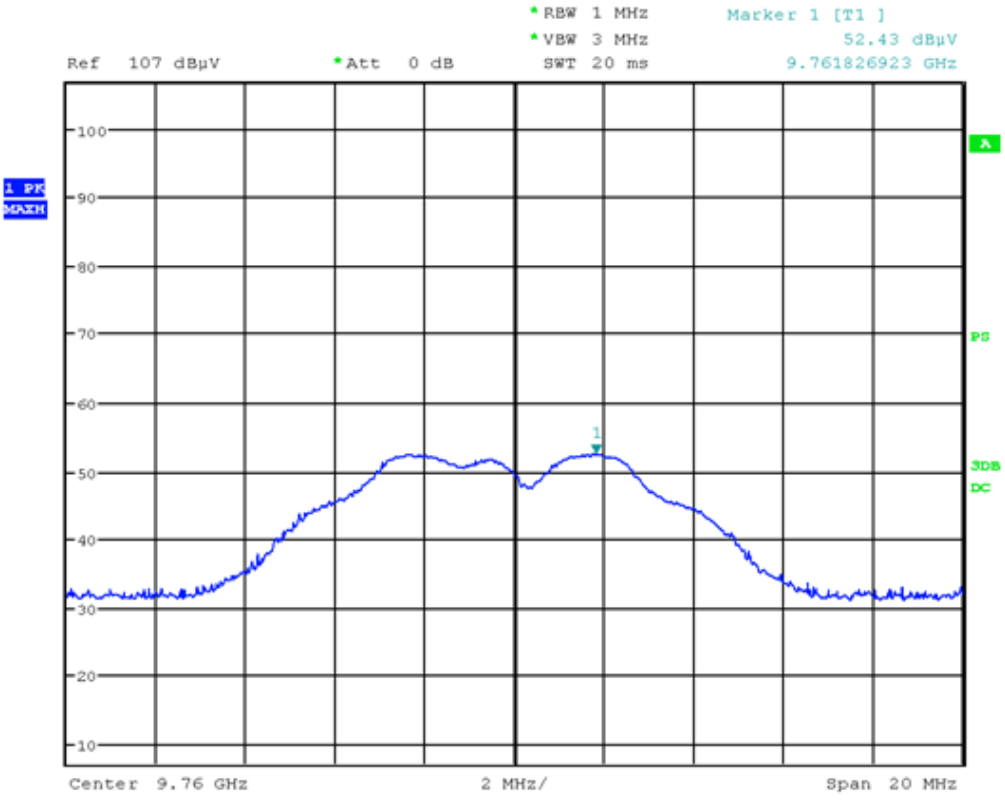
Picture 54: spurious emission channel 18 - AV



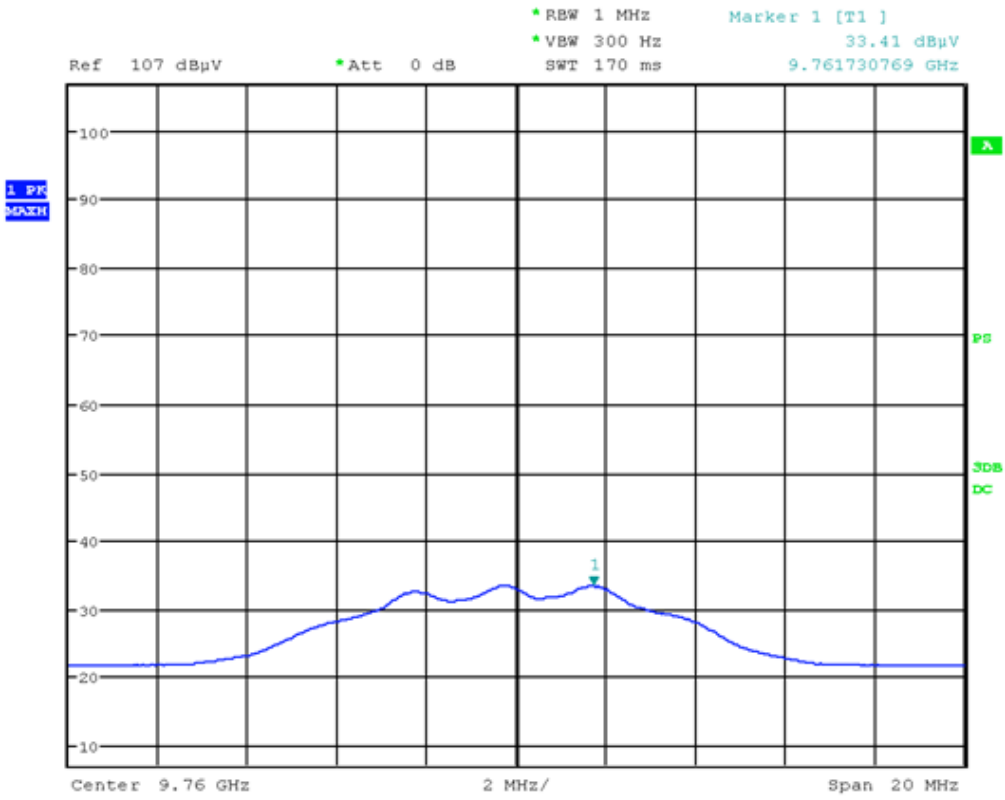
Picture 55: spurious emission channel 18 - PK



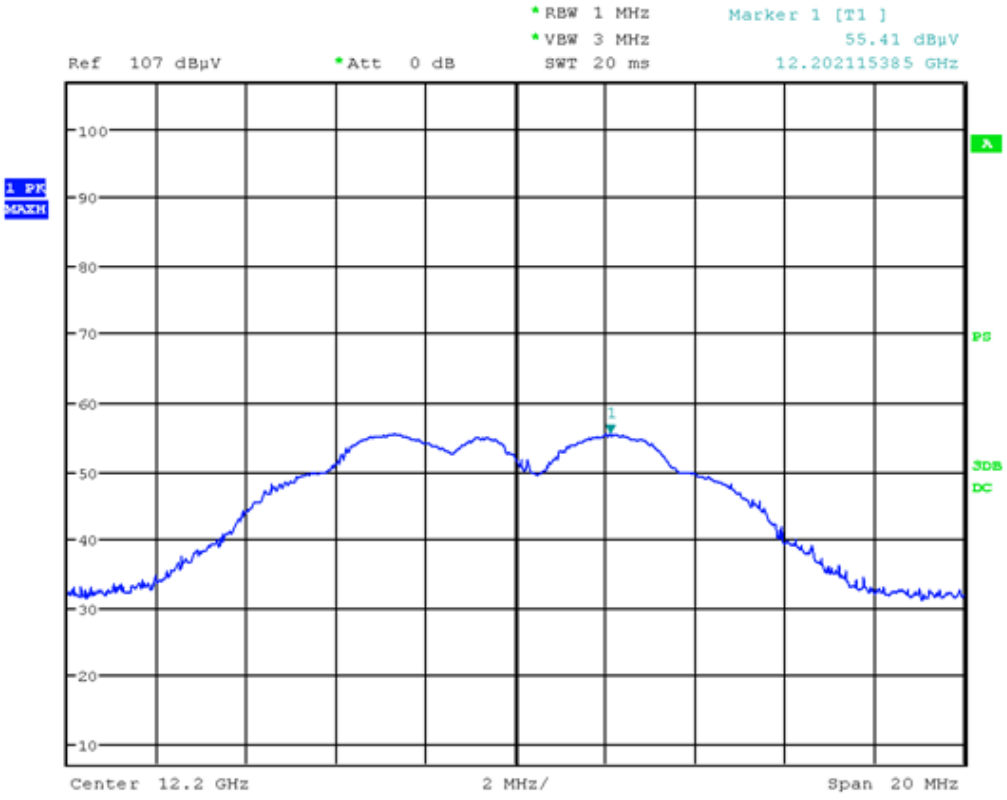
Picture 56: spurious emission channel 18 - AV



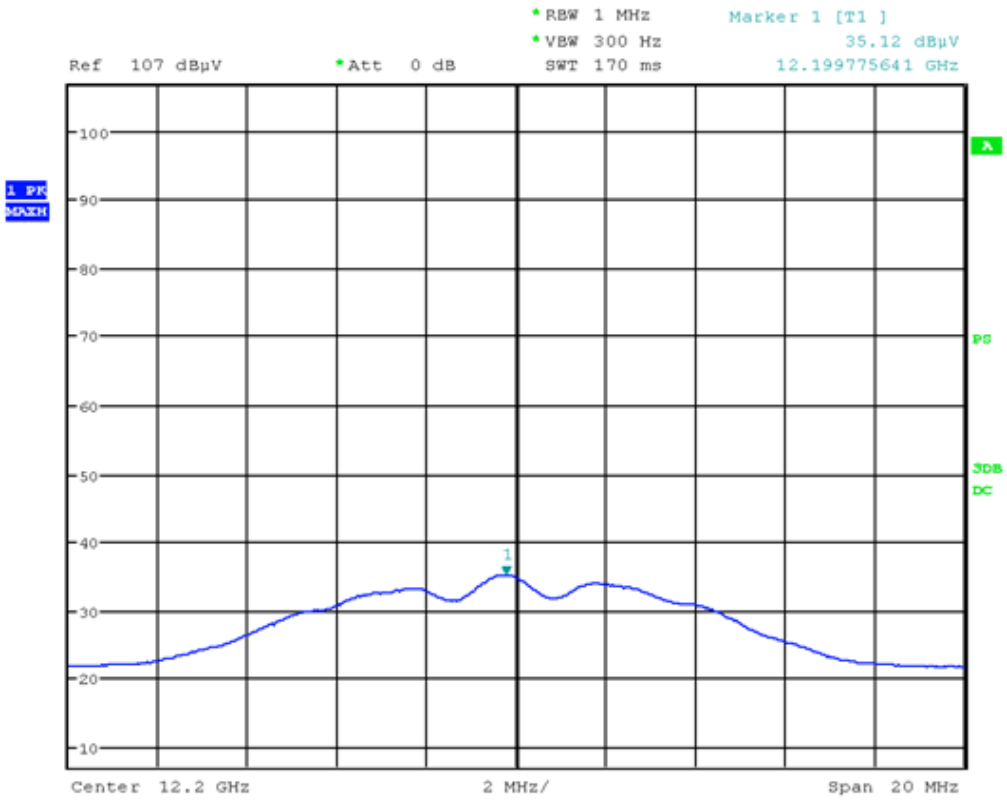
Picture 57: spurious emission channel 18 - PK



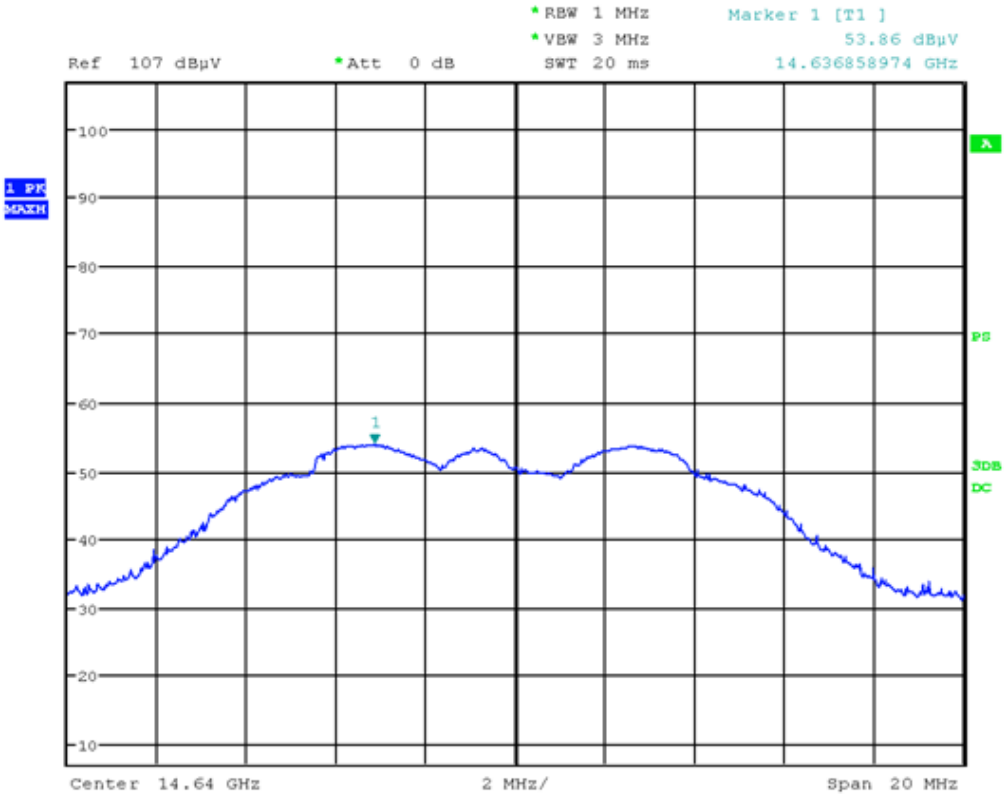
Picture 58: spurious emission channel 18 - AV



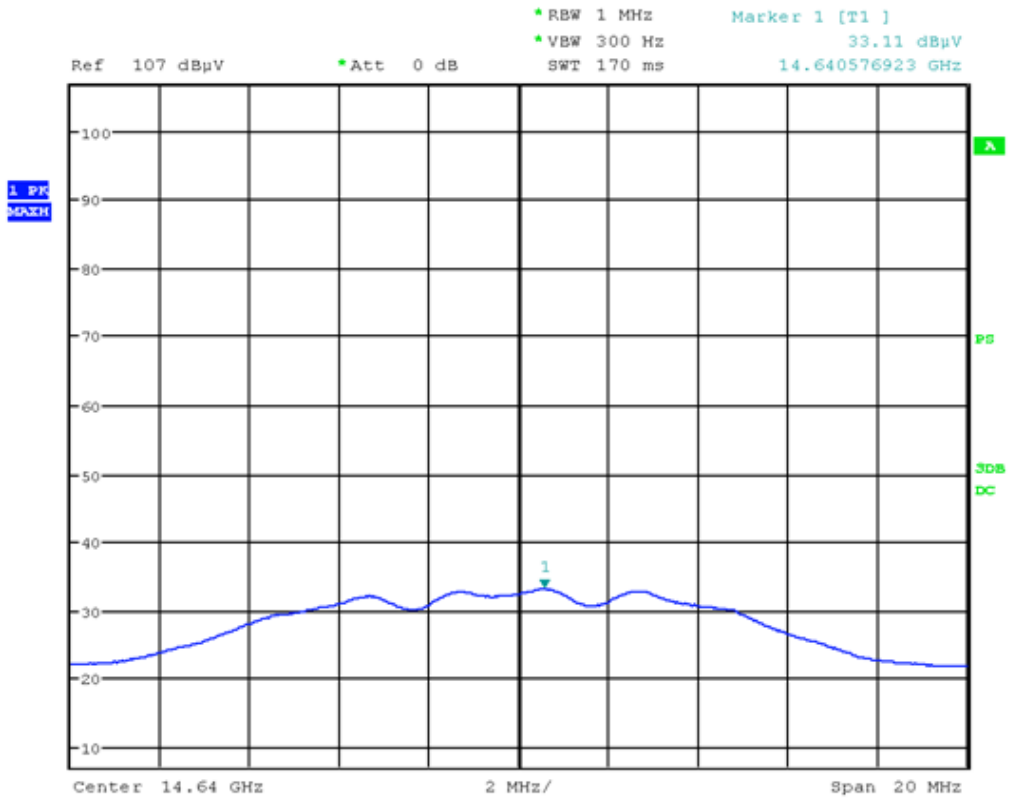
Picture 59: spurious emission channel 18 - PK



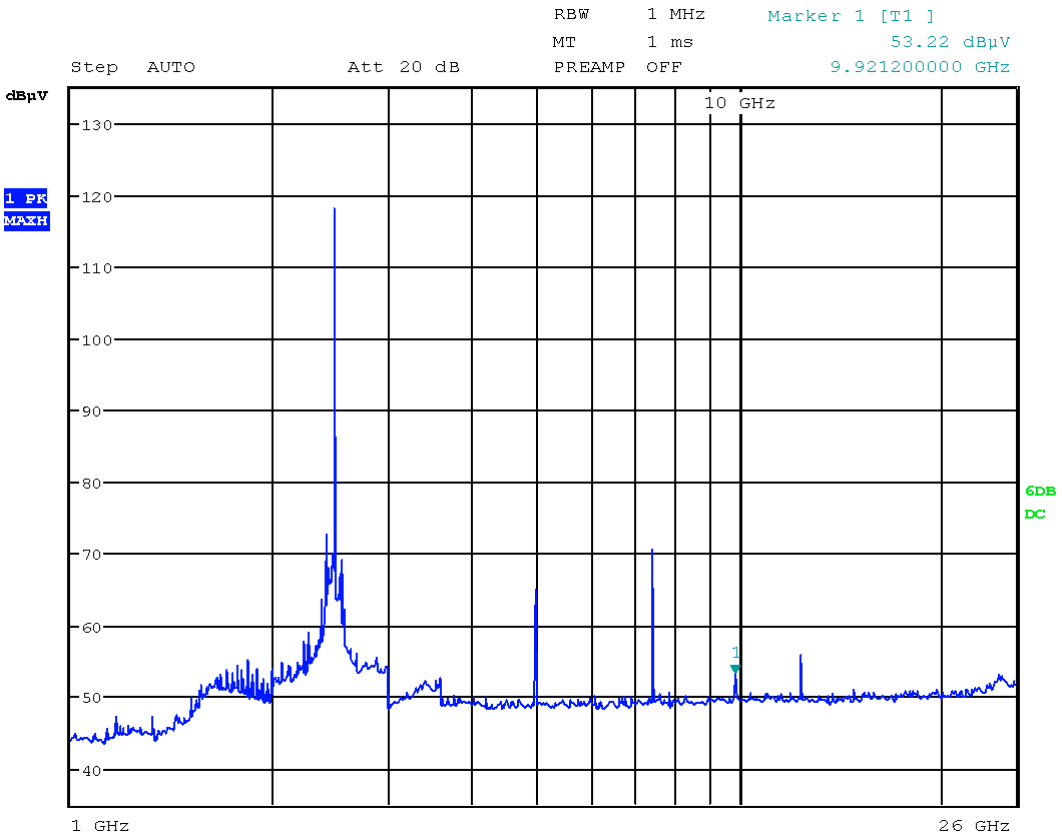
Picture 60: spurious emission channel 18 - AV



Picture 61: spurious emission channel 18 - PK

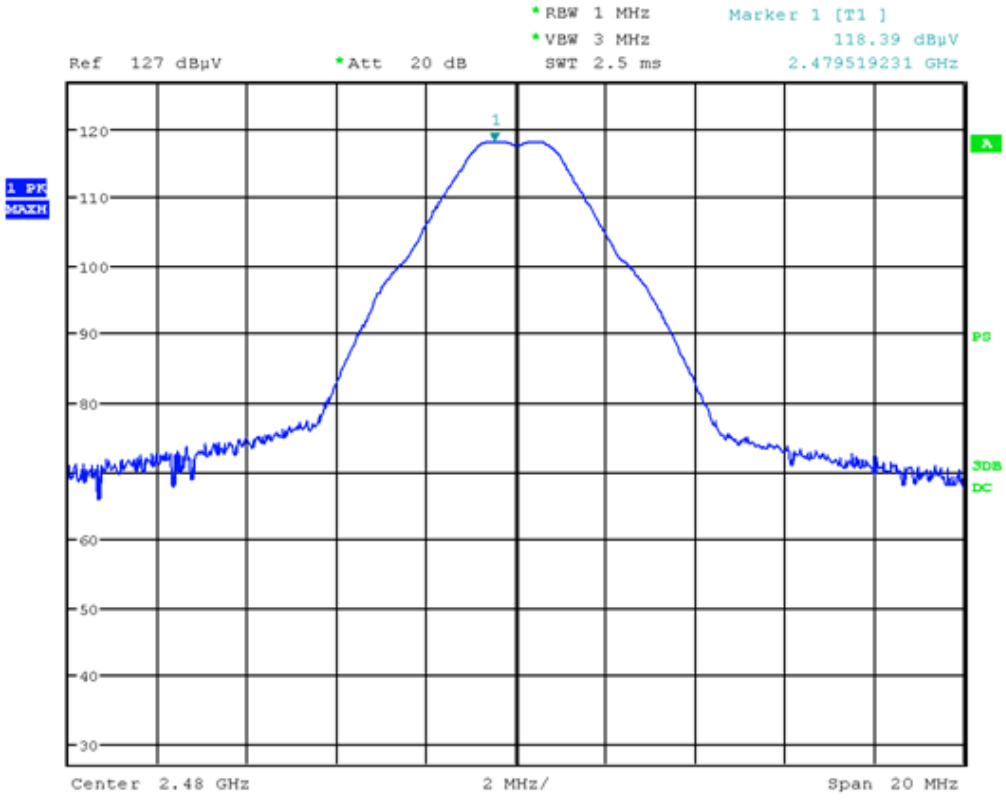


Picture 62: spurious emission channel 18 – AV

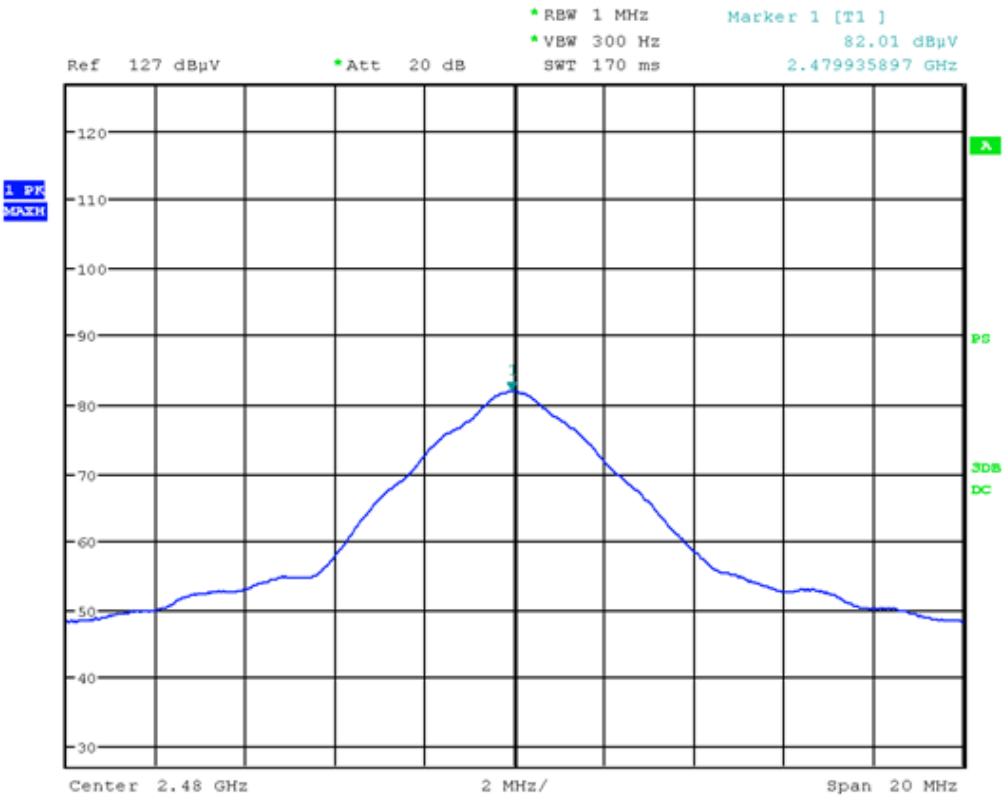


Frequency (GHz)	Reading (dBµV)	Detector	Limit (dBµV)	Restricted band	Result
Channel 26					
2.4795	118.39	PK	Carrier	No	Carrier
2.4799	82.01	AV	Carrier	No	Carrier
4.9609	66.40	PK	74	Yes	Passed
4.9599	45.72	AV	54	Yes	Passed
7.4413	72.45	PK	- 20dBc	No	Passed
7.4408	45.82	AV	- 20dBc	No	Passed
12.4022	57.19	PK	74	Yes	Passed
12.3997	36.24	AV	54	Yes	Passed

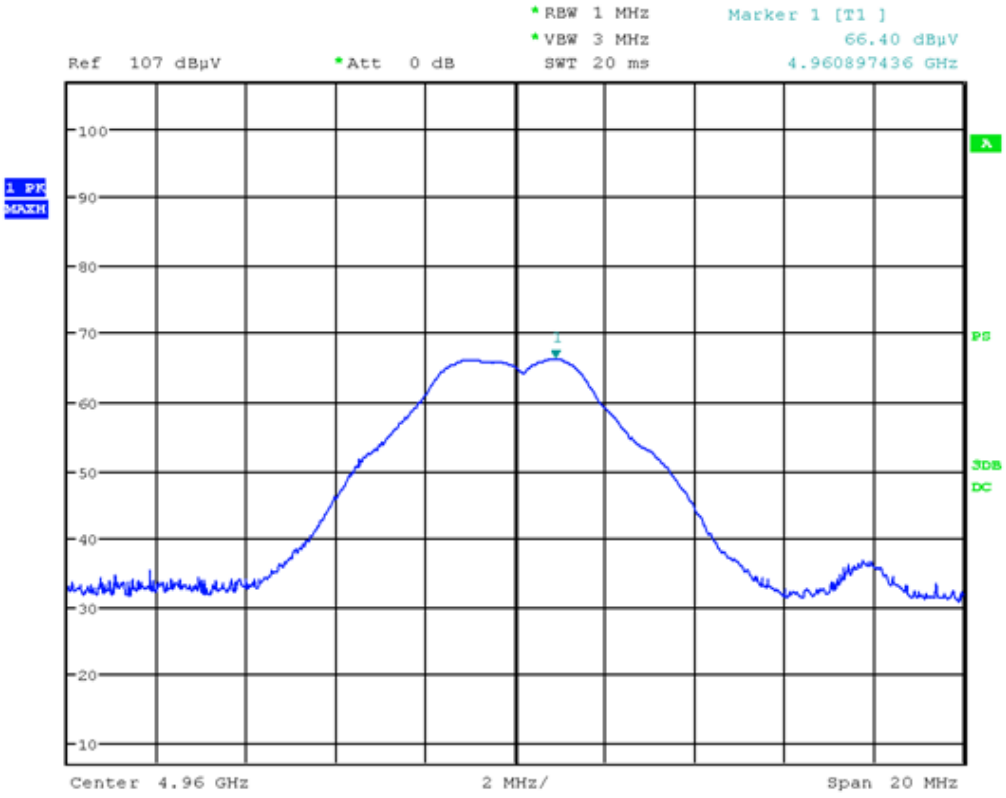
Picture 63: spurious emission channel 26 (1GHz - 26 GHz)



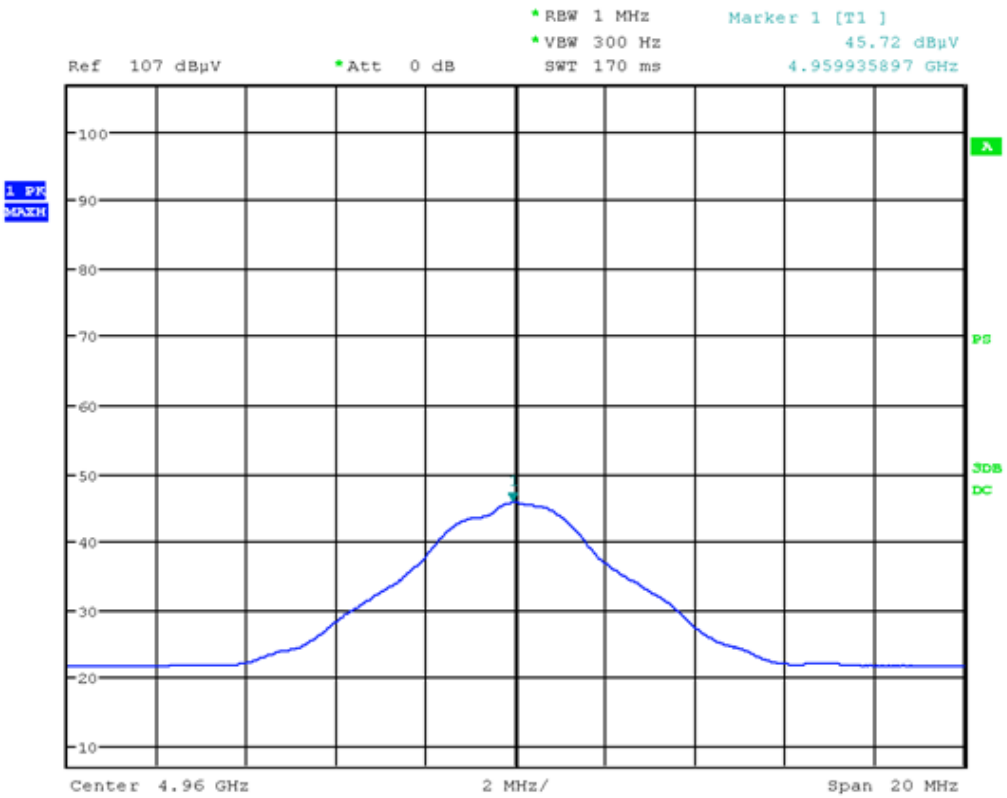
Picture 64: spurious emission channel 26 - PK



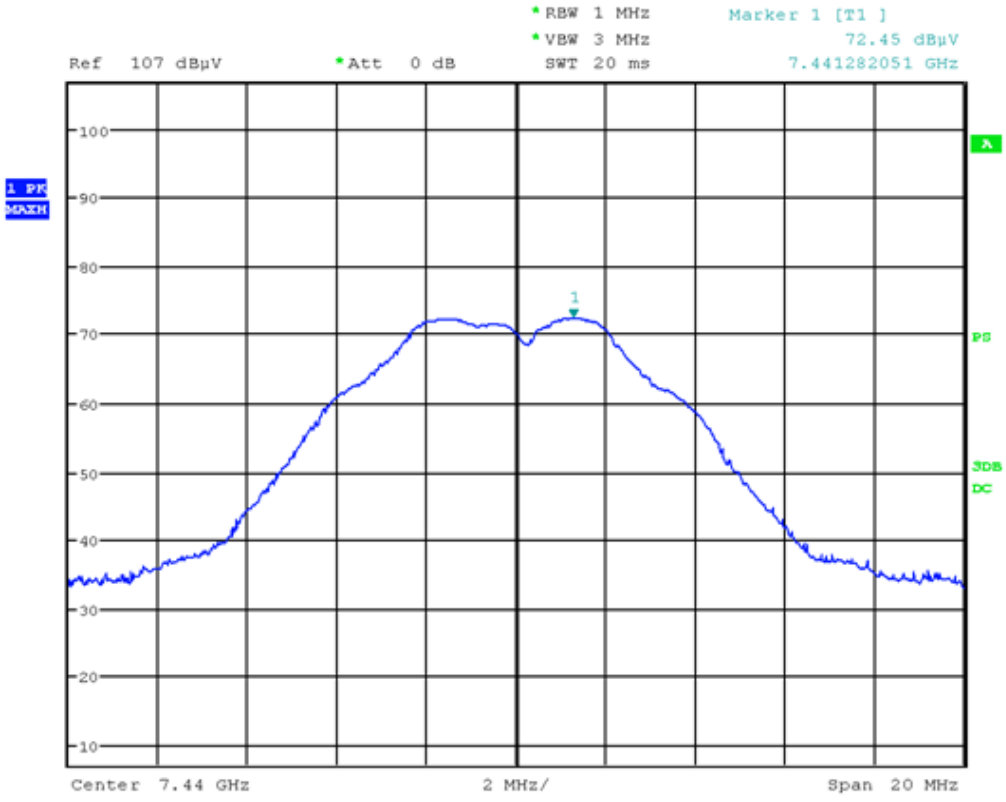
Picture 65: spurious emission channel 26 - AV



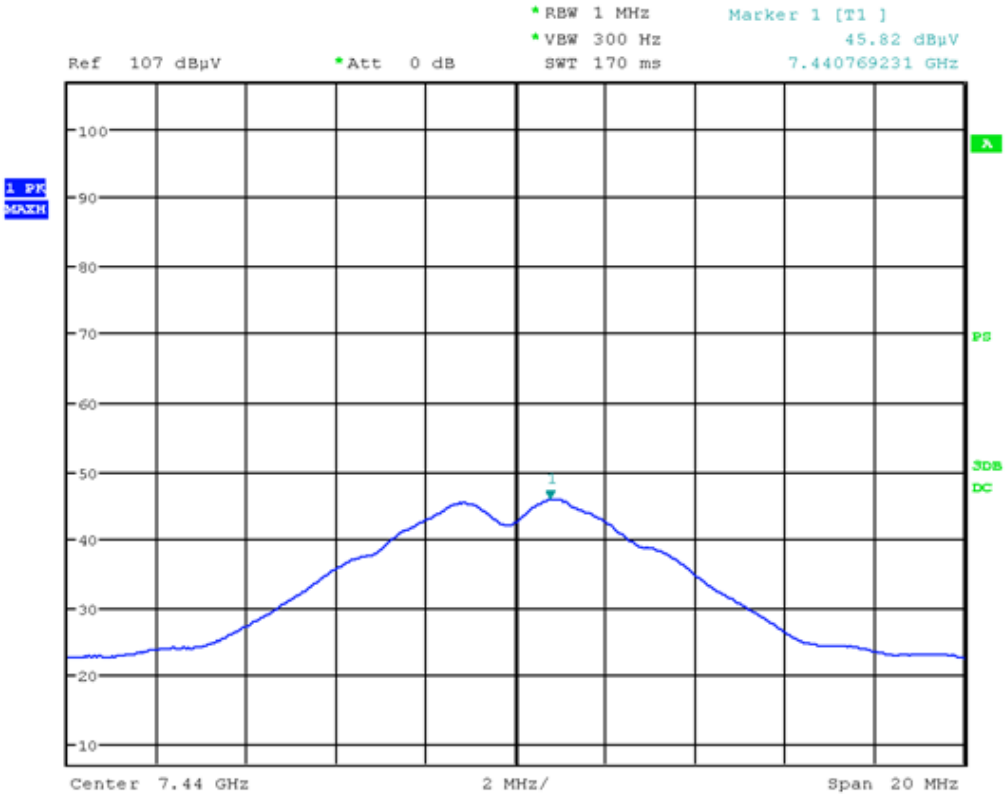
Picture 66: spurious emission channel 26 - PK



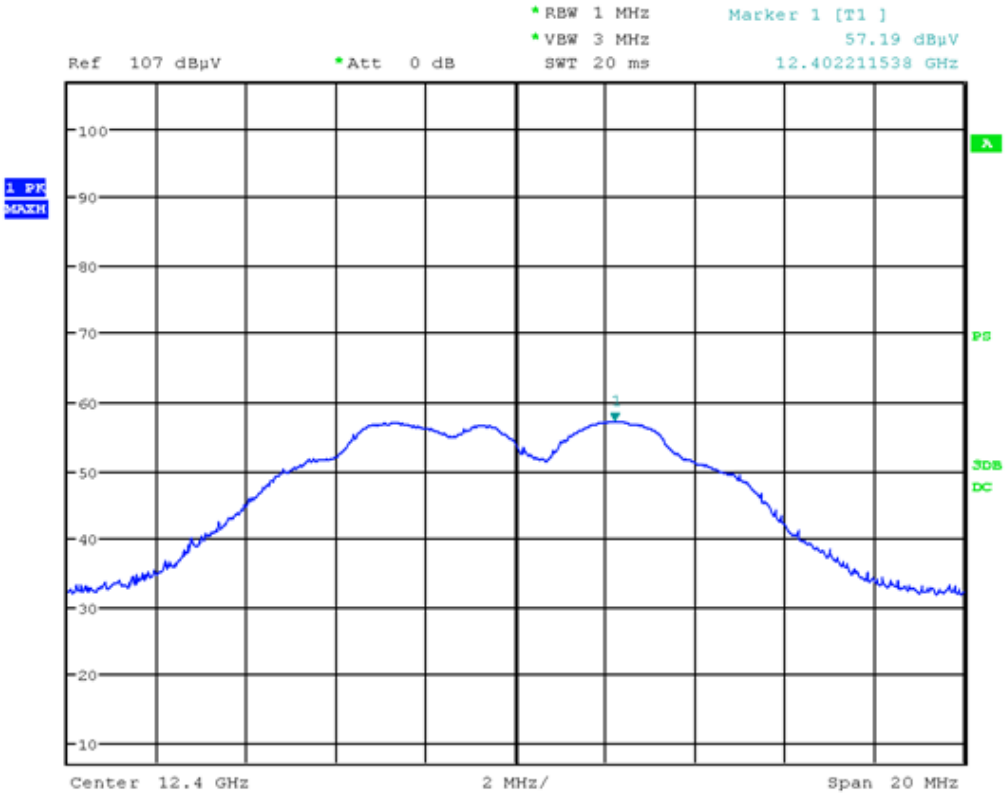
Picture 67: spurious emission channel 26 - AV



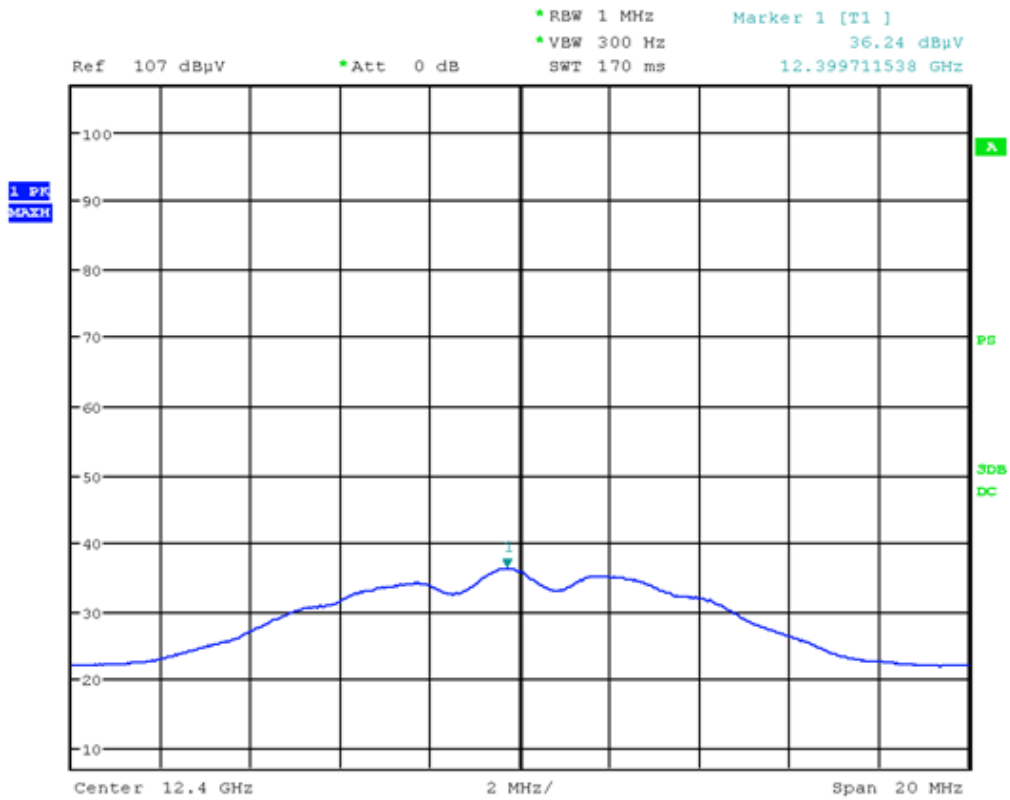
Picture 68: spurious emission channel 26 - PK



Picture 69: spurious emission channel 26 - AV



Picture 70: spurious emission channel 26 - PK



Picture 71: spurious emission channel 26 - AV

11 Radiated emission measurement (<1 GHz)

according to CFR 47 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 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

11.2 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

11.3 Limits

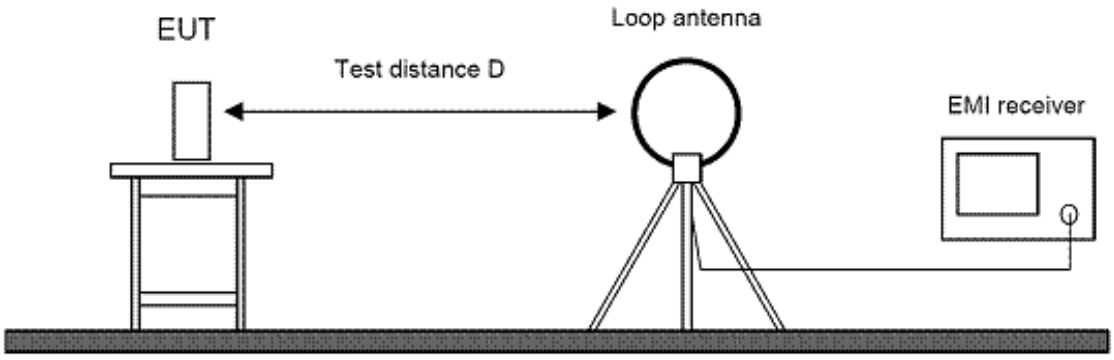
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.
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

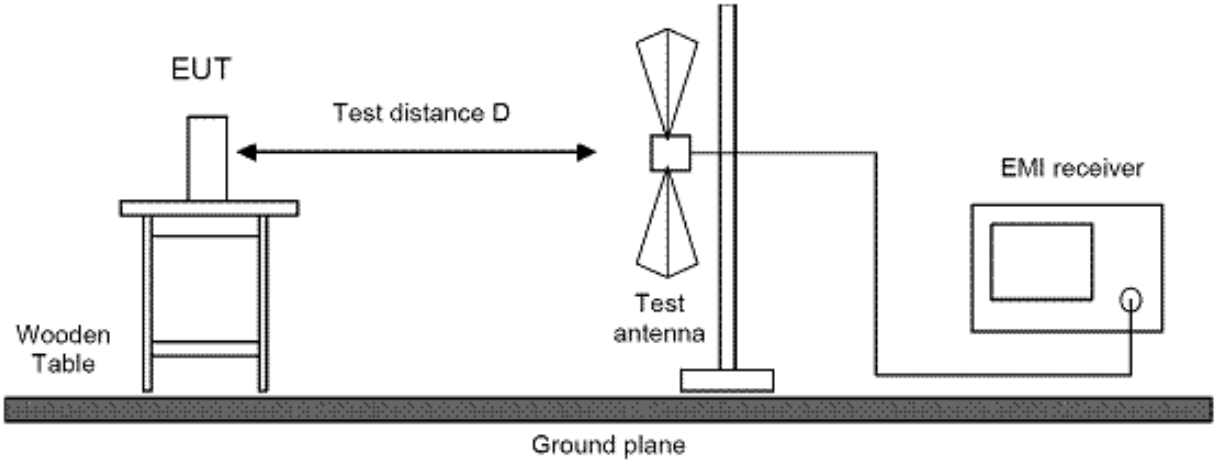
11.4 Test procedure

1. Configure the EUT according to ANSI C63.4. 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.

11.5 Test setup



Picture 72: Test setup for radiated emission measurement (< 30 MHz)



Picture 73: 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.
It was also investigated that the EUT-position1 is the respective worst-case for the measurements below 1GHz.
For the measurements below 30MHz the loop-antenna was polarized to “l”.

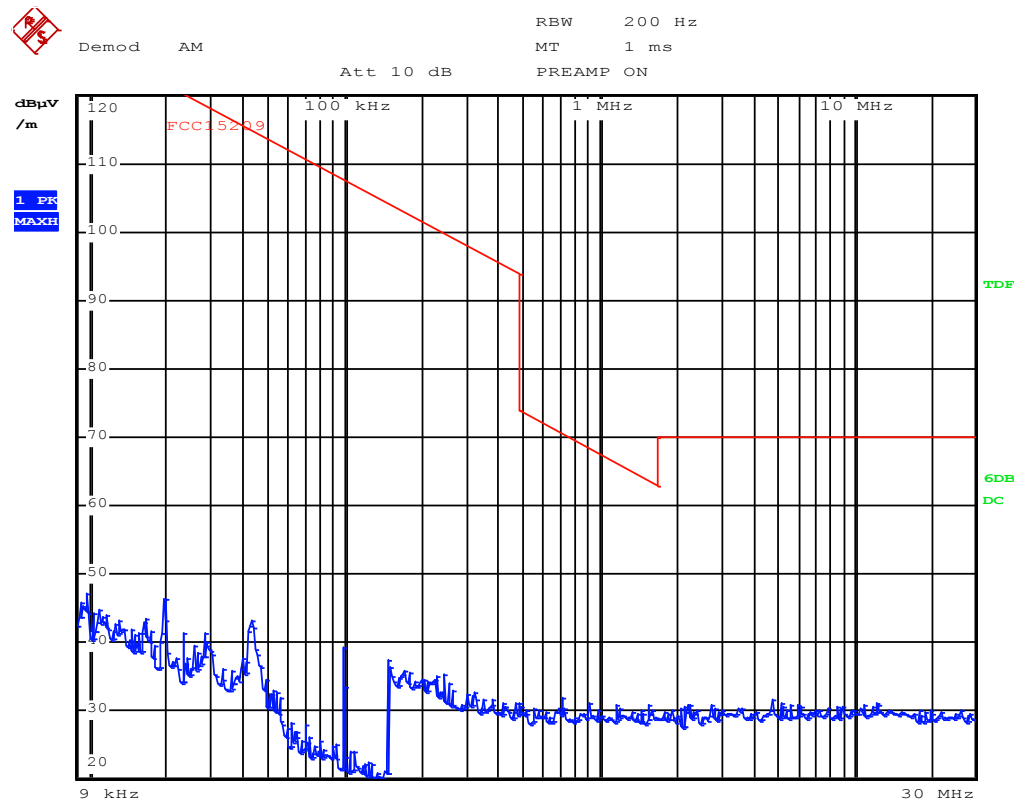
11.8 Test results

Transmit mode

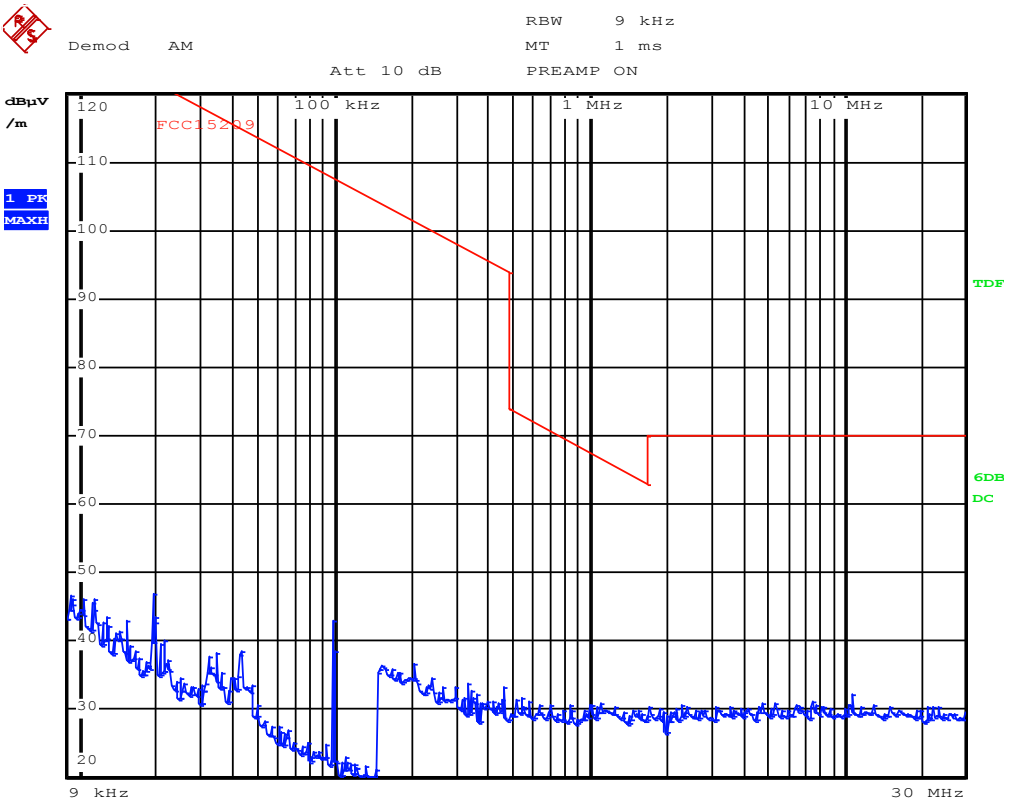
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-20

Radiated Emission Measurement 9 kHz – 30 MHz

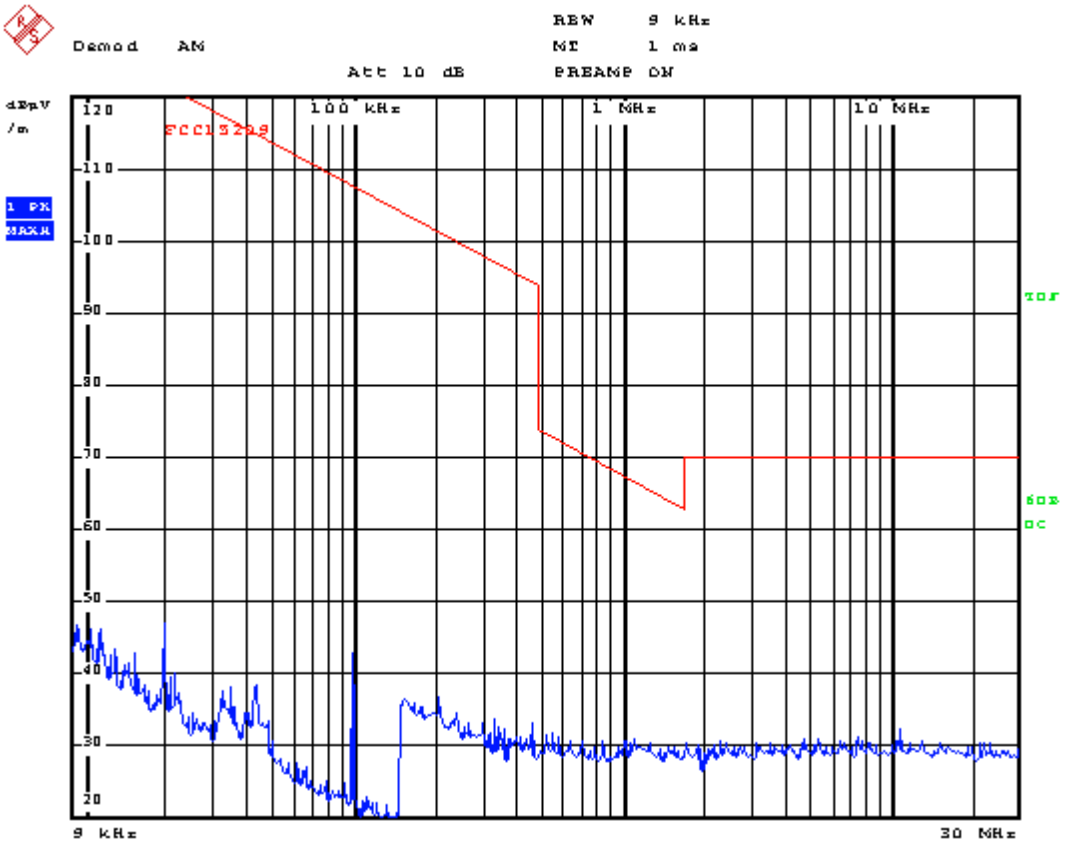
Note:
Measured value = dBµV/m @ 3 m
Recalculation factor = 40 dB / decade
Recalculated value1 = dBµV/m @ 3 m - 40 dB = **dBµV/m @ 30 m**
Recalculated value2 = dBµV/m @ 30 m - 40 dB = **dBµV/m @ 300 m**



Picture 74: Radiated emission 9 kHz – 30MHz (Channel 11)



Picture 75: Radiated emission 9 kHz – 30MHz (Channel 18)



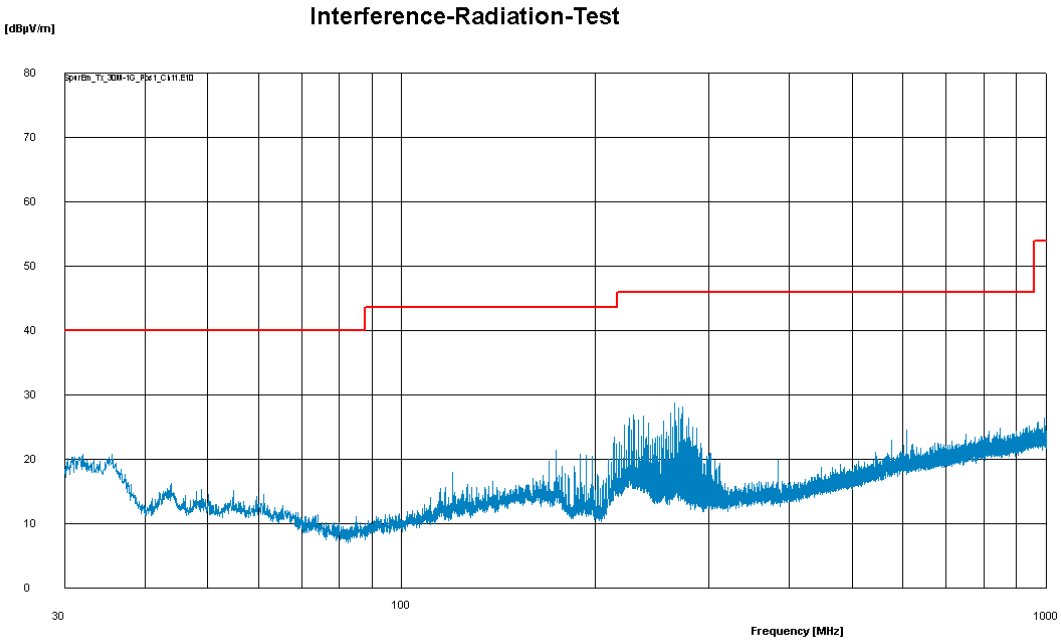
Picture 76: Radiated emission 9 kHz – 30MHz (Channel 26)

Transmit mode

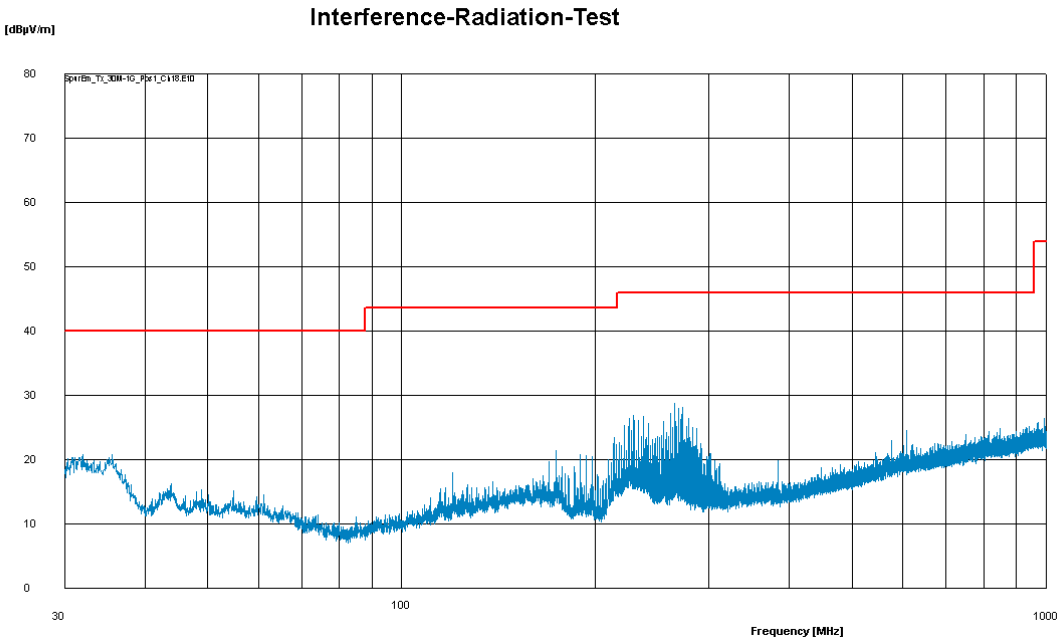
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-20

Radiated Emission Measurement 30 MHz - 1 GHz

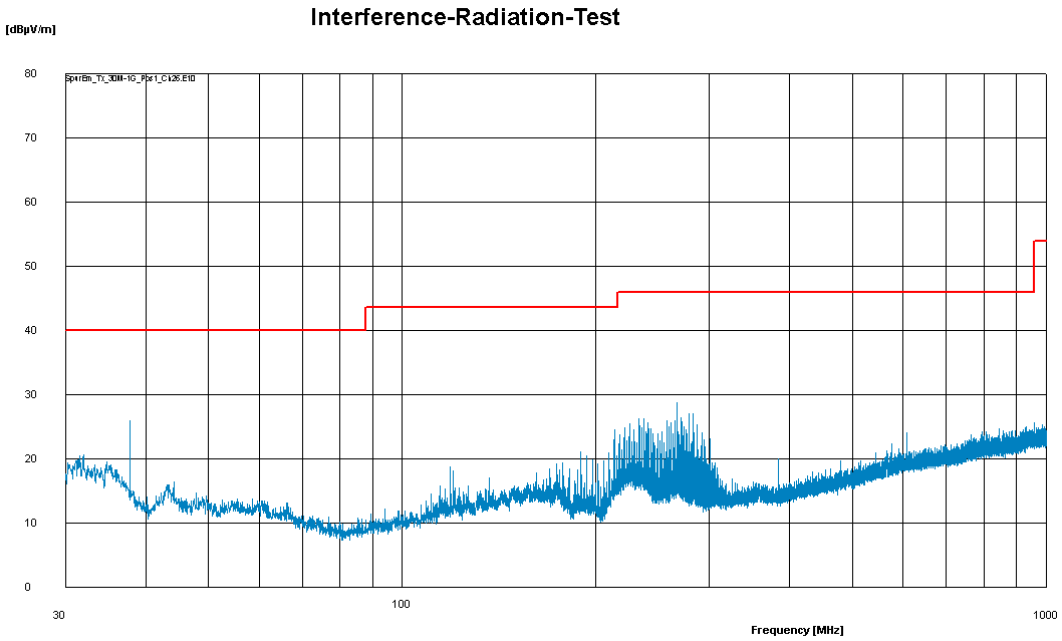
It was investigated that EUT position 1 is the respective worst-case.



Picture 77: Radiated emission 30 MHz – 1000MHz (Channel 11)



Picture 78: Radiated emission 30 MHz – 1000MHz (Channel 18)



Picture 79: Radiated emission 30 MHz – 1000MHz (Channel 26)

12 Radiated emission measurement (>1 GHz)

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

12.1 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

12.2 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

12.3 Limits

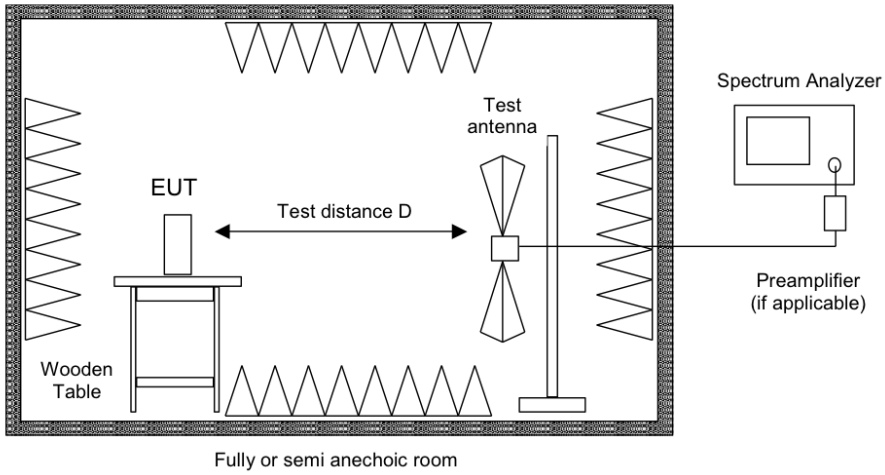
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the 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

12.4 Test procedure

6. Configure the EUT according to ANSI C63.4. The EUT was placed on the top of the turntable 0.8 meter above ground. The receiving antenna was placed 3 meters from the turntable. The test setup was placed inside a fully anechoic chamber.
7. Power on the EUT and all peripherals.
8. The broadband antenna was set to vertical polarization.
9. 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.
10. The turn table was rotated in intervals of 15°.
11. After a full 360°-turn the antenna polarization was changed to horizontal and the test was repeated at step 4 and 5.
12. After the scan suspicious frequencies were selected and the RBW was set to 1 MHz and the VBW was reduced to a minimum of 10 Hz (300 Hz by default) to get average values determined by video averaging.
13. The receiving antenna was set to vertical polarization.
14. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
15. The receiving antenna was then set to horizontal polarization and the measurement was repeated at step 9.
16. The highest recorded level was noted.

12.5 Test setup



Picture 80: Test setup for radiated emission measurement (> 1 GHz)

12.6 Test deviation

There is no deviation with the original standard.

12.7 EUT operation during test

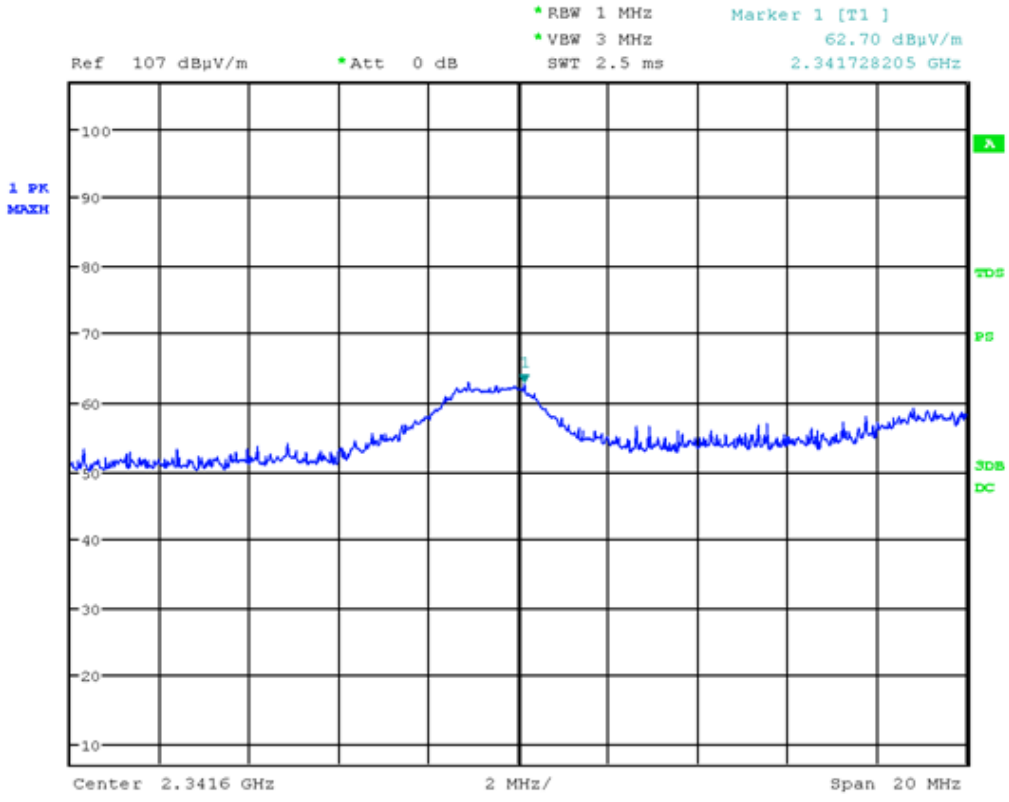
The EUT was programmed to be in continuously transmitting mode.
For these measurements it was investigated that EUT-position2 is the respective worst-case.

12.8 Test results channel 11

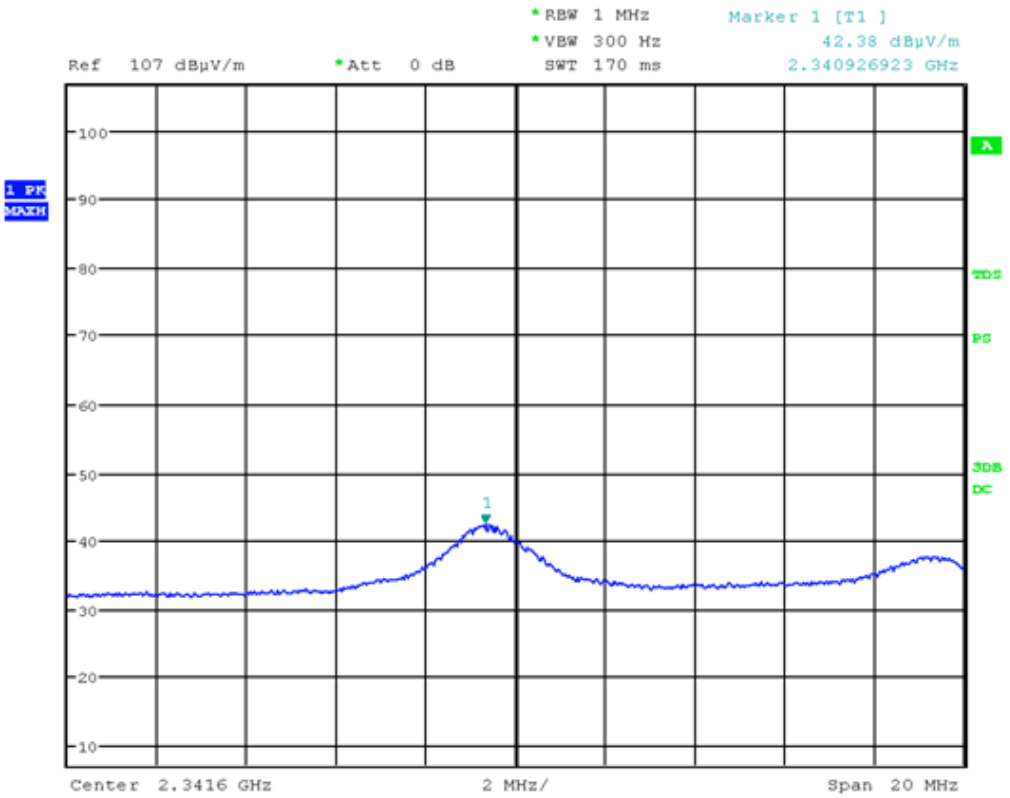
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-27

Final Results:

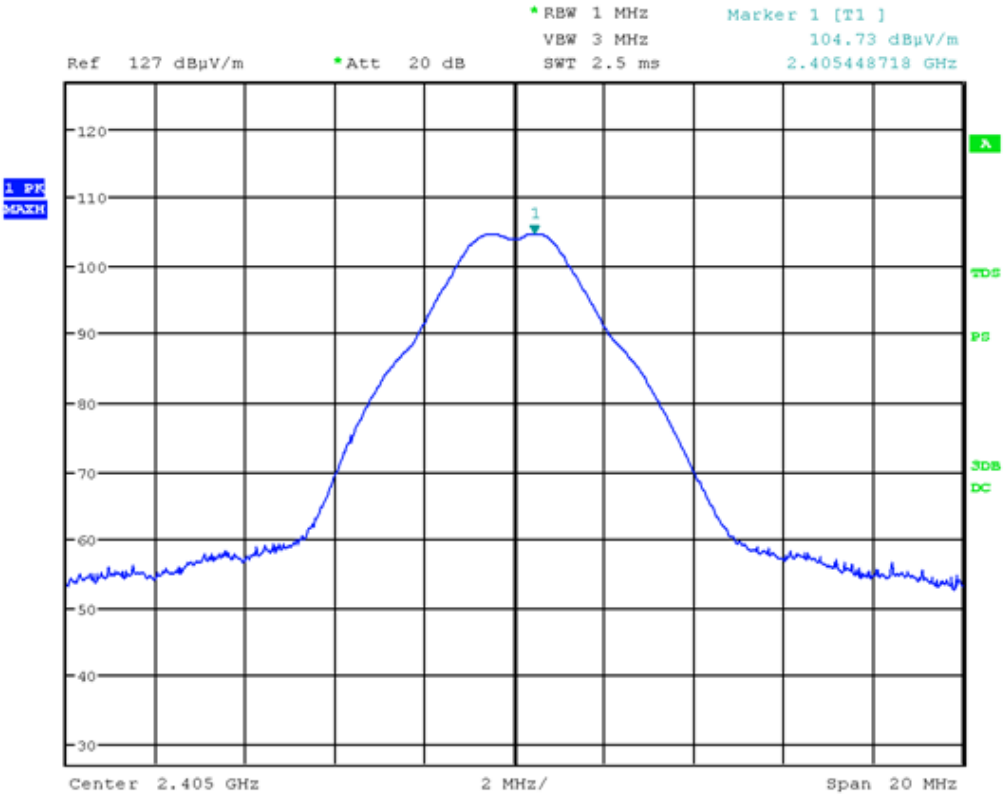
Frequency [GHz]	Antenna polarization	Reading [dBµV/m]	Detector	Limit [dBµV/m]	Restricted Band	Result
Channel 11						
2.3417	H	62.70	PK	74	Yes	Passed
2.3409		42.38	AV	54		Passed
2.4054	V	104.73	PK	- - -	No	Carrier
2.4050		73.45	AV	- - -		Carrier
2.4045	H	107.83	PK	- - -	No	Carrier
2.4050		75.17	AV	- - -		Carrier
4.8091	H	60.49	PK	74	Yes	Passed
4.8101		45.65	AV	54		Passed
7.2136	H	55.61	PK	-20dBc	No	Passed
7.2159		40.19	AV	-20dBc		Passed



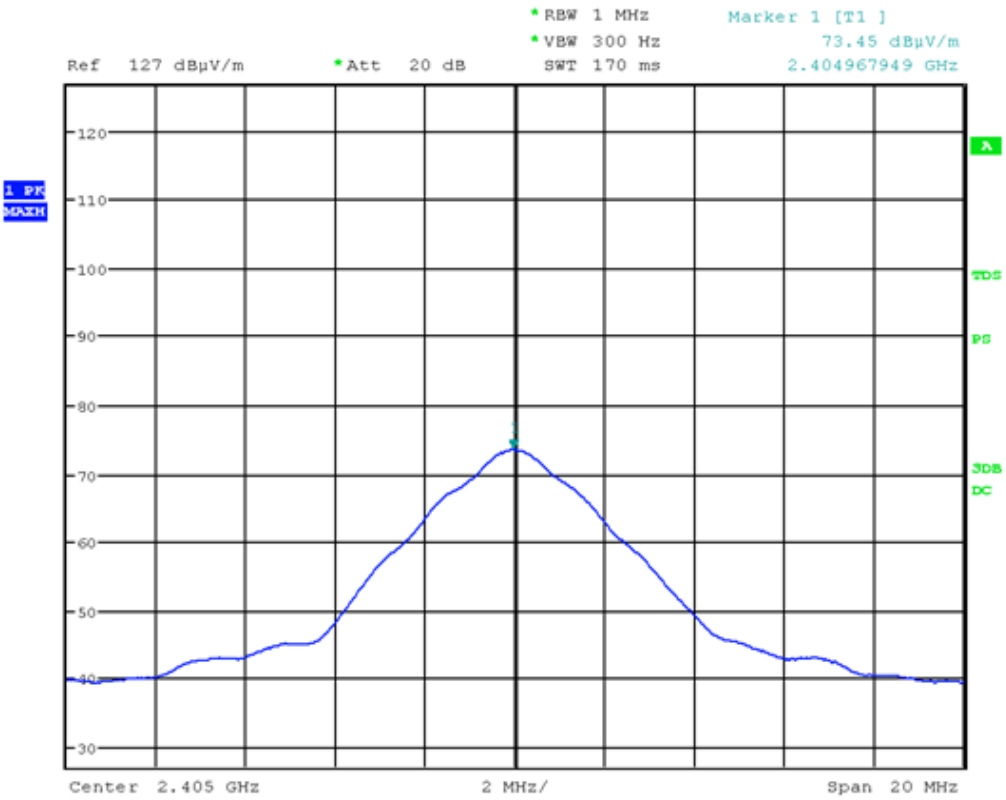
Picture 81: spurious emission channel 11 - PK, horizontal polarization



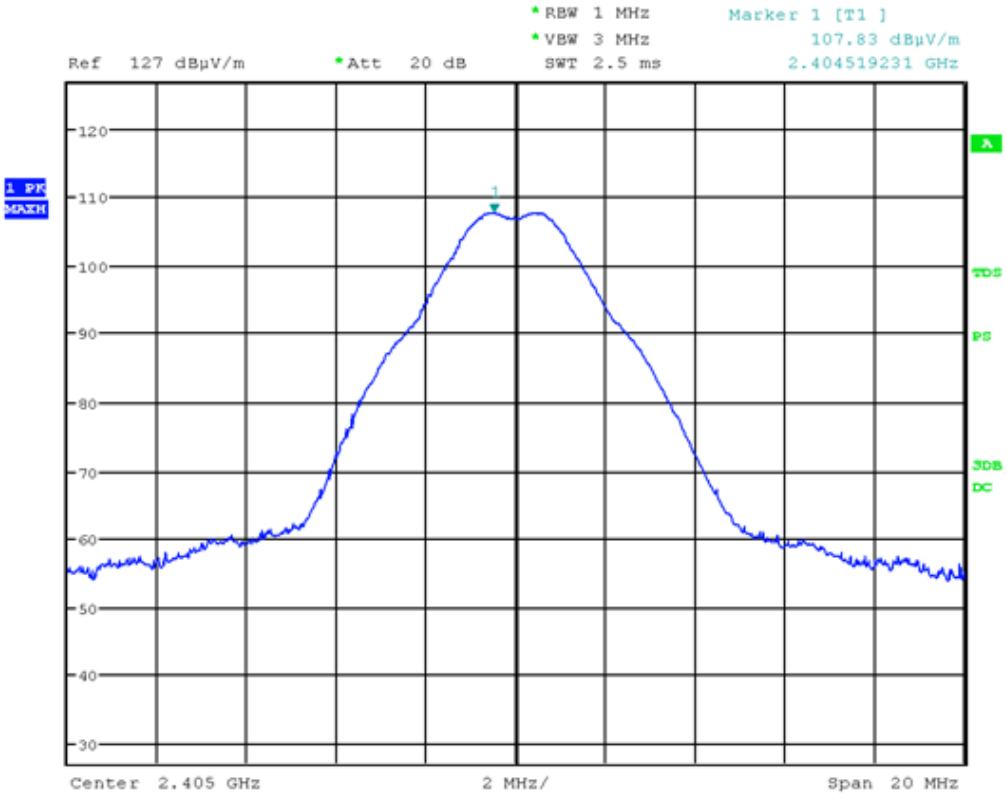
Picture 82: spurious emission channel 11 - AV, horizontal polarization



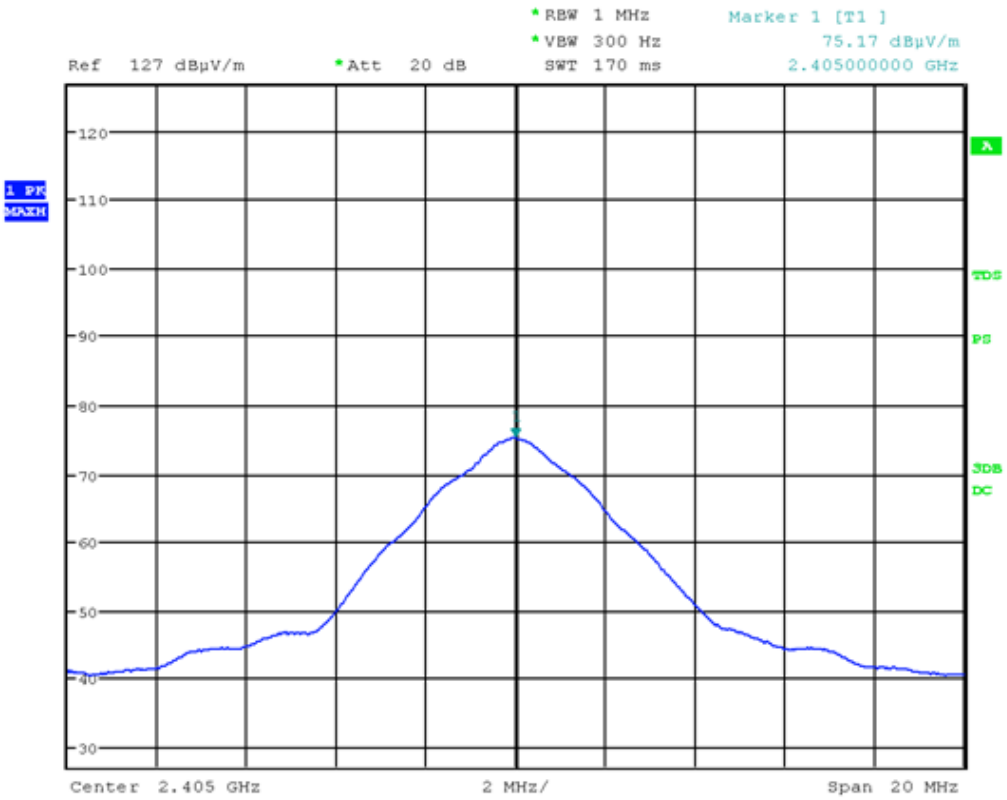
Picture 83: spurious emission channel 11 – PK, vertical polarization



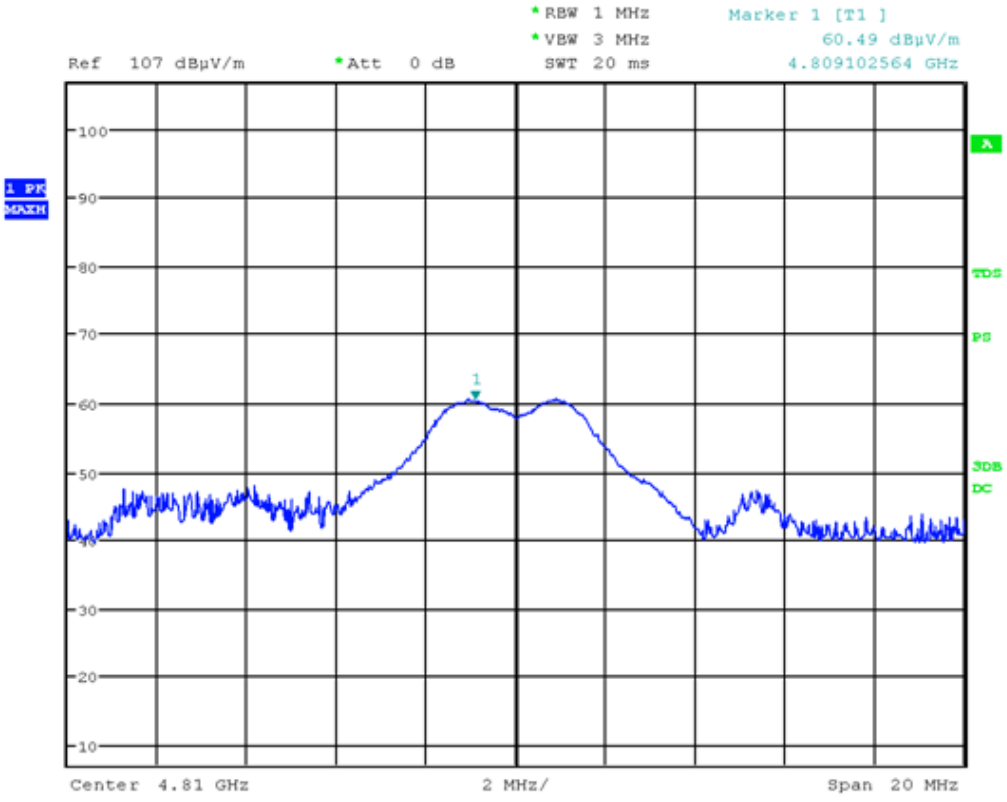
Picture 84: spurious emission channel 11 - AV, vertical polarization



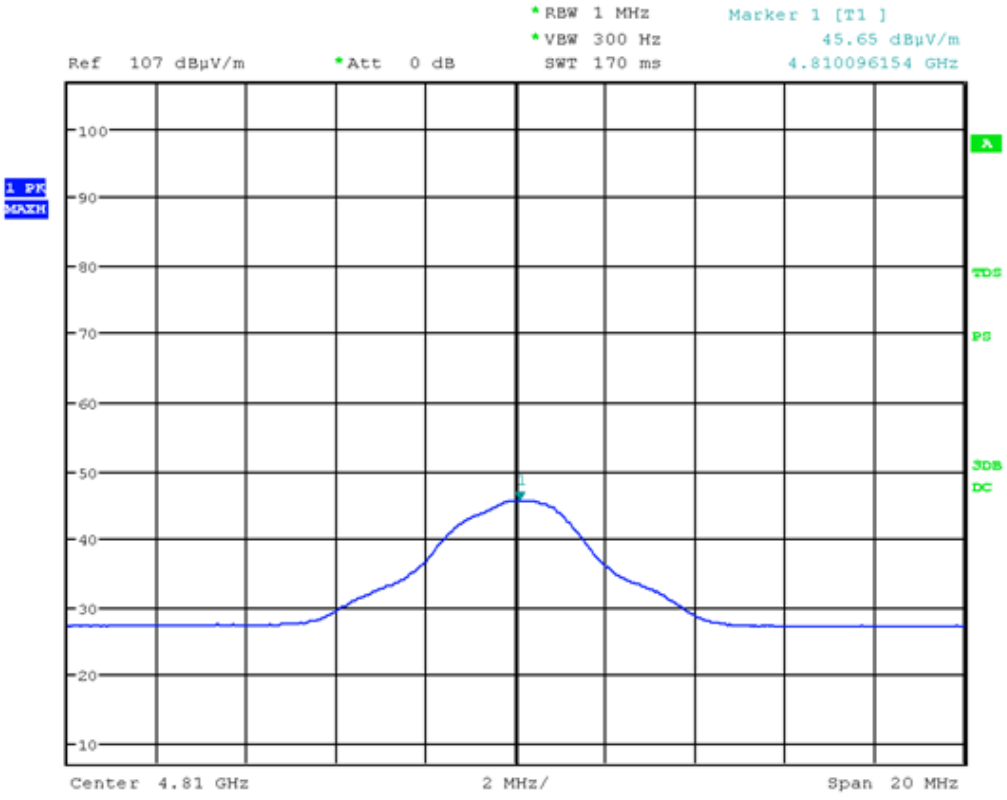
Picture 85: spurious emission channel 11 - PK, horizontal polarization



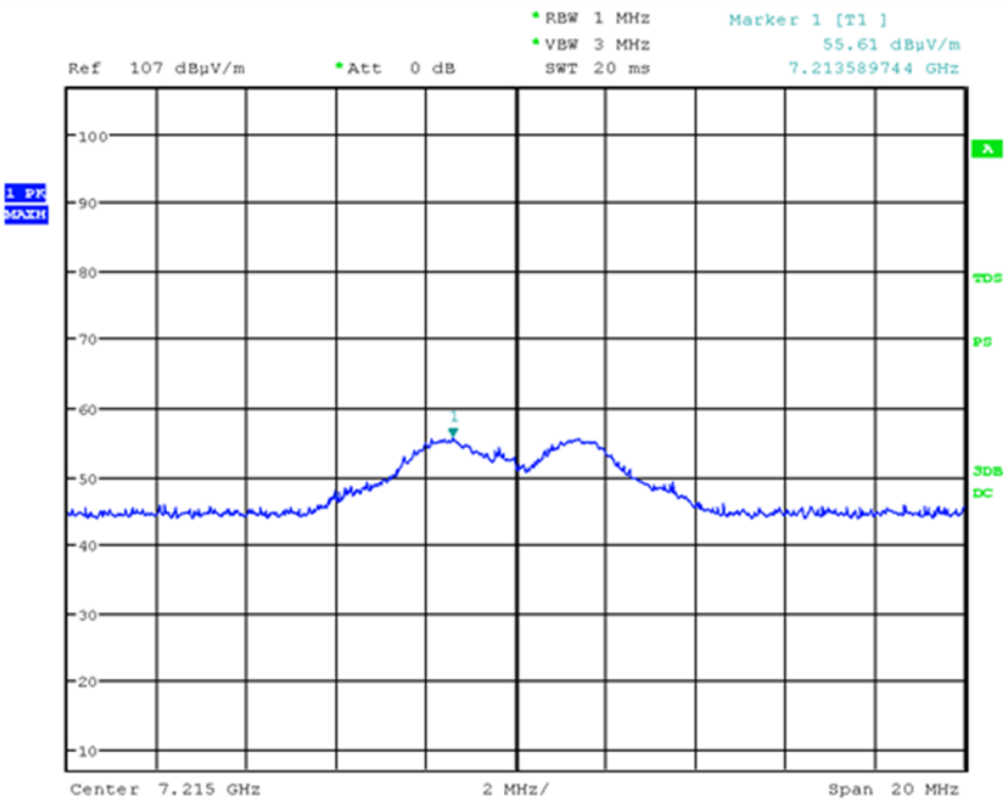
Picture 86: spurious emission channel 11 - AV, horizontal polarization



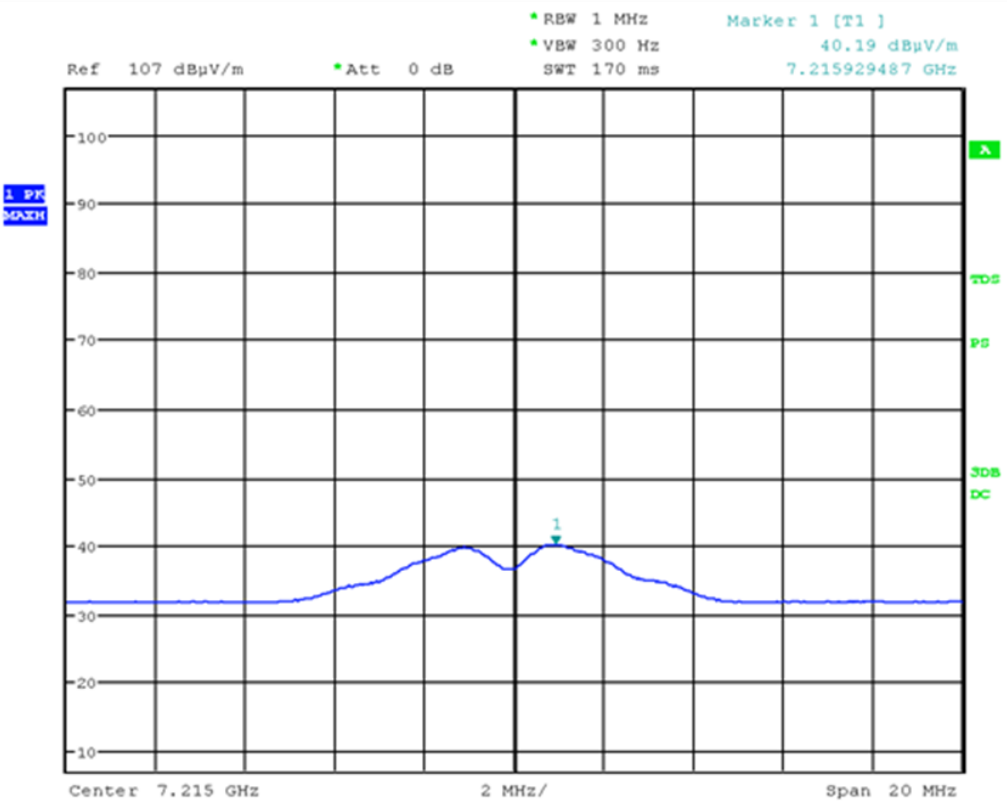
Picture 87: spurious emission channel 11 - PK, horizontal polarization



Picture 88: spurious emission channel 11 - AV, horizontal polarization



Picture 89: spurious emission channel 11 - PK, horizontal polarization



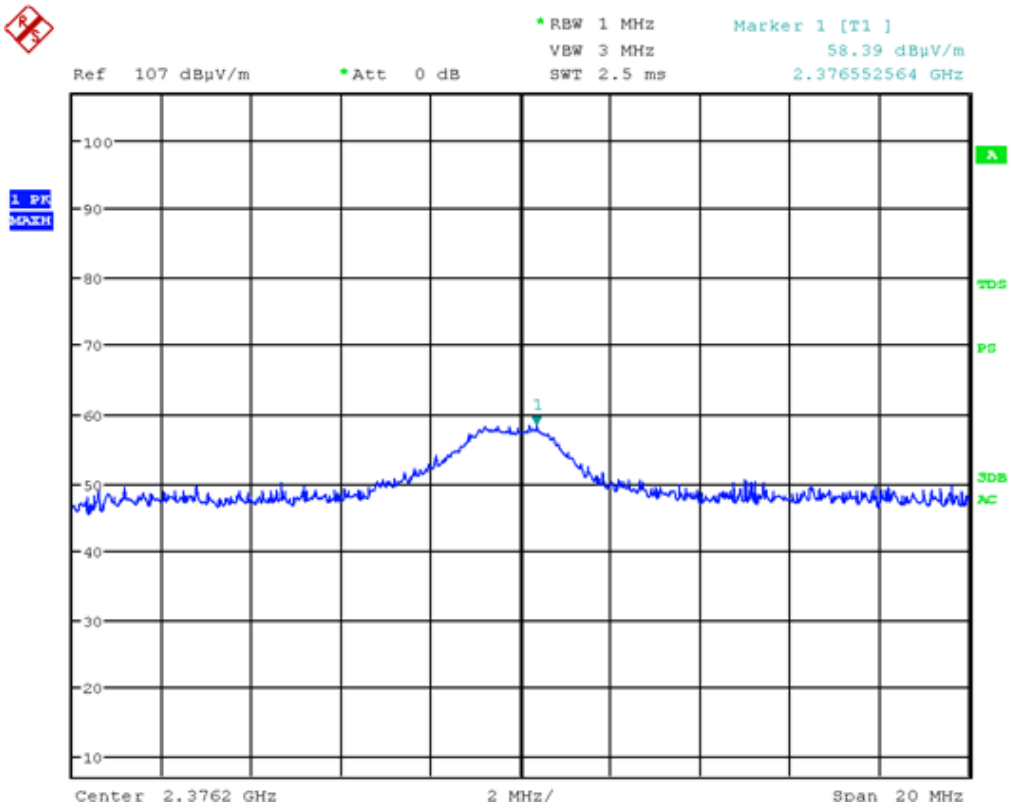
Picture 90: spurious emission channel 11 - AV, horizontal polarization

12.9 Test results channel 18

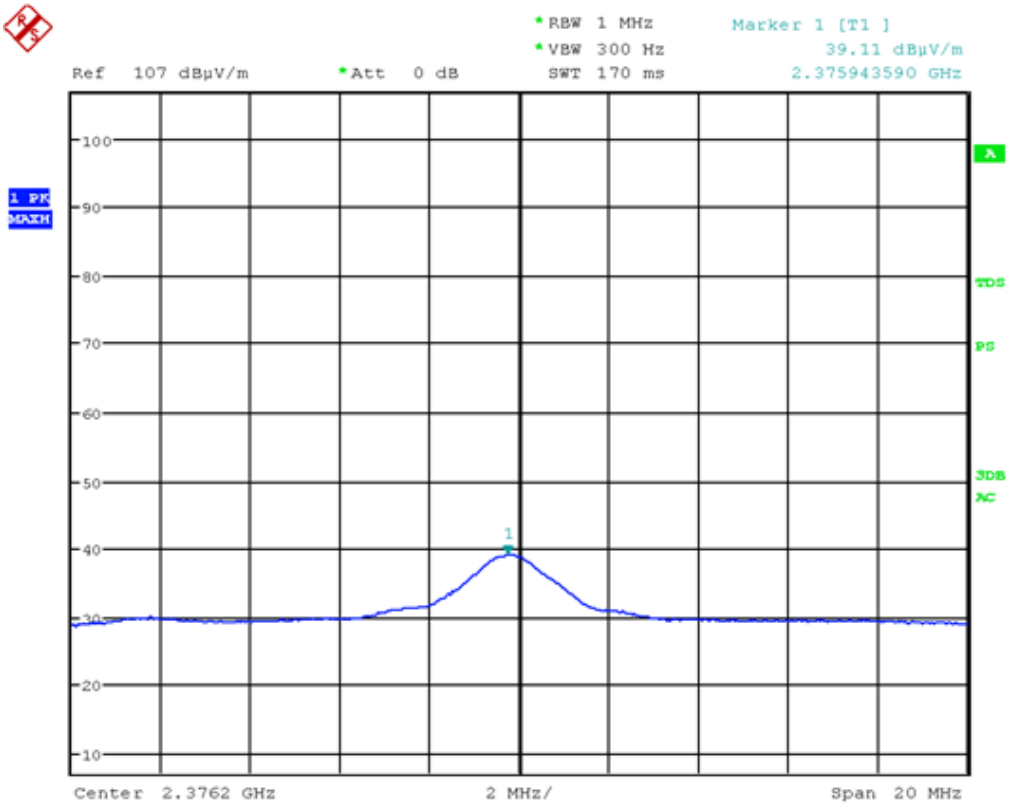
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-27

Final Results:

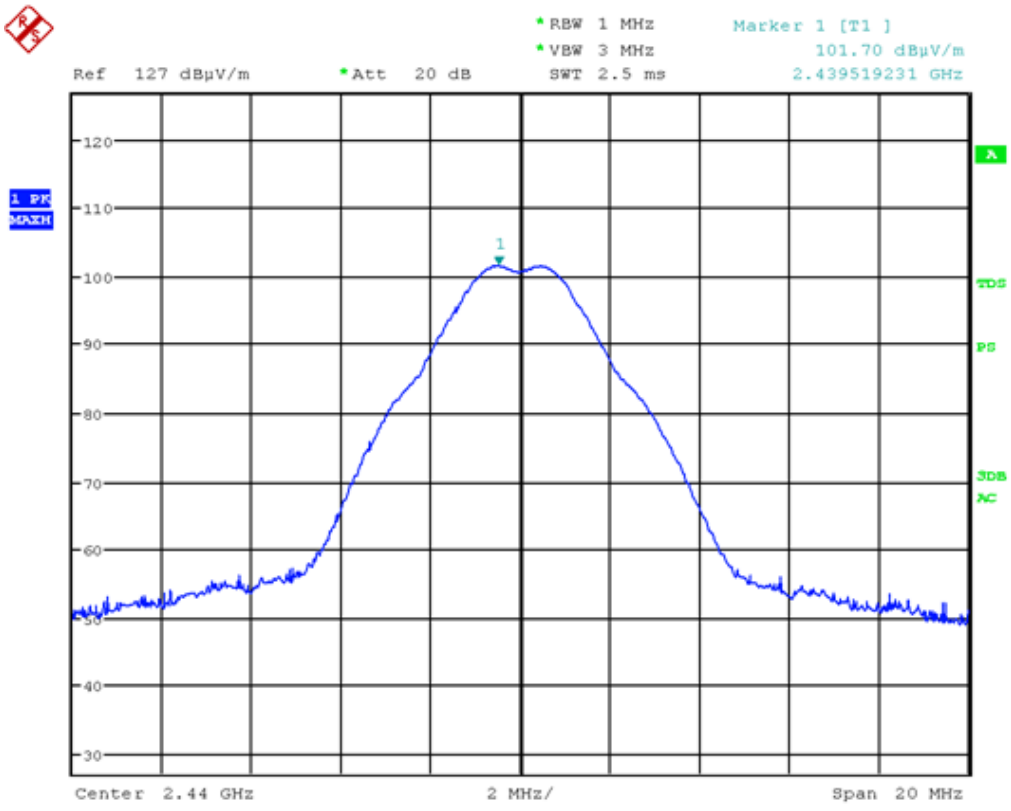
Frequency [GHz]	Antenna polarization	Reading [dBµV/m]	Detector	Limit [dBµV/m]	Restricted Band	Result
Channel 18						
2.3766	H	58.39	PK	74	Yes	Passed
2.3759		39.11	AV	54		Passed
2.4395	V	101.70	PK	- - -	No	Carrier
2.4400		71.19	AV	- - -		Carrier
2.4404	H	106.97	PK	- - -	No	Carrier
2.4400		75.01	AV	- - -		Carrier
4.8809	H	59.29	PK	74	Yes	Passed
4.8801		45.23	AV	54		Passed
7.3186	H	48.72	PK	74	Yes	Passed
7.3213		34.18	AV	54		Passed



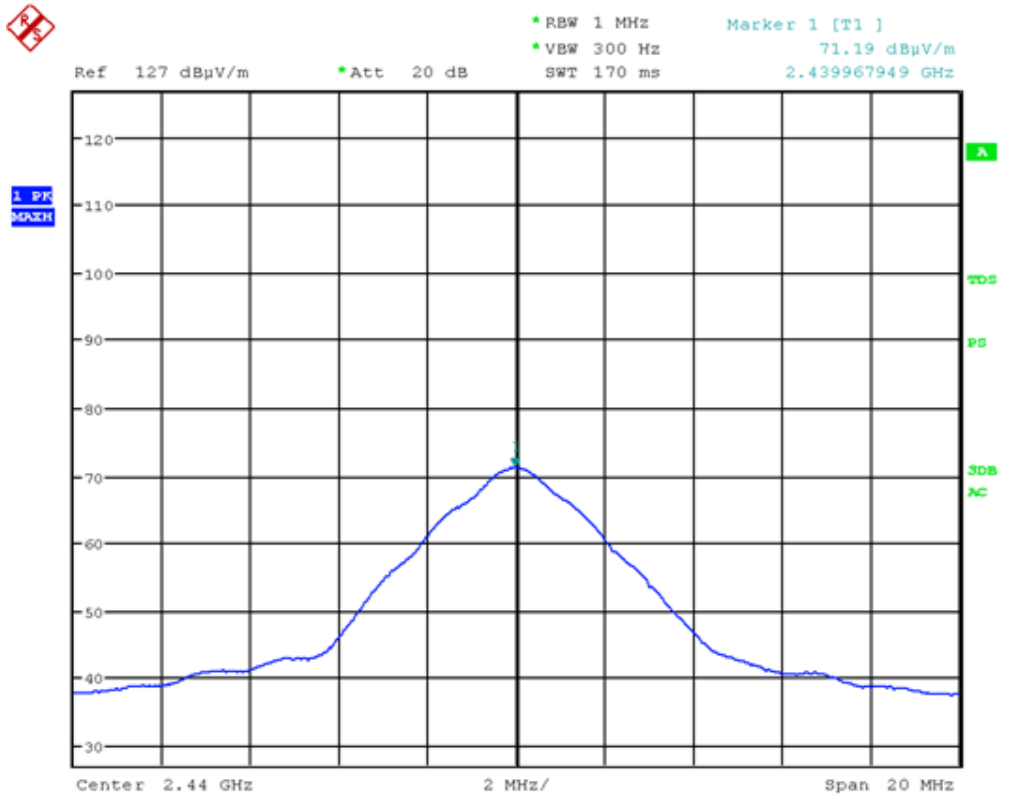
Picture 91: spurious emission channel 18 – PK, horizontal polarization



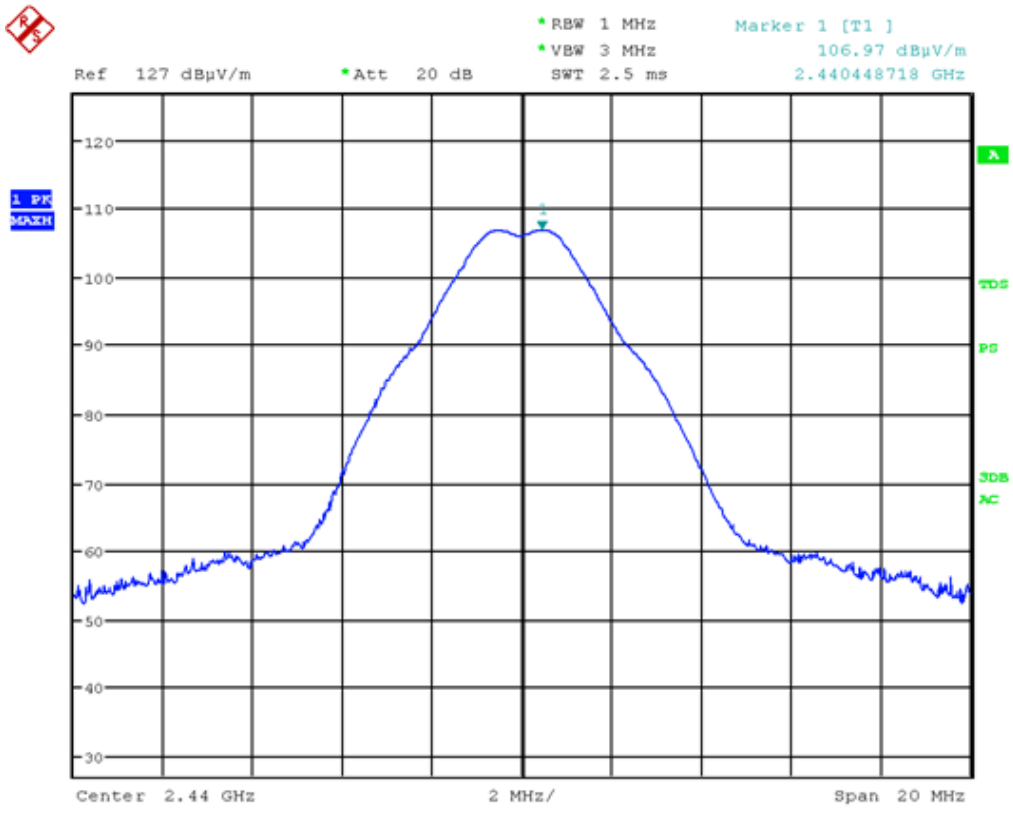
Picture 92: spurious emission channel 18 - AV, horizontal polarization



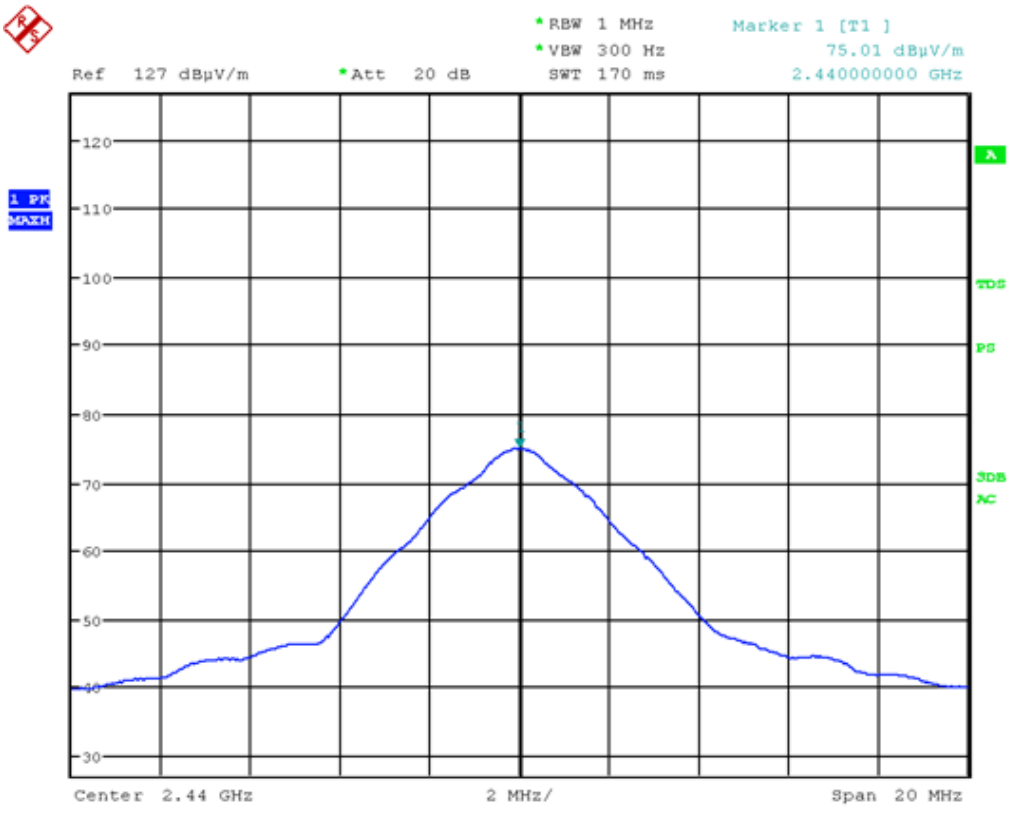
Picture 93: spurious emission channel 18 - PK, vertical polarization



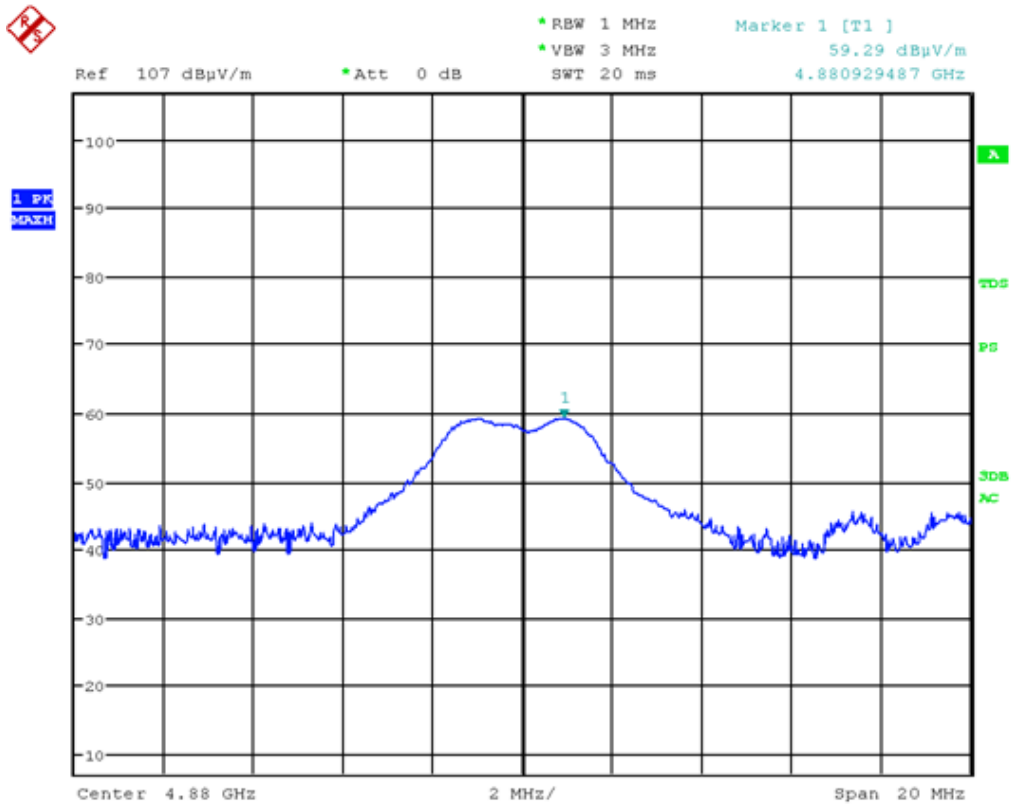
Picture 94: spurious emission channel 18 - AV, vertical polarization



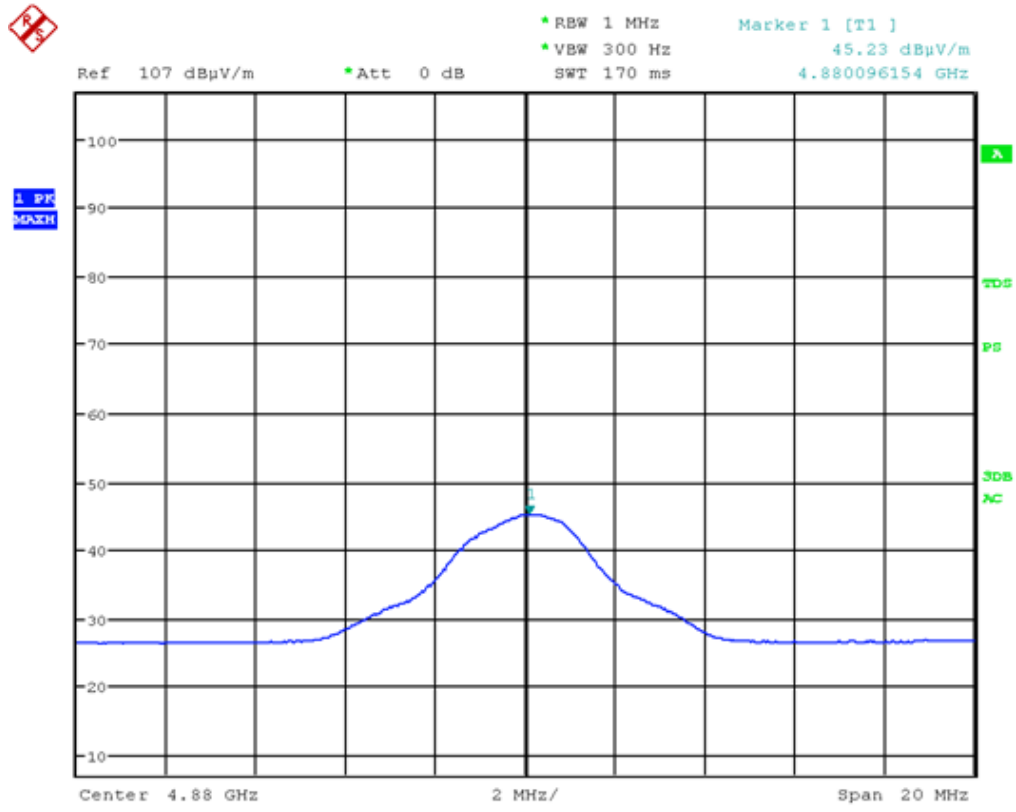
Picture 95: spurious emission channel 18 - PK, horizontal polarization



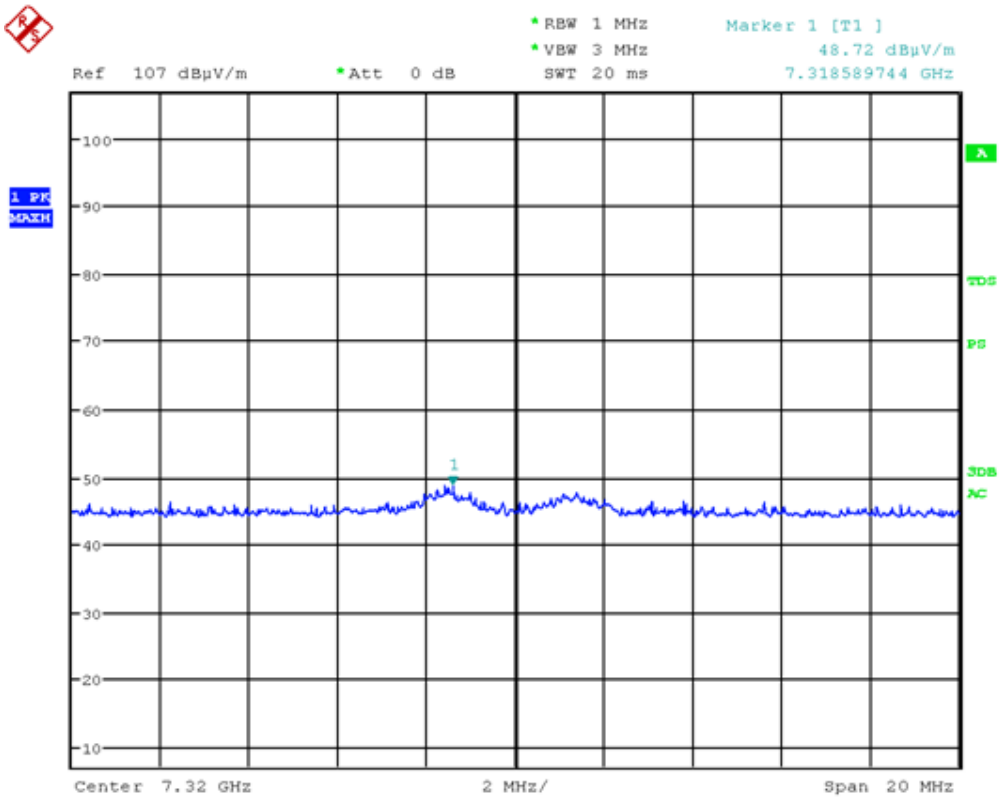
Picture 96: spurious emission channel 18 - AV, horizontal polarization



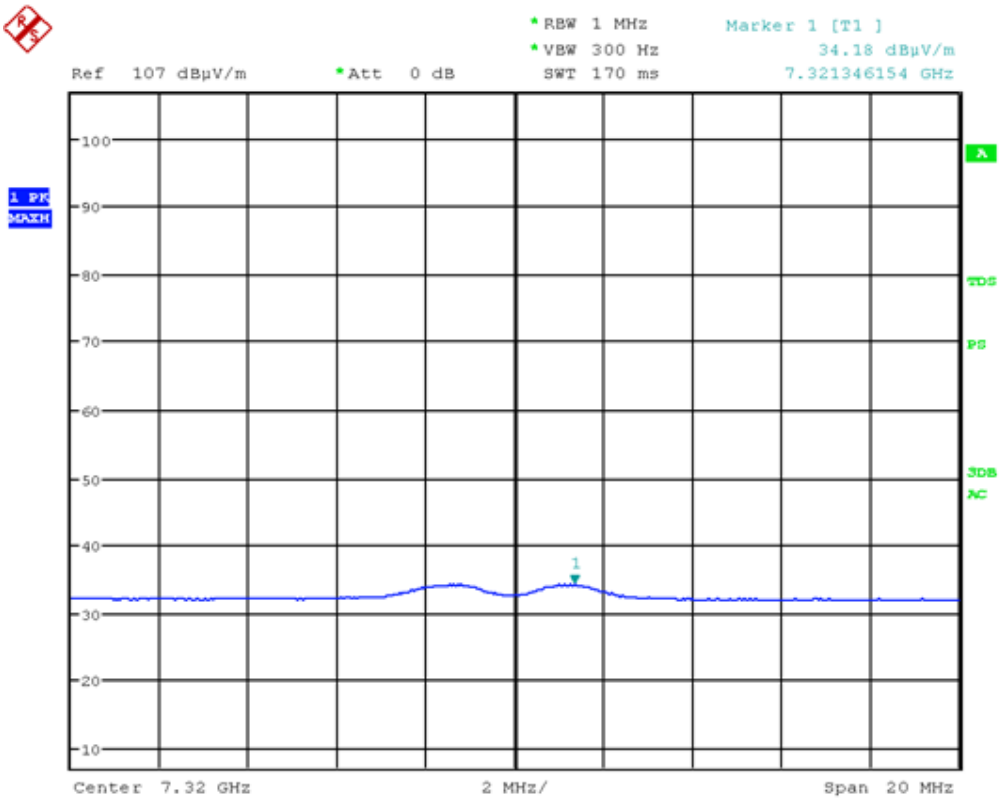
Picture 97: spurious emission channel 18 - PK, horizontal polarization



Picture 98: spurious emission channel 18 - AV, horizontal polarization



Picture 99: spurious emission channel 18 - PK, horizontal polarization



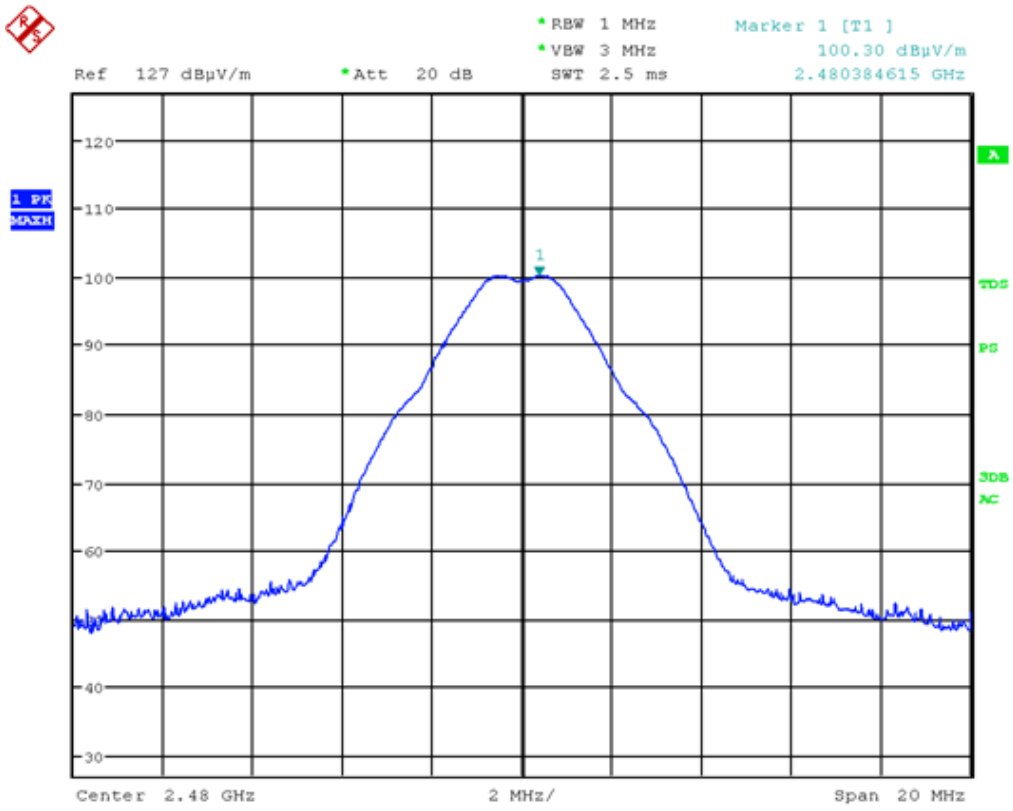
Picture 100: spurious emission channel 18 - AV, horizontal polarization

12.10 Test results channel 26

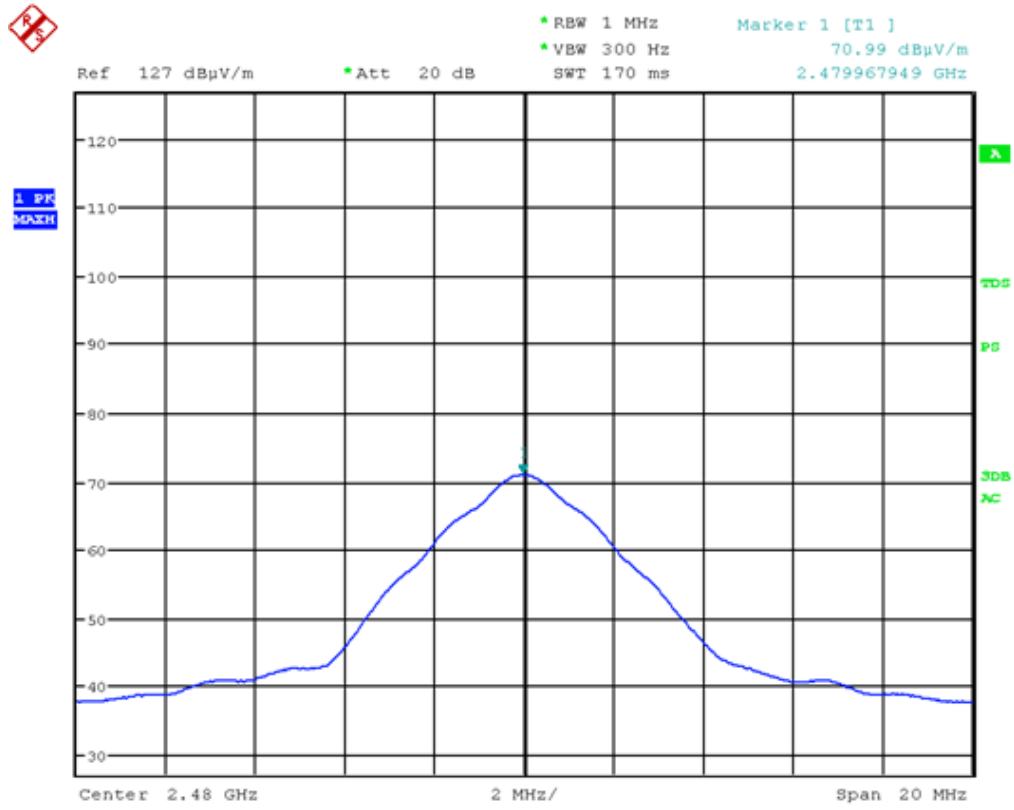
Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2014-08-27

Final Results:

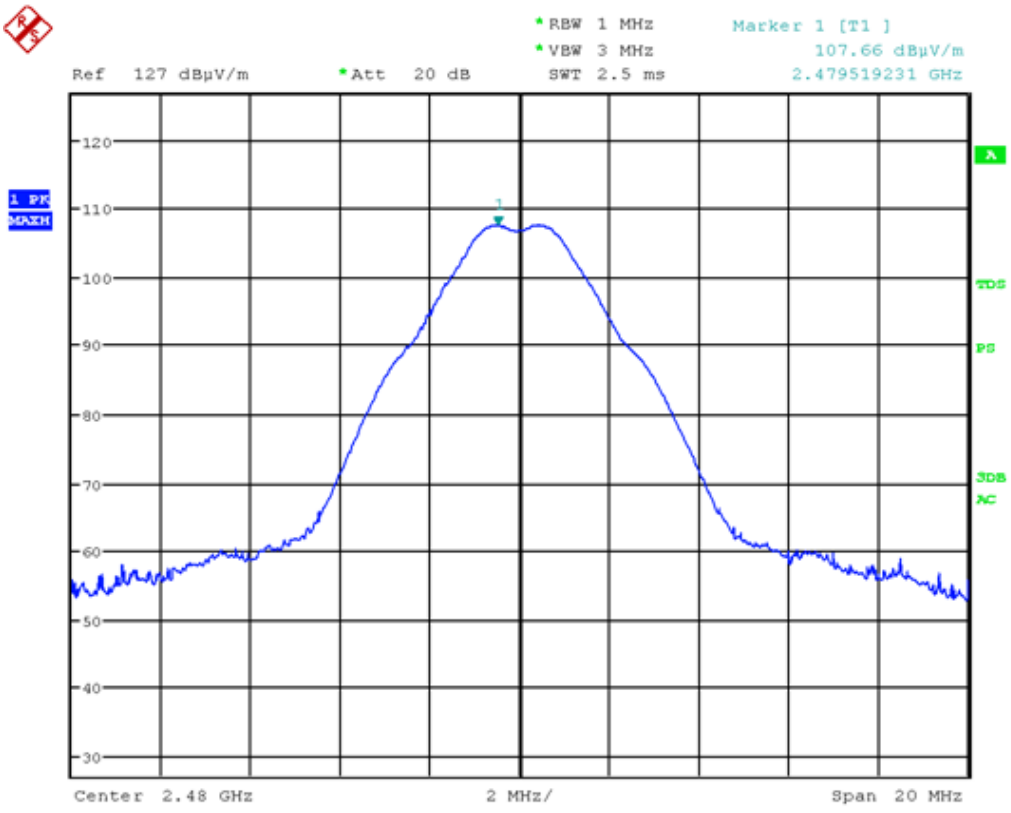
Frequency [GHz]	Antenna polarization	Reading [dBµV/m]	Detector	Limit [dBµV/m]	Restricted Band	Result
Channel 26						
2.4804	V	100.30	PK	- - -	No	Carrier
2.4800		70.99	AV	- - -		Carrier
2.4795	H	107.66	PK	- - -	No	Carrier
2.4800		75.37	AV	- - -		Carrier
4.9591	V	59.19	PK	74	Yes	Passed
4.9600		45.37	AV	54		Passed



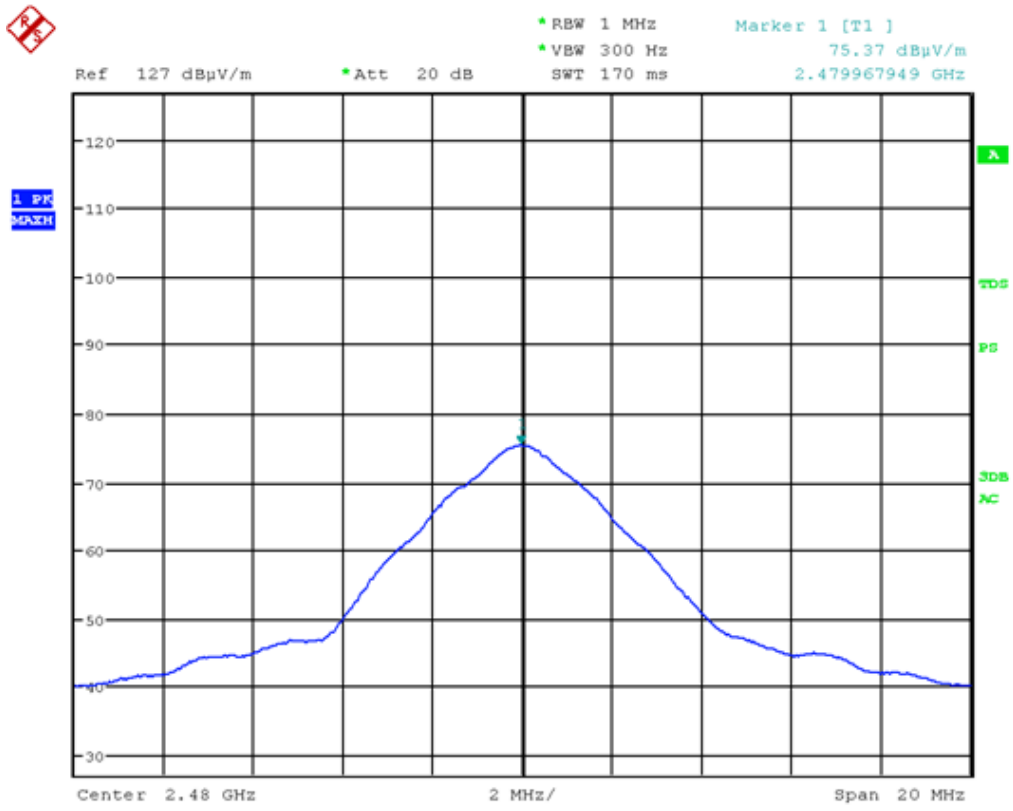
Picture 101: spurious emission channel 26 – PK, vertical polarization



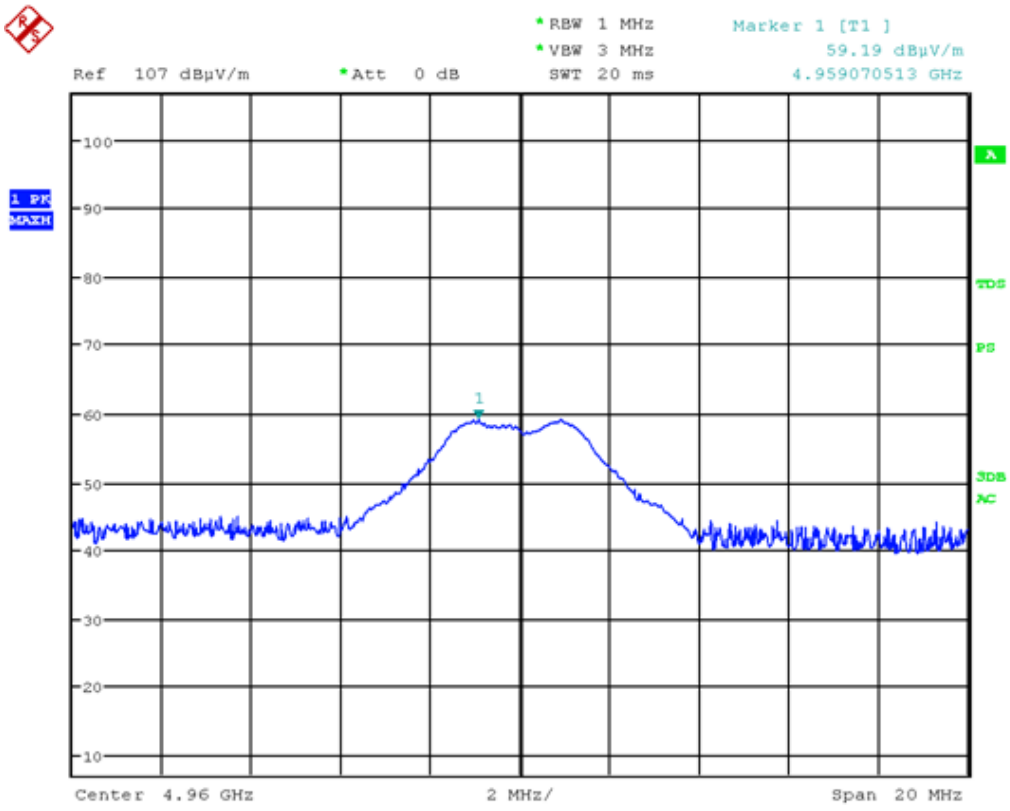
Picture 102: spurious emission channel 26 - AV, vertical polarization



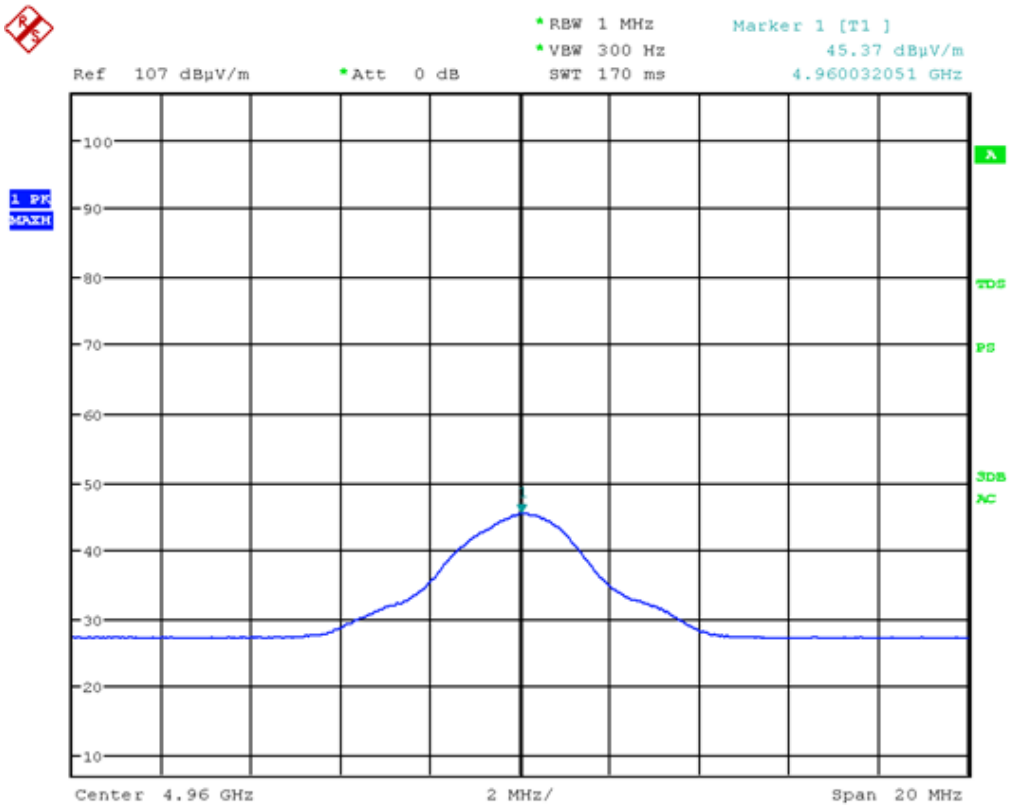
Picture 103: spurious emission channel 26 - PK, horizontal polarization



Picture 104: spurious emission channel 26 - AV, horizontal polarization



Picture 105: spurious emission channel 26 - PK, vertical polarization



Picture 106: spurious emission channel 26 - AV, vertical polarization

13 Radio frequency radiation exposure evaluation for mobile devices

according to CFR 47 Part 2, section 2.1091, OET Bulletin 65, RSS-Gen Issue 4, section 3.2, and RSS-102 Issue 4, section 2.5.2

13.1 Equipment data

Antenna detachable (see antenna specifications):	☒ yes	☐ no
Antenna gain G referring to isotropic radiator:	0.0 dBi	
	Numeric gain:	1.0
Conducted output power CP (maximum):	11.68 dBm	
	Numeric power:	14.72 mW
Separation distance between user and transmitting device:	☐ R ≤ 20 cm	☒ R > 20 cm

13.2 RF exposure evaluation calculating EIRP

The device operates at or above 1.5 GHz and the maximum equivalent isotropically radiated power (e.i.r.p.) of the device is equal to or less than 5 W: ☒ yes ☐ no

$$EIRP = G \cdot CP = 1.0 \cdot 14.72 \cdot 10^{-3} W = 0.015 W$$

13.3 RF exposure evaluation calculating power density

The device operates at or above 1.5 GHz and the maximum permissible exposure (MPE) of the device is equal to or less than the power density limit specified for general population / uncontrolled exposure of 1 mW / cm²: ☒ yes ☐ no

$$S = \frac{G \cdot CP}{4 * \pi * R^2}$$

S: power density
π: pi ≈ 3.1416
R: minimum distance

$$S = \frac{1.0 \cdot 14.72\ mW}{4 * \pi * 400\ cm^2} = 0,00293\ \ mW\ /\ cm^2$$

14 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	2015-02
Test receiver	ESCS 30	845552/0008	E00551	2014-01	2015-01
LISN	ESH2-Z5	881362/037	E00004	2013-03	2015-03
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	2013-09	2015-09
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	2014-10	2015-10
Climatic chamber 340 l	VC³ 4034	58566123250010	C00015	2014-09	2016-09
Cable set shielded room	Cable no. 30	---	E00424	2014-07	2015-07
Cable set CDC	Cables no. 37 and 38	---	E00459 E00460	2014-05	2015-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2014-10	2015-10
Cable set OATS 10 m	Cables no. 19, 33 and 36	---	E00453 E00455 E00458	2014-10	2015-10
Cable set anechoic chamber 01	Cables no. 01, 09, 11 and 13	---	W00095 E00307 E00319 E00436	2014-04	2015-04

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	2014-04	2015-04

Table 1: Equipment calibration status

Note: Expiration date of measurement facility registration (OATS) by
- FCC (registration number 221458): 2017-04
- Industry Canada (test site number 3472A-1): 2015-10

15 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 2: 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 %.

16 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, November 10th, 2014

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

17 Revision History

Date	Description	Person	Revision
2014-11-10	First edition	M. Müller	- - - -