

# Test Report

**Customer:**

WTW Wissenschaftlich-Technische  
Werkstätten GmbH

Dr.-Karl-Slevogt-Straße 1  
82362 Weilheim

Tel.: +49 881 183-245  
Fax: +49 881 183-314

## RF test report

140708-AU01+W02



Industry  
Canada

Industrie  
Canada

**WTW Wissenschaftlich-Technische  
Werkstätten GmbH**

**IQ Sensor Net**

MIQ/WL PS



The test result refers exclusively  
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EMV **TESTHAUS** GmbH  
Revision: 1.0



# EMV **TESTHAUS** GmbH

Gustav-Hertz-Straße 35  
94315 Straubing  
Tel.: +49 9421 56868-0  
Fax: +49 9421 56868-100  
Email: [company@emv-testhaus.com](mailto:company@emv-testhaus.com)

## Accreditation:



FCC facility registration number: 221458  
Test Firm Type "2.948 listed": Valid until 22.04.2017  
Test Firm Type "accredited": Valid until 11.06.2015  
MRA US-EU, FCC designation number: DE0010  
BnetzA-CAB-02/21-02/04 Valid until 27.11.2018

## 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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Gustav-Hertz-Straße 35  
94315 Straubing  
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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)
ANSI C63.10 June 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Public Notice DA 00-705 March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
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 Apparatus
RSS-247 Issue 1, May 2015	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices



EMV **TESTHAUS** GmbH  
Gustav-Hertz-Straße 35  
94315 Straubing  
Germany  
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## 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 0.150 MHz to 30 MHz	RSS-Gen Issue 4, section 8.8
15.247(a)	Carrier Frequency Separation	RSS-247 Issue 1, section 5.1 (2)
15.247(a)	Number of Hopping Frequencies	RSS-247 Issue 1, section 5.1 (4)
15.247(a)	Time of Occupancy (Dwell time)	RSS-247 Issue 1, section 5.1 (4)
15.247(a)	20 dB bandwidth	RSS-247 Issue 1, section 5.1 (1)
15.247(b)	Maximum conducted output power	RSS-Gen Issue 4, section 6.12 RSS-247 Issue 1, section 5.4
15.247(d)	Band-edge Compliance	RSS-247 Issue 1, section 5.5
15.247(d)	Spurious RF Conducted Emission	RSS-247 Issue 1, section 5.5
15.247(d)	Radiated emission 9 kHz to 10 <sup>th</sup> Harmonic	RSS-Gen Issue 4, section 6.13 RSS-247 Issue 1, section 5.5



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Gustav-Hertz-Straße 35  
94315 Straubing  
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## 1.2 Summary of test results

Standard	Test result
FCC CFR 47 Part 15, section 15.247	Passed
RSS-247 Issue 718 Annex 8 and RSS-Gen Issue 4	Passed



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94315 Straubing  
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## 2 Equipment under Test (EUT)

Product type:	IQ Sensor Net
Model Name:	MIQ/WL PS
Manufacturer:	WTW Wissenschaftlich-Technische Werkstätten GmbH
Serial number:	99990010
FCC ID:	2AFB2-MIQWLPS001
IC:	20401 -MIQWLPS001
Application freq. band:	2400 MHz – 2483.5 MHz
Frequency range:	Even-Band: 2414.5MHz - 2458.5 MHz Odd-Band: 2415.5 MHz - 2459.5 MHz
Operating frequency:	Even-Band: 2414.5MHz - 2458.5 MHz Odd-Band: 2415.5 MHz - 2459.5 MHz
Channel spacing:	2 MHz
Number of RF-channels:	Even-Band: 23 Odd-Band: 23
Maximum output power:	<input checked="" type="checkbox"/> ≤ 125 mW <input type="checkbox"/> > 125 mW
Type of modulation:	FHSS
Antenna type:	external dipole antenna with sma-connector
Antenna gain:	2.5 dBi
Power supply:	100 ... 240 V AC, 50/60 Hz
Temperature range:	-20°C to +55°C



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## 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 part of a sensor network to measure oxygen concentration. The measurement data are transferred via 2.4-GHz-band.

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

For tests the EUT was configured as follows:

- channel selection where required according to table 1:

Channel	Even-Band	Odd-Band
Low	2414.5 MHz	2415.5 MHz
Mid	2436.5 MHz	2437.5 MHz
High	2458.5 MHz	2459.5 MHz

Table 1: Channel selection

- hopping where required (Even-/Odd-band)
- Software revision: V2.08
- Power reduction level: 9



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The following combinations of tests, channels and bands were applied:

<b>Test</b>	<b>Even-Band</b> Channel low//high	<b>Odd-Band</b> Channel low/high	<b>Even-Band</b> Channel low <b>Odd-Band</b> Channel high
AC power line conducted emissions			<b>X</b>
Carrier frequency separation	<b>X</b>	<b>X</b>	
Number of hopping frequencies	<b>X</b>	<b>X</b>	
Time of occupancy (Dwell time)	<b>X</b>	<b>X</b>	
6 dB bandwidth	<b>X</b>	<b>X</b>	
20 dB bandwidth	<b>X</b>	<b>X</b>	
Occupied bandwidth (99 %)	<b>X</b>	<b>X</b>	
Maximum conducted output power	<b>X</b>	<b>X</b>	
Band-edge compliance			<b>X</b>
Spurious RF conducted emission			<b>X</b>
Radiated emission 9 kHz to 10th harmonic			<b>X</b>



## 2.4 Configuration

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

Device	Model:	S/N
IQ Sensor Net	MIQ/WL PS	99990010
Oxygen sensor	TriOxmatic 700 IQ	----
AC power source	CHROMA 61602, 120VAC / 60Hz	616020002099

### Used cables

Numbers:	Description: (type / lengths / remarks)	Serial No
1	AC power supply cable / 2.0 m / protection class 2	N/A
1	DC power supply cable / 2.3m / plus and minus (only necessary for tests according to ETSI-standards)	N/A
1	cable MIQ/WL PS <-> TriOxmatic 700 IQ /4.0m / power supply for oxygen sensor and data transmission	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.
<input checked="" type="checkbox"/>	ESCS 30	Rohde & Schwarz	E00003
<input type="checkbox"/>	ESCI	Rohde & Schwarz	E00001
<input type="checkbox"/>	ESH3 Z2	Rohde & Schwarz	E00028
<input type="checkbox"/>	ESH 2-Z5	Rohde & Schwarz	E00004
<input checked="" type="checkbox"/>	ESH 2-Z5	Rohde & Schwarz	E00005

## 3.3 Limits

Frequency [MHz]	Quasi-peak [dB $\mu$ V]	Avarage [dB $\mu$ V]
0.15 – 0.5	66 - 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50



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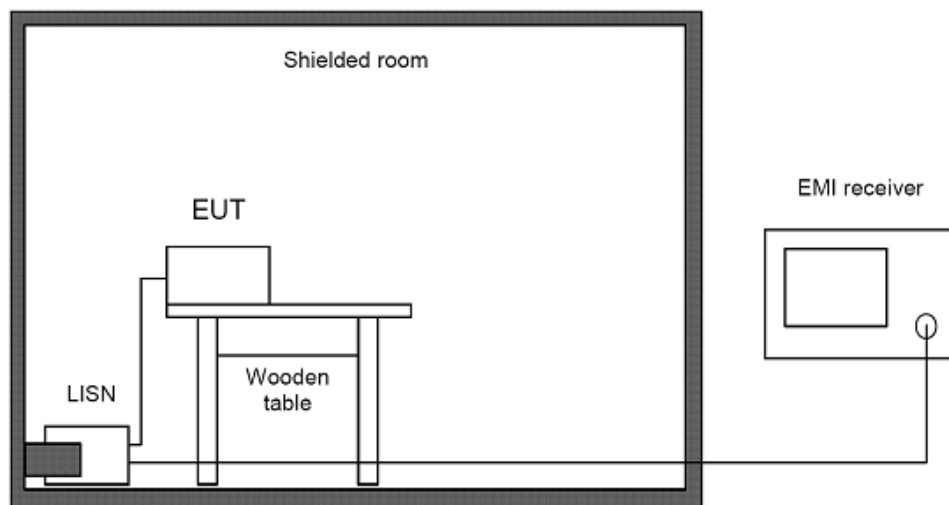
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### 3.4 Test procedure

1. The tests of conducted emission were carried out in a shielded room using a line impedance stabilization network (LISN) 50  $\mu$ H/50 Ohms and an EMI test receiver.
2. The EMI test receiver was connected to the LISN and set to a measurement bandwidth of 9 kHz in the frequency range from 0.15 MHz to 30 MHz.
3. The EUT was placed on a wooden table and connected to the LISN.
4. To accelerate the measurement the detector of the EMI test receiver was set to peak and the whole frequency range from 0.15 MHz to 30 MHz were scanned.
5. After that all peaks values with fewer margins than 10 dB to quasi-peak limit or exceeding the limit were marked and re-measured with quasi-peak detector.
6. If after that all values are under the average limit no addition measurement is necessary. In case there are still values between quasi-peak and average limit than these values were re-measured again with an average detector.
7. These measurements were done on all current carrying conductors.

Note: Tests shall be performed with antenna connected as specified in clause 6.2 of ANSI C63.10. According to FCC KDB 174176 D01 Q5 additional testing of intentional radiators operating below 30 MHz with permanent or detachable antenna shall be performed using a dummy load to check for compliance within the transmitter's fundamental emission band.

### 3.5 Test setup



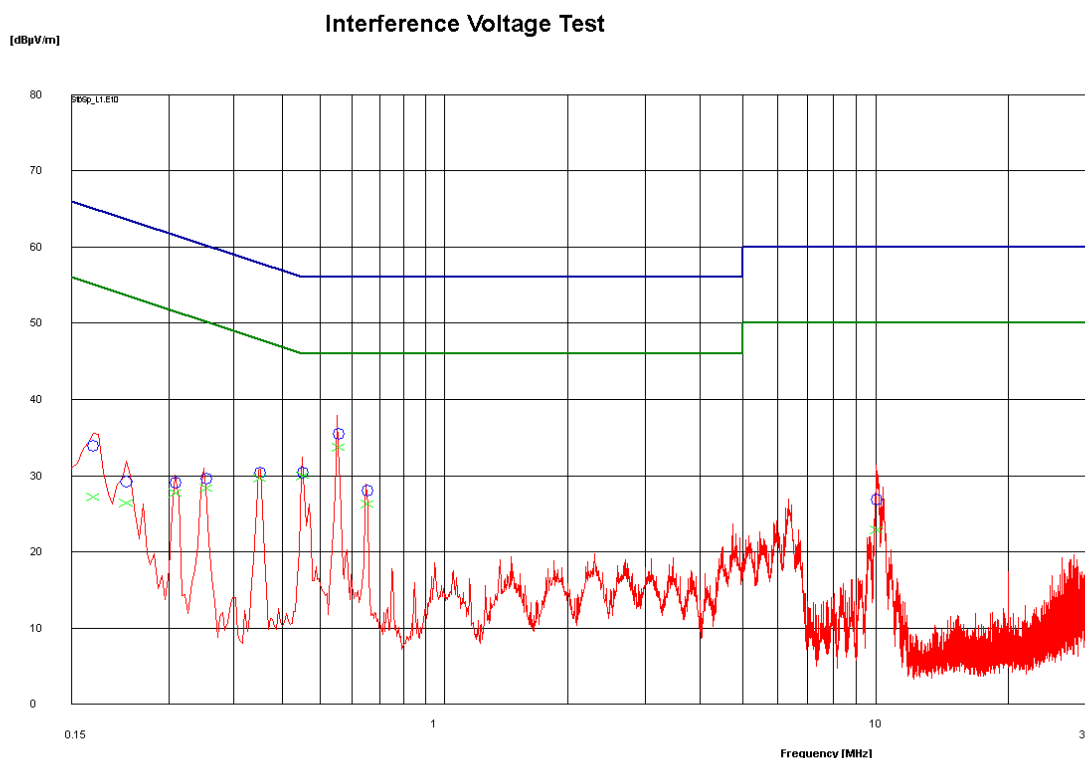
Picture 1: Outline of conducted emission test setup

Comments: - none -



### 3.6 Test results

Temperature:	21°C	Humidity:	56%
Tested by:	M. Müller	Test date:	2015-05-19



Picture 2: AC power line conducted emissions, phase1 - trace

E.	Freq. [MHz]	U_CISPR ...	Limit CISPR	delta CISPR	U_AV ...	Limit AV	delta AV	Date	P.	Remarks	U_Scan ...	Cor.
✓	0.168	33.9	65.1	31.1	27.2	55.1	27.9	2015-05-19 12:47...	L		35.5	0.0
✓	0.1995	29.3	63.6	34.3	26.4	53.6	27.2	2015-05-19 12:47...	L		32.0	0.0
✓	0.258	29.1	61.5	32.4	27.7	51.5	23.8	2015-05-19 12:48...	L		30.1	0.0
✓	0.3035	29.7	60.1	30.5	28.4	50.1	21.8	2015-05-19 12:48...	L		31.1	0.0
✓	0.402	30.4	57.8	27.4	29.7	47.8	18.1	2015-05-19 12:48...	L		30.8	0.0
✓	0.501	30.4	56.0	25.6	30.0	46.0	16.0	2015-05-19 12:48...	L		32.4	0.0
✓	0.605	35.5	56.0	20.5	33.7	46.0	12.3	2015-05-19 12:48...	L		38.0	0.0
✓	0.704	28.1	56.0	27.9	26.3	46.0	19.8	2015-05-19 12:49...	L		28.9	0.0
✓	10.023	26.9	60.0	33.1	22.9	50.0	27.1	2015-05-19 12:49...	L		31.4	0.0

Picture 3: AC power line conducted emissions, phase1 - table

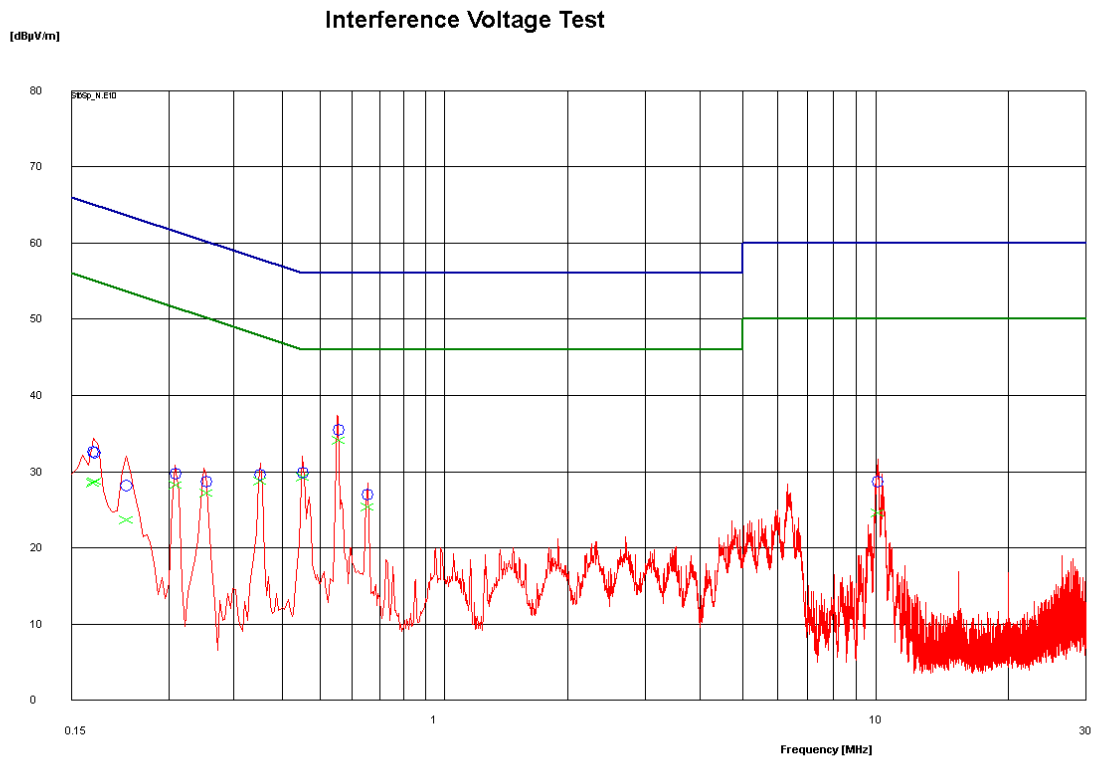


EMV **TESTHAUS** GmbH  
Gustav-Hertz-Straße 35  
94315 Straubing  
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Picture 4: AC power line conducted emissions, neutral - trace

E..	Freq. [MHz]	U_CISPR ...	Limit CISPR	delta CISPR	U_AV ...	Limit AV	delta AV	Date	P..	Remarks	U_Scan ...	Cor.
✓	0.169	32.5	65.0	32.5	28.7	55.0	26.3	2015-05-19 12:50...	N		32.2	0.0
✓	0.168	32.6	65.1	32.4	28.5	55.1	26.5	2015-05-19 12:51...	N		34.4	0.0
✓	0.1995	28.2	63.6	35.4	23.7	53.6	29.9	2015-05-19 12:51...	N		32.1	0.0
✓	0.258	29.7	61.5	31.8	28.2	51.5	23.3	2015-05-19 12:51...	N		30.9	0.0
✓	0.3035	28.7	60.1	31.5	27.2	50.1	22.9	2015-05-19 12:51...	N		30.4	0.0
✓	0.402	29.7	57.8	28.1	28.7	47.8	19.1	2015-05-19 12:51...	N		31.1	0.0
✓	0.501	29.8	56.0	26.2	29.3	46.0	16.7	2015-05-19 12:52...	N		32.0	0.0
✓	0.605	35.5	56.0	20.6	34.1	46.0	11.9	2015-05-19 12:52...	N		37.4	0.0
✓	0.7035	27.1	56.0	28.9	25.4	46.0	20.6	2015-05-19 12:52...	N		28.6	0.0
✓	10.0945	28.7	60.0	31.3	24.6	50.0	25.4	2015-05-19 12:52...	N		31.6	0.0

Picture 5: AC power line conducted emissions, neutral - table

## 4 Carrier Frequency Separation

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

### 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 <b>TESTHAUS</b> GmbH	E00354

### 4.2 Test instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

### 4.3 Limits

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

### 4.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
2. The EUT was connected to the spectrum analyzer
3. The EUT has its hopping function enabled
4. The unit was operated in continuous transmit mode with modulation.
5. After the trace has stabilized the peak of the adjacent channels was recorded using the delta Marker function.



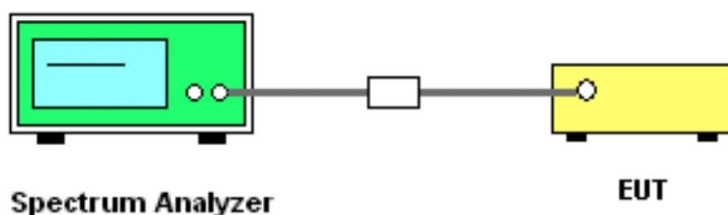
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## 4.5 Test setup



Picture 6: Test setup carrier frequency separation 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 with enabled hopping function.

## 4.8 Test results

Temperature:	23°C	Humidity:	41%
Tested by:	M. Müller	Test date:	2015-05-15

Test Result			
Band	Carrier Frequency Separation (MHz)	Minimum Separation (MHz)	Result
Even	2.000	0.6891	PASS
Odd	2.000	0.6923	PASS

with

### Even-band:

Maximum 20-dB-bandwidth: 1.0337 MHz (>> 25 kHz), see clause 7.8 on page 31  
Maximum output power: 13.01 dBm (20.00 mW < 125 mW),  
see clause 8.8 on page 38  
Minimum separation required:  $2/3 * 20\text{-dB-Bandwidth} = 0.6891 \text{ MHz}$

### Odd-band:

Maximum 20-dB-bandwidth: 1.0385 MHz (>> 25 kHz), see clause 7.8 on page 31  
Maximum output power: 12.91 dBm (19.54 mW < 125 mW),  
see clause 8.8 on page 38  
Minimum separation required:  $2/3 * 20\text{-dB-Bandwidth} = 0.6923 \text{ MHz}$

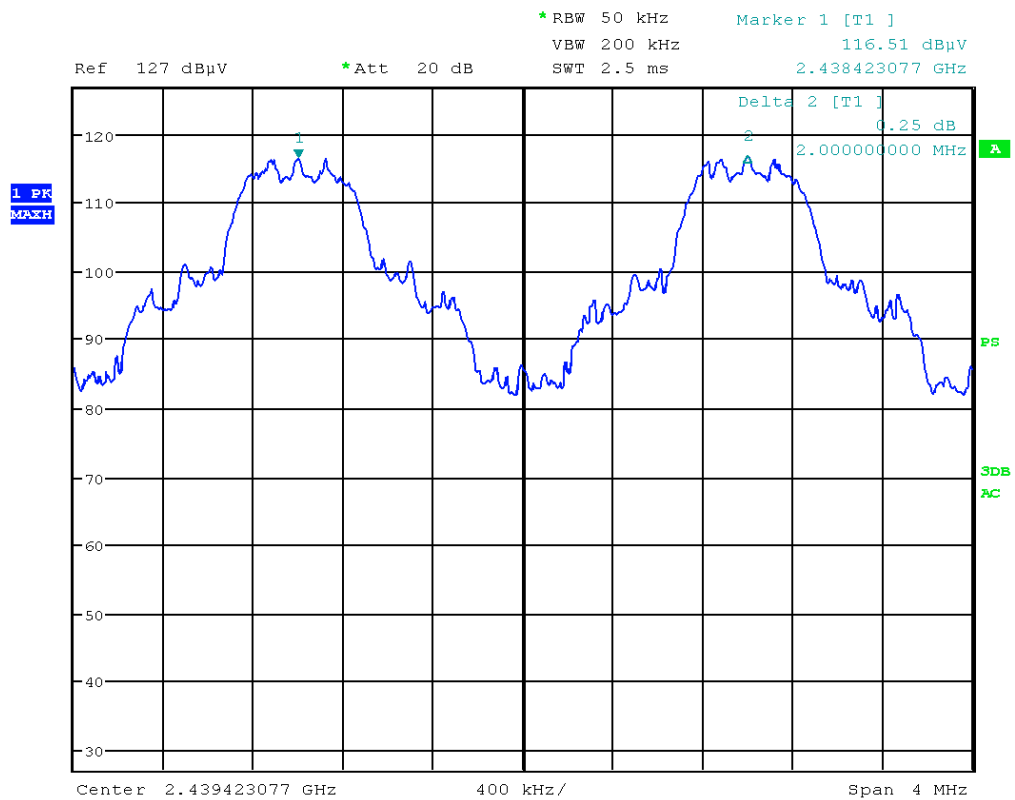


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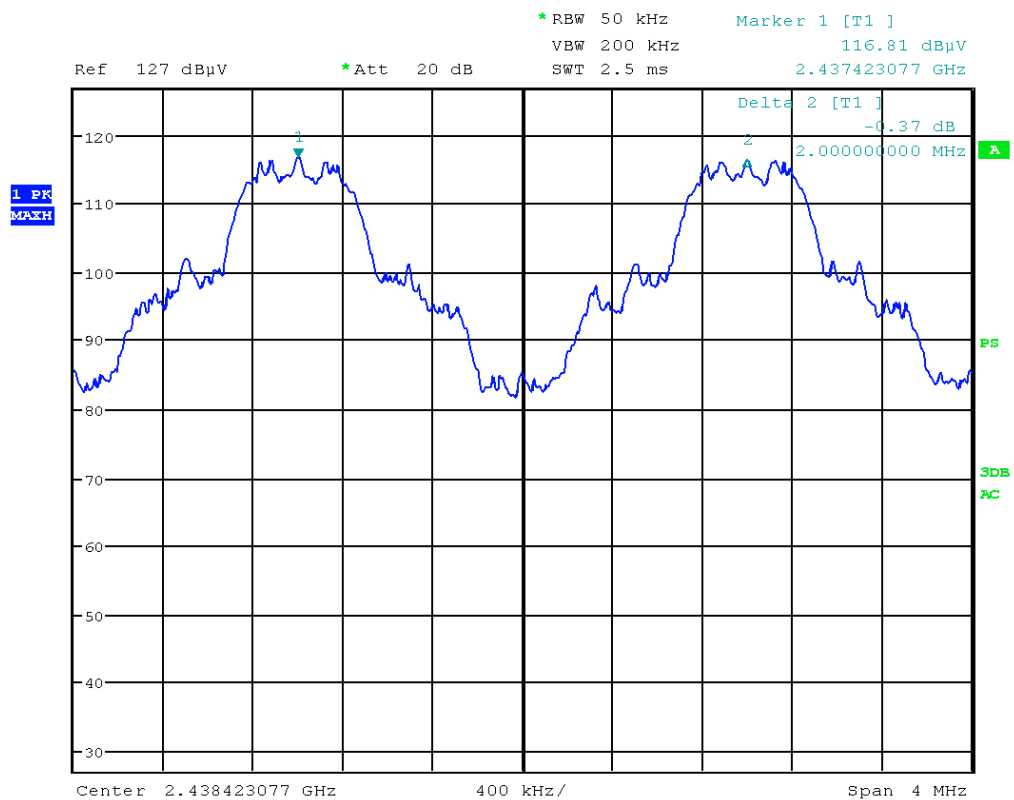
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Picture 7: Carrier Frequency Separation - Even-band



Picture 8: Carrier Frequency Separation - Odd-band

# 5 Number of Hopping Frequencies

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 <b>TESTHAUS</b> GmbH	E00354

## 5.2 Test instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

## 5.3 Limits

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

## 5.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
2. The EUT was connected to the spectrum analyzer
3. The EUT has its hopping function enabled
4. The unit was operated in continuous transmit mode with modulation.
5. After the trace has stabilized count the peaks.
6. To get a higher resolution the frequency range was split in two parts.



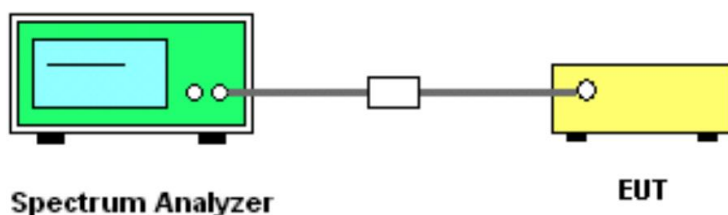
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## 5.5 Test setup



Picture 9: Test setup Number of hopping channels measurement

## 5.6 Test Deviation

There is no deviation with the original standard.

## 5.7 EUT operation during test

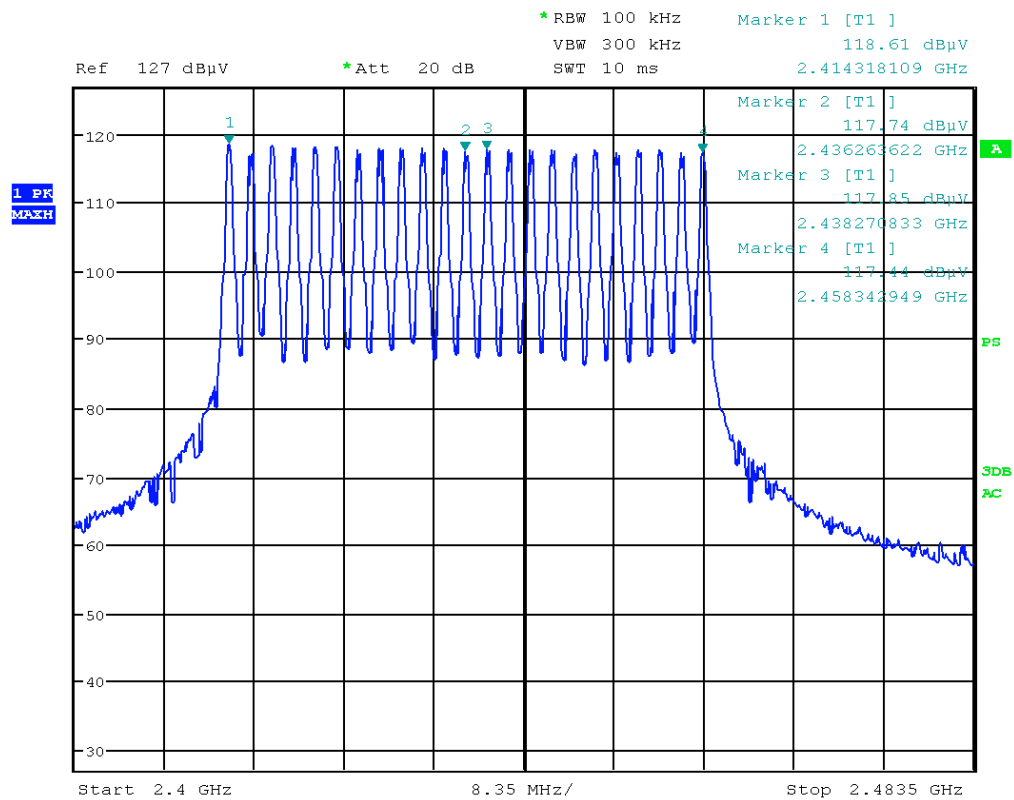
The EUT was programmed to be in continuously transmitting mode with enabled hopping function.

## 5.8 Test results

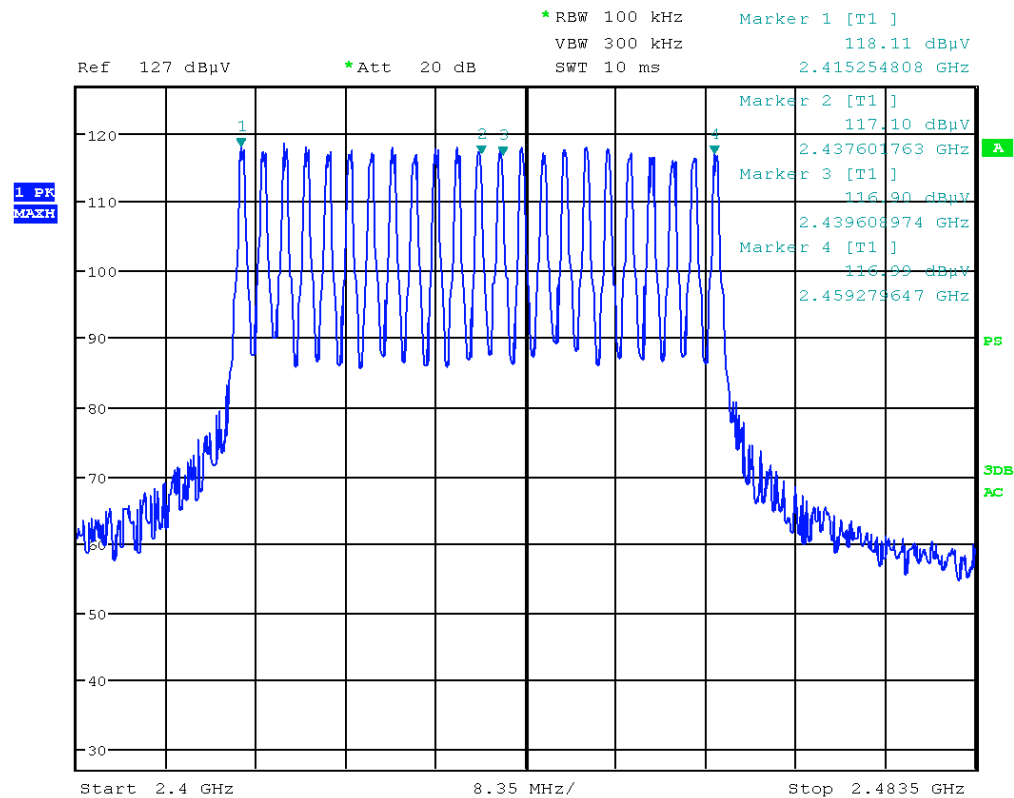
Temperature:	23°C	Humidity:	41%
Tested by:	M. Müller	Test date:	2015-05-15

Test Result	
Band	Number of Hopping Channels
Even	23
Odd	23





Picture 10: Number of hopping frequencies - Even-band



Picture 11: Number of hopping frequencies - Odd-band

# 6 Time of Occupancy (Dwell time)

according to CFR 47 Part 15, section 15.247(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 <b>TESTHAUS</b> GmbH	E00354

## 6.2 Test instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

## 6.3 Limits

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

## 6.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
2. The EUT was connected to the spectrum analyzer
3. The EUT has its hopping function enabled
4. The unit was operated in continuous transmit mode with modulation.



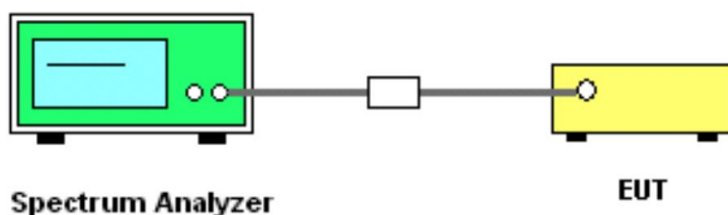
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## 6.5 Test setup



Picture 12: Test setup time of occupancy measurement

## 6.6 Test Deviation

There is no deviation with the original standard.

## 6.7 EUT operation during test

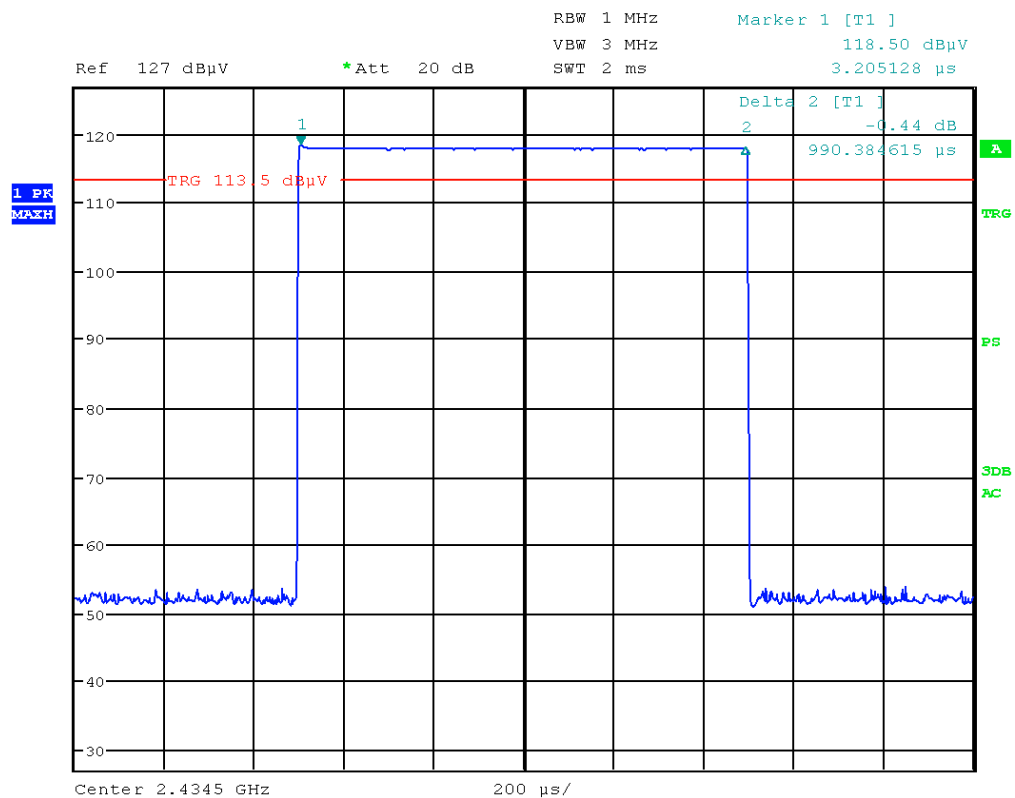
The EUT was programmed to be in continuously transmitting mode with enabled hopping function.

## 6.8 Test results

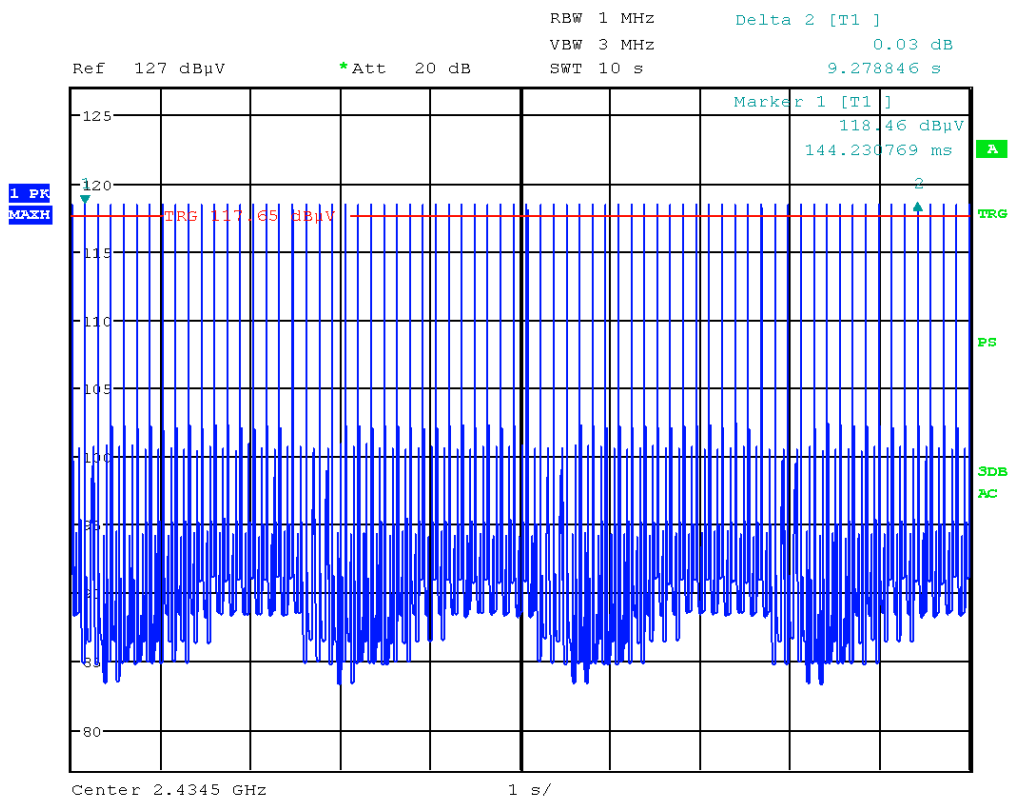
Temperature:	23°C	Humidity:	41%
Tested by:	M. Müller	Test date:	2015-05-15

Band	Time of Transmission (23ch * 0.4s)	Number of hops within time of transmission	Signal On time (msec)	Result (Dwell Time) (msec)	Limit (msec)	Result
Even	9.2s	64	0.99038	63.38432	400	PASS
Odd	9.2s	64	0.99359	63.58976	400	PASS

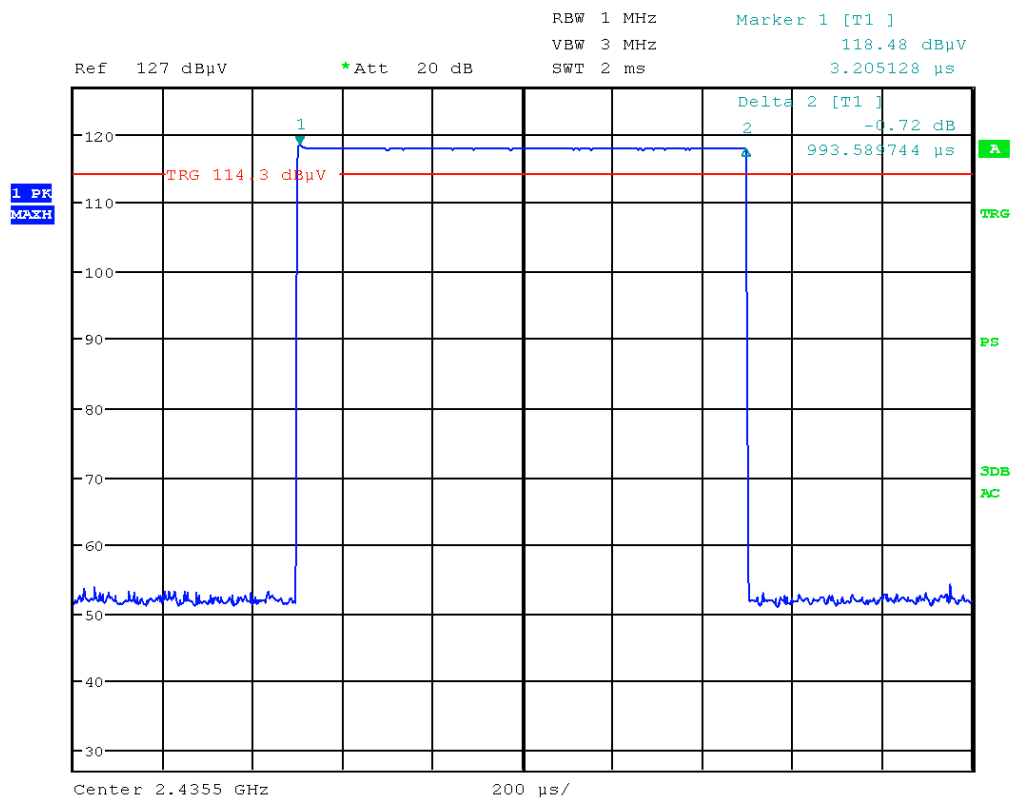
Dwell Time = Number of hops within Time of Transmission\*Signal On Time



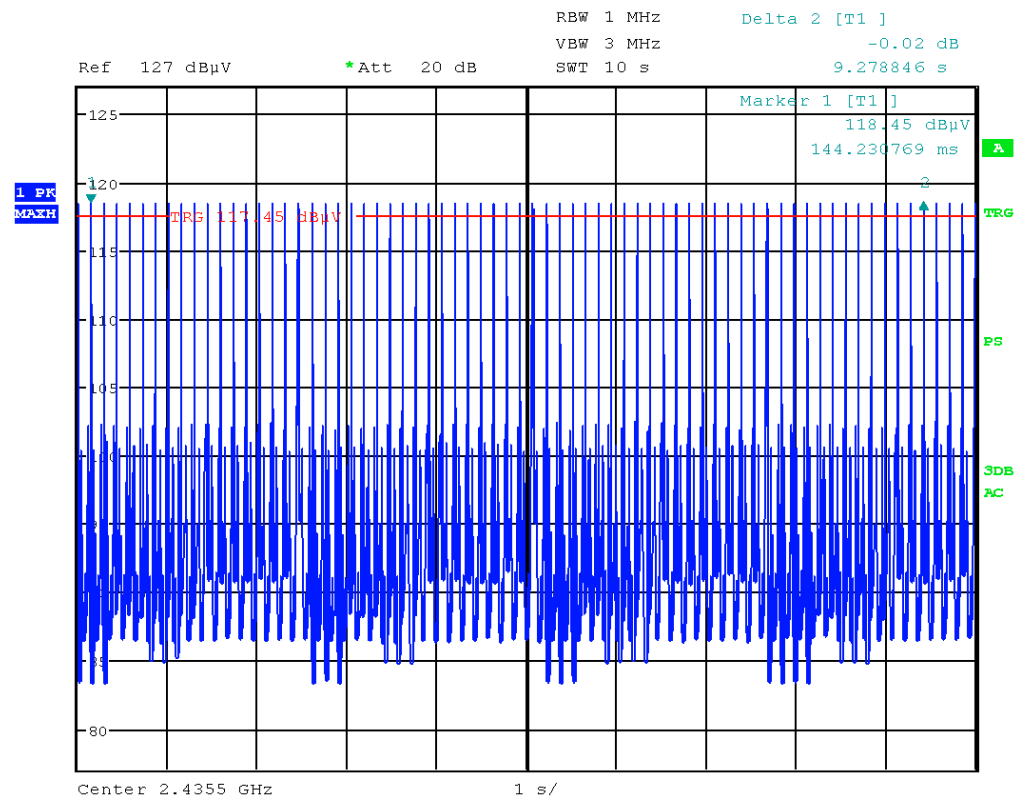
Picture 13: Signal-on-Time - Even-band



Picture 14: Number of hops within Time of Transmission - Even-band



Picture 15: Signal-on-Time - Odd-band



Picture 16: Number of hops within Time of Transmission - Odd-band

# 7 20 dB bandwidth

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

## 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 <b>TESTHAUS</b> GmbH	E00354

## 7.2 Test Instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

## 7.3 Limits

N/A

## 7.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
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. Resolution and video bandwidth were set to at least 1 % of the 20 dB bandwidth.
5. Measure the spectrum width with power higher than 20 dB below carrier. The transmitter output (antenna port) was connected to the spectrum analyzer.



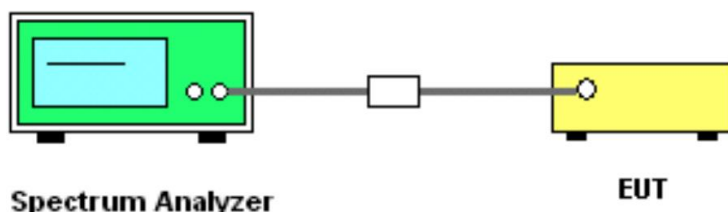
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## 7.5 Test setup



Picture 17: Test setup for 20dB bandwidth measurement

## 7.6 Test deviation

There is no deviation with the original standard.

## 7.7 EUT operation during test

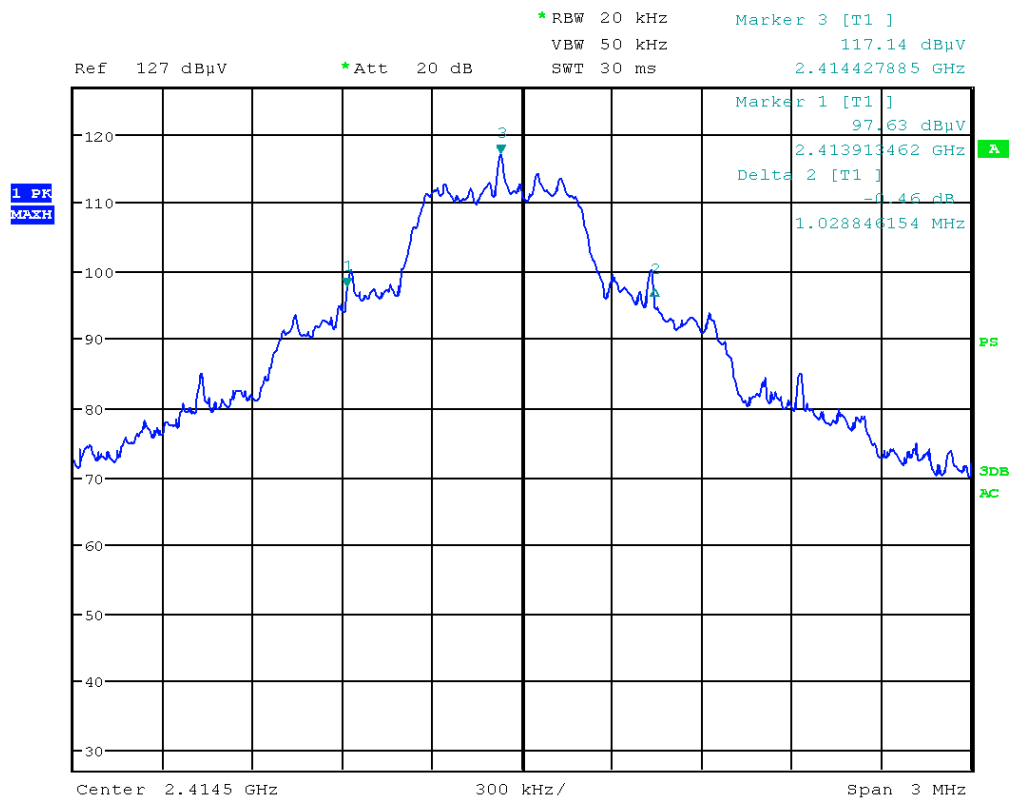
The EUT was programmed to be in continuously transmitting mode.

## 7.8 Test results

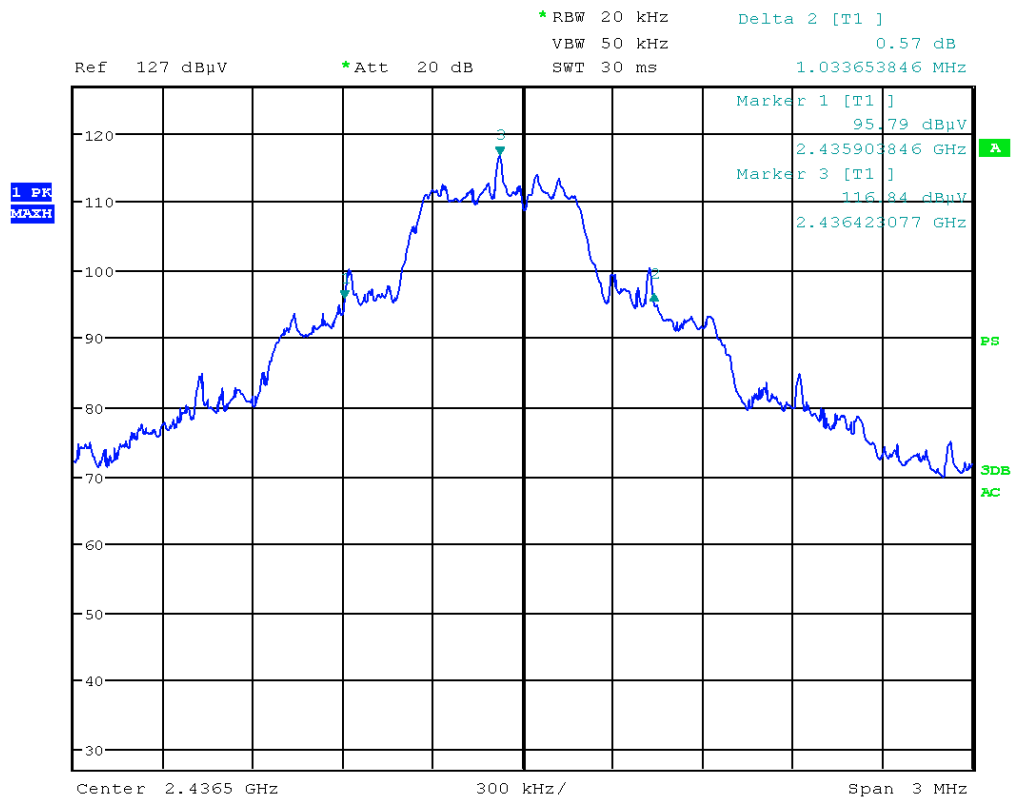
Temperature:	23°C	Humidity:	41%
Tested by:	M. Müller	Test date:	2015-05-15

Band	Channel	Frequency (GHz)	20 dB bandwidth (MHz)
Even	Low	2.4144	1.0288
	Mid	2.4364	1.0337
	High	2.4584	1.0337

Band	Channel	Frequency (GHz)	20 dB bandwidth (MHz)
Odd	Low	2.4154	1.0288
	Mid	2.4374	1.0385
	High	2.4594	1.0337

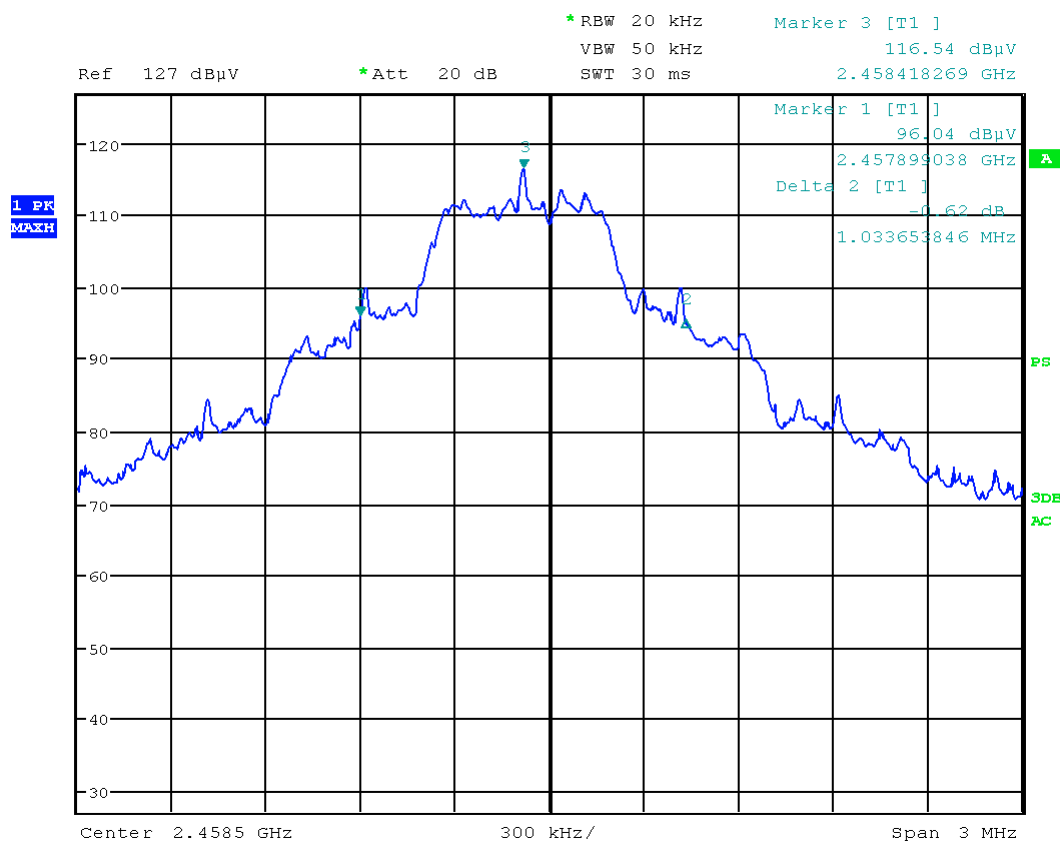


Picture 18: 20dB bandwidth - Even-band, channel low

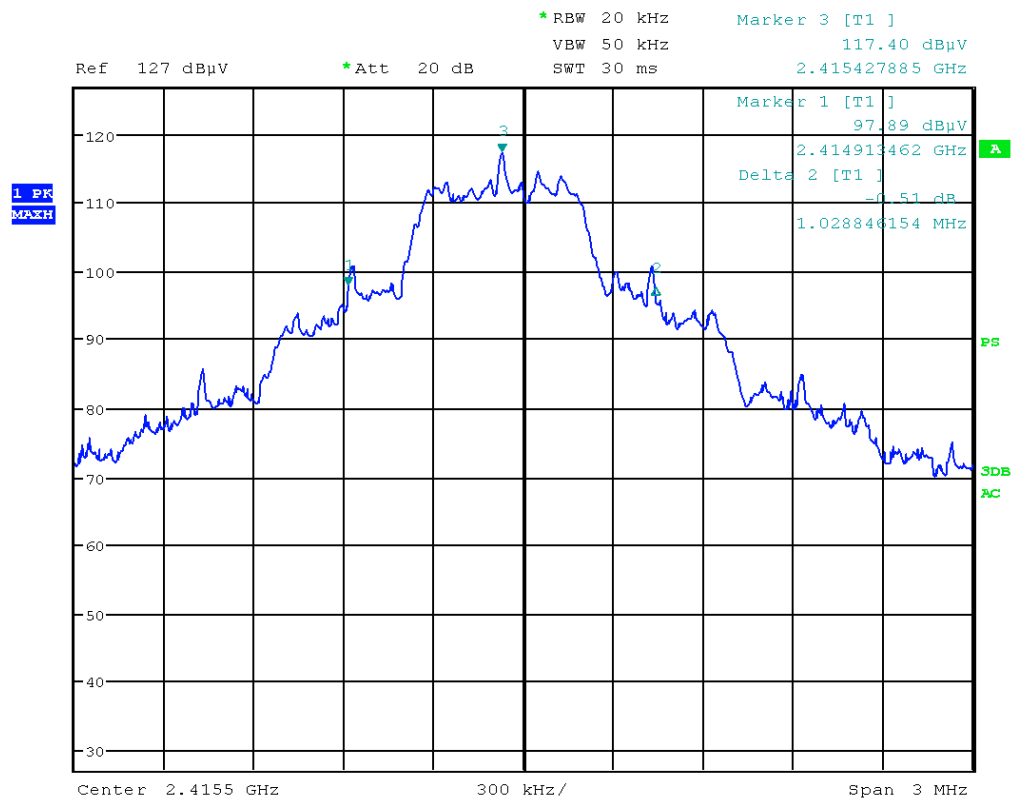


Picture 19: 20dB bandwidth - Even-band, channel mid





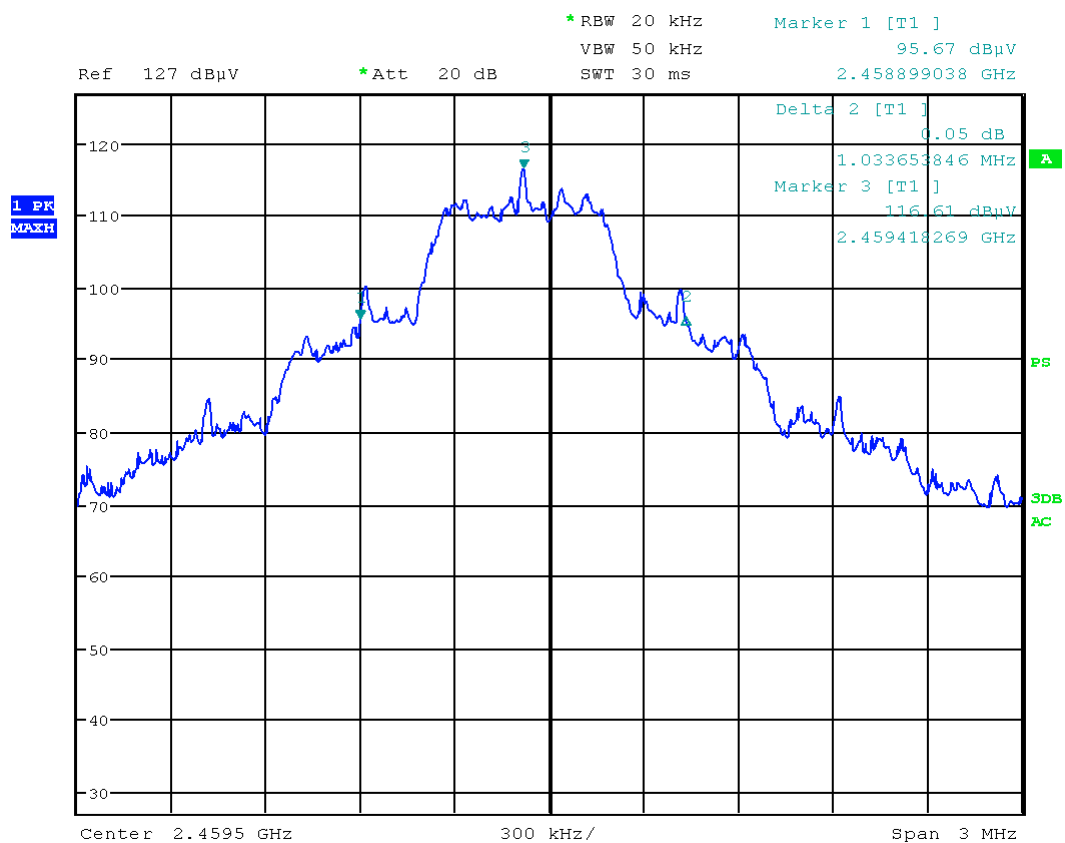
Picture 20: 20dB bandwidth - Even-band, channel high



Picture 21: 20dB bandwidth - Odd-band, channel low



Picture 22: 20dB bandwidth - Odd-band, channel mid



Picture 23: 20dB bandwidth - Odd-band, channel high

# 8 Maximum conducted output power

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

## 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 <b>TESTHAUS</b> GmbH	E00354

## 8.2 Test instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

## 8.3 Limits

For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt (30 dBm).

For all other frequency hopping systems in the 2400–2483.5 MHz band:  
0.125 watts (21 dBm).

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.



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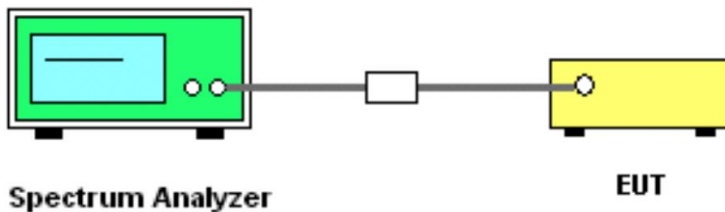
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## 8.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
2. The transmitter output (antenna port) was connected to the spectrum analyzer.
3. Test was performed in accordance with standard mentioned above.

## 8.5 Test setup



Picture 24: Test setup for conducted output power 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:	23°C	Humidity:	41%
Tested by:	M. Müller	Test date:	2015-05-15

Band	Channel	Frequency (GHz)	Detector	Conducted power		Limit (dBm)	Result
				reading (dBm)	final (dBm)		
Even	Low	2.4143	PK	12.55	13.00	21	PASS
	Mid	2.4363	PK	11.98	12.43	21	PASS
	High	2.4585	PK	11.47	11.92	21	PASS

Band	Channel	Frequency (GHz)	Detector	Conducted power		Limit (dBm)	Result
				reading (dBm)	final (dBm)		
Odd	Low	2.4156	PK	12.46	12.91	21	PASS
	Mid	2.4376	PK	11.89	12.34	21	PASS
	High	2.4593	PK	11.19	11.64	21	PASS

Comments: Final conducted power value is reading value + cable attenuation (0.45 dB)

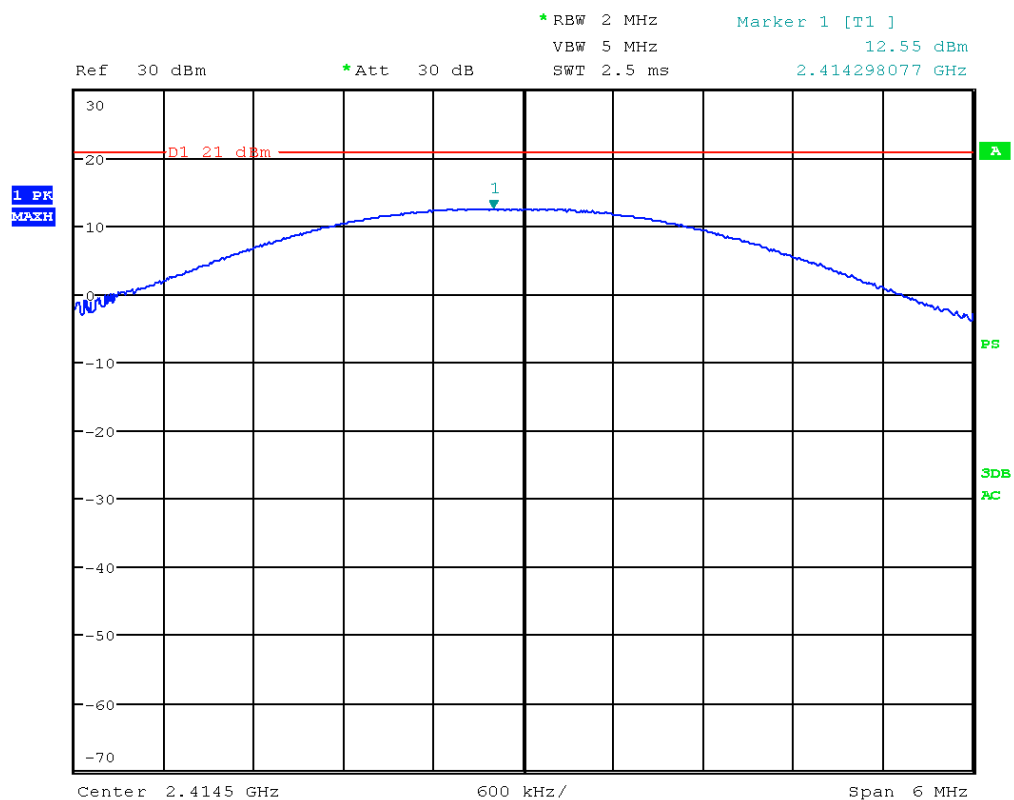


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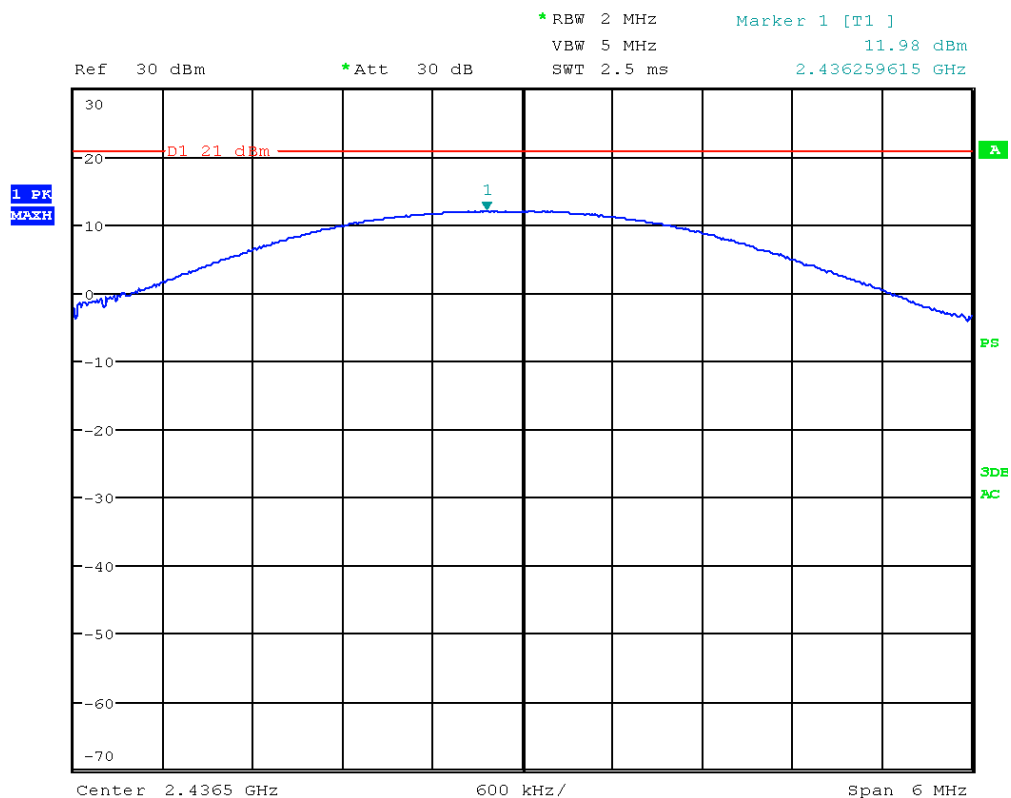
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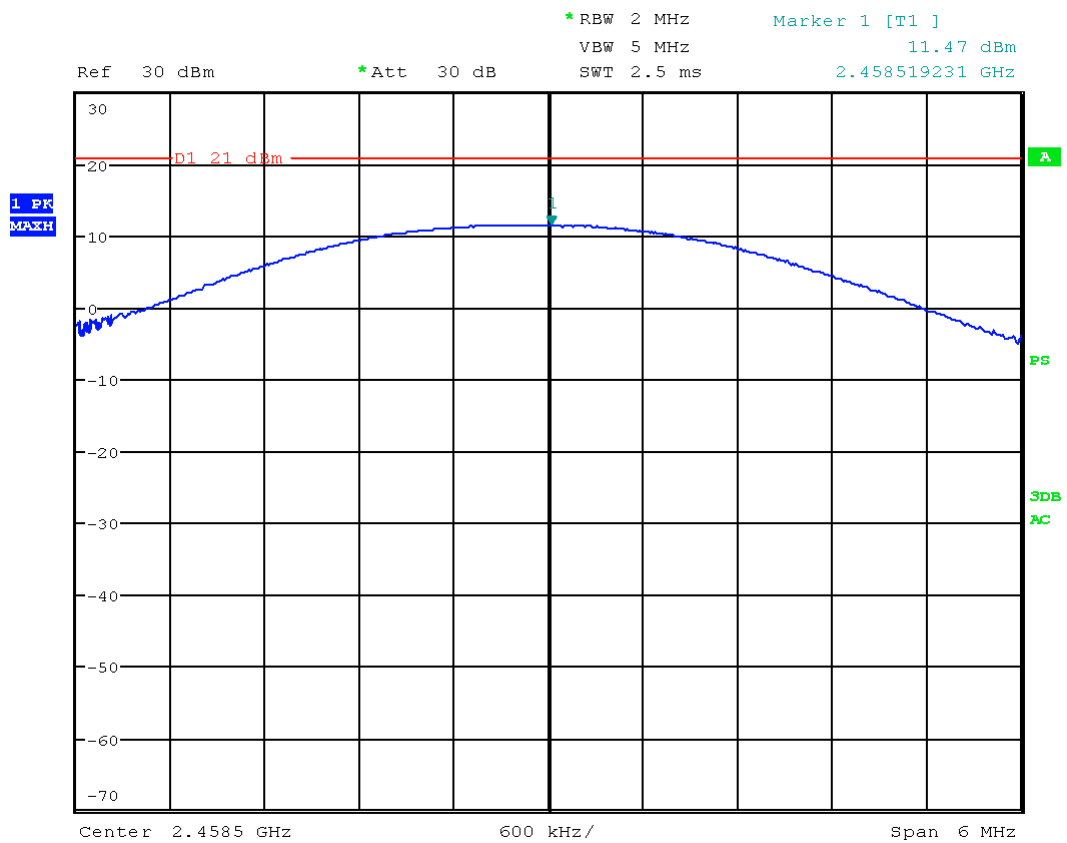
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Picture 25: Conducted output power - Even-band, channel low

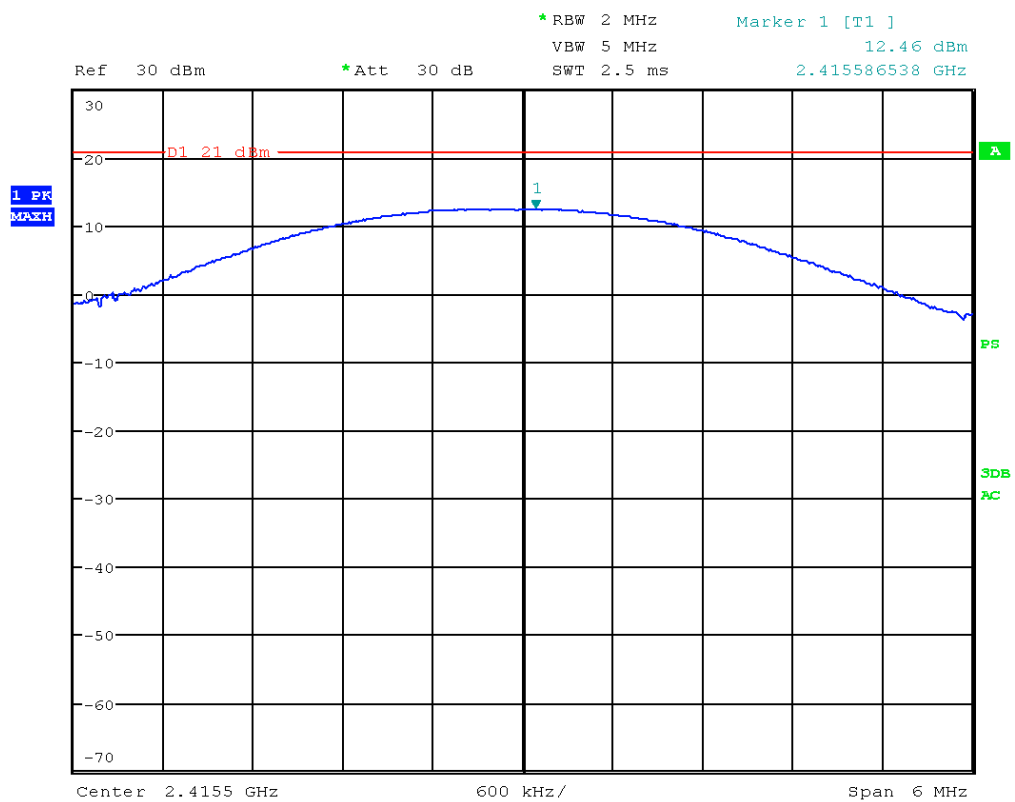


Picture 26: Conducted output power - Even-band, channel mid

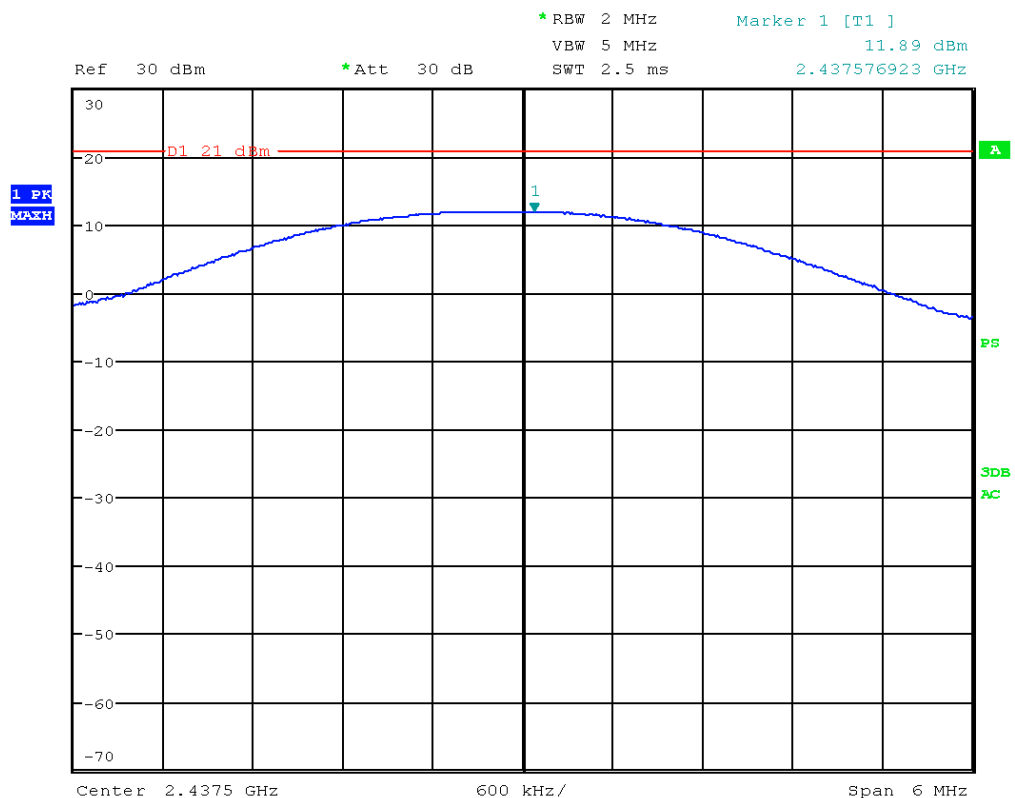


Picture 27: Conducted output power - Even-band, channel high

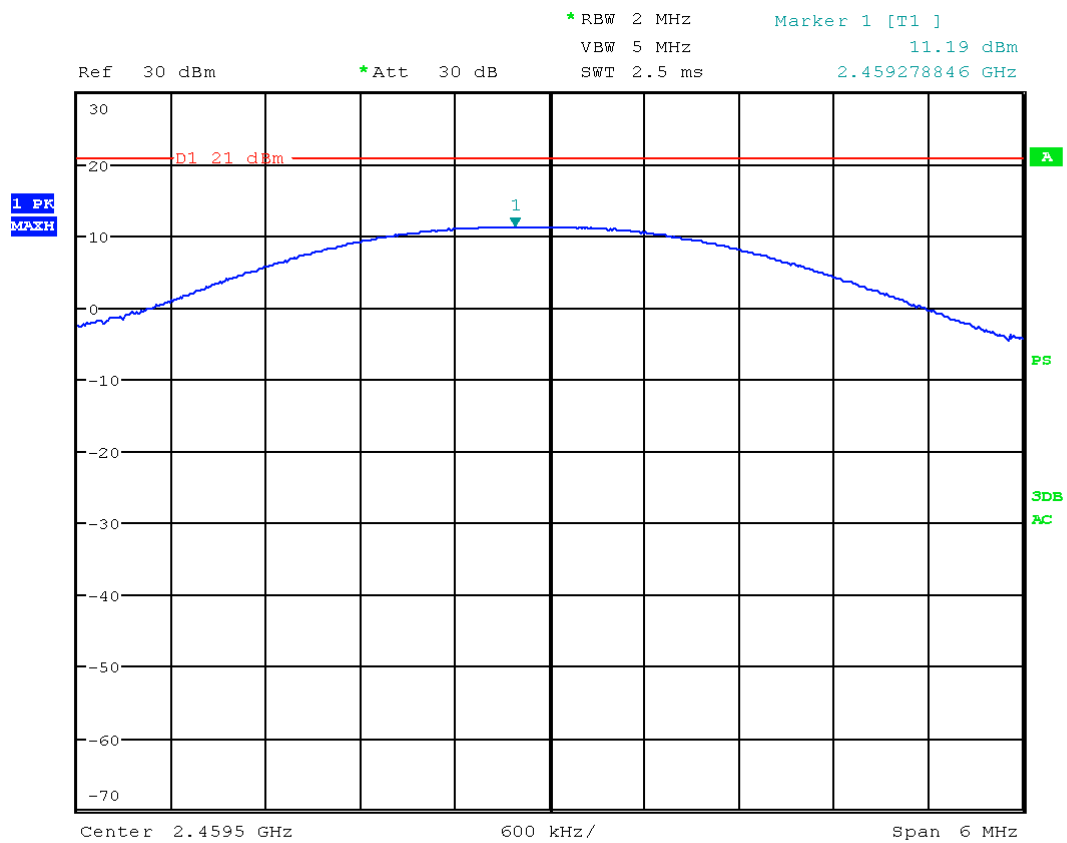




Picture 28: Conducted output power - Odd-band, channel low



Picture 29: Conducted output power - Odd-band, channel mid



Picture 30: Conducted output power - Odd-band, channel high

# 9 Band-edge Compliance

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

## 9.1 Test location

☒ radiated measurement

## 9.2 Test Instruments

	Description	Manufacturer	Inventory No.
<input checked="" type="checkbox"/>	ESU26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	AMF-5D-00501800-28-13P	Miteq	W00089
<input type="checkbox"/>	AMF-6F-16002650-25-10P	Miteq	W00090
<input checked="" type="checkbox"/>	BBHA 9170	Schwarzbeck	W00054
<input type="checkbox"/>	BBHA 9170	Schwarzbeck	W00055
<input checked="" type="checkbox"/>	COSB 4-1-26	Conformitas	W00091

## 9.3 Limits

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

## 9.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
2. 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.
3. Power on the EUT and all peripherals.
4. Set frequency to lowest channel
5. Set marker 20dB below the peak both sides of the intentional emission.
6. Record this trace
7. Set frequency to highest channel
8. Repeat step 4 and 5.



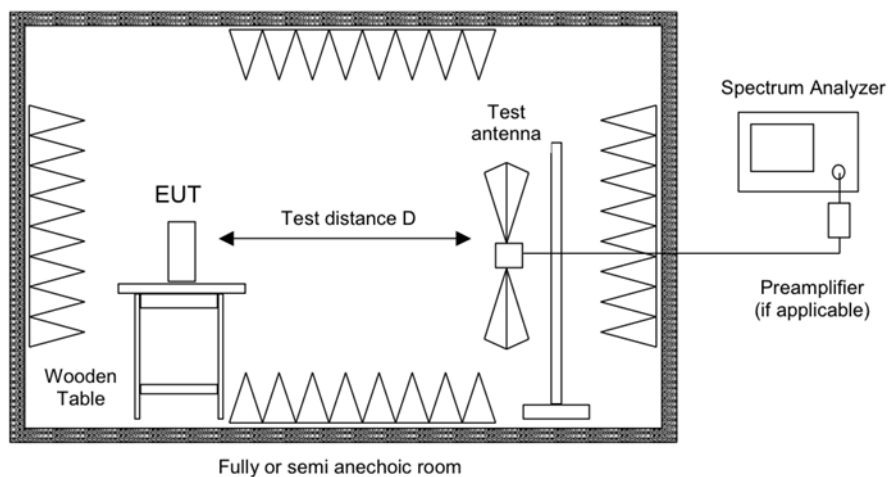
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## 9.5 Test setup



Picture 31: 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.

It was investigated that the worst-case for this test is EUT-position2 in conjunction with measurement antenna polarization set to horizontal.

During pre-measurements it was determined that in hopping mode EUT complies with bend edge requirements, too.

## 9.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-05-12

Frequency (GHz)	Detector	Reading value (dBµV/m)	Restricted Band	Limit (dBµV/m)	Result
2.3100	PK	54.30	Yes	74	Pass
2.3104	AV	37.29	Yes	54	Pass
2.3358	PK	59.25	Yes	74	Pass
2.3367	AV	42.29	Yes	54	Pass
2.3900	PK	69.44	Yes	74	Pass
2.3885	AV	45.66	Yes	54	Pass
2.4148	PK	109.66	No	---	Carrier
2.4146	AV	109.01	No	---	Carrier

Frequency (GHz)	Detector	Reading value (dBµV/m)	Restricted Band	Limit (dBµV/m)	Result
2.4588	PK	108.04	No	---	Carrier
2.4588	AV	107.42	No	---	Carrier
2.4835	PK	68.97	Yes	74	Pass
2.4853	AV	51.22	Yes	54	Pass
2.5000	PK	64.20	Yes	74	Pass
2.5373	AV	45.68	No	-20dBc	Pass
2.5628	PK	54.59	No	-20dBc	Pass
2.6157	AV	46.95	No	-20dBc	Pass

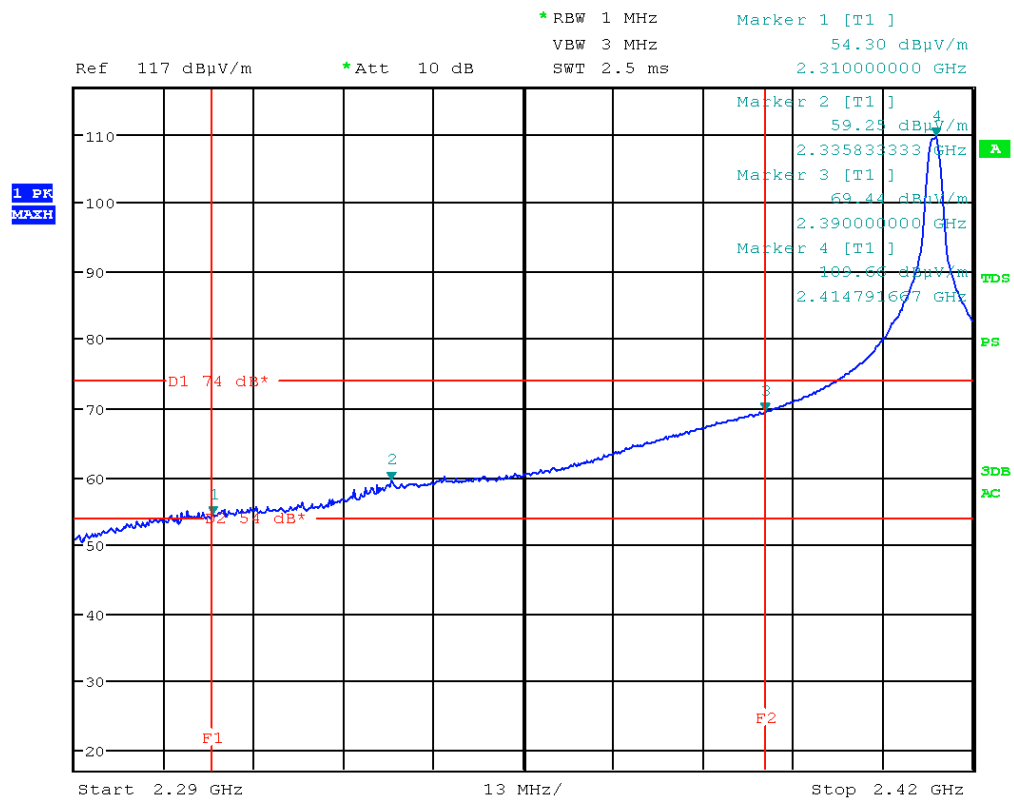


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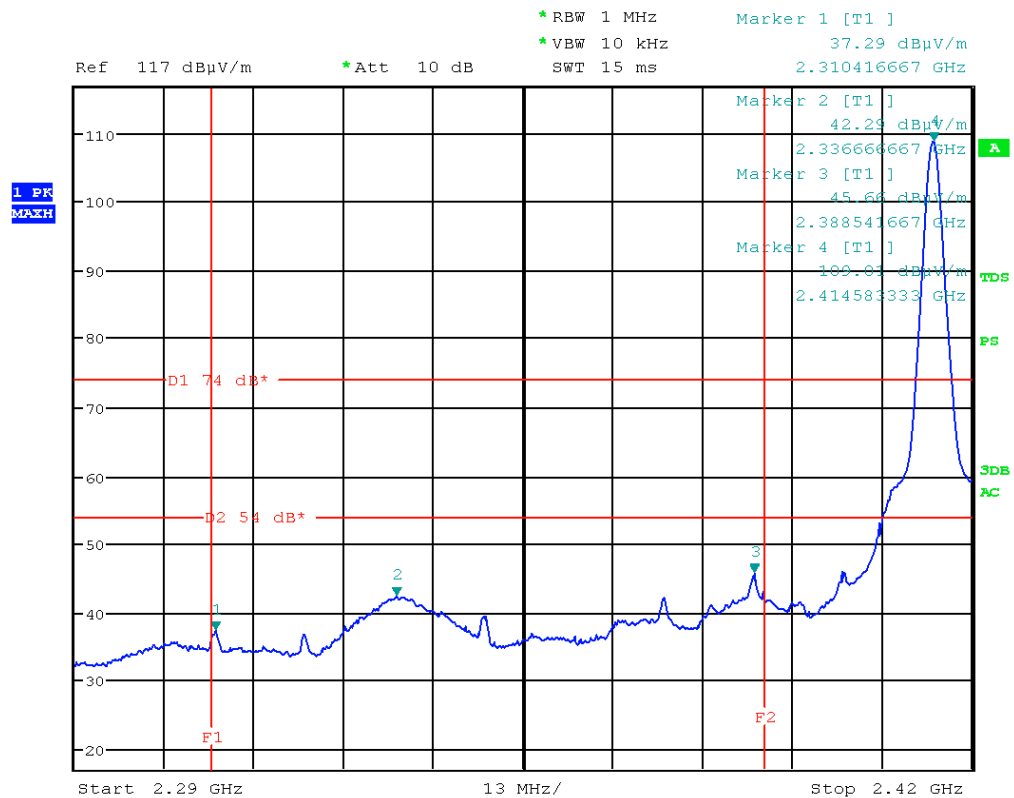
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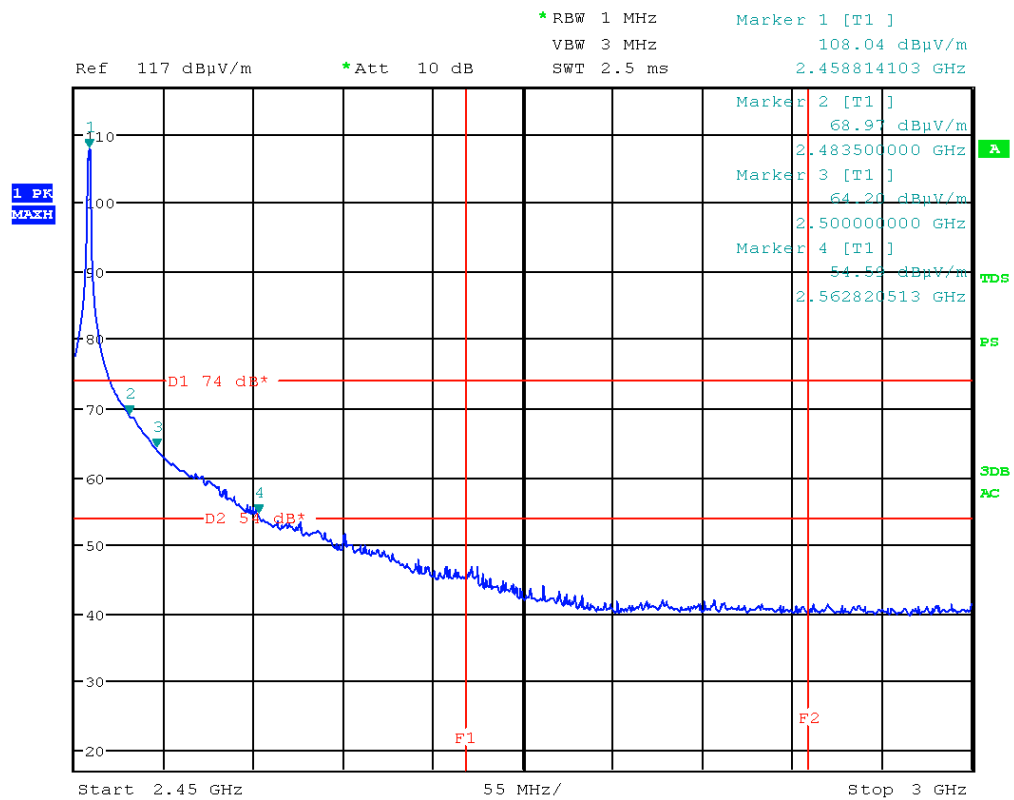
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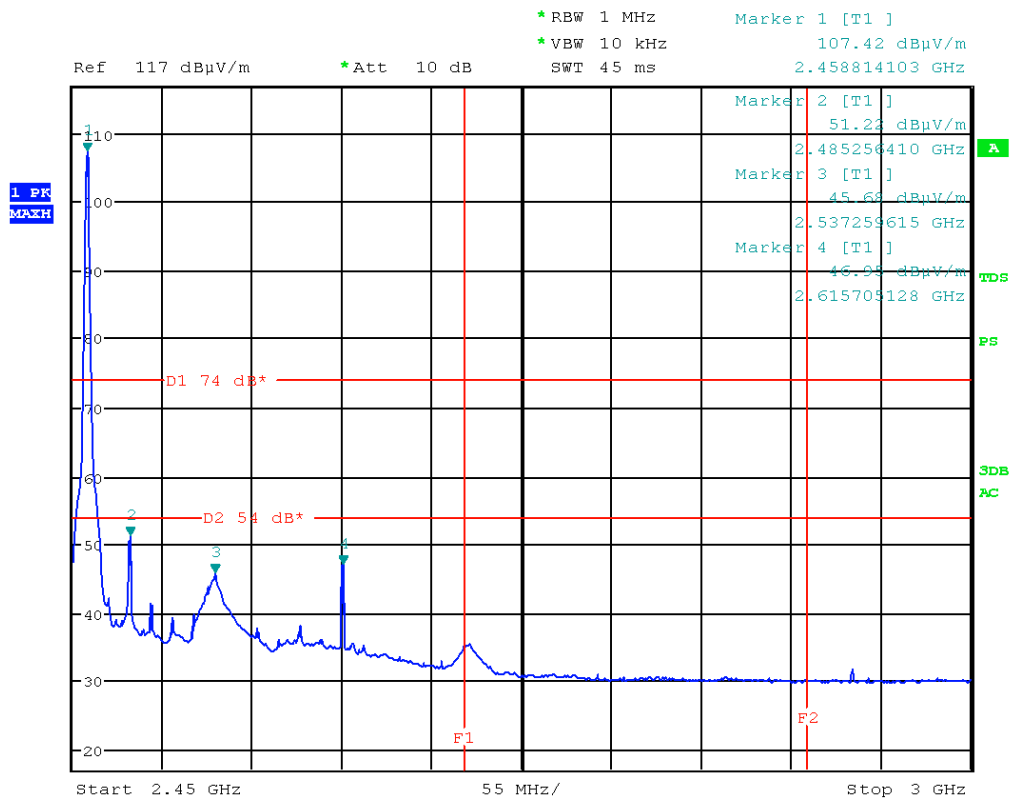
Picture 32: lower edge - PK



Picture 33: lower edge - AV



Picture 34: upper edge - PK



Picture 35: 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 <b>TESTHAUS</b> GmbH	E00354

## 10.2 Test Instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESCS 30 (FF)	Rohde & Schwarz	E00003
<input checked="" type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	ESR 7	Rohde & Schwarz	E00739
<input type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input type="checkbox"/>	VULB 9163 (FF)	Schwarzbeck	E00013
<input type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011

## 10.3 Limits

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

## 10.4 Test procedure

1. The test was performed in accordance with FCC Public Notice DA 00-705.
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 of 100 kHz and the video bandwidth of 100 kHz were used.
5. Measure the spectrum from the lowest frequency generated in the EUT up through the 10<sup>th</sup> harmonic.



EMV **TESTHAUS** GmbH  
Gustav-Hertz-Straße 35  
94315 Straubing  
Germany  
Revision: 1.0

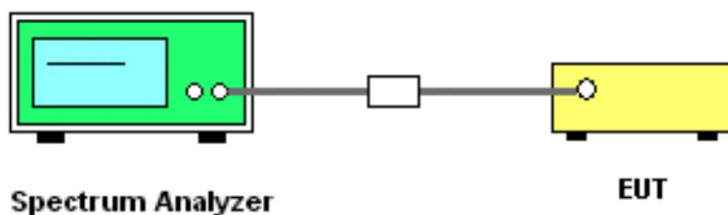
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## 10.5 Test setup



Picture 36: Test setup for conducted spurious emission measurement

## 10.6 Test deviation

There is no deviation with the original standard.

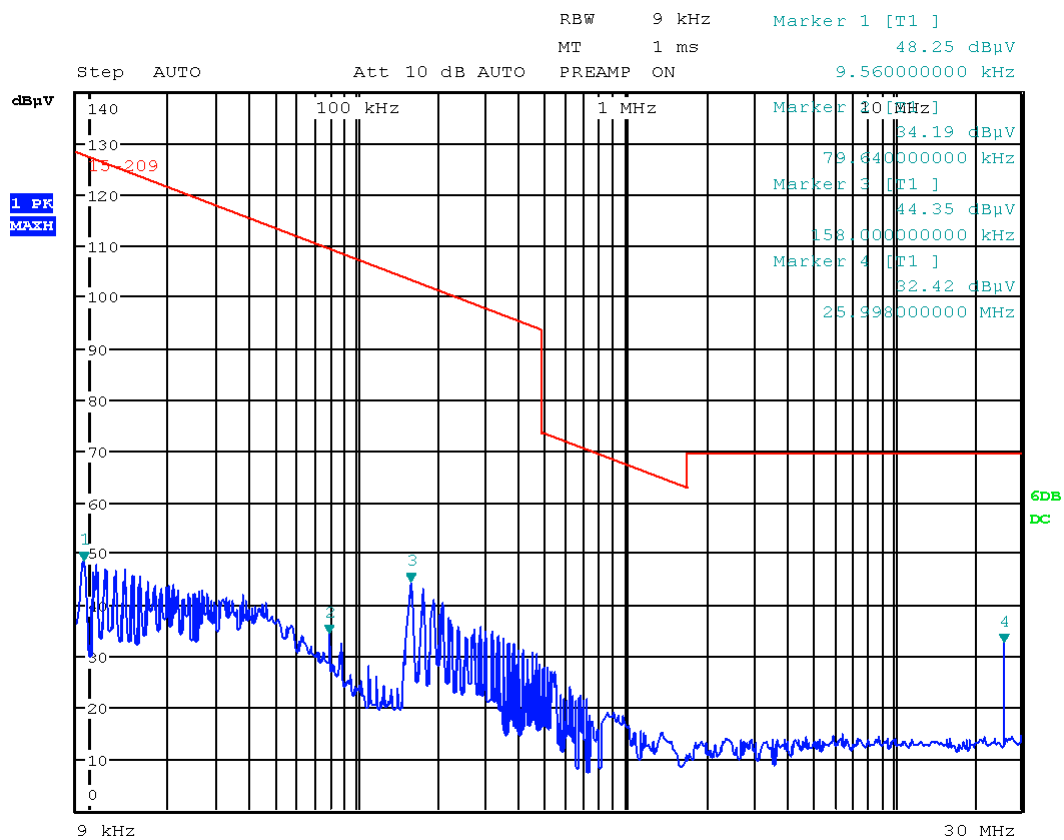
## 10.7 EUT operation during test

The EUT was programmed to be in continuously transmitting mode.

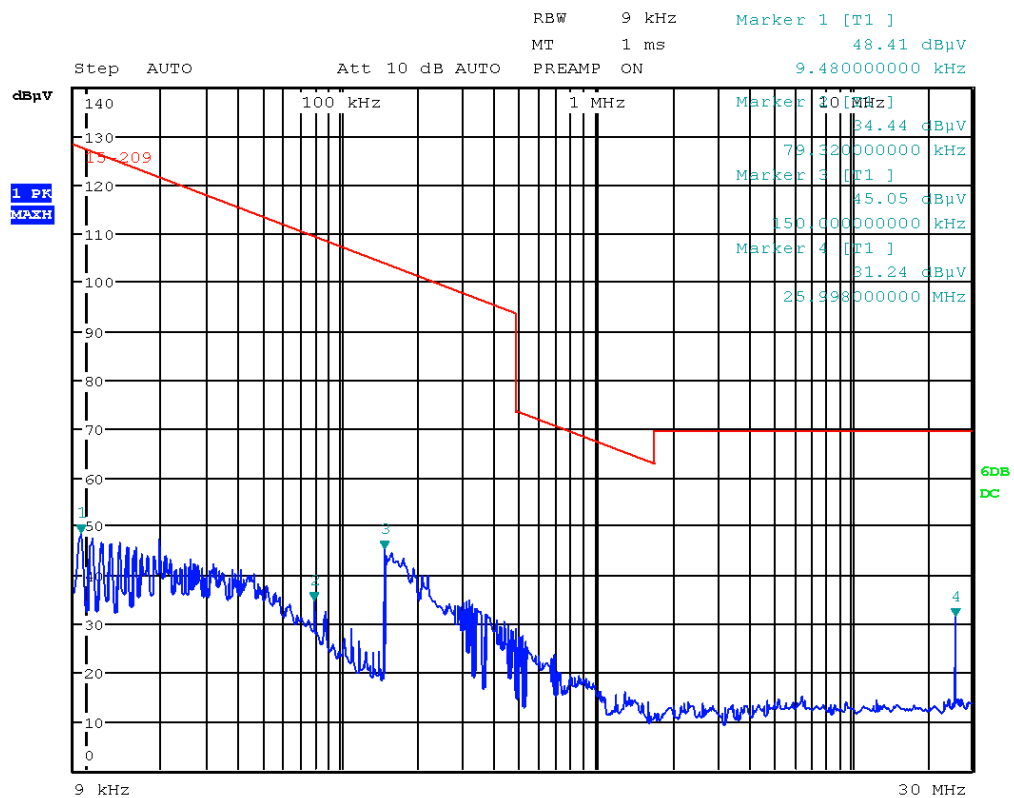
## 10.8 Test results

Temperature:	22°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-05-18

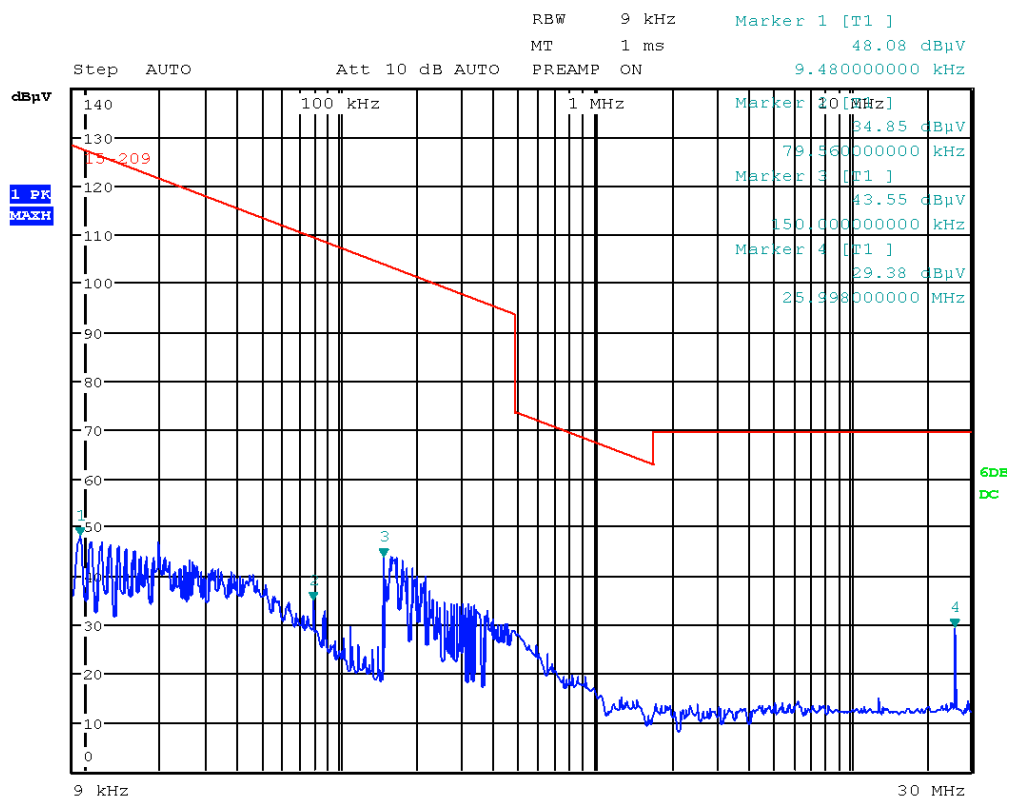
## 10.9 Test results 9 kHz - 30 MHz



Picture 37: spurious emission - Even-band, channel low

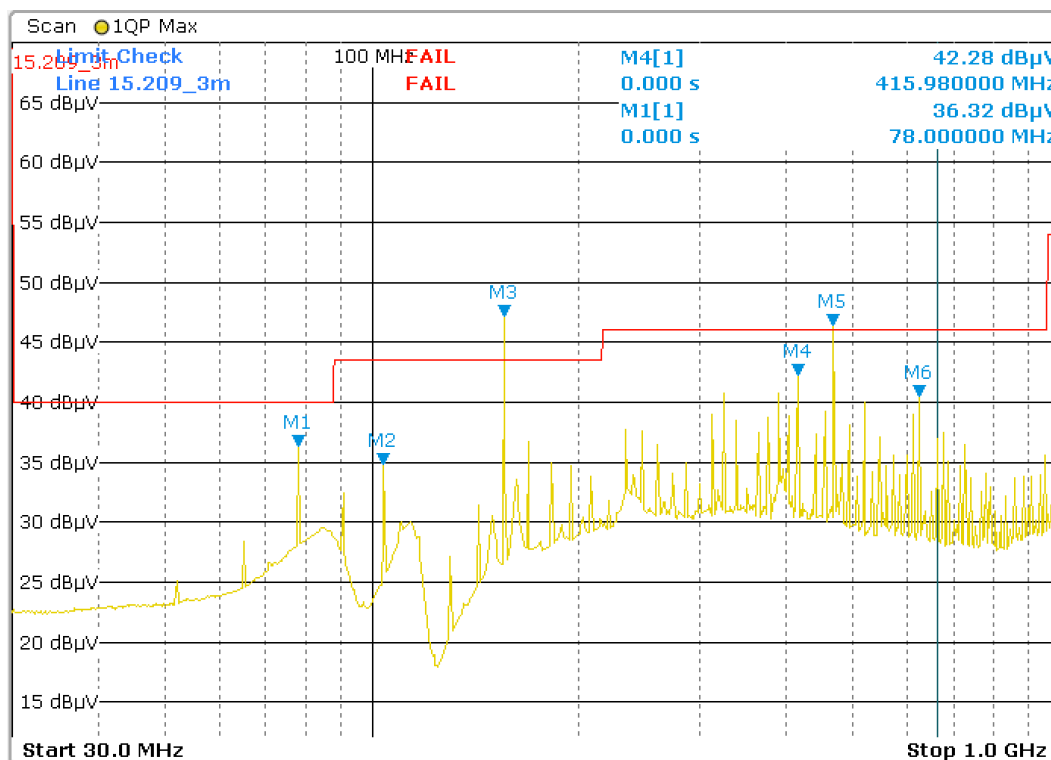


Picture 38: spurious emission - Odd-band, channel mid



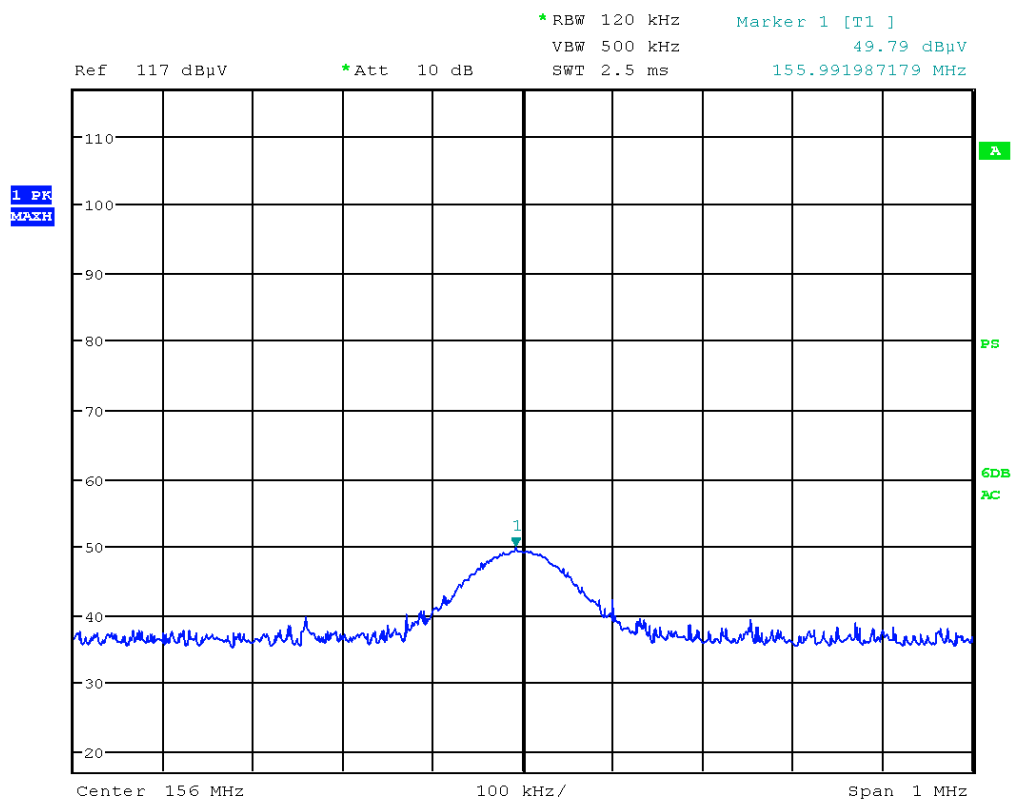
Picture 39: spurious emission - Odd-band, channel high

## 10.10 Test results 30 MHz - 1 GHz

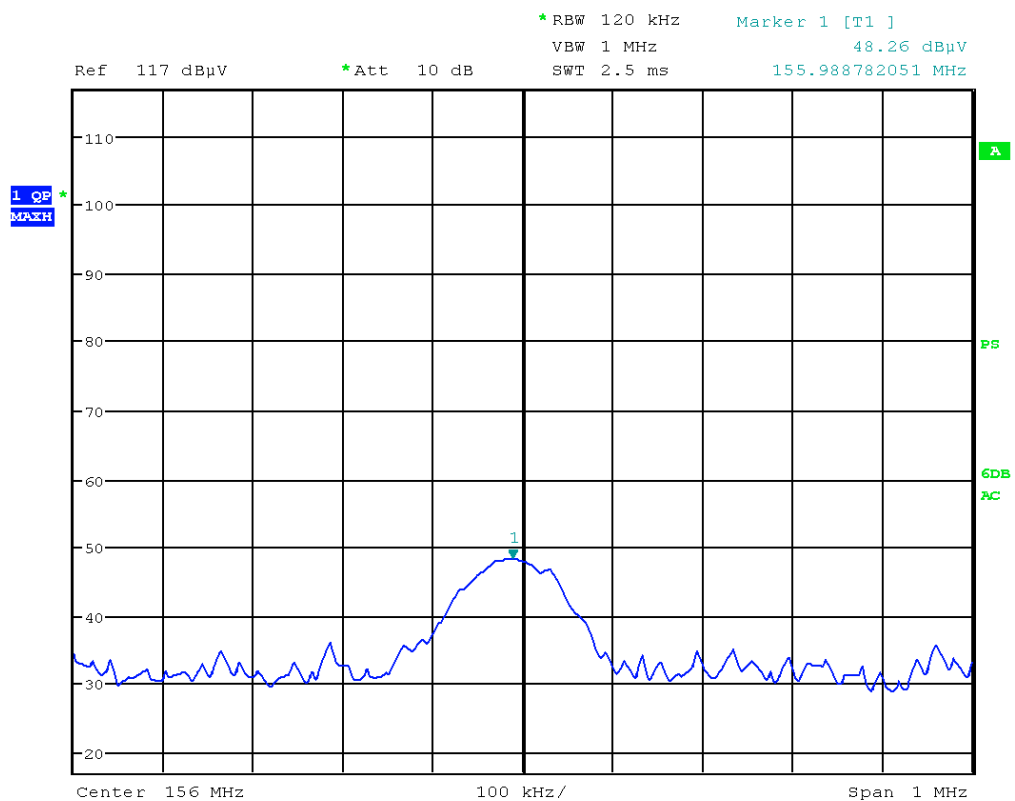


Frequency [MHz]	Marker	Detector	Reading [dBμV]	Restricted Band	Limit [dBμV]	Result
78.000	1	QP (Prescan)	36.32	No	-20dBc	Pass
104.010	2	QP (Prescan)	34.85	No	-20dBc	Pass
156.000	3	QP (Prescan)	47.20	No	-20dBc	Pass
155.992	single plot	PK	49.79	No	----	Pass
155.989	single plot	QP	48.26	No	-20dBc	Pass
415.980	4	QP (Prescan)	42.28	No	-20dBc	Pass
467.970	5	QP (Prescan)	46.49	No	-20dBc	Pass
467.966	single plot	PK	49.36	No	----	Pass
467.970	single plot	QP	48.45	No	-20dBc	Pass
623.970	6	QP (Prescan)	40.49	No	-20dBc	Pass
2414.548	single plot	PK	119.10	No	----	Carrier
2414.548	single plot	QP	116.50	No	----	Carrier

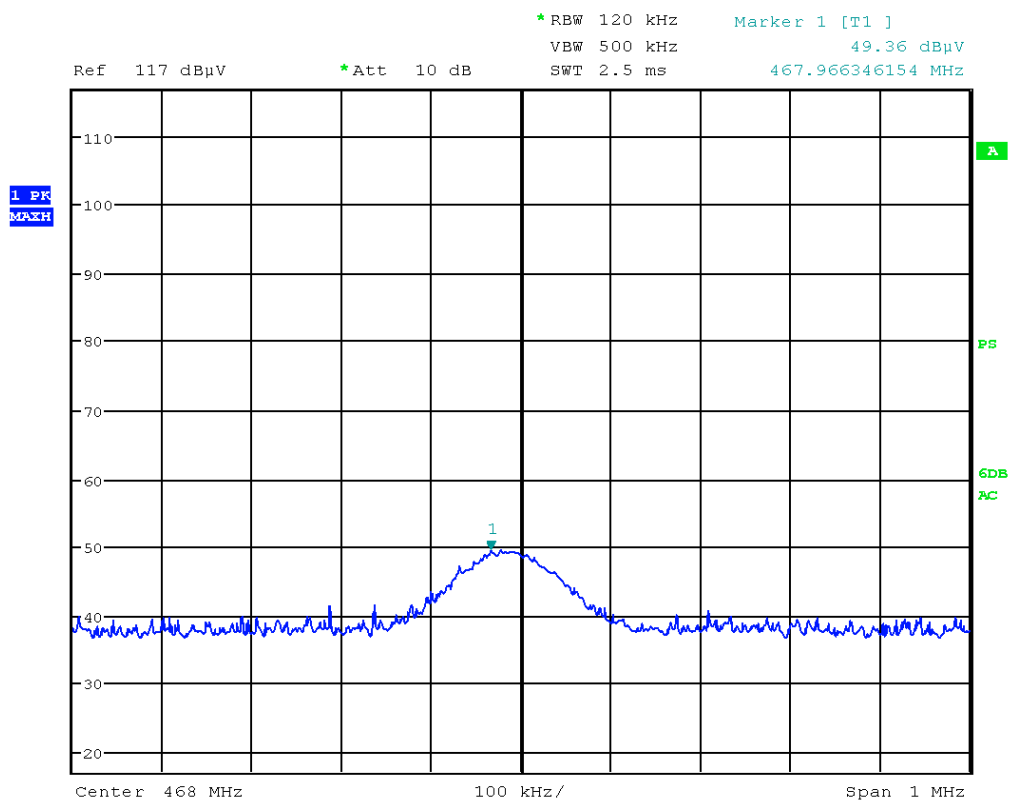
Picture 40: spurious emission - Even-band, channel low (30MHz – 1GHz)



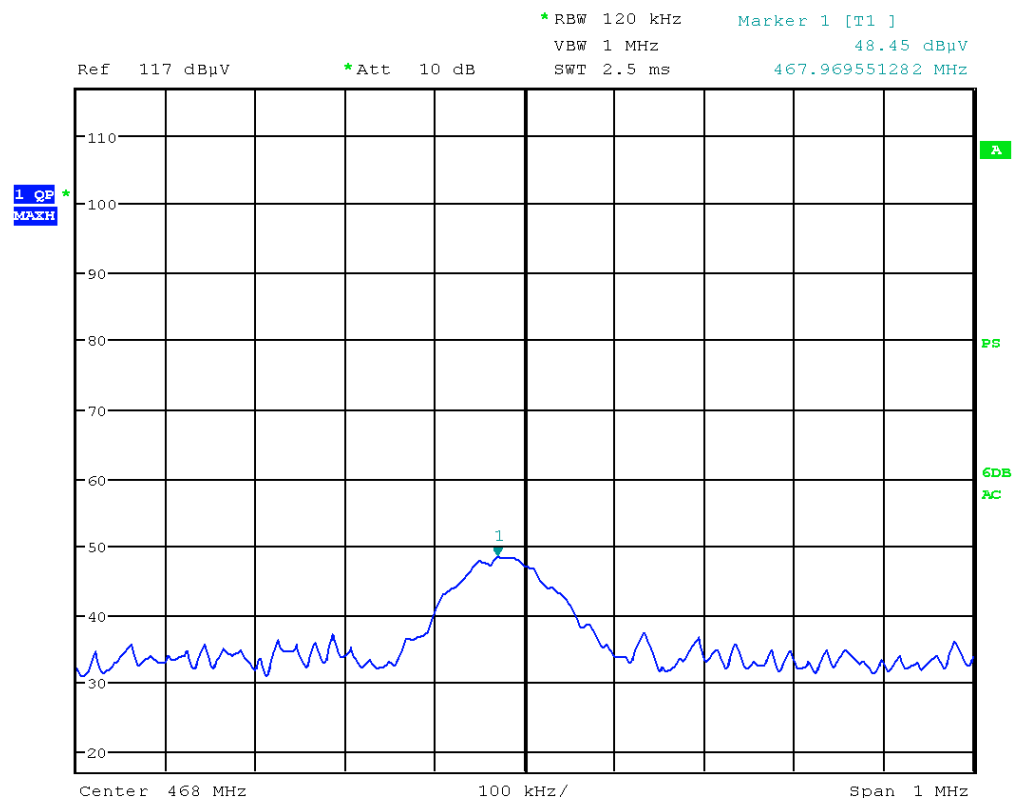
Picture 41: single plot - Even-band, channel low (PK)



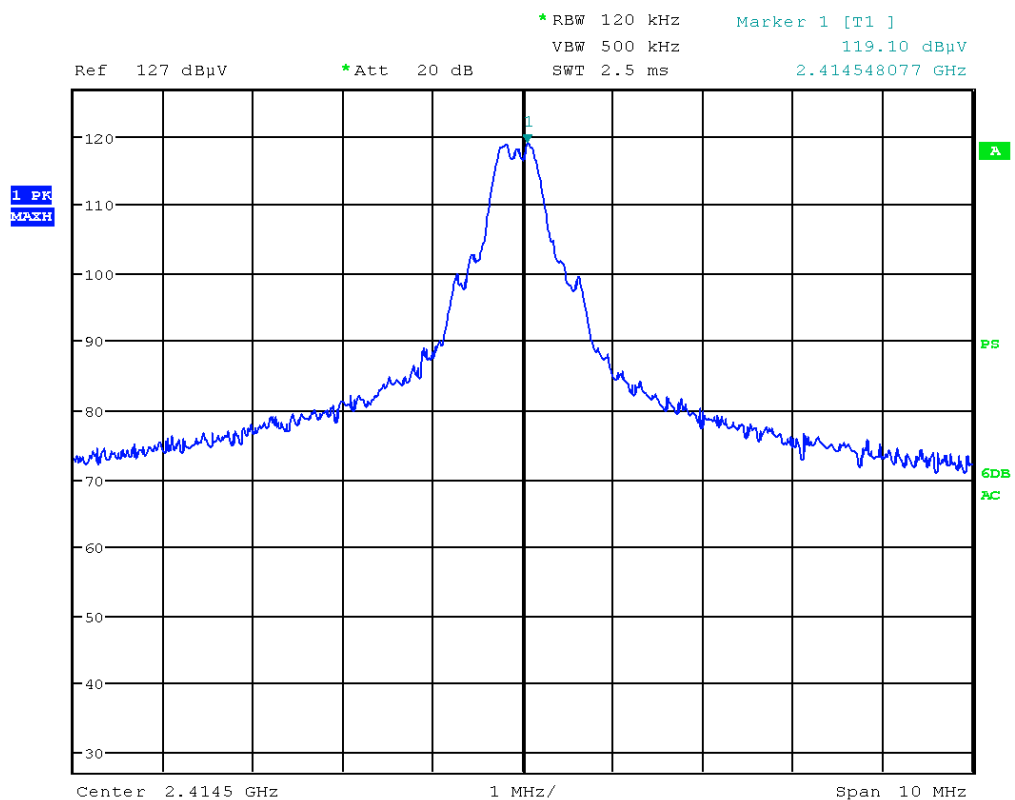
Picture 42: single plot - Even-band, channel low (QP)



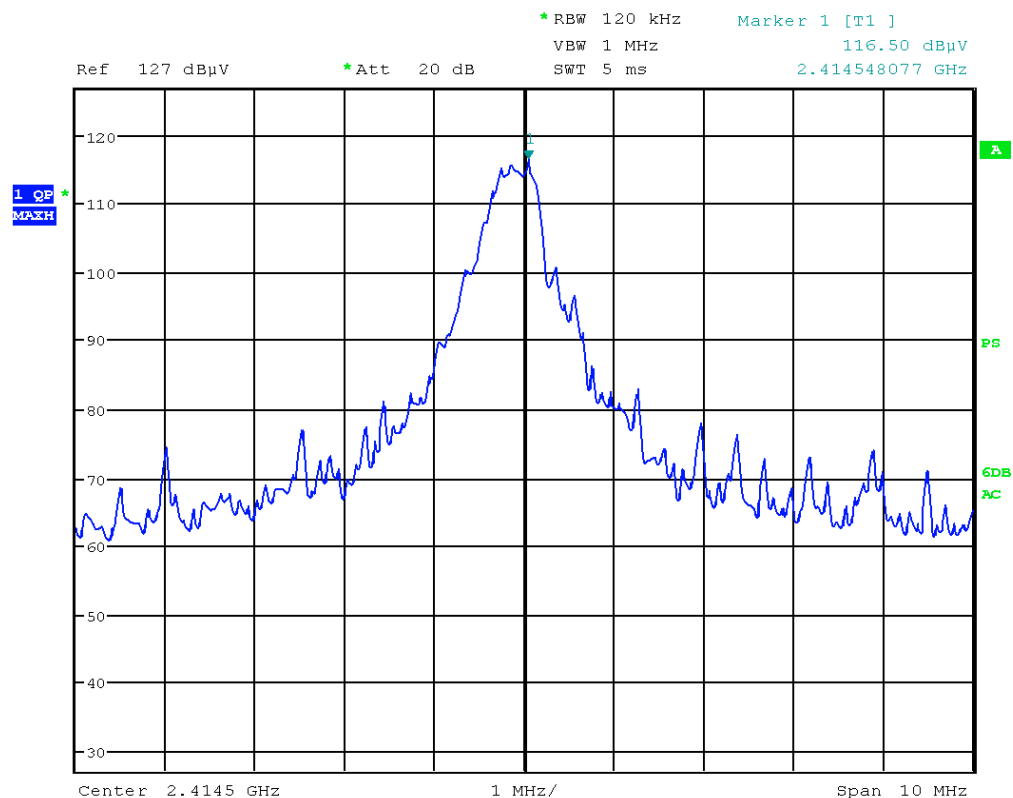
Picture 43: single plot - Even-band, channel low (PK)



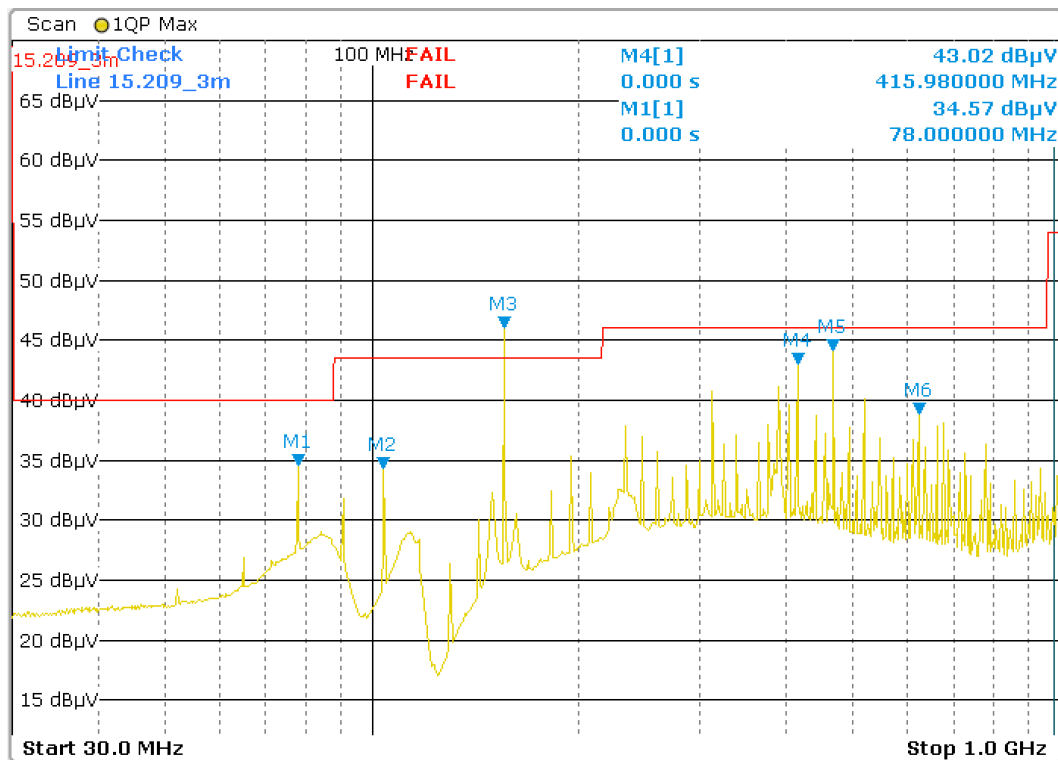
Picture 44: single plot - Even-band, channel low (QP)



Picture 45: single plot - Even-band, channel low (PK)



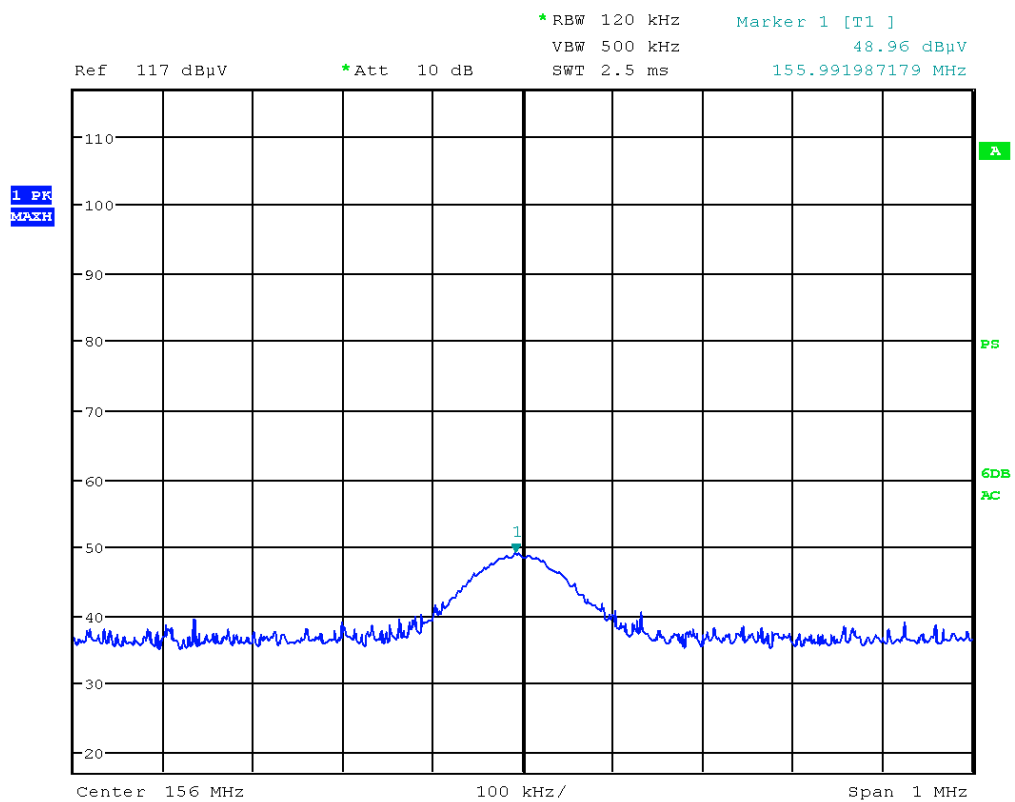
Picture 46: single plot - Even-band, channel low (QP)



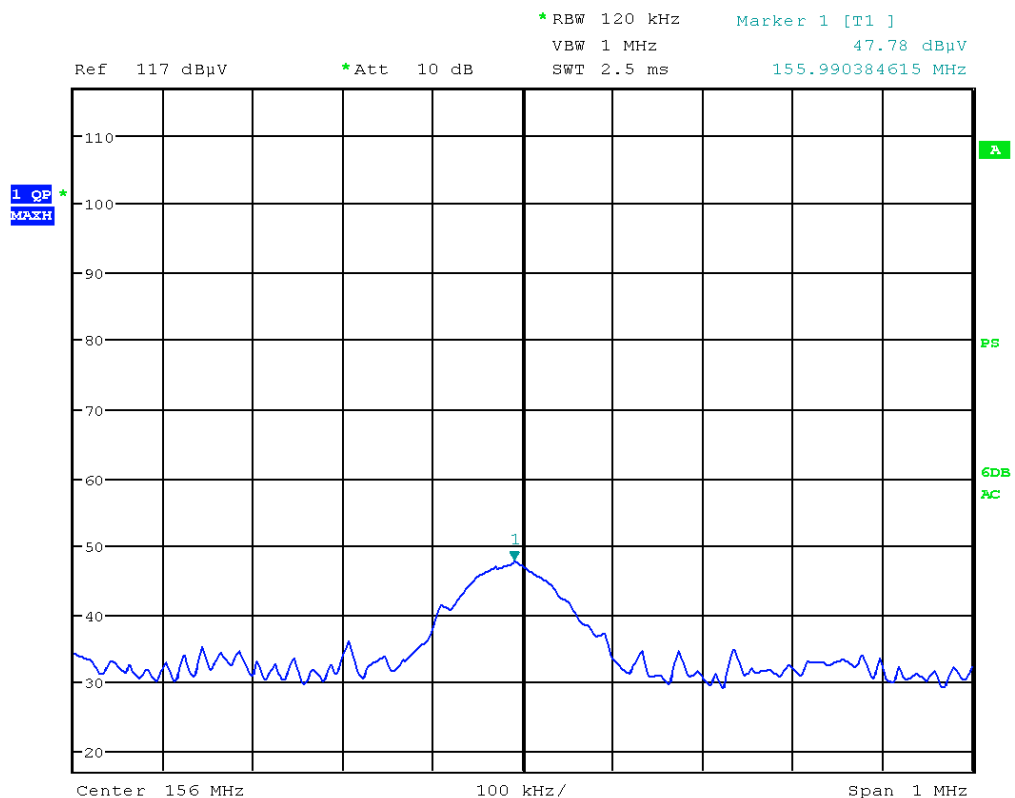
Frequency [MHz]	Marker	Detector	Reading [dBμV]	Restricted Band	Limit [dBμV]	Result
78.000	1	QP (Prescan)	36.32	No	-20dBc	Pass
104.010	2	QP (Prescan)	34.85	No	-20dBc	Pass
156.000	3	QP (Prescan)	47.20	No	-20dBc	Pass
155.992	single plot	PK	48.96	No	----	Pass
155.990	single plot	QP	47.78	No	-20dBc	Pass
415.980	4	QP (Prescan)	42.28	No	-20dBc	Pass
467.970	5	QP (Prescan)	46.49	No	-20dBc	Pass
467.973	single plot	PK	48.14	No	----	Pass
467.970	single plot	QP	46.29	No	-20dBc	Pass
623.970	6	QP (Prescan)	40.49	No	-20dBc	Pass
2437.548	single plot	PK	118.48	No	----	Carrier
2437.244	single plot	QP	115.95	No	----	Carrier

Picture 47: spurious emission - Odd-band, channel mid (30MHz – 1GHz)

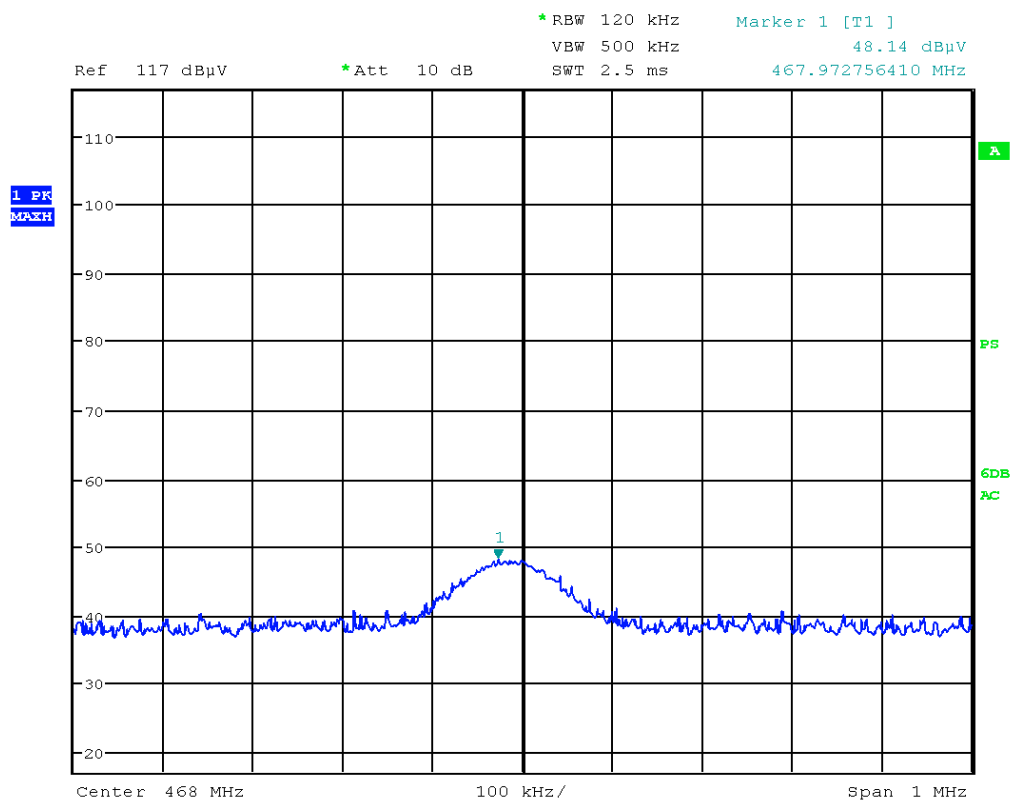




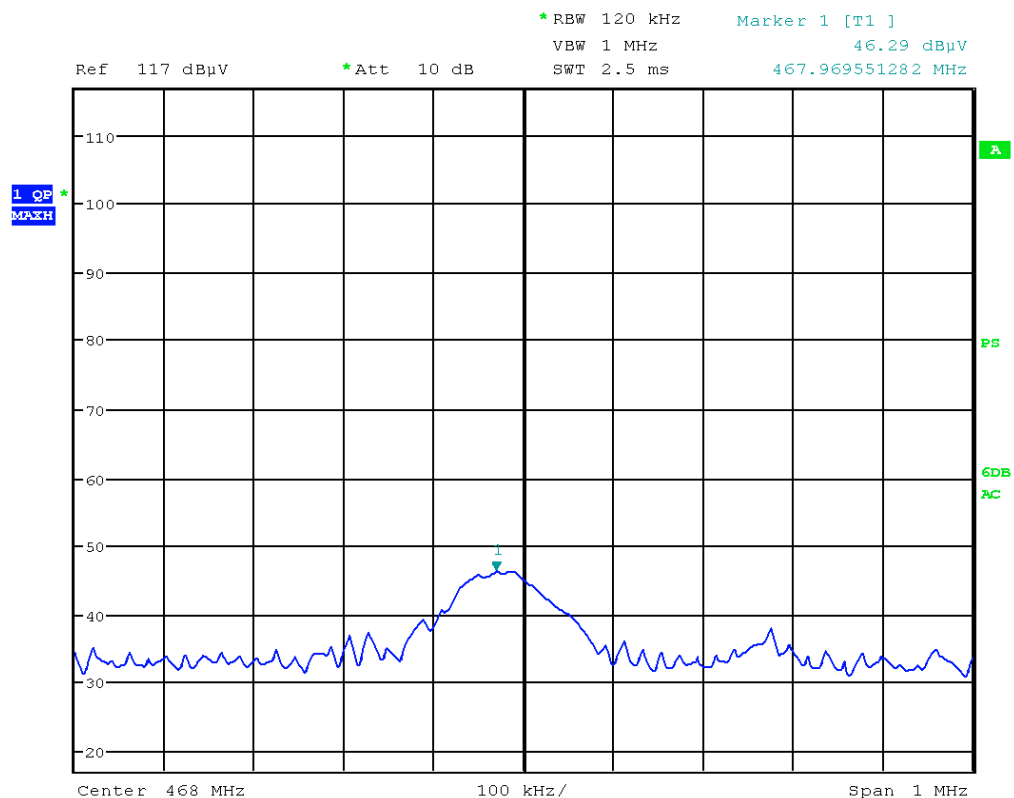
Picture 48: single plot - Odd-band, channel mid (PK)



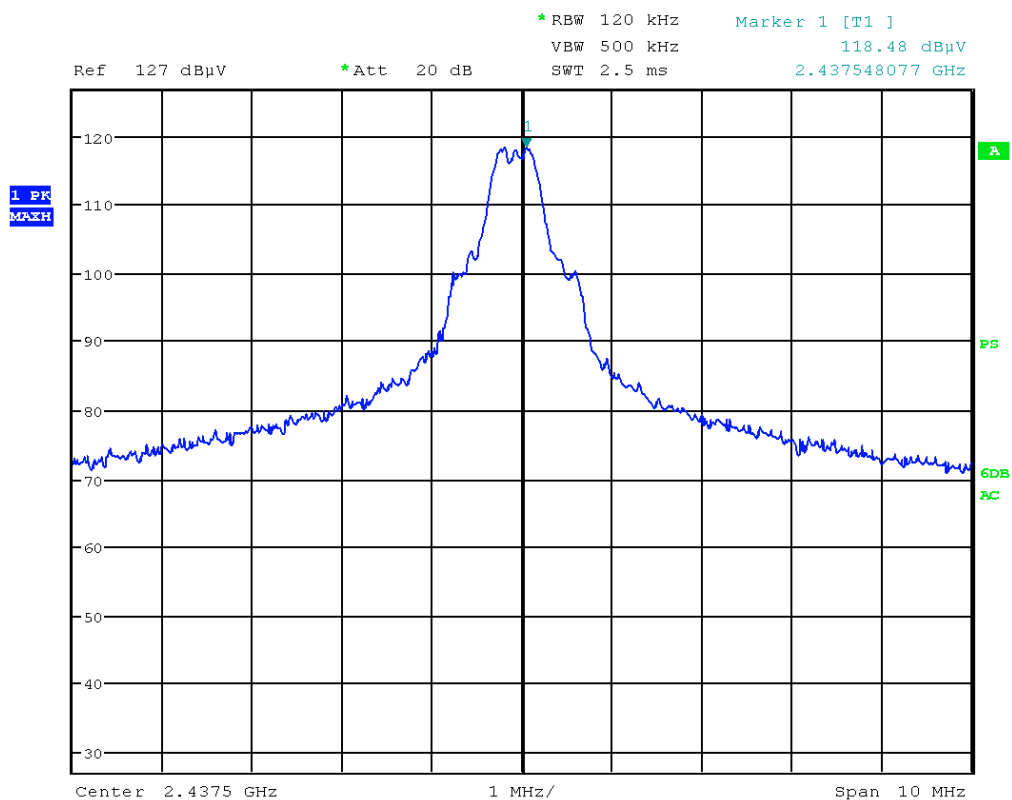
Picture 49: single plot - Odd-band, channel mid (QP)



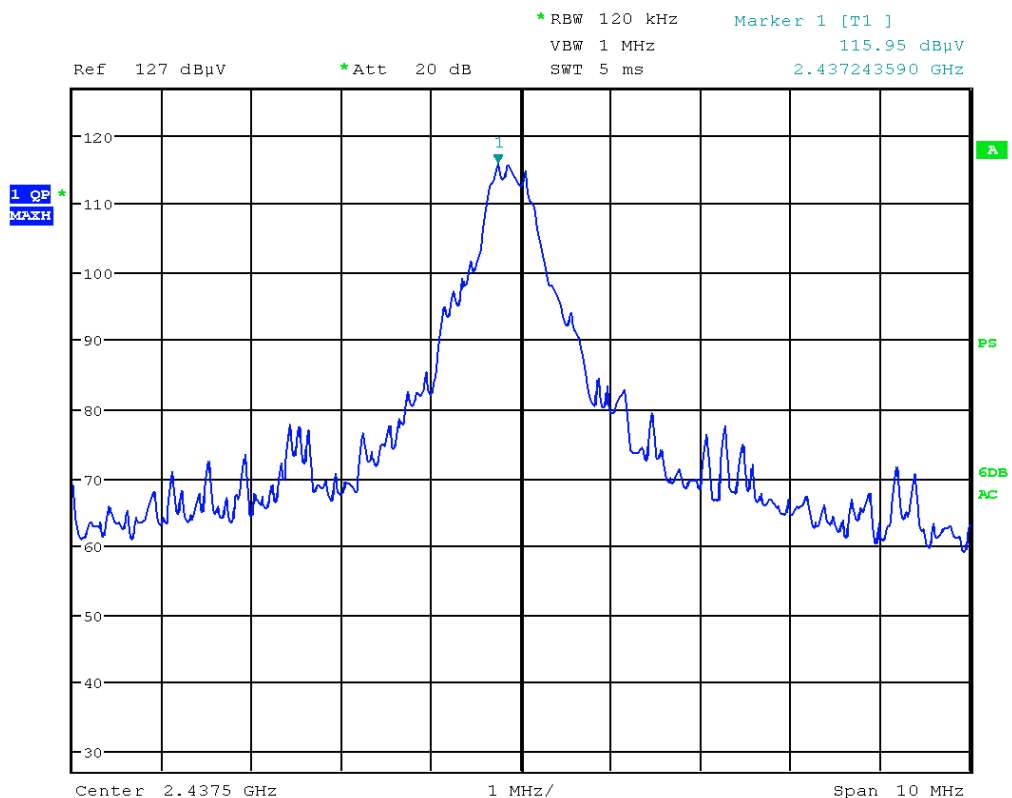
Picture 50: single plot - Odd-band, channel mid (PK)



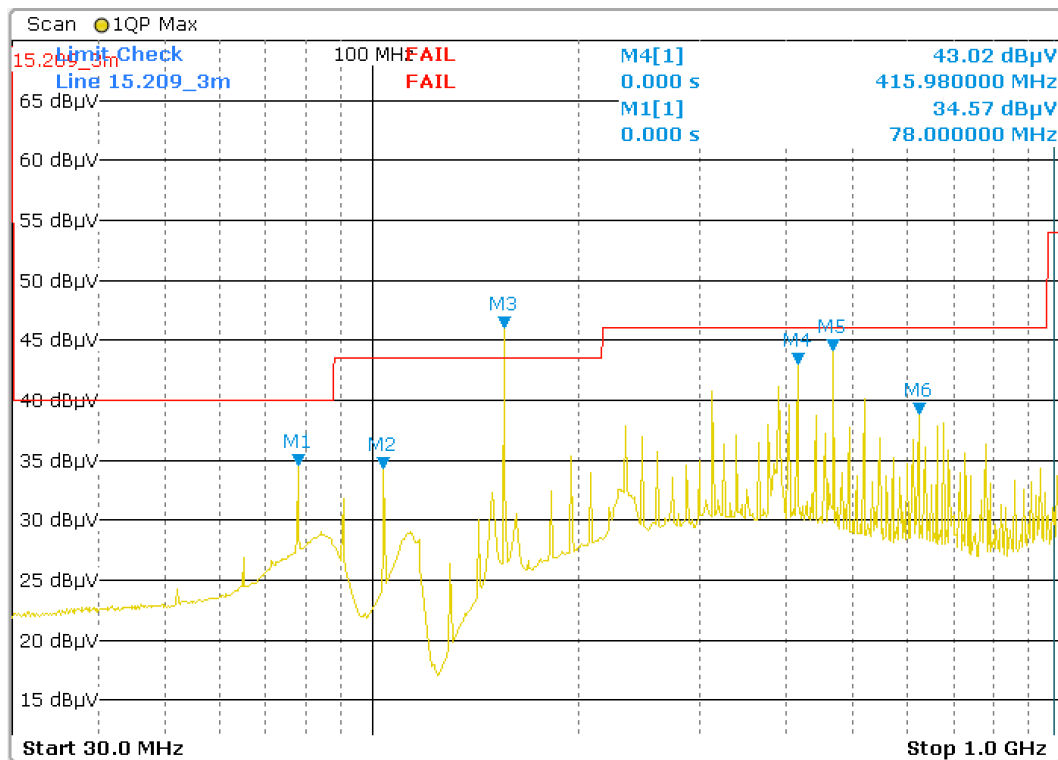
Picture 51: single plot - Odd-band, channel mid (QP)



Picture 52: single plot - Odd-band, channel mid (PK)

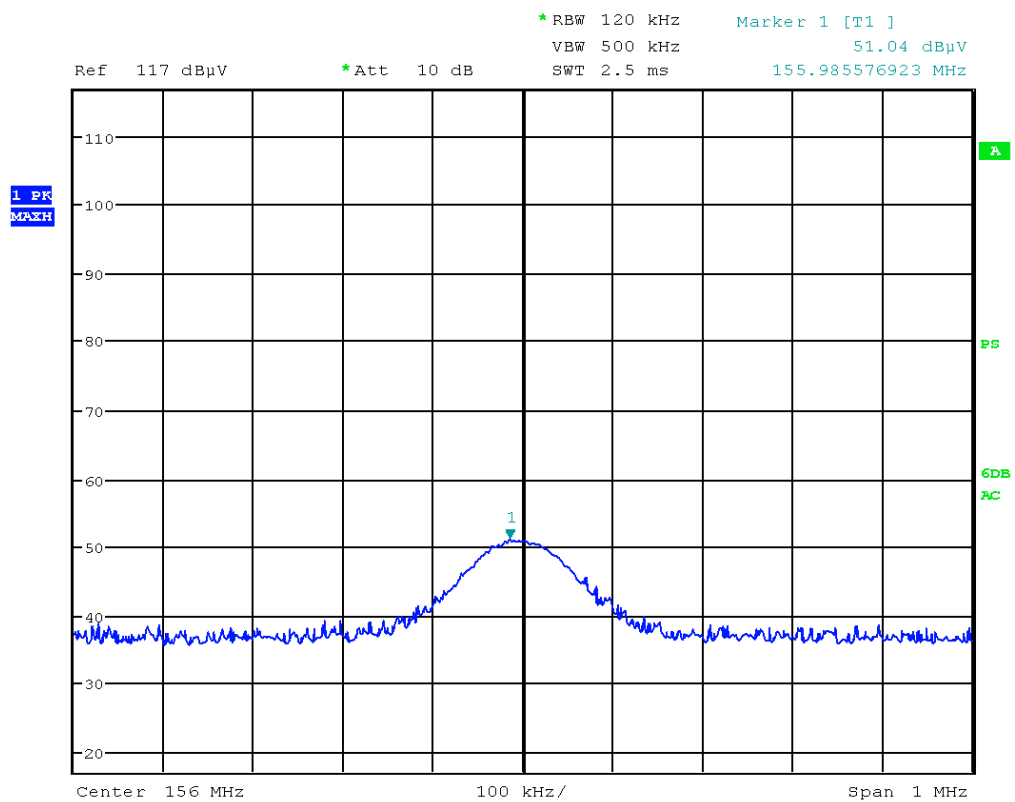


Picture 53: single plot - Odd-band, channel mid (QP)

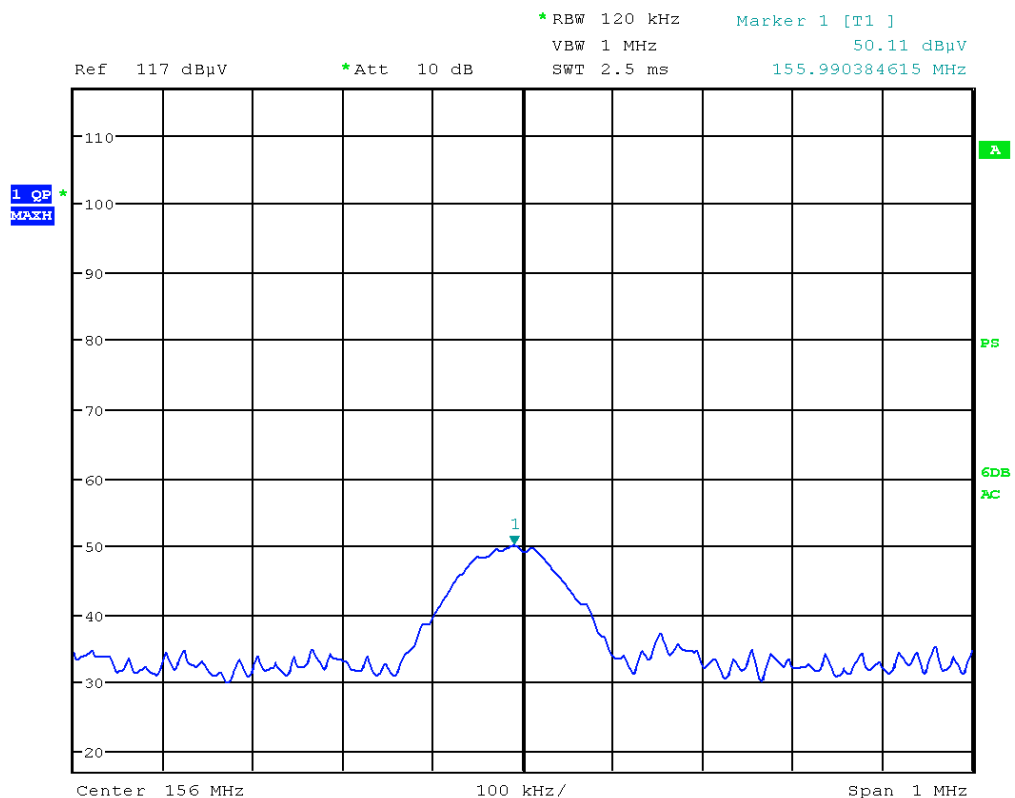


Frequency [MHz]	Marker	Detector	Reading [dBμV]	Restricted Band	Limit [dBμV]	Result
78.000	1	QP (Prescan)	35.10	No	-20dBc	Pass
104.010	2	QP (Prescan)	32.15	No	-20dBc	Pass
156.000	3	QP (Prescan)	49.92	No	-20dBc	Pass
155.986	single plot	PK	51.04	No	----	Pass
155.990	single plot	QP	50.11	No	-20dBc	Pass
415.980	4	QP (Prescan)	43.07	No	-20dBc	Pass
467.970	5	QP (Prescan)	49.46	No	-20dBc	Pass
467.998	single plot	PK	51.18	No	----	Pass
467.970	single plot	QP	49.79	No	-20dBc	Pass
623.970	6	QP (Prescan)	43.51	No	-20dBc	Pass
2459.548	single plot	PK	117.67	No	----	Carrier
2459.548	single plot	QP	115.59	No	----	Carrier

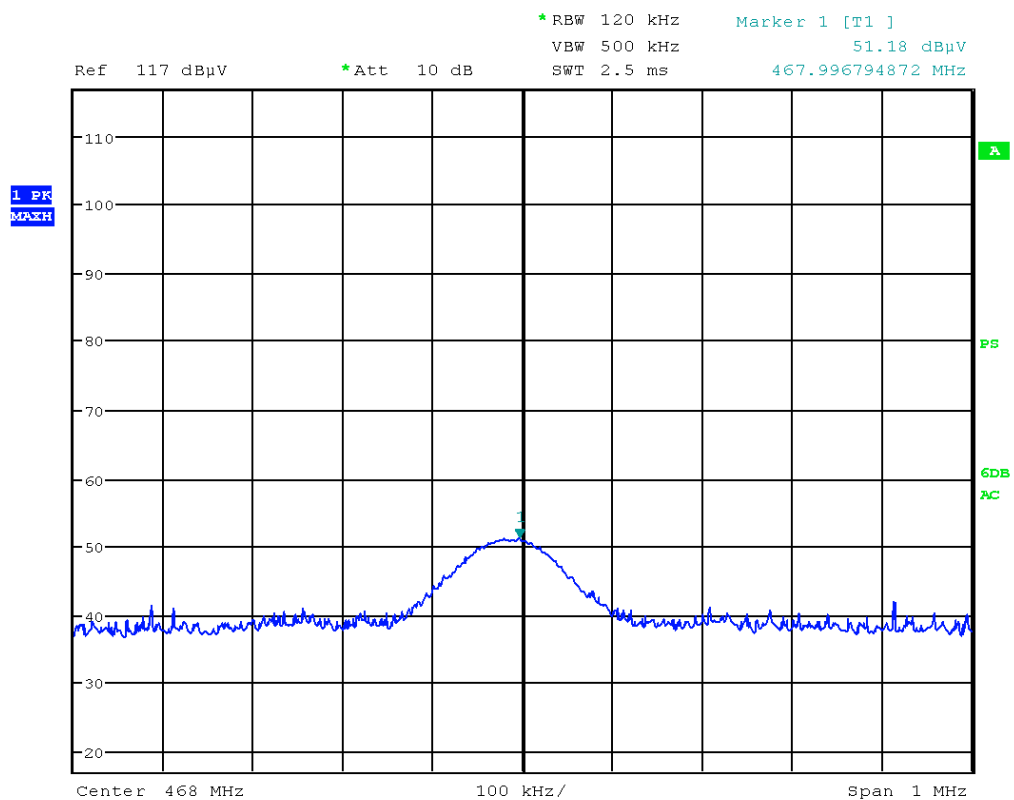
Picture 54: spurious emission - Odd-band, channel high (30MHz – 1GHz)



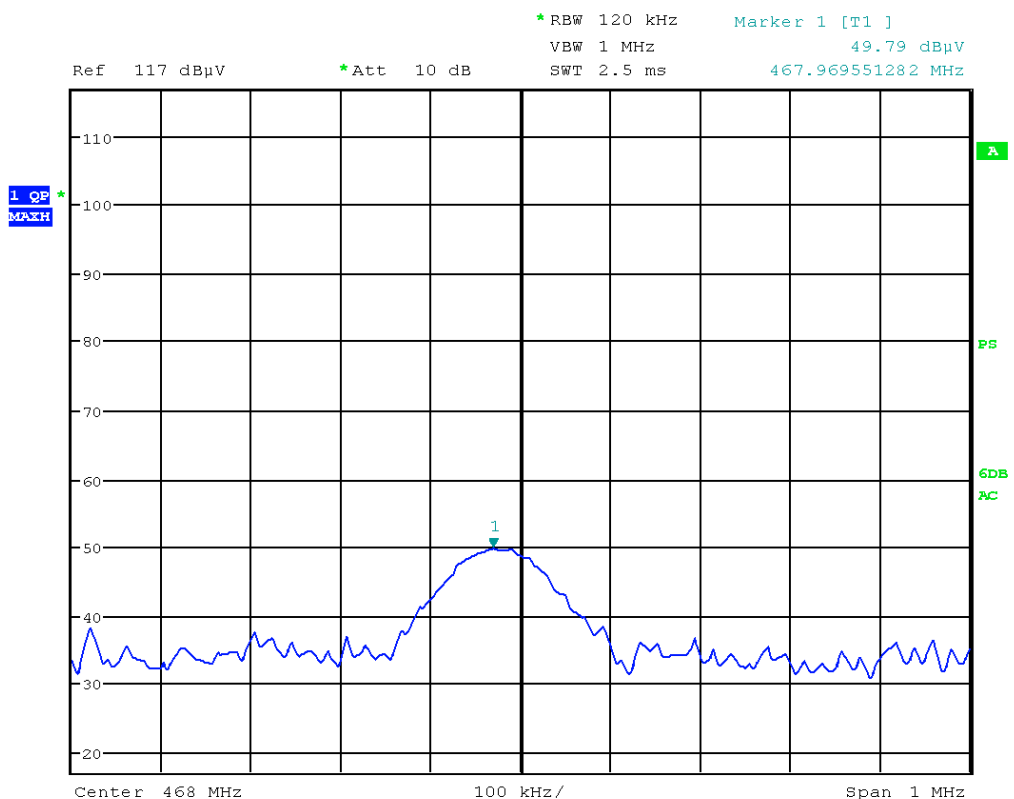
Picture 55: single plot - Odd-band, channel high (PK)



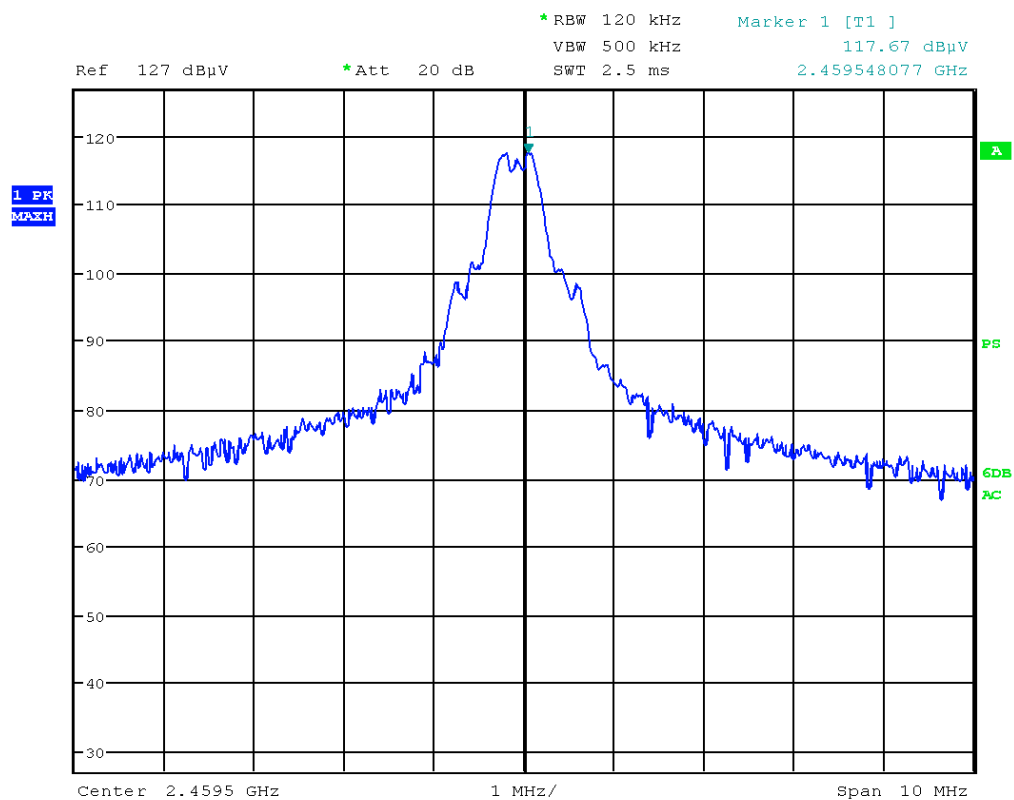
Picture 56: single plot - Odd-band, channel high (QP)



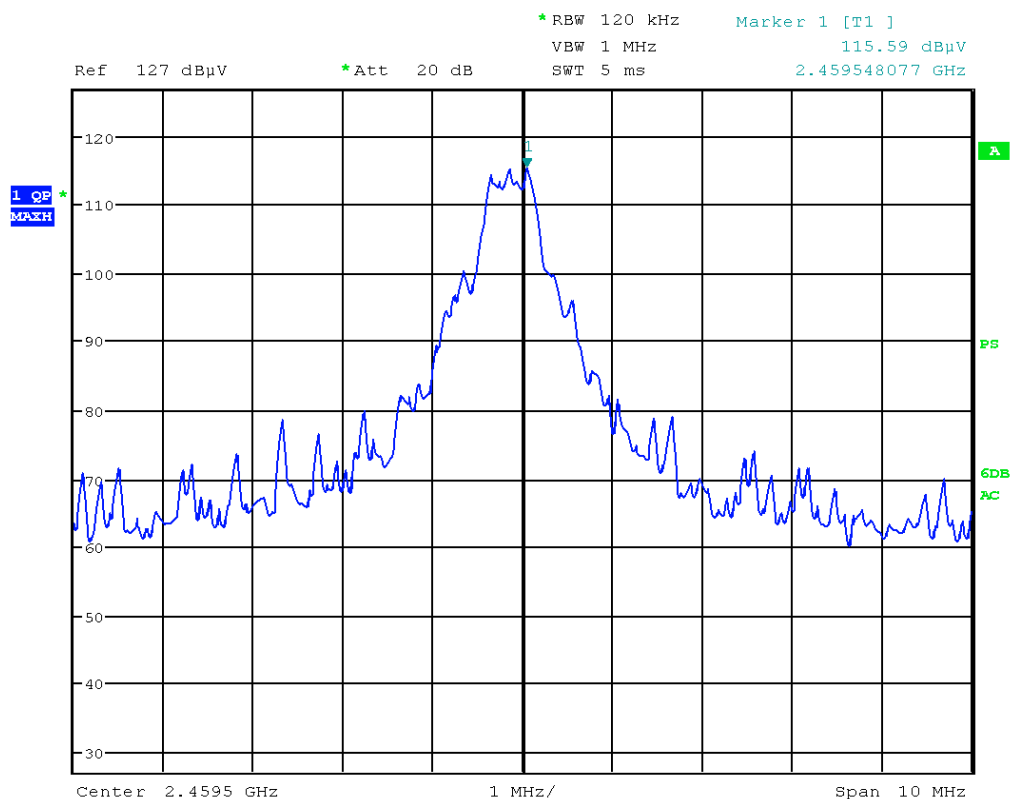
Picture 57: single plot - Odd-band, channel high (PK)



Picture 58: single plot - Odd-band, channel high (QP)



Picture 59: single plot - Odd-band, channel high (PK)



Picture 60: single plot - Odd-band, channel high (QP)

## 10.11 Test results 1 GHz - 26 GHz

Even-band, channel low					
f[GHz]	E <sub>meas</sub> [dBμV]	Detector	Restr. Band	Limit [dBμV]	Result
2.4145	119.56	PK	No	----	Carrier
2.4145	94.48	AV (200Hz)		----	Carrier
4.8285	59.73	PK	Yes	74	Pass
4.8287	50.78	AV (200Hz)		54	Pass
7.2428	53.45	PK	No	-20dBc	Pass
7.2432	43.28	AV (200Hz)		-20dBc	Pass
9.6584	53.81	PK	No	-20dBc	Pass
9.6576	42.36	AV (200Hz)		-20dBc	Pass
12.0731	58.27	PK	Yes	74	Pass
12.0721	45.64	AV (200Hz)		54	Pass

Picture 61: spurious emission - Even-band, channel low - Table (1GHz - 26GHz)



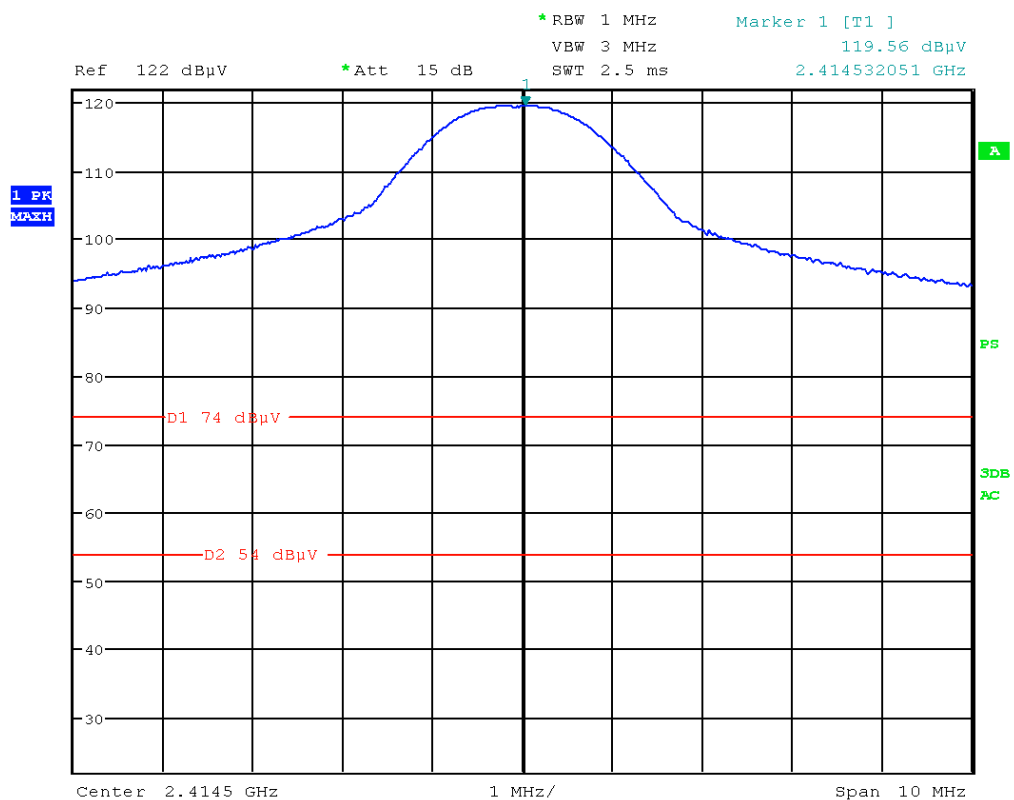
EMV **TESTHAUS** GmbH  
 Gustav-Hertz-Straße 35  
 94315 Straubing  
 Germany  
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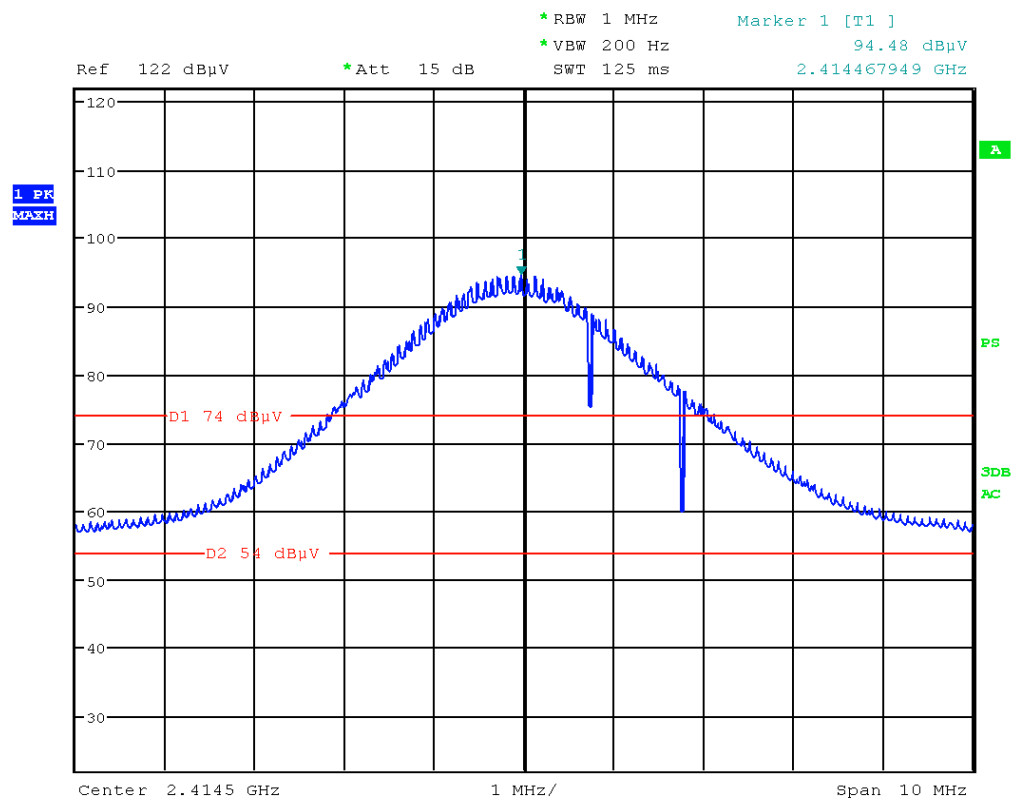
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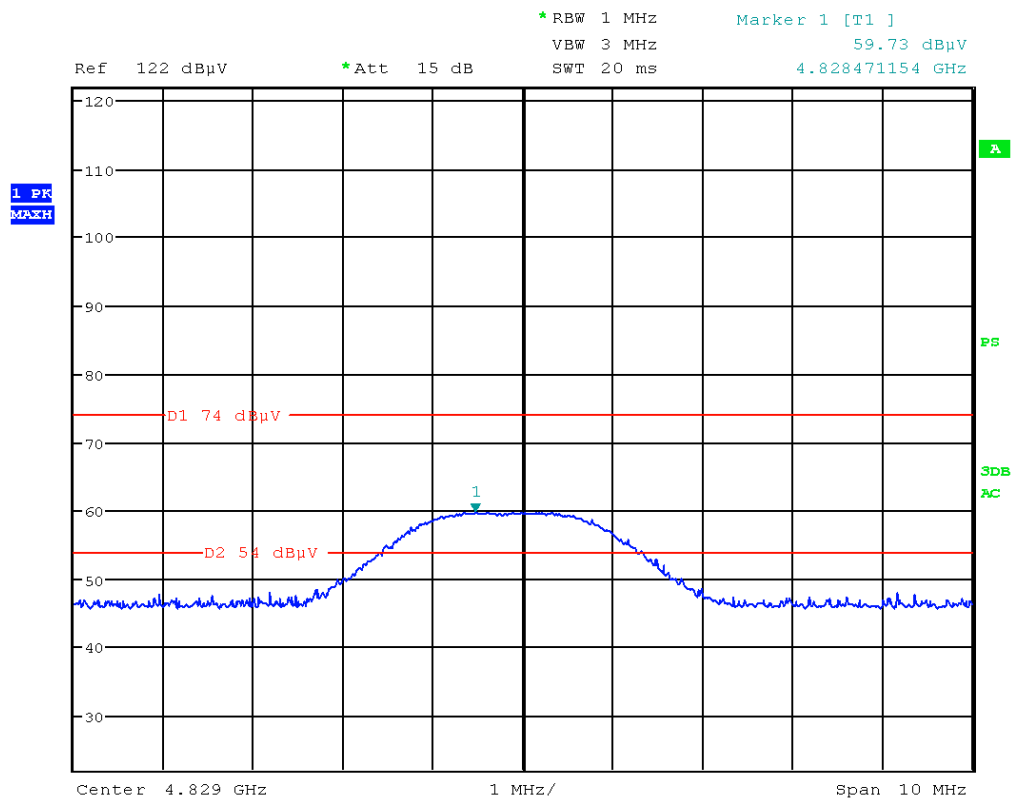




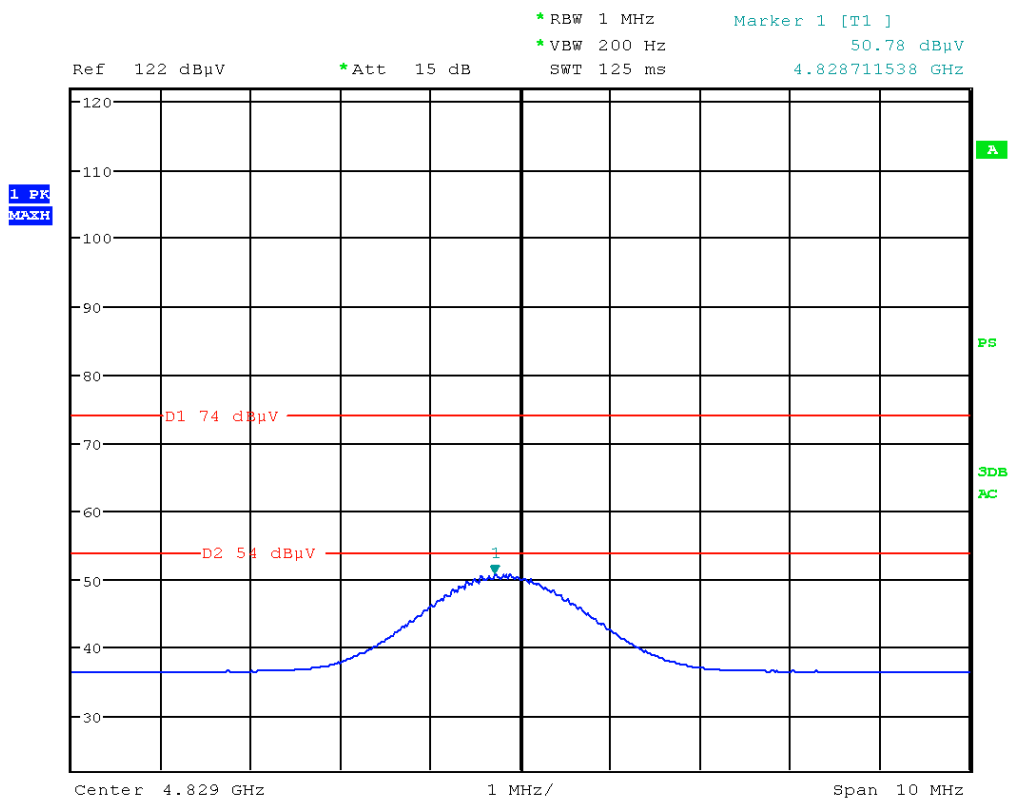
Picture 62: spurious emission - Even-band, channel low - PK (1GHz - 26GHz)



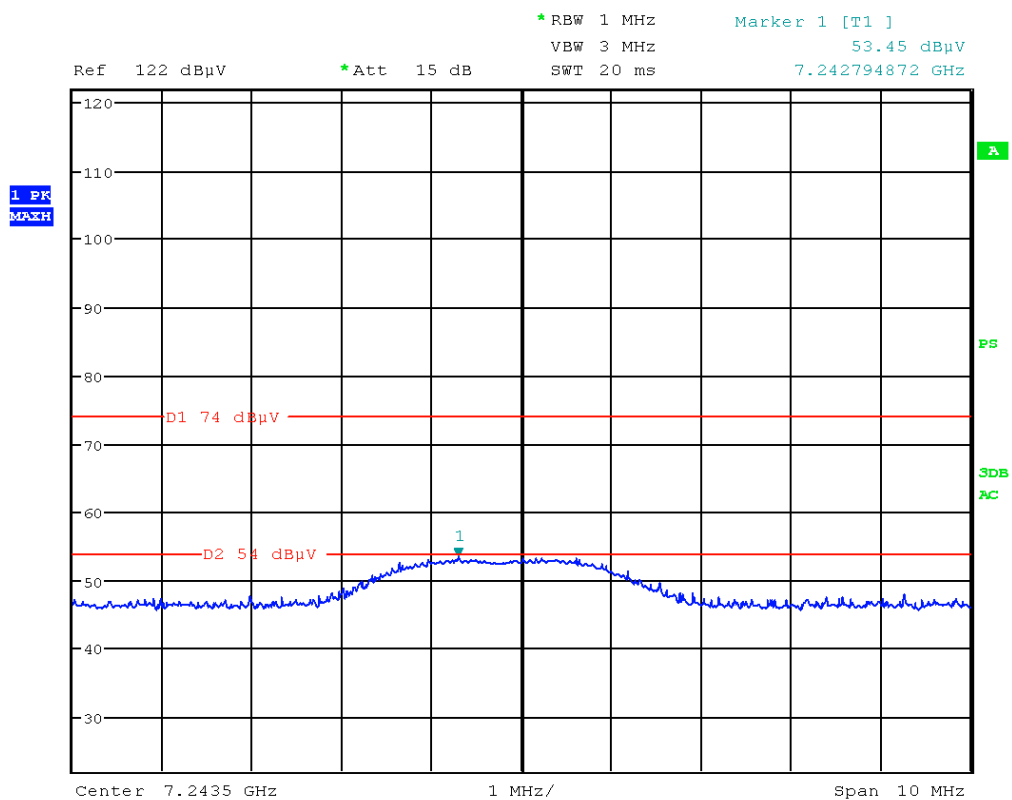
Picture 63: spurious emission - Even-band, channel low - AV (1GHz - 26GHz)



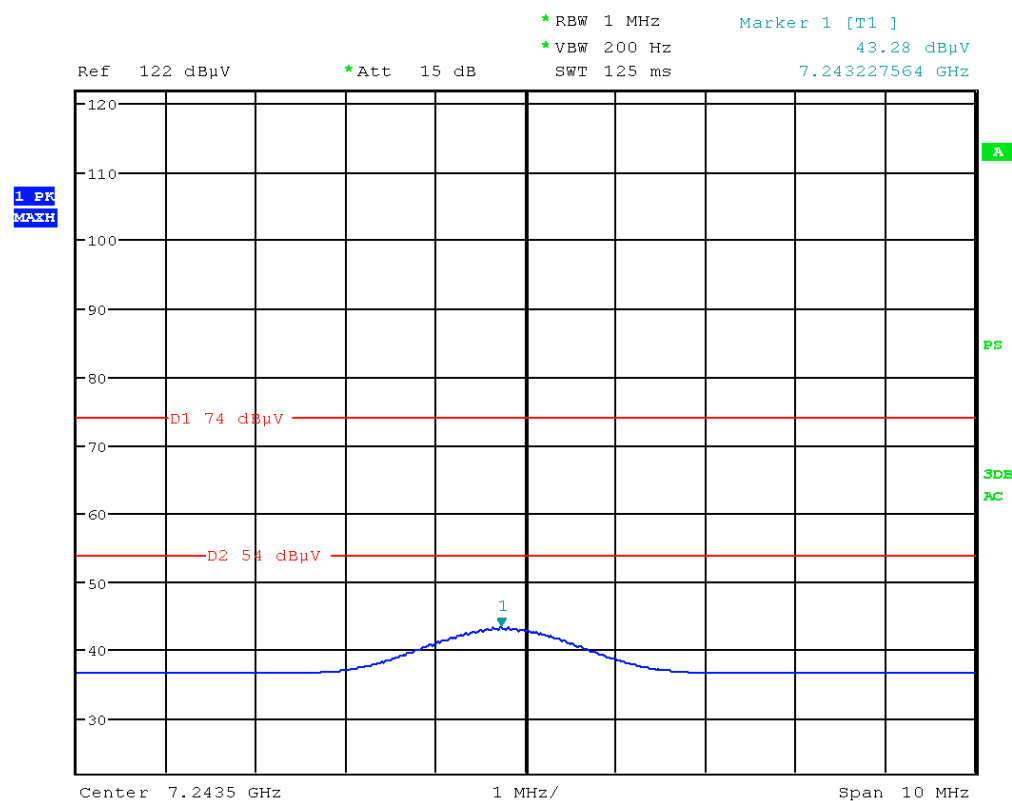
Picture 64: spurious emission - Even-band, channel low - PK (1GHz - 26GHz)



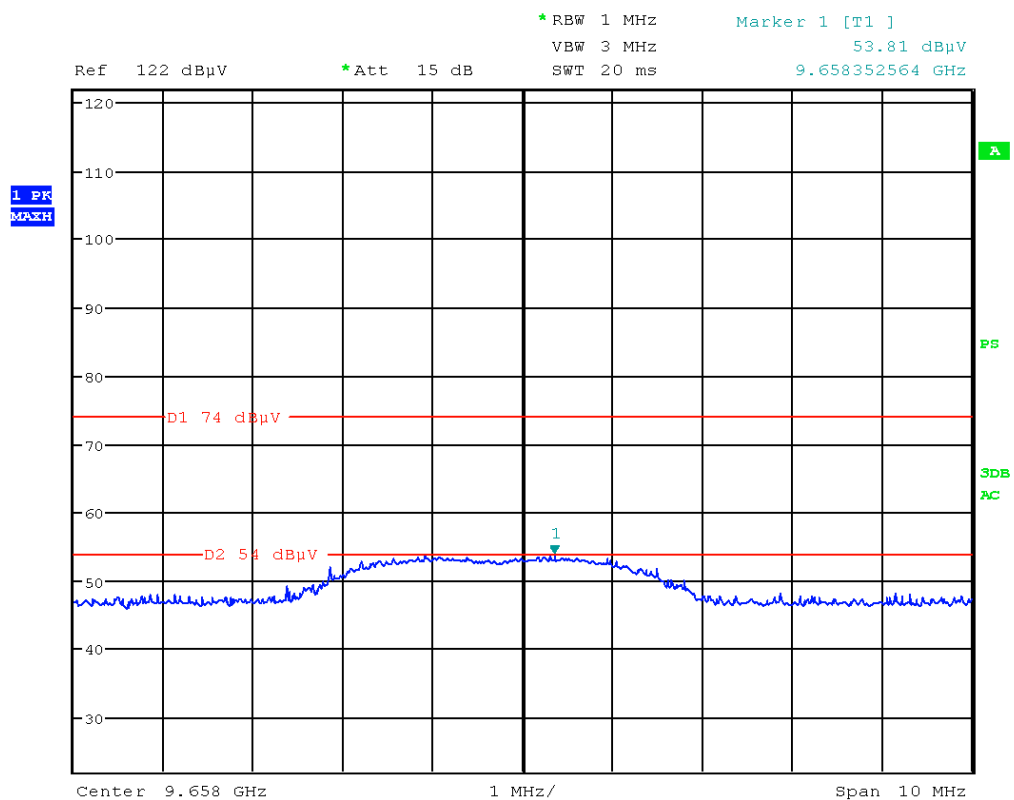
Picture 65: spurious emission - Even-band, channel low - AV (1GHz - 26GHz)



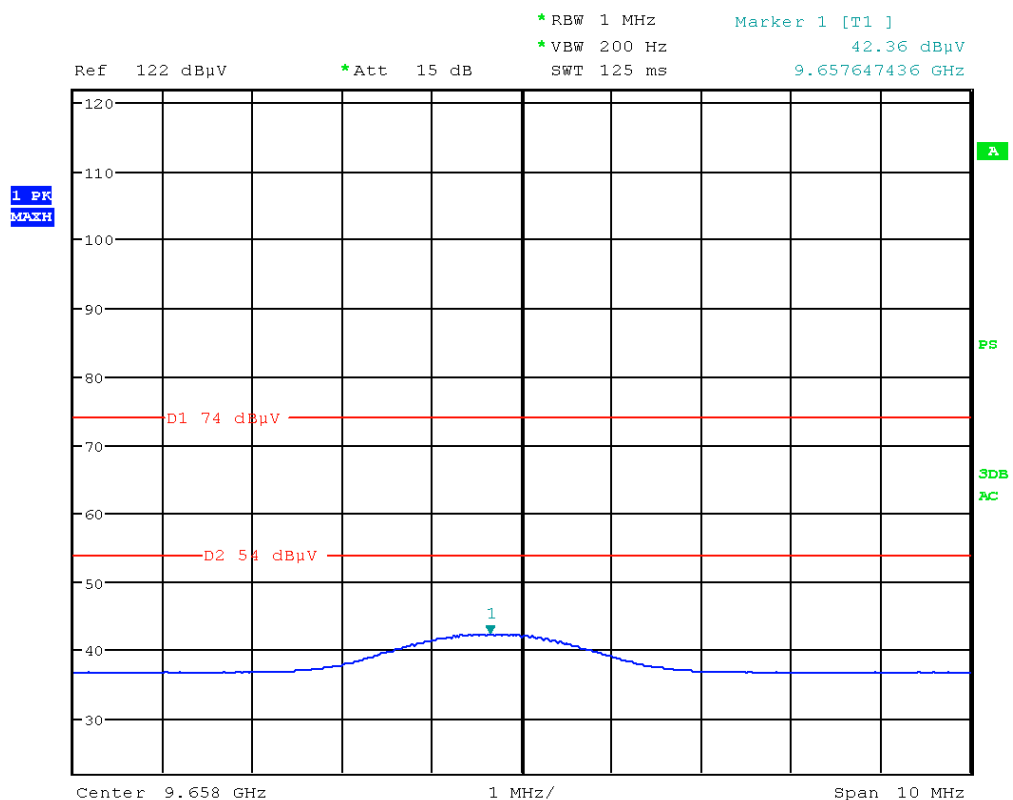
Picture 66: spurious emission - Even-band, channel low - PK (1GHz - 26GHz)



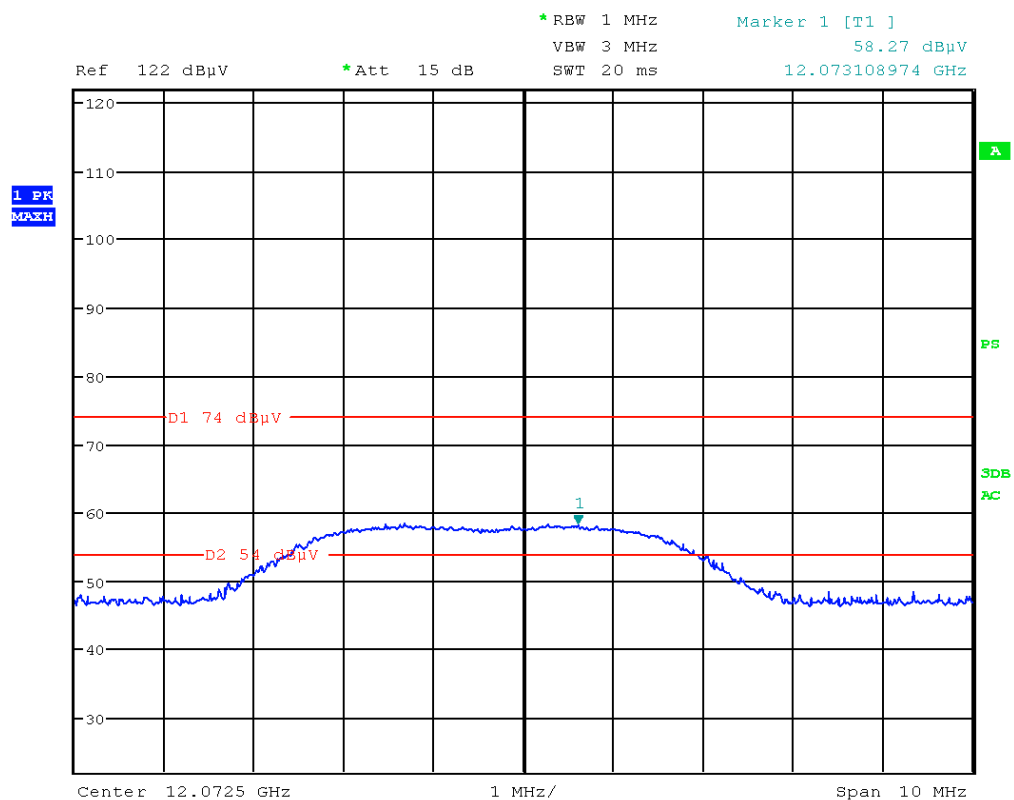
Picture 67: spurious emission - Even-band, channel low - AV (1GHz - 26GHz)



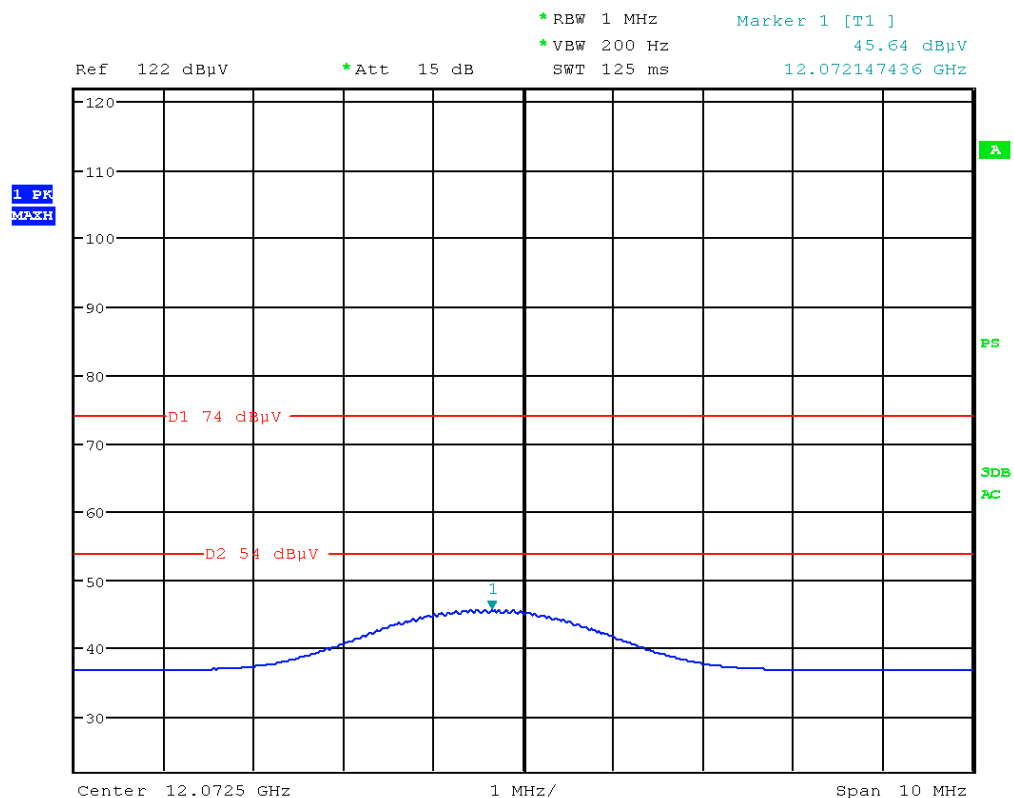
Picture 68: spurious emission - Even-band, channel low - PK (1GHz - 26GHz)



Picture 69: spurious emission - Even-band, channel low - AV (1GHz - 26GHz)



Picture 70: spurious emission - Even-band, channel low - PK (1GHz - 26GHz)

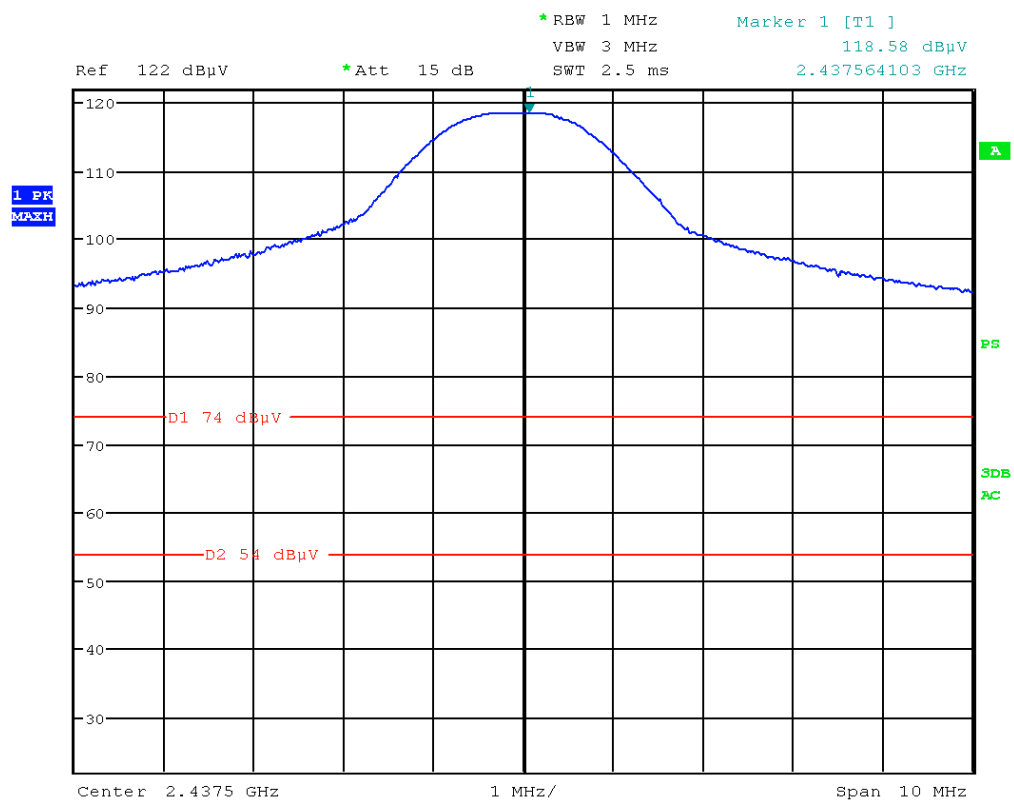


Picture 71: spurious emission - Even-band, channel low - AV (1GHz - 26GHz)

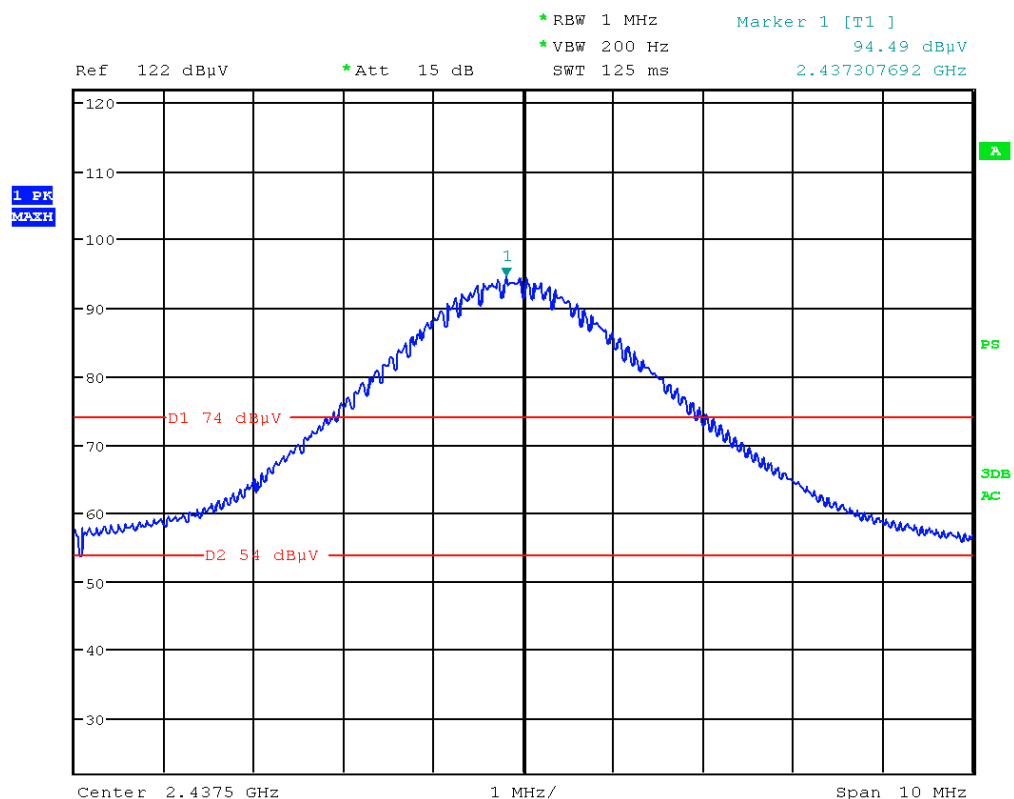
Odd-band, channel mid					
f[GHz]	E <sub>meas</sub> [dBμV]	Detector	Restr. Band	Limit [dBμV]	Result
2.4376	118.58	PK	No	----	Carrier
2.4373	94.49	AV (200Hz)		----	Carrier
4.8749	59.12	PK	Yes	74	Pass
4.8747	49.98	AV (200Hz)		54	Pass
7.3126	52.20	PK	Yes	74	Pass
7.3121	41.98	AV (200Hz)		54	Pass
9.7490	52.69	PK	No	-20dBc	Pass
9.7498	41.01	AV (200Hz)		-20dBc	Pass
12.1862	56.04	PK	Yes	74	Pass
12.1872	43.68	AV (200Hz)		54	Pass

Picture 72: spurious emission - Odd-band, channel mid - Table (1GHz - 26GHz)

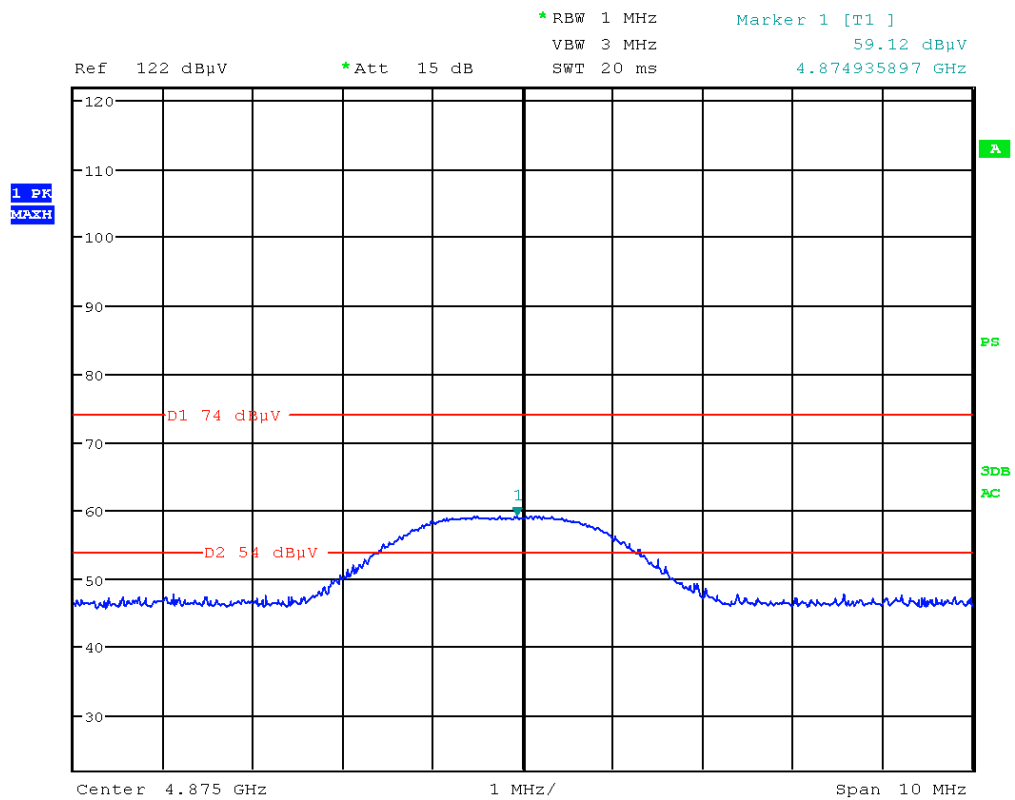




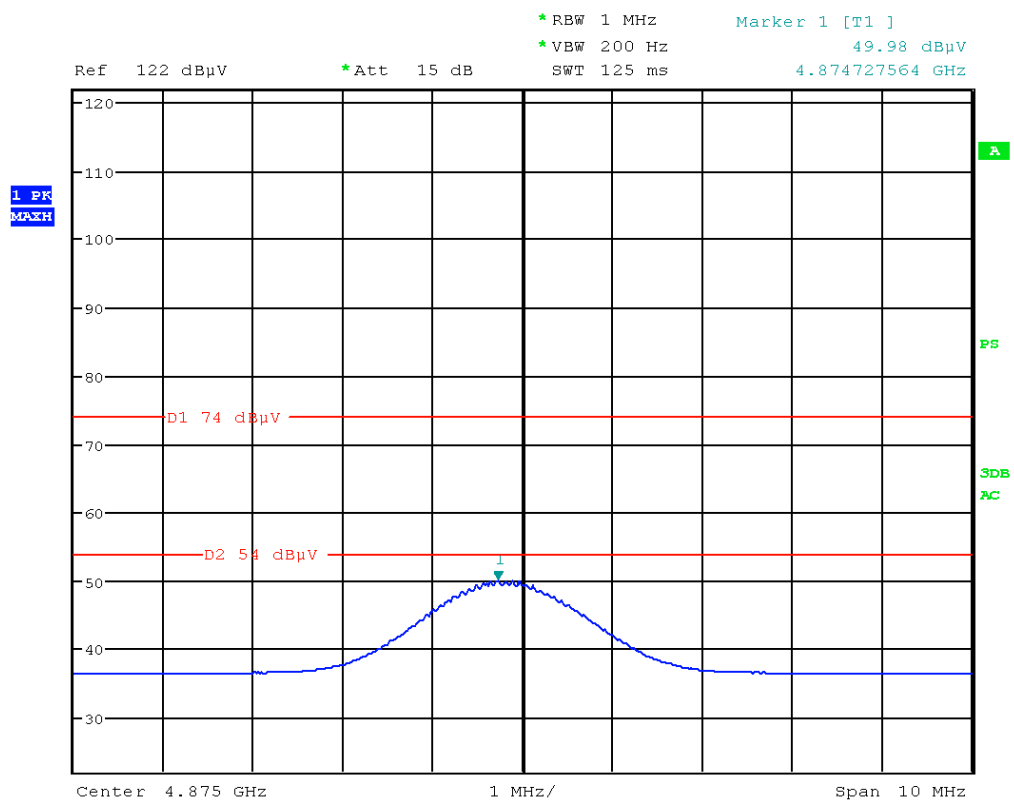
Picture 73: spurious emission - Odd-band, channel mid - PK (1GHz - 26GHz)



Picture 74: spurious emission - Odd-band, channel mid - AV (1GHz - 26GHz)

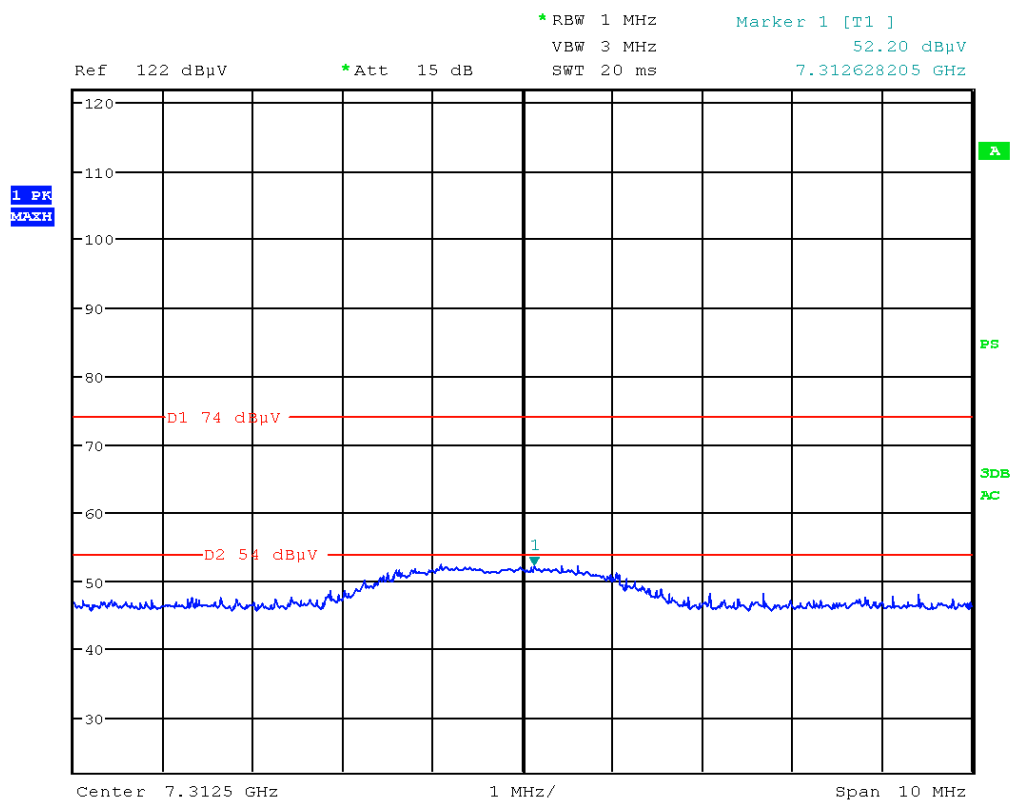


Picture 75: spurious emission - Odd-band, channel mid - PK (1GHz - 26GHz)

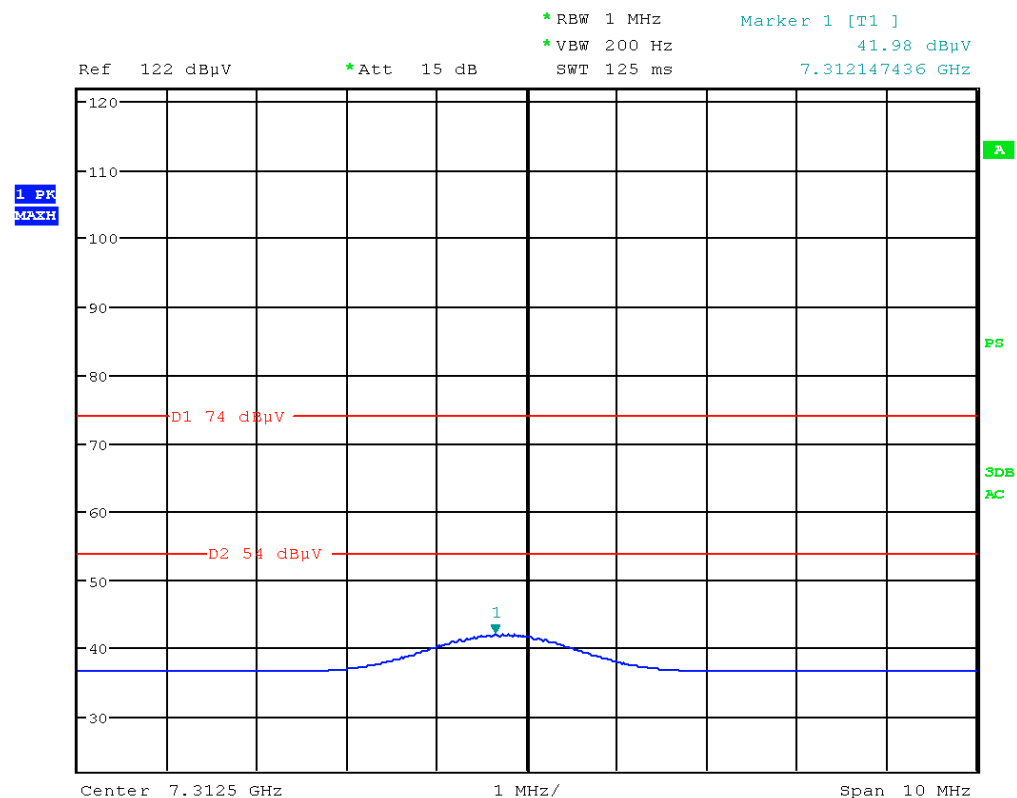


Picture 76: spurious emission - Odd-band, channel mid - AV (1GHz - 26GHz)

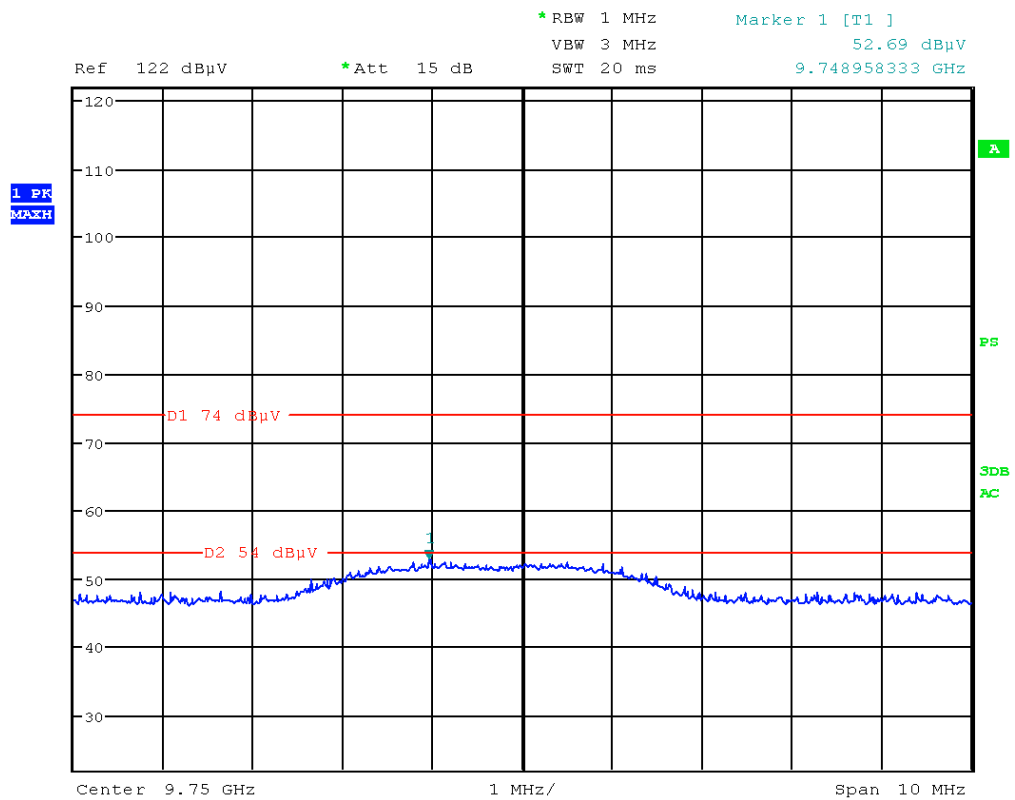




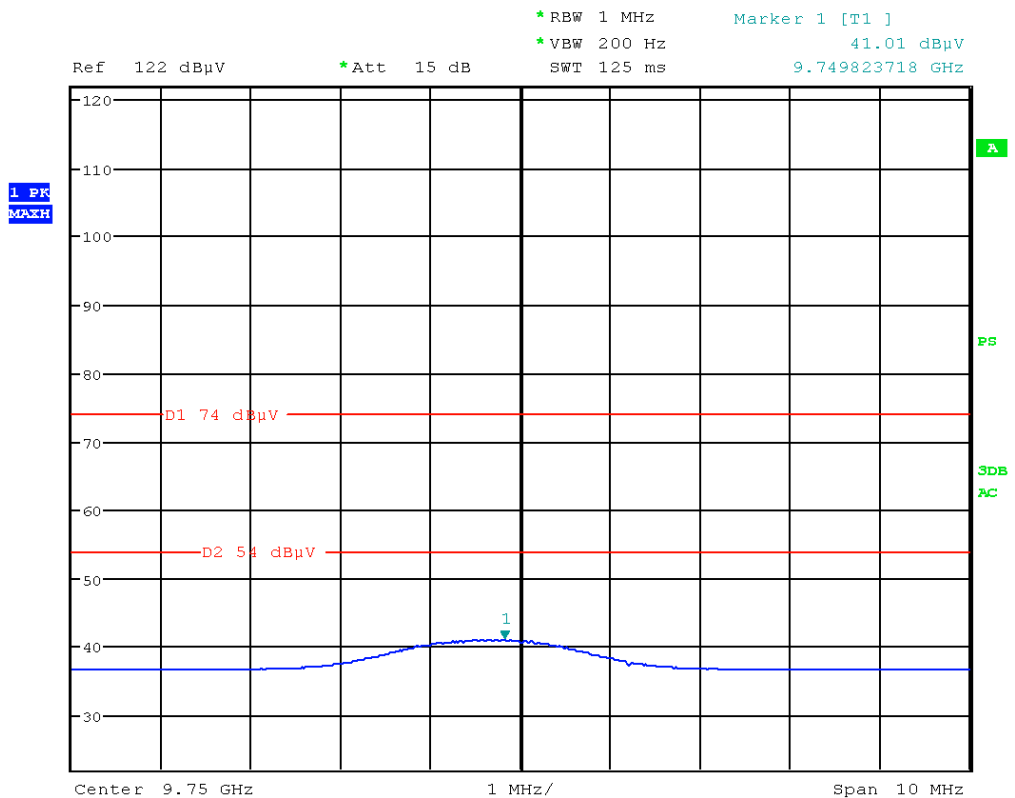
Picture 77: spurious emission - Odd-band, channel mid - PK (1GHz - 26GHz)



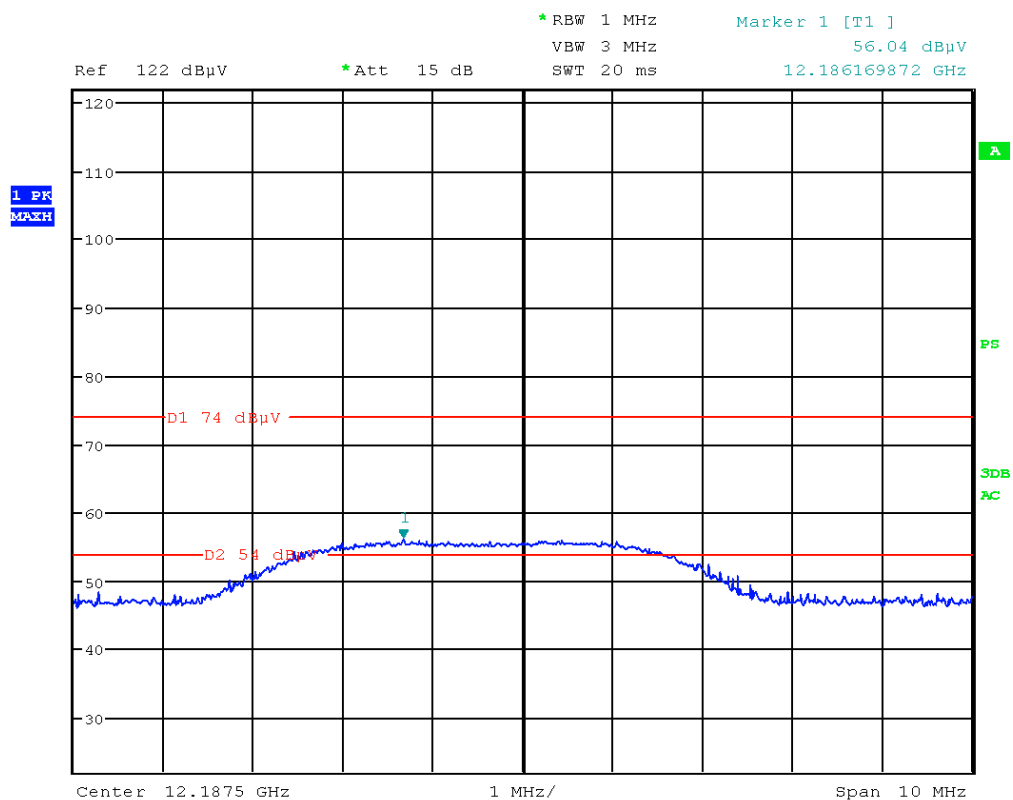
Picture 78: spurious emission - Odd-band, channel mid - AV (1GHz - 26GHz)



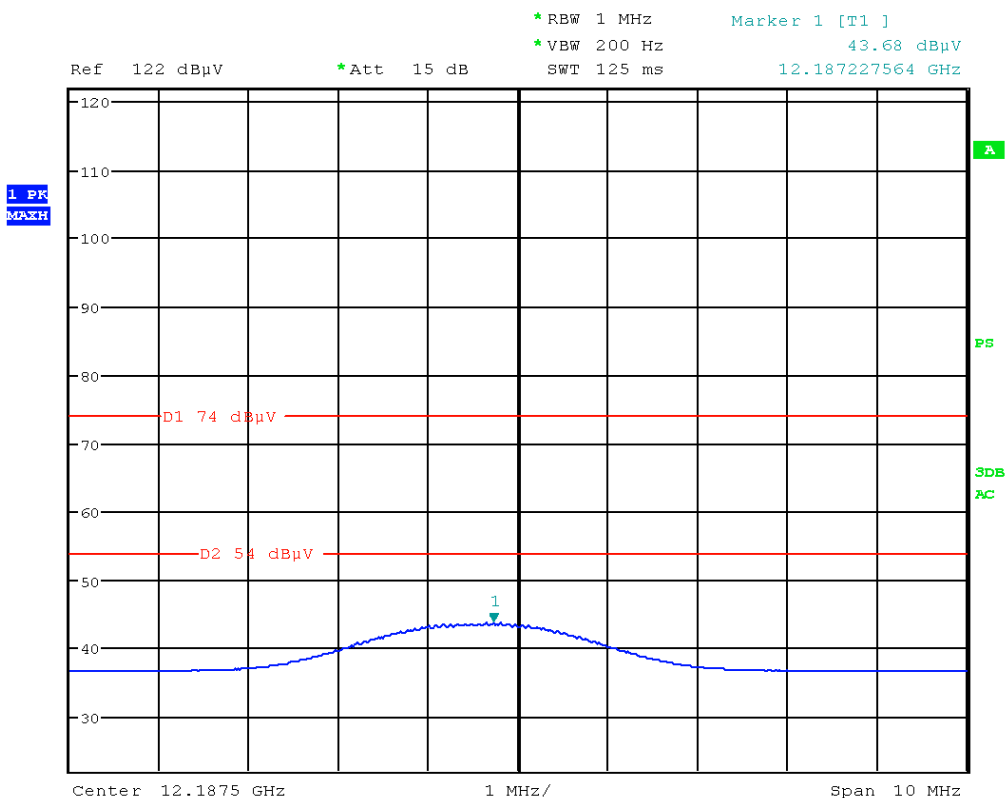
Picture 79: spurious emission - Odd-band, channel mid - PK (1GHz - 26GHz)



Picture 80: spurious emission - Odd-band, channel mid - AV (1GHz - 26GHz)



Picture 81: spurious emission - Odd-band, channel mid - PK (1GHz - 26GHz)



Picture 82: spurious emission - Odd-band, channel mid - AV (1GHz - 26GHz)

Odd-band, channel high					
f[GHz]	E <sub>meas</sub> [dBμV]	Detector	Restr. Band	Limit [dBμV]	Result
2.4596	118.35	PK	No	----	Carrier
2.4595	105.81	AV (300Hz)		----	Carrier
4.9182	57.06	PK	Yes	74	Pass
4.9187	50.60	AV (300Hz)		54	Pass
7.3778	51.76	PK	Yes	74	Pass
7.3782	41.34	AV (300Hz)		54	Pass
9.8374	51.92	PK	Yes	74	Pass
9.8377	41.30	AV (300Hz)		54	Pass
12.2960	54.04	PK	Yes	74	Pass
12.2975	42.80	AV (300Hz)		54	Pass

Picture 83: spurious emission - Odd-band, channel high - Table (1GHz - 26GHz)

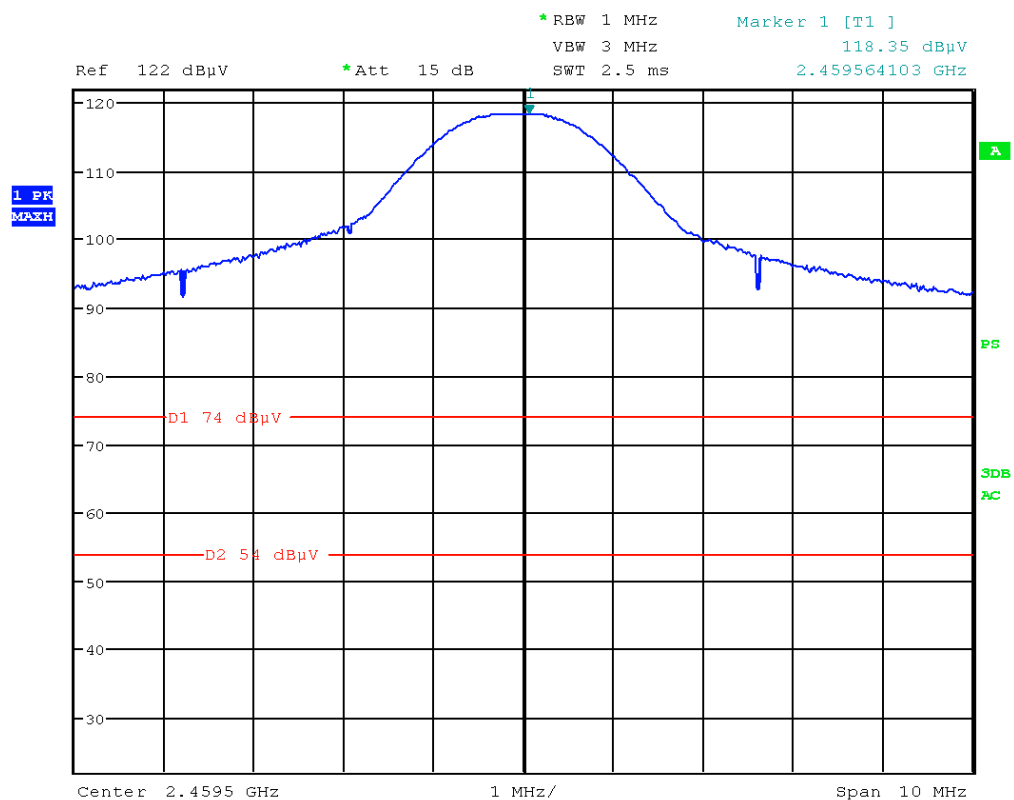


EMV **TESTHAUS** GmbH  
Gustav-Hertz-Straße 35  
94315 Straubing  
Germany  
Revision: 1.0

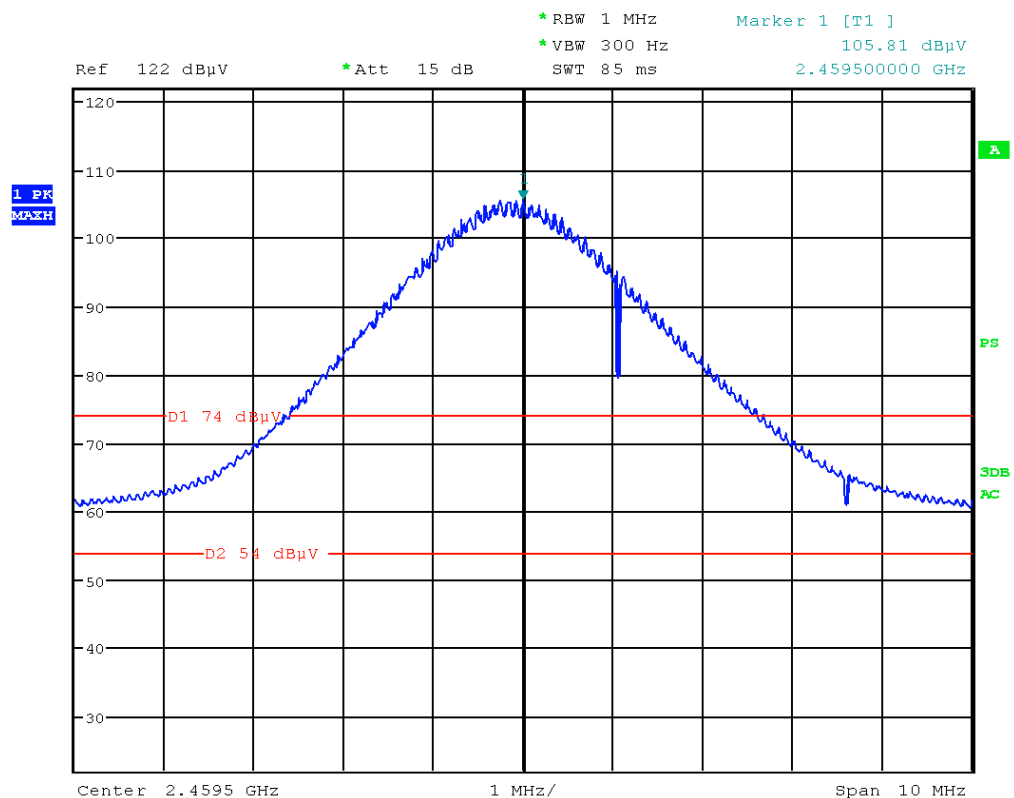
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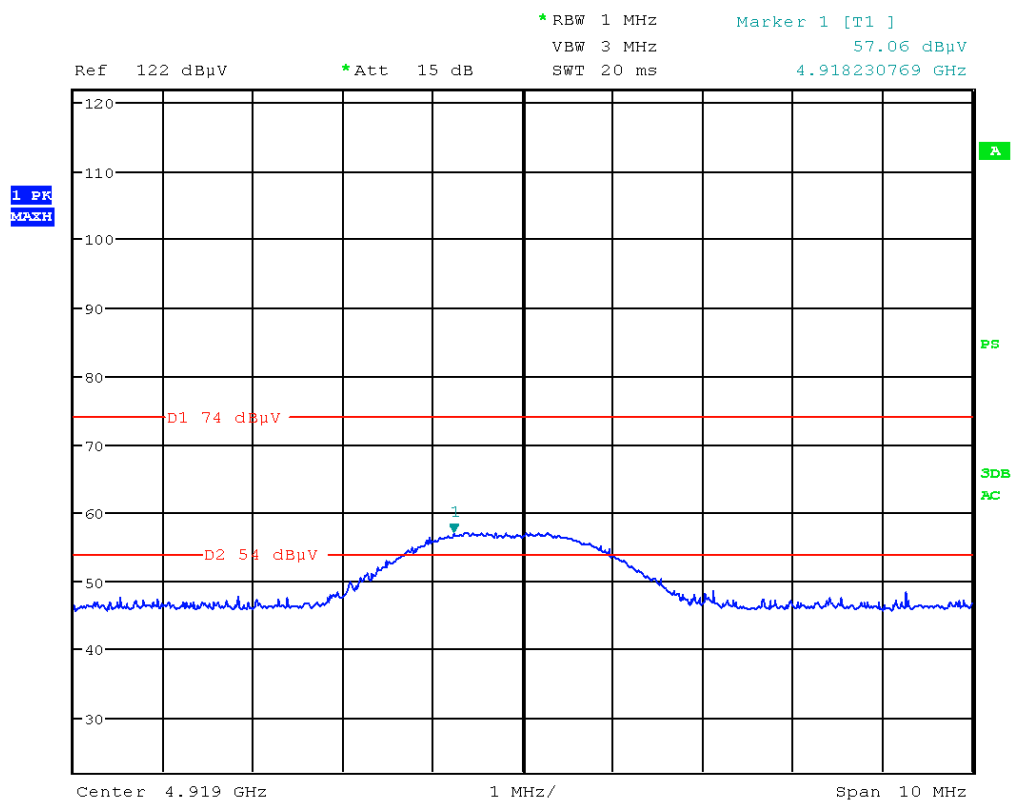
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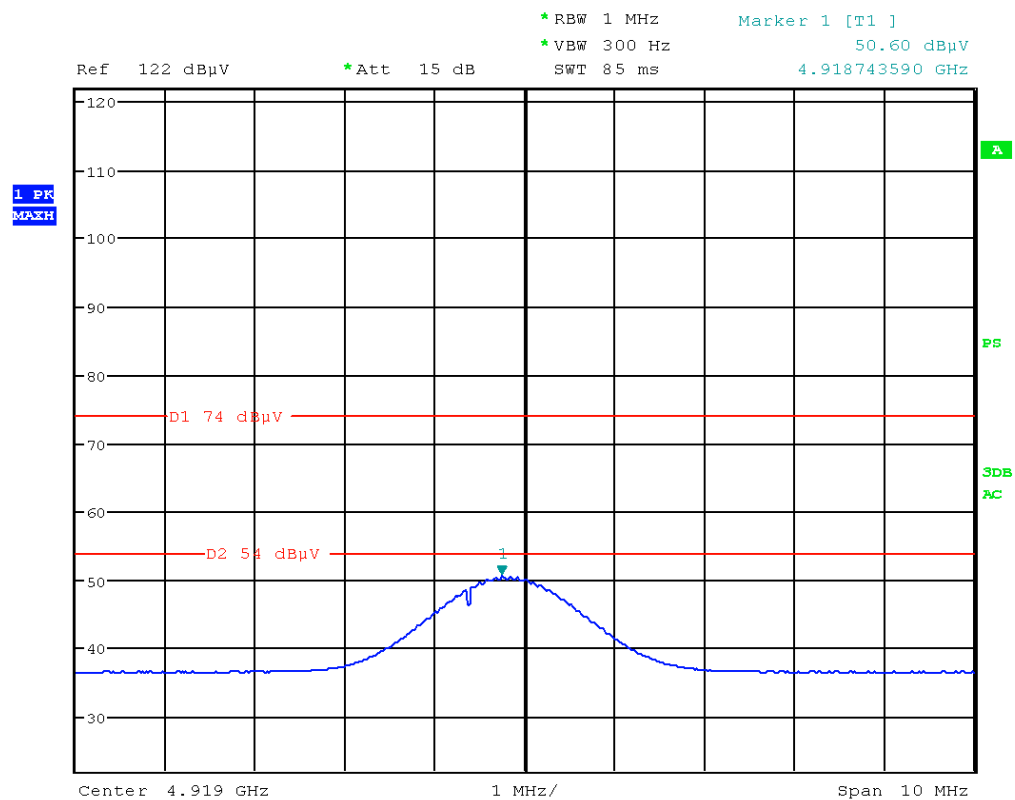
Picture 84: spurious emission - Odd-band, channel high - PK (1GHz - 26GHz)



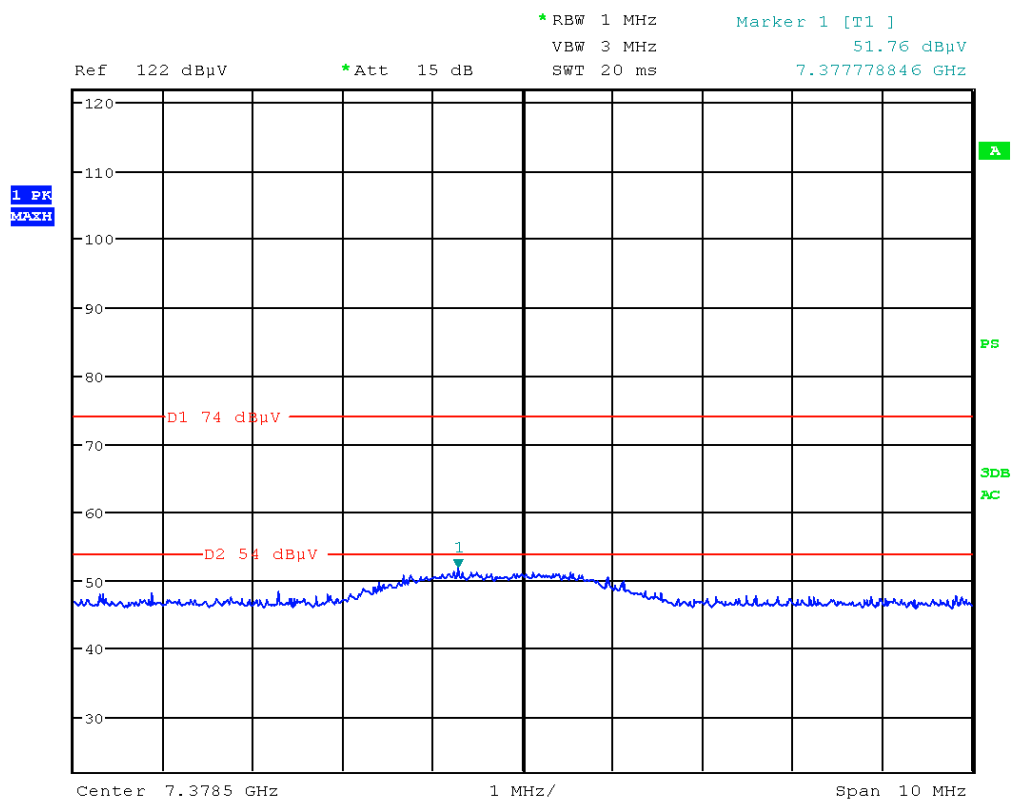
Picture 85: spurious emission - Odd-band, channel high - AV (1GHz - 26GHz)



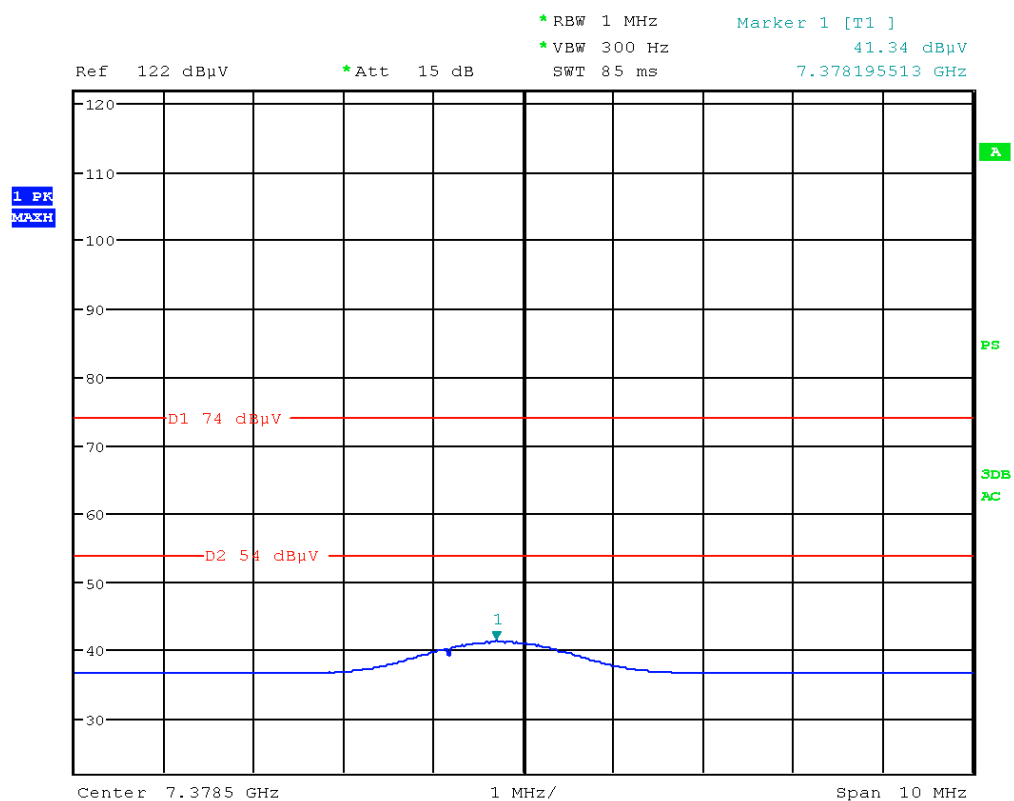
Picture 86: spurious emission - Odd-band, channel high - PK (1GHz - 26GHz)



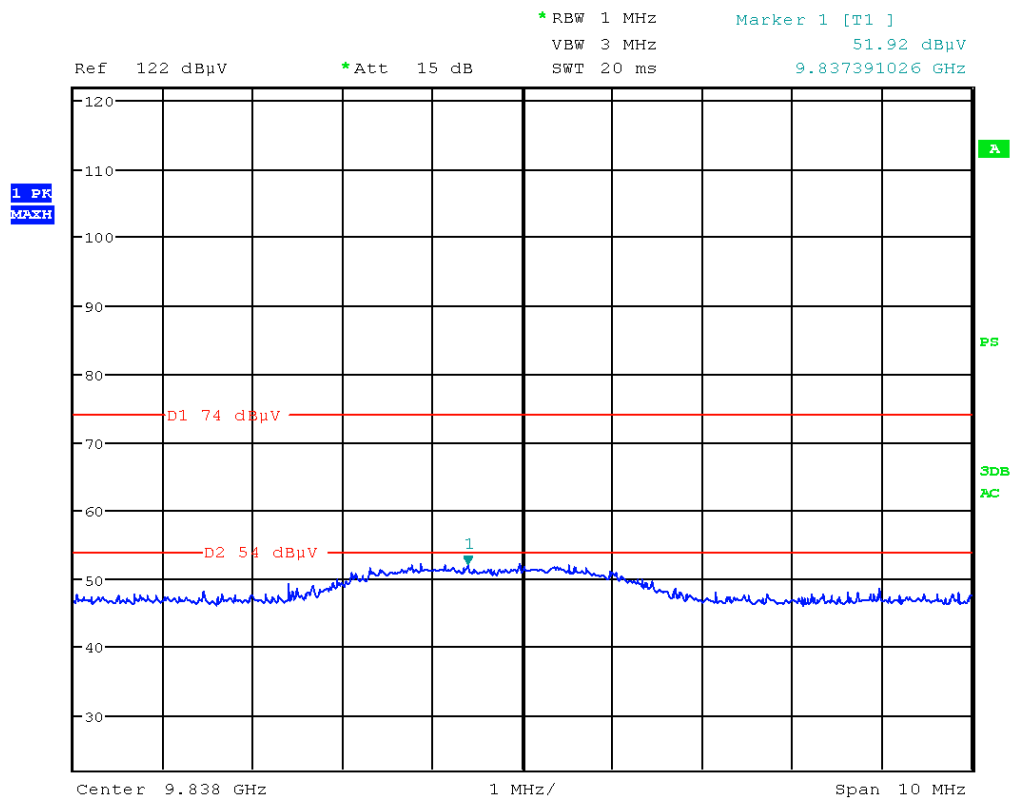
Picture 87: spurious emission - Odd-band, channel high - AV (1GHz - 26GHz)



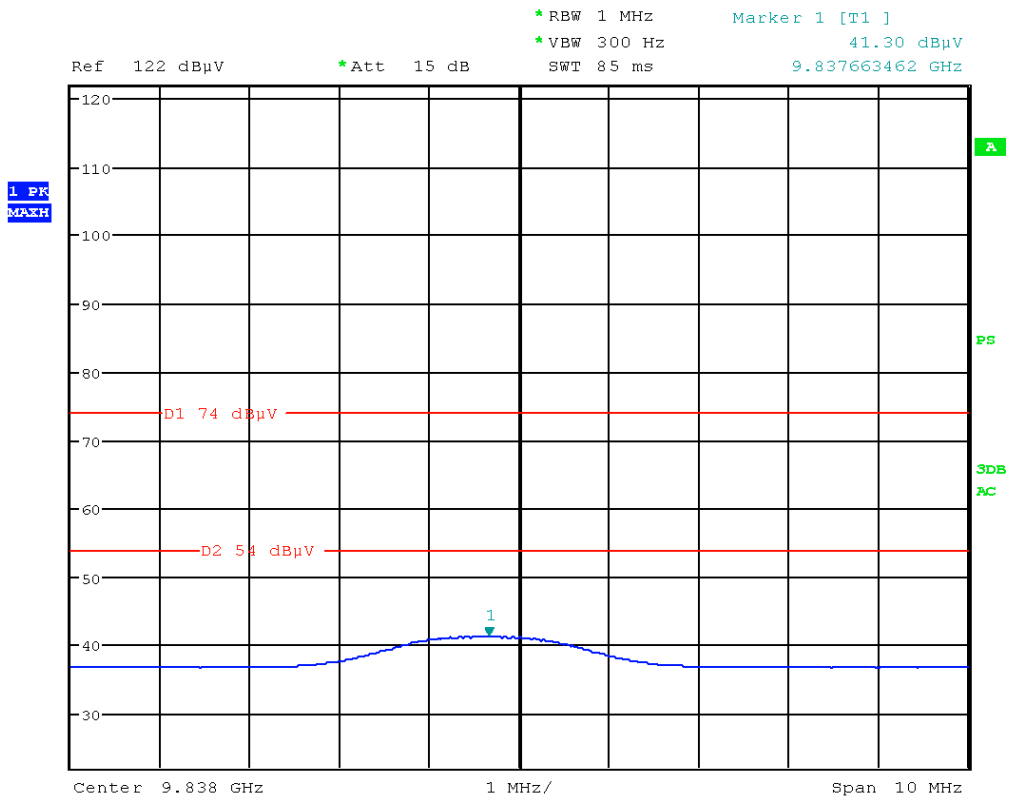
Picture 88: spurious emission - Odd-band, channel high - PK (1GHz - 26GHz)



Picture 89: spurious emission - Odd-band, channel high - AV (1GHz - 26GHz)

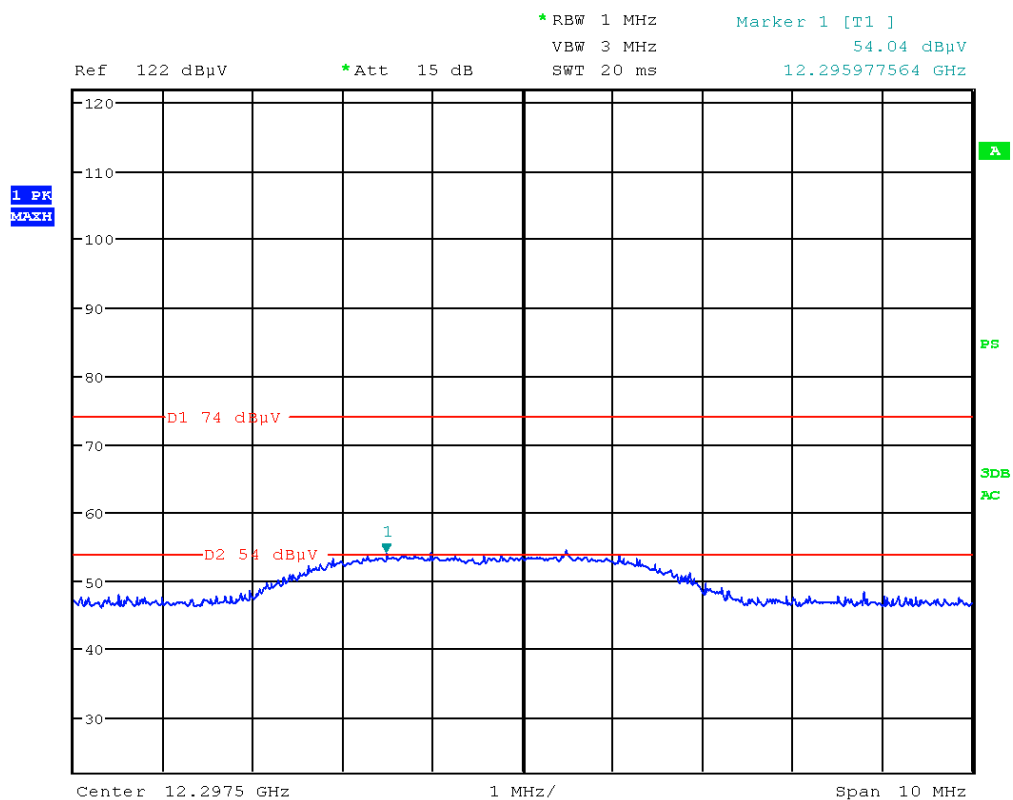


Picture 90: spurious emission - Odd-band, channel high - PK (1GHz - 26GHz)

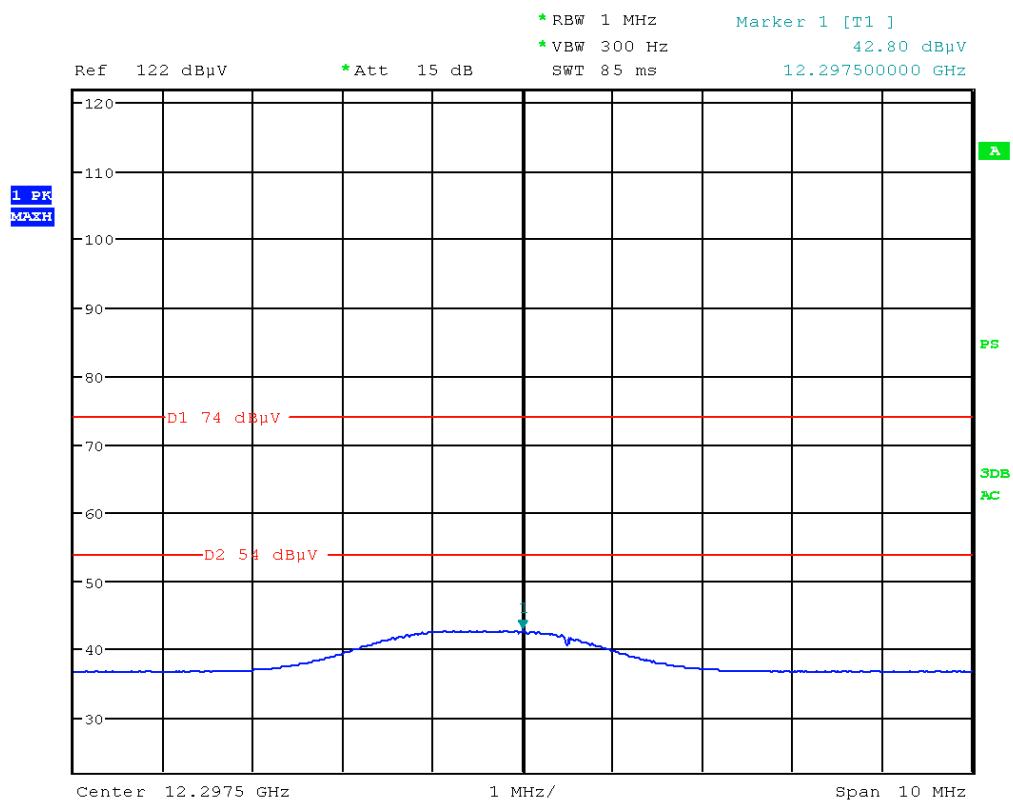


Picture 91: spurious emission - Odd-band, channel high - AV (1GHz - 26GHz)





Picture 92: spurious emission - Odd-band, channel high - PK (1GHz - 26GHz)



Picture 93: spurious emission - Odd-band, channel high - AV (1GHz - 26GHz)

# 11 Radiated emission measurement (<1 GHz)

according to CFR 47 Part 15, sections 15.205(a), 15.209(a), 15.247(d)

## 11.1 Test Location

- ☒ Scan with peak detector in 3 m anechoic chamber (9 kHz - 30 MHz).
- ☒ Scan with quasi-peak detector in 3 m SAC (30 MHz - 1 GHz).
- ☒ Final CISPR measurement with quasi peak detector on 3 m open area test site.

Description	Manufacturer	Inventory No.
Anechoic chamber	EMV <b>TESTHAUS</b> GmbH	E00100
SAC	Albatross Projects	E00716
Open area test site	EMV <b>TESTHAUS</b> GmbH	E00354

## 11.2 Test instruments

	Description	Manufacturer	Inventory No.
<input checked="" type="checkbox"/>	ESR7 (SAC / OATS)	Rohde & Schwarz	E00739
<input type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	ESCI (AC / OATS)	Rohde & Schwarz	E00001
<input checked="" type="checkbox"/>	VULB 9163 (OATS)	Schwarzbeck	E00013
<input checked="" type="checkbox"/>	VULB 9162 (SAC)	Schwarzbeck	E00643
<input checked="" type="checkbox"/>	HFH2-Z2 (AC / OATS)	Rohde & Schwarz	E00060
<input checked="" type="checkbox"/>	Feedline OATS	Huber & Suhner	200024



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## 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 [ $\mu\text{V/m}$ ]	Field strength [ $\text{dB}\mu\text{V/m}$ ]	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. The test is performed in accordance with FCC Public Notice DA 00-705.
2. 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.
3. Power on the EUT and all peripherals.
4. The broadband antenna is set to vertical polarization.
5. The EMI receiver performs 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.
6. The turn table is rotated to 6 different positions ( $360^\circ / 6$ ) and the antenna polarization is changed to horizontal.
7. Repeat the test procedure at step 4 and 5.
8. 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.
9. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
10. 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.
11. For emissions below 30MHz, measurements are performed with a loop antenna. The antenna height is not changed during this test.



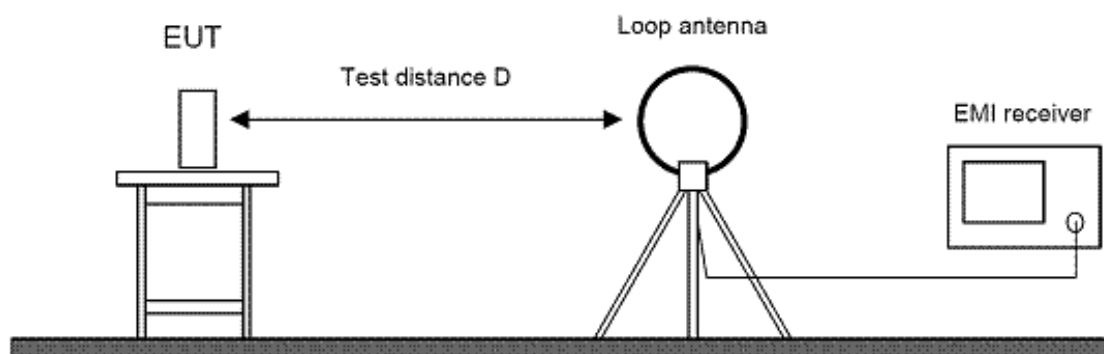
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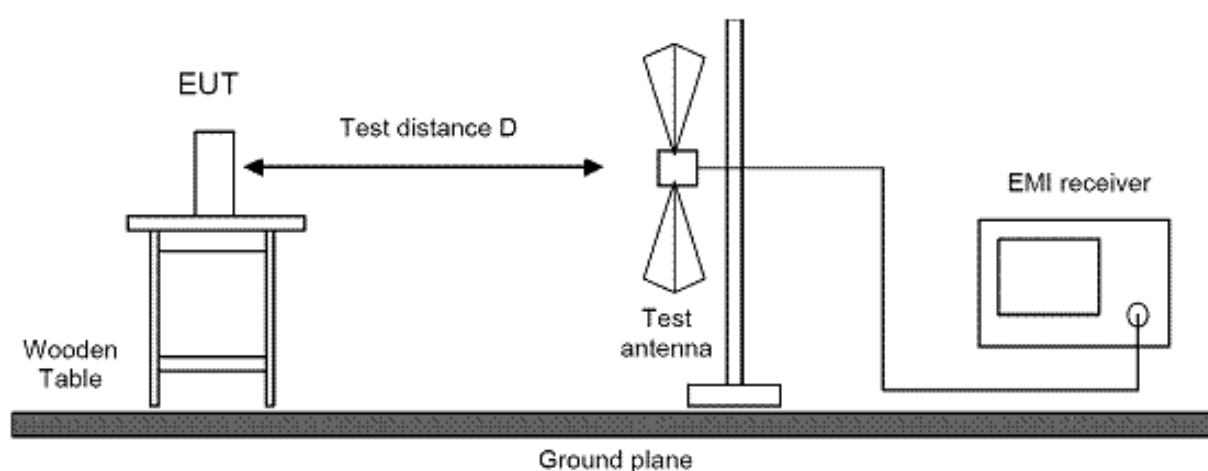
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## 11.5 Test setup



Picture 94: Test setup for radiated emission measurement (< 30 MHz)



Picture 95: 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-position2 is the respective worst-case for the measurements below 1GHz.

For the measurements below 30MHz the loop-antenna was polarized to "I".



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## 11.8 Test results

### Transmit mode

Temperature:	21°C	Humidity:	44%
Tested by:	M. Müller	Test date:	2015-05-28

### Radiated Emission Measurement 9 kHz – 30 MHz

Note:

Measured value = dB $\mu$ V/m @ 3 m

Recalculation factor = 40 dB / decade

Recalculated value1 = dB $\mu$ V/m @ 3 m - 40 dB = **dB $\mu$ V/m @ 30 m**

Recalculated value2 = dB $\mu$ V/m @ 30 m - 40 dB = **dB $\mu$ V/m @ 300 m**

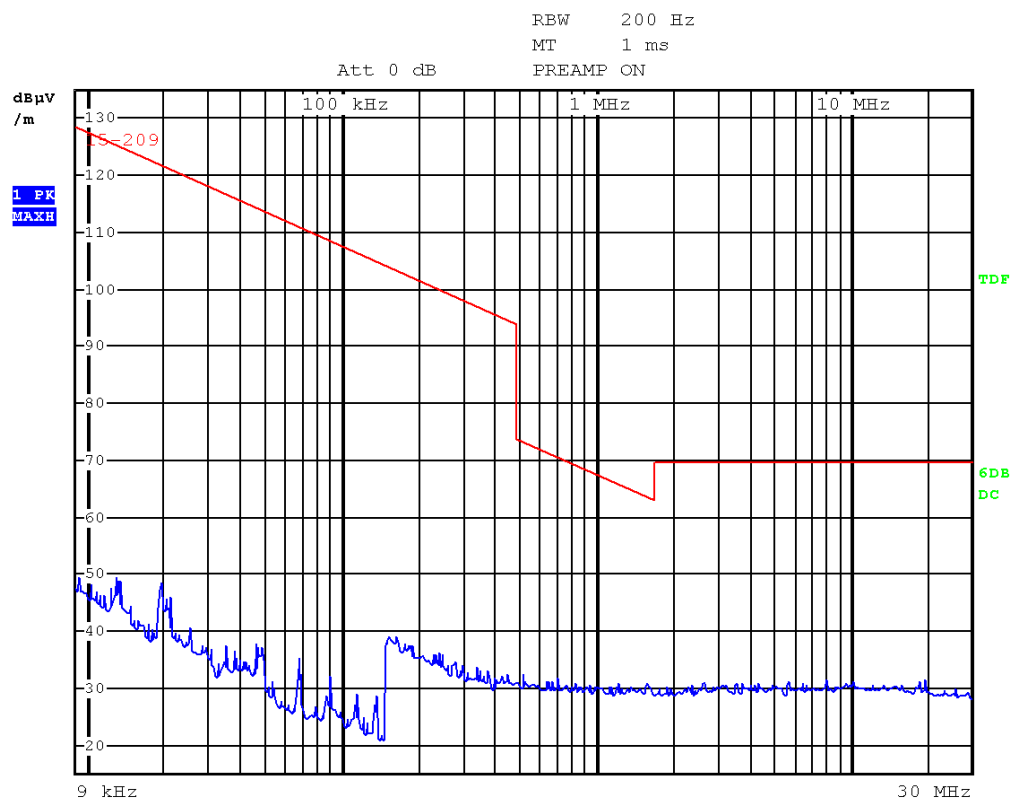


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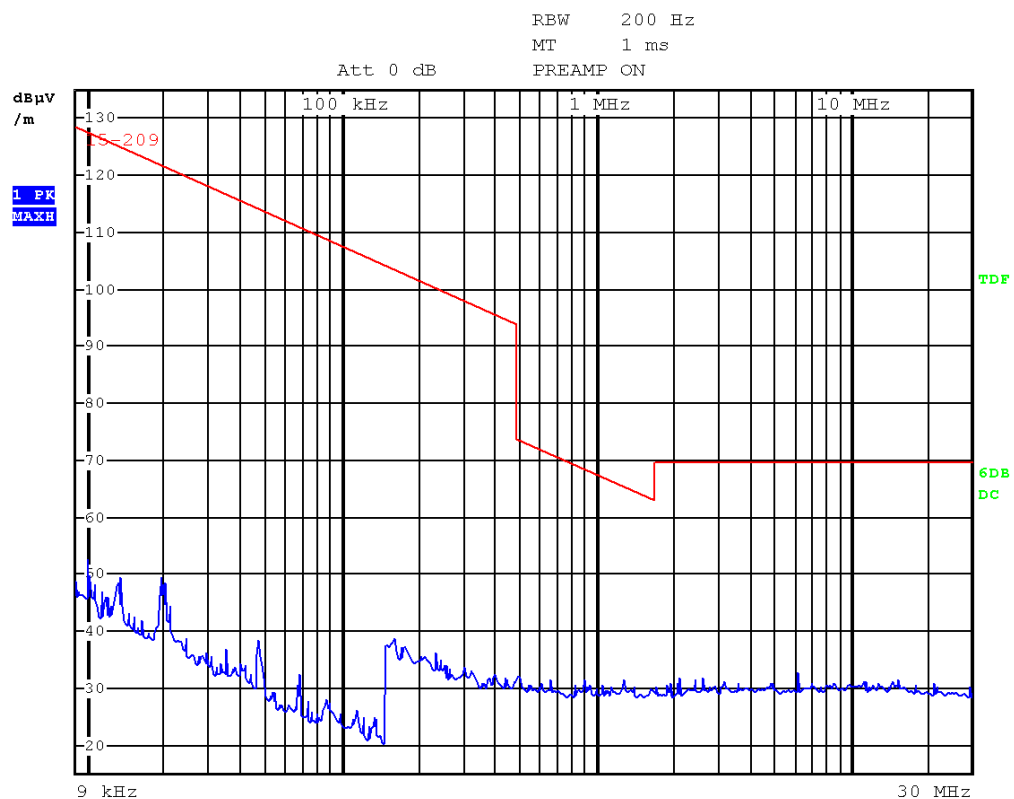
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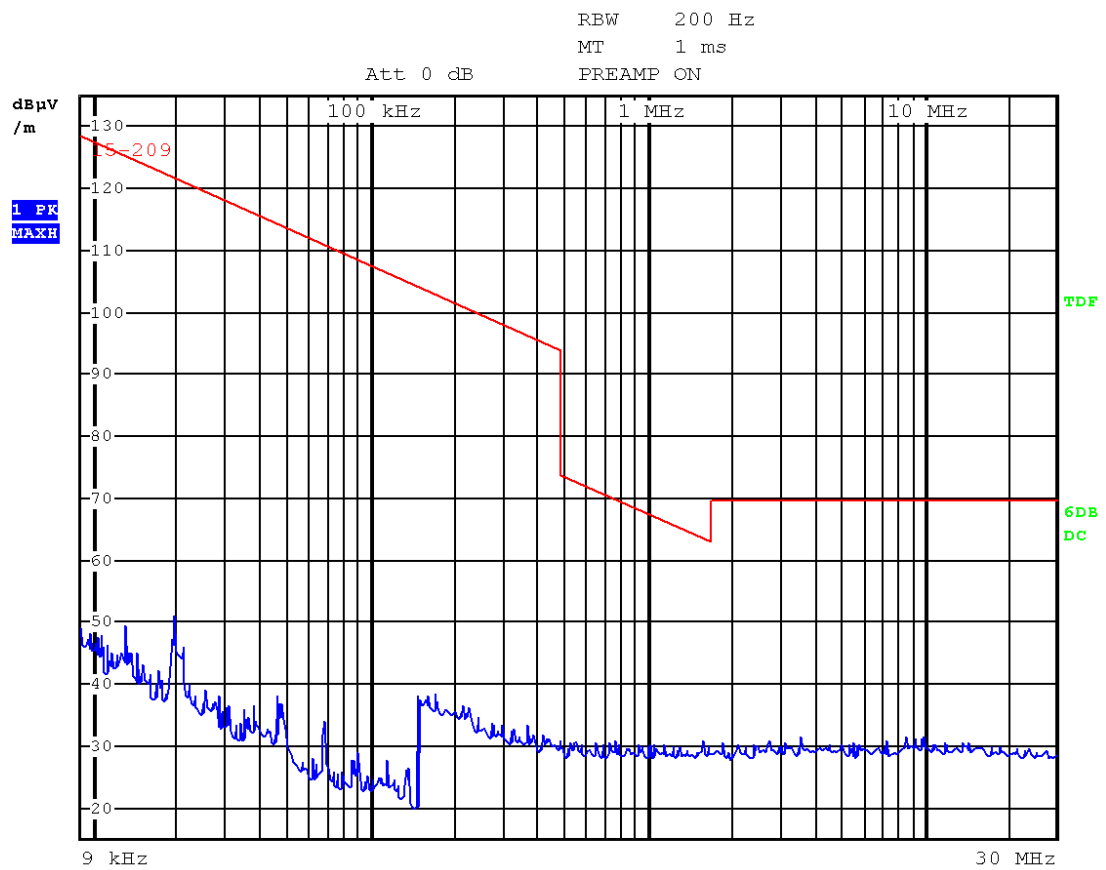
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Picture 96: Radiated emission 9 kHz – 30MHz (Even-band, channel low)



Picture 97: Radiated emission 9 kHz – 30MHz (Odd-band, channel mid)



Picture 98: Radiated emission 9 kHz – 30MHz (Odd-band, channel high)

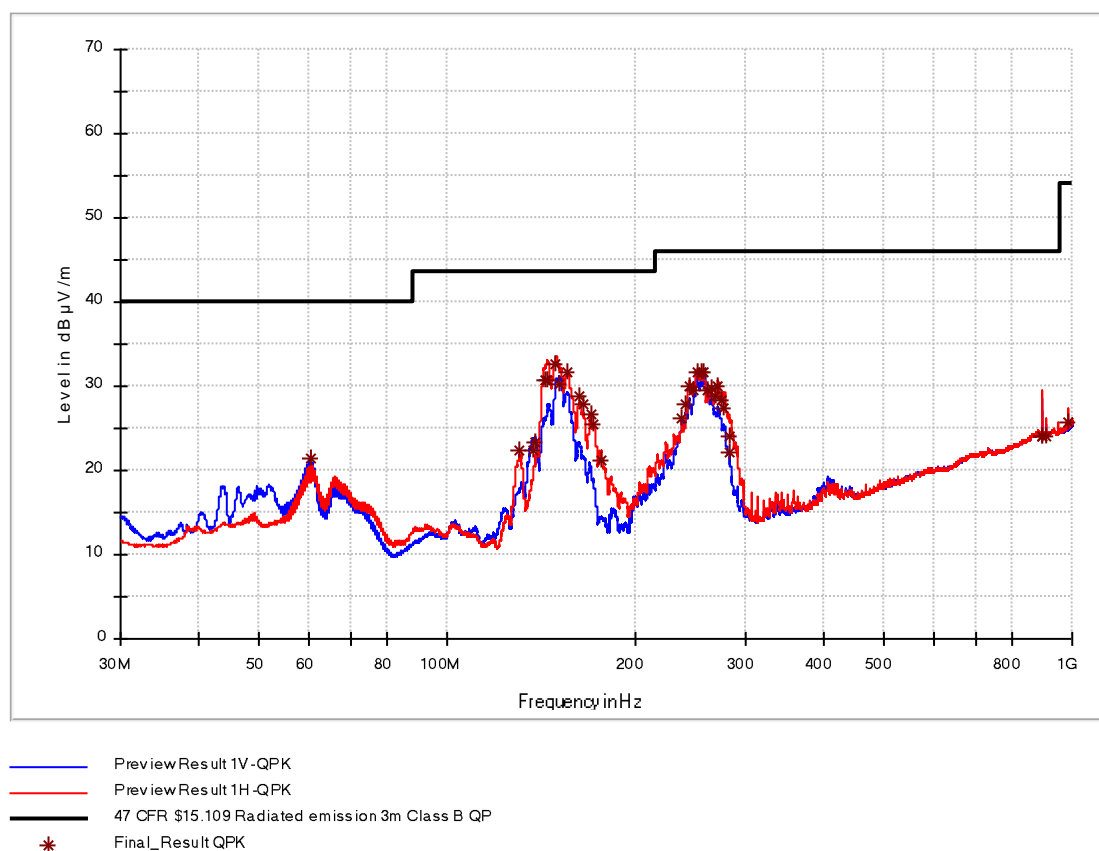


## Transmit mode

Temperature:	22°C	Humidity:	43%
Tested by:	M. Müller	Test date:	2015-05-27

## Radiated Emission Measurement 30 MHz - 1 GHz

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

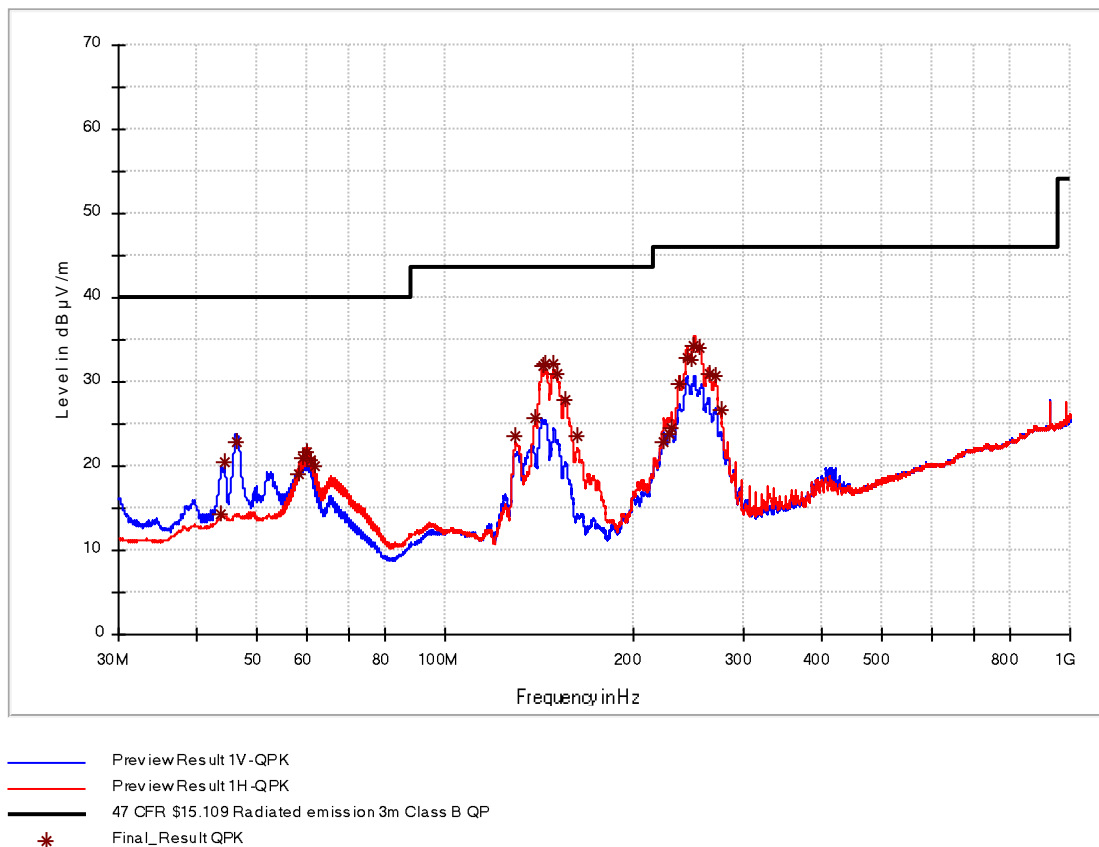


Picture 99: Radiated emission 30 MHz – 1000MHz, trace (Even-band, channel low)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
60.300000	21.51	40.00	18.49	1000.0	120.000	100.0	V	96.0	14.1
130.500000	22.39	43.50	21.11	1000.0	120.000	281.0	H	70.0	10.1
136.980000	22.38	43.50	21.12	1000.0	120.000	100.0	V	-26.0	9.8
137.880000	23.26	43.50	20.24	1000.0	120.000	100.0	V	130.0	9.7
143.070000	30.60	43.50	12.90	1000.0	120.000	209.0	H	120.0	9.6
144.750000	30.83	43.50	12.67	1000.0	120.000	211.0	H	120.0	9.6
149.370000	32.68	43.50	10.82	1000.0	120.000	209.0	H	103.0	9.7
150.690000	30.24	43.50	13.26	1000.0	120.000	211.0	H	70.0	9.7
156.000000	31.78	43.50	11.72	1000.0	120.000	209.0	H	249.0	9.9
162.870000	28.87	43.50	14.63	1000.0	120.000	159.0	H	249.0	10.2
164.730000	27.74	43.50	15.76	1000.0	120.000	159.0	H	248.0	10.2
169.620000	26.58	43.50	16.92	1000.0	120.000	181.0	H	244.0	10.4
171.450000	25.45	43.50	18.05	1000.0	120.000	181.0	H	244.0	10.5
176.280000	21.09	43.50	22.41	1000.0	120.000	209.0	H	244.0	10.9
237.330000	26.11	46.00	19.89	1000.0	120.000	211.0	V	216.0	13.6
240.870000	27.81	46.00	18.19	1000.0	120.000	181.0	V	189.0	13.7
244.110000	29.89	46.00	16.11	1000.0	120.000	105.0	H	249.0	13.8
247.950000	29.55	46.00	16.45	1000.0	120.000	100.0	H	248.0	13.9
250.980000	31.68	46.00	14.32	1000.0	120.000	100.0	H	248.0	14.0
254.340000	31.63	46.00	14.37	1000.0	120.000	100.0	H	248.0	14.0
257.400000	31.60	46.00	14.40	1000.0	120.000	181.0	V	188.0	14.1
261.720000	29.59	46.00	16.41	1000.0	120.000	100.0	H	249.0	14.1
264.330000	29.83	46.00	16.17	1000.0	120.000	100.0	H	244.0	14.2
268.800000	28.91	46.00	17.09	1000.0	120.000	105.0	H	274.0	14.3
271.140000	29.96	46.00	16.04	1000.0	120.000	105.0	H	275.0	14.3
275.340000	28.27	46.00	17.73	1000.0	120.000	105.0	H	275.0	14.3
277.560000	27.43	46.00	18.57	1000.0	120.000	105.0	H	275.0	14.4
282.000000	24.13	46.00	21.87	1000.0	120.000	105.0	H	274.0	14.4
283.860000	22.04	46.00	23.96	1000.0	120.000	100.0	H	0.0	14.4
893.760000	24.15	46.00	21.85	1000.0	120.000	281.0	H	120.0	24.6
897.000000	24.04	46.00	21.96	1000.0	120.000	105.0	V	60.0	24.6
908.400000	24.07	46.00	21.93	1000.0	120.000	159.0	H	68.0	24.7
987.960000	25.75	54.00	28.25	1000.0	120.000	159.0	H	9.0	25.5

Picture 100: Radiated emission 30 MHz – 1000MHz, table (Even-band, channel low)





Picture 101: Radiated emission 30 MHz – 1000MHz, trace (Odd-band, channel mid)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
43.860000	14.37	40.00	25.63	1000.0	120.000	105.0	V	224.0	14.8
44.340000	20.51	40.00	19.49	1000.0	120.000	105.0	V	283.0	14.9
46.230000	22.87	40.00	17.13	1000.0	120.000	100.0	V	283.0	15.1
58.170000	19.15	40.00	20.85	1000.0	120.000	209.0	H	249.0	14.5
59.370000	21.06	40.00	18.94	1000.0	120.000	209.0	H	248.0	14.3
60.150000	21.63	40.00	18.37	1000.0	120.000	209.0	H	248.0	14.2
60.960000	20.81	40.00	19.19	1000.0	120.000	209.0	H	248.0	14.0
61.740000	19.98	40.00	20.02	1000.0	120.000	239.0	H	216.0	13.8
129.660000	23.57	43.50	19.93	1000.0	120.000	181.0	H	249.0	10.2
139.350000	25.70	43.50	17.80	1000.0	120.000	211.0	H	250.0	9.7
142.980000	31.88	43.50	11.62	1000.0	120.000	209.0	H	249.0	9.6
144.930000	32.14	43.50	11.36	1000.0	120.000	210.0	H	251.0	9.6
149.250000	32.26	43.50	11.24	1000.0	120.000	209.0	H	249.0	9.7
151.290000	31.03	43.50	12.47	1000.0	120.000	209.0	H	249.0	9.7
155.700000	27.92	43.50	15.58	1000.0	120.000	211.0	H	244.0	9.9
162.840000	23.55	43.50	19.95	1000.0	120.000	159.0	H	274.0	10.2
223.890000	22.77	46.00	23.23	1000.0	120.000	159.0	H	248.0	13.1
227.760000	23.79	46.00	22.21	1000.0	120.000	159.0	H	248.0	13.2
230.010000	24.61	46.00	21.39	1000.0	120.000	159.0	H	248.0	13.3
237.240000	29.80	46.00	16.20	1000.0	120.000	131.0	H	248.0	13.6
243.930000	32.78	46.00	13.22	1000.0	120.000	105.0	H	248.0	13.8
248.640000	32.69	46.00	13.31	1000.0	120.000	105.0	H	249.0	13.9
250.350000	34.34	46.00	11.66	1000.0	120.000	100.0	H	250.0	13.9
255.210000	33.94	46.00	12.06	1000.0	120.000	100.0	H	248.0	14.0
263.880000	30.98	46.00	15.02	1000.0	120.000	100.0	H	248.0	14.2
270.780000	30.73	46.00	15.27	1000.0	120.000	105.0	H	274.0	14.3
276.480000	26.63	46.00	19.37	1000.0	120.000	100.0	H	249.0	14.4

Picture 102: Radiated emission 30 MHz – 1000MHz, table (Odd-band, channel mid)

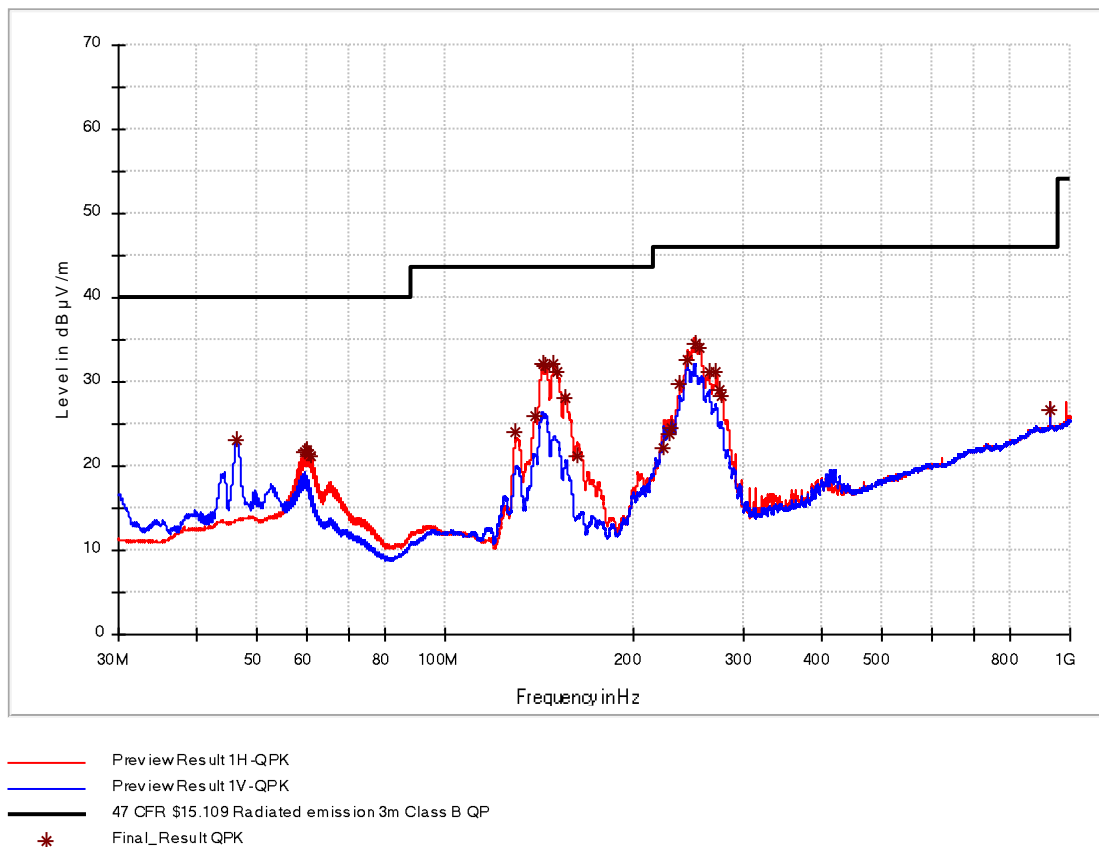


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Picture 103: Radiated emission 30 MHz – 1000MHz, trace (Odd-band, channel high)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
46.260000	22.98	40.00	17.02	1000.0	120.000	100.0	V	283.0	15.1
59.730000	21.66	40.00	18.34	1000.0	120.000	150.0	H	240.0	14.2
60.120000	21.86	40.00	18.14	1000.0	120.000	209.0	H	248.0	14.2
60.510000	21.39	40.00	18.61	1000.0	120.000	212.0	H	250.0	14.1
60.900000	21.20	40.00	18.80	1000.0	120.000	209.0	H	248.0	14.0
129.690000	23.94	43.50	19.56	1000.0	120.000	181.0	H	250.0	10.1
139.410000	25.86	43.50	17.64	1000.0	120.000	209.0	H	248.0	9.7
143.070000	32.04	43.50	11.46	1000.0	120.000	209.0	H	249.0	9.6
144.930000	32.02	43.50	11.48	1000.0	120.000	209.0	H	248.0	9.6
149.430000	32.09	43.50	11.41	1000.0	120.000	209.0	H	244.0	9.7
151.380000	31.15	43.50	12.35	1000.0	120.000	209.0	H	248.0	9.7
156.180000	28.12	43.50	15.38	1000.0	120.000	211.0	H	244.0	9.9
162.720000	21.30	43.50	22.20	1000.0	120.000	161.0	H	244.0	10.2
224.040000	22.19	46.00	23.81	1000.0	120.000	161.0	H	250.0	13.1
227.670000	23.77	46.00	22.23	1000.0	120.000	159.0	H	248.0	13.2
230.250000	24.51	46.00	21.49	1000.0	120.000	161.0	H	250.0	13.3
237.510000	29.82	46.00	16.18	1000.0	120.000	131.0	H	248.0	13.6
244.320000	32.72	46.00	13.28	1000.0	120.000	105.0	H	248.0	13.8
250.680000	34.61	46.00	11.39	1000.0	120.000	100.0	H	248.0	13.9
255.330000	33.99	46.00	12.01	1000.0	120.000	100.0	H	249.0	14.0
264.450000	31.22	46.00	14.78	1000.0	120.000	105.0	H	248.0	14.2
271.110000	31.13	46.00	14.87	1000.0	120.000	105.0	H	274.0	14.3
275.310000	29.07	46.00	16.93	1000.0	120.000	105.0	H	276.0	14.3
277.680000	28.45	46.00	17.55	1000.0	120.000	105.0	H	274.0	14.4
925.620000	26.60	46.00	19.40	1000.0	120.000	159.0	H	274.0	24.8

Picture 104: Radiated emission 30 MHz – 1000MHz, table (Odd-band, channel high)



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# 12 Radiated emission measurement (>1 GHz)

according to CFR 47 Part 15, sections 15.205(a), 15.209(a), 15.247(d)

## 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 <b>TESTHAUS</b> GmbH	E00100

## 12.2 Test instruments

	Description	Manufacturer	Inventory No.
<input checked="" type="checkbox"/>	ESU26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	AMF-5D-00501800-28-13P	Miteq	W00089
<input checked="" type="checkbox"/>	AMF-6F-16002650-25-10P	Miteq	W00090
<input checked="" type="checkbox"/>	BBHA 9120D	Schwarzbeck	W00053
<input checked="" type="checkbox"/>	BBHA 9170	Schwarzbeck	W00055
<input checked="" type="checkbox"/>	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.



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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

1. The test is performed in accordance with FCC Public Notice DA 00-705.
2. 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.
3. Power on the EUT and all peripherals.
4. The broadband antenna was set to vertical polarization.
5. The EMI receiver performed a scan from 1000 MHz to 10<sup>th</sup> 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.
6. The turn table was rotated in intervals of 15°.
7. After a full 360°-turn the antenna polarization was changed to horizontal and the test was repeated at step 4 and 5.
8. After the scan suspicious frequencies were selected and the RBW was set to 1 MHz and the VBW was set to 10Hz and the detector was changed to average reading.
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.



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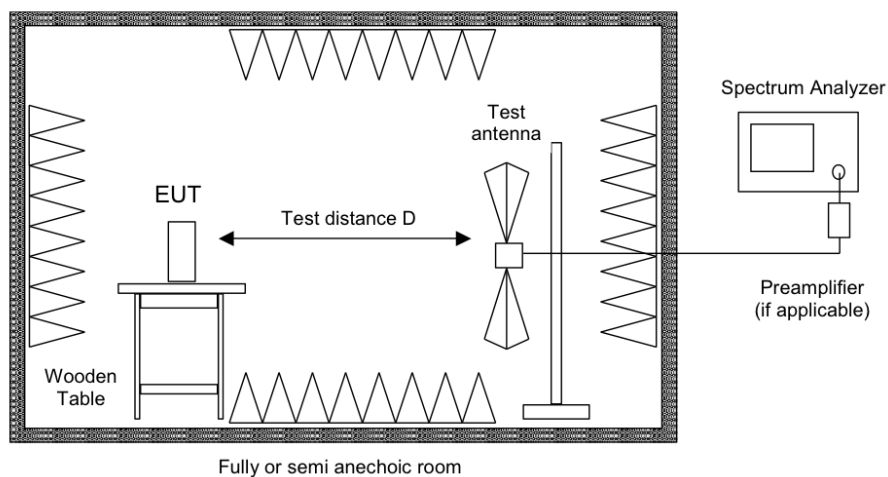
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## 12.5 Test setup



Picture 105: 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 in conjunction with antenna polarised to horizontal is the respective worst-case.

## 12.8 Test results Even-band, channel low

Temperature:	20°C	Humidity:	45%
Tested by:	M. Müller	Test date:	2015-05-13

Channel low							
f[GHz]	E <sub>meas</sub> [dBμV/m]	Ant	Turntable [ ° ]	Detector	Restr. Band	Limit [dBμV/m]	Result
2.4146	110.13	H	140.1	PK	No	----	Carrier
2.4144	85.88			AV (200Hz)		----	Carrier
4.8286	60.45	H	342.2	PK	Yes	74	Pass
4.8287	50.43			AV (200Hz)		54	Pass
7.2428	53.21	H	267.5	PK	No	-20dBc	Pass
7.2432	42.63			AV (200Hz)		-20dBc	Pass
9.6585	54.79	H	8.1	PK	No	-20dBc	Pass
9.6876	41.91			AV (200Hz)		-20dBc	Pass

Picture 106: Radiated emission 1 GHz – 26 GHz

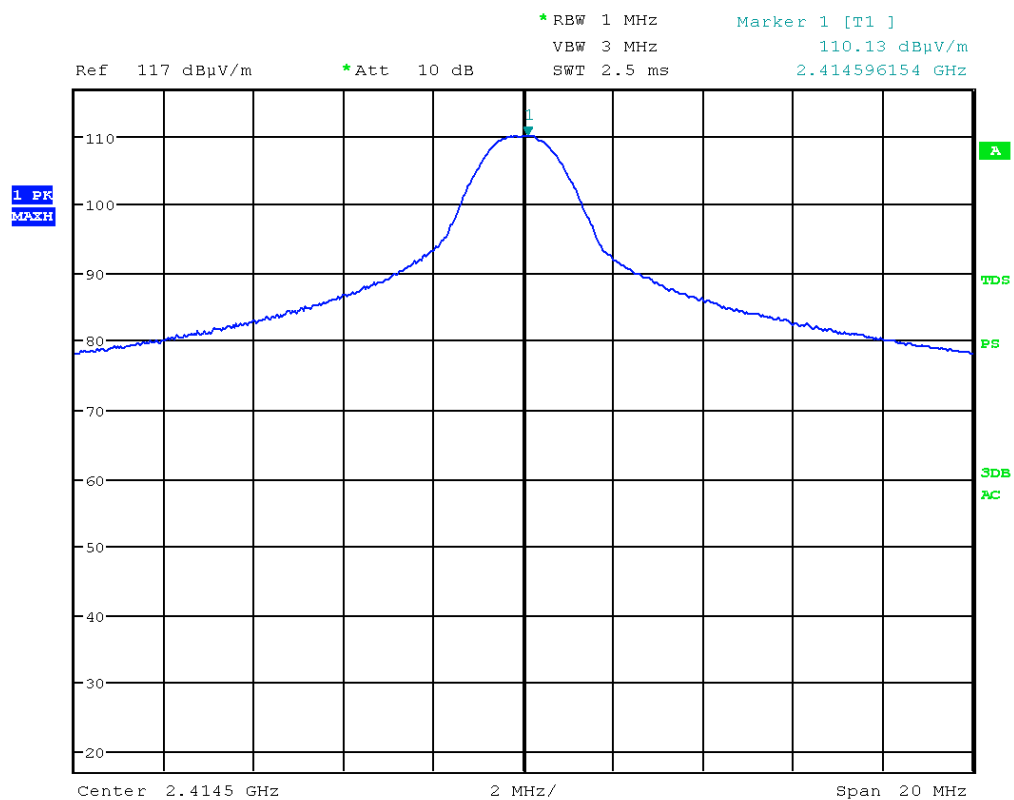


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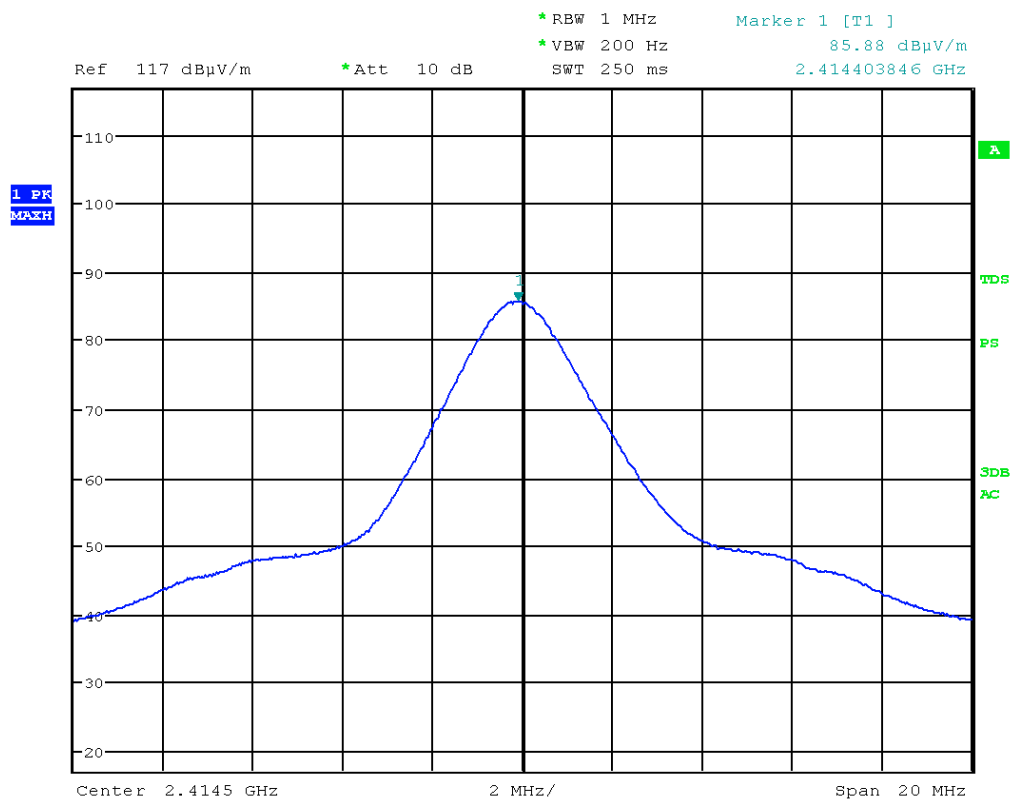
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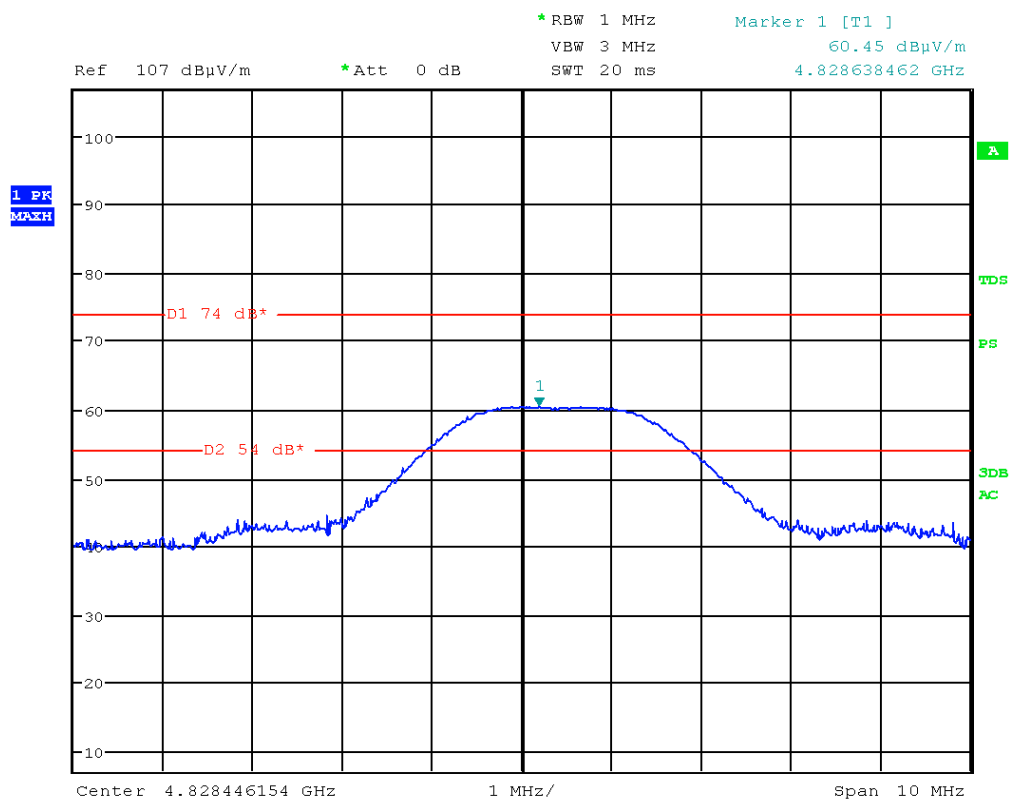
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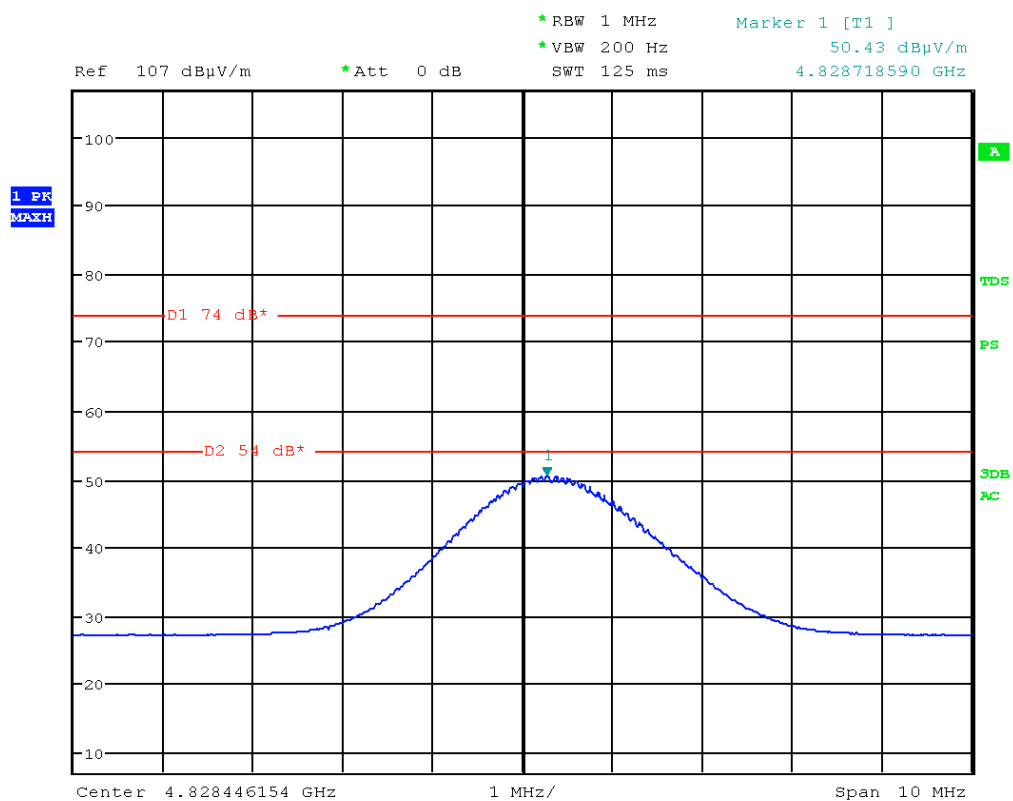
Picture 107: Radiated emission 1 GHz – 26 GHz - PK



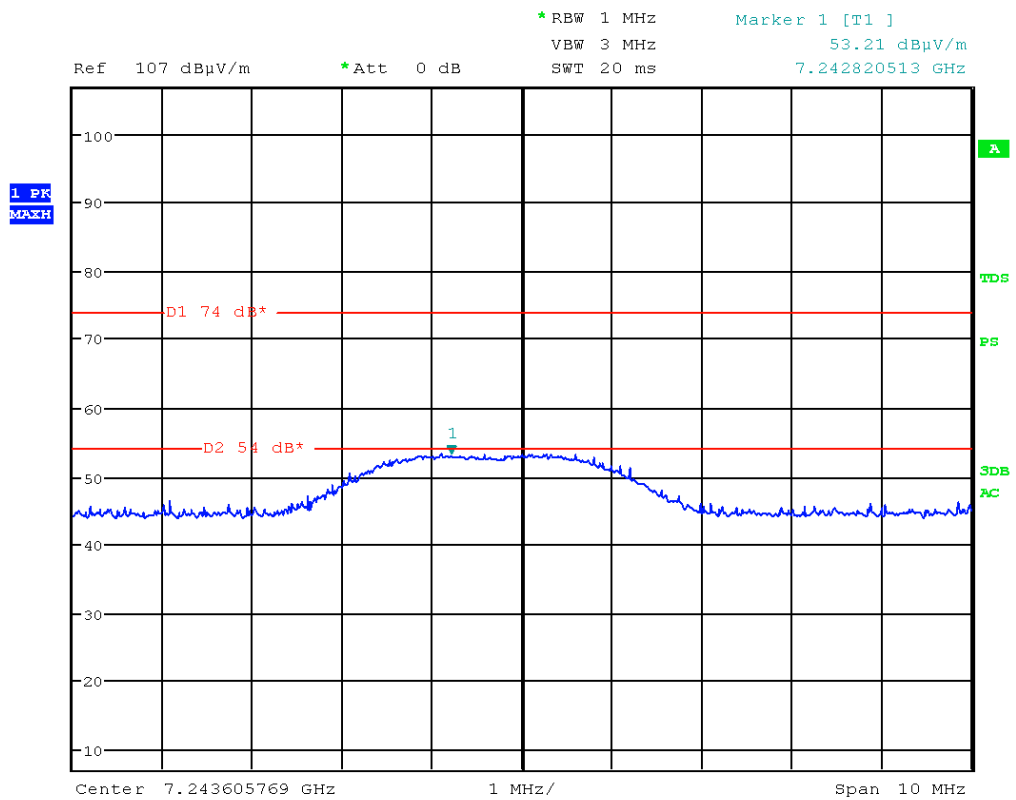
Picture 108: Radiated emission 1 GHz – 26 GHz - AV



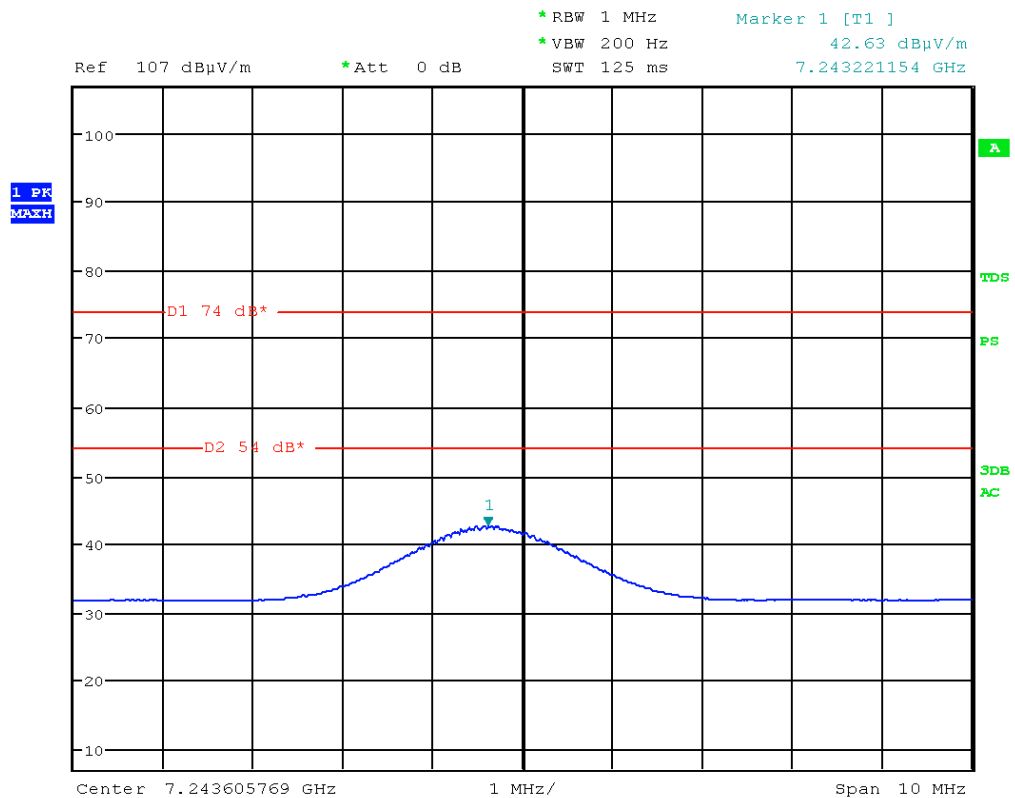
Picture 109: Radiated emission 1 GHz – 26 GHz - PK



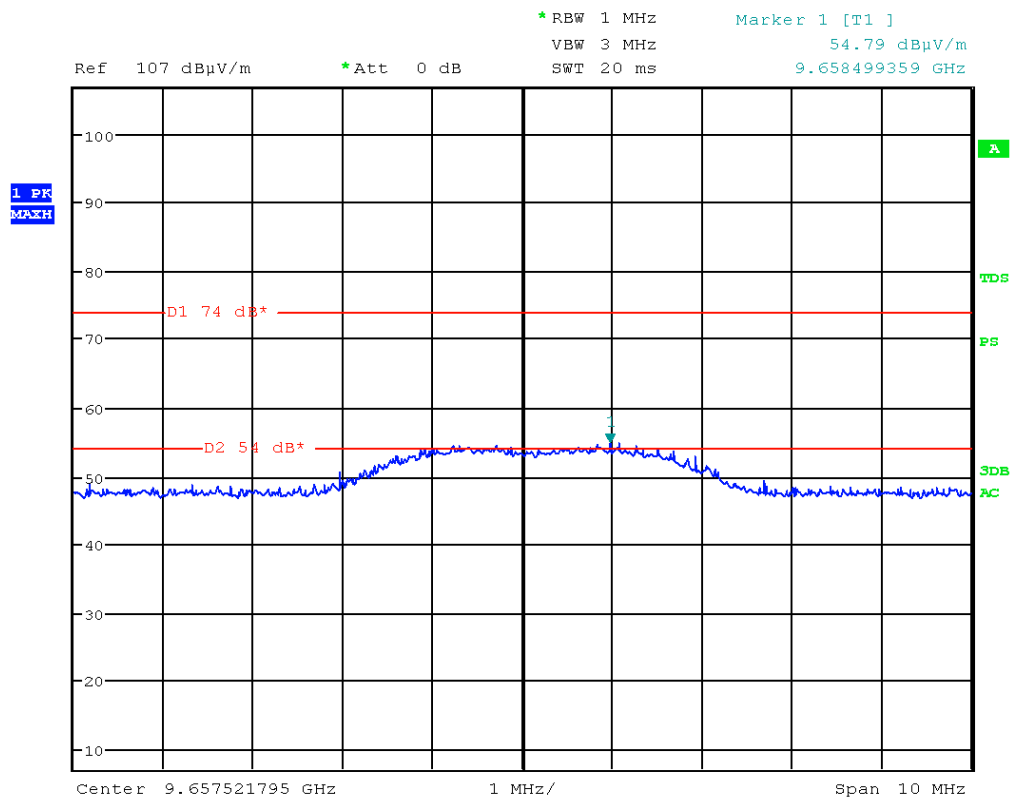
Picture 110: Radiated emission 1 GHz – 26 GHz - AV



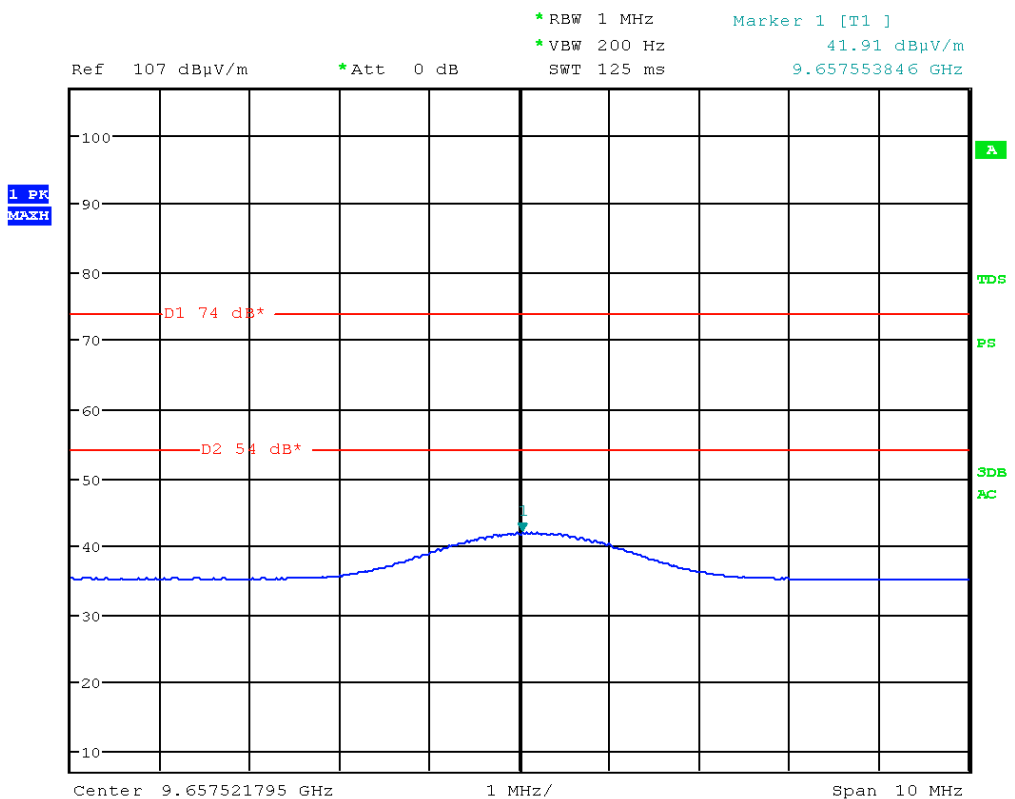
Picture 111: Radiated emission 1 GHz – 26 GHz - PK



Picture 112: Radiated emission 1 GHz – 26 GHz - AV



Picture 113: Radiated emission 1 GHz – 26 GHz - PK



Picture 114: Radiated emission 1 GHz – 26 GHz - AV

## 12.9 Test results Odd-band, channel mid

Temperature:	20°C	Humidity:	45%
Tested by:	M. Müller	Test date:	2015-05-13

Channel mid							
f[GHz]	E <sub>meas</sub> [dBμV/m]	Ant	Turntable [ ° ]	Detector	Restr. Band	Limit [dBμV/m]	Result
2.4372	110.25	H	144.4	PK	No	----	Carrier
2.4374	97.42			AV (300Hz)		----	Carrier
4.8744	56.63	H	313.4	PK	Yes	74	Pass
4.8749	50.81			AV (300Hz)		54	Pass
7.3117	50.52	H	8.1	PK	Yes	74	Pass
7.3123	37.84			AV (300Hz)		54	Pass
9.7487	52.07	H	343.1	PK	No	-20dBc	Pass
9.7498	39.91			AV (300Hz)		-20dBc	Pass

Picture 115: Radiated emission 1 GHz – 26 GHz



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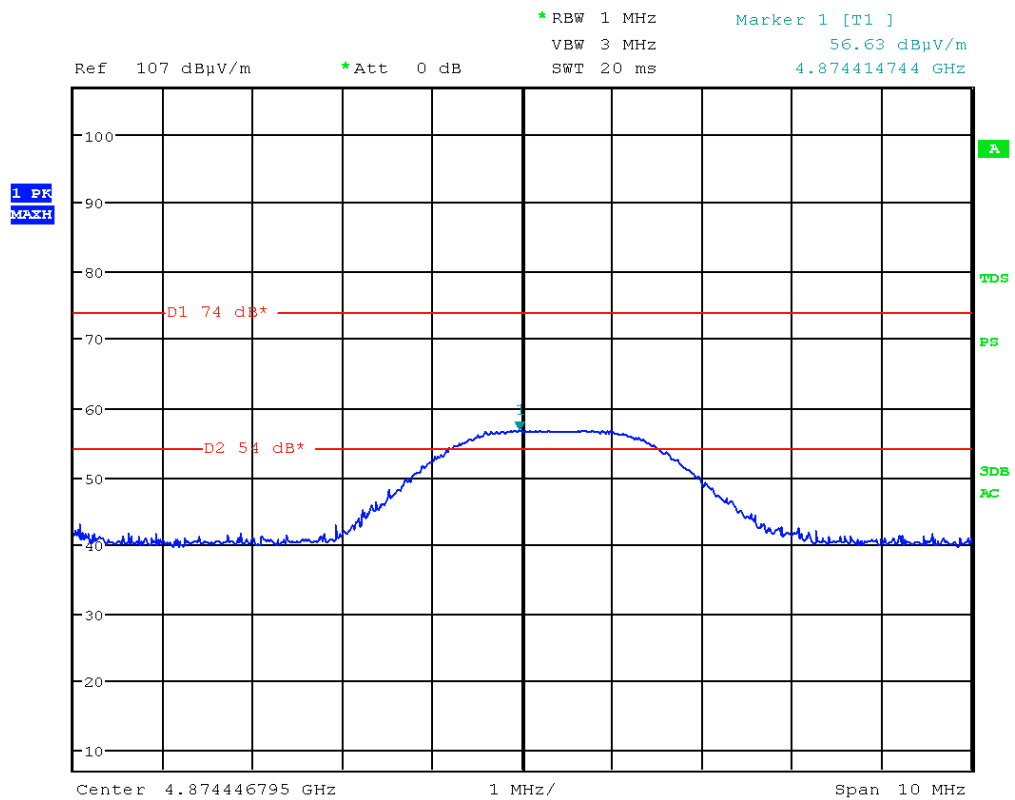
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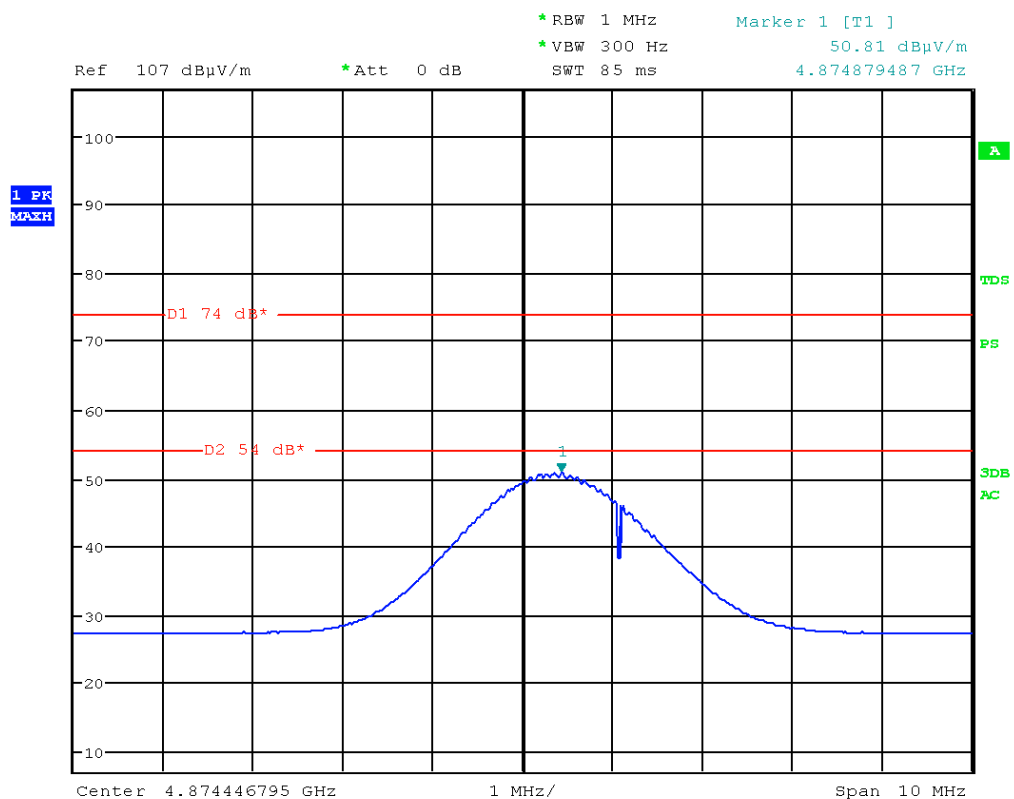
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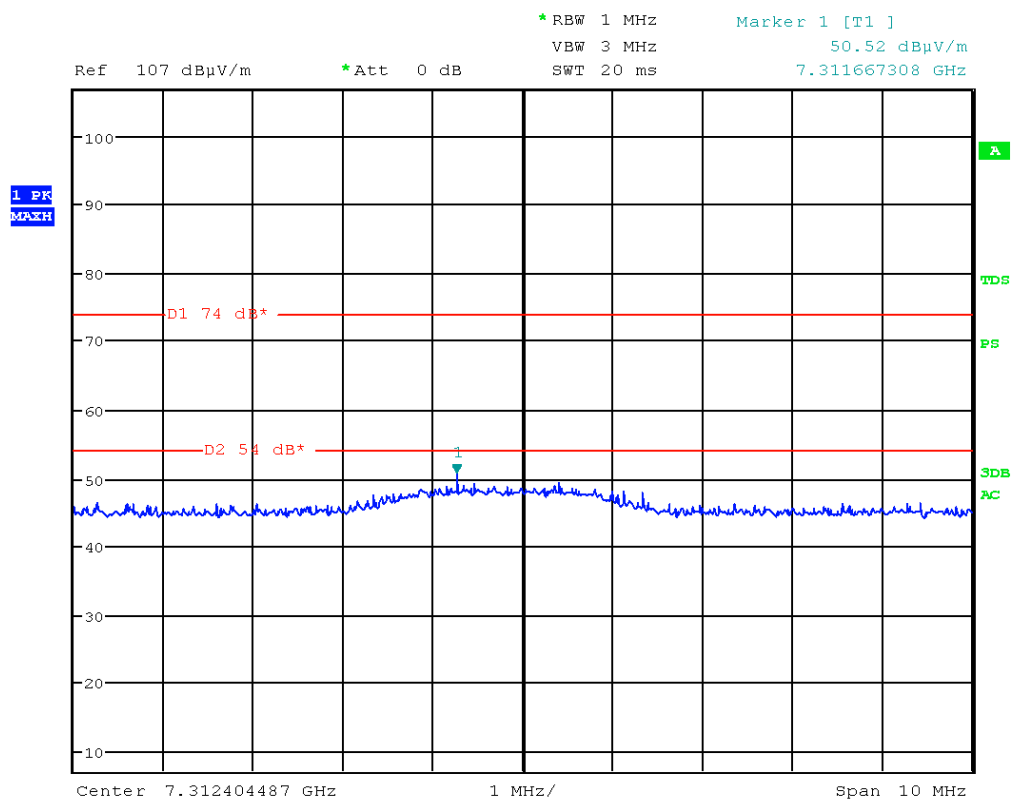




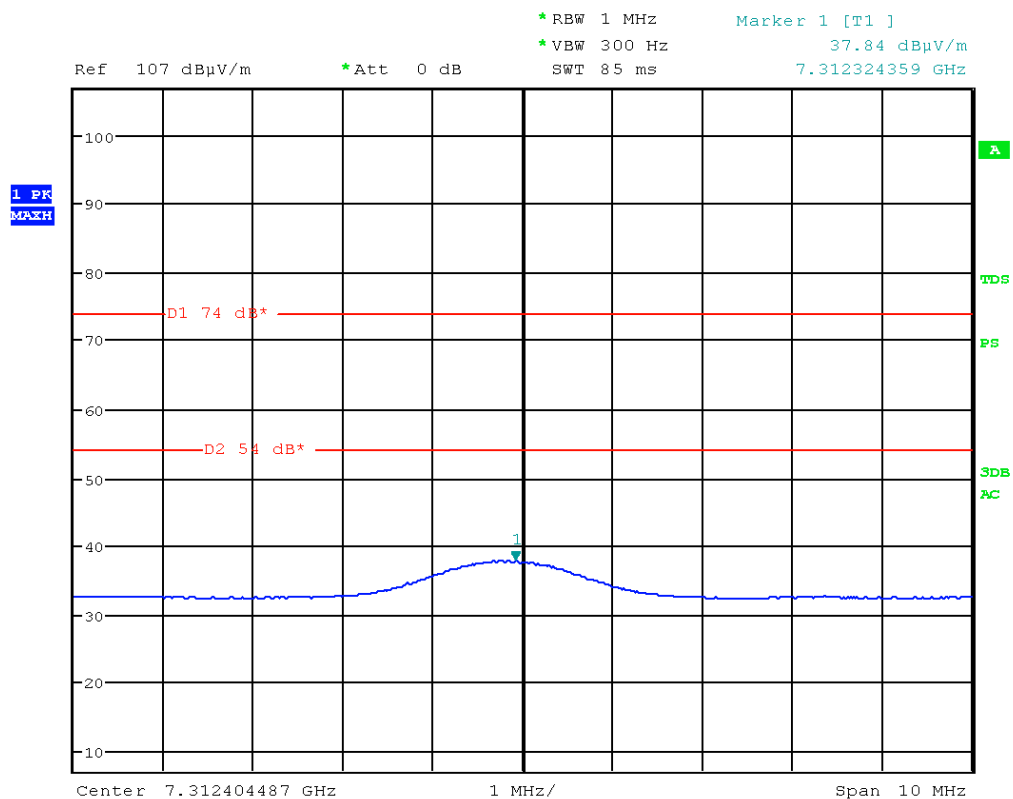
Picture 118: Radiated emission 1 GHz – 26 GHz - PK



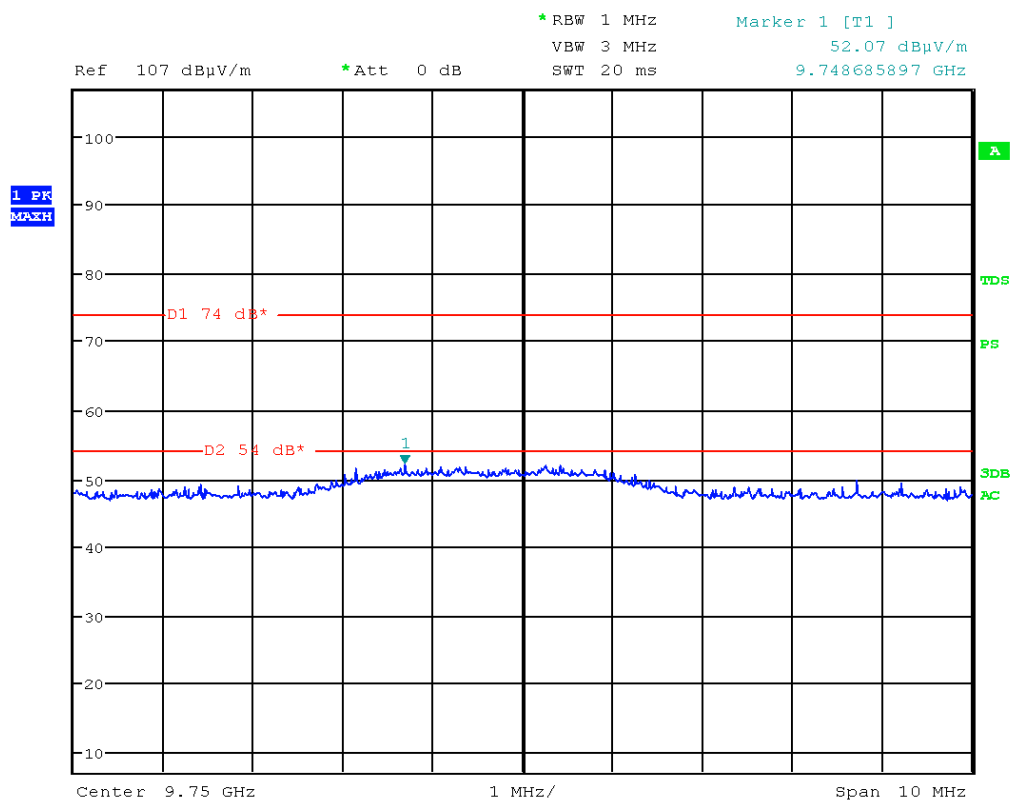
Picture 119: Radiated emission 1 GHz – 26 GHz - AV



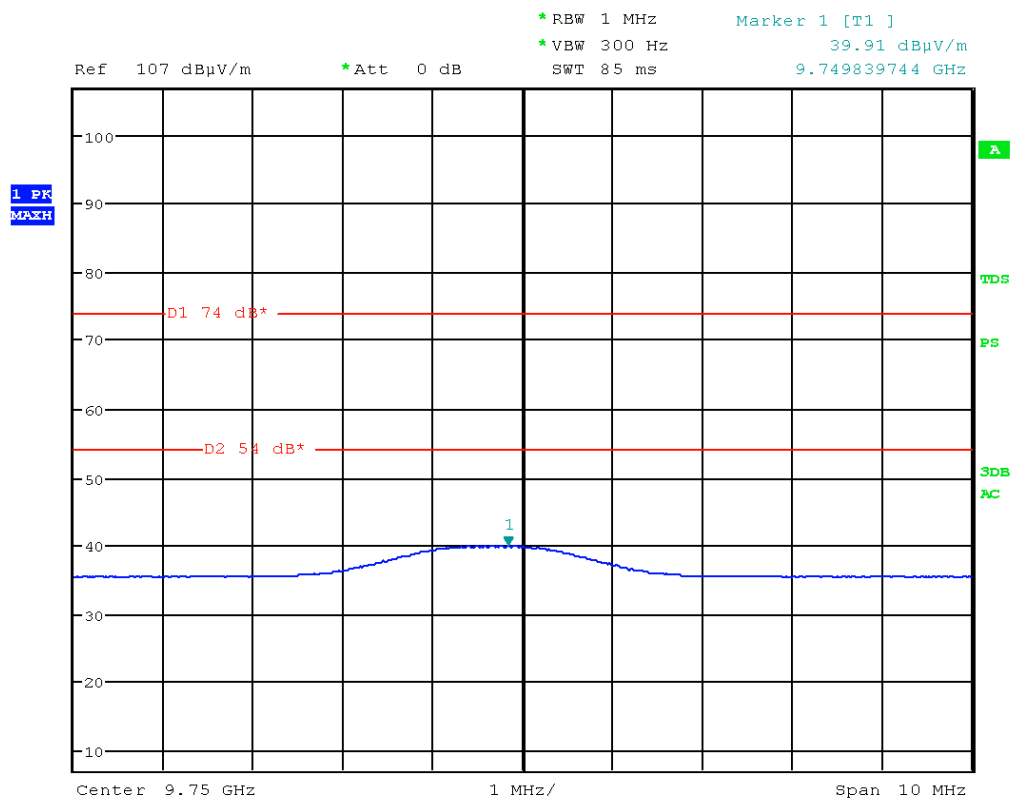
Picture 120: Radiated emission 1 GHz – 26 GHz - PK



Picture 121: Radiated emission 1 GHz – 26 GHz - AV



Picture 122: Radiated emission 1 GHz – 26 GHz - PK



Picture 123: Radiated emission 1 GHz – 26 GHz - AV

## 12.10 Test results Odd-band channel high

Temperature:	20°C	Humidity:	45%
Tested by:	M. Müller	Test date:	2015-05-13

Channel high							
f[GHz]	E <sub>meas</sub> [dBµV/m]	Ant	Turntable [ ° ]	Detector	Restr. Band	Limit [dBµV/m]	Result
2.4596	109.10	H	338.7	PK	No	----	Carrier
2.4594	96.42			AV (300Hz)		----	Carrier
4.9184	55.73	H	340.0	PK	Yes	74	Pass
4.9187	50.07			AV (300Hz)		54	Pass
7.3778	49.77	H	265.7	PK	Yes	74	Pass
7.3783	39.43			AV (300Hz)		54	Pass

Picture 124: Radiated emission 1 GHz – 26 GHz

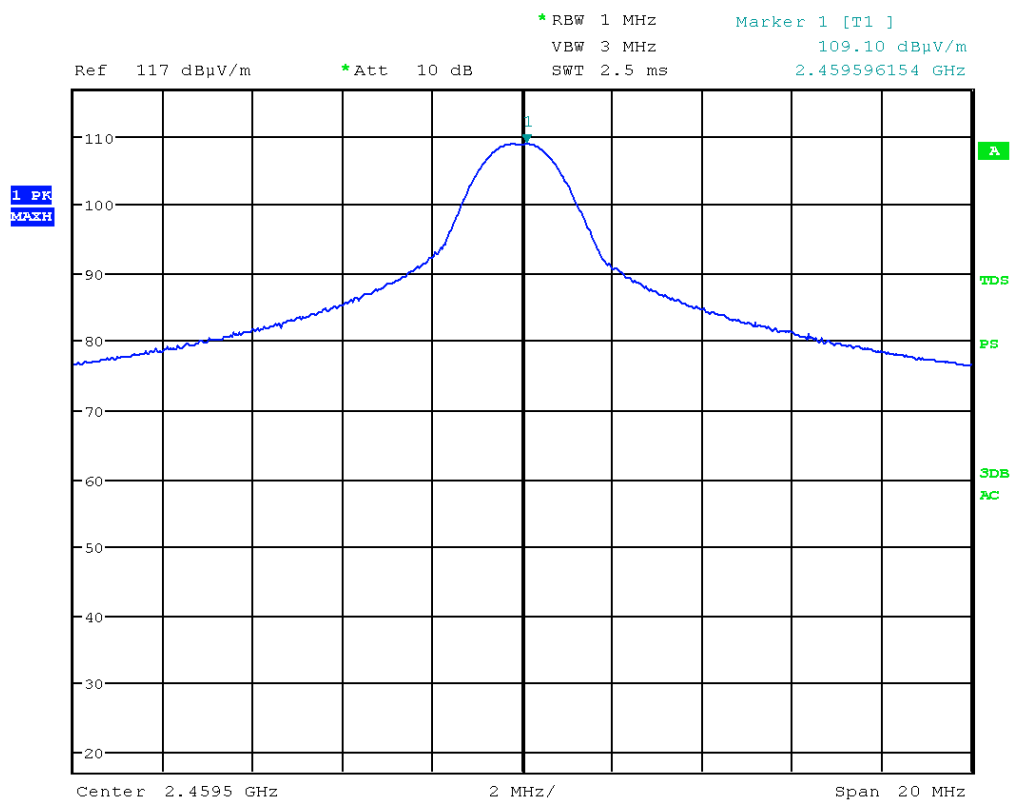


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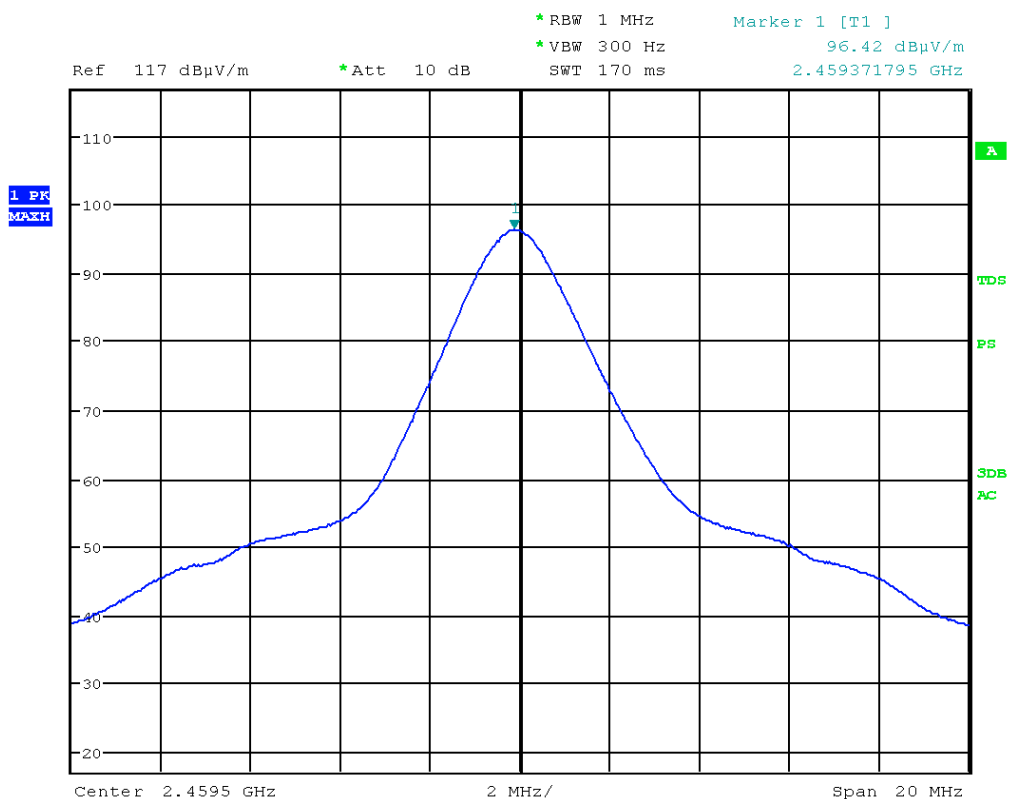
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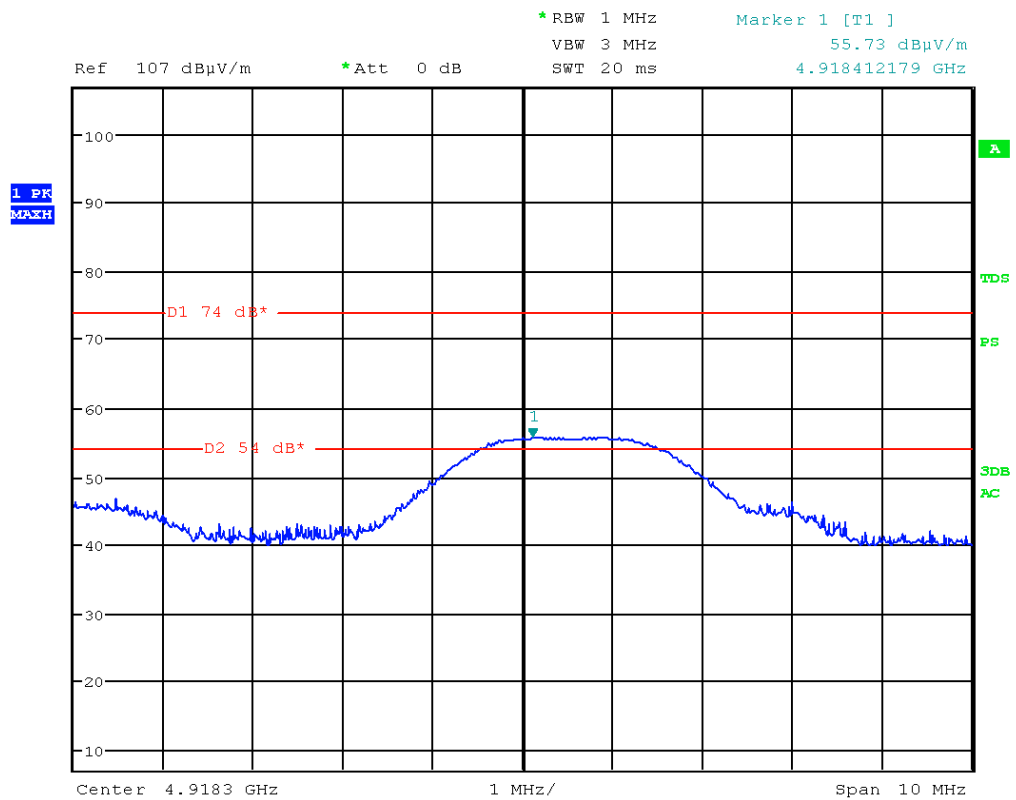
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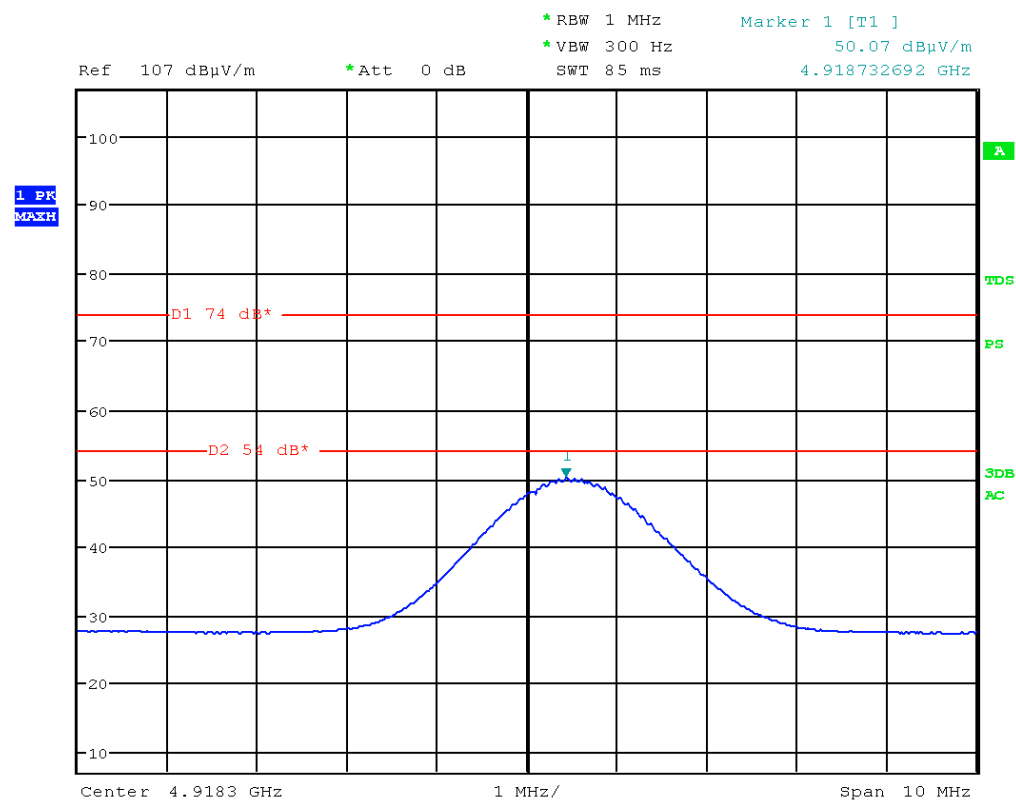
Picture 125: Radiated emission 1 GHz – 26 GHz - PK



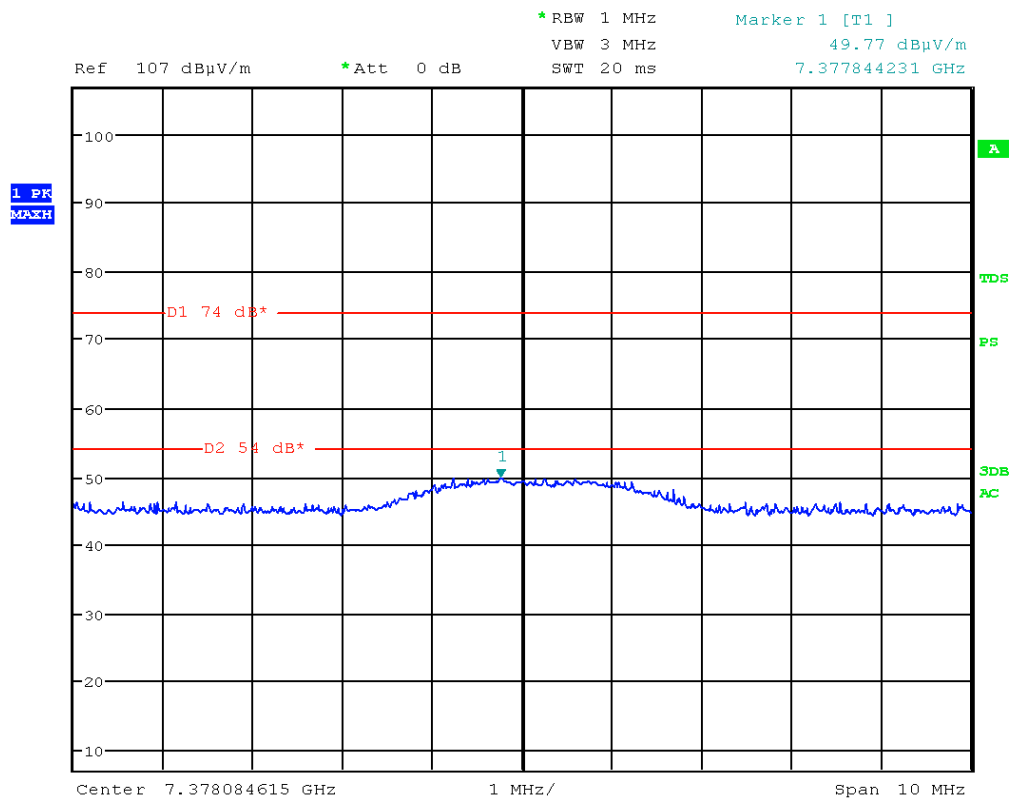
Picture 126: Radiated emission 1 GHz – 26 GHz - AV



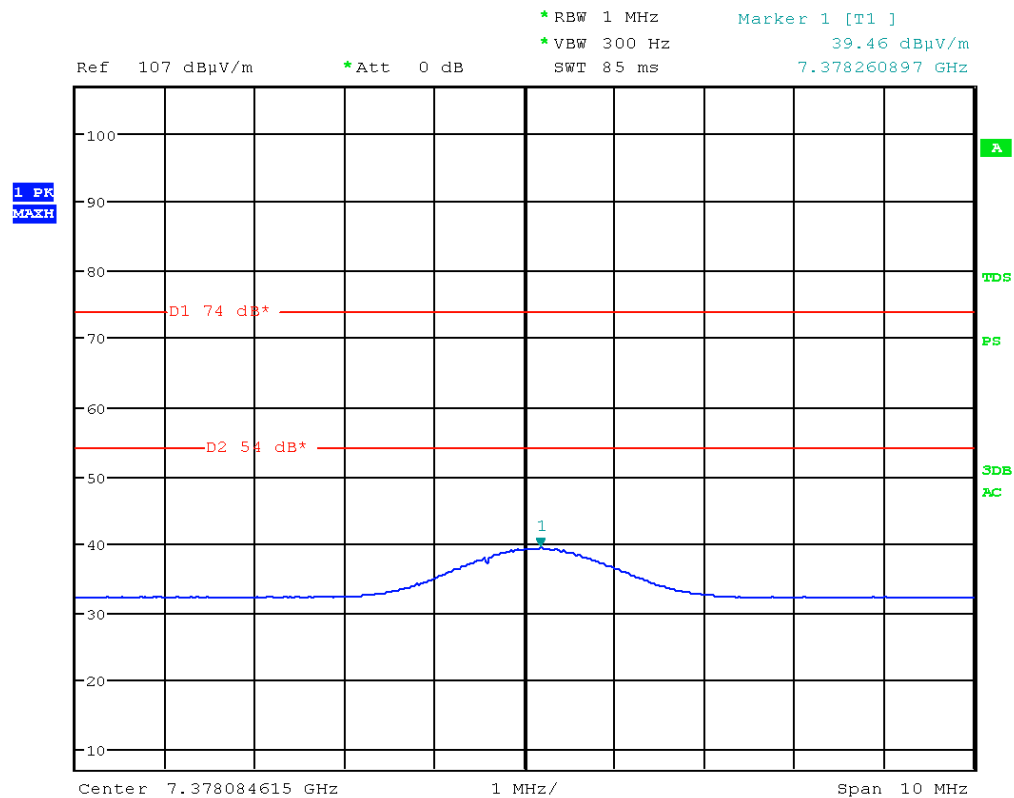
Picture 127: Radiated emission 1 GHz – 26 GHz - PK



Picture 128: Radiated emission 1 GHz – 26 GHz - AV



Picture 129: Radiated emission 1 GHz – 26 GHz - PK



Picture 130: Radiated emission 1 GHz – 26 GHz – AV

# 13 Exposure of humans to RF fields

according to RSS-102 Issue 5, section 2.5.2

External detachable antenna (see antenna specification)

Gi: 2,5dBi = numeric gain 1,78

Output power conducted: 13,00dBm = 19,95mW

$\pi = 3,1416$

R=20cm

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

G: numerical antenna gain

CP: conducted output power [W]

$$S = \frac{1,78 * 19,95 \text{ mW}}{4 * \pi * (20 \text{ cm})^2} = 0,007 \text{ mW} / \text{cm}^2$$

Limit:

1mW/cm<sup>2</sup>



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# 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	ESR7	101059	E00739	2015-01	2017-01
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	893406/009	E00005	2014-01	2016-01
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	9163-114	W00055	2014-03	2016-03
Loop antenna	HFH2-Z2	871398/0050	E00060	2014-07	2016-07
Magnetic field probe	RF-R 400-1	02-2030	E00270	N/A (see note 1)	
Shielded room	P92007	B83117C1109T211	E00107	N/A	
Semi Anechoic Chamber (SAC)	---	C62128-A520-A643	E00716	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 I	VC <sup>3</sup> 4034	58566123250010	C00015	2014-09	2016-09
Cable set shielded room	Cable no. 30	---	E00424	2014-07	2015-07
Cable set SAC	Cables no. 04, 11 and 52	---	E00434 E00319 E00755	2015-04	2016-04
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	2014-10	2015-10



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Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
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	2015-04	2016-04
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 1: Used for relative measurements only

Note 2: Expiration date of measurement facility registration (OATS) by

- FCC (registration number 221458): 2017-04

- Industry Canada (test site number 3472A-1): 2015-10



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# 15 Measurement uncertainty

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	$\pm 4,0$ dB	2
Radiated emission open field (30 MHz to 1 GHz)	$\pm 4,5$ dB	2
Radiated emission absorber chamber (> 1000 MHz)	$\pm 5,4$ 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 %.



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## 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.

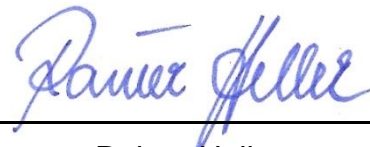
Place, Date:      Straubing, June 08<sup>th</sup>, 2015



Martin Müller

Test engineer

EMV **TESTHAUS** GmbH



Rainer Heller

Head of EMC / radio department

EMV **TESTHAUS** GmbH



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Gustav-Hertz-Straße 35  
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# 17 Revision History

Date	Description	Person	Revision
2015-06-08	First edition	M. Müller	----



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