

# Test Report

**Customer:**

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## RF test report

160617-AU01+W03



Industry Industrie  
Canada Canada

**Elatec GmbH**

**RFID Reader**

TWN4 MultiTech 2



The test result refers exclusively to the tested model.  
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## Accreditation:



FCC facility registration number: 221458  
Test Firm Type "2.948 listed": Valid until 2017-04-22  
Test Firm Type "accredited": Valid until 2017-06-09  
MRA US-EU, FCC designation number: DE0010  
BnetzA-CAB-02/21-02/04 Valid until 2018-11-27

Industry Canada test site numbers with registration expiry date:  
3472A-1, expiring 2018-11-09  
3472A-2, expiring 2018-11-12

## Test Laboratory:

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# 1 Test regulations

47 CFR Part 2: 10-2016	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: 10-2016	Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
ANSI C63.10:2013-06	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
ICES-003 Issue 6, January 2016	Spectrum Management and Telecommunications Interference-Causing Equipment Standard Information Technology Equipment (ITE) – Limits and methods of measurement
RSS-Gen Issue 4, November 2014	Spectrum Management and Telecommunications Radio Standards Specification General Requirements and Information for the Certification of Radiocommunication Equipment
RSS-210 Issue 9, August 2016	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment



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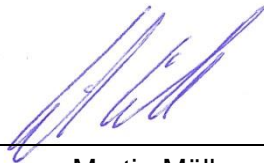
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## 2 Summary of test results

Standard	Test result
47 CFR Part 15, sections 15.207 and 15.225	Passed
RSS-210 Issue 9 Section 4.3 and Annex B6 (with appropriate references to RSS-Gen Issue 4)	Passed

Straubing, January 17, 2017



Martin Müller  
Test engineer  
EMV **TESTHAUS** GmbH



Christian Kiermeier  
Technical executive  
EMV **TESTHAUS** GmbH



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### 3 Equipment under Test (EUT)

Product type: RFID Reader  
Model Name: TWN4 MultiTech 2  
Applicant: Elatec GmbH  
Manufacturer: Elatec GmbH  
Serial number: #8  
FCC ID: WP5TWN4F3  
IC certification number: 7948A-TWN4F3  
Application frequency band: 13.110 to 14.010 MHz  
Frequency range: 13.560 MHz  
Operating frequency: 13.560 MHz  
Number of RF-channels: 1  
Modulation: ASK  
Antenna connector:  permanent  temporary  none  
Antenna types: PCB antenna  
 detachable  not detachable  
Maximum antenna gain: 0 dBi  
Maximum conducted power: 2 mW (maximum RF output power of RFID chip)  
Power supply: USB powered  
nominal: 5.0 VDC  $\pm$  15 %  
Temperature range: -20°C to +50°C

Remark:  
The tests were performed with PC supplied by 120V AC / 60Hz.



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### 3.1 Photo documentation

For external photos of the EUT see annex B, for internal ones see annex C.  
For photos taken during testing and including EUT-positions see annex A.

### 3.2 Short description of the EUT

EUT is a RFID reader employing 3 frequencies. The other frequencies are documented within the following test reports:

160617-AU02+W01 -> 125 kHz  
160617-AU02+W02 -> 134 kHz

### 3.3 Operation mode

During the pre-tests it was observed that the “continuous-tag-reading-mode” is the respective worst- case. Therefore this mode was selected for final testing. The device was configured by manufacturer to activate the RFID reader for continuous transmission via RFID card.

BLE module was only included to complete hardware setup. During tests it was deactivated.

The EUT was tested in 3 orthogonal positions. This is documented in annex A.





### 3.4 Configuration

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

Device	Model:	Serial or inventory no.
RFID Reader	TWN4 MultiTech 2	#8
RFID tag	13.56 MHz	----
Test-PC	Esprimo P9900	E00351
Notebook	Lifebook A531	E00521
AC power source (120 V / 60 Hz)	Chroma 616062	E00633
DC supply	Statron 3252.1	E00541
Digital multimeter	UT61D	H150188102

### 3.5 Used cables

Count	Description (type / lengths / remarks)	Serial no.
1	USB cable (1.5 m, shielded)	---



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## 4 AC power line conducted emissions

according to 47 CFR Part 15, section 15.207, and  
RSS-210, section 3.1 with RSS-Gen, section 8.8

### 4.1 Test location

Description	Manufacturer	Inventory No.
Shielded room	Siemens - Matsushita	E00107

### 4.2 Test instruments

	Description	Manufacturer	Inventory No.
<input checked="" type="checkbox"/>	ESCS 30	Rohde & Schwarz	E00003
<input type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input type="checkbox"/>	ESCI	Rohde & Schwarz	E00001
<input type="checkbox"/>	ESH3-Z2	Rohde & Schwarz	E00028
<input checked="" type="checkbox"/>	ESH2-Z5	Rohde & Schwarz	E00004
<input type="checkbox"/>	ESH2-Z5	Rohde & Schwarz	E00005
<input checked="" type="checkbox"/>	Cable set shielded room	Huber + Suhner	E00424

### 4.3 Limits

Frequency [MHz]	Quasi-peak [dB $\mu$ V]	Average [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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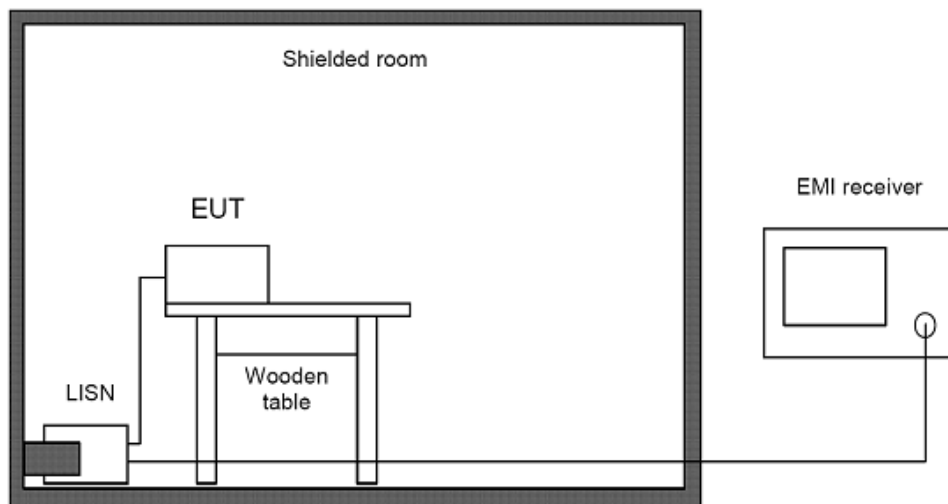
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## 4.4 Test procedure

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 was scanned.
5. After that all peaks values with less margin 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 then these values were re-measured with average detector.
7. These measurements were done on all power lines.

According to ANSI C63.10, section 6.2.2 testing of intentional radiators with detachable antennas shall be done with a dummy load otherwise the tests should be done with connected antenna and if adjustable fully extended.

## 4.5 Test setup

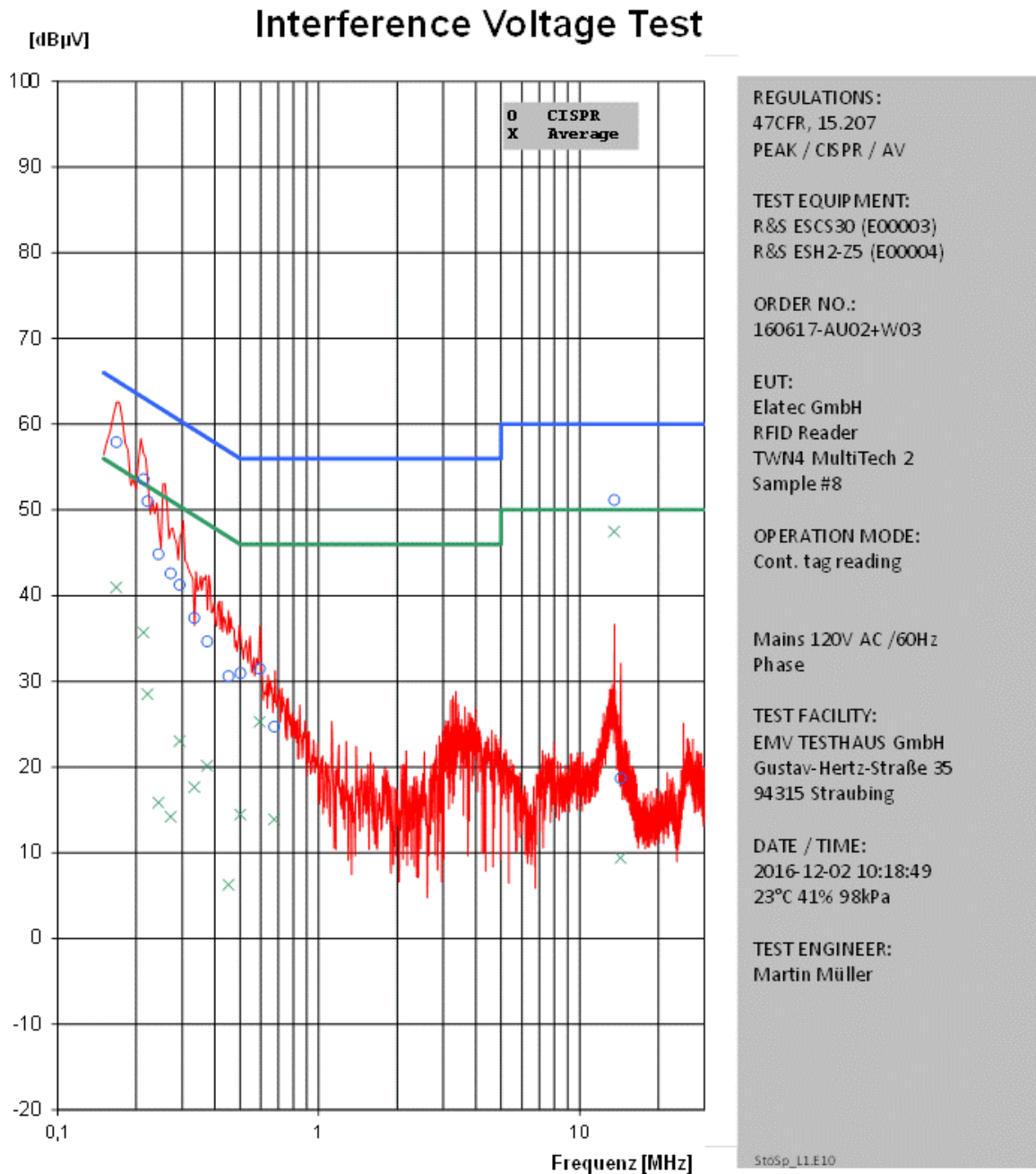


Picture 1: Outline of conducted emission test setup

Comments: All peripheral devices were additionally decoupled by means of a line stabilization network.

## 4.6 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-12-02



Picture 2: Graphic - Conducted emission on mains, phase 1 (without termination)



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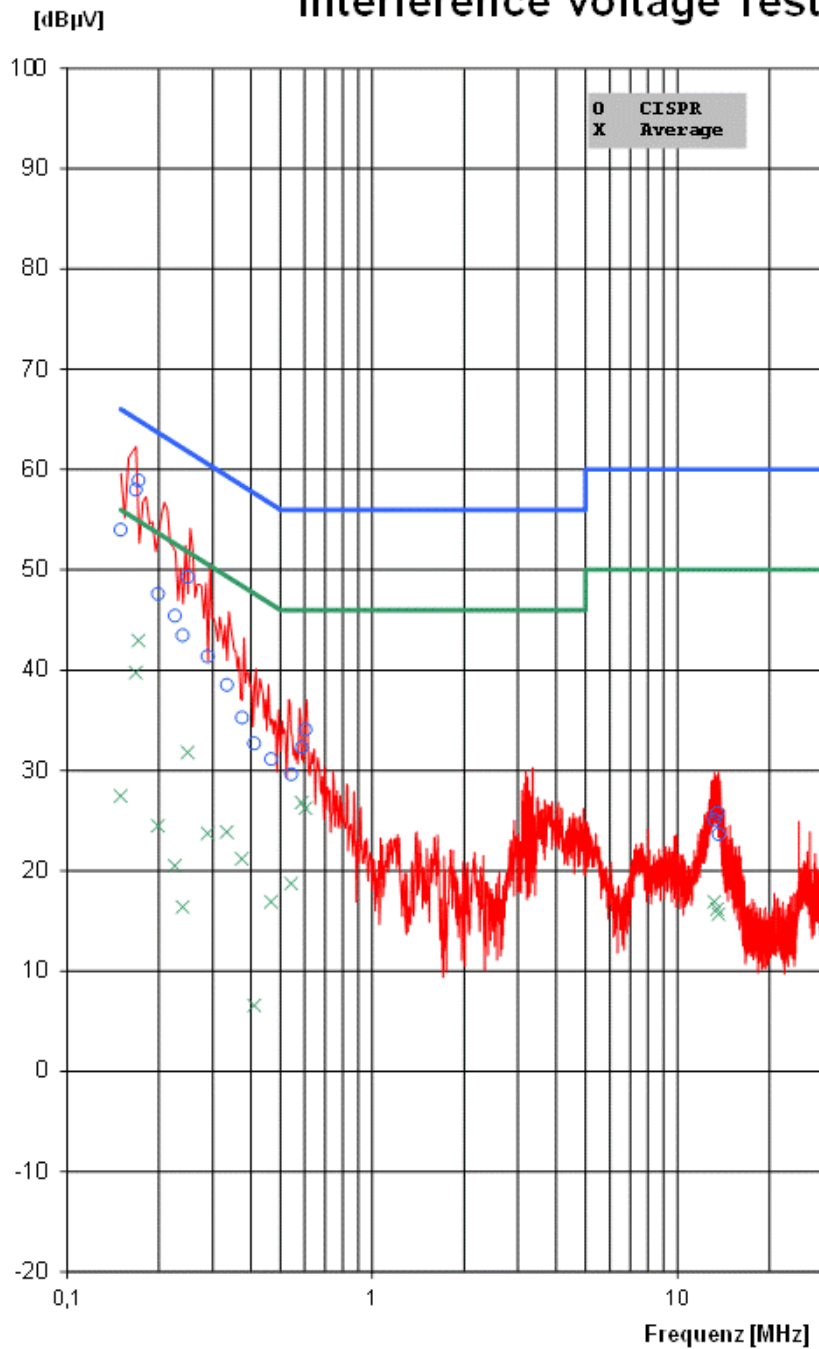
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## Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
0,17	57,9	65,1	7,2	41,0	55,1	14,1	0,0	
0,21	53,6	63,1	9,5	35,7	53,1	17,4	0,0	
0,22	51,0	62,8	11,8	28,5	52,8	24,3	0,0	
0,24	44,8	62,0	17,1	15,8	52,0	36,1	0,0	
0,27	42,6	61,1	18,5	14,2	51,1	36,9	0,0	
0,29	41,2	60,4	19,2	23,0	50,4	27,4	0,0	
0,33	37,4	59,4	22,0	17,6	49,4	31,7	0,0	
0,37	34,7	58,4	23,8	20,1	48,4	28,3	0,0	
0,45	30,6	56,8	26,3	6,2	46,8	40,6	0,0	
0,50	31,0	56,0	25,1	14,5	46,0	31,5	0,0	
0,60	31,5	56,0	24,6	25,3	46,0	20,7	0,0	
0,68	24,7	56,0	31,3	13,9	46,0	32,1	0,0	
13,56	51,2	60,0	8,8	47,5	50,0	2,5	0,0	
14,36	18,7	60,0	41,3	9,4	50,0	40,6	0,0	

Picture 3: Table - Conducted emission on mains, phase 1 (without termination)

# Interference Voltage Test



REGULATIONS:  
47CFR, 15.207  
PEAK / CISPR / AV

TEST EQUIPMENT:  
R&S ESCS30 (E00003)  
R&S ESH2-Z5 (E00004)

ORDER NO.:  
160617-AU02+W03

EUT:  
Elatec GmbH  
RFID Reader  
TWN4 MultiTech 2  
Sample #8

OPERATION MODE:  
Cont. tag reading

Mains 120V AC /60Hz  
Neutral

TEST FACILITY:  
EMV TESTHAUS GmbH  
Gustav-Hertz-Straße 35  
94315 Straubing

DATE / TIME:  
2016-12-02 10:19:05  
23°C 41% 98kPa

TEST ENGINEER:  
Martin Müller

StoSp\_N.E10

Picture 4: Graphic - Conducted emission on mains, neutral (without termination)



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## Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
0,15	54,0	66,0	12,0	27,4	56,0	28,6	0,0	
0,17	58,0	65,1	7,1	39,7	55,1	15,3	0,0	
0,17	58,9	64,9	6,0	42,9	54,9	12,0	0,0	
0,20	47,6	63,7	16,1	24,5	53,7	29,2	0,0	
0,23	45,4	62,6	17,2	20,5	52,6	32,1	0,0	
0,24	43,5	62,1	18,7	16,4	52,1	35,8	0,0	
0,25	49,3	61,8	12,5	31,8	51,8	20,0	0,0	
0,29	41,4	60,6	19,2	23,7	50,6	26,8	0,0	
0,33	38,5	59,4	20,8	23,9	49,4	25,5	0,0	
0,37	35,3	58,4	23,1	21,2	48,4	27,3	0,0	
0,41	32,7	57,6	24,9	6,6	47,6	41,1	0,0	
0,47	31,1	56,6	25,4	16,9	46,6	29,7	0,0	
0,54	29,6	56,0	26,4	18,7	46,0	27,3	0,0	
0,59	32,3	56,0	23,7	26,8	46,0	19,2	0,0	
0,60	34,1	56,0	21,9	26,2	46,0	19,8	0,0	
13,22	25,1	60,0	34,9	16,9	50,0	33,1	0,0	
13,47	25,8	60,0	34,2	16,2	50,0	33,8	0,0	
13,64	23,7	60,0	36,4	15,7	50,0	34,4	0,0	

Picture 5: Table - Conducted emission on mains, neutral (without termination)



# 5 Radiated emission measurement (<1 GHz)

according to 47 CFR Part 15, section 15.205(a), 15.209(a), 15.225(a) to (e), and RSS-210, section 4.3 and Annex B6 with RSS-Gen, sections 8.10 and 8.9

## 5.1 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 area test site (OATS)	EMV <b>TESTHAUS</b> GmbH	E00354

## 5.2 Test instruments

	Description	Manufacturer	Inventory No.
<input checked="" type="checkbox"/>	ESCI (OATS)	Rohde & Schwarz	E00552
<input checked="" type="checkbox"/>	ESCI (CDC)	Rohde & Schwarz	E00001
<input type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	VULB 9163 (OATS)	Schwarzbeck	E00013
<input checked="" type="checkbox"/>	VULB 9160 (CDC)	Schwarzbeck	E00011
<input checked="" type="checkbox"/>	HFH2-Z2	Rohde & Schwarz	E00060
<input checked="" type="checkbox"/>	Cable set CDC	Huber + Suhner	E00060
<input checked="" type="checkbox"/>	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
<input type="checkbox"/>	Cable set OATS 10 m	Huber + Suhner	E00453, E00455, E00458



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## 5.3 Limits

The field strength of any emissions appearing outside of the 13.110 to 14.010 MHz band including spurious emissions falling into restricted bands as specified in 15.205(a) shall not exceed the general radiated emission limits as specified in 15.209.

Frequency [MHz]	Field strength Fs [ $\mu\text{V/m}$ ]	Field strength [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

As noted in 15.205(d)(7) devices according to 15.225 are exempt from complying with restricted band requirements for the 13.36 to 13.41 MHz band. Instead they have to comply with the limits as specified in 15.225 (a) to (d):

Frequency [MHz]	Field strength Fs [ $\mu\text{V/m}$ ]	Field strength [dB $\mu\text{V/m}$ ]	Measurement distance d [m]
13.553 - 13.567	15,848	84	30
13.410 - 13.553	334	50.47	30
13.567 - 13.710	334	50.47	30
13.110 - 13.410	106	40.51	30
13.710 - 14.010	106	40.51	30
f < 13.110	according to limits in §15.209		
f > 14.010			



## 5.4 Test procedure

1. EUT was configured according to ANSI C63.10. It 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 compact diagnostic chamber.
2. EUT and all peripherals were powered on.
3. The broadband antenna was set to vertical polarization.
4. The EMI receiver performed a scan from 30 MHz to 1000 MHz with peak detector peak and measurement bandwidth set to 120 kHz.
5. The turn table was rotated to 6 different positions ( $360^\circ / 6$ ) and the antenna polarization was changed to horizontal.
6. Test procedure at step 4 and 5 was repeated.
7. The test setup was then placed in an OATS at 3 m distance and all peak values over or with less margin to the limit than 6dB were marked and re-measured with a quasi-peak detector.
8. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
9. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emission field strength of both horizontal and vertical polarization. The highest value was recorded.
10. For emissions below 30 MHz measurements were done using a loop antenna. Prescan was performed with peak detector and final measurements with quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz where average detector applies. Antenna height was not changed during this test. Appropriate CISPR bandwidths of 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above were used.



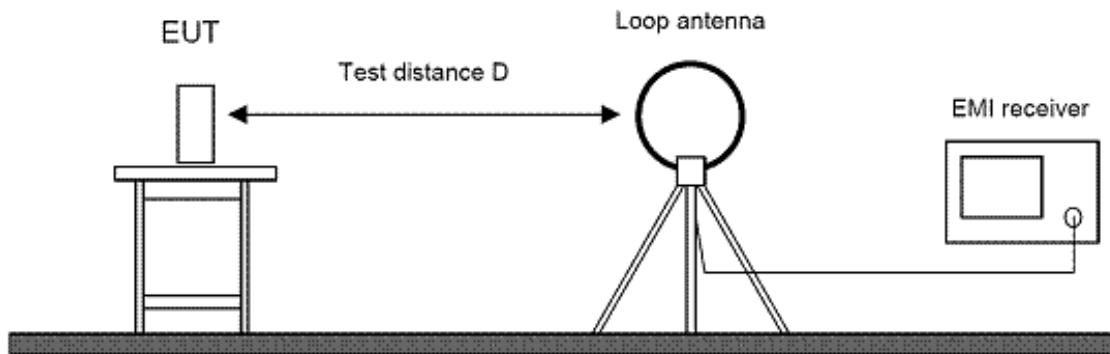
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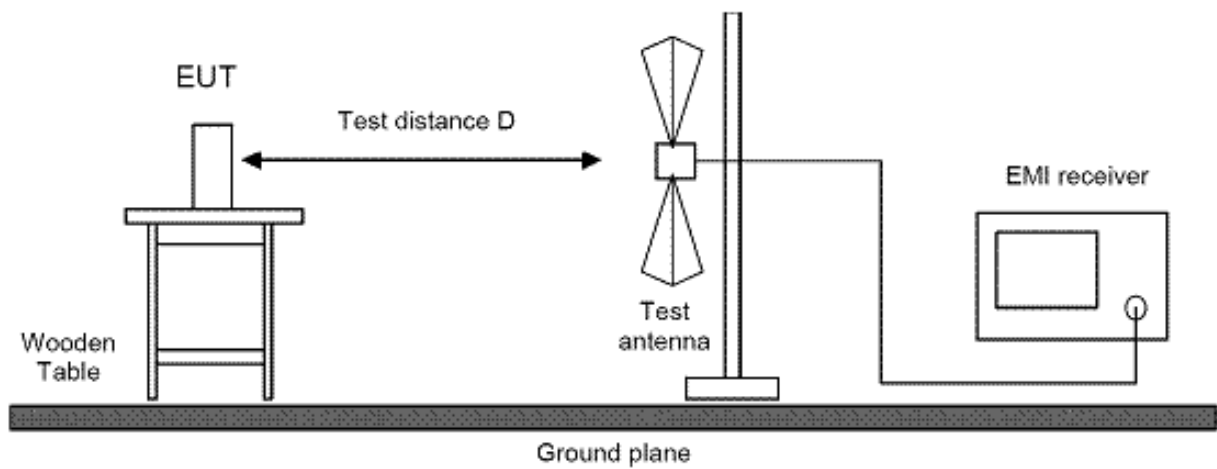
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## 5.5 Test setup



Picture 6: Test setup for radiated emission measurement (< 30 MHz)



Picture 7: Test setup for radiated emission measurement (< 1 GHz)

## 5.6 Test deviation

There is no deviation from the standards referred to.

## 5.7 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-12-01

### Radiated Emission Measurement 9 kHz - 30 MHz

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

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

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

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

$$f_{\text{MHz}}(300 \text{ m}) \approx 0.159 \text{ MHz}$$

$$f_{\text{MHz}}(30 \text{ m}) \approx 1.592 \text{ MHz}$$

$$f_{\text{MHz}}(3 \text{ m}) \approx 15.923 \text{ MHz}$$

For  $9 \text{ kHz} \leq f \leq 159 \text{ kHz}$  and  $490 \text{ kHz} < f \leq 1.592 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{limit}} / d_{\text{measure}})$$

For  $159 \text{ kHz} < f \leq 490 \text{ kHz}$  and  $1.592 \text{ MHz} < f \leq 15.923 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$$

For  $f > 15.923 \text{ MHz}$ :

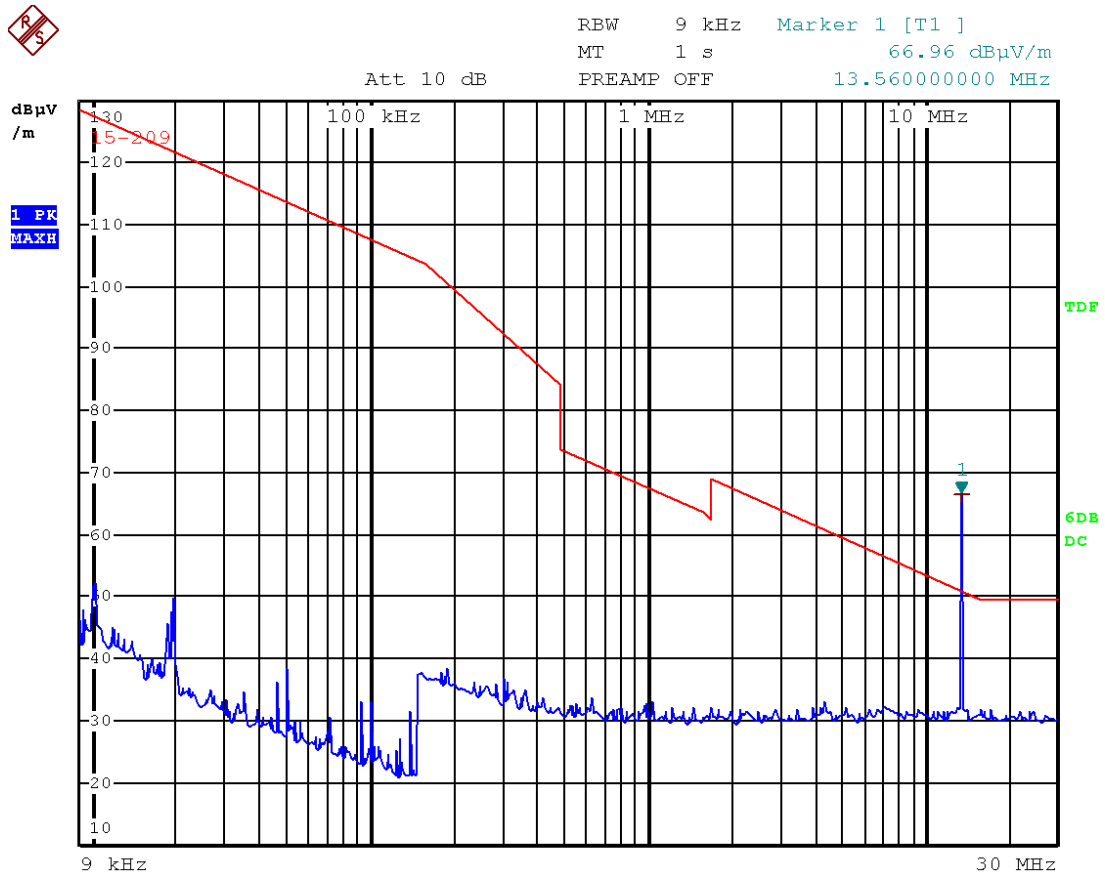
$$\text{Recalculation factor} = -20 \log(d_{\text{limit}} / d_{\text{measure}})$$

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



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

The following picture shows the worst-case-emissions for the spurious emissions at EUT-position 1, antenna in line.



Picture 8: Radiated emission 9 kHz – 30 MHz @ 3m distance

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin	Result
13.560	66.96	PK	-21.40	45.56	---	---	Carrier
13.560	66.63	QP	-21.40	45.23	84.00	-38.77	Carrier



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

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

$$\text{Recalculation factor} = -40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$$

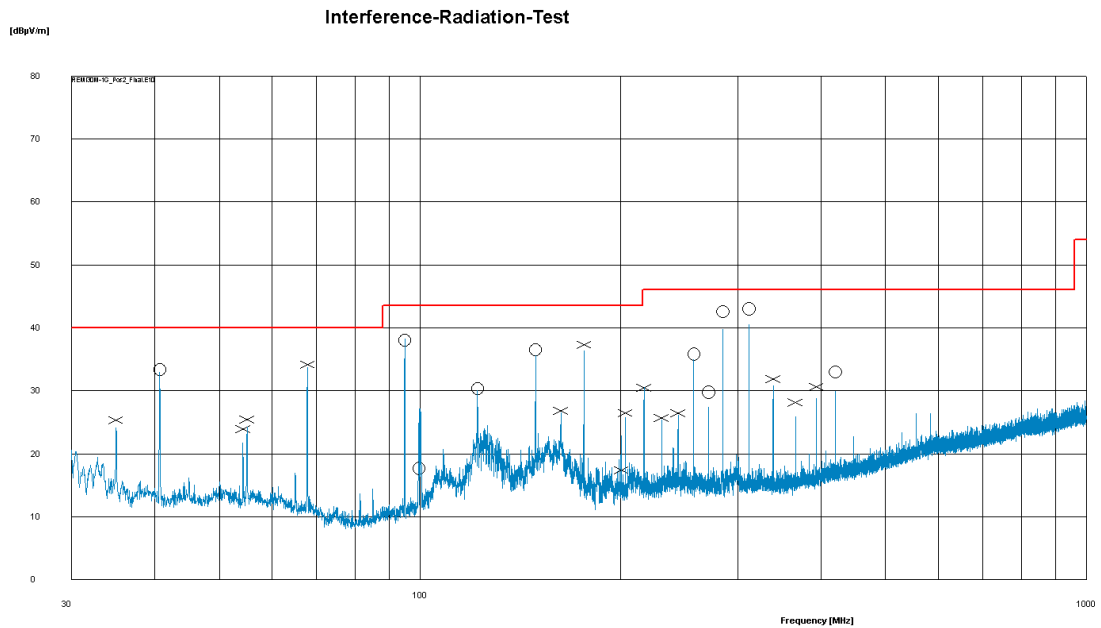
<b>f<sub>MHz</sub></b> <b>[MHz]</b>	<b>d<sub>near field</sub></b> <b>[m]</b>	<b>d<sub>measure</sub></b> <b>[m]</b>	<b>d<sub>limit</sub></b> <b>[m]</b>	<b>Recalculation</b> <b>factor [dB]</b>
13.56	3.523	3.0	30.0	21.40



# Radiated Emission Measurement 30 MHz - 1000 MHz

Frequency range	Polarisation	Step size	IF Bandwidth	Detector		Measurement Time		Pre-amplifier
				Prescan	Final scan	Prescan	Final scan	
30 MHz – 1 GHz	H / V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB

The following pictures show the worst-case-emissions at EUT-position 2.



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f [MHz]	E <sub>final</sub> [dBV/m]	Limit [dB $\mu$ V/m]	Height [cm]	TT [°]	Polarisation	Result
34.98	25.30	40.00	100	286.8	V	Pass
40.68	33.36	40.00	250	232.9	H	Pass
54.24	23.87	40.00	100	127.2	V	Pass
55.02	25.38	40.00	100	87.5	V	Pass
67.80	34.15	40.00	126	98	V	Pass
94.92	38.06	43.52	267	252.8	H	Pass
99.72	17.67	43.52	250	10.2	H	Pass
122.04	30.38	43.52	250	253.2	H	Pass
149.16	36.54	43.52	250	78.5	H	Pass
162.72	26.81	43.52	100	213.3	V	Pass
176.28	37.29	43.52	100	233.6	V	Pass
200.58	17.33	43.52	100	117.2	V	Pass
203.40	26.42	43.52	100	126.9	V	Pass
216.96	30.50	46.02	100	117.1	V	Pass
230.52	25.71	46.02	100	272.6	V	Pass
244.08	26.45	46.02	100	1.8	V	Pass
257.64	35.86	46.02	250	87.9	H	Pass
271.20	29.77	46.02	250	78.1	H	Pass
284.76	42.60	46.02	183	98.4	H	Pass
311.88	43.02	46.02	209	204.2	H	Pass
339.00	31.82	46.02	100	78.1	V	Pass
366.12	28.14	46.02	100	78	V	Pass
393.24	30.61	46.02	100	78.2	V	Pass
420.36	33.01	46.02	250	223.5	H	Pass

Picture 9: Radiated emission 30 MHz - 1000MHz @ 3m distance



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# Spectrum Mask

## Test procedure

The EUT was placed in a fully anechoic chamber and the testing was performed in accordance with ANSI C63.10 and 47 CFR Part 15, section 15.225 (a) to (d). The measurement distance was 3 m. To find the closest margin of the spectrum to the limit mask adapted to the test distance the EUT was rotated by 360 degrees with detector of the test receiver set to peak. The loop antenna placed in a fixed height of 1 meter was rotated by 360 degrees to get the maximum of emission. In case of exceeding the limits the detector is switched to quasi peak for final testing in position of maximum emission.



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## Test result

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-12-01

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

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

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

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

$$f_{\text{MHz}}(300 \text{ m}) \approx 0.159 \text{ MHz}$$

$$f_{\text{MHz}}(30 \text{ m}) \approx 1.592 \text{ MHz}$$

$$f_{\text{MHz}}(3 \text{ m}) \approx 15.923 \text{ MHz}$$

For  $9 \text{ kHz} \leq f \leq 159 \text{ kHz}$  and  $490 \text{ kHz} < f \leq 1.592 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{limit}} / d_{\text{measure}})$$

For  $159 \text{ kHz} < f \leq 490 \text{ kHz}$  and  $1.592 \text{ MHz} < f \leq 15.923 \text{ MHz}$ :

$$\text{Recalculation factor} = -40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$$

For  $f > 15.923 \text{ MHz}$ :

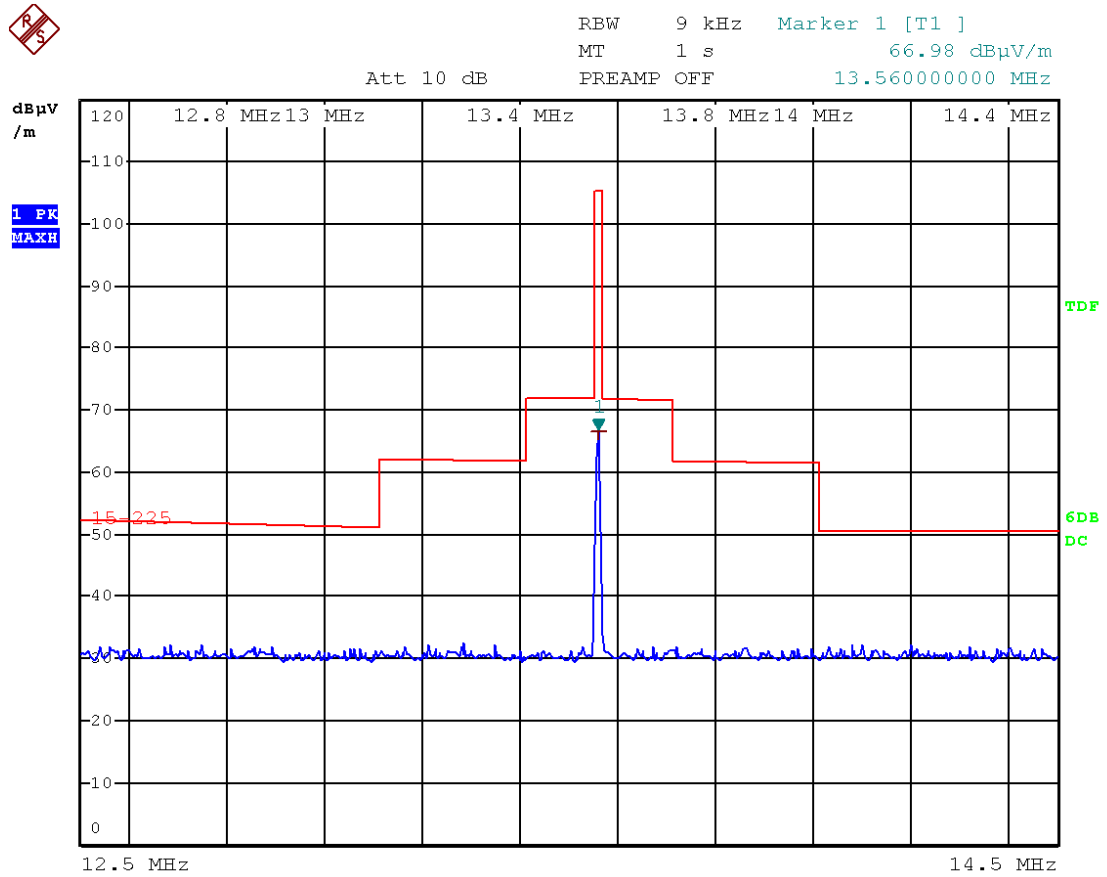
$$\text{Recalculation factor} = -20 \log(d_{\text{limit}} / d_{\text{measure}})$$

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



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

The following picture shows the worst-case-emissions for spectrum mask at EUT-position 1, antenna in line.



Picture 10: Spectrum mask for 13.56 MHz @ 3m distance

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	66.98	PK	-21.40	45.58	---	---	---
13.560	66.65	QP	-21.40	45.25	84.00	-38.75	Pass



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

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

$$\text{Recalculation factor} = -40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$$

$f_{\text{MHz}}$ [MHz]	$d_{\text{near field}}$ [m]	$d_{\text{measure}}$ [m]	$d_{\text{limit}}$ [m]	Recalculation factor [dB]
13.560	3.523	3.000	30.000	-21.40



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## 6 Radiated emission measurement (>1 GHz)

according to 47 CFR Part 15, section 15.209(a),  
RSS-210, section 4.3 with RSS-Gen, section 8.9

Remark:

This measurement needs not to be applied because

- the intentional radiator operates below 10 GHz and tenth harmonic of the highest fundamental frequency is lower than 1 GHz (see 47 CFR Part 15, section 15.33(a)(1), and RSS-Gen, section 6.13), and
- the digital part of the device does not generate or use internal frequencies higher than 108 MHz (see 47 CFR Part 15 section 15.33(b)(1), and RSS-Gen, section 2.3.3 with ICES-003, section 6.2).



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# 7 Carrier frequency stability

according to CFR 47 Part 15, section 15.225(e), and  
RSS-210, Annex B6 with RSS-Gen, section 6.11

## 7.1 Test Location

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	Climatic chamber VC 4100	Vötsch Industrietechnik	C00014
<input checked="" type="checkbox"/>	Climatic chamber VC <sup>3</sup> 4034	Vötsch Industrietechnik	C00015

## 7.2 Test instruments

	Description	Manufacturer	Inventory No.
<input type="checkbox"/>	ESU 26	Rohde & Schwarz	W00002
<input checked="" type="checkbox"/>	ESCI 3	Rohde & Schwarz	E00552
<input checked="" type="checkbox"/>	RF-R 400-1	Langer EMV-Technik	E00270

## 7.3 Limits

The frequency tolerance of the carrier signal shall be maintained within  $\pm 0.01\%$  (100 ppm) of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C.

For battery operated equipment, the equipment tests shall be performed using a new battery. Alternatively, an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer.



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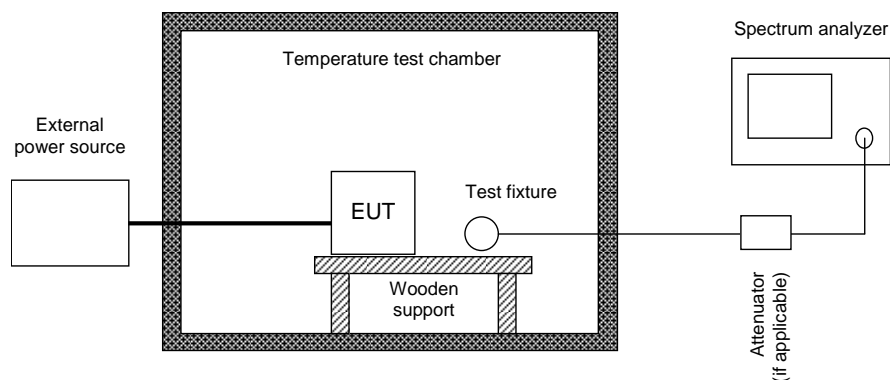
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## 7.4 Test procedure

1. If possible EUT is operating providing an unmodulated carrier. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to the shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.  
If an unmodulated carrier is not available a significant and stable point on the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1% of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance allowed is larger than the uncertainty of the measured frequency tolerance.
2. The carrier frequency is measured depending on the variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer. Alternatively, tests shall be performed using a new battery.
3. The carrier frequency is measured over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage.

## 7.5 Test setup



Picture 11: Test setup for carrier frequency stability measurement

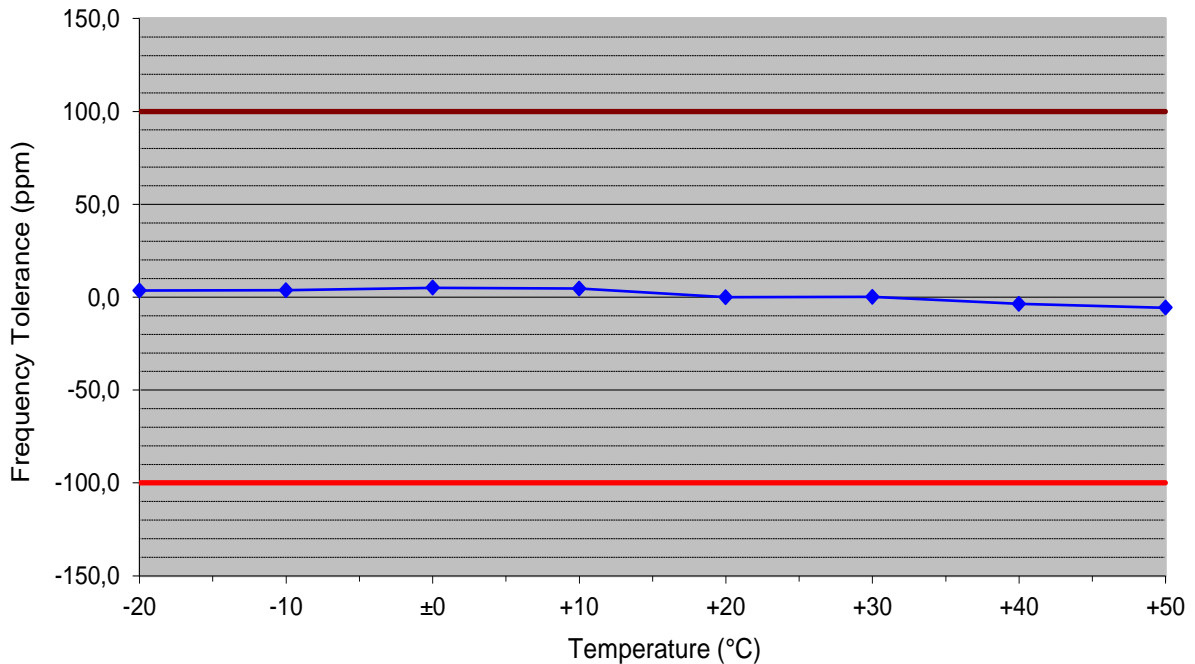
## 7.6 Test deviation

There is no deviation from the standards referred to.

## 7.7 Test result

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-12-05

### Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,560025 MHz			
Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560073	48	3,5	+100,0	-100,0	96,5
-10	13,560075	50	3,7	+100,0	-100,0	96,3
±0	13,560094	69	5,1	+100,0	-100,0	94,9
+10	13,560088	63	4,6	+100,0	-100,0	95,4
+20	13,560025	0	0,0	+100,0	-100,0	100,0
+30	13,560027	2	0,1	+100,0	-100,0	99,9
+40	13,559976	-49	-3,6	+100,0	-100,0	96,4
+50	13,559948	-77	-5,7	+100,0	-100,0	94,3

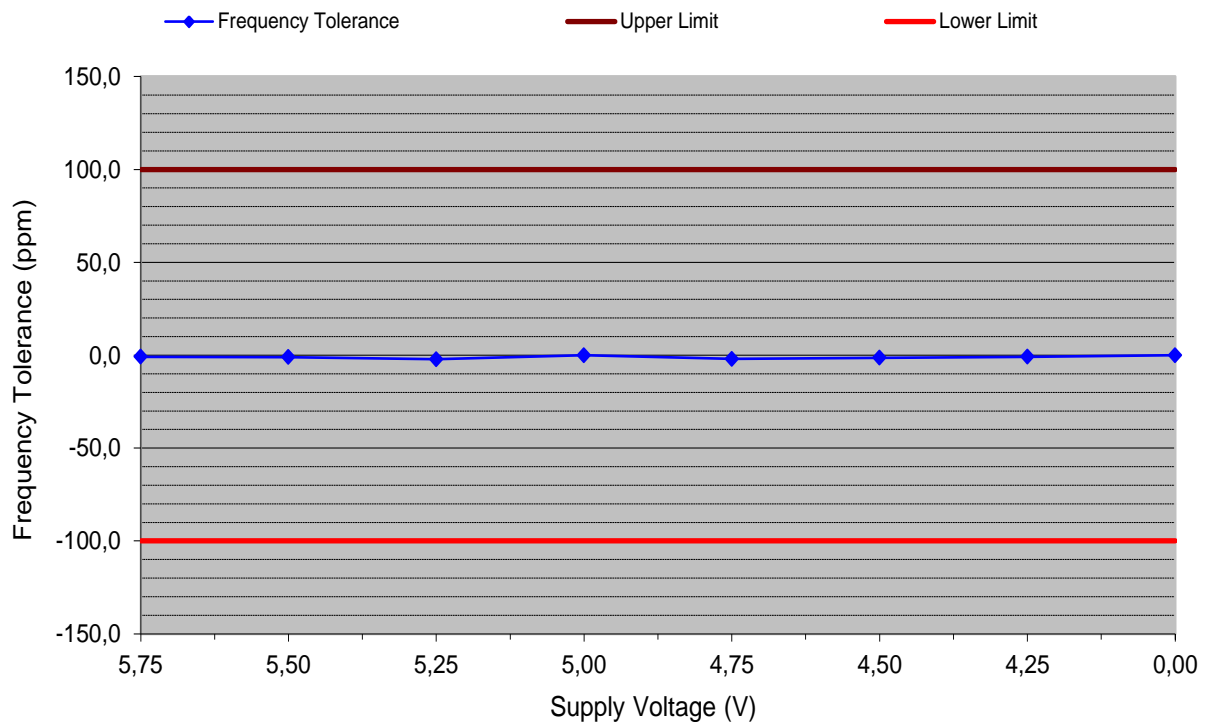


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## Carrier frequency stability vs. supply voltage



Temperature: +20 °C      Battery End Point: Not applicable  
 Frequency under nominal conditions: 13,560025 MHz

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
5,75	13,560014	-11	-0,8	+100,0	-100,0	99,2
5,50	13,560011	-14	-1,0	+100,0	-100,0	99,0
5,25	13,559995	-30	-2,2	+100,0	-100,0	<b>97,8</b>
5,00	13,560025	0	0,0	+100,0	-100,0	100,0
4,75	13,559998	-27	-2,0	+100,0	-100,0	98,0
4,50	13,560006	-19	-1,4	+100,0	-100,0	98,6
4,25	13,560013	-12	-0,9	+100,0	-100,0	99,1



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# 8 Bandwidths

according to CFR 47 Part 2, section 2.202(a), and RSS-Gen, section 6.6

## 8.1 Test Location

See clause 5.1 on page 16.

## 8.2 Test instruments

See clause 5.2 on page 16.

## 8.3 Limits

The bandwidths are recorded only. There are no limits specified in CFR 47 Part 15, section 15.225, and RSS-210, Annex B6

## 8.4 Test setup

See clause 5.5 on page 19.

## 8.5 Test deviation

There is no deviation from the standards referred to.



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## 8.6 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-12-01

### Occupied bandwidth (99 %)

#### Test procedure

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured. The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used given that a peak or peak hold may produce a wider bandwidth than actual.

The trace data points are recovered and directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded. The span between the two recorded frequencies is the occupied bandwidth. For this purpose the appropriate measurement function of the spectrum analyzer is used.

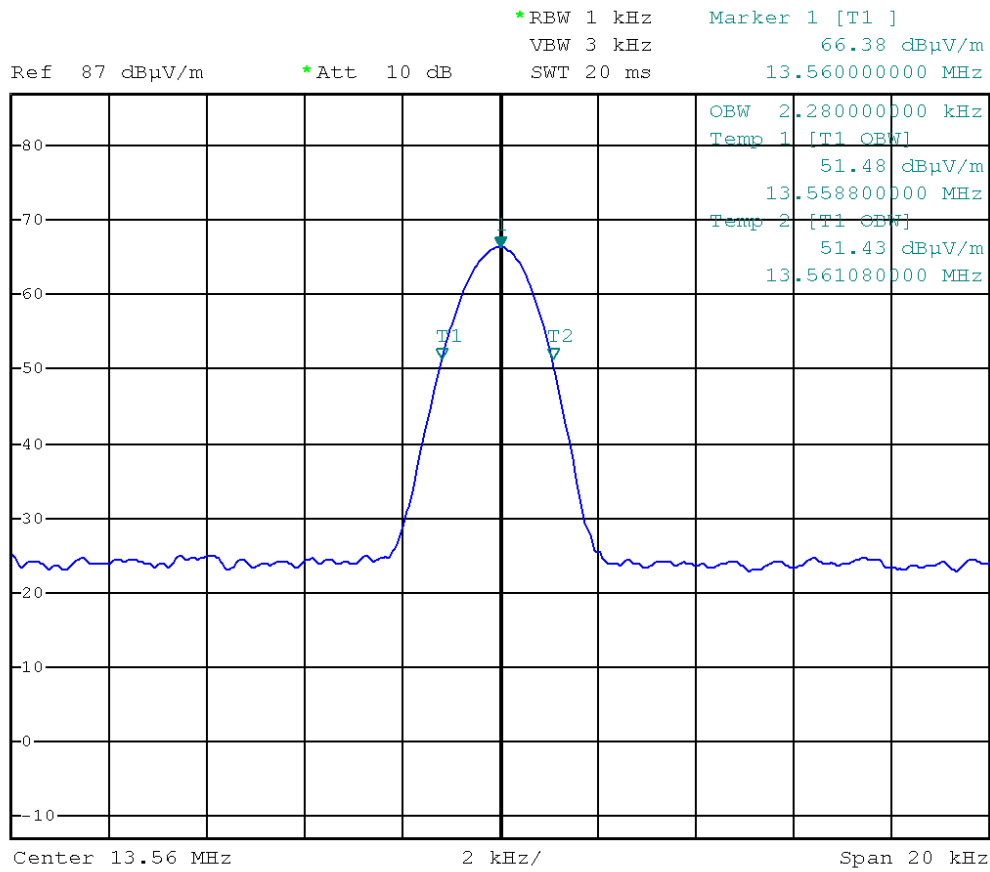


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Picture 12: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 2.2800 kHz



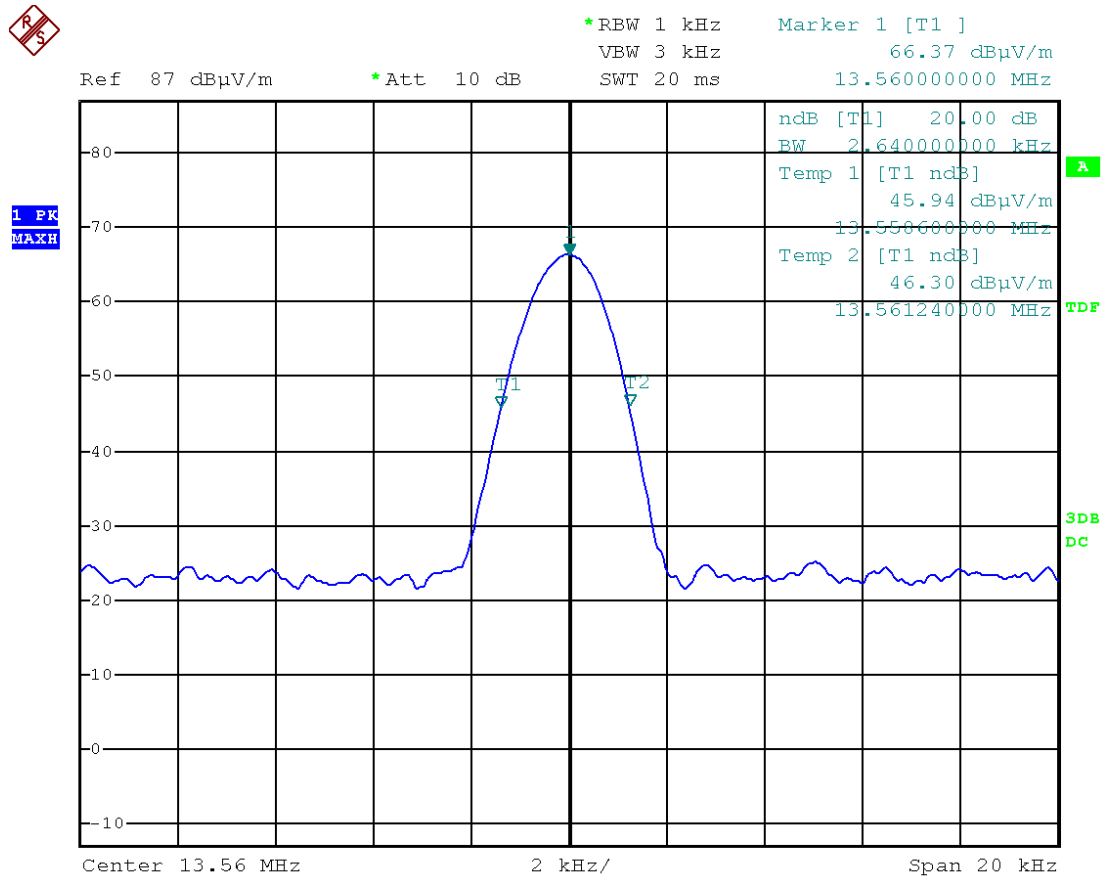
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# -20 dB emission bandwidth

## Test procedure

Where indicated, the -20 dB emission bandwidth is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated 20 dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth equal to approximately 1.0% of the emission bandwidth.



Picture 13: -20 dB emission bandwidth

Measured -20 dB emission bandwidth: 2.6400 kHz



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$f_{\text{assigned}}$ (MHz)	Index	$f_{-20\text{dB}}$ (MHz)	$\Delta f_T$ (kHz)	$\Delta f_U$ (kHz)	$f_{-20\text{dB}(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.558600	0.077	0.030	13.558493	13.110000	448.493	Passed
	high	13.561240	0.069	0.000	13.561309	14.010000	448.691	Passed
	Bandwidth	2.640 kHz			2.816 kHz			

- with:
- $f_{-20\text{dB}(\text{low})}$  = lower frequency in MHz where emission is at least 20 dB below the carrier
  - $f_{-20\text{dB}(\text{high})}$  = upper frequency in MHz where emission is at least 30 dB below the carrier
  - $f_{\text{assigned}}$  = assigned frequency in kHz
  - $\Delta f_{T(\text{low})}$  = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
  - $\Delta f_{U(\text{low})}$  = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
  - $\Delta f_{T(\text{high})}$  = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
  - $\Delta f_{U(\text{high})}$  = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
  - $\Delta f_{\text{volt}(\text{high})}$  = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
  - $f_{-20\text{dB}(T, U)}$  = frequency in MHz where emission is at least 20 dB below the carrier, including offset caused by variations of temperature and supply voltage as recorded in clause 7.7

Measured -20 dB emission bandwidth:

At nominal conditions: 2.640 kHz

Including variations in temperature and supply voltage: 2.816 kHz



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## 9 Equipment calibration status

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Test receiver	ESCI 3	100013	E00001	2016-02	2018-02
Test receiver	ESCI 3	100328	E00552	2016-09	2018-09
Test receiver	ESCS 30	825442/0002	E00003	2016-04	2018-04
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9160	9160-3050	E00011	2015-09	2017-09
Broadband antenna	VULB 9163	9163-114	E00013	2015-09	2017-09
Magnetic field probe	RF-R 400-1	02-2030	E00270	N/A (see note 1)	
Shielded room	P92007	B83117C1109T211	E00107	N/A	
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69-2-0006	E00026	N/A	
Open area test site (OATS)	---	---	E00354	2015-10	2017-10
Climatic chamber 340 I	VC <sup>3</sup> 4034	58566123250010	C00015	2016-10	2018-10
Cable set shielded room	Cable no. 30	---	E00424	2016-07	2018-07
Cable set CDC	Cables no. 37 and 38	---	E00459 E00460	2015-05	2017-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2015-11	2017-11

Table 1: Equipment calibration status

Note 1: Used for relative measurements only (see test instruments for “Carrier frequency stability”, clause 7.2)

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

Note 3: Expiration date of test firm accreditation for OATS and SAC:  
 FCC test firm type “accredited”: 2017-06



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# 10 Measurement uncertainty

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	± 3.8 dB	2
Radiated emission open field (3 m) (30 MHz to 300 MHz) (300MHz to 1 GHz)	± 5.4 dB ± 5.9 dB	2
Radiated emission absorber chamber (> 1000 MHz)	± 4.5 dB	2

Table 2: Measurement uncertainty

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



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# 11 Revision History

Date	Description	Person	Revision
2017-01-17	First edition	M. Müller	0



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