Test Report

Customer:

GMMC GmbH

Kehlbergstrasse 109
8054 Graz
Austria
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RF test report

170186-AU01+W02

Industry Canada Industrie Canada

GMMC GmbH

13.56 MHz Multi Standard - Multi Antenna Reader/Writer

SANGOMA-MSMA 2v5

EMV **TESTHAUS** GmbH

Gustav-Hertz-Straße 35
94315 Straubing
Germany
Tel.: +49 9421 56868-0
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Accreditation:

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

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

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

Test Laboratory:

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

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

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1 Test regulations

47 CFR Part 2: 03-2017	Code of Federal Regulations Part 2 - Frequency allocation and radio treaty matters; General rules and regulations
47 CFR Part 15: 03-2017	Code of Federal Regulations Part 15 - Radio Frequency Devices
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 Equimpment
RSS-210 Issue 9, August 2016	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

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, March 31, 2017

Martin Müller
Test engineer
EMV **TESTHAUS** GmbH

Christian Kiermeier
Technical executive
EMV **TESTHAUS** GmbH

3 Equipment under Test (EUT)

Product type:	13.56 MHz Multi Standard - Multi Antenna Reader/Writer
Model Name:	SANGOMA-MSMA 2v5
Applicant:	GMMC GmbH
Manufacturer:	GMMC GmbH
Serial number:	#1
FCC ID:	2AKHW-SANGMSMA4
IC certification number:	22202-SANGMSMA4
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 types:	PCB antennas
	☒ detachable ☐ not detachable
Power supply:	USB powered nominal: 5.0 VDC ± 15 %
Temperature range:	-20°C to +85°C

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

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/writer operating at the frequency of 13.56 MHz.

3.3 Operation mode

During the pre-tests it was observed that the “continuous-wave-mode” is the respective worst-case. Therefore this mode was selected for final testing.

Because EUT supports 4 antennas tests were performed as follows:

	Test			
Mode	AC power line conducted emissions	Radiated emissions according to 47 CFR, Part 15, section 15.209	Radiated emissions according to 47 CFR, Part 15, section 15.225	Bandwidth tests
Antenna 2010, stand alone	not performed [1]	performed	performed	performed
Antenna Jay, stand alone	not performed [1]	performed	performed	performed
Antenna 4040, stand alone	not performed [1]	performed	performed	performed
Antenna 7248, stand alone	not performed [1]	performed	performed	performed
Antenna switching	performed	performed	not performed	not performed

Note1: Antenna switching mode performed as worst-case.

EUT is not able to use two or more antennas at the same time (no simultaneous operation possible).
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.
13.56 MHz Multi Standard - Multi Antenna Reader/Writer	SANGOMA-MSMA 2v5	#1
RFID antenna	2010	---
RFID antenna	Jay	---
RFID antenna	4040	---
RFID antenna	7248	---
Notebook	Lifebook A531	E00521
Power supply notebook	ADP-65JH AD	S26113-E557-V55-01
PC	Esprimo P9900 (Fujitsu)	YL6K001113
Monitor	Belinea 1930 S2	BA10002
DC power supply [2]	Statron 3231.1	E00017
AC power supply (120V / 60Hz)	61602	ABP000000730

Note2: Used for test “carrier frequency stability” only.

3.5 Used cables

Count	Description (type / lengths / remarks)	Serial no.
4	Antenna cable (unshielded / 2.0 m)	---
1	USB cable (shielded / 0.3 m)	---
2	DC power supply cable (unshielded / 1.0 m) [3]	---

Note3: Used for test “carrier frequency stability” only.

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.
☒	ESCS 30	Rohde & Schwarz	E00003
☐	ESU 26	Rohde & Schwarz	W00002
☐	ESCI	Rohde & Schwarz	E00001
☐	ESH3-Z2	Rohde & Schwarz	E00028
☐	ESH2-Z5	Rohde & Schwarz	E00004
☒	ESH2-Z5	Rohde & Schwarz	E00005
☒	Cable set shielded room	Huber + Suhner	E00424

4.3 Limits

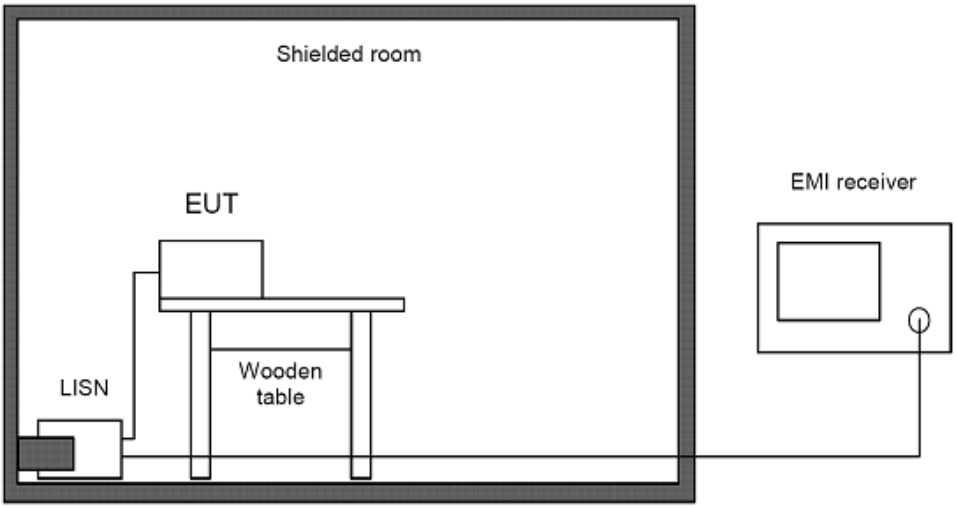
Frequency [MHz]	Quasi-peak [dBµV]	Avarage [dBµV]
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

4.4 Test procedure

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

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.

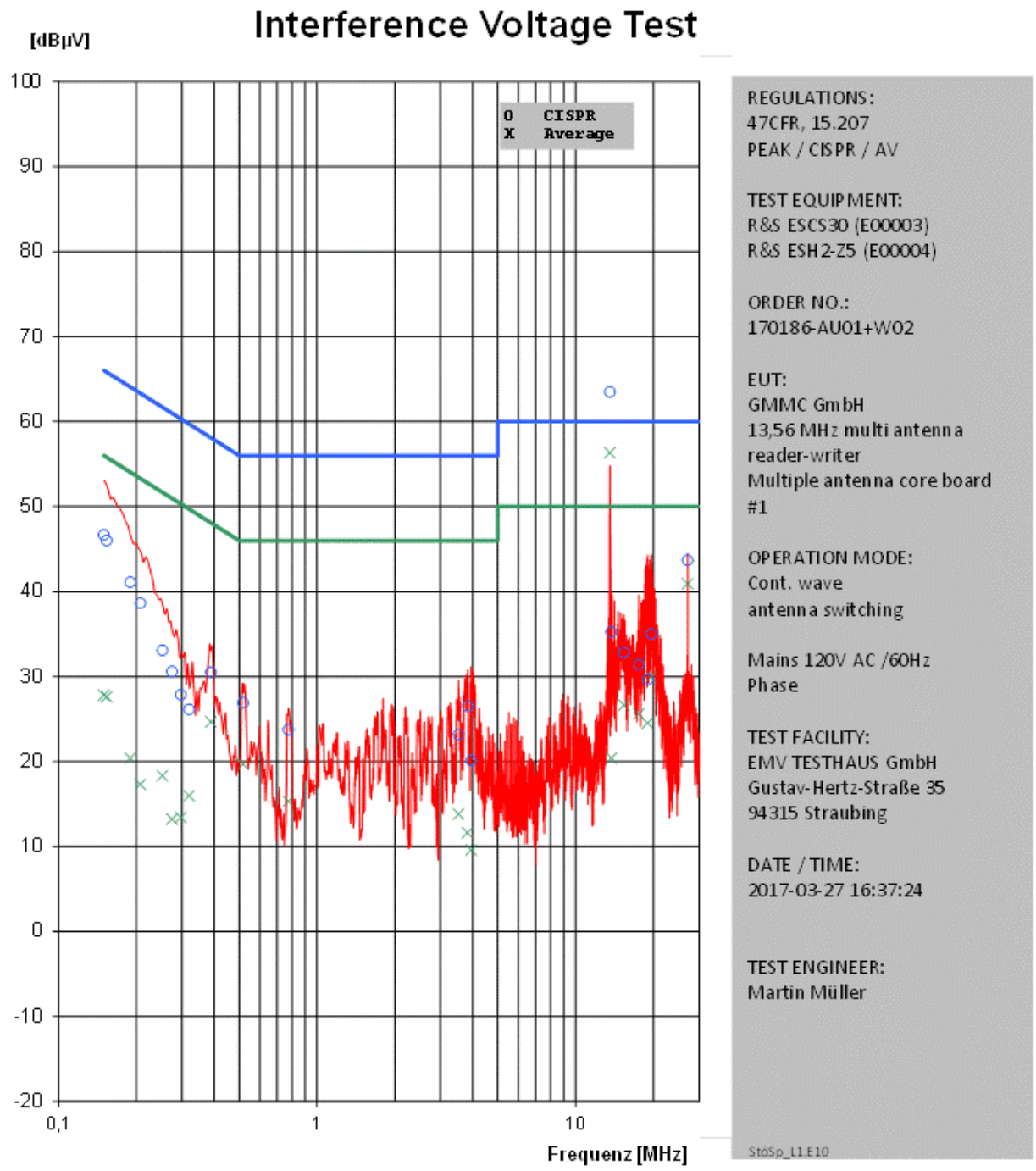
4.5 Test setup



Picture 1: Outline of conducted emission test setup

4.6 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

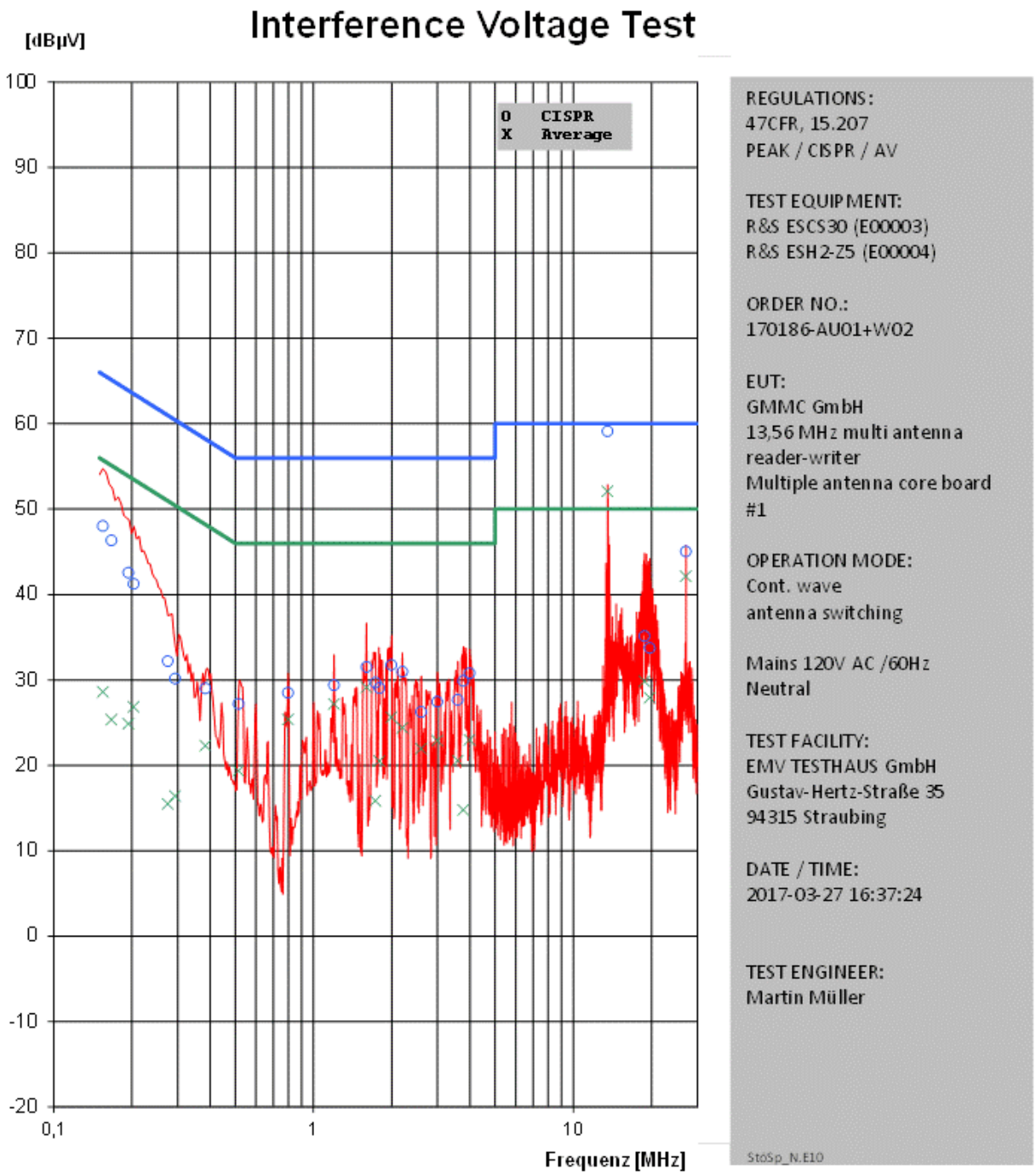


Picture 2: Graphic - Conducted emission on mains, phase 1 (without termination)

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	46,7	66,0	19,3	27,8	56,0	28,2	0,0	
0,15	46,0	65,8	19,8	27,6	55,8	28,2	0,0	
0,19	41,1	64,1	23,0	20,4	54,1	33,7	0,0	
0,21	38,7	63,3	24,7	17,3	53,3	36,0	0,0	
0,25	33,1	61,7	28,6	18,3	51,7	33,3	0,0	
0,28	30,6	61,0	30,4	13,2	51,0	37,8	0,0	
0,30	27,9	60,3	32,5	13,4	50,3	36,9	0,0	
0,32	26,1	59,7	33,6	16,0	49,7	33,7	0,0	
0,39	30,5	58,1	27,6	24,6	48,1	23,4	0,0	
0,52	26,9	56,0	29,1	19,7	46,0	26,3	0,0	
0,78	23,7	56,0	32,3	15,3	46,0	30,7	0,0	
3,53	23,2	56,0	32,8	13,8	46,0	32,2	0,0	
3,83	26,5	56,0	29,5	11,6	46,0	34,4	0,0	
3,95	20,1	56,0	35,9	9,6	46,0	36,4	0,0	
13,56	63,5	60,0	**-3,5**	56,3	50,0	**-6,3**	0,0	
13,77	35,3	60,0	24,8	20,4	50,0	29,6	0,0	
15,37	32,9	60,0	27,2	26,6	50,0	23,4	0,0	
17,56	31,4	60,0	28,6	25,6	50,0	24,4	0,0	
19,00	29,7	60,0	30,3	24,5	50,0	25,5	0,0	
19,63	35,0	60,0	25,0	29,9	50,0	20,1	0,0	
27,12	43,7	60,0	16,3	40,9	50,0	9,1	0,0	

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

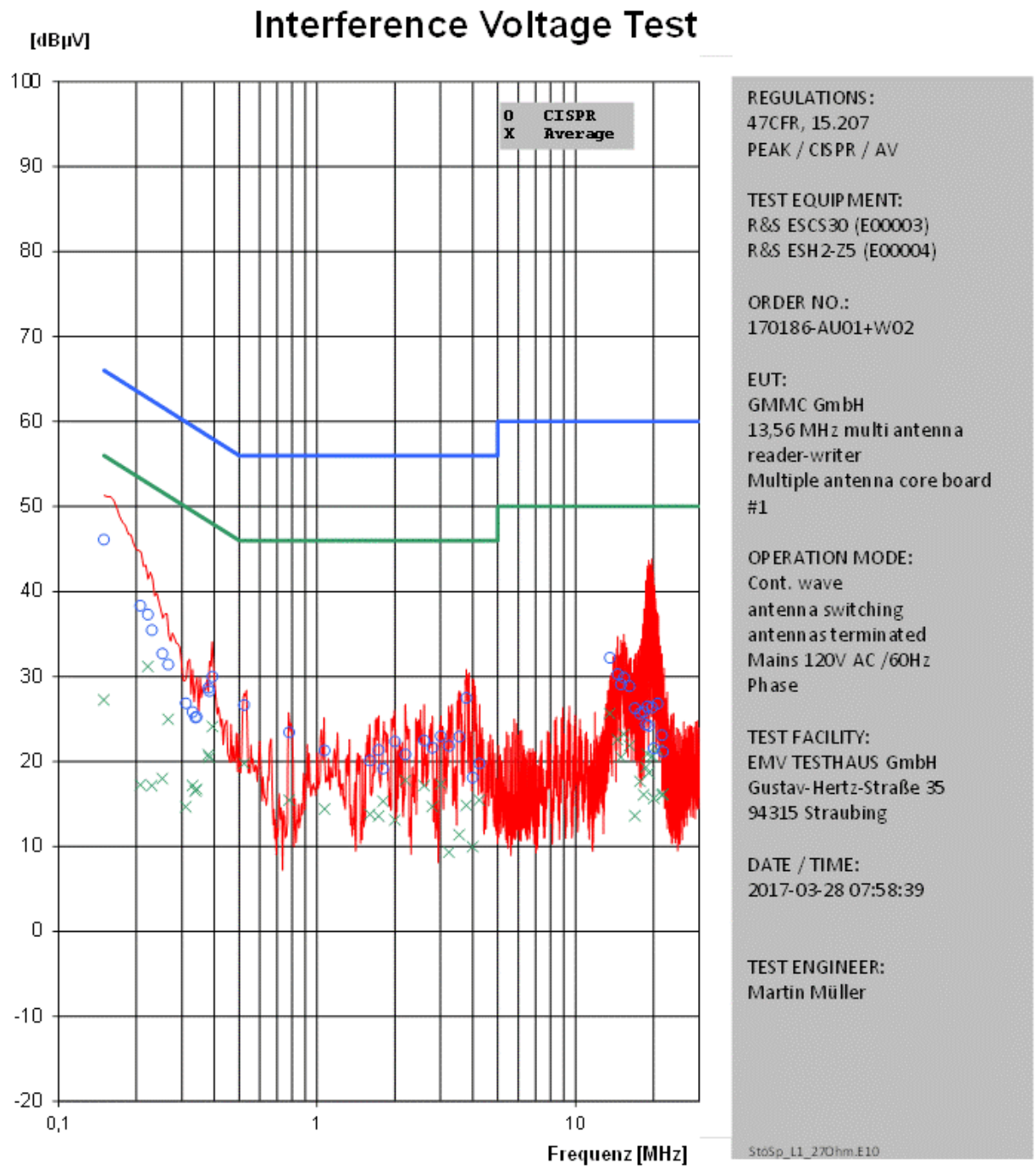


Picture 4: Graphic - Conducted emission on mains, neutral (without termination)

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	48,0	65,8	17,7	28,6	55,8	27,2	0,0	
0,17	46,3	65,1	18,8	25,3	55,1	29,8	0,0	
0,19	42,6	63,9	21,3	24,9	53,9	29,0	0,0	
0,20	41,2	63,5	22,2	26,9	53,5	26,6	0,0	
0,28	32,2	61,0	28,8	15,5	51,0	35,5	0,0	
0,29	30,2	60,4	30,3	16,4	50,4	34,0	0,0	
0,38	29,0	58,2	29,2	22,3	48,2	25,9	0,0	
0,51	27,2	56,0	28,8	19,4	46,0	26,7	0,0	
0,80	28,5	56,0	27,5	25,4	46,0	20,7	0,0	
1,20	29,4	56,0	26,6	27,2	46,0	18,8	0,0	
1,60	31,5	56,0	24,5	29,1	46,0	16,9	0,0	
1,73	29,7	56,0	26,3	15,9	46,0	30,2	0,0	
1,79	29,0	56,0	27,0	20,5	46,0	25,5	0,0	
1,99	31,8	56,0	24,2	25,6	46,0	20,4	0,0	
2,20	30,9	56,0	25,1	24,4	46,0	21,6	0,0	
2,59	26,3	56,0	29,7	22,0	46,0	24,0	0,0	
2,99	27,4	56,0	28,6	22,9	46,0	23,1	0,0	
3,59	27,7	56,0	28,3	20,6	46,0	25,5	0,0	
3,77	29,9	56,0	26,1	14,8	46,0	31,2	0,0	
3,99	30,8	56,0	25,2	23,0	46,0	23,0	0,0	
13,56	59,1	60,0	0,9	52,1	50,0	**-2,1**	0,0	
18,78	35,1	60,0	24,9	29,8	50,0	20,2	0,0	
19,69	33,7	60,0	26,3	27,9	50,0	22,1	0,0	
27,12	45,0	60,0	15,0	42,1	50,0	7,9	0,0	

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



Picture 6: Graphic - Conducted emission on mains, phase 1 (with termination 27 Ω)

Interference Voltage Test

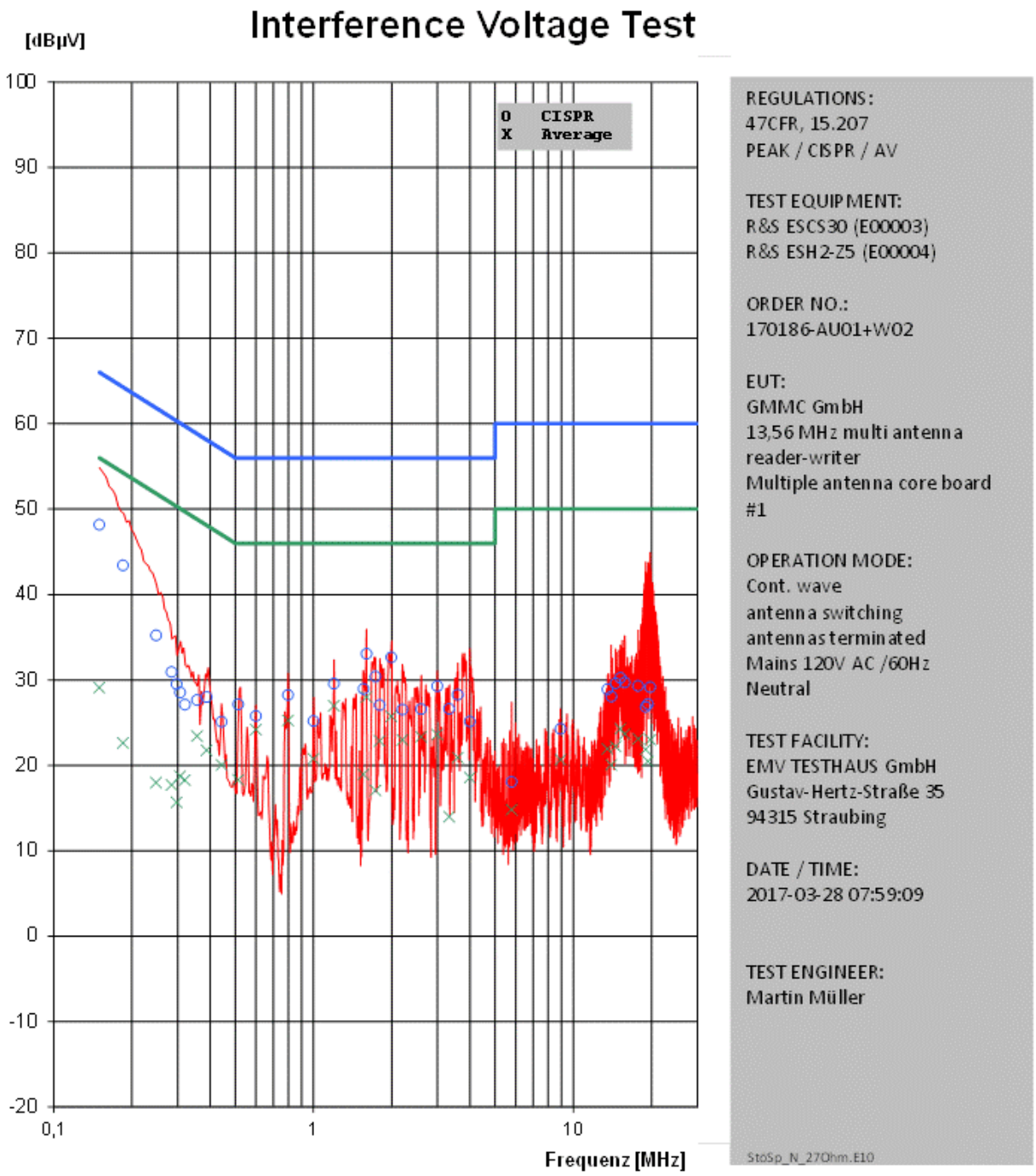
Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
0,15	46,1	66,0	19,9	27,2	56,0	28,8	0,0	
0,21	38,3	63,3	25,0	17,2	53,3	36,1	0,0	
0,22	37,3	62,8	25,5	31,2	52,8	21,6	0,0	
0,23	35,4	62,4	27,0	17,1	52,4	35,3	0,0	
0,25	32,7	61,7	29,0	18,0	51,7	33,7	0,0	
0,27	31,4	61,2	29,8	24,9	51,2	26,3	0,0	
0,31	26,8	59,9	33,1	14,7	49,9	35,3	0,0	
0,33	25,8	59,5	33,6	17,1	49,5	32,3	0,0	
0,34	25,2	59,2	34,1	16,5	49,2	32,7	0,0	
0,34	25,2	59,1	33,9	16,7	49,1	32,4	0,0	
0,38	28,7	58,3	29,6	20,8	48,3	27,5	0,0	
0,39	30,0	58,0	28,0	24,1	48,0	23,9	0,0	
0,38	28,3	58,2	30,0	20,5	48,2	27,8	0,0	
0,52	26,6	56,0	29,4	19,8	46,0	26,3	0,0	
0,78	23,4	56,0	32,6	15,4	46,0	30,6	0,0	
1,07	21,3	56,0	34,7	14,4	46,0	31,6	0,0	
1,60	20,1	56,0	35,9	13,8	46,0	32,2	0,0	
1,73	21,3	56,0	34,7	13,6	46,0	32,5	0,0	
1,80	19,2	56,0	36,8	15,3	46,0	30,7	0,0	
2,00	22,3	56,0	33,7	13,1	46,0	32,9	0,0	
2,20	20,8	56,0	35,2	17,8	46,0	28,2	0,0	
2,60	22,5	56,0	33,5	17,1	46,0	28,9	0,0	
2,80	21,6	56,0	34,4	14,7	46,0	31,3	0,0	
3,01	23,0	56,0	33,0	17,3	46,0	28,7	0,0	
3,24	21,8	56,0	34,2	9,3	46,0	36,7	0,0	
3,55	22,9	56,0	33,1	11,3	46,0	34,7	0,0	
3,78	27,5	56,0	28,6	14,8	46,0	31,2	0,0	
4,00	18,1	56,0	37,9	10,0	46,0	36,1	0,0	
4,25	19,8	56,0	36,3	15,4	46,0	30,6	0,0	
13,56	32,2	60,0	27,8	25,6	50,0	24,4	0,0	
14,55	30,3	60,0	29,7	22,5	50,0	27,5	0,0	
14,99	29,1	60,0	30,9	20,5	50,0	29,5	0,0	
15,38	29,9	60,0	30,1	23,2	50,0	26,8	0,0	
16,17	28,9	60,0	31,2	21,8	50,0	28,2	0,0	
16,99	26,3	60,0	33,7	13,6	50,0	36,4	0,0	
17,75	25,6	60,0	34,4	17,6	50,0	32,4	0,0	
18,38	25,8	60,0	34,2	16,1	50,0	33,9	0,0	
18,69	24,3	60,0	35,7	19,3	50,0	30,7	0,0	
18,96	26,5	60,0	33,5	20,9	50,0	29,1	0,0	
19,18	24,2	60,0	35,8	18,6	50,0	31,4	0,0	

Picture 7: Table1 - Conducted emission on mains, phase 1 (with termination 27 Ω)

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
19,75	26,3	60,0	33,7	20,6	50,0	29,4	0,0	
20,10	21,6	60,0	38,5	15,7	50,0	34,3	0,0	
20,76	26,8	60,0	33,2	21,4	50,0	28,6	0,0	
21,56	23,1	60,0	36,9	16,0	50,0	34,0	0,0	
21,76	21,1	60,0	38,9	16,1	50,0	33,9	0,0	

Picture 8: Table2 - Conducted emission on mains, phase 1 (with termination 27 Ω)



Picture 9: Graphic - Conducted emission on mains, neutral (with termination 27 Ω)

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	48,2	66,0	17,8	29,1	56,0	26,9	0,0	
0,19	43,4	64,3	20,8	22,6	54,3	31,6	0,0	
0,25	35,2	61,8	26,6	18,0	51,8	33,8	0,0	
0,28	30,9	60,7	29,8	17,7	50,7	33,0	0,0	
0,30	29,5	60,3	30,8	15,7	50,3	34,7	0,0	
0,31	28,5	60,1	31,5	18,7	50,1	31,3	0,0	
0,32	27,1	59,7	32,6	18,3	49,7	31,4	0,0	
0,36	27,7	58,8	31,2	23,4	48,8	25,4	0,0	
0,39	28,0	58,1	30,1	21,8	48,1	26,4	0,0	
0,44	25,1	57,0	31,9	20,1	47,0	27,0	0,0	
0,51	27,1	56,0	28,9	18,3	46,0	27,7	0,0	
0,60	25,8	56,0	30,2	24,2	46,0	21,8	0,0	
0,80	28,2	56,0	27,8	25,2	46,0	20,8	0,0	
1,00	25,2	56,0	30,8	20,7	46,0	25,3	0,0	
1,20	29,6	56,0	26,4	27,0	46,0	19,0	0,0	
1,56	28,9	56,0	27,1	18,9	46,0	27,1	0,0	
1,60	33,1	56,0	22,9	28,0	46,0	18,0	0,0	
1,73	30,4	56,0	25,6	17,1	46,0	28,9	0,0	
1,80	27,1	56,0	29,0	22,8	46,0	23,2	0,0	
1,99	32,7	56,0	23,4	25,7	46,0	20,3	0,0	
2,20	26,5	56,0	29,5	23,0	46,0	23,0	0,0	
2,60	26,6	56,0	29,4	23,4	46,0	22,6	0,0	
2,99	29,3	56,0	26,7	23,6	46,0	22,4	0,0	
3,33	26,6	56,0	29,4	14,0	46,0	32,0	0,0	
3,59	28,3	56,0	27,7	20,9	46,0	25,1	0,0	
4,00	25,1	56,0	30,9	18,6	46,0	27,5	0,0	
5,79	18,1	60,0	41,9	14,8	50,0	35,2	0,0	
8,93	24,3	60,0	35,7	20,7	50,0	29,3	0,0	
13,56	28,9	60,0	31,1	21,9	50,0	28,1	0,0	
14,00	28,1	60,0	31,9	20,1	50,0	30,0	0,0	
14,55	29,6	60,0	30,4	22,2	50,0	27,8	0,0	
15,18	30,2	60,0	29,8	24,3	50,0	25,7	0,0	
15,77	29,7	60,0	30,3	23,7	50,0	26,3	0,0	
17,77	29,3	60,0	30,7	23,1	50,0	26,9	0,0	
18,97	26,8	60,0	33,2	21,8	50,0	28,2	0,0	
19,37	27,2	60,0	32,8	20,5	50,0	29,5	0,0	
19,78	29,2	60,0	30,8	23,0	50,0	27,0	0,0	

Picture 10: Table - Conducted emission on mains, neutral (with termination 27 Ω)

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 8.9 and 8.10

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 **TESTHAUS** GmbH	E00354

5.2 Test instruments

	Description	Manufacturer	Inventory No.
☒	ESCI (OATS)	Rohde & Schwarz	E00552
☐	ESU 26	Rohde & Schwarz	W00002
☒	ESCI (CDC)	Rohde & Schwarz	E00001
☒	VULB 9163 (OATS)	Schwarzbeck	E00013
☒	VULB 9160 (CDC)	Schwarzbeck	E00011
☒	HFH2-Z2	Rohde & Schwarz	E00060
☒	Cable set CDC	Huber + Suhner	E00459, E00460
☒	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
☐	Cable set OATS 10 m	Huber + Suhner	E00453, E00455, E00458

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

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 [µV/m]	Field strength [dBµV/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 < 30 MHz

The test method for radiated emissions below 30 MHz refers to section 6.4 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The loop antenna is set in parallel with the antenna of the EUT.
4. The EMI receiver performs a scan from 9 kHz to 30 MHz with peak detector and measurement bandwidth set to 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above.
5. The turn table is rotated to 8 different positions (360° / 8).
6. The antenna is set in line with the antenna of the EUT and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS with 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz, where average detector applies.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The highest value for each frequency is recorded.

5.5 Test procedure < 1 GHz

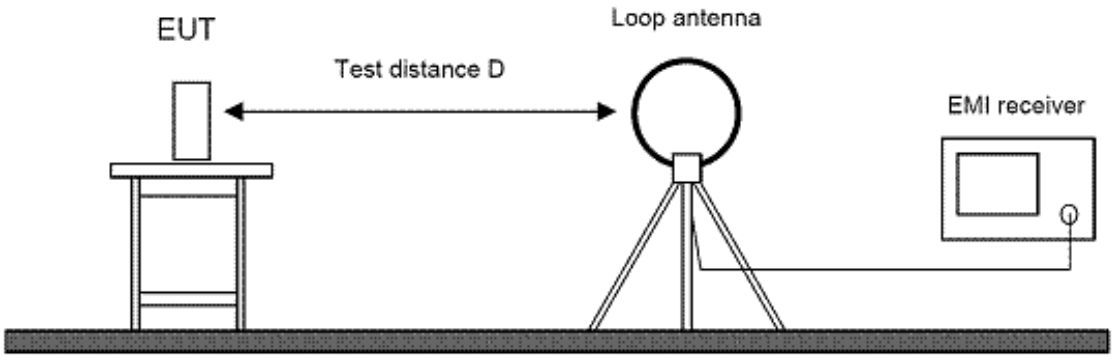
The test method for radiated emissions from 30 MHz to 1 GHz refers to section 6.5 of ANSI C63.10 and shall be as follows:

1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
2. EUT and all peripherals are powered on.
3. The broadband antenna is set to vertical polarization.
4. The EMI receiver performs a scan from 30 MHz to 1000 MHz with peak detector and measurement bandwidth set to 120 kHz.
5. The turn table is rotated to 6 different positions (360° / 6).
6. The antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
7. Then the test setup is placed in an OATS at 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector.
8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
9. The height of the broadband receiving antenna is varied between 1 meter and 4 meters above ground to find the maximum emission field strength of both horizontal and vertical polarization.
10. The highest value for each frequency is recorded.

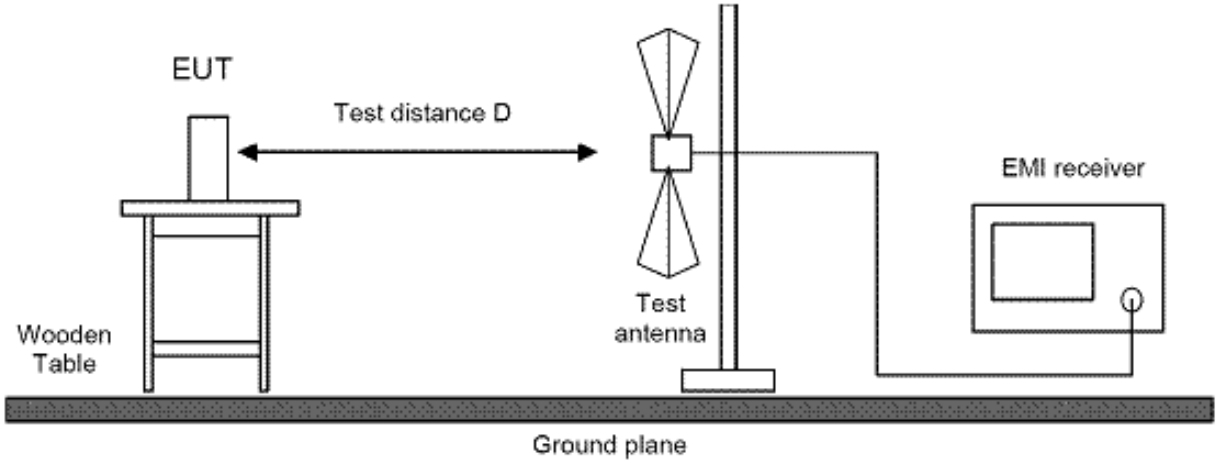
5.6 Test procedure “Spectrum mask”

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.

5.7 Test setup



Picture 11: Test setup for radiated emission measurement (< 30 MHz)



Picture 12: Test setup for radiated emission measurement (< 1 GHz)

5.8 Test deviation

There is no deviation from the standards referred to.

5.9 Test results “antenna 2010”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

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”:

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

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

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

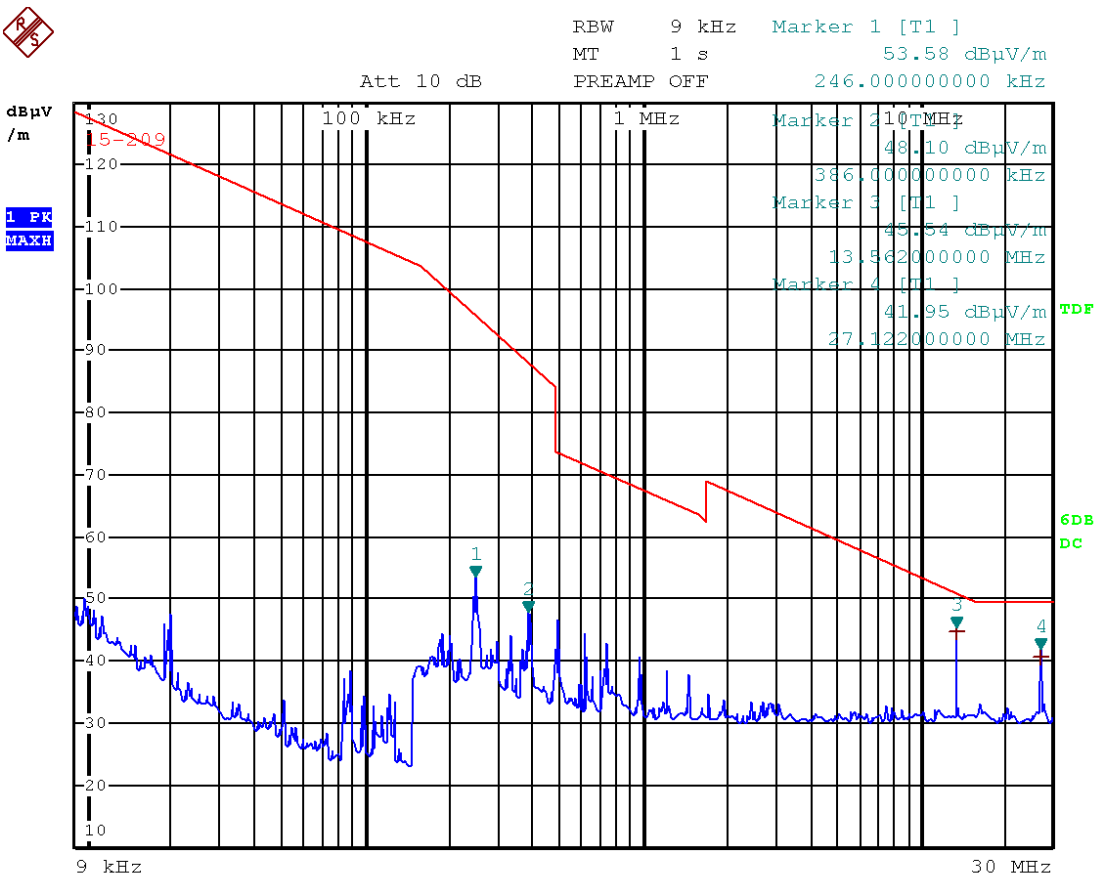
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = -40 log(d_{limit} / $d_{measure}$)
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
For f > 15.923 MHz:
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

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

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 13: Radiated emission 9 kHz – 30 MHz antenna 2010

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	44.68	QPK	-21.40	23.28	84.00	-60.72	Pass
27.122	40.69	QPK	-20.00	20.69	29.54	-8.85	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.562	3.523	3.000	30.000	-21.40

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

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

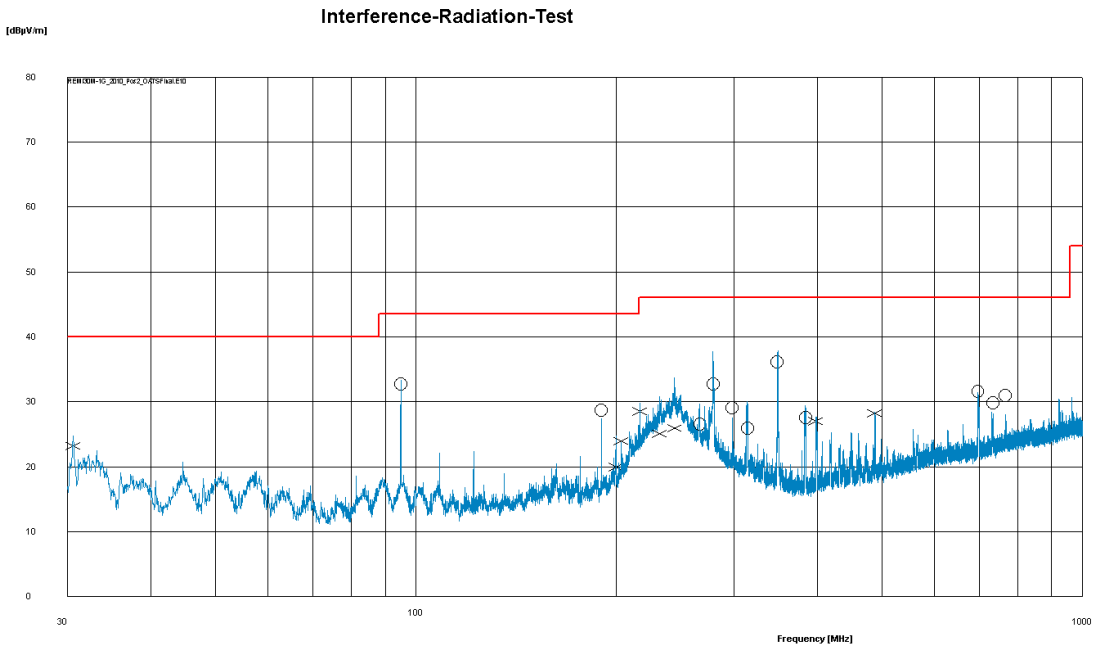
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
27.122	1.761	3.000	30.000	-20.00

Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Polari-sation*	*Step size*	*IF Band-width*	*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



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.20	40.00	100	1.3	V	Pass
94.92	32.76	43.52	100	348.6	H	Pass
189.84	28.77	43.52	100	350.9	H	Pass
199.74	19.95	43.52	100	161.5	V	Pass
203.40	23.94	43.52	100	245.9	V	Pass
216.96	28.51	46.02	100	106.1	V	Pass
231.96	25.02	46.02	100	48.7	V	Pass
244.56	25.94	46.02	100	129.4	V	Pass
266.58	26.55	46.02	100	75.1	H	Pass
279.18	32.69	46.02	100	82.3	H	Pass
298.32	29.12	46.02	100	88.3	H	Pass
314.82	25.96	46.02	100	98.0	H	Pass
348.54	36.19	46.02	100	245.6	H	Pass
384.84	27.52	46.02	100	263.7	H	Pass
398.34	27.00	46.02	100	166.7	V	Pass
487.92	28.19	46.02	100	11.2	V	Pass
696.96	31.62	46.02	100	40.5	H	Pass
734.70	29.82	46.02	100	358.3	H	Pass
766.74	30.95	46.02	100	347.8	H	Pass

Picture 14: Radiated emission 30 MHz - 1000MHz antenna 2010

Spectrum Mask

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

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

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

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

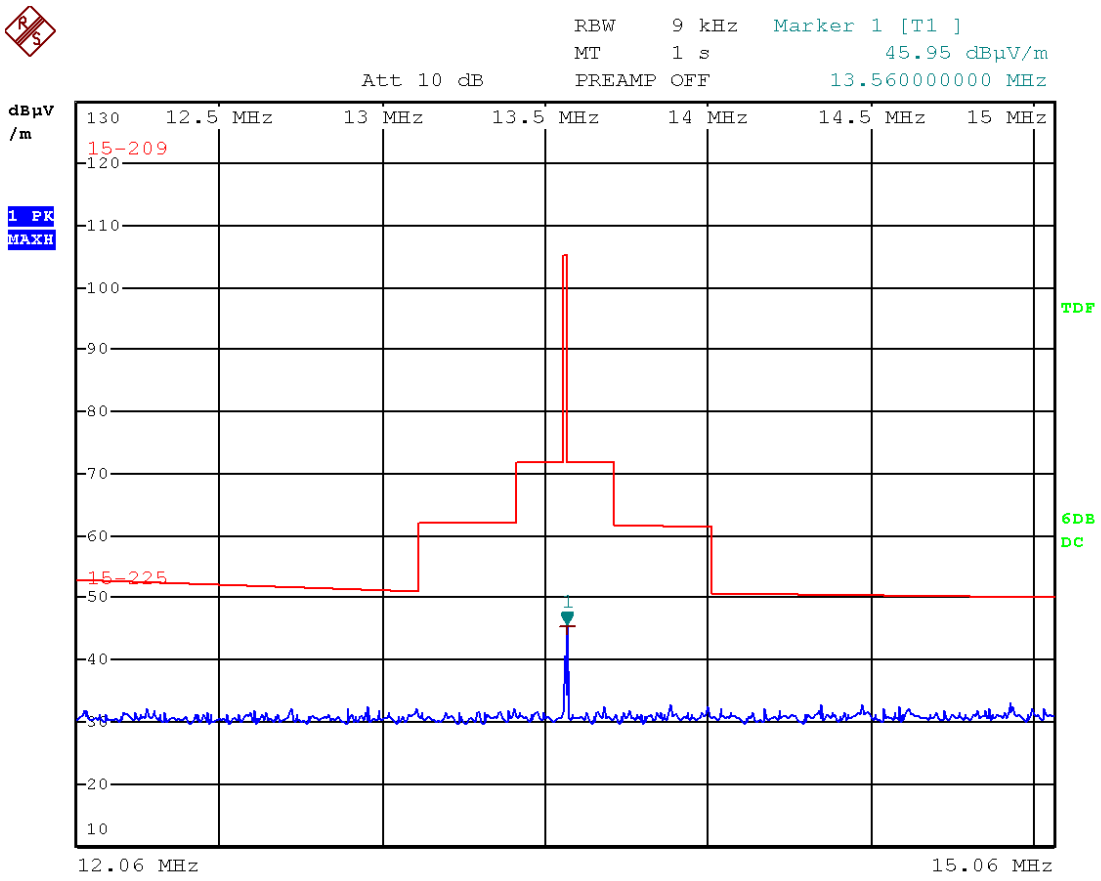
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

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

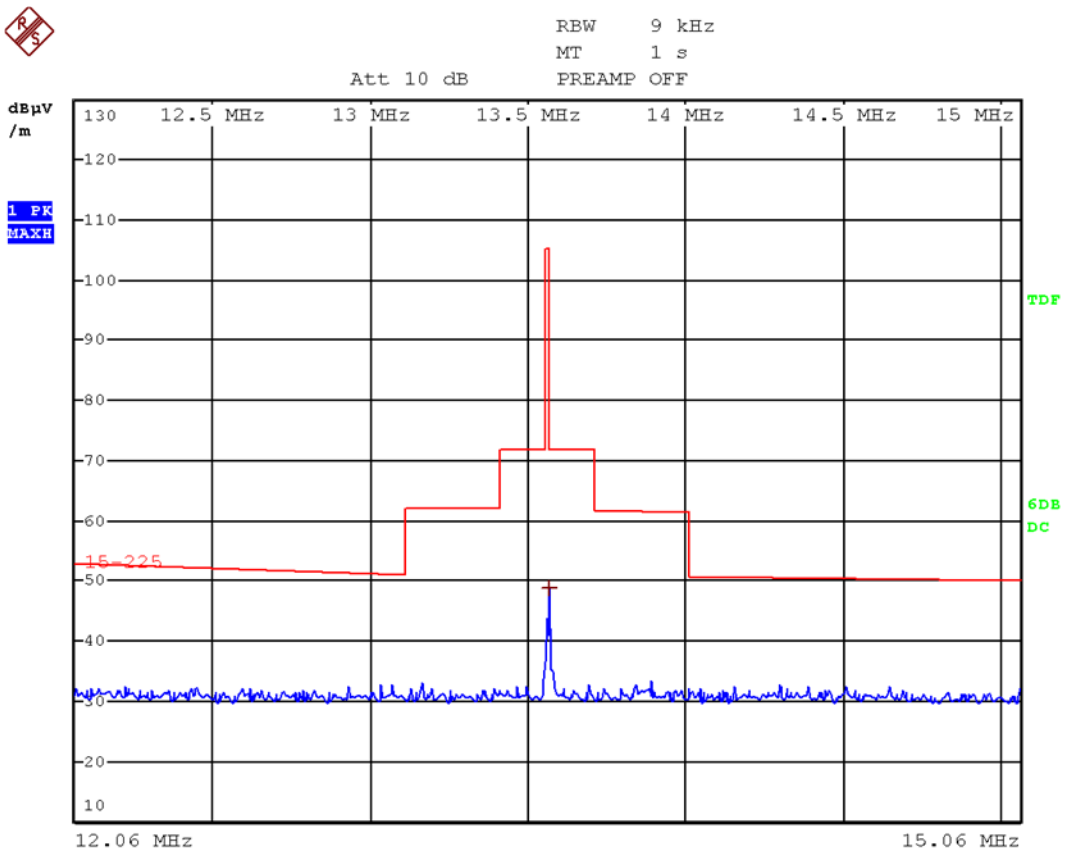
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

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



Picture 15: Spectrum mask for 13.56 MHz antenna 2010 (cable 200 cm)

Frequency [MHz]	**Measured value [dBµV/m]**	**Detector**	**Recalculation factor [dB]**	**Field strength [dBµV/m]**	**Limit [dBµV/m]**	**Margin [dB]**	**Result**
13.560	45.95	PK	-21.40	24.55	---	---	Pass
13.560	45.34	QPK	-21.40	23.94	84.00	-60.06	Pass



Picture 16: Spectrum mask for 13.56 MHz antenna 2010 (cable 10 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	48.98	PK	-21.40	27.58	---	---	Pass
13.560	48.94	QPK	-21.40	27.54	84.00	-56,46	Pass

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

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

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

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

5.10 Test results “antenna Jay”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

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”:

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

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

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

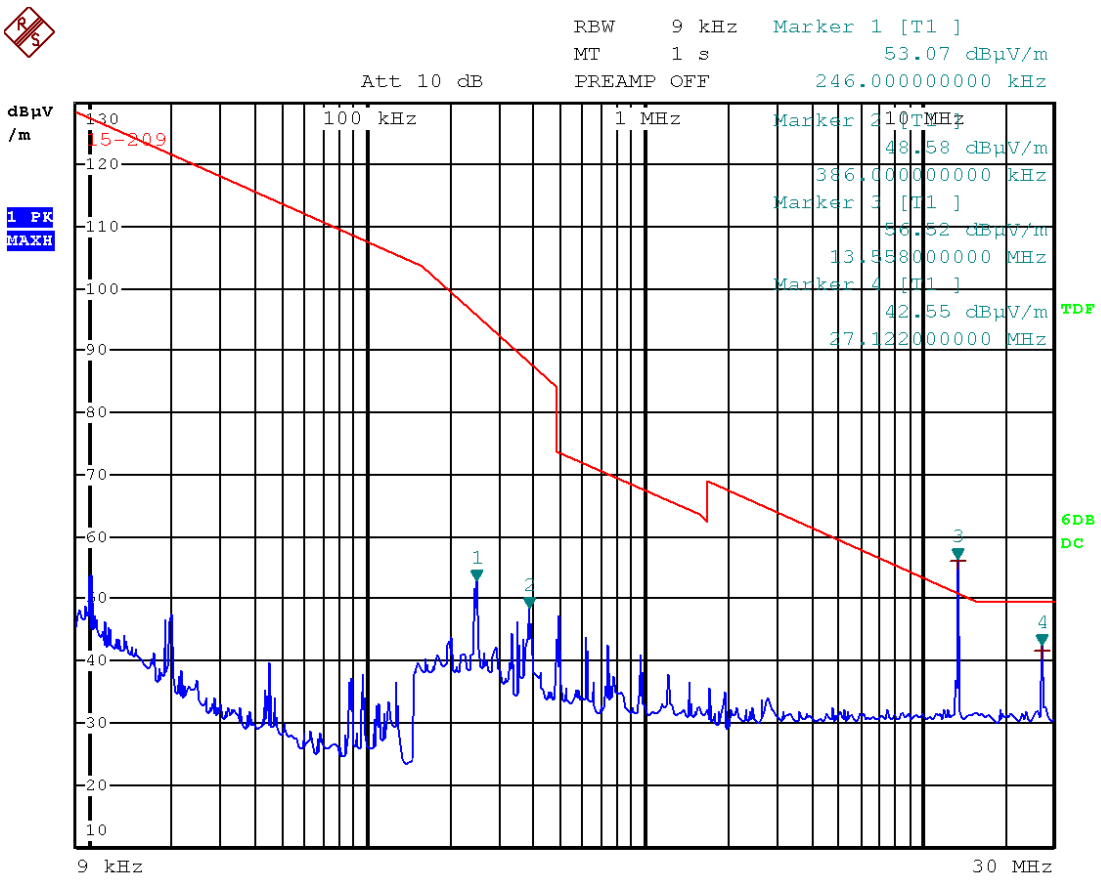
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

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

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 17: Radiated emission 9 kHz – 30 MHz antenna Jay

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.558	56.28	QPK	-21.40	34.88	84.00	-49.12	Pass
27.122	41.68	QPK	-20.00	21.68	29.54	-7.86	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.558	3.523	3.000	30.000	-21.40

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

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

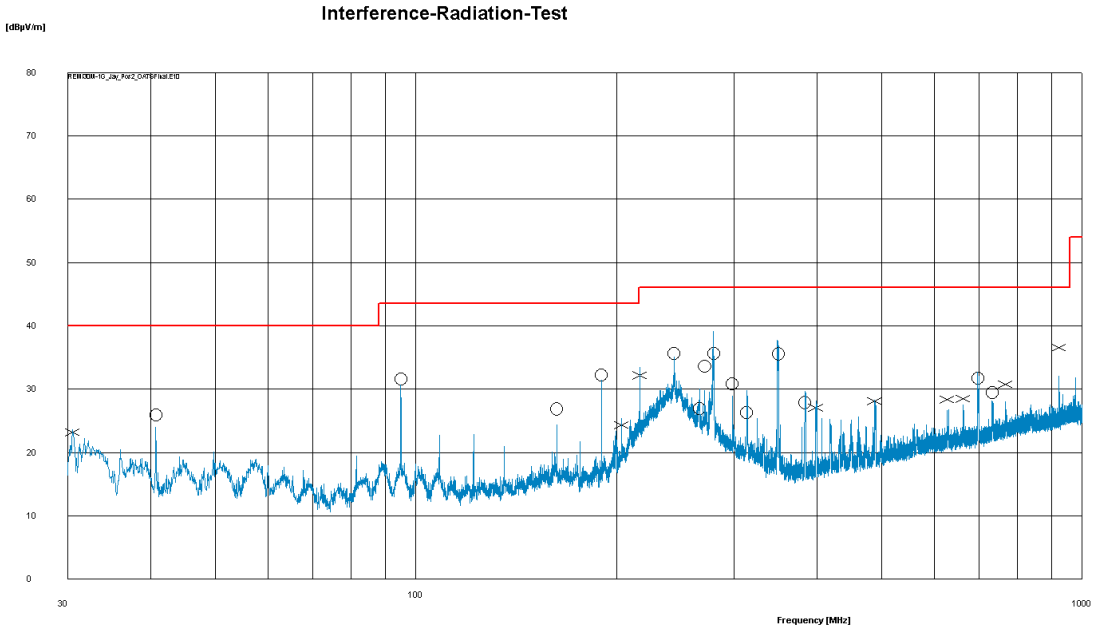
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
27.122	1.761	3.000	30.000	-20.00

Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Polari-sation*	*Step size*	*IF Band-width*	*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



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.54	23.14	40.00	100	3.4	V	Pass
40.68	25.96	40.00	100	340.7	H	Pass
94.92	31.61	43.52	100	358.6	H	Pass
162.72	26.88	43.52	100	135.1	H	Pass
189.84	32.28	43.52	100	358.7	H	Pass
203.40	24.30	43.52	100	238.1	V	Pass
216.96	32.18	46.02	100	113.8	V	Pass
244.08	35.65	46.02	100	17.4	H	Pass
266.58	26.98	46.02	100	74.6	H	Pass
271.20	33.60	46.02	100	17.5	H	Pass
279.60	35.63	46.02	100	89.9	H	Pass
298.32	30.90	46.02	100	16.9	H	Pass
313.68	26.34	46.02	100	98.5	H	Pass
349.86	35.59	46.02	100	246.0	H	Pass
383.40	27.90	46.02	100	256.5	H	Pass
398.34	27.12	46.02	100	175.3	V	Pass
487.92	28.05	46.02	100	0.2	V	Pass
627.30	28.33	46.02	100	72.1	V	Pass
662.10	28.51	46.02	100	98.2	V	Pass
696.96	31.78	46.02	100	40.6	H	Pass
732.36	29.42	46.02	100	358.6	H	Pass
766.62	30.70	46.02	100	277.8	V	Pass
922.14	36.52	46.02	100	129.8	V	Pass

Picture 18: Radiated emission 30 MHz - 1000MHz antenna Jay

Spectrum Mask

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

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

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

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

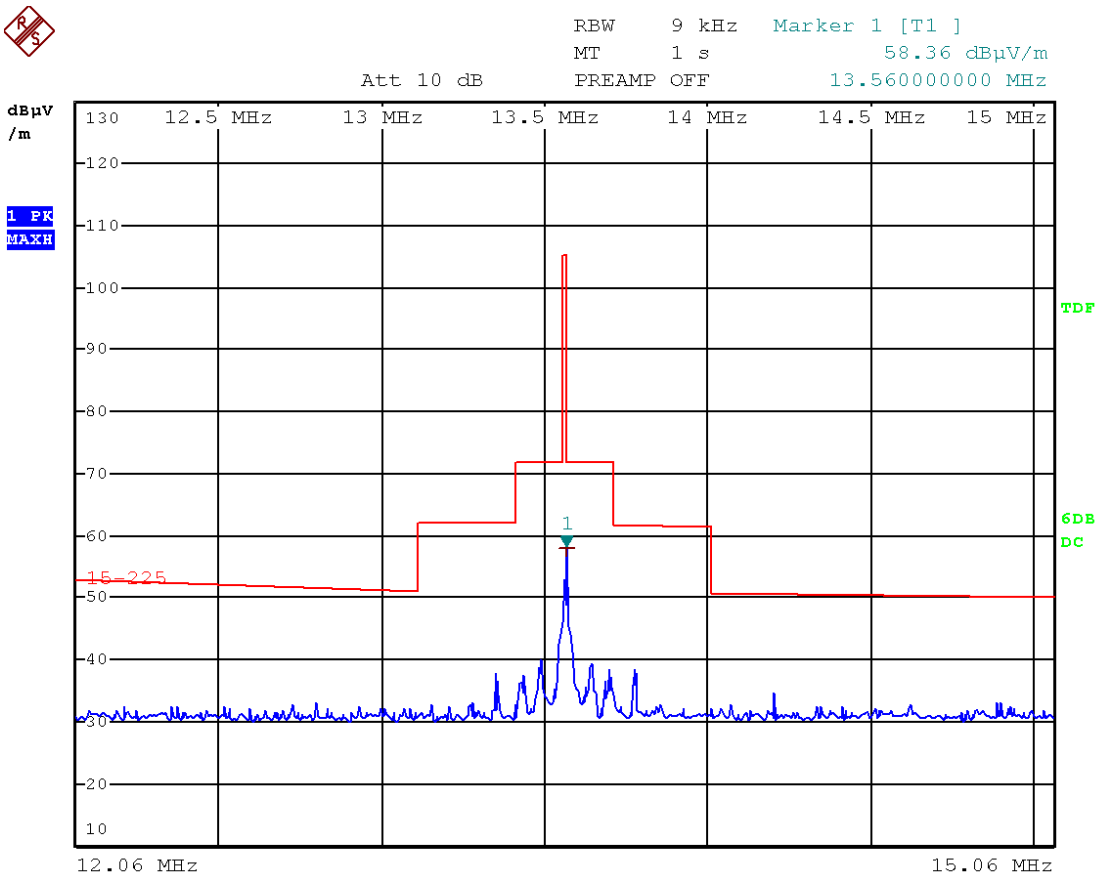
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

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

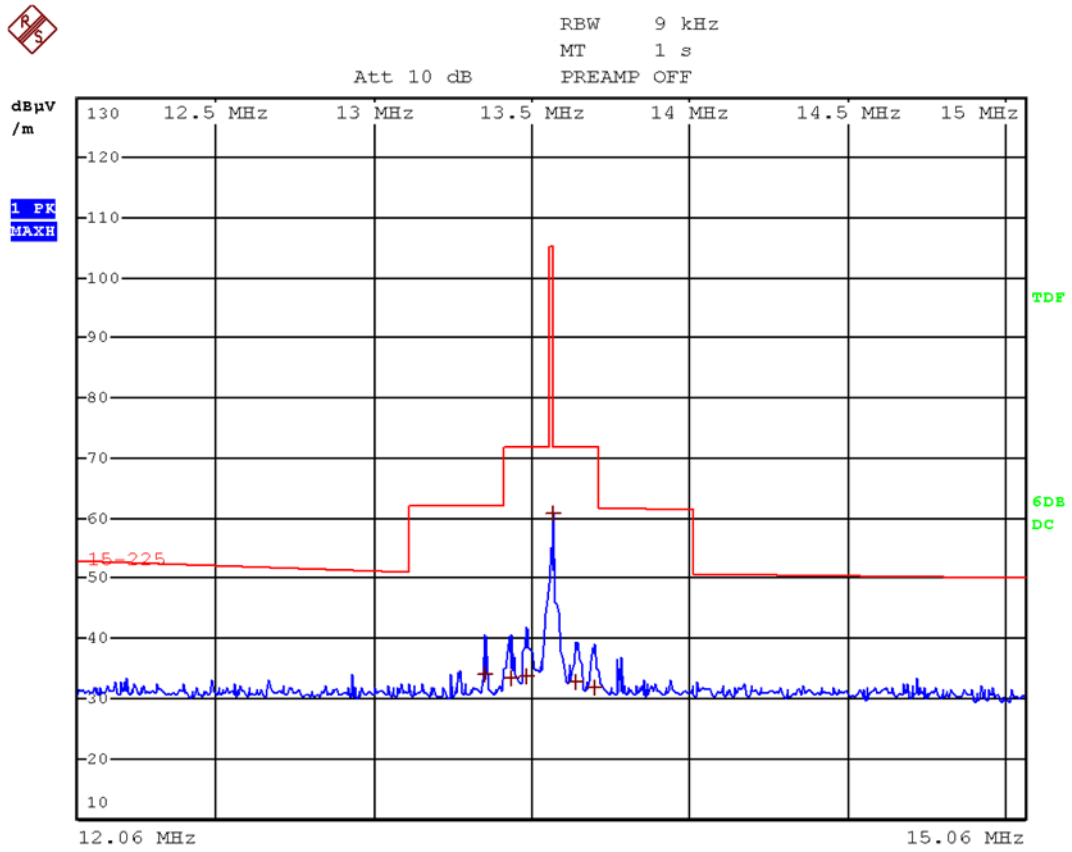
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 19: Spectrum mask for 13.56 MHz antenna Jay (cable 200 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	58.36	PK	-21.40	36.96	---	---	Pass
13.560	57.94	QPK	-21.40	36.54	84.00	-47.46	Pass



Picture 20: Spectrum mask for 13.56 MHz antenna Jay (cable 10 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	60,82	PK	-21.40	39,42	---	---	Pass
13.560	60,76	QPK	-21.40	39,36	84.00	-44.64	Pass

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

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

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

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

5.11 Test results “antenna 4040”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

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”:

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

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

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

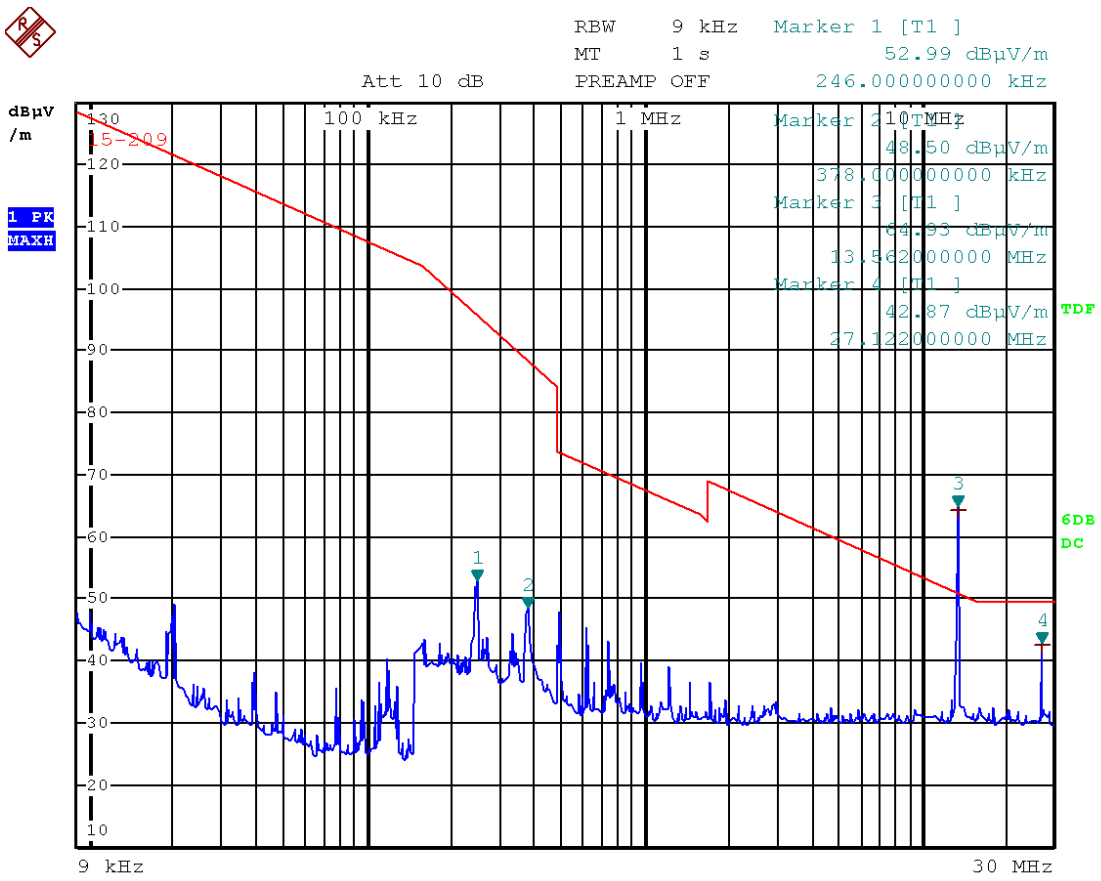
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = -40 log(d_{limit} / $d_{measure}$)
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
For f > 15.923 MHz:
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

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

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

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



Picture 21: Radiated emission 9 kHz – 30 MHz antenna 4040

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	64.38	QPK	-21.40	42.98	84.00	-41.02	Pass
27.122	42.62	QPK	-20.00	22.62	29.54	-6.92	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.562	3.523	3.000	30.000	-21.40

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

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

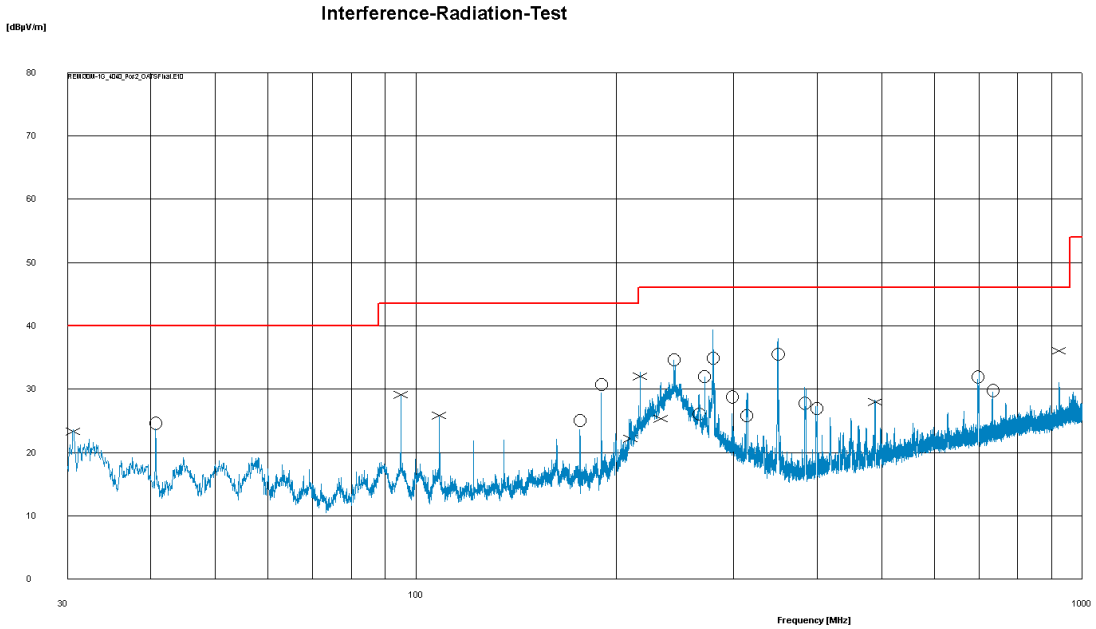
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
27.122	1.761	3.000	30.000	-20.00

Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Polari-sation*	*Step size*	*IF Band-width*	*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



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.32	40	100	1.8	V	Pass
40.68	24.61	40	100	353.9	H	Pass
94.92	29.11	43.52	100	256.0	V	Pass
108.48	25.85	43.52	100	238.4	V	Pass
176.28	25.06	43.52	100	11.2	H	Pass
189.84	30.75	43.52	100	340.1	H	Pass
210.00	22.21	43.52	100	74.3	V	Pass
216.96	31.94	46.02	100	96.3	V	Pass
233.10	25.30	46.02	100	59.1	V	Pass
244.08	34.63	46.02	100	34.5	H	Pass
266.34	26.05	46.02	100	72.3	H	Pass
271.20	32.03	46.02	100	27.1	H	Pass
279.12	34.87	46.02	100	72.8	H	Pass
298.32	28.79	46.02	100	97.8	H	Pass
313.68	25.77	46.02	100	88.4	H	Pass
349.86	35.49	46.02	100	264.0	H	Pass
383.34	27.78	46.02	100	246.2	H	Pass
399.84	26.93	46.02	100	263.5	H	Pass
489.84	27.98	46.02	100	356.1	V	Pass
697.02	31.93	46.02	100	40.7	H	Pass
734.70	29.80	46.02	100	0.1	H	Pass
922.14	36.04	46.02	100	130.0	V	Pass

Picture 22: Radiated emission 30 MHz - 1000MHz antenna 4040

Spectrum Mask

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

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

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

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

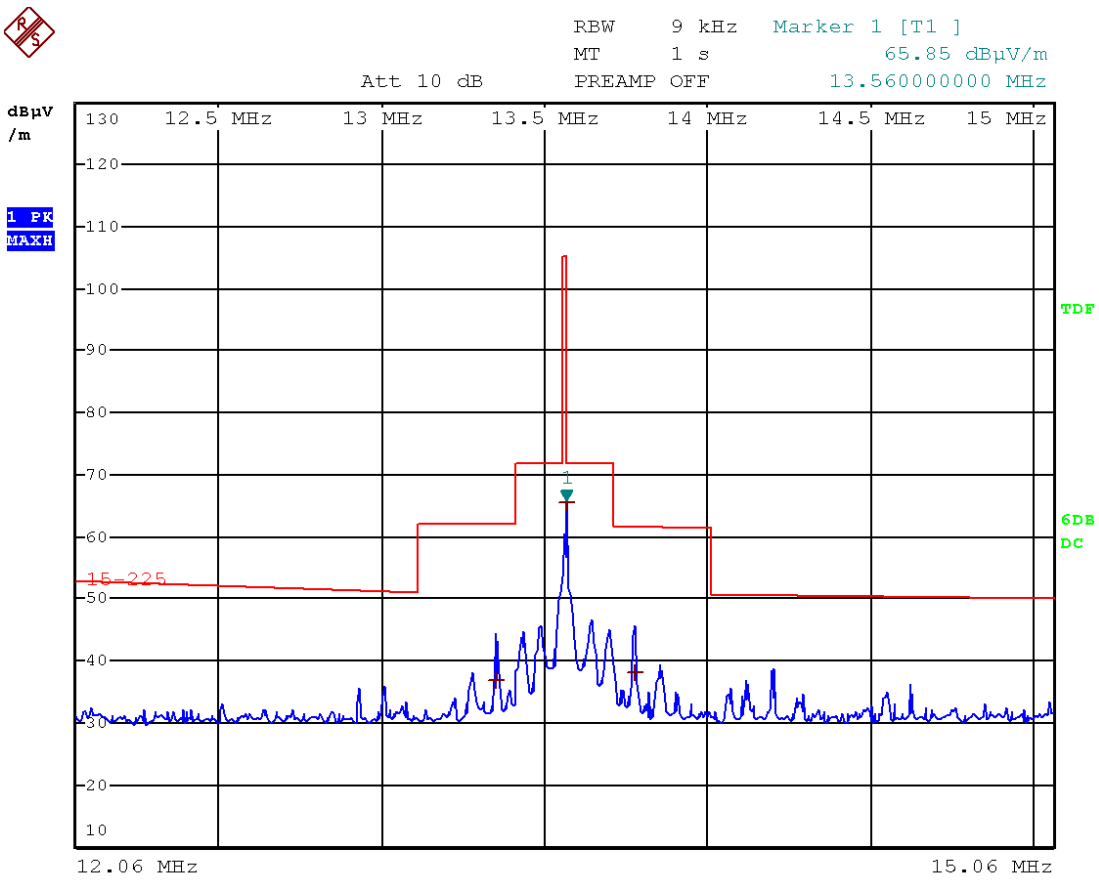
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

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

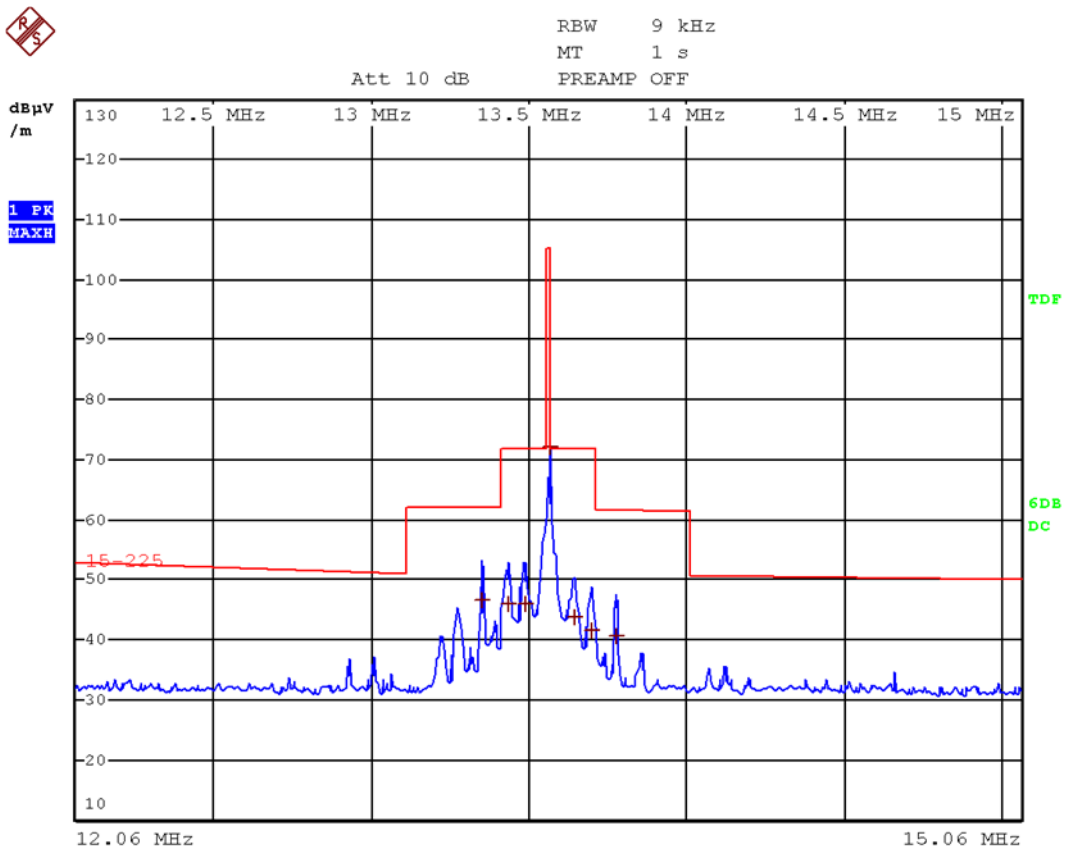
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 23: Spectrum mask for 13.56 MHz antenna 4040 (cable 200 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.348	36.97	QPK	-21.53	15.44	40.51	-25.07	Pass
13.560	65.85	PK	-21.40	44.45	---	---	Pass
13.560	65.60	QPK	-21.40	44.20	84.00	-39.80	Pass
13.772	38.28	QPK	-21.26	17.02	40.51	-23.49	Pass



Picture 24: Spectrum mask for 13.56 MHz antenna 4040 (cable 10 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	72,11	PK	-21.40	50,71	---	---	Pass
13.560	72,05	QPK	-21.40	50,65	84.00	-33.35	Pass

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.348	3.579	3.000	30.000	-21.53
13.560	3.523	3.000	30.000	-21.40
13.772	3.469	3.000	30.000	-21.26

5.12 Test results “antenna 7248”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

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”:

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

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

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

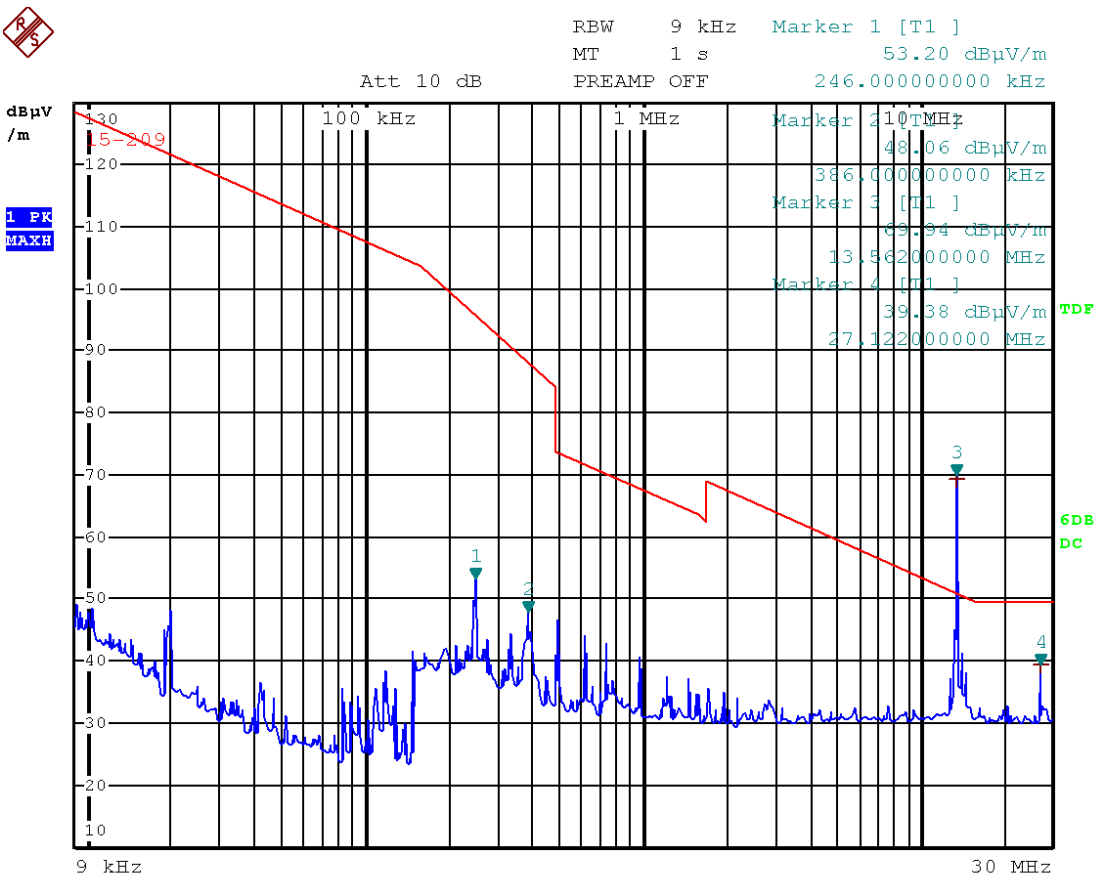
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = -40 log(d_{limit} / $d_{measure}$)
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
For f > 15.923 MHz:
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

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

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 25: Radiated emission 9 kHz – 30 MHz antenna 7248

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	69.38	QPK	-21.40	47.98	84.00	-36.02	Pass
27.122	39.32	QPK	-20.00	19.32	29.54	-10.22	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.562	3.523	3.000	30.000	-21.40

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

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

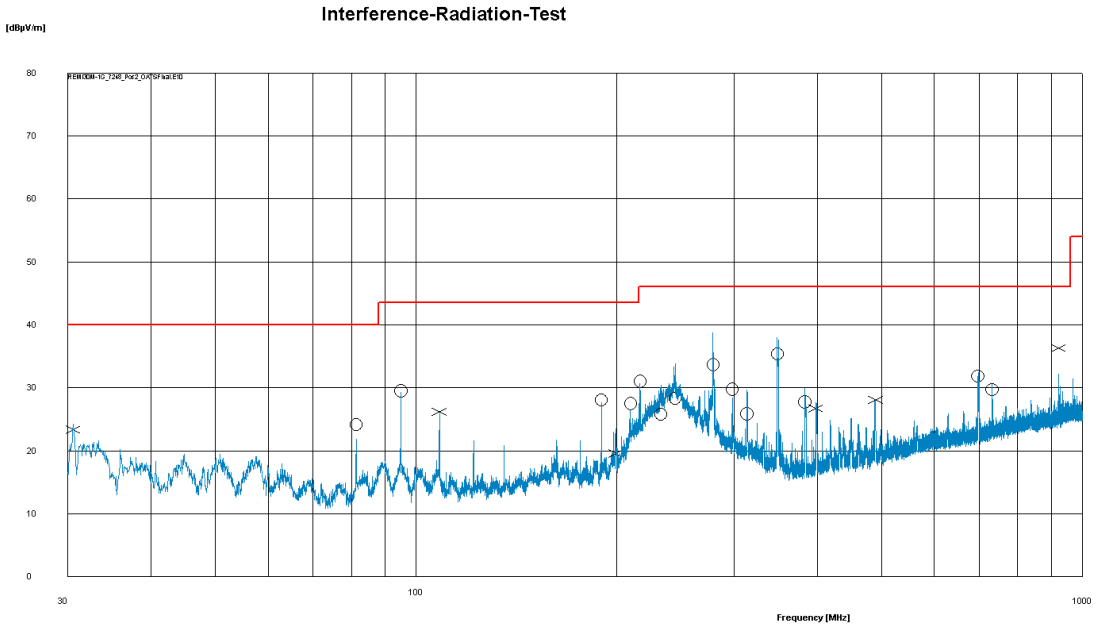
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
27.122	1.761	3.000	30.000	-20.00

Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Polari-sation*	*Step size*	*IF Band-width*	*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



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.35	40	100	356.5	V	Pass
81.36	24.17	40	100	340.5	H	Pass
94.92	29.55	43.52	100	0.1	H	Pass
108.48	26.18	43.52	100	240.3	V	Pass
189.84	28.10	43.52	100	1.5	H	Pass
199.62	19.57	43.52	100	222.5	V	Pass
209.88	27.53	43.52	100	82.7	H	Pass
216.96	31.03	46.02	100	9.1	H	Pass
233.22	25.77	46.02	100	67.0	H	Pass
244.92	28.35	46.02	100	48.9	H	Pass
279.12	33.70	46.02	100	82.5	H	Pass
298.32	29.79	46.02	100	174.6	H	Pass
313.68	25.89	46.02	100	98.3	H	Pass
348.54	35.41	46.02	100	246.3	H	Pass
383.34	27.76	46.02	100	263.7	H	Pass
398.34	26.68	46.02	100	184.7	V	Pass
489.84	28.13	46.02	100	356.2	V	Pass
696.96	31.89	46.02	100	40.5	H	Pass
731.88	29.75	46.02	100	358.7	H	Pass
922.14	36.29	46.02	100	129.9	V	Pass

Picture 26: Radiated emission 30 MHz - 1000MHz antenna 7248

Spectrum Mask

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

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

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

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

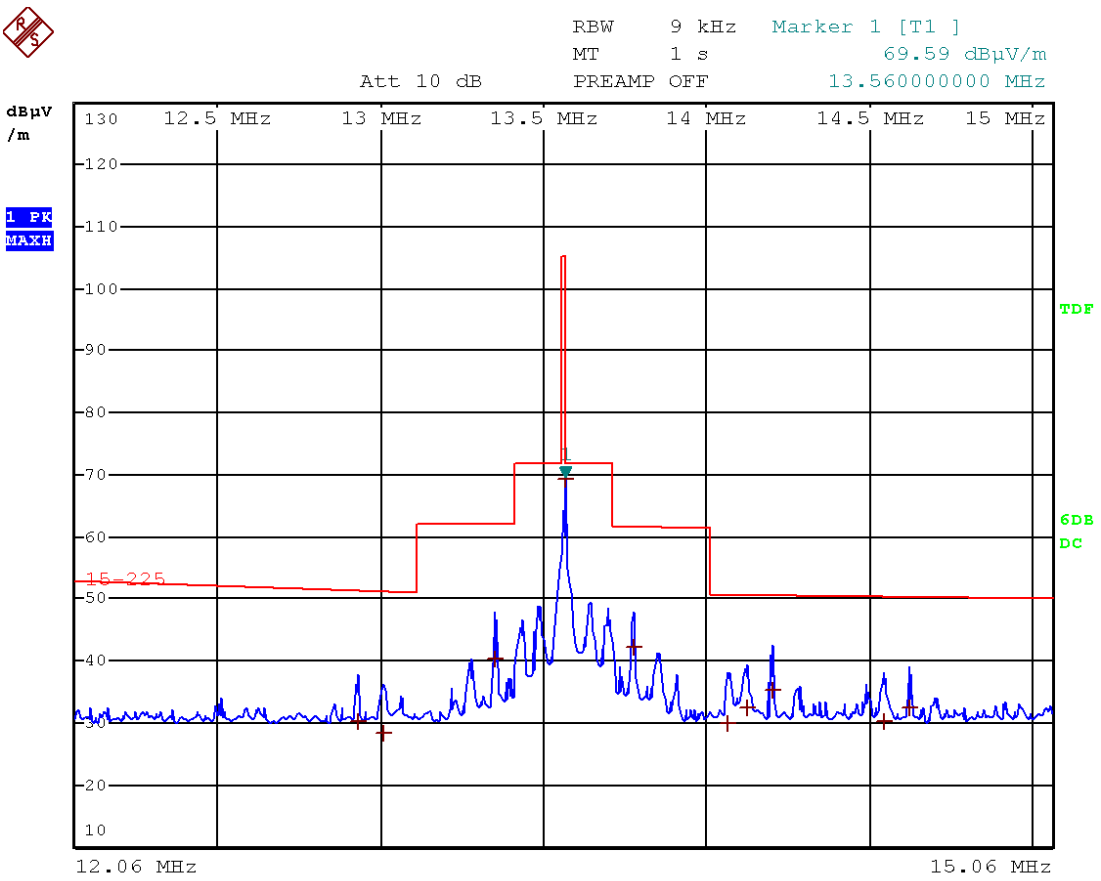
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = $-40 \log(d_{limit} / d_{measure})$
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = $-40 \log(d_{near\ field} / d_{measure}) - 20 \log(d_{limit} / d_{near\ field})$
For f > 15.923 MHz:
Recalculation factor = $-20 \log(d_{limit} / d_{measure})$

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

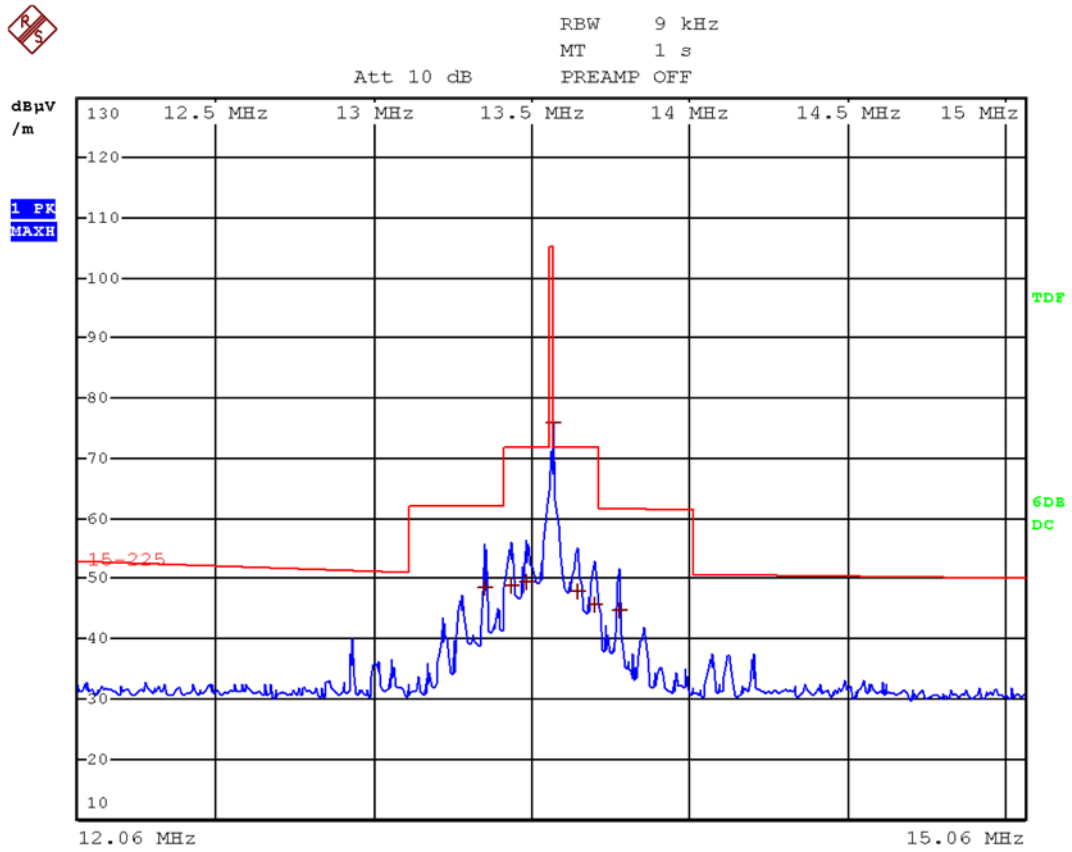
Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

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



Picture 27: Spectrum mask for 13.56 MHz antenna 7248 (cable 200 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
12.928	30.16	QPK	-21.81	8.35	29.54	-21.19	Pass
13.004	28.53	QPK	-21.76	6.77	29.54	-22.77	Pass
13.348	40.52	QPK	-21.53	18.99	40.51	-21.52	Pass
13.560	69.59	PK	-21.40	48.19	---	---	Pass
13.560	69.40	QPK	-21.40	48.00	84.00	-36.00	Pass
13.772	42.16	QPK	-21.26	20.90	40.51	-19.61	Pass
14.060	29.86	QPK	-21.08	8.78	29.54	-20.76	Pass
14.120	32.38	QPK	-21.04	11.34	29.54	-18.20	Pass
14.196	35.40	QPK	-21.00	14.40	29.54	-15.14	Pass
14.540	30.27	QPK	-20.79	9.48	29.54	-20.06	Pass
14.620	32.54	QPK	-20.74	11.80	29.54	-17.74	Pass



Picture 28: Spectrum mask for 13.56 MHz antenna 7248 (cable 10 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	75,93	PK	-21.40	54,53	---	---	Pass
13.560	75,90	QPK	-21.40	54,50	84.00	-29,5	Pass

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
12.928	3.695	3.000	30.000	-21.81
13.004	3.673	3.000	30.000	-21.76
13.348	3.579	3.000	30.000	-21.53
13.560	3.523	3.000	30.000	-21.40
13.772	3.469	3.000	30.000	-21.26
14.060	3.398	3.000	30.000	-21.08
14.120	3.383	3.000	30.000	-21.04
14.196	3.365	3.000	30.000	-21.00
14.540	3.285	3.000	30.000	-20.79
14.620	3.267	3.000	30.000	-20.74

5.13 Test results “antenna-switching-mode”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

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”:

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

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

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

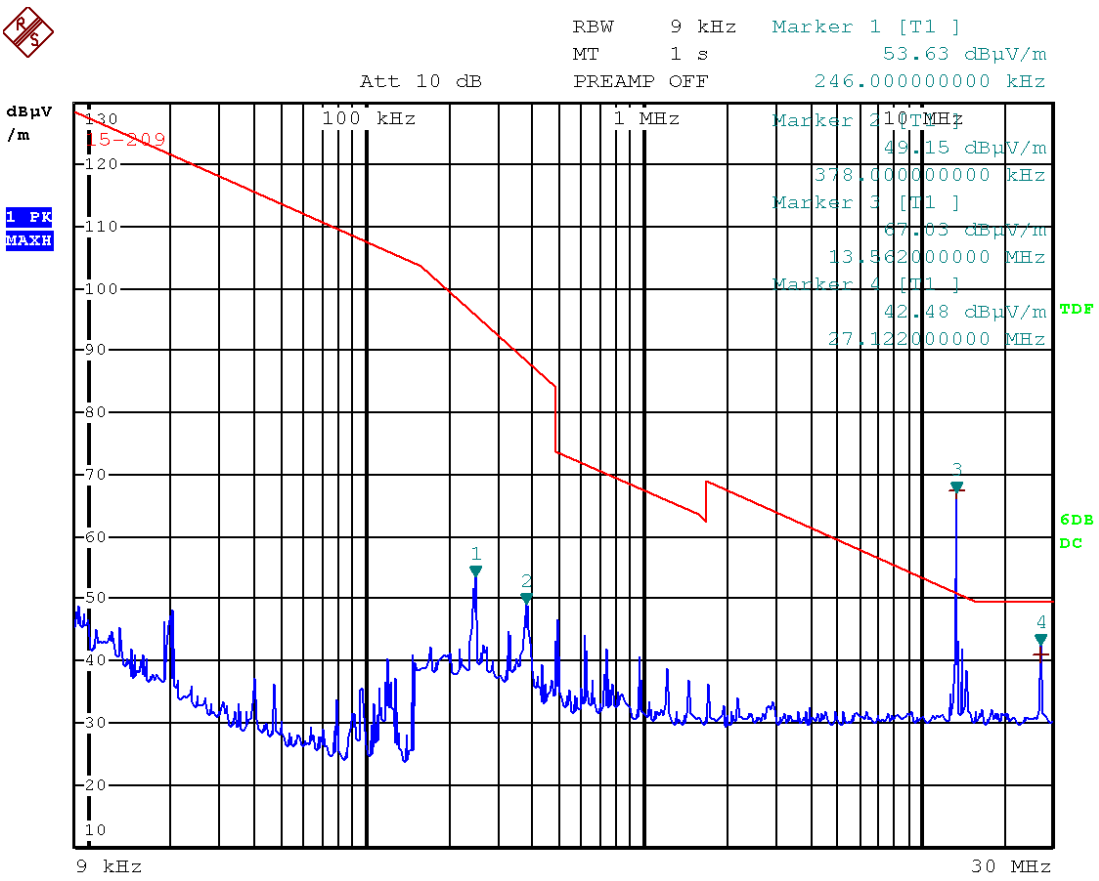
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

For 9 kHz ≤ f ≤ 159 kHz and 490 kHz < f ≤ 1.592 MHz:
Recalculation factor = -40 log(d_{limit} / $d_{measure}$)
For 159 kHz < f ≤ 490 kHz and 1.592 MHz < f ≤ 15.923 MHz:
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
For f > 15.923 MHz:
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

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

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☐ parallel	☒ in line	☐ angle: ….°	
EUT Position:	☒ Position 1	☐ Position 2	☐ Position 3	

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



Picture 29: Radiated emission 9 kHz – 30 MHz antenna-switching-mode

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	67.47	QPK	-21.40	46.07	84.00	-37.93	Pass
27.122	40.99	QPK	-20.00	20.99	29.54	-8.55	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).

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

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

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

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.562	3.523	3.000	30.000	-21.40

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

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

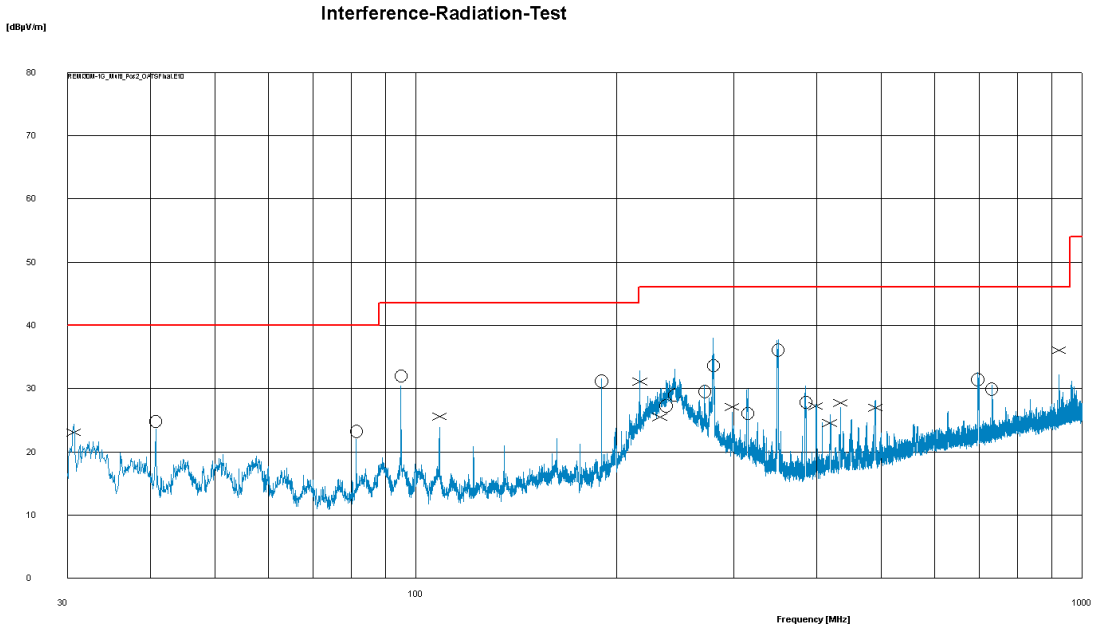
Recalculation factor = -20 log(d_{limit} / $d_{measure}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
27.122	1.761	3.000	30.000	-20.00

Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan:	☒ 3 m		
	Final scan:	☒ 3 m	☐ 10 m	☐ ….. m
Polarisation:	☒ horizontal	☒ vertical		
EUT Position:	☐ Position 1	☒ Position 2	☐ Position 3	

Frequency range	*Polari-sation*	*Step size*	*IF Band-width*	*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



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.66	23.04	40.00	100	357.4	V	Pass
40.68	24.83	40.00	100	135.6	H	Pass
81.36	23.23	40.00	100	358.7	H	Pass
94.92	31.99	43.52	100	348.5	H	Pass
108.48	25.53	43.52	100	240.4	V	Pass
189.84	31.19	43.52	100	358.6	H	Pass
216.96	31.10	46.02	100	95.9	V	Pass
232.62	25.49	46.02	100	129.9	V	Pass
237.48	27.26	46.02	100	56.9	H	Pass
244.38	28.95	46.02	100	74.7	H	Pass
271.26	29.53	46.02	100	17.0	H	Pass
279.48	33.67	46.02	100	64.2	H	Pass
298.32	27.08	46.02	100	324.5	V	Pass
314.82	26.04	46.02	100	98.4	H	Pass
349.86	36.11	46.02	100	245.5	H	Pass
384.84	27.865	46.02	100	263.6	H	Pass
398.34	27.23	46.02	100	177.3	V	Pass
418.14	24.60	46.02	100	158.9	V	Pass
433.92	27.71	46.02	100	59.3	V	Pass
489.90	26.91	46.02	100	1.3	V	Pass
696.96	31.41	46.02	100	359.9	H	Pass
731.82	29.89	46.02	100	0.0	H	Pass
922.14	36.07	46.02	100	130.2	V	Pass

Picture 30: Radiated emission 30 MHz - 1000MHz antenna-switching-mode

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).

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.
☐	Climatic chamber VC 4100	Vötsch Industrietechnik	C00014
☒	Climatic chamber VC³ 4034	Vötsch Industrietechnik	C00015

7.2 Test instruments

	Description	Manufacturer	Inventory No.
☐	ESU 26	Rohde & Schwarz	W00002
☒	ESCI 3	Rohde & Schwarz	E00552
☒	RF-R 400-1	Langer EMV-Technik	E00270

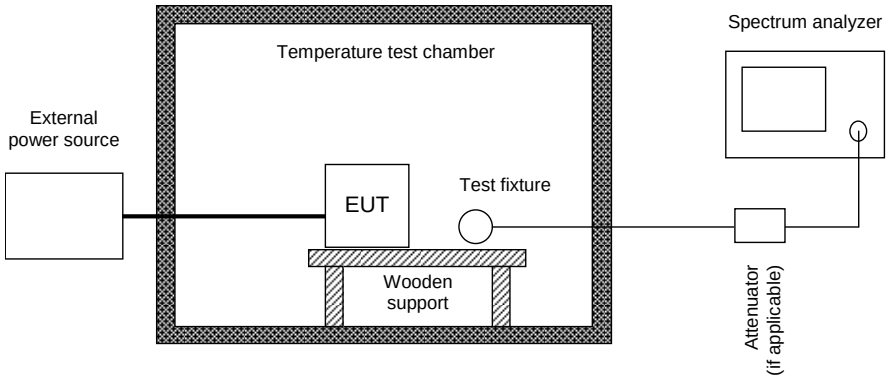
7.3 Limits

The frequency tolerance of the carrier signal shall be maintained within ±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.

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 31: Test setup for carrier frequency stability measurement

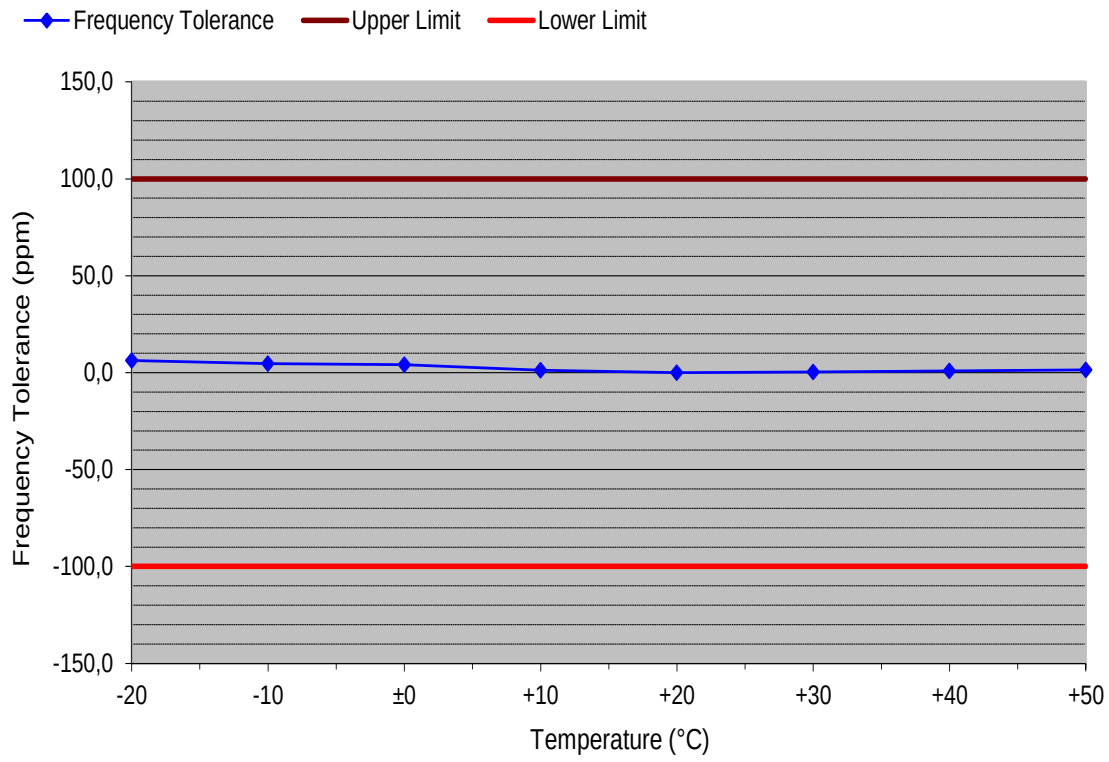
7.6 Test deviation

There is no deviation from the standards referred to.

7.7 Test results “antenna 2010”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-29

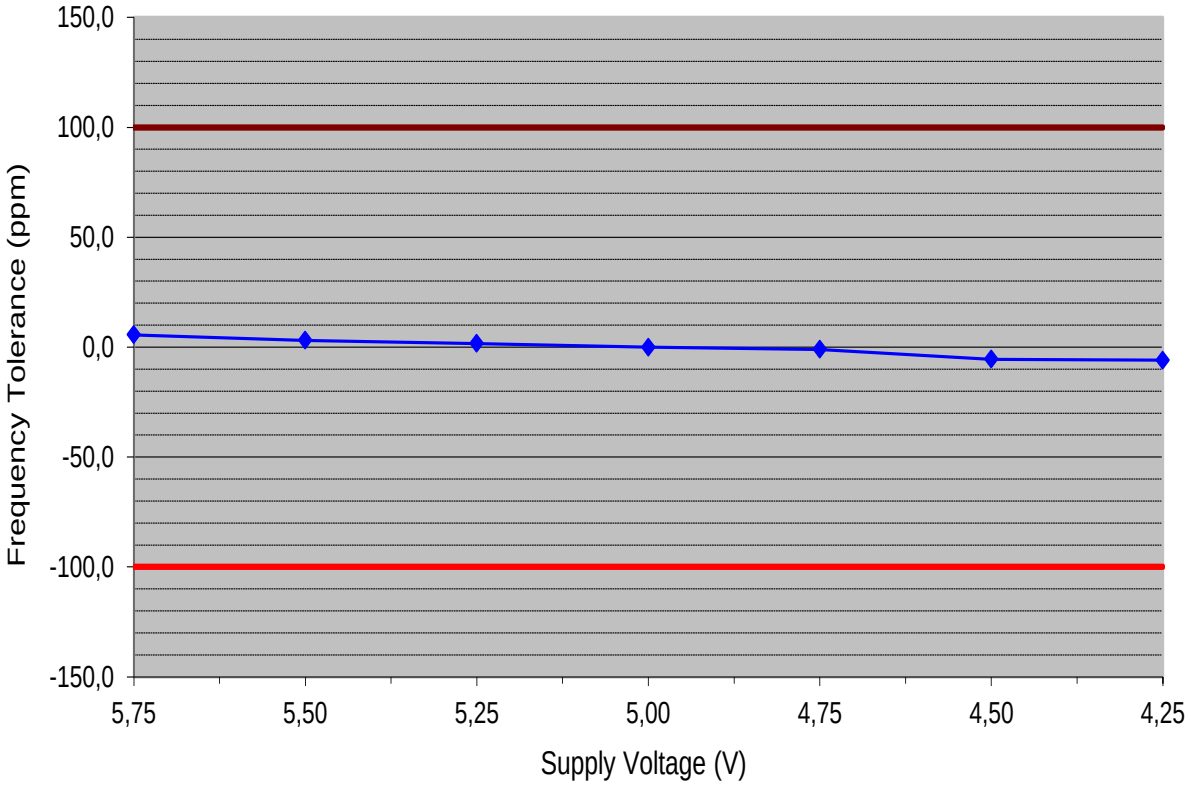
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,560637 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560721	84	6,2	+100,0	-100,0	**93,8**
-10	13,560700	63	4,6	+100,0	-100,0	95,4
±0	13,560692	55	4,1	+100,0	-100,0	95,9
+10	13,560654	17	1,3	+100,0	-100,0	98,7
+20	13,560637	0	0,0	+100,0	-100,0	100,0
+30	13,560641	4	0,3	+100,0	-100,0	99,7
+40	13,560648	11	0,8	+100,0	-100,0	99,2
+50	13,560656	19	1,4	+100,0	-100,0	98,6
+60	13,560674	37	2,7	+100,0	-100,0	97,3
+70	13,560698	61	4,5	+100,0	-100,0	95,5
+80	13,560663	26	1,9	+100,0	-100,0	98,1
+85	13,560709	72	5,3	+100,0	-100,0	94,7

Carrier frequency stability vs. supply voltage



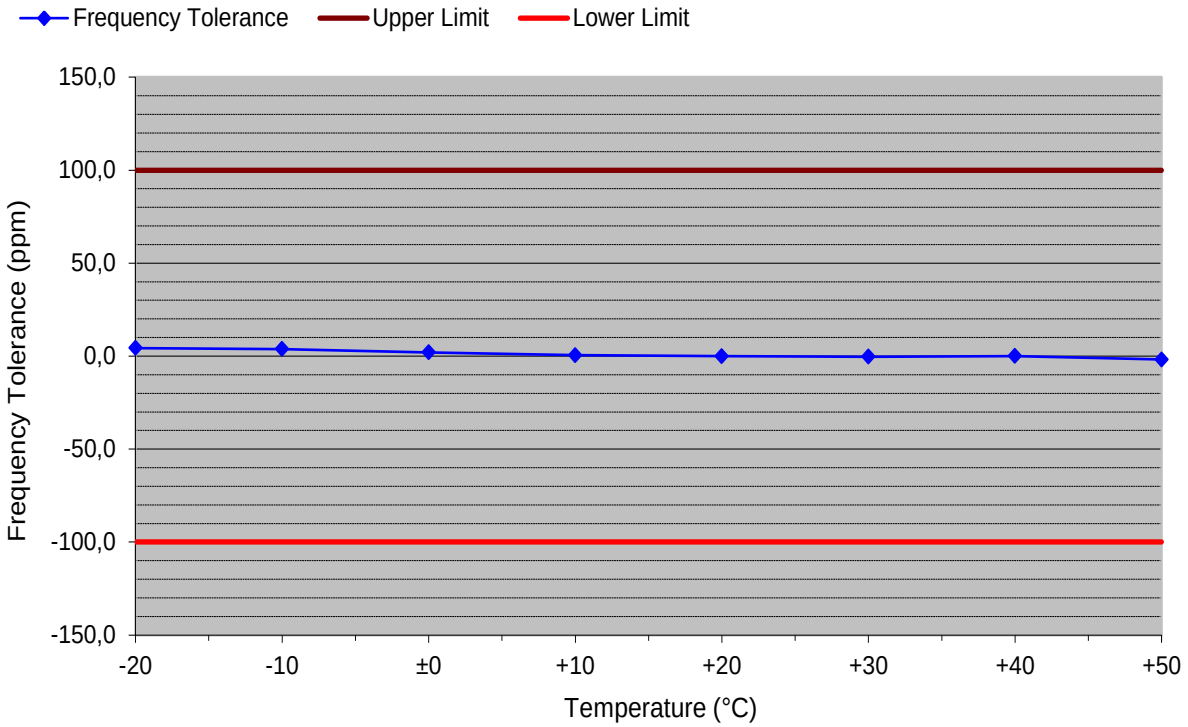
Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,560637 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
5,75	13,560713	76	5,6	+100,0	-100,0	94,4
5,50	13,560679	42	3,1	+100,0	-100,0	96,9
5,25	13,560659	22	1,6	+100,0	-100,0	98,4
5,00	13,560637	0	0,0	+100,0	-100,0	100,0
4,75	13,560623	-14	-1,0	+100,0	-100,0	99,0
4,50	13,560562	-75	-5,5	+100,0	-100,0	94,5
4,25	13,560556	-81	-6,0	+100,0	-100,0	**94,0**

7.8 Test results “antenna Jay”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-29

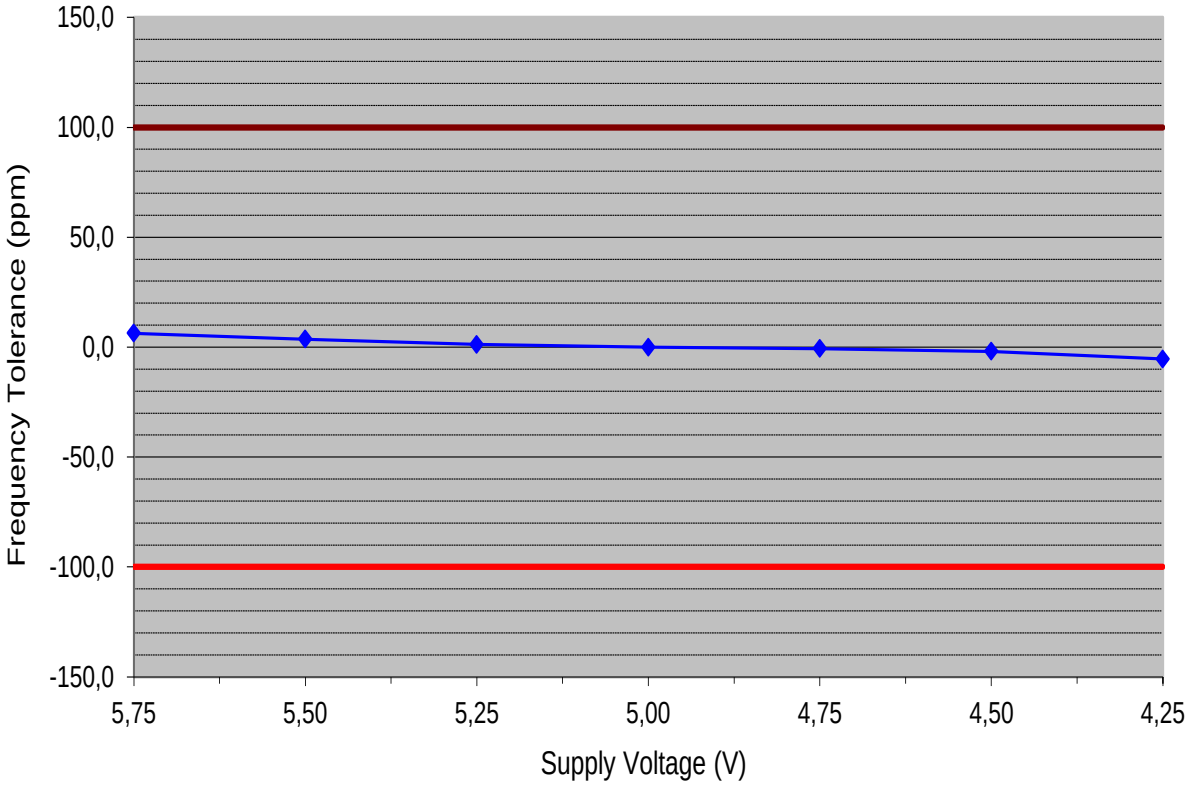
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,560647 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560706	59	4,4	+100,0	-100,0	**95,6**
-10	13,560698	51	3,8	+100,0	-100,0	96,2
±0	13,560674	27	2,0	+100,0	-100,0	98,0
+10	13,560654	7	0,5	+100,0	-100,0	99,5
+20	13,560647	0	0,0	+100,0	-100,0	100,0
+30	13,560643	-4	-0,3	+100,0	-100,0	99,7
+40	13,560648	1	0,1	+100,0	-100,0	99,9
+50	13,560622	-25	-1,8	+100,0	-100,0	98,2
+60	13,560615	-32	-2,4	+100,0	-100,0	97,6
+70	13,560621	-26	-1,9	+100,0	-100,0	98,1
+80	13,560668	21	1,5	+100,0	-100,0	98,5
+85	13,560713	66	4,9	+100,0	-100,0	95,1

Carrier frequency stability vs. supply voltage



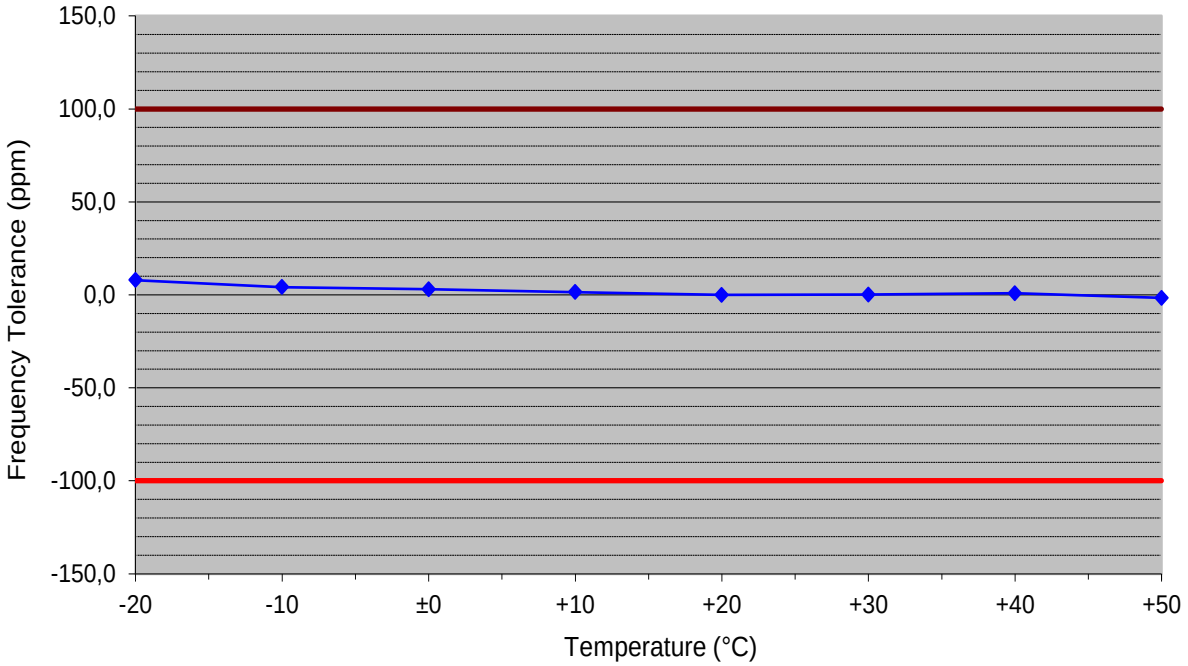
Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,560626 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
5,75	13,560711	85	6,3	+100,0	-100,0	**93,7**
5,50	13,560675	49	3,6	+100,0	-100,0	96,4
5,25	13,560642	16	1,2	+100,0	-100,0	98,8
5,00	13,560626	0	0,0	+100,0	-100,0	100,0
4,75	13,560617	-9	-0,7	+100,0	-100,0	99,3
4,50	13,560600	-26	-1,9	+100,0	-100,0	98,1
4,25	13,560553	-73	-5,4	+100,0	-100,0	94,6

7.9 Test results “antenna 4040”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-29

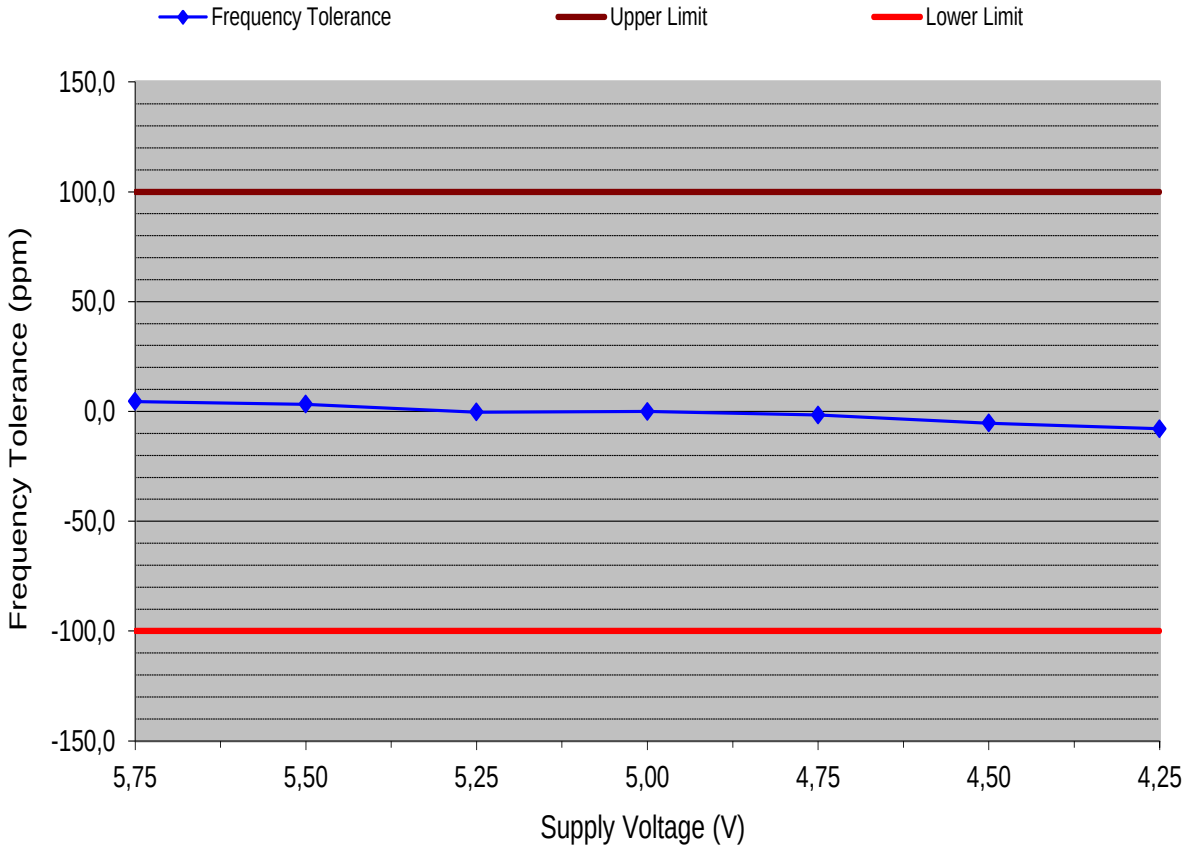
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,560652 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	(ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560759	107	7,9	+100,0	-100,0	**92,1**
-10	13,560708	56	4,1	+100,0	-100,0	95,9
±0	13,560693	41	3,0	+100,0	-100,0	97,0
+10	13,560672	20	1,5	+100,0	-100,0	98,5
+20	13,560652	0	0,0	+100,0	-100,0	100,0
+30	13,560654	2	0,1	+100,0	-100,0	99,9
+40	13,560664	12	0,9	+100,0	-100,0	99,1
+50	13,560630	-22	-1,6	+100,0	-100,0	98,4
+60	13,560605	-47	-3,5	+100,0	-100,0	96,5
+70	13,560617	-35	-2,6	+100,0	-100,0	97,4
+80	13,560640	-12	-0,9	+100,0	-100,0	99,1
+85	13,560678	26	1,9	+100,0	-100,0	98,1

Carrier frequency stability vs. supply voltage



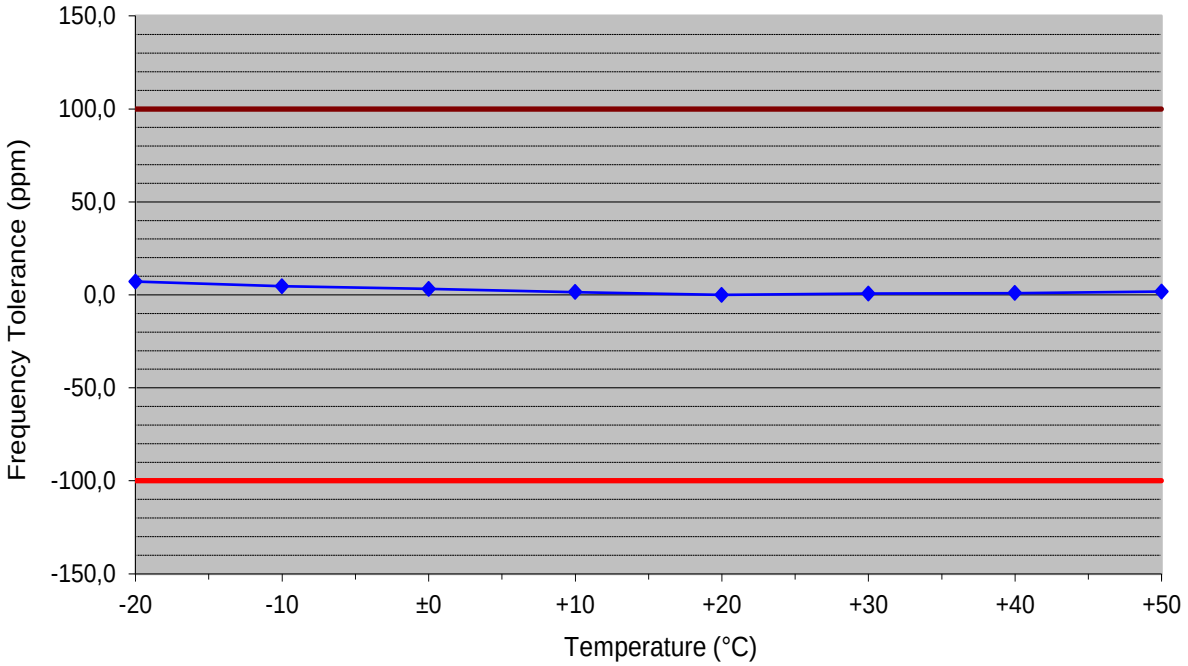
Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,560652 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
5,75	13,560713	61	4,5	+100,0	-100,0	95,5
5,50	13,560696	44	3,2	+100,0	-100,0	96,8
5,25	13,560648	-4	-0,3	+100,0	-100,0	99,7
5,00	13,560652	0	0,0	+100,0	-100,0	100,0
4,75	13,560629	-23	-1,7	+100,0	-100,0	98,3
4,50	13,560580	-72	-5,3	+100,0	-100,0	94,7
4,25	13,560545	-107	-7,9	+100,0	-100,0	**92,1**

7.10 Test results “antenna 7248”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-29

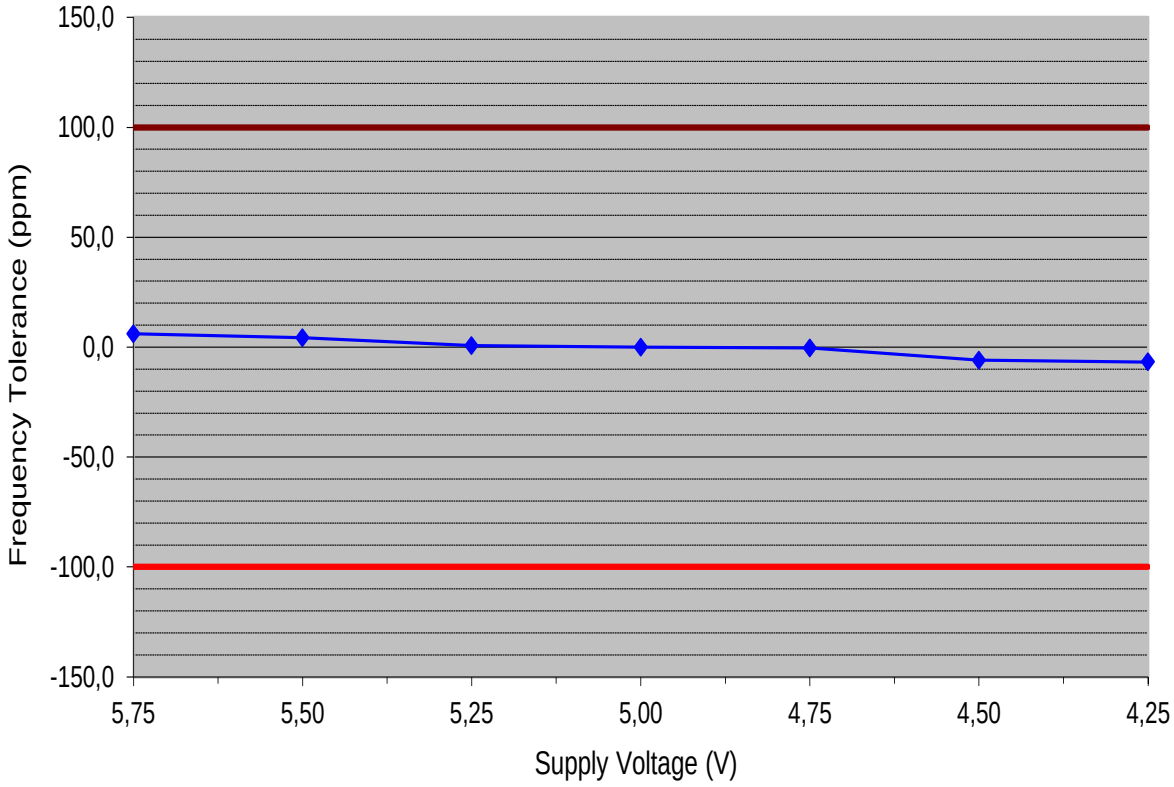
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,560633 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	(ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560730	97	7,2	+100,0	-100,0	**92,8**
-10	13,560695	62	4,6	+100,0	-100,0	95,4
±0	13,560676	43	3,2	+100,0	-100,0	96,8
+10	13,560653	20	1,5	+100,0	-100,0	98,5
+20	13,560633	0	0,0	+100,0	-100,0	100,0
+30	13,560642	9	0,7	+100,0	-100,0	99,3
+40	13,560646	13	1,0	+100,0	-100,0	99,0
+50	13,560657	24	1,8	+100,0	-100,0	98,2
+60	13,560634	1	0,1	+100,0	-100,0	99,9
+70	13,560613	-20	-1,5	+100,0	-100,0	98,5
+80	13,560659	26	1,9	+100,0	-100,0	98,1
+85	13,560668	35	2,6	+100,0	-100,0	97,4

Carrier frequency stability vs. supply voltage



Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,560633 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
5,75	13,560715	82	6,0	+100,0	-100,0	94,0
5,50	13,560691	58	4,3	+100,0	-100,0	95,7
5,25	13,560642	9	0,7	+100,0	-100,0	99,3
5,00	13,560633	0	0,0	+100,0	-100,0	100,0
4,75	13,560627	-6	-0,4	+100,0	-100,0	99,6
4,50	13,560552	-81	-6,0	+100,0	-100,0	94,0
4,25	13,560541	-92	-6,8	+100,0	-100,0	**93,2**

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 22.

8.2 Test instruments

See clause 5.2 on page 22.

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 procedure “occupied bandwidth (99%)”

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.

8.5 Test procedure “-20 dB emission bandwidth”

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.

8.6 Test setup

See clause 0 on page 24.

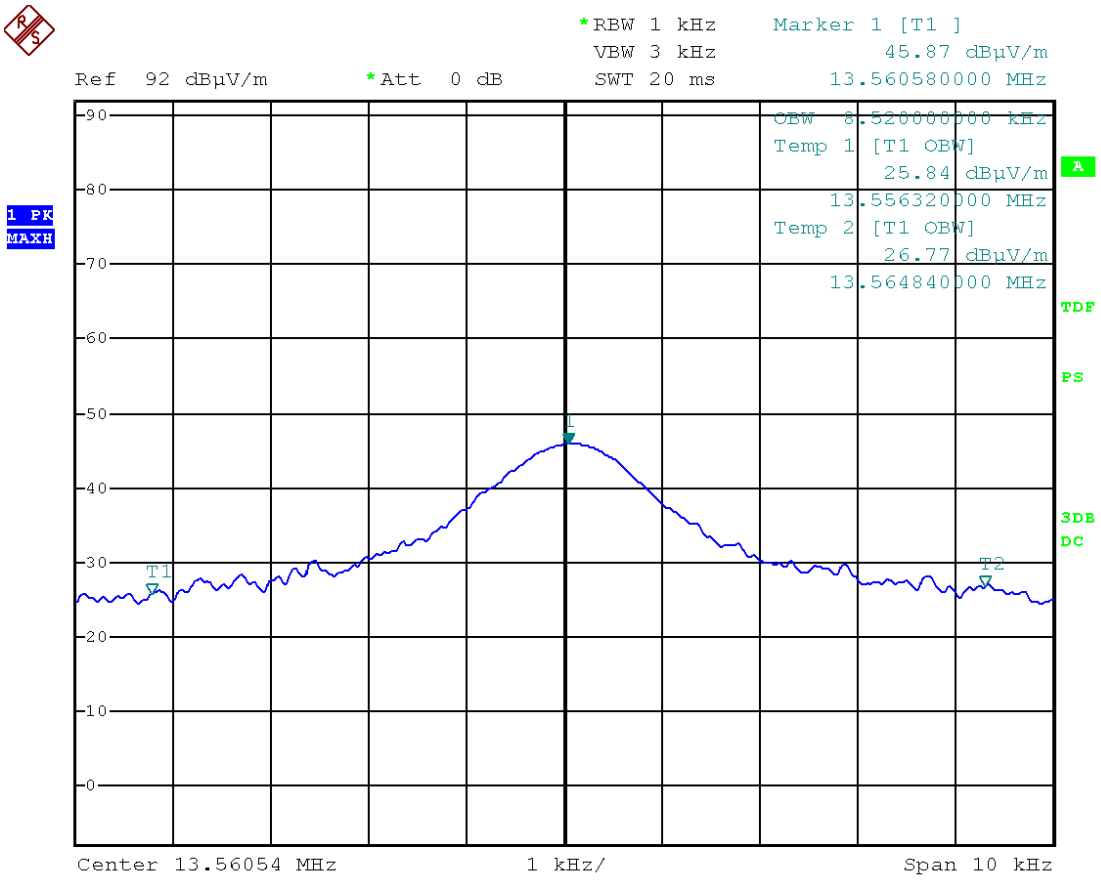
8.7 Test deviation

There is no deviation from the standards referred to.

8.8 Test results “antenna 2010”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

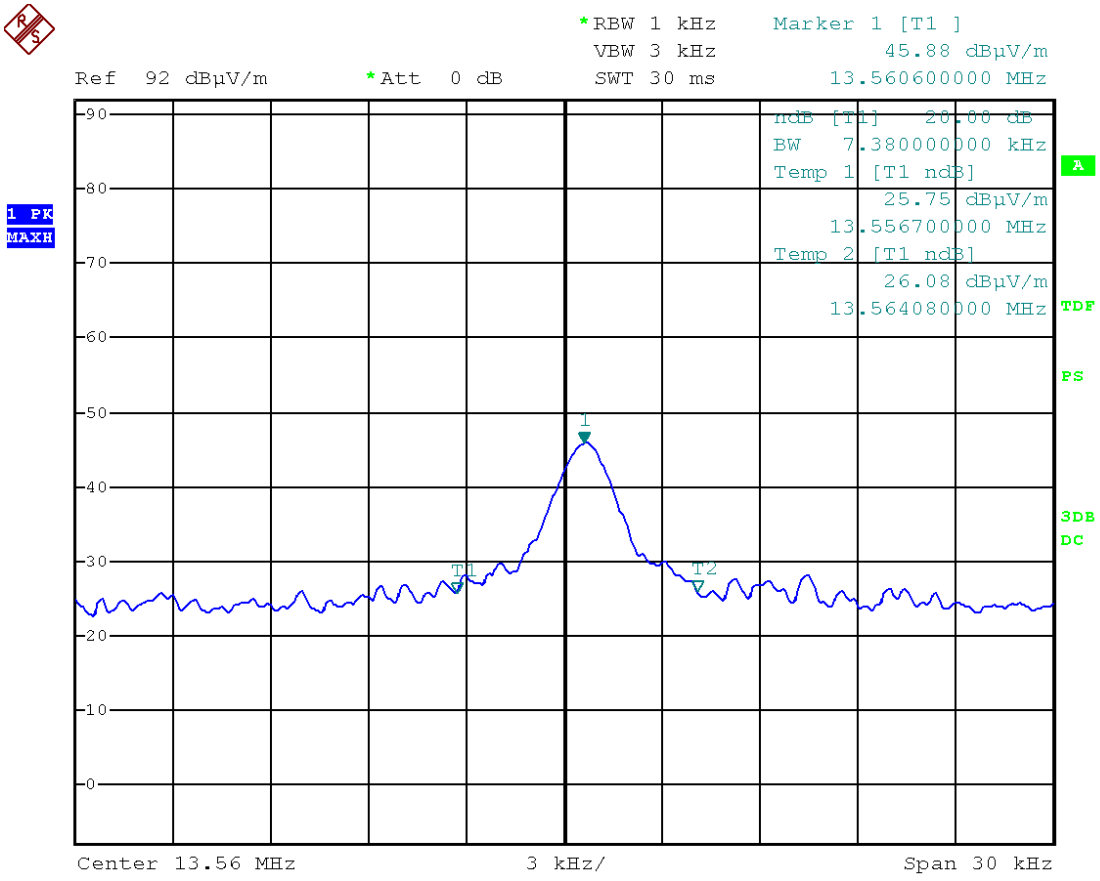
Occupied bandwidth (99 %)



Picture 32: Occupied bandwidth (99 %), antenna 2010

Measured occupied bandwidth (99 %): 8.520 kHz

-20 dB emission bandwidth



Picture 33: -20 dB emission bandwidth, antenna 2010

Measured -20 dB emission bandwidth: 7.380 kHz

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.556700	0.000	0.081	13.556619	13.110000	446.619	Passed
	high	13.564080	0.084	0.076	13.564164	14.010000	445.836	Passed
	Bandwidth	7.380 kHz			7.545 kHz			

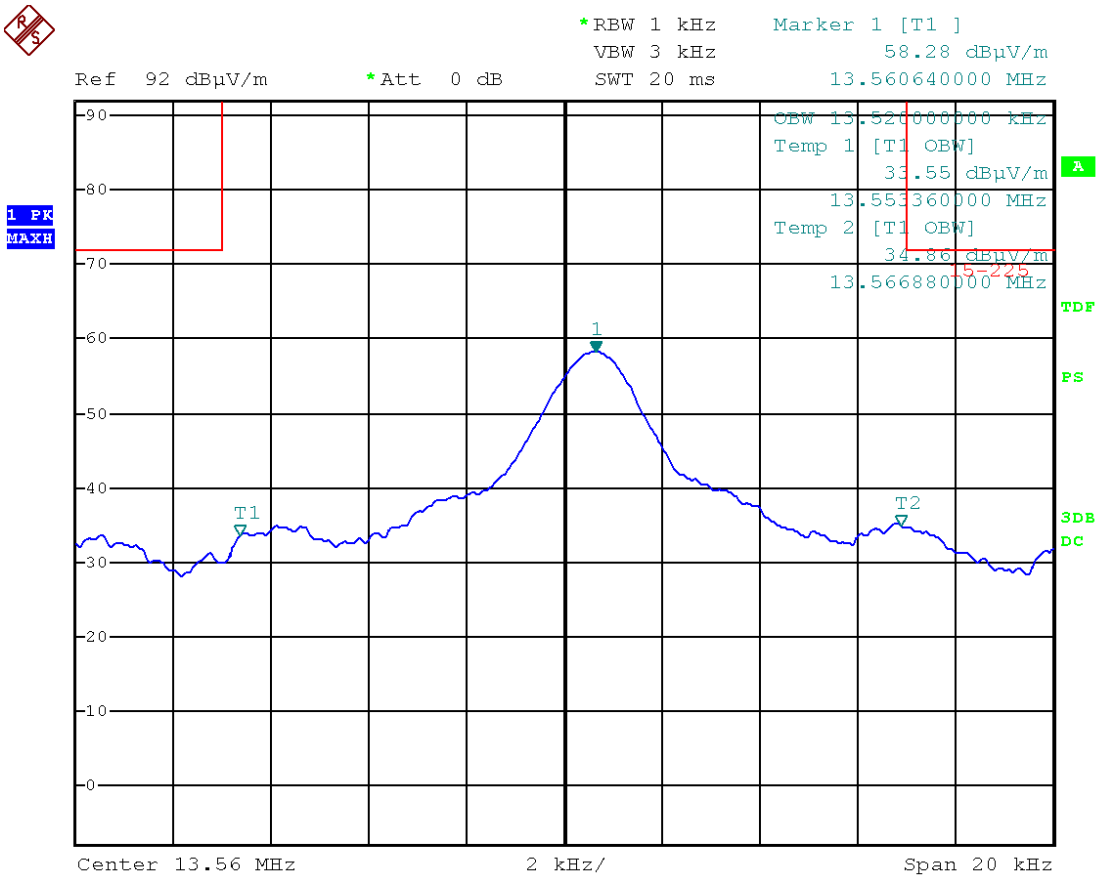
with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 30 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = 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: 7.380 kHz
Including variations in temperature and supply voltage: 7.545 kHz

8.9 Test results “antenna Jay”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

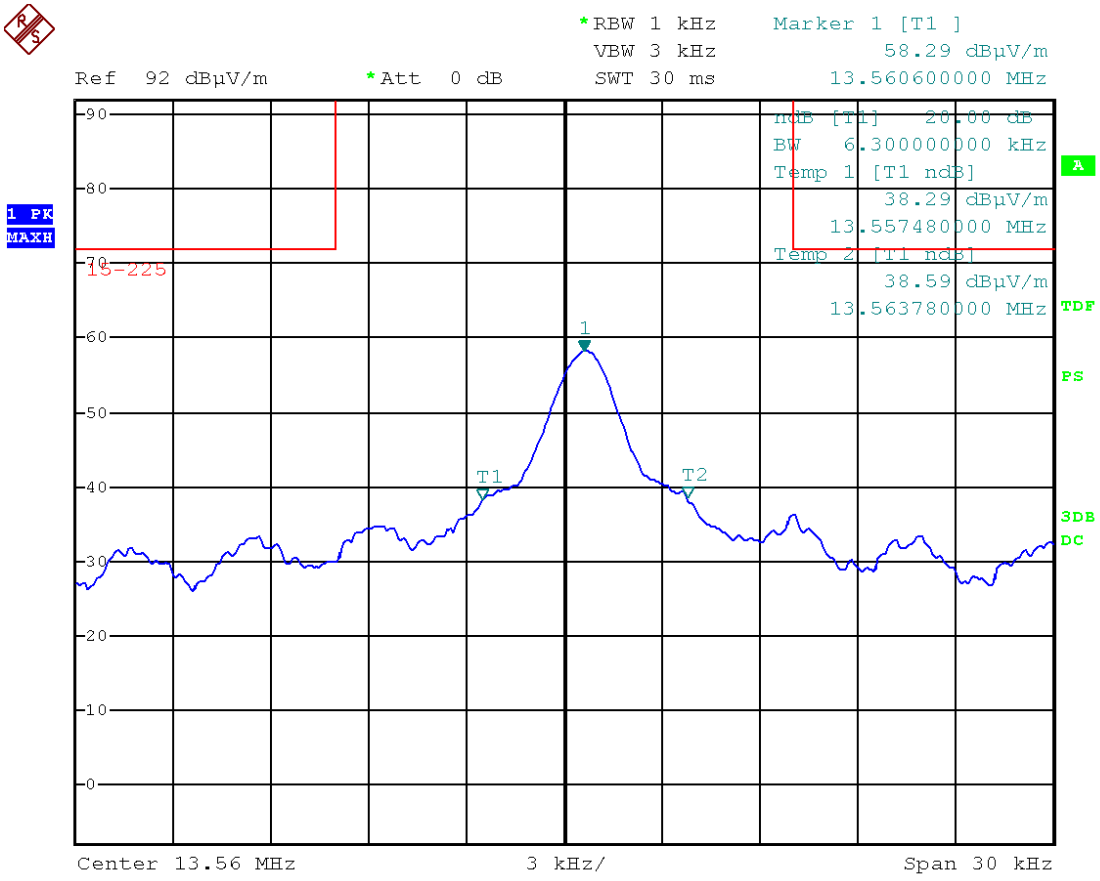
Occupied bandwidth (99 %)



Picture 34: Occupied bandwidth (99 %), antenna Jay

Measured occupied bandwidth (99 %): 13.520 kHz

-20 dB emission bandwidth



Picture 35: -20 dB emission bandwidth, antenna Jay

Measured -20 dB emission bandwidth: 6.300 kHz

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.557480	0.032	0.073	13.557407	13.110000	447.407	Passed
	high	13.563780	0.066	0.085	13.563865	14.010000	446.135	Passed
	Bandwidth	6.300 kHz			6.458 kHz			

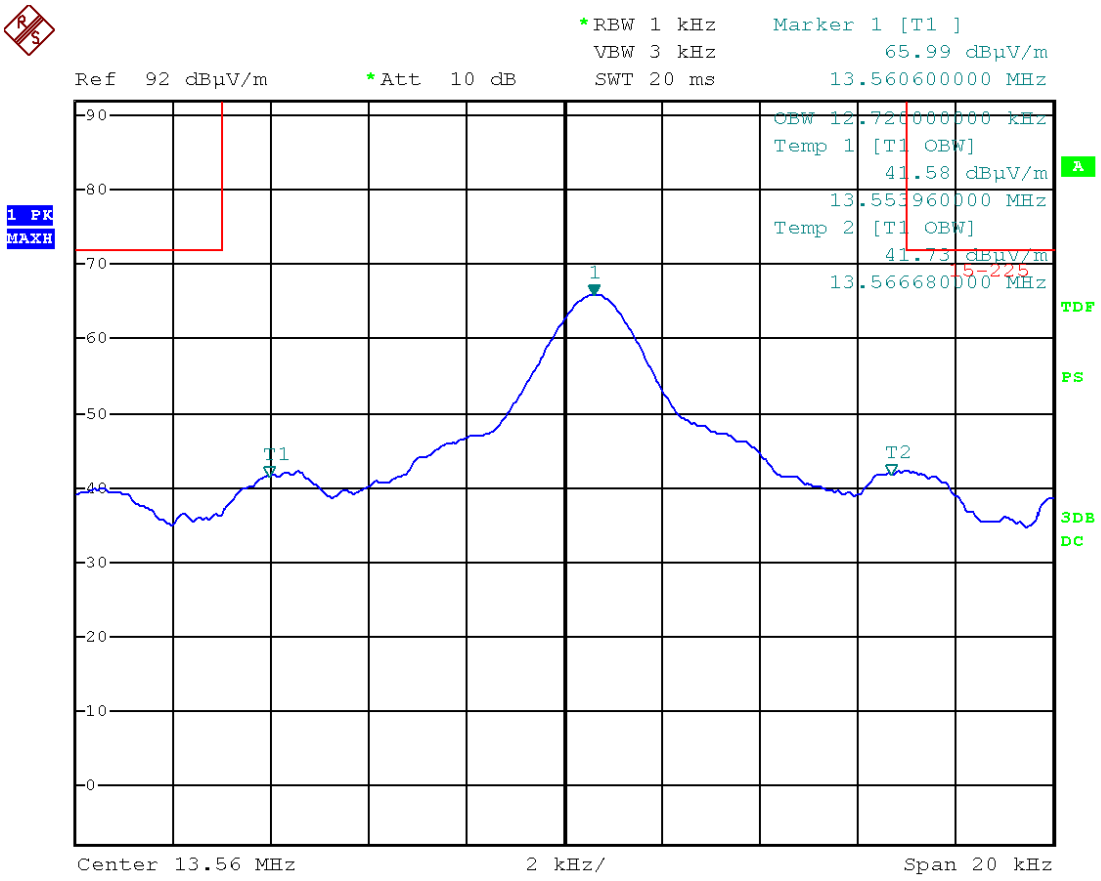
with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 30 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = 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 7.8

Measured -20 dB emission bandwidth:
At nominal conditions: 6.300 kHz
Including variations in temperature and supply voltage: 6.458 kHz

8.10 Test results “antenna 4040”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

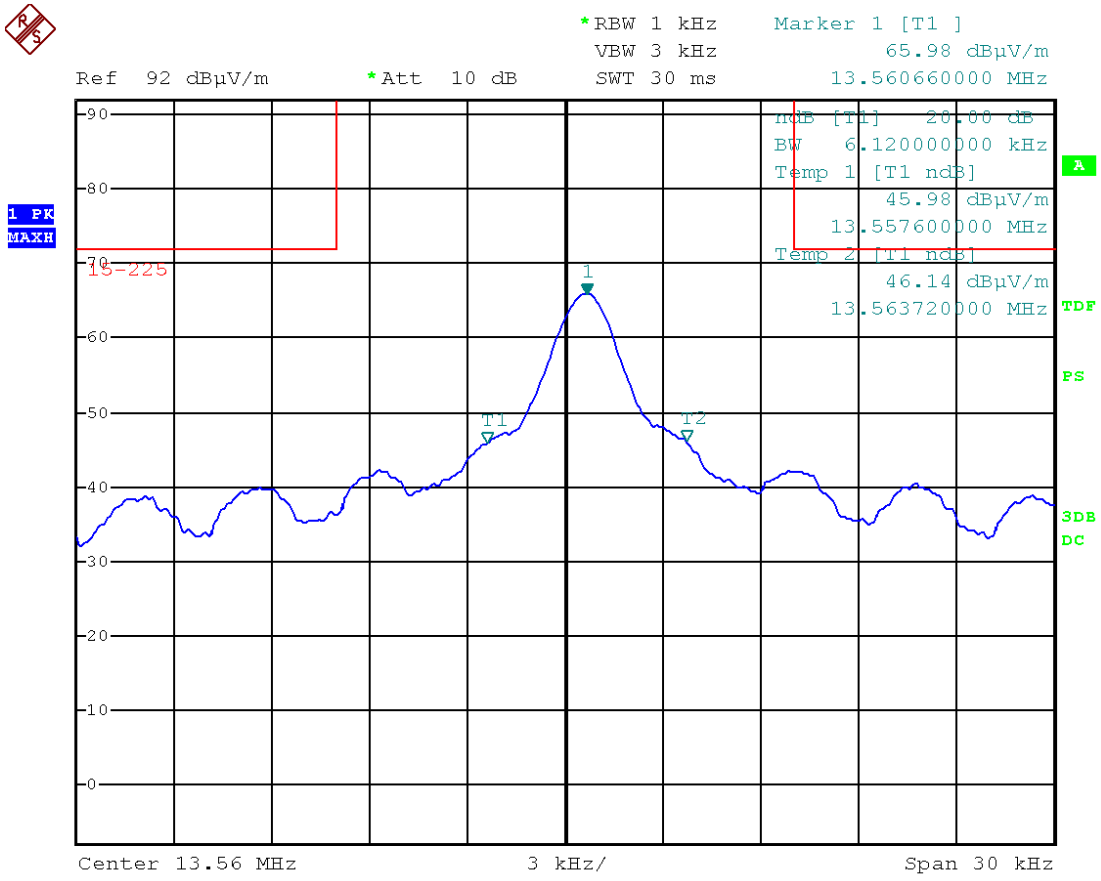
Occupied bandwidth (99 %)



Picture 36: Occupied bandwidth (99 %), antenna 4040

Measured occupied bandwidth (99 %): 12.720 kHz

-20 dB emission bandwidth



Picture 37: -20 dB emission bandwidth, antenna 4040

Measured -20 dB emission bandwidth: 6.120 kHz

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.557600	0.047	0.107	13.557493	13.110000	447.493	Passed
	high	13.563720	0.107	0.061	13.563827	14.010000	446.173	Passed
	Bandwidth	6.120 kHz			6.334 kHz			

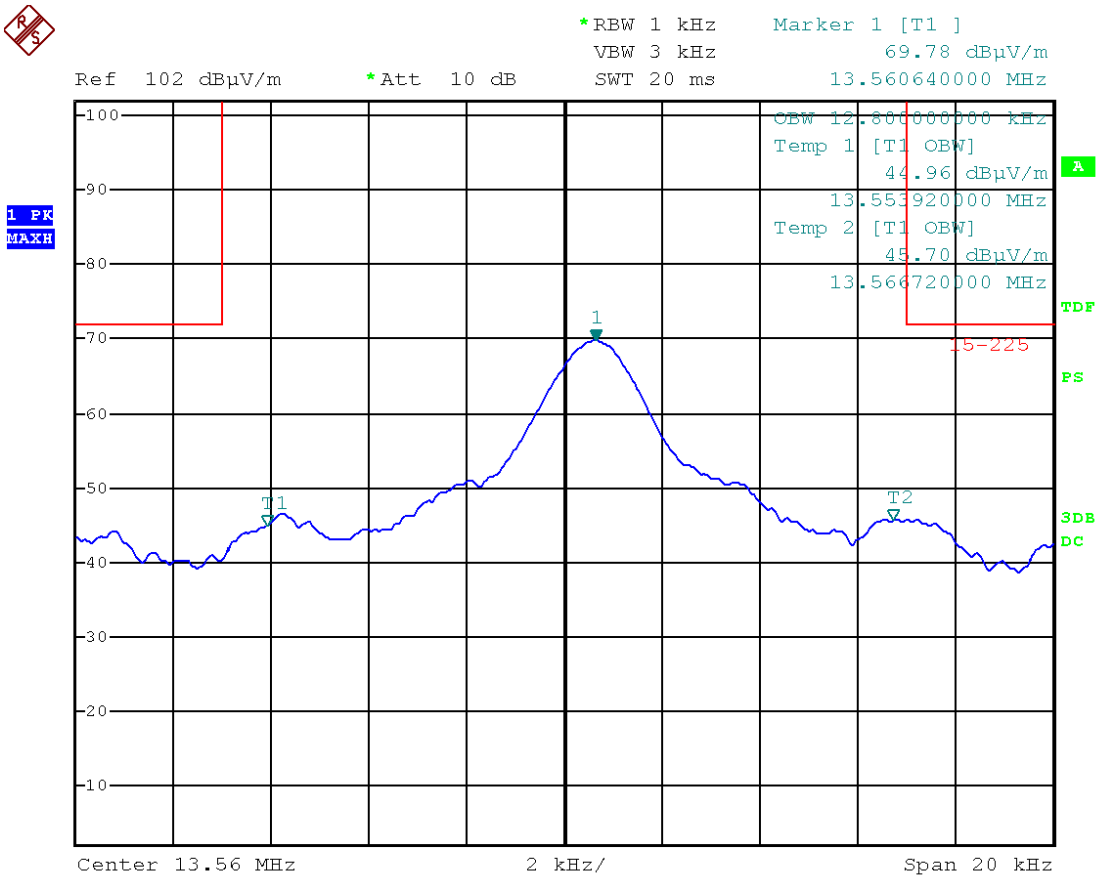
with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 30 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = 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 7.9

Measured -20 dB emission bandwidth:
At nominal conditions: 6.120 kHz
Including variations in temperature and supply voltage: 6.334 kHz

8.11 Test results “antenna 7248”

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

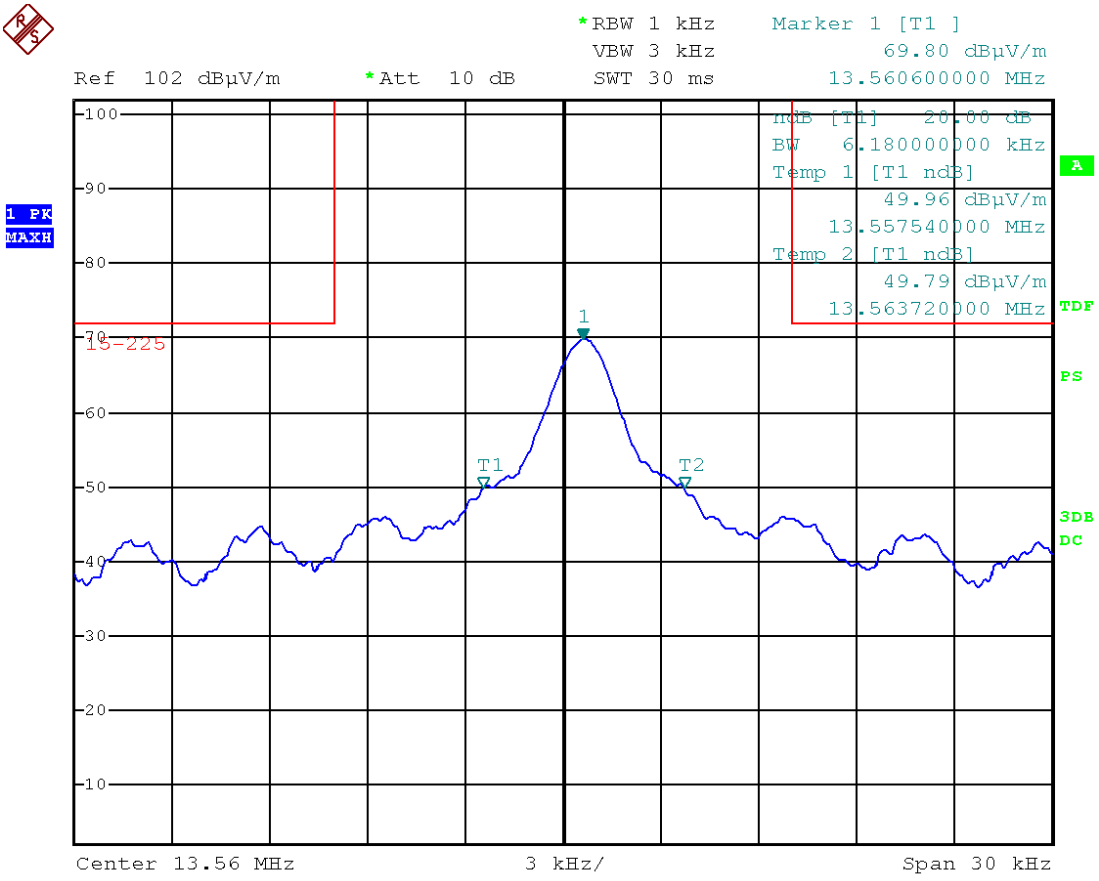
Occupied bandwidth (99 %)



Picture 38: Occupied bandwidth (99 %), antenna 7248

Measured occupied bandwidth (99 %): 12.800 kHz

-20 dB emission bandwidth



Picture 39: -20 dB emission bandwidth, antenna 7248

Measured -20 dB emission bandwidth: 6.180 kHz

$f_{assigned}$ (MHz)	Index	f_{-20dB} (MHz)	Δf_T (kHz)	Δf_U (kHz)	$f_{-20dB(T, U)}$ (MHz)	Limit (MHz)	Margin (kHz)	Result
13.560000	low	13.557540	0.020	0.092	13.557448	13.110000	447.448	Passed
	high	13.563720	0.097	0.082	13.563817	14.010000	446.183	Passed
	Bandwidth	6.180 kHz			6.369 kHz			

with:
$f_{-20dB(low)}$ = lower frequency in MHz where emission is at least 20 dB below the carrier
$f_{-20dB(high)}$ = upper frequency in MHz where emission is at least 30 dB below the carrier
$f_{assigned}$ = assigned frequency in kHz
$\Delta f_{T(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(low)}$ = maximum absolute value of negative frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{T(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by temperature variation in kHz
$\Delta f_{U(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$\Delta f_{volt(high)}$ = maximum absolute value of positive frequency offset to frequency at nominal conditions caused by voltage variation in kHz
$f_{-20dB(T, U)}$ = 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 7.10

Measured -20 dB emission bandwidth:
At nominal conditions: 6.180 kHz
Including variations in temperature and supply voltage: 6.369 kHz

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 l	VC³ 4034	58566123250010	C00015	2016-10	2018-10
Cable set shielded room	Cable no. 30	---	E00424	2016-07	2018-07
Cable set CDC	Cables no. 37 and 38	---	E00459 E00460	2015-05	2017-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2015-11	2017-11

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

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.

11 Revision History

Date	Description	Person	Revision
2017-03-31	First edition	M. Müller	0