Test Report

Customer:

Mühlbauer GmbH & Co. KG

Josef-Mühlbauer-Platz 1
93426 Roding
Germany

Tel.: +49 9461 952-0
Fax: +49 9461 952-1101

RF test report

150648-AU04+W01

Mühlbauer GmbH & Co. KG

RFID reader

MB1301

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

EMV **TESTHAUS** GmbH

Gustav-Hertz-Straße 35
94315 Straubing
Tel.: +49 9421 56868-0
Fax: +49 9421 56868-100
Email: info@emv-testhaus.com

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

Table of contents

List of pictures

List of tables

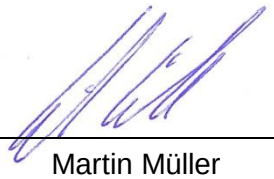
1 Test regulations

47 CFR Part 2:10-2015	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 15:10-2015	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
FCC KDB 447498 D01 February 7, 2014	Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies
ICES-003 Issue 6, January 2016	Spectrum Management and Telecommunications Interference-Causing Equipment Standard Information Technology Equipment (Including Digital Apparatus) - 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-102 Issue 5, March 2015	Spectrum Management and Telecommunications Radio Standards Specification Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
RSS-210 Issue 9, August 2016	Spectrum Management and Telecommunications Radio Standards Specification Licence-Exempt Radio Apparatus: 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 Annex B.6 (with appropriate references to RSS-Gen Issue 4)	Passed

Straubing, September 15, 2016



Martin Müller
Test engineer
EMV **TESTHAUS** GmbH

Rainer Heller
Head of EMC/Radio department
EMV **TESTHAUS** GmbH

3 Equipment under Test (EUT)

Product type:	RFID reader
Model Name:	MB1301
Hardware revision:	MB1332 Rev.3
Applicant:	Mühlbauer GmbH & Co. KG
Manufacturer:	Mühlbauer GmbH & Co. KG
Serial number:	100001 25018
FCC ID:	XJPMBRFID1301001
IC certification number:	----
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 antenna ☒ detachable ☐ not detachable
Highest frequency generated or used in the device or on which the device operates or tunes	300 MHz (used for internal clock of DSP + ARM9 according to block diagram supplied by the manufacturer → unintentional radiator of digital device)
Power supply:	External power source nominal: 24.0 VDC minimal: 20.4 VDC maximal: 27.6 VDC
Temperature range:	-20°C to +50°C

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 taging system for industrial application.
Two RF parts with their antennas were tested (Chip 0, Chip 1).

3.3 Operation mode

During pre-tests the following worst-case-modes were investigated for the respective test:

- continuous wave without tag, chips tested separately	-> spectrum mask -> carrier frequency stability -> bandwidths
- continuous tag reading on both chips at the same time	-> AC power line cond. emissions -> radiated emission measurement 9 kHz to 1 GHz

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.	Manufacturer
RFID reader	MB1301	100001 25018	Mühlbauer GmbH & Co. KG
RFID tag	Mühlbauer specified	----	Mühlbauer GmbH & Co. KG
Power supply [1)] (120 V / 60 Hz -> 24 V DC)	QUINT-PS/1AC/24DC/5	0000265182	PHOENIX CONTACT
Digital multimeter	UT61D	H150188104	reichelt elektronik GmbH & Co. KG
Power Supply (120 V / 60 Hz -> DC)	Statron 3231.1	0702007	Statron Gerätetechnik GmbH
AC power source (230 V / 50 Hz -> 120 V / 60 Hz)	Chroma 61602	ABP000000731	CHROMA A.T.E. Europe b.v.

[1)] : not part of EUT but used as typical power supply for AC power line conducted emissions test only.

3.5 Used cables

Count	Description (type / lengths / remarks)	Serial no.
2	DC cable, banana jack / 0.5m / unshielded	----

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

4.3 Limits

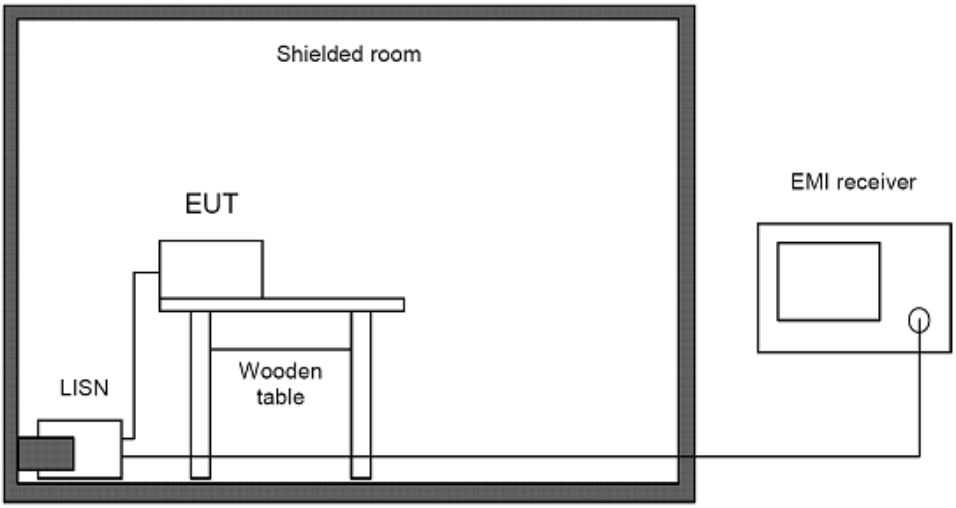
Frequency [MHz]	Quasi-peak [dBµV]	Average [dBµV]
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

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 µH/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 form 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 KDB 174176 D01 testing of intentional radiators with detachable antennas operating below 30 MHz shall be performed with antenna connected (fully extended, if adjustable) and additionally with a dummy load.

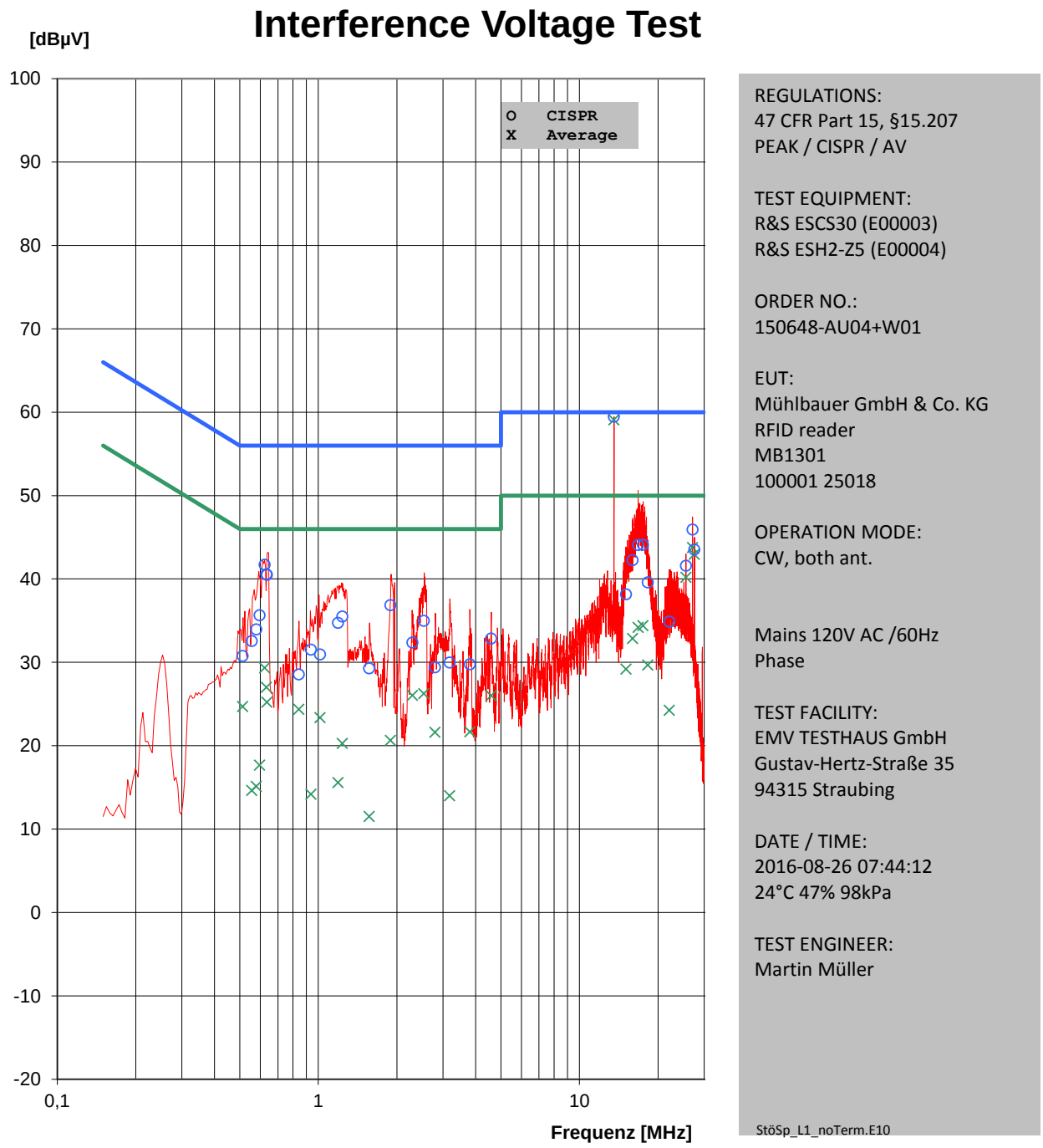
4.5 Test setup



Picture 1: Outline of conducted emission test setup

4.6 Test results

Temperature:	25°C	Humidity:	49%
Tested by:	Martin Müller	Test date:	2016-08-26



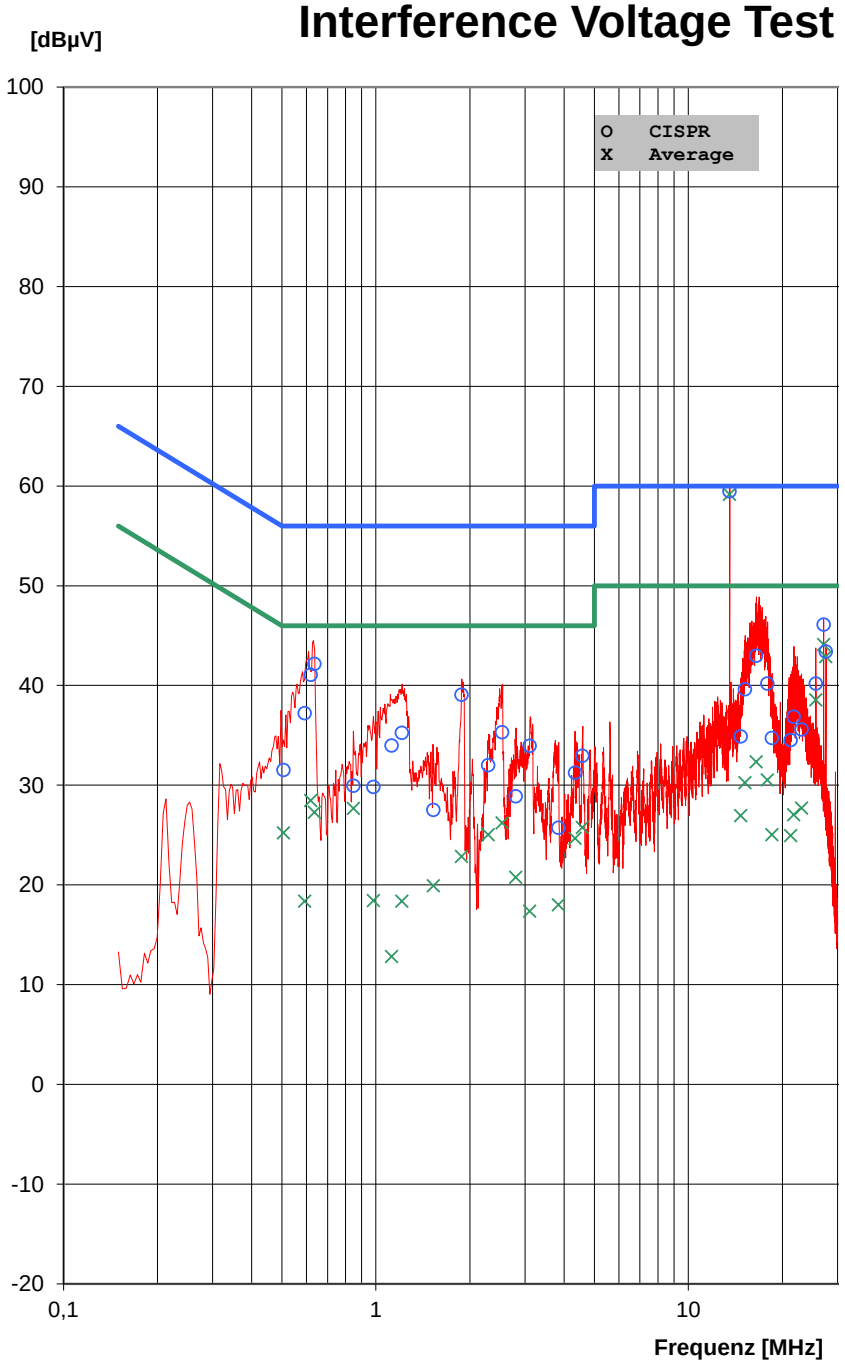
Picture 2: Graphic - Conducted emission on mains, phase (with antenna)

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark StöSp_L1_noTerm.F10
0,51	30,8	56,0	25,2	24,7	46,0	21,3	0,0	
0,56	32,5	56,0	23,5	14,6	46,0	31,4	0,0	
0,58	33,9	56,0	22,1	15,1	46,0	30,9	0,0	
0,60	35,6	56,0	20,4	17,7	46,0	28,4	0,0	
0,62	41,7	56,0	14,3	29,3	46,0	16,7	0,0	
0,63	40,5	56,0	15,5	27,0	46,0	19,0	0,0	
0,64	40,5	56,0	15,5	25,2	46,0	20,8	0,0	
0,84	28,6	56,0	27,5	24,4	46,0	21,7	0,0	
0,94	31,5	56,0	24,5	14,2	46,0	31,8	0,0	
1,02	30,9	56,0	25,1	23,4	46,0	22,6	0,0	
1,19	34,7	56,0	21,3	15,6	46,0	30,4	0,0	
1,24	35,5	56,0	20,5	20,3	46,0	25,7	0,0	
1,57	29,3	56,0	26,7	11,5	46,0	34,5	0,0	
1,89	36,9	56,0	19,2	20,6	46,0	25,4	0,0	
2,29	32,4	56,0	23,6	26,0	46,0	20,0	0,0	
2,54	35,0	56,0	21,0	26,3	46,0	19,8	0,0	
2,80	29,4	56,0	26,6	21,6	46,0	24,4	0,0	
3,18	30,0	56,0	26,0	14,0	46,0	32,0	0,0	
3,81	29,7	56,0	26,3	21,7	46,0	24,4	0,0	
4,59	32,9	56,0	23,1	26,0	46,0	20,0	0,0	
13,56	59,5	60,0	0,5	59,1	50,0	**-9,1**	0,0	
15,09	38,2	60,0	21,9	29,2	50,0	20,8	0,0	
16,00	42,2	60,0	17,8	32,9	50,0	17,1	0,0	
16,78	44,1	60,0	15,9	34,2	50,0	15,8	0,0	
17,52	44,1	60,0	15,9	34,4	50,0	15,6	0,0	
18,29	39,6	60,0	20,4	29,7	50,0	20,4	0,0	
22,07	34,9	60,0	25,1	24,2	50,0	25,8	0,0	
25,60	41,6	60,0	18,4	40,2	50,0	9,8	0,0	
27,12	45,9	60,0	14,1	43,8	50,0	6,2	0,0	
27,57	43,5	60,0	16,5	43,0	50,0	7,1	0,0	

Picture 3: Table - Conducted emission on mains, phase (with antenna)

Interference Voltage Test



REGULATIONS:
47 CFR Part 15, §15.207
PEAK / CISPR / AV

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

ORDER NO.:
150648-AU04+W01

EUT:
Mühlbauer GmbH & Co. KG
RFID reader
MB1301
100001 25018

OPERATION MODE:
CW, both ant.

Mains 120V AC /60Hz
Neutral

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

DATE / TIME:
2016-08-26 07:44:12
24°C 47% 98kPa

TEST ENGINEER:
Martin Müller

StöSp_N_noTerm.E10

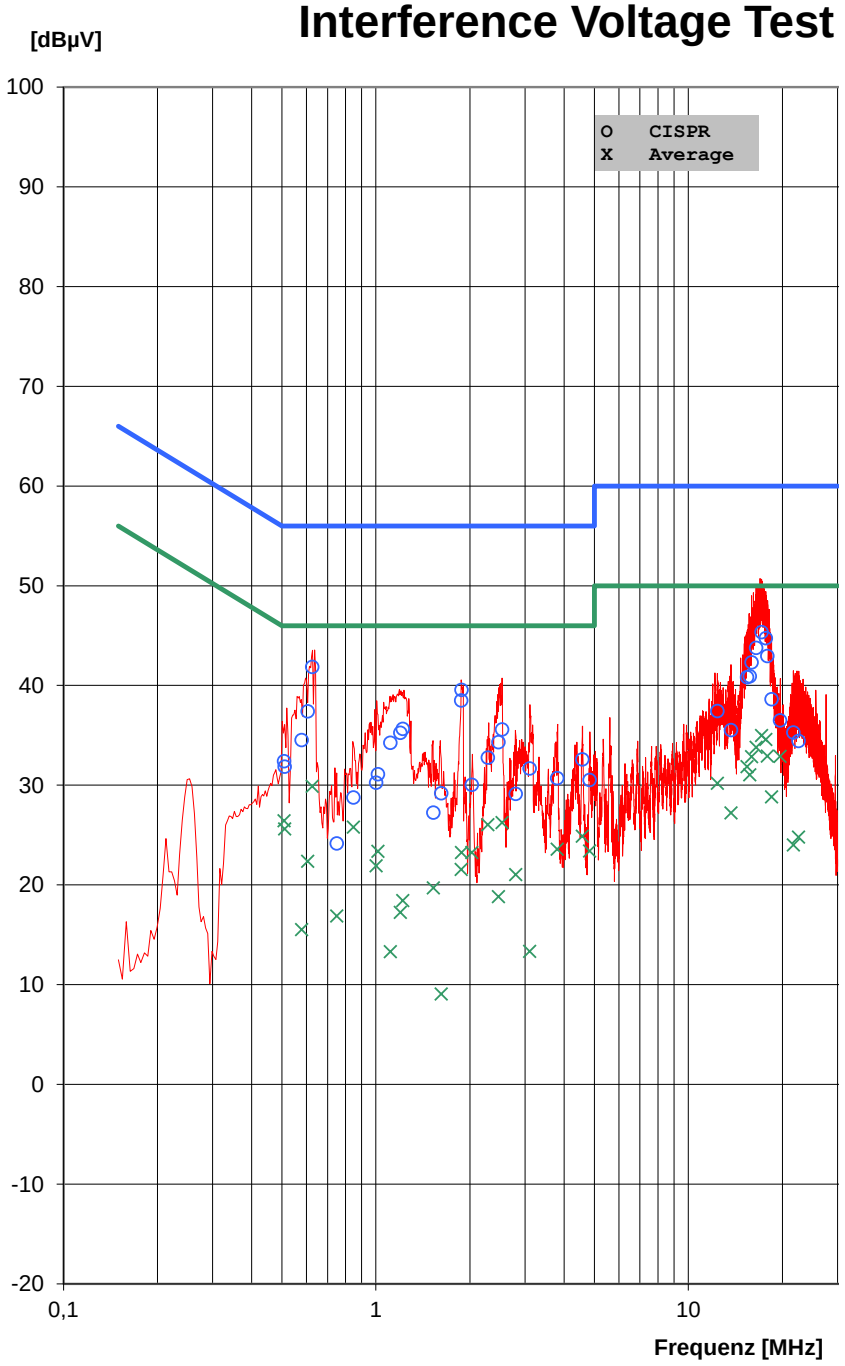
Picture 4: Graphic - Conducted emission on mains, neutral (with antenna)

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark StöSp_N_noTerm.F10
0,51	31,5	56,0	24,5	25,2	46,0	20,8	0,0	
0,59	37,2	56,0	18,8	18,4	46,0	27,6	0,0	
0,62	41,1	56,0	14,9	28,4	46,0	17,6	0,0	
0,64	42,1	56,0	13,9	27,3	46,0	18,7	0,0	
0,85	29,9	56,0	26,1	27,7	46,0	18,3	0,0	
0,98	29,8	56,0	26,2	18,4	46,0	27,6	0,0	
1,12	34,0	56,0	22,0	12,8	46,0	33,2	0,0	
1,21	35,3	56,0	20,8	18,4	46,0	27,7	0,0	
1,53	27,5	56,0	28,5	19,9	46,0	26,1	0,0	
1,88	39,1	56,0	16,9	22,8	46,0	23,2	0,0	
2,29	32,0	56,0	24,0	25,0	46,0	21,0	0,0	
2,54	35,3	56,0	20,7	26,2	46,0	19,8	0,0	
2,80	28,9	56,0	27,1	20,8	46,0	25,3	0,0	
3,11	33,9	56,0	22,1	17,4	46,0	28,7	0,0	
3,84	25,7	56,0	30,3	18,0	46,0	28,0	0,0	
4,34	31,2	56,0	24,8	24,7	46,0	21,3	0,0	
4,59	32,9	56,0	23,1	25,7	46,0	20,3	0,0	
13,56	59,5	60,0	0,5	59,2	50,0	**-9,2**	0,0	
14,73	34,9	60,0	25,1	26,9	50,0	23,1	0,0	
15,20	39,6	60,0	20,4	30,3	50,0	19,8	0,0	
16,50	43,0	60,0	17,0	32,3	50,0	17,7	0,0	
17,92	40,2	60,0	19,8	30,5	50,0	19,5	0,0	
18,54	34,7	60,0	25,3	25,0	50,0	25,0	0,0	
21,29	34,5	60,0	25,5	24,9	50,0	25,1	0,0	
21,78	36,8	60,0	23,2	27,0	50,0	23,0	0,0	
23,05	35,6	60,0	24,4	27,7	50,0	22,3	0,0	
25,60	40,2	60,0	19,8	38,5	50,0	11,5	0,0	
27,12	46,1	60,0	13,9	44,1	50,0	5,9	0,0	
27,57	43,4	60,0	16,6	42,9	50,0	7,1	0,0	

Picture 5: Table - Conducted emission on mains, neutral (with antenna)

Interference Voltage Test



REGULATIONS:
47 CFR Part 15, §15.207
PEAK / CISPR / AV

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

ORDER NO.:
150648-AU04+W01

EUT:
Mühlbauer GmbH & Co. KG
RFID reader
MB1301
100001 25018

OPERATION MODE:
CW, both ant.
with 50 Ohm

Mains 120V AC /60Hz
Phase

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

DATE / TIME:
2016-08-26 08:14:49
24°C 47% 98kPa

TEST ENGINEER:
Martin Müller

StöSp_L1_withTerm.E10

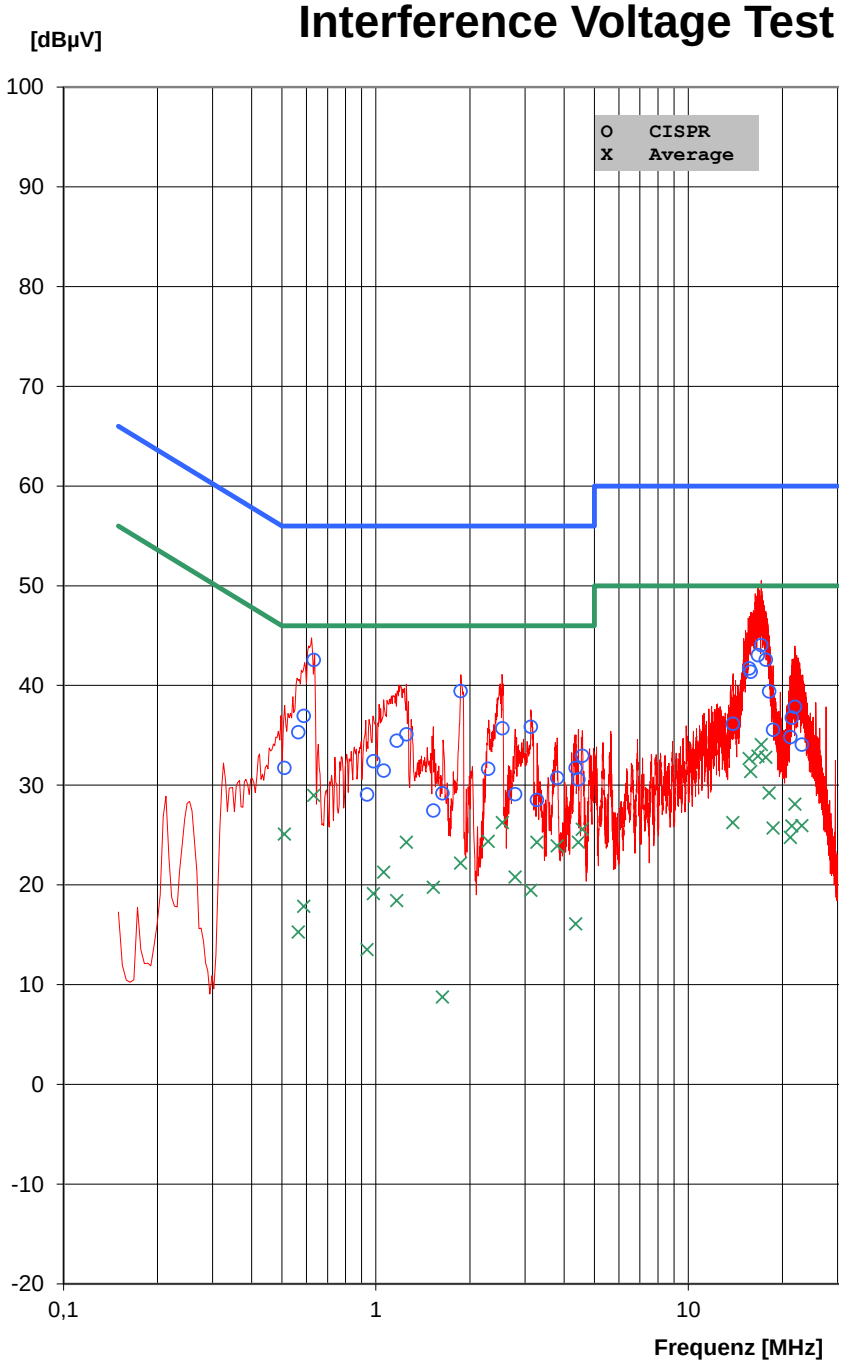
Picture 6: Graphic - Conducted emission on mains, phase (with termination 50 Ω)

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark StöSp_L1_withTerm.F10
0,51	31,8	56,0	24,2	25,6	46,0	20,4	0,0	
0,51	32,4	56,0	23,6	26,4	46,0	19,6	0,0	
0,58	34,5	56,0	21,5	15,5	46,0	30,5	0,0	
0,61	37,4	56,0	18,6	22,4	46,0	23,7	0,0	
0,63	41,8	56,0	14,2	29,9	46,0	16,1	0,0	
0,75	24,1	56,0	31,9	16,9	46,0	29,1	0,0	
0,85	28,8	56,0	27,3	25,8	46,0	20,2	0,0	
1,00	30,3	56,0	25,8	21,9	46,0	24,1	0,0	
1,02	31,1	56,0	24,9	23,4	46,0	22,6	0,0	
1,11	34,2	56,0	21,8	13,3	46,0	32,7	0,0	
1,20	35,2	56,0	20,8	17,2	46,0	28,8	0,0	
1,22	35,6	56,0	20,4	18,4	46,0	27,6	0,0	
1,53	27,2	56,0	28,8	19,7	46,0	26,3	0,0	
1,62	29,2	56,0	26,8	9,1	46,0	36,9	0,0	
1,88	38,5	56,0	17,5	21,5	46,0	24,5	0,0	
1,88	39,5	56,0	16,5	23,3	46,0	22,8	0,0	
2,03	30,0	56,0	26,0	23,3	46,0	22,8	0,0	
2,29	32,7	56,0	23,3	26,0	46,0	20,0	0,0	
2,47	34,3	56,0	21,7	18,8	46,0	27,2	0,0	
2,54	35,6	56,0	20,4	26,3	46,0	19,8	0,0	
2,81	29,1	56,0	26,9	21,0	46,0	25,0	0,0	
3,11	31,7	56,0	24,4	13,3	46,0	32,7	0,0	
3,81	30,7	56,0	25,3	23,6	46,0	22,4	0,0	
4,58	32,6	56,0	23,4	24,9	46,0	21,1	0,0	
4,84	30,5	56,0	25,5	23,4	46,0	22,6	0,0	
12,39	37,4	60,0	22,6	30,2	50,0	19,8	0,0	
13,69	35,5	60,0	24,5	27,2	50,0	22,8	0,0	
15,42	40,8	60,0	19,2	31,8	50,0	18,2	0,0	
15,73	40,9	60,0	19,1	31,0	50,0	19,0	0,0	
15,94	42,3	60,0	17,7	32,9	50,0	17,2	0,0	
16,48	43,8	60,0	16,2	33,8	50,0	16,2	0,0	
17,16	45,3	60,0	14,7	35,0	50,0	15,0	0,0	
17,70	44,7	60,0	15,3	34,6	50,0	15,4	0,0	
17,92	42,9	60,0	17,1	32,9	50,0	17,1	0,0	
18,48	38,6	60,0	21,4	28,8	50,0	21,2	0,0	
19,69	36,5	60,0	23,5	32,9	50,0	17,1	0,0	
21,71	35,3	60,0	24,7	24,0	50,0	26,0	0,0	
22,54	34,4	60,0	25,6	24,8	50,0	25,2	0,0	

Picture 7: Table - Conducted emission on mains, phase (with termination 50 Ω)

Interference Voltage Test



REGULATIONS:
47 CFR Part 15, §15.207
PEAK / CISPR / AV

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

ORDER NO.:
150648-AU04+W01

EUT:
Mühlbauer GmbH & Co. KG
RFID reader
MB1301
100001 25018

OPERATION MODE:
CW, both ant.
with 50 Ohm

Mains 120V AC /60Hz
Neutral

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

DATE / TIME:
2016-08-26 08:15:13
24°C 47% 98kPa

TEST ENGINEER:
Martin Müller

StöSp_N_withTerm.E10

Picture 8: Graphic - Conducted emission on mains, neutral (with termination 50 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 StöSp_N_withTerm.F10
0,51	31,7	56,0	24,3	25,1	46,0	20,9	0,0	
0,56	35,3	56,0	20,7	15,3	46,0	30,7	0,0	
0,59	36,9	56,0	19,1	17,8	46,0	28,2	0,0	
0,63	42,5	56,0	13,5	29,0	46,0	17,1	0,0	
0,94	29,1	56,0	26,9	13,5	46,0	32,5	0,0	
0,98	32,4	56,0	23,6	19,1	46,0	26,9	0,0	
1,06	31,4	56,0	24,6	21,3	46,0	24,7	0,0	
1,17	34,5	56,0	21,5	18,4	46,0	27,6	0,0	
1,25	35,1	56,0	20,9	24,3	46,0	21,7	0,0	
1,53	27,4	56,0	28,6	19,8	46,0	26,2	0,0	
1,63	29,2	56,0	26,8	8,8	46,0	37,2	0,0	
1,87	39,4	56,0	16,6	22,2	46,0	23,8	0,0	
2,29	31,6	56,0	24,4	24,4	46,0	21,6	0,0	
2,54	35,7	56,0	20,3	26,3	46,0	19,8	0,0	
2,79	29,1	56,0	26,9	20,8	46,0	25,2	0,0	
3,13	35,8	56,0	20,2	19,4	46,0	26,6	0,0	
3,28	28,5	56,0	27,5	24,3	46,0	21,7	0,0	
3,81	30,7	56,0	25,3	23,9	46,0	22,1	0,0	
4,36	31,7	56,0	24,3	16,1	46,0	29,9	0,0	
4,45	30,6	56,0	25,4	24,3	46,0	21,7	0,0	
4,58	32,9	56,0	23,1	25,6	46,0	20,4	0,0	
13,91	36,2	60,0	23,9	26,3	50,0	23,8	0,0	
15,66	41,7	60,0	18,3	32,7	50,0	17,3	0,0	
15,86	41,4	60,0	18,6	31,4	50,0	18,6	0,0	
16,73	43,0	60,0	17,0	32,9	50,0	17,1	0,0	
17,12	44,0	60,0	16,0	34,1	50,0	15,9	0,0	
17,72	42,6	60,0	17,4	32,8	50,0	17,2	0,0	
18,16	39,4	60,0	20,6	29,2	50,0	20,8	0,0	
18,69	35,5	60,0	24,5	25,7	50,0	24,3	0,0	
21,23	34,8	60,0	25,2	24,8	50,0	25,2	0,0	
21,47	36,8	60,0	23,3	25,9	50,0	24,1	0,0	
21,96	37,9	60,0	22,2	28,1	50,0	21,9	0,0	
23,13	34,1	60,0	26,0	25,9	50,0	24,1	0,0	

Picture 9: Table - Conducted emission on mains, neutral (with termination 50 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 B.6 with RSS-Gen, sections 8.10 and 8.9

5.1 Test Location

Measurements < 30 MHz

☒ Scan with peak detector in 3 m compact diagnostic chamber.

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

Measurements > 30 MHz

☒ Scan with quasi peak detector in 3 m semi anechoic chamber.

☒ Final CISPR measurement with quasi peak detector in 3 m semi anechoic chamber.

Description	Manufacturer	Inventory No.
CDC	Albatross Projects GmbH	E00026
Open area test site (OATS)	EMV **TESTHAUS** GmbH	E00354
Semi anechoic chamber (SAC)	Albatross Projects GmbH	E00716

5.2 Test instruments

	Description	Manufacturer	Inventory No.
☒	ESCI (OATS)	Rohde & Schwarz	E00552
☐	ESU 26 (AC)	Rohde & Schwarz	W00002
☒	ESCI (CDC)	Rohde & Schwarz	E00001
☒	ESR7 (SAC)	Rohde & Schwarz	E00739
☐	VULB 9163 (OATS)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011
☒	VULB 9162-041 (SAC)	Schwarzbeck	E00643
☒	HFH2-Z2 (CDC & OATS)	Rohde & Schwarz	E00060
☒	Cable set CDC	Huber + Suhner	E00459, E00446
☐	Cable set AC 3 m	Huber + Suhner	W00095, E00432, E00307
☒	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
☒	Cable set SAC 3 m	Huber + Suhner	E00804, E00806, E00807

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			

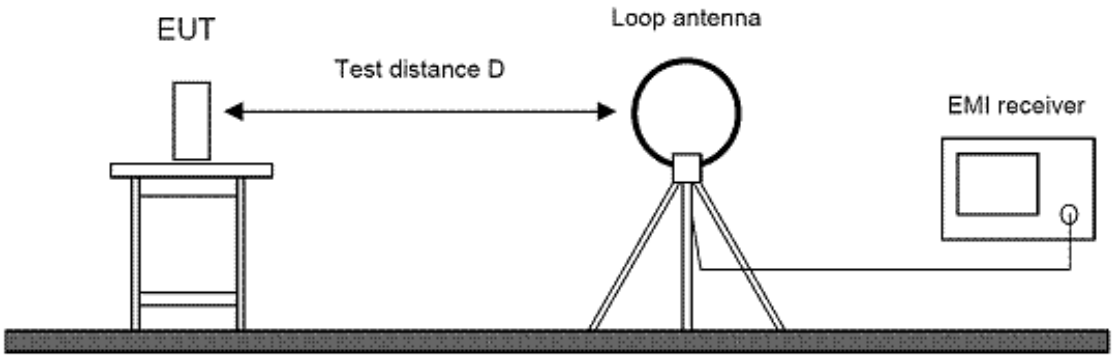
Note:
Limits for 3 m test distance are calculated according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”.

According to 15.35(b) on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions of 20 dB above the maximum permitted average emission limit.

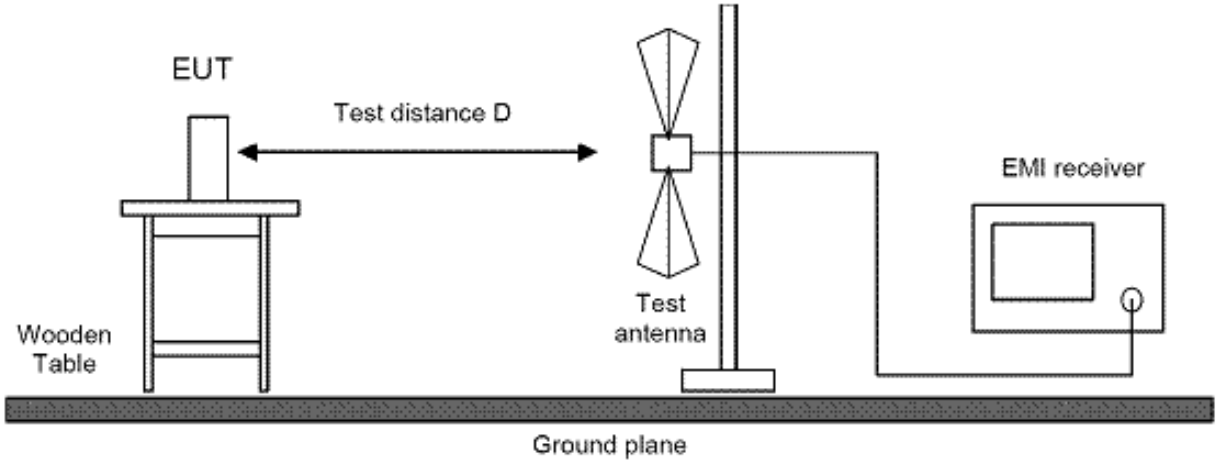
5.4 Test procedure

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° / 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 6 dB 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.

5.5 Test setup



Picture 10: Test setup for radiated emission measurement (< 30 MHz)



Picture 11: 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:	22°C	Humidity:	51%
Tested by:	Martin Müller	Test date:	2016-08-16

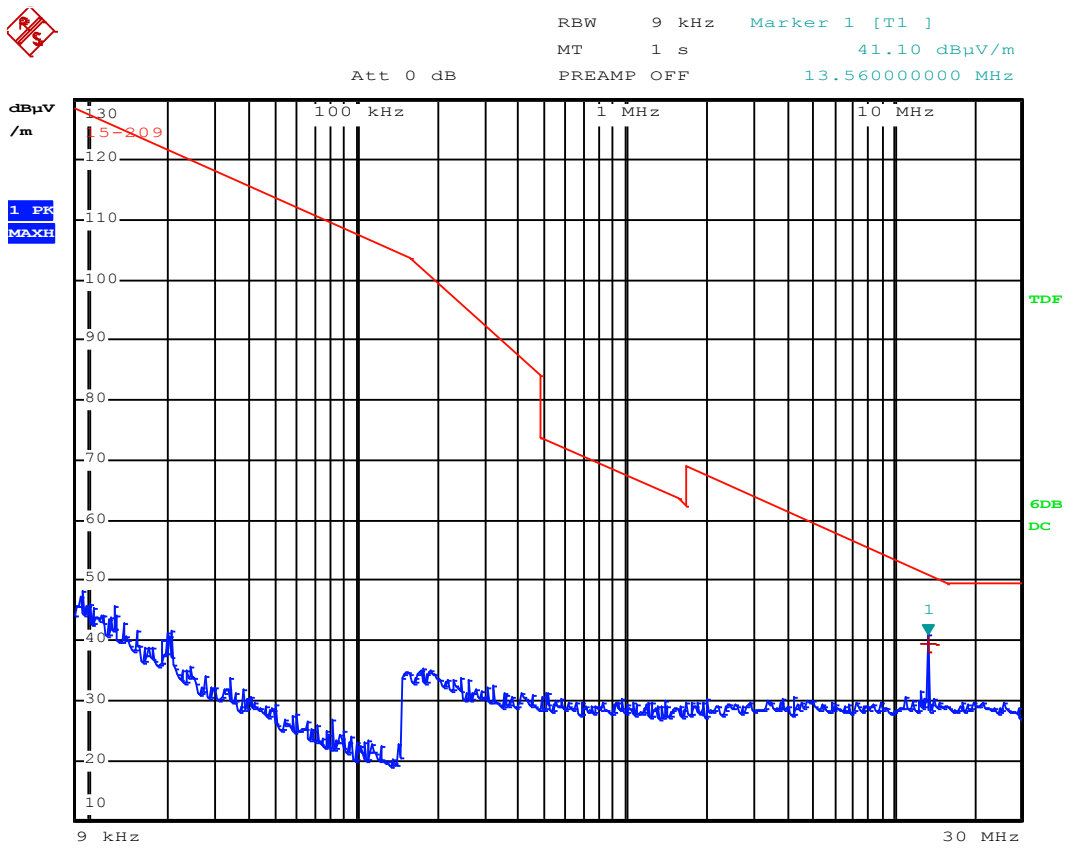
Radiated Emission Measurement 9 kHz - 30 MHz

Test procedure

The EUT was placed in a fully anechoic chamber and the spurious emission testing was performed in accordance with ANSI C63.10, 47 CFR Part 15, Subpart C. The measurement distance was 3 m.

Worst-cases for the respective tests were as follows:

- chip 0 stand alone: EUT-position2 in combination with antenna in line
- chip 1 stand alone: EUT-position1 in combination with antenna in line
- chip 0 & chip 1 both active: EUT-position1 in combination with antenna in line

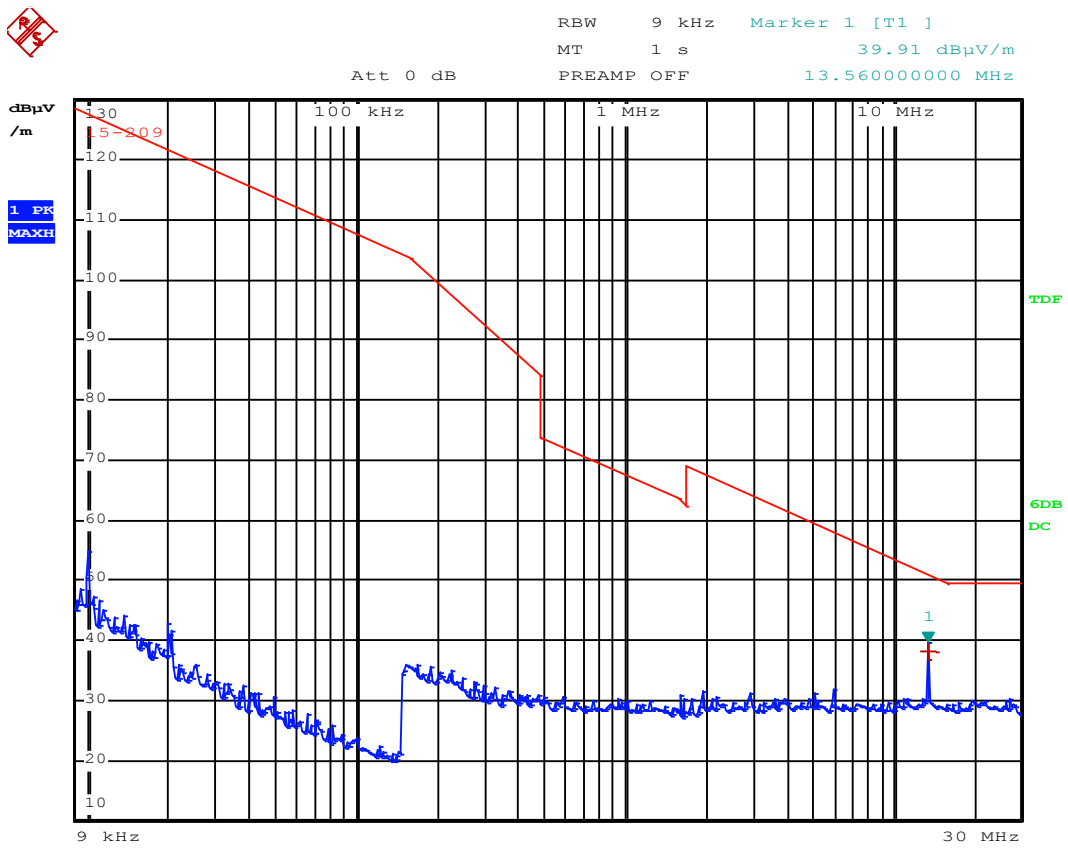


Picture 12: Radiated emission 9 kHz – 30 MHz @ 3m distance, chip 0

Frequency (MHz)	Measured value (dBµV/m)	Detector	Recalculation factor (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin	Result
13.560	39.36	QP	-21.39	17.97	84	66.03	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 39.36 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.523 m @ 13.560 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.60) dB
= -21.39 dB
Recalculated value = 39.36 dBµV/m @ 3 m - 21.39 dB = **17.97 dBµV/m @ 30 m**

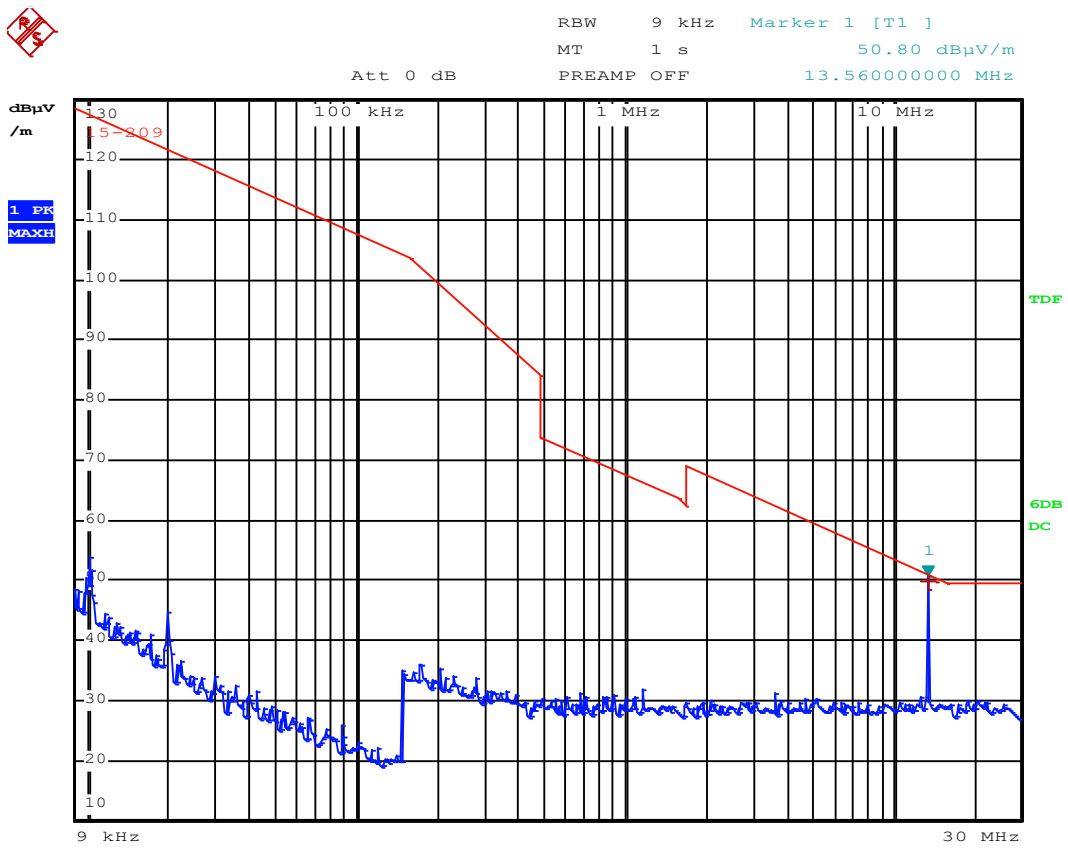


Picture 13: Radiated emission 9 kHz – 30 MHz @ 3m distance, chip 1

Frequency (MHz)	Measured value (dBµV/m)	Detector	Recalculation factor (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin	Result
13.560	38.08	QP	-21.39	16.69	84	67.31	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 38.08 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.523 m @ 13.560 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.60) dB
= -21.39 dB
Recalculated value = 38.08 dBµV/m @ 3 m - 21.39 dB = **16.69 dBµV/m @ 30 m**



Picture 14: Radiated emission 9 kHz – 30 MHz @ 3m distance, chip 0 & chip 1

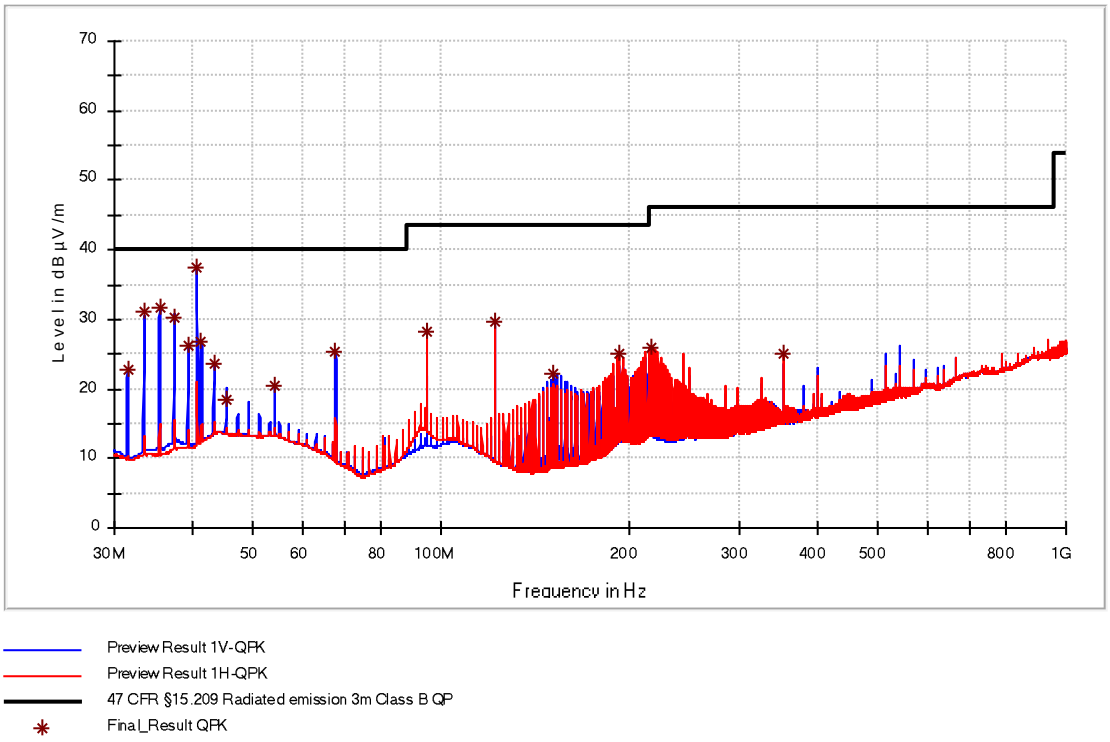
Frequency (MHz)	Measured value (dBµV/m)	Detector	Recalculation factor (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin	Result
13.560	49.82	QP	-21.39	28.43	84	55.57	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 49.82 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.523 m @ 13.560 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.60) dB
= -21.39 dB
Recalculated value = 49.82 dBµV/m @ 3 m - 21.39 dB = **28.43 dBµV/m @ 30 m**

Radiated Emission Measurement 30 MHz - 1000 MHz

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



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
31.500000	22.71	40.00	17.29	1000.0	120.000	100.0	V	2.0	10.9
33.480000	31.17	40.00	8.83	1000.0	120.000	100.0	V	2.0	11.6
35.430000	31.71	40.00	8.29	1000.0	120.000	100.0	V	19.0	12.0
37.410000	30.11	40.00	9.89	1000.0	120.000	103.0	V	172.0	12.6
39.390000	26.17	40.00	13.83	1000.0	120.000	100.0	V	157.0	13.1
40.680000	37.33	40.00	2.67	1000.0	120.000	100.0	V	2.0	13.6
41.340000	26.69	40.00	13.31	1000.0	120.000	100.0	V	2.0	13.9
43.320000	23.65	40.00	16.35	1000.0	120.000	100.0	V	2.0	15.1
45.270000	18.48	40.00	21.52	1000.0	120.000	100.0	V	2.0	15.2
54.240000	20.40	40.00	19.60	1000.0	120.000	100.0	V	155.0	14.7
67.800000	25.42	40.00	14.58	1000.0	120.000	100.0	V	19.0	11.3
94.920000	28.31	43.50	15.19	1000.0	120.000	296.0	H	52.0	13.0
122.040000	29.57	43.50	13.93	1000.0	120.000	273.0	H	155.0	11.0
151.650000	22.08	43.50	21.42	1000.0	120.000	100.0	V	189.0	9.6
192.990000	25.10	43.50	18.40	1000.0	120.000	150.0	H	0.0	12.4
216.630000	26.00	46.00	20.00	1000.0	120.000	102.0	H	2.0	12.7
352.560000	24.96	46.00	21.04	1000.0	120.000	100.0	H	35.0	16.1

Picture 15: Radiated emission 30 MHz - 1000MHz @ 3m distance

Spectrum Mask

Test procedure

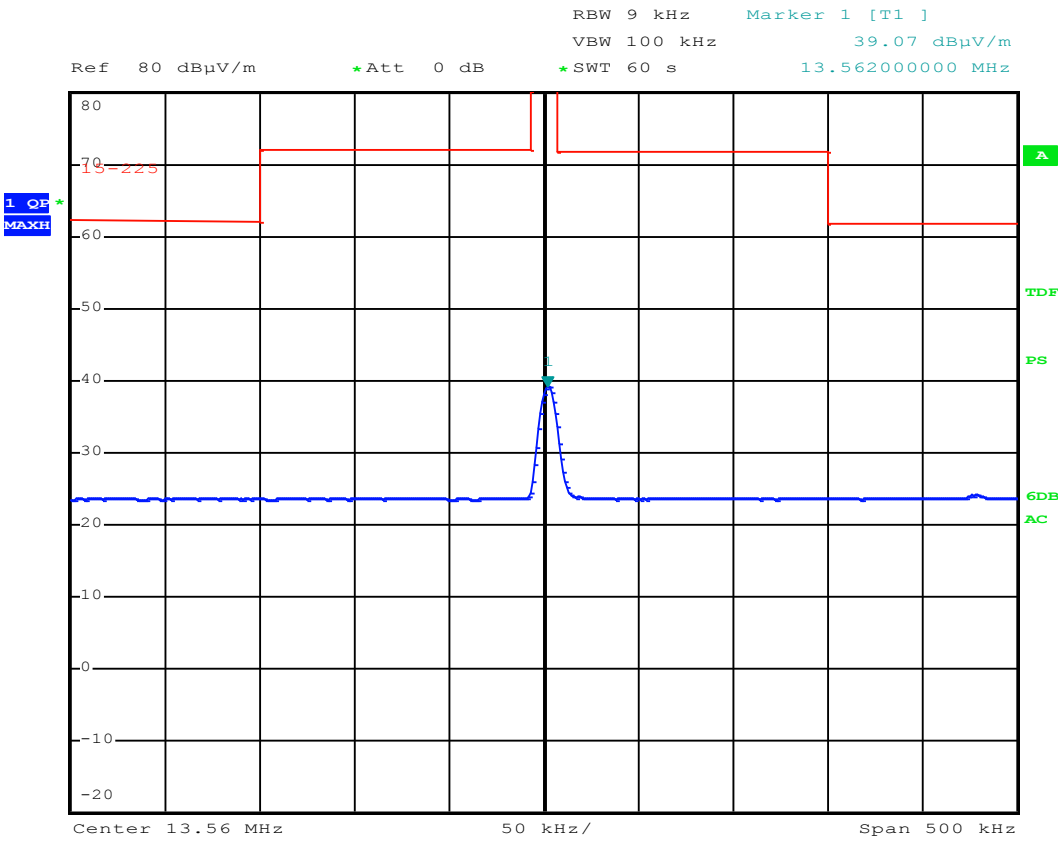
The EUT was placed in a fully anechoic chamber and the testing was performed in accordance with ANSI C63.10 and 47 CFR Part 15, section 15.225 (a) to (d). The measurement distance was 3 m. To find the closest margin of the spectrum to the limit mask adapted to the test distance the EUT was rotated by 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.

Worst-cases for the respective tests were as follows:

- chip 0 stand alone: EUT-position2 in combination with antenna in line
- chip 1 stand alone: EUT-position1 in combination with antenna in line
- chip 0 & chip 1 both active: EUT-position1 in combination with antenna in line

Test result Chip 0

Temperature:	24°C	Humidity:	50%
Tested by:	Martin Müller	Test date:	2016-08-16



Picture 16: Spectrum mask for 13.56 MHz @ 3m distance

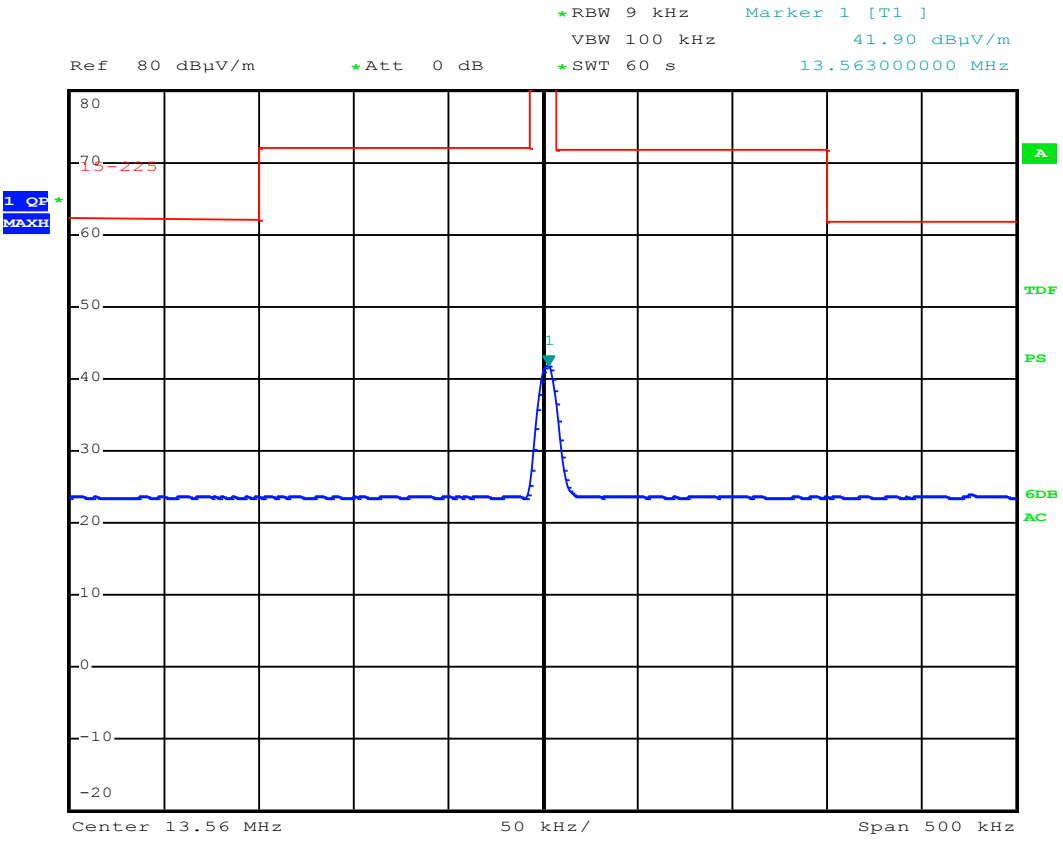
Frequency (MHz)	Measured value (dBµV/m)	Detector	Recalculation factor (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin	Result
13.562	39.07	QP	-21.39	17.68	84	66.32	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 39.07 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.522 m @ 13.562 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.61) dB
= -21.39 dB
Recalculated value = 39.07 dBµV/m @ 3 m - 21.39 dB = **17.68 dBµV/m @ 30 m**

Test result Chip 1

Temperature:	24°C	Humidity:	50%
Tested by:	Martin Müller	Test date:	2016-08-16



Picture 17: Spectrum mask for 13.56 MHz @ 3m distance

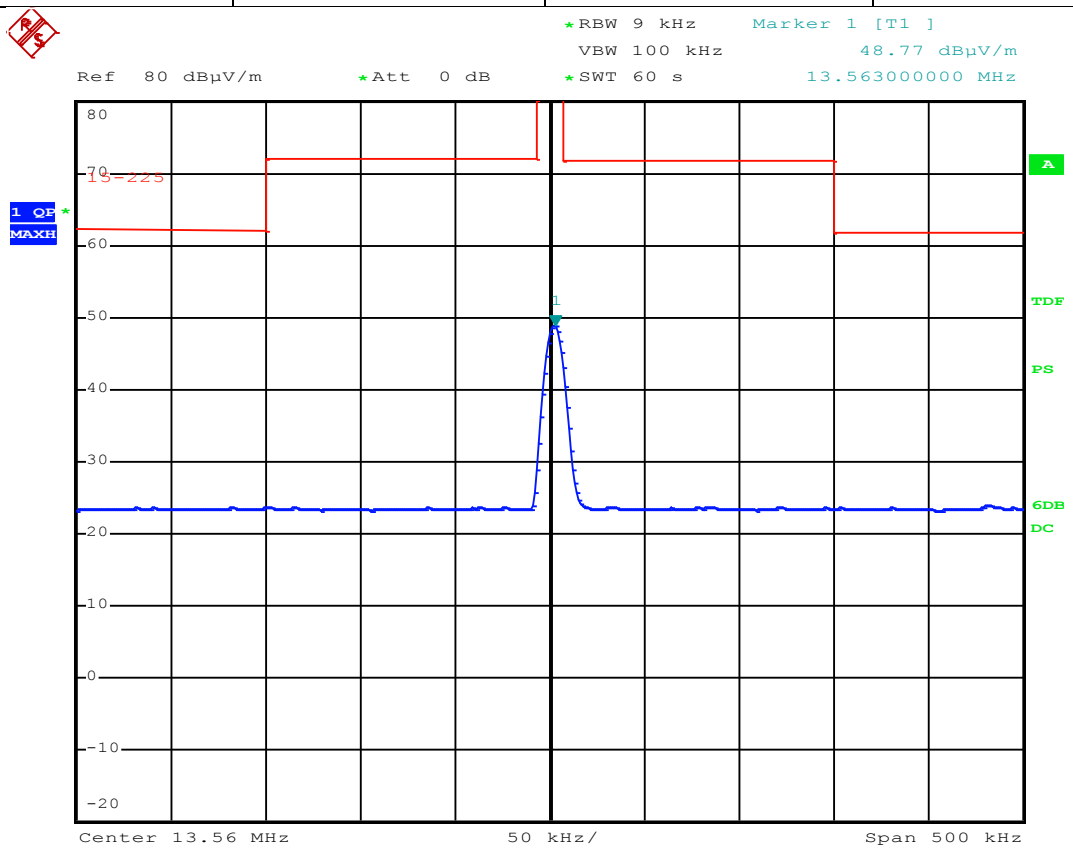
Frequency (MHz)	Measured value (dBµV/m)	Detector	Recalculation factor (dB)	Field strength (dBµV/m)	Limit (dBµV/m)	Margin	Result
13.563	41.90	QP	-21.39	20.51	84	63.49	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 41.90 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.522 m @ 13.563 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.61) dB
= -21.39 dB
Recalculated value = 41.90 dBµV/m @ 3 m - 21.39 dB = **20.51 dBµV/m @ 30 m**

Test result Chip 0 & Chip 1

Temperature:	24°C	Humidity:	50%
Tested by:	Martin Müller	Test date:	2016-08-16



Picture 18: 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	Result
13.563	48.77	QP	-21.39	27.38	84	56.62	PASS

Note 1:
Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 “Extrapolation from the measurement of a single point”:

Measured value = 48.77 dBµV/m @ 3 m
$d_{near\ field}$ = 47.77 / f_{MHz} = 3.522 m @ 13.563 MHz
$d_{measure}$ = 3 m
d_{limit} = 30 m
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
= -(2.79 + 18.60) dB
= -21.39 dB
Recalculated value = 48.77 dBµV/m @ 3 m - 21.39 dB = **27.38 dBµV/m @ 30 m**

6 Radiated emission measurement (>1 GHz)

according to 47 CFR Part 15, section 15.209(a),
RSS-210, section 4.3 and Annex B.6 with RSS-Gen, section 8.9

6.1 Test Location

☒ Scan with peak and average detector in 3 m semi anechoic chamber.

☒ Final measurement with peak and average detector in 3 m semi anechoic chamber.

Description	Manufacturer	Inventory No.
Semi anechoic chamber (SAC)	Albatross Projects GmbH	E00716

6.2 Test instruments

	Description	Manufacturer	Inventory No.
☐	ESCI (OATS)	Rohde & Schwarz	E00552
☐	ESU 26 (AC)	Rohde & Schwarz	W00002
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☒	ESR7 (SAC)	Rohde & Schwarz	E00739
☐	VULB 9163 (OATS)	Schwarzbeck	E00013
☐	VULB 9160 (CDC)	Schwarzbeck	E00011
☐	VULB 9162-041 (SAC)	Schwarzbeck	E00643
☐	HFH2-Z2 (CDC & OATS)	Rohde & Schwarz	E00060
☒	BBHA 9120	Schwarzbeck	E00052
☒	AMF-5D-00501800	Parzich	W00089
☐	Cable set CDC	Huber + Suhner	E00459, E00446
☐	Cable set AC 3 m	Huber + Suhner	W00095, E00432, E00307
☐	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
☒	Cable set SAC 3 m	Huber + Suhner	E00804, E00806, E00807

6.3 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

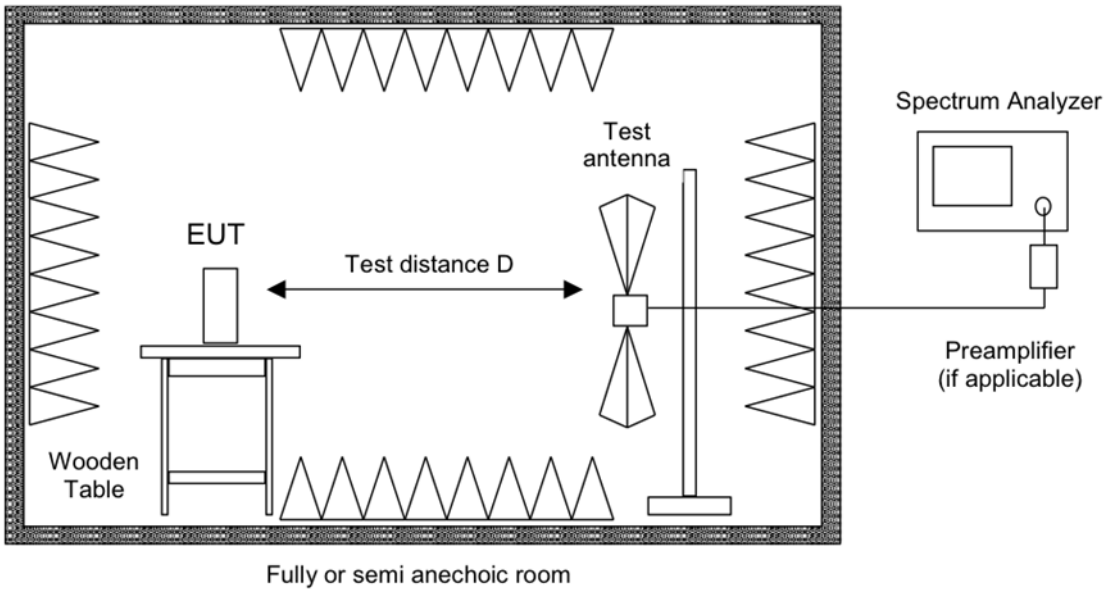
According to 15.35(b) on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions of 20 dB above the maximum permitted average emission limit.

6.4 Test procedure

1. The test setup is placed inside a semi anechoic chamber with floor absorbers between receiving antenna and EUT.
2. EUT and peripherals are configured according to ANSI C63.10. EUT is placed on the top of the turntable 0.8 meter above ground. EUT and all peripherals are powered on.
3. Exploratory radiated emissions measurements are performed by moving the receiving antenna over all sides of the EUT at a closer distance while observing the display of the test receiver to find the emissions to be re-tested during final radiated emission measurements. As a result a list of frequencies containing position of EUT as well as polarization of receiving antenna.
4. For final radiated emission measurements the receiving antenna is placed 3 meters from the turntable.
5. The receiving antenna is set to vertical polarization.
6. The EMI receiver performs a scan from 1000 MHz up to the frequency as specified in 15.33(a) for intentional radiator part and 15.33(b) for unintentional radiator part of EUT. The detector is set to Peak and Average with a measurement bandwidth of 1 MHz.
7. The turn table is rotated to 12 different positions (360° / 12 = 30°) and the antenna is moved between 1 m and 4 m height. The tilt of the antenna is changed automatically by changing the height of the antenna.
8. Change polarization to horizontal and repeat step 6 and 7.
9. After recording prescan values in horizontal and vertical polarization data reduction is performed using a margin of 10 dB to the appropriate limit.
   The critical frequencies are re-measured using a Peak and Average detector with a bandwidth set to 1 MHz. At every frequency the polarization with the emission closest to the limit is selected for final test.
10. During Final measurement the turntable is rotated by +/ - 30° to determine the position of the highest radiation around the maximum emission found during the prescan.
11. The height of the broadband receiving antenna is varied between 1 m and 4 m above ground, the slope of the antenna is changed automatically by variation of the antenna height to find the maximum emissions field strength of both horizontal and vertical polarization. The highest value is recorded.

During pre-tests EUT-position 2 was investigated as worst-case.

6.5 Test setup



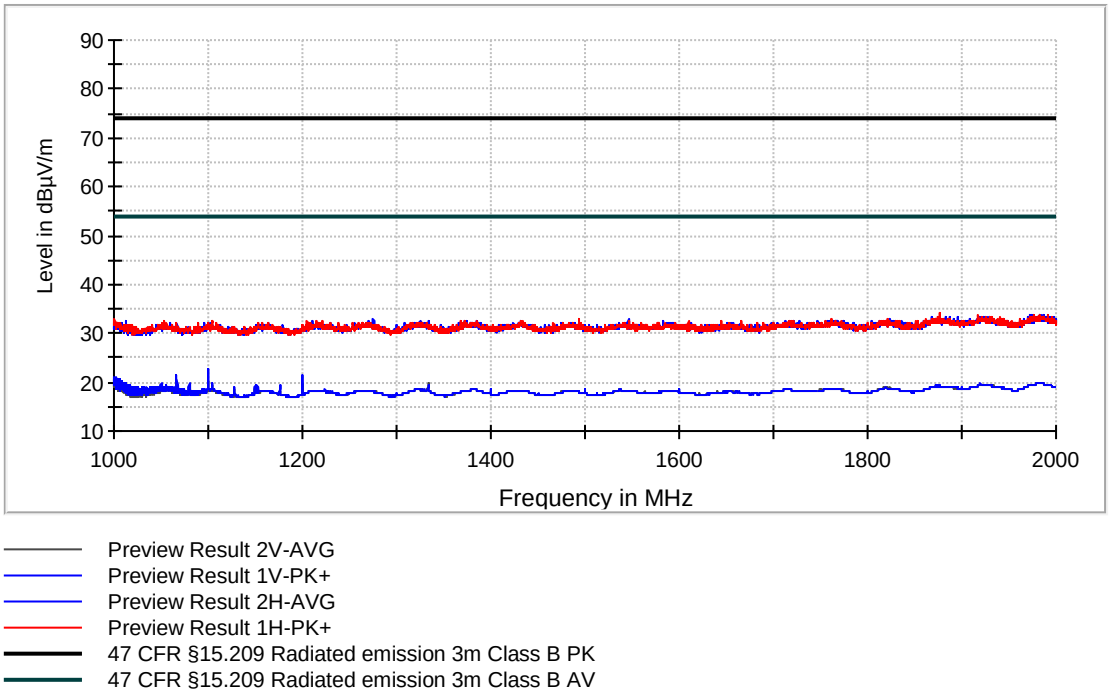
Picture 19: Test setup for radiated emission measurement (> 1 GHz)

6.6 Test deviation

There is no deviation from the standards referred to.

6.7 Test results

Temperature:	25°C	Humidity:	51%
Tested by:	Martin Müller	Test date:	2016-08-30



Picture 20: Radiated emission measurement (>1 GHz)

7 Carrier frequency stability

according to 47 CFR Part 15, section 15.225(e), and RSS-210, Annex B.6 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	Rohde & Schwarz	E00552
☒	RF-R 400-1	Langer EMV-Technik	E00270

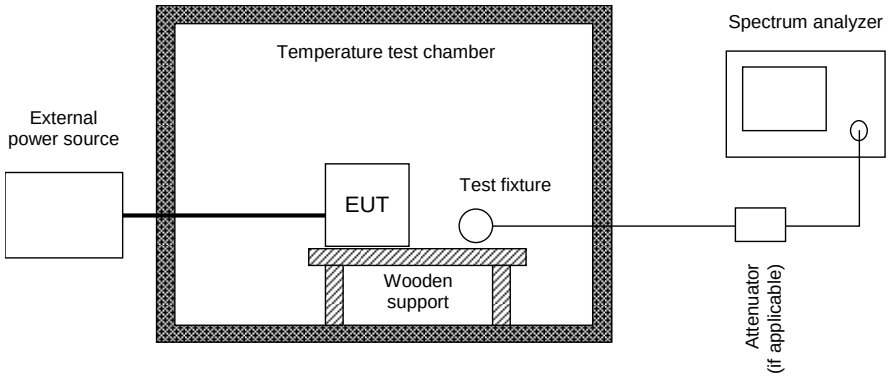
7.3 Limits

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 21: Test setup for carrier frequency stability measurement

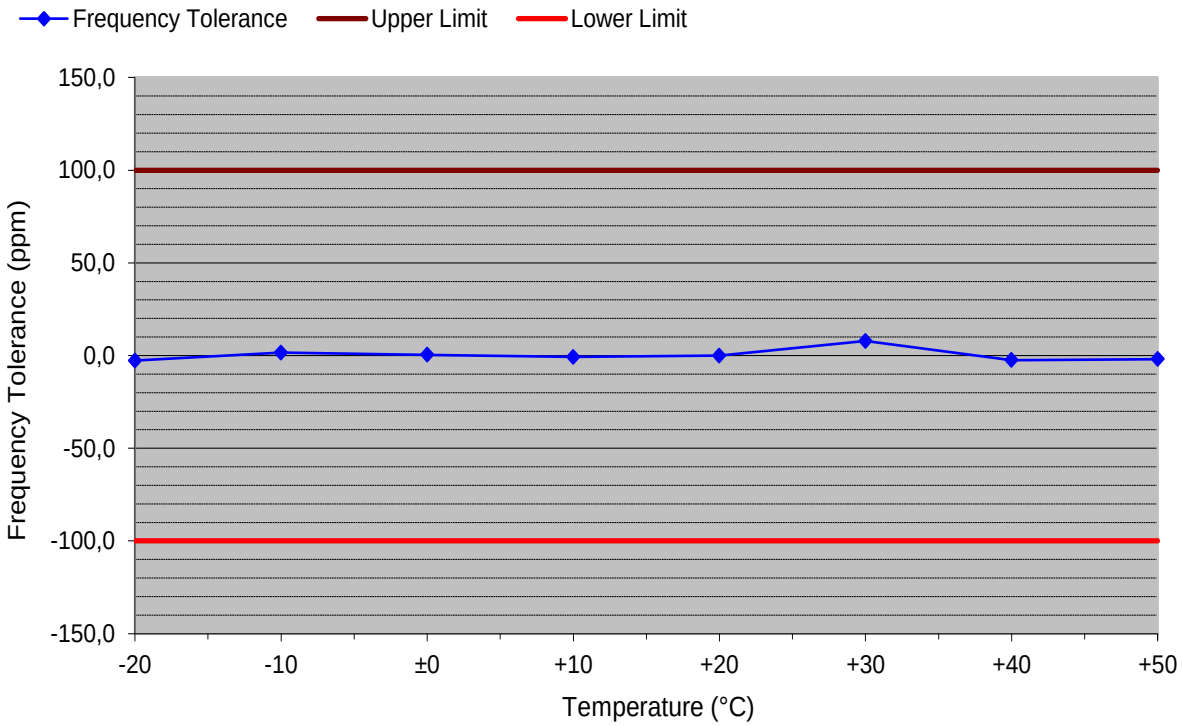
7.6 Test deviation

There is no deviation from the standards referred to.

Test result

Temperature:	----	Humidity:	----
Tested by:	Martin Müller	Test date:	2016-04-14

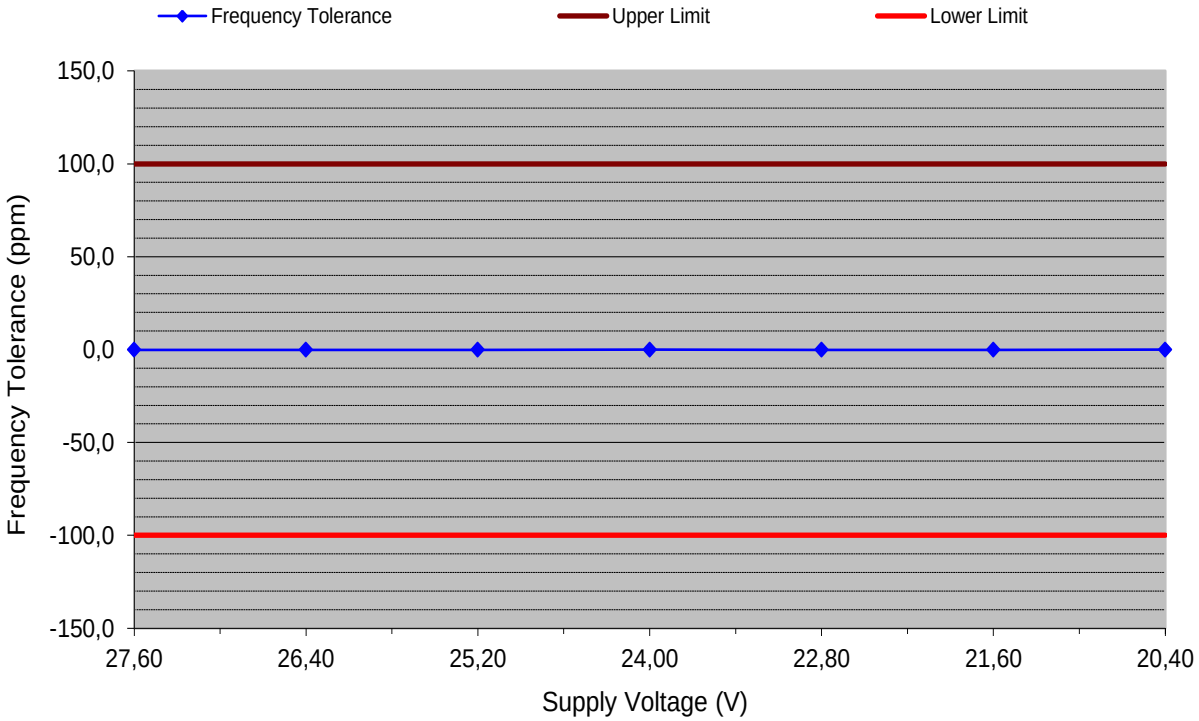
Carrier frequency stability vs. temperature, Chip 0



Supply voltage:	24 V	Frequency under nominal conditions:	13,559876 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	
-20	13,559839	-37	-2,7	+100,0	-100,0	
-10	13,559898	22	1,6	+100,0	-100,0	
±0	13,559881	5	0,4	+100,0	-100,0	
+10	13,559866	-10	-0,7	+100,0	-100,0	
+20	13,559876	0	0,0	+100,0	-100,0	
+30	13,559982	106	7,8	+100,0	-100,0	
+40	13,559843	-33	-2,4	+100,0	-100,0	
+50	13,559850	-26	-1,9	+100,0	-100,0	

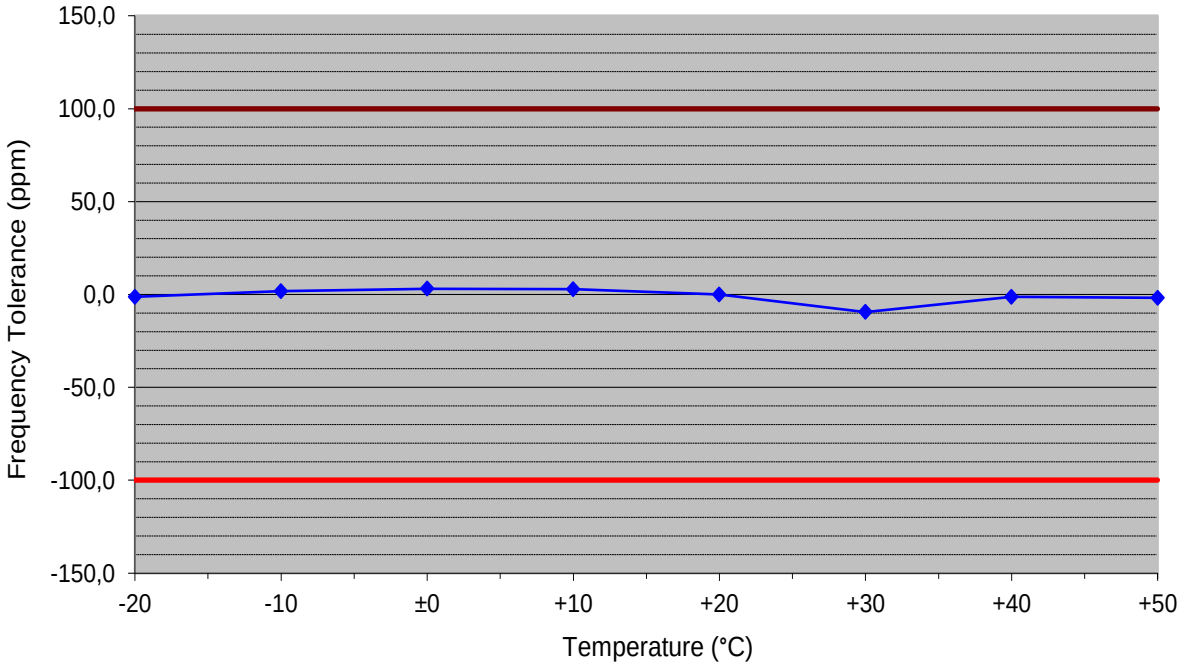
Carrier frequency stability vs. supply voltage, Chip 0



Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,56 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	
27,60	13,559874	-2	-0,1	+100,0	-100,0	
26,40	13,559874	-2	-0,1	+100,0	-100,0	
25,20	13,559874	-2	-0,1	+100,0	-100,0	
24,00	13,559876	0	0,0	+100,0	-100,0	
22,80	13,559874	-2	-0,1	+100,0	-100,0	
21,60	13,559874	-2	-0,1	+100,0	-100,0	
20,40	13,559875	-1	-0,1	+100,0	-100,0	

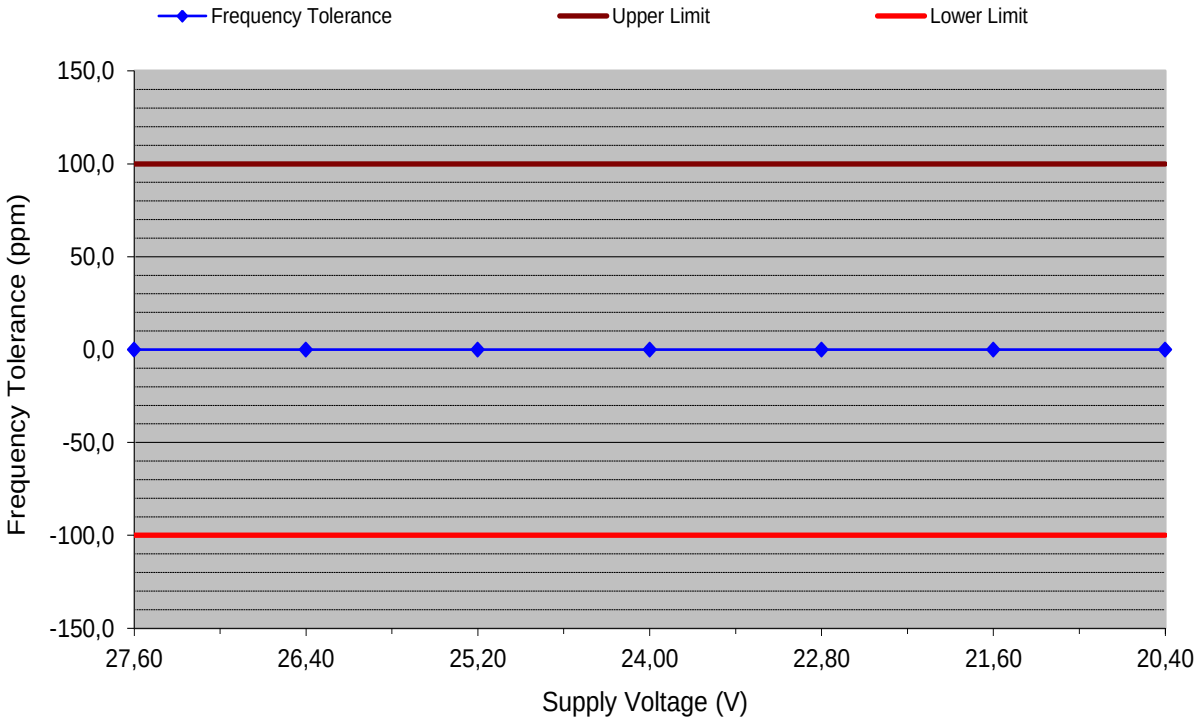
Carrier frequency stability vs. temperature, Chip 1



Supply voltage:	24 V	Frequency under nominal conditions:	13,559978 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	(ppm)	Upper Limit (ppm)	Lower Limit (ppm)	
-20	13,559960	-18	-1,3	+100,0	-100,0	
-10	13,560002	24	1,8	+100,0	-100,0	
±0	13,560020	42	3,1	+100,0	-100,0	
+10	13,560016	38	2,8	+100,0	-100,0	
+20	13,559978	0	0,0	+100,0	-100,0	
+30	13,559850	-128	-9,4	+100,0	-100,0	
+40	13,559960	-18	-1,3	+100,0	-100,0	
+50	13,559953	-25	-1,8	+100,0	-100,0	

Carrier frequency stability vs. supply voltage, Chip 1



Temperature:	+20 °C	Battery End Point:	Not applicable
Frequency under nominal conditions:	13,56 MHz		

Supply Voltage (V)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	
27,60	13,559977	-1	-0,1	+100,0	-100,0	
26,40	13,559977	-1	-0,1	+100,0	-100,0	
25,20	13,559977	-1	-0,1	+100,0	-100,0	
24,00	13,559978	0	0,0	+100,0	-100,0	
22,80	13,559978	0	0,0	+100,0	-100,0	
21,60	13,559978	0	0,0	+100,0	-100,0	
20,40	13,559978	0	0,0	+100,0	-100,0	

8 Bandwidths

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

8.1 Test Location

See clause 5.1 on page 21.

8.2 Test instruments

See clause 5.2 on page 21.

8.3 Limits

The bandwidths are recorded only. There are no limits specified in 47 CFR Part 15, section 15.225, and RSS-210, Annex B.6

8.4 Test setup

See clause 5.5 on page 24.

8.5 Test deviation

There is no deviation from the standards referred to.

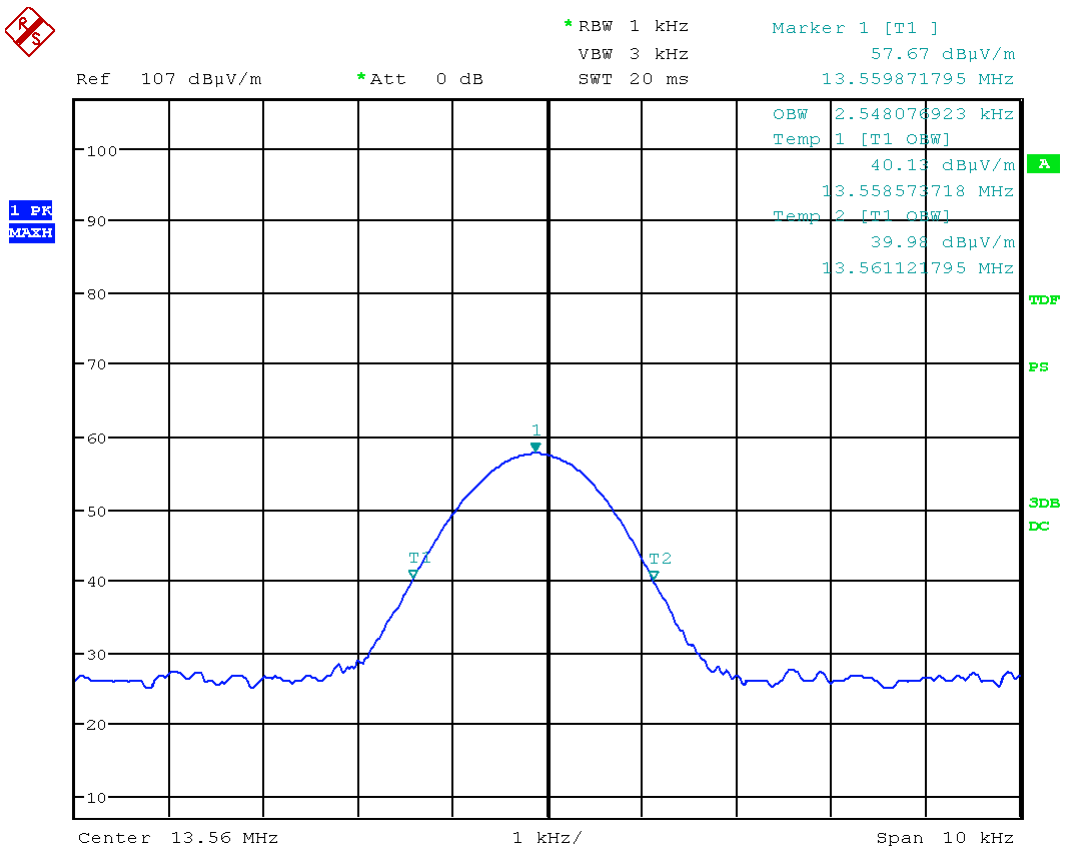
8.6 Test results Chip 0

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-04-14

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.



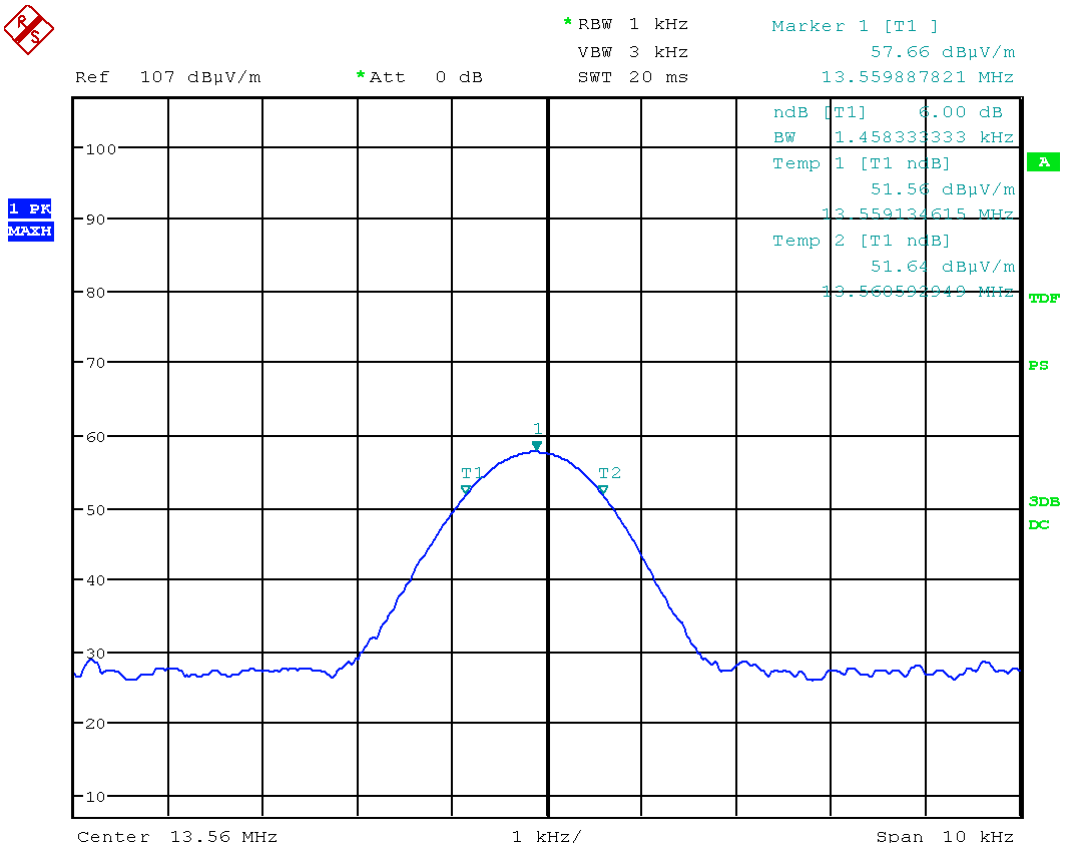
Picture 22: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 2.5481 kHz

-6 dB emission bandwidth

Test procedure

Where indicated, the -6 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 6 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



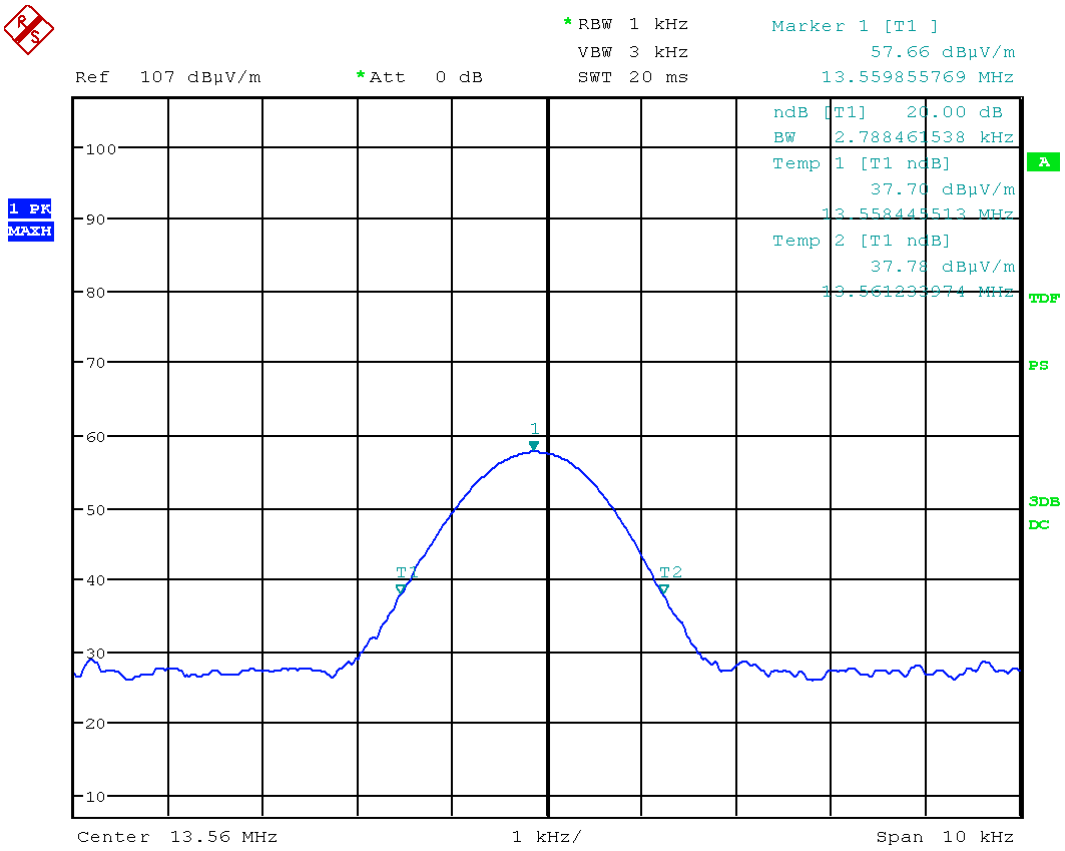
Picture 23: -6 dB emission bandwidth

Measured -6 dB emission bandwidth: 1.4583 kHz

-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 24: -20 dB emission bandwidth

Measured -20 dB emission bandwidth: 2.7885 kHz

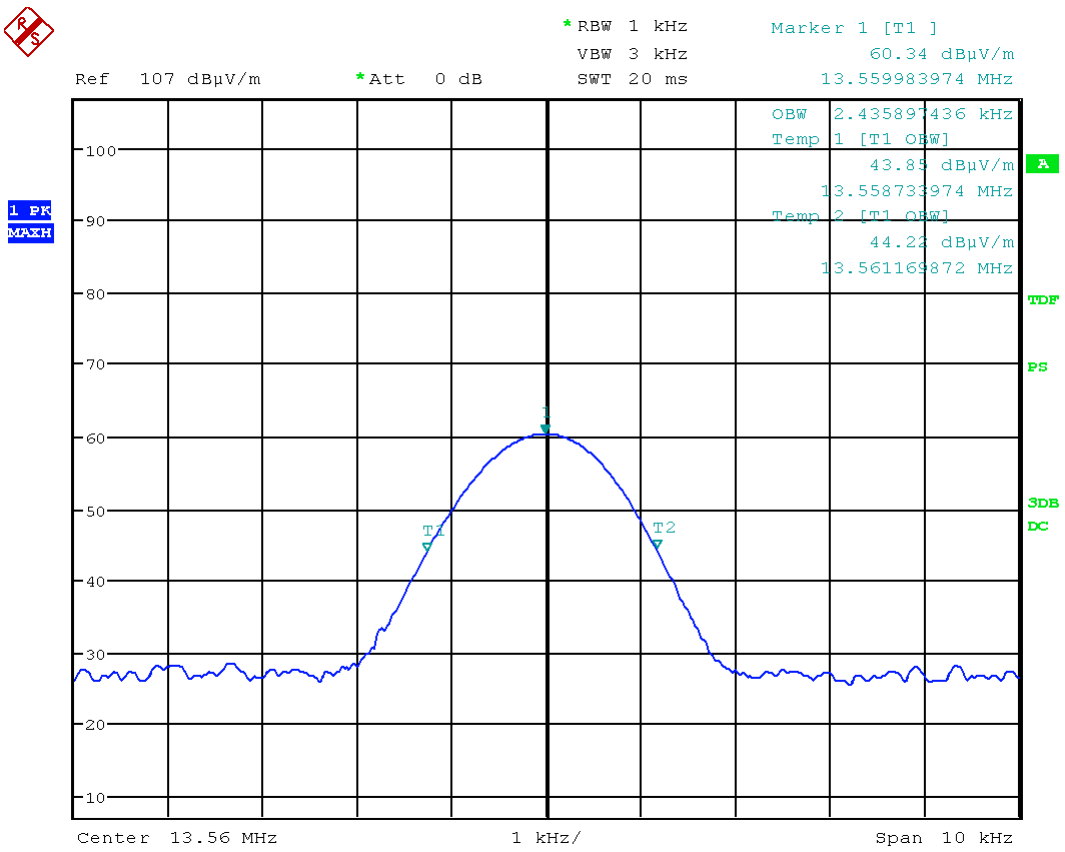
8.7 Test results Chip 1

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2016-04-14

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.



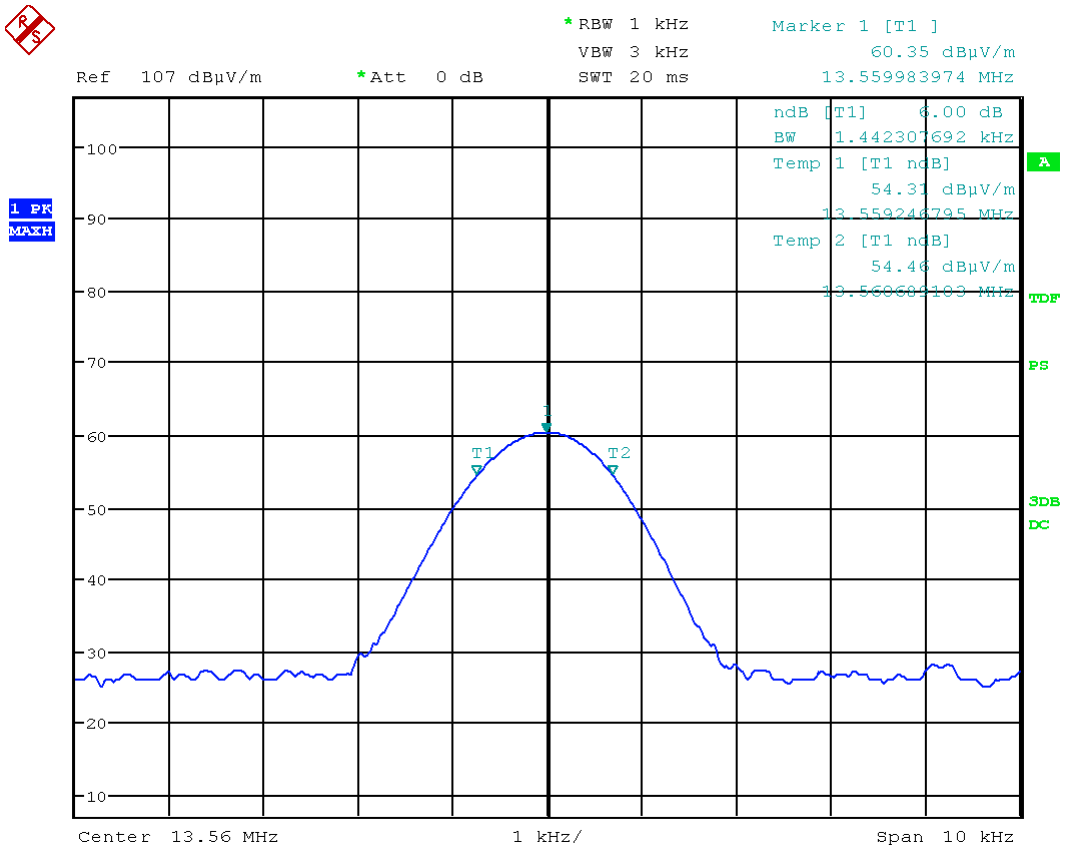
Picture 25: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 2.4359 kHz

-6 dB emission bandwidth

Test procedure

Where indicated, the -6 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 6 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



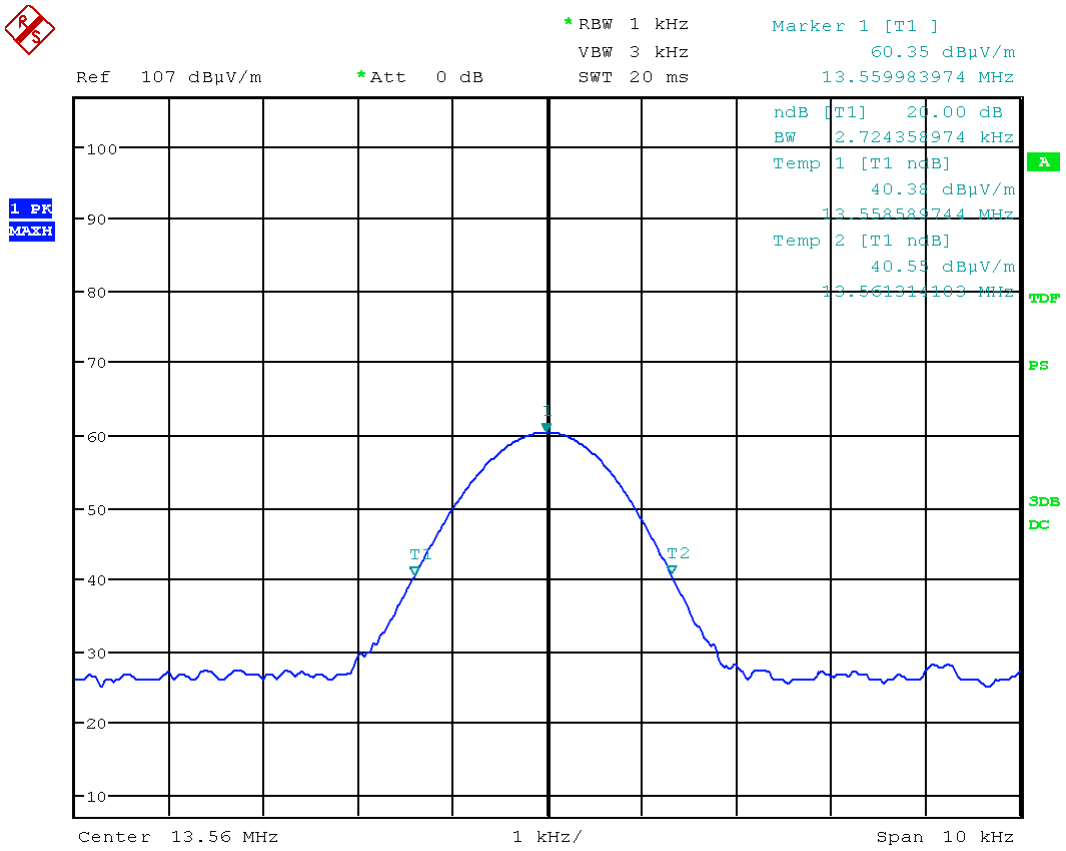
Picture 26: -6 dB emission bandwidth

Measured -6 dB emission bandwidth: 1.4423 kHz

-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 27: -20 dB emission bandwidth

Measured -20 dB emission bandwidth: 2.7244 kHz

9 Estimation of RF radiation exposure for mobile devices

according to 47 CFR Part 2, section 2.1091, and RSS-102, sections 3.2 and 4

This estimation follows the general guidelines for RF Exposure according to KDB 447498.

As noted in §2.1091(b) a mobile device is defined as “a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a **separation distance of at least 20 centimeters** is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.”
According to §2.1091(c) the limits to be used for evaluation are defined in §1.1310.

As specified in §1.1310(d)(2) at operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE), derived from whole-body SAR limits and listed in Table 1 of §1.1310(e) may be used.

Table 1 below shows the limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3 - 3.0	614	1.63	*100	6
3.0 - 30	1842/f	4.89/f	$*900/f^2$	6
30 - 300	61.4	0.163	1.0	6
300 - 1500			f/300	6
1500 - 100000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3 - 1.34	614	1.63	*100	30
1.34 - 30	824/f	2.19/f	$*180/f^2$	30
30 - 300	27.5	0.073	0.2	30
300 - 1500			f/1500	30
1500 - 100000			1.0	30

Table 1: Limits for maximum permissible exposure (MPE) according to table 1 of §1.1310(e)

Notes:
1. f = frequency in MHz.
2. * = Plane-wave equivalent power density.
3. Limits for electric field strength correspond to appropriate limits for magnetic field strength using wave impedance in free space of about 120·π Ω.

Appropriate RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment) can be found in table 4 of RSS-102, section 4:

Frequency Range (MHz)	**Electric Field (V/m rms)**	**Magnetic Field (A/m rms)**	**Power Density (W/m^2)**	**Reference Period (minutes)**
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	0.73/f	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619\ f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\ f^{0.5}$	$4.21 \times 10^{-4}\ f^{0.5}$	$6.67 \times 10^{-5}\ f$	$616000/f^{1.2}$
Note: f is frequency in MHz. *Based on nerve stimulation (NS). ** Based on specific absorption rate (SAR).				

Table 2: RF field strength limits according to table 4 of RSS-102

Antenna (chip)	Frequency (MHz)	RF field strength, PK (dBµV/m)	RF field strength, QP (dBµV/m)
0	13.562	42.17	----
	13.562	----	39.07
1	13.560	44.36	----
	13.563	----	41.90
0 & 1	13.561	**51.06**	----
	13.563	----	48.77

Table 3: Measured RF field strength at 3 m

Maximum peak value measured at 13.561 MHz in a test distance of 3 m:
E_{meas}(3 m) = 51.06 dBµV/m

Worst case field strength is calculated for a separation distance of 20 centimeters.

Using an extrapolation factor of 40 dB/decade (~ r^{-2}) results in:
E_{calc}(20 cm) = 51.06 dBµV/m - 40 · log(0.2 m/3 m) = 51.06 dBµV/m + 47.04 dB
E_{calc}(20 cm) = 98.10 dBµV/m = 0,08 V/m

Using an extrapolation factor of 60 dB/decade (~ r^{-3}) results in:
E_{calc}(20 cm) = 51.06 dBµV/m - 60 · log(0.2 m/3 m) = 51.06 dBµV/m + 70.56 dB
E_{calc}(20 cm) = 121.62 dBµV/m = 1.21 V/m

Comparing these results to the limits for general population/uncontrolled exposure for 13.56 MHz shows that even with worst case calculation the limits are kept.
As the limits for electric field strength correspond to appropriate limits for magnetic field strength using wave impedance in free space of about 120·π Ω it is sufficient to check the limits for electric field strength.

E_{calc}(20 cm) (V/m)	Limit 47 CFR Par 1, §1.1310(e) (V/m)	Limit RSS-102, table 4 (V/m)
1.21	60.77	27.46

Table 4: Calculated results compared to RF field strength limits

10 Equipment calibration status

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Test receiver	ESU 26	100026	W00002	2016-03	2018-03
Test receiver	ESCI	100013	E00001	2016-02	2018-02
Test receiver	ESCI	100328	E00552	2016-07	2018-07
Test receiver	ESR7	101059	E00739	2016-02	2018-02
LISN	ESH2-Z5	881362/037	E00004	2015-06	2017-06
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Broadband antenna	VULB 9160	9160-3050	E00011	2014-09	2016-09
Broadband antenna	VULB 9163	9163-114	E00013	2015-09	2017-09
Broadband antenna	VULB 9162-041	9162-041	E00643	2015-11	2017-11
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-07	2018-07
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	
Semi-anechoic chamber (SAC)	P26726	C62128-A520-A643-x-0006	E00716	2015-03	2017-03
Anechoic chamber (AC)	---	---	E00100	2014-10	2016-10
Climatic chamber 340 l	VC³ 4034	58566123250010	C00015	2014-09	2016-09
Cable set shielded room	Cable no. 30	---	E00424	2016-07	2017-07
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
Cable set SAC 3 m	Cables no. 57, 58 and 59	---	E00453 E00455 E00458	2015-10	2017-10
Cable set anechoic chamber	Cables no. 01, 02 and 09	---	W00095 E00307 E00432	2015-04	2016-04

Table 5: Equipment calibration status

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

Note 2: Expiry date of measurement facility registration by

- FCC (registration number 221458): 2017-04
- Industry Canada (test site numbers 3472A-1 and 3472A-2): 2018-11

11 Measurement uncertainty

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

Table 6: 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.

12 Revision History

Date	Description	Person	Revision
2016-09-15	First edition	M. Müller	0