Test Report

Customer:

eGym GmbH

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Tel.: +49 89 921 3105-00
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RF test report

170673-AU01+W01

eGym GmbH

RFID Reader

eGym RFID Board

EMV **TESTHAUS** GmbH

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

Accreditation:

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

Test Firm Type “2.948 listed”: Valid until 2017-07-12
Test Firm Type “accredited”: Valid until 2019-05-06
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: 10-2017	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: 03-2017	Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
ANSI C63.10:2013-06	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
ICES-003 Issue 6, January 2016	Spectrum Management and Telecommunications Interference-Causing Equipment Standard Information Technology Equipment (ITE) – Limits and methods of measurement
RSS-Gen Issue 4, November 2014	Spectrum Management and Telecommunications Radio Standards Specification General Requirements and Information for the Certification of Radiocommunication Equipment
RSS-210 Issue 9, August 2016	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

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, May 15, 2018

Andreas Menacher
Test engineer
EMV **TESTHAUS** GmbH

Konrad Graßl
Head of radio department
EMV **TESTHAUS** GmbH

3 Equipment under Test (EUT)

Product type:	RFID Reader
Model Name:	eGym RFID Board
Applicant:	eGym GmbH
Manufacturer:	eGym GmbH
Serial number:	2
FCC ID:	2APOCEGYMRFID01S
IC certification number:	23832-EGYMRFID01S
Application frequency band:	13.110 to 14.010 MHz
Frequency range:	13.520 to 13.597 MHz
Operating frequency:	13.560 MHz
Number of RF-channels:	1
Modulation:	ASK
Antenna connector:	☐ permanent ☐ temporary ☒ none
Antenna types:	PCB antenna ☐ detachable ☒ not detachable
Maximum antenna gain:	n/a
Maximum conducted power:	---
Power supply:	USB powered nominal: 5.0 VDC ± 5 %
Temperature range:	-20°C to +50°C

Remark:

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 working at the frequency 13.56 MHz.

3.3 Operation mode

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

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

3.4 Configuration

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

Device	Model:	Serial or inventory no.
RFID Reader[1]	eGym RFID Board	2
RFID tag	13.56 MHz	----
AC power source (120 V / 60 Hz)	Chroma 616062	E00633
Power supply[2]	Chromecast	S005BBV0500100
DC supply[3]	Statron 3212.1	E00017
Digital multimeter[3]	METRA HIT 29S	SEB00199

3.5 Used cables

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

[1] Device was configured by the manufacturer to read the tag continuously. No PC was used for testing.
[2] Only representative.
[3] Only used for Carrier frequency stability test.

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

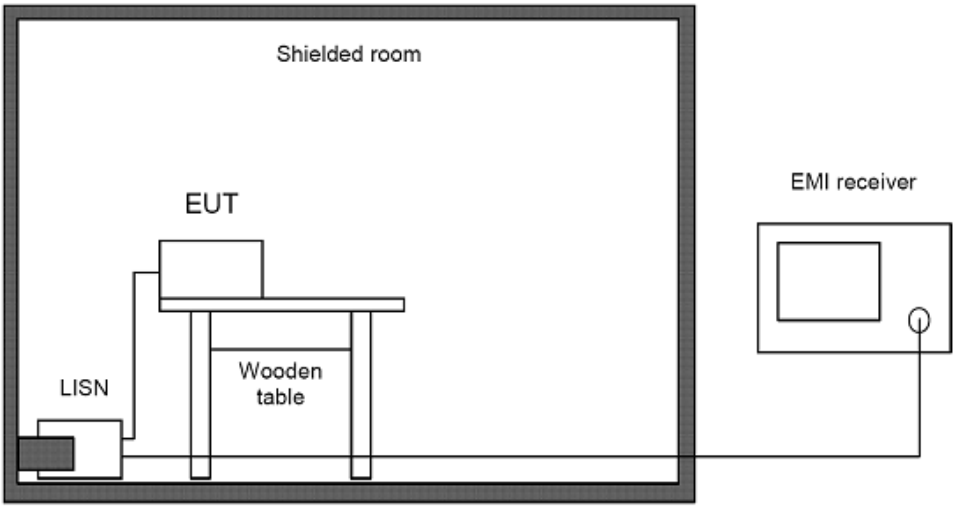
Frequency [MHz]	Quasi-peak [dBµV]	Avarage [dBµV]
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

4.4 Test procedure

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

4.5 Test setup

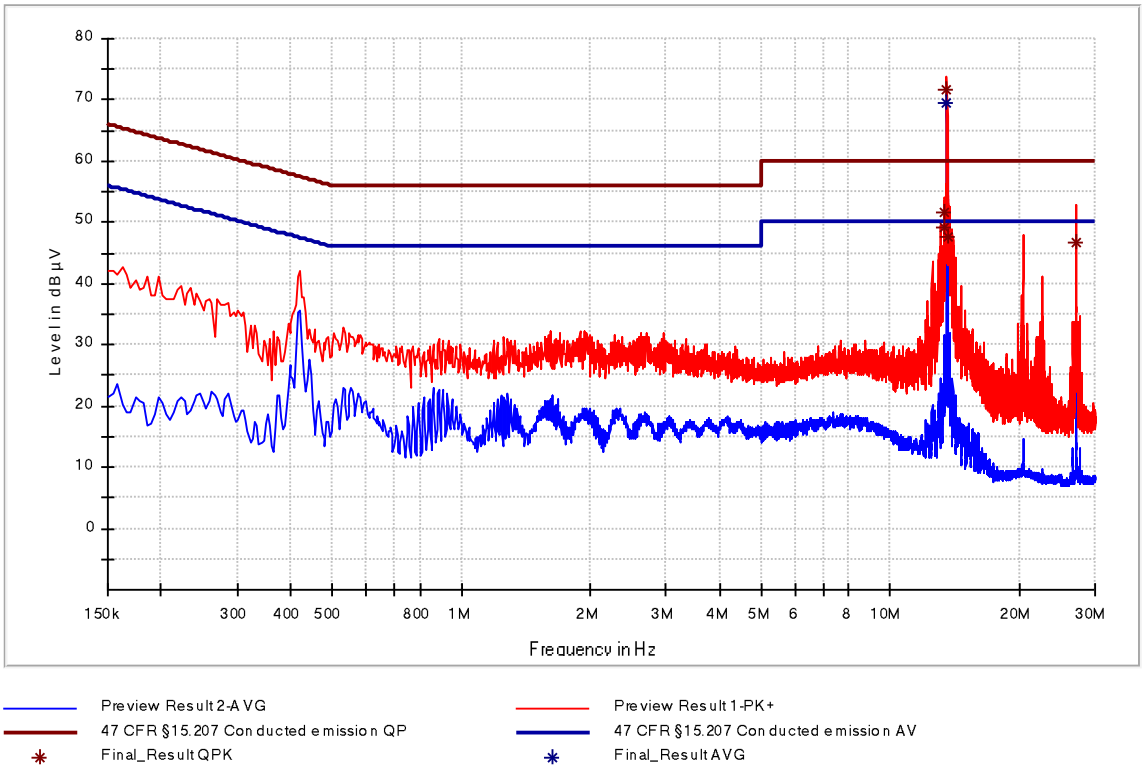


Picture 1: Outline of conducted emission test setup

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

4.6 Test results

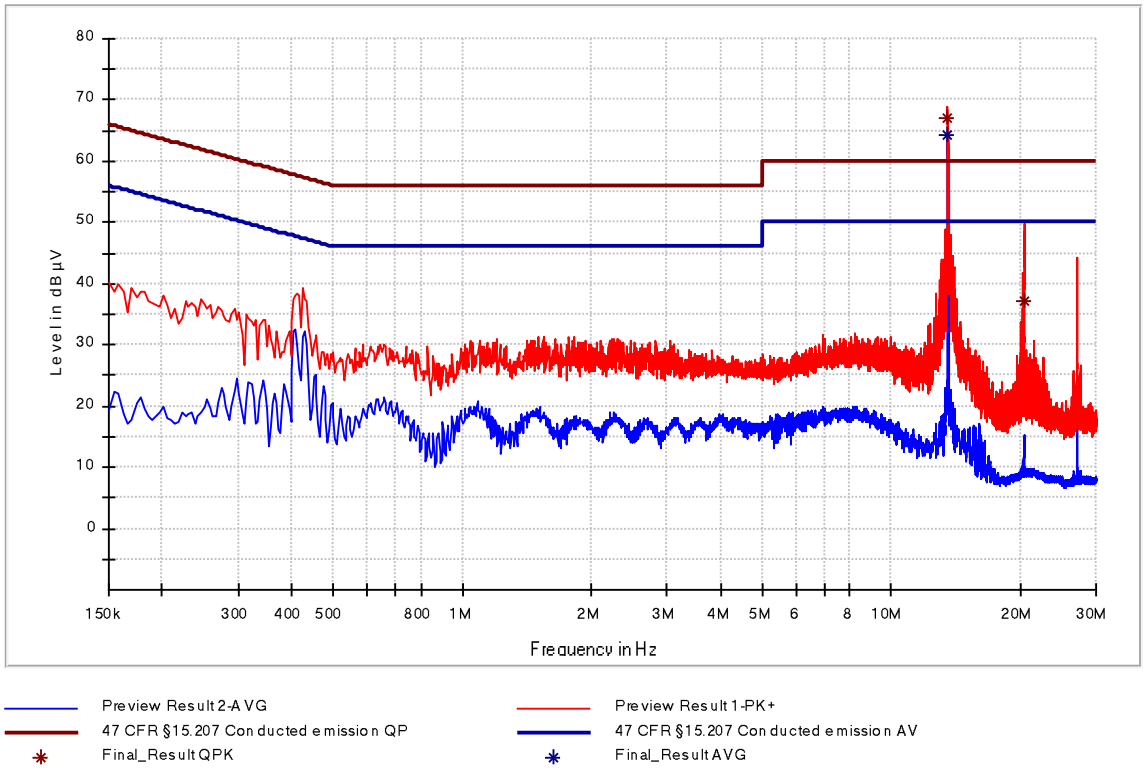
Temperature:	22°C	Humidity:	41%
Tested by:	Andreas Menacher	Test date:	2018-03-14



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

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
13.349000	51.68	---	60.00	8.32	L1	GND
13.425000	49.30	---	60.00	10.70	L1	GND
13.561000	---	69.41	50.00	-19.41	L1	GND
13.561000	71.70	---	60.00	-11.70	L1	GND
13.649000	47.60	---	60.00	12.40	L1	GND
27.121000	46.79	---	60.00	13.21	L1	GND

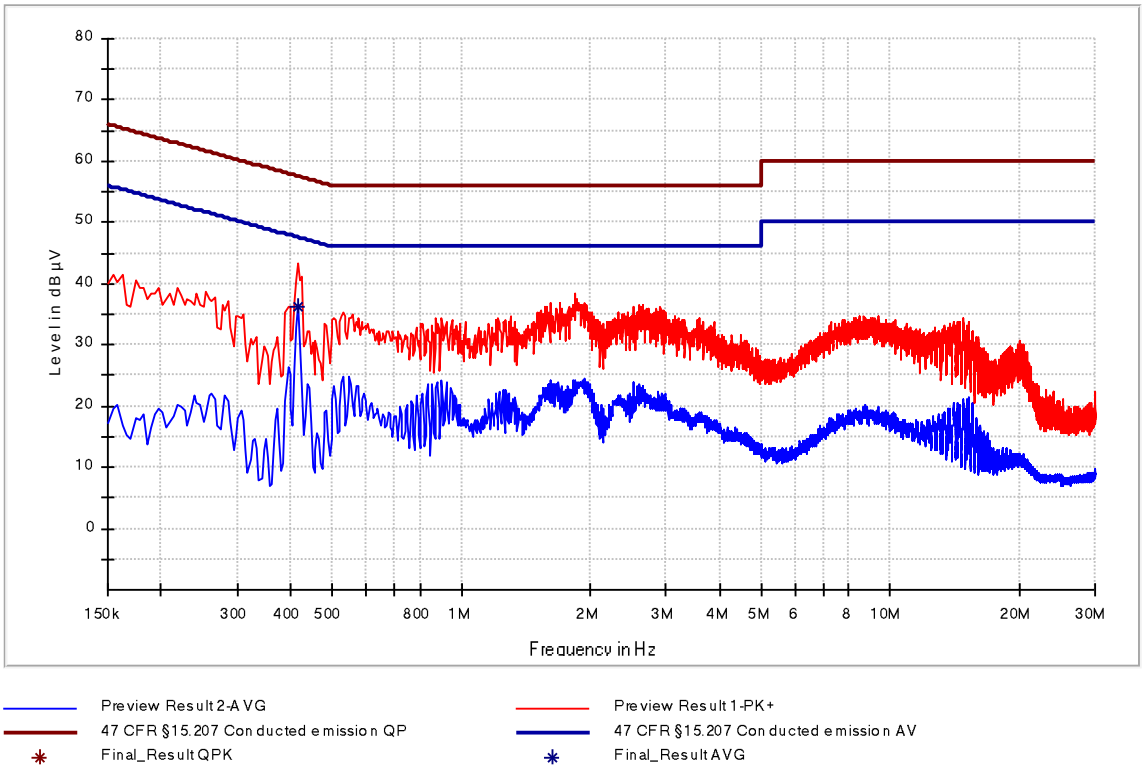
Picture 3: Table - Conducted emission on mains, phase 1 (without termination)



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

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
13.561000	---	64.14	50.00	-14.14	N	GND
13.561000	67.13	---	60.00	-7.13	N	GND
20.333000	37.29	---	60.00	22.71	N	GND

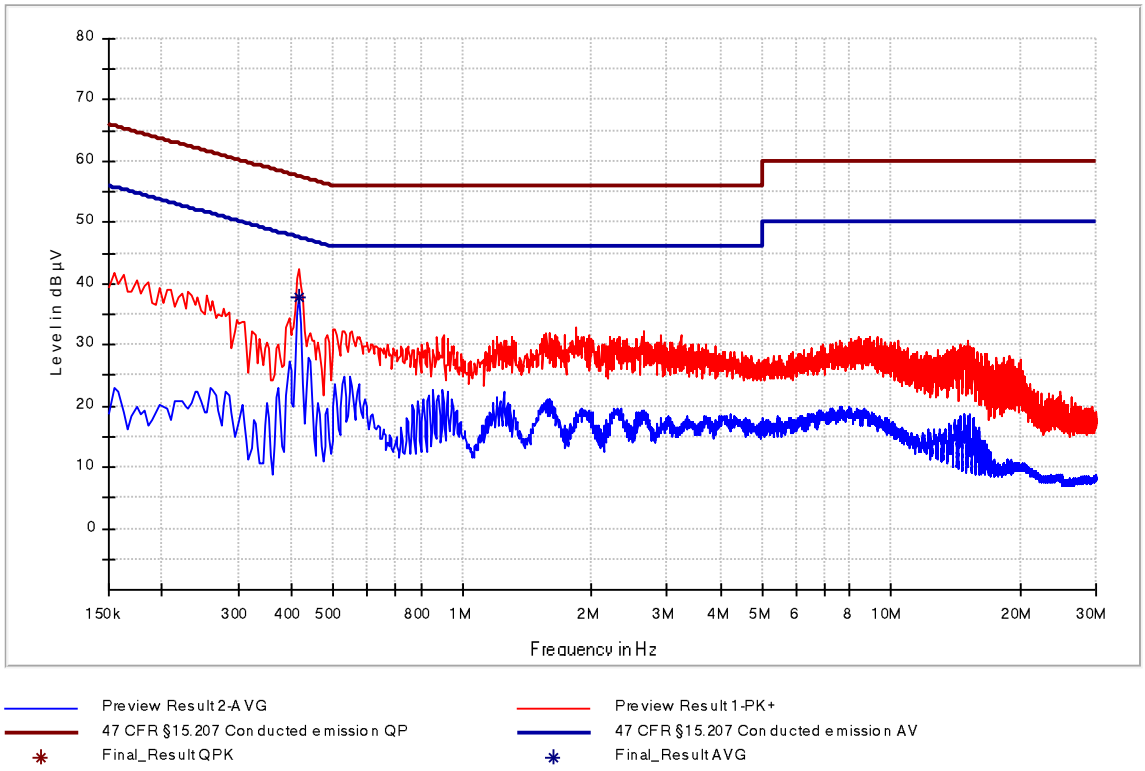
Picture 5: Table - Conducted emission on mains, neutral (without termination)



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

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
0.417000	---	36.27	47.51	11.24	L1	GND

Picture 7: Table - Conducted emission on mains, phase 1 (with termination)



Picture 8: Graphic - Conducted emission on mains, neutral (with termination)

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	PE
0.417000	---	37.88	47.51	9.63	N	GND

Picture 9: Table - Conducted emission on mains, neutral (with termination)

5 Radiated emission measurement (<1 GHz)

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

5.1 Test Location

☒ Scan with peak detector in 3 m CDC.

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

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

5.2 Test instruments

	Description	Manufacturer	Inventory No.
☒	ESCI (OATS)	Rohde & Schwarz	E00552
☐	ESCI (CDC)	Rohde & Schwarz	E00001
☐	ESU 26	Rohde & Schwarz	W00002
☒	ESR 7	Rohde & Schwarz	E00739
☒	VULB 9163 (OATS)	Schwarzbeck	E00013
☒	VULB 9163 (SAC)	Schwarzbeck	E00012
☒	HFH2-Z2	Rohde & Schwarz	E00060
☒	Cable set CDC	Huber + Suhner	E00060
☒	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
☒	Cable set SAC 3 m	Huber + Suhner	E00434, E00755, E00320

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

Radiated emissions below 30 MHz

1. For emissions below 30 MHz measurements are done using a loop antenna. Prescan is performed with peak detector and final measurements with quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 kHz where average detector applies. Antenna height is 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 are used.
2. EUT is configured according to ANSI C63.10. It is placed on the top of the turntable 0.8 meter above ground. The receiving antenna is placed 3 meters from the turntable. The test setup is placed inside a fully anechoic room (called “CDC”).
3. Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position
4. After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
5. With the test receiver set to the first frequency of the list, the EUT is rotated by ±45° around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
6. Step 5 is repeated for all other frequencies in the list.
7. Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission.

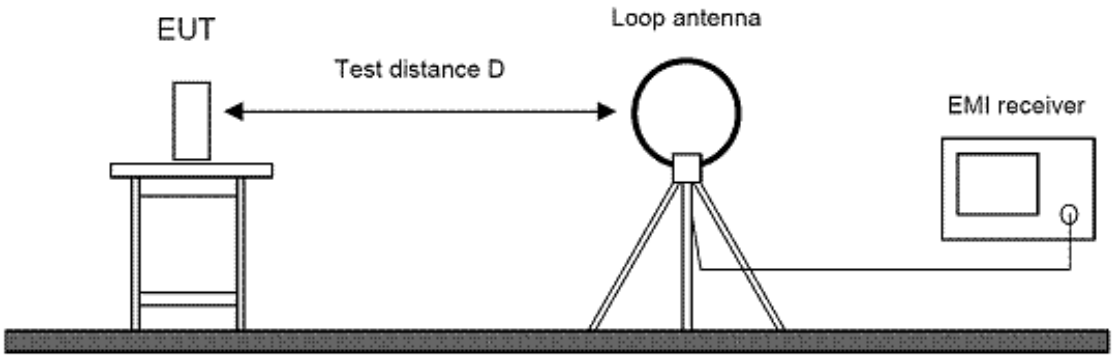
Radiated emissions from 30 MHz to 1 GHz

1. EUT is configured according to ANSI C63.10. It was placed on the top of the turntable 0.8 meter above ground. The receiving antenna is placed 3 meters from the turntable. The test setup was placed inside a semi-anechoic chamber (SAC).
2. EUT and all peripherals are powered on.
3. The broadband antenna is set to vertical polarization.
4. The table position is set to 0°.
5. The antenna height is set to 1 m.
6. The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
7. The antenna height is increased to 4 m in steps of 50 cm. At each height, step 6 is repeated.
8. The polarization of the measurement antenna is changed to horizontal.
9. The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step 6 is repeated.
10. The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps 5 to 9 are repeated.
11. After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.

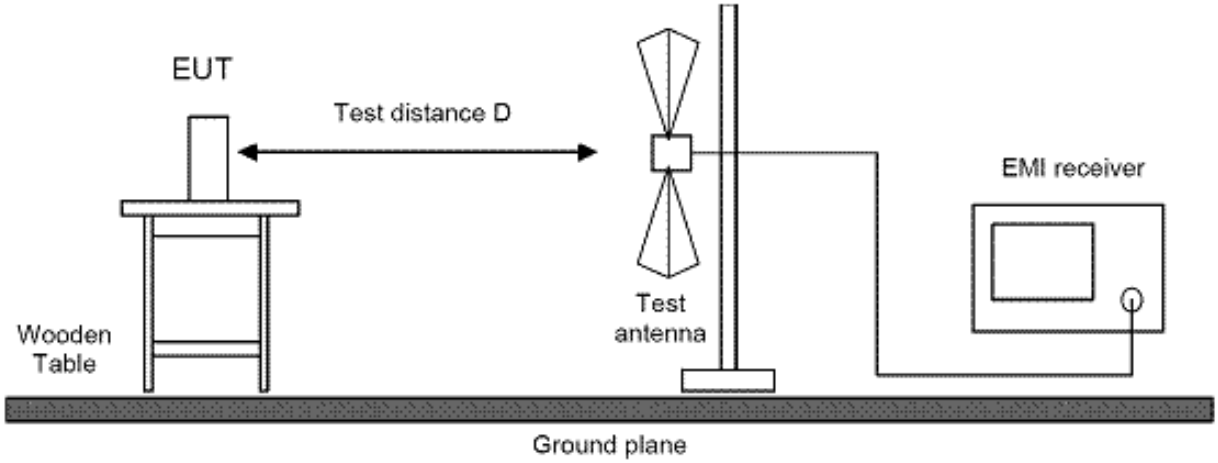
12. With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
13. The antenna is moved by ±50 cm around this height and the EUT is rotated by ±60° around this table position while measuring the emission level continuously.
14. For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
15. Steps 12 to 14 are repeated for all other frequencies in the list.

If the EUT may be used in various positions, steps 1 to 15 are repeated in two other orthogonal positions.

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:	20°C	Humidity:	41%
Tested by:	Andreas Menacher	Test date:	2018-03-22

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:

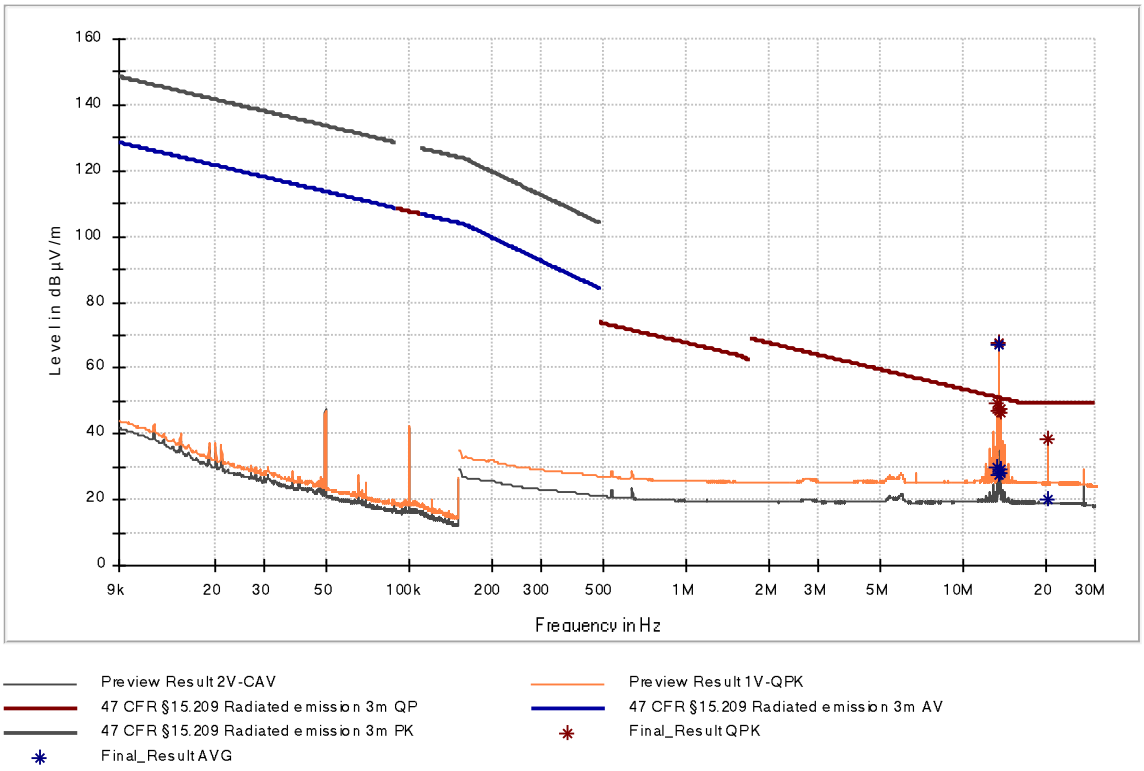
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

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.

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

The following picture shows the worst-case-emissions for the spurious emissions at EUT-position 2, antenna in line.



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

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin	Result
13.350	29.79	AV	-21.53	8.26	---	---	---
13.350	49.28	QP	-21.53	27.75	40.51	12.76	Pass
13.485	27.74	AV	-21.44	6.30	---	---	---
13.485	47.16	QP	-21.44	25.72	50.47	24.75	Pass
13.560	67.09	AV	-21.40	45.69	---	---	Carrier
13.560	67.75	QP	-21.40	46.35	84.00	40.96	Carrier
13.634	27.83	AV	-21.34	6.49	---	---	---
13.634	46.58	QP	-21.34	25.24	50,47	25.23	Pass
13.769	29.15	AV	-21.26	7.89	---	---	---
13.769	47.80	QP	-21.26	26.54	40.51	13.97	Pass
20.339	20.00	AV	-17.87	2.13	---	---	---
20.339	38.37	QP	-17.87	20.50	29.54	9.04	Pass

Picture 13: Table radiated emission 9 kHz – 30 MHz @ 3m distance

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}

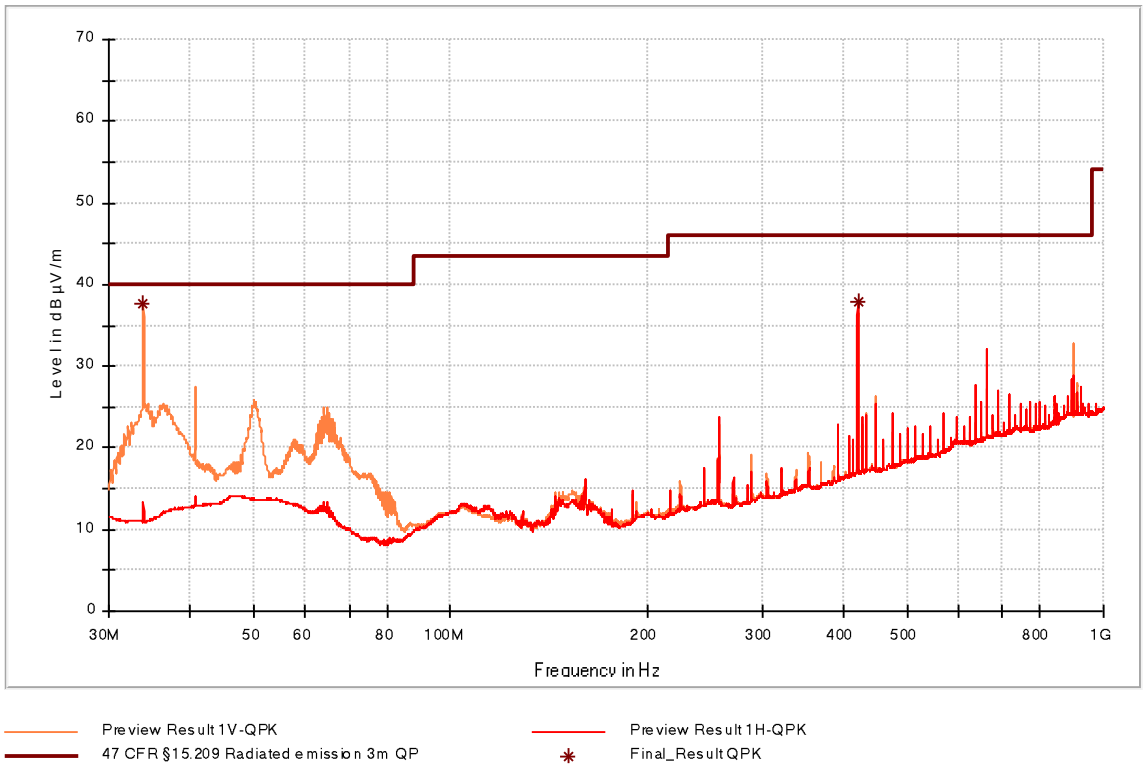
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.350	3.578	3.0	30.0	-21.53
13.485	3.542	3.0	30.0	-21.44
13.560	3.523	3.0	30.0	-21.40
13.634	3.503	3.0	30.0	-21.34
13.769	3.469	3.0	30.0	-21.26
20.339	2.348	3.0	30.0	-17.87

Radiated Emission Measurement 30 MHz - 1000 MHz

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

The following picture shows the worst-case-emissions at EUT-position 2.



Picture 14: Radiated emission 30 MHz - 1 GHz @ 3 m distance

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)
33.900000	37.64	40.00	2.36	101.0	V	26.0
420.360000	37.85	46.00	8.15	200.0	H	241.0

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.

Test result

Temperature:	20°C	Humidity:	41%
Tested by:	Andreas Menacher	Test date:	2018-03-22

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:

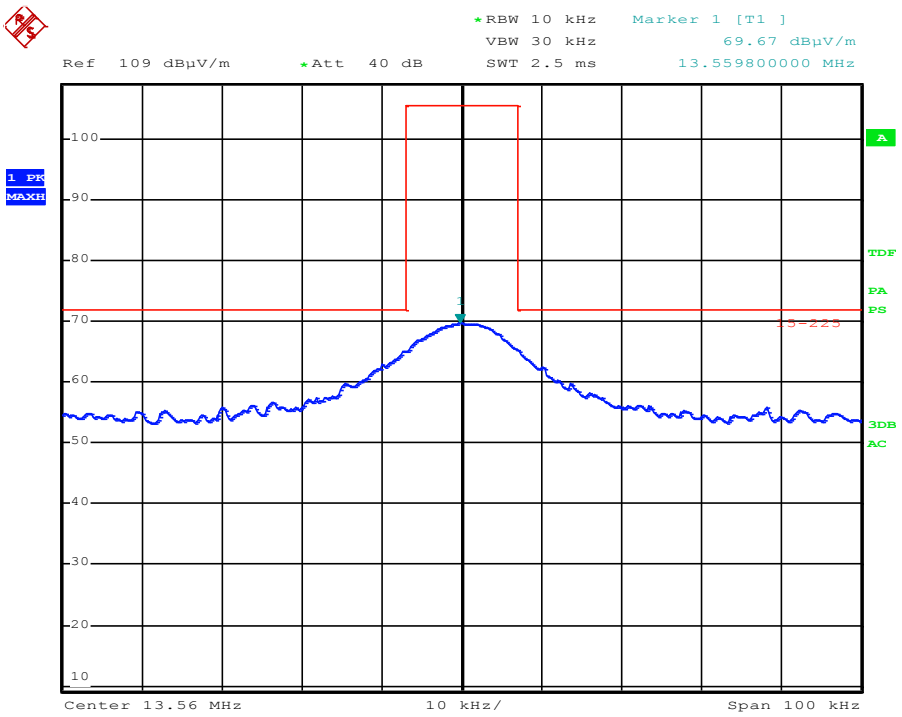
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

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.

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

The following picture shows the worst-case-emissions for spectrum mask at EUT-position 3, antenna parallel.



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 [dB]	BW [kHz]
13.559	69.67	PK	-21.40	48.27	84.00	35.73	10

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]
13.559	3.523	3.000	30.000	-21.40

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

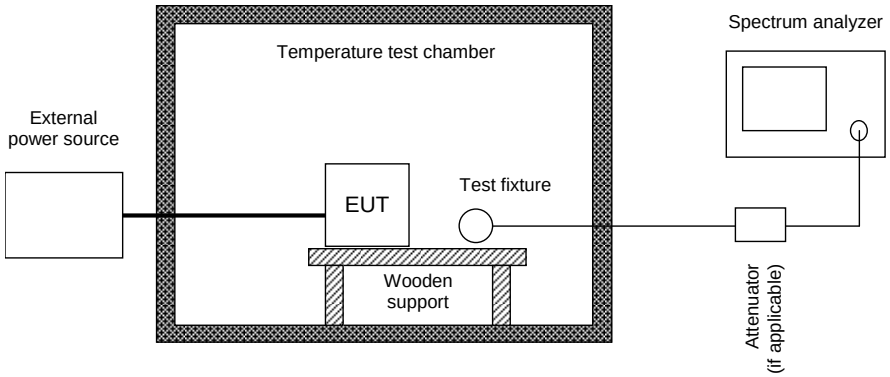
7.3 Limits

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 17: Test setup for carrier frequency stability measurement

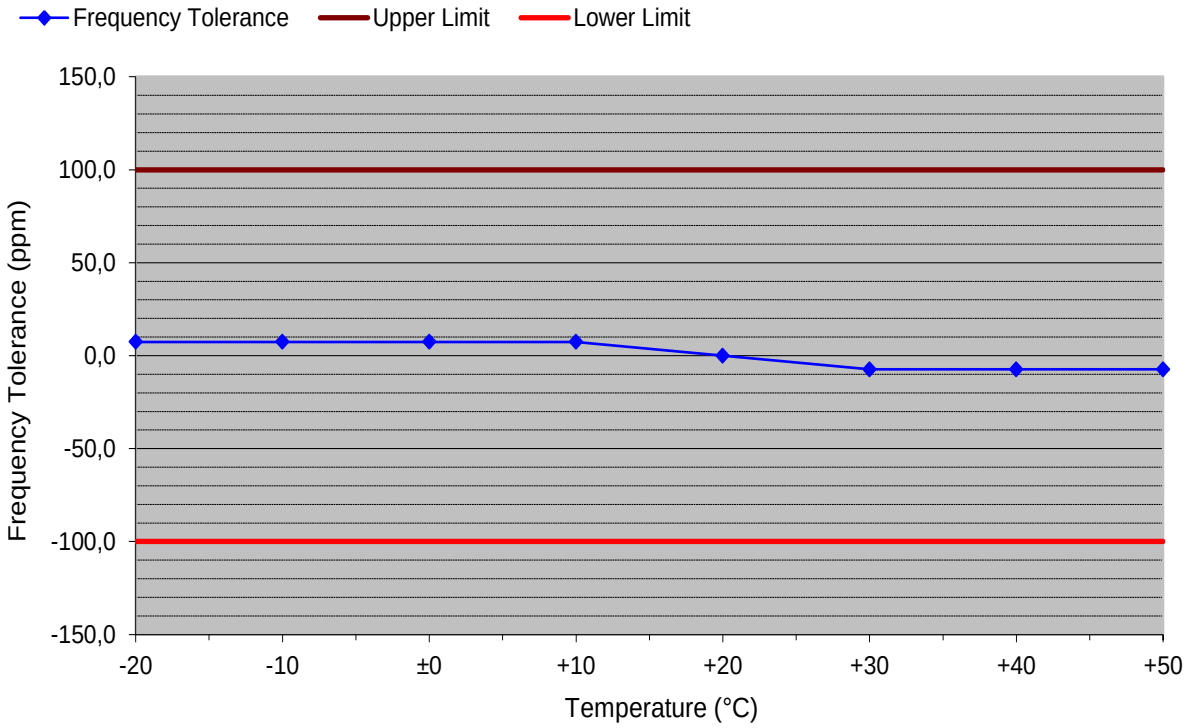
7.6 Test deviation

There is no deviation from the standards referred to.

7.7 Test result

Temperature:	21°C	Humidity:	41%
Tested by:	Andreas Menacher	Test date:	2018-03-23

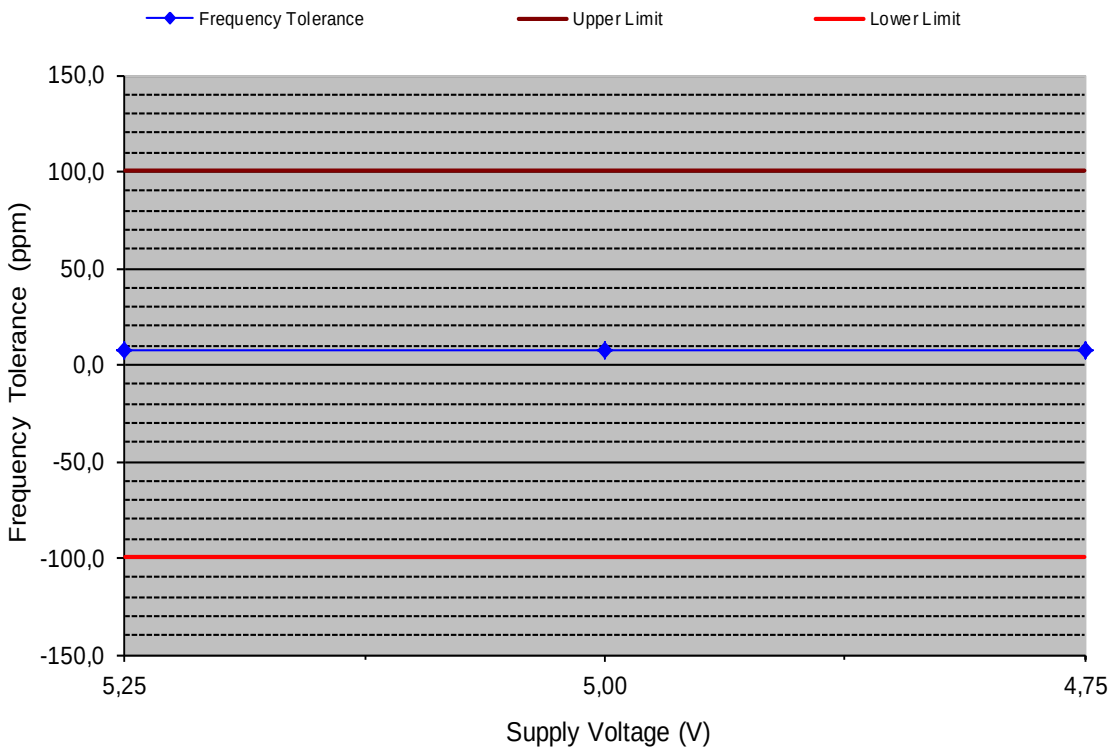
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,5601 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,560200	100	7,4	+100,0	-100,0	**92,6**
-10	13,560200	100	7,4	+100,0	-100,0	**92,6**
±0	13,560200	100	7,4	+100,0	-100,0	**92,6**
+10	13,560200	100	7,4	+100,0	-100,0	**92,6**
+20	13,560100	0	0,0	+100,0	-100,0	100,0
+30	13,560000	-100	-7,4	+100,0	-100,0	**92,6**
+40	13,560000	-100	-7,4	+100,0	-100,0	**92,6**
+50	13,560000	-100	-7,4	+100,0	-100,0	**92,6**

Carrier frequency stability vs. supply voltage



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)	Margin (ppm)
5,25	13,560100	100	7,4	+100,0	-100,0	92,6
5,00	13,560100	100	7,4	+100,0	-100,0	92,6
4,75	13,560100	100	7,4	+100,0	-100,0	92,6

8 Bandwidths

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

8.1 Test Location

See clause 5.1 on page 16.

8.2 Test instruments

See clause 5.2 on page 16.

8.3 Limits

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

8.4 Test setup

See clause 5.5 on page 20.

8.5 Test deviation

There is no deviation from the standards referred to.

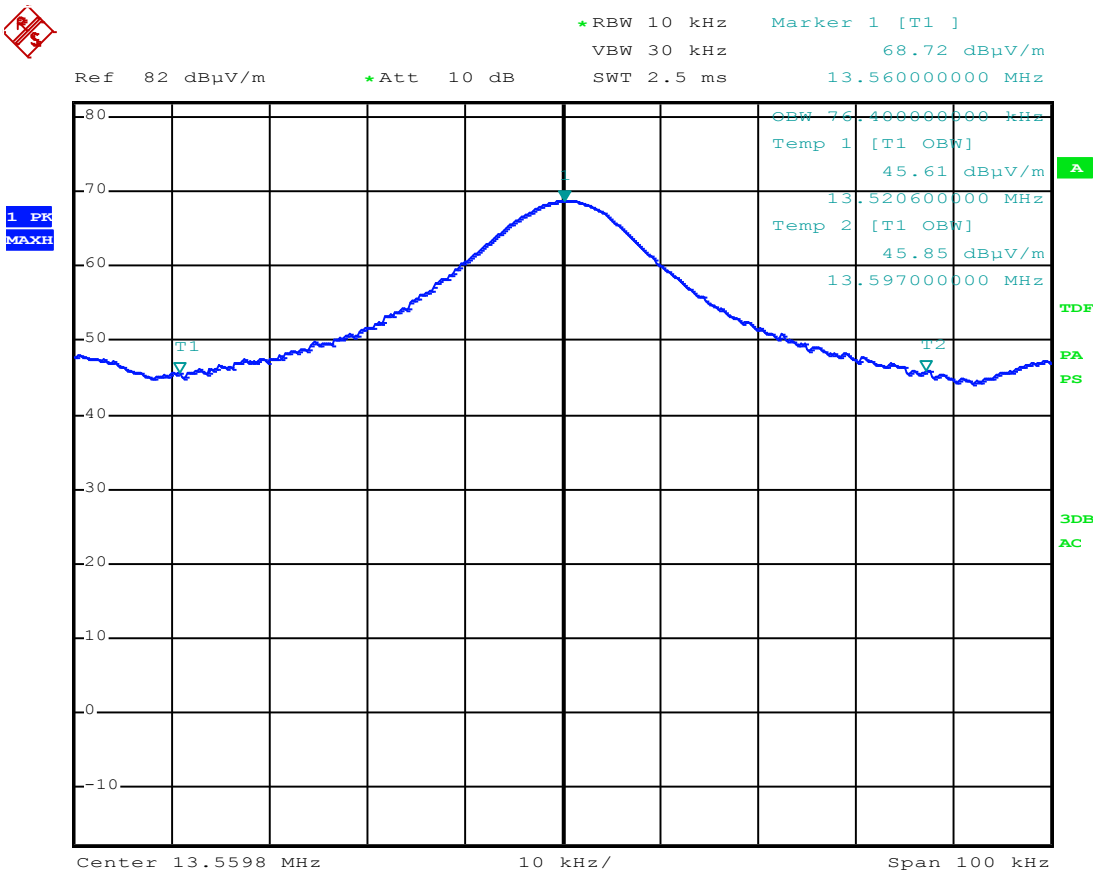
8.6 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Andreas Menacher	Test date:	2018-03-22

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.



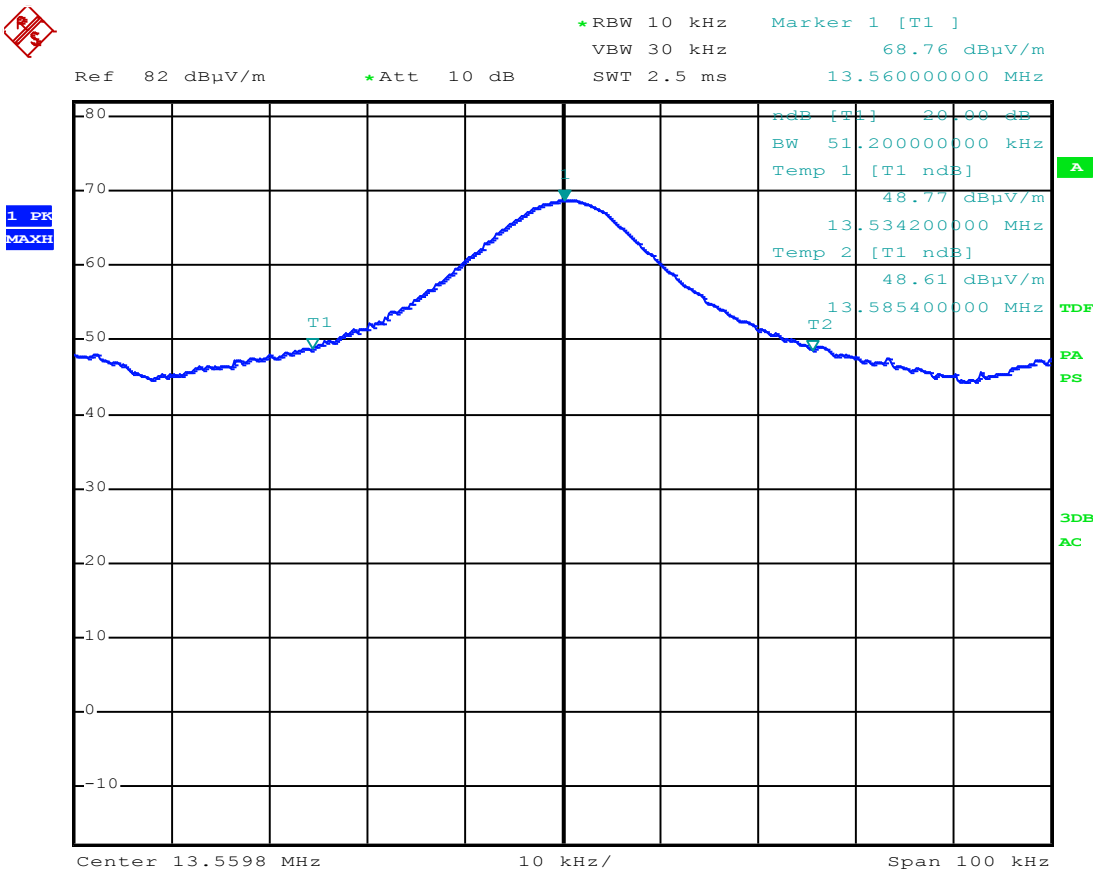
Picture 18: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 76.400 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 19: -20 dB emission bandwidth

Measured -20 dB emission bandwidth: 51.200 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	13,534200	---	---	13,534200	13.110000	424.200	Passed
	high	13,585400	0.200	0.100	13.585700	14.010000	424.300	Passed
	Bandwidth	51.200 kHz			51.500 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: 51.200 kHz
Including variations in temperature and supply voltage: 51.500 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	2018-05[4]
Test receiver	ESR 7	101059	E00739	2016-02	2019-02
LISN	ESH2-Z5	881362/037	E00004	2016-10	2018-10
LISN	ESH2-Z5	893406/009	E00005	2016-02	2019-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9163	9163-228	E00012	2016-04	2019-04
Broadband antenna	VULB 9163	9163-114	E00013	2018-03[5]	2021-03
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	
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	2017-05	2019-05
Cable set OATS 3 m	Cables no. 19, 34 and 36	---	E00453 E00456 E00458	2015-11	2018-11
Cable set SAC 3m	Cables no. 04, 52 and 12		E00434 E00755 E00320	2015-11	2018-11

Table 1: Equipment calibration status

[4] Valid until 03.05.2015
[5] Valid until 30.03.2018

Note 1:	Used for relative measurements only (see test instruments for “Carrier frequency stability”, clause 7.2)	
Note 2:	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”:	2019-05

10 Measurement uncertainty

Description	Max. deviation	k=
Conducted emission AMN (150kHz to 30 MHz)	± 3.4 dB	2
Radiated emission (3 m) (9 kHz – 30 MHz) (30 MHz to 300 MHz) (300MHz to 1 GHz)	± 4.8 dB ± 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
2018-05-15	First edition	Andreas Menacher	0