Test Report

Customer:

Elatec GmbH

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Tel.: +49 89 5529961-13
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RF test report

170509-AU01+Z04

Elatec GmbH

RFID Reader

TWN4 Legic NFC

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 “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: 10-2017	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 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, October 11, 2017

Christian Kiermeier
Test engineer
EMV **TESTHAUS** GmbH

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

3 Equipment under Test (EUT)

Product type:	RFID Reader
Model Name:	TWN4 Legic NFC
Applicant:	Elatec GmbH
Manufacturer:	Elatec GmbH
Serial number:	2017077945
FCC ID:	WP5TWN4F5
IC certification number:	7948A-TWN4F5
Application frequency band:	13.110 to 14.010 MHz
Frequency range:	13.560 MHz
Operating frequency:	13.560 MHz
Number of RF-channels:	1
Modulation:	ASK
Antenna connector:	☐ permanent ☐ temporary ☒ none
Antenna types:	PCB antenna ☐ detachable ☒ not detachable
Maximum antenna gain:	0 dBi
Maximum conducted power:	2 mW (maximum RF output power of RFID chip)
Power supply:	USB powered nominal: 5.0 VDC ± 15 %
Temperature range:	-20°C to +50°C

Remark:
The tests were performed with PC supplied by 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 employing 2 frequencies. The other frequencies are documented within the following test reports:

170509-AU01+Z03 -> 125 kHz

3.3 Operation mode

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

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	*Type designation*	*Serial or inventory no.*	*Manufacturer*
RFID Reader	TWN4 Legic NFC	2017077945	Elatec GmbH
RFID tag	13,56 MHz	---	---
Notebook	Lifebook A531	E00521	Fujitsu
AC power source (120 V / 60 Hz)	Chroma 616062	E00633	Chroma
DC supply	Statron 3252.1	E00541	Statron

3.5 Used cables

Port	*Classification*	*Cable type*	*Cable length*	
			used	*maximum*[1]
USB cable	signal/control	Shielded	1,5 m	1,5 m

[1] As specified by applicant

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 instruments

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Shielded room	P92007	Siemens Matsushita	E00107
☐	EMI test receiver	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESCS 30	Rohde & Schwarz	E00003
☒	Artificial mains network	ESH2-Z5	Rohde & Schwarz	E00004
☒	Artificial mains network	ESH2-Z5	Rohde & Schwarz	E00005
☒	Attenuator (10 dB)	50FHB-010-10	JFW Industries	E00471
☒	Measurement software	E10	EMV TESTHAUS GmbH	E00443
☐	Measurement software	EMC 32	Rohde & Schwarz	---
☒	Cable set	RF cable	Huber + Suhner	E00424

4.2 Limits

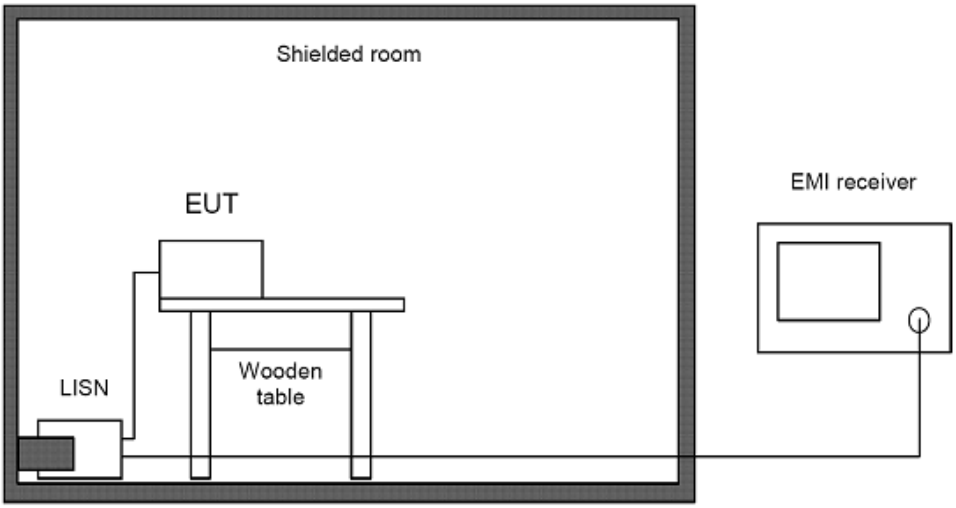
Frequency [MHz]	**Quasi-peak [dBµV]**	**Avarage [dBµV]**
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50

4.3 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.

4.4 Test setup

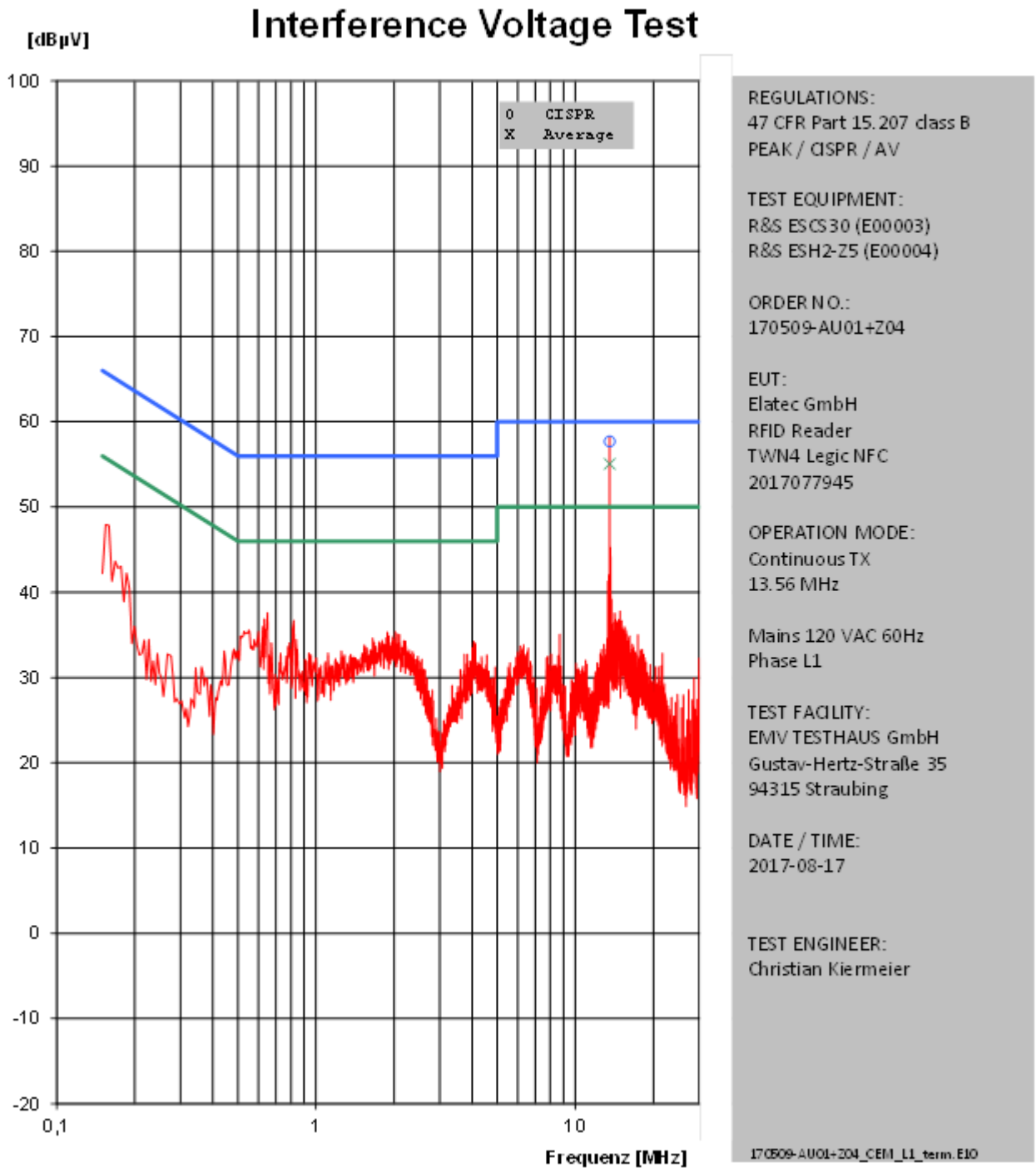


Picture 1: Outline of conducted emission test setup

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

4.5 Test results

Temperature:	22°C	Humidity:	41%
Tested by:	Christian Kiermeier	Test date:	2017-08-17

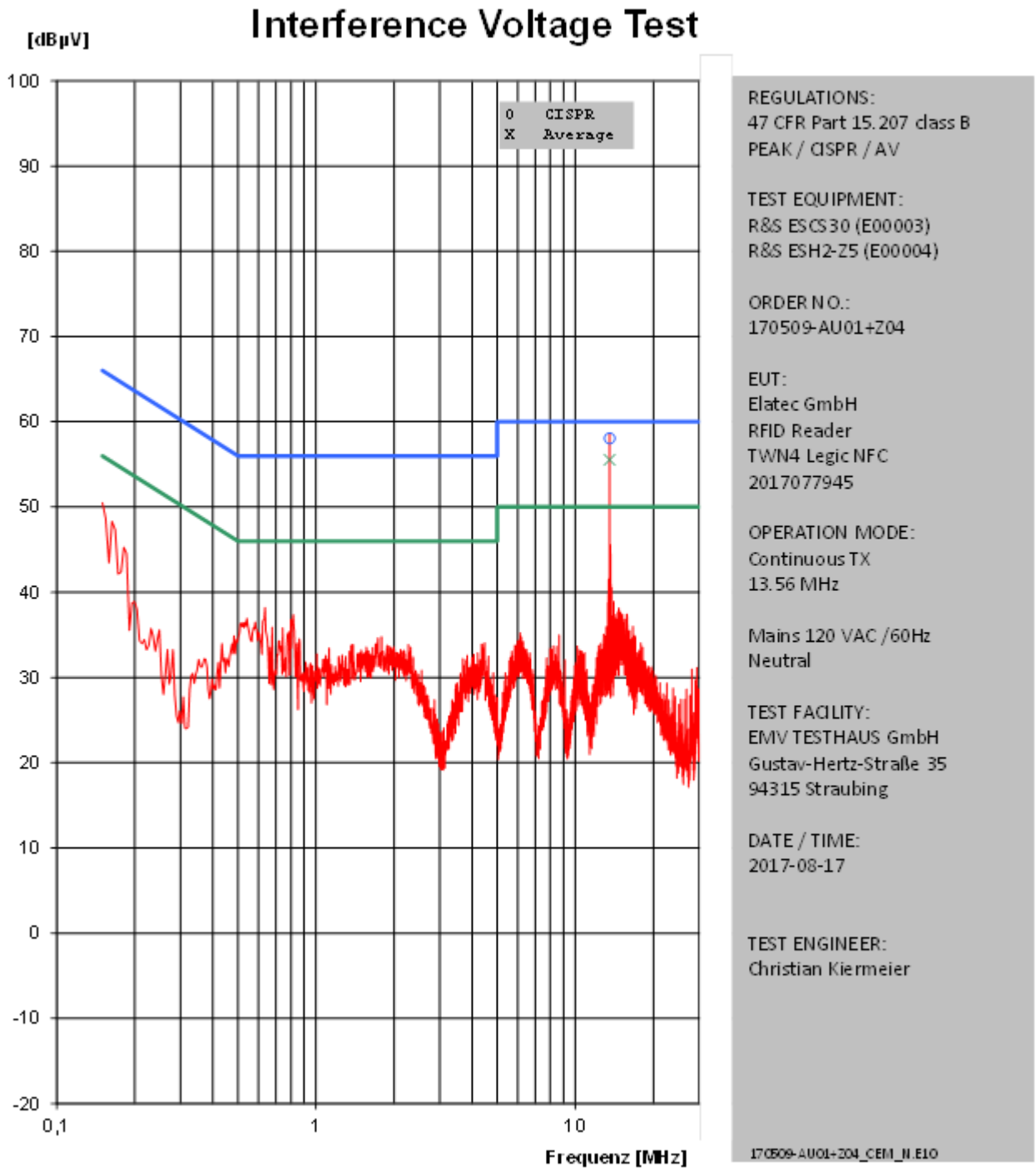


Picture 2: Graphic - Conducted emission on mains, phase 1 (without termination)

Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
13,56	57,7	60,0	2,3	55,1	50,0	**-5,1**	0,0	170509-AU01-Z04_CEM1_L1_term.E10

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

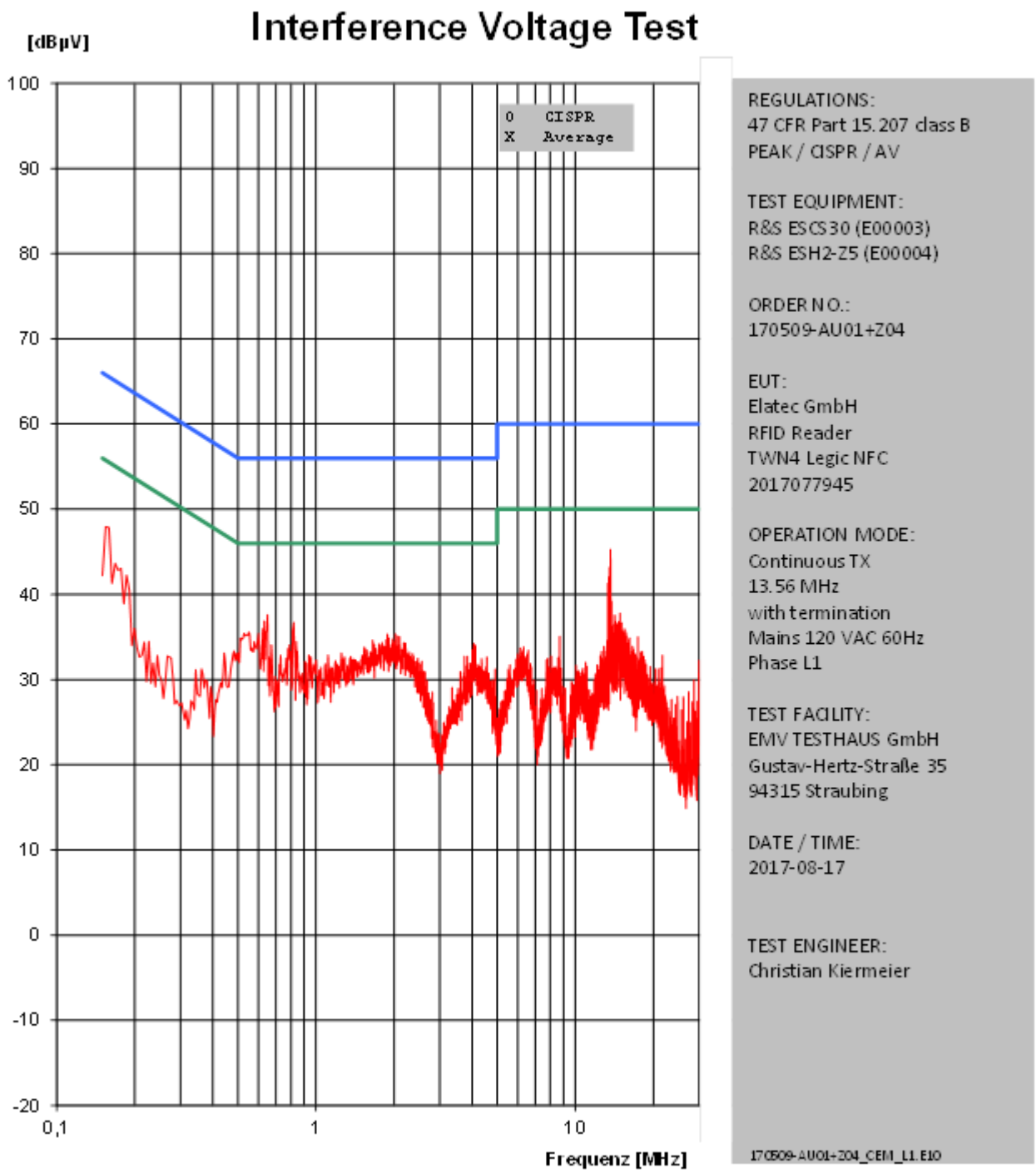


Picture 4: Graphic - Conducted emission on mains, neutral (without termination)

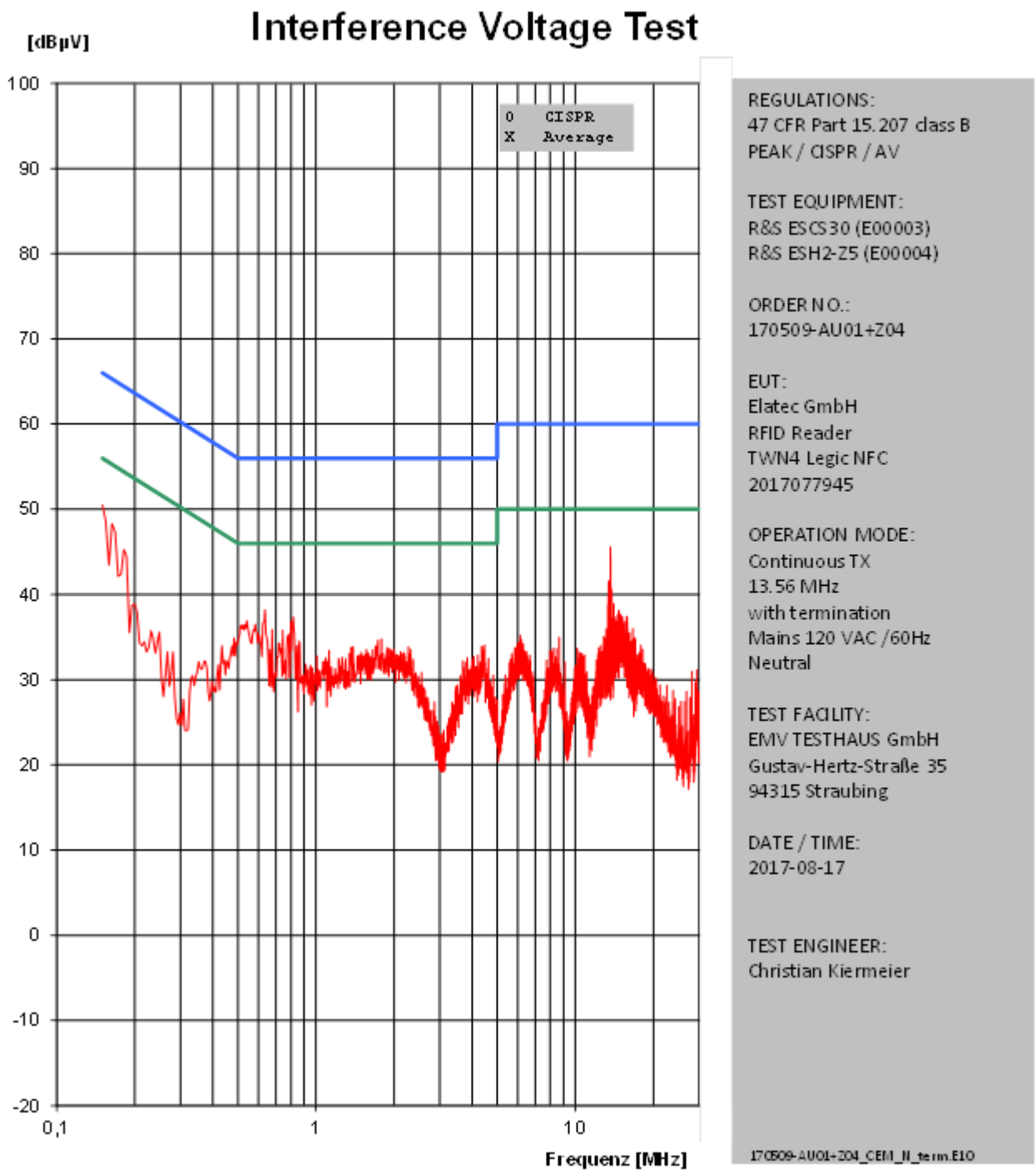
Interference Voltage Test

Freq. [MHz]	U_CISPR [dBµV]	Limit [dBµV]	delta_U [dB]	U_AV [dBµV]	Limit [dBµV]	delta_U [dB]	Corr. [dB]	Remark
								170509-AU01+Z04_CEM_N.EIO
13,56	58,0	60,0	2,0	55,5	50,0	**-5,5**	0,0	

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



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



Picture 7: Graphic - 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

Emission < 30 MHz

☒ Scan with PK / AV detector in 3 m CDC.

☒ Final CISPR measurement with QP detector in 3 m OATS

Emission > 30 MHz

☒ Scan with QP detector in 3 m SAC.

☒ Final CISPR measurement with QP detector in 3 m SAC

5.2 Test instruments

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☒	Semi Anechoic Chamber (SAC)	---	Albatross Projects	E00716
☒	Open area test site	---	EMV **TESTHAUS** GmbH	E00354
☒	EMI test receiver (CDC / OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver (SAC)	ESR 7	Rohde & Schwarz	E00739
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☒	Loop Antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	Switch box	COSB 4-1-26	Conformitas	W00091
☐	Preamplifier	AMF-5D-00501800	Parzich	W00089
☐	Measurement software	E10 v1.4.12	EMV TESTHAUS GmbH	E00443
☒	Measurement software	EMC 32	Rohde & Schwarz	---
☒	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

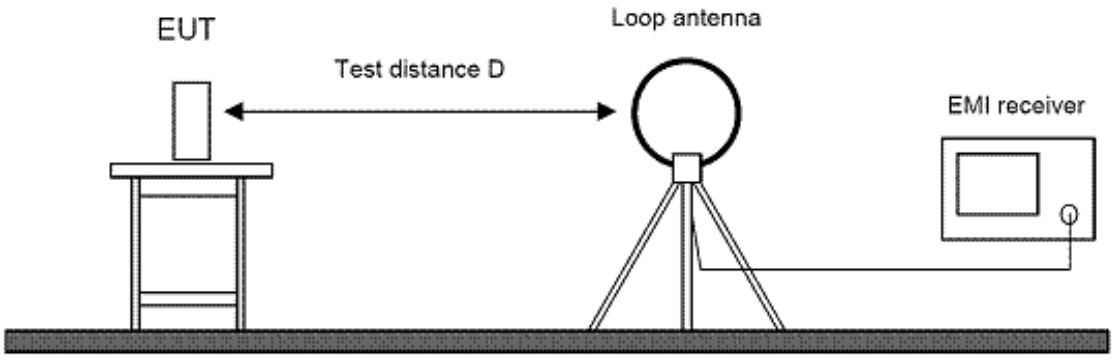
As noted in 15.205(d)(7) devices according to 15.225 are exempt from complying with restricted band requirements for the 13.36 to 13.41 MHz band. Instead they have to comply with the limits as specified in 15.225 (a) to (d):

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			

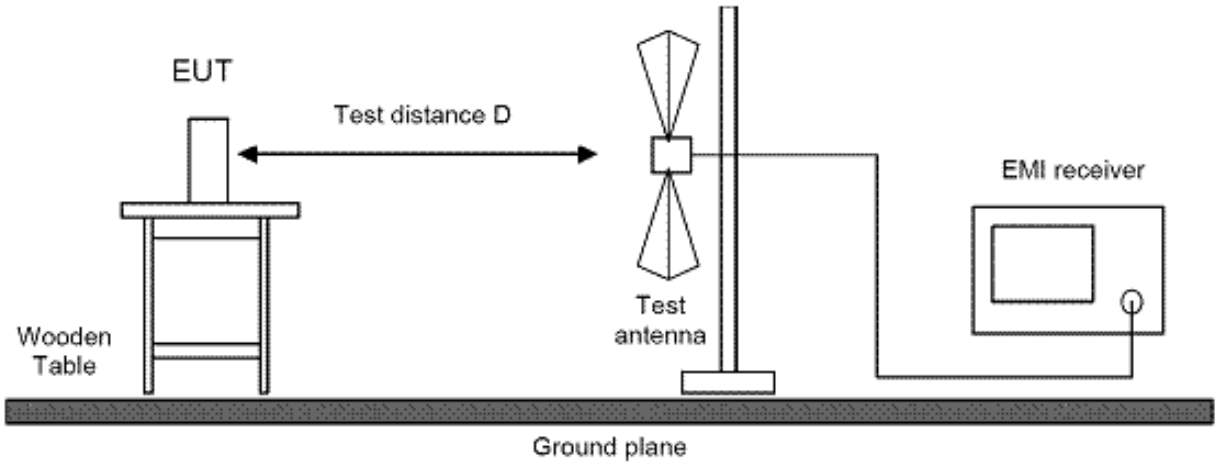
5.4 Test procedure

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 6dB were marked and re-measured with a quasi-peak detector.
8. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
9. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emission field strength of both horizontal and vertical polarization. The highest value was recorded.
10. For emissions below 30 MHz measurements were done using a loop antenna. Prescan was performed with peak detector and final measurements with quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz where average detector applies. Antenna height was not changed during this test. Appropriate CISPR bandwidths of 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above were used.

5.5 Test setup



Picture 8: Test setup for radiated emission measurement (< 30 MHz)



Picture 9: 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:	Christian Kiermeier	Test date:	2017-08-21

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:

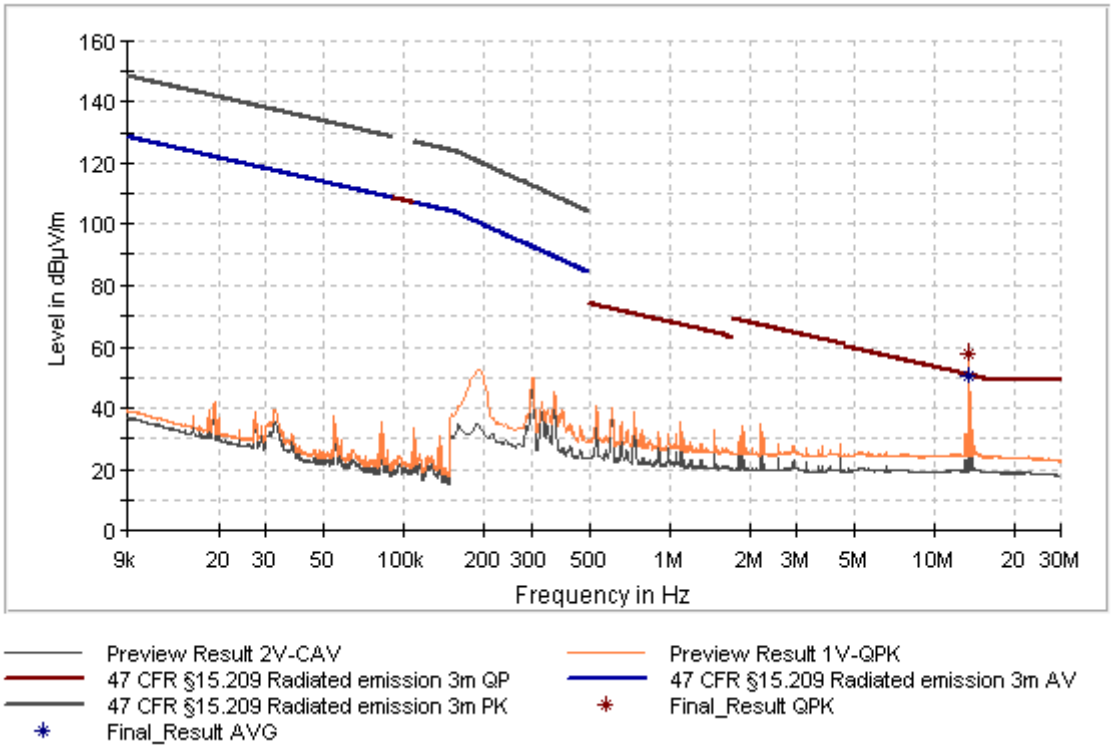
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

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 10: 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**
13.560000	57,86	QP	-21.40	36,46	84.00	-47.54	Carrier

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}

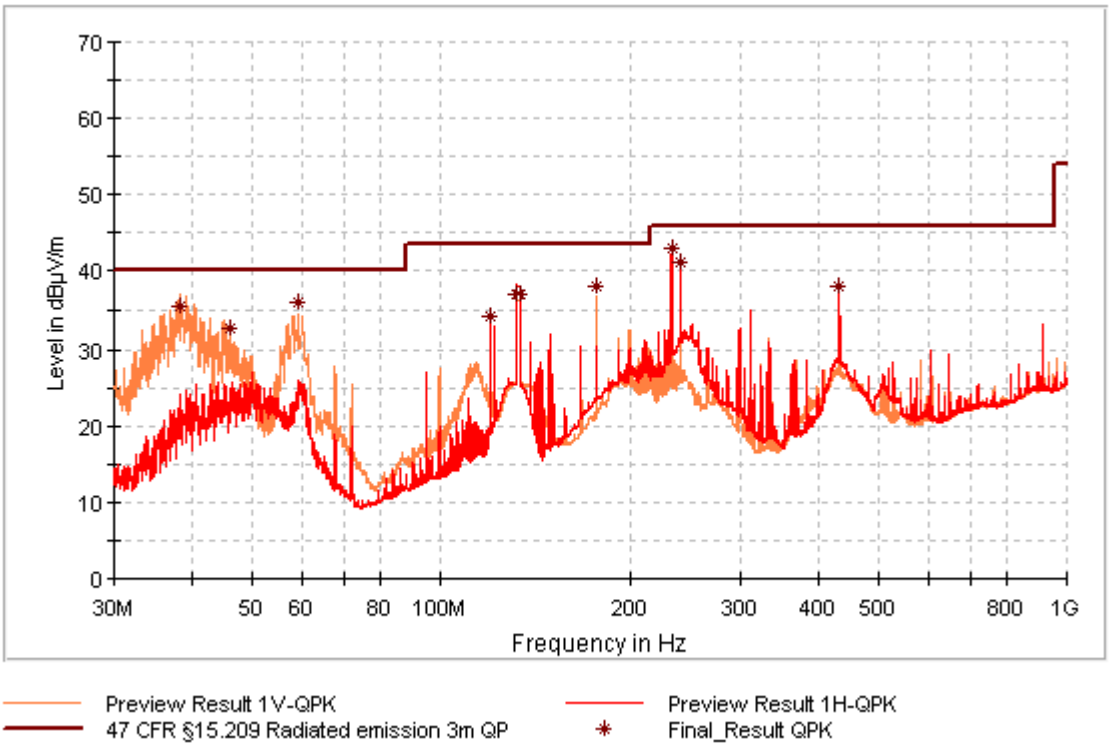
Recalculation factor = -40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)

f_{MHz} [MHz]	$d_{near\ field}$ [m]	$d_{measure}$ [m]	d_{limit} [m]	Recalculation factor [dB]
13.56	3.523	3.0	30.0	21.40

Radiated Emission Measurement 30 MHz - 1000 MHz

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

Test was performed in standard conficuration.



f [MHz]	E_{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
38.190000	35.50	40.00	101.0	173.0	V	Pass
46.080000	32.39	40.00	101.0	18.0	V	Pass
59.070000	35.92	40.00	102.0	78.0	V	Pass
120.000000	34.12	43.50	274.0	292.0	H	Pass
132.750000	37.05	43.50	170.0	125.0	H	Pass
133.230000	37.02	43.50	164.0	126.0	H	Pass
176.280000	37.97	43.50	100.0	289.0	V	Pass
233.190000	42.99	46.00	100.0	134.0	H	Pass
240.000000	41.04	46.00	117.0	130.0	H	Pass
432.000000	38.02	46.00	190.0	117.0	H	Pass

Picture 11: 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:	Christian Kiermeier	Test date:	2017-08-25

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:

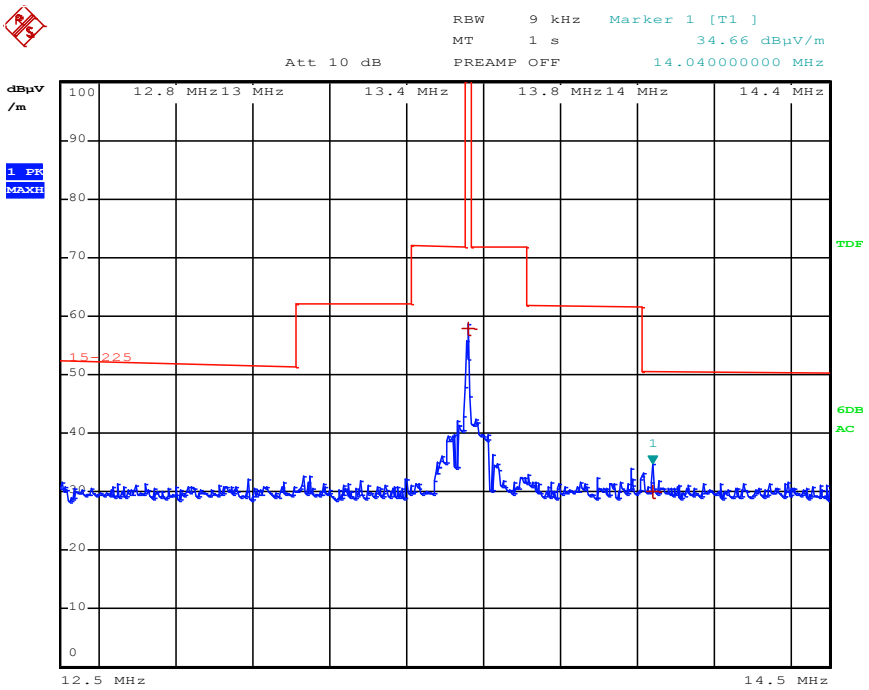
f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

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 1, antenna in line.



Picture 12: Spectrum mask for 13.56 MHz @ 3m distance

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	57,83	QP	-21.40	37,43	84.00	-46,57	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

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

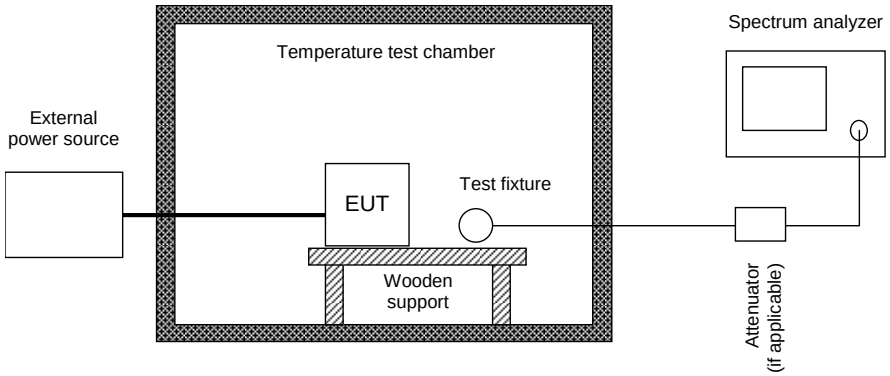
7.3 Limits

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 13: Test setup for carrier frequency stability measurement

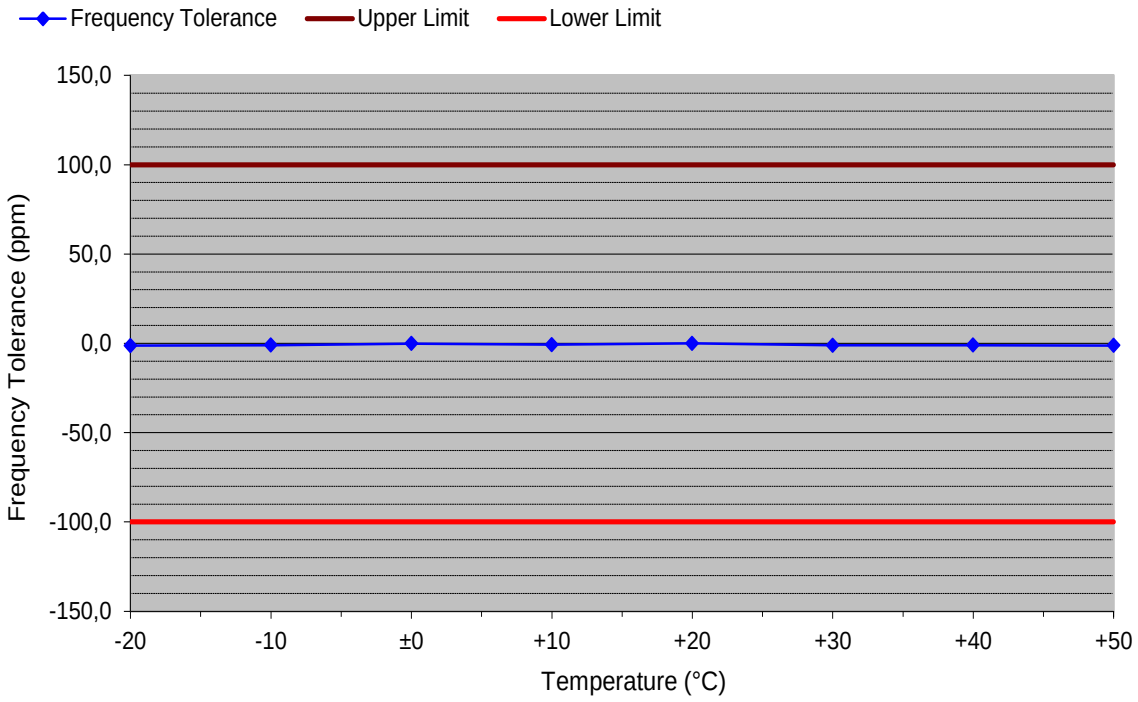
7.6 Test deviation

There is no deviation from the standards referred to.

7.7 Test result

Temperature:	20°C	Humidity:	41%
Tested by:	Christian Kiermeier	Test date:	2017-08-29

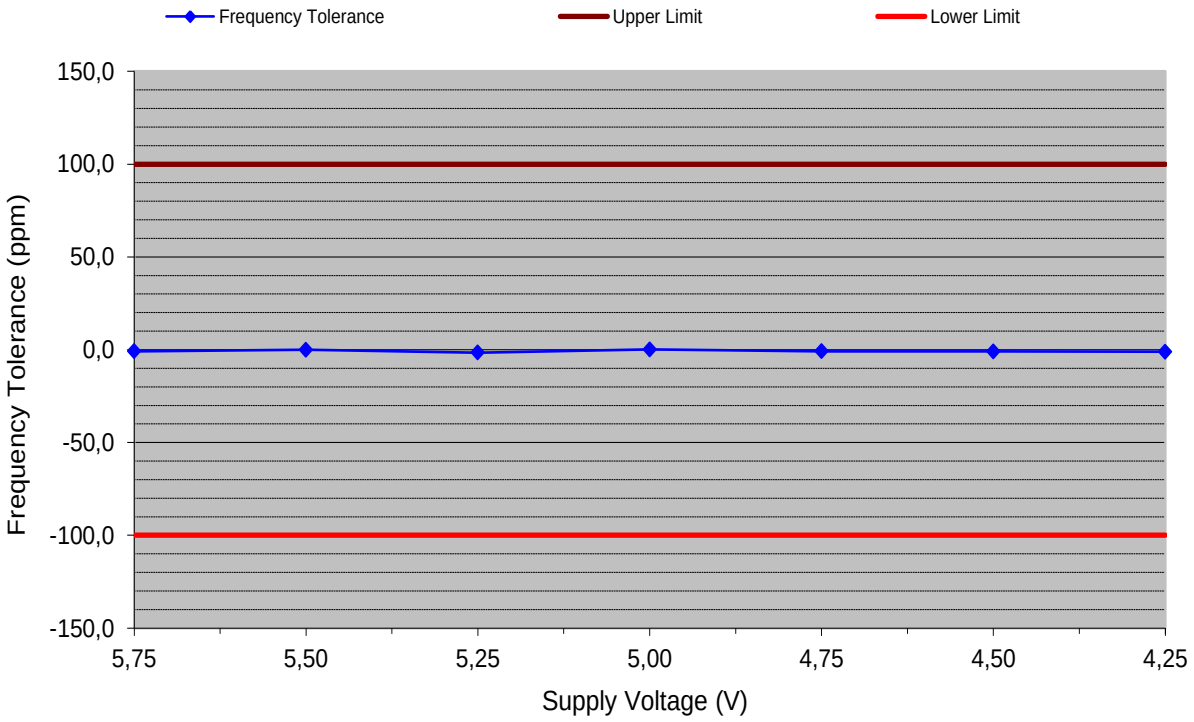
Carrier frequency stability vs. temperature



Supply voltage:	5 V	Frequency under nominal conditions:	13,56 MHz

Temperature (°C)	Frequency (MHz)	Frequency Tolerance (Hz)	Frequency Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
-20	13,559983	-17	-1,3	+100,0	-100,0	**98,7**
-10	13,559986	-14	-1,0	+100,0	-100,0	99,0
±0	13,559998	-2	-0,1	+100,0	-100,0	99,9
+10	13,559990	-10	-0,7	+100,0	-100,0	99,3
+20	13,560000	0	0,0	+100,0	-100,0	100,0
+30	13,559985	-15	-1,1	+100,0	-100,0	98,9
+40	13,559986	-14	-1,0	+100,0	-100,0	99,0
+50	13,559984	-16	-1,2	+100,0	-100,0	98,8

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)
5,75	13,559988	-12	-0,9	+100,0	-100,0	99,1
5,50	13,559999	-1	-0,1	+100,0	-100,0	99,9
5,25	13,559979	-21	-1,5	+100,0	-100,0	**98,5**
5,00	13,560002	2	0,1	+100,0	-100,0	99,9
4,75	13,559988	-12	-0,9	+100,0	-100,0	99,1
4,50	13,559987	-13	-1,0	+100,0	-100,0	99,0

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 18.

8.2 Test instruments

See clause 0 on page 18.

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 21.

8.5 Test deviation

There is no deviation from the standards referred to.

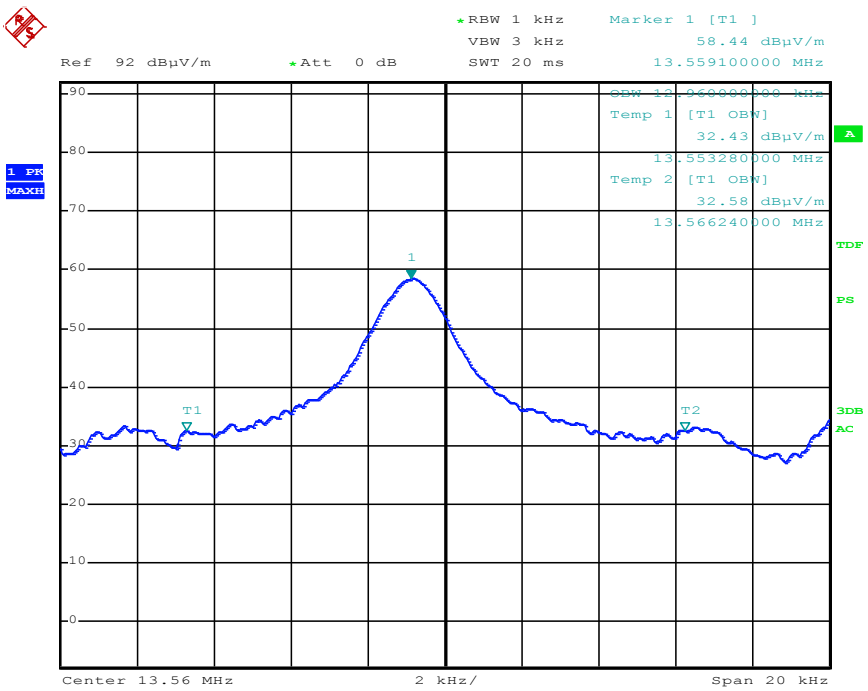
8.6 Test results

Temperature:	20°C	Humidity:	41%
Tested by:	Christian Kiermeier	Test date:	2017-06-08

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.



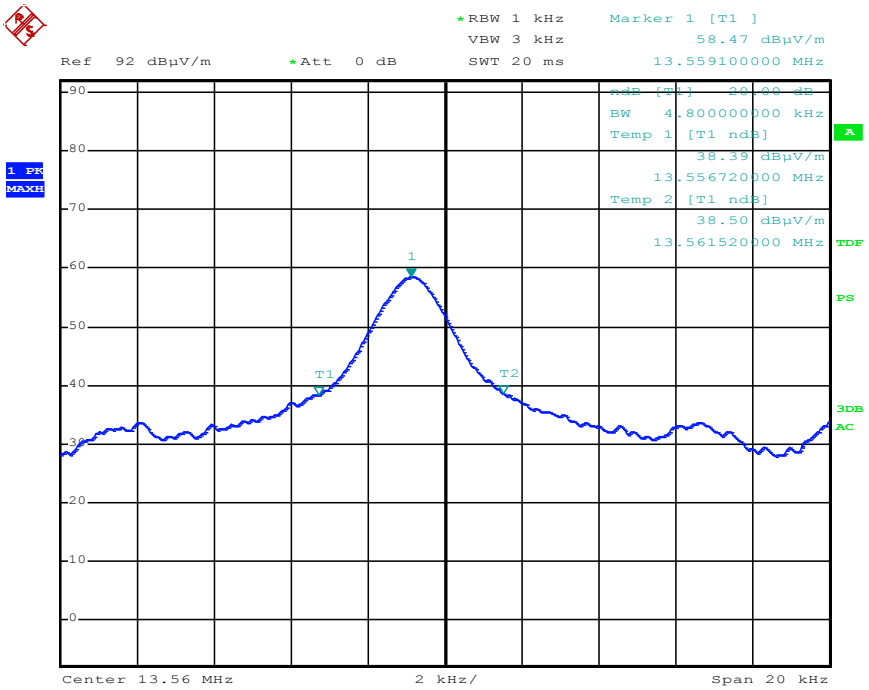
Picture 14: Occupied bandwidth (99 %)

Measured occupied bandwidth (99 %): 12.96 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 15: -20 dB emission bandwidth

Measured -20 dB emission bandwidth: 4.80 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	13,556720	0.017	0.021	13.556699	13.110000	447.433	Passed
	high	13,561520	0.000	0.002	13.561522	14.010000	447.256	Passed
	Bandwidth	4.800 kHz			4.823 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: 4.800 kHz
Including variations in temperature and supply voltage: 4.823 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
Test receiver	ESR 7	101059	E00739	2016-02	2018-02
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9162	9160-3050	E00011	2015-11	2017-11
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
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	2017-11
Cable set SAC 3 m	Cables no. 04, 52 and 12	---	E00434 E00755 E00320	2015-11	2017-11

Table 1: Equipment calibration status

Note 1: Industry Canada (test sites number 3472A-1 and 3472A-2): 2018-11
Note 2: 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 (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
2017-10-11	First edition	Ch. Kiermeier	0