Product Service

Choose certainty.
Add value.

October 4, 2017

Prüfbericht / *Test Report* Nr. / *No.* TR-33368-03325-03 (Edition 4)

Applicant:	Häfele GmbH & Co. KG
Type of equipment:	Radio Interface
Type designation:	BLEBox
Order No.:	
Test standards:	FCC Code of Federal Regulations, CFR 47, Part 15, Sections 15.205, 15.207, 15.215 and 15.247 KDB 558074 D01 v04 Industry Canada Radio Standards Specifications RSS-GEN Issue 4, Section 8.8 and RSS-247 Issue 2, Section 5

Trade Register Munich
HRB 85742
VAT ID No. DE129484267
Information pursuant to Section 2(1)
DL-InfoV (Germany) at
www.tuev-sued.com/imprint

Management:
Robert Kees
Dr. Jens Butenandt
Holger Lindner

Phone: +49 9421 55 22-0
Fax: +49 9421 55 22-99
www.tuev-sued.de

Bundesnetzagentur

BNetzA-CAB-16/21-15

TÜV SÜD Product Service GmbH

Äußere Frühlingstraße 45
94315 Straubing
Germany

Table of Contents

1 Description of the Equipment Under Test (EUT)

General data of EUT	
Type designation[1]:	BLEBox
Parts[2]:	
Serial number(s):	
Manufacturer:	Häfele GmbH & Co. KG
Type of equipment:	Radio Interface
Version:	
FCC ID:	2AHJI- BLEBOX01
Industry Canada ID:	21197-BLEBOX01
Additional parts/accessories:	As received, each. HW 1111; SW V20.1

[1] Type designation of the system if EUT consists of more than one part.
[2] Type designations of the parts of the system, if applicable.

Technical data of EUT	
Application frequency range:	2400.0 MHz - 2483.5 MHz
Frequency range:	2401 MHz to 2480 MHz
Operating frequency:	2401 MHz; 2480 MHz; 2480 MHz
Type of modulation	GFSK
Pulse train:	---
Pulse width:	---
Number of RF-channels:	40
Channel spacing:	2 MHz
Designation of emissions[3]	1M67F1D
Type of antenna:	Integrated antenna
Size/length of antenna:	7 mm x 2 mm
Connection of antenna:	☐ detachable ☒ not detachable
Type of power supply:	AC supply
Specifications for power supply:	nominal voltage: 110 V nominal frequency: 60 Hz

[3] Also known as "Class of Emission".

2 Administrative Data

Application details	
Applicant (full address):	Häfele GmbH & Co. KG Adolf-Häfele-Str. 1 72202 Nagold Germany
Contact person:	Mr. Christoph Stopper
Order number:	
Receipt of EUT:	2017-03-05; 2017-07-20
Date(s) of test:	2017-03-05 to 2017-07-21
Note(s):	

Report details	
Report number:	TR-33368-03325-03
Edition:	4
Issue date:	2017-10-04

3 Identification of the Test Laboratory

Details of the Test Laboratory	
Company name:	TÜV SÜD Product Service GmbH
Address:	Aeussere Fruehlingstrasse 45 D-94315 Straubing Germany
Laboratory accreditation:	DAkkS Registration No. D-PL-11321-11-01
Laboratory recognition:	Registration No. BNetzA-CAB-16/21-15
Industry Canada test site registration:	3050A-2
Contact person:	Mr. Markus Biberger Phone: +49 9421 5522-0 Fax: +49 9421 5522-99

4 Summary

Summary of test results
The tested sample complies with the requirements set forth in the **Code of Federal Regulations CFR 47, Part 15, Sections 15.205, 15.207, 15.215 and 15.247** **KDB 558074 D01 v04** of the Federal Communication Commission (FCC) and the **Radio Standards Specifications** **RSS-GEN Issue 4, Section 8.8 and** **RSS-247 Issue 2, Section 5** of Industry Canada (IC).

Die Prüfergebnisse beziehen sich ausschließlich auf das zur Prüfung vorgestellte Prüfmuster. Ohne schriftliche Genehmigung des Prüflabors darf der Prüfbericht auszugsweise nicht vervielfältigt werden. *The test results relate only to the individual item which has been tested. Without the written approval of the test laboratory this report may not be reproduced in extracts.*

Datum / *Date*	Geprüft von / *Tested by*	Freigabe durch / *Checked by*
2017-10-04	Martin Steindl Responsible for testing	Markus Biberger Reviewer

Prüfergebnis / *Test Result*

☒ **Erfüllt / *Passed***

☐ **Nicht erfüllt / *Not passed***

5 Operation Mode and Configuration of EUT

Operation Mode(s)
Transmitting on lowest, middle an highest frequency channel with Bluetooth Low Energy and Propritary Radio. Receiving

Configuration(s) of EUT
The EUT was configured as external device of a LOOX LED Driver

List of ports and cables				
Port	*Description*	*Classification*[4]	*Cable type*	*Cable length*
1	AC supply of LOOX LED Driver	ac power	Unshielded	1 m
2	DC supply of EUT	dc power	Unshielded	50 cm

List of devices connected to EUT				
Item	*Description*	*Type Designation*	*Serial no. or ID*	*Manufacturer*
1	AC/DC adapter	LOOX LED Driver		Häfele

List of support devices				
Item	*Description*	*Type Designation*	*Serial no. or ID*	*Manufacturer*
1	Test board			Nordic

[4] Ports shall be classified as ac power, dc power or signal/control port

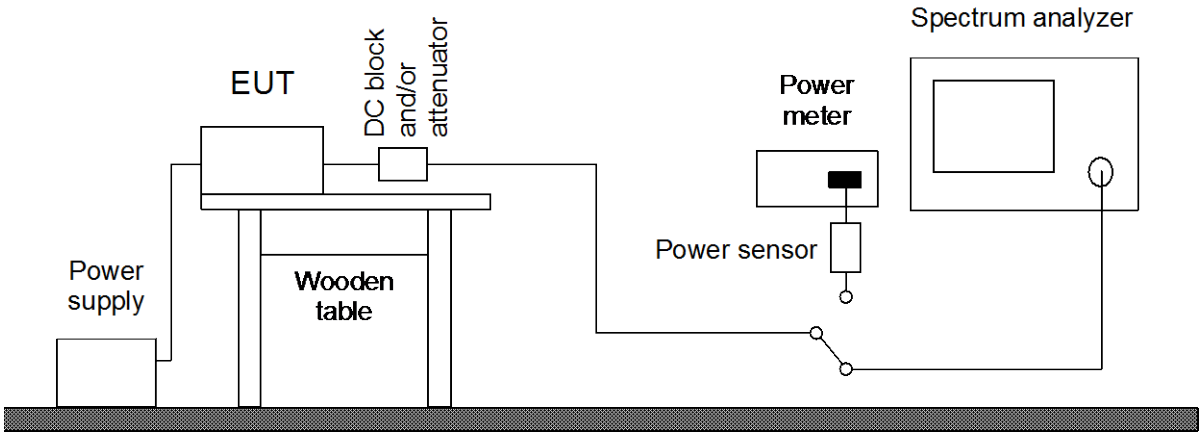
6 Measurement Procedures

6.1 Conducted Output Power

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 2, section 2.1046(a) CFR 47 Part 15, section 15.247(b)(2) IC RSS-247, Issue 2, section 5.4(4)
Guide:	ANSI C63.10 / CFR 47 Part 2, section 2.1046 KDB558074 v04

Conducted output power is measured at the RF output terminals (e.g. antenna connector if antenna is detachable) when the transmitter is adjusted in accordance with the tune-up procedure, if applicable. The RF output terminals are connected to a spectrum analyzer and/or a power meter with appropriate sensor. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as DC block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable.

If a spectrum analyzer is used for peak measurement the resolution bandwidth (RBW) is set to a value equal or greater than the digital transmission systems (DTS) bandwidth. The video bandwidth (VBW) shall be at least three times greater than the RBW. The settings used have to be indicated within the appropriate test record(s).



Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Spectrum analyzer	FSP30	1666	100063	Rohde & Schwarz
☒	Spectrum analyzer	FSV40	2364	101448	Rohde & Schwarz
☐	Spectrum analyzer	FSP30	(R&S)	1093.4495.30	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	EMI test receiver	ESMI	1569	839379/013 839587/006	Rohde & Schwarz
☐	Power meter	NRVS	1264	836856/015	Rohde & Schwarz
☐	Peak power sensor	NRV-Z31	1701	8579604.03	Rohde & Schwarz
☐	Power sensor	NRV-Z52	1499	837901/030	Rohde & Schwarz
☐	Power sensor	NRV-Z4	1034	863828/015	Rohde & Schwarz
☐	DC-block	7006	1636	A2798	Weinschel
☒	Microwave cable	ST-18/SMAm/SMAm/48	1949	696378	Huber+Suhner
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda

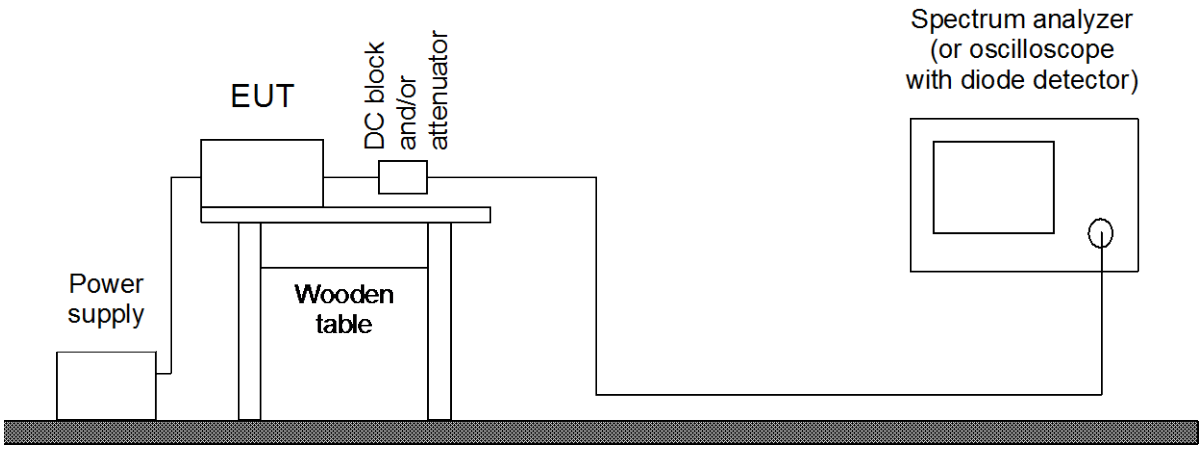
6.2 Bandwidth Measurements

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 2, section 2.202(a) CFR 47 Part 15, section 15.215(c) and 15.247(a)(2) IC RSS-Gen Issue 4, section 6.6 IC RSS-247 Issue 2, section 5.2(1) ANSI C63.10, section 6.9.1
Guide:	ANSI C63.10 / IC RSS-Gen Issue 4, section 6.6 KDB 55074 D01 v04
Measurement setup:	☒ Conducted: See below ☐ Radiated: Radiated Emission in Fully or Semi Anechoic Room (6.6)

If antenna is detachable bandwidth measurements shall be performed at the antenna connector (conducted measurement) when the transmitter is adjusted in accordance with the tune-up procedure, if applicable. The RF output terminals are connected to a spectrum analyzer. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable.

If radiated measurements are performed the same test setups and instruments are used as with radiated emission measurements for the appropriate frequency range.

The analyzer settings are specified by the test description of the appropriate test record(s).



Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Spectrum analyzer	FSP30	1666	100036	Rohde & Schwarz
☒	Spectrum analyzer	FSV40	2364	101448	Rohde & Schwarz
☐	EMI test receiver	ESPI7	1711	836914/0002	Rohde & Schwarz
☐	Diode detector negative	8473D	1581	01492	Hewlett Packard
☐	Oscilloscope	54602B	1535	US35060304	Hewlett Packard
☐	Digital oscilloscope	Wave Surfer 452	1796	LCRY0301J11938	LeCroy
☐	Test probe	TP 01	1628	001	TÜV SÜD PS
☐	DC-block	7006	1636	A2798	Weinschel
☒	Microwave cable	ST-18/SMAm/SMAm/48	1949	696378	Huber+Suhner
☐	Attenuator	4776-10	1638	9412	Narda
☐	Attenuator	4776-20	1639	9503	Narda

6.3 Power spectral density

Measurement Procedure:		
Rules and specifications:	CFR 47 Part 15, sections 15.215(b) and 15.247 KDB558074 v03r03 IC RSS-247 Issue 2, section 5.2(2)	
Guide:	ANSI C63.4, ANSI C63.10	
Measurement setup:	☒ Conducted:	Bandwidth Measurements (6.2)
	☐ Radiated:	Radiated Emission in Fully or Semi Anechoic Room (6.6)

If antenna is detachable bandwidth measurements shall be performed at the antenna connector (conducted measurement) when the transmitter is adjusted in accordance with the tune-up procedure, if applicable. The RF output terminals are connected to a spectrum analyzer. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as dc block and appropriate attenuators (50 Ohms). The electrical characteristics of the radio frequency load attached to the output terminals shall be stated, if applicable.

If radiated measurements are performed the same test setups and instruments are used as with radiated emission measurements for the appropriate frequency range.

The center frequency of the spectrum analyzer is set to the center frequency of the digital transmission systems (DTS) channel center frequency and the span shall be set to 1.5 times the DTS bandwidth. The resolution bandwidth (RBW) shall be set in the range 3 kHz to 100 kHz. The video bandwidth (VBW) shall be at least three times greater than the RBW. The detector is set to peak and the trace mode to max-hold. The maximum power spectral density is the maximum amplitude level of the fully stabilized trace. If the measured value exceeds the limit the RBW is reduced, but not less than 3 kHz and the test is repeated.

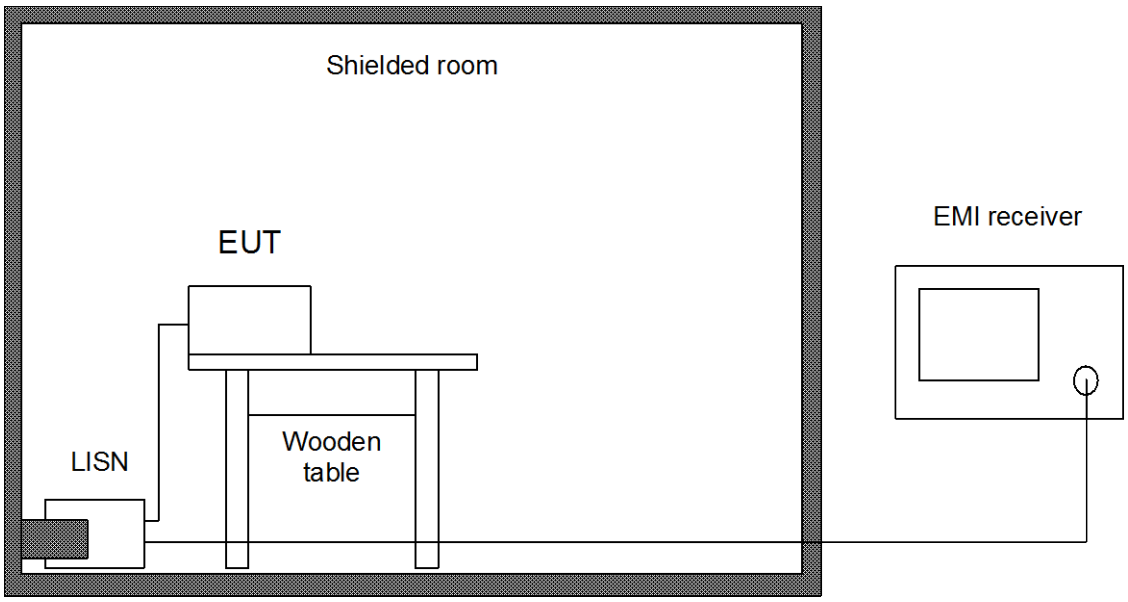
6.4 Conducted AC Powerline Emission

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, section 15.207 IC RSS-GEN Issue 4, section 8.8
Guide:	ANSI C63.10 / CISPR 22

Conducted emission tests in the frequency range 150 kHz to 30 MHz are performed using Line Impedance Stabilization Networks (LISNs). To simplify testing with quasi-peak and average detector the following procedure is used:

First the whole spectrum of emission caused by the equipment under test (EUT) is recorded with detector set to peak using CISPR bandwidth of 10 kHz. After that all emission levels having less margin than 10 dB to or exceeding the average limit are retested with detector set to quasi-peak.
If average limit is kept with quasi-peak levels no additional scan with average detector is necessary. In cases of emission levels between quasi-peak and average limit an additional scan with detector set to average is performed.

According to ANSI C63.10, section 6.2.5, testing of intentional radiators with detachable antenna shall be performed using a suitable dummy load connected to the antenna output terminals. Otherwise, the tests shall be made with the antenna connected and, if adjustable, fully extended.
Testing with dummy load may be necessary to distinguish (unintentional) conducted emissions on the supply lines from (intentional) emissions radiated by the antenna and coupling directly to supply lines and/or LISN. Usage of dummy load has to be stated in the appropriate test record(s) and notes should be added to clarify the test setup.



Test instruments used:

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☒	Test receiver	ESCI	2364	101448	Rohde & Schwarz
☒	V-network	ESH 3-Z5	1059	894785/005	Rohde & Schwarz
☐	V-network	ESH 3-Z5	1218	830952/025	Rohde & Schwarz
☐	Artificial mains network	ESH 2-Z5	1536	842966/004	Rohde & Schwarz
☒	Microwave cable	FB293C1080005050	2157	72110-02	Rosenberger Micro-Coax
☐	Coax cable	RG214 N/N 5m	1188	---	Senton
☐	Shielded room	No. 1	1451	---	Albatross
☐	Shielded room	No. 4	1454	3FD 100 544	Euroshield
☒	Shielded room	No. 9	21083	---	Albatross
☒	Measurement Software	EMC32_K1 V9.26.01	2230	100281	Rohde & Schwarz

6.5 Radiated Emission Measurement 9 kHz to 30 MHz

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, sections 15.209 and 15.247 IC RSS-GEN Issue 4, sections 6.4, 6.13 and 8.9 IC RSS-247 Issue 2, section 5.5
Guide:	ANSI C63.10

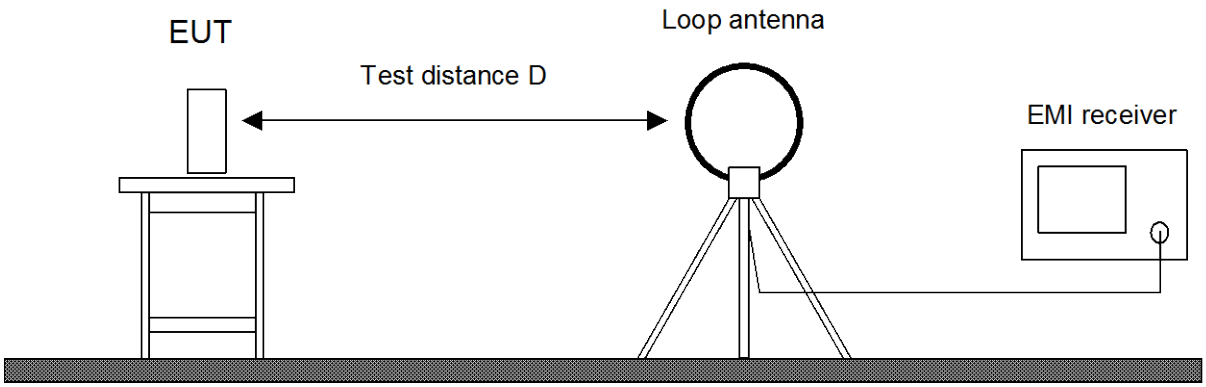
Radiated emission in the frequency range 9 kHz to 30 MHz is measured using an active loop antenna. First the whole spectrum of emission caused by the equipment is recorded at a distance of 3 meters in a fully or semi anechoic room with the detector of the spectrum analyzer or EMI receiver set to peak. This configuration is also used for recording the spectrum of intentional radiators.

Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.
If worst case emission of the EUT cannot be recorded with EUT in standard position and loop antenna in vertical polarization the EUT (or the radiating part of the EUT) is rotated by 90 degrees instead of changing the loop antenna to horizontal polarization. This procedure is selected to minimize the influence of the environment (e.g. effects caused by the floor especially with longer distances).

Final measurement is performed at a test distance D of 30 meters using an open field test site. In case the regulation requires testing at other distances, the result is extrapolated by either making measurements at an additional distance D of 10 meters to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). In cases of very low emissions measurements are performed at shorter distances and results are extrapolated to the required distance. The provisions of CFR 47 Part 15 sections 15.31(d) and (f)(2) apply. According to CFR 47 Part 15 section 15.209(d) final measurement is performed with detector function set to quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 kHz where, for non-pulsed operation, average detector is employed.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.



TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Test instruments used:

	Type		*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Spectrum analyzer		FSP30	1666	100036	Rohde & Schwarz
☒	EMI test receiver		ESR7	22642	101713	Rohde & Schwarz
☐	Test receiver		ESHS 10	1028	860043/016	Rohde & Schwarz
☐	EMI test receiver		ESU8	2044	100232	Rohde & Schwarz
☐	Preamplifier	Cabin no. 2	CPA9231A	1716	3557	Schaffner
☒	Loop antenna		HFH2-Z2	1016	882964/1	Rohde & Schwarz
☒	Microwave cable	Cabin no. 8	EF393	2053	---	Albatross Projects
☐	Microwave cable	Cabin no. 8	FB293C1050005050	2054	63834-1	Rosenberger Micro-Coax
☐	Microwave cable	Cabin no. 8	FB293C1080005050	2055	63833-1	Rosenberger Micro-Coax
☐	Microwave cable	Cabin no. 8	LCF12-50	2057	P1.3.9	RFS
☐	Microwave cable	Cabin no. 8	LCF12-50	2057	P1.4.12	RFS
☒	Microwave cable	Cabin no. 8	LCF12-50	2057	P1.6.19	RFS
☐	Microwave cable	Cabin no. 8	FA210AF040005050G	2127	72061-01	Rosenberger Micro-Coax
☐	Microwave cable	Cabin no. 8	FA210AF04000505G	2056	64567-01	Rosenberger Micro-Coax
☒	Microwave cable	Cabin no. 8	FA210AF04000505	2068	64610-1	Rosenberger Micro-Coax
☐	Fully anechoic room		No. 2	1452	---	Albatross
☐	Semi anechoic room		No. 3	1453	---	Siemens
☒	Semi anechoic room		No. 8	2057	---	Albatross
☒	Measurement Software		EMC32_K8 V9.25.00	1852	100016	Rohde & Schwarz

6.6 Radiated Emission in Fully or Semi Anechoic Room

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, sections 15.209 and 15.247 KDB 558074 v04 IC RSS-GEN Issue 4, sections 6.5, 6.13 and 8.9 IC RSS-247 Issue 2, section 5.5
Guide:	ANSI C63.10

Radiated emission in fully or semi anechoic room is measured in the frequency range from 30 MHz to the maximum frequency as specified in CFR 47 Part 15 section 15.33.

Measurements are made in both the horizontal and vertical planes of polarization using a spectrum analyzer with the detector function set to peak and resolution as well as video bandwidth set to 100 kHz (below 1 GHz) or 1 MHz (above 1 GHz).

Testing up to 1 GHz is performed with a linear polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna"). For testing above 1 GHz horn antennas are used.

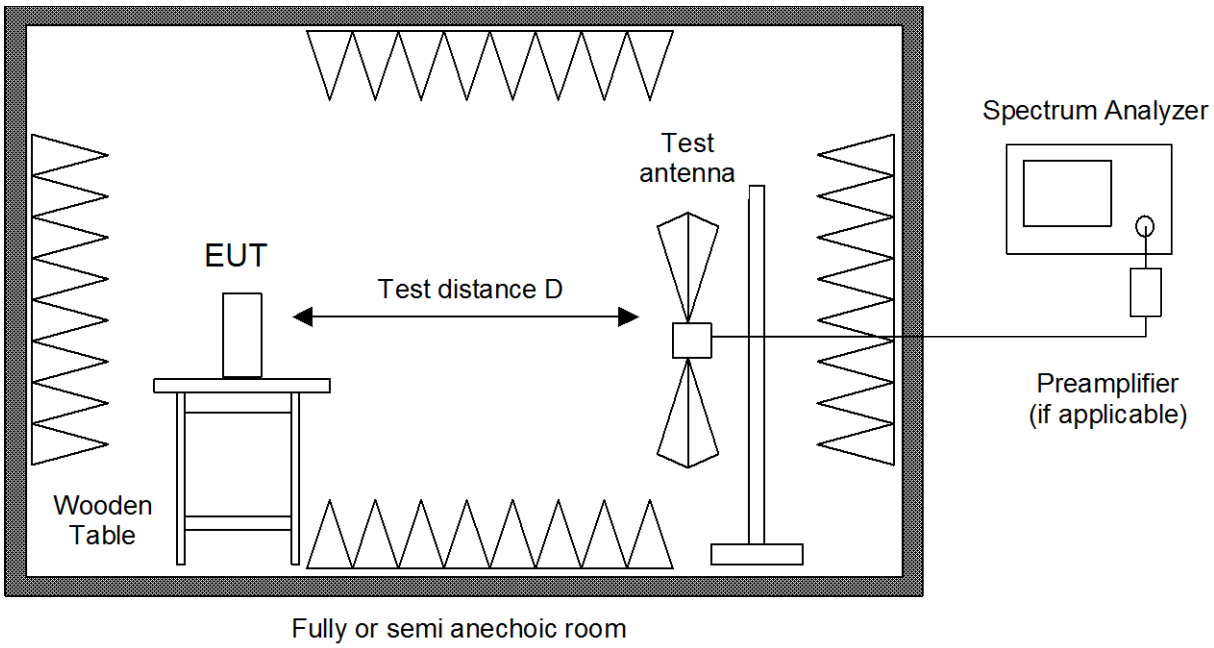
All tests below 8.2 GHz are performed at a test distance D of 3 meters. For higher frequencies the test distance may be reduced (e.g. to 1 meter) due to the sensitivity of the measuring instrument(s) and the test results are calculated according to CFR 47 Part 15 section 15.31(f)(1) using an extrapolation factor of 20 dB/decade. If required, preamplifiers are used for the whole frequency range. Special care is taken to avoid overload, using appropriate attenuators and filters, if necessary.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

During testing the EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For final testing below 1 GHz a semi anechoic room complying with the NSA requirements of ANSI C63.4 respectively ANSI C63.10 for alternative test sites is used (see 6.7). If prescans are recorded in fully anechoic room they are indicated appropriately.



Test instruments used:

	Type		*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Spectrum analyzer		FSP30	1666	100036	Rohde & Schwarz
☐	EMI test receiver	Cabin no. 3	ESPI7	2010	101018	Rohde & Schwarz
☐	EMI test receiver		ESU8	2044	100232	Rohde & Schwarz
☒	EMI test receiver		ESR7	22642	101713	Rohde & Schwarz
☒	Spectrum analyzer		FSV40	2364	101448	Rohde & Schwarz
☐	Preamplifier	Cabin no. 2	CPA9231A	1716	3557	Schaffner
☐	Preamplifier		R14601	1142	13120026	Advantest
☐	Preamplifier (1 - 8 GHz)		AFS3-00100800-32-LN	1684	847743	Miteq
☐	Preamplifier (0.5 - 8 GHz)		AMF-4D-005080-25-13P	1685	860149	Miteq

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

	Type	*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	Preamplifier (8 - 18 GHz)	ACO/180-3530	1484	32641	CTT
☐	External Mixer	WM782A	1576	845881/005	Tektronix
☐	Harmonic Mixer Accessories	FS-Z30	1577	624413/003	Rohde & Schwarz
☐	Trilog antenna Cabin no. 2	VULB 9163	1802	9163-214	Schwarzbeck
☐	Trilog antenna Cabin no. 3	VULB 9163	1722	9163-188	Schwarzbeck
☐	Trilog antenna Cabin no. 8	VULB 9163	2058	9163-408	Schwarzbeck
☐	Trilog antenna Cabin no. 2	VULB 9162	2256	9162-048	Schwarzbeck
☐	Horn antenna	3115	1516	9508-4553	EMCO
☒	Horn antenna	HF907	2073	100154	Rohde & Schwarz
☐	Horn antenna	3160-03	1010	9112-1003	EMCO
☐	Horn antenna	3160-04	1011	9112-1001	EMCO
☐	Horn antenna	3160-05	1012	9112-1001	EMCO
☐	Horn antenna	3160-06	1013	9112-1001	EMCO
☒	Horn antenna	3160-07	1014	9112-1008	EMCO
☒	Horn antenna	3160-08	1015	9112-1002	EMCO
☒	Horn antenna	3160-09	1265	9403-1025	EMCO
☐	Horn antenna	3160-10	1575	399185	EMCO
☐	Microwave cable Cabin no. 2	UFA210A-FG	1681	23516	Rosenberger Micro-Coax
☐	Microwave cable Cabin no. 2	KKSF1040016	2020	289854/4	Huber + Suhner
☐	Microwave cable Cabin no. 2	FA210AF020000000	2060	64566-2	Rosenberger Micro-Coax
☐	Microwave cable Cabin no. 8	EF393	2053	---	Albatross Projects
☐	Microwave cable Cabin no. 8	FB293C1050005050	2054	63834-1	Rosenberger Micro-Coax
☒	Microwave cable Cabin no. 8	FB293C1080005050	2055	63833-1	Rosenberger Micro-Coax
☐	Microwave cable Cabin no. 8	LCF12-50	2057	P1.3.9	RFS
☒	Microwave cable Cabin no. 8	LCF12-50	2057	P1.4.12	RFS
☐	Microwave cable Cabin no. 8	LCF12-50	2057	P1.6.19	RFS
☐	Microwave cable Cabin no. 8	FA210AF040005050G	2127	72061-01	Rosenberger Micro-Coax
☒	Microwave cable Cabin no. 8	FA210AF04000505G	2056	64567-01	Rosenberger Micro-Coax
☐	Microwave cable Cabin no. 8	FA210AF04000505	2068	64610-1	Rosenberger Micro-Coax
☐	Fully anechoic room	No. 2	1452	---	Albatross
☒	Semi anechoic room	No. 8	2057	---	Albatross
☐	Measurement Software	EMC32_K2 V9.25.00	2033	100003	Rohde & Schwarz
☒	Measurement Software	EMC32_K8 V9.25.00	1852	100016	Rohde & Schwarz

6.7 Radiated Emission at Alternative Test Site

Measurement Procedure:	
Rules and specifications:	CFR 47 Part 15, sections 15.209, 15.215(b) and 15.247 KDB 558074 v04 IC RSS-GEN Issue 4, sections 6.5, 6.13 and 8.9 IC RSS-247 Issue 2, section 5.5
Guide:	ANSI C63.10

Radiated emission in the frequency range 30 MHz to 1 GHz is measured within a semi-anechoic room with groundplane complying with the NSA requirements of ANSI C63.4 respectively ANSI C63.10 for alternative test sites. A linear polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna") is used. The measurement bandwidth of the test receiver is set to 120 kHz with quasi-peak detector selected.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

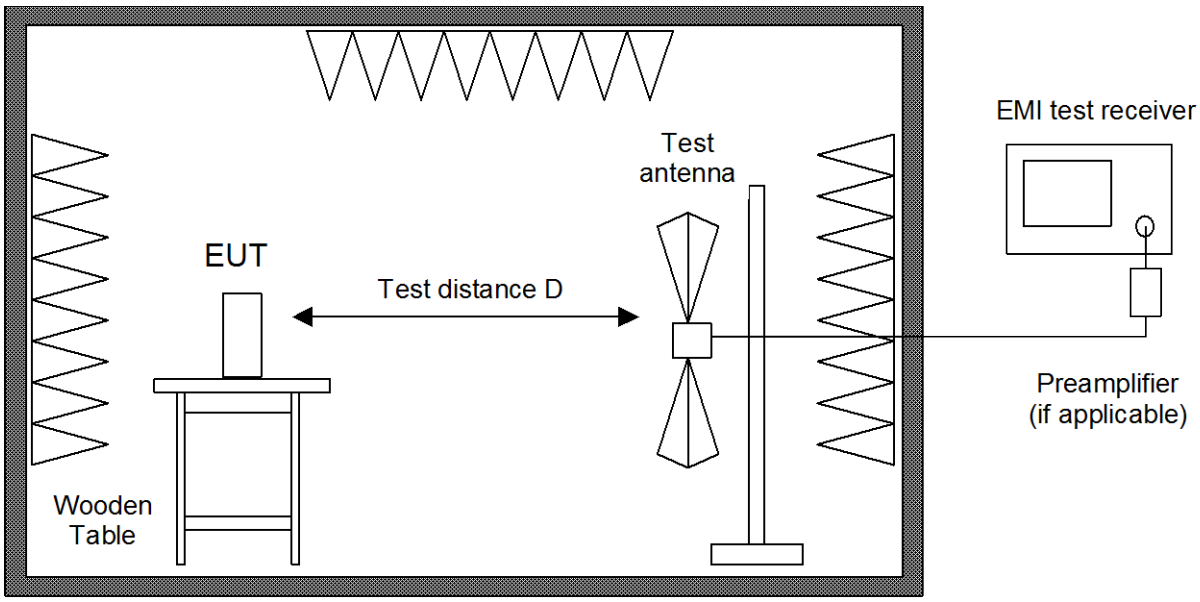
Hand-held or body-worn devices are tested in the position producing the highest emission relative to the limit as verified by prescans in fully anechoic room.

If no prescan in a fully anechoic room is used first a peak scan is performed in four positions to get the whole spectrum of emission caused by EUT with the measuring antenna raised and lowered from 1 to 4 m to find table position, antenna height and antenna polarization for the maximum emission levels.
Data reduction is applied to these results to select those levels having less margin than 10 dB to or exceeding the limit using subranges and limited number of maximums. Further maximization is following.
With detector of the test receiver set to quasi-peak final measurements are performed immediately after frequency zoom (for drifting disturbances) and maximum adjustment.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

In cases where prescans in a fully anechoic room are taken (e. g. if EUT is operating for a short time only or battery is dircharged quickly) final measurements with quasi-peak detector are performed manually at frequencies indicated by prescan with EUT rotating all around and receiving antenna raising and lowering within 1 meter to 4 meters to find the maximum levels of emission.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For measuring emissions of intentional radiators and receivers a test distance D of 3 meters is selected. Testing of unintentional radiators is performed at a distance of 10 meters. If limits specified for 3 meters shall be used for measurements performed at 10 meters distance the limits are calculated according to CFR 47 Part 15 section 15.31(d) and (f)(1) using an inverse linear-distance extrapolation factor of 20 dB/decade.

According to section 13 of KDB558074 the requirement for radiated emissions on the band edges was performed with a reduced bandwidth of 100 kHz instead of 1 MHz.



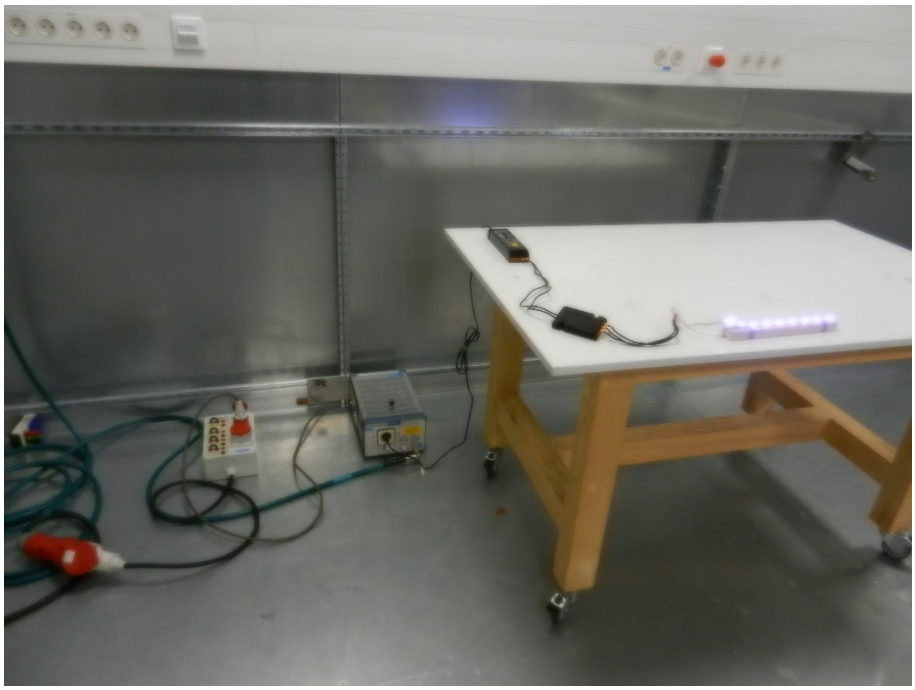
Alternate test site (semi anechoic room)

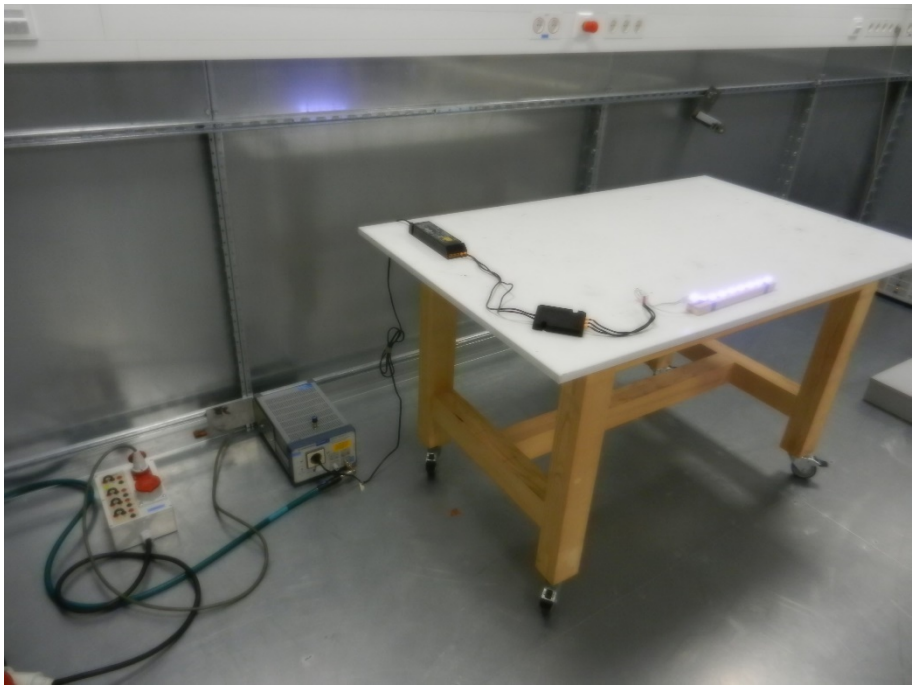
Test instruments used:

	Type		*Designation*	*Inv.-no.*	*Serial No. or ID*	*Manufacturer*
☐	EMI test receiver		ESU8	2044	100232	Rohde & Schwarz
☒	EMI test receiver		ESR7	22642	101713	Rohde & Schwarz
☒	Trilog antenna	Cabin no. 8	VULB 9163	2058	9163-408	Schwarzbeck
☒	Microwave cable	Cabin no. 8	EF393	2053	---	Albatross Projects
☒	Microwave cable	Cabin no. 8	LCF12-50	2057	P1.6.19	RFS
☐	Microwave cable	Cabin no. 8	LCF12-50	2057	P1.3.9	RFS
☒	Microwave cable	Cabin no. 8	FA210AF04000505	2068	64610-1	Rosenberger Micro-Coax
☒	Microwave cable	Cabin no. 8	FA210AF040005050G	2127	72061-01	Rosenberger Micro-Coax
☒	Semi anechoic room		No. 8	2057	---	Albatross
☒	Measurement Software		EMC32_K8 V9.25.00	1852	100016	Rohde & Schwarz

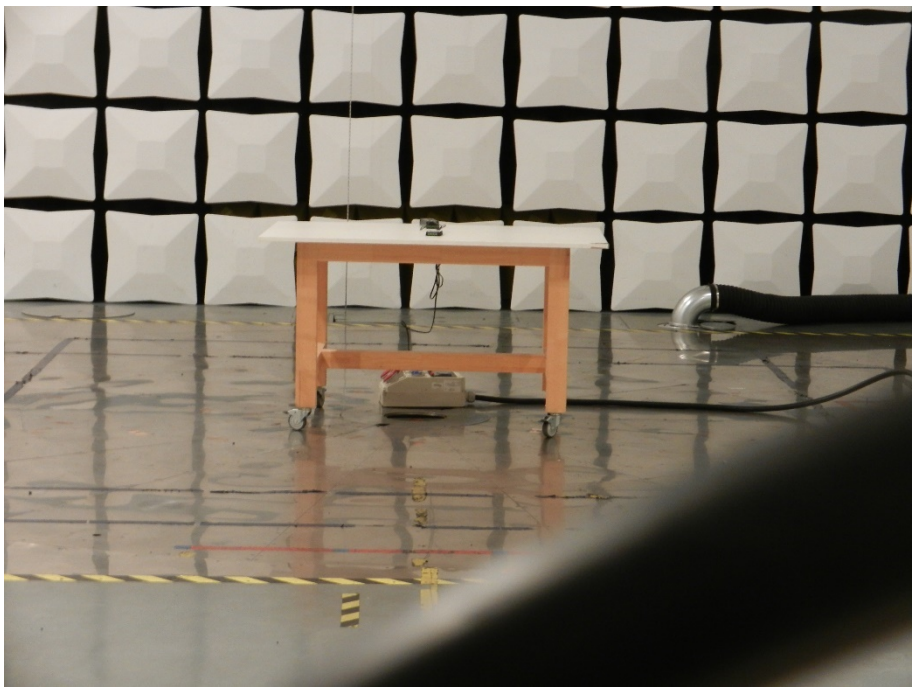
7 Photographs Taken During Testing

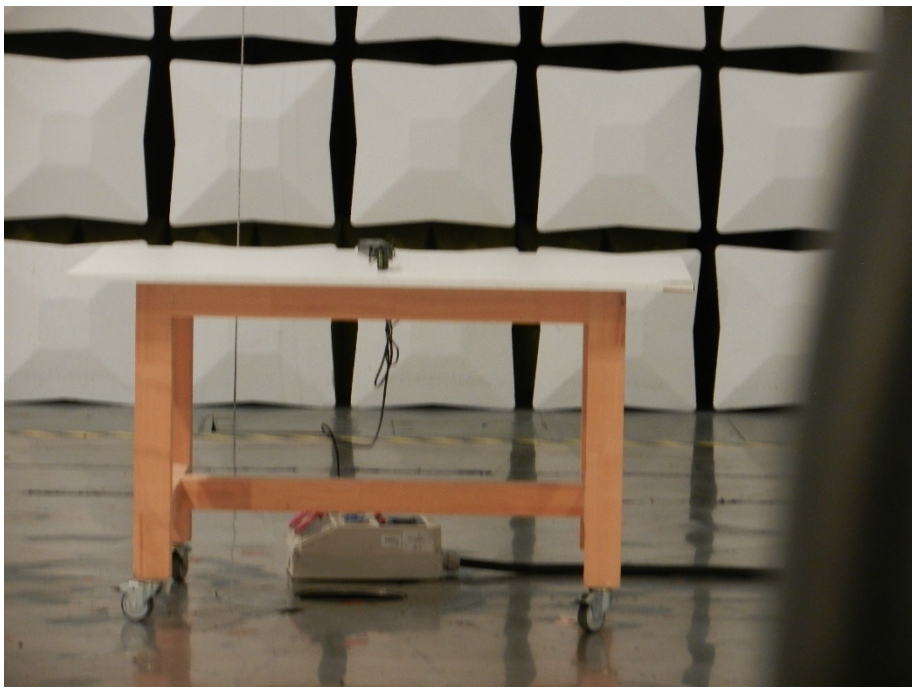
Test setup for conducted AC powerline emission measurement





Test setup for radiated emission measurement 9 kHz – 30 MHz

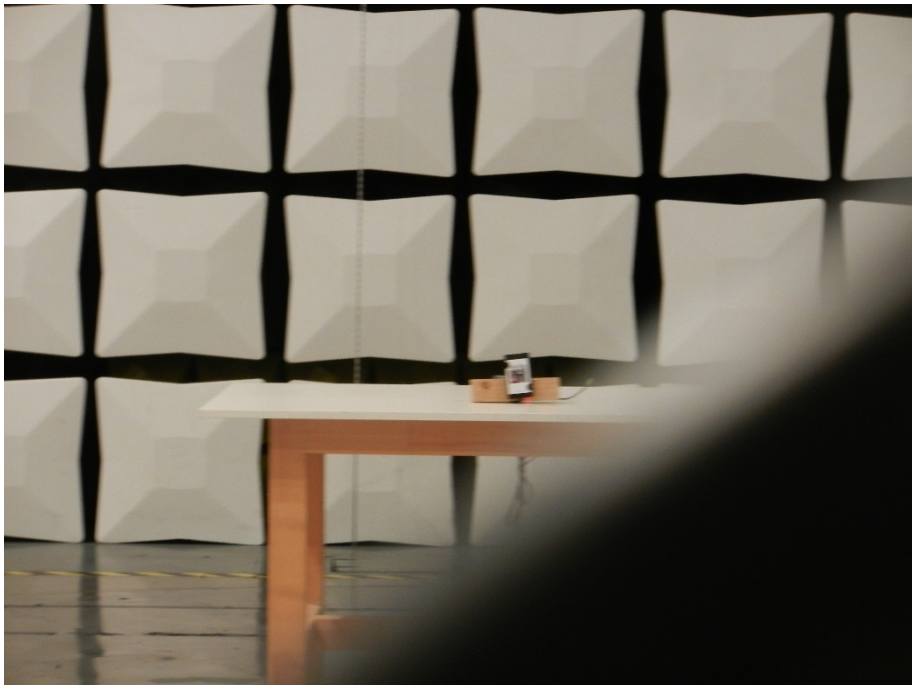




TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

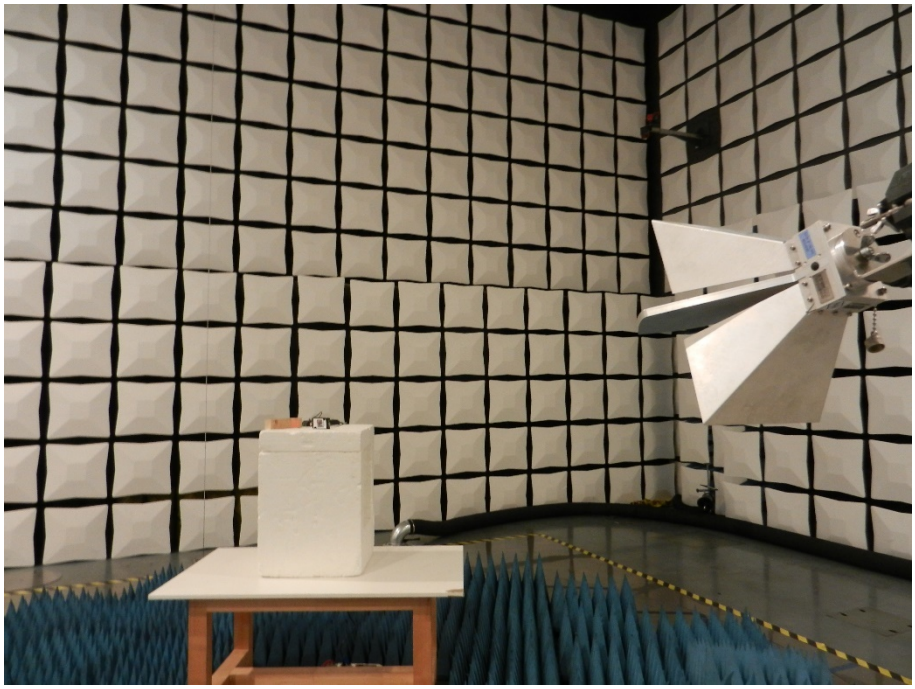
Test setup for radiated emission measurement 9 kHz – 30 MHz - continued -

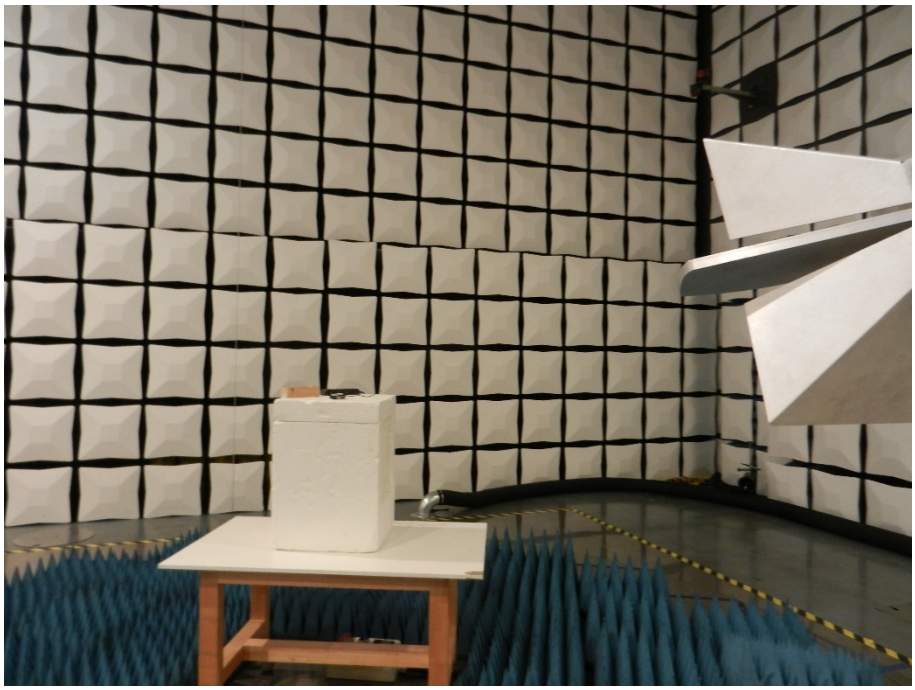


TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Test setup for radiated emission measurement (fully anechoic room)

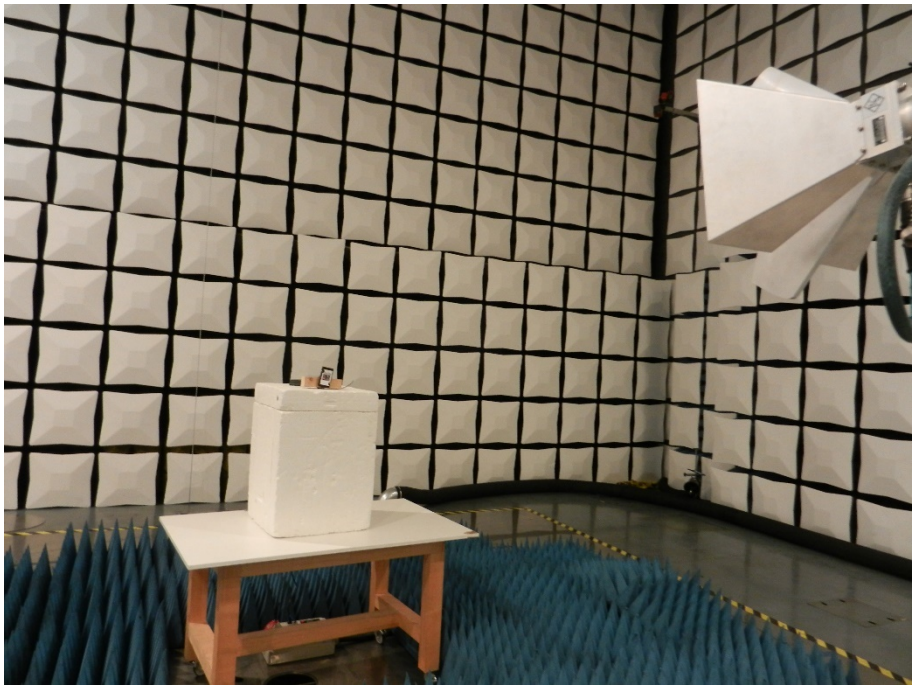




TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

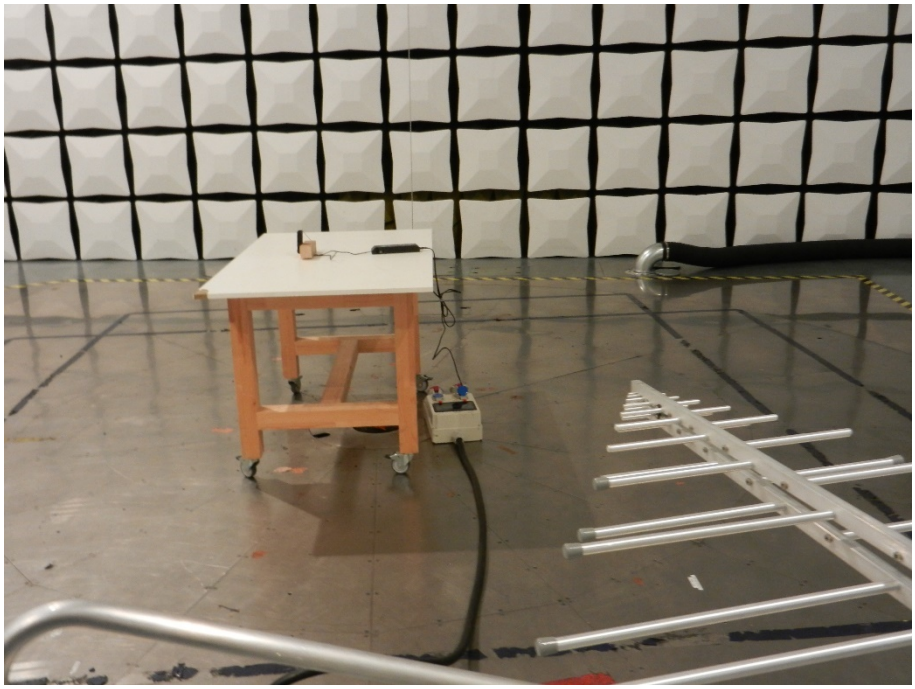
Test setup for radiated emission measurement (fully anechoic room) - continued -



TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Test setup for radiated emission measurement (alternate test site)



8 Test Results

FCC CFR 47 Parts 2 and 15			
Section(s)	*Test*	*Page*	*Result*
2.1046(a)	Conducted output power	---	Not applicable
2.202(a)	Occupied bandwidth		Recorded
15.204	Antenna requirement	---	Integrated Antenna
15.215(c)	Bandwidth of the emission	---	Not applicable
2.201, 2.202	Class of emission	34	Calculated
15.35(c)	Pulse train measurement for pulsed operation	---	Not applicable
15.205(a)	Restricted bands of operation	35	Test passed
15.247(a)(2)	DTS (6 dB) Bandwidth	32	Test passed
15.247(e)	Power spectral density	36	Test passed
15.247(b)(3)	Maximum peak output power	37	Test passed
15.207	Conducted AC powerline emission 150 kHz to 30 MHz	38	Test passed
15.247(d)	Unwanted conducted emissions 30 MHz to 25 GHz	41	Test passed
15.205(b) 15.247(d)	Unwanted radiated emission 9 kHz to 30 MHz	44	Test passed
15.205(b) 15.215(b) 15.247(d)	Unwanted radiated emission 30 MHz to 25 GHz	45	Test passed
15.247(i) 2.1093	RF exposure requirement	52	Test passed

IC RSS-Gen Issue 4			
Section(s)	*Test*	*Page*	*Result*
6.12	Transmitter output power (conducted)	---	Not applicable
6.6	Occupied Bandwidth		Recorded
9	Designation of emissions	34	Calculated
6.10	Pulsed operation	---	Not applicable
8.8	Conducted AC powerline emission 150 kHz to 30 MHz	38	Test passed
8.10	Restricted bands and unwanted emission frequencies	---	Not applicable [5]
6.4, 6.13, 8.9	Unwanted emissions 9 kHz to 30 MHz	---	Not applicable [5]
6.5, 6.13, 8.9	Unwanted emissions 30 MHz to 25 GHz	---	Not applicable [5]
3.2	Exposure of Humans to RF Fields	54	Exempted from SAR and RF evaluation

IC RSS-247 Issue 2			
Section(s)	*Test*	*Page*	*Result*
5.2(1)	Minimum 6 dB bandwidth	32	Test passed
5.2(2)	Power spectral density	36	Test passed
5.4(4)	Transmitter Output Power and Equivalent Isotropically Radiated Power	37	Test passed
5.5	Unwanted conducted emissions 30 MHz to 25 GHz	41	Test passed
5.5	Unwanted radiated emission 9 kHz to 30 MHz	44	Test passed
5.5	Unwanted radiated emission 30 MHz to 25 GHz	45	Test passed

[5] See IC RSS-247 Issue 2, section 5.5

8.1 DTS bandwidth

Rules and specifications:	CFR 47 Part 15, section 15.247(a)(2) IC RSS-247 Issue 2, section 5.2(1)
Guide:	ANSI C63.10
Description:	The minimum 6 dB bandwidth shall be at least 500 kHz RBW = 100 kHz; VBW ≥ 3 × RBW; Sweep = auto couple. Detector = Peak; Trace mode = max hold.
Measurement procedure:	Bandwidth Measurements (6.2)

Comment:	See section 1 of ANNEX to test report for plots
Date of test:	2017-07-20 and 2017-08-21
Test site:	Radio laboratory

Mode	Frequency (MHz)	Channel Bandwith (MHz)	Limit (kHz)	Result
BLE	2402	689.4	≥ 500	Pass
BLE	2440	709.3	≥ 500	Pass
BLE	2480	704.3	≥ 500	Pass
Prop	2401	589.4	≥ 500	Pass
Prop	2440	594.4	≥ 500	Pass
Prop	2480	639.4	≥ 500	Pass

Test Result:	Test passed

8.2 Occupied Bandwidth

Rules and specifications:	CFR 47 Part 2, section 2.202(a) ANSI C63.10, section 6.9.1
Guide:	ANSI C63.10
Description:	The occupied bandwidth according to CFR 47 Part 2, section 2.202(a), is measured as the 99% emission bandwidth, i.e. below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. The occupied bandwidth according to ANSI C63.10, section 6.9.1; is measured as the frequency range defined by the points that are 20 dB down relative to the maximum level of the modulated carrier. The span range of the spectrum analysator display shall be between two times and five times of the occupied bandwidth. The resolution bandwidth of the spectrum analyzer should be approximately 1 % to 5 % of the occupied bandwidth, unless otherwise specified, depending on the applicable requirement. The video bandwidth shall be at least three times greater than the resolution bandwidth. The dynamic range of the spectrum analyzator at the selected resolution bandwidth shall be more than 10 dB below the target “dB down” (attenuation) requirement.
Measurement procedure:	Bandwidth Measurements (6.2)

Comment:	See section 2 of ANNEX to test report for plots
Date of test:	2017-07-20 and 2017-08-21
Test site:	Radio laboratory

Mode	Frequency (MHz)	Occupied Bandwidth (MHz)	Minimum Frequency (GHz)	Maximum Frequency (GHz)
BLE	2402	1.049204	2.40148625	2.40253546
BLE	2440	1.049204	2.43948625	2.44053546
BLE	2480	1.049204	2.47948625	2.48053546
Prop	2401	1.683317	2.40016084	2.40185516
Prop	2440	1.713287	2.43915085	2.44086414
Prop	2480	1.673327	2.47916583	2.48083916

8.3 Designation of Emissions

Rules and specifications:	CFR 47 Part 2, sections 2.201 and 2.202 IC RSS-Gen Issue 4, section 9
Guide:	ANSI C63.10 / TRC-43

Type of modulation:	Frequency Shift Keying (FSK)

B_n = Necessary Bandwidth	$B_n = 2DK + B$
D = Peak deviation	D = 700 kHz
K = Overall numerical factor	K = 1
B = Modulation rate	B = 270 kHz
Calculation:	$B_n = 2 \cdot (700\ kHz) \cdot 1 + (270\ kHz) = 1.67\ MHz$

Designation of Emissions:	**1M67F1D**

8.4 Restricted Bands of Operation

Rules and specifications:	CFR 47 Part 15, sections 15.205(a) and 15.247(d)
Guide:	ANSI C63.10
Limit:	Only spurious emissions are permitted in any of the frequency bands listed in CFR 47 Part 15, section 15.205(a). In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits specified in CFR 47 Part 15, section 15.209(a).
Measurement procedure:	Conducted Output Power (6.1)

Comment:	See section 3 of ANNEX to test report for plots
Date of test:	2017-07-20 and 2017-08-21
Test site:	Radio laboratory

No fundamental emissions within restricted bands of operation

Test Result:	Test passed

8.5 Power Spectral Density

Rules and specifications:	CFR 47 Part 15, section 15.247(e) IC RSS-247 Issue 2, section 5.2(2)
Guide:	ANSI C63.10
Limit:	For digital modulated systems, the power spectral density conducted from the intentinal radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission
Measurement procedure:	Power spectral density (6.3)

Comment:	See section 4 of ANNEX to test report for plots
Date of test:	2017-07-20; 2017-08-21
Test site:	Radio laboratory

Mode	Frequency (MHz)	Power Spectral Density (dBm)	Limit (dBm)	Margin
BLE	2402	-2.4	8.0	10.4
BLE	2440	-2.8	8.0	10.8
BLE	2480	-3.4	8.0	11.4
Prop	2401	-0.7	8.0	8.7
Prop	2440	-0.5	8.0	8.5
Prop	2480	-0.6	8.0	8.6

Test Result:	Test passed

8.6 Maximum output power

Rules and specifications:	CFR 47 Part 15, section 15.247(b)(2) IC RSS-247 Issue 2, section 5.4(4)
Guide:	ANSI C63.10
Limit:	The maximum output power is 1 W (30 dBm) for systems employing digital modulation
Measurement procedure:	Conducted Output Power (6.1)

Comment:	See section 5 of ANNEX to test report for plots
Date of test:	2017-07-20; 2017-08-21
Test site:	Radio laboratory

Mode	Frequency (MHz)	Condocted output power PEP (dBm)	Limit (dBm)	Margin
BLE	2402	-2.2	30.0	32.2
BLE	2440	-2.8	30.0	32.8
BLE	2480	-3.3	30.0	33.3
Prop	2401	-0.7	30.0	30.7
Prop	2440	-0.4	30.0	30.4
Prop	2480	-0.5	30.0	30.5

Test Result:	Test passed

8.7 Conducted Powerline Emission Measurement 150 kHz to 30 MHz

Rules and specifications:	CFR 47 Part 15, section 15.207 IC RSS-GEN Issue 4, section 8.8		
Guide:	ANSI C63.10 / CISPR 22		
Limit:	Frequency of Emission (MHz)	Conducted Limit (dBµV)	
		Quasi-peak	Average
	0.15 - 0.5	66 to 56	56 to 46
	0.5 - 5	56	46
	5 - 30	60	50
Measurement procedure:	Conducted AC Powerline Emission (6.4)		

Test Result:	Test passed

Sample calculation of final values:

Final Value (dBµV) = Reading Value (dBµV) + Correction Factor (dB)

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Comment:	Tested with DC 12 V power supply See section 6.1 of ANNEX to test report for plots
Date of test:	2017-07-21
Test site:	Shielded room, cabin no. 9

Tested on:	L1

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Corr. dB*
0.474		28.1	46.4	18.4	1000	9	0.0
0.474	32.2		56.4	24.3	1000	9	0.0
3.966		25.5	46.0	20.5	1000	9	0.3
3.966	32.8		56.0	23.3	1000	9	0.3

Tested on:	N

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Corr. dB*
3.926		25.8	46.0	20.2	1000	9	0.3
3.926	31.2		56.0	24.8	1000	9	0.3
4.290		23.8	46.0	22.1	1000	9	0.3
4.290	30.3		56.0	25.7	1000	9	0.3

Test Result:	Test passed

Comment:	Tested with DC 24 V power supply See section 6.2 of ANNEX to test report for plots
Date of test:	2017-07-21
Test site:	Shielded room, cabin no. 9

Tested on:	L1

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Corr. dB*
0.446		25.0	47.0	22.0	1000	9	0.0
0.446	40.0		57.0	17.0	1000	9	0.0
3.682		16.3	46.0	29.7	1000	9	0.3
3.682	36.4		56.0	19.6	1000	9	0.3
3.702		15.7	46.0	30.3	1000	9	0.3
3.702	35.5		56.0	20.5	1000	9	0.3
3.726		16.3	46.0	29.7	1000	9	0.3
3.726	36.0		56.0	20.0	1000	9	0.3
3.750		16.5	46.0	29.5	1000	9	0.3
3.750	36.0		56.0	20.0	1000	9	0.3

Tested on:	N

Frequency MHz	*QuasiPeak dBµV*	*CAverage dBµV*	*Limit dBµV*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Corr. dB*
0.446		25.6	47.0	21.3	1000	9	0.0
0.446	40.7		57.0	16.3	1000	9	0.0
3.706		16.4	46.0	29.6	1000	9	0.3
3.706	35.2		56.0	20.8	1000	9	0.3
3.750		16.4	46.0	29.6	1000	9	0.3
3.750	34.2		56.0	21.8	1000	9	0.3
4.034		16.9	46.0	29.1	1000	9	0.3
4.034	35.2		56.0	20.8	1000	9	0.3
4.054		16.2	46.0	29.8	1000	9	0.3
4.054	34.3		56.0	21.7	1000	9	0.3

Test Result:	Test passed

8.8 Conducted Emission Measurement 30 MHz to 25 GHz

Rules and specifications:	CFR 47 Part 15, section 15.247(d) IC RSS-247 Issue 2, section 5.5
Guide:	ANSI C63.10
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that condains the highest level of the desired power. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation shall be 30 dB instead of 20 dB.
Measurement procedure:	Conducted Output Power (6.1)

Comment:	See section 7 of ANNEX to test report for plots
Date of test:	2017-07-20; 2017-08-21
Test site:	Radio laboratory

See Plots and tables for details

Test Result:	Test passed

Conducted Output Power; BLE, lowest channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2402	-2.6	---	---	---
4804	-41.7	39.1	≥20.0	Pass
7206	-46.0	43.4	≥20.0	Pass

Conducted Output Power; BLE, middle channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2440	-2.7	---	---	---
4880	-40.6	37.9	≥20.0	Pass
7320	-49.0	46.3	≥20.0	Pass

Conducted Output Power; BLE, highest channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2480	-3.4	---	---	---
4960	-41.2	37.8	≥20.0	Pass
4770	-49.4	46.0	≥20.0	Pass

Conducted Output Power; Propritary radio, lowest channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2401	-3.1	---	---	---
4802	-47.6	44.5	≥20.0	Pass
7203	-43.1	40.0	≥20.0	Pass

Conducted Output Power; Propritary radio, middle channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2440	-1.8	---	---	---
4880	-46.6	44.8	≥20.0	Pass
7320	-47.7	45.9	≥20.0	Pass

Conducted Output Power; Propritary radio, highest channel:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (dBc)	Limit (dBc)	Margin
2480	-1.1	---	---	---
4960	-37.6	36.5	≥20.0	Pass
7440	-52.7	51.6	≥20.0	Pass

8.9 Radiated Emission Measurement 9 kHz to 30 MHz

Rules and specifications:	CFR 47 Part 15, sections 15.215(b) and 15.249(d) IC RSS-210 Issue 9, section B.10(b) IC RSS-247 Issue 2, section 5.5			
Guide:	ANSI C63.10			
Limit:	Frequency of Emission (MHz)	Field Strength (µV/m)	Field Strength (dBµV/m)	Measurement Distance d (meters)
	0.009 - 0.490	2400/F(kHz)	67.6 - 20 · log(F(kHz))	300
	0.490 - 1.705	24000/F(kHz)	87.6 - 20 · log(F(kHz))	30
	1.705 - 30.000	30	29.5	30
	Additionally, the level of any unwanted emissions shall not exceed the level of the fundamental emission.			
Measurement procedure:	Radiated Emission Measurement 9 kHz to 30 MHz (6.5)			

Comment:	See section 8 of ANNEX to test report for plots
Date of test:	2017-05-04
Test site:	Open field test site

Test Result:	Test passed

No emissions above noise level detected.
See plots for details.

Sample calculation of final values:

Extrapolation Factor (dB) = (Log(d) - Log(d_1)) · Extrapolation Factor (dB/decade)

Final Value (dBµV/m) = Reading Value d_1 (dBµV) + Correction Factor (dB/m) + Extrapolation Factor (dB) + Pulse Train Correction (dB)

Note: Extrapolation factor (dB) and final value (dBµV/m) are relating to distance d.

8.10 Radiated Emission Measurement 30 MHz to 25 GHz

Rules and specifications:	CFR 47 Part 15, sections 15.215(b) and 15.249 IC RSS-210 Issue 9, section B.10 IC RSS-247 Issue 2, section 5.5		
Guide:	ANSI C63.10		
Limit:	Frequency of Emission (MHz)	Field Strength (µV/m)	Field Strength (dBµV/m)
	30 - 88	100	40.0
	88 - 216	150	43.5
	216 - 960	200	46.0
	Above 960	500	54.0
	Additionally, the level of any unwanted emissions shall not exceed the level of the fundamental emission.		
Measurement procedures:	Radiated Emission in Fully or Semi Anechoic Room (6.6) Radiated Emission at Alternative Test Site (6.7)		

Comment:	See section 9 of ANNEX to test report for plots
Date of test:	2017-05-04 and 2017-05-09
Test site:	Semi-anechoic room, cabin no. 8
Test distance:	Frequencies ≤ 8.2 GHz: 3 meters Frequencies > 8.2 GHz: 1 meter

Test Result:	Test passed

Sample calculation of final values:

Final Value (dBµV/m) = Reading Value (dBµV) + Correction Factor (dB/m) + Pulse Train Correction (dB)

Operation mode:	Bluetooth Low Energy on lowest channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	67.9	47.0
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	67.9	45.8
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2401.000	horizontal	Average	41.6	33.3		74.9		
2401.000	horizontal	Peak	54.6	33.3		87.9		
4802.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4802.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
4804.000	vertical	Peak	53.7	2.2		55.9	74.0	18.1
7203.000	horizontal	Average	3.4	44.7		48.1	67.9	19.8

Test Result:	Test passed

Operation mode:	Bluetooth Low Energy on middle channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	67.9	47.0
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	67.9	45.8
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2440.000	horizontal	Average	42.6	33.3		75.9		
2440.000	horizontal	Peak	54.6	33.3		87.9		
4880.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4880.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
7320.000	horizontal	Average	3.3	44.7		48.0	54.0	6.0
7320.000	horizontal	Peak	18.8	44.7		63.5	74.0	10.5

Test Result:	Test passed

Operation mode:	Bluetooth Low Energy on highest channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	68.5	47.7
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	68.5	46.5
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2480.000	horizontal	Average	42.6	33.3		75.9		
2480.000	horizontal	Peak	87.7	0.8		88.5		
4960.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4960.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
7440.000	horizontal	Average	3.3	44.7		48.0	54.0	6.0
7440.000	horizontal	Peak	18.8	44.7		63.5	74.0	10.5

Test Result:	Test passed

Operation mode:	Propietary radio on lowest channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	67.9	47.0
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	67.9	45.8
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2401.000	horizontal	Average	42.6	33.3		75.9		
2401.000	horizontal	Peak	54.6	33.3		87.9		
4802.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4802.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
7203.000	horizontal	Average	3.3	44.7		48.0	67.9	19.8
7203.000	horizontal	Peak	18.8	44.7		63.5	74.0	10.5

Test Result:	Test passed

Operation mode:	Propietary radio on middle channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	67.9	47.0
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	67.9	45.8
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2440.000	horizontal	Average	42.6	33.3		75.9		
2440.000	horizontal	Peak	54.6	33.3		87.9		
4880.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4880.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
7320.000	horizontal	Average	3.3	44.7		48.0	54.0	6.0
7320.000	horizontal	Peak	18.8	44.7		63.5	74.0	10.5

Test Result:	Test passed

Operation mode:	Propietary radio on highest channel

Frequency (MHz)	Antenna Polarization	Detector	Receiver Reading (dBµV)	Correction Factor (dB/m)	Pulse Train Correction (dB)	Final Value (dBµV/m)	Limit (dBµV/m)	Margin (dB)
33.355	vertical	Quasi-Peak	7.0	13.8		20.8	69.6	48.8
48.930	vertical	Quasi-Peak	6.3	15.8		22.1	69.6	47.6
124.760	horizontal	Quasi-Peak	10.1	11.4		21.5	43.5	22.0
2480.000	horizontal	Average	42.6	33.3		75.9		
2480.000	horizontal	Peak	88.8	0.8		89.6		
4960.000	horizontal	Average	12.9	41.0		53.9	54.0	**0.1**
4960.000	horizontal	Peak	31.7	41.0		72.7	74.0	1.3
7440.000	horizontal	Average	3.3	44.7		48.0	54.0	6.0

Test Result:	Test passed

8.11 RF Exposure

Rules and specifications:	CFR 47 Part 15, sections 247(i) CFR 47 Part 1, section 1.1307(b)(1)
Guide:	KDB 447498 D01 v06, section 4.3.1 a)
Limit:	Standalone SAR test exclusion considerations
	Unless specifically required by the *published RF exposure KDB procedures*, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding *SAR Test Exclusion Threshold* conditions(s), listed below is (are) satisfied: a) For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 1-g and 10-g SAR Test Exclusion Thresholds are determined by the following: $(P_{max,(mW)} / d_{min,\ (mm)})(\sqrt{f_{(GHz)}}) \leq 3.0$ for 1-g SAR and ≤ *7.5* for 10-g extremity SAR.
	$f_{(GHz)}$ is the RF channel transmit frequency in GHz $P_{max,(mW)}$ is the max. power of channel, including tune-up tolerance, rounded to the nearest mW before calculation $d_{min,\ (mm)}$ is the min. test separation distance, rounded to the nearest mm before calculation. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied.

Spectral power density				Declared by applicant	Measured
Prediction [6]:	P	=	Max. Power input of antenna		
Where:	G	=	Power gain of the antenna relativ to an isotropic radiator		
	f	=	Frequency of the channel		
	d	=	Distance to the center of radiation of the antenna		
Maximum output power:	P	=	-0.4 dBm = 912 µW	☒	☒
Antenna gain:	G	=	1.3 dBi = 1.35		
	P_{max}	=	1 mW		
	f	=	2.48 GHz		
Prediction distance:	R	=	5 mm		
	STET	**=**	**0.3**		
Limit	**$STET_{lim}$**	**=**	**3.0**		

[6] MPE Prediction of MPE according to equation from page 19 of OET Bulletin 65, Ed. 97-01

Test Result:	Test passed

8.12 Exposure of Humans to RF Fields

Rules and specifications:	IC RSS-Gen Issue 4, section 3.2
Guide:	IC RSS-102 Issue 5, section 2.5

Exposure of Humans to RF Fields	Applicable	Declared by applicant	Measured	Exemption
The antenna is				
☐ detachable				
The conducted output power (CP in watts) is measured at the antenna connector: CP = **..... W**			☐	
The effective isotropic radiated power (EIRP in watts) is calculated using				
☐ the numerical antenna gain: G = **.....**		☐		
$EIRP = G \cdot CP \Rightarrow EIRP$ = **..... W**				
☐ the field strength[7] in V/m: FS = **..... V/m**			☐	
$EIRP = \frac{(FS \cdot D)^2}{30} \Rightarrow EIRP$ = **..... W**				
with:				
Distance between the antennas in m: D = **..... m**			☐	
☒ not detachable				
A field strength measurement is used to determine the effective isotropic radiated power (EIRP in watts) given by[7]: $EIRP = \frac{(FS \cdot D)^2}{30} \Rightarrow EIRP$ = **273.6 µW**				
with:				
Field strength in V/m: FS = **30.2 mV/m**			☒	
Distance between the two antennas in m: D = **3 m**			☒	
Selection of output power				
The output power TP is the higher of the conducted or effective isotropic radiated power (e.i.r.p.): TP = **273.6 µW**				

[7] The conversion formula is valid only for properly matched antennas. In other cases the transmitter output power may have to be measured by a terminated measurement when applying the exemption clauses.
If an open area test site is used for field strength measurement, the effect due to the metal ground reflecting plane should be subtracted from the maximum field strength value in order to reference it to free space, before calculating TP.

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany

Phone: +49 9421 5522-0
Fax: +49 9421 5522-99
Web: www.tuev-sued.de

Exposure of Humans to RF Fields (continued)		Applicable	Declared by applicant	Measured	Exemption
Separation distance between the user and the transmitting device is					
☒ less than or equal to 20 cm	☐ greater than 20 cm		☒		
Transmitting device is					
☐ in the vicinity of the human head	☐ body-worn		☐		

SAR evaluation				
SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in the table. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in the table are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in the table are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in the table, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required. For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.				

Frequency (MHz)	Exemption limits (mW)[8] at separation distance of									
	≤5 mm	10 mm	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm	≥50 mm
≤300 [9]	71	101	132	162	193	223	254	284	315	345
450	52	70	88	106	123	141	159	177	195	213
835	17	30	42	55	67	80	92	105	117	130
1900	7	10	18	34	60	99	153	225	316	431
2450	4	7	15	30	52	83	123	173	235	309
3500	2	6	16	32	55	86	124	170	225	290
5800	1	6	15	27	41	56	71	85	97	106

Carrier frequency:	f	=	**2440 MHz**
Distance:	d	=	**5 mm**
Transmitter output power:	TP	=	**273.6 µW**
Limit:	TP_{limit}	=	**4 mW** ☒

☐ SAR evaluation is documented in test report no. .....

[8] The excemption limit in the table are based on measurements and simulations on half-wave dipole antennas at separaton distances of 5 mm to 25 mm from a flat phantom, providing a SAR value of approximately 0.4 W/kg for 1 g of tissue. For low frequencies (300 MHz to 835 MHz), the exemption limits are derived from alinear fit. For high frequencies (1900 MHz and above), the exemption limits are derived from athird order polynomial fit.

[9] Transmitters operating between 3 kHz and 10 MHz, meeting the exemption from routine SAR evaluation, shall demonstrate compliance to the instantaneous limits in IC RSS-102, issue 5, section 4.

Exposure of Humans to RF Fields (continued)	Applicable	Declared by applicant	Measured	Exemption
RF exposure evaluation				
RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows: ☐ below 20 MHz[10] and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance). ☐ between 3 kHz and 10 MHz exposure limits apply as following: ☐ In a uncontrolled environment the basic restriction for the instantaneous internal electric field strength is equal to or less than 2.7 · 10-4 *f* V/m_{rms} at any part of the body where *f* is in Hz. The instantaneous RF field strength is equal or less than 83 V/m_{rms} and equal or less than 90 A/m_{rms}. ☐ In a controlled environment the basic restriction for the instantaneous internal electric field strength is equal to or less than 1.35 · 10-4 *f* V/m_{rms} at any part of the body where *f* is in Hz. The instantaneous RF field strength is equal or less than 170 V/m_{rms} and equal or less than 180 A/m_{rms}. ☐ at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 4,49/$f^{0.5}$ W (adjusted for tune-up tolerance, where *f* is in MHz. ☐ at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance). ☐ at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 · $10^{-2}f^{0.6834}$ W (adjusted for tune-up tolerance), where *f* is in MHz. ☐ at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance). In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.				
Carrier frequency: f = Transmitter output power: TP = Limit: TP_{limit} =				☐
☐ RF exposure evaluation is documented in test report no.				

[10] Transmitters operating between 3 kHz and 10 MHz, meeting the exemption from routine RF Exposure evaluation, shall demostrate compilance tot he instanteneous limits in IC RSS-102, issue 5, section 4.

9 Referenced Regulations

All tests were performed with reference to the following regulations and standards:

☒	CFR 47 Part 2	Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)	October 1, 2016
☒	CFR 47 Part 15	Code of Federal Regulations Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)	October 1, 2016
☐	ANSI C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz	June 13, 2014 (published on June 20, 2014)
☒	ANSI C63.10	American national Standard of Procedures for Compilance Testing of Unlicensed Wireless Devices	June 27, 2013 (published on September 13, 2013)
☒	RSS-Gen	Radio Standards Specification RSS-Gen Issue 4 containing General Requirements for Compilance of Radio Apparatus, published by Industry Canada	November 2014
☐	RSS-210	Radio Standards Specification RSS-210 Issue 9 for Licence-Exempt Radio Apparatus: Category I Equipment, published by Industry Canada	August 2016
☒	RSS-247	Radio Standards Specification RSS-247 Issue 2 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Excempt Local Area Network (LE-LAN) Devices	February 2017
☐	RSS-310	Radio Standards Specification RSS-310 Issue 3 for Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category II Equipment, published by Industry Canada	December 2010
☒	RSS-102	Radio Standards Specification RSS-102 Issue 5: Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), published by Industry Canada	March 2015
☐	ICES-003	Interference-Causing Equipment Standard ICES-003 Issue 6: Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement, published by Industry Canada	January 2016
☒	CISPR 22	Third Edition of the International Special Committee on Radio Interference (CISPR), Pub. 22, “Information Technology Equipment – Radio Disturbance Characteristics – Limits and Methods of Measurement”	1997

☐	CAN/CSA CISPR 22-10	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement (Adopted IEC CISPR 22:2008, sixth edition, 2008-09)	2010
☐	TRC-43	Designation of Emissions, Class of Station and Nature of Service, published by Industry Canada	November 2012
☒	KDB 558074	Guidance for performing compliance measurements on digital transmission systems (DTS) operating under section 15.247 (KDB 447498 D01 v06)	April 2017

10 Test Equipment List with Calibration Data

Type	*Inv.-No.*	*Type Designation*	*Serial Number*	*Manufacturer*	*Calibration Organization*	*Last Calibration*	*Next Calibration*
EMI test receiver	1863	ESCI3	100008	Rohde & Schwarz	Rohde & Schwarz	2016/10	2017/10
EMI test receiver		ESR7	101713	Rohde & Schwarz	Rohde & Schwarz	2016/11	2017/11
Spectrum analyser	2364	FSV40	101448	Rohde & Schwarz	Rohde & Schwarz	2016/11	2017/11
V-network	1059	ESH3-Z5	894785/005	Rohde & Schwarz	Rohde & Schwarz	2016/10	2019/10
Double ridged horn antenna	2073	HF907	100154	Rohde & Schwarz	Rohde & Schwarz	2017/06	2019/06
Horn antenna	1014	3160-07	9112-1008	EMCO Elektronik		see note 1	
Horn antenna	1015	3160-08	9112-1002	EMCO Elektronik		see note 1	
Horn antenna	1265	3160-09	9403-1025 (931941-010)	EMCO Elektronik		see note 1	
Loop antenna	1016	HFH2-Z2	882964/0001	Rohde & Schwarz	Rohde & Schwarz	2016/07	2018/07
TRILOG Broadband Antenna	2058	VULB 9163	9163-408	Schwarzbeck	Rohde & Schwarz	2016/07	2018/07

Note 1: No calibration required.
Note 2: Not calibrated separately but with the whole test system when recording calibration data.
Note 3: No calibration required. Devices are checked before use.
Note 4: No calibration required. Devices are checked by calibrated equipment during test.

11 Revision History

Revision History			
Edition	*Date*	*Issued by*	*Modifications*
1	2017-08-28	M. Steindl (lc)	First Edition
2	2017-09-11	M. Steindl (lc)	Correction of type designation; Deleted address on wrong entry
3	2017-09-20	M. Steindl (lc)	Updated reference to IC RSS-247, Issue 2. Added references to protocols Altered the distance for human exposure calculations to „smaller than 20 cm.
4	2017-10-04	M. Steindl (lc)	Altered 8.11 RF Exposure to KDB 447498 D01 v06