

FCC Measurement/Technical Report on

BOX827

FCC ID: XO2-BOX827 IC: 8713A-BOX827

Test Report Reference: MDE_HDW_2301_FCC_03

Test Laboratory: 7layers GmbH Borsigstrasse 11 40880 Ratingen Germany



Note:

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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization

Certification for an Intentional Radiator.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-21 Edition). The following subparts are applicable to the results in this test report.

- Part 2, Subpart J Equipment Authorization Procedures, Certification
- Part 15, Subpart C Intentional Radiators
- § 15.201 Equipment authorization requirement
- § 15.207 Conducted limits
- § 15.209 Radiated emission limits; general requirements
- § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz

Note:

The tests were selected and performed with reference to the FCC Public Notice "Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating under Section 15.247 of the FCC Rules, 558074 D01 15.247 Meas Guidance v05r02, 2019-04-02". ANSI C63.10-2013 is applied.



1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for DTS (e.g. WLAN 2.4 GHz, BT LE) equipment from FCC and IC

DTS equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Occupied bandwidth	§ 15.247 (a) (2)	RSS-247 Issue 3: 5.2 (a)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 3: 5.4 (d)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 5: 6.13 / 8.9/8.10; RSS-247 Issue 3: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 5: 6.13 / 8.9/8.10; RSS-247 Issue 3: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 3: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 3: 5.2 (b)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 5: 8.3
Receiver spurious emissions	-	-



1.3 MEASUREMENT SUMMARY

Subpart C §15.247 Creating to ANSI C63.10, chapter Final Result Occupied Bandwidth (6 dB) The measurement was performed according to ANSI C63.10, chapter Final Result 11.8.1 OP-Mode Setup Date FCC IC Radio Technology, Operating Frequency S02_AA01 2023-10-18 Passed Passed Bluetooth LE 1 Mbps, high S02_AA01 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, high S02_AA01 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, high S02_AA01 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, now S02_AA01 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, now S02_AA01 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, now S02_AA01 2023-10-18 Passed Passed Cocupied Bandwidth (99%) The measurement was performed according to ANSI C63.10, chapter Final Result 6.9.3 OP-Mode Setup Date FCC IC Radio Technology, Operating Frequency S02_AA01 2023-10-18 N/A Performed Bluetooth LE 1 Mbp					
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47 CFR CHAPTER I FCC PART 15 IC RSS-Gen & IC TRC-43; Ch. 6.7 & Ch. 8 Subpart C §15.247 Occupied Bandwidth (99%) Final Result 6.9.3 Final Result Final Result OP-Mode Setup Date FCC IC Radio Technology, Operating Frequency Sol_AA01 2023-10-18 N/A Performed Bluetooth LE 1 Mbps, high S02_AA01 2023-10-18 N/A Performed Bluetooth LE 1 Mbps, nid S02_AA01 2023-10-18 N/A Performed Bluetooth LE 1 Mbps, nid S02_AA01 2023-10-18 N/A Performed Bluetooth LE 2 Mbps, high S02_AA01 2023-10-18 N/A Performed Bluetooth LE 2 Mbps, low S02_AA01 2023-10-18 N/A Performed Fund Result Stappert C §15.247 Subpart C §15.247 Performed So2_AA01 2023-10-18 N/A Performed Peak Power Output For C PART 15 § 15.247 (b) (3) Subpart C §15.247 Performed Subpart C §15.247 Setup Date FCC IC Radio Technology, Operating Frequency, Measurement was performed according to ANSI C63.10, chap	Bluetooth LE 2 Mbps, low	S02_AA01	2023-10-18	Passed	Passed
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Bluetooth LE 2 Mbps, low, conductedS02_AA012023-10-18PassedPassed	Bluetooth LE 1 Mbps, mid, conducted	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 2 Mbps, low, conductedS02_AA012023-10-18PassedPassed	Bluetooth LE 2 Mbps, high, conducted	S02_AA01	2023-10-18	Passed	Passed
		S02_AA01	2023-10-18	Passed	Passed
	Bluetooth LE 2 Mbps, mid, conducted	S02_AA01	2023-10-18	Passed	Passed



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§ 15.247 (d)

Spurious RF Conducted Emissions

The measurement was performed according to ANSI C63.10, chapter **Final Result** 11.11

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
Bluetooth LE 1 Mbps, high	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 1 Mbps, low	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 1 Mbps, mid	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 2 Mbps, high	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 2 Mbps, low	S02_AA01	2023-10-18	Passed	Passed
Bluetooth LE 2 Mbps, mid	S02_AA01	2023-10-18	Passed	Passed

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Transmitter Spurious Radiated Emissions

The measurement was performed according to ANSI C63.10, chapter **Final Result** 6.4, 6.5, 6.6.5

OP-Mode Radio Technology, Operating Frequency, Measurement range	Setup	Date
Bluetooth LE 1 Mbps, high, 1 GHz - 26 GHz	S01_AB01	2023-10-23
Bluetooth LE 1 Mbps, high, 30 MHz - 1 GHz	S01_AB01	2023-10-19
Bluetooth LE 1 Mbps, low, 1 GHz - 26 GHz	S01_AB01	2023-10-23
Bluetooth LE 1 Mbps, low, 30 MHz - 1 GHz	S01_AB01	2023-10-18
Bluetooth LE 1 Mbps, mid, 1 GHz - 26 GHz	S01_AB01	2023-10-23
Bluetooth LE 1 Mbps, mid, 30 MHz - 1 GHz	S01_AB01	2023-10-19
Bluetooth LE 1 Mbps, mid, 9 kHz - 30 MHz	S01_AB01	2023-10-19
Bluetooth LE 2 Mbps, high, 1 GHz - 8 GHz	S01_AB01	2023-10-23
Bluetooth LE 2 Mbps, high, 30 MHz - 1 GHz	S01_AB01	2023-10-19

Bluetooth LE 2 Mbps, high, 30 MHz - 1 GHzS01_AB01Bluetooth LE 2 Mbps, low, 1 GHz - 8 GHzS01_AB01Bluetooth LE 2 Mbps, low, 30 MHz - 1 GHzS01_AB01Bluetooth LE 2 Mbps, mid, 1 GHz - 8 GHzS01_AB01Bluetooth LE 2 Mbps, mid, 30 MHz - 1 GHzS01_AB01Bluetooth LE 2 Mbps, mid, 30 MHz - 1 GHzS01_AB01Bluetooth LE 2 Mbps, mid, 9 KHz - 30 MHzS01_AB01

FCC

Passed

2023-10-23

2023-10-19

2023-10-23

2023-10-19

2023-10-19

IC

Passed



Subpart C §15.247 Band Edge Compliance Conducted The measurement was performed according to ANSI C63.10, chapter Final Result 11.11 **OP-Mode** FCC Setup Date IC Radio Technology, Operating Frequency, Band Edge S02_AA01 2023-10-18 Passed Passed Bluetooth LE 1 Mbps, high, high Bluetooth LE 1 Mbps, low, low S02_AA01 2023-10-18 Passed Passed S02_AA01 2023-10-18 Bluetooth LE 2 Mbps, high, high Passed Passed S02 AA01 2023-10-18 Bluetooth LE 2 Mbps, low, low Passed Passed **47 CFR CHAPTER I FCC PART 15** § 15.247 (d) Subpart C §15.247 Band Edge Compliance Radiated The measurement was performed according to ANSI C63.10, chapter **Final Result** 6.6.5 **OP-Mode** Date FCC IC Setup Radio Technology, Operating Frequency, Band Edge Bluetooth LE 1 Mbps, high, high S01_AB01 2023-10-23 Passed Passed Bluetooth LE 2 Mbps, high, high S01_AB01 2023-10-23 Passed Passed **47 CFR CHAPTER I FCC PART 15** § 15.247 (e) Subpart C §15.247 Power Density The measurement was performed according to ANSI C63.10, chapter Final Result 11.10.2 **OP-Mode** Date FCC IC Setup Radio Technology, Operating Frequency Bluetooth LE 1 Mbps, high S02_AA01 2023-10-18 Passed Passed Bluetooth LE 1 Mbps, low S02_AA01 2023-10-18 Passed Passed Bluetooth LE 1 Mbps, mid S02_AA01 2023-10-18 Passed Passed S02 AA01 Bluetooth LE 2 Mbps, high 2023-10-18 Passed Passed Bluetooth LE 2 Mbps, low S02_AA01 2023-10-18 Passed Passed S02_AA01 2023-10-18 Bluetooth LE 2 Mbps, mid Passed Passed N/A: Not applicable N/P: Not performed

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2 REVISION HISTORY / SIGNATURES

Report version control				
Version	Release date	Change Description	Version validity	
initial	2023-10-24		valid	

COMMENT: -

2 Auch

(responsible for accreditation scope) Dipl.-Ing. Robert Machulec

(responsible for testing and report) MSc. Joel Asongwe





3 ADMINISTRATIVE DATA

3.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11
	40880 Ratingen
	Germany
	cerniariy

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01 -02 -03
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
	,

Responsible for accreditation scope: Dipl.-Ing. Robert Machulec Report Template Version:

2022-05-25

3.2 PROJECT DATA

Responsible for testing and report: MSc. Joel Asongwe Employees who performed the tests: documented internally at 7Layers

Date of Report: Testing Period:

2023-10-24 2023-10-18 to 2023-10-23

3.3 APPLICANT DATA

Company Name:	H&D Wireless AB
Address:	Färögatan 33, Kista Science Tower 164 51 Kista Sweden
Contact Person:	Mikael Olsson

3.4 MANUFACTURER DATA

Company Name:	please see Applicant Data
Address:	
Contact Person:	



4 TEST OBJECT DATA

4.1 GENERAL EUT DESCRIPTION

Kind of Device product description	BOX827 is a self-sustained IoT sensor that can be used in many applications such as industrial fans, pumps, telphers etc. The BOX includes GPS, NFC (Receiver only), BLE and LTE cellular communication.
Product name	BOX827
Туре	BOX827
Declared EUT data by	the supplier
Voltage Type	DC (USB)
Voltage Level	5V
Antenna / Gain	3.5
Tested Modulation Type	GFSK
EUT ports (connected cables during testing):	USB cable
Tested data rates	1Mbps; 2Mbps
Special software used for testing	No special SW used

4.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
aa01	DE1495000aa01	Sample with temporary SMA connector
Sample Parameter		Value
Serial No.	00510	
HW Version	R6C	
SW Version	hwtest-1.4.1	
Comment	-	

Sample Name	Sample Code	Description
ab01	DE1495000ab01	Radiated sample
Sample Parameter		Value
Serial No.	00681	
HW Version	R6C	
SW Version	hwtest-1.4.1	
Comment	-	

NOTE: The short description is used to simplify the identification of the EUT in this test report.



4.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

	Details (Manufacturer, Type Model, OUT Code)	Description
-	-	-

4.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.

But nevertheless Auxiliary Equipment can influence the test results.

Device	Details (Manufacturer, Type Model, HW, SW, S/N)	Description
Laptop	ASUS,X415,P1411CEA-EB915R, SN:M8NXCV19W915356,	Used as power supply and for programming
Laptop power suppply	ASUS, AC Adaptor, AD2108020,	

4.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	Combination of EUTs	Description and Rationale
S01_AB01	ab01, Laptop, Laptop power suppply	Used for radiated measurements
S02_AA01	aa01, Laptop, Laptop power suppply	Used for conducted measurements at temporary antenna connector



4.6 OPERATING MODES / TEST CHANNELS

This chapter describes the operating modes of the EUTs used for testing.

BT LE Test Channels: Channel: Frequency [MHz]

2.4 GHz ISM						
2400 -	2400 - 2483.5 MHz					
low	mid	high				
0	19	39				
2402	2440	2480				

4.7 PRODUCT LABELLING

4.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

4.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.



5 TEST RESULTS

5.1 OCCUPIED BANDWIDTH (6 DB)

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 11.8.1

5.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.

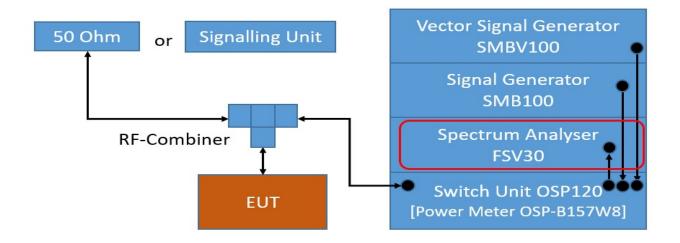
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The results recorded were measured with the modulation which produce the worst-case (smallest) emission bandwidth.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: Two times nominal bandwidth
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 15000)
- Sweeptime: Auto
- Detector: Peak



TS8997; Channel Bandwidth



5.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (a) (2) Systems using digital modulation techniques may operate in the 902-928 MHz and 2400-2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.1.3 TEST PROTOCOL

Ambient temperature:	23 °C				
Air Pressure: Humidity: BT LE 1 Mbit/s	1002 hPa 40 %				
Band / Mode	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0	2402	0.760	0.5	0.260
	10	2440	0.808	0.5	0.308
	19	2440	10.000	0.5	0.500

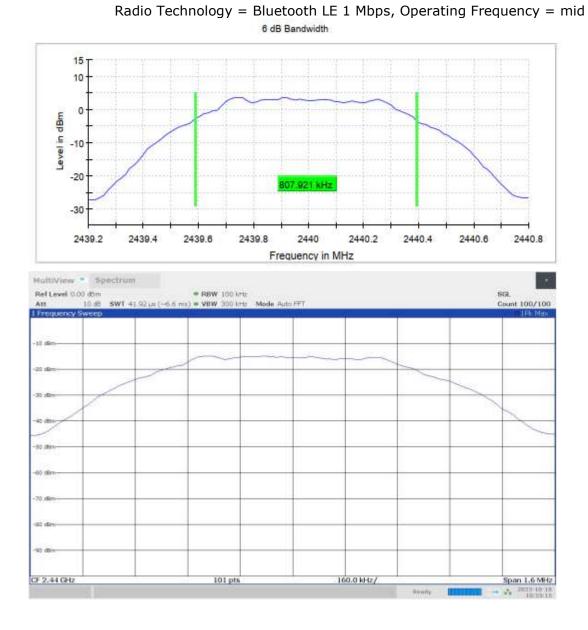
BT LE 2 Mbit/s

Band / Mode	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0	2402	1.442	0.5	0.942
	19	2440	1.442	0.5	0.942
	39	2480	1.442	0.5	0.942

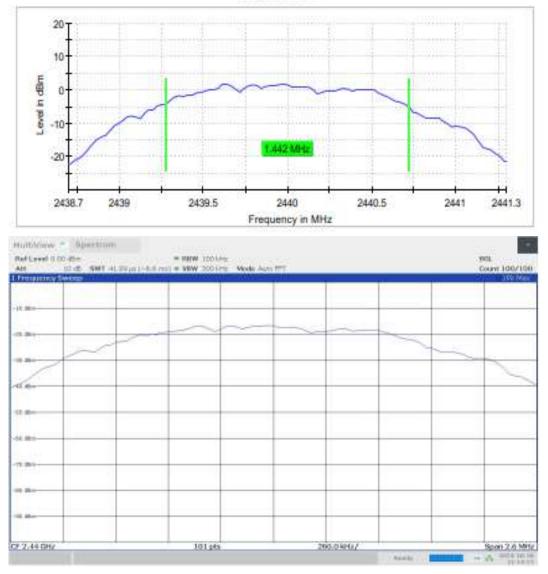
Remark: Please see next sub-clause for the measurement plot.



5.1.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)







Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = mid 6 dB Bandwidth

5.1.5 TEST EQUIPMENT USED

- R&S TS8997



5.2 OCCUPIED BANDWIDTH (99%)

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 6.9.3

5.2.1 TEST DESCRIPTION

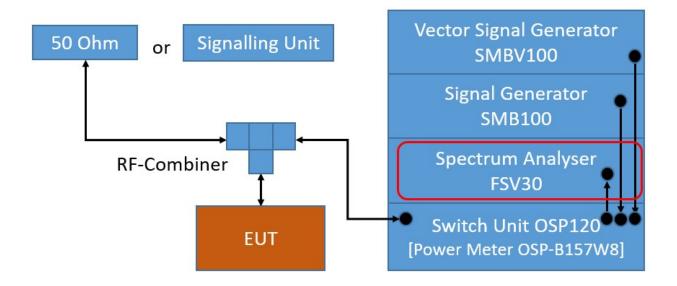
The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.

The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

- Resolution Bandwidth (RBW): 1 to 5 % of the OBW
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 1.5 to 5 times the OBW
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 75000)
- Sweeptime: Auto
- Detector: Peak



TS8997; Channel Bandwidth



5.2.2 TEST REQUIREMENTS / LIMITS

No applicable limit:

5.2.3 TEST PROTOCOL

Ambient temperature: Air Pressure: Humidity: BT LE 1 Mbit/s	23 °C 1002 hPa 40 %		
Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
Band 2.4 GHz ISM	Channel No.	Frequency [MHz] 2402	99 % Bandwidth [MHz] 1.040
	Channel No. 0 19		

BT LE 2 Mbit/s

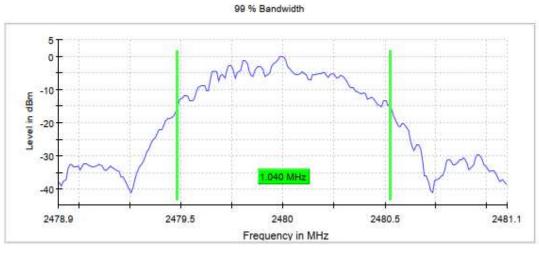
Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	0	2402	2.025
	19	2440	2.040
	39	2480	2.055

Remark: Please see next sub-clause for the measurement plot.



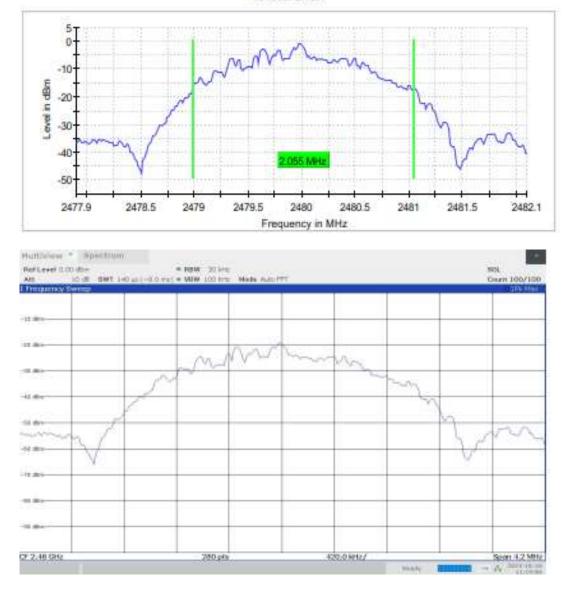
5.2.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high



MultiView . Spectrum = RBW 20 kHz SWT 210 (~7.1 mz) = VBW 100 kHz Ref Level 0.00 dbm SGL Count 100/100 10.48 Model Auto FFT Att 1 Erm 10.0 20.15 Mr. 00.1 40.0 50.18 60 iK 70.4 20 0 CF 2.48 GHz 220 pts 220.0 kHz/ Span 2.2 MHz - · 110104





Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = high 99 % Bandwidth

5.2.5 TEST EQUIPMENT USED - R&S TS8997



5.3 PEAK POWER OUTPUT

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 11.9.1.3

5.3.1 TEST DESCRIPTION

DTS EQUIPMENT:

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power.

Maximum peak conducted output power (e.g. Bluetooth Low Energy):

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered. The reference level of the spectrum analyser was set higher than the output power of the EUT.

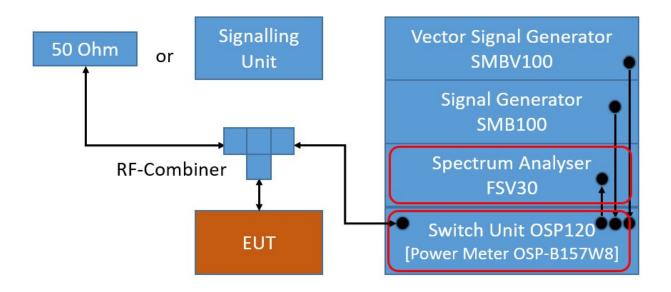
Analyser settings:

- Resolution Bandwidth (RBW): ≥ DTS bandwidth
- Video Bandwidth (VBW): ≥ 3 times RBW or maximum of analyzer
- Span: \geq 3 times RBW
- Trace: Maxhold
- Sweeps: Till stable (min. 300, max. 15000)
- Sweeptime: Auto
- Detector: Peak

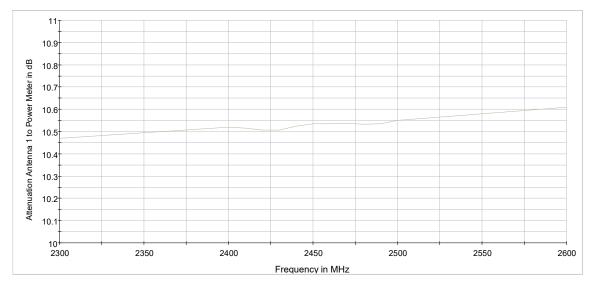
Maximum conducted average output power (e.g. WLAN):

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered. Measurement is performed using the gated RF average power meter integrated in the OSP 120 module OSP-B157W8 with signal bandwidth >300 MHz.

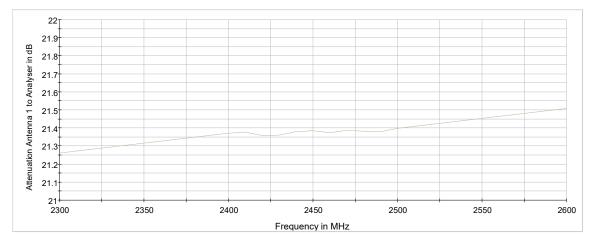




TS8997; Output Power



Attenuation of the measurement path to Power Meter





Attenuation of the measurement path to Analyser

5.3.2 TEST REQUIREMENTS / LIMITS

DTS devices:

FCC Part 15, Subpart C, §15.247 (b) (3)

For systems using digital modulation techniques in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands: 1 watt.

==> Maximum conducted peak output power: 30 dBm (excluding antenna gain, if antennas with directional gains that do not exceed 6 dBi are used).

Frequency Hopping Systems:

FCC Part 15, Subpart C, §15.247 (b) (1)

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

FCC Part 15, Subpart C, §15.247 (b) (2)

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

Used conversion factor: Limit (dBm) = $10 \log (\text{Limit (W)}/1\text{mW})$

22 00

5.3.3 TEST PROTOCOL

Ambient temperature:

Air Pressure: Humidity: BT LE 1 Mbit/s		1002 hPa 40 %				
Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]	E.I.R.P [dBm]
2.4 GHz ISM	0	2402	5.2	30.0	24.8	5.2
	19	2440	5.2	30.0	24.8	5.2
	39	2480	5.1	30.0	24.9	5.1

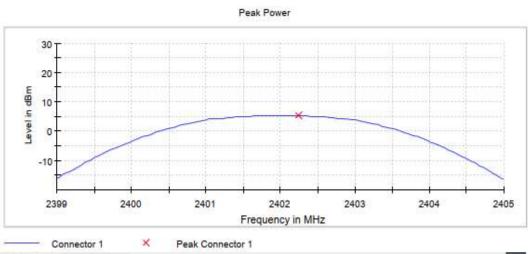
BT LE 2 Mbit/s

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]	E.I.R.P [dBm]
2.4 GHz ISM	0	2402	5.2	30.0	24.8	5.2
	19	2440	5.2	30.0	24.8	5.2
	39	2480	5.1	30.0	24.9	5.1

Remark: Please see next sub-clause for the measurement plot.



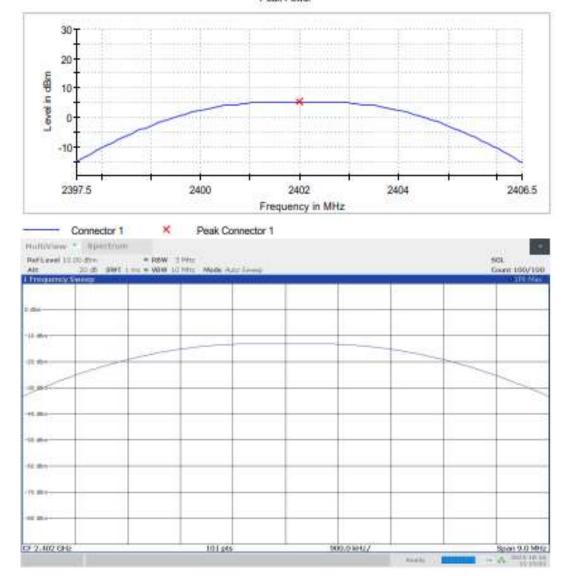
5.3.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)



Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low

	r = VBW 10/HHz Mode Auto Sweep		Count 100/1
Frequency Sweep	and the second s	Y Y Y	IN 191 M
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2.402 GHz	IOI pts	600.0 kHz/	Span 6.0 M





Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = low Peak Power

5.3.5 TEST EQUIPMENT USED

- R&S TS8997



5.4 SPURIOUS RF CONDUCTED EMISSIONS

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 11.11

5.4.1 TEST DESCRIPTION

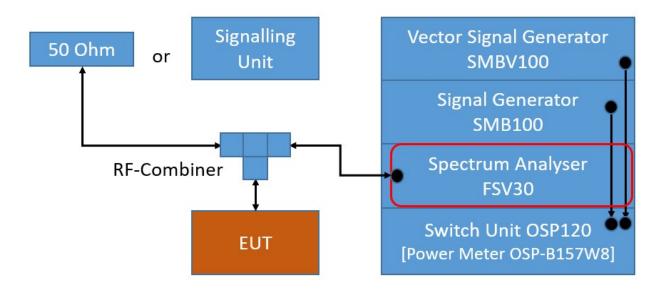
The Equipment Under Test (EUT) was set up to perform the spurious emissions measurements.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

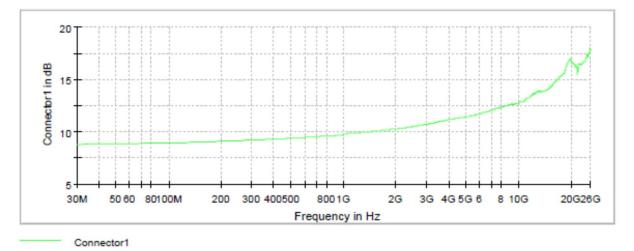
- Frequency range: 30 26000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Trace: Maxhold
- Sweeps: Till Stable (max. 120)
- Sweep Time: Auto
- Detector: Peak

The reference value for the measurement of the spurious RF conducted emissions is determined during the test "band edge compliance conducted". This value is used to calculate the 20 dBc or 30 dBc limit.



TS8997; Spurious RF Conducted Emissions





Attenuation of the measurement part

5.4.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (c)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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 contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.4.3 TEST PROTOCOL

Ambient tempe Air Pressure: Humidity: BT LE 1 Mbit/s	rature:	23 °C 1002 hPa 40 %						
Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0	2402	7205.8	-42.1	PEAK	100	5.2	-14.8	27.3
19	2440	7315.7	-47.1	PEAK	100	5.2	-14.8	32.3
39	2480	7435.7	-46.6	PEAK	100	5.1	-14.9	31.7

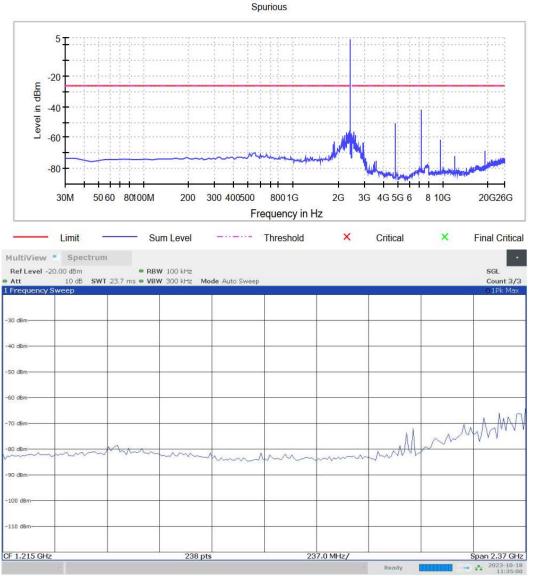
BT LE 2 Mbit/s

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0	2402	7205.8	-41.8	PEAK	100	5.2	-14.8	27.0
19	2440	7315.7	-47.2	PEAK	100	5.2	-14.8	32.4
39	2480	7435.7	-47.7	PEAK	100	5.1	-14.9	32.8

Remark: Please see next sub-clause for the measurement plot.



5.4.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

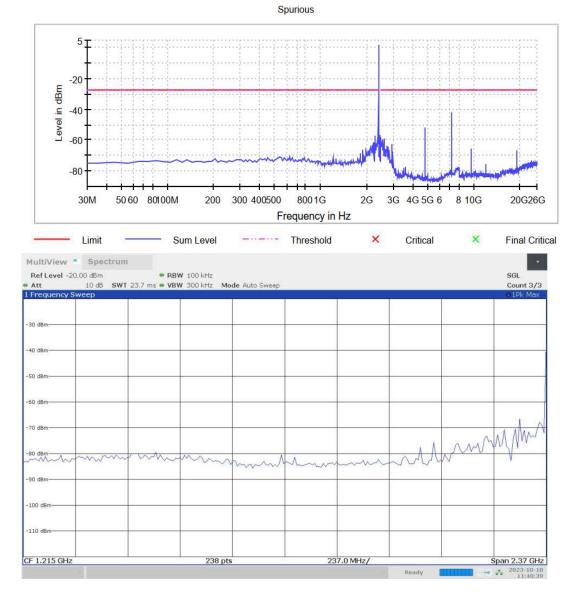


Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low Spurious



Nef Level 0.00 dBm Ntt 10 dB SWT 1.02 r Frequency Sweep	RBW 100 kHz ms = VBW 300 kHz Mode A	uto Sweep				SGL Count 3/3 0.1Pk Max
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dBm						
0 111 75 011			8.35 MHz/		S	pan 83.5 Mł
-	101 pts		6.53 WH27	Ready	•	2023-10- 11:35:
	■ RBW 100 kHz ms ● VBW 300 kHz Mode	Auto Sweep	0.33 MH2/	Ready		* 2023-10- 11:35:1 SGL Count 3/
- Spectrum ef Level -30.00 dBm et 0 dB SWT 236	• RBW 100 kHz	Auto Sweep	6.33 MHz/	Ready	·······	** 2023-10- 11:35: SGL Count 3/
HiView Spectrum St Level -30.00 dBm t 0 dB SWT 236 requency Sweep	• RBW 100 kHz	Auto Sweep	6.33 MHz/	Ready		* 2023-10- 11:35:1 SGL Count 3/
dBm	• RBW 100 kHz	Auto Sweep	6.33 Winz/	Ready		* 2023-10- 11:35:1 SGL Count 3/
dBm-	• RBW 100 kHz	Auto Sweep.	6.33 Whz/	Ready	→ 	** 2023-10- 11:35: SGL Count 3/
dBm-	• RBW 100 kHz	Auto Sweep	6.33 Minz/	Ready	÷	* 2023-10- 11:35:1 SGL Count 3/
dBm-	• RBW 100 kHz	Auto Sweep	6.33 Whz/	Ready		* 2023-10- 11:35:0 SGL Count 3/
dBm-	• RBW 100 kHz	Auto Sweep		Ready		* 2023-10- 11:35:1 SGL Count 3/
ef Level -30.00 dBm tt 0 dB SWT 236 requency Sweep dBm- dBm-	• RBW 100 kHz	Auto Sweep		Ready		* 2023-10- 11:35:1 SGL Count 3/
dBm	• RBW 100 kHz					2022-10- 11:35:1 SGL Count 3/ o TPK Mat
dBm	• RBW 100 kHz					2022-10- 11:35:1 SGL Count 3/ o TPK Mat
dBm	• RBW 100 kHz					2023-10- 11:35:0 SGL Count 3/ o 1Pk May
dBm	• RBW 100 kHz					2022-10- 11:35:1 SGL Count 3/ o TPK Mat
dBm	• RBW 100 kHz					2023-10- 11:35:0 SGL Count 3/ o 1Pk May
dBm	• RBW 100 kHz					♣ ²⁰²³⁻¹⁰⁻ 11:35:0





Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = low



t 10 dB SWI requency Sweep	f 1.02 ms 🖷 VBW	100 kHz 300 kHz Mode	Auto Sweep	8				SGL Count G I PK N
			······································				[
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dBm				~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			Y	~
dBm								
2.44175 GHz		101 pts		8.	.35 MHz/		5	span 83.5
Level -30.00 dBm	= RBW	100 kHz			12	Ready		* 2023-1 11:4 SGL
FLevel -30.00 dBm 0 dB SV equency Sweep			: Auto Sweep		·=	Ready		* 2023-1 11:4 SGL Count :
fLevel -30.00 dBm : 0 dB SV	= RBW		e Auto Sweep		12	Ready		* 2023-1 11:4 SGL Count 3
fLevel -30.00 dBm : 0 dB SV equency Sweep	= RBW		e Auto Sweep			Ready		* 2023-1 11:4 SGL Count 3
f Level -30.00 dBm : 0 dB SV equency Sweep dBm	= RBW		e Auto Sweep			Ready		* 2023-1 11:4 SGL Count 3
f Level -30.00 dBm 0 dB SV equency Sweep	= RBW		t Auto Sweep		-	Ready		* 2023-1 11:4 SGL Count :
f Level -30.00 dBm 0 dB SV equency Sweep iBm	= RBW		t Auto Sweep		-	Ready		* 2023-1 11:4 SGL Count :
F Level -30.00 dBm C 0 dB SV equency Sweep dBm	= RBW		: Auto Sweep			Ready	······································	* 2023-1 11:4 SGL Count 3
F Level -30.00 dBm C 0 dB SV equency Sweep dBm dBm dBm	= RBW		: Auto Sweep			Ready		* 2023-1 11:4 SGL Count 3
f Level -30.00 dBm O dB SV equency Sweep IBm IBm	= RBW		e Auto Sweep			Ready	·····································	* 2023-1 11:4 SGL Count 3
FLevel -30.00 dBm OdB SV equency Sweep dBm dBm dBm	= RBW		r Auto Sweep			Ready	·····································	* 2023-1 11:4 SGL Count 3
FLevel -30.00 dBm OdB SV equency Sweep dBm dBm dBm	RBW WT 236 ms VBW	300 kHz Mode						* 2023-1 11:4 SGL Count 3
E Level -30.00 dBm equency Sweep dBm dBm dBm dBm dBm dBm dBm dBm	RBW WT 236 ms VBW	300 kHz Mode						** ²⁰²³⁻¹ 11:4
FLevel -30.00 dBm OdB SV equency Sweep dBm dBm dBm	RBW WT 236 ms VBW	300 kHz Mode						* 2023-1 11:4 SGL Count 3
FLevel -30.00 dBm O dB SV equency Sweep	RBW WT 236 ms VBW	300 kHz Mode						* 2023-1 11:4 SGL Count 3
E Level -30.00 dBm equency Sweep dBm dBm dBm dBm dBm dBm dBm dBm	RBW WT 236 ms VBW	300 kHz Mode						* 2023-1 11:4 SGL Count 3
FLevel -30.00 dBm O dB SV equency Sweep	RBW WT 236 ms VBW	300 kHz Mode					antipolest.co.pl.qt/st/h	* 2023-1 11:4 SGL Count 3
Level -30.00 dBm O dB SV equency Sweep dBm dBm dBm dBm dBm dBm dBm	RBW WT 236 ms VBW	300 kHz Mode					للا من مراجع من مراجع الم	* 2023-1 11:4 SGL Count 3

5.4.5 TEST EQUIPMENT USED

- R&S TS8997



5.5 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 6.4, 6.5, 6.6.5

5.5.1 TEST DESCRIPTION

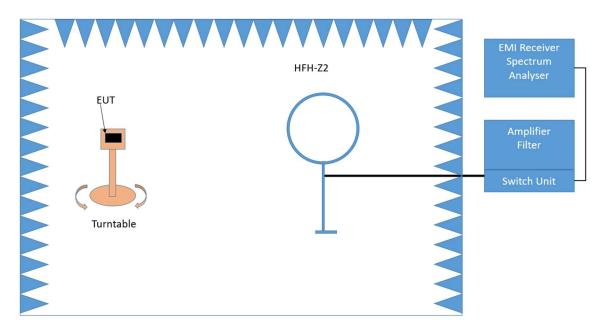
The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapters of ANSI C63.10:

- < 30 MHz: Chapter 6.4
- 30 MHz 1 GHz: Chapter 6.5
- > 1 GHZ: Chapter 6.6 (procedure according 6.6.5 used)

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered.

Below 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.



1. Measurement up to 30 MHz

Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz



The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 0.15 MHz and 0.15 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF-Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

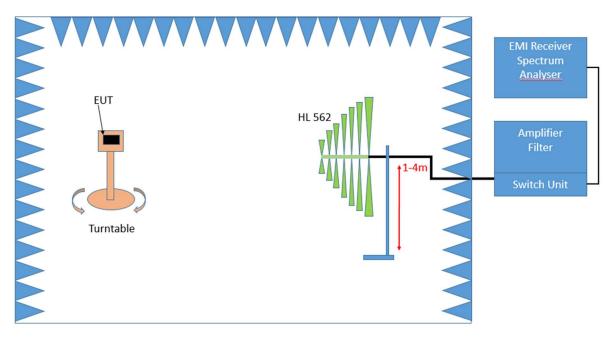
Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement

For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak (9 kHz 150 kHz, Peak / Average 150 kHz- 30 MHz)
- Frequency range: 0.009 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF-Bandwidth: 0.2 10 kHz
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

Step 1: Preliminary scan

This is a preliminary test to identify the highest amplitudes relative to the limit. Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 1000 MHz
- Frequency steps: 30 kHz
- IF-Bandwidth: 120 kHz



- Measuring time / Frequency step: 100 ms
- Turntable angle range: -180° to 90°
- Turntable step size: 90°
- Height variation range: 1 4 m
- Height variation step size: 1.5 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by 360°. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary between 1 - 4 meter. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: 360 °
- Height variation range:1 4 m
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 2, the final measurement will be performed: EMI receiver settings for step 3:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

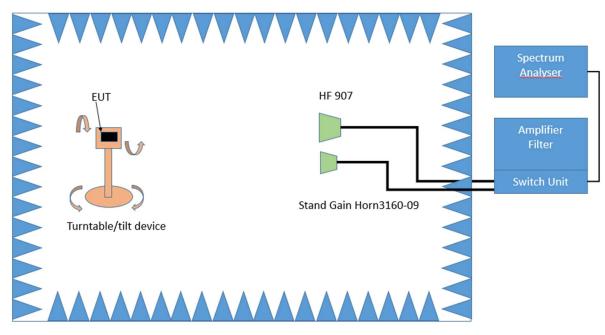


Above 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.

The turn table step size (azimuth angle) for the preliminary measurement is 45 °. Spectrum analyser settings:

- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:

The turn table azimuth will slowly vary by $\pm 22.5^{\circ}$. The elevation angle will slowly vary by $\pm 45^{\circ}$ Spectrum analyser settings: - Detector: Peak

Step 3:

- Spectrum analyser settings for step 3:
- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s



5.5.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (d)

... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 - 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 - 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 - 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 - 88	100@3m	3	40.0@3m
88 - 216	150@3m	3	43.5@3m
216 - 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit $(dB\mu V/m) = 20 \log (Limit (\mu V/m)/1\mu V/m)$



Limit

Type

RB

RB

RB

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Margin to

Limit [dB]

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9.8

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16.5

13.0

15.4

15.9

18.4

8.4

14.0

19.8

19.8

10.0

9.1

17.9

13.8

14.9

14.0

15.4

15.7

20.6

15.5

20.6

12.3

19.9

13.0

21.2

16.3

6.9

5.5.3 TEST PROTOCOL

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Air Pro Humic BT LE	1 Mbit/s;	e: prrection (AV): 0	23 °C 1002 hF 40 %	Pa		
Ch.	Ch. Center	Spurious	Spurious	Detec-	RBW	Limit
No.	Freq. [MHz]	Freq. [MHz]	Level [dBµV/m]	tor	[kHz]	[dBµV/m]
0	2402	73.0	29.2	QP	120	40.0
0	2402	135.3	23.2	QP	120	43.5
0	2402	249.7	36.3	QP	120	46.0
19	2440	137.5	19.8	QP	120	43.5
19	2440	168.0	27.0	QP	120	43.5
19	2440	249.7	33.0	QP	120	46.0
19	2440	401.0	30.6	QP	120	46.0
39	2480	108.1	27.6	QP	120	43.5
39	2480	168.0	25.1	QP	120	43.5
39	2480	249.7	37.6	QP	120	46.0
39	2480	401.0	32.0	QP	120	46.0
39	2480	611.5	26.2	QP	120	46.0
0	2402	4804.2	54.2	PEAK	1000	74.0
0	2402	4804.2	44.0	AV	1000	54.0
19	2440	7332.4	44.9	AV	1000	54.0
19	2440	7332.4	56.1	PEAK	1000	74.0
39	2480	2483.6	40.2	AV	1000	54.0
39	2480	2483.6	59.1	PEAK	1000	74.0

40.0

58.6

38.3

53.4

38.5

53.4

41.7

54.1

41.0

52.8

47.1

57.7

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Remark: Please see next sub-clause for the measurement plot.

2483.7

2483.7

2484.9

2484.9

2485.5

2485.5

2488.0

2488.0

2488.1

2488.1

7439.6

7439.6



Applie	ed duty cycle co	rrection (AV): 0	dB					
Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec- tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]	Limit Type
0	2402	73.0	28.6	QP	120	40.0	11.5	RB
0	2402	108.1	25.4	QP	120	43.5	18.1	RB
0	2402	168.0	26.5	QP	120	43.5	17.1	RB
0	2402	249.7	37.9	QP	120	46.0	8.1	RB
0	2402	401.0	31.8	QP	120	46.0	14.2	RB
0	2402	608.2	29.3	QP	120	46.0	16.7	RB
0	2402	977.2	22.8	QP	120	54.0	31.2	RB
19	2440	73.8	14.3	QP	120	40.0	25.7	RB
19	2440	249.7	33.8	QP	120	46.0	12.2	RB
19	2440	401.0	30.5	QP	120	46.0	15.6	RB
39	2480	249.7	34.8	QP	120	46.0	11.2	RB
39	2480	401.0	31.7	QP	120	46.0	14.3	RB
39	2480	2483.6	40.8	AV	1000	54.0	13.2	RB
39	2480	2483.6	58.9	PEAK	1000	74.0	15.1	RB
39	2480	7438.5	42.5	AV	1000	54.0	11.5	RB
39	2480	7438.5	58.6	PEAK	1000	74.0	15.4	RB

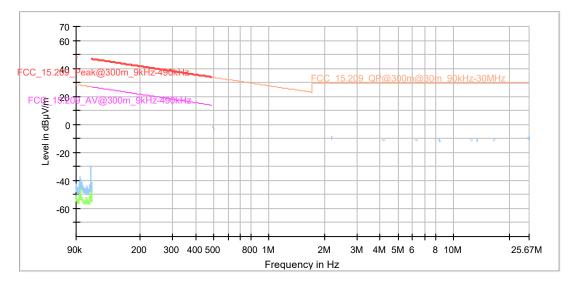
BT LE 2 Mbit/s

Remark: Measurement performed up to 8GHz. Please see next sub-clause for the measurement plot.

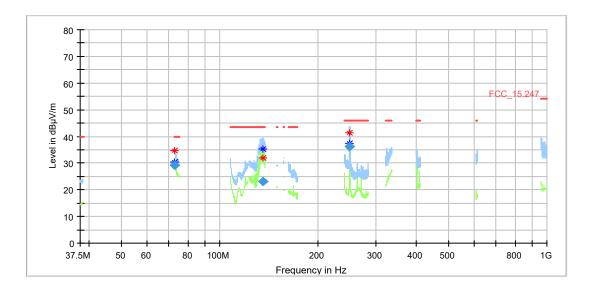


5.5.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

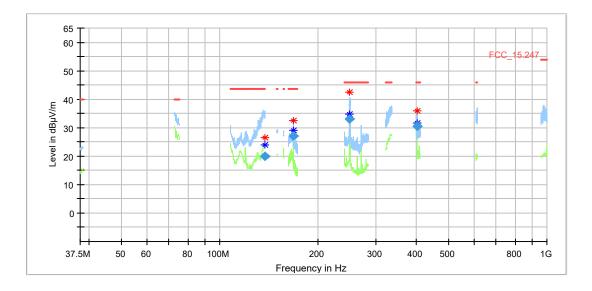
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = mid, Measurement range = 9 kHz - 30 MHz



 $\label{eq:Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low, \\ Measurement range = 30 \mbox{ MHz} - 1 \mbox{ GHz}$

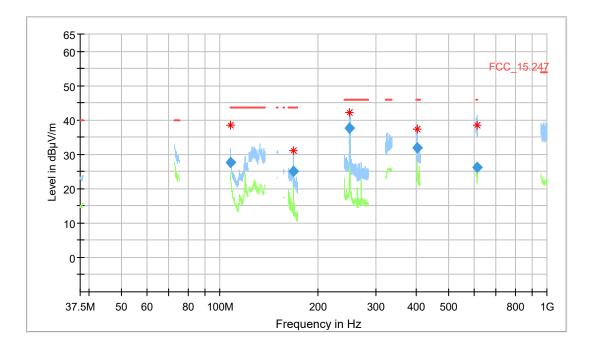




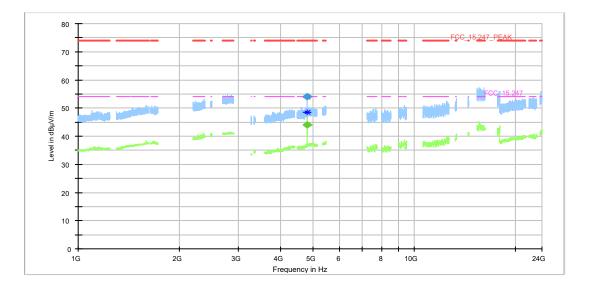


Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = mid, Measurement range = 30 MHz - 1 GHz

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high, Measurement range = 30 MHz - 1 GHz

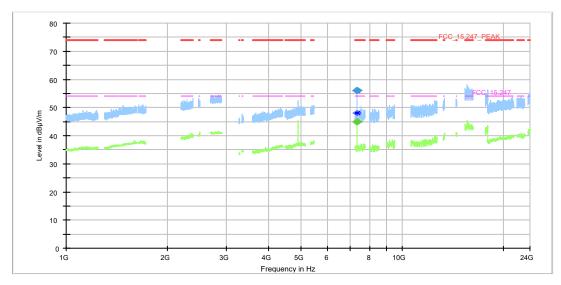




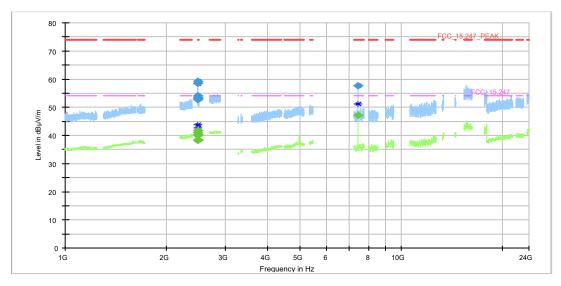


Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low, Measurement range = 1 GHz - 26 GHz

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = mid, Measurement range = 1 GHz - 26 GHz

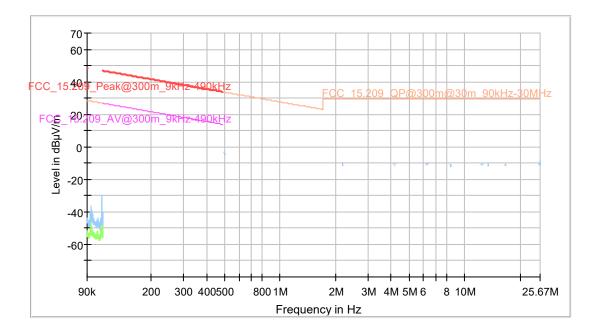




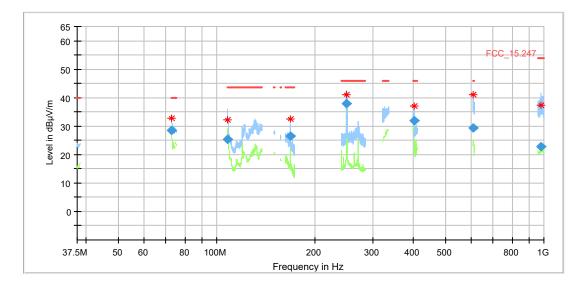


Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high, Measurement range = 1 GHz - 26 GHz

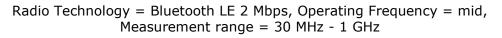
Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = mid, Measurement range = 9 kHz - 30 MHz

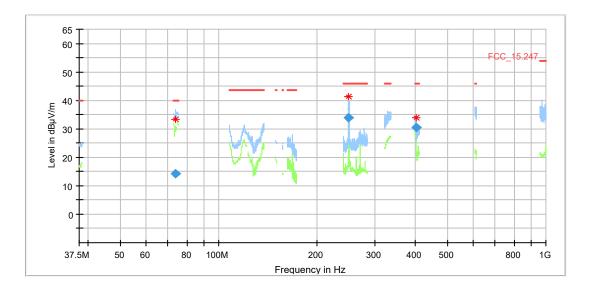




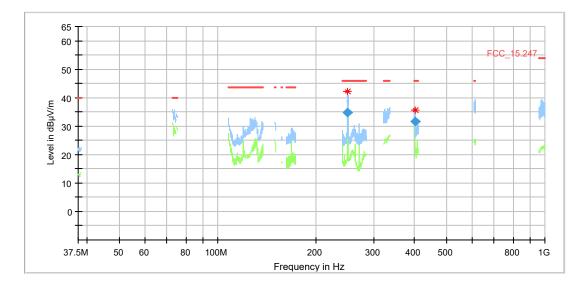


Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = low, Measurement range = 30 MHz - 1 GHz



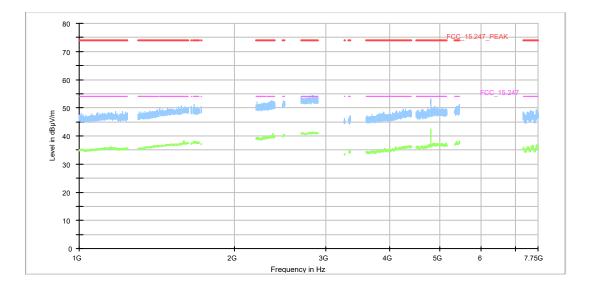




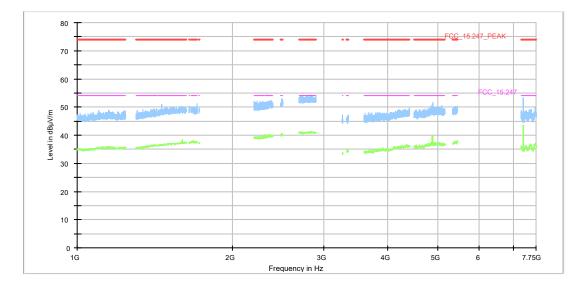


Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = high, Measurement range = 30 MHz - 1 GHz

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = low, Measurement range = 1 GHz - 8 GHz

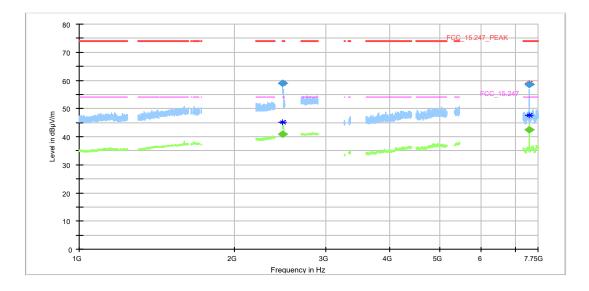






Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = mid, Measurement range = 1 GHz - 8 GHz

Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = high, Measurement range = 1 GHz - 8 GHz



5.5.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC
- Radiated Emissions SAC H-Field
- Radiated Emissions SAC up to 1 GHz



5.6 BAND EDGE COMPLIANCE CONDUCTED

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 11.11

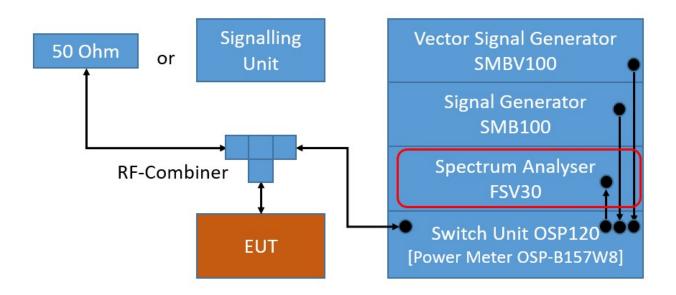
5.6.1 TEST DESCRIPTION

For the conducted measurement, the Equipment Under Test (EUT) is placed in a shielded room. The reference power was measured in the test case "Spurious RF Conducted Emissions".

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

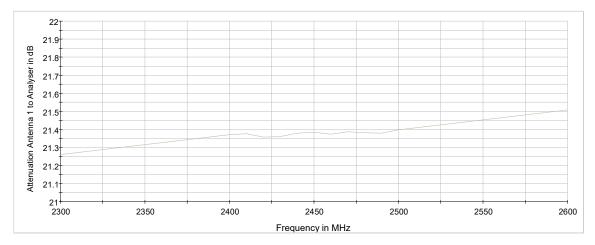
Analyser settings:

- Lower Band Edge: Measured range: 2310.0 MHz to 2483.5 MHz Upper Band Edge Measured range: 2400.0 MHz to 2500 MHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweeptime: Auto
- Sweeps: Till stable (min. 300, max. 15000)
- Trace: Maxhold



TS8997; Band Edge Conducted





Attenuation of the measurement path

5.6.2 TEST REQUIREMENTS / LIMITS

FCC Part 15.247 (d)

"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 contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. ...

If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c))."

For the conducted measurement the RF power at the band edge shall be "at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power..."



5.6.3 TEST PROTOCOL

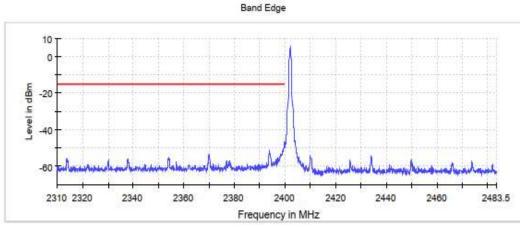
Ambient tempe Air Pressure: Humidity: BT LE 1 Mbit/s	rature:	23 °C 1002 hPa 40 %						
Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0	2402	2400.0	-47.0	PEAK	100	5.2	-14.8	32.2
39	2480	2483.5	-52.0	PEAK	100	5.1	-14.9	37.1
BT LE 2 Mbit/s								
Channel No.	Channel	Band	Spurious	Detector	RBW	Ref.	Limit	Margin

Channel No.	Channel Center Frequency [MHz]	Edge Freq. [MHz]	Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	[dBm]	Margin to Limit [dB]
0	2402	2400.0	-28.1	PEAK	100	5.2	-14.8	13.3
39	2480	2483.5	-49.1	PEAK	100	5.1	-14.9	34.2

Remark: Please see next sub-clause for the measurement plot.



5.6.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)



Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low, Band Edge = low Band Edge

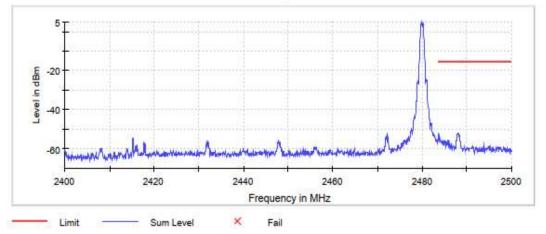
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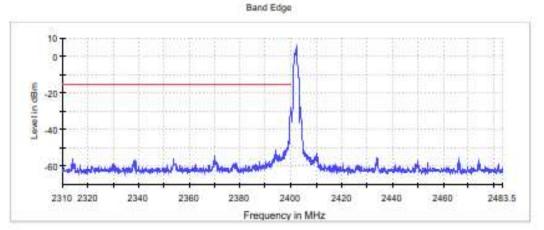
Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high, Band Edge = high Band Edge





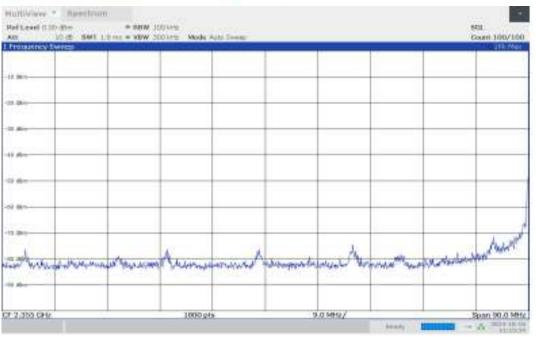
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Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = low, Band Edge = low

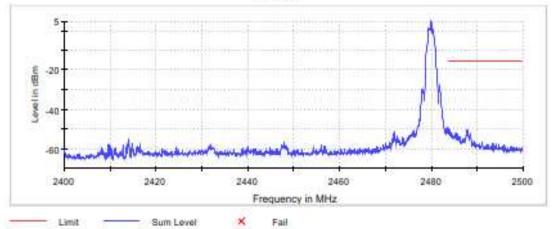
Limit ---- Sum Level X Fail





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Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = high, Band Edge = high Band Edge





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Neff Level CDC don Atr DC do Self LOLIO In Sec.	WW 2003tht - Model Auto Sweep		NOL
Neff Level CDC don Atr DC do Self LOLIO In Sec.	WW 2003tht - Model Auto Sweep		NOL
1 Prezz John V Bargenson 1 8 380 - 12 380 - 21 380 - 44 45- - 45 45- -	WW 2003tht - Model Auto Sweep		anat a

5.6.5 TEST EQUIPMENT USED

- R&S TS8997



5.7 BAND EDGE COMPLIANCE RADIATED

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 6.6.5

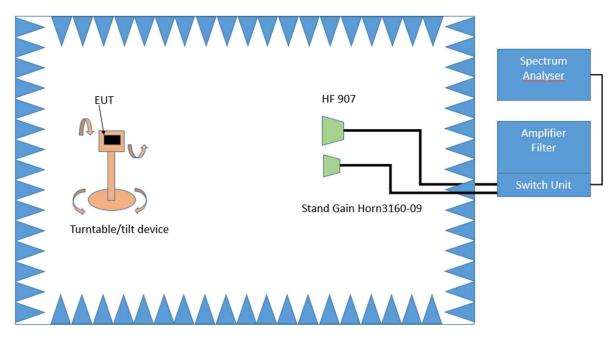
5.7.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapter of ANSI C63.10:

• Chapter 6.10.5

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only (procedure according ANSI C63.10, chapter 6.6.5.



3. Measurement above 1 GHz

Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.

The turn table step size (azimuth angle) for the preliminary measurement is 45 °. Spectrum analyser settings:

- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:

TEST REPORT REFERENCE: MDE_HDW_2301_FCC_03



The turn table azimuth will slowly vary by \pm 22.5°. The elevation angle will slowly vary by \pm 45° Spectrum analyser settings: - Detector: Peak

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

5.7.2 TEST REQUIREMENTS / LIMITS

For band edges connected to a restricted band, the limits are specified in Section 15.209(a)

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 - 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 - 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 - 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 - 88	100@3m	3	40.0@3m
88 - 216	150@3m	3	43.5@3m
216 - 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit $(dB\mu V/m) = 20 \log (Limit (\mu V/m)/1\mu V/m)$



Margin to

Limit [dB]

14.9

13.8

5.7.3 TEST PROTOCOL

Ambient temperature:	24 °C
Air Pressure:	1005 hPa
Humidity:	45 %
BT LE 1 Mbit/s	
Applied duty cycle correction $(\Lambda)/): 0$	

Applied duty cycle correction (AV): 0 dB_____ Ch. RBW **Spurious Level** Detec-Limit Ch. Center **Band Edge** No. Freq. [MHz] Freq. [MHz] [dBµV/m] tor [kHz] [dBµV/m] 39 2480 2483.5 59.1 PEAK 1000 74.0

40.2

BT LE 2 Mbit/s

2480

39

Applied duty cycle correction (AV): 0 dB

Ch. No.	Ch. Center Freg. [MHz]	Band Edge Freg. [MHz]	Spurious Level [dBuV/m]	Detec- tor	RBW [kHz]	Limit [dBuV/m]	Margin to Limit [dB]
39	2480	2483.5	58.9	PEAK	1000	74.0	15.1
39	2480	2483.5	40.8	AV	1000	54.0	13.2

AV

1000

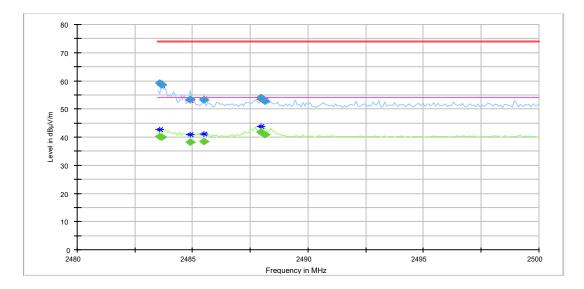
54.0

Remark: Please see next sub-clause for the measurement plot.

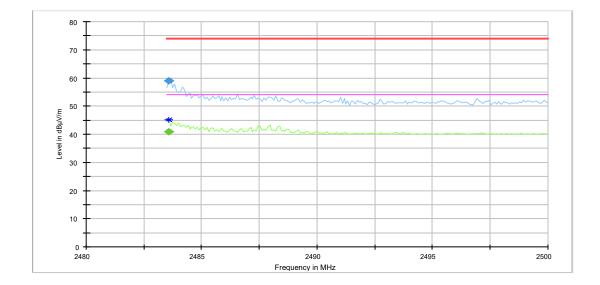
2483.5

5.7.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high, Band Edge = high







Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = high, Band Edge = high

5.7.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC



5.8 POWER DENSITY

Standard FCC Part 15 Subpart C

The test was performed according to: ANSI C63.10, chapter 11.10.2

5.8.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up in a shielded room to perform the Power Density measurements.

The results recorded were measured with the modulation which produces the worst-case (highest) power density.

The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Maximum Peak Power Spectral Density (e.g. Bluetooth low energy):

Analyser settings:

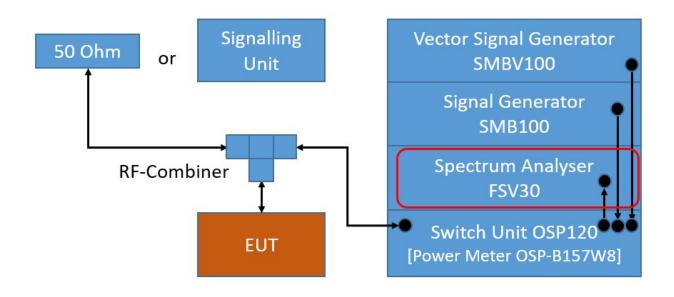
- Resolution Bandwidth (RBW): 100 kHz, 10 kHz or 3 kHz
- Video Bandwidth (VBW): ≥ 3 times RBW
- Trace: Maxhold
- Sweeps: Till stable (min. 200, max. 15000)
- Sweeptime: Auto
- Detector: Peak

Maximum Average Power Spectral Density (e.g. WLAN):

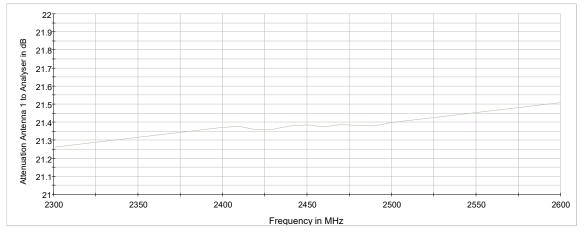
Analyser settings:

- Resolution Bandwidth (RBW): 100 kHz, 10 kHz or 3 kHz
- Video Bandwidth (VBW): ≥ 3 times RBW
- Sweep Points: ≥ 2 times span / RBW
- Trace: Maxhold
- Sweeps: Till stable (max. 150)
- Sweeptime: ≤ Number of Sweep Points x minimum transmission duration
- Detector: RMS





TS8997; Power Spectral Density



Attenuation of the measurement path

5.8.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (e)

For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

The same method of determining the conducted output power shall be used to determine the power spectral density.



FCC Part 15, Subpart C, §15.247 (f)

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.

The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission

5.8.3 TEST PROTOCOL

Ambient temperature:	23 °C
Air Pressure:	1002 hPa
Humidity:	40 %
BT LE 1 Mbit/s	

Band	Channel No.	Frequency [MHz]	Power Density [dBm / RBW]	RBW [kHz]	Limit [dBm/3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0	2402	-4.6	10.0	8.0	12.6
	19	2440	-4.7	10.0	8.0	12.7
	39	2480	-4.9	10.0	8.0	12.9

BT LE 2 Mbit/s

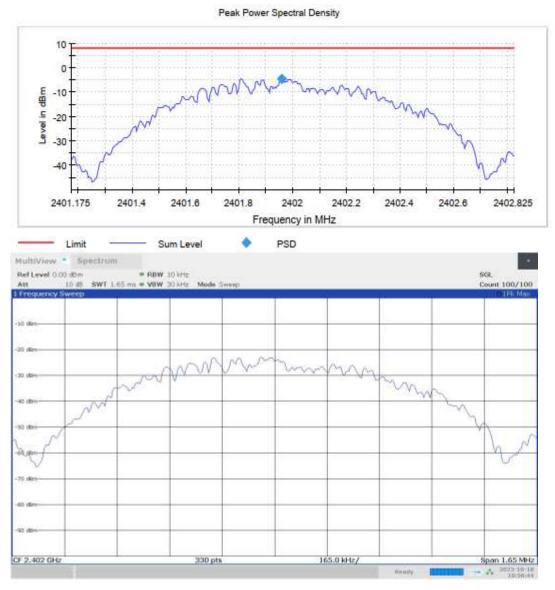
...

Band	Channel No.	Frequency [MHz]	Power Density [dBm / RBW]	RBW [kHz]	Limit [dBm/3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0	2402	-6.3	10.0	8.0	14.3
	19	2440	-6.2	10.0	8.0	14.2
	39	2480	-6.3	10.0	8.0	14.3

Remark: Please see next sub-clause for the measurement plot.

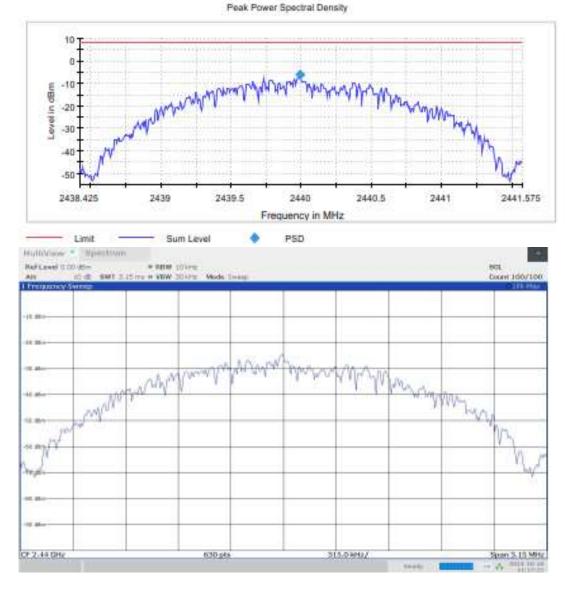


5.8.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)



Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low





Radio Technology = Bluetooth LE 2 Mbps, Operating Frequency = mid

- 5.8.5 TEST EQUIPMENT USED
 - R&S TS8997



6 TEST EQUIPMENT

6.1 TEST EQUIPMENT HARDWARE

1 R&S TS8997 2.4 and 5 GHz Bands Conducted Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH		N/A	N/A
1.2	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2021-06	2024-06
1.3	EX520	Digital Multimeter 12	Extech Instruments Corp	05157876	2022-06	2024-06
1.4	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2023-08	2025-08
1.5	NGSM 32/10	Power Supply	Rohde & Schwarz GmbH & Co. KG	3456	2022-01	2024-01
1.6	Temperature Chamber KWP 120/70	Temperature Chamber Weiss 01	Weiss	59226012190010	2022-05	2024-05
1.7	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2022-05	2024-05
1.8	FSW43	Signal Analyser	Rohde & Schwarz GmbH & Co. KG	102013	2023-07	2025-07
1.9	Opus10 THI (8152.00)		Lufft Mess- und Regeltechnik GmbH		N/A	N/A
1.10	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2023-01	2026-01
1.11	OSP120	Contains Power Meter and Switching Unit OSP- B157W8 PLUS	Rohde & Schwarz	101158	2021-08	2024-08
1.12	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	N/A	N/A

2 Radiated Emissions FAR 2.4 GHz FCC Radiated emission tests for 2.4 GHz ISM devices in a fully anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	Opus10 TPR (8253.00)		Lufft Mess- und Regeltechnik GmbH		N/A	N/A
2.2	CO3000	Controller for bore sight mast FAC		CO3000/1460/54 740522/P	N/A	N/A
2.3	7D00101800-	Broadband Amplifier 100 MHz - 18 GHz	Miteq		N/A	N/A



Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.4	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001- PRB	N/A	N/A
2.5	Fluke 177	Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
2.6	JS4-18002600- 32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785	N/A	N/A
2.7	FSW43	Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	103779	2023-04	2025-04
	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
2.9	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069	N/A	N/A
2.10	WHKX 7.0/18G- 8SS	High Pass Filter	Wainwright Instruments GmbH	09	N/A	N/A
		Bore Sight Antenna Mast			N/A	N/A
2.12	TT 1.5 WI	Turn Table	Maturo GmbH	-	N/A	N/A
2.13	5HC3500/18000 -1.2-KK	High Pass Filter	Trilithic	200035008	N/A	N/A
2.14	Opus 20 THI (8120.00)		Lufft Mess- und Regeltechnik GmbH	115.0318.0802.0 33	2023-08	2025-08
2.15	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5- 10kg/024/37907 09	N/A	N/A
-	AFS42- 00101800-25-S- 42	Amplifier 25 MHz - 18 GHz	Miteq	2035324	N/A	N/A
2.17	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2021-09	2024-09

3 Radiated Emissions SAC H-Field Radiated emission tests in the H-Field in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1		Filter for EUT, 2 Lines, 250 V, 16 A		241515	N/A	N/A
3.2	Opus10 TPR (8253.00)		Lufft Mess- und Regeltechnik GmbH		N/A	N/A
3.3			Rohde & Schwarz GmbH & Co. KG	101603	2022-01	2024-01
-	Anechoic Chamber 01		Frankonia	none	N/A	N/A



Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.5		Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
3.6	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH	12488	N/A	N/A
3.7	NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
3.8	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
3.9	HFH2-Z2	Loop Antenna + 3 Axis Tripod	Rohde & Schwarz GmbH & Co. KG	829324/006	2021-01	2024-01
3.10	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	N/A	N/A

4 Radiated Emissions SAC up to 1 GHz Radiated emission tests up to 1 GHz in a semi anechoic room

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
4.1	N5000/NP	2 Lines, 250 V, 16 A		241515	N/A	N/A
4.2	Opus10 TPR (8253.00)	T/P Logger 13	Lufft Mess- und Regeltechnik GmbH		N/A	N/A
4.3	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2022-01	2024-01
4.4	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none	N/A	N/A
4.5	HL 562 ULTRALOG	Biconical-log- per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2021-09	2024-09
4.6	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2023-08	2025-08
4.7	Opus10 THI (8152.00)	T/H Logger 10	Lufft Mess- und Regeltechnik GmbH		N/A	N/A
4.8	EP 1200/B, NA/B1	AC Source, Amplifier with integrated variable Oscillator	Spitzenberger & Spies GmbH & Co. KG	B6278	N/A	N/A
4.9	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99	N/A	N/A
4.10	CS-RUB6	Rubidium Frequency Standard	Rohde & Schwarz GmbH & Co. KG	100321	N/A	N/A



Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
4.11	-	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/1192 0513	N/A	N/A

The calibration interval is the time interval between "Last Calibration" and "Calibration Due"

6.2 TEST EQUIPMENT SOFTWARE

Semi-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
INNCO Mast Controller	1.02.62
MATURO Mast Controller	12.19
MATURO Turn-Table Controller	30.10
Fully-Anechoic Chamber:	
Software	Version
EMC32 Measurement Software	10.60.10
MATURO Turn-Unit Cotrolller	11.10
MATURO Mast Controller	12.10
MATURO Turntable Controller	12.11
Conducted AC Emissions:	
Software	Version
EMC32 Measurement Software	10.60.20



7 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

		LISN	cable loss
		insertion	(incl. 10
		loss	dB
		ESH3-	atten-
Frequency	Corr.	Z5	uator)
MHz	dB	dB	dB
0.15	10.1	0.1	10.0
5	10.3	0.1	10.2
7	10.5	0.2	10.3
10	10.5	0.2	10.3
12	10.7	0.3	10.4
14	10.7	0.3	10.4
16	10.8	0.4	10.4
18	 10.9	0.4	10.5
20	10.9	0.4	10.5
22	11.1	0.5	10.6
24	11.1	0.5	10.6
26	11.2	0.5	10.7
28	11.2	0.5	10.7
30	11.3	0.5	10.8

7.1 LISN R&S ESH3-Z5 (150 KHZ - 30 MHZ)

Sample calculation

 U_{LISN} (dB μ V) = U (dB μ V) + Corr. (dB)

U = Receiver reading

LISN Insertion loss = Voltage Division Factor of LISN

Corr. = sum of single correction factors of used LISN, cables, switch units (if used)

Linear interpolation will be used for frequencies in between the values in the table.



AFloss 1loss 2loss 3loss 4corr.(n(inside(outside(switch(to(-40 dB/dis	d _{Limit} neas. stance	d _{used} (meas.
AF (inside (outside (switch (to (-40 dB/ dis	stance	(meas.
Frequency HFH-Z2) Corr. chamber) chamber) unit) receiver) decade) (I		distance
	imit)	(used)
MHz dB (1/m) dB dB dB dB dB dB	m	m
0.009 20.50 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.01 20.45 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.015 20.37 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.02 20.36 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.025 20.38 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.03 20.32 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.05 20.35 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.08 20.30 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.1 20.20 -79.6 0.1 0.1 0.1 -80	300	3
0.2 20.17 -79.6 0.1 0.1 0.1 -80	300	3
0.3 20.14 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.49 20.12 -79.6 0.1 0.1 0.1 0.1 -80	300	3
0.490001 20.12 -39.6 0.1 0.1 0.1 0.1 -40	30	3
0.5 20.11 -39.6 0.1 0.1 0.1 0.1 -40	30	3
0.8 20.10 -39.6 0.1 0.1 0.1 0.1 -40	30	3
1 20.09 -39.6 0.1 0.1 0.1 0.1 -40	30	3
2 20.08 -39.6 0.1 0.1 0.1 0.1 -40	30	3
3 20.06 -39.6 0.1 0.1 0.1 -40	30	3
4 20.05 -39.5 0.2 0.1 0.1 0.1 -40	30	3
5 20.05 -39.5 0.2 0.1 0.1 0.1 -40	30	3
6 20.02 -39.5 0.2 0.1 0.1 0.1 -40	30	3
8 19.95 -39.5 0.2 0.1 0.1 0.1 -40	30	3
10 19.83 -39.4 0.2 0.1 0.2 0.1 -40	30	3
12 19.71 -39.4 0.2 0.1 0.2 0.1 -40	30	3
14 19.54 -39.4 0.2 0.1 0.2 0.1 -40	30	3
16 19.53 -39.3 0.3 0.1 0.2 0.1 -40	30	3
18 19.50 -39.3 0.3 0.1 0.2 0.1 -40	30	3
20 19.57 -39.3 0.3 0.1 0.2 0.1 -40	30	3
22 19.61 -39.3 0.3 0.1 0.2 0.1 -40	30	3
24 19.61 -39.3 0.3 0.1 0.2 0.1 -40	30	3
26 19.54 -39.3 0.3 0.1 0.2 0.1 -40	30	3
28 19.46 -39.2 0.3 0.1 0.3 0.1 -40	30	3
30 19.73 -39.1 0.4 0.1 0.3 0.1 -40	30	3

7.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) distance correction = -40 * LOG (d_{Limit} / d_{used})

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values



7.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(<u>d_{Limit} = 3 m)</u>

Frequency	AF R&S HL562	Corr.
MHz	dB (1/m)	dB
30	18.6	0.6
50	6.0	0.9
100	9.7	1.2
150	7.9	1.6
200	7.6	1.9
250	9.5	2.1
300	11.0	2.3
350	12.4	2.6
400	13.6	2.9
450	14.7	3.1
500	15.6	3.2
550	16.3	3.5
600	17.2	3.5
650	18.1	3.6
700	18.5	3.6
750	19.1	4.1
800	19.6	4.1
850	20.1	4.4
900	20.8	4.7
950	21.1	4.8
1000	21.6	4.9

	cable loss 1 (inside	cable loss 2 (outside	cable loss 3 (switch	cable loss 4 (to	distance corr. (-20 dB/	d _{Limit} (meas. distance	d _{used} (meas. distance
c	hamber)	chamber)	unit)	receiver)	decade)	(limit)	(used)
	dB	dB	dB	dB	dB	m	m
	0.29	0.04	0.23	0.02	0.0	3	3
	0.39	0.09	0.32	0.08	0.0	3	3
	0.56	0.14	0.47	0.08	0.0	3	3
	0.73	0.20	0.59	0.12	0.0	3	3
	0.84	0.21	0.70	0.11	0.0	3	3
	0.98	0.24	0.80	0.13	0.0	3	3
	1.04	0.26	0.89	0.15	0.0	3	3
	1.18	0.31	0.96	0.13	0.0	3	3
	1.28	0.35	1.03	0.19	0.0	3	3
	1.39	0.38	1.11	0.22	0.0	3	3
	1.44	0.39	1.20	0.19	0.0	3	3
	1.55	0.46	1.24	0.23	0.0	3	3
	1.59	0.43	1.29	0.23	0.0	3	3
	1.67	0.34	1.35	0.22	0.0	3	3
	1.67	0.42	1.41	0.15	0.0	3	3
	1.87	0.54	1.46	0.25	0.0	3	3
	1.90	0.46	1.51	0.25	0.0	3	3
	1.99	0.60	1.56	0.27	0.0	3	3
	2.14	0.60	1.63	0.29	0.0	3	3
	2.22	0.60	1.66	0.33	0.0	3	3
	2.23	0.61	1.71	0.30	0.0	3	3

 $(\underline{d_{\text{Limit}}} = 10 \text{ m})$

	·/								
30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) distance correction = -20 * LOG (d_{Limit} / d_{used})

Linear interpolation will be used for frequencies in between the values in the table.

Tables show an extract of values.



7.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

			•		· · · · · · · · · · · · · · · · · · ·				
						cable			
				cable		loss 3			
				loss 1		(switch			
	AF			(relay +	cable	unit,	anhla		
	R&S			cable inside	loss 2 (outside	atten- uator &	cable loss 4 (to		
Frequency	HF907	Corr.		chamber)	chamber)	pre-amp)	receiver)		
MHz	dB (1/m)	dB		dB	dB	dB	dB		
1000	24.4	-19.4		0.99	0.31	-21.51	0.79		
2000	24.4	-19.4		1.44	0.31	-20.63	1.38		
3000	31.0	-17.4		1.44	0.53	-19.85	1.33		
4000	33.1	-10.1		2.41	0.55	-19.83	1.33		
5000	34.4	-14.7		2.41	0.86	-19.13	1.31		
6000	34.4	_		2.76	0.88	-17.83	1.40		
7000	35.6	-12.7		2.74		-17.83	1.47		
7000	35.0	-11.0		2.82	0.86	-16.19	1.46		
							cable loss 4		
				cable			(switch		
				loss 1	cable	cable	unit,		used
	AF			(relay	loss 2	loss 3	atten-	cable	for
	R&S			inside	(inside	(outside	uator &	loss 5 (to	FCC
Frequency	HF907	Corr.		chamber)	chamber)	chamber)	pre-amp)	receiver)	15.247
MHz	dB (1/m)	dB		dB	dB	dB	dB	dB	
3000	31.0	-23.4		0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3		0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7		0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2		0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8		0.66	2.82	0.86	-25.58	1.46	
L					-				11
				cable					
				loss 1	cable	cable	cable	cable	cable
	AF			(relay	loss 2	loss 3	loss 4	loss 5	loss 6
	R&S			inside	(High	(pre-	(inside	(outside	(to
Frequency	HF907	Corr.		chamber)	Pass)	amp)	chamber)	chamber)	receiver)
MHz	dB (1/m)	dB		dB	dB	dB	dB	dB	dB
7000	35.6	-57.3		0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3		0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3		0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2		0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3		0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7		0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5		0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3		0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1		0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1		1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4		1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7		1.70	0.53	-62.88	4.41	1.55	1.91
		•/			0.00	02.00		2.00	

Sample calculation

E (dB μ V/m) = U (dB μ V) + AF (dB 1/m) + Corr. (dB)

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) Linear interpolation will be used for frequencies in between the values in the table. Tables show an extract of values.



					,		
			cable	cable	cable	cable	cable
	AF		loss 1	loss 2	loss 3	loss 4	loss 5
	EMCO		(inside	(pre-	(inside	(switch	(to
Frequency	3160-09	Corr.	chamber)	amp)	chamber)	unit)	receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

7.5 ANTENNA EMCO 3160-09 (18 GHZ - 26.5 GHZ)

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values.



Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d _{Limit} (meas. distance (limit)	d _{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-9.5	3	1.0
27.0	43.4	-11.2	4.4				-9.5	3	1.0
28.0	43.4	-11.1	4.5				-9.5	3	1.0
29.0	43.5	-11.0	4.6				-9.5	3	1.0
30.0	43.5	-10.9	4.7				-9.5	3	1.0
31.0	43.5	-10.8	4.7				-9.5	3	1.0
32.0	43.5	-10.7	4.8				-9.5	3	1.0
33.0	43.6	-10.7	4.9				-9.5	3	1.0
34.0	43.6	-10.6	5.0				-9.5	3	1.0
35.0	43.6	-10.5	5.1				-9.5	3	1.0
36.0	43.6	-10.4	5.1				-9.5	3	1.0
37.0	43.7	-10.3	5.2				-9.5	3	1.0
38.0	43.7	-10.2	5.3				-9.5	3	1.0
39.0	43.7	-10.2	5.4				-9.5	3	1.0
40.0	43.8	-10.1	5.5				-9.5	3	1.0

7.6 ANTENNA EMCO 3160-10 (26.5 GHZ - 40 GHZ)

Sample calculation

 $E (dB \mu V/m) = U (dB \mu V) + AF (dB 1/m) + Corr. (dB)$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable) Linear interpolation will be used for frequencies in between the values in the table.

distance correction = -20 * LOG ($d_{\text{Limit}}/d_{\text{used}}$) Linear interpolation will be used for frequencies in between the values in the table.

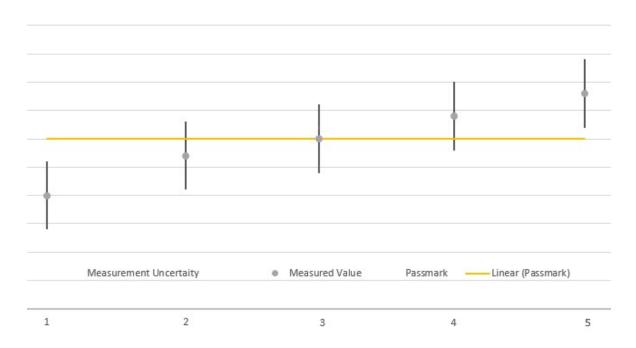
Table shows an extract of values.



8 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
6 dB / 26 dB / 99% Bandwidth	Power Frequency	± 2.9 dB ± 11.2 kHz
Conducted Output Power	Power	± 2.2 dB
Band Edge Compliance	Power Frequency	± 2.2 dB ± 11.2 kHz
Frequency Stability	Frequency	± 25 Hz
Power Spectral Density	Power	± 2.2 dB

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	on pass mark	within pass mark	Passed
4	above pass mark	within pass mark	Failed
5	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so-called shared risk principle.



9 PHOTO REPORT

Please see separate photo report.