

FCC Measurement/Technical Report on

I-1, Analog Instant Camera

FCC ID: 2AHU9-9001

IC: 21310-9001

Test Report Reference: MDE_IMPOSSIBLE_1501_FCCa

Test Laboratory:

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Note:

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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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 (10-1-13 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 1:

The tests were selected and performed with reference to the FCC Public Notice “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, 558074 D01 DTS Meas Guidance v03r03, 2015-06-09”. ANSI C63.10–2013 is applied.

Note 2:

The tests were selected and performed with reference to the FCC Public Notice DA 00-705, released March 30, 2000. Instead of applying ANSI C63.4-1992 which is referenced in the FCC Public Note, the newer ANSI C63.10-2013 is applied.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

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 4: 8.8
Occupied bandwidth	§ 15.247 (a) (2)	RSS-247 Issue 1: 5.2 (1)
Peak conducted output power	§ 15.247 (b) (3), (4)	RSS-247 Issue 1: 5.4 (4)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 1: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 1: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 1: 5.5
Power density	§ 15.247 (e)	RSS-247 Issue 1: 5.2 (2)
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	—	—

Correlation of measurement requirements for FHSS (e.g. Bluetooth®) equipment

from
FCC and IC

FHSS equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 4: 8.8
Occupied bandwidth	§ 15.247 (a) (1)	RSS-247 Issue 1: 5.1 (2)
Peak conducted output power	§ 15.247 (b) (1), (4)	RSS-247 Issue 1: 5.4 (2)
Transmitter spurious RF conducted emissions	§ 15.247 (d)	RSS-Gen Issue 4: 6.13/8.9/8.10; RSS-247 Issue 1: 5.5
Transmitter spurious radiated emissions	§ 15.247 (d); § 15.209 (a)	RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 1: 5.5
Band edge compliance	§ 15.247 (d)	RSS-247 Issue 1: 5.5
Dwell time	§ 15.247 (a) (1) (iii)	RSS-247 Issue 1: 5.1 (4)
Channel separation	§ 15.247 (a) (1)	RSS-247 Issue 1: 5.1 (2)
No. of hopping frequencies	§ 15.247 (a) (1) (iii)	RSS-247 Issue 1: 5.1 (4)
Hybrid systems (only)	§ 15.247 (f); § 15.247 (e)	RSS-247 Issue 1: 5.3
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 4: 8.3
Receiver spurious emissions	—	-

1.3 Measurement Summary / Signatures

47 CFR CHAPTER I FCC PART 15 Subpart C **§ 15.207**
§15.247

Conducted Emissions at AC Mains	Final Result		
The measurement was performed according to ANSI C63.10	Final Result		
OP-Mode	Setup	FCC	IC
Data transfer			
worst case	S02_AH02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C **§ 15.247 (a) (2)**
§15.247

Occupied Bandwidth (6 dB)	Final Result		
The measurement was performed according to ANSI C63.10	Final Result		
OP-Mode	Setup	FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_AA02	Passed	Passed
Bluetooth LE, low	S01_AA02	Passed	Passed
Bluetooth LE, mid	S01_AA02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C **-**
§15.247

Occupied Bandwidth (99%)	Final Result		
The measurement was performed according to ANSI C63.10	Final Result		
OP-Mode	Setup	FCC	IC
Radio Technology, Operating Frequency			
Bluetooth LE, high	S01_AA02	N/A	Passed
Bluetooth LE, low	S01_AA02	N/A	Passed
Bluetooth LE, mid	S01_AA02	N/A	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C **§ 15.247 (b) (3)**
§15.247

Peak Power Output	Final Result		
The measurement was performed according to ANSI C63.10	Final Result		
OP-Mode	Setup	FCC	IC
Radio Technology, Operating Frequency, Measurement method			
Bluetooth LE, high, conducted	S01_AA02	Passed	Passed
Bluetooth LE, low, conducted	S01_AA02	Passed	Passed
Bluetooth LE, mid, conducted	S01_AA02	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C
§15.247
§ 15.247 (d)

Spurious RF Conducted Emissions

The measurement was performed according to ANSI C63.10

Final Result
OP-Mode

 Radio Technology, Operating Frequency
 Bluetooth LE, high
 Bluetooth LE, low
 Bluetooth LE, mid

Setup
FCC
IC

S01_AA02

Passed

Passed

S01_AA02

Passed

Passed

S01_AA02

Passed

Passed

47 CFR CHAPTER I FCC PART 15 Subpart C
§15.247
§ 15.247 (d)

Transmitter Spurious Radiated Emissions

The measurement was performed according to ANSI C63.10

Final Result
OP-Mode

 Radio Technology, Operating Frequency, Measurement range
 Bluetooth LE, high, 1 GHz - 26 GHz
 Bluetooth LE, high, 30 MHz - 1 GHz
 Bluetooth LE, low, 1 GHz - 26 GHz
 Bluetooth LE, low, 30 MHz - 1 GHz
 Bluetooth LE, mid, 1 GHz - 26 GHz
 Bluetooth LE, mid, 30 MHz - 1 GHz
 Bluetooth LE, mid, 9 kHz - 30 MHz

Setup
FCC
IC

S01_AH02

Passed

Passed

47 CFR CHAPTER I FCC PART 15 Subpart C
§15.247
§ 15.247 (d)

Band Edge Compliance Conducted

The measurement was performed according to ANSI C63.10

Final Result
OP-Mode

 Radio Technology, Operating Frequency, Band Edge
 Bluetooth LE, high, high
 Bluetooth LE, low, low

Setup
FCC
IC

S01_AA02

Passed

Passed

S01_AA02

Passed

Passed

47 CFR CHAPTER I FCC PART 15 Subpart C
§15.247
§ 15.247 (d)

Band Edge Compliance Radiated

The measurement was performed according to ANSI C63.10

Final Result
OP-Mode

 Radio Technology, Operating Frequency, Band Edge
 Bluetooth LE, high, high

Setup
FCC
IC

S01_AH02

Passed

Passed

47 CFR CHAPTER I FCC PART 15 Subpart C
§15.247
§ 15.247 (e)

Power Density

The measurement was performed according to ANSI C63.10

Final Result**OP-Mode**

Radio Technology, Operating Frequency
Bluetooth LE, high
Bluetooth LE, low
Bluetooth LE, mid

Setup	FCC	IC
S01_AA02	Passed	Passed
S01_AA02	Passed	Passed
S01_AA02	Passed	Passed

N/A: Not applicable

N/P: Not performed



(responsible for accreditation scope)
Marco Kullik



(responsible for testing and report)
Robert Machulec



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2 Administrative Data

2.1 Testing Laboratory

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

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

This facility has been fully described in a report submitted to the IC and accepted under the registration number: Site# 3699A-1.

The test facility is also accredited by the following accreditation organisation:

Laboratory accreditation no: DAkkS D-PL-12140-01-01

Responsible for accreditation scope: Marco Kullik

Report Template Version: 2016-03-11

2.2 Project Data

Responsible for testing and report: Robert Machulec

Employees who performed the tests: documented internally at 7Layers

Date of Report: 2016-04-29

Testing Period: 2016-04-07 to 2016-04-11

2.3 Applicant Data

Company Name: Impossible B.V.

Address: Hoge Bothofstraat 45
7511 ZA Enschede
Netherlands

Contact Person: Stefanie Koch

2.4 Manufacturer Data

Company Name: please see applicant data

Address:

Contact Person:

3 Test object Data

3.1 General EUT Description

Kind of Device product description	Analog Instant Camera with Bluetooth LE module
Product name	Analog Instant Camera
Type	I-1, Analog Instant Camera
Declared EUT data by the supplier	
Voltage Type	DC (USB)
Voltage Level	5V
Tested Modulation Type	GFSK
General product description	The equipment under test is an analog instant camera with integrated Bluetooth low energy module for data communication.
The EUT provides the following ports:	Enclosure; USB connector (connected to AUX1)
Tested data rates	1Mbit/s

The main components of the EUT are listed and described in chapter 3.2 EUT Main components.

3.2 EUT Main components

Sample Name	Sample Code	Description
DE1171001aa02	aa02	Conducted Sample
Sample Parameter		
Integral Antenna		Value
Serial No.	-	
HW Version	I-1 G1	
SW Version	V1.0	
Comment		

Sample Name	Sample Code	Description
DE1171001ah02	ah02	Radiated Sample
Sample Parameter		
Integral Antenna		Value
Serial No.	94	
HW Version	I-1 G1	
SW Version	V1.0	
Comment		

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

3.3 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.

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

3.4 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, HW, SW, S/N)	Description
AUX1	, -, -, -	USB Cable, 1.1m
AUX2	, -, -, 000106	AC/DC Adapter, Wicked Chili, 5 V USB
AUX3	, I9305XXUFOA1, KTU84P.I9305XXFNL1 , RF1D3435ZSN	GT-I9305
L17MB-P	LG, -, -, 412WAPLOU560	TFT Display EMC TFT 5
Lifebook Eseries E781	Fujitsu, -, -, DSCK013817	Laptop RE
M-BT58	Logitech, -, -, HC60915A2XC	EMC MOUSE 1
PJW1942NA	Fujitsu Ltd., -, -, 13300281B	AC Adapter 3 Laptop RE
RS 6000 USB ON	CHERRY, -, -, G 0000273 2P28	EMC KEYBOARD 1

3.5 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_AA02	DE1171001aa02, AUX1,	Test setup for all conducted measurements
S01_AH02	DE1171001ah02, AUX1, AUX2,	Setup for all radiated measurements
	DE1171001ah02, AUX1, AUX3, L17MB-P,	Computer periphery setup
S02_AH02	PJW1942NA, Lifebook Eseries E781, M-BT58, RS 6000 USB ON,	

3.6 Operating Modes

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

Operating mode data transfer:

The EUT is sending data to a smart phone using Bluetooth low energy connection.
The EUT are controlled by applicants software "IM_Bluetooth_FCC_Tester"

Operating mode transmit at low mid and high channel:

The EUT is sending data stand alone at single channels.

The EUT are controlled by applicants software "IM_Bluetooth_DTM_Tester"

3.6.1 Test Channels

BT LE Test Channels:
Channel:
Frequency [MHz]

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

3.7 Product labelling

3.7.1 FCC ID label

Please refer to the documentation of the applicant.

3.7.2 Location of the label on the EUT

Please refer to the documentation of the applicant.

4 Test Results

4.1 Conducted Emissions at AC Mains

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.10. The Equipment Under Test (EUT) was setup in a shielded room to perform the conducted emissions measurements in a typical installation configuration. The EUT was powered from $50\mu\text{H} \parallel 50 \text{ Ohm}$ Line Impedance Stabilization Network (LISN). The LISN's unused connections were terminated with 50 Ohm loads.

The measurement procedure consists of two steps. It is implemented into the EMI test software EMC-32 from R&S.

Step 1: Preliminary scan

Intention of this step is, to determine the conducted EMI-profile of the EUT.

EMI receiver settings:

- Detector: Peak – Maxhold & Average
- Frequency range: 150 kHz – 30 MHz
- Frequency steps: 2.5 kHz
- IF-Bandwidth: 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)
- Measurement on phase + neutral lines of the power cords

On basis of this preliminary scan the highest amplitudes and the corresponding frequencies relative to the limit are identified. Emissions above the limit and emissions which are in the 10 dB range below the limit are considered.

Step 2: Final measurement

Intention of this step is, to determine the highest emissions with the settings defined in the test specification for the frequencies identified in step 1.

EMI receiver settings:

- Detector: Quasi-Peak
- IF Bandwidth: 9 kHz
- Measuring time: 1 s / frequency

At each frequency determined in step 1, four measurements are performed in the following combinations:

- 1) Neutral lead - reference ground (PE grounded)
- 2) Phase lead - reference ground (PE grounded)
- 3) Neutral lead - reference ground (PE floating)
- 4) Phase lead - reference ground (PE floating)

The highest value is reported.

4.1.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.207

Frequency Range (MHz)	QP Limit (dB μ V)	AV Limit (dB μ V)
0.15 – 0.5	66 to 56	56 to 46
0.5 – 5	56	46
5 – 30	60	50

Used conversion factor: Limit (dB μ V) = 20 log (Limit (μ V)/1 μ V).

4.1.3 Test Protocol

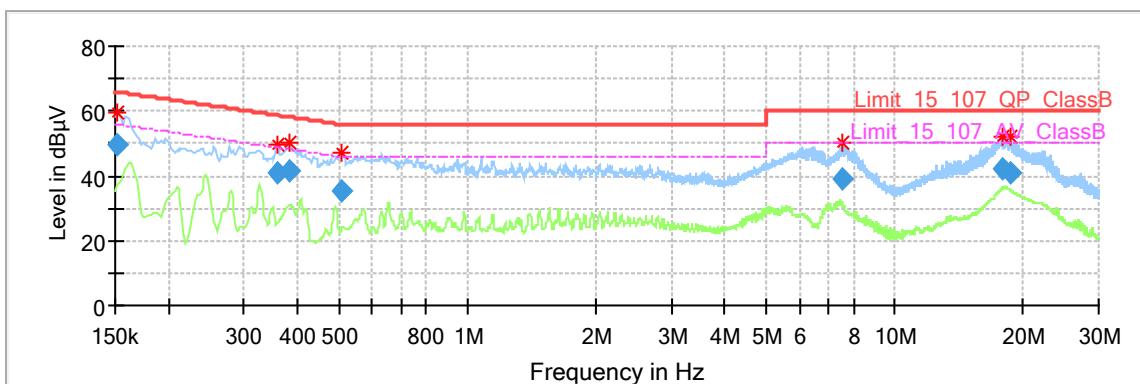
Temperature: 23 °C
 Air Pressure: 1004 hPa
 Humidity: 34 %

Power line	Frequency [MHz]	Measured value QP [dB μ V]	Measured value AV [dB μ V]	QP Limit [dB μ V]	AV Limit [dB μ V]	Margin QP [dB]	Margin AV [dB]
L1	0.2	49.6	-	65.9	-	16.3	-
L1	0.4	40.8	-	58.8	-	18.0	-
L1	0.4	41.6	-	58.2	-	16.6	-
L1	0.5	35.6	-	56.0	-	20.5	-
L1	7.5	39.2	-	60.0	-	20.9	-
L1	17.8	42.3	-	60.0	-	17.7	-
L1	18.7	41.0	-	60.0	-	19.0	-

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

4.1.4 Measurement Plot (showing the highest value, "worst case")

Operating mode = worst case



4.1.5 Test Equipment used

Conducted Emissions

4.2 Occupied Bandwidth (6 dB)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

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

The EUT was connected to spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: 30 / 50 MHz (for 20 / 40 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: 2000
- Sweptime: 20 ms
- Detector: Peak

4.2.2 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.

4.2.3 Test Protocol

Ambient temperature: 20°C

Air Pressure: 1010 Pa

Humidity: 0.3

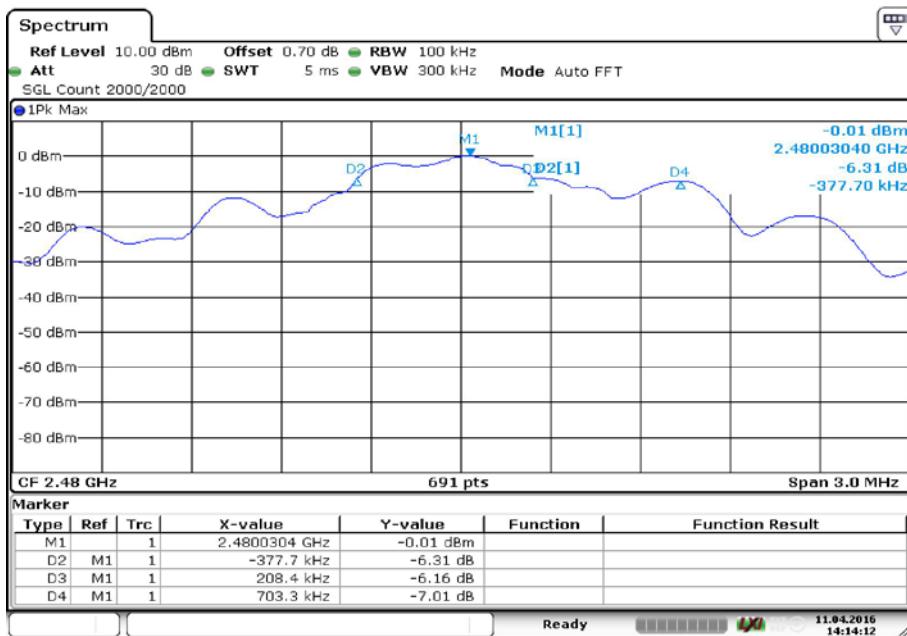
BT LE GFSK

Band	Channel No.	Frequency [MHz]	6 dB Bandwidth [MHz]	Limit [MHz]	Margin to Limit [MHz]
2.4 GHz ISM	0.0	2402.0	0.9	0.5	0.4
	19.0	2440.0	1.1	0.5	0.6
	39.0	2480.0	0.6	0.5	0.1

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

4.2.4 Measurement Plot (showing the highest value, "worst case")

Radio Technology = Bluetooth LE, Operating Frequency = high



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4.2.5 Test Equipment used

R&S TS8997

4.3 Occupied Bandwidth (99%)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

4.3.1 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 spectrum analyzer via a short coax cable with a known loss.
 Analyzer settings:

- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: 30 / 50 MHz (for 20 / 40 MHz nominal bandwidth)
- Trace: Maxhold
- Sweeps: 2000
- Sweptime: 20 ms
- Detector: Sample

The 99 % measurement function of the spectrum analyser function was used to determine the 99 % bandwidth.

4.3.2 Test Requirements / Limits

No applicable limit:

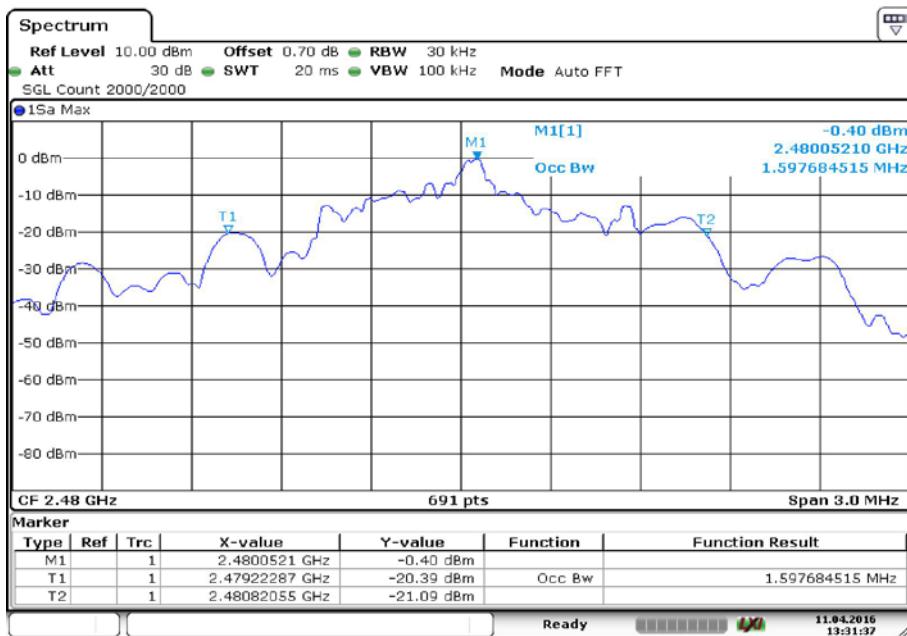
4.3.3 Test Protocol

BT LE			
Band	Channel No.	Frequency [MHz]	99 % Bandwidth [MHz]
2.4 GHz ISM	0.0	2402.0	1.4
	19.0	2440.0	1.7
	39.0	2480.0	1.6

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

4.3.4 Measurement Plot (showing the highest value, "worst case")

Radio Technology = Bluetooth LE, Operating Frequency = high



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4.3.5 Test Equipment used

R&S TS8997

4.4 Peak Power Output

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.4.1 Test Description

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. The reference level of the spectrum analyzer was set higher than the output power of the EUT.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Maxhold
- Sweeps: 2000
- Sweptime: 5 ms
- Detector: Peak

The channel power function of the spectrum analyser was used (Used channel bandwidth = DTS bandwidth)

4.4.2 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) = $10 \log (\text{Limit (W)})/1\text{mW}$

4.4.3 Test Protocol

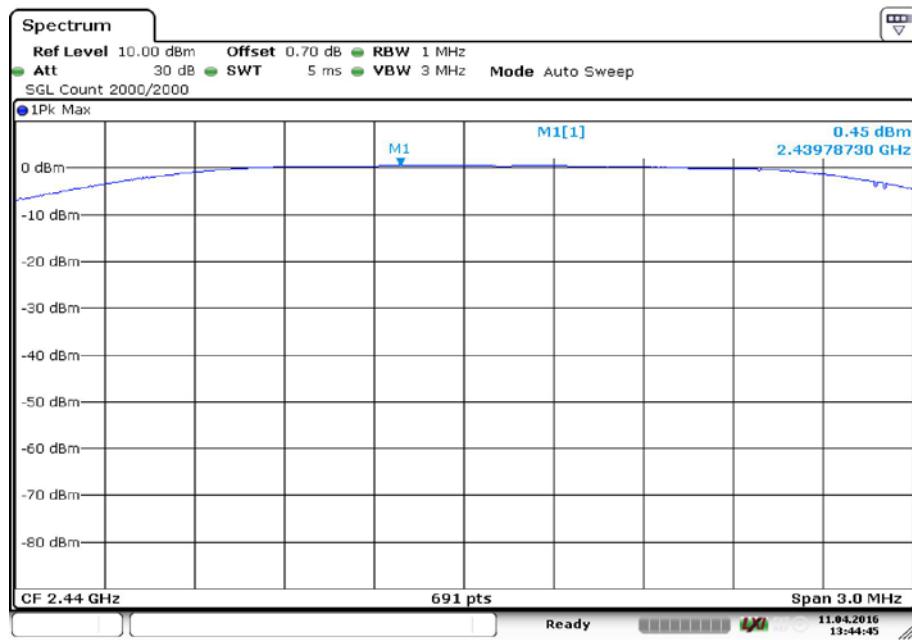
BT LE

Band	Channel No.	Frequency [MHz]	Peak Power [dBm]	Limit [dBm]	Margin to Limit [dB]
2.4 GHz ISM	0.0	2402.0	0.4	30.0	29.6
	19.0	2440.0	0.5	30.0	29.6
	39.0	2480.0	0.1	30.0	29.9

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

4.4.4 Measurement Plot (showing the highest value, "worst case")

Radio Technology = Bluetooth LE, Operating Frequency = mid, Measurement method = conducted



Date: 11.APR.2016 13:44:45

4.4.5 Test Equipment used

R&S TS8997

4.5 Spurious RF Conducted Emissions

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

4.5.1 Test Description

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

The EUT was connected to spectrum analyzer via a short coax cable with a known loss.
 Analyzer settings:

- Frequency range: 30 – 25000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Trace: Maxhold
- Sweeps: 2
- Sweep Time: 330 s
- 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 limit.

4.5.2 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.

4.5.3 Test Protocol

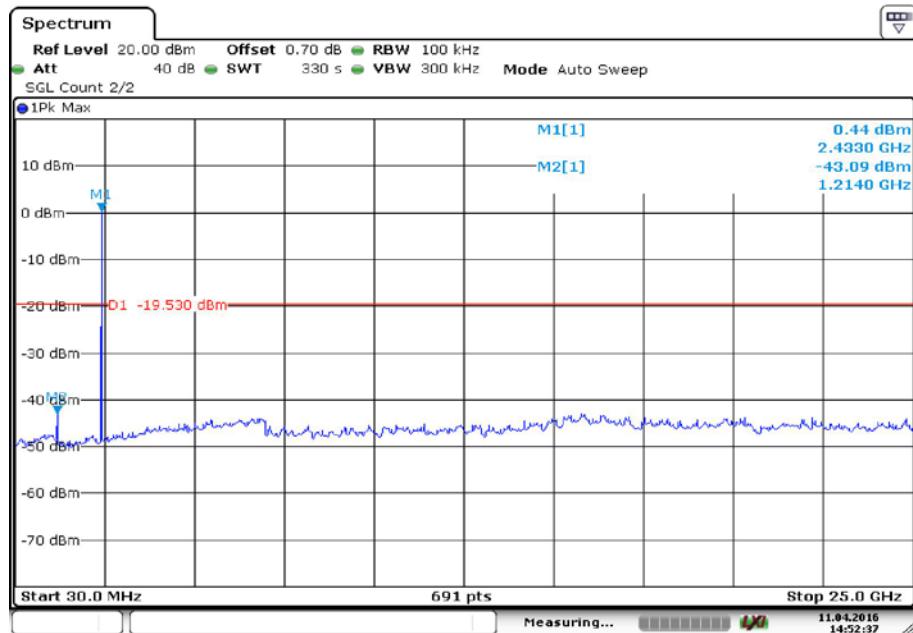
BT LE GFSK

Channel No	Channel Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]
0.0	2402.0			PEAK	100.0		-20.0	---
19.0	2440.0			PEAK	100.0		-20.0	---
39.0	2480.0			PEAK	100.0		-20.0	---

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

4.5.4 Measurement Plot (showing the highest value, "worst case")

Radio Technology = Bluetooth LE, Operating Frequency = mid



Date: 11.APR.2016 14:52:37

4.5.5 Test Equipment used

R&S TS8997

4.6 Transmitter Spurious Radiated Emissions

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.6.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

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 from a DC power source.

1. Measurement up to 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

- Anechoic chamber
- Antenna distance: 3 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.

- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- 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

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 – 3 m
- Height variation step size: 2 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 $\pm 45^\circ$ around this value. 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 by ± 100 cm around the antenna height determined. 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: $\pm 45^\circ$ around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 3, the final measurement will be performed:

EMI receiver settings for step 4:

- 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.

3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

Step 1:

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.

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 °.

Step 2:

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size $\pm 45^\circ$ for the elevation axis is performed.

The turn table azimuth will slowly vary by $\pm 22.5^\circ$.

The elevation angle will slowly vary by $\pm 45^\circ$.

EMI receiver settings (for all steps):

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.6.2 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 ($\mu\text{V}/\text{m}$)	Measurement distance (m)	Limits ($\text{dB}\mu\text{V}/\text{m}$)
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 ($\mu\text{V}/\text{m}$)	Measurement distance (m)	Limits ($\text{dB}\mu\text{V}/\text{m}$)
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 ($\text{dB}\mu\text{V}/\text{m}$) = $20 \log (\text{Limit} (\mu\text{V}/\text{m})/1\mu\text{V}/\text{m})$

4.6.3 Test Protocol

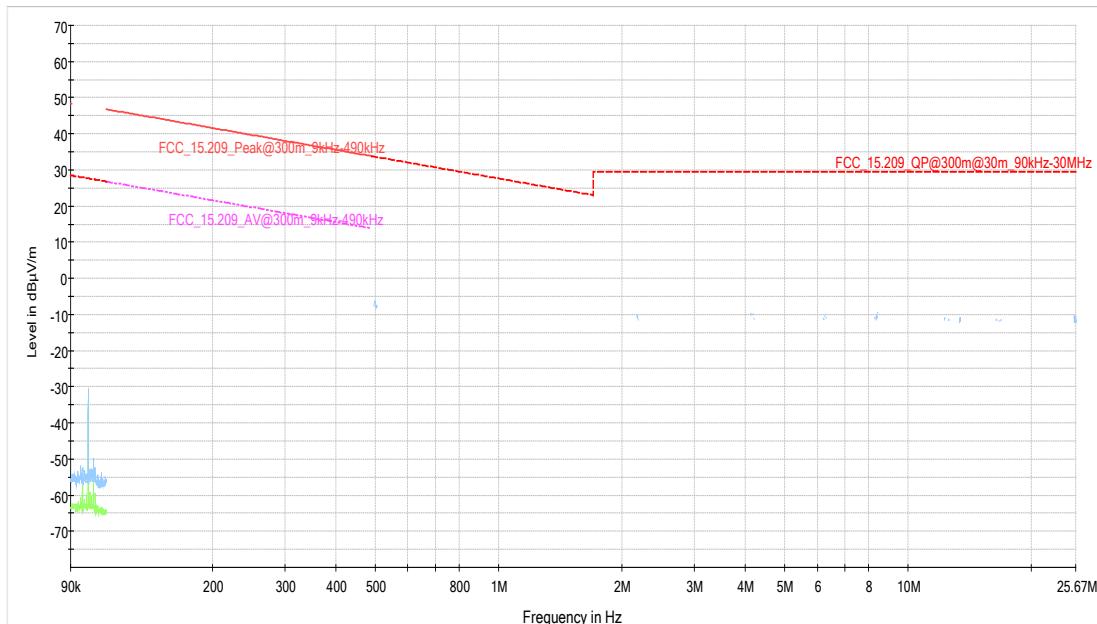
BT low
 Energy

Ch. No.	Ch. Center Freq. [MHz]	Spurious Freq. [MHz]	Spurious Level [dB μ V/m]	Detector	RBW [kHz]	Limit [dB μ V/m]	Margin to Limit [dB]	Limit Type
0.0	2402.0	4804.0	50.6	AV	1000.0	54.0	3.4	RB
0.0	2402.0	4804.0	55.0	PEAK	1000.0	74.0	19.0	RB
19.0	2440.0	4880.0	52.3	AV	1000.0	54.0	1.7	RB
19.0	2440.0	4880.0	57.8	PEAK	1000.0	74.0	16.3	RB
39.0	2480.0	4960.0	47.4	AV	1000.0	54.0	6.6	RB
39.0	2480.0	4960.0	57.1	PEAK	1000.0	74.0	16.9	RB
39.0	2480.0	2483.5	65.1	PEAK	1000.0	74.0	8.9	RB
39.0	2480.0	2492.2	41.9	AV	1000.0	54.0	12.1	RB
39.0	2480.0	7439.8	45.4	PEAK	1000.0	74.0	28.6	RB
39.0	2480.0	7440.0	44.2	AV	1000.0	54.0	9.8	RB

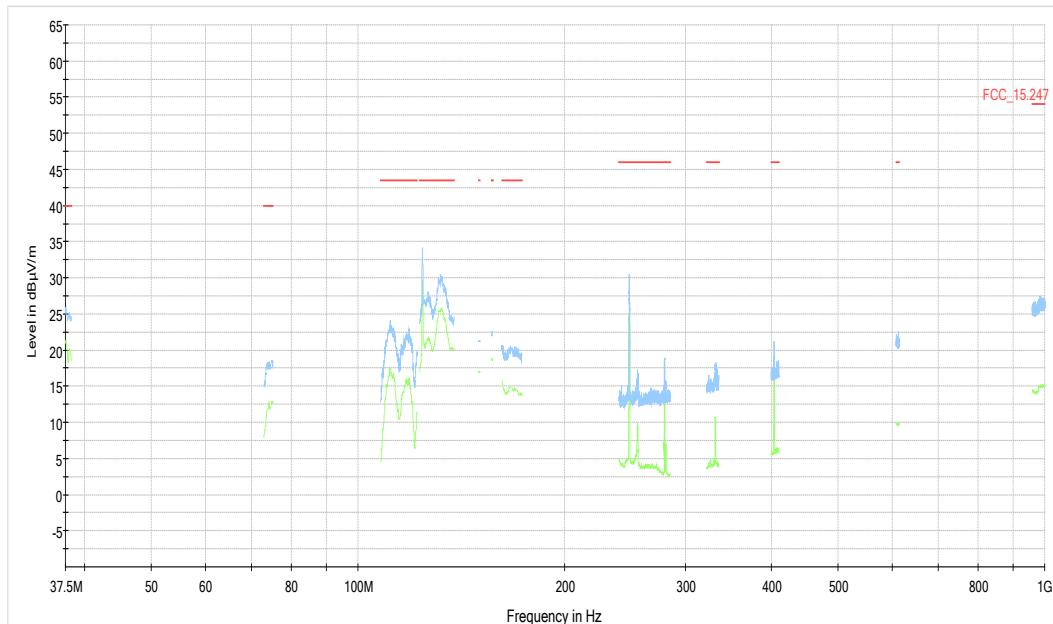
Remark: Please see next sub-clause for the measurement plot. AV values contain a DC correction.

4.6.4 Measurement Plot (showing the highest value, "worst case")

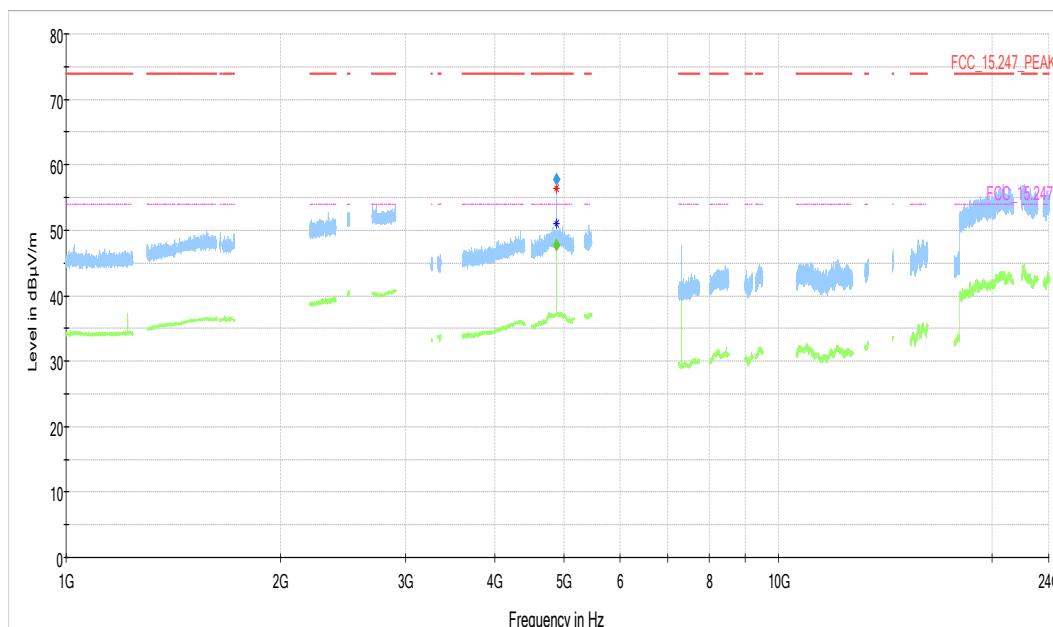
Radio Technology = Bluetooth LE, Operating Frequency = mid, Measurement range = 9 kHz - 30 MHz



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



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



4.6.5 Test Equipment used

Radiated Emissions

4.7 Band Edge Compliance Conducted

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

4.7.1 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 spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Frequency Range 30 MHz – 25 GHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweptime: 330 s
- Sweeps: 2
- Trace: Maxhold

4.7.2 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..."

4.7.3 Test Protocol

BT LE GFSK

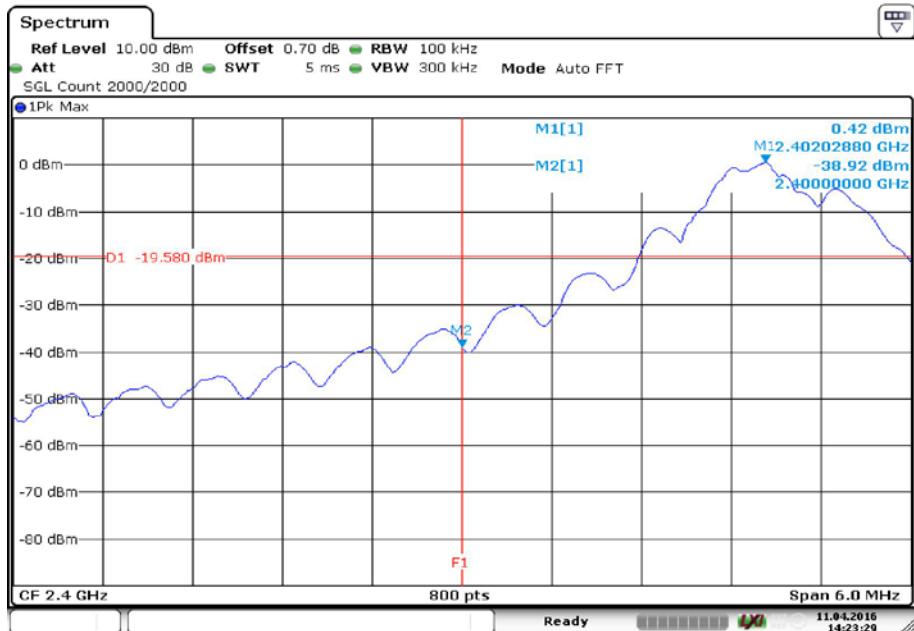
Channel No.	Channel Center Frequency [MHz]	Band Edge Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Ref. Level [dBm]	Limit [dBm]	Margin to Limit [dB]

0.0	2402.0	2400.0	-38.9	PEAK	100.0	0.4	-19.6	19.3
39.0	2480.0	2483.5	-48.9	PEAK	100.0	0.1	-19.9	29.0

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

4.7.4 Measurement Plot (showing the highest value, "worst case")

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



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4.7.5 Test Equipment used

R&S TS8997

4.8 Band Edge Compliance Radiated

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

4.8.1 Test Description

Please see test description for the test case "Spurious Radiated Emissions"

4.8.2 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 (μ V/m)	Measurement distance (m)	Limits ($\text{dB}\mu$ V/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 (μ V/m)	Measurement distance (m)	Limits ($\text{dB}\mu$ V/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 ($\text{dB}\mu$ V/m) = 20 log (Limit (μ V/m)/1 μ V/m)

4.8.3 Test Protocol

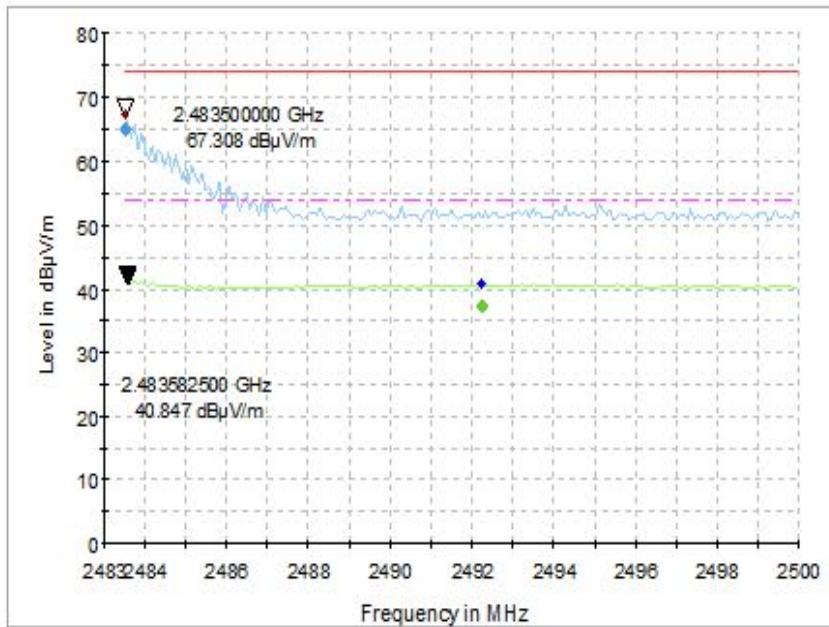
BT LE GFSK

Ch. No.	Ch. Center Freq. [MHz]	Band Edge Freq. [MHz]	Spurious Level [$\text{dB}\mu$ V/m]	Detector	RBW [kHz]	Limit [$\text{dB}\mu$ V/m]	Margin to Limit [dB]	Limit Type
39.0	2480.0	2483.5	67.3	PEAK	1000.0	74.0	6.7	BE
39.0	2480.0	2483.5	40.8	AV	1000.0	54.0	13.2	BE

Remark: Please see next sub-clause for the measurement plot. AV values contain a DC correction.

4.8.4 Measurement Plot (showing the highest value, "worst case")

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



4.8.5 Test Equipment used

Radiated Emissions

4.9 Power Density

Standard **FCC Part 15 Subpart C**

The test was performed according to:
 ANSI C63.10

4.9.1 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 spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 3 kHz
- Video Bandwidth (VBW): 30 kHz
- Trace: Maxhold
- Sweeps: 2000
- Sweptime: 5 ms
- Detector: Peak

4.9.2 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.

4.9.3 Test Protocol

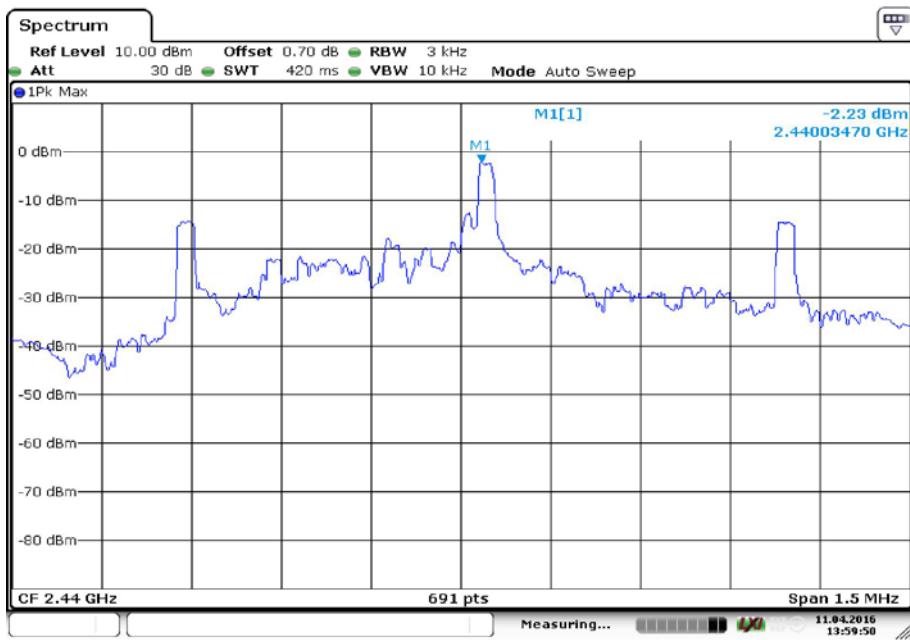
Ambient temperature: 20°C
 Air Pressure: 1010 Pa
 Humidity: 0.3
 BT LE

Band	Channel No.	Frequency [MHz]	Power Density [dBm/3kHz]	Limit [dBm/3kHz]	Margin to Limit [dB]
2.4 GHz ISM	0.0	2402.0	-2.2	8.0	10.2
	19.0	2440.0	-2.2	8.0	10.2
	39.0	2480.0	-2.7	8.0	10.7

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

4.9.4 Measurement Plot (showing the highest value, "worst case")

Radio Technology = Bluetooth LE, Operating Frequency = mid



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4.9.5 Test Equipment used

R&S TS8997

5 Test Equipment

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069	
	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09	
	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	
	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/119 20513	
	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11-13
	Anechoic Chamber	10.58 x 6.38 x 6.00 m ³	Frankonia	none	2017-01-09
	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2017-12-08
	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790 709	
	AS 620 P	Antenna mast	HD GmbH	620/37	
	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2016-05-11
	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785	
	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037	
	HL 562	Ultralog new biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-06-30
	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03-10
	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368	

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	HFH2-Z2	Loop Antenna	Rohde & Schwarz GmbH & Co. KG	829324/006	2017-11-27
	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-11-17
	Opus10 TPR (8253.00)	ThermoAirpresure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-02-27
	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304	
	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675	
	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz GmbH & Co. KG	100609	2019-04-14
	HF 907	Double-ridged horn	Rohde & Schwarz GmbH & Co. KG	102444	2018-05-11

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 EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz GmbH & Co. KG	101158	2016-08-21
	A8455-4	4 Way Power Divider (SMA)		-	
	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-02-27
	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	107695	2017-06-06
	VT 4002	Climatic Chamber	Vötsch	58566002150010	2018-03-08
	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-02-24
	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz GmbH & Co. KG	259291	2016-08-23

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	Voltcraft M-3860M	Digital Multimeter 01 (Multimeter)	Voltcraft	IJ096055	
	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673	
	Datum, Model: MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2016-06-25

3 Conducted Emissions

Shielded Room 02

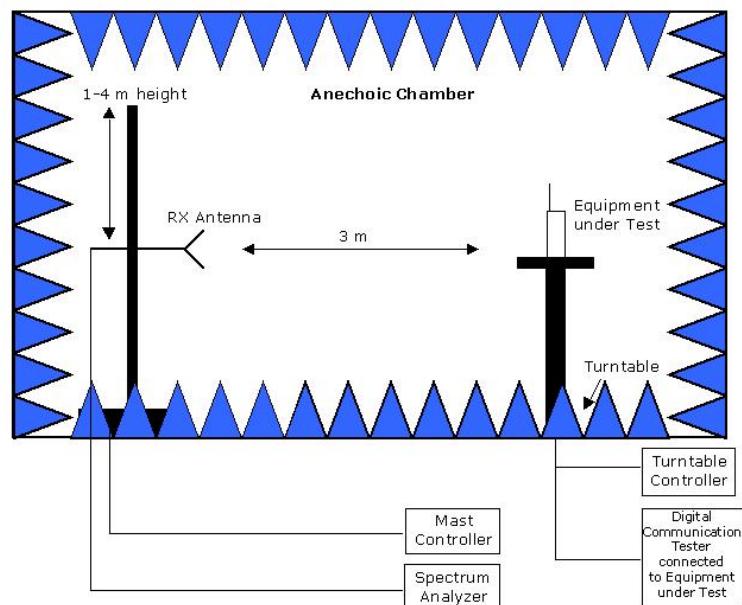
Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	828304/029	
	ISN/CDN ST08	Impedance Stabilization Network, Coupling Decoupling Network	Teseq	36292	2016-01-09
	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11-13
	ISN T800	Impedance Stabilization Network	Teseq	36159	
	EP 1200/B, NA/B1	Amplifier with integrated variable Oscillator	Spitzenberger & Spieß	B6278	2018-07-23
	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2017-12-08
	Opus10 THI (8152.00)	ThermoHygro Datalogger 02 (Environ)	Lufft Mess- und Regeltechnik GmbH	7489	2017-02-27
	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	829996/002	
	NRVS	Powermeter	Rohde & Schwarz GmbH & Co. KG	836333/064	
	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-02-27

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Calibration Due
	CMD 55	Digital Radio Communication Tester	Rohde & Schwarz	831050/020	2017-12-02
	ESH 3-Z6	One-Line V-Network	Rohde & Schwarz	100489	
	ESH 3-Z6x	ESH 3-Z6	Rohde & Schwarz	100570	
	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304	
	CMW 500	CMW 500	Rohde & Schwarz	107500	2017-07-12

6 Photo Report

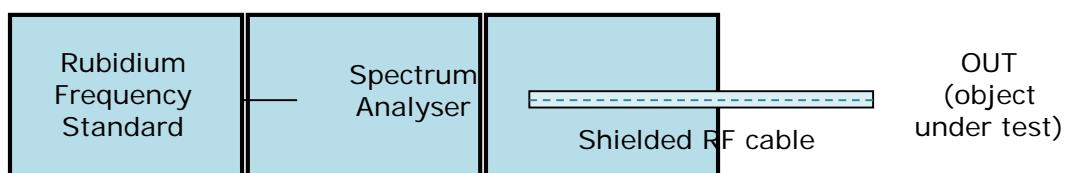
Please see separate photo report.

7 Setup Drawings



Remark: Depending on the frequency range suitable antenna types, attenuators or preamplifiers are used.

Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.



Drawing 2: Setup for conducted radio tests.

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