

Test Report

Report Number:

F170297E8

Equipment under Test (EUT):

Wireless Communication System Module

NINA-W10 series

Applicant:

u-blox AG

Manufacturer:

u-blox AG



Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

- [1] **ANSI C63.10-2013**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15**, Radio Frequency Devices
- [3] **RSS-247 Issue 2 (February 2017)**, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [4] **RSS-Gen Issue 4 (November 2014)**, General Requirements for Compliance of Radio Apparatus

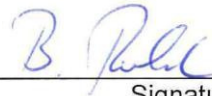
Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

tested and
written by:

Bernward ROHDE

Name



Signature

26.02.2018

Date

Authorized
reviewer:

Bernd STEINER

Name



Signature

26.02.2018

Date

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	-

1.2 Manufacturer

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Applicant represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

Accredited by *Deutsche Akkreditierungsstelle GmbH* in compliance with
DIN EN ISO/IEC 17025 under Reg. No. < **D-PL-17186-01-02** >.

1.4 EUT (Equipment Under Test)

Test object: *	Wireless Communication System Module
Model / PMN: *	NINA-W101 and NINA-W102
FCC ID: *	XPYNINAW10
IC-Number: *	8595A-NINAW10
HVIN:*	NINA-W101 and NINA-W102
HMN:*	N/A
Order number:*	-
Serial number: *	866D4CA6EB2B5390300 [marked #403] 867D4CA6EB2B9B20300 [marked #403]
PCB identifier: *	918130.05 918230.05
Hardware version: *	05
Software version / FVIN: *	N/A

* Declared by the applicant

Frequency List Bluetooth classic

Channel 00	RX:	2402 MHz	TX:	2402 MHz
Channel 39	RX:	2441 MHz	TX:	2441 MHz
Channel 78	RX:	2480 MHz	TX:	2480 MHz

Frequency List Bluetooth Low Energy

Channel 00	RX:	2402 MHz	TX:	2402 MHz
Channel 19	RX:	2440 MHz	TX:	2440 MHz
Channel 39	RX:	2480 MHz	TX:	2480 MHz

Ancillary Equipment:

Laptop PC:	Fujitsu LIFEBOOK S751
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*Provided by the applicant

1.5 Technical Data of Equipment

Fulfills Bluetooth specification: *	4.2 BR/EDR (Bluetooth classic) 4.2 BLE (Bluetooth Low Energy)					
Antenna type: *	See antenna list below					
Antenna name: *	See antenna list below					
Antenna gain: *	See antenna list below					
Antenna connector: *	None (NINA-W101) U.FL (NINA-W102)					
Evaluation board: *	EVK-NINA-W131/EVK-NINA-W132 (by u-blox AG)					
Supply voltage evaluation board:*	U _{nom} =	5.0 V DC	U _{min} =	5.0 V DC	U _{max} =	12.0 V DC
Supply voltage – EUT: *	U _{nom} =	3.3 V DC	U _{min} =	3.0 V DC	U _{max} =	3.6 V DC
Type of modulation (Bluetooth classic): *	1 Mbps: GFSK 2 Mbps: $\pi/4$ -DQPSK 3 Mbps: 8DPSK					
Type of modulation (Bluetooth Low Energy): *	1 Mbps: GFSK					
Operating frequency range:*	2402 MHz to 2480 MHz (Bluetooth classic & Bluetooth Low Energy)					
Channel spacing: *	1 MHz (Bluetooth classic) 2 MHz (Bluetooth Low Energy)					
Number of channels: *	79 (Bluetooth classic) 40 (Bluetooth Low Energy)					
Temperature range: *	-40 °C to +85 °C					
Lowest / highest internal clock frequency: *	40 MHz / 2480 MHz					

Antenna List:

Antenna name	Manufacturer	Type	Comment	Gain [dBi]
u-blox LILY Antenna	ProAnt	SMD PIFA	antenna on NINA-W102	3
FlatWhip-2400	ProAnt	Monopole	SMA/RSMA	3
InSide-2400	ProAnt	Patch	10cm cable/U.FL	3
Ex-IT 2400 -SMA 28-001 -RP-SMA 28-001 -MHF 28-001	ProAnt	Monopole	SMA RSMA 10 cm cable/U.FL	3
Ex-IT 2400 -SMA 70-002 -RP-SMA 70-002	ProAnt	Monopole	SMA RSMA	3
GW26.0111.HT	Taoglas	Single-band monopole	SMA	3
ANT-2.4-CW-RH-RPS ANT-2.4-CW-RH-SMA	Linx	Single-band monopole	RP-SMA connector SMA connector	-1
Ex-IT 2400 -MHF 70-001	ProAnt	Monopole	10cm cable/U.FL	3
Outside-2400	ProAnt	Patch	7 cm cable/U.FL 10 cm cable/U.FL 25 cm cable/U.FL	3
InSide-WLAN	ProAnt	Patch	dual band 10 cm cable/U.FL	3
InSide-WLAN Square	ProAnt	Patch	dual band 10 cm cable/U.FL	3
Ex-IT WLAN - SMA - RP-SMA - MHF	ProAnt	Monopole	dual band SMA RSMA 10cm cable/U.FL	3

1.6 Dates

Date of receipt of test sample:	22.08.2017
Start of test:	23.08.2017
End of test:	03.11.2017

2 Operational States

The EUT is a Wireless Communication System Module that is capable to operate WLAN, Bluetooth classic and Bluetooth Low Energy. It is intended for integration into various applications.

To put the module into a specific Operation Mode, a PC-software provided by the applicant named "s-center 1.0.0.5" was used.

The antenna port conducted tests were performed with the EUT marked #403 with the serial number 866D4CA6EB2B5390300.

The radiated tests were performed with the EUT marked #403 with the serial number 867D4CA6EB2B9B20300. Since this EUT has the maximum antenna gain of 3 dBi, the tests encompass both, antenna and housing emissions.

The following operation modes were identified as worst case condition and used during the tests:

EUT in Bluetooth classic mode

Operation mode	Description of the operation mode	channel	mode	Data rate / Mbps
1	Continuous transmitting on 2402 MHz	0	DH5	1 Mbps
2	Continuous transmitting on 2441 MHz	39	DH5	1 Mbps
3	Continuous transmitting on 2480 MHz	78	DH5	1 Mbps
4	Continuous transmitting on 2402 MHz	0	2DH5	2 Mbps
5	Continuous transmitting on 2441 MHz	39	2DH5	2 Mbps
6	Continuous transmitting on 2480 MHz	78	2DH5	2 Mbps
7	Continuous transmitting on 2402 MHz	0	3DH5	3 Mbps
8	Continuous transmitting on 2441 MHz	39	3DH5	3 Mbps
9	Continuous transmitting on 2480 MHz	78	3DH5	3 Mbps

EUT in Bluetooth Low Energy mode

Operation mode	Description of the operation mode	channel	Data rate / Mbps
10	Continuous transmitting on 2402 MHz	0	1 Mbps
11	Continuous transmitting on 2441 MHz	19	1 Mbps
12	Continuous transmitting on 2480 MHz	39	1 Mbps

Power Settings Bluetooth and Bluetooth Low Energy for all measurements:

Bluetooth mode	Data rate [Mbps]	Channel	Power Setting
Bluetooth classic	1 / 2 / 3	0 – 78	6
Bluetooth Low Energy	1	0 - 39	9

3 Additional Information

All tests were performed with unmodified samples.

The EUT was not labeled with the final label.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 4 [4]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed	14 et seq.
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	17 et seq.
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	22 et seq.
Band edge compliance	2400.0 - 2483.5	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	25 et seq.
Radiated emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	34 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	70 et seq.

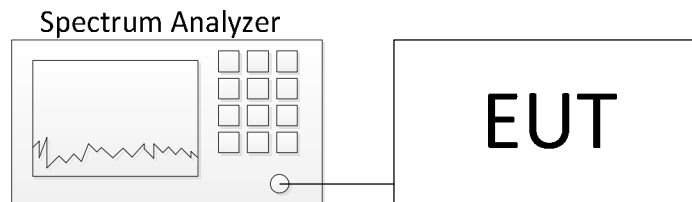
5 Results

5.1 Duty cycle

5.1.1 Method of measurement

The measurement was performed as an antenna port conducted measurement, as shown below.

Test Setup:



The method described in chapter 11.6 b) of document [1] was used to perform the following test.

Only the worst case plot for each mode was submitted below.

The following measurement technique was used:

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between two bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

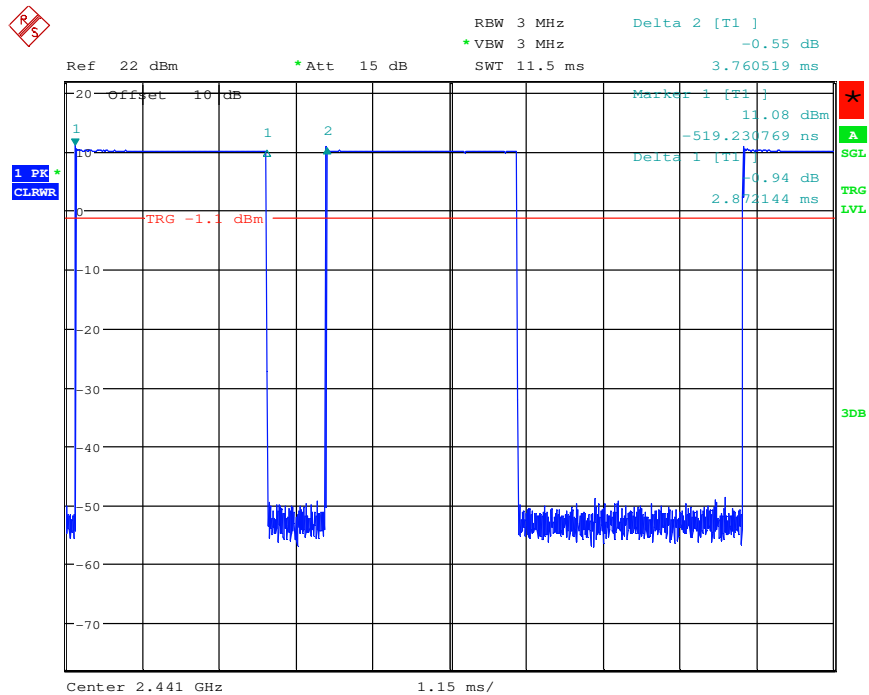
- Set the center frequency of the instrument to the center frequency of the transmission.
- Set $RBW \geq OBW$ if possible; otherwise, set RBW to the largest available value.
- Set $VBW \geq RBW$.
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$ and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if $T \leq 16.7$ microseconds.)

5.1.2 Test results

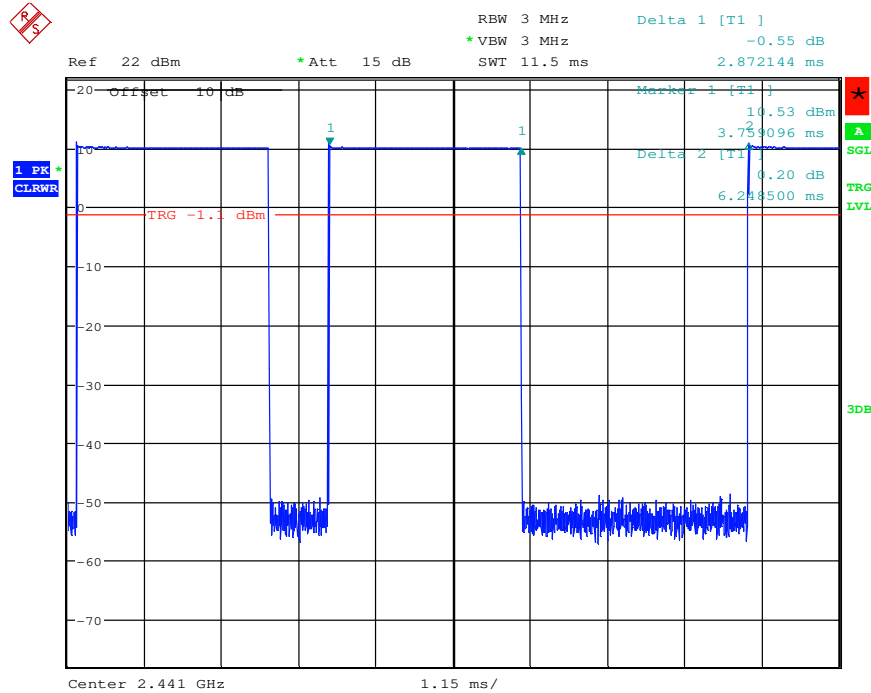
Ambient temperature	22 °C	Relative humidity	45 %
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EUT in Bluetooth classic mode

170279 DutyCycle1 BT DH5 BT39.wmf: Duty cycle measurement on channel 39 in DH5-mode



170279 DutyCycle2 BT DH5 BT39.wmf: Duty cycle measurement on channel 39 in DH5-mode



The signal combination was repeated after a short and a long Tx Cycle. Therefore the duty cycle could only be evaluated correctly, by looking at two consecutive TX periods.

$$T_{TX_On_1} = 2.872ms, T_{TX_Period_1} = 3.761ms, T_{TX_On_2} = 2.872ms, T_{TX_Period_2} = 6.249ms, \quad (1)$$

$$\frac{50}{T_{TX_On_1}} = \frac{50}{2.872ms} = 17.409kHz \leq RBW \leq VBW \quad (2)$$

Measurement Points 4001 for 11.5 ms $2.872ms = 999$ measurement points Signal has 999 measurement points (and fulfils the requirement of at least 100 Points resolution for the signal).

$$x = \frac{(T_{TX_On_1} + T_{TX_On_2})}{(T_{TX_Period_1} + T_{TX_Period_2})} = \frac{(2.872ms + 2.872ms)}{(3.761ms + 6.249ms)} = 0.574 = 57.4\% \quad (3)$$

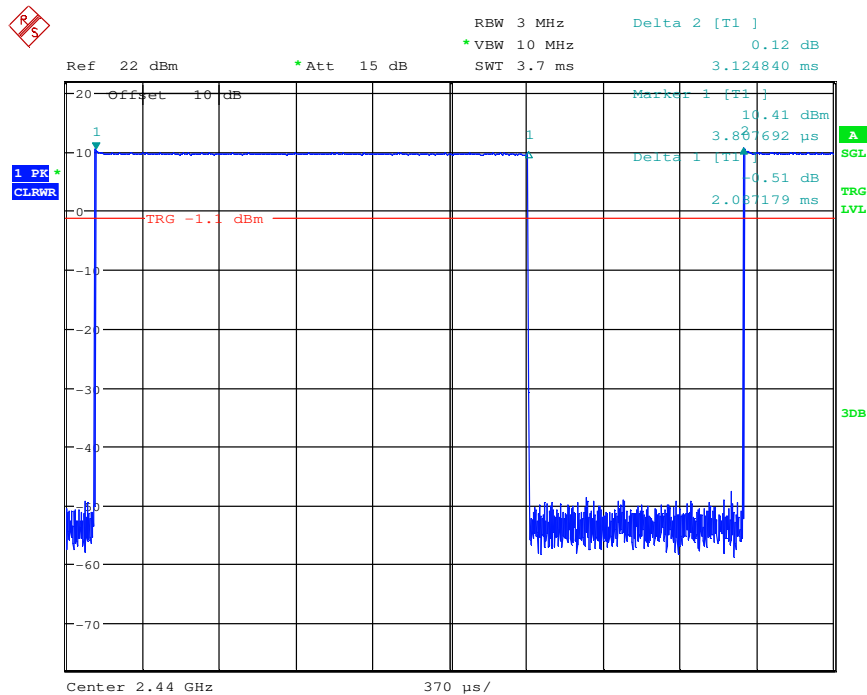
$$\text{Correction factor: } 10 \cdot \log\left(\frac{1}{x}\right) = 10 \cdot \log\left(\frac{1}{0.574}\right) = 2.4dB \quad (3)$$

For average measurements a correction factor of 2.4 dB is used for all tests in DH5 mode.

Correction factor DH5:	$T_{XOn_1} + T_{XOn_2}$: 5.744 ms; $T_{XCycle_1} + T_{XCycle_2}$: 10.010; Correction factor: 2.4 dB
Correction factor 2DH5:	$T_{XOn_1} + T_{XOn_2}$: 5.744 ms; $T_{XCycle_1} + T_{XCycle_2}$: 10.008; Correction factor: 2.4 dB
Correction factor 3DH5:	$T_{XOn_1} + T_{XOn_2}$: 5.744 ms; $T_{XCycle_1} + T_{XCycle_2}$: 10.008; Correction factor: 2.4 dB

EUT in Bluetooth Low Energy mode

170279 DutyCycle BTLE BTLE19.wmf: Duty cycle measurement on channel 19



$$T_{TX_On} = 2.087ms, T_{TX_Period} = 3.125ms \quad (4)$$

$$\frac{50}{T_{TX_On}} = \frac{50}{2.087ms} = 23.958kHz \leq RBW \leq VBW \quad (5)$$

Measurement Points 4001 for 3.7 ms 2.087ms = 2256 measurement points Signal has 2256 measurement points (and fulfils the requirement of at least 100 Points resolution for the signal).

$$x = \frac{T_{TX_On}}{T_{TX_Period}} = \frac{2.087ms}{3.125ms} = 0.668 = 66.8\% \quad (3)$$

$$\text{Correction factor: } 10 \cdot \log\left(\frac{1}{x}\right) = 10 \cdot \log\left(\frac{1}{0.668}\right) = 1.8dB \quad (6)$$

For average measurements a correction factor of 1.8 dB is used for all tests.

TEST EQUIPMENT USED FOR THE TEST:

30

5.2 Maximum peak conducted output power

5.2.1 Method of measurement

The EUT was measured conducted at the antenna ports with the aid of a spectrum analyzer.



Acceptable measurement configurations

Procedure 11.9.1.1 in [1] was used for the following test.

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

- Set the $RBW \geq DTS$ bandwidth.
- Set $VBW \geq [3 \times RBW]$.
- Set $span \geq [3 \times RBW]$.
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use peak marker function to determine the peak amplitude level.

The measurement was performed at the upper and lower end and the middle of the assigned frequency band.

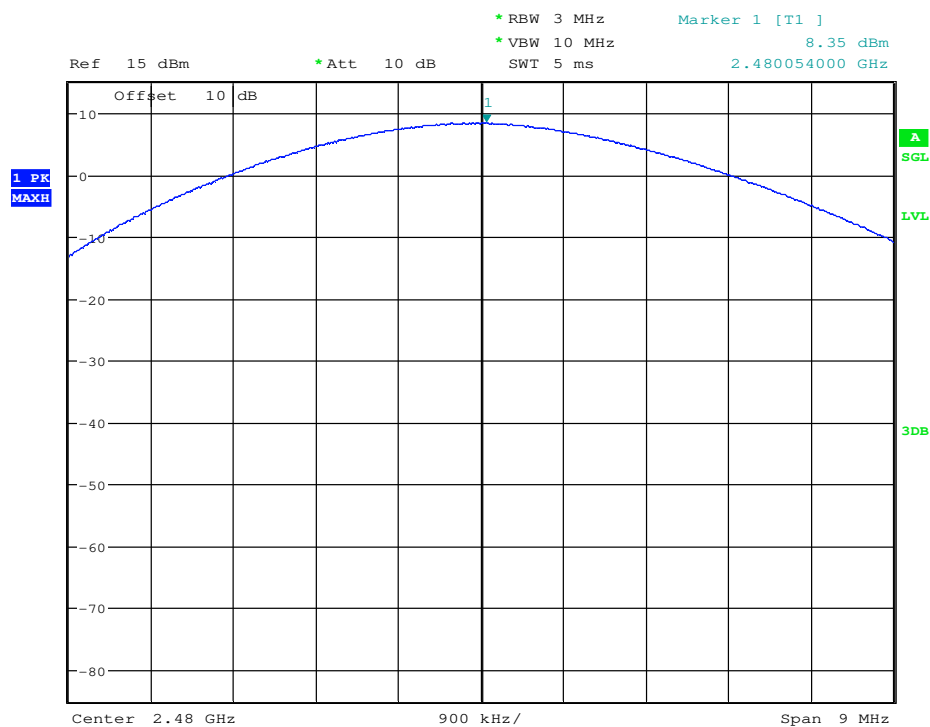
5.2.2 Test results

Ambient temperature	22 °C	Relative humidity	62 %
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All antenna gains are below 6 dBi, therefore no conducted output limit reduction is necessary.

EUT in Bluetooth classic mode

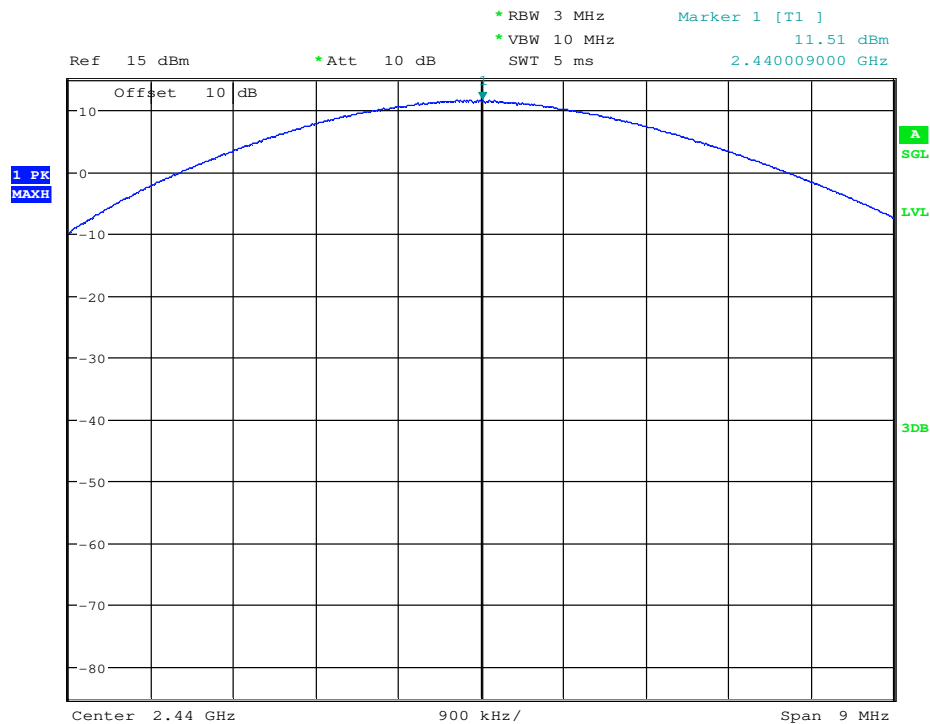
170279_MaxPeakPwr_BT_3DH5_BT79.wmf: Maximum peak conducted output power (operation mode 9):



Operation mode	Frequency [MHz]	Conducted output [dBm]	Limit [dBm]
1	DH5	2402	5.4
2	DH5	2441	6.1
3	DH5	2480	6.2
4	2DH5	2402	7.0
5	2DH5	2441	7.8
6	2DH5	2480	7.9
7	3DH5	2402	7.5
8	3DH5	2441	8.3
9	3DH5	2480	8.4

EUT in Bluetooth Low Energy mode

170279_MaxPeakPwr_BTLE_BTLE19.wmf: Maximum peak conducted output power (operation mode 11):



Operation mode	Frequency [MHz]	Conducted output [dBm]	Limit [dBm]
10	LE	2402	11.3
11	LE	2440	11.5
12	LE	2480	11.2

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

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5.3 DTS Bandwidth

5.3.1 Method of measurement

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The measurement procedure refers to part 11.8.1 of document [1].

- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

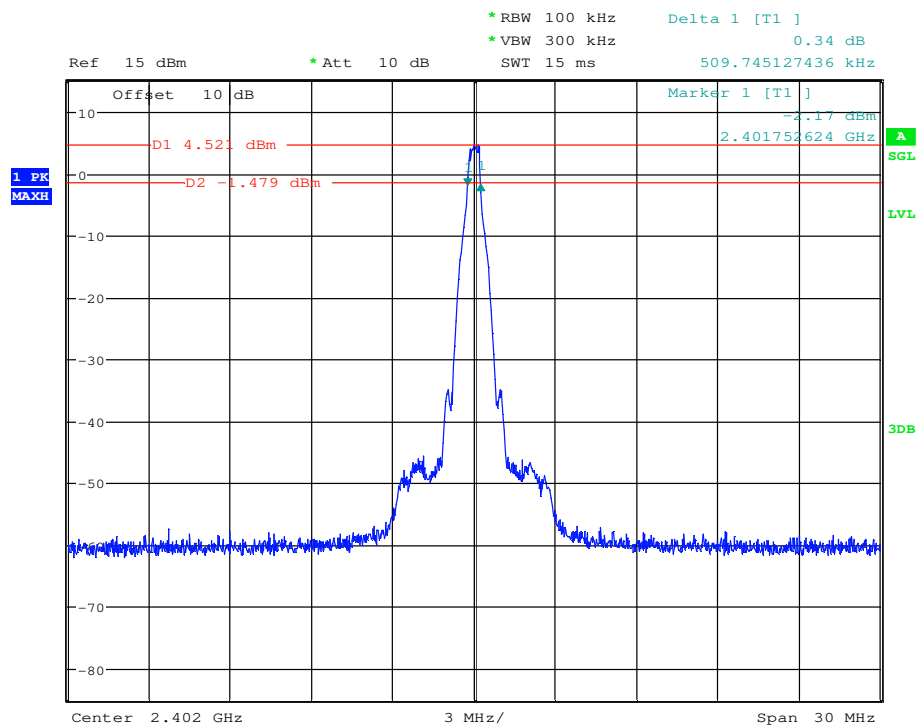
5.3.2 Test result

Ambient temperature	22 °C	Relative humidity	33 %
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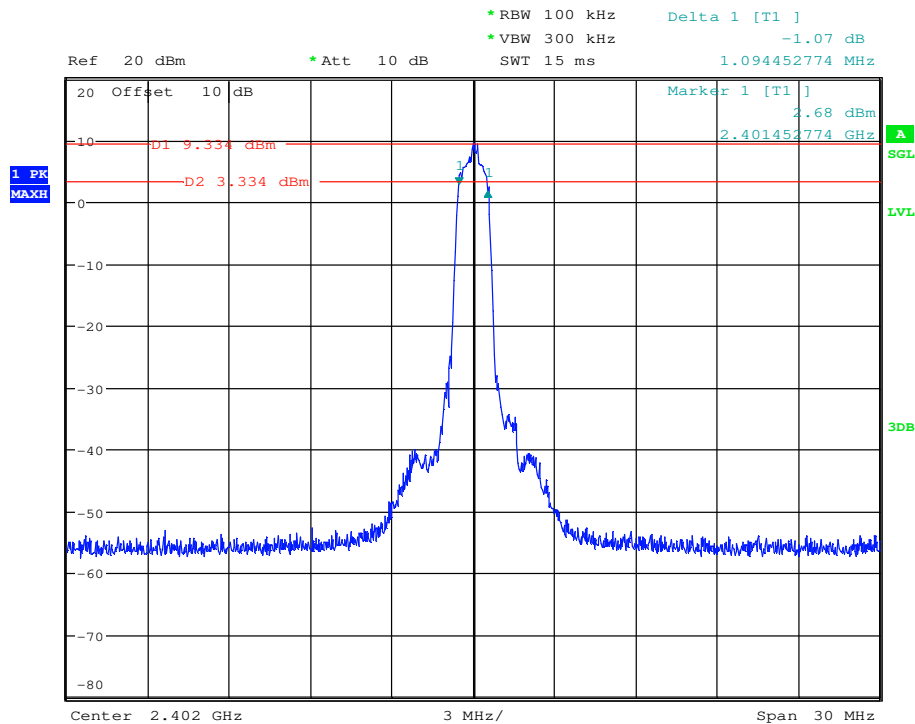
The following results were measured at the antenna port of the EUT. The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

EUT in Bluetooth classic mode

170279 6dB-BW BT DH5 BT1.wmf: 6-dB Bandwidth (operation mode 1):



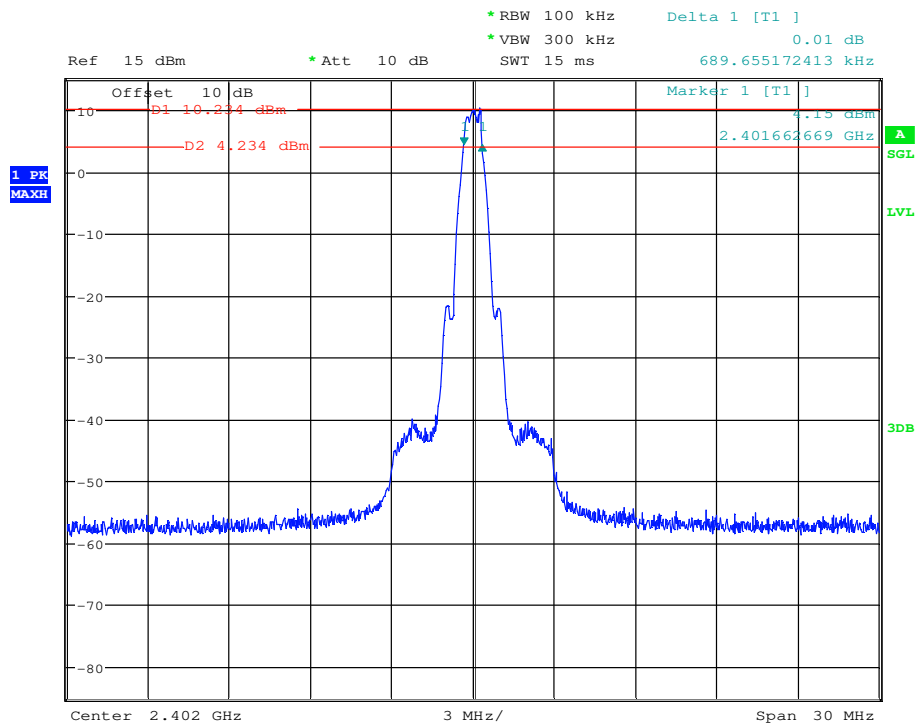
170297 6dB-BW BT 2DH5 BT1.wmf: 99% Bandwidth (operation mode 4):



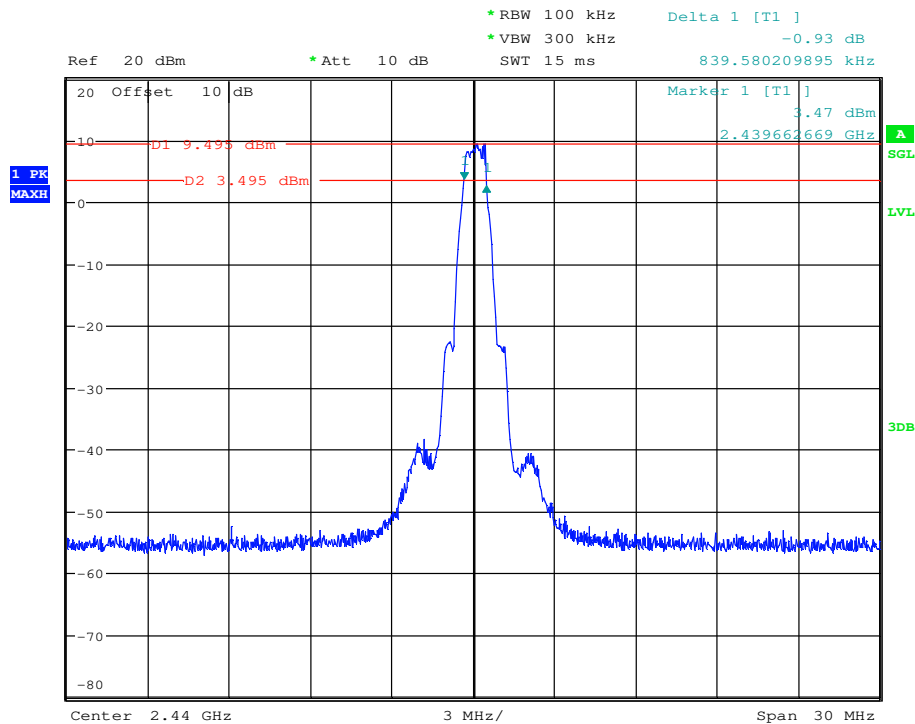
Operation Mode		Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	DH5	2402	0.5	0.510	0.836	Passed
2	DH5	2441	0.5	0.510	0.836	Passed
3	DH5	2480	0.5	0.510	0.836	Passed
4	2DH5	2402	0.5	1.109	1.176	Passed
5	2DH5	2441	0.5	1.094	1.176	Passed
6	2DH5	2480	0.5	1.094	1.176	Passed
7	3DH5	2402	0.5	1.079	1.176	Passed
8	3DH5	2441	0.5	1.079	1.176	Passed
9	3DH5	2480	0.5	1.079	1.176	Passed

EUT in Bluetooth Low Energy mode

170279 6dB-BW BTLE_BT1.wmf: 6-dB Bandwidth (operation mode 22):



170297 6dB-BW BTLE BTLE19.wmf: 99% Bandwidth (operation mode 23):



Operation Mode		Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
22	LE	2402	0.5	0.690	1.012	Passed
23	LE	2441	0.5	0.690	1.096	Passed
24	LE	2480	0.5	0.690	1.012	Passed

Test: Passed

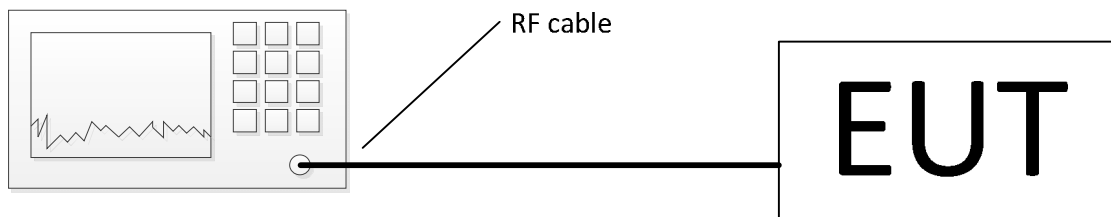
TEST EQUIPMENT USED FOR THE TEST:

30

5.4 Peak Power Spectral Density

5.4.1 Method of measurement

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The measurement procedure refers to part 11.10.2 of document [1].

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- Set the VBW $\geq 3 \times \text{RBW}$.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds limit, reduce RBW (not less than 3 kHz) and repeat.

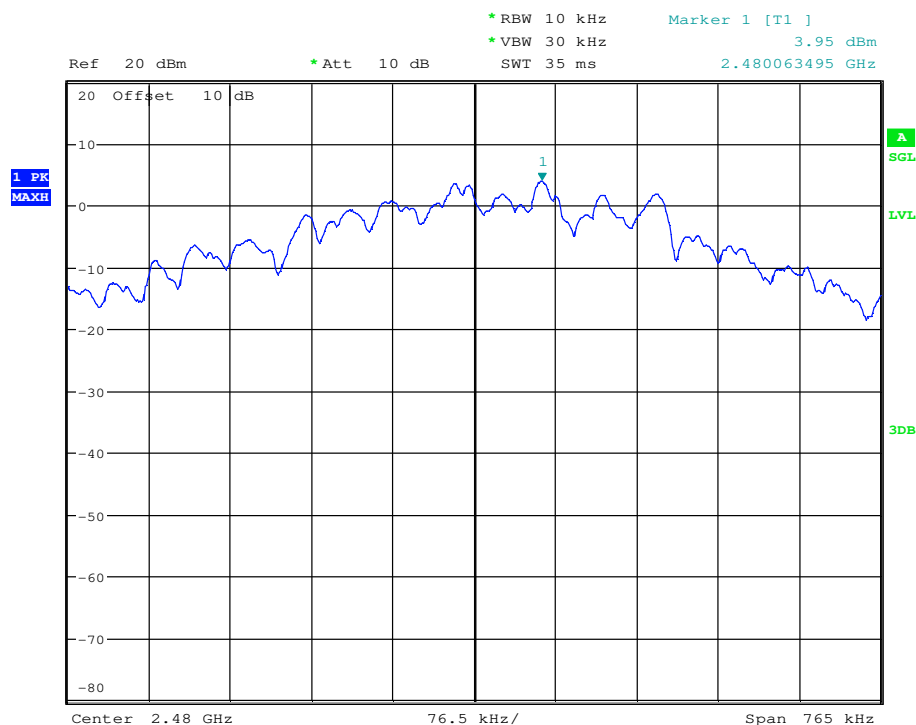
5.4.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %
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The following results were measured at the antenna port of the EUT. The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

EUT in Bluetooth classic mode

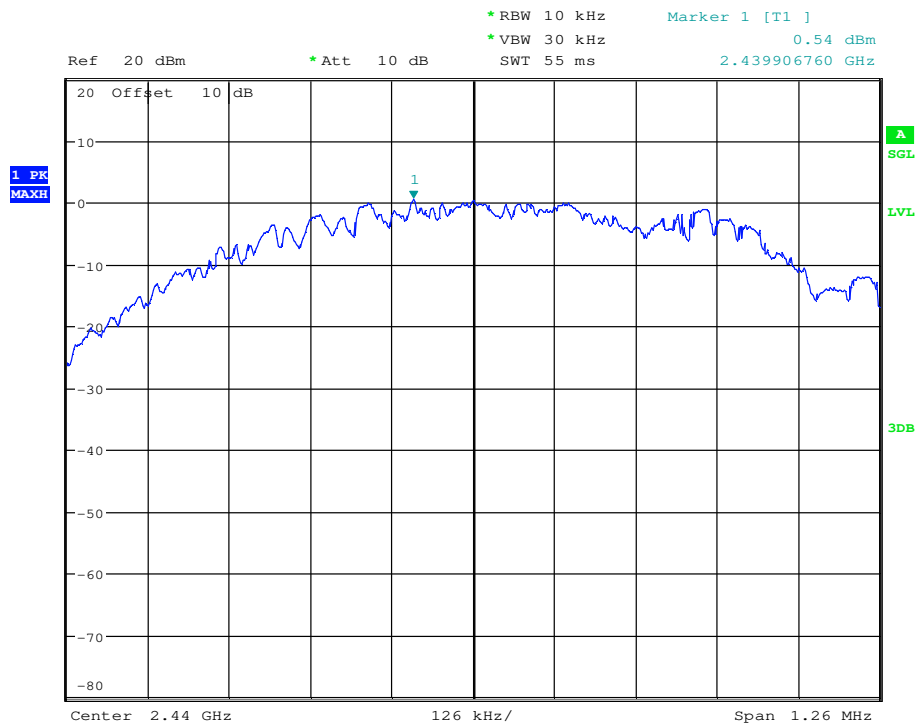
170297_MaxPeakPwr_BT_DH5_BT79.wmf: Power Spectral Density (operation mode 3):



Operation Mode	Peak Frequency [MHz]	Power Spectral Density Limit [dBm/3kHz]	Power Spectral Density Reading [dBm / 10 kHz]	Result
1 DH5	2402.063	8	3.8	Passed
2 DH5	2441.063	8	3.7	Passed
3 DH5	2480.063	8	4.0	Passed
4 2DH5	2401.992	8	2.8	Passed
5 2DH5	2440.993	8	2.8	Passed
6 2DH5	2479.993	8	3.0	Passed
7 3DH5	2401.995	8	3.0	Passed
8 3DH5	2440.995	8	3.0	Passed
9 3DH5	2479.995	8	3.3	Passed

EUT in Bluetooth Low Energy mode

170297_PwrSpecDens_BTLE_BTLE19.wmf: Power Spectral Density (operation mode 11):



Operation Mode	Peak Frequency [MHz]	Power Spectral Density Limit [dBm/3kHz]	Power Spectral Density Reading [dBm / 10 kHz]	Result
10 LE	2402.000	8	-0.2	Passed
11 LE	2439.907	8	0.5	Passed
12 LE	2480.000	8	-0.2	Passed

Test: Passed

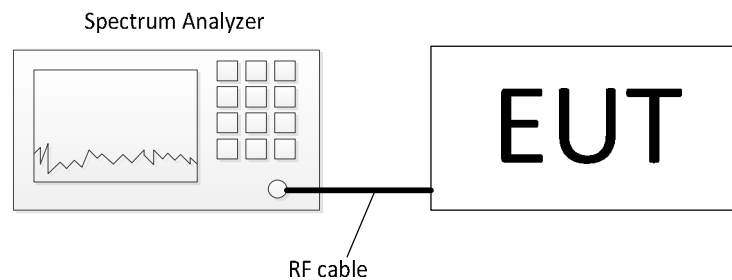
TEST EQUIPMENT USED FOR THE TEST:

30

5.5 Band-edge compliance

5.5.1 Method of measurement (band edges next to unrestricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyzer. The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

Measurement Procedure Reference – Reference Level:

- RBW = 100 kHz.
- VBW \geq 300 kHz.
- Set the span to \geq 1.5 times the DTS Bandwidth.
- Detector = Peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the the maximum PSD level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW \geq 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points \geq span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilise.
- Use the peak marker function to determine the maximum amplitude level.

The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20 dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

The measurements were performed at the lower end of the 2.4 GHz band.

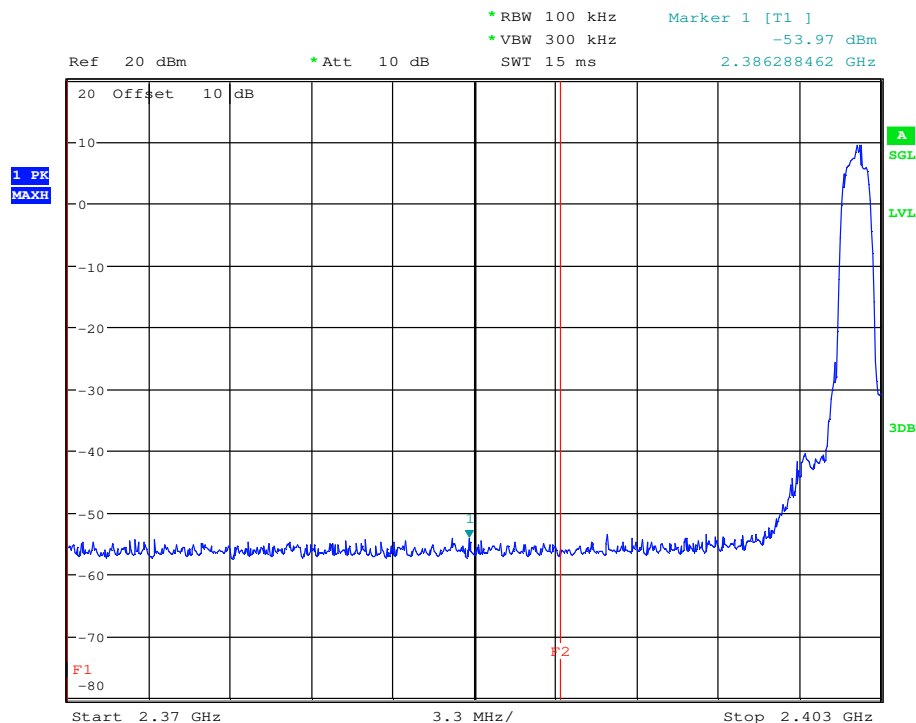
5.5.2 Test result (band edges next to unrestricted bands (conducted))

Ambient temperature	22 °C	Relative humidity	40 %
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The following results were measured at the antenna port of the EUT. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

EUT in Bluetooth classic mode

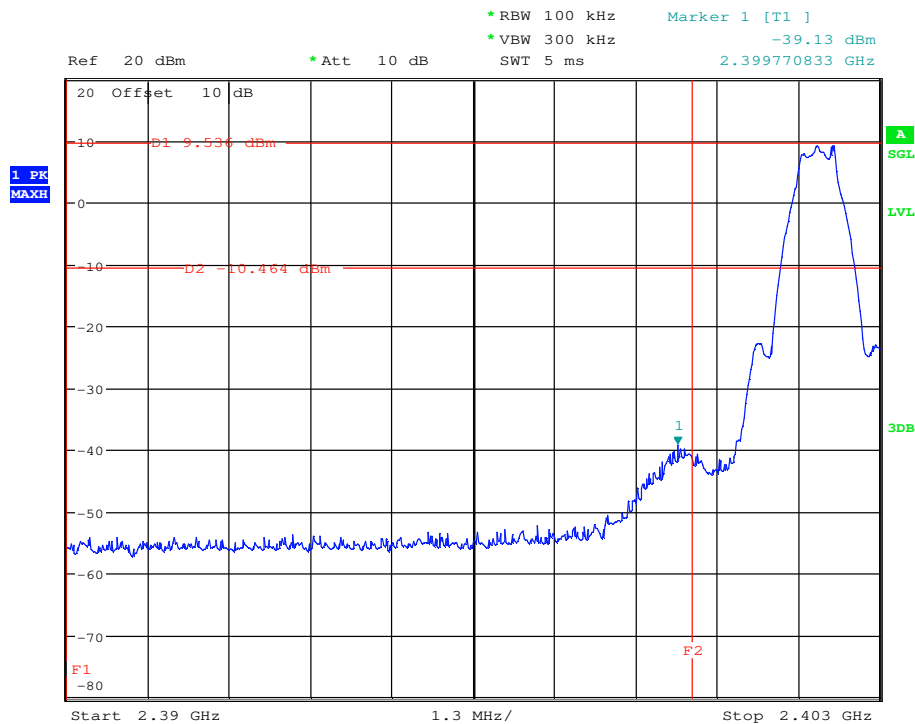
170297 BandEdgeRestr BT 3DH5 BT1.wmf: conducted band-edge compliance (operation mode 7):



Operation mode	Emission Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
1 DH5	2399.958	9.9	-10.1	-39.2	29.1	Passed
4 2DH5	2399.854	9.9	-10.1	-39.3	29.3	Passed
7 3DH5	2399.917	9.8	-10.2	-39.0	28.8	Passed

EUT in Bluetooth Low Energy mode

170297_BandEdgeUnrestr_BTLE_BT1.wmf: conducted band-edge compliance (operation mode 10):



Operation mode	Emission Frequency [MHz]	Reference Level [dBm]	Limit [dBm]	Emission Level [dBm]	Margin [dB]	Result
10 LE	2399.771	9.5	-10.5	-38.8	28.4	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

30

5.5.3 Method of measurement (band edges next to restricted bands (conducted))

The same test set-up as used for the final conducted emission measurement shall be used (refer also sub-clause 5.6.1 of this test report).

After trace stabilisation the marker shall be set on the signal peak. The frequency line shall be set on the edge of the assigned frequency band. Now set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. The level of the measured field strength shall be compared to the general limits specified in § 15.205.

The measurement was performed at the lower and the upper end of the 2.4 GHz band.

The calculation was performed with the following formula as described in chapter 11.12.2.2 e) in [1]:

$$E [\text{dB}\mu\text{V/m}] = EIRP [\text{dBm}] - 20\log(d) + 104.8 + G_{\text{Ant}} [\text{dBi}] + G_{\text{Array}} [\text{dB}] + Att_{\text{MeasCable}} [\text{dB}] + Att_{\text{RF-Switch}} [\text{dB}]$$

$E [\text{dB}\mu\text{V/m}]$ = Field Strength [$\text{dB}\mu\text{V/m}$]

$EIRP [\text{dBm}]$ = Reading [dBm]

d = measurement distance in m

$G_{\text{Ant}} [\text{dBi}]$ = Gain of the EUT antenna

$G_{\text{Array}} [\text{dB}]$ = Array Gain [in case of multiple transmitting antenna port]

$Att_{\text{MeasCable}} [\text{dB}]$ = Attenuation of the measurement cables

$Att_{\text{RF-Switch}} [\text{dB}]$ = Attenuation of the RF Switch

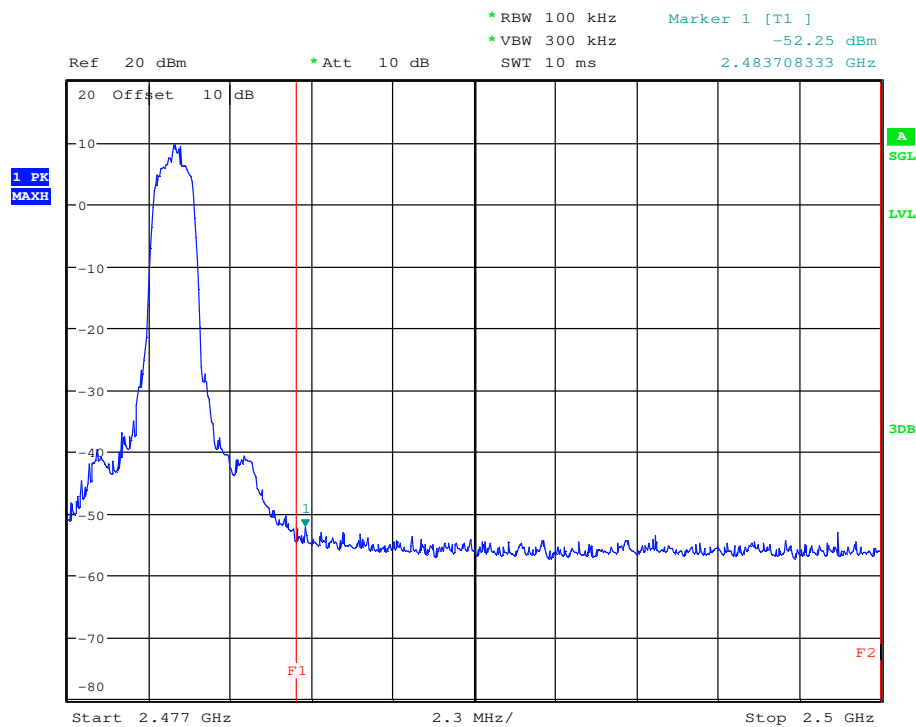
5.5.4 Test result (band edges next to restricted bands (conducted))

Ambient temperature	22 °C	Relative humidity	40 %
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The plots show an exemplary measurement result for the worst documented case. The other results are listed in the following tables.

EUT in Bluetooth classic mode

170297 BandEdgeRestr BT 2DH5 BT79.wmf: conducted band-edge compliance (operation mode 6):



Band Edge Compliance, DH5-mode, channel 0 (Operation mode 1)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
1	2376.189	52.8	74.0	21.2	-45.5	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
1	2378.339	40.0	54.0	14.0	-58.3	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Band Edge Compliance, DH5-mode, channel 78, (Operation mode 3)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
3	2483.510	65.2	74.0	8.8	-33.0	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
3	2483.510	44.7	54.0	9.3	-53.5	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Band Edge Compliance, 2DH5-mode, channel 0, (Operation mode 4)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
4	2376.607	53.1	74.0	20.9	-45.2	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
4	2379.672	39.9	54.0	14.1	-58.3	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

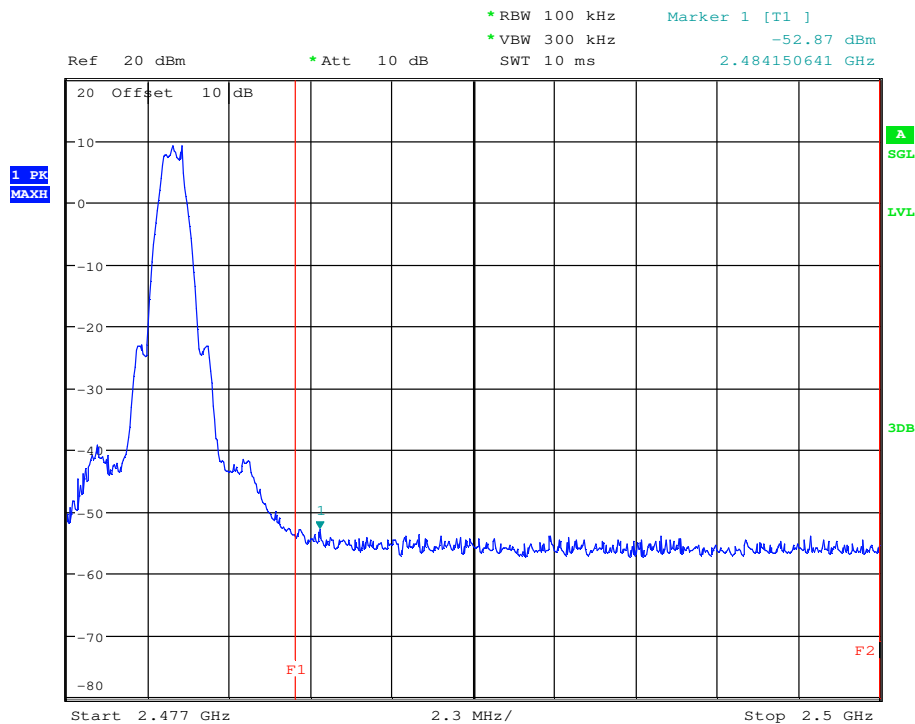
Band Edge Compliance, 2DH5-mode, channel 78, (Operation mode 6)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
6	2483.505	67.8	74.0	6.2	-30.4	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
6	2483.500	44.5	54.0	9.5	-53.8	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Band Edge Compliance, 3DH5-mode, channel 0, (Operation mode 7)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
7	2386.303	52.4	74.0	21.6	-45.9	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
7	2384.483	42.2	54.0	11.8	-56.0	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Band Edge Compliance, 3DH5-mode, channel 78, (Operation mode 9)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
9	2483.505	67.6	74.0	6.4	-30.6	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
9	2483.510	45.3	54.0	8.7	-53.0	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

EUT in Bluetooth Low Energy mode

170297_BandEdgeRestr_BTLE_BTLE39.wmf: conducted band-edge compliance (operation mode 12):



Band Edge Compliance, channel 0 (Operation mode 10)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
10	2389.611	52.5	74.0	21.5	-45.8	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
10	2389.556	42.8	54.0	11.2	-55.5	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Band Edge Compliance, channel 39 (Operation mode 12)							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
12	2483.516	65.9	74.0	8.1	-32.4	3.0	Passed
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
12	2483.501	45.0	54.0	9.0	-53.2	3.0	Passed
Measurement uncertainty				+0.66 dB / -0.72 dB			

Test: Passed

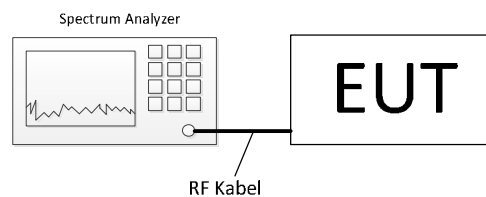
TEST EQUIPMENT USED FOR THE TEST:

30

5.6 Maximum unwanted emissions

5.6.1 Method of measurement (conducted emissions in the restricted bands)

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly mounted to a spectrum analyzer.



The measurement procedure refers to part 11.12.2.2 in document [1].

If emissions were detected during the preliminary measurements, they were measured using the following measurement procedures:

Procedure for average measurement: 11.12.2.5.2 – Trace averaging across ON and OFF times of the EUT transmissions followed by duty cycle correction:

If continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is constant (duty cycle variations are less than $\pm 2\%$), then the following procedure shall be used:

- The EUT shall be configured to operate at the maximum achievable duty cycle.
- Measure the duty cycle D of the transmitter output signal as described in 11.6 in [1].
- Set the RBW = 1 MHz (unless otherwise specified).
- Set the VBW $\geq 3 \times$ RBW.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to $\geq 2 \times$ (span/RBW).
- Averaging type = power
- Sweep time = auto
- Perform a trace average of at least 100 traces
- Correct the resulting measurement value by adding the duty cycle correction value if applicable.

Peak measurement procedure: 11.12.2.4 in [1]

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the RBW = specified in Table 1.
- Set the VBW $\geq 3 \times$ RBW.
- Set sweep time = auto.
- Detector = peak.
- Trace mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker function to determine the peak power over the emission bandwidth.

Table 1 RBW as a function of frequency

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

5.6.1.1 Limit calculations

The following general procedure is described in chapter 11.12.2.2 in [1].

- Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 11.12.2.3 through 11.12.2.5 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
- Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP (see 11.12.2.6 for guidance on determining the applicable antenna gain).
- Add the appropriate maximum ground reflection factor to the EIRP (6 dB for frequencies ≤ 30 MHz; 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and 0 dB for frequencies > 1000 MHz).
- For MIMO devices, measure the power of each chain and sum the EIRP of all chains in linear terms (i.e., watts and mW).
- Convert the resultant EIRP to an equivalent electric field strength using the following relationship:

$$E. = EIRP - 20\log(d) + 104.8 \quad (1)$$

where

E is the electric field strength in dB μ V/m

EIRP is the equivalent isotropically radiated power in dBm

d is the specified measurement distance in m

- Compare the resultant electric field strength level with the applicable regulatory limit.
- Perform the radiated spurious emission test.

Chapter 14 in [1] states, that for transmitters with multiple outputs in the same band, summing of emissions and accounting for array gain have to be considered.

For the case that both antenna ports transmit continuously, both results were summed as linear values as described in 14.3.2.2 in document [1].

To account for directional gain which might occur in case of N transmit antennas in the test mode spatial multiplexing, which is the mode the EUT uses, the directional has to be calculated as:

$$10\log \left[\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{Ant}} g_{j,k} \right\}^2 / N_{Ant} \right]$$

Whereby

N_{SS} is the number of independent spatial streams of data.

N_{Ant} is the total number of antennas

$g_{j,k}$ is $10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not

G_k is the gain in dBi of the kth antenna

Since the EUT has only 1 antenna, no array gain is applicable here.

5.6.2 Method of measurement (conducted emissions in the unrestricted bands)

In any 100 kHz outside the authorized frequency band, the power shall be attenuated by 20 dB, compared to the highest in band power in any 100 kHz. This shall be demonstrated by using the peak power procedure. The reference level shall be measured using the procedure described in 5.6.2.1 and the emission level according to procedure 5.6.2.2. The procedures are based on chapter 11.11.2 and 11.11.3 in [1].

For the operation modes in which both antenna ports transmit simultaneously, the level of the both ports were summed in linear value for each frequency step. The applicable plots show the result of that sum.

5.6.2.1 Reference level measurement

- a) Set instrument center frequency to DTS channel center frequency.
- b) Set the span to ≥ 1.5 times the DTS bandwidth.
- c) Set the RBW = 100 kHz.
- d) Set the VBW $\geq 3 \times$ RBW.
- e) Detector = peak.
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum PSD level.

5.6.2.2 Emission level measurement

- a) Set the center frequency and span to encompass frequency range to be measured.
- b) Set the RBW = 100 kHz.
- c) Set the VBW $\geq 3 \times$ RBW.
- d) Detector = peak.
- e) Ensure that the number of measurement points $\geq \text{span}/\text{RBW}$
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum amplitude level.

5.6.3 Test results (conducted emissions)

5.6.3.1 Emissions below 1 GHz

No significant emissions were found below 1 GHz, therefore no plots and result tables for this frequency range are submitted below.

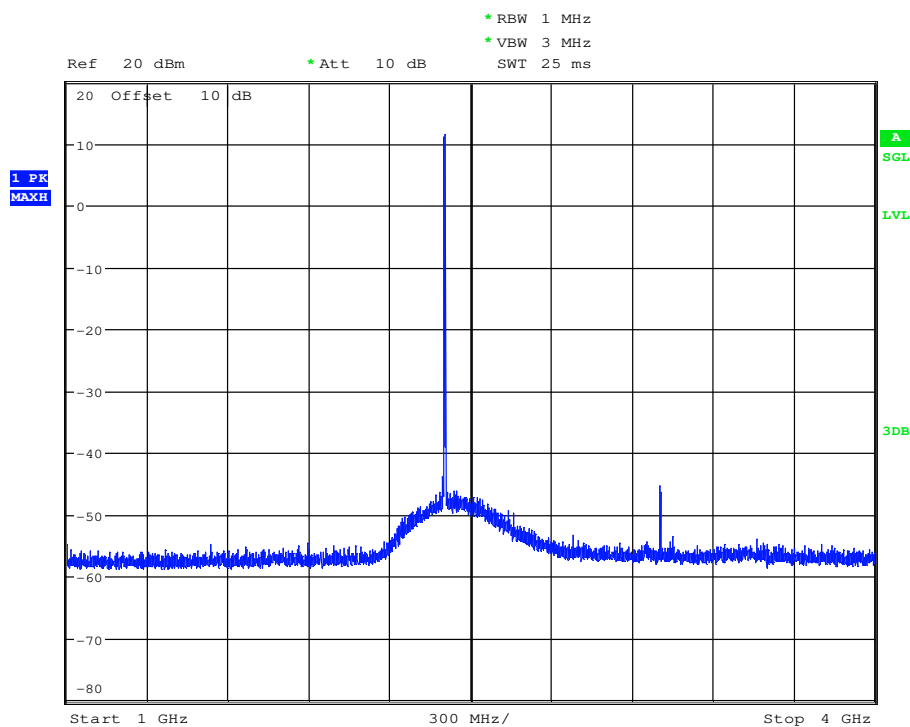
5.6.3.2 Emissions above 1 GHz

Ambient temperature	22 °C	Relative humidity	59 %
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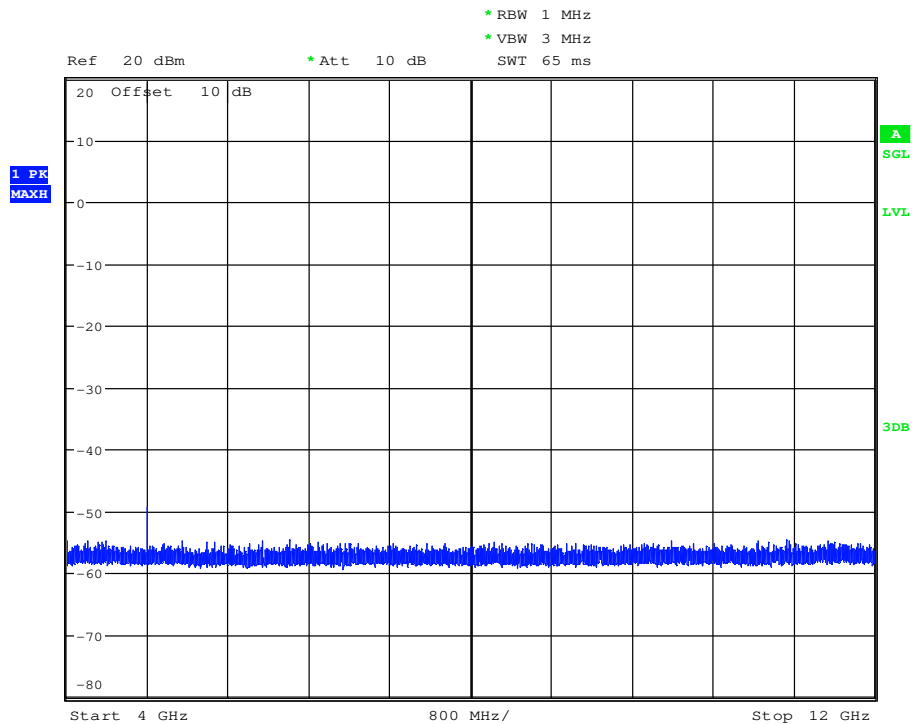
The following results were measured at antenna port of the EUT. Only the plots for the worst case emissions are submitted below.

EUT in Bluetooth classic mode

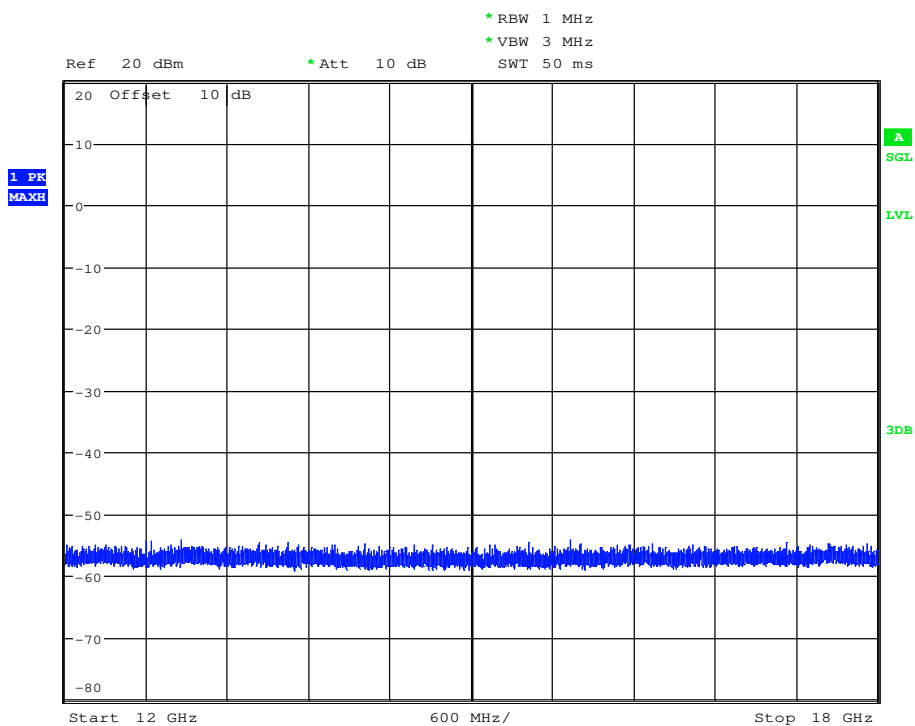
170297_SpurEmiss1-4G_BT_2DH5_BT1.wmf: conducted spurious emissions (operation mode 4):



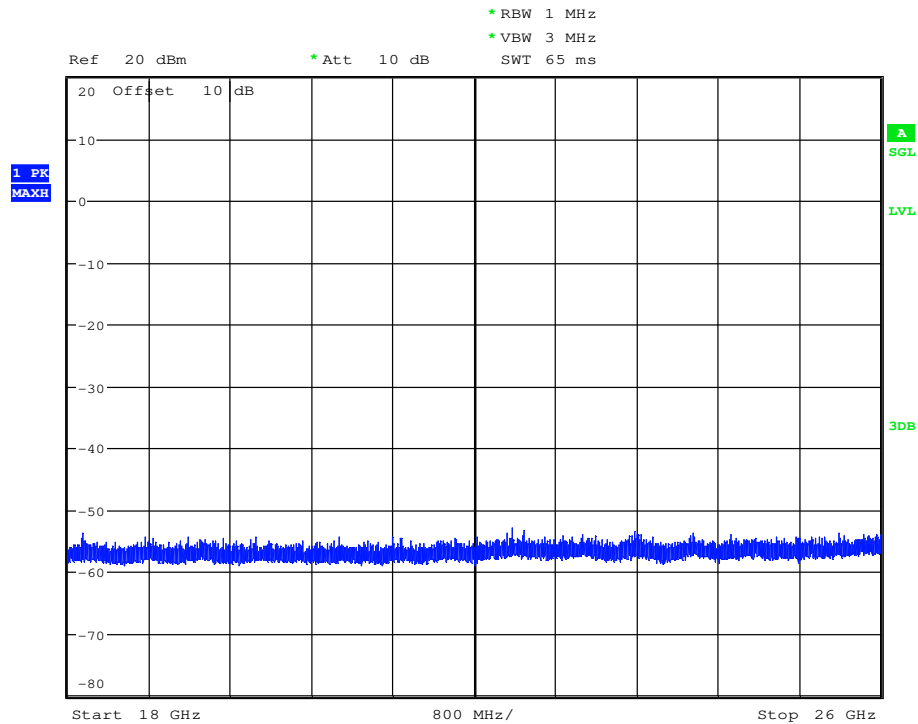
170297_SpurEmiss4-12G_BT_DH5_BT1.wmf: conducted spurious emissions (operation mode 1):



170297_SpurEmiss12-18G_BT_DH5_BT1.wmf: conducted spurious emissions (operation mode 1):



170297_SpurEmiss18-26G_BT_DH5_BT1.wmf: conducted spurious emissions (operation mode 1):



Spurious Emissions, DH5-mode, channel 0, (Operation mode 1)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
1	4804.000	50.4	74.0	23.6	-47.9	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
1	4804.060	43.4	54.0	10.6	-54.9	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
1	2402.160	9.8	-	-	-		
1	3202.680	-45.5	-10.2	35.3	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, DH5-mode, channel 39, (Operation mode 2)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
2	4882.180	49.9	74.0	24.1	-48.3	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
2	4881.940	42.4	54.0	11.6	-55.8	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
2	2441.180	9.4	-	-	-		
2	3254.670	-46.5	-10.6	35.9	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, DH5-mode, channel 78, (Operation mode 3)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
3	4960.300	49.5	74.0	24.5	-48.8	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
3	4959.910	41.7	54.0	12.3	-56.5	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
3	2480.020	10.0	-	-	-		
3	3306.660	-47.0	-10.0	37.1	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, 2DH5-mode, channel 0, (Operation mode 4)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
4	4803.460	51.0	74.0	23.0	-47.3	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
4	4804.090	42.7	54.0	11.3	-55.6	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
4	2401.970	8.5	-	-	-		
4	3202.680	-46.0	-11.5	34.5	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, 2DH5-mode, channel 39, (Operation mode 5)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
5	4882.140	50.7	74.0	23.3	-47.6	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
5	4882.080	42.1	54.0	11.9	-56.2	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
5	2441.030	9.5	-	-	-		
5	3254.670	-46.4	-10.5	36.0	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, 2DH5-mode, channel 78, (Operation mode 6)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
6	4960.450	50.0	74.0	24.0	-48.3	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
6	4960.090	41.0	54.0	13.0	-57.2	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
6	2480.180	9.4	-	-	-		
6	3306.680	-46.4	-10.6	35.8	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

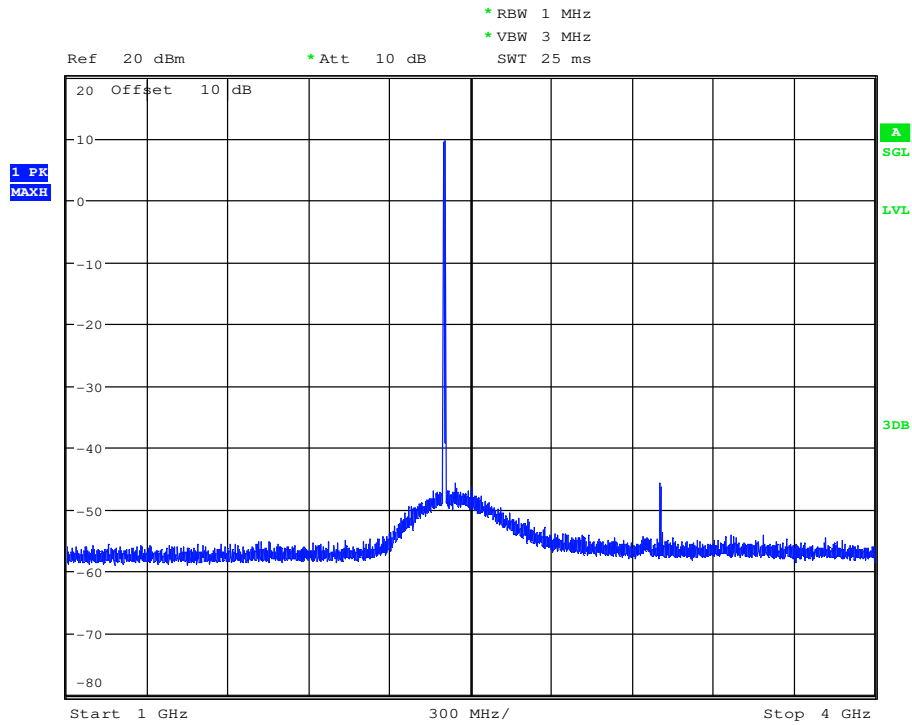
Spurious Emissions, 3DH5-mode, channel 0, (Operation mode 7)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
7	4804.000	51.1	74.0	22.9	-47.1	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
7	4804.000	42.9	54.0	11.1	-55.4	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
7	2402.030	9.6	-	-	-		
7	3202.680	-46.1	-10.4	35.7	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, 3DH5-mode, channel 39, (Operation mode 8)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
8	4882.120	50.8	74.0	23.2	-47.4	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
8	4882.000	42.4	54.0	11.6	-55.8	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
8	2441.030	9.6	-	-	-		
8	3254.670	-46.5	-10.4	36.1	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

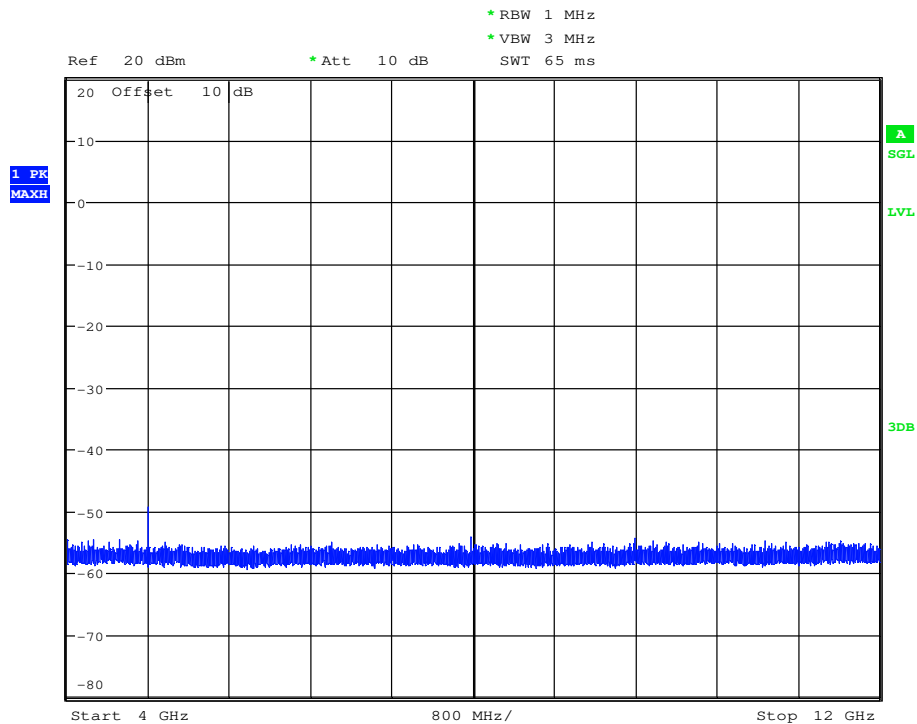
Spurious Emissions, 3DH5-mode, channel 78, (Operation mode 9)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
9	4959.730	50.2	74.0	23.8	-48.1	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
9	4959.850	41.0	54.0	13.0	-57.3	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
9	2480.030	9.4	-	-	-		
9	3306.700	-46.7	-10.6	36.2	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

EUT in Bluetooth Low Energy mode

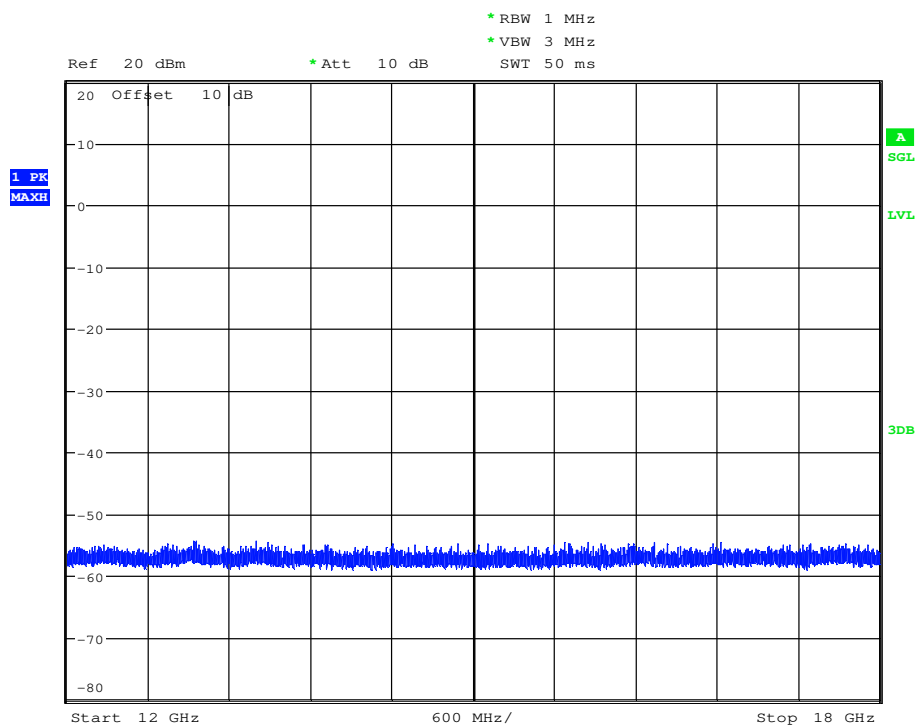
170297 SpurEmiss1-4G BTLE BT1.wmf: conducted spurious emissions (operation mode 10):



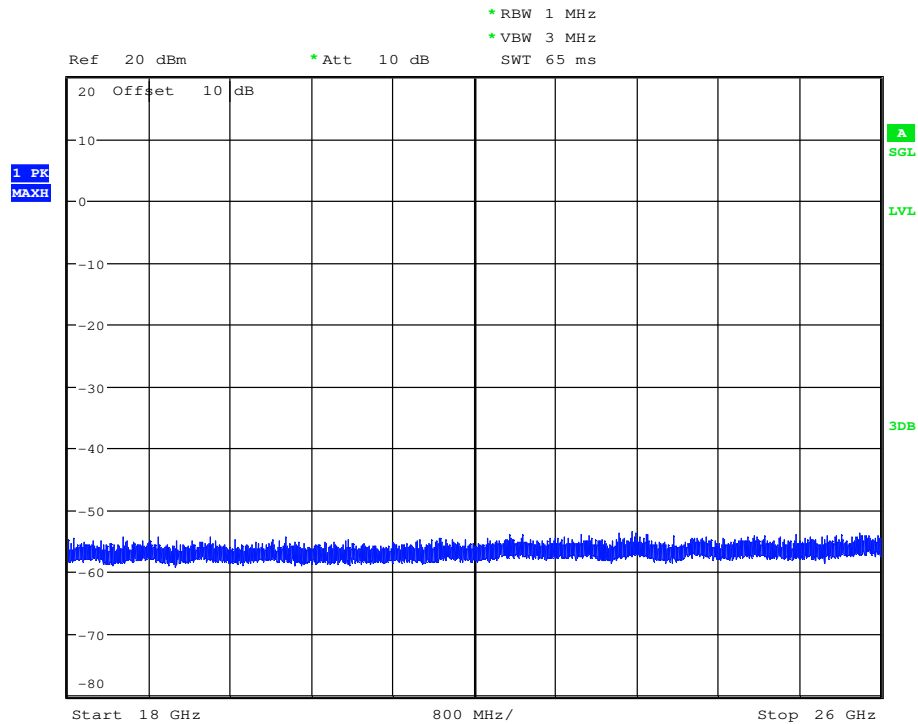
170297 SpurEmiss4-12G BTLE BT1.wmf: conducted spurious emissions (operation mode 10):



170297 SpurEmiss12-18G BTLE BT1.wmf: conducted spurious emissions (operation mode 10):



170297_SpurEmiss18-26G_BTLE_BT1.wmf: conducted spurious emissions (operation mode 10):



Spurious Emissions, channel 0, (Operation mode 10)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
10	4804.510	50.4	74.0	23.6	-47.9	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
10	4803.910	44.1	54.0	9.9	-54.2	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
10	2402.030	9.5	-	-	-		
10	3202.680	-46.1	-10.5	35.6	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, channel 19, (Operation mode 11)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
11	4880.300	50.2	74.0	23.8	-48.0	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
11	4880.030	43.2	54.0	10.8	-55.0	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
11	2440.360	9.7	-	-	-		
11	3253.350	-46.4	-10.3	36.1	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Spurious Emissions, channel 39, (Operation mode 12)							
Peak Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Peak Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
12	4959.520	49.1	74.0	24.9	-49.1	3.0	Passed
Average Emission – Restricted Band							
Operation Mode	Frequency [MHz]	Field Strength [dBuV/m]	Average Limit [dBuV/m]	Margin [dB]	Reading [dBm]	Antenna Gain + Array Gain [dBi]	Result
12	4959.790	41.7	54.0	12.3	-56.5	3.0	Passed
Emissions in the non-restricted Bands							
Operation Mode	Frequency [MHz]	Reading [dBm]	Limit [dBm]	Margin [dB]	Result		
12	2480.240	9.4	-	-	-		
12	3306.680	-46.9	-10.6	36.3	Passed		
Measurement uncertainty				+0.66 dB / -0.72 dB			

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

30

5.6.4 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into five stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out on an open area test site with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 1 GHz to 25 / 40 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 25 / 40 GHz.

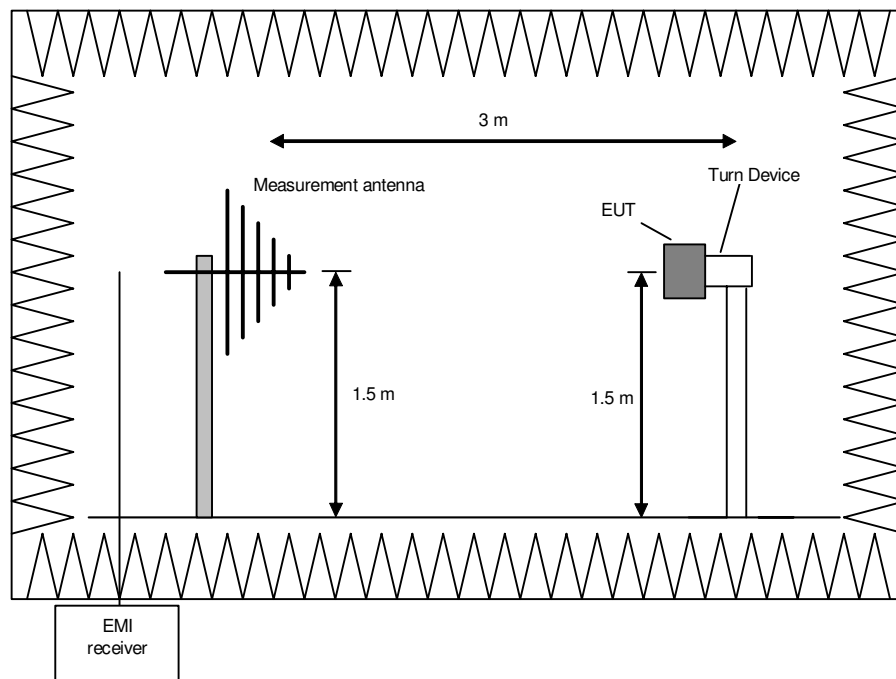
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top devices will set up on a non-conducting turn device on the height of 1.5m. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Pre-scans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.

The following procedure will be used:

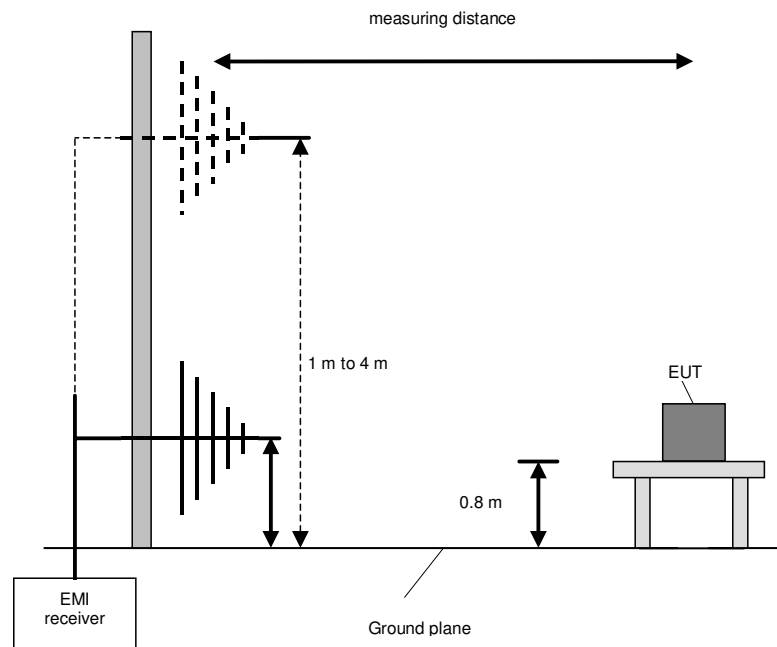
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0°.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
7. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0° to 360°, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 40 GHz)

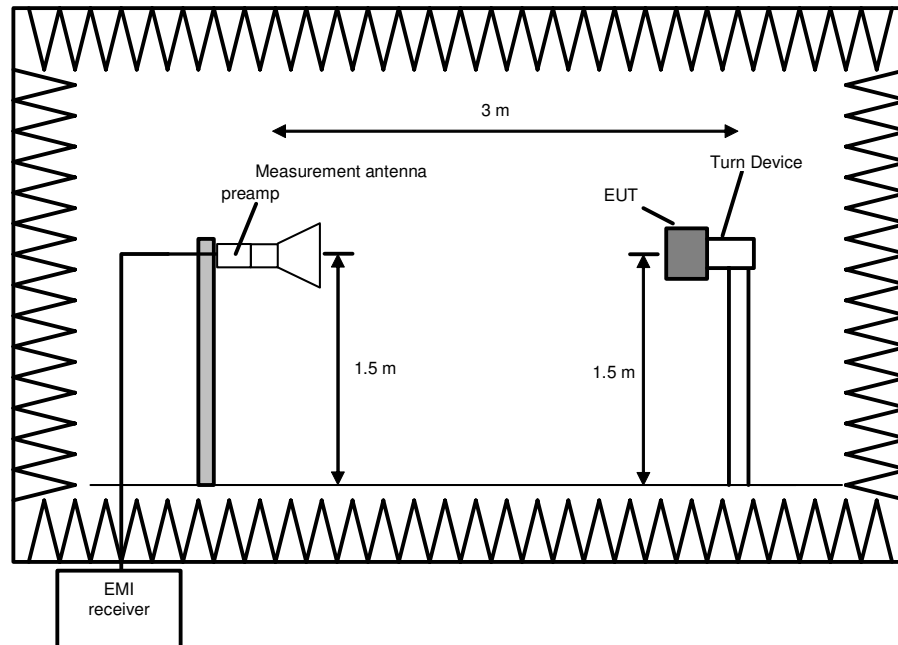
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyzer set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarization of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30° steps according 6.6.5.4 in [1].

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	100 kHz
4 GHz to 12 GHz	100 kHz
12 GHz to 18 GHz	100 kHz
18 GHz to 25 / 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz



Procedure preliminary measurement:

Pre-scans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

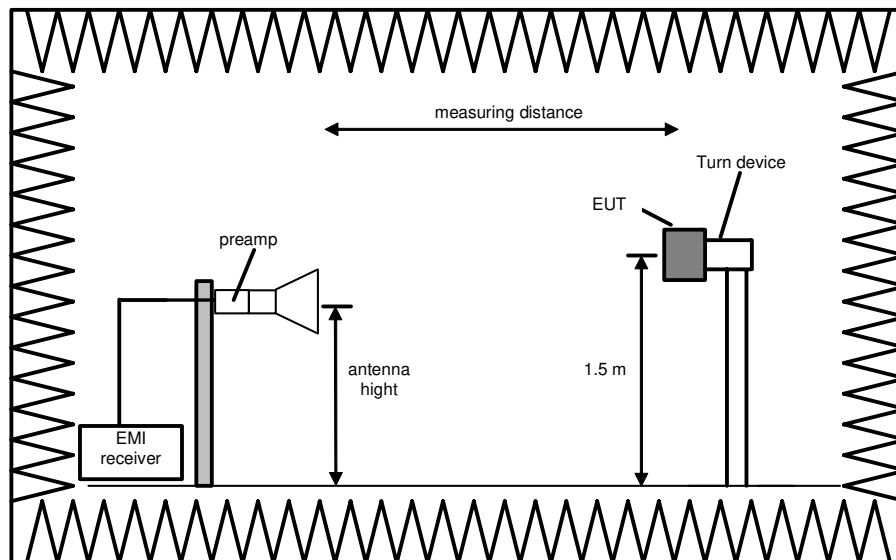
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarization, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Final measurement (1 GHz to 25 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 25 / 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 GHz.

The following procedure will be used:

- 1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna polarization to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyzer to EMI mode with peak and average detector activated.
- 4) Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
- 5) Note the highest displayed peak and average values
- 6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.6.5 Test results (radiated emissions)

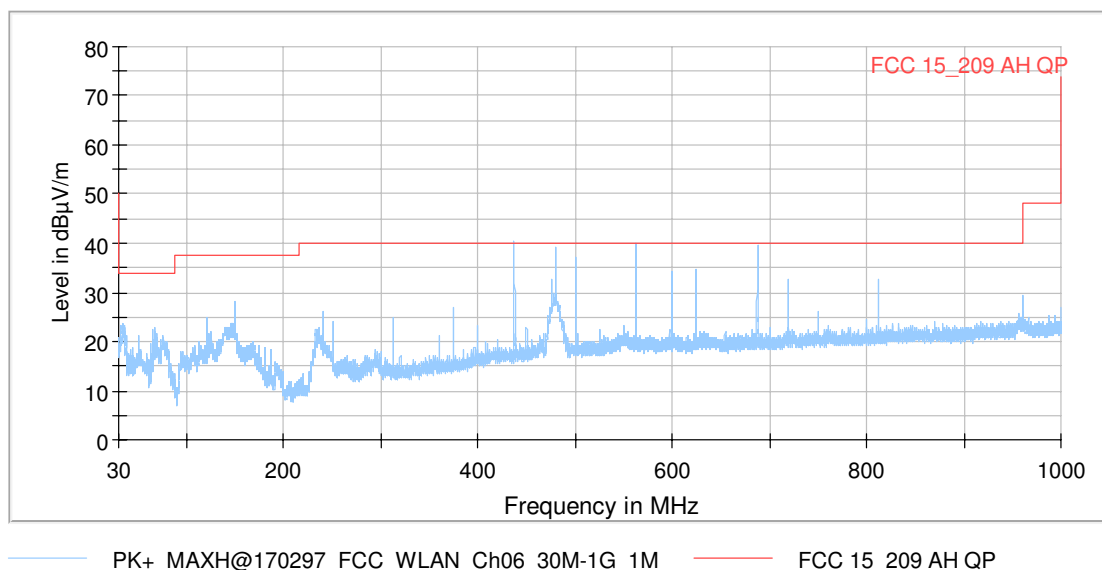
5.6.5.1 Preliminary radiated emission measurement

Ambient temperature	21 °C	Relative humidity	55 %
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Position of EUT:	The EUT was set-up on a non-conducting table of a height of 0.8 m or an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.
Cable guide:	For detail information of test set-up and the cable guide refer to the pictures in Test setup Photo annex.
Test record:	All results are shown in the following.
Supply voltage:	During all measurements the host of the EUT was powered with 5 V DC via an USB cable.
Remark:	<p>Document [1] states in 11.12.2.1, that in case of conducted measurements, additional radiated cabinet emission measurements must be performed. The measurements were performed at the worst case modulations for each frequency range.</p> <p>For all radiated measurements the sample with integral antenna (NINA-W102) was used.</p> <p>Since the lowest internal clock frequency is 40 MHz, the radiated emissions were tested starting at 30 MHz.</p> <p>The Emissions below 1 GHz were equal for all antenna ports, transmit frequencies, modulation schemes and data rates. Therefore only the results of an exemplary test case are submitted below.</p>

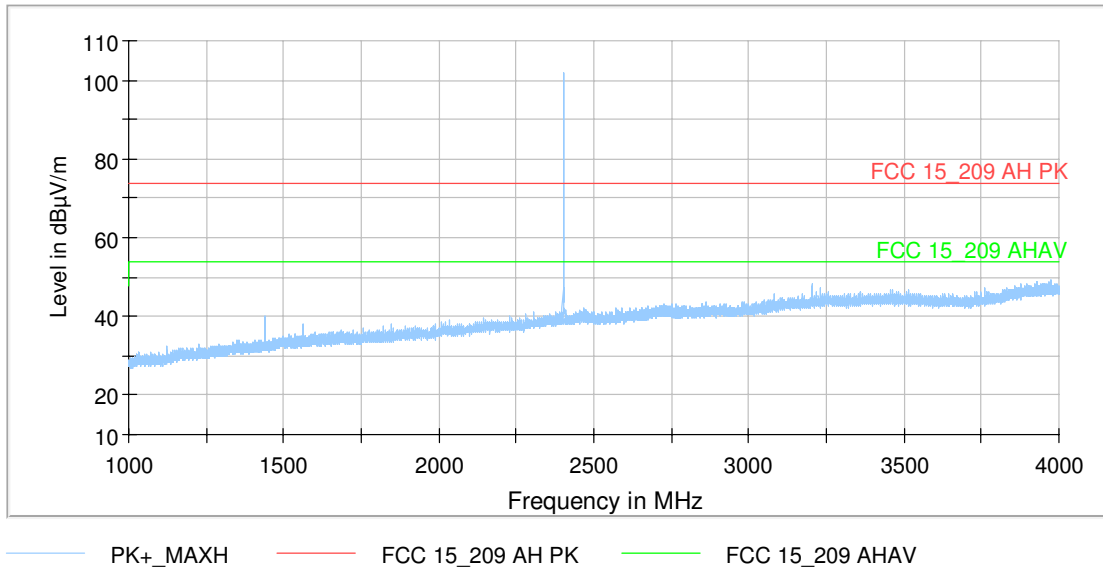
All modes (Bluetooth Classic, Bluetooth Low Energy)

All modes.Rtf: Spurious emissions from 30 MHz to 1 GHz (all operation modes):

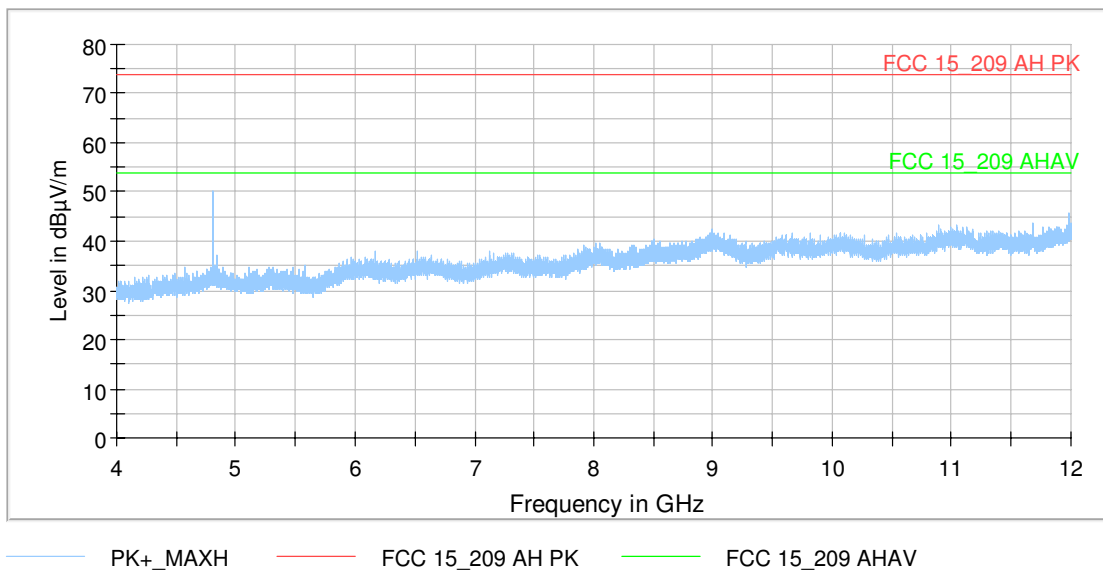


EUT in Bluetooth classic mode

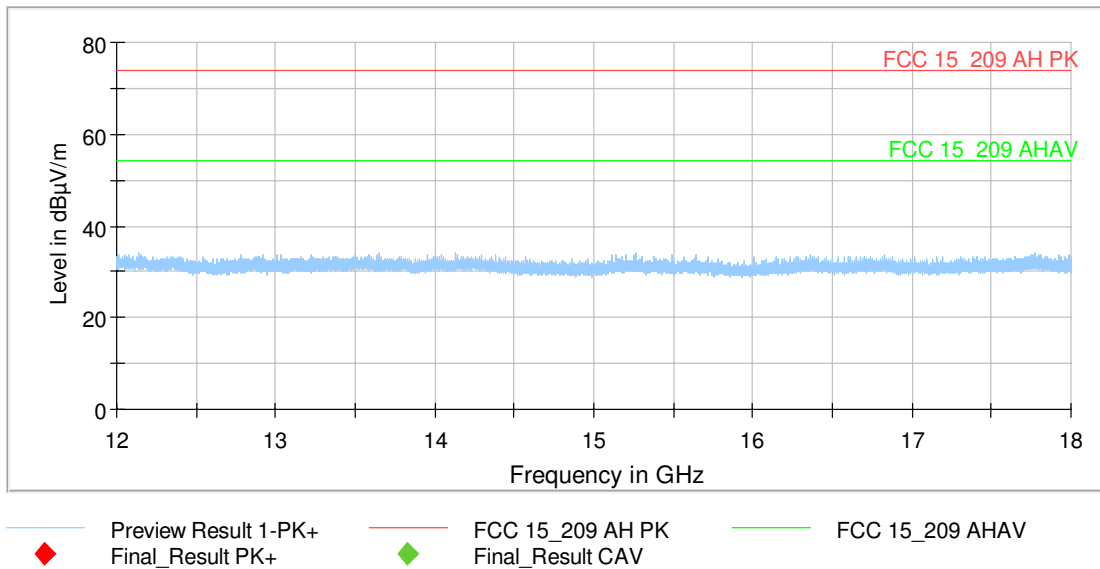
170297 FCC BT-DH5_Ch0 1-4G Pwr6.Rtf: Spurious emissions from 1 GHz to 4 GHz
(operation mode 1, DH5-mode):



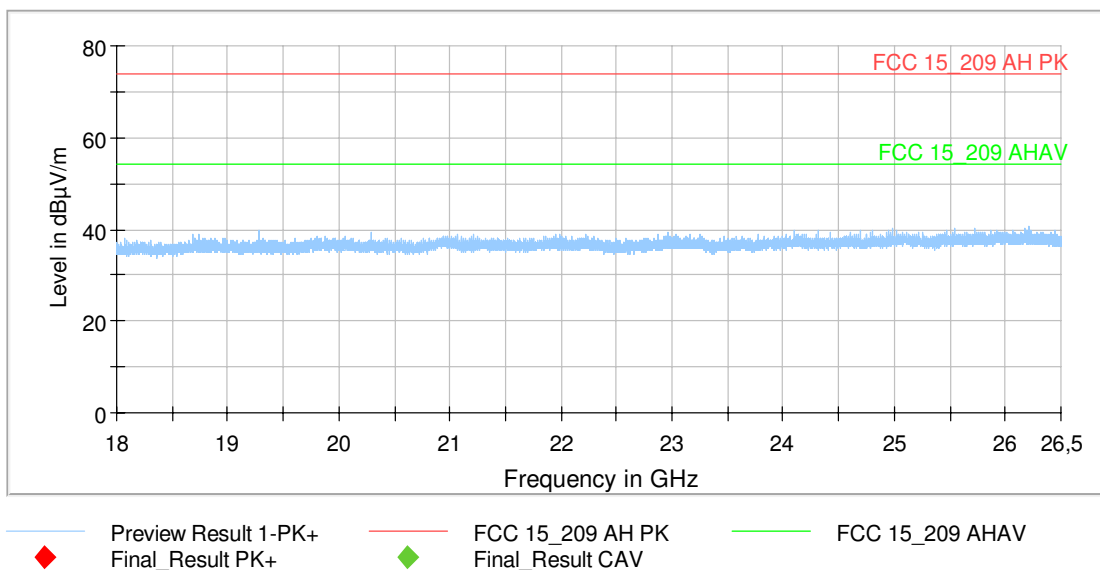
170297 FCC BT-DH5_Ch0 4-12G Pwr6.Rtf: Spurious emissions from 4 GHz to 12 GHz
(operation mode 1, DH5-mode):



170297 FCC BT Ch00 12-18G.Rtf: Spurious emissions from 12 to 18 GHz (operation mode 1, DH5-mode):

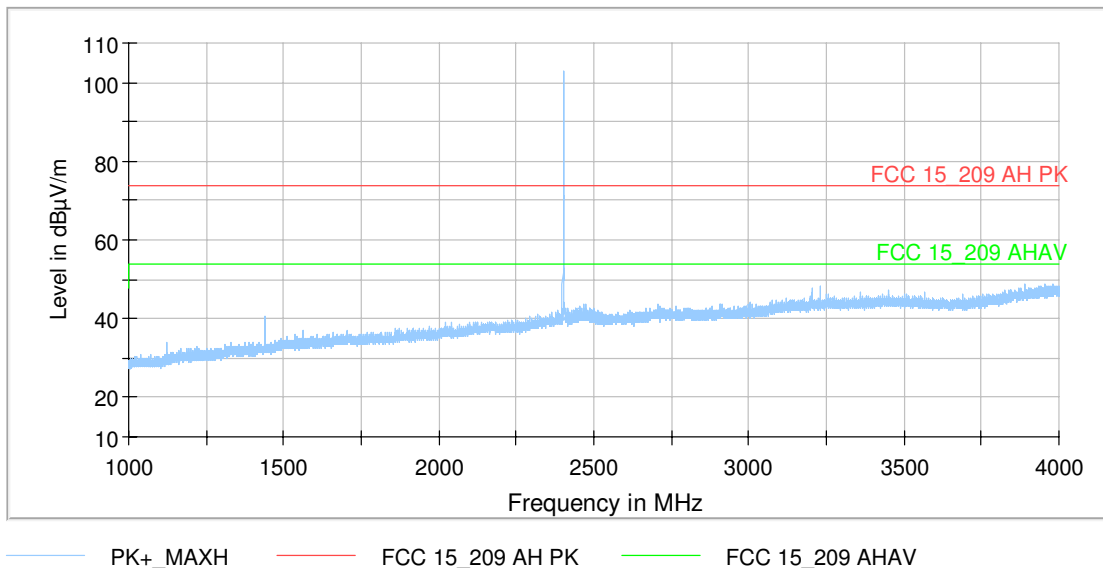


170297 FCC BT Ch00 18-26.5G.Rtf: Spurious emissions from 18 – 25 GHz (operation mode 1, DH5-mode)::

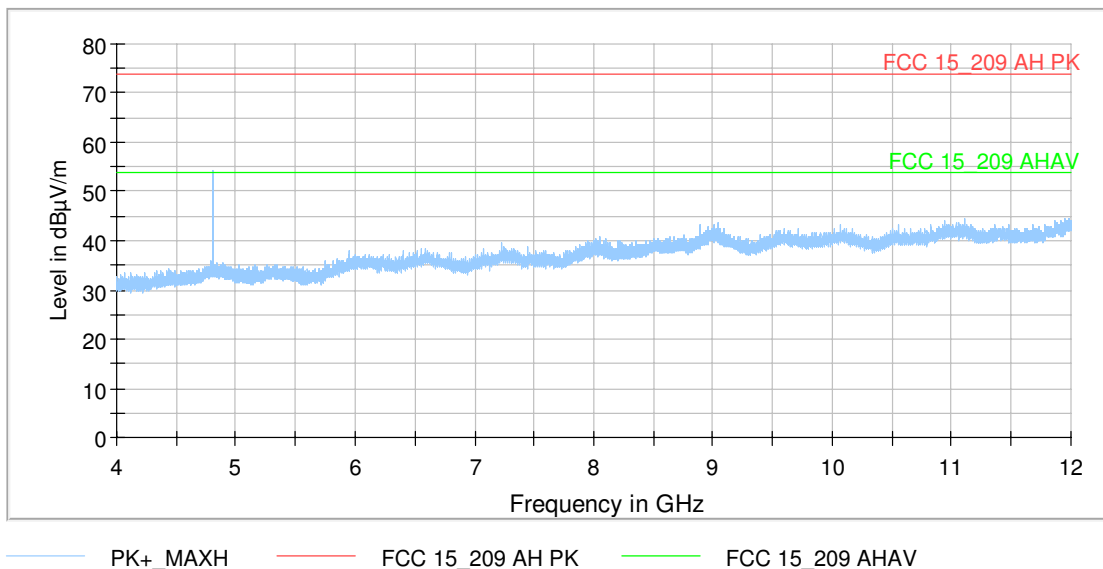


EUT in Bluetooth Low Energy mode

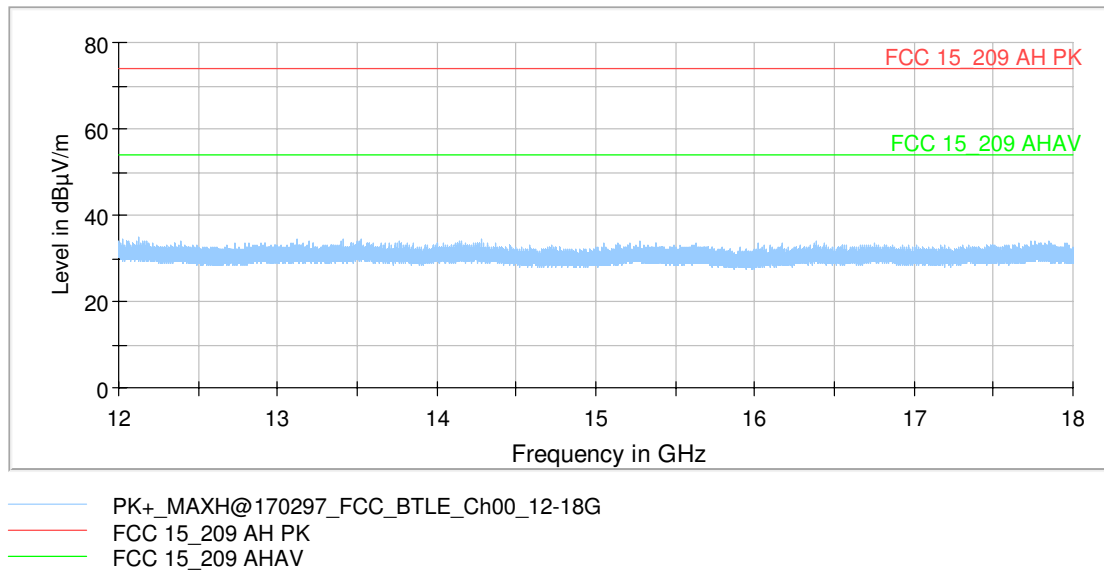
170297 FCC BTLE Ch00 1-4G Pwr9.Rtf: Spurious emissions from 1 GHz to 4 GHz (operation mode 10):



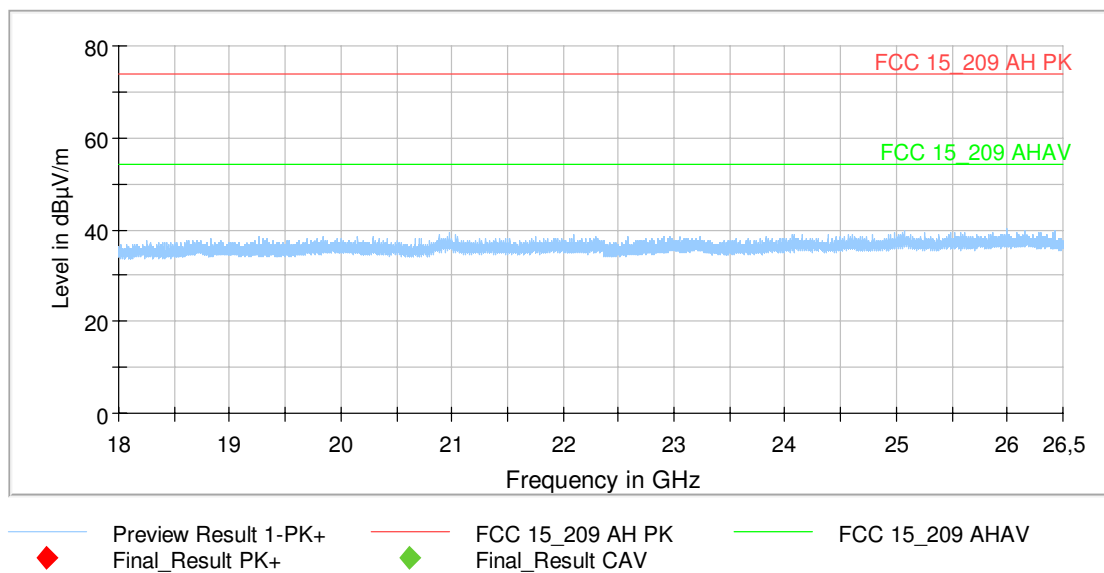
170297 FCC BTLE Ch00 4-12G Pwr9.Rtf: Spurious emissions from 4 GHz to 12 GHz (operation mode 10):



170297 FCC BTLE Ch00 12-18G.Rtf: Spurious emissions from 12 to 18 GHz (operation mode 10):



170297 FCC BTLE Ch00 18-26.5G.Rtf: Spurious emissions from 18 – 25 GHz (operation mode 10):



TEST EQUIPMENT USED FOR THE TEST:

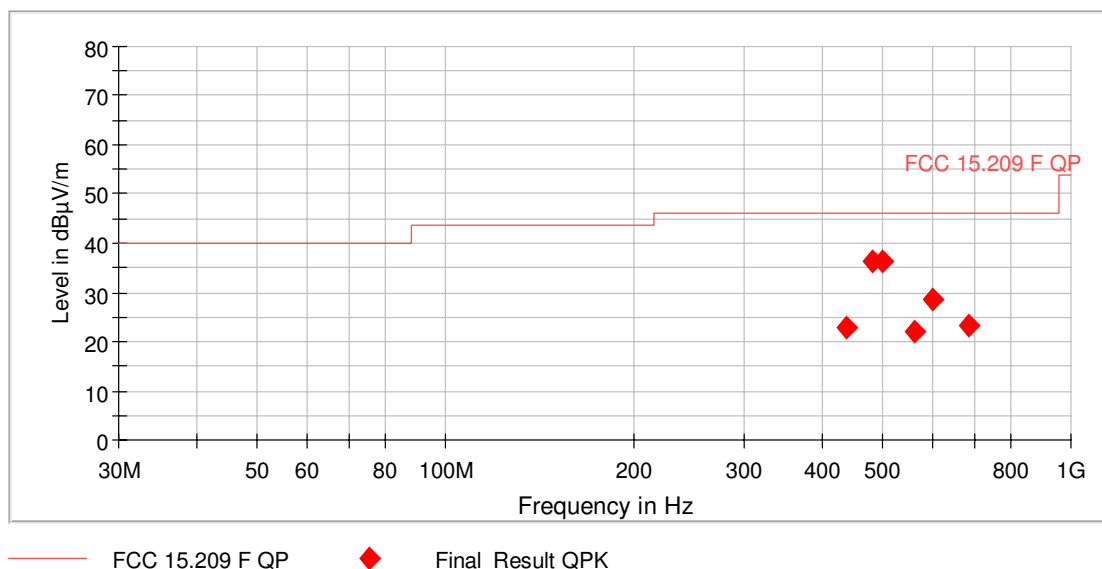
7 - 29, 31 – 42, 44 – 51, 72

5.6.5.2 Final radiated emission measurement (9 kHz to 1 GHz)

Ambient temperature	22 °C	Relative humidity	55 %
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- Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m or an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.
- Cable guide: For detail information of test set-up and the cable guide refer to the pictures in test setup photos.
- Test record: All results are shown in the following.
- Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.
- Resolution bandwidth: For all measurements a resolution bandwidth of 100 kHz was used.
- Additional information: Since the lowest internal clock frequency is 40 MHz, the radiated emissions were tested starting at 30 MHz.
- The correction factor is calculated as Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB]
- The result Peak/Average is the result of Reading [dBμV/m] – Correction factor [dB]

170297 Nina BT DH5 ch39 30M-1G FF.rtf: Spurious emissions from 30 MHz to 1 GHz (all operation modes)



Final_Result

Frequency [MHz]	QuasiPeak [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Meas. Time [ms]	Bandwidth [kHz]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
437.448500	22.72	46.00	23.28	1000.0	120.000	232.0	H	290.0	25.3
479.983000	36.47	46.00	9.53	1000.0	120.000	175.0	H	58.0	26.2
499.965000	36.51	46.00	9.49	1000.0	120.000	184.0	H	55.0	26.4
562.481500	21.93	46.00	24.07	1000.0	120.000	357.0	V	357.0	27.9
600.020500	28.62	46.00	17.38	1000.0	120.000	103.0	V	262.0	28.0
687.466000	23.28	46.00	22.72	1000.0	120.000	120.0	H	61.0	28.3
Measurement uncertainty					+2.2 dB / -3.6 dB				

5.6.5.3 Final radiated emission measurement (1 GHz to 25 GHz)

Ambient temperature	22 °C	Relative humidity	55 %
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Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via an USB cable.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits.

EUT in Bluetooth classic mode

Since the DH5 mode was found to be the worst case mode during the conducted measurements, only these tests were performed as radiated measurements.

Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

Frequency (MHz)	MaxPeak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1437.460000	---	40.35	54	13.65	H	49.0	120.0	28.1	Passed
1437.460000	43.68	---	74	30.32	H	49.0	120.0	28.1	Passed
1562.440000	---	31.49	54	22.51	H	0.0	90.0	29.3	Passed
1562.440000	39.74	---	74	34.26	H	0.0	90.0	29.3	Passed
2401.960000	---	100.25	-	-	V	152.0	90.0	34.0	Fund.
2401.960000	103.45	---	-	-	V	152.0	90.0	34.0	Fund.
3202.660000	---	53.50	54	0.50	V	20.0	29.0	37.1	Passed
3202.660000	63.03	---	74	10.97	V	20.0	29.0	37.1	Passed
3205.240000	---	38.89	54	15.11	H	318.0	150.0	37.1	Passed
3205.240000	51.66	---	74	22.34	H	318.0	150.0	37.1	Passed
4803.850000	---	50.10	54	3.90	V	293.0	150.0	-0.9	Passed
4803.850000	55.79	---	74	18.21	V	293.0	150.0	-0.9	Passed
4804.050000	---	49.61	54	4.39	V	310.0	150.0	-0.9	Passed
4804.050000	54.89	---	74	19.11	V	310.0	150.0	-0.9	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the middle of the assigned frequency band (operation mode 2)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1437.460000	---	39.88	54	14.12	H	36.0	120.0	28.1	Passed
1437.460000	43.47	---	74	30.53	H	36.0	120.0	28.1	Passed
1562.440000	---	34.91	54	19.09	H	357.0	120.0	29.3	Passed
1562.440000	41.88	---	74	32.12	H	357.0	120.0	29.3	Passed
2400.040000	---	44.95	54	9.05	H	167.0	90.0	34.0	Passed
2400.040000	48.65	---	74	25.35	H	167.0	90.0	34.0	Passed
2440.900000	---	98.70	-	-	H	175.0	0.0	34.2	Fund.
2440.900000	102.13	---	-	-	H	175.0	0.0	34.2	Fund.
2441.020000	---	100.02	-	-	H	181.0	150.0	34.2	Fund.
2441.020000	103.22	---	-	-	H	181.0	150.0	34.2	Fund.
3229.360000	---	53.33	54	0.67	V	295.0	29.0	37.1	Passed
3229.360000	63.78	---	74	10.22	V	295.0	29.0	37.1	Passed
3254.680000	---	44.43	54	9.57	V	350.0	90.0	37.6	Passed
3254.680000	52.66	---	74	21.34	V	350.0	90.0	37.6	Passed
4881.750000	---	47.90	54	6.10	V	295.0	150.0	-0.9	Passed
4881.750000	54.56	---	74	19.44	V	295.0	150.0	-0.9	Passed
4881.950000	---	46.89	54	7.11	V	223.0	150.0	-0.9	Passed
4881.950000	52.63	---	74	21.37	V	223.0	150.0	-0.9	Passed
4882.050000	---	49.01	54	4.99	V	301.0	150.0	-0.9	Passed
4882.050000	54.40	---	74	19.60	V	301.0	150.0	-0.9	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the upper end of the assigned frequency band (operation mode 3)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1437.460000	---	39.85	54	14.16	H	49.0	90.0	28.1	Passed
1437.460000	42.78	---	74	31.22	H	49.0	90.0	28.1	Passed
2400.040000	---	44.90	54	9.10	H	179.0	90.0	34.0	Passed
2400.040000	49.13	---	74	24.87	H	179.0	90.0	34.0	Passed
2479.960000	---	98.78	-	-	H	183.0	150.0	34.1	Fund.
2479.960000	102.12	---	-	-	H	183.0	150.0	34.1	Fund.
2480.020000	---	98.82	-	-	H	183.0	150.0	34.1	Fund.
2480.020000	102.20	---	-	-	H	183.0	150.0	34.1	Fund.
3229.360000	---	53.40	54	0.60	V	215.0	29.0	37.1	Passed
3229.360000	63.39	---	74	10.61	V	215.0	29.0	37.1	Passed
3306.640000	---	46.27	54	7.73	H	350.0	0.0	37.3	Passed
3306.640000	52.88	---	74	21.12	H	350.0	0.0	37.3	Passed
4959.650000	---	39.70	54	14.30	V	303.0	29.0	-0.9	Passed
4959.650000	48.36	---	74	25.64	V	303.0	29.0	-0.9	Passed
4960.000000	---	39.23	54	14.77	V	241.0	29.0	-0.9	Passed
4960.000000	46.55	---	74	27.45	V	241.0	29.0	-0.9	Passed
4960.250000	---	41.36	54	12.64	V	292.0	150.0	-0.9	Passed
4960.250000	48.85	---	74	25.15	V	292.0	150.0	-0.9	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

EUT in Bluetooth Low Energy mode

Transmitter operates at the lower end of the assigned frequency band (operation mode 10)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1124.920000	---	26.73	54	27.27	V	61.0	90.0	25.7	Passed
1124.920000	36.62	---	74	37.38	V	61.0	90.0	25.7	Passed
1437.460000	---	37.94	54	16.06	H	32.0	0.0	28.1	Passed
1437.460000	42.03	---	74	31.97	H	32.0	0.0	28.1	Passed
2401.840000	---	103.15	-	-	H	178.0	0.0	34.0	Fund.
2401.840000	105.32	---	-	-	H	178.0	0.0	34.0	Fund.
2402.020000	---	103.65	-	-	H	182.0	0.0	34.0	Fund.
2402.020000	105.38	---	-	-	H	182.0	0.0	34.0	Fund.
3202.660000	---	52.77	54	1.23	H	199.0	120.0	37.1	Passed
3202.660000	63.27	---	74	10.73	H	199.0	120.0	37.1	Passed
3205.240000	---	38.46	54	15.54	H	302.0	120.0	37.1	Passed
3205.240000	50.47	---	74	23.53	H	302.0	120.0	37.1	Passed
3229.360000	---	38.45	54	15.55	H	294.0	150.0	37.1	Passed
3229.360000	50.39	---	74	23.61	H	294.0	150.0	37.1	Passed
4803.500000	---	48.32	54	5.68	V	230.0	120.0	-1.0	Passed
4803.500000	55.92	---	74	18.08	V	230.0	120.0	-1.0	Passed
4804.100000	---	52.94	54	1.06	V	289.0	150.0	-0.9	Passed
4804.100000	57.95	---	74	16.05	V	289.0	150.0	-0.9	Passed
4804.450000	---	49.66	54	4.34	V	317.0	150.0	-0.9	Passed
4804.450000	56.53	---	74	17.47	V	317.0	150.0	-0.9	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the middle of the assigned frequency band (operation mode 11)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1437.460000	---	35.40	54	18.60	V	53.0	90.0	28.1	Passed
1437.460000	41.50	---	74	32.50	V	53.0	90.0	28.1	Passed
1687.420000	---	38.66	54	15.34	V	350.0	60.0	30.2	Passed
1687.420000	44.84	---	74	29.16	V	350.0	60.0	30.2	Passed
2439.940000	---	105.80	-	-	H	179.0	150.0	34.2	Fund.
2439.940000	107.40	---	-	-	H	179.0	150.0	34.2	Fund.
3282.640000	---	38.73	54	15.27	H	1.0	150.0	37.3	Passed
3282.640000	52.46	---	74	21.54	H	1.0	150.0	37.3	Passed
4879.450000	---	51.57	54	2.43	V	288.0	150.0	-0.8	Passed
4879.450000	59.01	---	74	14.99	V	288.0	150.0	-0.8	Passed
4879.950000	---	52.36	54	1.64	V	303.0	60.0	-0.8	Passed
4879.950000	57.31	---	74	16.69	V	303.0	60.0	-0.8	Passed
4880.450000	---	52.81	54	1.19	V	303.0	150.0	-0.8	Passed
4880.450000	59.52	---	74	14.48	V	303.0	150.0	-0.8	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the upper end of the assigned frequency band (operation mode 12)

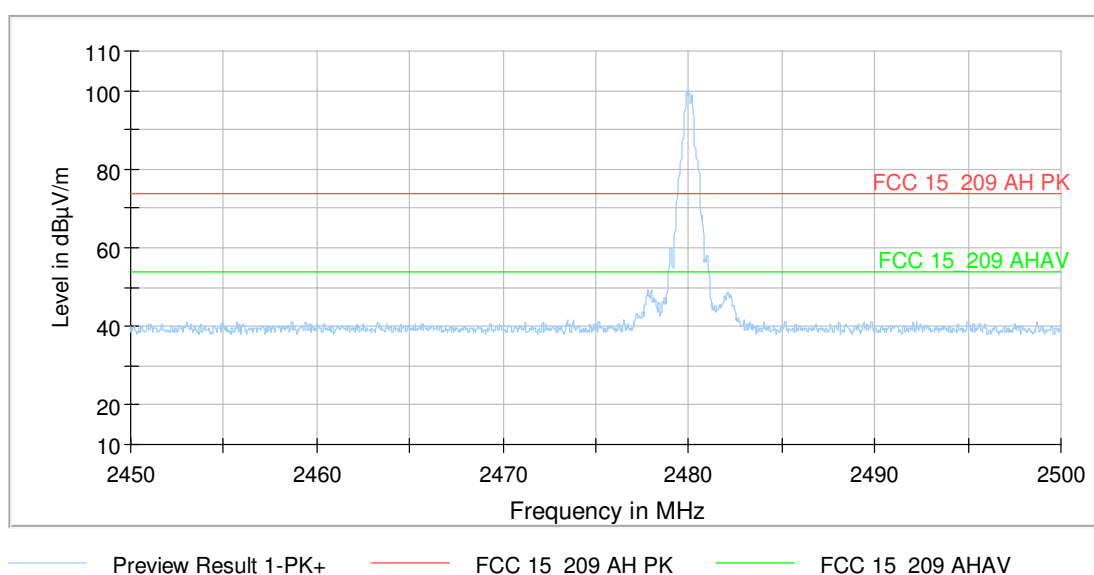
Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
1437.460000	41.19	---	74	32.81	V	305.0	60.0	28.1	Passed
1437.460000	---	36.26	54	17.74	V	305.0	60.0	28.1	Passed
1687.420000	46.97	---	74	27.03	V	355.0	0.0	30.2	Passed
1687.420000	---	41.10	54	12.90	V	355.0	0.0	30.2	Passed
1893.820000	39.85	---	74	34.15	H	180.0	90.0	31.1	Passed
1893.820000	---	29.39	54	24.61	H	180.0	90.0	31.1	Passed
2479.720000	108.03	---	-	-	H	177.0	150.0	34.1	Fund.
2479.720000	---	105.11	-	-	H	177.0	150.0	34.1	Fund.
2480.080000	107.57	---	-	-	V	180.0	90.0	34.1	Fund.
2480.080000	---	106.06	-	-	V	180.0	90.0	34.1	Fund.
3282.700000	51.72	---	74	22.28	V	50.0	0.0	37.3	Passed
3282.700000	---	38.85	54	15.15	V	50.0	0.0	37.3	Passed
3306.640000	---	49.24	54	4.76	H	347.0	0.0	37.3	Passed
3306.640000	54.17	---	74	19.83	H	347.0	0.0	37.3	Passed
4959.500000	---	49.15	54	4.85	V	306.0	150.0	-0.9	Passed
4959.500000	56.18	---	74	17.82	V	306.0	150.0	-0.9	Passed
4959.950000	---	51.97	54	2.03	V	301.0	150.0	-0.9	Passed
4959.950000	56.80	---	74	17.20	V	301.0	150.0	-0.9	Passed
4960.450000	---	48.86	54	5.14	V	78.0	0.0	-0.9	Passed
4960.450000	55.52	---	74	18.48	V	78.0	0.0	-0.9	Passed
+Measurement uncertainty			+2.2 dB / -3.6 dB						

5.6.5.4 Band-edge-compliance (radiated)

Only the plot of the worst case emission is submitted below

EUT in Bluetooth classic mode

170297_FCC_BT-DH5_Ch78_UpBE_Pwr6.rtf: Spurious emissions (operation mode 3):



Transmitter operates at the lower end of the assigned frequency band (operation mode 1)

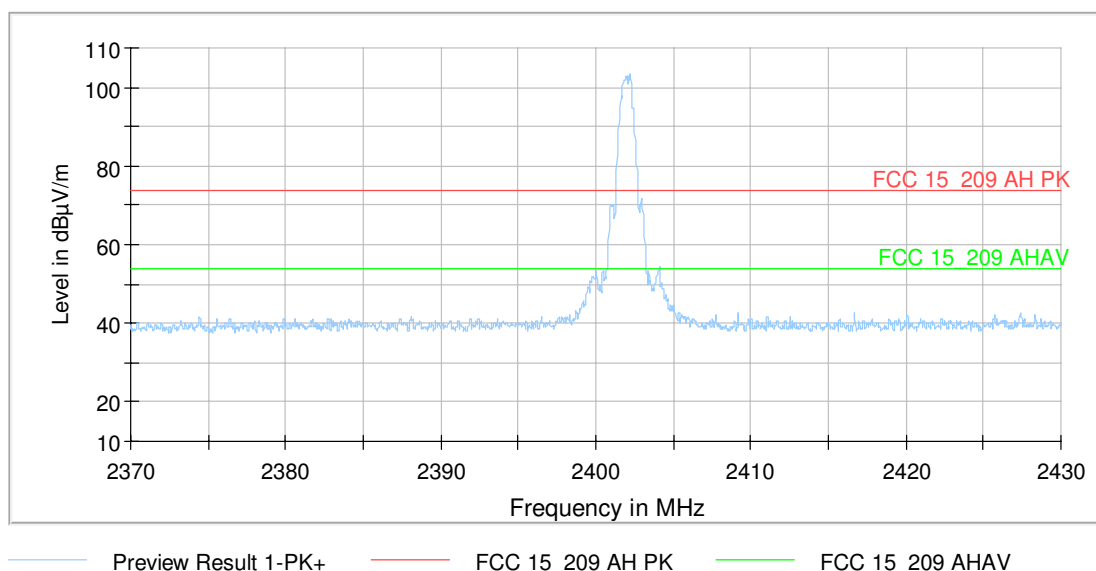
Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
2379.990000	---	33.38	54	20.62	V	357.0	0.0	33.9	Passed
2379.990000	42.89	---	74	31.11	V	357.0	0.0	33.9	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the upper end of the assigned frequency band (operation mode 3)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
2484.050000	---	34.94	54	19.06	H	47.0	120.0	34.1	Passed
2484.050000	45.52	---	74	28.48	H	47.0	120.0	34.1	Passed
2485.175000	---	34.26	54	19.74	H	138.0	90.0	34.1	Passed
2485.175000	45.00	---	74	29.00	H	138.0	90.0	34.1	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

EUT in Bluetooth Low Energy mode

170297_FCC_BTLE_Ch00_LowBE_Pwr9.rtf: Spurious emissions (operation mode 10):



Transmitter operates at the lower end of the assigned frequency band (operation mode 10)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
2374.440000	---	37.27	54	16.73	V	178.0	60.0	33.9	Passed
2374.440000	49.24	---	74	24.76	V	178.0	60.0	33.9	Passed
2388.120000	---	38.68	54	15.32	H	206.0	150.0	34.0	Passed
2388.120000	50.36	---	74	23.64	H	206.0	150.0	34.0	Passed
Measurement uncertainty			+2.2 dB / -3.6 dB						

Transmitter operates at the upper end of the assigned frequency band (operation mode 12)

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)	Result
No emission found in the frequency range									
Measurement uncertainty			+2.2 dB / -3.6 dB						

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7 - 29, 31 - 42, 44 - 51, 72

5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

Ambient temperature	22 °C	Relative humidity	50 %
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Position of EUT: For this test, the EUT was connected to an ancillary device. The EUT was echoing packets, that were received from an ancillary device

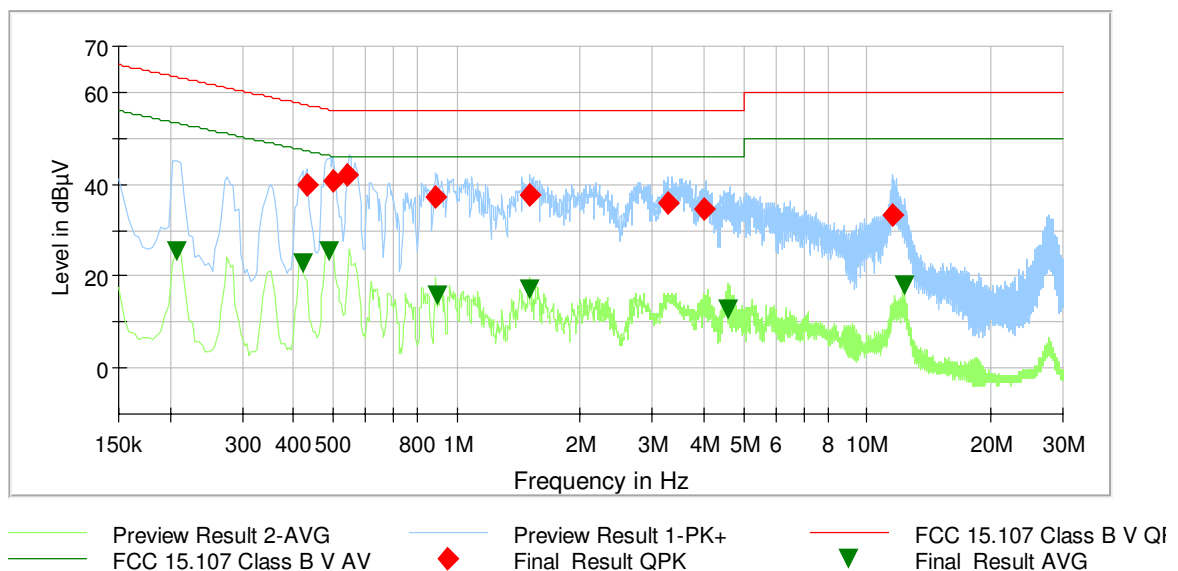
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: Measurement performed with US 120V/60Hz. For the test a power supply type "9820A-120090" by "NORDIC POWER" was used.
The power supply provided 12 V DC.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by "◇" and the average measured points by "+".

EUT operating in Bluetooth classic mode:



Data record name: AC_powerline conducted FCC_BT.rtf

Final Result – EUT in Bluetooth classic mode

Frequency [MHz]	QuasiPeak [dBμV]	Average [dBμV]	Limit [dBμV]	Margin [dB]	Meas. Time [ms]	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.208500	---	25.22	53.26	28.05	5000.0	9.000	N	GND	9.9
0.421800	---	22.87	47.41	24.54	5000.0	9.000	N	GND	9.9
0.430800	40.04	---	57.24	17.20	5000.0	9.000	N	GND	9.9
0.486600	---	25.57	46.23	20.65	5000.0	9.000	N	GND	9.9
0.501900	40.91	---	56.00	15.09	5000.0	9.000	N	GND	9.9
0.543300	41.97	---	56.00	14.03	5000.0	9.000	N	GND	9.9
0.888900	37.32	---	56.00	18.68	5000.0	9.000	L1	GND	9.9
0.894300	---	15.85	46.00	30.15	5000.0	9.000	N	GND	9.9
1.498200	37.44	---	56.00	18.56	5000.0	9.000	L1	GND	9.9
1.500000	---	17.32	46.00	28.68	5000.0	9.000	N	GND	9.9
3.256800	35.99	---	56.00	20.01	5000.0	9.000	L1	GND	10.2
4.020000	34.47	---	56.00	21.53	5000.0	9.000	L1	GND	10.3
4.564500	---	12.67	46.00	33.33	5000.0	9.000	L1	GND	10.3
11.534100	33.47	---	60.00	26.53	5000.0	9.000	L1	GND	10.7
12.303600	---	18.12	50.00	31.88	5000.0	9.000	L1	GND	10.7

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 – 6

6 Test Equipment

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Shielded chamber M47	-	Albatross Projects	B83117-C6439-T262 -	480662	Calibration not necessary	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	15.02.2016	02.2018
3	LISN	NSLK8128	Schwarzbeck	8128155	480058	16.02.2016	02.2018
4	High pass filter	HR 0.13-5ENN	FSY Microwave Inc.	DC 0109 SN 002	480340	Calibration not necessary	
5	EMI Software	ES-K1	Rohde & Schwarz	-	480111	Calibration not necessary	
6	Netzteil AC	AC6803A AC Quelle 2000VA	Keysight	JPVJ002509	482350	Calibration not necessary	
7	EMI Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
8	HF-Cable	Sucoflex 104	Huber+Suhner	517406	482391	Annual verification (system cal.)	
29	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
30	Spectrum Analyser	FSU46	Rohde & Schwarz	200125	480956	07.03.2017	03.2018
31	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586	481720	24.02.2016	02.2018
32	Controller	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
33	Turntable	DS420HE	Deisel	420/620/80	480315	Calibration not necessary	
34	Antenna support	AS615P	Deisel	615/310	480187	Calibration not necessary	
36	Antenna (Log.Per.)*	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
37	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Calibration not necessary	
39	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Calibration not necessary	
41	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
42	RF-cable No.38	Sucoflex 106B	Suhner	0709/6B / Kabel 38	481328	Calibration not necessary	
43	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	29.02.2016	29.02.2018
44	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	01.06.2020
46	RF-cable 2 m	KPS-1533-800-KPS	Insulated Wire	-	480302	Calibration not necessary	
47	Kabel 36	Sucoflex 106B	Suhner	500003/6B / Kabel 36	481680	Calibration not necessary	
49	Preamplifier 100 MHz - 16 GHz	AFS6-00101600-10P-6-R	Narda MITEQ		482333	23.11.2016	11.2018
50	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	18.02.2016	02.2018
51	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	17.02.2016	02.2018
52	4 GHz High Pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments	1	480587	Calibration not necessary	
60	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	18.02.2016	02.2018
61	Peak Power Sensor	NRV-Z32	Rohde & Schwarz	849745/016	480551	18.02.2016	02.2018

* All tests with this antenna were performed in the time range when the antenna was calibrated.

7 Report History

Report Number	Date	Comment
F170297E8	02.03.2018	Initial Test Report

8 List of Annexes

ANNEX A TEST SETUP PHOTOS 7 pages

170297_E6_01.jpg Test setup – antenna port conducted measurements
 170297_E6_02.jpg Test setup fully anechoic chamber
 170297_E6_03.jpg Test setup fully anechoic chamber
 170297_E6_04.jpg Test setup open area test site
 170297_E6_05.jpg Test setup fully anechoic chamber
 170297_E6_06.jpg Test setup fully anechoic chamber
 170297_E6_07.jpg Test setup fully anechoic chamber

ANNEX B EXTERNAL PHOTOS 8 pages

170297_E8_13.jpg: EUT #403 (int ant) on not marketed eval board – top view
 170297_E8_14.jpg: EUT #403 (onboard antenna) on not marketed eval board
 170297_E8_15.jpg: EUT #403 (onboard antenna) on not marketed eval board – bottom view
 170297_E8_23.jpg: EUT (onboard antenna) - bottom side
 170297_E8_10.jpg: EUT #403 with antenna trace design on not marketed eval board – top view
 170297_E8_11.jpg: EUT #403 with antenna trace design on not marketed eval board – close-up
 170297_E8_12.jpg: EUT #403 with antenna trace design on not marketed eval board – bottom view
 170297_E8_22.jpg: EUT #403 – bottom view

ANNEX C INTERNAL PHOTOS 2 pages

170297_E8_20.jpg: EUT with antenna trace design on not marketed eval board – without shielding
 170297_E8_21.jpg: EUT (with onboard antenna removed) without shielding on not marketed eval board