PHOENIX TESTLAB
Königswinkel 10
32825 Blomberg
Germany
Phone: +49 (0) 52 35 95 00-0
Fax: +49 (0) 52 35 95 00-10

Test Report

Report Number:

F145298E2

Applicant:

u-blox Malmö AB

Manufacturer:

u-blox Malmö AB

Equipment under Test (EUT):

ODIN-W161

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

Laboratory accredited by
Deutsche Akkreditierungsstelle GmbH (DAkkS)
in compliance with DIN EN ISO/IEC 17025
under the Reg. No. D-PL-17186-01-02,
FCC Test site registration number 90877 and
Industry Canada Test site registration IC3469A-1

REFERENCES

[1] **ANSI C63.10-2013** American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

[2] **FCC CFR 47 Part 15 (December 2014)** Radio Frequency Devices

[3] **Publication Number 558074 (June 2014)** DTS Meas Guidance v03r02

[4] **RSS-210 Issue 8 (December 2010)** Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

[5] **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.

Test engineer:	Wolfgang KASALOWSKY	W. Kasalowsky	8 July 2015
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER	B. Stu	8 July 2015
	Name	Signature	Date

RESERVATION

This test report is only valid in its original form.

The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

Contents: Page

1 IDENTIFICATION

1.1 Applicant

Name:	u-blox Malmö AB
Address:	Östra Varvsgatan 4, 5 tr, SE-211 75 Malmö
Country:	Sweden
Name for contact purposes:	Mr. Mats ANDERSSON
Phone:	+ 46 40 63 07 100
Fax:	+ 46 40 23 71 37
eMail Address:	mats.andersson@u-blox.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	u-blox Malmö AB
Address:	Östra Varvsgatan 4, 5 tr, SE-211 75 Malmö
Country:	Sweden
Name for contact purposes:	Mr. Mats ANDERSSON
Phone:	+ 46 40 63 07 100
Fax:	+ 46 40 23 71 37
eMail Address:	mats.andersson@u-blox.com
Applicant represented during the test by the following person:	-

1.3 Test laboratory

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

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under the Reg. No. D-PL-17186-01-02, FCC Test site registration number 90877 and Industry Canada Test site registration IC3469A-1.

1.4 EUT (Equipment Under Test)

Test object: *	Bluetooth module
Type: *	ODIN-W161
FCC ID: *	PVH1953
IC: *	5325A-1953
Serial number: *	Bluetooth: 292006259605, 292006260225, 292006260219
PCB identifier: *	0953-03
Hardware version: *	3.1
Software version: *	cB-2284(bt_hci_release_1.1.1) cB-0946(bt_spa_1.0.4_release minus one dBm)

1.5 Technical data of equipment

Channel 0	RX:	2402 MHz	TX:	2402 MHz
Channel 19	RX:	2440 MHz	TX:	2440 MHz
Channel 39	RX:	2480 MHz	TX:	2480 MHz

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
DC in (carrier board)	6.3 mm jack plug	-	2 m *
RS 232 Interface (carrier board)	9-pin D-Sub plug	Laptop PC	2 m *

*: Length during the test if no other specified.

1.6 Product Information

The type of modulation used by the equipment	FHSS
Fulfills Bluetooth specification	Bluetooth Low Energy
The number of Hopping Frequencies	40
The Dwell Time	3.75 ms
The Minimum Channel Occupation Time	625 µs
Adaptive / non-adaptive equipment	adaptive Equipment (Non-LBT equipment)
The maximum RF Output Power (e.i.r.p.)	<10 dBm
The maximum (corresponding) Duty Cycle	50 %
Operating Frequency Range	2402 MHz to 2480 MHz
Type of Equipment	Module mounted on an evaluation board
Operating temperature range	-40 °C to 85 °C
Operating voltage range (Host)	3.6 V to 6.0 V DC
Operating voltage range (EUT)	3.0 to 3.6 V DC
Details provided are for the	stand-alone equipment
Antenna Type	Integral Antenna
	Fractus FR05-S1-NO-1-003
Antenna Gain	1 dBi
Power Supply	External Power Supply or AC/DC adapter
Test modes available which can facilitate testing	Test modes are described in the test object specification
The equipment type	Bluetooth using one specific fixed configuration setting
Internal clock frequencies	32768 Hz / 26.000 MHz
Type of modulation:	GFSK

1.7 Dates

Date of receipt of test sample:	03 September 2014
Start of test:	25 September 2014
End of test:	26 September 2014

2 OPERATIONAL STATES

The equipment under test (EUT) is a WLAN dual band and Bluetooth dual mode module soldered on to a carrier board.
The radiated measurements were performed with the output connected to the chip antenna on the reference design. The conducted measurements were performed at the UFL connector on the radio module.
Because the ODIN-W161 is a module, which will be implemented in a final application, it was mounted on a carrier board (cB-0964-A1) to connect it to a Laptop with the test software and the external power supply.

All tests were carried out with an unmodified sample.

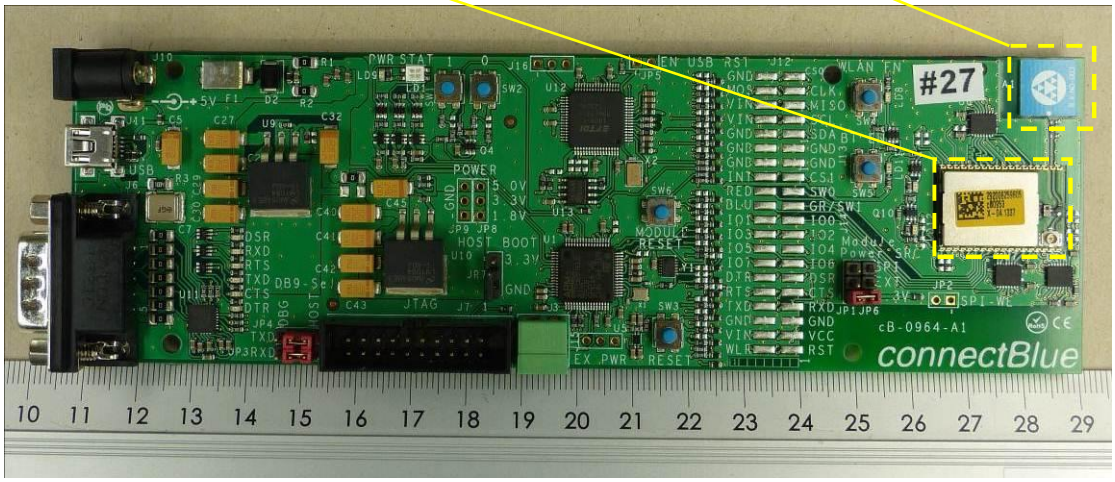
Operation mode:

With a test software which was provided by the applicant the hopping can be enabled and disabled. Furthermore the equipment could be set to transmit only and receive only mode with a certain modulation scheme and data rate on a certain frequency. This software was installed on a laptop PC, which was connected to the Equipment under test via the carrier board.

The EUT was a Bluetooth Low Energy device. The table below shows the available modulations and data rates for the appropriate test cases.

Operation mode	Description of the operation mode	mode	channel	Modulation	Data rate / Mbps
1	Continuous transmitting on 2402 MHz	BTLE	0	GFSK	1 MBit/s
2	Continuous transmitting on 2440 MHz	BTLE	19	GFSK	1 MBit/s
3	Continuous transmitting on 2480 MHz	BTLE	39	GFSK	1 MBit/s
4	Normal operation mode (hopping on all channels)	BTLE	0 – 39	GFSK	1 MBit/s

Physical boundaries of the ODIN-W161 and chip antenna on reference design:



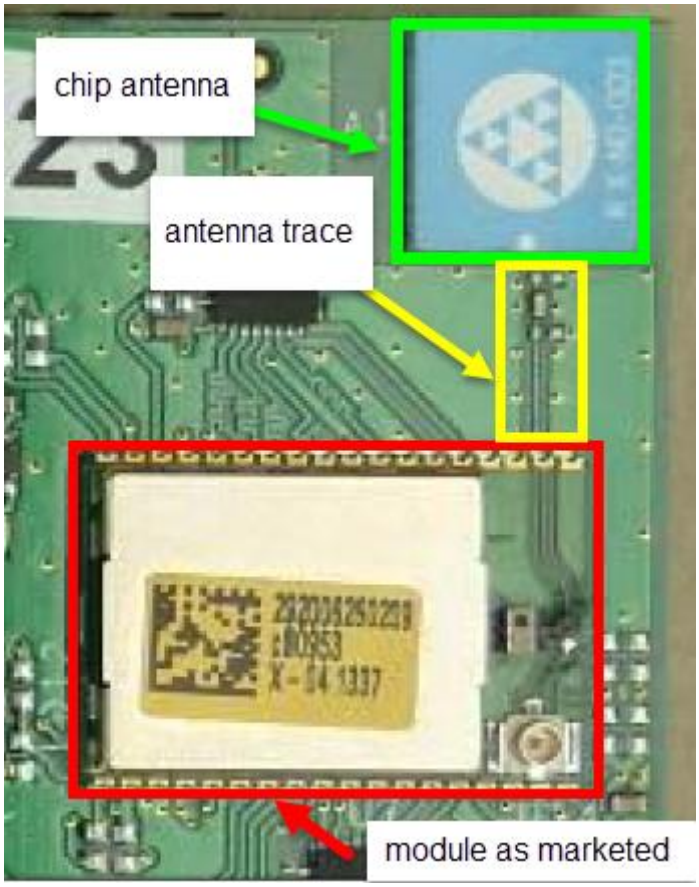
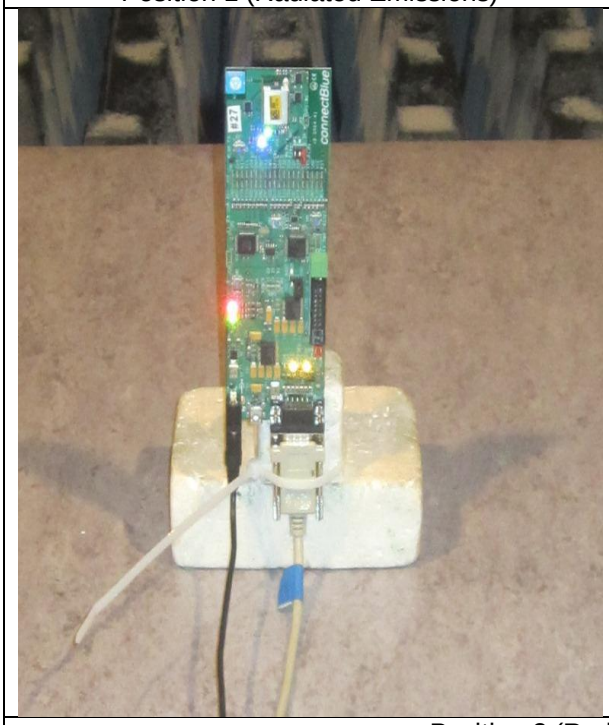
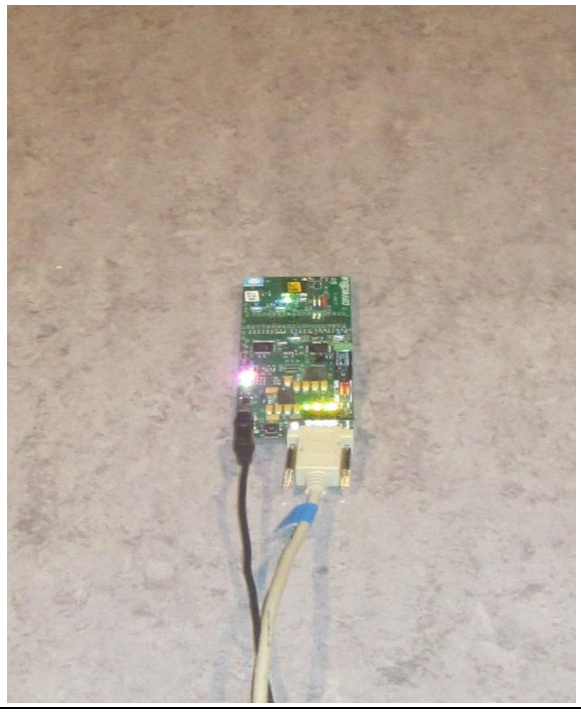
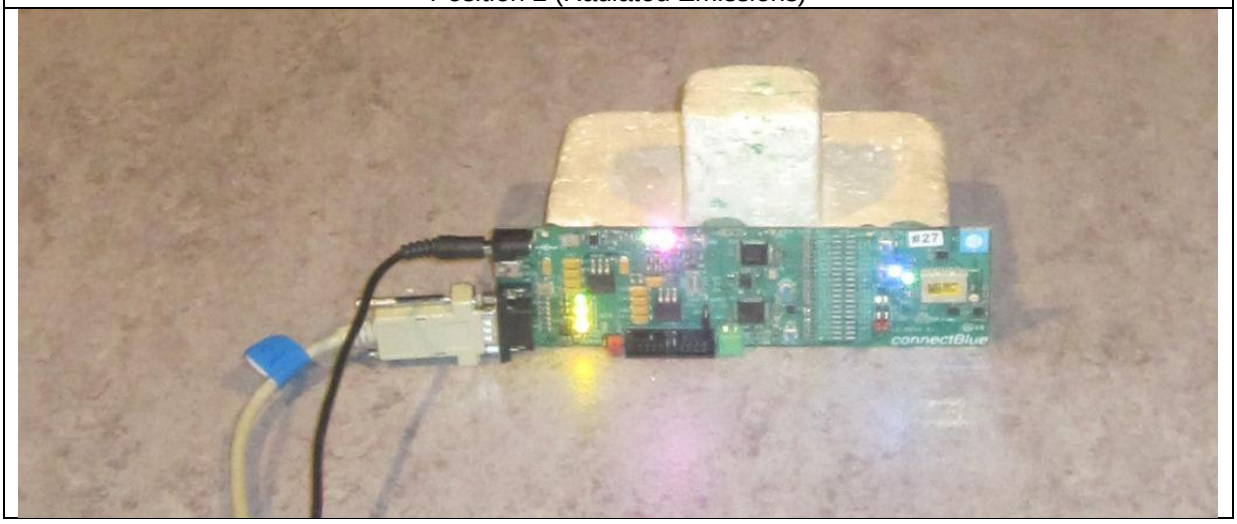


Table 1 Worst case test setup

Position 1 (Radiated Emissions)	Position 3 (Radiated Emissions)
	
Position 2 (Radiated Emissions)	
	

Preliminary tests were performed to find worst-case configuration and position. The radiated emission measurements were carried out in the orthogonal direction that emits the highest spurious emission levels.

The following test modes were adjusted during the tests:

Test items	Operation mode
Maximum Peak Output Power	1 – 3
DTS Bandwidth	1 – 3
Peak Power Spectral Density	1 – 3
Band Edge Compliance	1, 3
Maximum Unwanted Emissions	1 - 3
Conducted emissions on supply line	4

3 OVERVIEW

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS 210, Issue 8 [4] or RSS-Gen, Issue 4 [5]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	A8.4 (4) [4]	Passed	11 et seq
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	A8.2 (a) [4]	Passed	13 et seq
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	A8.2 (b) [4]	Passed	15 et seq
Band edge compliance	2400.0 - 2483.5	15.247 (d)	A8.5 [4]	Passed	17 et seq.
Unwanted emissions (transmitter)	0.009 – 26,500	15.247 (d) 15.205 (a) 15.209 (a)	A8.5 [4] 8.9[5], 2.5 [4]	Passed	20 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [5]	Passed	37 et seq.

4 TEST RESULTS

4.1 Maximum peak output power

4.1.1 Method of measurement

The EUT has to be connected to the power meter via a low loss cable.

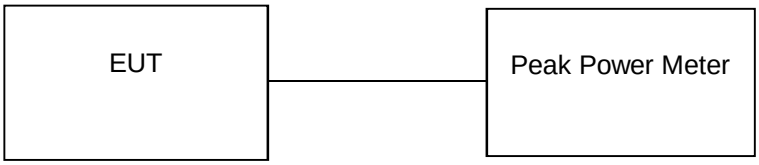
Acceptable measurement configurations

The measurement procedures described herein are based on the use of an antenna-port conducted test configuration.

PKPM1 – Peak power meter method was used for this test. The procedure is described in chapter 9.1.3 of document [3].

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

Test set-up:



4.1.2 Test results

Ambient temperature	21 °C	Relative humidity	42 %

The highest antenna gain is 1.0 dBi. Therefore no reduction of the Peak power limit is necessary.

Operation Mode	Antenna gain combined [dBi]	Maximum peak output power [dBm]	Margin [dB]	Peak power limit [dBm]
1	1.0	5.7	24.3	30
2	1.0	5.9	24.1	30
3	1.0	5.9	24.1	30
Measurement uncertainty		+0.66 dB / -0.72 dB		

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

26, 27

4.2 DTS Bandwidth

4.2.1 Method of measurement

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyser. The measurement procedure refers to part 8.1 of document [3].

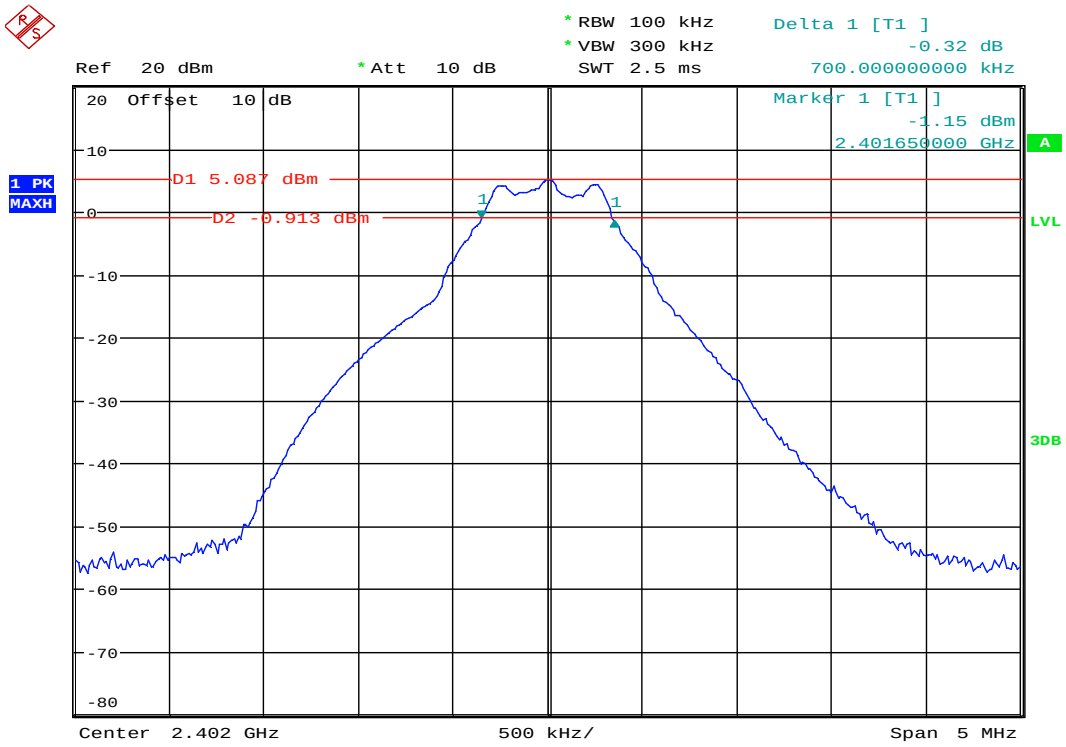
- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper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

4.2.2 Test result

Ambient temperature	21 °C	Relative humidity	42 %

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.

136117_6dB-BW_BTLE_BT1.wmf: DTS Bandwidth (operation mode 1):



Operation Mode	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	Result
1	2402.000	0.500	0.700	Passed
2	2440.000	0.500	0.687	Passed
3	2480.000	0.500	0.700	Passed
Measurement uncertainty		+0.66 dB / -0.72 dB		

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7

4.3 Peak Power Spectral Density

4.3.1 Method of measurement

The relating measurements were carried out in a conducting manner. Therefore, the antenna connector was directly connected to a spectrum analyser. The measurement procedure refers to part 10.2 of document [3].

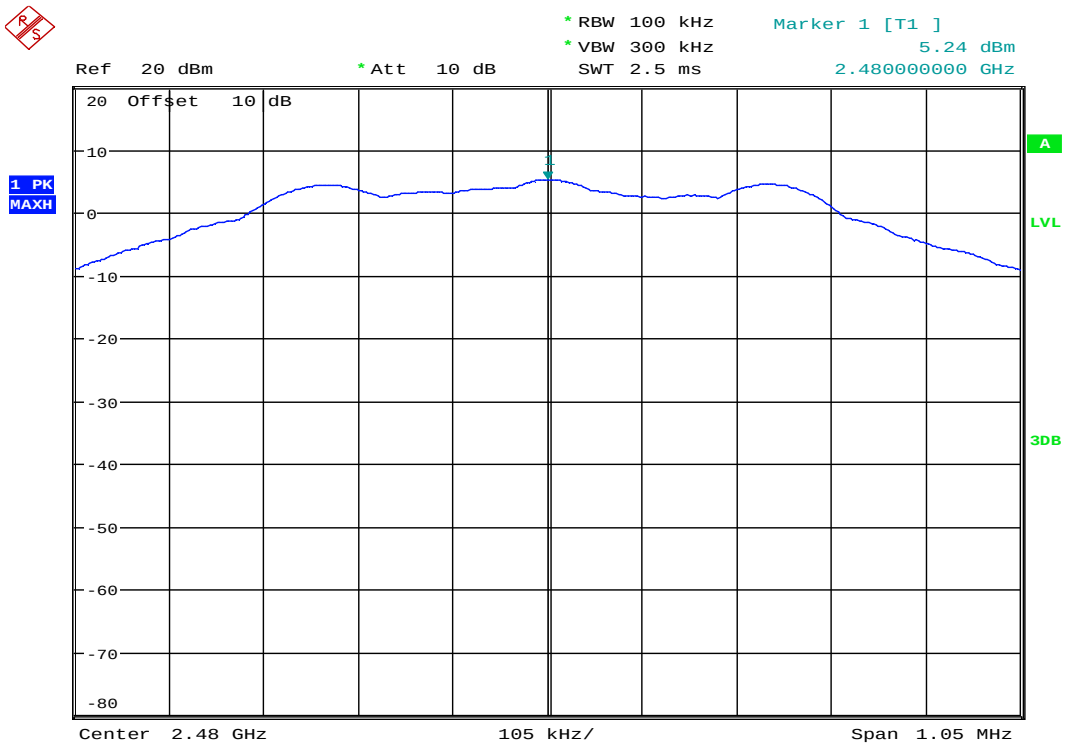
- Set analyser center frequency to DTS channel center frequency
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
- Set the VBW ≥ 3 x RBW.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker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

4.3.2 Test result

Ambient temperature	21 °C	Relative humidity	42 %

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.

136117_PwrSpecDens_BTLE_BT79.wmf: Power Spectral Density (operation mode 3):



Operation Mode	Peak Frequency [MHz]	Power Spectral Density Limit [dBm/3kHz]	Power Spectral Density Reading [dBm/100kHz]	Array Gain [dB]	Power Spectral Density Level [dBm/100kHz]	Margin [dB]	Result
1	2402.000	8.0	5.1	0.0	5.1	2.9	Passed
2	2441.159	8.0	5.2	0.0	5.2	2.8	Passed
3	2480.157	8.0	5.2	0.0	5.2	2.8	Passed
Measurement uncertainty			+0.66 dB / -0.72 dB				

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

7

4.4 Band-edge compliance

4.4.1 Method of measurement (band edges next to unrestricted bands (radiated))

The related measurements were carried out in a radiated manner. The measurement procedure refers to part 11.2 and 11.3 of document [3].

Measurement Procedure – Reference Level:

- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Set the span to ≥ 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 amplitude level.

Measurement Procedure – Unwanted Emissions

- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ 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.

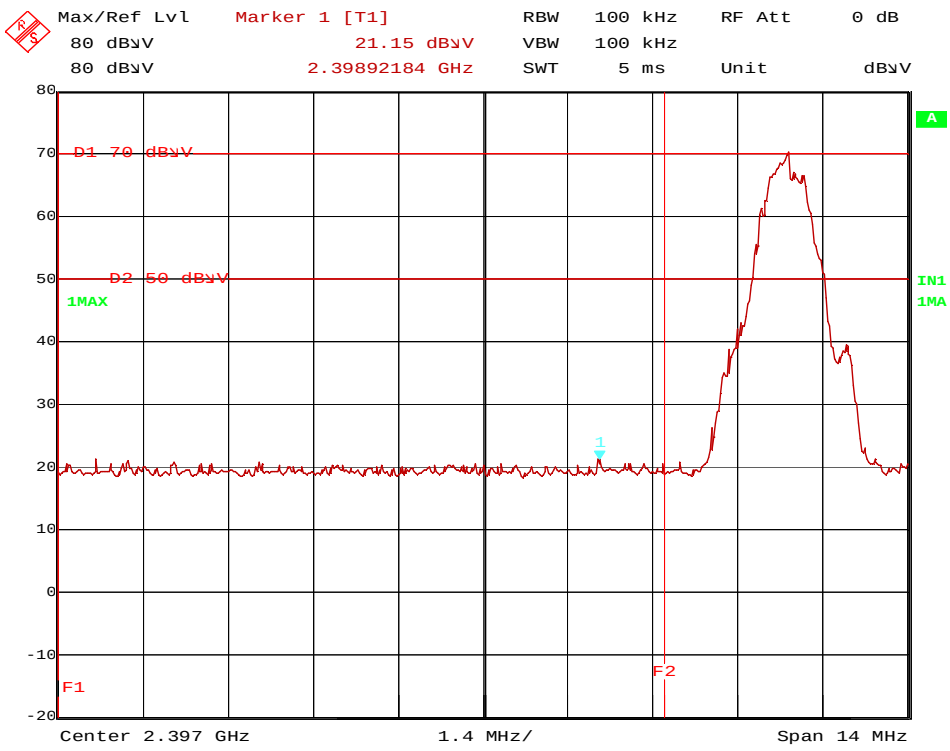
The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by 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.

4.4.2 Test result (band edges next to unrestricted bands (radiated))

Ambient temperature	22 °C	Relative humidity	72 %

145298_BEdge_Pos3_BTLE_ch0.wmf: radiated band-edge compliance (operation mode 1):



Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

5, 6, 8 - 15, 17-25

4.4.3 Method of measurement (band edges next to restricted bands (radiated))

The same test set-up and test method as used for the final conducted emission measurement shall be used (refer also subclause **Fehler! Verweisquelle konnte nicht gefunden werden.**of this test report).

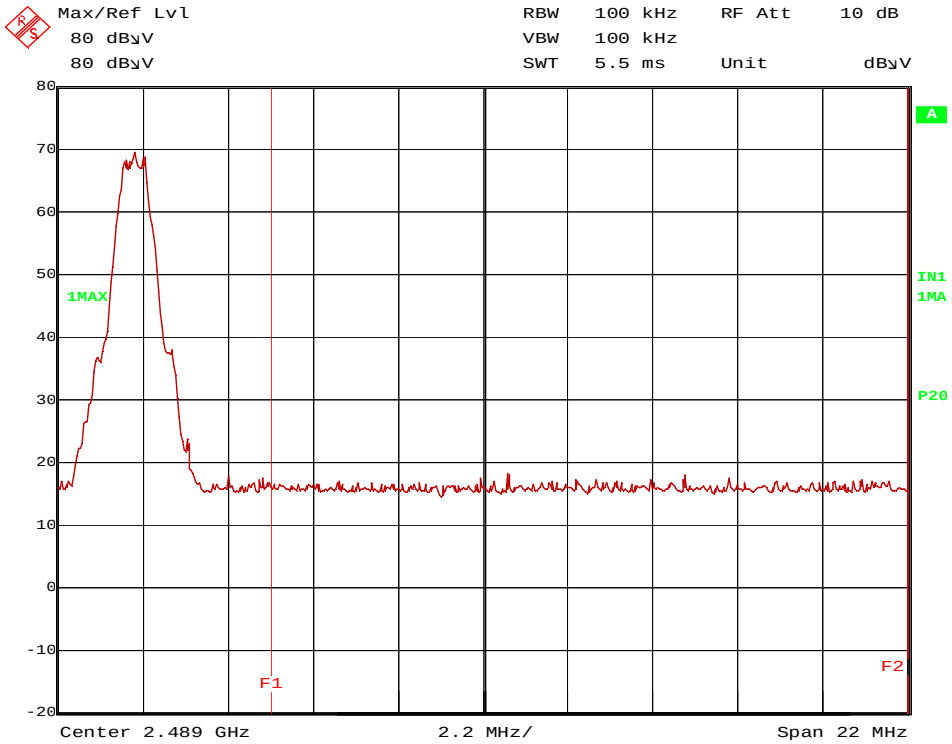
The measurement was performed at the upper end of the 2.4 GHz band.

4.4.4 Test result (band edges next to restricted bands (radiated))

Ambient temperature	22 °C	Relative humidity	72 %

The plots show the preliminary measurement result.

145298_BEdge_Pos3_BTLE_ch39.wmf: radiated band-edge compliance (operation mode 3):



Noise level of the peak measurement was lower than the average limit for spurious emissons in the restricted band as shown in the table below. Therefore no final measurement was necessary.

Frequency MHz	Meas. Result dBµV/m	Average Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Restr. Band
2490	51,4	54,0	2,6	18.0	28,5	0,0	2,9	150	Yes

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

6, 8 - 11, 13, 17, 18

4.5 Maximum unwanted emissions

4.5.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into four 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 side with reflecting ground plane and various antenna heights 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 110 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 110 GHz.

All measurements will be carried out with the EUT working on the middle of the assigned frequency band.

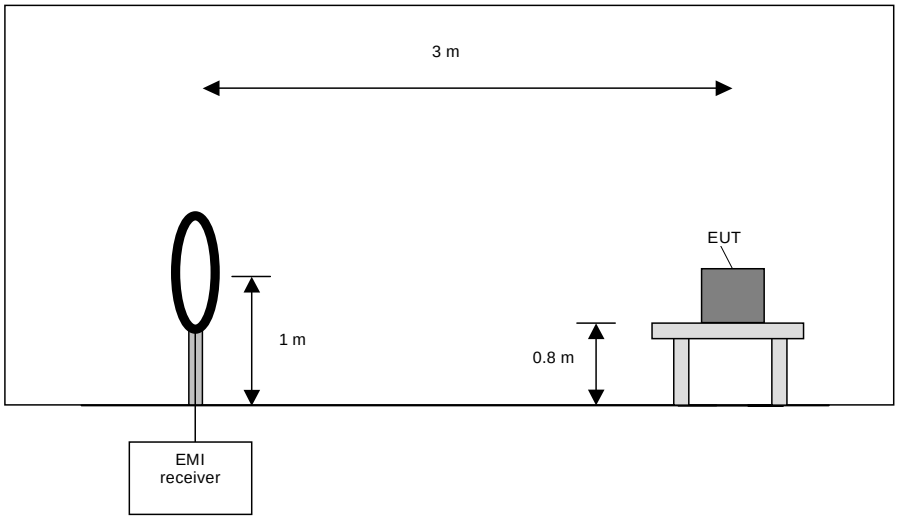
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of
3 meters. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to found the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

Prescans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation 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) Make a hardcopy of the spectrum.
5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).
7) Rotate the measuring antenna and repeat steps 1) to 5).

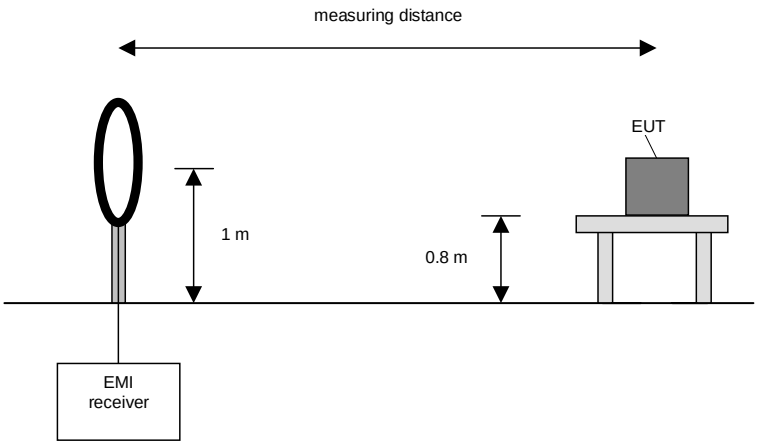
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m whichever is appropiate. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according to [2].

On the during the preliminary measurement detected frequencies the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

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

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Final measurement procedure:

The following procedure will be used:

1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
3) Rotate the measuring antenna to find the maximum and note the value.
4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).

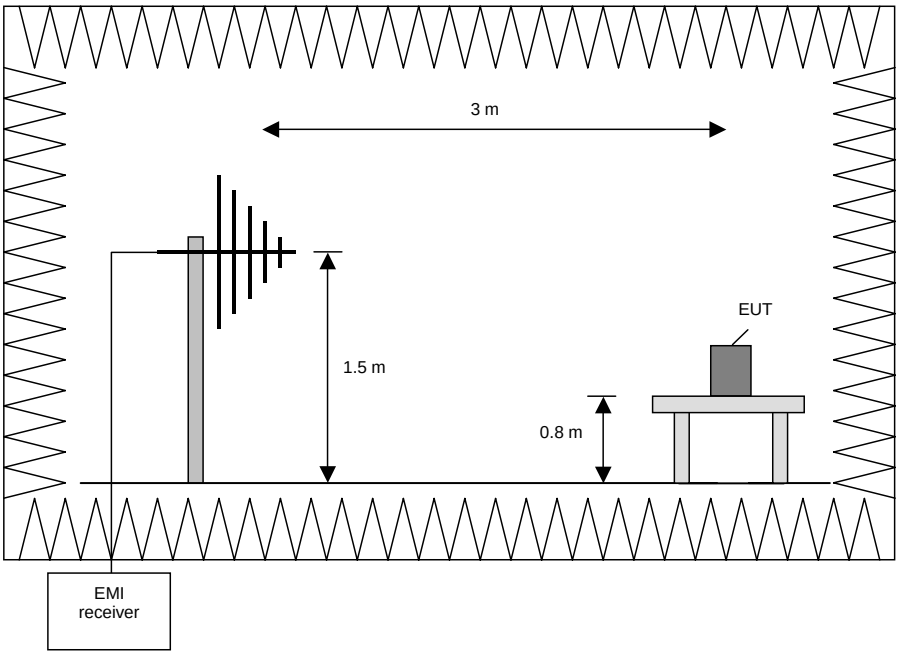
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup 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 polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °.

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:

Prescans were performed in the frequency range 30 MHz to 230 MHz and 230 MHz to 1 GHz.
The following procedure will be used:

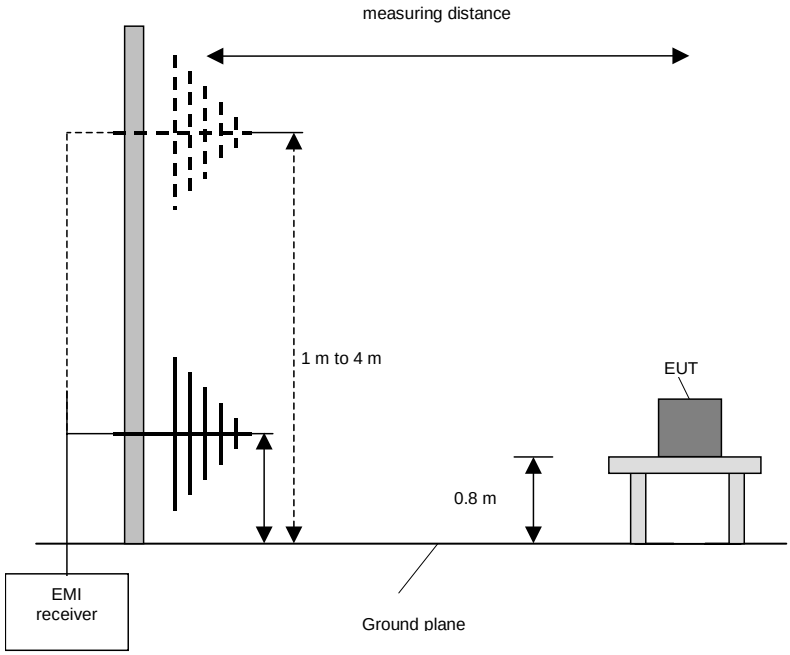
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6. Repeat 1) to 4) for each orthogonal axes of the EUT (only if the EUT is a module or is used in a handheld application).
7. Repeat 1) to 5) with the vertical polarisation of the measuring antenna.

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 polarisation 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 (only if the EUT is a module or is used in a handheld application).

Preliminary and final measurement (1 GHz to 110 GHz)

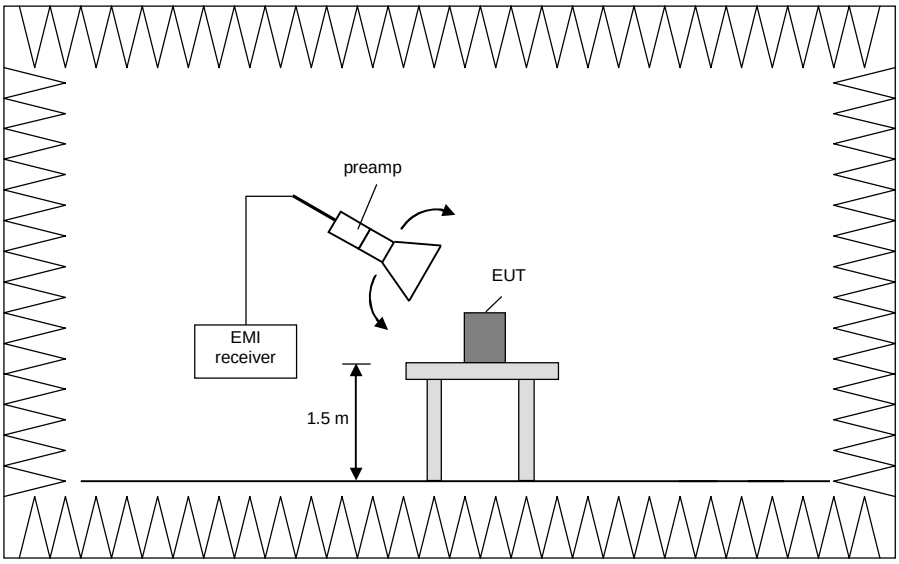
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support a height of 150 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set up of the Equipment under test will be in accordance to ANSI C63.10-2013 [1].

Preliminary measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending on the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna, the antenna close to the EUT and while moving the antenna over all sides of the EUT. With the spectrum analyser in CLEAR / WRITE mode the cone of the emission should be found and then the measuring distance will be set to 3 m with the receiving antenna moving in this cone of emission. At this position the final measurement will be carried out.

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 26.5 GHz	100 kHz
26.5 GHz to 40 GHz	100 kHz
40 GHz to 60 GHz	100 kHz
50 GHz to 75 GHz	100 kHz
75 GHz to 110 GHz	100 kHz

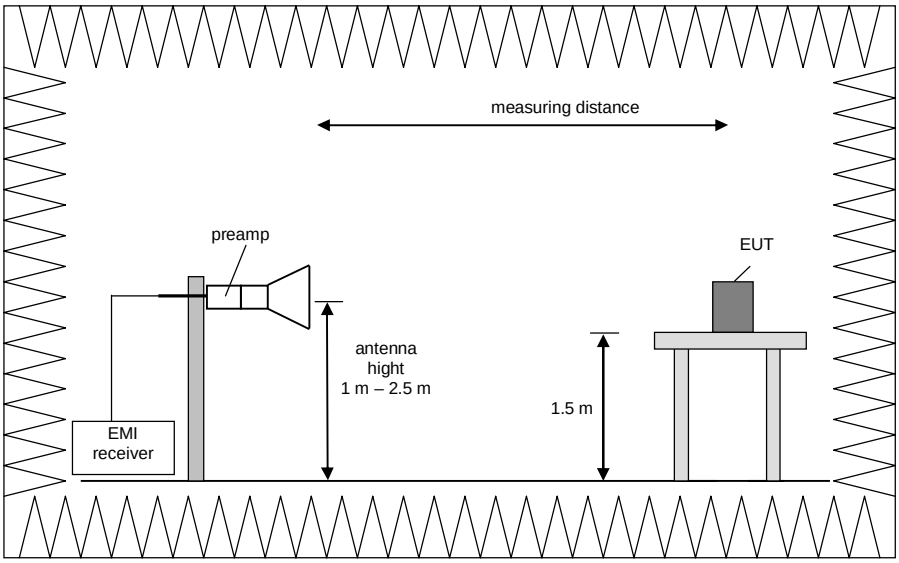


Final measurement (1 GHz to 110 GHz)

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 in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 ° in order to have the antenna inside the cone of radiation.

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 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 26.5 GHz, 26.5 GHz to 40 GHz, 40 GHz to 60 GHz, 60 GHz to 75 GHz and 75 GHz to 110 GHz.
The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary move the EUT to another orthogonal axis).
2) Change the antenna polarisation and repeat 1) with vertical polarisation.
3) Make a hardcopy of the spectrum.
4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
5) Change the analyser mode to Clear / Write and found the cone of emission.
6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and average detector, which causes the maximum emission.
8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Steps 1) to 6) are defined as preliminary measurement.

4.5.2 Test results (radiated emissions)

4.5.2.1 Preliminary radiated emission measurement

Ambient temperature	22 °C	Relative humidity	71 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m below 1 GHz and 1,5 m above 1 GHz. 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 the annex A.

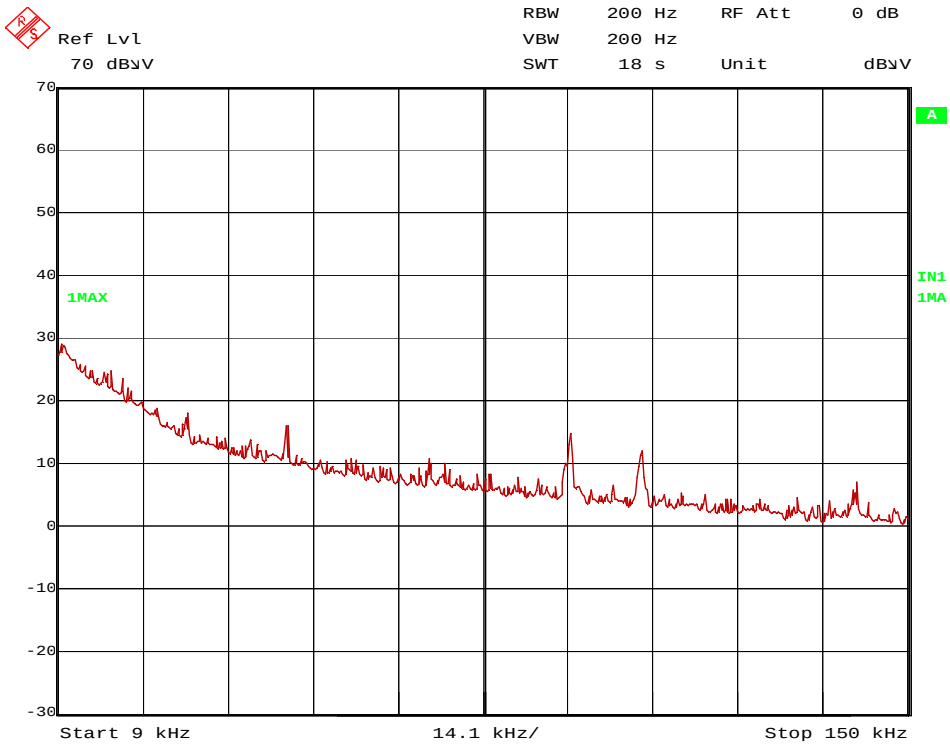
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 5 V DC via a laboratory power supply.

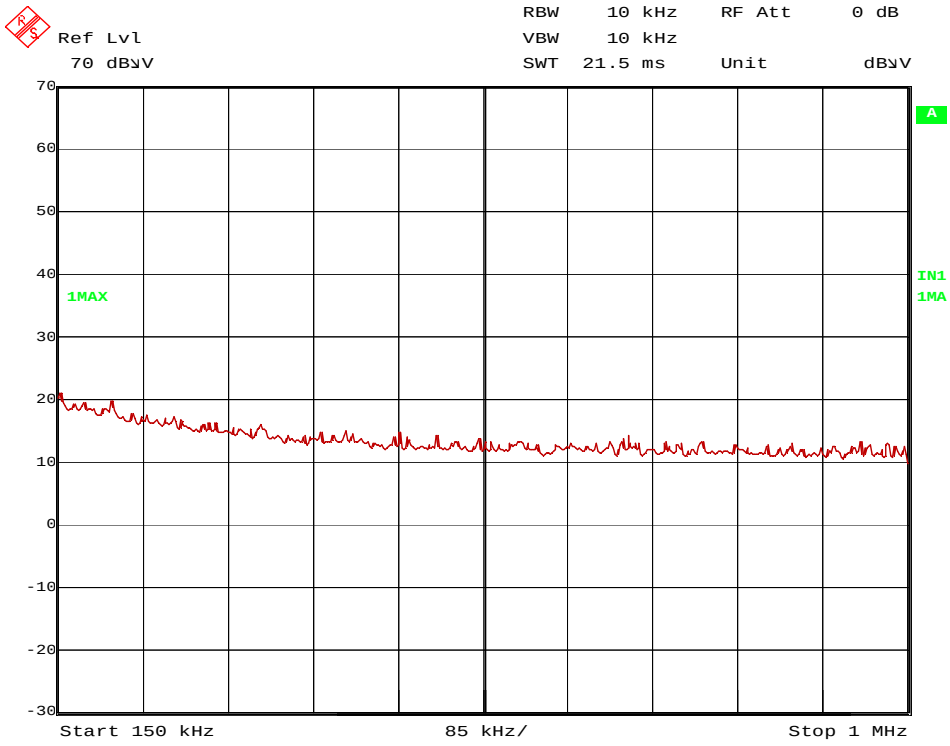
Remark: Only the plots of the worst case emissions are submitted for every frequency range above 1 GHz in the preliminary results.

The Emissions below 1 GHz were similar for all transmit frequencies, modulation schemes and data rates. Therefore only the results of an exemplary test case are submitted below.

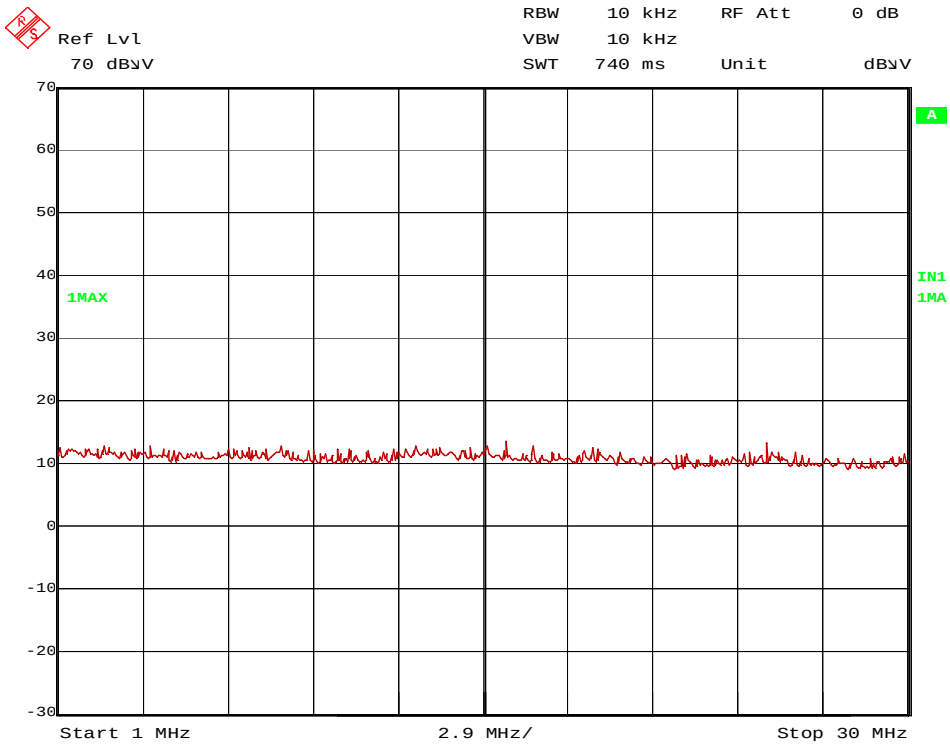
145298_9-150k.wmf: Spurious emissions from 9 kHz to 150 kHz:



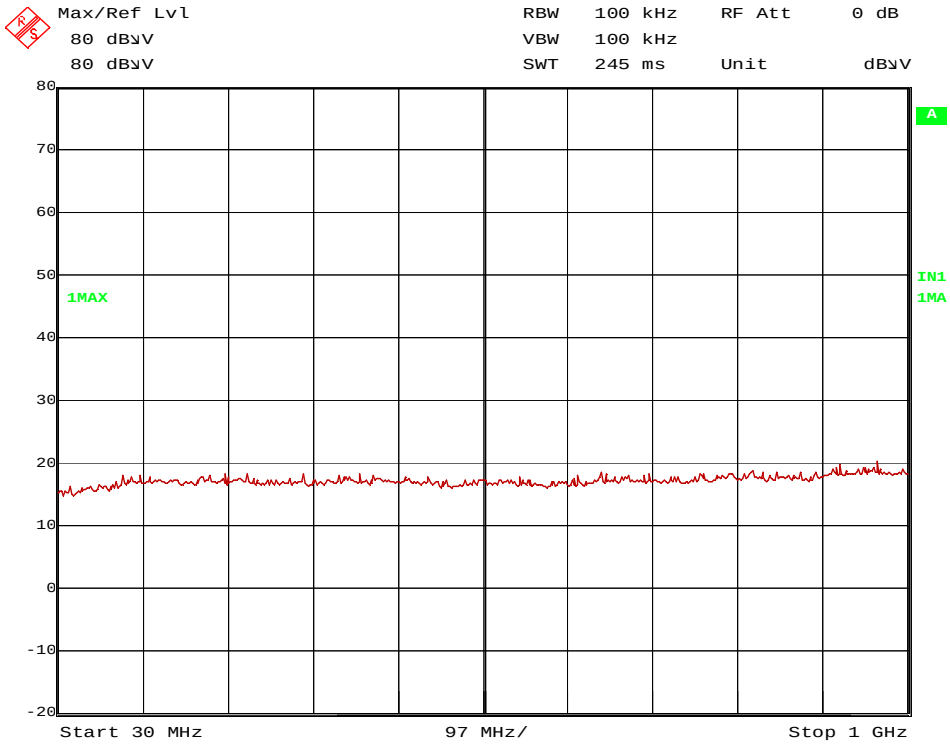
145298_150k-1M.wmf: Spurious emissions from 150 kHz to 1 MHz:



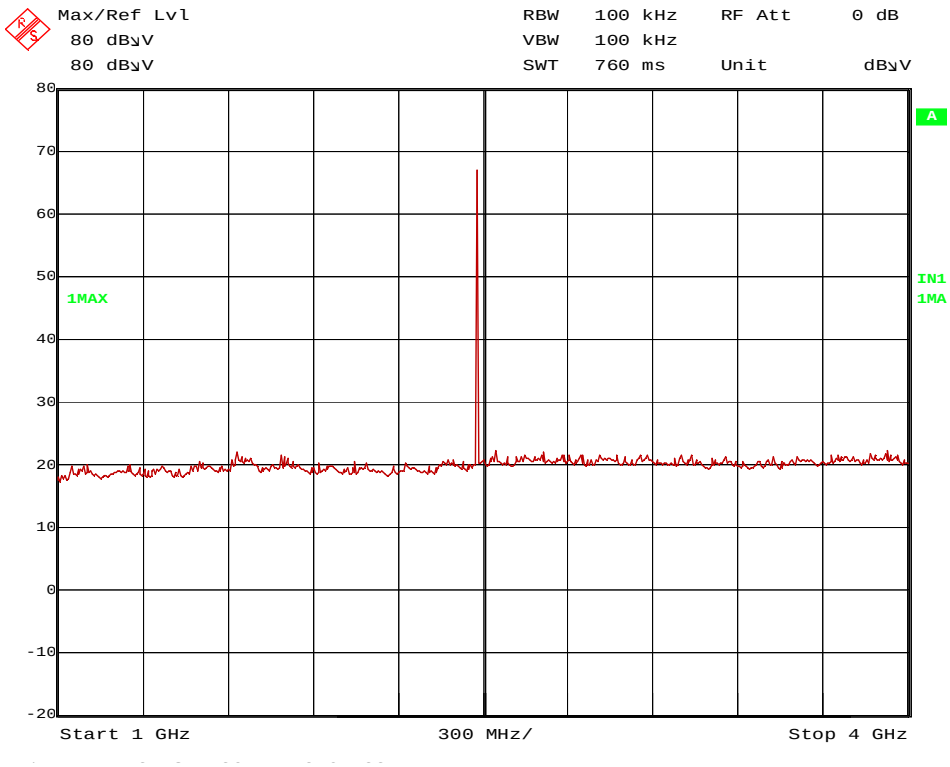
145298_1-30M: Spurious emissions from 1 MHz to 30 MHz:



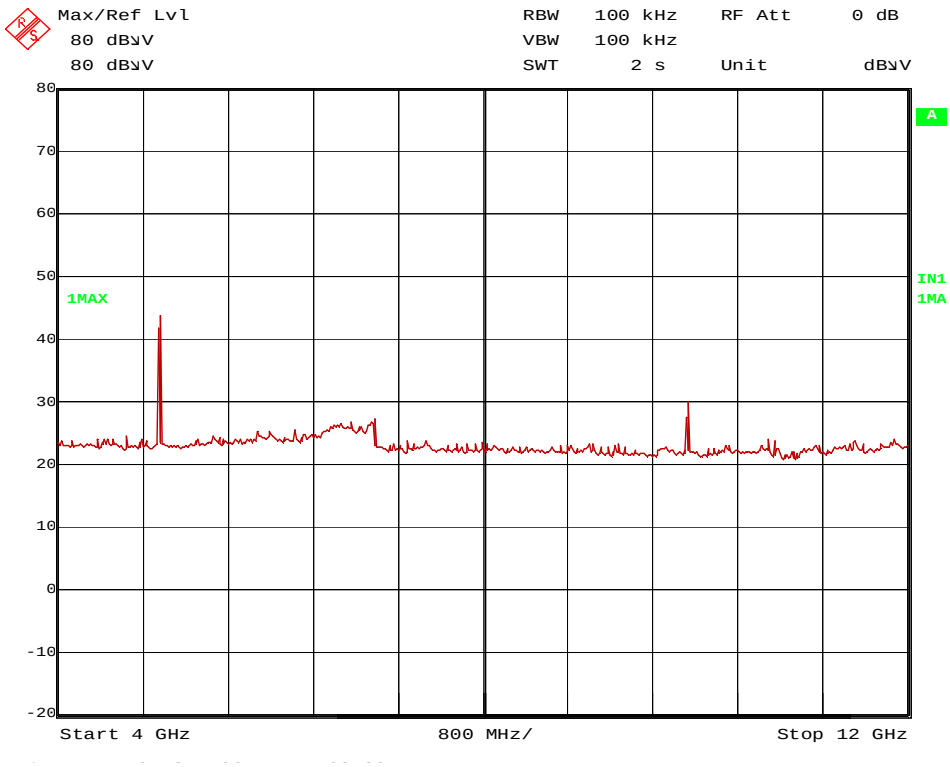
145298_SpurEm_30M-1G_Pos2_BT-BTLE_allModes.wmf: Spurious emissions from 30 MHz to 1 GHz:



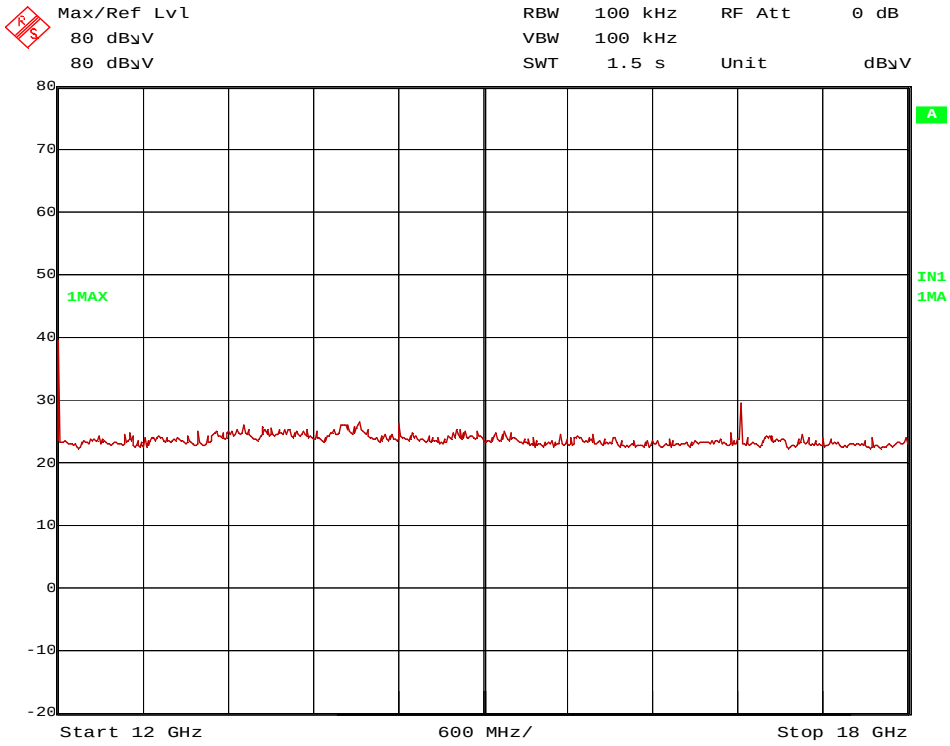
145298_SpurEm_1-4G_Pos3_BTLE_ch39.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



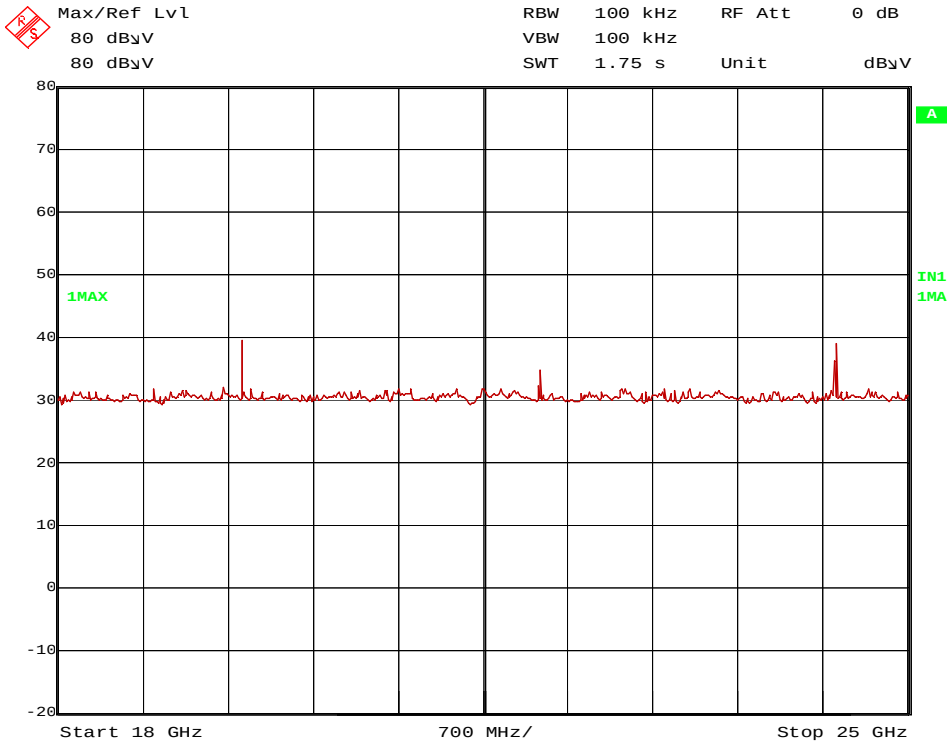
145298_SpurEm_4-12G_Pos2_BTLE_ch39.wmf: Spurious emissions from 4 GHz to 12 GHz (operation mode 3):



145298_SpurEm_12-18G_BTLE_Pos2_ch0.wmf: Spurious emissions from 12 to 18 GHz (operation mode 1):



145298_SpurEm_18-25G_BTLE_Pos2_ch19.wmf: Spurious emissions from 18 – 25 GHz (operation mode 2):



The following frequencies were found inside the restricted bands during the preliminary radiated emission test:

- 4804 MHz, 4880 MHz, 4960 MHz, 12010 MHz, 12200 MHz, 12400 MHz, 19216 MHz, 19520 MHz.

The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 9760 MHz, 9920 MHz, 16814 MHz, 21618 MHz, 21960 MHz, 24020 MHz, 24400 MHz, 24800 MHz.

These frequencies have to be measured in a final measurement. The results are presented in the following.

TEST EQUIPMENT USED FOR THE TEST:

6, 8 – 15, 17 – 25, 28, 29

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

No emissions could be measured on the open area test site. Therefore no results for the final measurements are submitted.

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

Ambient temperature	22 °C	Relative humidity	71 %

Position of EUT:	The EUT was set-up on a non-conducting table 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 annex A of this test report.
Test record:	All results are shown in the following.
Supply voltage:	During all measurements the host of the EUT was powered with 5 V via an laboratory power supply..
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. Position 2 was found to have the worst case spurious emissions.

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

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4804	56.1	74.0	17.9	43.8	32.6	25.6	5.3	150	Hor	Yes
12010	53.6	74.0	20.4	44.7	33.6	26.3	1.6	150	Hor.	Yes
16814	46.4	74.0	27.6	39.0	33.8	28.4	2.0	150	Hor.	No
19216	47.5	74.0	26.5	45.9	37.1	37.7	2.3	150	Hor.	Yes
21618	45.7	74.0	28.3	43.8	37.2	37.8	2.5	150	Hor.	No
24020	46.0	74.0	28.0	44.3	37.2	38.2	2.7	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4804	47.3	54.0	6.7	35.0	32.6	25.6	5.3	150	Hor.	Yes
12010	37.4	54.0	16.6	28.5	33.6	26.3	1.6	150	Hor.	Yes
16814	30.0	54.0	24.0	22.6	33.8	28.4	2.0	150	Hor.	No
19216	31.4	54.0	22.6	29.8	37.1	37.7	2.3	150	Hor.	Yes
21618	30.4	54.0	23.6	28.5	37.2	37.8	2.5	150	Hor.	No
24020	30.6	54.0	23.4	28.9	37.2	38.2	2.7	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

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

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4880	56.0	74.0	18.0	43.5	32.8	25.6	5.3	150	Hor.	Yes
9760	54.5	74.0	19.5	33.2	37.3	23.9	7.9	150	Vert	No
12200	53.6	74.0	20.4	44.7	33.6	26.4	1.6	150	Hor.	Yes
19520	49.0	74.0	25.0	47.6	37.1	38.0	2.3	150	Hor.	Yes
21960	44.1	74.0	29.9	42.2	37.2	37.9	2.6	150	Hor.	No
24400	47.1	74.0	26.9	45.5	37.2	38.4	2.7	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4880	47.3	54.0	6.7	34.8	32.8	25.6	5.3	150	Hor.	Yes
9760	41.2	54.0	12.8	19.8	37.3	23.9	7.9	150	Vert.	No
12200	37.5	54.0	16.5	28.6	33.6	26.4	1.6	150	Hor.	Yes
19520	33.0	54.0	21.0	31.6	37.1	38.0	2.3	150	Hor.	Yes
21960	29.8	54.0	24.2	27.9	37.2	37.9	2.6	150	Hor.	No
24400	31.3	54.0	22.7	29.7	37.2	38.4	2.7	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

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

Result measured with the peak detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4960	59.3	74.0	14.7	46.7	32.9	25.1	5.0	150	Hor.	Yes
9920	56.9	74.0	17.1	35.5	37.4	23.1	7.0	150	Vert.	No
12400	53.3	74.0	20.7	44.3	33.7	26.3	1.6	150	Hor.	Yes
24800	48.8	74.0	25.2	47.1	37.3	38.3	2.8	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Result measured with the average detector:

Frequency MHz	Meas. Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Height cm	Pol.	Restr. Band
4960	50.9	54.0	3.1	38.4	32.9	25.1	5.0	150	Hor.	Yes
9920	42.9	54.0	11.1	21.5	37.4	23.1	7.0	150	Vert.	No
12400	37.5	54.0	16.5	28.5	33.7	26.3	1.6	150	Hor.	Yes
24800	32.2	54.0	21.8	30.5	37.3	38.3	2.8	150	Hor.	No
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

6, 8 – 15, 17 – 25, 28, 29

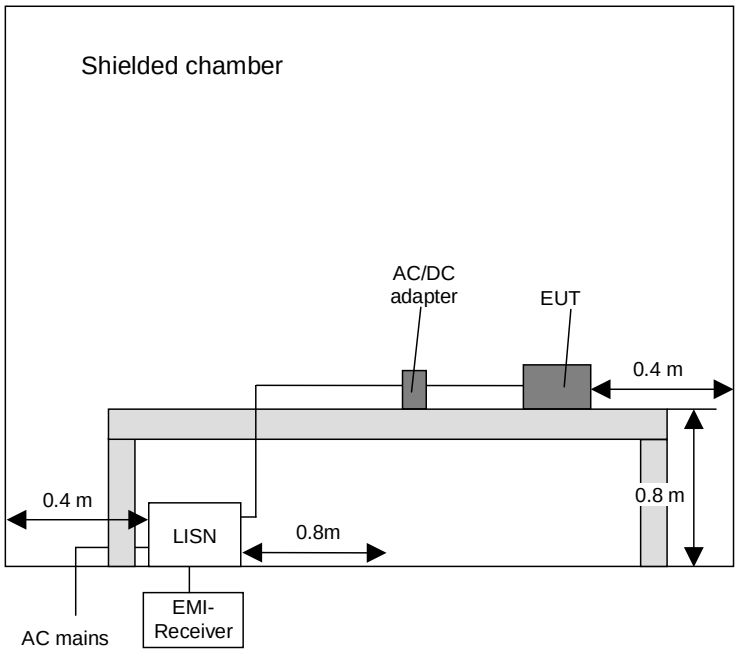
4.6 Conducted emissions on power supply lines (150 kHz to 30 MHz)

4.6.1 Method of measurement

This test will be carried out in a shielded chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The setup of the Equipment under test will be in accordance to ANSI C63.4-2009 [1].

The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriable limit. this emission will be measured with the average and quasi-peak detector on all lines.

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz

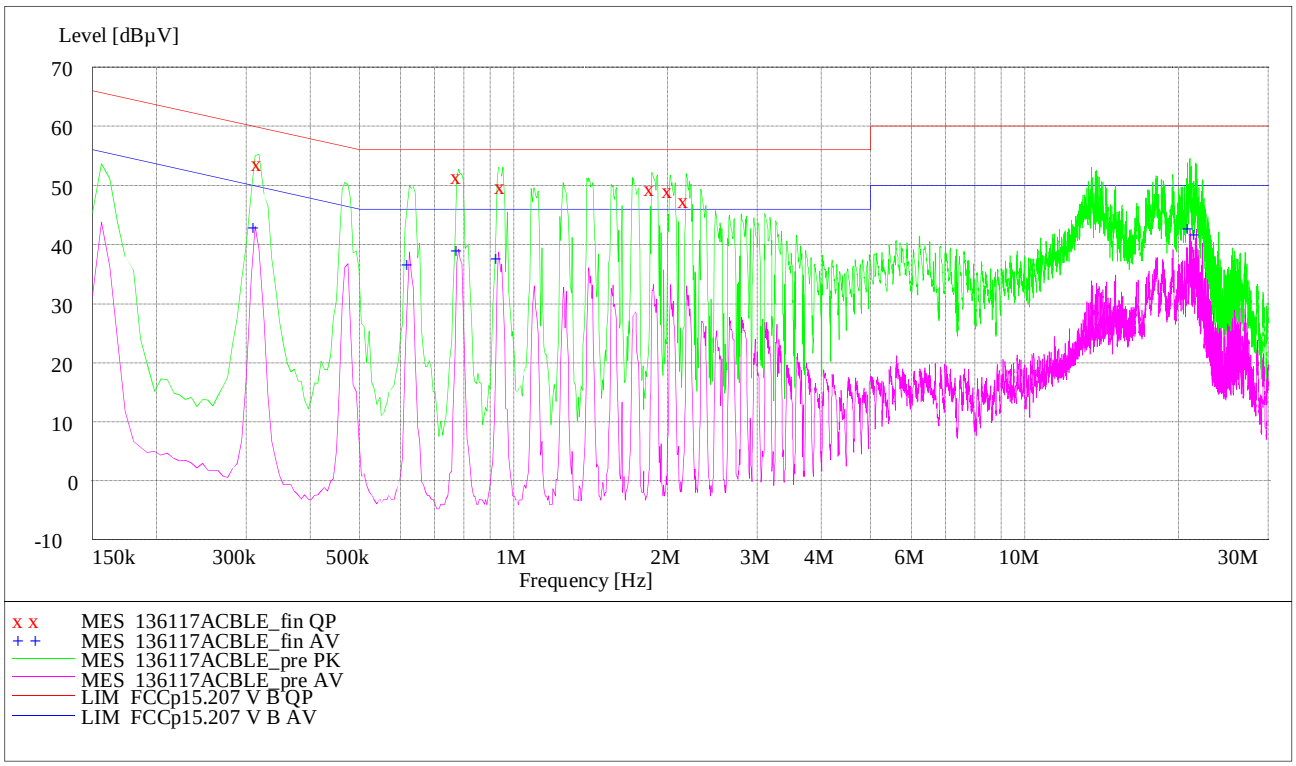


4.6.2 Test results (conducted emissions on power supply lines)

Ambient temperature	21 °C	Relative humidity	27 %

Position of EUT:	For the test the EUT were plugged into a laptop PC via a RS232 cable. The A Bluetooth Low Energy connection was established between the EUT and an ancillary device with a data transfer via iperf. The laptop PC with the inserted EUT was set-up on a non-conducting table of a height of 0.8 m.
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 2121 from Mascot was used.

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 an x and the average measured points by an +.



Result measured with the quasipeak detector (marked by an x):

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.318000	54.00	0.9	59.8	5.8	L1	FLO
0.780000	51.80	0.8	56.0	4.2	L1	FLO
0.954000	50.10	0.8	56.0	5.9	L1	FLO
1.866000	49.60	0.7	56.0	6.4	L1	GND
2.022000	49.50	0.8	56.0	6.5	L1	FLO
2.172000	47.70	0.8	56.0	8.3	L1	FLO

Result measured with the average detector (marked by a +):

Frequency MHz	Level dBµV	Transducer dB	Limit dBµV	Margin dB	Line	PE
0.312000	43.00	0.8	49.9	6.9	L1	GND
0.624000	37.00	0.8	46.0	9.0	L1	GND
0.780000	39.30	0.8	46.0	6.7	L1	GND
0.936000	37.80	0.7	46.0	8.2	L1	GND
21.084000	42.80	2.5	50.0	7.2	N	GND
21.672000	42.10	2.6	50.0	7.9	N	FLO

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 – 5

5 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTS

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Shielded chamber M47	-	Albatross Projects	B83117-C6439-T262 -	480662	Weekly verification (system cal.)	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	03/21/2014	03/2016
3	LISN	NSLK8128	Schwarzbeck	8128155	480058	12/20/2013	12/2014
4	High pass filter	HR 0.13-5ENN	FSY Microwave Inc.	DC 0109 SN 002	480340	Weekly verification (system cal.)	
5	EMI Software	ES-K1	Rohde & Schwarz	-	480111	-	-
6	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
7	Spectrum analyser	FSU	Rohde & Schwarz	200125	480956	07/15/2013	07/2015
8	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	02/26/2014	02/2016
9	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
10	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
11	Antenna support	AS615P	Deisel	615/310	480187	-	-
12	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
13	Antenna	3115 A	EMCO	9609-4918	480183	11/10/2011	11/2017
14	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Six month verification (system cal.)	
15	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Six month verification (system cal.)	
16	Standard Gain Horn Antenne 26.4 – 40.1 GHz	22240-20	Flann Microwave	469	480229	Six month verification (system cal.)	
17	RF-cable No. 3	Sucoflex 106B	Huber&Suhner	0563/6B / Kabel 3	480670	Weekly verification (system cal.)	
18	RF-cable No. 40	Sucoflex 106B	Huber&Suhner	0708/6B / Kabel 40	481330	Weekly verification (system cal.)	
19	RF-cable No. 36	Sucoflex 106B	Huber&Suhner	500003/6B / Kabel 36-	481680	Weekly verification (system cal.)	
20	RF-cable 1 m	KPS-1533-400-KPS	Insulated Wire	-	480300	Six month verification (system cal.)	
21	RF-cable 2 m	KPS-1533-800-KPS	Insulated Wire		480302	Six month verification (system cal.)	
22	Preamplifier	JS3-00101200-23-5A	Miteq	681851	480337	Six month verification (system cal.)	
23	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	Six month verification (system cal.)	
24	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	Six month verification (system cal.)	
25	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/18/2014	02/2016
26	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	07/2013	07/2015
27	Peak Power Sensor	NRV-Z32	Rohde & Schwarz	849745/016	480551	07/2013	07/2015
28	4 GHz High Pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments	1	480587	Weekly verification (system cal.)	

29	Single Control Unit	SCU	Maturo GmbH	SCU/006/971107	480831	Calibration not necessary	
30	High-pass Filter	H26G40G1	Microwave Circuits. Inc.	33471	480593	Six month verification (system cal.)	
31	Temperature Test Chamber	MK 240	Binder	05-79022	480462	02/18/2014	08/2015

6 REPORT HISTORYaktualisieren

Report Number	Date	Comment
F145298E2	08 July 2015	Document created

7 LIST OF ANNEXES

ANNEX A TEST SET-UP PHOTOS 6 pages

145298_13.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_02.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_14.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_15.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_17.jpg: Test setup - Radiated emission (fully anechoic chamber)
145298_18.jpg: Test setup – conducted emissions on power supply lines

ANNEX B EXTERNAL PHOTOGRAPHS 2 pages

145298_05.jpg: Carrier Board with EUT – Top View
145298_35.jpg: Carrier Board with EUT – Top View (Detail)
145298_06.jpg: Carrier Board – Bottom View
145298_07.jpg: Carrier Board – Connectors

ANNEX C INTERNAL PHOTOGRAPHS 2 pages

145298_08.jpg: EUT - top view with shielding
145298_09.jpg: EUT - top view shielding removed
145298_10.jpg: EUT – bottom view