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Test Report

Report Number: F145863E2

Applicant:

Miele & Cie. KG

Manufacturer:

Miele & Cie. KG

Equipment under Test (EUT):

EK038

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 of Procedures for Compliance Testing of Unlicensed Wireless Devices

[2] **FCC CFR 47 Part 15 (June 2015)** Radio Frequency Devices

[3] **RSS-247 (May 2015)** 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.

	Name	Signature	Date
Test engineer:	Paul NEUFELD		2 December 2015
Authorized reviewer:	Bernd STEINER		2 December 2015

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.

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1 IDENTIFICATION

1.1 Applicant

Name:	Miele & Cie. KG
Address:	Carl-Miele-Straße 29, 33332 Gütersloh
Country:	Germany
Name for contact purposes:	Gunnar Borgelt
Phone:	05241/89-6292
Fax:	05241/89-786292
eMail Address:	gunnar.borgelt@miele.de
Applicant represented during the test by the following person:	Christian Bömke

1.2 Manufacturer

Name:	Miele & Cie. KG
Address:	Carl-Miele-Straße 29, 33332 Gütersloh
Country:	Germany
Name for contact purposes:	Gunnar Borgelt
Phone:	05241/89-6292
Fax:	05241/89-786292
eMail Address:	gunnar.borgelt@miele.de
Manufacturer represented during the test by the following person:	Christian Bömke

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: *	ZigBee Module
Model / PMN: *	EK038
FCC ID: *	2ACUWEK038
IC: *	5669C-EK038
Serial number: *	Prototype
PCB identifier / HVIN: *	EK038
Hardware version: *	EK038 290914
Software version: *	V204_ID3642

Channel 11	RX:	2405 MHz	TX:	2405 MHz
Channel 12	RX:	2410 MHz	TX:	2410 MHz
Channel 13	RX:	2415 MHz	TX:	2415 MHz
Channel 14	RX:	2420 MHz	TX:	2420 MHz
Channel 15	RX:	2425 MHz	TX:	2425 MHz
Channel 16	RX:	2430 MHz	TX:	2430 MHz
Channel 17	RX:	2435 MHz	TX:	2435 MHz
Channel 18	RX:	2440 MHz	TX:	2440 MHz
Channel 19	RX:	2445 MHz	TX:	2445 MHz
Channel 20	RX:	2450 MHz	TX:	2450 MHz
Channel 21	RX:	2455 MHz	TX:	2455 MHz
Channel 22	RX:	2460 MHz	TX:	2460 MHz
Channel 23	RX:	2465 MHz	TX:	2465 MHz
Channel 24	RX:	2470 MHz	TX:	2470 MHz
Channel 25	RX:	2475 MHz	TX:	2475 MHz
Channel 26	RX:	2480 MHz	TX:	2480 MHz

Fulfills Radio specification: *	ZigBee
Antenna type: *	PCB Antenna
Antenna gain: *	<2 dBi
Antenna connector: *	none
Power supply - EUT	3.3 V DC
Type of modulation: *	OQPSK
Operating frequency range:*	2405 MHz to 2480 MHz
Number of channels: *	16
Temperature range: *	0 °C to +105 °C
Lowest / highest internal clock frequency: *	32MHz

* declared by the applicant.

The following external I/O cables were used:

Identification	Length
DC power cable	2 m *

*: Length during the test if not other specified.

1.5 Dates

Date of receipt of test sample:	10 November 2014
Start of test:	10 November 2014
End of test:	12 November 2014
Start of test:	30 October 2015
End of test:	02 November 2015

2 OPERATIONAL STATES

The equipment under test (EUT) is a ZigBee module for integration in various final applications. The module is equipped with an integral printed circuit board (PCB) antenna. The applicant provided various modules which were set to operate in different test modes.

The following modules with their test modes were provided:

Module 1	Operation Mode 1	Transmitting continuously on ZigBee channel 11
Module 2	Operation Mode 2	Transmitting continuously on ZigBee channel 18
Module 3	Operation Mode 3	Transmitting continuously on ZigBee channel 26
Module 4	Operation Mode 4	Normal operation (Retransmission of packets from a ZigBee router)

All tests were carried out with an unmodified sample.

If not mentioned otherwise the module was powered by 3.3 VDC from a laboratory power supply

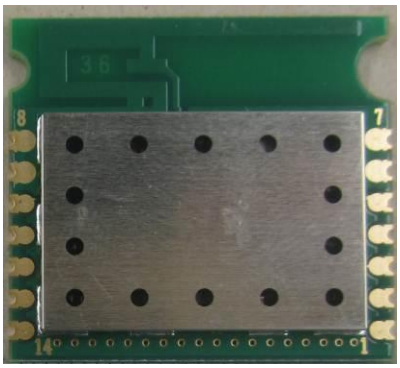
Preliminary tests were performed to find worst-case configuration and position. The radiated emission measurements were carried out in the positioner angle that emits the highest (spurious) emission levels.

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 Power Supply	4

3 ADDITIONAL INFORMATION

Photo of the module as marketed:



The Power was set to the maximum of 7dBm for all channels.

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 (4) [3]	Passed	12 et seq
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (1) [3]	Passed	15 et seq
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (2) [3]	Passed	17 et seq
Band edge compliance	2400.0 - 2483.5	15.247 (d)	5.5 [3] 8.9 [4], 8.10 [4]	Passed	19 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	23 et seq.
Conducted emissions on supply line	0.15 - 30	15.207 (a)	8.8 [4]	Passed	37 et seq.

5 TEST RESULTS

5.1 Duty Cycle

5.1.1 Method of measurement

The radiated measurement setup was made according 5.6.1 in [1].

Acceptable measurement configurations

The measurement procedures described herein are based on radiated measurements.

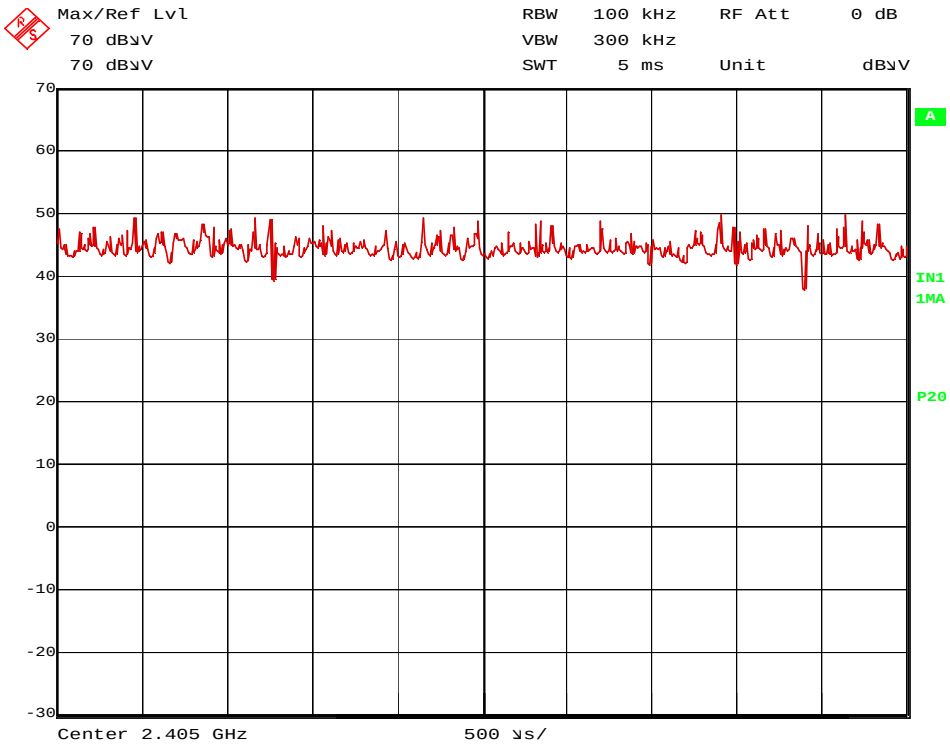
Procedure 11.6 of ANSI C63.10 [1] was used for the following test.

There is only one modulation sceme possible and the duty cycle is equal for each channel. Therefore the test were only performed on one arbitrary selected frequency.

5.1.2 Test results

Ambient temperature	21 °C	Relative humidity	40 %

145863_ZeroSpanSweep.wmf: Duty Cycle measurement



The EUT is transmitting data continuously in test mode. Therefore no duty cycle correction or similar measurement techniques have to be used.

TEST EQUIPMENT USED FOR THE TEST:

6, 8 -11, 13, 17, 18, 32, 33

5.2 Maximum peak output power

5.2.1 Method of measurement

The EUT was measured in a radiated setup within an anechoic chamber. The radiated measurement setup was made according to chapter 5.6.1.

Acceptable measurement configurations

Annex G in [1] is used for calculating radiated values to conducted values.

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

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

With the following formula the received Voltage at the analyser is converted into logarithmic power value:

$$1\mu V \cdot 10^{\frac{U_{dB\mu V}}{20}} = V_{Out}$$

$$P_{Out-lin} = \frac{V_{Out}^2}{R}$$

$$P_{Out-\log} = 10 \cdot \log(P_{Out-lin})$$

Where:

U_{dBuV}	is the measured logarithmic Voltage at the analyzer in dBµV
V_{Out}	is the converted linear output voltage in V
$P_{out-log}$	is the logarithmic output Power in dBW
$P_{out-lin}$	is the linear input Power in Watt

The radiated logarithmic power levels are then calculated into conducted values by using the formula (G.8) in [1]:

$$P_R = P_{meas} - G_R + L_C + L_{atten} - G_{amp}$$

Where:

P_{meas}	is the measured power level, in dBW, dBm, ore psd
G_R	is the gain of the receive (measurement) antenna, in dBi
L_C	is the signal loss of the measurement cable, in dB
L_{atten}	is the value of the external attenuation (if used), in dB
G_{amp}	is the value of external amplification (if used), in dB

The free-space propagation loss is determined from Equation (G.9) in [1]:

$$L_P = 20\log F + 20\log d - 27.5$$

Where:

L_P	is the basic free space propagation path loss, in dB
F	is the center frequency of the radiated DUT signal, in MHz
d	is the measurement distance, in meters

The EIRP power can finally derived by formula (G.7) in [1]:

$$EIRP = P_R + L_P$$

Where:

EIRP	is the equivalent (or effective) isotropical radiated power (in same units as P_R)
P_R	is the adjusted received power level, in dBW, dBm, or psd
L_P	is the basic free-space path loss, in dB

The peak conducted output power can be calculated by the following formula:

$$P_{conducted} = P_{EIRP} - G_{Antenna}$$

Where:

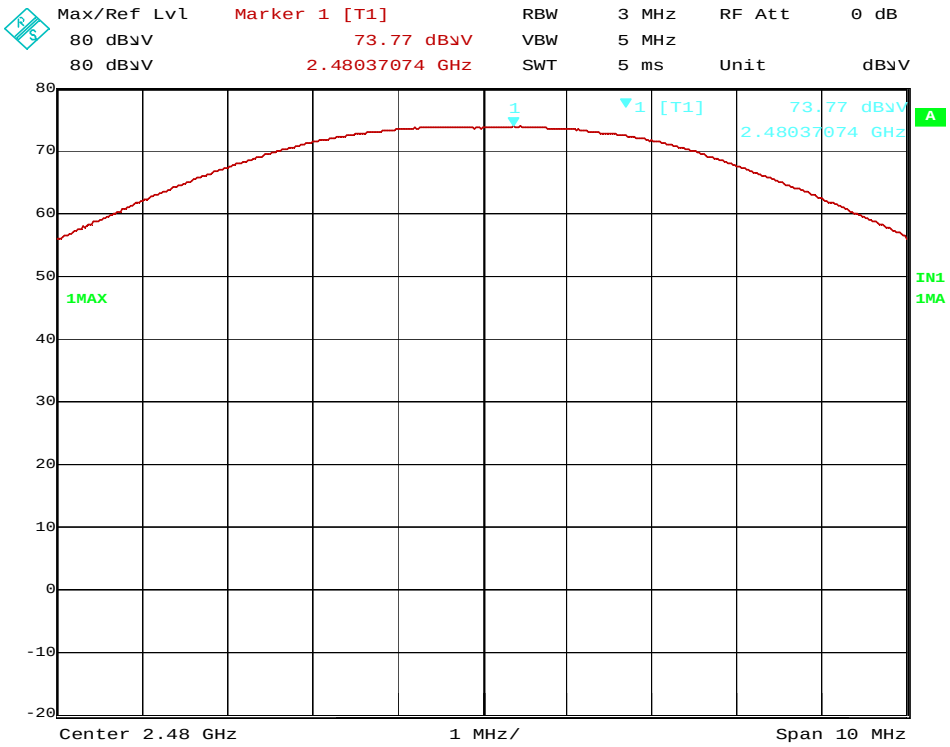
P_{EIRP}	is the equivalent (or effective) isotropical radiated power
$P_{conducted}$	is conducted output power without antenna gain
$G_{Antenna}$	is the gain of the measurement antenna

5.2.2 Test results

Ambient temperature	21 °C	Relative humidity	40 %

The following results were measured in a radiated setup. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

145863_MPOP_Pos1_ch11_Tisch.wmf: Maximum peak output power (operation mode 1):



The highest antenna gain is 2.0 dBi. Therefore no reduction of the Peak power limit is necessary.

Operation Mode	Frequency [MHz]	Antenna gain combined [dBi]	Measured Voltage (radiated) [dBµV]	Measured Power (radiated) [dBm]	Free Space Loss [dB]	Receiver Antenna Gain [dB]	Cable attenuation [dB]	EIRP Power [dBm]	Conducted output power	Limit [dBm]
1	2405	2	73.0	-35.8	49.7	9.6	3.0	9.1	7.1	30
2	2440	2	73.4	-35.4	49.8	9.7	3.0	9.5	7.5	30
3	2480	2	73.8	-35.0	49.9	9.8	2.9	9.8	7.8	30
Measurement uncertainty				+2.2 dB / -3.6 dB						

Conducted output power = measured power (radiated) + Free Space Loss – Receiver Antenna Gain + Cable attenuation – EUT Antenna gain

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

6, 8 -11, 13, 17, 18, 32, 33

5.3 DTS Bandwidth

5.3.1 Method of measurement

The EUT was measured in a radiated setup within an anechoic chamber. The radiated measurement setup was made according to chapter 5.6.1.

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

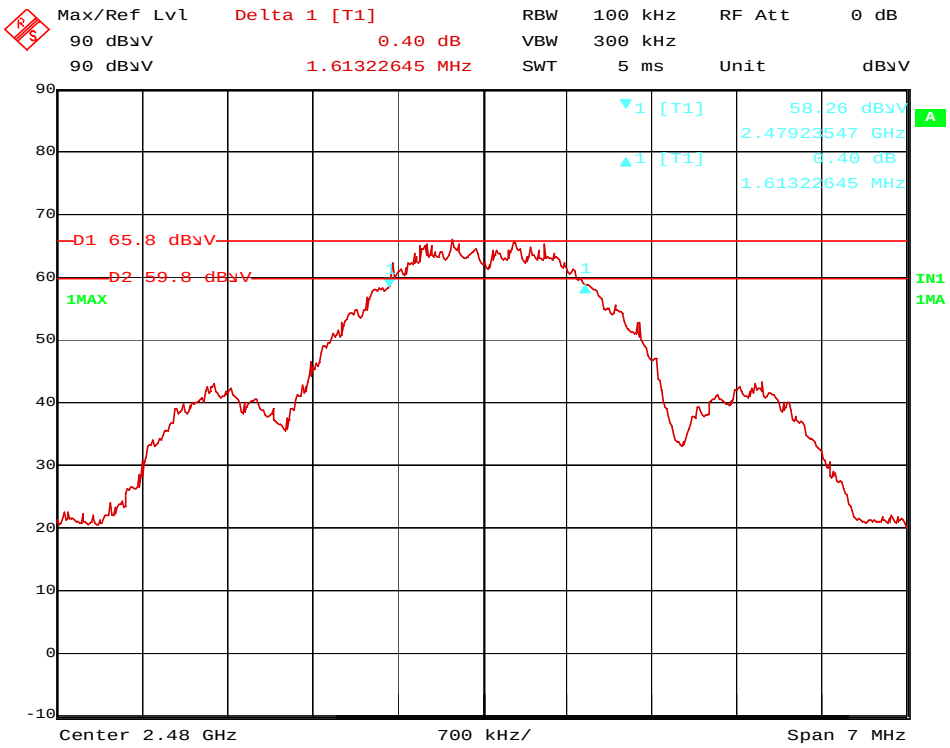
- Set RBW = 100 kHz.
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper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

5.3.2 Test result

Ambient temperature	21 °C	Relative humidity	40 %

The following results were measured in a radiated setup. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

145863_DTSBW_Pos1_ch26: DTS Bandwidth (operation mode 3):



Operation Mode	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	Result
1	2405	0.5	1.641	Passed
2	2440	0.5	1.627	Passed
3	2480	0.5	1.613	Passed
Measurement uncertainty		+2.2 dB / -3.6 dB		

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

6, 8 -11, 13, 17, 18, 32, 33

5.4 Peak Power Spectral Density

5.4.1 Method of measurement

The EUT was measured in a radiated setup within an anechoic chamber. The radiated measurement setup was made according 5.6.1.

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

- 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.

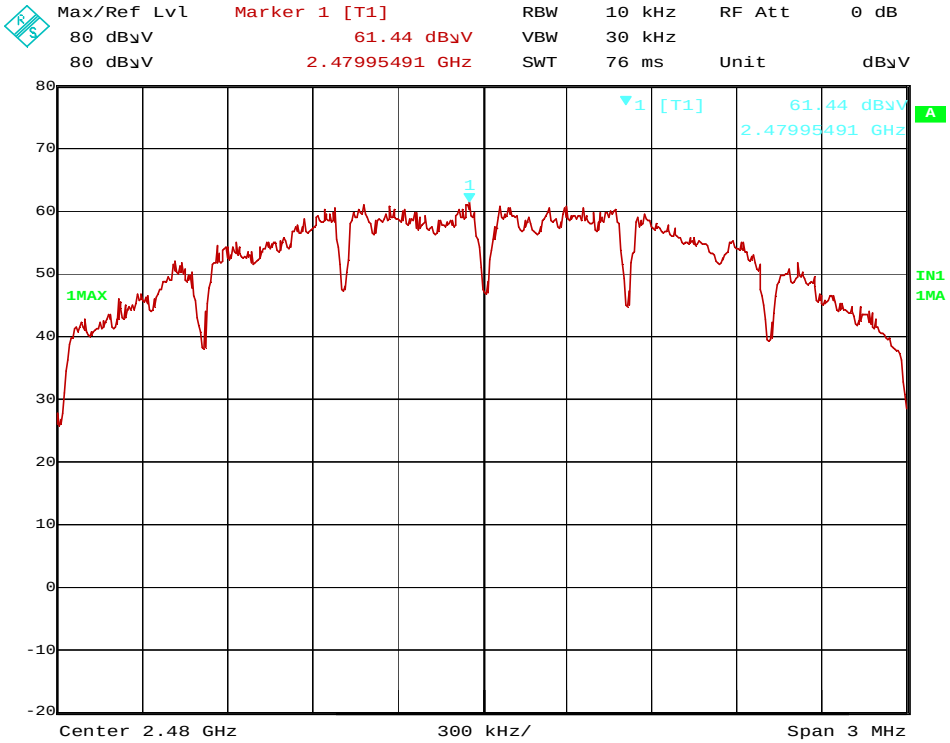
The conversion from radiated to conducted values was performed using the formulas in 5.2.1.

5.4.2 Test result

Ambient temperature	21 °C	Relative humidity	40 %

The following results were measured in a radiated setup. The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

PSD ch 26 0°.wmf: Power Spectral Density (operation mode 3):



Operation Mode	Peak Frequency [MHz]	Measured Voltage (radiated) [dBµV/10kHz]	Measured Power (radiated) [dBm/10kHz]	Free Space Loss [dB]	Receiver Antenna Gain [dB]	Cable attenuation [dB]	Power Spectral Density Level [dBm/10kHz]	Power Spectral Density Limit [dBm/3kHz]
1	2404.752	60.7	-46.3	49.7	9.6	3	-3.2	8
2	2440.469	60.8	-46.2	49.8	9.7	3	-3.1	8
3	2480.291	61.4	-45.6	49.9	9.8	2.9	-2.6	8
Measurement uncertainty			+2.2 dB / -3.6 dB					

Power Spectral Density Level = Measured Power radiated +Free Space Loss-Receiver Antenna Gain+Cable attenuation

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

6, 8 -11, 13, 17, 18, 32, 33

5.5 Band-edge compliance

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

The EUT was measured in a radiated setup within an anechoic chamber. The radiated measurement setup was made according 5.6.1.

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 ≥ 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 stabilise.
- 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 ≥ 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.

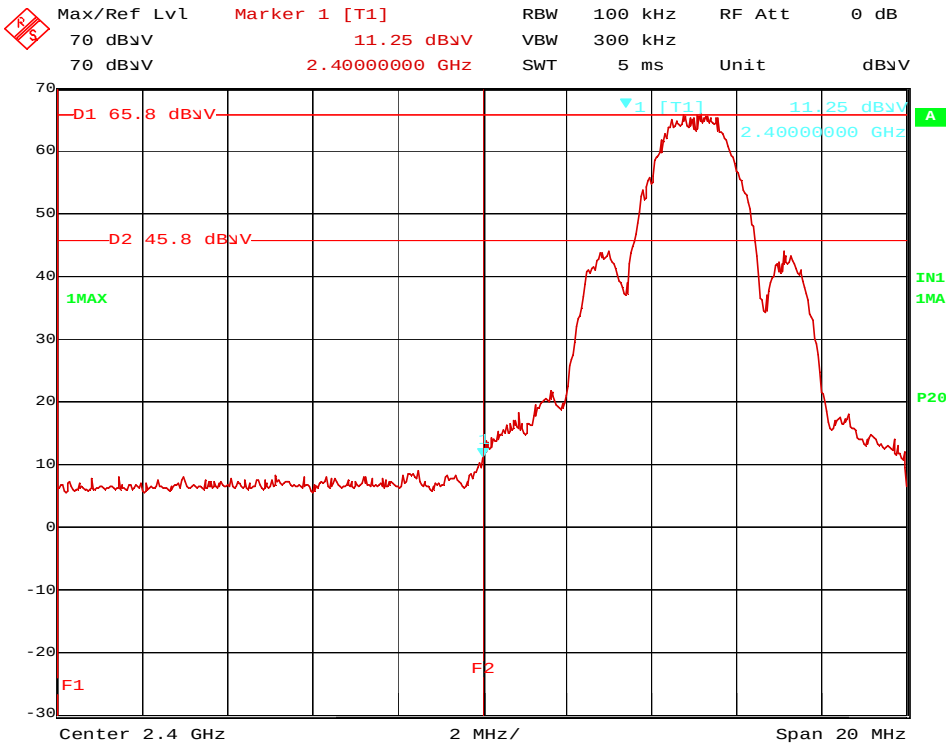
The measurements were performed at the lower end of the 2.4 GHz band.

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

Ambient temperature	21 °C	Relative humidity	40 %

The following results were measured in a radiated setup.
The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

145863_BandEdgeLow_Pos1_ch11.wmf: conducted band-edge compliance (operation mode 1):



Operation Mode	ZigBee channel	Band-Edge	Reference Level [dBµV]	Limit [dBµV]	Unwanted Emission Frequency MHz	Unwanted Emission Value [dBµV]	Margin dB
1	11	low	65.8	45.8	2400.000	11.3	34.5
Measurement uncertainty			+2.2 dB / -3.6 dB				

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
6, 8 -11, 13, 17, 18, 32, 33

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

The EUT was measured in a radiated setup within an anechoic chamber. The radiated measurement setup was made according 5.6.1.

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.

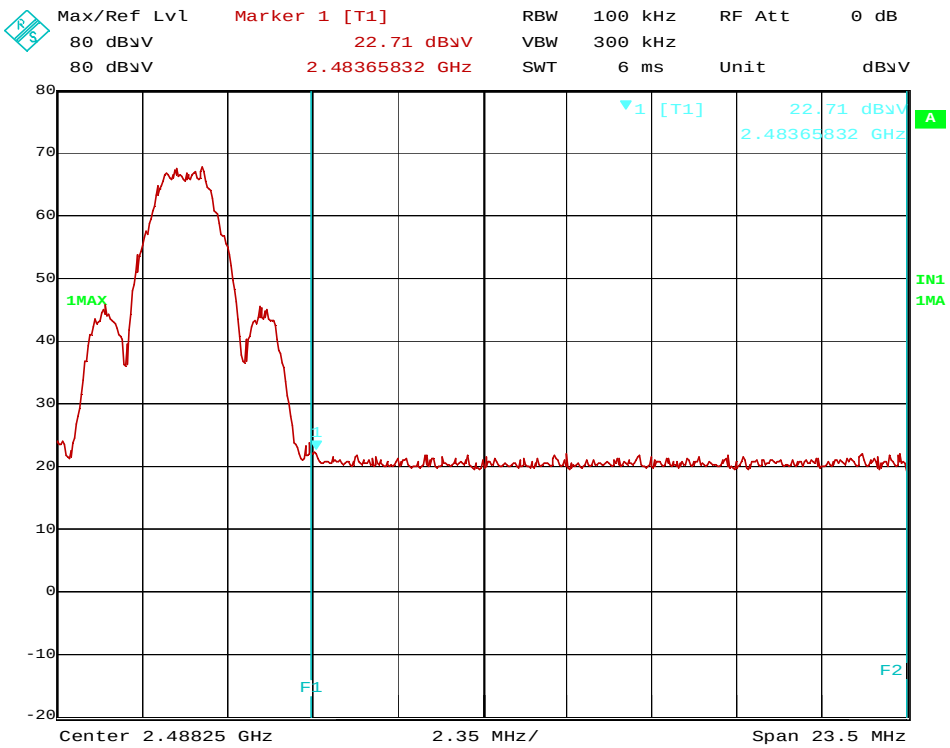
The measurement was performed at the lower and the upper end of the 2.4 GHz band.

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

Ambient temperature	22 °C	Relative humidity	59 %

The plot shows an exemplary measurement result for the worst documented case. The other results are listed in the following table.

145863_UpperBandEdge_Pos1_ch26.wmf: conducted band-edge compliance (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.	Pos.
2483.7	64.8	74.0	9.2	32.4	28.6	0	3.8	150	Hor.	1
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.	Pos.
2483.7	53.3	54.0	0.7	20.9	28.6	0	3.8	150	Hor.	1
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
6, 8 -11, 13, 17, 18, 32, 33

5.6 Maximum unwanted emissions

5.6.1 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 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an open area test side 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.

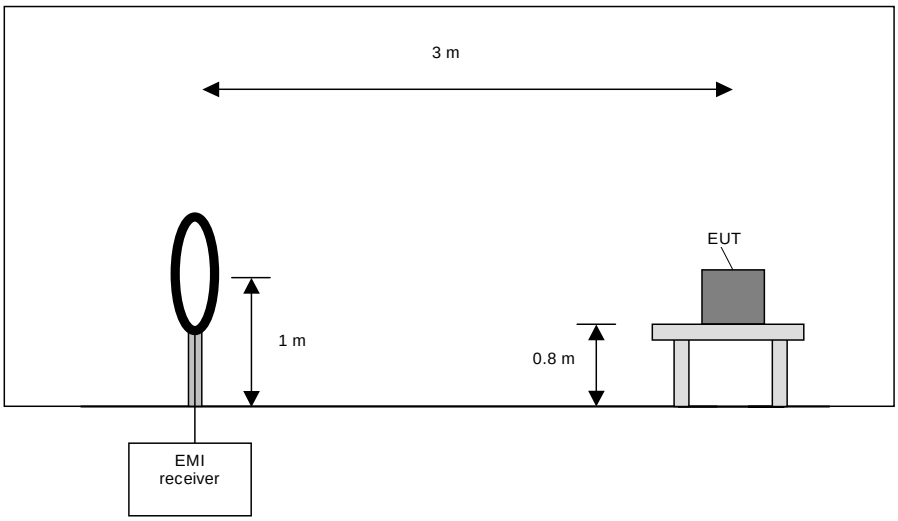
Preliminary measurement (9 kHz to 30 MHz):

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 set up 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 (because of EUT is a module and might be used in a handheld equipment application).
7) Rotate the measuring antenna and repeat steps 1) to 5).

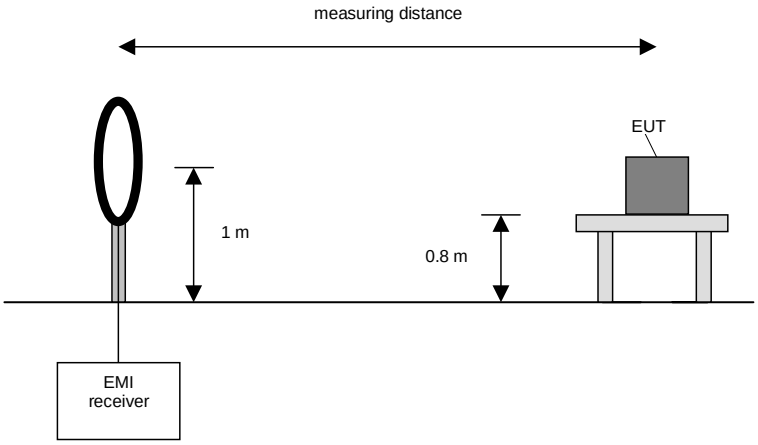
Final measurement (9 kHz to 30 MHz):

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. 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 Section 15.31 (f) (2) [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 Section 15.209 (d) [2].

On the frequencies, which were detected during the preliminary measurements, 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 (if the EUT is a module and might be used in a handheld equipment application).

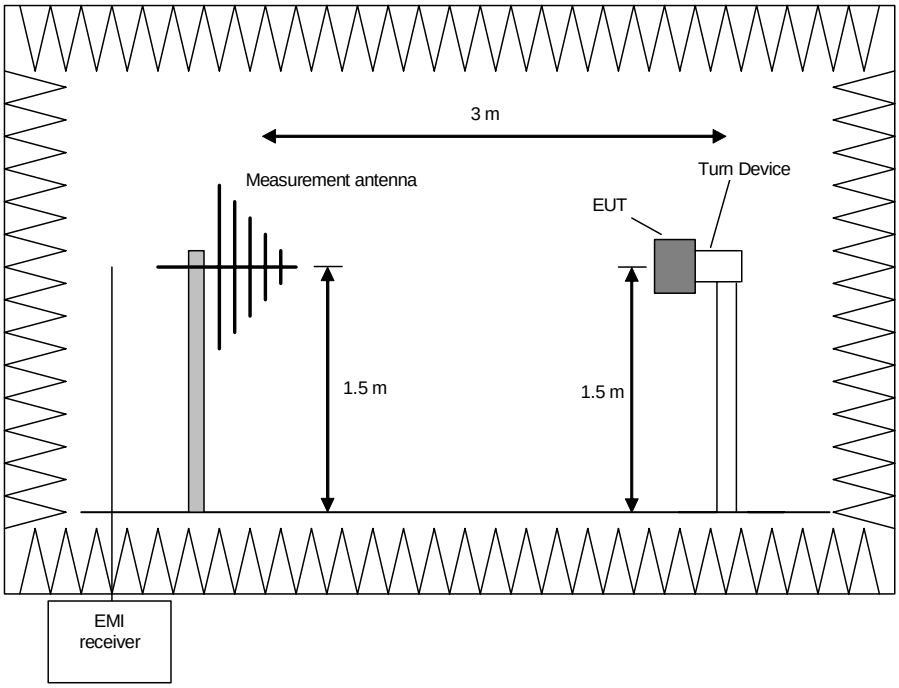
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. 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 polarisation 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:

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

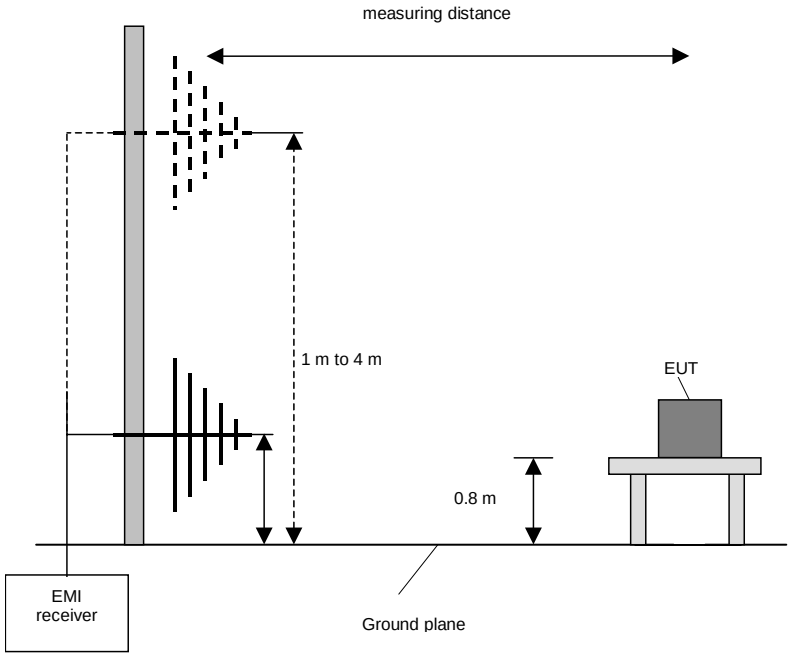
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarisation of the measuring 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 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 (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 40 GHz)

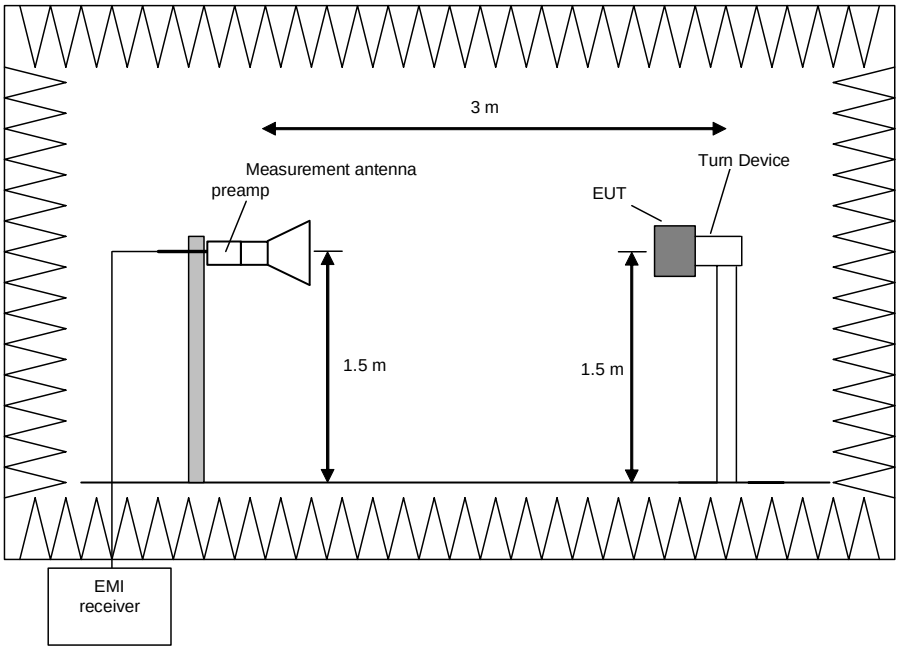
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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 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 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:

Prescans were performed in the frequency range 1 to 40 GHz.
The following procedure will be used:

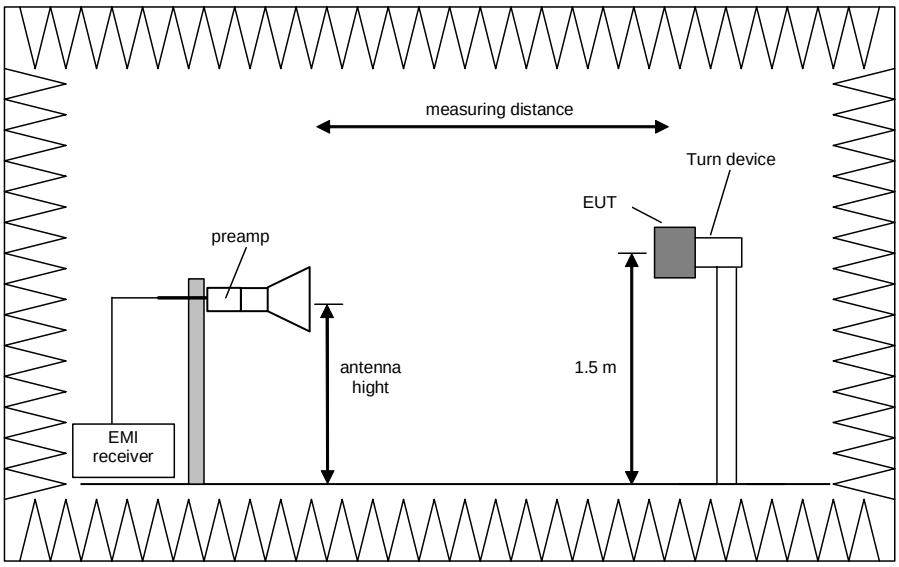
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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 polarisation, 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 40 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 26.5 GHz and 26.5 – 40 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 polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
3) Set the spectrum analyser 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.

5.6.2 Test results (radiated emissions) – Emissions from internal antenna and cabinet

5.6.2.1 Preliminary radiated emission measurement

Ambient temperature	21 °C	Relative humidity	40 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m and on a turn device on 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 the 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 3.3 V via an AC/DC Adapter.

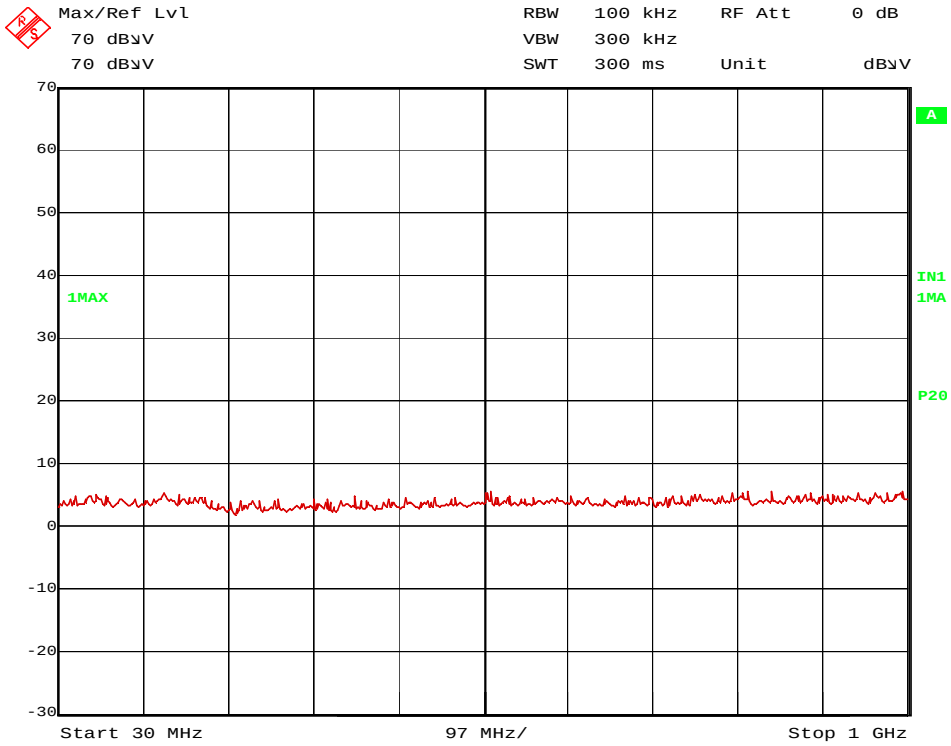
Remark: The lowest internal frequency of the EUT is 32 MHz, therefore only emissions starting from 30 MHz were measured for this test report.

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 equal for all antenna ports, transmit frequencies, modulation schemes and data rates. Therefore only the results of an exemplary test case are submitted below.

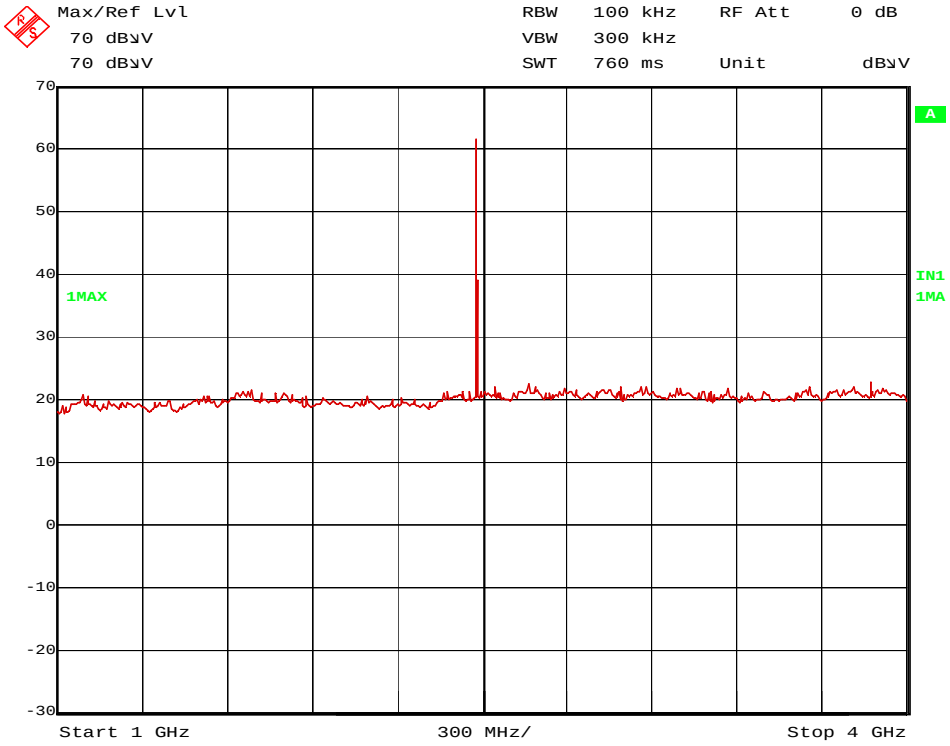
Only for channel 26 spurious emissions could be found, therefore only plots of this range are submitted below.

145863_SpurEmiss_Pos1_ch26_30M-1GHz.wmf: Spurious emissions from 30 MHz to 1 GHz:

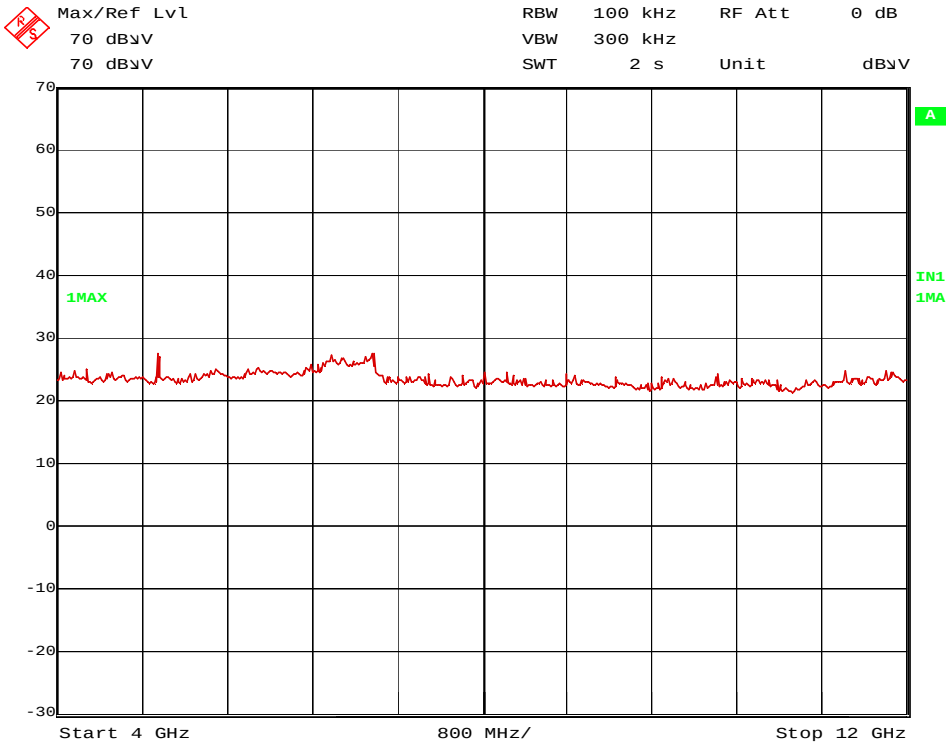


Transmitter operates at the upper end of the assigned frequency band (operation mode 3)

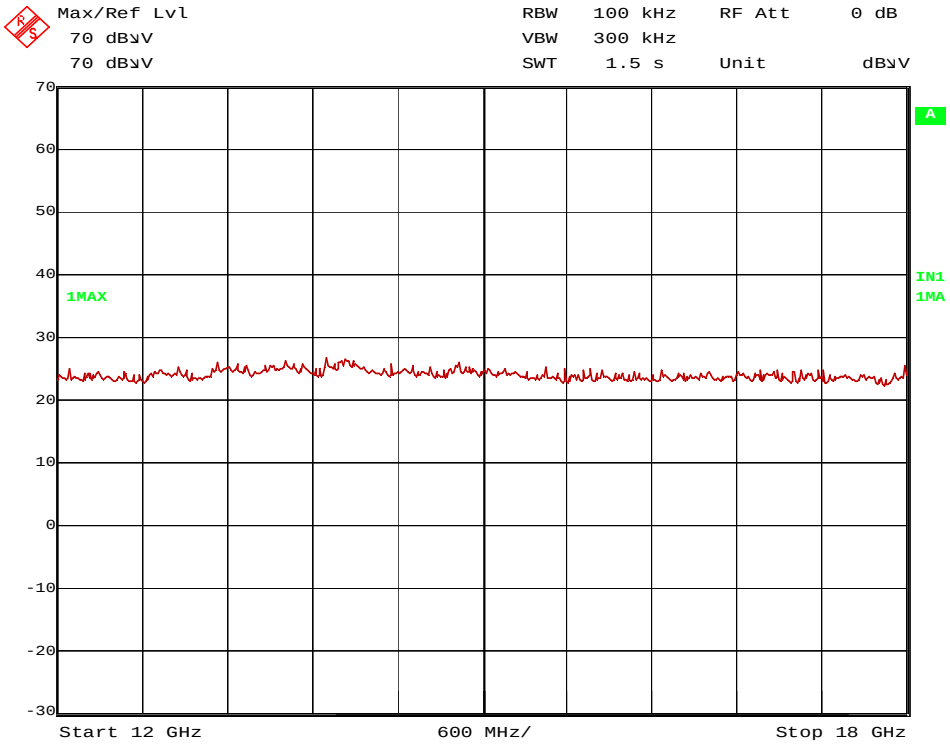
145863_SpurEmiss_Pos1_ch26_1-4GHz.wmf: Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



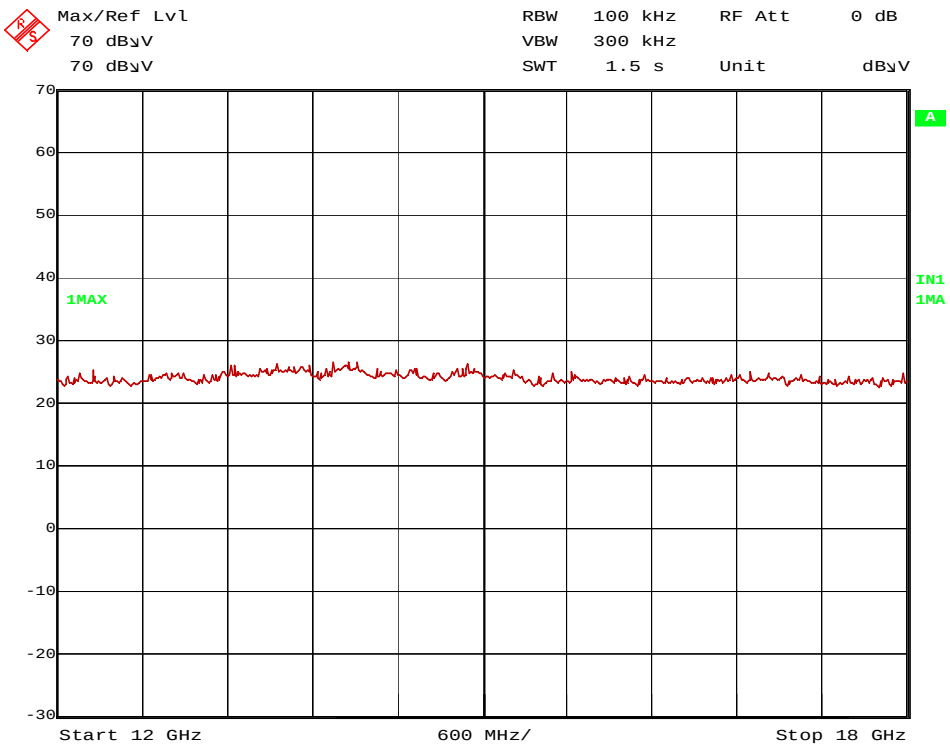
145863_SpurEmiss_Pos3_ch26_4-12GHz.wmf: Spurious emissions from 4 GHz to 12 GHz (operation mode 3):



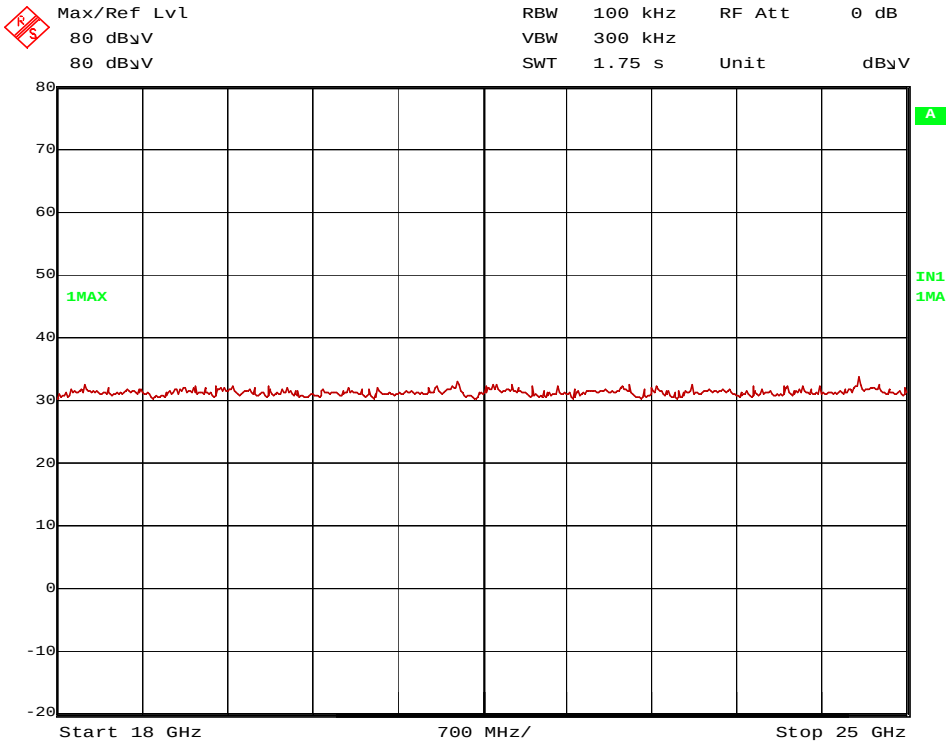
145863_SpurEmiss_Pos1_Hor_ch26_12-18GHz.wmf: Spurious emissions from 12 to 18 GHz
Horizontal antenna polarization (operation mode 3):



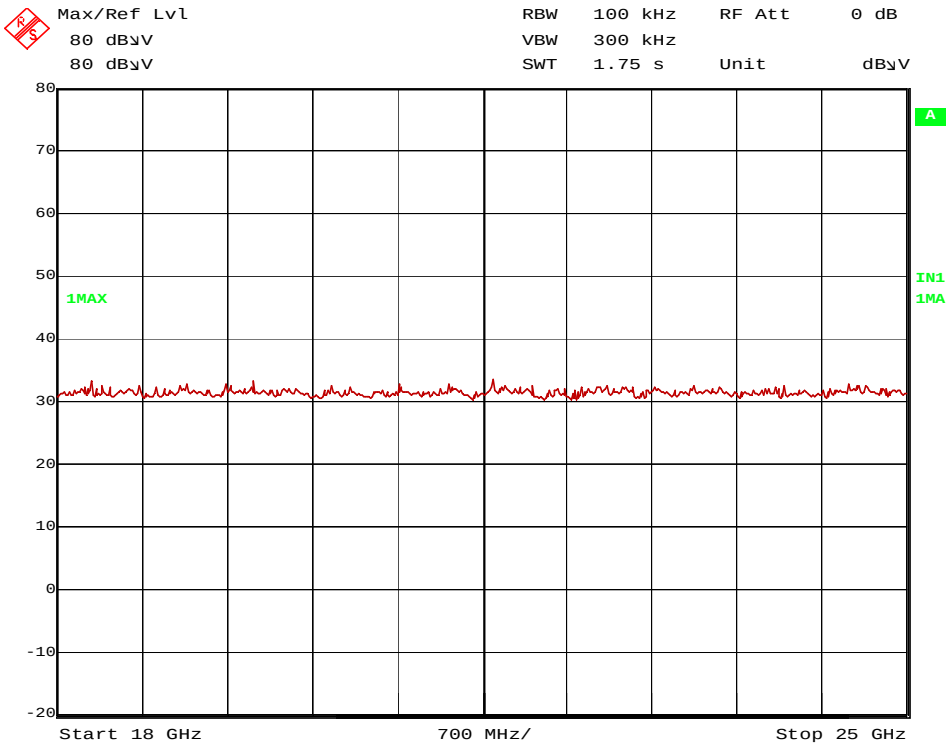
145863_SpurEmiss_Pos1_Hor_ch26_12-18GHz.wmf: Spurious emissions from 12 to 18 GHz
Vertical antenna polarization (operation mode 3):



145863_SpurEmiss_Pos1_Hor_ch26_18-25GHz.wmf: Spurious emissions from 18 – 25 GHz Horizontal antenna polarization (operation mode 3):



145863_SpurEmiss_Pos1_Ver_ch26_18-25GHz.wmf: Spurious emissions from 18 – 25 GHz Vertical antenna polarization (operation mode 3):



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

- 4960 MHz.

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

- None

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

TEST EQUIPMENT USED FOR THE TEST:
5, 6, 8 – 15, 17 – 24, 33

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

No emissions could be found in the final measurement on the open area test site, therefore no results for the final measurements are submitted.

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

Ambient temperature	21 °C	Relative humidity	40 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 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 3.3 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. On all other angles of the EUT and all other frequencies, apart from the one that is documented, no spurious emissions were found.

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.
4960.0	46.5	74.00	27.5	33.9	32.9	25.6	5.3	150	Hor.
+2.2 dB / -3.6 dB				+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.
4960.0	34.8	54.00	19.2	22.2	32.9	25.6	5.3	150	Hor.
+2.2 dB / -3.6 dB				+2.2 dB / -3.6 dB					

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
6, 8 - 15,17-25, 29, 32, 33

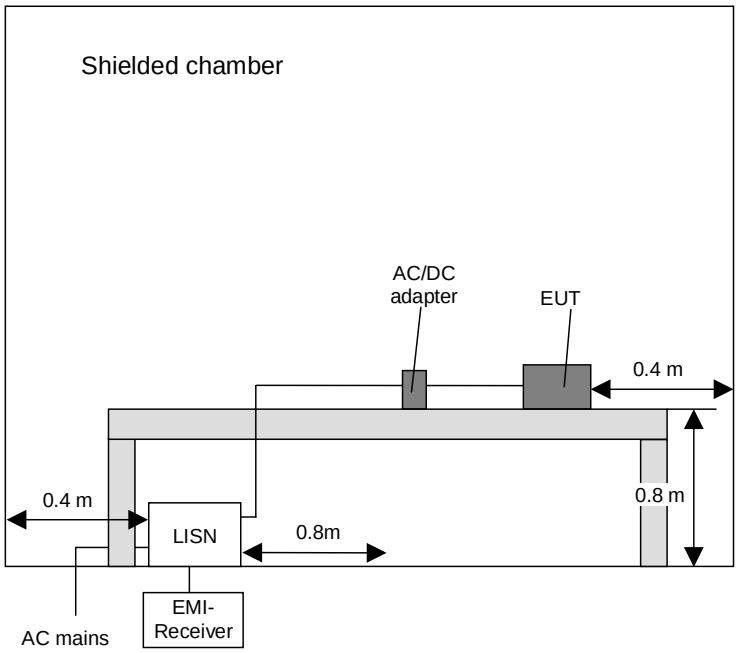
5.7 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.7.1 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 C63.10-2013 [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



5.7.2 Test results (conducted emissions on power supply lines)

Ambient temperature	22 °C	Relative humidity	44 %

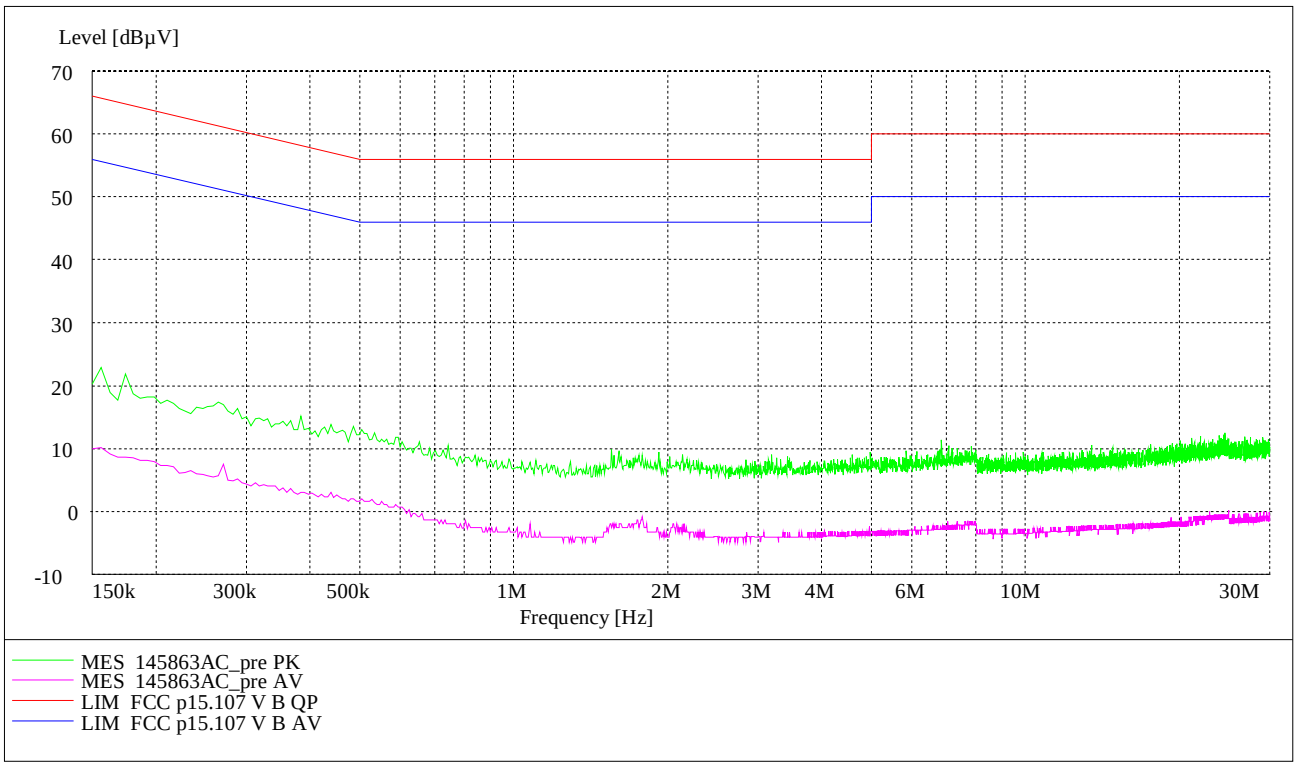
Position of EUT: For the test the EUT was connected with a ZigBee Router via wireless interface. The EUT was set to retransmit packets that were send from the ZigBee router.
The EUT was set-up on a non-conducting table of a height of 0.8 m.

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 laboratory power supply with a power of 3.3 V DC 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 +.



Data record name: 145863AC

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:
1 – 5, 32

6 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	01/22/2014	03/2015
						03/19/2015	03/2016
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	02/24/2014	03/2015
						09/03/2015	03/2016
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	11/10/2014	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	02/2014	02/2016
26	Power Meter	NRVD	Rohde & Schwarz	833697/030	480589	02/2014	03/2015
27	Peak Power Sensor	NRV-Z32	Rohde & Schwarz	849745/016	480551	02/2014	03/2015

6328	4 GHz High Pass Filter	WHKX4.0/18 G-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
32	Multimeter	Fluke 175	Fluke Deutschland GmbH	18660318	481515	10/2014	10/2016
33	Turn Device	TDF 1.5-10Kg	Maturo	-	482034	-	

7 REPORT HISTORY

Report Number	Date	Comment
F145863E2	2 December 2015	Document created

8 LIST OF ANNEXES

ANNEX A TEST SET-UP PHOTOS 4 pages

145863_17: Test setup - Radiated emission (fully anechoic chamber)
145863_18: Test setup - Radiated emission (fully anechoic chamber)
145863_19: Test setup - Radiated emission (fully anechoic chamber)
145863_12: Test setup – conducted emissions on power supply lines

ANNEX B EXTERNAL PHOTOGRAPHS 2 pages

145863_13.jpg: EUT with power supply cables – Top View
145863_14.jpg: EUT with power supply cables – Bottom View

ANNEX C INTERNAL PHOTOGRAPHS 3 pages

145863_05.JPG: EUT - top view, with shielding
145863_06.JPG: EUT - top view, shielding removed
145863_07.JPG: EUT – bottom view