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Test Report

Report Number:

F172289E3

Equipment under Test (EUT):

BT10

Wireless adaptor

Applicant:

Endress+Hauser GmbH+Co. KG

Manufacturer:

Endress+Hauser GmbH+Co. KG

ilac-MRA
DAkkS 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		16.04.2018
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		16.04.2018
	Name	Signature	Date

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 generalizations 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:	Endress+Hauser GmbH+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Ralph Stib
Phone:	0049 7622-28-1943
Fax:	0049 7622-28-81943
eMail Address:	ralph.stib@pcm.endress.com
Applicant partly represented during the test by the following person:	None

1.2 Manufacturer

Name:	Endress+Hauser GmbH+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Ralph Stib
Phone:	0049 7622-28-1943
Fax:	0049 7622-28-81943
eMail Address:	ralph.stib@pcm.endress.com
Applicant partly represented during the test by the following person:	None

1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02, FCC Test Firm Accreditation with the registration number 469623, designation number DE0004 and Industry Canada Test site registration SITE# IC3469A-1.

1.4 EUT (Equipment Under Test)

Test object: *	**Wireless adaptor**
Model / PMN: *	BT10
FCC ID: *	LCGBT10
IC-Number: *	2519A-BT10
HVIN:*	**BT10**
Order number:*	-
Serial number: *	BTM_3_001
PCB identifier: *	71374363 Index 3
Hardware version: *	01.00
Software version / FVIN: *	00.68.00

* Declared by the applicant

BTLE frequencies:				
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:	
Cables (connected to the EUT):**	Data and power supply
Power supply: *	Töllner laboratory power supply
Laptop PC:*	Fujitsu Lifebook S751 (PM No. 201036)

*Provided by the laboratory
**Provided by the applicant

1.5 Technical Data of Equipment

Fulfills Bluetooth specification: *	4.2 BLE (Bluetooth Low Energy)					
Antenna type: *	PCB					
Antenna name: *	None					
Antenna gain: *	2.40 dBi					
Antenna connector: *	None					
Supply voltage – Wireless adaptor: *	U_{nom} =	4.0 V DC	U_{min} =	3.0 V DC	U_{max} =	5.0 V DC
Type of modulation (Bluetooth Low Energy): *	1 Mbps: GFSK					
Operating frequency range:*	2402 MHz to 2480 MHz (Bluetooth Low Energy)					
Channel spacing: *	2 MHz (Bluetooth Low Energy)					
Number of channels: *	40 (Bluetooth Low Energy)					
Temperature range: *	-40 °C to +85 °C					
Lowest / highest internal clock frequency: *	32 MHz / 2480 MHz					

1.6 Dates

Date of receipt of test sample:	04.10.2017
Start of test:	04.12.2018
End of test:	12.04.2018

2 Operational States

Description of function of the EUT:

The equipment under test (EUT) is the Bluetooth Low Energy-radio part of a wireless adaptor for the implementation in measurement equipment.

The following states were defined as the operating conditions:

For the BTLE radio tests the “BT Testsoftware” as provided by the applicant was used to configure the HF parameter of the EUT via the controlling laptop. A USB connection was used to control the settings of the EUT.

For the tests the EUT was supplied with 4 V DC via laboratory power supply.

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	12 et seq.
DTS Bandwidth	2400.0 - 2483.5	15.247 (a) (2)	5.2 (a) [3]	Passed	15 et seq.
Peak Power Spectral Density	2400.0 - 2483.5	15.247 (e)	5.2 (b) [3]	Passed	20 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	22 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	26 et seq.

5 Results

5.1 Duty cycle

The measurement was performed radiated in an anechoic chamber.

The method described in chapter 11.6 b) of document [1] respectively 6.0 b) of [5] was used to perform the following test.

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.

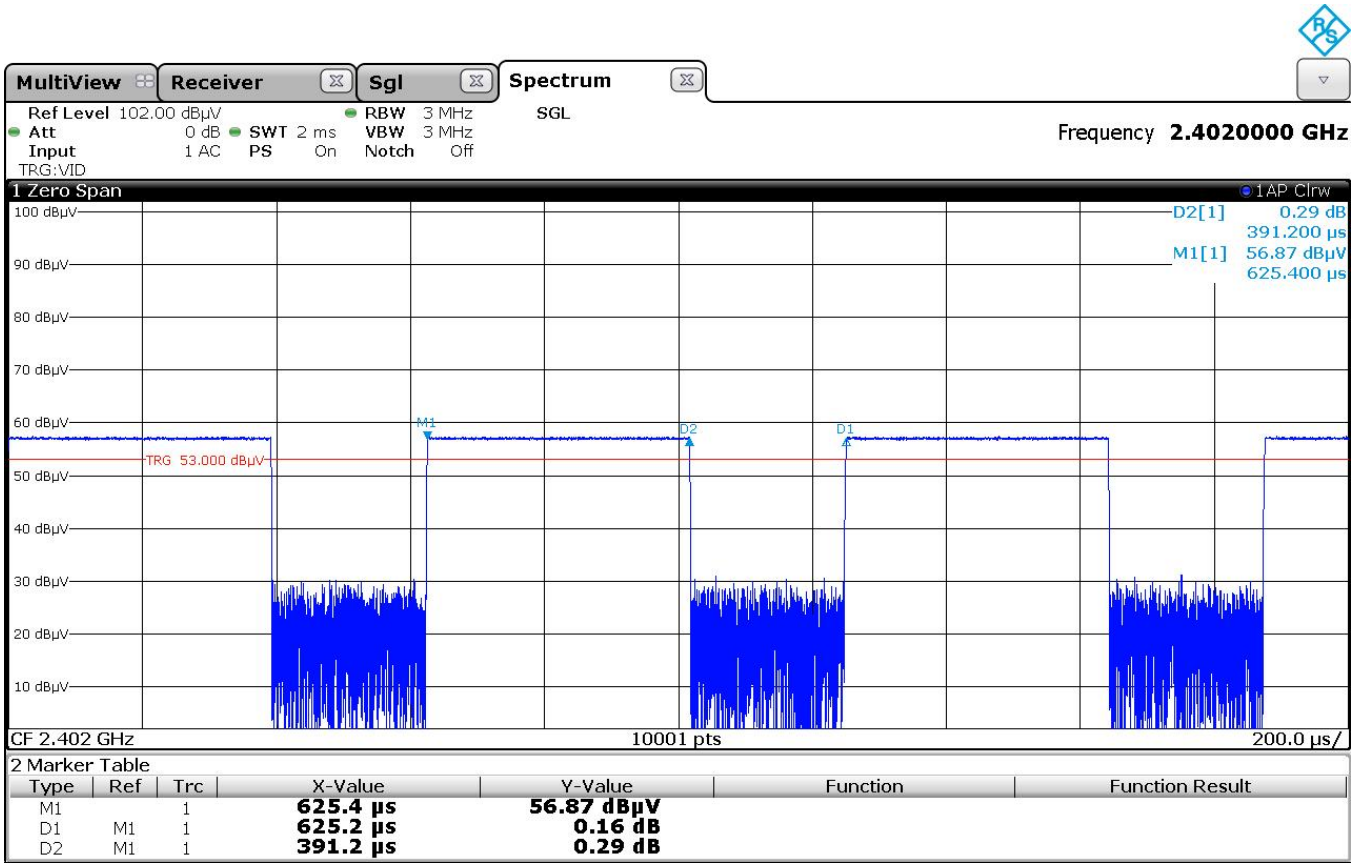
- Set the center frequency of the instrument to the center frequency of the transmission.
- Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
- Set VBW ≥ RBW.
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are > 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 ≤ 16.7 microseconds.)

5.1.1 Test results

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

Since only one modulation needs a duty cycle correction, only one duty cycle plot is submitted below.

Duty Cycle BLE_Ch00: Duty cycle measurement on channel 0 (operation mode 1):



Operation mode	TX_on [µs]	TX_ges [µs]	RBW [MHz]	50/T [kHz]	50/T < RBW?
1	391.2	625.4	3	128	Yes
2	391.2	625	3	128	Yes
3	391.2	625	3	128	Yes

Operation mode	Sweep points	Sweep time [µs]	Meas points	Meas points >100?	Duty cycle %	DCCF [dB]
1	10001	2000	3127	Yes	62.55	2.04
2	10001	2000	3125	Yes	62.59	2.03
3	10001	2000	3125	Yes	62.59	2.03

The DCCF (duty cycle correction factor) is calculated by:

$$DCCF = 10 * log_{10}\left(\frac{1}{Duty\ cycle}\right)$$

Therefore, for average measurements a correction factor of 2.04 dB is used for all tests.

TEST EQUIPMENT USED FOR THE TEST:

1 - 9

5.2 Maximum peak output power

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

The maximum peak output power was tested radiated in a fully anechoic room with the internal antenna.
An antenna-gain of 2.15 dBi (according to the datasheet) was used for the calculation.

Acceptable measurement configuration

Procedure 11.9.1.1 in [1], respectively 9.1.1 in [5] 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:

a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Set span ≥ [3 × RBW].
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

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

The measured Electric field strength was corrected with the following correction factor:

Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain[dB] = correction factor [dB]

The formula in 11.12.2.2 e) in [1] was used to calculate the EIRP power:

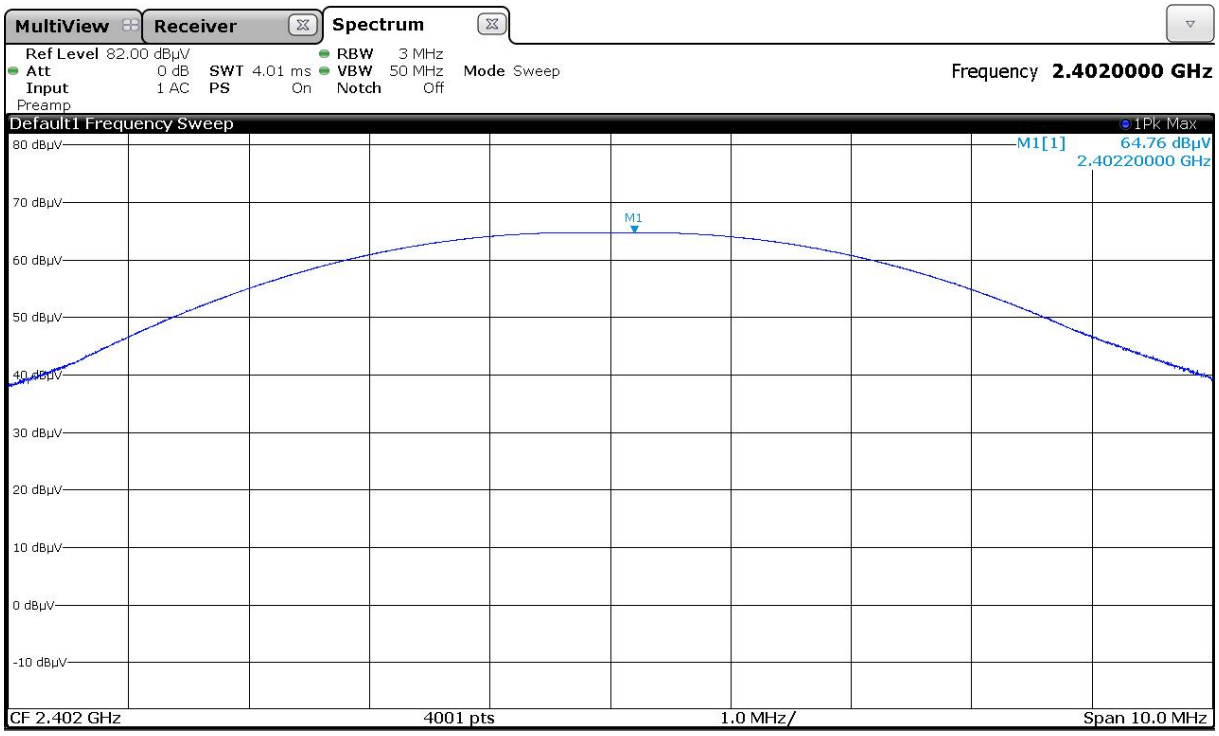
$E = EIRP - 20\log(d) + 104.8$
$EIRP = E - 95.3$

$MPOP = EIRP - G$

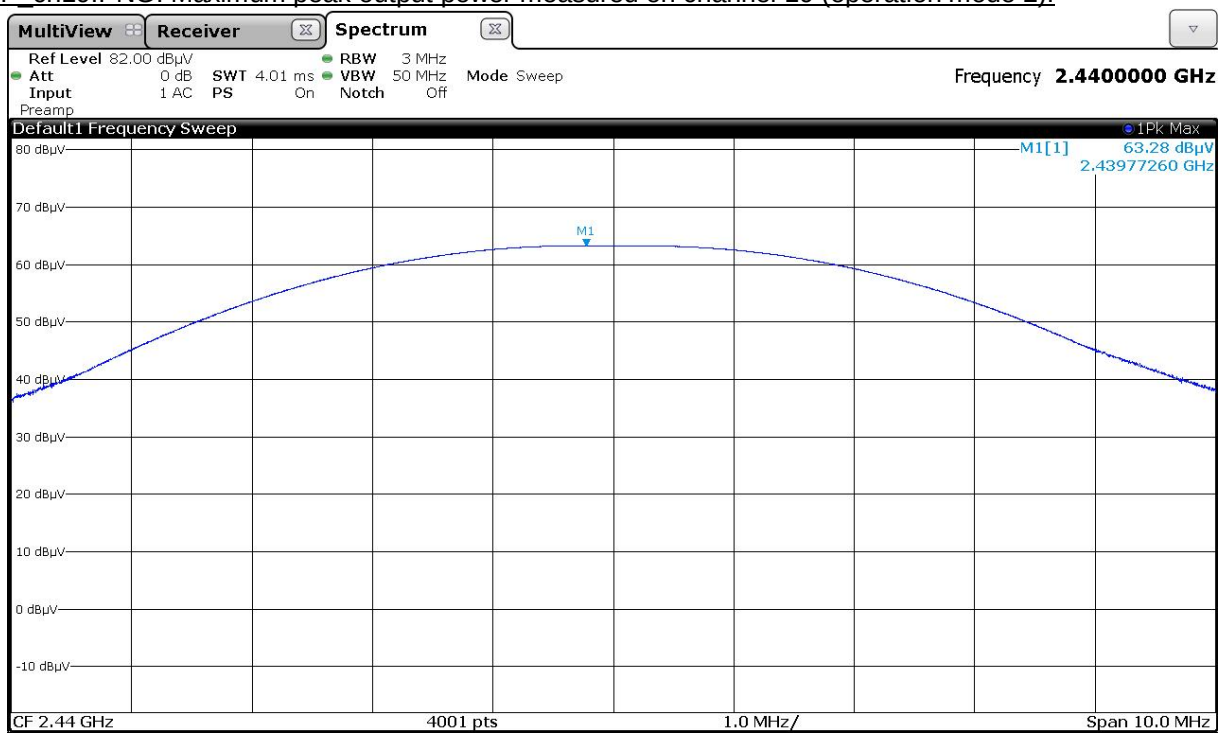
E is the electric field strength in dBµV/m
EIRP is the equivalent isotropically radiated power in dBm
d is the specified measurement distance in m
G is the antenna gain in dBi
MPOP is the maximum peak output power – measured antenna port conducted – in dBm

Result: radiated measurement on sample with integral antenna

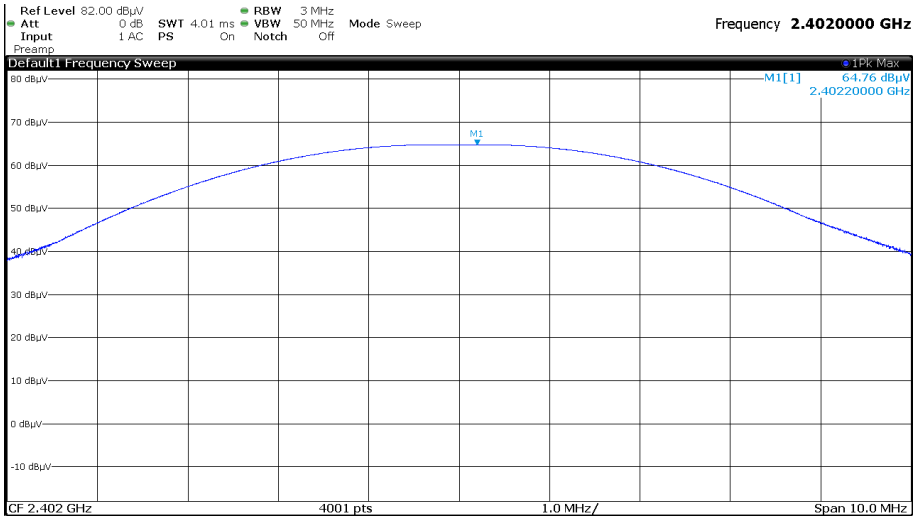
MPOP_ch0.PNG: Maximum peak output power measured on channel 0 (operation mode 1):



MPOP_ch19.PNG: Maximum peak output power measured on channel 19 (operation mode 2):



MPOP_ch39.PNG: Maximum peak output power measured on channel 00 (operation mode 1):



Operation mode	Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @ 3m [dBµV/m]	EIRP [dBm]	Maximum Peak Output power [dBm]	Limit [dBm]
1	2402	64.8	34.0	98.8	3.6	1.2	30
2	2440	63.3	34.2	97.5	2.3	-0.1	30
3	2480	62.3	34.1	96.4	1.2	-1.2	30

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 9

5.3 DTS Bandwidth / 99% Bandwidth

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

5.3.1 Method of measurement

For the DTS bandwidth measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1; respectively 8.1 option 1 of [5].

Acceptable measurement configurations

The measurement for the DTS bandwidth 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.

Procedure 6.9.3 [1] was used for measuring the 99 % bandwidth:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

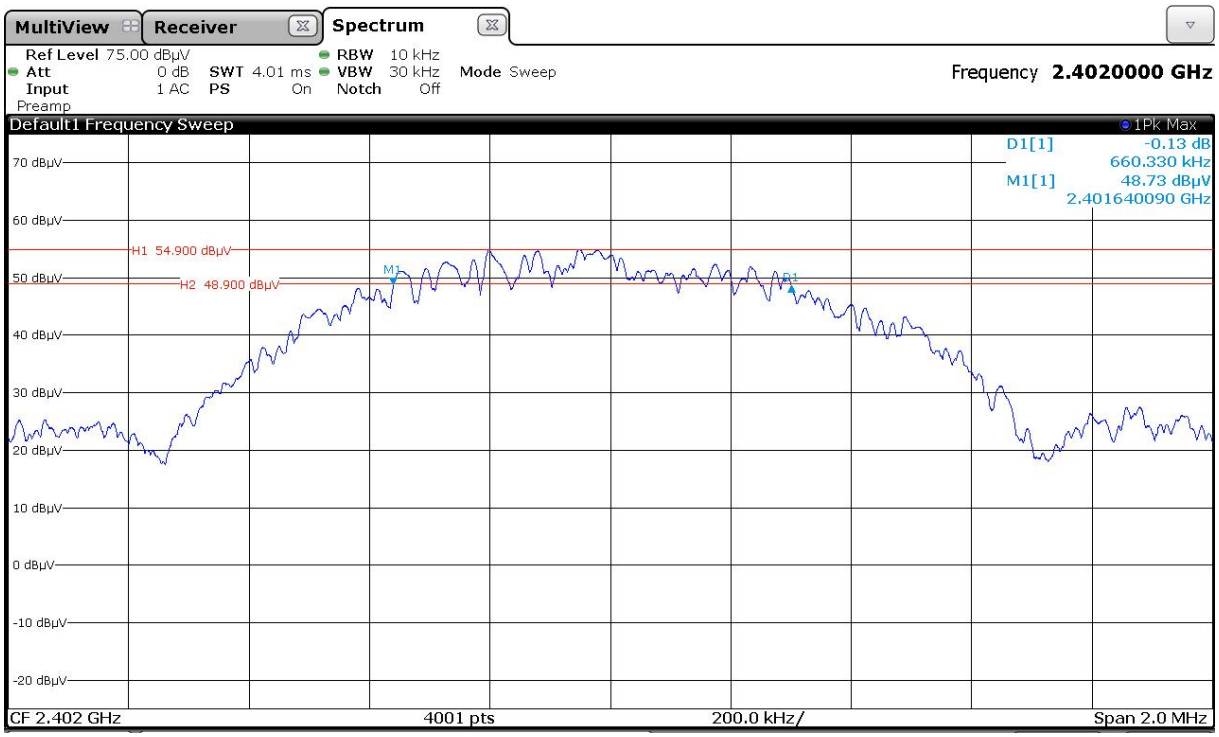
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2 [1].
- Step a) through step c) might require iteration to adjust within the specified range.
- e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
- f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
- g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.
- The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labelled. Tabular data maybe reported in addition to the plot(s).

Since this is only a relative measurement, no measurement level correction was performed.

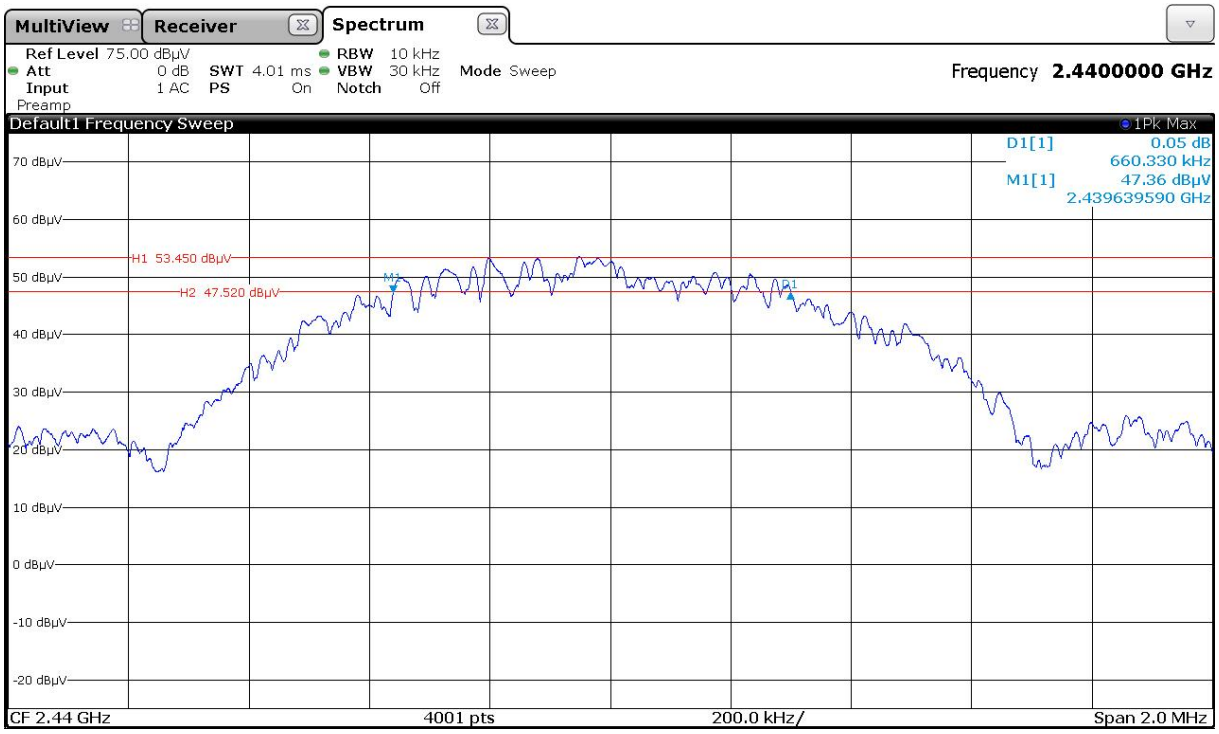
5.3.2 Test result

Ambient temperature	22 °C	Relative humidity	59 %

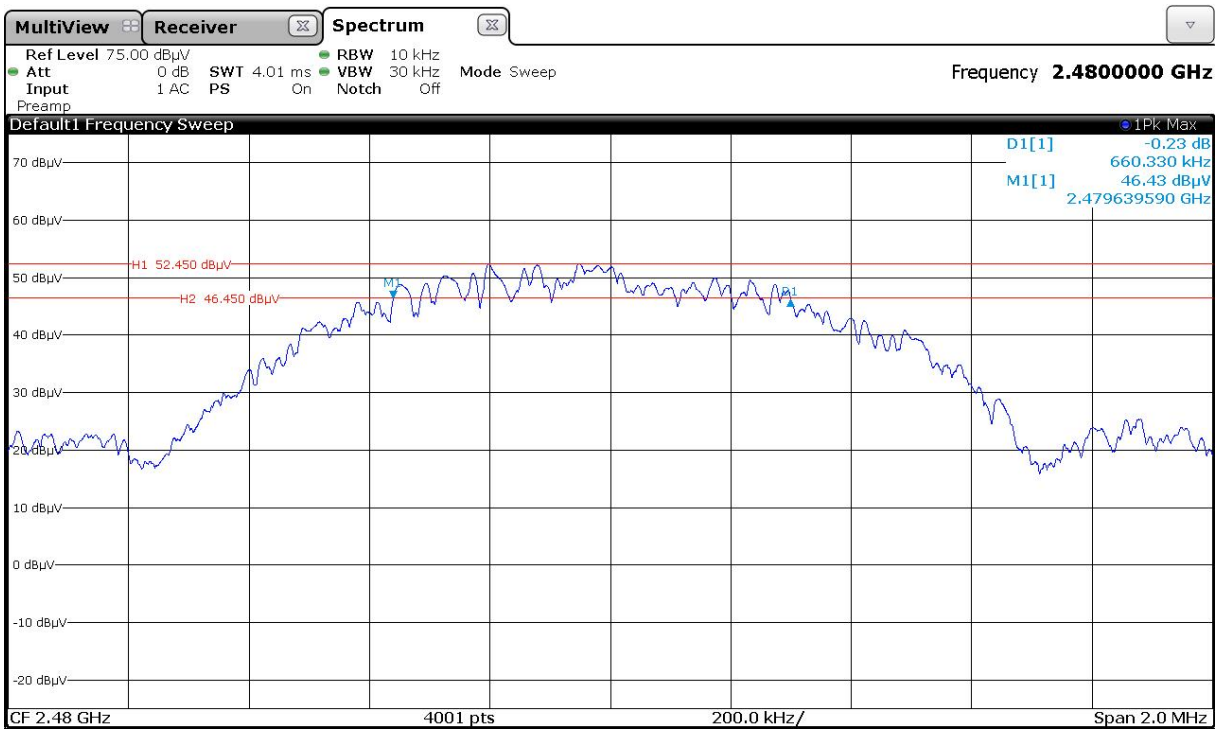
DTS_BW_ch0.wmf: 6-dB Bandwidth (operation mode 1):



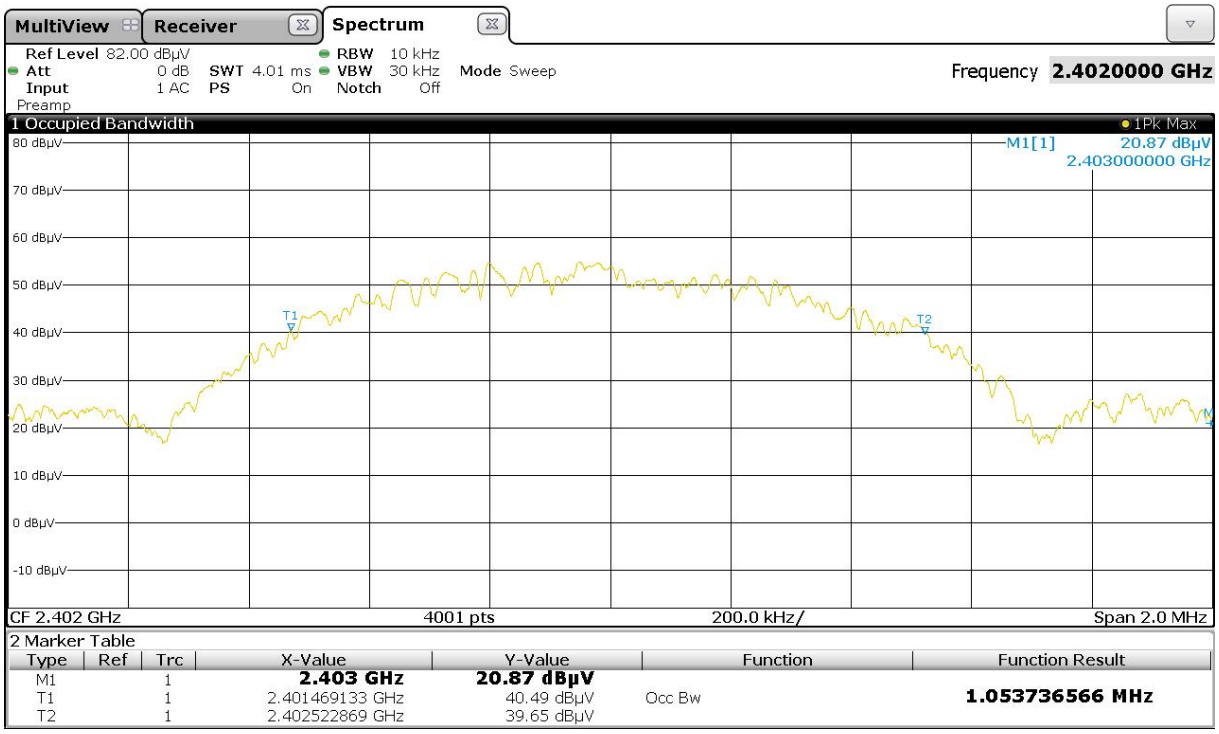
DTS_BW_ch19.wmf: 6-dB Bandwidth (operation mode 2):



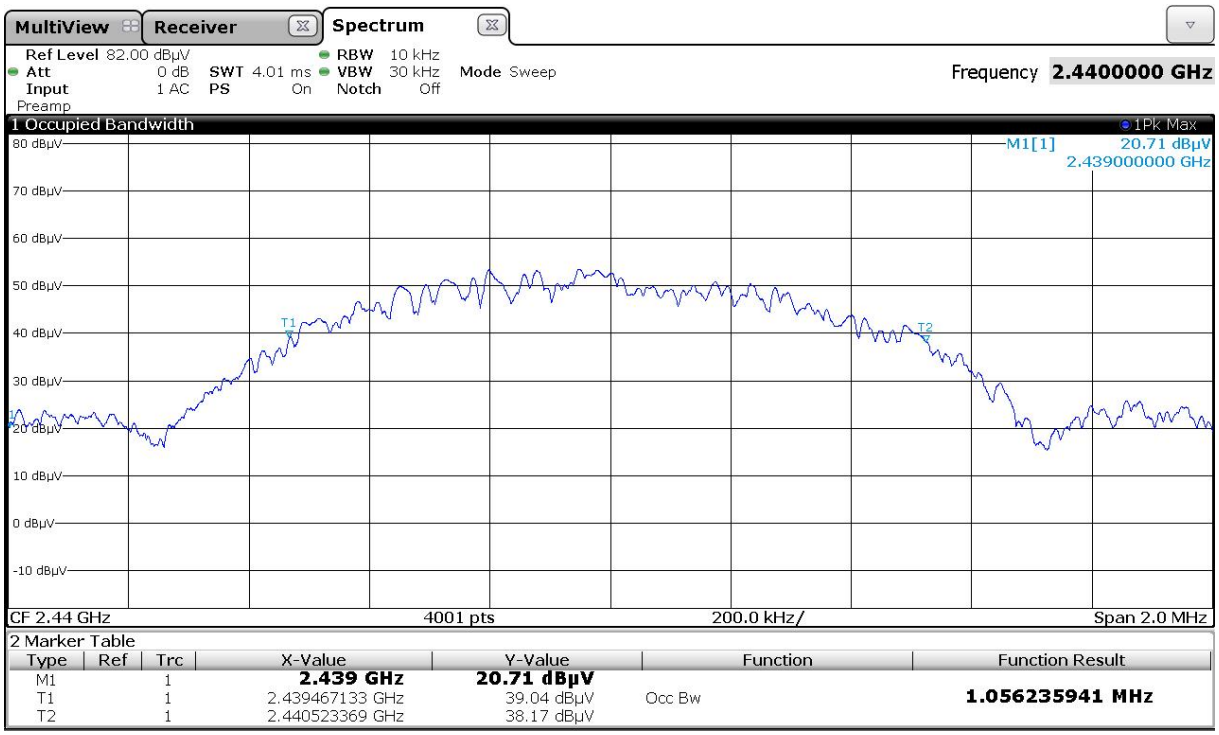
DTS_BW_ch39.wmf: 6-dB Bandwidth (operation mode 3):



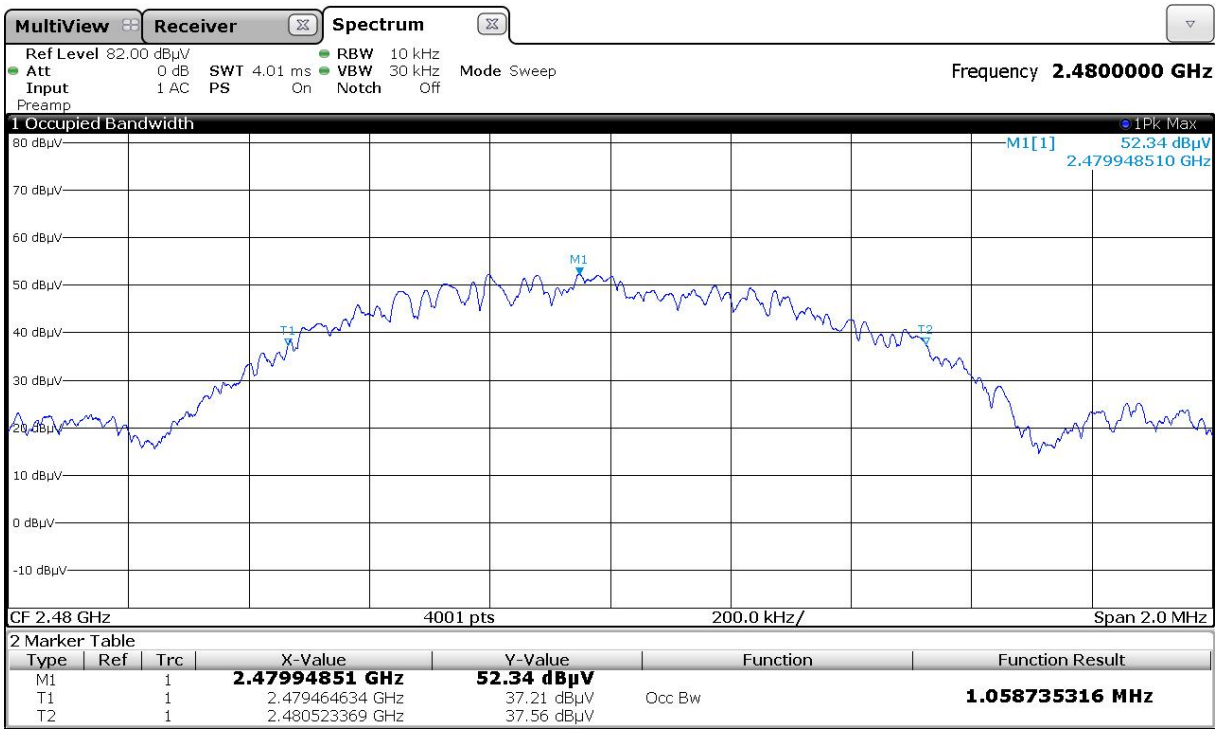
99%_BW_ch0.png: 99% Bandwidth (operation mode 1):



99%_BW_ch19.png: 99% Bandwidth (operation mode 2):



99%_BW_ch39.png: 99% Bandwidth (operation mode 3):



Operation Mode	Center Frequency [MHz]	Minimum 6-dB Bandwidth Limit [MHz]	6 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	2402	0.5	0.660	1.054	Passed
2	2440	0.5	0.660	1.056	Passed
3	2480	0.5	0.660	1.059	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 9

5.4 Peak Power Spectral Density

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

5.4.1 Method of measurement

For the peak power spectral density measurement, the EUT was measured radiated in the anechoic chamber.

The measurement procedure refers to part 11.10.2 of document [1] respectively 10.2 [5].

- Set analyzer 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.

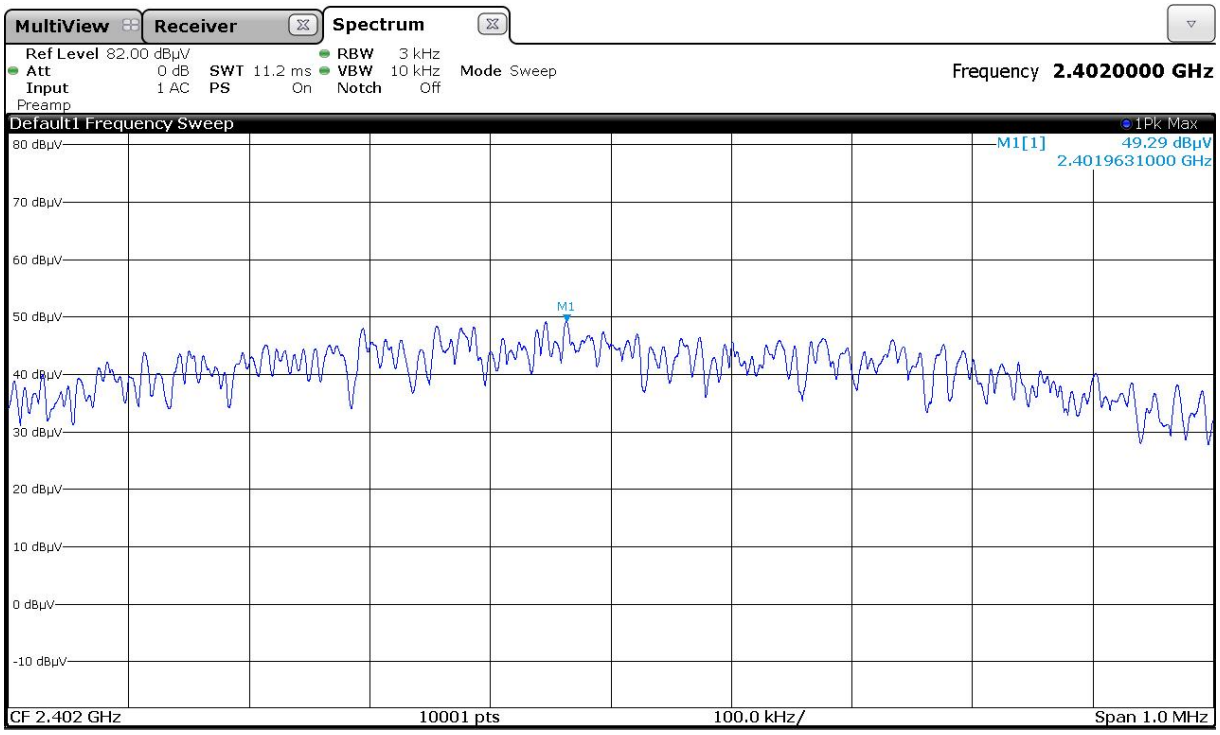
The measurement result in [dBmV/m] was calculated to [dBm] using the formula
in chapter 11.12.2.2 e) in [1].

5.4.2 Test result

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.

MPSD Ch0.wmf: Power Spectral Density (operation mode 1):



OP mode	Peak Frequency [MHz]	Reading [dBµV]	Corr. Fact. [dB/m]	Field strength @3m [dBµV/m]	EIRP [dBm / 3 kHz]	Result [dBm / 3 kHz]	PSD Limit [dBm / 3 kHz]	Result
1	2401.963	49.3	34	83.3	-11.9	-14.9	8	Passed
2	2439.946	47.8	34.2	82.0	-13.2	-16.2	8	Passed
3	2479.945	46.7	34.1	80.8	-14.4	-17.4	8	Passed
Measurement uncertainty					+2.2 dB / -3.6 dB			

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 9

5.5 Band-edge compliance

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

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

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1, respectively see chapter 11.0 in [5].

Acceptable measurement configurations

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 stabilize.
- Use the peak marker function to determine the maximum PSD level.

Measurement Procedure – Unwanted Emissions

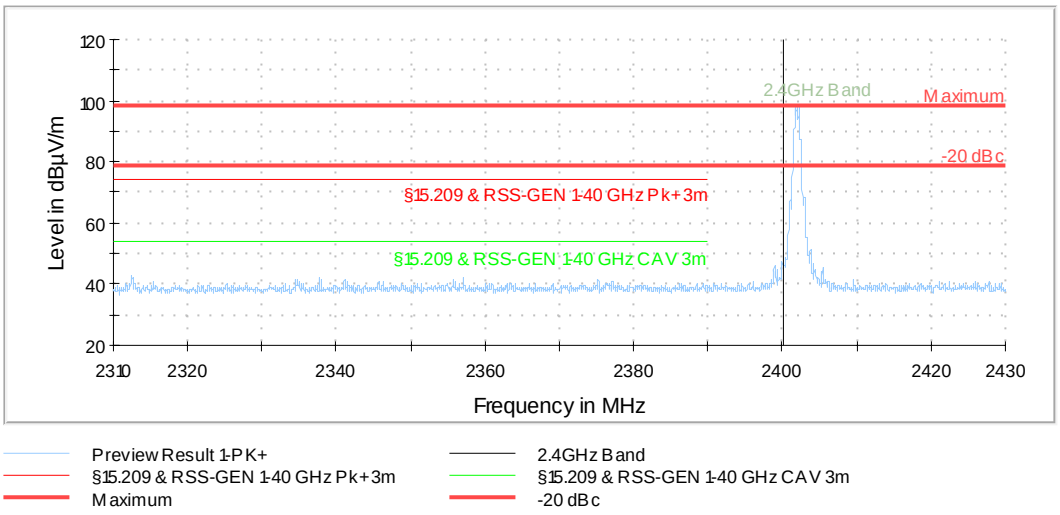
- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW ≥ 300 kHz.
- Detector = Peak.
- Ensure that the number of measurement points ≥ span/RBW.
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilize.
- Use the peak marker 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))

LowerBandEdge_ch00.wmf: radiated band-edge compliance at an unrestricted band-edge (operation mode 1):



Operation Mode	Tx Frequency [MHz]	Emission Frequency [MHz]	Reference Level [dBµV/m]	Limit [dBµV/m]	Emission Level [dBµV/m]	Margin [dB]	Result
1	2412	-	-	-	-	-	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 8, 10 - 12

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

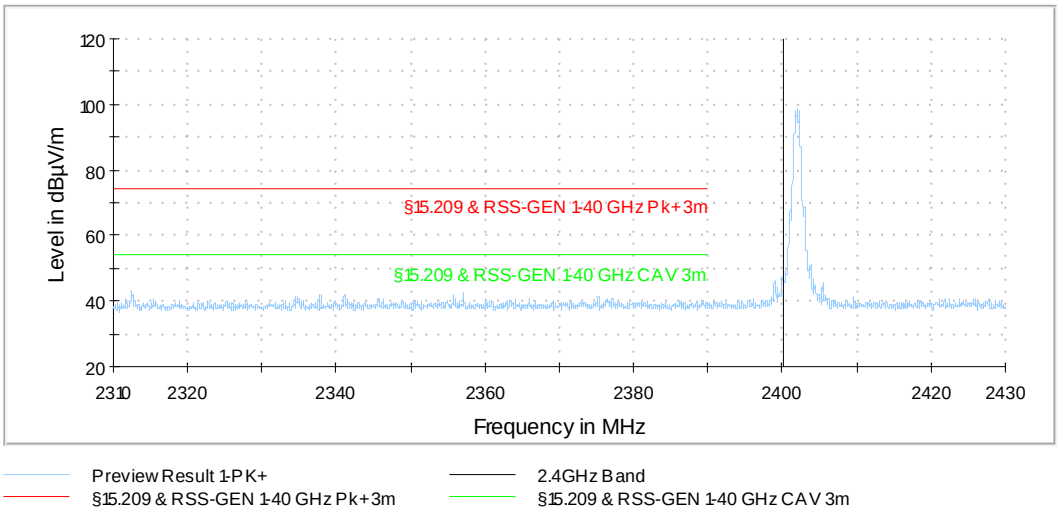
The EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1 respectively chapter 12.0 of [5].

Acceptable measurement configurations

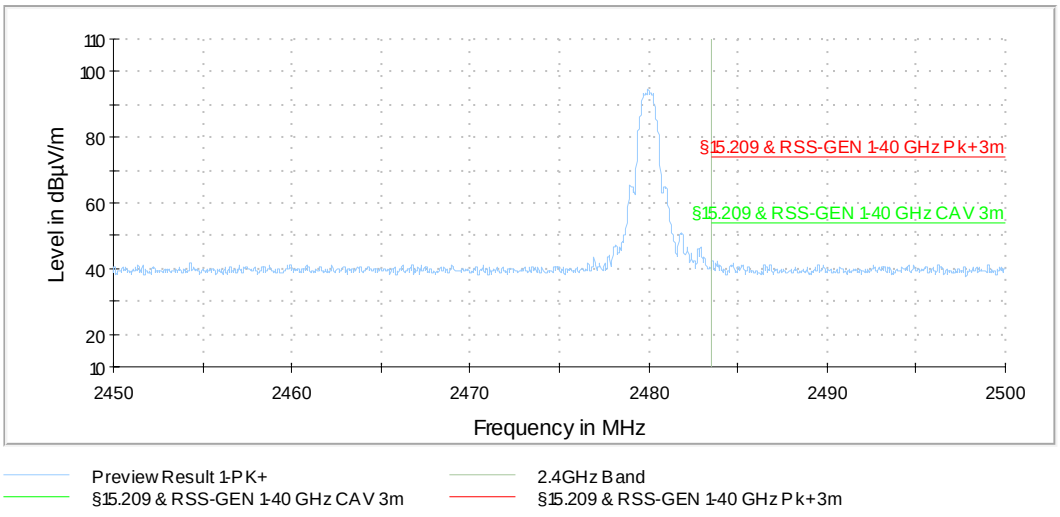
The same measurement configurations as described in 5.6.1. were used for the preview and final measurement.

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

LowerBandEdge ch0: radiated band-edge compliance at a restricted band-edge (operation mode 1):



UpperBandEdge ch39.wmf: radiated band-edge compliance at a restricted band-edge (operation mode 3):



Band edge compliance			Lower band edge			Operation mode 1			
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2312.400000	---	38.5	54	15.5	H	87	0	35.4	Passed
2312.400000	46.4	---	74	27.6	H	87	0	33.4	Passed
2337.750000	---	37.3	54	16.7	H	113	30	35.6	Passed
2337.750000	46.4	---	74	27.6	H	113	30	33.6	Passed
2357.130000	---	37.7	54	16.3	H	124	0	35.8	Passed
2357.130000	46.9	---	74	27.1	H	124	0	33.8	Passed
2398.980000	---	36.6	54	17.4	H	79	60	35.8	Passed
2398.980000	59.3	---	74	14.7	H	79	60	33.8	Passed
2312.400000	---	38.5	54	15.5	H	87	0	35.4	Passed
2312.400000	46.4	---	74	27.6	H	87	0	33.4	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

Band edge compliance			Upper band edge			Operation mode 3			
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2484.500000	---	33.8	54	20.2	H	358	30	36.0	Passed
2484.500000	48.5	---	74	25.5	H	358	30	34.0	Passed
2484.750000	---	33.7	54	20.3	V	253	120	36.0	Passed
2484.750000	46.1	---	74	27.9	V	253	120	34.0	Passed
2486.825000	---	33.8	54	20.2	V	0	150	36.0	Passed
2486.825000	45.7	---	74	28.3	V	0	150	34.0	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1 - 8, 10 - 12

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 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 above 1 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range above 1 GHz.

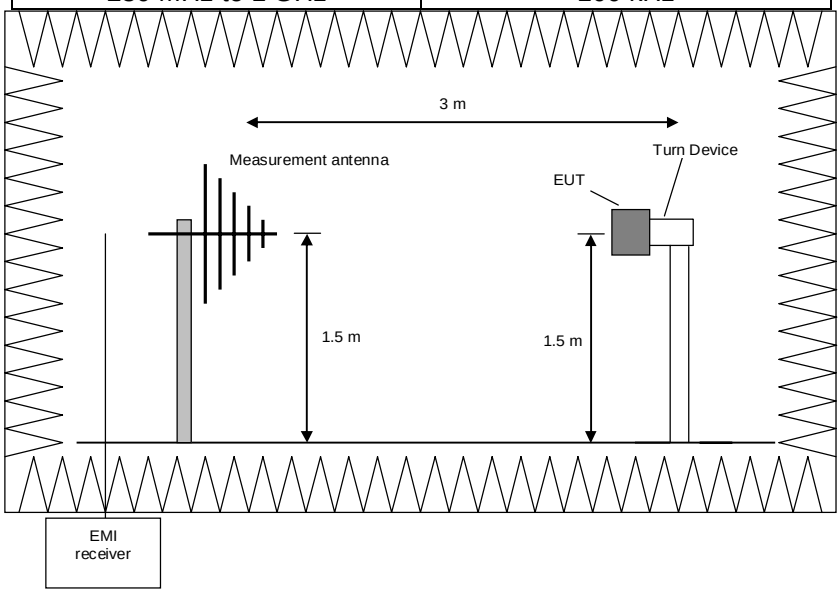
Preliminary measurement (30 MHz to 1 GHz)

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 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 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 1 GHz.
The following procedure will be used:

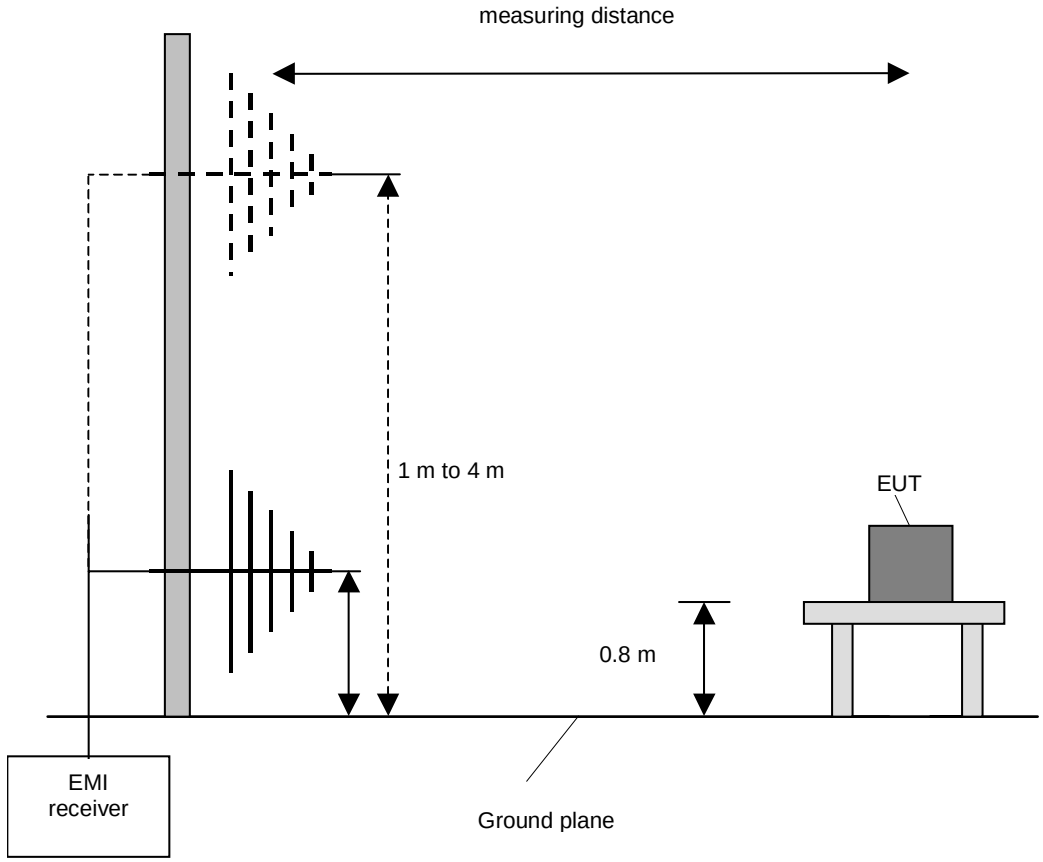
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
5. Make a hardcopy of the spectrum.
6. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) 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.

Preliminary and final measurement (1 GHz to 40 GHz)

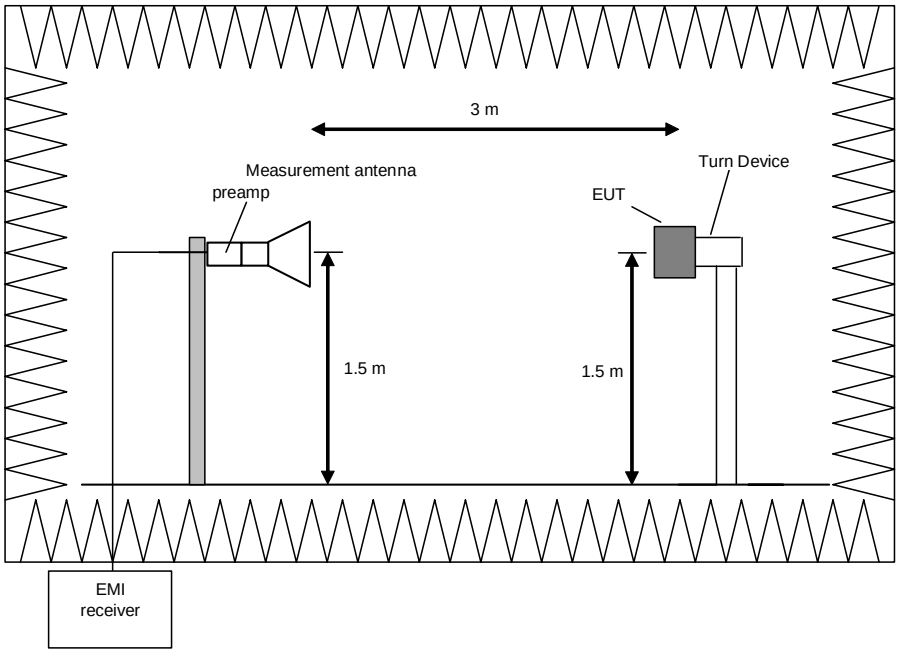
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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:

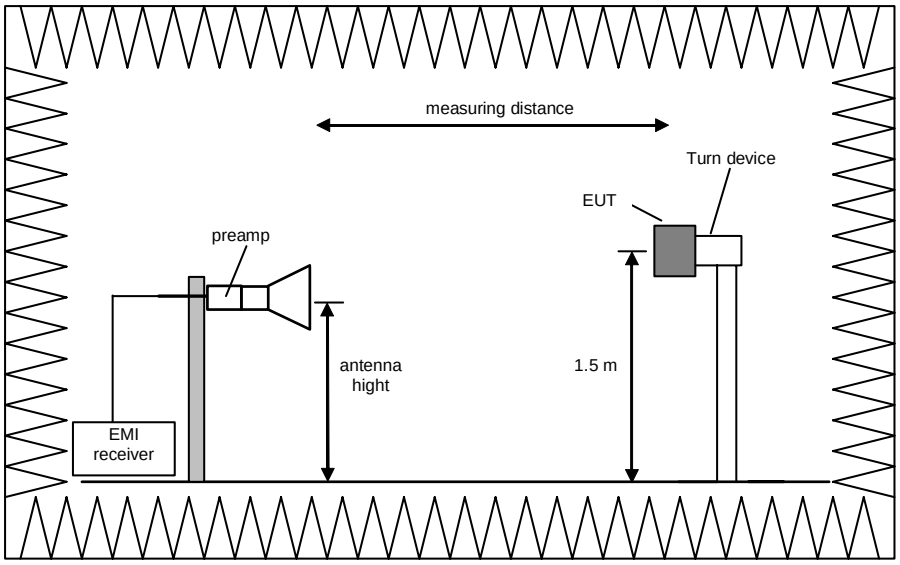
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an 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 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 25 /26.5 GHz and 26.5 GHz to 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 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 TT Pos. 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 30 MHz – 26.5 GHz

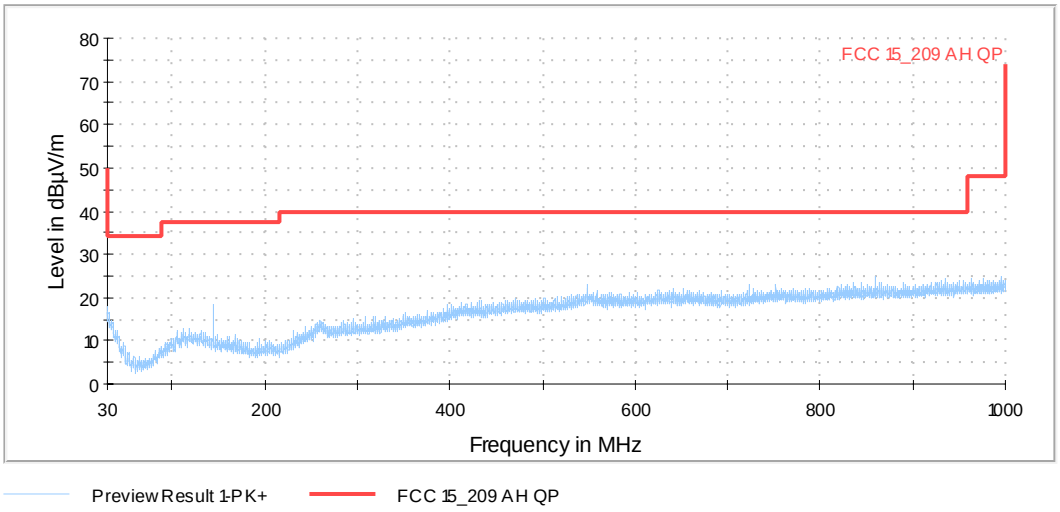
Measurements were done with a sample with integral antenna.

5.6.2.1 Preliminary radiated emission measurement 30 MHz – 26.5 GHz

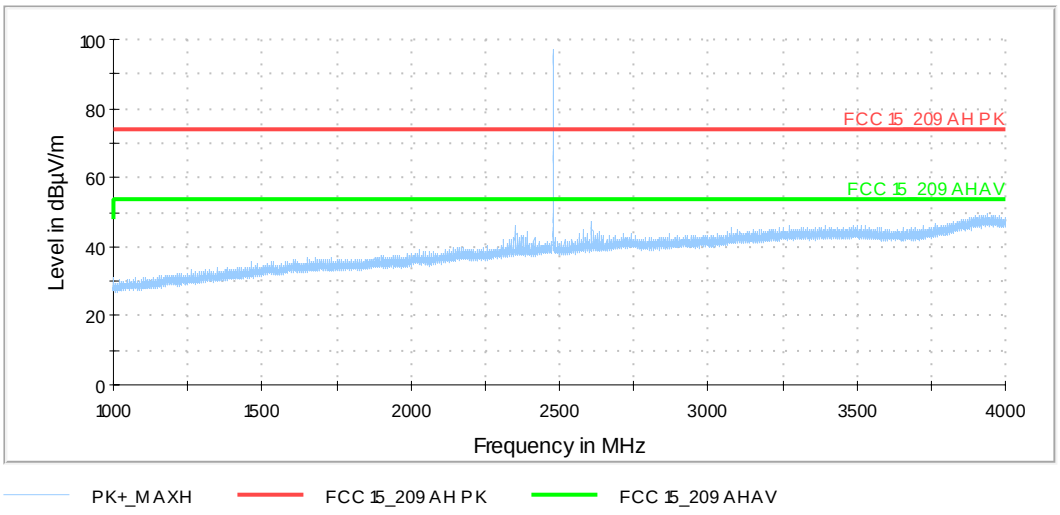
Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017

Position of EUT:	The EUT was set-up on a 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 the annex A in the test report.
Test record:	Only the plot of the worst case emission is submitted below.
Supply voltage:	During all measurements the EUT was powered with 4 V d.c..
Remark:	Since there were no differences in the spectrum for f < 1 GHz, only one representative plot is submitted below.

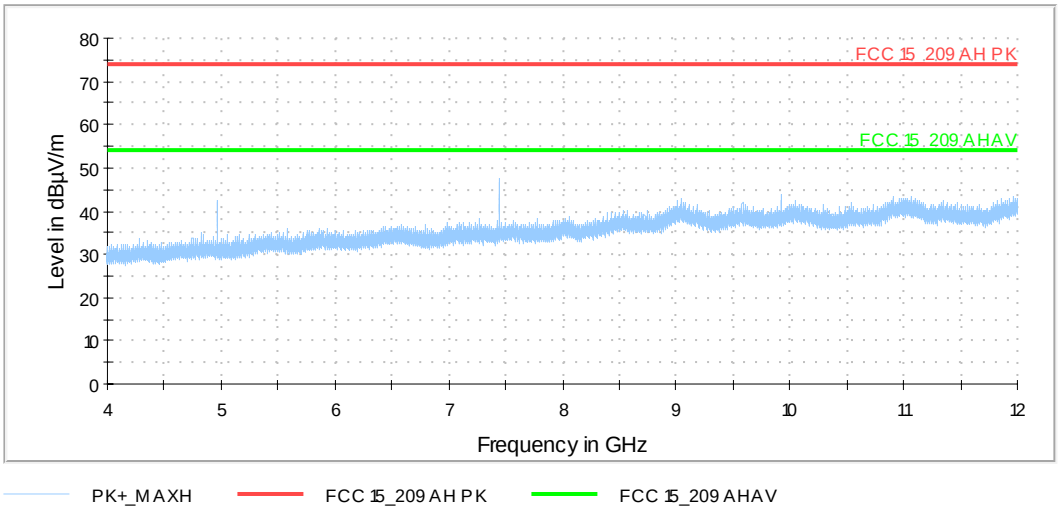
172289 30MHz-1GHz ch19 TX: Spurious emissions from 30 MHz to 1 GHz (operation mode 2):
(Preliminary results)



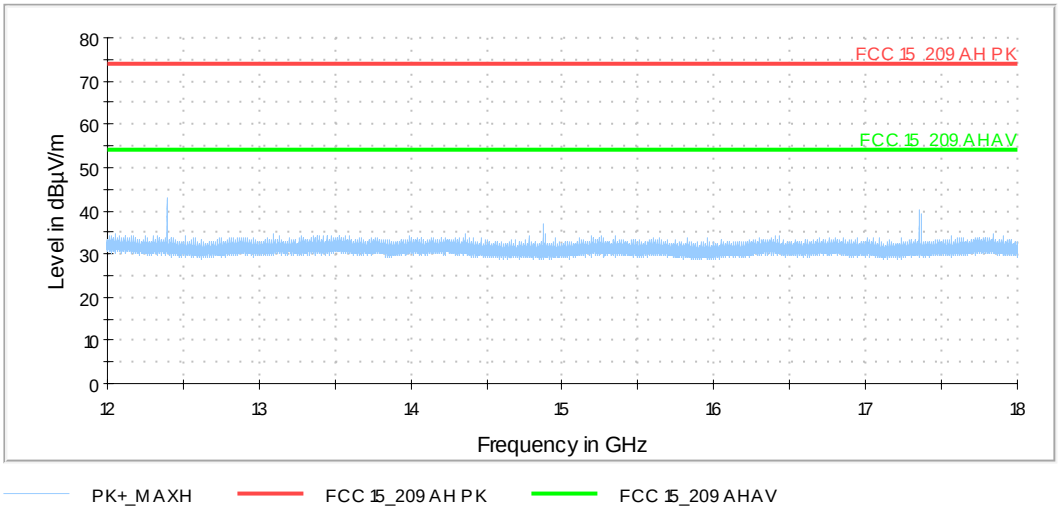
172289 1-4GHz ch39: Spurious emissions from 1 GHz to 4 GHz (operation mode 3):



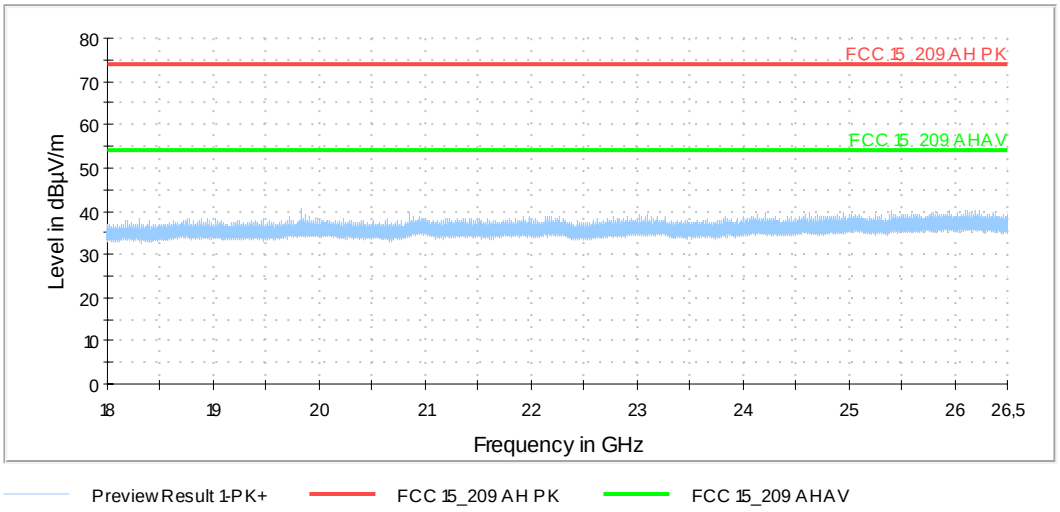
17289 4-12GHz ch09: Spurious emissions from 4 GHz to 12 GHz (operation mode 3):



17289 12-18GHz ch39: Spurious emissions from 12 GHz to 18 GHz (operation mode 3):



172289 18-26.5GHz ch39: Spurious emissions from 18 GHz to 26.5 GHz (operation mode 3):



5.6.2.2 Final radiated measurements

Ambient temperature	22 °C	Relative humidity	40 %
Tested by	B. Rohde	Date	05.12.2017 12.04.2018

Position of EUT: For the final test on the open area test site the EUT was placed on a table with the height of 0.8 m. The distance between EUT and antenna was 3 m.

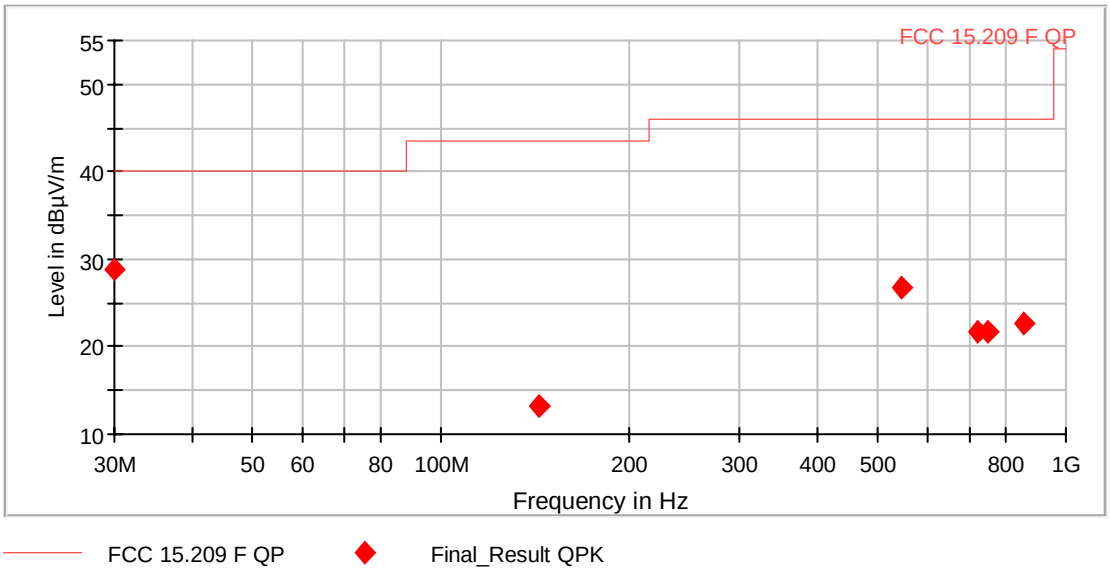
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Only the plot of the worst case emission is submitted below.

Supply voltage: During all measurements the EUT was powered with 24 V d.c..

Remark: Since there were no differences in the spectrum for f < 1 GHz, only one representative plot is submitted below.

5.6.2.2.1 Common Results (All operation modes)



170754 30MHz-1GHz ch06 TX: Spurious emissions from 30 MHz to 1 GHz (operation mode 2):

Results 30 MHz - 1 GHz								
Operation mode 2		No difference in this frequency range between the operation modes						
Frequency [MHz]	QuasiPeak [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Height [cm]	Correction [dB]	Result
30.000000	28.9	40	11.1	V	165	100	27.1	Passed
143.684000	13.1	43.5	30.4	H	112	400	18.8	Passed
547.786000	26.7	46	19.3	H	127	100	29.1	Passed
722.968000	21.6	46	24.4	H	88	387	31.4	Passed
752.553000	21.7	46	24.3	H	112	277	32.2	Passed
859.059000	22.7	46	23.3	H	241	370	33.4	Passed
Measurement uncertainty			+4.4 dB / -4.4 dB					

5.6.2.2.2 Transmitter operates at the lower end of the frequency band

Results 1 - 25 GHz									
Operation mode 1	Duty cycle correction factor of 2.04 dB was applied for the Average reading								
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2529.950000	---	47.3	54	6.7	H	139	0	36.0	Passed
2529.950000	55.9	---	74	18.1	H	139	0	34.0	Passed
3927.350000	---	42.1	54	11.9	V	128	120	42.2	Passed
3927.350000	53.2	---	74	20.8	V	128	120	40.2	Passed
4803.400000	---	40.5	54	13.5	H	134	29	0.2	Passed
4803.400000	49.2	---	74	24.8	H	134	29	-1.8	Passed
7205.150000	---	43.2	54	10.8	V	105	90	6.4	Passed
7205.150000	53.0	---	74	21.0	V	105	90	4.4	Passed
16812.100000	46.1	---	74	27.9	V	49	29	10.7	Passed
16812.100000	---	35.8	54	18.2	V	49	29	12.7	Passed
16815.700000	45.9	---	74	28.1	H	125	60	10.6	Passed
16815.700000	---	34.7	54	19.3	H	125	60	12.6	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

5.6.2.2.3 Transmitter operates in the middle of the frequency band

Results 1 - 25 GHz									
Operation mode 2	Duty cycle correction factor of 2.04 dB was applied for the Average reading								
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2529.950000	---	47.3	54	6.7	H	139	0	36.0	Passed
2529.950000	55.9	---	74	18.1	H	139	0	34.0	Passed
3927.350000	---	42.1	54	11.9	V	128	120	42.2	Passed
3927.350000	53.2	---	74	20.8	V	128	120	40.2	Passed
4803.400000	---	40.5	54	13.5	H	134	29	0.2	Passed
4803.400000	49.2	---	74	24.8	H	134	29	-1.8	Passed
7205.150000	---	43.2	54	10.8	V	105	90	6.4	Passed
7205.150000	53.0	---	74	21.0	V	105	90	4.4	Passed
16812.100000	46.1	---	74	27.9	V	49	29	10.7	Passed
16812.100000	---	35.8	54	18.2	V	49	29	12.7	Passed
16815.700000	45.9	---	74	28.1	H	125	60	10.6	Passed
16815.700000	---	34.7	54	19.3	H	125	60	12.6	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

5.6.2.2.4 Transmitter operates at the upper end of the frequency band

Results 1 - 25 GHz									
Operation mode 3			Duty cycle correction factor of 2.04 dB was applied for the Average reading						
Frequency [MHz]	Max Peak [dBµV/m]	Average [dBµV/m]	Limit [dBµV/m]	Margin dB	Pol	Azimuth [°]	Elevation [°]	Correction [dB]	Result
2607.900000	---	47.7	54	6.3	H	105	0	36.6	Passed
2607.900000	56.2	---	74	17.8	H	105	0	34.6	Passed
3942.000000	---	42.0	54	12.0	V	131	150	42.0	Passed
3942.000000	52.2	---	74	21.8	V	131	150	40.0	Passed
4959.400000	---	39.2	54	14.8	H	114	29	0.3	Passed
4959.400000	48.5	---	74	25.5	H	114	29	-1.7	Passed
7440.700000	---	43.7	54	10.3	V	158	90	7.4	Passed
7440.700000	53.6	---	74	20.4	V	158	90	5.4	Passed
9920.950000	---	39.8	54	14.2	H	142	0	8.8	Passed
9920.950000	50.6	---	74	23.4	H	142	0	6.8	Passed
12399.900000	---	34.3	54	19.7	V	155	30	14.1	Passed
12399.900000	47.2	---	74	26.8	V	155	30	12.1	Passed
14878.350000	43.7	---	74	30.3	H	108	90	11.2	Passed
14878.350000	---	33.5	54	20.5	H	108	90	13.2	Passed
17359.900000	45.2	---	74	28.8	V	55	0	10.6	Passed
17359.900000	---	32.8	54	21.2	V	55	0	12.6	Passed
Measurement uncertainty				+2.2 dB / -3.6 dB					

TEST EQUIPMENT USED FOR THE TEST:

30 MHz – 1GHz final:	12, 25 - 31
30 MHz – 1GHz preliminary 1 GHz – 26.5 GHz:	1 - 7, 10 - 11, 13 - 24

6 Test Equipment

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Antenna mast	AS615P	Deisel	615/310	480187	Calibration not necessary	
2	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
3	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
4	RF-cable No.3	Sucoflex 106B	Suhner	0563/6B / Kabel 3	480670	Calibration not necessary	
5	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
6	Antenna (Log.Per.)	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
7	RF-Cable No. 40	Sucoflex 106B	Suhner	0708/6B / Kabel 40	481330	Calibration not necessary	
8	HF-Cable	Sucoflex 104	Huber+Suhner	517406	482391	Calibration not necessary	
9	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.06.2017	06.2019
10	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
11	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	24.02.2016	02.2018*1
12	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
13	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
14	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
15	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
16	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	18.02.2016	02.2018*1
17	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	17.02.2016	02.2018*1
18	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	18.02.2016	02.2018*1
19	Software	EMC32	Rohde & Schwarz		481800	Calibration not necessary	
20	High pass Filter	WHKX8.0/18G-8SS	Wainwright Instruments GmbH	4	480586	Calibration not necessary	
21	High pass Filter	WHK2.8/18G-10SS	Wainwright Instuments GmbH	1	480867	Calibration not necessary	
22	High pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
23	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
24	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B / Kabel 36	480865	Calibration not necessary	
25	Attenuator 6 dB	WA2-6	Weinschel	8254	410119	Calibration not necessary	
26	Open area test site M6	Freifeld M6	Phoenix Contact	-	480085	Calibration not necessary	
27	Antenna mast	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	Calibration not necessary	

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
28	Turntable	DS412	Deisel	412/316	480087	Calibration not necessary	
29	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
30	Antenna (Bilog)	CBL6111D	Schaffner Elektrotest GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
31	Measurement Receiver	ESR7	Rohde & Schwarz	101939	482558	19.09.2017	09.2019

*1 All relevant test were done in the calibration period.

7 Report History

Report Number	Date	Comment
F170297E8	16.04.2018	Initial Test Report

8 List of Annexes

Annex A Test setup photos 7 pages

172289_E3_01.jpg Test setup fully anechoic chamber
172289_E3_02.jpg Test setup fully anechoic chamber
172289_E3_03.jpg Test setup fully anechoic chamber
172289_E3_04.jpg Test setup fully anechoic chamber
172289_E3_05.jpg Test setup fully anechoic chamber
172289_E3_06.jpg Test setup fully anechoic chamber
172289_E3_07.jpg Test setup open area test site

Annex B External Photos 3 pages

172289_E3_ext_01: EUT – top view
172289_E3_ext_02: EUT – bottom view
172289_E3_ext_03: EUT – side view

Annex C Internal Photos 2 pages

172289_E3_int_01: EUT without shielding – top view
172289_E3_int_02: EUT without shielding – bottom view