

# Test Report

Report Number:

**F170923E10**

Equipment under Test (EUT):

B&R radio board with 13.56 MHz NFC and onboard BR/EDR/LE & WiFi Module

**RFM-1-BTWNF**

Applicant:

**B&R Industrial Automation GmbH**

Manufacturer:

**B&R Industrial Automation GmbH**



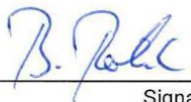

Deutsche  
Akkreditierungsstelle  
D-PL-17186-01-01  
D-PL-17186-01-02  
D-PL-17186-01-03

## 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 5 (April 2018)**, General Requirements for Compliance of Radio Apparatus
- [5] **508074 D01 DTS Meas Guidance v04 (April 2017)**, Guidance for performing compliance measurements on transmission systems (DTS) operating under section 15.247

## 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:	<u>Bernward ROHDE</u>	<u></u>	<u>25.06.2018</u>
	Name	Signature	Date
Authorized reviewer:	<u>Bernd STEINER</u>	<u></u>	<u>25.06.2018</u>
	Name	Signature	Date

**This test report is only valid in its original form.**

Any reproduction of its contents in extracts without written permission of the accredited test laboratory PHOENIX TESTLAB GmbH is prohibited.

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.

This test report is valid in hardcopy form as well as in electronic form.

## Contents

## Page

1	Identification.....	4
1.1	Applicant.....	4
1.2	Manufacturer.....	4
1.3	Test Laboratory.....	4
1.4	EUT (Equipment Under Test) .....	5
1.5	Technical Data of Equipment.....	6
1.6	Dates .....	7
2	Operational States .....	7
3	Additional Information .....	8
4	Overview.....	8
5	Results.....	9
5.1	Duty cycle .....	9
5.2	Maximum peak output power.....	10
5.3	20 dB Bandwidth / 99% Bandwidth.....	13
5.3.1	Method of measurement .....	13
5.3.2	Test result.....	15
5.4	Band-edge compliance.....	19
5.4.1	Method of measurement (band edges next to unrestricted bands (radiated)) .....	19
5.4.2	Test result (band edges next to unrestricted bands (radiated)).....	20
5.4.3	Method of measurement (band edges next to restricted bands (radiated)) .....	21
5.4.4	Test result (band edges next to restricted bands (radiated)) .....	21
5.5	Maximum unwanted emissions.....	22
5.5.1	Method of measurement (radiated emissions) .....	22
5.5.2	Test results (radiated emissions).....	29
6	Test equipment and ancillaries used for tests .....	35
7	Report History.....	36
8	List of Annexes .....	36

# 1 Identification

## 1.1 Applicant

Name:	B&R Industrial Automation GmbH
Address:	B&R Straße 1 5142 Eggelsberg
Country:	Austria
Name for contact purposes:	Mr. Bernhard FALCH
Phone:	+43 7748 6586 1323
Fax:	+43 7748 6586 26
eMail Address:	Bernhard.falch@br-automation.com
Applicant represented during the test by the following person:	none

## 1.2 Manufacturer

Name:	B&R Industrial Automation GmbH
Address:	B&R Straße 1 5142 Eggelsberg
Country:	Austria
Name for contact purposes:	Mr. Bernhard FALCH
Phone:	+43 7748 6586 1323
Fax:	+43 7748 6586 26
eMail Address:	Bernhard.falch@br-automation.com
Applicant 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)

EUT	
Test object: *	B&R radio board with 13.56 MHz NFC and onboard BR/EDR/LE & WiFi Module
Type / PMN: *	RFM-1-BTWNF
FCC ID: *	2ADTV-RFM-1-BTWNF
IC Certification Number: *	12444A-RFM1BTWNF
Serial number: *	Engineering sample
PCB identifier: *	WIFI-BT-NFC
MAC Address:*	5C-F3-70-41-6D-92
HVIN (Hardware Version Identification Number): *	RFM-1-BTWNF
FVIN (Firmware Version Identification Number): *	v1.0

\* As declared by the applicant

BT frequencies:				
Channel 00	RX:	2402 MHz	TX:	2402 MHz
Channel 39	RX:	2440 MHz	TX:	2440 MHz
Channel 78	RX:	2480 MHz	TX:	2480 MHz

## 1.5 Technical Data of Equipment

EUT						
Fulfills specifications: *	Bluetooth V4.0-EDR					
Antenna type: *	onboard chip antenna					
Antenna gain: *	0.5 dBi					
Antenna connector: *	none					
Power supply - EUT	U <sub>nom</sub> =	5.0 V DC	U <sub>min</sub> =	4.75 V DC	U <sub>max</sub> =	5.25 V DC
Type of modulation: *	BT (DH5)      GFSK BT (2DH5)     Pi/4 DQPSK BT (3DH5)     8DPSK					
Operating frequency range: *	2402 – 2480 MHz					
Number of channels: *	79					
Temperature range: *	0 °C to +75 °C					
Lowest / highest Internal clock frequency: *	13.56 MHz / 2.480GHz					

\* Declared by the applicant

Ancillary devices:	
Industrial PC: *	BRaccessoryPC1a

\* Provided by the applicant

### The following external I/O cables were used:

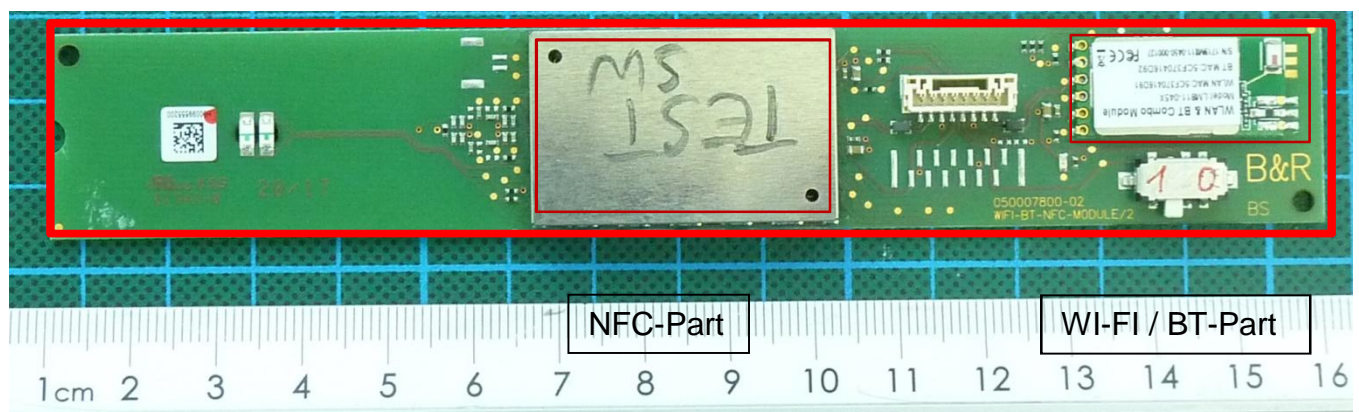
Identification	Connector		Length
	EUT	Ancillary	
System connector (DC and data lines USB used)	Mini plug	USB	2.5 m

\*: Length during the test if no other specified.

## 1.6 Dates

Date of receipt of test sample:	07.07.2017
Start of test:	24.04.2018
End of test:	13.06.2018

Physical Boundaries of the EUT:



## 2 Operational States

The EUT is radio module that incorporates a 13.56 MHz RFID and an additional already FCC/IC certified BR/EDR/LE & WiFi Module.

During the Bluetooth radio tests the RFID module was active and continuously transmitting (reading tag). So both transmitters were operating simultaneously.

The test modes were set via an ancillary industrial computer provided by the applicant. The test modes were set by using a test-software called "RTK\_BT\_MP 8723BU" as used for the Realtech RTL8723B chip as provided by the applicant.

The power settings as shown in the table below were applied.

The worst case was chosen from the original module report (report no.: STR170482171-2 by Shenzhen SEM; FCC ID: VVX811-04XX)

All tests were done with an unmodified sample.

Operation mode	Description of the operation mode	Mode	Power	Channel	Modulation	Data rate / Mbps
1	Continuous transmitting on 2402 MHz	BT DH5	4	0	GFSK	1 Mbps
2	Continuous transmitting on 2440 MHz	BT DH5	4	39	GFSK	1 Mbps
3	Continuous transmitting on 2480 MHz	BT DH5	4	78	GFSK	1 Mbps

### 3 Additional Information

The combo BR/EDR/LE & WiFi module is tested and certified for stand-alone configuration only. This test report covers only the additional measurements to show compliance with the regulations for simultaneous transmission with the 13.56 MHz RFID transmitter

The test-case "Radiated emissions (transmitter)" were tested with power setting 7.

### 4 Overview

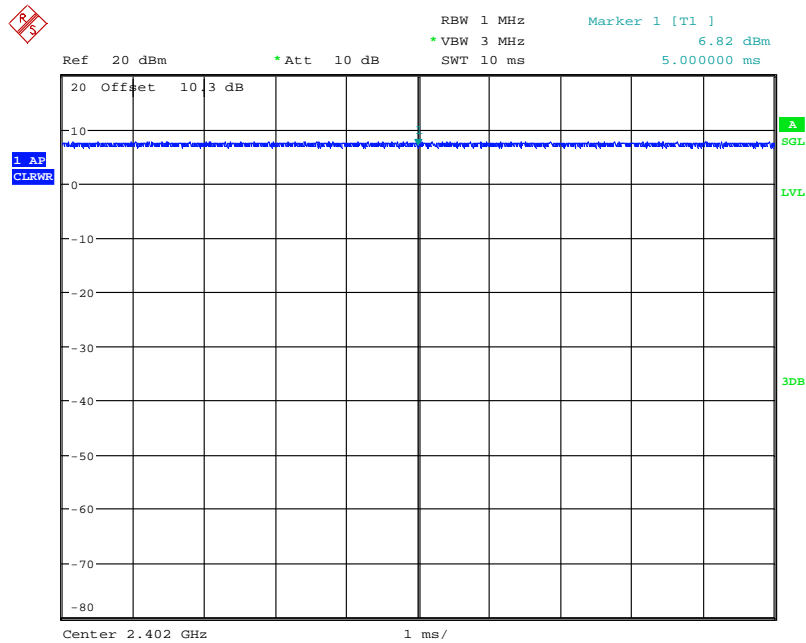
Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [3] or RSS-Gen, Issue 5 [4]	Status	Refer page
Maximum Peak Output Power	2400.0 - 2483.5	15.247 (b) (3), (4)	5.4 (d) [3]	Passed	10 et seq
20 dB Bandwidth	2400.0 - 2483.5	15.247 (a)	5.2 (a) [3]	Passed	10 et seq
Band edge compliance	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	22 et seq.



## 5 Results

### 5.1 Duty cycle

The Bluetooth module was set to test-mode with 100% duty cycle; therefore a duty cycle calculation is not applicable.



Date: 13.JUN.2018 09:33:32

## 5.2 Maximum peak output power

Measurement with ufl- antenna connector was used for the conducted tests.

### Acceptable measurement configuration

Procedure 7.8.5 in [1] was used for the following test.

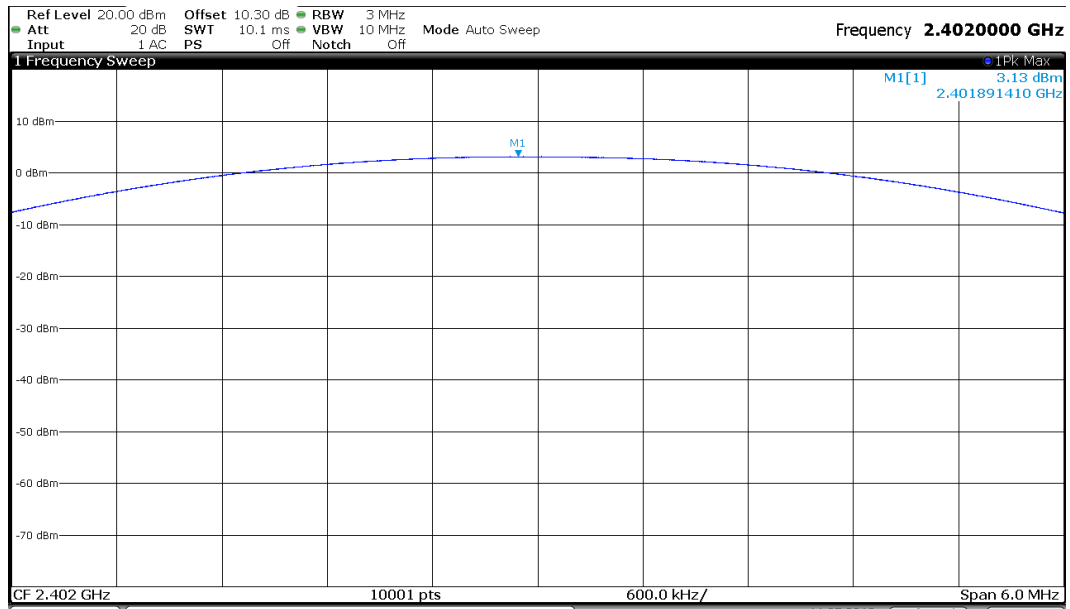
The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the 20 dB bandwidth is available to perform the measurement:

- a) Use the following spectrum analyzer settings:
  - 1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel
  - 2) RBW > 20 dB bandwidth of the emission being measured.
  - 3) VBW  $\geq$  RBW.
  - 4) Sweep: Auto.
  - 5) Detector function: Peak.
  - 6) Trace: Max hold.
- b) Allow trace to stabilize.
- c) Use the marker-to-peak function to set the marker to the peak of the emission.
- d) The indicated level is the peak output power, after any corrections for external attenuator cables.
- e) A plot of the test results and setup description shall be included in the test report.

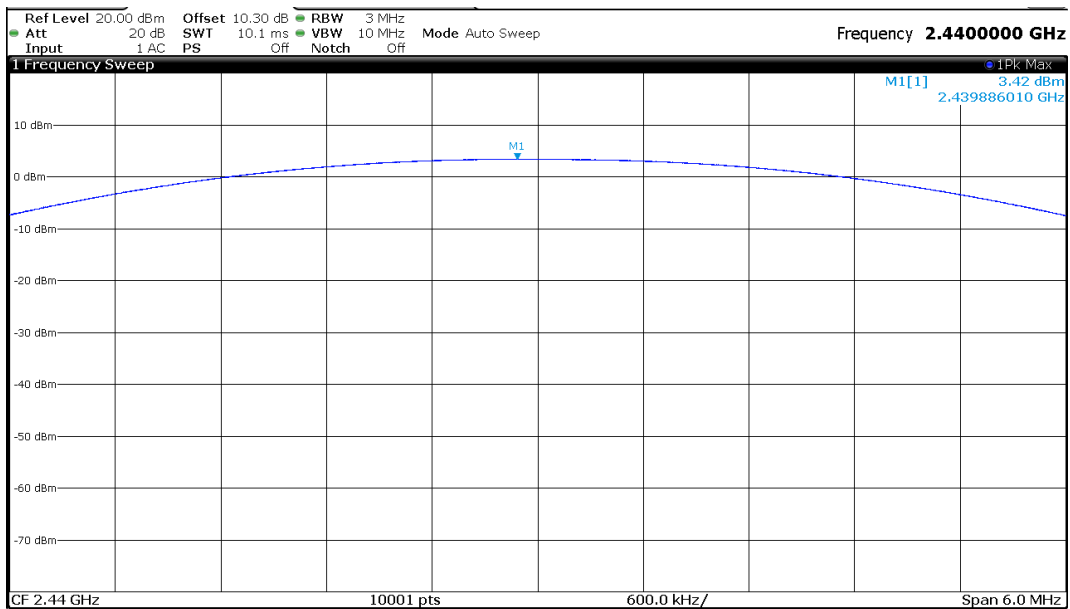
An offset of 10.3 dB was used to compensate the cable loss and a 10 dB attenuator and cables.  
So the reading matches the final maximum peak output power value.

**Result:** conducted measurement on sample with ufl-antenna connector

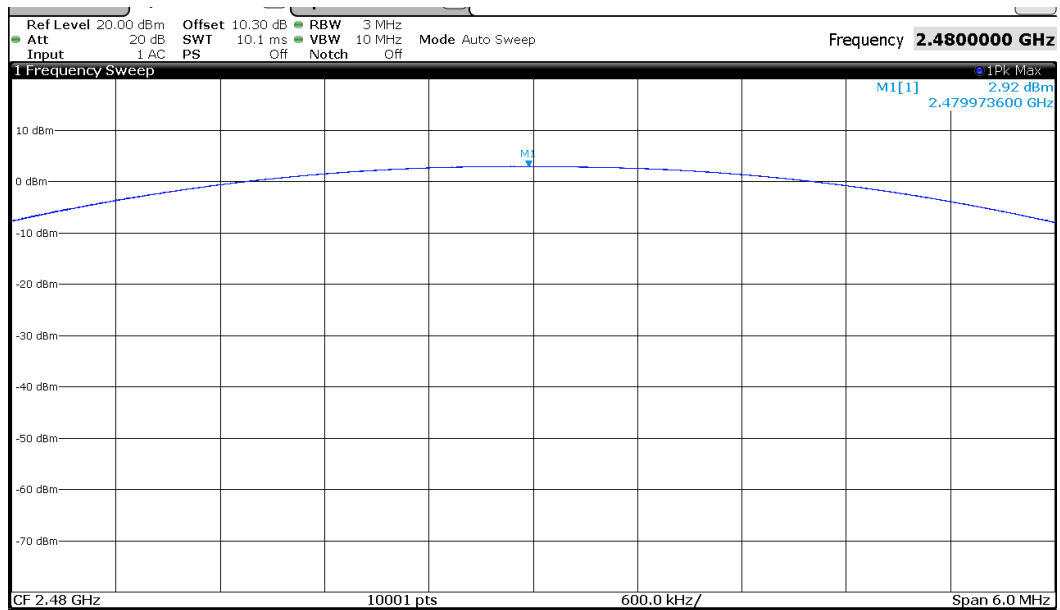
MPOP\_ch00.PNG: Maximum peak output power measured on channel 00 (operation mode 1):



MPOP\_ch38.PNG: Maximum peak output power measured on channel 38 (operation mode 2):



MPOP\_ch78.PNG: Maximum peak output power measured on channel 78 (operation mode 3):



Operation mode	Frequency [MHz]	Maximum peak conducted output power * [dBm]	Limit [dBm]
1	2402	3.13	30
2	2440	3.42	30
3	2480	2.92	30

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

32, 9

## 5.3 20 dB Bandwidth / 99% Bandwidth

### 5.3.1 Method of measurement

Measurement with ufl- antenna connector was used for the conducted tests.

#### Acceptable measurement configurations

The measurement for the 20 dB bandwidth procedure refers to part 6.9.2 of document [1].

The occupied bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are -6 dB, -20 dB, and -26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this sub-clause, the ratio is designated by “-xx dB.” The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the “-xx dB” bandwidth; other requirements might specify that the “-xx dB” bandwidth be entirely contained within the authorized or designated frequency band.

- a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.
- b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.
- c) 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 of document [1].
- d) Steps a) through c) might require iteration to adjust within the specified tolerances.
- e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target “-xx dB down” requirement; that is, if the requirement calls for measuring the -20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
- f) Set detection mode to peak and trace mode to max hold.
- g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).
- h) Determine the “-xx dB down amplitude” using  $[(\text{reference value}) - xx]$ . Alternatively, this calculation may be made by using the marker-delta function of the instrument.
- i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
- j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the “-xx dB down amplitude” determined in step h).
- h) If a marker is below this “-xx dB down amplitude” value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the “-xx dB down amplitude” determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.
- k) 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 labeled. Tabular data may be reported in addition to the plot(s).

The following procedure 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.
- 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 labeled. Tabular data maybe reported in addition to the plot(s).

### 5.3.2 Test result

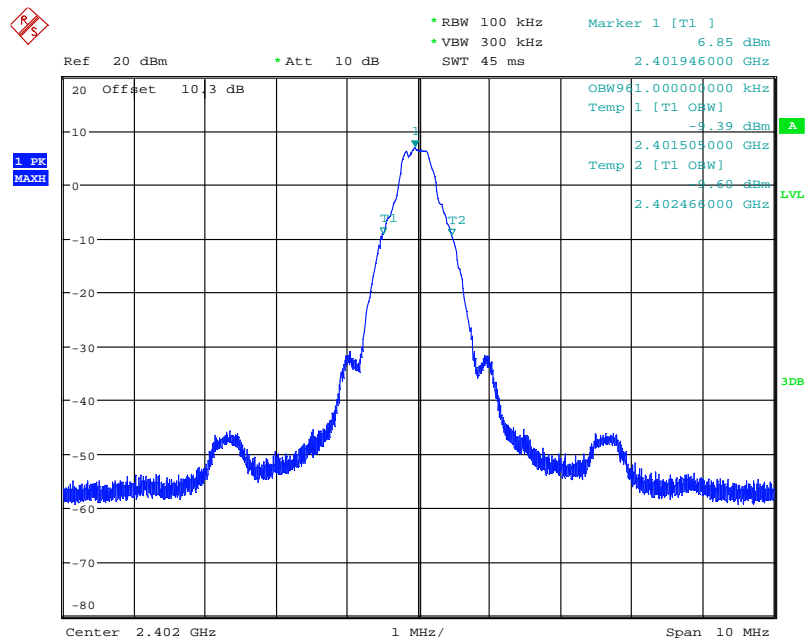
Ambient temperature	22 °C	Relative humidity	59 %
---------------------	-------	-------------------	------

The plots show the results for the worst case.

DTS\_BW\_ch00.wmf: 20-dB Bandwidth (operation mode 1):



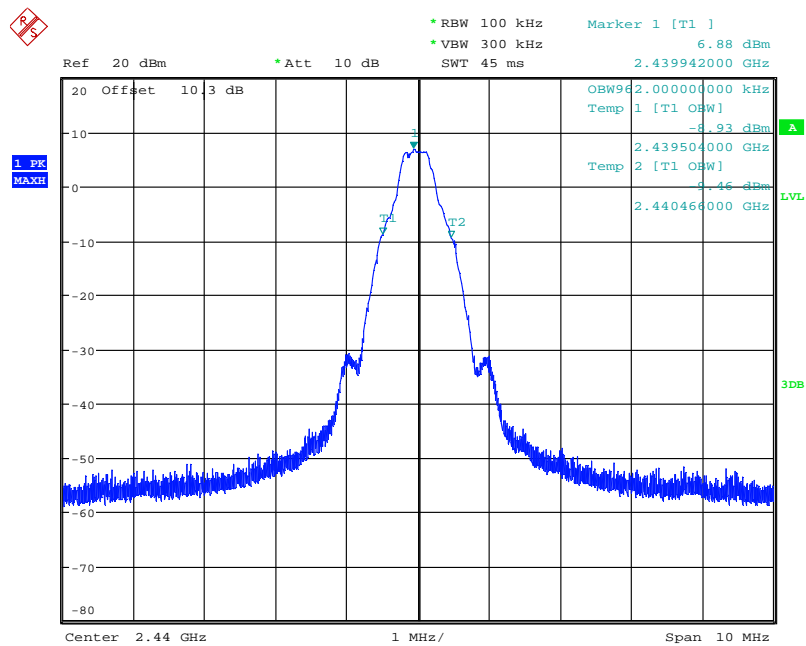
99% BW\_ch00.png: 99% Bandwidth (operation mode 1):



DTS BW ch38.wmf: 20-dB Bandwidth (operation mode 2):



99% BW ch38.png: 99% Bandwidth (operation mode 2):

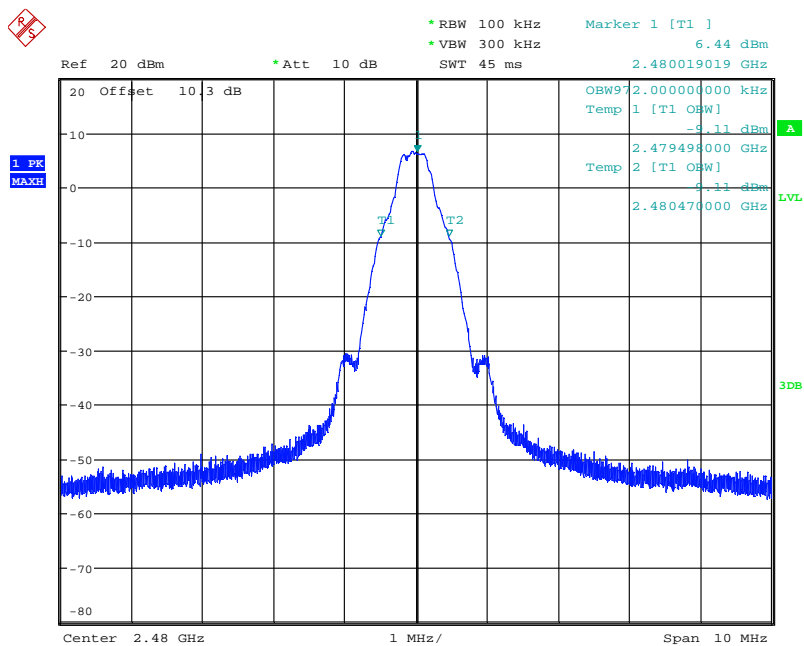




DTS BW\_ch78.wmf: 20-dB Bandwidth (operation mode 3):



99% BW\_ch78.png: 99% Bandwidth (operation mode 3):



Operation Mode	Center Frequency [MHz]	20 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
1	2402	1.042	0.961	Passed
2	2440	1.038	0.962	Passed
3	2480	1.039	0.972	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

32

## **5.4 Band-edge compliance**

### **5.4.1 Method of measurement (band edges next to unrestricted bands (radiated))**

The EUT was measured radiated in the anechoic chamber using the procedures described in 5.5.1.

#### **Acceptable measurement configurations**

The measurement procedure refers to part 11.11.2 and 11.11.3 of document [1].

##### **Measurement Procedure Reference – Reference Level:**

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

##### **Measurement Procedure – Unwanted Emissions**

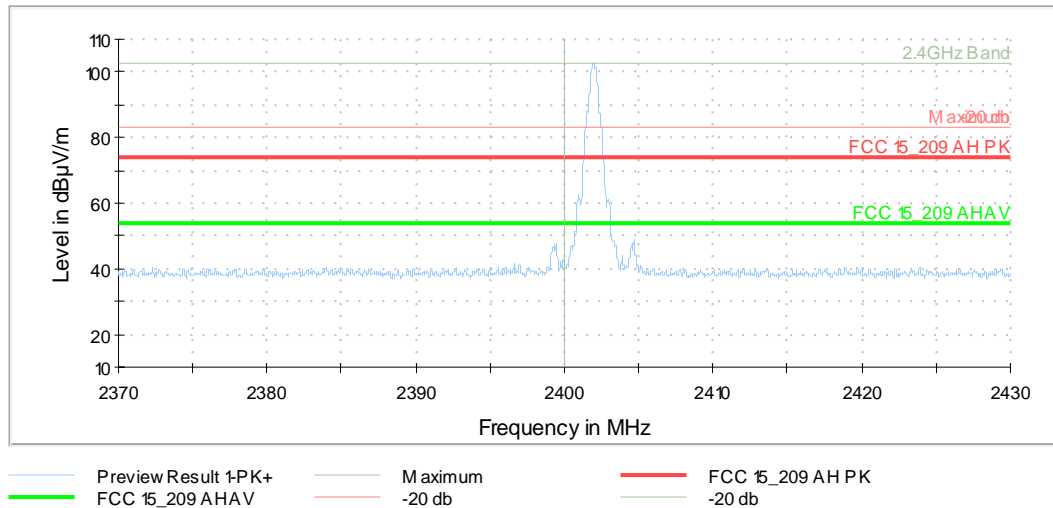
- Set the center frequency and span to encompass the frequency range to be measured.
- RBW = 100 kHz.
- VBW  $\geq 300$  kHz.
- Detector = Peak.
- Ensure that the number of measurement points  $\geq \text{span}/\text{RBW}$ .
- Sweep time = auto couple.
- Trace Mode = max hold.
- Allow the trace to stabilize.
- 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 encompassed by the span. After trace stabilization, the maximum peak was 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.

#### 5.4.2 Test result (band edges next to unrestricted bands (radiated))

LowerBandEdge\_ch0.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	2402	2399.34	102.9	82.9	47.8	35.1	Passed

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1- 9, 24

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

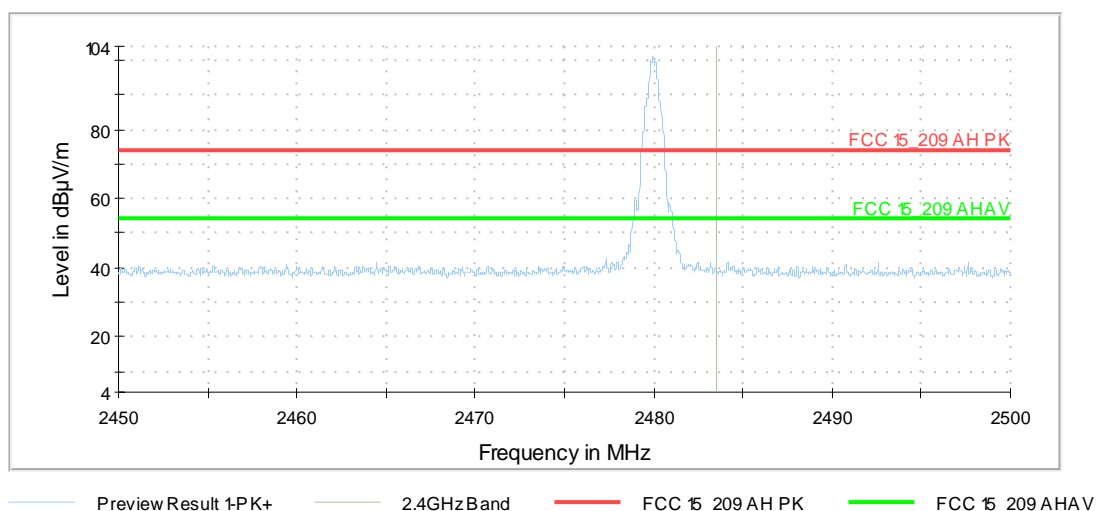
The EUT was measured radiated in the anechoic chamber using the procedures described in 5.5.1.

#### Acceptable measurement configurations

The same measurement configurations as described in 5.5.1. were used for the preview and final measurement.

#### 5.4.4 Test result (band edges next to restricted bands (radiated))

UpperBandEdge\_ch39.wmf: radiated band-edge compliance at a restricted band-edge (operation mode 3):



Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
2484.000000	---	32.0	54	22.0	H	326	90	34.0
2484.000000	44.5	---	74	29.5	H	326	90	34.0
2484.175000	---	33.5	54	20.5	H	216	120	34.0
2484.175000	46.3	---	74	27.7	H	216	120	34.0
2484.475000	---	35.7	54	18.3	H	211	150	34.0
2484.475000	49.2	---	74	24.8	H	211	150	34.0
2490.775000	---	31.3	54	22.7	V	0	29	34.0
2490.775000	43.5	---	74	30.5	V	0	29	34.0
2492.600000	---	31.5	54	22.5	H	223	90	33.9
2492.600000	43.8	---	74	30.2	H	223	90	33.9
2497.625000	---	31.1	54	22.9	H	0	30	33.8
2497.625000	43.6	---	74	30.4	H	0	30	33.8
Measurement uncertainty				+/- 4.79 dB				

Test: Passed

TEST EQUIPMENT USED FOR THE TEST:

1- 9, 24

## 5.5 Maximum unwanted emissions

### 5.5.1 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 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.

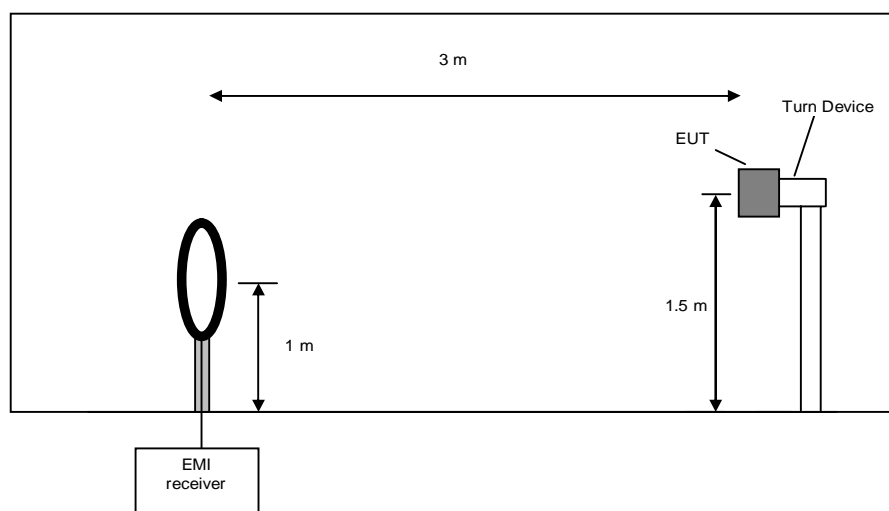
#### **Preliminary measurement (9 kHz to 30 MHz):**

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. 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 9 kHz to 30 MHz will be monitored with a spectrum analyzer 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 analyzer 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:

Pre-scans were performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

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

The following procedure will be used:

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

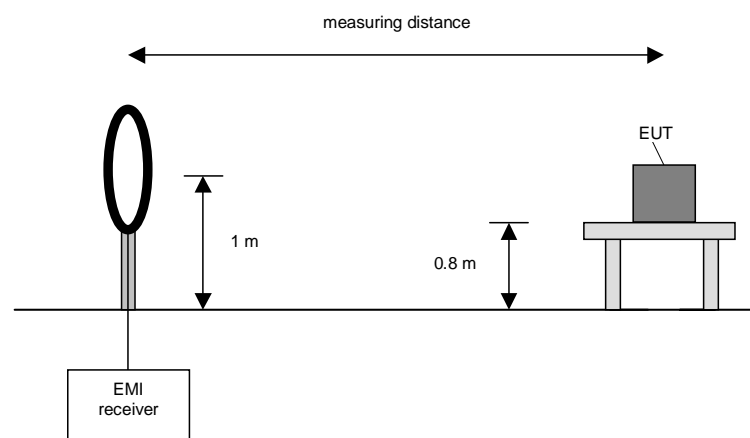
#### **Final measurement (9 kHz to 30 MHz):**

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).

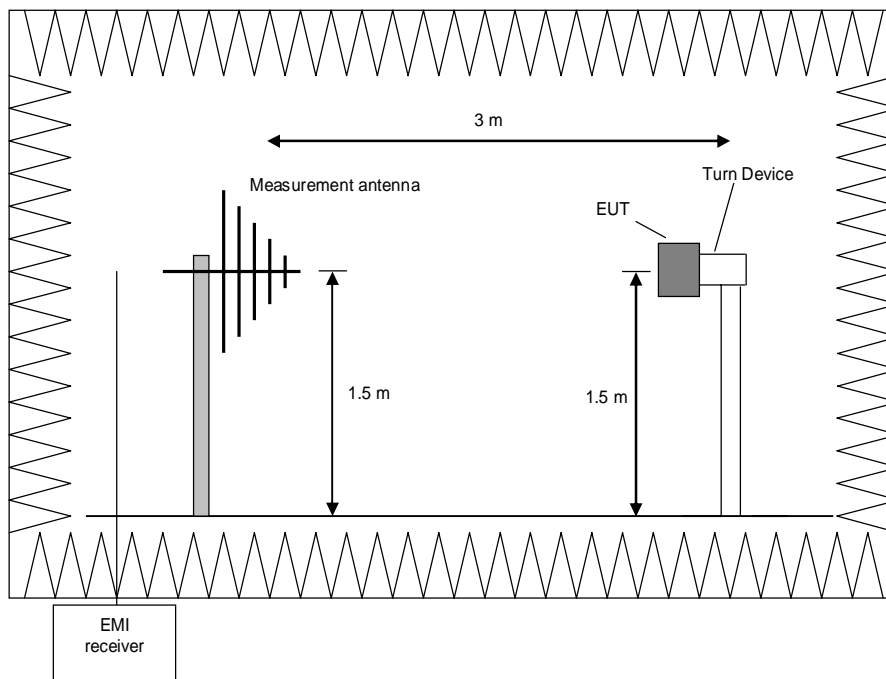
#### Preliminary measurement (30 MHz to 1 GHz)

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 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 °. 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:

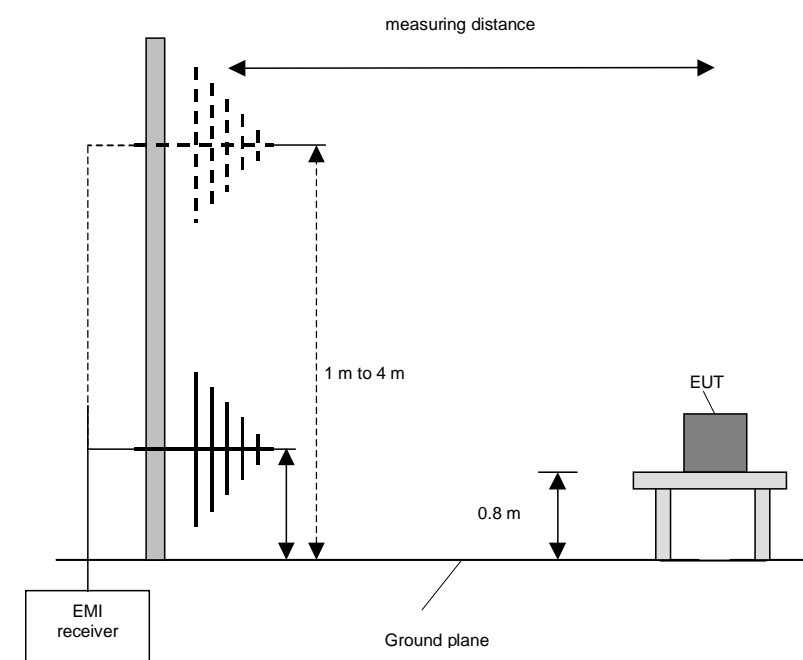
8. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0°.
9. Manipulate the system cables within the range to produce the maximum level of emission.
10. Rotate the EUT by 360° to maximize the detected signals.
11. Repeat 1) to 3) with the vertical polarization of the measuring antenna.
12. Make a hardcopy of the spectrum.
13. Repeat 1) to 5) with the EUT raised by an angle of 0° (45°, 90°) according to 6.6.5.4 in [1].
14. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.

#### Final measurement (30 MHz to 1 GHz)

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

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

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



#### Procedure final measurement:

The following procedure will be used:

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

#### **Preliminary and final measurement (1 GHz to 40 GHz)**

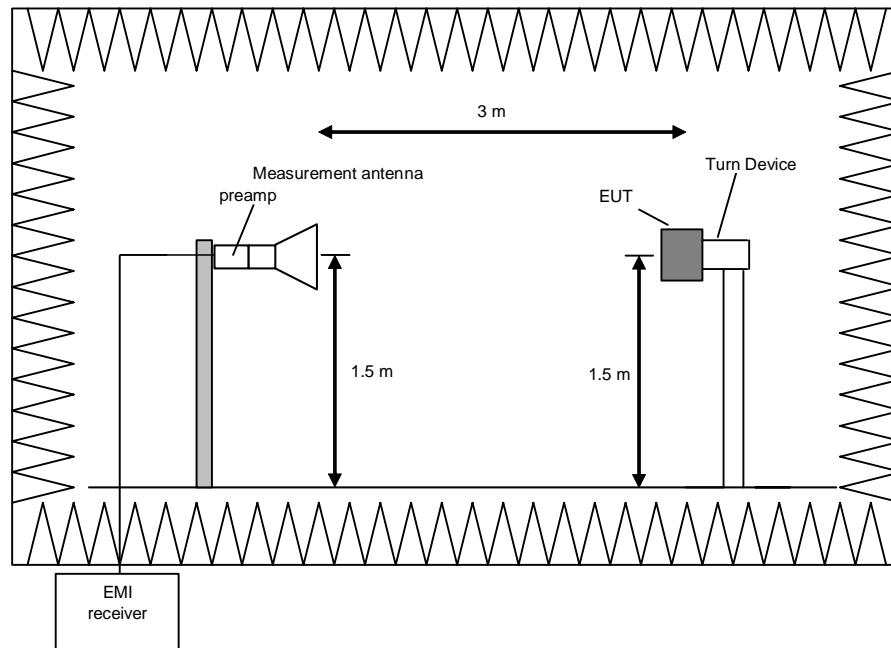
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

#### **Preliminary measurement (1 GHz to 40 GHz)**

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

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

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



#### Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

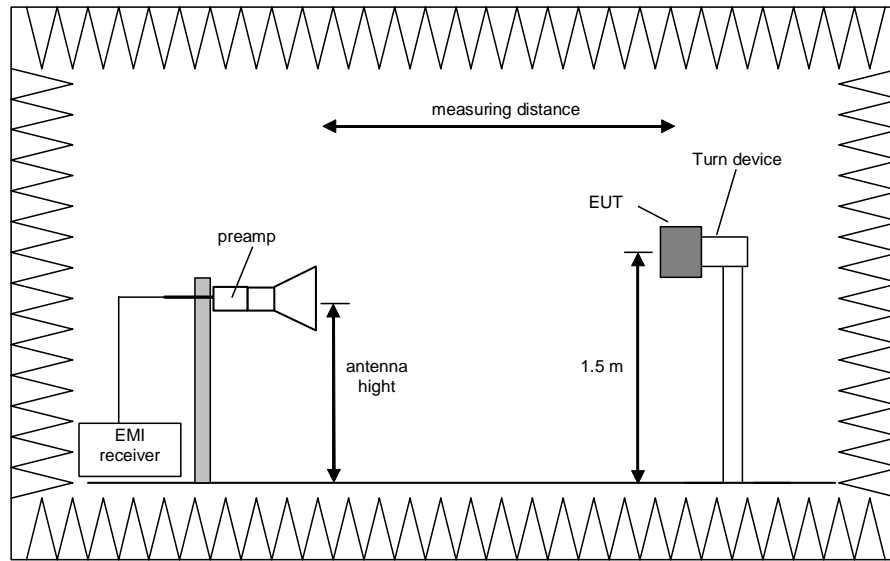
1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an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

## 5.5.2 Test results (radiated emissions)

### 5.5.2.1 Preliminary radiated emission measurement 9kHz – 26.5 GHz

Ambient temperature	22 °C	Relative humidity	59 %
---------------------	-------	-------------------	------

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.

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.

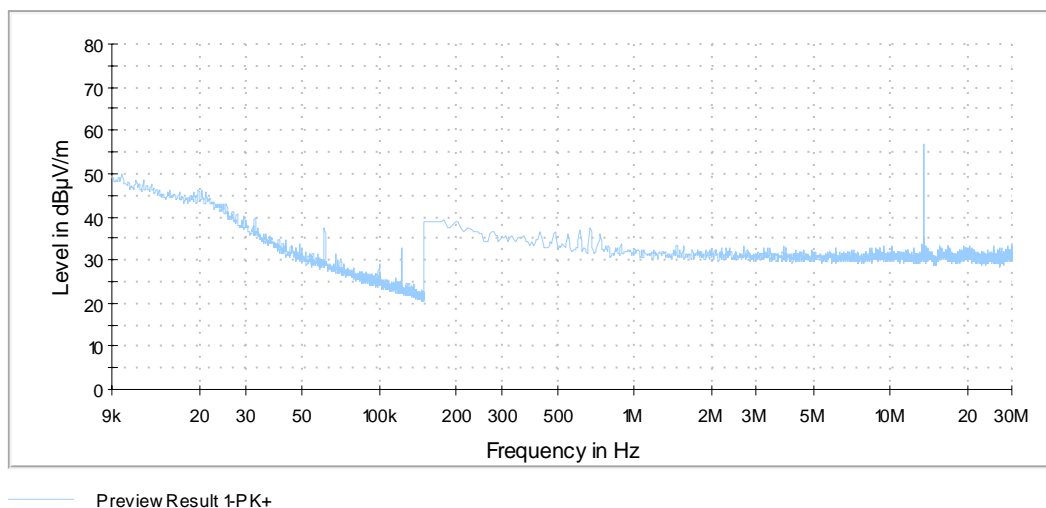
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

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

Supply voltage: During all measurements the EUT was powered with 5 V via USB.

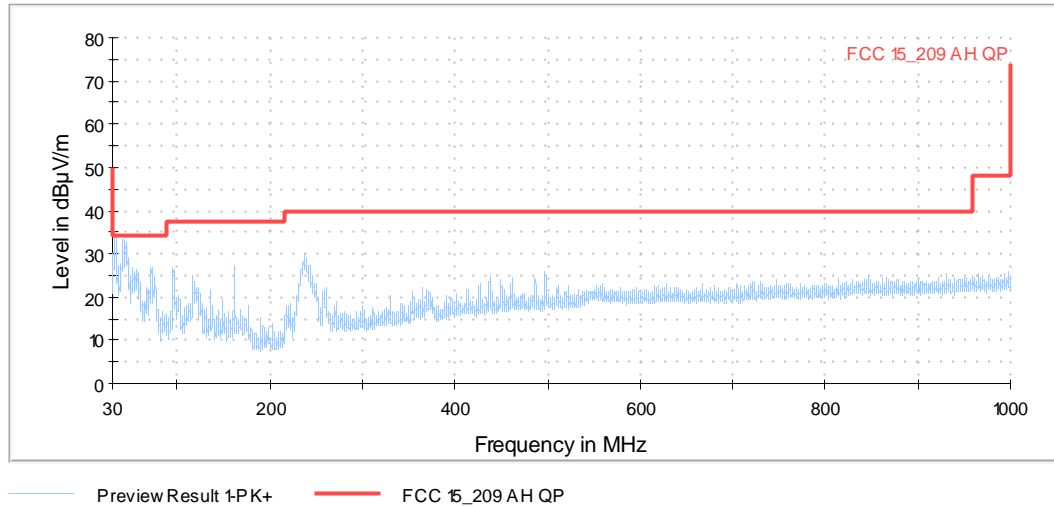
#### **Transmitter operates at the lower end of the assigned frequency band (operation mode 1)**

170923 9kHz-30MHz ch00: Spurious emissions from 9 kHz to 30 MHz (operation mode 1):

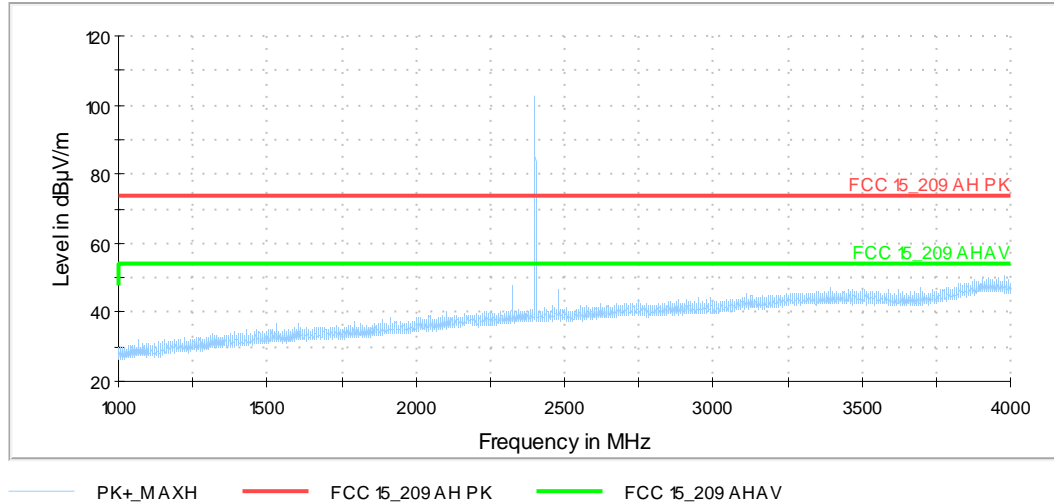


Remark: The peak at 68 kHz was caused by the measurement system and not by the equipment under test  
The peak at 13.56 MHz is the simultaneous transmitting RFID reader – so a wanted signal

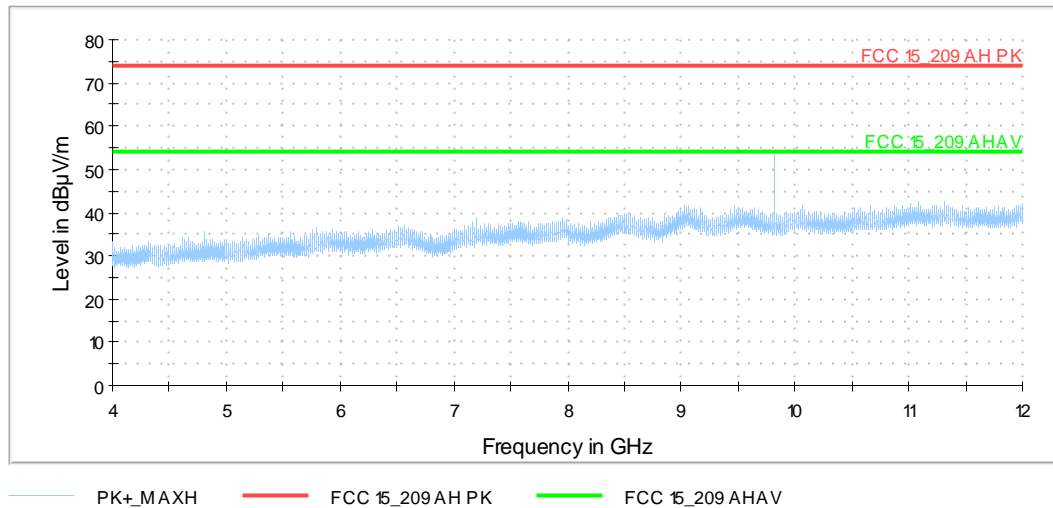
170923 30MHz-1GHz ch00 TX: Spurious emissions from 30 MHz to 1 GHz (operation mode 1):  
(Preliminary results)



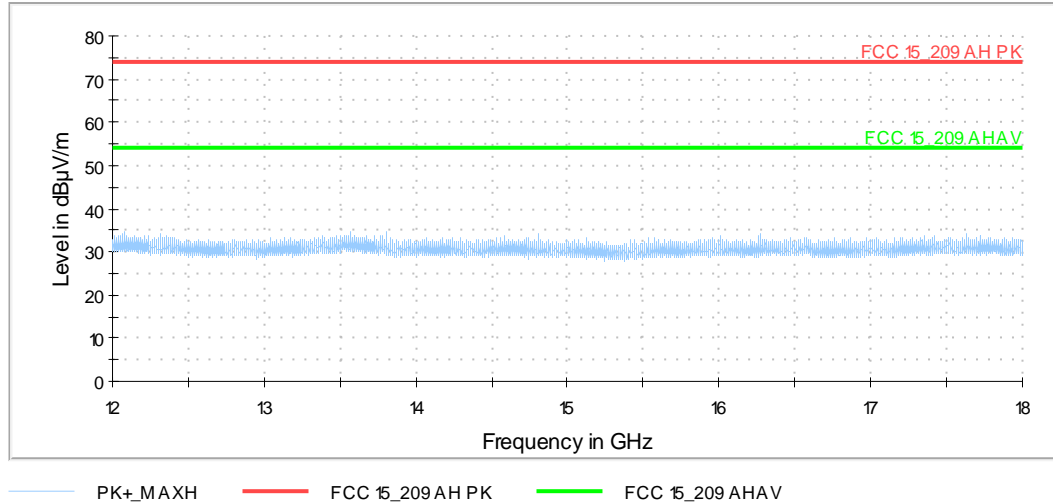
170923 1-4GHz ch00 : Spurious emissions from 1 GHz to 4 GHz (operation mode 1):  
(Preliminary and final results)



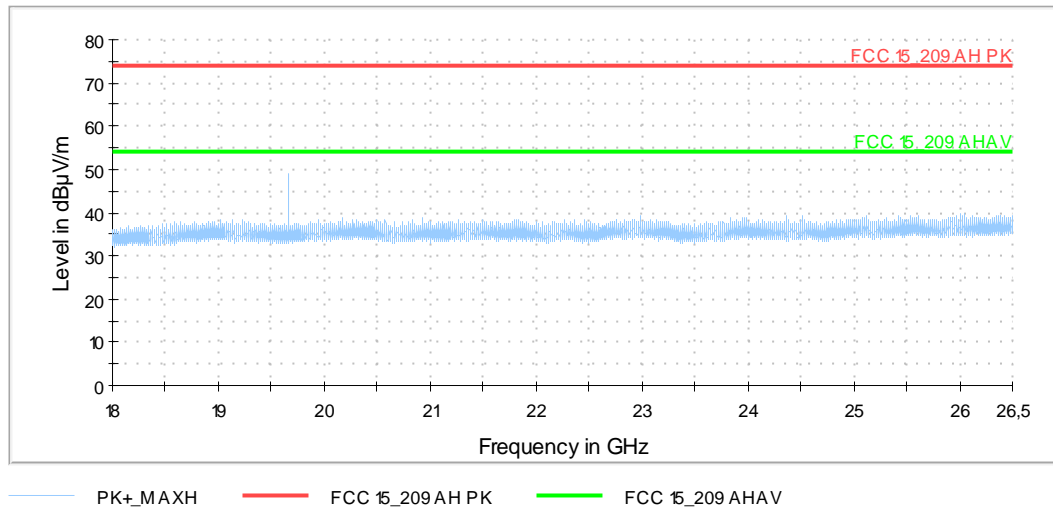
170923 4-12GHz ch00 : Spurious emissions from 4 GHz to 12 GHz (operation mode 1):  
(Preliminary and final results)



170923 12-18GHz ch00: Spurious emissions from 12 GHz to 18 GHz (operation mode 1):  
(Preliminary and final results)



170923 18-25GHz ch00: Spurious emissions from 18 GHz to 25 GHz (operation mode 1):  
(Preliminary and final results)





### 5.5.2.2 Final radiated measurements

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

Results 9kHz - 30 MHz								
Frequency [MHz]	Reading [dBμV]	Result* [dBμV/m]	Limit acc. 15.209 [dBμV/m]	Margin [dB]	Detector (acc. to §15.209 (d)	Antenna factor [dB/m]	Measuring Distance [m]	Distance correction factor** [dB]
13.560000	35.2	15.1 @ 30m	29.5	14.4	QP	19.9	3	40.0
Measurement uncertainty					+/- 4.79 dB			

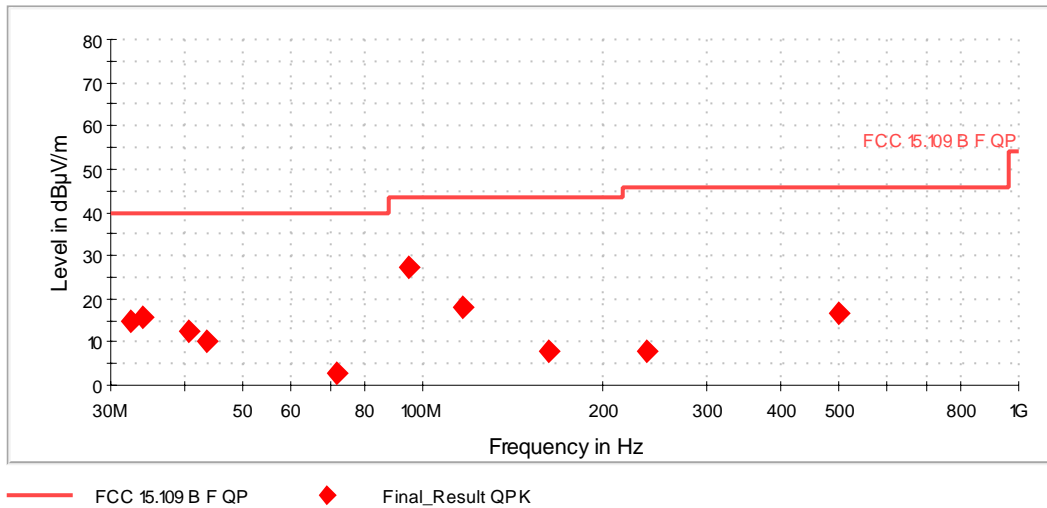
\*Result @ norm dist = Reading + Antenna factor - Distance Extrapolation Factor

\*\* 40dB/decade according Part §15.31 (f) (2)

Frequency [MHz]	QuasiPeak [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Pol	Azimuth [deg]	Corr. [dB]
32.376500	14.6	40.0	25.4	V	17	150	26.1
33.928500	15.8	40.0	24.2	V	37	126	25.5
40.621500	12.4	40.0	27.6	V	181	150	22.3
43.483000	10.3	40.0	29.7	V	330	142	20.7
71.855500	2.6	40.0	37.4	V	20	178	13.7
94.893000	27.4	43.5	16.1	H	249	352	16.8
116.815000	18.2	43.5	25.3	H	29	400	18.5
162.696000	7.7	43.5	35.8	V	70	115	18.3
236.949500	7.7	46.0	38.3	V	94	141	18.9
497.297500	16.6	46.0	29.4	V	132	369	27.0
Measurement uncertainty				+/- 4.79 dB			

Frequency [MHz]	MaxPeak [dBμV/m]	Average [dBμV/m]	Limit [dBμV/m]	Margin (dB)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB)
4804.000000	---	34.1	54	19.9	H	19	0	-1.9
4804.000000	43.9	---	74	30.1	H	19	0	-1.9
9827.900000	---	52.8	54	1.2	H	325	30	6.8
9827.900000	56.2	---	74	17.8	H	325	30	6.8
11314.250000	---	38.1	54	15.9	V	281	90	7.9
11314.250000	49.4	---	74	24.6	V	281	90	7.9
11998.050000	---	38.0	54	16.0	V	220	0	7.5
11998.050000	50.9	---	74	23.1	V	220	0	7.5
13569.360000	---	29.2	54	24.8	V	268	120	11.6
13569.360000	42.3	---	74	31.7	V	268	120	11.6
19655.750000	---	47.8	54	6.2	V	286	60	6.6
19655.750000	51.6	---	74	22.4	V	286	60	6.6
Measurement uncertainty				+/- 4.79 dB				

170923 30MHz-1GHz ch00 TX: Spurious emissions from 30 MHz to 1 GHz (operation mode 1):  
(Final results)



Plots final results see page 29 – 32.

TEST EQUIPMENT USED FOR THE TEST:	
9kHz – 30 MHz, preliminary:	3, 5, 9 - 11
9kHz – 30 MHz, final:	10, 12 - 13
30 MHz – 1GHz, preliminary:	1 - 3, 5, 9, 14 - 16
30 MHz – 1GHz final:	17 - 24
1 GHz – 26.5 GHz:	1, 3 - 7, 9, 15, 25 - 31

## 6 Test equipment and ancillaries used for tests

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	13.02.2018	2.2019
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	ESW44	Rohde & Schwarz	101635	482467	22.06.2017	06.2019
10	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	19.12.2017	12.2018
11	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
12	Outdoor test site	OATS Parkplatz	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	
13	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	27.02.2018	02.2019
14	RF-cable No.36	Sucoflex 106B	Suhner	0587/6B / Kabel 36	480865	Calibration not necessary	
15	Software	EMC32	Rohde & Schwarz		481800	Calibration not necessary	
16	Antenna (Bilog)	CBL6112B	Schaffner EMV GmbH (-Chase)	2688	480328	19.06.2017	06.2020
17	Attenuator 6 dB	R412706000	Radiall	9833	410082	Calibration not necessary	
18	Open area test site M6	Freifeld M6	Phoenix Contact	-	480085	20.04.2017	10.2018
19	Antenna mast	MA240-0	Inn-Co GmbH	MA240-0/030/6600603	480086	Calibration not necessary	
20	Turntable	DS412	Deisel	412/316	480087	Calibration not necessary	
21	Controller	HD100	Deisel	100/349	480139	Calibration not necessary	
22	EMI Receiver	ESIB 7	Rohde & Schwarz	100304	480521	26.02.2018	02.2020
23	Antenna (Bilog)	CBL6111D	Schaffner Elektrotech GmbH / Teseq GmbH	25761	480894	19.10.2017	10.2020
24	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
25	standard gain horn antenna	18240-20	Flann Microwave	483	480294	Calibration not necessary	
26	standard gain horn antenna	20240-20	Flann Microwave	411	480297	Calibration not necessary	
27	Microwave cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
28	Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	14.03.2018	03.2020
29	Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	14.03.2018	03.2020

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
30	Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	14.03.2018	03.2020
31	High-pass Filter	WHKX4.0/18G-8SS	Wainwright Instruments GmbH	1	480587	Calibration not necessary	
32	Spectrum analyzer	FSU46	Rohde & Schwarz	200125	480956	01.03.2018	03.2019

## 7 Report History

Report Number	Date	Comment
F170923E10	21.06.2018	Initial Test Report

## 8 List of Annexes

### ANNEX A TEST SETUP PHOTOS

6 pages

- 170923\_TS01.jpg Test setup – radiated test in anechoic chamber
- 170923\_TS02.jpg Test setup – radiated test in anechoic chamber
- 170923\_TS03.jpg Test setup – radiated test in anechoic chamber
- 170923\_TS04.jpg Test setup – radiated test in anechoic chamber
- 170923\_TS08.jpg Test setup – radiated test on open area test site
- 170923\_TS09.jpg Test setup – radiated test on open area test site

### ANNEX B INTERNAL PHOTOS

5 pages

- 170923\_pcb\_01.jpg PCB – top view
- 170923\_pcb\_02.jpg PCB – top view without shielding
- 170923\_pcb\_03.jpg PCB bottom view
- 170923\_pcb\_04.jpg PCB – WLAN&BT combo module close-up
- 170923\_pcb\_05.jpg PCB –RFID part close-up