

# Test Report

Report Number:

**F182223E1 2<sup>nd</sup> Version**

Equipment under Test (EUT):

**WiFi Communication Module**

Applicant:

**Xaptum, Inc.**

Manufacturer:

**Xaptum, Inc.**




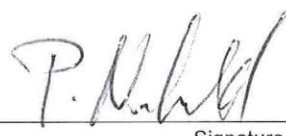
Deutsche  
Akkreditierungsstelle  
D-PL-17186-01-01  
D-PL-17186-01-02  
D-PL-17186-01-03

## 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] **558074 D01 15.247 Meas Guidance v05v02 (April 2019)**, GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

## 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<br>written by:       | Bernward ROHDE |   | 16.12.2020 |
|                                 | Name           | Signature  | Date       |
| Reviewed<br>and approved<br>by: | Paul NEUFELD   |  | 16.12.2020 |
|                                 | 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 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.

| <b>Contents:</b>   | <b>Page</b> |
|--|-------------|
| 1 Identification .....   | 6           |
| 1.1 Applicant.....   | 6           |
| 1.2 Manufacturer .....   | 6           |
| 1.3 Test Laboratory .....  | 6           |
| 1.4 EUT (Equipment under Test) .....   | 7           |
| 1.5 Technical Data of Equipment .....  | 9           |
| 1.6 Dates .....  | 10          |
| 2 Operational States .....   | 11          |
| 2.1 Description of function of the EUT .....   | 11          |
| 2.2 The following states were defined as the operating conditions.....               | 12          |
| 2.3.1 Operation Modes/Power settings .....   | 12          |
| 2.3.2 Radio tests .....  | 12          |
| 3 Additional Information .....   | 13          |
| 4 Overview.....  | 13          |
| 5 Results.....   | 14          |
| 5.1 Duty cycle .....   | 14          |
| 5.2 Maximum peak output power .....  | 14          |
| 5.3 DTS Bandwidth / 99% Bandwidth .....  | 14          |
| 5.4 Peak Power Spectral Density.....   | 14          |
| 5.5 Band-edge compliance.....  | 15          |
| 5.5.1 Method of measurement (band edges next to unrestricted bands (radiated)) ..... | 15          |
| 5.5.1.1 Test results (radiated) .....  | 16          |
| 5.5.2 Method of measurement (band edges next to restricted bands (radiated)) .....   | 18          |
| 5.5.2.1 Test results (radiated) .....  | 18          |
| 5.6 Maximum unwanted emissions .....   | 21          |
| 5.6.1 Method of measurement (radiated emissions) .....                               | 21          |
| 5.6.1.1 Preliminary measurement (9 kHz to 30 MHz):.....                              | 22          |
| 5.6.1.2 Preliminary measurement (30 MHz to 1 GHz) .....                              | 23          |
| 5.6.1.3 Preliminary measurement (1 GHz to 40 GHz) .....                              | 24          |
| 5.6.1.4 Final measurement (9 kHz to 30 MHz): .....                                   | 25          |
| 5.6.1.5 Final measurement (30 MHz to 1 GHz) .....                                    | 27          |
| 5.6.1.6 Final measurement (1 GHz to 40 GHz) .....                                    | 28          |
| 5.6.2 Test results (radiated emissions).....   | 30          |
| 5.6.2.1 Results Preliminary measurement (radiated emission) .....                    | 30          |

|         |   |    |
|---------|---|----|
| 5.6.2.2 | Results Final measurement (radiated emission) .....                 | 38 |
| 5.7     | Conducted emissions on power supply lines (150 kHz to 30 MHz) ..... | 39 |
| 6       | Test Equipment used for Tests .....                                 | 40 |
| 7       | Test site Validation .....  | 41 |
| 8       | Report History.....   | 41 |
| 9       | List of Annexes .....   | 41 |

# 1 Identification

## 1.1 Applicant

|  |   |
|--|---|
| Name:  | Xaptum, Inc.  |
| Address:   | 541 N Fairbanks Ct<br>Suite 2200<br>Chicago, IL 60611 |
| Country:   | USA   |
| Name for contact purposes:                                     | David Bild  |
| Phone:   | +1-505-818-7889                                       |
| eMail address:   | david.bild@xaptum.com                                 |
| Applicant represented during the test by the following person: | -   |

## 1.2 Manufacturer

|   |   |
|---|---|
| Name:   | Xaptum, Inc.  |
| Address:  | 541 N Fairbanks Ct<br>Suite 2200<br>Chicago, IL 60611 |
| Country:  | USA   |
| Name for contact purposes:  | David Bild  |
| Phone:  | +1-505-818-7889                                       |
| eMail address:  | david.bild@xaptum.com                                 |
| Manufacturer represented during the test by the following person: | -   |

## 1.3 Test Laboratory

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

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

## 1.4 EUT (Equipment under Test)

| EUT                                   |  |
|---------------------------------------|--|
| Test object: *                        | Stand-alone radio module                 |
| PMN / Model name: *                   | LBEE5HY1MW                               |
| FCC ID: *                             | 2AQPLLBEE5HY1MW                          |
| ISED Certification number: *<br>IC: * | 24569-LBEE5HY1MW                         |
| HVIN: *                               | LBEE5HY1MW                               |
| HMN: *                                | n/a                                      |
| FVIN: *                               | No information provided by the applicant |
| Serial number: *                      | n/a                                      |
| PCB identifier: *                     | n/a                                      |
| Hardware version: *                   | n/a                                      |
| Software version: *                   | n/a                                      |

\* Declared by the applicant

Note: Phoenix Testlab GmbH does not take samples. The samples used for the tests are provided exclusively by the applicant.

| IEEE 802.11 b/g/n20 frequencies |    |          |    |          |
|---------------------------------|----|----------|----|----------|
| Channel 01                      | RX | 2412 MHz | TX | 2412 MHz |
| Channel 06                      | RX | 2437 MHz | TX | 2437 MHz |
| Channel 11                      | RX | 2462 MHz | TX | 2462 MHz |

| Ancillary Equipment               |   |
|-----------------------------------|---|
| Cables<br>(connected to the EUT): | -USB 2.0 type A <-> USB 2.0 type B micro, ~0.2 m* <sup>1</sup><br>+2 m USB extension* <sup>2</sup><br>-Laboratory cables for power supply |
| Fiber optic converter:            | Opto USB2.0, MK Messtechnik (PM. No. 482617) * <sup>2</sup>   |
| Laptop PC:                        | Fujitsu Lifebook S751 (PM No. 201036) * <sup>2</sup>  |

\*<sup>1</sup> Provided by the applicant

\*<sup>2</sup> Provided by the laboratory



## 1.5 Technical Data of Equipment

| General radio module                         |   |     |                    |       |                    |       |
|--|---|-----|--------------------|-------|--------------------|-------|
| Antenna type: *                              | Dipole antenna                                    |     |                    |       |                    |       |
| Antenna name: *                              | RD2458-5, Laird Technologies                      |     |                    |       |                    |       |
| Antenna gain: *                              | 3 dBi (max in the 2.4 GHz band)                   |     |                    |       |                    |       |
| Antenna connector: *                         | SMA   |     |                    |       |                    |       |
| Evaluation board: *                          | xaprw001  |     |                    |       |                    |       |
| Power supply EUT: *                          | DC  |     |                    |       |                    |       |
| Supply voltage eval board: *                 | U <sub>nom</sub> =                                | 5 V | U <sub>min</sub> = | 5 V   | U <sub>max</sub> = | 12 V  |
| Supply voltage radio module: *               | U <sub>nom</sub> =                                | 3.3 | U <sub>min</sub> = | 1.7 V | U <sub>max</sub> = | 3.6 V |
| Temperature range: *                         | -40 °C to +85 °C                                  |     |                    |       |                    |       |
| Lowest / highest internal clock frequency: * | 32 kHz to 498 MHz / 2462 MHz in 2.4 GHz WLAN mode |     |                    |       |                    |       |

\* Declared by the applicant

| Radio module                   |                              |                                     |                    |     |                    |                                   |
|--------------------------------|------------------------------|-------------------------------------|--------------------|-----|--------------------|-----------------------------------|
| Power supply EUT: *            |                              |                                     | DC                 |     |                    |                                   |
| Supply voltage radio module: * |                              |                                     | U <sub>nom</sub> = | 3.3 | U <sub>min</sub> = | 1.7 V    U <sub>max</sub> = 3.6 V |
| IEEE 802.11 b                  | Conducted output power: *    | 20.54 dBm* <sup>2</sup>             |                    |     |                    |                                   |
| IEEE 802.11 b                  | Type of modulation: *        | DSSS (1/2/5.5/11 Mbit/s)            |                    |     |                    |                                   |
| IEEE 802.11 b                  | Operating frequency range: * | 2412 – 2462 MHz                     |                    |     |                    |                                   |
| IEEE 802.11 b                  | Number of channels: *        | 11 (5 MHz channel spacing)          |                    |     |                    |                                   |
| IEEE 802.11 g                  | Conducted output power: *    | 23.83 dBm* <sup>2</sup>             |                    |     |                    |                                   |
| IEEE 802.11 g                  | Type of modulation: *        | OFDM (6/9/12/18/24/36/48/54 Mbit/s) |                    |     |                    |                                   |
| IEEE 802.11 g                  | Operating frequency range: * | 2412 – 2462 MHz                     |                    |     |                    |                                   |
| IEEE 802.11 g                  | Number of channels: *        | 11 (5 MHz channel spacing)          |                    |     |                    |                                   |
| IEEE 802.11 n-HT20             | Conducted output power: *    | 23.43 dBm* <sup>2</sup>             |                    |     |                    |                                   |
| IEEE 802.11 n-HT20             | Type of modulation: *        | OFDM (up to 72.2 Mbit/s)            |                    |     |                    |                                   |
| IEEE 802.11 n-HT20             | Operating frequency range: * | 2412 – 2462 MHz                     |                    |     |                    |                                   |
| IEEE 802.11 n-HT20             | Number of channels: *        | 11 (5 MHz channel spacing)          |                    |     |                    |                                   |

\* Declared by the applicant

\*<sup>2</sup> Values were taken from the original test report

## 1.6 Dates

|                                 |            |
|---------------------------------|------------|
| Date of receipt of test sample: | 13.02.2019 |
| Start of test:                  | 01.03.2019 |
| End of test:                    | 18.04.2019 |

## 2 Operational States

### 2.1 Description of function of the EUT

The EUT is a communication module. The module is capable to use the following technologies:

- WiFi 2.4 GHz (20 MHz)
- WiFi 5 GHz (20/40/80 MHz)
  - UNII-1
  - UNII-2A
  - UNII-2C
  - UNII-3
- Bluetooth
- Bluetooth Low Energy

As declared by the applicant **only the following technologies were used:**

- WiFi 2.4 GHz (20 MHz)
- WiFi 5 GHz (20/40MHz)
  - UNII-1
  - UNII-3

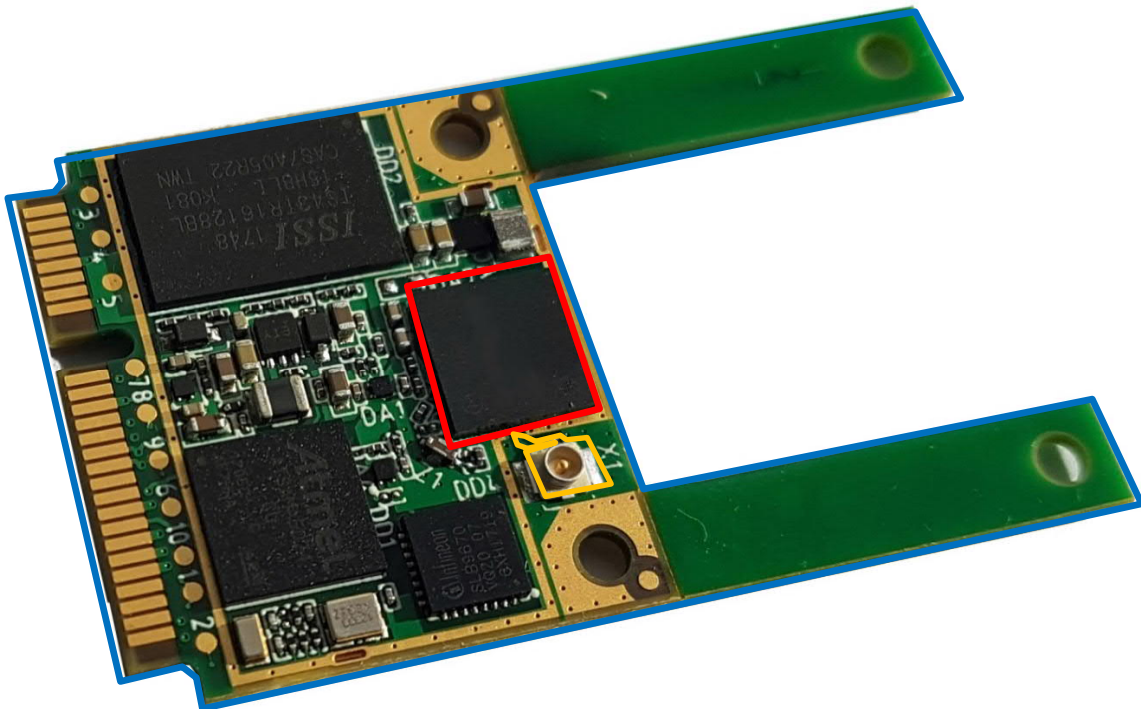
As declared by the applicant the other technologies are deactivated by software.

The 2.4GHz and 5 GHz bands are not used simultaneously.

This test report incorporates only limited test-cases for the WiFi 2.4 GHz (20 MHz).  
Purpose of this report is to add a new antenna to the existing filing.

The EUT (photo provided by the applicant):

EUT with trace design on evaluation board



## 2.2 The following states were defined as the operating conditions

The EUT was placed on an evaluation board, the evaluation board and the EUT were powered with 3.3 V DC via laboratory power supply and the data connection was established via USB.

The USB data connection was converted to a fibre connection for remote control during the radiated tests.

### 2.2.1 Radio tests

For the radio tests the following settings were used:

A connection to the EUT was established via USB cable.

The USB connection was converted to a serial connection on the EUT.

The following COM port settings were used with "tera term".

Baud rate: 115200  
Data: 8 bit  
Parity: None  
Stop: 1 bit  
Flow control: None

The EUT was set in a test-mode, the radio parameter were set with a linux shell script (wifi\_testmode.sh).

### 2.2.2 Operation Modes/Power settings

| Operation mode # | Radio technology | Frequency [MHz] | Channel | Modulation / Mode | Data rate | Power setting  |
|------------------|------------------|-----------------|---------|-------------------|-----------|----------------|
| 1                | WLAN             | 2412            | 1       | b-mode            | 11 Mbit/s | 68 quarter dBm |
| 2                | WLAN             | 2437            | 6       | b-mode            | 11 Mbit/s | 68 quarter dBm |
| 3                | WLAN             | 2462            | 11      | b-mode            | 11 Mbit/s | 68 quarter dBm |
| 4                | WLAN             | 2412            | 1       | g-mode            | 6 Mbit/s  | 48 quarter dBm |
| 5                | WLAN             | 2437            | 6       | g-mode            | 6 Mbit/s  | 64 quarter dBm |
| 6                | WLAN             | 2462            | 11      | g-mode            | 6 Mbit/s  | 48 quarter dBm |
| 7                | WLAN             | 2412            | 1       | n-mode            | MCS0      | 48 quarter dBm |
| 8                | WLAN             | 2437            | 6       | n-mode            | MCS0      | 56 quarter dBm |
| 9                | WLAN             | 2462            | 11      | n-mode            | MCS0      | 48 quarter dBm |

### 3 Additional Information

This test report incorporates the limited tests with a further antenna (RD2458-5, Laird Technologies). It contains just limited test cases with the goal to add a new antenna to an existing filing.

The complete radio test for 2.4 GHz WiFi are documented in test report:  
1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID: VPYLBEE5HY1MW.

### 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]                         | Verified*  | ---        |
| DTS Bandwidth                      | 2400.0 - 2483.5       | 15.247 (a) (2)                         | 5.2 (a) [3]                         | not tested | ---        |
| Peak Power Spectral Density        | 2400.0 - 2483.5       | 15.247 (e)                             | 5.2 (b) [3]                         | not tested | ---        |
| Band edge compliance               | 2400.0 - 2483.5       | 15.247 (d)<br>15.205 (a)<br>15.209 (a) | 5.5 [3]<br>8.9 [4],<br>8.10 [4]     | Passed     | ---        |
| Radiated emissions (transmitter)   | 0.009 – 26,500        | 15.247 (d)<br>15.205 (a)<br>15.209 (a) | 5.5 [3]<br>8.9 [4],<br>8.10 [4]     | Passed     | 15 et seq. |
| Conducted emissions on supply line | 0.15 - 30             | 15.207 (a)                             | 8.8 [4]                             | not tested | ---        |

\* The Maximum Peak Output Power was verified and compared with the original results.

## **5 Results**

### **5.1 Duty cycle**

For detailed results see test-reports 1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID VPYLBEE5HY1MW.

### **5.2 Maximum peak output power**

The Maximum Peak output power was verified ( Operation mode 1 -9 ) and compared with the results from the original filing.

The results are similar to the original results within the measurement uncertainty.

For detailed results see test-reports 1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID VPYLBEE5HY1MW.

### **5.3 DTS Bandwidth / 99% Bandwidth**

For detailed results see test-reports 1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID VPYLBEE5HY1MW.

### **5.4 Peak Power Spectral Density**

For detailed results see test-reports 1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID VPYLBEE5HY1MW.

## 5.5 Band-edge compliance

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

For the measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1.

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

#### Measurement Procedure Reference – Reference Level:

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

#### Measurement Procedure – Unwanted Emissions

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

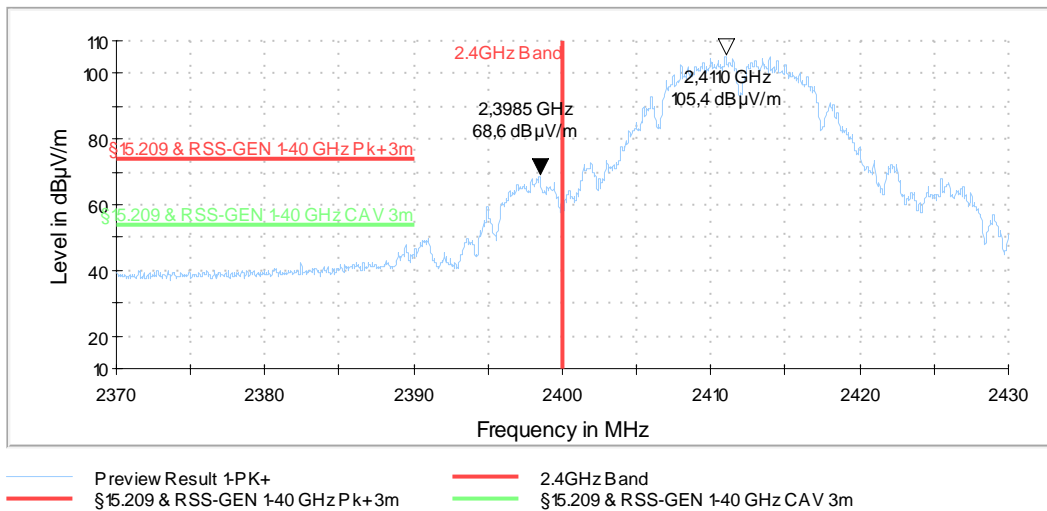
The measurement procedure at the band edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by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

### 5.5.1.1 Test results (radiated)

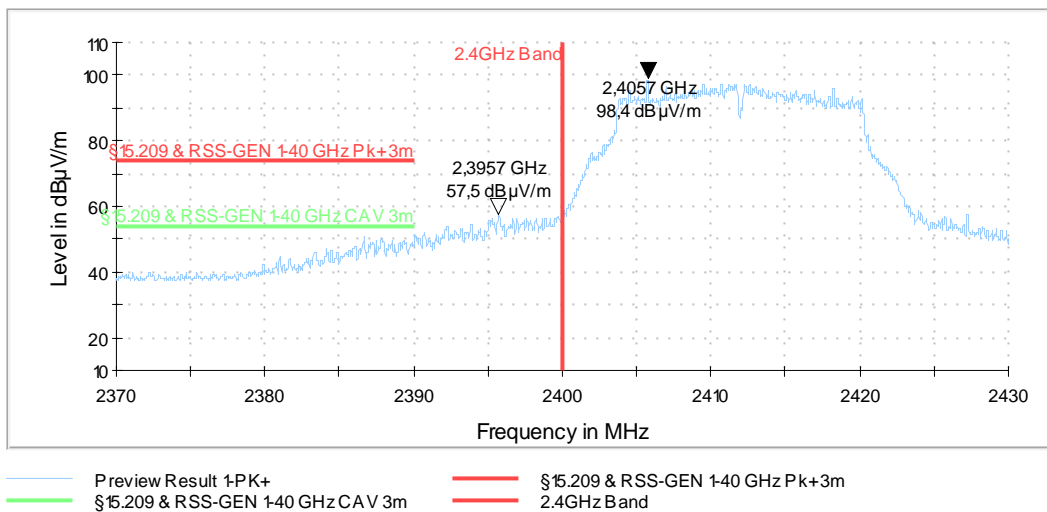
|                     |  |
|---------------------|--|
| Ambient temperature |  |
| Relative humidity   |  |

|           |            |
|-----------|------------|
| Date      | 02.03.2019 |
| Tested by | B. ROHDE   |

Operation mode 1

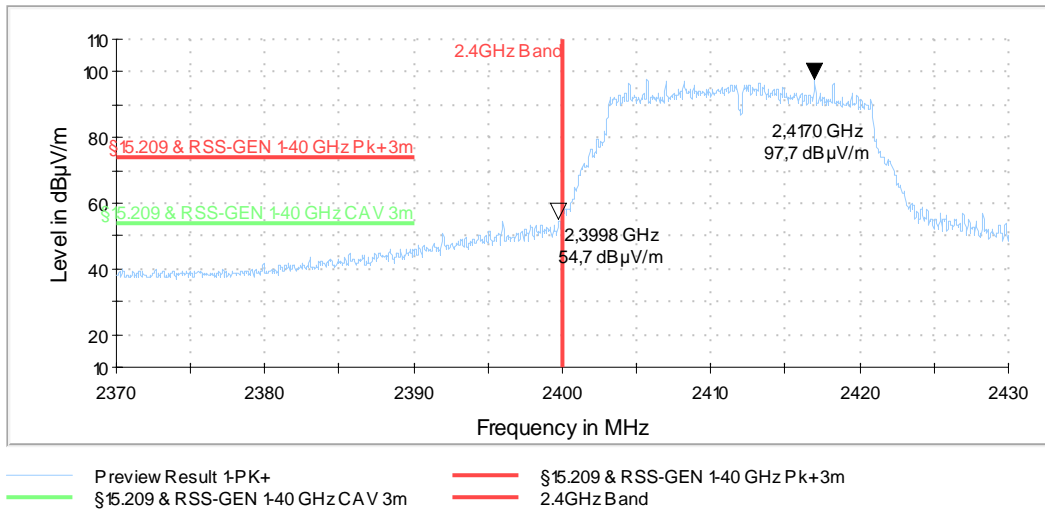


Operation mode 4





## Operation mode 7



| Operation Mode | Tx Frequency [MHz] | Emission Frequency [MHz] | Reference Level [dBµV] | Limit [dBm] | Emission Level [dBµV] | Margin [dB] | Result |
|----------------|--------------------|--------------------------|------------------------|-------------|-----------------------|-------------|--------|
| 1              | 2412               | 2398.5                   | 105.4                  | 85.4        | 68.6                  | 16.8        | Passed |
| 4              | 2412               | 2395.7                   | 98.4                   | 78.4        | 57.5                  | 20.9        | Passed |
| 7              | 2412               | 2399.8                   | 97.7                   | 77.7        | 54.7                  | 23.0        | Passed |

Test equipment (please refer to chapter 6 for details)

1 - 11

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

For the measurement, the EUT was measured radiated in the anechoic chamber using the procedures described in 5.6.1.

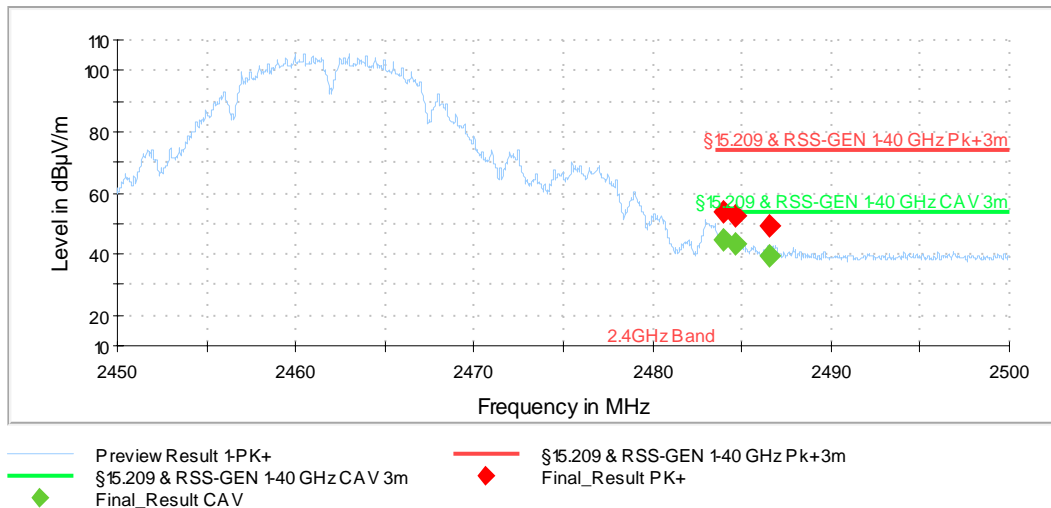
The relating measurements were carried radiated. The measurement procedure refers to part 6.10.5.2 of document [1].

#### 5.5.2.1 Test results (radiated)

|                     |  |
|---------------------|--|
| Ambient temperature |  |
| Relative humidity   |  |

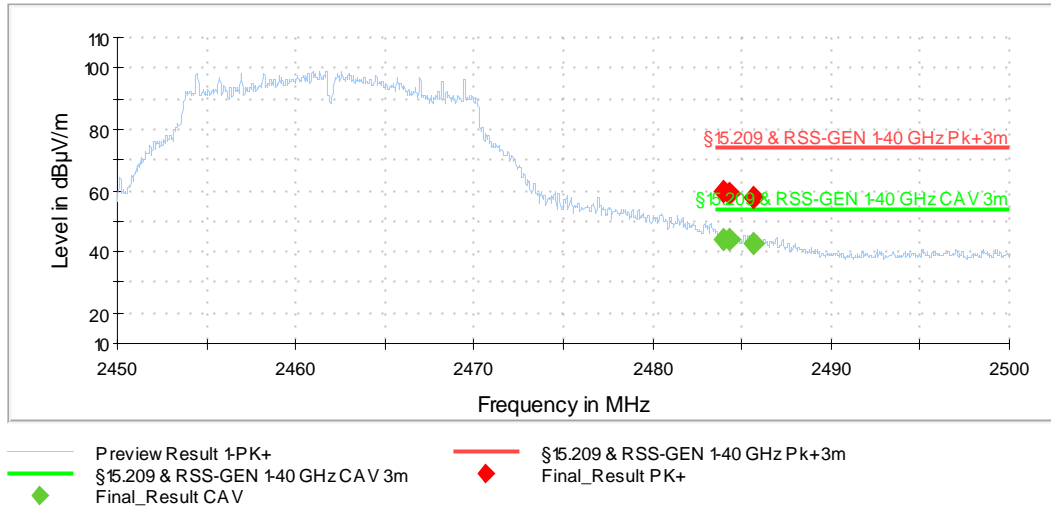
|           |            |
|-----------|------------|
| Date      | 02.03.2019 |
| Tested by | B. ROHDE   |

Operation mode 3



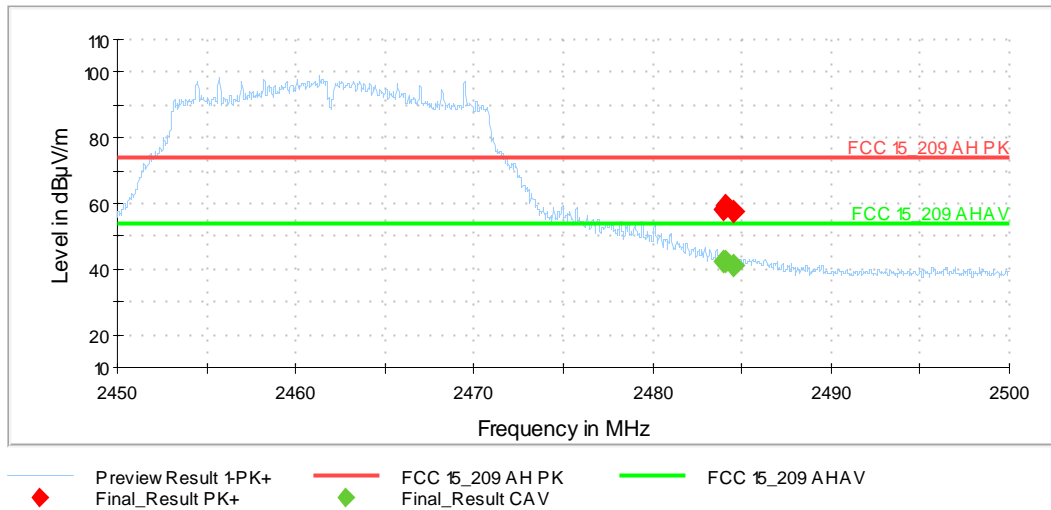
| Upper band edge         |          |          |   |                   |     |         |           |            |        |
|-------------------------|----------|----------|---|-------------------|-----|---------|-----------|------------|--------|
| Operation mode 3        |          |          | No duty cycle correction factor was applied for the Average reading |                   |     |         |           |            |        |
| Frequency               | Max Peak | Average  | Limit   | Margin            | Pol | Azimuth | Elevation | Correction | Result |
| [MHz]                   | [dBμV/m] | [dBμV/m] | [dBμV/m]  | dB                |     | [°]     | [°]       | [dB]       |        |
| 2484.000000             | 53.9     | ---      | 74  | 20.1              | V   | 29      | 30        | 34.0       | Passed |
| 2484.000000             | ---      | 44.8     | 54  | 9.2               | V   | 29      | 30        | 34.0       | Passed |
| 2484.650000             | 52.2     | ---      | 74  | 21.8              | V   | 21      | 0         | 34.0       | Passed |
| 2484.650000             | ---      | 43.2     | 54  | 10.8              | V   | 21      | 0         | 34.0       | Passed |
| 2486.500000             | 49.5     | ---      | 74  | 24.5              | V   | 288     | 150       | 34.0       | Passed |
| 2486.500000             | ---      | 39.5     | 54  | 14.5              | V   | 288     | 150       | 34.0       | Passed |
| Measurement uncertainty |          |          |   | +2.2 dB / -3.6 dB |     |         |           |            |        |

## Operation mode 6



| Upper band edge         |          |          |   |                   |     |         |           |            |        |
|-------------------------|----------|----------|---|-------------------|-----|---------|-----------|------------|--------|
| Operation mode 6        |          |          | No duty cycle correction factor was applied for the Average reading |                   |     |         |           |            |        |
| Frequency               | Max Peak | Average  | Limit   | Margin            | Pol | Azimuth | Elevation | Correction | Result |
| [MHz]                   | [dBμV/m] | [dBμV/m] | [dBμV/m]  | dB                |     | [°]     | [°]       | [dB]       |        |
| 2484.000000             | 59.6     | ---      | 74  | 14.4              | V   | 37      | 0         | 34.0       | Passed |
| 2484.000000             | ---      | 43.8     | 54  | 10.2              | V   | 37      | 0         | 34.0       | Passed |
| 2484.250000             | 58.8     | ---      | 74  | 15.2              | V   | 259     | 150       | 34.0       | Passed |
| 2484.250000             | ---      | 43.7     | 54  | 10.3              | V   | 259     | 150       | 34.0       | Passed |
| 2485.625000             | 58.0     | ---      | 74  | 16.0              | V   | 115     | 150       | 34.0       | Passed |
| 2485.625000             | ---      | 42.9     | 54  | 11.1              | V   | 115     | 150       | 34.0       | Passed |
| Measurement uncertainty |          |          |   | +2.2 dB / -3.6 dB |     |         |           |            |        |

## Operation mode 9



| Upper band edge         |          |          |   |                   |     |         |           |            |        |
|-------------------------|----------|----------|---|-------------------|-----|---------|-----------|------------|--------|
| Operation mode 9        |          |          | No duty cycle correction factor was applied for the Average reading |                   |     |         |           |            |        |
| Frequency               | Max Peak | Average  | Limit   | Margin            | Pol | Azimuth | Elevation | Correction | Result |
| [MHz]                   | [dBμV/m] | [dBμV/m] | [dBμV/m]  | dB                |     | [°]     | [°]       | [dB]       |        |
| 2484.000000             | 58.3     | ---      | 74  | 15.7              | V   | 305     | 0         | 34.0       | Passed |
| 2484.000000             | ---      | 42.0     | 54  | 12.0              | V   | 305     | 0         | 34.0       | Passed |
| 2484.100000             | 59.3     | ---      | 74  | 14.7              | V   | 251     | 30        | 34.0       | Passed |
| 2484.100000             | ---      | 42.5     | 54  | 11.5              | V   | 251     | 30        | 34.0       | Passed |
| 2484.500000             | 57.4     | ---      | 74  | 16.6              | V   | 346     | 150       | 34.0       | Passed |
| 2484.500000             | ---      | 41.1     | 54  | 12.9              | V   | 346     | 150       | 34.0       | Passed |
| Measurement uncertainty |          |          |   | +2.2 dB / -3.6 dB |     |         |           |            |        |

Test equipment (please refer to chapter 6 for details)

1 - 11

## **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 site 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 site with reflecting ground plane and various antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 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.

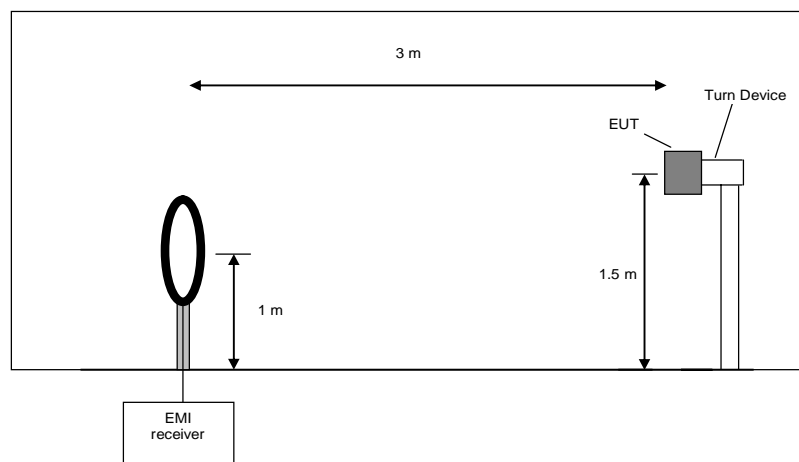
#### 5.6.1.1 Preliminary measurement (9 kHz to 30 MHz):

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.

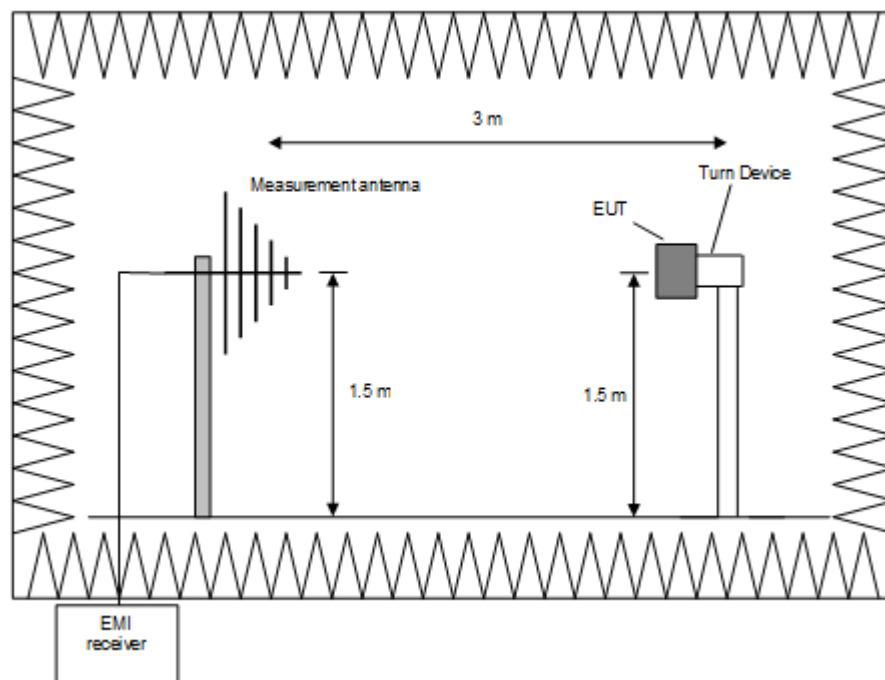
### 5.6.1.2 Preliminary measurement (30 MHz to 1 GHz)

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 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.

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

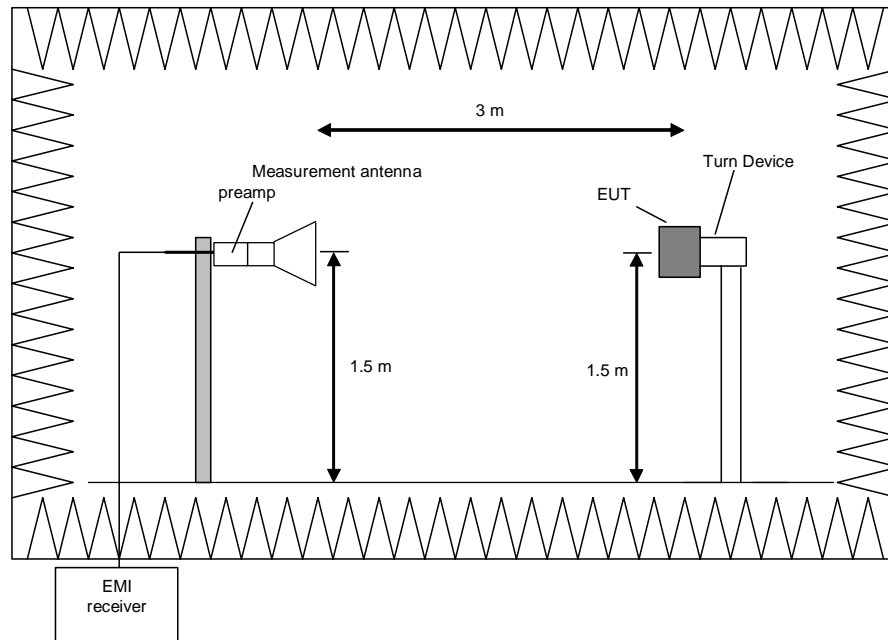
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

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.

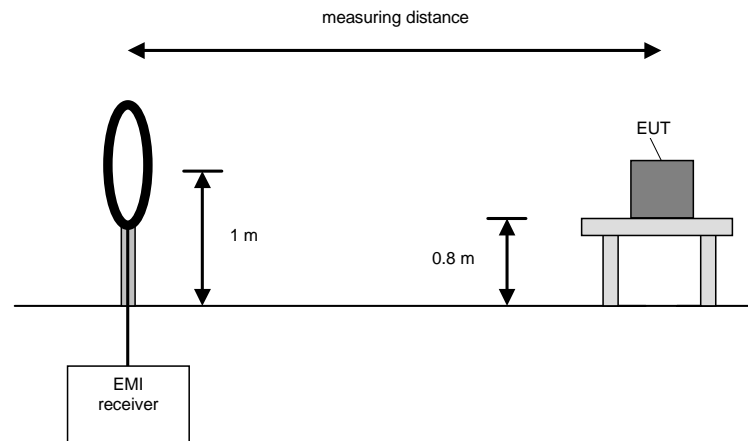
#### **5.6.1.4 Final measurement (9 kHz to 30 MHz):**

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances is 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:

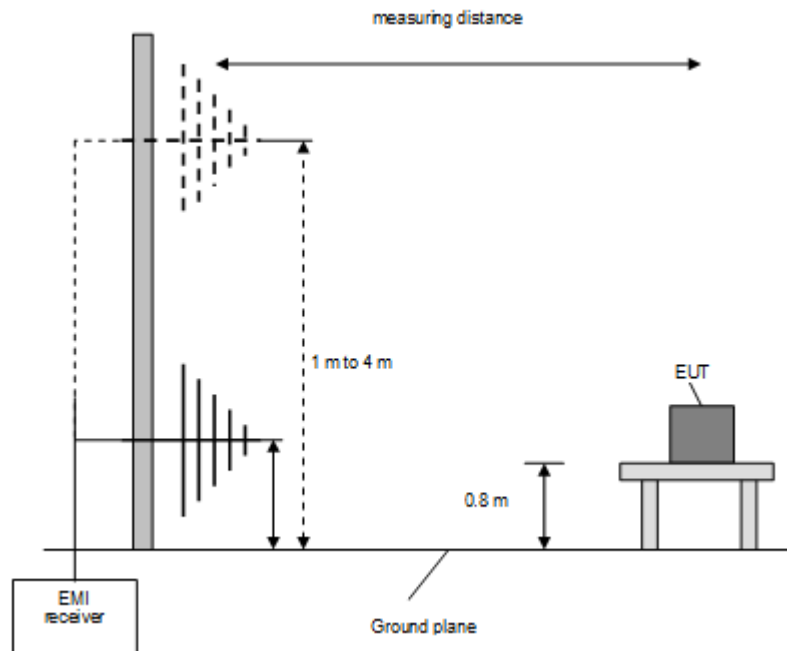
- 1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 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).

#### 5.6.1.5 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  $0^\circ$  to  $360^\circ$ , 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).

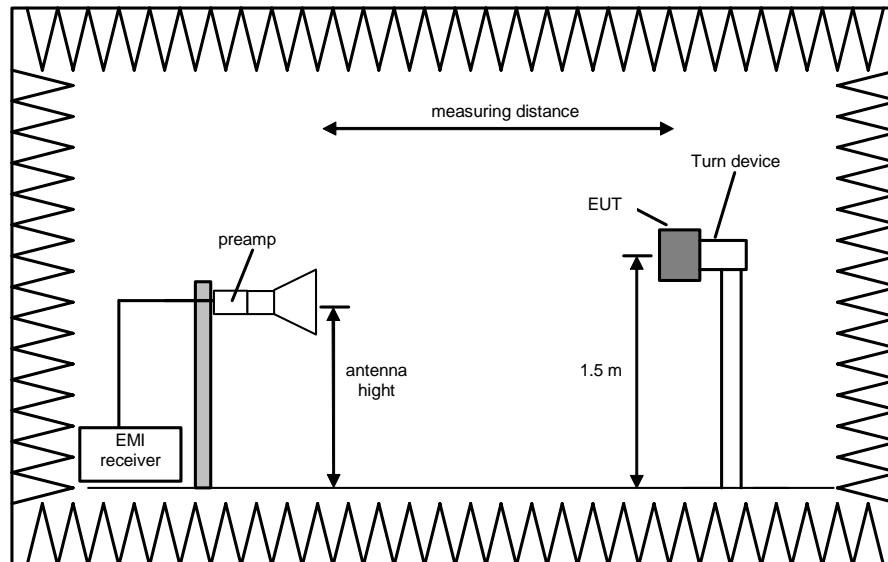
#### 5.6.1.6 Final measurement (1 GHz to 40 GHz)

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].

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)**

### **5.6.2.1 Results Preliminary measurement (radiated emission)**

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

No preliminary measurement done in the frequency range 9 kHz to 30 MHz.

#### **5.6.2.1.2 Preliminary measurement (30 MHz to 1 GHz):**

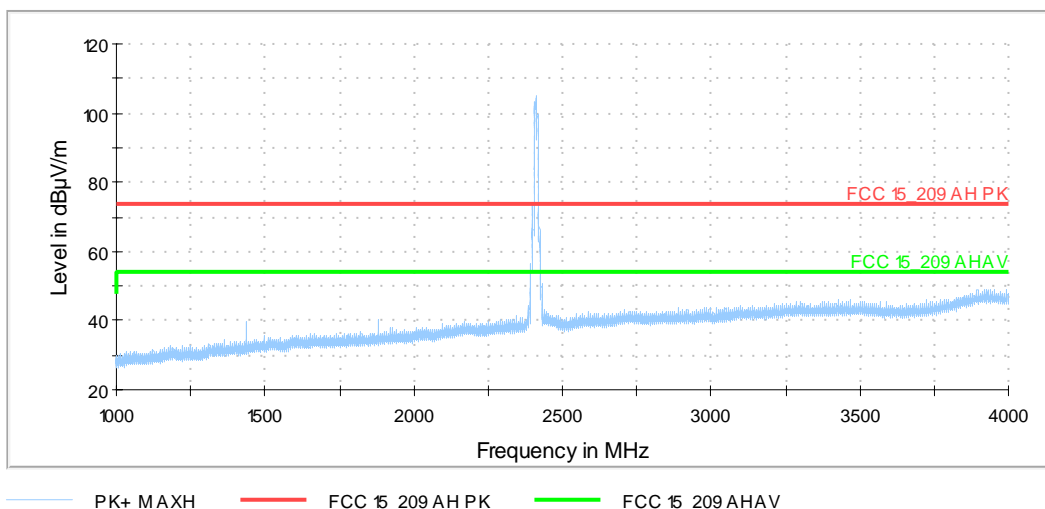
No preliminary measurement done in the frequency range 30 MHz to 1 GHz.

#### 5.6.2.1.3 Preliminary measurement (1 GHz to 26.5 GHz):

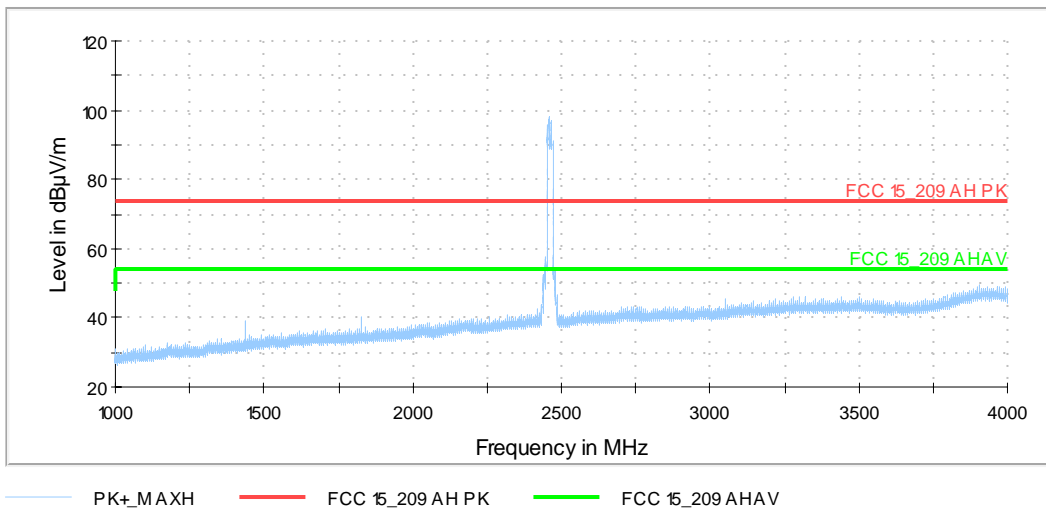
|                     |       |           |                          |
|---------------------|-------|-----------|--------------------------|
| Ambient temperature | 21° C | Date      | 01.03.2019<br>18.04.2019 |
| Relative humidity   | 29%   | Tested by | B. ROHDE                 |

- Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.
- Cable guide: For detail information of test set-up and the cable guide refer to the pictures in Test setup Photo annex.
- Test record: All results are shown in the following.
- Supply voltage: During all measurements the host of the EUT was supplied with 5 V DC via an USB cable and 3.3 V DC via laboratory power supply.
- Remark: Only the worst-case channel for every mode according to the original report was tested.  
The FCC limit eCFR §15.209 as used in the plots is identical to the ISED RSS-Gen limit.

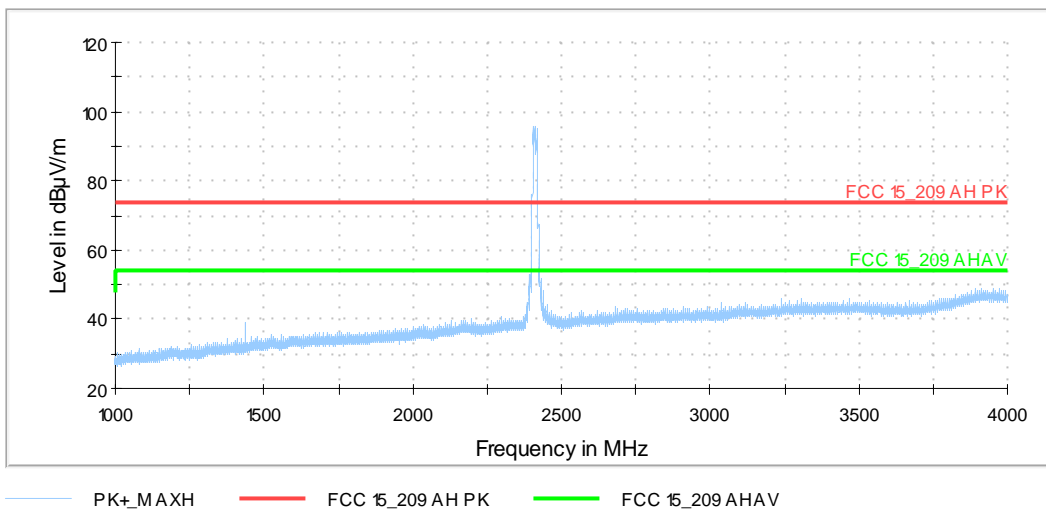
Operation mode 1: Spurious emissions from 1 – 4 GHz:  
(Preliminary plot)



Operation mode 6: Spurious emissions from 1 – 4 GHz:  
(Preliminary plot)

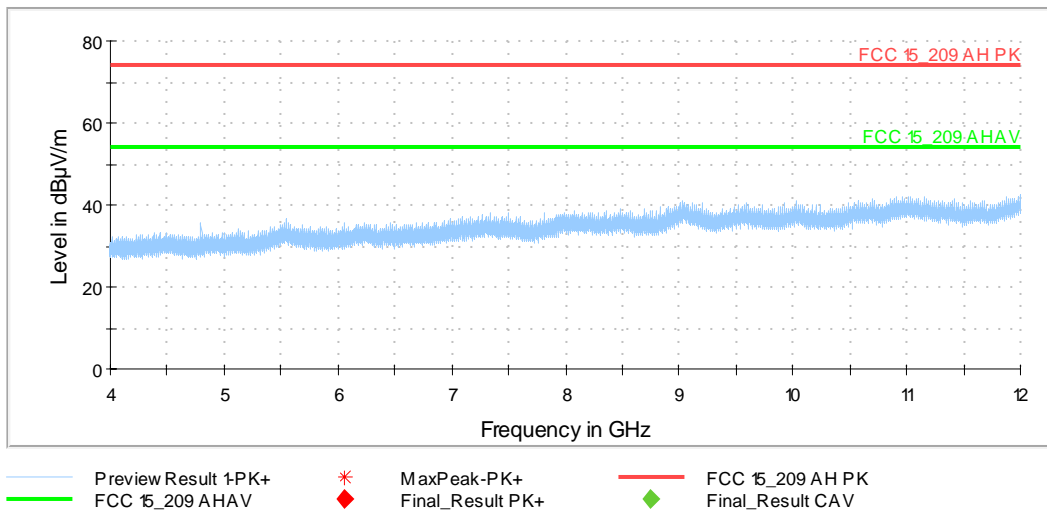


Operation mode 7: Spurious emissions from 1 – 4 GHz:  
(Preliminary plot)

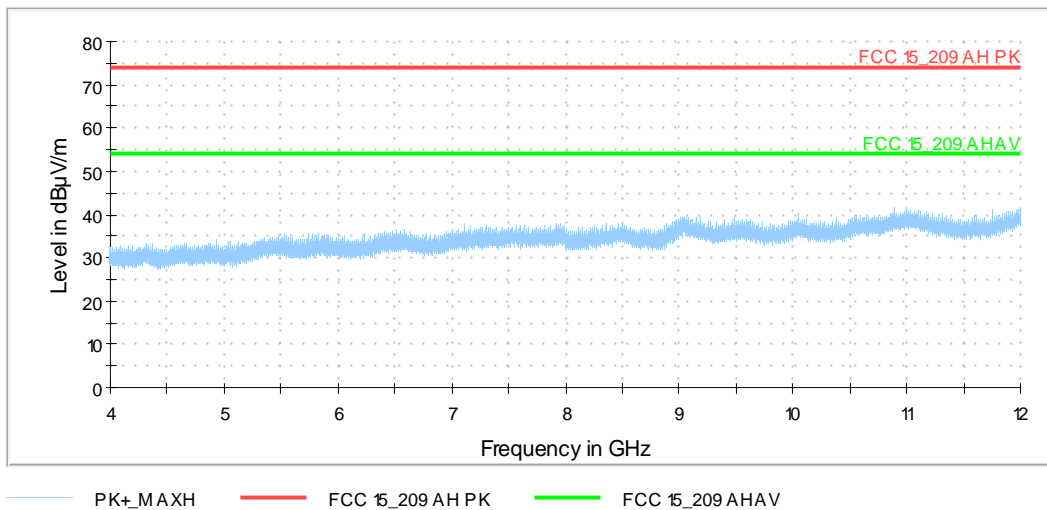




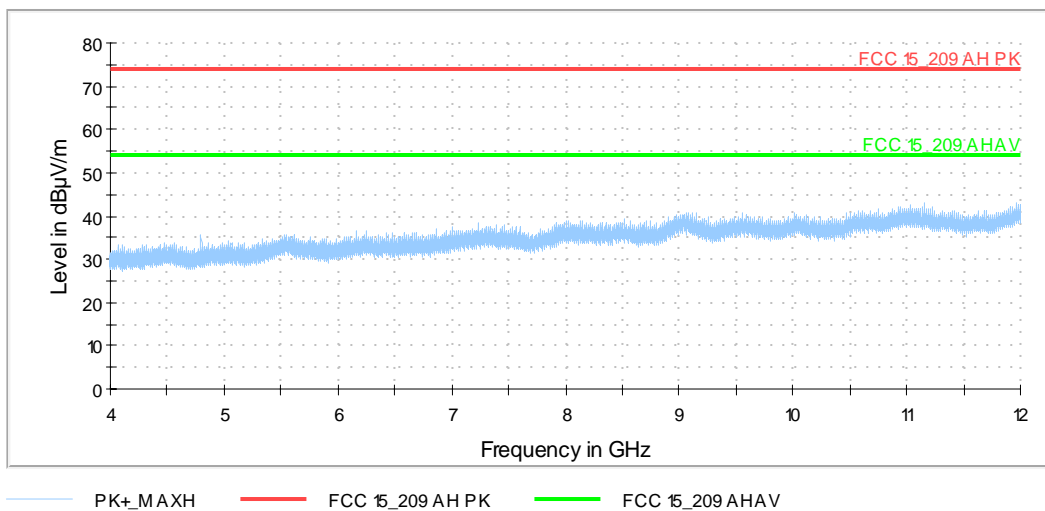
Operation mode 1: Spurious emissions from 4 - 12 GHz:  
(Preliminary plot)



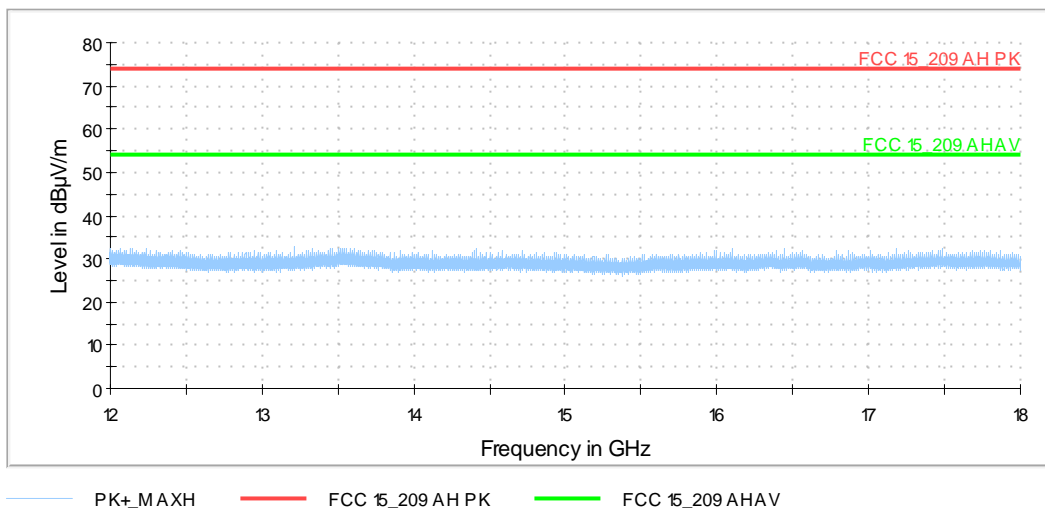
Operation mode 6: Spurious emissions from 4 - 12 GHz:  
(Preliminary plot)



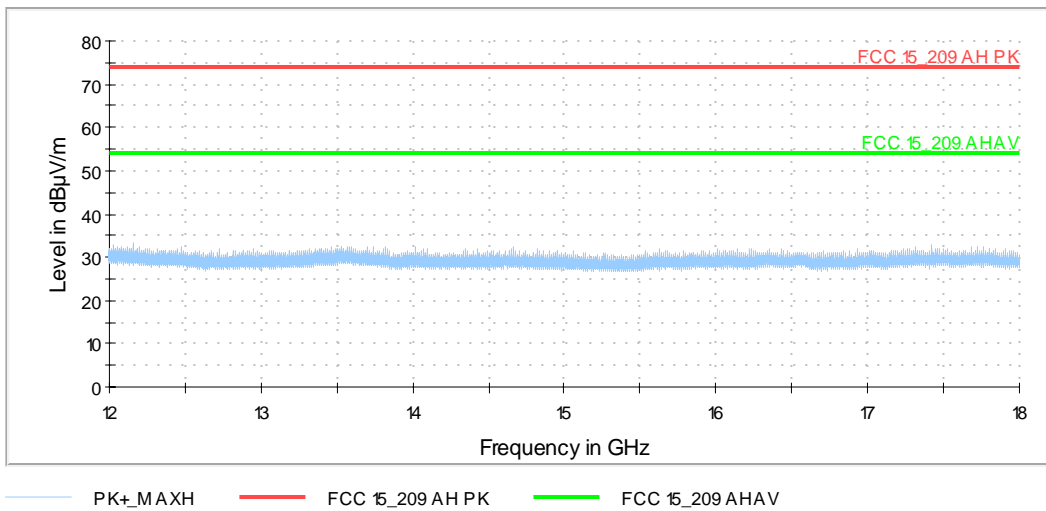
Operation mode 7: Spurious emissions from 4 - 12 GHz:  
(Preliminary plot)



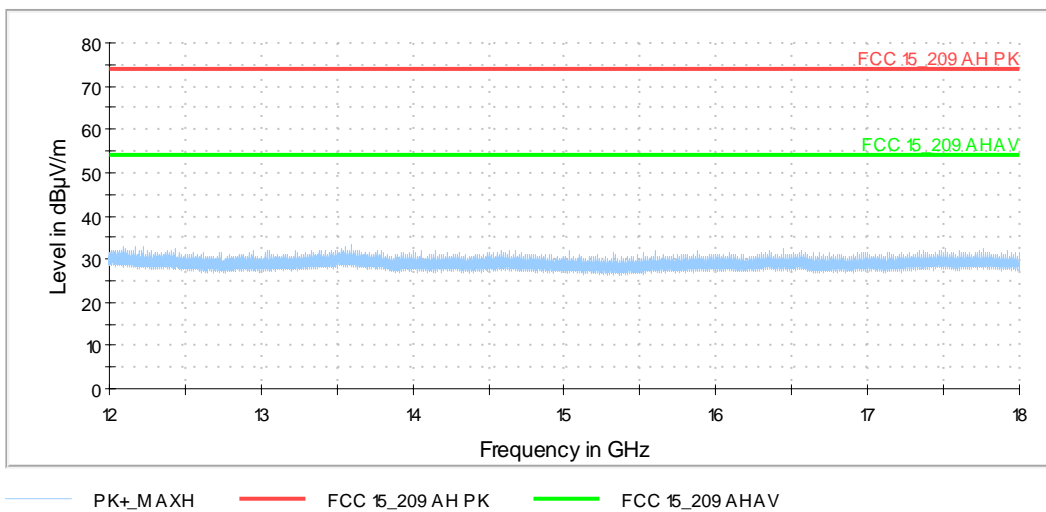
Operation mode 1: Spurious emissions from 12 - 18 GHz:  
(Preliminary plot)



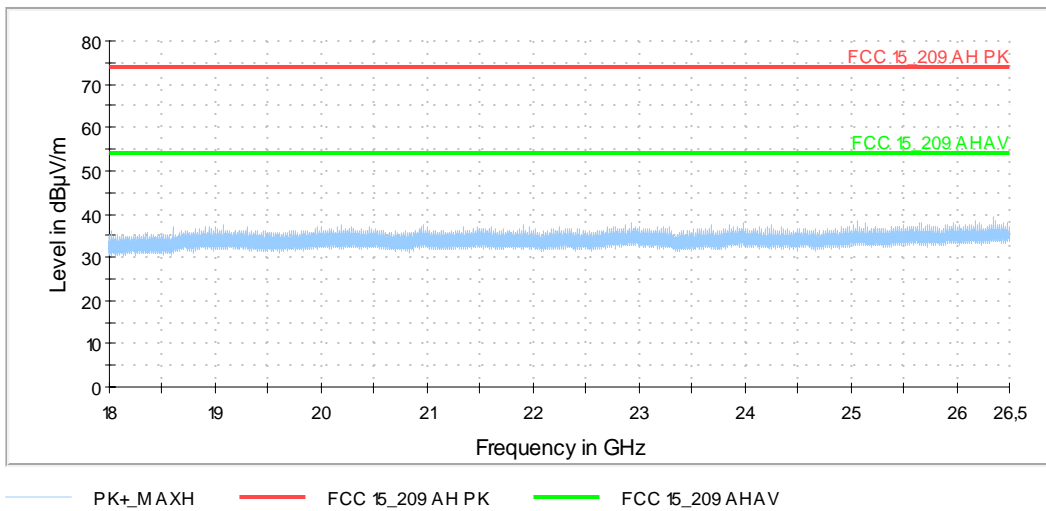
Operation mode 6: Spurious emissions from 12 - 18 GHz:  
(Preliminary plot)



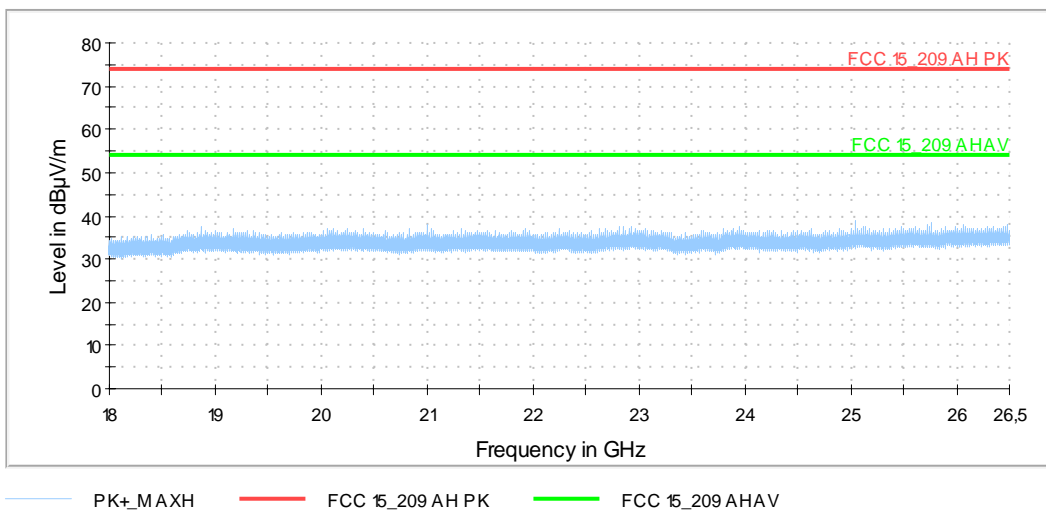
Operation mode 7: Spurious emissions from 12 - 18 GHz:  
(Preliminary plot)



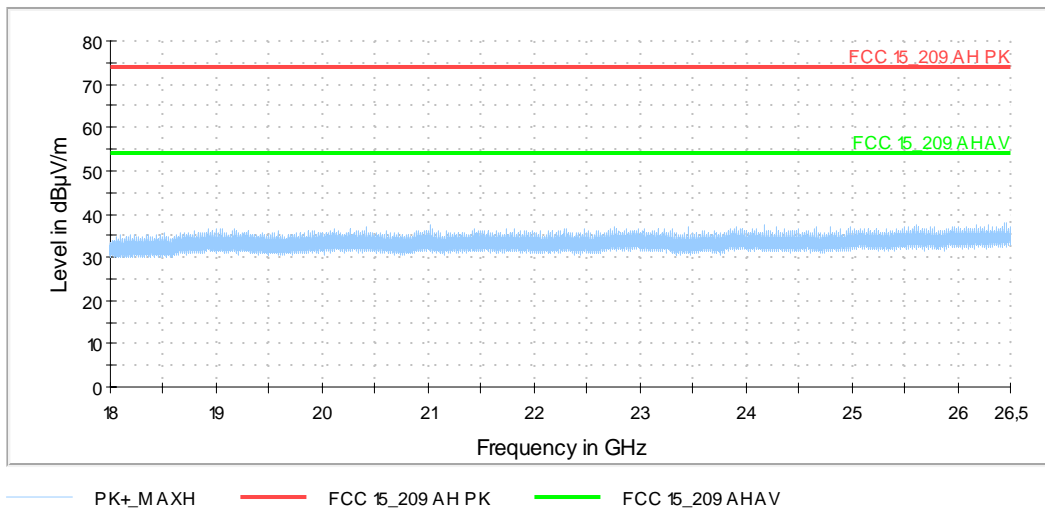
Operation mode 1: Spurious emissions from 18 – 26.5 GHz:  
(Preliminary plot)



Operation mode 6: Spurious emissions from 18 – 26.5 GHz:  
(Preliminary plot)



Operation mode 7: Spurious emissions from 18 – 26.5 GHz:  
(Preliminary plot)



Test equipment (please refer to chapter 6 for details)

1 - 20

### 5.6.2.2 Results Final measurement (radiated emission)

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

No final measurement was conducted.

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

No final measurement was conducted.

#### 5.6.2.2.3 Final measurement (1 GHz to 26.5 GHz):

|                     |       |
|---------------------|-------|
| Ambient temperature | 21° C |
| Relative humidity   | 29%   |

|           |                          |
|-----------|--------------------------|
| Date      | 01.03.2019<br>18.04.2019 |
| Tested by | B.ROHDE                  |

|                         |   |
|-------------------------|---|
| Position of EUT:        | The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.                    |
| Cable guide:            | For detail information of test set-up and the cable guide refer to the pictures in Test setup Photo annex.                      |
| Test record:            | All results are shown in the following.   |
| Supply voltage:         | During all measurements the host of the EUT was supplied with 5 V DC via an USB cable and 3.3 V DC via laboratory power supply. |
| Remark:                 | Only the worst case channel for every mode according to the original report was tested.   |
| 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.  |

#### Operation mode 1

| Spurious Emissions (Operation mode 1) 1 – 26.5 GHz                              |                      |                     |                   |                   |     |                |                  |                    |        |
|---|----------------------|---------------------|-------------------|-------------------|-----|----------------|------------------|--------------------|--------|
| No duty cycle correction factor was applied for the average reading             |                      |                     |                   |                   |     |                |                  |                    |        |
| Frequency<br>[MHz]  | Max Peak<br>[dBμV/m] | Average<br>[dBμV/m] | Limit<br>[dBμV/m] | Margin<br>dB      | Pol | Azimuth<br>[°] | Elevation<br>[°] | Correction<br>[dB] | Result |
| All emissions were more than 20 dB below the limit – no final emission measured |                      |                     |                   |                   |     |                |                  |                    |        |
| Measurement uncertainty   |                      |                     |                   | +2.2 dB / -3.6 dB |     |                |                  |                    |        |

#### Operation mode 6

| Spurious Emissions (Operation mode 6) 1 – 26.5 GHz                              |                      |                     |                   |                   |     |                |                  |                    |        |
|---|----------------------|---------------------|-------------------|-------------------|-----|----------------|------------------|--------------------|--------|
| No duty cycle correction factor was applied for the average reading             |                      |                     |                   |                   |     |                |                  |                    |        |
| Frequency<br>[MHz]  | Max Peak<br>[dBμV/m] | Average<br>[dBμV/m] | Limit<br>[dBμV/m] | Margin<br>dB      | Pol | Azimuth<br>[°] | Elevation<br>[°] | Correction<br>[dB] | Result |
| All emissions were more than 20 dB below the limit – no final emission measured |                      |                     |                   |                   |     |                |                  |                    |        |
| Measurement uncertainty   |                      |                     |                   | +2.2 dB / -3.6 dB |     |                |                  |                    |        |

#### Operation mode 7

| Spurious Emissions (Operation mode 7) 1 – 26.5 GHz                              |                      |                     |                   |                   |     |                |                  |                    |        |
|---|----------------------|---------------------|-------------------|-------------------|-----|----------------|------------------|--------------------|--------|
| No duty cycle correction factor was applied for the average reading             |                      |                     |                   |                   |     |                |                  |                    |        |
| Frequency<br>[MHz]  | Max Peak<br>[dBμV/m] | Average<br>[dBμV/m] | Limit<br>[dBμV/m] | Margin<br>dB      | Pol | Azimuth<br>[°] | Elevation<br>[°] | Correction<br>[dB] | Result |
| All emissions were more than 20 dB below the limit – no final emission measured |                      |                     |                   |                   |     |                |                  |                    |        |
| Measurement uncertainty   |                      |                     |                   | +2.2 dB / -3.6 dB |     |                |                  |                    |        |

|  |
|--|
| Test equipment (please refer to chapter 6 for details) |
| 1 - 20   |

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

For detailed results see test-reports 1802WSU008-U1 by MRT Technology (Suzhou) Co., Ltd, FCC ID VPYLBEE5HY1MW.

## 6 Test Equipment used for Tests

| No. | Test equipment                   | Type                     | Manufacturer                | Serial No.        | PM. No. | Cal. Date                 | Cal Due |
|-----|----------------------------------|--------------------------|-----------------------------|-------------------|---------|---------------------------|---------|
| 1   | Antenna (Log.Per.)               | HL050                    | Rohde & Schwarz             | 100438            | 481170  | 09.10.2017                | 10.2020 |
| 2   | HF-Cable                         | Sucoflex 104             | Huber+Suhner                | 517402            | 482392  | Calibration not necessary |         |
| 3   | Antenna mast                     | AS615P                   | Deisel                      | 615/310           | 480187  | Calibration not necessary |         |
| 4   | Fully anechoic chamber M20       | B83117-E2439-T232        | Albatross Projects          | 103               | 480303  | Calibration not necessary |         |
| 5   | Turntable                        | DS420 HE                 | Deisel                      | 420/620/00        | 480315  | Calibration not necessary |         |
| 6   | Multiple Control Unit            | MCU                      | Maturo GmbH                 | MCU/043/971107    | 480832  | Calibration not necessary |         |
| 7   | Positioners                      | TDF 1.5- 10Kg            | Maturo                      | 15920215          | 482034  | Calibration not necessary |         |
| 8   | EMI Receiver / Spectrum Analyser | ESW44                    | Rohde & Schwarz             | 101635            | 482467  | 29.03.2018                | 03.2020 |
| 9   | Software                         | WMS32                    | Rohde & Schwarz             |                   | 481800  | Calibration not necessary |         |
| 10  | RF-cable No.3                    | Sucoflex 106B            | Suhner                      | 0563/6B / Kabel 3 | 480670  | Calibration not necessary |         |
| 11  | RF-cable No.40                   | SF 106B/11N/11N/1 500MM  | Suhner                      | 500192/6B         | 482125  | Calibration not necessary |         |
| 12  | standard gain horn antenna       | 18240-20                 | Flann Microwave             | 483               | 480294  | Calibration not necessary |         |
| 13  | Preamplifier 12 GHz - 18 GHz     | JS3-12001800-16-5A       | MITEQ Hauppauge N.Y.        | 571667            | 480343  | 10.07.2018                | 07.2020 |
| 14  | standard gain horn antenna       | 20240-20                 | Flann Microwave             | 411               | 480297  | Calibration not necessary |         |
| 15  | Preamplifier 18 GHz - 26 GHz     | JS4-18002600-20-5A       | MITEQ Hauppauge N.Y.        | 658697            | 480342  | 10.07.2018                | 07.2020 |
| 16  | High pass Filter                 | WHKX8.0/18G-8SS          | Wainwright Instruments GmbH | 4                 | 480586  | Calibration not necessary |         |
| 17  | Highpass Filter                  | WHK2.8/18G-10SS          | Wainwright Instruments GmbH | 1                 | 480867  | Calibration not necessary |         |
| 18  | High pass Filter                 | WHKX4.0/18G-8SS          | Wainwright Instruments GmbH | 1                 | 480587  | Calibration not necessary |         |
| 19  | Microwave cable 2m               | Insulated Wire Inc.      | Insulated Wire              | KPS-1533-800-KPS  | 480302  | Calibration not necessary |         |
| 20  | Preamplifier 100 MHz - 16 GHz    | AFS6-00101600-23-10P-6-R | Narda MITEQ                 | 2011215           | 482333  | 10.07.2018                | 07.2020 |



## 7 Test site Validation

| Test equipment             | PM. No. | Frequency range | Type of validation | According to        | Val. Date  | Val Due    |
|----------------------------|---------|-----------------|--------------------|---------------------|------------|------------|
| OATS M6                    | 480085  | 30 – 1000 MHz   | NSA                | ANSI C63.4-2014     | 25.10.2018 | 24.10.2020 |
| Fully anechoic chamber M20 | 480303  | 1 -18 GHz       | SVSWR              | CISPR 16-1-4 Amd. 1 | 13.07.2018 | 12.07.2020 |
| Shielded chamber M4        | 480088  | 9 kHz – 30 MHz  | GND-Plane          | ANSI C63.4-2014     | 06.11.2018 | 05.11.2020 |

## 8 Report History

| Report Number                     | Date       | Comment   |
|-----------------------------------|------------|---|
| F182223E1                         | 28.10.2019 | Initial Test Report   |
| F182223E1 2 <sup>nd</sup> Version | 16.12.2020 | Reissuing requested by customer, due to delayed certification process |
|                                   |            |   |
|                                   |            |   |

## 9 List of Annexes

Annex A      Test Setup Photos

5 pages