

# Test Report

Report Number:

**F170756E2**

Equipment under Test (EUT):

**Control Panel for welding inverters**

**Einschub TT/MW Smart 210mm**

Applicant:

**Fronius International GmbH**

Manufacturer:

**Fronius International 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.

|                                 |                               |                                                                                                        |                           |
|---------------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------|
| Tested and<br>written by:       | <u>Bernward ROHDE</u><br>Name | <u></u><br>Signature | <u>03.06.2019</u><br>Date |
| Reviewed<br>and approved<br>by: | <u>Bernd STEINER</u><br>Name  | <u></u><br>Signature | <u>03.06.2019</u><br>Date |

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| <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          |
| 3 Additional Information .....                                                       | 13          |
| 4 Overview.....                                                                      | 14          |
| 5 Results.....                                                                       | 15          |
| 5.1 Duty cycle .....                                                                 | 15          |
| 5.1.1 Method of measurement .....                                                    | 15          |
| 6.1.1 Test results.....                                                              | 16          |
| 6.2 Maximum conducted (average) output power .....                                   | 17          |
| 6.2.1 Method of measurement (conducted).....                                         | 17          |
| 6.2.1.1 Test results (conducted) .....                                               | 18          |
| 6.3 DTS Bandwidth / 99% Bandwidth.....                                               | 19          |
| 6.3.1 Method of measurement (conducted).....                                         | 19          |
| 6.3.1.1 Test results (conducted) .....                                               | 20          |
| 6.4 Average Power Spectral Density .....                                             | 22          |
| 6.4.1 Method of measurement (conducted).....                                         | 22          |
| 6.4.1.1 Test results (conducted) .....                                               | 23          |
| 6.5 Band-edge compliance.....                                                        | 24          |
| 6.5.1 Method of measurement (band edges next to unrestricted bands (conducted))..... | 24          |
| 6.5.1.1 Test results (conducted) .....                                               | 25          |
| 6.5.2 Method of measurement (band edges next to restricted bands (conducted)) .....  | 29          |
| 6.5.2.1 Test results (conducted) .....                                               | 30          |
| 6.5.3 Method of measurement (band edges next to restricted bands (radiated)).....    | 33          |
| 6.5.3.1 Test results (radiated).....                                                 | 34          |
| 6.6 Maximum unwanted emissions.....                                                  | 35          |
| 6.6.1 Method of measurement (radiated emissions) .....                               | 35          |

|         |                                                                    |    |
|---------|--------------------------------------------------------------------|----|
| 6.6.1.1 | Test results (radiated emissions) .....                            | 42 |
| 6.7     | Conducted emissions on power supply lines (150 kHz to 30 MHz)..... | 51 |
| 7       | Test Equipment used for Tests .....                                | 53 |
| 8       | Report History.....                                                | 55 |
| 9       | List of Annexes .....                                              | 55 |

# 1 Identification

## 1.1 Applicant

|                                                                       |                                    |
|-----------------------------------------------------------------------|------------------------------------|
| Name:                                                                 | Fronius International GmbH         |
| Address:                                                              | Günter-Fronius-Straße 1, 4600 Wels |
| Country:                                                              | Austria                            |
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| Fax:                                                                  | +43-7242-241-0                     |
| email Address:                                                        | herndler.jan@fronius.com           |
| Applicant partly represented during the test by the following person: | Jan HERNDLER                       |

## 1.2 Manufacturer

|                                                                       |                                    |
|-----------------------------------------------------------------------|------------------------------------|
| Name:                                                                 | Fronius International GmbH         |
| Address:                                                              | Günter-Fronius-Straße 1, 4600 Wels |
| Country:                                                              | Austria                            |
| Name for contact purposes:                                            | MR. Jan HERNDLER                   |
| Phone:                                                                | +43-7242-241-2648                  |
| Fax:                                                                  | +43-7242-241-0                     |
| email Address:                                                        | herndler.jan@fronius.com           |
| Applicant partly represented during the test by the following person: | Jan HERNDLER                       |

## 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: *                                   | Control panel for welding inverters |
| Type / PMN                                       | Einschub TT/MW Smart 210mm          |
| FCC ID: *                                        | QKWSPBBCU1                          |
| ISED Certification number: *<br>IC: *            | 12270A-SPBBCU1                      |
| HVIN (Hardware Version Identification Number): * | Einschub TT/MW Smart 210mm          |
| FVIN (Firmware Version Identification Number): * | V1.4B                               |
| HMN (Host model name): *                         | N/A                                 |
| Order number:*                                   | 43,0001,3533                        |
| Serial number: *                                 | N/A                                 |
| PCB identifier: *                                | 1654600                             |

\* Declared by the applicant

| Frequency List WLAN (IEEE, 802.11b, 802.11g, 802.11n HT20) |     |          |     |          |
|------------------------------------------------------------|-----|----------|-----|----------|
| Channel 01                                                 | RX: | 2412 MHz | TX: | 2412 MHz |
| Channel 02                                                 | RX: | 2417 MHz | TX: | 2417 MHz |
| Channel 03                                                 | RX: | 2422 MHz | TX: | 2422 MHz |
| Channel 04                                                 | RX: | 2427 MHz | TX: | 2427 MHz |
| Channel 05                                                 | RX: | 2432 MHz | TX: | 2432 MHz |
| Channel 06                                                 | RX: | 2437 MHz | TX: | 2437 MHz |
| Channel 07                                                 | RX: | 2442 MHz | TX: | 2442 MHz |
| Channel 08                                                 | RX: | 2447 MHz | TX: | 2447 MHz |
| Channel 09                                                 | RX: | 2452 MHz | TX: | 2452 MHz |
| Channel 10                                                 | RX: | 2457 MHz | TX: | 2457 MHz |
| Channel 11                                                 | RX: | 2462 MHz | TX: | 2462 MHz |

| Frequency List WLAN (IEEE, 802.11n HT40) |     |          |     |          |
|------------------------------------------|-----|----------|-----|----------|
| Channel 03                               | RX: | 2422 MHz | TX: | 2422 MHz |
| Channel 04                               | RX: | 2427 MHz | TX: | 2427 MHz |
| Channel 05                               | RX: | 2432 MHz | TX: | 2432 MHz |
| Channel 06                               | RX: | 2437 MHz | TX: | 2437 MHz |
| Channel 07                               | RX: | 2442 MHz | TX: | 2442 MHz |
| Channel 08                               | RX: | 2447 MHz | TX: | 2447 MHz |
| Channel 09                               | RX: | 2452 MHz | TX: | 2452 MHz |



## 1.5 Technical Data of Equipment

| Radio mode                                   |                                                                                                                               |          |                    |           |                    |           |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|----------|--------------------|-----------|--------------------|-----------|
| Fulfils radio specification: *               | IEEE 802.11 b/g/HT20/HT40                                                                                                     |          |                    |           |                    |           |
| Antenna type: *                              | Dipole Antenna                                                                                                                |          |                    |           |                    |           |
| Antenna name: *                              | GW.40.2153                                                                                                                    |          |                    |           |                    |           |
| Antenna gain: *                              | 3.74 dBi                                                                                                                      |          |                    |           |                    |           |
| Antenna connector: *                         | RP SMA                                                                                                                        |          |                    |           |                    |           |
| Power supply EUT: *                          | DC                                                                                                                            |          |                    |           |                    |           |
| Supply voltage EUT – Control Unit:*          | U <sub>nom</sub> =                                                                                                            | 24 V DC  | U <sub>min</sub> = | 21.6 V DC | U <sub>max</sub> = | 26.4 V DC |
| Supply voltage Wi-Fi module:*                | U <sub>nom</sub> =                                                                                                            | 3.3 V DC | U <sub>min</sub> = | 2.5 V DC  | U <sub>max</sub> = | 3.6 V DC  |
| Type of modulation: *                        | 802.11b: DSSS (DBPSK, DQPSK, CCK)<br>802.11g: OFDM (BPSK, QPSK, 16-QAM, 64-QAM)<br>802.11n: OFDM (BPSK, QPSK, 16-QAM, 64-QAM) |          |                    |           |                    |           |
| Operating frequency range: *                 | 2412 – 2462 MHz (IEEE, 802.11b, 802.11g, 802.11n HT20)<br>2422 – 2452 MHz (IEEE, 802.11n HT40)                                |          |                    |           |                    |           |
| Number of channels: *                        | 11 (IEEE, 802.11b, 802.11g, 802.11n HT20) or<br>7 (IEEE, 802.11n HT40)                                                        |          |                    |           |                    |           |
| Temperature range: *                         | -10 °C to +60 °C                                                                                                              |          |                    |           |                    |           |
| Lowest / highest internal clock frequency: * | 32.768 kHz / 2480 MHz                                                                                                         |          |                    |           |                    |           |

\* Declared by the applicant

| Ancillary Equipment: |                                       |
|----------------------|---------------------------------------|
| Laptop PC:*          | Fujitsu Lifebook S751 (PM No. 201036) |
| Power (AC-Adaptor)   | UE36LCP1-240150SPA** by UE electronic |

\*Provided by the laboratory

\*\*Provided by the applicant

The following external I/O cables were used:

| Identification       | Connector                      |           | Length |
|----------------------|--------------------------------|-----------|--------|
|                      | EUT                            | Ancillary |        |
| Power (DC)*          | 2 x Measuring cables were used |           | ~2 m   |
| Ethernet*            | HSD                            | RJ45      | 3 m    |
| Power (AC-Adaptor)** |                                | CE        | ~2 m   |

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

\*\* Used for the "Conducted emissions on power supply lines", delivered by the applicant

## 1.6 Dates

|                                 |            |
|---------------------------------|------------|
| Date of receipt of test sample: | 13.10.2017 |
| Start of test:                  | 19.10.2017 |
| End of test:                    | 20.08.2018 |

## 2 Operational States

### 2.1 Description of function of the EUT

The equipment under test (EUT) is the WLAN-radio part of a control panel for welding units.

During the WLAN tests the RFID module was active and continuously transmitting.  
So both transmitters were operating simultaneously.

EUT:



As declared by the applicant, only the 13.56.MHz RFID, Bluetooth low energy and Wi-Fi (2.4 GHz) will be used in the final application.

During the Wi-Fi radio tests the RFID module was active and continuously transmitting.  
So Wi-Fi and RFID were operating simultaneously. BT/BLE and Wi-Fi share the same antenna and can't send simultaneously.

For the radio tests the "Dut labtool" as provided by the applicant was used to configure the rf-parameter of the EUT via a controlling laptop. A LAN connection was used to control the settings of the EUT.

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

For the tests the EUT was supplied with 24 V DC via laboratory power supply if not otherwise mentioned.  
As pre-tests have shown the following operation modes are the worst cases:

| Operation mode | Description of the operation mode   | channel | mode         | Data rate / Mbps | Power setting |
|----------------|-------------------------------------|---------|--------------|------------------|---------------|
| 1              | Continuous transmitting on 2412 MHz | 1       | 802.11b      | 1 Mbps           | 15            |
| 2              | Continuous transmitting on 2437 MHz | 6       | 802.11b      | 1 Mbps           | 15            |
| 3              | Continuous transmitting on 2462 MHz | 11      | 802.11b      | 1 Mbps           | 15            |
| 4              | Continuous transmitting on 2412 MHz | 1       | 802.11g      | 6 Mbps           | 15            |
| 5              | Continuous transmitting on 2437 MHz | 6       | 802.11g      | 6 Mbps           | 15            |
| 6              | Continuous transmitting on 2462 MHz | 11      | 802.11g      | 6 Mbps           | 15            |
| 7              | Continuous transmitting on 2412 MHz | 1       | 802.11n HT20 | MCS7             | 14            |
| 8              | Continuous transmitting on 2437 MHz | 6       | 802.11n HT20 | MCS7             | 14            |
| 9              | Continuous transmitting on 2462 MHz | 11      | 802.11n HT20 | MCS7             | 14            |
| 10             | Continuous transmitting on 2422 MHz | 3       | 802.11n HT40 | MCS7             | 14            |
| 11             | Continuous transmitting on 2437 MHz | 6       | 802.11n HT40 | MCS7             | 14            |
| 12             | Continuous transmitting on 2452 MHz | 9       | 802.11n HT40 | MCS7             | 14            |

This test-report incorporates the worst case results for the Wi-Fi (2.4GHz) only.

### **3 Additional Information**

All tests were done with an unmodified sample.

The EUT was not labeled with the final label.

As declared by the applicant, the USB port of the EUT is only used for service purposes. Therefore no lines were connected to the USB port of the EUT during the tests.

This test-report covers the simultaneous transmission of the Wi-Fi part with the 13.56 MHz NFC part only. The NFC specific test-cases are documented in PHOENIX TESTLAB test report F170756E1.

Bluetooth low energy test cases are documented in in PHOENIX TESTLAB test report F170756E3.

## 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 Conducted Average Output Power | 2400.0 - 2483.5       | 15.247 (b) (3), (4)                    | 5.4 (d) [3]                         | Passed | 17 et seq. |
| DTS Bandwidth                          | 2400.0 - 2483.5       | 15.247 (a) (2)                         | 5.2 (a) [3]                         | Passed | 19 et seq. |
| Average Power Spectral Density         | 2400.0 - 2483.5       | 15.247 (e)                             | 5.2 (b) [3]                         | Passed | 22 et seq. |
| 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 | 24 et seq. |
| 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 | 35 et seq. |
| Conducted emissions on supply line     | 0.15 - 30             | 15.207 (a)                             | 8.8 [4]                             | Passed | 51 et seq. |

Antenna requirements fulfilled, EUT is fixed installed in a host (welding machine), the antenna is therefore not accessible.

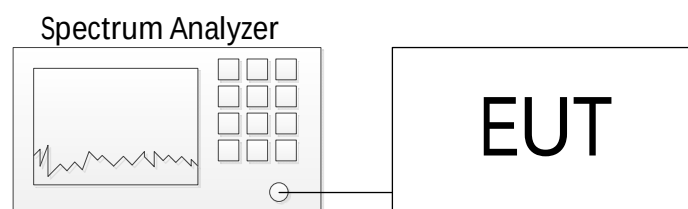
## 5 Results

### 5.1 Duty cycle

#### 5.1.1 Method of measurement

The measurement was performed as an antenna port conducted measurement, as shown below.

Test Setup:



The method described in chapter 11.6.0 b) of document [1] or 6.0 b) of document [5] was used to perform the following test.

Only the worst case plot for each mode was submitted below.

The following measurement technique was used:

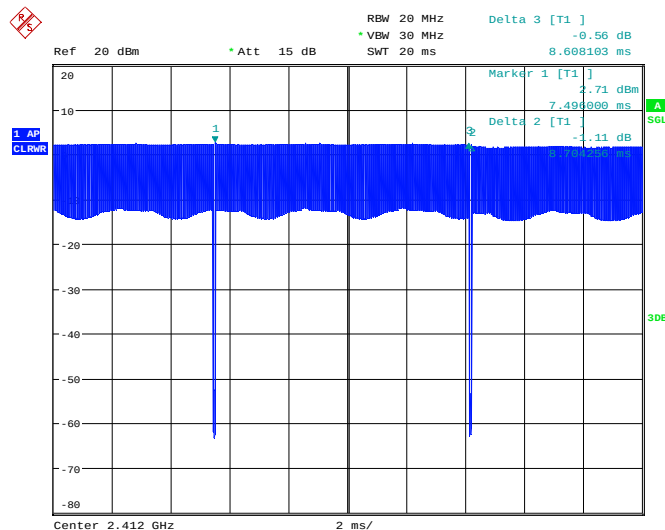
The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between two bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

- Set the center frequency of the instrument to the center frequency of the transmission.
- Set  $RBW \geq OBW$  if possible; otherwise, set RBW to the largest available value.
- Set  $VBW \geq RBW$ .
- Set detector = peak or average.
- The zero-span measurement method shall not be used unless both RBW and VBW are  $> 50/T$  and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if  $T \leq 16.7$  microseconds.)

### 6.1.1 Test results

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 52 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |



| Operation mode | TX_on [μs] | TX_ges [μs] | RBW [MHz] | 50/T [kHz] | 50/T < RBW? |
|----------------|------------|-------------|-----------|------------|-------------|
| 1 – 3          | 8608       | 8704        | 20        | 6          | Yes         |
| 3 – 6          | 1428       | 1490        | 20        | 35         | Yes         |
| 7 – 9          | 167        | 227         | 20        | 299        | Yes         |
| 10 – 12        | 99         | 159         | 50        | 505        | Yes         |

| Operation Mode | Sweep points | Sweep time [μs] | Meas points | Meas points >100? | Duty cycle % | DCCF [dB] |
|----------------|--------------|-----------------|-------------|-------------------|--------------|-----------|
| 1 – 3          | 10001        | 20000           | 4352        | Yes               | 98.90        | 0.05      |
| 3 – 6          | 10001        | 3000            | 4967        | Yes               | 95.84        | 0.18      |
| 7 – 9          | 10001        | 500             | 4540        | Yes               | 73.57        | 1.33      |
| 10 – 12        | 10001        | 300             | 5301        | Yes               | 62.26        | 2.06      |

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

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

Therefore, for average measurements no correction factor is used for all tests in test mode 1 -3.

Therefore, for average measurements a correction factor of 0.18 dB is used for all tests in test mode 4 - 6.

Therefore, for average measurements a correction factor of 1.33 dB is used for all tests in test mode 7 - 9.

Therefore, for average measurements a correction factor of 2.06 dB is used for all tests in test mode 10 - 12.

Test equipment (please refer to chapter 6 for details)

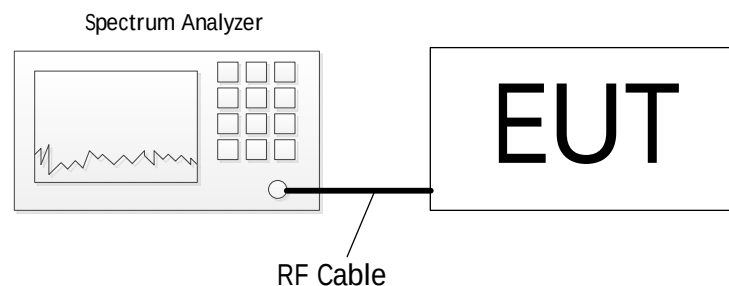
1



## 6.2 Maximum conducted (average) output power

### 6.2.1 Method of measurement (conducted)

The EUT was measured conducted at the antenna ports with the aid of a spectrum analyzer.



#### Acceptable measurement configurations

Procedure 11.9.2.2.4 in [1] was used for the following test.

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

- - Measure the duty cycle D of the transmitter output signal as described in 11.6 [1].
- - Set span to at least 1.5 times the OBW.
- - Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- - Set VBW  $\geq [3 \times \text{RBW}]$ .
- Number of points in sweep  $\geq [2 \times \text{span} / \text{RBW}]$ . (This gives bin-to-bin spacing  $\leq \text{RBW} / 2$ , so that narrowband signals are not lost between frequency bins.)
- Sweep time = auto.
- Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
- Do not use sweep triggering. Allow the sweep to "free run."
- Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
- Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- Add  $[10 \log (1 / D)]$ , where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add  $[10 \log (1/0.25)] = 6 \text{ dB}$  if the duty cycle is 25%.

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

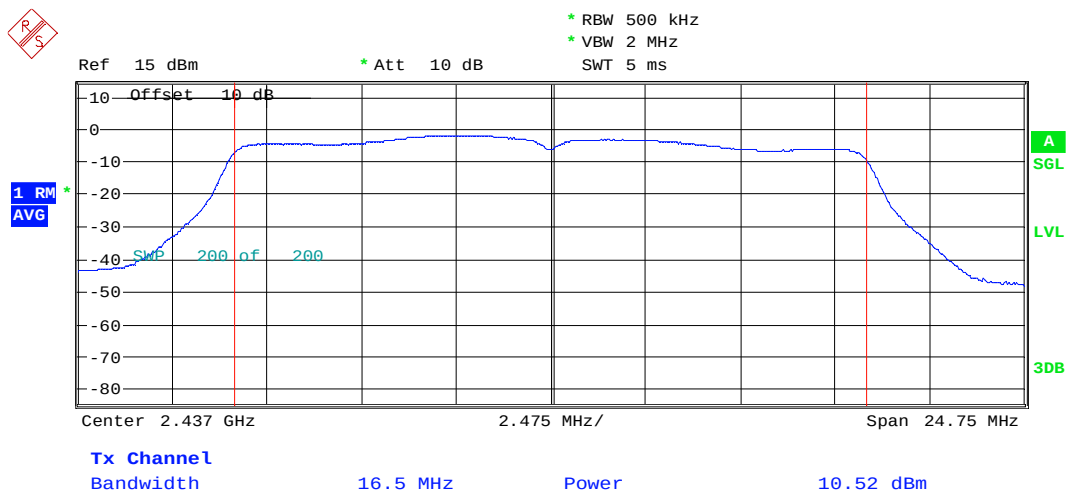
Antenna gain below 6 dBi, therefore no power reduction was necessary.

### 6.2.1.1 Test results (conducted)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 56 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |

Maximum conducted output power (Operation mode 5):



| Operation mode |     | Frequency [MHz] | Duty cycle correction [dB] | Conducted output power [dBm] | Limit [dBm] |
|----------------|-----|-----------------|----------------------------|------------------------------|-------------|
| 1              | b   | 2412            | 0.00                       | 7.7                          | 30          |
| 2              | b   | 2437            | 0.00                       | 10.6                         | 30          |
| 3              | b   | 2462            | 0.00                       | 9.2                          | 30          |
| 4              | g   | 2412            | 0.18                       | 8.7                          | 30          |
| 5              | g   | 2437            | 0.18                       | 10.7                         | 30          |
| 6              | g   | 2462            | 0.18                       | 9.8                          | 30          |
| 7              | n20 | 2412            | 1.33                       | 8.0                          | 30          |
| 8              | n20 | 2437            | 1.33                       | 9.9                          | 30          |
| 9              | n20 | 2462            | 1.33                       | 9.0                          | 30          |
| 10             | n40 | 2422            | 2.06                       | 8.9                          | 30          |
| 11             | n40 | 2437            | 2.06                       | 9.2                          | 30          |
| 12             | n40 | 2452            | 2.06                       | 9.3                          | 30          |

Test equipment (please refer to chapter 6 for details)

1

## 6.3 DTS Bandwidth / 99% Bandwidth

### 6.3.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



DTS bandwidth:

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

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

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:

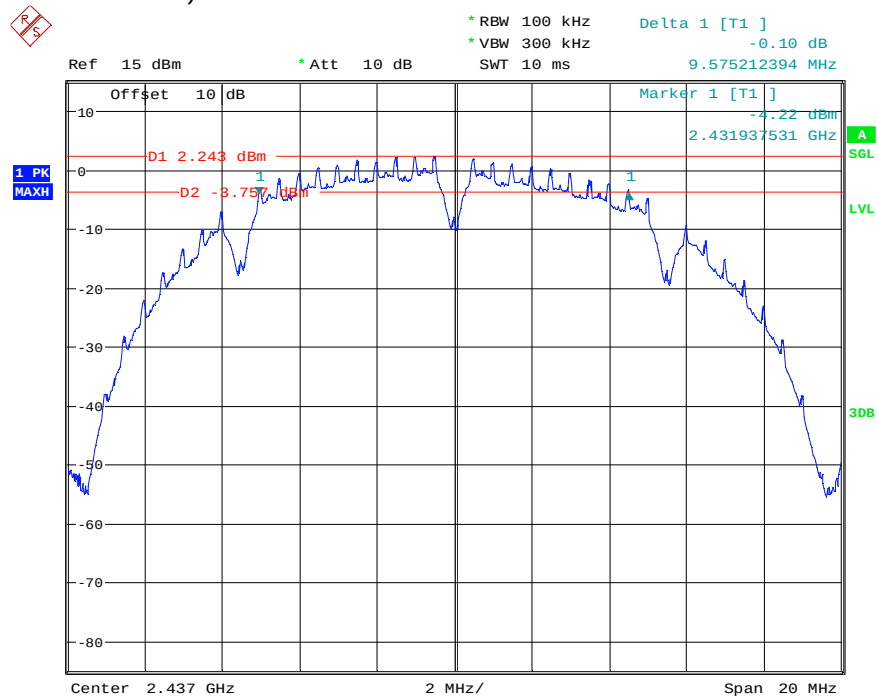
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately 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  $[10 \log (\text{OBW}/\text{RBW})]$  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).

### 6.3.1.1 Test results (conducted)

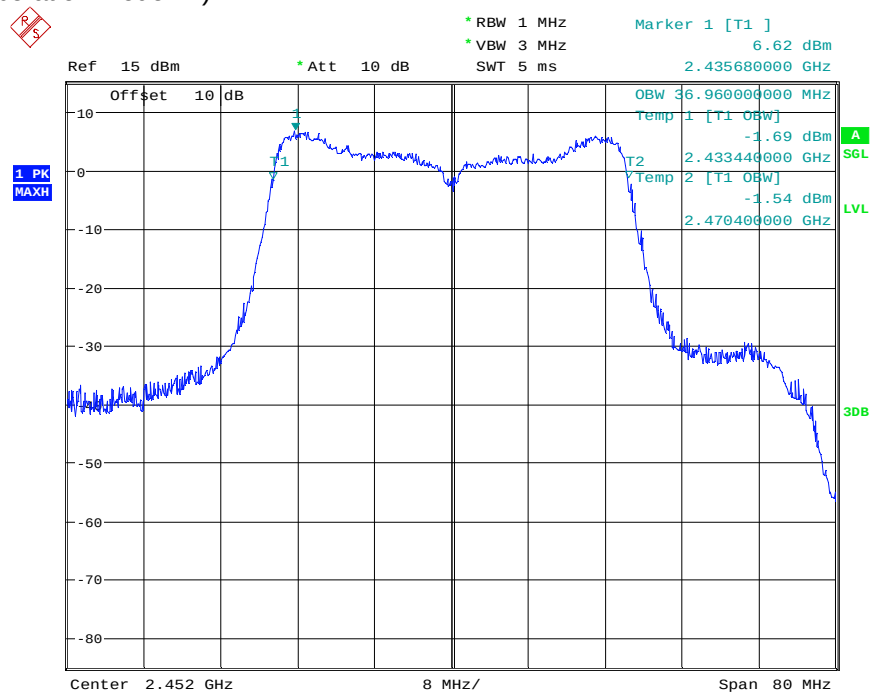
|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |

DTS bandwidth (Operation mode 2):



99% bandwidth (Operation mode 12):



| Operation Mode          | Center Frequency [MHz] | Minimum 6-dB Bandwidth Limit [MHz] | 6 dB Bandwidth [MHz] | 99 % Bandwidth [MHz] | Result |
|-------------------------|------------------------|------------------------------------|----------------------|----------------------|--------|
| 1                       | 2412                   | 0.5                                | 10.545               | 13.500               | Passed |
| 2                       | 2437                   | 0.5                                | 9.575                | 12.810               | Passed |
| 3                       | 2462                   | 0.5                                | 9.615                | 13.170               | Passed |
| 4                       | 2412                   | 0.5                                | 15.772               | 16.900               | Passed |
| 5                       | 2437                   | 0.5                                | 15.487               | 16.500               | Passed |
| 6                       | 2462                   | 0.5                                | 15.757               | 16.700               | Passed |
| 7                       | 2412                   | 0.5                                | 17.031               | 17.750               | Passed |
| 8                       | 2437                   | 0.5                                | 16.582               | 17.550               | Passed |
| 9                       | 2462                   | 0.5                                | 16.402               | 17.650               | Passed |
| 10                      | 2422                   | 0.5                                | 35.507               | 36.720               | Passed |
| 11                      | 2437                   | 0.5                                | 31.659               | 35.840               | Passed |
| 12                      | 2452                   | 0.5                                | 36.407               | 36.960               | Passed |
| Measurement uncertainty |                        |                                    | +1.8 dB / -2.4 dB    |                      |        |

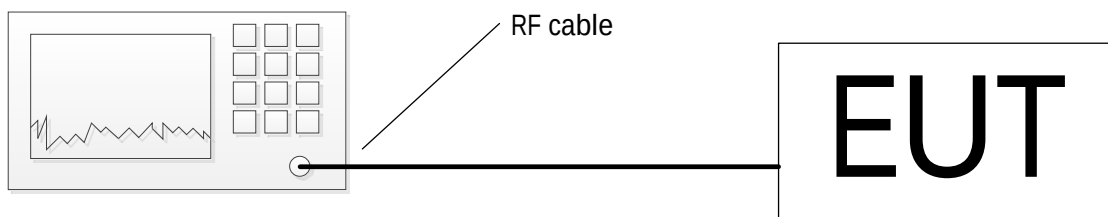
Test equipment (please refer to chapter 6 for details)

1

## 6.4 Average Power Spectral Density

### 6.4.1 Method of measurement (conducted)

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The measurement procedure refers to part 11.10.5 of document [1].

Method AVGPSD-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction.

The following procedure is applicable when the EUT cannot be configured to transmit continuously (i.e.,  $D < 98\%$ ), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is constant (i.e., duty cycle variations are less than  $\pm 2\%$ ):

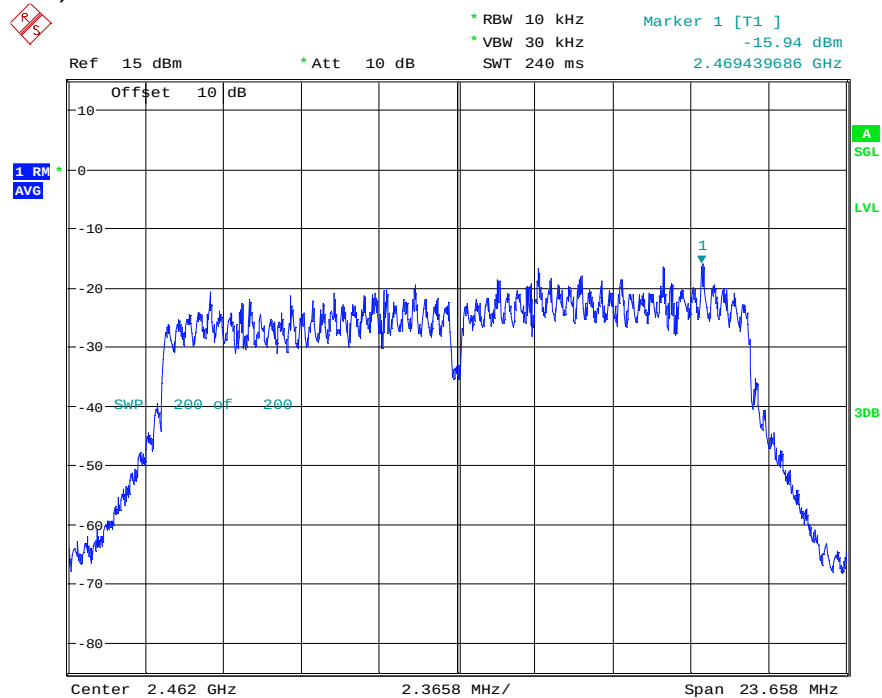
- Measure the duty cycle (D) of the transmitter output signal as described in 11.6.
- Set instrument center frequency to DTS channel center frequency.
- Set span to at least 1.5 times the OBW.
- Set RBW to:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$ .
- Set VBW  $\geq [3 \times \text{RBW}]$ .
- Detector = power averaging (rms) or sample detector (when rms not available).
- Ensure that the number of measurement points in the sweep  $\geq [2 \times \text{span} / \text{RBW}]$ .
- Sweep time = auto couple.
- Do not use sweep triggering; allow sweep to "free run."
- Employ trace averaging (rms) mode over a minimum of 100 traces.
- Use the peak marker function to determine the maximum amplitude level.
- Add  $[10 \log (1 / D)]$ , where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time.
- m) If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

#### 6.4.1.1 Test results (conducted)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 54 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |

PSD (Operation mode 9):



| Operation Mode          |     | Peak Frequency [MHz] | Power Spectral Density Limit [dBm/3kHz] | Duty cycle correction [dB] | Power Spectral Density Reading [dBm / 10 kHz] | Result |
|-------------------------|-----|----------------------|-----------------------------------------|----------------------------|-----------------------------------------------|--------|
| 1                       | b   | 2411.165             | 8                                       | 0.0                        | -19.2                                         | Passed |
| 2                       | b   | 2436.198             | 8                                       | 0.0                        | -15.7                                         | Passed |
| 3                       | b   | 2462.552             | 8                                       | 0.0                        | -17.4                                         | Passed |
| 4                       | g   | 2404.475             | 8                                       | 0.2                        | -17.8                                         | Passed |
| 5                       | g   | 2434.485             | 8                                       | 0.2                        | -16.2                                         | Passed |
| 6                       | g   | 2469.463             | 8                                       | 0.2                        | -17.6                                         | Passed |
| 7                       | n20 | 2404.511             | 8                                       | 1.3                        | -16.1                                         | Passed |
| 8                       | n20 | 2435.722             | 8                                       | 1.3                        | -14.8                                         | Passed |
| 9                       | n20 | 2469.440             | 8                                       | 1.3                        | -14.6                                         | Passed |
| 10                      | n40 | 2436.973             | 8                                       | 2.1                        | -16.3                                         | Passed |
| 11                      | n40 | 2434.441             | 8                                       | 2.1                        | -15.4                                         | Passed |
| 12                      | n40 | 2436.940             | 8                                       | 2.1                        | -15.9                                         | Passed |
| Measurement uncertainty |     |                      |                                         |                            | +1.8 dB / -2.4 dB                             |        |

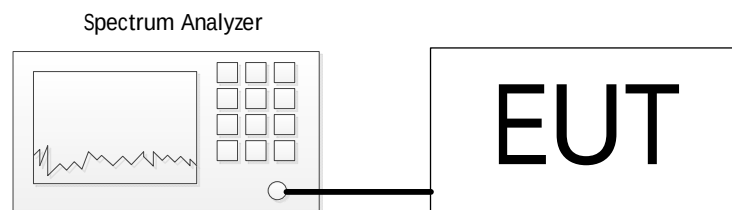
Test equipment (please refer to chapter 6 for details)

1

## 6.5 Band-edge compliance

### 6.5.1 Method of measurement (band edges next to unrestricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



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 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.

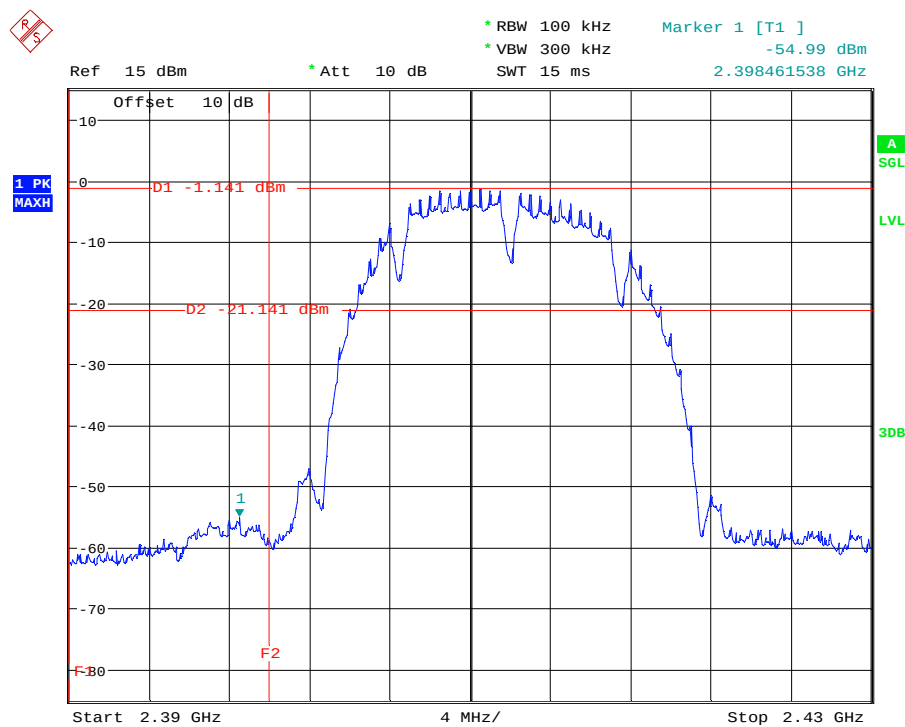


### 6.5.1.1 Test results (conducted)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |

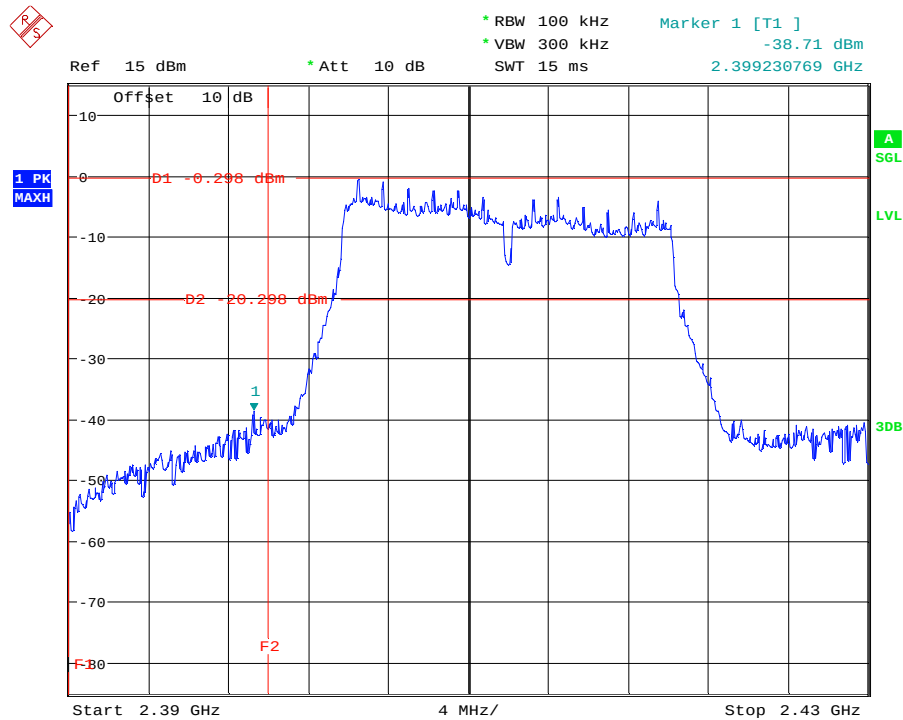
Unrestricted band edge (Operation mode 1):



Date: 20.AUG.2018 14:05:06

| Operation mode | Data rate        | Frequency [MHz] | Reference Level [dBm] | Limit [dBm] | Emission Level [dBm] | Margin [dB] | Result |
|----------------|------------------|-----------------|-----------------------|-------------|----------------------|-------------|--------|
| 1              | b-mode, 1 Mbit/s | 2398.462        | -1.1                  | -21.1       | -54.7                | 33.6        | Passed |

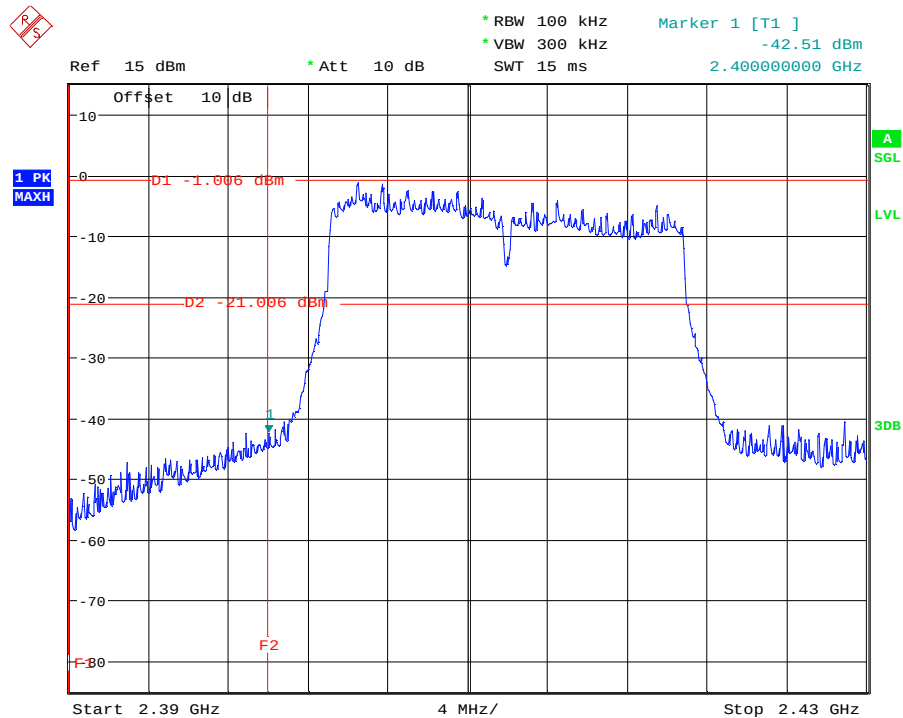
Unrestricted band edge (Operation mode 4):



Date: 20.AUG.2018 14:56:25

| Operation mode | Data rate        | Frequency [MHz] | Reference Level [dBm] | Limit [dBm] | Emission Level [dBm] | Margin [dB] | Result |
|----------------|------------------|-----------------|-----------------------|-------------|----------------------|-------------|--------|
| 4              | g-mode, 6 Mbit/s | 2399.231        | -0.3                  | -20.3       | -38.4                | 18.1        | Passed |

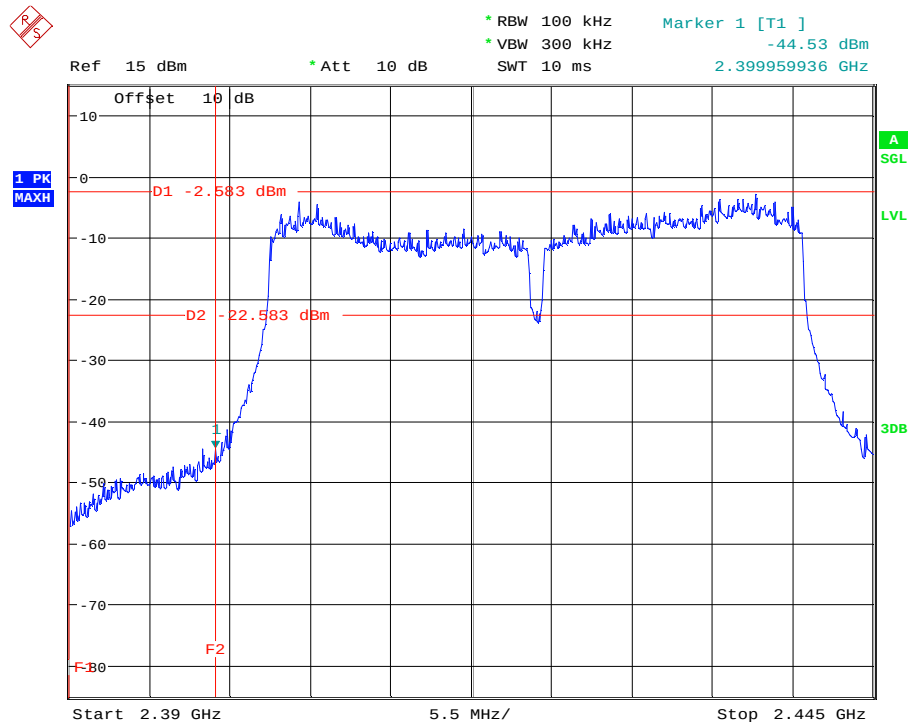
Unrestricted band edge (Operation mode 7):



Date: 20.AUG.2018 15:34:51

| Operation mode | Data rate  | Frequency [MHz] | Reference Level [dBm] | Limit [dBm] | Emission Level [dBm] | Margin [dB] | Result |
|----------------|------------|-----------------|-----------------------|-------------|----------------------|-------------|--------|
| 7              | HT20, MCS7 | 2400            | -1                    | -21         | -42.2                | 21.2        | Passed |

Unrestricted band edge (Operation mode 10):



Date: 20.AUG.2018 16:20:22

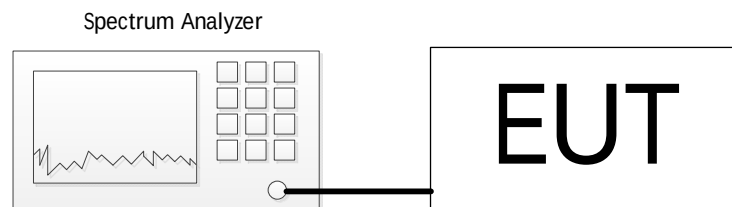
| Operation mode | Data rate  | Frequency [MHz] | Reference Level [dBm] | Limit [dBm] | Emission Level [dBm] | Margin [dB] | Result |
|----------------|------------|-----------------|-----------------------|-------------|----------------------|-------------|--------|
| 10             | HT40, MCS7 | 2399.96         | -2.6                  | -22.6       | -44.2                | 21.6        | Passed |

Test equipment (please refer to chapter 6 for details)

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### 6.5.2 Method of measurement (band edges next to restricted bands (conducted))

The EUT was tested with a spectrum analyzer connected directly to the EUT.



The same test set-up as used for the final conducted emission measurement shall be used (refer also sub-clause 6.6 of this test report).

After trace stabilization the marker shall be set on the signal peak. The frequency line shall be set on the edge of the assigned frequency band. Now set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. The level of the measured field strength shall be compared to the general limits specified in § 15.205.

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

The calculation was performed with the following formula as described in chapter 11.12.2.2 e) in [1]:

$$E \text{ [dBmV/m]} = EIRP \text{ [dBm]} - 20\log(d) + 104.8 + G_{Ant} \text{ [dBi]} + G_{Array} \text{ [dB]} + Att_{MeasCable} \text{ [dB]} + Att_{RF-Switch} \text{ [dB]}$$

$E \text{ [dBmV/m]} = \text{Field Strength [dBuV/m]}$

$EIRP \text{ [dBm]} = \text{Reading [dBm]}$

$d = \text{measurement distance in m}$

$G_{Ant} \text{ [dBi]} = \text{Gain of the EUT antenna}$

$G_{Array} \text{ [dB]} = \text{Array Gain [in case of multiple transmitting antenna port]}$

$Att_{MeasCable} \text{ [dB]} = \text{Attenuation of the measurement cables}$

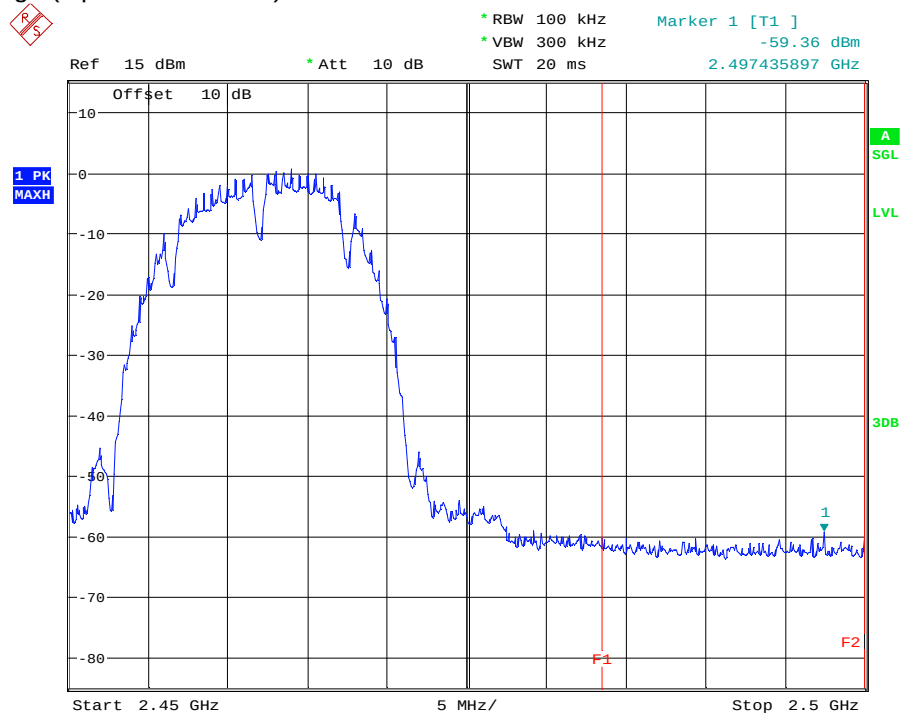
$Att_{RF-Switch} \text{ [dB]} = \text{Attenuation of the RF Switch}$

### 6.5.2.1 Test results (conducted)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |            |
|-----------|------------|
| Date      | 20.08.2018 |
| Tested by | B. ROHDE   |

Restricted band edge (Operation mode 3):



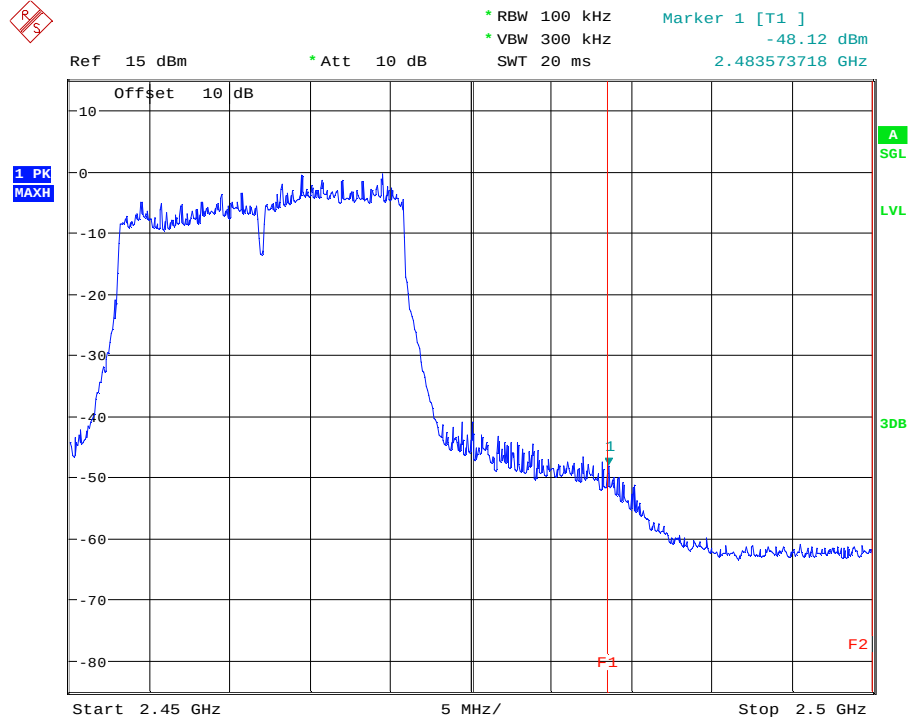
| Upper band edge         |                 |                         |                        |                     |               |                                 |        |
|-------------------------|-----------------|-------------------------|------------------------|---------------------|---------------|---------------------------------|--------|
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Peak Limit [dBuV/m]    | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 3                       | 2498.831        | 45.1                    | 74                     | 28.9                | -53.9         | 3.7                             | Passed |
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Average Limit [dBuV/m] | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 3                       | 2495.676        | 33.6                    | 54                     | 20.4                | -65.4         | 3.7                             | Passed |
| Measurement uncertainty |                 |                         |                        | +0.66 dB / -0.72 dB |               |                                 |        |

Restricted band edge (Operation mode 6):



| Upper band edge         |                 |                         |                        |                     |               |                                 |        |
|-------------------------|-----------------|-------------------------|------------------------|---------------------|---------------|---------------------------------|--------|
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Peak Limit [dBuV/m]    | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 6                       | 2483.569        | 69.9                    | 74                     | 4.1                 | -29.1         | 3.7                             | Passed |
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Average Limit [dBuV/m] | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 6                       | 2483.529        | 50.2                    | 54                     | 3.8                 | -49           | 3.7                             | Passed |
| Measurement uncertainty |                 |                         |                        | +0.66 dB / -0.72 dB |               |                                 |        |

Restricted band edge (Operation mode 9):



| Upper band edge         |                 |                         |                        |                     |               |                                 |        |
|-------------------------|-----------------|-------------------------|------------------------|---------------------|---------------|---------------------------------|--------|
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Peak Limit [dBuV/m]    | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 9                       | 2484.079        | 65.6                    | 74                     | 8.4                 | -33.4         | 3.7                             | Passed |
| Operation Mode          | Frequency [MHz] | Field Strength [dBuV/m] | Average Limit [dBuV/m] | Margin [dB]         | Reading [dBm] | Antenna Gain + Array Gain [dBi] | Result |
| 9                       | 2483.674        | 48.7                    | 54                     | 5.3                 | -51.6         | 3.7                             | Passed |
| Measurement uncertainty |                 |                         |                        | +0.66 dB / -0.72 dB |               |                                 |        |

Test equipment (please refer to chapter 6 for details)

1



### **6.5.3 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 6.6.1.

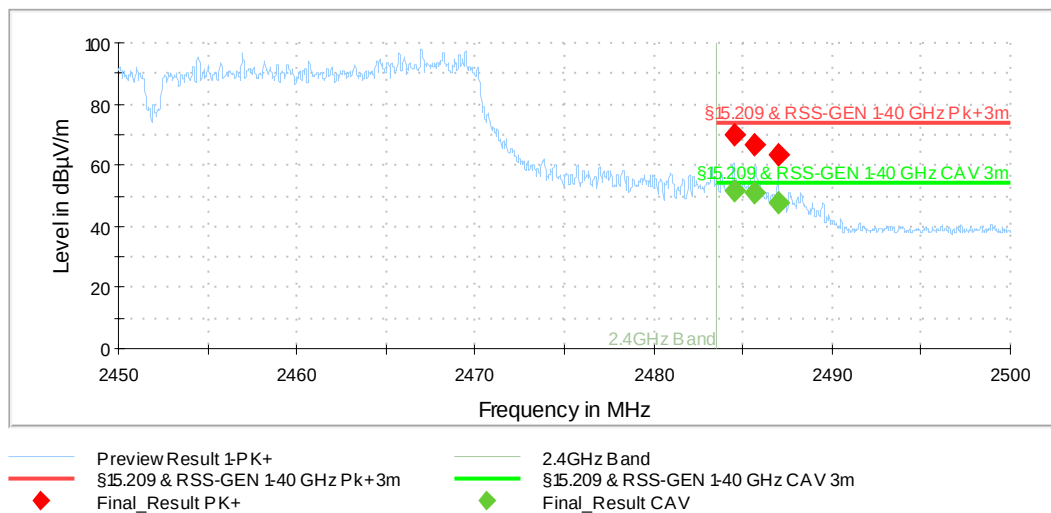
The relating measurements were carried radiated. The measurement procedure refers to part 6.10.5.2 of document [1].

### 6.5.3.1 Test results (radiated)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 52 %  |

|           |            |
|-----------|------------|
| Date      | 26.10.2017 |
| Tested by | B. ROHDE   |

Restricted band edge (Operation mode 12):



| Upper band edge         |          |          |                                                                             |                   |     |         |           |            |        |
|-------------------------|----------|----------|-----------------------------------------------------------------------------|-------------------|-----|---------|-----------|------------|--------|
| Operation mode 12       |          |          | Duty cycle correction factor of 2.06 dB 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]       |        |
| 2484.500000             | 69.8     | ---      | 74                                                                          | 4.2               | V   | 183     | 90        | 34.0       | Passed |
| 2484.500000             | ---      | 53.9     | 54                                                                          | 0.1               | V   | 183     | 90        | 36.1       | Passed |
| 2485.700000             | 66.8     | ---      | 74                                                                          | 7.2               | H   | 177     | 0         | 34.0       | Passed |
| 2485.700000             | ---      | 52.9     | 54                                                                          | 1.1               | H   | 177     | 0         | 36.1       | Passed |
| 2487.000000             | ---      | 49.8     | 54                                                                          | 4.2               | V   | 183     | 120       | 36.1       | Passed |
| 2487.000000             | 63.1     | ---      | 74                                                                          | 10.9              | V   | 183     | 120       | 34.0       | Passed |
| Measurement uncertainty |          |          |                                                                             | +2.2 dB / -3.6 dB |     |         |           |            |        |

Test equipment (please refer to chapter 6 for details)

2 - 11

## 6.6 Maximum unwanted emissions

### 6.6.1 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.

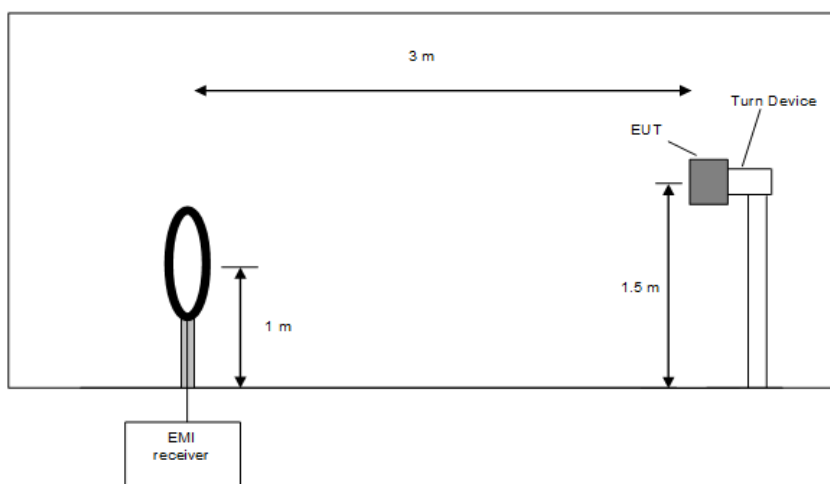
#### Preliminary measurement (9 kHz to 30 MHz):

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.

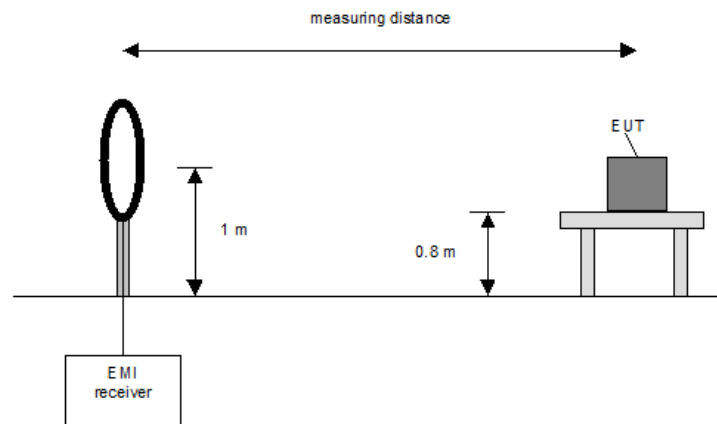
#### Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in 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).

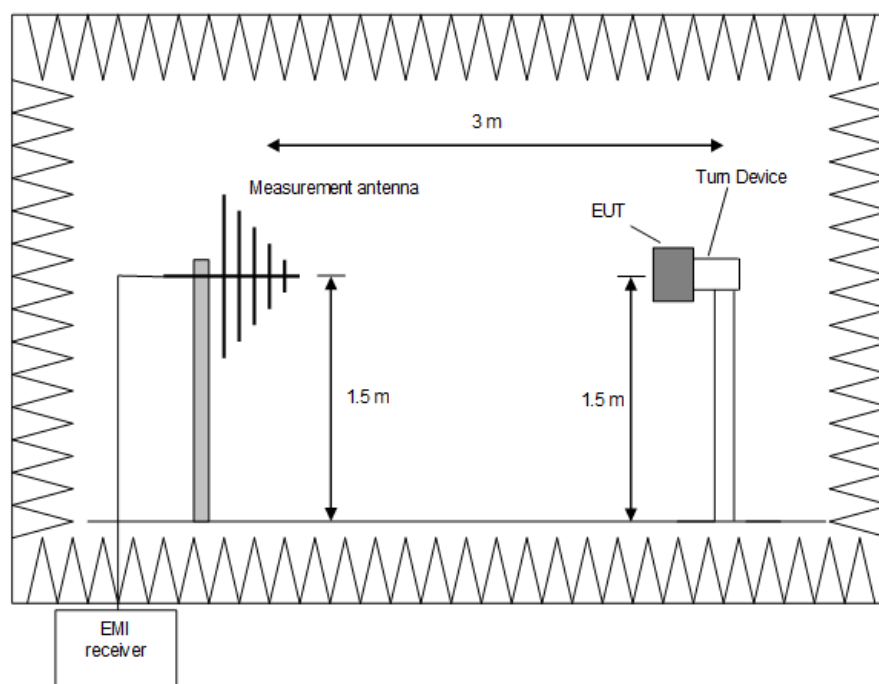
### **Preliminary measurement (30 MHz to 1 GHz)**

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:

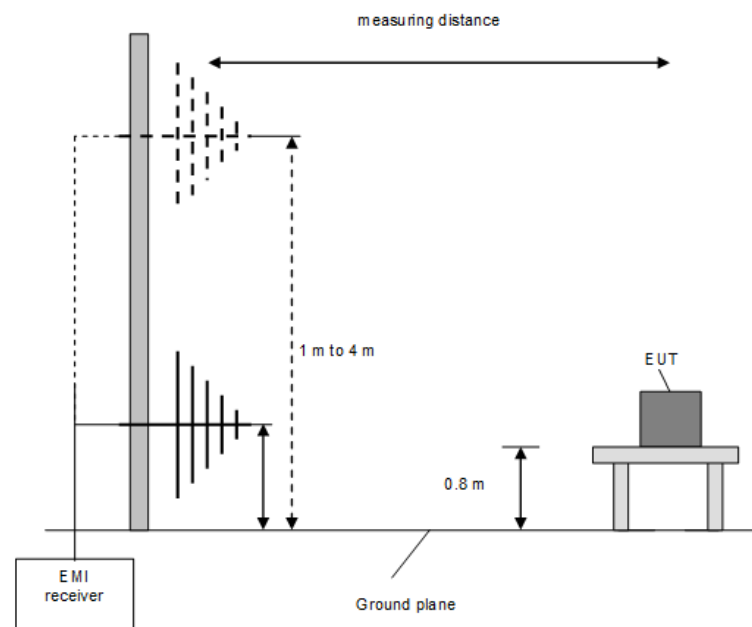
8. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0°.
9. Manipulate the system cables within the range to produce the maximum level of emission.
10. Rotate the EUT by 360° to maximize the detected signals.
11. Repeat 1) to 3) with the vertical polarization of the measuring 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.

### 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)**

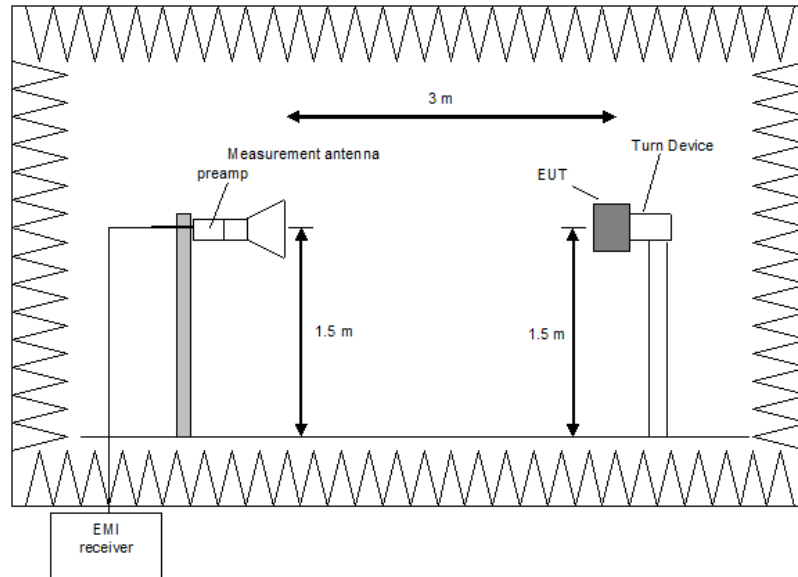
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5m. The set-up of the Equipment under test will be in accordance to [1].

#### **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:

Pre-scans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

1. Monitor the frequency range at horizontal polarization and a EUT azimuth of 0°.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarization of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarization, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

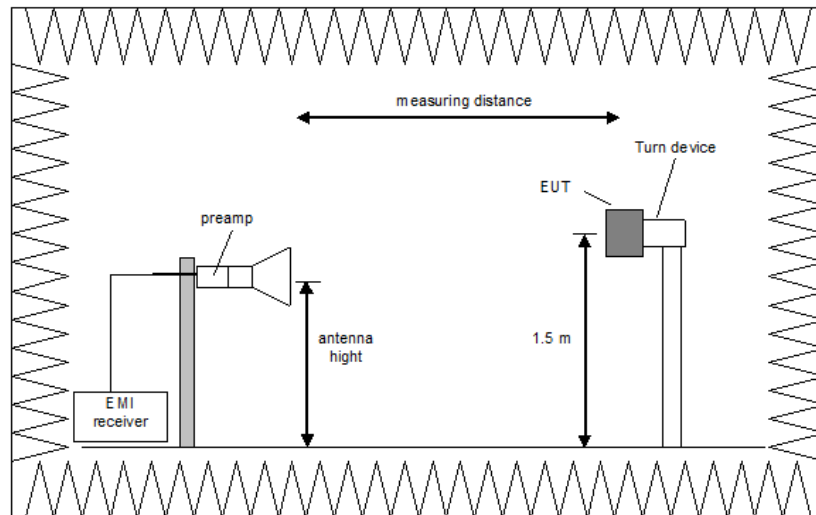
#### Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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

| Frequency range         | Resolution bandwidth |
|-------------------------|----------------------|
| 1 GHz to 4 GHz          | 1 MHz                |
| 4 GHz to 12 GHz         | 1 MHz                |
| 12 GHz to 18 GHz        | 1 MHz                |
| 18 GHz to 25 / 26.5 GHz | 1 MHz                |
| 26.5 GHz to 40 GHz      | 1 MHz                |





#### Procedure of measurement:

The measurements were performed in the frequency ranges 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 25 /26.5 GHz and 26.5 GHz to 40 GHz.

The following procedure will be used:

- 1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna polarization to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyzer to EMI mode with peak and average detector activated.
- 4) Rotate the turntable from 0° to 360° to find the TT Pos. that produces the highest emissions.
- 5) Note the highest displayed peak and average values
- 6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

### 6.6.1.1 Test results (radiated emissions)

#### 6.6.1.1.1 Preliminary radiated emission measurement

##### 6.6.1.1.1.1 Emissions below 1 GHz

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |                                                      |
|-----------|------------------------------------------------------|
| Date      | 24.11.2017 <sup>*1</sup><br>26.10.2017 <sup>*2</sup> |
| Tested by | M. BASTERT<br>B. ROHDE                               |

<sup>\*1</sup> Preliminary measurement 9 kHz – 30 MHz

<sup>\*2</sup> Preliminary measurement 30 MHz – 1 GHz

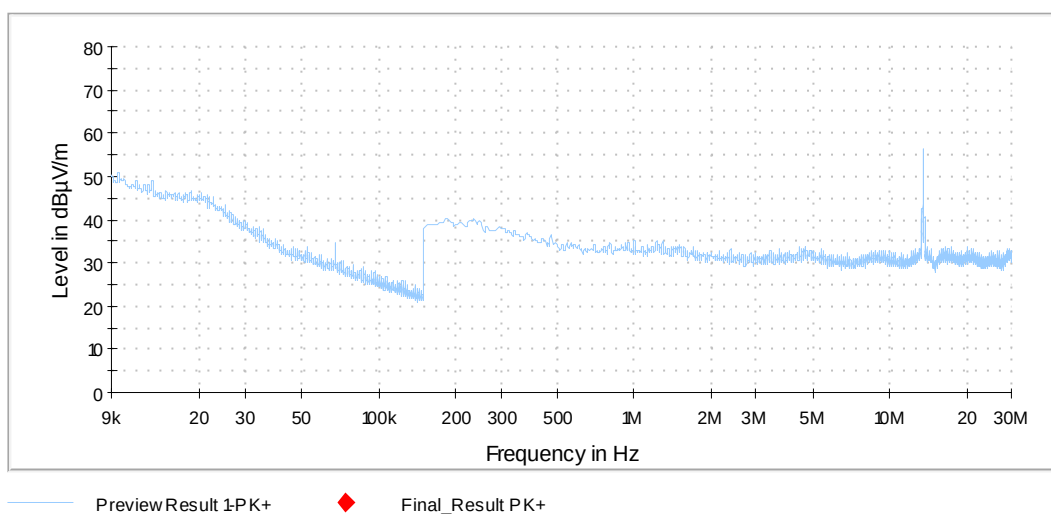
Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

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.

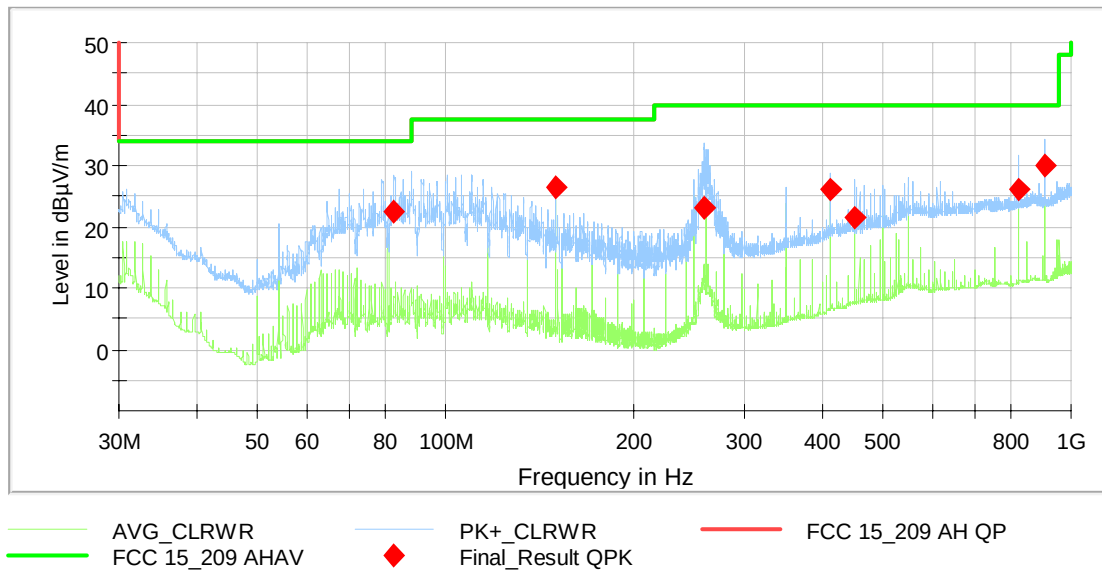
Supply voltage: During all measurements the host of the EUT was powered with 24 V DC via an laboratory power supply.

Spurious emissions from 30 MHz – 1 GHz (All operation modes; preliminary plot):



The emission at 68 kHz is caused by the measuring system and is therefore not measured.  
The emission at 13.56 MHz is a wanted signal and is therefore not rated, in this test report.

Spurious emissions from 30 MHz – 1 GHz (All operation modes; preliminary plot):



The following frequencies were found for final measurement:

| Frequency<br>[MHz] |
|--------------------|
| 13.560000          |
| 82.746000          |
| 150.000000         |
| 259.158000         |
| 411.444000         |
| 450.000000         |
| 822.870000         |
| 909.492000         |

|                                                        |                            |
|--------------------------------------------------------|----------------------------|
| Test equipment (please refer to chapter 6 for details) |                            |
| Preliminary measurements 9 kHz - 30 MHz                | 4, 6, 11 - 14              |
| Preliminary measurements 30 MHz - 1 GHz                | 2 - 4, 6, 10 - 11, 15 - 18 |

#### 6.6.1.1.1.2 Emissions above 1 GHz

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |                                        |
|-----------|----------------------------------------|
| Date      | 19.10.2017<br>20.10.2017<br>27.10.2017 |
| Tested by | B. ROHDE                               |

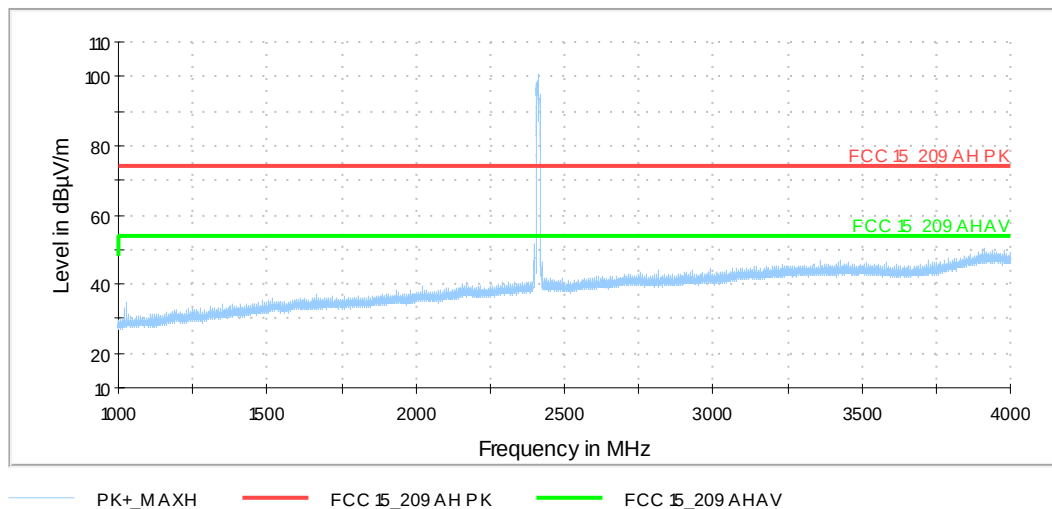
Position of EUT: The EUT was set-up on an EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

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

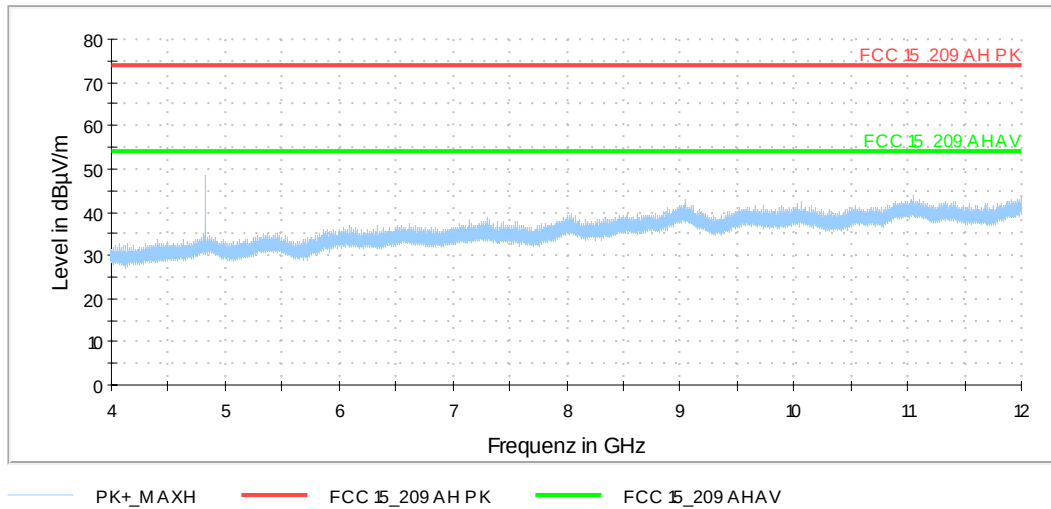
Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 24 V DC via a laboratory power supply.

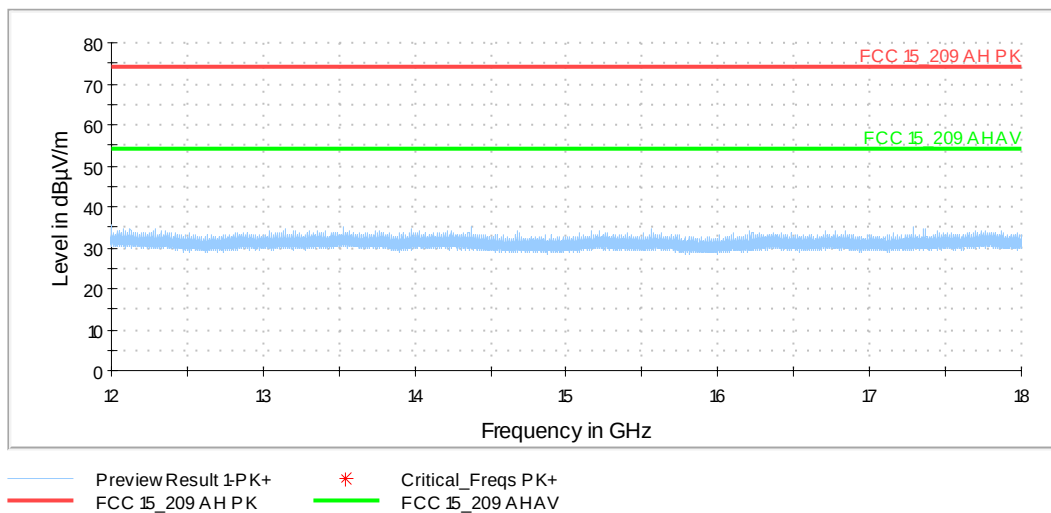
Spurious emissions from 1 – 4 GHz (Operation mode 1; Preliminary plot):  
no significant emission, no final measurement



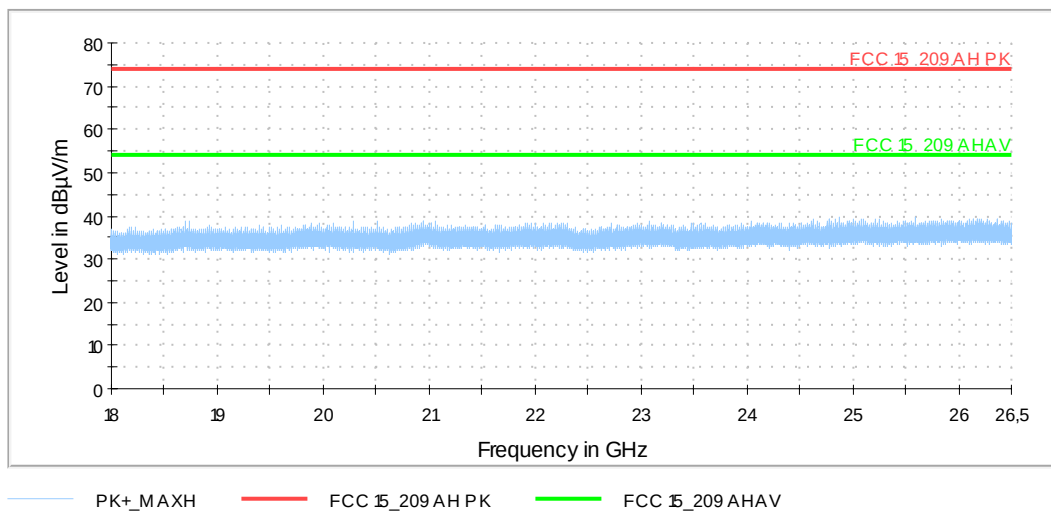
Spurious emissions from 4 - 12 GHz (Operation mode 1; Preliminary and final plot):



Spurious emissions from 12 - 18 GHz (Operation mode 1; Preliminary plot):  
no significant emission, no final measurement



Spurious emissions from 18 – 26.5 GHz (Operation mode 2; Preliminary plot):  
no significant emission, no final measurement



|                                                        |                             |
|--------------------------------------------------------|-----------------------------|
| Test equipment (please refer to chapter 6 for details) |                             |
| Preliminary measurements above 1 GHz                   | 2 - 8, 10 - 11, 16, 19 - 25 |

#### 6.6.1.1.2 Final radiated emission measurement (9 kHz to 1 GHz)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |            |
|-----------|------------|
| Date      | 27.04.2018 |
| Tested by | M. Bastert |

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in test setup photos.

Test record: All results are shown in the following.

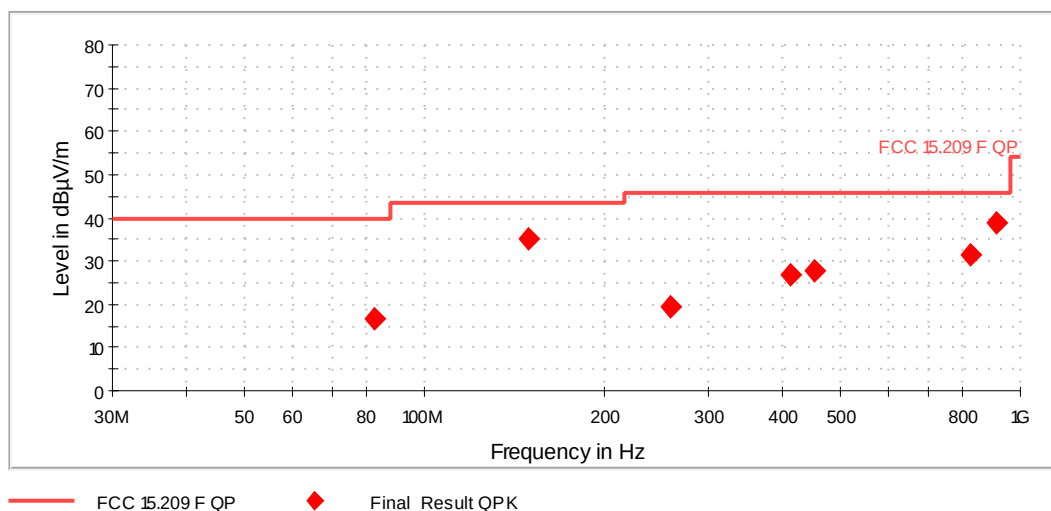
Supply voltage: During all measurements the host of the EUT was powered with 24 V DC via an laboratory power supply.

The correction factor is calculated as Antenna Factor [dB] + Cable Attenuation [dB] - Amplifier Gain [dB]

The result Peak/Average is the result of Reading [dBμV/m] – Correction factor [dB]

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

Spurious emissions from 30 MHz – 1 GHz (All operation modes; final plot):



| Spurious Emissions (All Operation modes) 9kHz - 30 MHz     |                   |                     |                                  |                |                                        |                             |                              |                                            |
|------------------------------------------------------------|-------------------|---------------------|----------------------------------|----------------|----------------------------------------|-----------------------------|------------------------------|--------------------------------------------|
| Frequency<br>[MHz]                                         | Reading<br>[dBμV] | Result*<br>[dBμV/m] | Limit acc.<br>15.209<br>[dBμV/m] | Margin<br>[dB] | Detector<br>(acc. to<br>§15.209<br>(d) | Antenna<br>factor<br>[dB/m] | Measuring<br>Distance<br>[m] | Distance<br>correction<br>factor**<br>[dB] |
| No emission found, so no final measurement was carried out |                   |                     |                                  |                |                                        |                             |                              |                                            |

| Spurious Emissions (All Operation modes) 30 MHz - 1 GHz |                       |                   |              |             |                |                |                    |        |
|---------------------------------------------------------|-----------------------|-------------------|--------------|-------------|----------------|----------------|--------------------|--------|
| Frequency<br>[MHz]                                      | QuasiPeak<br>[dBμV/m] | Limit<br>[dBμV/m] | Margin<br>dB | Pol         | Azimuth<br>[°] | Height<br>[cm] | Correction<br>[dB] | Result |
| 82.746000                                               | 16.8                  | 40                | 23.2         | V           | 0              | 353            | 16.2               | Passed |
| 150.000000                                              | 35.0                  | 43.5              | 8.5          | V           | 90             | 235            | 19.1               | Passed |
| 259.158000                                              | 19.5                  | 46                | 26.5         | H           | 22             | 228            | 21.6               | Passed |
| 411.444000                                              | 26.9                  | 46                | 19.1         | V           | 110            | 103            | 25.1               | Passed |
| 450.000000                                              | 27.6                  | 46                | 18.4         | V           | 115            | 226            | 25.4               | Passed |
| 822.870000                                              | 31.3                  | 46                | 14.7         | V           | 7              | 102            | 29.9               | Passed |
| 909.492000                                              | 38.9                  | 46                | 7.1          | H           | 13             | 109            | 30.4               | Passed |
| Measurement uncertainty                                 |                       |                   |              | +/- 4.78 dB |                |                |                    |        |

|                                                        |             |
|--------------------------------------------------------|-------------|
| Test equipment (please refer to chapter 6 for details) |             |
| Final measurements 9 kHz - 30 MHz                      | 26 - 28     |
| Final measurements 30 MHz - 1 GHz                      | 29 – 34, 37 |



#### 6.6.1.1.3 Final radiated emission measurement (1 GHz to 25 GHz)

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |                                        |
|-----------|----------------------------------------|
| Date      | 19.10.2017<br>20.10.2017<br>27.10.2017 |
| Tested by | B. ROHDE                               |

Position of EUT: The EUT was set-up on a EUT turn device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in test setup photos.

Test record: All results are shown in the following.

Supply voltage: During all measurements the host of the EUT was powered with 24 V DC via an laboratory power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

Additional information: For simplification all values were compared to the restricted band limits.

| Spurious Emissions 1 – 25 GHz (Operation mode 1) |          |          |                                                                          |             |     |         |           |            |        |
|--------------------------------------------------|----------|----------|--------------------------------------------------------------------------|-------------|-----|---------|-----------|------------|--------|
| Operation mode 1                                 |          |          | Duty cycle correction factor of 0 dB 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]       |        |
| 4823.950000                                      | ---      | 48.4     | 54                                                                       | 5.6         | V   | 274     | 90        | -1.7       | Passed |
| 4823.950000                                      | 51.8     | ---      | 74                                                                       | 22.2        | V   | 274     | 90        | -1.7       | Passed |
| 4831.950000                                      | ---      | 36.0     | 54                                                                       | 18.0        | V   | 261     | 90        | -1.6       | Passed |
| 4831.950000                                      | 46.0     | ---      | 74                                                                       | 28.0        | V   | 261     | 90        | -1.6       | Passed |
| 9048.900000                                      | ---      | 38.0     | 54                                                                       | 16.0        | V   | 123     | 150       | 9.3        | Passed |
| 9048.900000                                      | 50.3     | ---      | 74                                                                       | 23.7        | V   | 123     | 150       | 9.3        | Passed |
| Measurement uncertainty                          |          |          |                                                                          | +/- 5.38 dB |     |         |           |            |        |

| Spurious Emissions 1 – 25 GHz (Operation mode 2) |          |          |                                                                          |             |     |         |           |            |        |
|--------------------------------------------------|----------|----------|--------------------------------------------------------------------------|-------------|-----|---------|-----------|------------|--------|
| Operation mode 2                                 |          |          | Duty cycle correction factor of 0 dB 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]       |        |
| 4873.950000                                      | ---      | 46.7     | 54                                                                       | 7.3         | V   | 254     | 90        | -1.5       | Passed |
| 4873.950000                                      | 50.7     | ---      | 74                                                                       | 23.3        | V   | 254     | 90        | -1.5       | Passed |
| 10746.250000                                     | ---      | 36.7     | 54                                                                       | 17.3        | H   | 101     | 90        | 6.9        | Passed |
| 10746.250000                                     | 49.1     | ---      | 74                                                                       | 24.9        | H   | 101     | 90        | 6.9        | Passed |
| 11897.100000                                     | ---      | 38.3     | 54                                                                       | 15.7        | H   | 322     | 120       | 6.3        | Passed |
| 11897.100000                                     | 50.4     | ---      | 74                                                                       | 23.6        | H   | 322     | 120       | 6.3        | Passed |
| Measurement uncertainty                          |          |          |                                                                          | +/- 5.38 dB |     |         |           |            |        |

| Spurious Emissions 1 – 25 GHz (Operation mode 3) |          |          |                                                                          |             |     |         |           |            |        |
|--------------------------------------------------|----------|----------|--------------------------------------------------------------------------|-------------|-----|---------|-----------|------------|--------|
| Operation mode 3                                 |          |          | Duty cycle correction factor of 0 dB 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]       |        |
| 4923.950000                                      | ---      | 46.2     | 54                                                                       | 7.8         | V   | 247     | 90        | -1.6       | Passed |
| 4923.950000                                      | 50.3     | ---      | 74                                                                       | 23.7        | V   | 247     | 90        | -1.6       | Passed |
| 7255.650000                                      | ---      | 33.2     | 54                                                                       | 20.8        | V   | 112     | 60        | 4.6        | Passed |
| 7255.650000                                      | 46.1     | ---      | 74                                                                       | 27.9        | V   | 112     | 60        | 4.6        | Passed |
| 11032.150000                                     | ---      | 38.4     | 54                                                                       | 15.6        | H   | 218     | 0         | 8.3        | Passed |
| 11032.150000                                     | 50.7     | ---      | 74                                                                       | 23.3        | H   | 218     | 0         | 8.3        | Passed |
| Measurement uncertainty                          |          |          |                                                                          | +/- 5.38 dB |     |         |           |            |        |

|                                                        |
|--------------------------------------------------------|
| Test equipment (please refer to chapter 6 for details) |
| 2 - 8, 10 - 11, 16, 19 - 25                            |

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

|                     |       |
|---------------------|-------|
| Ambient temperature | 22 °C |
| Relative humidity   | 45 %  |

|           |            |
|-----------|------------|
| Date      | 29.03.2018 |
| Tested by | B. ROHDE   |

Position of EUT: Tabletop equipment, see photos in annex A of this test report

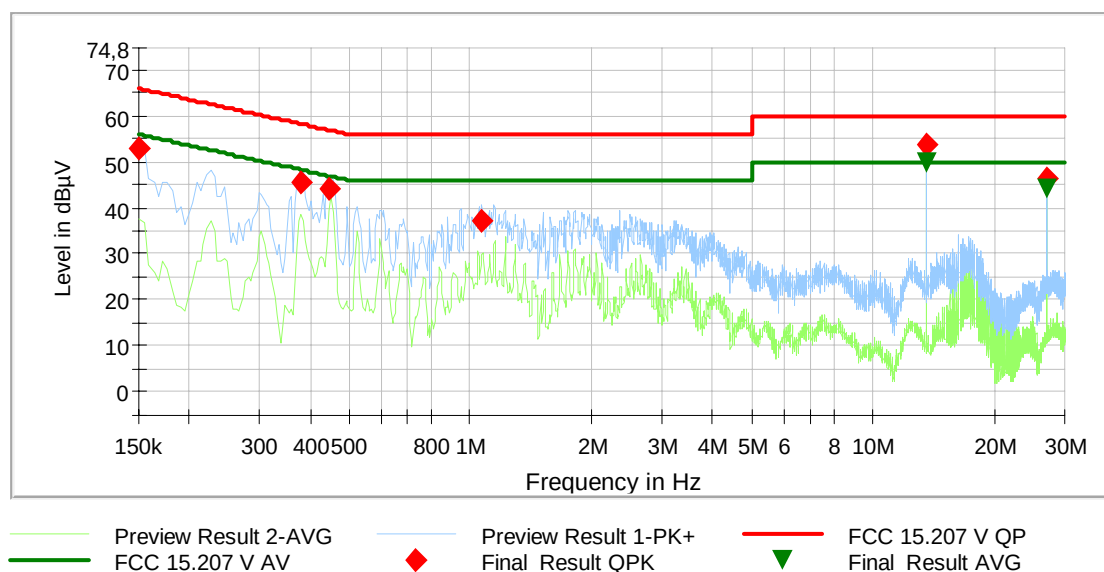
Cable guide: For detail information of test set-up and the cable guide refer to the photos in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: For the test the evaluation board of the EUT was connected to an ancillary laptop "P/N CA01007-0920" by "FUJITSU LIMITED" via Ethernet. The EUT was connected to a power supply "Phoenix contact type: STEP-PS/277AC/24DC/3.5" which was itself powered with 120V/60Hz. The AC mains emissions were tested at the power supply.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by "◆" and the average measured points by "▼".

Conducted emissions on power supply (all operation modes):



| Frequency [MHz]         | QuasiPeak [dBμV] | Average [dBμV] | Limit [dBμV] | Margin [dB] | Meas. Time [ms] | Bandwidth (kHz) | Line | PE  | Corr. (dB) |
|-------------------------|------------------|----------------|--------------|-------------|-----------------|-----------------|------|-----|------------|
| 0.150000                | 53.02            | ---            | 66.00        | 12.98       | 5000.0          | 9.000           | N    | GND | 9.8        |
| 0.381300                | 45.34            | ---            | 58.25        | 12.91       | 5000.0          | 9.000           | N    | GND | 9.9        |
| 0.445200                | 44.04            | ---            | 56.96        | 12.93       | 5000.0          | 9.000           | N    | GND | 9.9        |
| 1.060800                | 37.37            | ---            | 56.00        | 18.63       | 5000.0          | 9.000           | N    | FLO | 9.9        |
| 13.560000               | ---              | 49.92          | 50.00        | 0.08        | 5000.0          | 9.000           | N    | GND | 10.8       |
| 13.560000               | 53.61            | ---            | 60.00        | 6.39        | 5000.0          | 9.000           | N    | FLO | 10.8       |
| 27.119400               | ---              | 44.02          | 50.00        | 5.98        | 5000.0          | 9.000           | N    | GND | 11.2       |
| 27.119400               | 46.19            | ---            | 60.00        | 13.81       | 5000.0          | 9.000           | N    | GND | 11.2       |
| Measurement uncertainty |                  |                |              | +/- 2.76 dB |                 |                 |      |     |            |

Test: Passed

|                                                        |
|--------------------------------------------------------|
| Test equipment (please refer to chapter 6 for details) |
| 33, 35 - 38                                            |

## 7 Test Equipment used for Tests

| No. | Test equipment                   | Type                | Manufacturer                | Serial No.         | PM. No. | Cal. Date                 | Cal Due |
|-----|----------------------------------|---------------------|-----------------------------|--------------------|---------|---------------------------|---------|
| 1   | Spectrum Analyser                | FSU46               | Rohde & Schwarz             | 200125             | 480956  | 01.03.2018                | 03.2019 |
| 2   | Antenna mast                     | AS615P              | Deisel                      | 615/310            | 480187  | Calibration not necessary |         |
| 3   | Fully anechoic chamber M20       | B83117-E2439-T232   | Albatross Projects          | 103                | 480303  | Calibration not necessary |         |
| 4   | Turntable                        | DS420 HE            | Deisel                      | 420/620/00         | 480315  | Calibration not necessary |         |
| 5   | RF-cable No.3                    | Sucoflex 106B       | Suhner                      | 0563/6B / Kabel 3  | 480670  | Calibration not necessary |         |
| 6   | Multiple Control Unit            | MCU                 | Maturo GmbH                 | MCU/043/971107     | 480832  | Calibration not necessary |         |
| 7   | Antenna (Log.Per.)               | HL050               | Rohde & Schwarz             | 100438             | 481170  | 09.10.2017                | 10.2020 |
| 8   | RF-Cable No. 40                  | Sucoflex 106B       | Suhner                      | 0708/6B / Kabel 40 | 481330  | Calibration not necessary |         |
| 9   | HF-Cable                         | Sucoflex 104        | Huber+Suhner                | 517406             | 482391  | Calibration not necessary |         |
| 10  | Positioners                      | TDF 1.5- 10Kg       | Maturo                      | 15920215           | 482034  | Calibration not necessary |         |
| 11  | EMI Receiver / Spectrum Analyser | ESW44               | Rohde & Schwarz             | 101635             | 482467  | 22.06.2017                | 06.2019 |
| 12  | Fully anechoic chamber M20       | B83117-E2439-T232   | Albatross Projects          | 103                | 480303  | Calibration not necessary |         |
| 13  | Antenna support                  | AS620P              | Deisel                      | 620/375            | 480325  | Calibration not necessary |         |
| 14  | loop antenna                     | HFH2-Z2             | Rohde & Schwarz             | 832609/014         | 480059  | 29.02.2016                | 03.2018 |
| 15  | Antenna (Bilog)                  | CBL6112B            | Schaffner EMV GmbH (-Chase) | 2688               | 480328  | 19.06.2017                | 06.2020 |
| 16  | Software                         | WMS32               | Rohde & Schwarz             |                    | 481800  | Calibration not necessary |         |
| 17  | RF-cable No.36                   | Sucoflex 106B       | Suhner                      | 0587/6B / Kabel 36 | 480865  | Calibration not necessary |         |
| 18  | HF-Cable                         | Sucoflex 104        | Huber+Suhner                | 517402             | 482392  | Calibration not necessary |         |
| 19  | standard gain horn antenna       | 18240-20            | Flann Microwave             | 483                | 480294  | Calibration not necessary |         |
| 20  | standard gain horn antenna       | 20240-20            | Flann Microwave             | 411                | 480297  | Calibration not necessary |         |
| 21  | Microwave cable 2m               | Insulated Wire Inc. | Insulated Wire              | KPS-1533-800-KPS   | 480302  | Calibration not necessary |         |
| 22  | Preamplifier 100 MHz - 13 GHz    | JS3-00101200-23-5A  | MITEQ Hauppauge N.Y.        | 681851             | 480337  | 18.02.2016                | 02.2018 |
| 23  | Preamplifier 18 GHz - 26 GHz     | JS4-18002600-20-5A  | MITEQ Hauppauge N.Y.        | 658697             | 480342  | 17.02.2016                | 02.2018 |
| 24  | Preamplifier 12 GHz - 18 GHz     | JS3-12001800-16-5A  | MITEQ Hauppauge N.Y.        | 571667             | 480343  | 18.02.2016                | 02.2018 |
| 25  | High pass Filter                 | WHKX4.0/18G-8SS     | Wainwright Instruments GmbH | 1                  | 480587  | Calibration not necessary |         |
| 26  | Outdoor test site                | -                   | PHOENIX TESTLAB GmbH        | -                  | 480293  | Calibration not necessary |         |
| 27  | EMI Receiver / Spectrum Analyser | ESI 40              | Rohde & Schwarz             | 100064/040         | 480355  | 27.02.2018                | 02.2019 |

| No. | Test equipment                   | Type           | Manufacturer                            | Serial No.          | PM. No. | Cal. Date                 | Cal Due |
|-----|----------------------------------|----------------|-----------------------------------------|---------------------|---------|---------------------------|---------|
| 28  | loop antenna                     | HFH2-Z2        | Rohde & Schwarz                         | 100417              | 481912  | 19.12.2017                | 12.2018 |
| 29  | Open area test site M6           | Freifeld M6    | Phoenix Contact                         | -                   | 480085  | Calibration not necessary |         |
| 30  | Antenna mast                     | MA240-0        | Inn-Co GmbH                             | MA240-0/030/6600603 | 480086  | Calibration not necessary |         |
| 31  | Turntable                        | DS412          | Deisel                                  | 412/316             | 480087  | Calibration not necessary |         |
| 32  | Controller                       | HD100          | Deisel                                  | 100/349             | 480139  | Calibration not necessary |         |
| 33  | Software                         | EMC32          | Rohde & Schwarz                         | 100061              | 481022  | Calibration not necessary |         |
| 34  | Antenna (Bilog)                  | CBL6111D       | Schaffner Elektrotest GmbH / Teseq GmbH | 25761               | 480894  | 19.10.2017                | 10.2020 |
| 35  | LISN                             | NSLK8128       | Schwarzbeck                             | 8128155             | 480058  | 14.03.2018                | 03.2020 |
| 36  | Shielded chamber M4              | B83117-S1-X158 | Siemens                                 | 190075              | 480088  | Calibration not necessary |         |
| 37  | EMI Receiver / Spectrum Analyser | ESIB 26        | Rohde & Schwarz                         | 100292              | 481182  | 28.02.2018                | 02.2020 |
| 38  | Transient Filter Limiter         | CFL 9206A      | Teseq GmbH                              | 38268               | 481982  | 14.03.2018                | 03.2020 |

## 8 Report History

| Report Number | Date       | Comment             |
|---------------|------------|---------------------|
| F170756E2     | 03.06.2019 | Initial Test Report |
|               |            |                     |
|               |            |                     |
|               |            |                     |

## 9 List of Annexes

Annex A      Test Setup Photos

9 pages