# EMI – TEST REPORT

**- FCC Part 15.249, RSS210 -**

| | | |
|---|---|---|
| **Type / Model Name** | : | Type 2779_rLeaf |
| **Product Description** | : | Remote control with Bluetooth 4.0 Low Energy |
| **Applicant** | : | ruwido austria gmbh |
| Address | : | Köstendorfer Strasse 8 |
| | | 5202 NEUMARKT, AUSTRIA |
| **Manufacturer** | : | ruwido austria gmbh |
| Address | : | Köstendorfer Strasse 8 |
| | | 5202 NEUMARKT, AUSTRIA |
| **Licence holder** | : | ruwido austria gmbh |
| Address | : | Köstendorfer Strasse 8 |
| | | 5202 NEUMARKT, AUSTRIA |

| | |
|---|---|
| **Test Result** according to the standards listed in clause 1 test standards: | **POSITIVE** |

| | |
|---|---|
| **Test Report No. : T40947-00-02GK** | 21. June 2016<br>Date of issue |

Deutsche Akkreditierungsstelle
D-PL-12030-01-01
D-PL-12030-01-02

# Contents

# 1 TEST STANDARDS

The tests were performed according to following standards:

**FCC Rules and Regulations Part 15, Subpart A - General (September, 2015)**

| | |
|---|---|
| Part 15, Subpart A, Section 15.31 | Measurement standards |
| Part 15, Subpart A, Section 15.33 | Frequency range of radiated measurements |
| Part 15, Subpart A, Section 15.35 | Measurement detector functions and bandwidths |

**FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (September, 2015)**

| | |
|---|---|
| Part 15, Subpart C, Section 15.203 | Antenna requirement |
| Part 15, Subpart C, Section 15.204 | External radio frequency power amplifiers and antenna modifications |
| Part 15, Subpart C, Section 15.205 | Restricted bands of operation |
| Part 15, Subpart C, Section 15.207 | Conducted limits |
| Part 15, Subpart C, Section 15.209 | Radiated emission limits, general requirements |
| Part 15, Subpart C, Section 15.249 | Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz |
| ANSI C63.4: 2014 | Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz. |
| ANSI C63.10: 2013 | Testing Unlicensed Wireless Devices |
| ANSI C95.1:2005 | IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz |
| CISPR 16-4-2: 2013 | Uncertainty in EMC measurement |
| CISPR 22: 2008<br>EN 55022: 2010 | Information technology equipment |

# 2 EQUIPMENT UNDER TEST

## 2.1 Photo documentation of the EUT

Detailed photos see Attachment B

## 2.2 Equipment category

Bluetooth Low Energy device, portable equipment.

## 2.3 Short description of the equipment under test (EUT)

The EUT is a Bluetooth Low Energy wireless remote control system. The EUT is compatible with the standard 802.15.1. It supports the 2.4 GHz frequency band. A single PCB antenna is used within the system. The modulation used by the EUT is GFSK with a data rate of 1 Mbits which means worst case for testing. The EUT has only one integrated antenna, no temporary connector and no external antenna can be connected.

| | | | |
|---|---|---|---|
| Number of tested samples | : | 1 (emission test) | 1 (CPC measurement) |
| Serial number | : | Pre-production sample | Pre-production sample |
| Firmware version | : | V 1.0.1 | V 1.0.1 |

| Items | Description |
|---|---|
| BT type | 4.0 Low Energy |
| BT chipset type | Texas Instruments CC2541 |
| Modulation | GFSK |
| Frequency range | 2400 MHz to 2483.5 MHz |
| Channel numbers | 40 |
| Data rate (kbps) | 1000 |
| Antenna type | PCB |

**EUT configuration:**
(The CDF filled by the applicant can be viewed at the test laboratory.)

## 2.4 Variants of the EUT

None

## 2.5 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

| Channel | Frequency | Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---|---|---|---|---|---|---|---|
| 37 | 2402 | 9 | 2422 | 18 | 2442 | 28 | 2462 |
| 0 | 2404 | 10 | 2424 | 19 | 2444 | 29 | 2464 |
| 1 | 2406 | 38 | 2426 | 20 | 2446 | 30 | 2466 |
| 2 | 2408 | 11 | 2428 | 21 | 2448 | 31 | 2468 |
| 3 | 2410 | 12 | 2430 | 22 | 2450 | 32 | 2470 |
| 4 | 2412 | 13 | 2432 | 23 | 2452 | 33 | 2472 |
| 5 | 2414 | 14 | 2434 | 24 | 2454 | 34 | 2474 |
| 6 | 2416 | 15 | 2436 | 25 | 2456 | 35 | 2476 |
| 7 | 2418 | 16 | 2438 | 26 | 2458 | 36 | 2478 |
| 8 | 2420 | 17 | 2440 | 27 | 2460 | 39 | 2480 |

Note: the marked frequencies are determined for final testing.

## 2.6 Transmit operating modes

The EUT uses GFSK and provide following data rate:

1000 kbps (kbps = *kilobits per second)*

## 2.7 Antenna

The following antenna shall be used with the EUT:

| Number | Characteristic | Certification name | Plug | Frequency range (GHz) | Gain (dBi) |
|---|---|---|---|---|---|
| 1 | Omni | PCB antenna | none | 2.4 - 2.4835 | n/a |

## 2.8 Power supply system utilised

Power supply voltage, $V_{nom}$ : 3.7 VDC (battery powered)

## 2.9 Peripheral devices and interface cables

The following peripheral devices and interface cables are connected during the measurements:

- _____ Model : _____
- _____ Model : _____
- _____ Model : _____

## 2.10 Determination of worst case conditions for final measurement

Measurements have been made in all three orthogonal axes and the settings of the EUT were changed to locate at which position and at what setting of the EUT produce the maximum of the emissions. For the further measurement the EUT is set in X position with the following settings:

| BT 4.0 LE | Available channels | Tested channels | Power setting | Modulation | Data rate |
|---|---|---|---|---|---|
| 802.15.1 | 00 to 39 | 37, 18, 39 | 0 dBm | GFSK | 1000 kbps |

1000 kbps, GFSK with TX continuous modulated.

### 2.10.1 Test jig

No Test jig was used for test.

### 2.10.2 Test software

The device for emission test uses a special firmware that allows enabling a continuous modulated output signal.

# 3 TEST RESULT SUMMERY

Operating in the 2400 MHz – 2483.5 MHz band:

| FCC Rule Part | RSS Rule Part | Description | Result |
|---|---|---|---|
| 15.35(c) | RSS-Gen, 6.10 | Pulsed operation | passed |
| 15.203 | RSS Gen, 8.3 | Antenna requirement | passed |
| 15.204 | RSS Gen, 8.2 | External radio frequency power amplifiers | passed |
| 15.205(a) | RSS Gen, 8.1 | Emissions in restricted bands | passed |
| 15.207(a) | RSS Gen, 8.8 | AC power line conducted emissions | not applicable |
| 15.215(c) | - | EBW | passed |
| - | RSS-Gen, 6.6 | OBW | passed |
| 15.249(a) | RSS-210, A2.9(a) | Field strength of fundamental | passed |
| 15.249(d) | RSS-210, A2.9(b) | Out-of-band emission, radiated | passed |
| - | RSS-Gen, 6.11 | Transmitter frequency stability | not applicable |

The mentioned RSS Rule Parts in the above table are related to:
RSS Gen, Issue 4, November 2014
RSS 210, Issue 8, December 2010

## 3.1 Final assessment

The equipment under test fulfills the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 13 April 2016

Testing concluded on : 13 June 2016

Checked by:

Klaus Gegenfurtner
I confirm the correctness and Integrity of this document
2016.06.21 09:08:09 +02'00'

Klaus Gegenfurtner
Teamleader Radio

Tested by:

Konrad Graßl
I am the author of this document
2016.06.21 08:23:02 +02'00'

Konrad Graßl
Radio Team

# 4 TEST ENVIRONMENT

## 4.1 Address of the test laboratory

**CSA Group Bayern GmbH**
**Ohmstrasse 1-4**
**94342 STRASSKIRCHEN**
**GERMANY**

## 4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature: 15-35 ° C

Humidity: 30-60 %

Atmospheric pressure: 86-106 kPa

## 4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor k = 2. The true value is located in the corresponding interval with a probability of 95 % The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 11.2003 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

| Measurement uncertainty | |
|---|---|
| **Test** | **Uncertainty** |
| Conducted emissions mains | ± 3.1 dB |
| Power spectral density | ± 2.7 dB |
| bandwidth measurement | ± 100 kHz (depends on the used RBW) |
| Maximum output power | ± 1.0 dB |
| Spurious emissions radiated below 30 MHz | ± 3 dB |
| Spurious emissions radiated 30 MHz to 1 GHz | ± 4.4 dB |
| Spurious emissions radiated 1 GHz to 12.75 GHz | ± 3.7 dB |
| Spurious emissions radiated above 12.75 GHz | ± 5.0 dB |

## 4.4 Measurement protocol for FCC and IC

### 4.4.1 General information

4.4.1.1 Test methodology

Conducted and radiated disturbance testing is performed according to the procedures set out by the International Special Committee on Radio Interference (CISPR) Publication 22, European Standard EN 55022 as shown under section 1 of this report.

The Open Area test site is a listed Open Site under the Canadian Test-Sites File-No:

**IC 3009A-01**

The anechoic chamber site is a listed chamber under the Canadian Test-Sites File-No:

**IC 3009A-02**

In compliance with RSS 210 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.4.1.3 Details of test procedures

The test methods used comply with CISPR Publication 22, EN 55022 - " Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement" and with ANSI C63.4 - "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". In compliance with 47 CFR Part 15 Subpart A, Section 15.38 testing for FCC compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

# 5 TEST CONDITIONS AND RESULTS

## 5.1 AC power line conducted emissions

For test instruments and accessories used see section 6 Part **A 4**.

### 5.1.1 Description of the test location

Test location: NONE

**Remarks:** Not applicable, the EUT is battery powered and has no externally connectable cables.

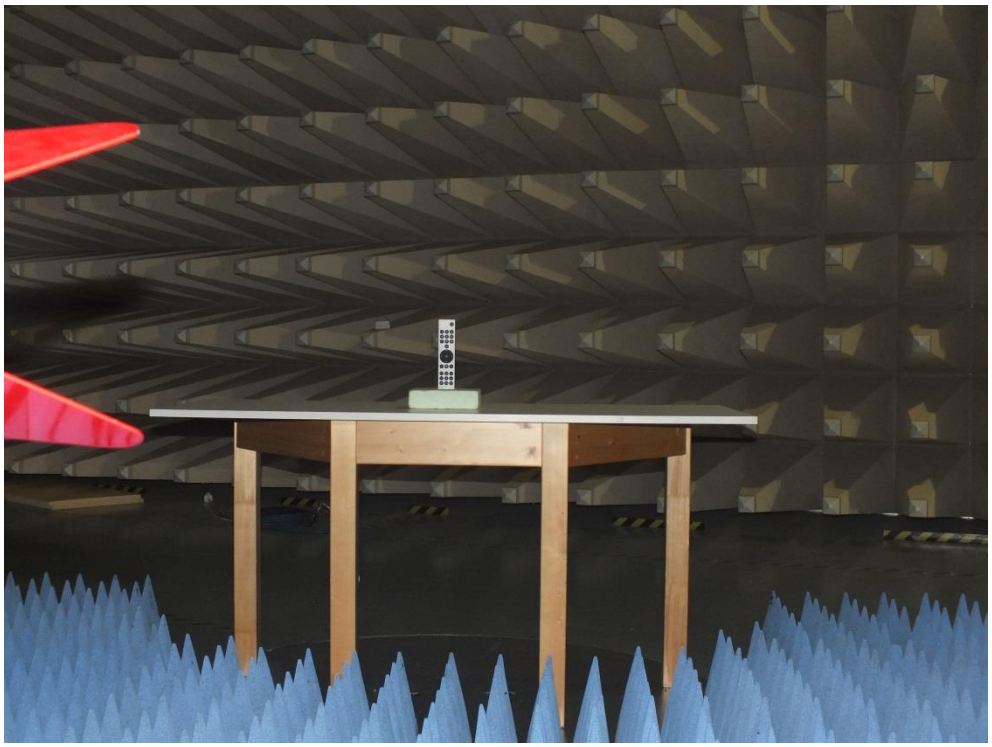
## 5.2 Field strength of fundamental

For test instruments and accessories used see section 6 Part **CPR 3**.

### 5.2.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

### 5.2.2 Photo documentation of the test set-up



### 5.2.1 Applicable standard

According to FCC Part 15C, Section 15.249(a):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the effective limits.

### 5.2.2 Description of Measurement

The radiated emission of the fundamental wave from the EUT is measured using a spectrum analyser and appropriate linear polarized antennas. The set up of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.5. The EUT is measured in TX continuous mode modulated under normal conditions.

Analyser settings:
Peak measurement: RBW: 3 MHz VBW: 10 MHz Detector: Max peak

### 5.2.3 Test result

| Frequency | Level PK | Limit PK | Margin PK | Level AV | Limit AV | Margin AV |
|---|---|---|---|---|---|---|
| (MHz) | dB(µV/m) | dB(µV/m) | (dB) | dB(µV/m) | dB(µV/m) | (dB) |
| 2402 | 87.7 | 114.0 | -26.3 | 51.3 | 94.0 | -42.7 |
| 2442 | 87.6 | 114.0 | -26.4 | 51.2 | 94.0 | -42.8 |
| 2480 | 84.7 | 114.0 | -29.3 | 48.3 | 94.0 | -45.7 |

Note: The correction factor includes cable loss and antenna factor.
Additional the peak values are corrected with the duty cycle of -36.4 dB to get the average value.

Average-Limit according to FCC Part 15C, Section 15.249(a):

| Frequency | Field strength of fundamental | |
|---|---|---|
| (MHz) | (mV/m) | dB(µV/m) |
| 902 - 928 | 50 | 94 |
| **2400 - 2483.5** | **50** | **94** |
| 5725-5875 | 50 | 94 |
| 24000 - 24250 | 250 | 108 |

Peak-Limit according to FCC Part 15C, Section 15.249(e):
However the peak fieldstrength shall not exceed the maximum permitted average limit by more than 20 dB.

The requirements are **FULFILLED.**

**Remarks:** _____

_____

## 5.3 Out-of-band emission, radiated

For test instruments and accessories used see section 6 Part **SER1, SER 2, SER 3**.

### 5.3.1 Description of the test location

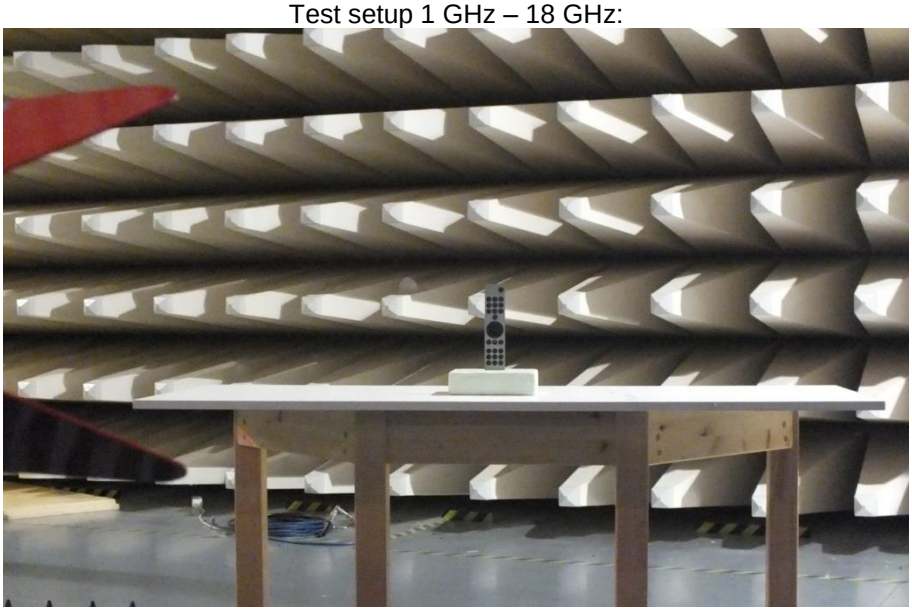
Test location: OATS 1
Test location: Anechoic chamber 1

Test distance: 3 m

### 5.3.2 Photo documentation of the test set-up

Test setup 30 MHz – 1000 MHz:

Test setup 1 GHz – 18 GHz:



### 5.3.3 Applicable standard

According to FCC Part 15C, Section 15.249 (d):
Emission radiated outside of the specified frequency bands, except harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated limit in FCC Part 15C, Section 15.209, whichever is the lesser attenuation.

### 5.3.4 Description of Measurement

The radiated emissions from the EUT are measured in the frequency range of 9 kHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarized antennas. The setup of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.3. In the frequency range above 1 GHz a spectrum analyser is used with appropriate linear polarized antennas. If the emission level in peak mode complies with the average limit testing is stopped and peak values will be reported, otherwise, the emission is measured in average mode again and reported. The EUT is measured in TX continuous mode modulated under normal conditions.

Instrument settings:

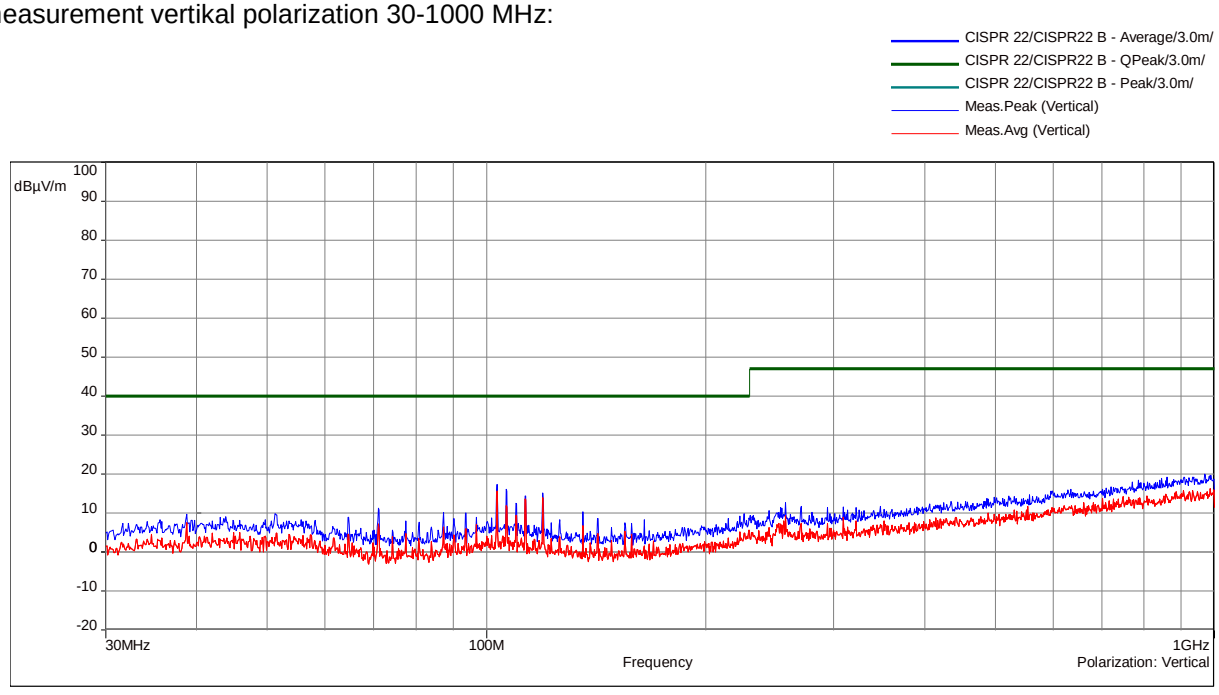
| | | |
|---|---|---|
| 9 kHz – 150 kHz | RBW: | 200 Hz |
| 150 kHz - 30 MHz | RBW: | 9 kHz |
| 30 MHz – 1000 MHz: | RBW: | 120 kHz |
| 1000 MHz – 25 GHz | RBW: | 1 MHz |

### 5.3.1 Test result

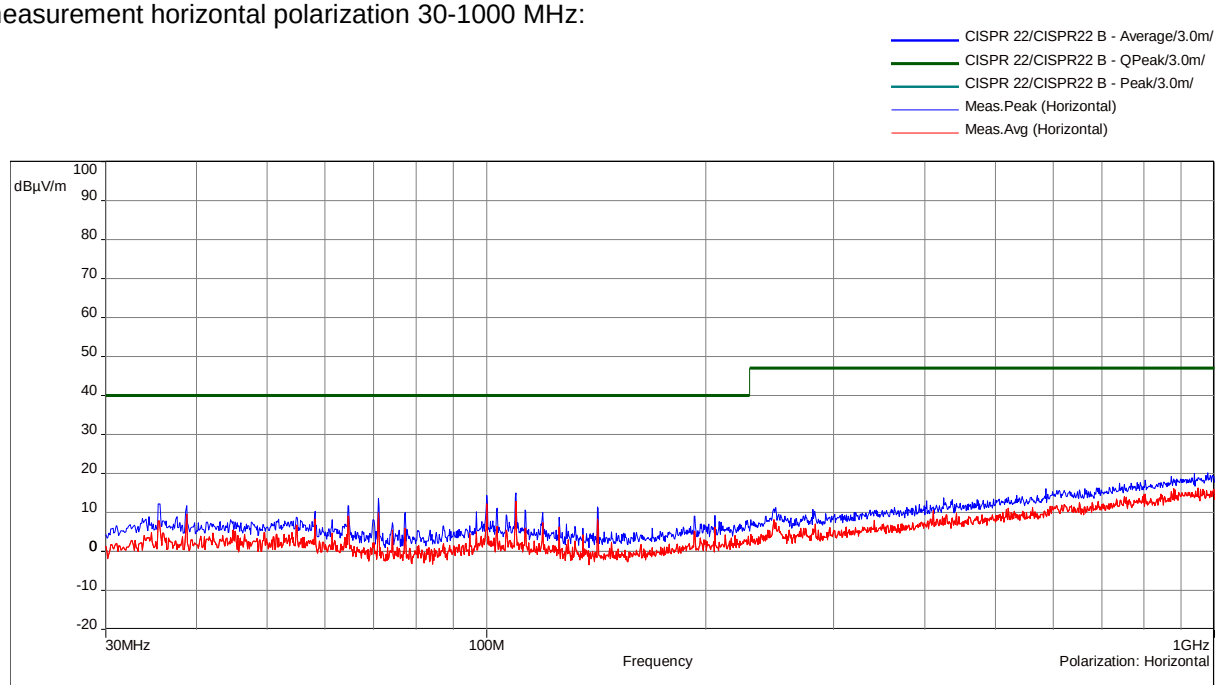
Note:
Pre-measurements were performed in the frequency range 9 kHz to 30 MHz, 30 MHz to 1000 MHz and 18 GHz to 25 GHz. The EUT showed no detectable suspects.

Only for reference the plots of the pre-measurement in TX mode at 2402 MHz

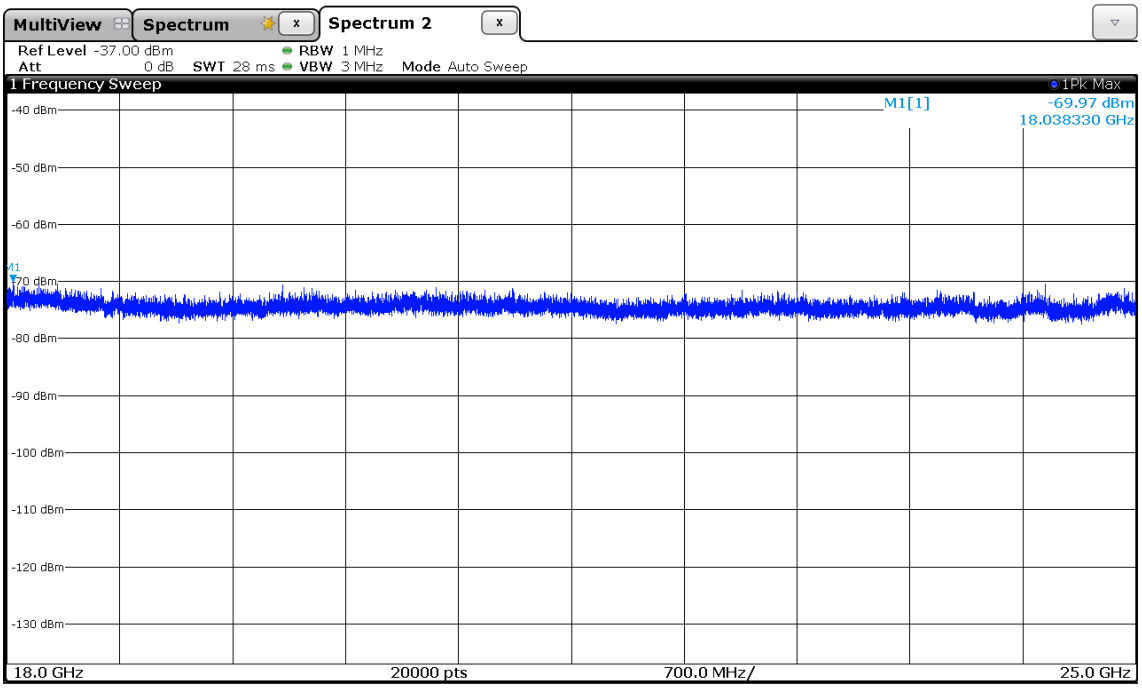
Pre-measurement vertikal polarization 30-1000 MHz:



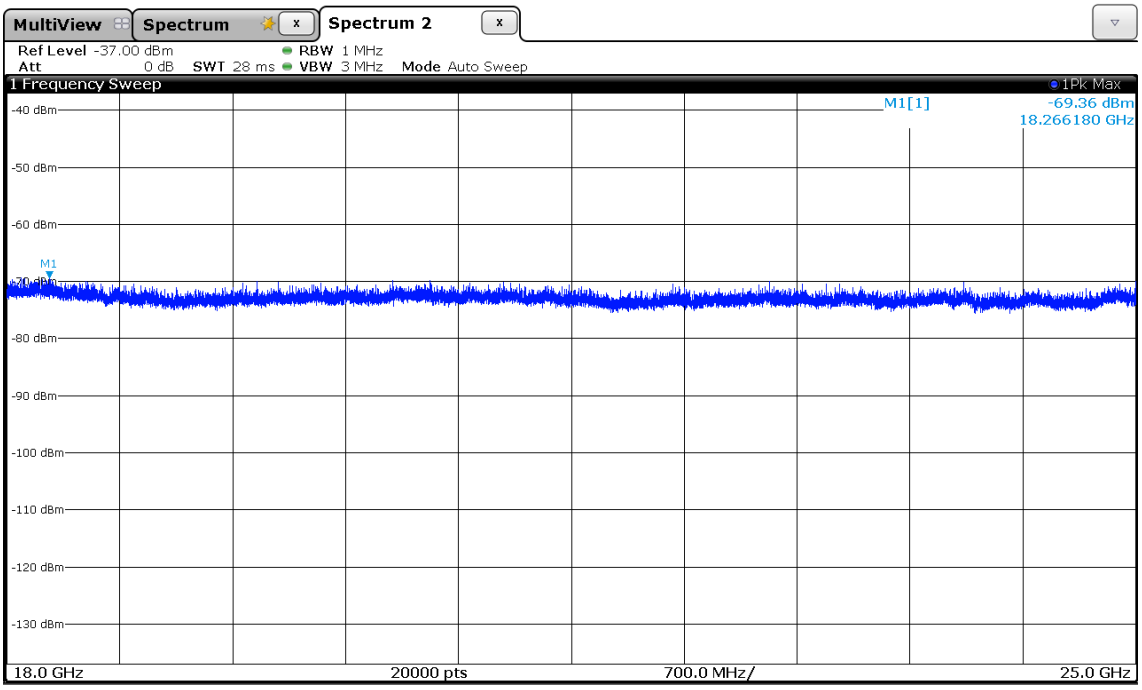
Pre-measurement horizontal polarization 30-1000 MHz:




Pre-measurement vertikal polarization 18 GHz to 25 GHz



Pre-measurement horizontal polarization




### 5.3.2 Test result 30 MHz - 1000 MHz

| Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|
| 33.80 | 6.8 | 4.2 | 13.9 | 12.7 | 20.7 | 16.9 | 40.0 | -19.3 |
| 68.60 | 6.4 | 5.4 | 14.1 | 13.4 | 20.5 | 18.8 | 40.0 | -19.5 |
| 111.90 | 7.0 | 8.7 | 11.0 | 11.8 | 18.0 | 20.5 | 43.5 | -23.0 |
| 207.70 | 5.6 | 11.5 | 11.6 | 12.3 | 17.2 | 23.8 | 43.5 | -19.7 |
| 315.10 | 7.5 | 13.0 | 17.3 | 16.9 | 24.8 | 29.9 | 46.0 | -16.1 |
| 455.00 | 6.8 | 6.0 | 21.3 | 21.0 | 28.1 | 27.0 | 46.0 | -17.9 |
| 540.60 | 9.2 | 10.5 | 23.7 | 23.5 | 32.9 | 34.0 | 46.0 | -12.0 |
| 614.00 | 5.9 | 5.9 | 25.7 | 25.5 | 31.6 | 31.4 | 46.0 | -14.4 |
| 715.40 | 5.6 | 5.6 | 27.4 | 26.9 | 33.0 | 32.5 | 46.0 | -13.0 |
| 826.30 | 7.4 | 7.5 | 29.9 | 29.4 | 37.3 | 36.9 | 46.0 | -8.7 |
| 964.80 | 7.6 | 7.6 | 32.0 | 31.5 | 39.6 | 39.1 | 54.0 | -14.4 |

Note:
The correction factor includes cable loss and antenna factor. No emission difference could be detected for the intentional radiated frequencies 2402 MHz, 2450 MHz and 2480 MHz within the frequency range from 30 MHz to 1000 MHz. The values show only the noise floor of the OATS 1, but there were no values measureable belonging to the EUT.

### 5.3.3 Test result f > 1 GHz

2402 MHz

Peak limit:

| EUT | Detector | Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | Peak | 2400.00 | | 76.6 | | -14.6 | | 62.0 | 74.0 | -12.0 |
| Z | Peak | 4804.00 | 43.1 | 44.1 | 2.3 | 2.3 | 45.4 | 46.4 | 74.0 | -27.6 |
| Y | Peak | 16581.00 | 47.8 | | 5.4 | | 53.2 | | 74.0 | -20.8 |

Average limit:

| EUT | Detector | Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| Z | Peak | 4804.00 | 43.1 | 44.1 | 2.3 | 2.3 | 45.4 | 46.4 | 54.0 | -7.6 |
| Y | Peak | 16581.00 | 47.8 | | 5.4 | | 53.2 | | 54.0 | -0.8 |

Apart of the value at 2400 MHz all peak values fulfil the average limit, therefore an average measurement is not required.
Calculation of the average value at 2400 MHz: peak value – DC = average value
62 dBµV/m – 36.4 dB = 25.6 dBµV/m

| Frequency | Reading PK | D factor | Level AV | Limit AV | Delta |
|---|---|---|---|---|---|
| (MHz) | dB(µV) | dB(µV/m) | dB(µV/m) | dB(µV/m) | (dB) |
| 2400 | 62.0 | -36.4 | 25.6 | 54.0 | -28.4 |

2442 MHz

| EUT | Detector | Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | Peak | 2400.00 | 53.9 | 53.7 | -14.6 | -14.6 | 39.2 | 39.1 | 54.0 | -14.8 |
| Y | Peak | 1328.65 | 59.5 | | -19.6 | | 39.9 | | 54.0 | -14.1 |
| Y | Peak | 2483.50 | 53.2 | 53.8 | -14.0 | -14.0 | 39.3 | 39.8 | 54.0 | -14.2 |
| Z | Peak | 4883.40 | | 44.2 | | 2.3 | | 46.5 | 54.0 | -7.5 |
| Z | Peak | 12920.20 | 48.0 | | 2.1 | | 50.1 | | 54.0 | -3.9 |
| Z | Peak | 15769.80 | | 48.4 | | 3.9 | | 52.3 | 54.0 | -1.7 |
| Z | Peak | 16581.40 | 44.6 | | 5.4 | | 50.0 | | 54.0 | -4.0 |

Note: All peak values fulfil the average limit, therefore an average measurement is not required.

2480 MHz

| EUT | Detector | Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | Peak | 2483.50 | 60.0 | 64.7 | -14.0 | -14.0 | 46.0 | 50.7 | 54.0 | -3.3 |
| Y | Peak | 4959.40 | 43.7 | | 2.7 | | 46.4 | | 54.0 | -7.6 |
| Z | Peak | 4959.40 | | 42.9 | | 2.7 | | 45.6 | 54.0 | -8.4 |
| Z | Peak | 13491.00 | | 47.9 | | 1.3 | | 49.2 | 54.0 | -4.8 |
| Z | Peak | 15714.20 | 48.0 | | 3.6 | | 51.6 | | 54.0 | -2.4 |

Note: All peak values fulfil the average limit, therefore an average measurement is not required.

Note: Average values were calculated from the subtraction of peak values minus correction duty cycle factor.

Limit according to FCC Part 15C, Section 15.209:

| Frequency (MHz) | 15.209 Limits (µV/m) | Measurement distance (m) |
|---|---|---|
| 0.009 - -0.49 | 2400/f(kHz) | 300 |
| 0.49 – 1.705 | 24000/f(kHz) | 30 |
| 1.705 – 30.0 | 30 | 30 |
| 30 - 88 | 100 | 3 |
| 88 - 216 | 150 | 3 |
| 216 - 960 | 200 | 3 |
| Above 960 | 500 | 3 |

Average limit according to FCC Part 15C, Section 15.249(a):

| Fundamental frequency | Field strength of harmonics | |
|---|---|---|
| (MHz) | (µV/m) | dB(µV/m) |
| 902 - 928 | 500 | 54 |
| **2400 - 2483.5** | 500 | 54 |
| 5725 - 5875 | 500 | 54 |
| 24000 - 24250 | 2500 | 68 |

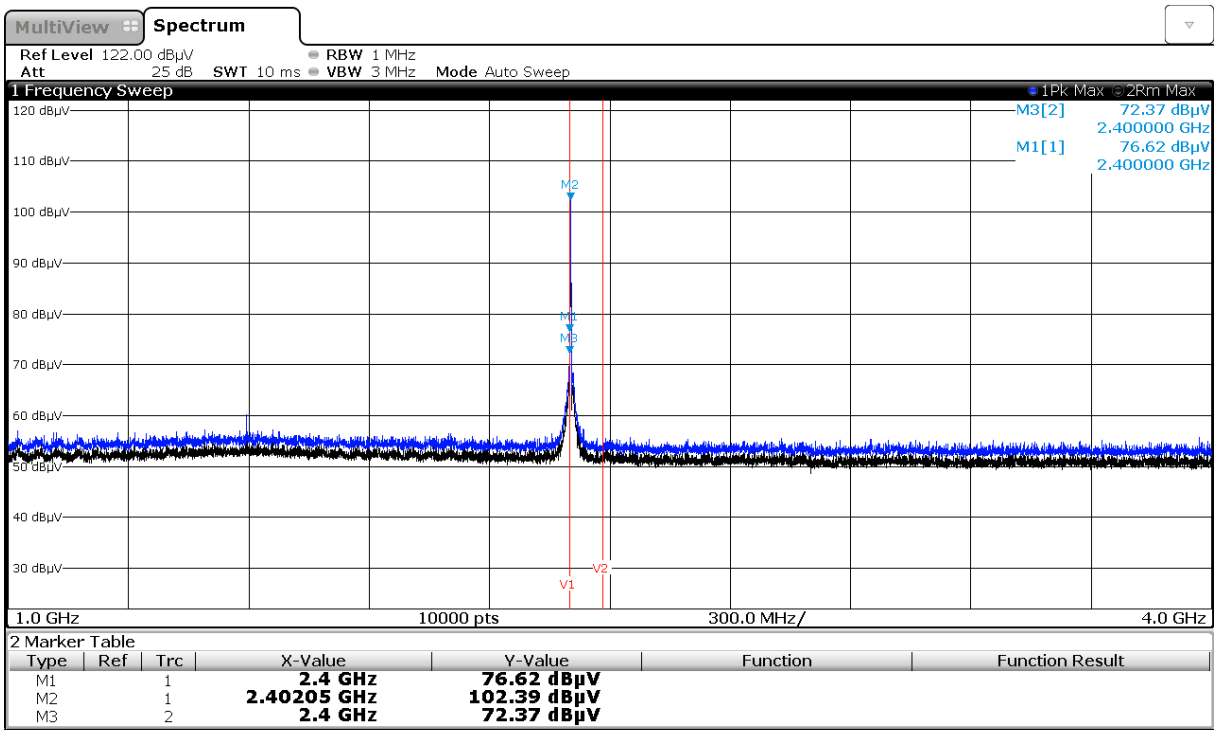
The requirements are **FULFILLED.**

**Remarks:** The measurement was performed up to the 10th harmonic (25000 MHz). For detailed test result please refer to following test protocols.

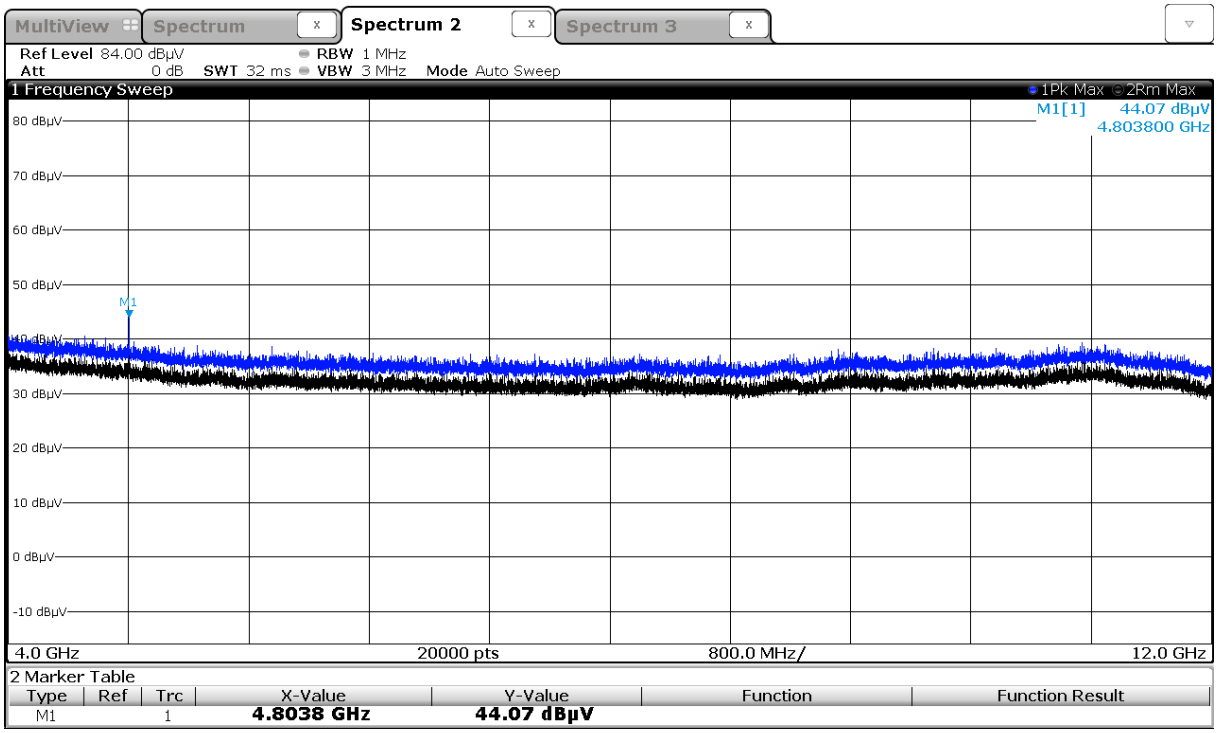
### 5.3.4 Test protocols

For reference the plots from 1 GHz up to 18 GHz (only raw data) at TX 2402 MHz

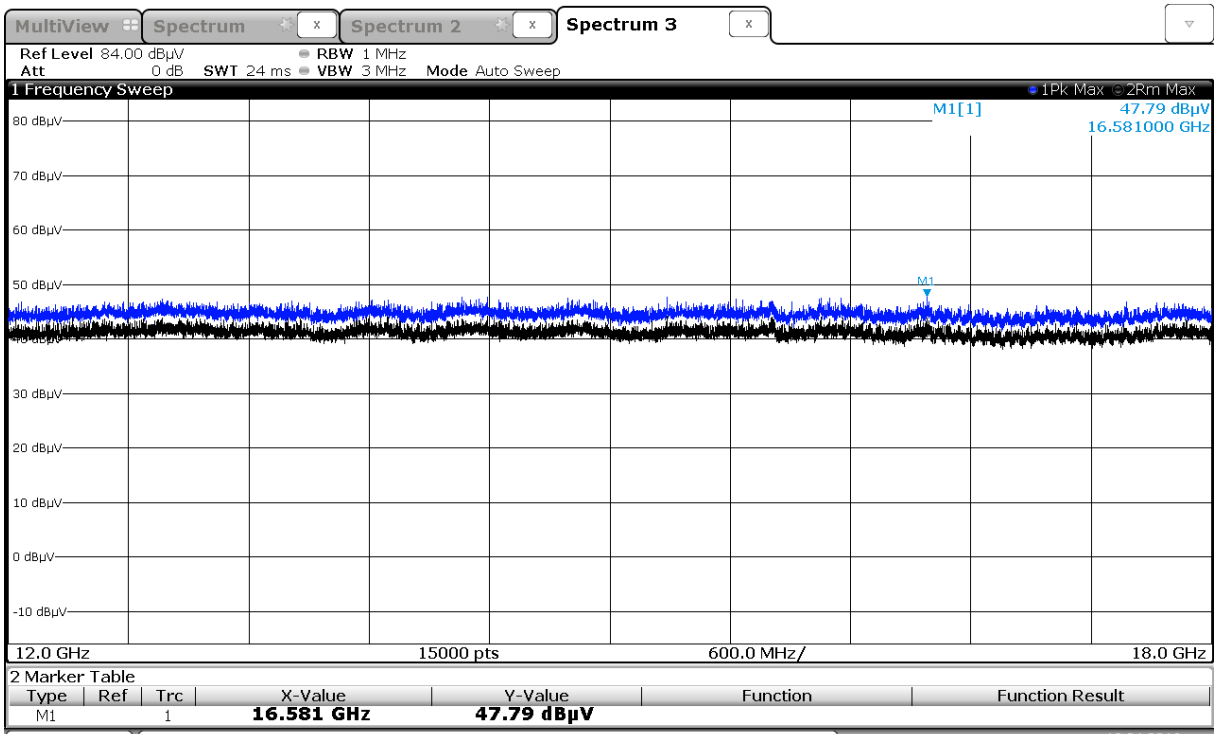
1-4 GHz




4-12 GHz



12-18 GHz


MultiView
Spectrum
Spectrum 2
Spectrum 3
Ref Level 84.00 dBµV
RBW 1 MHz
Att 0 dB
SWT 24 ms
VBW 3 MHz
Mode Auto Sweep
1 Frequency Sweep
1Pk Max
2Rm Max
M1[1]
47.79 dBµV
16.581000 GHz
80 dBµV
70 dBµV
60 dBµV
50 dBµV
30 dBµV
20 dBµV
10 dBµV
0 dBµV
-10 dBµV
12.0 GHz
15000 pts
600.0 MHz/
18.0 GHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 16.581 GHz 47.79 dBµV

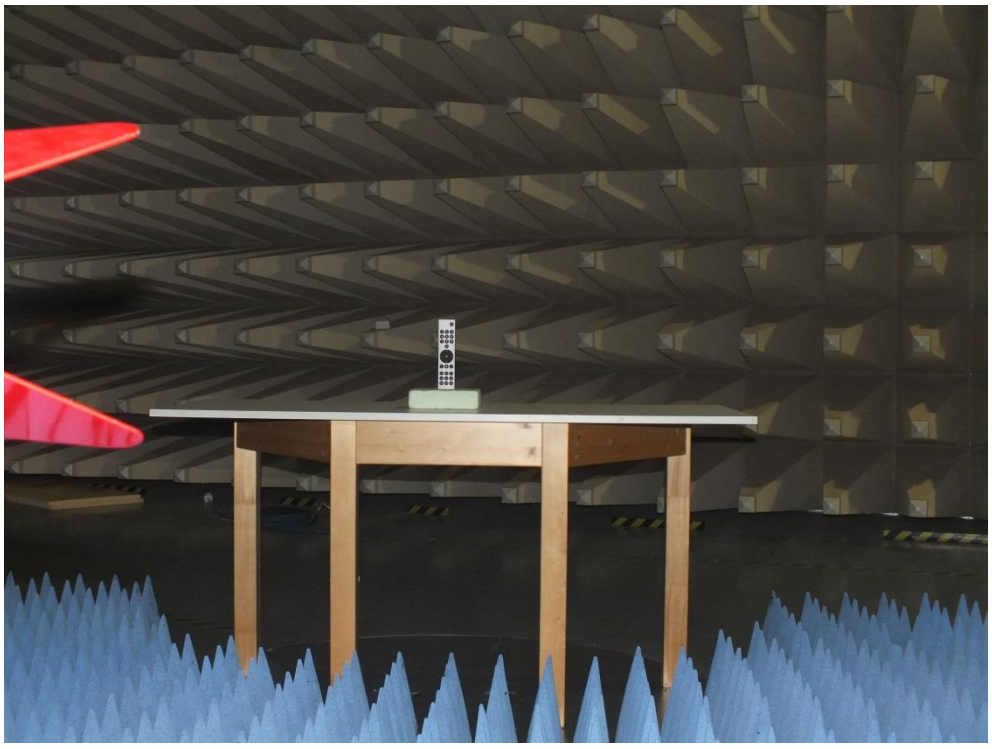
## 5.4 EBW and OBW

For test instruments and accessories used see section 6 Part **MB**.

### 5.4.1 Description of the test location

Test location: AREA4

### 5.4.2 Photo documentation of the test set-up



### 5.4.3 Applicable standard

According to FCC Part 15, Section 15.215(c):
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in Section 15.217 through Section 15.257, must be designed to ensure that the 20 dB bandwidth of the emission is contained within the frequency band designated in the rule section under which the equipment is operated.

### 5.4.4 Description of Measurement

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio of -20 dB (99%). The x-dB-down (OBW) function of the analyser is used. The measurement is performed with normal modulation in TX continuous mode.

Spectrum analyser settings:
RBW: 30 kHz, VBW: 100 kHz, Span: 3 MHz, Trace mode: max. hold, Detector: max. peak;

### 5.4.5 Test result

| Centre *f* | 20dB bandwidth | 20dB bandwidth | Measured EBW |
|---|---|---|---|
| (MHz) | $f_1$ | $f_2$ | (MHz) |
| 2401.97230 | 2401.36480 | 2402.57980 | 1.21500 |
| 2441.96780 | 2441.36930 | 2442.56630 | 1.19700 |
| 2480.25280 | 2479.93930 | 2480.56630 | 0.62700 |

| Centre *f* | 99% bandwidth | 99% bandwidth | Measured OBW |
|---|---|---|---|
| (MHz) | $f_1$ | $f_2$ | (MHz) |
| 2401.973000 | 2401.43525 | 2402.510750 | 1.075500 |
| 2441.958750 | 2441.42475 | 2442.492750 | 1.068000 |
| 2479.962500 | 2479.42775 | 2480.497250 | 1.069500 |

| Operating frequency band | 20 dB Bandwidth |
|---|---|
| (MHz) | (MHz) |
| $f_{low}$ > 2400 | $f_{low}$ = 2401.36480 |
| $f_{high}$< 2483.5 | $f_{high}$ = 2480.56630 |
| Operating Band occupancy | 79.20 |

| | |
|---|---|
| Operating Band occupancy percentage | 94.85 % |
| Operating channel occupancy percentage | 60.75 % |

Limit according to FCC Part 15C, Section 15.215(c):
If frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.Due to the channelising of the operating band into 39 channels with 20 dB channel bandwidth of 1.22 MHz within a channel pattern of 2 MHz the limit central 80% of the permitted band can not be applied. Therefore the stability of the EUT will be shown staying within the central 80% of the operating channel.

The requirements are **FULFILLED.**

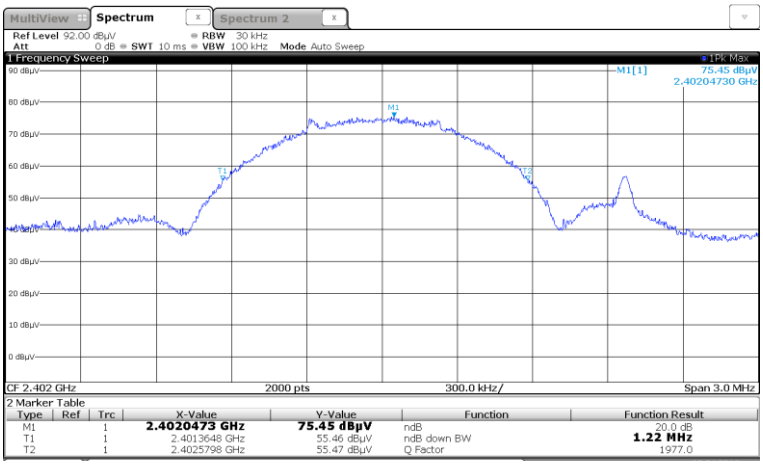
**Remarks:** For detailed test result please refer to following test protocols.

The OBW99 is measured for RSS only.

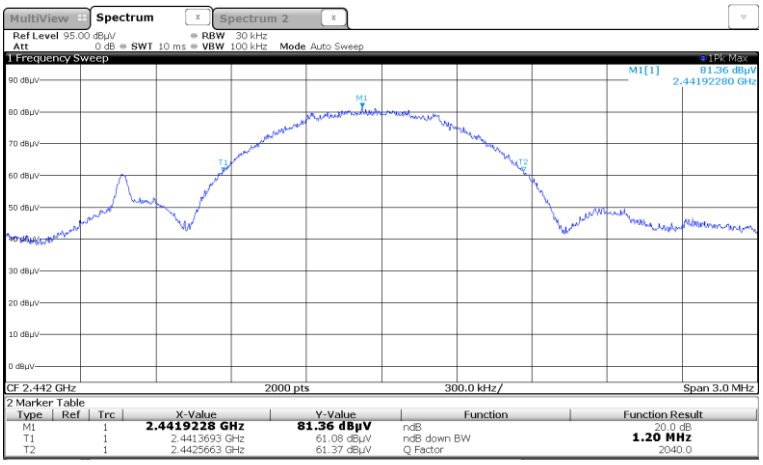
### 5.4.6 Test protocols

**EBW**

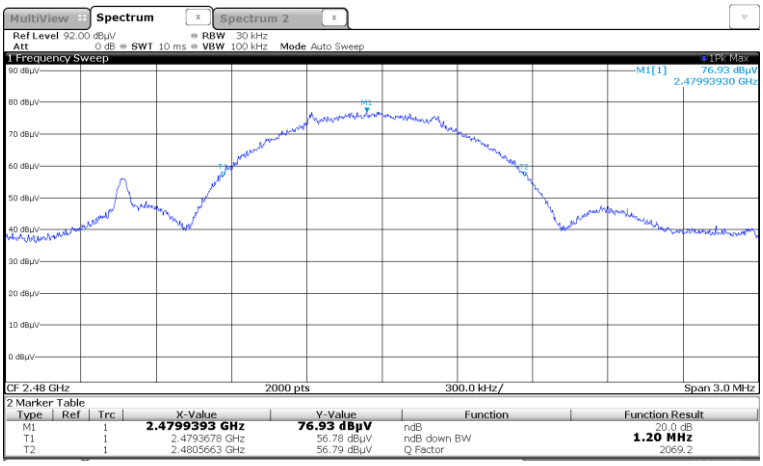
2402 MHz




2442 MHz

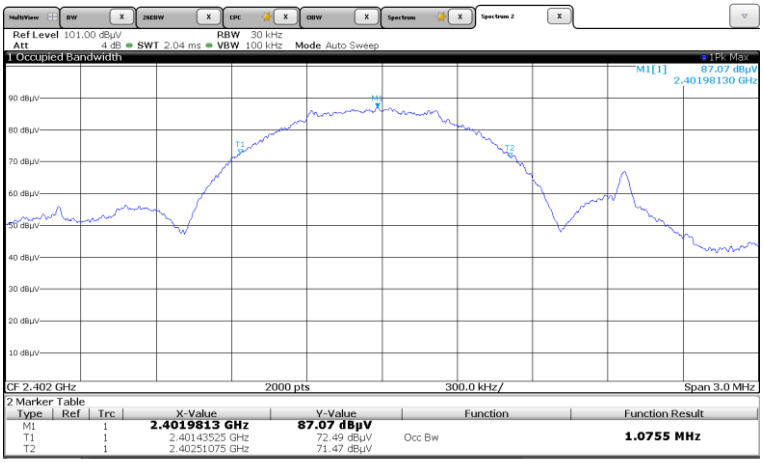



2480 MHz

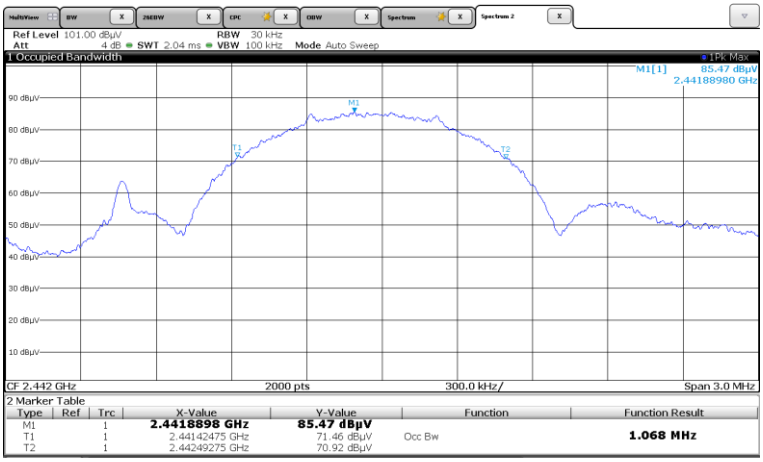


**OBW**

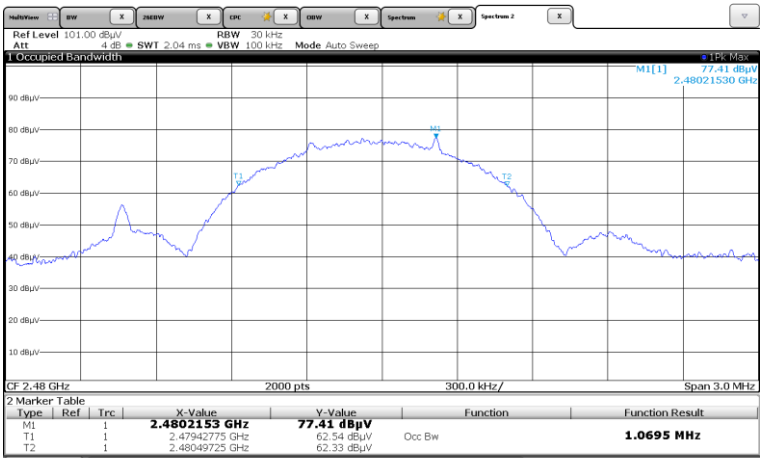
2402 MHz




2442 MHz




2480 MHz



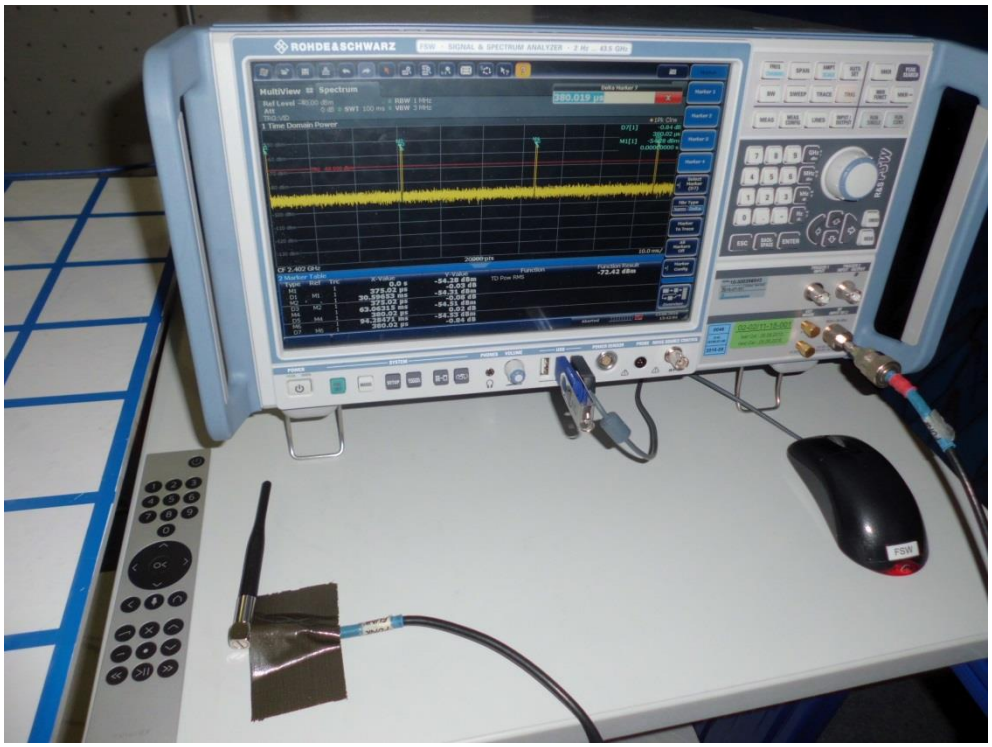
## 5.5 Correction for pulse operation (duty cycle)

For test instruments and accessories used see section 6 Part **DC**.

### 5.5.1 Description of the test location

Test location: Anechoic chamber 2

### 5.5.2 Photo documentation of the test set-up




### 5.5.3 Applicable standard

According to FCC Part 15A, Section 15.35(c):
When the radiated emission limits are expressed in terms of average value and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete puls train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the puls train exceeds 0.1s, the measured field strength shall be determined from the average absolute voltage during a 0.1s interval during which the field strength is at its maximum. The exact method of calculating the average field strength shall be submitted.

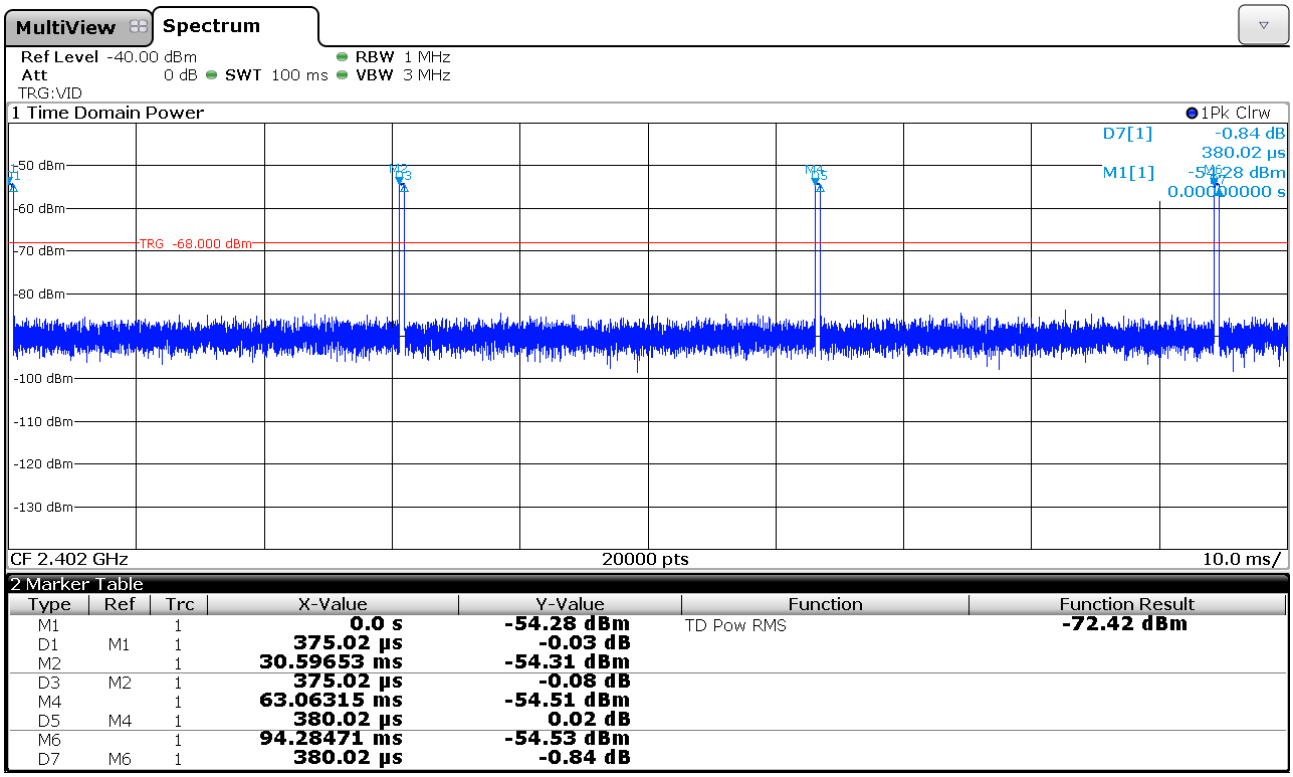
### 5.5.4 Description of Measurement

The duty cycle factor (dB) is calculated applying the following formula:

$$K_E = 20 \log (t_{iw}/0.1\ s)$$

$K_E$: pulse operation correction factor
$t_{iw}$ pulse duration for the complete pulse track

### 5.5.5 Test result




Note: The worst case regarding duty cycle of a BLE device is in advertising mode. Channel 37 was choosen for measurement.

Complete burst duration (4 bursts): 375.02 µs + 375.02 µs + 380.02 µs + 380.02 µs = 1510.08 µs

KE = 20 log (1510.08 µs */0.1 s*) = -36.4 dB

**Remarks:** _____

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## 5.6 Antenna application

### 5.6.1 Applicable standard

According to FCC Part 15C, Section 15.203(a):
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section.

### 5.6.2 Result

The EUT uses an integrated PCB antenna. No other antenna than the furnished by the responsible party or external power amplifier can be applied by a customer.

The antenna of the EUT meets the requirement of FCC Part 15C, Section 15.203 and 15.204.

The requirements are **FULFILLED.**

**Remarks:** _____

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# 6 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

| Test ID | Model Type | Equipment No. | Next Calib. | Last Calib. | Next Verif. | Last Verif. |
|---|---|---|---|---|---|---|
| CPR 3 | FSW43 | 02-02/11-15-001 | 05/08/2016 | 05/08/2015 | | |
| | AFS4-01000400-10-10P-4 | 02-02/17-13-002 | | | | |
| | BBHA 9120 E 251 | 02-02/24-05-006 | 19/04/2017 | 19/04/2016 | 19/10/2016 | 19/04/2016 |
| | Sucoflex N-2000-SMA | 02-02/50-05-075 | | | | |
| | SF104/11N/11N/1500MM | 02-02/50-13-015 | | | | |
| | SF104/11SMA/11N/1500MM | 02-02/50-13-016 | | | | |
| DC | FSW43 | 02-02/11-15-001 | 05/08/2016 | 05/08/2015 | | |
| | RF Antenna | 02-02/24-05-032 | | | | |
| MB | FSW43 | 02-02/11-15-001 | 05/08/2016 | 05/08/2015 | | |
| | AFS4-01000400-10-10P-4 | 02-02/17-13-002 | | | | |
| | BBHA 9120 E 251 | 02-02/24-05-006 | 19/04/2017 | 19/04/2016 | 19/10/2016 | 19/04/2016 |
| | Sucoflex N-2000-SMA | 02-02/50-05-075 | | | | |
| | SF104/11N/11N/1500MM | 02-02/50-13-015 | | | | |
| | SF104/11SMA/11N/1500MM | 02-02/50-13-016 | | | | |
| SER 2 | ESVS 30 | 02-02/03-05-003 | 09/07/2016 | 09/07/2015 | | |
| | VULB 9168 | 02-02/24-05-005 | 20/04/2017 | 20/04/2016 | 20/10/2016 | 20/04/2016 |
| | NW-2000-NB | 02-02/50-05-113 | | | | |
| | KK-EF393/U-16N-21N20 m | 02-02/50-12-018 | | | | |
| | KK-SD_7/8-2X21N-33,0M | 02-02/50-15-028 | | | | |
| SER 3 | FSW43 | 02-02/11-15-001 | 05/08/2016 | 05/08/2015 | | |
| | AFS5-12001800-18-10P-6 | 02-02/17-06-002 | | | | |
| | AFS4-01000400-10-10P-4 | 02-02/17-13-002 | | | | |
| | AMF-4F-04001200-15-10P | 02-02/17-13-003 | | | | |
| | BBHA 9120 E 251 | 02-02/24-05-006 | 19/04/2017 | 19/04/2016 | 19/10/2016 | 19/04/2016 |
| | WBH2-18NHG | 02-02/24-08-002 | 19/04/2017 | 19/04/2016 | 19/10/2016 | 19/04/2016 |
| | Sucoflex N-2000-SMA | 02-02/50-05-075 | | | | |
| | SF104/11N/11N/1500MM | 02-02/50-13-015 | | | | |
| | SF104/11SMA/11N/1500MM | 02-02/50-13-016 | | | | |
| | SF104/11SMA/11N/1500MM | 02-02/50-13-017 | | | | |