# RF – TEST REPORT

**- FCC Part 15.247, RSS-247 -**

| | | |
|---|---|---|
| **Type / Model Name** | : | CUA-V200-CE8BD91-K78-J1 |
| **Product Description** | : | OBD Adapter with BLE module |
| **Applicant** | : | Carly Solutions GmbH & Co. KG |
| Address | : | Kolpingring 8 |
| | | 82041 OBERHACHING, GERMANY |
| **Manufacturer** | : | Carly Solutions GmbH & Co. KG |
| Address | : | Kolpingring 8 |
| | | 82041 OBERHACHING, GERMANY |

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

| | |
|---|---|
| **Test Report No. : 80080584-02 Rev_1** | 13. September 2021<br>Date of issue |

Deutsche Akkreditierungsstelle
D-PL-12030-01-03
D-PL-12030-01-04

# Contents



ATTACHMENT A as separate supplement

# 1 TEST STANDARDS

The tests were performed according to following standards:

**FCC Rules and Regulations Part 15, Subpart A - General (September 2020)**

| | |
|---|---|
| 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 2020)**

| | |
|---|---|
| Part 15, Subpart C, Section 15.203 | Antenna requirement |
| Part 15, Subpart C, Section 15.204 modifications | External radio frequency power amplifiers and antenna |
| 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 15.247 | Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz |
| ANSI C63.10: 2013 | Testing Unlicensed Wireless Devices |
| ETSI TR 100 028 V1.3.1: 2001-03, | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2 |
| KDB 558074 D01 v05r02 | Guidance for compliance measurements on DTS; FHSS and hybrid system devices operating under Section 15.247 of the FCC rules, April 2, 2019. |

**ISED Canada Rules and Regulations (May 2021)**

| | |
|---|---|
| RSS-Gen, Issue 5 + Amendment 1 + 2 | General Requirements for Compliance of Radio Apparatus |
| RSS-247, Issue 2 | Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices |
| ANSI C63.10: 2013 | Testing Unlicensed Wireless Devices |
| ETSI TR 100 028 V1.3.1: 2001-03, | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2 |

# 2 EQUIPMENT UNDER TEST

## 2.1 Information provided by the Client

Please note, we do not take any responsibility for information provided by the client or his representative which may have an influence on the validity of the test results.

## 2.2 Sampling

The customer is responsible for the choice of sample. Sample configuration, start-up and operation is carried out by the customer or according his/her instructions.

## 2.3 General remarks

None

## 2.4 Photo documentation of the EUT – Detailed photos see ATTACHMENT A

## 2.5 Equipment type

BLE device

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

The EUT is an OBD Adapter that can be plugged into the OBD port of an OBD ready vehicle. The EUT is sold and used with a smartphone app, that can be installed via the Apple App Store or the Google Play Store on the mobile device of the user. The EUT allows the user after connection to analyse his vehicle and communicates with the mobile device running the app via Bluetooth LE. It is equipped with a BT module CC2541 from Texas Instruments. A single PCB antenna is used within the system. The EUT has only one integrated antenna, no temporary connector and no external antenna can be connected.

| | | | |
|---|---|---|---|
| Number of tested samples | : | 1 radiated sample | 1 conducted sample |
| Serial number | : | 9978006544 | 9978006534 |
| Firmware number CC2541 | : | CarlyBLE 1.003.0012 | CarlyBLE 1.003.0012 |
| Firmware number STM32L4 | : | Bootloader: 2.000.0005<br>Main: 1.158.0150 | Bootloader: 2.000.0005<br>Main: 1.158.0150 |
| Type | : | CUA-V200-CE8BD91-K78-J1 | CUA-V200-CE8BD91-K78-J1 |

| Items | Description |
|---|---|
| BT type | 5.0 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 |

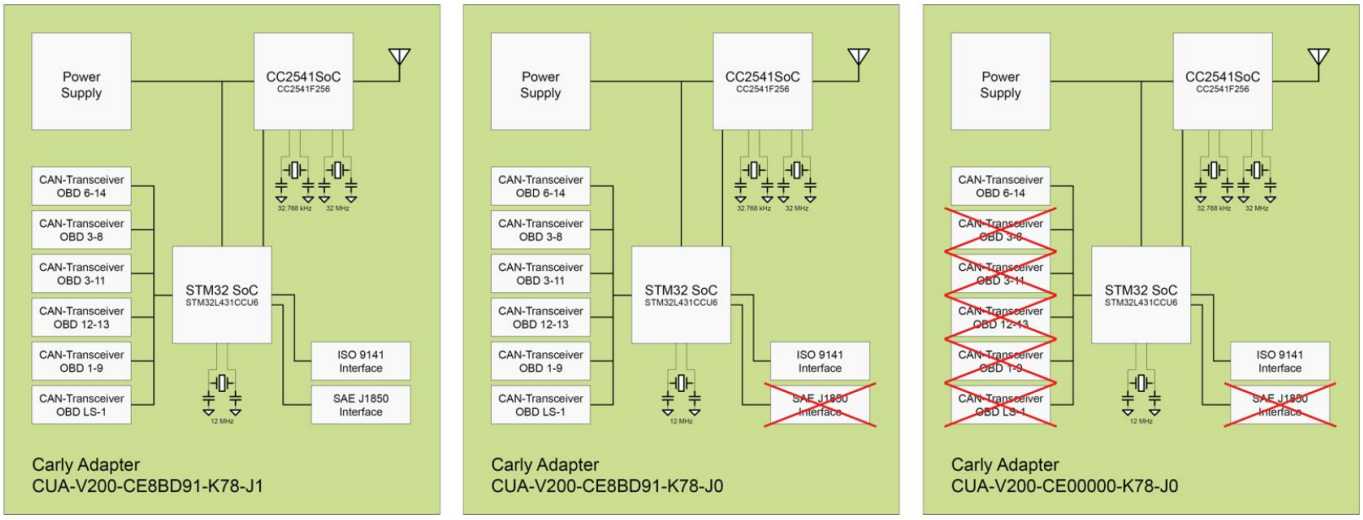
## 2.7 Variants of the EUT

The Carly Adapter CUA-V200 is currently produced and sold in three variants with the type names:

CUA-V200-CE8BD91-K78-J1
CUA-V200-CE8BD91-K78-J0
CUA-V200-CE00000-K78-J0

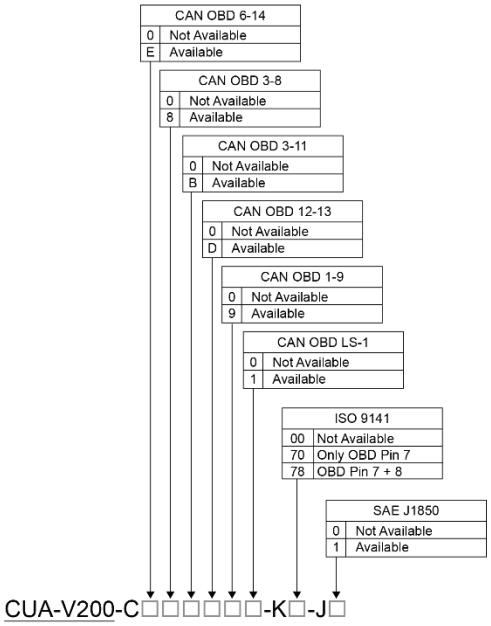
The CUA-V200-CE8BD91-K78-J1 is the fully equipped variant with 6 CAN transceivers and discrete ISO 9141 and SAE J1850 interface.
The CUA-V200-CE8BD91-K78-J0 contains all options like the fully equipped variant, except the SAE J1850 interface.
The CUA-V200-CE00000-K78-J0 only has one CAN transceiver (OBD 6-14) and the ISO 9141 interface components populated on the PCB.

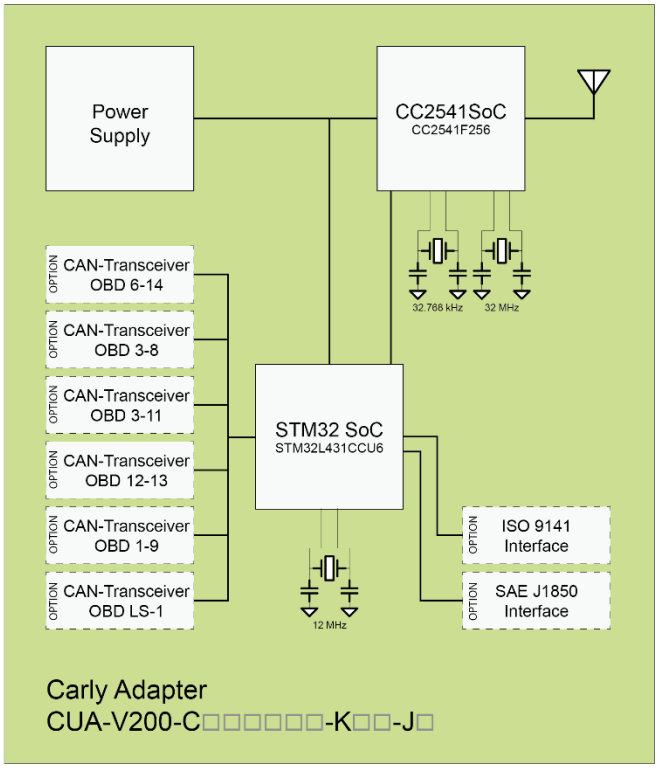
Please see the following block diagram showing all three variants.




**All measurements were done with the fully equipped CUA-V200-CE8BD91-K78-J1.**

The Carly Adapter CUA-V200 is designed, so that it can be produced in different variants. The variants have different type names, that exactly identify the respective variant. According to the customer all variants are built on same PCB and contain the same microcontrollers, power supply components, oscillators and RF components. The only difference in these variants is the population of components related to the wired car communication bus. The definition of variants follows a strict type code pattern, that defines the type name of the variant:




## 2.8 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

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

Note: the marked frequencies are determined for final testing.

## 2.9 Transmit operating modes

The EUT allows the user to select the following modes:
- TX continuous modulated
- TX continuous unmodulated
- RX

## 2.10 Antenna

The following antennas shall be used with the EUT:

| Number | Characteristic | Model number | Plug | Frequency range (GHz) | Gain (dBi) |
|---|---|---|---|---|---|
| 1 | Omni | Unictron Technologies Corporation H2UB4K1H1B0100 | - | 2.4-2.5 | -0.3 |

The EUT has only an integrated PCB antenna, no temporary connector and no external antenna to be connected.

## 2.11 Power supply system utilised

Power supply voltage, $V_{nom}$ : 12 V/DC

## 2.12 Peripheral devices and interface cables

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

- OBD 2 cable Model : Autool
- - Model : -

## 2.13 Determination of worst-case conditions for final measurement

Measurements are made in all three orthogonal axes and the settings of the EUT are changed to locate at which position and at what setting of the EUT produce the maximum of the emissions.

The tests are carried out in the following frequency band:

**2400 MHz – 2483.5 MHz**

**For the final test the following channels and test modes are selected:**

| BLE | Available channel | Tested channels | Power setting | Modulation | Modulation type | Data rate |
|---|---|---|---|---|---|---|
| 802.15.1 | 0 - 39 | 37, 17, 39 | P0 | DSSS | GFSK | 1.0 Mbps |

- TX continuous mode

### 2.13.1 Test jig

No test jig is used.

### 2.13.2 Test software

The EUT supports the Direct Test Mode that allows enabling a continuous transmission modulated, unmodulated and receiving mode. It can be set by SMARTRF STUDIO 2.21.0. The output power is set to P0 by firmware and cannot be changed.
For setting the test modes the EUT is connected to a notebook via a CC debugger from Texas instruments and a programmer board (Carly Universal Adapter V2) provided by the customer.

# 3 TEST RESULT SUMMARY

BLE device using digital modulation and operates in the 2400 MHz – 2483.5 MHz band:

| FCC Rule Part | RSS Rule Part | Description | Result |
|---|---|---|---|
| 15.207(a) | RSS-Gen, 8.8 | AC power line conducted emissions | not applicable |
| 15.247(a)(2) | RSS-247, 5.2(a) | -6 dB EBW | passed |
| 15.247(b)(3) | RSS-247, 5.4(d) | Maximum peak conducted output power | passed |
| 15.247(b)(4) | RSS-247, 5.4(d) | Defacto limit | passed |
| 15.247(d) | RSS-247, 5.5 | Unwanted emission, radiated | passed |
| 15.247(d) | RSS-Gen, 8.10 | Emissions in restricted bands | passed |
| 15.247(e) | RSS-247, 5.2(b) | PSD | passed |
| 15.35(c) | RSS-Gen, 6.10 | Pulsed operation | passed |
| 15.203 | RSS-Gen, 6.8 | Antenna requirement | passed |
| - | RSS-Gen, 6.11 | Transmitter frequency stability | passed |
| - | RSS-Gen, 6.7 | 99 % Bandwidth | passed |

15.207(a) Not applicable, the EUT can not be connected to the public utility (AC) power line.

The mentioned RSS Rule Parts in the above table are related to:
RSS-Gen, Issue 5 + Amendment 1 + Amendment 2, February 2021
RSS-247, Issue 2, February 2017

## 3.1 Final assessment

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

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

Testing commenced on : 07 June 2021

Testing concluded on : 25 June 2021

Checked by:

Jürgen Pessinger i. A. 2021.09.13 09:26:18 +02'00'

Klaus Gegenfurtner
Teamleader Radio

Tested by:

Sabine Kugler 2021.09.13 09:12:19 +02'00'

Sabine Kugler
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 / 2011 + A1 / 2014 „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 Type | Range | Confidence Level (%) | Calculated Uncertainty |
|---|---|---|---|
| AC Conducted Spurious Emissions | 0.15 MHz to 30 MHz | 95% | ± 3.29 dB |
| 20 dB Bandwidth | Center frequency of EUT | 95% | $\pm 2.5 \times 10^{-7}$ |
| 99% Occupied Bandwidth | Center frequency of EUT | 95% | $\pm 2.5 \times 10^{-7}$ |
| Radiated Spurious Emissions | 9 kHz to 30 MHz | 95% | ± 3.53 dB |
| Radiated Spurious Emissions | 30 MHz to 1000 MHz | 95% | ± 3.71 dB |
| Radiated Spurious Emissions | 1000 MHz to 10000 MHz | 95% | ± 2.34 dB |
| Peak conducted output power | 902 MHz to 928 MHz | 95% | ± 0.35 dB |
| Conducted Spurious Emissions | 9 kHz to 10000 MHz | 95% | ± 2.15 dB |

## 4.4 Conformity Decision Rule

The conformity decision rule is based on the ILAC G8 published at the time of reporting.

## 4.5 Measurement protocol for FCC and ISED

### 4.5.1 General information

CSA Group Bayern GmbH is recognized as wireless testing laboratory under the CAB identifier:

**FCC: DE 0011**
**ISED: DE0009**

### 4.5.2 General Standard information

The test methods used comply with ANSI C63.10 - "Testing Unlicensed Wireless Devices".

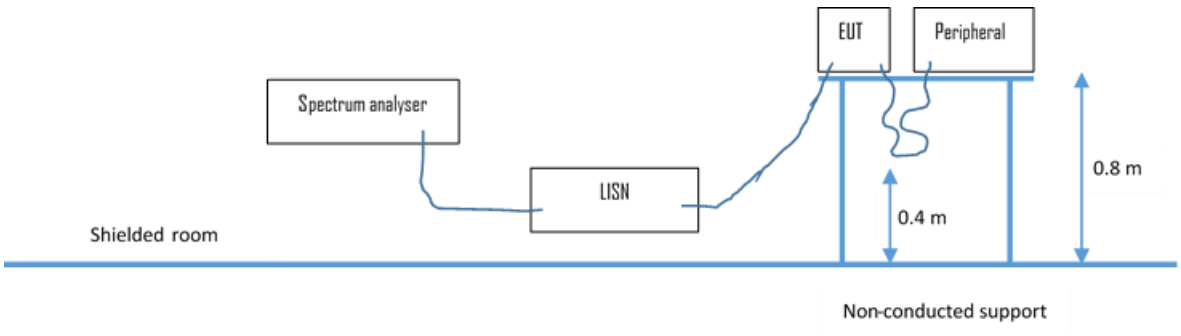
#### 4.5.2.1 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions.

### 4.5.3 Details of test procedures

#### 4.5.3.1 Conducted emission

Test setup according ANSI C63.10




The final level, expressed in dBμV, is arrived at by taking the reading directly from the Spectrum analyser. This level is compared to the limit.

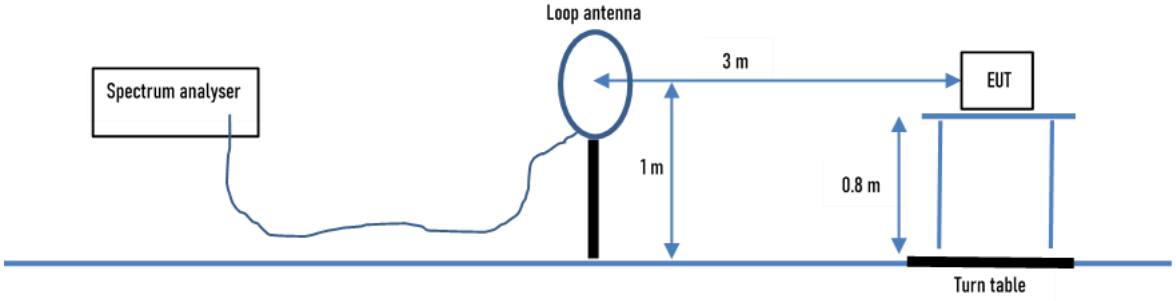
To convert between dBμV and μV, the following conversions apply:

dBμV = 20(log μV)
μV = Inverse log(dBμV/20)

Conducted emissions on the 50 Hz and/or 60 Hz power interface of the EUT are measured in the frequency range of 150 kHz to 30 MHz. The measurements are performed using a receiver, which has CISPR characteristic bandwidth and quasi-peak detection and a Line Impedance Stabilization Network (LISN) with 50 Ω / 50 μH (CISPR 16) characteristics. The receiver is protected by means of an impedance matched pulse limiter connected directly to the RF input. Table top equipment is placed on a non-conducting table 80 centimetres above the floor and is positioned 40 centimetres from the vertical ground plane (wall) of the screen room. If the minimum limit margin appears to be less than 20 dB with a peak mode measurement, the emission is re-measured using a tuned receiver with quasi-peak and average detection and recorded on the data sheets.

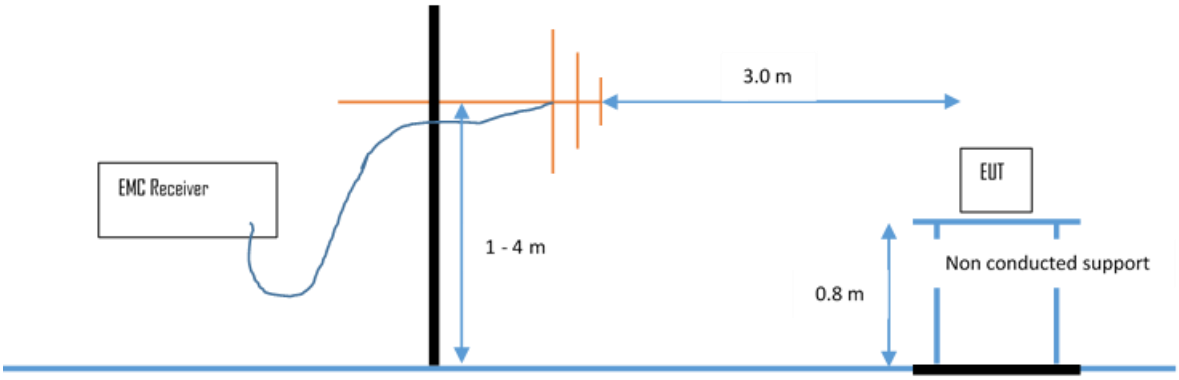
## 4.5.3.2 Radiated emission

**4.5.3.2.1 OATS1 test site (9 kHz - 30 MHz):**
Test setup according ANSI C63.10




Emissions from the EUT are measured in the frequency range of 9 MHz to 30 MHz using a tuned receiver and a calibrated loop antenna. Table top equipment is placed on a 1.0 X 1.5 m non-conducting table 80 centimetres above the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. The antenna is positioned 3, 10 or 30 metres horizontally from the EUT and is repeated vertically. To locate maximum emissions from the test sample the antenna is varied along the site axis and the EUT is rotated 360 degrees.

**4.5.3.2.2 OATS1 test site (30 MHz - 1 GHz):**
Test setup according ANSI C63.10.




Spurious emissions from the EUT are measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarised antennas. Measurements between 30 MHz and 1000 MHz are made with 120 kHz/6 dB bandwidth and quasi-peak detection. Table top equipment is placed on a 1.0 X 1.5 m non-conducting table 80 centimetres above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. To locate maximum emissions from the test sample the antenna is varied in height from 1 to 4 metres and the EUT is rotated 360 degrees. The final level in dBµV/m is calculated by taking the reading from the EMI receiver (Level dBµV) and adding the correction factors and cable loss factor (dB). The FCC limit is subtracted from this result in order to provide the limit margin listed in the measurement protocol.

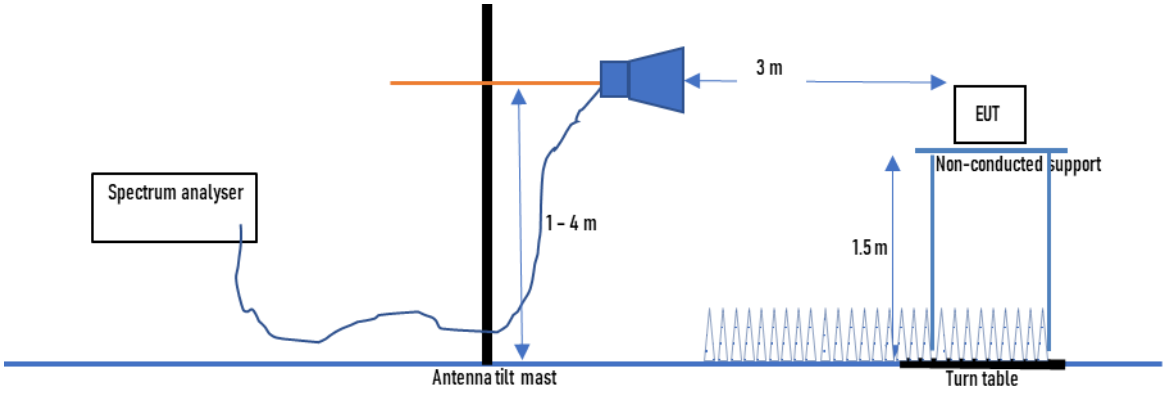
The resolution bandwidth setting:
30 MHz – 1000 MHz: RBW: 120 kHz

Example:

| Frequency (MHz) | Level (dBµV) | + | Factor (dB) | = | Level (dBµV/m) | - | Limit (dBµV/m) | = | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 719.0 | 75.0 | + | 32.6 | = | 107.6 | - | 110.0 | = | -2.4 |

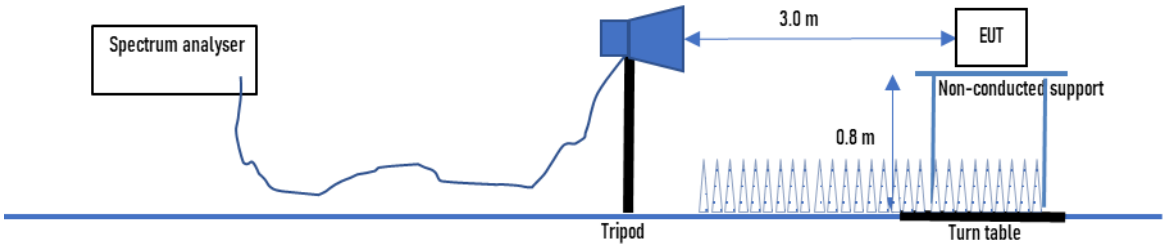
#### 4.5.3.2.3 Anechoic chamber 1 (1000 MHz – 18000 MHz)

Test setup according ANSI C63.10.




Radiated emissions from the EUT are measured in the frequency range 1 GHz up to 18 GHz as specified in 47 CFR Part 15, Subpart A, Section 15.33, using a spectrum analyser and appropriate linearly polarized antennas. Table top equipment is placed on a non-conducting table, 1.5 metre above the ground plane. The turntable is fully covered with the appropriate absorber (Type VHP-12). Any controlling device is positioned such that it does not significantly influence the measurement results. Interconnecting cables that hang closer than 40 cm to the ground plane are folded back and forth in the centre, forming a bundle 30 cm to 40 cm long. Measurements are made in in three orientations of the EUT and the horizontal and vertical polarization planes of measurement antenna in a fully anechoic room. The measurement antenna is adjusted and the EUT orientated to permit the measurement of the maximum emission from the EUT. The conditions determined as worst-case will then be used for the final measurements.

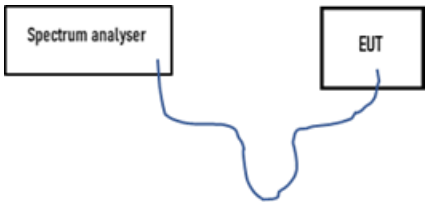
#### 4.5.3.2.4 Anechoic chamber 1 (18 GHz – 40 GHz)




Emissions from the EUT are measured in the frequency range 18 GHz up to 40 GHz as specified in 47 CFR Part 15, Subpart A, Section 15.33, using a spectrum analyser and appropriate linearly polarized antennas. Table top equipment is placed on a non-conducting table, 0.8 metre above the ground plane. The turntable is fully covered with the appropriate absorber (Type VHP-12). Any controlling device is positioned such that it does not significantly influence the measurement results. Interconnecting cables that hang closer than 40 cm to the ground plane are folded back and forth in the centre, forming a bundle 30 cm to 40 cm long. Measurements are made in in three orientations of the EUT and the horizontal and vertical polarization planes of measurement antenna in a fully anechoic room. The measurement antenna is adjusted and the EUT orientated to permit the measurement of the maximum emission from the EUT. The conditions determined as worst-case will then be used for the final measurements. Where appropriate, the test distance may be reduced in order to detect emissions under better uncertainty. The limit is adopted.

### 4.5.3.3 Conducted RF Measurement

Test setup according ANSI C63.10




A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT is operating in transmit mode using the assigned frequency according to ANSI C63.10. The correction factor takes the cable loss into account.

# 5 TEST CONDITIONS AND RESULTS

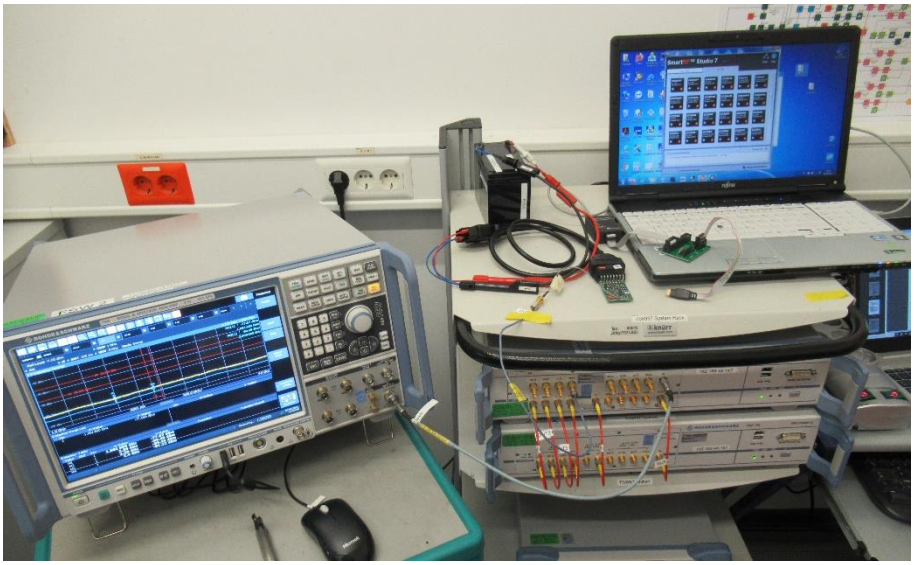
## 5.1 EBW and OBW

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

### 5.1.1 Description of the test location

Test location: Shielded Room S6

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



### 5.1.3 Applicable standard

According to FCC Part 15, Section 15.247(a)(2):
Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

### 5.1.4 Description of Measurement

The bandwidth was measured at an amplitude level reduced from the reference level of a modulated channel by a ratio of -6 dB. The reference level is the level of the highest signal amplitude observed at the transmitter at either the fundamental frequency or the first order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical. An alternative is to use the bandwidth measurement of the analyser.

Spectrum analyser settings for EBW:
RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Sweep time: 5 s, Span: 2 EBW;
Spectrum analyser settings for OBW:
RBW: 1-5% OBW, VBW: 3 RBW, Detector: Max peak, Sweep time: 5 s, Span: 2 OBW;

### 5.1.5 Test result

6dB bandwidth

| Channel | Centre frequency (MHz) | 6 dB bandwidth (kHz) | Minimum limit (kHz) |
|---|---|---|---|
| 37 | 2402 | 792.08 | 500 |
| 17 | 2440 | 772.28 | 500 |
| 39 | 2480 | 792.08 | 500 |

99% bandwidth

| Channel | Centre frequency (MHz) | 99 % bandwidth (kHz) |
|---|---|---|
| 37 | 2402 | 1055 |
| 17 | 2440 | 1055 |
| 39 | 2480 | 1060 |

Limit according to FCC Part 15, Section 15.247(a)(2):
Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

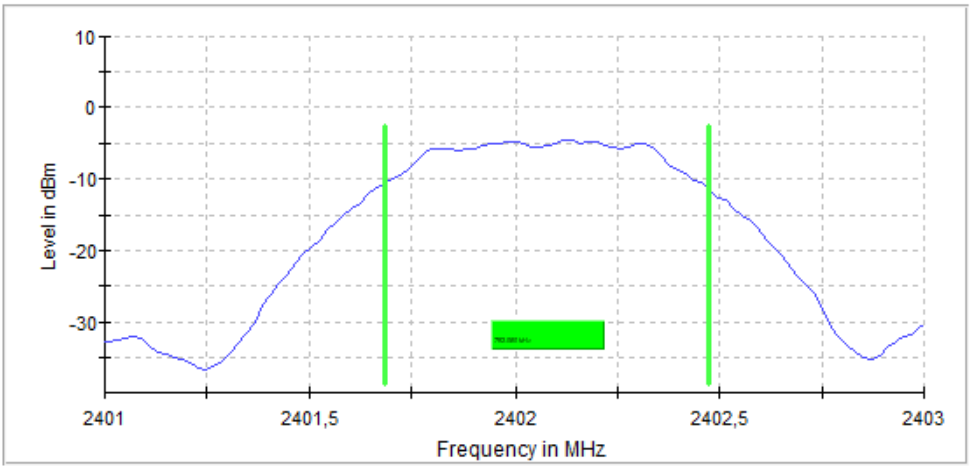
The requirements are **FULFILLED.**

**Remarks:** For detailed test result please see the following test protocols

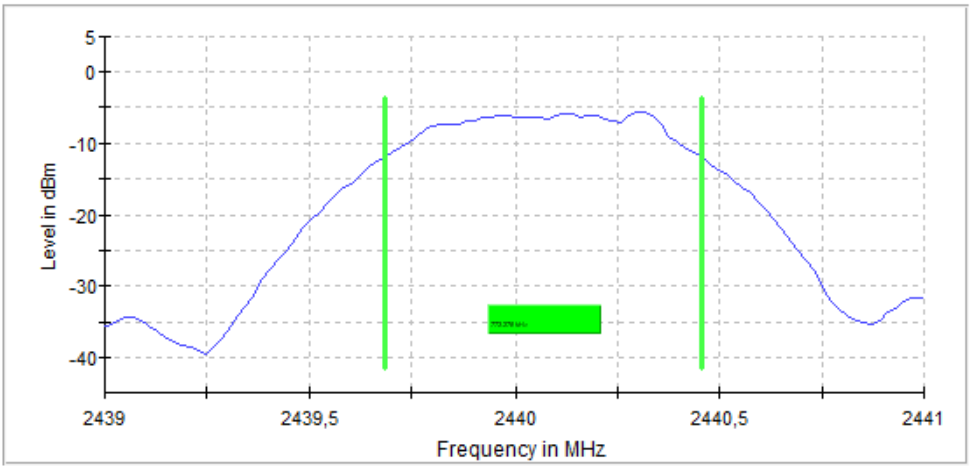
OBW99 is measured for RSS only.

### 5.1.6 Test protocols EBW

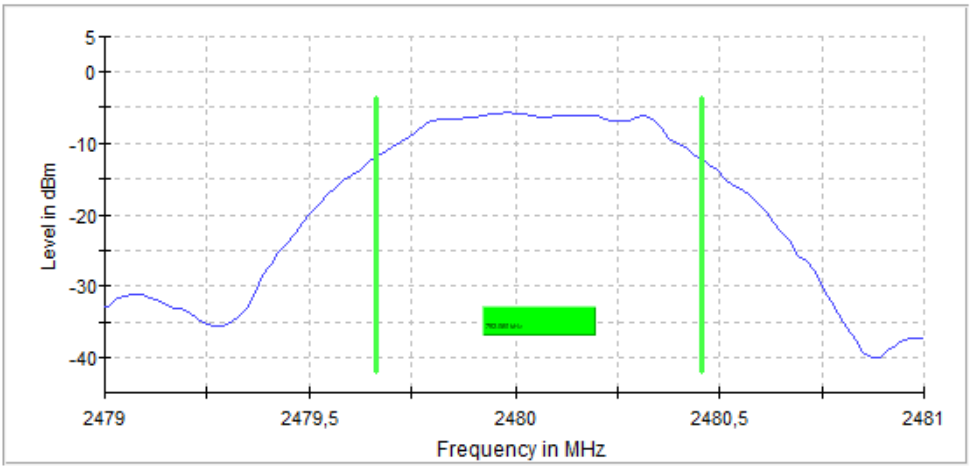
Channel 37 (2402 MHz)



Channel 17 (2440 MHz)

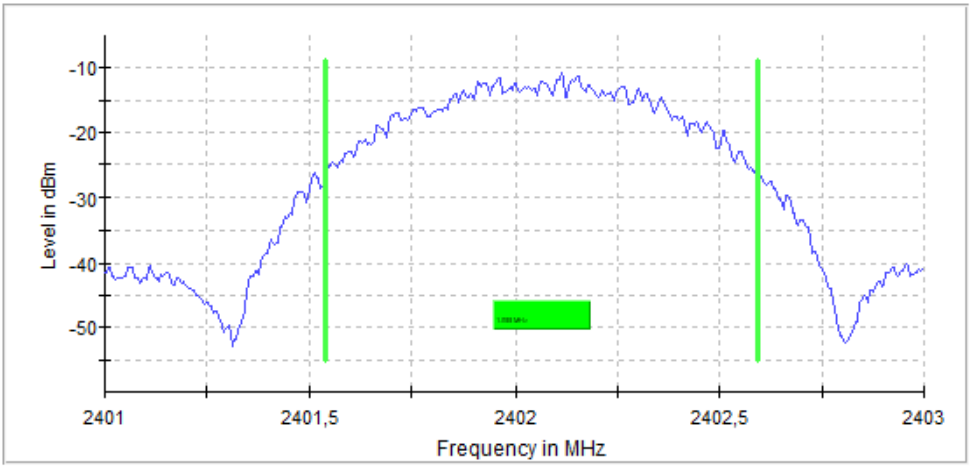



Channel 39 (2480 MHz)

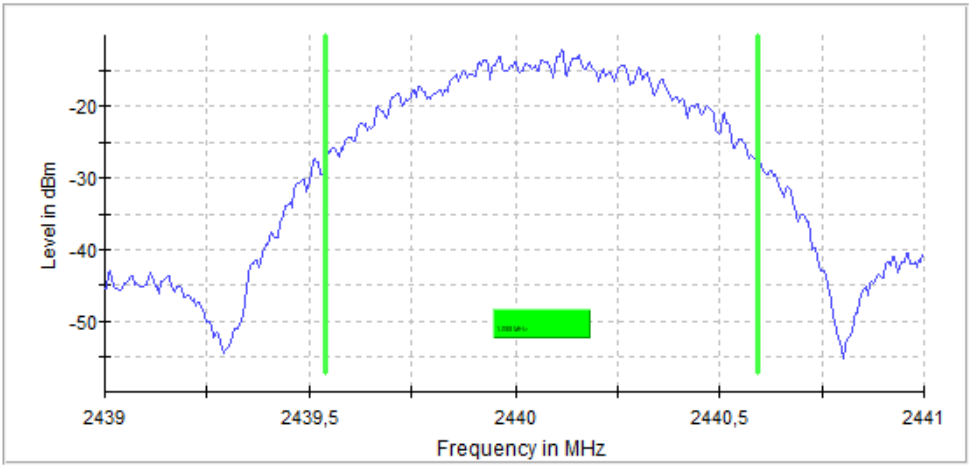



### 5.1.7 Test protocols OBW

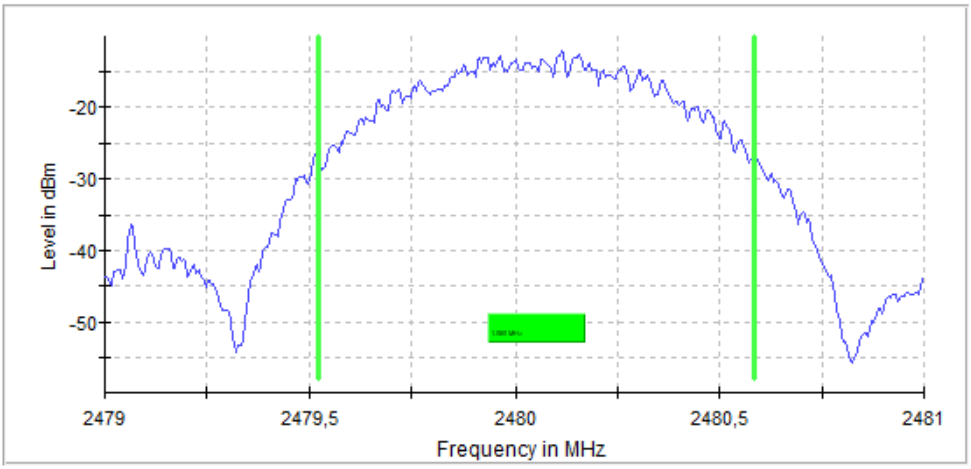
Channel 37 (2402 MHz)



Channel 17 (2440 MHz)




Channel 39 (2480 MHz)



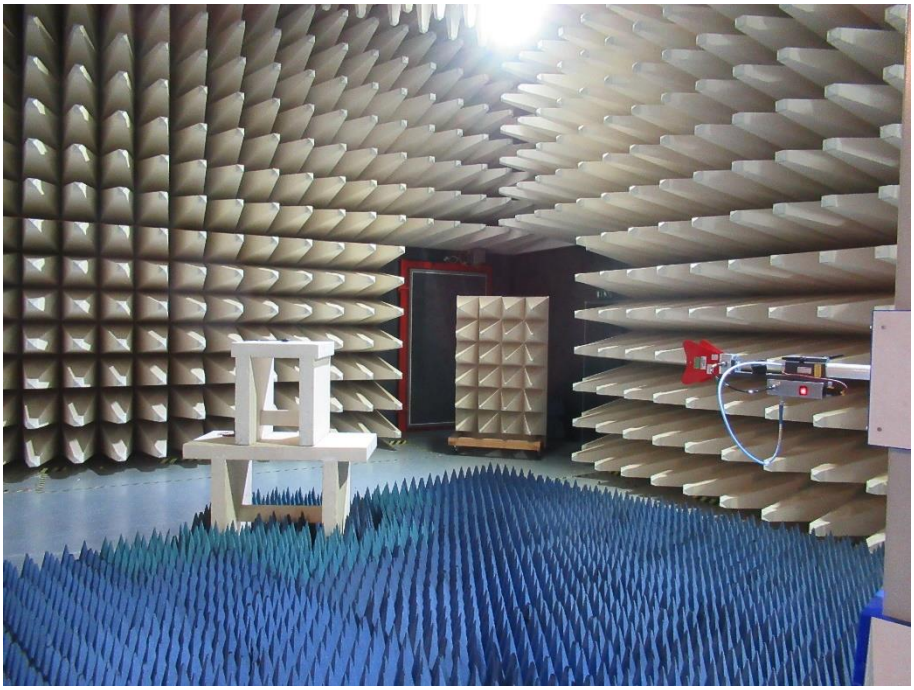
## 5.2 Maximum peak radiated output power

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

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



### 5.2.3 Applicable standard

According to FCC Part 15, Section 15.247(b)(3):
The maximum peak conducted output power of the intentional radiator shall not exceed the following:
For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

### 5.2.4 Description of Measurement

The maximum peak radiated output power is measured using a spectrum analyser following the procedure set out in ANSI C63.10, item 11.9.2.2. The EUT is set in TX continuous mode while measuring. The radiated measurement was performed in terms of fieldstrength. Therefore, the formula set out in ANSI C63.10, item 9.5 (Equation 22) is changed into the following term:

$$E = EIRP - (20*\log_{10}(3)) + 104.7$$

### 5.2.5 Test result

Measured peak EIRP output power:

| Test results radiated | | | | | |
|---|---|---|---|---|---|
| | | Fieldstrength E (dBµV/m) | EIRP (dBm) | EIRP Limit (dBm) | Margin (dB) |
| Lowest frequency: CH37 | | | | | |
| $T_{nom}$ | *P0* | 88.2 | -7.0 | 36.0 | -43.0 |
| Middle frequency: CH17 | | | | | |
| $T_{nom}$ | *P0* | 92.0 | -3.3 | 36.0 | -39.3 |
| Highest frequency: CH39 | | | | | |
| $T_{nom}$ | *P0* | 92.8 | -2.5 | 36.0 | -38.5 |

Measured peak conducted output power:

| Test results conducted | | | | | | |
|---|---|---|---|---|---|---|
| | | P (dBm) | G (dBi) | A (dBm) | Limit (dBm) | Margin (dB) |
| Lowest frequency: CH37 | | | | | | |
| $T_{nom}$ | *P0* | -3.2 | -0.3 | -2.9 | 30.0 | -32.9 |
| Middle frequency: CH17 | | | | | | |
| $T_{nom}$ | *P0* | -4.7 | -0.3 | -4.4 | 30.0 | -34.4 |
| Highest frequency: CH39 | | | | | | |
| $T_{nom}$ | *P0* | -4.4 | -0.3 | -4.1 | 30.0 | -34.1 |

Cable loss of 0.6 dB of the measurement system is considered in peak conducted output power A.

Peak Power Limit according to FCC Part 15, Section 15.247(b)(3):

| Frequency (MHz) | Peak Power Limit | |
|---|---|---|
| | (dBm) | (W) |
| 902-928 | 30 | 1.0 |
| **2400-2483.5** | **30** | **1.0** |
| 5725-5850 | 30 | 1.0 |

| Frequency (MHz) | EIRP Limit | |
|---|---|---|
| | (dBm) | (W) |
| 902-928 | 36 | 4.0 |
| **2400-2483.5** | **36** | **4.0** |
| 5725-5850 | 36 | 4.0 |

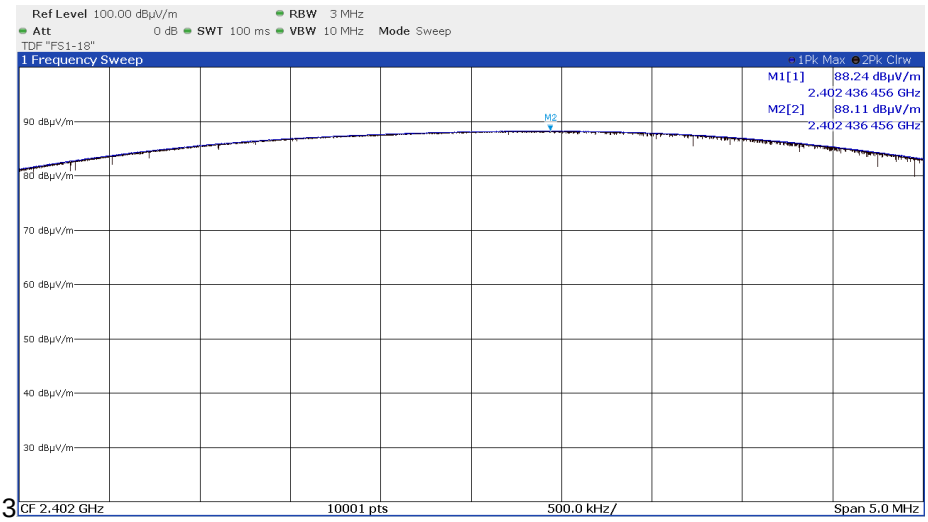
The requirements are **FULFILLED.**

**Remarks:** For detailed test result please see the following test protocols

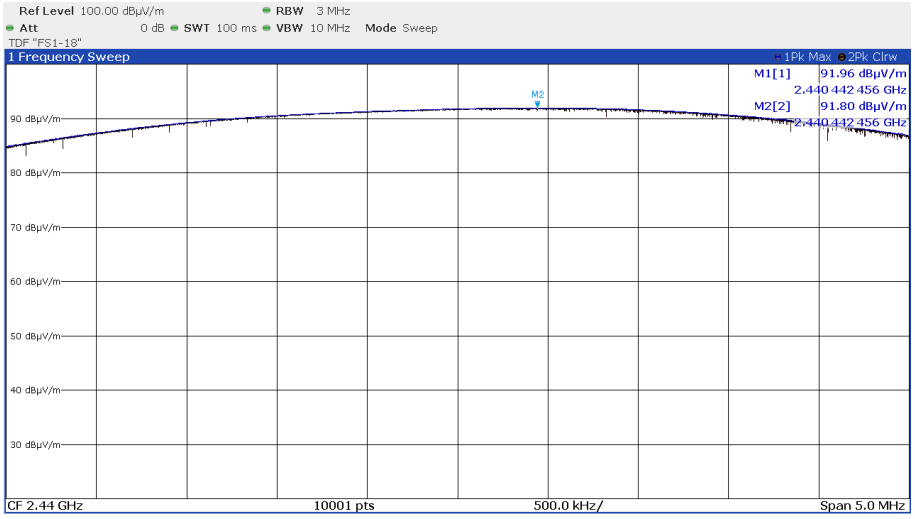
### 5.2.6 Test protocols

Radiated measurements:

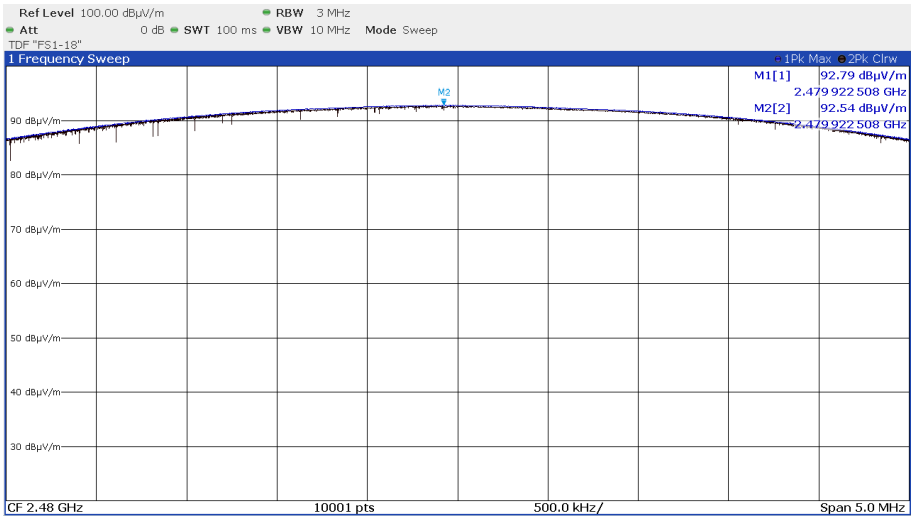
Channel 37 (2402 MHz)




Channel 17 (2440 MHz)

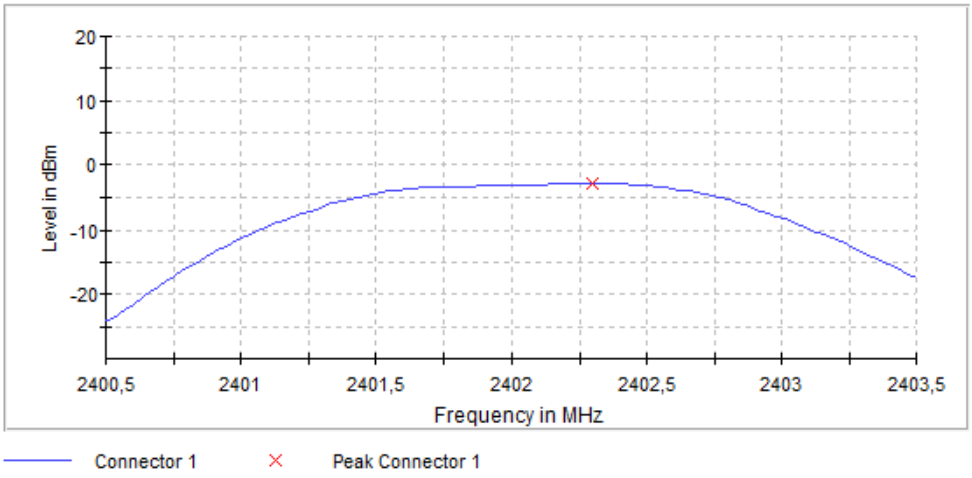


Channel 39 (2480 MHz)

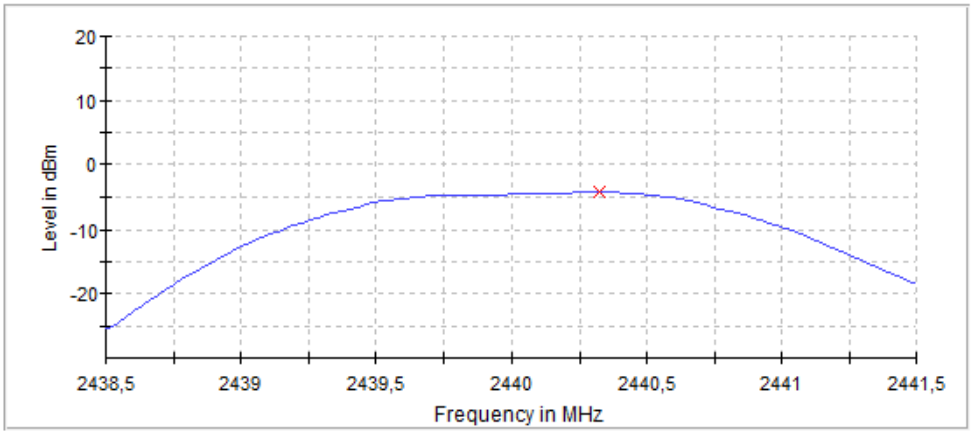



Conducted measurements:

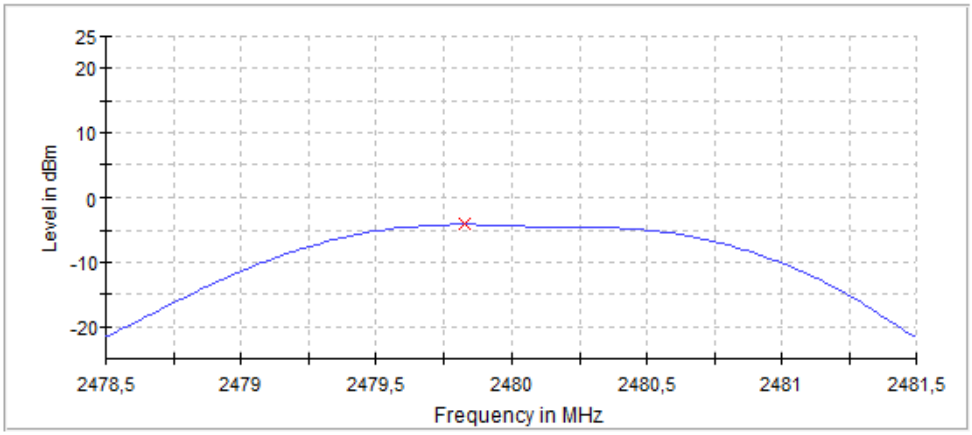
Channel 37 (2402 MHz)



Channel 17 (2440 MHz)




Channel 39 (2480 MHz)



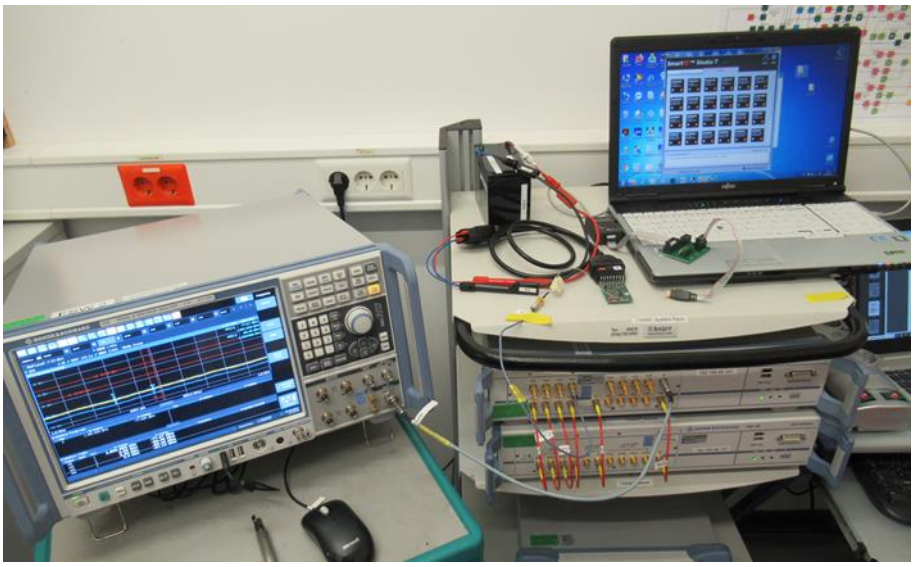
## 5.3 Power spectral density

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

### 5.3.1 Description of the test location

Test location: Shielded Room S6

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



### 5.3.3 Applicable standard

According to FCC Part 15, Section 15.247(e):
For digitally modulated systems, the power spectral density radiated from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the radiated output power shall be used to determine the power spectral density.

### 5.3.4 Description of Measurement

The measurement is performed using the procedure set out in 11.10 of ANSI C63.10. The power measurement was done as peak power measurement. Therefore, the PKPSD is measured. The max peak was located and with the spectrum analyser and a marker set to peak.

Spectrum analyser settings:
RBW: 3 kHz, VBW: 10 kHz, Detector: Peak, Sweep time: Auto

### 5.3.5 Test result

| DUT Frequency (MHz) | Frequency (MHz) | PSD (dBm) | Limit Max (dBm) | Result |
|---|---|---|---|---|
| 2402.000000 | 2402.112500 | -10.775 | 8.0 | PASS |
| 2440.000000 | 2440.112500 | -12.163 | 8.0 | PASS |
| 2480.000000 | 2480.112500 | -11.949 | 8.0 | PASS |

Power spectral density limit according to FCC Part 15, Section 15.247(e):

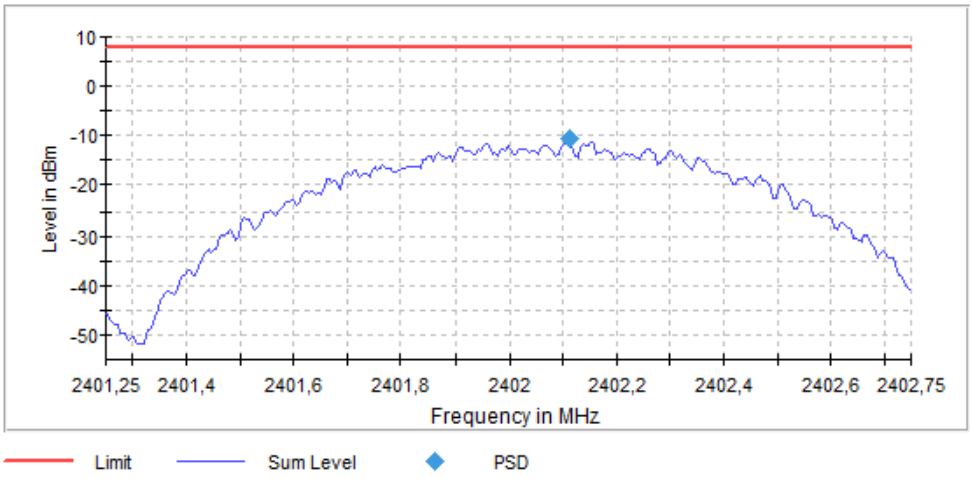
| Frequency (MHz) | Power spectral density limit (EIRP) (dBm/3 kHz) |
|---|---|
| 2400 - 2483.5 | 14 |

The requirements are **FULFILLED.**

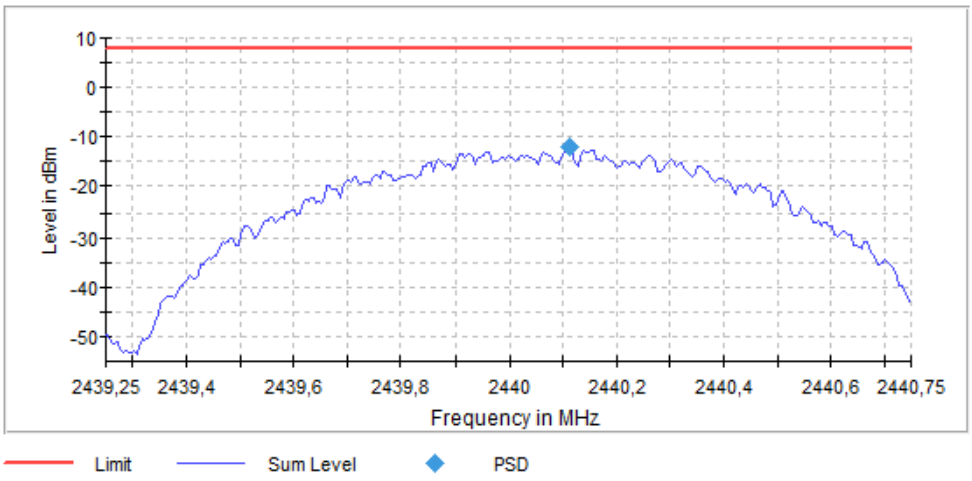
**Remarks:** For detailed test result please see the following test protocols

### 5.3.6 Test protocols

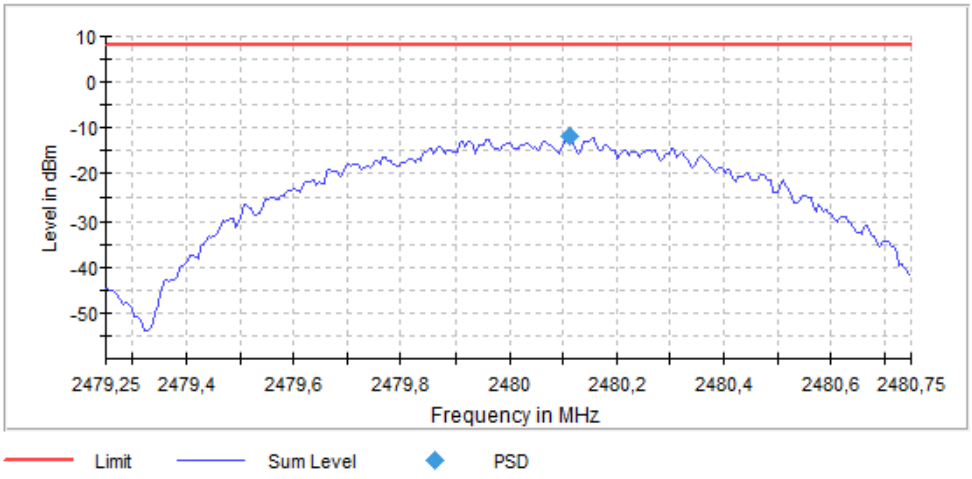
Channel 37 (2402 MHz)




Channel 17 (2440 MHz)




Channel 39 (2480 MHz)



## 5.4 Radiated emissions in restricted bands

For test instruments and accessories used see section 6 Part **SER 1, SER 2, SER 3**.

### 5.4.1 Description of the test location

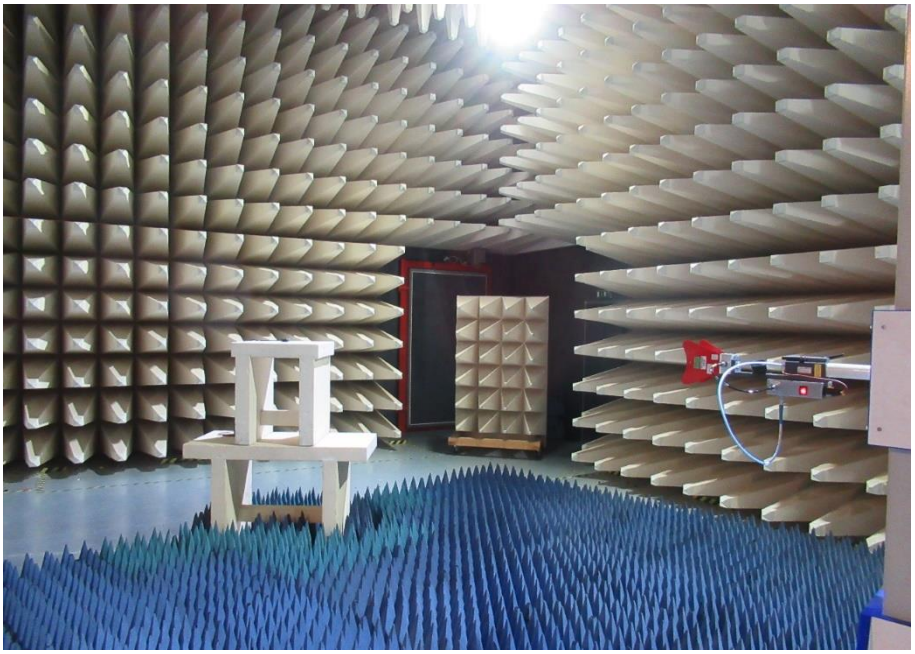
Test location: Anechoic chamber 1
Test location: OATS 1

Test distance: 3 m

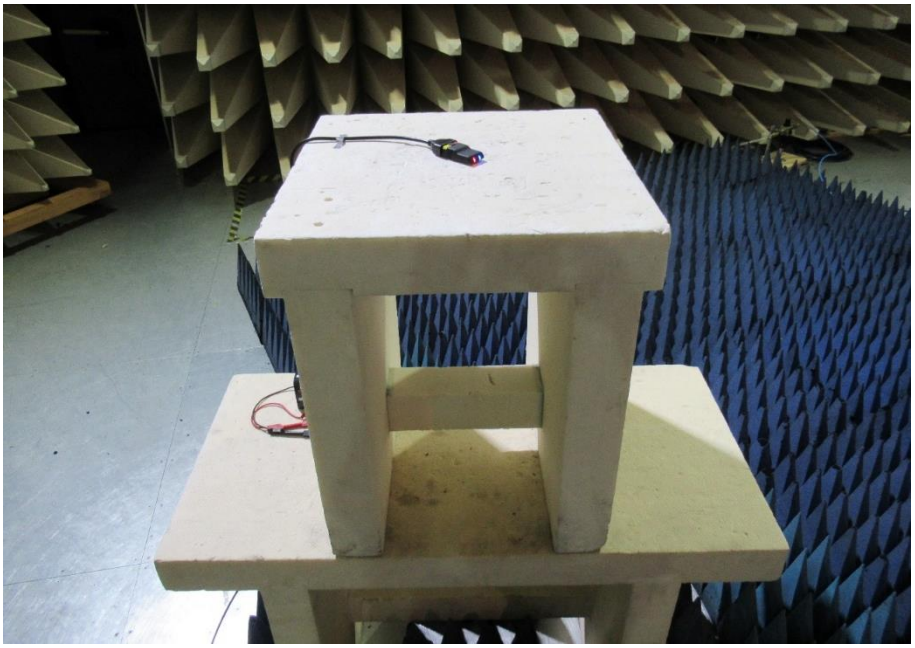
### 5.4.2 Photo documentation of the test set-up

OATS1:

Anechoic chamber 1:

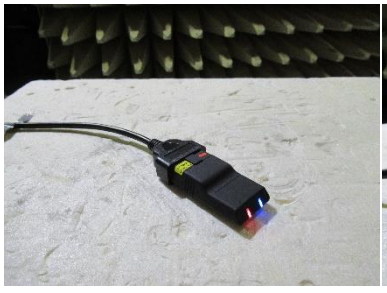


Detail:



EUT orientation:

X



Y

Z

### 5.4.3 Applicable standard

According to FCC Part 15, Section 15.205(a):
In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

### 5.4.4 Description of Measurement

The restricted bands are measured radiated. The span of the spectrum analyser is set wide enough to capture the restricted band and measure the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation. The restricted bands are measured falling emissions into it and the nearest restricted band are checked for emissions also the restricted band for the harmonics of the carrier.

Spectrum analyser settings:

| | | | |
|---|---|---|---|
| 9 kHz – 150 kHz: | RBW: 200 Hz, | Detector: Quasi peak, Mes. Time: 1 s, | |
| 150 kHz – 30 MHz: | RBW: 9 kHz, | Detector: Quasi peak, Mes. Time: 1 s, | |
| 30 MHz – 1 GHz: | RBW: 120 MHz, | Detector: Quasi peak, Mes. Time: 1 s, | |
| 1 GHz – 26 GHz: | RBW: 1 MHz,VBW: 3 MHz, | Detector: Max. peak, Trace: Max. hold, | Sweep: Auto |

### 5.4.5 Test result

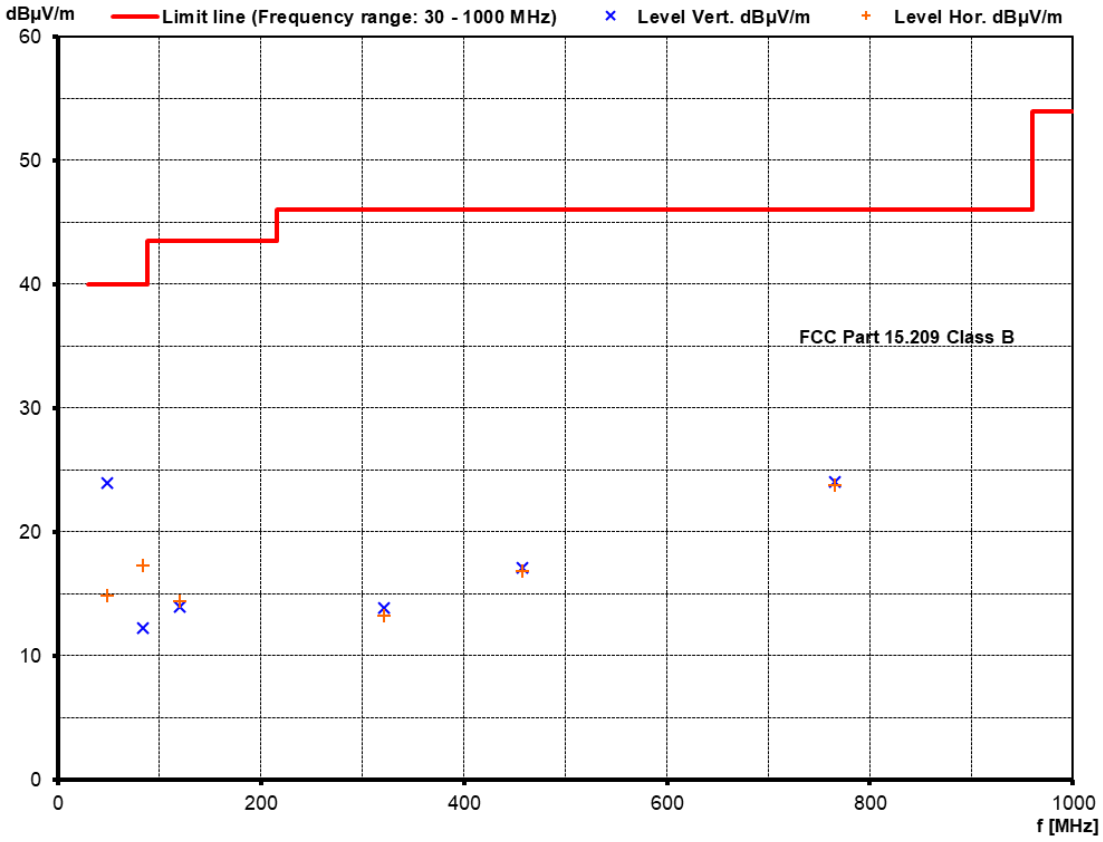
f < 1000 MHz

| Frequency | Reading PK | D factor | Level PK | Limit AV | Delta |
|---|---|---|---|---|---|
| (MHz) | dB(µV) | dB(µV/m) | dB(µV/m) | dB(µV/m) | (dB) |
| 0.47 | 32.0 | -80.0 | -48.0 | 14.2 | -62.2 |

Note: The measurement results from distance 3m are extrapolated (D factor) to the specific distance. During the measurements no emissions from the EUT could be detected in the frequency range 9 kHz to 30 MHz, given values only represent the noise floor.

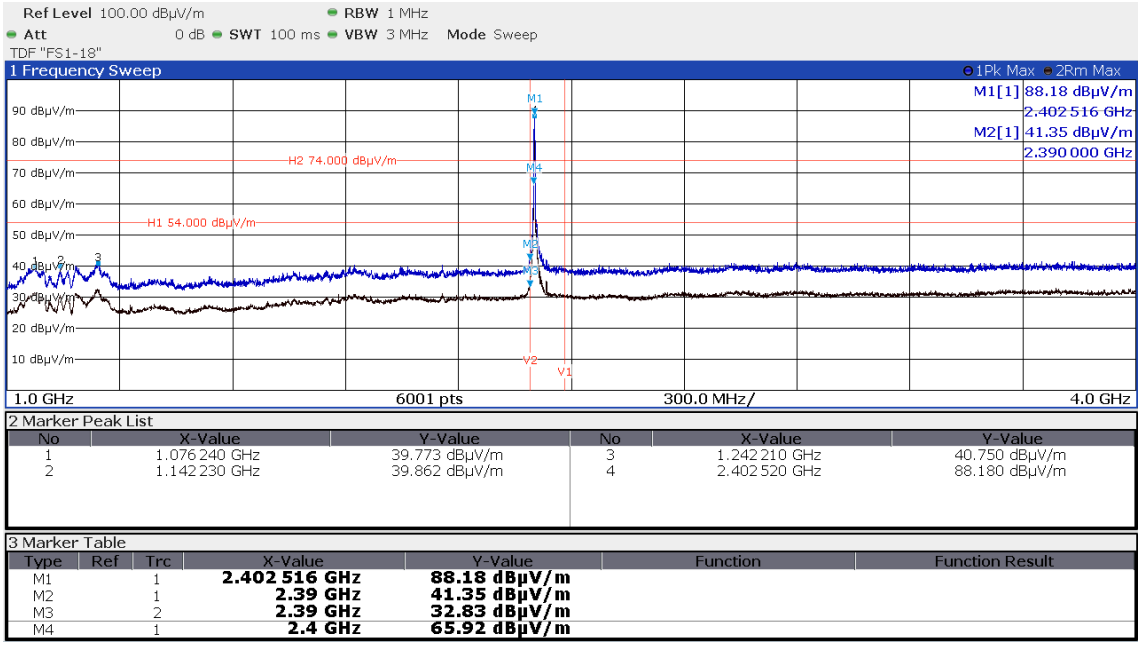
| Frequency (MHz) | Reading Vert. (dBµV) | Reading Hor. (dBµV) | Correct. Vert. (dB) | Correct. Hor. (dB) | Level Vert. (dBµV/m) | Level Hor. (dBµV/m) | Limit (dBµV/m) | Dlimit (dB) |
|---|---|---|---|---|---|---|---|---|
| 48.43 | 8.9 | 0.9 | 15.1 | 13.9 | 24.0 | 14.8 | 40.0 | -16.0 |
| 83.86 | 2.3 | 7.6 | 9.9 | 9.7 | 12.2 | 17.3 | 40.0 | -22.7 |
| 119.76 | 2.4 | 2.1 | 11.5 | 12.3 | 13.9 | 14.4 | 43.5 | -29.1 |
| 320.76 | -3.0 | -3.2 | 16.8 | 16.4 | 13.8 | 13.2 | 46.0 | -32.2 |
| 457.17 | -3.4 | -3.5 | 20.5 | 20.3 | 17.1 | 16.8 | 46.0 | -28.9 |
| 765.90 | -3.1 | -3.0 | 27.2 | 26.8 | 24.1 | 23.8 | 46.0 | -21.9 |

Note: No emissions detected in the frequency range 30 MHz to 1 GHz. The recorded values are solely noise values of the OATS.



f > 1000 MHz

CH37 2402 MHz:

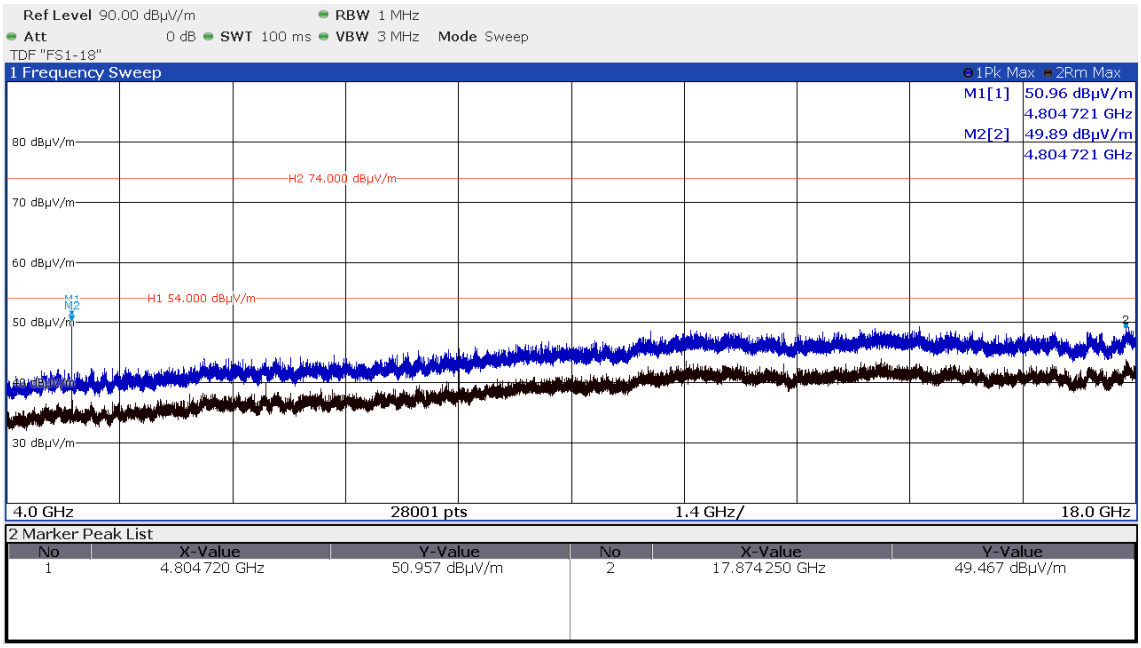



2 Marker Peak List

| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 1.076 240 GHz | 39.773 dBµV/m | 3 | 1.242 210 GHz | 40.750 dBµV/m |
| 2 | 1.142 230 GHz | 39.862 dBµV/m | 4 | 2.402 520 GHz | 88.180 dBµV/m |

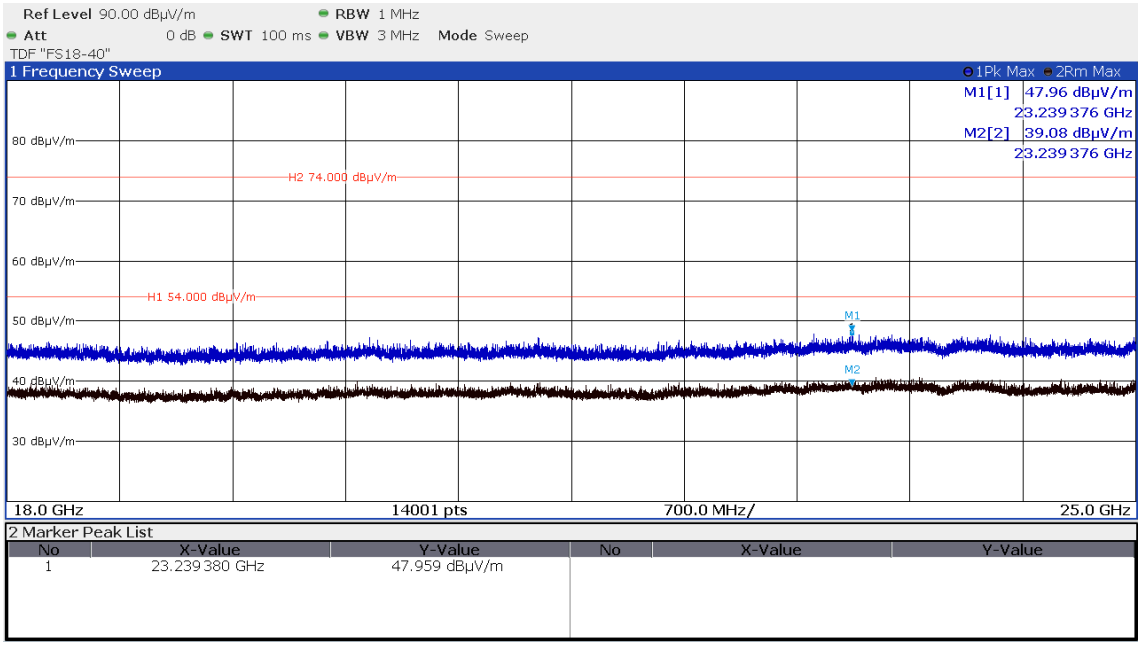
3 Marker Table

| Type | Ref | Trc | X-Value | Y-Value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | **2.402 516 GHz** | **88.18 dBµV/m** | | |
| M2 | | 1 | **2.39 GHz** | **41.35 dBµV/m** | | |
| M3 | | 2 | **2.39 GHz** | **32.83 dBµV/m** | | |
| M4 | | 1 | **2.4 GHz** | **65.92 dBµV/m** | | |




2 Marker Peak List

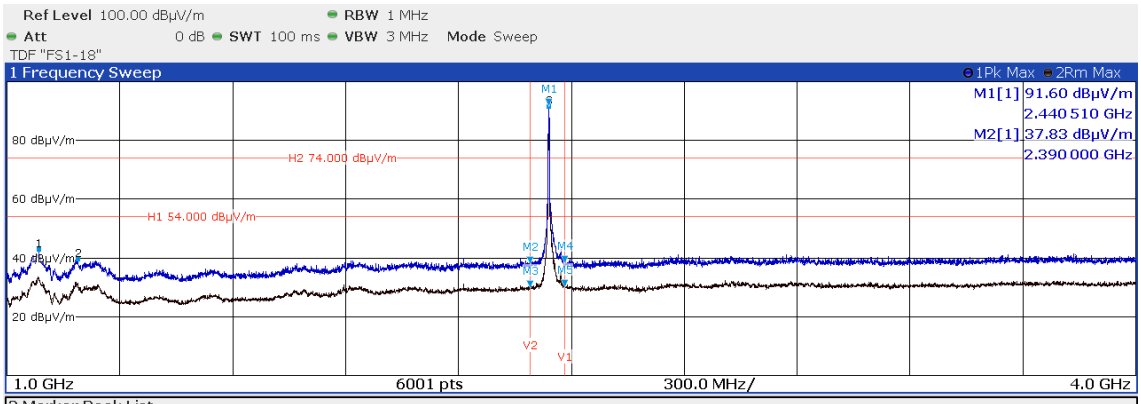
| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 4.804 720 GHz | 50.957 dBµV/m | 2 | 17.874 250 GHz | 49.467 dBµV/m |




2 Marker Peak List

| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 23.239 380 GHz | 47.959 dBµV/m | | | |

CH17 2440 MHz:

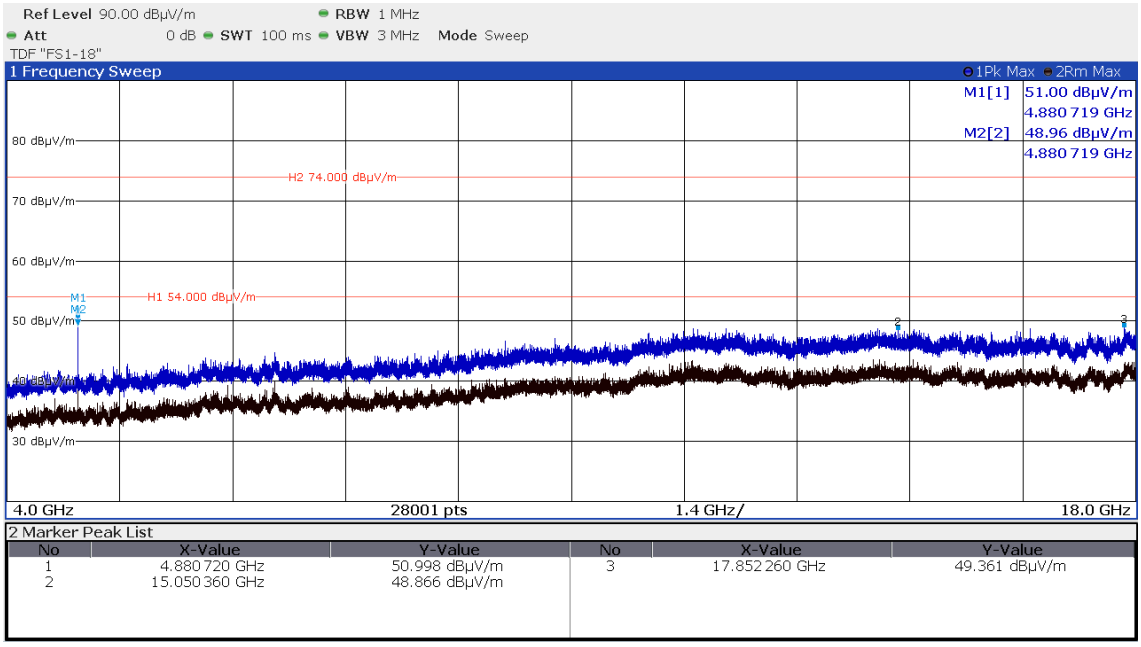



2 Marker Peak List

| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 1.084 740 GHz | 42.921 dBµV/m | 3 | 2.440 510 GHz | 91.602 dBµV/m |
| 2 | 1.189 220 GHz | 39.446 dBµV/m | | | |

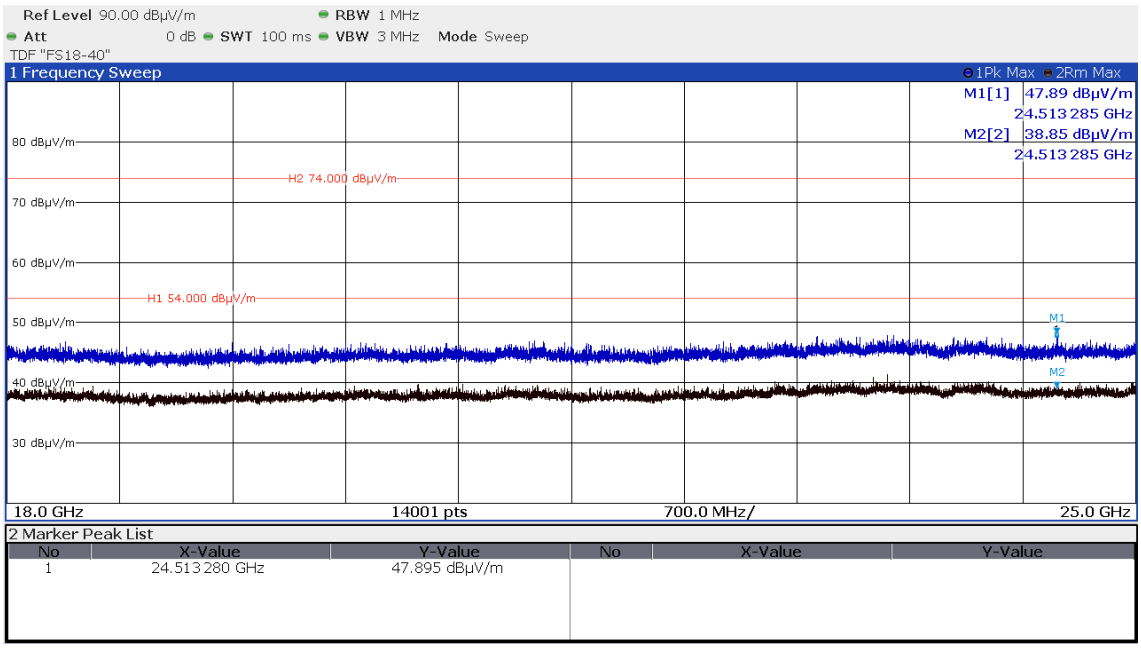
3 Marker Table

| Type | Ref | Trc | X-Value | Y-Value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | **2.440 51 GHz** | **91.60 dBµV/m** | | |
| M2 | | 1 | **2.39 GHz** | **37.83 dBµV/m** | | |
| M3 | | 2 | **2.39 GHz** | **29.48 dBµV/m** | | |
| M4 | | 1 | **2.483 5 GHz** | **38.11 dBµV/m** | | |
| M5 | | 2 | **2.483 5 GHz** | **29.77 dBµV/m** | | |




2 Marker Peak List

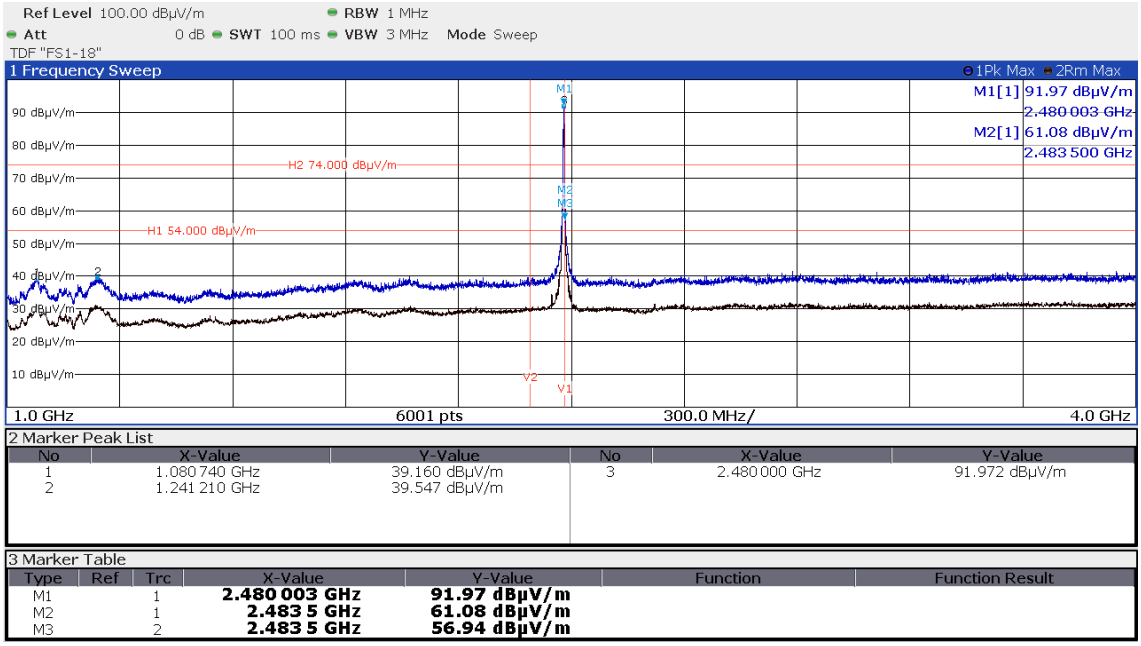
| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 4.880 720 GHz | 50.998 dBµV/m | 3 | 17.852 260 GHz | 49.361 dBµV/m |
| 2 | 15.050 360 GHz | 48.866 dBµV/m | | | |

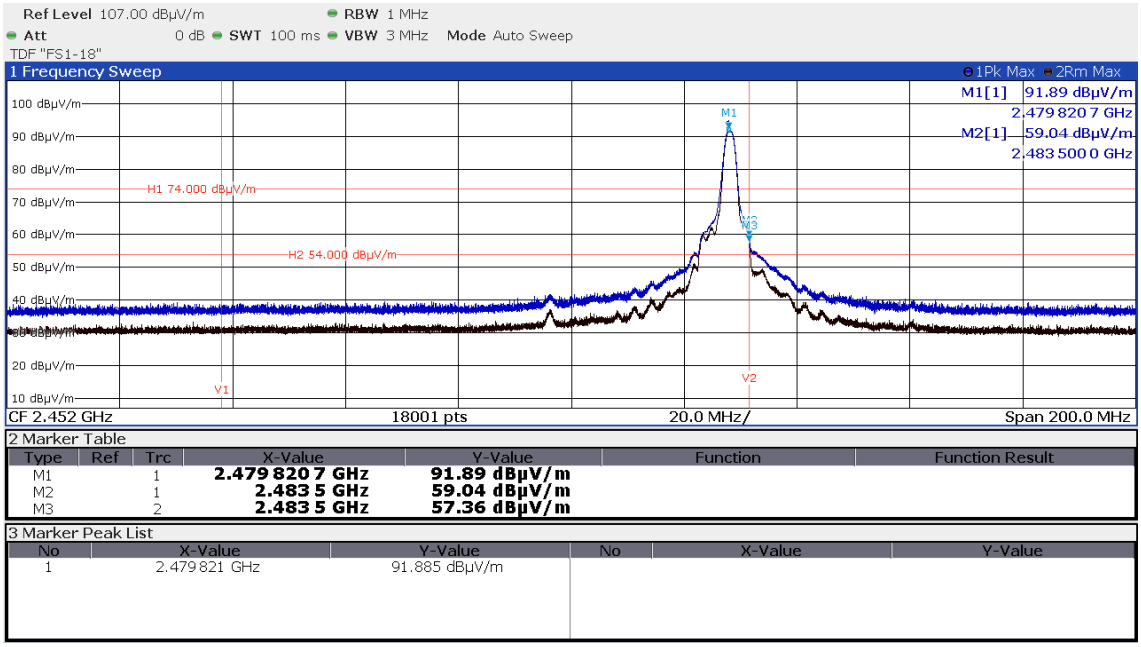



2 Marker Peak List

| No | X-Value | Y-Value | No | X-Value | Y-Value |
|---|---|---|---|---|---|
| 1 | 24.513 280 GHz | 47.895 dBµV/m | | | |

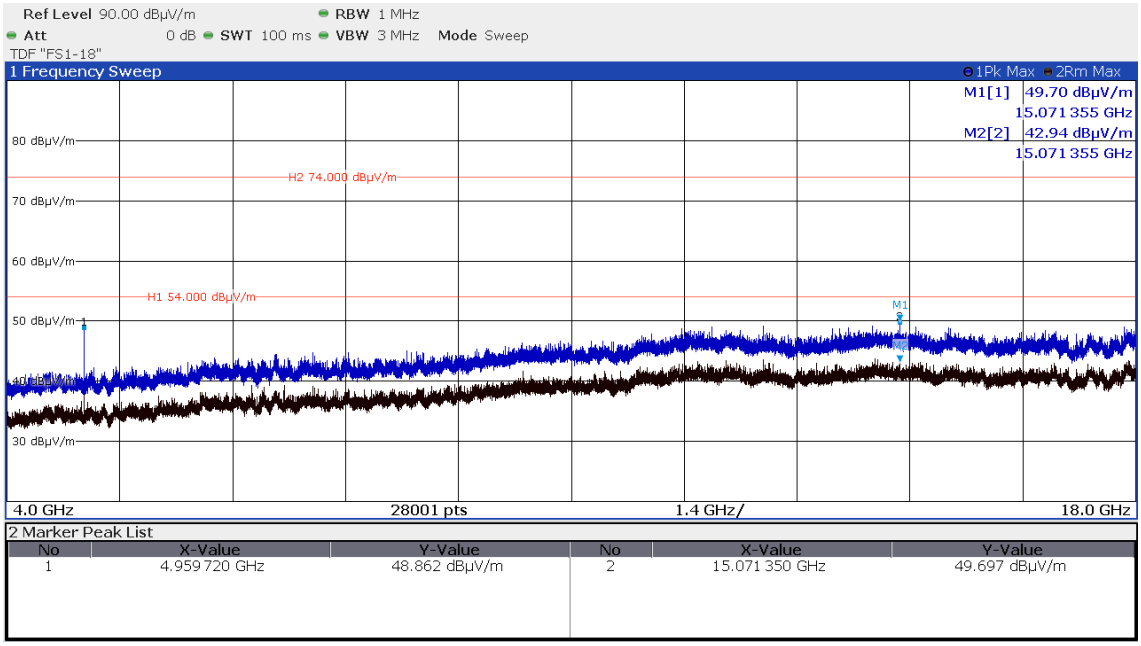
CH39 2480 MHz:

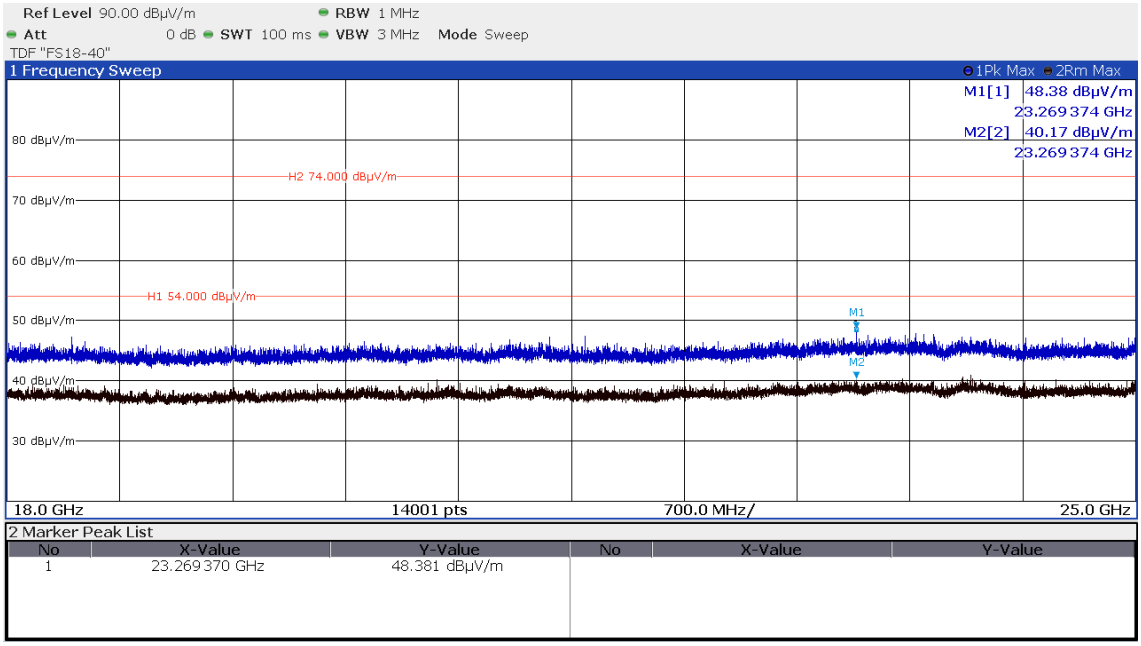



Correction for pulse operation (see section 5.5):

| Frequency *f* | Peak emission | Peak limit | Peak margin | Correction factor $K_E$ | Average value | Average limit | Average margin |
|---|---|---|---|---|---|---|---|
| (MHz) | (dBµV/m) | (dBµV/m) | (dB) | (dB) | (dBµV/m) | (dBµV/m) | (dB) |
| 2483.5 | 59.0 | 74.0 | -15.0 | -47.7 | 11.3 | 54.0 | -42.7 |




Radiated limits according to FCC Part 15 Section 15.209(a) for spurious emissions which fall in restricted bands:

| 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 |

**Restricted bands of operation:**

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 – 0.110 | 16.42 – 16.423 | 399.9 – 410 | 4.5 – 5.15 |
| 0.495 – 0.505 | 16.69475 – 16.69525 | 608 – 614 | 5.35 – 5.46 |
| 2.1735 – 2.1905 | 16.80425 – 16.80475 | 960 – 1240 | 7.25 – 7.75 |
| 4.125 – 4.128 | 25.5 – 25.67 | 1300 – 1427 | 8.025 – 8.5 |
| 4.17725 – 4.17775 | 37.5 – 38.25 | 1435 – 1626.5 | 9.0 – 9.2 |
| 4.20725 – 4.20775 | 73 – 74.6 | 1645.5 – 1646.5 | 9.3 – 9.5 |
| 6.215 – 6.218 | 74.8 – 75.2 | 1660 – 1710 | 10.6 – 12.7 |
| 6.26775 – 6.26825 | 108 – 121.94 | 1718.8 – 1722.2 | 13.25 – 13.4 |
| 6.31175 – 6.31225 | 123 – 138 | 2200 – 2300 | 14.47 – 14.5 |
| 8.291 – 8.294 | 149.9 – 150.05 | 2310 – 2390 | 15.35 – 16.2 |
| 8.362 – 8.366 | 156.52475 – 156.52525 | 2483.5 – 2500 | 17.7 – 21.4 |
| 8.37625 – 8.38675 | 156.7 – 156.9 | 2690 – 2900 | 22.01 – 23.12 |
| 8.41425 – 8.41475 | 162.0125 – 167.17 | 3260 – 3267 | 23.6 – 24.0 |
| 12.29 – 12.293 | 167.72 – 173.2 | 3332 – 3339 | 31.2 – 31.8 |
| 12.51975 – 12.52025 | 240 – 285 | 3345.8 – 3358 | 36.43 – 36.5 |
| 12.57675 – 12.57725 | 322 – 335.4 | 3600 – 4400 | Above 38.6 |

RSS-Gen, Table 6 – Restricted Frequency Bands

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 - 0.110 | 12.57675 - 12.57725 | 399.9 - 410 | 7.250 - 7.750 |
| 0.495 - 0.505 | 13.36 - 13.41 | 608 - 614 | 8.025 – 8.500 |
| 2.1735 - 2.1905 | 16.42 - 16.423 | 960 - 1427 | 9.0 - 9.2 |
| 3.020 - 3.026 | 16.69475 - 16.69525 | 1435 - 1626.5 | 9.3 - 9.5 |
| 4.125 - 4.128 | 16.80425 - 16.80475 | 1645.5 - 1646.5 | 10.6 - 12.7 |
| 4.17725 - 4.17775 | 25.5 - 25.67 | 1660 - 1710 | 13.25 - 13.4 |
| 4.20725 - 4.20775 | 37.5 - 38.25 | 1718.8 - 1722.2 | 14.47 - 14.5 |
| 5.677 - 5.683 | 73 - 74.6 | 2200 - 2300 | 15.35 - 16.2 |
| 6.215 - 6.218 | 74.8 - 75.2 | 2310 - 2390 | 17.7 - 21.4 |
| 6.26775 - 6.26825 | 108 – 138 | 2483.5 - 2500 | 22.01 - 23.12 |
| 6.31175 - 6.31225 | 149.9 - 150.05 | 2655 - 2900 | 23.6 - 24.0 |
| 8.291 - 8.294 | 156.52475 - 156.52525 | 3260 – 3267 | 31.2 - 31.8 |
| 8.362 - 8.366 | 156.7 - 156.9 | 3332 - 3339 | 36.43 - 36.5 |
| 8.37625 - 8.38675 | 162.0125 - 167.17 | 3345.8 - 3358 | Above 38.6 |
| 8.41425 - 8.41475 | 167.72 - 173.2 | 3500 - 4400 | |
| 12.29 - 12.293 | 240 – 285 | 4500 - 5150 | |
| 12.51975 - 12.52025 | 322 - 335.4 | 5350 - 5460 | |

The requirements are **FULFILLED.**

**Remarks:** The measurement was performed up to the 10th harmonic. Only the worst-case plots are listed.

For pulse operation correction see section 5.5.

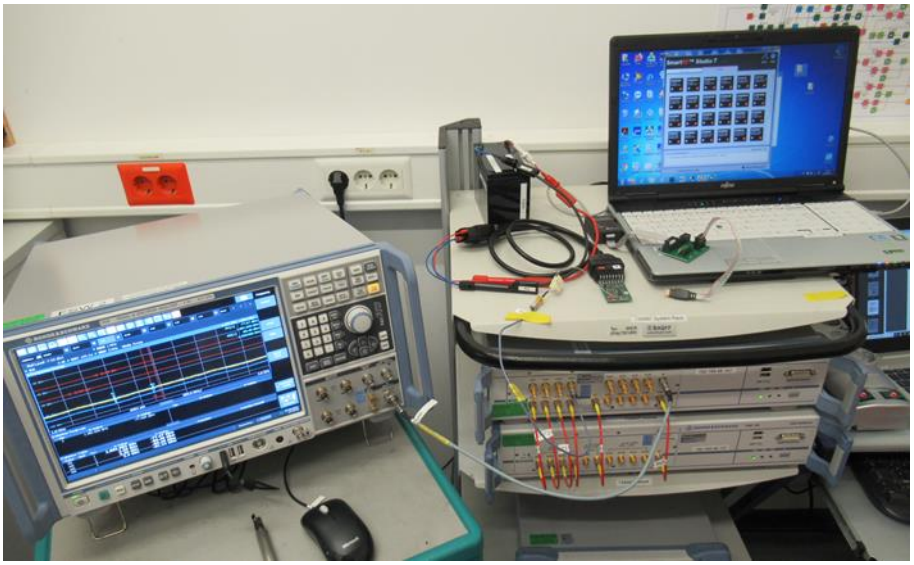
## 5.5 Correction for pulse operation (duty cycle)

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

### 5.5.1 Description of the test location

Test location: Shielded Room S6

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



### 5.5.1 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 pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the pulse 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.

### 5.5.2 Description of Measurement

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

$$K_E = 20 \log (T_{on} / T_{conn})$$

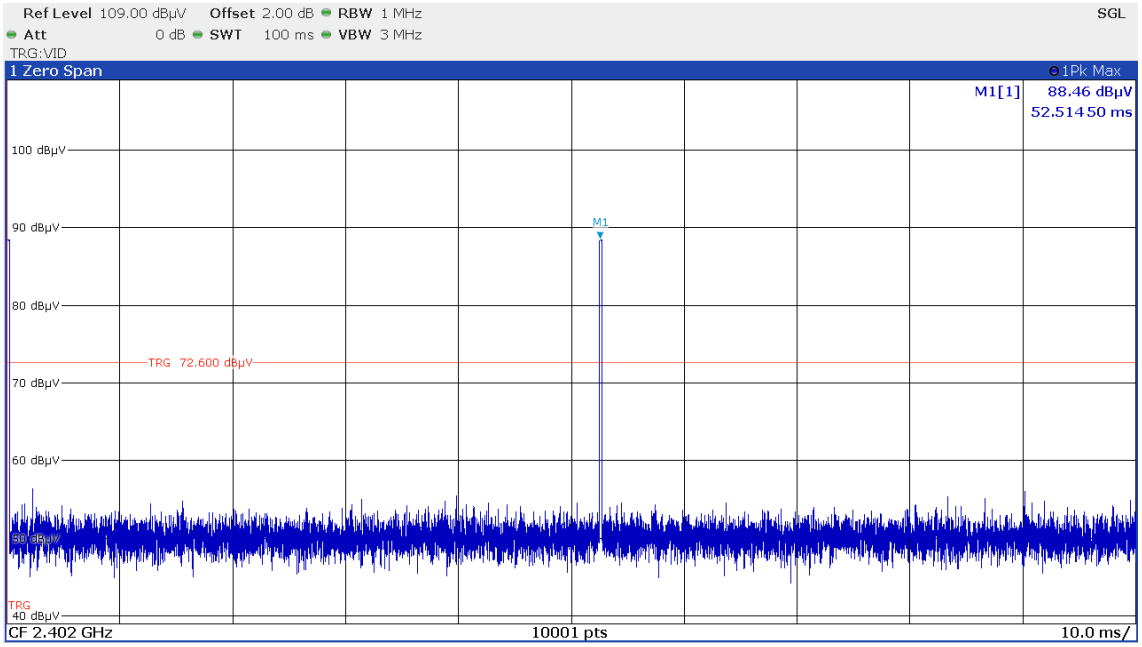
$K_E$: pulse operation correction factor
$T_{on}$ on air duration
$T_{conn}$ connection interval duration

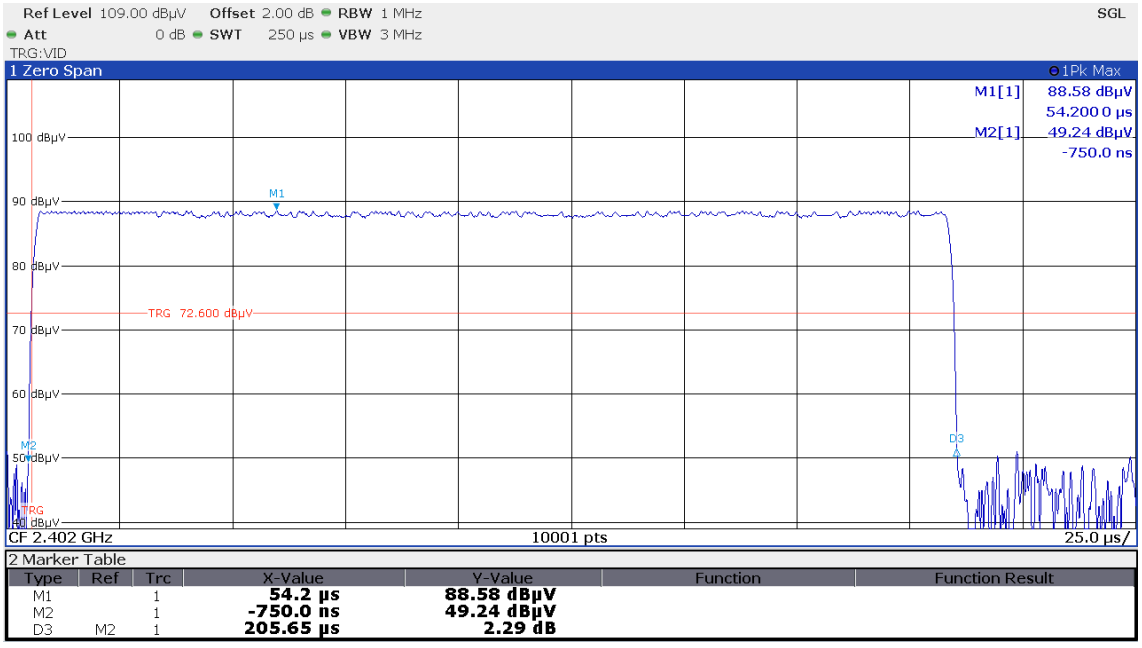
### 5.5.3 Test result

$K_E$ = 20 log (*0.20565*2 / 100*) = -47.7 dB

**Remarks:** For detailed test results please see the following test protocol.

### 5.5.4 Test protocol



## 5.6 Antenna application

### 5.6.1 Applicable standard

According to FCC Part 15C, Section 15.203:
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. The manufacturer may design the unit that broken antennas can be replaced by the user, but the use of a standard antenna jack is prohibited.

The EUT has an integrated antenna. No other antenna can be used with the device.

The supplied antenna meets the requirements of part 15.203 and 15.204.

The requirements are **FULFILLED.**

**Remarks:** None

## 5.7 Defacto EIRP-Limit

According to FCC Part 15C, Section 15.247(b)(4):
The conducted output power limit specified in paragraph (b) of 15.247 is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from intentional radiator shall be reduced below the stated values in paragraph (b)(1), (b)(2) and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

**Defacto EIRP-Limit:**

$$Pout = 30 – (Gx – 6);$$

The antenna is < 6 dBi gain, no Defacto limit applies.

The requirements are **FULFILLED.**

**Remarks:** None

# 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 | 06/04/2022 | 06/04/2021 | | |
| | AMF-6D-01002000-22-10P | 02-02/17-15-004 | | | | |
| | 3117 | 02-02/24-05-009 | 18/06/2021 | 18/06/2020 | | |
| | BAM 4.5-P | 02-02/50-17-024 | | | | |
| | NCD | 02-02/50-17-025 | | | | |
| | KK-SF106-2X11N-6,5M | 02-02/50-18-016 | | | | |
| | BAT-EMC 3.20.0.23 | 02-02/68-13-001 | | | | |
| MB | FSW43 | 02-02/11-15-001 | 06/04/2022 | 06/04/2021 | | |
| | OSP-B157W8 with OSP120 | 02-02/30-13-002 | 14/08/2021 | 14/08/2020 | | |
| | OSP-B157WX with OSP120 | 02-02/30-18-007 | 06/08/2021 | 06/08/2020 | | |
| | Sucoflex N-1000-SMA | 02-02/50-05-072 | | | | |
| | KMS116-GL140SE-KMS116- | 02-02/50-16-010 | | | | |
| | Semflex K-400-K | 02-02/50-19-013 | | | | |
| | SMB-K27 PULSETRAIN | 02-02/68-19-001 | | | | |
| SER 1 | ESCI | 02-02/03-05-005 | 24/11/2021 | 24/11/2020 | | |
| | HFH 2 - Z 2 | 02-02/24-15-001 | 30/03/2022 | 30/03/2021 | | |
| | KK-EF393/U-16N-21N20 m | 02-02/50-12-018 | | | | |
| SER 2 | ESVS 30 | 02-02/03-05-006 | 15/07/2021 | 15/07/2020 | | |
| | VULB 9168 | 02-02/24-05-005 | 18/12/2021 | 18/12/2020 | 07/07/2022 | 07/07/2021 |
| | 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 | 06/04/2022 | 06/04/2021 | | |
| | AMF-6D-01002000-22-10P | 02-02/17-15-004 | | | | |
| | LNA-40-18004000-33-5P | 02-02/17-20-002 | | | | |
| | 3117 | 02-02/24-05-009 | 18/06/2021 | 18/06/2020 | | |
| | BBHA 9170 | 02-02/24-05-013 | 19/05/2023 | 19/05/2020 | 04/02/2022 | 04/02/2021 |
| | BAM 4.5-P | 02-02/50-17-024 | | | | |
| | NCD | 02-02/50-17-025 | | | | |
| | KK-SF106-2X11N-6,5M | 02-02/50-18-016 | | | | |
| | KMS116-GL140SE-KMS116- | 02-02/50-20-026 | | | | |
| | BAT-EMC 3.20.0.23 | 02-02/68-13-001 | | | | |

- End of test report -