

EMI – TEST REPORT

- FCC Part 15.247, RSS247 -

Type / Model Name : HR550 FS

Product Description : Wireless hand wheel system

Applicant : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Manufacturer : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Licence holder : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Test Result according to the standards
listed in clause 1 test standards:

POSITIVE

Test Report No. : **T38868-03-05HS**

22. March 2018

Date of issue



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

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test results
without the written permission of the test laboratory.

Contents

| | | |
|----------|---|-----------|
| 1 | <u>TEST STANDARDS</u> | 3 |
| 2 | <u>EQUIPMENT UNDER TEST</u> | 4 |
| 2.1 | Photo documentation of the EUT – Detailed photos see ATTACHMENT C | 4 |
| 2.2 | Equipment type | 4 |
| 2.1 | Short description of the equipment under test (EUT) | 4 |
| 2.2 | Variants of the EUT | 4 |
| 2.3 | Operation frequency and channel plan | 4 |
| 2.4 | Transmit operating modes | 5 |
| 2.5 | Antennas | 5 |
| 2.6 | Power supply system utilised | 5 |
| 2.7 | Peripheral devices and interface cables | 5 |
| 2.8 | Determination of worst case conditions for final measurement | 5 |
| 3 | <u>TEST RESULT SUMMARY</u> | 7 |
| 3.1 | Final assessment | 7 |
| 4 | <u>TEST ENVIRONMENT</u> | 8 |
| 4.1 | Address of the test laboratory | 8 |
| 4.2 | Environmental conditions | 8 |
| 4.3 | Statement of the measurement uncertainty | 9 |
| 4.4 | Measurement protocol for FCC and ISSED | 10 |
| 5 | <u>TEST CONDITIONS AND RESULTS</u> | 12 |
| 5.1 | AC power line conducted emissions | 12 |
| 5.2 | EBW and OBW | 15 |
| 5.3 | Maximum peak conducted output power | 18 |
| 5.4 | Power spectral density | 20 |
| 5.5 | Unwanted emissions | 22 |
| 5.6 | Unwanted emissions in restricted bands, radiated | 23 |
| 5.7 | Band edge compliance | 29 |
| 5.8 | Antenna application | 30 |
| 6 | <u>USED TEST EQUIPMENT AND ACCESSORIES</u> | 31 |

ATTACHMENT C as separate supplement

ATTACHMENT C1 as separate supplement

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September 2016)

| | |
|-----------------------------------|---|
| 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 2016)

| | |
|------------------------------------|---|
| 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 15.247 | 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 v04 Guidance for performing compliance measurements on DTS
operating under §15.247, April 5, 2017.

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – Detailed photos see ATTACHMENT C

2.2 Equipment type

IEEE 82.15.4 device

2.1 Short description of the equipment under test (EUT)

The EUT is a mobile wireless hand wheel for remote control a CNC machine.

Number of tested samples: 1 HR 550 FS
 Serial number: HR 550 FS, X 58 241 186,
 Firmware: Channel A: 1199899-01; Channel B: 1199893-01

EUT configuration:

(The CDF filled by the applicant can be viewed at the test laboratory.)

2.2 Variants of the EUT

| Device-Name | Comment | Antenna | Part number |
|-------------|---------------------------------------|----------------|-------------|
| HR 550 FS | Hand wheel, without mechanical raster | 2 Integrated F | 1200495-01 |
| HR 550 FS | Hand wheel, with mechanical raster | 2 Integrated F | 1183021-01 |

2.3 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

| Channel | Frequency | Channel | Frequency |
|---------|-----------|---------|-----------|
| 11 | 2405 | 19 | 2445 |
| 12 | 2410 | 20 | 2450 |
| 13 | 2415 | 21 | 2455 |
| 14 | 2420 | 22 | 2460 |
| 15 | 2425 | 23 | 2465 |
| 16 | 2430 | 24 | 2470 |
| 17 | 2435 | 25 | 2475 |
| 18 | 2440 | 26 | 2480 |

Note: The marked frequencies are used for testing.

2.4 Transmit operating modes

The EUT allows the user to switch the transmission on or off. There are no further operating modes.

The EUT use O-QPSK modulation and may provide following data rate:

- 250 kbps (kbps = *kilobits per second*)

2.5 Antennas

The EUT use two integrated PCB-F-antennas.

2.6 Power supply system utilised

Power supply voltage, V_{nom} : Dedicated NiMh battery pack

2.7 Peripheral devices and interface cables

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

- Base station (wireless) Model : HRA 551 FS
- - Model : -
- - Model : -

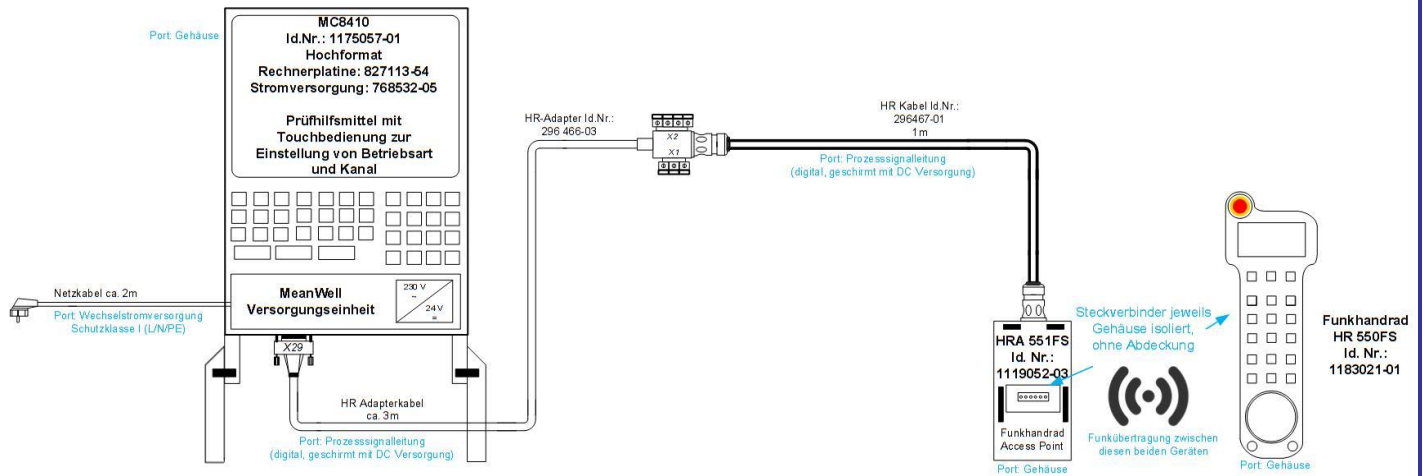
2.8 Determination of worst case conditions for final measurement

The EUT is tested as system, normal transmission is initiated.

| IEEE Standard | Available channel | Tested channels | Power setting | Modulation | Modulation type | Data rate |
|---------------|-------------------|-----------------|---------------|------------|-----------------|-----------|
| 802.15.4 | 11 to 26 | 11, 18, 26 | Pmax | DSSS | O-QPSK | 250 kbps |

Note: The 802.15.4 is only used physically. No other common device may connect to.

Schematic test set-up



2.8.1 Test jig

No test jig was used for testing.

2.8.2 Test software

For testing the normal communication is set up between base station and the portable remote.

3 TEST RESULT SUMMARY

IEEE 802.15.4 device using digital modulation:

Operating in the 2400 MHz – 2483.5 MHz:

| FCC Rule Part | RSS Rule Part | Description | Result |
|---------------|----------------|-------------------------------------|------------|
| 15.207(a) | RSS Gen, 8.8 | AC power line conducted emissions | passed |
| 15.247(a)(2) | RSS247, 5.2(1) | -6 dB EBW | passed |
| 15.247(b)(3) | RSS247, 5.4(4) | Maximum peak conducted output power | passed |
| 15.247(b)(4) | RSS247, 5.4(4) | Defacto limit | passed |
| 15.247(d) | RSS247, 5.5 | Unwanted emission, radiated | Not tested |
| 15.247(d) | RSS-Gen, 8.10 | Emissions in restricted bands | passed |
| 15.247(e) | RSS247, 5.2(2) | PSD | passed |
| 15.35(c) | RSS-Gen, 6.10 | Pulsed operation | passed |
| 15.247(b)(4) | - | Antenna requirement | passed |
| | RSS-Gen, 6.11 | Transmitter frequency stability | Not tested |
| | RSS-Gen, 6.6 | 99 % Bandwidth | passed |

The mentioned RSS Rule Parts in the above table are related to:
 RSS Gen, Issue 4, November 2014
 RSS 247, Issue 2, February 2017

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 : 28 June 2017

Testing concluded on : 03 August 2017

Checked by:

Tested by:

 Klaus Gegenfurtner
 Teamleader Radio

 Hermann Smetana
 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 Type | Range | Confidence Level | Calculated Uncertainty |
|-------------------------------------|------------------------|------------------|--------------------------|
| AC power line conducted emissions | 0.15 MHz to 30 MHz | 95% | ± 3.29 dB |
| EBW and OBW | 2400 MHz to 3000 MHz | 95% | $\pm 2.5 \times 10^{-7}$ |
| Maximum peak conducted output power | 2400 MHz to 3000 MHz | 95% | ± 0.62 dB |
| Power spectral density | 2400 MHz to 3000 MHz | 95% | ± 0.62 dB |
| Conducted Spurious Emissions | 9 kHz to 10000 MHz | 95% | ± 2.15 dB |
| Conducted Spurious Emissions | 10000 MHz to 40000 MHz | 95% | ± 3.47 dB |
| 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 |
| Field strength of the fundamental | 100 kHz to 100 MHz | 95% | ± 3.53 dB |

4.4 Measurement protocol for FCC and ISCED

4.4.1 General information

4.4.1.1 Test methodology

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

IC 3009A-1

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

IC 3009A-2

In compliance with RSS 247 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.10 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 General Standard information

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 C63.10 and applying the CISPR 22 limits.

4.4.1.3.1 Radiated emission (electrical field 30 MHz - 1 GHz)

Description of measurement

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. The setup of the equipment under test is established in accordance with ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so that they are at least 40 centimetres from 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 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 or CISPR 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) | - | CISPR Limit = (dBµV/m) | = | Delta (dB) |
|--------------------|-----------------|---|----------------|---|-------------------|---|---------------------------|---|---------------|
| 719.0 | 75.0 | + | 32.6 | = | 107.6 | - | 110.0 | = | -2.4 |

4.4.1.3.2 Radiated emission (electrical field 1 GHz - 40 GHz)Description of measurement

Radiated emissions from the EUT are measured in the frequency range 1 GHz up to the maximum frequency 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 1.0 X 1.5 metre non-conducting table, 1.5 metre above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is following set out in ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so they are at least 40 centimetres from 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. Measurements are made in both the horizontal and vertical polarization planes in a fully anechoic room using a spectrum analyzer set to max peak detector function and a resolution 1 MHz and video bandwidth 3 MHz for peak measurement. The conditions determined as worst case will then be used for the final measurements. When the EUT is larger than the beam width of the measuring antenna it will be moved over the surface for the four sides of the equipment. Where appropriate, the test distance may be reduced in order to detect emissions under better uncertainty and are calculated at the specified test distance.

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: Shielded Room S2

5.1.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT C1

5.1.3 Applicable standard

According to FCC Part 15, Section 15.207(a):

Except as shown in paragraphs (b) and (c) of this Section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the given limits.

5.1.4 Description of Measurement

The measurements are performed following the procedures set out in ANSI C63.10 described under item 4.4.3. If the minimum limit margin appears to be less than 20 dB with a peak mode measurement, the emissions are re-measured using a tuned receiver with quasi-peak and average detection and recorded on the data sheets.

5.1.5 Test result

Frequency range: 0.15 MHz - 30 MHz

Min. limit margin 5.2 dB at 12.476 MHz

Limit according to FCC Part 15, Section 15.207(a):

| Frequency of Emission (MHz) | Conducted Limit (dBµV) | |
|--------------------------------|------------------------|------------|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56 * | 56 to 46 * |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

* Decreases with the logarithm of the frequency

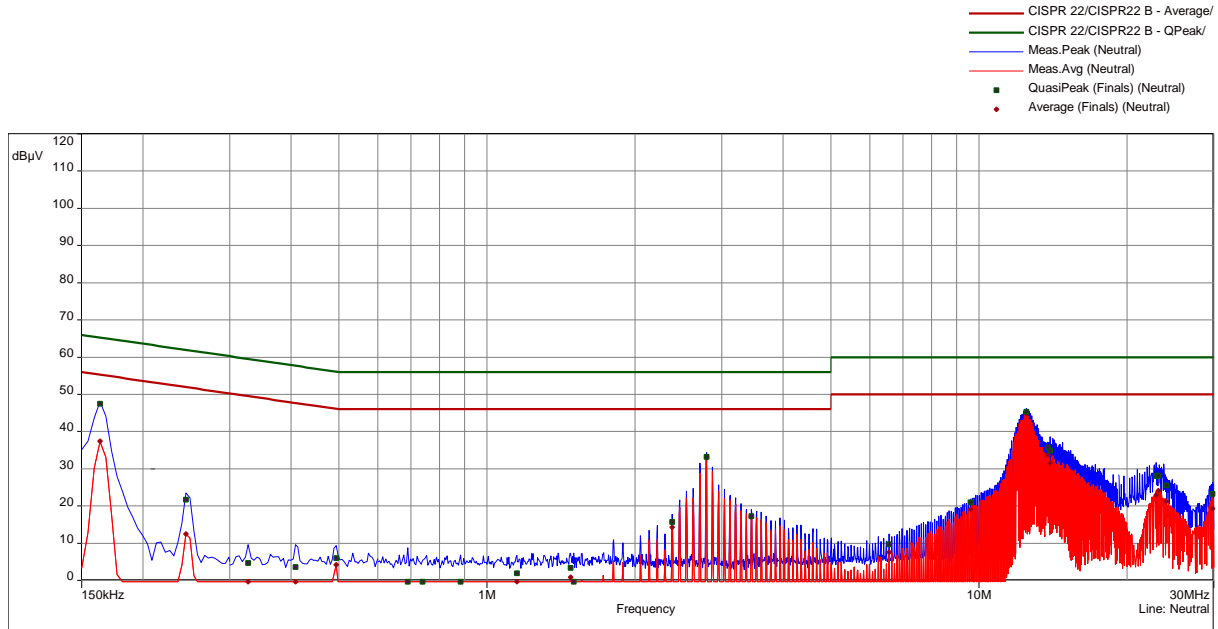
The requirements are **FULFILLED**.

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

5.1.6 Test protocol

Test point L1
Operation mode: TX, charging
Remarks:

Result: passed

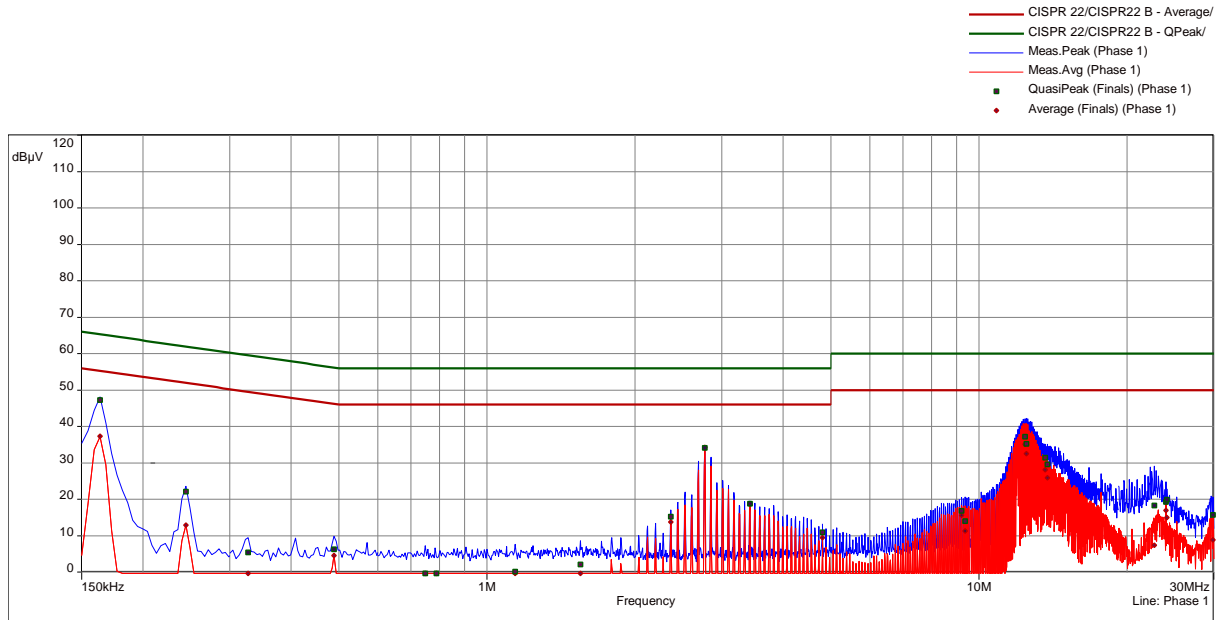


CISPR 22/CISPR22B

| freq MHz | SR | QP dB(μV) | margin dB | limit dB | AV dB(μV) | margin dB | limit dB | line | corr dB |
|-------------|----|--------------|--------------|-------------|--------------|--------------|-------------|---------|------------|
| 0.164 | 1 | 47.3 | 18.0 | 65.3 | 37.4 | 17.9 | 55.3 | Phase 1 | 10.1 |
| 0.245 | 1 | 22.0 | 39.9 | 61.9 | 12.9 | 39.1 | 51.9 | Phase 1 | 10.1 |
| 0.327 | 2 | 5.4 | 54.2 | 59.5 | -0.7 | 50.3 | 49.5 | Phase 1 | 10.1 |
| 0.489 | 2 | 6.2 | 50.0 | 56.2 | 4.6 | 41.6 | 46.2 | Phase 1 | 10.2 |
| 0.749 | 3 | -1.4 | 57.4 | 56.0 | -4.4 | 50.4 | 46.0 | Phase 1 | 10.2 |
| 0.789 | 3 | -1.4 | 57.4 | 56.0 | -4.4 | 50.4 | 46.0 | Phase 1 | 10.2 |
| 1.140 | 3 | 0.1 | 55.9 | 56.0 | -3.2 | 49.2 | 46.0 | Phase 1 | 10.2 |
| 1.547 | 4 | 2.1 | 53.9 | 56.0 | -0.9 | 46.9 | 46.0 | Phase 1 | 10.3 |
| 2.361 | 4 | 15.3 | 40.7 | 56.0 | 13.7 | 32.3 | 46.0 | Phase 1 | 10.3 |
| 2.769 | 5 | 34.1 | 21.9 | 56.0 | 34.2 | 11.8 | 46.0 | Phase 1 | 10.4 |
| 3.422 | 5 | 18.8 | 37.2 | 56.0 | 18.7 | 27.3 | 46.0 | Phase 1 | 10.4 |
| 4.805 | 6 | 10.9 | 45.1 | 56.0 | 9.5 | 36.5 | 46.0 | Phase 1 | 10.5 |
| 9.206 | 6 | 16.9 | 43.1 | 60.0 | 15.5 | 34.5 | 50.0 | Phase 1 | 10.8 |
| 9.368 | 6 | 14.0 | 46.0 | 60.0 | 11.3 | 38.7 | 50.0 | Phase 1 | 10.8 |
| 12.390 | 7 | 37.2 | 22.8 | 60.0 | 35.1 | 14.9 | 50.0 | Phase 1 | 11.0 |
| 12.471 | 7 | 35.2 | 24.8 | 60.0 | 32.5 | 17.5 | 50.0 | Phase 1 | 11.0 |
| 13.614 | 7 | 31.5 | 28.5 | 60.0 | 28.1 | 21.9 | 50.0 | Phase 1 | 11.1 |
| 13.776 | 7 | 29.6 | 30.4 | 60.0 | 25.9 | 24.1 | 50.0 | Phase 1 | 11.1 |
| 22.719 | 8 | 18.3 | 41.7 | 60.0 | 7.4 | 42.6 | 50.0 | Phase 1 | 11.6 |
| 24.002 | 8 | 19.3 | 40.7 | 60.0 | 17.0 | 33.0 | 50.0 | Phase 1 | 11.6 |
| 24.065 | 8 | 19.9 | 40.1 | 60.0 | 15.0 | 35.1 | 50.0 | Phase 1 | 11.6 |
| 29.856 | 8 | 15.7 | 44.3 | 60.0 | 8.9 | 41.1 | 50.0 | Phase 1 | 11.6 |

Test point N
Operation mode: TX, charging
Remarks:

Result: passed



CISPR 22/CISPR22B

| freq | SR | QP | margin | limit | AV | margin | limit | line | corr |
|--------|----|--------|--------|-------|--------|--------|-------|---------|------|
| MHz | | dB(μV) | dB | dB | dB(μV) | dB | dB | | dB |
| 0.164 | 9 | 47.5 | 17.7 | 65.3 | 37.5 | 17.8 | 55.3 | Neutral | 10.1 |
| 0.245 | 9 | 21.7 | 40.3 | 61.9 | 12.5 | 39.5 | 51.9 | Neutral | 10.1 |
| 0.327 | 10 | 4.7 | 54.9 | 59.5 | -1.3 | 50.9 | 49.5 | Neutral | 10.2 |
| 0.408 | 10 | 3.6 | 54.1 | 57.7 | -1.8 | 49.5 | 47.7 | Neutral | 10.2 |
| 0.494 | 10 | 6.0 | 50.1 | 56.1 | 4.2 | 41.9 | 46.1 | Neutral | 10.2 |
| 0.690 | 11 | -1.2 | 57.2 | 56.0 | -4.3 | 50.3 | 46.0 | Neutral | 10.2 |
| 0.740 | 11 | -0.2 | 56.2 | 56.0 | -3.7 | 49.7 | 46.0 | Neutral | 10.2 |
| 0.884 | 11 | -1.4 | 57.4 | 56.0 | -4.4 | 50.4 | 46.0 | Neutral | 10.2 |
| 1.149 | 11 | 1.9 | 54.1 | 56.0 | -1.3 | 47.3 | 46.0 | Neutral | 10.2 |
| 1.479 | 12 | 3.4 | 52.6 | 56.0 | 0.8 | 45.2 | 46.0 | Neutral | 10.3 |
| 1.502 | 12 | -1.2 | 57.2 | 56.0 | -4.2 | 50.2 | 46.0 | Neutral | 10.3 |
| 2.379 | 12 | 15.7 | 40.3 | 56.0 | 14.3 | 31.7 | 46.0 | Neutral | 10.3 |
| 2.792 | 13 | 33.2 | 22.8 | 56.0 | 33.0 | 13.0 | 46.0 | Neutral | 10.4 |
| 3.444 | 13 | 17.3 | 38.7 | 56.0 | 17.0 | 29.0 | 46.0 | Neutral | 10.4 |
| 6.564 | 14 | 9.7 | 50.3 | 60.0 | 7.6 | 42.4 | 50.0 | Neutral | 10.7 |
| 9.600 | 14 | 21.0 | 39.0 | 60.0 | 19.1 | 30.9 | 50.0 | Neutral | 10.9 |
| 12.476 | 15 | 45.4 | 14.6 | 60.0 | 44.8 | 5.2 | 50.0 | Neutral | 11.1 |
| 13.790 | 15 | 35.7 | 24.3 | 60.0 | 33.7 | 16.3 | 50.0 | Neutral | 11.3 |
| 13.956 | 15 | 34.9 | 25.1 | 60.0 | 31.6 | 18.4 | 50.0 | Neutral | 11.3 |
| 22.899 | 16 | 28.1 | 31.9 | 60.0 | 23.0 | 27.1 | 50.0 | Neutral | 11.9 |
| 23.147 | 16 | 28.2 | 31.8 | 60.0 | 24.1 | 25.9 | 50.0 | Neutral | 11.9 |
| 24.051 | 16 | 25.6 | 34.4 | 60.0 | 21.2 | 28.8 | 50.0 | Neutral | 11.9 |
| 29.793 | 16 | 23.2 | 36.8 | 60.0 | 19.3 | 30.7 | 50.0 | Neutral | 12.0 |

5.2 EBW and OBW

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

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 – Detailed photos see ATTACHMENT C1

5.2.3 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.

5.2.4 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;

5.2.5 Test result

| Channel | Centre frequency (MHz) | 6 dB bandwidth (MHz) | Minimum limit (MHz) |
|---------|------------------------|----------------------|---------------------|
| 11 | 2405 | 1.586 | 0.5 |
| 18 | 2440 | 1.584 | 0.5 |
| 26 | 2480 | 1.485 | 0.5 |

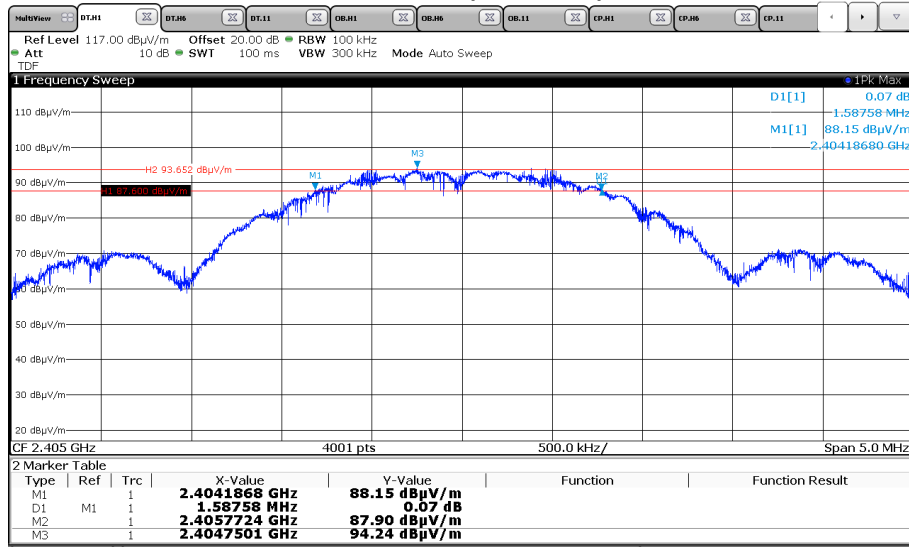
| Channel | Centre frequency (MHz) | 99 % bandwidth (MHz) |
|---------|------------------------|----------------------|
| 11 | 2405 | 2.389 |
| 18 | 2440 | 2.412 |
| 26 | 2480 | 2.411 |

The requirements are **FULFILLED**.

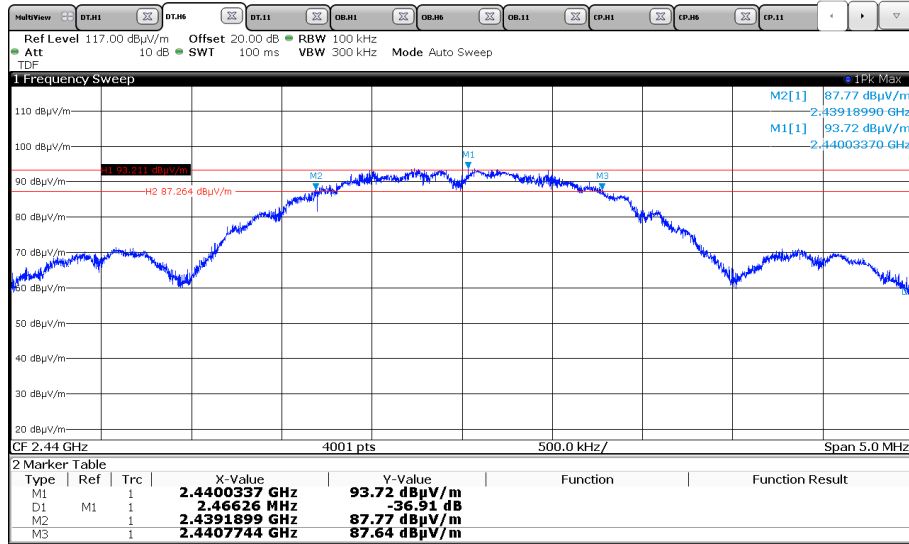
Remarks: For detailed test results please refer to following test protocols. The RSS Gen defines no limit for the occupied bandwidth!

5.2.6 Test protocols EBW

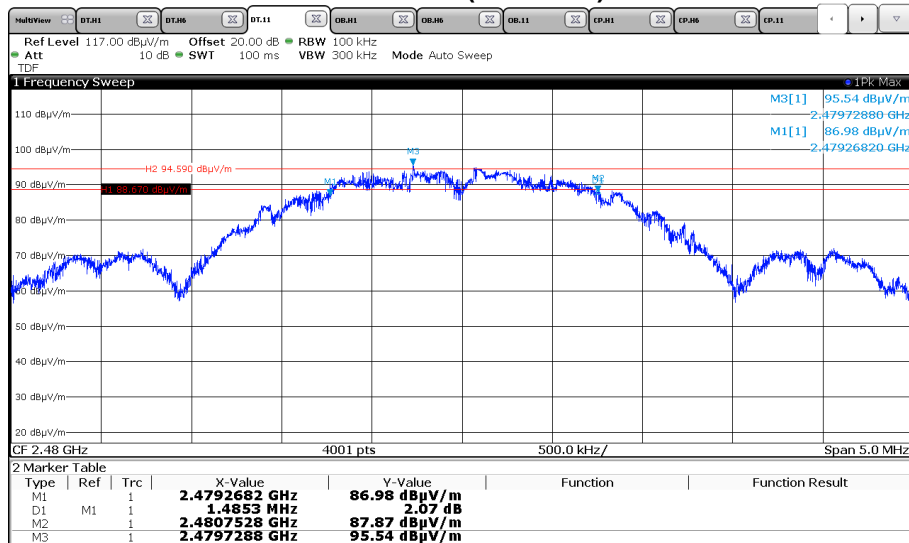
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)

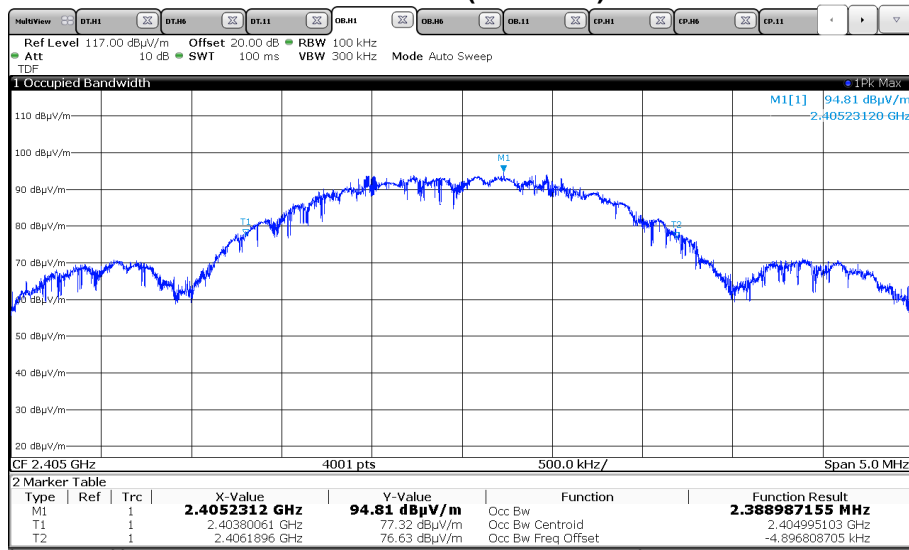


Channel 26 (2480 MHz)

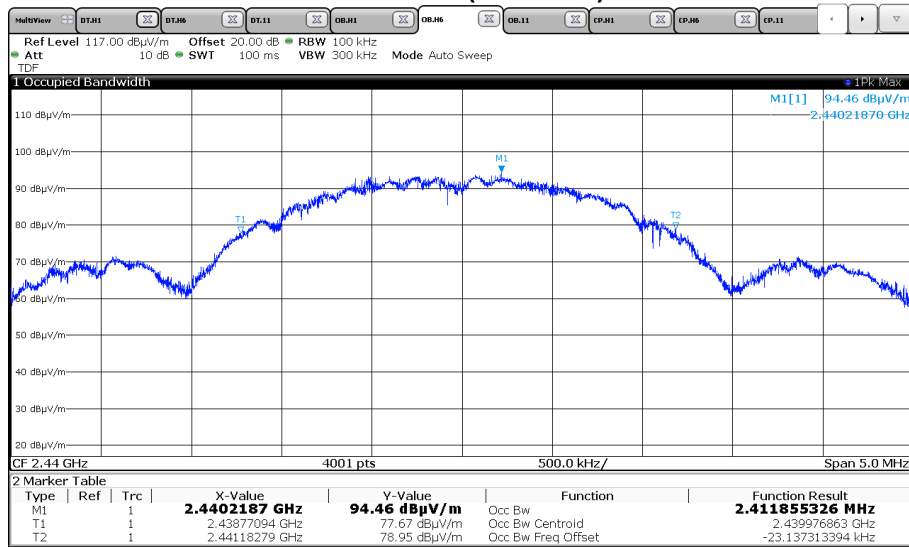


5.2.7 Test protocols OBW

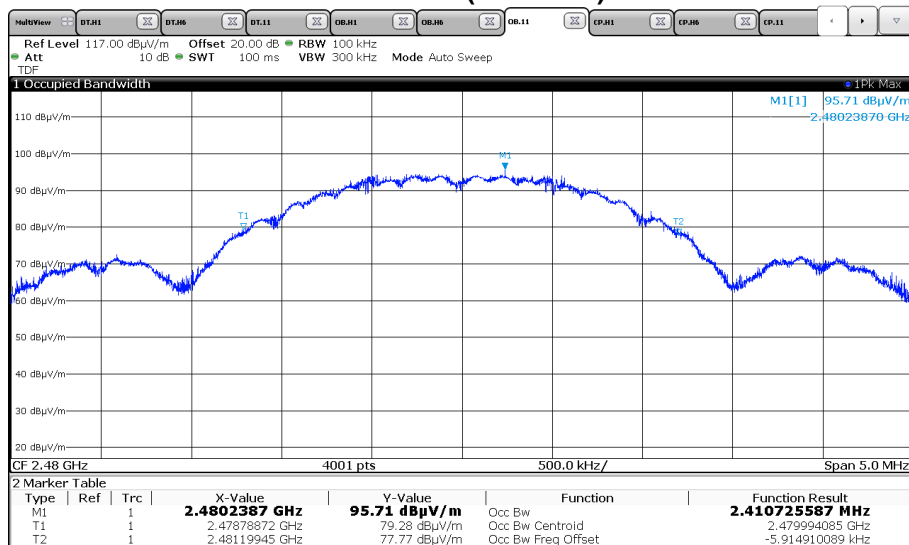
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)



Channel 26 (2480 MHz)



5.3 Maximum peak conducted output power

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

5.3.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.3.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT C1

5.3.3 Applicable standard

According to FCC Part 15, Section 15.247(b)(3):

For systems using digital modulation in the 2400 – 2483.5 MHz and 5725 – 5850 MHz bands, the maximum peak output power of the transmitter shall not exceed 1 Watt. The limit is based on transmitting antennas of directional gain that do not exceed 6 dBi.

5.3.4 Description of Measurement

The maximum peak conducted output power is measured using a spectrum analyser following the procedure set out in KDB 558074, item 9.1.1. The EUT is set in TX continuous mode while measuring.

5.3.5 Test result

| 802.15.4, 250 kbps, TX | | Test results radiated | | | |
|-------------------------|-----------|-----------------------------|---------------|---------------------|----------------|
| | | Fieldstrength E (dBμV/m) | EIRP (dBm) | EIRP Limit (dBm) | Margin (dB) |
| Lowest frequency: CH11 | | | | | |
| T_{nom} | V_{nom} | 106.2 | 10.9 | 36.0 | -25.1 |
| Middle frequency: CH18 | | | | | |
| T_{nom} | V_{nom} | 100.5 | 5.2 | 36.0 | -30.8 |
| Highest frequency: CH26 | | | | | |
| T_{nom} | V_{nom} | 102.7 | 7.4 | 36.0 | -28.6 |

| 802.15.4, 250 kbps, TX | | Test results conducted | | | | |
|-------------------------|-----------|------------------------|-----------------------|------------|------------------|----------------|
| | | EIRP (dBm) | Antenna Gain (dBi) | A (dBm) | A Limit (dBm) | Margin (dB) |
| Lowest frequency: CH11 | | | | | | |
| T_{nom} | V_{nom} | 10.9 | 2.5 | 8.4 | 30.0 | -21.6 |
| Middle frequency: CH18 | | | | | | |
| T_{nom} | V_{nom} | 5.2 | 2.5 | 2.7 | 30.0 | -27.3 |
| Highest frequency: CH26 | | | | | | |
| T_{nom} | V_{nom} | 7.4 | 2.5 | 4.9 | 30.0 | -25.1 |

FCC ID: YJKHR0GACZ4**IC: 11148A-HR0GACZ4**

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

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

The requirements are **FULFILLED**.**Remarks:**

5.4 Power spectral density

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

5.4.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.4.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT C1

5.4.3 Applicable standard

According to FCC Part 15, Section 15.247(e):

For digitally modulated systems, the power spectral density conducted 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 conducted output power shall be used to determine the power spectral density.

5.4.4 Description of Measurement

The measurement is performed using the procedure 10.2 set out in KDB-558074. 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: 10 s,

5.4.5 Test result

| 802.15.1, 1000 kbps, 1 TX | | Test results PkPSD radiated | | | |
|-----------------------------|-----------|-----------------------------|--------------------------|-------------------------|----------------|
| | | PSD [Pmax] (dBμV/m) | PSD [Pmax] (dBm/3kHz) | PSD Limit (dBm/3kHz) | Margin (dB) |
| Lowest frequency: 2405 MHz | | | | | |
| T_{nom} | V_{nom} | 99.4 | 4.2 | 14.0 | -9.8 |
| Middle frequency: 2440 MHz | | | | | |
| T_{nom} | V_{nom} | 93.5 | -1.7 | 14.0 | -15.7 |
| Highest frequency: 2480 MHz | | | | | |
| T_{nom} | V_{nom} | 95.7 | 0.5 | 14.0 | -13.5 |

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

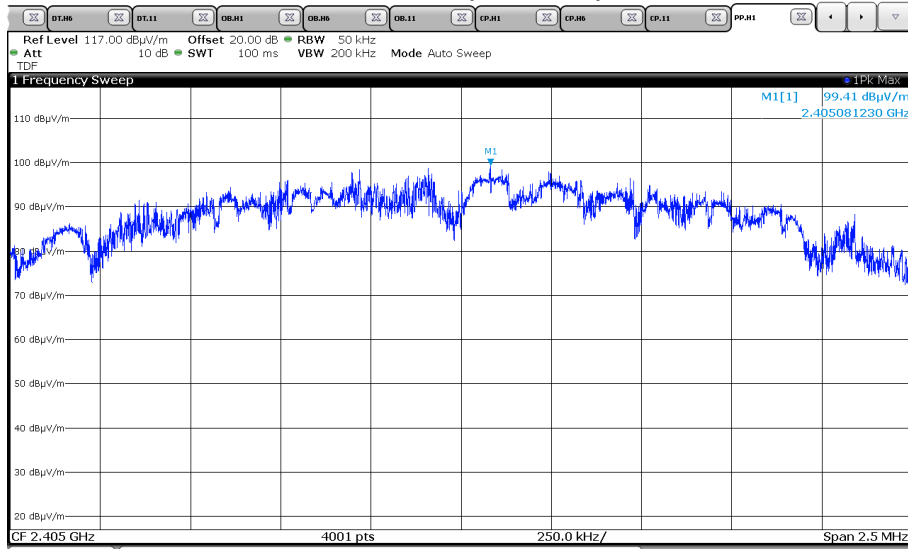
| Frequency (MHz) | Power spectral density limit |
|--------------------|------------------------------|
| | (dBm/3 kHz) |
| 2400 - 2483.5 | 8 |

The requirements are **FULFILLED**.

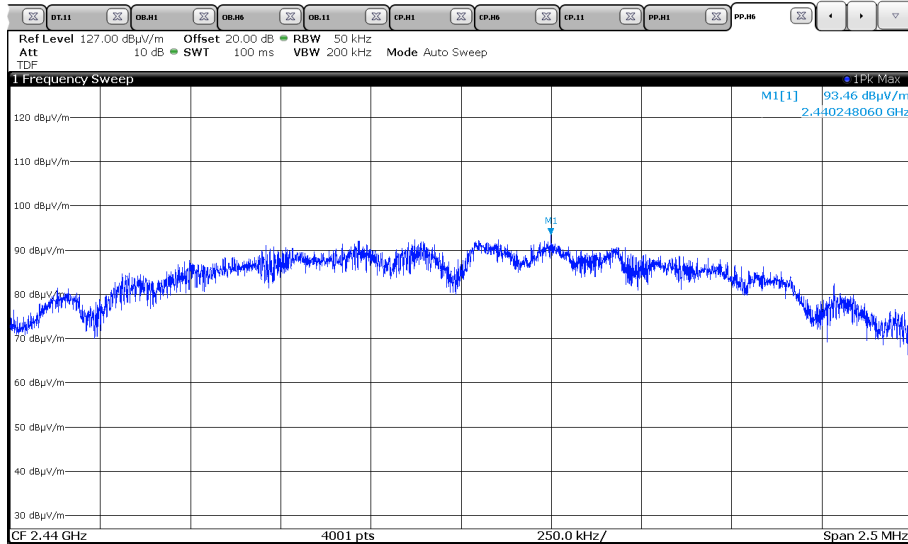
Remarks: For detailed test results please refer to following test protocols.

5.4.6 Power spectral density plots

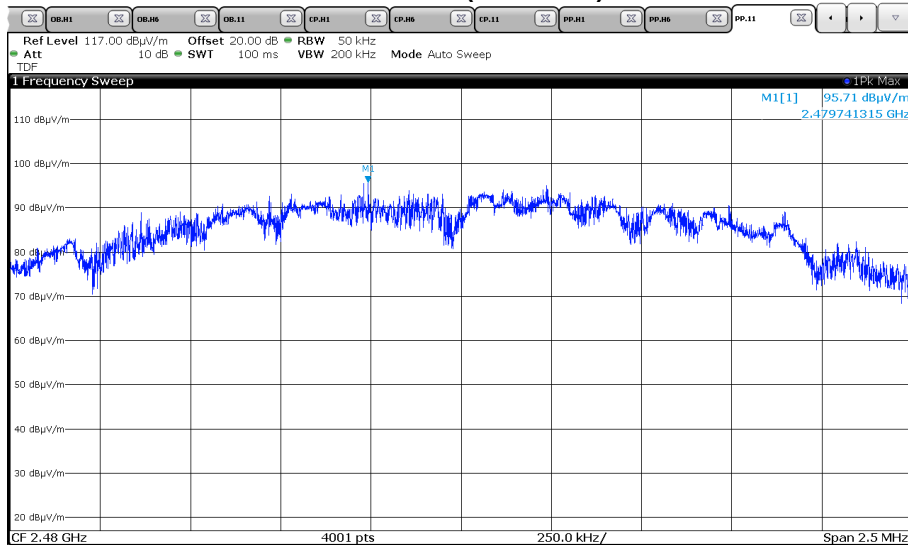
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)



Channel 26 (2480 MHz)



5.5 Unwanted emissions

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

5.5.1 Description of the test location

Test location: NONE

Remarks: Not tested, the EUT holds the general limit under FCC Part 15209. For reference level see plot
under item 5.2.7.

5.6 Unwanted emissions in restricted bands, radiated

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

5.6.1 Description of the test location

Test location: OATS 1
 Test location: Anechoic chamber 1
 Test distance: 3 m
 Test distance: 1 m, 18-26 GHz

5.6.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT C1

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).

5.6.3 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:

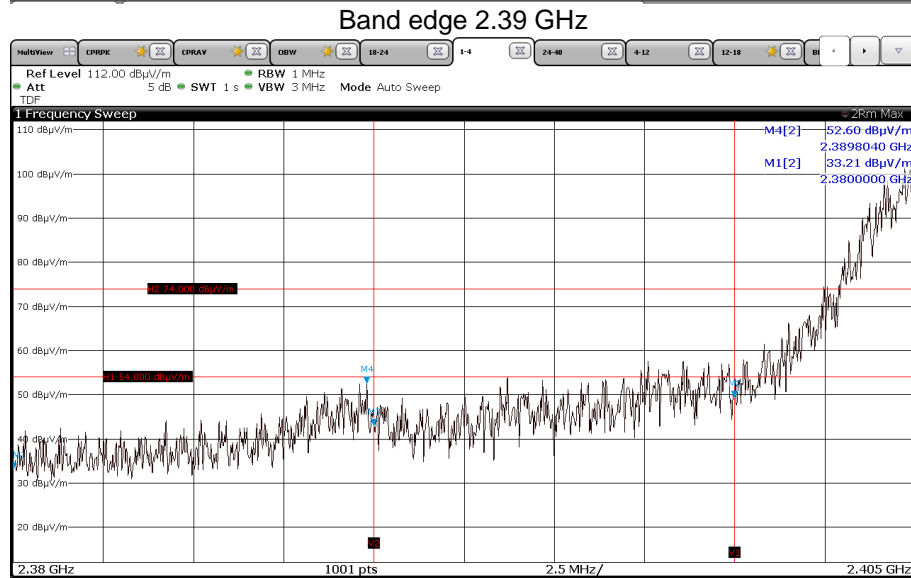
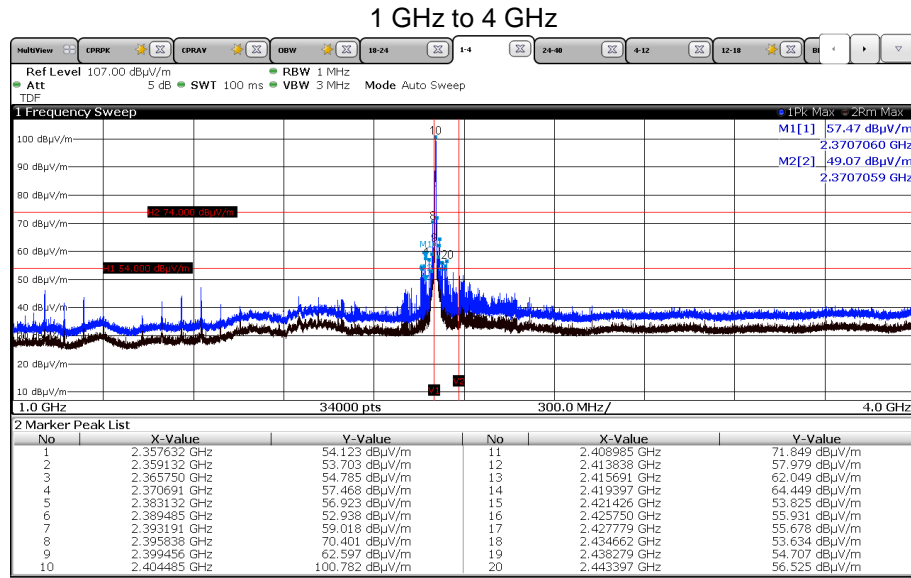
9 kHz – 150 kHz RBW: 200 Hz
 150 kHz - 30 MHz RBW: 9 kHz
 30 MHz – 1000 MHz: RBW: 120 kHz
 1000 MHz – 26 GHz: RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

5.6.1 Test result

f < 1 GHz:

| 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) |
|--------------------|----------------------------|---------------------------|---------------------------|--------------------------|----------------------------|---------------------------|-------------------|----------------|
| 296.07 | 5.6 | 10.1 | 16.7 | 16.3 | 22.3 | 26.4 | 46.0 | -19.6 |
| 715.00 | 17.9 | 9.5 | 27.4 | 26.9 | 45.3 | 36.4 | 46.0 | -0.7 |

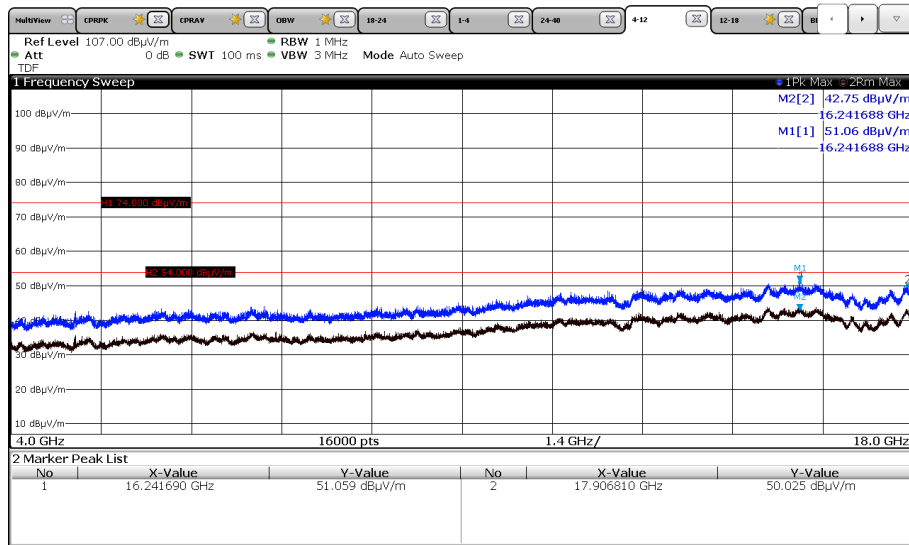
f > 1 GHz:
Ch11:



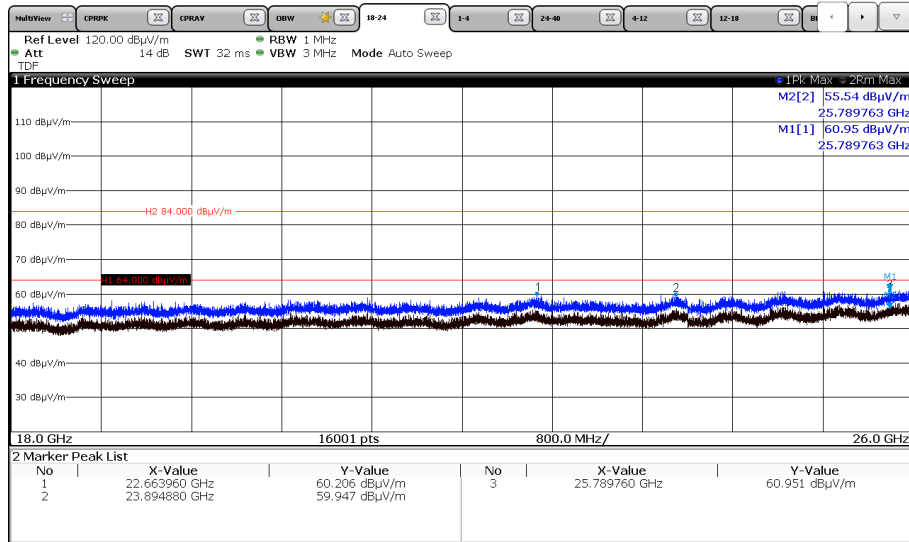
FCC ID: YJKHR0GACZ4

IC: 11148A-HR0GACZ4

4 GHz to 18 GHz

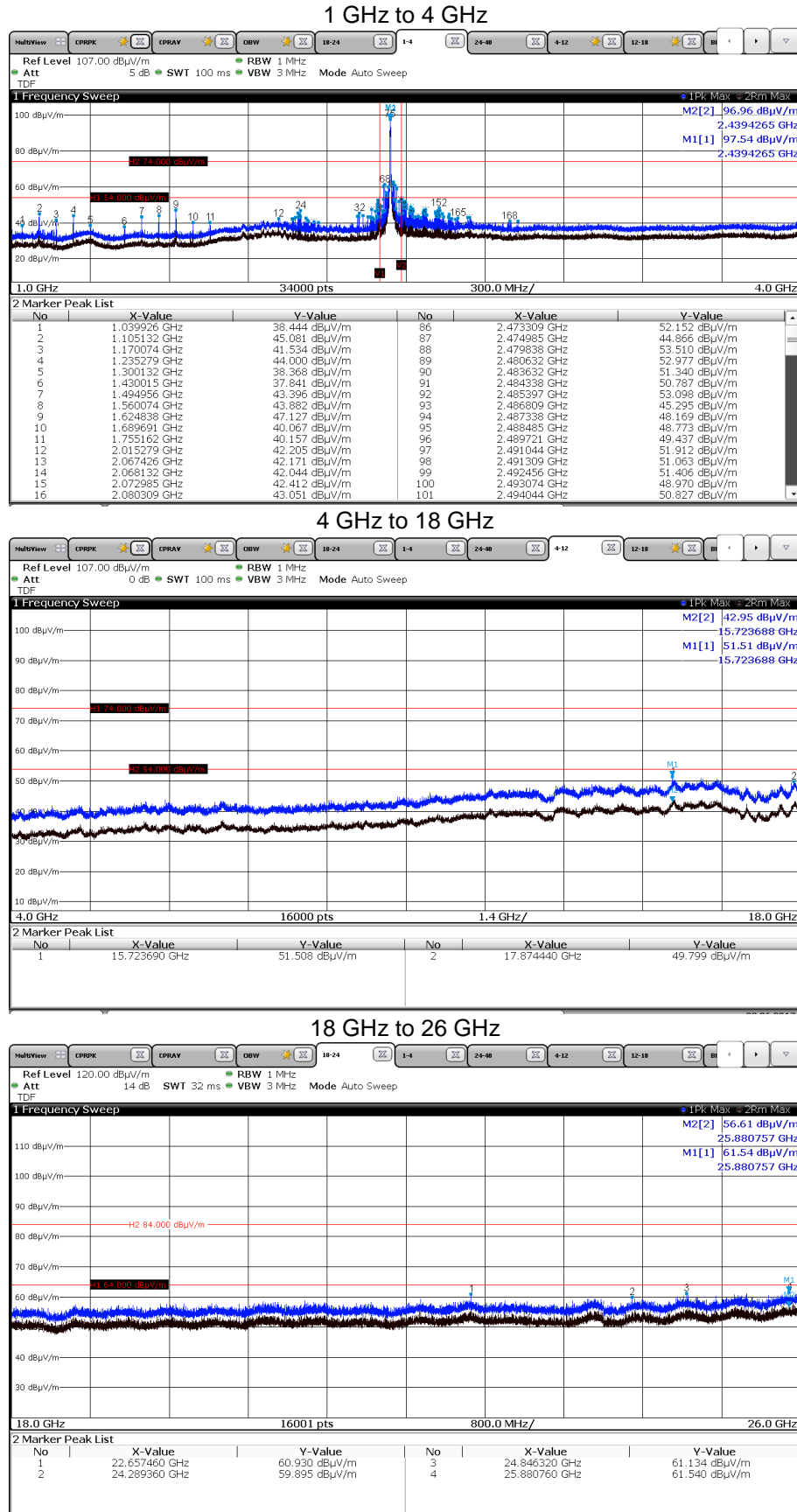


18 GHz to 26 GHz



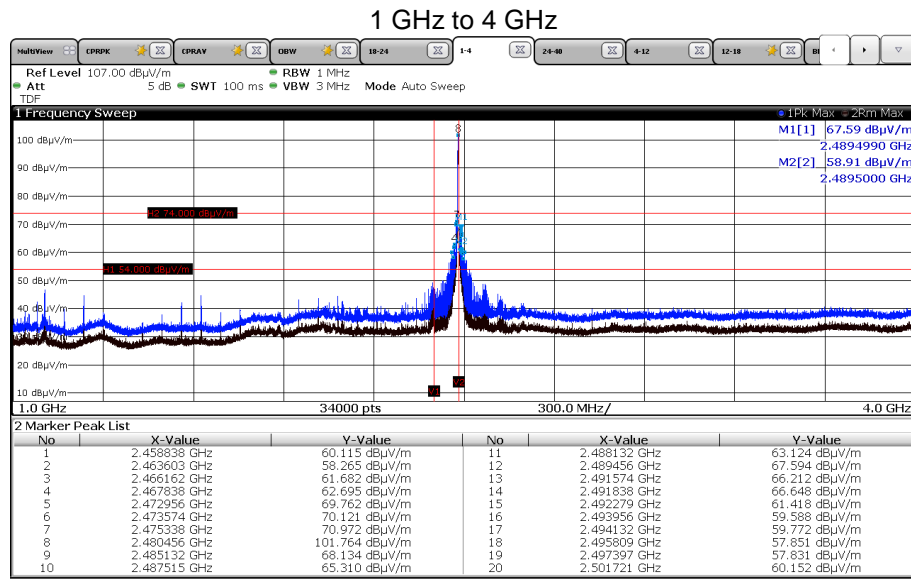
Remark: All peak emissions were below the limits of part 15.209.

Ch18:

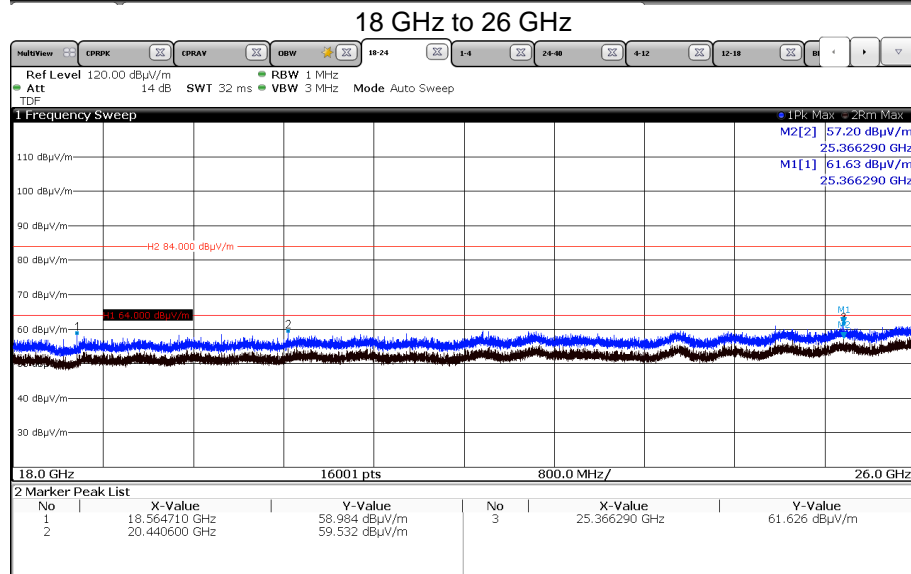
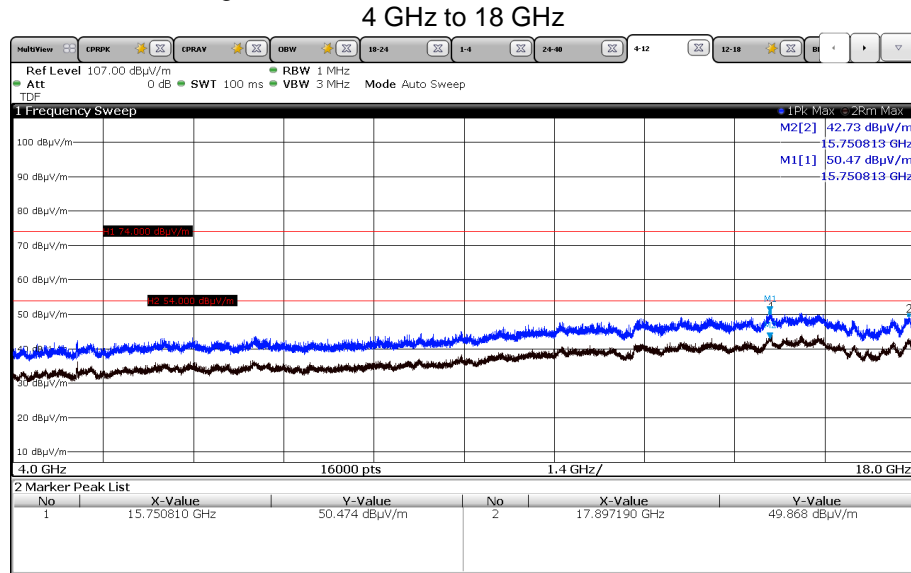


Remark: All peak emissions were below the limits of part 15.209.

Ch26:



Note: The bandedge has to be re-measured under item 5.7.



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

| Frequency (MHz) | Field strength of spurious emissions | | Measurement distance (metres) |
|--------------------|--------------------------------------|----------------|----------------------------------|
| | (μ V/m) | dB(μ V/m) | |
| 0.009-0.490 | 2400/F (kHz) | | 300 |
| 0.490-1.705 | 24000/F (kHz) | | 30 |
| 1.705-30 | 30 | 29.5 | 30 |
| 30-88 | 100 | 40 | 3 |
| 88-216 | 150 | 43.5 | 3 |
| 216-960 | 200 | 46 | 3 |
| Above 960 | 500 | 54 | 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 |

The requirements are **FULFILLED**.

Remarks: The measurement was performed up to the 10th harmonic.

5.7 Band edge compliance

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

5.7.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.7.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT C1

5.7.3 Applicable standard

According to FCC Part 15C, Section 15.247(d):

In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

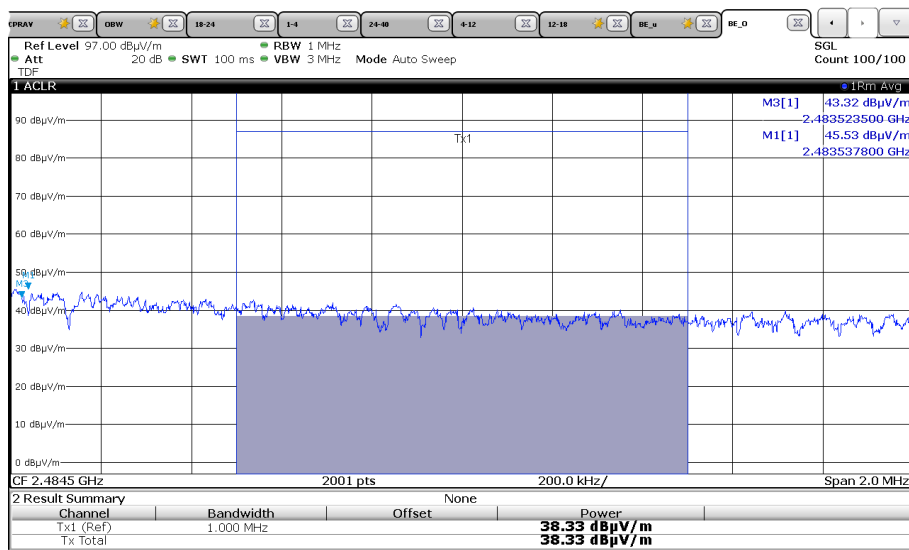
5.7.4 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT was operating in transmit mode at the assigned frequency according OET 558074, 4/5/2017.

Spectrum analyser settings:

RBW: 1 MHz, VBW: 3 MHz, Detector: RMS, Trace: AV, Count 100, Sweep: auto

5.7.5 Test result



Limit according to FCC Subpart 15.247(d):

In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limit specified in §15.209(a) (see §15.205(c)).

The requirements are **FULFILLED**.

Remarks:

5.8 Antenna application

5.8.1 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.

All supplied antennas meet the requirements of part 15.203 and 15.204.

5.8.2 Antenna requirements

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:

$$P_{out} = 30 - (G_x - 6);$$

Remarks: No defacto limit results because of antennas smaller than 6 dBi gain.

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. |
|----------------|------------------------|----------------------|--------------------|--------------------|--------------------|--------------------|
| A 4 | ESCI | 02-02/03-15-001 | 31/05/2018 | 31/05/2017 | | |
| | ESH 2 - Z 5 | 02-02/20-05-004 | 26/10/2017 | 26/10/2015 | 18/01/2018 | 18/07/2017 |
| | N-4000-BNC | 02-02/50-05-138 | | | | |
| | N-1500-N | 02-02/50-05-140 | | | | |
| | ESH 3 - Z 2 | 02-02/50-05-155 | 18/11/2019 | 18/11/2016 | 21/10/2017 | 21/04/2017 |
| CPR 3 | FSW43 | 02-02/11-15-001 | 07/04/2018 | 07/04/2017 | | |
| | JS4-18004000-30-5A | 02-02/17-05-017 | | | | |
| | AMF-6D-01002000-22-10P | 02-02/17-15-004 | | | | |
| | 3117 | 02-02/24-05-009 | 10/05/2018 | 10/05/2017 | | |
| | BBHA 9170 | 02-02/24-05-014 | 02/06/2018 | 02/06/2015 | 09/12/2017 | 09/12/2016 |
| | KMS102-0.2 m | 02-02/50-11-020 | | | | |
| | SF104/11N/11N/300MM | 02-02/50-13-008 | | | | |
| | Ultimate 1000W | 02-02/50-16-004 | | | | |
| | 18N-20 | 02-02/50-17-003 | | | | |
| | NMS111-GL200SC01-NMS11 | 02-02/50-17-012 | | | | |
| | Bandpass Filter | 02-02/50-17-019 | | | | |
| MB | FSW43 | 02-02/11-15-001 | 07/04/2018 | 07/04/2017 | | |
| | JS4-18004000-30-5A | 02-02/17-05-017 | | | | |
| | AMF-6D-01002000-22-10P | 02-02/17-15-004 | | | | |
| | 3117 | 02-02/24-05-009 | 10/05/2018 | 10/05/2017 | | |
| | BBHA 9170 | 02-02/24-05-014 | 02/06/2018 | 02/06/2015 | 09/12/2017 | 09/12/2016 |
| | KMS102-0.2 m | 02-02/50-11-020 | | | | |
| | SF104/11N/11N/300MM | 02-02/50-13-008 | | | | |
| | Ultimate 1000W | 02-02/50-16-004 | | | | |
| | 18N-20 | 02-02/50-17-003 | | | | |
| | NMS111-GL200SC01-NMS11 | 02-02/50-17-012 | | | | |
| | Bandpass Filter | 02-02/50-17-019 | | | | |
| SER 2 | ESVS 30 | 02-02/03-05-003 | 12/07/2018 | 12/07/2017 | | |
| | VULB 9168 | 02-02/24-05-005 | 12/04/2018 | 12/04/2017 | 12/10/2017 | 12/04/2017 |
| | 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 | 07/04/2018 | 07/04/2017 | | |
| | JS4-18004000-30-5A | 02-02/17-05-017 | | | | |
| | AMF-6D-01002000-22-10P | 02-02/17-15-004 | | | | |
| | 3117 | 02-02/24-05-009 | 10/05/2018 | 10/05/2017 | | |
| | BBHA 9170 | 02-02/24-05-014 | 02/06/2018 | 02/06/2015 | 09/12/2017 | 09/12/2016 |
| | KMS102-0.2 m | 02-02/50-11-020 | | | | |
| | SF104/11N/11N/300MM | 02-02/50-13-008 | | | | |
| | Ultimate 1000W | 02-02/50-16-004 | | | | |
| | 18N-20 | 02-02/50-17-003 | | | | |
| | NMS111-GL200SC01-NMS11 | 02-02/50-17-012 | | | | |
| | Bandpass Filter | 02-02/50-17-019 | | | | |