
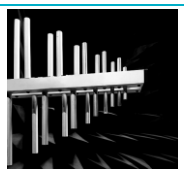
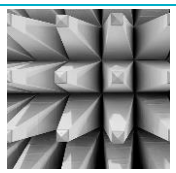

CTC advanced
member of RWTÜV group

Bundesnetzagentur

BNetzA-CAB-02/21-102

# TEST REPORT

**Test report no.: 1-1654/20-01-02-B**

## Testing laboratory


**CTC advanced GmbH**
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: https://www.ctcadvanced.com
e-mail: mail@ctcadvanced.com


**Accredited Testing Laboratory:**
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

## Applicant


**Westermo Neratec AG**
Rosswiesstrasse 29
8608 Bubikon / SWITZERLAND
Phone: +41 55 253 2078
Contact: Michael Aeschbacher
e-mail: Michael.Aeschbacher@westermo.com


## Manufacturer


**Westermo Neratec AG**
Rosswiesstrasse 29
8608 Bubikon / SWITZERLAND


## Test standard/s

| | |
|---|---|
| FCC - Title 47 CFR Part 90 | FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 90 - Private Land Mobile Radio Services |

For further applied test standards please refer to section 3 of this test report.

## Test Item

| | |
|---|---|
| **Kind of test item:** | **WLAN Accesspoint** |
| **Model name:** | **Ibex-RT-320-LV** |
| **FCC ID:** | **2AEJD-3623-0720** |
| **IC:** | **9301A-36230720** |
| Frequency: | 4940 MHz to 4990 MHz band;<br>Tested frequencies: 4950 MHz, 4965 MHz & 4980 MHz |
| Technology tested: | IEEE 802.11 a (WLAN) |
| Antenna: | two external antennas |
| Power supply: | 16.0 V to 30.0 V DC via external power supply |
| Temperature range: | -40°C to +70°C |

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

## Test report authorized:

cn=Marco Bertolino, o=CTC advanced GmbH, ou=BTL-161128, email=Marco.Bertolino@ctcadvanced.com, c=DE
2021.05.21 08:45:01 +02'00'

Marco Bertolino
Lab Manager
Radio Communications

## Test performed:

cn=David Lang, o=CTC advanced GmbH, ou=LNG-161129, email=david.lang@ctcadvanced.com, c=DE
2021.05.21 08:28:30 +02'00'

David Lang
Lab Manager
Radio Communications

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# 2 General information

## 2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CTC advanced GmbH.
The testing service provided by CTC advanced GmbH has been rendered under the current "General Terms and Conditions for CTC advanced GmbH".
CTC advanced GmbH will not be liable for any loss or damage resulting from false, inaccurate, inappropriate or incomplete product information provided by the customer.
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Under no circumstances does the CTC advanced GmbH test report include or imply any product or service warranties from CTC advanced GmbH, including, without limitation, any implied warranties of merchantability, fitness for purpose, or non-infringement, all of which are expressly disclaimed by CTC advanced GmbH.
All rights and remedies regarding vendor's products and services for which CTC advanced GmbH has prepared this test report shall be provided by the party offering such products or services and not by CTC advanced GmbH.
In no case this test report can be considered as a Letter of Approval.

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

**This test report replaces the test report with the number 1-1654/20-01-02-A and dated 2021-05-19.**

## 2.2 Application details

| | |
|---|---|
| Date of receipt of order: | 2021-01-04 |
| Date of receipt of test item: | 2021-04-07 |
| Start of test:* | 2021-04-08 |
| End of test:* | 2021-05-18 |
| Person(s) present during the test: | -/- |

*Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

## 2.3 Test laboratories sub-contracted

None

## 3 Test standard/s, references and accreditations

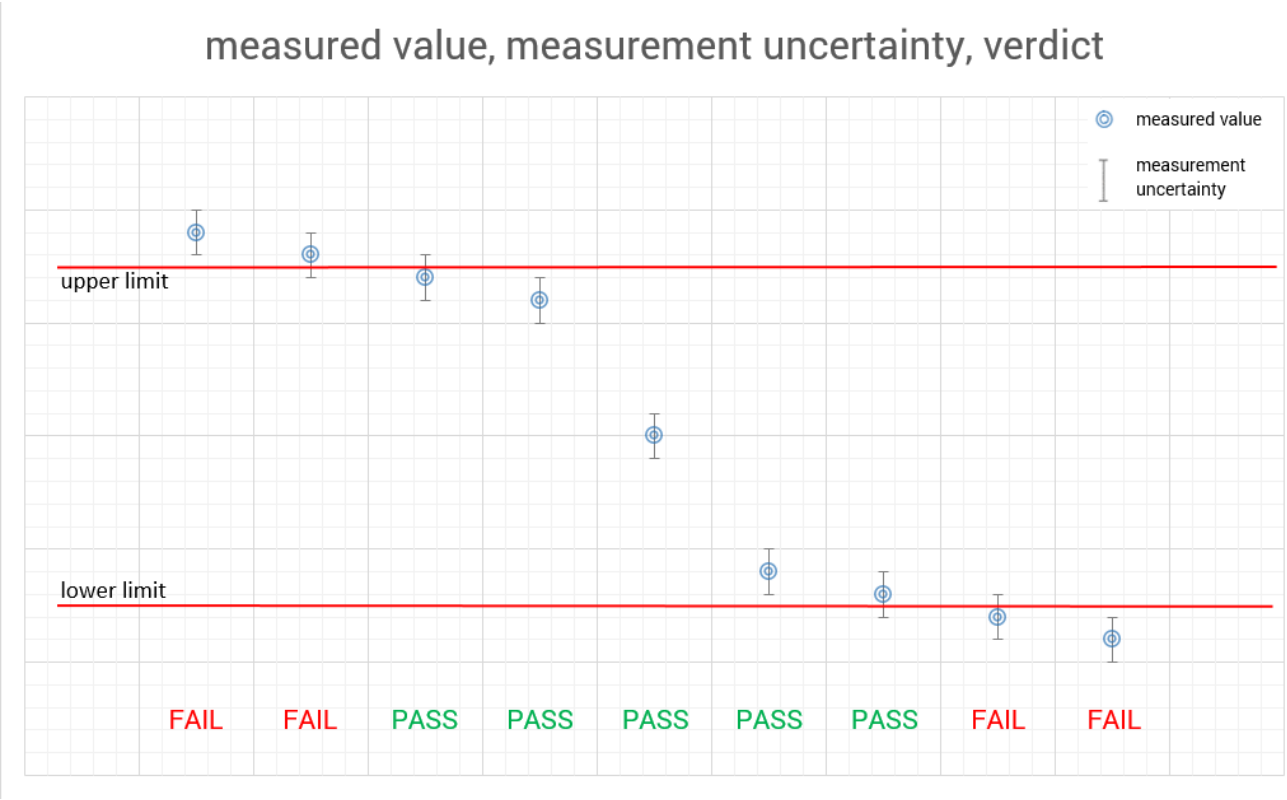
| Test standard | Date | Description |
|---|---|---|
| FCC - Title 47 CFR Part 90 | -/- | FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 90 - Private Land Mobile Radio Services |
| RSS - 111 Issue 5 | September 2014 | Broadband Public Safety Equipment Operating in the Band 4940-4990 MHz |
| RSS - Gen Issue 5 incl. Amendment 1 & 2 | February 2021 | Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus |

| Guidance | Version | Description |
|---|---|---|
| ANSI C63.26-2015 | -/- | American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services |
| SP 4940 MHz | -/- | Spectrum Utilization Policy, Technical and Licensing Requirements for Broadband Public Safety in the Band 4940–4990 MHz |

| Accreditation | Description |
|---|---|
| D-PL-12076-01-04 | Telecommunication and EMC Canada<br>https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf |
| D-PL-12076-01-05 | Telecommunication FCC requirements<br>https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf |

## 4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.
The measurement uncertainty is mentioned in this test report, see chapter 8, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



# 5 Test environment

| | | | |
|---|---|---|---|
| Temperature | : | $T_{nom}$<br>$T_{max}$<br>$T_{min}$ | +20 °C during room temperature tests<br>+70 °C during high temperature tests<br>-40 °C during low temperature tests |
| Relative humidity content | : | | 55 % |
| Barometric pressure | : | | 1021 hpa |
| Power supply | : | $V_{nom}$<br>$V_{max}$<br>$V_{min}$ | 20.0 V DC via external power supply<br>30.0 V<br>16.0 V |

# 6 Test item

## 6.1 General description

| | | |
|---|---|---|
| Kind of test item | : | WLAN Accesspoint |
| Model name | : | Ibex-RT-320-LV |
| HMN | : | -/- |
| PMN | : | Ibex-RT-320-LV |
| HVIN | : | Ibex-RT-320-LV |
| FVIN | : | 6.6 |
| S/N serial number | : | 622 |
| Hardware status | : | V02 |
| Software status | : | N/A |
| Firmware status | : | 6.6 |
| Frequency band | : | 4940 MHz to 4990 MHz band;<br>Tested frequencies: 4950 MHz, 4965 MHz & 4980 MHz |
| Type of radio transmission<br>Use of frequency spectrum | :<br>: | OFDM |
| Type of modulation | : | (D)BPSK, (D)QPSK, 16 – QAM, 64 – QAM |
| Number of channels | : | 7 |
| Antenna | : | two external antennas;<br>2x Huber and Suhner Type: 1356.17.0010, P/N 84012128 with 12 dBi antenna gain |
| Power supply | : | 16.0 V to 30.0 V DC via external power supply<br>AC Adapter: CUI INC SMI24-24-V-P6 (100-240V~50-60Hz 0.58A / 24 V DC 1A) |
| Temperature range | : | -40°C to +70°C |

## 6.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup and EUT photos are included in test report: 1-1654/20-01-01_AnnexA
1-1654/20-01-01_AnnexB
1-1654/20-01-01_AnnexD

## 7 Description of the test setup

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed. Where possible, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

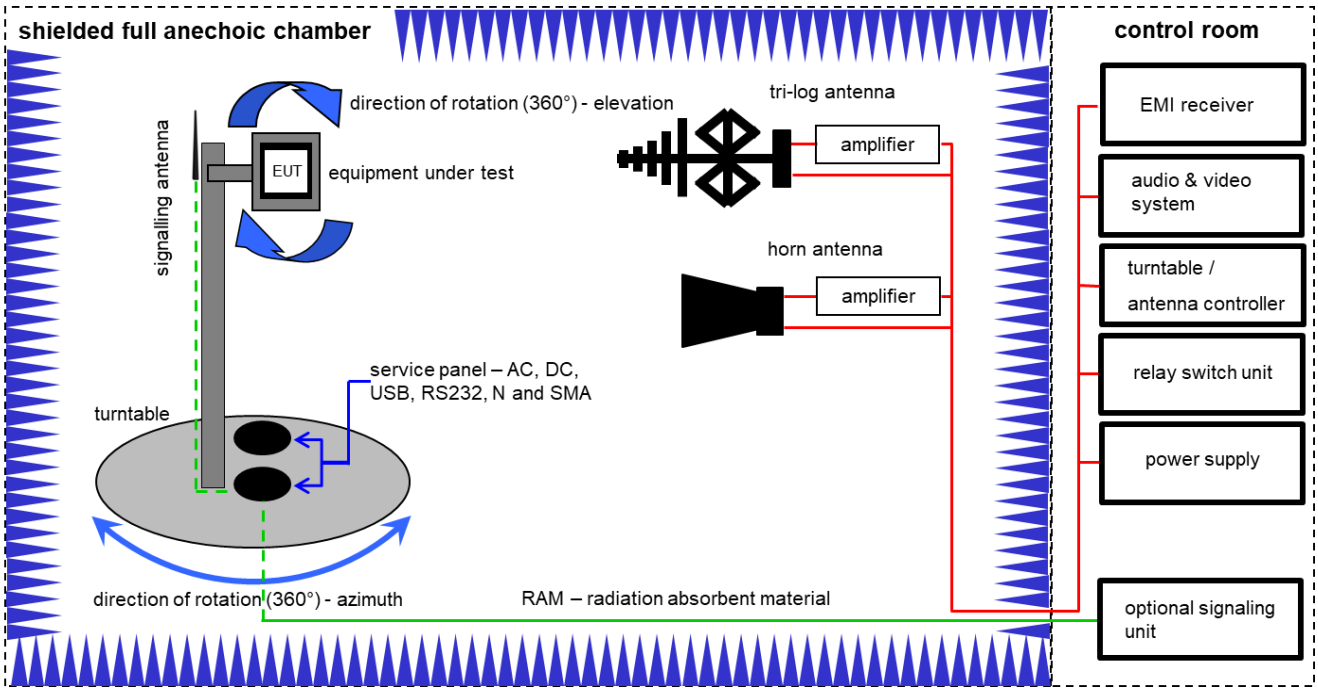
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Each block diagram listed can contain several test setup configurations. All devices belonging to a test setup are identified with the same letter syntax. For example: Column Setup and all devices with an A.

**Agenda:** Kind of Calibration

| | | | |
|---|---|---|---|
| k | calibration / calibrated | EK | limited calibration |
| ne | not required (k, ev, izw, zw not required) | zw | cyclical maintenance (external cyclical maintenance) |
| ev | periodic self verification | izw | internal cyclical maintenance |
| Ve | long-term stability recognized | g | blocked for accredited testing |
| vlkl! | Attention: extended calibration interval | | |
| NK! | Attention: not calibrated | *) | next calibration ordered / currently in progress |

## 7.1 Shielded fully anechoic chamber




Measurement distance: tri-log antenna and horn antenna 3 meter; loop antenna 3 meter

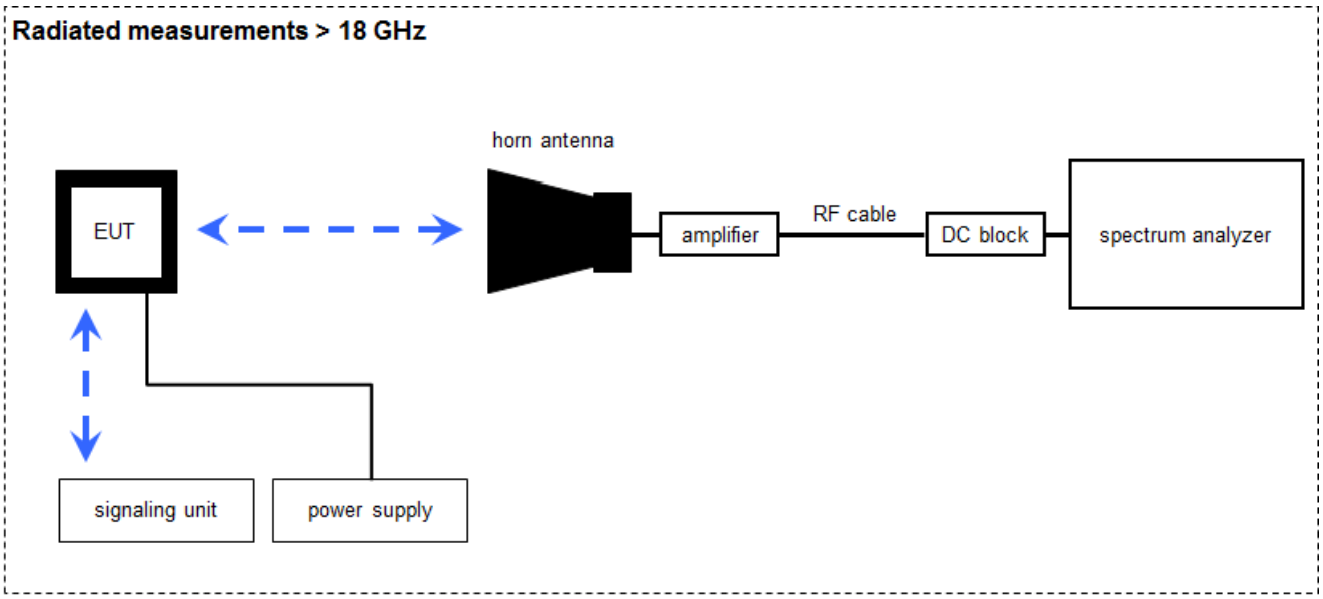
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

*Example calculation:*
OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 µW)

**Equipment table:**

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Double-Ridged Waveguide Horn Antenna 1-18.0GHz | 3115 | EMCO | 9107-3696 | 300001604 | vIKI! | 12.03.2021 | 11.03.2023 |
| 2 | A | Highpass Filter | WHK1.1/15G-10SS | Wainwright | 37 | 400000148 | ne | -/- | -/- |
| 3 | A | Highpass Filter | WHKX7.0/18G-8SS | Wainwright | 18 | 300003789 | ne | -/- | -/- |
| 4 | A | 4U RF Switch Platform | L4491A | Agilent Technologies | MY50000032 | 300004510 | ne | -/- | -/- |
| 5 | A, B | Computer | Intel Core i3 3220/3,3 GHz, Prozessor | -/- | 2V2403033A5421 | 300004591 | ne | -/- | -/- |
| 6 | A | Highpass Filter | WHKX2.6/18G-10SS | Wainwright | 12 | 300004651 | ne | -/- | -/- |
| 7 | A | NEXIO EMV-Software | BAT EMC V3.20.0.17 | EMCO | | 300004682 | ne | -/- | -/- |
| 8 | A | Anechoic chamber | | TDK | | 300003726 | ne | -/- | -/- |
| 9 | A | EMI Test Receiver 9kHz-26,5GHz | ESR26 | Rohde & Schwarz | 101376 | 300005063 | k | 09.12.2020 | 08.12.2021 |
| 10 | A | RF-Amplifier | AMF-6F06001800-30-10P-R | NARDA-MITEQ Inc | 2011571 | 300005240 | ev | -/- | -/- |
| 11 | A | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz | VULB9163 | Schwarzbeck Mess - Elektronik | 01029 | 300005379 | vIKI! | 02.07.2019 | 01.07.2021 |

## 7.2 Radiated measurements > 18 GHz




Measurement distance: horn antenna 50 cm

OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

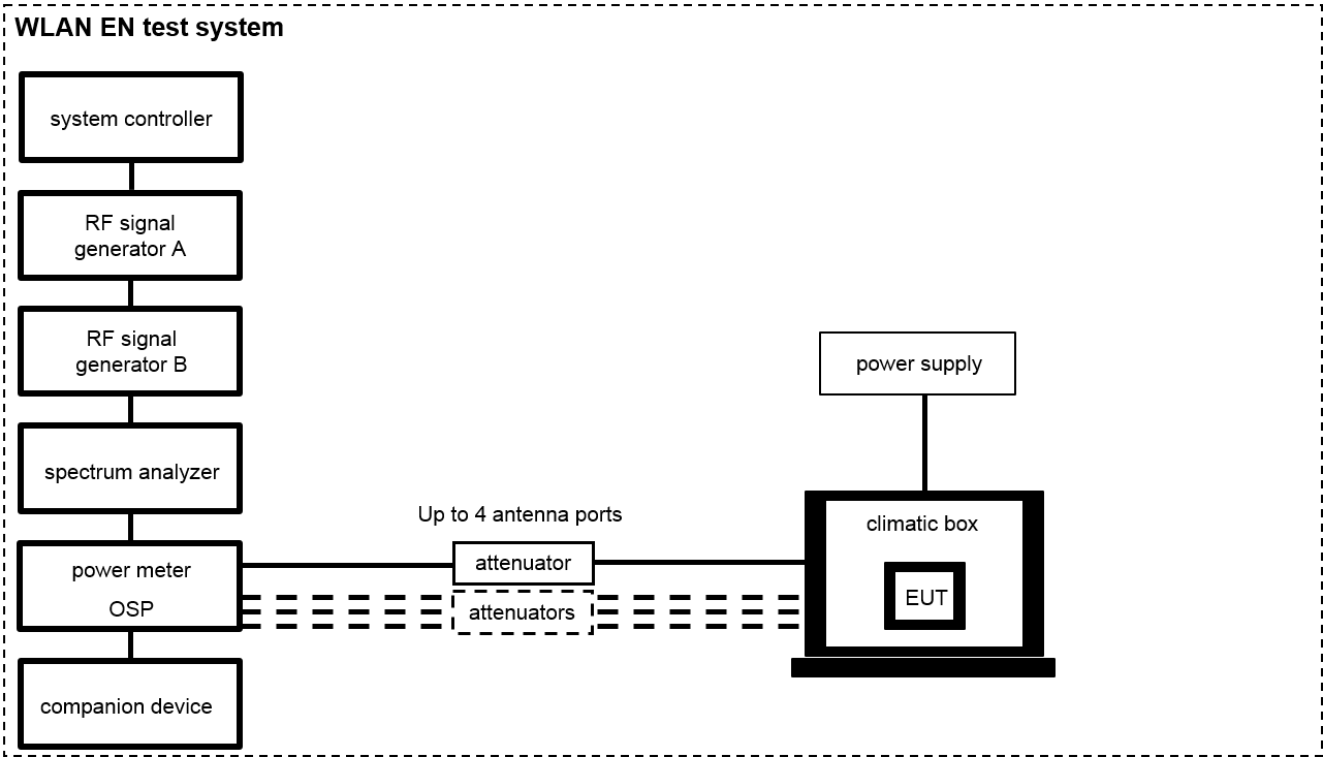
*Example calculation:*
OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

**Equipment table:**

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Synthesized Sweeper 10 MHz - 40 GHz | 83640A | HP | 3119A00458 | 300002266 | vIKI! | 13.12.2019 | 12.12.2021 |
| 2 | A | Std. Gain Horn Antenna 18.0-26.5 GHz | 638 | Narda | 01096 | 300000486 | vIKI! | 21.01.2020 | 20.01.2022 |
| 3 | A | Std. Gain Horn Antenna 26.5-40.0 GHz | V637 | Narda | 82-16 | 300000510 | vIKI! | 23.01.2020 | 22.01.2022 |
| 4 | A | Broadband Low Noise Amplifier 18-50 GHz | CBL18503070-XX | CERNEX | 19338 | 300004273 | ev | -/- | -/- |
| 5 | A | Signal Analyzer 40 GHz | FSV40 | Rohde & Schwarz | 101042 | 300004517 | k | 07.12.2020 | 06.12.2021 |
| 6 | A | RF-Cable | ST18/SMAm/SMAm /48 | Huber & Suhner | Batch no. 600918 | 400001182 | ev | -/- | -/- |
| 7 | A | DC-Blocker 0.1-40 GHz | 8141A | Inmet | | 400001185 | ev | -/- | -/- |

## 7.3 Conducted measurements WLAN EN test system

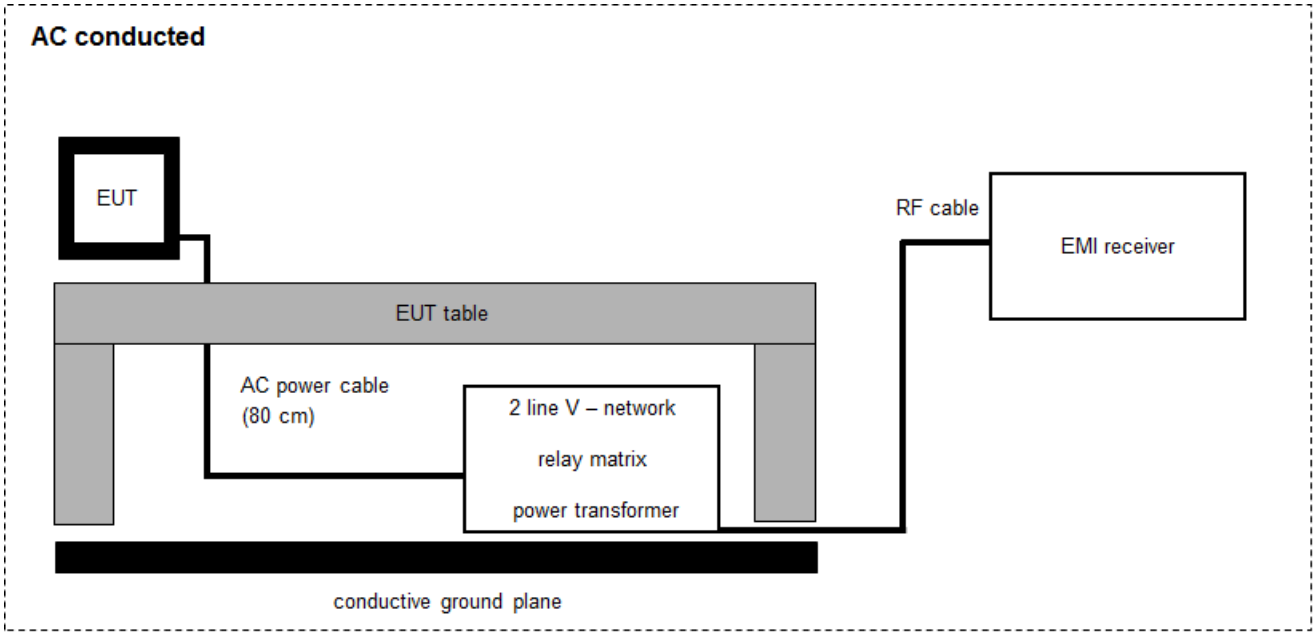
The EUT's RF signal is coupled out by the antenna connector which is supplied by the manufacturer. The signal is first 10dB attenuated before it is power divided (~6dB loss per branch). One of the signal paths is connected to the companion device, the other one is connected to the spectrum analyzer. The losses for all signal paths are first checked within a calibration. The measurement readings on the signaling unit/spectrum analyzer are corrected by the specific test set-up loss. The attenuator, power divider, signaling unit and the spectrum analyzer are impedance matched on 50 Ohm.




**Equipment table:**

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | B | Temperature Test Chamber | VT 4002 | Heraeus Voetsch | 521/84193 | 300003889 | ev | 08.05.2020 | 07.05.2022 |
| 2 | A, B | Signal Analyzer 40 GHz | FSV40 | Rohde & Schwarz | 101353 | 300004819 | k | 12.01.2021 | 11.01.2022 |
| 3 | A | Control-PC of OSP | exone Variety | | 060931P1302P 00109 | 300004869 | ne | -/- | -/- |
| 4 | A; B, C | RF-Cable WLAN-Tester Port 1 | ST18/SMAm/SMAm /36 | Huber & Suhner | Batch no. 601494 | 400001216 | g | -/- | -/- |
| 5 | A, B | RF-Cable WLAN-Tester Analyzer | ST18/SMAm/SMAm /36 | Huber & Suhner | Batch no. 54876 | 400001220 | ev | -/- | -/- |
| 6 | A, B | Tester Software RadioStar (C.BER2 for BT Conformance) | Version 1.0.0.X | CTC advanced GmbH | 0001 | 400001380 | ne | -/- | -/- |
| 7 | B | DC Power Supply | HMP2020 | Rohde & Schwarz | 102219 | 300005264 | vIKI! | 09.12.2020 | 08.12.2022 |
| 8 | C | OSP Power Sensors | OSP-B157W8 | Rohde & Schwarz | 100948 | 300005566 | k | 16.12.2020 | 15.12.2021 |

## 7.4 AC conducted emissions




FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

*Example calculation:*
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

**Equipment table:**

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Two-line V-Network (LISN) 9 kHz to 30 MHz | ESH3-Z5 | Rohde & Schwarz | 892475/017 | 300002209 | vIKI! | 11.12.2019 | 10.12.2021 |
| 2 | A | RF-Filter-section | 85420E | HP | 3427A00162 | 300002214 | NK! | -/- | -/- |
| 3 | A | EMI Test Receiver | ESCI 3 | R&S | 100083 | 300003312 | k | 09.12.2020 | 08.12.2021 |
| 4 | A | Analyzer-Reference-System (Harmonics and Flicker) | ARS 16/1 | SPS | A3509 07/0 0205 | 300003314 | vIKI! | 17.01.2020 | 16.01.2022 |
| 5 | A | Hochpass 150 kHz | EZ-25 | R&S | 100010 | 300003798 | ev | -/- | -/- |
| 6 | A | PC | TecLine | F+W | | 300003532 | ne | -/- | -/- |

# 8 Measurement uncertainty

| Measurement uncertainty | | |
|---|---|---|
| **Test case** | **Uncertainty** | |
| Antenna gain | ± 3 dB | |
| Power spectral density | ± 1.56 dB | |
| DTS bandwidth | ± 100 kHz (depends on the used RBW) | |
| Occupied bandwidth | ± 100 kHz (depends on the used RBW) | |
| Maximum output power conducted | ± 1.56 dB | |
| Detailed spurious emissions @ the band edge - conducted | ± 1.56 dB | |
| Band edge compliance radiated | ± 3 dB | |
| Spurious emissions conducted | > 3.6 GHz | ± 1.56 dB |
| | > 7 GHz | ± 1.56 dB |
| | > 18 GHz | ± 2.31 dB |
| | ≥ 40 GHz | ± 2.97 dB |
| Spurious emissions radiated below 30 MHz | ± 3 dB | |
| Spurious emissions radiated 30 MHz to 1 GHz | ± 3 dB | |
| Spurious emissions radiated 1 GHz to 12.75 GHz | ± 3.7 dB | |
| Spurious emissions radiated above 12.75 GHz | ± 4.5 dB | |
| Spurious emissions conducted below 30 MHz (AC conducted) | ± 2.6 dB | |

# 9 Summary of measurement results

| | |
|---|---|
| ☒ | No deviations from the technical specifications were ascertained |
| ☐ | There were deviations from the technical specifications ascertained |
| ☐ | This test report is only a partial test report.<br>The content and verdict of the performed test cases are listed below. |

| TC Identifier | Description | Verdict | Date | Remark |
|---|---|---|---|---|
| RF-Testing | CFR Part 2, CFR Part 90,<br>RSS-111 | See table! | 2021-05-21 | -/- |

| Test specification clause | Test case | Guideline | Temperature conditions | Power source voltages | Mode | C | NC | NA | NP | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| | Antenna gain | -/- | -/- | -/- | OFDM | Declared by manufacturer | | | | -/- |
| §2.1049,<br>RSS-111 5.2 | Occupied Bandwidth | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.1215 (a)(1),<br>§90.1215 (c),<br>RSS-111 4.1 | Output Power | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.1215 (a)(2),<br>§90.1215 (d),<br>RSS-111 4.2 | Power Spectral Density | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.1215 (e),<br>RSS-111 5.4 | Ratio of Peak Excursion | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.210,<br>RSS-111 4.3 | Emission masks | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.213,<br>RSS-111 5.2 | Frequency Stability | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.209,<br>§90.1213 | Bandwidth limitations | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §90.210,<br>RSS-111 4.3 | TX spurious emissions rad. 30 MHz to 40 GHz | | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.107(a)<br>§15.207 | Conducted emissions < 30 MHz | -/- | Nominal | Nominal | OFDM | ☒ | ☐ | ☐ | ☐ | -/- |

**Notes:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **C** | Compliant | **NC** | Not compliant | **NA** | Not applicable | **NP** | Not performed |

## 10 Additional information and comments

Reference documents: Configuration_Instruction_RT-320-LV.pdf (2021-01-08)

Co-applicable documents: 1-1654_20-01-02_Annex_MR_A1.pdf
1-1654_20-01-02_Annex_MR_A2.pdf

Special test descriptions: None

Configuration descriptions: Data rate and power setting used for testing:

| Modulation / Data rate | Power setting (tp) |
|---|---|
| IEEE 802.11a / 6 Mbit,s | 13 |

EUT selection: ☒ Only one device available

☐ Devices selected by the customer

☐ Devices selected by the laboratory (Randomly)

Provided channels:

Channels with 20 MHz channel bandwidth:

| Center Frequency (MHz) | Channel Nos. employed | Lower Frequency (MHz) | Upper Frequency (MHz) |
|---|---|---|---|
| **4950** | **1 to 8*** | **4940** | **4960** |
| 4955 | 6 to 9 | 4945 | 4965 |
| 4960 | 7 to 10 | 4950 | 4970 |
| **4965** | **8 to 11** | **4955** | **4975** |
| 4970 | 9 to 12 | 4960 | 4980 |
| 4975 | 10 to 13 | 4965 | 4985 |
| **4980** | **11 to 18*** | **4970** | **4990** |

Note: The frequencies used for the tests are marked in bold in the list.

## 11 Additional EUT parameter

| | | |
|---|---|---|
| Test mode: | ☐ | No test mode available<br>Iperf was used to ping another device with the largest support packet size |
| | ☒ | Test mode available<br>Special software is used.<br>EUT is transmitting pseudo random data by itself |
| Modulation types: | ☒ | Wide Band Modulation (None Hopping – e.g. DSSS, OFDM) |
| | ☐ | Frequency Hopping Spread Spectrum (FHSS) |
| Antennas and transmit operating modes: | ☒ | Operating mode 1 (single antenna)<br>- *Equipment with 1 antenna,*<br>- *Equipment with 2 diversity antennas operating in switched diversity mode by which at any moment in time only 1 antenna is used,*<br>- *Smart antenna system with 2 or more transmit/receive chains, but operating in a mode where only 1 transmit/receive chain is used)* |
| | ☐ | Operating mode 2 (multiple antennas, no beamforming)<br>- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously but without beamforming.* |
| | ☐ | Operating mode 3 (multiple antennas, with beamforming)<br>- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously with beamforming.*<br>*In addition to the antenna assembly gain (G), the beamforming gain (Y) may have to be taken into account when performing the measurements.* |

# 12 Measurement results

## 12.1 Antenna gain

As declared by manufacturer (see referenced documents).

## 12.2 Identify worst case data rate

**Description:**

All modes of the module will be measured with an average power meter or spectrum analyzer to identify the maximum transmission power.

In further tests only the identified worst case modulation scheme or bandwidth will be measured and this mode is used as representative mode for all other modulation schemes.

**Measurement:**

| Measurement parameter | |
|---|---|
| RMS Power Sensor | |
| Test setup | See chapter 7.3 C |
| Measurement uncertainty | See chapter 8 |

**Results:**

| Modulation (Data rate) / Output Power @ 4965 MHz (dBm) | |
|---|---|
| OFDM / a – mode / 6Mbit/s | **10.83*** |
| OFDM / a – mode / 9Mbit/s | 10.77 |
| OFDM / a – mode / 12Mbit/s | 10.69 |
| OFDM / a – mode / 18Mbit/s | 10.30 |
| OFDM / a – mode / 24Mbit/s | 10.30 |
| OFDM / a – mode / 36Mbit/s | 10.08 |
| OFDM / a – mode / 48Mbit/s | 9.90 |
| OFDM / a – mode / 54Mbit/s | 9.76 |

Note:
*Based on the highest output power over all data rates 6Mbit/s mode was used to perform the measurements.

No path loss data applied to the above values. Relative measurements for worst case data rate identification.

## 12.3 Occupied Bandwidth – 99% Emission Bandwidth

**Description:**

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Span | 30 MHz / 50 MHz |
| Measurement procedure | Measurement of the 99% bandwidth using the integration function of the analyzer |
| Trace mode | Single count with 2500 counts |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~ §90.209 Bandwidth limitations / 99%BW - 6 MBit/s OFDM |
| Test setup | See chapter 7.3 A |
| Measurement uncertainty | See chapter 8 |

**Usage:**

| FCC | ISED |
|---|---|
| The OBW of the transmitter must remain within the borders of the frequency band as specified. | |

**Results:**

| antenna port 1 | 99% emission bandwidth / kHz | | |
|---|---|---|---|
| | lowest channel | middle channel | highest channel |
| OFDM / a – mode | 18669 | 18741 | 18741 |

**Plots:** See external result files

## 12.4 Transmitter Output Power

**Description:**

Measurement of the maximum conducted RMS output power. The measurements are performed using the data rate identified in the previous chapter.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector: | RMS |
| Sweep time: | ≥10*(swp points)*(total on/off time) |
| Resolution bandwidth: | 1 MHz |
| Video bandwidth: | ≥ 3 MHz |
| Span: | > EBW |
| Trace mode: | Max hold |
| Analyzer function | Band power / channel power<br>Interval > 99% OBW |
| Used test setup: | See chapter 7.3 A |
| Measurement uncertainty: | See chapter 8 |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~<br>§90.205 Output Power and Power Density - 6 MBit/s OFDM<br>1-1654_20-01-02_Annex_MR_A2.pdf ~<br>§90.205 Output Power and Power Density - 6 MBit/s OFDM |

**Limits:**

| FCC / ISED | | |
|---|---|---|
| **Channel bandwidth (MHz)** | **Low power maximum conducted output power (dBm)** | **High power maximum conducted output power (dBm)** |
| 1 | 7 | 20 |
| 5 | 14 | 27 |
| 10 | 17 | 30 |
| 15 | 18.8 | 31.8 |
| **20** | **20** | 33 |
| Conducted limit with an gain of 12 dBi = **17 dBm** | | |

Note:
As per §90.1215 (a) (2) and SP4940 (7) the declared antenna gain of 12 dBi results in a reduced conducted output power limit of 17 dBm (20 dBm – (12dBi – 9 dBi)).
A Duty Cycle correction factor of 10 x log (0.969) = 0.13dB is considered in the subsequent results.

**Results:**

| antenna port 1 | maximum output power / dBm | | |
|---|---|---|---|
| | lowest channel | middle channel | highest channel |
| Output power conducted OFDM / a – mode | 11.61 | 10.95 | 11.5 |

| antenna port 2 | maximum output power / dBm | | |
|---|---|---|---|
| | lowest channel | middle channel | highest channel |
| Output power conducted OFDM / a – mode | 12.06 | 12.63 | 11.72 |

| antenna port 1 + 2 calculated | maximum output power / dBm | | |
|---|---|---|---|
| | lowest channel | middle channel | highest channel |
| Output power conducted OFDM / a – mode | 14.85 | 14.88 | 14.62 |

**Plots:** See external result files

## 12.5 Power Spectral Density

**Description:**

Measurement of the peak power spectral density of a digital modulated system. The PSD shows the strength of the variations as a function of the frequency. The measurement is repeated for both modulations at the lowest, middle and highest channel.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | RMS (ISED) / Peak (FCC) - calculated |
| Sweep time | 60s |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Span | > 1.5 x 99% BW |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~ §90.205 Output Power and Power Density - 6 MBit/s OFDM<br>1-1654_20-01-02_Annex_MR_A2.pdf ~ §90.205 Output Power and Power Density - 6 MBit/s OFDM |
| Test setup | See chapter 7.3 A |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| FCC / ISED | |
|---|---|
| **Low power maximum conducted output power (dBm)** | **High power maximum conducted output power (dBm)** |
| 8 dBm / MHz | 21 dBm / MHz |
| Conducted limit with an gain of 12 dBi = **5 dBm / MHz** | |

Note:
As per §90.1215 (a) (2) and SP4940 (7) the declared antenna gain of 12 dBi results in a reduced conducted output power limit of 5 dBm/MHz (8 dBm/MHz – (12dBi – 9 dBi)).

**Results:** antenna port 1

| measured | power spectral density (dBm / MHz) | | |
|---|---|---|---|
| | Lowest channel | Middle channel | Highest channel |
| OFDM / a – mode (RMS) | 0.1 | -0.4 | 0.2 |

**Results:** antenna port 2

| measured | power spectral density (dBm / MHz) | | |
|---|---|---|---|
| | Lowest channel | Middle channel | Highest channel |
| OFDM / a – mode (RMS) | 0.8 | 1.4 | 0.2 |

**Results:** antenna port 1 + 2 (sum power)

| calculated | power spectral density (dBm / MHz) | | |
|---|---|---|---|
| | Lowest channel | Middle channel | Highest channel |
| OFDM / a – mode (RMS) | 3.5 | 3.6 | 3.2 |

**Plots:** See external result files

## 12.6 Ratio of Peak Excursion

**Description:**

The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the maximum conducted output power shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | RMS / Peak |
| Sweep time | 60s |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Span | > 1.5 x 99% BW |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~ §90.1215(e) Peak Excursion - 6 MBit/s OFDM |
| Test setup | See chapter 7.3 A |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| Low power maximum conducted output power (dBm) | High power maximum conducted output power (dBm) |
|---|---|
| **FCC / ISED** | |
| 13 dB across any 1 MHz bandwidth | |

**Results:** antenna port 1

| measured | power spectral density (dBm / MHz) | | |
|---|---|---|---|
| | Lowest channel | Middle channel | Highest channel |
| OFDM / a – mode (Peak) | 10.3 | 10.2 | 10.5 |
| OFDM / a – mode (RMS) | 0.1 | - 0.4 | 0.2 |
| Peak to RMS Ratio | **10.2** | **10.6** | **10.3** |

**Results:** antenna port 2

| measured | power spectral density (dBm / MHz) | | |
|---|---|---|---|
| | Lowest channel | Middle channel | Highest channel |
| OFDM / a – mode (Peak) | 11.0 | 12.0 | 10.5 |
| OFDM / a – mode (RMS) | 0.8 | 1.4 | 0.2 |
| Peak to RMS Ratio | **10.2** | **10.6** | **10.3** |

**Plots:** See external result files

## 12.7 Emission Mask

**Description:**

The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | RMS |
| Sweep time | 30s |
| Resolution bandwidth | 200 kHz |
| Video bandwidth | 500 kHz |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~ §90.210 Emission masks - 6 MBit/s OFDM,<br><br>1-1654_20-01-02_Annex_MR_A2.pdf ~ §90.210 Emission masks - 6 MBit/s OFDM |
| Test setup | See chapter 7.3 A |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| FCC and ISED |
|---|
| For high power transmitters (greater that 20 dBm) operating in the 4940-4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows: |
| On any frequency removed from the assigned frequency between 0-45% of the authorized bandwidth (BW): 0 dB.<br>On any frequency removed from the assigned frequency between 45-50% of the authorized bandwidth: 568 log (% of (BW)/45) dB.<br>On any frequency removed from the assigned frequency between 50-55% of the authorized bandwidth: 26 + 145 log (% of BW/50) dB.<br>On any frequency removed from the assigned frequency between 55-100% of the authorized bandwidth: 32 + 31 log (% of (BW)/55) dB.<br>On any frequency removed from the assigned frequency between 100-150% of the authorized bandwidth: 40 + 57 log (% of (BW)/100) dB.<br>On any frequency removed from the assigned frequency between above 150% of the authorized bandwidth: 50 dB or 55 + 10 log (P) dB, whichever is the lesser attenuation.<br><br>Where (P) is the output power in watts. |

**Plots:** See external result files

## 12.8 Frequency Stability

**Description:**

Frequency Stability vs. Temperature: The equipment under test was connected to an external AC power supply and the RF output was connected to the Spectrum Analyzer. The EUT was placed inside the temperature chamber.

After the temperature stabilized for approximately 20 minutes, the frequency output was recorded from the Spectrum Analyzer.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 300 Hz |
| Video bandwidth | 300 Hz |
| Span | 200 kHz |
| Test setup | See chapter 7.3 B |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| FCC |
|---|
| As per footnote [10]<br>Except for DSRCS equipment in the 5850-5925 MHz band, frequency stability is to be specified in the station authorization. Frequency stability for DSRCS equipment in the 5850-5925 MHz band is specified in subpart M of the applicable standard. |

| ISED |
|---|
| The applicant shall ensure frequency stability by showing that the occupied bandwidth is maintained within the band of operation when tested at the temperature and supply voltage variations specified for the frequency stability measurement. |

**Results:** antenna port 1

| OFDM / a – mode @ 4965 MHz | Frequency Deviation | |
|---|---|---|
| **Temperature (°C)** | Deviation (kHz) | Deviation (ppm) |
| 70 | 11 | 2 |
| 60 | 21 | 4 |
| 50 | 27 | 5 |
| 40 | 24 | 5 |
| 30 | 19 | 4 |
| 20 | 5 | 1 |
| 10 | 16 | 3 |
| 0 | 35 | 7 |
| -10 | 50 | 10 |
| -20 | **53*** | **11** |
| -30 | 51 | 10 |
| -40 | 44 | 9 |

| OFDM / a – mode @ 4965 MHz | Frequency Deviation | |
|---|---|---|
| **Voltage DC (V)** | Deviation (kHz) | Deviation (ppm) |
| 20.4 (85% of Vnom) | 18 | 4 |
| 27.6 (115% of Vnom) | 17 | 3 |

* Maximum frequency devaiation

Note: Adding the maximum determined frequency deviation of **53 kHz** to the outermost frequencies of the emission bandwidth reported in section 13.3 (Occupied Bandwidth) shows that under all environmental conditions the emission bandwidth of the transmitter remains within the assigned frequency and channel.

## 12.9 Spurious Emissions at Antenna Terminals

**Description:**

The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | RMS |
| Sweep time | 600s |
| Resolution bandwidth | 200 kHz |
| Video bandwidth | 30 kHz |
| External result file(s) | 1-1654_20-01-02_Annex_MR_A1.pdf ~ §2.1051 / §90.210 Spurious emissions at antenna terminals - 6 MBit/s OFDM<br><br>1-1654_20-01-02_Annex_MR_A2.pdf ~ §2.1051 / §90.210 Spurious emissions at antenna terminals - 6 MBit/s OFDM |
| Test setup | See chapter 7.3 |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| FCC / ISED<br>For high power transmitters (greater that 20 dBm) operating in the 4940-4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows: |
|---|
| On any frequency removed from the assigned frequency between above 150% of the authorized bandwidth: 50 dB or 55 + 10 log (P) dB, whichever is the lesser attenuation.<br><br>Where (P) is the output power in watts. |

**Plots:** See external result files

## 12.10 Spurious Emissions (radiated above 30 MHz))

**Description:**

The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | Peak / RMS |
| Sweep time | Auto |
| Resolution bandwidth | 200 kHz |
| Video bandwidth | 30 kHz |
| Span | 30 MHz to 40 GHz |
| Trace mode | Max Hold |
| Test setup | See chapter 7.1 A & 7.2 A |
| Measurement uncertainty | See chapter 8 |

**Limits:**

| FCC |
|---|
| For high power transmitters (greater that 20 dBm) operating in the 4940-4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows: |
| On any frequency removed from the assigned frequency between above 150% of the authorized bandwidth: 50 dB or 55 + 10 log (P) dB, whichever is the lesser attenuation.<br><br>Where (P) is the output power in watts. |

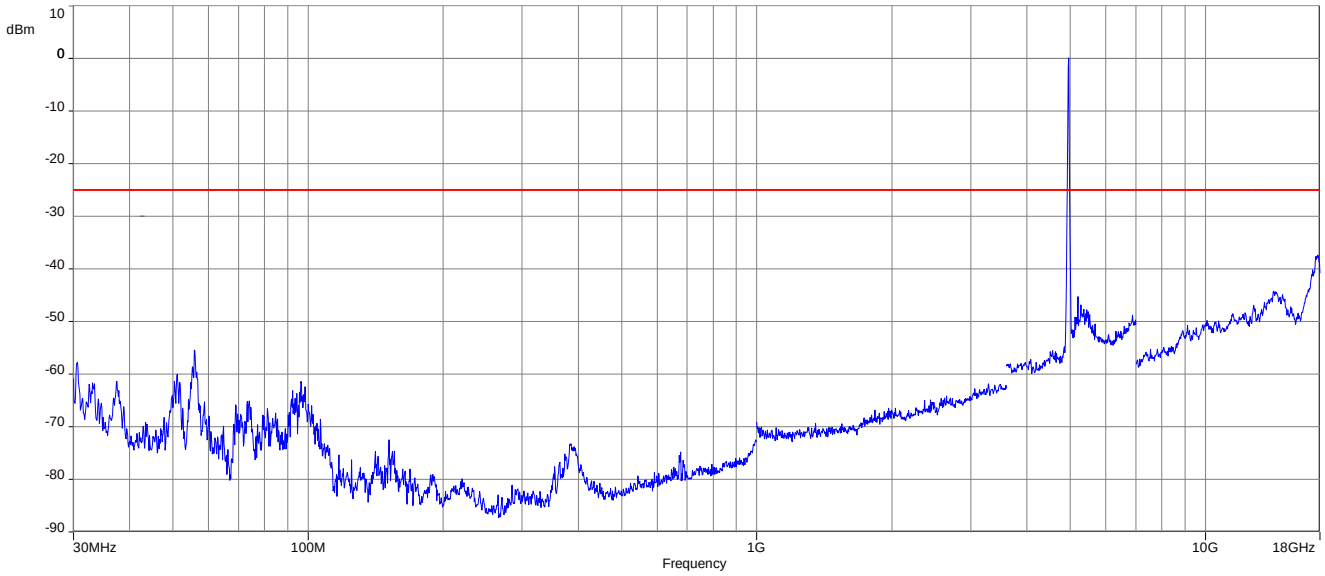
Note:
The limit for radiated measurements was calculated with (P) representing the calculated sum power over all antenna terminals.

**Results:** OFDM (20 MHz nominal channel bandwidth)

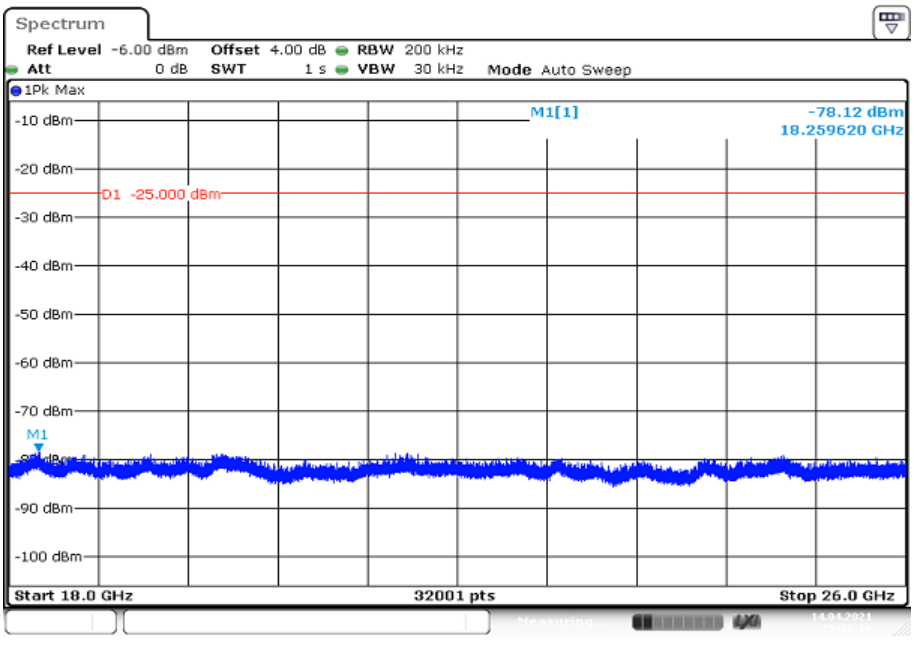
| TX spurious emissions radiated / dBm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| lowest channel | | | middle channel | | | highest channel | | |
| f / MHz | Detector | Level / dBm | f / MHz | Detector | Level / dBm | f / MHz | Detector | Level / dBm |
| All detected emissions are more than 20 dB below the limit. | | | All detected emissions are more than 20 dB below the limit. | | | All detected emissions are more than 20 dB below the limit. | | |

**Plots:** OFDM

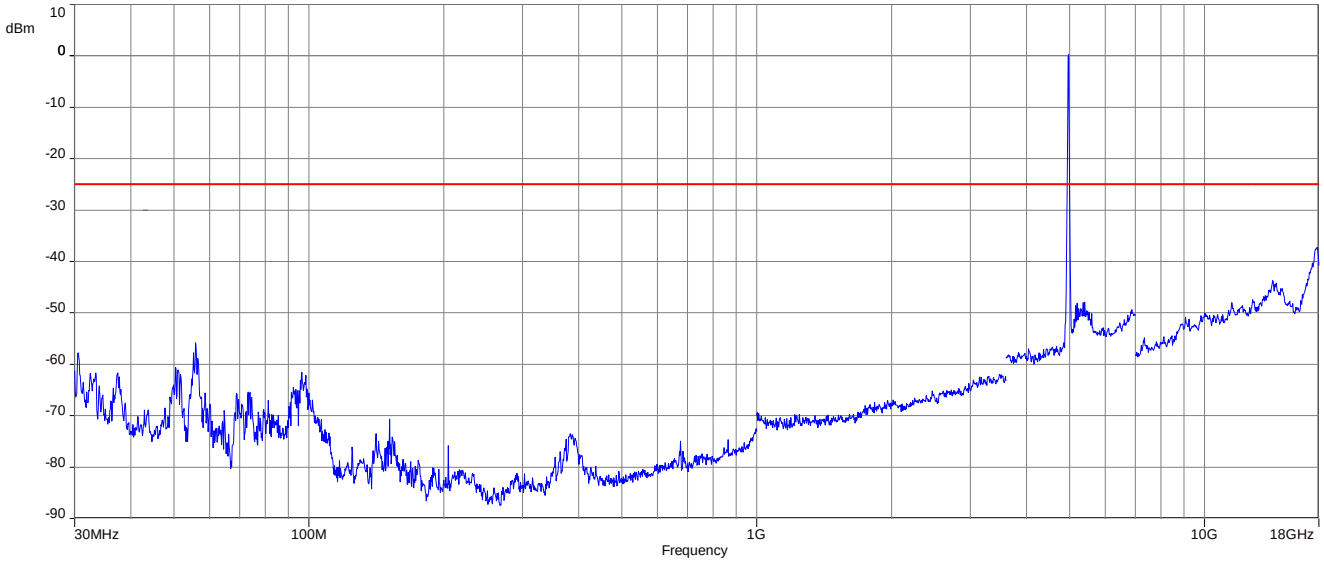
**Plot 1:** Lowest channel, 30 MHz to 18 GHz, vertical & horizontal polarization



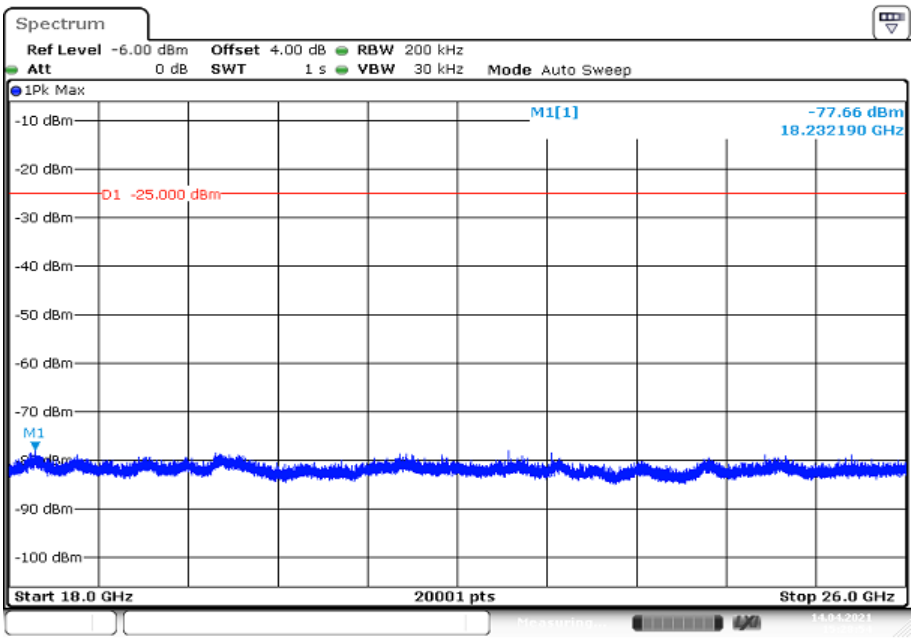

**Plot 2:** Lowest channel, 18 GHz to 40 GHz, vertical & horizontal polarization, peak & average



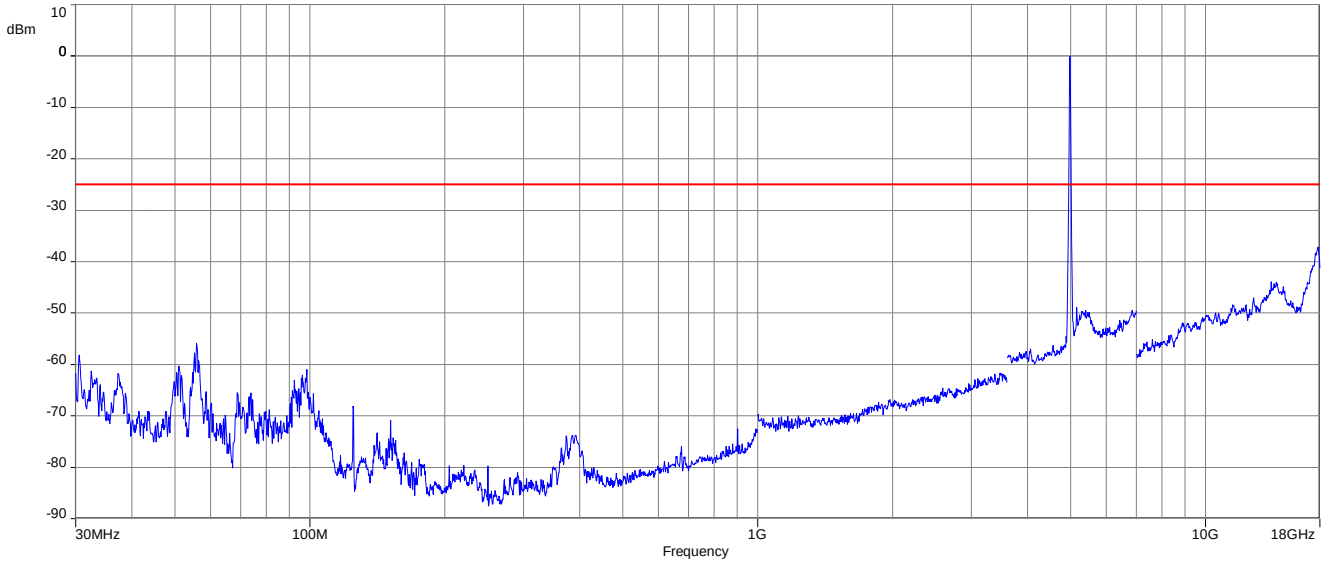
**Plot 2:** Middle channel, 30 MHz to 18 GHz, vertical & horizontal polarization



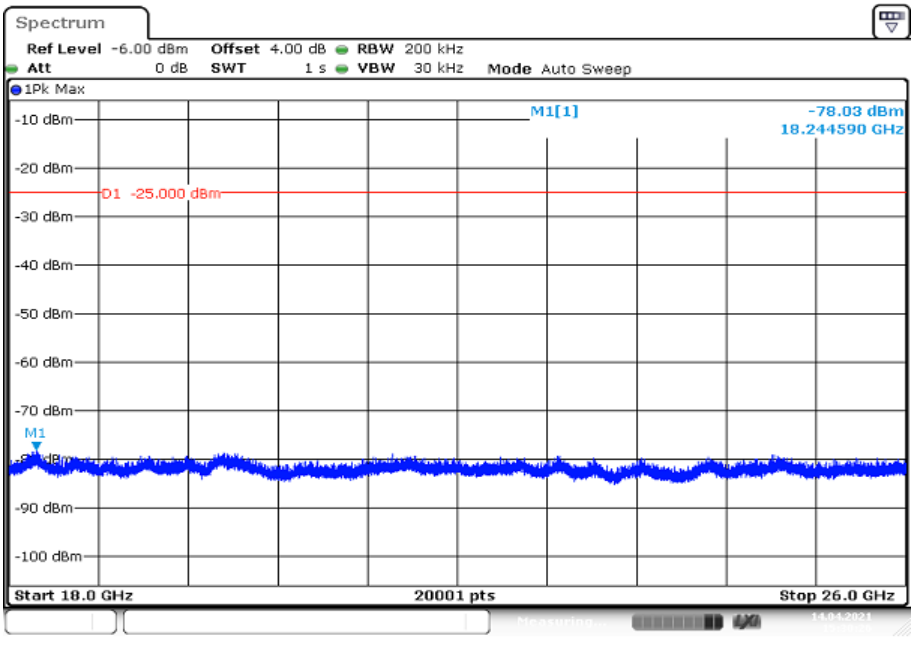

**Plot 3:** Middle channel, 18 GHz to 40 GHz, vertical & horizontal polarization, peak & average



**Plot 5:** Highest channel, 30 MHz to 18 GHz, vertical & horizontal polarization




**Plot 6:** Highest channel, 18 GHz to 40 GHz, vertical & horizontal polarization, peak & average



## 12.11 Spurious emissions conducted below 30 MHz (AC conducted)

**Description:**

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

**Measurement:**

| Measurement parameter | |
|---|---|
| Detector | Peak - Quasi Peak / Average |
| Sweep time | Auto |
| Resolution bandwidth | F < 150 kHz: 200 Hz<br>F > 150 kHz: 9 kHz |
| Video bandwidth | F < 150 kHz: 1 kHz<br>F > 150 kHz: 100 kHz |
| Span | 9 kHz to 30 MHz |
| Trace mode | Max. hold |
| Test setup | See chapter 7.4 |
| Measurement uncertainty | See chapter 8 |

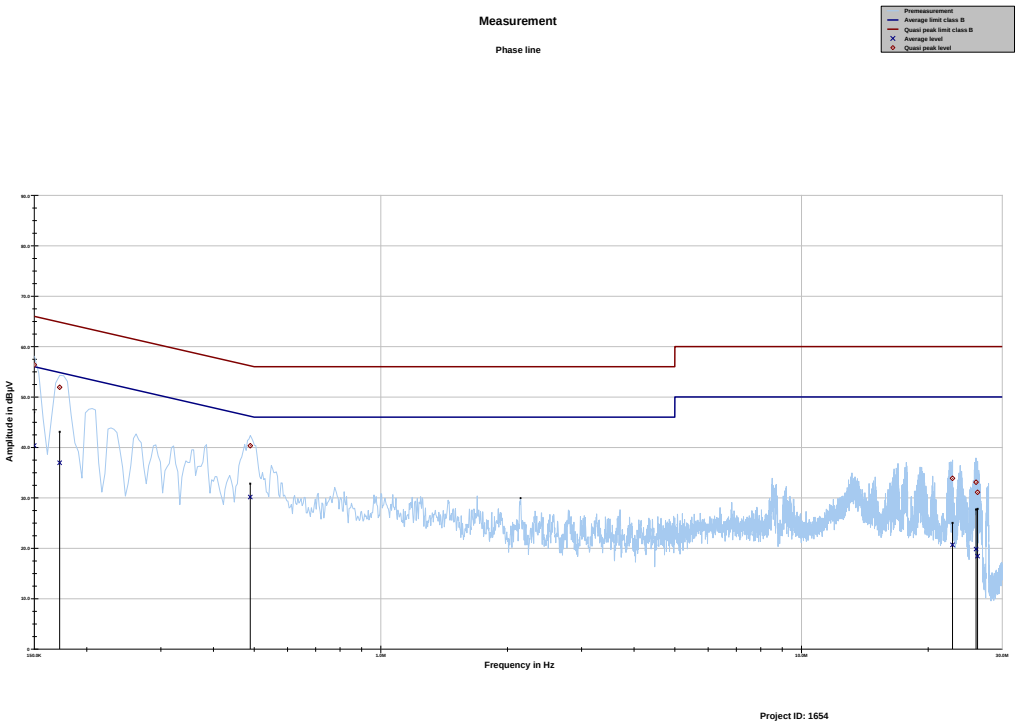
**Limits:**

| FCC | | ISED |
|---|---|---|
| Frequency / MHz) | Quasi-Peak / (dBµV / m) | Average / (dBµV / m) |
| 0.15 – 0.5 | 66 to 56* | 56 to 46* |
| 0.5 – 5 | 56 | 46 |
| 5 – 30.0 | 60 | 50 |

*Decreases with the logarithm of the frequency

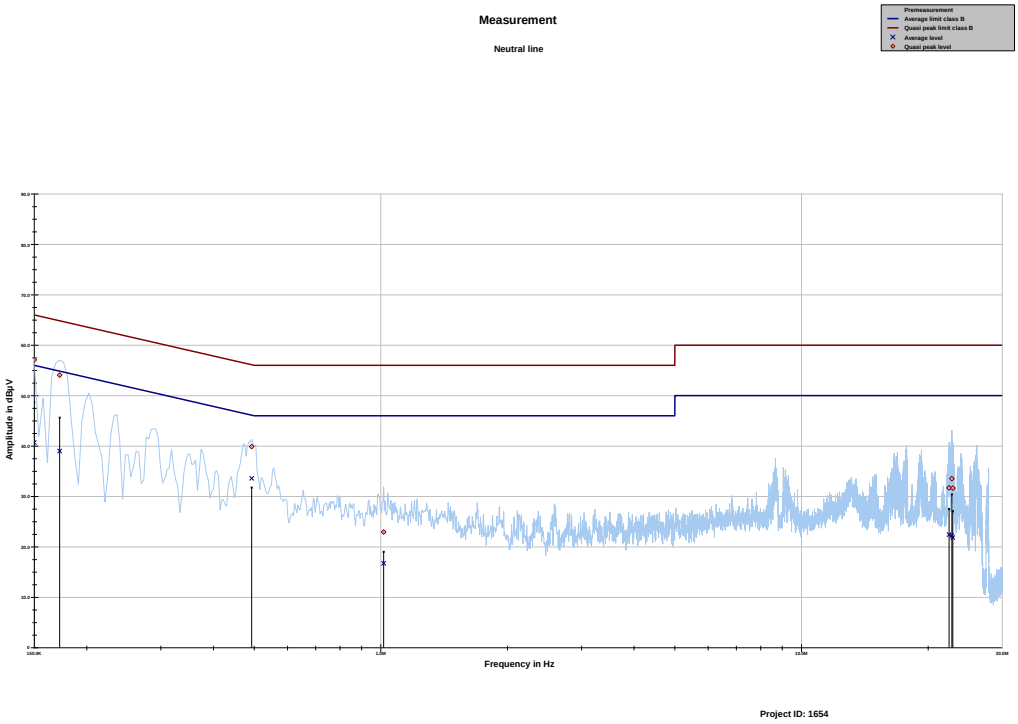
**Plots:**

**Plot 1:** 150 kHz to 30 MHz, phase line




| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin average | Limit AV |
|---|---|---|---|---|---|---|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| | | | | | | |
| 0.150000 | 56.37 | 9.63 | 66.000 | 40.37 | 15.63 | 56.000 |
| 0.172387 | 51.92 | 12.93 | 64.845 | 36.95 | 18.41 | 55.360 |
| 0.489544 | 40.32 | 15.85 | 56.176 | 30.16 | 16.14 | 46.299 |
| 22.858387 | 33.86 | 26.14 | 60.000 | 20.67 | 29.33 | 50.000 |
| 26.000100 | 33.09 | 26.91 | 60.000 | 19.83 | 30.17 | 50.000 |
| 26.223975 | 31.10 | 28.90 | 60.000 | 18.43 | 31.57 | 50.000 |

**Plot 2:** 150 kHz to 30 MHz, neutral line




| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin Average | Limit AV |
|---|---|---|---|---|---|---|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| | | | | | | |
| **0.150000** | 57.09 | 8.91 | 66.000 | 40.70 | 15.30 | 56.000 |
| **0.172387** | 54.06 | 10.78 | 64.845 | 39.01 | 16.35 | 55.360 |
| **0.493275** | 39.88 | 16.23 | 56.112 | 33.60 | 12.59 | 46.192 |
| **1.015650** | 22.97 | 33.03 | 56.000 | 16.74 | 29.26 | 46.000 |
| **22.436756** | 31.71 | 28.29 | 60.000 | 22.43 | 27.57 | 50.000 |
| **22.776300** | 33.54 | 26.46 | 60.000 | 22.21 | 27.79 | 50.000 |
| **22.891969** | 31.64 | 28.36 | 60.000 | 21.85 | 28.15 | 50.000 |

## 13 Observations

No observations except those reported with the single test cases have been made.

## 14 Glossary

| | |
|---|---|
| **EUT** | Equipment under test |
| **DUT** | Device under test |
| **UUT** | Unit under test |
| **GUE** | GNSS User Equipment |
| **FCC** | Federal Communications Commission |
| **FCC ID** | Company Identifier at FCC |
| **IC** | Industry Canada |
| **PMN** | Product marketing name |
| **HMN** | Host marketing name |
| **HVIN** | Hardware version identification number |
| **FVIN** | Firmware version identification number |
| **EMC** | Electromagnetic Compatibility |
| **HW** | Hardware |
| **SW** | Software |
| **Inv. No.** | Inventory number |
| **S/N or SN** | Serial number |
| **C** | Compliant |
| **NC** | Not compliant |
| **NA** | Not applicable |
| **NP** | Not performed |
| **PP** | Positive peak |
| **QP** | Quasi peak |
| **AVG** | Average |
| **OC** | Operating channel |
| **OCW** | Operating channel bandwidth |
| **OBW** | Occupied bandwidth |
| **OOB** | Out of band |
| **DFS** | Dynamic frequency selection |
| **CAC** | Channel availability check |
| **OP** | Occupancy period |
| **NOP** | Non occupancy period |
| **DC** | Duty cycle |
| **PER** | Packet error rate |
| **CW** | Clean wave |
| **MC** | Modulated carrier |
| **WLAN** | Wireless local area network |
| **RLAN** | Radio local area network |
| **DSSS** | Dynamic sequence spread spectrum |
| **OFDM** | Orthogonal frequency division multiplexing |
| **FHSS** | Frequency hopping spread spectrum |

## 15 Document history

| Version | Applied changes | Date of release |
|---|---|---|
| -/- | Initial release | 2021-04-20 |
| A | Conducted Emissions on AC Mains added (12.11) | 2021-05-19 |
| B | Editorial changes | 2021-05-21 |

## 16 Accreditation Certificate – D-PL-12076-01-04

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**Note: The current certificate annex is published on the website (link see below) of the Accreditation Body DAkkS or may be received by CTC advanced GmbH on request**

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## 17 Accreditation Certificate – D-PL-12076-01-05

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########## END OF TEST REPORT ##########