



TEST REPORT

Test report no.: 1-4198_22-02-02_TR1-R02



Testing laboratory

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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 with the registration number:

D-PL-12047-01-00.

ISED Testing Laboratory Recognized Listing Number: DE0001

FCC designation number: DE0002

Applicant

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Manufacturer

ANDREAS STIHL AG & Co. KG

Andreas-Stihl-Straße 4

71336 Waiblingen / GERMANY

Test standard/s

FCC - Title 47 CFR Part 15 FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

RSS - 247 Issue 3 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

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

Test Item

Kind of test item: HMI
Model name: Premium Plus BEF HMI
FCC ID: 2ALP8HMI1
ISED certification number: 23431-HMI1
Frequency: 2400 MHz to 2483.5 MHz
Technology tested: Bluetooth® LE
Antenna: Integrated antenna
Power supply: 36 V DC by battery
Temperature range: -15°C to +60°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:



Marco Bertolino
Supervisor Radio Services
Radio Labs

Test performed:



Michael Dorongovski
Lab Manager
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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. cetecom 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.

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This test report replaces the test report with the number 1-4198_22-02-02_TR1-R01 and dated 2024-04-16.

2.2 Application details

| | |
|------------------------------------|------------|
| Date of receipt of order: | 2024-02-06 |
| Date of receipt of test item: | 2024-03-07 |
| Start of test:* | 2024-03-08 |
| End of test:* | 2024-03-14 |
| 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

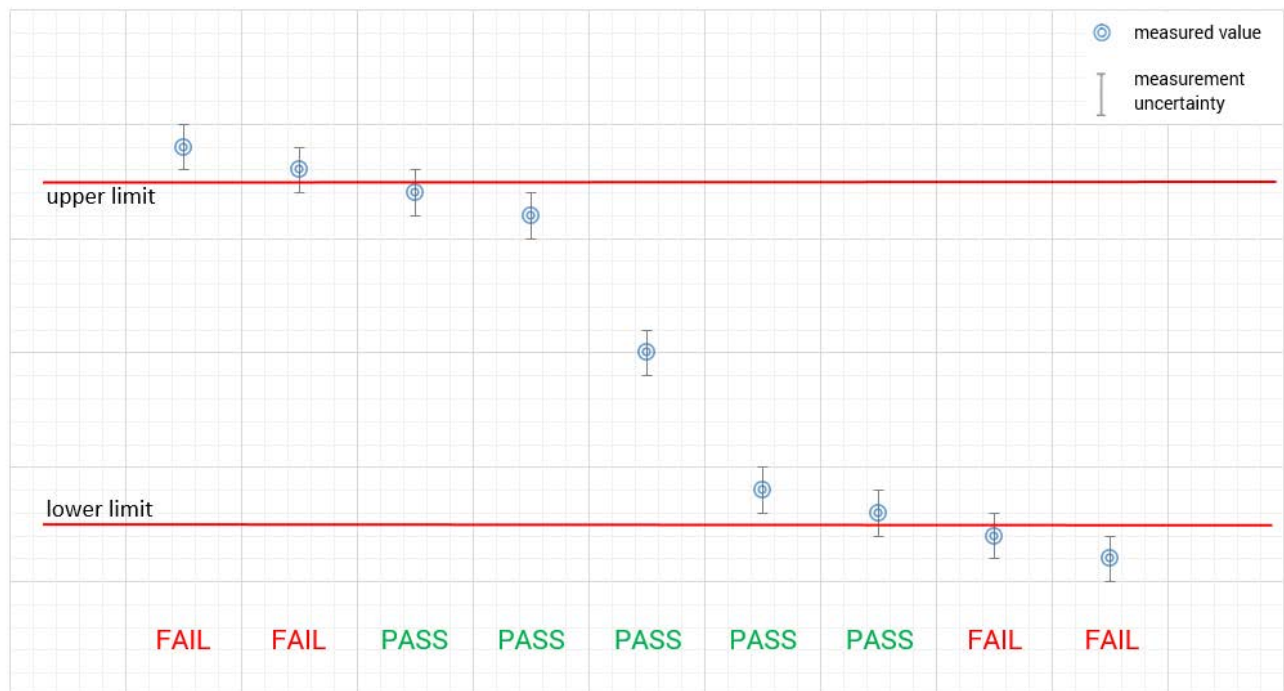
| Test standard | Date | Description |
|---|---------------|--|
| FCC - Title 47 CFR Part 15 | -/- | FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices |
| RSS - 247 Issue 3 | August 2023 | Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices |
| 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 |
| KDB 558074 D01 | v05r02 | GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES |
| ANSI C63.4-2014 | -/- | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz |
| ANSI C63.10-2013 | -/- | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |

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 9, 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."

measured value, measurement uncertainty, verdict



5 Test environment

| | | | |
|---------------------------|---|-------------------------------------|--|
| Temperature | : | T_{nom} T_{max} T_{min} | +22 °C during room temperature tests No tests under extreme temperature conditions required. No tests under extreme temperature conditions required. |
| Relative humidity content | : | | 50 % |
| Barometric pressure | : | | 1022 hpa |
| Power supply | : | V_{nom} V_{max} V_{min} | 36.0 V DC by external power supply No tests under extreme voltage conditions required. No tests under extreme voltage conditions required. |

6 Test item

6.1 General description

| | | |
|----------------------------|---|--|
| Kind of test item | : | HMI |
| Model name | : | Premium Plus BEF HMI |
| HMN | : | N/A |
| PMN | : | HMI1 |
| HVIN | : | HMI01 |
| FVIN | : | N/A |
| S/N serial number | : | Rad. Radiated sample 1 Cond. Conducted sample 1 |
| Hardware status | : | HW00.29 |
| Software status | : | Bootloader: SW00.16 |
| Firmware status | : | SW01.64 |
| Frequency band | : | 2400 MHz to 2483.5 MHz |
| Type of radio transmission | : | DTS |
| Use of frequency spectrum | : | |
| Type of modulation | : | GFSK |
| Number of channels | : | 40 |
| Antenna | : | Integrated antenna |
| Power supply | : | 36 V DC by battery |
| Temperature range | : | -15°C to +60°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: 1-4198_22-02-01_TR1-A101-R1
1-4198_22-02-01_TR1-A103-R1

7 Sequence of testing

7.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, it is placed on a table with 0.8 m height.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement*

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

Final measurement

- Identified emissions during the pre-measurement are maximized by the software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated about its vertical axis for maximum response at each azimuth about the EUT. (For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT)
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

*)Note: The sequence will be repeated three times with different EUT orientations.

7.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position $\pm 45^\circ$ and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

7.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height is 1.5 m.
- At each turntable position and antenna polarization the analyzer sweeps with positive peak detector to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximizes the peaks by rotating the turntable from 0° to 360°. This measurement is repeated for different EUT-table positions (0° to 150° in 30°-steps) and for both antenna polarizations.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

7.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

Premeasurement

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

8 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).

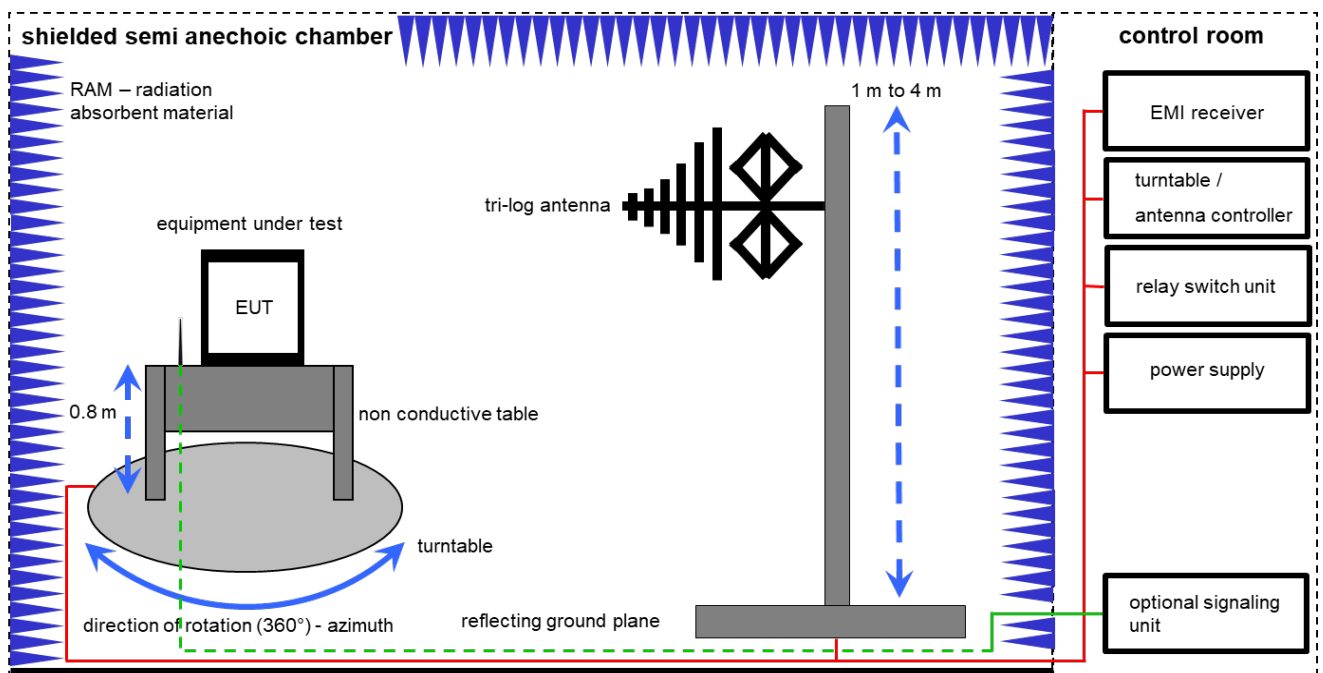
Each block diagram listed can contain several test setup configurations. All devices belonging to a test setup are identified with the same letter syntax. For example: Column Setup and all devices with an A.

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 |
| vlk! | Attention: extended calibration interval | | |
| NK! | Attention: not calibrated | *) | next calibration ordered / currently in progress |

8.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter; EMC32 software version: 10.59.00

FS = UR + CL + AF

(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

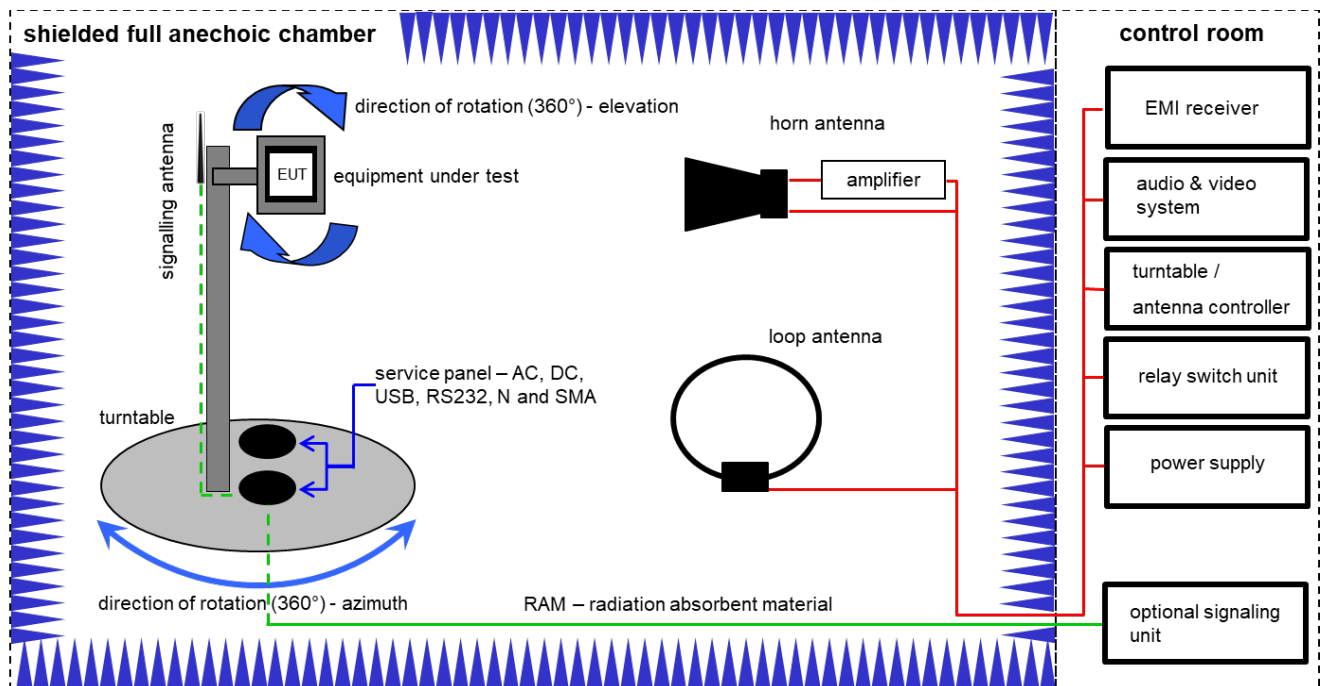
Example calculation:

FS [dBμV/m] = 12.35 [dBμV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBμV/m] (35.69 μV/m)

Equipment table:

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|-----|-------|--|--------------|-----------------------------|------------|-----------|---------------------|------------------|------------------|
| 1 | A | Switch-Unit | 3488A | HP | 2719A14505 | 300000368 | ev | -/- | -/- |
| 2 | A | Semi anechoic chamber | 3000023 | MWB AG | -/- | 300000551 | ne | -/- | -/- |
| 3 | A | Positioning Controller | Model 2090 | ETS-Lindgren | 64672 | 300003746 | izw | -/- | -/- |
| 4 | A | Turntable Interface-Box | Model 105637 | ETS-Lindgren | 44583 | 300003747 | izw | -/- | -/- |
| 5 | A | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz | VULB9163 | Schwarzbeck Mess-Elektronik | 318 | 300003696 | vKI! | 31.01.2024 | 30.01.2026 |
| 6 | A | Turntable | 2089-4.0 | EMCO | -/- | 300004394 | ne | -/- | -/- |
| 7 | A | PC | TecLine | F+W | -/- | 300004388 | ne | -/- | -/- |
| 8 | A | EMI Test Receiver | ESR3 | Rohde & Schwarz | 102587 | 300005771 | k | 06.12.2023 | 31.12.2024 |

8.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter; loop antenna 3 meter

FS = UR + CA + AF

(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:

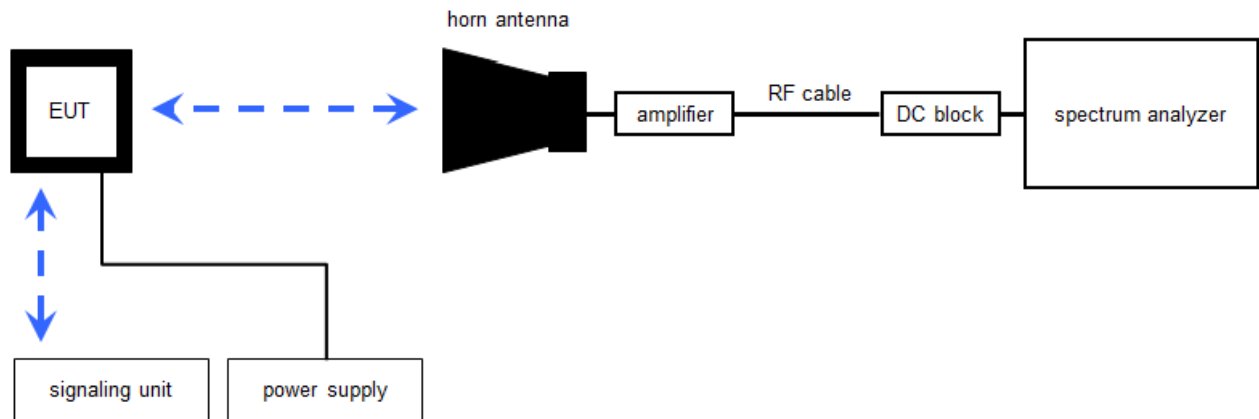
FS [dBμV/m] = 40.0 [dBμV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBμV/m] (71.61 μV/m)

Equipment table:

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|-----|------------|--|---------------------------------|----------------------|------------|-----------|---------------------|------------------|------------------|
| 1 | A, B, C, D | DC power supply, 60Vdc, 50A, 1200 W | 6032A | HP | 2818A03450 | 300001040 | vIKI! | 05.12.2023 | 31.12.2026 |
| 2 | C | Active Loop Antenna 9 kHz to 30 MHz | 6502 | EMCO | 2210 | 300001015 | vIKI! | 02.08.2023 | 31.08.2025 |
| 3 | A, B, C, D | Anechoic chamber | FAC 3/5m | MWB / TDK | 87400/02 | 300000996 | ev | -/- | -/- |
| 4 | A, B, C, D | Switch / Control Unit | 3488A | HP | * | 300000199 | ne | -/- | -/- |
| 5 | A, B, D | Double-Ridged Waveguide Horn Antenna 1-18.0GHz | 3115 | EMCO | 8812-3088 | 300001032 | vIKI! | 10.10.2023 | 31.10.2025 |
| 6 | D | Band Reject filter | WRCG2400/2483-2375/2505-50/10SS | Wainwright | 11 | 300003351 | ev | -/- | -/- |
| 7 | A, B, C, D | EMI Test Receiver 20Hz- 26,5GHz | ESU26 | R&S | 100037 | 300003555 | k | 11.12.2023 | 31.12.2024 |
| 8 | D | Highpass Filter | WHK1.1/15G-10SS | Wainwright | 3 | 300003255 | ev | -/- | -/- |
| 9 | D | Highpass Filter | WHKX7.0/18G-8SS | Wainwright | 19 | 300003790 | ne | -/- | -/- |
| 10 | D | High Pass Filter | VHF-3500+ | Mini Circuits | -/- | 400000193 | ne | -/- | -/- |
| 11 | B, D | Broadband Amplifier 0.5-18 GHz | CBLU5184540 | CERNEX | 22049 | 300004481 | ev | -/- | -/- |
| 12 | A, B, C, D | 4U RF Switch Platform | L4491A | Agilent Technologies | MY50000037 | 300004509 | ne | -/- | -/- |
| 13 | A, B, C, D | NEXIO EMV-Software | BAT EMC V2022.0.32.0 | Nexio | -/- | 300004682 | ne | -/- | -/- |

8.3 Radiated measurements > 18 GHz

Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

FS = UR + CA + AF

(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

Example calculation:

FS [dBμV/m] = 40.0 [dBμV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBμV/m] (6.79 μV/m)

Equipment table:

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|-----|-------|--|-------------------|----------------------|---------------------|-----------|---------------------|------------------|------------------|
| 1 | A | Microwave System Amplifier, 0.5-26.5 GHz | 83017A | HP | 00419 | 300002268 | ev | -/- | -/- |
| 2 | A | Std. Gain Horn Antenna 18.0-26.5 GHz | 638 | Narda | 01096 | 300000486 | vKI! | 24.01.2024 | 23.01.2026 |
| 3 | A | Signal analyzer | FSV30 | Rohde&Schwarz | 1321.3008K30/103170 | 300004855 | vKI! | 09.12.2022 | 31.12.2024 |
| 4 | A | RF-Cable | ST18/SMAM/SMAM/48 | Huber & Suhner | Batch no. 600918 | 400001182 | ev | -/- | -/- |
| 5 | A | DC-Blocker 0.1-40 GHz | 8141A | Inmet | -/- | 400001185 | ev | -/- | -/- |
| 6 | A | Power supply | N5767A | Agilent Technologies | US14J1569P | 300004851 | vKI! | 06.12.2023 | 31.12.2026 |

8.4 Conducted measurements Bluetooth system



OP = AV + CA
 (OP-output power; AV-analyzer value; CA-loss signal path)

Example calculation:

OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

Equipment table:

| No. | Setup | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|-----|-------|-----------------------|----------------------|-----------------------|---------------------|-----------|---------------------|------------------|------------------|
| 1 | A | Hygro-Thermometer | -/-, 5-45C, 20-100rF | Thies Clima | -/- | 400000080 | ev | 15.09.2022 | 14.09.2024 |
| 2 | A | PC Laboratory 19" | Exone i3 | Fröhlich + Walter | 35230157A0370 | 300004646 | ne | -/- | -/- |
| 3 | A | Signal analyzer | FSV30 | Rohde&Schwarz | 1321.3008K30/103170 | 300004855 | vKI! | 09.12.2022 | 31.12.2024 |
| 4 | A | USB-GPIB-Interface | 82357B | Agilent Technologies | MY54323070 | 300004852 | ne | -/- | -/- |
| 5 | A | Power supply | N5767A | Agilent Technologies | US14J1569P | 300004851 | vKI! | 06.12.2023 | 31.12.2026 |
| 6 | A | Tester Software C.BER | Version 5.0 | CTC advanced GmbH | 0001 | 400001379 | ne | -/- | -/- |
| 7 | A | Switch matrix | RSM 1.1 | cetecom advanced GmbH | 31534892 | 400001456 | ev | 20.09.2023 | 19.09.2024 |

9 Measurement uncertainty

| Measurement uncertainty | |
|--|--|
| Test case | Uncertainty |
| Antenna gain | ± 3 dB |
| Spectrum bandwidth | ± 21.5 kHz absolute; ± 15.0 kHz relative |
| Maximum output power | ± 1 dB |
| Detailed conducted spurious emissions @ the band edge | ± 1 dB |
| Band edge compliance radiated | ± 3 dB |
| Band edge compliance conducted | ± 1.5 dB |
| Spurious emissions conducted | ± 3 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 |

10 Summary of measurement results

| | |
|-------------------------------------|--|
| <input checked="" type="checkbox"/> | No deviations from the technical specifications were ascertained |
| <input type="checkbox"/> | There were deviations from the technical specifications ascertained |
| <input type="checkbox"/> | This test report is only a partial test report. The content and verdict of the performed test cases are listed below. |

| TC Identifier | Description | Verdict | Date | Remark |
|---------------|-----------------------------------|------------|------------|--------|
| RF-Testing | CFR Part 15 RSS - 247, Issue 3 | See table! | 2024-11-06 | -/- |

| Test specification clause | Test case | Guideline | Temperature conditions | Power source voltages | Mode | C | NC | NA | NP | Remark |
|---|---|--|------------------------|-----------------------|--------|-------------------------------------|--------------------------|-------------------------------------|--------------------------|--------|
| §15.247(b)(4) RSS - 247 / 5.4 (4) | System gain | -/- | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(e) RSS - 247 / 5.2 (b) | Power spectral density | KDB 558074 DTS clause: 8.4 | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(a)(2) RSS - 247 / 5.2 (a) | DTS bandwidth – 6 dB bandwidth | KDB 558074 DTS clause: 8.2 | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| RSS Gen clause 4.6.1 | Occupied bandwidth | -/- | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(b)(3) RSS - 247 / 5.4 (4) | Maximum output power | KDB 558074 DTS clause: 8.3.1.1 | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.205 RSS - 247 / 5.5 RSS - Gen | Band edge compliance cond. & rad. | KDB 558074 DTS clause: 8.7.2 or 8.7.3 | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(d) RSS - 247 / 5.5 | TX spurious emissions conducted | KDB 558074 DTS clause: 8.5 | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.209(a) RSS - Gen | Spurious emissions radiated below 30 MHz | -/- | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen | Spurious emissions radiated 30 MHz to 1 GHz | -/- | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen | Spurious emissions radiated above 1 GHz | -/- | Nominal | Nominal | 1 Msps | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | -/- |
| §15.107(a) §15.207 | Conducted emissions below 30 MHz (AC conducted) | -/- | Nominal | Nominal | 1 Msps | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | -/- |

Note: C = Compliant; NC = Not compliant; NA = Not applicable; NP = Not performed

11 Additional comments

The Bluetooth® word mark and logos are owned by the Bluetooth SIG Inc. and any use of such marks by CTC advanced GmbH is under license.

Reference documents: 1-4198_22-02-02_TR1-A201-R1.pdf

Special test descriptions: None

Configuration descriptions:

| Bluetooth Low Energy | |
|---|------------------|
| Longest Supported payload (37 – 255 Byte) | Tx: 255, RX: 255 |
| LE 1M PHY supported | Yes |
| LE 2M PHY supported | No |
| Stable Modulation Index supported (SMI) | No |
| LE Coded PHY supported (S=2) | No |
| LE Coded PHY supported (S=8) | No |

Test mode:

☒ Bluetooth LE Test mode enabled
(EUT is controlled by CMW)

☐ Special software is used.
EUT is transmitting pseudo random data by itself

Antennas and transmit operating modes:

☒ Operating mode 1 (single antenna)

- Equipment with 1 antenna,
- Equipment with 2 diversity antennas operating in switched diversity mode by which at any moment in time only 1 antenna is used,
- 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)

- 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)

- Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously with beamforming.
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 System gain

Measurement:

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the EUT.

| Measurement parameters (radiated) | |
|-----------------------------------|----------------------|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 3 MHz |
| Video bandwidth | 3 MHz |
| Span | 5 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 8.2 A |
| Measurement uncertainty | See sub clause 9 |

| Measurement parameters (conducted) | |
|------------------------------------|--|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf Common2G4 Peak OP 3 MHz/3 MHz |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | ISED |
|---|------|
| 6 dBi / > 6 dBi output power and power density reduction required | |

Results:

| T _{nom} | V _{nom} | 2402 MHz | 2440 MHz | 2480 MHz |
|---|------------------|----------|----------|----------|
| Conducted power [dBm] Measured with GFSK modulation (1 Msps) | | -0.1 | 0.2 | 0.9 |
| Radiated power [dBm] Measured with GFSK modulation (1 Msps) | | 3.0 | 3.0 | 2.4 |
| Gain [dBi] Calculated | | 3.1 | 2.8 | 1.5 |

12.2 Power spectral density

Description:

Measurement of the power spectral density of a digital modulated system.

| Measurement parameters | |
|-------------------------|--|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf FCC Part 15.247 Peak Power Spectral Density DTS |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | ISED |
|--|------|
| Power spectral density | |
| For digitally modulated systems the transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration. | |

Results:

| | Frequency | | |
|---|-----------|----------|----------|
| | 2402 MHz | 2440 MHz | 2480 MHz |
| Power spectral density [dBm / 3kHz] 1 Msps | -16.3 | -16.0 | -15.4 |

12.3 DTS bandwidth – 6 dB bandwidth

Description:

Measurement of the 6 dB bandwidth of the modulated signal.

| Measurement parameters | |
|-------------------------|--|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf FCC Part 15.247 Bandwidth 6dB DTS |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | ISED |
|---|------|
| DTS bandwidth – 6 dB bandwidth | |
| Systems using digital modulation techniques may operate in the 2400–2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz. | |

Results:

| | Frequency | | |
|--|-----------|----------|----------|
| | 2402 MHz | 2440 MHz | 2480 MHz |
| 6 dB bandwidth [kHz] 1 Msps | 701 | 711 | 712 |

12.4 Occupied bandwidth – 99% emission bandwidth

Description:

Measurement of the 99% bandwidth of the modulated signal acc. RSS-GEN.

| Measurement parameters | |
|-------------------------|---|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf FCC Part 15.247 Bandwidth 99PCT-20dB |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Usage:

| -/- | ISED |
|---|------|
| Occupied bandwidth – 99% emission bandwidth | |
| OBW is necessary for emission designator | |

Results:

| | Frequency | | |
|---------------------------------------|-----------|----------|----------|
| | 2402 MHz | 2440 MHz | 2480 MHz |
| 99% bandwidth [kHz] 1 Msps | 1045 | 1048 | 1051 |

12.5 Maximum output power

Description:

Measurement of the maximum output power conducted. EUT in single channel mode.

| Measurement parameters | |
|-------------------------|--|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf FCC Part 15.247 Maximum Peak Conducted Output Power DTS |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | ISED |
|--|------|
| Maximum output power | |
| Conducted: 1.0 W – antenna gain max. 6 dBi | |

Results:

| | Frequency | | |
|--|-----------|----------|----------|
| | 2402 MHz | 2440 MHz | 2480 MHz |
| Maximum output power conducted [dBm] 1 Msps | -0.1 | 0.2 | 0.9 |

12.6 Band edge compliance radiated

Description:

Measurement of the radiated band edge compliance. The EUT is turned in the position that results in the maximum level at the band edge. Then a sweep over the corresponding restricted band is performed. The EUT is set to single channel mode and the transmit frequency 2402 MHz for the lower restricted band and 2480 MHz for the upper restricted band. Measurement distance is 3m.

| Measurement parameters | |
|-------------------------|---|
| Detector | Peak / RMS |
| Sweep time | Auto |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Span | Lower Band: 2300 – 2400 MHz higher Band: 2480 – 2500 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 8.2 B |
| Measurement uncertainty | See sub clause 9 |

Limits:

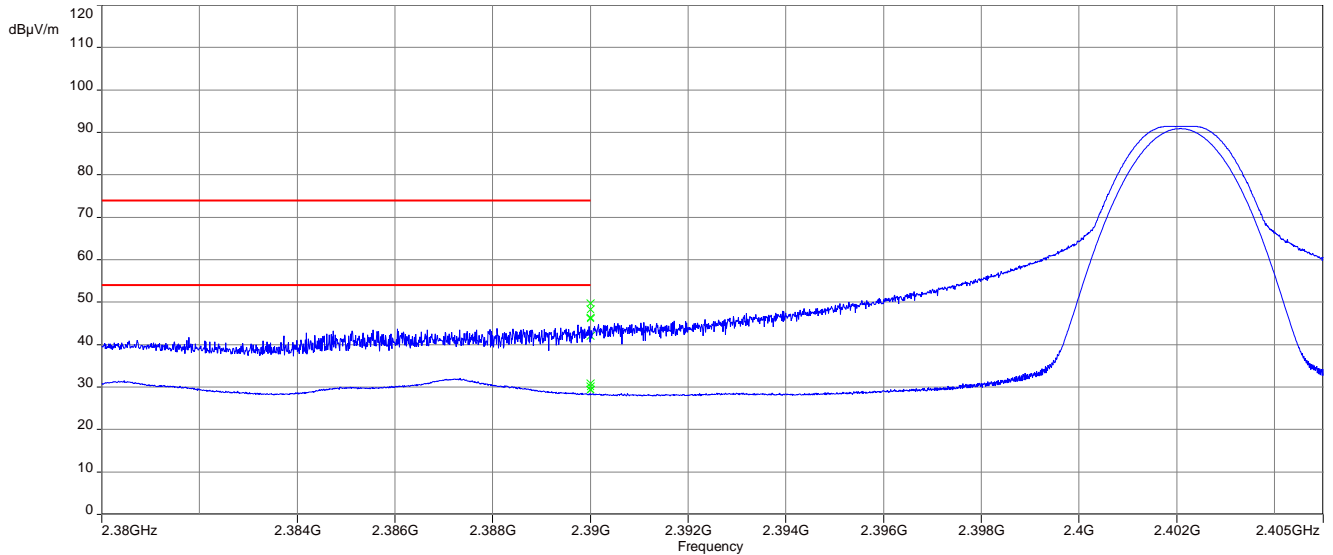
| FCC | ISED |
|---|------|
| Band edge compliance radiated | |
| <p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).</p> | |
| 54 dBµV/m AVG 74 dBµV/m Peak | |

Result:

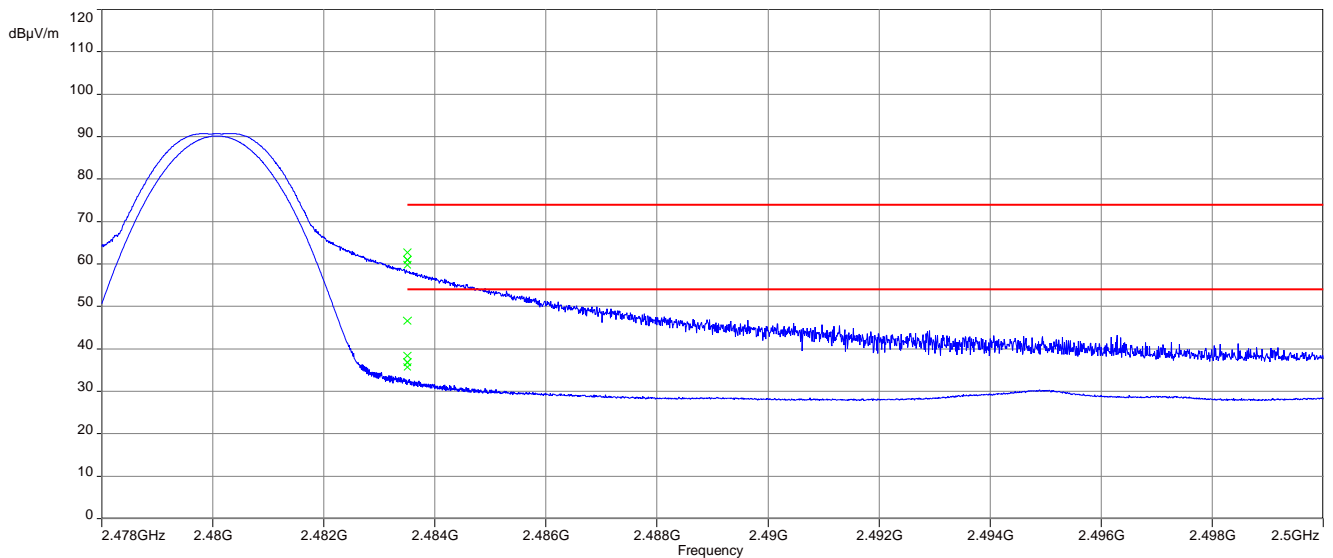
| Scenario | Band edge compliance radiated [dBµV/m] |
|-----------------------|--|
| Data rate | 1 Msps |
| Lower restricted band | 31.0 dBµV/m AVG 49.8 dBµV/m Peak |
| Upper restricted band | 38.5 dBµV/m AVG 62.7 dBµV/m Peak |

Plots:

Plot 1: Lower restricted band, 1 Msps



Plot 2: Upper restricted band, 1 Msps



12.7 TX spurious emissions conducted

Description:

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

| Measurement parameters | |
|-------------------------|--|
| External result file | 1-4198_22-02-02_TR1-A201-R1.pdf FCC Part 15.247 TX Spurious Conducted |
| Test setup | See sub clause 8.4 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | ISED |
|--|------|
| TX spurious emissions conducted | |
| In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required | |

Results: Compliant (see external result file)

12.8 Spurious emissions radiated below 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz. The limits are recalculated to a measurement distance of 3 m according the ANSI C63.10.

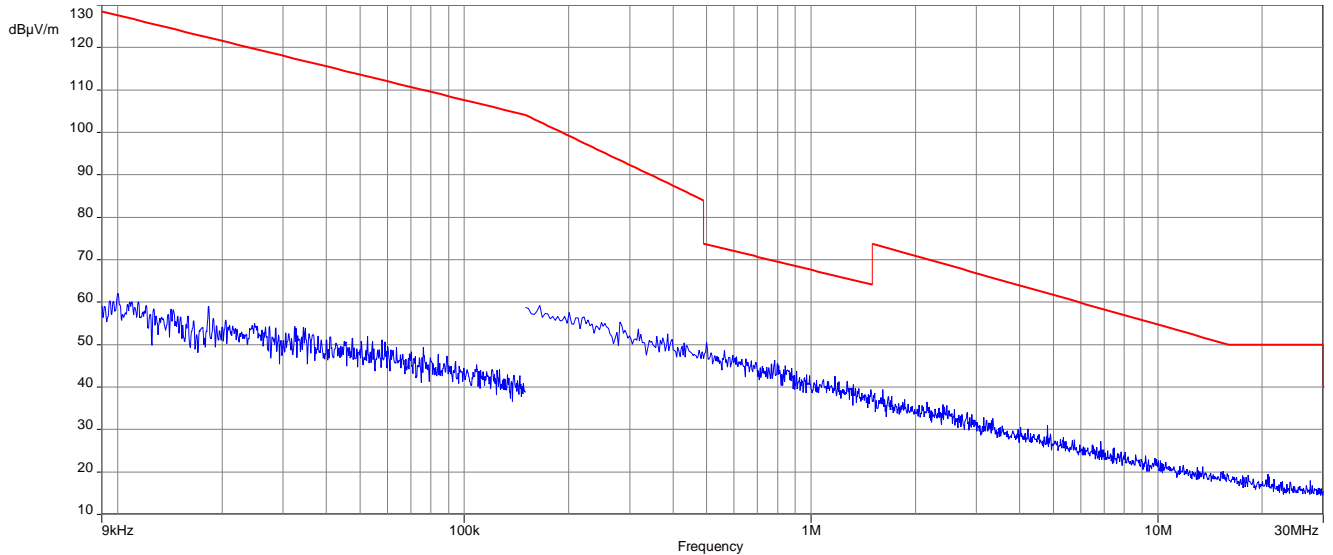
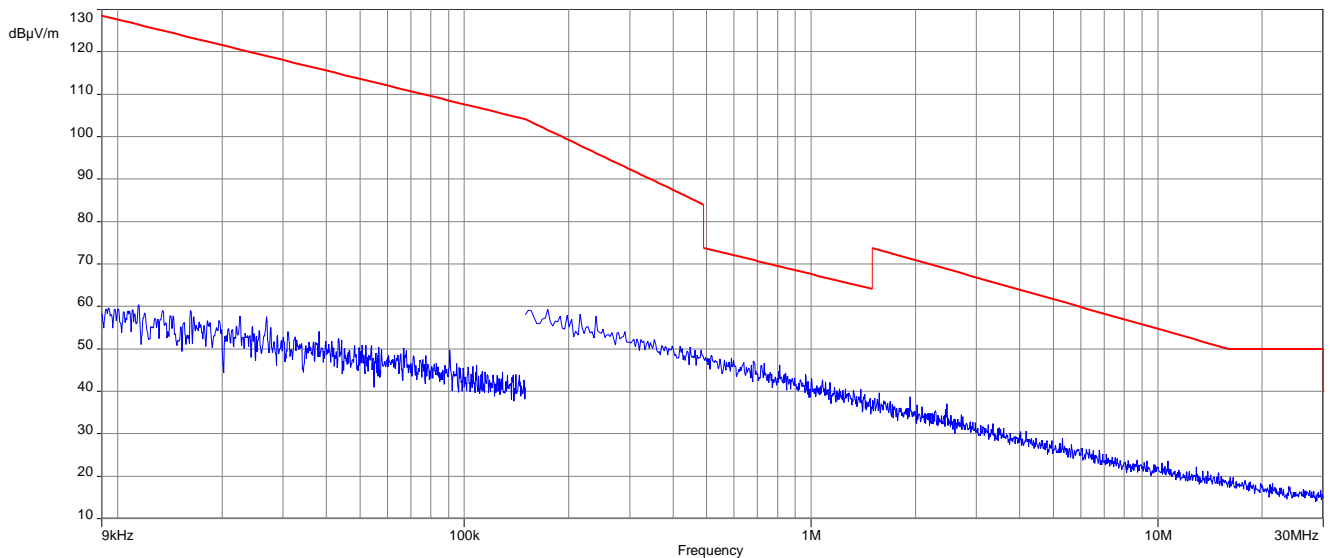
| Measurement parameters | |
|-------------------------|---|
| Detector | Peak / Quasi peak |
| Sweep time | Auto |
| Resolution bandwidth | F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz |
| Video bandwidth | F < 150 kHz: 1 kHz F > 150 kHz: 30 kHz |
| Span | 9 kHz to 30 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 8.2 C |
| Measurement uncertainty | See sub clause 9 |

Limits:

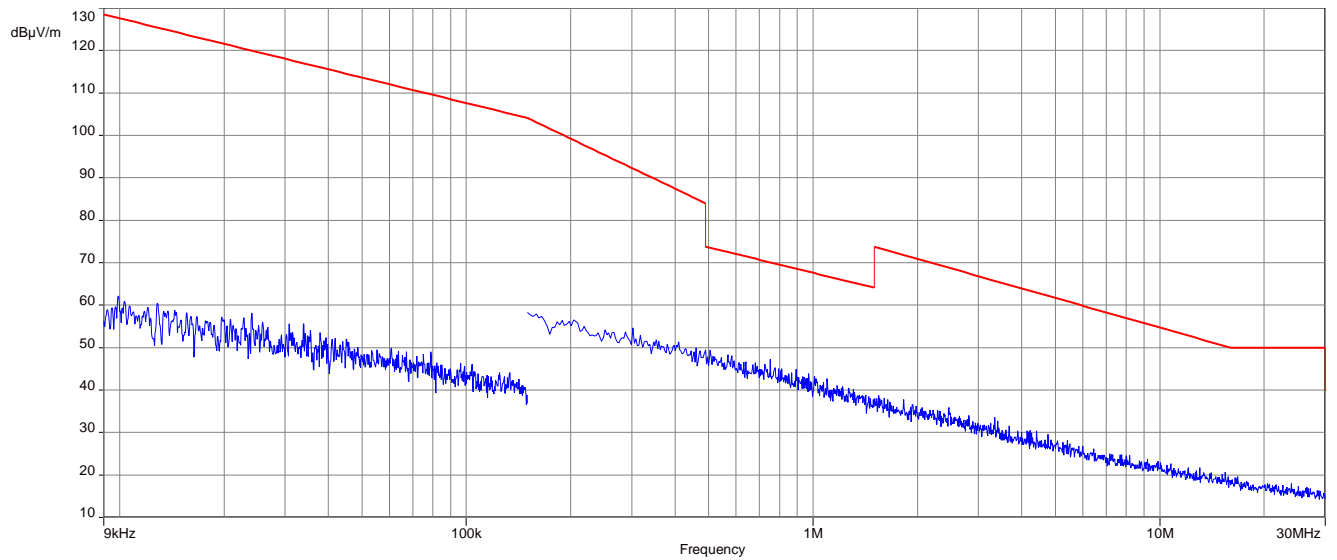
| FCC | | ISED |
|---|-----------------------|----------------------|
| TX spurious emissions radiated below 30 MHz | | |
| Frequency (MHz) | Field strength (µV/m) | Measurement distance |
| 0.009 – 0.490 | 2400/F(kHz) | 300 |
| 0.490 – 1.705 | 24000/F(kHz) | 30 |
| 1.705 – 30.0 | 30 | 30 |

Results:

| TX spurious emissions radiated below 30 MHz [dBµV/m] | | |
|---|----------|----------------|
| F [MHz] | Detector | Level [dBµV/m] |
| All detected emissions are more than 20 dB below the limit. | | |
| | | |
| | | |

Plots:**Plot 1:** 9 kHz to 30 MHz, 2402 MHz, transmit mode, 1 Msps**Plot 2:** 9 kHz to 30 MHz, 2440 MHz, transmit mode, 1 Msps

Plot 3: 9 kHz to 30 MHz, 2480 MHz, transmit mode, 1 Msps



12.9 Spurious emissions radiated 30 MHz to 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

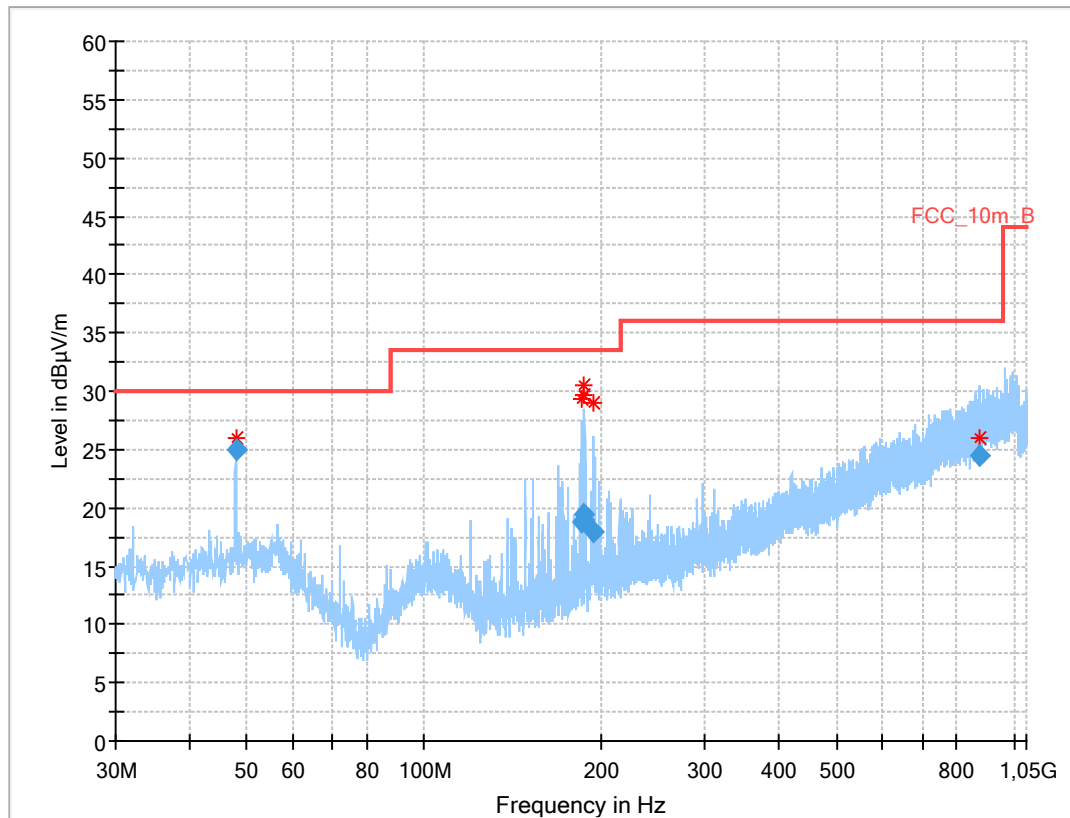
| Measurement parameters | |
|-------------------------|----------------------|
| Detector | Peak / Quasi Peak |
| Sweep time | Auto |
| Resolution bandwidth | 120 kHz |
| Video bandwidth | 3 x RBW |
| Span | 30 MHz to 1 GHz |
| Trace mode | Max hold |
| Measured modulation | GFSK |
| Test setup | See sub clause 8.1 A |
| Measurement uncertainty | See sub clause 9 |

Limits:

| FCC | | ISED |
|--|-------------------------|----------------------|
| TX spurious emissions radiated | | |
| In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. 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)). | | |
| §15.209 | | |
| Frequency (MHz) | Field strength (dBµV/m) | Measurement distance |
| 30 - 88 | 30.0 | 10 |
| 88 - 216 | 33.5 | 10 |
| 216 - 960 | 36.0 | 10 |
| Above 960 | 54.0 | 3 |

Plots: Transmit mode

Plot 1: 30 MHz to 1 GHz, TX mode, vertical & horizontal polarization, 1 Msps, valid for all channels

**Final results:**

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|------------|
| 48.003 | 25.03 | 30.0 | 5.0 | 1000 | 120.0 | 195.0 | V | 142 | 15 |
| 184.434 | 18.79 | 33.5 | 14.7 | 1000 | 120.0 | 173.0 | V | -23 | 12 |
| 187.149 | 19.45 | 33.5 | 14.1 | 1000 | 120.0 | 195.0 | V | -31 | 12 |
| 187.159 | 18.97 | 33.5 | 14.5 | 1000 | 120.0 | 195.0 | V | -5 | 12 |
| 193.824 | 17.85 | 33.5 | 15.7 | 1000 | 120.0 | 181.0 | V | -10 | 13 |
| 876.666 | 24.44 | 36.0 | 11.6 | 1000 | 120.0 | 195.0 | V | -37 | 25 |

12.10 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

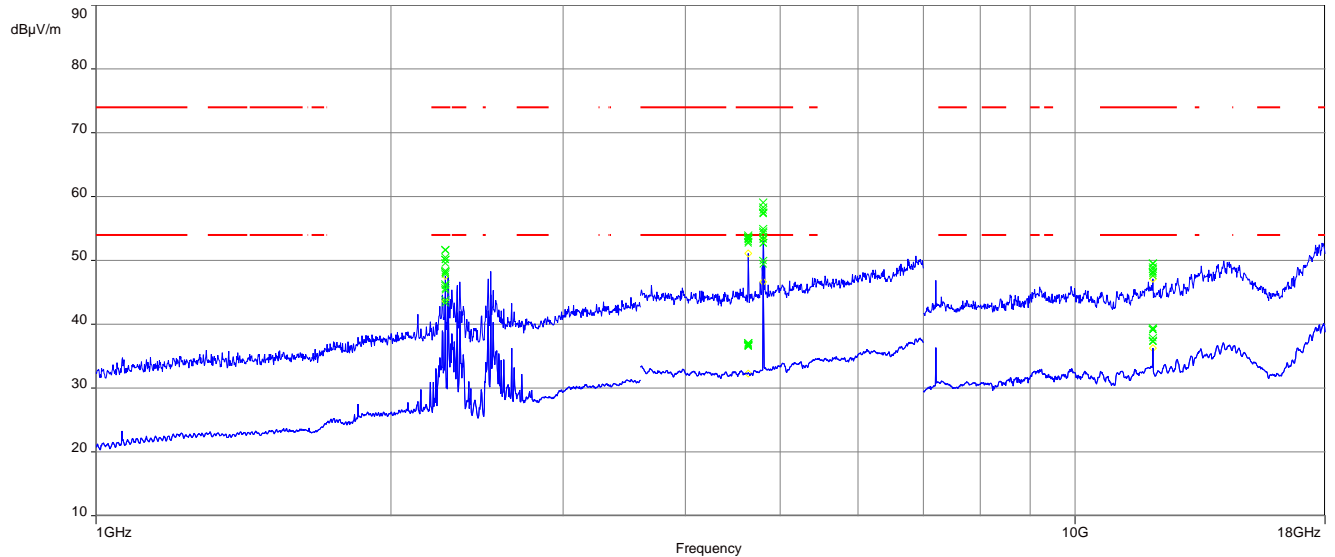
| Measurement parameters | |
|-------------------------|---|
| Detector | Peak / RMS |
| Sweep time | Auto |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 x RBW |
| Span | 1 GHz to 26 GHz |
| Trace mode | Max hold |
| Measured modulation | GFSK |
| Test setup | See sub clause 8.2 D (1 GHz - 18 GHz) See sub clause 8.3 A (18 GHz - 26 GHz) |
| Measurement uncertainty | See sub clause 9 |

Limits:

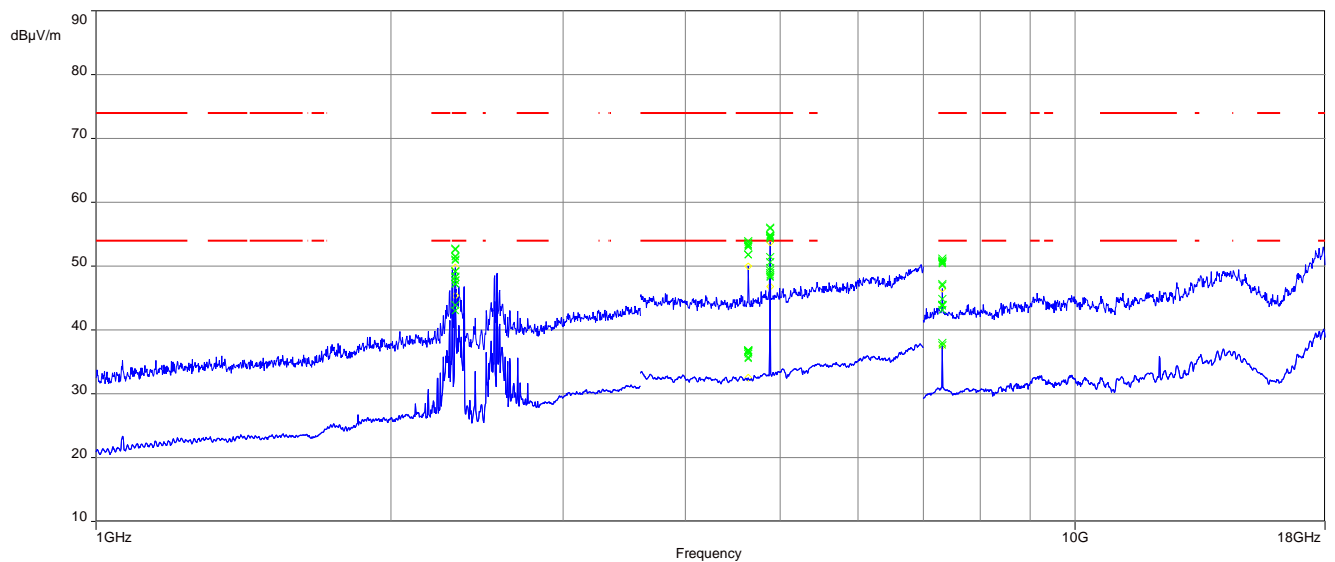
| FCC | | ISED | |
|--|-------------------------|----------------------|--|
| TX spurious emissions radiated | | | |
| In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. 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)). | | | |
| §15.209 | | | |
| Frequency (MHz) | Field strength (dBµV/m) | Measurement distance | |
| Above 960 | 54.0 (Average) | 3 | |
| Above 960 | 74.0 (Peak) | 3 | |

Results: Transmitter mode, 1 Msps

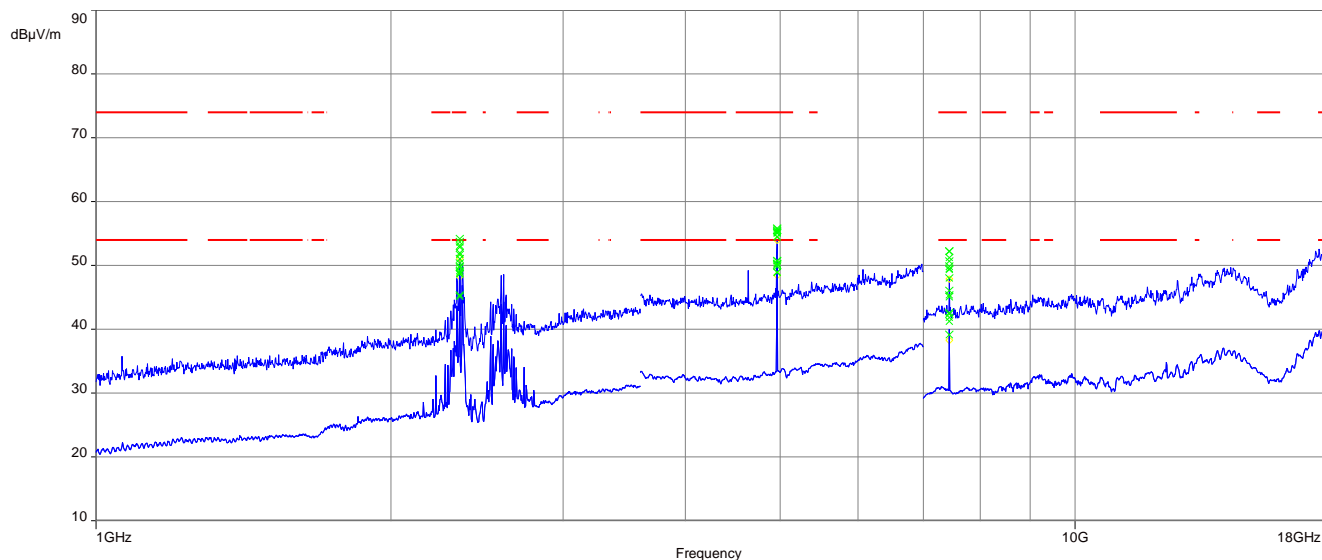
| TX spurious emissions radiated [dB μ V/m] | | | | | | | | |
|---|----------|----------------------|----------|----------|----------------------|----------|----------|----------------------|
| 2402 MHz | | | 2440 MHz | | | 2480 MHz | | |
| F [MHz] | Detector | Level [dB μ V/m] | F [MHz] | Detector | Level [dB μ V/m] | F [MHz] | Detector | Level [dB μ V/m] |
| 2273 | Peak | 51.8 | 2327 | Peak | 52.7 | 2352 | Peak | 54.2 |
| | AVG | 48.5 | | AVG | 49.2 | | AVG | 50.4 |
| 4635 | Peak | 53.9 | 4635 | Peak | 54.0 | 4635 | Peak | 54.0 |
| | AVG | 37.2 | | AVG | 36.9 | | AVG | 36.9 |
| 4804 | Peak | 59.1 | 4881 | Peak | 56.1 | 4960 | Peak | 55.8 |
| | AVG | 53.0 | | AVG | 51.5 | | AVG | 49.8 |
| 12012 | Peak | 49.6 | 7320 | Peak | 51.2 | 7440 | Peak | 52.3 |
| | AVG | 39.4 | | AVG | 44.8 | | AVG | 45.4 |

Plots: Transmitter mode**Plot 1:** 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps

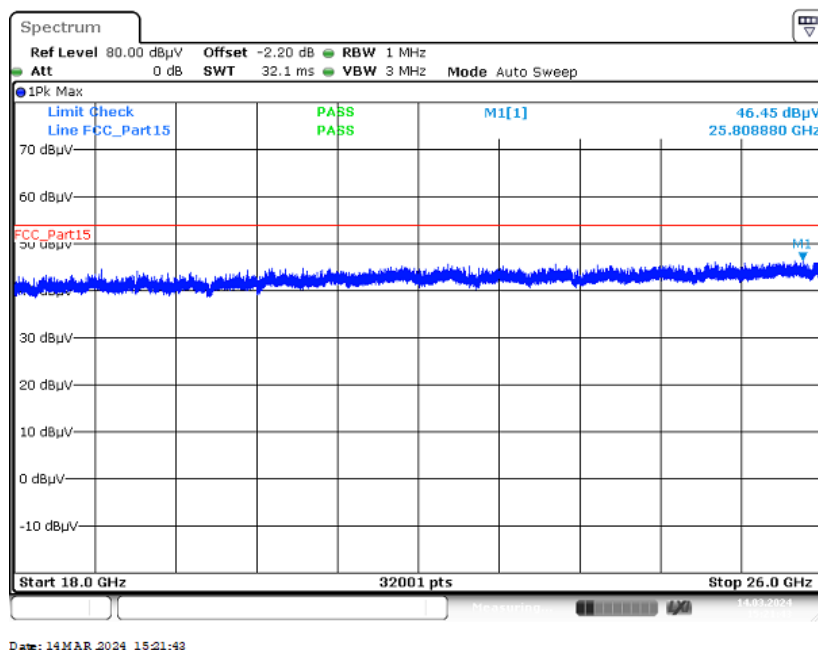
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps

The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 3: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps

The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 4: 18 GHz to 26 GHz, TX mode, vertical & horizontal polarization, 1 Msps, valid for all channels

13 Glossary

| | |
|------------------------|--|
| AVG | Average |
| C | Compliant |
| C/N₀ | Carrier to noise-density ratio, expressed in dB-Hz |
| CAC | Channel availability check |
| CW | Clean wave |
| DC | Duty cycle |
| DFS | Dynamic frequency selection |
| DSSS | Dynamic sequence spread spectrum |
| DUT | Device under test |
| EN | European Standard |
| ETSI | European Telecommunications Standards Institute |
| EMC | Electromagnetic Compatibility |
| EUT | Equipment under test |
| FCC | Federal Communications Commission |
| FCC ID | Company Identifier at FCC |
| FHSS | Frequency hopping spread spectrum |
| FVIN | Firmware version identification number |
| GNSS | Global Navigation Satellite System |
| GUE | GNSS User Equipment |
| HMN | Host marketing name |
| HVIN | Hardware version identification number |
| HW | Hardware |
| IC | Industry Canada |
| Inv. No. | Inventory number |
| MC | Modulated carrier |
| NA | Not applicable |
| NC | Not compliant |
| NOP | Non occupancy period |
| NP | Not performed |
| OBW | Occupied bandwidth |
| OC | Operating channel |
| OCW | Operating channel bandwidth |
| OFDM | Orthogonal frequency division multiplexing |
| OOB | Out of band |
| OP | Occupancy period |
| PER | Packet error rate |
| PMN | Product marketing name |
| PP | Positive peak |
| QP | Quasi peak |
| RLAN | Radio local area network |
| S/N or SN | Serial number |
| SW | Software |
| UUT | Unit under test |
| WLAN | Wireless local area network |

14 Document history

| Version | Applied changes | Date of release |
|---------|-----------------|-----------------|
| -/- | Initial release | 2024-04-16 |
| R02 | HVIN changed | 2024-11-06 |

END OF TEST REPORT