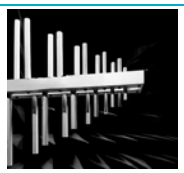
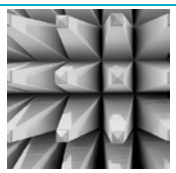

CTC advanced
member of RWTÜV group

# TEST REPORT

**Test report no.: 1-3676/17-01-08**

DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-01

## 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: http://www.ctcadvanced.com
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**Accredited Testing Laboratory:**
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) 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-12076-01-01

## Applicant


**FLIR Systems AB**
Antennvägen 6
187 66 Täby / SWEDEN
Phone: +46 87 53 25 00
Fax: +46 87 53 23 64
Contact: Göran Skedung
e-mail: goran.skedung@flir.se
Phone: +46 87 53 27 59


## Manufacturer


**FLIR Systems AB**
Antennvägen 6
187 66 Täby / SWEDEN


## Test standard/s

| | |
|---|---|
| 47 CFR Part 15 | Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices |
| RSS - 247 Issue 2 | Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices |
| RSS - Gen Issue 4 | Spectrum Management and Telecommunications Radio Standards Specifications - General Requirements and Information for the Certification of Radio Apparatus |

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

## Test Item

| | |
|---|---|
| **Kind of test item:** | **Infrared Camera** |
| **Model name:** | **FLIR-T5590** |
| **FCC ID:** | **ZLV-FLIRT5590** |
| **IC:** | **5306A-FLIRT5590** |
| Frequency: | DTS band 2400 MHz to 2483.5 MHz |
| Technology tested: | Bluetooth®, +EDR |
| Antenna: | Integrated PIFA antenna |
| Power supply: | 3.7 V DC by Li-polymer battery |
| Temperature range: | -20°C to +55°C |

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

## Test report authorized:

cn=Andreas Luckenbill, o=CTC advanced GmbH, ou=LUC-170203, email=Andreas.Luckenbill@ctcadvanced.com, c=DE
2017.06.12 08:06:39 +02'00'

Andreas Luckenbill
Lab Manager
Radio Communications & EMC

## Test performed:

cn=Mihail Dorongovskij, o=CTC advanced GmbH, ou=DOR-281116, email=Mihail.Dorongovskij@ctcadvanced.com, c=DE
2017.06.12 08:05:50 +02'00'

Mihail Dorongovskij
Testing Manager
Radio Communications & EMC

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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.
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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.

## 2.2 Application details

| | |
|---|---|
| Date of receipt of order: | 2017-04-21 |
| Date of receipt of test item: | 2017-04-24 |
| Start of test: | 2017-04-24 |
| End of test: | 2017-05-01 |
| Person(s) present during the test: | Mr. Göran Skedung |

## 2.3 Test laboratories sub-contracted

None

# 3 Test standard/s and references

| Test standard | Date | Description |
|---|---|---|
| 47 CFR Part 15 | | Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices |
| RSS - 247 Issue 2 | February 2017 | Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices |
| RSS - Gen Issue 4 | November 2014 | Spectrum Management and Telecommunications Radio Standards Specifications - General Requirements and Information for the Certification of Radio Apparatus |

| Guidance | Version | Description |
|---|---|---|
| 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 Test environment

| | | | |
|---|---|---|---|
| Temperature | : | $T_{nom}$<br>$T_{max}$<br>$T_{min}$ | +22 °C during room temperature tests<br>No tests under extreme conditions required<br>No tests under extreme conditions required |
| Relative humidity content | : | | 55 % |
| Barometric pressure | : | | 1021 hpa |
| Power supply | : | $V_{nom}$<br>$V_{max}$<br>$V_{min}$ | 3.7 V DC by Li-polymer battery<br>No tests under extreme conditions required<br>No tests under extreme conditions required |

# 5 Test item

## 5.1 General description

| | | |
|---|---|---|
| Kind of test item | : | Infrared Camera |
| Type identification | : | FLIR-T5590 |
| HMN | : | -/- |
| PMN | : | T600, T620, T640 T660 |
| HVIN | : | FLIR-T5590 |
| FVIN | : | -/- |
| S/N serial number | : | Rad. 65203486<br>Cond. 65203757 |
| HW hardware status | : | T198635-01 |
| SW software status | : | 5.14.17 |
| Frequency band | : | DTS band 2400 MHz to 2483.5 MHz<br>(lowest channel 2402 MHz; highest channel 2480 MHz) |
| Type of radio transmission<br>Use of frequency spectrum | :<br>: | FHSS |
| Type of modulation | : | GFSK, Pi/4 QPSK, 8 DPSK |
| Number of channels | : | 79 |
| Antenna | : | Integrated PIFA antenna |
| Power supply | : | 3.7 V DC by Li-polymer battery |
| Temperature range | : | -20°C to +55°C |

## 5.2 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: 1-3676/17-01-01_AnnexA
1-3676/17-01-01_AnnexB
1-3676/17-01-01_AnnexD

# 6 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).

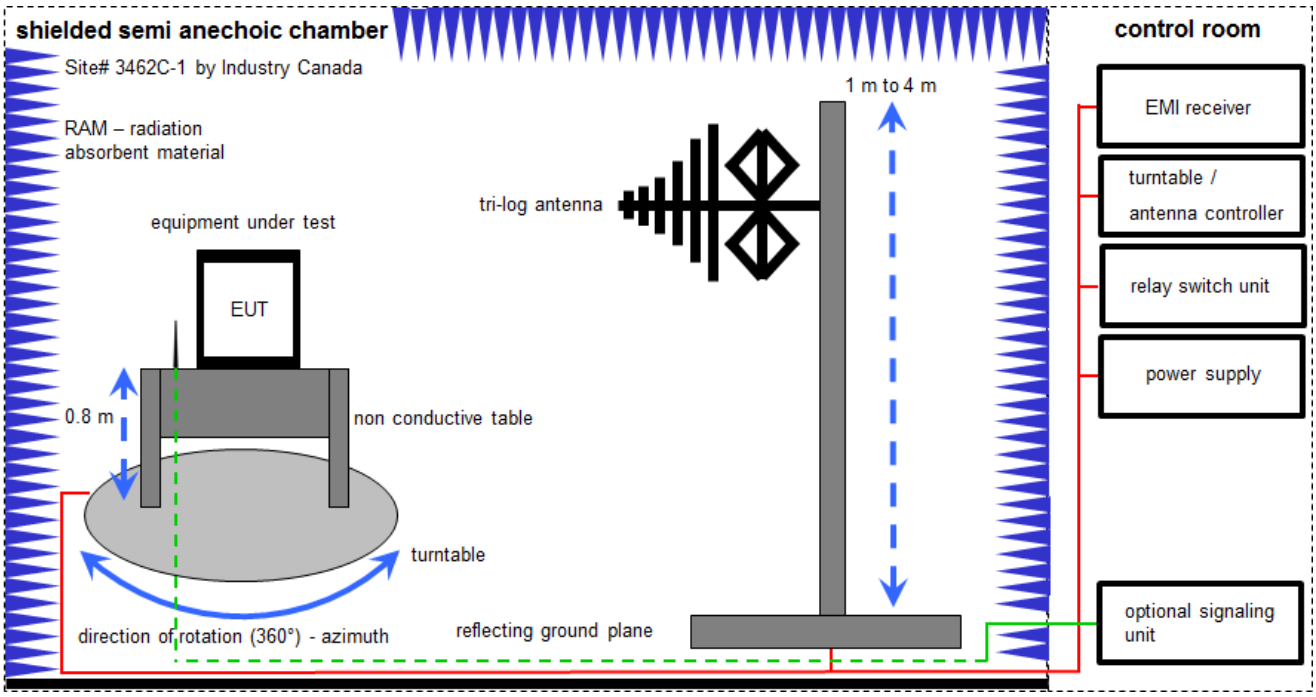
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

**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 |

## 6.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 9 kHz 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

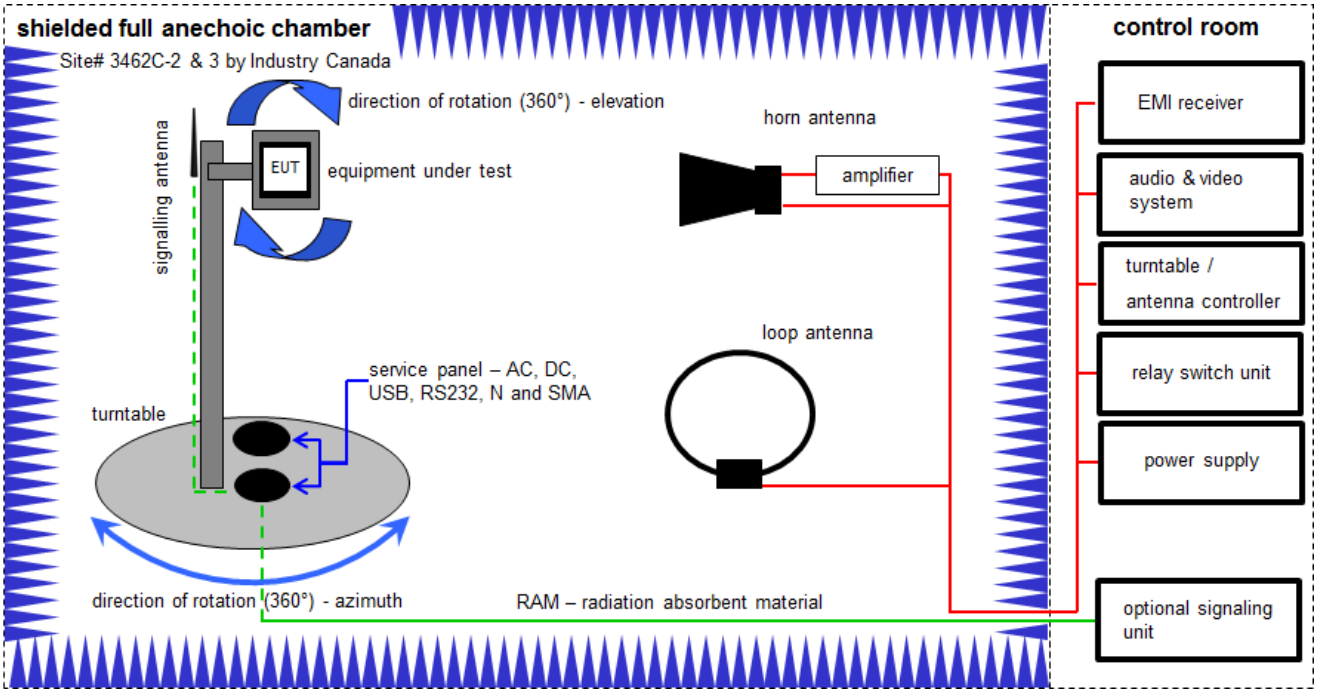
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

*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. | Lab / Item | 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 | Meßkabine 1 | HF-Absorberhalle | MWB AG 300023 | -/- | 300000551 | ne | -/- | -/- |
| 3 | A | EMI Test Receiver | ESCI 3 | R&S | 100083 | 300003312 | k | 01.02.2017 | 31.01.2018 |
| 4 | A | Antenna Tower | Model 2175 | ETS-Lindgren | 64762 | 300003745 | izw | -/- | -/- |
| 5 | A | Positioning Controller | Model 2090 | ETS-Lindgren | 64672 | 300003746 | izw | -/- | -/- |
| 6 | A | Turntable Interface-Box | Model 105637 | ETS-Lindgren | 44583 | 300003747 | izw | -/- | -/- |
| 7 | A | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz | VULB9163 | Schwarzbeck | 295 | 300003787 | k | 25.04.2016 | 25.04.2018 |
| 8 | A | CBT (Bluetooth Tester + EDR Signalling) | CBT 1153.9000K35, CBT-B55, CBT-K55 | R&S | 100313 | 300003516 | vIKI! | 22.09.2016 | 22.09.2018 |

## 6.2 Shielded fully anechoic chamber




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

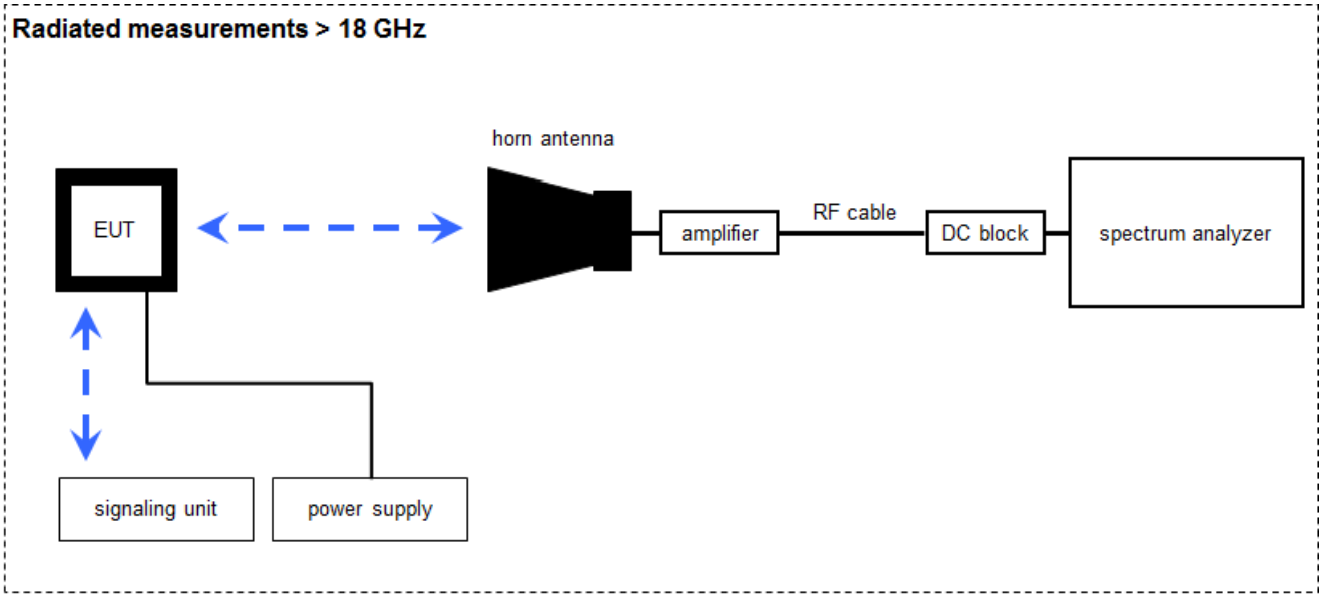
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

*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. | Lab / Item | 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 | 8812-3088 | 300001032 | vlKl! | 20.05.2015 | 20.05.2017 |
| 2 | A, B | Anechoic chamber | FAC 3/5m | MWB / TDK | 87400/02 | 300000996 | ev | -/- | -/- |
| 3 | B | Active Loop Antenna 10 kHz to 30 MHz | 6502 | EMCO/2 | 8905-2342 | 300000256 | k | 24.06.2015 | 24.06.2017 |
| 4 | A | Band Reject filter | WRCG2400/2483-2375/2505-50/10SS | Wainwright | 11 | 300003351 | ev | -/- | -/- |
| 5 | A | Highpass Filter | WHKX2.9/18G-12SS | Wainwright | 1 | 300003492 | ev | -/- | -/- |
| 6 | A, B | EMI Test Receiver 20Hz- 26,5GHz | ESU26 | R&S | 100037 | 300003555 | k | 31.01.2017 | 30.01.2018 |
| 7 | A | Highpass Filter | WHKX7.0/18G-8SS | Wainwright | 19 | 300003790 | ne | -/- | -/- |
| 8 | A | Broadband Amplifier 0.5-18 GHz | CBLU5184540 | CERNEX | 22049 | 300004481 | ev | -/- | -/- |
| 9 | A, B | 4U RF Switch Platform | L4491A | Agilent Technologies | MY50000037 | 300004509 | ne | -/- | -/- |
| 10 | A, B | NEXIO EMV-Software | BAT EMC V3.16.0.49 | EMCO | -/- | 300004682 | ne | -/- | -/- |
| 11 | A,B | PC | ExOne | F+W | -/- | 300004703 | ne | -/- | -/- |
| 12 | A | RF-Amplifier | AMF-6F06001800-30-10P-R | NARDA-MITEQ Inc | 2011572 | 300005241 | ev | -/- | -/- |
| 13 | A | CBT (Bluetooth Tester + EDR Signalling) | CBT 1153.9000K35, CBT-B55, CBT-K55 | R&S | 100313 | 300003516 | vlKl! | 22.09.2016 | 22.09.2018 |

## 6.3 Radiated measurements > 18 GHz




Measurement distance: horn antenna 50 cm

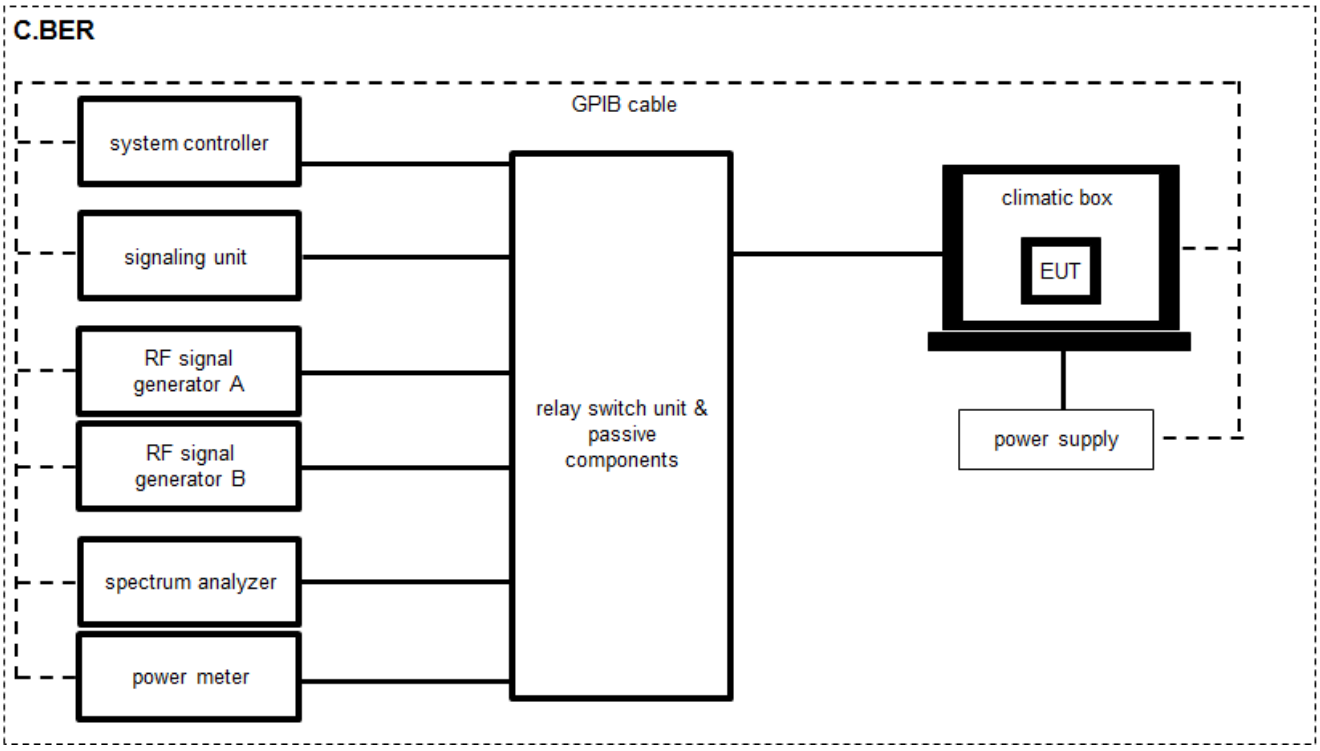
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

*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. | Lab / Item | 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 | -/- | 300000486 | k | 10.09.2015 | 10.09.2017 |
| 3 | A | RF-Cable | ST18/SMAm/SMAm/48 | Huber & Suhner | Batch no. 600918 | 400001182 | ev | -/- | -/- |
| 4 | A | RF-Cable | ST18/SMAm/SMAm/48 | Huber & Suhner | Batch no. 127377 | 400001183 | ev | -/- | -/- |
| 5 | A | DC-Blocker 0.1-40 GHz | 8141A | Inmet | -/- | 400001185 | ev | -/- | -/- |
| 6 | A | Synchron Power Meter | SPM-4 | CTC | 1 | 400001294 | ev | -/- | -/- |
| 7 | A | Signal Analyzer 40 GHz | FSV40 | R&S | 101042 | 300004517 | k | 25.01.2017 | 24.01.2018 |
| 8 | A | CBT (Bluetooth Tester + EDR Signalling) | CBT 1153.9000K35, CBT-B55, CBT-K55 | R&S | 100313 | 300003516 | vIKI! | 22.09.2016 | 22.09.2018 |

## 6.4 Conducted measurements C.BER system



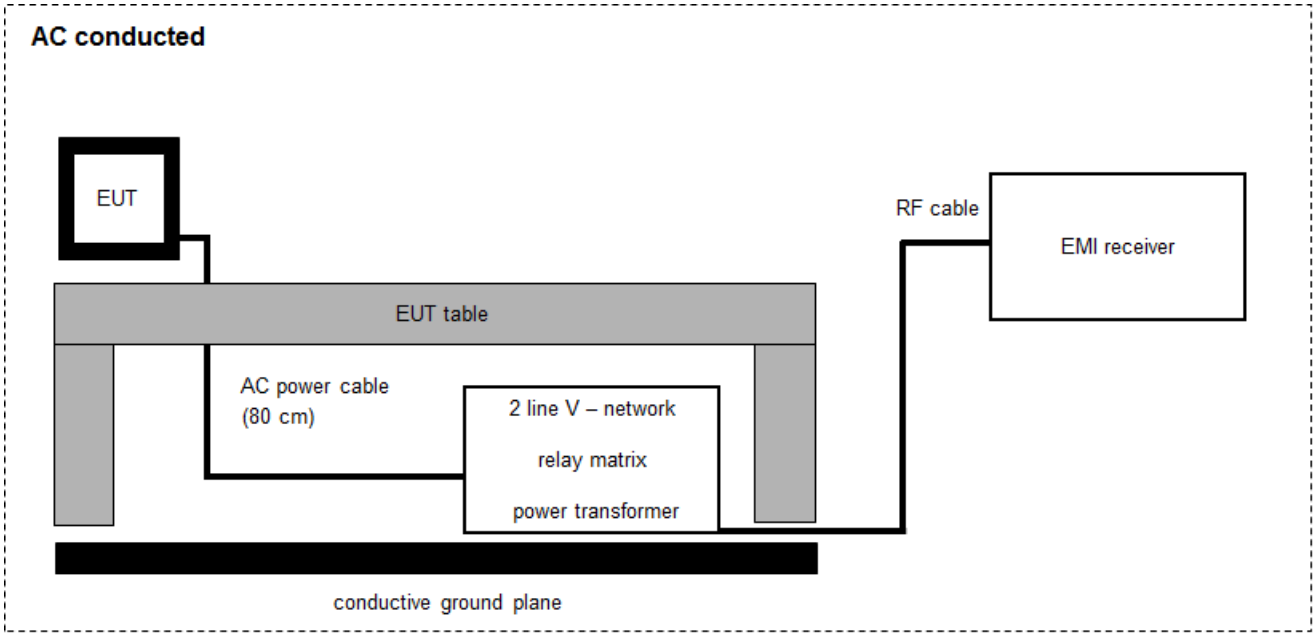

OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

*Example calculation:*
OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

**Equipment table:**

| No. | Lab / Item | Equipment | Type | Manufacturer | Serial No. | INV. No. | Kind of Calibration | Last Calibration | Next Calibration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Switch / Control Unit | 3488A | HP | | 300001691 | ne | -/- | -/- |
| 2 | A | Signal Analyzer 20Hz-26,5GHz-150 to + 30 DBM | FSIQ26 | R&S | 835540/018 | 300002681 | k | 28.01.2016 | 28.01.2018 |
| 3 | A | Frequency Standard (Rubidium Frequency Standard) | MFS (Rubidium) | R&S (Datum) | 002 | 300002681 | vIKI! | 27.01.2017 | 26.01.2019 |
| 4 | A | Directional Coupler | 101020010 | Krytar | 70215 | 300002840 | ev | -/- | -/- |
| 5 | A | DC-Blocker | 8143 | Inmet Corp. | none | 300002842 | ne | -/- | -/- |
| 6 | A | Powersplitter | 6005-3 | Inmet Corp. | | 300002841 | ev | -/- | -/- |
| 7 | A | CBT (Bluetooth Tester + EDR Signalling) | CBT 1153.9000K35, CBT-B55, CBT-K55 | R&S | 100313 | 300003516 | vIKI! | 22.09.2016 | 22.09.2018 |
| 8 | A | RF-Cable | ST18/SMAm/SMAm/ 72 | Huber & Suhner | Batch no. 605505 | 400001187 | ev | -/- | -/- |
| 9 | A | RF-Cable | Sucoflex 104 | Huber & Suhner | 147636/4 | 400001188 | ev | -/- | -/- |

## 6.5 AC conducted




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. | Lab / Item | 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 | R&S | 893045/004 | 300000584 | k | 31.01.2017 | 30.01.2018 |
| 2 | A | RF-Filter-section | 85420E | HP | 3427A00162 | 300002214 | k | 27.11.2006 | -/- |
| 3 | A | AC-Spannungsquelle variabel | MV2616-V | EM-Test | 0397-12 | 300003259 | k | 11.12.2015 | 11.12.2017 |
| 4 | A | Analyzer-Reference-System (Harmonics and Flicker) | ARS 16/1 | SPS | A3509 07/0 0205 | 300003314 | Ve | 02.02.2016 | 02.02.2018 |
| 5 | A | Hochpass 150 kHz | EZ-25 | R&S | 100010 | 300003798 | ev | 08.04.2008 | -/- |
| 6 | A | MXE EMI Receiver 20 Hz to 26,5 GHz | N9038A | Agilent Technologies | MY51210197 | 300004405 | k | 16.08.2016 | 16.08.2017 |
| 7 | A | CBT (Bluetooth Tester + EDR Signalling) | CBT 1153.9000K35, CBT-B55, CBT-K55 | R&S | 100313 | 300003516 | vlKl! | 22.09.2016 | 22.09.2018 |

# 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, 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 height is 1.5 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 premeasurement are maximized by the software by rotating the turntable from 0° to 360°. In case of the 2-axis positioner is used the elevation axis is also rotated from 0° to 360°.
- 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.

## 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 ± 45° 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 Measurement uncertainty

| Measurement uncertainty | |
|---|---|
| **Test case** | **Uncertainty** |
| Antenna gain | ± 3 dB |
| Carrier frequency separation | ± 21.5 kHz |
| Number of hopping channels | -/- |
| Time of occupancy | According BT Core specification |
| 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 |
| 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 |

# 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 15<br>RSS - 247, Issue 2 | See table! | 2017-06-12 | -/- |

| Test specification clause | Test case | Temperature conditions | Power source voltages | Mode | C | NC | NA | NP | Remark |
|---|---|---|---|---|---|---|---|---|---|
| §15.247(b)(4)<br>RSS - 247 /<br>5.4.(f)(ii) | Antenna gain | Nominal | Nominal | GFSK | ☐ | ☐ | ☐ | ☒ | declared by manufacturer |
| §15.247(a)(1)<br>RSS - 247 / 5.1.(b) | Carrier frequency separation | Nominal | Nominal | GFSK | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.247(a)(1)<br>RSS - 247 / 5.1 (d) | Number of hopping channels | Nominal | Nominal | GFSK | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.247(a)(1) (iii)<br>RSS - 247 / 5.1 (c) | Time of occupancy (dwell time) | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.247(a)(1)<br>RSS - 247 / 5.1 (a) | Spectrum bandwidth of a FHSS system bandwidth | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒<br>☒<br>☒ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | -/- |
| §15.247(b)(1)<br>RSS - 247 / 5.4 (b) | Maximum output power | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒<br>☒<br>☒ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | -/- |
| §15.247(d)<br>RSS - 247 / 5.5 | Detailed spurious emissions @ the band edge - conducted | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒<br>☒<br>☒ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | -/- |
| §15.205<br>RSS - 247 /<br>5.5 RSS - Gen | Band edge compliance radiated | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒<br>☒<br>☒ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | -/- |
| §15.247(d)<br>RSS - 247 / 5.5 | Spurious emissions conducted | Nominal | Nominal | GFSK<br>Pi/4 DQPSK<br>8 DPSK | ☒<br>☒<br>☒ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | ☐<br>☐<br>☐ | -/- |
| §15.209(a)<br>RSS - Gen | Spurious emissions radiated below 30 MHz | Nominal | Nominal | GFSK | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.247(d)<br>RSS - 247 / 5.5<br>§15.109<br>RSS - Gen | Spurious emissions radiated 30 MHz to 1 GHz | Nominal | Nominal | GFSK<br>RX mode | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.247(d)<br>RSS - 247 / 5.5<br>§15.109<br>RSS - Gen | Spurious emissions radiated above 1 GHz | Nominal | Nominal | GFSK<br>RX mode | ☒ | ☐ | ☐ | ☐ | -/- |
| §15.107(a)<br>§15.207 | Conducted emissions below 30 MHz (AC conducted) | Nominal | Nominal | GFSK<br>RX mode | ☒ | ☐ | ☐ | ☐ | -/- |

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

## 10 Additional comments

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| | |
|---|---|
| Reference documents: | 3-3-TECH-587 940-01 Flir T640 Antenna characterization_A.PDF |
| Special test descriptions: | None |
| Configuration descriptions: | TX tests: were performed with x-DH5 packets and static PRBS pattern payload.<br>RX/Standby tests: BT test mode enabled, scan enabled, TX Idle |
| Test mode: | ☒ Bluetooth Test mode loop back enabled<br>(EUT is controlled over CBT/CMU/CMW)<br><br>☐ Special software is used.<br>EUT is transmitting pseudo random data by itself |
| 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) |

# 11 Measurement results

## 11.1 Antenna gain

**Limits:**

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

| Peak antenna gain according “3-3-TECH-587 940-01 Flir T640 Antenna characterization_A.pdf” | |
|---|---|
| PIFA antenna | 0.6 dBi |

## 11.2 Carrier frequency separation

**Description:**

Measurement of the carrier frequency separation of a hopping system. The carrier frequency separation is constant for all modulation-modes. We use GFSK-modulation to show compliance. EUT in hopping mode.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 100 kHz |
| Video bandwidth | 300 kHz |
| Span | 4 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

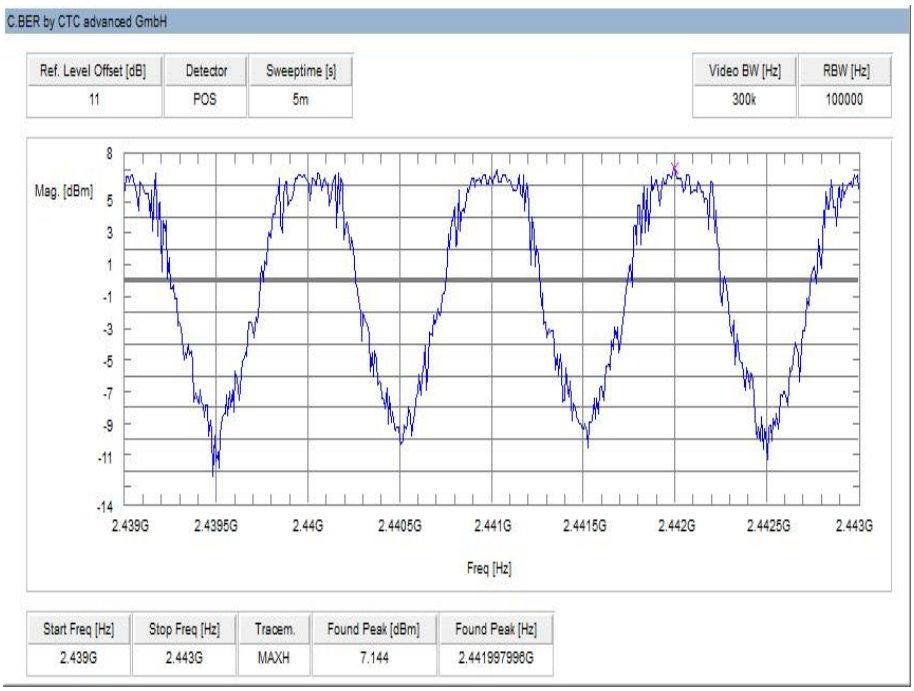
| FCC | IC |
|---|---|
| Carrier frequency separation | |
| Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater. | |

**Result:**

| | |
|---|---|
| Carrier frequency separation | ~ 1 MHz |

**Plot:**

**Plot 1:** Carrier frequency separation (GFSK modulation)



## 11.3 Number of hopping channels

**Description:**

Measurement of the total number of used hopping channels. The number of hopping channels is constant for all modulation-modes. We use GFSK-modulation to show compliance. EUT in hopping mode.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 500 kHz |
| Video bandwidth | 500 kHz |
| Span | Plot 1: 2400 – 2445 MHz<br>Plot 2: 2445 – 2485 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

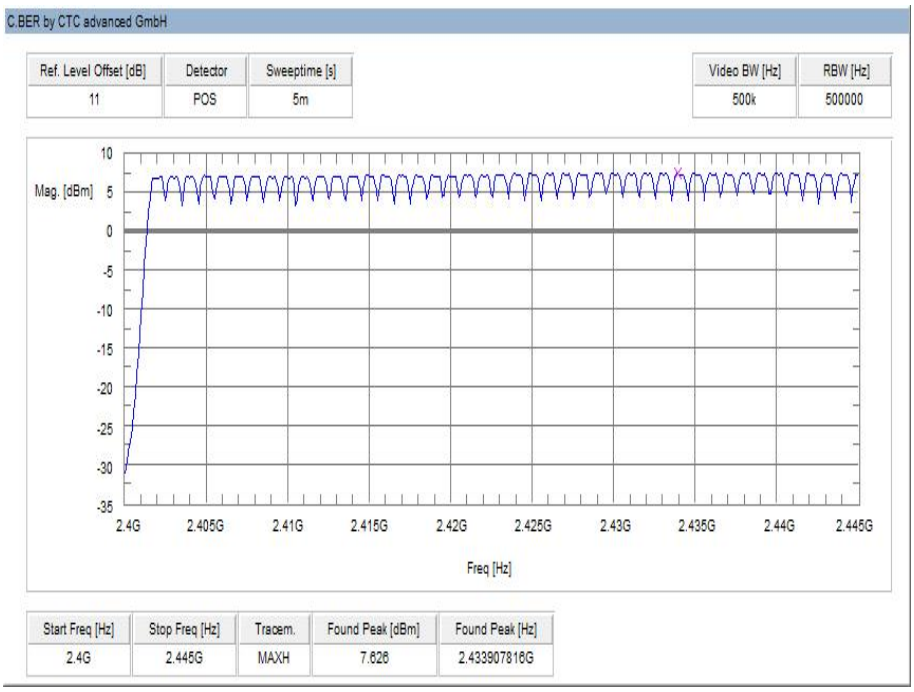
| FCC | IC |
|---|---|
| Number of hopping channels | |
| At least 15 non overlapping hopping channels | |

**Result:**

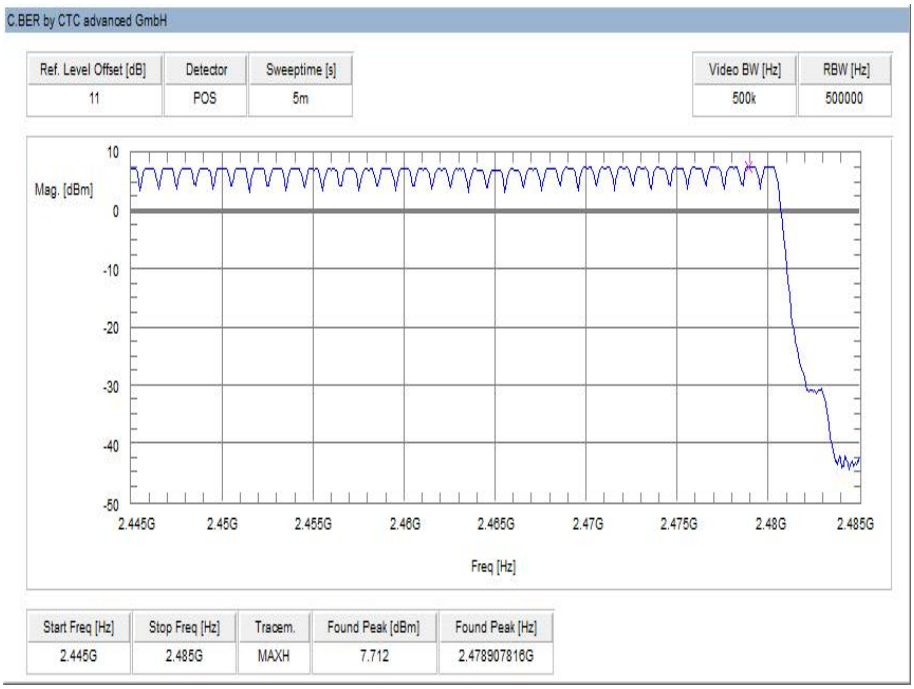
| | |
|---|---|
| Number of hopping channels | 79 |

**Plots:**

**Plot 1:** Number of hopping channels (GFSK modulation)




**Plot 2:** Number of hopping channels (GFSK modulation)



## 11.4 Time of occupancy (dwell time)

**Measurement:**

For Bluetooth® devices no measurements mandatory depending on the fixed requirements according to the Bluetooth® Core Specifications!

**For Bluetooth® devices:**

The channel staying time of 0.4 s within a 31.6 second period in data mode is constant for Bluetooth® devices and independent from the packet type (packet length). The calculation for a 31.6 second period is a follows:

Channel staying time = time slot length * hop rate / number of hopping channels * 31.6 s

Example for a DH1 packet (with a maximum length of one time slot)
Channel staying time = 625 µs * 1600*1/s / 79 * 31.6 s = 0.4 s (in a 31.6 s period)

For multi-slot packets the hopping is reduced according to the length of the packet.

Example for a DH3 packet (with a maximum length of three time slots)
Channel staying time = 3 * 625 µs * 1600/3 *1/s / 79 * 31.6 s = 0.4 s (in a 31.6 s period)

Example for a DH5 packet (with a maximum length of five time slots)
Channel staying time = 5 * 625 µs * 1600/5 *1/s / 79 * 31.6 s = 0.4 s (in a 31.6 s period)

This is according the Bluetooth® Core Specification V2.0 & V2.1 & V3.0 & V4.0 (+ critical errata) for all Bluetooth® devices and all modulations.

**The following table shows the relations:**

| Packet Size | Pulse Width [ms] * | Max. number of transmissions per channel in 31.6 sec |
|---|---|---|
| DH1 | 0.366 | 640 |
| DH3 | 1.622 | 214 |
| DH5 | 2.870 | 128 |

* according Bluetooth® specification

**Results:**

| Packet Size | Pulse Width [ms]* | Max. number of transmissions in 31.6 sec | Time of occupancy (dwell time) [Pulse width * Number of transmissions] |
|---|---|---|---|
| DH1 | 0.366 | 640 | 234.2 ms |
| DH3 | 1.622 | 214 | 347.1 ms |
| DH5 | 2.870 | 128 | 367.4 ms |

**Limits:**

| FCC | IC |
|---|---|
| Time of occupancy (dwell time) | |
| The frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4. | |

## 11.5 Spectrum bandwidth of a FHSS system

**Description:**

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal. The measurement is performed according to the “Measurement Guidelines” (DA 00-705, March 30, 2000). EUT in single channel mode.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 30 kHz |
| Video bandwidth | 100 kHz |
| Span | 3 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

| FCC | IC |
|---|---|
| Spectrum bandwidth of a FHSS system | |
| GFSK < 1500 kHz<br>Pi/4 DQPSK < 1500 kHz<br>8DPSK < 1500 kHz | |

**Results:**

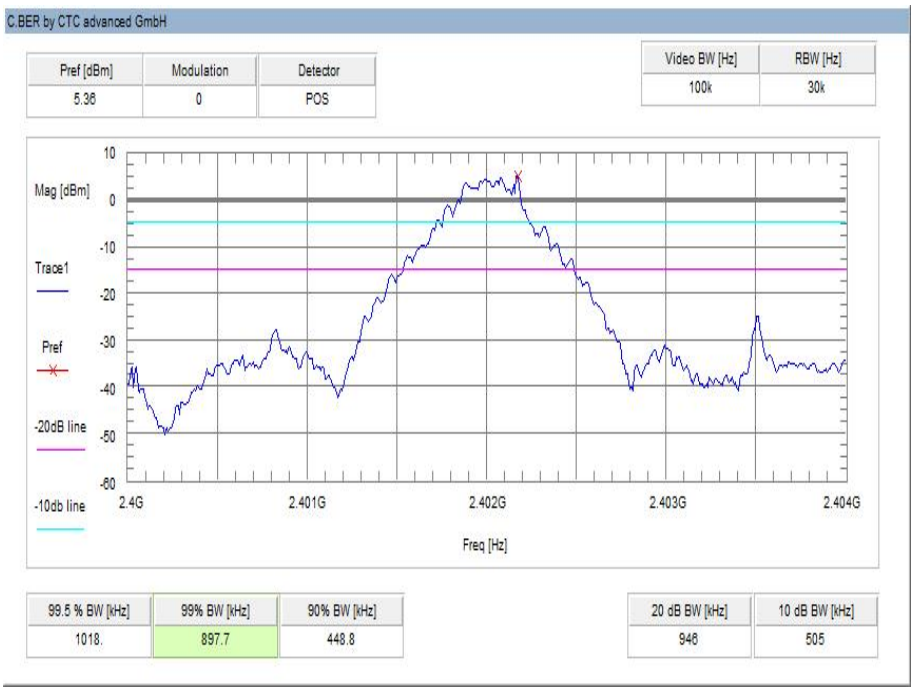
| Modulation | 20 dB bandwidth [kHz] | | |
|---|---|---|---|
| Frequency | 2402 MHz | 2441 MHz | 2480 MHz |
| GFSK | 946 | 946 | 954 |
| Pi/4 DQPSK | 1299 | 1307 | 1299 |
| 8DPSK | 1291 | 1299 | 1299 |

**Results:**

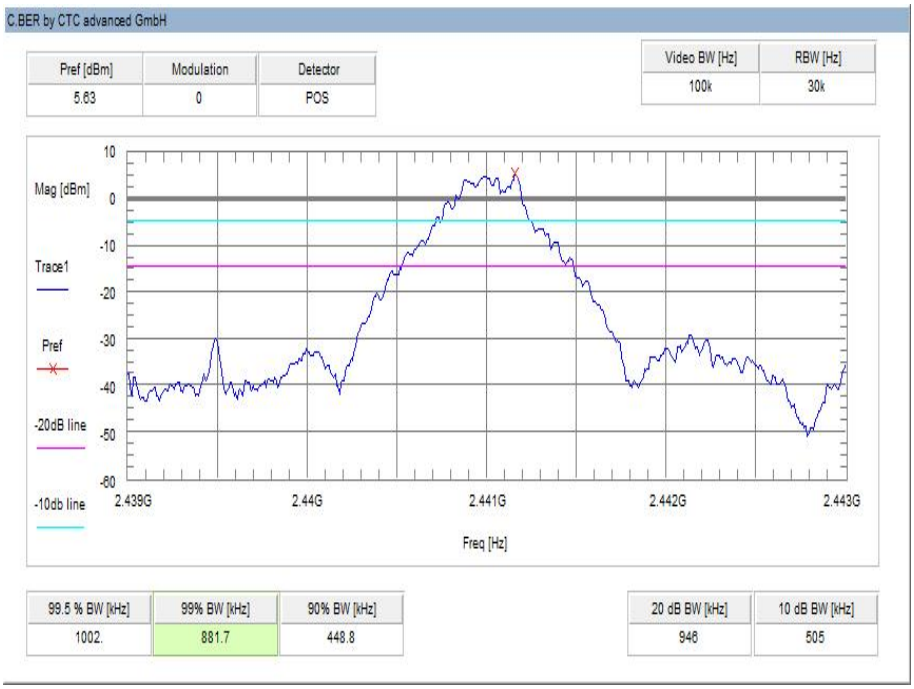
| Modulation | 99 % bandwidth [kHz] | | |
|---|---|---|---|
| Frequency | 2402 MHz | 2441 MHz | 2480 MHz |
| GFSK | 897.7 | 881.7 | 881.7 |
| Pi/4 DQPSK | 1178 | 1186 | 1210 |
| 8DPSK | 1194 | 1210 | 1218 |

**Plots:**

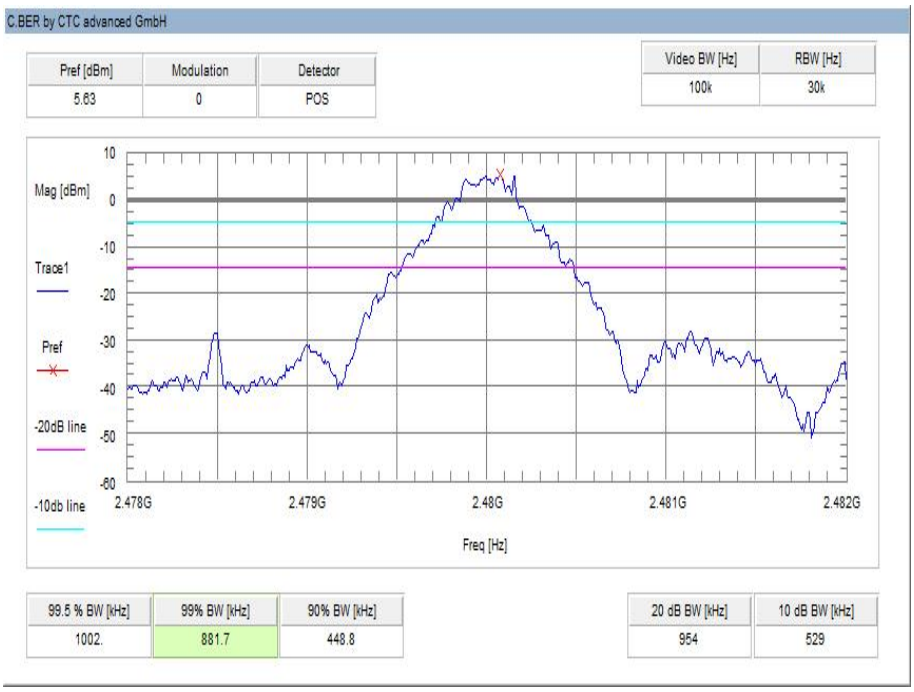
**Plot 1:** lowest channel – 2402 MHz, GFSK modulation



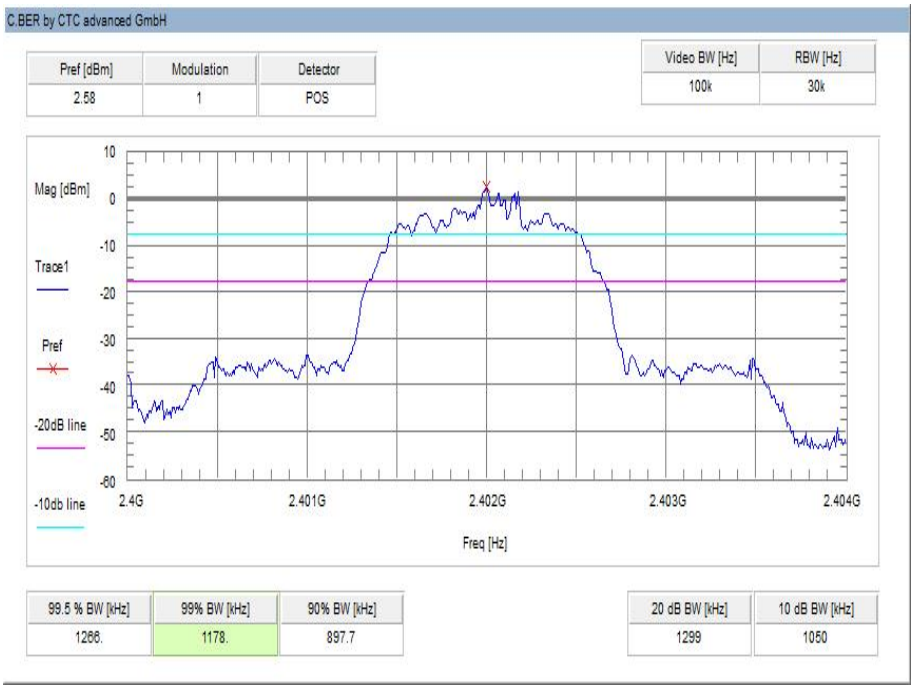

**Plot 2:** middle channel – 2441 MHz, GFSK modulation



**Plot 3:** highest channel – 2480 MHz, GFSK modulation

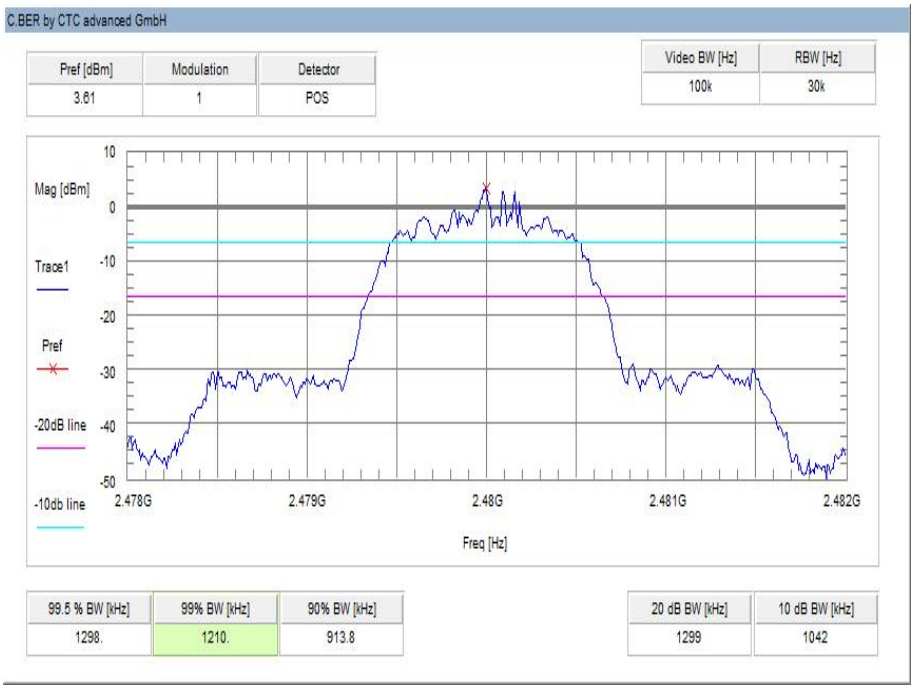



**Plot 4:** lowest channel – 2402 MHz, Pi / DQPSK modulation

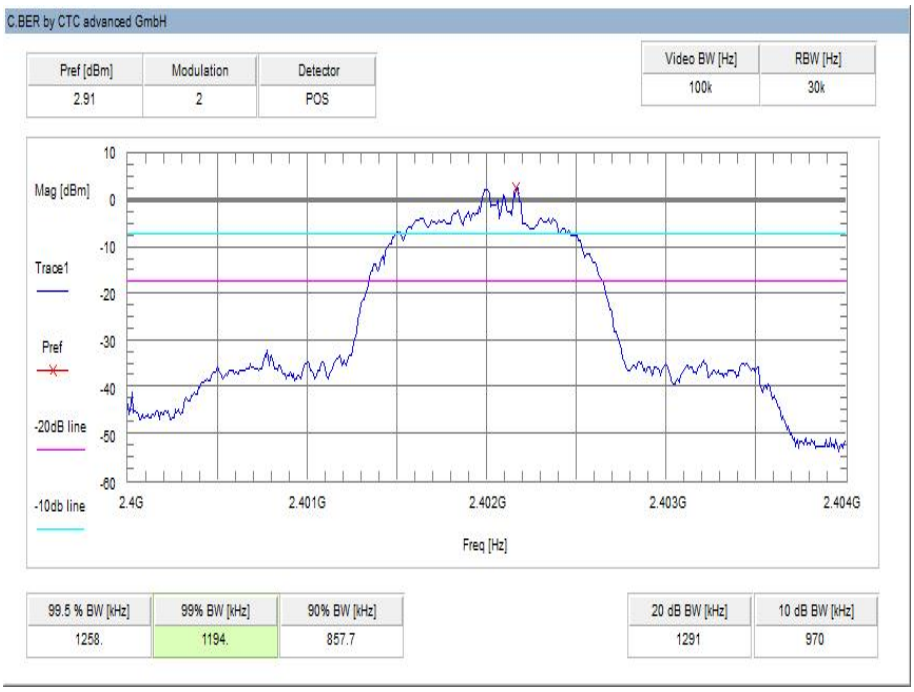


**Plot 5:** middle channel – 2441 MHz, Pi / DQPSK modulation

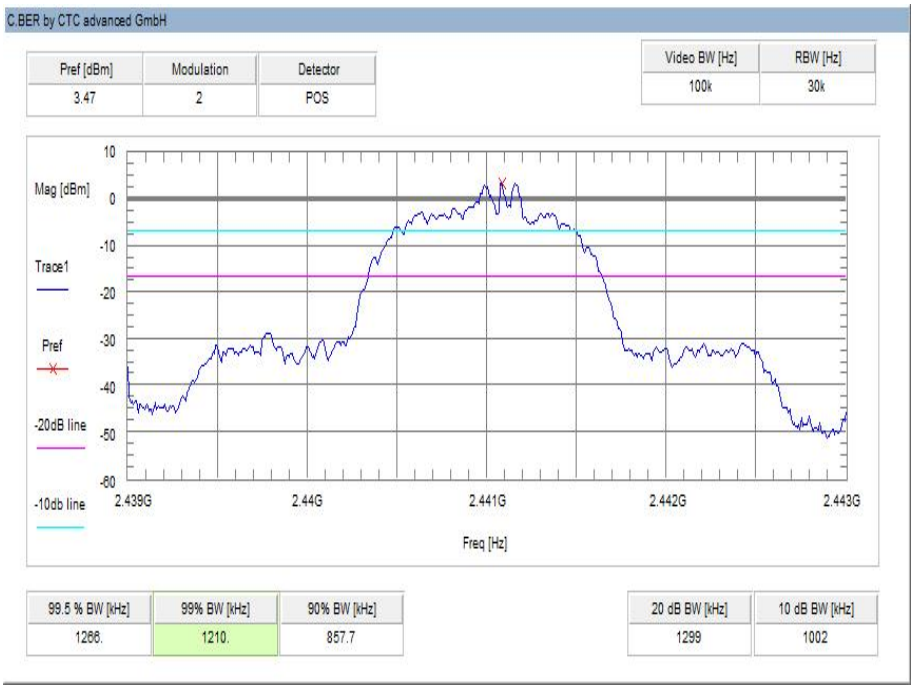
**Plot 6:** highest channel – 2480 MHz, Pi / DQPSK modulation



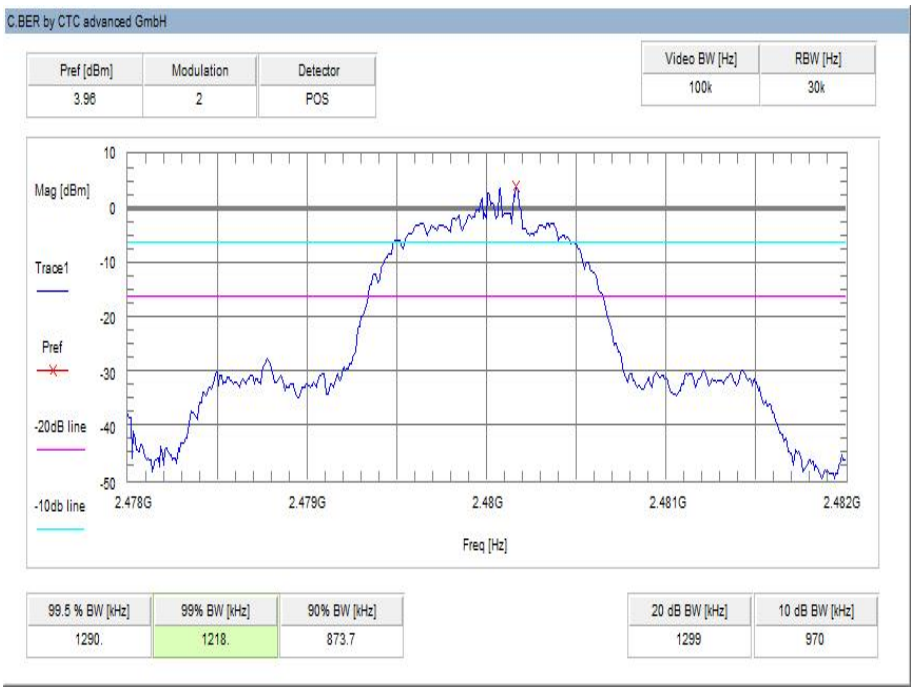
**Plot 7:** lowest channel – 2402 MHz, 8 DPSK modulation




**Plot 8:** middle channel – 2441 MHz, 8 DPSK modulation



**Plot 9:** highest channel – 2480 MHz, 8 DPSK modulation



## 11.6 Maximum output power

**Description:**

Measurement of the maximum output power conducted and radiated. EUT in single channel mode. The measurement is performed according to the ANSI C63.10.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 3 MHz |
| Video bandwidth | 10 MHz |
| Span | 6 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

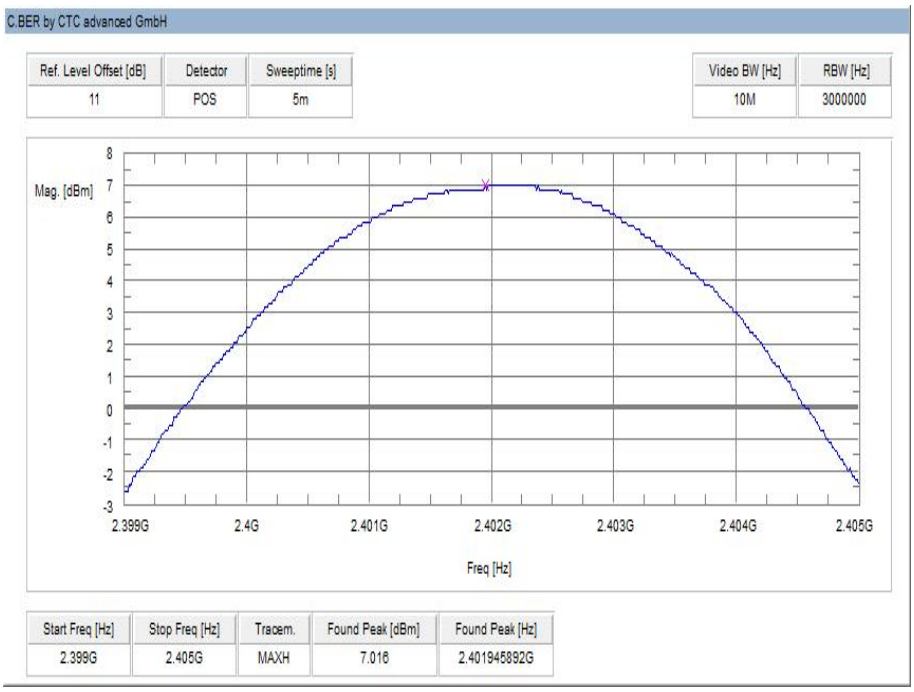
| FCC | IC |
|---|---|
| Maximum output power | |
| [Conducted: 0.125 W – antenna gain max. 6 dBi]<br>Systems using more than 75 hopping channels:<br>Conducted: 1.0 W – antenna gain max. 6 dBi | |

**Results:**

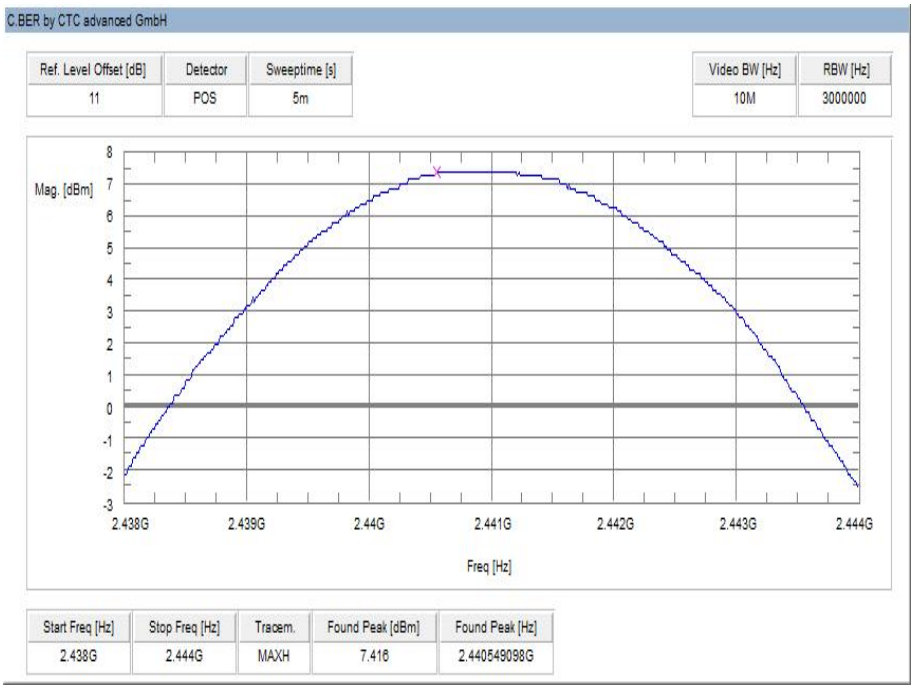
| Modulation | Maximum output power conducted [dBm] | | |
|---|---|---|---|
| Frequency | 2402 MHz | 2441 MHz | 2480 MHz |
| GFSK | 7.0 | 7.4 | 7.5 |
| Pi/4 DQPSK | 5.7 | 6.3 | 6.4 |
| 8 DPSK | 5.9 | 6.6 | 6.7 |

**Plots:**

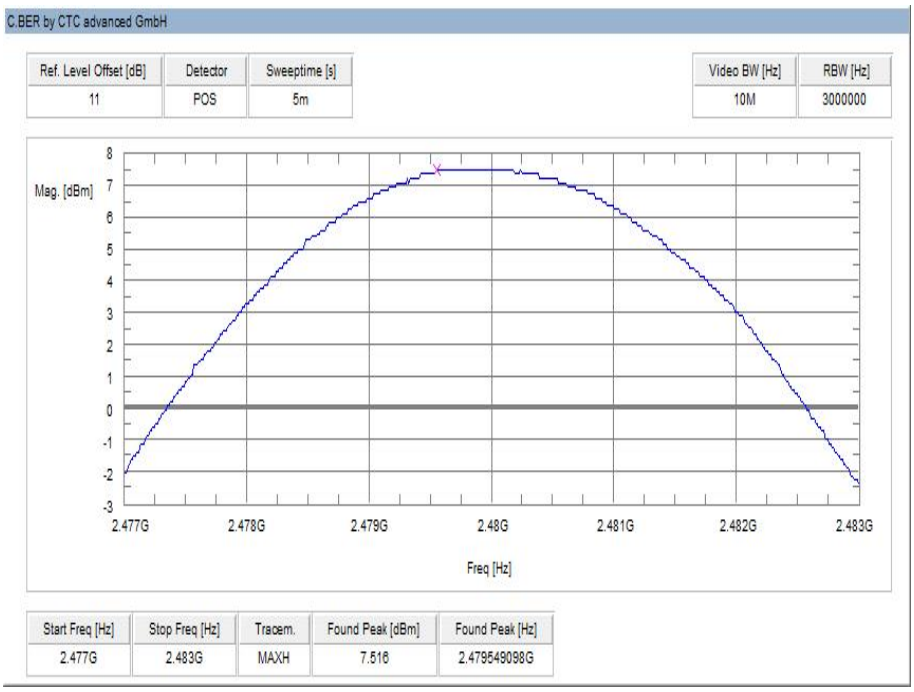
**Plot 1:** lowest channel – 2402 MHz, GFSK modulation



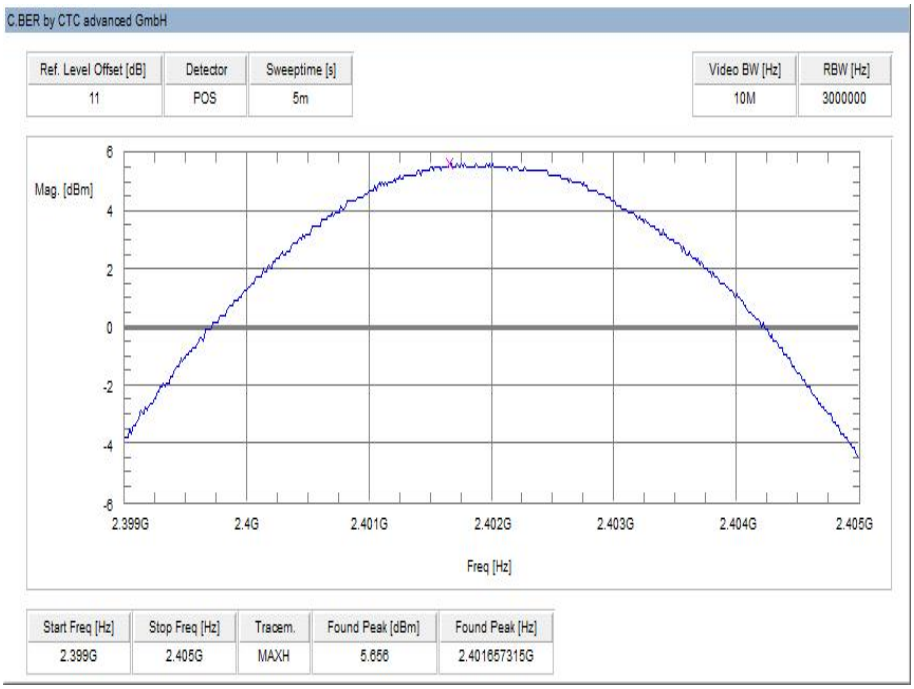

**Plot 2:** middle channel – 2441 MHz, GFSK modulation



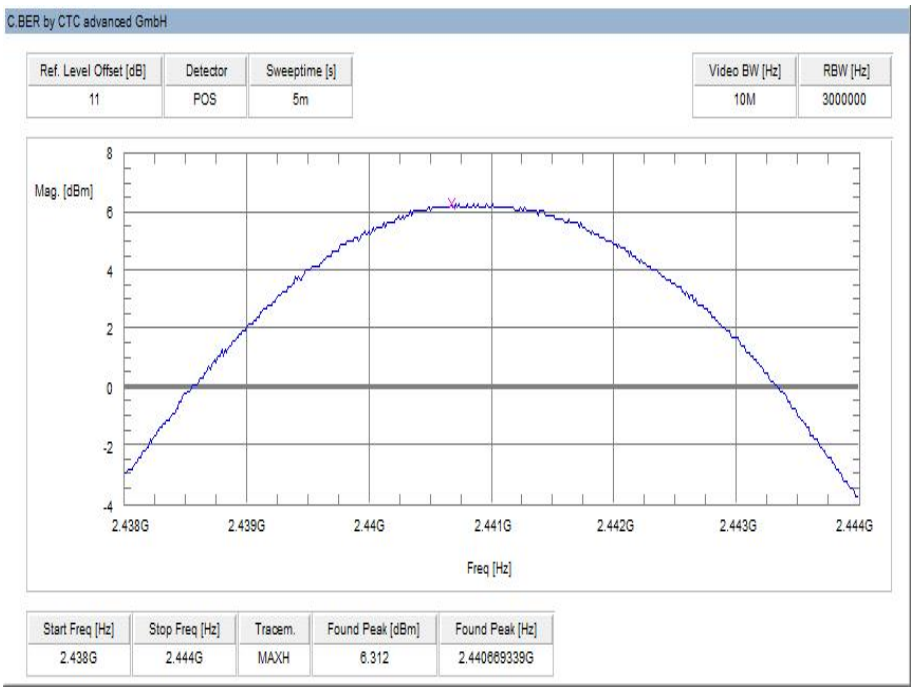
**Plot 3:** highest channel – 2480 MHz, GFSK modulation



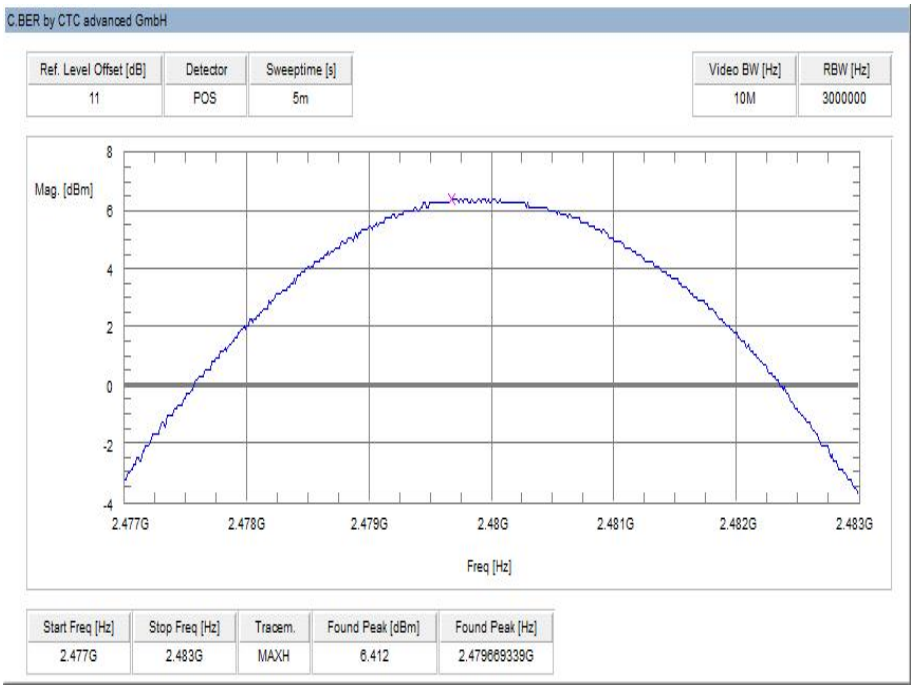

**Plot 4:** lowest channel – 2402 MHz, Pi / DQPSK modulation



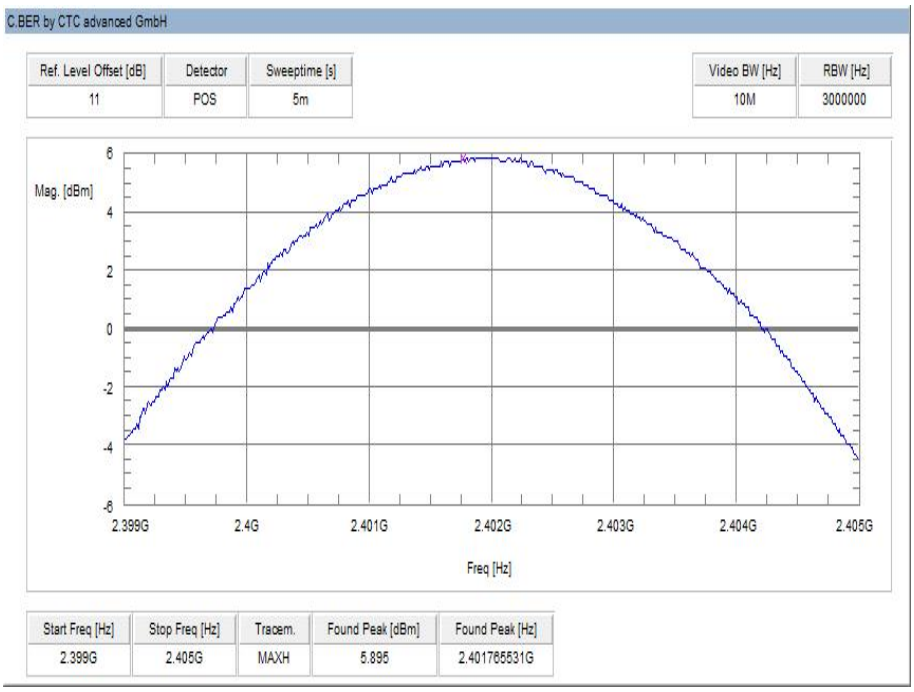
**Plot 5:** middle channel – 2441 MHz, Pi / DQPSK modulation



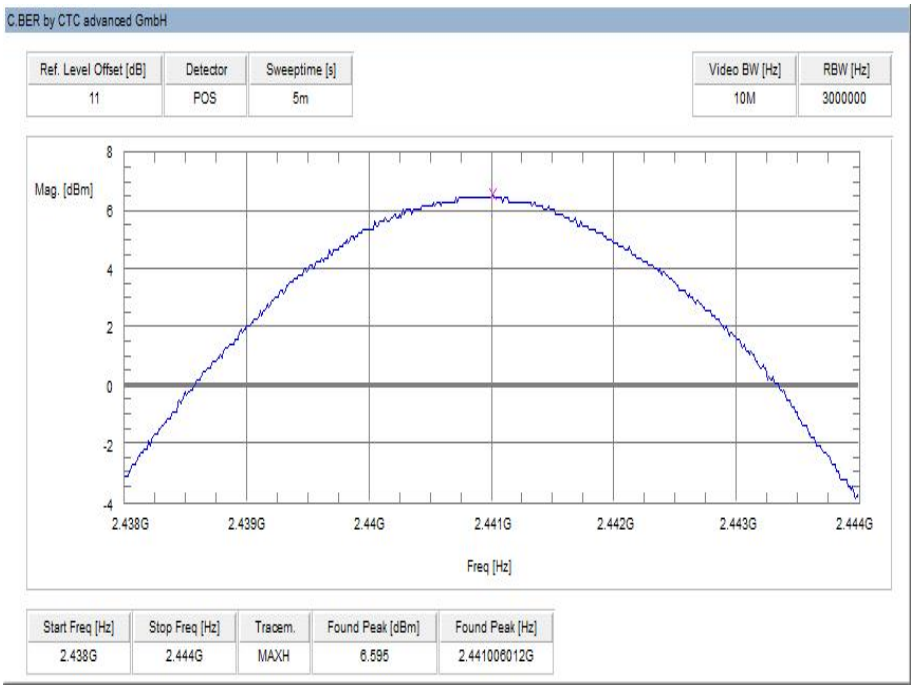

**Plot 6:** highest channel – 2480 MHz, Pi / DQPSK modulation



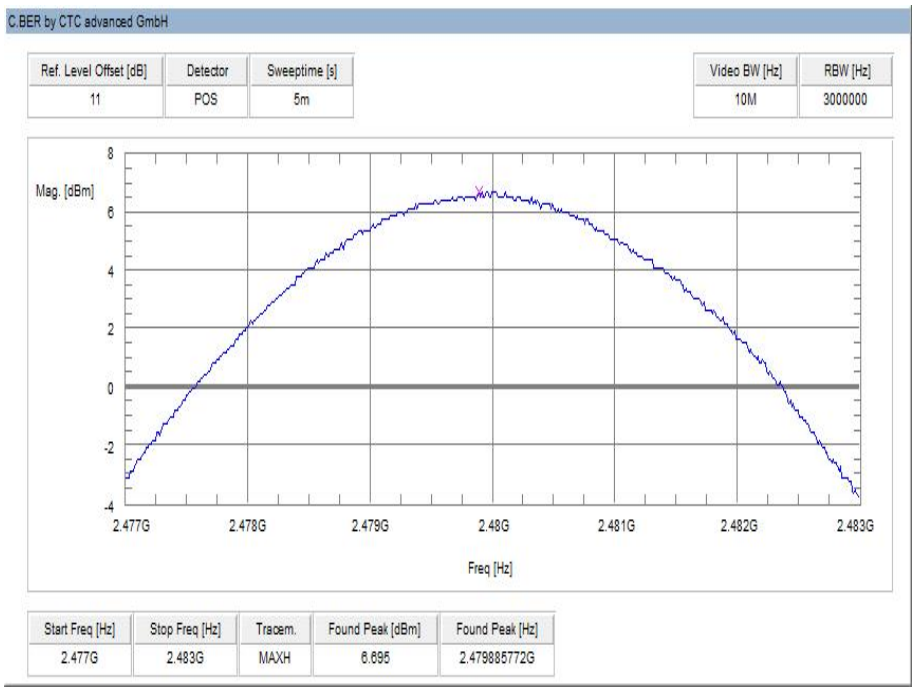
**Plot 7:** lowest channel – 2402 MHz, 8 DPSK modulation




**Plot 8:** middle channel – 2441 MHz, 8 DPSK modulation



**Plot 9:** highest channel – 2480 MHz, 8 DPSK modulation



## 11.7 Detailed spurious emissions @ the band edge - conducted

**Description:**

Measurement of the conducted band edge compliance. EUT is measured at the lower and upper band edge in single channel and hopping mode. The measurement is repeated for all modulations.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 100 kHz |
| Video bandwidth | 300 kHz / 500 kHz |
| Span | Lower Band Edge: 2395 – 2405 MHz<br>Upper Band Edge: 2478 – 2489 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

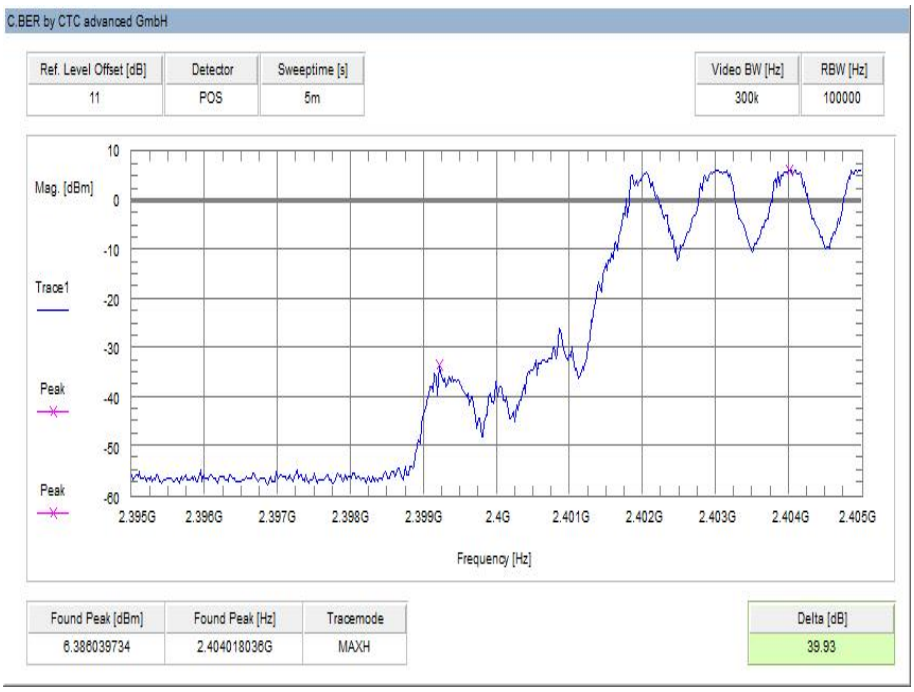
| FCC | IC |
|---|---|
| In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within 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:**

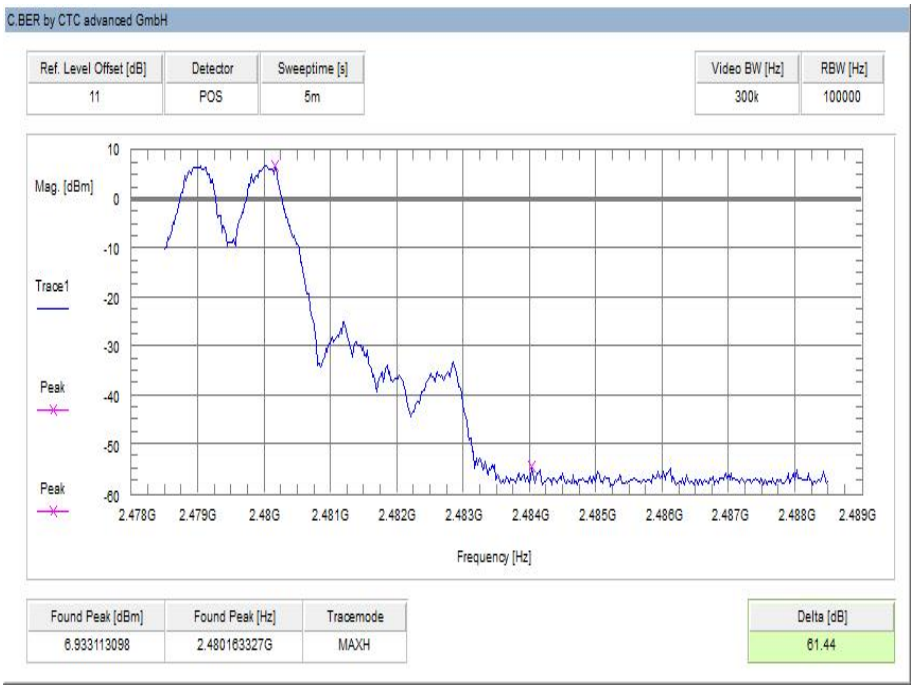
| Scenario | Spurious band edge conducted [dB] | | |
|---|---|---|---|
| Modulation | GFSK | Pi/4 DQPSK | 8DPSK |
| Lower band edge – hopping off | > 20 dB | > 20 dB | > 20 dB |
| Lower band edge – hopping on | > 20 dB | > 20 dB | > 20 dB |
| Upper band edge – hopping off | > 20 dB | > 20 dB | > 20 dB |
| Upper band edge – hopping on | > 20 dB | > 20 dB | > 20 dB |

**Plots:**

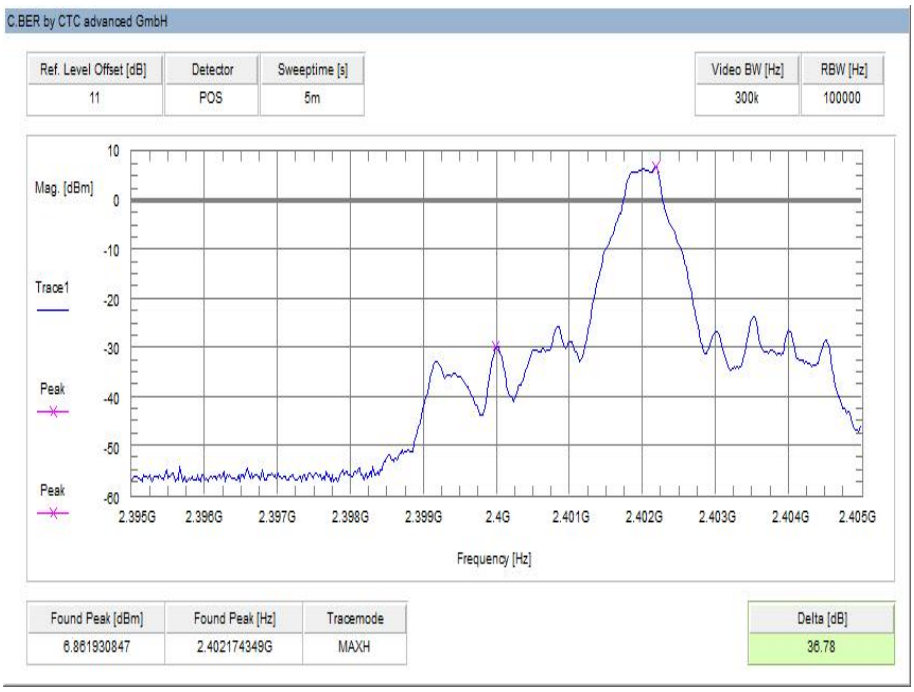
**Plot 1:** Lower band edge – hopping on, GFSK modulation



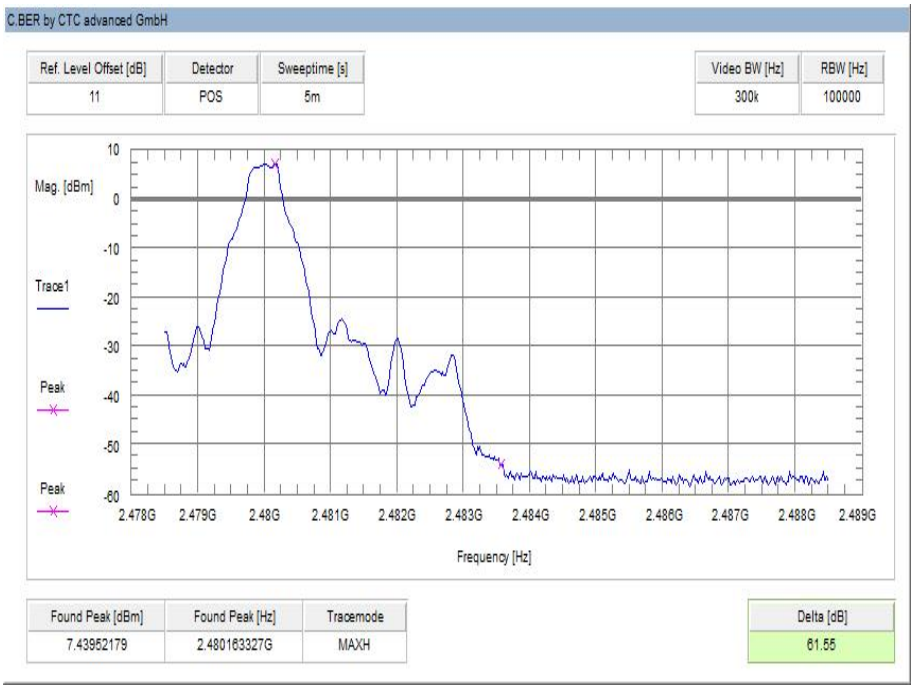

**Plot 2:** Upper band edge – hopping on, GFSK modulation



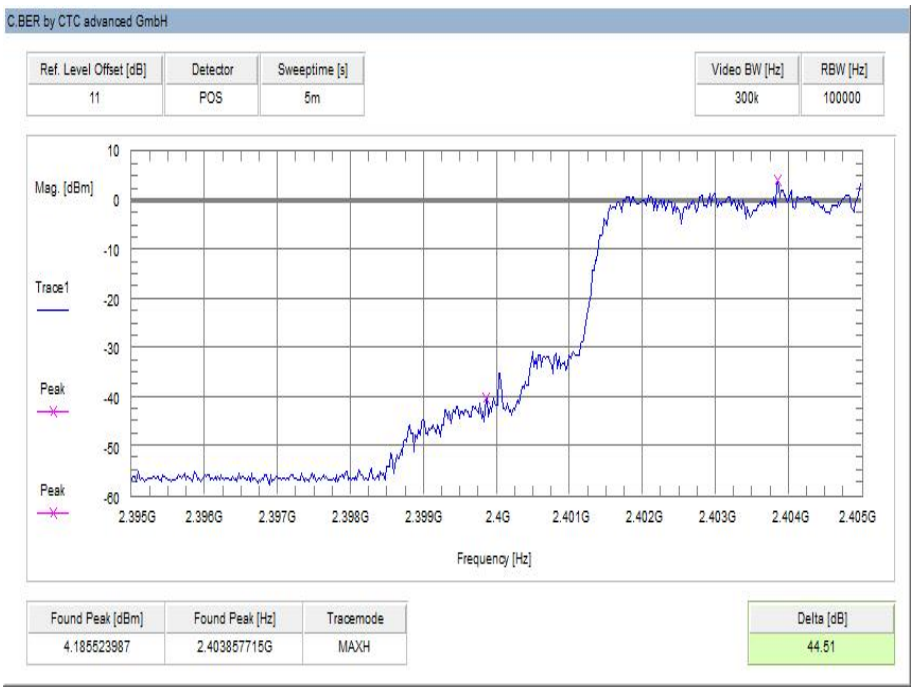
**Plot 3:** Lower band edge – hopping off, GFSK modulation



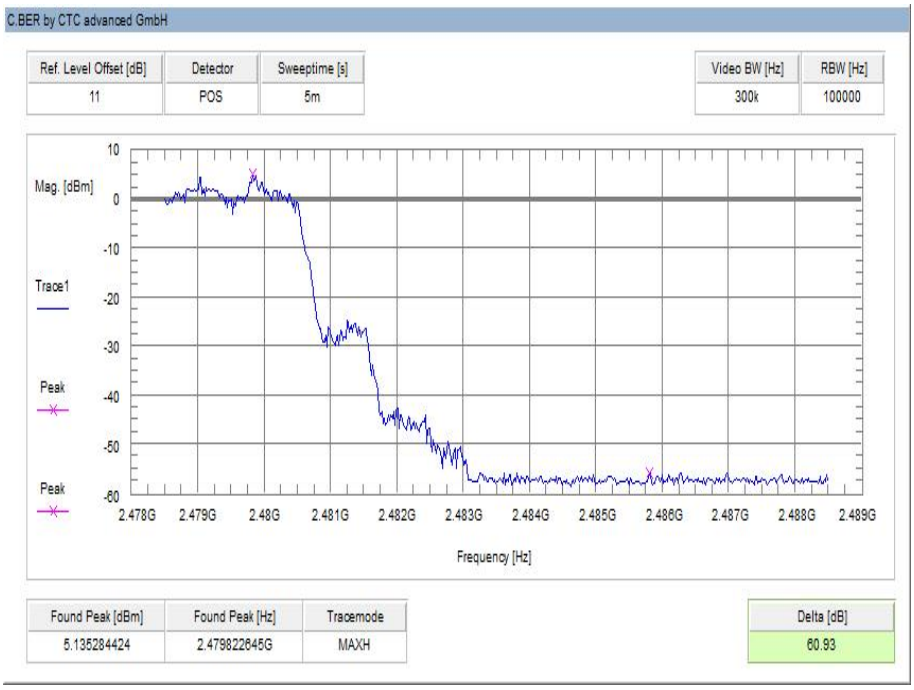

**Plot 4:** Upper band edge – hopping off, GFSK modulation



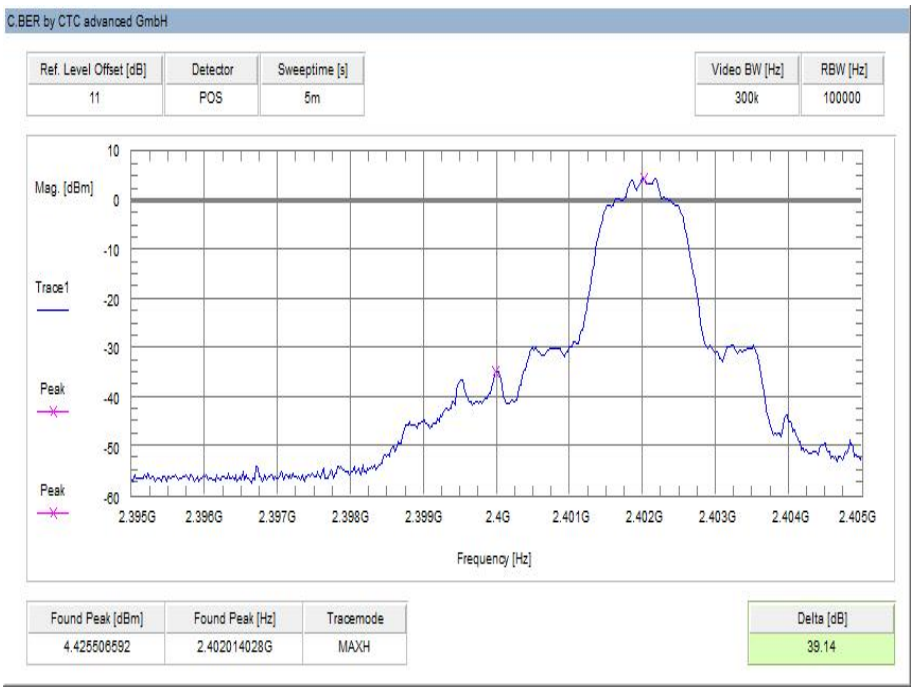
**Plot 5:** Lower band edge – hopping on, Pi/4 DQPSK modulation



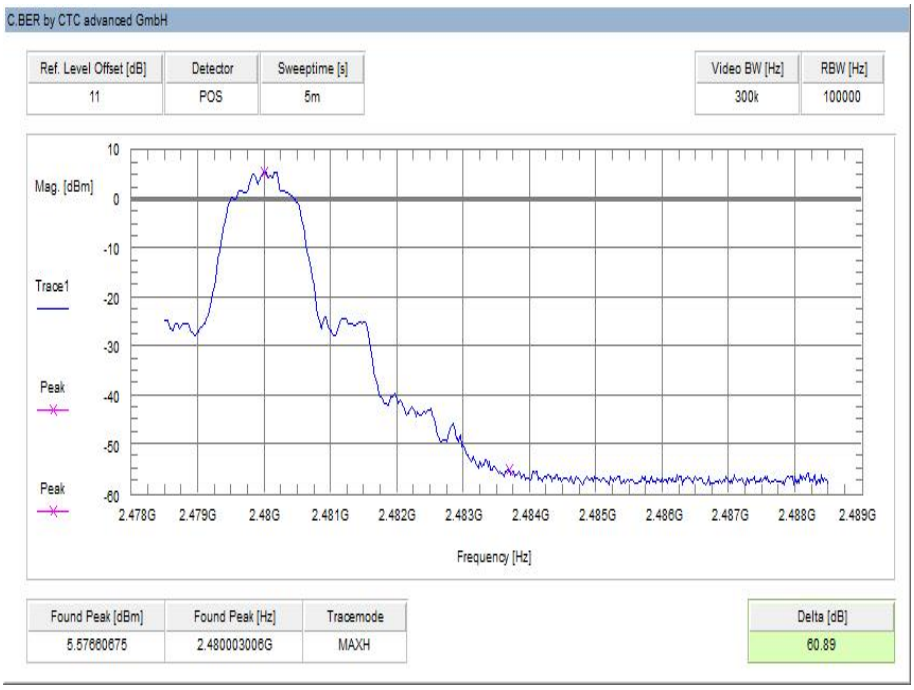

**Plot 6:** Upper band edge – hopping on, Pi/4 DQPSK modulation



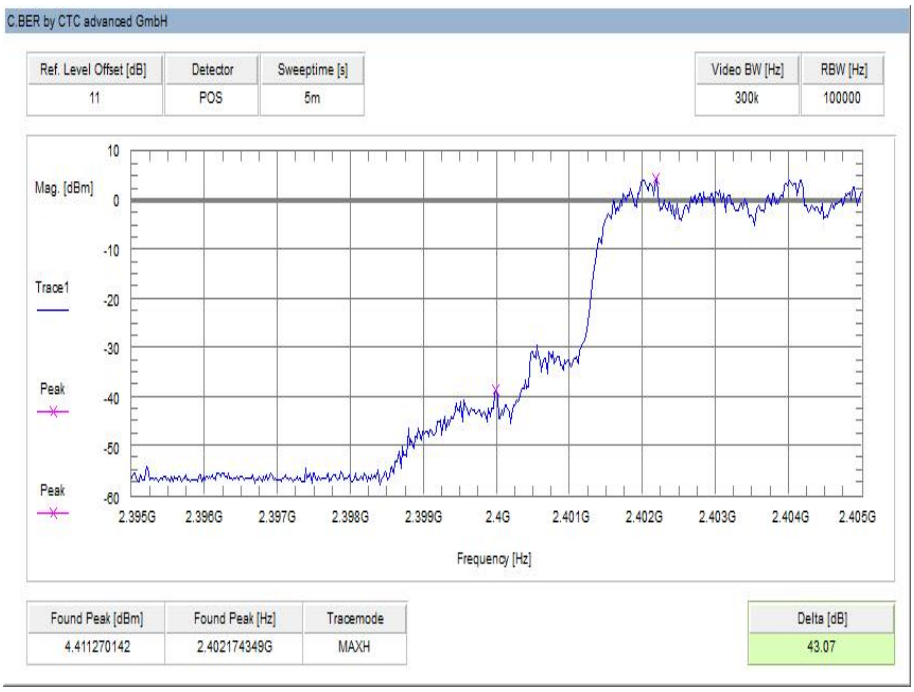
**Plot 7:** Lower band edge – hopping off, Pi/4 DQPSK modulation



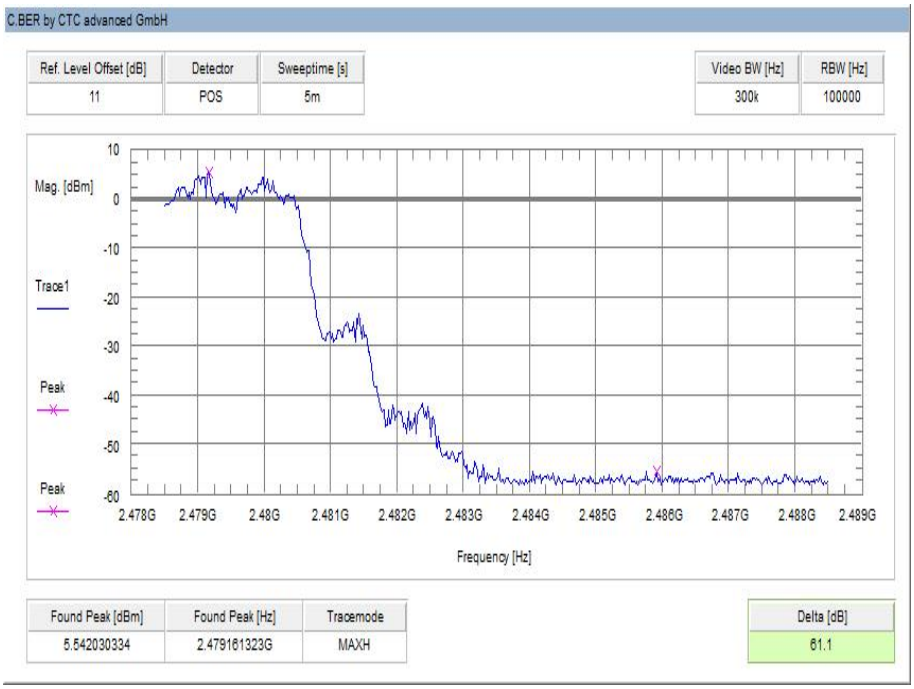

**Plot 8:** Upper band edge – hopping off, Pi/4 DQPSK modulation



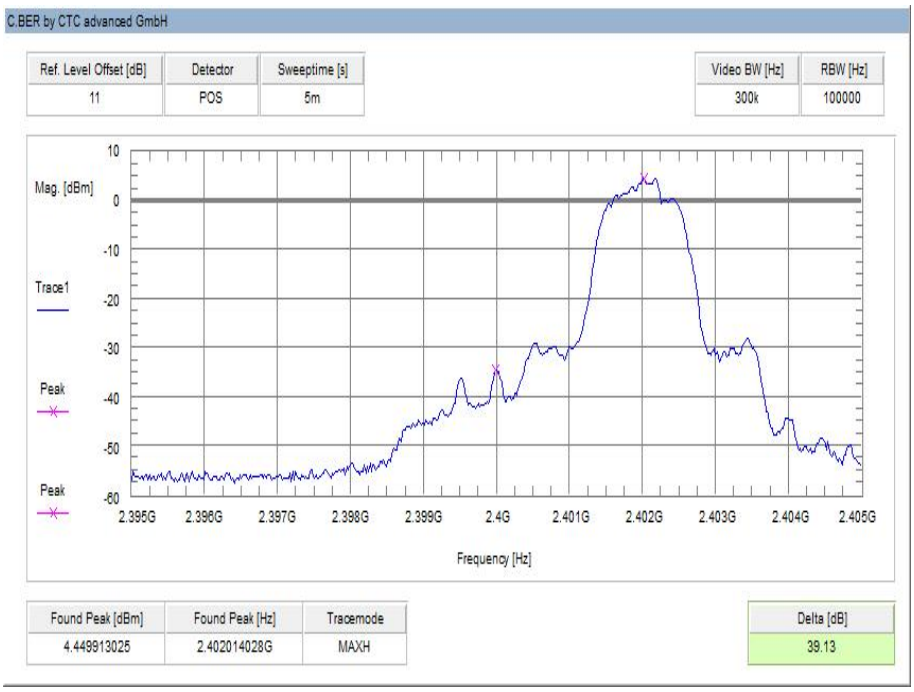
**Plot 9:** Lower band edge – hopping on, 8DPSK modulation



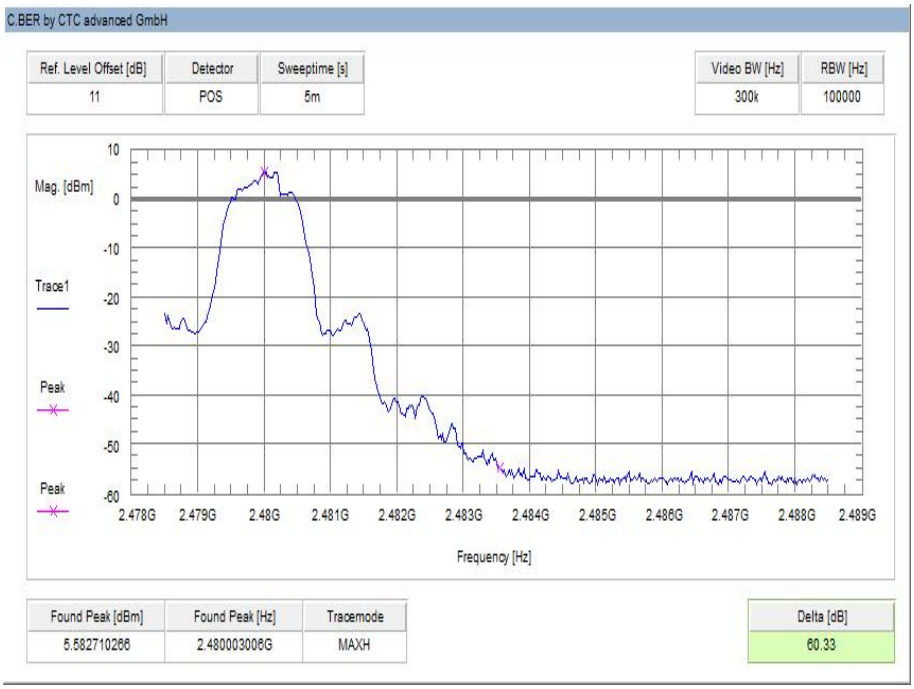

**Plot 10:** Upper band edge – hopping on, 8DPSK modulation



**Plot 11:** Lower band edge – hopping off, 8DPSK modulation




**Plot 12:** Upper band edge – hopping off, 8DPSK modulation



## 11.8 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 channel is channel 00 for the lower restricted band and channel 78 for the upper restricted band. The measurement is repeated for all modulations. Measurement distance is 3m.

| Measurement parameters | |
|---|---|
| Detector | Peak / RMS |
| Sweep time | Auto |
| Resolution bandwidth | 1 MHz |
| Video bandwidth | 3 MHz |
| Span | Lower Band: 2370 – 2400 MHz<br>Upper Band: 2480 – 2500 MHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.2 B |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

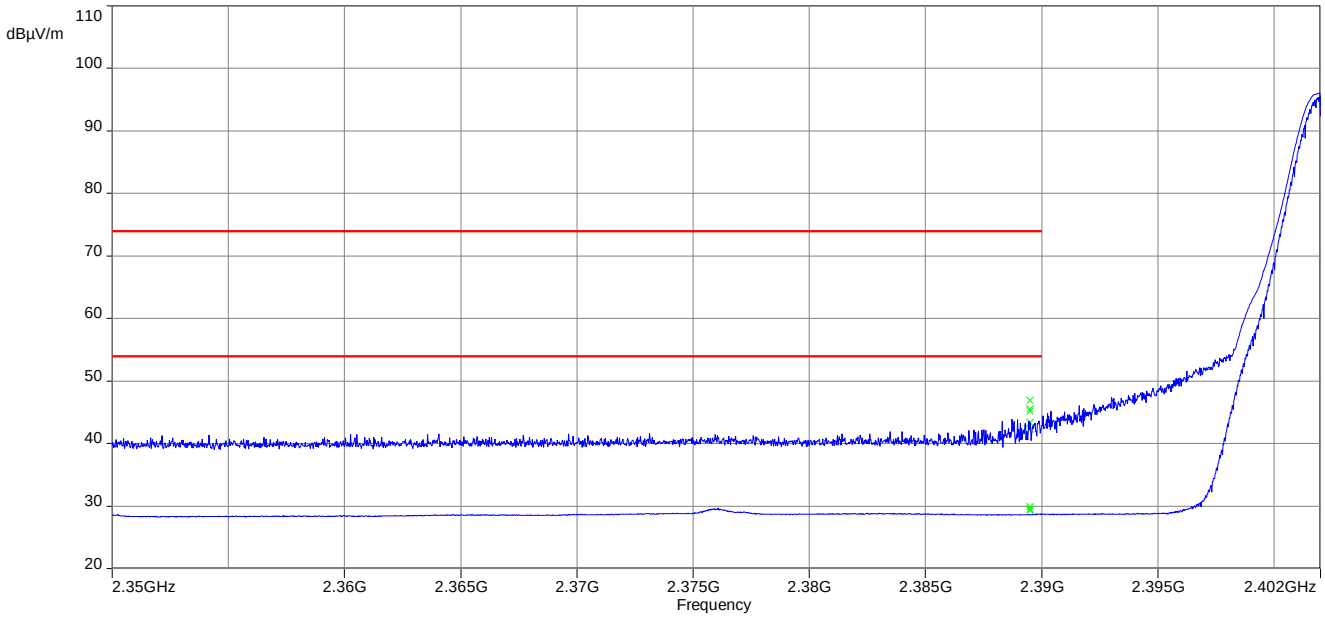
| FCC | IC |
|---|---|
| Band edge compliance radiated | |
| In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below 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 Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)). | |
| 54 dBµV/m AVG<br>74 dBµV/m Peak | |

**Results:**

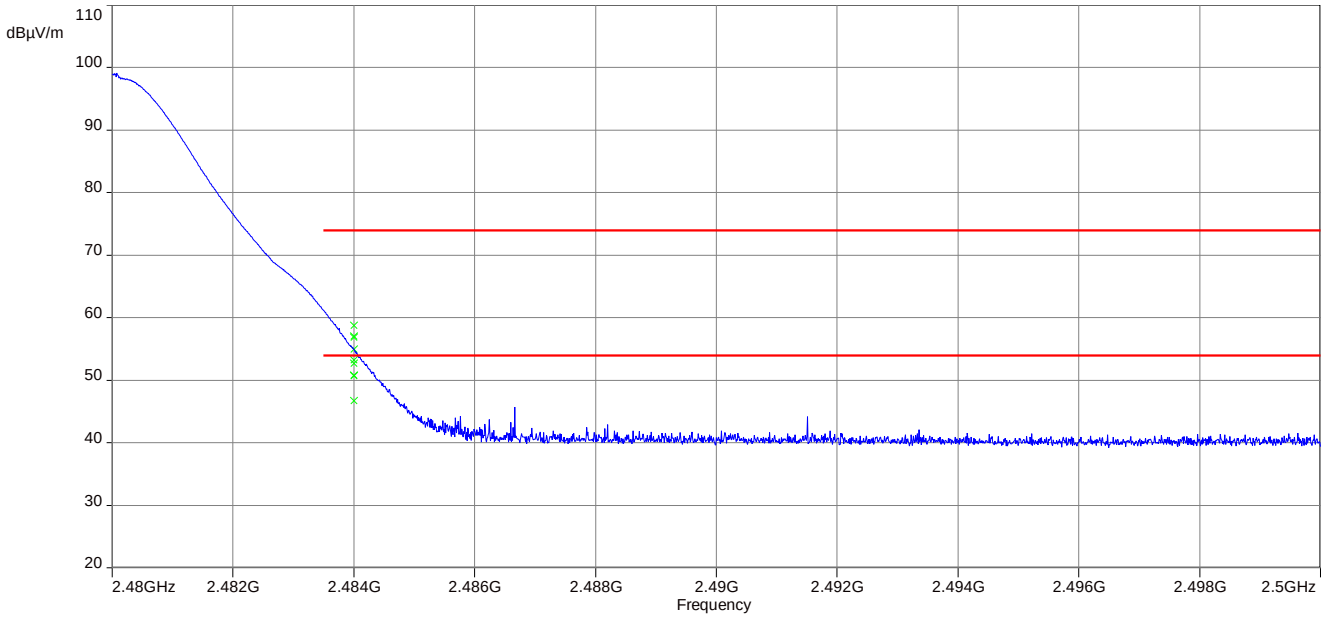
| Scenario | Band edge compliance radiated [dBµV/m] | | |
|---|---|---|---|
| Modulation | GFSK | Pi/4 DQPSK | 8DPSK |
| Lower restricted band | < 54 AVG / < 74 PP | < 54 AVG / < 74 PP | < 54 AVG / < 74 PP |
| Upper restricted band | < 54 AVG / < 74 PP | < 54 AVG / < 74 PP | < 54 AVG / < 74 PP |

**Plots:**

**Plot 1:** Lower band edge, GFSK modulation, vertical & horizontal polarization

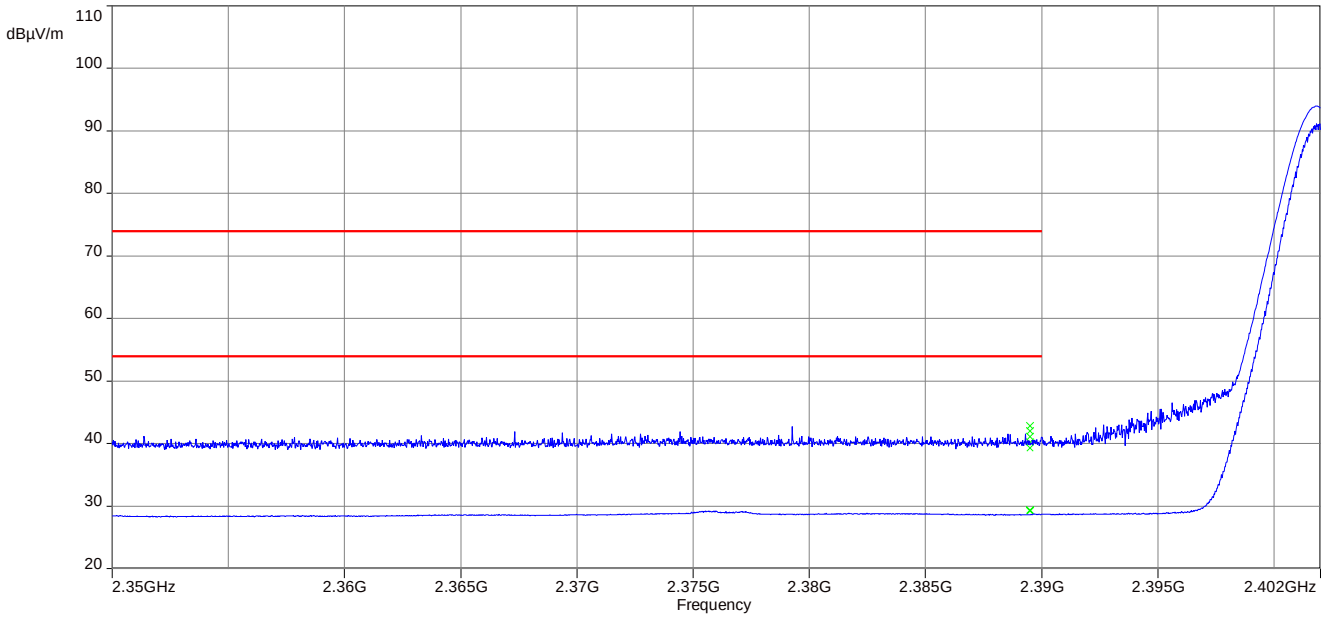



**Plot 2:** Upper band edge, GFSK modulation, vertical & horizontal polarization

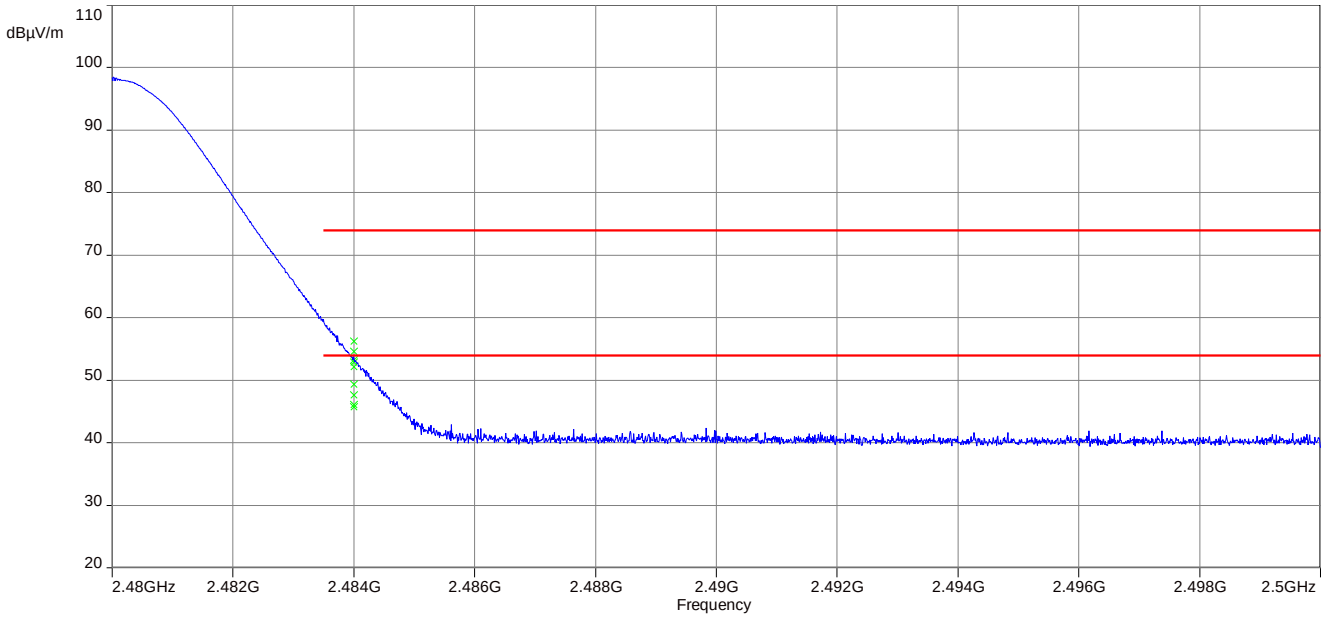



| | | |
|---|---|---|
| Calculated average value: | Detected band edge peak value: | 58.3 dBµV/m @ 3m |
| | Duty cycle correction factor: | -30.1 dB (See chapter 11.12) |
| | Calculated band edge average value: | 28.2 dBµV/m @ 3m |

**Plot 3:** Lower band edge, Pi/4 DQPSK modulation, vertical & horizontal polarization

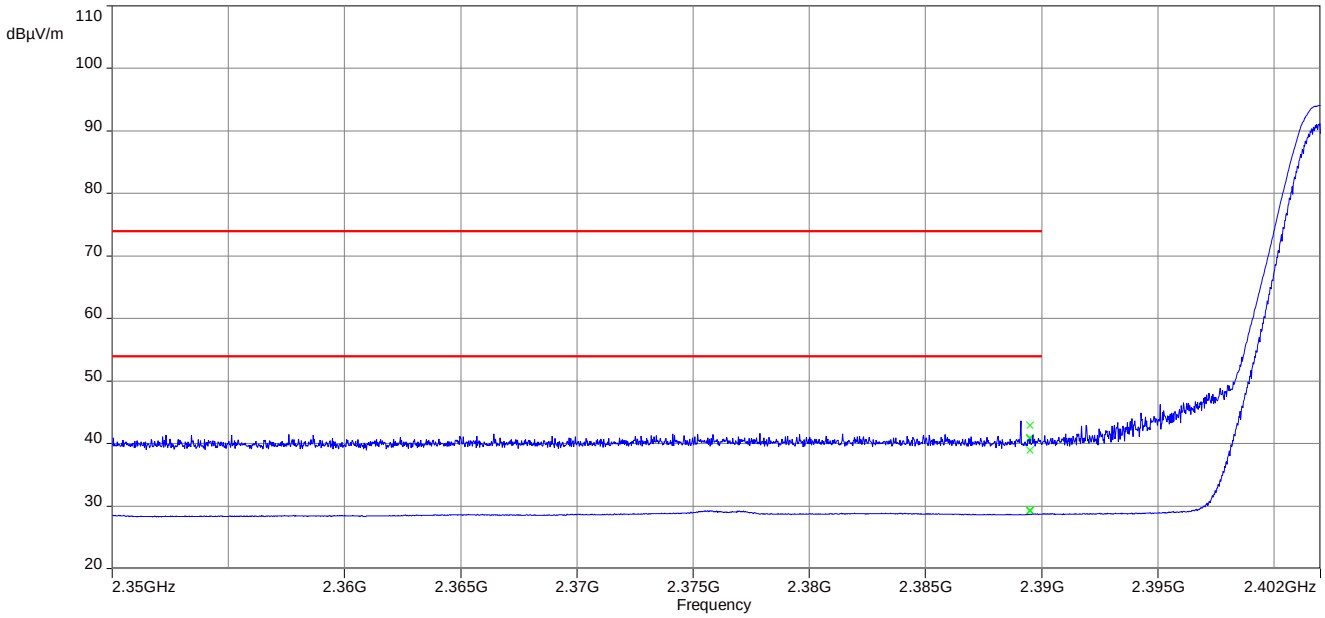



**Plot 4:** Upper band edge, Pi/4 DQPSK modulation, vertical & horizontal polarization

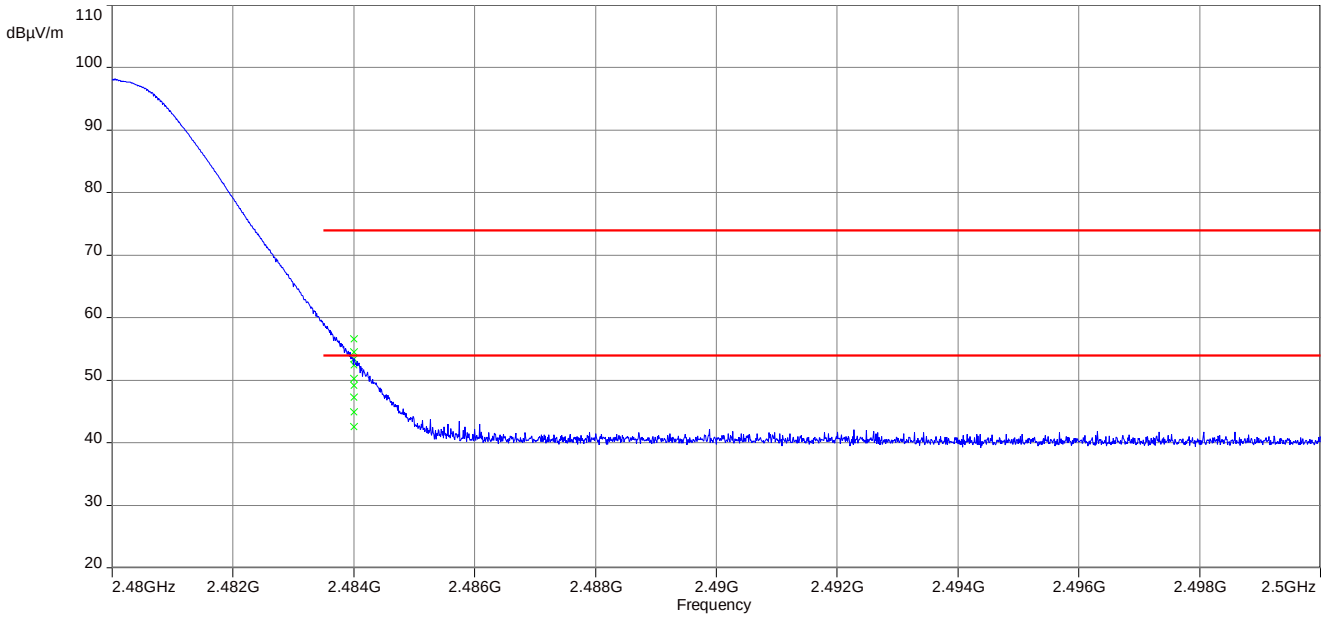



| | | |
|---|---|---|
| Calculated average value: | Detected band edge peak value: | 55.5 dBµV/m @ 3m |
| | Duty cycle correction factor: | -30.1 dB (See chapter 11.12) |
| | Calculated band edge average value: | 25.4 dBµV/m @ 3m |

**Plot 5:** Lower band edge, 8 DPSK modulation, vertical & horizontal polarization




**Plot 6:** Upper band edge, 8 DPSK modulation, vertical & horizontal polarization




| | | |
|---|---|---|
| Calculated average value: | Detected band edge peak value: | 55.9 dBµV/m @ 3m |
| | Duty cycle correction factor: | -30.1 dB (See chapter 11.12) |
| | Calculated band edge average value: | 25.8 dBµV/m @ 3m |

## 11.9 Spurious emissions conducted

**Description:**

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit channel is channel 00, channel 39 and channel 78. The measurement is repeated for all modulations.

| Measurement parameters | |
|---|---|
| Detector | Peak |
| Sweep time | Auto |
| Resolution bandwidth | 100 kHz |
| Video bandwidth | 300 kHz |
| Span | 9 kHz to 25 GHz |
| Trace mode | Max hold |
| Test setup | See sub clause 6.4 A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

| FCC | IC |
|---|---|
| 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:**

| TX spurious emissions conducted | | | | | |
|---|---|---|---|---|---|
| GFSK - mode | | | | | |
| f [MHz] | | amplitude of emission [dBm] | limit max. allowed emission power | actual attenuation below frequency of operation [dB] | results |
| 2402 | | 6.7 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2441 | | 6.6 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2480 | | 7.3 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |

**Results:**

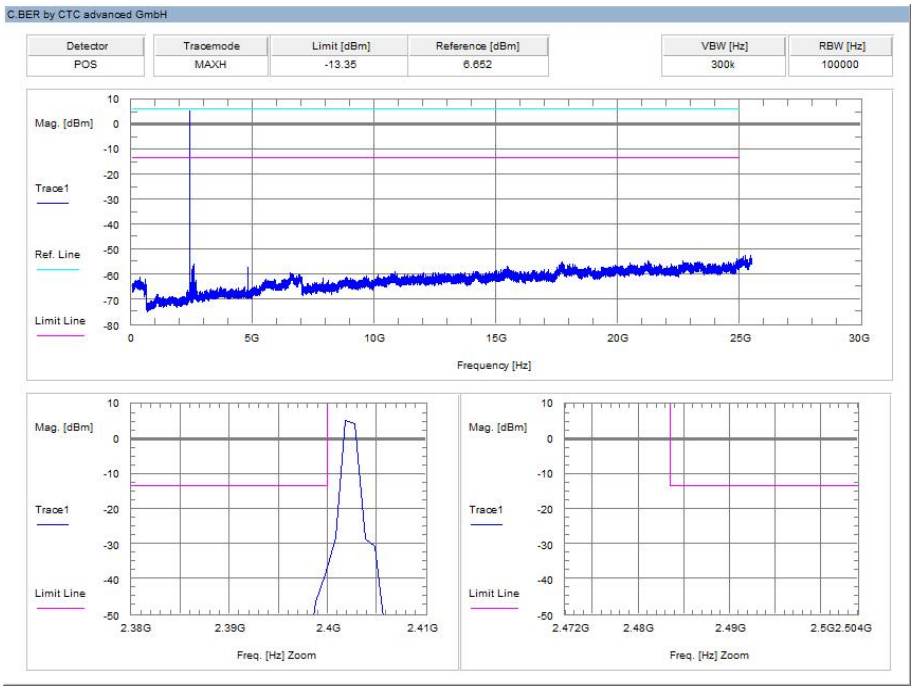
| TX spurious emissions conducted | | | | | |
|---|---|---|---|---|---|
| Pi/4-DQPSK - mode | | | | | |
| f [MHz] | | amplitude of emission [dBm] | limit max. allowed emission power | actual attenuation below frequency of operation [dB] | results |
| 2402 | | 4.2 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2441 | | 4.8 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2480 | | 4.4 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |

**Results:**

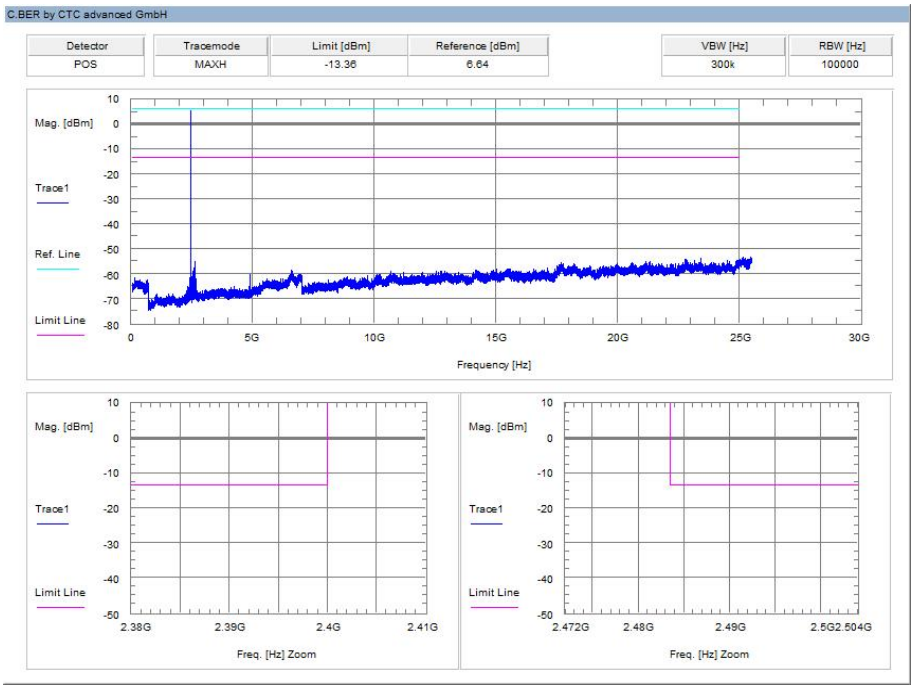
| TX spurious emissions conducted | | | | | |
|---|---|---|---|---|---|
| 8DPSK - mode | | | | | |
| f [MHz] | | amplitude of emission [dBm] | limit max. allowed emission power | actual attenuation below frequency of operation [dB] | results |
| 2402 | | 4.4 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2441 | | 5.2 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |
| 2480 | | 5.2 | 30 dBm | | Operating frequency |
| All detected emissions are below the -20 dBc criteria. Please take a look at the plot! | | | -20 dBc | | compliant |
| | | | | | |
| | | | | | |

**Plots:**

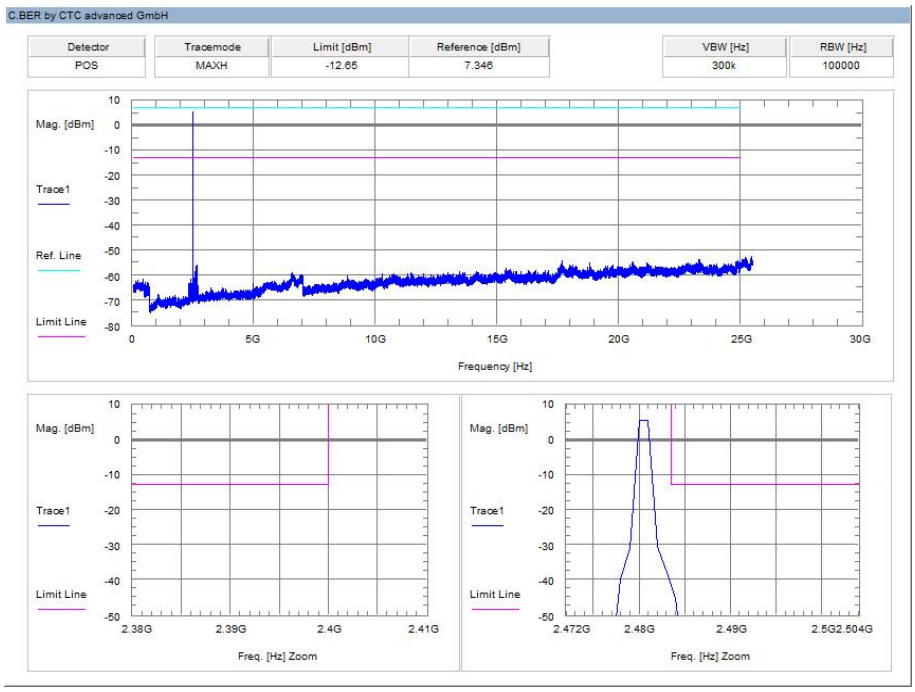
**Plot 1:** lowest channel – 2402 MHz, GFSK modulation



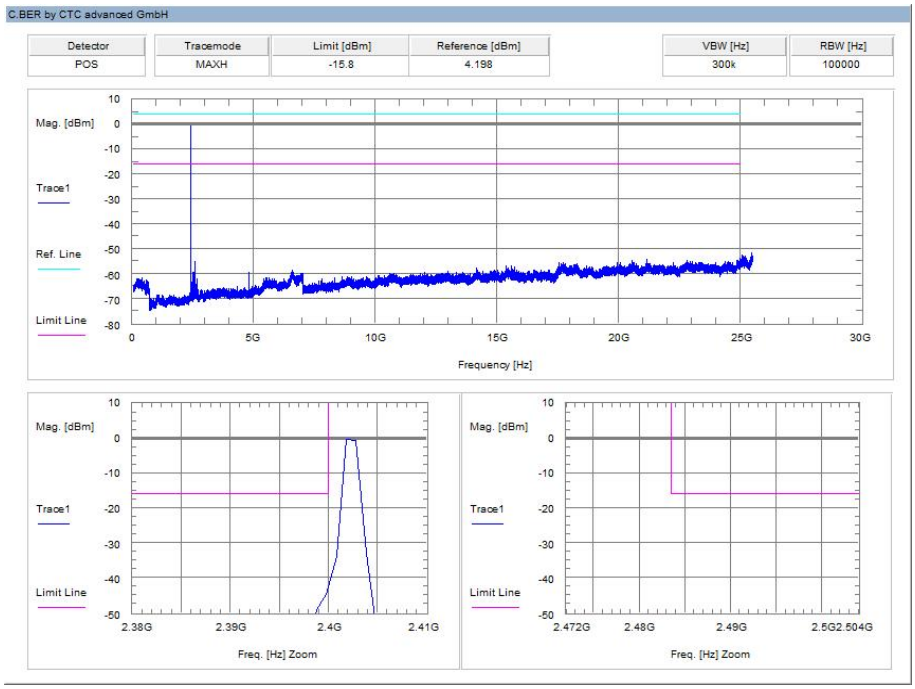

**Plot 2:** middle channel – 2441 MHz, GFSK modulation



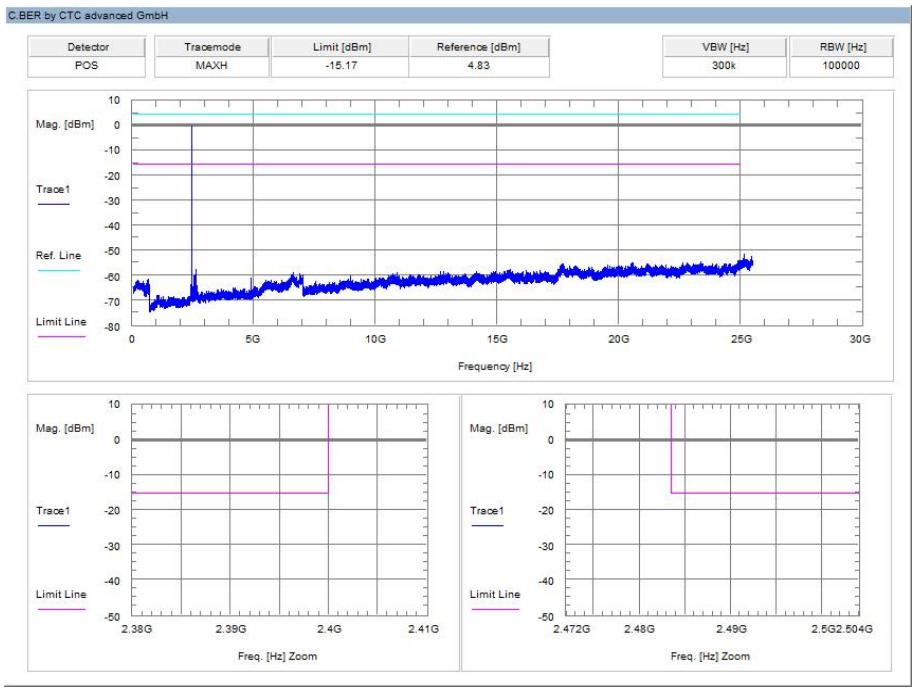
**Plot 3:** highest channel – 2480 MHz, GFSK modulation



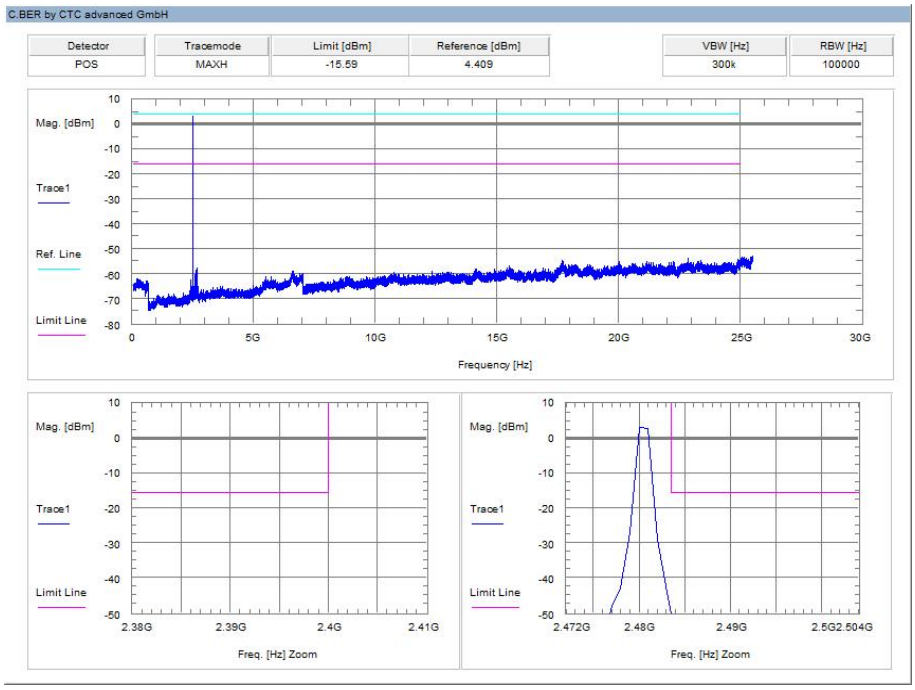

**Plot 4:** lowest channel – 2402 MHz, Pi / DQPSK modulation



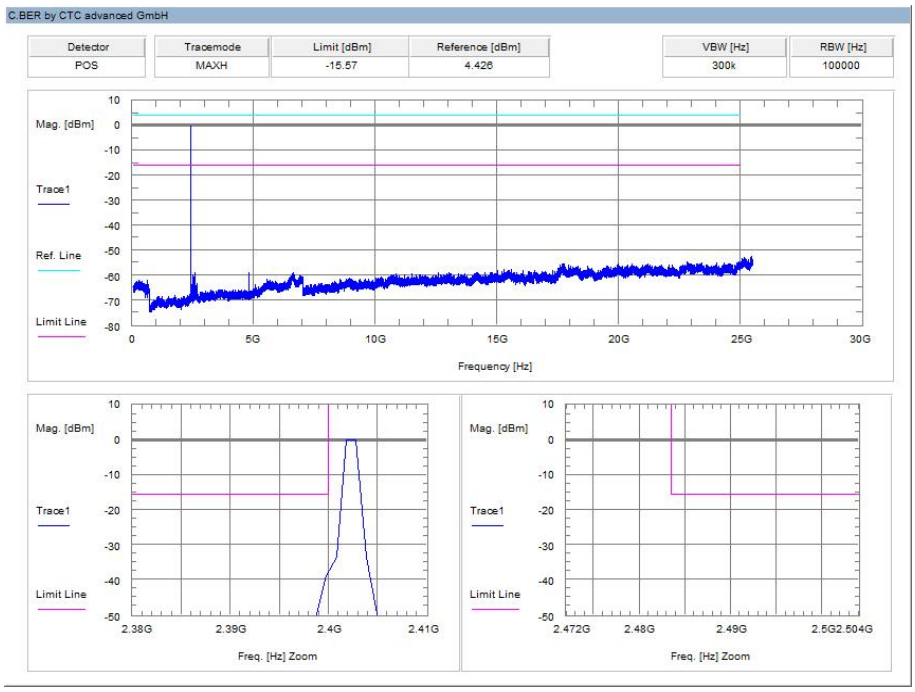
**Plot 5:** middle channel – 2441 MHz, Pi / DQPSK modulation



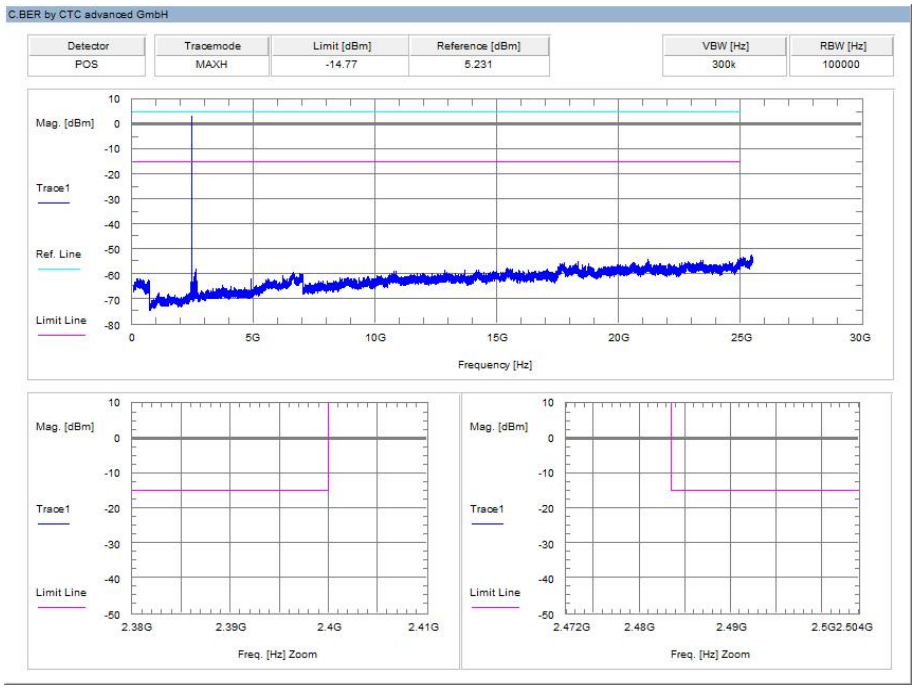

**Plot 6:** highest channel – 2480 MHz, Pi / DQPSK modulation



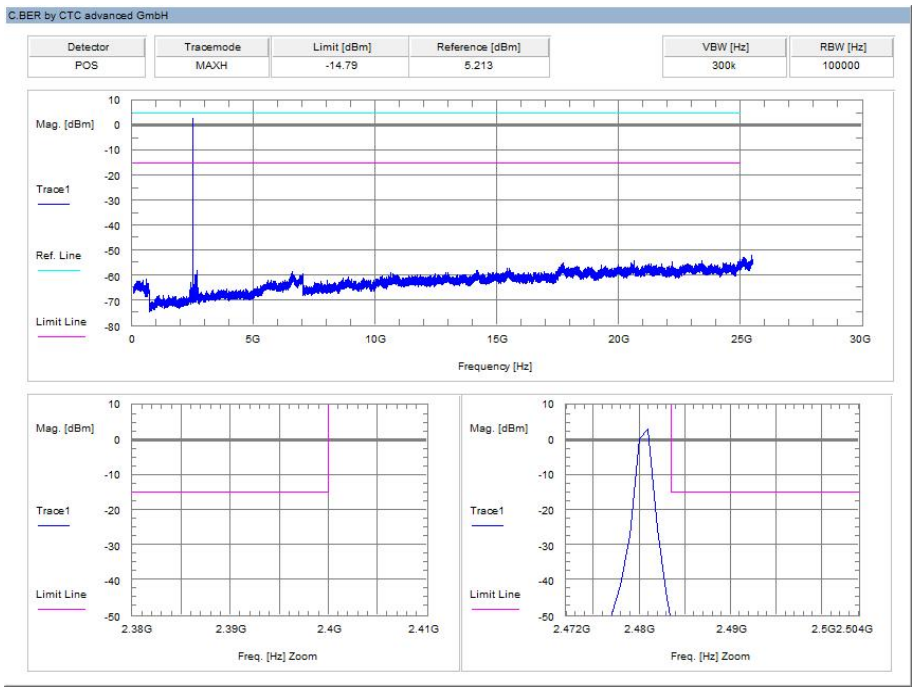
**Plot 7:** lowest channel – 2402 MHz, 8 DPSK modulation




**Plot 8:** middle channel – 2441 MHz, 8 DPSK modulation



**Plot 9:** highest channel – 2480 MHz, 8 DPSK modulation



## 11.10 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 channels are 00; 39 and 78. The measurement is performed in the mode with the highest output power. 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<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 sub clause 6.2 C |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

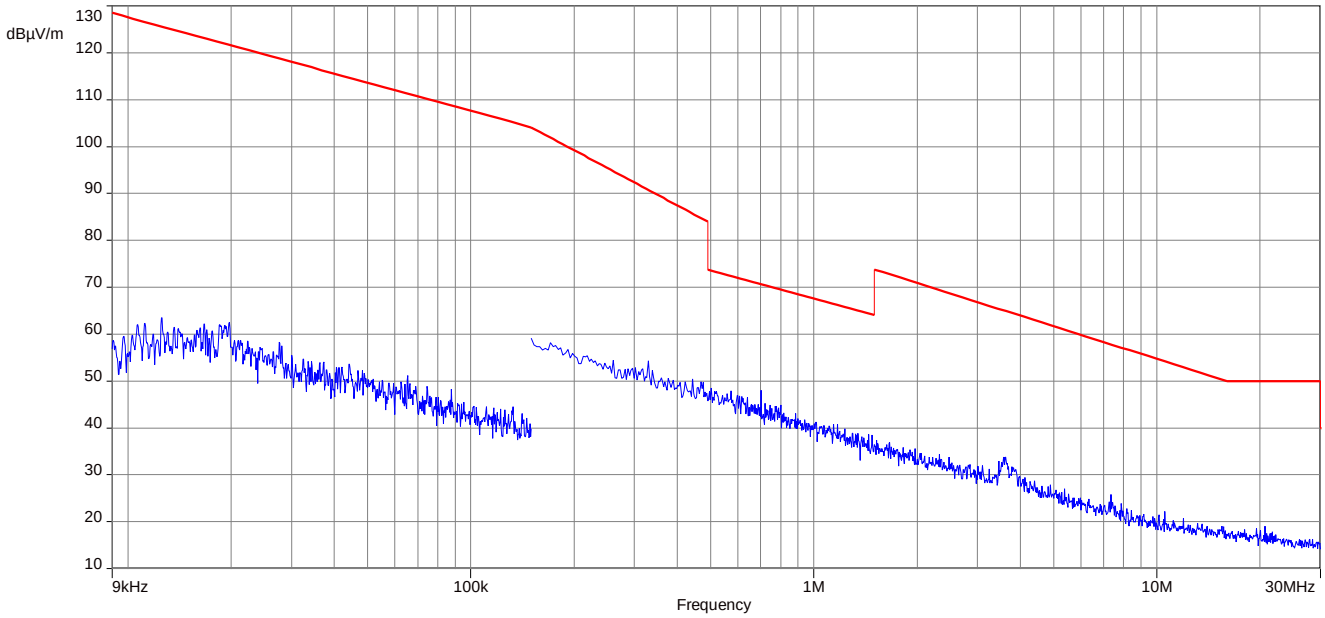
| FCC | | IC |
|---|---|---|
| TX spurious emissions radiated below 30 MHz | | |
| Frequency (MHz) | Field strength (dBµV/m) | Measurement distance |
| 0.009 – 0.490 | 2400/F(kHz) | 300 |
| 0.490 – 1.705 | 24000/F(kHz) | 30 |
| 1.705 – 30.0 | 30 | 30 |

**Results:**

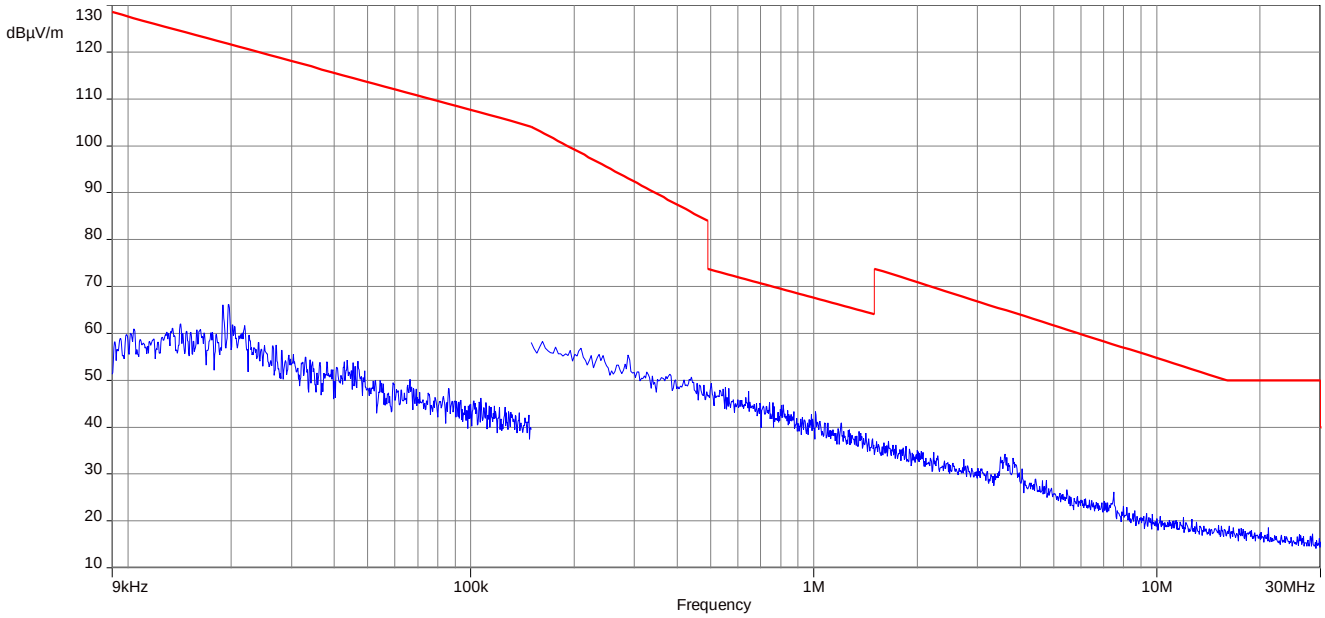
| TX spurious emissions radiated below 30 MHz [dBµV/m] | | |
|---|---|---|
| F [MHz] | Detector | Level [dBµV/m] |
| All detected emissions are more than 20 dB below the limit. | | |
| | | |
| | | |

**Plots:**

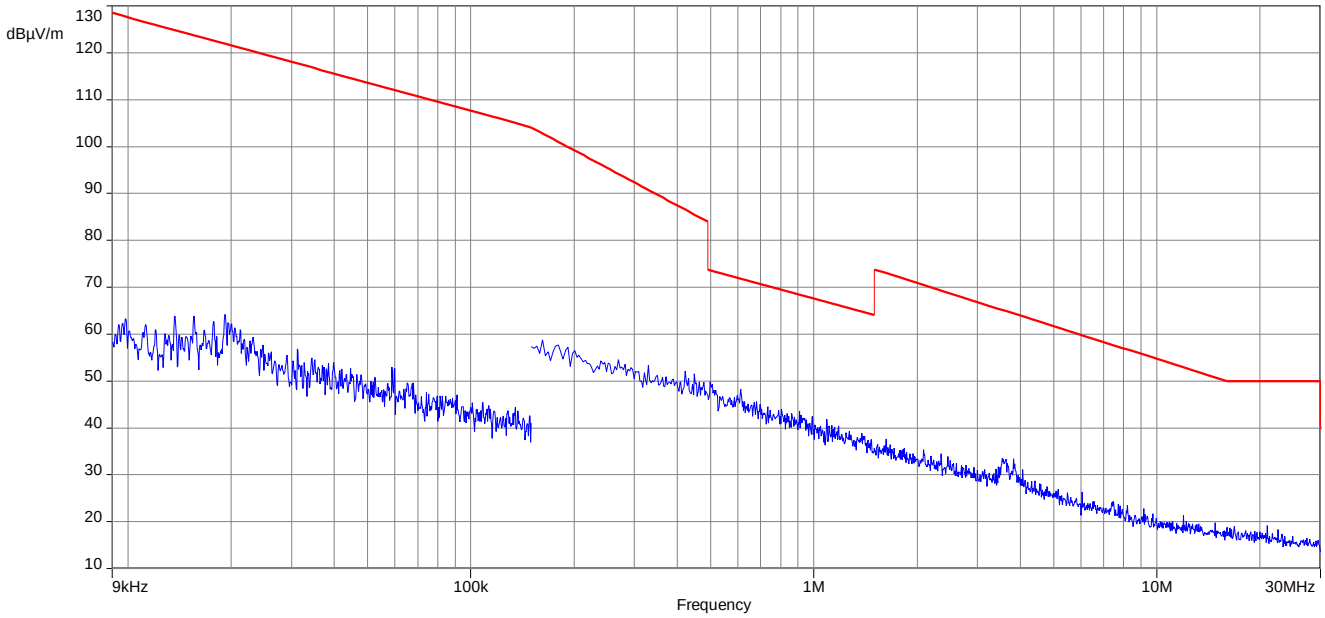
**Plot 1:** 9 kHz to 30 MHz, channel 00, transmit mode




**Plot 2:** 9 kHz to 30 MHz, channel 39, transmit mode



**Plot 3:** 9 kHz to 30 MHz, channel 78, transmit mode



## 11.11 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 channel is channel 00, channel 39 and channel 78. The measurement is performed in the mode with the highest output power.

| 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 ☐ Pi/4 DQPSK ☐ 8DPSK |
| Test setup | See sub clause 6.1 A |
| Measurement uncertainty | See sub clause 8 |

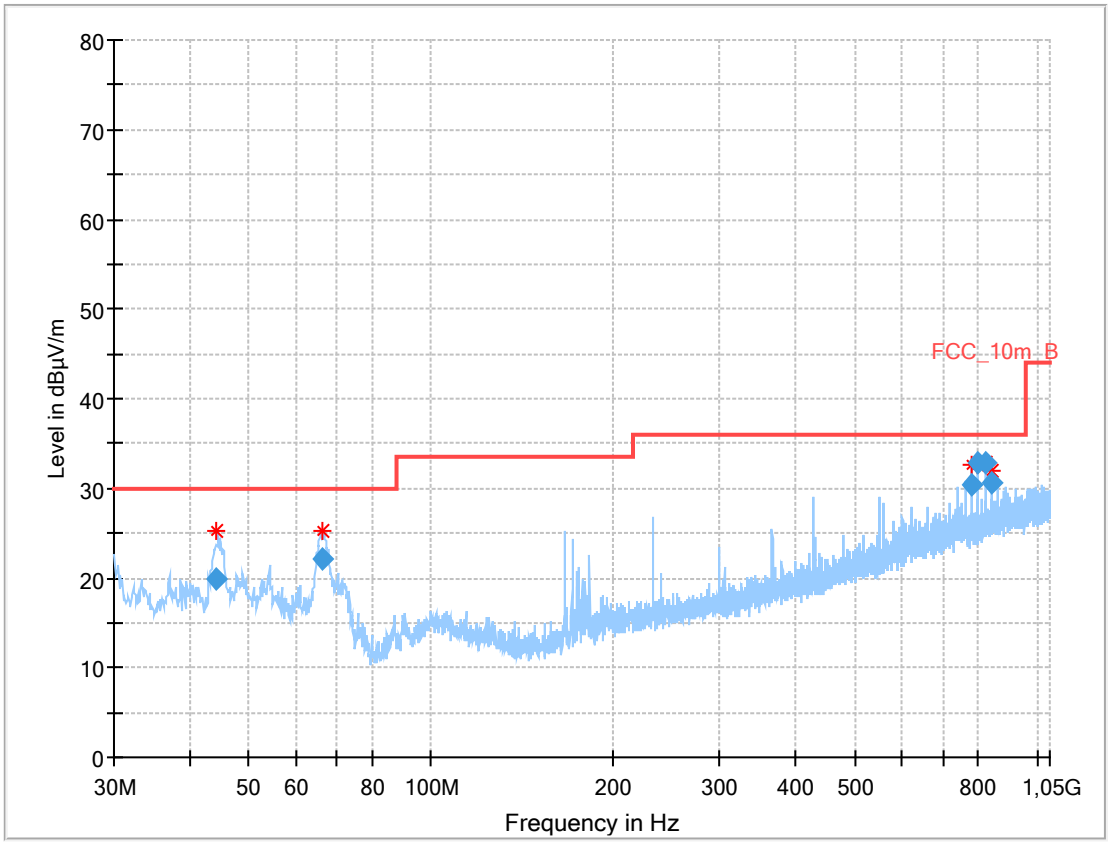
The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

**Limits:**

| FCC | | IC |
|---|---|---|
| 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

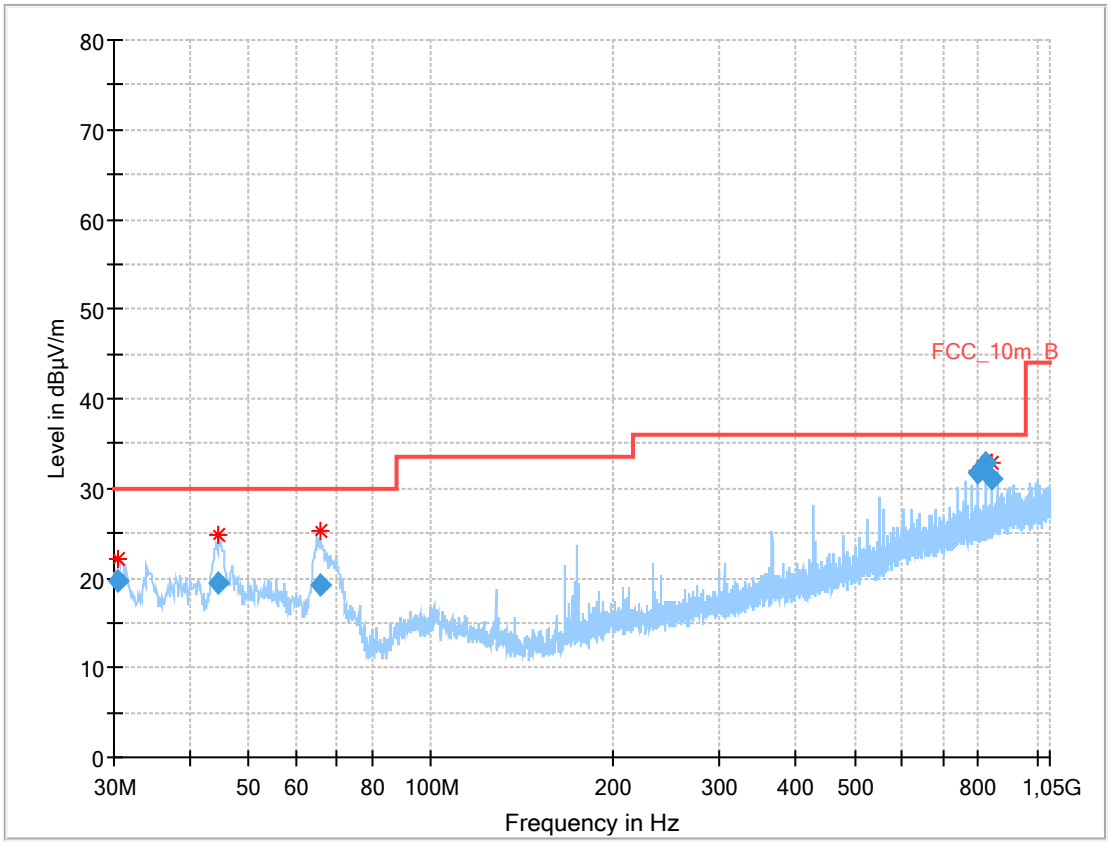
**Plot 1:** 30 MHz to 1 GHz, TX mode, channel 00, vertical & horizontal polarization




**Final results:**

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 44.279100 | 19.82 | 30.00 | 10.18 | 1000.0 | 120.000 | 100.0 | V | 172.0 | 13.6 |
| 66.158850 | 22.09 | 30.00 | 7.91 | 1000.0 | 120.000 | 170.0 | V | 80.0 | 10.5 |
| 779.984550 | 30.47 | 36.00 | 5.53 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 22.7 |
| 800.004000 | 32.91 | 36.00 | 3.09 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 22.8 |
| 820.012650 | 32.78 | 36.00 | 3.22 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 23.1 |
| 840.015150 | 30.61 | 36.00 | 5.39 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 23.4 |

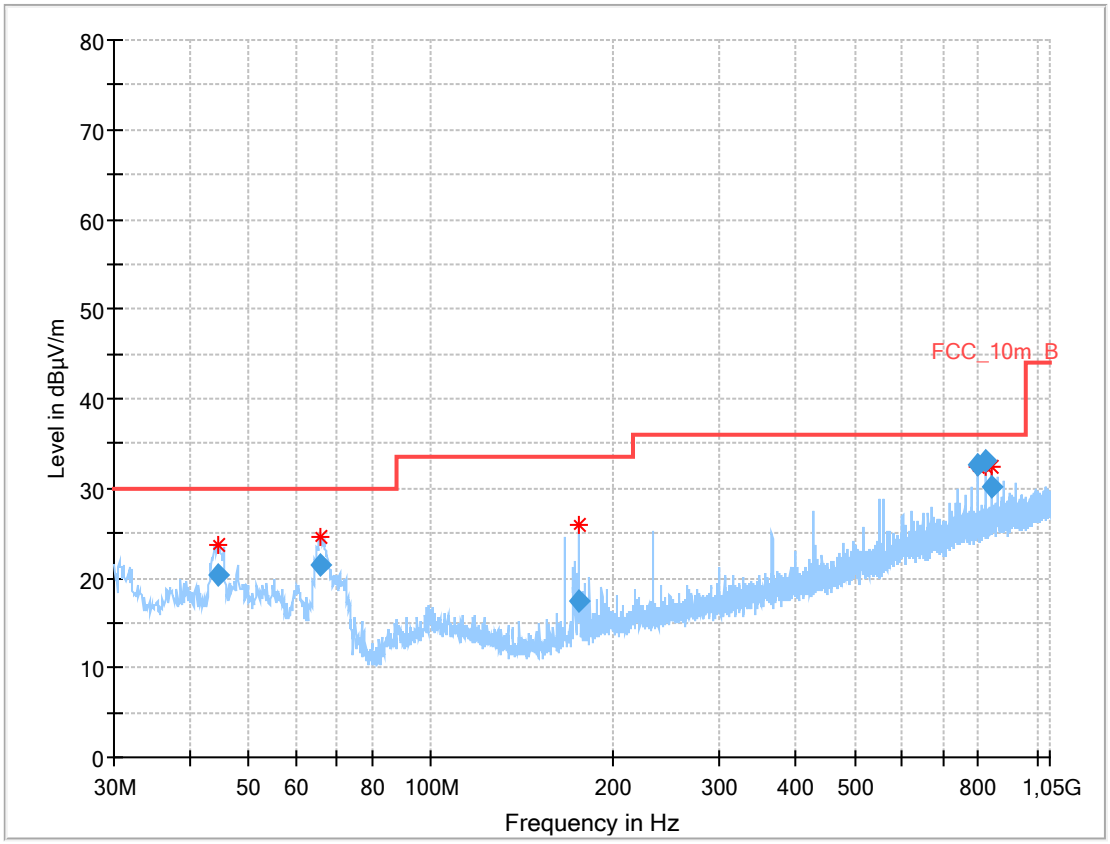
**Plot 2:** 30 MHz to 1 GHz, TX mode, channel 39, vertical & horizontal polarization




**Final results:**

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 30.386400 | 19.66 | 30.00 | 10.34 | 1000.0 | 120.000 | 101.0 | V | 170.0 | 11.9 |
| 44.727300 | 19.44 | 30.00 | 10.56 | 1000.0 | 120.000 | 170.0 | V | 190.0 | 13.6 |
| 65.513100 | 19.20 | 30.00 | 10.80 | 1000.0 | 120.000 | 170.0 | V | 280.0 | 10.6 |
| 799.968300 | 31.71 | 36.00 | 4.29 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 22.7 |
| 819.995250 | 32.82 | 36.00 | 3.18 | 1000.0 | 120.000 | 100.0 | H | 100.0 | 23.1 |
| 840.000300 | 30.99 | 36.00 | 5.01 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 23.4 |

**Plot 3:** 30 MHz to 1 GHz, TX mode, channel 78, vertical & horizontal polarization

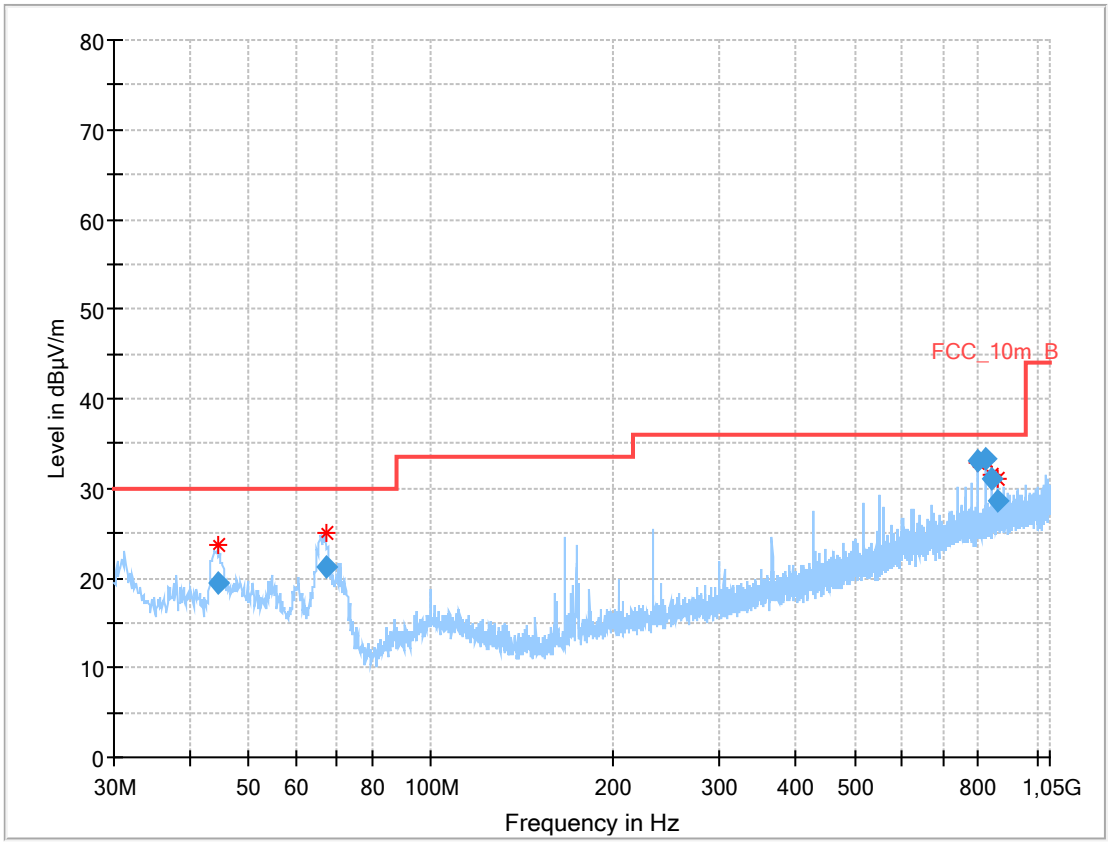



**Final results:**

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 44.591250 | 20.44 | 30.00 | 9.56 | 1000.0 | 120.000 | 98.0 | V | 260.0 | 13.6 |
| 65.943900 | 21.52 | 30.00 | 8.48 | 1000.0 | 120.000 | 170.0 | V | 81.0 | 10.6 |
| 174.888750 | 17.46 | 33.50 | 16.04 | 1000.0 | 120.000 | 98.0 | V | 80.0 | 10.6 |
| 799.980300 | 32.65 | 36.00 | 3.35 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 22.7 |
| 819.993150 | 33.00 | 36.00 | 3.00 | 1000.0 | 120.000 | 98.0 | H | 100.0 | 23.1 |
| 840.007350 | 30.09 | 36.00 | 5.91 | 1000.0 | 120.000 | 100.0 | H | 81.0 | 23.4 |

**Plots:** Receiver mode

**Plot 1:** 30 MHz to 1 GHz, RX / idle – mode, vertical & horizontal polarization




**Final results:**

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 44.482050 | 19.50 | 30.00 | 10.50 | 1000.0 | 120.000 | 100.0 | V | 190.0 | 13.6 |
| 67.140450 | 21.33 | 30.00 | 8.67 | 1000.0 | 120.000 | 170.0 | V | 82.0 | 10.3 |
| 799.996200 | 33.06 | 36.00 | 2.94 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 22.7 |
| 820.001700 | 33.27 | 36.00 | 2.73 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 23.1 |
| 839.981700 | 31.02 | 36.00 | 4.98 | 1000.0 | 120.000 | 101.0 | H | 100.0 | 23.4 |
| 860.005500 | 28.67 | 36.00 | 7.33 | 1000.0 | 120.000 | 98.0 | H | 262.0 | 23.7 |

## 11.12 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 channel is channel 00, channel 39 and channel 78. The measurement is performed in the mode with the highest output power.

| 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 ☐ Pi/4 DQPSK ☐ 8DPSK |
| Test setup | See sub clause 6.2 A (1 GHz - 18 GHz)<br>See sub clause 6.3 A (18 GHz - 26 GHz) |
| Measurement uncertainty | See sub clause 8 |

The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

**Limits:**

| FCC | | IC |
|---|---|---|
| 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 | 3 |

**Results:** Transmitter mode

| TX spurious emissions radiated [dBµV/m] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2402 MHz | | | 2441 MHz | | | 2480 MHz | | |
| F [MHz] | Detector | Level [dBµV/m] | F [MHz] | Detector | Level [dBµV/m] | F [MHz] | Detector | Level [dBµV/m] |
| 4804 | Peak | 56.0 | -/- | Peak | -/- | -/- | Peak | -/- |
| | AVG | 25.9* | | AVG | -/- | | AVG | -/- |
| -/- | Peak | -/- | -/- | Peak | -/- | -/- | Peak | -/- |
| | AVG | -/- | | AVG | -/- | | AVG | -/- |
| -/- | Peak | -/- | -/- | Peak | -/- | -/- | Peak | -/- |
| | AVG | -/- | | AVG | -/- | | AVG | -/- |

*) Average emission adjusting factor:

**F = 20 * log (dwell time / 100 ms)**

The dwell time of the longest possible Bluetooth transmission (DH5-packet) is 3.125 ms.

In a period of 100 ms, we have a maximum of 1 transmission and that implies a correction factor for spurious measurement emissions:

**F = 20 * log (1 * 3.125 / 100) = -30.1 dB**

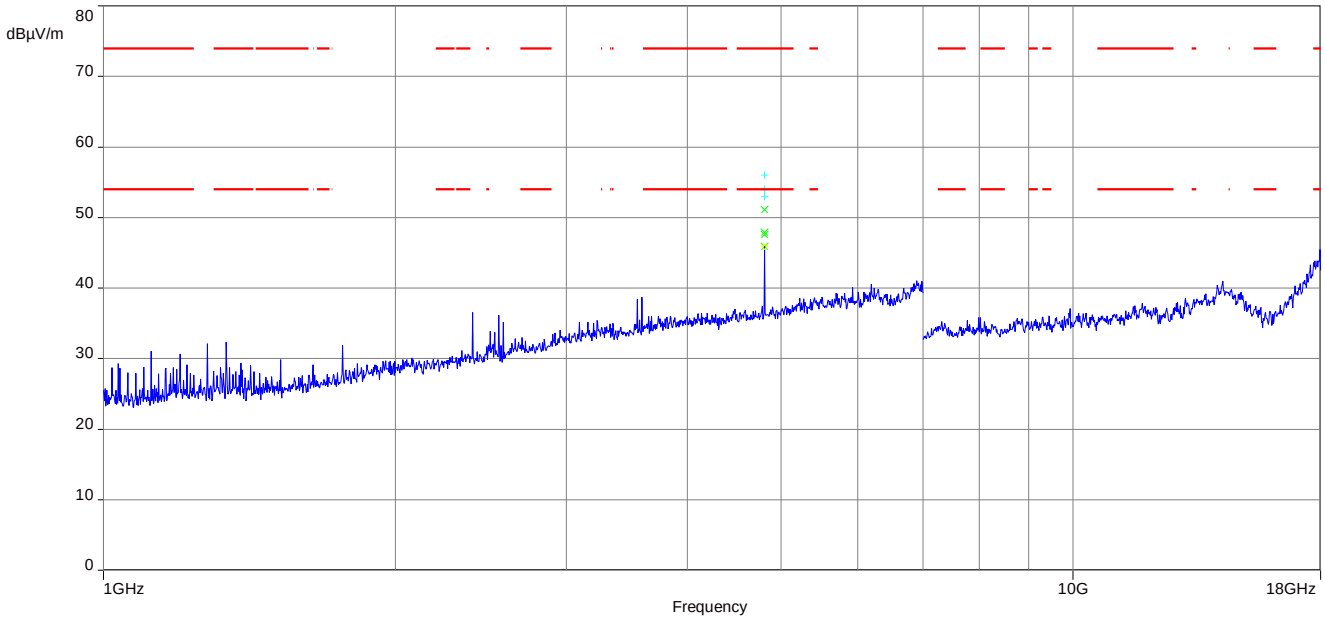
**Results:** Receiver mode

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

**Note:** The limit was recalculated with 20 dB / decade (Part 15.31) for all radiated spurious emissions 30 MHz to 1 GHz from 3 meter limit to a 10 meter distance. (40dB/decade for emissions < 30MHz)

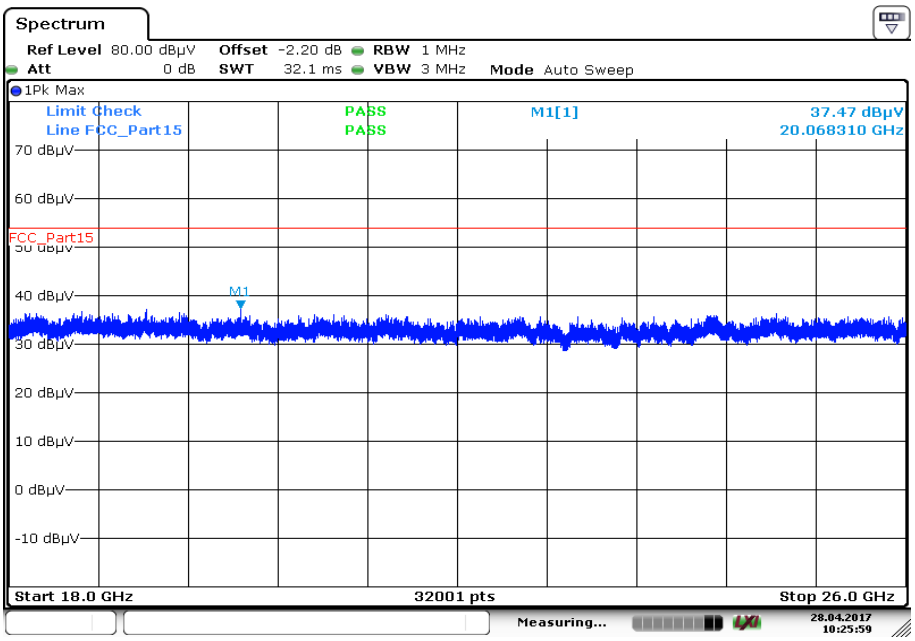
**Plots:** Transmitter mode

**Plot 1:** 1 GHz to 18 GHz, TX mode, channel 00, vertical & horizontal polarization

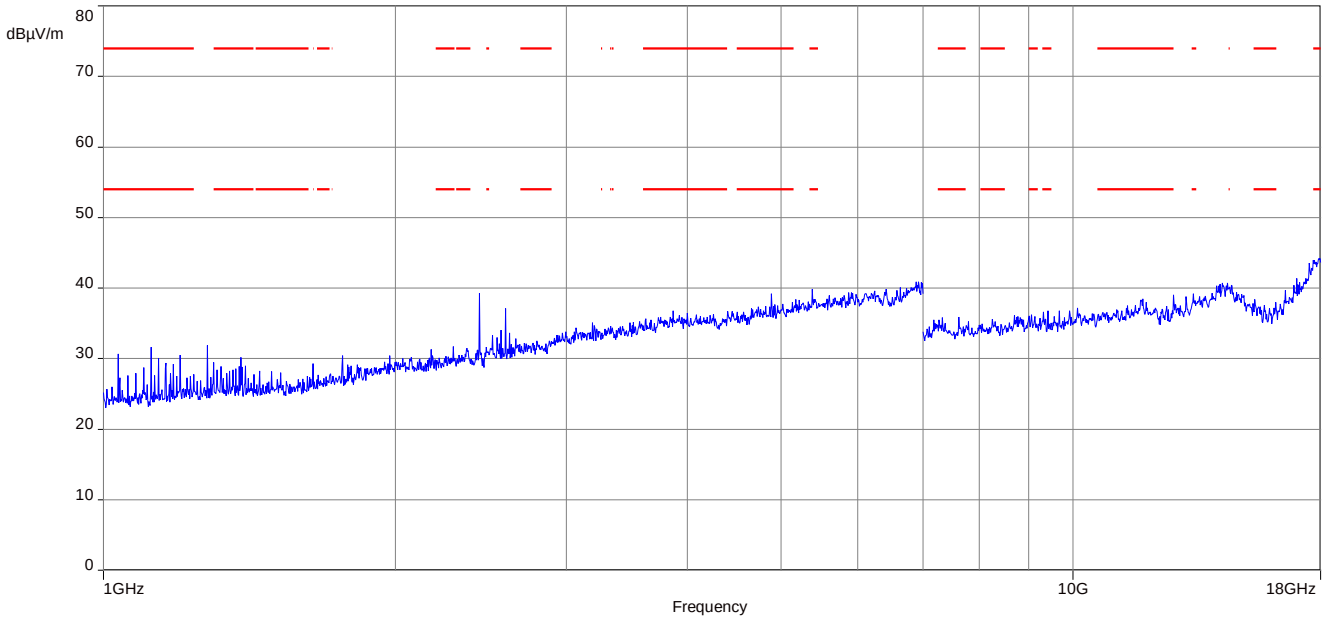



The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 2:** 18 GHz to 26 GHz, TX mode, channel 00, vertical & horizontal polarization

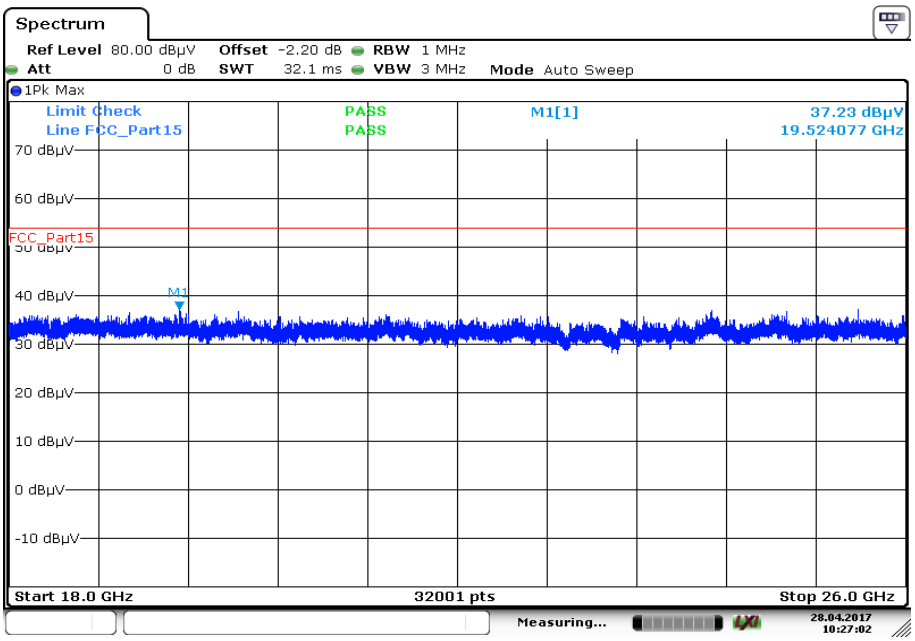


**Plot 3:** 1 GHz to 18 GHz, TX mode, channel 39, vertical & horizontal polarization

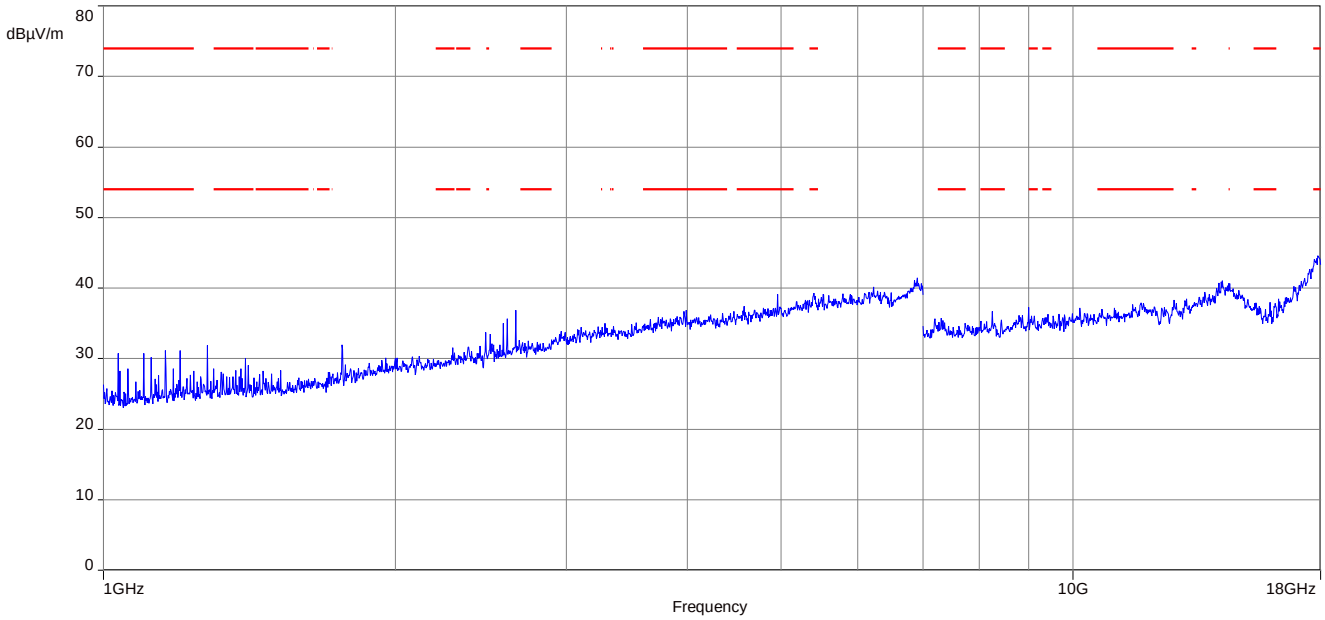



The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 4:** 18 GHz to 26 GHz, TX mode, channel 39, vertical & horizontal polarization

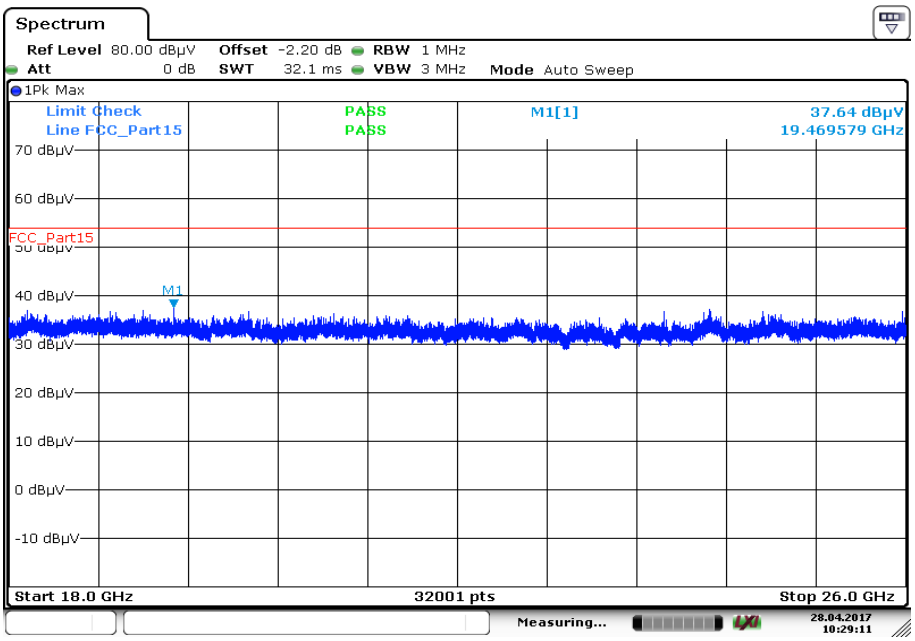


**Plot 5:** 1 GHz to 18 GHz, TX mode, channel 78, vertical & horizontal polarization



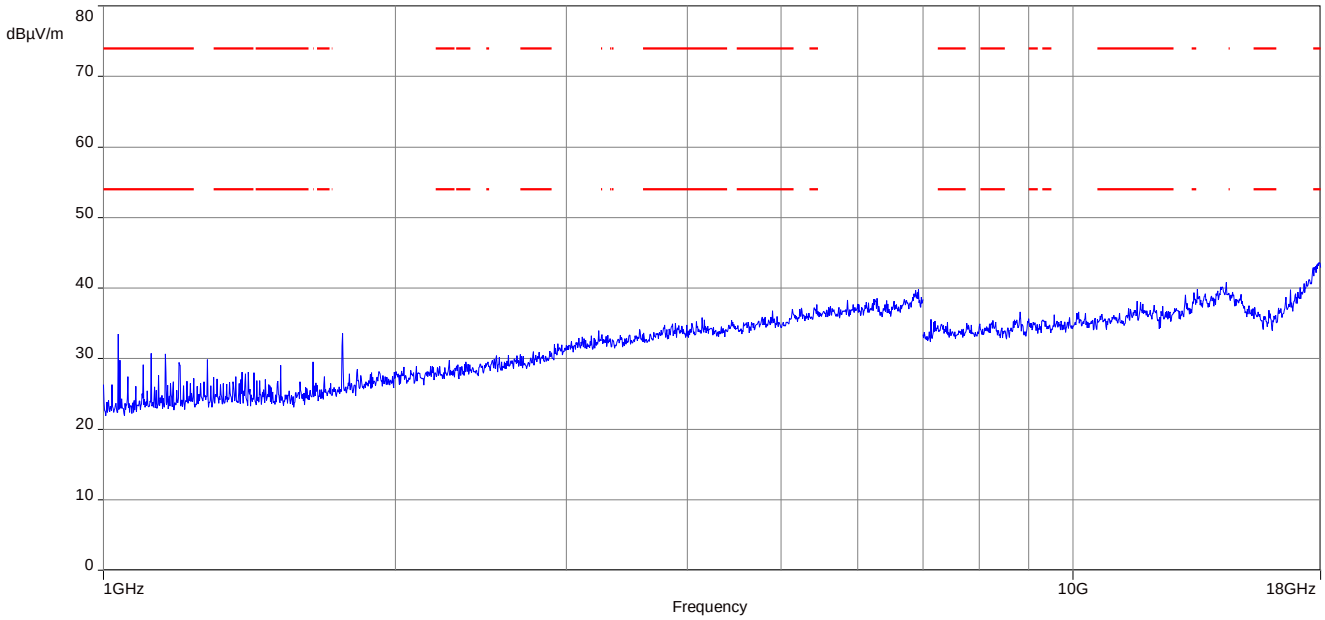

The carrier signal is notched with a 2.4 GHz band rejection filter.

**Plot 6:** 18 GHz to 26 GHz, TX mode, channel 78, vertical & horizontal polarization

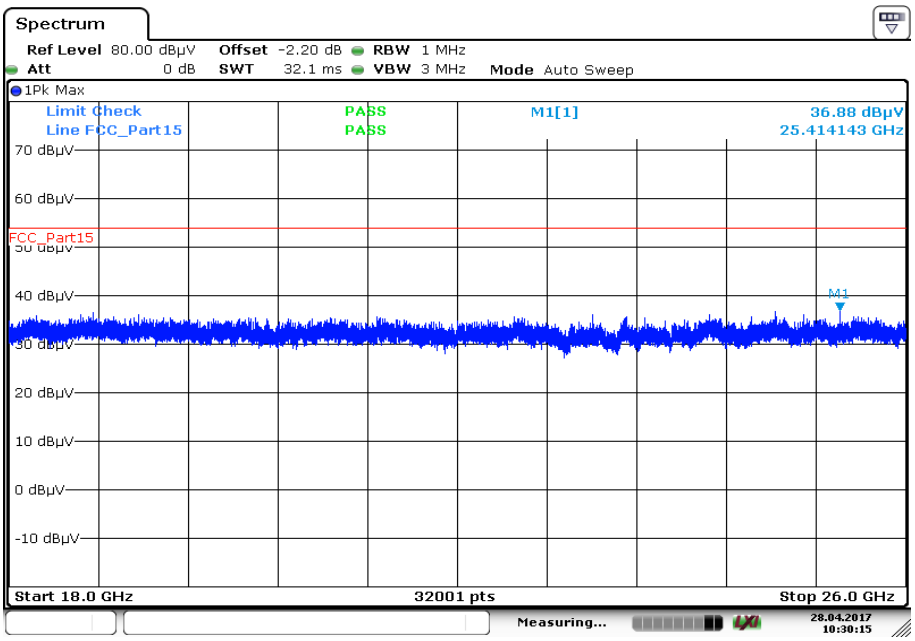


**Plots:** Receiver mode

**Plot 1:** 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization




**Plot 2:** 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization

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

**Description:**

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit channel is channel 39. This measurement is representative for all channels and modes. If critical peaks are found channel 00 and channel 78 will be measured too. The measurement is performed in the mode with the highest output power. Both power lines, phase and neutral line, are measured. Found peaks are remeasured with average and quasi peak detection to show compliance to the limits.

| Measurement parameters | |
|---|---|
| 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 sub clause 6.5. A |
| Measurement uncertainty | See sub clause 8 |

**Limits:**

| FCC | | IC |
|---|---|---|
| TX spurious emissions conducted < 30 MHz | | |
| 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 |

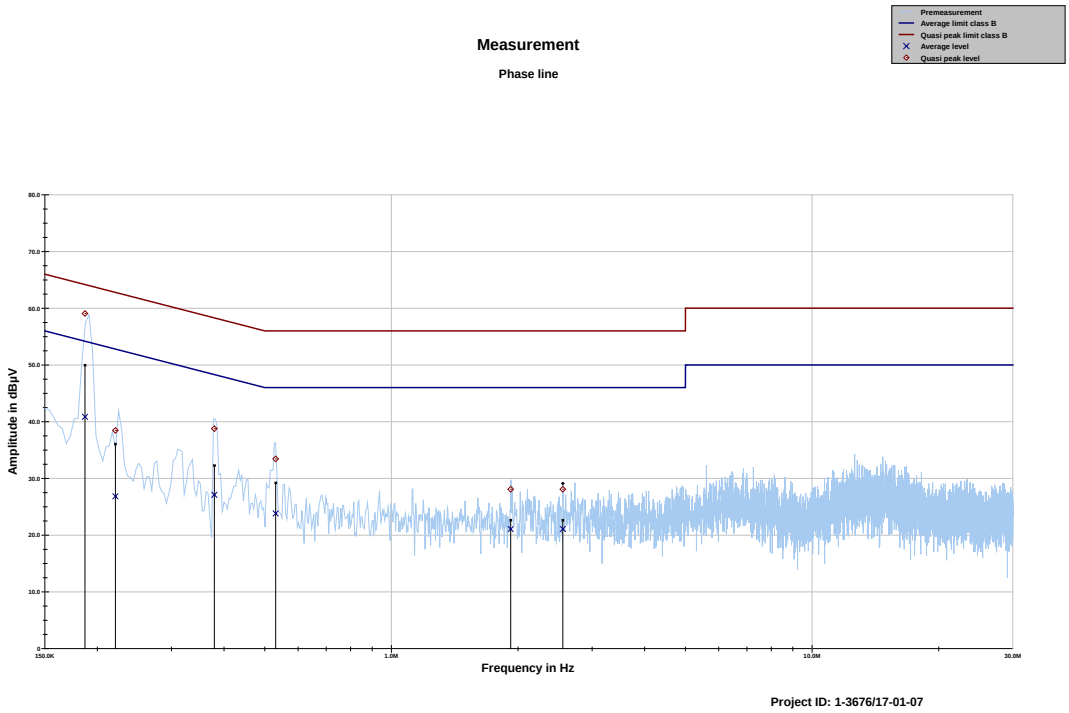
*Decreases with the logarithm of the frequency

**Results:**

| Spurious emissions conducted < 30 MHz [dBµV/m] | | |
|---|---|---|
| F [MHz] | Detector | Level [dBµV/m] |
| No emissions detected | | |
| | | |
| | | |

**Plots:**

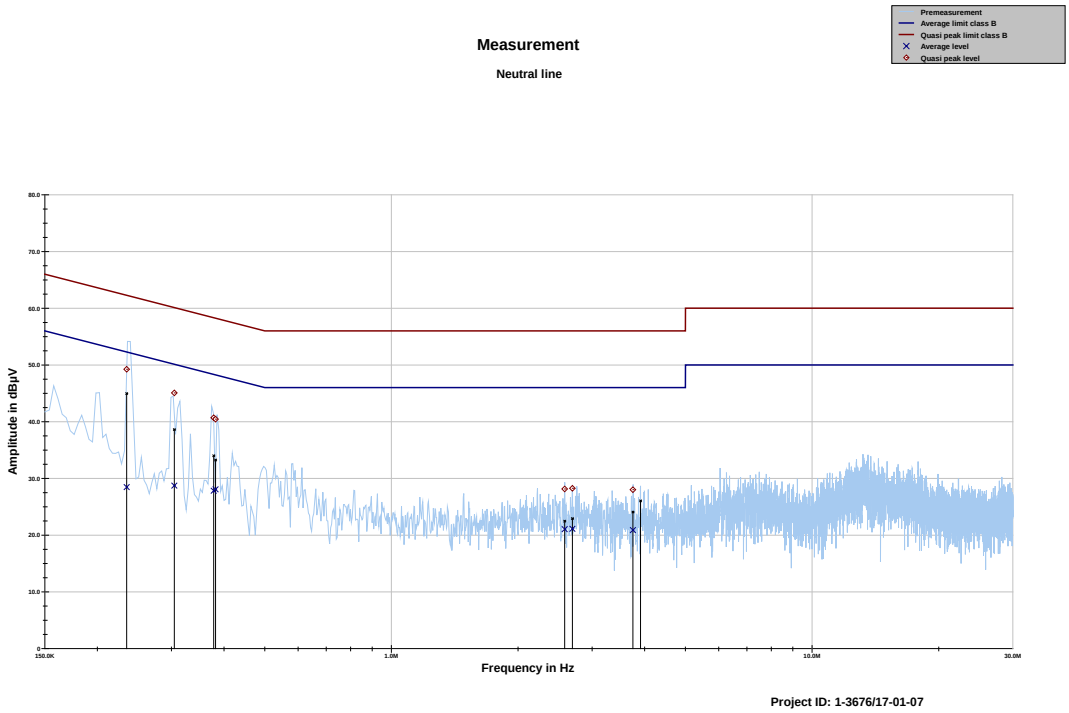
**Plot 1:** 150 kHz to 30 MHz, phase line




**Final results:**

| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin average | Limit AV |
|---|---|---|---|---|---|---|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| **0.186870** | 59.07 | 5.11 | 64.175 | 40.86 | 14.09 | 54.947 |
| **0.220805** | 38.46 | 24.32 | 62.789 | 26.83 | 27.14 | 53.977 |
| **0.379310** | 38.77 | 19.53 | 58.295 | 27.10 | 22.35 | 49.448 |
| **0.530702** | 33.43 | 22.57 | 56.000 | 23.82 | 22.18 | 46.000 |
| **1.920732** | 28.09 | 27.91 | 56.000 | 21.06 | 24.94 | 46.000 |
| **2.554909** | 28.09 | 27.91 | 56.000 | 21.07 | 24.93 | 46.000 |

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




**Final results:**

| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin average | Limit AV |
|---|---|---|---|---|---|---|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| **0.234803** | 49.23 | 13.05 | 62.278 | 28.46 | 25.11 | 53.577 |
| **0.304707** | 45.07 | 15.04 | 60.114 | 28.73 | 22.85 | 51.580 |
| **0.378138** | 40.69 | 17.63 | 58.320 | 27.82 | 21.66 | 49.482 |
| **0.382002** | 40.44 | 17.80 | 58.236 | 28.06 | 21.31 | 49.371 |
| **2.582061** | 28.14 | 27.86 | 56.000 | 21.05 | 24.95 | 46.000 |
| **2.693107** | 28.25 | 27.75 | 56.000 | 21.11 | 24.89 | 46.000 |
| **3.750640** | 28.00 | 28.00 | 56.000 | 20.89 | 25.11 | 46.000 |

## Annex A Document history

| Version | Applied changes | Date of release |
|---|---|---|
| | Initial release | 2017-06-12 |

## Annex B Further information

**Glossary**

| | | |
|---|---|---|
| AVG | - | Average |
| DUT | - | Device under test |
| EMC | - | Electromagnetic Compatibility |
| EN | - | European Standard |
| EUT | - | Equipment under test |
| ETSI | - | European Telecommunications Standard Institute |
| FCC | - | Federal Communication Commission |
| FCC ID | - | Company Identifier at FCC |
| HW | - | Hardware |
| IC | - | Industry Canada |
| Inv. No. | - | Inventory number |
| N/A | - | Not applicable |
| PP | - | Positive peak |
| QP | - | Quasi peak |
| S/N | - | Serial number |
| SW | - | Software |
| PMN | - | Product marketing name |
| HMN | - | Host marketing name |
| HVIN | - | Hardware version identification number |
| FVIN | - | Firmware version identification number |
| OBW | | Occupied Bandwidth |
| OC | | Operating Channel |
| OCW | | Operating Channel Bandwidth |
| OOB | | Out Of Band |

## Annex C Accreditation Certificate

first page

DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

**Beliehene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV**
Unterzeichnerin der Multilateralen Abkommen
von EA, ILAC und IAF zur gegenseitigen Anerkennung

# Akkreditierung

Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

**CTC advanced GmbH**
**Untertürkheimer Straße 6-10, 66117 Saarbrücken**

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

**Funk**
**Mobilfunk (GSM / DCS) + OTA**
**Elektromagnetische Verträglichkeit (EMV)**
**Produktsicherheit**
**SAR / EMF**
**Umwelt**
**Smart Card Technology**
**Bluetooth***
**Automotive**
**Wi-Fi-Services**
**Kanadische Anforderungen**
**US-Anforderungen**
**Akustik**
**Near Field Communication (NFC )**

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 25.11.2016 mit der Akkreditierungsnummer D-PL-12076-01 und ist gültig bis 17.01.2018. Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 63 Seiten.

Registrierungsnummer der Urkunde: **D-PL-12076-01-01**

Frankfurt, 25.11.2016

Im Auftrag Dipl.-Ing. (FH) Ralf Egner
Abteilungsleiter

Siehe Hinweise auf der Rückseite

last page

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