

Wireless test report – 368549-1TRFWL

Applicant:

Tait International LTD

Product name:

Bluetooth module (within portable Transceiver)

Model:

TP9306K5BA-ZZ

Type code:

TPDK5C

FCC ID:

CASTPDK5C

ISED Registration number:

737A-TPDK5C

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.247 - partial**

Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

◆ **RSS-247, Issue 2, Feb 2017, Section 5 - partial**

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs)
and Licence-Exempt Local Area Network (LE-LAN) Devices

5) Standard specifications for frequency hopping systems and digital transmission systems operating in the
bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: **March 8, 2019**

Test engineer(s): Andrey Adelberg, Senior Wireless/EMC Specialist

Signature:



Reviewed by: Kevin Rose, Wireless/EMC Specialist

Signature:



Test location(s)

| | |
|--------------|------------------------------------|
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| Site number | FCC: CA2040; IC: 2040A-4 (3 m SAC) |

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Applicant and manufacturer

| | |
|-----------------|------------------------|
| Company name | Tait International LTD |
| Address | 245 Wooldridge Rd |
| City | Christchurch |
| Province/State | – |
| Postal/Zip code | 8051 |
| Country | New Zealand |

1.2 Test specifications

| | |
|--|--|
| FCC 47 CFR Part 15, Subpart C, Clause 15.247 | Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz |
| RSS-247, Issue 2, Feb 2017, Section 5 | Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices |

1.3 Test methods

| | |
|--|---|
| 558074 D01 DTS Meas Guidance v05 (August 24, 2018) | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 |
| DA 00-705, Released March 30, 2000 | Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems |
| ANSI C63.10 v2013 | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| RSS-Gen, Issue 5, April 2018 | General Requirements for Compliance of Radio Apparatus |

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 below. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

Only limited subset of testing was performed as per customer’s test plan.

1.6 Test report revision history

| Revision # | Date of issue | Details of changes made to test report |
|------------|---------------|--|
| TRF | March 8, 2019 | Original report issued |

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Table 2.1-1: FCC general requirements results

| Part | Test description | Verdict |
|------------|------------------------------|----------------|
| §15.207(a) | Conducted limits | Not applicable |
| §15.31(e) | Variation of power source | Pass |
| §15.31(m) | Number of tested frequencies | Pass |
| §15.203 | Antenna requirement | Pass |

Notes: EUT is a battery-operated device, the testing was performed using fully charged batteries.

2.2 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems

Table 2.2-1: FCC 15.247 results for FHSS

| Part | Test description | Verdict |
|--------------------|---|----------------|
| §15.247(a)(1)(i) | Requirements for operation in the 902–928 MHz band | Not applicable |
| §15.247(a)(1)(ii) | Requirements for operation in the 5725–5850 MHz band | Not applicable |
| §15.247(a)(1)(iii) | Requirements for operation in the 2400–2483.5 MHz band | Not tested |
| §15.247(b)(1) | Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band | Pass |
| §15.247(b)(2) | Maximum peak output power in the 902–928 MHz band | Not applicable |
| §15.247(c)(1) | Fixed point-to-point operation with directional antenna gains greater than 6 dBi | Not applicable |
| §15.247(c)(2) | Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams | Not applicable |
| §15.247(d) | Spurious emissions | Pass |
| §15.247(f) | Time of occupancy for hybrid systems | Not applicable |

2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

Table 2.3-1: FCC 15.247 results for DTS

| Part | Test description | Verdict |
|---------------|---|----------------|
| §15.247(a)(2) | Minimum 6 dB bandwidth | Not tested |
| §15.247(b)(3) | Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands | Pass |
| §15.247(c)(1) | Fixed point-to-point operation with directional antenna gains greater than 6 dBi | Not applicable |
| §15.247(c)(2) | Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams | Not applicable |
| §15.247(d) | Spurious emissions | Pass |
| §15.247(e) | Power spectral density | Not tested |
| §15.247(f) | Time of occupancy for hybrid systems | Not applicable |

2.4 ISED RSS-Gen, Issue 5, test results

Table 2.4-1: RSS-Gen results

| Part | Test description | Verdict |
|------|---|----------------|
| 7.3 | Receiver radiated emission limits | Not applicable |
| 7.4 | Receiver conducted emission limits | Not applicable |
| 6.9 | Operating bands and selection of test frequencies | Pass |
| 8.8 | AC power-line conducted emissions limits | Not applicable |

Notes: ¹ According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

EUT is a battery-operated device, the testing was performed using fully charged batteries.

2.5 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

Table 2.5-1: RSS-247 results for FHSS

| Part | Test description | Verdict |
|---------|--|-------------------------|
| 5.1 (a) | Bandwidth of a frequency hopping channel | Not tested ¹ |
| 5.1 (b) | Minimum channel spacing | Not tested ¹ |
| 5.1 (c) | Systems operating in the 902–928 MHz band | Not applicable |
| 5.1 (d) | Systems operating in the 2400–2483.5 MHz band | Not tested ¹ |
| 5.1 (e) | Systems operating in the 5725–5850 MHz band | Not applicable |
| 5.3 | Hybrid Systems | |
| 5.3 (a) | Digital modulation turned off | Not applicable |
| 5.3 (b) | Frequency hopping turned off | Not applicable |
| 5.4 | Transmitter output power and e.i.r.p. requirements | |
| 5.4 (a) | Systems operating in the 902–928 MHz band | Not applicable |
| 5.4 (b) | Systems operating in the 2400–2483.5 MHz band | Pass |
| 5.4 (c) | Systems operating in the 5725–5850 MHz | Not applicable |
| 5.4 (e) | Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band | Not applicable |
| 5.4 (f) | Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams | Not applicable |
| 5.5 | Unwanted emissions | Pass |

Notes: ¹ See section 1.5 – Exclusions

2.6 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)

Table 2.6-1: RSS-247 results for DTS

| Part | Test description | Verdict |
|---------|--|-------------------------|
| 5.2 (a) | Minimum 6 dB bandwidth | Not tested ¹ |
| 5.2 (b) | Maximum power spectral density | Not tested ¹ |
| 5.3 | Hybrid Systems | |
| 5.3 (a) | Digital modulation turned off | Not applicable |
| 5.3 (b) | Frequency hopping turned off | Not applicable |
| 5.4 | Transmitter output power and e.i.r.p. requirements | |
| 5.4 (d) | Systems employing digital modulation techniques | Pass |
| 5.4 (e) | Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band | Not applicable |
| 5.4 (f) | Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams | Not applicable |
| 5.5 | Unwanted emissions | Pass |

Notes: ¹ See section 1.5 – Exclusions

Section 3. Equipment under test (EUT) details

3.1 Sample information

| | |
|------------------------|-------------------|
| Receipt date | February 25, 2019 |
| Nemko sample ID number | 1, 2 |

3.2 EUT information

| | |
|---------------|--|
| Product name | Bluetooth module (within portable Transceiver) |
| Model | TP9306K5BA-ZZ |
| Type code | TPDK5C |
| Serial number | 26126423 (conducted), 26126425 (radiated) |

3.3 Technical information

| | |
|--|-------------------------------------|
| Applicant IC company number | 737A |
| IC UPN number | TPDK5C |
| All used IC test site(s) Reg. number | 2040A-4 |
| RSS number and Issue number | RSS-247 Issue 2, Feb 2017 |
| Frequency band | 2400–2480 MHz |
| Frequency Min (MHz) | 2402 |
| Frequency Max (MHz) | 2480 |
| RF power Max (W), Conducted | 0.0137 (11.38 dBm) |
| Field strength, Units @ distance | N/A |
| Measured BW (kHz) | Not tested (Default 1 MHz channel) |
| Calculated BW (kHz), as per TRC-43 | N/A |
| Type of modulation | GFSK, $\pi/4$ -DQPSK, 8DPSK, BLE |
| Emission classification (F1D, G1D, D1D) | F1D |
| Transmitter spurious, dB μ V/m @ 3 m | 48.60 (at 4956 MHz) |
| Power requirements | 7.4 V from Li-Ion Battery |
| Antenna information | Internal antenna with 1.39 dBi gain |

3.4 Product description and theory of operation

EUT is a Bluetooth and Bluetooth LE radio module incorporated within hand-held radio transceiver unit operating within 762–780 MHz UHF band.

3.5 EUT exercise details

EUT was controlled from computer via programming cable.

3.6 EUT setup diagram

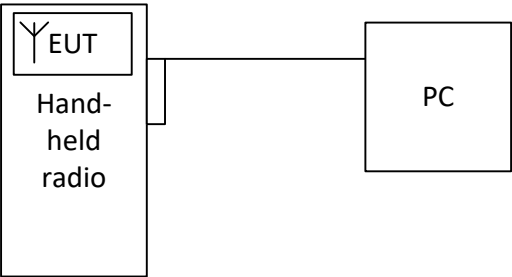


Figure 3.6-1: Setup diagram (programming)

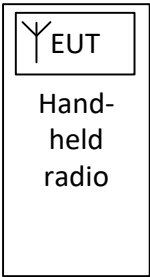


Figure 3.6-2: Setup diagram (operation)

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

| | |
|-------------------|---------------|
| Temperature | 15–30 °C |
| Relative humidity | 20–75 % |
| Air pressure | 860–1060 mbar |

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.



Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of $K = 2$ with 95% certainty.

Table 6.1-1: Measurement uncertainty

| Test name | Measurement uncertainty, dB |
|-----------------------------------|-----------------------------|
| All antenna port measurements | 0.55 |
| Conducted spurious emissions | 1.13 |
| Radiated spurious emissions | 3.78 |
| AC power line conducted emissions | 3.55 |

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

| Equipment | Manufacturer | Model no. | Asset no. | Cal cycle | Next cal. |
|-----------------------------|-----------------|--------------|-----------|-----------|------------------|
| 3 m EMI test chamber | TDK | SAC-3 | FA002047 | 1 year | January 24, 2020 |
| Flush mount turntable | Sunol | FM2022 | FA002082 | — | NCR |
| Controller | Sunol | SC104V | FA002060 | — | NCR |
| Antenna mast | Sunol | TLT2 | FA002061 | — | NCR |
| Bilog antenna (20–3000 MHz) | Sunol | JB3 | FA002108 | 1 year | January 3, 2020 |
| Receiver/spectrum analyzer | Rohde & Schwarz | ESU 26 | FA002043 | 1 year | March 26, 2019 |
| Spectrum analyzer | Rohde & Schwarz | FSU | FA001877 | 1 year | October 26, 2019 |
| Horn (1–18 GHz) | ETS Lindgren | 3117 | FA002840 | 1 year | January 16, 2020 |
| Preamp (1–18 GHz) | ETS Lindgren | 124334 | FA002873 | 1 year | November 4, 2019 |
| Horn antenna (18–40 GHz) | EMCO | 3116 | FA001847 | 1 year | October 9, 2019 |
| Pre-amplifier (18–26 GHz) | Narda | BBS-1826N612 | FA001550 | — | VOU |

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test date

Start date March 5, 2019

8.1.3 Observations, settings and special notes

None

8.1.4 Test data

| | | | |
|---|---|-----------------------------|---|
| EUT Power requirements: | <input type="checkbox"/> AC | <input type="checkbox"/> DC | <input checked="" type="checkbox"/> Battery |
| If EUT is an AC or a DC powered, was the noticeable output power variation observed? | <input type="checkbox"/> YES | <input type="checkbox"/> NO | <input checked="" type="checkbox"/> N/A |
| If EUT is battery operated, was the testing performed using fresh batteries? | <input type="checkbox"/> YES | <input type="checkbox"/> NO | <input checked="" type="checkbox"/> N/A |
| If EUT is rechargeable battery operated, was the testing performed using fully charged batteries? | <input checked="" type="checkbox"/> YES | <input type="checkbox"/> NO | <input type="checkbox"/> N/A |

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

8.2.1 Definitions and limits

FCC:

Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

ISED:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.2-1: Frequency Range of Operation

| Frequency range over which the device operates (in each band) | Number of test frequencies required | Location of measurement frequency inside the operating frequency range |
|---|-------------------------------------|--|
| 1 MHz or less | 1 | Center (middle of the band) |
| 1–10 MHz | 2 | 1 near high end, 1 near low end |
| Greater than 10 MHz | 3 | 1 near high end, 1 near center and 1 near low end |

Note: “near” means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test date

Start date March 5, 2019

8.2.3 Observations, settings and special notes

None

8.2.4 Test data

Table 8.2-2: Test channels selection

| Start of Frequency range, MHz | End of Frequency range, MHz | Frequency range bandwidth, MHz | Low channel, MHz | Mid channel, MHz | High channel, MHz |
|-------------------------------|-----------------------------|--------------------------------|------------------|------------------|-------------------|
| 2400 | 2483.5 | 83.5 | 2402 | 2440 | 2479 |

8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement

8.3.1 Definitions and limits

FCC:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

ISED:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

8.3.2 Test date

| | |
|-------------------|---------------|
| Start date | March 5, 2019 |
|-------------------|---------------|

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

| | | |
|--|------------------------------|---|
| Must the EUT be professionally installed? | <input type="checkbox"/> YES | <input checked="" type="checkbox"/> NO |
| Does the EUT have detachable antenna(s)? | <input type="checkbox"/> YES | <input checked="" type="checkbox"/> NO |
| If detachable, is the antenna connector(s) non-standard? | <input type="checkbox"/> YES | <input type="checkbox"/> NO <input checked="" type="checkbox"/> N/A |

8.4 FCC 15.247(b) and RSS-247 5.4 (b) Transmitter output power and e.i.r.p. requirements for FHSS 2 GHz

8.4.1 Definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt (30 dBm). For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts (21 dBm).
 - (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

ISED:

For FHSs operating in the band 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W (30 dBm) if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W (21 dBm) if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (36 dBm), except as provided in section 5.4(e).

Section 5.4(e)

Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

8.4.1 Test date

Start date September 4, 2018

8.4.2 Observations, settings and special notes

Spectrum analyser settings for output power:

| | |
|----------------------|--|
| Resolution bandwidth | > the 20 dB bandwidth of the emission being measured |
| Video bandwidth | ≥ RBW |
| Frequency span | approximately 5 times the 20 dB bandwidth, centered on a hopping channel |
| Detector mode | Peak |
| Trace mode | Max Hold |

8.4.3 Test data

Table 8.4-1: Output power and EIRP results for GFSK modulation

| Frequency, MHz | Output power, dBm | Output power limit, dBm | Margin, dB | Antenna gain, dBi | EIRP, dBm | EIRP limit, dBm | EIRP margin, dB |
|----------------|-------------------|-------------------------|------------|-------------------|-----------|-----------------|-----------------|
| 2402 | 10.71 | 30.00 | 19.29 | 1.39 | 12.10 | 36.00 | 23.90 |
| 2440 | 10.30 | 30.00 | 19.70 | 1.39 | 11.69 | 36.00 | 24.31 |
| 2480 | 10.04 | 30.00 | 19.96 | 1.39 | 11.43 | 36.00 | 24.57 |

EIRP = Output power + Antenna gain

Table 8.4-2: Output power and EIRP results for $\pi/4$ -DQPSK modulation

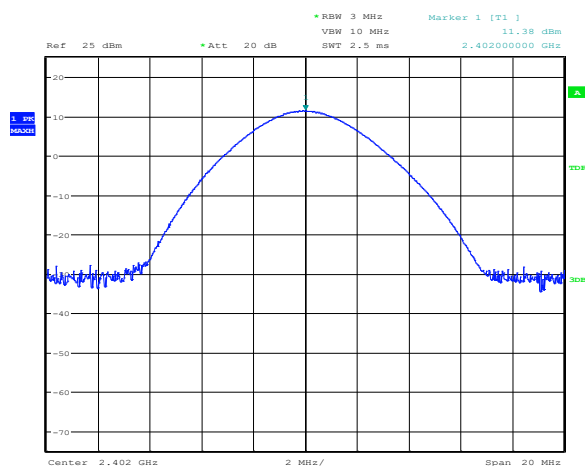
| Frequency, MHz | Output power, dBm | Output power limit, dBm | Margin, dB | Antenna gain, dBi | EIRP, dBm | EIRP limit, dBm | EIRP margin, dB |
|----------------|-------------------|-------------------------|------------|-------------------|-----------|-----------------|-----------------|
| 2402 | 10.71 | 30.00 | 19.29 | 1.39 | 12.10 | 36.00 | 23.90 |
| 2440 | 10.65 | 30.00 | 19.35 | 1.39 | 12.04 | 36.00 | 23.96 |
| 2480 | 10.35 | 30.00 | 19.65 | 1.39 | 11.74 | 36.00 | 24.26 |

EIRP = Output power + Antenna gain

Table 8.4-3: Output power and EIRP results for 8DPSK modulation

| Frequency, MHz | Output power, dBm | Output power limit, dBm | Margin, dB | Antenna gain, dBi | EIRP, dBm | EIRP limit, dBm | EIRP margin, dB |
|----------------|-------------------|-------------------------|------------|-------------------|-----------|-----------------|-----------------|
| 2402 | 11.38 | 30.00 | 18.62 | 1.39 | 12.77 | 36.00 | 23.23 |
| 2440 | 11.26 | 30.00 | 18.74 | 1.39 | 12.65 | 36.00 | 23.35 |
| 2480 | 11.06 | 30.00 | 18.94 | 1.39 | 12.45 | 36.00 | 23.55 |

EIRP = Output power + Antenna gain



Date: 5.MAR.2019 13:00:59

Figure 8.4-1: Output power sample plot

8.5 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements for DTS in 2 GHz

8.5.1 Definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 2400–2483.5 MHz band: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
 - (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (c) Operation with directional antenna gains greater than 6 dBi.
- (1) Fixed point-to-point operation:
- (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.
 - (iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.
- (2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:
- (i) Different information must be transmitted to each receiver.
 - (ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or staff having the highest gain.
 - (B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.
 - (iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.
- (iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

ISED:

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 MHz band, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

i Different information must be transmitted to each receiver.

ii If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or staff having the highest gain.

iii If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.

iv Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

8.5.1 Test date

Start date September 4, 2018

8.5.2 Observations, settings and special notes

The test was performed using a peak method

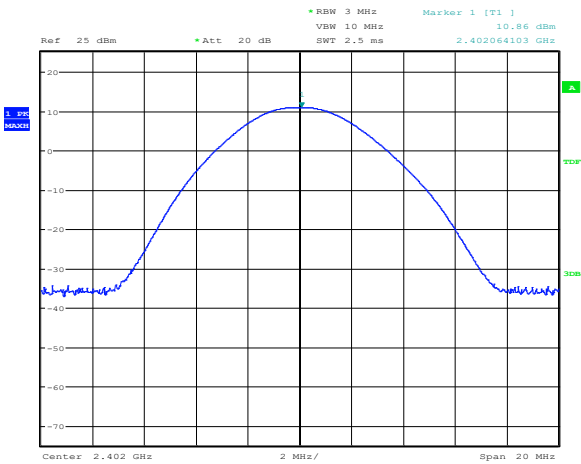
8.5.3 Test data

Table 8.5-1: Output power measurements results

| Frequency, MHz | Conducted output power, dBm | | Margin, dB | Antenna gain, dBi | EIRP, dBm | EIRP limit, dBm | EIRP margin, dB |
|-------------------|-----------------------------|-------|------------|----------------------|--------------|--------------------|-----------------|
| | Measured | Limit | | | | | |
| 2402 | 10.86 | 30.00 | 19.14 | 1.39 | 12.25 | 36.00 | 23.75 |
| 2440 | 10.60 | 30.00 | 19.40 | 1.39 | 11.99 | 36.00 | 24.01 |
| 2480 | 10.35 | 30.00 | 19.65 | 1.39 | 11.74 | 36.00 | 24.26 |

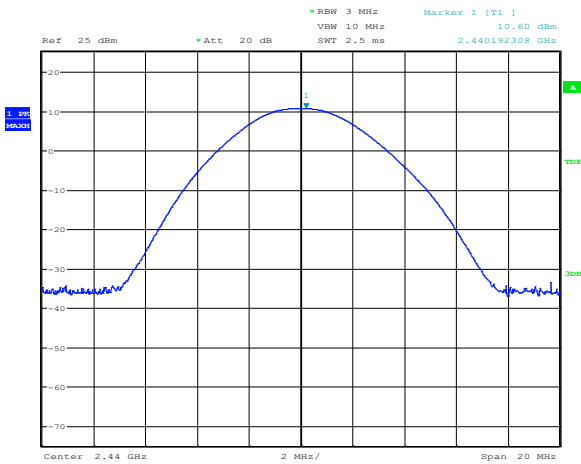
Section 8
Test name
Specification

Testing data
FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements
FCC Part 15 Subpart C and RSS-247, Issue 2



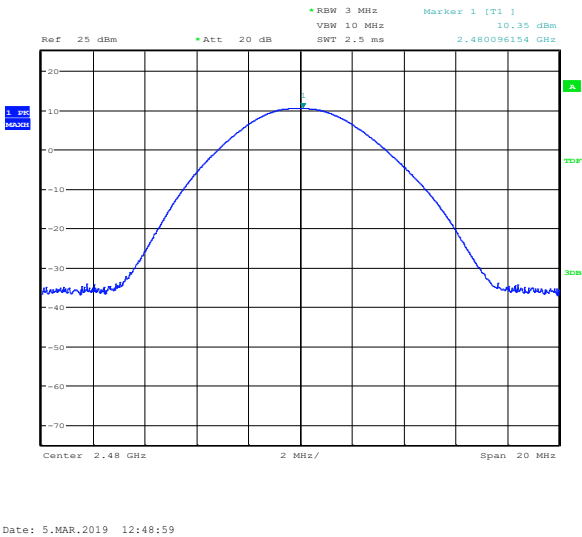
Date: 5.MAR.2019 12:46:22

Figure 8.5-1: Output power on low channel



Date: 5.MAR.2019 12:47:56

Figure 8.5-2: Output power on mid channel



Date: 5.MAR.2019 12:48:59

Figure 8.5-3: Output power on high channel

8.6 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions

8.6.1 Definitions and limits

FCC:

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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §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)).

ISED:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.6-1: FCC §15.209 and RSS-Gen – Radiated emission limits

| Frequency, MHz | Field strength of emissions | | Measurement distance, m |
|-------------------|-----------------------------|---------------------------------|-------------------------|
| | µV/m | dBµV/m | |
| 0.009–0.490 | 2400/F | $67.6 - 20 \times \log_{10}(F)$ | 300 |
| 0.490–1.705 | 24000/F | $87.6 - 20 \times \log_{10}(F)$ | 30 |
| 1.705–30.0 | 30 | 29.5 | 30 |
| 30–88 | 100 | 40.0 | 3 |
| 88–216 | 150 | 43.5 | 3 |
| 216–960 | 200 | 46.0 | 3 |
| above 960 | 500 | 54.0 | 3 |

Notes: In the emission table above, the tighter limit applies at the band edges.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.6-2: ISED restricted frequency bands

| MHz | MHz | MHz | GHz |
|-------------------|---------------------|---------------|-------------|
| 0.090–0.110 | 12.57675–12.57725 | 399.9–410 | 7.25–7.75 |
| 0.495–0.505 | 13.36–13.41 | 608–614 | 8.025–8.5 |
| 2.1735–2.1905 | 16.42–16.423 | 960–1427 | 9.0–9.2 |
| 3.020–3.026 | 16.69475–16.69525 | 1435–1626.5 | 9.3–9.5 |
| 4.125–4.128 | 16.80425–16.80475 | 1645.5–1646.5 | 10.6–12.7 |
| 4.17725–4.17775 | 25.5–25.67 | 1660–1710 | 13.25–13.4 |
| 4.20725–4.20775 | 37.5–38.25 | 1718.8–1722.2 | 14.47–14.5 |
| 5.677–5.683 | 73–74.6 | 2200–2300 | 15.35–16.2 |
| 6.215–6.218 | 74.8–75.2 | 2310–2390 | 17.7–21.4 |
| 6.26775–6.26825 | 108–138 | 2483.5–2500 | 22.01–23.12 |
| 6.31175–6.31225 | 149.9–150.05 | 2655–2900 | 23.6–24.0 |
| 8.291–8.294 | 156.52475–156.52525 | 3260–3267 | 31.2–31.8 |
| 8.362–8.366 | 156.7–156.9 | 3332–3339 | 36.43–36.5 |
| 8.37625–8.38675 | 162.0125–167.17 | 3345.8–3358 | |
| 8.41425–8.41475 | 167.72–173.2 | 3500–4400 | |
| 12.29–12.293 | 240–285 | 4500–5150 | Above 38.6 |
| 12.51975–12.52025 | 322–335.4 | 5350–5460 | |

Note: Certain frequency bands listed in Table 8.6-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.6-3: FCC restricted frequency bands

| MHz | MHz | MHz | GHz |
|-------------------|---------------------|---------------|-------------|
| 0.090–0.110 | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| 0.495–0.505 | 16.69475–16.69525 | 608–614 | 5.35–5.46 |
| 2.1735–2.1905 | 16.80425–16.80475 | 960–1240 | 7.25–7.75 |
| 4.125–4.128 | 25.5–25.67 | 1300–1427 | 8.025–8.5 |
| 4.17725–4.17775 | 37.5–38.25 | 1435–1626.5 | 9.0–9.2 |
| 4.20725–4.20775 | 73–74.6 | 1645.5–1646.5 | 9.3–9.5 |
| 6.215–6.218 | 74.8–75.2 | 1660–1710 | 10.6–12.7 |
| 6.26775–6.26825 | 108–121.94 | 1718.8–1722.2 | 13.25–13.4 |
| 6.31175–6.31225 | 123–138 | 2200–2300 | 14.47–14.5 |
| 8.291–8.294 | 149.9–150.05 | 2310–2390 | 15.35–16.2 |
| 8.362–8.366 | 156.52475–156.52525 | 2483.5–2500 | 17.7–21.4 |
| 8.37625–8.38675 | 156.7–156.9 | 2690–2900 | 22.01–23.12 |
| 8.41425–8.41475 | 162.0125–167.17 | 3260–3267 | 23.6–24.0 |
| 12.29–12.293 | 167.72–173.2 | 3332–3339 | 31.2–31.8 |
| 12.51975–12.52025 | 240–285 | 3345.8–3358 | 36.43–36.5 |
| 12.57675–12.57725 | 322–335.4 | 3600–4400 | Above 38.6 |
| 13.36–13.41 | | | |

8.6.1 Test date

Start date March 4, 2019

8.6.2 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.

EUT was set to transmit with 100 % duty cycle.

Radiated measurements were performed at 3 m. The testing was performed with all variants of modulations, only the worst-case plots provided.

Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is –20 dBc/100 kHz.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

| | |
|-----------------------|----------|
| Resolution bandwidth: | 100 kHz |
| Video bandwidth: | 300 kHz |
| Detector mode: | Peak |
| Trace mode: | Max Hold |

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

| | |
|-----------------------|----------|
| Resolution bandwidth: | 1 MHz |
| Video bandwidth: | 3 MHz |
| Detector mode: | Peak |
| Trace mode: | Max Hold |

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

| | |
|-----------------------|----------|
| Resolution bandwidth: | 1 MHz |
| Video bandwidth: | 10 Hz |
| Detector mode: | Peak |
| Trace mode: | Max Hold |

Spectrum analyser settings for conducted spurious emissions measurements:

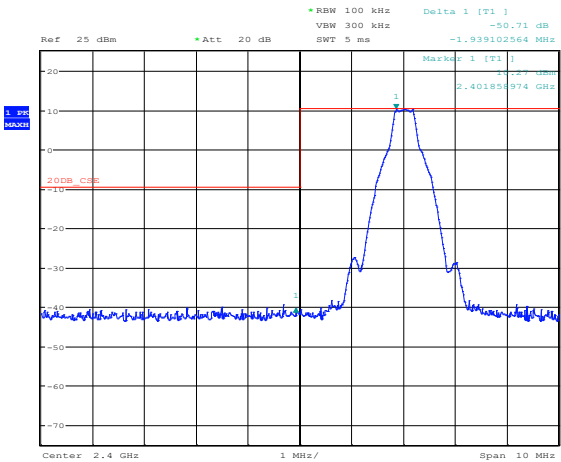
| | |
|-----------------------|----------|
| Resolution bandwidth: | 100 kHz |
| Video bandwidth: | 300 kHz |
| Detector mode: | Peak |
| Trace mode: | Max Hold |

8.6.4 Test data

Table 8.6-4: Radiated field strength measurement results

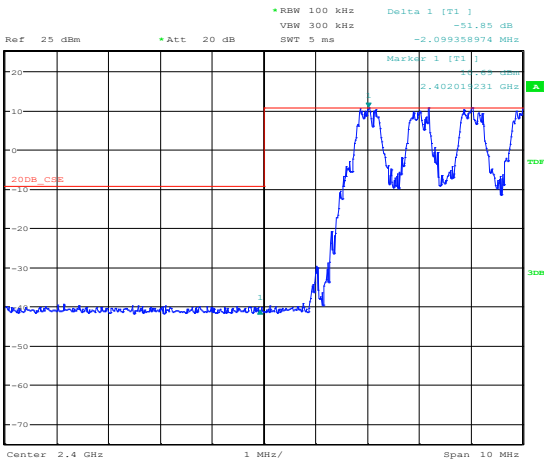
| Channel | Frequency, MHz | Peak Field strength, dBμV/m | | Margin, dB | Average Field strength, dBμV/m | | Margin, dB |
|---------|----------------|-----------------------------|-------|------------|--------------------------------|-------|------------|
| | | Measured | Limit | | Measured | Limit | |
| Low | 2390 | 53.11 | 74.00 | 20.89 | 46.15 | 54.00 | 7.85 |
| Low | 4804 | 50.23 | 74.00 | 23.77 | 44.04 | 54.00 | 9.96 |
| Low | 7206 | 50.31 | 74.00 | 23.69 | 43.87 | 54.00 | 10.13 |
| Mid | 4880 | 49.32 | 74.00 | 24.68 | 43.09 | 54.00 | 10.91 |
| High | 2483.5 | 55.28 | 74.00 | 18.72 | 48.60 | 54.00 | 5.40 |
| High | 4956 | 50.09 | 74.00 | 23.91 | 43.34 | 54.00 | 10.66 |

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.



Date: 5.MAR.2019 13:08:31

Figure 8.6-1: Conducted spurious emissions at the lower band edge for GFSK modulation, hopping off

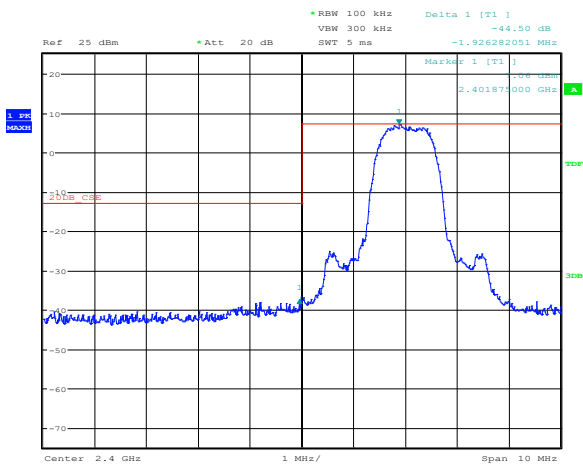


Date: 5.MAR.2019 13:15:24

Figure 8.6-2: Conducted spurious emissions at the lower band edge for GFSK modulation, hopping on

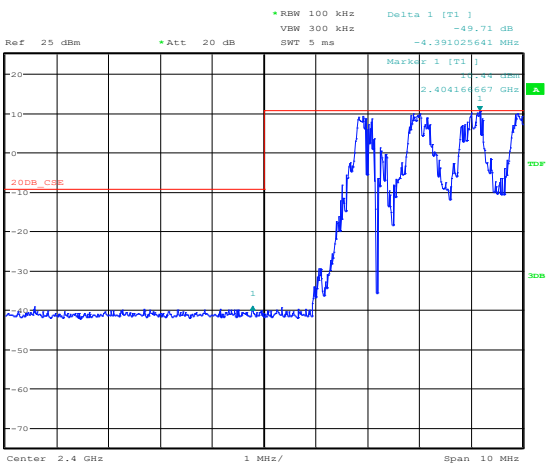
Section 8
Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



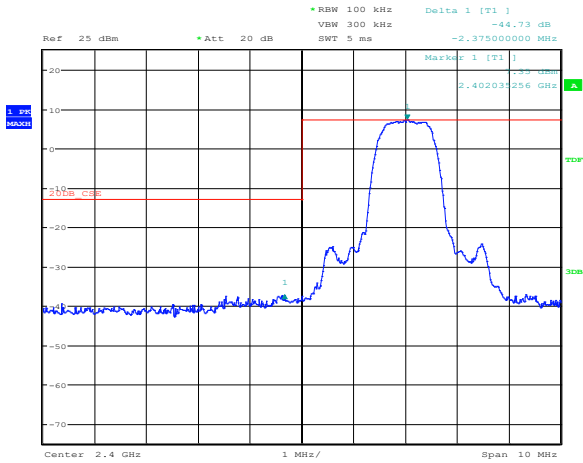
Date: 5.MAR.2019 13:04:19

Figure 8.6-3: Conducted spurious emissions at the lower band edge for $\pi/4$ -DQPSK modulation, hopping off



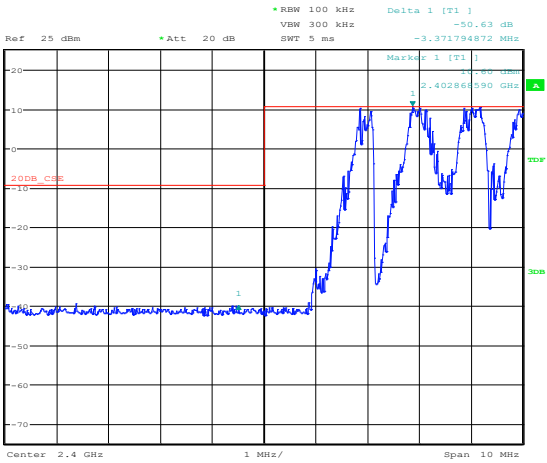
Date: 5.MAR.2019 13:24:16

Figure 8.6-4: Conducted spurious emissions at the lower band edge for $\pi/4$ -DQPSK modulation, hopping on



Date: 5.MAR.2019 13:03:29

Figure 8.6-5: Conducted spurious emissions at the lower band edge for 8DPSK modulation, hopping off

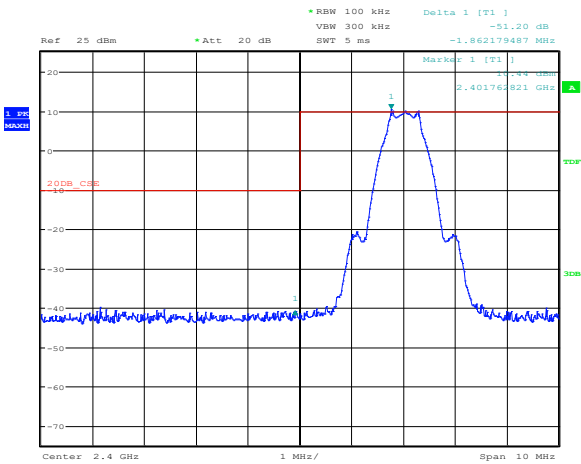


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Figure 8.6-6: Conducted spurious emissions at the lower band edge for 8DPSK modulation, hopping on

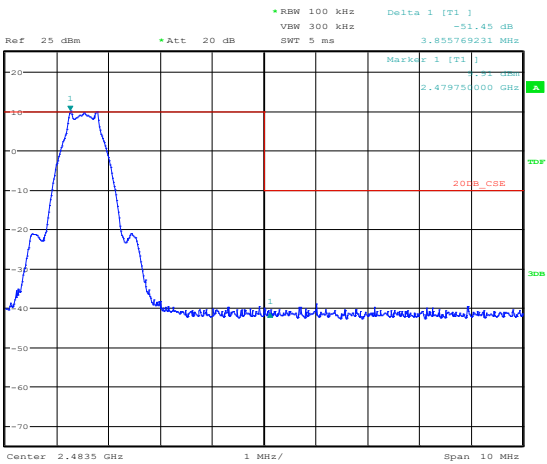
Section 8
Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



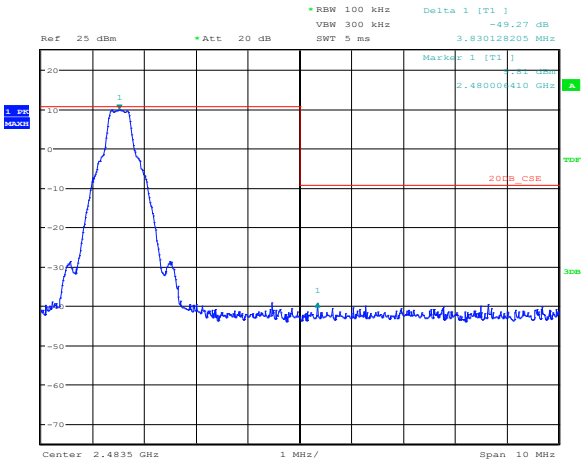
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Figure 8.6-7: Conducted spurious emissions at the lower band edge for BLE modulation



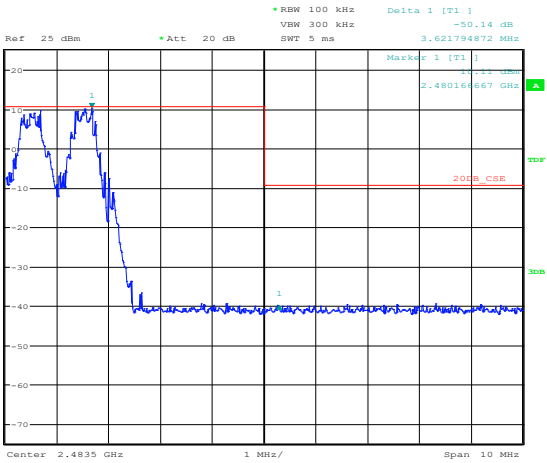
Date: 5.MAR.2019 13:07:19

Figure 8.6-8: Conducted spurious emissions at the upper band edge for BLE modulation



Date: 5.MAR.2019 13:35:40

Figure 8.6-9: Conducted spurious emissions at the upper band edge for GFSK modulation, hopping off

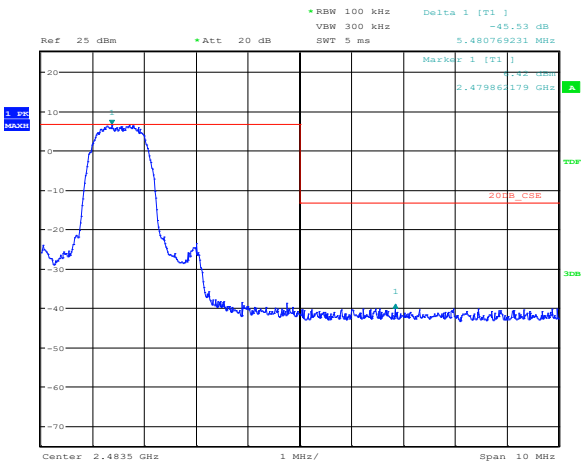


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Figure 8.6-10: Conducted spurious emissions at the upper band edge for GFSK modulation, hopping on

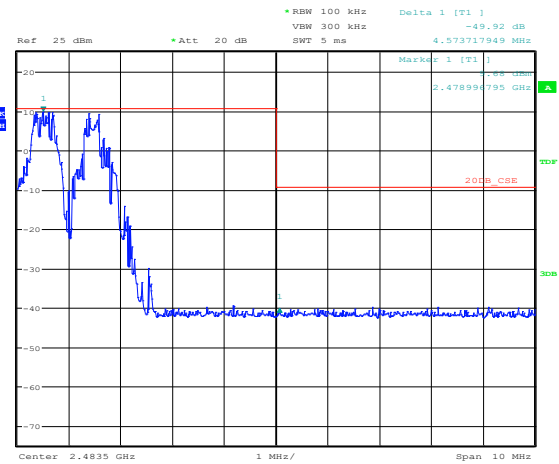
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Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



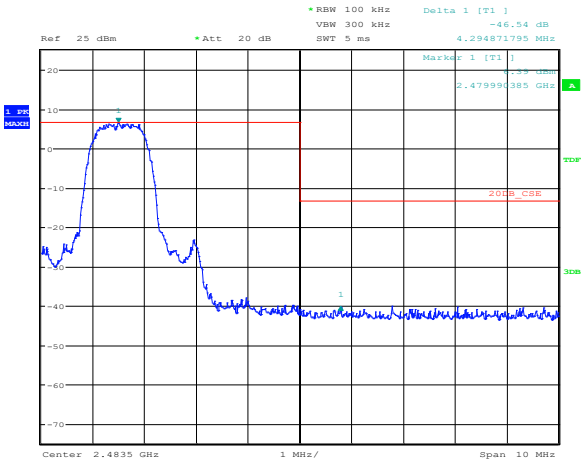
Date: 5.MAR.2019 13:38:09

Figure 8.6-11: Conducted spurious emissions at the low upper band edge for $\pi/4$ -DQPSK modulation, hopping off



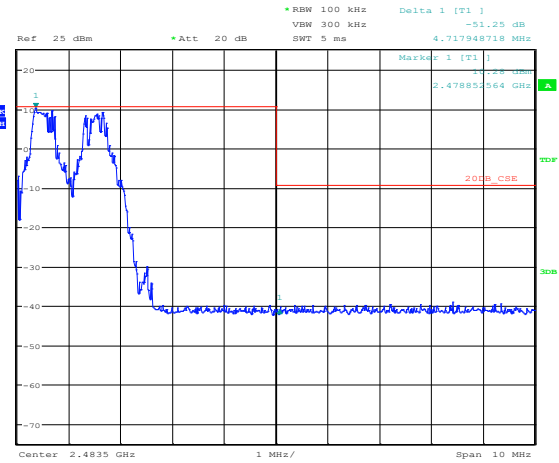
Date: 5.MAR.2019 13:26:05

Figure 8.6-12: Conducted spurious emissions at the upper band edge for $\pi/4$ -DQPSK modulation, hopping on



Date: 5.MAR.2019 13:44:46

Figure 8.6-13: Conducted spurious emissions at the upper band edge for 8DPSK modulation, hopping off

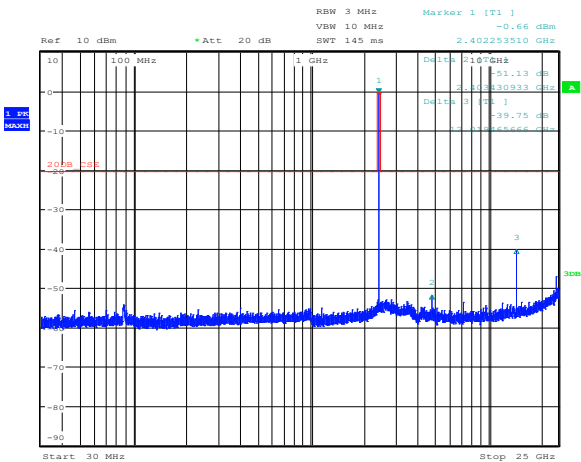


Date: 5.MAR.2019 13:29:38

Figure 8.6-14: Conducted spurious emissions at the upper band edge for 8DPSK modulation, hopping on

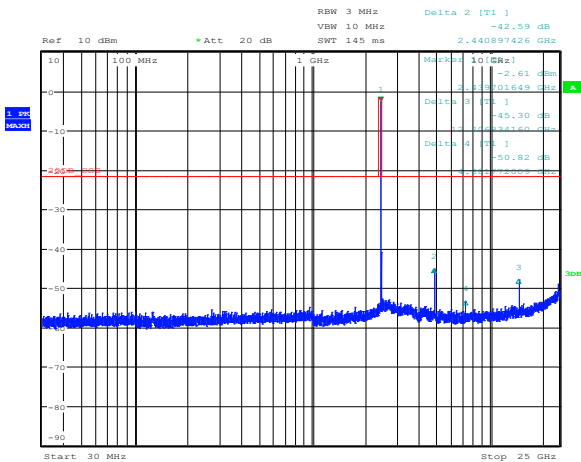
Section 8
Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



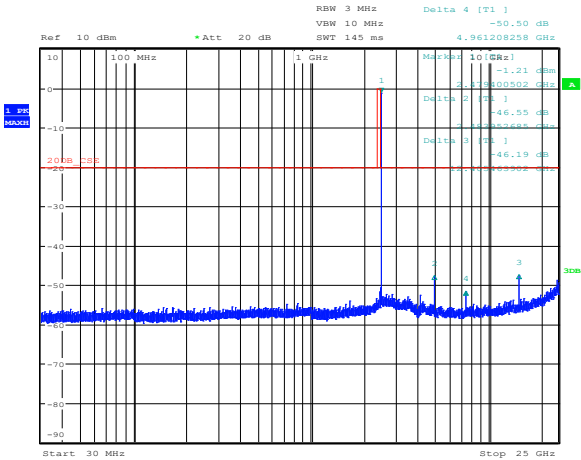
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Figure 8.6-15: Conducted spurious emissions for GFSK, low channel



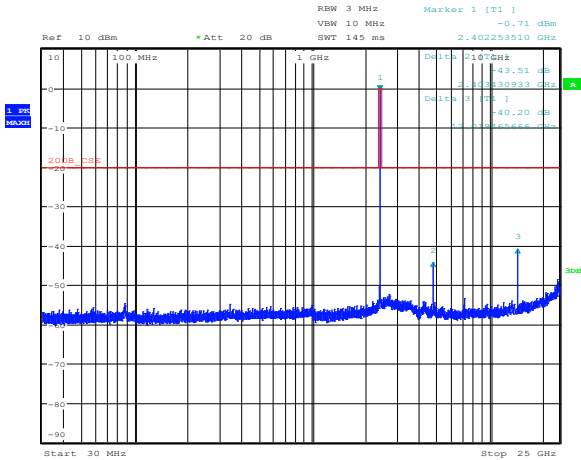
Date: 5.MAR.2019 13:55:51

Figure 8.6-16: Conducted spurious emissions for GFSK, mid channel



Date: 5.MAR.2019 13:54:53

Figure 8.6-17: Conducted spurious emissions for GFSK, high channel

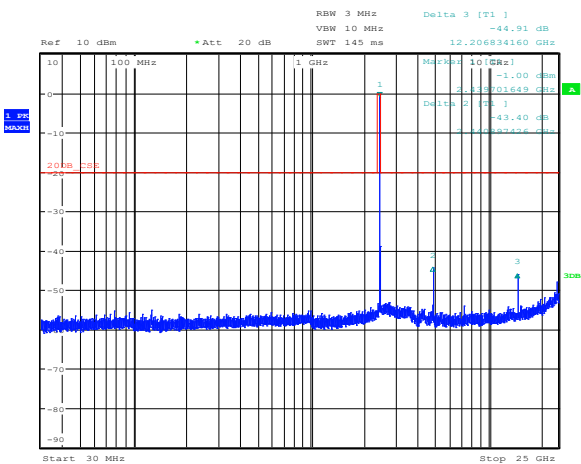


Date: 5.MAR.2019 13:51:16

Figure 8.6-18: Conducted spurious emissions for $\pi/4$ -DQPSK, low channel

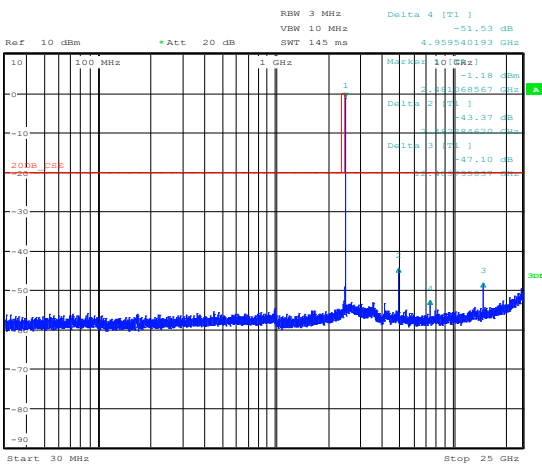
Section 8
Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



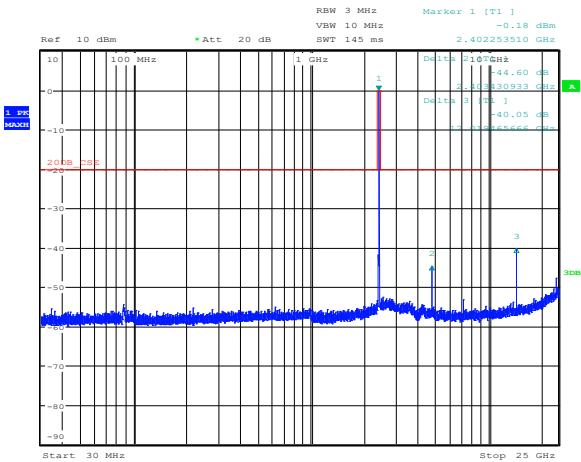
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Figure 8.6-19: Conducted spurious emissions for $\pi/4$ -DQPSK, mid channel



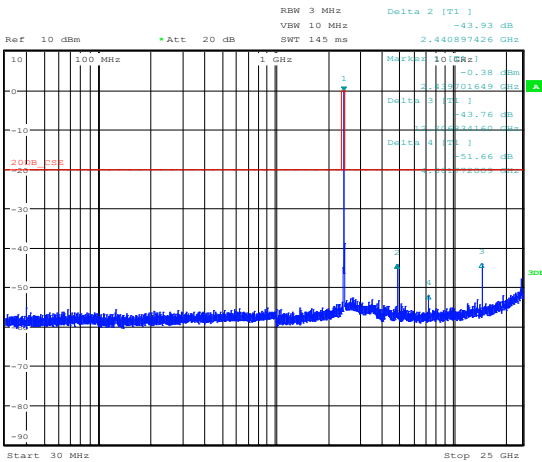
Date: 5.MAR.2019 13:53:03

Figure 8.6-20: Conducted spurious emissions for $\pi/4$ -DQPSK, high channel



Date: 5.MAR.2019 13:50:03

Figure 8.6-21: Conducted spurious emissions for 8DPSK, low channel

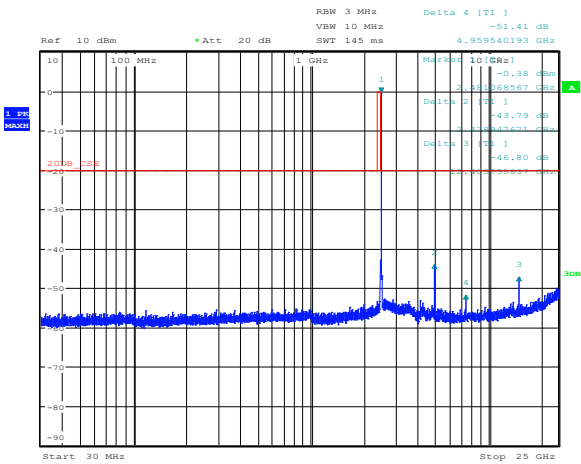


Date: 5.MAR.2019 13:48:49

Figure 8.6-22: Conducted spurious emissions for 8DPSK, mid channel

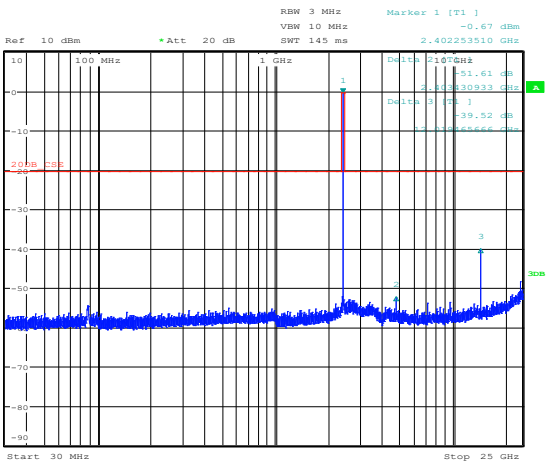
Section 8
Test name
Specification

Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



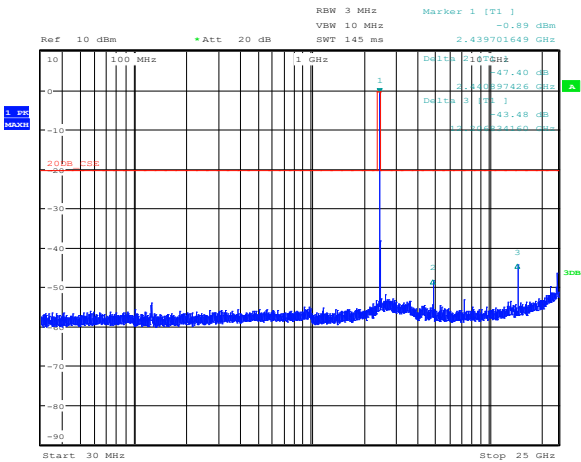
Date: 5.MAR.2019 13:47:42

Figure 8.6-23: Conducted spurious emissions for 8DPSK, high channel



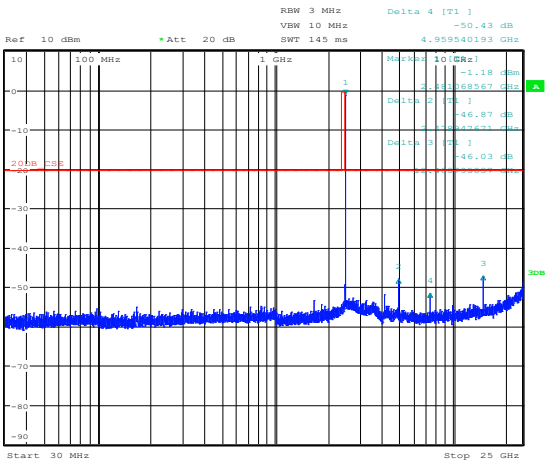
Date: 5.MAR.2019 13:57:46

Figure 8.6-24: Conducted spurious emissions for BLE, low channel



Date: 5.MAR.2019 13:58:42

Figure 8.6-25: Conducted spurious emissions for BLE, mid channel



Date: 5.MAR.2019 13:59:28

Figure 8.6-26: Conducted spurious emissions for BLE, high channel

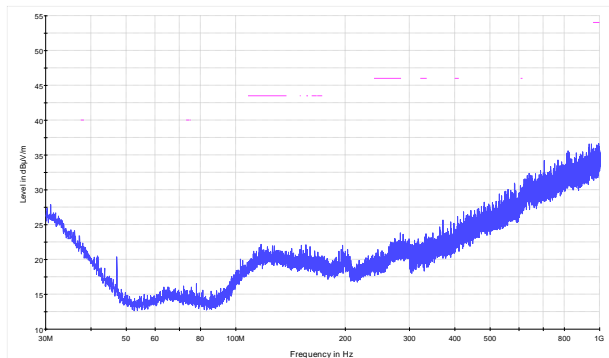


Figure 8.6-27: Radiated spurious emissions below 1 GHz, low channel

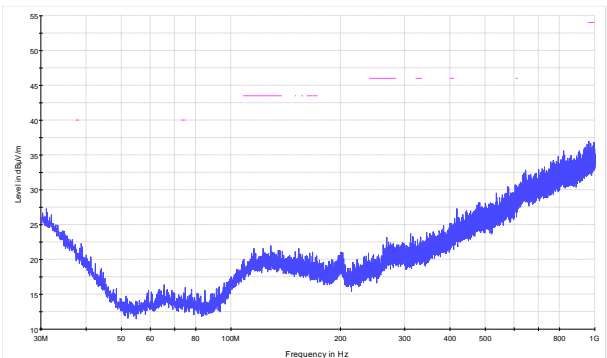


Figure 8.6-28: Radiated spurious emissions below 1 GHz, mid channel

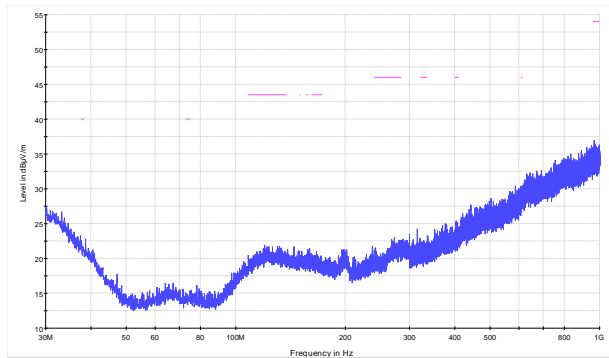


Figure 8.6-29: Radiated spurious emissions below 1 GHz, high channel

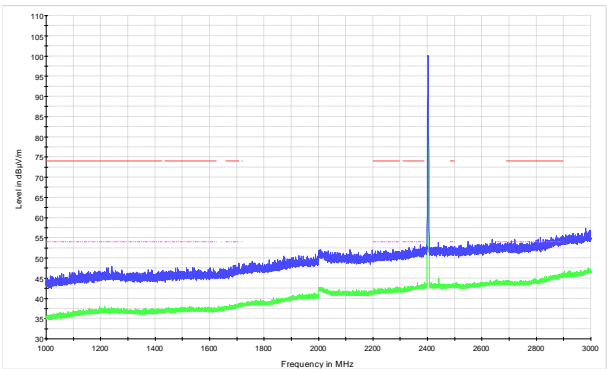


Figure 8.6-30: Radiated spurious emissions within 1–3 GHz, low channel

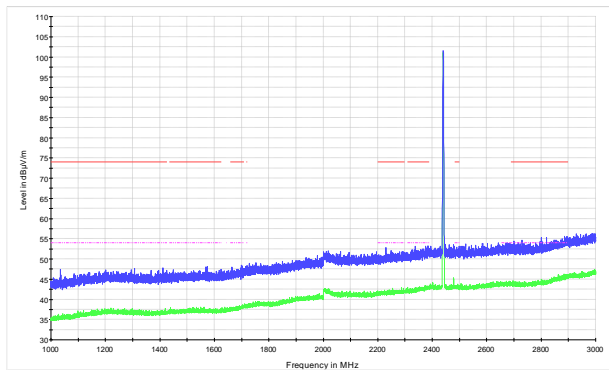


Figure 8.6-31: Radiated spurious emissions within 1–3 GHz, mid channel

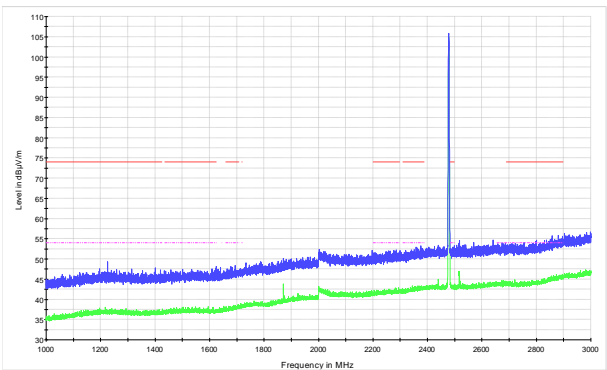


Figure 8.6-32: Radiated spurious emissions within 1–3 GHz, high channel

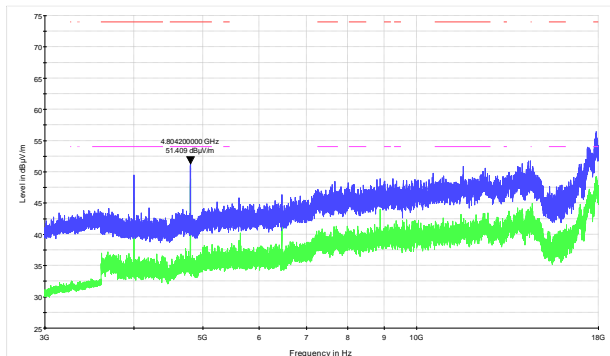


Figure 8.6-33: Radiated spurious emissions within 3–18 GHz, low channel

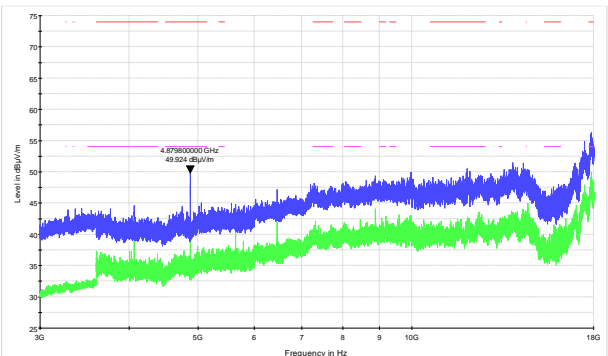


Figure 8.6-34: Radiated spurious emissions within 3–18 GHz, mid channel

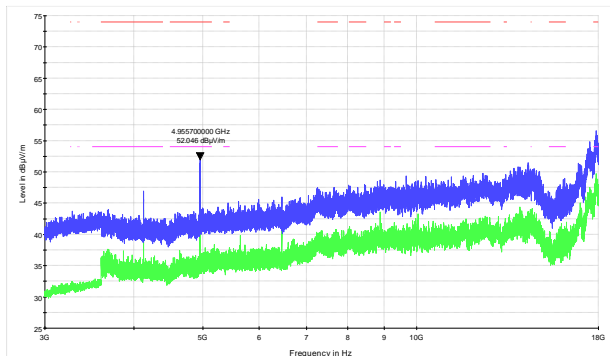


Figure 8.6-35: Radiated spurious emissions within 3–18 GHz, high channel

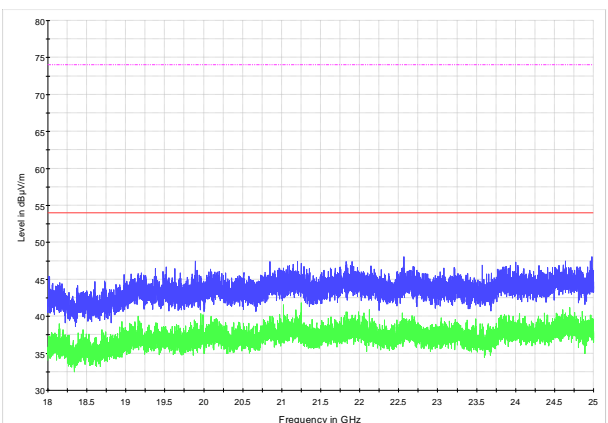


Figure 8.6-36: Radiated spurious emissions above 18 GHz, low channel

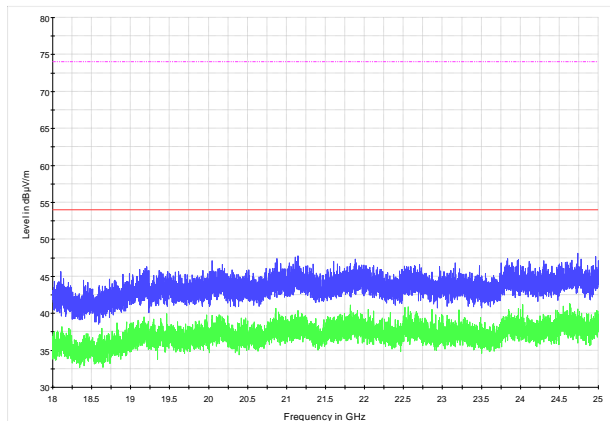


Figure 8.6-37: Radiated spurious emissions above 18 GHz, mid channel

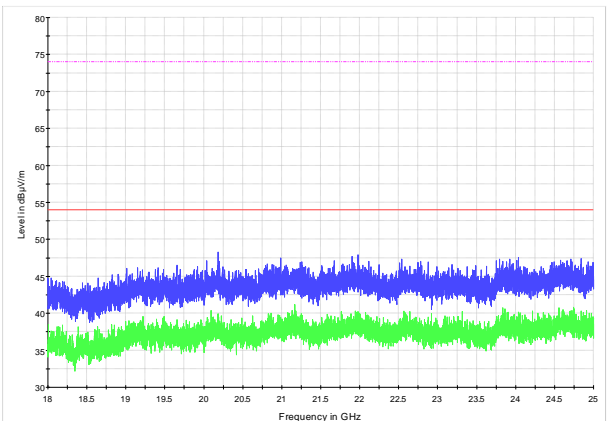
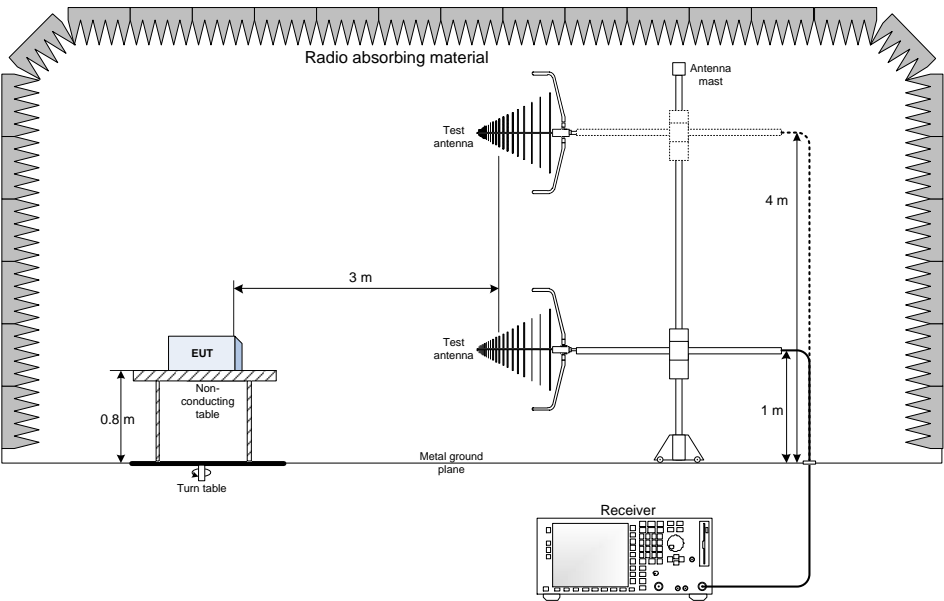


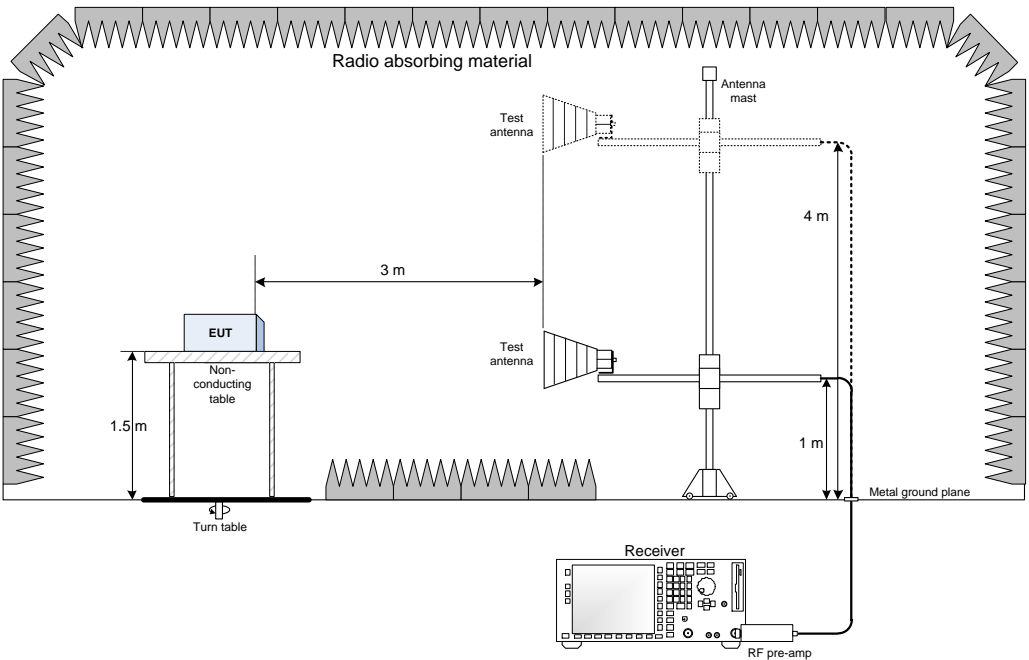
Figure 8.6-38: Radiated spurious emissions above 18 GHz, high channel

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port set-up

