

Wireless test report – 387154-1TRFWL

Applicant:

Tait International Limited

Product name:

Bluetooth/Wi-Fi module (within portable Transceiver)

Model:

TPGHKA

FCC ID:

CASTPGHKA

ISED Registration number:

737A-TPGHKA

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 License-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: December 11, 2019

Fahar Abdul Sukoor, Wireless/EMC Specialist

Test engineer(s)



Signature

Andrey Adelberg, Senior Wireless/EMC Specialist

Reviewed by

Signature

Test location(s)

Company name	Nemko Canada Inc.			
Facilities	Ottawa site: 303 River Road Ottawa, Ontario Canada K1V 1H2	Montréal site: 292 Labrosse Avenue Pointe-Claire, Québec Canada H9R 5L8	Cambridge site: 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2	Almonte site: 1500 Peter Robinson Road West Carleton, Ontario Canada K0A 1L0
	Tel: +1 613 737 9680 Fax: +1 613 737 9691	Tel: +1 514 694 2684 Fax: +1 514 694 3528	Tel: +1 519 650 4811	Tel: +1 613 256-9117 Fax: +1 613 256-8848
Test site registration	Organization	Recognition numbers and location		
	FCC/ISED	CA2040 (Ottawa/Almonte); CA2041 (Montreal); CA0101 (Cambridge)		
Website	www.nemko.com			

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.

Copyright notification

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

© Nemko Canada Inc.

Table of contents

Table of contents	3
Section 1. Report summary	4
1.1 Applicant and manufacturer	4
1.2 Test specifications	4
1.3 Test methods	4
1.4 Statement of compliance	4
1.5 Exclusions	4
1.6 Test report revision history	4
Section 2. Summary of test results	5
2.1 FCC Part 15 Subpart C, general requirements test results	5
2.2 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems	5
2.3 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)	5
2.4 ISED RSS-Gen, Issue 5, test results	6
2.5 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)	6
2.6 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)	6
Section 3. Equipment under test (EUT) details	7
3.1 Sample information	7
3.2 EUT information	7
3.3 Technical information	7
3.4 Product description and theory of operation	7
3.5 EUT exercise details	7
3.6 EUT setup diagram	8
Section 4. Engineering considerations	9
4.1 Modifications incorporated in the EUT	9
4.2 Technical judgment	9
4.3 Deviations from laboratory tests procedures	9
Section 5. Test conditions	10
5.1 Atmospheric conditions	10
5.2 Power supply range	10
Section 6. Measurement uncertainty	11
6.1 Uncertainty of measurement	11
Section 7. Test equipment	12
7.1 Test equipment list	12
Section 8. Testing data	13
8.1 FCC 15.31(e) Variation of power source	13
8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies	14
8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement	15
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	16
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	18
8.6 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions	21
Section 9. Block diagrams of test set-ups	33
9.1 Radiated emissions set-up for frequencies below 1 GHz	33
9.2 Radiated emissions set-up for frequencies above 1 GHz	33
9.3 Antenna port set-up	34

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Tait International Limited
Address	245 Wooldridge Rd, Harewood
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 5725–5850 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

558074 D01 DTS Meas Guidance v05r02 (April 02 2019)	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	December 11, 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

Notes: See section 1.5 – Exclusions

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

Notes: See section 1.5 – Exclusions

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	November 7, 2019
Nemko sample ID number	1(conducted), 2(radiated)

3.2 EUT information

Product name	Bluetooth/Wi-Fi module (within portable Transceiver)
Model	TPGHKA
Serial number	26219582(conducted),26219583 (radiated)

3.3 Technical information

Applicant IC company number	737A
IC UPN number	737A-TPGHKA
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	11.3 mW (10.54 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	52.7 dB μ V/m @ 4880 MHz (mid channel)
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 Wifi radio module incorporated within hand-held radio transceiver unit operating in low UHF band.
This report covers Bluetooth module of transmitter.

3.5 EUT exercise details

EUT was controlled from computer via programming cable.
Power level settings are at power level 7(high) in software (HCI Tester)

3.6 EUT setup diagram

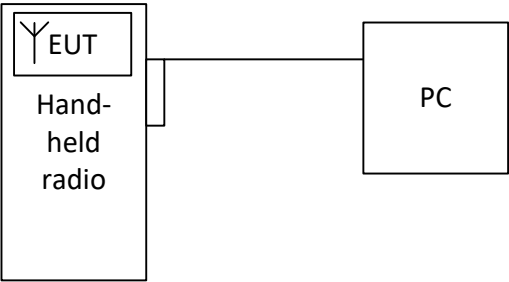


Figure 3.6-1: Setup diagram (programming)

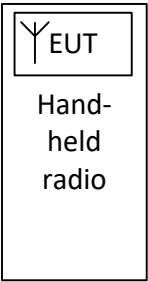


Figure 3.6-2: Setup diagram (operation)

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	FA003012	1 year	December 12, 2019
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	June 4, 2020
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	June 21, 2020
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	September 11, 2020
Preamplifier (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	September 26, 2020
Bilog antenna (20–2000 MHz)	Sun AR	JB1	FA003009	1 year	December 6, 2019
Horn antenna (18–40 GHz)	ETS Lindgren	3116-B	FA002948	1 year	September 07, 2020

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 November 14, 2019

8.1.3 Observations, settings and special notes

None

8.1.4 Test data

EUT Power requirements:

	☐ AC	☐ DC	☒ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☐ NO	☒ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☒ YES	☐ NO	☐ 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 November 14, 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	2480

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 November 14, 2019

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

Must the EUT be professionally installed?	☐ YES	☒ NO
Does the EUT have detachable antenna(s)?	☐ YES	☒ NO
If detachable, is the antenna connector(s) non-standard?	☐ YES	☐ NO ☒ 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 November 14, 2019

8.4.2 Observations, settings and special notes

The test was performed using a peak method.
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	10.54	30.00	19.46	1.39	11.93	36.00	24.07
2440	10.20	30.00	19.80	1.39	11.59	36.00	24.41
2480	9.86	30.00	20.14	1.39	11.25	36.00	24.75

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	8.61	30.00	21.39	1.39	10.00	36.00	26.00
2440	8.10	30.00	21.90	1.39	9.49	36.00	26.51
2480	7.52	30.00	22.48	1.39	8.91	36.00	27.09

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	8.93	30.00	21.07	1.39	10.32	36.00	25.68
2440	8.49	30.00	21.51	1.39	9.88	36.00	26.12
2480	8.12	30.00	21.88	1.39	9.51	36.00	26.49

EIRP = Output power + Antenna gain

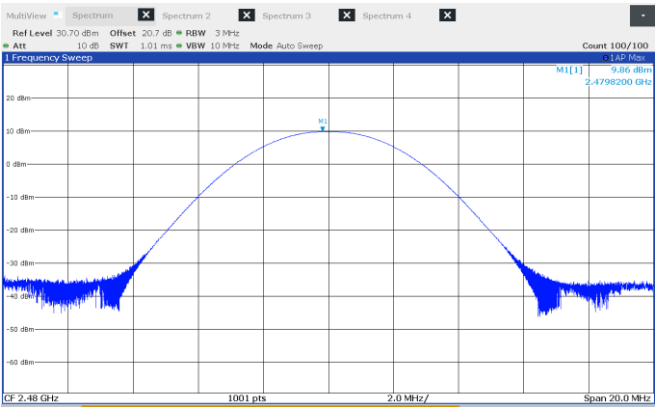


Figure 8.4-1: Output power sample plot

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 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 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 stave 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 November 14, 2019

8.5.2 Observations, settings and special notes

The test was performed using a peak method.
EUT is set to transmit at BLE mode.

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	5.86	30.00	24.14	1.39	7.25	36.00	28.75
2440	5.23	30.00	24.77	1.39	6.62	36.00	29.38
2480	4.25	30.00	25.75	1.39	5.64	36.00	30.36

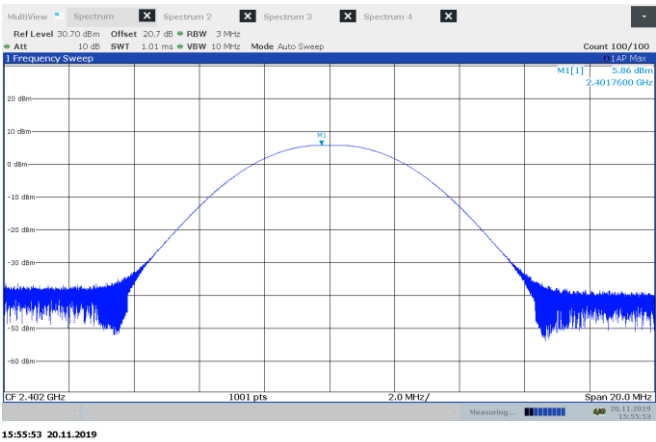


Figure 8.5-1: Output power sample plot

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 November 14, 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 up to 18 GHz . 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.

Restricted Band edge measurements are not measured as per customer test plan.

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	4804.11	50.1	74.0	23.9	45.5	54.0	8.5
mid	4880.10	52.7	74.0	21.3	49.1	54.0	4.9
high	4959.95	52.5	74.0	21.5	49.5	54.0	4.5

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

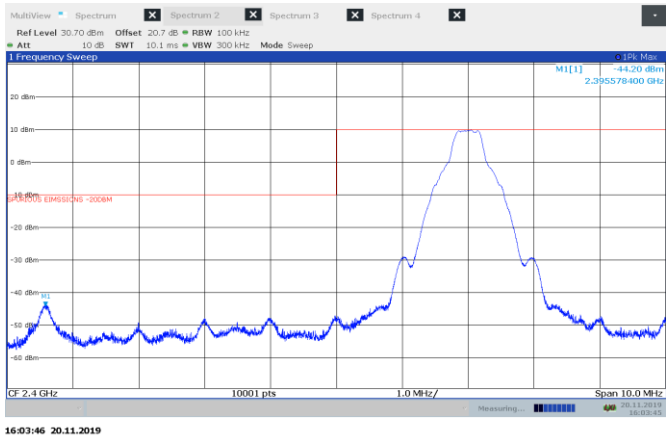


Figure 8.6-1: Conducted spurious emissions at the lower band edge for GFSK modulation, hopping off

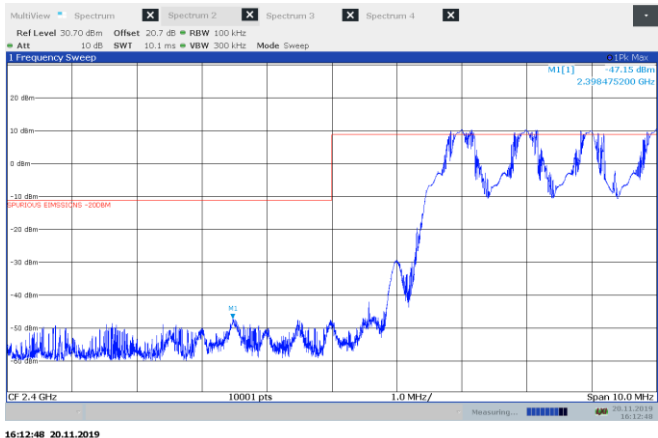


Figure 8.6-2: Conducted spurious emissions at the lower band edge for GFSK modulation, hopping on

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

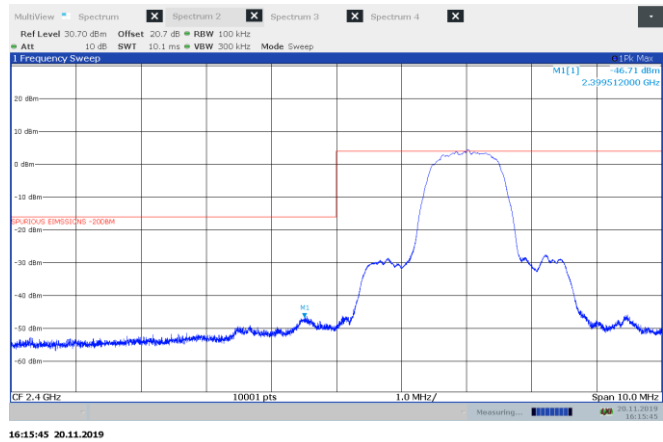


Figure 8.6-3: Conducted spurious emissions at the lower band edge for $\pi/4$ -DQPSK modulation, hopping off

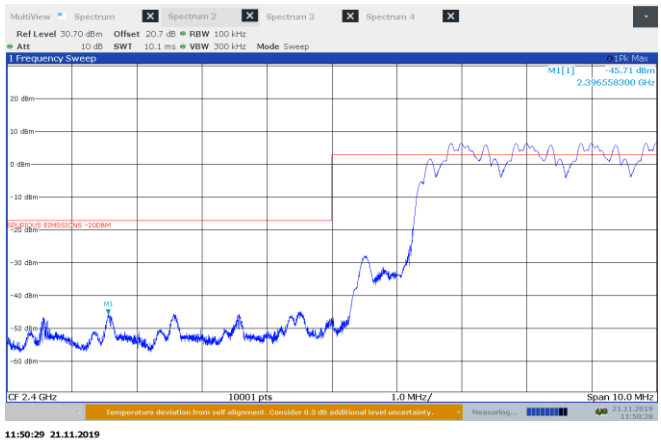


Figure 8.6-4: Conducted spurious emissions at the lower band edge for $\pi/4$ -DQPSK modulation, hopping on

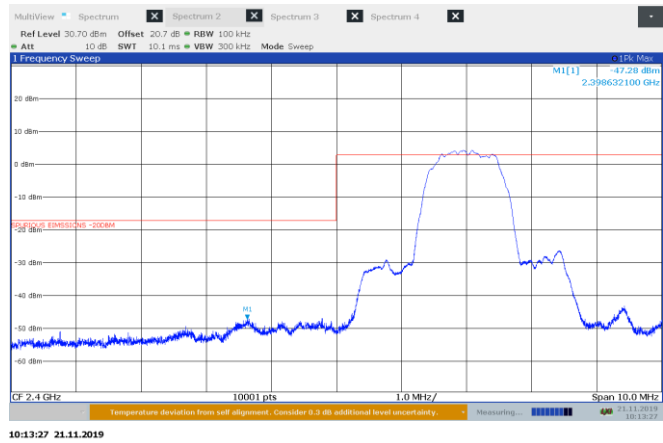


Figure 8.6-5: Conducted spurious emissions at the lower band edge for 8DPSK modulation, hopping off

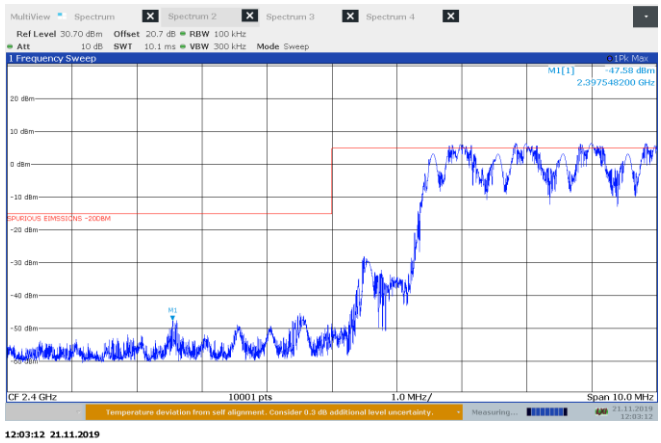


Figure 8.6-6: Conducted spurious emissions at the lower band edge for 8DPSK modulation, hopping on

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

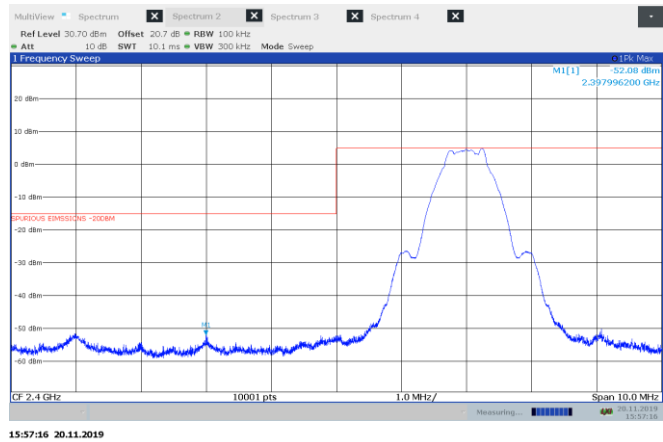


Figure 8.6-7: Conducted spurious emissions at the lower band edge for BLE modulation

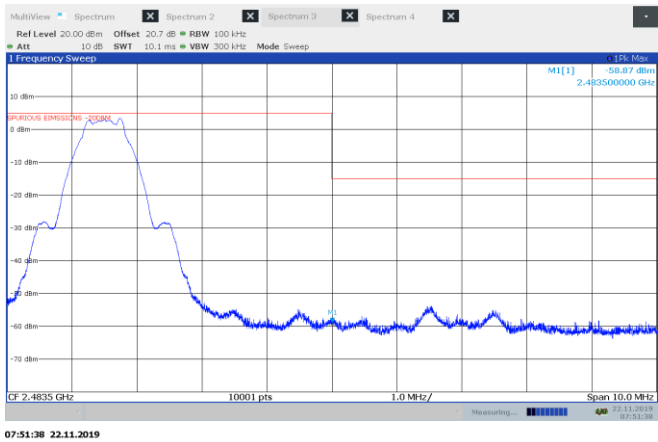


Figure 8.6-8: Conducted spurious emissions at the upper band edge for BLE modulation

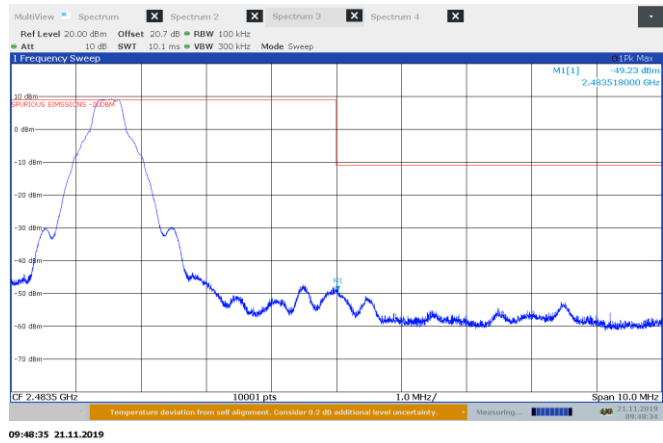


Figure 8.6-9: Conducted spurious emissions at the upper band edge for GFSK modulation, hopping off

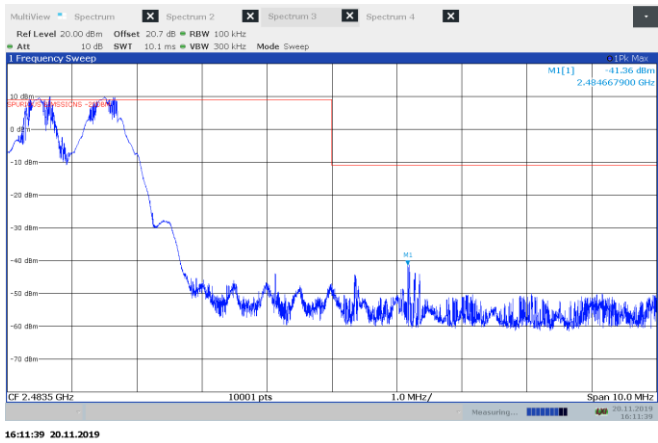


Figure 8.6-10: Conducted spurious emissions at the upper band edge for GFSK modulation, hopping on

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

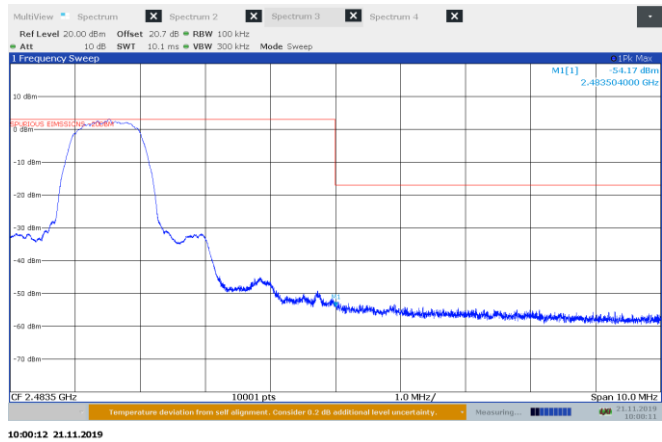


Figure 8.6-11: Conducted spurious emissions at the low upper band edge for $\pi/4$ -DQPSK modulation, hopping off

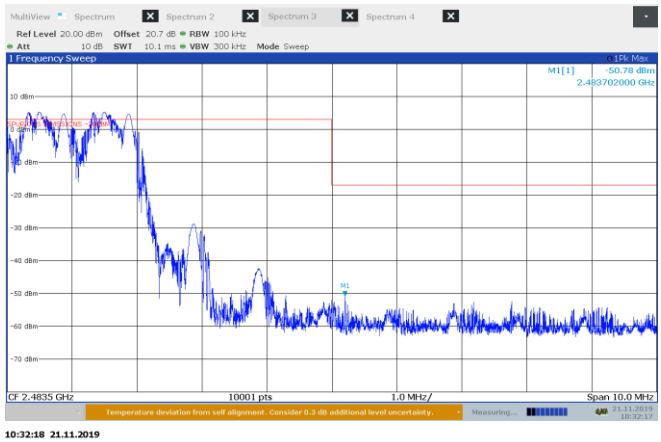


Figure 8.6-12: Conducted spurious emissions at the upper band edge for $\pi/4$ -DQPSK modulation, hopping on

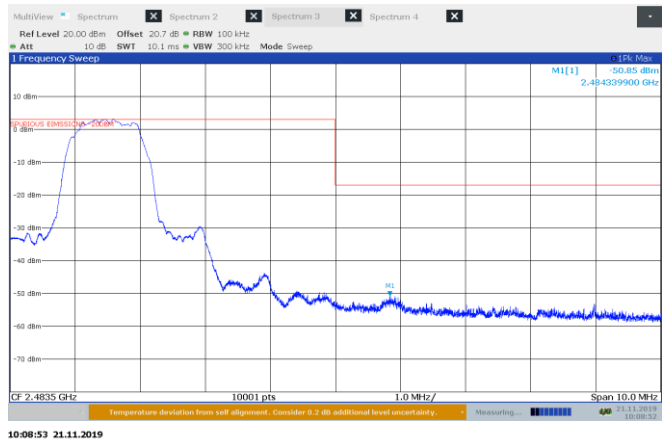


Figure 8.6-13: Conducted spurious emissions at the upper band edge for 8DPSK modulation, hopping off

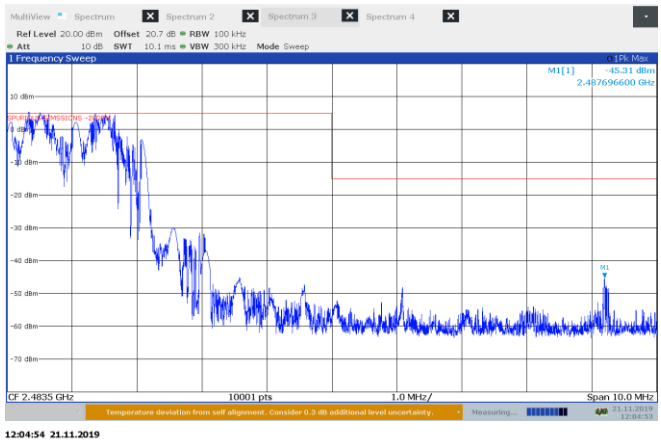


Figure 8.6-14: Conducted spurious emissions at the upper band edge for 8DPSK modulation, hopping on

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

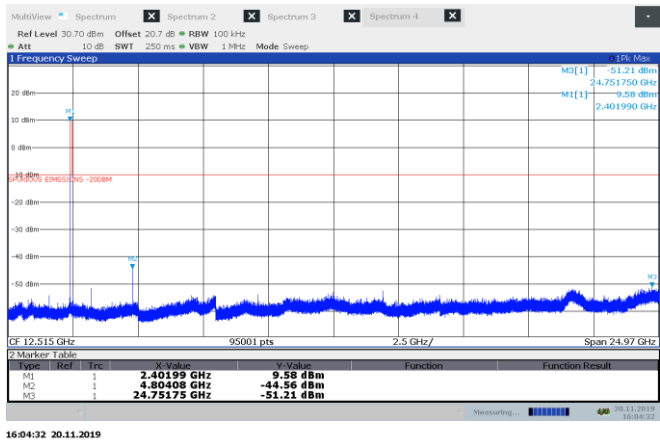


Figure 8.6-15: Conducted spurious emissions for GFSK, low channel

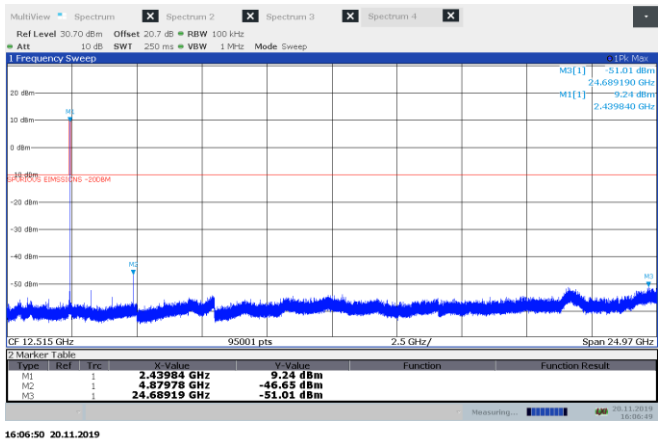


Figure 8.6-16: Conducted spurious emissions for GFSK, mid channel

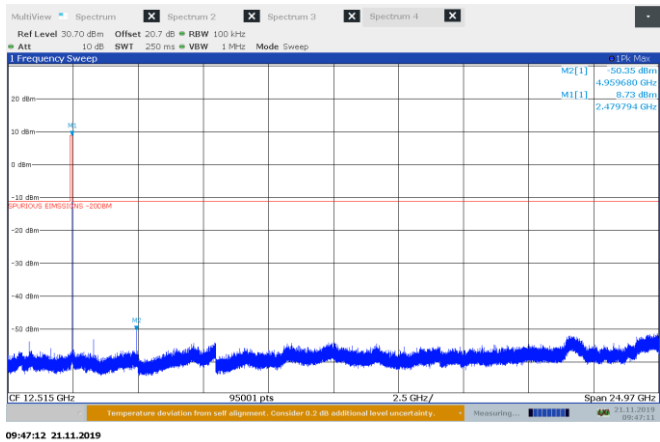


Figure 8.6-17: Conducted spurious emissions for GFSK, high channel

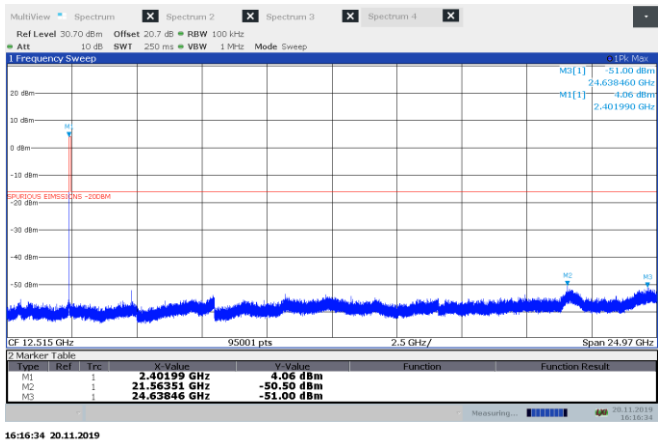


Figure 8.6-18: Conducted spurious emissions for $\pi/4$ -DQPSK, low channel

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

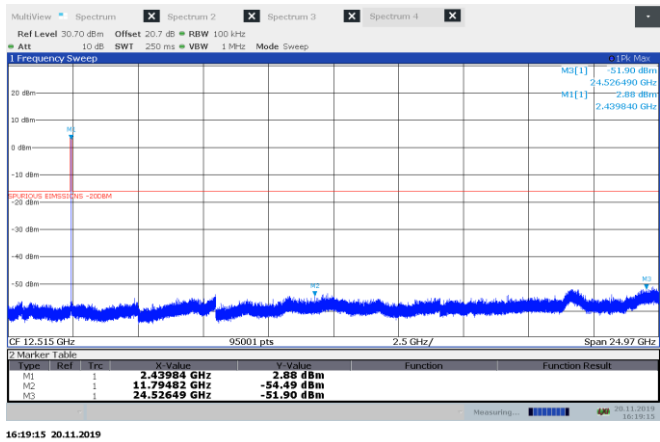


Figure 8.6-19: Conducted spurious emissions for $\pi/4$ -DQPSK, mid channel

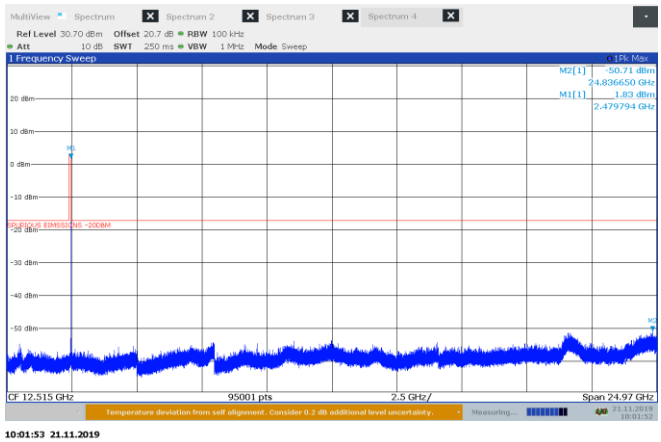


Figure 8.6-20: Conducted spurious emissions for $\pi/4$ -DQPSK, high channel

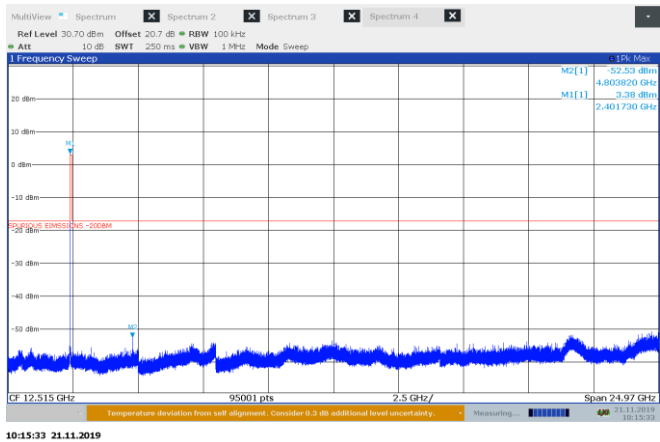


Figure 8.6-21: Conducted spurious emissions for 8DPSK, low channel

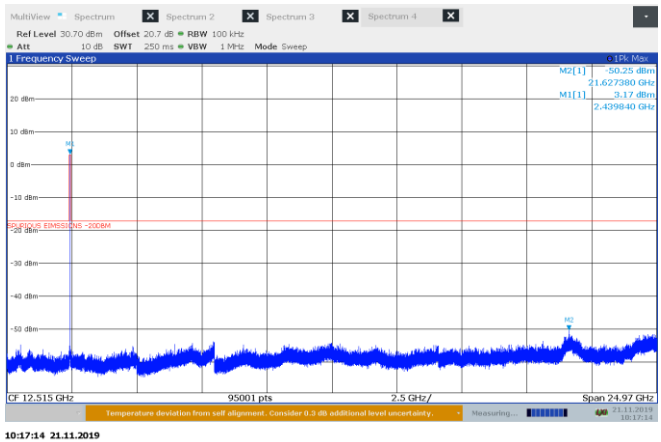


Figure 8.6-22: Conducted spurious emissions for 8DPSK, mid channel

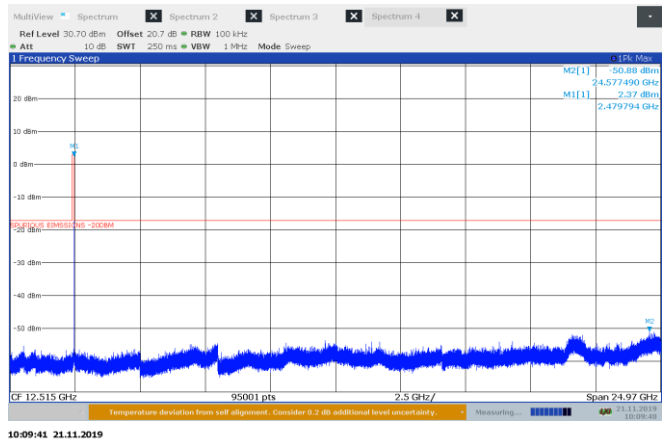


Figure 8.6-23: Conducted spurious emissions for 8DPSK, high channel

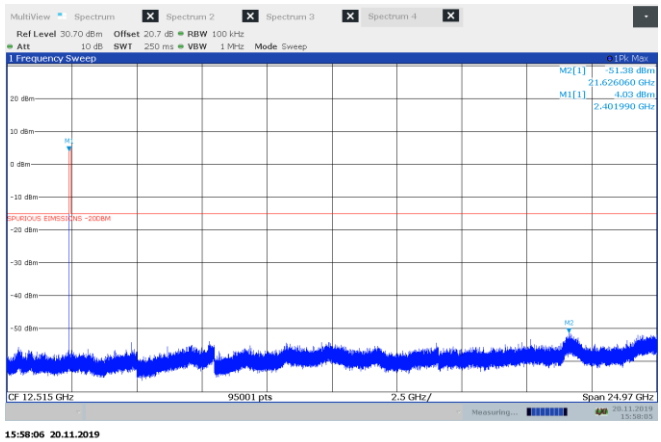


Figure 8.6-24: Conducted spurious emissions for BLE, low channel

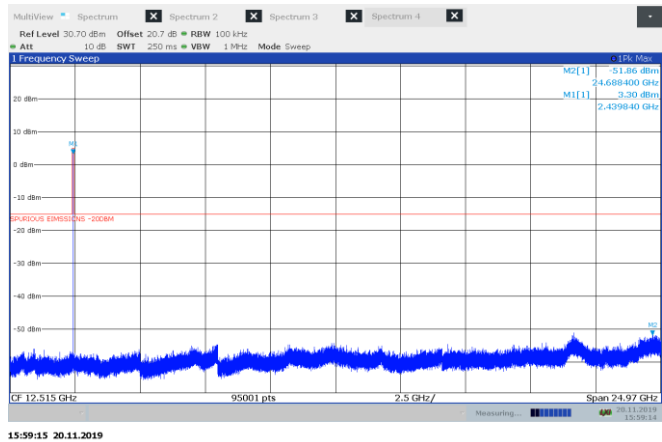


Figure 8.6-25: Conducted spurious emissions for BLE, mid channel

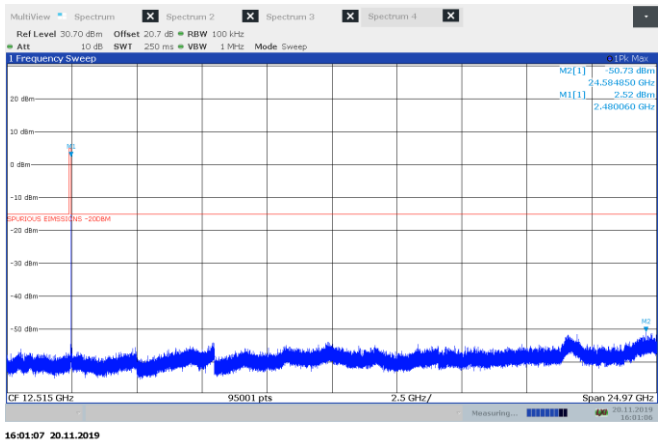


Figure 8.6-26: Conducted spurious emissions for BLE, high channel

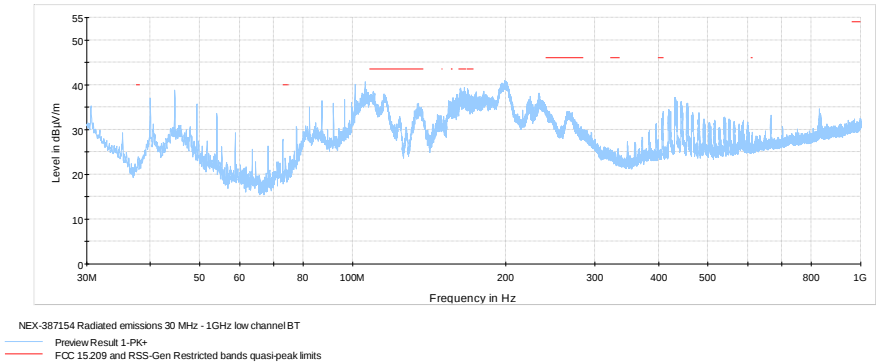


Figure 8.6-27: Radiated spurious emissions below 1 GHz, low channel

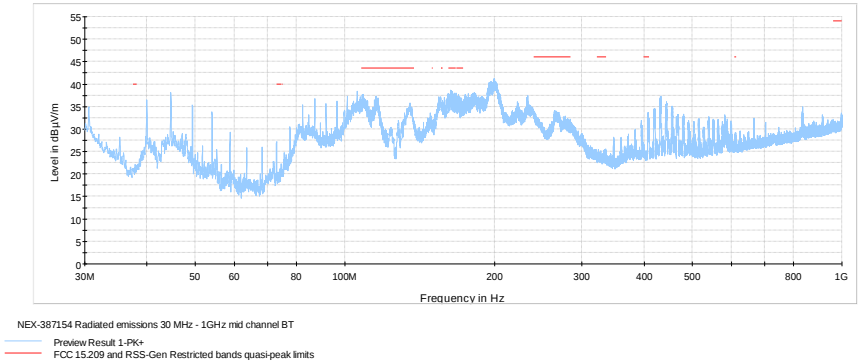


Figure 8.6-28: Radiated spurious emissions below 1 GHz, mid channel

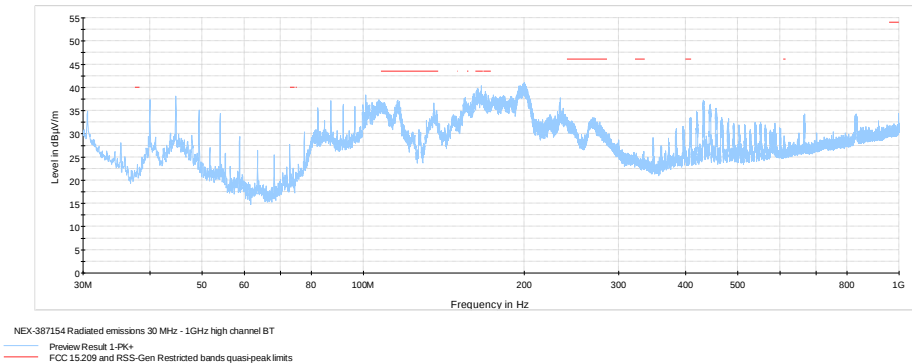


Figure 8.6-29: Radiated spurious emissions below 1 GHz, high channel

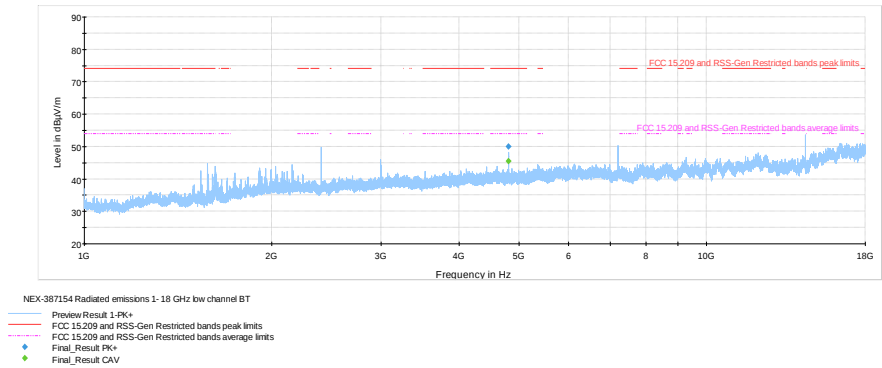


Figure 8.6-30: Radiated spurious emissions within 1-18 GHz, low channel

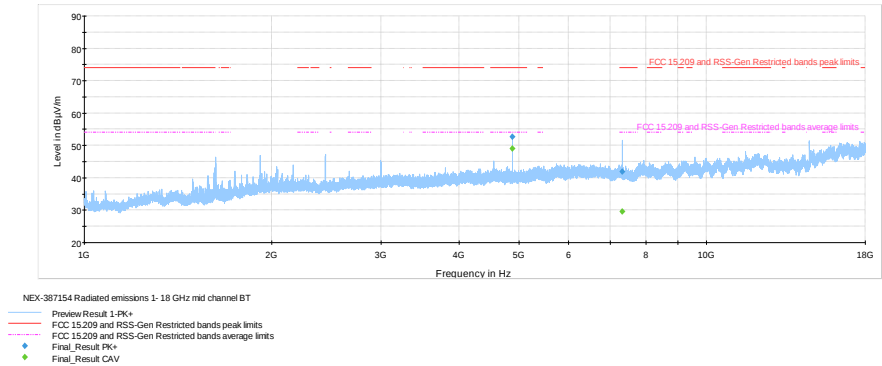


Figure 8.6-31: Radiated spurious emissions within 1-18 GHz, mid channel

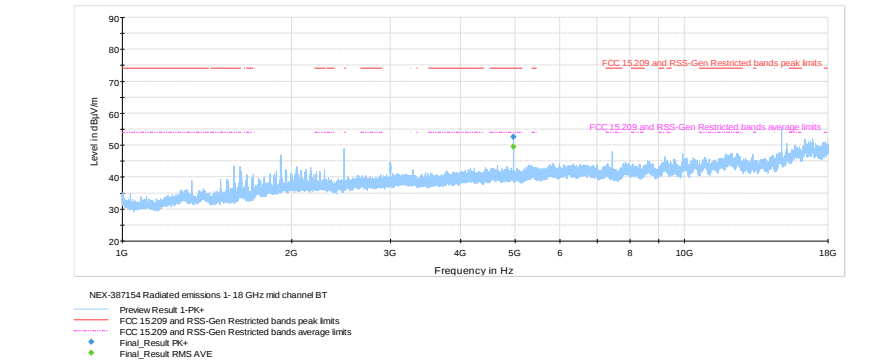


Figure 8.6-32: Radiated spurious emissions within 1-18 GHz, high channel

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

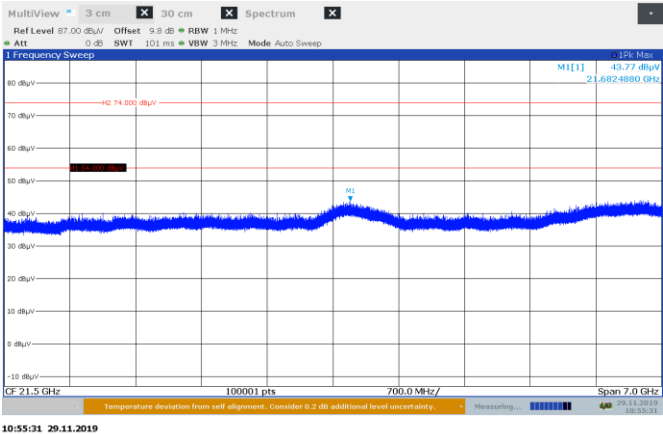


Figure 8.6-33: Radiated spurious emissions above 18 GHz, low channel

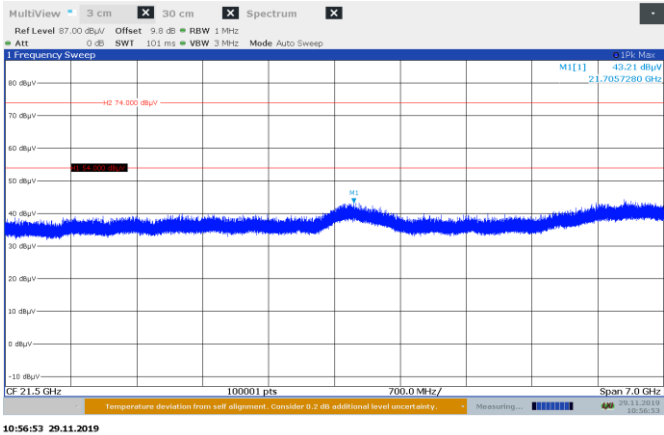


Figure 8.6-34: Radiated spurious emissions above 18 GHz, mid channel

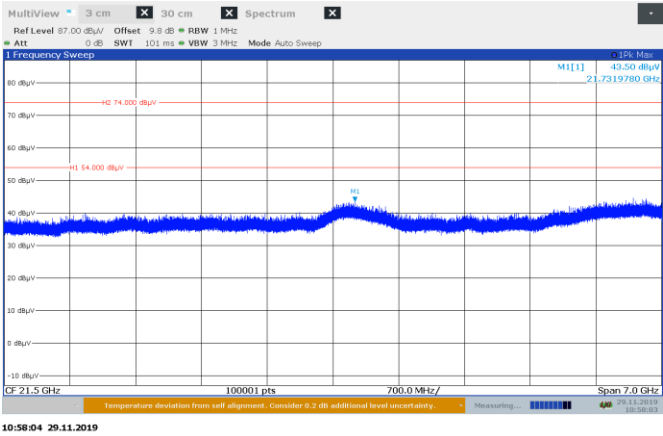
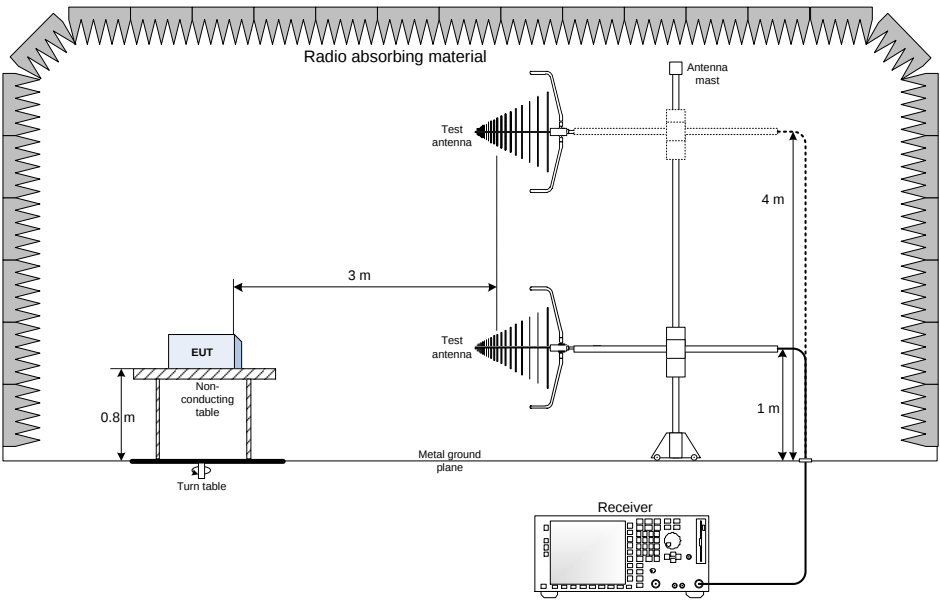


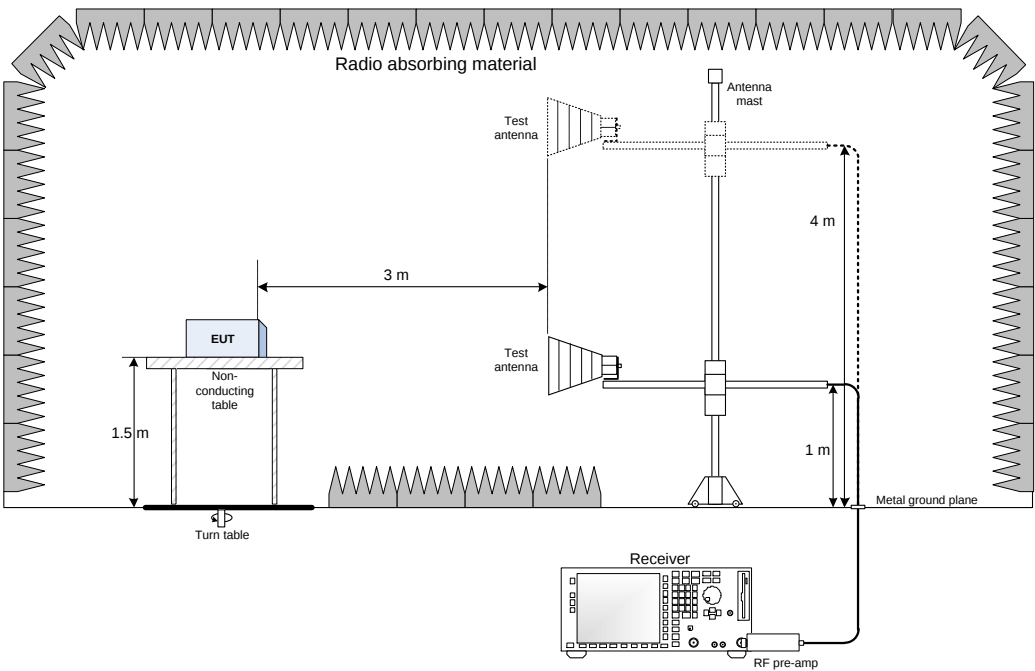
Figure 8.6-35: Radiated spurious emissions above 18 GHz, high channel

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

