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Wireless test report – 359758-1TRFWL

Applicant:

eers Global Technologies Inc.

Product name:

High-noise hearing protective communication device

Model:

SonX

FCC ID: 2ANPP-SONXA10

IC Registration number: 2ANPP-23228

Specifications:

- FCC 47 CFR Part 15 Subpart C, §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 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: February 7, 2019

Test engineer(s):	Avul Nzenza	Signature:	
Reviewed by:	Andrey Adelberg, Senior Wireless/EMC Specialist	Signature:	Andrey Adelberg

Test location

Company name	Nemko Canada Inc.
Address	292 Labrosse Avenue
City	Pointe-Claire
Province	Quebec
Postal code	H9R 5L8
Country	Canada
Telephone	+1 514 694 2684
Facsimile	+1 514 694 3528
Website	www.nemko.com
Site number	FCC: CA2041; IC: 2040G-5 (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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	eers Global Technologies Inc.
Address	355, rue Peel, Bureau 710 H3C 2G9 Montréal QC Canada

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 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 completed against all relevant requirements of the test standard. 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

None

1.6 Test report revision history

Table 1.6-1: Test report revision history

Revision #	Details of changes made to test report
TRF	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[1]
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass[2]

Notes:

[1] Equipment is DC powered (battery).

Testing was performed with fresh and fully charged batteries

[2] The equipment will be professionally installed.

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	Pass
§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	Pass
§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	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.4 RSS-Gen requirements 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[1]
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 fresh batteries.

2.5 RSS-247 requirements test results

Table 2.5-1: ***RSS-247 results for FHSS***

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing	Pass
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	Pass
5.1 (e)	Systems operating in the 5725–5850 MHz band	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: None

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	Pass
5.2 (b)	Maximum power spectral density	Pass
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: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	August 27, 2018
Nemko sample ID number	#1

3.2 EUT information

Product name	High-noise hearing protective communication device
Model	SonX
Serial number	None

3.3 Technical information

Applicant IC company number	2ANPP
IC UPN number	23228
All used IC test site(s) Reg. number	2040G-5
RSS number and Issue number	RSS-247 Issue 2, Feb. 2017
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF power (W), Conducted	0.00007 (-11.58 dBm)
Field strength, Units @ distance	N/A
Measured BW (MHz) (99%)	4.24
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK, EDR2, EDR3
Emission classification (F1D, G1D, D1D)	4M24F1D
Transmitter spurious, Units @ distance	52.1 dBµV/m Peak and 48.8 dBµV/m Average @ 3 m @ 4804.0 MHz
Power requirements	3.7 VDC (Battery)
Antenna information	Internal PCB antenna The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator. The Antenna Gain is 1.7 dBi

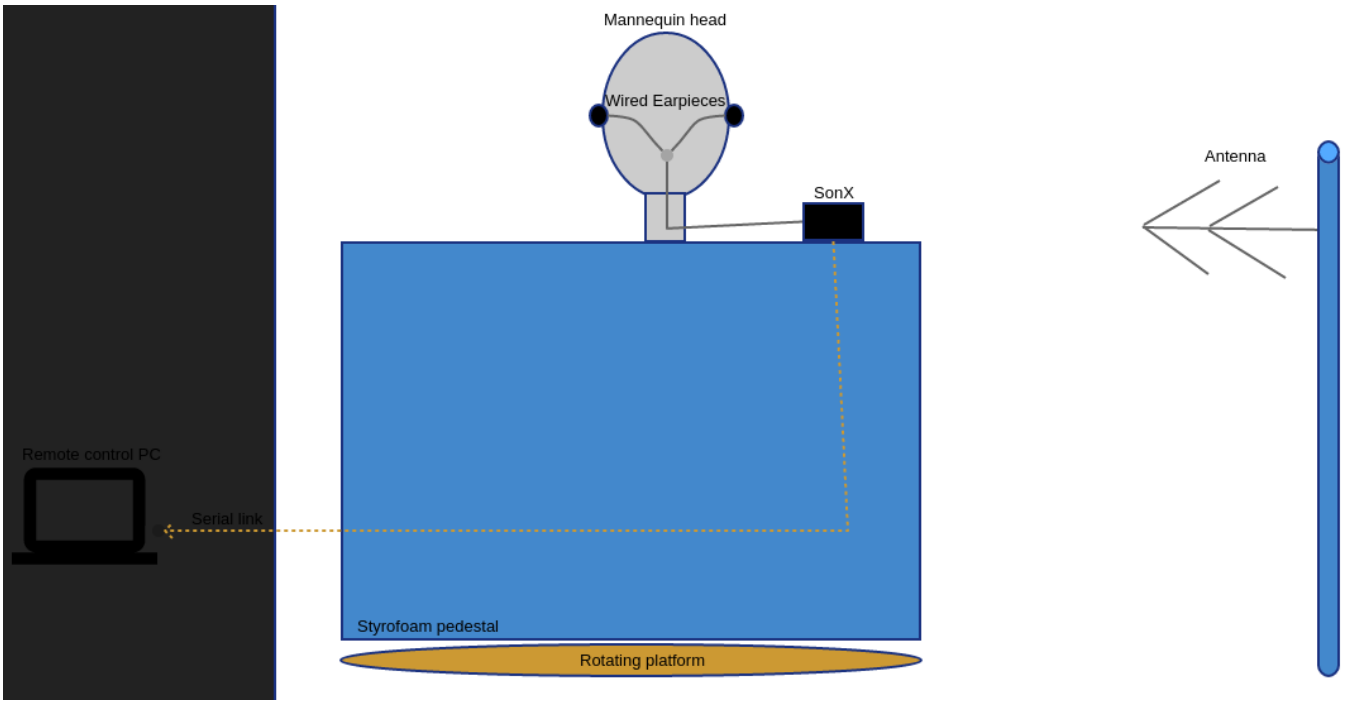
3.4 Product description and theory of operation

The product is intended to act as a radio communication and hearing protective device in noisy industrial environments.
It is composed of a lapel-mounted processing unit (including user-replaceable battery) and two wired earpieces with noise-attenuating earplugs that are intended to be worn in the outer ear canal.
Each earpiece has an in-ear microphone (for voice pick-up), an outer-ear microphone (for ambient noise pick-up), and a speaker for transmission of incoming signals to the ear canal.
The device is used as a push-to-talk radio, allowing half-duplex broadcast communications up to 25 meters.
It supports several different radio channels, with channel selection left at the discretion of individual users.
The product also includes Bluetooth Classic/LE connectivity, allowing data communication with a web platform, and voice communication with cellular phones or hand-held radio systems for long-range operation.

3.5 EUT exercise details

The unit is activated with a continuous transmissions signal using GFSK, EDR2 and EDR3 modulation.

3.6 Block Diagram



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 ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

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

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78

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	FA002532	2 year	June 5/19
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	Sept. 18/18
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	Dec. 6/18
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	April 27/19
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	Sept. 21/18
Pre-amplifier (18–40 GHz)	COM-POWER	PAM-840	FA002508	1 year	Sept 8/18
2400-2483 MHz Notch Filter	Microwave Circuits	N0324413	FA002693	—	VOU
Horn antenna (1–18 GHz)	EMCO	RGA-60	FA002577	1 year	Aug. 16/19

Notes: NCR - no calibration required
VOU - verify on use

Table 7.1-2: test software

Test description	Manufacturer of Software	Details
Radiated emissions – Ottawa	Rhode & Schwarz	EMC32, Software for EMC Measurements, Version 9.26.01

Notes: None

Section 8. Testing data

8.1 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements, 2 GHz operation

8.1.1 Definitions and limits

FCC:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

ISED:

a) The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

b) FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400–2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

d) FHSs operating in the band 2400–2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

5.3 Hybrid systems

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

a With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

8.1.2 Test date

Start date	August 27, 2018

8.1.3 Observations, settings and special notes

Spectrum analyser settings for carrier frequency separation:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for number of hopping frequencies:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	the frequency band of operation
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for time of occupancy (dwell time):

Resolution bandwidth	1 MHz
Video bandwidth	≥ RBW
Frequency span	Zero span
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for 20 dB bandwidth:

Resolution bandwidth	≥ 1% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.1.4 Test data

Table 8.1-1: 20 dB bandwidth results

Frequency, MHz	20 dB bandwidth, kHz
EDR3	
2402	1386
2441	1370
2480	1354
EDR2	
2402	1450
2441	1442
2480	1450
GFSK	
2402	785
2441	804
2480	751

Table 8.1-2: 99% bandwidth results

Frequency, MHz	99% bandwidth, kHz
EDR3	
2402	1378
2441	1306
2480	1266
EDR2	
2402	1410
2441	1386
2480	1354
GFSK	
2402	772
2441	1025
2480	863

Table 8.1-3: Carrier frequency separation results

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
EDR3		
1005	899	106
EDR2		
1047	895	152
GFSK		
1023	669	354

Notes: The maximum power of the unit is 2 mW (less than 125 mW). We have applied the 2/3 of 20 dB BW rule

Table 8.1-4: Number of hopping frequencies results

Number of hopping frequencies	Minimum limit	Margin
EDR3		
79	15	64
EDR2		
79	15	64
GFSK		
79	15	64

Table 8.1-5: Average time of occupancy results

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
EDR3				
2.9	84	243	400	157
EDR2				
2.9	75	217	400	183
GFSK				
2.9	91	264	400	136

Measurement Period is 31.6 s, which is equal to 0.4 s multiplied by the number of hopping channels 79

Samples of 20 dB bandwidth Measurements

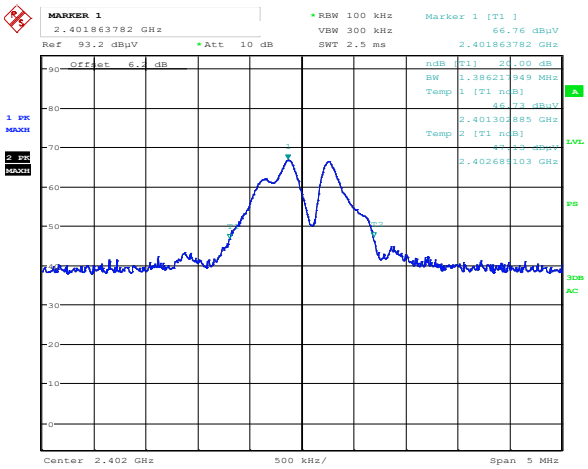


Figure 8.1-1: 20 dB bandwidth on low channel

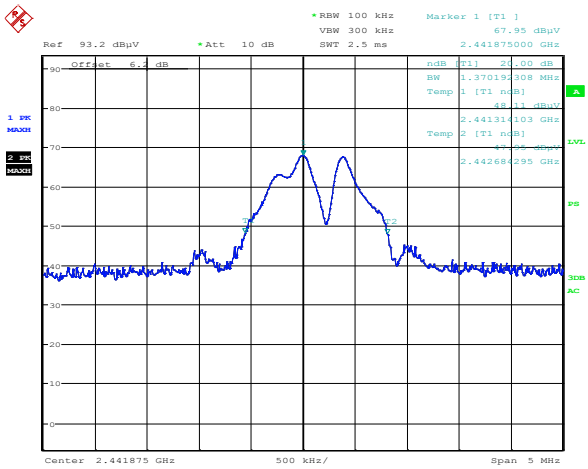


Figure 8.1-2: 20 dB bandwidth on mid channel

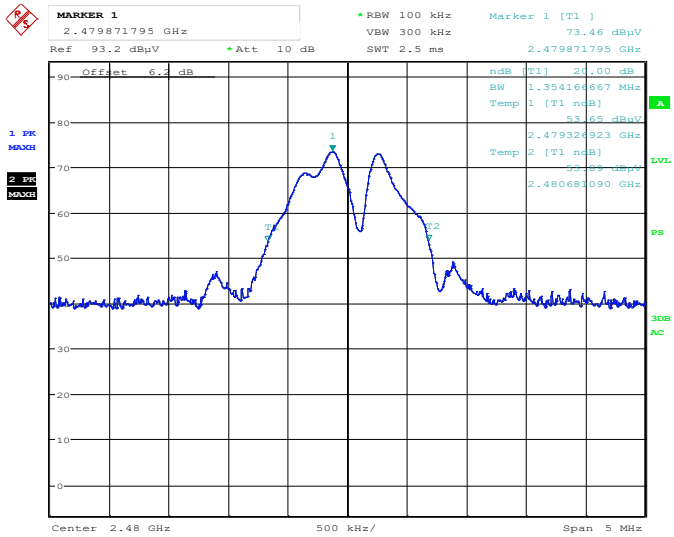


Figure 8.1-3: 20 dB bandwidth on high channel

Carrier frequency separation

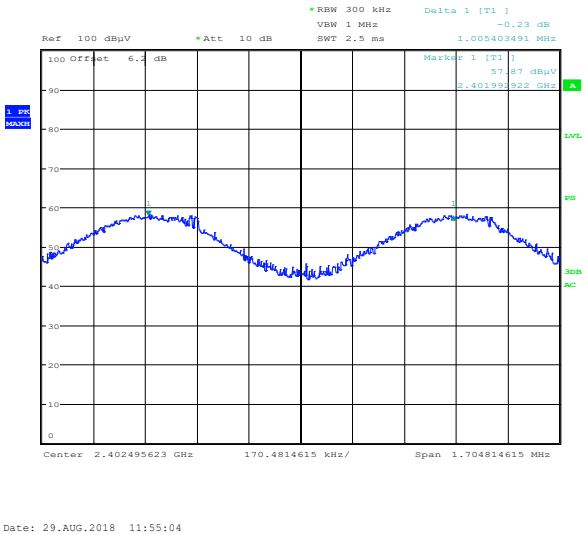


Figure 8.1-4: Carrier frequency separation – EDR3

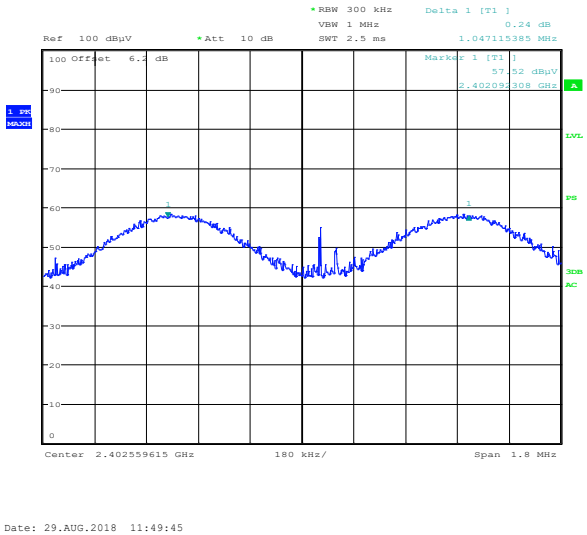


Figure 8.1-5: Carrier frequency separation – EDR2

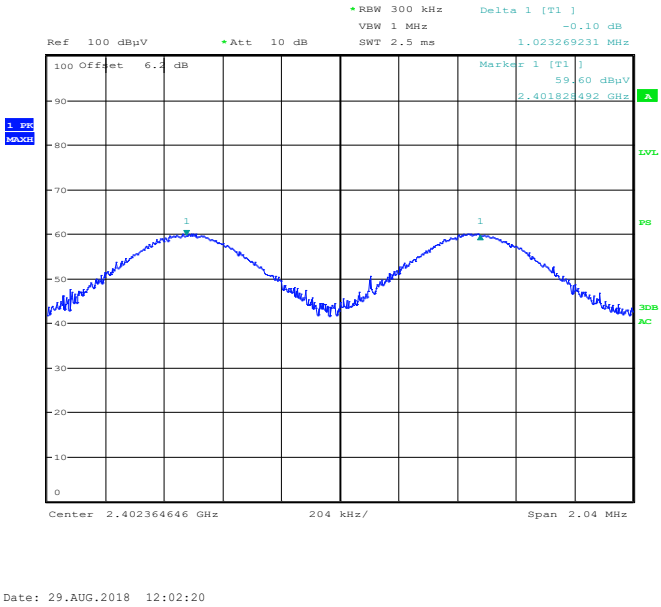


Figure 8.1-6: Carrier frequency separation – GFSK

Sample of Measurements

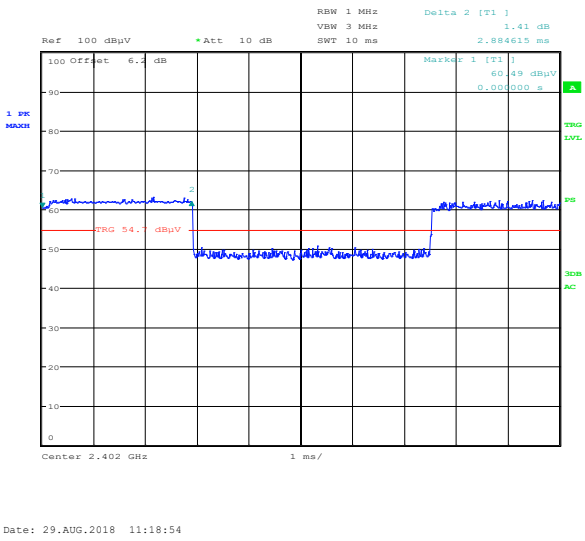


Figure 8.1-7: Dwell time

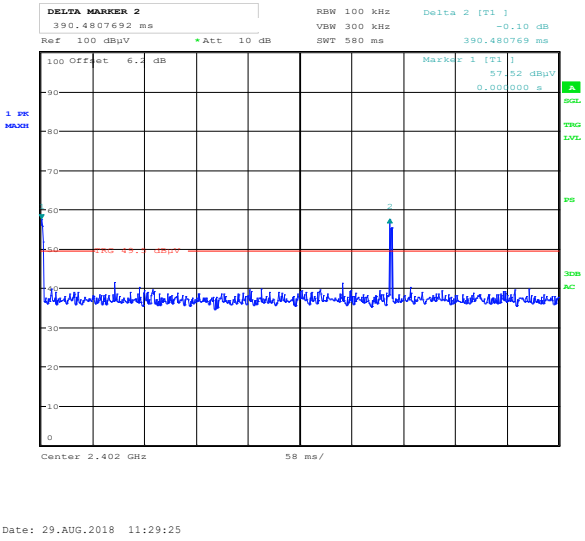


Figure 8.1-8: Pulse repetition on the same channel

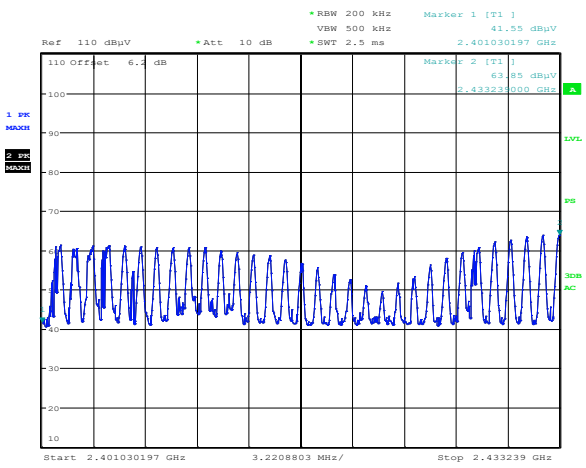


Figure 8.1-9: Number of hopping channels (32)

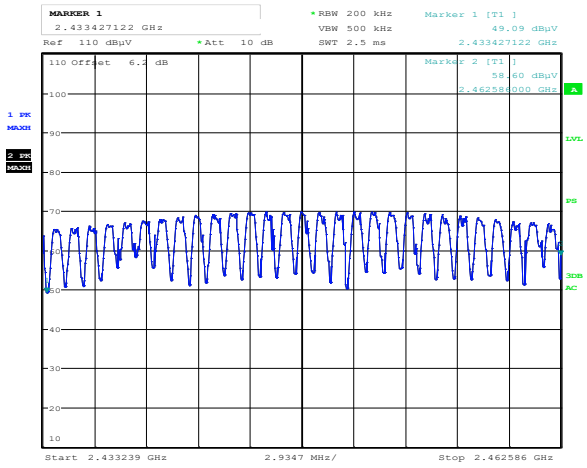


Figure 8.1-10: Number of hopping channels (29)

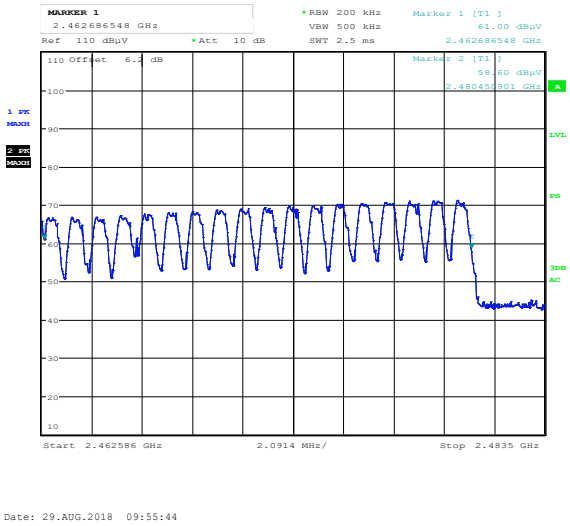


Figure 8.1-11: Number of hopping channels (18)

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

8.2.1 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.

8.2.2 Test date

Start date	August 28, 2018

8.2.3 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

8.2.4 Test data

Table 8.2-1: ***Output power results***

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	Antenna Gain, dBi	Output Power, dBm	Output Power Limit, dBm	Output Power margin, dBm
EDR3							
2402	76.79	95.23	-18.44	1.70	-20.14	30.00	50.14
2441	80.85	95.23	-14.38	1.70	-16.08	30.00	46.08
2480	78.81	95.23	-16.42	1.70	-18.12	30.00	48.12
EDR2							
2402	75.58	95.23	-19.65	1.70	-21.35	30.00	51.35
2441	79.59	95.23	-15.64	1.70	-17.34	30.00	47.34
2480	77.64	95.23	-17.59	1.70	-19.29	30.00	49.29
GFSK							
2402	75.09	95.23	-20.14	1.70	-21.84	30.00	51.84
2441	79.41	95.23	-15.82	1.70	-17.52	30.00	47.52
2480	77.85	95.23	-17.38	1.70	-19.08	30.00	49.08

Table 8.2-2: EIRP measurements results

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	EIRP Limit, dBm	EIRP margin, dBm
EDR3					
2402	76.79	95.23	-18.44	36.00	54.44
2441	80.85	95.23	-14.38	36.00	50.38
2480	78.81	95.23	-16.42	36.00	52.42
EDR2					
2402	75.58	95.23	-19.65	36.00	55.65
2441	79.59	95.23	-15.64	36.00	51.64
2480	77.64	95.23	-17.59	36.00	53.59
GFSK					
2402	75.09	95.23	-20.14	36.00	56.14
2441	79.41	95.23	-15.82	36.00	51.82
2480	77.85	95.23	-17.38	36.00	53.38

Sample of Output Power Measurement

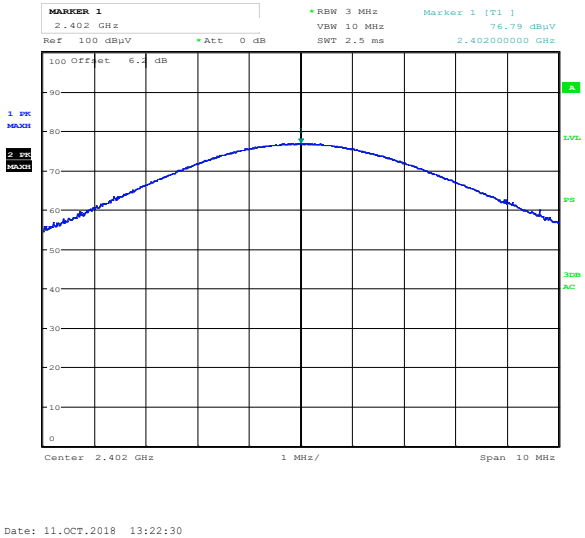


Figure 8.2-1: ***Field Strength of fundamental on low channel***

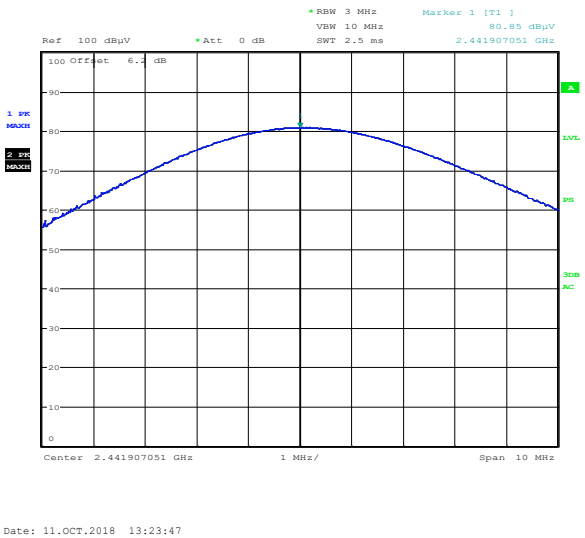


Figure 8.2-2: ***Field Strength of fundamental on mid channel***

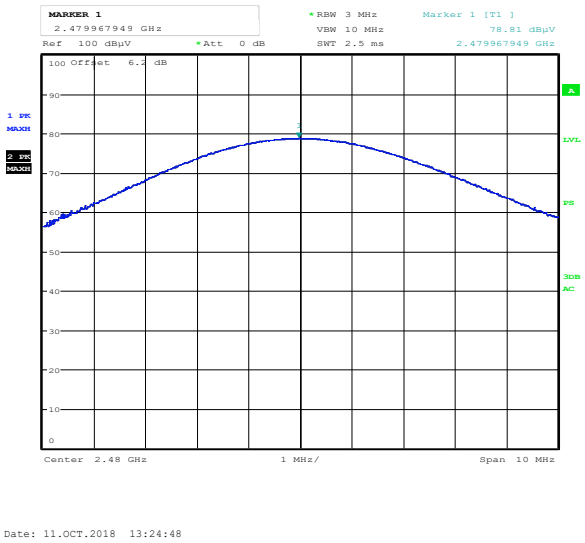


Figure 8.2-3: ***Field Strength of fundamental on high channel***

8.3 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for DTS systems

8.3.1 Definitions and limits

FCC:
Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

ISED:
The minimum 6 dB bandwidth shall be 500 kHz.

8.3.1 Test date

Start date	August 27, 2018

8.3.2 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

8.3.3 Test data

Table 8.3-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, kHz
2402	913.5	500.0	413.5
2442	969.6	500.0	469.6
2480	913.5	500.0	413.5

Notes: None

8.3.4 Test data, continued

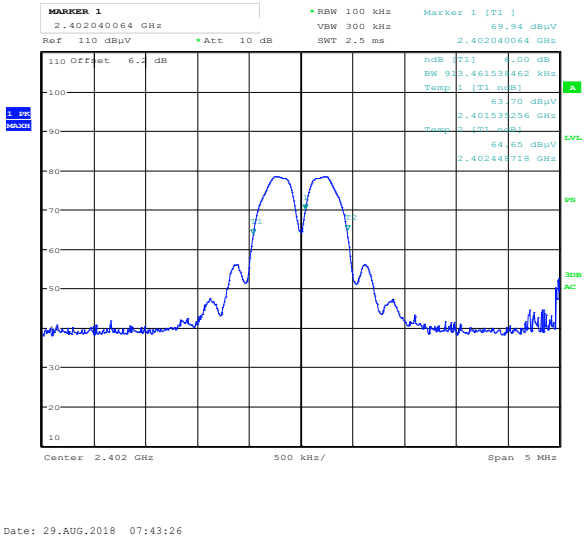


Figure 8.3-1: 6 dB bandwidth on low channel

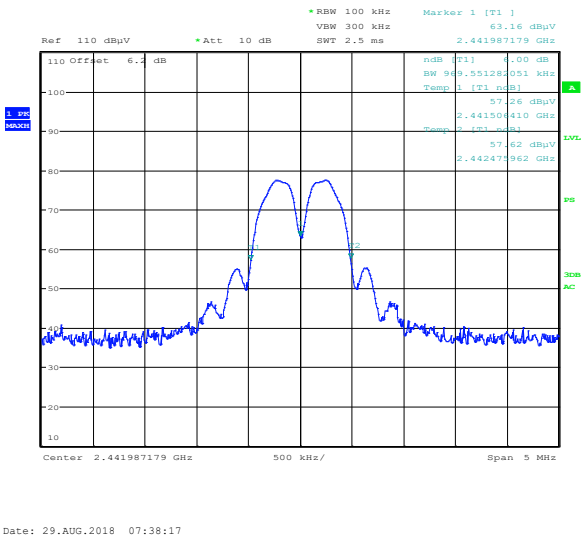


Figure 8.3-2: 6 dB bandwidth on mid channel

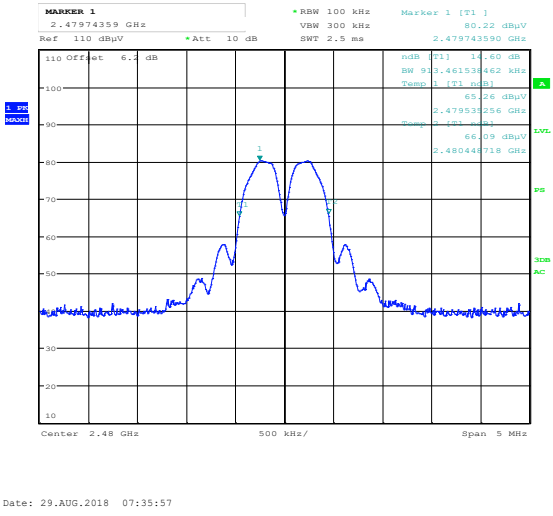


Figure 8.3-3: 6 dB bandwidth on high channel

8.3.5 Test data, continued

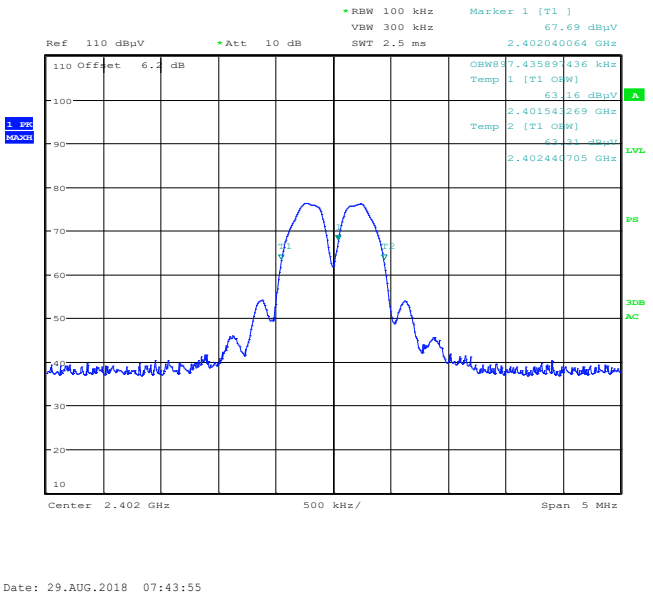


Figure 8.3-4: 99% bandwidth on low channel

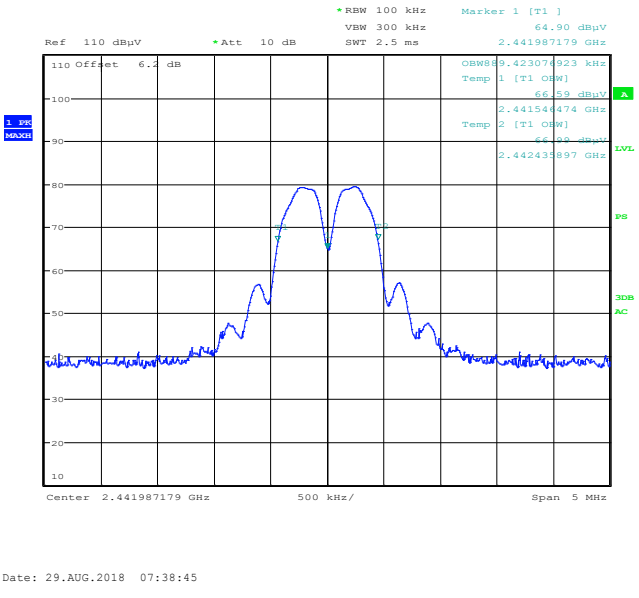


Figure 8.3-5: 99% bandwidth on mid channel

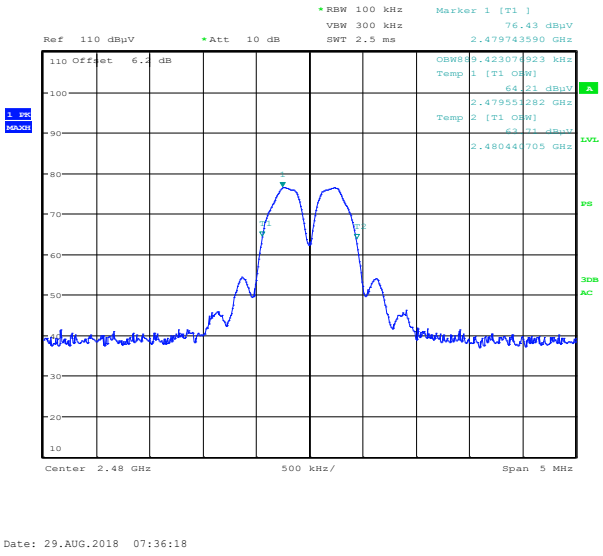


Figure 8.3-6: 99% bandwidth on high channel

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

8.4.1 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 stave 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 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).

8.4.2 Test date

Start date	August 28, 2018

8.4.3 Observations, settings and special notes

The test was performed using Peak detector with max hold Method

8.4.4 Test data

Table 8.4-1: Output power measurements results

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	Antenna Gain, dBi	Output Power, dBm	Output Power Limit, dBm	Output Power margin, dBm
LE							
2402	83.44	95.23	-11.79	1.70	-13.49	30.00	43.49
2441	85.35	95.23	-9.88	1.70	-11.58	30.00	41.58
2480	84.08	95.23	-11.15	1.70	-12.85	30.00	42.85

Table 8.4-2: EIRP measurements results

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	EIRP Limit, dBm	EIRP Power margin, dBm
2402	83.44	95.23	-11.79	36	47.79
2441	85.35	95.23	-9.88	36	45.88
2480	84.08	95.23	-11.15	36	47.15

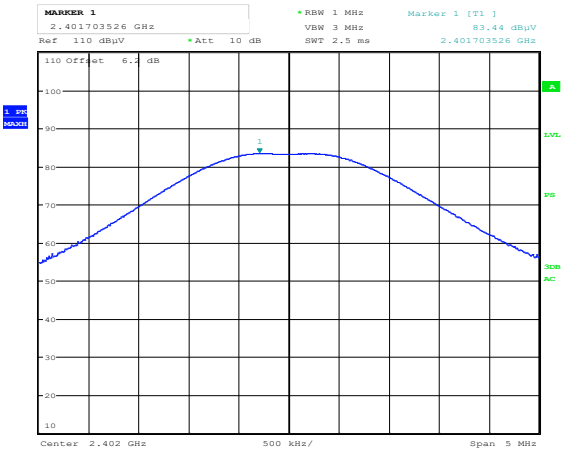


Figure 8.4-1: Output power on low channel

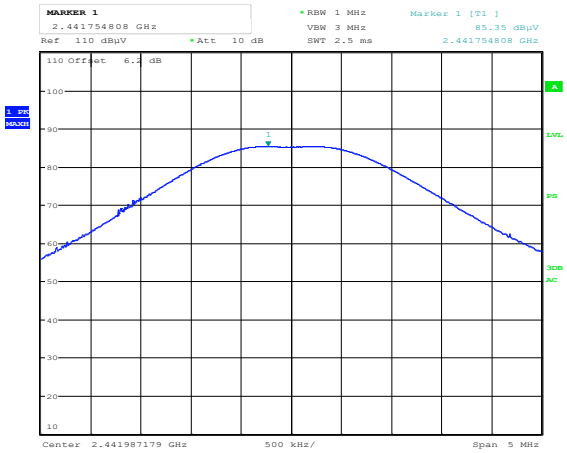


Figure 8.4-2: Output power on mid channel

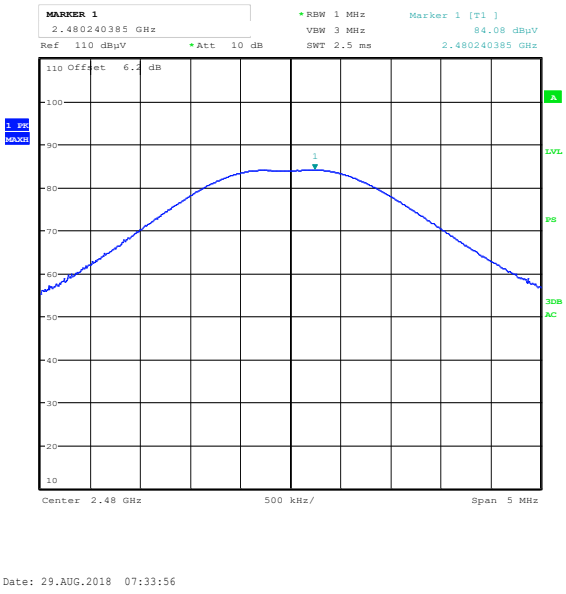


Figure 8.4-3: Output power on high channel

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

8.5.1 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 8.5-1: 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 8.5-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in 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 8.5-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard.

Table 8.5-3: 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			

8.5.2 Test date

Start date	August 28, 2018

8.5.3 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 a distance of 3 m

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

8.5.4 Test data

Sample of Band Edge Measurements

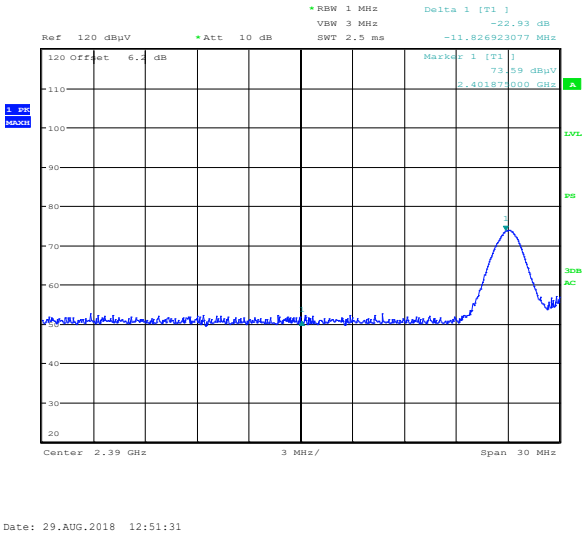


Figure 8.5-1: ***Lower band edge emission, tx on low ch***

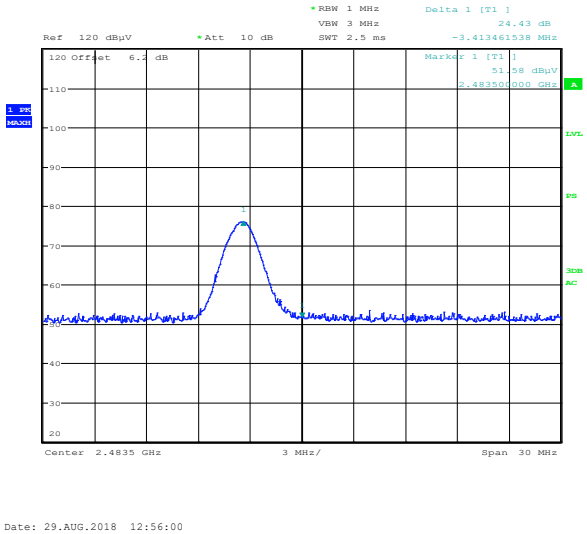


Figure 8.5-2: ***Upper band edge emission, tx on high channel***

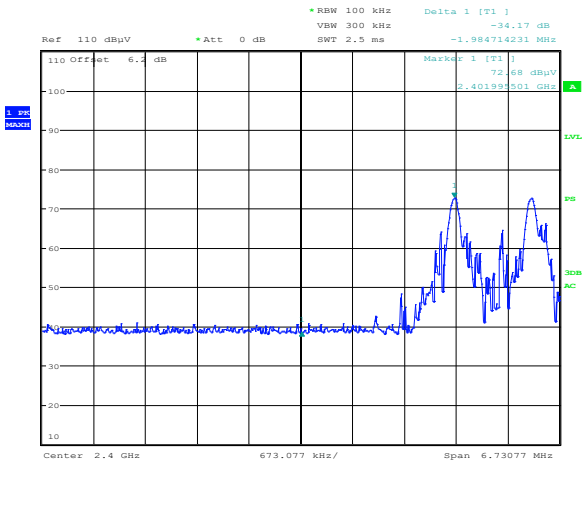


Figure 8.5-3: ***Lower band edge emission, tx hopping on, FHSS mode***

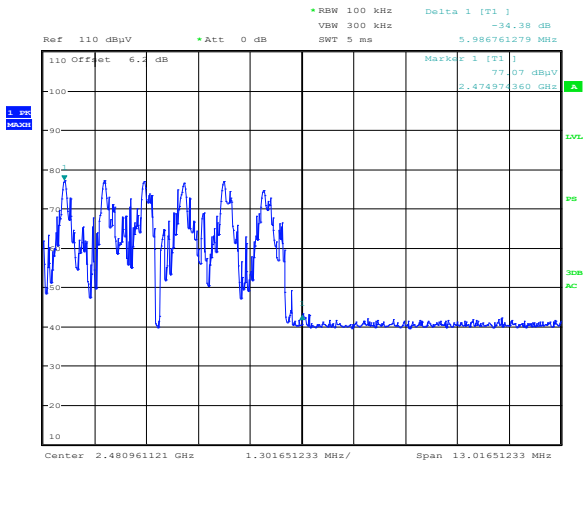
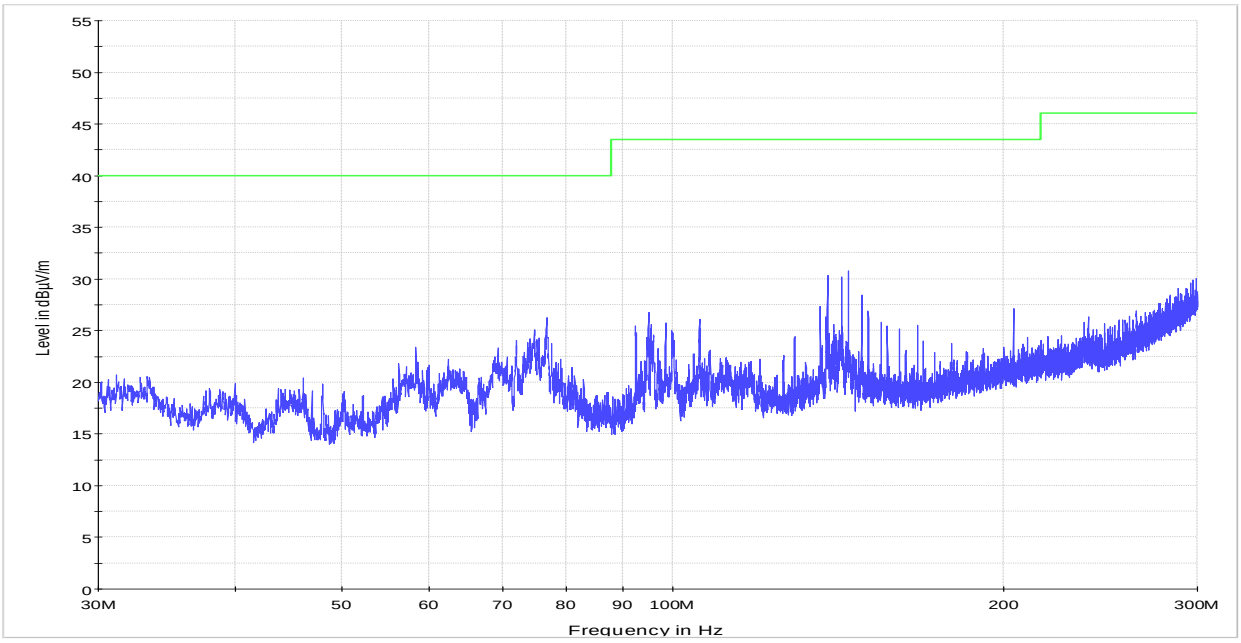


Figure 8.5-4: ***Upper band edge emission, tx hopping on, FHSS mode***

8.5.4 Test data, continued

Sample of Radiated Spurious (Out-of-band) Emissions Measurements



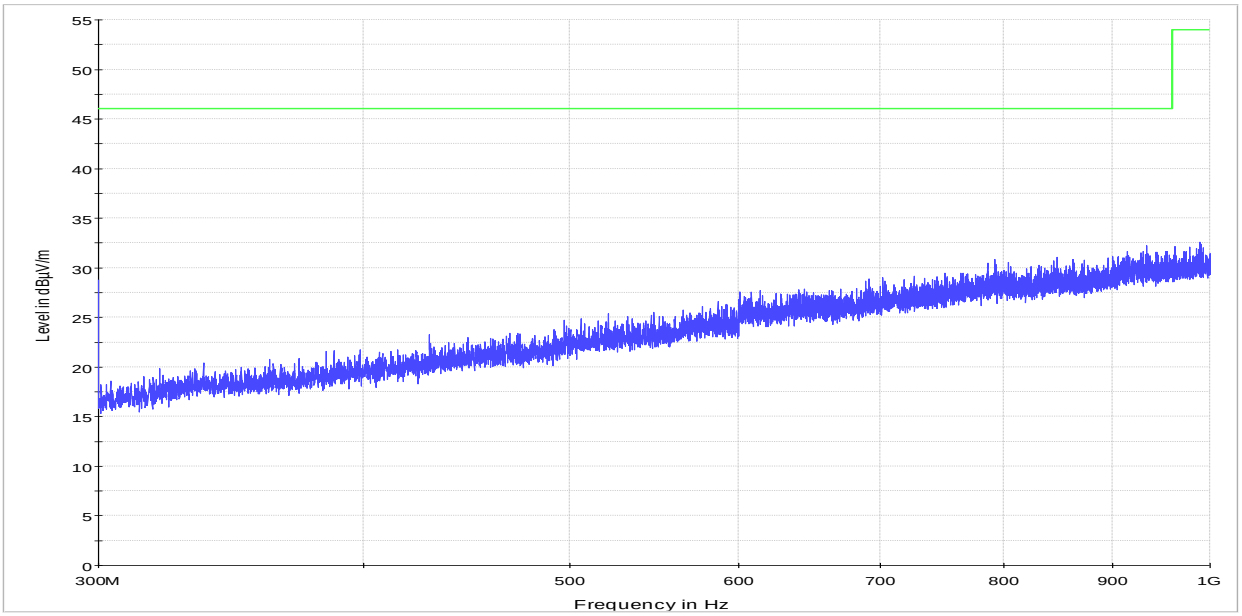
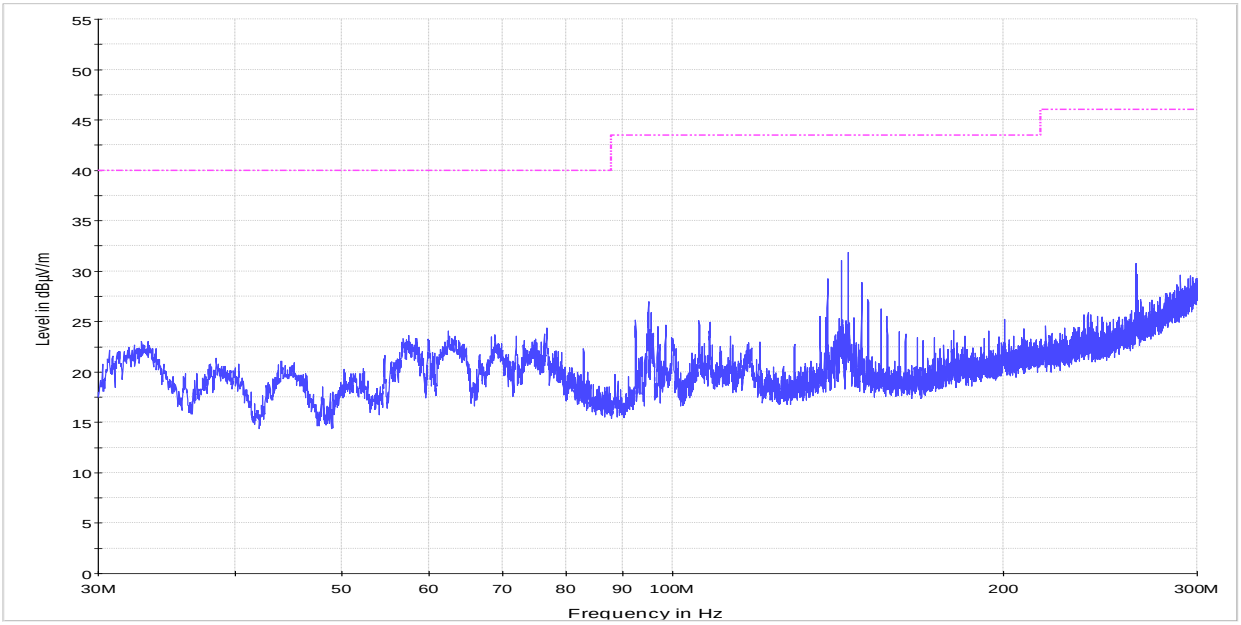


Figure 8.5-5: Radiated spurious (out-of-band) emissions, low channel, 30 to 1000 MHz

8.5.4 Test data, continued



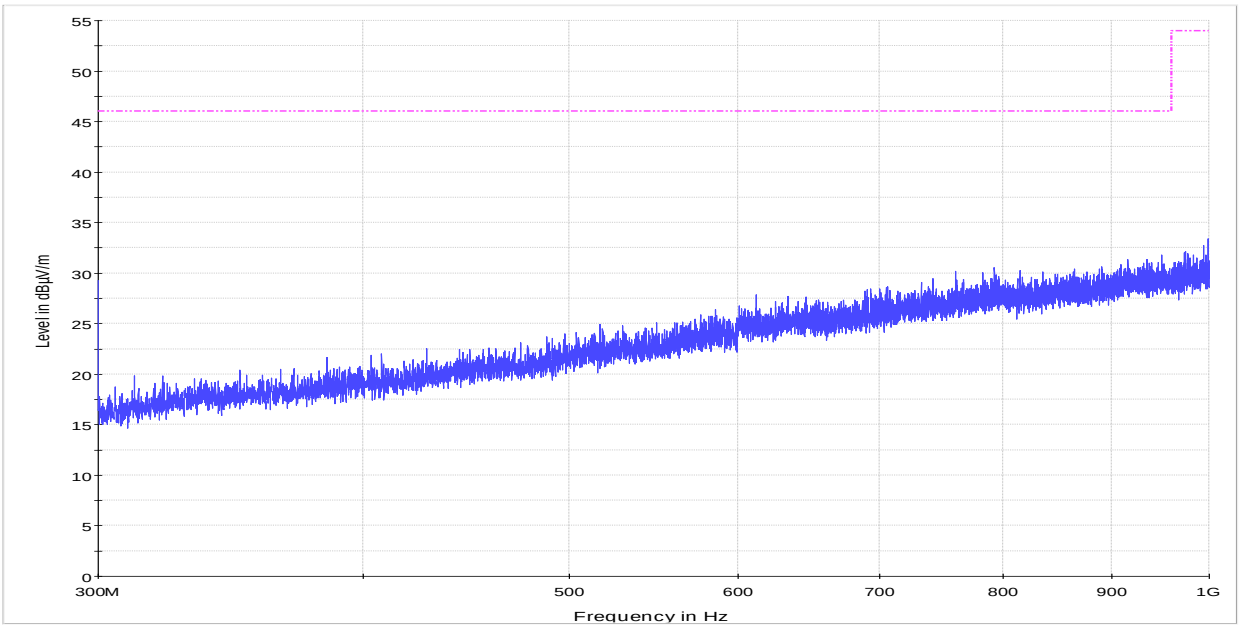
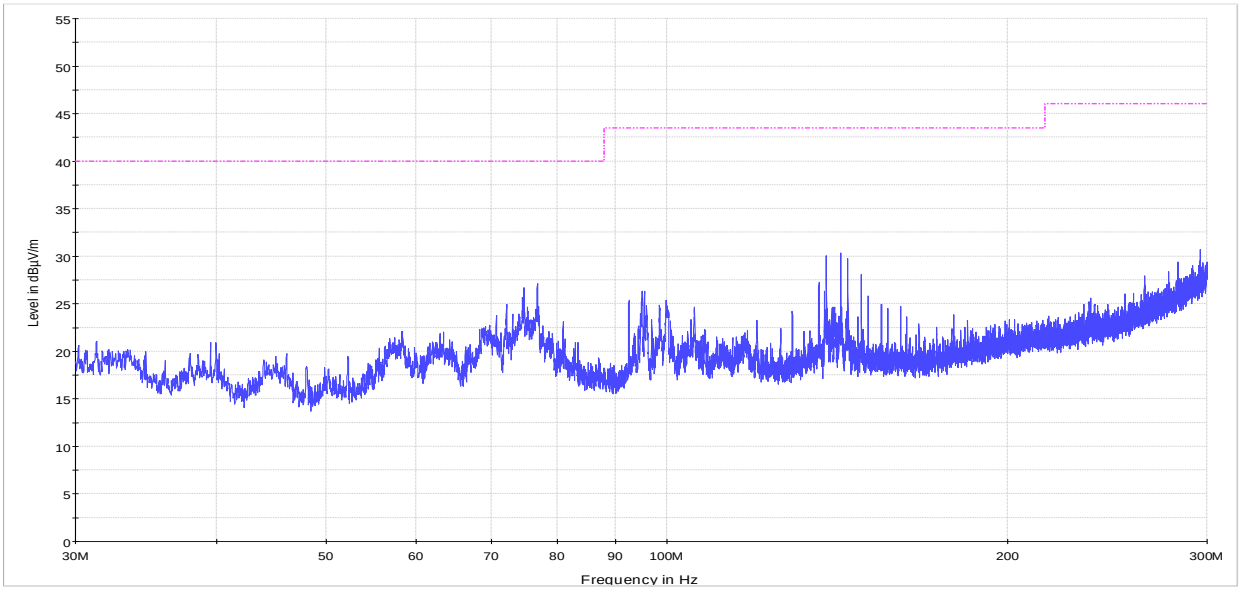


Figure 8.5-6: Radiated spurious (out-of-band) emissions, Mid channel, 30 to 1000 MHz

8.5.4 Test data, continued



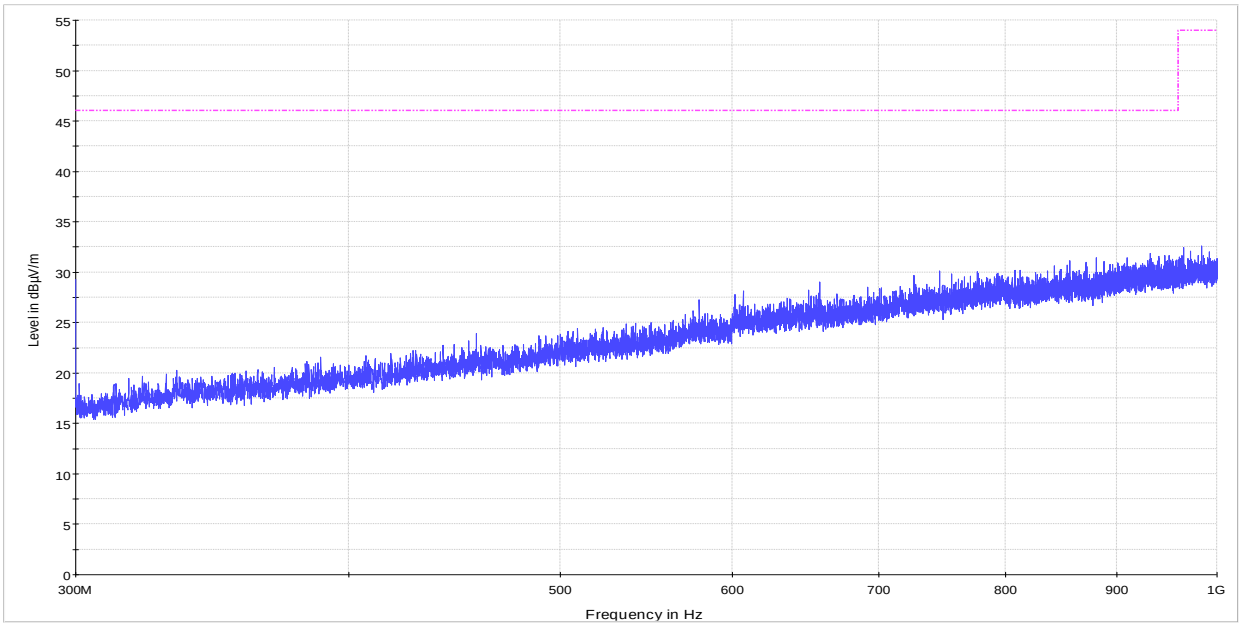


Figure 8.5-7: Radiated spurious (out-of-band) emissions, High channel, 30 to 1000 MHz

8.5.4 Test data, continued

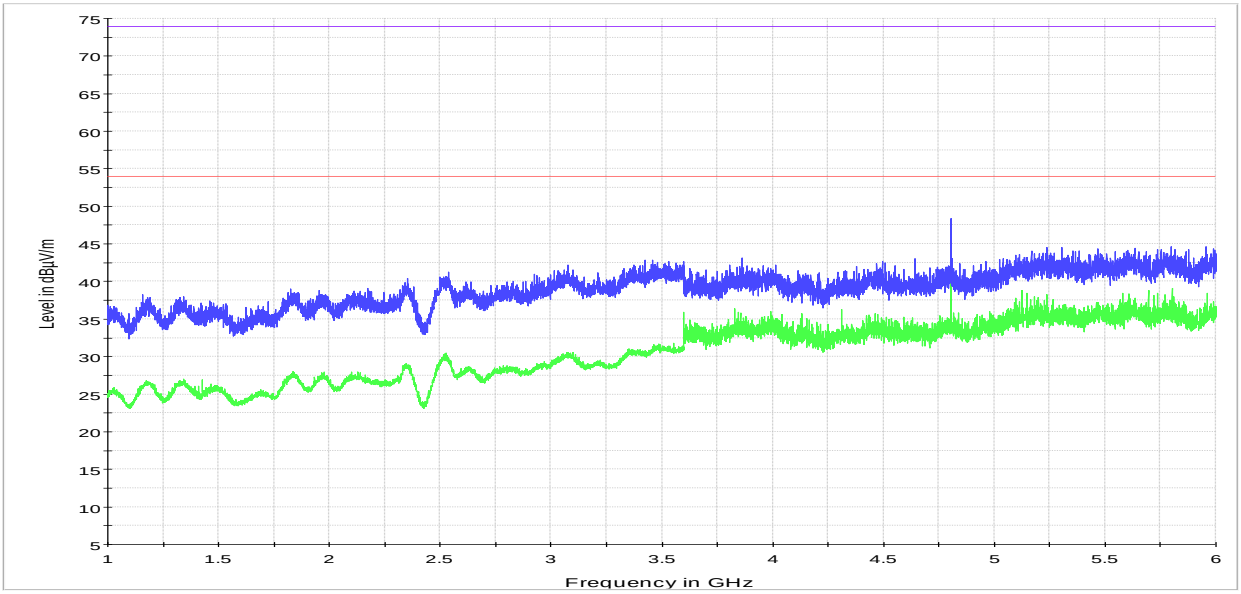


Figure 8.5-8: Radiated spurious emissions, low channel – 1 to 6 GHz

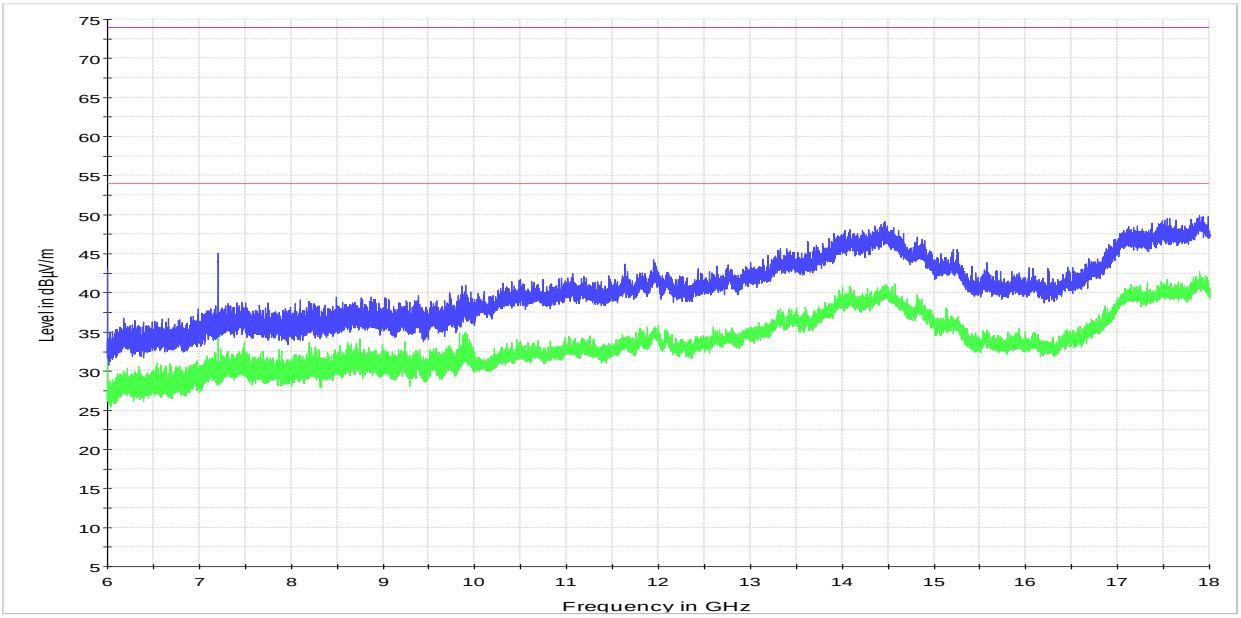


Figure 8.5-9: Radiated spurious emissions, low channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

8.5.4 Test data, continued

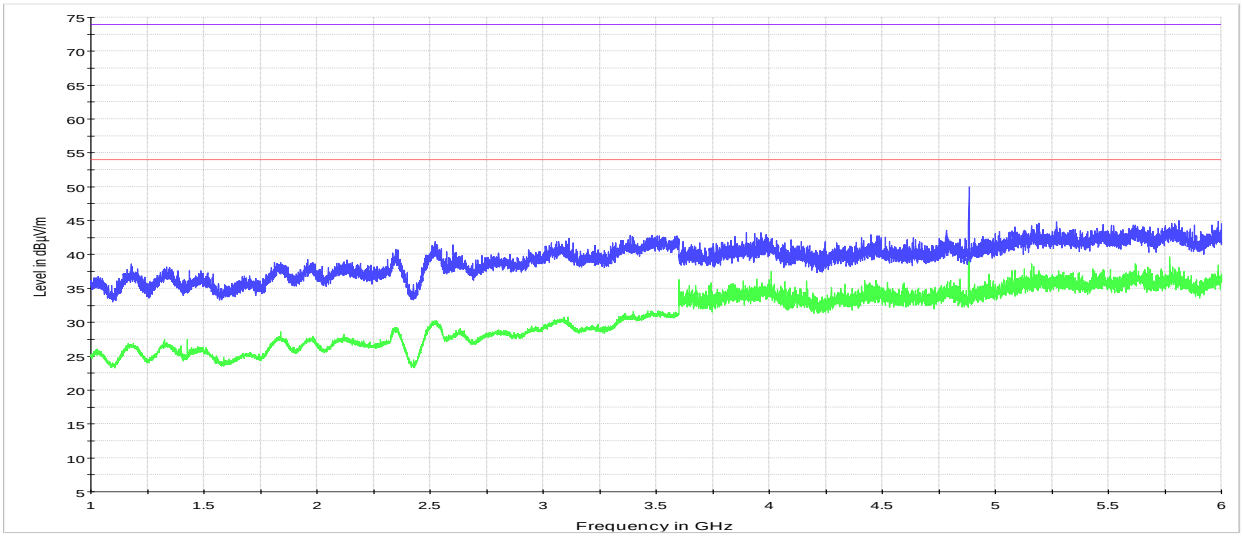


Figure 8.5-10: Radiated spurious emissions, Mid channel – 1 to 6 GHz

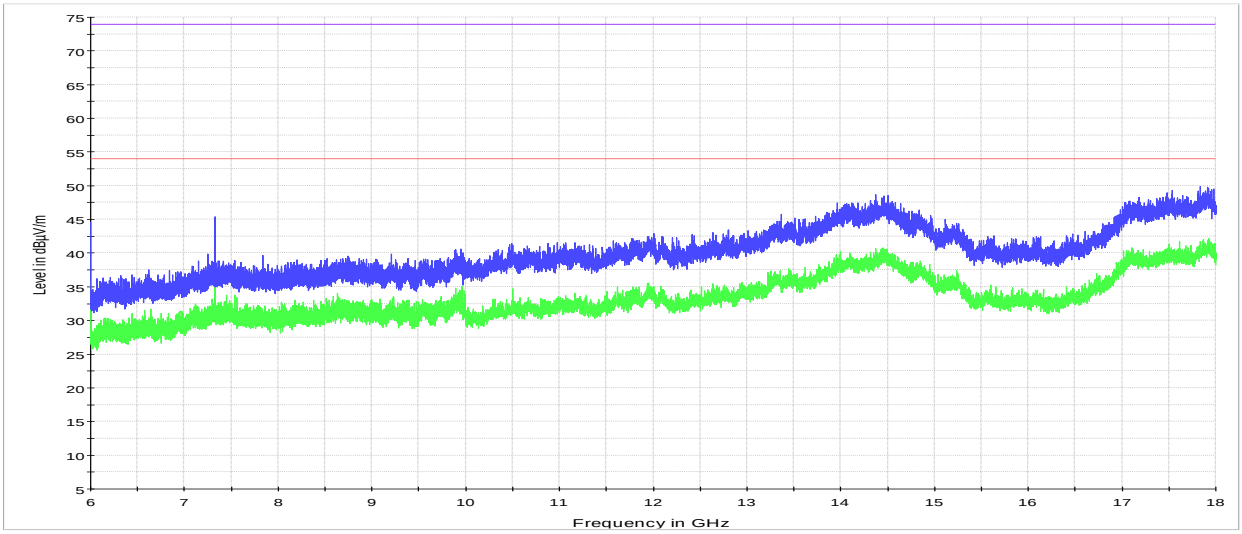


Figure 8.5-11: Radiated spurious emissions, Mid channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

8.5.4 Test data, continued

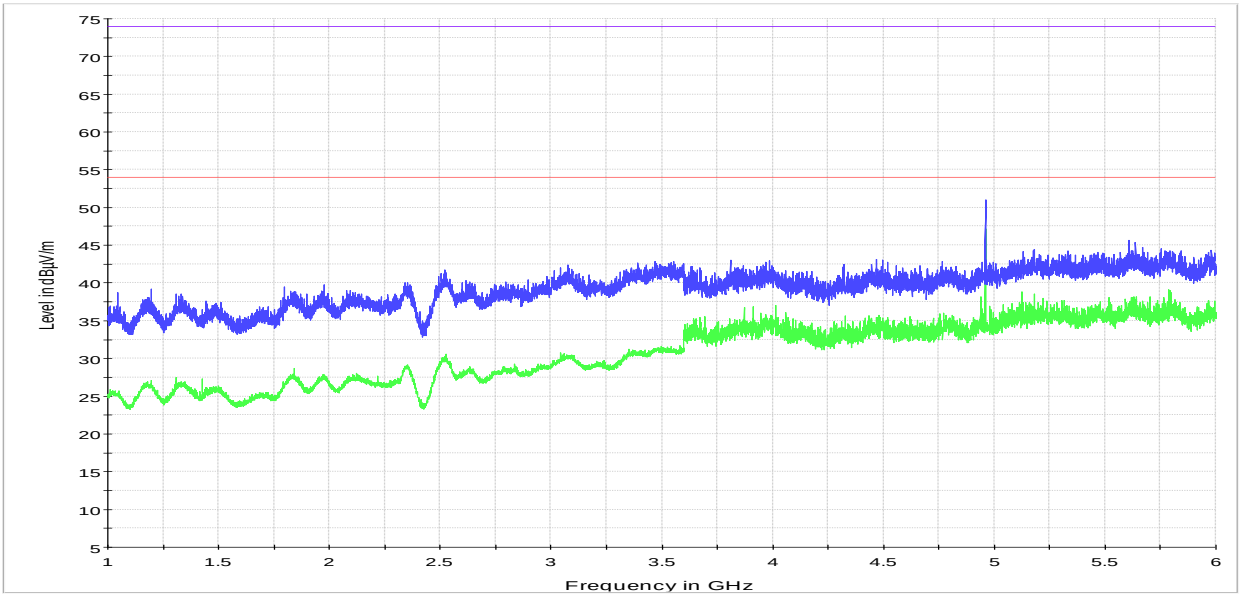


Figure 8.5-12: Radiated spurious emissions, High channel – 1 to 6 GHz

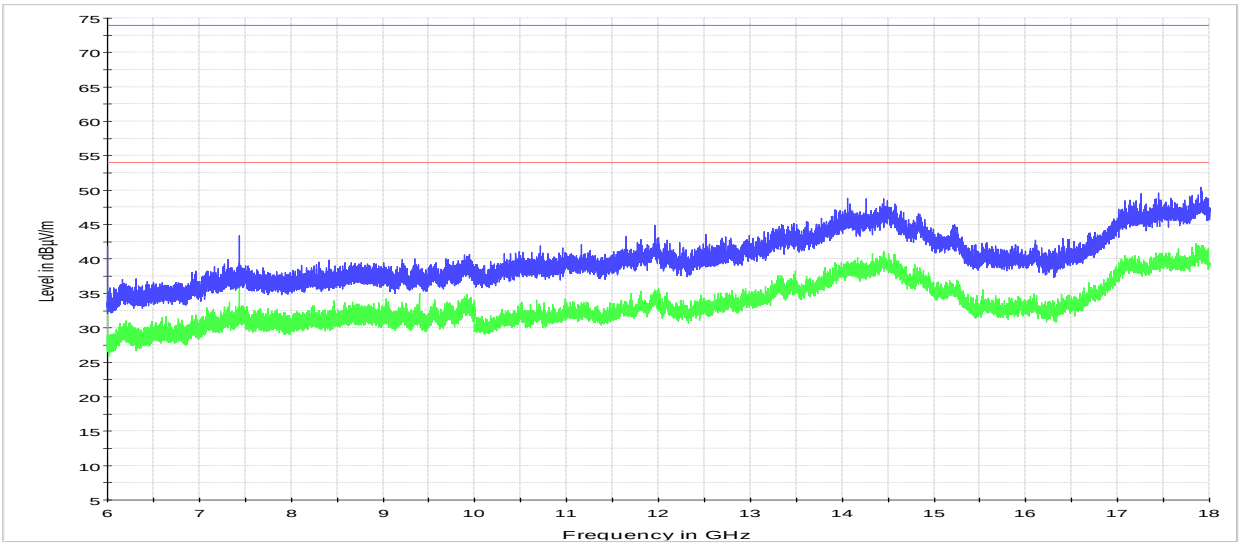


Figure 8.5-13: Radiated spurious emissions, High channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

8.5.4 Test data, continued

Table 8.5-4: Radiated spurious emissions test results.

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit			Limit	
GFSK_Low	2390.0	50.8	74.0	23.2	42.1	54.0	11.9
GFSK_Low	4804.0	47.5	74.0	26.5	43.9	54.0	10.1
GFSK_Low	7206.4	48.8	74.0	25.2	44.5	54.0	9.5
GFSK_Mid	4884.5	44.9	74.0	29.1	41.7	54.0	12.3
GFSK_Mid	7326.4	50.5	74.0	23.5	46.2	54.0	7.8
GFSK_High	2483.5	52.1	74.0	21.9	44.3	54.0	9.7
GFSK_High	4960.5	45.5	74.0	28.5	41.2	54.0	12.8
GFSK_High	7440.4	45.7	74.0	28.3	41.4	54.0	12.6
EDR2_Low	2390.0	51.3	74.0	22.7	46.3	54.0	7.7
EDR2_Low	4804.0	52.1	74.0	21.9	48.8	54.0	5.2
EDR2_Low	7206.4	48.1	74.0	25.9	43.8	54.0	10.2
EDR2_Mid	4885.0	50.1	74.0	23.9	46.8	54.0	7.2
EDR2_Mid	7325.6	44.6	74.0	29.4	39.4	54.0	14.6
EDR2_High	2483.5	51.0	74.0	23.0	40.2	54.0	13.8
EDR2_High	4960.5	50.7	74.0	23.3	46.0	54.0	8.0
EDR2_High	7440.4	43.6	74.0	30.4	39.0	54.0	15.0
EDR3_Low	2390.0	50.6	74.0	23.4	40.1	54.0	13.9
EDR3_Low	4804.5	48.4	74.0	25.6	44.3	54.0	9.7
EDR3_Low	7205.6	45.1	74.0	28.9	39.7	54.0	14.3
EDR3_Mid	4884.5	50.0	74.0	24.0	46.9	54.0	7.1
EDR3_Mid	7325.6	45.4	74.0	28.6	38.6	54.0	15.4
EDR3_High	2483.5	51.6	74.0	22.4	39.6	54.0	14.4
EDR3_High	4960.5	51.0	74.0	23.0	47.1	54.0	6.9
EDR3_High	7440.0	43.3	74.0	30.7	38.2	54.0	15.8
LE_Low	2390.0	50.8	74.0	23.2	41.2	54.0	12.8
LE_Low	4804.5	47.03	74.0	27.0	40.1	54.0	13.9
LE_Low	7205.6	44.8	74.0	29.2	34.2	54.0	19.8
LE_Mid	4884.5	44.5	74.0	29.5	40.0	54.0	14.0
LE_Mid	7325.6	46.4	74.0	27.6	34.7	54.0	19.3
LE_High	2483.5	52.1	74.0	21.9	41.2	54.0	12.8
LE_High	4960.5	44.9	74.0	29.1	40.52	54.0	13.5
LE_High	7440.0	46.0	74.0	28.0	41.0	54.0	13.0

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

8.6 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices

8.6.1 Definitions and limits

FCC:
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

ISED:
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.6.2 Test date

Start date	August 29, 2018

8.6.3 Observations, settings and special notes

The test was performed using method PKPSD (peak PSD).
Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Frequency span:	5 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.6.4 Test data

Table 8.6-1: PSD measurements results

Frequency, MHz	PSD, dBµV/m /3 kHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402	76.17	-19.06	8.00	27.06
2441	76.54	-18.69	8.00	26.69
2480	79.01	-16.22	8.00	24.22

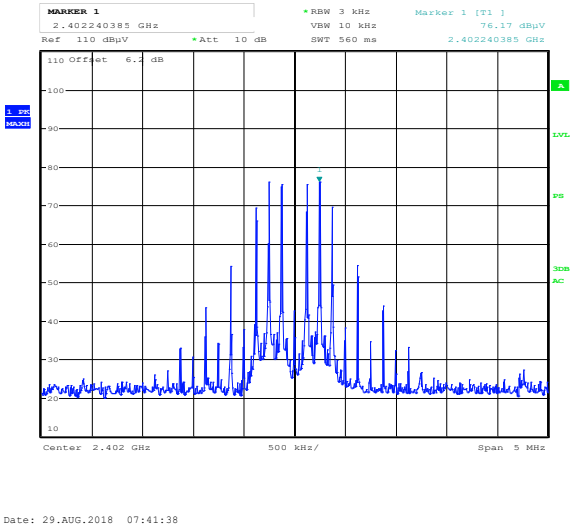


Figure 8.6-1: PSD plot on low channel

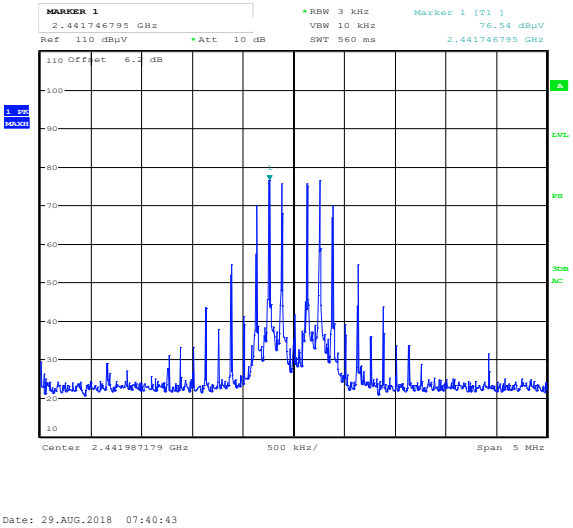


Figure 8.6-2: PSD plot on mid channel

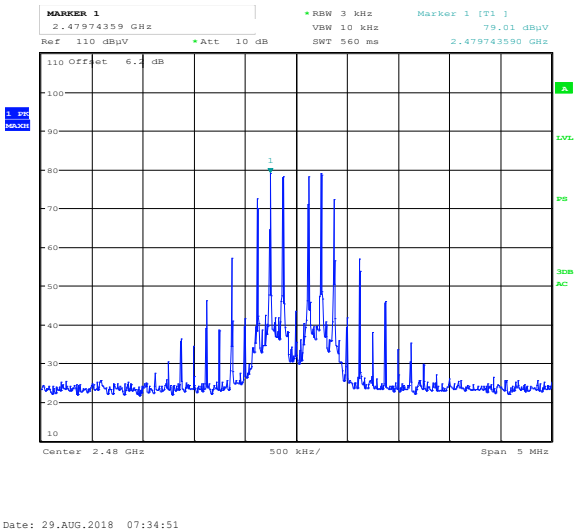
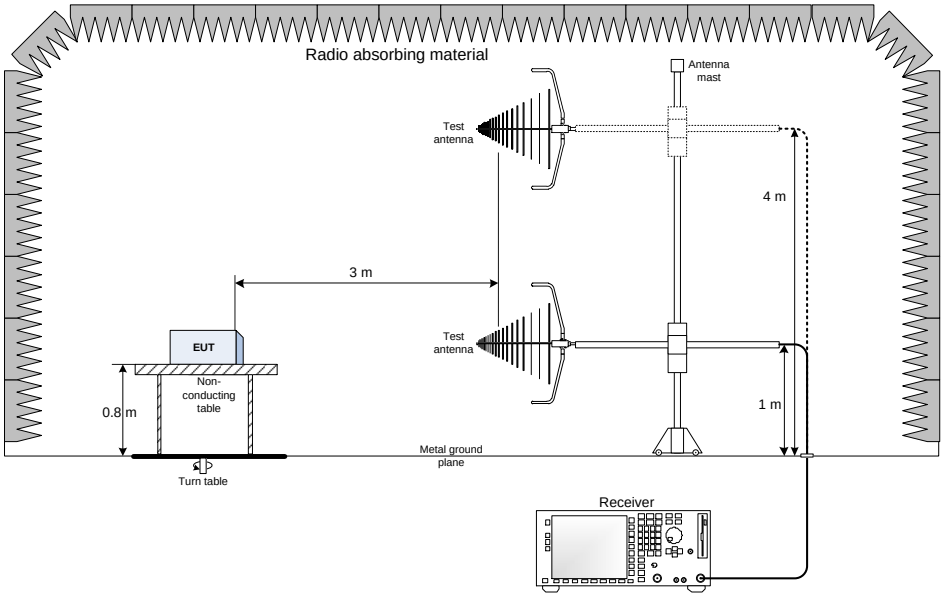


Figure 8.6-3: PSD plot on high channel

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