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RADIO TEST REPORT – 347058-1TRFWL

Applicant:

Thales Canada, Transportation Solutions

Product name:

Wayside Radio Unit (WRU) / Access Point (AP)

Model:

3CU10211BZAA

Model variant:

3CU10211CAAA

FCC ID:

2AO3U3CU10211

ISED Registration number:

23653-3CU10211

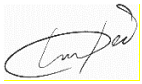
Specifications:

- 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, Part 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: January 25, 2019

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

Lab and test locations

Company name	Nemko Canada Inc.		
Facilities	Ottawa site: 303 River Road, Ottawa, ON, Canada, K1V 1H2 Tel: +1 613 737 9680 Fax: +1 613 737 9691	Montreal site: 292 Labrosse Avenue, Pointe-Claire, QC, Canada, H9R 5L8 Tel: +1 514 694 2684 Fax: +1 514 694 3528	Almonte site: 1500 Peter Robinson Road, West Carleton, ON, Canada, K0A 1L0 Tel: +1 613 256-9117 Fax: +1 613 256-8848

Test site registration	**Organization**	**Recognition numbers and location**
	FCC	CA2040 (Ottawa); CA2041 (Montreal)
	ISED	CA2040A-4 (Ottawa); CA2040G-5 (Montreal); CA2040A-3 (Almonte)
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 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	Thales Canada, Transportation Solutions
Address	105 Moatfield Drive, Toronto, ON, Canada, M3B 0A4

1.2 Test specifications

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

1.3 Test methods

ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
DA 00-705 Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

1.4 Exclusions

None

1.5 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.

1.6 Test report revision history

Table 1.6-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	January 25, 2019	Original report issued

Section 2. Summary of test results

2.1 Testing period

Test start date	January 18, 2018
Test end date	January 19, 2018

2.2 FCC Part 15 Subpart C, general requirements test results

Table 2.2-1: *Result summary for Subpart C, general*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31€	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed
[2] The EUT is professionally installed equipment.

2.3 FCC Part 15 Subpart C, intentional radiators test results

Table 2.3-1: *Result summary for Subpart C, intentional radiators for frequency hopping spread spectrum systems*

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Pass
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247€(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247€(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: None

2.4 ISED RSS-GEN, Issue 4, test results

Table 2.4-1: *Result summary for ISED RSS-GEN*

Part	Test description	Verdict
6.6	Occupied bandwidth	Pass
7.1.2	Receiver radiated emission limits	Not applicable [1]
7.1.3	Receiver conducted emission limits	Not applicable [1]
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.5 ISED RSS-247, Issue 2, test results

Table 2.5-1: *Result summary for ISED RSS-247, intentional radiators for frequency hopping spread spectrum systems*

Section	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing for frequency hopping systems	Pass
5.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
5.1 (c)	Frequency hopping 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)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (d)	Systems employing digital modulation techniques	Not applicable
5.4 (c)	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	January 9, 2018
Nemko sample ID number	1

3.2 EUT information

Product name	Wayside Radio Unit (WRU) / Access Point (AP)
Model	3CU10211BZAA
Model variant	3CU10211CAAA
Serial number	Prototype

3.3 Technical information

Applicant IC company number	23653
IC UPN number	3CU10211
All used IC test site(s) Reg. number	2040A-4
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 Min (W)	N/A
RF power Max (W), Conducted	0.089 (19.5 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (20 dB) and 99 Percent	20 dB bandwidth: 960 kHz 99% bandwidth: 892 kHz
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	Gaussian Frequency Shift Keying (GFSK) for 802.11/FHSS
Emission classification (F1D, G1D, D1D)	G1D
Transmitter spurious, Units @ distance	73.5 dBµV/m Peak and 53.5 dBµV/m Average at 2483.5 MHz @ 3 m
Power requirements	AC Input 120 V_{AC}, 60 Hz
Antenna information	Andrew Flat Planar Array Microceptor Antenna, QD-2402, 16 dBi The EUT is professionally installed.

3.4 Product description

Urban rail signalling trackside cbtc radio

3.5 EUT exercise details

The EUT was setup in continuous transmit state.

3.6 EUT setup diagram

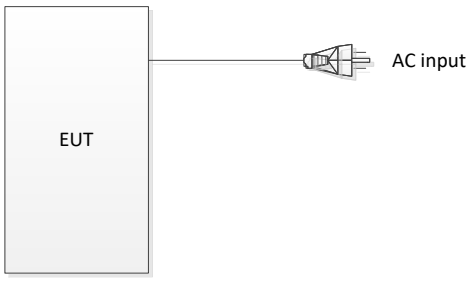


Figure 3.6-1: *Setup diagram*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT for compliance

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

4.2 Technical judgment

Model 3CU10211BZAA was tested as a representative sample:

The 3CU10211BZAA and 3CU10211CAAA are equivalent in all aspects except for the following deviations:

1) The Fiber Optics Port plugin SFP transceivers. BZAA – Single Mode Transceiver, CAAA Multimode Transceiver.
2) Fiber optic cable: BZAA – Single Mode fiber optic cable, CAAA Multimode Fiber Optic Cable.

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	86–106 kPa

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

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.

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

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 09/18
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 31/18
Spectrum analyzer	Rohde & Schwarz	FSP	FA001920	1 year	Aug. 08/18
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	June 21/18
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	June 27/18
Preamp (1–18 GHz)	ETS-Lindgren	124334	FA002877	1 year	Nov. 14/18
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	June 27/18
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
50 Ω coax cable	C.C.A.	None	FA002555	1 year	May 2/18
50 Ω coax cable	Huber + Suhner	None	FA002074	1 year	May 12/18
50 Ω coax cable	Huber + Suhner	None	FA002830	1 year	May 12/18
Notch filter 2400–2483 MHz	Microwave Circuits	2400–2483 MHz	FA001940	—	VOU

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

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.1.1 Definitions and limits

FCC §15.207:

a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

IC RSS-GEN Part 8.8:

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.1-1: *AC power line conducted emissions limit*

Frequency of emission, MHz	Conducted limit, dBµV	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Notes: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.1.2 Test summary

Verdict	Pass
Test date	January 19, 2018
Test engineer	David Duchesne

It was verified that the emissions exceeding 15.207 and RSS-Gen limits originated from digital portion of the EUT and therefore are excluded from the assessment of the present document.

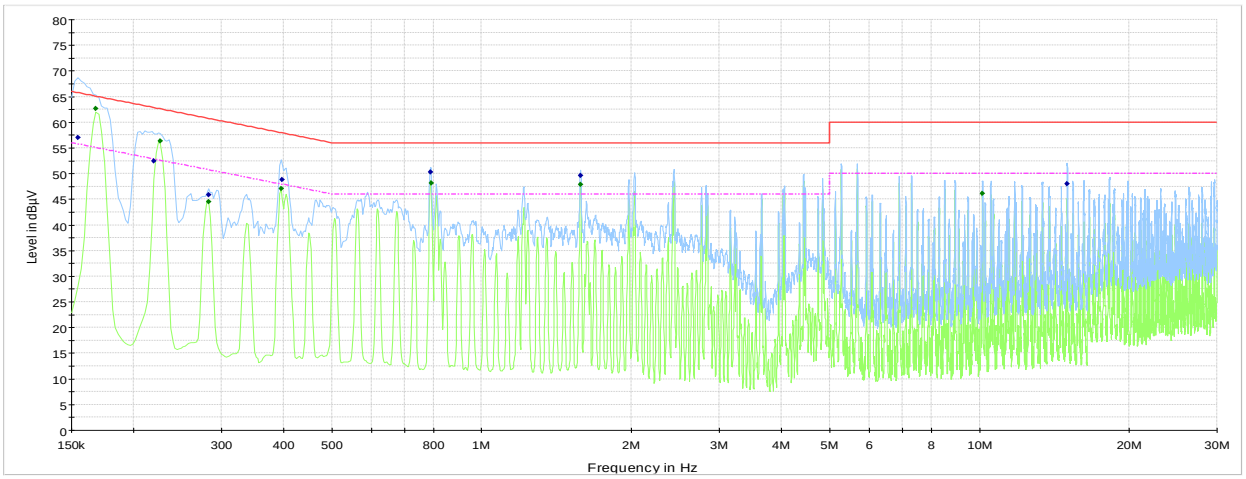
8.1.3 Observations, settings and special notes

Port under test – Coupling device	AC Input – Artificial Mains Network (AMN)
EUT power input during test	5 V_{DC} (Powered via external power adapter @ 120 V_{AC} 60 Hz)
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings:

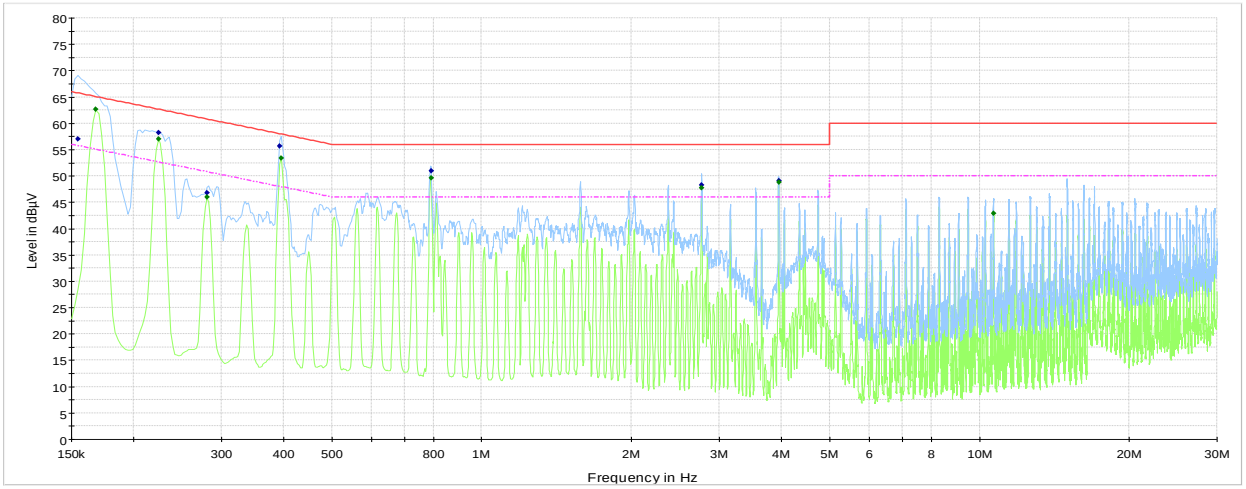
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview measurement), Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 100 ms (Quasi-peak final measurement) – 160 ms (CAverage final measurement)

8.1.4 Test data



The spectral plot has been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)

Figure 8.1-1: *AC power line conducted emissions – spectral plot on phase line*



The spectral plot has been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)

Figure 8.1-2: *AC power line conducted emissions – spectral plot on neutral line*

8.2 FCC 15.247 (a (1 (iii))) and RSS-247 5.1(a), (b) and (d) Frequency Hopping Systems requirements

8.2.1 Definitions and limits

FCC §15.247:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(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.

IC RSS-247 Part 5.1:

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.

8.2.2 Test summary

Verdict	Pass
Test date	January 18, 2018
Test engineer	David Duchesne

8.2.3 Observations, settings and special notes

None

Spectrum analyzer settings for carrier frequency separation:

Resolution bandwidth	RBW ≥ 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	RBW ≥ 1% of the span
Video bandwidth	≥ RBW
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% to 5 % 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

8.2.4 Test data

Table 8.2-1: *20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz
2402	960
2438	956
2480	956

Table 8.2-2: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit[1], kHz	Margin, kHz
1000	960	40

Notes: [1] The 20 dB bandwidth was utilized as the minimum limit as it was greater than 25 kHz.

Table 8.2-3: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
79	15	64

Table 8.2-4: *Average time of occupancy results*

Dwell time of each pulse, ms	Number of pulses within 31.6 s period	Total dwell time within period[1], ms	Limit, ms	Margin, ms
0.82	5	4.1	400.00	395.9

Notes: Period for average time of occupancy measurement: 0.4 s × 79 channels = 31.6 s

8.2.4 Test data, continued

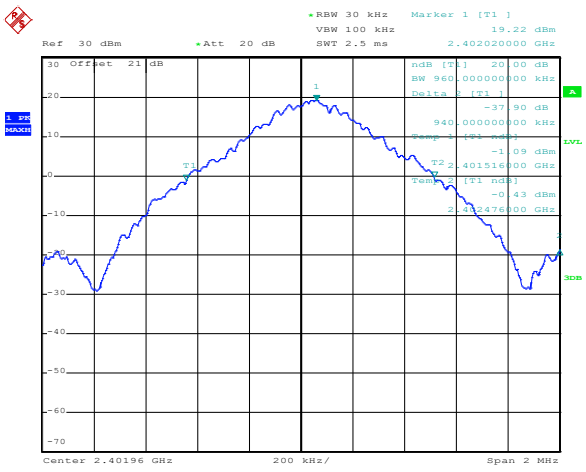


Figure 8.2-1: *20 dB bandwidth on low channel*

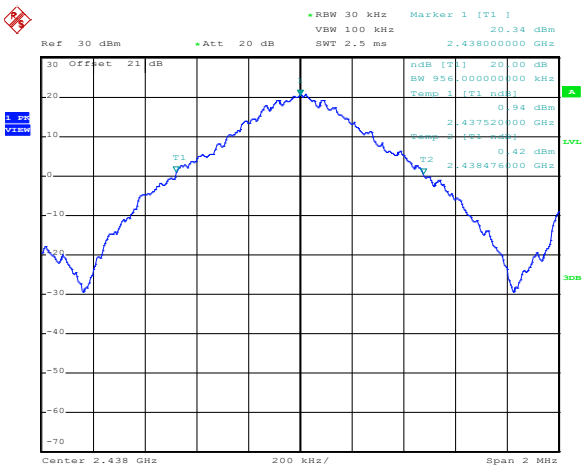


Figure 8.2-2: *20 dB bandwidth on mid channel*

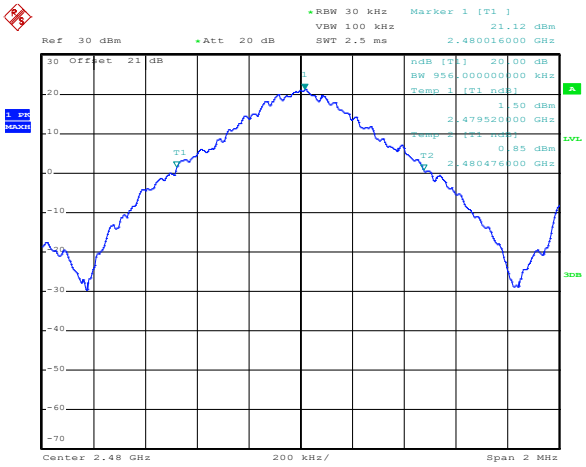


Figure 8.2-3: *20 dB bandwidth on high channel*

8.2.4 Test data, continued

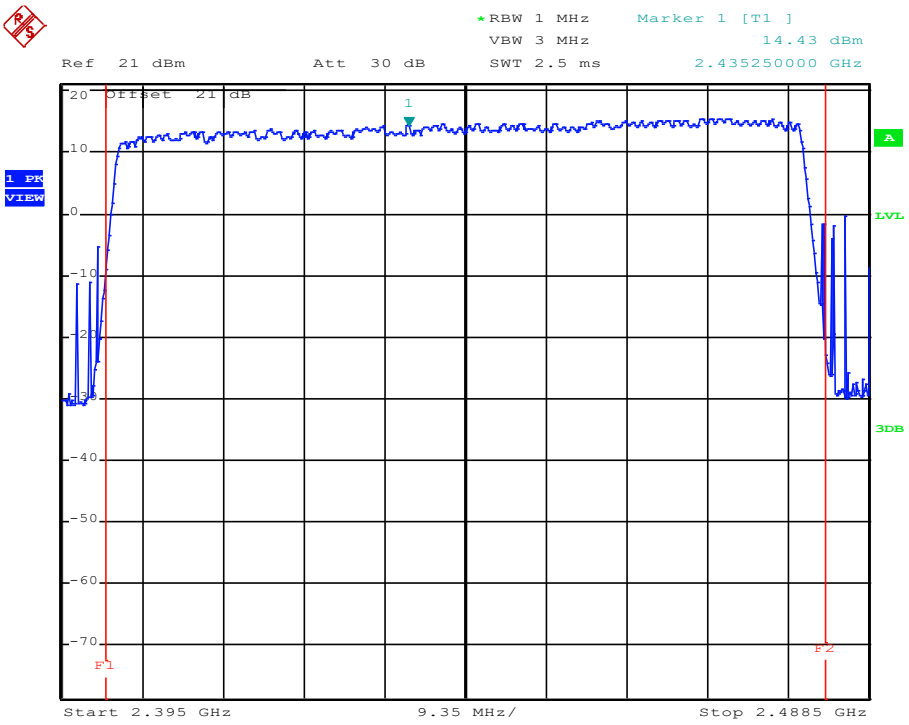


Figure 8.2-4: *Number of hopping channels, (79)*

8.2.4 Test data, continued

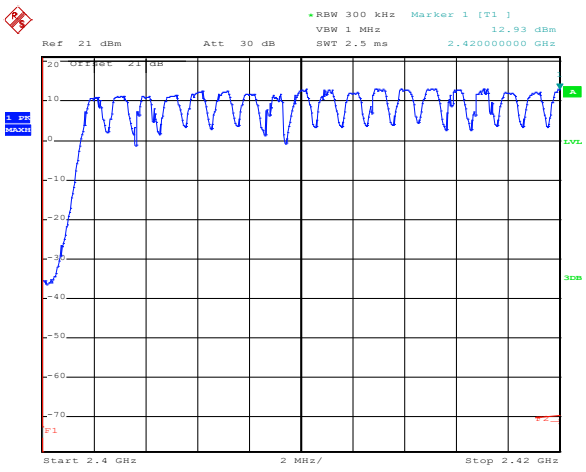


Figure 8.2-5: *Number of hopping channels, 2.4 to 2.42 GHz = 18*

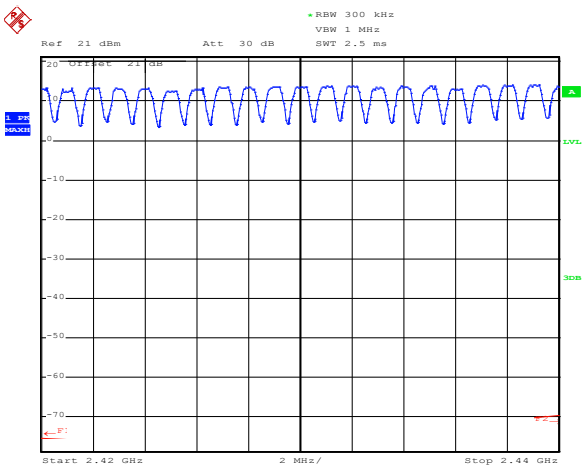


Figure 8.2-6: *Number of hopping channels, 2.42 to 2.44 GHz = 21*

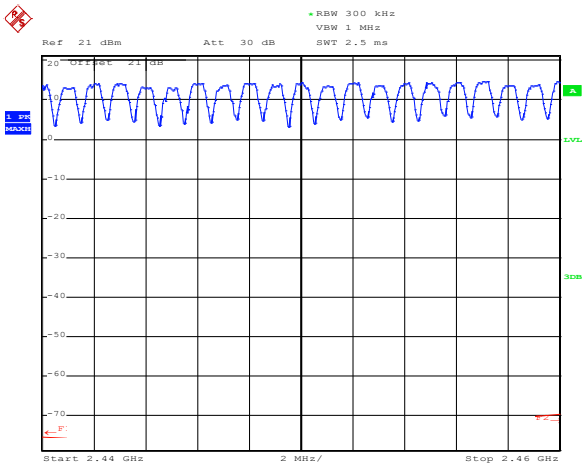


Figure 8.2-7: *Number of hopping channels, 2.44 to 2.46 GHz = 20*

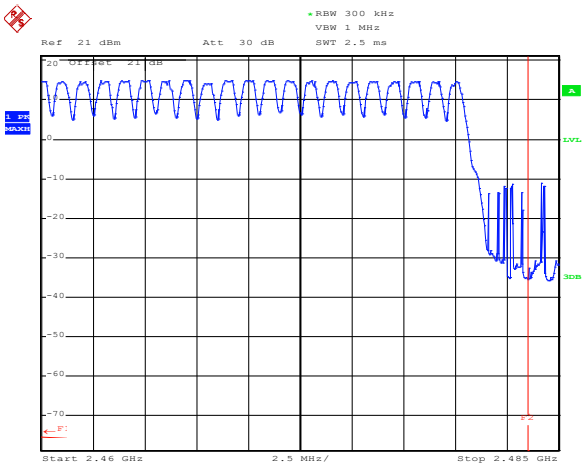


Figure 8.2-8: *Number of hopping channels, 2.46 to 2.485 GHz = 20*

8.2.4 Test data, continued

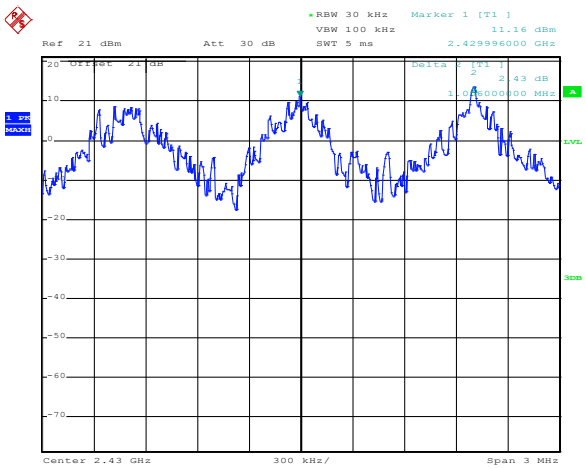


Figure 8.2-9: *Carrier frequency separation = 1 MHz*

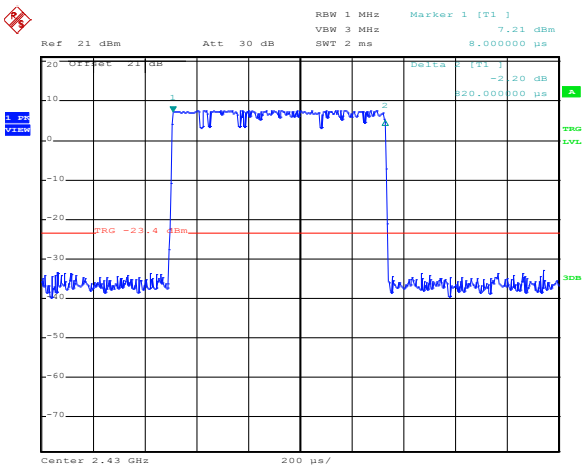


Figure 8.2-10: *Average time of occupancy pulse = 0.82 ms*

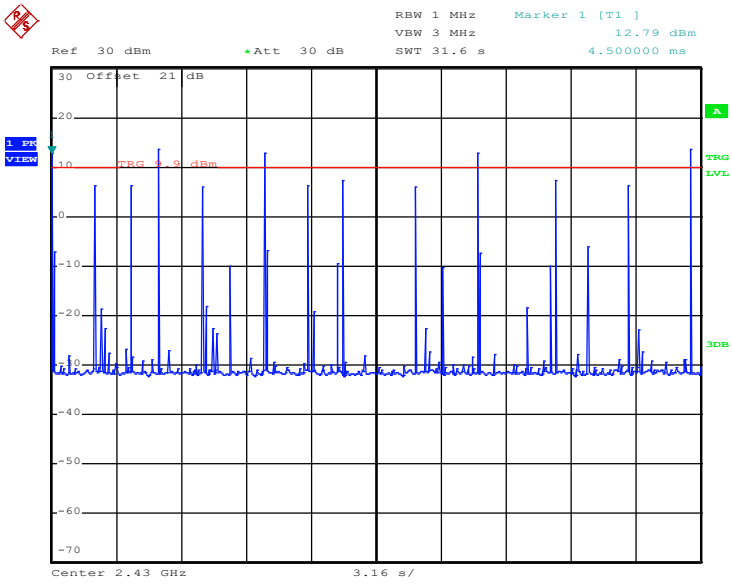


Figure 8.2-11: *Time of occupancy over 31.6 seconds (Worst case) = 4.1 ms (5 pulses x 0.82 ms (Dwell time))*

8.3 RSS-GEN 6.6 Occupied bandwidth

8.3.1 Definitions and limits

IC RSS-GEN Part 6.6:

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3× the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3×RBW.

Note: Video averaging is not permitted.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously. The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the 99% occupied bandwidth.

8.3.2 Test summary

Verdict	Pass
Test date	January 18, 2018
Test engineer	David Duchesne

8.3.3 Observations, settings and special notes

None

Spectrum analyser settings:

Resolution bandwidth	1% to 5 % of occupied bandwidth
Video bandwidth	≥3×RBW
Frequency span	2 MHz
Detector mode	Peak
Trace mode	Max Hold

8.3.5 Test data

Table 8.3-1: *99% bandwidth results*

Frequency, MHz	99 % bandwidth, kHz
2402	892
2438	880
2480	888

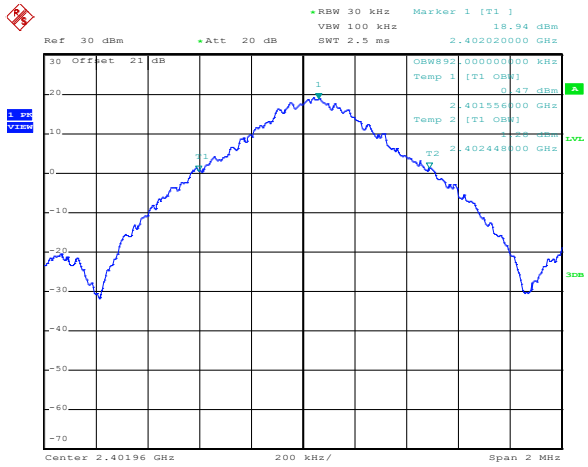


Figure 8.3-1: *99% bandwidth on low channel*

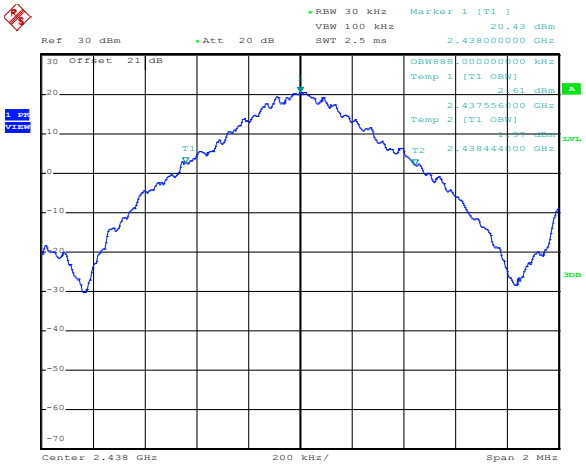


Figure 8.3-2: *99% bandwidth on mid channel*

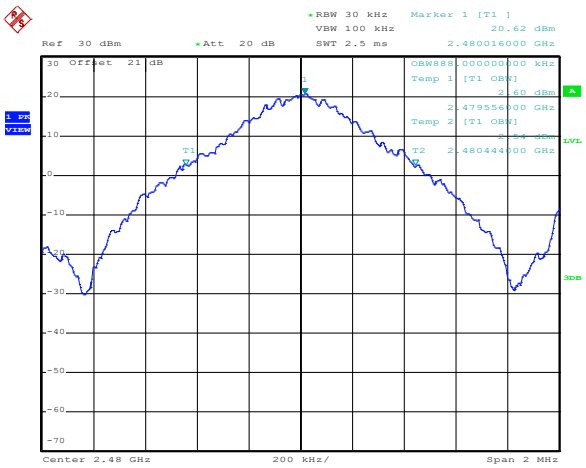


Figure 8.3-3: *99% bandwidth on high channel*

8.4 FCC 15.247(b (1) (4)) and RSS-247 5.4 (b) Transmitter output power and e.i.r.p. requirements

8.4.1 Definitions and limits

FCC §15.247:

(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. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

(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.

IC RSS-247 Part 5.4:

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

8.4.2 Test summary

Verdict	Pass
Test date	January 18, 2018
Test engineer	David Duchesne

8.4.3 Observations, settings and special notes

None

Spectrum analyser settings:

Resolution bandwidth	> the 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	20 MHz
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: *Output power and EIRP measurements results*

Frequency, MHz	Power setting, dBm	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Measured	Limit*					
2402	18 (Fpga –r 700 17310010)	19.5	20.0	0.5	16.0	35.5	36.0	0.5
2438	16 (Fpga –r 700 13310010)	19.1	20.0	0.9	16.0	35.1	36.0	0.9
2480	16 (Fpga –r 700 13310010)	19.4	20.0	0.6	16.0	35.4	36.0	0.6

Notes: EIRP = Output power + Antenna gain
* Output power limit was reduced by 10 dB as antenna gain is 10 dB higher than 6 dBi.

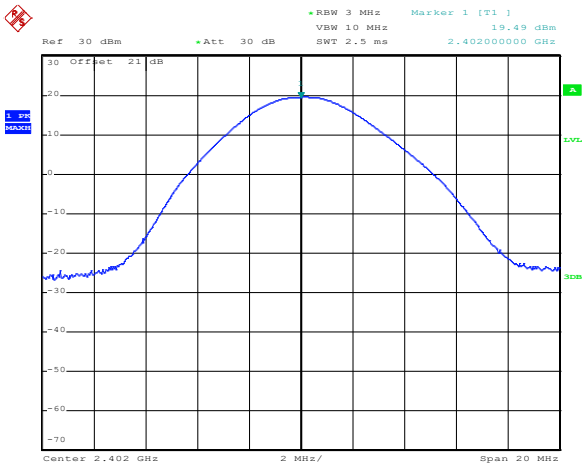


Figure 8.4-1: *Peak output power on low channel*

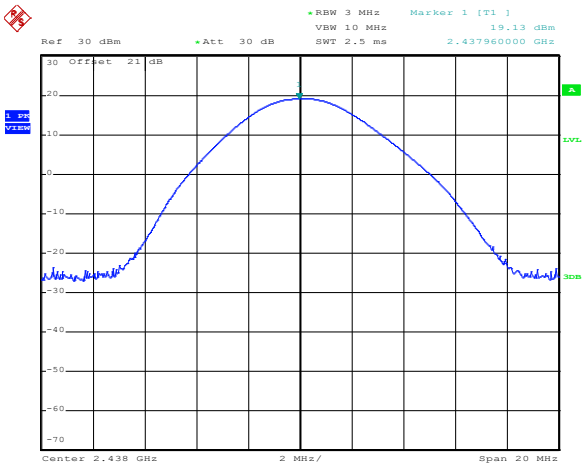


Figure 8.4-2: *Peak output power on mid channel*

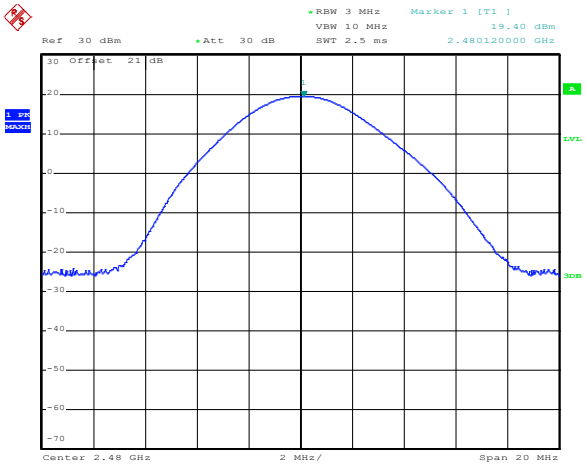


Figure 8.4-3: *Peak output power on high channel*

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

8.5.1 Definitions and limits

FCC §15.247 (d):

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)).

IC RSS-247 Part 5.5:

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

Notes: None

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			

Notes: None

8.5.2 Test summary

Verdict	Pass
Test date	January 18, 2018
Test engineer	David Duchesne

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 from30 MHz to 18 GHz. Radiated measurements above 18 GHz were performed at a distance of 1 m.
- The spectral plots have been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators)

8.5.3 Observations, settings and special notes, continued

Spectrum analyser settings for conducted spurious emissions measurements:

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

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

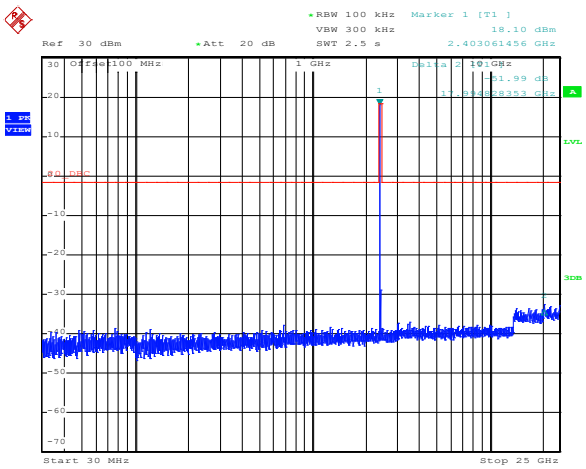


Figure 8.5-1: *Conducted spurious emissions, Tx-2402 MHz*

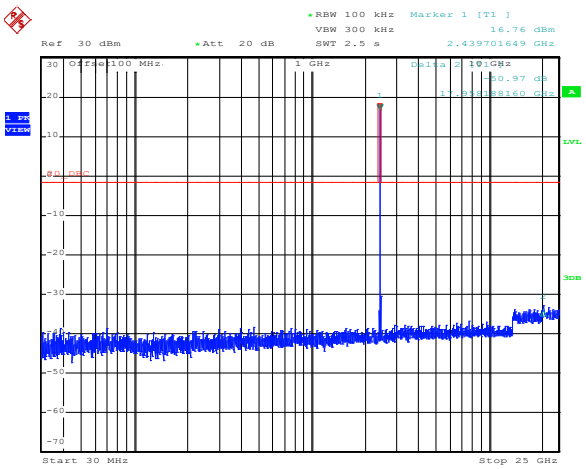


Figure 8.5-2: *Conducted spurious emissions, Tx-2438 MHz*

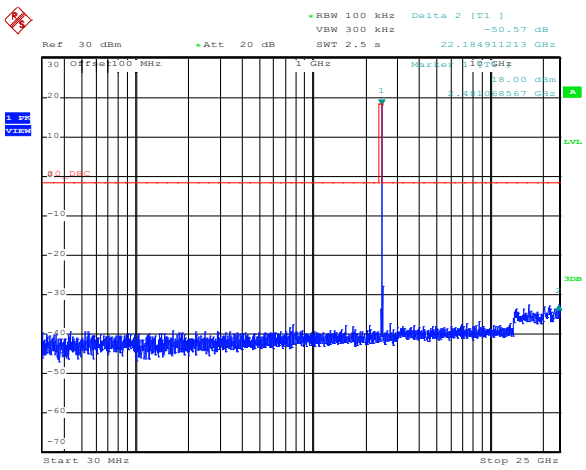


Figure 8.5-3: *Conducted spurious emissions, Tx-2480 MHz*

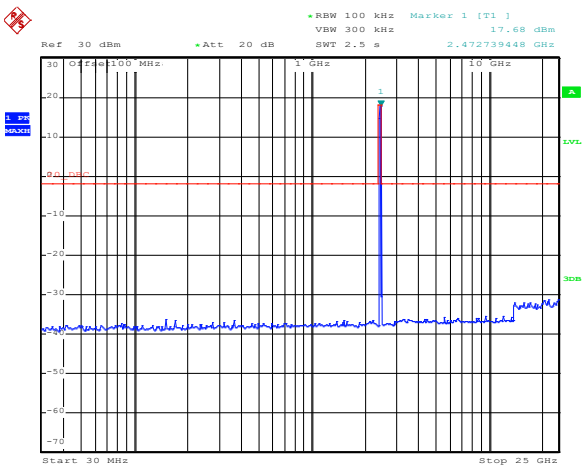


Figure 8.5-4: *Conducted spurious emissions, Tx-hopping*

8.5.4 Test data, continued

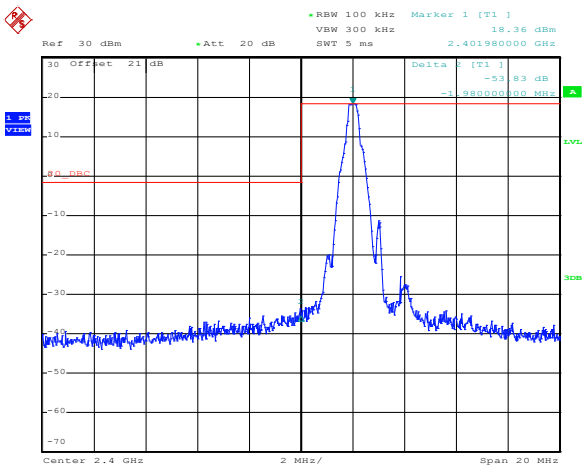


Figure 8.5-5: *Conducted spurious emissions at the lower band edge, Tx-2402 MHz*

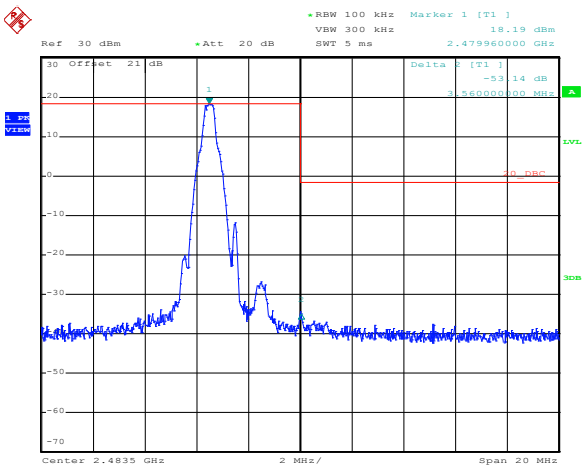


Figure 8.5-6: *Conducted spurious emissions at the upper band edge, Tx-2480 MHz*

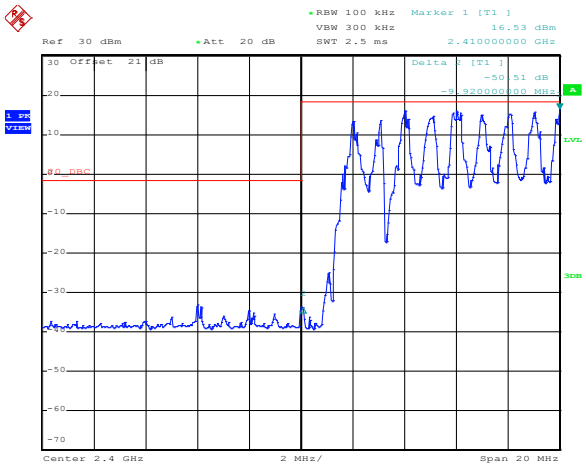


Figure 8.5-7: *Conducted spurious emissions at the lower band edge, Hopping*

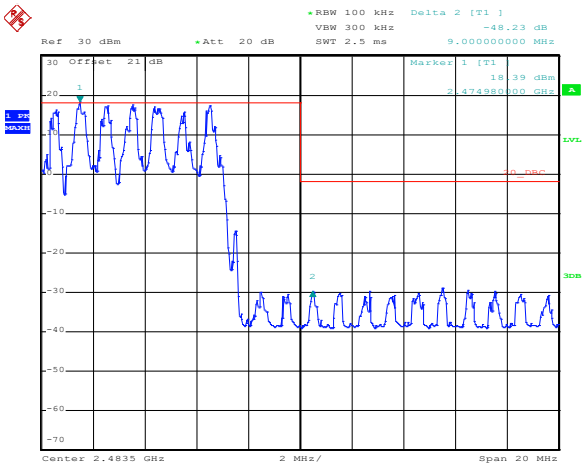


Figure 8.5-8: *Conducted spurious emissions at the upper band edge, Hopping*

8.5.4 Test data, continued

Duty cycle/average factor calculations

§15.35(c) When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed; the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

$$Duty\ cycle\ or\ average\ factor = 20 \times \log_{10}\left(\frac{Tx_{100_{ms}}}{100_{ms}}\right)$$

$$Duty\ cycle\ or\ average\ factor = 20 \times \log_{10}\left(\frac{0.82_{ms}}{100_{ms}}\right) = -41.72\ dB$$

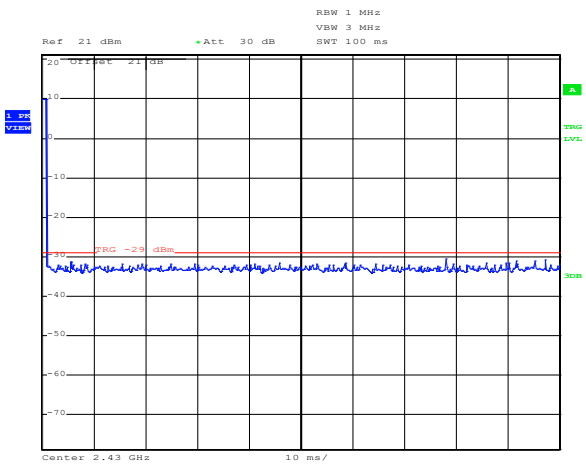


Figure 8.5-9: *Transmission within 100 ms*

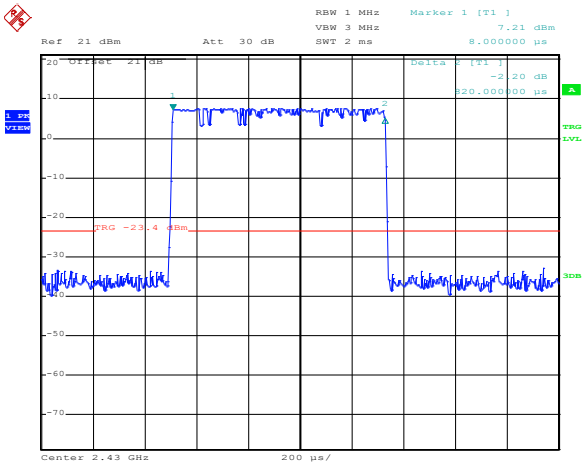


Figure 8.5-10: *pulse witdth = 0.82 ms*

Table 8.5-4: *Radiated Spurious emissions results*

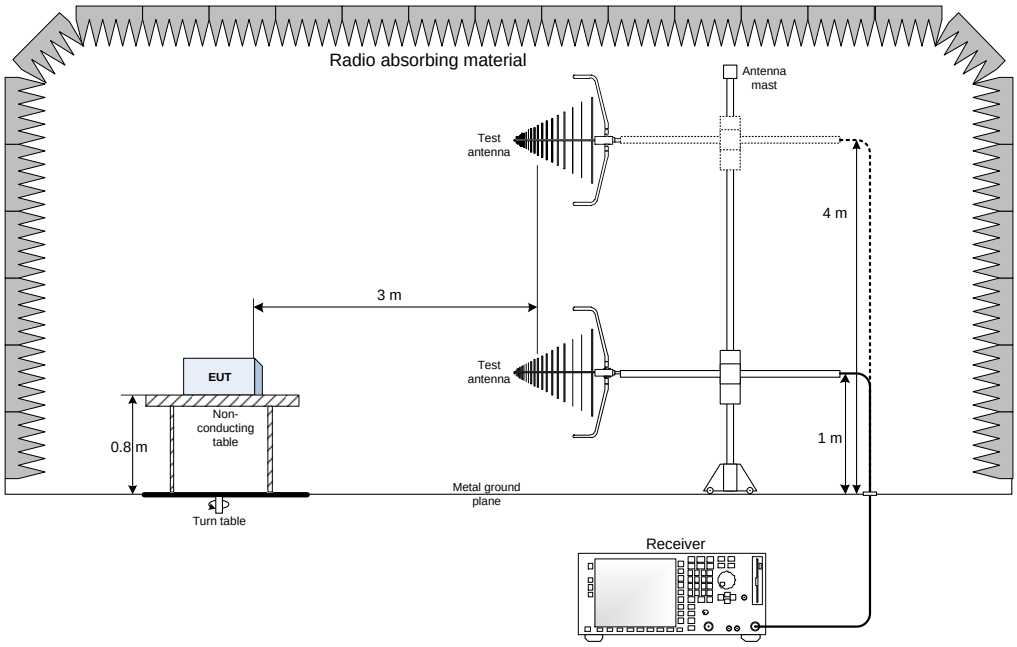
Mode	Frequency, MHz	Peak field strength, dBµV/m	Peak field strength limit (dBµV/m)	Peak field strength margin, (dB)	Duty cycle correction factor, (dB)	Calculated average field strength[1] (dBµV/m)	Average field strength limit (dBµV/m)	Average field strength margin, (dB)
High Chn. 2480 MHz	2483.5	73.5	74.0	0.5	-20.0	53.5	54.0	0.5
Low Chn. 2402 MHz	2390	62.4	74.0	11.6	-20.0	42.4	54.0	11.6
Tx Hopping	2483.5	71.2	74.0	2.8	-20.0	51.2	54.0	2.8
Tx Hopping	2390	50.3	74.0	23.7	-20.0	30.3	54.0	23.7

Notes: [1]Calculated average field strength (dBµV/m) = Peak field strength (dBµV/m) + Duty cycle correction factor (dB). Duty cycle correction factor as calculated from §15.35 (c)

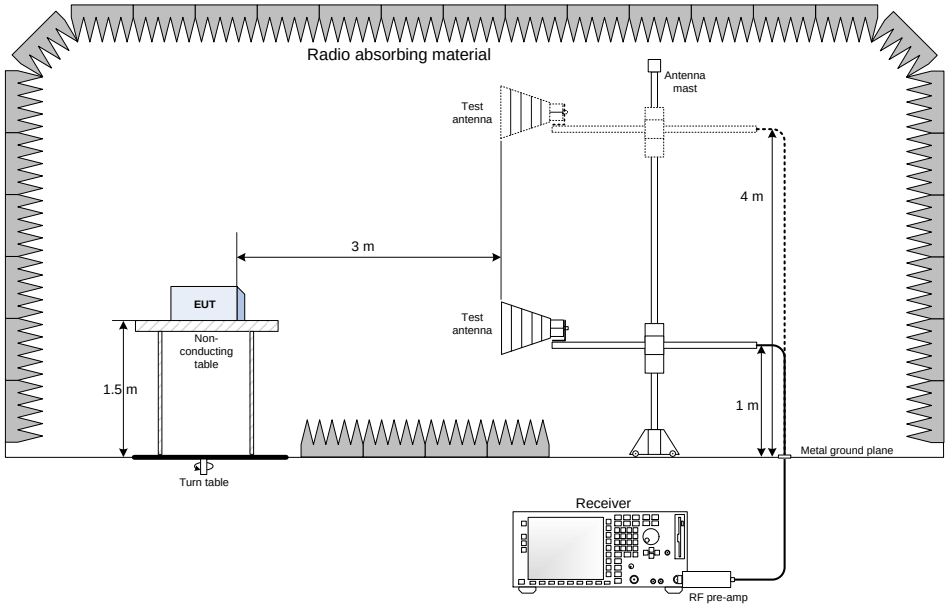
All other spurious emissions within restricted bands were greater than 20 dB from limit

Section 9. Block diagrams of test set-ups

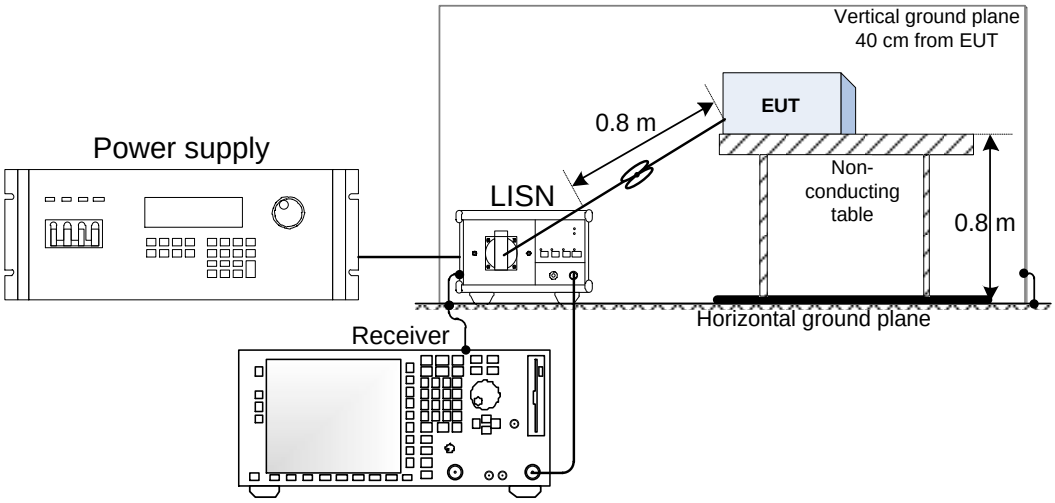
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 AC conducted emissions set-up



9.4 Antenna port set-up