



ONE WORLD • OUR APPROVAL

RADIO TEST REPORT – 337515-6TRFWL

Applicant:

BOT Home Automation Inc.

Product name:

Ring

Model:

Base Station

FCC ID:

2AEUPBHABS001

IC Registration number:

IC: 20271-BHABS001

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

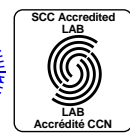
Date of issue: October 5, 2017

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	Montreal site: 292 Labrosse Avenue, Pointe-Claire, QC, Canada, H9R 5L8	Almonte site: 1500 Peter Robinson Road, West Carleton, ON, Canada, K0A 1L0
	Tel: +1 613 737 9680	Tel: +1 514 694 2684	Tel: +1 613 256-9117
	Fax: +1 613 737 9691	Fax: +1 514 694 3528	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

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

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

© Nemko Canada Inc.

Table of contents

Table of contents	3
Section 1. Report summary	4
1.1 Applicant and manufacturer	4
1.2 Test specifications	4
1.3 Test methods	4
1.4 Exclusions	4
1.5 Statement of compliance	4
1.6 Test report revision history	4
Section 2. Summary of test results	5
2.1 Testing period	5
2.2 FCC Part 15 Subpart C, general requirements test results	5
2.3 FCC Part 15 Subpart C, intentional radiators test results	5
2.4 ISSED RSS-GEN, Issue 4, test results	6
2.5 ISSED RSS-247, Issue 2, test results	6
Section 3. Equipment under test (EUT) details	7
3.1 Sample information	7
August 21, 2017 7	
3.2 EUT information	7
3.3 Technical information	7
3.4 Product description and theory of operation	7
3.5 EUT exercise details	7
3.6 EUT setup diagram	8
Section 4. Engineering considerations	9
4.1 Modifications incorporated in the EUT for compliance	9
4.2 Technical judgment	9
4.3 Deviations from laboratory tests procedures	9
Section 5. Test conditions	10
5.1 Atmospheric conditions	10
5.2 Power supply range	10
Section 6. Measurement uncertainty	11
6.1 Uncertainty of measurement	11
Section 7. Test equipment	12
7.1 Test equipment list	12
Section 8. Testing data	13
8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits	13
8.2 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for systems using digital modulation techniques	16
8.3 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements	18
8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions	21
8.5 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices	32
Section 9. Block diagrams of test set-ups	34
9.1 Radiated emissions set-up for frequencies below 1 GHz	34
9.2 Radiated emissions set-up for frequencies above 1 GHz	34
9.3 Conducted emissions set-up	35

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	BOT Home Automation Inc.
Address	1523 26 th Street, Santa Monica, California United States 90404

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

558074 D01 DTS Meas Guidance v04 (April 5, 2017)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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	October 5, 2017	Original report issued

Section 2. Summary of test results

2.1 Testing period

Test start date	August 25, 2017
Test end date	October 4, 2017

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(e)	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 antennas are located within the enclosure of EUT and not user accessible.

2.3 FCC Part 15 Subpart C, intentional radiators test results

Table 2.3-1: Result summary for Subpart C, intentional radiator

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	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	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	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation 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 for digitally modulated devices	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
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
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

Section	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing for frequency hopping systems	Not applicable
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	Not applicable
5.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
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 (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	Not applicable
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
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 21, 2017
Nemko sample ID number	Item # 3

3.2 EUT information

Product name	Ring
Model	Base Station
Serial number	BHHB11731PG000029

3.3 Technical information

Applicant IC company number	20271
IC UPN number	BHABS001
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)	2405
Frequency Max (MHz)	2475
RF power Min (W)	N/A
RF power Max (W), Conducted	0.083 (19.2 dBm)
Field strength, Units @ distance	N/A
Measured BW (MHz) (6 dB)	1.66
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	OQPSK
Emission classification (F1D, G1D, D1D)	G1D
Transmitter spurious, Units @ distance	62.2 dBμV/m Peak and 41.8 dBμV/m Average at 2483.5 MHz @ 3 m
Power requirements	5 V _{DC} (via external 100-240 VAC, 50/60 Hz power adapter)
Antenna information	Antenna gain is 5.8 dBi (Inverted F) The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

Communications Hub for Home Security Products

3.5 EUT exercise details

The EUT was setup in continuous transmit state.

3.6 EUT setup diagram

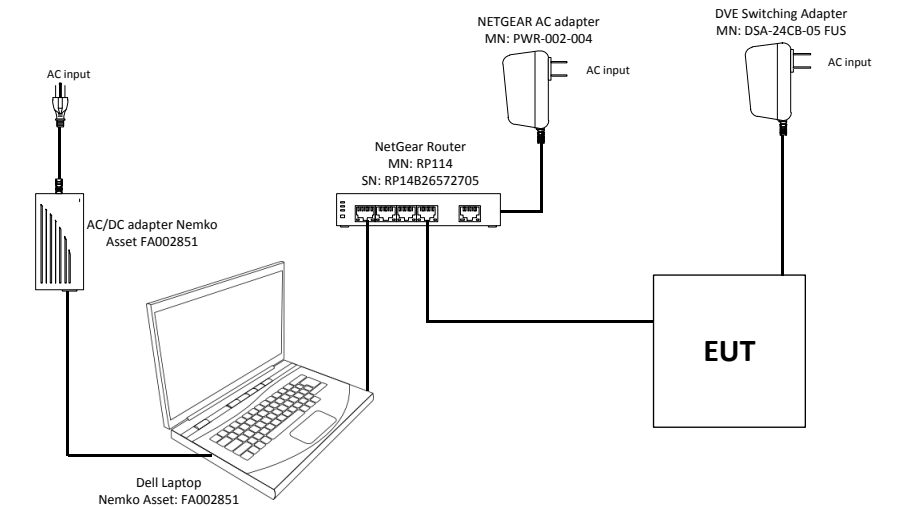


Figure 3.6-1: Setup diagram for radiated measurements

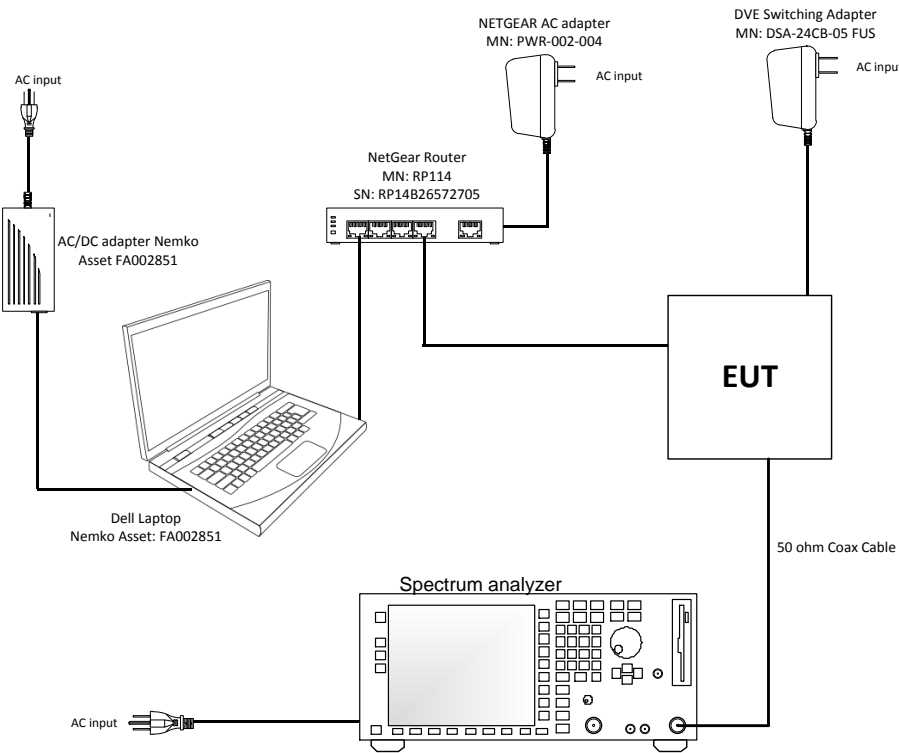


Figure 3.6-2: Setup diagram for antenna port (conducted) measurements

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

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	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 $\pm 5\%$, for which the equipment was designed.



Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

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

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

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.
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 31/18
AC Power source	Chenwa	2700M-10k	FA002716	—	VOU
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	May 19/18
50 Ω coax cable	C.C.A.	None	FA002556	1 year	May 2/18
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 1/17
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 31/18
Horn with Preamp	ETS-Lindgren	3117-PA	FA002840	1 year	Nov. 11/17
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	June 27/18
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	Huber + Suhner	None	FA002830	1 year	May 12/18
50 Ω coax cable	C.C.A.	None	FA002555	1 year	May 2/18
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 μ H/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, dB μ V	
	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	August 25, 2017	Temperature	22 °C
Test engineer	David Duchesne	Air pressure	1002 mbar
Test location	Ottawa	Relative humidity	67 %

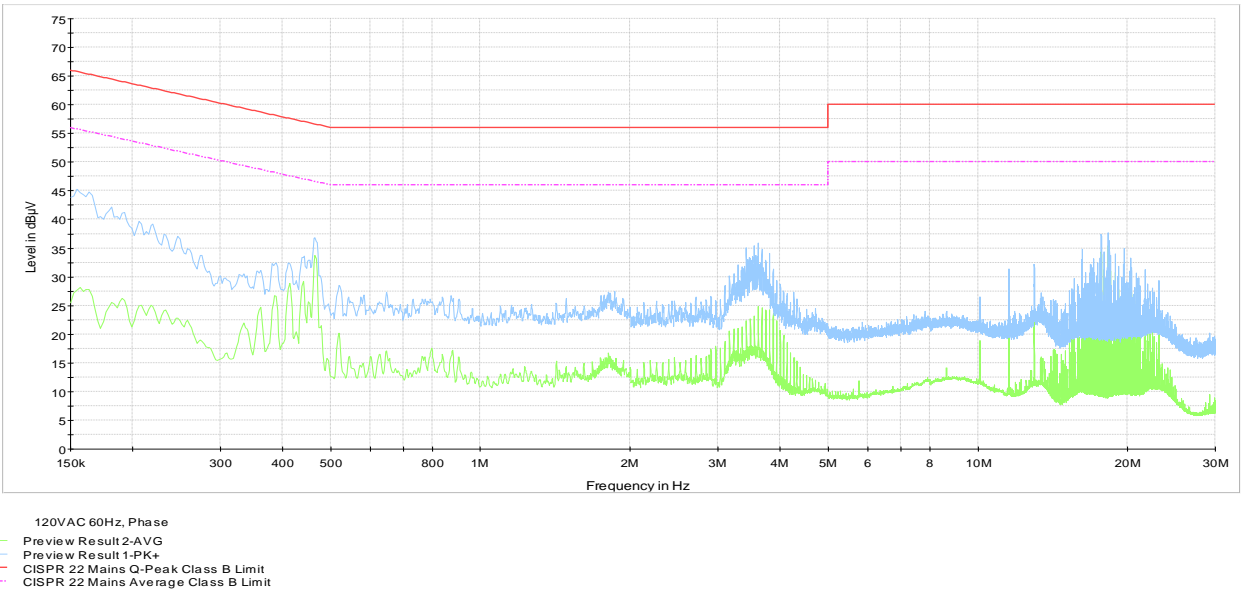
8.1.3 Observations, settings and special notes

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:

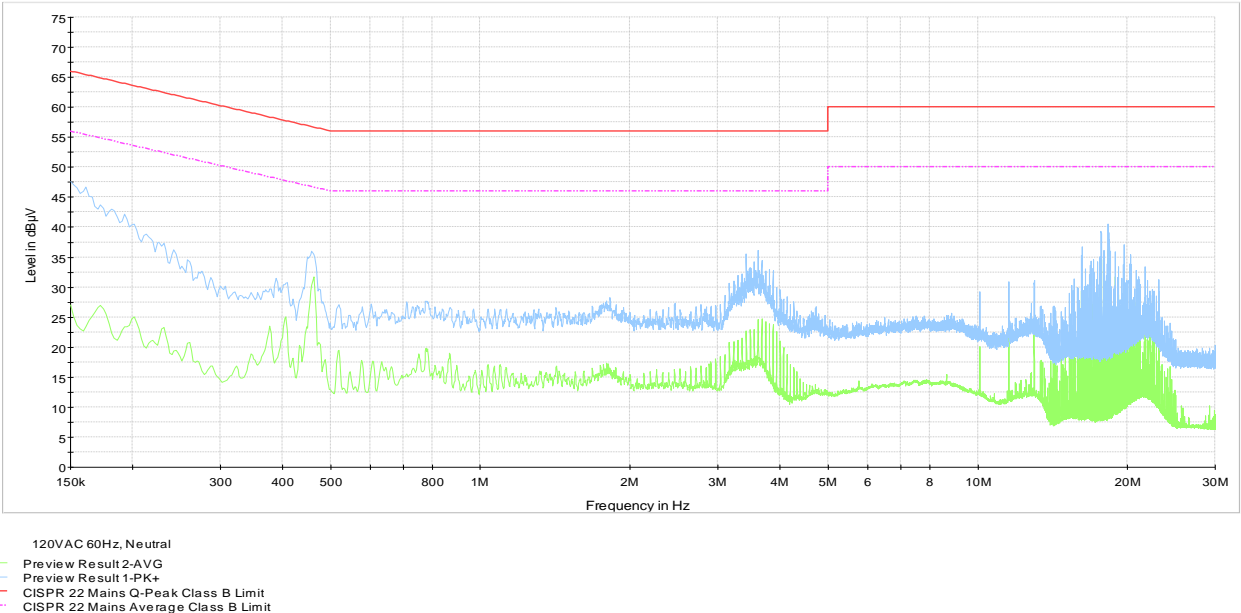
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview measurement), Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	<ul style="list-style-type: none">– 100 ms (Peak and Average preview measurement)– 100 ms (Quasi-peak final measurement)– 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)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for systems using digital modulation techniques

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:
- (2) 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.

IC RSS-247 Part 5.2:

- a. The minimum 6 dB bandwidth shall be 500 kHz.

8.2.2 Test summary

Verdict	Pass		
Test date	August 28, 2017	Temperature	25.1 °C
Test engineer	David Duchesne	Air pressure	1011 mbar
Test location	Ottawa	Relative humidity	44.1 %

8.2.3 Observations, settings and special notes

Measurements were performed as per 558074 D01 DTS Meas Guidance v04 (The test was performed using method described in Section 8.1)

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

Section 8

Test name

Specification

Testing data
FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for systems using digital modulation techniques
FCC Part 15 Subpart C and RSS-247, Issue 2



8.2.5 Test data

Table 8.2-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
2405	1.65	0.50	1.15
2435	1.66	0.50	1.16
2475	1.65	0.50	1.15

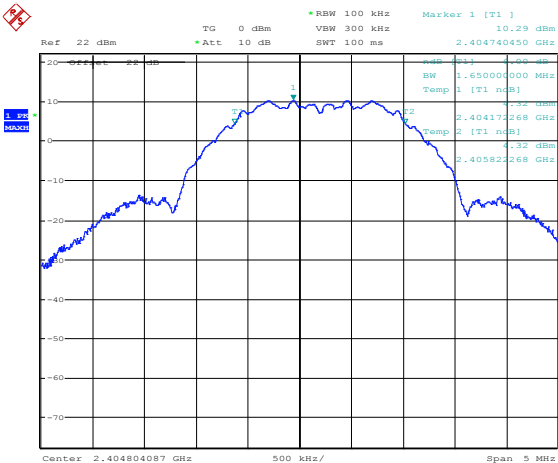


Figure 8.2-1: 6 dB bandwidth on low channel

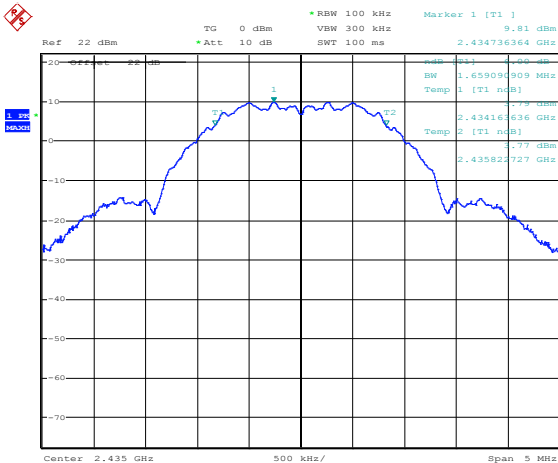


Figure 8.2-2: 6 dB bandwidth on mid channel

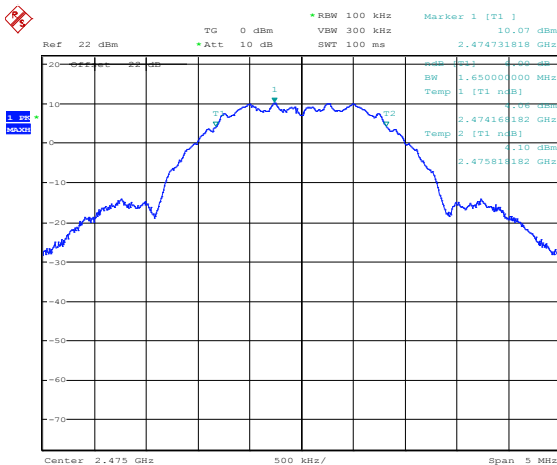


Figure 8.2-3: 6 dB bandwidth on high channel

8.3 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC §15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 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 peak 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 (b)(3)(i) and (b)(3)(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 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.

IC RSS-247 Part 5.4:

- d. For DTSS employing digital modulation techniques operating in the bands 902–928 MHz and 2400–2483.5 MHz, 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 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.

8.3.1 Definitions and limits, continued

IC RSS-247 Part 5.4:

- f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:
 - i. Different information must be transmitted to each receiver.
 - ii. If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or staff having the highest gain.
 - iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.
 - iv. Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

8.3.2 Test summary

Verdict	Pass		
Test date	October 4, 2017	Temperature	22 °C
Test engineer	David Duchesne	Air pressure	1023 mbar
Test location	Ottawa	Relative humidity	60 %

8.3.3 Observations, settings and special notes

- Measurements were performed as per 558074 D01 DTS Meas Guidance v04 (The test was performed using method described in Section 9.1.1).
- The spectral plots have been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).

Spectrum analyser settings:

Resolution bandwidth	3 MHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	40 MHz
Detector mode	Peak
Trace mode	Max Hold

8.3.4 Test data

Table 8.3-1: Output power measurements results

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2405	19.2	30.0	10.8	5.8	25.0	36.0	11.0
2435	18.9	30.0	11.1	5.8	24.7	36.0	11.3
2475	18.7	30.0	11.3	5.8	24.5	36.0	11.5

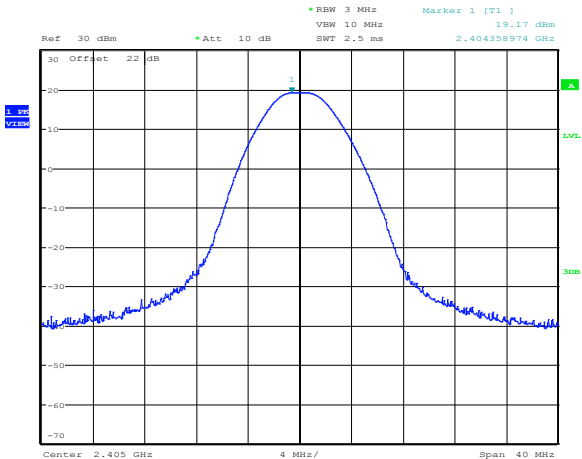


Figure 8.3-1: Peak output power on low channel

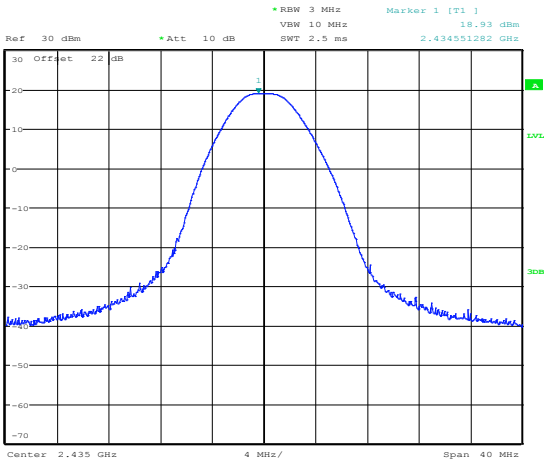


Figure 8.3-2: Peak output power on mid channel

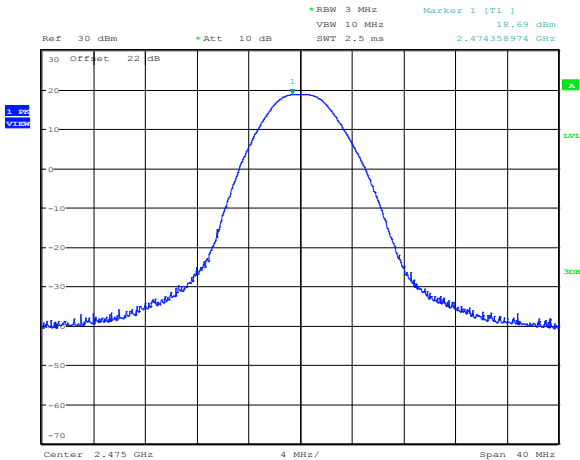


Figure 8.3-3: Peak output power on high channel

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

8.4.1 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 8.4-1: 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 8.4-2: ISSED 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 8.4-3: 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

8.4.2 Test summary

Verdict	Pass		
Test date	October 4, 2017	Temperature	22 °C
Test engineer	David Duchesne	Air pressure	1023 mbar
Test location	Ottawa	Relative humidity	60 %

8.4.3 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 from 30 MHz to 18 GHz. Radiated measurements above 18 GHz were performed at a distance of 1 m.
- Since fundamental power was tested using peak method, the spurious emissions limit is –20 dBc/100 kHz.
- For radiated emissions within restricted bands:
 - Measurements were performed as per ANSI C63.10: 2013 Section 12.7.5 and Section 12.7.6 for peak measurements.
 - Measurements were performed as per ANSI C63.10: 2013 Section 12.7.7 for average measurements
- For radiated emissions @ band edge:
 - Measurements were performed as per 558074 D01 DTS Meas Guidance v04 Section 13.3.1 for Trace averaging with continuous EUT transmission at full power.
- For antenna-port conducted:
 - Measurements were performed as per 558074 D01 DTS Meas Guidance v04 Section 12.2.4 for peak measurements.
- The spectral plots have been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators)

8.4.3 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:	3 MHz
Detector mode:	RMS
Trace mode:	Average (100 Traces)

Spectrum analyser settings for average radiated measurements at bands edge:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	RMS
Trace mode:	Average (100 Traces)
Span:	2 MHz (Instrument set to center frequency of the emission to be measured (within 2 MHz of the authorized band edge).

8.4.4 Test data

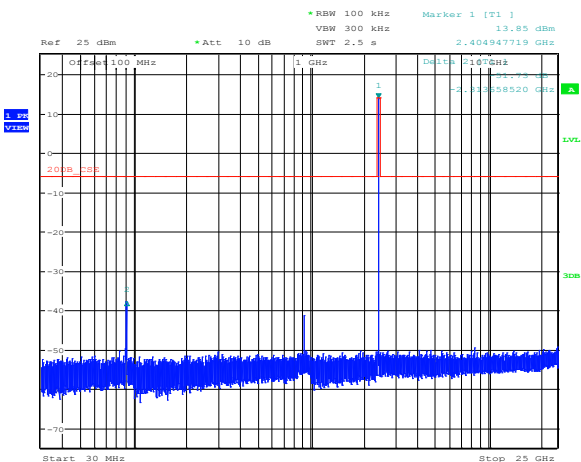


Figure 8.4-1: Conducted spurious emissions on low channel

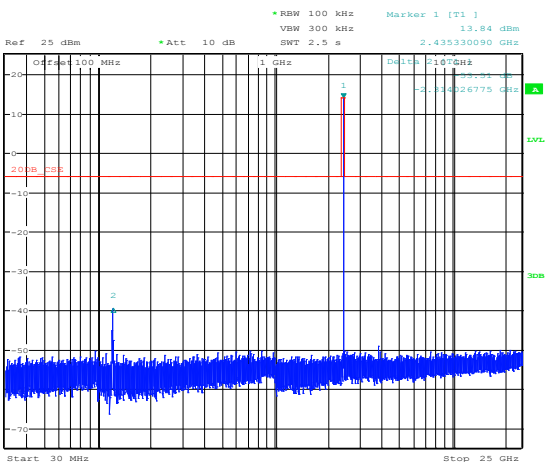


Figure 8.4-2: Conducted spurious emissions on mid channel

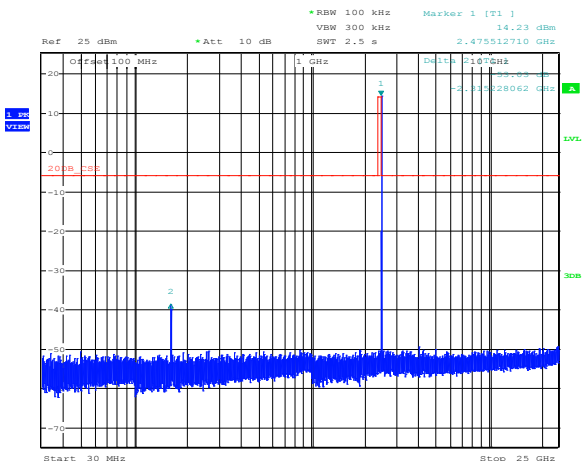


Figure 8.4-3: Conducted spurious emissions on high channel

8.4.4 Test data, continued

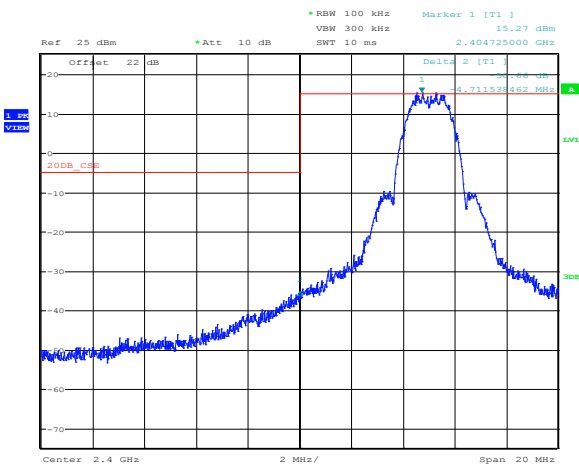


Figure 8.4-4: Conducted spurious emissions at the lower band edge, low channel

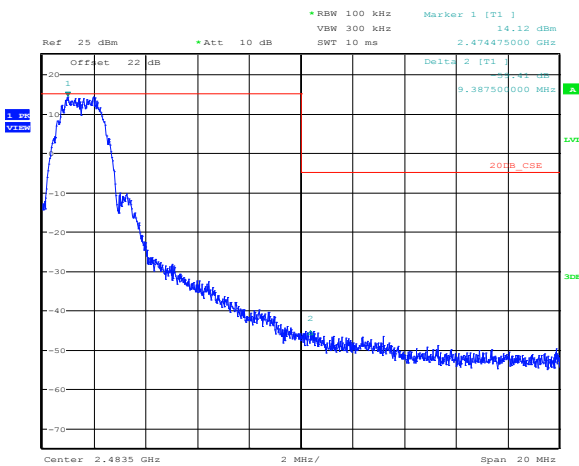
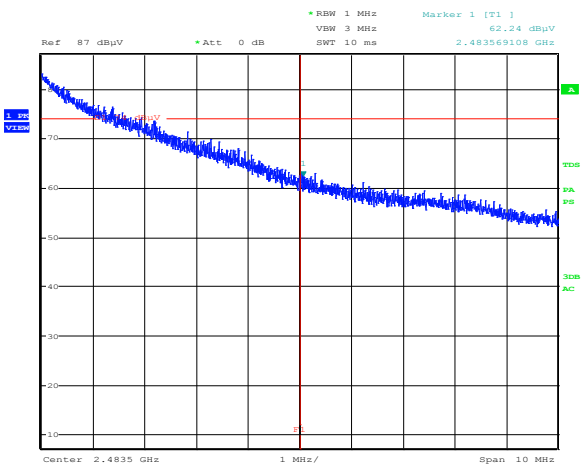


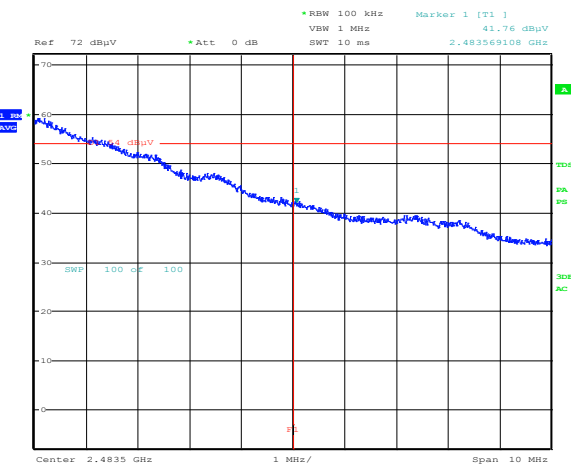
Figure 8.4-5: Conducted spurious emissions at the upper band edge, high channel

8.4.4 Test data, continued



Date: 4.OCT.2017 12:06:01

Figure 8.4-6: Radiated emissions at the upper band edge, peak



Date: 4.OCT.2017 12:08:14

Figure 8.4-7: Radiated emissions at the upper band edge, average

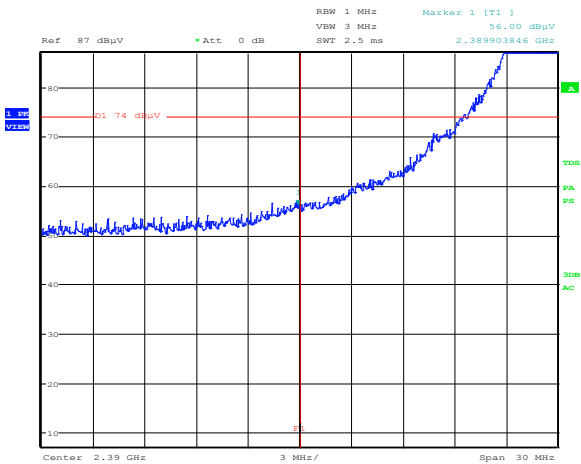


Figure 8.4-8: Radiated restricted bands spurious emissions at 2.39 GHz ,
peak

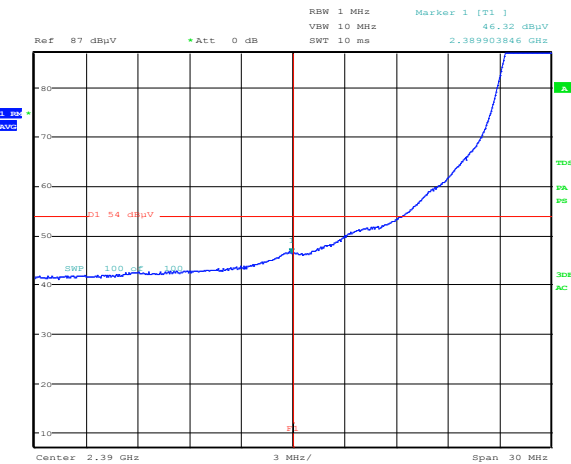


Figure 8.4-9: Radiated restricted bands spurious emissions at 2.39 GHz ,
average

Table 8.4-4: Radiated field strength measurement results

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	56.0	74.0	18.0	46.3	54.0	7.7
High	2483.5	62.2	74.0	11.8	41.8	54.0	12.2

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

8.4.4 Test data, continued

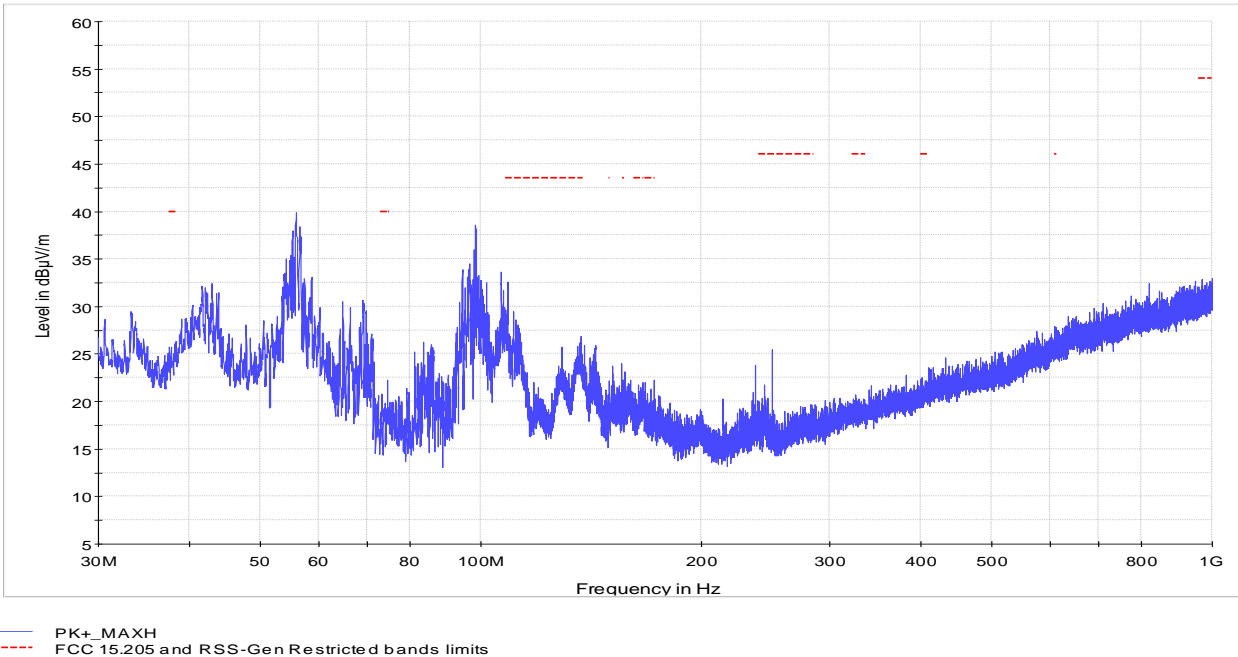


Figure 8.4-10: Radiated spurious emissions below 1 GHz, low channel

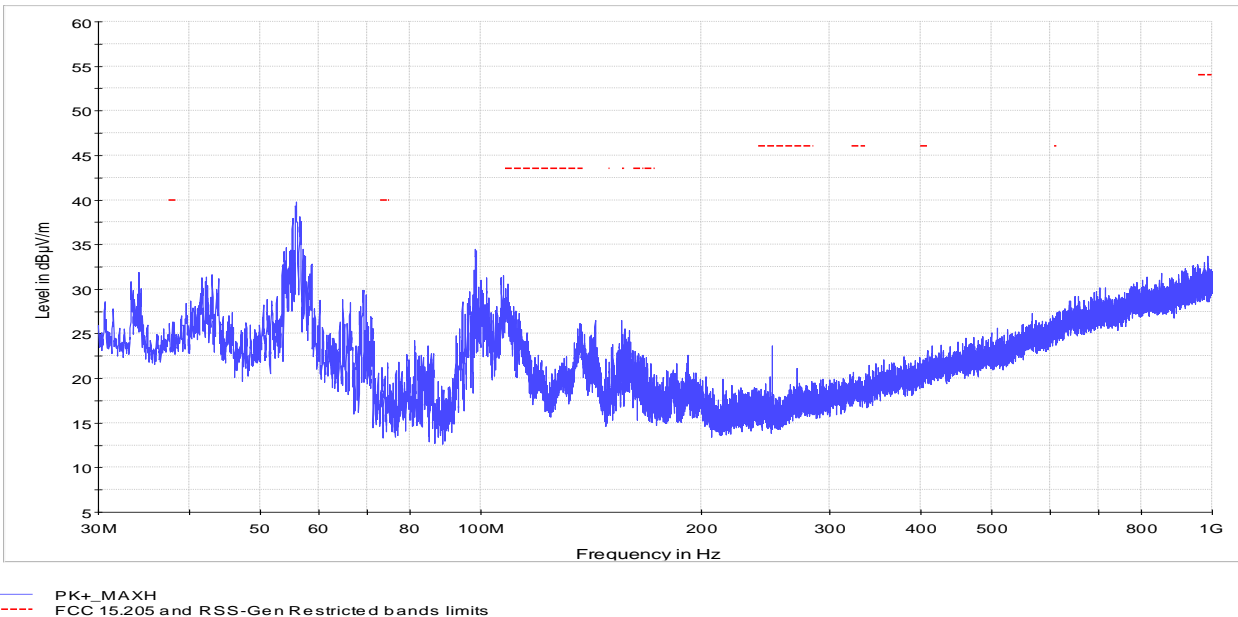


Figure 8.4-11: Radiated spurious emissions below 1 GHz, mid channel

8.4.4 Test data, continued

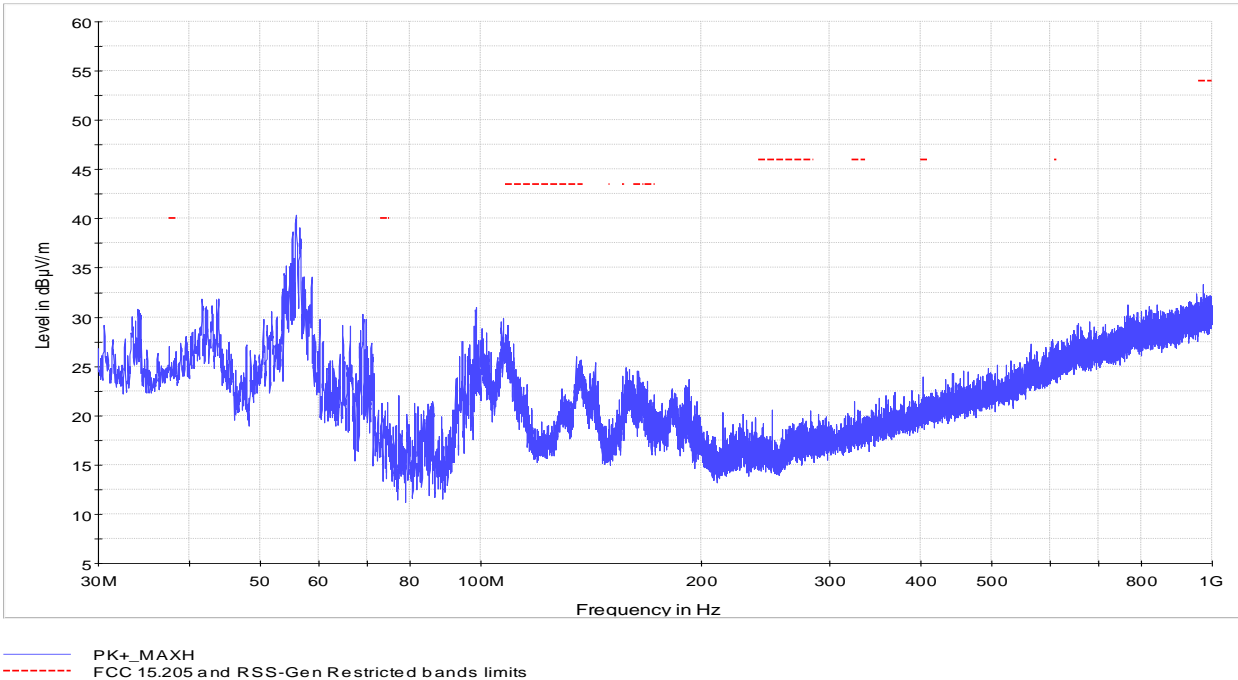


Figure 8.4-12: Radiated spurious emissions below 1 GHz, high channel

8.4.4 Test data, continued

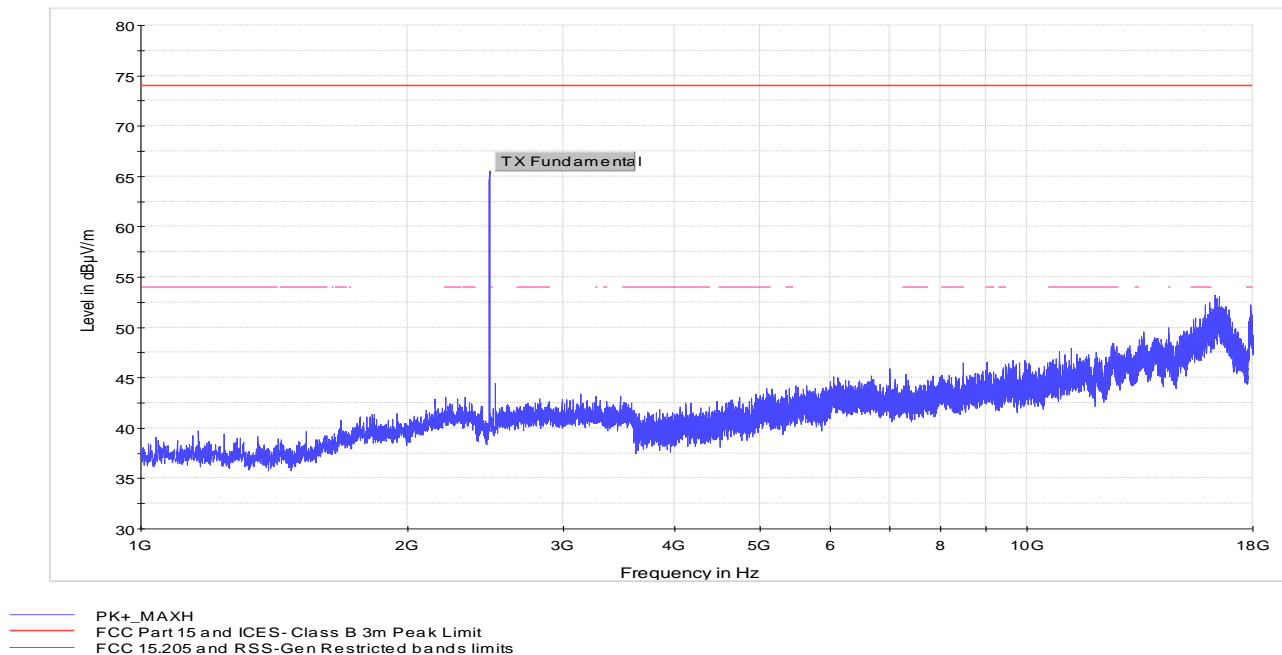


Figure 8.4-13: Radiated spurious emissions within 1–18 GHz, low channel

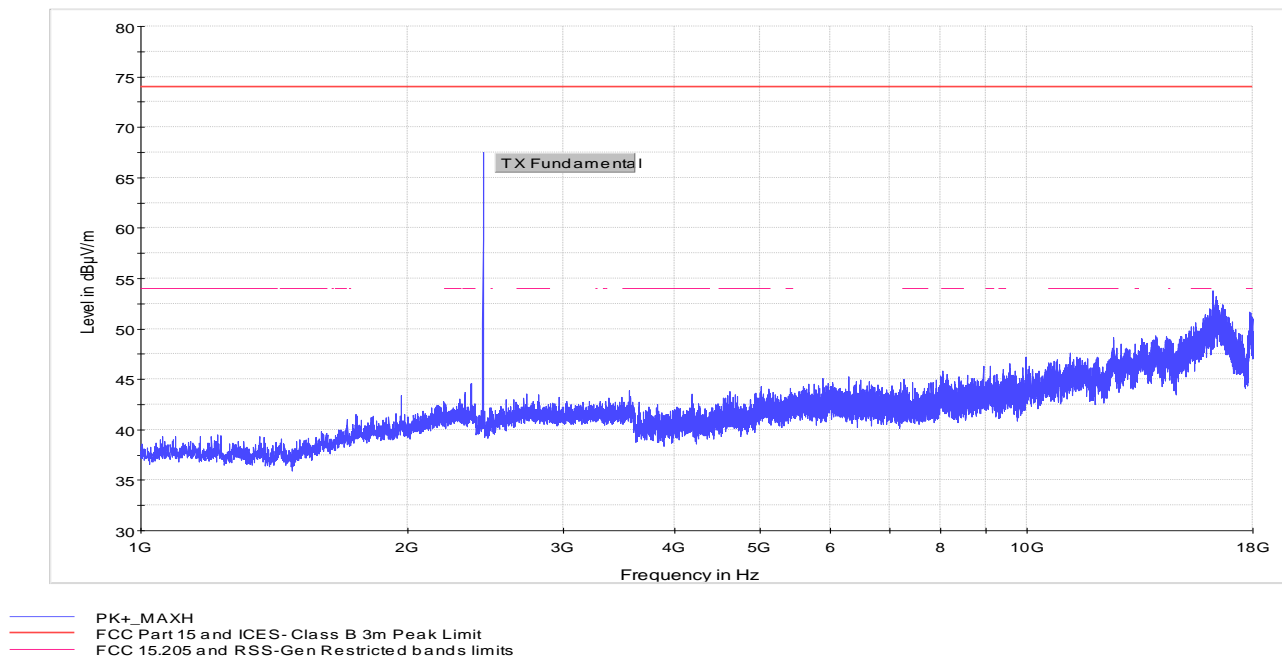


Figure 8.4-14: Radiated spurious emissions within 1–18 GHz, mid channel

8.4.4 Test data, continued

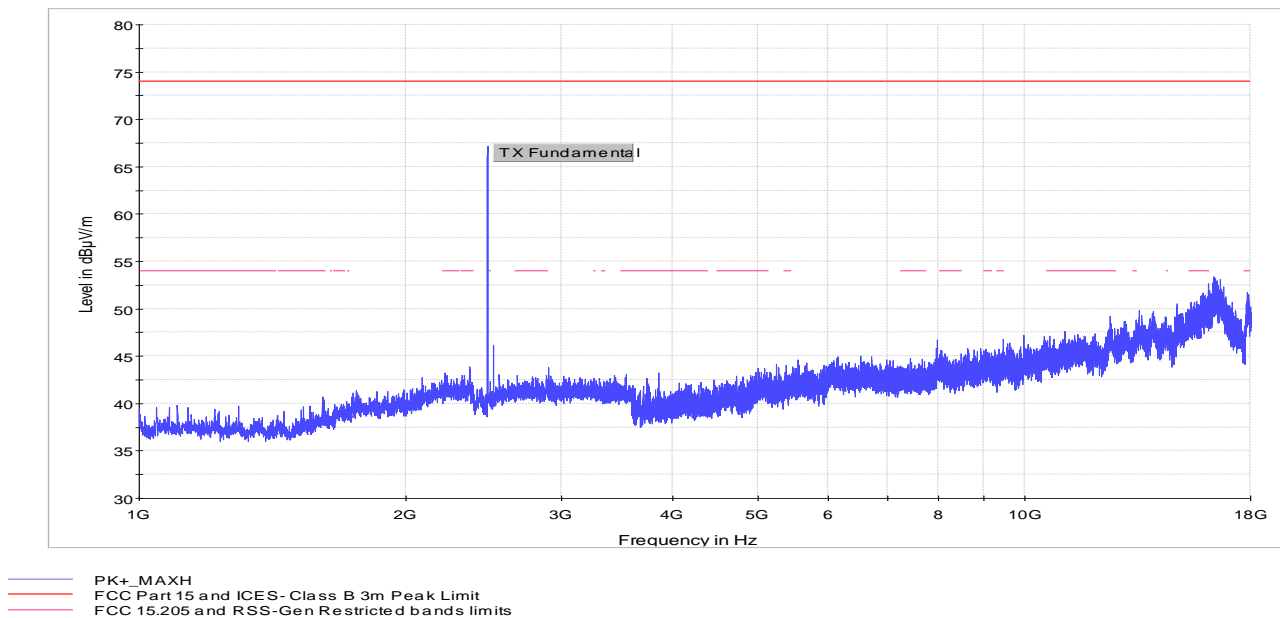


Figure 8.4-15: Radiated spurious emissions within 1–18 GHz, high channel

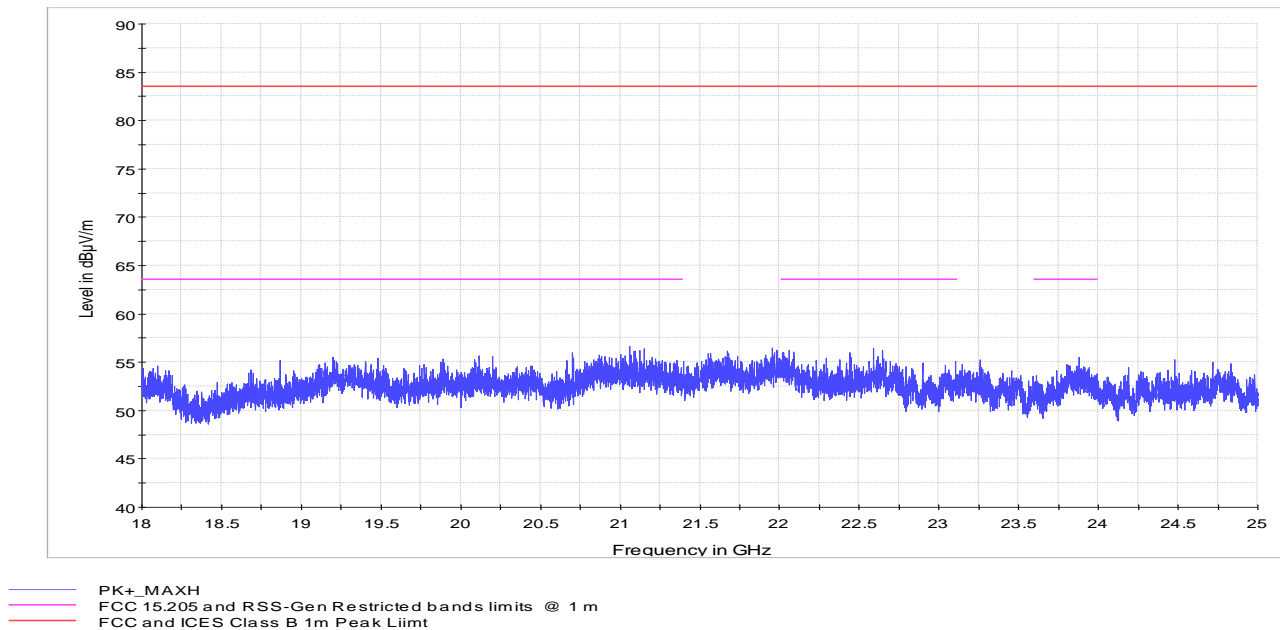


Figure 8.4-16: Radiated spurious emissions within 18–25 GHz, low channel

8.4.4 Test data, continued

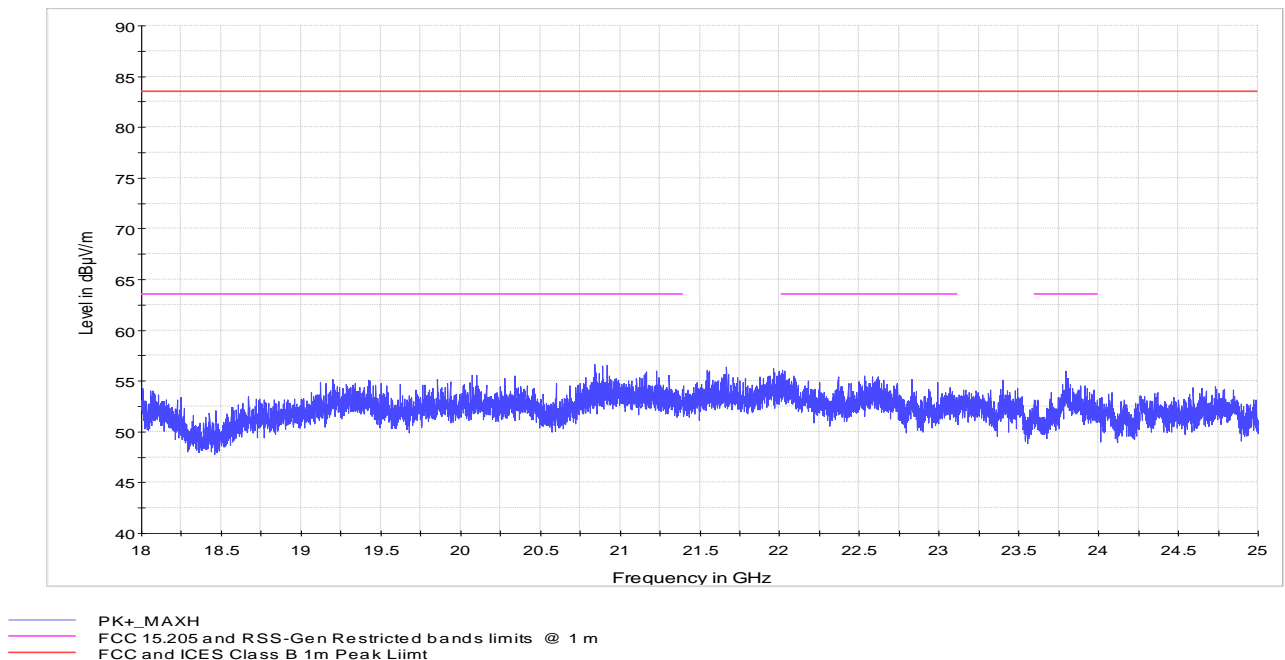


Figure 8.4-17: Radiated spurious emissions within 18–25 GHz, mid channel

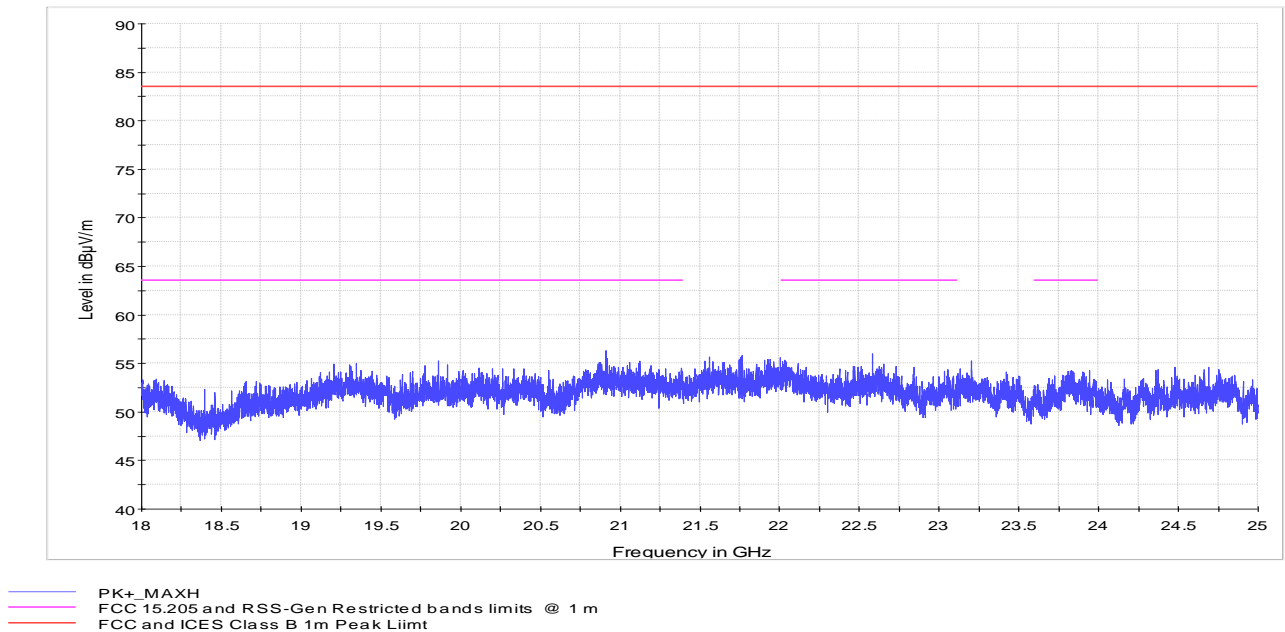


Figure 8.4-18: Radiated spurious emissions within 18–25 GHz, high channel

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

8.5.1 Definitions and limits

FCC §15.247 (e):

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.

IC RSS-247 Part 5.5:

- b. 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).

8.5.2 Test summary

Verdict	Pass		
Test date	October 4, 2017	Temperature	22 °C
Test engineer	David Duchesne	Air pressure	1023 mbar
Test location	Ottawa	Relative humidity	60 %

8.5.3 Observations, settings and special notes

Measurements were performed as per 558074 D01 DTS Meas Guidance v04 (The test was performed using method described in Section 10.2)

Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	5 MHz
Detector mode:	Peak
Trace mode:	Max-hold

8.5.4 Test data

Table 8.5-1: PSD measurements results

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2405	2.2	8.0	5.8
2435	1.9	8.0	6.1
2475	3.0	8.0	5.0

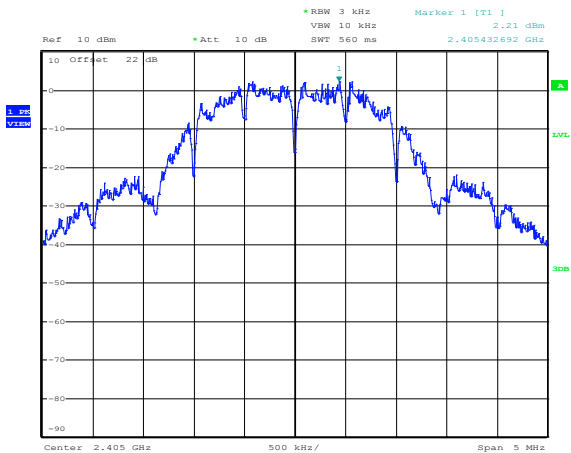


Figure 8.5-1: PSD sample plot on low channel

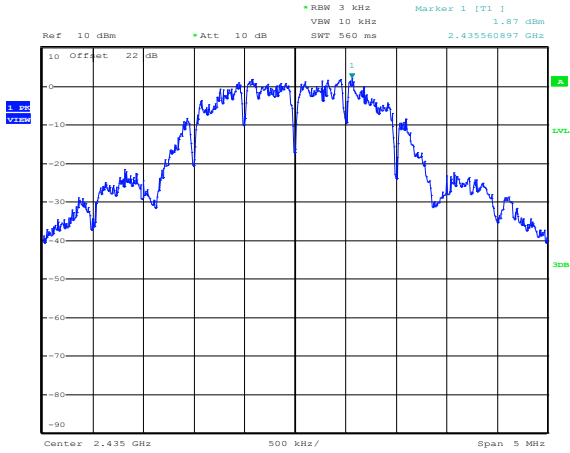


Figure 8.5-2: PSD sample plot on mid channel

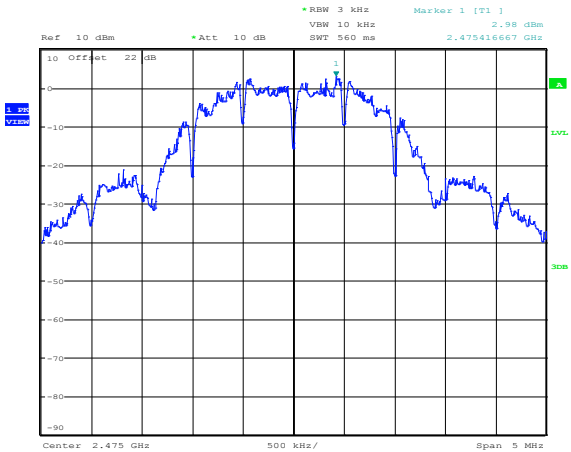
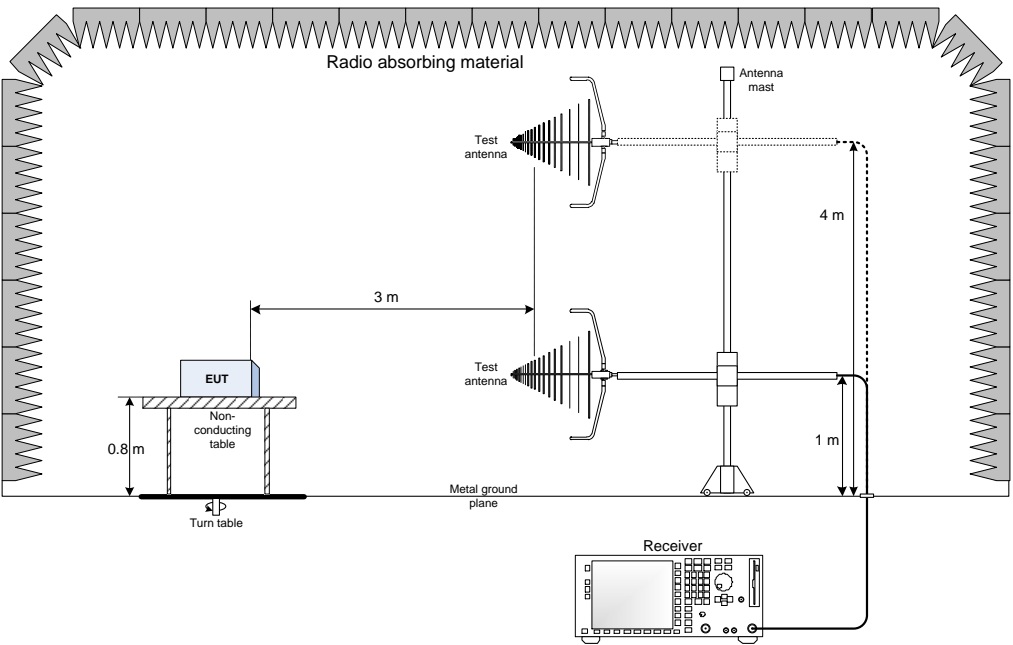


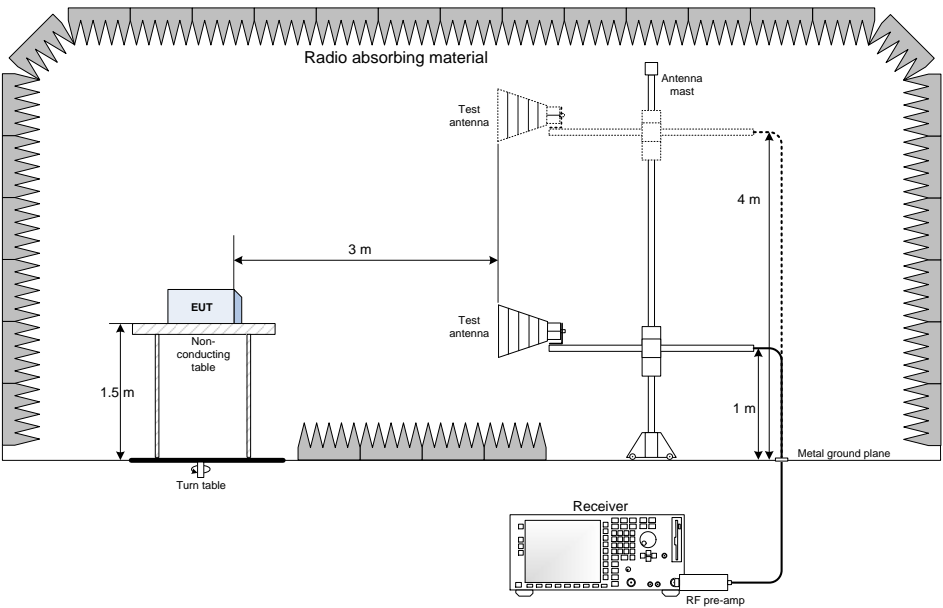
Figure 8.5-3: PSD sample plot on high channel

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



9.3 Conducted emissions set-up

