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RADIO TEST REPORT – 337515-9TRFWL

Applicant:

BOT Home Automation Inc.

Product name:

Ring

Model:

Base Station

FCC ID:

2AEUPBHABS001

IC Registration number:

20271-BHABS001

Specifications:

Co-location testing

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 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

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	BOT Home Automation Inc.
Address	1523 26th 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
FCC 47 CFR Part 15, Subpart E, Clause 15.407	Unlicensed National Information Infrastructure Devises
FCC 47 CFR Part 15, Subpart C, Clause 15.249	Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz, and 24.0–24.25 GHz.
FCC 47 CFR Part 22, Subpart C, Clause 22.359	Emission limitations.
RSS-247, Issue 2, Feb 2017, Section 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
RSS-247, Issue 2, Feb 2017, Section 6	Technical requirements for licence-exempt local area network devices and digital transmission systems operating in the 5 GHz band
RSS-210 Issue 9, August 2016, Annex B.10	Devices operating in 902–928, 2400–2483.5 and 5725–5875 MHz
RSS-139 Issue 3, July 2015, Section 6	Advanced Wireless Services (AWS) Equipment Operating in the Bands 1710-1780 MHz and 2110-2180 MHz

1.3 Test methods

789033 D02 General UNII Test Procedures New Rules v01r04 (May2, 2017)	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013)	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
662911 D02 MIMO with Cross Polarized Antenna v01 (October 25, 2011)	Emissions testing of transmitters with multiple outputs in the same band (MIMO) with Cross Polarized Antenna
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

As per Nemko quote Q102124338R1, the EUT was assessed for radiated emissions as a verification with multiple transmitters enabled at the same time to ensure compliance was maintained.

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 or as per detailed in the section 1.4 Exclusions above. 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	September 18, 2017
Test end date	September 18, 2017

2.2 FCC test results

Table 2.2-1: *Result summary*

Part	Section	Test description	Verdict
§15.247	d	Unwanted emissions (Radiated)	Pass
§15.249	d	Spurious emissions (except harmonics)	Pass
§15.407	(b)(1)	Undesirable emission limits (Operating in the band 5.15-5.25 GHz)	Pass
§22.359	(a)	Out of band emissions	Pass

Notes:
– The EUT was only assessed for the radiated emissions. No conducted measurements were performed.
– Only emissions that were a product of multiple transmitters enabled were verified for continued compliance.

2.3 RSS test results

Table 2.3-1: *Result summary RSS*

Part	Section	Test description	Verdict
RSS-247	5.5	Unwanted emissions[1]	Pass
RSS-210	B.10 (b)	Spurious emissions (except for harmonics)	Pass
RSS-247	6.2.1.2	Unwanted emission limits (Operating in the band 5.15-5.25 GHz)	Pass
RSS-139	6.6	Transmitter Unwanted Emissions	Pass

Notes:
– The EUT was only assessed for the radiated emissions. No conducted measurements were performed.
– Only emissions that were a product of multiple transmitters enabled were verified for continued compliance.

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	WL18DBMOD
All used IC test site(s) Reg. number	2040A-4

Table 3.3-1: *Antenna information*

LTE Antenna	Antenna type	Band 12 Peak gain, dBi	Band 5 peak gain, dBi	Band 4 peak gain, dBi
Main	Monopole	2.7	1.5	5.4
Diversity	Monopole	1	1.5	3.9
Wi-Fi Antenna	**Antenna type**		**2.4 GHz Band peak gain, dBi**	**5 GHz Band peak gain, dBi**
Wi-Fi Right	Inverted F		3.3	4.6
Wi-Fi Left	Inverted F		3.9	4.6
Dual band antenna	**Antenna type**		**900 MHz Band peak gain, dBi**	**2.4 GHz Band peak gain, dBi**
Z-Wave	Inverted F		1.2	NA
Zigbee	Inverted F		NA	5.8

Notes: None

3.4 Co-location test plan

Table 3.4-1: *Co-Location configurations*

Radio module device	Radio parameters
Configuration 1: LTE + ZigBee + Z-Wave + SimpleLink (TI1310)	
LTE	1728 MHz
Zigbee	Low Channel 11: 2405 MHz
Z-Wave	High Channel 916 MHz
SimpleLink (TI1310)	High Channel 927.8 MHz
Configuration 2: BT + ZigBee + Z-Wave + SimpleLink (TI1310)	
BT	Low Channel 00: 2402 MHz
Zigbee	Low Channel 11: 2405 MHz
Z-Wave	High Channel 916 MHz
SimpleLink (TI1310)	High Channel 927.8 MHz
Configuration 3: WiFi 2.4 GHz + ZigBee + Z-Wave + SimpleLink (TI1310)	
WIFI	Low Channel 01: 2412 MHz
Zigbee	Low Channel 11: 2405 MHz
Z-Wave	High Channel 916 MHz
SimpleLink (TI1310)	High Channel 927.8 MHz
Configuration 4: WiFi 5 GHz + ZigBee + Z-Wave + SimpleLink (TI1310)	
WIFI (UNI band)	Low Channel 36: 5180 MHz
Zigbee	Low Channel 11: 2405 MHz
Z-Wave	High Channel 916 MHz
SimpleLink (TI1310)	High Channel 927.8 MHz

Notes: None

3.5 Product description and theory of operation

Communications Hub for Home Security Products

3.6 EUT exercise details

The EUT was setup in continuous transmit state.

3.7 EUT setup diagram

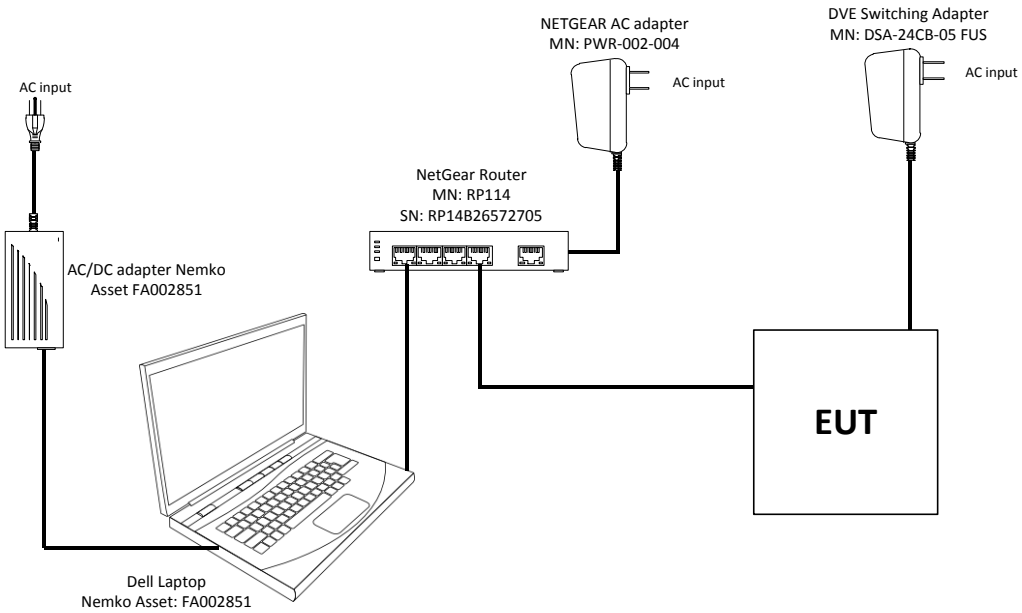


Figure 3.7-1: *Setup diagram*

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

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 ±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
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.
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 31/18
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 1/17
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
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
Notch filter 5150–5350 MHz	Microwave Circuits	5150–5350 MHz	FA001941	—	VOU
High pass filter	Microwave Circuits	H1G212G1	FA002342	—	VOU

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

Section 8. Testing data

8.1 Spurious emissions caused by co-located transmitters

8.1.1 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)).

FCC §15.249 (d):

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

FCC §15.407 (b):

(1) For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of −27 dBm/MHz.
(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.
(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209.
(7) The provisions of § 15.205 apply to intentional radiators operating under this section.
(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency block edges as the design of the equipment permits.

FCC §22.359 (a)

Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log (P) dB.

RSS-210 Section B.10 (b):

Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

RSS-247 Section 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.

RSS-247 Section 6.2.1.2:

For transmitters operating in the band 5150–5250 MHz, all emissions outside the band 5150–5350 MHz shall not exceed −27 dBm/MHz e.i.r.p. However, any unwanted emissions that fall into the band 5250–5350 MHz must be 26 dBc, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth, above 5.25 GHz. Otherwise, the transmission is considered as intentional and the devices shall implement dynamic frequency selection (DFS) and transmitter power control (TPC) as per the requirements for the band 5250–5350 MHz.

RSS-139 Section 6.6:

i. In the first 1.0 MHz bands immediately outside and adjacent to the equipment's smallest operating frequency block,Footnote 2 which can contain the equipment's occupied bandwidth, the emission power per any 1% of the emission bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least 43 + 10 log10 p (watts) dB.
ii. After the first 1.0 MHz outside the equipment's smallest operating frequency block, which can contain the equipment's occupied bandwidth, the emission power in any 1 MHz bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least 43 + 10 log10 p (watts) dB.

IC RSS-Gen Section 8.10:

Restricted bands, identified in table 6 of RSS-Gen Section 8.10, are designated primarily for safety-of-life services (distress calling and certain aeronautical bands), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following restrictions apply:

a. fundamental components of modulation of licence-exempt radio apparatus shall not fall within the restricted bands of below;
b. unwanted emissions falling into restricted bands of below shall comply with the limits specified in RSS-Gen;
c. unwanted emissions not falling within restricted frequency bands shall either comply with the limits specified in the applicable RSS, or with those specified in RSS-Gen.

8.1.1 Definitions and limits, continued

Table 8.1-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, 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 8.1-2: *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

8.1.2 Definitions and limits, continued

Table 8.1-3: *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

8.1.3 Test summary

Verdict	Pass		
Test date	September 18, 2017	Temperature	21 °C
Test engineer	David Duchesne	Air pressure	995 mbar
Test location	Ottawa	Relative humidity	50 %

8.1.4 Observations, settings and special notes

- The spectrum was searched from 30 MHz to 18 GHz.
- The spectral plots have been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators).
- Radiated measurements were performed at a distance of 3 m

8.1.3 Observations, settings and special notes

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)

For WIFI

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).

8.1.4 Test data

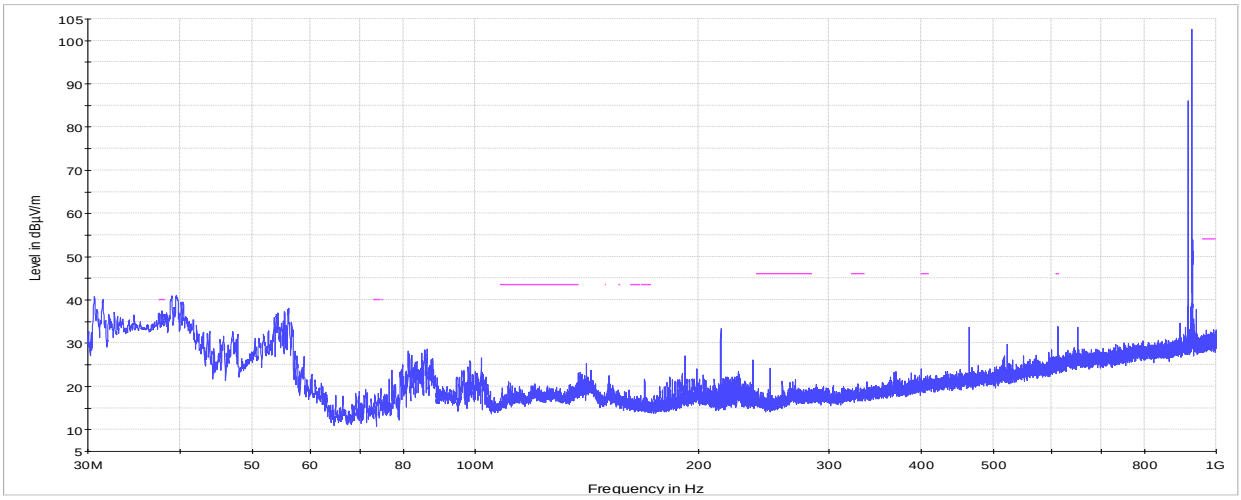
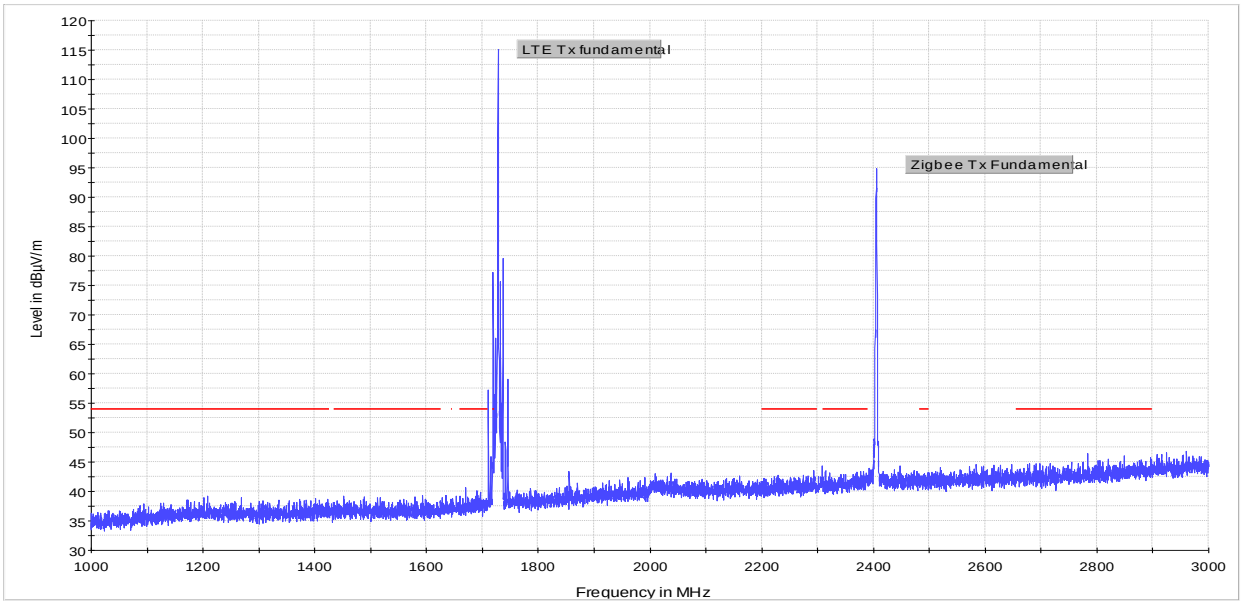


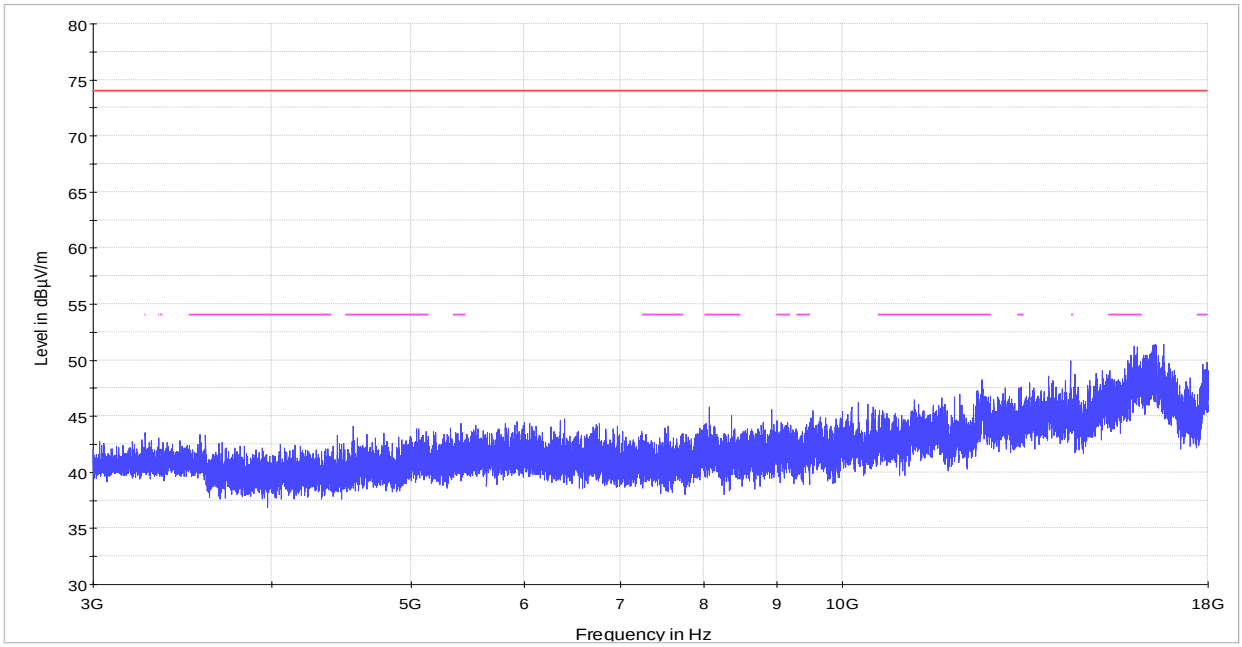
Figure 8.1-1: *Radiated spurious emissions products from co-located transmitters, Configuration 1*



The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators.

Figure 8.1-2: *Radiated spurious emissions products from co-located transmitters within 1–3 GHz, Configuration 1*

8.1.4 Test data, continued



The spectral plot is a summation of a vertical and horizontal scan. The spectral scan has been corrected with the associated transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators.

Figure 8.1-3: *Radiated spurious emissions products from co-located transmitters within 3–18 GHz, Configuration 1*

8.1.4 Test data, continued

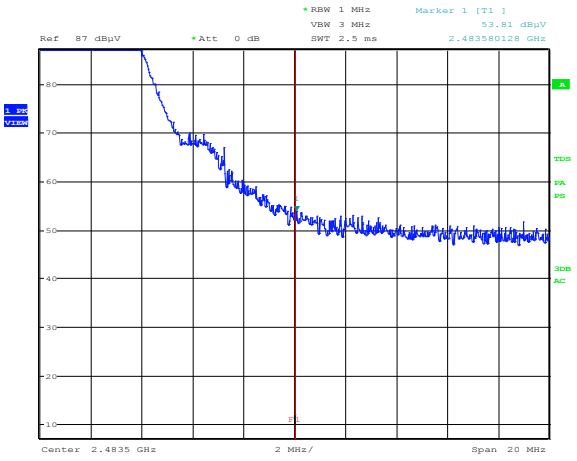


Figure 8.1-4: *Upper band edge, Configuration 2 (BLE High Channel and Zigbee High Channel) Peak detector*

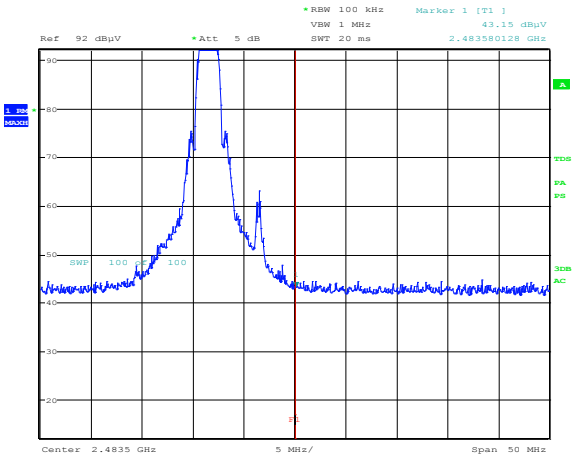


Figure 8.1-5: *Lower band edge, Configuration 2 (BLE Low Channel and Zigbee Low Channel) Avg. detector*

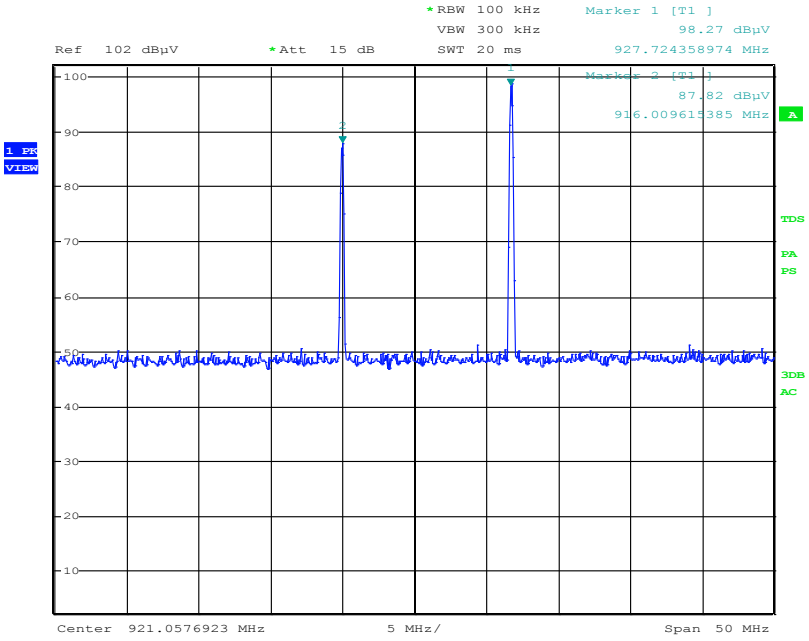


Figure 8.1-6: *Configuration 2 (Z-Wave and TI Chip) Peak detector*

8.1.4 Test data, continued

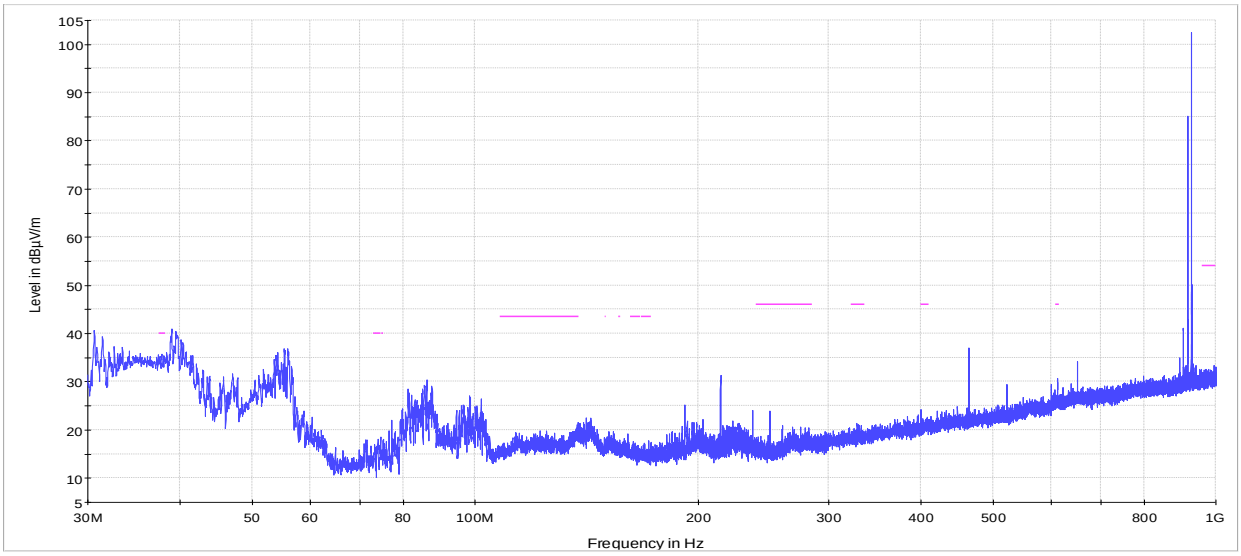


Figure 8.1-7: *Radiated spurious emissions products from co-located transmitters below 1 GHz, Configuration 2*

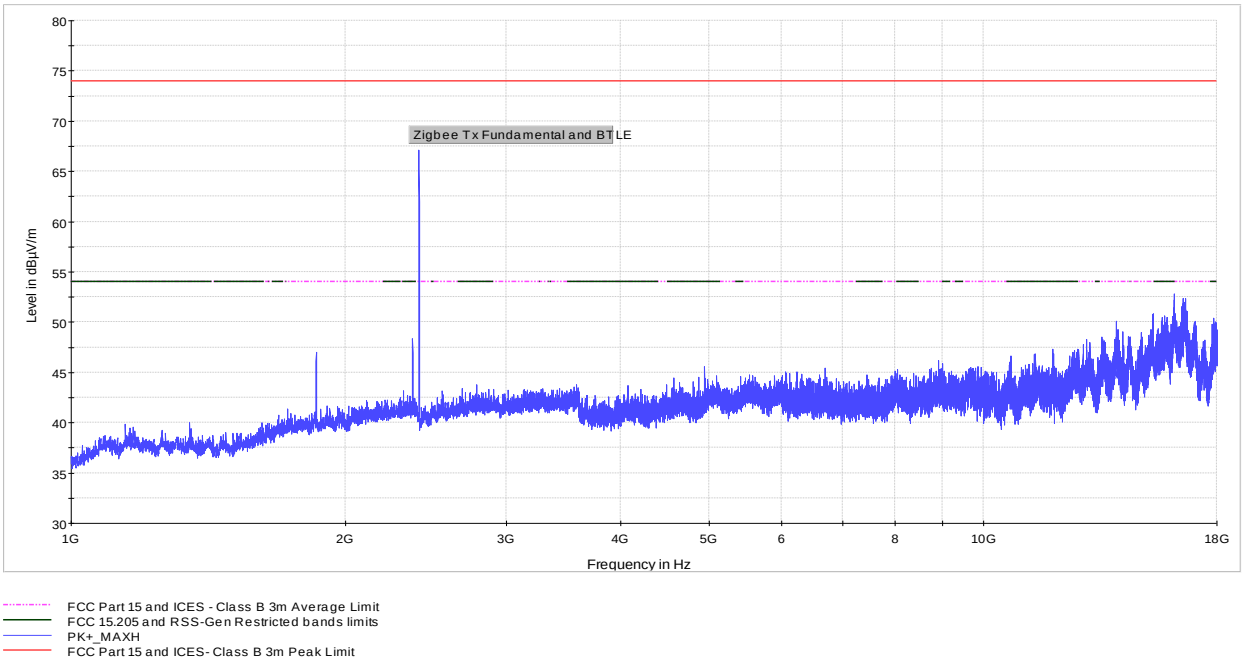


Figure 8.1-8: *Radiated spurious emissions products from co-located transmitters within 1–18 GHz, Configuration 2*

8.1.4 Test data, continued

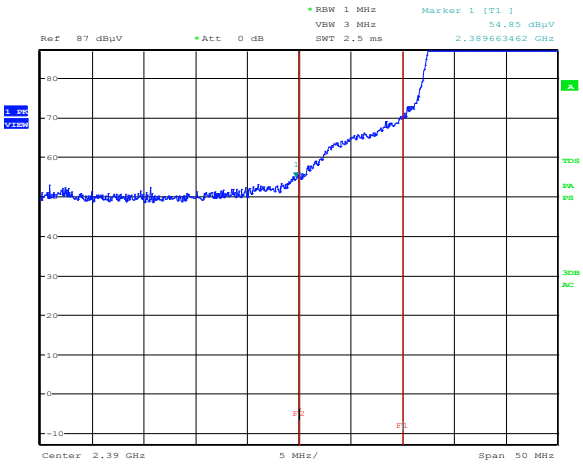


Figure 8.1-9: *Upper band edge, Configuration 2 (WIFI Low Channel and Zigbee Low Channel) Peak detector*

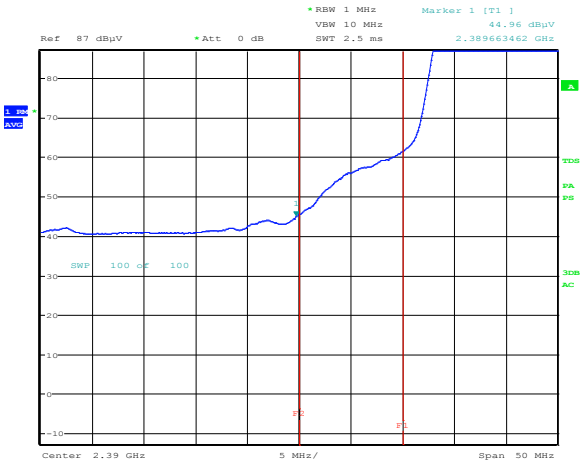


Figure 8.1-10: *Lower band edge, Configuration 2 (WIFI Low Channel and Zigbee Low Channel) Avg. detector*

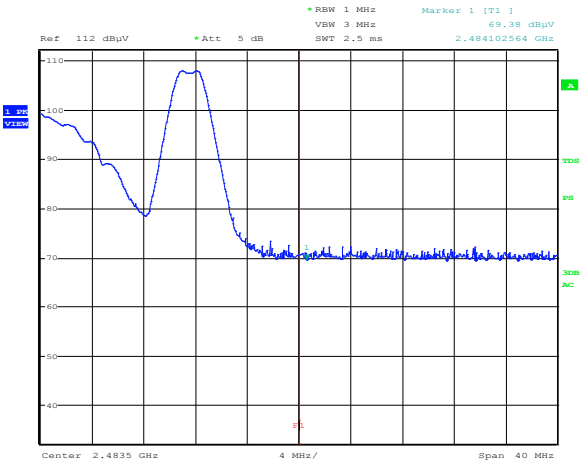


Figure 8.1-11: *Upper band edge, Configuration 2 (WIFI High Channel and Zigbee High Channel) Peak detector*

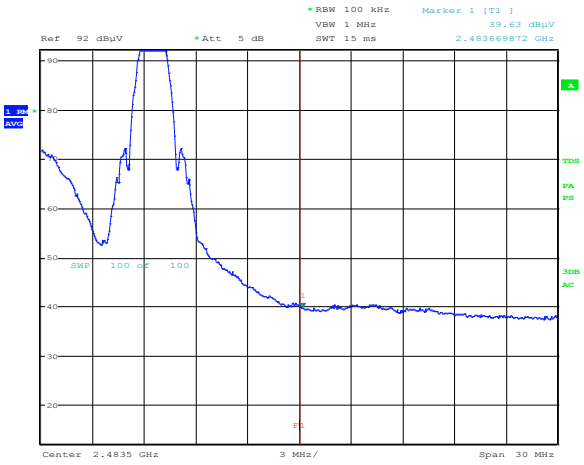


Figure 8.1-12: *Lower band edge, Configuration 2 (WIFI high Channel and Zigbee High Channel) Avg. detector*

8.1.4 Test data, continued

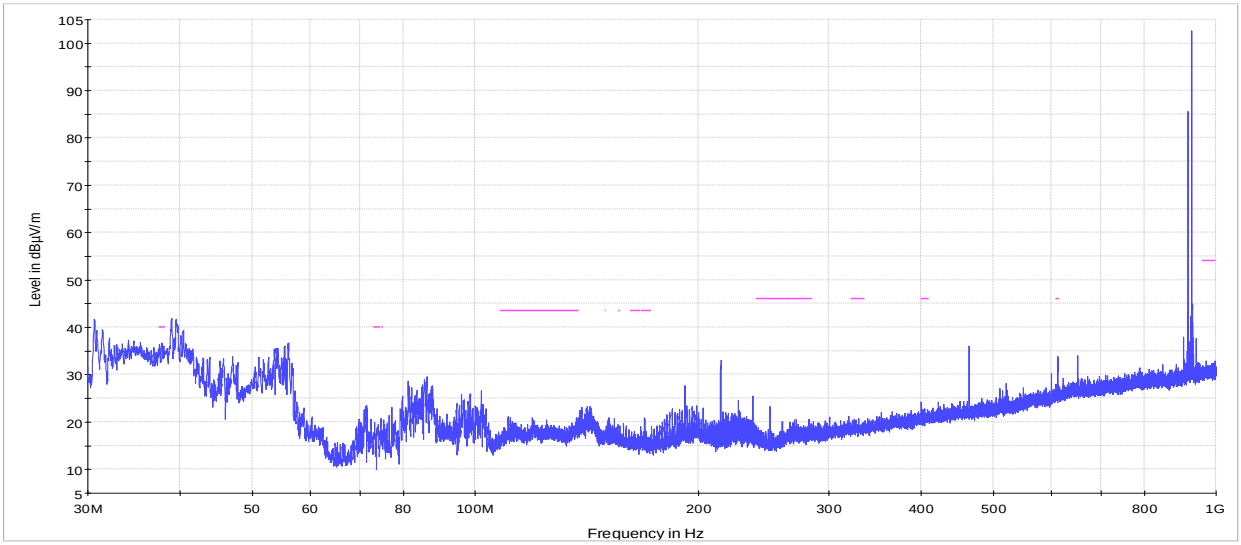


Figure 8.1-13: *Radiated spurious emissions products from co-located transmitters below 1 GHz, Configuration 3*

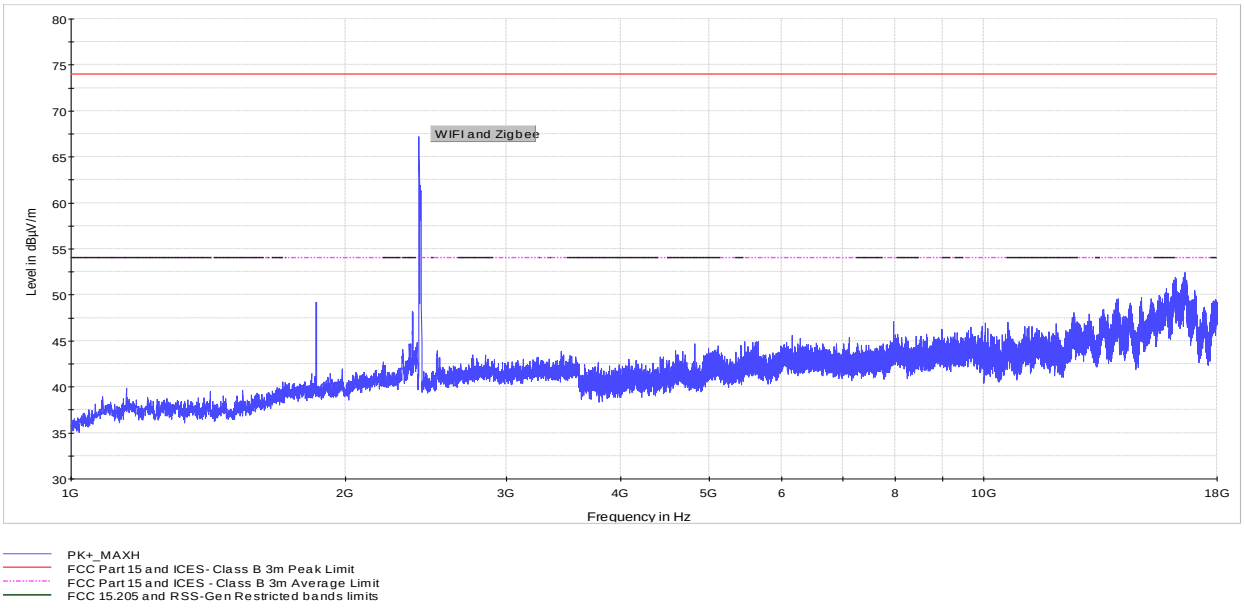


Figure 8.1-14: *Radiated spurious emissions products from co-located transmitters within 1–18 GHz, Configuration 3*

8.1.4 Test data, continued

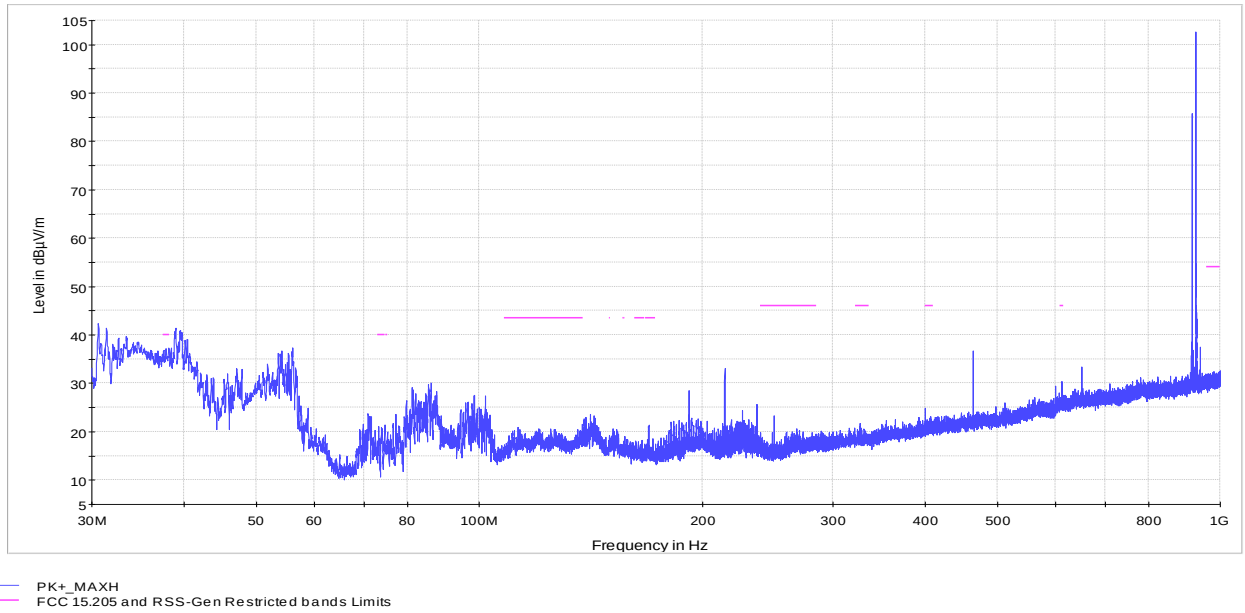


Figure 8.1-15: *Radiated spurious emissions products from co-located transmitters below 1 GHz, Configuration 4*

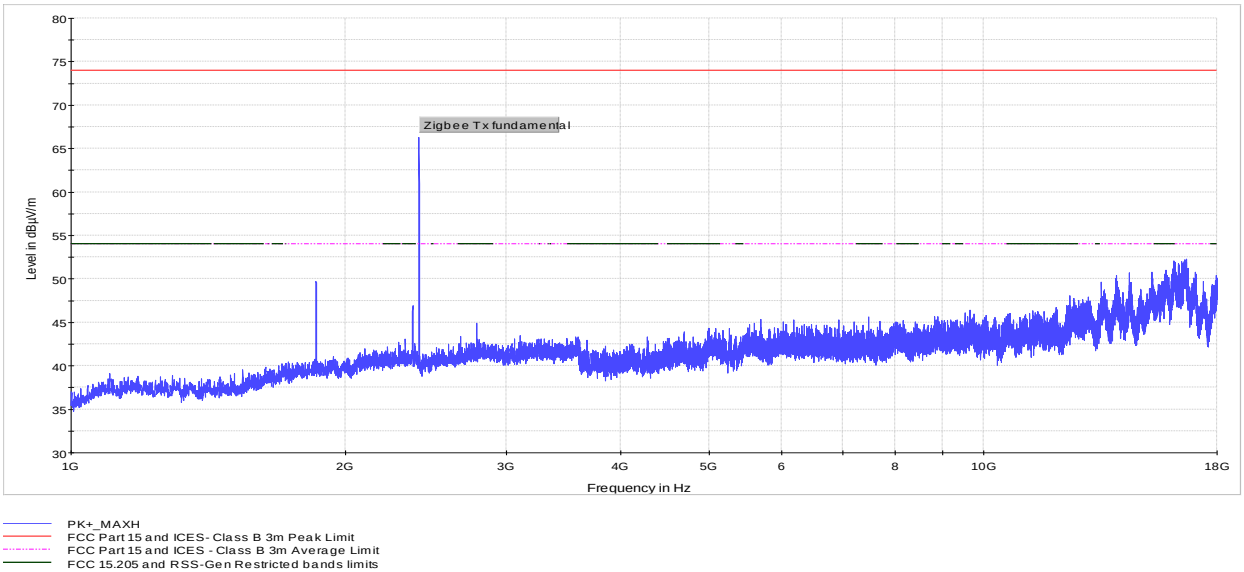
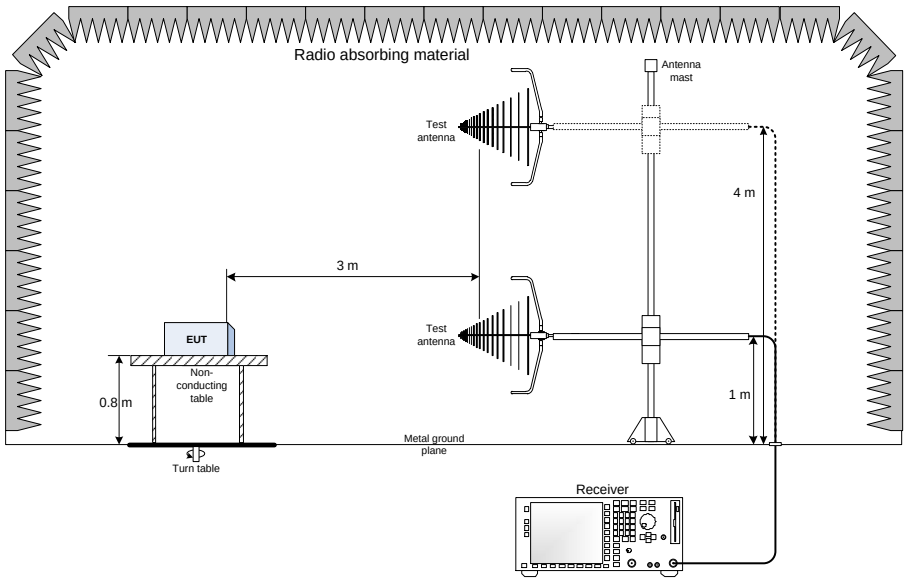


Figure 8.1-16: *Radiated spurious emissions products from co-located transmitters within 1–18 GHz, Configuration 4*

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