ONE WORLD ○ OUR APPROVAL

Wireless Test Report – 368533-13TRFWL

Applicant:

Ring LLC

Product name:

Ring

Model:

Base Station US

FCC ID:

2AEUPBHABU002

ISED Registration number:

20271-BHABU002

Specifications:

Co-location

Date of issue: April 4, 2019

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

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada.
The tests included in this report are within the scope of this accreditation

Lab and Test location(s)

Company name	Nemko Canada Inc. (Cambridge)	
Facility	130 Saltsman Drive, Unit #1 Cambridge, ON Canada, N3E 0B2 Tel: +1 519 680 4811 Test Firm Registration Number: 332406	
Test site registration	**Organization**	**Designation Number**
	FCC	CA0101
	ISED	CA0101
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 Test specifications 4

1.2 Test methods 4

1.3 Exclusions 4

1.4 Statement of compliance 4

1.5 Test report revision history 4

Section 2. Summary of test results **5**

2.1 Testing period 5

2.2 FCC test results 5

2.3 RSS test results 5

Section 3. Equipment under test (EUT) details **6**

3.1 Applicant and manufacturer 6

3.2 Sample information 6

3.3 EUT information 6

3.4 Technical information 6

3.5 Co-location test plan 7

3.6 Product description and theory of operation 7

3.7 EUT exercise details 7

3.8 EUT setup diagram 8

3.9 EUT sub assemblies 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 Spurious emissions caused by co-located transmitters 13

Section 9. Block diagrams of test set-ups **21**

9.1 Radiated emissions set-up for frequencies below 1 GHz 21

9.2 Radiated emissions set-up for frequencies above 1 GHz 21

Section 1. Report summary

1.1 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

1.2 Test methods

789033 D02 General UNII Test Procedures New Rules v02r01 (December 14, 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
558074 D01 DTS Meas Guidance v05r01 (February 11, 2019)	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

1.3 Exclusions

The EUT was assessed for radiated emissions as a verification with multiple transmitters enabled at the same time to ensure compliance was maintained. Unable to filter GSM1900 @ 1880 MHz. GSM1900 (1810 – 1910 MHz) omitted from radiated measurements

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard or as per detailed in the section 1.3 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.

1.5 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	April 4, 2019	Original report issued

Section 2. Summary of test results

2.1 Testing period

Test start date	February 13, 2019
Test end date	April 4, 2019

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 Applicant and manufacturer

Company name	Ring LLC
Address	1523 26th Street, Santa Monica, CA, United States, 90404

3.2 Sample information

Receipt date	April 3, 2019
Nemko sample ID number	Item # 4

3.3 EUT information

Product name	Ring
Model	Base Station US
Serial number	BHBU21851PG000028

3.4 Technical information

Applicant IC company number	20271
IC UPN number	20271-BHABU002
All used IC test site(s) Reg. number	332406

Table 3.4-1: *Antenna information*

GSM Antenna	**Antenna type**	**Band 2 Peak gain, dBi**	
Main	Monopole	3.6	
Tri band antenna	**Antenna type**	**900 MHz Band peak gain, dBi**	
Halo	Inverted F	3.1	
Dual band antenna	**Antenna type**	**900 MHz Band peak gain, dBi**	**2.4 GHz Band peak gain, dBi**
Z-Wave	Inverted F	0.8	NA
Zigbee	Inverted F	NA	4.8

Notes: None

3.5 Co-location test plan

Table 3.5-1: *Co-Location configuration*

Radio module device	Radio parameters
Configuration 1: GSM + ZigBee + Z-Wave + SimpleLink (TI1310)	
GSM	Channel 661: 1880 MHz
Zigbee	Low Channel 11: 2405 MHz
Z-Wave	High Channel 916 MHz
SimpleLink (TI1310)	High Channel 927.8 MHz

Notes: None

3.6 Product description and theory of operation

Communications Hub for Home Security Products

3.7 EUT exercise details

The EUT was setup in continuous transmit state.

3.8 EUT setup diagram

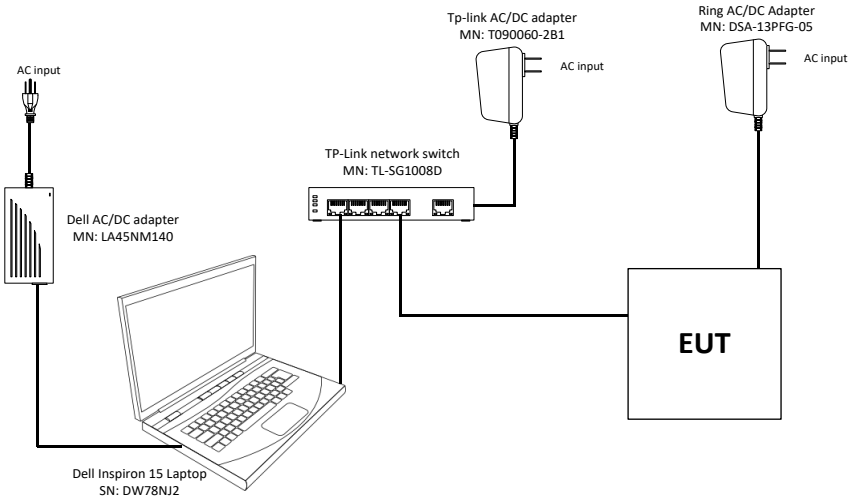


Figure 3.8-1: *Setup diagram*

3.9 EUT sub assemblies

Table 3.9-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
AC/DC Adapter	Ring	DSA-13PFG-05	BHAB11851DV000116
Laptop	Dell	Inspiron 15	DW78NJ2
Network switch	TP-Link	TL-SG1008D	2171682000263

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.	Serial no.	Asset no.	Cal./Ver. cycle	Next cal./ver.
3 m EMI test chamber	TDK	SAC-3		FA003012	1 year	Aug. 22/19
Flush mount turntable	SUNAR	FM2022		FA003006	—	NCR
Controller	SUNAR	SC110V	050118-1	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	042418-5	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	101367	FA002969	1 year	June 1/19
Spectrum analyzer	Rohde & Schwarz	FSW43	104437	FA002971	1 year	June 1/19
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	00052793	FA002911	1 year	Aug. 16/19
Preamp (1–18 GHz)	ETS-Lindgren	124334	00224880	FA002956	1 year	Sept 18/19
Bilog antenna (30–2000 MHz)	SUNAR	JB1	A053018-2	FA003010	1 year	Sept. 6/19
50 Ω coax cable	Huber + Suhner	None	457630	FA003047	1 year	Nov 12/19
50 Ω coax cable	Huber + Suhner	None	457624	FA003044	1 year	Nov 12/19
Filter 2.4 – 2.4835 GHz	Microwave Circuits	N0324413	499781	FA003027	1 year	Oct. 1/19
High Pass Filter 3 – 18 GHz	Microwave Circuits	H3G020G8	499786	FA003026	1 year	Oct. 1/19
Filter 902 – 928 MHz	Microwave Circuits	N03916M1	499787	FA003032	1 year	Oct. 1/19
Horn antenna (18-25 GHz)	ETS-Lindgren	3116B	00122305	FA002948	1 year	Apr. 18/19

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.

8.1.2 Definitions and limits, continued

Table 8.1-1: *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 8.1-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Notes: Certain frequency bands listed in and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

8.1.1 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

8.1.2 Test summary

Verdict	Pass		
Test date	April 4, 2019	Temperature	22 °C
Test engineer	Mark Libbrecht	Air pressure	985 mbar
Test location	Cambridge	Relative humidity	29 %

8.1.3 Observations, settings and special notes

- The spectrum was searched from 30 MHz to 25 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 from 30 MHz – 1GHz, and 3 GHz – 18 GHz
- Unable to filter GSM1900 @ 1880 MHz. GSM1900 (1810 – 1910 MHz) omitted from radiated measurements
- Measurements 1 GHz – 3 GHz measured at 30 cm.
- Measurements 18 – 25 GHz measured at 3 cm.

8.1.3 Observations, settings and special notes

Spectrum analyzer settings for radiated measurements below 1 GHz:

Detector mode	Peak or Quasi-Peak
Resolution bandwidth	100 kHz or 120 kHz
Video bandwidth	300 kHz
Trace mode	Max Hold

Spectrum analyser settings for radiated measurements above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.1.4 Test data

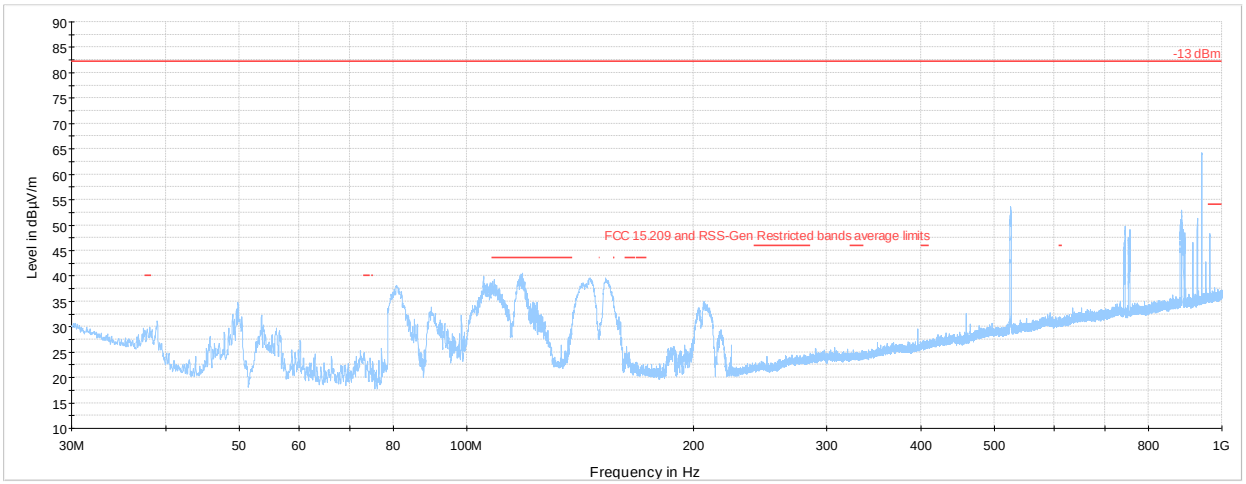


Figure 8.1-1: *Radiated spurious emissions products from co-located transmitters, 30 MHz – 1 GHz*

8.1.4 Test data, continued

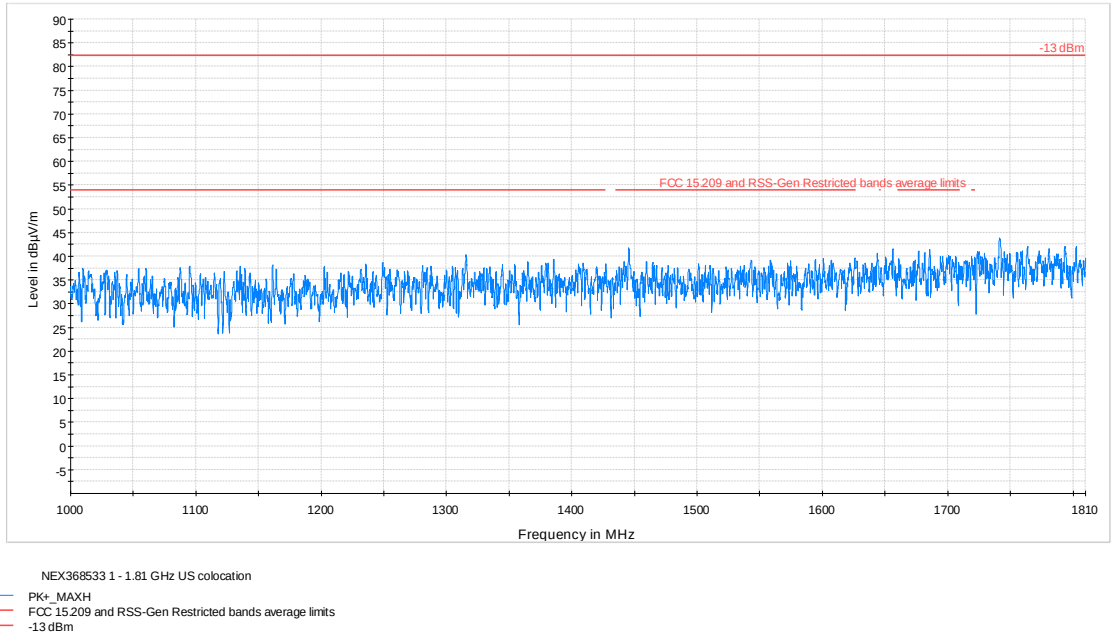
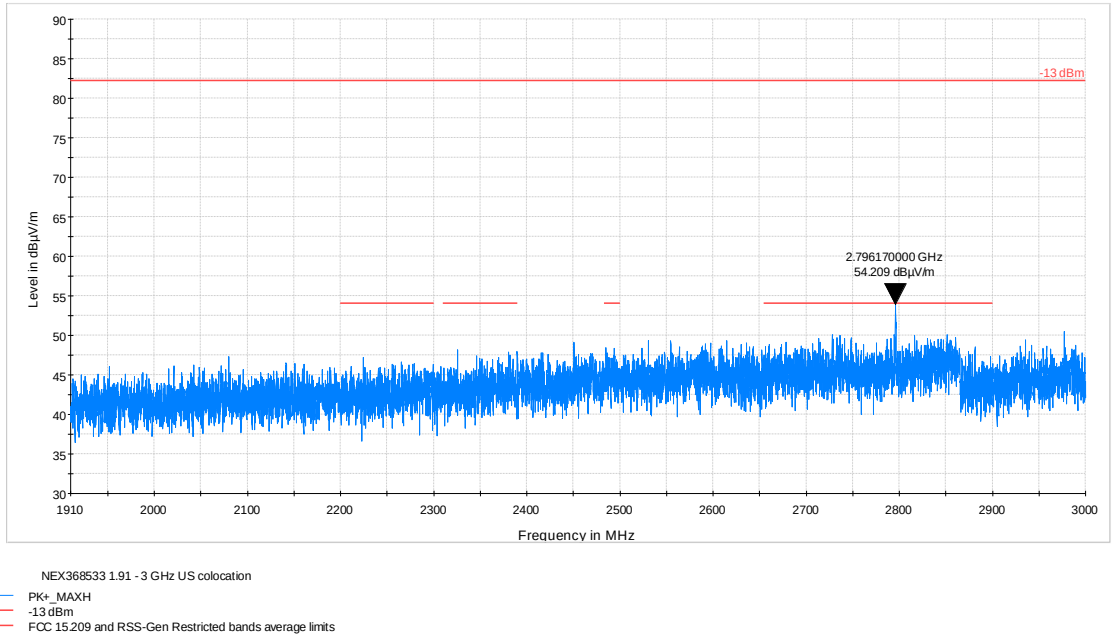


Figure 8.1-2: *Radiated spurious emissions products from co-located transmitters within 1–1.810 GHz*



Note: Emissions above the limit were from intentional emissions or their harmonic, no intermodulation emissions were detected

Figure 8.1-3: *Radiated spurious emissions products from co-located transmitters within 1.810–3 GHz*

8.1.4 Test data, continued

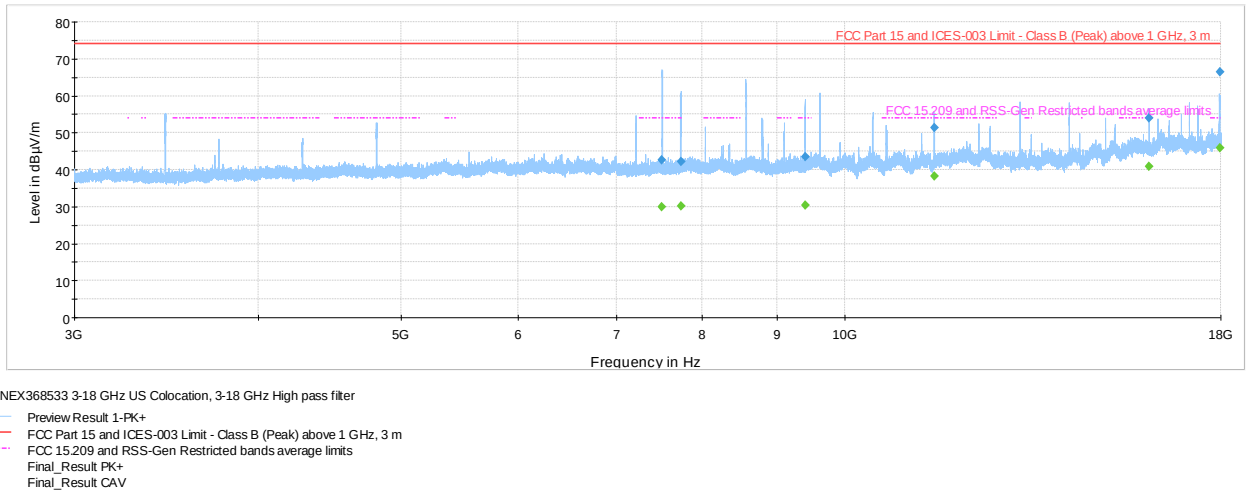


Figure 8.1-4: *Radiated spurious emissions products from co-located transmitters within 3–18 GHz*

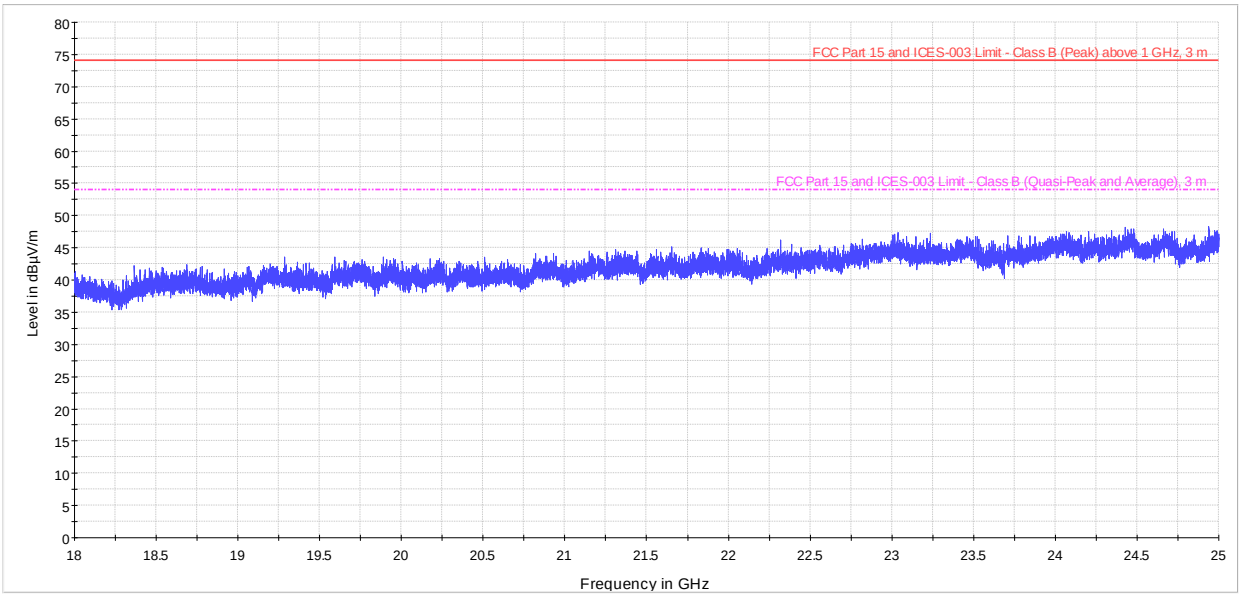
Table 8.1-4: *Radiated disturbance (Peak) results for (Colocation)*

Frequency (MHz)	Peak field strength[1 and 3] (dBµV/m)	3 m Peak limit (dBµV/m)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Antenna height (cm)	Pol. (V/H)	Turn table position (°)	Correction factor[2] (dB)
7514.500	42.70	74.0	31.30	100	1000	310.0	H	45	-2.2
7745.300	42.29	74.0	31.71	100	1000	260.0	V	121	-2.1
9399.700	43.53	74.0	30.47	100	1000	310.0	H	18	0.1
11499.700	51.44	74.0	22.56	100	1000	254.0	V	8	1.2
16088.500	53.93	74.0	20.07	100	1000	300.0	H	29	7.3
17967.700	66.48	74.0	7.52	100	1000	305.0	H	10	14.4

Notes:
[1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions have been recorded.

Sample calculation: 42.7 dBµV/m (field strength) = 44.9 dBµV (receiver reading) -2.2 dB (Correction factor)

8.1.4 Test data, continued

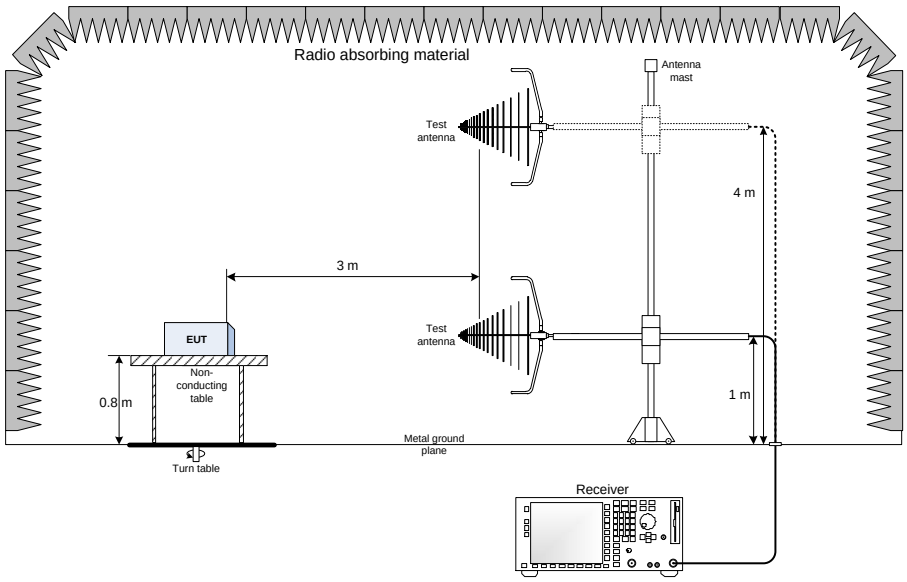
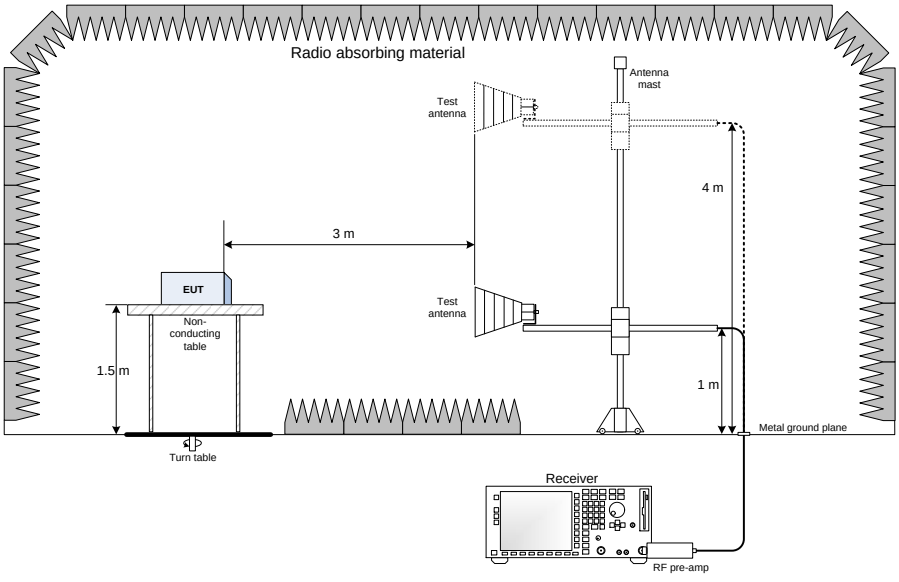


NEX368533 18 - 25 GHz US colocation
AVG_MAXH
PK+_MAXH
FCC Part 15 and ICES-003 Limit - Class B (Peak) above 1 GHz, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m

Figure 8.1-5: *Radiated spurious emissions products from co-located transmitters within 18 - 25 GHz*

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