

# EMC TEST REPORT – 337515-1TRFWL

Applicant:

**BOT Home Automation Inc.**

Product name:

**Ring**

Model:

**WL18MODGI**

FCC ID:

**2AEUPWL18DBMOD**

IC Registration number:

**20271-WL18DBMOD**

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.247**

Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

- §15.247(d) Unwanted emissions (Radiated)
- §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

◆ **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,

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

- Section 5.5 Unwanted emissions (Radiated)
- Section 5.4 (d) Transmitter output power and e.i.r.p. requirements (Systems employing digital modulation techniques)

Date of issue: **September 25, 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:<br>303 River Road, Ottawa, ON, Canada,<br>K1V 1H2 | Montreal site:<br>292 Labrosse Avenue, Pointe-Claire, QC,<br>Canada, H9R 5L8 | Almonte site:<br>1500 Peter Robinson Road, West<br>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 | <b>Organization</b>                                            | <b>Recognition numbers and location</b>                                      |                                                                                  |
|                        | FCC                                                            | CA2040 (Ottawa); CA2041 (Montreal)                                           |                                                                                  |
|                        | ISED                                                           | CA2040A-4 (Ottawa); CA2040G-5 (Montreal); CA2040A-3 (Almonte)                |                                                                                  |
| Website                | <a href="http://www.nemko.com">www.nemko.com</a>               |                                                                              |                                                                                  |

## 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.

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## Section 1. Report summary

### 1.1 Applicant and manufacturer

|              |                                                                            |
|--------------|----------------------------------------------------------------------------|
| Company name | BOT Home Automation Inc.                                                   |
| Address      | 1523 26 <sup>th</sup> 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 |
| 662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013) | Emissions Testing of Transmitters with Multiple Outputs in the Same Band                                      |
| 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 only assessed for FCC 47 CFR Part 15 Subpart C, §15.247(d), §15.247(b)(3) and RSS-247, Issue 2, Feb 2017, Section 5.5, Section 5.4 (d)

### 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        | September 25, 2017 | Original report issued                 |

## Section 2. Summary of test results

### 2.1 Testing period

|                 |                   |
|-----------------|-------------------|
| Test start date | September 1, 2017 |
| Test end date   | September 3, 2017 |

### 2.2 FCC Part 15 Subpart C, intentional radiators test results

**Table 2.2-1: Result summary for §15.247**

| Part          | Test description                                                                                                                                                                                                                                                                            | Verdict |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| §15.247(d)    | Unwanted emissions (Radiated) <sup>1</sup>                                                                                                                                                                                                                                                  | Pass    |
| §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 <sup>2</sup>                                                                                                                                                     | Pass    |
| Notes:        | <sup>1</sup> The EUT was only assessed for the radiated portion §15.247(d). No conducted measurements were performed.<br><sup>2</sup> The EUT utilized the previous filling for the test data. The EUT has been re-assessed with a new antenna factors to demonstrate continued compliance. |         |

### 2.3 RSS-247, Issue 2, test results

**Table 2.3-1: Result summary for RSS-247**

| Section | Test description                                                                                                                                                                                                                                                                                   | Verdict |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 5.5     | Unwanted emissions <sup>1</sup>                                                                                                                                                                                                                                                                    | Pass    |
| 5.4 (d) | Transmitter output power and e.i.r.p. requirements (Systems employing digital modulation techniques) <sup>2</sup>                                                                                                                                                                                  | Pass    |
| Notes:  | <sup>1</sup> The EUT was only assessed for the radiated portion RSS-247 Part 5.5). No conducted measurements were performed.<br><sup>2</sup> The EUT utilized the previous filling for the test data. The EUT has been re-assessed with a new antenna factors to demonstrate 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                                                                                                                                                                             |
| RSS number and Issue number             | RSS-247 Issue 2, Feb 2017                                                                                                                                                           |
| Frequency band                          | 2400–2483.5 MHz                                                                                                                                                                     |
| Type of modulation                      | WIFI: 802.11b/g/n<br>BTLE: GFSK                                                                                                                                                     |
| Emission classification (F1D, G1D, D1D) | W7D                                                                                                                                                                                 |
| Transmitter spurious, Units @ distance  | WIFI: 62.7 dBμV/m peak and 52.5 dBμV/m average at 2.387 GHz @ 3m<br>BTLE: 66.0 dBμV/m peak and 50.3 dBμV/m average at 4.964 GHz @ 3m                                                |
| Power requirements                      | 5 V <sub>DC</sub> (via external 100–240 VAC, 50/60 Hz power adapter)                                                                                                                |
| Antenna information                     | Antenna gain: is 3.3 dBi (WI-FI Right side) and 3.9 dBi (WI-FI left side) Inverted F<br>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

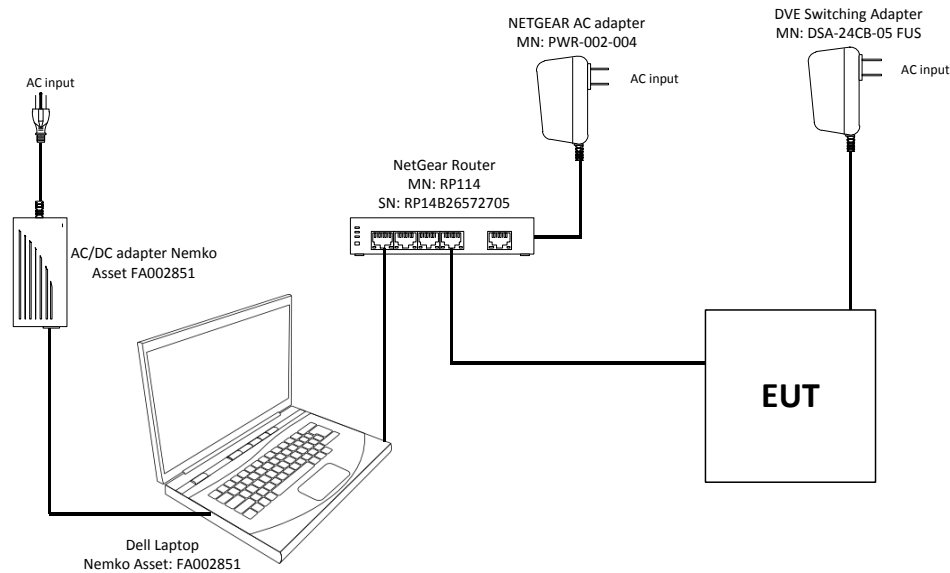


Figure 3.6-1: Setup diagram

**Section 4. Engineering considerations**

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**4.1 Modifications incorporated in the EUT for compliance**

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

**4.2 Technical judgment**

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None

**4.3 Deviations from laboratory tests procedures**

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No deviations were made from laboratory procedures.

# Section 5. Test conditions

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## 5.1 Atmospheric conditions

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|                   |            |
|-------------------|------------|
| 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

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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 |
|-----------------------------|-----------------------------|
| 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 |
| Horn antenna (18–40 GHz)    | EMCO               | 3116          | FA001847  | 1 year    | June 27/18 |
| Pre-amplifier (18–26 GHz)   | Narda              | BBS-1826N612  | FA001550  | —         | VOU        |
| 50 $\Omega$ coax cable      | Huber + Suhner     | None          | FA002830  | 1 year    | May 12/18  |
| 50 $\Omega$ 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 15.247(d) and RSS-247 Section 5.5 Spurious (out-of-band) unwanted emissions

#### 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)).

##### 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.

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

| Frequency,<br>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: 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

### 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     | September 1, 2017 and September 3, 2017 | Temperature       | 21 °C     |
| Test engineer | David Duchesne                          | Air pressure      | 1004 mbar |
| Test location | Ottawa                                  | Relative humidity | 45 %      |

### 8.1.3 Observations, settings and special notes

- The spectrum was searched from 30 MHz to the 10<sup>th</sup> harmonic.
- 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 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 for WIFI configuration:
  - 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.

### 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

### BLE Duty Cycle

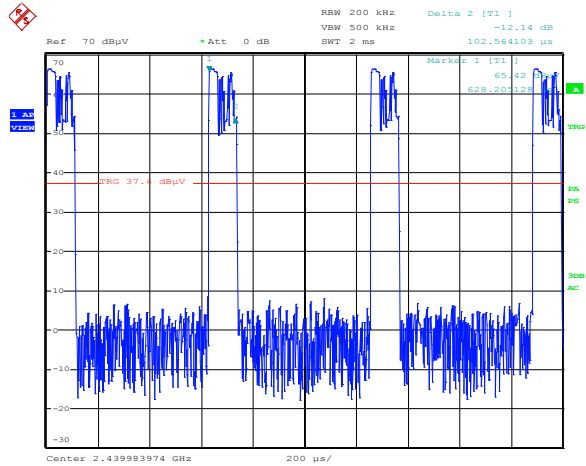


Figure 8.1-1: Pulse width

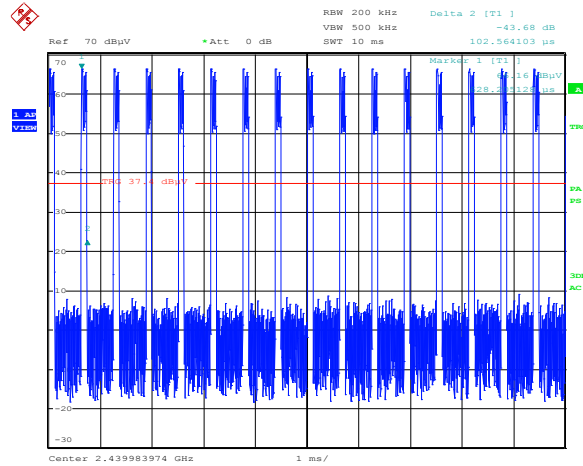


Figure 8.1-2: Number of pulses within 10 ms time frame

### BLE Duty cycle calculation:

Tx on Time:  $0.103 \text{ ms} \times 160$  (160 pulses within 100 ms time frame) = 16.48 ms

Duty cycle correction factor:  $20 \times \log_{10} [(16.48) / 100] = -15.66 \text{ dB}$

Table 8.1-4: Radiated – Spurious (out-of-band) unwanted emissions measurement results for BLE

| Channel | Frequency, MHz | Peak Field strength, dBμV/m |       | Peak margin, dB | DCCF, dB | Average Field strength, dBμV/m |       | Margin, dB |
|---------|----------------|-----------------------------|-------|-----------------|----------|--------------------------------|-------|------------|
|         |                | Measured                    | Limit |                 |          | Calculated                     | Limit |            |
| Low     | 2389.0         | 55.9                        | 74.0  | 18.1            | -15.7    | 40.2                           | 54.0  | 13.8       |
| High    | 2483.5         | 64.1                        | 74.0  | 9.9             | -15.7    | 48.4                           | 54.0  | 5.6        |
| Low     | 4800.0         | 59.4                        | 74.0  | 14.6            | -15.7    | 43.7                           | 54.0  | 10.3       |
| Mid     | 4880.0         | 61.9                        | 74.0  | 12.1            | -15.7    | 46.2                           | 54.0  | 7.8        |
| High    | 4964.8         | 66.0                        | 74.0  | 8.0             | -15.7    | 50.3                           | 54.0  | 3.7        |

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

Average field strength calculation was performed using the following formula: Average Field strength = Peak Field strength + Duty cycle correction factor

DCCF = -15.7 dB

All other emissions were greater than 20 dB form limit.

Table 8.1-5: Radiated – Spurious (out-of-band) unwanted emissions measurement results for WIFI, 802.11b Data rate 1 Mbps

| Channel | Frequency, MHz | Peak Field strength, dBμV/m |       | Margin, dB | Average Field strength, dBμV/m |       | Margin, dB |
|---------|----------------|-----------------------------|-------|------------|--------------------------------|-------|------------|
|         |                | Measured                    | Limit |            | Measured                       | Limit |            |
| Low     | 2387.05        | 62.7                        | 74.0  | 11.3       | 52.5                           | 54.0  | 1.5        |
| High    | 2487.54        | 62.3                        | 74.0  | 11.7       | 44.7                           | 54.0  | 9.3        |
| Low     | 4819.0         | 50.1                        | 74.0  | 23.9       | 45.3                           | 54.0  | 8.7        |
| Mid     | 4874.1         | 50.2                        | 74.0  | 23.8       | 46.3                           | 54.0  | 7.7        |
| High    | 4924.0         | 50.7                        | 74.0  | 23.3       | 46.2                           | 54.0  | 7.8        |

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

8.1.4 Test data, continued

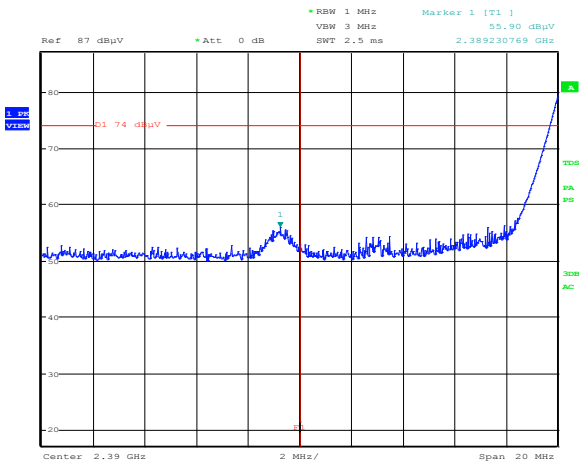


Figure 8.1-3: BLE low channel – Radiated – Spurious (out-of-band) unwanted emissions @ 2.39 GHz, Peak detector

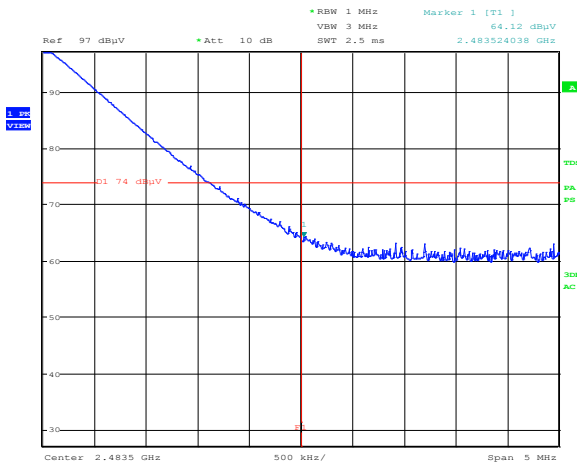


Figure 8.1-4: BLE High channel – Radiated – Spurious (out-of-band) unwanted emissions @ 2.4835 GHz, peak detector

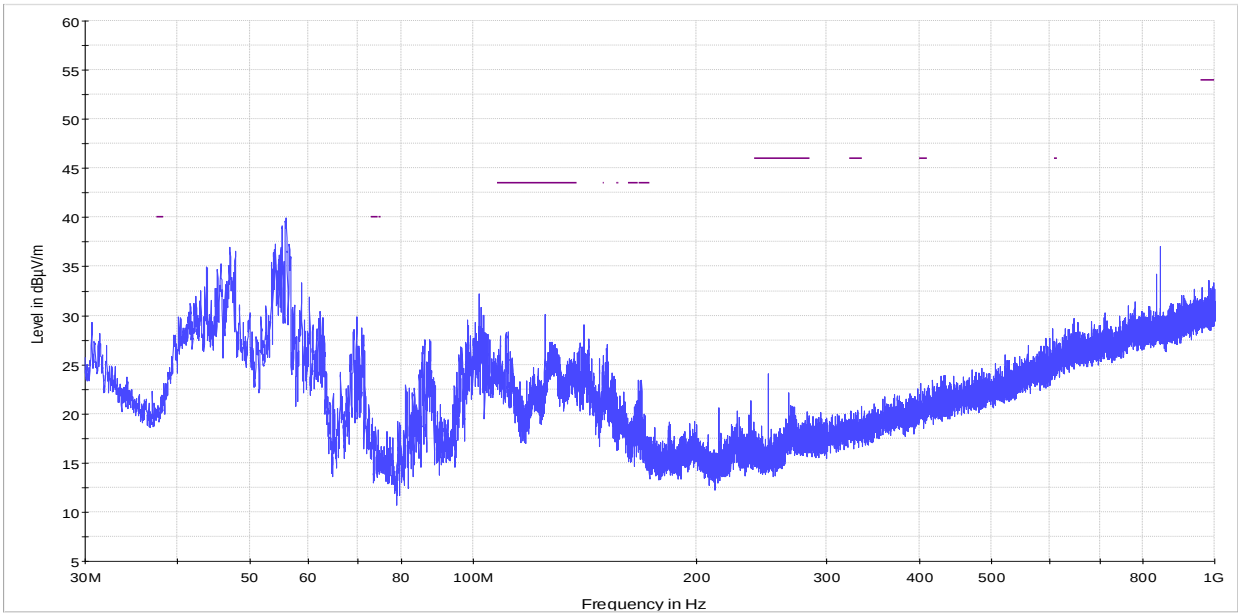


Figure 8.1-5: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, BLE low channel

8.1.4 Test data, continued

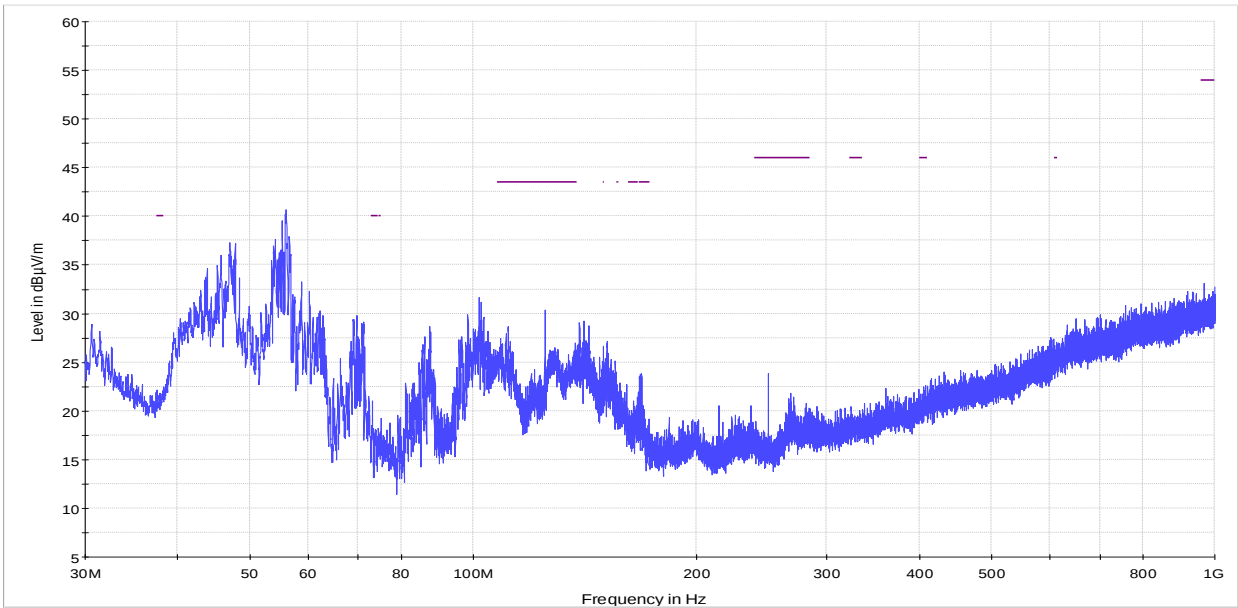


Figure 8.1-6: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, BLE mid channel

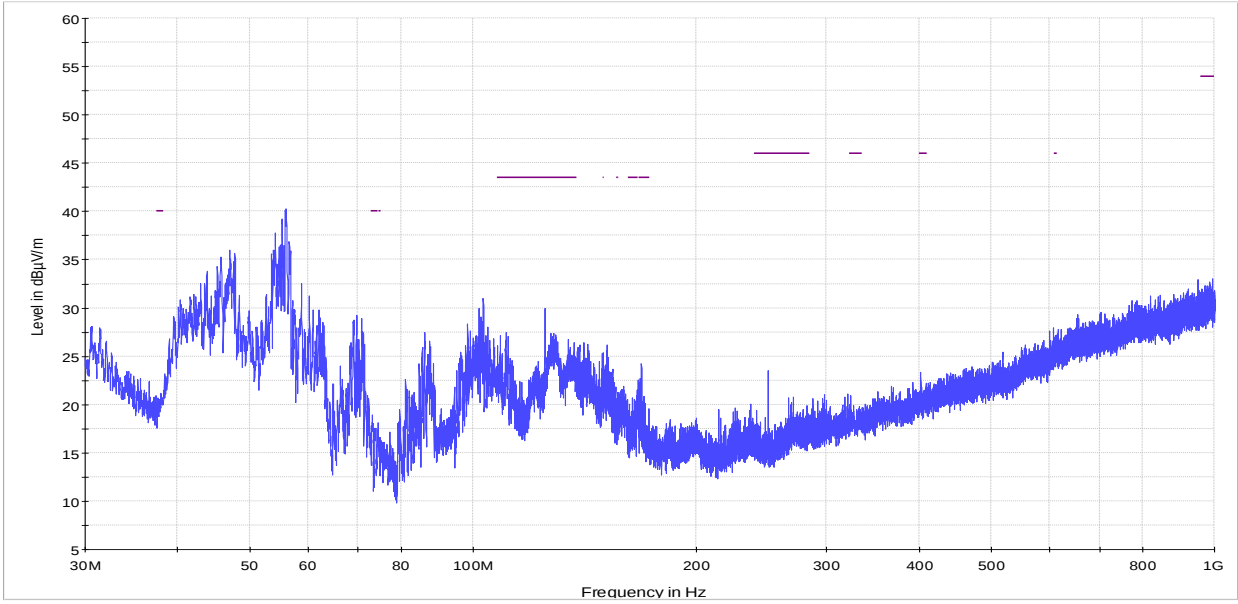


Figure 8.1-7: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, BLE High channel

8.1.4 Test data, continued

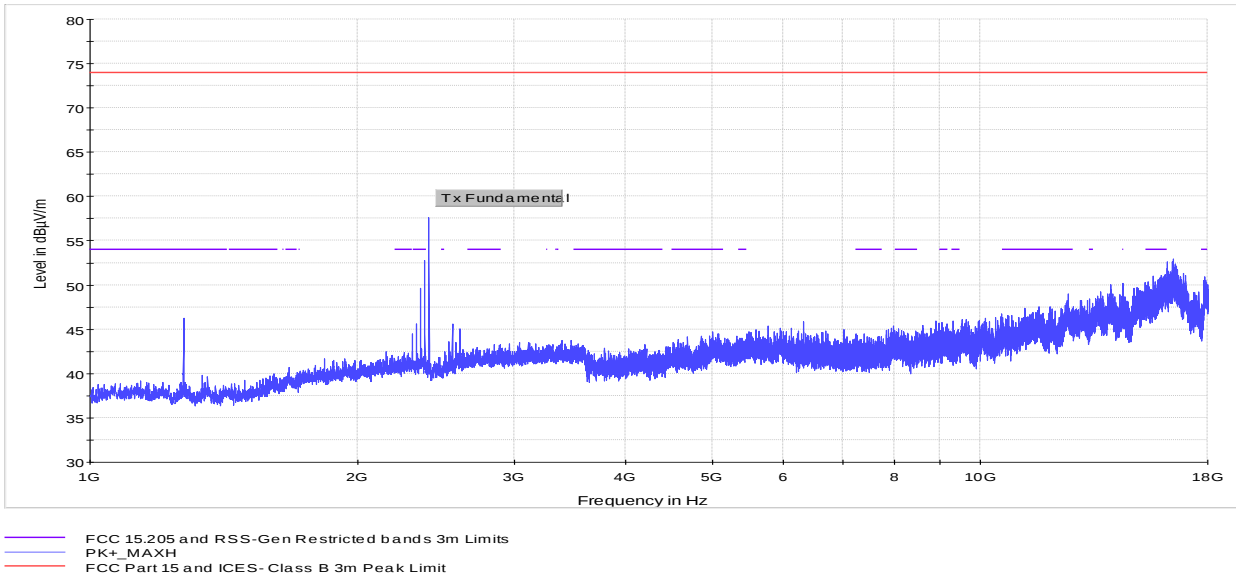


Figure 8.1-8: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, BLE low channel

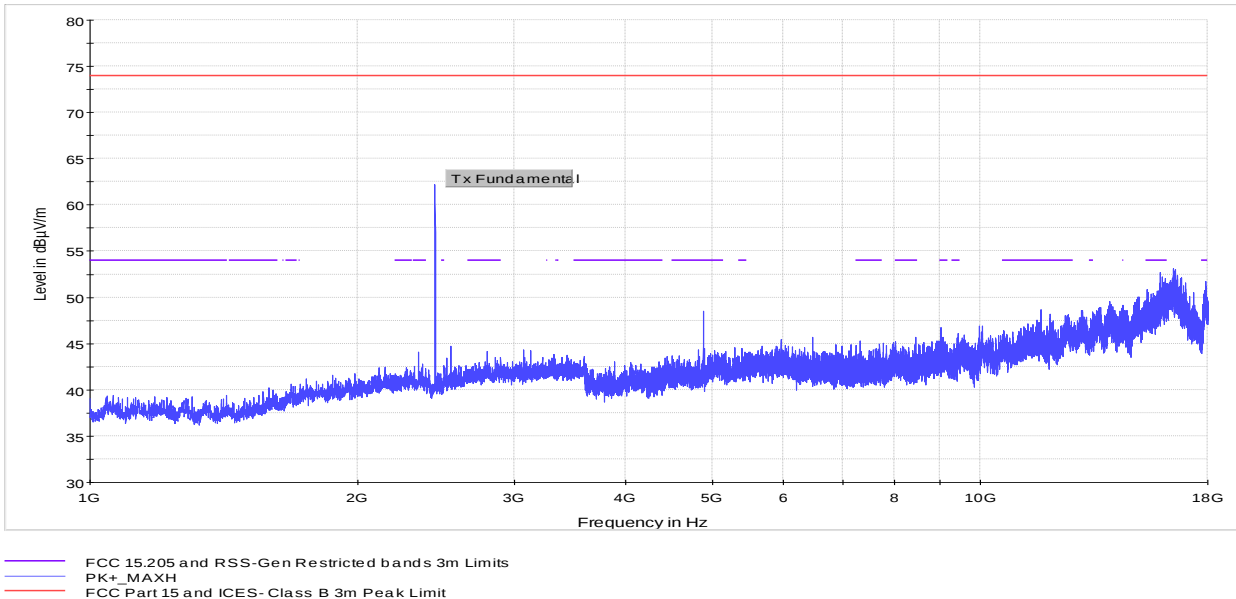


Figure 8.1-9: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, BLE mid channel

8.1.4 Test data, continued

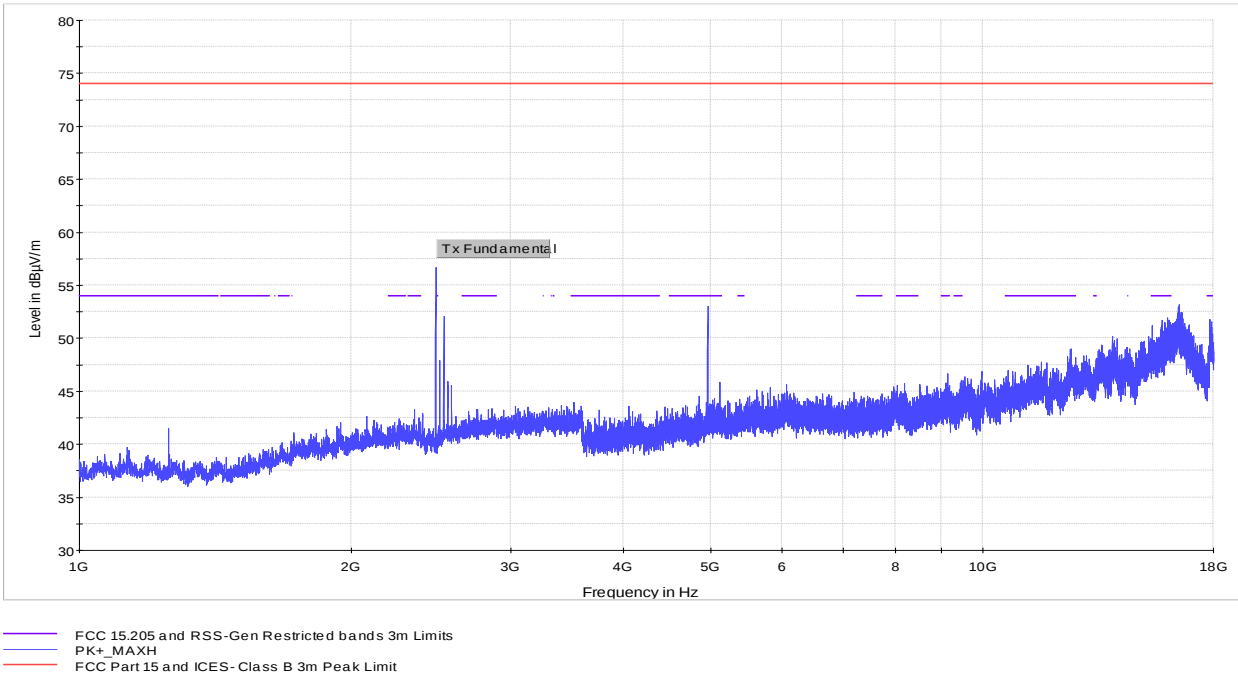


Figure 8.1-10: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, BLE High channel

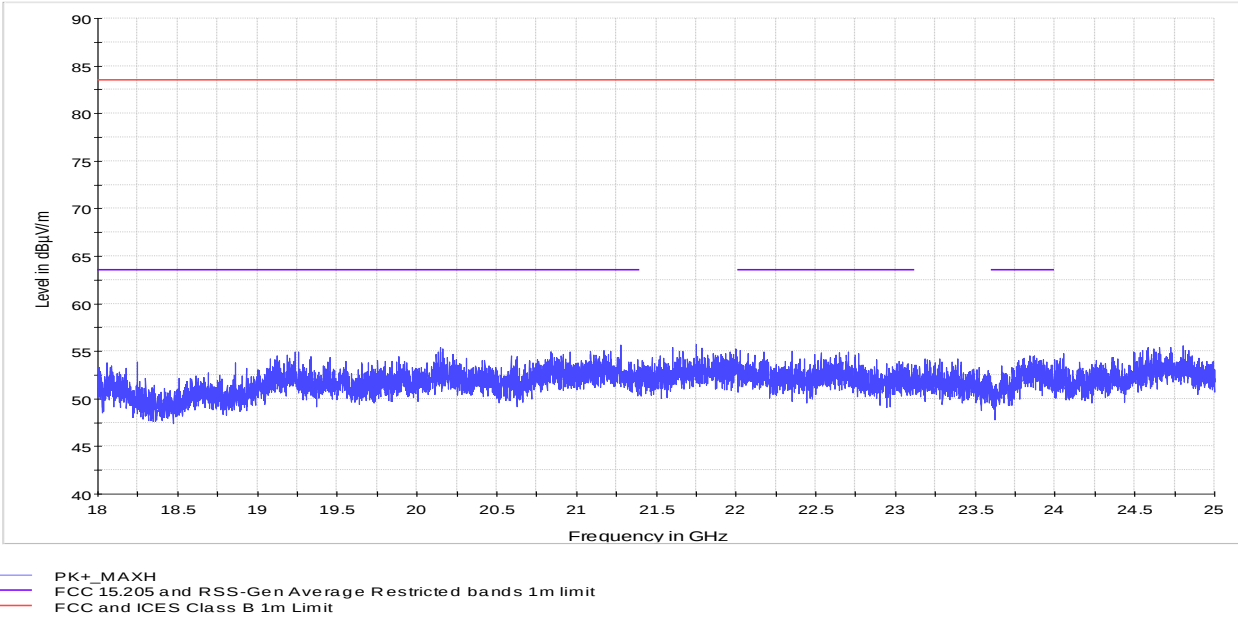


Figure 8.1-11: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, BLE low channel

8.1.4 Test data, continued

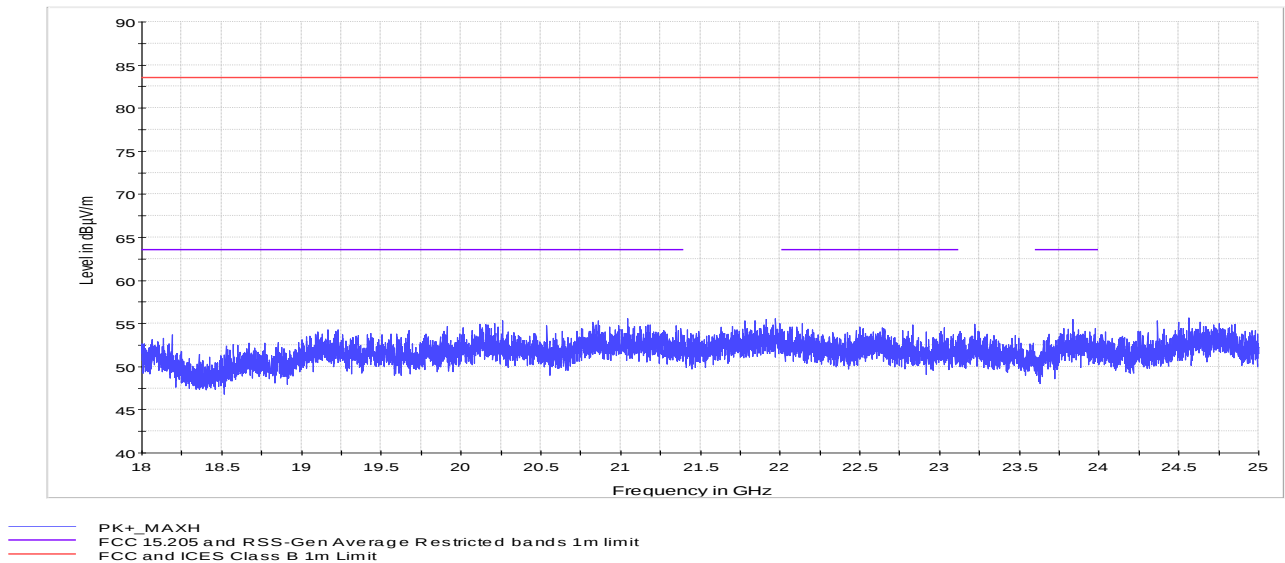


Figure 8.1-12: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, BLE mid channel

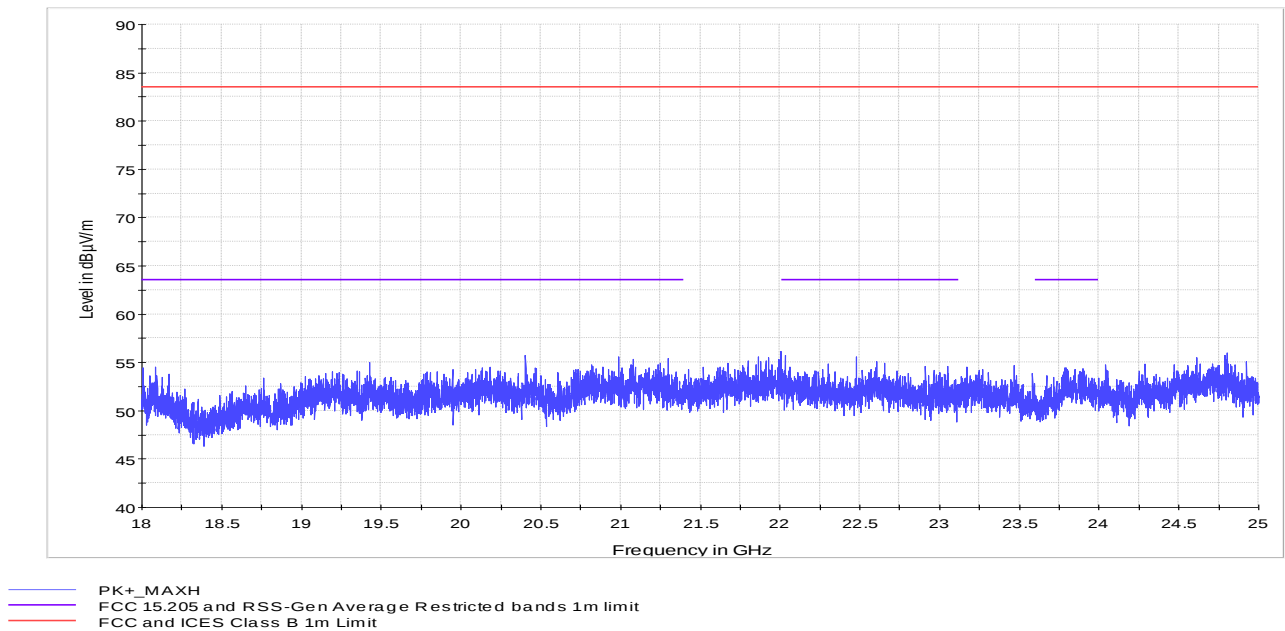


Figure 8.1-13: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, BLE High channel

8.1.4 Test data, continued

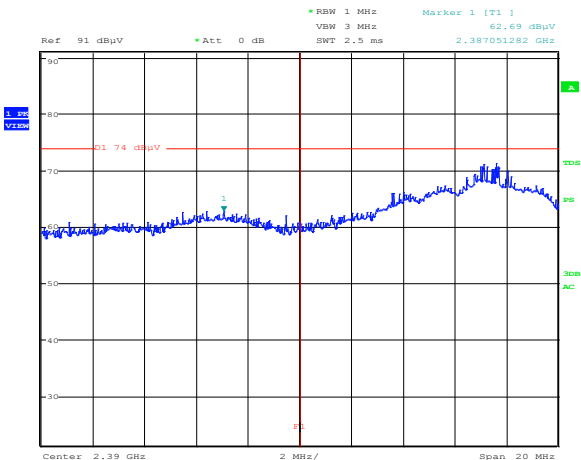


Figure 8.1-14: WIFI Low channel – 802.11b Data rate 1M bps – Radiated – Spurious (out-of-band) unwanted emissions @ 2.39 GHz, Peak detector

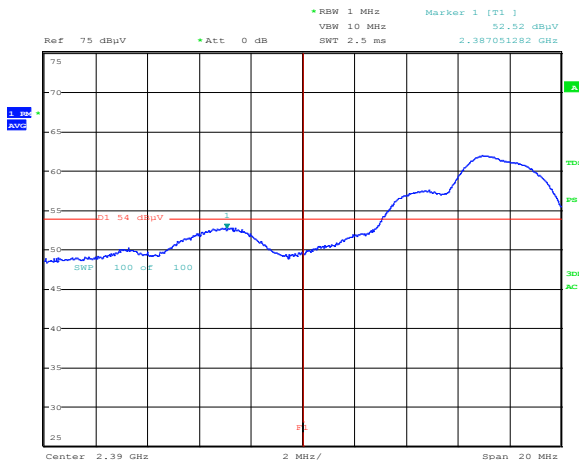


Figure 8.1-15: WIFI low channel – 802.11b Data rate 1M bps – Radiated – Spurious (out-of-band) unwanted emissions @ 2.39 GHz, Average detector

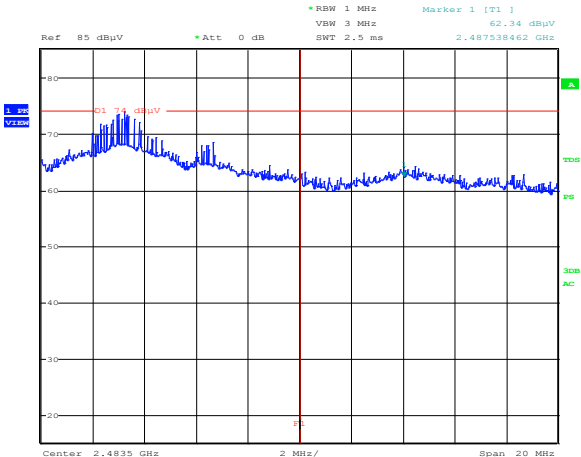


Figure 8.1-16: WIFI High channel – 802.11b Data rate 1M bps – Radiated – Spurious (out-of-band) unwanted emissions @ upper band edge, Peak detector

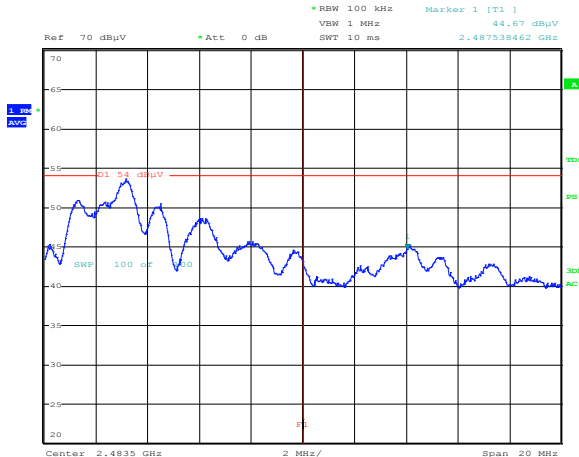


Figure 8.1-17: WIFI High channel – 802.11b Data rate 1M bps – Radiated – Spurious (out-of-band) unwanted emissions @ upper band edge, Average detector

8.1.4 Test data, continued

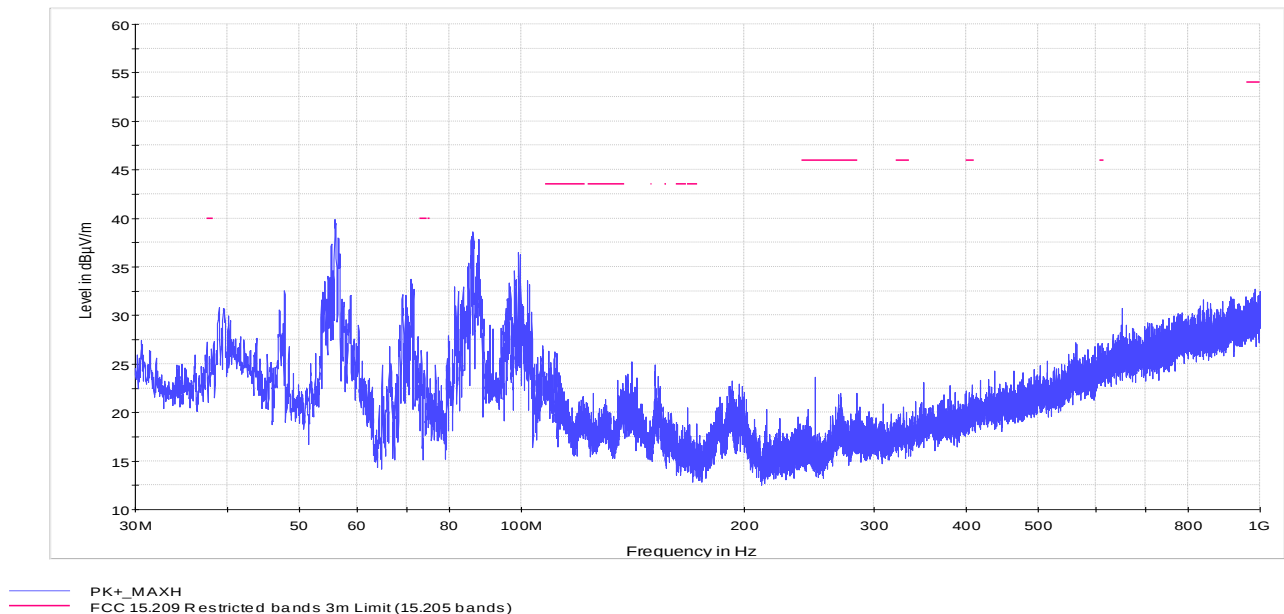


Figure 8.1-18: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, WIFI Low channel – 802.11b Data rate 1M bps

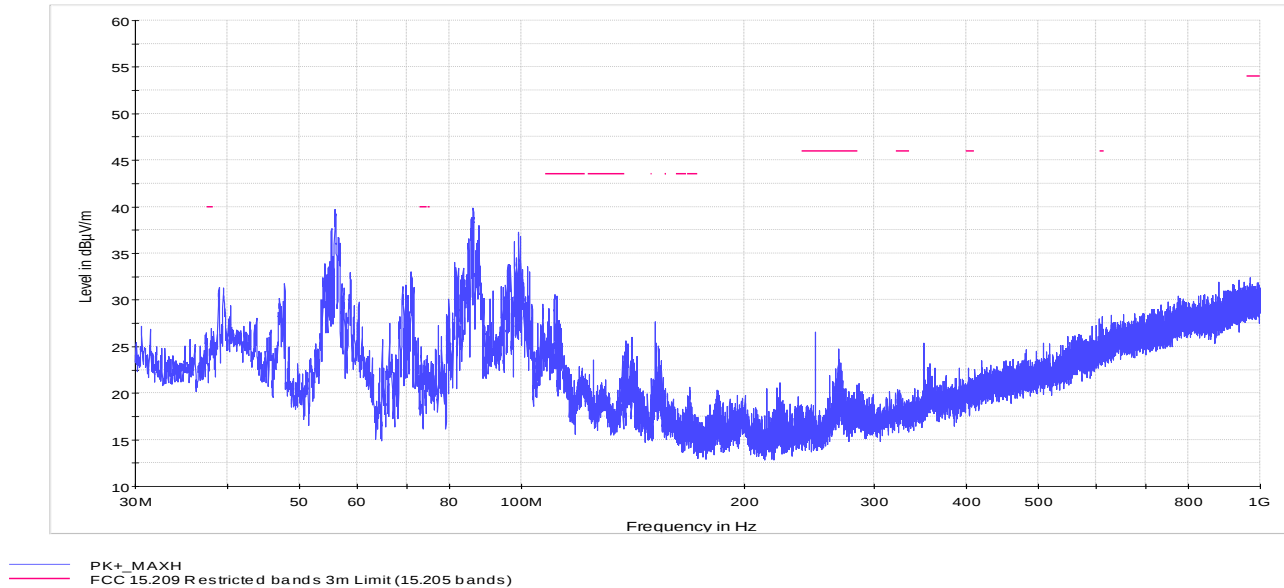


Figure 8.1-19: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, WIFI Mid channel – 802.11b Data rate 1M bps

8.1.4 Test data, continued

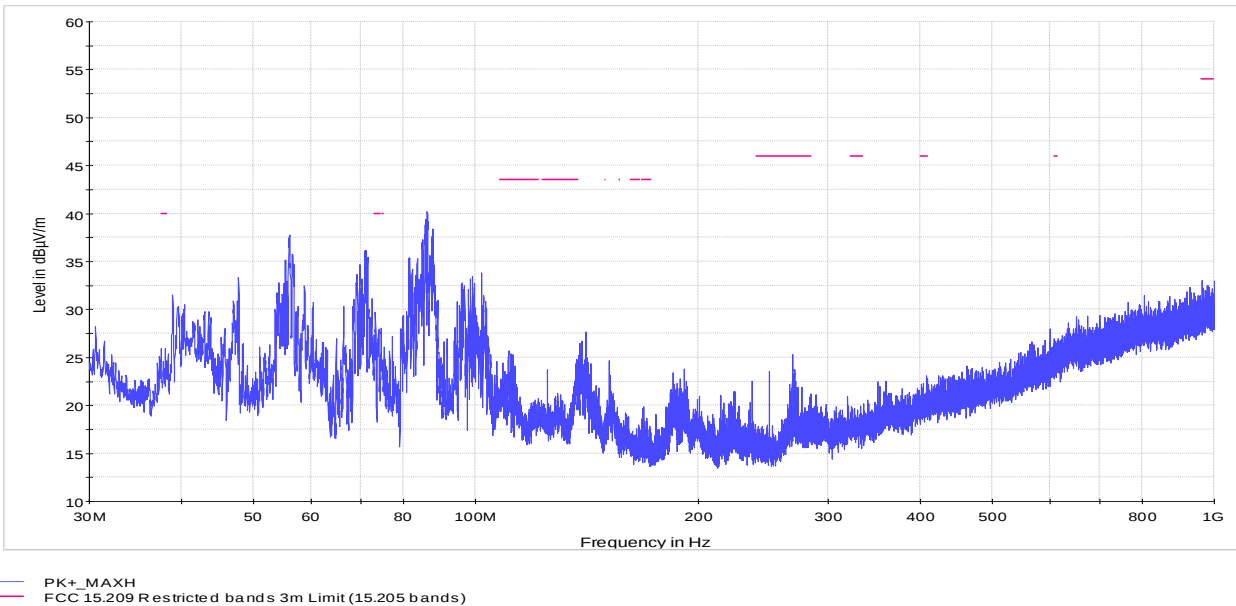


Figure 8.1-20: Radiated – Spurious (out-of-band) unwanted emissions below 1 GHz, WIFI High channel – 802.11b Data rate 1M bps

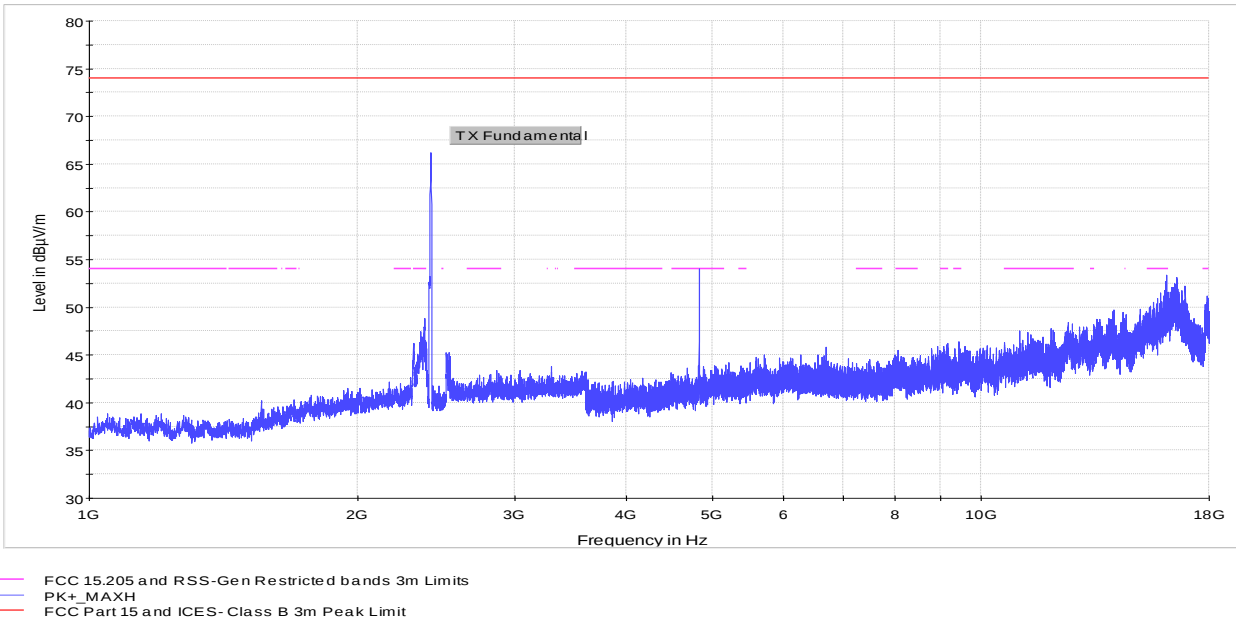


Figure 8.1-21: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, WIFI Low channel – 802.11b Data rate 1M bps

8.1.4 Test data, continued

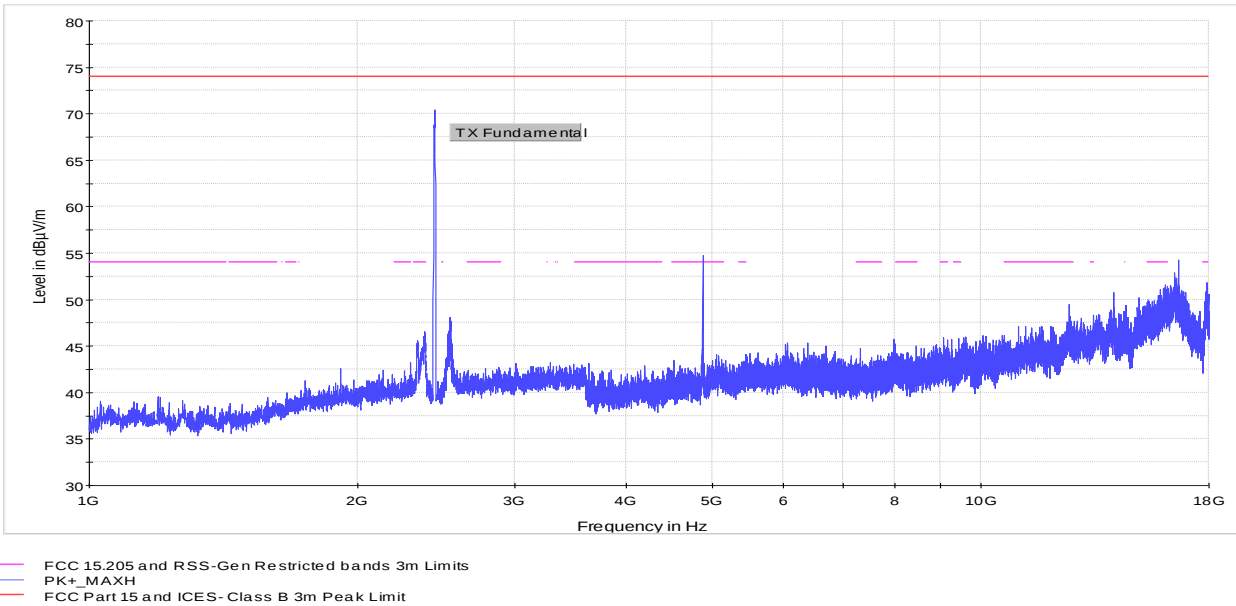


Figure 8.1-22: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, WIFI Midchannel – 802.11b Data rate 1M bps

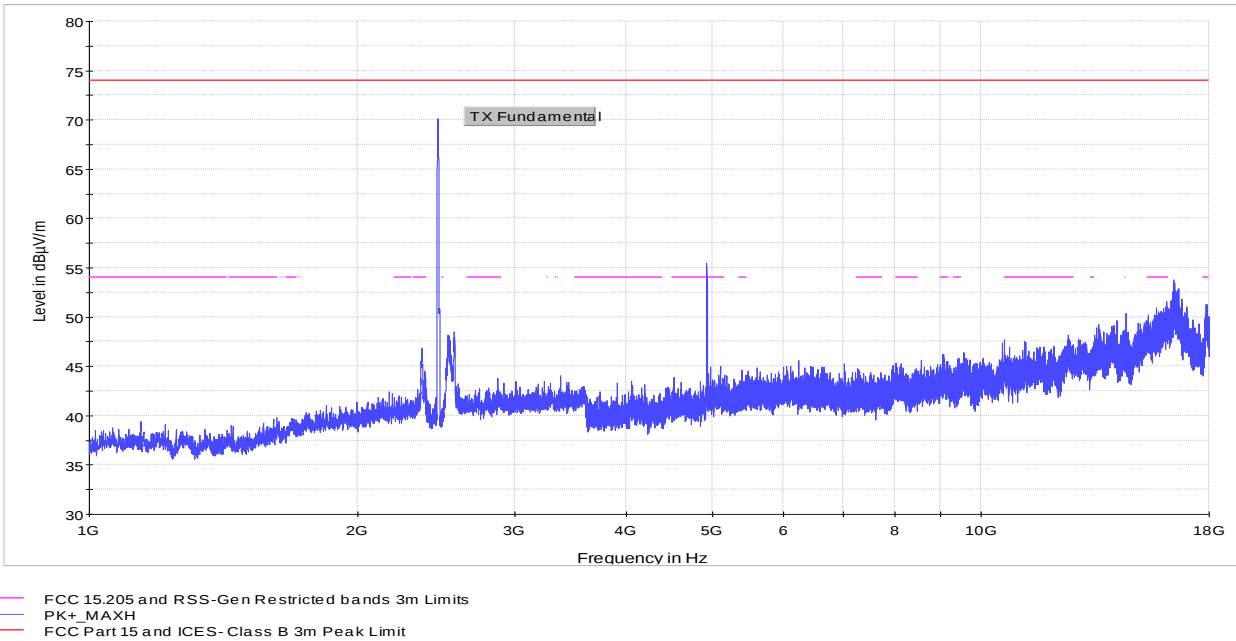


Figure 8.1-23: Radiated – Spurious (out-of-band) unwanted emissions within 1–18 GHz, WIFI High channel – 802.11b Data rate 1M bps

8.1.4 Test data, continued

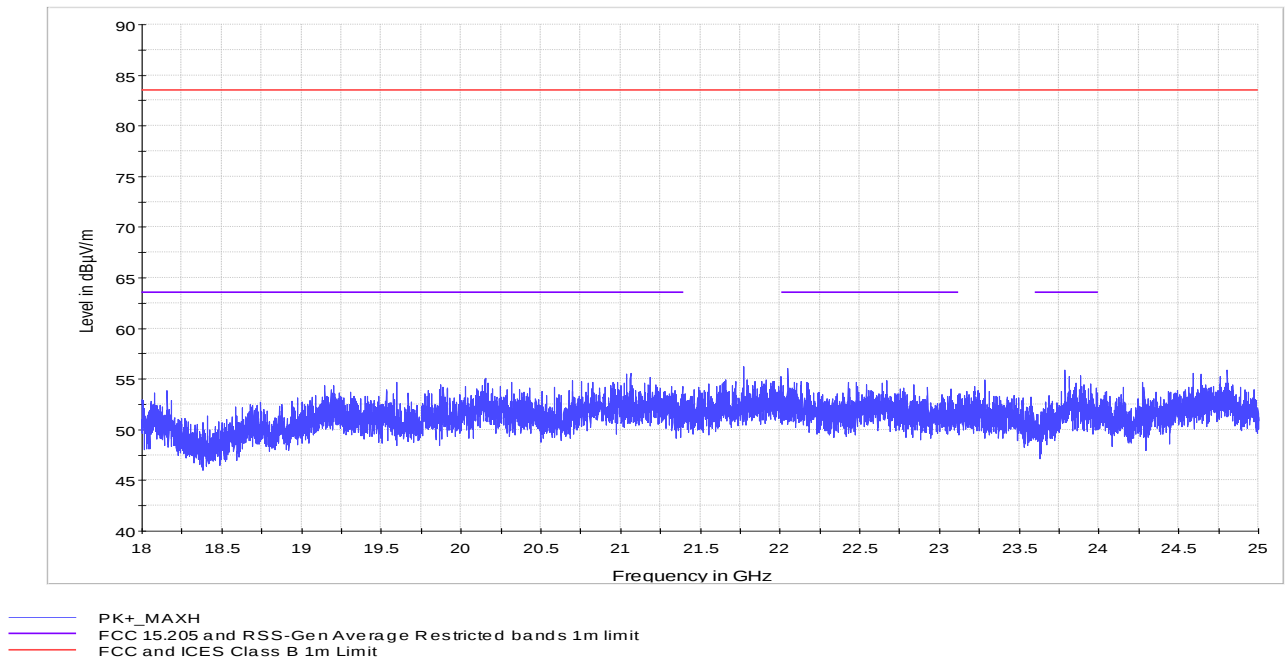


Figure 8.1-24: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, WIFI Low channel – 802.11b Data rate 1M bps

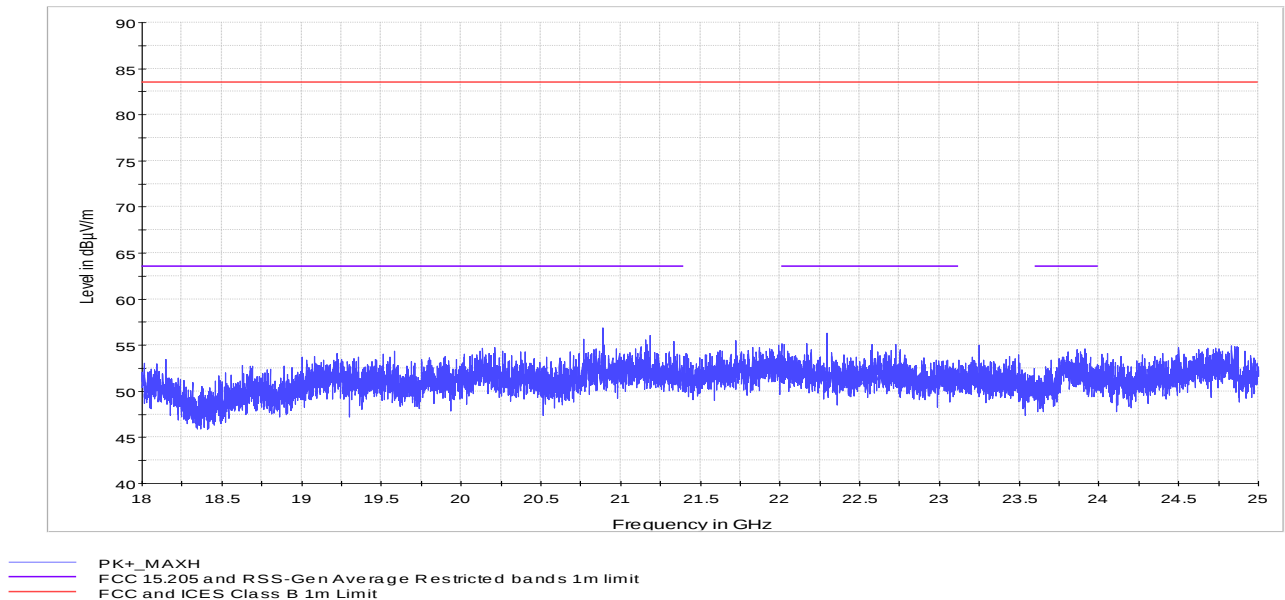


Figure 8.1-25: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, WIFI Mid channel – 802.11b Data rate 1M bps

8.1.4 Test data, continued

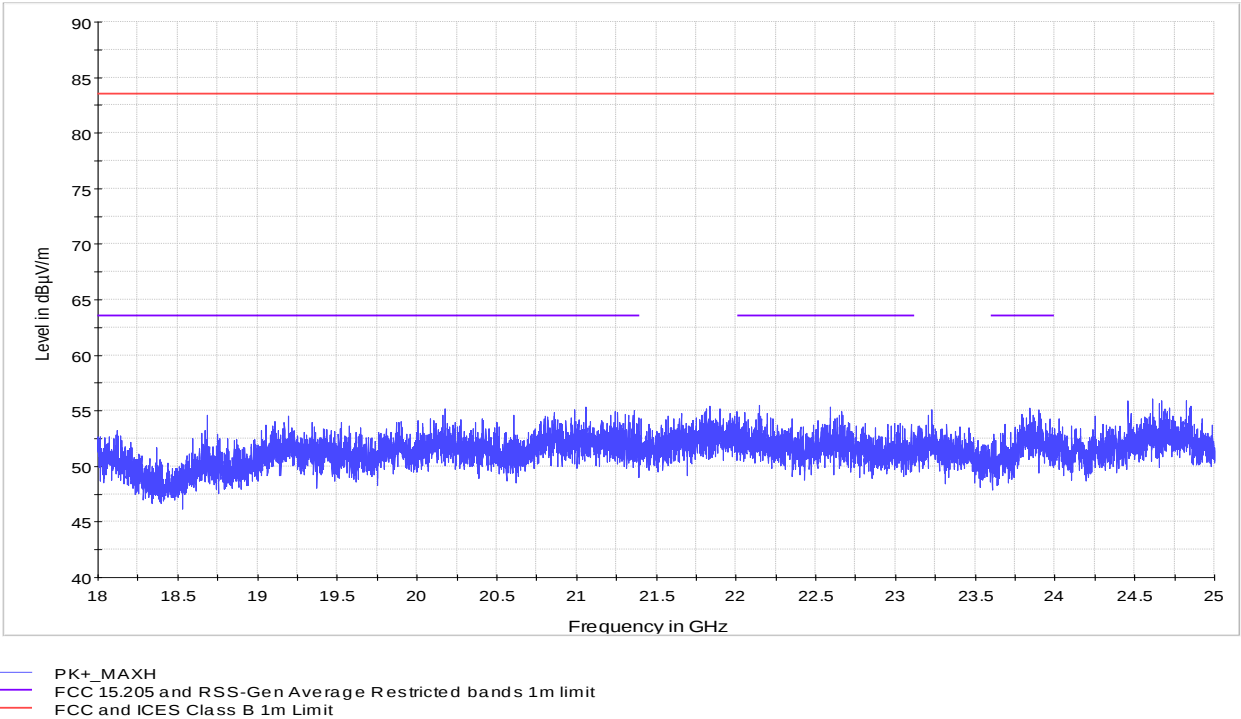
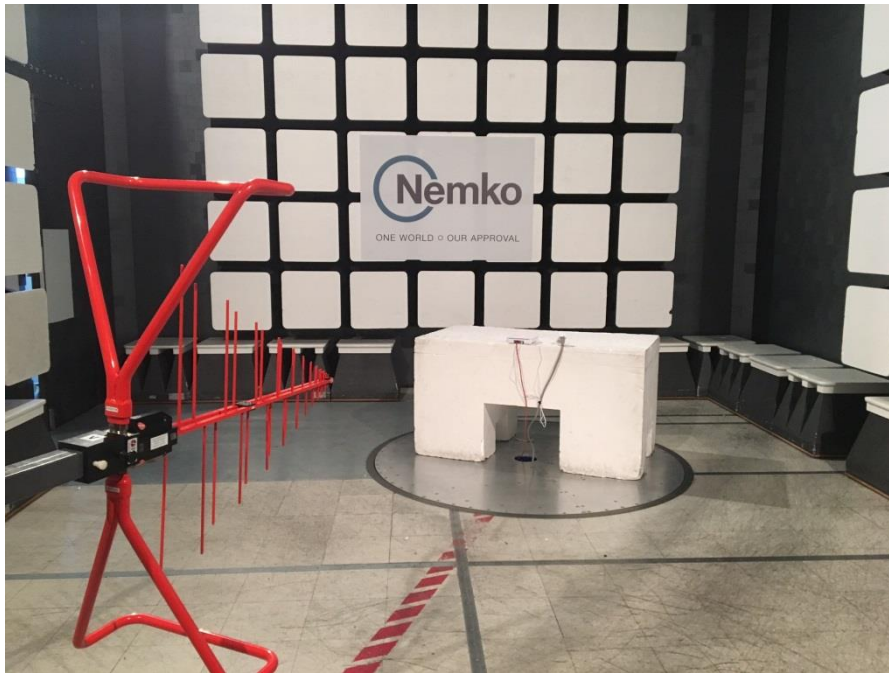


Figure 8.1-26: Radiated – Spurious (out-of-band) unwanted emissions within 18–25 GHz, WIFI High channel – 802.11b Data rate 1M bps

#### 8.1.5 Setup photos

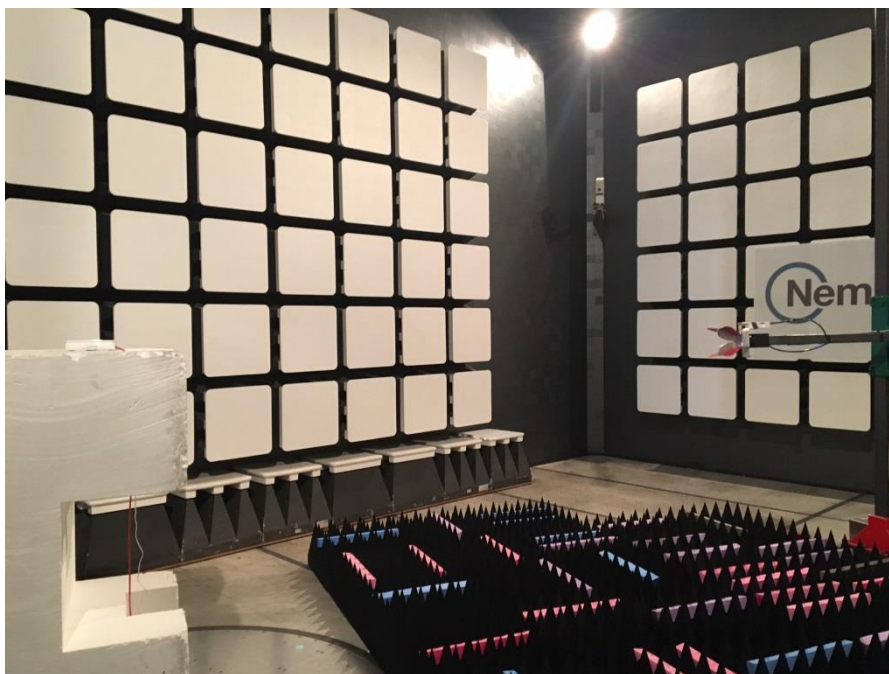


**Figure 8.1-27:** Radiated – Spurious (out-of-band) unwanted emissions setup photo – below 1 GHz



**Figure 8.1-28:** Radiated – Spurious (out-of-band) unwanted emissions setup photo – below 1 GHz

8.1.5 Setup photos, continued



**Figure 8.1-29:** Radiated – Spurious (out-of-band) unwanted emissions setup photo – above 1 GHz



**Figure 8.1-30:** Radiated – Spurious (out-of-band) unwanted emissions setup photo – above 1 GHz

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

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### 8.2.1 Definitions and limits

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#### 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.

#### RSS-247 Section 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.

### 8.2.1 Definitions and limits, continued

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**RSS-247 Section 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).

### 8.2.2 Test summary

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|         |      |
|---------|------|
| Verdict | Pass |
|---------|------|

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### 8.2.3 Observations, settings and special notes

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Measurement data in was taken from Sporton Report No.: FR4O0971C, FR4O0971B form FCC ID: Z64-WL18DBMOD. Client has changed the antenna; new calculations have been performed to demonstrate continued compliance.

## 8.2.4 Test data

**Table 8.2-1: Output power measurements results for WIFI**

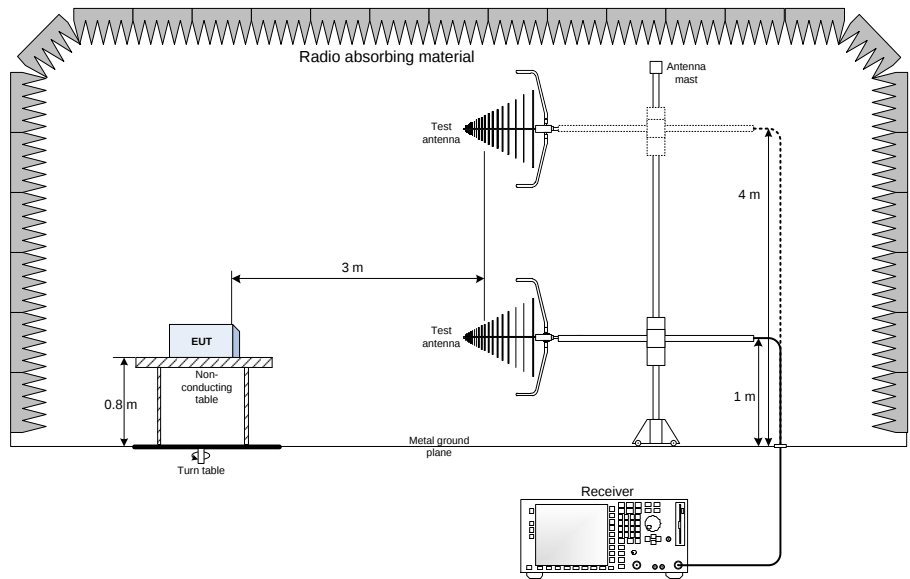
| Mod  | Data rate | Chan. | Freq. (MHz) | Peak conducted power, dBm | Peak conducted power limit, dBm | Margin, dB  | Antenna gain, dBi | e.i.r.p., dBm | e.i.r.p. limit, dBm | e.i.r.p. margin, dBm |                      |
|------|-----------|-------|-------------|---------------------------|---------------------------------|-------------|-------------------|---------------|---------------------|----------------------|----------------------|
|      |           |       |             | Ant 1                     | Ant 1                           | Ant 1       | Ant 1             | Ant 1         | Ant 1               | Ant 1                |                      |
| 11b  | 1 Mbps    | 1     | 2412        | 18.11                     | 30.00                           | 11.89       | 3.90              | 22.01         | 36.00               | 13.99                |                      |
| 11b  | 1 Mbps    | 6     | 2437        | 17.95                     | 30.00                           | 12.05       | 3.90              | 21.85         | 36.00               | 14.15                |                      |
| 11b  | 1 Mbps    | 11    | 2462        | 17.80                     | 30.00                           | 12.20       | 3.90              | 21.70         | 36.00               | 14.30                |                      |
| 11g  | 6 Mbps    | 1     | 2412        | 19.99                     | 30.00                           | 10.01       | 3.90              | 23.89         | 36.00               | 12.11                |                      |
| 11g  | 6 Mbps    | 6     | 2437        | 20.62                     | 30.00                           | 9.38        | 3.90              | 24.52         | 36.00               | 11.48                |                      |
| 11g  | 6 Mbps    | 11    | 2462        | 19.82                     | 30.00                           | 10.18       | 3.90              | 23.72         | 36.00               | 12.28                |                      |
| HT20 | MCS0      | 1     | 2412        | 19.97                     | 30.00                           | 10.03       | 3.90              | 23.87         | 36.00               | 12.13                |                      |
| HT20 | MCS0      | 6     | 2437        | 20.56                     | 30.00                           | 9.44        | 3.90              | 24.46         | 36.00               | 11.54                |                      |
| HT20 | MCS0      | 11    | 2462        | 19.78                     | 30.00                           | 10.22       | 3.90              | 23.68         | 36.00               | 12.32                |                      |
| HT40 | MCS0      | 3     | 2422        | 19.07                     | 30.00                           | 10.93       | 3.90              | 22.97         | 36.00               | 13.03                |                      |
| HT40 | MCS0      | 6     | 2437        | 20.10                     | 30.00                           | 9.90        | 3.90              | 24.00         | 36.00               | 12.00                |                      |
| HT40 | MCS0      | 9     | 2452        | 19.29                     | 30.00                           | 10.71       | 3.90              | 23.19         | 36.00               | 12.81                |                      |
| Mod  | Data rate | Chan. | Freq. (MHz) | Peak conducted power, dBm | Peak conducted power limit, dBm | Margin, dB  | Antenna gain, dBi |               | e.i.r.p., dBm       | e.i.r.p. limit, dBm  | e.i.r.p. margin, dBm |
|      |           |       |             | Ant 1 and 2               | Ant 1 and 2                     | Ant 1 and 2 | Ant 1             | Ant 2         | Ant 1 and 2         | Ant 1 and 2          | Ant 1 and 2          |
| HT40 | MCS12     | 1     | 2412        | 23.75                     | 30.00                           | 6.25        | 3.90              | 3.30          | 27.65               | 36.00                | 8.35                 |
| HT40 | MCS12     | 6     | 2437        | 23.86                     | 30.00                           | 6.14        | 3.90              | 3.30          | 27.76               | 36.00                | 8.24                 |
| HT40 | MCS12     | 11    | 2462        | 23.37                     | 30.00                           | 6.63        | 3.90              | 3.30          | 27.27               | 36.00                | 8.73                 |

**Table 8.2-2: Output power measurements results for BLE**

| Mod  | Data rate | Chan. | Freq. (MHz) | Peak conducted power, dBm | Peak conducted power limit, dBm | Margin, dB | Antenna gain, dBi | e.i.r.p., dBm | e.i.r.p. limit, dBm | e.i.r.p. margin, dBm |
|------|-----------|-------|-------------|---------------------------|---------------------------------|------------|-------------------|---------------|---------------------|----------------------|
|      |           |       |             | Ant 1                     | Ant 1                           | Ant 1      | Ant 1             | Ant 1         | Ant 1               | Ant 1                |
| GFSK | 1 Mdps    | 0     | 2402        | 6.92                      | 30.00                           | 23.08      | 3.90              | 10.82         | 36.00               | 25.18                |
| GFSK | 1 Mdps    | 19    | 2440        | 6.73                      | 30.00                           | 23.27      | 3.90              | 10.63         | 36.00               | 25.37                |
| GFSK | 1 Mdps    | 39    | 2480        | 6.28                      | 30.00                           | 23.72      | 3.90              | 10.18         | 36.00               | 25.82                |

# 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

