

# Test report

**300304-1TRFWL**

Date of issue: March 1, 2016

Applicant:

**6harmonics Inc.**

Product:

**Television Band Device (TVBD)**

Model:

**GWS-4012-23**

FCC ID:

**2AASTGWS-4012-23**

IC Registration Number:

**20750A-GWS-4012-23**

Specifications:

**FCC 47 CFR Part 15 Subpart H**

Television Band Devices

**RSS-222 February 5, 2015; Issue 1**

White Space Devices (WSDs)

#### Test location

|              |                                                      |
|--------------|------------------------------------------------------|
| Company name | Nemko Canada Inc.                                    |
| Address      | 303 River Road                                       |
| City         | Ottawa                                               |
| Province     | Ontario                                              |
| Postal code  | K1V 1H2                                              |
| Country      | Canada                                               |
| Telephone    | +1 613 737 9680                                      |
| Facsimile    | +1 613 737 9691                                      |
| Toll free    | +1 800 563 6336                                      |
| Website      | www.nemko.com                                        |
| Site number  | FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber) |

|             |                                                                                     |
|-------------|-------------------------------------------------------------------------------------|
| Tested by   | Andrey Adelberg, Senior Wireless/EMC Specialist                                     |
| Reviewed by | Kevin Rose, Wireless/EMC Specialist                                                 |
| Date        | March 1, 2016                                                                       |
| Signature   |  |

#### 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

|                                                                                                   |           |
|---------------------------------------------------------------------------------------------------|-----------|
| <b>Table of contents</b>                                                                          | <b>3</b>  |
| <b>Section 1. Report summary</b>                                                                  | <b>4</b>  |
| 1.1 Applicant and manufacturer                                                                    | 4         |
| 1.2 Test specifications                                                                           | 4         |
| 1.3 Test procedures                                                                               | 4         |
| 1.4 Statement of compliance                                                                       | 4         |
| 1.5 Exclusions                                                                                    | 4         |
| 1.6 Test report revision history                                                                  | 4         |
| <b>Section 2. Summary of test results</b>                                                         | <b>5</b>  |
| 2.1 FCC Part 15, general requirements test results                                                | 5         |
| 2.2 FCC Part 15 Subpart H, test results                                                           | 5         |
| 2.3 IC RSS-GEN, Issue 4, test results                                                             | 5         |
| 2.4 RSS-222, test results                                                                         | 5         |
| <b>Section 3. Equipment under test (EUT) details</b>                                              | <b>6</b>  |
| 3.1 Sample information                                                                            | 6         |
| 3.2 EUT information                                                                               | 6         |
| 3.3 Technical information                                                                         | 6         |
| 3.4 Product description and theory of operation                                                   | 6         |
| 3.5 EUT exercise details                                                                          | 6         |
| 3.6 EUT setup diagram                                                                             | 7         |
| 3.7 EUT sub assemblies                                                                            | 7         |
| <b>Section 4. Engineering considerations</b>                                                      | <b>8</b>  |
| 4.1 Modifications incorporated in the EUT                                                         | 8         |
| 4.2 Technical judgment                                                                            | 8         |
| 4.3 Deviations from laboratory tests procedures                                                   | 8         |
| <b>Section 5. Test conditions</b>                                                                 | <b>9</b>  |
| 5.1 Atmospheric conditions                                                                        | 9         |
| 5.2 Power supply range                                                                            | 9         |
| <b>Section 6. Measurement uncertainty</b>                                                         | <b>10</b> |
| 6.1 Uncertainty of measurement                                                                    | 10        |
| <b>Section 7. Test equipment</b>                                                                  | <b>11</b> |
| 7.1 Test equipment list                                                                           | 11        |
| <b>Section 8. Testing data</b>                                                                    | <b>12</b> |
| 8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits                        | 12        |
| 8.2 FCC 15.709(a)(1) and RSS-222 6.2.1.2 Maximum conducted output power for fixed TVBDs           | 16        |
| 8.3 FCC 15.709(a)(5)(i) and RSS-222 6.2.1.2 The power spectral density from the TVBD              | 17        |
| 8.4 FCC 15.709(c)(1)(i) and RSS-222 6.3.2 Transmitter band edge for fixed TVBDs                   | 18        |
| 8.5 FCC 15.709(c)(3) and RSS-222 6.3.3 Radiated spurious emissions beyond the television channels | 20        |
| 8.6 FCC 15.709(c)(4) and RSS-222 6.4 Field Strength Emissions in the band 602–620 MHz             | 25        |
| <b>Section 9. Block diagrams and photos of test set-ups</b>                                       | <b>27</b> |
| 9.1 Radiated emissions set-up for frequencies below 1 GHz                                         | 27        |
| 9.2 Radiated emissions set-up for frequencies above 1 GHz                                         | 28        |
| 9.3 Conducted emissions set-up                                                                    | 28        |
| 9.4 Photo of set-up with Omnidirectional antenna                                                  | 29        |
| 9.5 Photo of set-up with Directional antenna                                                      | 30        |

## Section 1. Report summary

---

### 1.1 Applicant and manufacturer

---

|                 |                              |
|-----------------|------------------------------|
| Company name    | 6harmonics Inc.              |
| Address         | Suite 10 - 21 Concourse Gate |
| City            | Ottawa                       |
| Province/State  | ON                           |
| Postal/Zip code | K2E 7S4                      |
| Country         | Canada                       |

### 1.2 Test specifications

---

|                                   |                            |
|-----------------------------------|----------------------------|
| FCC 47 CFR Part 15, Subpart H     | Television Band Devices    |
| RSS-222 February 5, 2015; Issue 1 | White Space Devices (WSDs) |

### 1.3 Test procedures

---

|                                            |                                                                                                                 |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 416721 D01 White Space Test Procedures v02 | Certification Test Procedures for TV Band (White Space) Devices Authorized Under Subpart H of the Part 15 Rules |
| ANSI C63.10 v2013                          | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices                  |

### 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. 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 Exclusions

---

None

### 1.6 Test report revision history

---

| Revision # | Details of changes made to test report |
|------------|----------------------------------------|
| TRF        | Original report issued                 |

## Section 2. Summary of test results

### 2.1 FCC Part 15, general requirements test results

| Part        | Test description          | Verdict           |
|-------------|---------------------------|-------------------|
| \$15.207(a) | Conducted limits          | Pass              |
| \$15.31(e)  | Variation of power source | Pass <sup>1</sup> |
| \$15.203    | Antenna requirement       | Pass <sup>2</sup> |

Notes: <sup>1</sup> Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

<sup>2</sup>The Antennas are professionally installed.

### 2.2 FCC Part 15 Subpart H, test results

| Part              | Test description                               | Verdict |
|-------------------|------------------------------------------------|---------|
| \$15.709(a)(1)    | Maximum conducted output power for fixed TVBDs | Pass    |
| \$15.709(a)(5)(i) | Power spectral density for fixed TVBDs         | Pass    |
| \$15.709(c)(1)(i) | Adjacent channel power for fixed TVBDs         | Pass    |
| \$15.709(c)(3)    | Radiated spurious emissions from TVBDs         | Pass    |
| \$15.709(c)(4)    | Emissions in the band 602–620 MHz              | Pass    |
| \$15.709(c)(5)    | AC power line conducted limits                 | Pass    |

Note: none

### 2.3 IC RSS-GEN, Issue 4, test results

| Part  | Test description                                                         | Verdict        |
|-------|--------------------------------------------------------------------------|----------------|
| 7.1.2 | Receiver radiated emission limits                                        | Not applicable |
| 7.1.3 | Receiver conducted emission limits                                       | Not applicable |
| 8.8   | Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus | Pass           |

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

### 2.4 RSS-222, test results

| Section | Test description                                                                          | Verdict |
|---------|-------------------------------------------------------------------------------------------|---------|
| 6.2.1   | Transmitter power, power spectral density (PSD) and transmit power control for Fixed WSDs | Pass    |
| 6.3.2   | Transmitter band edge and adjacent channel power limits                                   | Pass    |
| 6.3.3   | Spurious emissions measurements and limits                                                | Pass    |
| 6.4     | Field strength emissions in the band 602-620 MHz                                          | Pass    |

Note: none

## Section 3. Equipment under test (EUT) details

---

### 3.1 Sample information

---

|                        |                   |
|------------------------|-------------------|
| Receipt date           | December 21, 2015 |
| Nemko sample ID number | 133-00753         |

### 3.2 EUT information

---

|               |                               |
|---------------|-------------------------------|
| Product name  | Television Band Device (TVBD) |
| Model         | GWS-4012-23                   |
| Serial number | 720000001                     |

### 3.3 Technical information

---

|                     |                                                                                                                                                          |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating band      | 470–698 MHz                                                                                                                                              |
| Operating frequency | 476–596 MHz and 626–692 MHz                                                                                                                              |
| Modulation type     | BPSK, QPSK, 16-QAM, and 64-QAM                                                                                                                           |
| Channel bandwidth   | 12 MHz                                                                                                                                                   |
| Emission designator | W7D                                                                                                                                                      |
| Power requirements  | 120 V <sub>AC</sub> 60 Hz                                                                                                                                |
| Antenna information | Shenglu Omnidirectional antenna, MN#: SL13319A, gain 2.5 dBi, SN#: 2015090004<br>Shenglu Directional antenna, MN#: SL14174A, gain 8 dBi, SN#: 2014120041 |

### 3.4 Product description and theory of operation

---

The 6Harmonics Inc. GWS radios are a new class of radios designed for the global white space radio market. The GWS-4012-23 is designed to provide up to 23 dBm of transmit power, offer a sensitivity of up to –100 dBm, and provide 16.5 Mbps of UDP throughput in a 12 MHz television channel. The product can be used for Point to Point or Point to Multi-point operation.

### 3.5 EUT exercise details

---

The GWS-4012-23 is powered from a POE Midspan. During the tests a laptop was used to connect to the GWS-4012-23 and configure the device to transmit continuously with the desired modulation and power.

3.6 EUT setup diagram

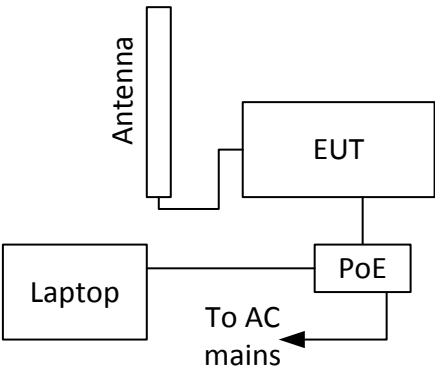


Figure 3.6-1: Setup diagram

3.7 EUT sub assemblies

Table 3.7-1: EUT sub assemblies

| Description                     | Brand name | Model/Part number | Serial number      |
|---------------------------------|------------|-------------------|--------------------|
| PoE Power supply                | PowerDsine | PD-9501G/SP/AC    | N15036517007500A03 |
| Omnidirectional antenna 2.5 dBi | Shenglu    | SL13319A          | 2015090004         |
| Directional antenna 8 dBi       | Shenglu    | SL14174A          | 2014120041         |

## Section 4. Engineering considerations

---

### 4.1 Modifications incorporated in the EUT

---

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      | 860–1060 mbar |

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

## 5.2 Power supply range

---

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages  $\pm 5\%$ , for which the equipment was designed.

Section 6. Measurement uncertainty

---

6.1 Uncertainty of measurement

---

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

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

## Section 7. Test equipment

### 7.1 Test equipment list

*Table 7.1-1: Equipment list*

| Equipment                   | Manufacturer           | Model no.          | Asset no. | Cal cycle | Next cal.   |
|-----------------------------|------------------------|--------------------|-----------|-----------|-------------|
| 3 m EMI test chamber        | TDK                    | SAC-3              | FA002047  | 1 year    | Feb. 25/16  |
| Flush mount turntable       | Sunol                  | FM2022             | FA002082  | —         | NCR         |
| Controller                  | Sunol                  | SC104V             | FA002060  | —         | NCR         |
| Antenna mast                | Sunol                  | TLT2               | FA002061  | —         | NCR         |
| Power source                | California Instruments | 5001ix             | FA002494  | 1 year    | Jan. 22 /16 |
| Receiver/spectrum analyzer  | Rohde & Schwarz        | ESU 26             | FA002043  | 1 year    | Jan. 07/16  |
| Bilog antenna (20–3000 MHz) | Sunol                  | JB3                | FA002108  | 1 year    | Apr. 12/16  |
| Horn antenna (1–18 GHz)     | EMCO                   | 3115               | FA000825  | 1 year    | Apr. 01/16  |
| Pre-amplifier (1–18 GHz)    | JCA                    | JCA118-503         | FA002091  | 1 year    | May 05/16   |
| LISN                        | Rohde & Schwarz        | ENV216             | FA002023  | 1 year    | Jan. 09/16  |
| Tunable Notch Filter        | K&L                    | 3TNF-500/1000-N/N  | FA001330  | —         | VOU         |
| Tunable Band Pass Filter    | K&L                    | 3BT-500/1000-5-N/N | FA001506  | —         | VOU         |

Note: NCR - no calibration required

## Section 8. Testing data

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

#### 8.1.1 Definitions and limits

**FCC:**

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

**IC:**

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

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

*Table 8.1-1: Conducted emissions limit*

| Frequency of emission,<br>MHz | Conducted limit, dB $\mu$ V |           |
|-------------------------------|-----------------------------|-----------|
|                               | Quasi-peak                  | Average** |
| 0.15–0.5                      | 66 to 56*                   | 56 to 46* |
| 0.5–5                         | 56                          | 46        |
| 5–30                          | 60                          | 50        |

Note: \* - The level decreases linearly with the logarithm of the frequency.

\*\* - A linear average detector is required.

#### 8.1.2 Test summary

|               |                   |                   |           |
|---------------|-------------------|-------------------|-----------|
| Test date     | December 21, 2015 | Temperature       | 23 °C     |
| Test engineer | Andrey Adelberg   | Air pressure      | 1015 mbar |
| Verdict       | Pass              | Relative humidity | 34 %      |

8.1.3 Observations, settings and special notes

---

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings for preview measurements:

|                      |                  |
|----------------------|------------------|
| Resolution bandwidth | 9 kHz            |
| Video bandwidth      | 30 kHz           |
| Detector mode        | Peak and Average |
| Trace mode           | Max Hold         |
| Measurement time     | 1000 ms          |

Receiver settings for final measurements:

|                      |                        |
|----------------------|------------------------|
| Resolution bandwidth | 9 kHz                  |
| Video bandwidth      | 30 kHz                 |
| Detector mode        | Quasi-Peak and Average |
| Trace mode           | Max Hold               |
| Measurement time     | 1000 ms                |

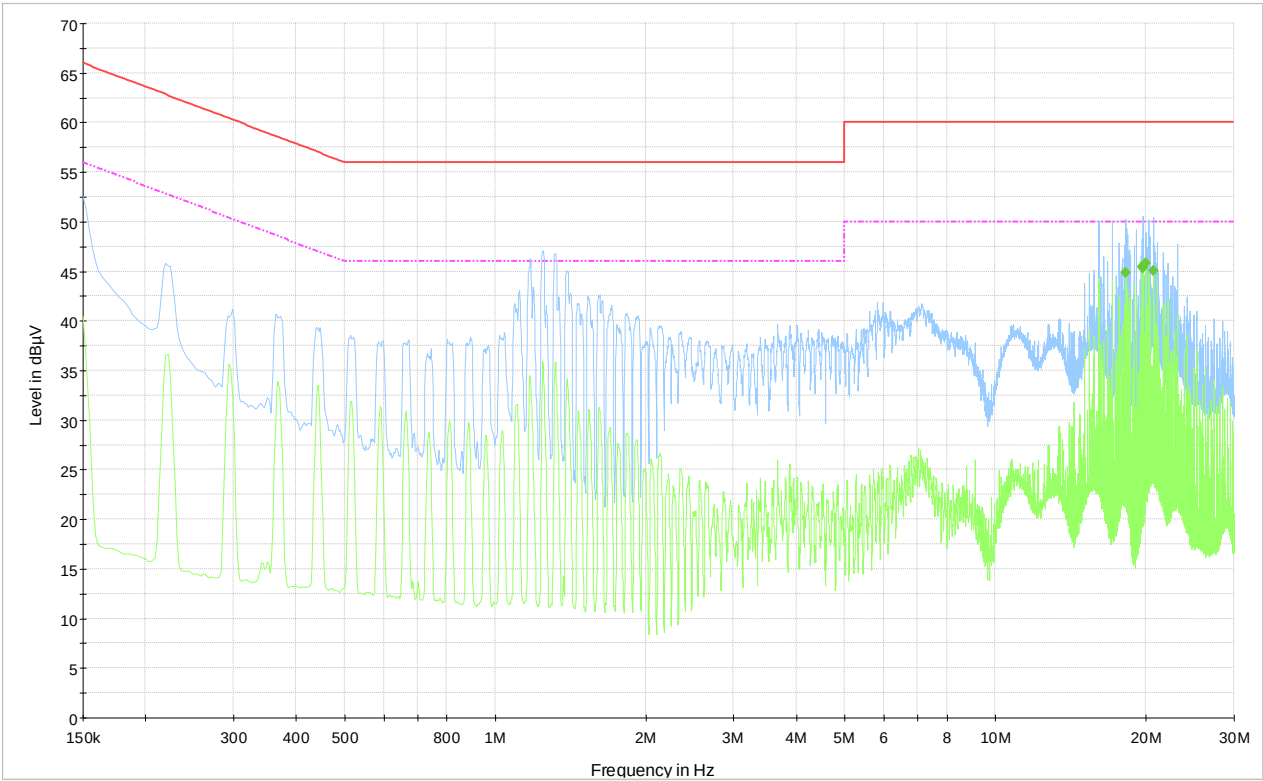
8.1.4 Test data



Plot 8.1-1: Conducted emissions on phase line

Table 8.1-2: Average conducted emissions results on phase line

| Frequency, MHz | Average result, dBµV | Meas. Time, ms | Bandwidth, kHz | Filter | Correction, dB | Margin, dB | Limit, dBµV |
|----------------|----------------------|----------------|----------------|--------|----------------|------------|-------------|
| 18.244000      | 45.27                | 1000           | 9              | On     | 10.45          | 4.70       | 50.00       |
| 19.634500      | 45.53                | 1000           | 9              | On     | 10.50          | 4.50       | 50.00       |
| 19.708750      | 45.04                | 1000           | 9              | On     | 10.50          | 5.00       | 50.00       |
| 19.985500      | 45.64                | 1000           | 9              | On     | 10.52          | 4.40       | 50.00       |
| 20.685250      | 44.88                | 1000           | 9              | On     | 10.53          | 5.10       | 50.00       |



Plot 8.1-2: Conducted emissions on neutral line

Table 8.1-3: Average conducted emissions results on neutral line

| Frequency,<br>MHz | Average result,<br>dBµV | Meas. Time,<br>ms | Bandwidth,<br>kHz | Filter | Correction,<br>dB | Margin,<br>dB | Limit,<br>dBµV |
|-------------------|-------------------------|-------------------|-------------------|--------|-------------------|---------------|----------------|
| 18.2440000        | 44.82                   | 1000              | 9                 | On     | 10.60             | 5.20          | 50.00          |
| 19.6300000        | 45.47                   | 1000              | 9                 | On     | 10.67             | 4.50          | 50.00          |
| 19.7087500        | 45.32                   | 1000              | 9                 | On     | 10.68             | 4.70          | 50.00          |
| 19.9810000        | 45.80                   | 1000              | 9                 | On     | 10.70             | 4.20          | 50.00          |
| 20.6830000        | 45.08                   | 1000              | 9                 | On     | 10.75             | 4.90          | 50.00          |

## 8.2 FCC 15.709(a)(1) and RSS-222 6.2.1.2 Maximum conducted output power for fixed TVBDs

### 8.2.1 Definitions and limits

#### FCC:

For fixed TVBDs, the maximum power delivered to the transmitting antenna shall not exceed one watt per 6 megahertz of bandwidth on which the device operates. The power delivered to the transmitting antenna is the maximum conducted output power reduced by the signal loss experienced in the cable used to connect the transmitter to the transmit antenna. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

#### IC:

Fixed WSD conducted power level per 6 MHz of bandwidth on which the devices operate shall not exceed the level of 30 dBm (1 W) during any time of continuous transmission.

Fixed WSD with a transmitting antenna of directional gain greater than 6 dBi shall reduce the maximum conducted output power and PSD by the amount in decibels that the directional gain of the antenna exceeds 6 dBi.

### 8.2.2 Test summary

|               |                   |                   |           |
|---------------|-------------------|-------------------|-----------|
| Test date     | December 21, 2015 | Temperature       | 23 °C     |
| Test engineer | Andrey Adelberg   | Air pressure      | 1015 mbar |
| Verdict       | Pass              | Relative humidity | 34 %      |

### 8.2.3 Observations, settings and special notes

Since channel bandwidth is 12 MHz instead of 6 MHz, the power integration was performed over 12 MHz channel.  
Spectrum analyser settings for output power:

|                       |                                |
|-----------------------|--------------------------------|
| Resolution bandwidth: | 100 kHz                        |
| Video bandwidth:      | 300 kHz                        |
| Detector mode:        | RMS                            |
| Sweep time:           | 5 s                            |
| Trace mode:           | Power Averaging over 10 traces |

### 8.2.4 Test data

**Table 8.2-1:** Conducted output power and EIRP measurements for Omnidirectional antenna

| Channel | Frequency, MHz | Power, dBm/12 MHz | Power limit, dBm/12 MHz | Margin, dB | Antenna gain, dBi | EIRP, dBm | EIRP limit, dBm | Margin, dB |
|---------|----------------|-------------------|-------------------------|------------|-------------------|-----------|-----------------|------------|
| Low     | 476.00         | 22.39             | 30.00                   | 7.61       | 2.50              | 24.89     | 36.00           | 11.11      |
| Mid     | 590.00         | 23.59             | 30.00                   | 6.41       | 2.50              | 26.09     | 36.00           | 9.91       |
| High    | 692.00         | 22.38             | 30.00                   | 7.62       | 2.50              | 24.88     | 36.00           | 11.12      |

Note: Antenna gain is equal and lower than 6 dBi, therefore no reduction in power limit was required.

**Table 8.2-2:** Conducted output power and EIRP measurements for Directional antenna

| Channel | Frequency, MHz | Power, dBm/12 MHz | Power limit, dBm/12 MHz | Margin, dB | Antenna gain, dBi* | EIRP, dBm | EIRP limit, dBm | Margin, dB |
|---------|----------------|-------------------|-------------------------|------------|--------------------|-----------|-----------------|------------|
| Low     | 476.00         | 17.18             | 29.00                   | 11.82      | 7.00               | 24.18     | 36.00           | 11.82      |
| Mid     | 590.00         | 17.16             | 29.00                   | 11.84      | 7.00               | 24.16     | 36.00           | 11.84      |
| High    | 692.00         | 17.07             | 29.00                   | 11.93      | 7.00               | 24.07     | 36.00           | 11.93      |

Note: Antenna gain is 8 dBi and cable loss is 1 dB, total system antenna gain is 7 dBi, therefore 1 dB reduction in power limit was required.

## 8.3 FCC 15.709(a)(5)(i) and RSS-222 6.2.1.2 The power spectral density from the TVBD

### 8.3.1 Definitions and limits

#### FCC:

The power spectral density from the TVBD shall not be greater than the following values when measured in any 100 kHz band during any time interval of continuous transmission:

(i) Fixed devices: 12.6 dBm conducted power. If transmitting antennas of directional gain greater than 6 dBi are used, this conducted power level shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

#### IC:

Fixed WSD conducted PSD per 100 kHz band within a 6 MHz wide channel shall not exceed the 12.6 dBm/100 kHz level during any time of continuous transmission.

Fixed WSD with a transmitting antenna of directional gain greater than 6 dBi shall reduce the maximum conducted output power and PSD by the amount in decibels that the directional gain of the antenna exceeds 6 dBi.

### 8.3.2 Test summary

|               |                   |                   |           |
|---------------|-------------------|-------------------|-----------|
| Test date     | December 21, 2015 | Temperature       | 23 °C     |
| Test engineer | Andrey Adelberg   | Air pressure      | 1015 mbar |
| Verdict       | Pass              | Relative humidity | 34 %      |

### 8.3.3 Observations, settings and special notes

Spectrum analyser settings for output power:

|                       |                                |
|-----------------------|--------------------------------|
| Resolution bandwidth: | 100 kHz                        |
| Video bandwidth:      | 300 kHz                        |
| Detector mode:        | RMS                            |
| Sweep time:           | 5 s                            |
| Trace mode:           | Power Averaging over 10 traces |

### 8.3.4 Test data

**Table 8.3-1:** Conducted PSD measurements for Omnidirectional antenna

| Channel | Frequency, MHz | PSD, dBm/100 kHz | PSD limit, dBm/100 kHz | Margin, dB | Antenna gain, dBi | EIRP PSD, dBm/100 kHz | EIRP limit, dBm/100 kHz | Margin, dB |
|---------|----------------|------------------|------------------------|------------|-------------------|-----------------------|-------------------------|------------|
| Low     | 476.00         | 5.42             | 12.60                  | 7.18       | 2.50              | 7.92                  | 18.60                   | 10.68      |
| Mid     | 590.00         | 6.87             | 12.60                  | 5.73       | 2.50              | 9.37                  | 18.60                   | 9.23       |
| High    | 692.00         | 5.77             | 12.60                  | 6.83       | 2.50              | 8.27                  | 18.60                   | 10.33      |

Note: Antenna gain is equal and lower than 6 dBi, therefore no reduction in PSD limit was required.

**Table 8.3-2:** Conducted PSD measurements for Directional antenna

| Channel | Frequency, MHz | PSD, dBm/100 kHz | PSD limit, dBm/100 kHz | Margin, dB | Antenna gain, dBi* | EIRP PSD, dBm/100 kHz | EIRP limit, dBm/100 kHz | Margin, dB |
|---------|----------------|------------------|------------------------|------------|--------------------|-----------------------|-------------------------|------------|
| Low     | 476.00         | 5.97             | 11.60                  | 5.63       | 7.00               | 12.97                 | 17.60                   | 4.63       |
| Mid     | 590.00         | 5.65             | 11.60                  | 5.95       | 7.00               | 12.65                 | 17.60                   | 4.95       |
| High    | 692.00         | 5.00             | 11.60                  | 6.60       | 7.00               | 12.00                 | 17.60                   | 5.60       |

Note: Antenna gain is 8 dBi and cable loss is 1 dB, total system antenna gain is 7 dBi, therefore 1 dB reduction in PSD limit was required.

8.4 FCC 15.709(c)(1)(i) and RSS-222 6.3.2 Transmitter band edge for fixed TVBDs

8.4.1 Definitions and limits

**FCC:**  
(1) In the television channels immediately adjacent to the channel in which the TVBD is operating, emissions from the TVBD shall not exceed the following levels:  
(i) Fixed devices: -42.8 dBm conducted power.  
Emission measurements in the adjacent channels shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.  
**IC:**  
WSDs band edge and adjacent channel power shall not exceed the conducted levels of -42.8 dBm/100 kHz

8.4.2 Test summary

|               |                   |                   |           |
|---------------|-------------------|-------------------|-----------|
| Test date     | December 22, 2015 | Temperature       | 22 °C     |
| Test engineer | Andrey Adelberg   | Air pressure      | 1009 mbar |
| Verdict       | Pass              | Relative humidity | 31 %      |

8.4.3 Observations, settings and special notes

Spectrum analyser settings for output power:

|                       |                                |
|-----------------------|--------------------------------|
| Resolution bandwidth: | 100 kHz                        |
| Video bandwidth:      | 300 kHz                        |
| Detector mode:        | RMS                            |
| Sweep time:           | 5 s                            |
| Trace mode:           | Power Averaging over 10 traces |

8.4.4 Test data

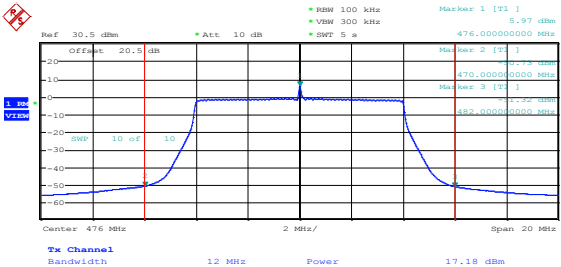


Figure 8.4-1: Band edges (and ACP) for low channel, directional antenna

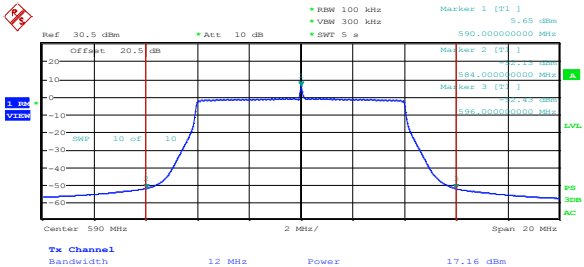
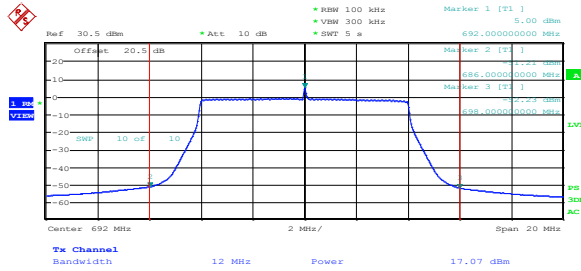


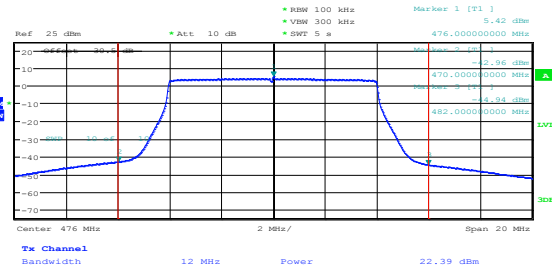
Figure 8.4-2: Band edges (and ACP) for mid channel, directional antenna

**Section 8**  
**Test name**  
**Specification**

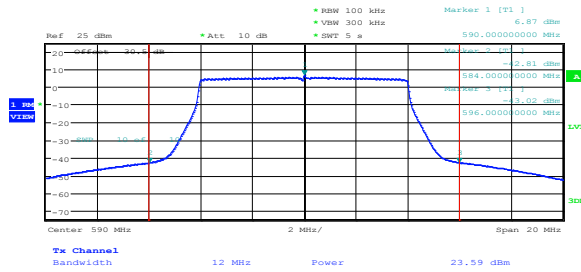
Testing data  
FCC 15.709(c)(1)(i) and RSS-222 6.3.2 Transmitter band edge for fixed TVBDs  
FCC Part 15 Subpart H and RSS-222



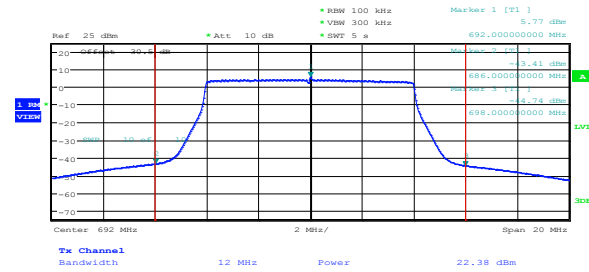
**Figure 8.4-3:** Band edges (and ACP) for high channel, directional antenna



**Figure 8.4-4:** Band edges (and ACP) for low channel, omnidirectional antenna



**Figure 8.4-5:** Band edges (and ACP) for mid channel, omnidirectional antenna



**Figure 8.4-6:** Band edges (and ACP) for high channel, omnidirectional antenna

**Table 8.4-1:** Band edge measurements for Omnidirectional antenna

| Channel | Frequency, MHz | Band edge level, dBm/100 kHz | Band edge limit, dBm/100 kHz | Margin, dB |
|---------|----------------|------------------------------|------------------------------|------------|
| Low     | 470            | -42.96                       | -42.80                       | 0.16       |
| Low     | 482            | -44.94                       | -42.80                       | 2.14       |
| Mid     | 584            | -42.81                       | -42.80                       | 0.01       |
| Mid     | 596            | -43.02                       | -42.80                       | 0.22       |
| High    | 686            | -43.41                       | -42.80                       | 0.61       |
| High    | 698            | -44.74                       | -42.80                       | 1.94       |

Note: Antenna gains are equal and lower than 6 dBi, therefore no reduction in band edge limit was required.

**Table 8.4-2:** Band edge measurements for Directional antenna

| Channel | Frequency, MHz | Band edge level, dBm/100 kHz | Band edge limit, dBm/100 kHz | Margin, dB |
|---------|----------------|------------------------------|------------------------------|------------|
| Low     | 470            | -50.73                       | -43.80                       | 6.93       |
| Low     | 482            | -51.32                       | -43.80                       | 7.52       |
| Mid     | 584            | -52.13                       | -43.80                       | 8.33       |
| Mid     | 596            | -52.43                       | -43.80                       | 8.63       |
| High    | 686            | -51.21                       | -43.80                       | 7.41       |
| High    | 698            | -52.23                       | -43.80                       | 8.43       |

Note: Antenna gain is 8 dBi and cable loss is 1 dB, total system antenna gain is 7 dBi, therefore 1 dB reduction in band edge limit was required.

## 8.5 FCC 15.709(c)(3) and RSS-222 6.3.3 Radiated spurious emissions beyond the television channels

### 8.5.1 Definitions and limits

**FCC:**  
At frequencies beyond the television channels immediately adjacent to the channel in which the TVBD is operating, the radiated emissions from TVBDs shall meet the requirements of § 15.209.

**IC:**  
Beyond the adjacent channel emissions, the emission limits of RSS-Gen apply. See RSS-Gen for guidance on performing those measurements

**Table 8.5-1: FCC §15.209 and RSS-Gen Radiated emission limits**

| Frequency,<br>MHz | Field strength of emissions |                                 | Measurement distance |
|-------------------|-----------------------------|---------------------------------|----------------------|
|                   | μV/m                        | dBμV/m                          | 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

### 8.5.2 Test summary

|               |                    |                   |           |
|---------------|--------------------|-------------------|-----------|
| Test date     | September 29, 2015 | Temperature       | 22 °C     |
| Test engineer | Andrey Adelberg    | Air pressure      | 1005 mbar |
| Verdict       | Pass               | Relative humidity | 34 %      |

### 8.5.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10<sup>th</sup> harmonic.  
Radiated measurements were performed at a distance of 3 m.

Spectrum analyser settings for radiated measurements below 1 GHz:

|                       |                    |
|-----------------------|--------------------|
| Resolution bandwidth: | 120 kHz            |
| Video bandwidth:      | 300 kHz            |
| Detector mode:        | Peak or Quasi-peak |
| Trace mode:           | Max Hold           |

Spectrum analyser settings for peak radiated measurements 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 above 1 GHz:

|                       |          |
|-----------------------|----------|
| Resolution bandwidth: | 1 MHz    |
| Video bandwidth:      | 3 MHz    |
| Detector mode:        | Average  |
| Trace mode:           | Max Hold |

8.5.4 Test data

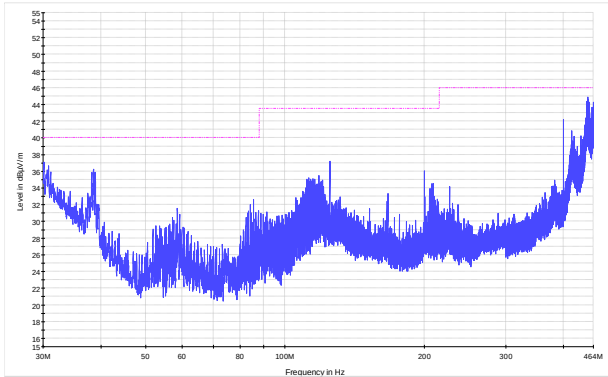


Figure 8.5-1: Radiated spurious emissions within 30–464 MHz for low channel for Omnidirectional antenna

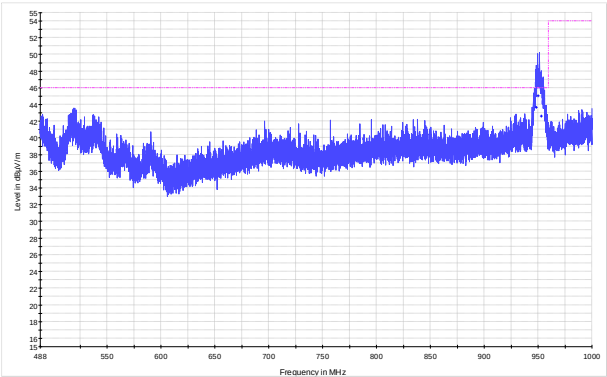


Figure 8.5-2: Radiated spurious emissions within 488–1000 MHz for low channel for Omnidirectional antenna

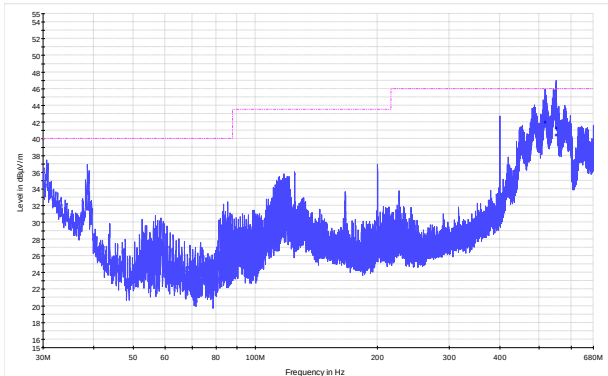


Figure 8.5-3: Radiated spurious emissions within 30–680 MHz for high channel for Omnidirectional antenna

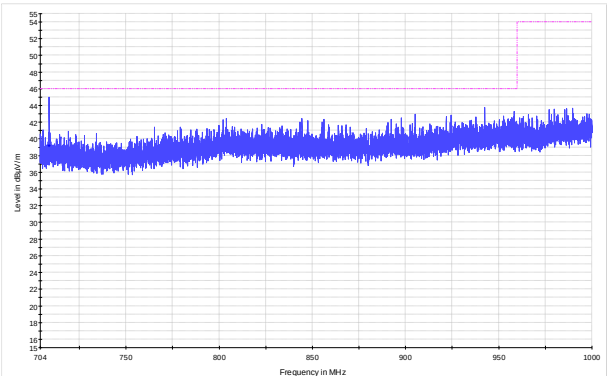


Figure 8.5-4: Radiated spurious emissions within 704–1000 MHz for high channel for Omnidirectional antenna

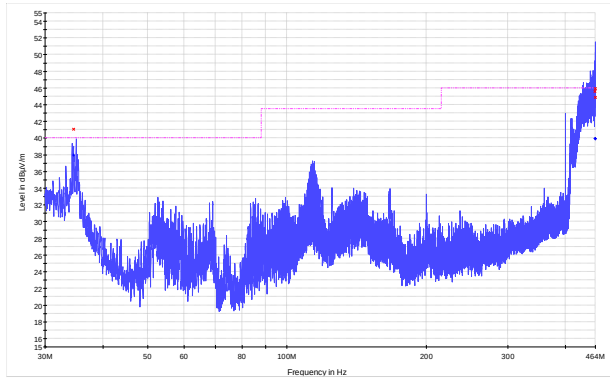


Figure 8.5-5: Radiated spurious emissions within 30–464 MHz for low channel for Directional antenna

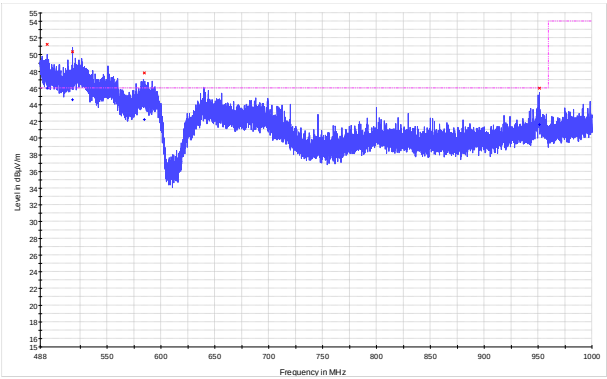


Figure 8.5-6: Radiated spurious emissions within 488–1000 MHz for low channel for Directional antenna

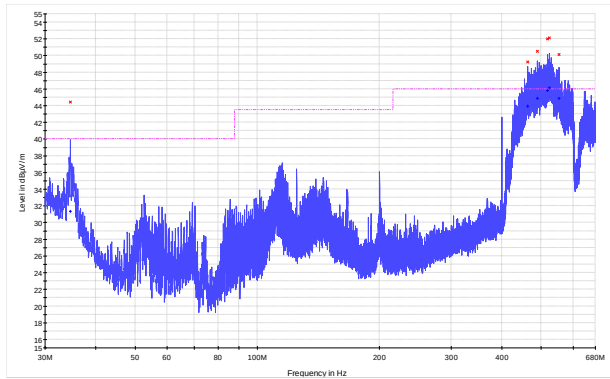


Figure 8.5-7: Radiated spurious emissions within 30–680 MHz for high channel for Directional antenna

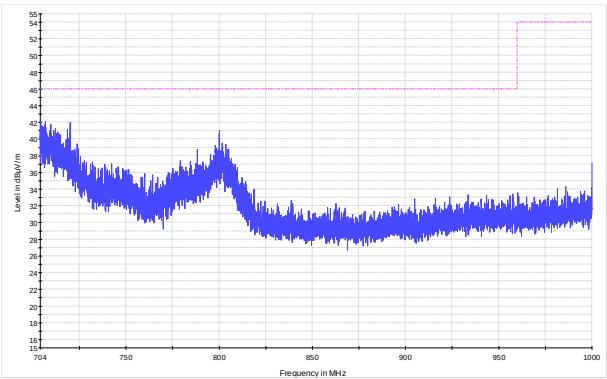


Figure 8.5-8: Radiated spurious emissions within 704–1000 MHz for high channel for Directional antenna

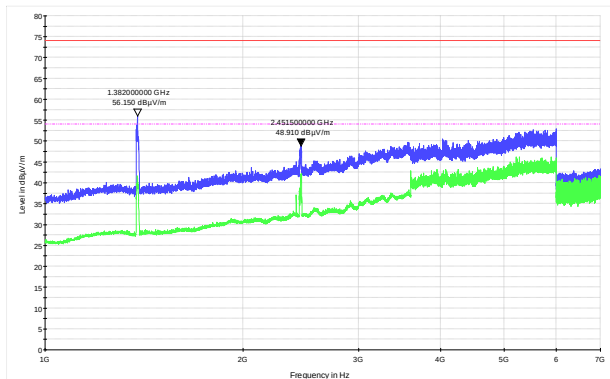


Figure 8.5-9: Radiated spurious emissions within 1–7 GHz for low channel for Omnidirectional antenna

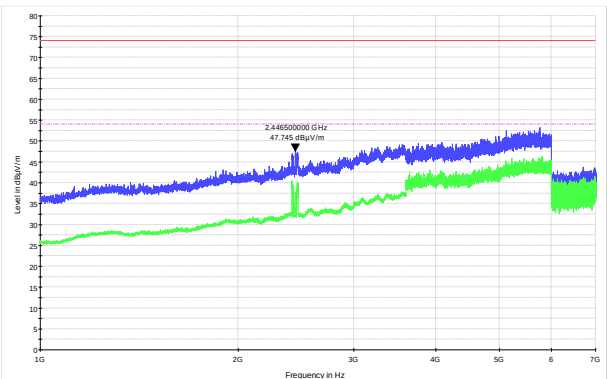
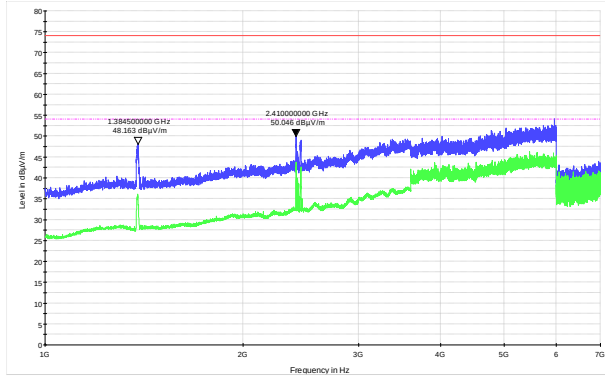
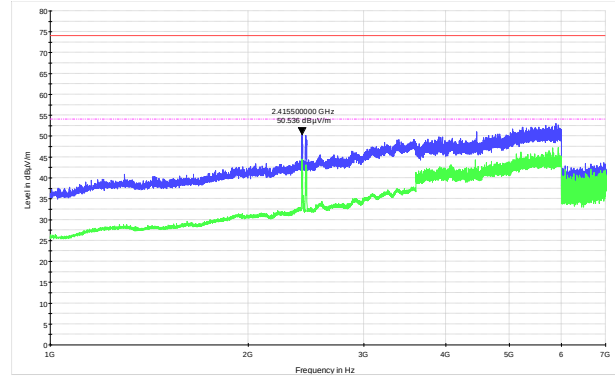


Figure 8.5-10: Radiated spurious emissions within 1–7 GHz for high channel for Omnidirectional antenna



**Figure 8.5-11:** Radiated spurious emissions within 1–7 GHz for low channel for Directional antenna



**Figure 8.5-12:** Radiated spurious emissions within 1–7 GHz for high channel for Directional antenna

**Table 8.5-2:** Radiated spurious emissions measurements beyond band edges for Omnidirectional antenna below 1 GHz

| Channel | Frequency, MHz | Quasi-Peak field strength, dBμV/m | Limit, dBμV/m | Margin, dB |
|---------|----------------|-----------------------------------|---------------|------------|
| Low     | 949.96         | 45.06                             | 46.00         | 0.94       |
| Low     | 948.44         | 43.65                             | 46.00         | 2.35       |
| Low     | 952.88         | 42.62                             | 46.00         | 3.38       |
| High    | 550.00         | 40.47                             | 46.00         | 5.53       |
| High    | 550.00         | 41.31                             | 46.00         | 4.69       |
| High    | 516.96         | 42.00                             | 46.00         | 4.00       |
| High    | 708.76         | 39.19                             | 46.00         | 6.81       |

**Table 8.5-3:** Radiated spurious emissions measurements beyond band edges for Omnidirectional antenna above 1 GHz

| Channel | Frequency, MHz | Peak field strength, dBμV/m | Average limit, dBμV/m | Margin, dB |
|---------|----------------|-----------------------------|-----------------------|------------|
| Low     | 1382.0         | 42.90*                      | 54.00                 | 11.1       |
| Low     | 2451.5         | 49.91                       | 54.00                 | 4.09       |
| High    | 2446.5         | 47.75                       | 54.00                 | 6.25       |

Note: \* - Average field strength result. Peak field strength was measured at 56.15 dBμV/m with 74 dBμV/m limit.

**Table 8.5-4:** Radiated spurious emissions measurements beyond band edges for Directional antenna below 1 GHz

| Channel | Frequency, MHz | Quasi-Peak field strength, dBμV/m | Limit, dBμV/m | Margin, dB |
|---------|----------------|-----------------------------------|---------------|------------|
| Low     | 34.60          | 38.00                             | 40.00         | 2.00       |
| Low     | 463.52         | 39.93                             | 46.00         | 6.07       |
| Low     | 463.72         | 39.96                             | 46.00         | 6.04       |
| Low     | 463.08         | 39.98                             | 46.00         | 6.02       |
| Low     | 517.92         | 44.62                             | 46.00         | 1.38       |
| Low     | 494.40         | 45.97                             | 46.00         | 0.03       |
| Low     | 584.48         | 42.25                             | 46.00         | 3.76       |
| Low     | 951.24         | 41.65                             | 46.00         | 4.36       |
| High    | 518.36         | 45.82                             | 46.00         | 0.18       |
| High    | 523.48         | 45.17                             | 46.00         | 0.83       |
| High    | 463.28         | 43.97                             | 46.00         | 2.03       |
| High    | 489.88         | 44.89                             | 46.00         | 1.11       |
| High    | 553.44         | 44.87                             | 46.00         | 1.13       |
| High    | 34.64          | 31.38                             | 40.00         | 8.62       |



Table 8.5-5: Radiated spurious emissions measurements beyond band edges for Directional antenna above 1 GHz

| Channel | Frequency, MHz | Peak field strength, dBµV/m | Average limit, dBµV/m | Margin, dB |
|---------|----------------|-----------------------------|-----------------------|------------|
| Low     | 1384.5         | 48.16                       | 54.00                 | 5.84       |
| Low     | 2410.0         | 50.05                       | 54.00                 | 3.95       |
| High    | 2415.0         | 50.54                       | 54.00                 | 3.46       |

8.6 FCC 15.709(c)(4) and RSS-222 6.4 Field Strength Emissions in the band 602–620 MHz

8.6.1 Definitions and limits

FCC:

Emissions in the band 602–620 MHz must also comply with the following field strength limits at a distance of one meter:

IC:

Transmitter field strength emissions must comply with the following field strength limits at a distance of one metre.

Table 8.6-1: 602–620 MHz band field strength limits

| Frequency, MHz | Field strength, dBμV/m/120 kHz |
|----------------|--------------------------------|
| 602–607        | $120 - 5 \times (F - 602)$     |
| 607–608        | 95                             |
| 608–614        | 30                             |
| 614–615        | 95                             |
| 615–620        | $120 - 5 \times (620 - F)$     |

Notes: F is frequency in MHz

8.6.2 Test summary

|               |                   |                   |           |
|---------------|-------------------|-------------------|-----------|
| Test date     | December 21, 2015 | Temperature       | 22 °C     |
| Test engineer | Andrey Adelberg   | Air pressure      | 1010 mbar |
| Verdict       | Pass              | Relative humidity | 33 %      |

8.6.3 Observations, settings and special notes

The spectrum was searched from 602 MHz to the 620 MHz.  
Radiated measurements were performed at a distance of 1 m.  
In order to eliminate the Spectrum analyzer overloading, notch filter tuned to the fundamental frequency was used:

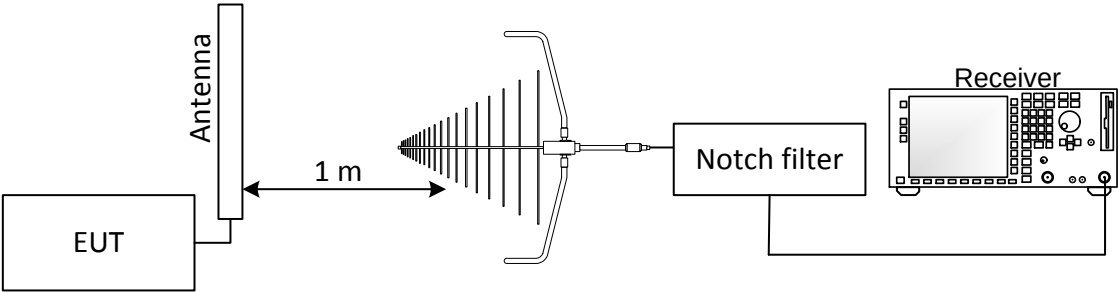
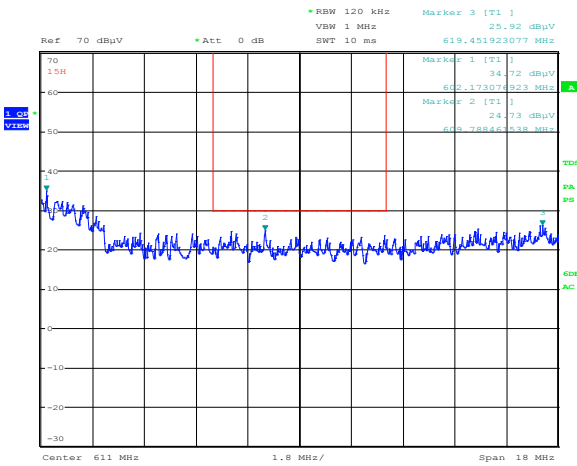


Figure 8.6-1: Setup diagram for 602–620 MHz radiated emissions measurements

Spectrum analyser settings:

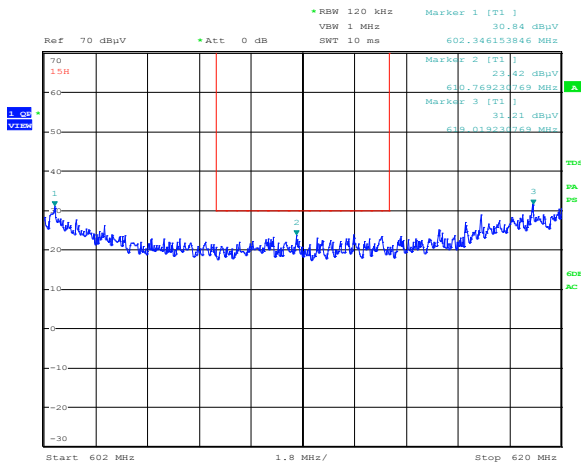
|                       |          |
|-----------------------|----------|
| Resolution bandwidth: | 120 kHz  |
| Video bandwidth:      | 300 kHz  |
| Detector mode:        | Peak     |
| Trace mode:           | Max Hold |

8.6.4 Test data



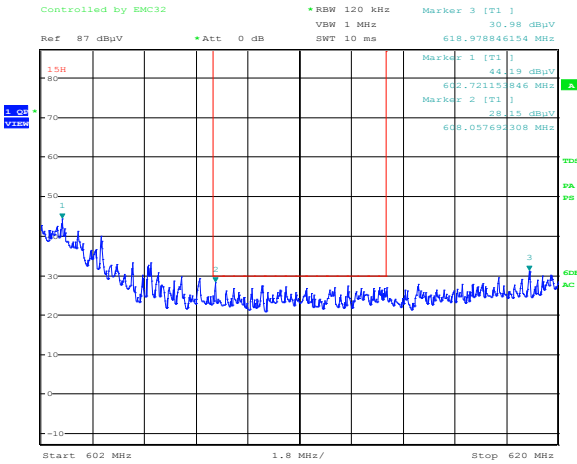
Date: 21.DEC.2015 14:40:43

Figure 8.6-2: Radiated spurious emissions within 602–620 MHz for lower adjacent channel to the restricted band (596 MHz), Omnidirectional antenna



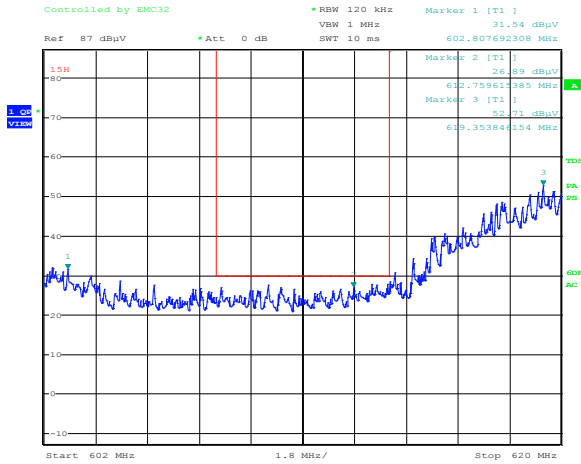
Date: 21.DEC.2015 14:42:41

Figure 8.6-3: Radiated spurious emissions within 602–620 MHz for upper adjacent channel to the restricted band (626 MHz), Omnidirectional antenna



Date: 21.DEC.2015 12:42:21

Figure 8.6-4: Radiated spurious emissions within 602–620 MHz for lower adjacent channel to the restricted band (596 MHz), Directional antenna

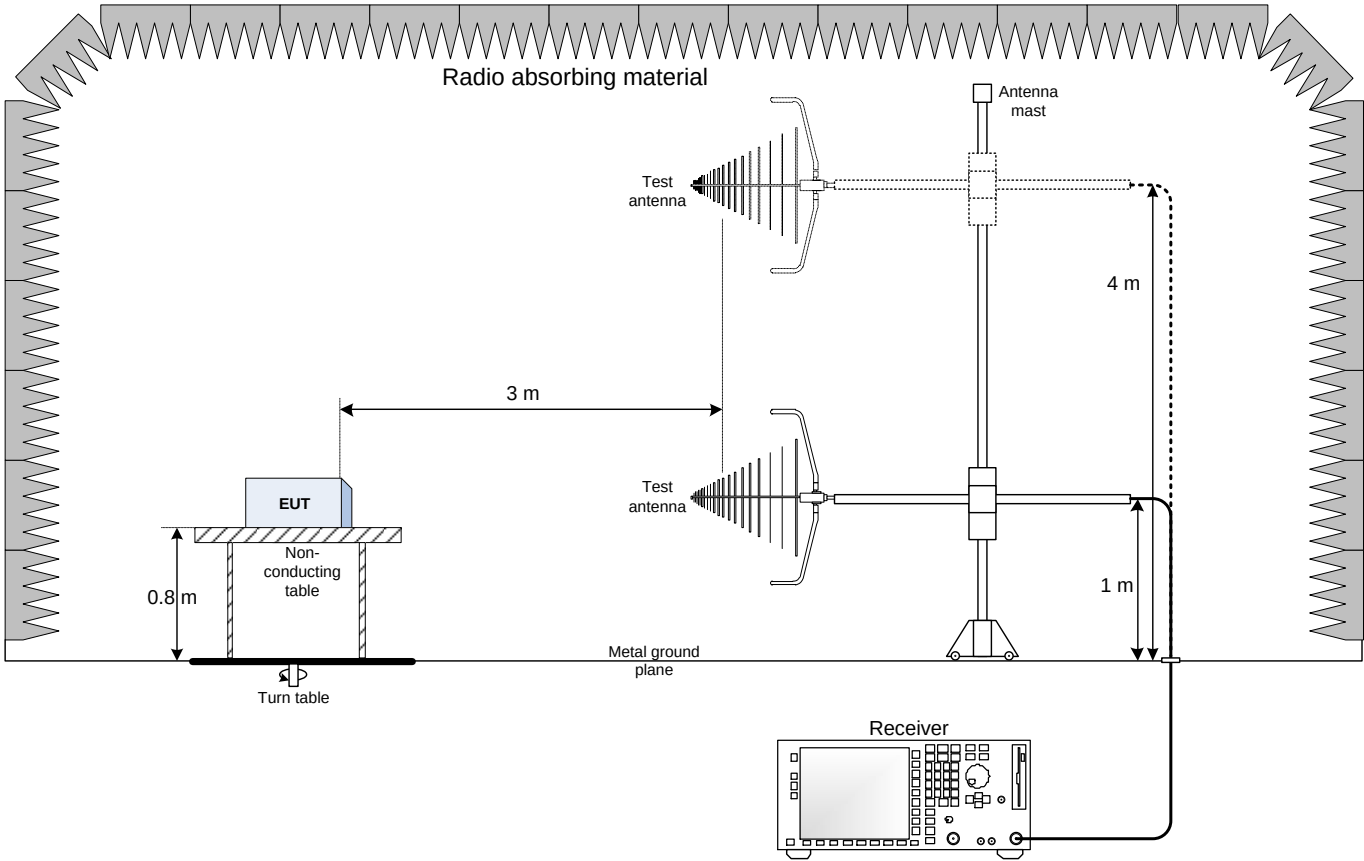


Date: 21.DEC.2015 12:47:35

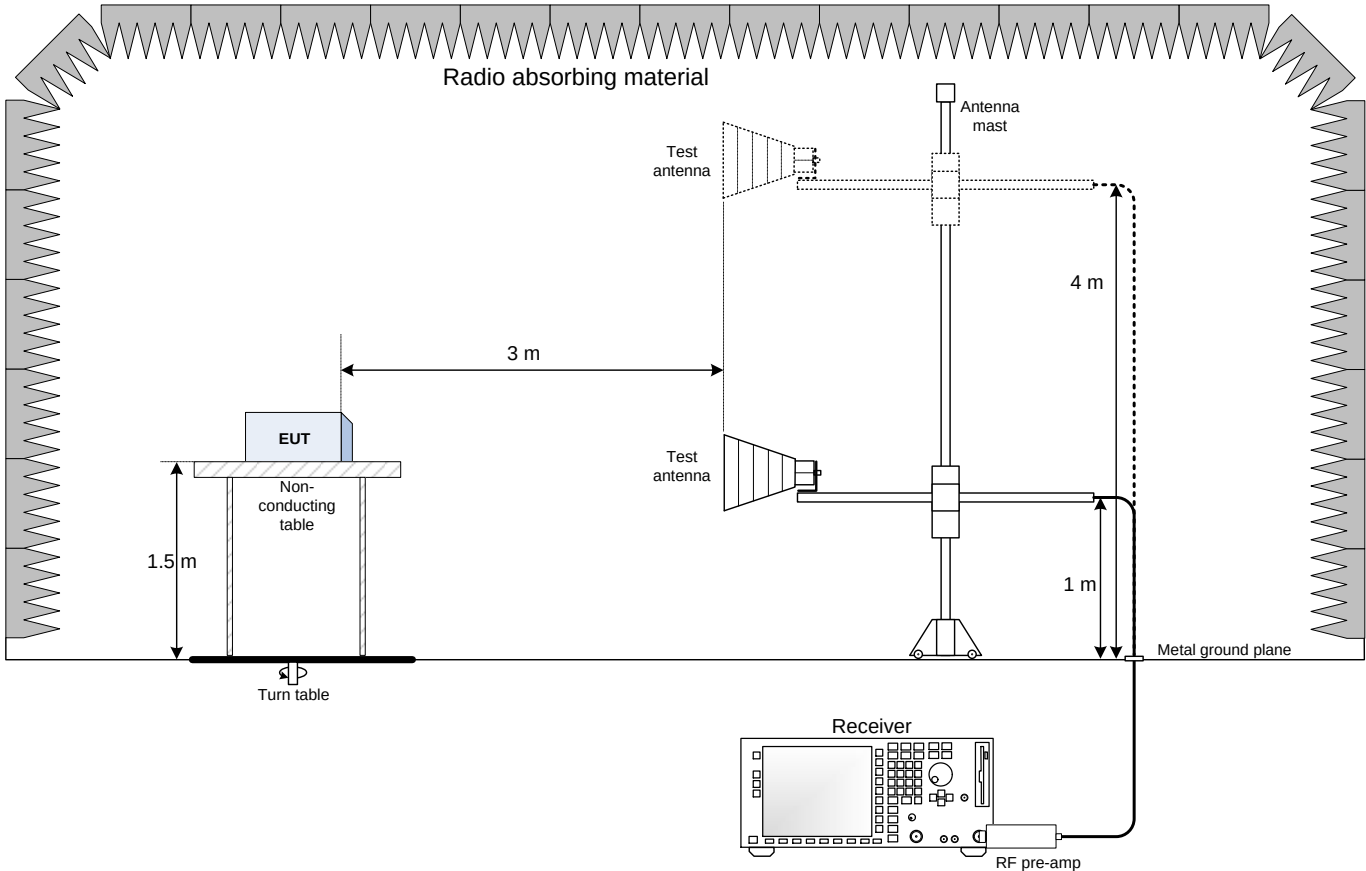
Figure 8.6-5: Radiated spurious emissions within 602–620 MHz for upper adjacent channel to the restricted band (626 MHz), Directional antenna

**Section 9.** Block diagrams and photos of test set-ups

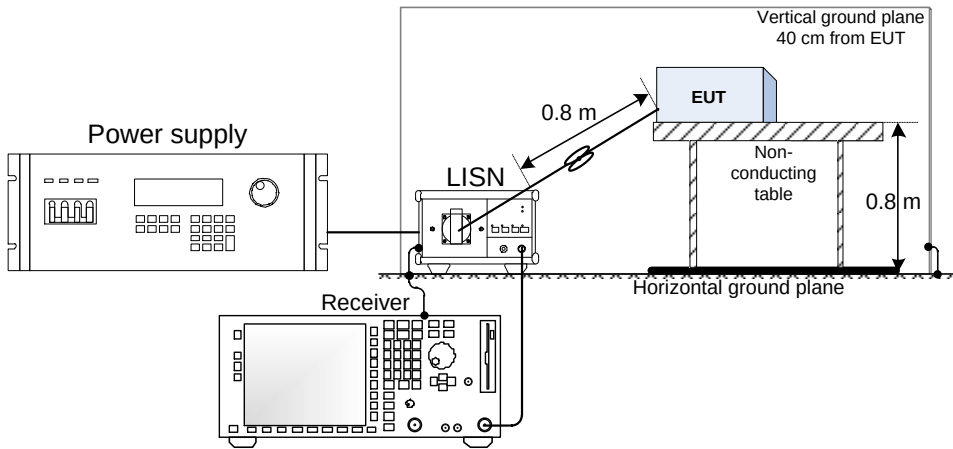
**9.1** Radiated emissions set-up for frequencies below 1 GHz



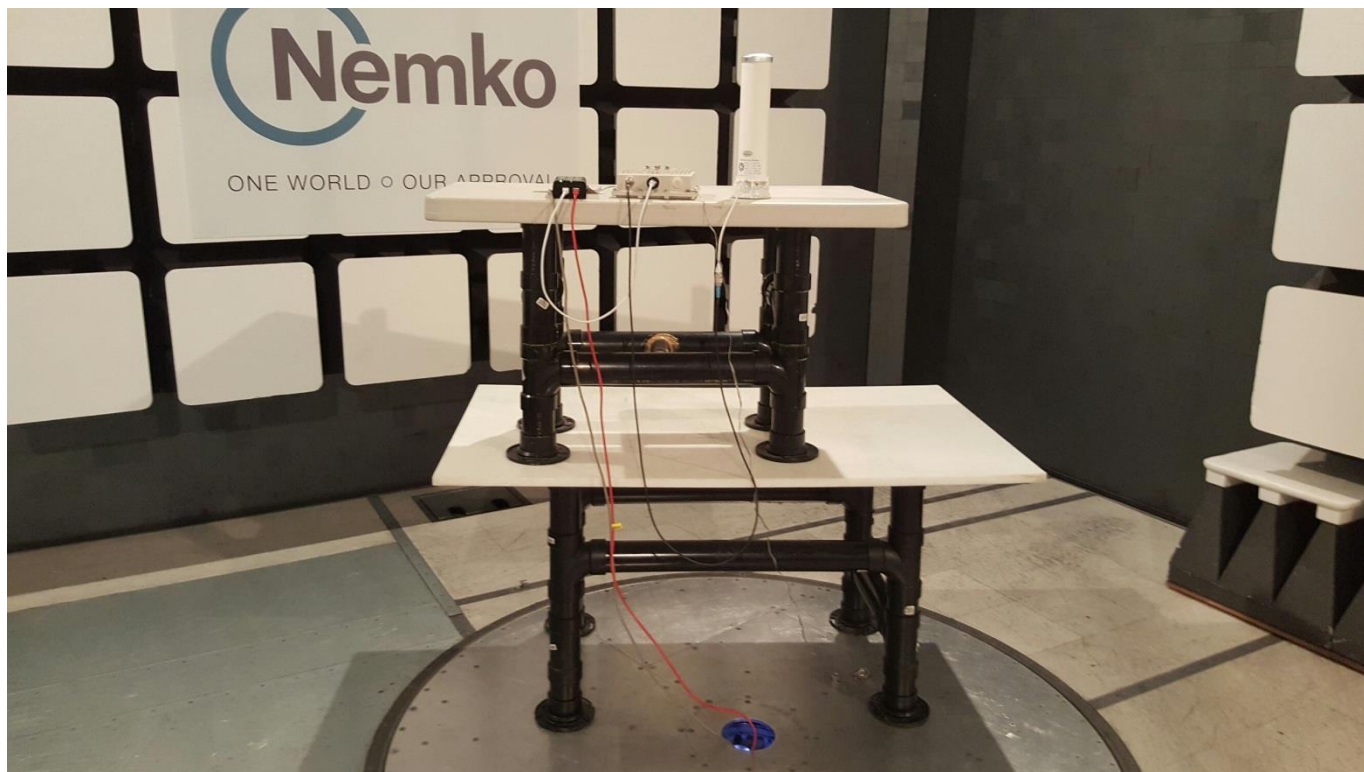
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



#### 9.4 Photo of set-up with Omnidirectional antenna



## 9.5 Photo of set-up with Directional antenna

