The Nebraska Center for Excellence in Electronics
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Amended

# FCC/IC Test Report

Includes NCEE Labs report R20150623-20B and its amendment in full

**Prepared for:** **Savox Communications**

**Address:** **2025 SW 5th Street**
**Lincoln, NE 68522**

**Product:** **Clarity**

**Test Report No:** **R20150623-20C**

**Approved By:**

**Nic S. Johnson, NCE**
**Technical Manager**
**iNARTE Certified EMC Engineer #EMC-003337-NE**

**DATE:** **10 July 2017**

**Total Pages:** **38**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

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# 1.0 Summary of test results

## 1.1 Test Results

The EUT has been tested according to the following specifications:

| APPLIED STANDARDS | | | |
|---|---|---|---|
| **Standard Section** | **Test Type and Limit** | **Result** | **Remark** |
| FCC Part 15.203 | Unique Antenna Requirement | Pass | Permanently attached antenna |
| FCC Part 15.207<br>RSS-Gen Section 8.8 | Conducted Emissions | N/A | No provisions for connection to AC mains |
| FCC Part 15.209<br>RSS-Gen Section 7.0 | Receiver Radiated Emissions, | Pass | Meets the requirement of the limit. |
| FCC Part 15.249<br>RSS-Gen Section 8.9<br>RSS-210, Section B.10(a) | Transmitter Radiated Emissions, | Pass | Meets the requirement of the limit. |
| FCC Part 15.249<br>RSS-Gen Section 6.6<br>RSS-Gen Section 6.12 | Bandwidth and peak EIRP | NA | Informational only |
| FCC Part 15.249<br>RSS-Gen Section 8.9<br>RSS-210, Section B.10(a) | Band Edge Measurement | Pass | Meets the requirement of the limit. |

## 1.2 Reason for amendment

Section 4.2.2(g) of the report has been modified to state that all 3 orthogonal axis were tested.

Section 2.4 was modified to state that the device operates in the 2400 – 2483.5 MHz band.

# 2.0 Description

## 2.1 Equipment under test

The Equipment Under Test (EUT) was a wireless covert neck-loop/microphone system used for interference free wireless communication. It operates from 2405 to 2480 MHz and has transmit and receive capabilities. It is intended to be paired with a remote.

EUT Received Date: 21 August 2015
EUT Tested Dates: 21 August 2015 – 28 August 2015

Testing was completed in August 2015. The report was issued in June 2017. All test methods and standards methods were reviewed to ensure they met the current requirements as of June 2017.

| | |
|---|---|
| MODEL | Clarity |
| Serial No. | NCEE Test 1 (assigned)<br><br>The serial number was assigned by the lab as the test sample was not serialized. |
| POWER SUPPLY | Internal 3VDC, non-rechargeable batteries |
| ANTENNA TYPE | Internal Board Mount antenna |

*NOTE:* For more detailed features description, please refer to the manufacturer's specifications or user's manual.

## 2.2 Laboratory description

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

| | |
|---|---|
| A2LA Certificate Number : | 1953.01 |
| FCC Accredited Test Site Designation No: | US1060 |
| Industry Canada Test Site Registration No: | 4294A-1 |
| NCC CAB Identification No: | US0177 |

Environmental conditions varied slightly throughout the tests:
Relative humidity of 52 ± 4%
Temperature of 23 ± 3° Celsius

## 2.3 Description of test modes

The EUT operates on, and was tested at the frequencies below:

| Channel | Frequency |
|---|---|
| Low | 2405 |
| Middle | 2440 |
| High | 2480 |

These are the only three representative channels tested in the frequency range according to FCC Part 15.31(m) and RSS-Gen Section 6.8. See the operational description for a list of all channel frequency and designations.

## 2.4 Applied standards

The EUT uses digital modulation and operates in the 2400 – 2483.5 MHz band. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

(1) FCC Part 15, Subpart C (15.207, 15.209, 15.249)
(2) ANSI C63.10:2013
(3) Industry Canada RSS-Gen Issue 4
(4) Industry Canada RSS-210 Issue 9

All test items have been performed and recorded as per the above.

## 2.5 Description of support units

None

## 2.6 Configuration of system under test

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, highest and one channel in the middle.

For duty cycle calculations, the unit was manually keyed as fast as possible.

## 3.0 Test equipment used

| DESCRIPTION AND MANUFACTURER | MODEL NO. | SERIAL NO. | LAST CALIBRATION DATE | CALIBRATION DUE DATE |
|---|---|---|---|---|
| Rohde & Schwarz Test Receiver | ES126 | 100037 | 20 Jan 2015 | 20 Jan 2016 |
| EMCO Biconilog Antenna | 3142B | 1654 | 26 Jan 2015 | 26 Jan 2016 |
| EMCO Horn Antenna | 3115 | 6416 | 14 Jan 2014 | 14 Jan 2016 |
| Rohde & Schwarz Preamplifier | TS-PR18 | 3545700803 | 19 Nov 2014* | 19 Nov 2015* |
| Trilithic High Pass Filter | 6HC330 | 23042 | 19 Nov 2014* | 19 Nov 2015* |

*Internal Characterization

## 4.0 Detailed results

### 4.1 Unique antenna requirement

#### 4.1.1 Standard applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

#### 4.1.2 Antenna description

The antenna is internal to the EUT. It is a PCB antenna and not replaceable.

## 4.2 Radiated emissions

Test Specifications: FCC Part 15.209
RSS-Gen Section 7.0
FCC Part 15.249
RSS-Gen Section 8.9
RSS-210, Section B.10(a)

Test Method: ANSI C63.10, Section(s) 6.5, 6.6, 11.11, 11.12.1
ANSI C63.4, Section (s) 8.3

### 4.2.1 Limits for radiated emissions measurements

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

| FREQUENCIES (MHz) | FIELD STRENGTH (μV/m) | MEASUREMENT DISTANCE (m) |
|---|---|---|
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 3 |
| 30-88 | 100 | 3 |
| 88-216 | 150 | 3 |
| 216-960 | 200 | 3 |
| Above 960 | 500 | 3 |

**NOTE:**
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

### 4.2.2 Test procedures

a. The EUT was placed on the top of a rotating table 0.8 meters and 1.5 meters above the ground plane in a 10 meter semi-anechoic chamber for measurements 30MHz - 1GHz and 1GHz -25 GHz respectively. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was measured in all 3 orthogonal axis. It was found that the Vertical position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

**NOTE:**
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

### 4.2.3 Deviations from test standard

No deviation.

### 4.2.4 Test setup

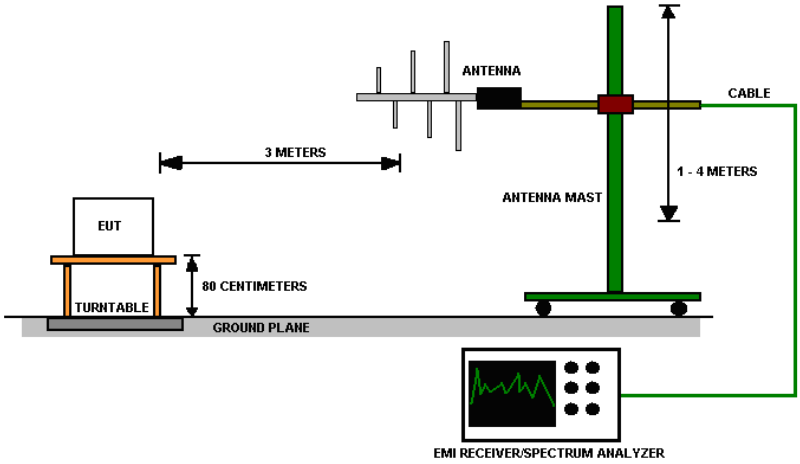


**Figure 1 - Radiated Emissions Test Setup**

The EUT was tested in both the vertical and horizontal in all 3 positions shown in Figure 2 below in order to measure emissions in all 3 orthogonal axis of the EUT and meet the requirements from ANSI C63.10 Section 5.10.1.

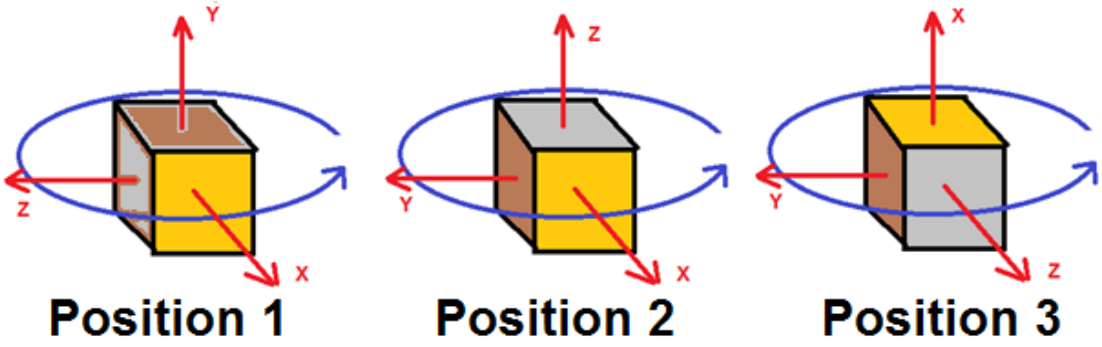


**Figure 2 - Testing configuration in all 3 axis**

Position 1 was found to produce the highest emissions in the preview scan. Therefore, all final measurements were performed in this orientation.

For the actual test configuration, please refer to the test setup photos exhibit for actual photos of the EUT.

### 4.2.5 EUT operating conditions

The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

### 4.2.6 Test results

| EUT | Clarity | MODE | Receive |
|---|---|---|---|
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 30MHz – 26GHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

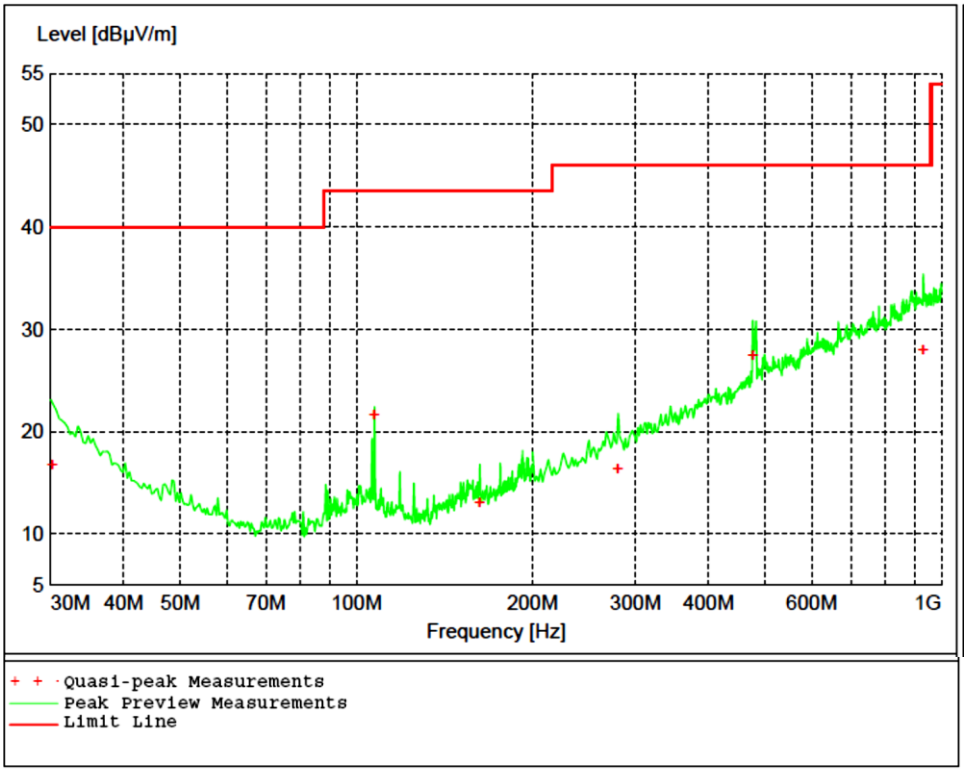


**Figure 3 - Radiated Emissions Plot, Receive**

"Position 1" orientation was found to be the worse-case

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. Since peak measurements were compliant with the average limit, average measurements were not required.

**Table 1 - Radiated Emissions Quasi-peak Measurements, Receive**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 30.180000 | 16.75 | 40.00 | 23.30 | 293 | 96 | HORI |
| 107.280000 | 21.60 | 43.50 | 21.90 | 233 | 116 | VERT |
| 162.480000 | 13.04 | 43.50 | 30.50 | 213 | 202 | HORI |
| 280.020000 | 16.30 | 46.00 | 29.70 | 104 | 354 | VERT |
| 476.280000 | 27.37 | 46.00 | 18.60 | 107 | 192 | VERT |
| 931.080000 | 28.02 | 46.00 | 18.00 | 99 | 26 | HORI |

**Table 2 - Radiated Emissions Average Measurements, Receive**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2455.800000 | 39.88 | 54.00 | 14.10 | 397 | 356 | HORI |
| 4877.200000 | 43.28 | 54.00 | 10.70 | 305 | 224 | VERT |
| 7348.600000 | 45.01 | 54.00 | 9.00 | 107 | 155 | VERT |
| 9777.200000 | 46.79 | 54.00 | 7.20 | 332 | 107 | HORI |
| 12207.800000 | 40.57 | 54.00 | 13.40 | 100 | 0 | HORI |

**Table 3 - Radiated Emissions Peak Measurements, Receive**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2455.800000 | 39.88 | 74.00 | 34.12 | 397 | 356 | HORI |
| 4877.200000 | 43.28 | 74.00 | 30.72 | 305 | 224 | VERT |
| 7348.600000 | 45.01 | 74.00 | 28.99 | 107 | 155 | VERT |
| 9777.200000 | 46.79 | 74.00 | 27.21 | 332 | 107 | HORI |
| 12207.800000 | 40.57 | 74.00 | 33.43 | 100 | 0 | HORI |

| | | | |
|---|---|---|---|
| EUT | Clarity | MODE | Low Channel |
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 30MHz – 26GHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

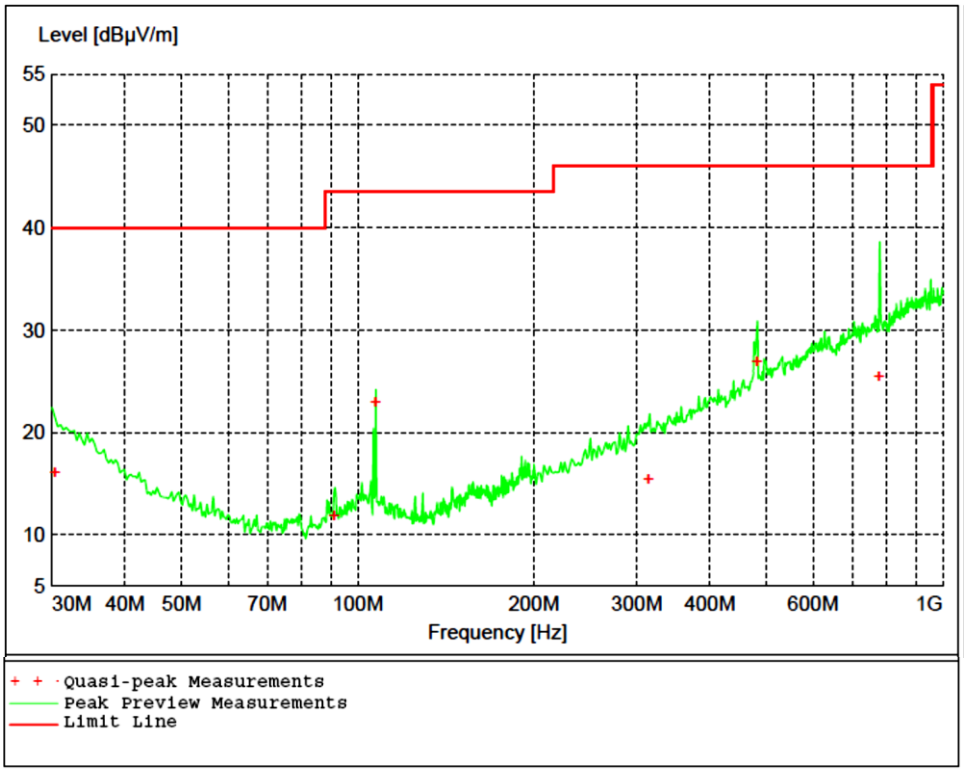


**Figure 4 - Radiated Emissions Plot, Channel 1**

"Position 1" orientation was found to be the worse-case

**Table 4 - Radiated Emissions Quasi-peak Measurements, Channel 1**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 30.360000 | 16.13 | 40.00 | 23.90 | 264 | 116 | HORI |
| 91.080000 | 11.92 | 43.50 | 31.60 | 141 | 103 | VERT |
| 107.340000 | 22.90 | 43.50 | 20.60 | 149 | 2 | VERT |
| 313.920000 | 15.40 | 46.00 | 30.60 | 100 | 14 | VERT |
| 481.680000 | 26.85 | 46.00 | 19.20 | 363 | 274 | HORI |
| 778.920000 | 25.41 | 46.00 | 20.60 | 309 | 143 | HORI |

**Table 5 - Radiated Emissions Average Measurements, Channel 1**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2405.000000 | 76.51 | 93.98 | 17.47 | 220 | 346 | VERT |
| 4810.000000 | 30.42 | 54.00 | 23.58 | 170 | 38 | VERT |
| 7215.800000 | 25.82 | 54.00 | 28.18 | 400 | 17 | VERT |
| 9620.000000 | 25.32 | 54.00 | 28.68 | 166 | 346 | HORI |
| 12025.200000 | 22.65 | 54.00 | 31.35 | 150 | 241 | VERT |
| 14422.800000 | 27.79 | 54.00 | 26.21 | 399 | 319 | HORI |
| 16106.200000 | 25.97 | 54.00 | 28.03 | 384 | 155 | HORI |

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 7. The maximum allowed 20dB was used.

**Table 6 - Radiated Emissions Peak Measurements, Channel 1**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2405.000000 | 96.51 | 113.98 | 17.47 | 220 | 346 | VERT |
| 4810.000000 | 50.42 | 74.00 | 23.58 | 170 | 38 | VERT |
| 7215.800000 | 45.82 | 74.00 | 28.18 | 400 | 17 | VERT |
| 9620.000000 | 45.32 | 74.00 | 28.68 | 166 | 346 | HORI |
| 12025.200000 | 42.65 | 74.00 | 31.35 | 150 | 241 | VERT |
| 14422.800000 | 47.79 | 74.00 | 26.21 | 399 | 319 | HORI |
| 16106.200000 | 45.97 | 74.00 | 28.03 | 384 | 155 | HORI |

| | | | |
|---|---|---|---|
| EUT | Clarity | MODE | Mid Channel |
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 30MHz – 26GHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

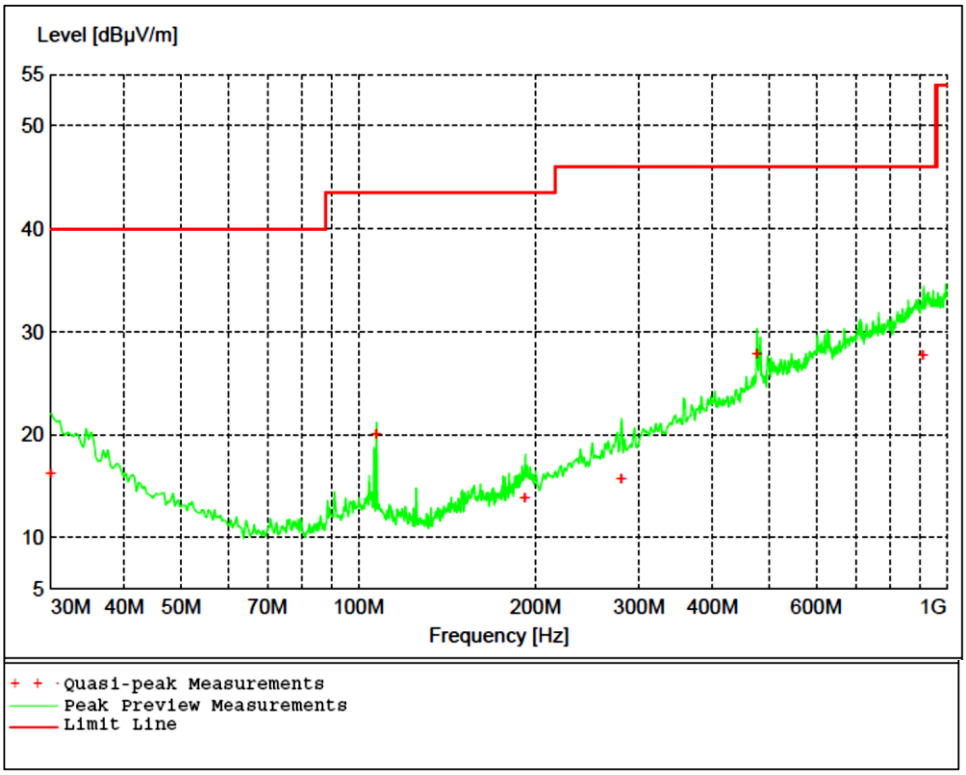


**Figure 5 - Radiated Emissions Plot, Channel 2**

"Position 1" orientation was found to be the worse-case

**REMARKS**:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

**Table 7 - Radiated Emissions Quasi-peak Measurements, Channel 2**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 30.000000 | 16.21 | 40.00 | 23.80 | 322 | 314 | VERT |
| 107.220000 | 20.01 | 43.50 | 23.50 | 149 | 126 | VERT |
| 192.000000 | 13.78 | 43.50 | 29.70 | 162 | 132 | HORI |
| 280.020000 | 15.72 | 46.00 | 30.30 | 400 | 316 | HORI |
| 476.280000 | 27.85 | 46.00 | 18.10 | 109 | 287 | VERT |
| 911.940000 | 27.65 | 46.00 | 18.30 | 114 | 143 | HORI |

**Table 8 - Radiated Emissions Average Measurements, Channel 2**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2440.000000 | 76.70 | 93.98 | 17.28 | 197 | 348 | VERT |
| 4880.000000 | 30.21 | 54.00 | 23.79 | 103 | 12 | VERT |
| 7320.000000 | 25.27 | 54.00 | 28.73 | 326 | 246 | VERT |
| 9762.400000 | 29.37 | 54.00 | 24.63 | 99 | 0 | VERT |
| 12209.400000 | 19.61 | 54.00 | 34.39 | 109 | 124 | HORI |
| 14670.400000 | 25.70 | 54.00 | 28.30 | 318 | 4 | VERT |
| 17087.000000 | 30.82 | 54.00 | 23.18 | 227 | 297 | VERT |

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 7. The maximum allowed 20dB was used.

**Table 9 - Radiated Emissions Peak Measurements, Channel 2**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2440.000000 | 96.70 | 113.98 | 17.28 | 197 | 348 | VERT |
| 4880.000000 | 50.21 | 74.00 | 23.79 | 103 | 12 | VERT |
| 7320.000000 | 45.27 | 74.00 | 28.73 | 326 | 246 | VERT |
| 9762.400000 | 49.37 | 74.00 | 24.63 | 99 | 0 | VERT |
| 12209.400000 | 39.61 | 74.00 | 34.39 | 109 | 124 | HORI |
| 14670.400000 | 45.70 | 74.00 | 28.30 | 318 | 4 | VERT |
| 17087.000000 | 50.82 | 74.00 | 23.18 | 227 | 297 | VERT |

| EUT | Clarity | MODE | High Channel |
|---|---|---|---|
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 30MHz – 26GHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

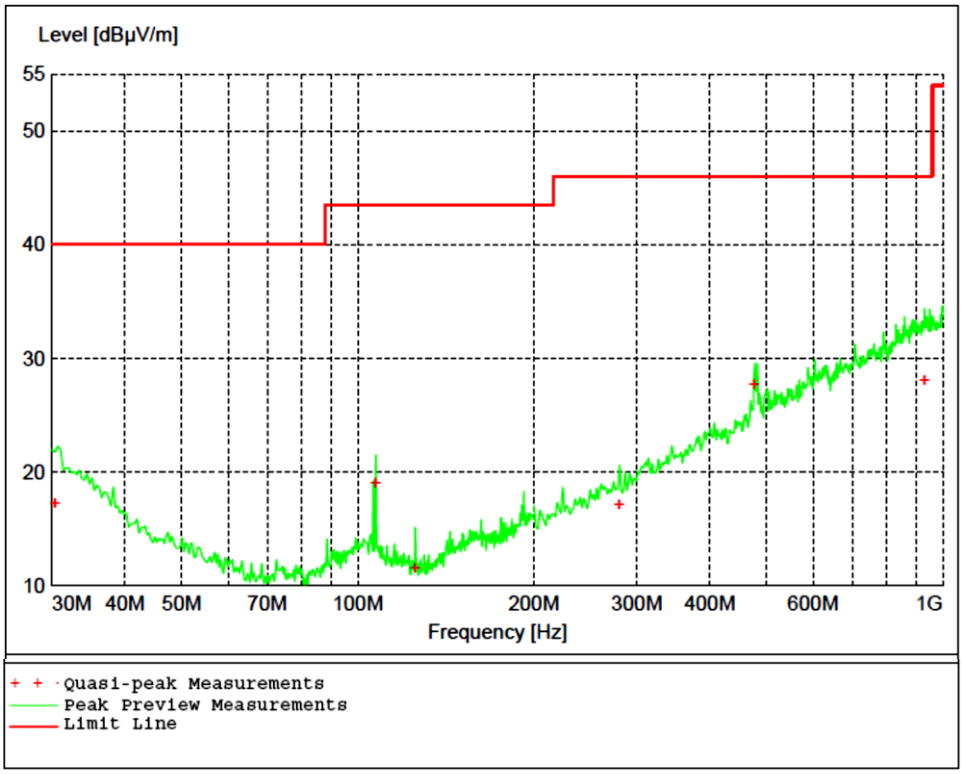


**Figure 6 - Radiated Emissions Plot, Channel 3**
"Z" orientation was found to be the worse-case

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.

**Table 10 - Radiated Emissions Quasi-peak Measurements, Channel 3**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 30.360000 | 17.18 | 40.00 | 22.80 | 99 | 103 | VERT |
| 107.340000 | 18.98 | 43.50 | 24.50 | 230 | 21 | VERT |
| 125.280000 | 11.57 | 43.50 | 31.90 | 312 | 282 | VERT |
| 279.960000 | 17.16 | 46.00 | 28.80 | 199 | 190 | HORI |
| 476.340000 | 27.73 | 46.00 | 18.30 | 152 | 179 | VERT |
| 931.080000 | 28.02 | 46.00 | 18.00 | 100 | 62 | HORI |

**Table 11 - Radiated Emissions Average Measurements, Channel 3**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2480.000000 | 77.34 | 93.98 | 16.64 | 200 | 339 | VERT |
| 4960.000000 | 31.12 | 54.00 | 22.88 | 148 | 19 | VERT |
| 7440.000000 | 27.39 | 54.00 | 26.61 | 99 | 0 | HORI |
| 9922.400000 | 29.95 | 54.00 | 24.05 | 125 | 322 | VERT |
| 12419.200000 | 20.06 | 54.00 | 33.94 | 379 | 319 | HORI |
| 14878.200000 | 27.34 | 54.00 | 26.66 | 151 | 0 | HORI |
| 17356.600000 | 31.08 | 54.00 | 22.92 | 183 | 156 | VERT |

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6 and 7. The maximum allowed 20dB was used.

**Table 12 - Radiated Emissions Peak Measurements, Channel 3**

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|---|---|---|---|---|---|---|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 2480.000000 | 97.34 | 113.98 | 16.64 | 200 | 339 | VERT |
| 4960.000000 | 51.12 | 74.00 | 22.88 | 148 | 19 | VERT |
| 7440.000000 | 47.39 | 74.00 | 26.61 | 99 | 0 | HORI |
| 9922.400000 | 49.95 | 74.00 | 24.05 | 125 | 322 | VERT |
| 12419.200000 | 40.06 | 74.00 | 33.94 | 379 | 319 | HORI |
| 14878.200000 | 47.34 | 74.00 | 26.66 | 151 | 0 | HORI |
| 17356.600000 | 51.08 | 74.00 | 22.92 | 183 | 156 | VERT |

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

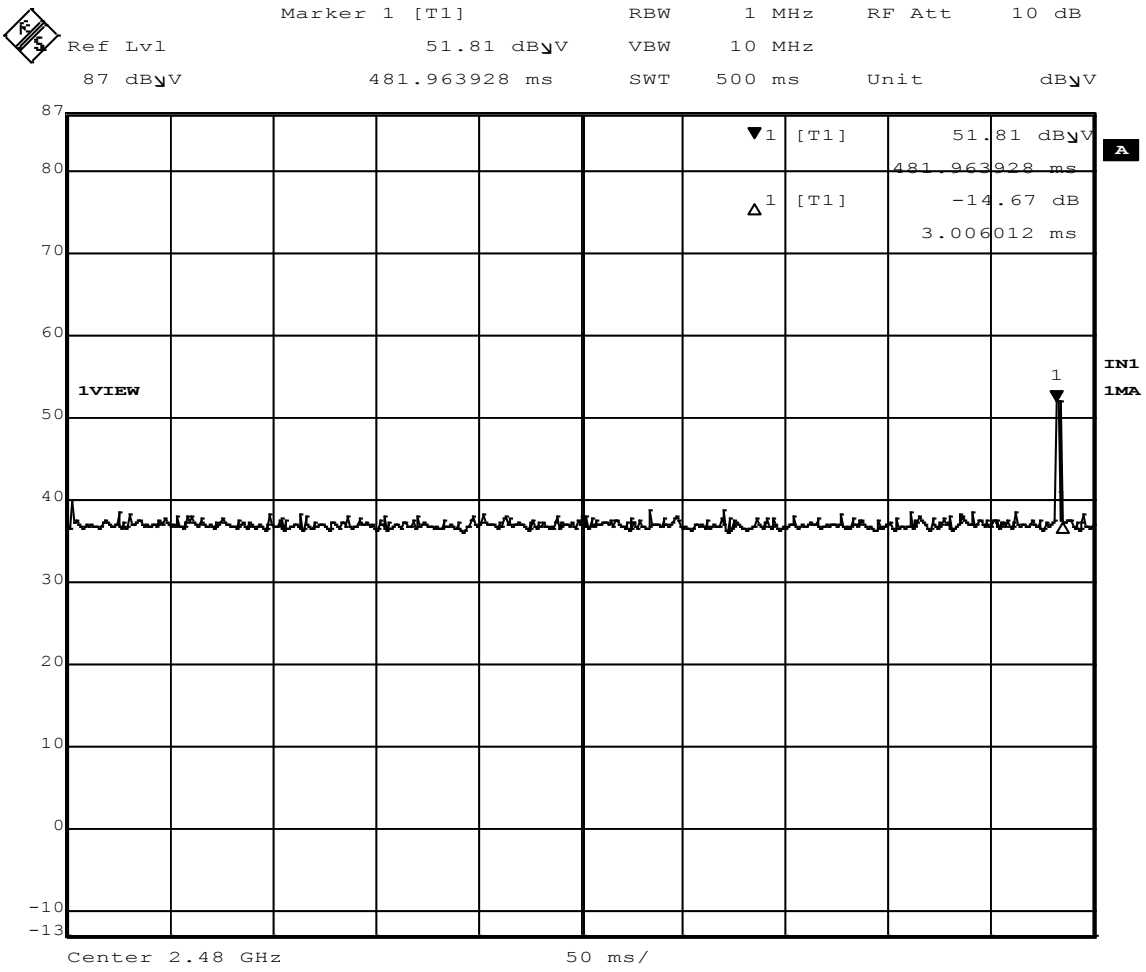


**Figure 7 - Period >100 ms, Fundamental**

According to FCC Part 15.35, the maximum period for an average calculation allowance is 0.1 seconds. The period is greater than 100 ms.

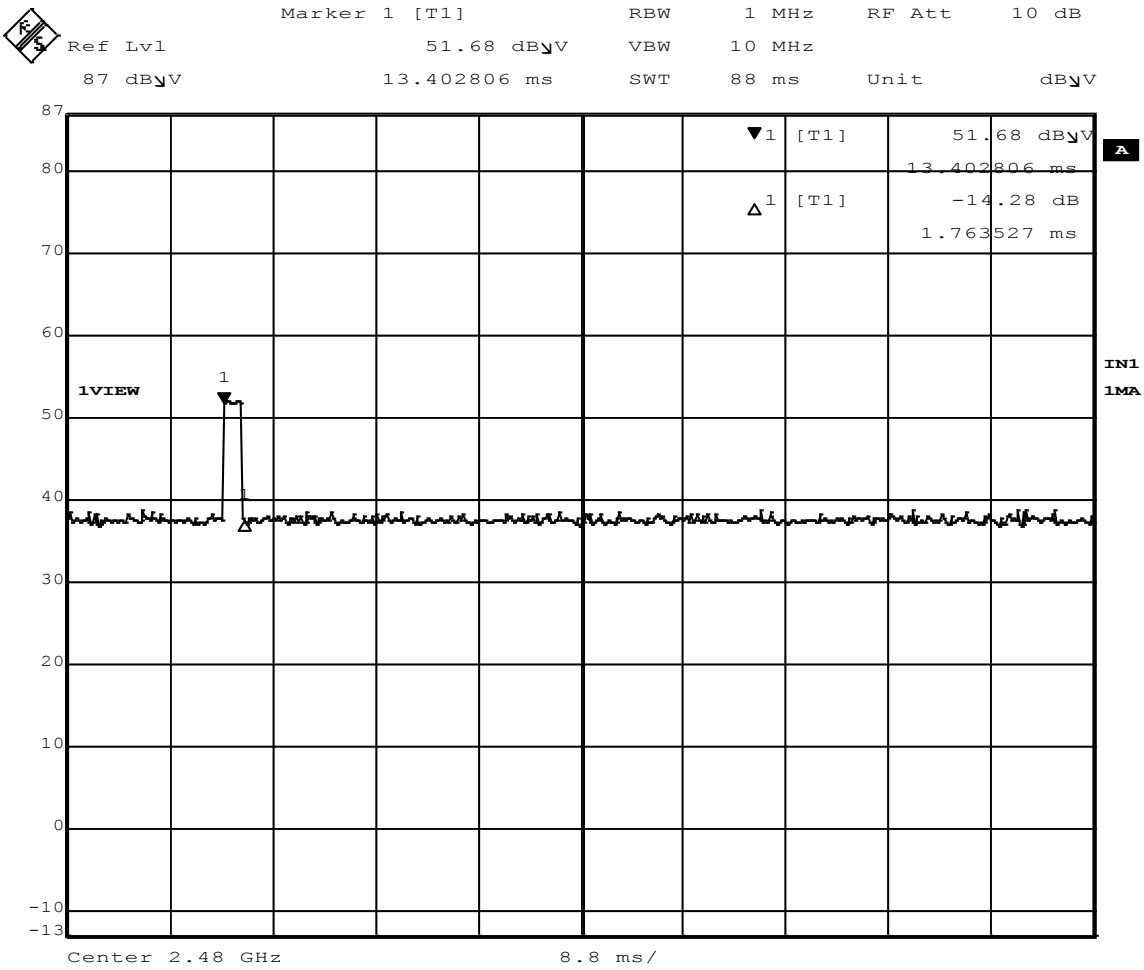


**Figure 8 – Maximum Pulse Width = 1.76 ms, Fundamental**

Duty cycle correction factor = 20*log(1.76/(100) > -49.06 dB
Note: 100ms is the longest allowed period per FCC Part 15.35
Note: 20dB is the maximum averaging factor, so a 20 dB averaging factor was applied

## 4.3 Bandwidth and Peak EIRP

Test Specifications: FCC Part 15.249
RSS-Gen Section 6.6
RSS-Gen Section 6.12

Test Method: ANSI C63.10, Section(s) 6.9.3

### 4.3.1 Limits of bandwidth measurements

The 99% occupied bandwidth and peak EIRP are displayed for informational purposes only.

### 4.3.2 Test procedures

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 1MHz RBW and 10 MHz VBW.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 1 MHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

### 4.3.3 Deviations from test standard

No deviation.

### 4.3.4 Test setup

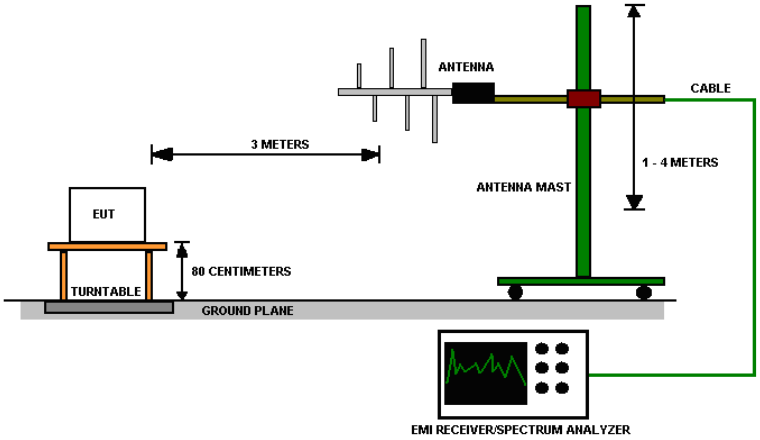


**Figure 9 - Bandwidth Measurements Test Setup**

### 4.3.5 EUT operating conditions

The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

### 4.3.6 Test results

| | | | |
|---|---|---|---|
| EUT | Clarity | MODE | Transmit |
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 2400.0MHz - 2483.5MHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

**99% Occupied Bandwidth**

| CHANNEL | CHANNEL FREQUENCY (MHz) | 99% Occupied BW (MHz) |
|---|---|---|
| 1 | 2405 | 3.82 |
| 2 | 2440 | 3.92 |
| 3 | 2480 | 3.80 |

**REMARKS**:
None

**Peak EIRP**

| CHANNEL | CHANNEL FREQUENCY (MHz) | EIRP PEAK POWER OUTPUT (dBm) | RESULT |
|---|---|---|---|
| 1 | 2405 | 0.86 | PASS |
| 2 | 2440 | 1.25 | PASS |
| 3 | 2480 | 0.60 | PASS |

All measurements were taken from the 99% occupied bandwidth screen captures.

**REMARKS**:
None

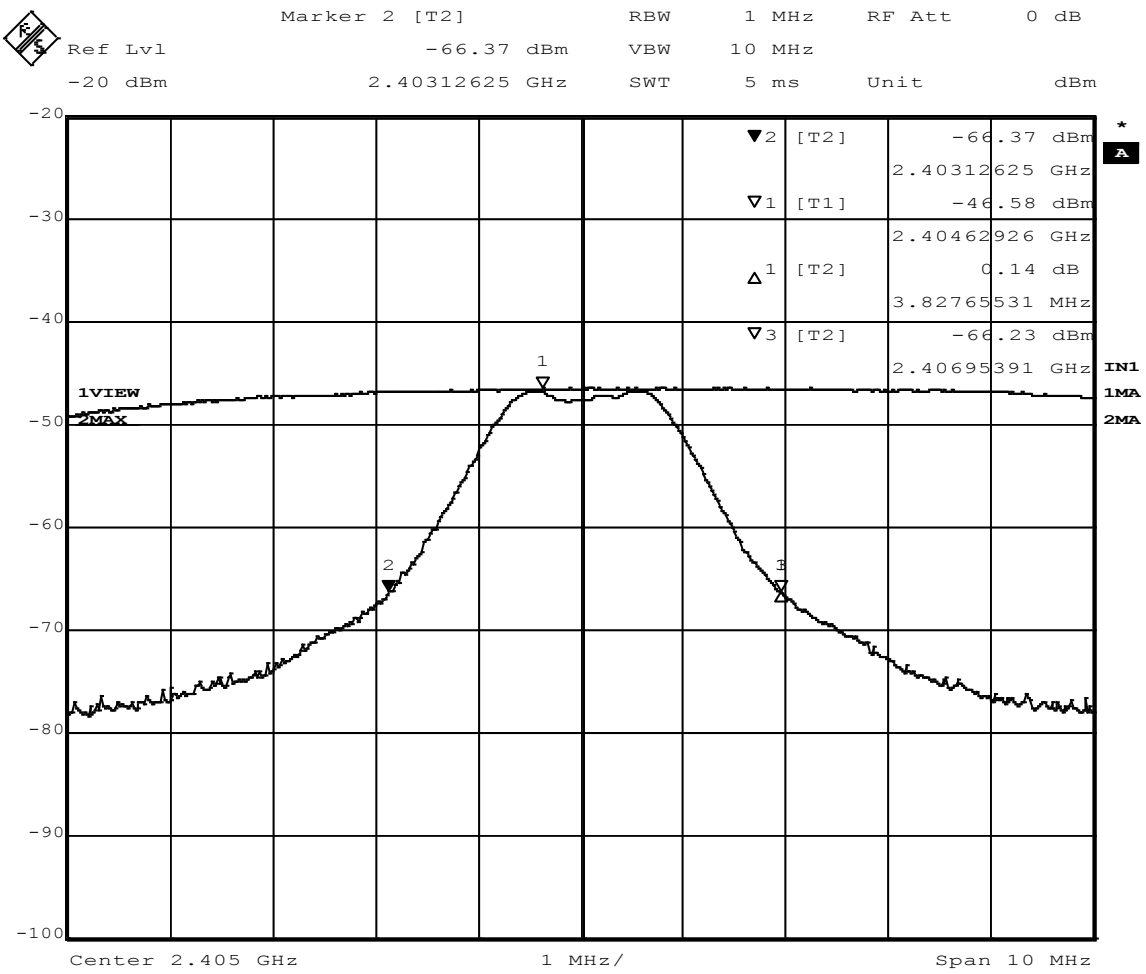


**Figure 10 - 99% Occupied Bandwidth, Low Channel. 3.82 MHz**

Maximum power = -46.58 dBm + 107 + CL + AF - 95.23 = <u>0.86 dBm</u>

CL = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

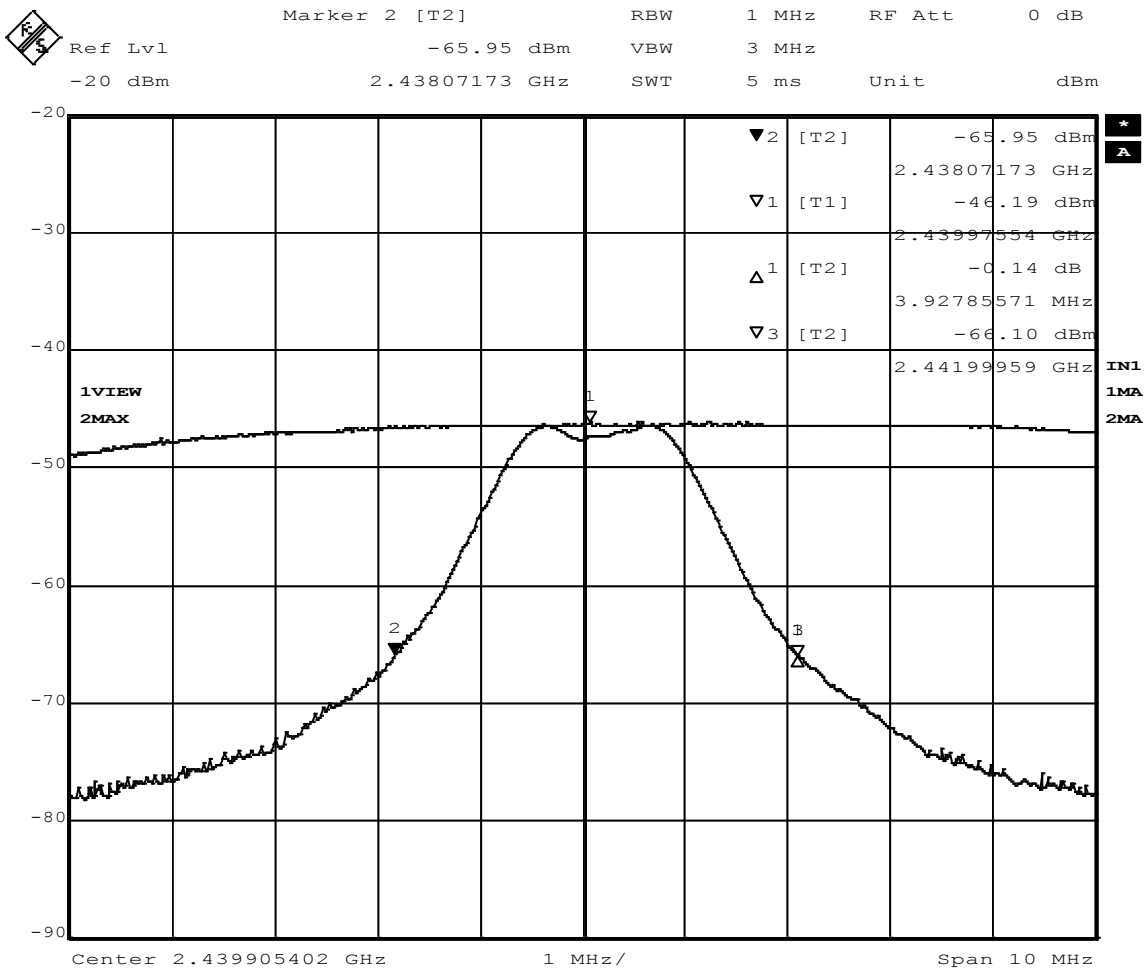


**Figure 11 - 99% Occupied Bandwidth, Mid Channel, 3.92 MHz**

Maximum power = -46.19 dBm + 107 + CL + AF - 95.23 = <u>1.25 dBm</u>

CL = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

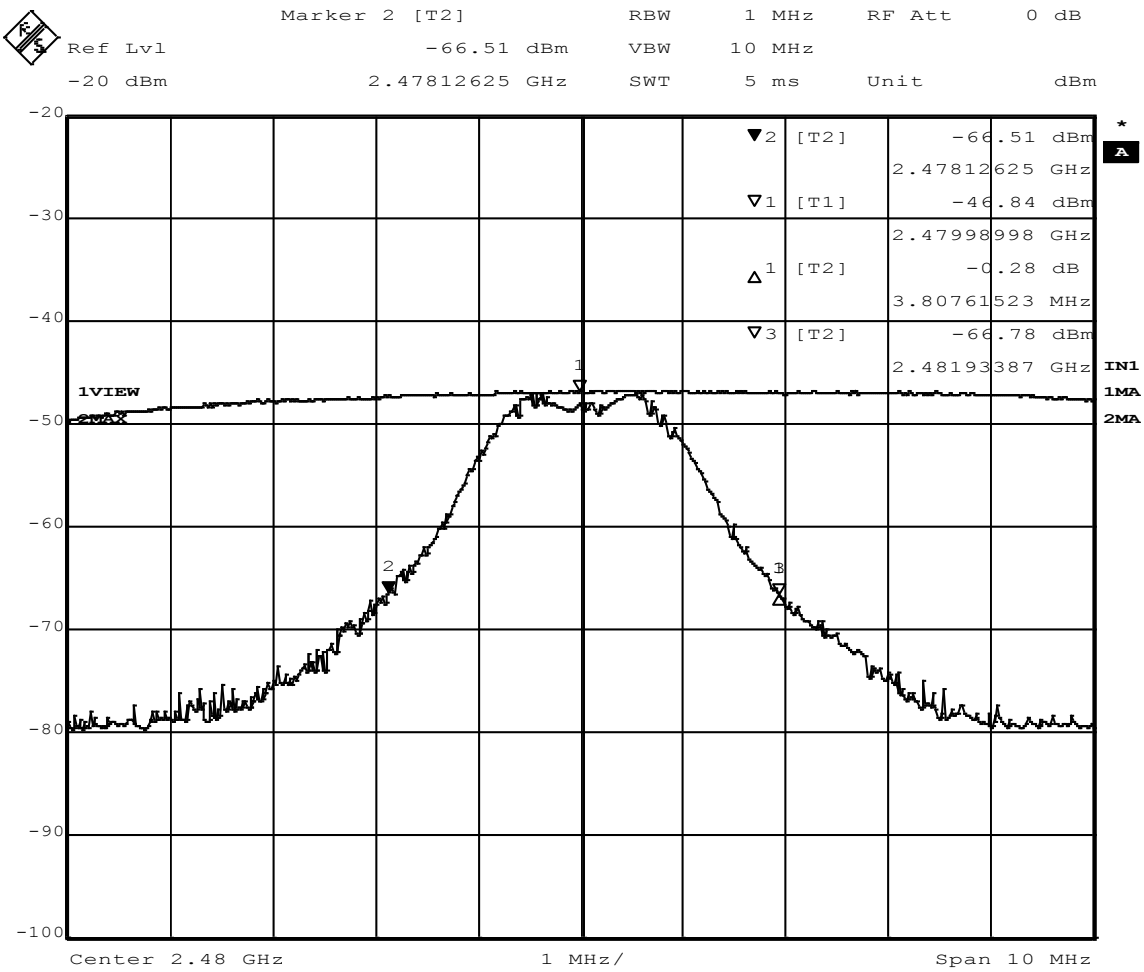


**Figure 12 - 99% Occupied Bandwidth, High Channel, 3.80 MHz**

Maximum power = -46.84 dBm + 107 + CL + AF - 95.23 = <u>0.60 dBm</u>

CL = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

## 4.4 Bandedges

Test Specification: FCC Part 15.249
RSS-Gen Section 8.9
RSS-210, Section B.10(a)

Test Method: ANSI C63.10, Section(s) 6.10.5.2, 11.13

### 4.4.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (2400.0MHz – 2483.5MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

### 4.4.2 Test procedures

The EUT was tested in the same method as described in section *4.3 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

### 4.4.3 Deviations from test standard

No deviation.

### 4.4.4 Test setup

See Section 4.3

### 4.4.5 EUT operating conditions

The EUT was powered by 3 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

### 4.4.6 Test results

| | | | |
|---|---|---|---|
| EUT | Clarity | MODE | Transmit |
| INPUT POWER | 3 VDC | FREQUENCY RANGE | 2400.0MHz - 2483.5MHz |
| ENVIRONMENTAL CONDITIONS | 50 % ± 5% RH<br>23 ± 3ºC | TECHNICIAN | KVepuri |

Highest Out of Band Emissions

| CHANNEL | Band edge /Measurement Frequency (MHz) | Relative Highest out of band level dBm | Relative Fundamental Level (dBm) | Delta | Min* (dBc) | Result |
|---|---|---|---|---|---|---|
| 1 | 2390.0 | -104.79 | -55.37 | 49.42 | 22.51 | PASS |
| 2 | 2400.0 | < -90.00** | -55.37 | < 34.63 | 20.00 | PASS |
| 3 | 2483.5 | -89.40 | -55.34 | 34.06 | 23.34 | PASS |

*Minimum delta = [ highest fundamental peak field strength from Section 4.2 ] – [ Part 15.209 radiated emissions limit. ]

**Figure 14 shows that the bandedge value at 2.4 GHz is clearly below -90 dBm on the uncorrected chart. 2.4 Ghz is found at the 4$^{th}$ major tick mark from the center (1.25 MHz x 4 – 5 MHz, center frequency = 2.405 GHz).

From Section 4.2

Fundamental average field strength at 2405MHz for low channel = 76.51dBµV/m
Fundamental average field strength at 2480MHz for high channel = 77.34dBµV/m

Channel 1 minimum delta = 76.51 – 54.0 dBµV/m = 22.51 dBc
Channel 3 minimum delta = 77.34 – 54.0 dBµV/m = 23.34 dBc

The delta measurements calculate the average field strength at the band edges as referenced to the average level at the fundamental frequency. The average duty cycle at the bandedge was 20 dB. Figures 17 and 18 in this section show the measurements of the duty cycle at bandedge frequencies.

Measurements do not include correction factors and are intended to be relative measurements only.

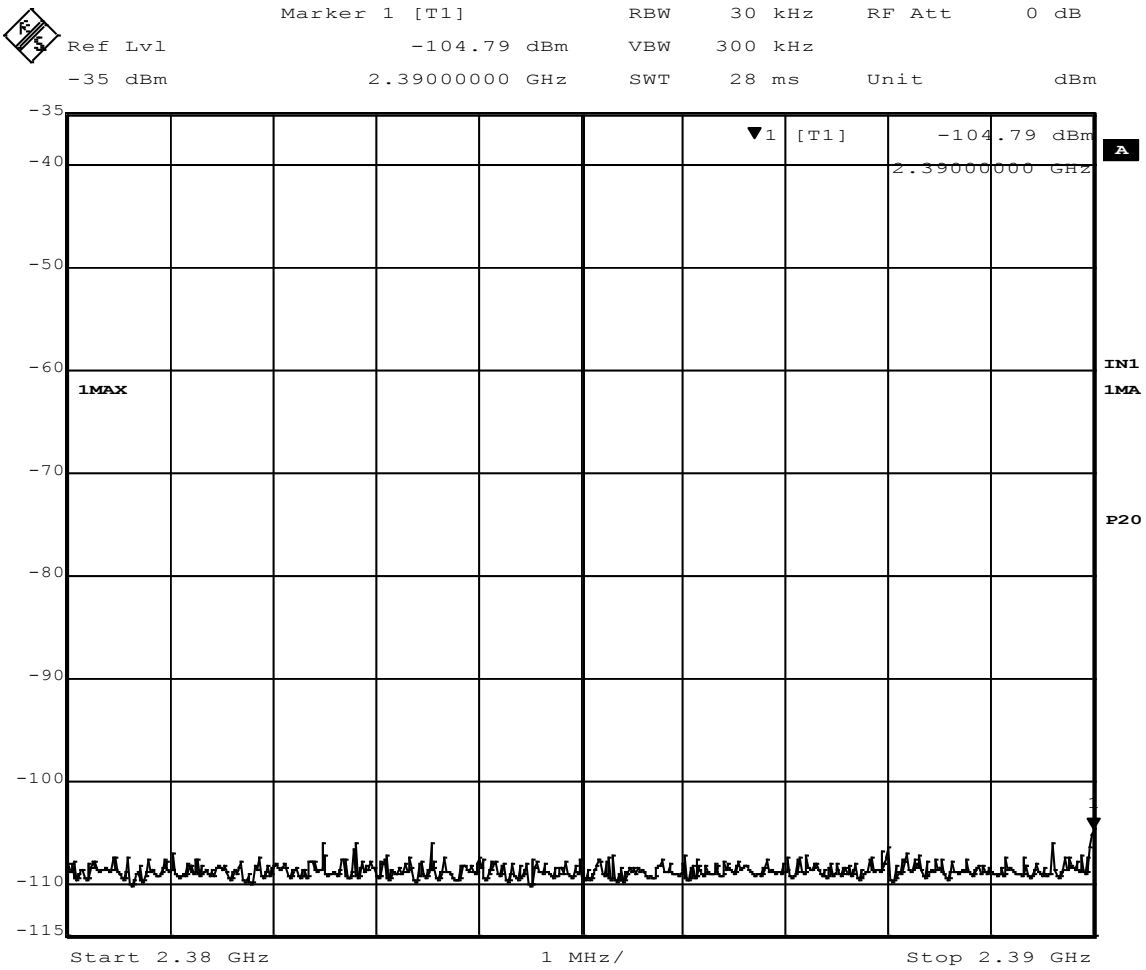


**Figure 13 - Band-edge Measurement, Low Channel, Restricted Frequency**

The plot shows an uncorrected measurement, used for relative measurements only.

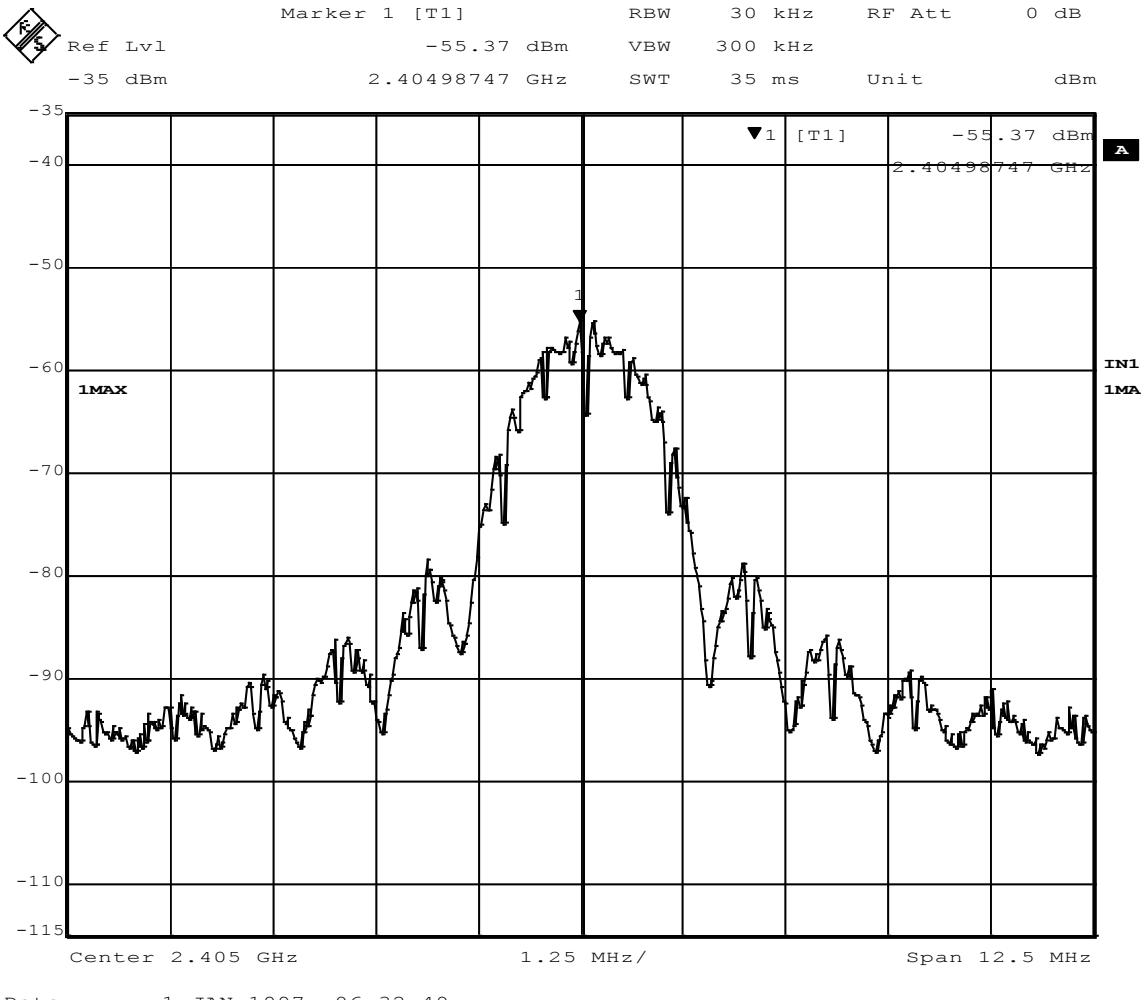


**Figure 14 - Band-edge Measurement, Low Channel, Fundamental**

The plot shows an uncorrected measurement, used for relative measurements only.

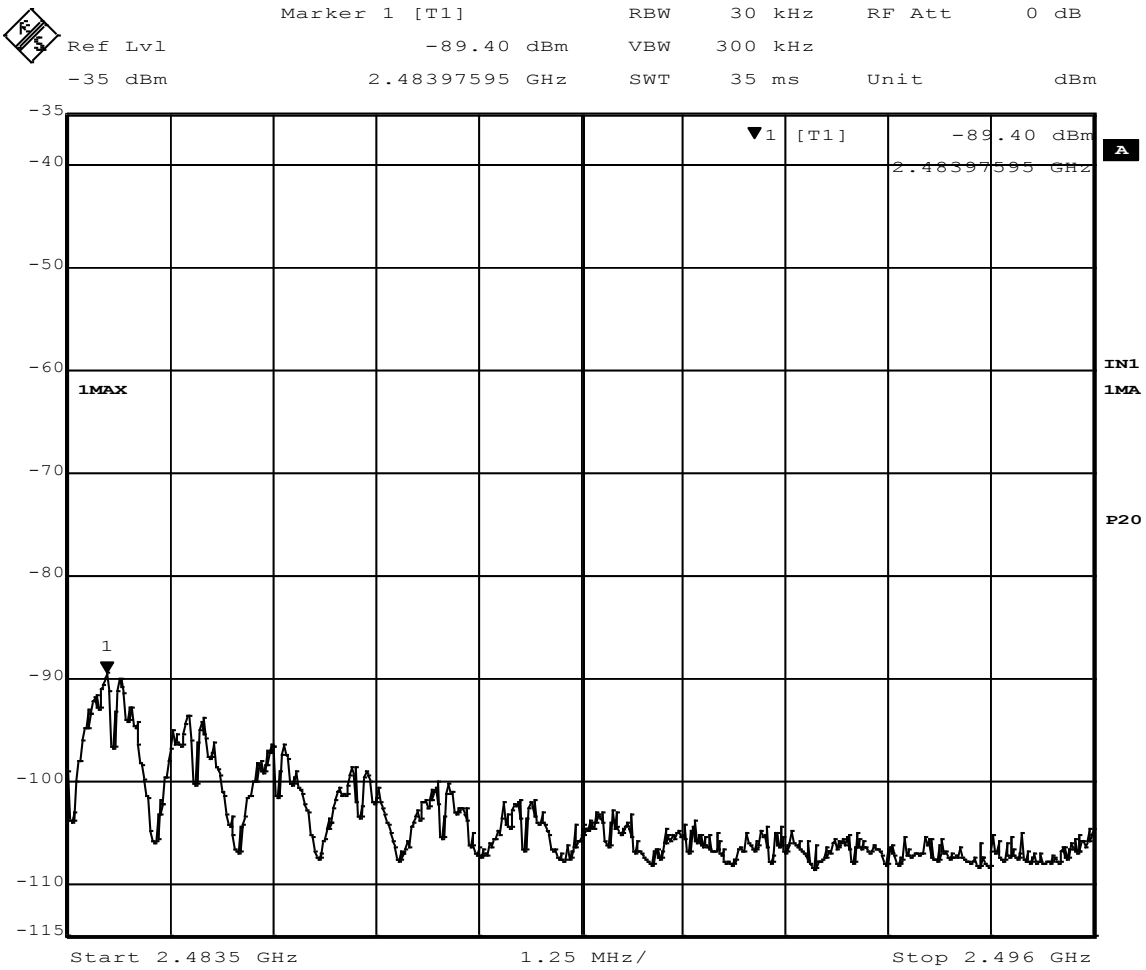


**Figure 15 - Band-edge Measurement, Restricted Frequency**

The plot shows an uncorrected measurement, used for relative measurements only.

Duty Cycle Correction Factor is calculated in Figures 8 and 9. 20dB was used.

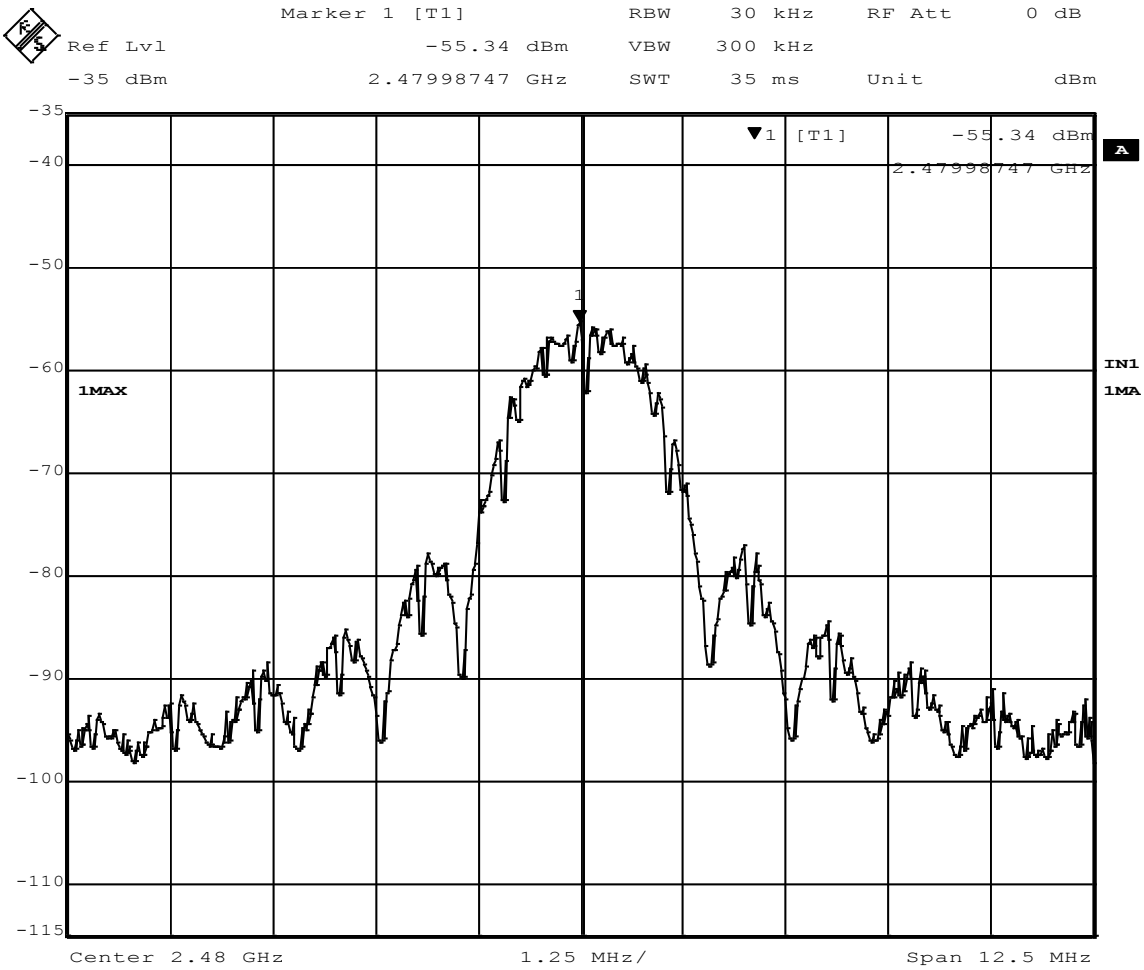


**Figure 16 - Band-edge Measurement, Fundamental**

The plot shows an uncorrected measurement, used for relative measurements only.

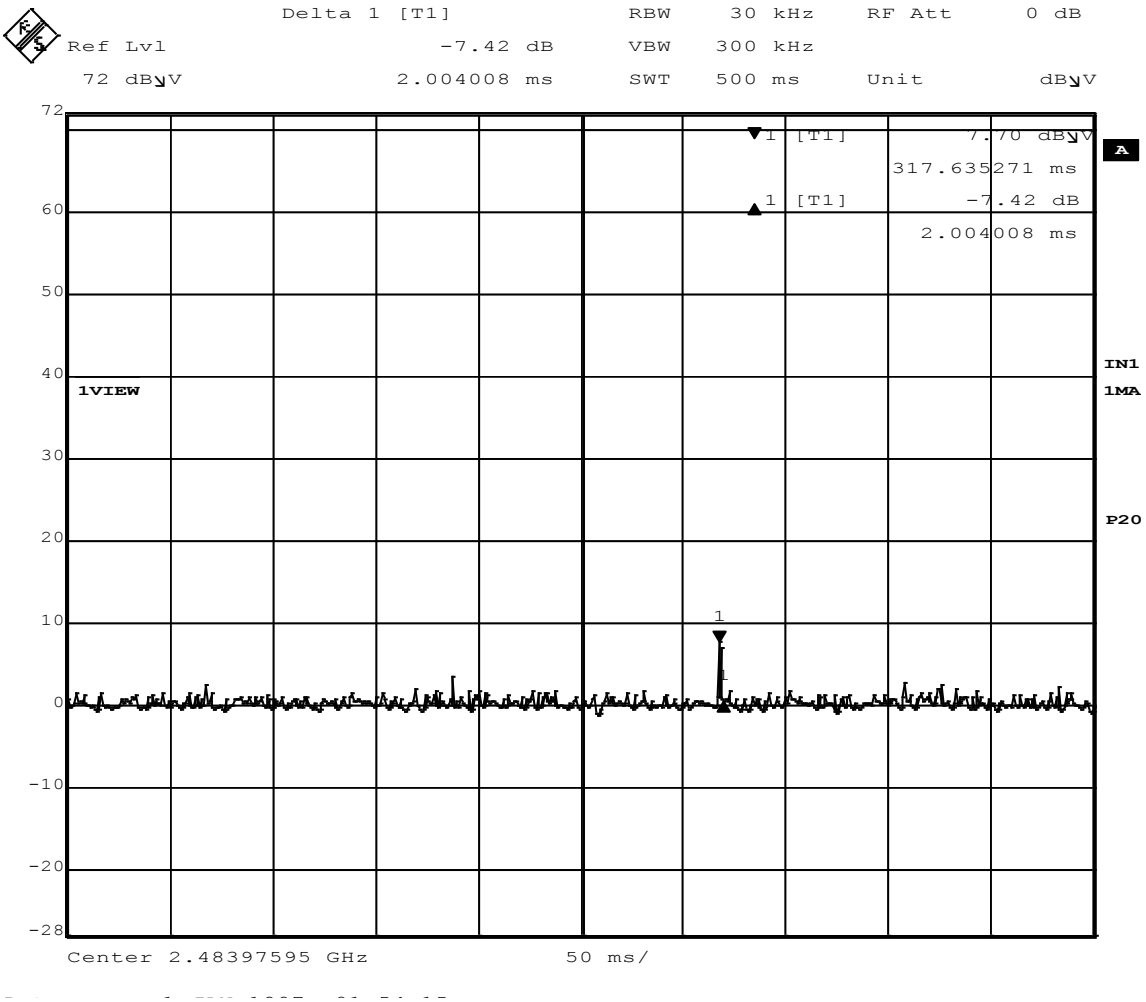


**Figure 17 - Period 100 ms, 2.484 GHz**

According to FCC Part 15.35, the maximum pulse train allowance is 0.1 seconds

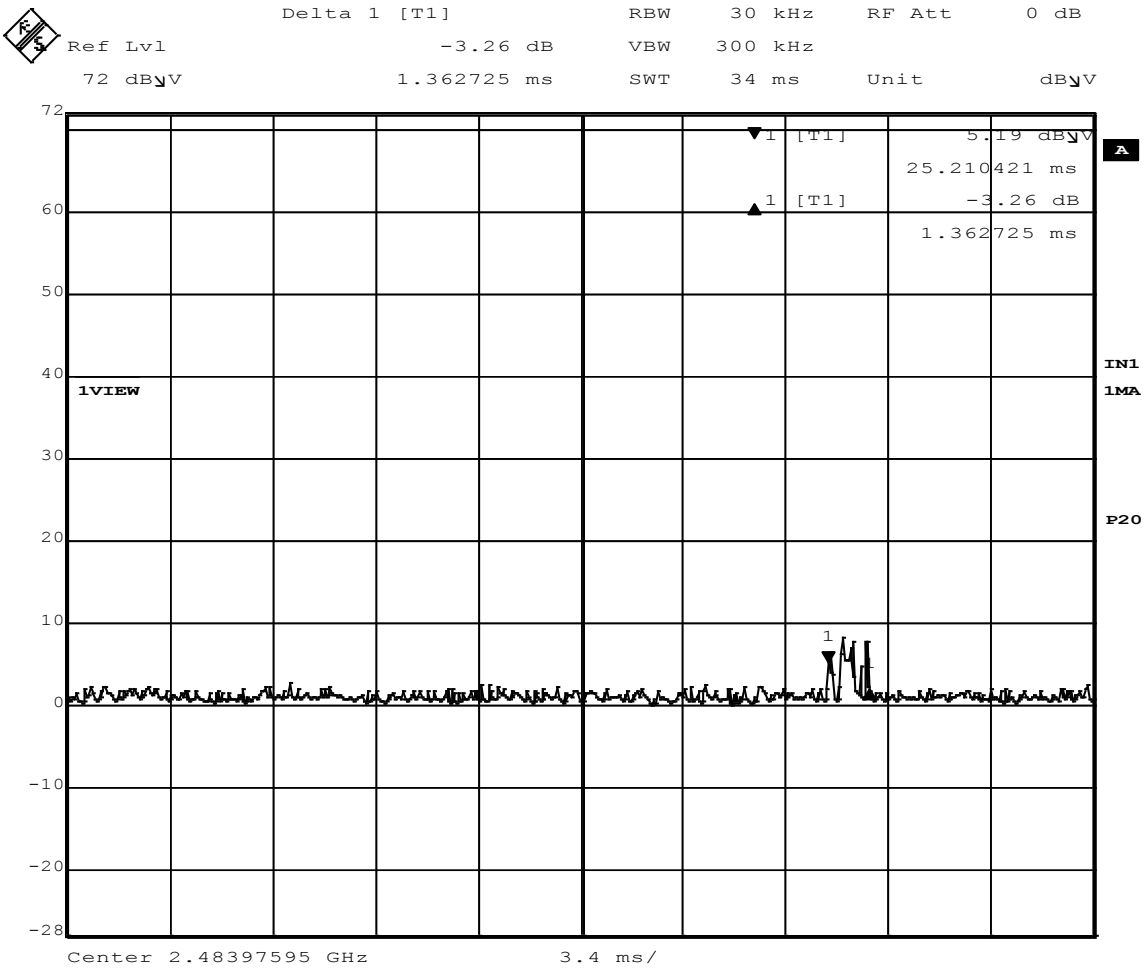


**Figure 18 – Maximum Pulse Width = 1.36 ms, 2.484 GHz**

Duty cycle correction factor = 20*log(1.36/(100)) > 51.30 dB
Note: 100ms is the longest allowed period per FCC Part 15.35
Note: 20dB is the maximum averaging factor, so that was used

# Appendix A: Measurement Uncertainty

Where relevant, the following measurement uncertainty levels apply to tests performed in this test report:

| Test | Frequency Range | NCEE Labs Uncertainty Value (dB) | Maximum Uncertainty Values per CISPR 16-4-2:2011 |
|---|---|---|---|
| AC Line Conducted Emissions | 150kHz - 30MHz | 3.30 | 3.40 |
| Radiated Emissions, 10m | 30MHz - 1GHz | 3.82 | 5.30 |
| Radiated Emissions, 3m | 30MHz – 1GHz | 4.25 | 5.30 |
| Radiated Emissions, 3m | 1GHz – 18GHz | 5.08 | 5.20 |
| Radiated Emissions, 3m | 6GHz – 18GHz | 5.08 | 5.50 |

Expanded uncertainty values are calculated to a confidence level of 95%.

NCEE Labs meets the maximum uncertainty requirements per CISPR 16-4-2:2011, and therefore does not require a minimum passing margin to state that an EUT is less than the field strength limits of the applicable CISPR, IEC or EN limit per CISPR 16-4-2:2011, Section 4.1.

# Appendix B: Sample Calculation

## Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log($T_{on}$/100) where $T_{on}$ is the maximum transmission time in any 100ms window.

## EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

*EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]$^2$ / [30 x Gain (numeric)]*

*Power (watts) = 10^[Power (dBm)/10] x 1000*

*Field Strength (dBµV/m) = Field Strength (dBm) = 107 (for 50Ω measurement systems)*

*Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6*

*Gain = 1 (numeric gain for isotropic radiator)*

*Conversion from 3m field strength to EIRP (d=3):*

*EIRP = (FS x d^2)/30 = FS [(d^2)/30] = FS [0.3}*

*EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = -95.23*

*10log( 10^) is the conversion from micro to milli*

# REPORT END