



**FCC CFR47 PART 15 SUBPART C  
INDUSTRY CANADA RSS-210 ISSUE 8**

**CERTIFICATION TEST REPORT**

**FOR**

**802.11a/b/g/n WLAN + Bluetooth PCI-E Custom Combination Card**

**MODEL NUMBER: BCM94331CSAX**

**FCC ID: QDS-BRCM1062  
IC: 4324A- BRCM1062**

**REPORT NUMBER: 11U14154-15**

**ISSUE DATE: FEBRUARY 03, 2012**

*Prepared for*

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**NVLAP LAB CODE 200065-0**

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## 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** BROADCOM CORPORATION  
190 MATHILDA PLACE  
SUNNYVALE, CA 94086, U.S.A.

**EUT DESCRIPTION:** 802.11a/b/g/n WLAN + Bluetooth PCI-E Custom Combination Card

**MODEL:** BCM94331CSAX

**SERIAL NUMBER:** C961095004UDJY01W

**DATE TESTED:** DEC 13, 2011 – FEB 03, 2012

| APPLICABLE STANDARDS                    |              |
|-----------------------------------------|--------------|
| STANDARD                                | TEST RESULTS |
| CFR 47 Part 15 Subpart C                | Pass         |
| INDUSTRY CANADA RSS-210 Issue 8 Annex 8 | Pass         |
| INDUSTRY CANADA RSS-GEN Issue 3         | Pass         |

Compliance Certification Services (UL CCS) tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL CCS based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL CCS will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For UL CCS By:

Tested By:



FRANK IBRAHIM  
EMC SUPERVISOR  
UL CCS

THANH NGUYEN  
EMC ENGINEER  
UL CCS

## 2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2009, FCC CFR 47 Part 2, FCC CFR 47 Part 15, RSS-GEN Issue 3, and RSS-210 Issue 8.

## 3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

## 4. CALIBRATION AND UNCERTAINTY

### 4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

### 4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

### 4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

| PARAMETER                             | UNCERTAINTY |
|---------------------------------------|-------------|
| Conducted Disturbance, 0.15 to 30 MHz | 3.52 dB     |
| Radiated Disturbance, 30 to 1000 MHz  | 4.94 dB     |

Uncertainty figures are valid to a confidence level of 95%.

## 5. EQUIPMENT UNDER TEST

### 5.1. DESCRIPTION OF EUT

The EUT is an 802.11a/b/g/n WLAN + Bluetooth PCI-E Custom Combination Card.

The radio module is manufactured by Broadcom.

### 5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

| Frequency Range (MHz) | Mode           | Output Power (dBm) | Output Power (mW) |
|-----------------------|----------------|--------------------|-------------------|
| 2402 – 2480           | Low Energy BLE | 7.03               | 5.05              |

### 5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an 802.11bgn WLAN and Bluetooth antenna with a maximum gain of 4.97 dBi.

### 5.4. SOFTWARE AND FIRMWARE

The EUT driver software installed during testing was Broadcom Bluetooth Version 1.4.3

The test utility software used during testing was Bluetool, ver. 1.4.3.0 and BCM\_BTDL, ver 1.8.4.pl

### 5.5. WORST-CASE CONFIGURATION AND MODE

Radiated emission and power line conducted emission were performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.

## 5.6. DESCRIPTION OF TEST SET

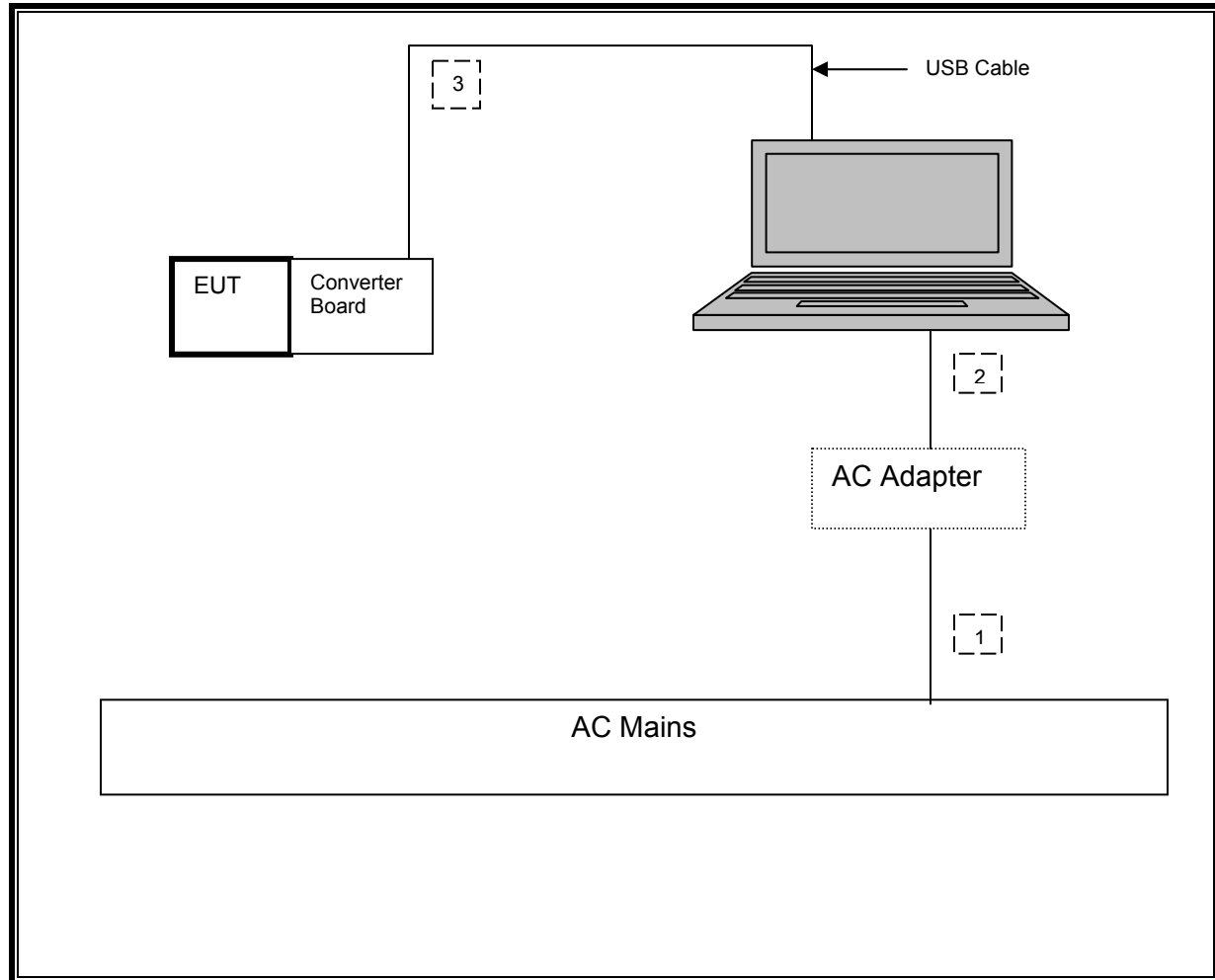
### SUPPORT EQUIPMENT

| Channel | Frequency (MHz) | Output Power (dBm) | Limit (dBm) | Margin (dB) |
|---------|-----------------|--------------------|-------------|-------------|
| Low     | 2402            | 7.03               | 30          | -22.97      |
| Middle  | 2440            | 6.78               | 30          | -23.22      |
| High    | 2480            | 6.80               | 30          | -23.20      |

### I/O CABLES

| I/O CABLE LIST |      |                      |                |             |              |                         |
|----------------|------|----------------------|----------------|-------------|--------------|-------------------------|
| Cable No.      | Port | # of Identical Ports | Connector Type | Cable Type  | Cable Length | Remarks                 |
| 1              | AC   | 1                    | US 115V        | Shielded    | 1.5m         | NA                      |
| 2              | DC   | 1                    | DC             | Un-shielded | 1.5m         | Ferrite at laptop's end |
| 3              | USB  | 1                    | USB            | Un-shielded | 1.0m         | NA                      |

## SETUP DIAGRAM



## TEST SETUP

The EUT was tested as an external module that installed on a converter board connected to a host Laptop PC USB cable.

## 6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

| TEST EQUIPMENT LIST        |                |                  |        |          |
|----------------------------|----------------|------------------|--------|----------|
| Description                | Manufacturer   | Model            | Asset  | Cal Due  |
| Spectrum Analyzer, 44 GHz  | Agilent / HP   | E4446A           | C00996 | 05/14/12 |
| Antenna, Bilog, 2 GHz      | Sunol Sciences | JB1              | C01171 | 07/16/12 |
| Antenna, Horn, 18 GHz      | EMCO           | 3115             | C00872 | 09/20/12 |
| Antenna, Horn, 26.5 GHz    | ARA            | MWH-1826/B       | C00980 | 07/28/12 |
| Preamplifier, 1300 MHz     | Agilent / HP   | 8447D            | C00778 | 11/11/12 |
| Preamplifier, 26.5 GHz     | Agilent / HP   | 8449B            | C00749 | 07/18/12 |
| Peak Power Meter           | Agilent / HP   | E9327A           | C00964 | 12/13/13 |
| Peak Power Sensor          | Agilent / HP   | E4416A           | C00963 | 12/13/13 |
| Reject Filter, 2.4-2.5 GHz | Micro-Tronics  | BRM50702         | N02685 | CNR      |
| LISN, 30 MHz               | FCC            | LISN-50/250-25-2 | N02625 | 12/13/12 |
| EMI Test Receiver, 30 MHz  | R & S          | ESHS 20          | N02396 | 08/19/13 |

## 7. ANTENNA PORT TEST RESULTS

### 7.1. 6 dB BANDWIDTH

#### LIMITS

FCC §15.247 (a) (2)

IC RSS-210 A8.2 (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

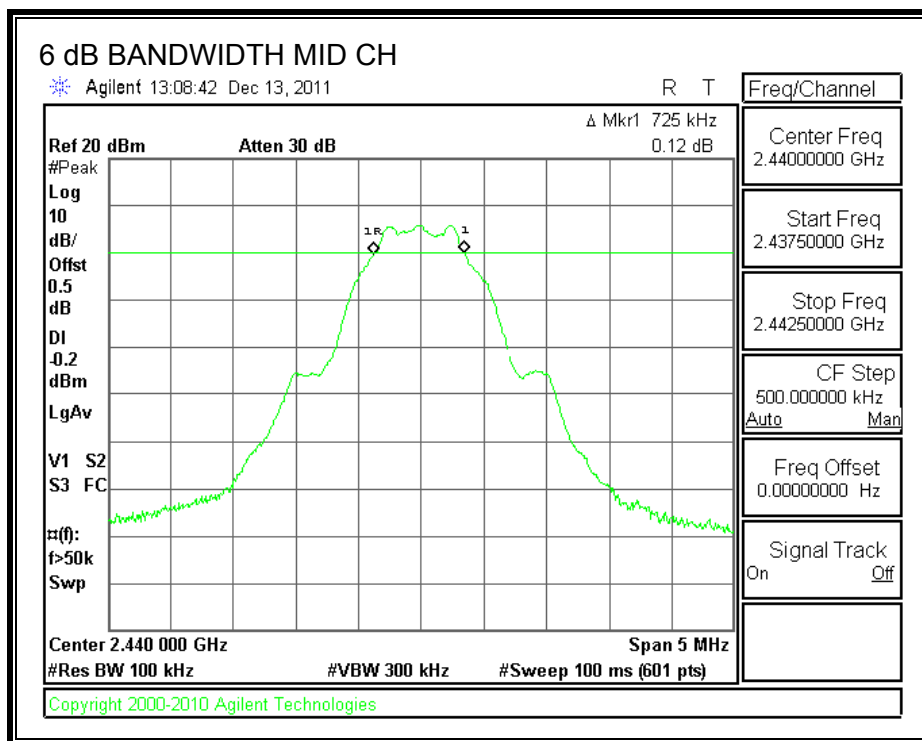
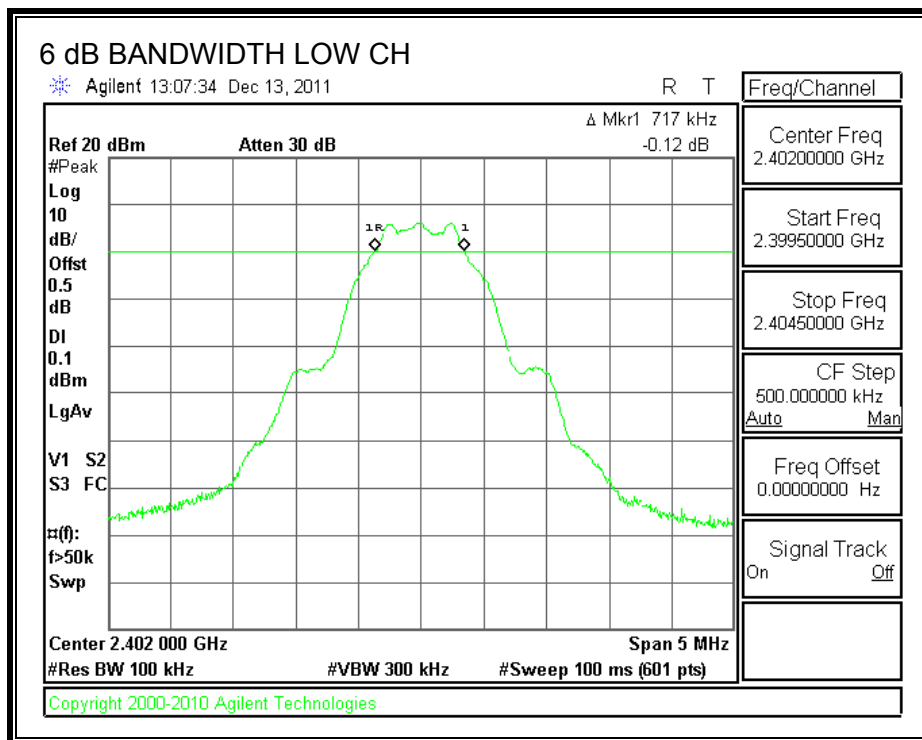
#### TEST PROCEDURE

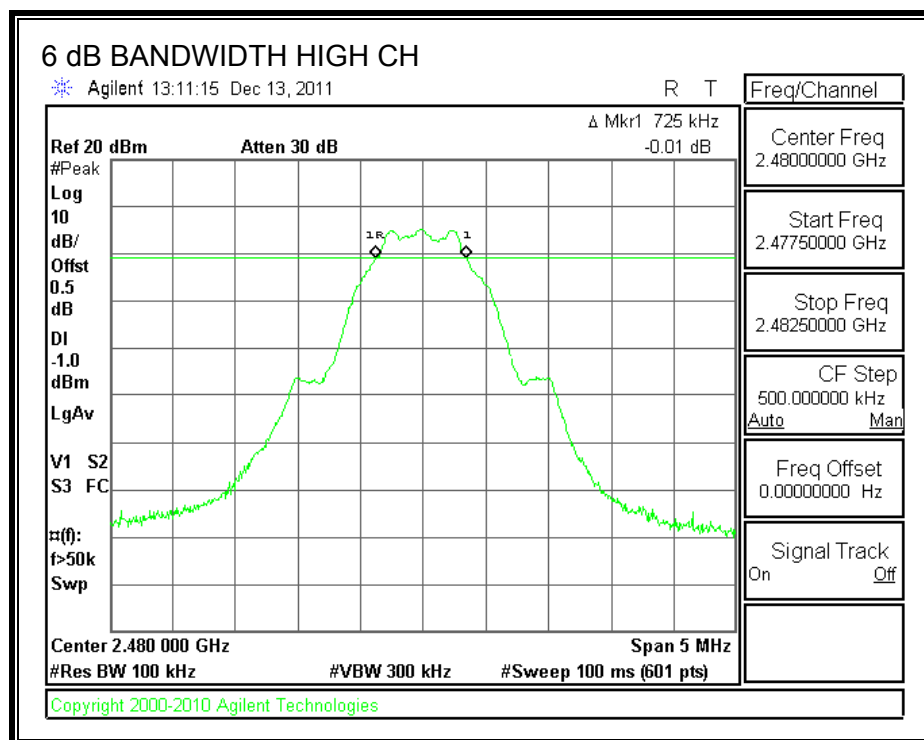
The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

#### RESULTS

| Channel | Frequency<br>(MHz) | 6 dB Bandwidth<br>(MHz) | Minimum Limit<br>(MHz) |
|---------|--------------------|-------------------------|------------------------|
| Low     | 2402               | 0.717                   | 0.5                    |
| Middle  | 2440               | 0.725                   | 0.5                    |
| High    | 2480               | 0.725                   | 0.5                    |

## 6 dB BANDWIDTH





## 7.2. 99% BANDWIDTH

### LIMIT

None; for reporting purposes only.

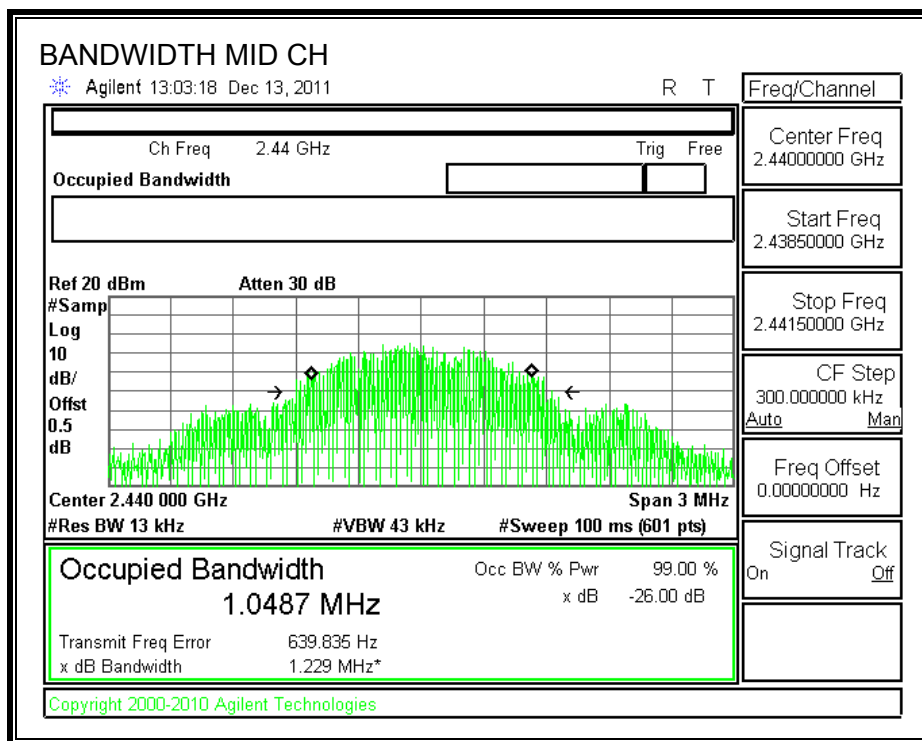
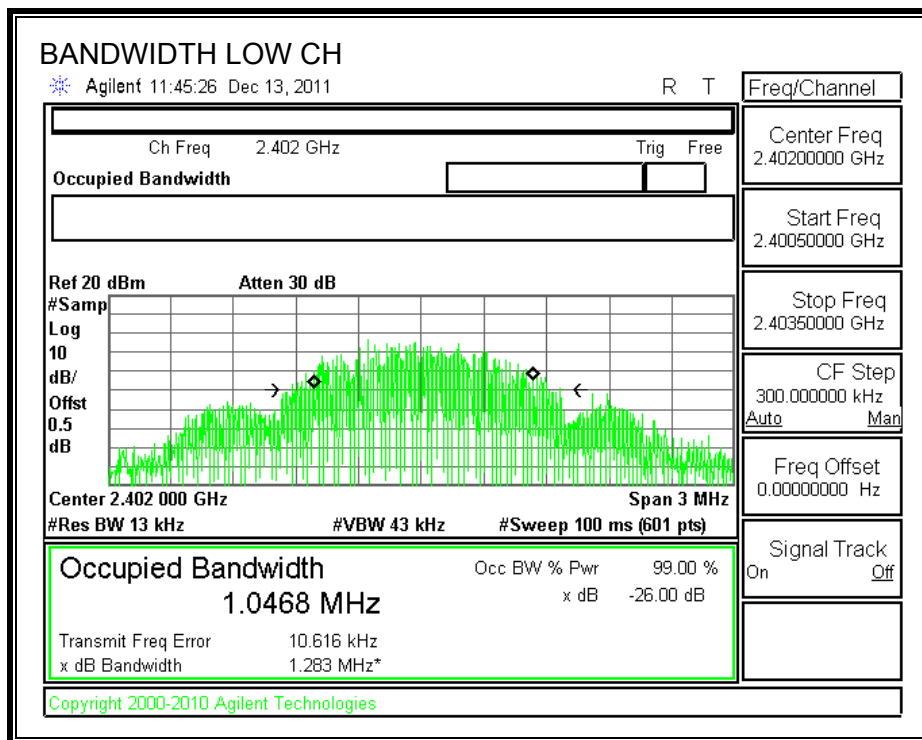
### TEST PROCEDURE

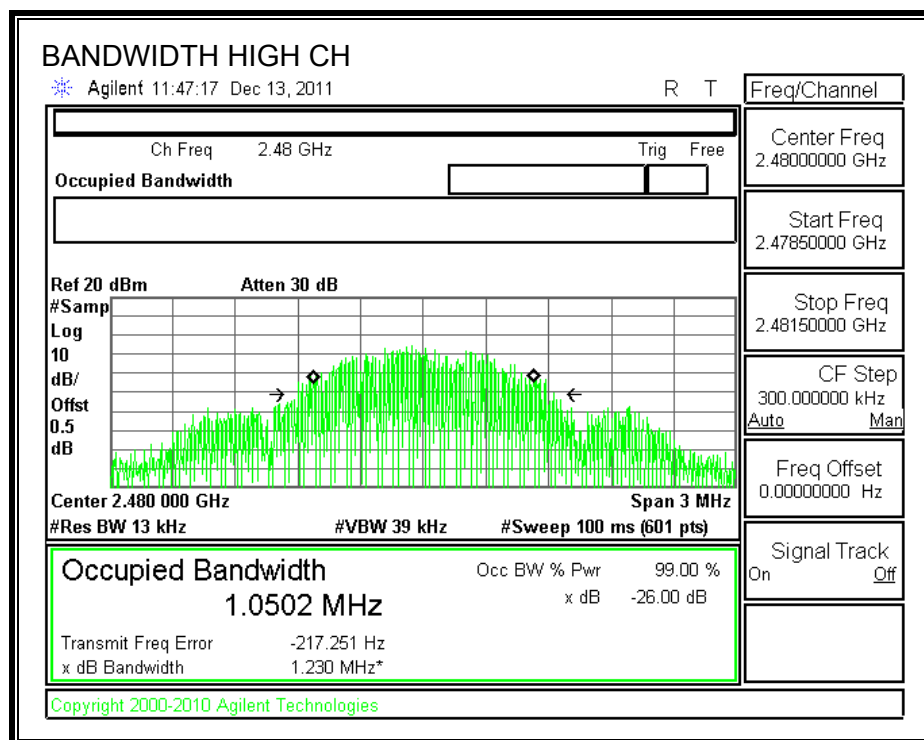
The transmitter output is connected to a spectrum analyzer. The RBW is set to  $\geq 1\%$  of the 99% bandwidth. The VBW is set to  $\geq$  RBW. The sweep time is coupled.

### RESULTS

| Channel | Frequency<br>(MHz) | 99% Bandwidth<br>(MHz) |
|---------|--------------------|------------------------|
| Low     | 2402               | 1.0468                 |
| Middle  | 2440               | 1.0487                 |
| High    | 2480               | 1.0502                 |

**99% BANDWIDTH**





### 7.3. OUTPUT POWER

#### LIMIT

§15.247 (b) (1)

RSS-210 Issue 7 Clause A8.4

The maximum antenna gain is less than 6 dBi, therefore the limit is 30 dBm.

Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

#### TEST PROCEDURE

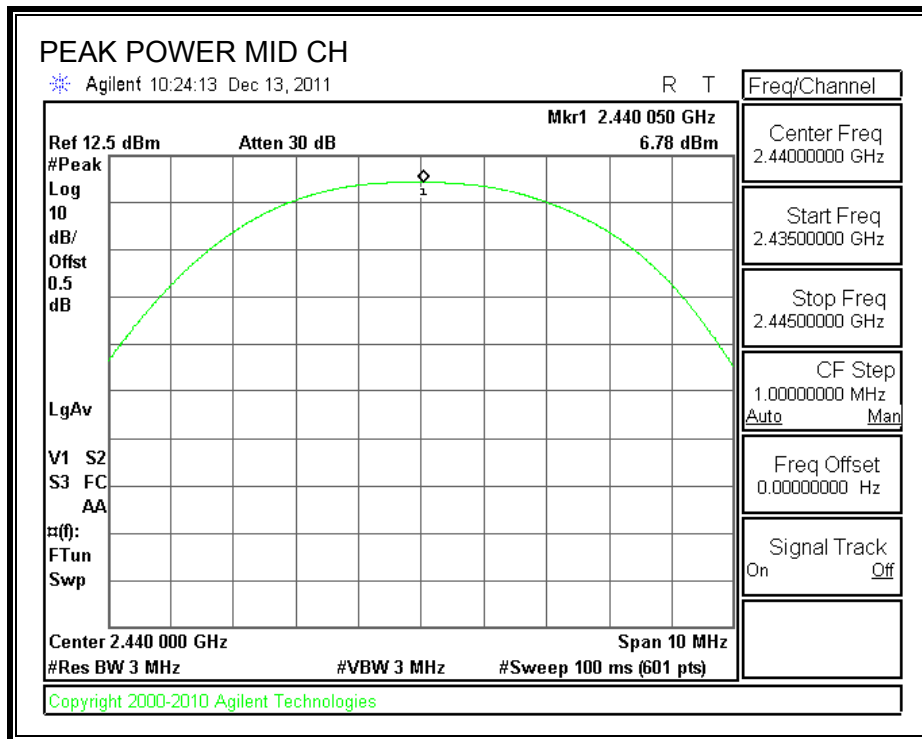
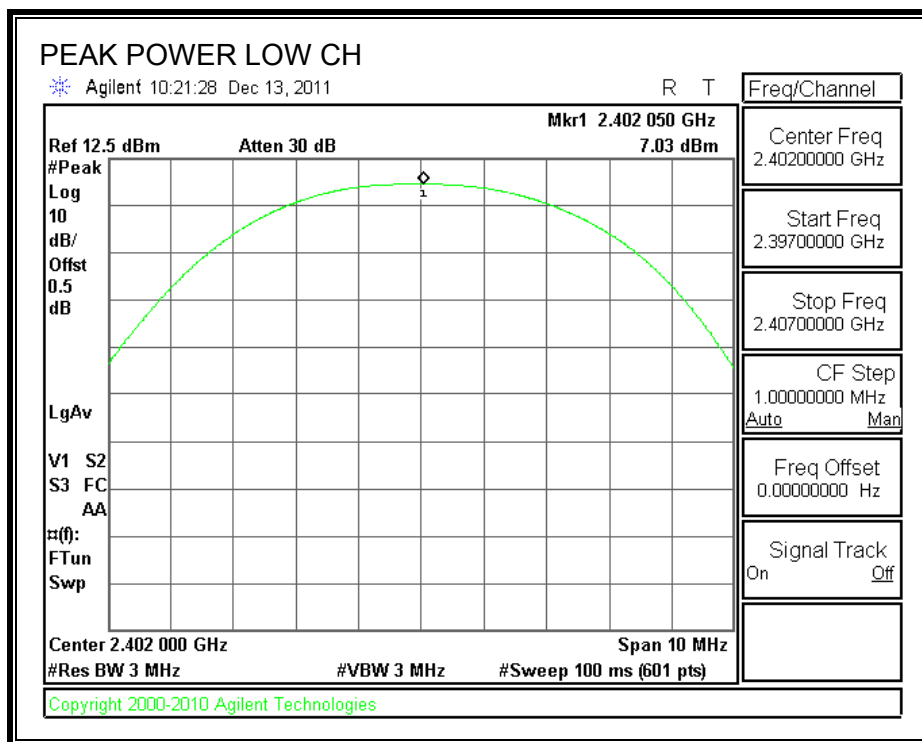
The transmitter output is connected to a spectrum analyzer the analyzer bandwidth is set to a value greater than the 20 dB bandwidth of the EUT.

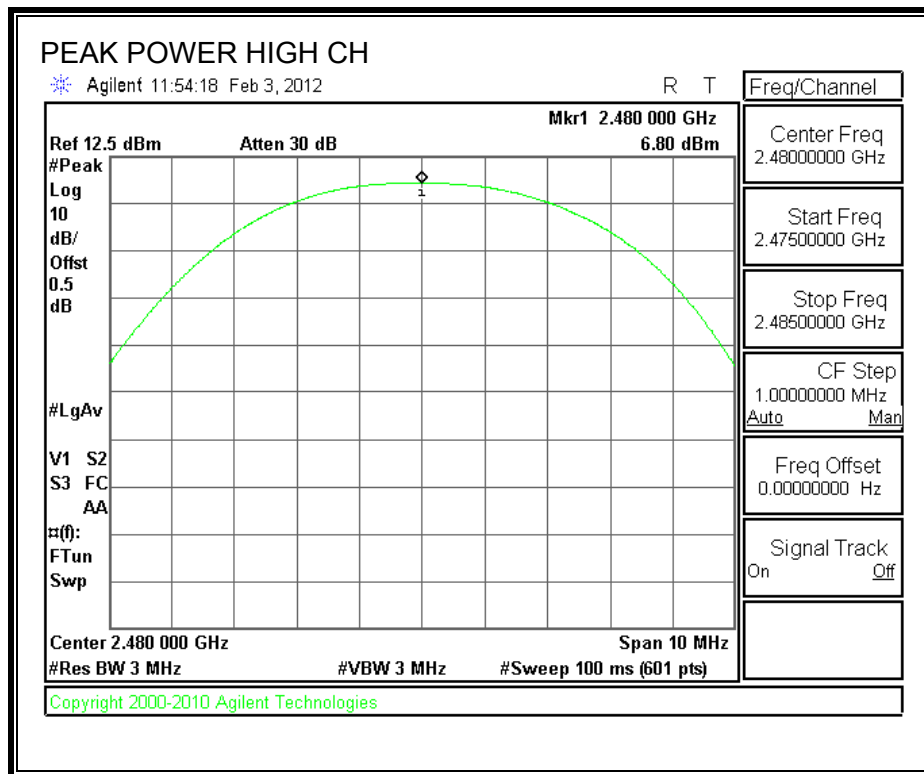
#### RESULTS

LE MODE

| Channel | Frequency<br>(MHz) | Output Power<br>(dBm) | Limit<br>(dBm) | Margin<br>(dB) |
|---------|--------------------|-----------------------|----------------|----------------|
| Low     | 2402               | 7.03                  | 30             | -22.97         |
| Middle  | 2440               | 6.78                  | 30             | -23.22         |
| High    | 2480               | 6.80                  | 30             | -23.20         |

## LE MODE





## 7.4. AVERAGE POWER

### LIMIT

None; for reporting purposes only.

### TEST PROCEDURE

The transmitter output is connected to a power meter.

### RESULTS

The cable assembly insertion loss of 0.5 dB (including 0.5 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

| Channel | Frequency<br>(MHz) | Average Power<br>(dBm) |
|---------|--------------------|------------------------|
| Low     | 2402               | 6.87                   |
| Middle  | 2442               | 6.69                   |
| High    | 2480               | 6.15                   |

## 7.5. POWER SPECTRAL DENSITY

### LIMITS

FCC §15.247 (e)

IC RSS-210 A8.2 (b)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

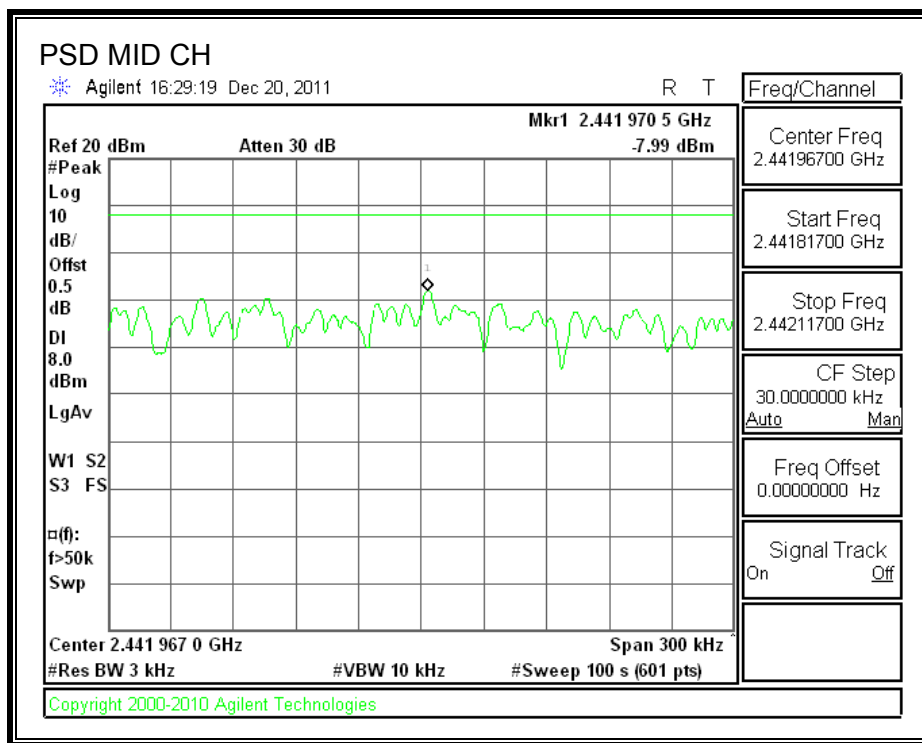
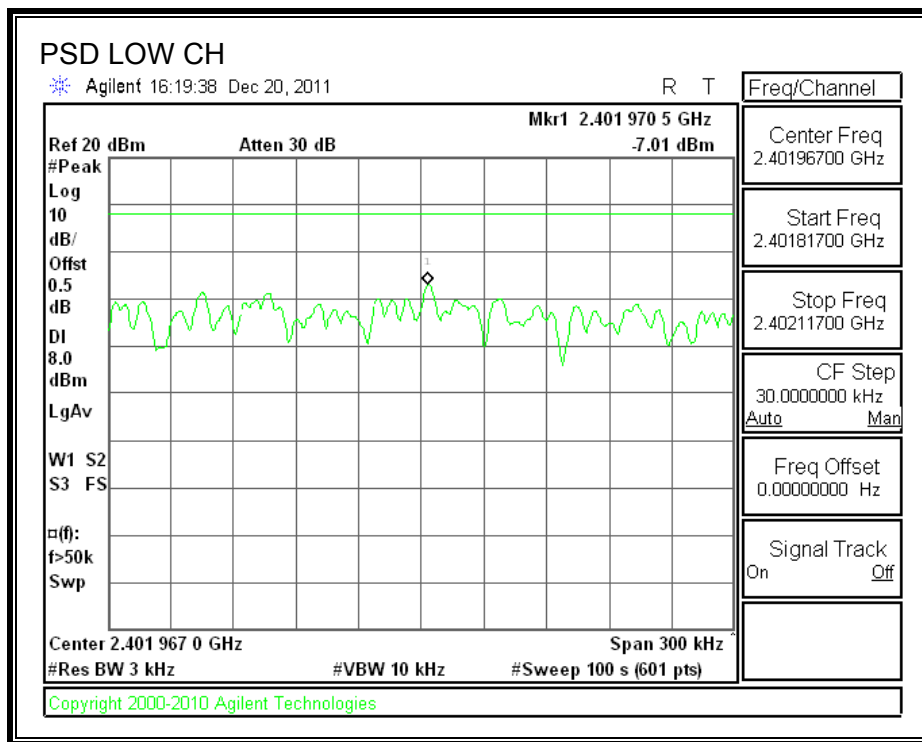
### TEST PROCEDURE

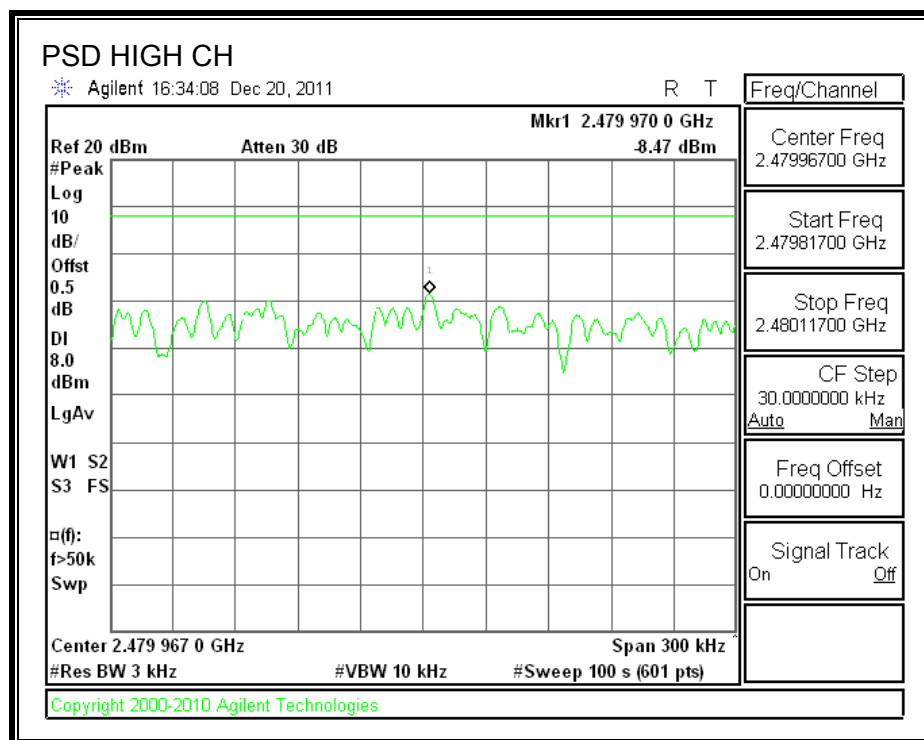
Output power was measured based on the use of a peak measurement, therefore the power spectral density was measured using PSD Option 1 in accordance with FCC document "Measurement of Digital Transmission Systems Operating under Section 15.247", March 23, 2005.

### RESULTS

| Channel | Frequency<br>(MHz) | PPSD<br>(dBm) | Limit<br>(dBm) | Margin<br>(dB) |
|---------|--------------------|---------------|----------------|----------------|
| Low     | 2402               | -7.01         | 8              | -15.01         |
| Middle  | 2442               | -7.99         | 8              | -15.99         |
| High    | 2480               | -8.47         | 8              | -16.47         |

# **POWER SPECTRAL DENSITY**





## **7.6. CONDUCTED SPURIOUS EMISSIONS**

### **LIMITS**

FCC §15.247 (d)

IC RSS-210 A8.5

Limit = -20 dBc

### **TEST PROCEDURE**

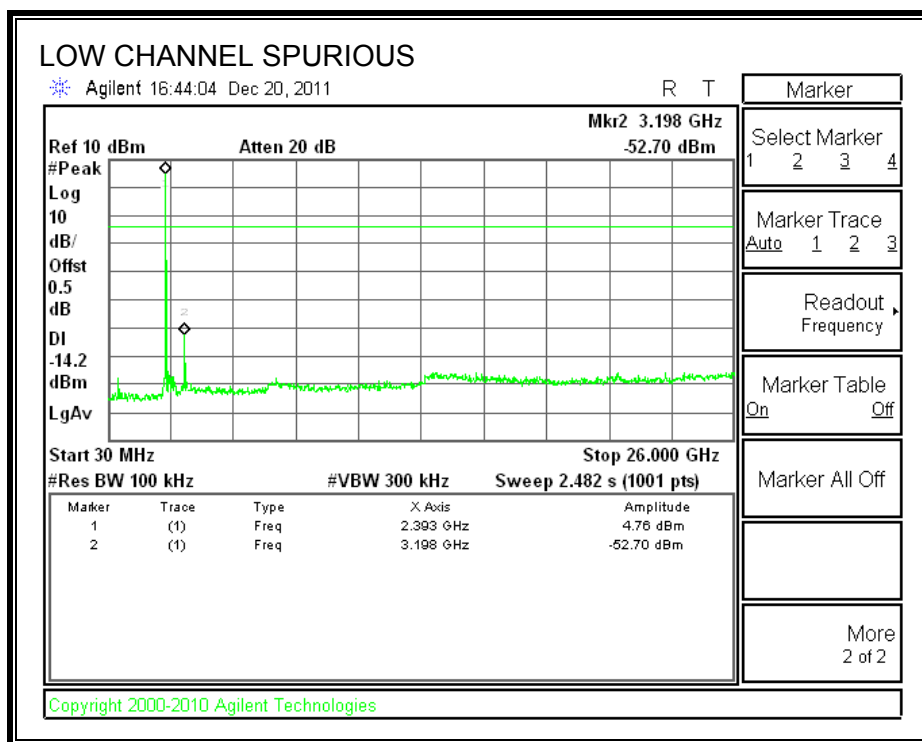
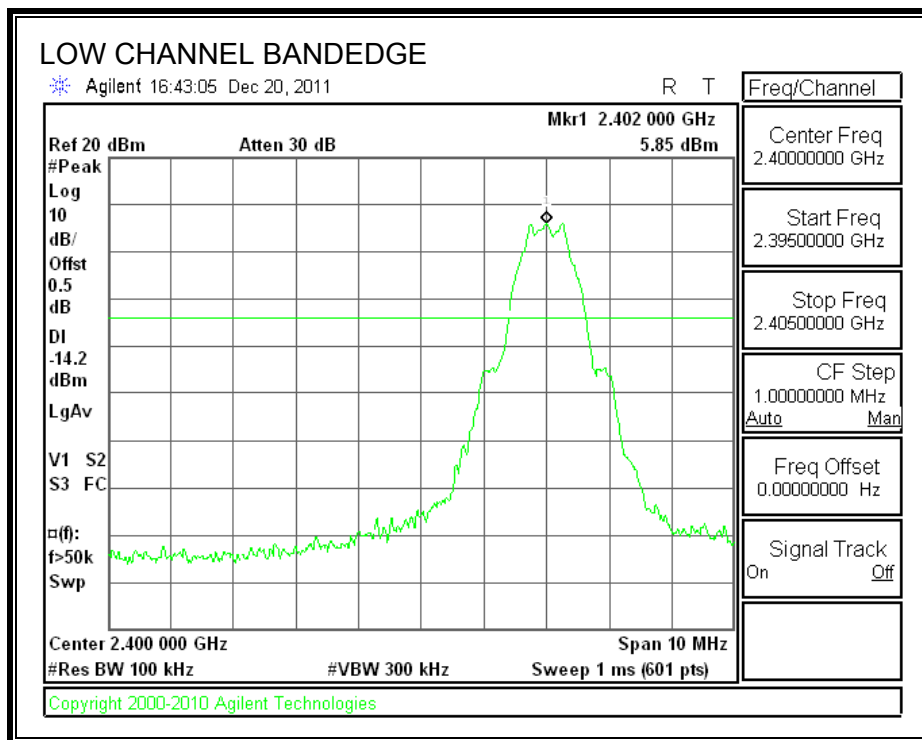
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

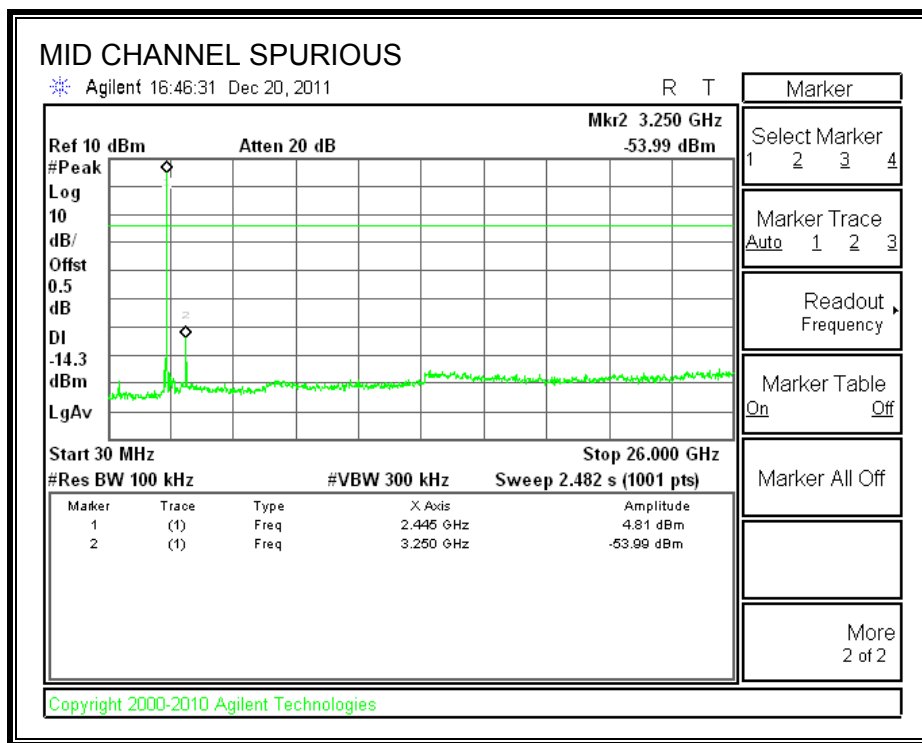
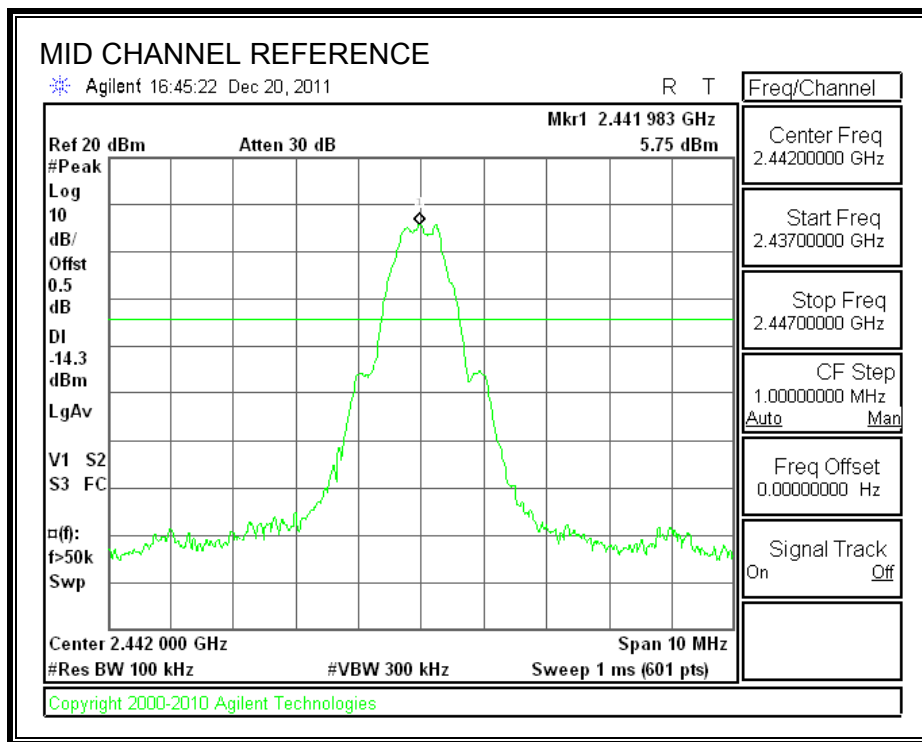
The band edges at 2.4 and 2.4835 GHz are investigated with the transmitter set to the normal hopping mode.

## RESULTS

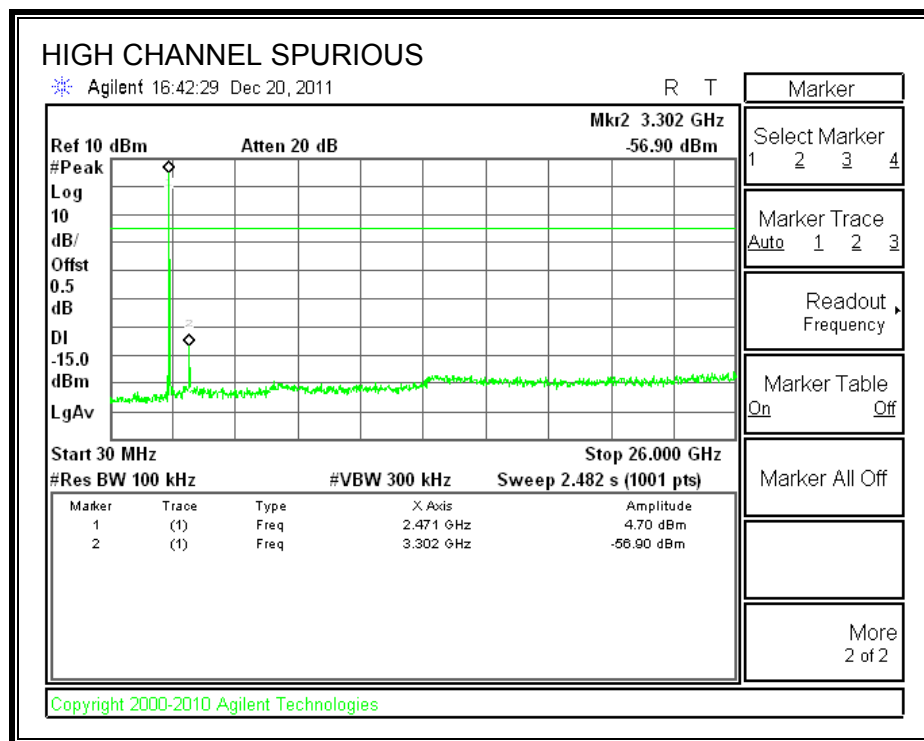
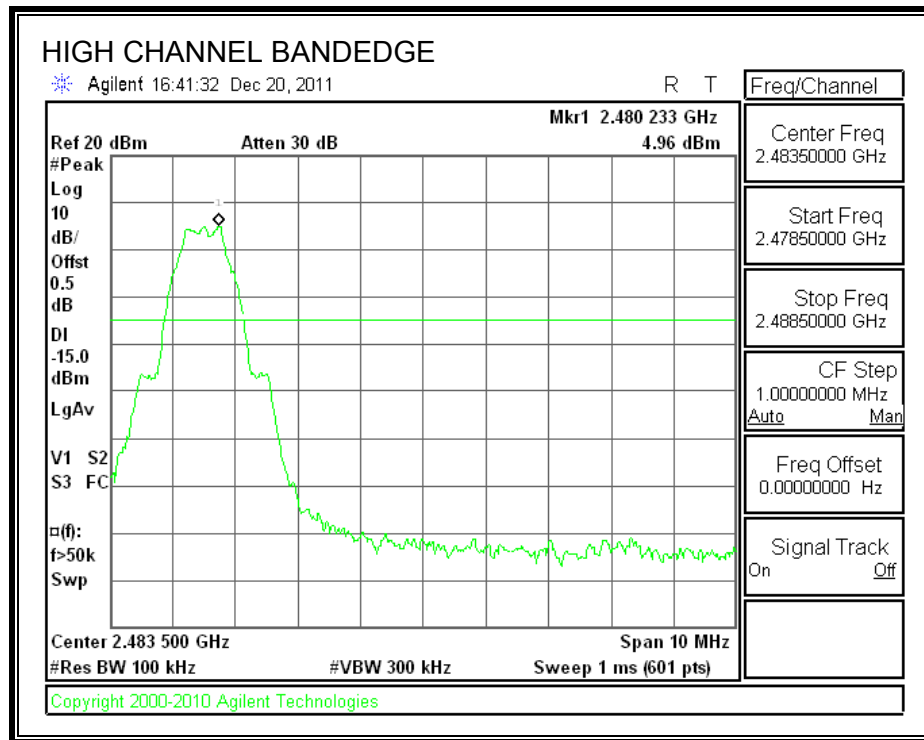
### SPURIOUS EMISSIONS, LOW CHANNEL



# **SPURIOUS EMISSIONS, MID CHANNEL**



# **SPURIOUS EMISSIONS, HIGH CHANNEL**



## 8. RADIATED TEST RESULTS

### 8.1. LIMITS AND PROCEDURE

#### LIMITS

FCC §15.205 and §15.209

IC RSS-210 Clause 2.6 (Transmitter)

IC RSS-GEN Clause 6 (Receiver)

| Frequency Range (MHz) | Field Strength Limit (uV/m) at 3 m | Field Strength Limit (dBuV/m) at 3 m |
|-----------------------|------------------------------------|--------------------------------------|
| 30 - 88               | 100                                | 40                                   |
| 88 - 216              | 150                                | 43.5                                 |
| 216 - 960             | 200                                | 46                                   |
| Above 960             | 500                                | 54                                   |

#### TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.4. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

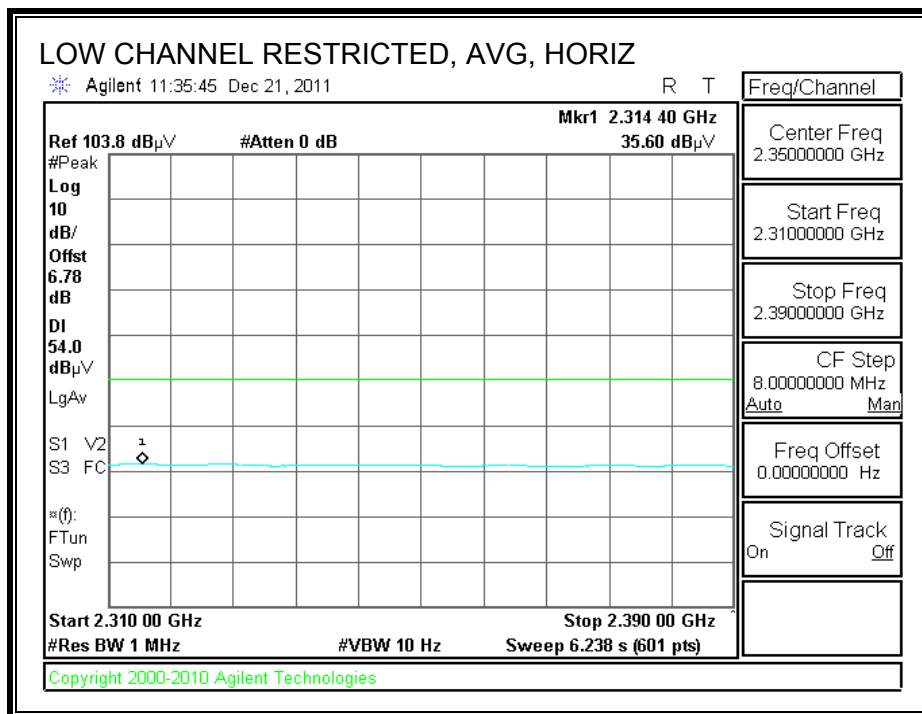
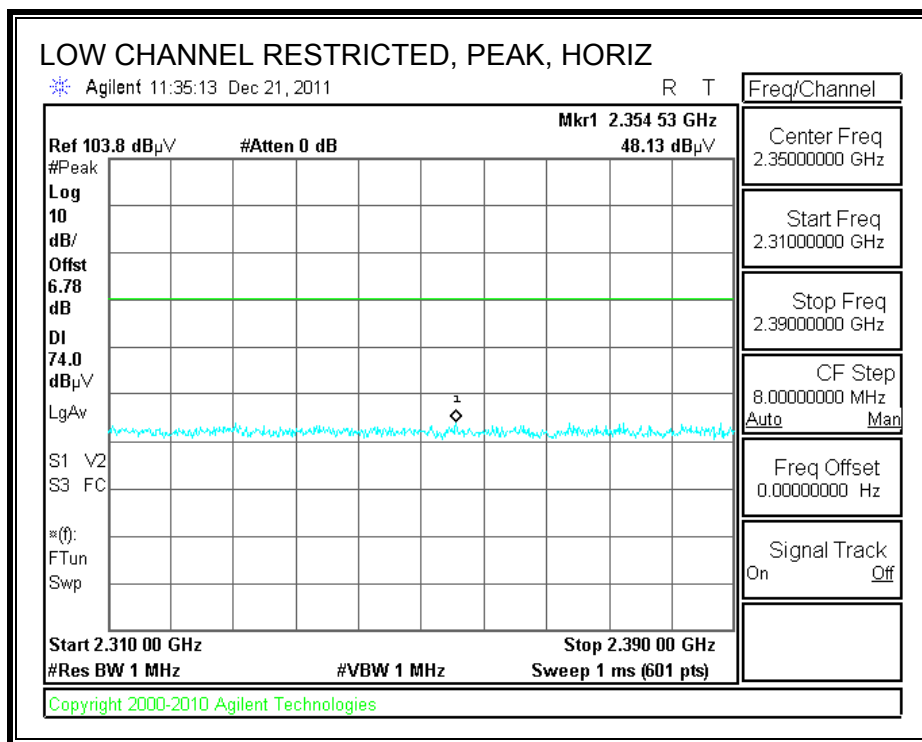
For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, and then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in the 2.4 GHz band.

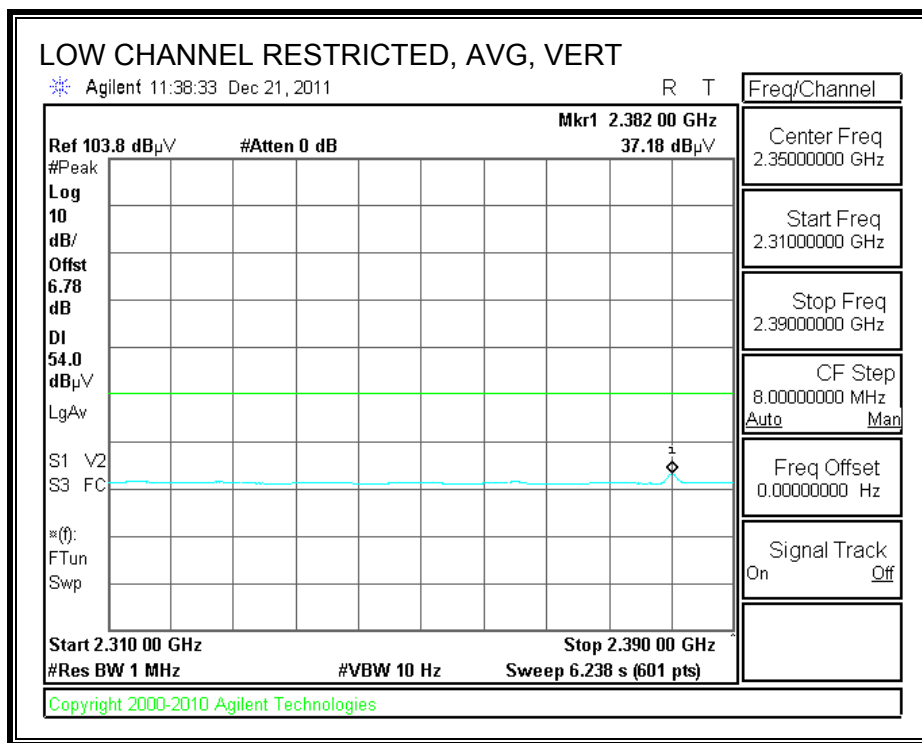
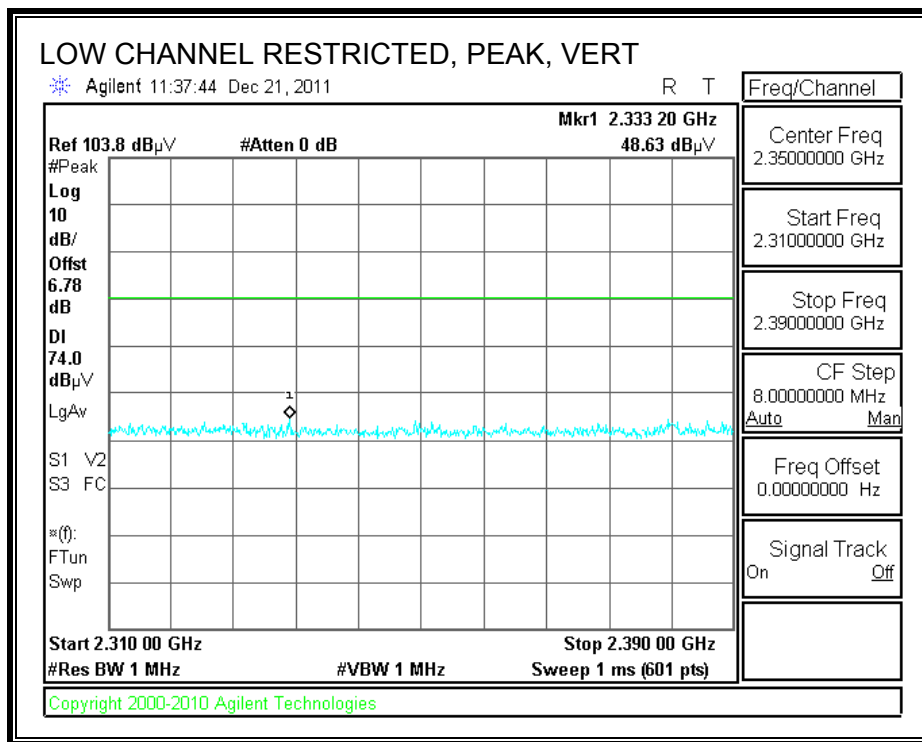
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

## 8.2. TX SPURIOUS ABOVE 1 GHz

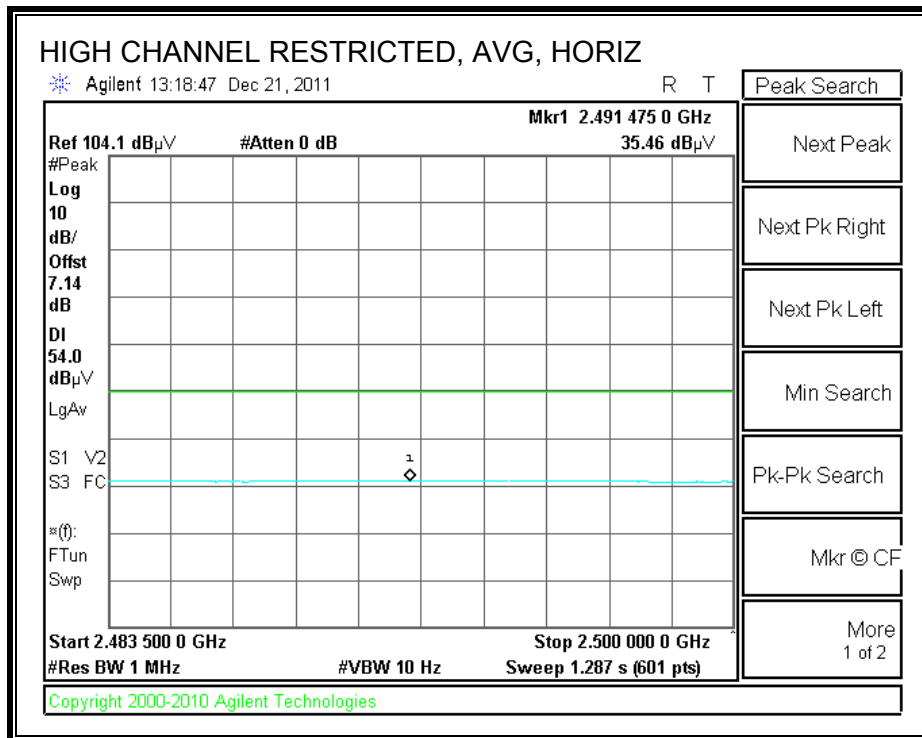
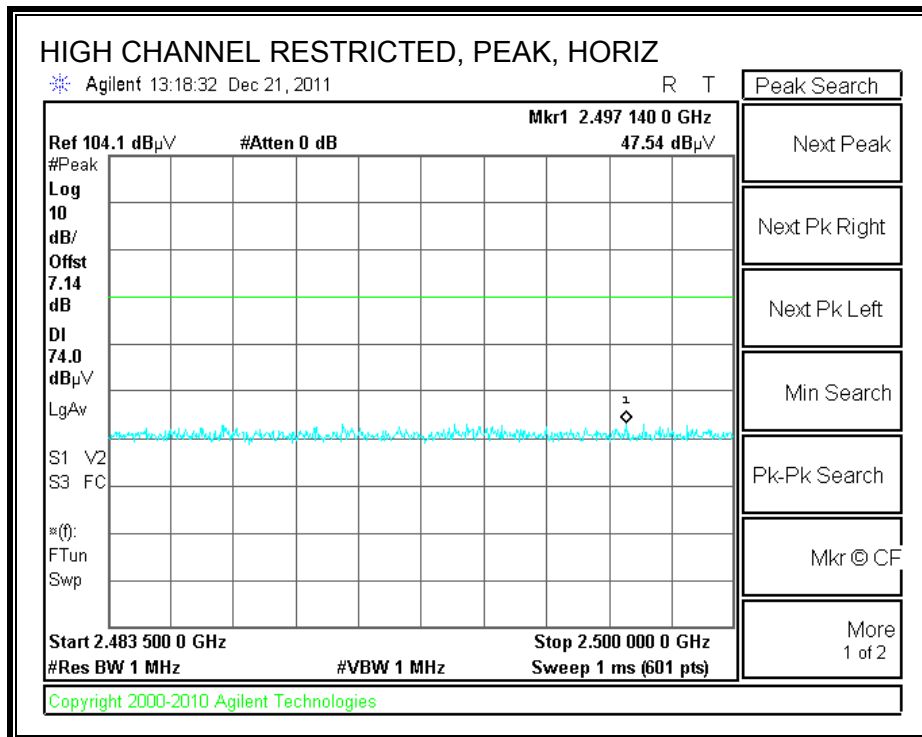
### RESTRICTED BANDEDGE (LOW CHANNEL, HORIZONTAL)



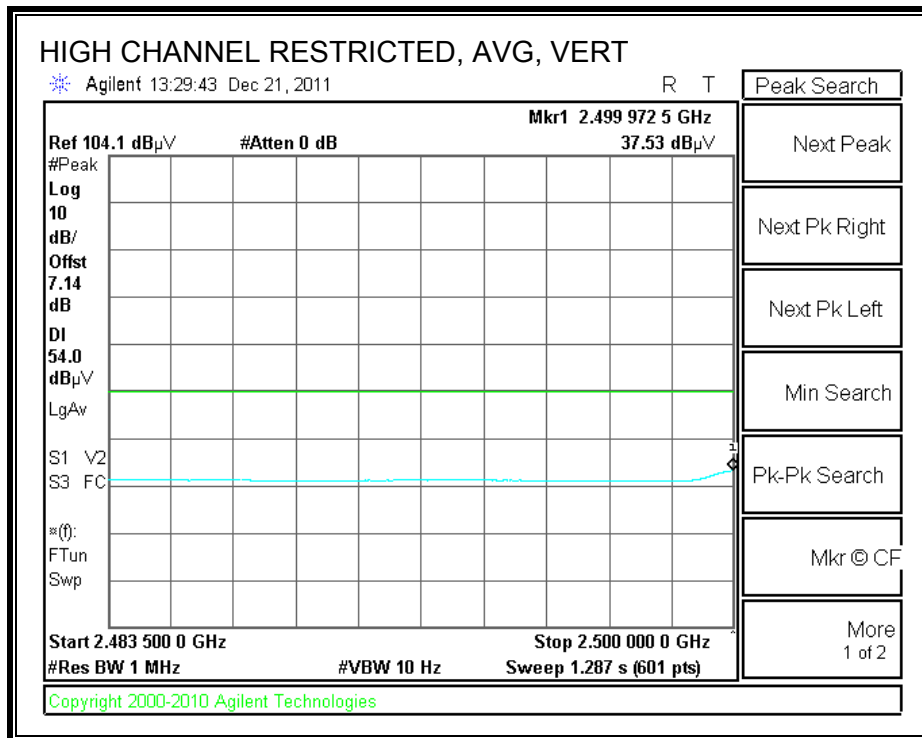
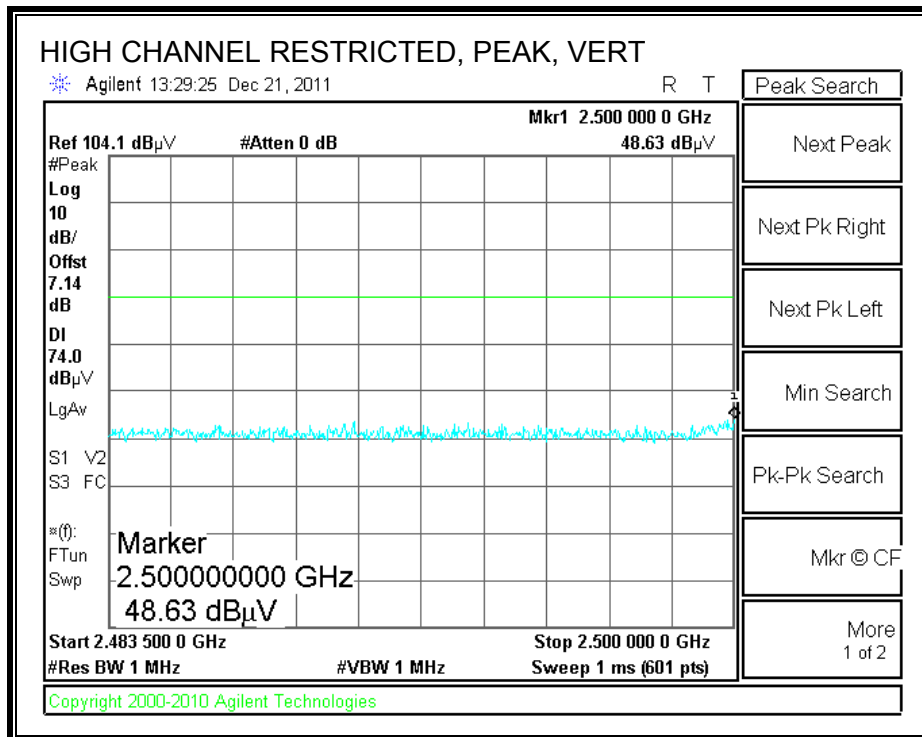
**RESTRICTED BANDEDGE (LOW CHANNEL, VERTICAL)**



**RESTRICTED BANEDGE (HIGH CHANNEL, HORIZONTAL)**



**RESTRICTED BANEDGE (HIGH CHANNEL, VERTICAL)**



# HARMONICS AND SPURIOUS EMISSIONS

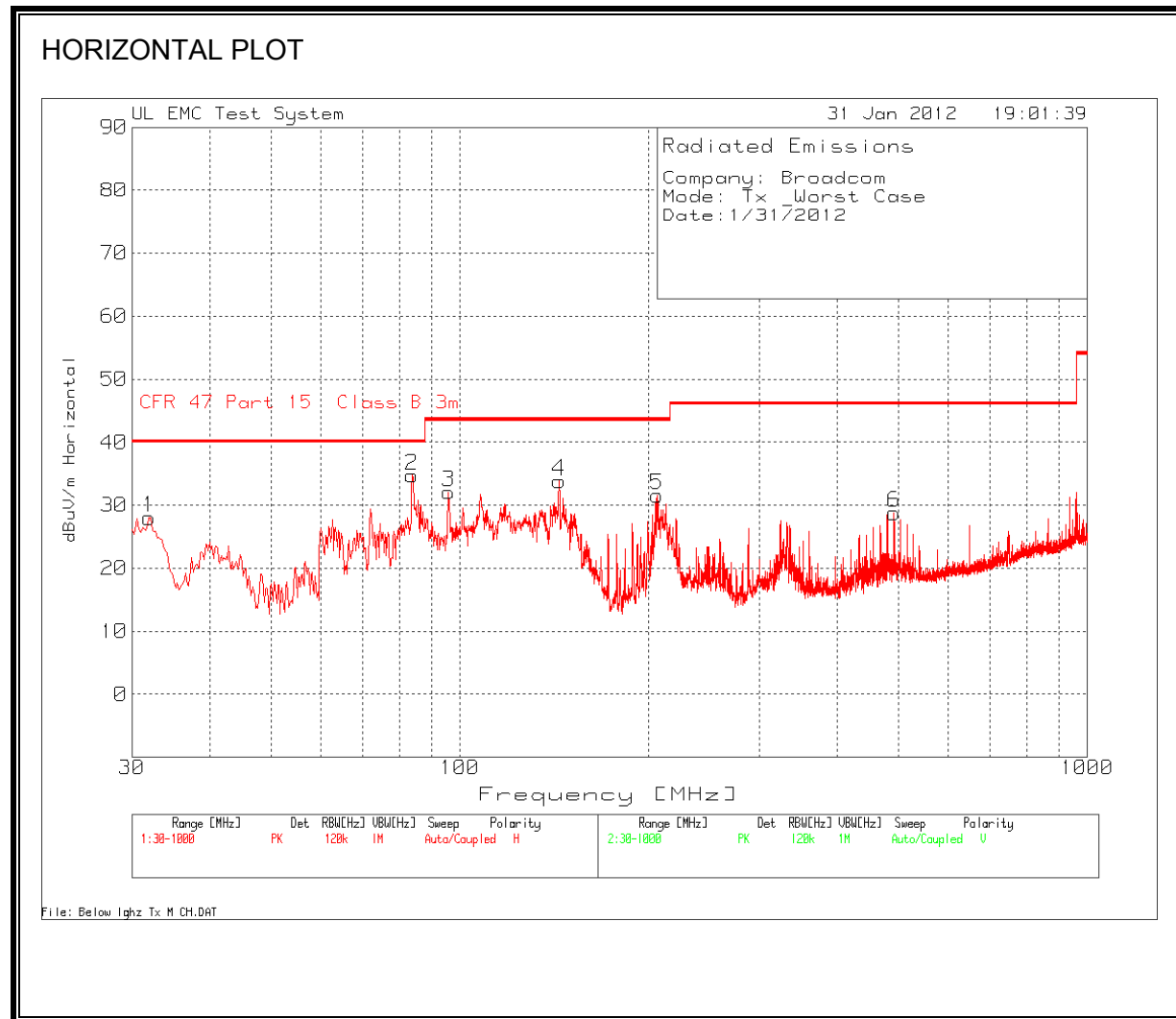
| High Frequency Measurement                            |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
|-------------------------------------------------------|-----------------------|-----------------|-----------------------|------------|----------|------------------------|--------------------------------|------------|----------------|---------------|------------------|-------------------|------------------------------|---------------|----------------------------------------------------------------------------------|--|--|
| Compliance Certification Services, Fremont 3m Chamber |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Company:                                              |                       | Broadcom        |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Project #:                                            |                       | 11U14154        |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Date:                                                 |                       | 1/31/2012       |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Test Engineer:                                        |                       | Dennis Huang    |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Configuration:                                        |                       | FCC 15.247      |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Mode:                                                 |                       | Tx LE Mode      |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Test Equipment:                                       |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| Horn 1-18GHz                                          |                       |                 | Pre-amplifier 1-26GHz |            |          | Pre-amplifier 26-40GHz |                                |            | Horn > 18GHz   |               |                  | Limit             |                              |               |                                                                                  |  |  |
| T60; S/N: 2238 @3m                                    |                       |                 | T34 HP 8449B          |            |          |                        |                                |            |                |               |                  | FCC 15.205        |                              |               |                                                                                  |  |  |
| Hi Frequency Cables                                   |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| 3' cable 22807700                                     |                       |                 | 12' cable 22807600    |            |          | 20' cable 22807500     |                                |            | HPF            |               |                  | Reject Filter     |                              |               | Peak Measurements<br>RBW=VBW=1MHz<br>Average Measurements<br>RBW=1MHz ; VBW=10Hz |  |  |
| 3' cable 22807700                                     |                       |                 | 12' cable 22807600    |            |          | 20' cable 22807500     |                                |            |                |               |                  | R_001             |                              |               |                                                                                  |  |  |
| f<br>GHz                                              | Dist<br>(m)           | Read Pk<br>dBuV | Read Avg.<br>dBuV     | AF<br>dB/m | CL<br>dB | Amp<br>dB              | D Corr<br>dB                   | Fldr<br>dB | Peak<br>dBuV/m | Avg<br>dBuV/m | Pk Lim<br>dBuV/m | Avg Lim<br>dBuV/m | Pk Mar<br>dB                 | Avg Mar<br>dB | Notes<br>(V/H)                                                                   |  |  |
| Low Channel - 2402MHz                                 |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| 4.804                                                 | 3.0                   | 42.8            | 28.6                  | 33.1       | 6.8      | -34.1                  | 0.0                            | 0.0        | 48.6           | 34.4          | 74               | 54                | -25.4                        | -19.6         | V                                                                                |  |  |
| 4.804                                                 | 3.0                   | 41.6            | 27.5                  | 33.1       | 6.8      | -34.1                  | 0.0                            | 0.0        | 47.4           | 33.3          | 74               | 54                | -26.6                        | -20.7         | H                                                                                |  |  |
| Mid Channel - 2440MHz                                 |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| 4.880                                                 | 3.0                   | 40.3            | 27.7                  | 33.2       | 6.8      | -34.0                  | 0.0                            | 0.0        | 46.2           | 33.6          | 74               | 54                | -27.8                        | -20.4         | V                                                                                |  |  |
| 7.320                                                 | 3.0                   | 41.8            | 28.3                  | 36.3       | 9.1      | -33.1                  | 0.0                            | 0.0        | 54.1           | 40.6          | 74               | 54                | -19.9                        | -13.4         | V                                                                                |  |  |
| 4.880                                                 | 3.0                   | 40.1            | 27.6                  | 33.2       | 6.8      | -34.0                  | 0.0                            | 0.0        | 46.0           | 33.5          | 74               | 54                | -28.0                        | -20.5         | H                                                                                |  |  |
| 7.320                                                 | 3.0                   | 40.7            | 28.2                  | 36.3       | 9.1      | -33.1                  | 0.0                            | 0.0        | 53.0           | 40.5          | 74               | 54                | -21.0                        | -13.5         | H                                                                                |  |  |
| High Channel - 2480MHz                                |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| 4.960                                                 | 3.0                   | 39.2            | 27.3                  | 33.2       | 6.9      | -34.0                  | 0.0                            | 0.0        | 45.2           | 33.4          | 74               | 54                | -28.8                        | -20.6         | V                                                                                |  |  |
| 7.440                                                 | 3.0                   | 40.4            | 28.3                  | 36.5       | 9.1      | -33.0                  | 0.0                            | 0.0        | 52.9           | 40.9          | 74               | 54                | -21.1                        | -13.1         | V                                                                                |  |  |
| 4.960                                                 | 3.0                   | 41.1            | 27.3                  | 33.2       | 6.9      | -34.0                  | 0.0                            | 0.0        | 47.1           | 33.3          | 74               | 54                | -26.9                        | -20.7         | H                                                                                |  |  |
| 7.440                                                 | 3.0                   | 40.8            | 28.3                  | 36.5       | 9.1      | -33.0                  | 0.0                            | 0.0        | 53.3           | 40.8          | 74               | 54                | -20.7                        | -13.2         | H                                                                                |  |  |
| Rev. 07.08.11                                         |                       |                 |                       |            |          |                        |                                |            |                |               |                  |                   |                              |               |                                                                                  |  |  |
| f                                                     | Measurement Frequency |                 |                       |            |          | Amp                    | Preamp Gain                    |            |                |               |                  | Avg Lim           | Average Field Strength Limit |               |                                                                                  |  |  |
| Dist                                                  | Distance to Antenna   |                 |                       |            |          | D Corr                 | Distance Correct to 3 meters   |            |                |               |                  | Pk Lim            | Peak Field Strength Limit    |               |                                                                                  |  |  |
| Read                                                  | Analyzer Reading      |                 |                       |            |          | Avg                    | Average Field Strength @ 3 m   |            |                |               |                  | Avg Mar           | Margin vs. Average Limit     |               |                                                                                  |  |  |
| AF                                                    | Antenna Factor        |                 |                       |            |          | Peak                   | Calculated Peak Field Strength |            |                |               |                  | Pk Mar            | Margin vs. Peak Limit        |               |                                                                                  |  |  |
| CL                                                    | Cable Loss            |                 |                       |            |          | HPF                    | High Pass Filter               |            |                |               |                  |                   |                              |               |                                                                                  |  |  |

### 8.3. RX SPURIOUS ABOVE 1 GHz

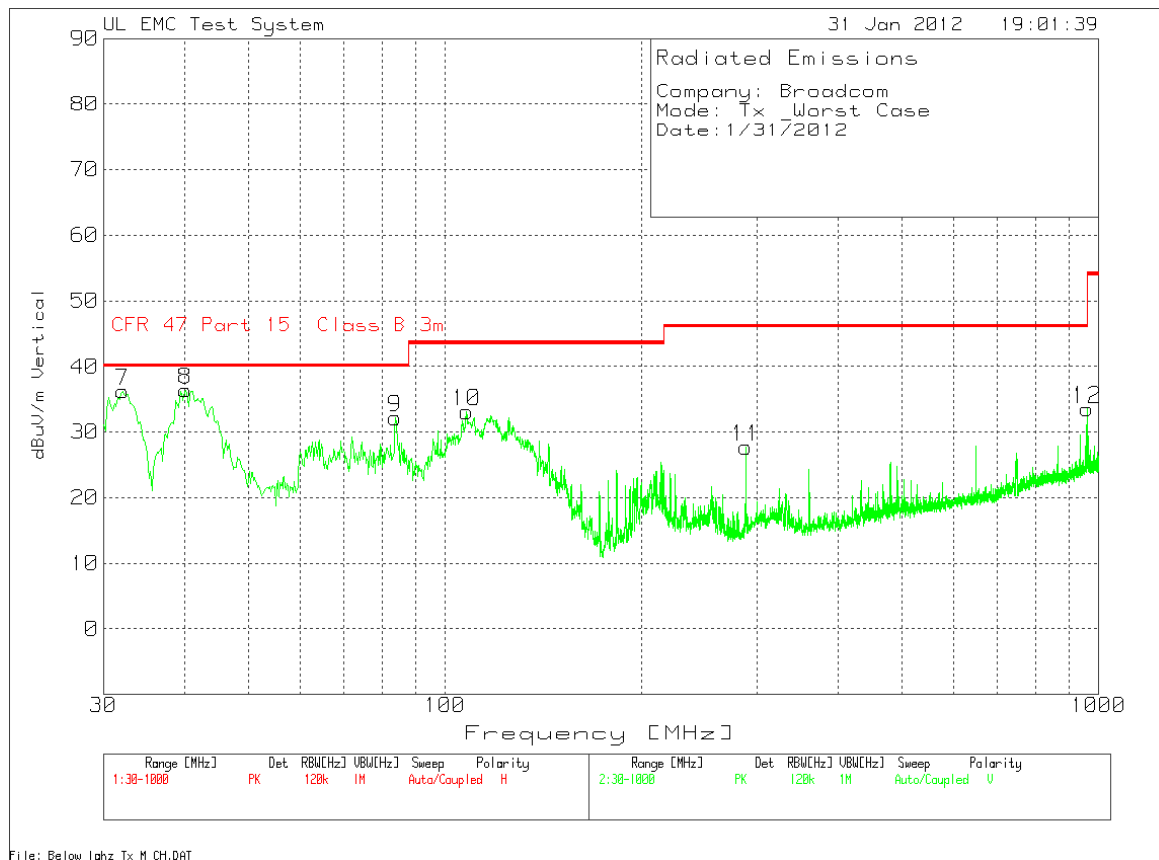
| High Frequency Measurement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                 |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|-----------------------|----------|-----------|--------------------------------|------------------------|----------------|---------------|------------------|-------------------|------------------------------|---------------|----------------|------------|--|
| Compliance Certification Services, Fremont 3m Chamber                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                 |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Company:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | Broadcom        |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Project #:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 11U14154        |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Date:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 1/31/2012       |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Test Engineer:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | Dennis Huang    |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Configuration:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | FCC 15.247      |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Mode:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | Rx_Worst-Case   |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| <b>Test Equipment:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       |                 |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| Horn 1-18GHz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       |                 |                   | Pre-amplifier 1-26GHz |          |           |                                | Pre-amplifier 26-40GHz |                |               |                  | Horn > 18GHz      |                              |               |                | Limit      |  |
| T60; S/N: 2238 @3m                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                 |                   | T34 HP 8449B          |          |           |                                |                        |                |               |                  |                   |                              |               |                | RX RSS 210 |  |
| <div style="display: flex; justify-content: space-between;"> <div> <b>3' cable 22807700</b><br/>           3' cable 22807700         </div> <div> <b>12' cable 22807600</b><br/>           12' cable 22807600         </div> <div> <b>20' cable 22807500</b><br/>           20' cable 22807500         </div> <div> <b>HPF</b><br/>           [ ]         </div> <div> <b>Reject Filter</b><br/>           [ ]         </div> <div> <b>Peak Measurements</b><br/>           RBW=VBW=1MHz<br/> <b>Average Measurements</b><br/>           RBW=1MHz ; VBW=10Hz         </div> </div> |                       |                 |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| f<br>GHz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Dist<br>(m)           | Read Pk<br>dBuV | Read Avg.<br>dBuV | AF<br>dB/m            | CL<br>dB | Amp<br>dB | D Corr<br>dB                   | Ftr<br>dB              | Peak<br>dBuV/m | Avg<br>dBuV/m | Pk Lim<br>dBuV/m | Avg Lim<br>dBuV/m | Pk Mar<br>dB                 | Avg Mar<br>dB | Notes<br>(V/H) |            |  |
| 1.226                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3.0                   | 51.1            | 39.0              | 25.6                  | 3.1      | -37.5     | 0.0                            | 0.0                    | 42.3           | 30.2          | 74               | 54                | -31.7                        | -23.8         | V              |            |  |
| 1.900                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3.0                   | 46.2            | 31.6              | 27.7                  | 3.9      | -36.5     | 0.0                            | 0.0                    | 41.3           | 26.7          | 74               | 54                | -32.7                        | -27.3         | V              |            |  |
| 1.226                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3.0                   | 46.4            | 33.8              | 25.6                  | 3.1      | -37.5     | 0.0                            | 0.0                    | 37.6           | 25.0          | 74               | 54                | -36.4                        | -29.0         | H              |            |  |
| 1.900                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3.0                   | 44.5            | 30.4              | 27.7                  | 3.9      | -36.5     | 0.0                            | 0.0                    | 39.6           | 25.5          | 74               | 54                | -34.4                        | -28.5         | H              |            |  |
| Rev. 07.08.11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                 |                   |                       |          |           |                                |                        |                |               |                  |                   |                              |               |                |            |  |
| f                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Measurement Frequency |                 |                   |                       |          | Amp       | Preamp Gain                    |                        |                |               |                  | Avg Lim           | Average Field Strength Limit |               |                |            |  |
| Dist                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Distance to Antenna   |                 |                   |                       |          | D Corr    | Distance Correct to 3 meters   |                        |                |               |                  | Pk Lim            | Peak Field Strength Limit    |               |                |            |  |
| Read                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Analyzer Reading      |                 |                   |                       |          | Avg       | Average Field Strength @ 3 m   |                        |                |               |                  | Avg Mar           | Margin vs. Average Limit     |               |                |            |  |
| AF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Antenna Factor        |                 |                   |                       |          | Peak      | Calculated Peak Field Strength |                        |                |               |                  | Pk Mar            | Margin vs. Peak Limit        |               |                |            |  |
| CL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Cable Loss            |                 |                   |                       |          | HPF       | High Pass Filter               |                        |                |               |                  |                   |                              |               |                |            |  |

## 8.4. WORST-CASE BELOW 1 GHz

### SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, HORIZONTAL & VERTICAL)



# VERTICAL PLOT



## HORIZONTAL AND VERTICAL DATA

### 30-1000MHz Frequency Measurement

Compliance Certification Services, Fremont 5m Chamber

Test Engr: Dennis Huang  
Date: 01/31/11  
Project #: 11U14154  
Company: Broadcom  
Test Target: FCC Class B  
Mode Oper: Tx (Worst Case)

|      |                    |        |                              |        |                  |
|------|--------------------|--------|------------------------------|--------|------------------|
| f    | Measurement Freq   | Amp    | Preamp Gain                  | Margin | Margin vs. Limit |
| Dist | Distance to Antenn | D Corr | Distance Correct to 3 meters |        |                  |
| Read | Analyzer Reading   | Filter | Filter Insert Loss           |        |                  |
| AF   | Antenna Factor     | Corr.  | Calculated Field Strength    |        |                  |
| CL   | Cable Loss         | Limit  | Field Strength Limit         |        |                  |

| f<br>MHz | Dist<br>(m) | Read<br>dBuV | AF<br>dB/m | Amp and CL<br>dB | D Corr<br>dB | Pad<br>dB | Corr.<br>dBuV/m | Limit<br>dBuV/m | Margin<br>dB | Ant. Pol.<br>V/H | Det.<br>P/A/QP | Notes |
|----------|-------------|--------------|------------|------------------|--------------|-----------|-----------------|-----------------|--------------|------------------|----------------|-------|
| 31.94    | 3.0         | 37.8         | 19.5       | 29.3             | 0.0          | 0.0       | 28.0            | 40.0            | -12.0        | H                | P              |       |
| 83.89    | 3.0         | 55.8         | 7.6        | 28.7             | 0.0          | 0.0       | 34.7            | 40.0            | -5.3         | H                | P              |       |
| 95.91    | 3.0         | 51.7         | 9          | 28.6             | 0.0          | 0.0       | 32.1            | 43.5            | -11.4        | H                | P              |       |
| 143.98   | 3.0         | 48.9         | 13         | 28.1             | 0.0          | 0.0       | 33.8            | 43.5            | -9.7         | H                | P              |       |
| 206.21   | 3.0         | 47.1         | 12         | 27.5             | 0.0          | 0.0       | 31.6            | 43.5            | -11.9        | H                | P              |       |
| 492.13   | 3.0         | 39.1         | 16.7       | 27               | 0.0          | 0.0       | 28.8            | 46.0            | -17.2        | H                | P              |       |
| 32.13    | 3.0         | 46.1         | 19.4       | 29.2             | 0.0          | 0.0       | 36.3            | 40.0            | -3.7         | V                | P              |       |
| 40.08    | 3.0         | 51.6         | 14         | 29.2             | 0.0          | 0.0       | 36.4            | 40.0            | -3.6         | V                | P              |       |
| 83.89    | 3.0         | 53.3         | 7.6        | 28.7             | 0.0          | 0.0       | 32.2            | 40.0            | -7.8         | V                | P              |       |
| 107.93   | 3.0         | 50.1         | 11.5       | 28.5             | 0.0          | 0.0       | 33.1            | 43.5            | -10.4        | V                | P              |       |
| 288.59   | 3.0         | 41.7         | 12.9       | 26.9             | 0.0          | 0.0       | 27.7            | 46.0            | -18.3        | V                | P              |       |
| 960.07   | 3.0         | 35.6         | 22.2       | 24.3             | 0.0          | 0.0       | 33.5            | 54.0            | -20.5        | V                | P              |       |

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Note: No other emissions were detected above the system noise floor.

## 8.5. AC POWER LINE CONDUCTED EMISSIONS

### LIMITS

FCC §15.207 (a)

RSS-Gen 7.2.2

| Frequency of Emission (MHz) | Conducted Limit (dBuV) |                       |
|-----------------------------|------------------------|-----------------------|
|                             | Quasi-peak             | Average               |
| 0.15-0.5                    | 66 to 56 <sup>*</sup>  | 56 to 46 <sup>*</sup> |
| 0.5-5                       | 56                     | 46                    |
| 5-30                        | 60                     | 50                    |

<sup>\*</sup> Decreases with the logarithm of the frequency.

### TEST PROCEDURE

The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

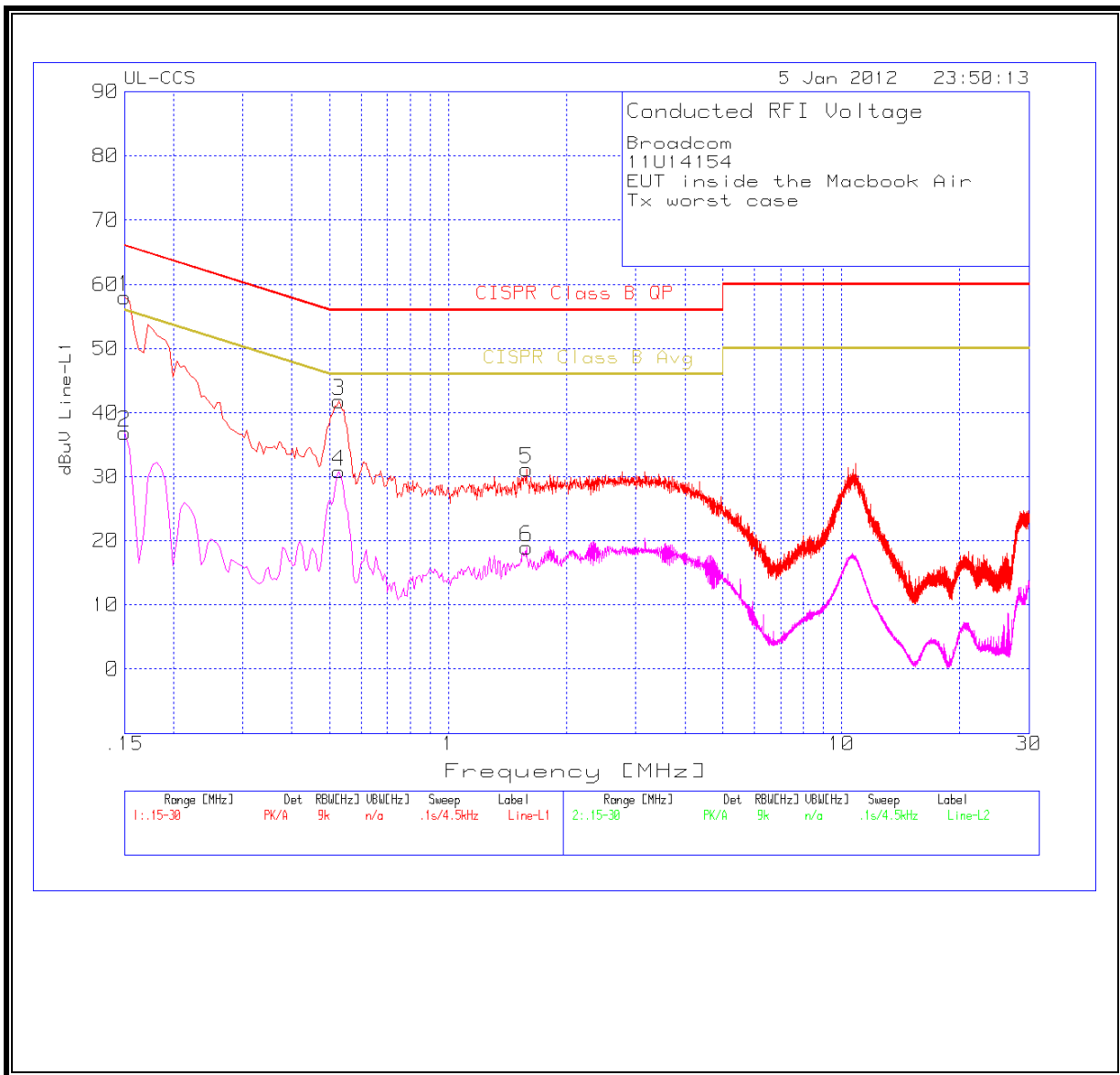
Line conducted data is recorded for both NEUTRAL and HOT lines.

## RESULTS

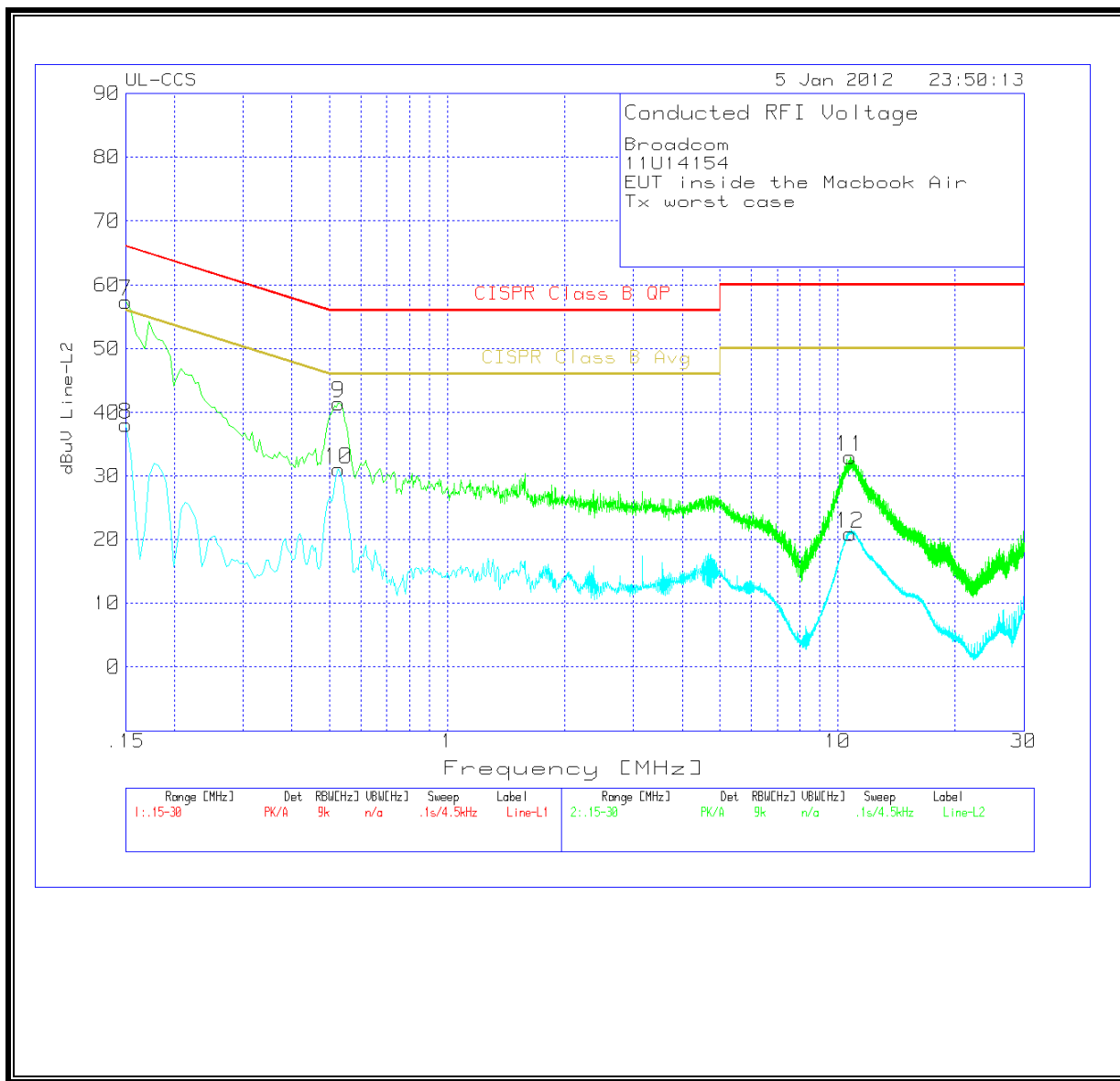
### 6 WORST EMISSIONS

| Broadcom                   |         |          |             |           |       |            |        |             |        |
|----------------------------|---------|----------|-------------|-----------|-------|------------|--------|-------------|--------|
| 11U14154                   |         |          |             |           |       |            |        |             |        |
| EUT inside the Macbook Air |         |          |             |           |       |            |        |             |        |
| Tx worst case              |         |          |             |           |       |            |        |             |        |
| Line-L1 .15 - 30MHz        |         |          |             |           |       |            |        |             |        |
| Test                       | Meter   | Detector | T24 IL      | LC Cables | dBuV  | CISPR      | Margin | CISPR Class | Margin |
| Frequency                  | Reading |          | L1.TXT [dB] |           |       | Class B QP |        | B Avg       |        |
| 0.15                       | 57.88   | PK       | 0.1         | 0         | 57.98 | 66         | -8.02  | -           | -      |
| 0.15                       | 36.86   | Av       | 0.1         | 0         | 36.96 | -          | -      | 56          | -19.04 |
| 0.528                      | 41.72   | PK       | 0.1         | 0         | 41.82 | 56         | -14.18 | -           | -      |
| 0.528                      | 30.73   | Av       | 0.1         | 0         | 30.83 | -          | -      | 46          | -15.17 |
| 1.581                      | 31.05   | PK       | 0.1         | 0.1       | 31.25 | 56         | -24.75 | -           | -      |
| 1.581                      | 18.77   | Av       | 0.1         | 0.1       | 18.97 | -          | -      | 46          | -27.03 |
| Line-L2 .15 - 30MHz        |         |          |             |           |       |            |        |             |        |
| Test                       | Meter   | Detector | T24 IL      | LC Cables | dBuV  | CISPR      | Margin | CISPR Class | Margin |
| Frequency                  | Reading |          | L1.TXT [dB] |           |       | Class B QP |        | B Avg       |        |
| 0.15                       | 57.24   | PK       | 0.1         | 0         | 57.34 | 66         | -8.66  | -           | -      |
| 0.15                       | 38.03   | Av       | 0.1         | 0         | 38.13 | -          | -      | 56          | -17.87 |
| 0.528                      | 41.41   | PK       | 0.1         | 0         | 41.51 | 56         | -14.49 | -           | -      |
| 0.528                      | 31.06   | Av       | 0.1         | 0         | 31.16 | -          | -      | 46          | -14.84 |
| 10.7475                    | 32.65   | PK       | 0.2         | 0.2       | 33.05 | 60         | -26.95 | -           | -      |
| 10.7475                    | 20.46   | Av       | 0.2         | 0.2       | 20.86 | -          | -      | 50          | -29.14 |

**LINE 1 RESULTS**



**LINE 2 RESULTS**



## 9. MAXIMUM PERMISSIBLE EXPOSURE

### FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

| Frequency range (MHz)                                   | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|---------------------------------------------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| (A) Limits for Occupational/Controlled Exposures        |                               |                               |                                     |                          |
| 0.3–3.0 .....                                           | 614                           | 1.63                          | *(100)                              | 6                        |
| 3.0–30 .....                                            | 1842/f                        | 4.89/f                        | *(900/f <sup>2</sup> )              | 6                        |
| 30–300 .....                                            | 61.4                          | 0.163                         | 1.0                                 | 6                        |
| 300–1500 .....                                          | .....                         | .....                         | f/300                               | 6                        |
| 1500–100,000 .....                                      | .....                         | .....                         | 5                                   | 6                        |
| (B) Limits for General Population/Uncontrolled Exposure |                               |                               |                                     |                          |
| 0.3–1.34 .....                                          | 614                           | 1.63                          | *(100)                              | 30                       |
| 1.34–30 .....                                           | 824/f                         | 2.19/f                        | *(180/f <sup>2</sup> )              | 30                       |

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|-----------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| 30–300 .....          | 27.5                          | 0.073                         | 0.2                                 | 30                       |
| 300–1500 .....        | .....                         | .....                         | f/1500                              | 30                       |
| 1500–100,000 .....    | .....                         | .....                         | 1.0                                 | 30                       |

f = frequency in MHz

\* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

## IC RULES

IC Safety Code 6, Section 2.2.1 (a) A person other than an RF and microwave exposed worker shall not be exposed to electromagnetic radiation in a frequency band listed in Column 1 of Table 5, if the field strength exceeds the value given in Column 2 or 3 of Table 5, when averaged spatially and over time, or if the power density exceeds the value given in Column 4 of Table 5, when averaged spatially and over time.

**Table 5**  
**Exposure Limits for Persons Not Classed As RF and Microwave Exposed Workers (Including the General Public)**

| 1<br>Frequency<br>(MHz) | 2<br>Electric Field<br>Strength; rms<br>(V/m) | 3<br>Magnetic Field<br>Strength; rms<br>(A/m) | 4<br>Power<br>Density<br>(W/m <sup>2</sup> ) | 5<br>Averaging<br>Time<br>(min) |
|-------------------------|-----------------------------------------------|-----------------------------------------------|----------------------------------------------|---------------------------------|
| 0.003–1                 | 280                                           | 2.19                                          |                                              | 6                               |
| 1–10                    | 280/ $f$                                      | 2.19/ $f$                                     |                                              | 6                               |
| 10–30                   | 28                                            | 2.19/ $f$                                     |                                              | 6                               |
| 30–300                  | 28                                            | 0.073                                         | 2*                                           | 6                               |
| 300–1 500               | 1.585 $f^{0.5}$                               | 0.0042 $f^{0.5}$                              | $f/150$                                      | 6                               |
| 1 500–15 000            | 61.4                                          | 0.163                                         | 10                                           | 6                               |
| 15 000–150 000          | 61.4                                          | 0.163                                         | 10                                           | 616 000 / $f^{1.2}$             |
| 150 000–300 000         | 0.158 $f^{0.5}$                               | 4.21 x 10 <sup>-4</sup> $f^{0.5}$             | 6.67 x 10 <sup>-5</sup> $f$                  | 616 000 / $f^{1.2}$             |

\* Power density limit is applicable at frequencies greater than 100 MHz.

- Notes:**
1. Frequency,  $f$ , is in MHz.
  2. A power density of 10 W/m<sup>2</sup> is equivalent to 1 mW/cm<sup>2</sup>.
  3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla (μT) or 12.57 milligauss (mG).

## EQUATIONS

Power density is given by:

$$S = \text{EIRP} / (4 * \text{Pi} * D^2)$$

where

S = Power density in W/m<sup>2</sup>

EIRP = Equivalent Isotropic Radiated Power in W

D = Separation distance in m

Power density in units of W/m<sup>2</sup> is converted to units of mW/cm<sup>2</sup> by dividing by 10.

Distance is given by:

$$D = \text{SQRT} (\text{EIRP} / (4 * \text{Pi} * S))$$

where

D = Separation distance in m

EIRP = Equivalent Isotropic Radiated Power in W

S = Power density in W/m<sup>2</sup>

For multiple collocated transmitters operating simultaneously in frequency bands where the limit is identical, the total power density is calculated using the total EIRP obtained by summing the Power \* Gain product (in linear units) of each transmitter.

$$\text{Total EIRP} = (P1 * G1) + (P2 * G2) + \dots + (Pn * Gn)$$

where

Px = Power of transmitter x

Gx = Numeric gain of antenna x

In the table(s) below, Power and Gain are entered in units of dBm and dBi respectively and conversions to linear forms are used for the calculations.

## LIMITS

From FCC §1.1310 Table 1 (B), the maximum value of S = 1.0 mW/cm<sup>2</sup>

From IC Safety Code 6, Section 2.2 Table 5 Column 4, S = 10 W/m<sup>2</sup>

## RESULTS

| Band    | Mode      | Separation Distance (m) | Output AV Power (dBm) | Antenna Gain (dBi) | IC Power Density (W/m <sup>2</sup> ) | FCC Power Density (mW/cm <sup>2</sup> ) |
|---------|-----------|-------------------------|-----------------------|--------------------|--------------------------------------|-----------------------------------------|
| 2.4 GHz | Bluetooth | 0.20                    | 6.87                  | 4.97               | 0.0304                               | 0.0030                                  |