1601 North A.W. Grimes Blvd., Suite B
Round Rock, TX 78665
e-mail: info@ptitest.com
(512) 244-3371 Fax: (512) 244-1846

May 16, 2011

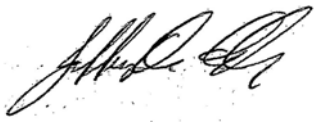
Tom Kennedy
EnergyHub, Inc.
232 3rd Street, Suite C201
Brooklyn, NY 11215

Dear Tom:

Enclosed is the Wireless Test Report for the Zigbee Daughter Card by EnergyHub, Inc. This report can be used to demonstrate compliance with FCC and IC requirements for wireless devices in the United States and Canada.

If you have any questions, please contact me.

Sincerely,



Jeffrey A. Lenk
President

Enclosure

Project 12147-10

# EnergyHub, Inc.
# Zigbee Daughter Card

# Wireless Certification Report

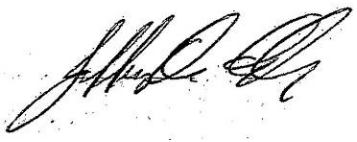
Prepared for:
EnergyHub, Inc.
232 3rd Street, Suite C201
Brooklyn, NY 11215

By

Professional Testing (EMI), Inc.
1601 N. A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

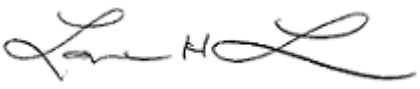
May 5, 2011
Revised May 16, 2011

Reviewed by



Jeffrey A. Lenk
President

Written by



Layne Lueckemeyer
Product Development Engineer

**Table of Contents**

| | |
|---|---|
| Applicant: | EnergyHub, Inc. |
| Applicant's Address: | 232 3rd Street, Suite C201<br>Brooklyn, NY 11215 |
| FCC ID: | ZANEHZPA20 |
| IC Identifier: | 9603A-EHZPA20 |
| Project Number: | 12147-10 |
| Test Dates: | February 23, March 15, and 23, 2011 |

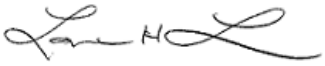
The **EnergyHub Zigbee Daughter Card** was tested to and found to be in compliance with FCC 47 CFR Part 15 and IC RSS-210 issue 8.

The highest emissions generated by the above equipment are listed below:

| Parameter | Frequency (MHz) | Level | Limit | Margin (dB) |
|---|---|---|---|---|
| Transmitter: Output Power @ 1 m | 2405 | -11.13 dBm @ 1 m | 30 dBm | -41.13 |
| Transmitter: Radiated Spurious | 4960 | 62.8 dBµV/m @ 1 m | 63.5 dBµV/m | -1.7 |
| Receiver: Radiated Spurious | 127.6 | 21.2 dBuV/m @ 10m | 33.0 dBuV/m | -11.8 |
| Transmitter: Mains Conducted | .34202 | 55.8 dBuV | 55.2 dBuV | -3.4 |

| Occupied Bandwidth | | |
|---|---|---|
| **6 dB** | **20 dB** | **26 dB** |
| 1.603 MHz | 2.804 MHz | 4.343 MHz |

I, Layne Lueckemeyer, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.



Layne Lueckemeyer
Product Development Engineer

This report has been reviewed and accepted by EnergyHub, Inc. The undersigned is responsible for ensuring that this device will continue to comply with the FCC and IC rules.

_____

Representative of EnergyHub, Inc.

# 1.0 Introduction

## 1.1 Scope

This report describes the extent of the equipment under test (EUT) conformance to the intentional radiator requirements of the United States and Canada.

Professional Testing (EMI), Inc. (PTI), follows the guidelines of NIST for all uncertainty calculations, estimates, and expressions thereof for EMC testing. The procedure of ANSI C63.4: 2009 were utilized for making all emissions measurements.

## 1.2 EUT Description

The Zigbee Daughter Card is a self-contained transceiver module that is used in the EnergyHub devices that communicate over Zigbee. The device is intended to be installed into other EnergyHub devices. These devices will then use the Communication Daughter Card to form a Zigbee network and communicate back to the HomeBase, which is the central network coordinator also made by EnergyHub.

The EUT was tested while in a continuous transmit mode. The EUT was tuned to a low, middle, and high channel to perform power, occupied bandwidth, and harmonic tests. The EUT was tuned to a middle channel to perform spurious tests. The EUT continuously transmitted at maximum power. The system tested consisted of the following:

| Manufacturer | Model | FCC ID Number | IC Identifier |
|---|---|---|---|
| EnergyHub, Inc. | Zigbee Daughter Card | ZANEHZPA20 | 9603A-EHZPA20 |

The following rules apply to the operation of the EUT:

| Guidelines | FCC Rules | IC Rules | |
|---|---|---|---|
| | Part 15 | RSS-GEN Issue 3 | RSS-210 Issue 8 |
| Transmitter Characteristics | 15.247 | 4.1-4.6, 7 | 2.2, 2.6-2.7, A2.9, A8, A9 |
| Spurious Radiated Power | 15.209 | 4.2, 4.7, 4.8, 6, 7 | 2.2, 2.6-2.7, A2.9, A8, A9 |
| Antenna Requirement | 15.203 | 7.1, 7.1.4 | |

## 1.3 Modifications

No modifications were made to the EUT during the performance of the test program.

## 1.4 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. This site is registered with the FCC under Section 2.948 and Industry Canada per RS-212, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas, 78758, while the main office is located at 1601 N. A.W. Grimes Blvd., Suite B, Round Rock, Texas, 78665.

## 1.5 Applicable Documents

| Document | Title | Release |
|---|---|---|
| ANSI C63.4 | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment | 2009 |
| ANSI C63.10 | American National Standard for Testing Unlicensed Wireless Devices | 2009 |
| 47 CFR | Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators | |
| RSS-210 | Low-power License-exempt Radio communication Devices (All Frequency Bands): Category I Equipment | Issue 8 |
| RSS-Gen | General Requirements and Information for the Certification of Radio Communication Equipment | Issue 3 |
| KDB Publication No. 558074 | Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) | 2007 |

# 2.0 Conducted Emissions Mains Terminal Measurements

Conducted emissions measurements were made on the mains terminals of the EUT to determine the line-to-ground radio noise emitted from each power-input terminal. Conducted emissions measurements on the mains terminals were performed at Professional Testing, located in Austin, Texas.

## 2.1 Test Procedure

The EUT was configured and operated in a manner consistent with typical applications. The EUT power cord in excess of one meter was folded back and forth forming a bundle 30 to 40 cm long in the approximate center of the cable. Power supply cords for the peripheral equipment were powered from an auxiliary line impedance stabilization network (LISN). Excess interface cable lengths were separately bundled in a non-inductive arrangement at the approximate center of the cable with the bundle 30 to 40 centimeters in length. The conducted emissions were maximized by varying the operating states and configuration of the EUT. The tests were performed in a RayProof modular shielded room.

The EUT was placed on a non-metallic table 0.4 meters from a vertical metal reference plane and 0.8 meters from a horizontal metal reference plane. The measurements were taken using a LISN. A spectrum analyzer with a measurement bandwidth of 9 kHz was used to record the conducted emissions measurements. The configuration of the shielded room showing the location of the EUT and the measurement equipment is given as Figure 2.1.1.1.

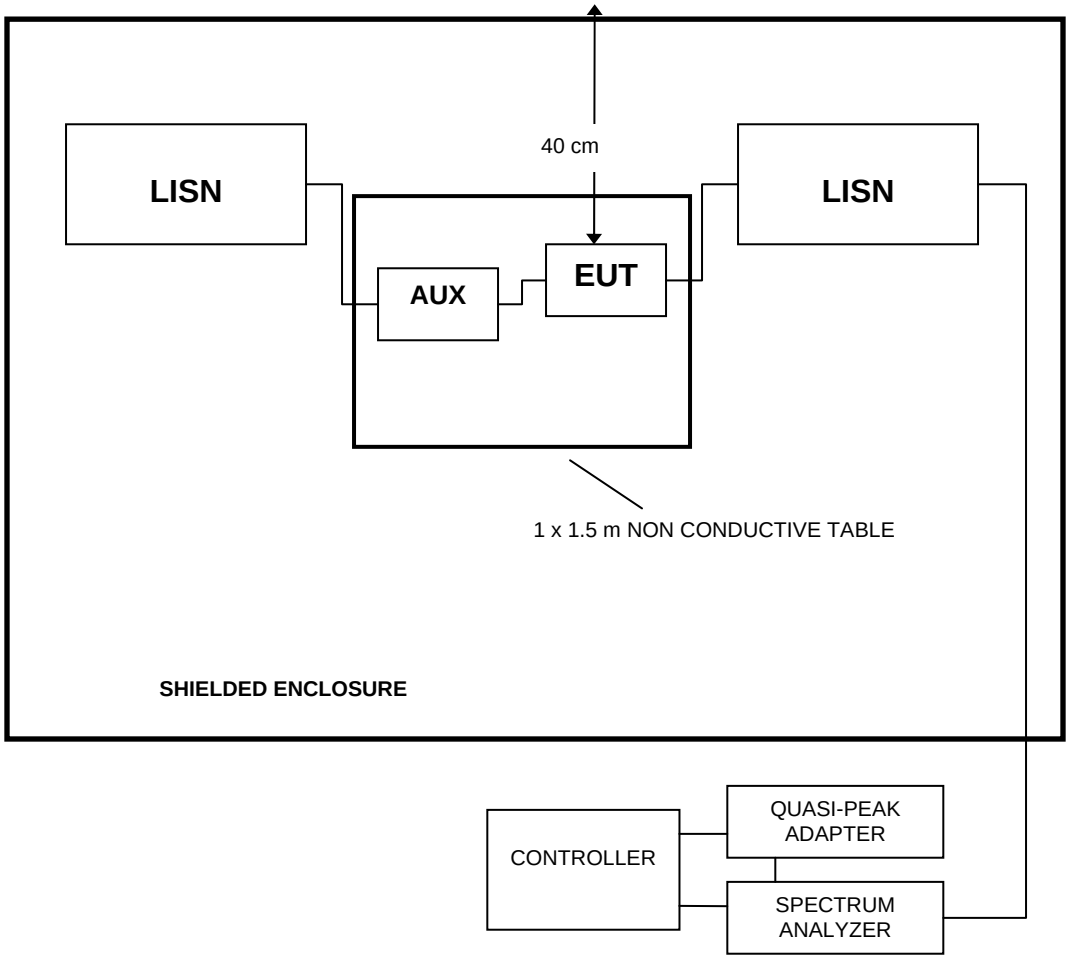



**Figure 2.1.1.1: Conducted Emissions Main Terminal Test Setup**

## 2.2 Test Criteria

The 47 CFR Part 15, Section 15.107 Class B conducted emissions limits are given below.

| Frequency (MHz) | Maximum RF Line Voltage dB(μV) | |
|---|---|---|
| | Quasi-Peak | Average |
| 0.15 to 0.50 | 66 to 56 | 56 to 46* |
| 0.50 to 5.0 | 56 | 46 |
| 5.0 to 30.0 | 60 | 50 |

*The lower limit shall apply at the transition frequency. Decreases with the logarithm of the frequency.

## 2.3 Test Results

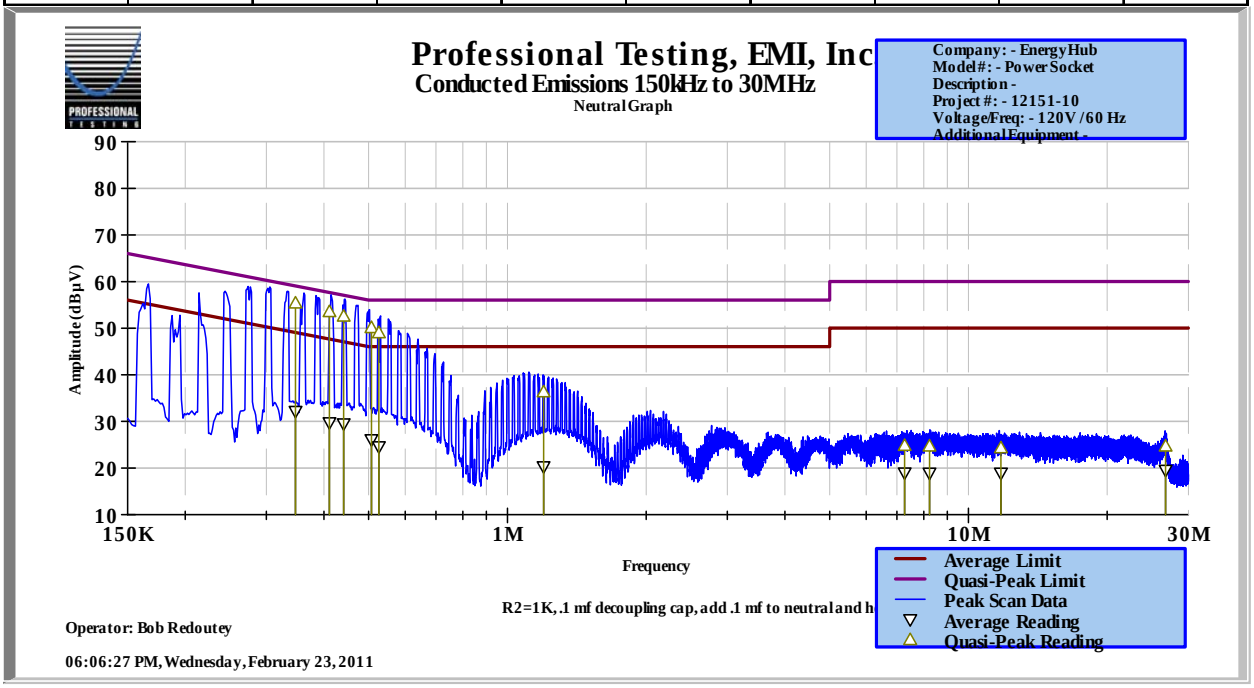
The conducted emissions generated by the EUT as measured on the mains terminals were found to be below 47 CFR Part 15, Section 15.107 Class B maximum emissions criteria.

**Table 2.3.1: Conducted Emissions Test Equipment**

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| 1129 | HP | 8568B | Spectrum Analyzer 100 Hz-1.5 GHz | 2140A01754 |
| 1629 | HP | 85662A | Spec Anal Display for AN1129 | 3001A18433 |
| 1277 | HP | 85650A | Quasi Peak Adapter | 2811A01117 |
| 0027 | EMCO | 3825/2 | LISN, 10 kHz-100 MHz | 9010-1708 |
| 1173 | PTI | 100k HPF | Filter, High Pass, 100 kHz | none |
| 1088 | PTI | PTI-ALF4 | Attenuator Limiter Filter | none |
| C109 | HP | None | Cable, BNC, 19" | none |
| C107 | Pomona | RG-58 | Cable, BNC, 10.5' | none |
| C108 | Pomona | RG-223 | Cable, BNC, 5.5' | none |
| 935 | FCC | FCC-TLISN-T4 | TLISN-T4, 9 kHz-30 MHz, CISPR 22 | 20153 |
| 939 | EMCO | 3825/2 | LISN, 10 kHz-100 MHz | 9603-2521 |
| 1185 | EMCO | 3825/2 | LISN, 10 kHz-100 MHz | 1235 |

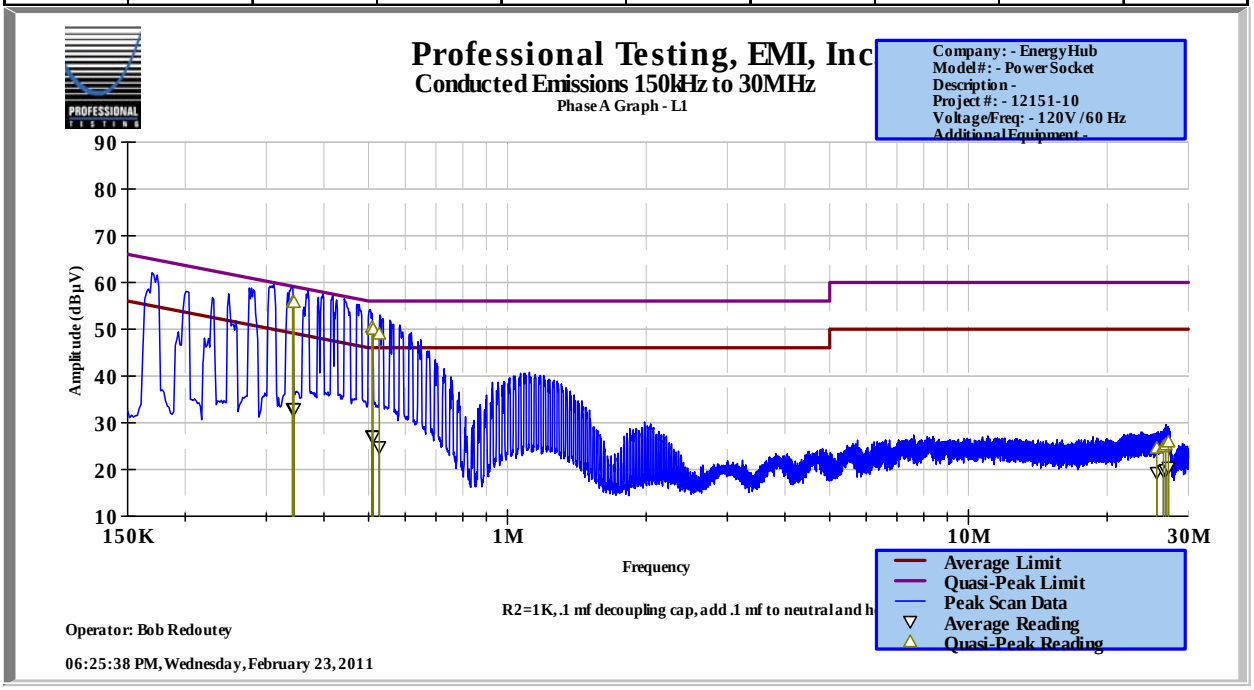
## Table 2.3.2 Conducted Emissions Mains Terminals Test Results – Neutral Lead

| Conducted Emissions Test Results Data Sheet - Neutral Lead | | | | | | | | Page: 1 of 2 | |
|---|---|---|---|---|---|---|---|---|---|
| EUT Line Voltage: | | | 120 VAC | | EUT Line Frequency: | | | 60 Hz | |
| Frequency Measured (MHz) | Peak Detector Reading (dBµV) | Quasi-peak Detector Reading (dBµV) | Quasi-peak Detector Limit (dBµV) | Quasi-peak Detector Margin (dB) | Quasi-peak Detector Test Results | Average Detector Reading (dBµV) | Average Detector Limit (dBµV) | Average Detector Margin (dB) | Average Detector Test Results |
| 0.34694 | 58.9 | 55.4 | 59 | -3.7 | PASS | 32.2 | 49 | -16.9 | PASS |
| 0.41108 | 57.3 | 53.5 | 57.6 | -4.1 | PASS | 29.7 | 47.6 | -17.9 | PASS |
| 0.44138 | 56.3 | 52.5 | 57 | -4.5 | PASS | 29.5 | 47 | -17.6 | PASS |
| 0.50688 | 54.1 | 50.1 | 56 | -5.9 | PASS | 26.1 | 46 | -19.9 | PASS |
| 0.5263 | 53.9 | 49 | 56 | -7 | PASS | 24.6 | 46 | -21.4 | PASS |
| 1.1979 | 41.4 | 36.3 | 56 | -19.7 | PASS | 20.3 | 46 | -25.7 | PASS |
| 7.2722 | 31.1 | 24.8 | 60 | -35.2 | PASS | 18.9 | 50 | -31.1 | PASS |
| 8.2342 | 31.2 | 24.7 | 60 | -35.3 | PASS | 18.9 | 50 | -31.1 | PASS |
| 11.7663 | 31.8 | 24.3 | 60 | -35.7 | PASS | 18.9 | 50 | -31.1 | PASS |
| 26.784 | 32 | 24.7 | 60 | -35.3 | PASS | 19.5 | 50 | -30.5 | PASS |



## Table 2.3.3 Conducted Emissions Mains Terminals Test Results – Phase Lead (Line 1)

| Conducted Emissions Test Results Data Sheet - Phase Lead (Line 1) | | | | | | Page: | 2 of 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| EUT Line Voltage: | | | 120 VAC | | EUT Line Frequency: | | | 60 Hz | |
| Frequency Measured (MHz) | Peak Detector Reading (dBµV) | Quasi-peak Detector Reading (dBµV) | Quasi-peak Detector Limit (dBµV) | Quasi-peak Detector Margin (dB) | Quasi-peak Detector Test Results | Average Detector Reading (dBµV) | Average Detector Limit (dBµV) | Average Detector Margin (dB) | Average Detector Test Results |
| 0.34202 | 59.1 | 55.8 | 59.2 | -3.4 | PASS | 33.1 | 49.2 | -16.1 | PASS |
| 0.34339 | 59.1 | 55.7 | 59.1 | -3.4 | PASS | 33 | 49.1 | -16.1 | PASS |
| 0.34429 | 59.1 | 55.7 | 59.1 | -3.4 | PASS | 33 | 49.1 | -16.1 | PASS |
| 0.5084 | 54.2 | 50.4 | 56 | -5.6 | PASS | 27.2 | 46 | -18.8 | PASS |
| 0.5111 | 54.2 | 50 | 56 | -6 | PASS | 27.1 | 46 | -18.9 | PASS |
| 0.5273 | 54.2 | 49 | 56 | -7 | PASS | 24.9 | 46 | -21.1 | PASS |
| 25.6096 | 32.2 | 24.5 | 60 | -35.5 | PASS | 19.4 | 50 | -30.6 | PASS |
| 26.5009 | 32 | 24.9 | 60 | -35.1 | PASS | 19.7 | 50 | -30.3 | PASS |
| 26.8018 | 32.4 | 25.3 | 60 | -34.7 | PASS | 20 | 50 | -30 | PASS |
| 27.1756 | 32.8 | 25.9 | 60 | -34.1 | PASS | 20.5 | 50 | -29.5 | PASS |



# 3.0 Output Power

Output power measurements were made on selected fundamental transmit frequencies of the EUT for the lowest, most center, and highest transmit frequency.

Tests of the fundamental emissions of the EUT also determined the worse case polarization of the device. The emissions of the device were measured with the EUT in three orthogonal axes.

## 3.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable, which allows 360-degree rotation. For measurements of the fundamental signal, a measurement antenna was positioned at a distance of 1 meter as measured from the closest point of the EUT. Rotating the EUT maximized the emissions.

A spectrum analyzer with peak detection was used to find the maximum field strength during the variability testing. Resolution bandwidth (RBW) is chosen to encompass the entire 6 dB bandwidth of the fundamental signal, up to 3 times the bandwidth if possible. RBW used is recorded. A calculation was then made to determine the output power at the antenna terminal. A diagram showing the test setup is given as Figure 2.1.1.

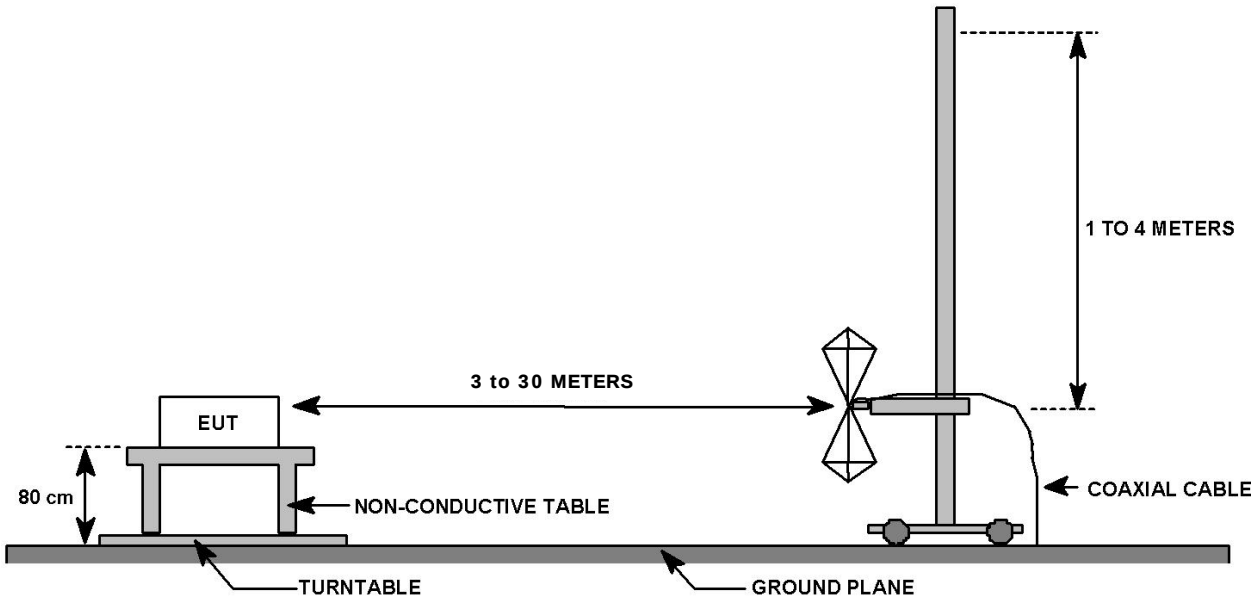



**Figure 3.1.1: Radiated Emission Test Setup**

## 3.2 Test Criteria

The maximum output power is 1 W for devices operating in the frequency range 2400 -2483.5 MHz according to FCC 15.247 and RSS-210.

## 3.3 Test Results

Radiated emission measurements of the output power level for the EUT were taken on March 15, 2011, and the EUT was found to be in compliance with applicable requirements.

**Table 3.3.1: Radiated Emissions Test Equipment**

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| 0085 | HP | 85650A | Quasi-peak Adapter (high band) | July 28, 2011 |
| 0949 | HP | 85662A | Spectrum Analyzer Display (high band) | NCR |
| 1841 | HP | 8566B | Spectrum Analyzer (high band) | June 8, 2011 |
| 0990 | HP | 85685A | RF Preselector (high band) | March 24, 2011 |
| 1281 | HP | 85650A | Quasi-peak Adapter (low band) | January 20, 2012 |
| 1834 | HP | 85662A | Spectrum Analyzer Display (low band) | NCR |
| 1145 | HP | 8568B | Spectrum Analyzer (low band) | July 28, 2011 |
| 1035 | HP | 85685A | RF Preselector (low band) | April 3, 2011 |
| 1454 | HP | 8447D | RF Preamplifier | July 06, 2011 |
| 1497 | Emco | 3108 | Biconical Antenna | August 4, 2011 |
| 1486 | Emco | 3147 | Log Periodic Dipole Array Antenna | August 4, 2011 |
| C026 | none | none | Coaxial Cable (low band) | August 02, 2011 |
| C027 | none | none | Coaxial Cable (high band) | August 02, 2011 |

**Table 3.3.2: Microwave Radiated Emissions Test Equipment**

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| 1780 | ETS-Lindgren | 3117 | Ridge Guide Antenna | November 11, 2011 |
| 1529 | Miteq | Antenna Mounted | Microwave Preamplifier (preamp 1) | July 16, 2011 |
| 1841 | HP | 8566B | Spectrum Analyzer | June 8, 2011 |
| 0949 | HP | 85662A | Spectrum Analyzer Display | NCR |
| 1530 | Miteq | None | Microwave Preamplifier (preamp 2) | July 16, 2011 |
| C030 | None | None | Coaxial Cable (MRE band) | March 22, 2011 |

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| XXXX | Pasternack | LLS | 2 sections, total 12ft | Cal Before Use |
| 0819 | EMCO | 3115 | Ridge Guide Antenna | October 15, 2011 |
| 0897 | Miteq | AFS44-00102650 | Microwave Preamplifier (preamp 1) | July 14, 2011 |
| (Rental unit) | Rohde & Schwarz | FSQ | Spectrum Analyzer | August 24, 2011 |
| 1542 | A.H. Systems | SAS 572 | Antenna, Horn 18-26.5GHz | NCR |

**Table 3.3.3: Output Power Test Results**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1m | Horn | 1 MHz | 1 MHz | Peak |
| **COMMENT** | **Transmitting** | | | | | | |

**Vertical Polarization**

| Frequency (MHz) | EUT Direction (degrees) | Antenna Elevation (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV /m) |
|---|---|---|---|---|---|---|---|
| 2405 | 0 | 1 | 86.2 | 26.4 | 29.0 | 2.8 | 91.6 |
| 2445 | 0 | 1 | 84.9 | 26.3 | 29.0 | 2.8 | 90.4 |
| 2480 | 0 | 1 | 85.6 | 26.4 | 29.0 | 2.8 | 91.0 |

## Calculations

$$P = \frac{(E * d)^2}{30 * G}$$

P=Power in watts, E=measured maximum field strength in V/m, d=distance in meters,
G=numeric gain of transmitting antenna

Distance=1 meters
Gain=0 dBi

**Calculated Result**

| Frequency (MHz) | Field Strength (dBµV) | E.I.R.P. | | Limit (dBm) |
|---|---|---|---|---|
| | | dBm | mW | |
| 2405 | 91.6 | -11.13 | 0.077 | 30 |
| 2445 | 90.4 | -12.33 | 0.058 | 30 |
| 2480 | 91.0 | -11.73 | 0.067 | 30 |

Note: Computed power by applying a bandwidth correction factor of 10 log (EBW/1 MHz) to the spectral peak of the emission.

Transmit Power: 10 log (1.60 MHz / 1 MHz) = 2.04
2.04 was added to the measured value to compute real power in mW

# 4.0 Occupied Bandwidth

Occupied bandwidth measurements were performed on the EUT to determine compliance with FCC 15.247 and RSS-210.

## 4.1 Test Procedure

The occupied bandwidth was measured with a spectrum analyzer connected to a double-ridged guide horn while the EUT was operating in continuous transmit mode at the appropriate center frequency. The analyzer center frequency was set to the EUT carrier frequency.

Display line and marker delta functions were used to measure the occupied bandwidth of the EUT. However, the 20 or 26 dB bandwidth is referenced to a peak power measurement taken at the entire bandwidth or more for RBW, then using 1% RBW for the 20 or 26 dB bandwidth. A diagram showing the test setup is given as Figure 3.1.1.

## 4.2 Test Criteria

The minimum 6 dB occupied bandwidth for the EUT is 500 kHz as stated in 15.247(a)(2) and RSS-210. The 20 dB bandwidth must be measured and reported for the FCC and the 26 dB bandwidth must be measured and reported for IC.

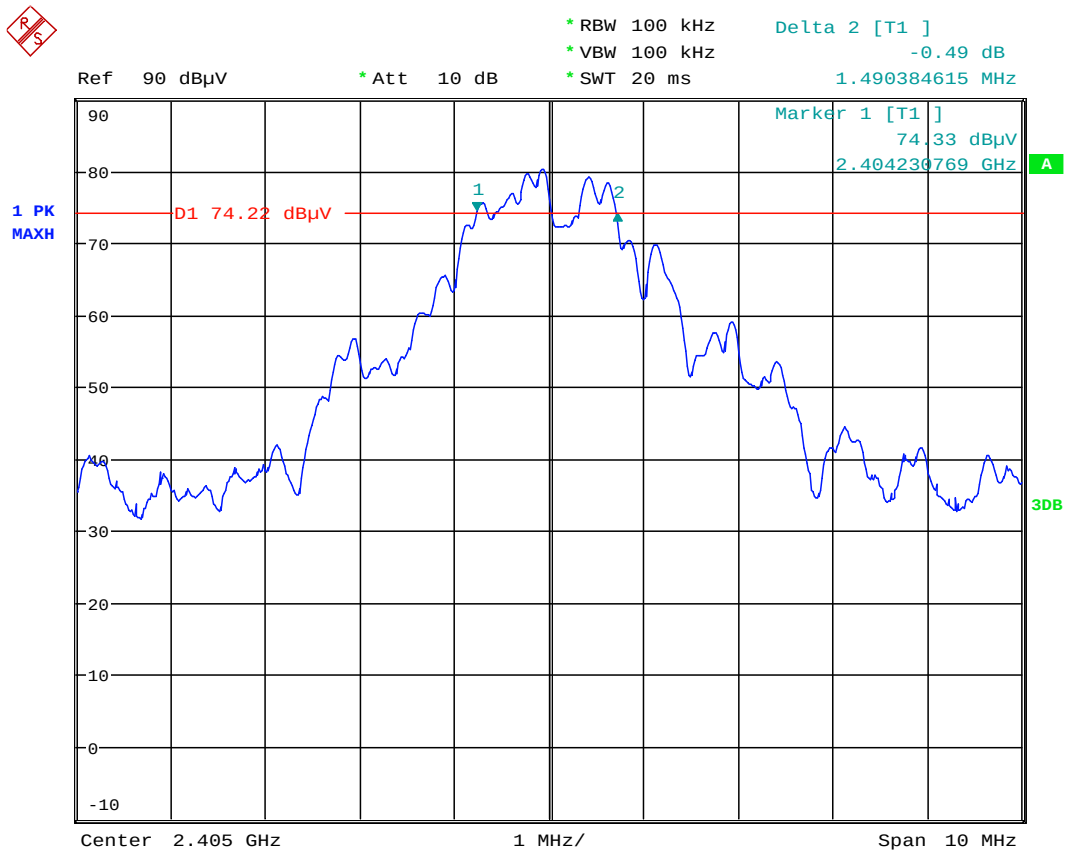
## 4.3 Test Results

Occupied bandwidth measurements were taken on March 15, and 23, 2011, and the EUT was found to be in compliance with applicable requirements. Test equipment used to perform this test is given in Tables 3.3.1 and 3.3.2.

**Table 4.3.1: Occupied Bandwidth Low Channel Test Results, Data Sheet 1**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Low Channel 6 dB Bandwidth – 1.490 MHz | | | | | | |

**6 dB**



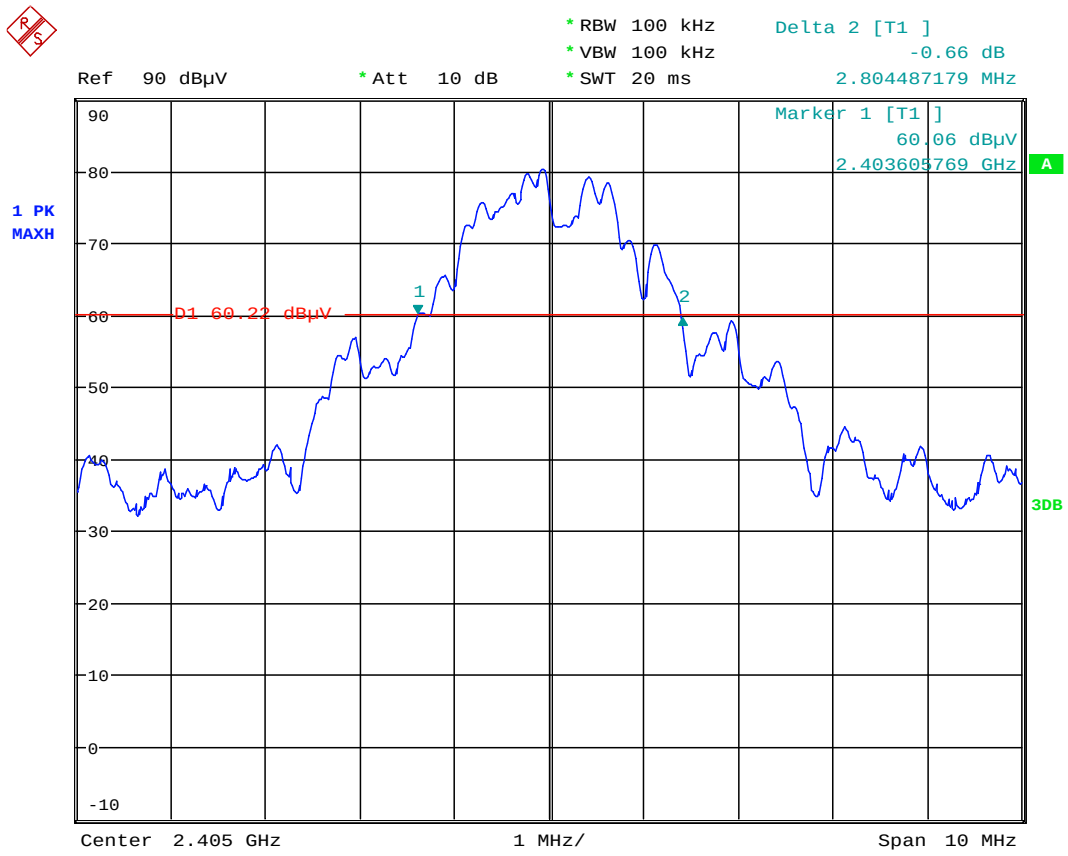

Date: 15.MAR.2011 19:47:44

**Result = Pass**

**Table 4.3.2: Occupied Bandwidth Low Channel Test Results, Data Sheet 2**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Low Channel 20 dB Bandwidth – 2.804 MHz | | | | | | |

**20 dB**



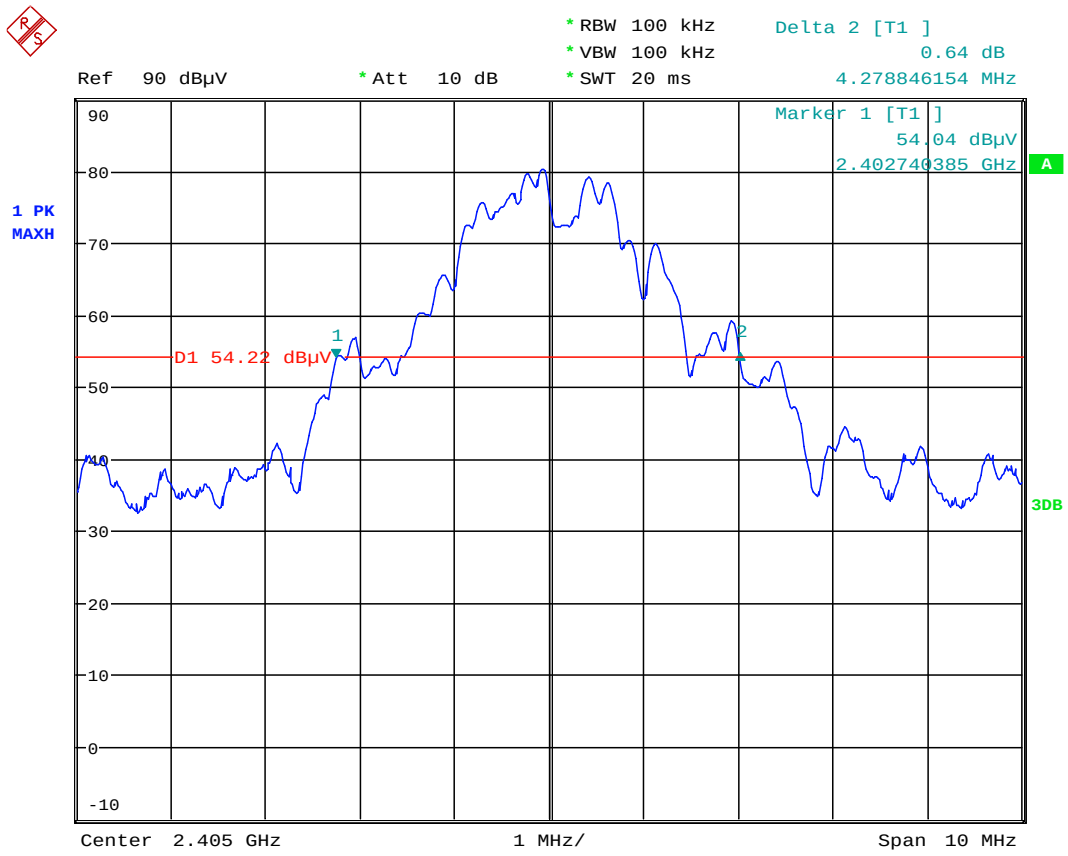

Date: 15.MAR.2011 19:48:19

**Result = Pass**

**Table 4.3.3: Occupied Bandwidth Low Channel Test Results, Data Sheet 3**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Low Channel 26 dB Bandwidth – 4.279 MHz | | | | | | |

**26 dB**



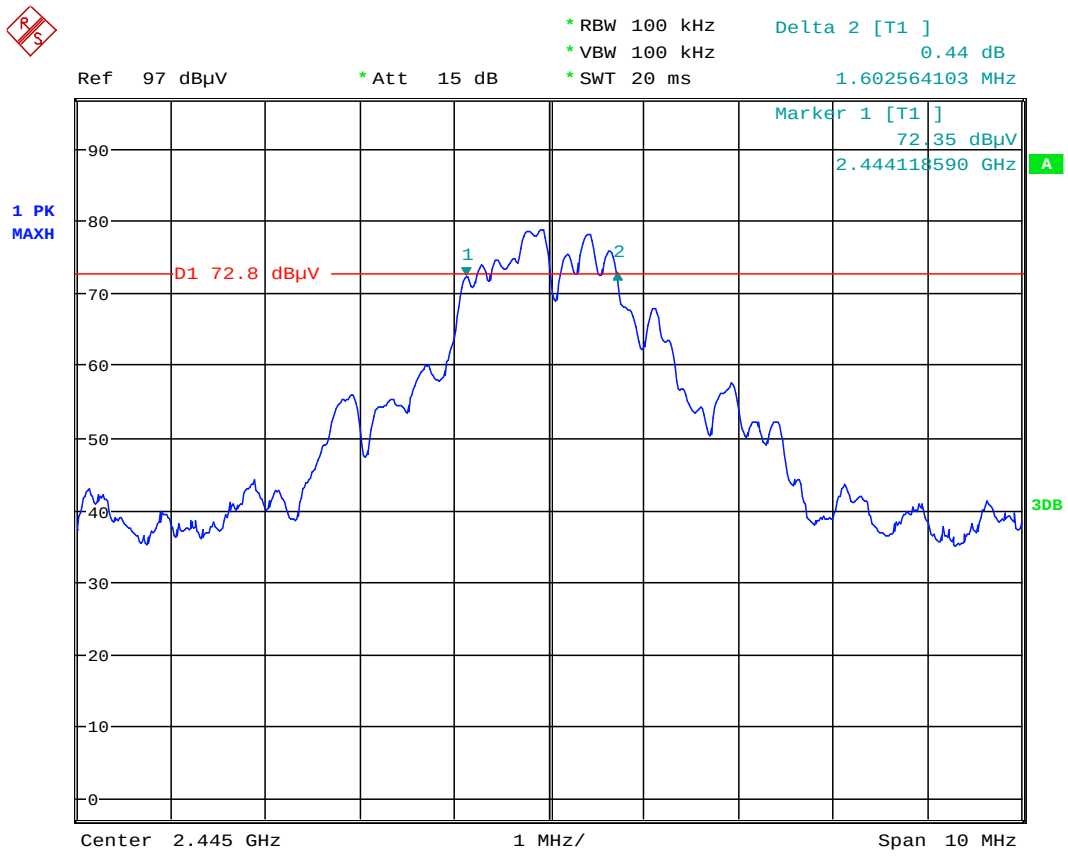

Date: 15.MAR.2011 19:48:58

**Result = Pass**

**Table 4.3.4: Occupied Bandwidth Mid Channel Test Results, Data Sheet 4**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Mid Channel 6 dB Bandwidth – 1.603 MHz | | | | | | |

**6 dB**



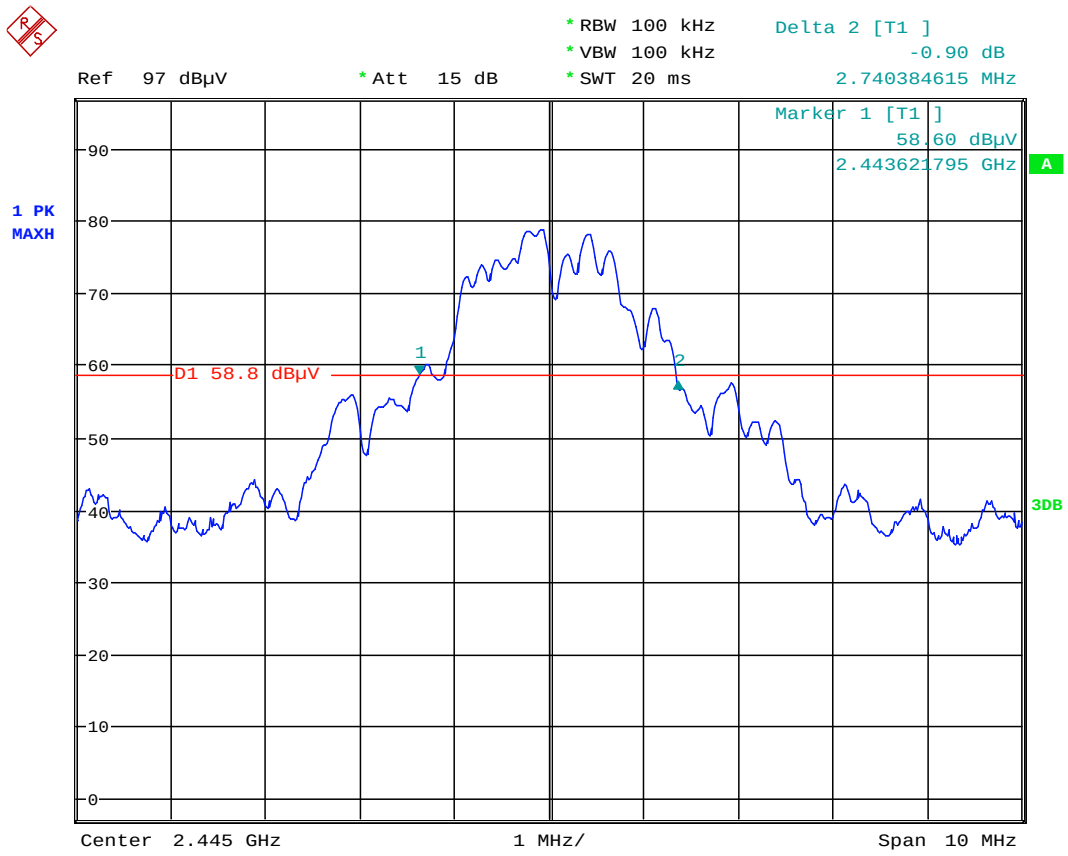

Date: 23.MAR.2011 20:49:36

**Result = Pass**

**Table 4.3.5: Occupied Bandwidth Mid Channel Test Results, Data Sheet 5**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Mid Channel 20 dB Bandwidth – 2.740 MHz | | | | | | |

**20 dB**

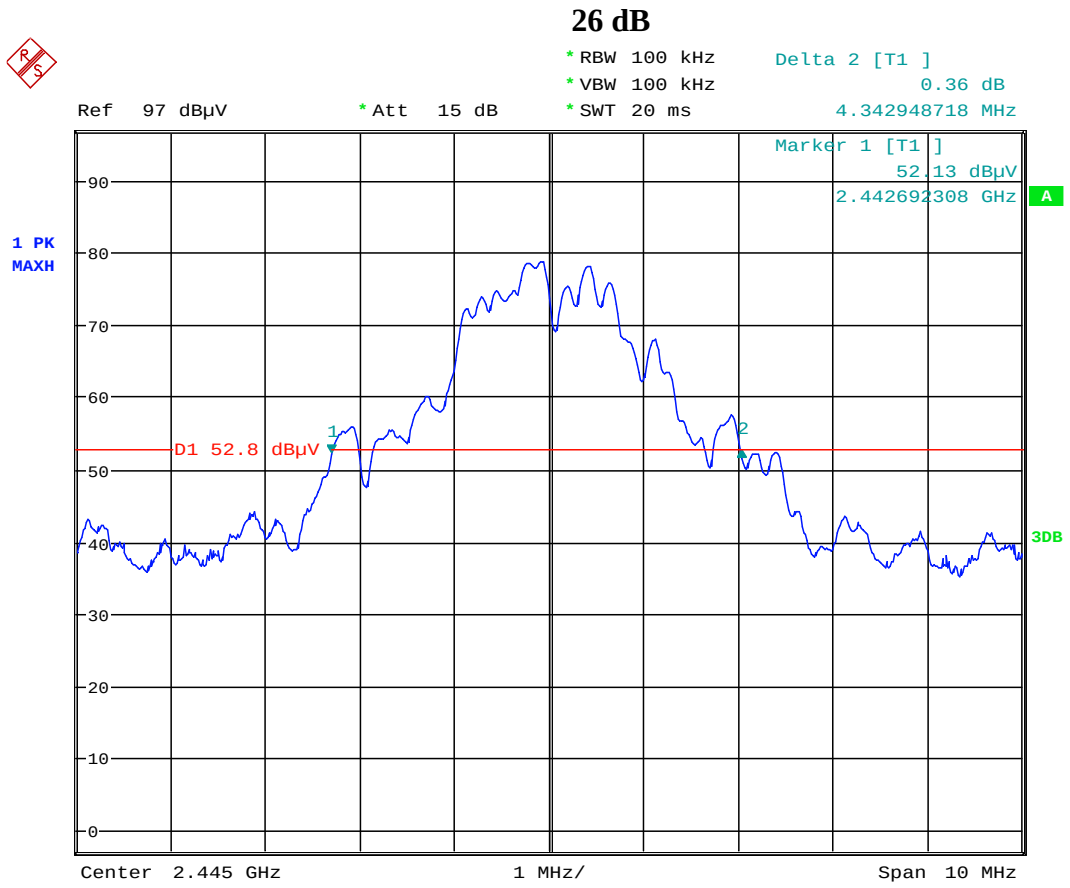



Date: 23.MAR.2011 20:50:23

**Result = Pass**

**Table 4.3.6: Occupied Bandwidth Mid Channel Test Results, Data Sheet 6**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | Mid Channel 26 dB Bandwidth – 4.343 MHz | | | | | | |

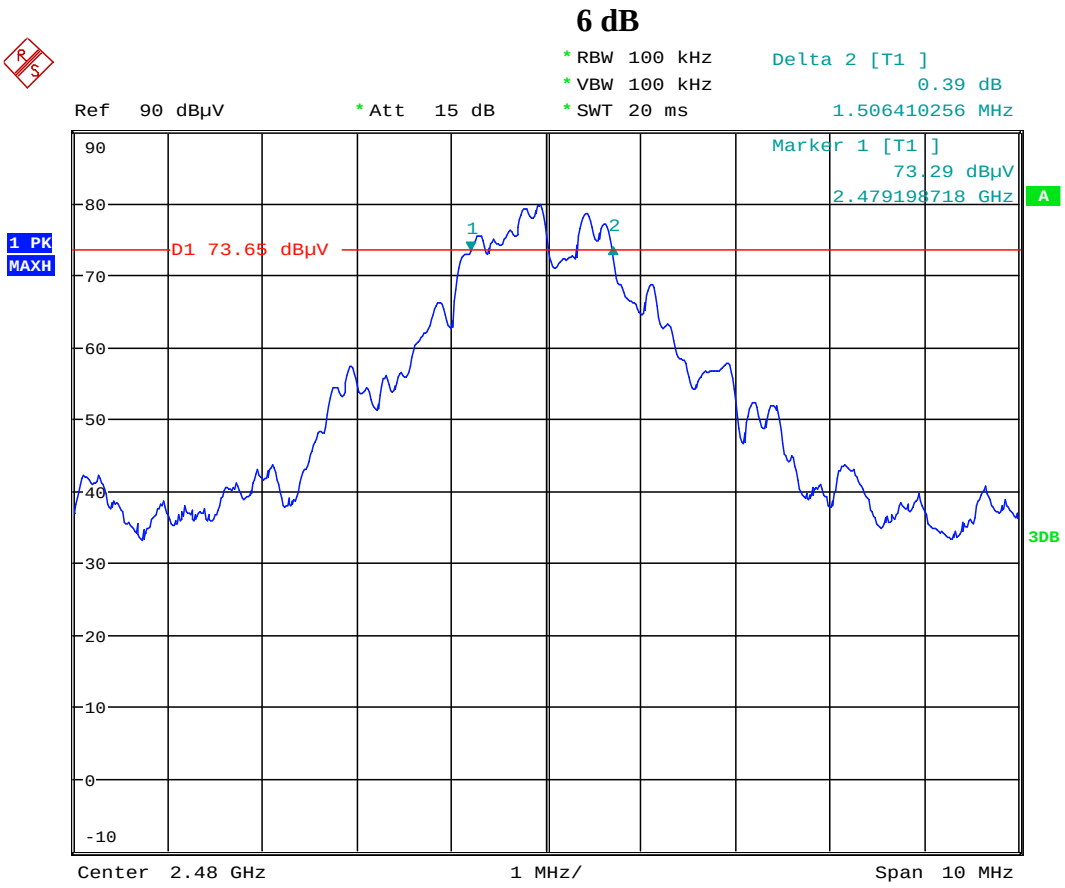



Date: 23.MAR.2011 20:51:08

**Result = Pass**

**Table 4.3.7: Occupied Bandwidth High Channel Test Results, Data Sheet 7**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | High Channel 6 dB Bandwidth – 1.506 MHz | | | | | | |



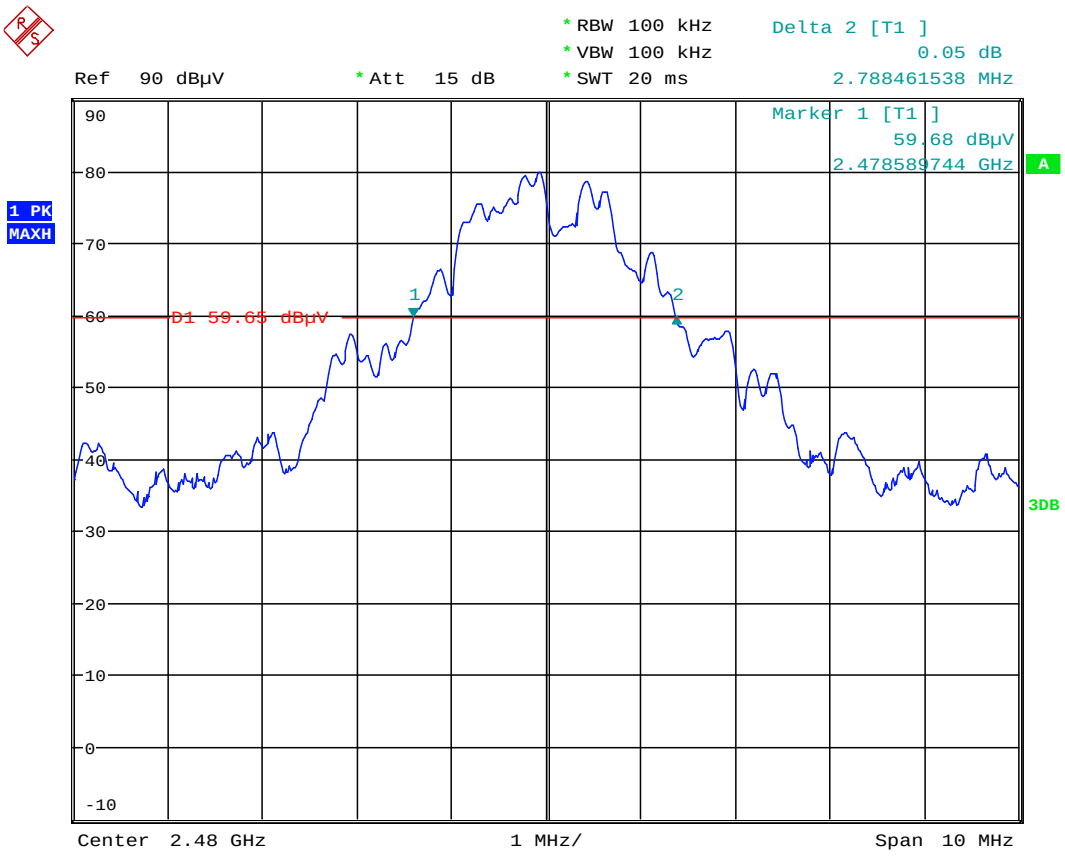

Date: 23.MAR.2011 22:22:58

**Result = Pass**

**Table 4.3.8: Occupied Bandwidth High Channel Test Results, Data Sheet 8**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | High Channel 20 dB Bandwidth – 2.788 MHz | | | | | | |

**20 dB**

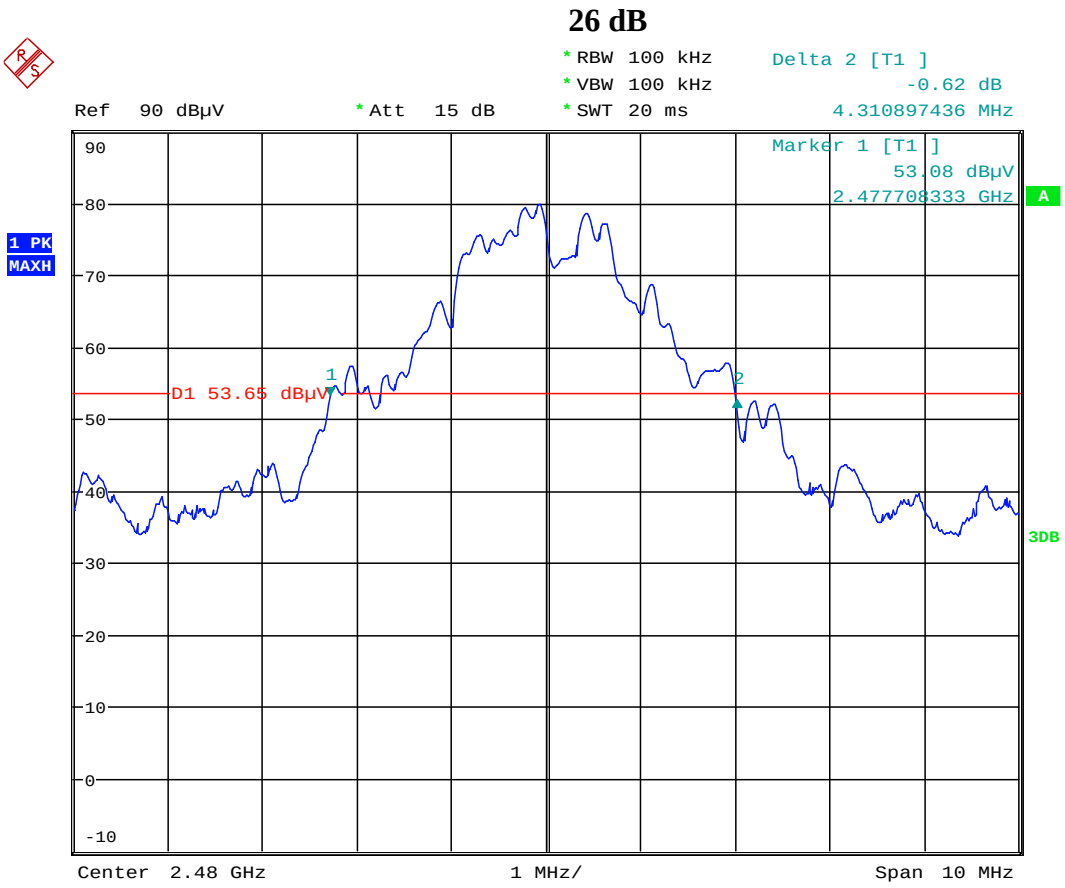



Date: 23.MAR.2011 22:23:30

**Result = Pass**

**Table 4.3.9: Occupied Bandwidth High Channel Test Results, Data Sheet 6**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 100 kHz | 100 kHz | Peak |
| **COMMENT** | High Channel 26 dB Bandwidth – 4.311 MHz | | | | | | |




Date: 23.MAR.2011 22:24:25

**Result = Pass**

# 5.0 Power Spectral Density

Power spectral density measurements were performed on the EUT to determine compliance with FCC 15.247(d) and RSS-210.

## 5.1 Test Procedure

The fundamental emission of the EUT is maximized and the spectrum analyzer is tuned to the highest point as measured in max-hold with peak detection. The analyzer is then centered on the maximum peak and set with the following parameters: RBW = 3 kHz, VBW > RBW, span = 300 kHz, and sweep time = 100s. The peak level is obtained after the sweep completes. The test setup is included in Appendix A.

## 5.2 Test Criteria and Methodology

According to section FCC 15.247(d) and RSS-210 the maximum power spectral density is +8 dBm in any 3 kHz bandwidth.

The calculation for deriving power spectral density is as follows:

**Calculations:**

$$P = \frac{(E * d)^2}{30 * G}$$

P=Power in watts, E=measured maximum field strength in V/m, d=distance in meters, G=numeric gain of transmitting antenna

Distance=1 meters
Gain=0 dBi

## 5.3 Test Results

Power spectral density measurements were taken on March 15, and 23, 2011, and the EUT was found to be in compliance with applicable requirements. Test equipment used to perform this test is given in Tables 3.3.1 and 3.3.2.

**Table 5.3.1: Power Spectral Density Low Channel Test Results, Data Sheet 1**

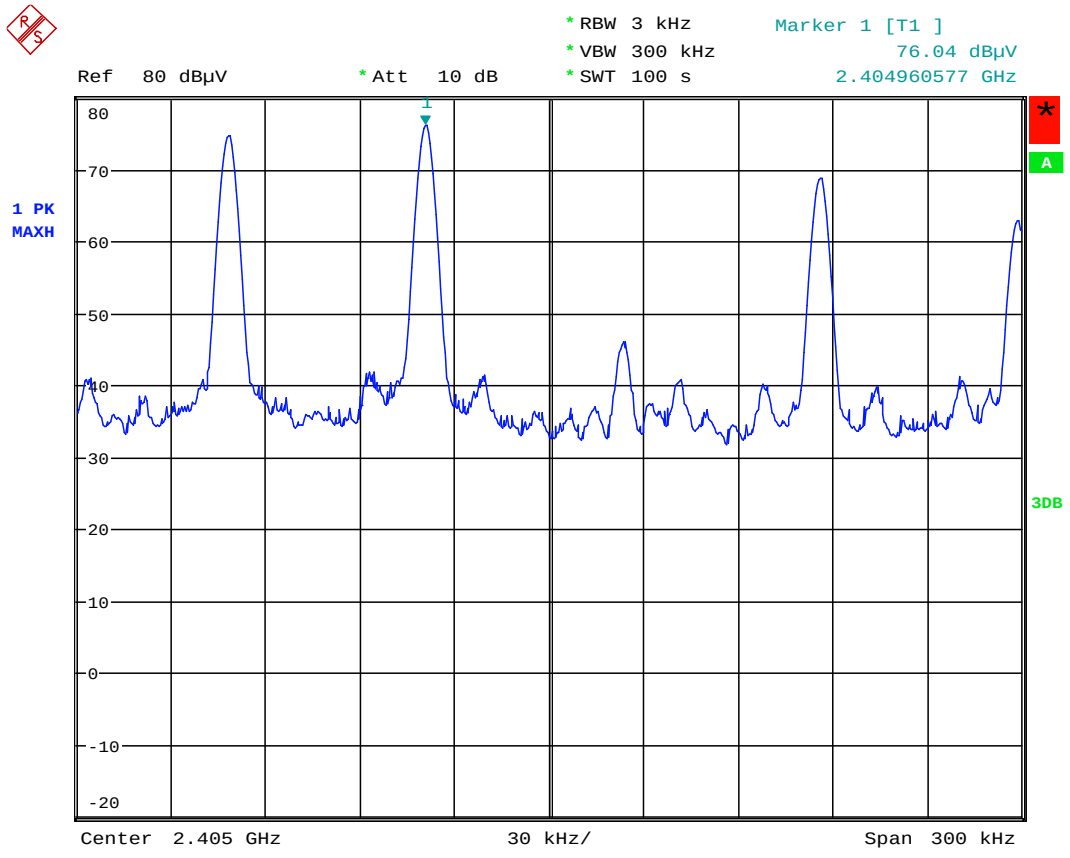
| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1 m | Horn | 3 kHz | 300 kHz | Peak |
| **COMMENT** | Low Channel | | | | | | |

**Measured Data**

| Frequency (MHz) | EUT Direction (degrees) | Antenna Elevation (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV /m) |
|---|---|---|---|---|---|---|---|
| 2405 | 0 | 1 | 76 | 26.4 | 29.0 | 2.8 | 81.4 |

**Calculated Result**

| Frequency (MHz) | Field Strength (dBµV / 3 kHz) | E.I.R.P (dBm / 3 kHz) | Limit (dBm / 3 kHz) |
|---|---|---|---|
| 2405 | 81.4 | -23.37 | 8 |




**Result = Pass**

**Table 5.3.2: Power Spectral Density Mid Channel Test Results, Data Sheet 2**

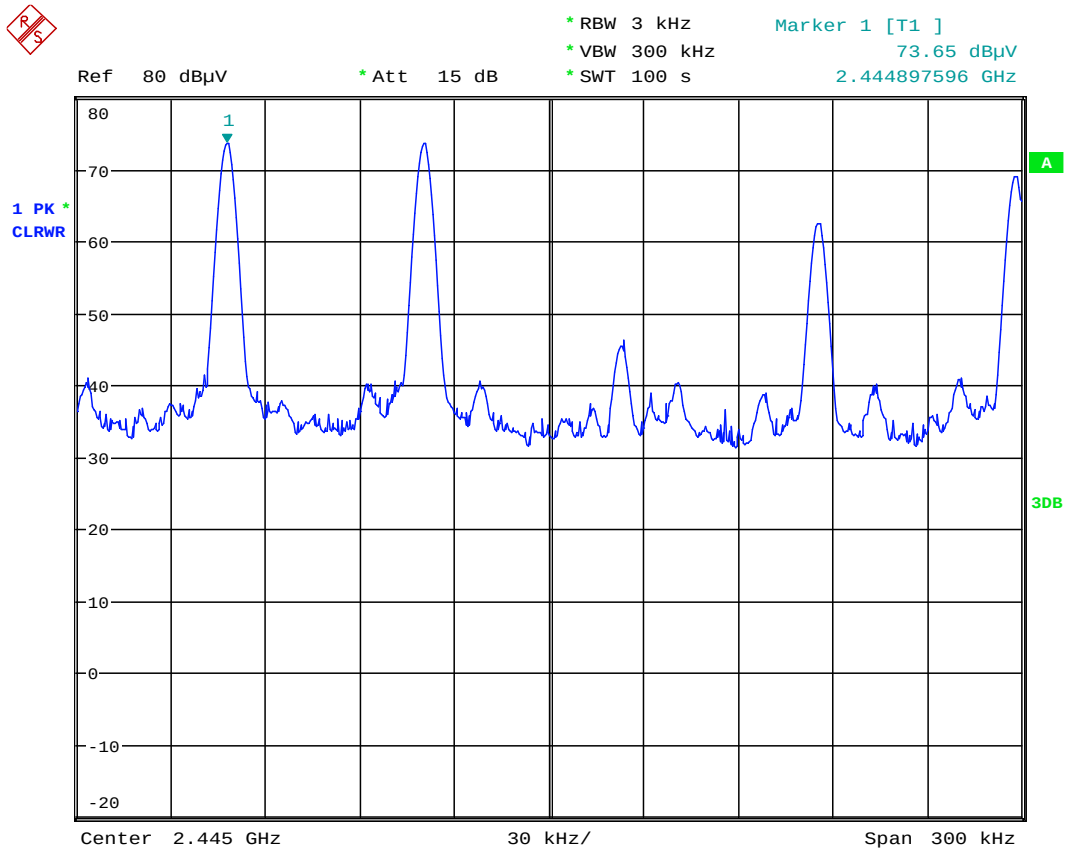
| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 3 kHz | 300 kHz | Peak |
| **COMMENT** | Mid Channel | | | | | | |

**Measured Data**

| Frequency (MHz) | EUT Direction (degrees) | Antenna Elevation (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV /m) |
|---|---|---|---|---|---|---|---|
| 2445 | 0 | 1 | 73.7 | 26.3 | 29.0 | 2.8 | 79.2 |

**Calculated Result**

| Frequency (MHz) | Field Strength (dBµV / 3 kHz) | E.I.R.P (dBm / 3 kHz) | Limit (dBm / 3 kHz) |
|---|---|---|---|
| 2445 | 79.2 | -25.57 | 8 |




Date: 23.MAR.2011 20:54:26

**Result = Pass**

**Table 5.3.3: Power Spectral Density High Channel Test Results, Data Sheet 3**

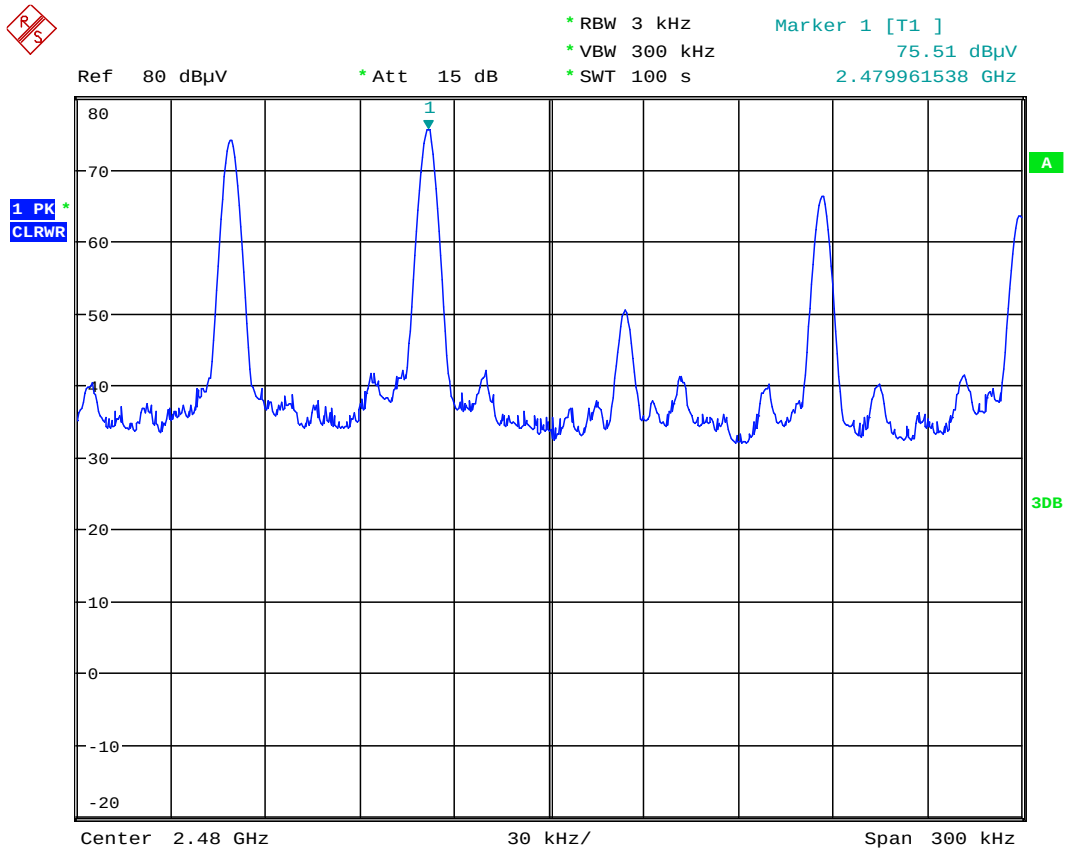
| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1 m | Horn | 3 kHz | 300 kHz | Peak |
| **COMMENT** | High Channel | | | | | | |

**Measured Data**

| Frequency (MHz) | EUT Direction (degrees) | Antenna Elevation (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV /m) |
|---|---|---|---|---|---|---|---|
| 2480 | 0 | 1 | 75.5 | 26.4 | 29.0 | 2.8 | 80.9 |

**Calculated Result**

| Frequency (MHz) | Field Strength (dBµV / 3 kHz) | E.I.R.P (dBm / 3 kHz) | Limit (dBm / 3 kHz) |
|---|---|---|---|
| 2480 | 80.9 | -23.87 | 8 |




Date: 23.MAR.2011 22:26:56

**Result = Pass**

# 6.0 Band Edge Spurious Emissions

Band edge spurious emissions measurements were performed on the EUT to determine compliance to FCC 15.247(c) and RSS-210.

## 6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable, which allows 360-degree rotation. For measurements of the fundamental signal, a measurement antenna was positioned at a distance of 1 meter as measured from the closest point of the EUT. Rotating the EUT maximized the emissions.

The spectrum analyzer was set for peak detection using a 500 kHz resolution bandwidth. The span is set wide enough to show the band edge and the edge of the emission of the screen. Measurement is made at the band edge using the marker delta method while transmitting on the channels nearest the band edge to determine if the EUT meets the test criteria. The test setup is included in Appendix A.

## 6.2 Test Criteria

According to FCC 15.247(c) and RSS-210 the band edge spurious emissions must be 20 dB below the highest peak in the operating band in any 100 kHz bandwidth. If the frequency falls in the restricted bands of 15.205 the maximum permitted average must be below the field strength listed in 15.209.

Alternatively, the band edge spurious emissions will meet criteria if they are attenuated below the limits specified in FCC 15.209 or RSS-210 Table 3

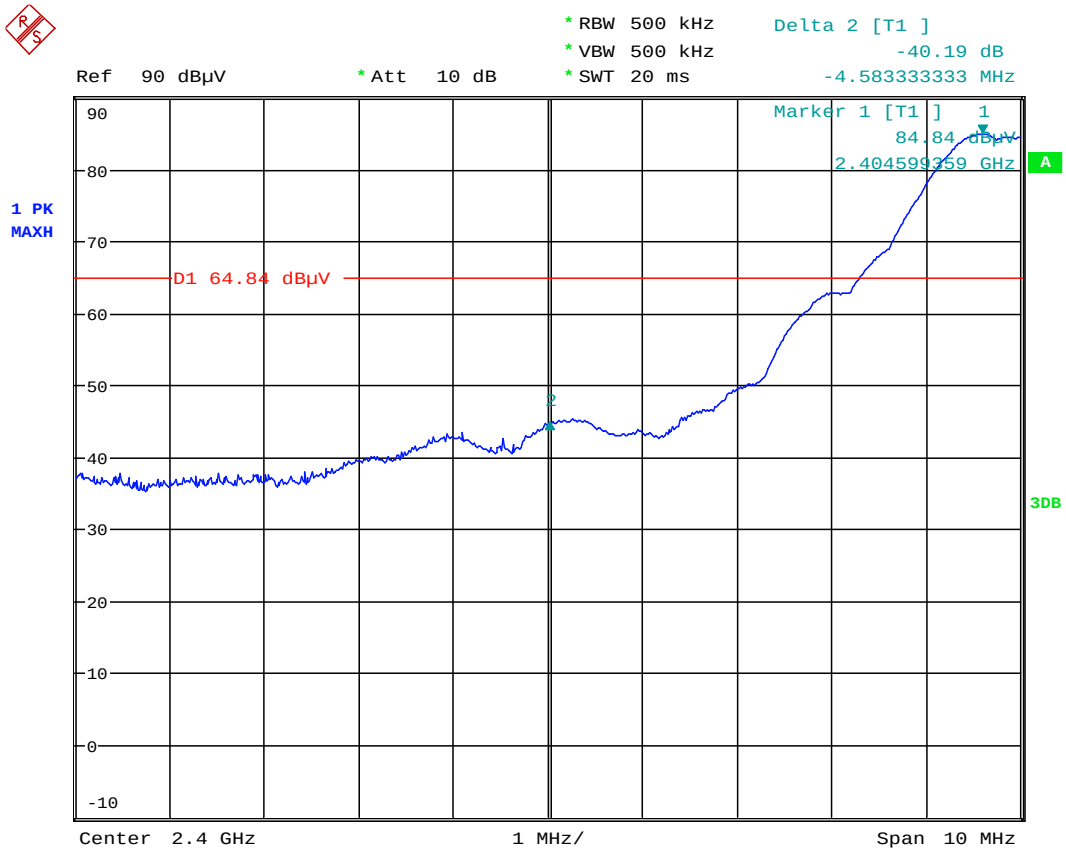
## 6.3 Test Results

Band edge spurious emissions measurements were taken on March 15, and 23, 2011, and the EUT was found to be in compliance with applicable requirements. Test equipment used to perform this test is given in Tables 3.3.1 and 3.3.2.

**Table 6.3.1 Band Edge Spurious Emissions Test Results Data Sheet 1**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | 15.247 | 1m | Horn | 500 kHz | 500 kHz | Peak |
| **COMMENT** | Transmitting | | | | | | |

| Frequency (MHz) | Recorded Level (dB) | Limit (dB) down from fundamental | Margin (dB) | Detector Function |
|---|---|---|---|---|
| 2400 | -40.19 | -20.0 | -20.19 | Peak |



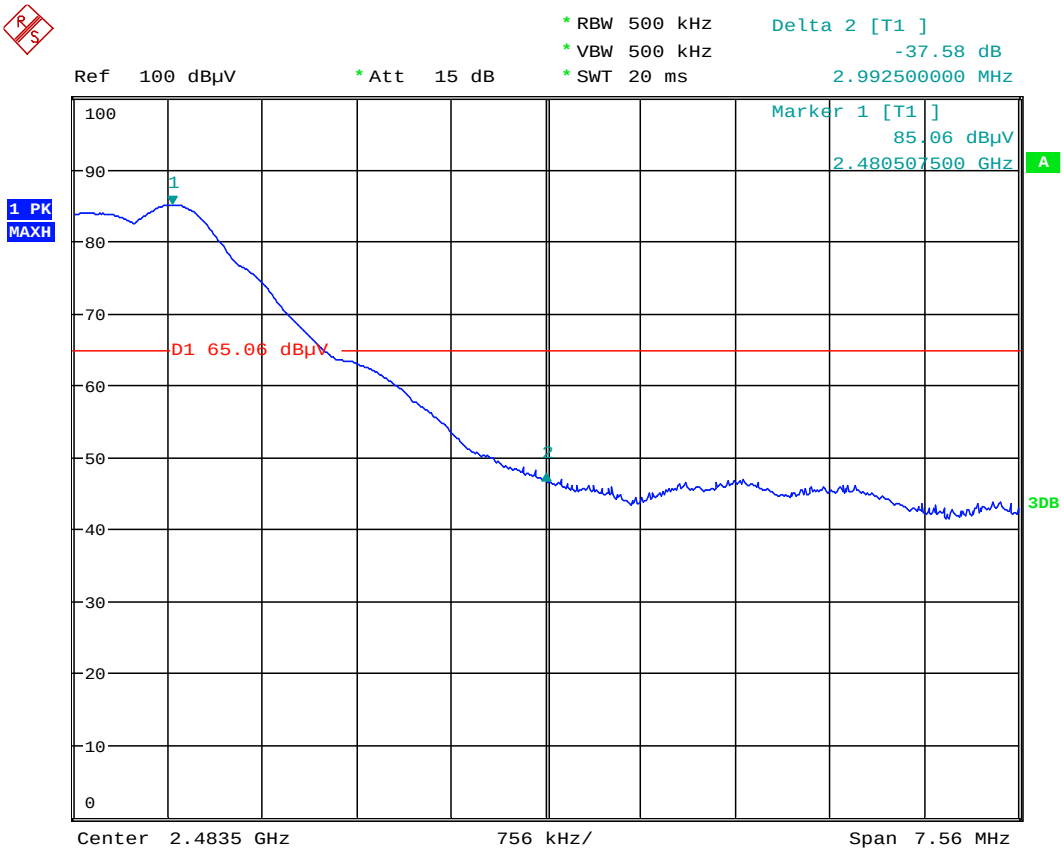

Date: 15.MAR.2011 19:49:58

**Result = Pass**

**Table 6.3.2 Band Edge Spurious Emissions Test Results Data Sheet 2**

| PROJECT # | DATE | RULE | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | 15.247 | 1m | Horn | 500 kHz | 500 kHz | Peak |
| **COMMENT** | Transmitting | | | | | | |

| Frequency (MHz) | Recorded Level (dB) | Limit (dB) down from fundamental | Margin (dB) | Detector Function |
|---|---|---|---|---|
| 2483.5 | -37.58 | -20.0 | -17.58 | Peak |




Date: 23.MAR.2011 22:28:39

**Result = Pass**

**Table 6.3.3 Band Edge Spurious Emissions (Restricted Bands)Test Results Data Sheet 3**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 23, 2011 | FCC B | 1 m | Horn | 1 MHz | 10 Hz / 1 MHz | Average / Peak |
| **COMMENT** | Investigated Restricted Bands at 2390 MHz and 2483.5 MHz | | | | | | |

| Frequency (GHz) | EUT Direction (degrees) | Antenna Elevation (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV /m) | Limit (dBµV /m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.39 | 0 | 1 | 38.2 | 26.4 | 28.1 | 2.8 | 42.7 | 83.5 | -40.8 | Peak Hold |
| 2.39 | 0 | 1 | 29.1 | 26.4 | 28.1 | 2.8 | 33.6 | 63.5 | -29.9 | Average |
| 2.4385 | 0 | 1 | 52.8 | 26.4 | 29.0 | 2.8 | 58.2 | 83.5 | -25.3 | Peak Hold |
| 2.4385 | 0 | 1 | 44.9 | 26.4 | 29.0 | 2.8 | 50.3 | 63.5 | -13.2 | Average |

# 7.0 Out of Band Spurious Emissions

Out of band spurious/harmonic emissions measurements were performed on the EUT to determine compliance to FCC sections 15.247(c), 15.209 and RSS-210.

## 7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 10 meters from the measurement antenna.

For spurious emissions below 1 GHz, quasi-peak detection was used with a resolution bandwidth of 120 kHz. All measurements below 1 GHz were normalized to 3 meters using a 20 dB/decade distance extrapolation. The emissions were maximized by rotating the EUT and raising and lowering the measurement antenna from 1 to 4 meters.

Spurious/harmonic emissions above 1 GHz peak were measured with average and peak detection with a resolution bandwidth of 1 MHz and measured at a distance of 1 meter. Average detection was used to determine compliance of the EUT if the peak did not meet the average limit. Non-harmonic emissions must satisfy the average limit and the peak limit (20 dB above average). A diagram showing the test setup is given as Figure 2.1.1. Above 1 GHz, testing was completed at the transmit frequency to determine compliance.

## 7.2 Test Criteria

The radiated limits of FCC 15.209 and RSS-210 are shown below. The limits specified are at 3 meters. The limits are quasi-peak for emissions below 1 GHz and average for emissions above 1 GHz. Also above 1 GHz, the peak limit is 20 dB above the average limit.

| Frequency MHz | Specification Distance (Meters) | Field Strength (dBuV/m) | Test Distance (Meters) | Field Strength (dBuV/m) |
|---|---|---|---|---|
| 30 to 88 | 3 | 40.0 | 10 | 29.5 |
| 88 to 216 | 3 | 43.5 | 10 | 33 |
| 216 to 960 | 3 | 46.0 | 10 | 35.5 |
| Above 960 | 3 | 54.0 | 1 | 63.5 |

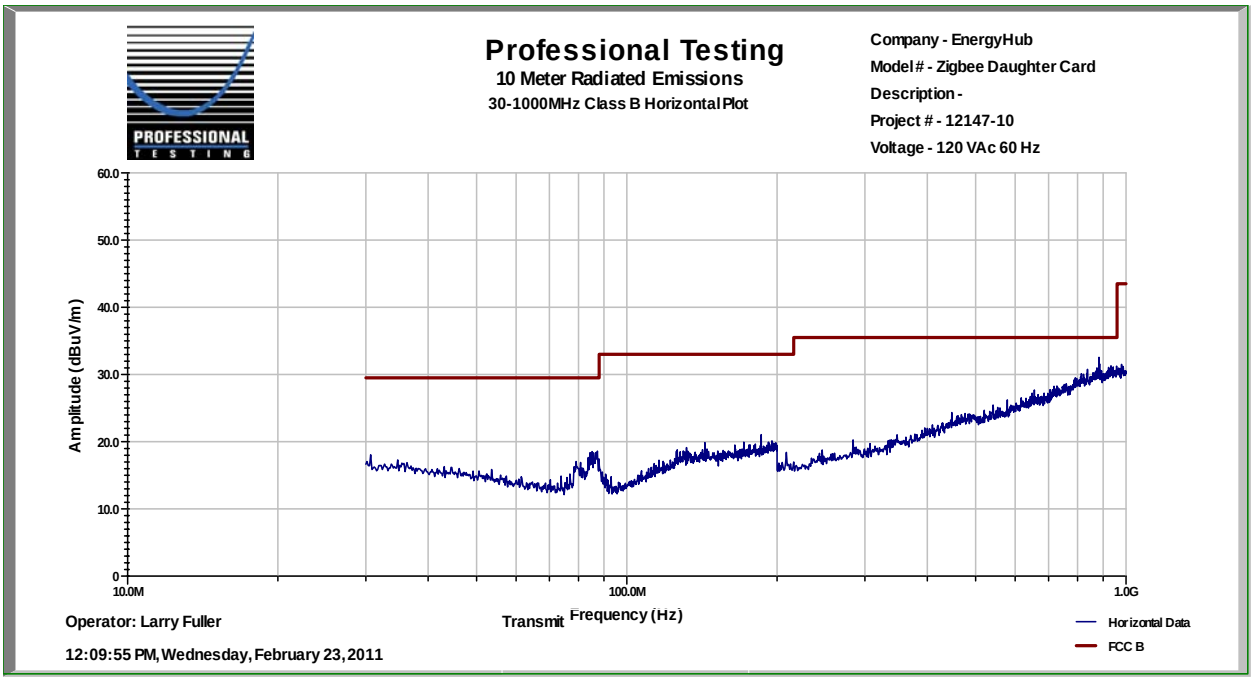
## 7.3 Test Results

Out of band spurious emissions measurements were taken on February 23, and March 15, 2011, and the EUT was found to be in compliance with applicable requirements. Test equipment used to perform this test is given in Tables 3.3.1 and 3.3.2.

**Table 7.3.1: Out of Band Spurious Emissions Test Results, 30 MHz to 1 GHz, Horizontal Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Transmitting | | | | | | |

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 31.5 | 10 | Noise | Floor | Quasi-peak | 21.8 | 9.4 | 29.5 | -20.1 |
| 87.2 | 10 | 32 | 4 | Quasi-peak | 28.7 | 12.2 | 29.5 | -17.3 |
| 199.8 | 10 | Noise | Floor | Quasi-peak | 21.4 | 12.1 | 33.1 | -21.0 |
| 566.4 | 10 | Noise | Floor | Quasi-peak | 26.8 | 20.3 | 35.6 | -15.3 |
| 841.6 | 10 | Noise | Floor | Quasi-peak | 26.1 | 24.6 | 35.6 | -11.0 |
| 993.6 | 10 | Noise | Floor | Quasi-peak | 26.5 | 26.9 | 43.5 | -16.6 |

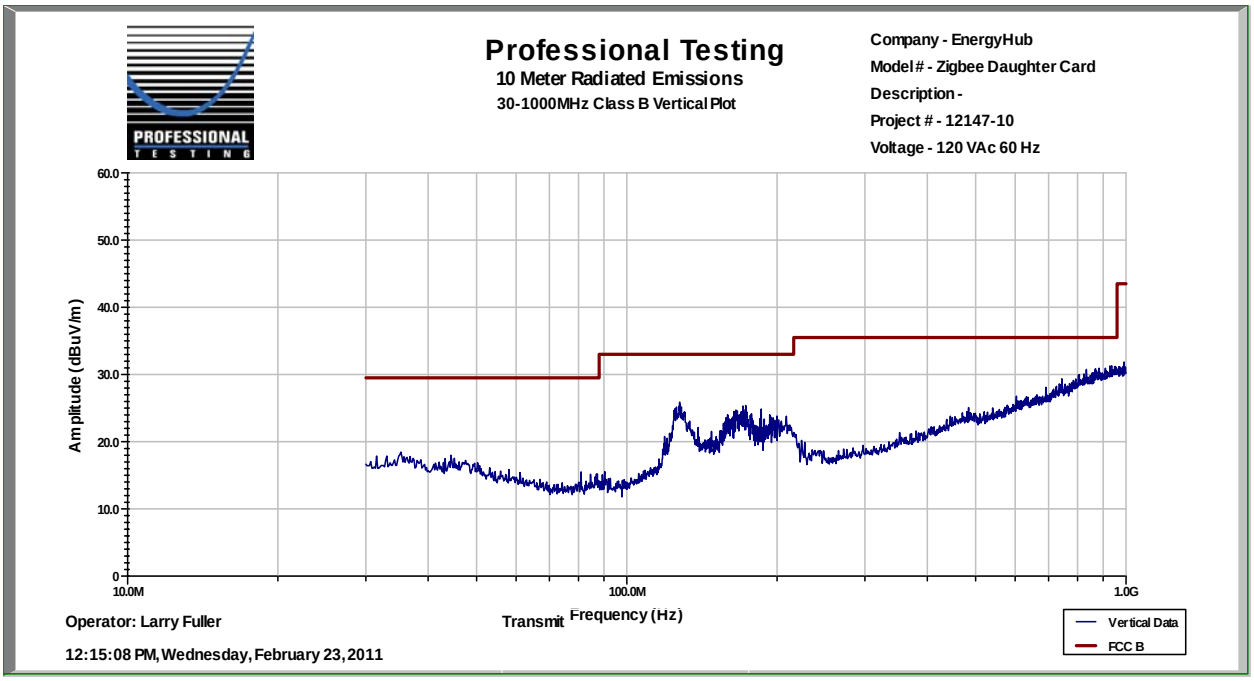



**Result = Pass**

**Table 7.3.2: Out of Band Spurious Emissions Test Results, 30 MHz to 1 GHz, Vertical Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Transmitting | | | | | | |

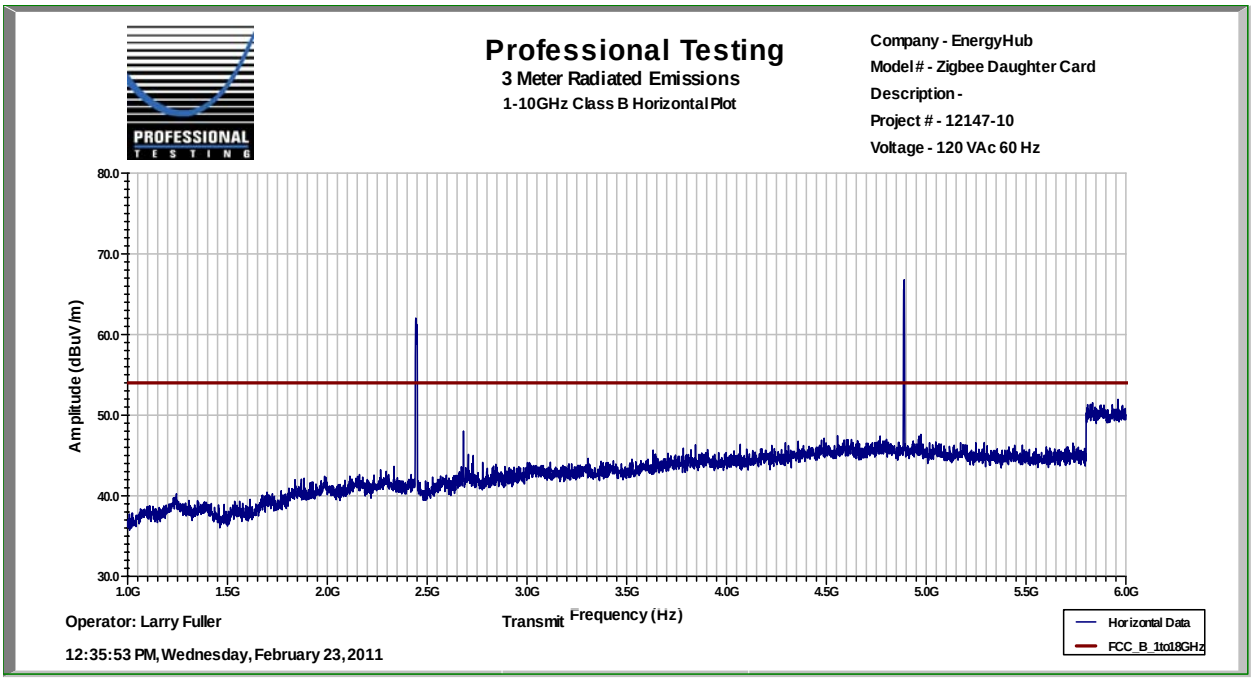
| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 31.5 | 10 | Noise | Floor | Quasi-peak | 21.8 | 9.4 | 29.5 | -20.1 |
| 127.6 | 10 | 319 | 1 | Quasi-peak | 33.2 | 21.2 | 33.1 | -11.9 |
| 173.1 | 10 | 1 | 1 | Quasi-peak | 27.8 | 17.3 | 33.1 | -15.8 |
| 566.4 | 10 | Noise | Floor | Quasi-peak | 26.9 | 20.4 | 35.6 | -15.2 |
| 841.6 | 10 | Noise | Floor | Quasi-peak | 26.3 | 24.8 | 35.6 | -10.8 |
| 993.6 | 10 | Noise | Floor | Quasi-peak | 26.5 | 26.9 | 43.5 | -16.6 |




**Result = Pass**

**Table 7.3.3: Out of Band Spurious Emissions Test Results, 1 GHz to 6 GHz, Horizontal Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 3 m | Horn | 1 MHz | 1 MHz | Average |
| **COMMENT** | Transmitting | | | | | | |

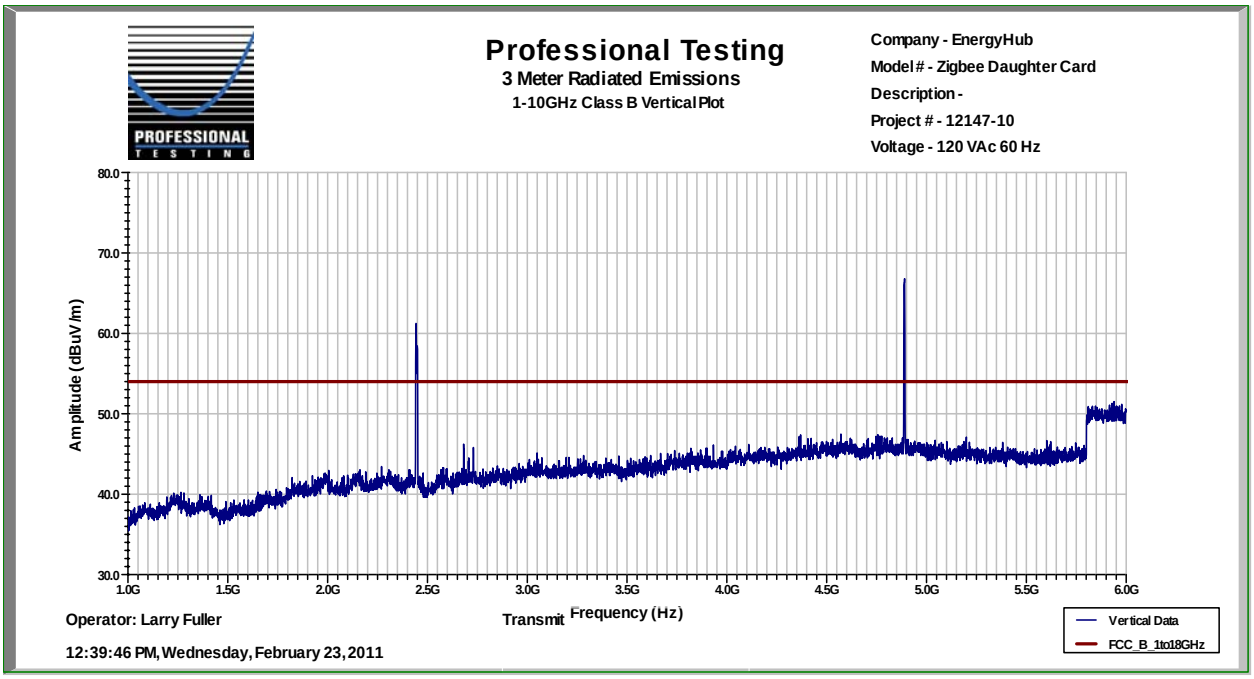



**Result = Pass**

Note: Graphical data for overview only. Pre-scan used to determine if spurious signals other than harmonics were present.

**Table 7.3.4: Out of Band Spurious Emissions Test Results, 1 GHz to 6 GHz, Vertical Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 3 m | Horn | 1 MHz | 1 MHz | Average |
| **COMMENT** | Transmitting | | | | | | |




**Result = Pass**

Note: Graphical data for overview only. Pre-scan used to determine if spurious signals other than harmonics were present.

**Table 7.3.5: Out of Band Spurious Emissions Test Results, 1 GHz to 25 GHz, Horizontal and Vertical Polarizations**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | FCC B | 1 m | Horn | 1 MHz | 1 MHz | Average |
| **COMMENT** | Transmitting 2405 MHz<br>Harmonics and spurious investigated up to 25 GHz | | | | | | |

**Horizontal Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.81 | 0 | 1 | 40.8 | 24.4 | 33.5 | 4.2 | 54.1 | 63.5 | -9.4 | Avg |
| 7.215 | 0 | 1 | 42.9 | 24.1 | 36.8 | 5.0 | 60.7 | 63.5 | -2.8 | Avg |
| 9.62 | Noise | Floor | 35.7 | 28.5 | 38.2 | 4.6 | 50.1 | 63.5 | -13.4 | Avg |
| 12.025 | Noise | Floor | 29.1 | 25.3 | 40.3 | 7.1 | 51.2 | 63.5 | -12.3 | Avg |
| 14.43 | Noise | Floor | 30.2 | 25.3 | 42.0 | 7.7 | 54.6 | 63.5 | -8.9 | Avg |
| 16.835 | Noise | Floor | 25.3 | 24.5 | 41.0 | 7.6 | 49.4 | 63.5 | -14.1 | Avg |
| 19.24 | Noise | Floor | 39.7 | 43.2 | 36.6 | 8.8 | 41.9 | 63.5 | -21.6 | Avg |
| 21.645 | Noise | Floor | 40.3 | 41.8 | 36.9 | 9.5 | 44.9 | 63.5 | -18.6 | Avg |
| 24.05 | Noise | Floor | 42.6 | 42.2 | 37.1 | 10.4 | 47.9 | 63.5 | -15.6 | Avg |

**Vertical Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.81 | 0 | 1 | 54.4 | 24.4 | 33.5 | 4.2 | 67.7 | 83.5 | -15.8 | Pk Hld |
| 4.81 | 0 | 1 | 47.7 | 24.4 | 33.5 | 4.2 | 61 | 63.5 | -2.5 | Avg |
| 7.215 | 0 | 1 | 43.5 | 24.1 | 36.8 | 5.0 | 61.3 | 63.5 | -2.2 | Avg |
| 9.62 | Noise | Floor | 35.9 | 28.5 | 38.2 | 4.6 | 50.3 | 63.5 | -13.2 | Avg |
| 12.025 | Noise | Floor | 29.1 | 25.3 | 40.3 | 7.1 | 51.2 | 63.5 | -12.3 | Avg |
| 14.43 | Noise | Floor | 30.2 | 25.3 | 42.0 | 7.7 | 54.6 | 63.5 | -8.9 | Avg |
| 16.835 | Noise | Floor | 25.3 | 24.5 | 41.0 | 7.6 | 49.4 | 63.5 | -14.1 | Avg |
| 19.24 | Noise | Floor | 39.7 | 43.2 | 36.6 | 8.8 | 41.9 | 63.5 | -21.6 | Avg |
| 21.645 | Noise | Floor | 40.3 | 41.8 | 36.9 | 9.5 | 44.9 | 63.5 | -18.6 | Avg |
| 24.05 | Noise | Floor | 42.6 | 42.2 | 37.1 | 10.4 | 47.9 | 63.5 | -15.6 | Avg |

**Result = Pass**

Note: A correction factor of -6.7 dB was applied due to the duty cycle of the EUT being < 46%.

**Table 7.3.6: Out of Band Spurious Emissions Test Results, 1 GHz to 25 GHz, Horizontal and Vertical Polarizations**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | FCC B | 1 m | Horn | 1 MHz | 1 MHz | Average |
| **COMMENT** | Transmitting 2445 MHz<br>Harmonics and spurious investigated up to 25 GHz | | | | | | |

**Horizontal Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.89 | 0 | 1 | 39 | 24.4 | 33.5 | 4.2 | 52.4 | 63.5 | -11.1 | Avg |
| 7.335 | 0 | 1 | 42 | 24.1 | 36.8 | 5.1 | 59.8 | 63.5 | -3.7 | Avg |
| 9.78 | Noise | Floor | 37.5 | 24.4 | 38.2 | 5.0 | 56.2 | 63.5 | -7.3 | Avg |
| 12.225 | Noise | Floor | 29.1 | 26.7 | 39.5 | 5.6 | 47.5 | 63.5 | -16.0 | Avg |
| 14.67 | Noise | Floor | 30.2 | 24.5 | 41.4 | 6.1 | 53.2 | 63.5 | -10.3 | Avg |
| 17.115 | Noise | Floor | 25.3 | 22.8 | 42.7 | 7.6 | 52.8 | 63.5 | -10.7 | Avg |
| 19.56 | Noise | Floor | 39.7 | 43.5 | 36.5 | 6.7 | 39.4 | 63.5 | -24.1 | Avg |
| 22.005 | Noise | Floor | 40.3 | 40.6 | 36.9 | 10.4 | 46.9 | 63.5 | -16.6 | Avg |
| 24.45 | Noise | Floor | 42.6 | 42.2 | 37.2 | 10.3 | 47.8 | 63.5 | -15.7 | Avg |

**Vertical Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.89 | 0 | 1 | 50.9 | 24.4 | 33.5 | 4.2 | 64.3 | 83.5 | -19.2 | Pk Hld |
| 4.89 | 0 | 1 | 44.2 | 24.4 | 33.5 | 4.2 | 57.6 | 63.5 | -5.9 | Avg |
| 7.335 | 0 | 1 | 42.7 | 24.1 | 36.8 | 5.1 | 60.5 | 63.5 | -3.0 | Avg |
| 9.78 | Noise | Floor | 32.5 | 24.4 | 38.2 | 5.0 | 51.2 | 63.5 | -12.3 | Avg |
| 12.225 | Noise | Floor | 29.1 | 26.7 | 39.5 | 5.6 | 47.5 | 63.5 | -16.0 | Avg |
| 14.67 | Noise | Floor | 30.2 | 24.5 | 41.4 | 6.1 | 53.2 | 63.5 | -10.3 | Avg |
| 17.115 | Noise | Floor | 25.3 | 22.8 | 42.7 | 7.6 | 52.8 | 63.5 | -10.7 | Avg |
| 19.56 | Noise | Floor | 39.7 | 43.5 | 36.5 | 6.7 | 39.4 | 63.5 | -24.1 | Avg |
| 22.005 | Noise | Floor | 40.3 | 40.6 | 36.9 | 10.4 | 46.9 | 63.5 | -16.6 | Avg |
| 24.45 | Noise | Floor | 42.6 | 42.2 | 37.2 | 10.3 | 47.8 | 63.5 | -15.7 | Avg |

**Result = Pass**

Note: A correction factor of -6.7 dB was applied due to the duty cycle of the EUT being < 46%.

**Table 7.3.7: Out of Band Spurious Emissions Test Results, 1 GHz to 25 GHz, Horizontal and Vertical Polarizations**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | March 15, 2011 | FCC B | 1 m | Horn | 1 MHz | 1 MHz | Average |
| **COMMENT** | Transmitting 2480 MHz<br>Harmonics and spurious investigated up to 25 GHz | | | | | | |

**Horizontal Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.96 | 0 | 1 | 44.3 | 24.4 | 33.5 | 4.2 | 57.7 | 63.5 | -5.8 | Avg |
| 7.44 | 0 | 1 | 33.2 | 24.7 | 37.3 | 4.5 | 50.3 | 63.5 | -13.2 | Avg |
| 9.92 | Noise | Floor | 29.6 | 23.5 | 38.2 | 5.0 | 49.3 | 63.5 | -14.2 | Avg |
| 12.4 | Noise | Floor | 29.1 | 27.8 | 39.9 | 6.2 | 47.4 | 63.5 | -16.1 | Avg |
| 14.88 | Noise | Floor | 30.2 | 23.4 | 41.1 | 7.3 | 55.2 | 63.5 | -8.3 | Avg |
| 17.36 | Noise | Floor | 25.3 | 21.5 | 44.6 | 8.7 | 57.1 | 63.5 | -6.4 | Avg |
| 19.84 | Noise | Floor | 39.7 | 43.7 | 36.5 | 8.2 | 40.8 | 63.5 | -22.7 | Avg |
| 22.32 | Noise | Floor | 40.3 | 40.5 | 37.1 | 9.4 | 46.3 | 63.5 | -17.2 | Avg |
| 24.8 | Noise | Floor | 42.6 | 42.1 | 37.2 | 10.1 | 47.8 | 63.5 | -15.7 | Avg |

**Vertical Polarization**

| Frequency Measured (MHz) | EUT Direction (Degrees) | Antenna Height (Meters) | Recorded Level (dBµV) | Amplifier Gain (dB) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.96 | 0 | 1 | 55.1 | 24.4 | 33.5 | 4.2 | 69.5 | 83.5 | -14.0 | Pk Hld |
| 4.96 | 0 | 1 | 48.4 | 24.4 | 33.5 | 4.2 | 62.8 | 63.5 | -1.7 | Avg |
| 7.44 | 0 | 1 | 42.8 | 24.7 | 37.3 | 4.5 | 59.9 | 63.5 | -3.6 | Avg |
| 9.92 | Noise | Floor | 30.6 | 23.5 | 38.2 | 5.0 | 50.3 | 63.5 | -13.2 | Avg |
| 12.4 | Noise | Floor | 29.1 | 27.8 | 39.9 | 6.2 | 47.4 | 63.5 | -16.1 | Avg |
| 14.88 | Noise | Floor | 30.2 | 23.4 | 41.1 | 7.3 | 55.2 | 63.5 | -8.3 | Avg |
| 17.36 | Noise | Floor | 25.3 | 21.5 | 44.6 | 8.7 | 57.1 | 63.5 | -6.4 | Avg |
| 19.84 | Noise | Floor | 39.7 | 43.7 | 36.5 | 8.2 | 40.8 | 63.5 | -22.7 | Avg |
| 22.32 | Noise | Floor | 40.3 | 40.5 | 37.1 | 9.4 | 46.3 | 63.5 | -17.2 | Avg |
| 24.8 | Noise | Floor | 42.6 | 42.1 | 37.2 | 10.1 | 47.8 | 63.5 | -15.7 | Avg |

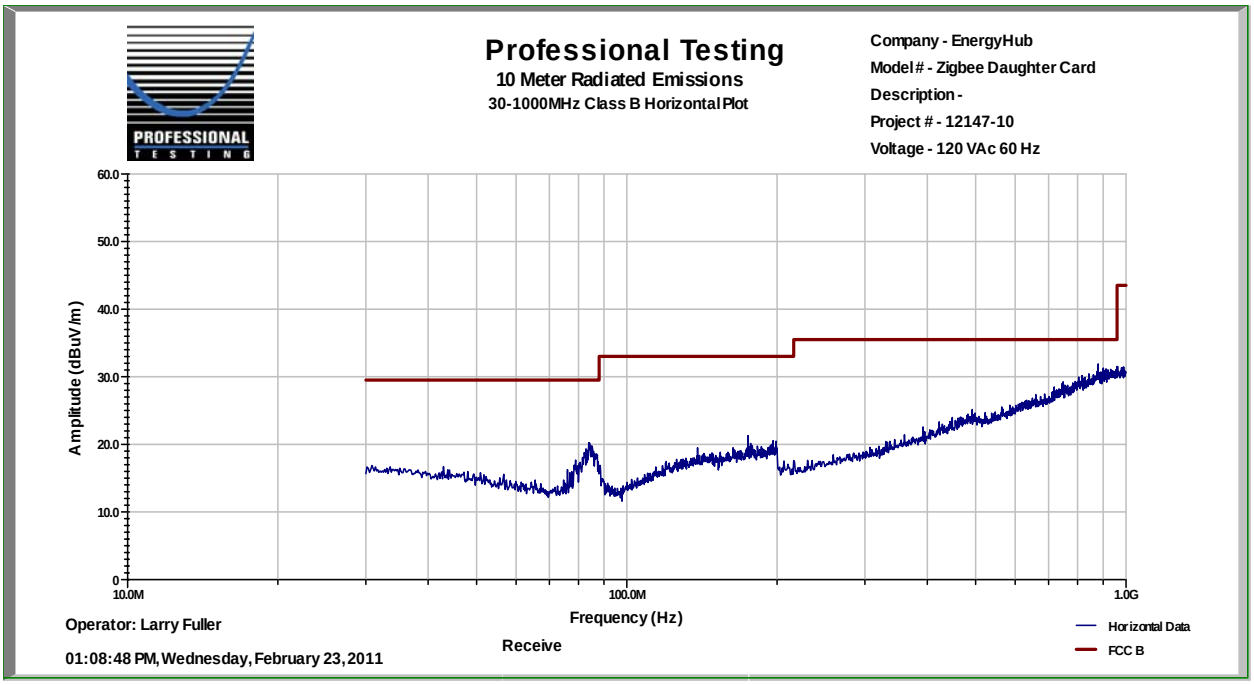
**Result = Pass**

Note: A correction factor of -6.7 dB was applied due to the duty cycle of the EUT being < 46 %.

**Table 7.3.8: Out of Band Spurious Emissions Test Results, Receive Mode 30 MHz to 1 GHz, Horizontal Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Receive | | | | | | |

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 31.5 | 10 | Noise | Floor | Quasi-peak | 21.8 | 9.4 | 29.5 | -20.1 |
| 87.2 | 10 | 32 | 4 | Quasi-peak | 28.7 | 12.2 | 29.5 | -17.3 |
| 199.8 | 10 | Noise | Floor | Quasi-peak | 21.4 | 12.1 | 33.0 | -20.9 |
| 566.4 | 10 | Noise | Floor | Quasi-peak | 26.8 | 20.3 | 35.5 | -15.2 |
| 841.6 | 10 | Noise | Floor | Quasi-peak | 26.1 | 24.6 | 35.5 | -10.9 |
| 993.6 | 10 | Noise | Floor | Quasi-peak | 26.5 | 26.9 | 43.5 | -16.6 |

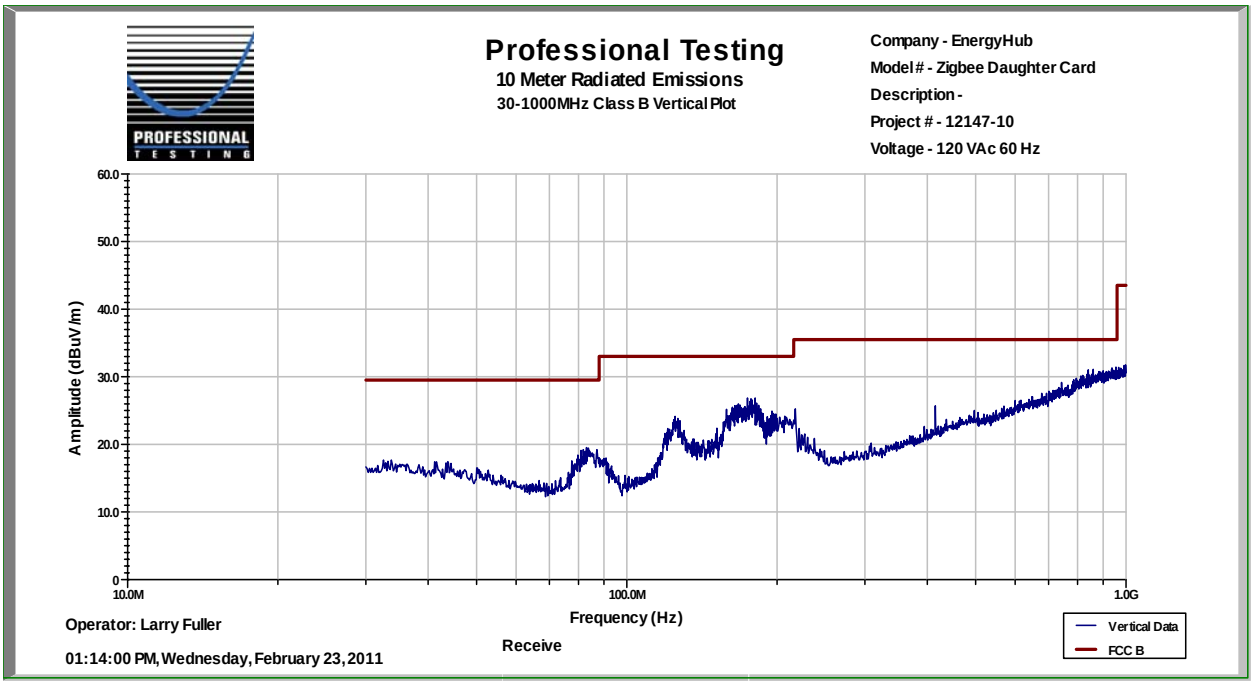



**Result = Pass**

**Table 7.3.9: Out of Band Spurious Emissions Test Results, Receive Mode 30 MHz to 1 GHz, Vertical Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Receive | | | | | | |

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 31.5 | 10 | Noise | Floor | Quasi-peak | 21.8 | 9.4 | 29.5 | -20.1 |
| 127.6 | 10 | 319 | 1 | Quasi-peak | 33.2 | 21.2 | 33.0 | -11.8 |
| 173.1 | 10 | 1 | 1 | Quasi-peak | 27.8 | 17.3 | 33.0 | -15.7 |
| 566.4 | 10 | Noise | Floor | Quasi-peak | 26.9 | 20.4 | 35.5 | -15.1 |
| 841.6 | 10 | Noise | Floor | Quasi-peak | 26.3 | 24.8 | 35.5 | -10.7 |
| 993.6 | 10 | Noise | Floor | Quasi-peak | 26.5 | 26.9 | 43.5 | -16.6 |

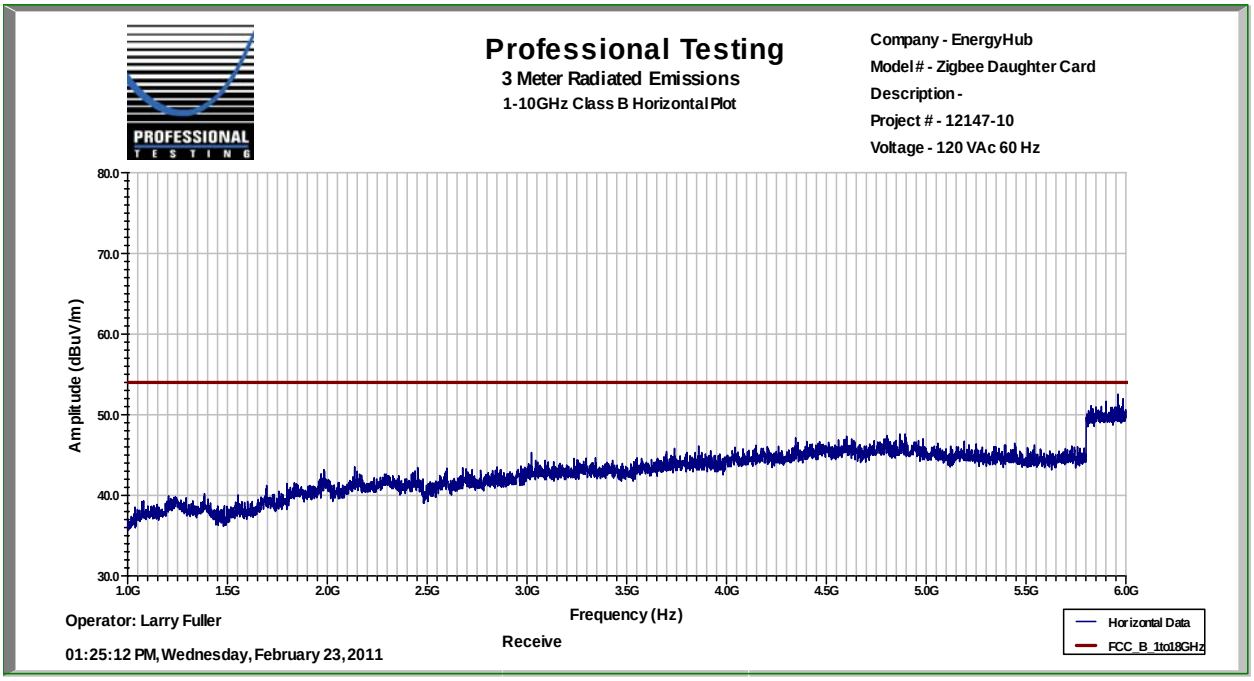



**Result = Pass**

**Table 7.3.10: Out of Band Spurious Emissions Test Results, Receive Mode 1 GHz to 6 GHz, Horizontal Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Receive | | | | | | |

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 2067 | 3 | Noise | Floor | Average | 46.3 | 44.4 | 54.0 | -9.6 |
| 4376 | 3 | Noise | Floor | Average | 45.1 | 47.4 | 54.0 | -6.6 |
| 6050 | 3 | Noise | Floor | Average | 46.3 | 50.2 | 54.0 | -3.7 |

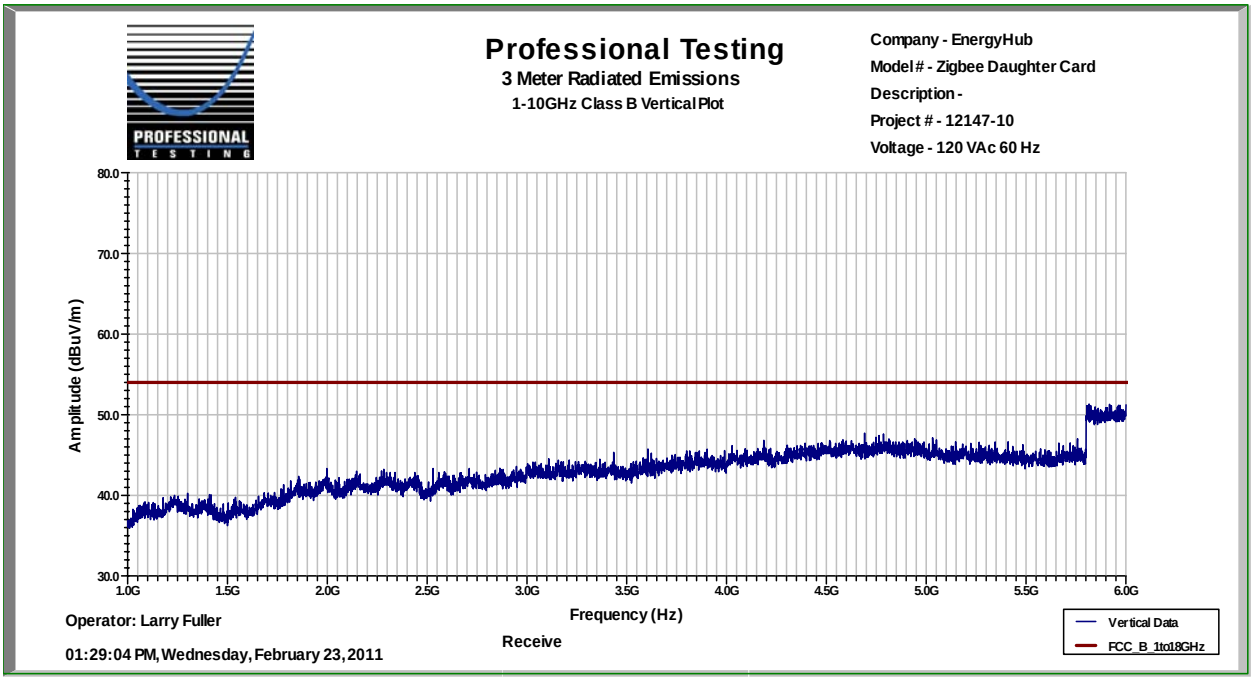



**Result = Pass**

**Table 7.3.11: Out of Band Spurious Emissions Test Results, Receive Mode 1 GHz to 6 GHz, Vertical Polarization**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | 10 m | Bicon \| Log | CISPR 120 kHz | 1 MHz | Quasi Peak |
| **COMMENT** | Receive | | | | | | |

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Recorded Amplitude (dBµV) | Corrected Level (dBµV/m) | Limit Level (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 2067 | 3 | Noise | Floor | Average | 46.3 | 44.4 | 54.0 | -9.6 |
| 4376 | 3 | Noise | Floor | Average | 45.1 | 47.4 | 54.0 | -6.6 |
| 6050 | 3 | Noise | Floor | Average | 46.3 | 50.2 | 54.0 | -3.7 |




**Result = Pass**

**Table 7.3.12: Duty Cycle Correction Factor Worksheet 1**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | N/A | N/A | N/A | N/A | N/A |
| **COMMENT** | The following duty cycle correction factor worksheet is supplied by the manufacturer. | | | | | | |

| ***IEEE 802.15.4-2003 2.4 GHz PHY Constants*** | | | |
|---|---|---|---|
| Data Rate | 250000 | bits / sec | |
| | 31250 | bytes / sec | |
| Symbols/byte | 2 | sym / bytes | |
| Symbol Timing | 62500 | sym / sec | |
| | 0.000016 | sec / sym | |
| Byte Timing | 0.000032 | sec / byte | |
| | | | |
| PHY PSDU | 6 | bytes | 4 Pramble, SPD, Length |
| Max Length | 127 | bytes | |
| Total Packet Length | 133 | bytes | |
| Maximum Time TX PKT | 0.004256 | sec | |

| ***IEEE 802.15.4-2003 MAC Constants*** | | |
|---|---|---|
| maxBE | 5 | IEEE 802.15.4 specifies 5, ZigBee specifies 8 |
| aMaxFrameResponseTime | 1220 | symbols |
| aMaxFrameRetries | 3 | |
| aUnitBackoffPeriod | 20 | symbols |
| macAckWaitDuration | 54 | symbols |
| macBattLifeExtPeriods | 6 | Backoff periods |
| macMaxCSMABackoffs | 4 | |
| macMinBE | 3 | IEEE 802.15.4 specifies 3, ZigBee specifies 5 |
| aMinLIFSPeriod | 40 | symbols |
| aMinSIFSPeriod | 12 | symbols |
| aMinCAPLength | 440 | symbols |
| NB | 0 | |
| CW | 2 | |
| BE | 3 | |

***Long Frame Scenario:***

1) Transmit Frame This is the length of the data frame
2) Wait for ACK
3) Receive ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

**Table 7.3.13: Duty Cycle Correction Factor Worksheet 2**

| PROJECT # | DATE | CLASS | DISTANCE | ANTENNA | RBW | VBW | DETECTOR |
|---|---|---|---|---|---|---|---|
| 12147-10 | February 23, 2011 | FCC B | N/A | N/A | N/A | N/A | N/A |
| **COMMENT** | The following duty cycle correction factor worksheet is supplied by the manufacturer. | | | | | | |

| MAC-Level Calculation (LIFS) | | | | |
|---|---|---|---|---|
| **Long InterFrame Spacing (Slotted w/ ACK)** | | | | Time |
| Device TX ON | Long Frame Payload | 127 | bytes | 0.004064 |
| Device TX ON | Preamble | 6 | bytes | 0.000192 |
| Device TX OFF | ACK Frame (includes Preamble) | 5 | bytes | 0.000352 |
| Device TX OFF | tack | 12 | sym | 0.000192 |
| Device TX OFF | tcca(CCA Assessment) | 7 | | 0.000112 |
| Notes | Backoff Required | 2 | | |
| Device TX OFF | Backoff Time | 70 | sym | 0.00112 |

| ***Transmit Time*** | | |
|---|---|---|
| TX Time (Packet) | 0.004256 | |

| ***NOT Transmit time (RX or Idle)*** | | |
|---|---|---|
| Wait for ACK (tack) | 0.000192 | |
| RX Time (ACK) | 0.000352 | |
| Backoff Time (tbo) | 0.00112 | (Backoff Time * Backoff Period) |
| CCA Assessment (tcca) | 0.000128 | (averaged over 8 symbols in RX Mode) |
| Turn Around Time (RX to TX) | 0.000192 | (After CCA, Radio turns over to TX in 12 symbols) |
| Total Off Time (sec) | 0.001984 | |

| | | |
|---|---|---|
| Number of TX Retransmissions | 4 | |
| Worse Case 10 Re-Transmits(100ms window) | | |
| TX Frame retransmits | 0.017024 | |
| RX or IDLE for retransmissions | 0.01984 | |
| Sum | 0.036864 | |
| Worst Case MAC duty cycle (%): | 46.18% | |
| | 6.710816936 | dB |

Note: This number is the worst case transmit duty cycle based on the 802.15.4 standard. The real application will be much lower. This is the duty cycle attenuation factor to be used for FCC certification.

# 8.0 Antenna Requirements

An antenna evaluation was performed on the EUT to determine compliance with FCC sections 15.203, 15.247(b) and RSS-210.

## 8.1 Evaluation Procedure

The design of the EUT antenna was evaluated for conformance to engineering requirements for gain and to prevent substitution of unapproved antennae. Gain of the antenna was assessed by reviewing the antenna manufacturer's data sheet.

## 8.2 Evaluation Criteria

The antenna design must meet at least one of the following criteria:

a) Antenna is permanently attached to the unit.
b) Antenna must use a unique type of connector to attach to the EUT.
c) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

## 8.3 Evaluation Results

The Zigbee Daughter Card met the criteria of this rule by virtue of having an internal antenna inaccessible to the user. Therefore, the EUT is compliant.

**End of Report**

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