L.S. Compliance, Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012
262-375-4400 Fax: 262-375-4248

COMPLIANCE TESTING OF:

# NERTEC 100 mW Module

Prepared For:

NERTEC Design, Incorporated
Trilliant
Attention: Mr. Robert Fischette
950 Cowie Street
Grandby, Quebec J2J 1P2

Test Report Number:

305275-Tx-v1

Test Dates:

August 8TH through November 8TH, 2005

# Table of Contents

## 1. L. S. Compliance In Review

**L.S. Compliance - Accreditations and Listing's**

**As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:**

**A2LA – American Association for Laboratory Accreditation**

Accreditation based on ISO/IEC 17025 : 1999
with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

**Federal Communications Commission (FCC) – USA**

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

**Industry Canada**

On file, 3 Meter Semi-Anechoic Chamber based on RSS-212 – Issue 1
File Number: IC 3088-A

On file, 3 and 10 Meter OATS based on RSS-212 – Issue 1
File Number: IC 3088

**U. S. Conformity Assessment Body (CAB) Validation**

Validated by the European Commission as a U. S. Competent Body operating under the U. S. /EU, Mutual Recognition Agreement (MRA) operating under the European Union Electromagnetic Compatibility –Council Directive 2004/108/EC (formerly 89/336/EEC), Article 10.2.
Date of Validation: January 16, 2001

Validated by the European Commission as a U.S. Notified Body operating under the U.S./EU, Mutual Recognition Agreement (MRA) operating under the European Union Telecommunication Equipment – Council Directive 99/5/EC, Annex V.

Date of Validation: November 20, 2002
Notified Body Identification Number: 1243

## 2. A2LA Certificate of Accreditation

THE AMERICAN
ASSOCIATION
FOR LABORATORY
ACCREDITATION

# ACCREDITED LABORATORY

A2LA has accredited

## L.S. COMPLIANCE, INC.
**Cedarburg, WI**

for technical competence in the field of

## Electrical Testing

The accreditation covers the specific tests and types of tests listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratories" and any additional program requirements in the identified field of testing.

Presented this 29th day of April 2005.

President
For the Accreditation Council
Certificate Number 1255.01
Valid to January 31, 2007

For tests or types of tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

## 3. A2LA Scope of Accreditation

**American Association for Laboratory Accreditation**

SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999

L.S. COMPLIANCE, INC.
W66 N220 Commerce Court
Cedarburg, WI 53012
James Blaha Phone: 262 375 4400

ELECTRICAL (EMC)

Valid to: January 31, 2007 Certificate Number: 1255.01

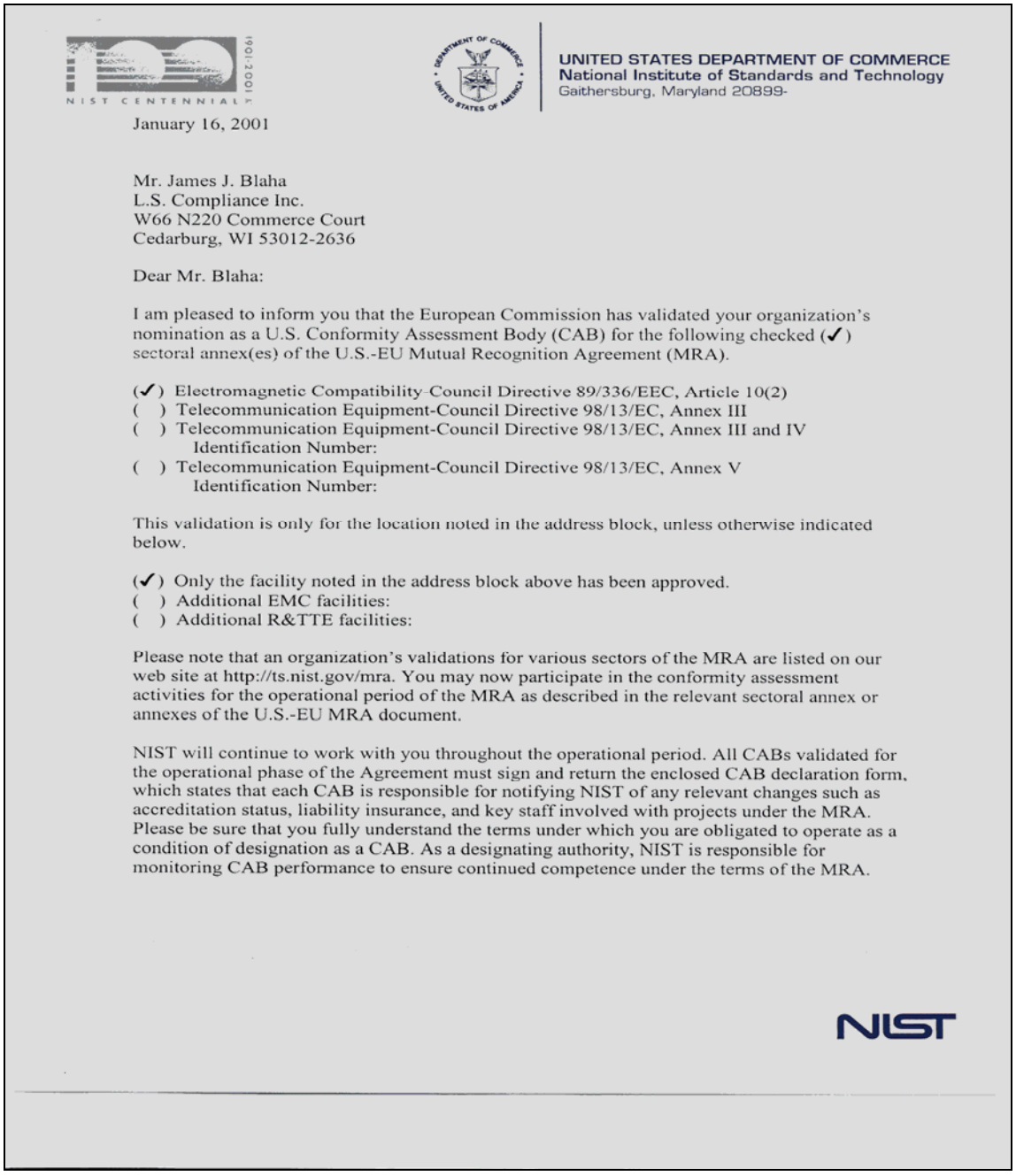
In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests:

| Test | Test Method(s) |
|---|---|
| **Emissions** | |
| Conducted<br>Continuous/Discontinuous | Code of Federal Regulations (CFR) 47,<br>FCC Method Parts 15, 18 using ANSI C63.4;<br>EN: 55011, 55022,<br>CISPR: 11, 12, 14-1 (excluding clicks), 22; |
| Radiated | Code of Federal Regulations (CFR) 47,<br>FCC Method Parts 15, 18 using ANSI C63.4 (3 meter chamber only);<br>EN: 55011, 55022,<br>CISPR: 11, 12, 14-1, 22; |
| Current Harmonics | IEC 61000-3-2; EN 61000-3-2 |
| Voltage Fluctuations & Flicker | IEC 61000-3-3; EN 61000-3-3 |
| Generic and Specific | EN 61000-6-3, EN 61000-6-4 |
| **Immunity** | |
| Generic and Specific | EN 61000-6-1<br>EN 61000-6-2<br>CISPR: 14-2, 24 |
| Conducted Immunity | |
| Fast Transients/Burst | IEC 61000-4-4;<br>EN 61000-4-4 |
| Surge | IEC: 61000-4-5; ENV 50142;<br>EN 61000-4-5 |
| RF Fields | IEC: 61000-4-6; ENV 50141;<br>EN 61000-4-6 |


**5301 Buckeystown Pike, Suite 350 • Frederick, MD 21704-8373 • Phone: 301-644 3248 • Fax: 301-662 2974**

| Test | Test Method(s) |
|---|---|
| Voltage Dips/Interruptions | IEC 61000-4-11;<br>EN 61000-4-11 |
| Radiated Immunity | |
| RF Fields | IEC: 61000-4-3;<br>EN: 61000-4-3 |
| RF Fields (50 Hz) | IEC 61000-4-8; EN 61000-4-8 |
| RF Fields (Pulse Mode) | ENV 50204 |
| Electrostatic Discharge (ESD) | IEC: 61000-4-2; EN 60801-2;<br>EN: 61000-4-2 |

## 4. Validation Letter – U.S. Competent Body for EMC Directive 2004/108/EC (formerly 89/336/EEC)



NIST CENTENNIAL 1901-2001

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

January 16, 2001

Mr. James J. Blaha
L.S. Compliance Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012-2636

Dear Mr. Blaha:

I am pleased to inform you that the European Commission has validated your organization's nomination as a U.S. Conformity Assessment Body (CAB) for the following checked (✓) sectoral annex(es) of the U.S.-EU Mutual Recognition Agreement (MRA).

(✓) Electromagnetic Compatibility-Council Directive 89/336/EEC, Article 10(2)
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III and IV
Identification Number:
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex V
Identification Number:

This validation is only for the location noted in the address block, unless otherwise indicated below.

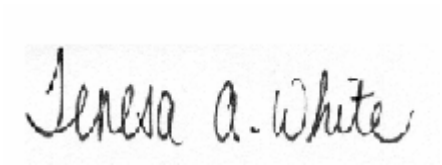
(✓) Only the facility noted in the address block above has been approved.
( ) Additional EMC facilities:
( ) Additional R&TTE facilities:

Please note that an organization's validations for various sectors of the MRA are listed on our web site at http://ts.nist.gov/mra. You may now participate in the conformity assessment activities for the operational period of the MRA as described in the relevant sectoral annex or annexes of the U.S.-EU MRA document.

NIST will continue to work with you throughout the operational period. All CABs validated for the operational phase of the Agreement must sign and return the enclosed CAB declaration form, which states that each CAB is responsible for notifying NIST of any relevant changes such as accreditation status, liability insurance, and key staff involved with projects under the MRA. Please be sure that you fully understand the terms under which you are obligated to operate as a condition of designation as a CAB. As a designating authority, NIST is responsible for monitoring CAB performance to ensure continued competence under the terms of the MRA.

NIST

## 5. Signature Page



Prepared By: February 20, 2006

Teresa A. White, Document Coordinator Date

Tested By: February 20, 2006

Abtin Spantman, EMC Engineer Date

Approved By: February 20, 2006

Brian E. Petted, VP of Engineering Date

## 6. Product and General Information

| | | | | | | |
|---|---|---|---|---|---|---|
| Manufacturer: | NERTEC Design, Incorporated | | | | | |
| Date(s) of Test: | August 8TH through November 8TH, 2005 | | | | | |
| Test Engineer(s): | | Tom Smith | √ | Abtin Spantman | | Ken Boston |
| Model #: | EM-0018B | | | | | |
| Serial #: | 201 and 202 | | | | | |
| Voltage: | 3.3 VDC | | | | | |
| Operation Mode: | Normal operation and continuous transmit with modulation | | | | | |

## 7. Introduction

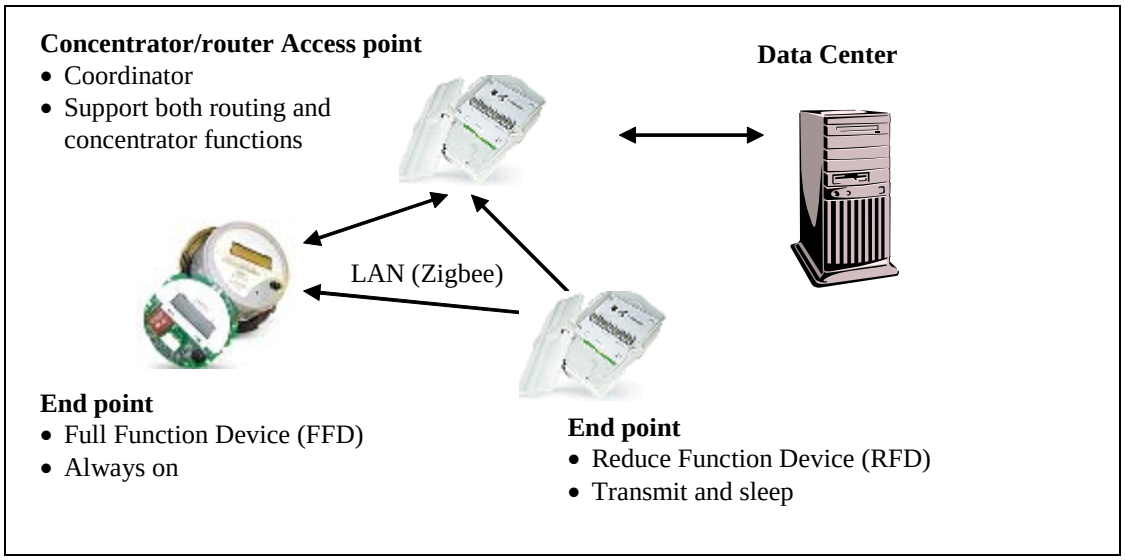
Between August 8TH and November 8TH, 2005, a series of Conducted and Radiated RF Emission tests were performed on two samples of the NERTEC Design, Incorporated's 100 mW transceiver module, here forth collectively referred to as the "*Equipment Under Test*" or "*EUT*". The first sample, serial number 201, was setup for radiated emissions measurements, while the second sample, serial number 202, was fitted with an SMA connector for conducted RF emissions measurements. These tests were performed using the procedures outlined in ANSI C63.4-2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.247 (Industry Canada RSS-210) for a low power transmitter. These tests were performed by Abtin Spantman, EMC Engineer at L.S. Compliance, Incorporated.

All Radiated and Conducted RF Emission tests were performed upon the EUT to measure the emissions in the frequency bands described in Title 47 CFR, FCC Part 15, including 15.35, 15.205, 15.247 and Industry Canada RSS-210 to determine whether these emissions are below the limits expressed within the standards. These tests were performed in accordance with the procedures described in the American National Standard for methods of measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2003). Another document used as a reference for the EMI Receiver specification was the Comite International Special Des Perturbations Radioelelectriques (CISPR) Number 16-1, 2003.

All tests were performed at L.S. Compliance, Inc., in Cedarburg, Wisconsin, unless otherwise noted.

## 8. Product Description

The NERTEC 100 mW transceiver module is a transceiver module to be used in electric meter installations for a mesh network type communication system. The module is used in either a Concentrator/Access Point application or in the end device (electric meter) application. The system and the function of each node is best displayed in the diagram below:



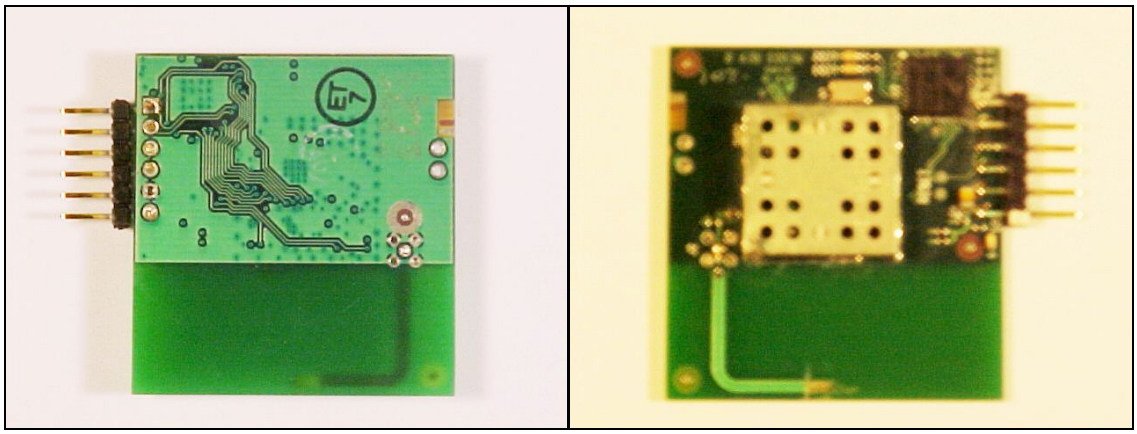

The purpose of the system is the transfer of data from the electric meter (kWH, functionality, etc.) to the data collection center.

The transceiver module is based on the Freescale MC13192 radio chip set and is designed to operate in the 2.4 GHz ISM band as allowed under 47CFR, part 15.247 for DTS type devices. The system is based on the IEEE 802.15.4 standard, with channels spaced at 5 MHz intervals in the ISM band. The system operates at a chip rate of 2 Mcps, a symbol rate of 62.5 ksps, and a bit rate of 250kbps. O-QPSK modulation is used with 16-ary orthogonal symbols. It transmits with a maximum power of 100 milliwatts (+20 dBm) into a printed circuit board antenna or an external whip antenna.

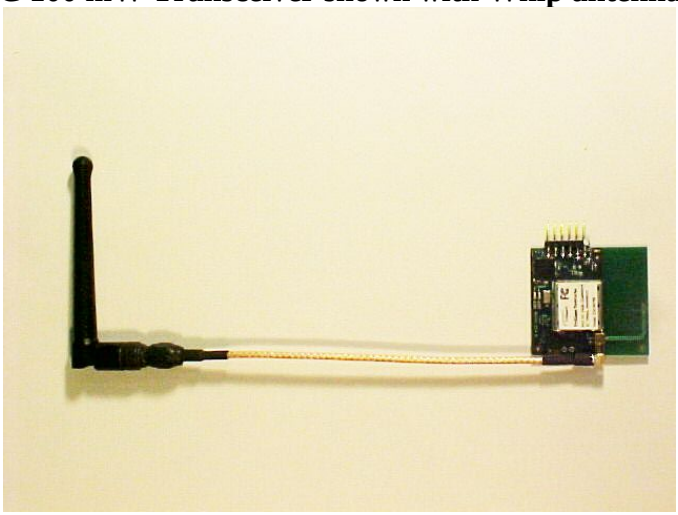
Due to the limited speed of communication of serial data to the radio, the transmission time is limited to 10 msec maximum within any 100 msec. window of time. This allows for a duty cycle relaxation factor of 20dB to be applied. 20 dB of averaging relaxation is requested and invoked in this report for this product per manufacturer request.

*The transmitter portion of the transceiver was tested as covered in this report.*

**The NERTEC 100 mW Transceiver shown with PCB trace antenna**



**The NERTEC 100 mW Transceiver shown with Whip antenna application.**



## 9. Test Requirements

The above mentioned tests were performed in order to determine the compliance of the NERTEC Design, Incorporated's 100 mW transceiver module, transmitter section, with limits contained in various provisions of Title 47 CFR, FCC Part 15, including:

| | | |
|---|---|---|
| 15.31 | 15.247a | 15.247d |
| 15.205 | 15.247b | 15.247e |
| 15.207 | 15.247c | |

## 10. Summary of Test Report

### DECLARATION OF CONFORMITY

The NERTEC Design, Incorporated's 100 mW transceiver module, transmitter section was found to **MEET** the requirements as described within the specification of Title 47 CFR FCC, Part 15.247, and Industry Canada RSS-210, Section 6.2.2(o) for a Digital Spread Spectrum (DTS) Transmitter.

Some emissions are seen to be within 3 dB of their respective limits. As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

## 11. Radiated Emissions Test

### Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15 and ANSI C63.4-2003. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in continuous transmit modulated mode for this portion of the testing, using 3.3 VDC power as provided by standard bench-type power supply connected with a one meter long cable. The unit has the capability to operate on 16 channels. EUT serial number 201 was presented for radiated emissions testing. This sample was programmed for various channels, and test modes using a lap-top PC with proprietary programming software, through standard jumper pins on the printed circuit board.

The applicable limits apply at a 3 meter distance. Measurements above 5 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of four (4) standard channels:

| Frequency | Transmit Power (mW) | Transmit Power (dBm) |
|---|---|---|
| Ch: 00, 2405 MHz | 89.1 mW | + 19.5 |
| Ch: 07, 2440 MHz | 50.1 mW | + 17.0 |
| Ch: 14, 2475 MHz | 41.7 mW | + 16.2 |
| Ch: 15, 2480 MHz | 4.0 mW | + 6.0 |

The RF power output was reduced, as needed, on channel 15, to comply with band-edge requirements.

### Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. From 18 GHz to 25 GHz, the EUT was measured at a 0.3 meter separation, using a standard gain Horn Antenna and pre-amplifier.

The power source voltage was continuously monitored. The EUT was rotated along three orthogonal axis during the investigations to find the highest emission levels.

## Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an N.I.S.T. traceable site. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and a HP 8546A EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the HP 8546A EMI Receiver database. As a result, the data taken from the HP 8546A EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The HP 8546A EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of 300 kHz), and a bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of 1 MHz). From 5 GHz to 18 GHz, an HP E4407B Spectrum Analyzer and an EMCO Horn Antenna were used. From 18 GHz to 25 GHz, the HP E4407B Spectrum Analyzer with a standard gain horn, and preamp were used.

## Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 for a DTS transmitter [Canada RSS-210, Clause 6.2.2(o)]. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

## CALCULATION OF RADIATED EMISSIONS LIMITS

The maximum peak output power of an intentional radiator in the 2400-2483.5 MHz band, as specified in 47 CFR 15.247 (b)(3), is 1 Watt. The harmonic and spurious RF emissions, as measured in any 100kHz bandwidth, as specified in 15.247 (d), shall be at least 20 dB below the measured power of the desired signal, and must also meet the requirements described in 15.205(c).

The following table depicts the Class B limits for an unintentional radiator. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands.

| Frequency (MHz) | 3 m Limit (μV/m) | 3 m Limit (dBμV/m) | 1 m Limit (dBμV/m) |
|---|---|---|---|
| 30-88 | 100 | 40.0 | - |
| 88-216 | 150 | 43.5 | - |
| 216-960 | 200 | 46.0 | - |
| 960-25,000 | 500 | 54.0 | 63.5 |

## Sample calculations:

Sample conversion from a field strength measurement with units of μV/m to dBμV/m would be:

$$dB\mu V/m = 20Log_{10}\left(\frac{XX\mu V/m}{1\mu V/m}\right)$$

Limit in the frequency range of (30-88 MHz) is calculated to be:

$$40.0dB\mu V/m = 20Log_{10}\left(\frac{100\mu V/m}{1\mu V/m}\right)$$

~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

Sample conversion from a field conducted RF power measurement in mW to a radiated field strength measurement in dBμV/m would be:

$$dB\mu V/m@3m = 95.23 + 10Log_{10}\left(\frac{XXmW}{1mW}\right)$$

AT the fundamental frequency, the limit for the RF power output of 1W (1000mW) at the antenna port of a transmitter with an antenna gain of 0 dBi would be equivalent to an Equivalent Isotropic Radiated Power (e.i.r.p.) measurement of 125.23 dBμV/m at 3 meters.

$$125.23dB\mu V/m@3m = 95.23 + 10Log_{10}\left(\frac{1000mW}{1mW}\right)$$

~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

Sample conversion from a measurement distance of 3 meters to a distance of 1meter would be:

$$dB = -20Log_{10}\left(\frac{XXm}{3m}\right)$$

A sample limit, within the frequency range of 960-25,000 MHz for example, when measured at 1 meter instead of 3 meters would change according to the equation:

$$63.5dB\mu V/m = 54.0dB\mu V/m + \left(-20Log_{10}\left(\frac{1m}{3m}\right)\right)$$

# Radiated Emissions Data Chart

**3 Meter Measurements of Electromagnetic Radiated Emissions**
**Test Standard: 47CFR, Part 15.205 and 15.247(DTS)**
**Frequency Range Inspected: 30 MHz to 25000 MHz**

| | | | | | | |
|---|---|---|---|---|---|---|
| Manufacturer: | NERTEC Design, Incorporated | | | | | |
| Date(s) of Test: | August 8TH through November 8TH, 2005 | | | | | |
| Test Engineer(s): | | Tom Smith | √ | Abtin Spantman | | Ken Boston |
| Model #: | EM-0018B | | | | | |
| Serial #: | 201 and 202 | | | | | |
| Voltage: | 3.3 VDC | | | | | |
| Operation Mode: | Normal operation and continuous transmit with modulation | | | | | |
| EUT Power: | | Single Phase ___VAC | | 3 Phase ___VAC | | |
| | | Battery: | √ | Other: Bench DC Power Supply | | |
| EUT Placement: | √ | 80cm non-conductive table | | 10cm Spacers | | |
| EUT Test Location: | √ | 3 Meter Semi-Anechoic FCC Listed Chamber | | 3/10m OATS | | |
| Measurements: | | Pre-Compliance | | Preliminary | √ | Final |
| Detectors Used: | √ | Peak | √ | Quasi-Peak | √ | Average |

**Environmental Conditions in the Lab:**
Temperature: 20 – 25°C
Relative Humidity: 30 – 60 %

**Test Equipment Used:**
EMI Measurement Instrument: HP8546A and Agilent E4407B
Log Periodic Antenna: EMCO #93146
Horn Antenna: EMCO #3115
Biconical Antenna: EMCO 93110
Pre-Amp: Advanced Microwave WHA6224
Standard Gain Horn: EMCO 3160-09

The following table depicts the level of significant spurious radiated RF emissions found:

| Frequency (MHz) | Antenna Polarity | Channel | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.205 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| 56.0 | V | All | 1.00 | 120 | 25.2 | 40.0 | 14.8 |
| | | | | | *(Note 1)* | | |

*Notes:*

*1) There were no other significant spurious emissions observed to be within 20 dB of the limits.*

## *Radiated Emissions Measurements for the PCB Antenna version*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 00:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2405 | V | 1.15 | 40 | 120.2 | 125.2 | 5.0 |
| 4810 | V | 1.00 | 95 | 48.4 | 54.0 (Note 5) | 5.6 |
| 7215 | H | 1.05 | 120 | 63.2 | 109.7 | 46.5 |
| 9620 | H | 1.00 | 345 | 49.7 | 109.7 | 60.0 |
| 12025 | H | 1.00 | 190 | 53.7 | 63.5 (Note 5) | 9.8 |
| 14430 | H | 1.00 | 210 | 46.1 | 109.7 | 63.6 |
| 16835 | H | 1.00 | 0 | 45.5 | 109.7 | 64.2 |
| 19240 | | | | (Note 3) | 74.0 (Note 5) | |
| 21645 | | | | (Note 3) | 120.2 | |
| 24050 | | | | (Note 3) | 120.2 | |

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 07:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2440 | V | 1.00 | 300 | 118.3 | 125.2 | 6.9 |
| 4880 | V | 1.00 | 300 | 45.9 | 54.0 (Note 5) | 8.1 |
| 7320 | H | 1.10 | 125 | 62.1 | 63.5 (Note 5) | 1.4 |
| 9760 | H | 1.05 | 340 | 46.3 | 107.9 | 61.6 |
| 12200 | H | 1.00 | 185 | 47.8 | 63.5 (Note 5) | 15.7 |
| 14640 | H | 1.00 | 210 | 41.4 | 107.9 | 66.5 |
| 17080 | H | 1.00 | 0 | 44.6 | 107.9 | 63.3 |
| 19520 | | | | (Note 3) | 74.0 (Note 5) | |
| 21960 | | | | (Note 3) | 118.3 | |
| 24400 | | | | (Note 3) | 118.3 | |

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 14:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2475 | V | 1.00 | 300 | 118.0 | 125.2 | 7.2 |
| 4950 | V | 1.00 | 300 | 43.1 | 54.0 (Note 5) | 10.9 |
| 7425 | H | 1.10 | 120 | 61.6 | 63.5 (Note 5) | 1.9 |
| 9900 | H | 1.10 | 330 | 43.1 | 107.5 | 64.4 |
| 12375 | H | 1.10 | 190 | 46.7 | 63.5 (Note 5) | 16.8 |
| 14850 | H | 1.00 | 210 | 42.0 | 107.5 | 65.5 |
| 17325 | H | 1.00 | 0 | 45.0 | 107.5 | 62.5 |
| 19800 | | | | (Note 3) | 74.0 (Note 5) | |
| 22275 | | | | (Note 3) | 74.0 (Note 5) | |
| 24750 | | | | (Note 3) | 118.0 | |

## *Radiated Emissions Measurements for the PCB Antenna version*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 15:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2480 | V | 1.00 | 255 | 109.2 | 125.2 | 16.0 |
| 4960 | V | 1.15 | 300 | 38.5 | 54.0 (Note 5) | 15.5 |
| 7440 | H | 1.05 | 120 | 46.3 | 63.5 (Note 5) | 17.2 |
| 9920 | H | 1.05 | 260 | 40.6 | 98.7 | 58.1 |
| 12400 | H | 1.00 | 0 | 38.0 | 63.5 (Note 5) | 25.5 |
| 14880 | H | 1.00 | 0 | 40.0 | 98.7 | 58.7 |
| 17360 | H | 1.00 | 0 | 45.0 | 98.7 | 53.7 |
| 19840 | | | | (Note 3) | 74.0 (Note 5) | |
| 22320 | | | | (Note 3) | 74.0 (Note 5) | |
| 24800 | | | | (Note 3) | 109.2 | |

Notes:

1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2) Measurements above 5 GHz were made at 1 meters of separation from the EUT, and at 0.3 m separation for frequencies between 18 – 25 GHz.
3) Measurement at receiver system noise floor.
4) For measurements of the fundamental power, because of spectral bandwidth, the receiver was set to RBW=VBW=3 MHz.
5) Emission falls within a restricted band of operation as defined in 47CFR 15.205 and is subject to part 15.205 limits.

## *Radiated Emissions Measurements for the Whip Antenna version*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 00:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2405 | H | 1.05 | 120 | 120.4 | 125.2 | 4.8 |
| 4810 | H | 1.45 | 30 | 43.8 | 54.0 (Note 5) | 10.2 |
| 7215 | V | 1.05 | 175 | 60.6 | 109.94 | 49.3 |
| 9620 | H | 1.00 | 350 | 51.7 | 109.94 | 58.2 |
| 12025 | H | 1.00 | 255 | 54.0 | 63.5 (Note 5) | 9.5 |
| 14430 | H | 1.00 | 180 | 44.2 | 109.94 | 65.7 |
| 16835 | H | 1.00 | 0 | 44.6 | 109.94 | 65.3 |
| 19240 | | | | (Note 3) | 74.0 (Note 5) | |
| 21645 | | | | (Note 3) | 120.4 | |
| 24050 | | | | (Note 3) | 120.4 | |

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 07:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2440 | H | 1.05 | 120 | 119.3 | 125.2 | 5.9 |
| 4880 | H | 1.15 | 20 | 43.2 | 54.0 (Note 5) | 10.8 |
| 7320 | V | 1.05 | 175 | 55.4 | 63.5 (Note 5) | 8.1 |
| 9760 | H | 1.00 | 350 | 48.8 | 108.84 | 60.0 |
| 12200 | H | 1.00 | 275 | 48.7 | 63.5 (Note 5) | 14.8 |
| 14640 | H | 1.05 | 355 | 42.8 | 108.84 | 66.0 |
| 17080 | H | 1.00 | 0 | 45.4 | 108.84 | 63.4 |
| 19520 | | | | (Note 3) | 74.0 (Note 5) | |
| 21960 | | | | (Note 3) | 119.3 | |
| 24400 | | | | (Note 3) | 119.3 | |

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 14:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2475 | H | 1.00 | 115 | 119.5 | 125.2 | 5.7 |
| 4950 | H | 1.35 | 35 | 39.8 | 54.0 (Note 5) | 14.2 |
| 7425 | V | 1.05 | 175 | 56.0 | 63.5 (Note 5) | 7.5 |
| 9900 | H | 1.00 | 350 | 48.1 | 109.0 | 60.9 |
| 12375 | H | 1.00 | 270 | 48.6 | 63.5 (Note 5) | 14.9 |
| 14850 | H | 1.00 | 355 | 42.2 | 109.0 | 66.8 |
| 17325 | H | 1.00 | 0 | 44.8 | 109.0 | 64.2 |
| 19800 | | | | (Note 3) | 74.0 (Note 5) | |
| 22275 | | | | (Note 3) | 74.0 (Note 5) | |
| 24750 | | | | (Note 3) | 119.5 | |

## *Radiated Emissions Measurements for the Whip Antenna version*

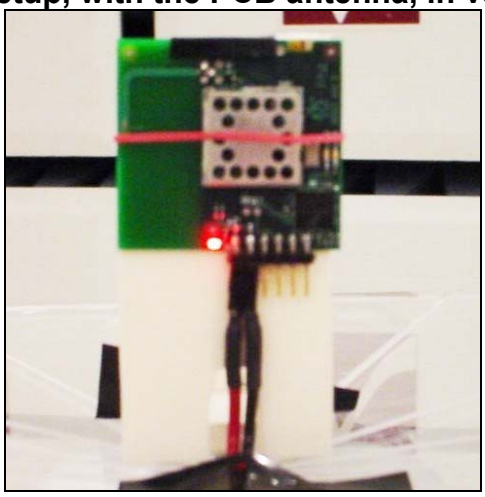
The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 15:

| Frequency (MHz) | Antenna Polarity | Height (meters) | Azimuth (0° - 360°) | Measured EFI (dBμV/m) | 15.247 Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|
| 2480 | H | 1.00 | 115 | 107.7 | 125.2 | 17.5 |
| 4960 | H | 1.30 | 15 | 44.4 | 54.0 (Note 5) | 9.6 |
| 7440 | V | 1.05 | 175 | 45.0 | 63.5 (Note 5) | 18.5 |
| 9920 | H | 1.00 | 350 | 49.5 | 97.2 | 47.7 |
| 12400 | | | | (Note 3) | 63.5 (Note 5) | |
| 14880 | | | | (Note 3) | 97.2 | |
| 17360 | | | | (Note 3) | 97.2 | |
| 19840 | | | | (Note 3) | 74.0 (Note 5) | |
| 22320 | | | | (Note 3) | 74.0 (Note 5) | |
| 24800 | | | | (Note 3) | 107.7 | |

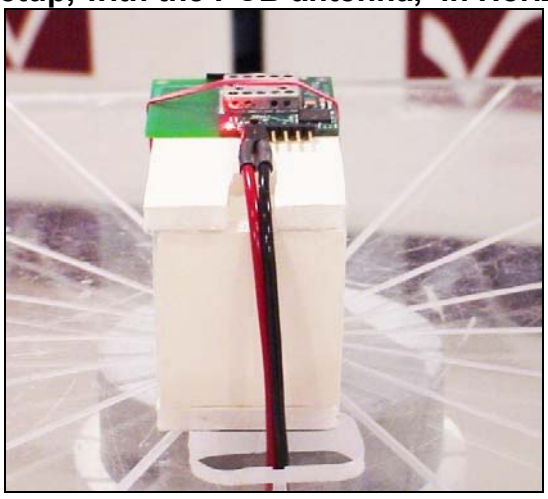
Notes:

1) Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2) Measurements above 5 GHz were made at 1 meters of separation from the EUT, and at 0.3 m separation for frequencies between 18 – 25 GHz.
3) Measurement at receiver system noise floor.
4) For measurements of the fundamental power, because of spectral bandwidth, the receiver was set to RBW=VBW=3 MHz.
5) Emission falls within a restricted band of operation as defined in 47CFR 15.205 and is subject to part 15.205 limits.

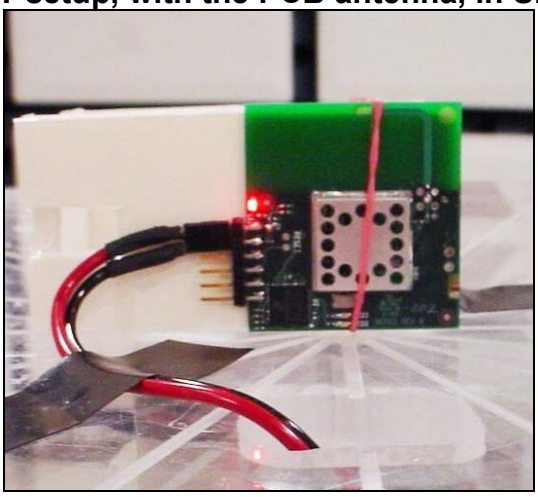
**View of the EUT setup, with the PCB antenna, in vertical orientation.**



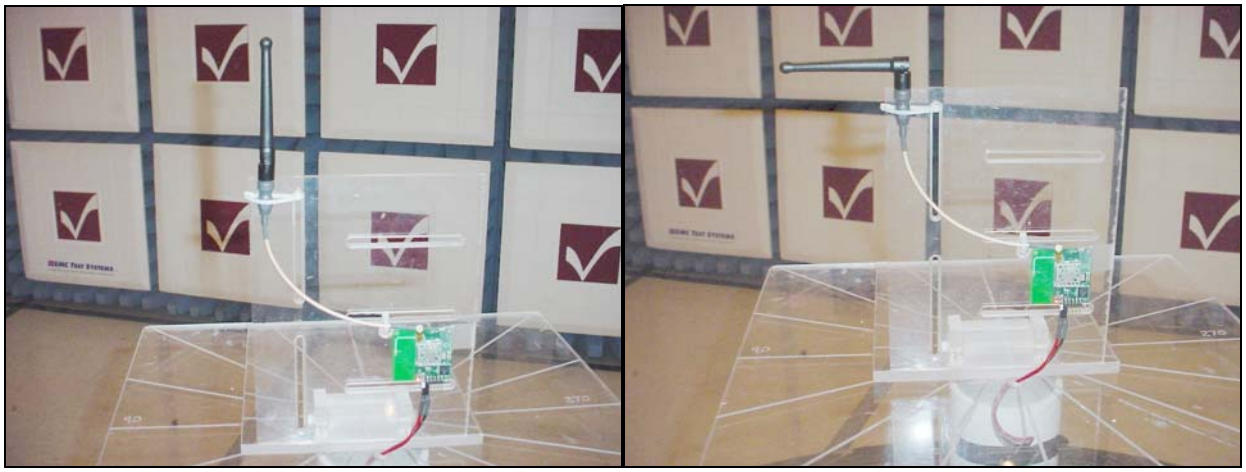
**View of the EUT setup, with the PCB antenna,  in Horizontal orientation.**



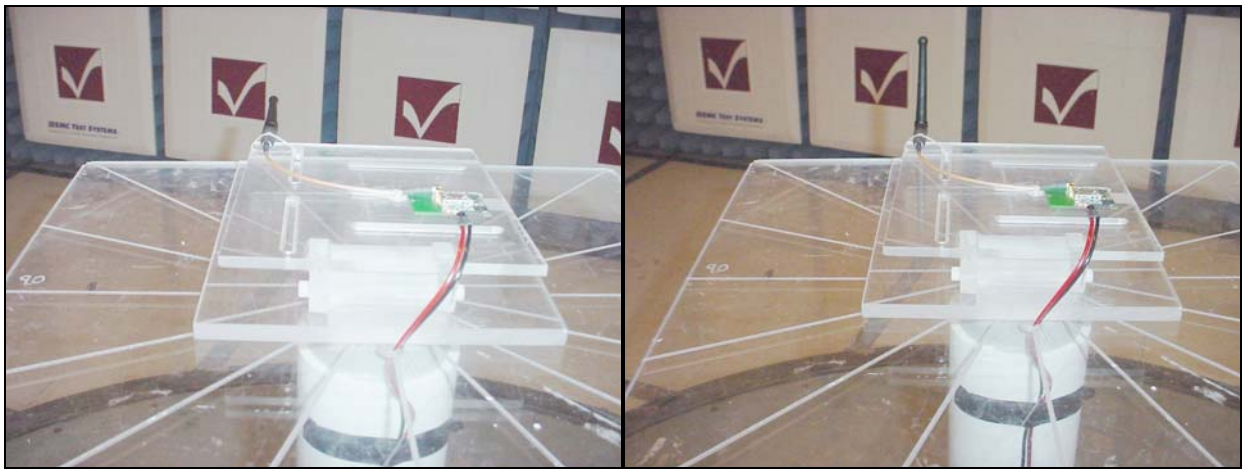
**View of the EUT setup, with the PCB antenna, in Side orientation.**



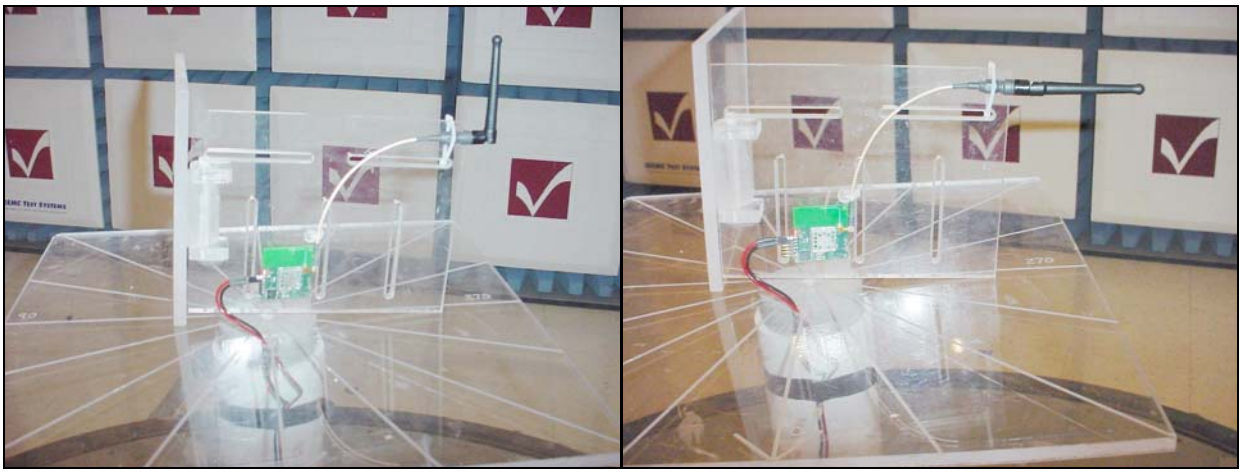
**View of the EUT setup, with the Whip antenna,**
**with EUT in vertical orientation.**



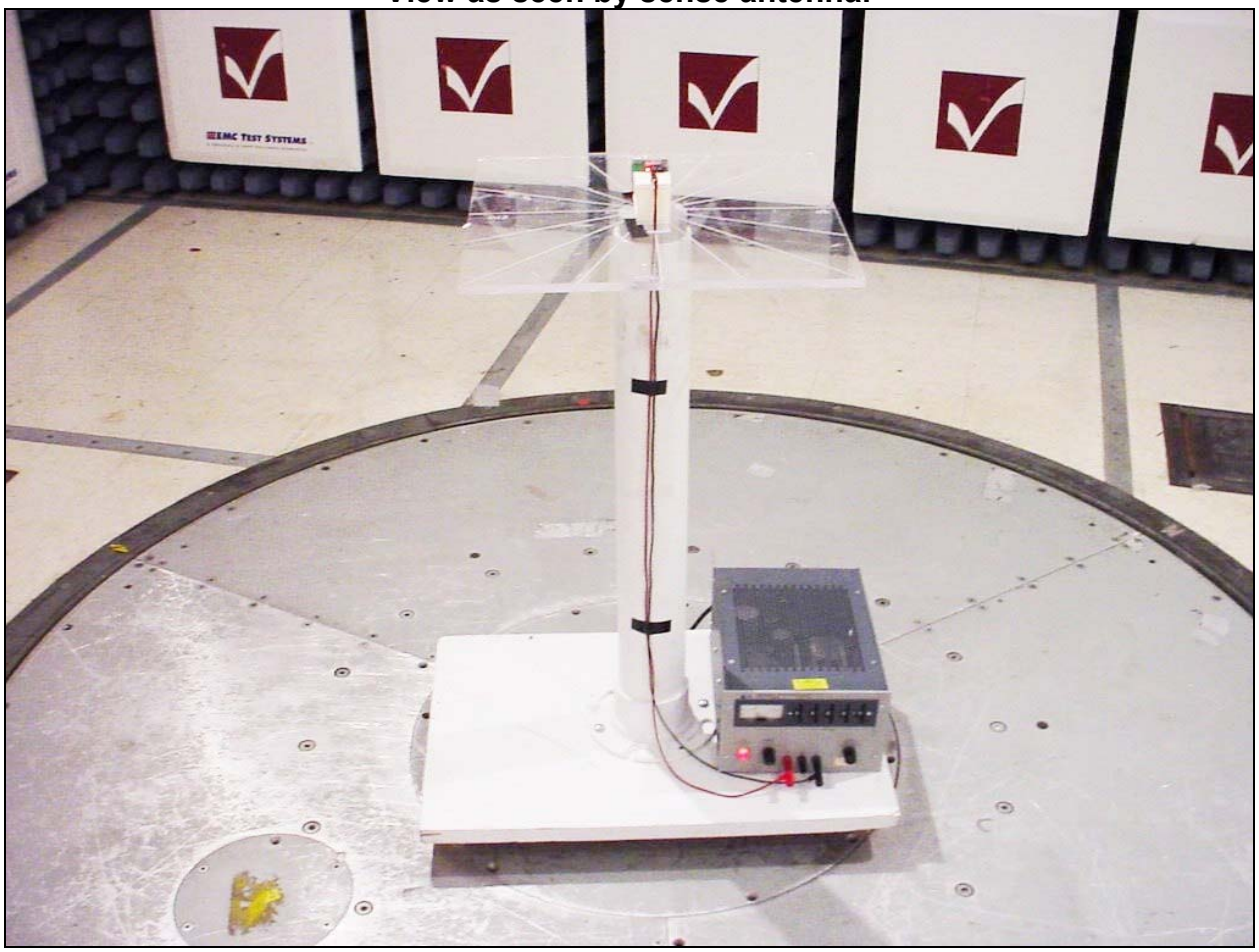
**View of the EUT setups with the Whip antenna,**
**with EUT in Horizontal orientation.**



**View of the EUT setup, with the Whip antenna,**
**With the EUT in Side orientation.**



**EUT setup in the test chamber**
**View as seen by sense antenna.**

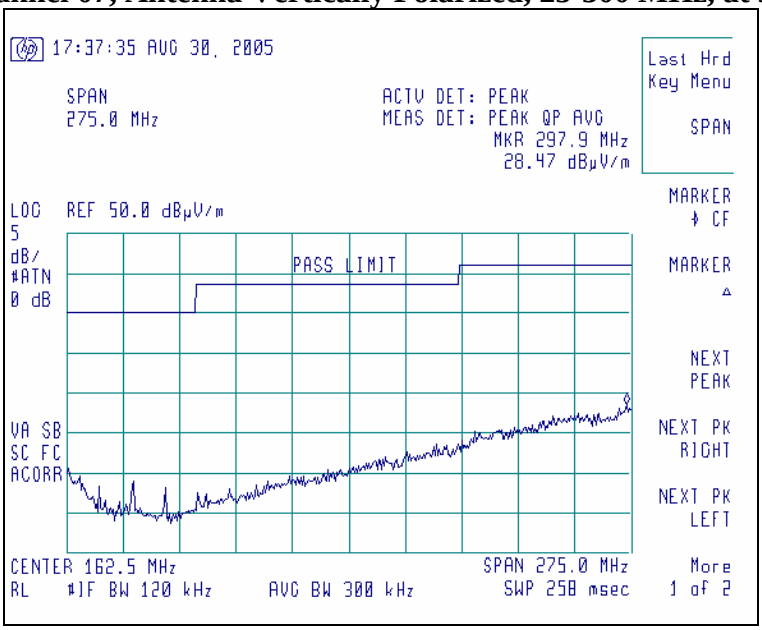


## *Screen Captures of Radiated RF Emissions:*

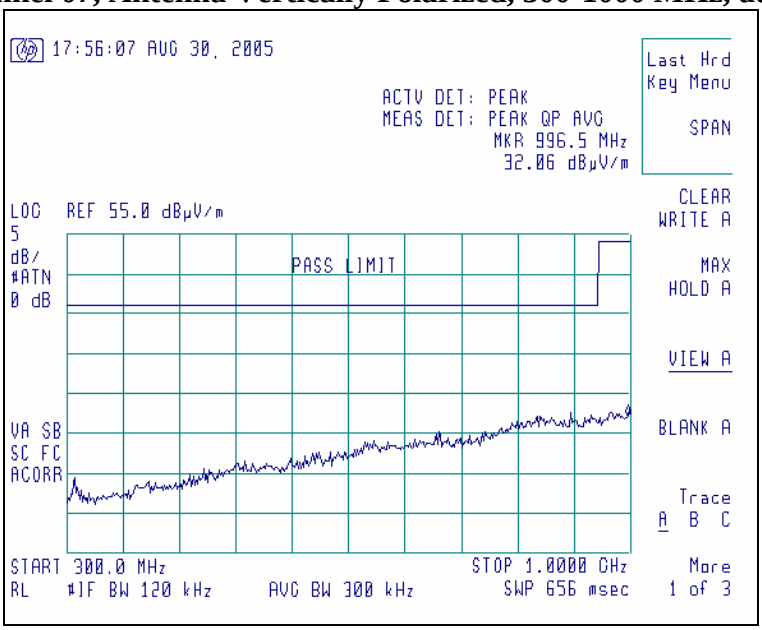
Please note these screen captures represent Peak Emissions. For radiated emission measurements, we utilize a Quasi-Peak detector function when measuring frequencies below 1 GHz, and an Average detector function when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 00, 07, 14 or 15, with the sense and EUT antennas both in vertical polarity for worst case presentations.

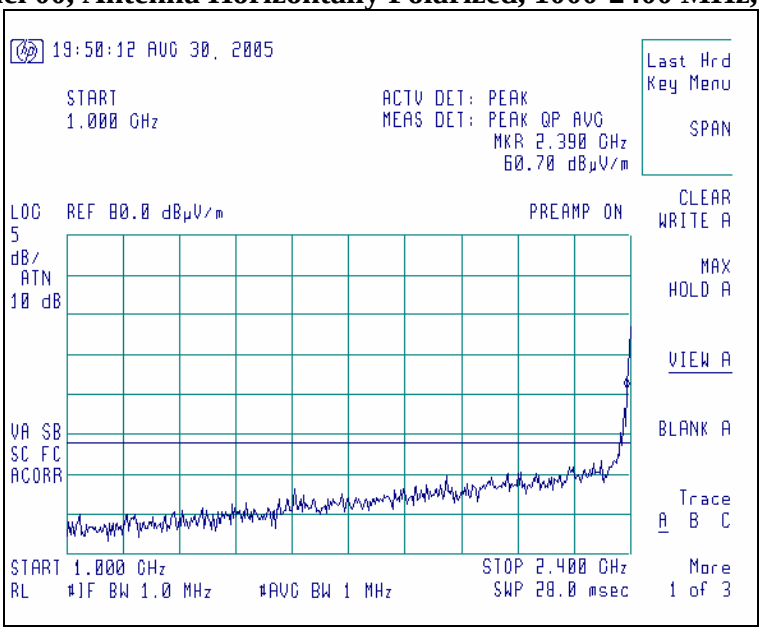
**Channel 07, Antenna Vertically Polarized, 25-300 MHz, at 3m.**



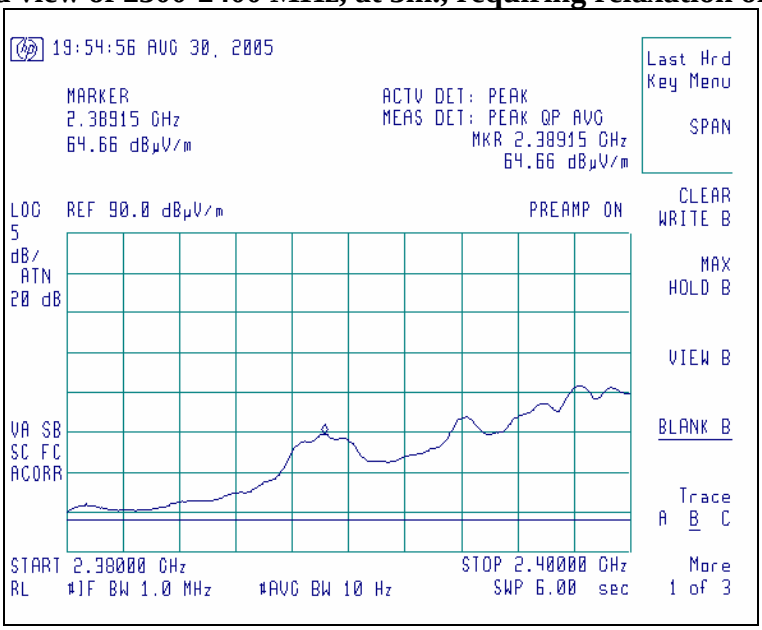

**Channel 07, Antenna Vertically Polarized, 300-1000 MHz, at 3m.**



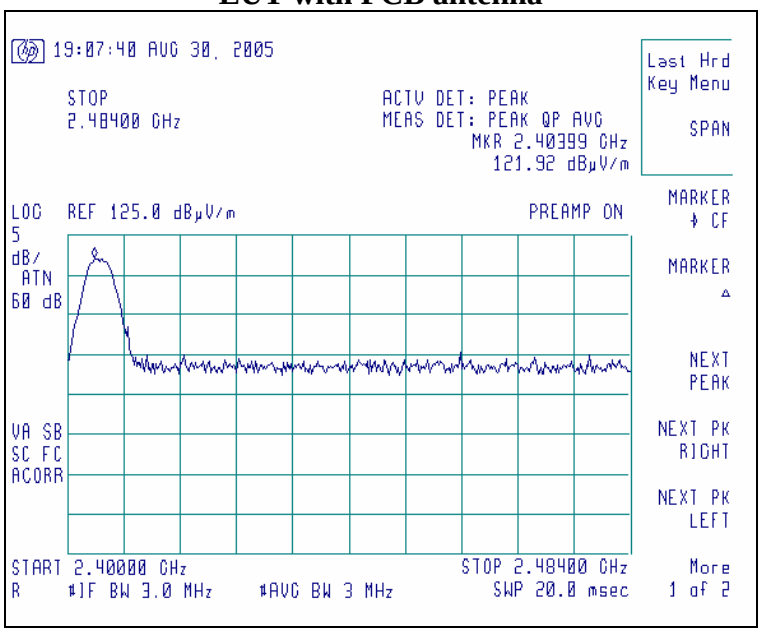
**Channel 00, Antenna Horizontally Polarized, 1000-2400 MHz, at 3m.**



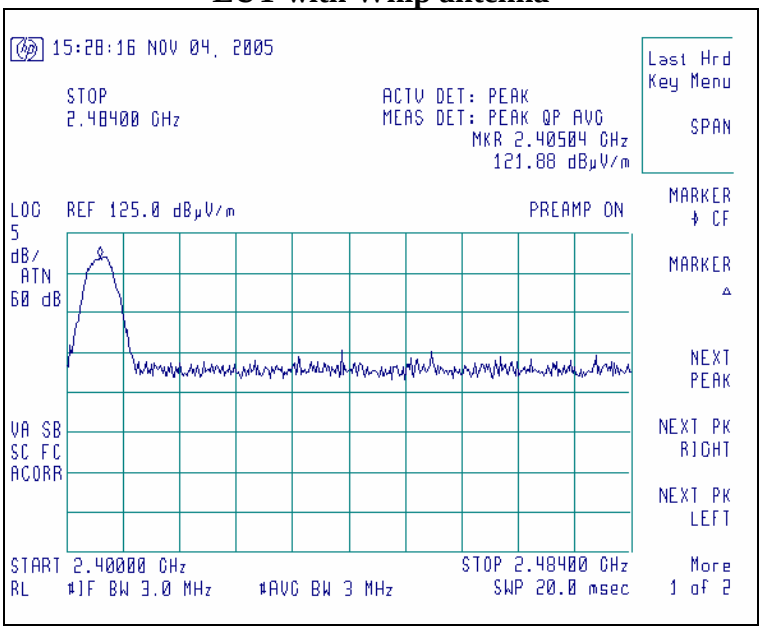

**Channel 00, Antenna Horizontally Polarized,**
**detailed view of 2300-2400 MHz, at 3m., requiring relaxation of limits.**



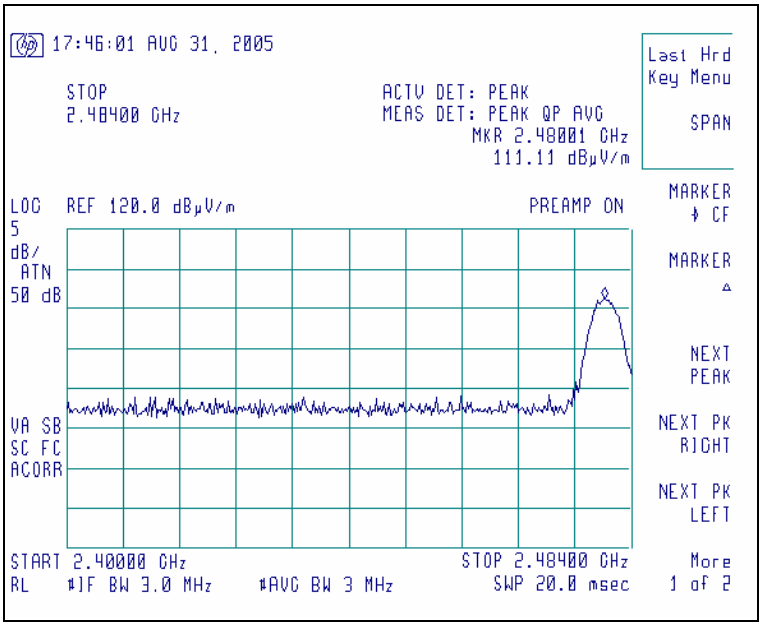
**Channel 00, Antenna Horizontally Polarized, 2400-2484 MHz, at 3m.**
**EUT with PCB antenna**



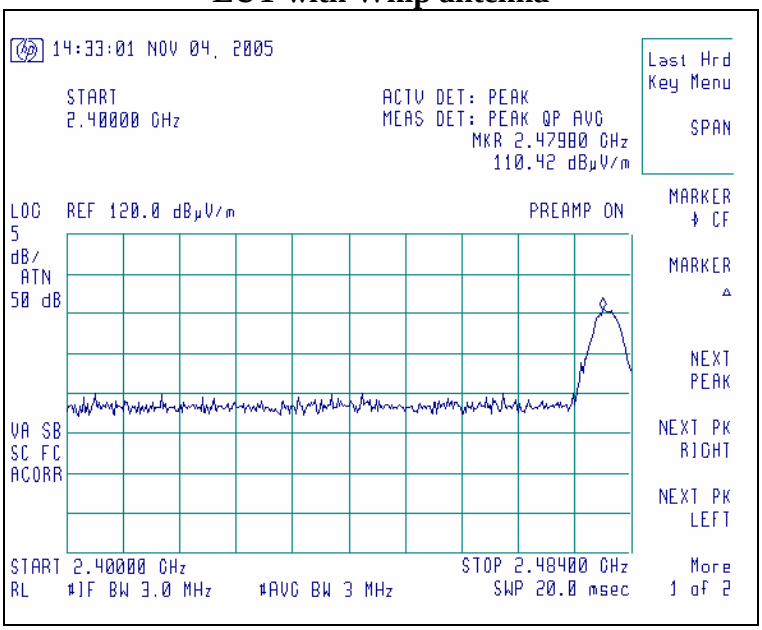

**Channel 00, Antenna Horizontally Polarized, 2400-2484 MHz, at 3m.**
**EUT with Whip antenna**



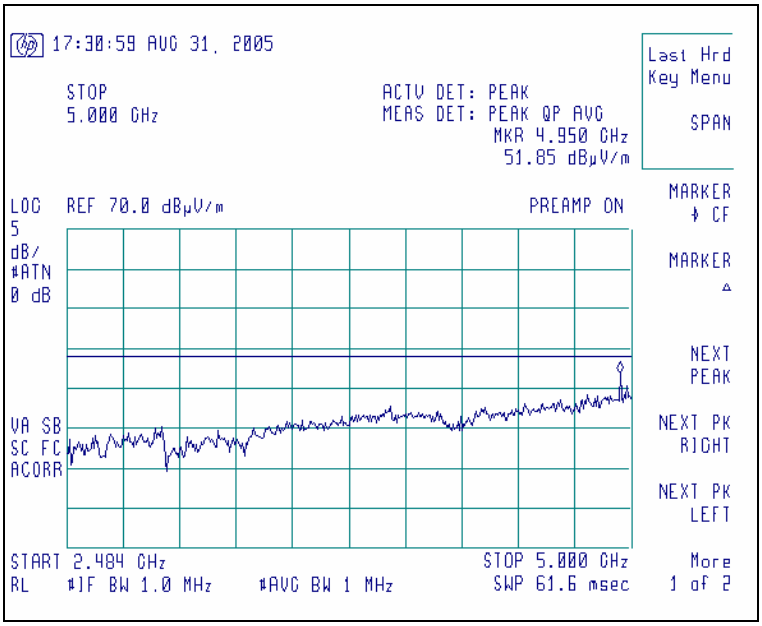
**Channel 15, Antenna Horizontally Polarized, 2400-2484 MHz, at 3m.**
**EUT with PCB antenna**



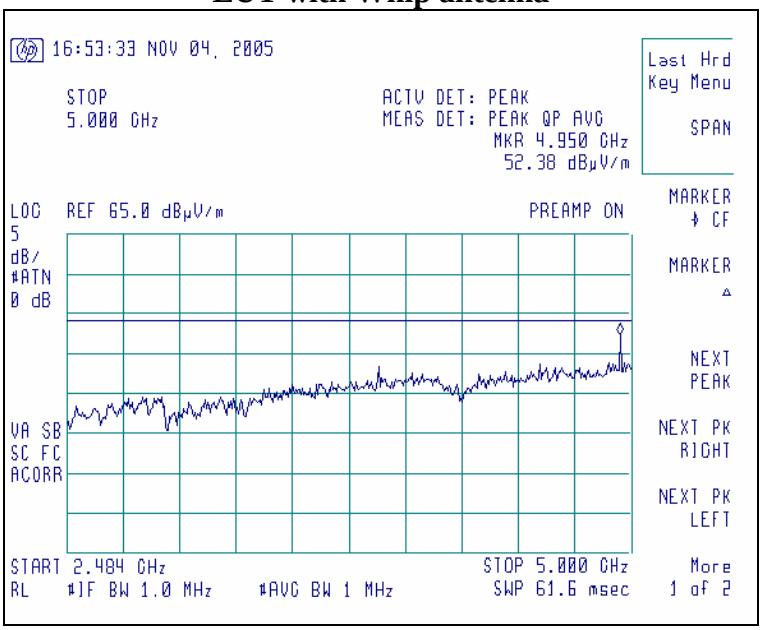

**Channel 15, Antenna Horizontally Polarized, 2400-2484 MHz, at 3m.**
**EUT with Whip antenna**



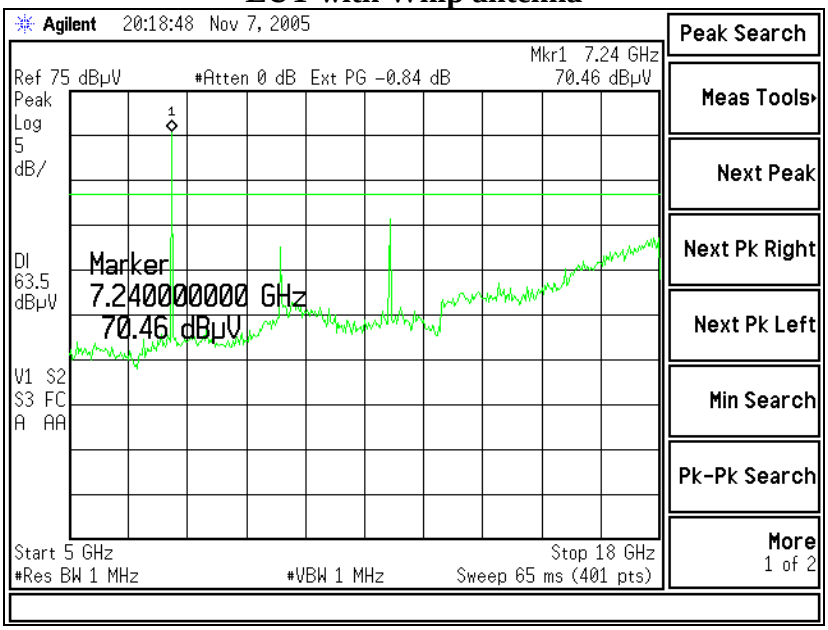
**Channel 14, Antenna Horizontally Polarized, 2484-5000 MHz, at 3m.**
**EUT with PCB antenna**



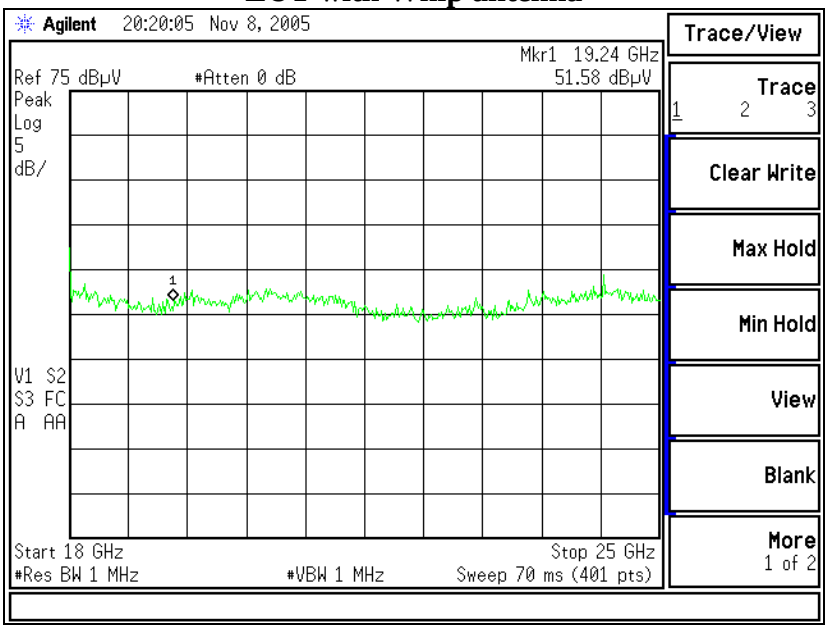

**Channel 14, Antenna Horizontally Polarized, 2484-5000 MHz, at 3m.**
**EUT with Whip antenna**



**Channel 00, Antenna Vertically Polarized, 5000-18000 MHz, at 1m.**
**EUT with Whip antenna**




**Channel 00, Antenna Vertically Polarized, 18000-25000 MHz, at 30cm.**
**EUT with Whip antenna**



## 12. Band-Edge Measurements

FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the band-edges where the intentional radiator operates. The following screen captures demonstrate compliance of the intentional radiator at the 2400-2483.5 MHz band-edges with a relaxation of the limits based on the communication protocol of this product, as described in Appendix D of this report.. The EUT was operated in continuous transmit mode with continuous modulation, with internally generated data as the modulating source. The EUT was operated at the lowest channel for the investigation of the lower band-edge, and at channels 14 and 15 for the investigation of the higher band-edge. The band-edge was investigated with both types of antennas.

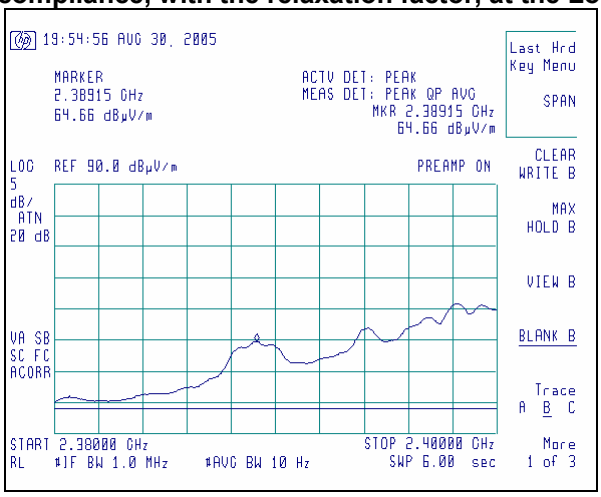
The Lower Band-Edge limit, under part 15.247, would be = -20dBc.
The Upper Band-Edge limit, under part 15.247, would be = 54 dBµV/m at 3 meters.

At the band-edge, a measurement was made with RBW= 1MHz, and VBW= 10 Hz to ensure that the measured emission is below 54.0 dBµV/m at 3meters. A relaxation factor of 20 dB is invoked for the band-edge tests per the declared operation protocol as described in "Appendix D" section of this report.

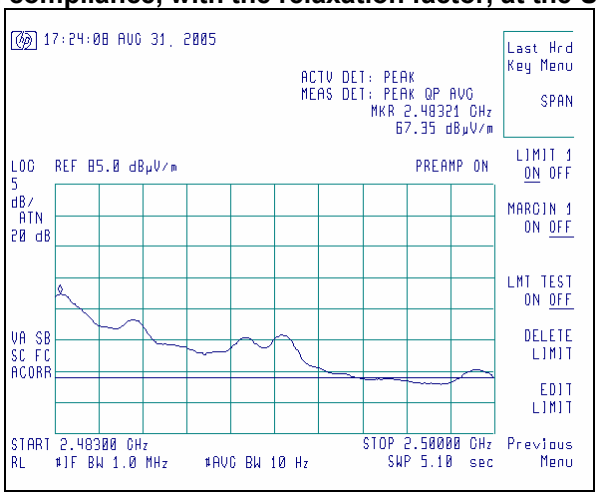
| | Measured Electric Field Intensity dBµV/m | Relaxation dB | Adjusted EFI Measurement dBµV/m at 3mteres |
|---|---|---|---|
| 00 | 65.7 | 20.0 | 45.7 |
| 14 | 67.3 | 20.0 | 47.3 |
| 15 | 66.6 | 20.0 | 46.6 |

## EUT with PCB antenna

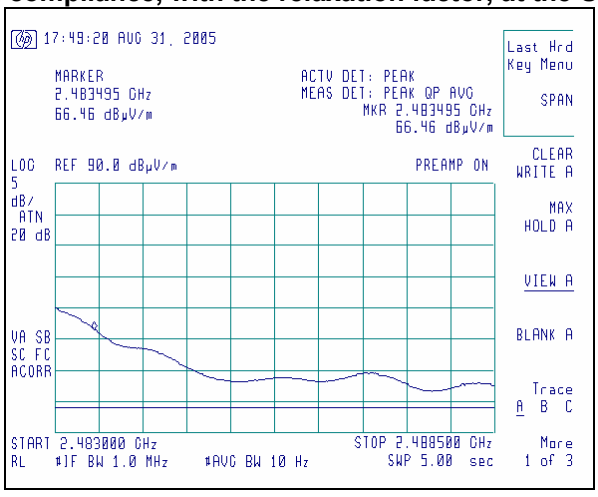
**Screen Capture showing compliance, with the relaxation factor, at the Lower Band-Edge (Ch: 00)**




**Screen Capture showing compliance, with the relaxation factor, at the Upper Band-Edge (Ch: 14)**

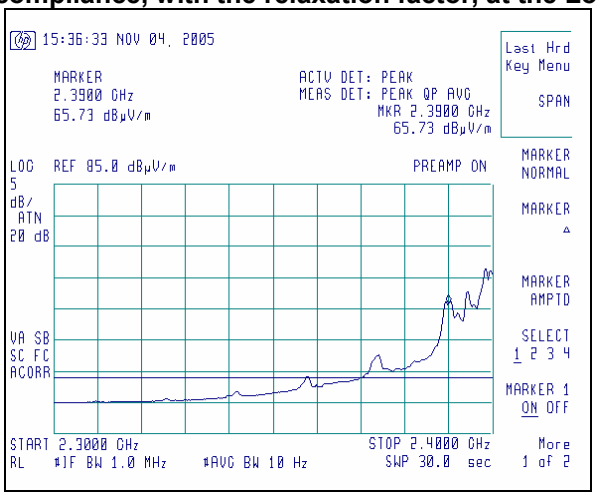



**Screen Capture showing compliance, with the relaxation factor, at the Upper Band-Edge (Ch: 15)**

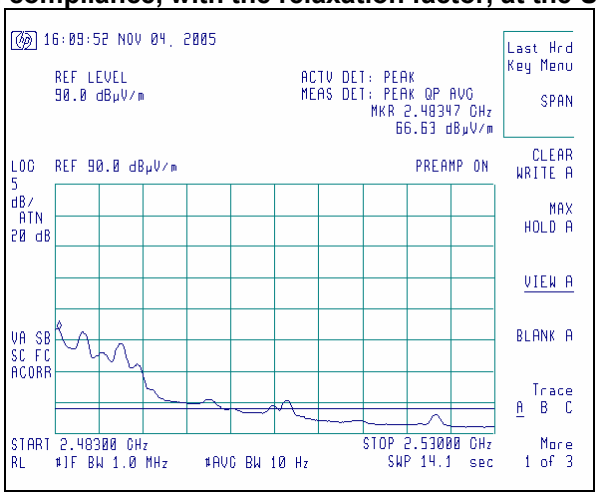


## EUT with Whip antenna

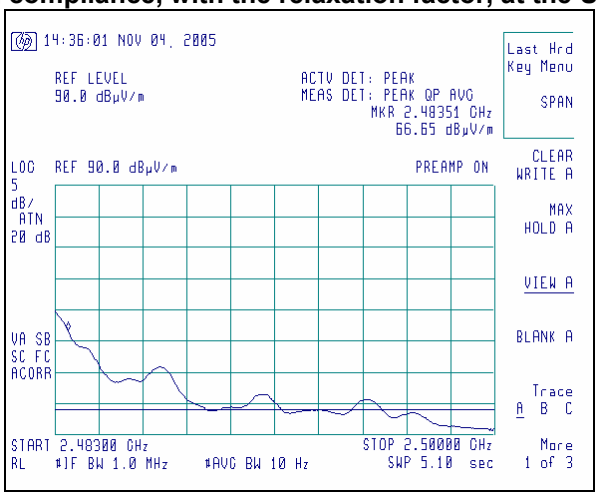
**Screen Capture showing compliance, with the relaxation factor, at the Lower Band-Edge (Ch: 00)**




**Screen Capture showing compliance, with the relaxation factor, at the Upper Band-Edge (Ch: 14)**




**Screen Capture showing compliance, with the relaxation factor, at the Upper Band-Edge (Ch: 15)**



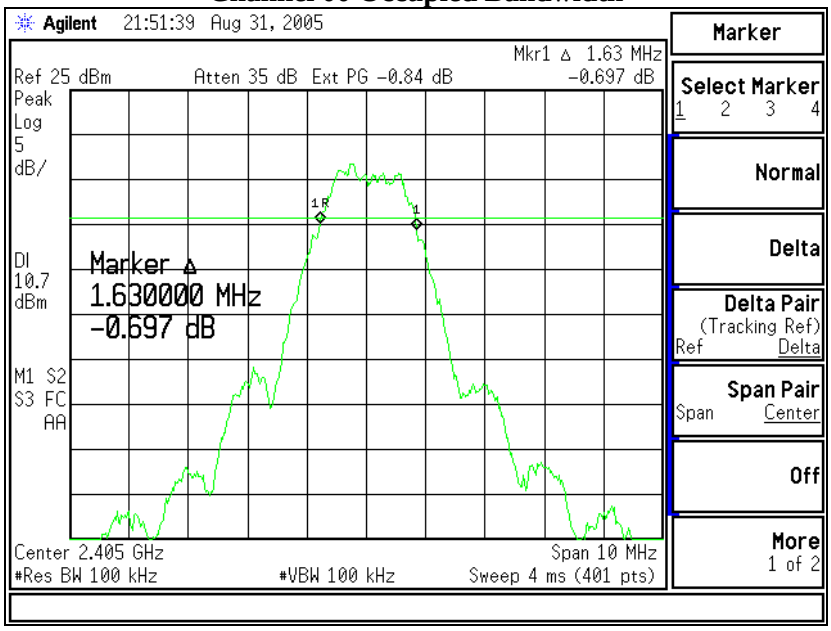
## 13. Occupied Bandwidth

The bandwidth requirement found in FCC Part 15.247(a)(2) requires a minimum -6dBc occupied bandwidth of 500 kHz. For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to the HP E4407B spectrum analyzer. The loss from the cable was added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. A Hewlett Packard model E4407B spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used in peak-hold mode while measurements were made, as presented in the chart below.

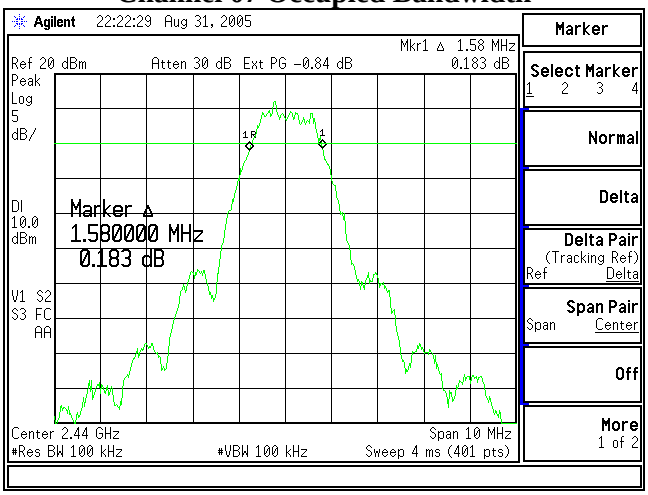
| Channel | Center Frequency (MHz) | Measured 6 dB BW (kHz) | Minimum Limit (kHz) |
|---|---|---|---|
| 00 | 2405 | 1630 | 500 |
| 07 | 2440 | 1580 | 500 |
| 14 | 2475 | 1580 | 500 |
| 15 | 2480 | 1600 | 500 |

### Plots of Occupied Bandwidth

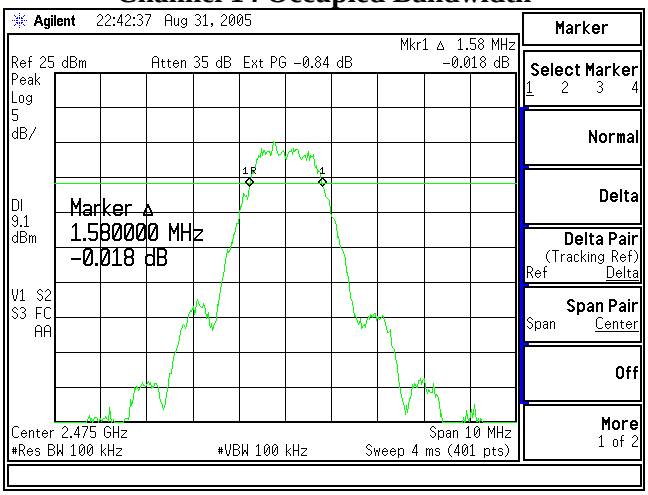
**Channel 00 Occupied Bandwidth**



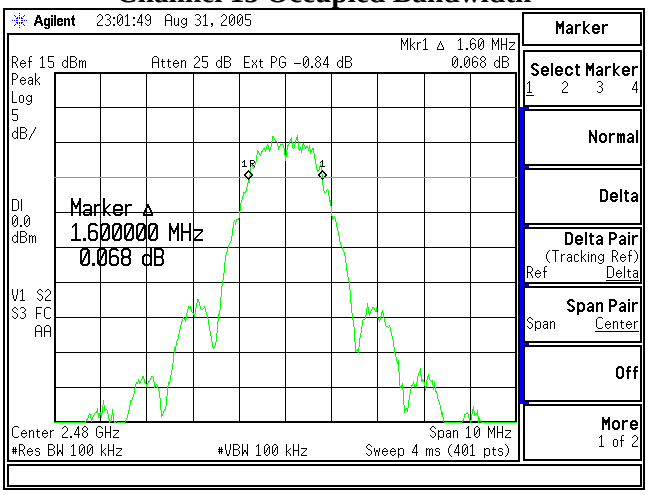
## Channel 07 Occupied Bandwidth




## Channel 14 Occupied Bandwidth




## Channel 15 Occupied Bandwidth



## 14. Conducted RF Emissions Test on AC Power Line

### Test Setup

The Conducted Emissions test was performed at L.S. Compliance, Inc. in Cedarburg, Wisconsin. The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15 (Industry Canada RSS-210). The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power was derived from a bench-type DC power supply, and the power supply was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120VAC, 60 Hz, was provided inside the Shielded Room via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to a 10 dB Attenuator-Limiter, and then to the HP 8546A EMI Receiver. The EMCO LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either phase.

### Test Procedure

The EUT was investigated in continuous transmit mode, with modulation from typical data pattern, for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, as specified in CISPR 16-1 (2003), Section 1, Table 1, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30MHz. Final readings were then taken and recorded.

### Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. Calibrations of the LISN and Limiter are traceable to N.I.S.T. All cables are calibrated and checked periodically for conformance. The emissions are measured on the HP 8546A EMI Receiver, which has automatic correction for all factors stored in memory and allows direct readings to be taken.

### Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15.207 Conducted Emissions for an Intentional Radiator. See the Data Charts and Graphs for more details of the test results.

# Calculation of Conducted Emissions Limits

The following table describes the Class B limits for an intentional radiator. These limits are obtained from Title 47 CFR, Part 15.107 (a) for Conducted Emissions.

| Frequency (MHz) | Quasi-Peak Limit (dBµV) | Average Limit (dBµV) |
|---|---|---|
| 0.15 – 0.5 | 66 – 56 * | 56 - 46 |
| 0.5 – 5.0 | 56 | 46 |
| 5.0 – 30.0 | 60 | 50 |

* Decreases with the logarithm of the frequency.

Sample calculation for the limits in the 0.15 to 0.5 MHz:

$$\text{Limit} = -19.12 \left( \text{Log}_{10} \left( F[\text{MHz}] / 0.15\ [\text{MHz}] \right) \right) + 66.0\ \text{dB}\mu\text{V}$$

For a frequency of 200 kHz for example:

$$\text{Quasi-Peak Limit (F = 200kHz)} = -19.12 \left( \text{Log}_{10} \left( 0.2[\text{MHz}] / 0.15\ [\text{MHz}] \right) \right) + 66.0\ \text{dB}\mu\text{V}$$

$$\text{Quasi-Peak Limit (F = 200kHz)} = 63.6\ \text{dB}\mu\text{V}$$

$$\text{Average Limit (F=200kHz)} = -19.12 \left( \text{Log}_{10} (0.2[\text{MHz}]/0.15[\text{MHz}]) \right) + 56.0\ \text{dB}\mu\text{V}$$

$$\text{Average Limit (F = 200 kHz)} = 53.6\ \text{dB}\mu\text{V}$$

# Measurement of Electromagnetic Conducted Emission

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 (a)

| | | | | | | |
|---|---|---|---|---|---|---|
| Manufacturer: | NERTEC Design, Incorporated | | | | | |
| Date(s) of Test: | August 8TH through November 8TH, 2005 | | | | | |
| Test Engineer: | | Tom Smith | √ | Abtin Spantman | | Ken Boston |
| Model #: | EM-0018B | | | | | |
| Serial #: | 201 | | | | | |
| Voltage: | 3.3 VDC | | | | | |
| Operation Mode: | Normal operation and continuous transmit with modulation | | | | | |
| Test Location: | √ | Shielded Room | | | | Chamber |
| EUT Placed On: | √ | 40cm from Vertical Ground Plane | | | | 10cm Spacers |
| | √ | 80cm above Ground Plane | | | | Other: |
| Measurements: | | Pre-Compliance | | Preliminary | √ | Final |
| Detectors Used: | | Peak | √ | Quasi-Peak | √ | Average |

**Environmental Conditions in the Lab:**

Temperature: 20 – 25° C

Atmospheric Pressure: 86 kPa – 106 kPa

Relative Humidity: 30 – 60%

**Test Equipment Utilized:**

EMI Receiver: HP 8546A

LISN: EMCO 3816/2NM

Transient Limiter: HP 119474A

| | | QUASI-PEAK | | | AVERAGE | | |
|---|---|---|---|---|---|---|---|
| Frequency (MHz) | Line | Q-Peak Reading (dBµV/m) | Q-Peak Limit (dBµ V/m) | Quasi-Peak Margin (dB) | Average Reading (dBµV/m) | Average Limit (dBµ V/m) | Average Margin (dB) |
| 0.155 | L1 | 49.0 | 65.7 | 16.7 | 21.7 | 55.7 | 34.0 |
| 0.310 | L1 | 43.6 | 60.0 | 16.4 | 16.6 | 50.0 | 33.4 |
| 0.337 | L1 | 43.1 | 59.3 | 16.2 | 15.9 | 49.3 | 33.4 |
| 0.381 | L1 | 41.1 | 58.3 | 17.2 | 13.8 | 48.3 | 34.5 |
| 0.606 | L1 | 34.8 | 56.0 | 21.2 | 6.5 | 46.0 | 39.5 |
| | | | | | | | |
| 0.155 | L2 | 48.0 | 65.7 | 17.7 | 21.9 | 55.7 | 33.8 |
| 0.265 | L2 | 44.0 | 61.3 | 17.3 | 17.1 | 51.3 | 34.2 |
| 0.310 | L2 | 44.1 | 60.0 | 15.9 | 17.2 | 50.0 | 32.8 |
| 0.630 | L2 | 42.9 | 58.7 | 15.8 | 15.7 | 48.7 | 33.0 |
| 0.468 | L2 | 38.9 | 56.6 | 17.7 | 11.4 | 46.6 | 35.2 |

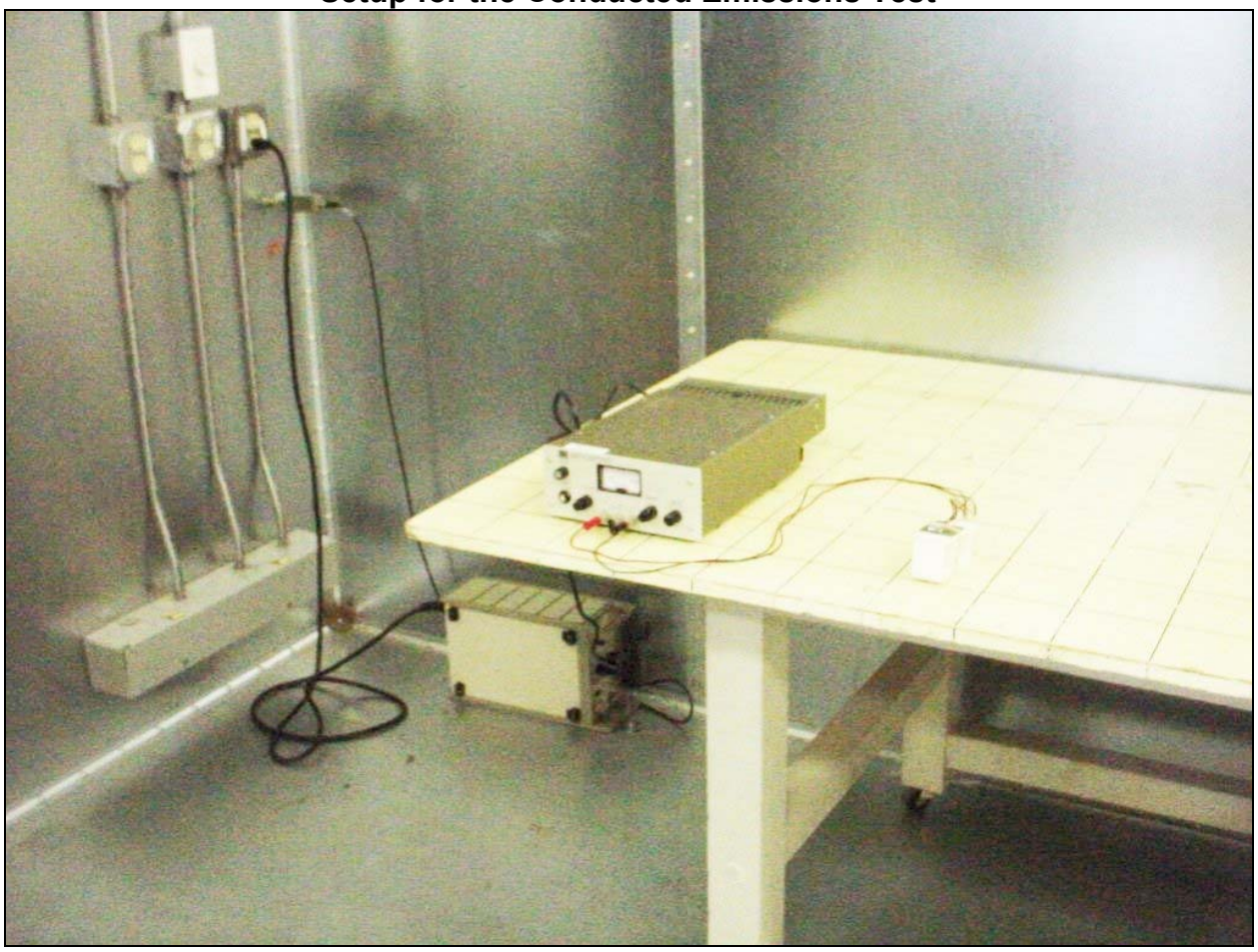
**Notes:**

1) The emissions listed are characteristic of the bench DC power supply used, and were not affected by the EUT.

2) All other emissions were better than 20 dB below the limits.

3) The EUT exhibited similar emissions in transmit and receive modes, and across the Low, Middle and High channels tested.

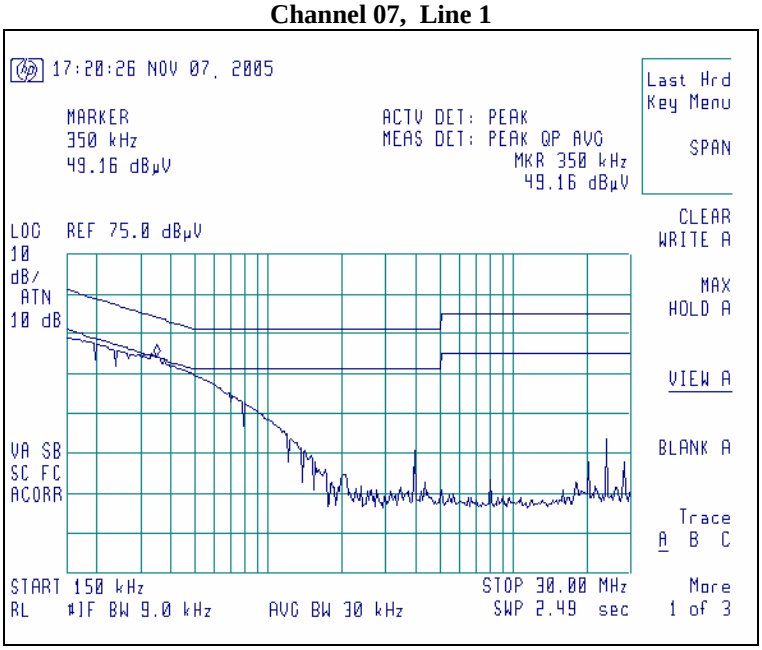
## Setup for the Conducted Emissions Test



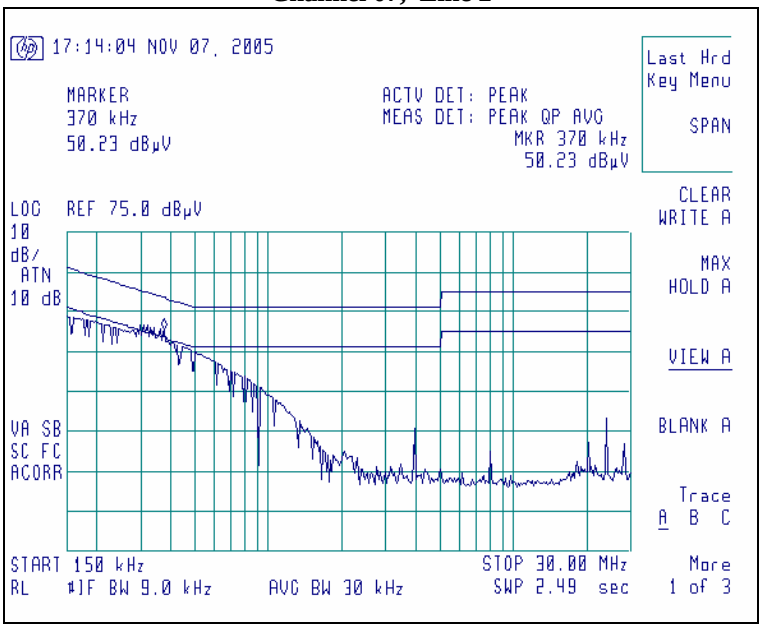
# Screen Captures of Conducted AC Mains Emissions:

*Please note these screen captures represent Peak Emissions. For conducted emission measurements, we utilize both a Quasi-Peak detector function as well as the Average detector function for measurements. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.207.*
*The signature scans shown here are from channel 07, chosen as being a good representative of channels.*

**Channel 07, Line 1**



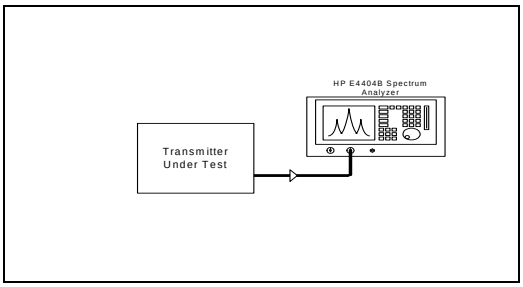

**Channel 07, Line 2**



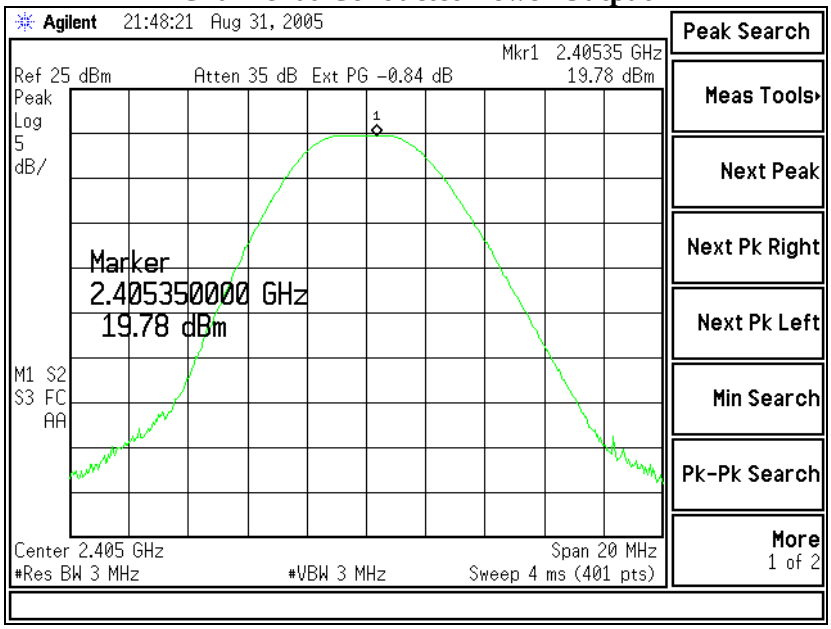
## 15. Power Output 15.247(b)

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable for the spectrum analyzer. The loss from the cable was added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with resolution and video bandwidths set to 3 MHz, and a span of 20 MHz, with measurements from a peak detector presented in the chart below. RF Power Output was also monitored while varying the DC voltage as sourced by a DC bench type power supply. No discernable variation in output power was seen while setting the DC voltage to 2.80 VDC (-15%) or to 3.80 VDC (+15%).

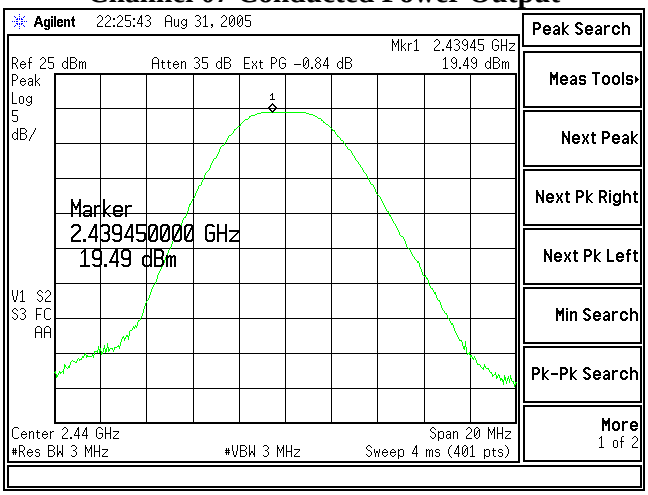
| CHANNEL | CENTER FREQ (MHz) | LIMIT (dBm) | MEASURED POWER (dBm) | MARGIN (dB) |
|---|---|---|---|---|
| 00 | 2405 | + 30 dBm | + 19.8 | 10.2 |
| 07 | 2440 | + 30 dBm | + 19.5 | 10.5 |
| 14 | 2475 | + 30 dBm | + 18.6 | 11.4 |
| 15 | 2480 | + 30 dBm | + 9.4 | 20.6 |



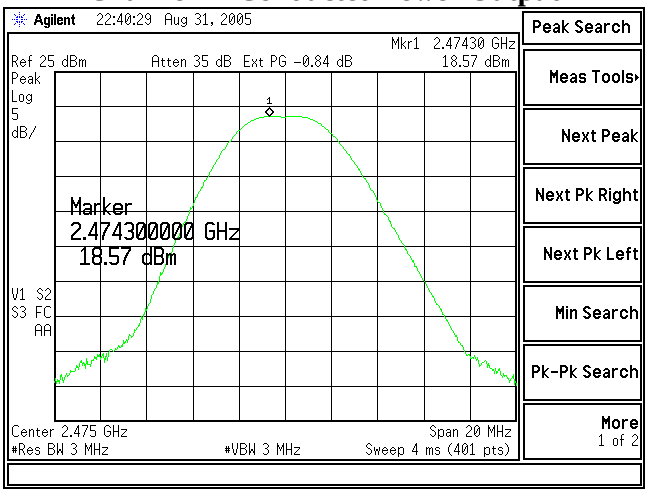

**Channel 00 Conducted Power Output**



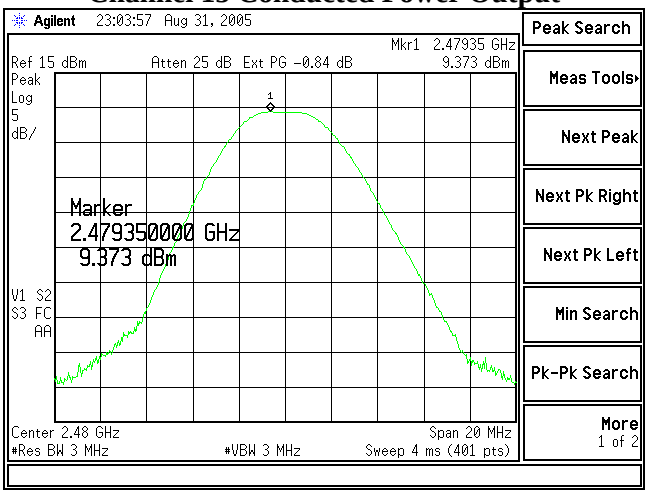
## Channel 07 Conducted Power Output




## Channel 14 Conducted Power Output




## Channel 15 Conducted Power Output



## 16. Spurious Emissions 15.247(d)

FCC Part 15.247(d) requires a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable. The loss from the cable was added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. A Hewlett Packard model E4407B spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

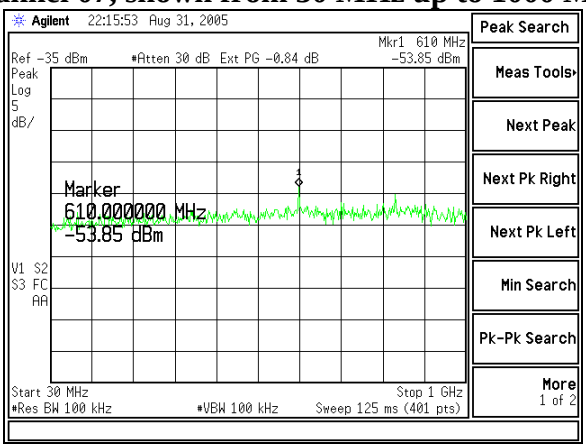
No significant emissions could be noted within -60 dBc of the fundamental level for this product.

| | Channel 00 | Channel 07 | Channel 14 | Channel 15 |
|---|---|---|---|---|
| Fundamental | + 14.4 (dBm) | + 13.9 (dBm) | + 14.1 (dBm) | + 5.1 (dBm) |
| 2nd Harmonic | - 60.2 (dBm) | - 59.5 (dBm) | -61.2 (dBm) | - 80.0 (dBm) |
| 3rd Harmonic | - 73.2 (dBm) | - 65.9 (dBm) | -62.7 (dBm) | - 74.2 (dBm) |
| 4th Harmonic | - 80.1 (dBm) | - 78.9 (dBm) | - 79.6 (dBm) | - 81.0 (dBm) |
| 5th Harmonic | - 71.6 (dBm) | - 74.0 (dBm) | - 76.1 (dBm) | - 81.6 (dBm) |
| 6th Harmonic | Note (1) | Note (1) | Note (1) | Note (1) |
| 7th Harmonic | Note (1) | Note (1) | Note (1) | Note (1) |
| 8th Harmonic | Note (1) | Note (1) | Note (1) | Note (1) |
| 9th Harmonic | Note (1) | Note (1) | Note (1) | Note (1) |
| 10th Harmonic | Note (1) | Note (1) | Note (1) | Note (1) |

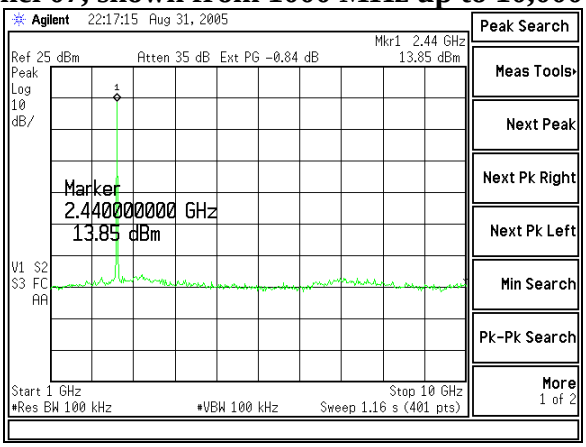
Notes:
(1) Measurement at system noise floor.

**Representative plots for the middle channel are presented here, for the conducted RF spurious measurements.**

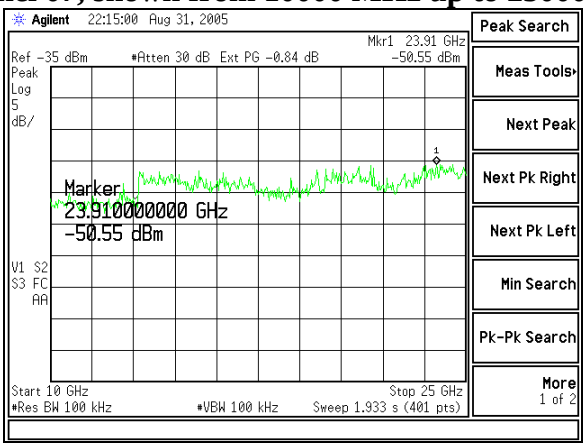
**Channel 07, shown from 30 MHz up to 1000 MHz**




**Channel 07, shown from 1000 MHz up to 10,000 MHz**




**Channel 07, shown from 10000 MHz up to 25000 MHz**

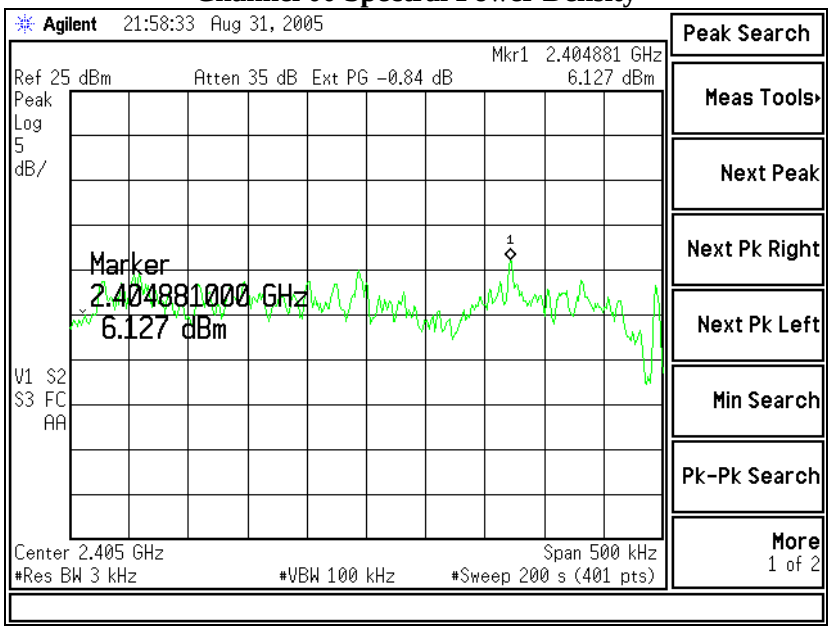


## 17. Spectral Density

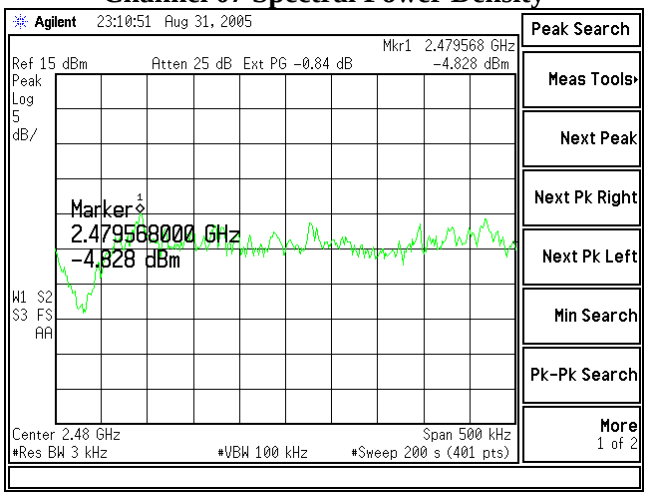
In accordance with FCC Part 15.247(e), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in previous sections. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep, and a power density measurement was performed. The highest density was found to be no greater than approximately +6.2 dBm, which is under the allowable limit by 1.8 dB.

| Channel | Center Frequency (MHz) | Measured Power (dBm/3kHz) | Limit (dBm/3kHz)) | Margin (dB) |
|---|---|---|---|---|
| 00 | 2405 | + 6.2 dBm | +8 dBm | 1.8 |
| 07 | 2440 | + 5.1dBm | +8 dBm | 2.9 |
| 14 | 2475 | + 3.8 dBm | +8 dBm | 4.2 |
| 15 | 2480 | - 4.8 dBm | +8 dBm | 12.8 |

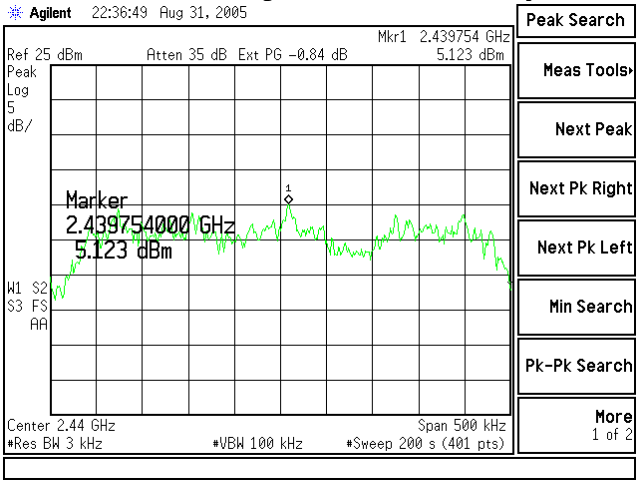
**Channel 00 Spectral Power Density**



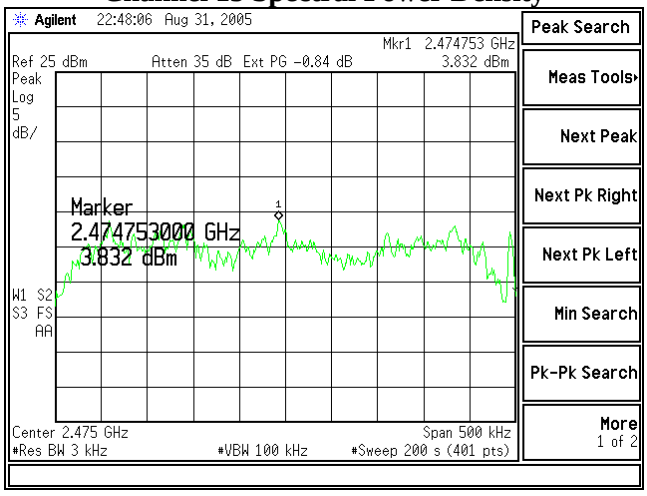
## Channel 07 Spectral Power Density




## Channel 14 Spectral Power Density




## Channel 15 Spectral Power Density



## 18. Frequency and Power Stability over Voltage and Temperature Variations

The stability of the device was examined as a function of the input voltage available to the EUT.
A Spectrum Analyzer was used to measure the frequency at the appropriate frequency markers. For this test, the EUT was placed in continuous transmit CW mode. Power to the EUT was supplied by an external bench-type variable power supply. The frequency of operation was monitored using the spectrum analyzer with RBW=VBW=100Hz settings while the voltage was varied.

| | DC Voltage Source | | |
|---|---|---|---|
| | 2.81 V | 3.30 V | 3.80 V |
| Channel 00 | 2405.007070 (MHz) | 2405.006730 (MHz) | 2405.007070 (MHz) |
| Channel 07 | 2440.007530 (MHz) | 2440.007030 (MHz) | 2440.007200 (MHz) |
| Channel 15 | 2480.006670 (MHz) | 2480.008900 (MHz) | 2480.009400 (MHz) |

The RF power output of the EUT was also monitored in a separate test, also using a spectrum analyzer with RBW=VBW=3MHz setting while the voltage was varied.

| | DC Voltage Source | | |
|---|---|---|---|
| | 2.81 V | 3.30 V | 3.80 V |
| Channel 00 | + 16.1 (dBm) | + 19.8 (dBm) | + 20.7 (dBm) |
| Channel 07 | + 16.0 (dBm) | + 19.5 (dBm) | + 20.3 (dBm) |
| Channel 15 | + 6.5 (dBm) | + 9.4 (dBm) | + 9.6 (dBm) |

The power was then cycled On/Off to observe system response. No unusual response was observed during power loss, the emission characteristics were well behaved, and the system returned to the proper power-up state (standby state, not transmitting).

## 19. MPE Calculations

The following MPE calculations are based on the Centurion whip antenna, with a measured EFI of 120.4 dBµV/m, at 3 meters, and conducted RF power of +19.8 dBm as presented to the antenna. The declared gain of the antenna is listed as 2.0 dBi, but the calculated gain of this antenna, as used in the calculations below, based on the EFI measurements is 5.4 dB.

***Antenna Type:***
***Centurion Wireless Technologies, Incorporated,***
***model number "WCR-2400-SMRP"***

**Prediction of MPE limit at a given distance**

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

| | | |
|---|---|---|
| Maximum peak output power at antenna input terminal: | 19.80 | (dBm) |
| Maximum peak output power at antenna input terminal: | 95.499 | (mW) |
| Antenna gain(typical): | 5.4 | (dBi) |
| Maximum antenna gain: | 3.467 | (numeric) |
| Prediction distance: | 20 | (cm) |
| Prediction frequency: | 2400 | (MHz) |
| MPE limit for uncontrolled exposure at prediction frequency: | 1 | (mW/cm^2) |
| Power density at prediction frequency: | 0.065876 | (mW/cm^2) |
| Maximum allowable antenna gain: | 17.2 | (dBi) |
| Margin of Compliance at 20 cm = | 11.8 | dB |

# Appendix A

## Test Equipment List

| Asset # | Manufacturer | Model # | Serial # | Description | Date | Due |
|---|---|---|---|---|---|---|
| AA960008 | EMCO | 3816/2NM | 9701-1057 | Line Impedance Stabilization Network | 9/27/05 | 9/27/06 |
| AA960031 | HP | 119474A | 3107A01708 | Transient Limiter | Note 1 | Note 1 |
| AA960077 | EMCO | 93110B | 9702-2918 | Biconical Antenna | 9/27/05 | 9/27/06 |
| AA960078 | EMCO | 93146 | 9701-4855 | Log-Periodic Antenna | 9/27/05 | 9/27/06 |
| AA960081 | EMCO | 3115 | 6907 | Double Ridge Horn Antenna | 12/07/05 | 12/07/06 |
| CC00221C | Agilent | E4407B | US39160256 | Spectrum Analyzer | 12/29/05 | 12/29/06 |
| EE960004 | EMCO | 2090 | 9607-1164 | Device Controller | N/A | N/A |
| EE960013 | HP | 8546A | 3617A00320 | Receiver RF Section | 9/29/05 | 9/29/06 |
| EE960014 | HP | 85460A | 3448A00296 | Receiver Pre-Selector | 9/29/05 | 9/29/06 |
| N/A | LSC | Cable | 0011 | 3 Meter ½" Armored Cable | Note 1 | Note 1 |
| N/A | LSC | Cable | 0050 | 10 Meter RG 214 Cable | Note 1 | Note 1 |
| N/A | Pasternack | Attenuator | N/A | 10 dB Attenuator | Note 1 | Note 1 |

*Note 1 - Equipment calibrated within a traceable system.*

## Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed
at approximately the 95% confidence level, using a coverage factor of k=2.

*Table of Expanded Uncertainty Values, (K=2) for Specified Measurements*

| Measurement Type | Particular Configuration | Uncertainty Values |
|---|---|---|
| Radiated Emissions | 3 – Meter chamber, Biconical Antenna | 4.24 dB |
| Radiated Emissions | 3-Meter Chamber, Log Periodic Antenna | 4.8 dB |
| Radiated Emissions | 10-Meter OATS, Biconical Antenna | 4.18 dB |
| Radiated Emissions | 10-Meter OATS, Log Periodic Antenna | 3.92 dB |
| Conducted Emissions | Shielded Room/EMCO LISN | 1.60 dB |
| Radiated Immunity | 3 Volts/Meter in 3-Meter Chamber | 1.128 Volts/Meter |
| Conducted Immunity | 3 Volts level | 1.0 V |

# Appendix B
## Antenna Specification

There are two antenna types defined for use with this EUT.

The first antenna type defined is a 2.5 cm printed circuit board trace antenna.

The second antenna type defined is a Whip type dipole antenna, model number "WCR-2400-SMRP", manufactured by Centurion Wireless Technologies, Incorporated. The antenna is equipped with a reverse gender SMA connector, and is connected to the EUT through a 15 centimeter long RG-178 type cable, with a reverse-gender MMCX type connector.

CENTURION Specifications

*WCR*

Model Number: **WCR2400**

**External Antenna – Connector Mount**

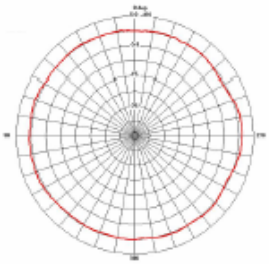
**Specifications:**

- ½ wave coaxial dipole
- Clutch allows 360º rotation
- Flexible element
- FCC Part 15 compliant polarized connector

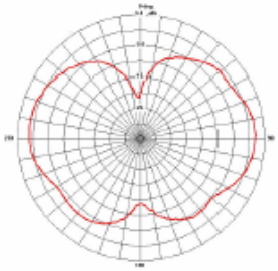
| | | |
|---|---|---|
| **Frequency** | 2.4 – 2.5 GHz | |
| **Polarization** | Vertical | |
| **Gain** | MMCX | 1.0 dBi |
| | SMA | 2.0 dBi |
| | SMRP | 1.0 dBi |
| **Nominal Impedance** | 50 ohms | |
| **VSWR** | 1.5:1 max at resonance | |
| **RF Power Handling** | 50 watts | |
| **Size (Length)** | 8cm | |
| **Temperature Range** | -40º to +80ºC | |
| **Drop Test** | 1M | |


**Connectors:**

| Model # | Part # | Connector |
|---|---|---|
| **WCR2400-MMCX** | WCR2400MMCX | MMCX Straight |
| **WCR2400-SMA** | WCR2400SMA | SMA-Male |
| **WCR2400-SMRP** | WCR2400SMRP | RP-SMA-Male (gold) |



**Azimuth**
WCR2400MMCX



**Elevation**
WCR2400MMCX


Specifications subject to change without notice. WCRb – 1/17/05

CENTURION

3425 N.44th Street, LINCOLN, NE 68504 USA
**SALES PHONE:** 800.228.4563
**PHONE:** 402.467.4491 • **FAX:** 402.467.4528
**www.centurion.com • sales@centurion.com**

GS-9000 REGISTERED ISO 9001

# Appendix C
## Firmware and Setup Instructions

The EUT was presented for testing with special firmware that accepted programming.
The modes were changed by reprogramming the EUT at each step. A laptop computer was used to reprogram the EUT using the headers already on the PCB, and a suite of different files used to re-program the RF chip-set at a register level, along with a custom programming adapter.

# Appendix D

## Operation Protocol and Duty Factor Calculations

Per client declarations, the transmitter portion of the transceiver is limited to 10 msec. of operation within any 100 msec. window of time. This allows for a duty cycle relaxation factor of up to 20 dB to be applied.