**MET Laboratories, Inc.** *Safety Certification - EMI - Telecom Environmental Simulation*
914 WEST PATAPSCO AVENUE ● BALTIMORE, MARYLAND 21230-3432 ● PHONE (410) 354-3300 ● FAX (410) 354-3313
33439 WESTERN AVENUE ● UNION CITY, CALIFORNIA 94587 ● PHONE (510) 489-6300 ● FAX (510) 489-6372
3162 BELICK STREET ● SANTA CLARA, CALIFORNIA 95054 ● PHONE (408 748-3585 ● FAX (510) 489-6372

April 8, 2009

Sentilla Corporation
201 Marshall Street
Redwood City, CA 94063

Dear Leo Szumel,

Enclosed is the EMC Wireless test report for compliance testing of the Sentilla Corporation, Sentilla OEM Module SENARM01 as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15, Subpart B, ICES-003, Issue 4 February 2004 for a Class B Digital Device and FCC Part 15 Subpart C, RSS-210, Issue 7, June 2007 for Intentional Radiators.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
MET LABORATORIES, INC.

Jennifer Warnell
Documentation Department

Reference: (\Sentilla Corporation\EMCS81444-FCC247 Rev. 3)

# Electromagnetic Compatibility Criteria
# Test Report

for the

**Sentilla Corporation**
**Sentilla OEM Module SENARM01**

**Tested under**
the FCC Certification Rules
contained in
Title 47 of the CFR, Parts 15 Subpart B & ICES-003
for Class B Digital Devices
&
15.247 Subpart C & RSS-210, Issue 7, June 2007
for Intentional Radiators

**MET Report: EMCS81444-FCC247 Rev. 3**

April 8, 2009

**Prepared For:**

**Sentilla Corporation**
**201 Marshall Street**
**Redwood City, CA 94063**

**Prepared By:**
**MET Laboratories, Inc.**
914 W. Patapsco Ave.
Baltimore, MD 21230

  

# Electromagnetic Compatibility Criteria
# Test Report

for the

## Sentilla Corporation
## Sentilla OEM Module SENARM01

**Tested under**
the FCC Certification Rules
contained in
Title 47 of the CFR, Parts 15 Subpart B & ICES-003
for Class B Digital Devices
&
15.247 Subpart C & RSS-210, Issue 7, June 2007
for Intentional Radiators

Anderson Soungpanya, Project Engineer
Electromagnetic Compatibility Lab

Jennifer Warnell
Documentation Department

**Engineering Statement:** The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Parts 15B, 15.247 and Industry Canada standards ICES-003, Issue 4 February 2004, RSS-210, Issue 7, June 2007 under normal use and maintenance.

Shawn McMillen,
Wireless Manager, Electromagnetic Compatibility Lab

# Report Status Sheet

| Revision | Report Date | Reason for Revision |
|---|---|---|
| ∅ | March 19, 2009 | Initial Issue. |
| 1 | March 24, 2009 | Editorial corrections. |
| 2 | March 27, 2009 | Editorial corrections. |
| 3 | April 8, 2009 | Corrections per engineer. |

# Table of Contents



  

# List of Tables



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# List of Photographs



# List of Terms and Abbreviations

| | |
|---|---|
| **AC** | **A**lternating **C**urrent |
| **ACF** | **A**ntenna **C**orrection **F**actor |
| **Cal** | **Cal**ibration |
| ***d*** | **M**easurement **D**istance |
| **dB** | **D**eci**b**els |
| **dBµA** | **D**eci**b**els above one **micro**amp |
| **dBµV** | **D**eci**b**els above one **micro**volt |
| **dBµA/m** | **D**eci**b**els above one **micro**amp **per m**eter |
| **dBµV/m** | **D**eci**b**els above one **micro**volt **per m**eter |
| **DC** | **D**irect **C**urrent µ |
| **E** | **E**lectric Field |
| **DSL** | **D**igital **S**ubscriber **L**ine |
| **ESD** | **E**lectro**s**tatic **D**ischarge |
| **EUT** | **E**quipment **U**nder **T**est |
| ***f*** | **F**requency |
| **FCC** | **F**ederal **C**ommunications **C**ommission |
| **GRP** | **G**round **R**eference **P**lane |
| **H** | Magnetic Field |
| **HCP** | **H**orizontal **C**oupling **P**lane |
| **Hz** | **H**ert**z** |
| **IEC** | **I**nternational **E**lectrotechnical **C**ommission |
| **kHz** | **k**ilo**h**ert**z** |
| **kPa** | **k**ilo**pa**scal |
| **kV** | **k**ilovolt |
| **LISN** | **L**ine **I**mpedance **S**tabilization **N**etwork |
| **MHz** | **M**ega**h**ertz |
| **µH** | **micro**henry |
| µ | **micro**farad |
| **µs** | **micros**econds |
| **NEBS** | **N**etwork **E**quipment-**B**uilding **S**ystem |
| **PRF** | **P**ulse **R**epetition **F**requency |
| **RF** | **R**adio **F**requency |
| **RMS** | **R**oot-**M**ean-**S**quare |
| **TWT** | **T**raveling **W**ave **T**ube |
| **V/m** | **V**olts **per m**eter |
| **VCP** | **V**ertical **C**oupling **P**lane |

# I. Executive Summary

## A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Sentilla Corporation Sentilla OEM Module SENARM01, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the Sentilla OEM Module SENARM01. Sentilla Corporation should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Sentilla OEM Module SENARM01, has been **permanently** discontinued

## B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with Sentilla Corporation, purchase order number 1825. All tests were conducted using measurement procedure ANSI C63.4-2003.

| FCC Reference | IC Reference | Description | Compliance |
|---|---|---|---|
| 47 CFR Part 15.247:2005 | RSS-210 Issue 7: 2007 | Applicable Standard | Compliant |
| 47 CFR Part 15.107 (a) | RSS-210 Issue 7: 2007 | Conducted Emission Limits for a Class B Digital Device | Compliant |
| 47 CFR Part 15.109 (a) | RSS-210 Issue 7: 2007 | Radiated Emission Limits for a Class B Digital Device | Compliant |
| Title 47 of the CFR, Part 15 §15.203 | N/A | Antenna Requirement | Compliant |
| Title 47 of the CFR, Part 15 §15.207(a) | RSS-210(7.2.2) | Conducted Emission Voltage | Compliant |
| Title 47 of the CFR, Part 15 §15.247(a)(1) | RSS-210(A8.1) | Occupied Bandwidth | Compliant |
| Title 47 of the CFR, Part 15 §15.247(b) | RSS-210(A8.4) | RF Output Power | Compliant |
| Title 47 of the CFR, Part 15 §15.209, §15.247(d) | RSS-210(A8.5) | Radiated Spurious Emissions | Compliant |
| Title 47 of the CFR, Part 15 §15.205 | RSS-210(A8.5) | Emissions at Restricted Band | Compliant |
| Title 47 of the CFR, Part 15 §15.209, §15.247(d) | RSS-210(A8.5) | Conducted Spurious Emissions | Compliant |
| Title 47 of the CFR, Part 15; §15.247(e) | RSS-210(A8.3) | Power Spectral Density | Compliant |
| Title 47 of the CFR, Part 15 §15.247(i) | RSS Gen(5.5) | Maximum Permissible Exposure | Compliant |
| N/A | RSS Gen(4.8) | Receiver Spurious Emissions | Compliant |

**Table 1. Executive Summary of EMC Part 15.247 ComplianceTesting**

# II. Equipment Configuration

# A. Overview

MET Laboratories, Inc. was contracted by Sentilla Corporation to perform testing on the Sentilla OEM Module SENARM01, under Sentilla Corporation's purchase order number 1825.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Sentilla Corporation, Sentilla OEM Module SENARM01.

The results obtained relate only to the item(s) tested.

| | | |
|---|---|---|
| **Model(s) Tested:** | Sentilla OEM Module SENARM01 | |
| **Model(s) Covered:** | Sentilla OEM Module SENARM01 | |
| **EUT Specifications:** | Primary Power: 2-3 V | |
| | FCC ID: TOQSENARM01 | |
| | Type of Modulations: | O-QPSK |
| | Equipment Code: | DTS |
| | Peak RF Output Power: | 5.09 dBm |
| | | 4.99 dBm |
| | | 5.01 dBm |
| | EUT Frequency Ranges: | 2405 – 2480 MHz |
| **Analysis:** | The results obtained relate only to the item(s) tested. | |
| **Environmental Test Conditions:** | Temperature: 15-35º C | |
| | Relative Humidity: 30-60% | |
| | Barometric Pressure: 860-1060 mbar | |
| **Evaluated by:** | Anderson Soungpanya | |
| **Report Date(s):** | March 27, 2009 | |

**Table 2. EUT Summary Table**

## B. References

| | |
|---|---|
| **CFR 47, Part 15, Subpart C** | Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies |
| **RSS-210, Issue 7, June 2007** | Low-power Licence-exempt Radiocommunications Devices (All Frequency Bands): Category I Equipment |
| **CFR 47, Part 15, Subpart B** | Electromagnetic Compatibility: Criteria for Radio Frequency Devices |
| **ICES-003, Issue 4 February 2004** | Electromagnetic Compatibility: Criteria for Radio Frequency Devices |
| **ANSI C63.4:2003** | Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz |
| **ANSI/NCSL Z540-1-1994** | Calibration Laboratories and Measuring and Test Equipment - General Requirements |
| **ANSI/ISO/IEC 17025:2000** | General Requirements for the Competence of Testing and Calibration Laboratories |

**Table 3. References**

## C. Test Site

All testing was performed at MET Laboratories, Inc., 3162 Belick Street, Santa Clara, CA 95054. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 10 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

## D. Description of Test Sample

The Sentilla Corporation Sentilla OEM Module SENARM01, Equipment Under Test (EUT), is as follows:

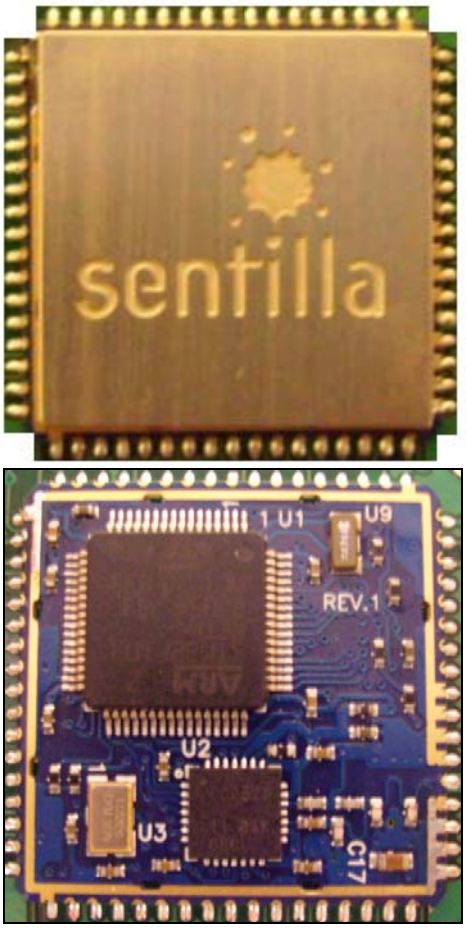
SENARM01 is a data acquisition, processing, and communication chip. It is designed to acquire data from a variety of sensors, process that data, and participate in a multihop wireless network. The device uses IEEE 802.15.4 standard for wireless communication. The device provides the ability to execute Java Virtual Machine bytecodes to control data acquisition, to interface with the wireless link and to process the data.

Physical characteristics:
The module is packaged in an LCC68 form factor. The package pins bring out analog input signals, digital input and output and RF interface. The package is physically shielded. The device buffers all input signals; the device sources (or sinks) a maximum of 25mA across all output pins. The RF interface of the module is brought to the surface mount contacts as well; these signals are interfaced to the antenna (either externally mounted or embedded on the PCB) via the reference layout.

Communication characteristics:
In normal operation, the device uses the complies with the following protocols to implement various layers of the protocol stack network -- 6loWPAN data link -- 802.15.4 MAC (CSMA) physical -- 802.15.4 PHY -- 250 kbps signal in 128 byte packets, are encoded using DSSS; the sequence of chips is modulated using O-QPSK and transmitted in a 2.4 GHz band.

Components
The device contains the following major components:
1. STM32F103 microcontroller from ST Micro
2. CC2520 transceiver from TI




**Photograph 1. Sentilla Corporation Sentilla OEM Module SENARM01**

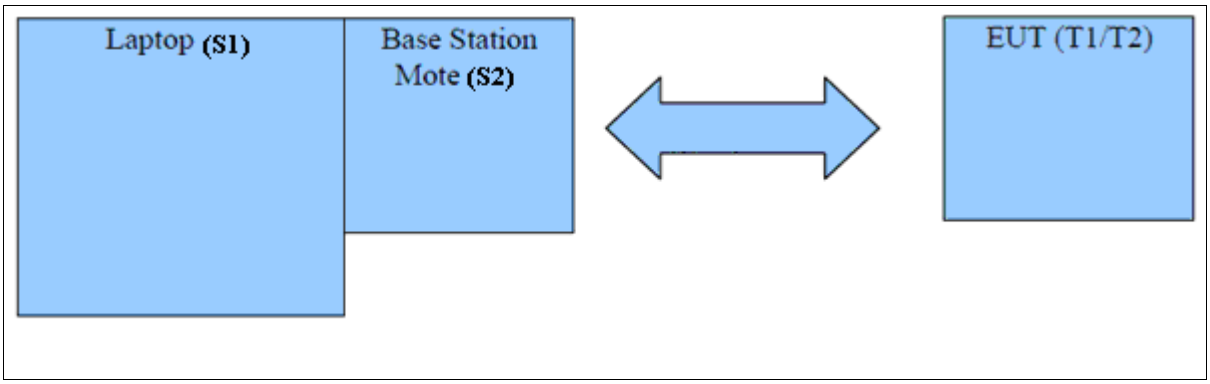



**Figure 1. Block Diagram of Test Configuration**

## E. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

| Ref. ID | Name / Description | Model Number | Serial Number |
|---|---|---|---|
| T1 | SENTILLA OEM MODULE (PIFA) | SENARM01 | 0012:7501:8AD7:9C56 |
| T2 | SENTILLA OEM MODULE (SMA) | SENARM01 | 0012:7501:8AD7:9C2F |

**Table 4. Equipment Configuration**

## F. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

| Ref. ID | Name / Description | Manufacturer | Model Number | Serial Number |
|---|---|---|---|---|
| S1 | LAPTOP | LENOVO | T60 | L3-BH645 |
| S2 | BASE STATION MOTE | SENTILLA | SENARM01 | 0012:7501:8AD7:9C39 |

**Table 5. Support Equipment**

## G. Ports and Cabling Information

The EUT did not require any support equipment for operation or monitoring.

## H. Mode of Operation

The EUT is battery powered; the provided batteries (2xAA) should be installed in the EUT prior to testing. Since the EUT does not have an ON/OFF switch, the batteries should be removed after the test.

The EUT boots into a command state where it will accept commands from a laptop. The command state may always be reached by power-cycling the EUT or using the reset button. There are four modes of operation that may be commanded by the laptop:

1. Transmission of modulated carrier on channel, C, and power level, P
2. Transmission of an 802.15.4-compliant packet stream on channel, C, and power level, P
3. Receive-only on command channel
4. Ping/response loop on channel C and power level P

Channel, C, power, P, are specified for modes (1), (2), and (4); a duration, T, is specified for all modes. The chosen mode terminates after T and the EUT returns to the command mode.

Command mode is indicated by all LEDs off. Modes (1) (2) and (3) are indicated by LED patterns:

1. 1 0 0 0 0 0 0 0
2. 0 1 0 0 0 0 0 0
3. 0 0 1 0 0 0 0 0
4. 0 0 0 1 0 0 0 0

## I. Method of Monitoring EUT Operation

Once put into a testing mode, the LED pattern should remain until the mode's duration has expired or until the reset button is pressed.

All commands are acknowledged to the laptop; if the acknowledgment is not received, the testing program on the laptop will say “timed out; try again” and this indicates that there was packet loss sending the command (or ACK) between EUT and laptop, or the EUT is non-operational.

During modes (1) or (2), operation can also be confirmed by monitoring wireless channel activity.

During mode (4), the number of ping transmissions and responses and the resulting success rate are printed once per second by the laptop.

## J. Modifications

### a) Modifications to EUT

No modifications were made to the EUT.

### b) Modifications to Test Standard

No modifications were made to the test standard.

## K. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Sentilla Corporation upon completion of testing.

# III. Electromagnetic Compatibility Criteria for Unintentional Radiators

## Electromagnetic Compatibility Criteria

## § 15.107 Conducted Emissions Limits

**Test Requirement(s):**

**15.107 (a)** Except for Class A digital devices, for equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 6. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

**15.107 (b)** For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in Table 6. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals. The lower limit applies at the band edges.

**15.207(a)**, Except as shown in paragraphs (b) and (c) of this section*, charging, AC adapters or battery eliminators the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the Table 6, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

| Frequency range (MHz) | Class A Conducted Limits (dBµV) | | *Class B Conducted Limits (dBµV) | |
|---|---|---|---|---|
| | Quasi-Peak | Average | Quasi-Peak | Average |
| * 0.15- 0.45 | 79 | 66 | 66 - 56 | 56 - 46 |
| 0.45 - 0.5 | 79 | 66 | 56 | 46 |
| 0.5 - 30 | 73 | 60 | 60 | 50 |

Note 1 — The lower limit shall apply at the transition frequencies.

Note 2 — The limit decreases linearly with the logarithm if the frequency in the range 0.15 MHz to 0.5 MHz.

* -- Limits per Subsection 15.207(a).

**Table 6. Conducted Limits for Radio Frequency Devices calculated from FCC Part 15 Subsections 15.107(a) (b) and 15.207(a)**

**Test Results:** The EUT was compliant with the Class B requirement(s) of this section.

**Test Engineer(s):** Lionel Gabrillo

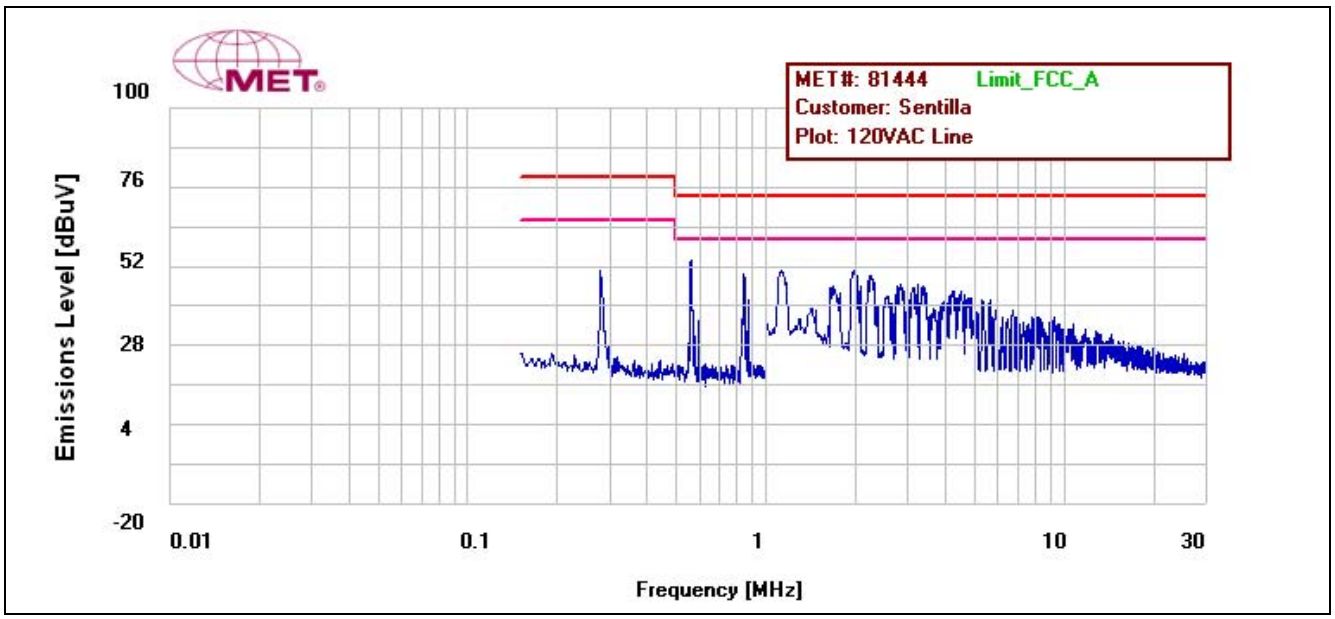
**Test Date(s):** 03/05/09

## Conducted Emissions - Voltage, AC Power, Phase Line (120VAC 60Hz)

| FREQ. (MHz) | Corrected Amplitude (dBuV) QP | Limit (dBuV) QP | Results QP | Margin (dB) QP | Corrected Amplitude (dBuV) AVG | Limit (dBuV) AVG | Results AVG | Margin (dB) AVG |
|---|---|---|---|---|---|---|---|---|
| 0.5636 | 55.84 | 73 | Pass | -17.16 | 45.58 | 60 | Pass | -14.42 |
| 0.8422 | 53.43 | 73 | Pass | -19.57 | 40.39 | 60 | Pass | -19.61 |
| 1.133 | 49.83 | 73 | Pass | -23.17 | 36.99 | 60 | Pass | -23.01 |

**Table 7. Conducted Emissions - Voltage, AC Power, Phase Line (120VAC 60Hz), Test Results**

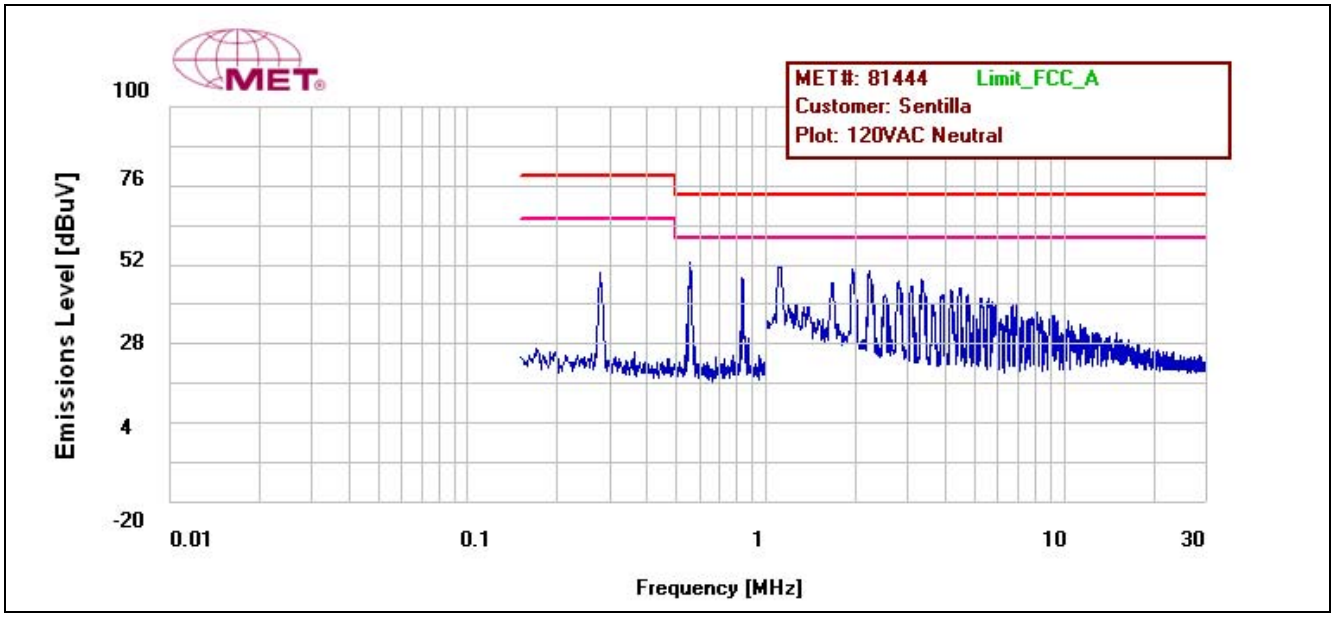



**Plot 1. Conducted Emissions, Phase Line Plot**

## Conducted Emissions - Voltage, AC Power, Neutral Line (120VAC 60Hz)

| FREQ. (MHz) | Corrected Amplitude (dBuV) QP | Limit (dBuV) QP | Results QP | Margin (dB) QP | Corrected Amplitude (dBuV) AVG | Limit (dBuV) AVG | Results AVG | Margin (dB) AVG |
|---|---|---|---|---|---|---|---|---|
| 0.5564 | 55.91 | 73 | Pass | -17.09 | 44.78 | 60 | Pass | -15.22 |
| 0.8372 | 54.02 | 73 | Pass | -18.98 | 42.78 | 60 | Pass | -17.22 |
| 1.9552 | 49.66 | 73 | Pass | -23.34 | 35.05 | 60 | Pass | -24.95 |

**Table 8. Conducted Emissions - Voltage, AC Power, Neutral Line (120VAC 60Hz), Test Results**




**Plot 2. Conducted Emissions, Neutral Line Plot**

## Conducted Emission Limits Test Setup

**Photograph 2. Conducted Emissions, Test Setup**

## Radiated Emission Limits

### § 15.109 Radiated Emissions Limits

**Test Requirement(s):** **15.109 (a)** Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the Class B limits expressed in Table 9.

**15.109 (b)** The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the Class A limits expressed in Table 9.

| Frequency (MHz) | Field Strength (dBµV/m) | |
|---|---|---|
| | §15.109 (b), Class A Limit (dBµV) @ 10m | §15.109 (a),Class B Limit (dBµV) @ 3m |
| 30 - 88 | 39.00 | 40.00 |
| 88 - 216 | 43.50 | 43.50 |
| 216 - 960 | 46.40 | 46.00 |
| Above 960 | 49.50 | 54.00 |

**Table 9. Radiated Emissions Limits calculated from FCC Part 15, §15.109 (a) (b)**

**Test Procedures:** The EUT was placed on a 0.8m-high wooden table inside a semi-anechoic chamber. The method of testing and test conditions of ANSI C63.4 were used. An antenna was located 3 m from the EUT on an adjustable mast. A pre-scan was first performed in order to find prominent radiated emissions. For final emissions measurements at each frequency of interest, the EUT was rotated and the antenna height was varied between 1 m and 4 m in order to maximize the emission. Measurements in both horizontal and vertical polarities were made and the data was recorded. Unless otherwise specified, measurements were made using a quasi-peak detector with a 120 kHz bandwidth.

**Test Results:** The EUT was compliant with the Class B requirement(s) of this section.

**Test Engineer(s):** Anderson Soungpanya

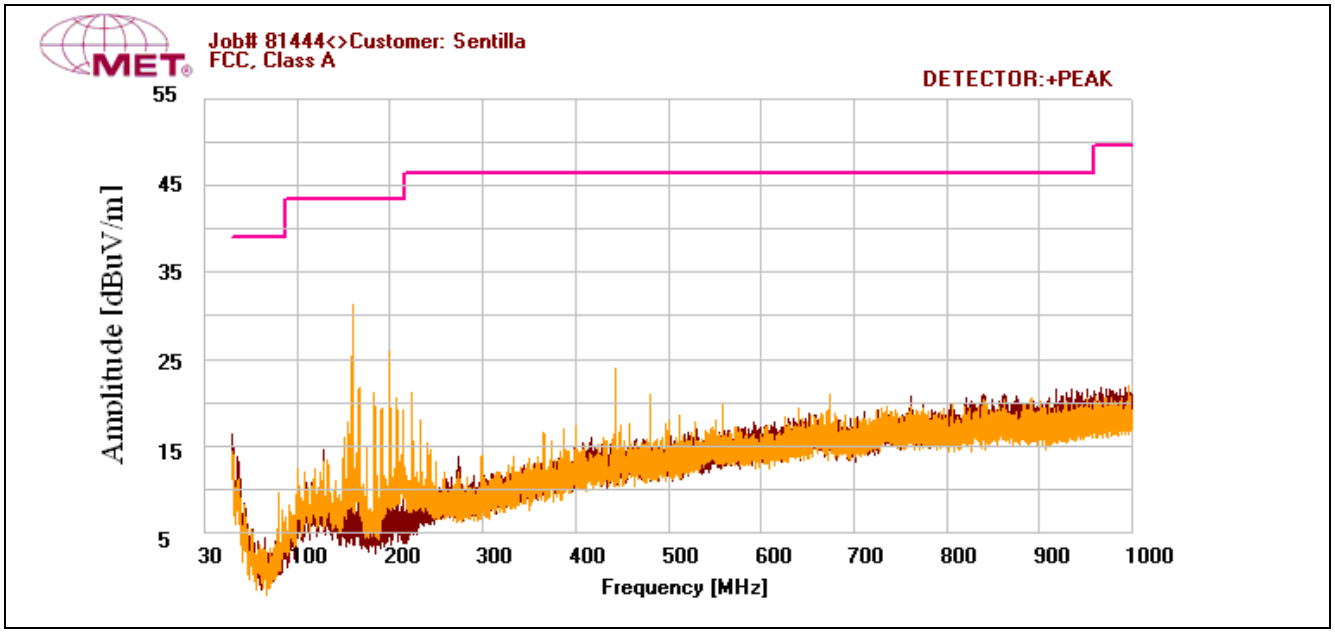
**Test Date(s):** 02/26/09

## Radiated Emissions Limits Test Results, Class B

| Frequency (MHz) | Antenna Polarity | EUT Azimuth (Degrees) | Antenna Height (cm) | Uncorrected Amplitude (dBuV) | ACF (dB/m) | Pre Amp Gain (dB) | CBL (dB) | DCF (dB) | Corrected Amplitude (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | V | 130 | 100 | 56.42 | 11.1 | 40 | 2.051 | 0 | 29.571 | 43.5 | -13.929 | 1 |
| 199.99 | V | 330 | 100 | 51.8 | 10.5 | 40 | 2.332 | 0 | 24.632 | 43.5 | -18.868 | 2 |
| 166.63 | V | 0 | 100 | 47.86 | 10.8 | 40 | 2.112 | 0 | 20.772 | 43.5 | -22.728 | 3 |
| 182.51 | V | 156 | 100 | 54.12 | 10.249 | 40 | 2.284 | 0 | 26.653 | 43.5 | -16.847 | 4 |
| 223.97 | V | 0 | 100 | 39.49 | 11.218 | 40 | 2.391 | 0 | 13.099 | 46.4 | -33.301 | 5 |
| 443.81 | V | 34 | 100 | 41.94 | 16.624 | 40 | 3.476 | 0 | 22.04 | 46.4 | -24.36 | 6 |

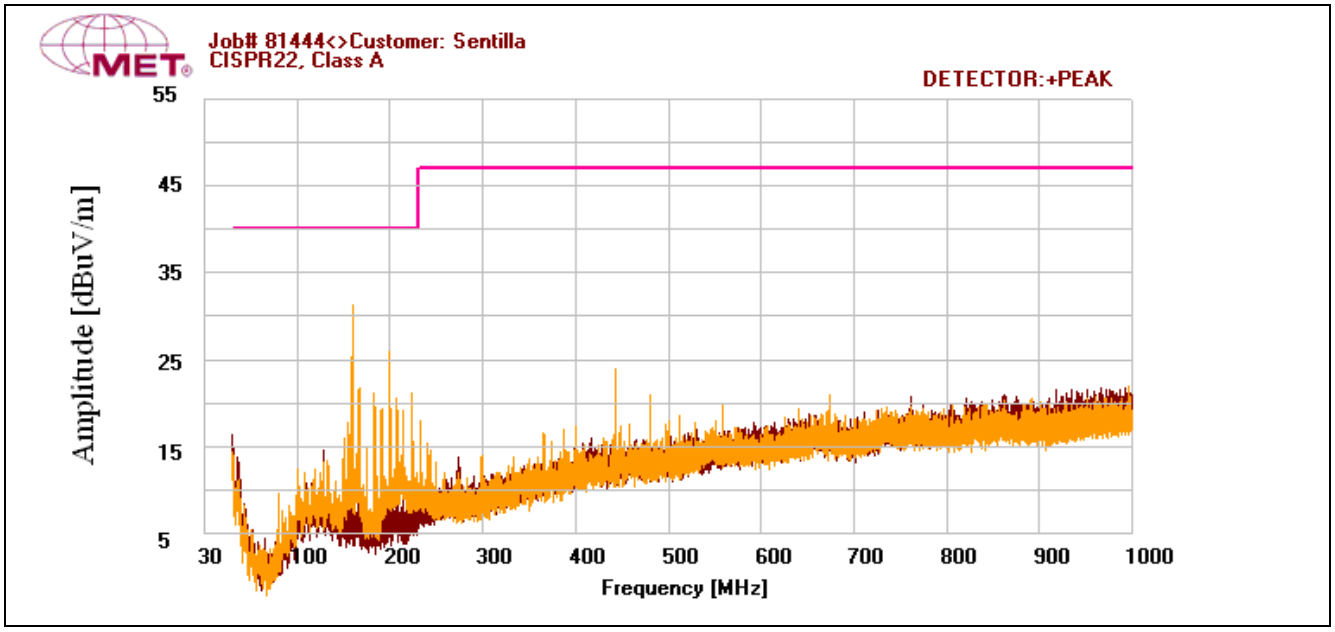
**Table 10. Radiated Emissions Limits, Test Results, FCC Limits**




**Plot 3. Radiated Emissions, Pre-Scan, FCC Limits**

| Frequency (MHz) | Antenna Polarity | EUT Azimuth (Degrees) | Antenna Height (cm) | Uncorrected Amplitude (dBuV) | ACF (dB/m) | Pre Amp Gain (dB) | CBL (dB) | DCF (dB) | Corrected Amplitude (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | V | 130 | 100 | 56.42 | 11.1 | 40 | 2.051 | 0 | 29.571 | 40 | -10.429 | 1 |
| 199.99 | V | 330 | 100 | 51.8 | 10.5 | 40 | 2.332 | 0 | 24.632 | 40 | -15.368 | 2 |
| 166.63 | V | 0 | 100 | 47.86 | 10.8 | 40 | 2.112 | 0 | 20.772 | 40 | -19.228 | 3 |
| 182.51 | V | 156 | 100 | 54.12 | 10.249 | 40 | 2.284 | 0 | 26.653 | 40 | -13.347 | 4 |
| 223.97 | V | 0 | 100 | 39.49 | 11.218 | 40 | 2.391 | 0 | 13.099 | 40 | -26.901 | 5 |
| 443.81 | V | 34 | 100 | 41.94 | 16.624 | 40 | 3.476 | 0 | 22.04 | 47 | -24.96 | 6 |

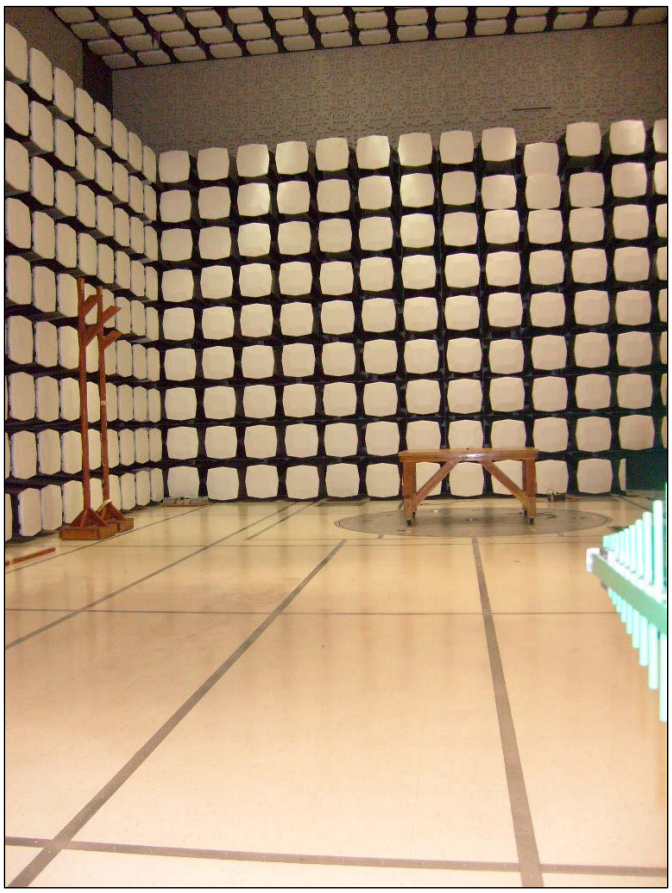
**Table 11. Radiated Emissions Limits, Test Results, ICES-003 Limits, 30 MHz – 1 GHz**



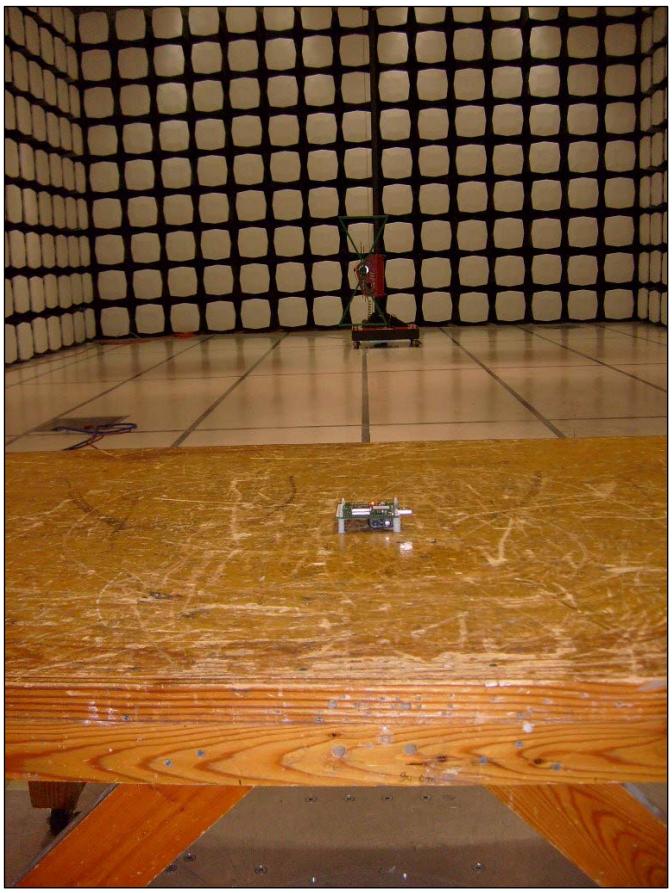

**Plot 4. Radiated Emissions, Pre-Scan, ICES-003 Limits, 30 MHz – 1 GHz**

## Radiated Emission Limits Test Setup

**Photograph 3. Radiated Emission, Test Setup**



**Photograph 4. Radiated Emissions, Antenna**



**Photograph 5. Radiated Emissions, Back View**

# IV. Electromagnetic Compatibility Criteria for Intentional Radiators

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.203 Antenna Requirement

**Test Requirement:** **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be 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.

**Results:** The EUT as tested is compliant the criterion of this rule by virtue of using an internal PCB antenna and a unique reverse SMA connecter for the Omni antenna. The EUT is therefore compliant with §15.203.

**Test Engineer(s):** Anderson Soungpanya

**Test Date(s):** 03/04/09

| Gain/Model | Manufacturer |
|---|---|
| 3.3 dBi PCB Antenna | Texas Instruments |
| 2.2 dBi Omni Antenna | HyperLink Technologies |

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.207 Conducted Emissions Limits

**Test Requirement(s):** **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

| Frequency range (MHz) | § 15.207(a), Conducted Limit (dBμV) | |
|---|---|---|
| | Quasi-Peak | Average |
| * 0.15- 0.45 | 66 - 56 | 56 - 46 |
| 0.45 - 0.5 | 56 | 46 |
| 0.5 - 30 | 60 | 50 |

**Table 12. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)**

**Test Procedure:** The EUT was placed on a 0.8 m-high wooden table inside a semi-anechoic chamber. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 μH Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.4-2003 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz"*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω/50 μH LISN as the input transducer to an EMC/field intensity meter. For the purpose of this testing, the transmitter was turned on.

**Test Results:** The EUT was compliant with this requirement.

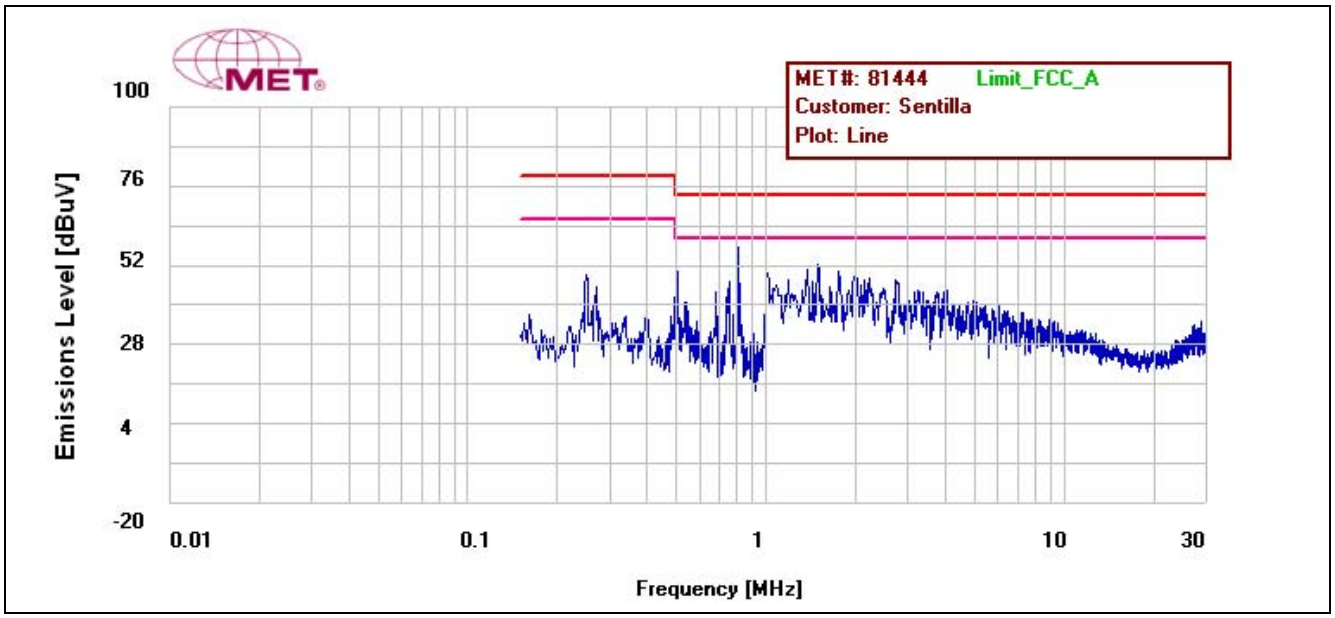
**Test Engineer(s):** Anderson Soungpanya

**Test Date(s):** 03/05/09

| Frequency (MHz) | Corrected Measurement (dBuV) QP | Limit (dBuV) QP | Margin (dB) QP | Corrected Measurement (dBuV) AVG | Limit (dBuV) AVG | Margin (dB) AVG |
|---|---|---|---|---|---|---|
| .809 | 57.61 | 73 | -15.39 | 52.96 | 60 | -7.04 |
| .501 | 52.85 | 73 | -20.15 | 45.89 | 60 | -14.11 |
| 1.50 | 46.36 | 73 | -26.64 | 40.44 | 60 | -19.56 |

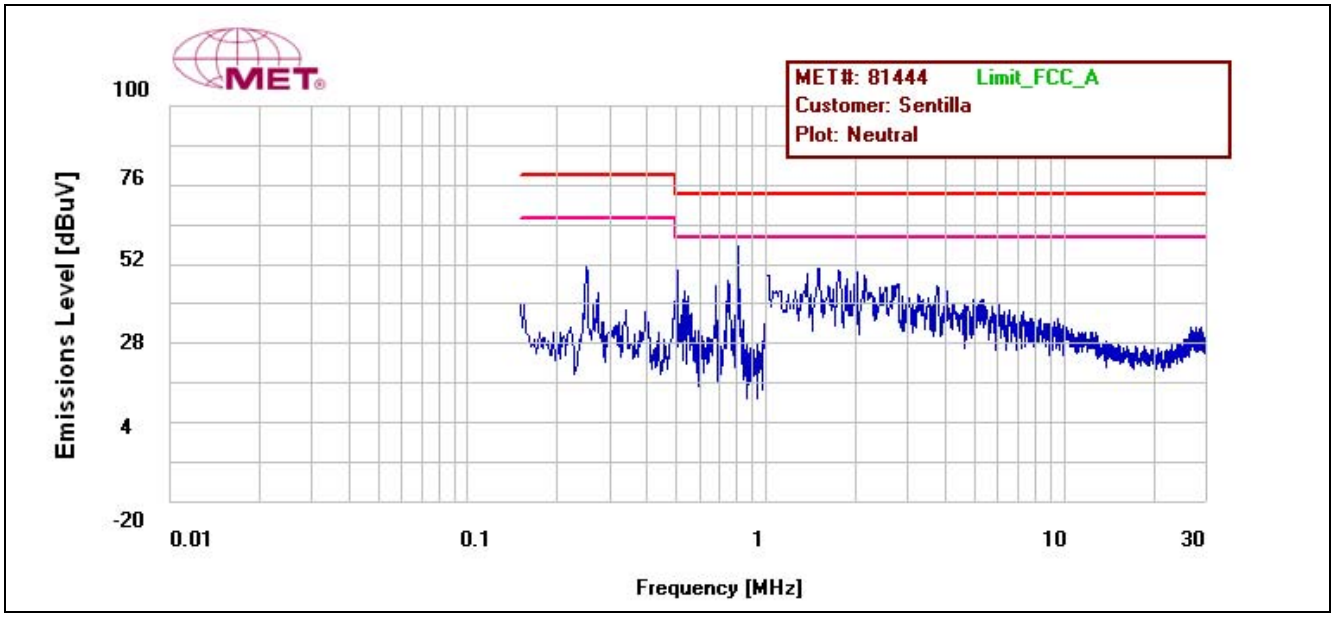
**Table 13. Conducted Emissions, 15.207, Phase Line, (120VAC 60Hz) Test Results**




**Plot 5. Conducted Emissions, (120VAC 60Hz) 15.207, Phase Line Plot**

| Frequency (MHz) | Corrected Measurement (dBuV) QP | Limit (dBuV) QP | Margin (dB) QP | Corrected Measurement (dBuV) AVG | Limit (dBuV) AVG | Margin (dB) AVG |
|---|---|---|---|---|---|---|
| .810 | 55.95 | 73 | -17.05 | 52.68 | 60 | -7.32 |
| .503 | 52.92 | 73 | -20.08 | 43.94 | 60 | -16.06 |
| 1.37 | 48.51 | 73 | -24.49 | 45.02 | 60 | -14.98 |

**Table 14. Conducted Emissions, 15.207, (120VAC 60Hz) Neutral Line, Test Results**




**Plot 6. Conducted Emissions, (120VAC 60Hz) 15.207, Neutral Line Plot**

**Photograph 6. Conducted Emissions, 15.207, Test Setup**

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(a) 6 dB and 99% Bandwidth

**Test Requirements:** **§ 15.247(a):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

**Test Procedure:** The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately 1% of the total emission bandwidth, VBW > RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

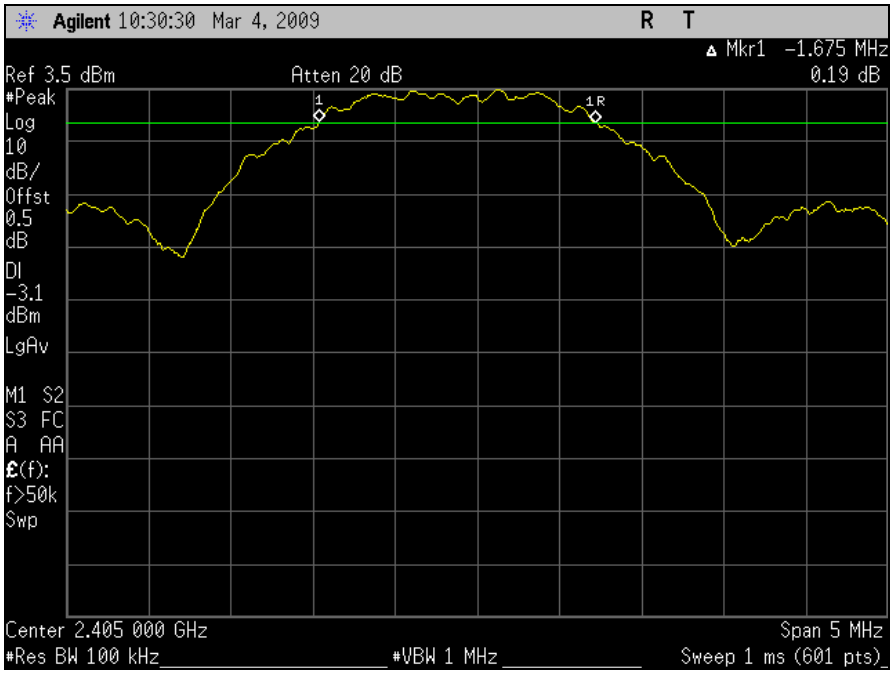
**Test Results** The EUT was compliant with § 15.247 (a).

The 6 dB and 99% Bandwidth was determined from the plots on the following pages.

| Carrier Channel | Frequency (MHz) | Measured 6 dB Bandwidth (MHz) |
|---|---|---|
| Low | 2405 | 1.675 |
| Mid | 2440 | 1.692 |
| High | 2480 | 1.650 |

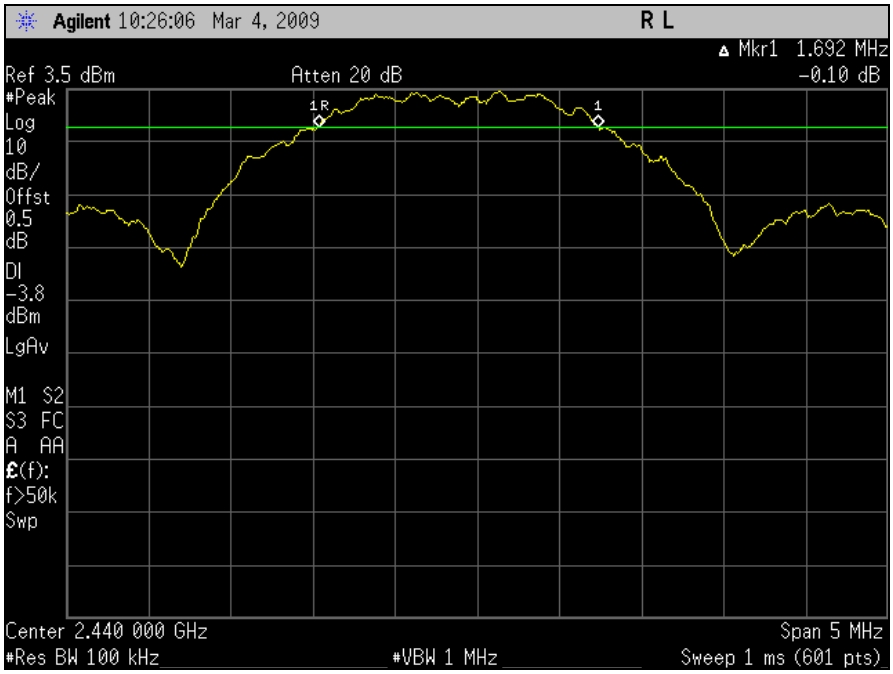
**Test Engineer(s):** Anderson Soungpanya

**Test Date(s):** 03/04/09

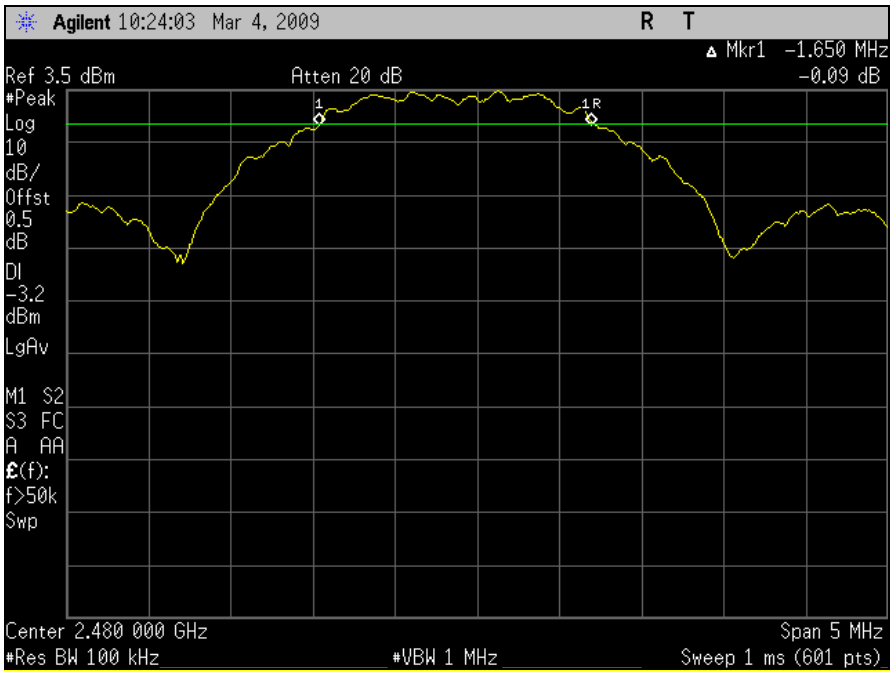



**Plot 7. 6 dB Occupied Bandwidth, Low Channel**

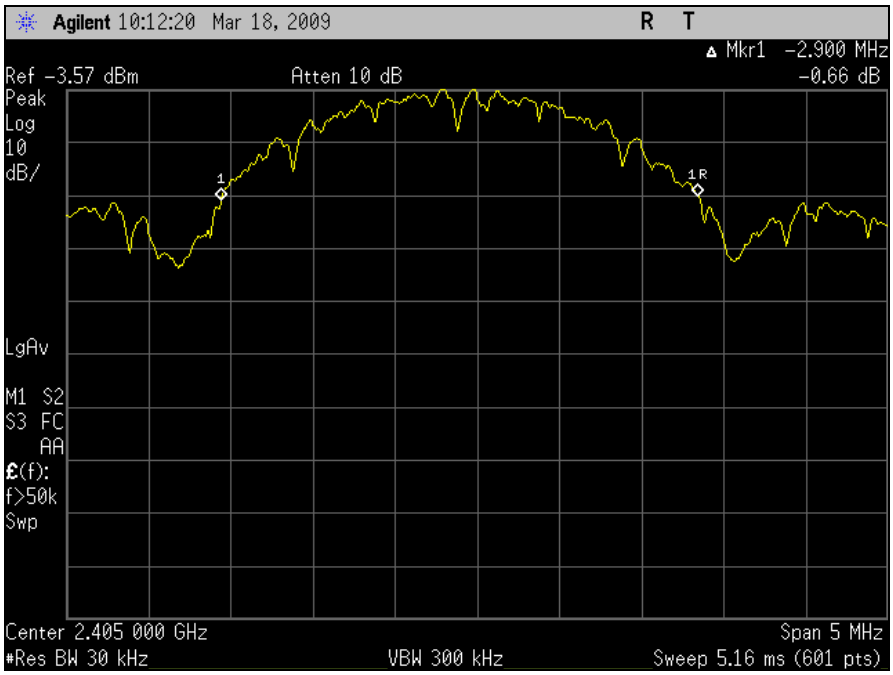



**Plot 8. 6 dB Occupied Bandwidth, Mid Channel**

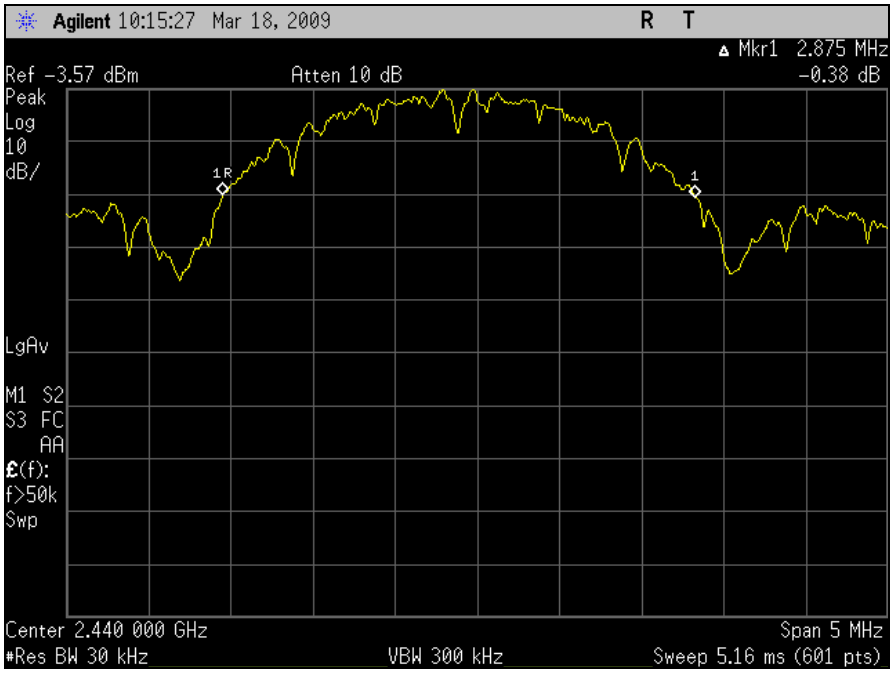



**Plot 9. 6 dB Occupied Bandwidth, High Channel**

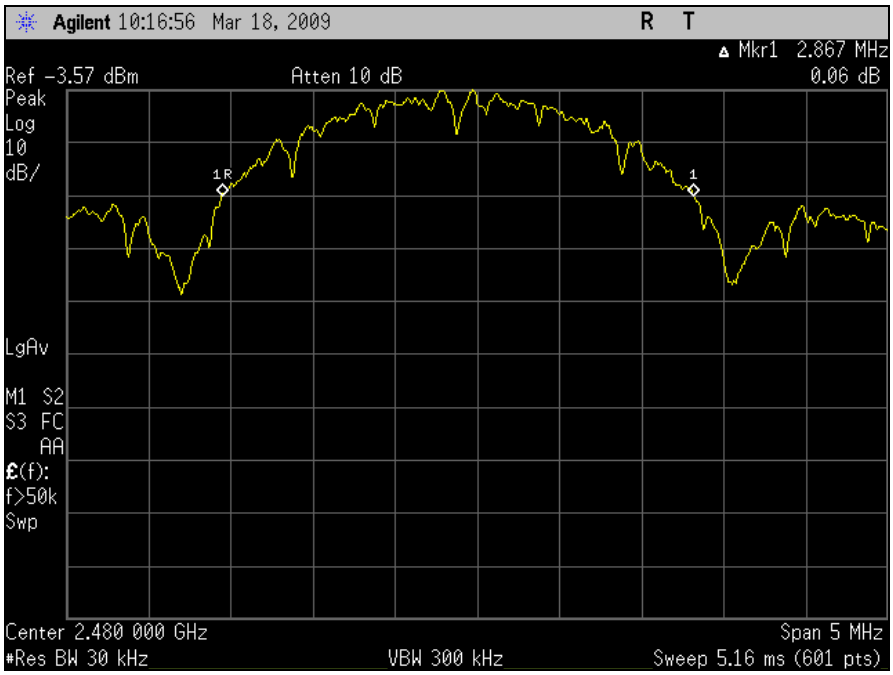
  




**Plot 10. 99% Occupied Bandwidth, Low Channel**




**Plot 11. 99% Occupied Bandwidth, Mid Channel**




**Plot 12. 99% Occupied Bandwidth, High Channel**

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(b) Peak Power Output and RF Exposure

**Test Requirements:** **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

| Digital Transmission Systems (MHz) | Output Limit (Watts) |
|---|---|
| 902-928 | 1.000 |
| 2400–2483.5 | 1.000 |
| 5725– 5850 | 1.000 |

**Table 15. Output Power Requirements from §15.247**

**§15.247(c):** if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the Table 15, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400 – 2483.5 MHz band may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Fixed, point-to-point operation excludes the use of point-to-multipoint systems, Omni-directional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

**Test Procedure:** The transmitter was connected to a calibrated spectrum analyzer. The EUT was measured at the low, mid and high channels of each band at a data rate which gave the maximum power level.

**Test Results:** The EUT was compliant with the Peak Power Output limits of **§ 15.247(b)**.

**Test Engineer(s):** Anderson Soungpanya

**Test Date(s):** 03/04/09

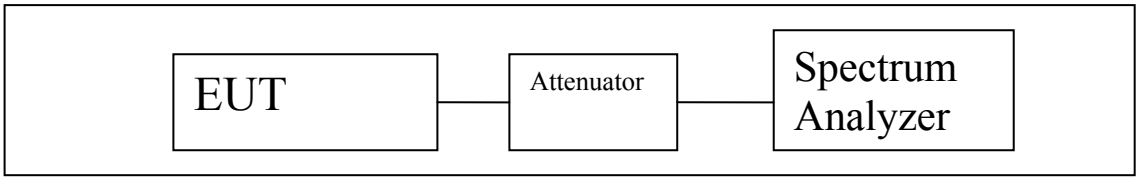
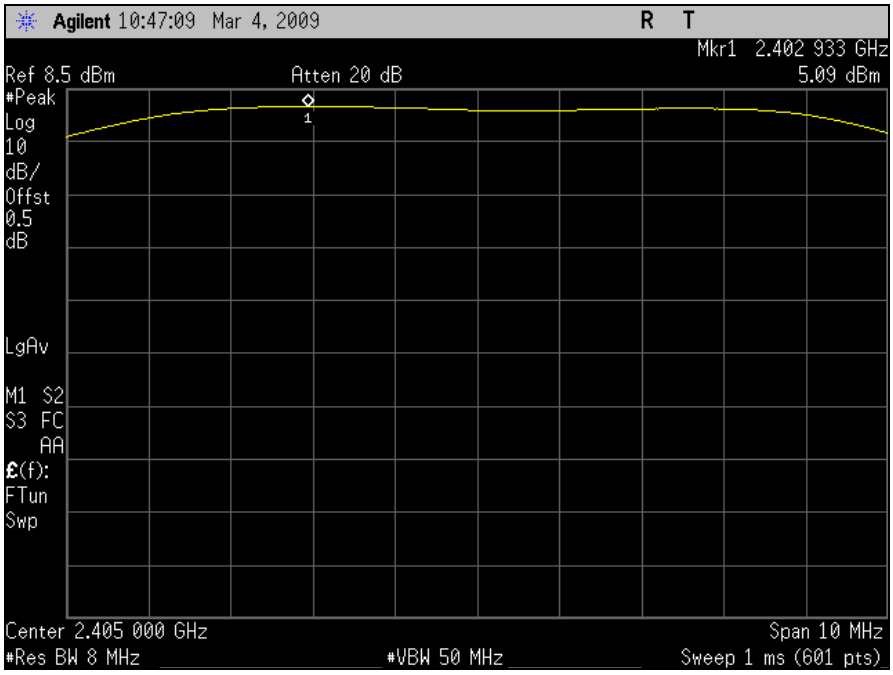


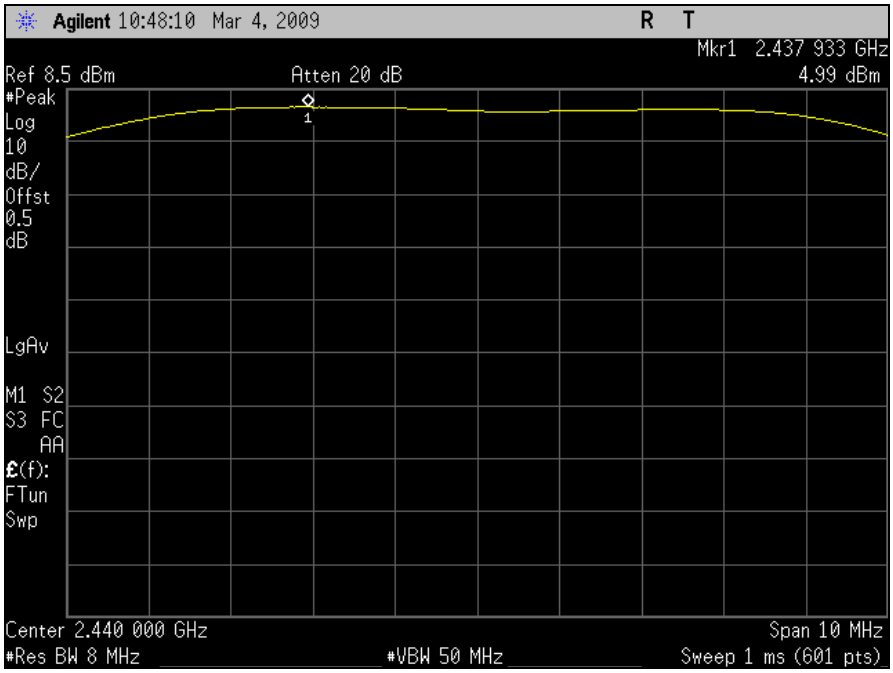

**Figure 2. Block Diagram of Test Setup for Peak Power Output**

| Carrier Channel | Frequency (MHz) | Measured Peak Output Power (dBm) |
|---|---|---|
| Low | 2405 | 5.09 |
| Mid | 2440 | 4.99 |
| High | 2480 | 5.01 |

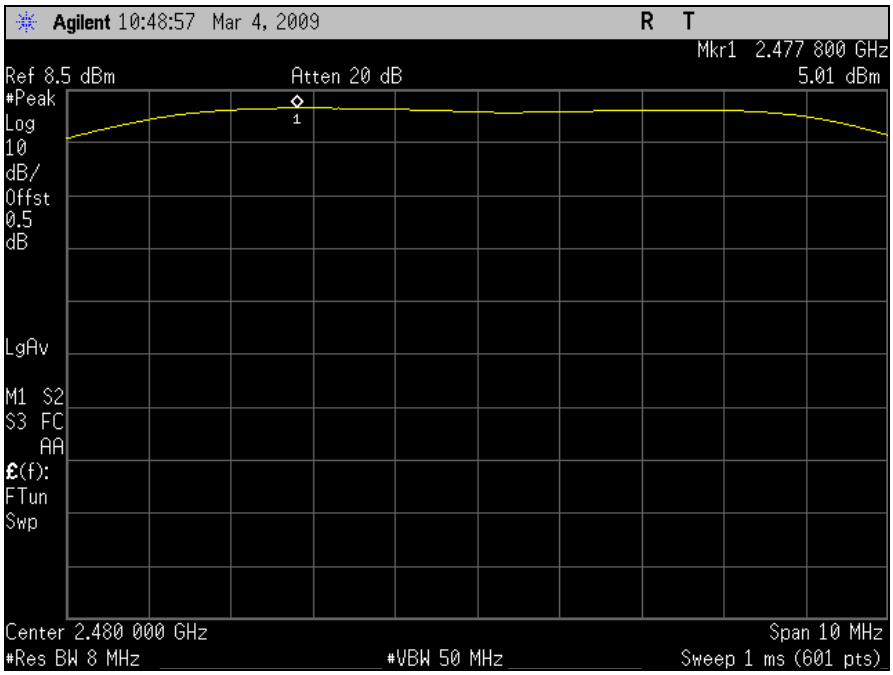



**Plot 13. Peak Output Power, Low Channel**




**Plot 14. Peak Output Power, Mid Channel**




**Plot 15. Peak Output Power, High Channel**

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(b) RF Exposure

**RF Exposure Requirements:** **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

**RF Radiation Exposure Limit:** **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

MPE Limit Calculation: EUT's operating frequencies @ 2400-2483.5 MHz; highest conducted power = 5.09 *dBm* (peak) therefore, **Limit for Uncontrolled exposure: 1 mW/cm$^2$ or 10 W/m$^2$**

EUT maximum antenna gain = *3.3 dBi.*

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

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density (1 mW/cm$^2$)
P = Power Input to antenna (3.24mW)
G = Antenna Gain (2.13 numeric)

$S = (3.24*2.13 / 4*3.14*20.0^2) = (6.90 / 5024) =$ **0.001374 mW/cm$^2$**@ 20cm separation

# Electromagnetic Compatibility Criteria for Intentional Radiators

## § 15.247(d) Radiated Spurious Emissions Requirements and Band Edge Measurements

**Test Requirements:** **§15.247(d)**; **§ 15.209 (a); §15.205:** Emissions outside the frequency band.

**§15.247(d):** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

**§15.205(a):** Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090–0.110---------- | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| [1] 0.495–0.505---------- | 16.69475–16.69525 | 608–614 | 5.35–5.46 |
| 2.1735–2.1905---------- | 16.80425–16.80475 | 960–1240 | 7.25–7.75 |
| 4.125–4.128---------- | 25.5–25.67 | 1300–1427 | 8.025–8.5 |
| 4.17725–4.17775---------- | 37.5–38.25 | 1435–1626.5 | 9.0–9.2 |
| 4.20725–4.20775---------- | 73–74.6 | 1645.5–1646.5 | 9.3–9.5 |
| 6.215–6.218---------- | 74.8–75.2 | 1660–1710 | 10.6–12.7 |
| 6.26775–6.26825---------- | 108–121.94 | 1718.8–1722.2 | 13.25–13.4 |
| 6.31175–6.31225---------- | 123–138 | 2200–2300 | 14.47–14.5 |
| 8.291–8.294---------- | 149.9–150.05 | 2310–2390 | 15.35–16.2 |
| 8.362–8.366---------- | 156.52475–156.52525 | 2483.5–2500 | 17.7–21.4 |
| 8.37625–8.38675---------- | 156.7–156.9 | 2655–2900 | 22.01–23.12 |
| 8.41425–8.41475---------- | 162.0125–167.17 | 3260–3267 | 23.6–24.0 |
| 12.29–12.293---------- | 167.72–173.2 | 3332–3339 | 31.2–31.8 |
| 12.51975–12.52025---------- | 240–285 | 3345.8–3358 36. | 43–36.5 |
| 12.57675–12.57725---------- | 322–335.4 | 3600–4400 | ([2]) |

**Table 16. Restricted Bands of Operation**

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.
[2] Above 38.6

**Test Requirement(s):** **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 17.

| Frequency (MHz) | § 15.209(a),Radiated Emission Limits (dBµV) @ 3m |
|---|---|
| 30 - 88 | 40.00 |
| 88 - 216 | 43.50 |
| 216 - 960 | 46.00 |
| Above 960 | 54.00 |

**Table 17. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)**

**Test Procedures:** The transmitter was set to the mid channel at the highest output power and placed on a 0.8 m high wooden table inside in a semi-anechoic chamber. Measurements were performed with the EUT rotated 360 degrees and varying the adjustable antenna mast with 1 m to 4 m height to determine worst case orientation for maximum emissions. Measurement were repeated the measurement at the low and highest channels.

For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

In accordance with §15.35(b) the limit on the radio frequency emissions as measured using instrumentation with a peak detector function shall be 20 dB above the maximum permitted average limit for the frequency being investigated unless a different peak emission limit is otherwise specified in the rules.

EUT Field Strength Final Amplitude = Raw Amplitude – Preamp gain + Antenna Factor + Cable

Only noise floor was measured above 18 GHz.

**Restricted Band Edge Measurement Procedure:**

STEP 1 - The field strength of the fundamental emission was measured using a 1MHz RBW and a 3MHz VBW for the peak value and a 1MHz RBW and a 10Hz VBW for the average value.

STEP 2 – A spectrum analyzer span was incorporated to encompass both the peak of the fundamental emission and the band edge emission under investigation. The RBW was set to 30 kHz and the VBW to 3x the RBW. The delta between the peak levels of the fundamental emission at the relevant band edge emission was measured and recorded.

STEP 3 – The resulting delta value was used to determine the band edge compliance.

The second highest channel was also investigated to show compliance for 15.205.

**Test Results:** The EUT was compliant with the Peak Power Output limits of **§ 15.247(d)**.

**Test Engineer(s):** Anderson Soungpanya

**Test Date(s):** 03/04/09

## Harmonic Emissions Requirements – Radiated (Omni)

| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.81 | V | 43.98 | 34.76 | 33.30 | 4.57 | 47.09 | Peak | 74 | -26.91 |
| 4.81 | V | 30.92 | 34.76 | 33.30 | 4.57 | 34.03 | Avg. | 54 | -19.97 |
| 7.215 | V | 45.18 | 35.01 | 35.67 | 5.79 | 51.63 | Peak | 74 | -22.37 |
| 7.215 | V | 31.02 | 35.01 | 35.67 | 5.79 | 37.47 | Avg. | 54 | -16.53 |
| 9.62 | V | 44.73 | 35.59 | 37.80 | 7.24 | 54.18 | Peak | 74 | -19.82 |
| 9.62 | V | 31.72 | 35.59 | 37.80 | 7.24 | 41.17 | Avg. | 54 | -12.83 |
| 12.025 | V | 44.38 | 35.01 | 39.87 | 6.61 | 55.85 | Peak | 74 | -18.15 |
| 12.025 | V | 30.9 | 35.01 | 39.87 | 6.61 | 42.37 | Avg. | 54 | -11.63 |

**Table 18. Radiated Harmonic Emissions, Low Channel, Omni**

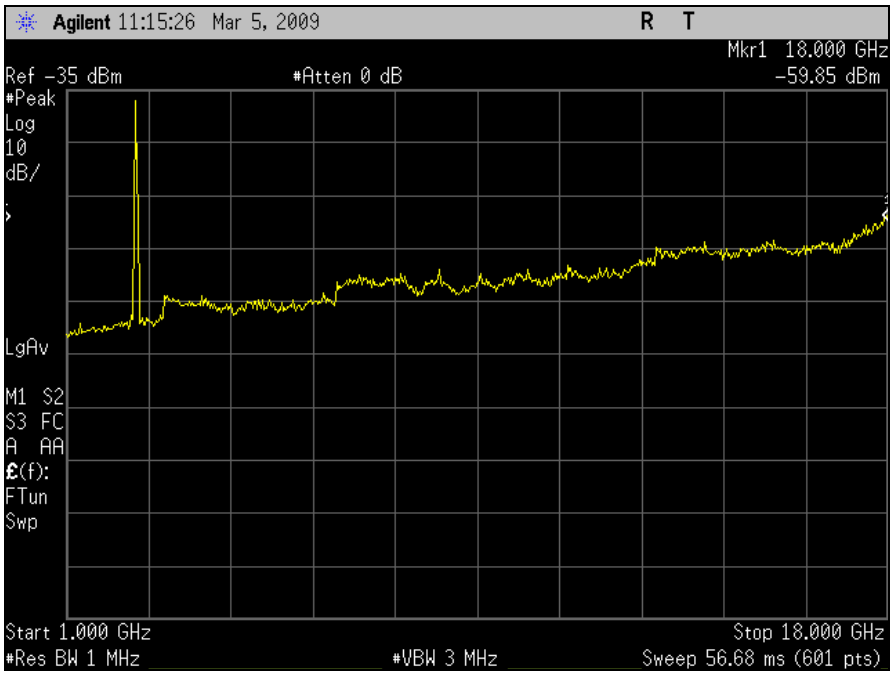
| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.88 | V | 47.47 | 34.74 | 33.52 | 4.64 | 50.88 | Peak | 74 | -23.12 |
| 4.88 | V | 35.9 | 34.74 | 33.52 | 4.64 | 39.31 | Avg. | 54 | -14.69 |
| 7.32 | V | 44.19 | 35.03 | 35.97 | 6.35 | 51.49 | Peak | 74 | -22.51 |
| 7.32 | V | 30.55 | 35.03 | 35.97 | 6.35 | 37.85 | Avg. | 54 | -16.15 |
| 9.76 | V | 45.63 | 35.55 | 37.97 | 7.15 | 55.19 | Peak | 74 | -18.81 |
| 9.76 | V | 31.62 | 35.55 | 37.97 | 7.15 | 41.18 | Avg. | 54 | -12.82 |
| 12.2 | V | 43.62 | 34.93 | 39.49 | 7.18 | 55.36 | Peak | 74 | -18.64 |
| 12.2 | V | 30.74 | 34.93 | 39.49 | 7.18 | 42.48 | Avg. | 54 | -11.52 |

**Table 19. Radiated Harmonic Emissions, Mid Channel, Omni**

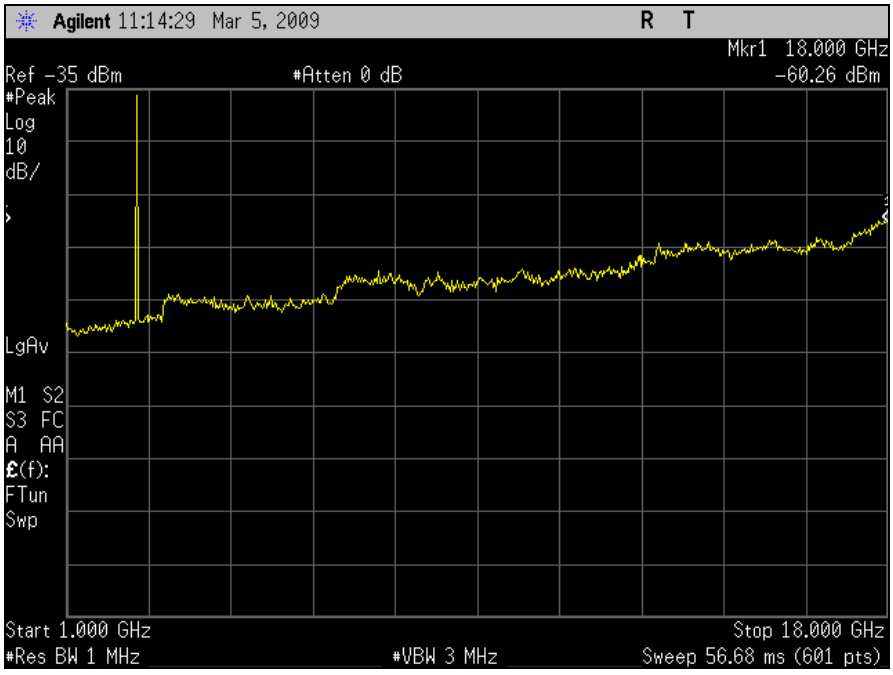
| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.96 | V | 47.71 | 34.72 | 33.72 | 4.71 | 51.42 | Peak | 74 | -22.58 |
| 4.96 | V | 35.45 | 34.72 | 33.72 | 4.71 | 39.16 | Avg. | 54 | -14.84 |
| 7.44 | V | 44.8 | 35.08 | 36.28 | 6.86 | 52.86 | Peak | 74 | -21.14 |
| 7.44 | V | 31.08 | 35.08 | 36.28 | 6.86 | 39.14 | Avg. | 54 | -14.86 |
| 9.92 | V | 44.6 | 35.54 | 38.14 | 7.02 | 54.23 | Peak | 74 | -19.77 |
| 9.92 | V | 31.58 | 35.54 | 38.14 | 7.02 | 41.21 | Avg. | 54 | -12.79 |
| 12.4 | V | 44.12 | 34.69 | 39.00 | 8.12 | 56.54 | Peak | 74 | -17.46 |
| 12.4 | V | 30.4 | 34.69 | 39.00 | 8.12 | 42.82 | Avg. | 54 | -11.18 |

**Table 20. Radiated Harmonic Emissions, High Channel, Omni**

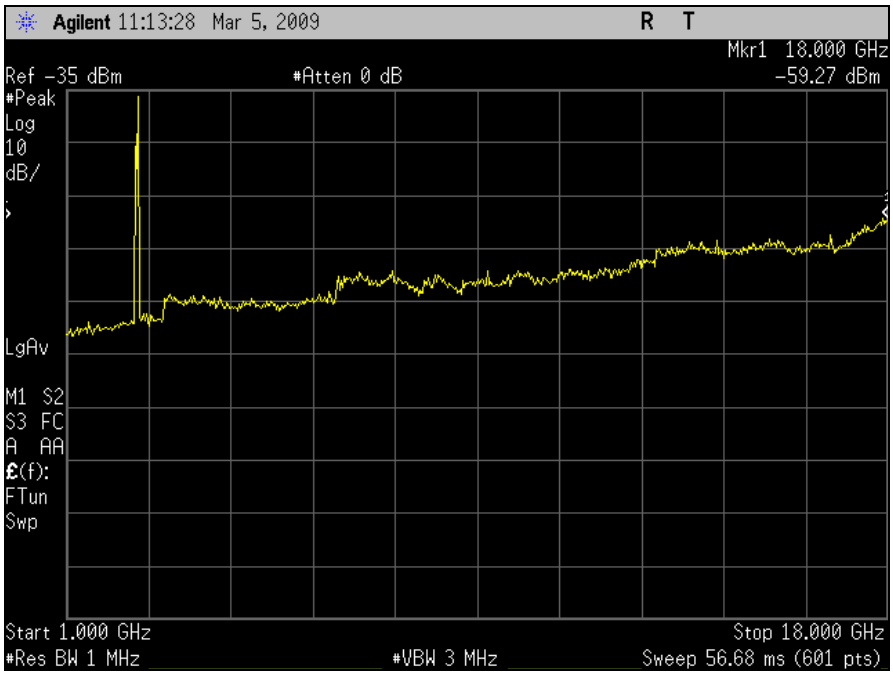
Note: All other emissions were measured at the noise floor of the spectrum analyzer.




**Plot 16. Radiated Harmonic Emissions, Low Channel, Omni**




**Plot 17. Radiated Harmonic Emissions, Mid Channel, Omni**




**Plot 18. Radiated Harmonic Emissions, High Channel, Omni**

## Harmonic Emissions Requirements – Radiated (PCB)

| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.81 | V | 44.86 | 34.76 | 33.30 | 4.57 | 47.97 | Peak | 74 | -26.03 |
| 4.81 | V | 32.81 | 34.76 | 33.30 | 4.57 | 35.92 | Avg. | 54 | -18.08 |
| 7.215 | V | 44.36 | 35.01 | 35.67 | 5.79 | 50.81 | Peak | 74 | -23.19 |
| 7.215 | V | 31.1 | 35.01 | 35.67 | 5.79 | 37.55 | Avg. | 54 | -16.45 |
| 9.62 | V | 44.89 | 35.59 | 37.80 | 7.24 | 54.34 | Peak | 74 | -19.66 |
| 9.62 | V | 31.82 | 35.59 | 37.80 | 7.24 | 41.27 | Avg. | 54 | -12.73 |
| 12.025 | V | 44.36 | 35.01 | 39.87 | 6.61 | 55.83 | Peak | 74 | -18.17 |
| 12.025 | V | 31.05 | 35.01 | 39.87 | 6.61 | 42.52 | Avg. | 54 | -11.48 |

**Table 21. Radiated Harmonic Emissions, Low Channel, PCB**

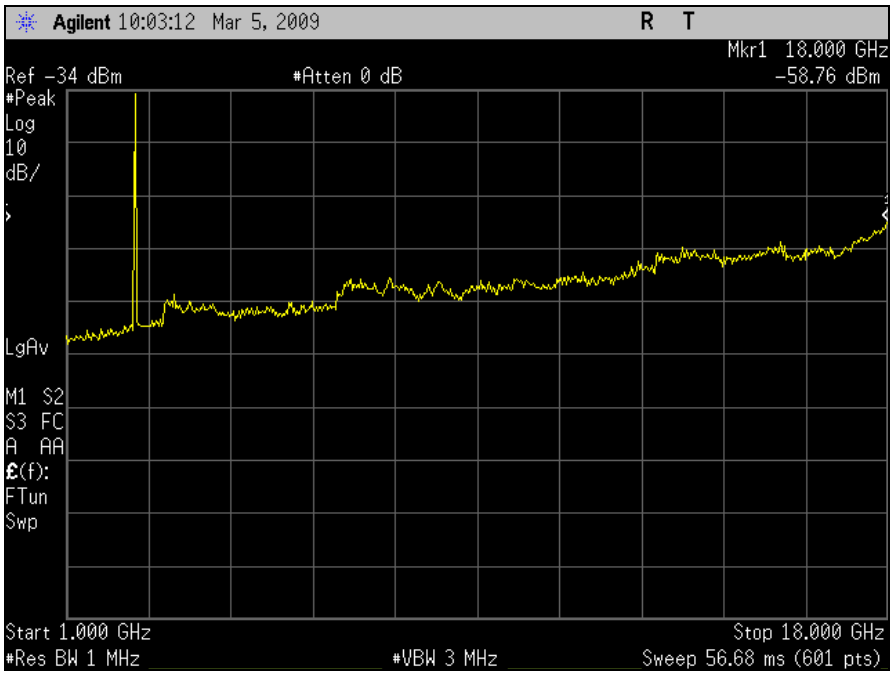
| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.88 | V | 45.87 | 34.74 | 33.52 | 4.64 | 49.28 | Peak | 74 | -24.72 |
| 4.88 | V | 36.79 | 34.74 | 33.52 | 4.64 | 40.20 | Avg. | 54 | -13.80 |
| 7.32 | V | 45.08 | 35.03 | 35.97 | 6.35 | 52.38 | Peak | 74 | -21.62 |
| 7.32 | V | 30.83 | 35.03 | 35.97 | 6.35 | 38.13 | Avg. | 54 | -15.87 |
| 9.76 | V | 46.21 | 35.55 | 37.97 | 7.15 | 55.77 | Peak | 74 | -18.23 |
| 9.76 | V | 31.79 | 35.55 | 37.97 | 7.15 | 41.35 | Avg. | 54 | -12.65 |
| 12.2 | V | 44.68 | 34.93 | 39.49 | 7.18 | 56.42 | Peak | 74 | -17.58 |
| 12.2 | V | 30.93 | 34.93 | 39.49 | 7.18 | 42.67 | Avg. | 54 | -11.33 |

**Table 22. Radiated Harmonic Emissions, Mid Channel, PCB**

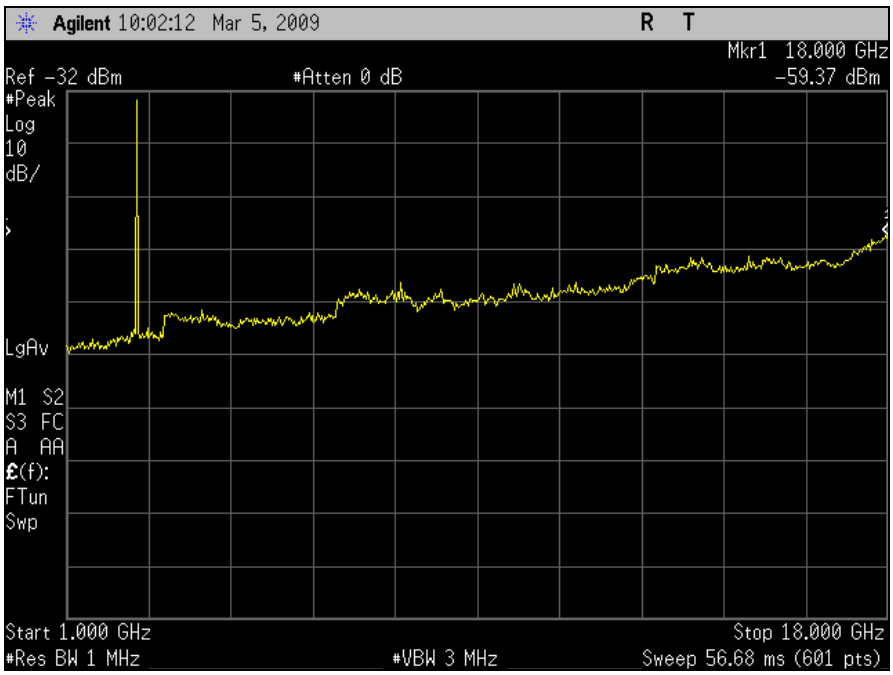
| Freq. (GHz) | Antenna Polarity (H/V) | Raw Amp. @ 3 m (Peak) / (Avg.) | P. Amp (dB) | Ant. Cor. Factor (dB/m) | Cable Loss (dB) | EUT Field Strength Final Amp. (dBuV/m) | Limit Detector Peak / Avg. (Peak) / (Avg.) | Limit @ 3 m (dBuV/m) | Delta (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4.96 | V | 46.57 | 34.72 | 33.72 | 4.71 | 50.28 | Peak | 74 | -23.72 |
| 4.96 | V | 36.1 | 34.72 | 33.72 | 4.71 | 39.81 | Avg. | 54 | -14.19 |
| 7.44 | V | 44.96 | 35.08 | 36.28 | 6.86 | 53.02 | Peak | 74 | -20.98 |
| 7.44 | V | 31.16 | 35.08 | 36.28 | 6.86 | 39.22 | Avg. | 54 | -14.78 |
| 9.92 | V | 46.53 | 35.54 | 38.14 | 7.02 | 56.16 | Peak | 74 | -17.84 |
| 9.92 | V | 31.71 | 35.54 | 38.14 | 7.02 | 41.34 | Avg. | 54 | -12.66 |
| 12.4 | V | 44.78 | 34.69 | 39.00 | 8.12 | 57.20 | Peak | 74 | -16.80 |
| 12.4 | V | 30.62 | 34.69 | 39.00 | 8.12 | 43.04 | Avg. | 54 | -10.96 |

**Table 23. Radiated Harmonic Emissions, High Channel, PCB**

Note: All other emissions were measured at the noise floor of the spectrum analyzer.

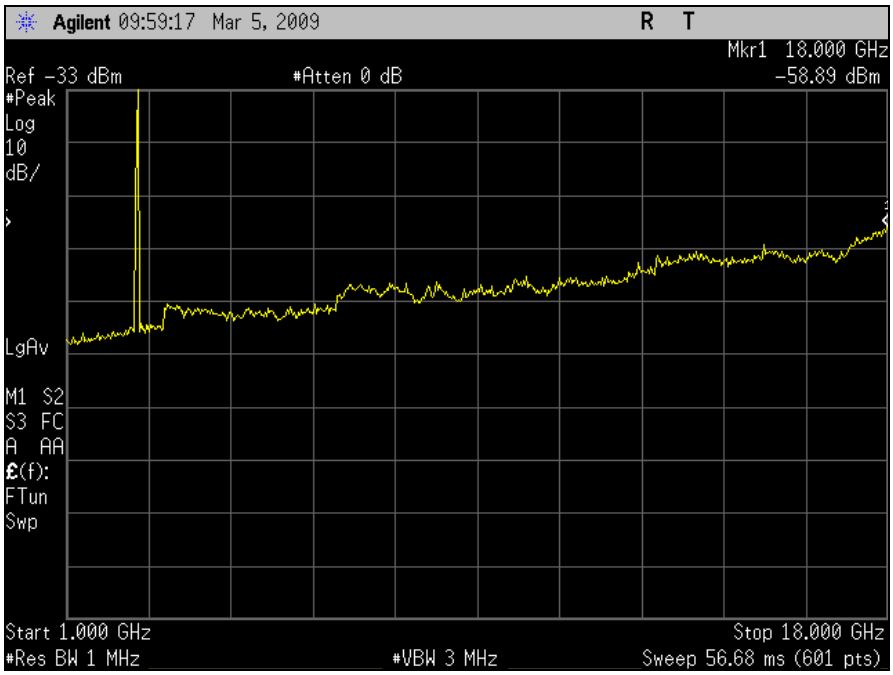



**Plot 19. Radiated Harmonic Emissions, Low Channel, PCB**



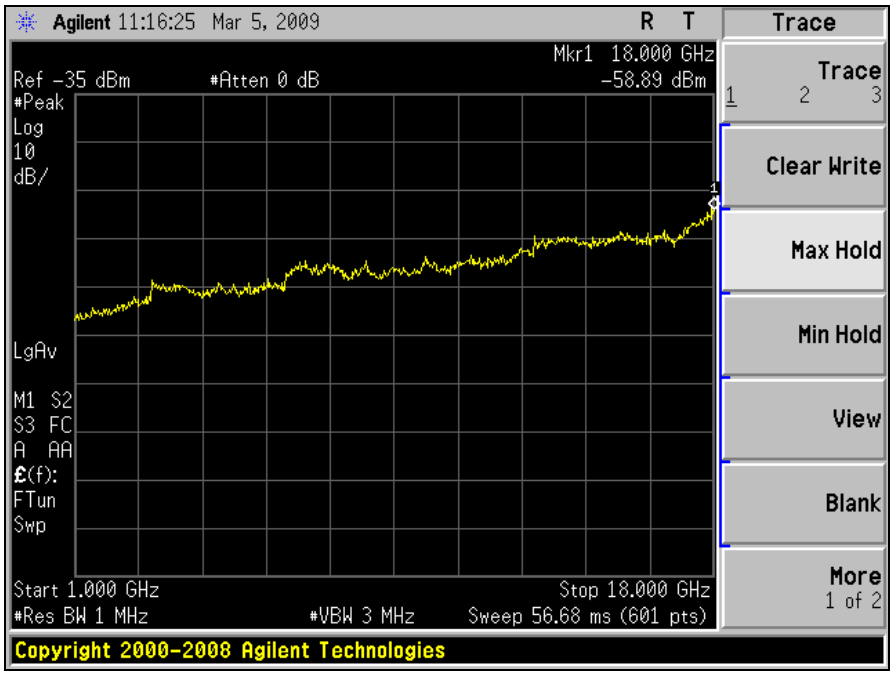

**Plot 20. Radiated Harmonic Emissions, Mid Channel, PCB**

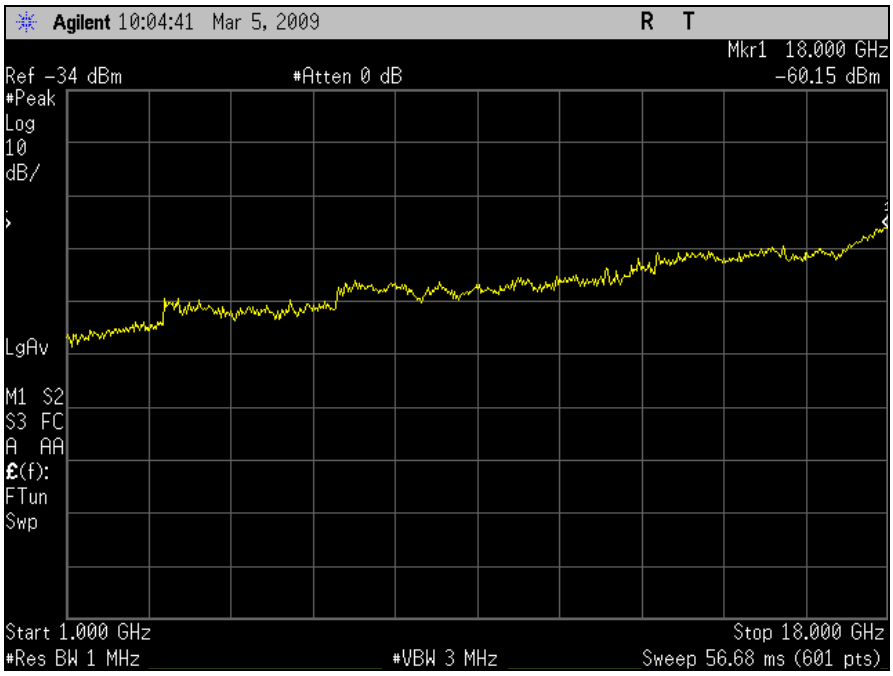



**Plot 21. Radiated Harmonic Emissions, High Channel, PCB**

## Receiver Spurious Emissions



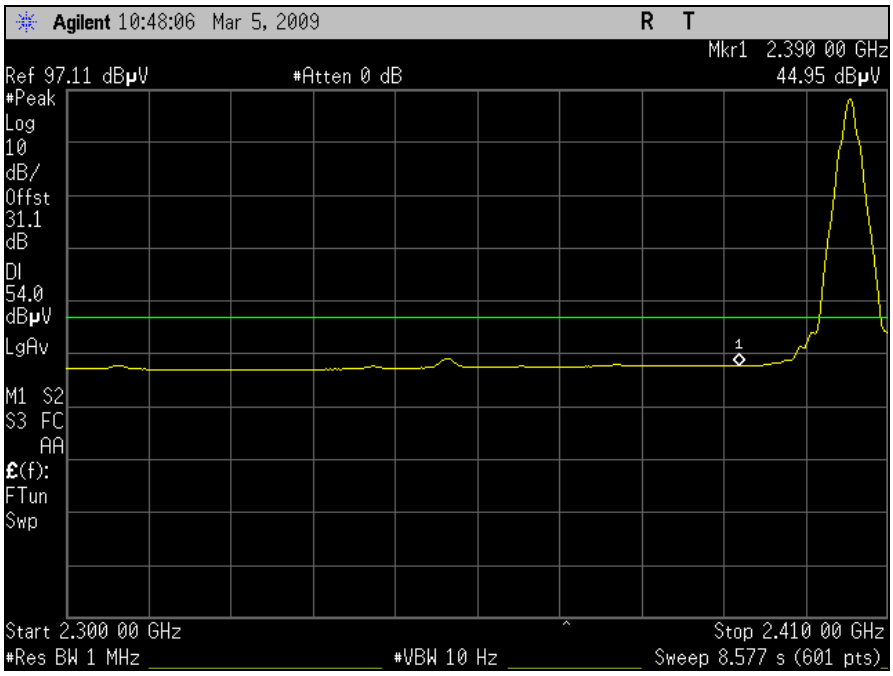

**Plot 22. Receiver Spurious Emission, 1 GHz – 18 GHz, Omni**



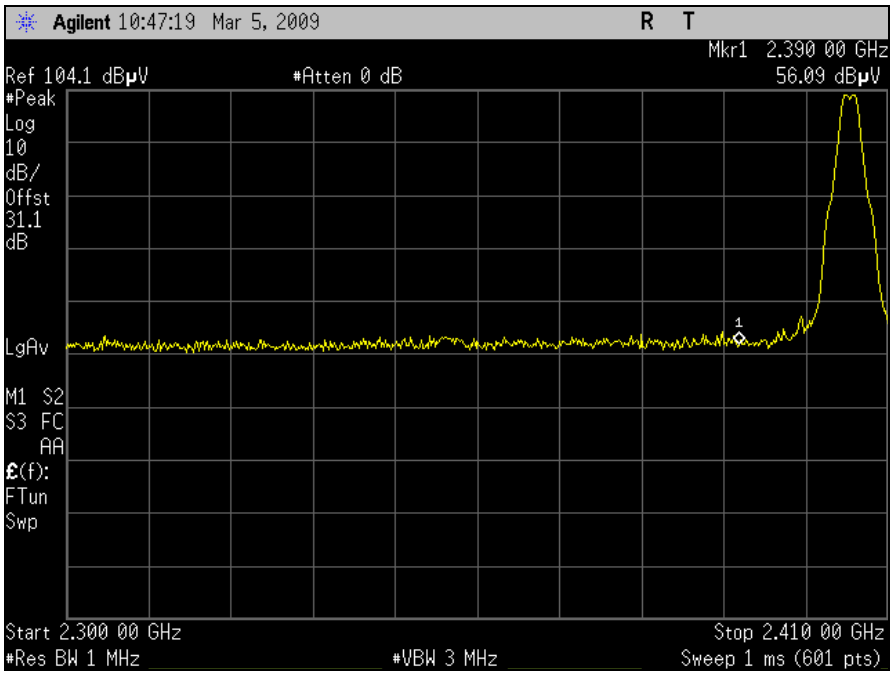

**Plot 23. Receiver Spurious Emission, 1 GHz – 18 GHz, PCB**

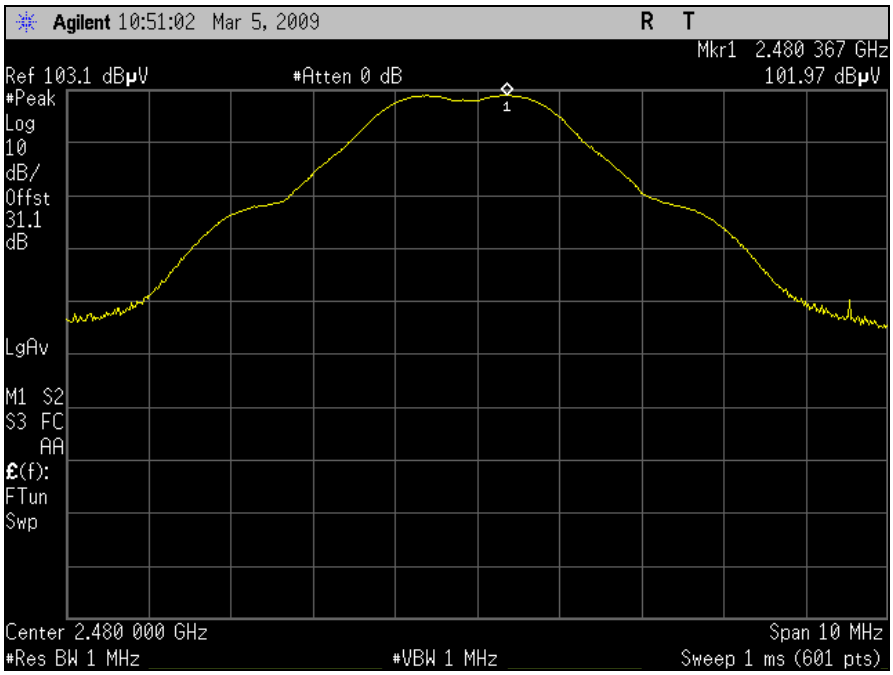
## Radiated Band Edge Measurements (Omni Antenna)



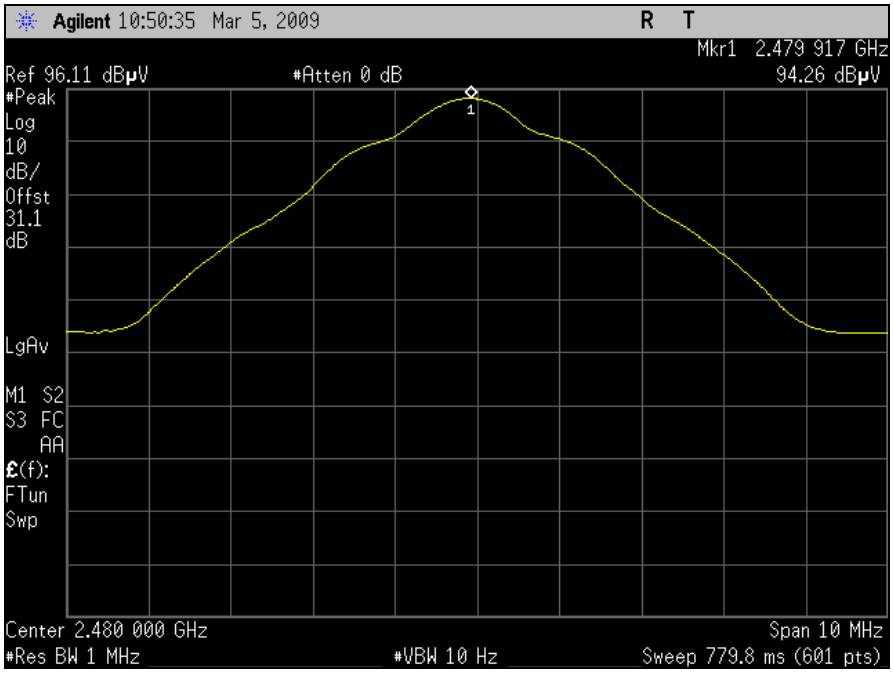

**Plot 24. Lower Band Edge, Average, Omni**



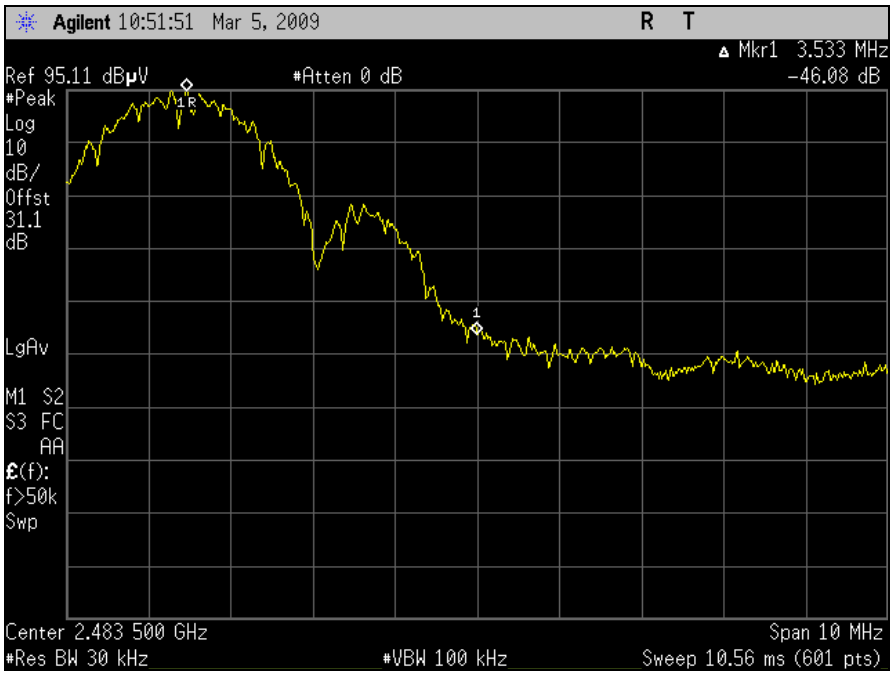

**Plot 25. Lower Band Edge, Peak, Omni**




**Plot 26. Upper Band Edge High Channel, Peak, Omni**

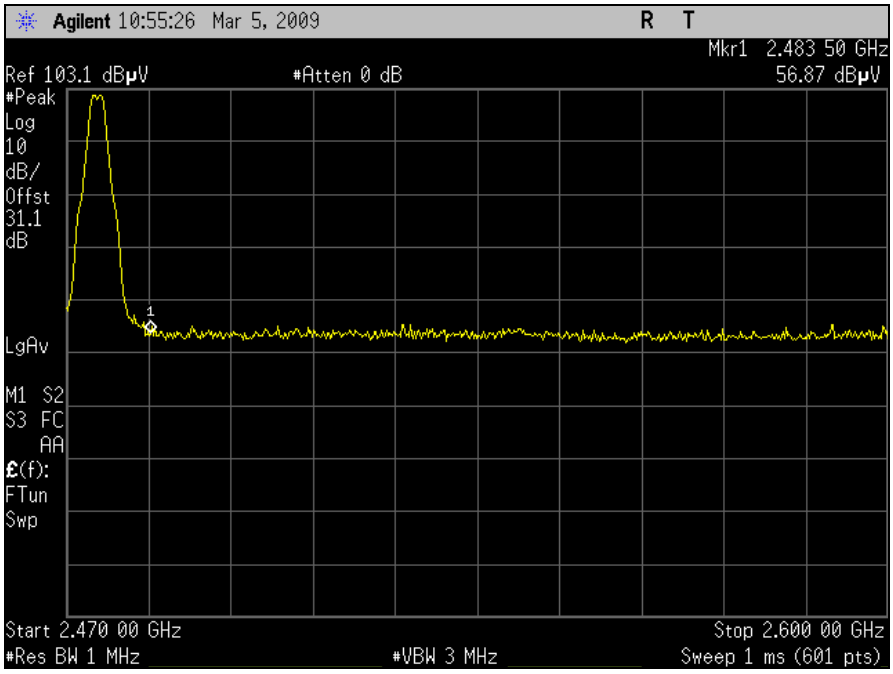



**Plot 27. Upper Band Edge High Channel, Average, Omni**

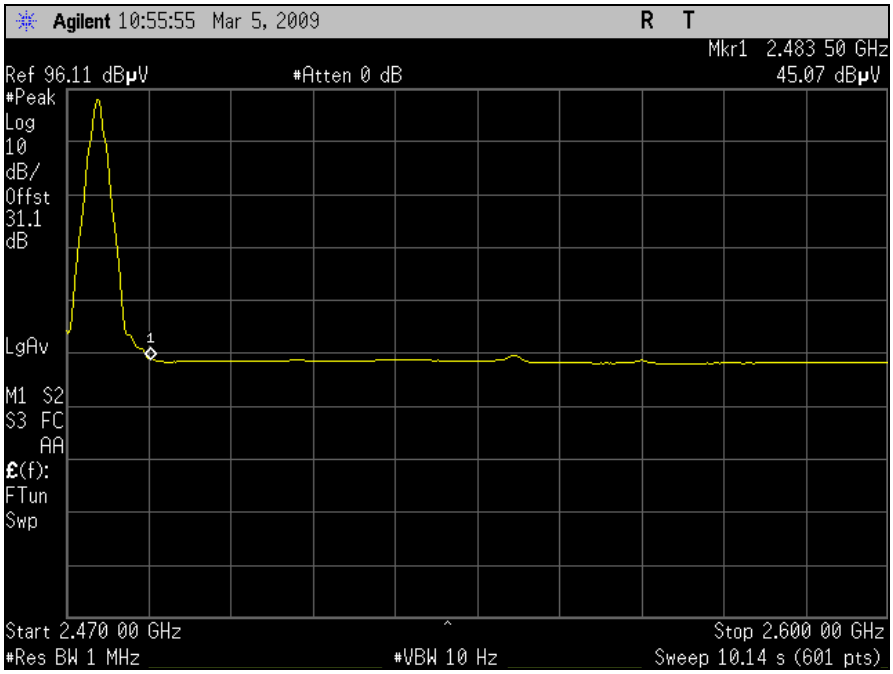



**Plot 28. Band Edge High Channel, Delta, Omni**

| Emission | Corrected Amplitude (dBuV) | Delta Method (dBuV) | Band Edge Measurement (dBuV) | Limit (dBuV) | Margin (dBuV) |
|---|---|---|---|---|---|
| Peak | 101.97 | 46.08 | 55.89 | 74 | 27.92 |
| Avg. | 94.26 | 46.08 | 48.18 | 54 | 5.82 |

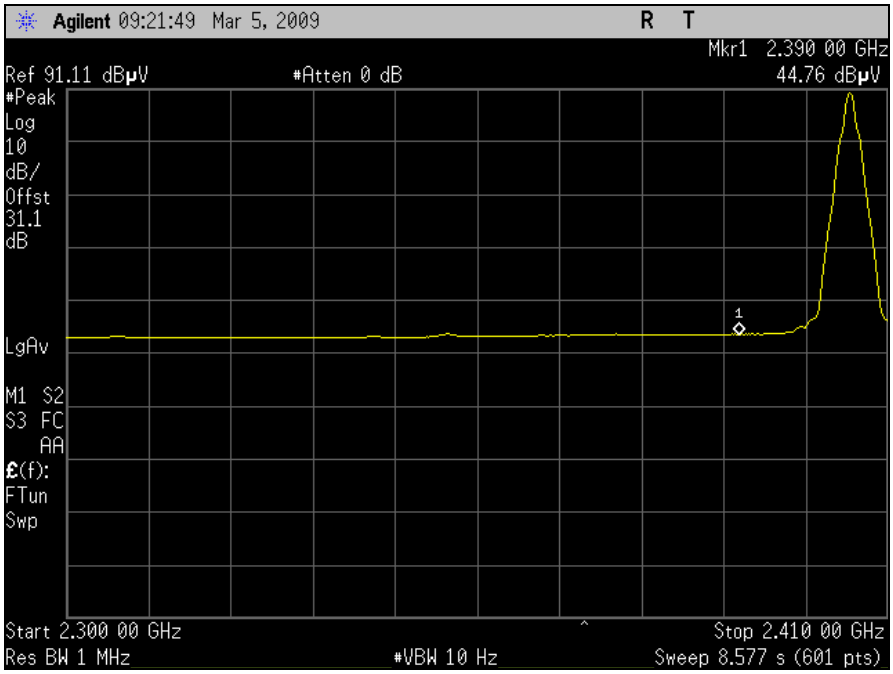



**Plot 29. 2nd Highest Upper Band Edge, Peak, Omni**

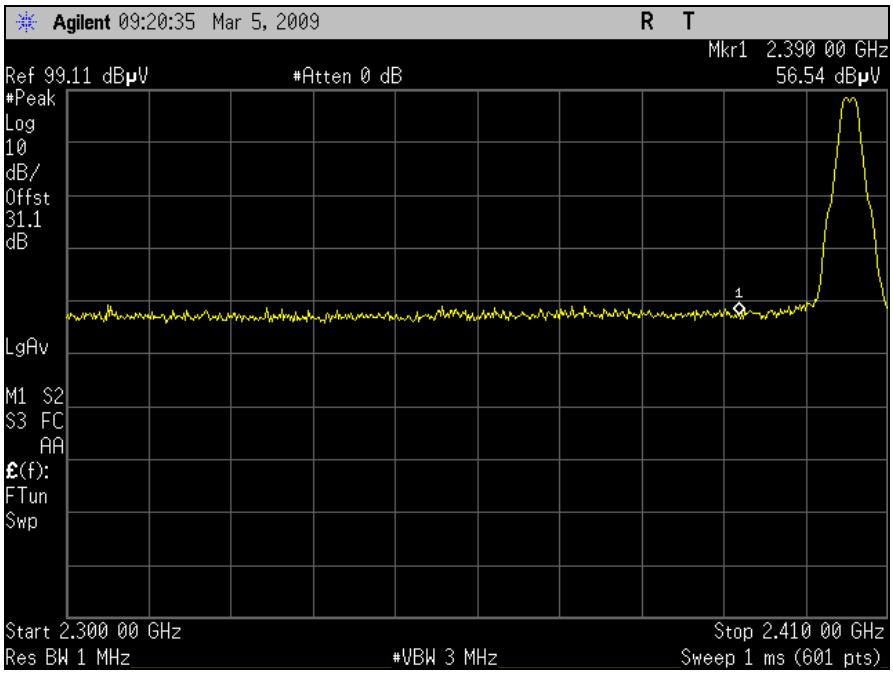



**Plot 30. 2nd Highest Upper Band Edge, Average, Omni**

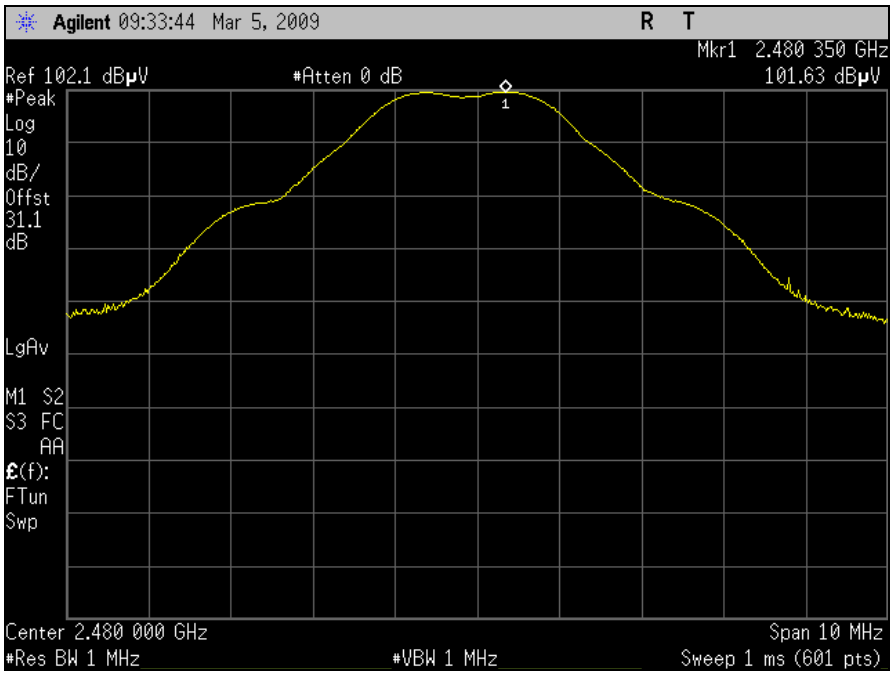
## Radiated Band Edge Measurements (PCB Antenna)



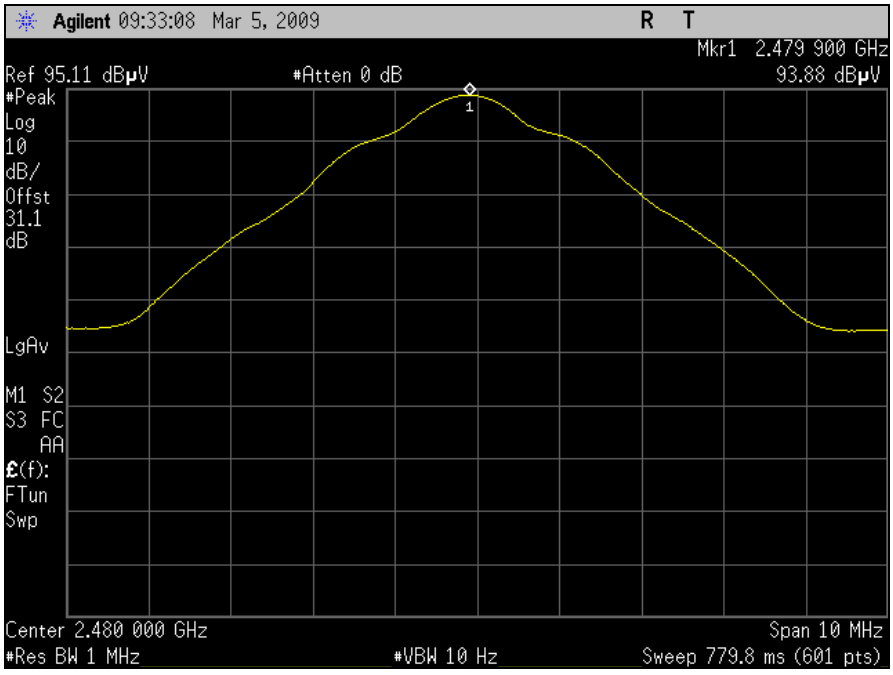

**Plot 31. Lower Band Edge, Average, PCB**



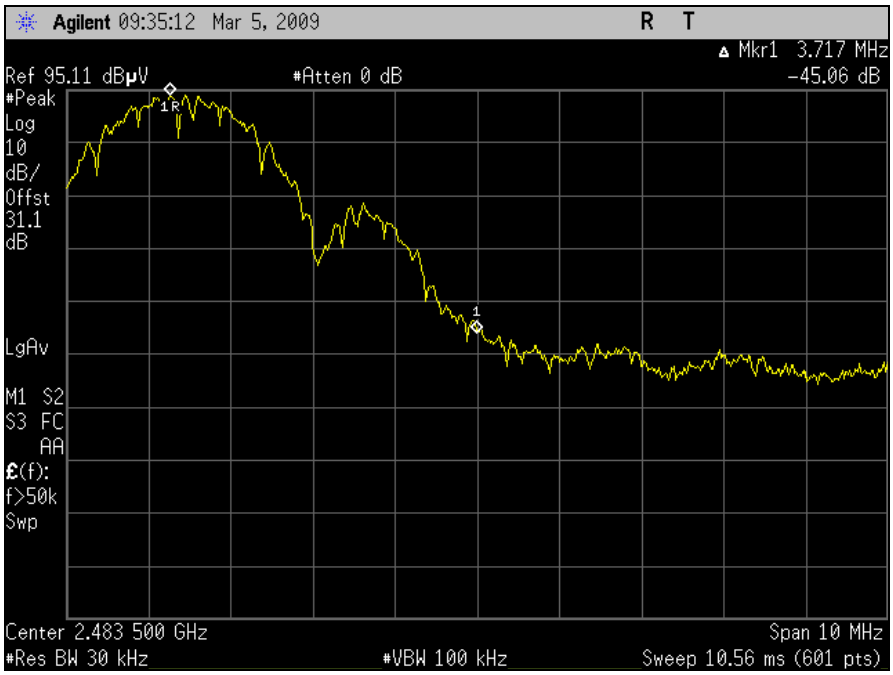

**Plot 32. Lower Band Edge, Peak, PCB**




**Plot 33. Upper Band Edge High Channel, Peak, PCB**

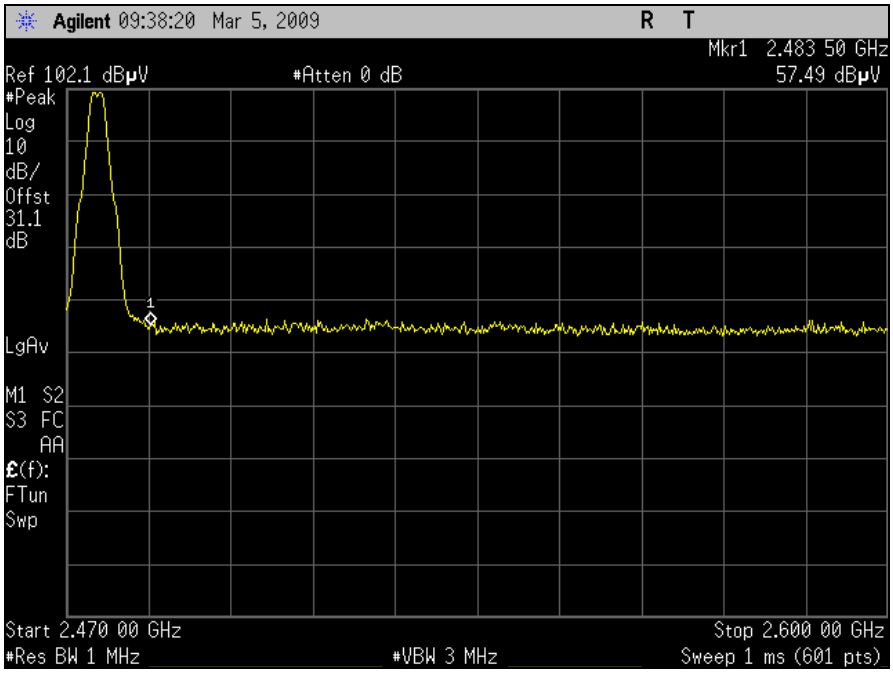



**Plot 34. Upper Band Edge High Channel, Average, PCB**

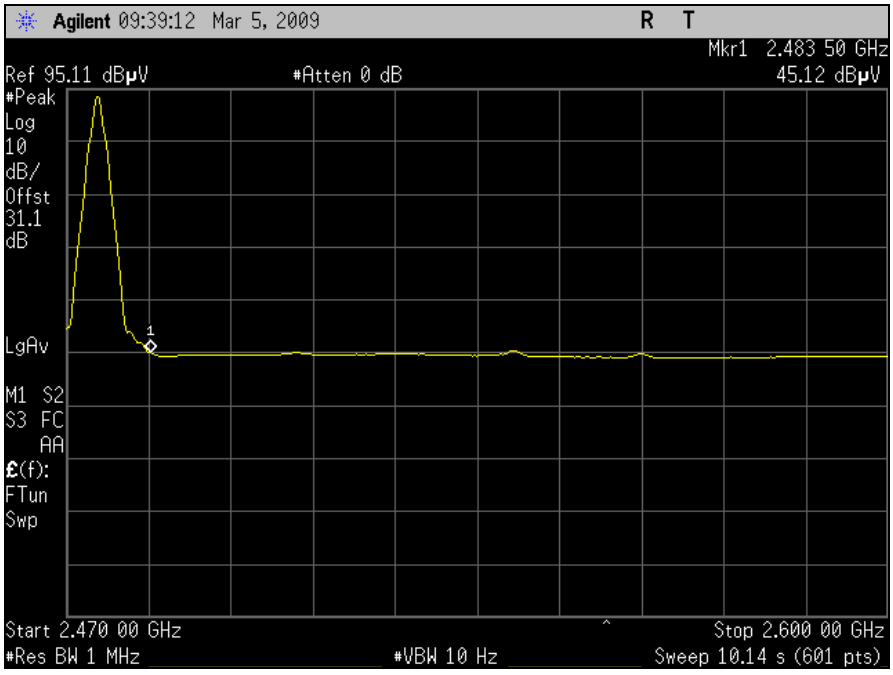



**Plot 35. Band Edge High Channel, Delta**

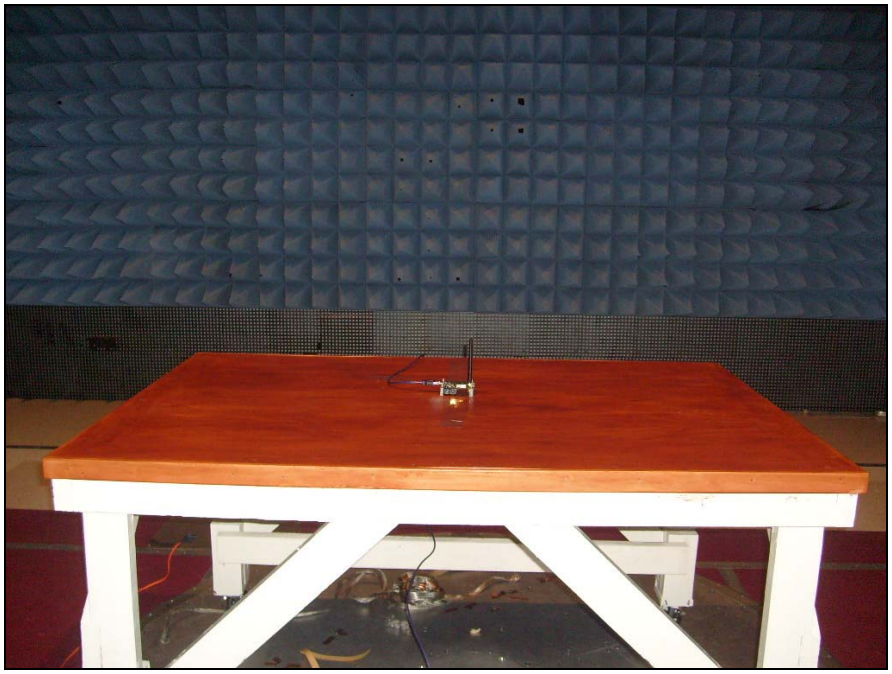
| Emission | Corrected Amplitude (dBuV) | Delta Method (dBuV) | Band Edge Measurement (dBuV) | Limit (dBuV) | Margin (dBuV) |
|---|---|---|---|---|---|
| Peak | 101.63 | 45.06 | 56.57 | 74 | 17.43 |
| Avg. | 93.88 | 45.06 | 48.82 | 54 | 5.18 |



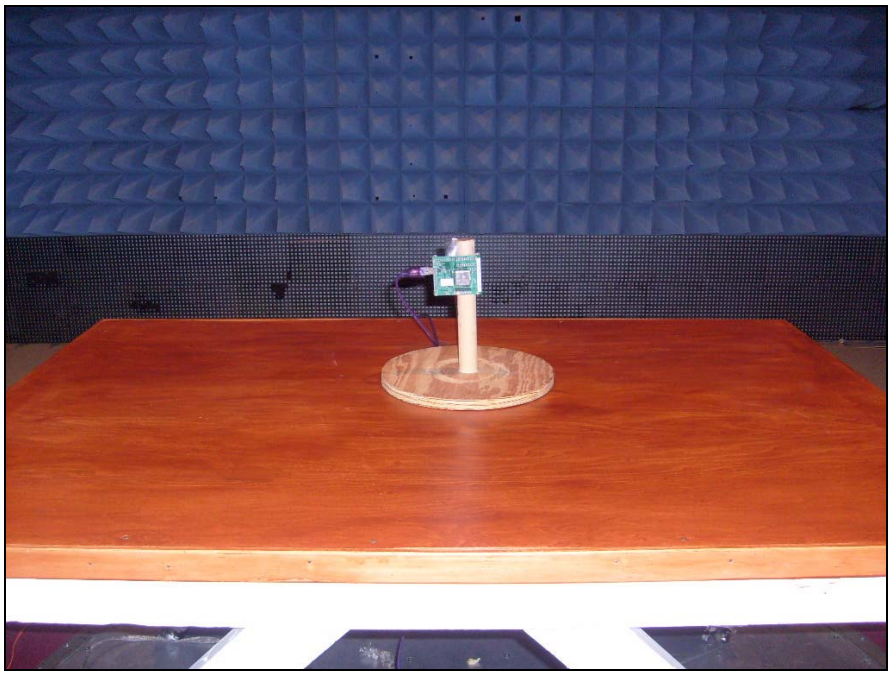

**Plot 36. 2nd Highest Channel Upper Band Edge, Peak, PCB**




**Plot 37. 2nd Highest Channel Upper Band Edge, Average, PCB**



**Photograph 7. Test Equipment and Setup for Various Radiated Measurements, Omni**



**Photograph 8. Test Equipment and Setup for Various Radiated Measurements, PCB**

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(d) Spurious Emissions Requirements –RF Conducted

**Test Procedure:** For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

For frequencies 30MHz-26GHz, measurements were made at coupler port of the EUT's Antenna Port.

**Test Results:** The EUT was compliant with the Spurious Emissions Requirements – RF Conducted limits of **§ 15.247 (d)**.

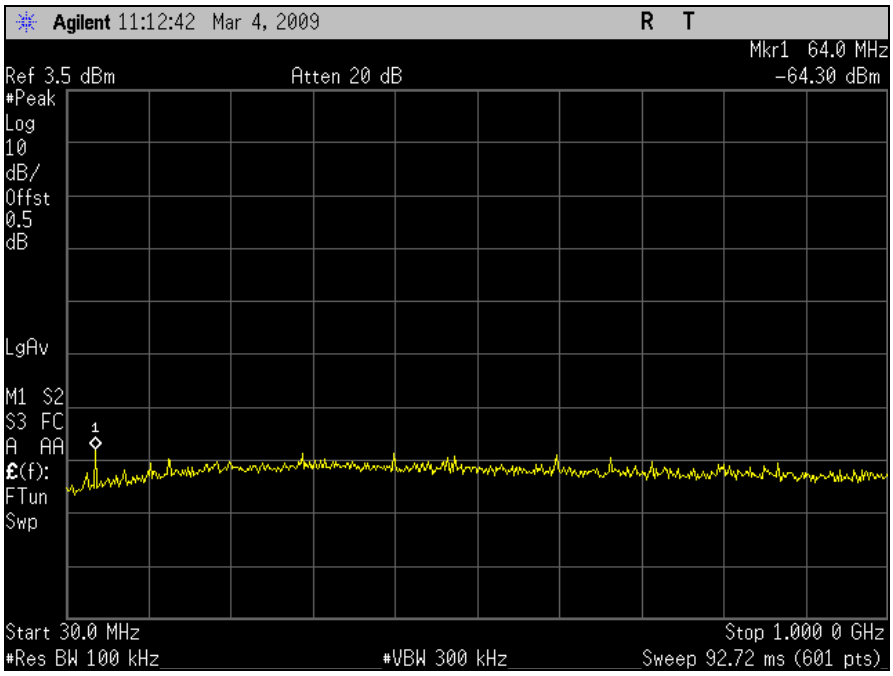
See following pages for detailed test results with RF Conducted Spurious Emissions and §15.205.

**Test Engineer(s):** Anderson Soungpanya

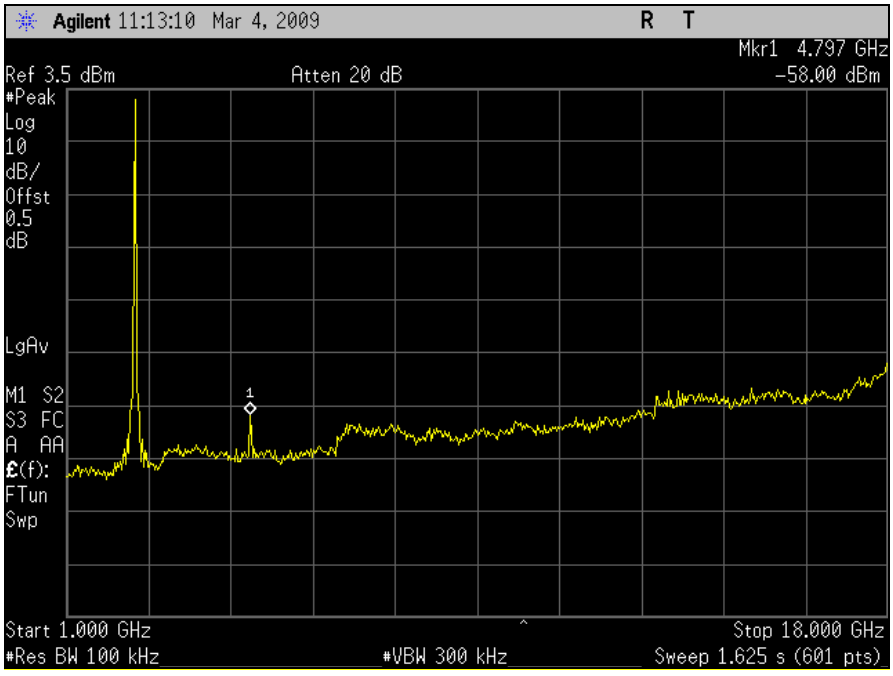
**Test Date(s):** 03/04/09


**Figure 3. Block Diagram of Test Setup for Spurious Conducted Emissions**

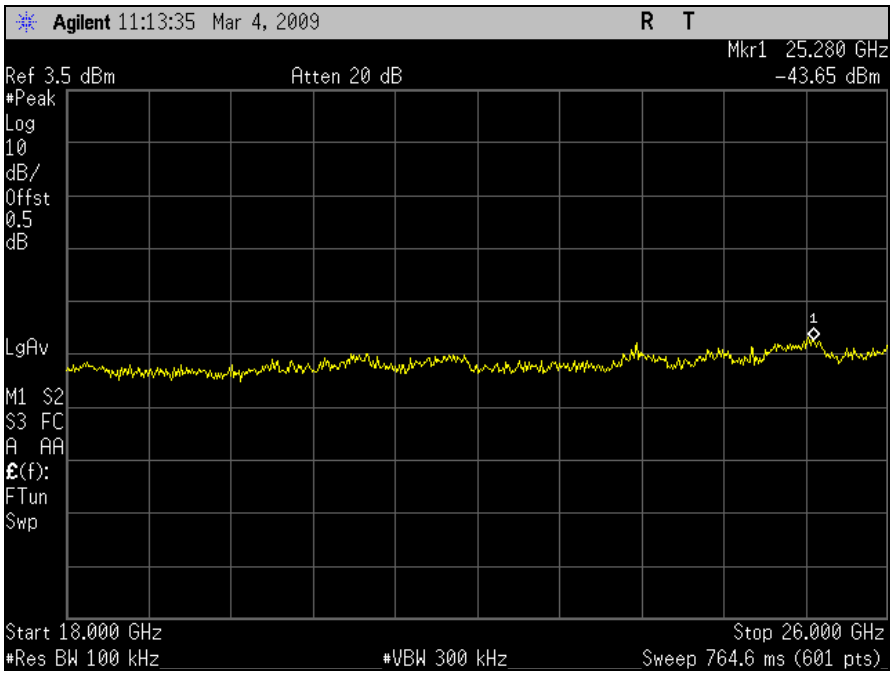
  



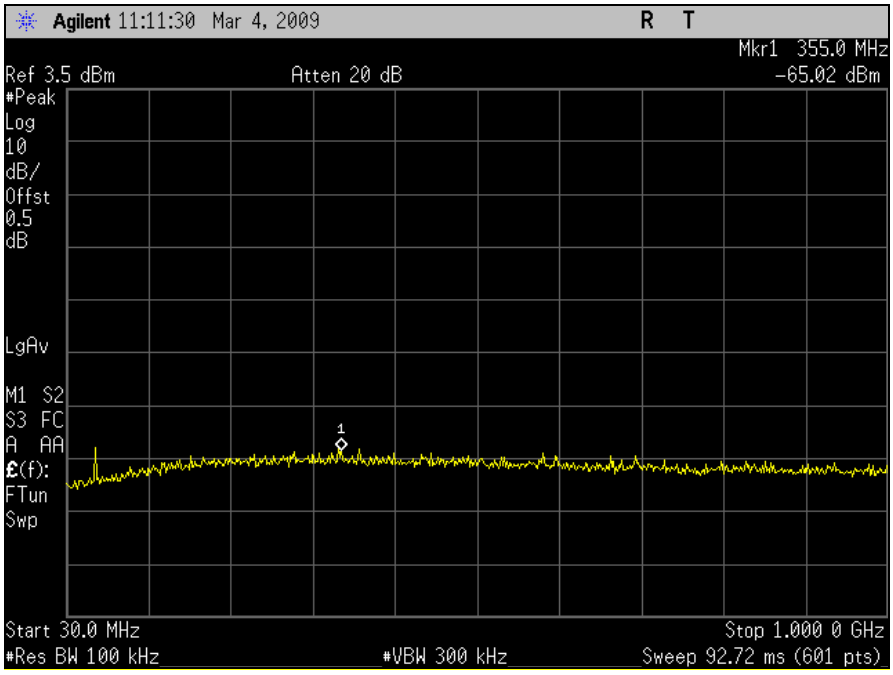

**Plot 38. Spurious Conducted Emissions, Low Channel, 30 MHz – 1 GHz**



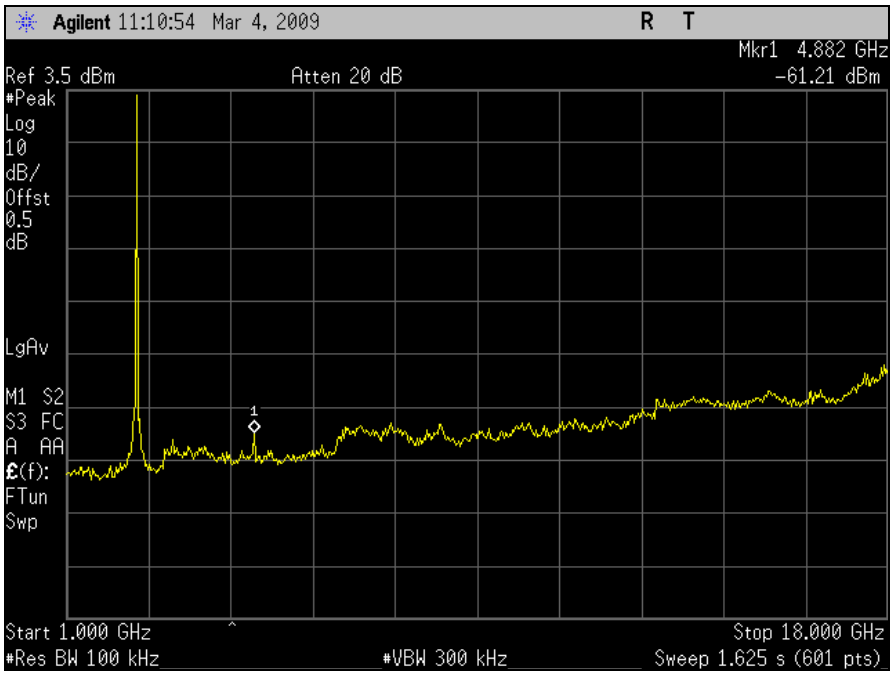

**Plot 39. Spurious Conducted Emissions, Low Channel, 1 GHz – 18 GHz**



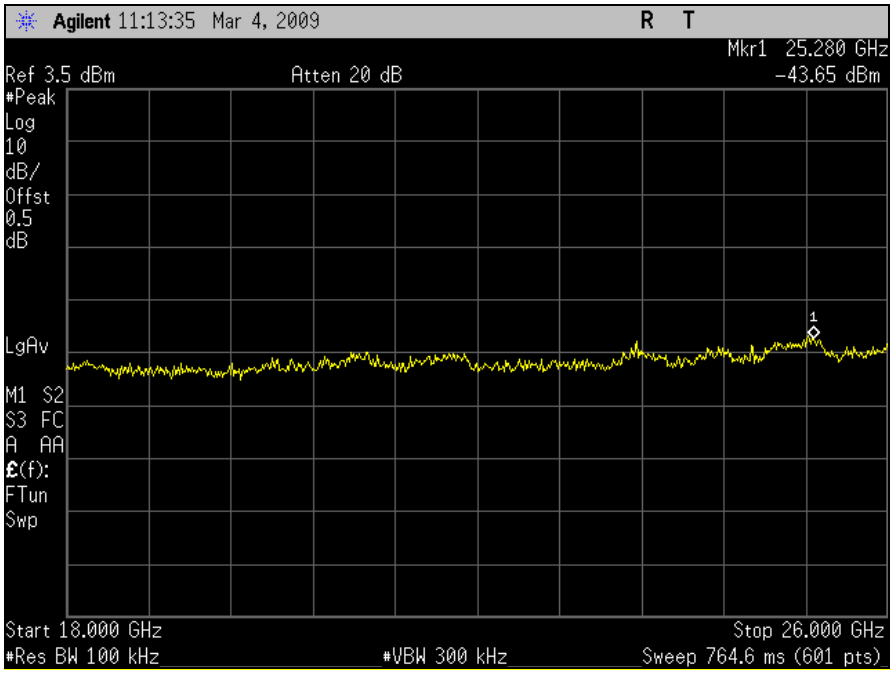

**Plot 40. Spurious Conducted Emissions, Low Channel, 18 GHz – 26 GHz**



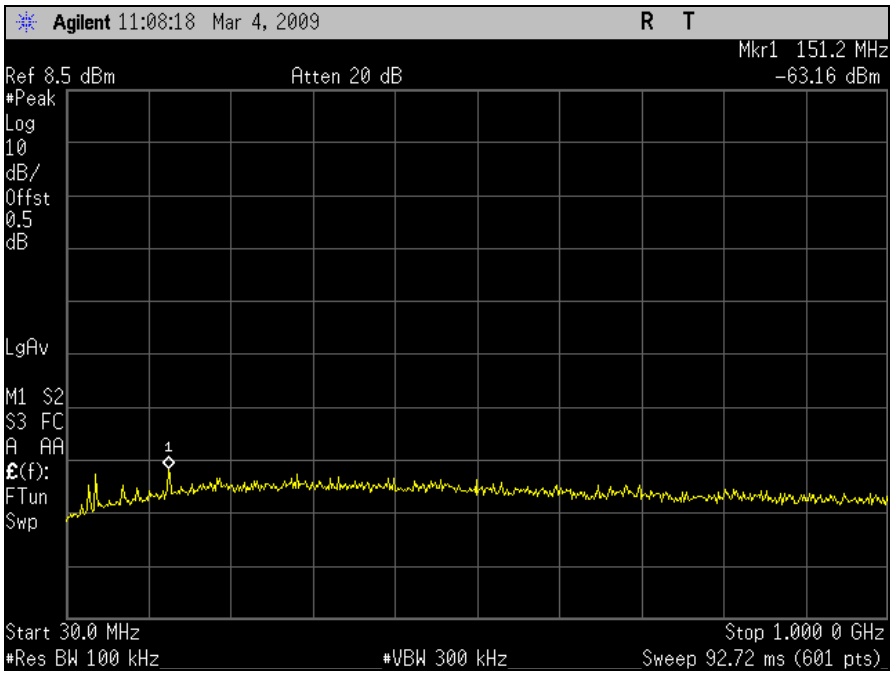

**Plot 41. Spurious Conducted Emissions, Mid Channel, 30 MHz – 1 GHz**



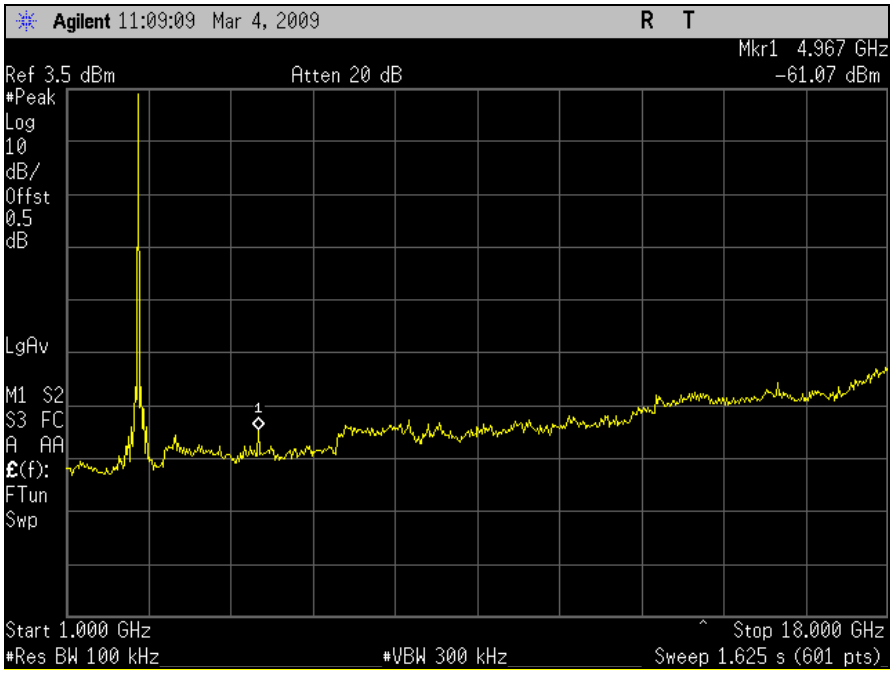

**Plot 42. Spurious Conducted Emissions, Mid Channel, 1 GHz – 18 GHz**



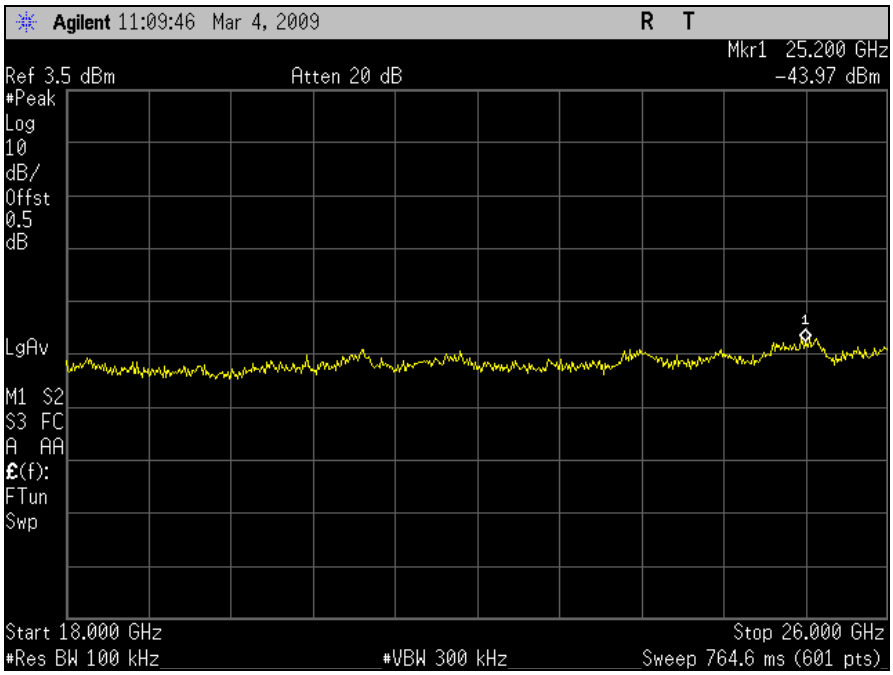

**Plot 43. Spurious Conducted Emissions, Mid Channel, 18 GHz – 26 GHz**




**Plot 44. Spurious Conducted Emissions, High Channel, 30 MHz – 1 GHz**

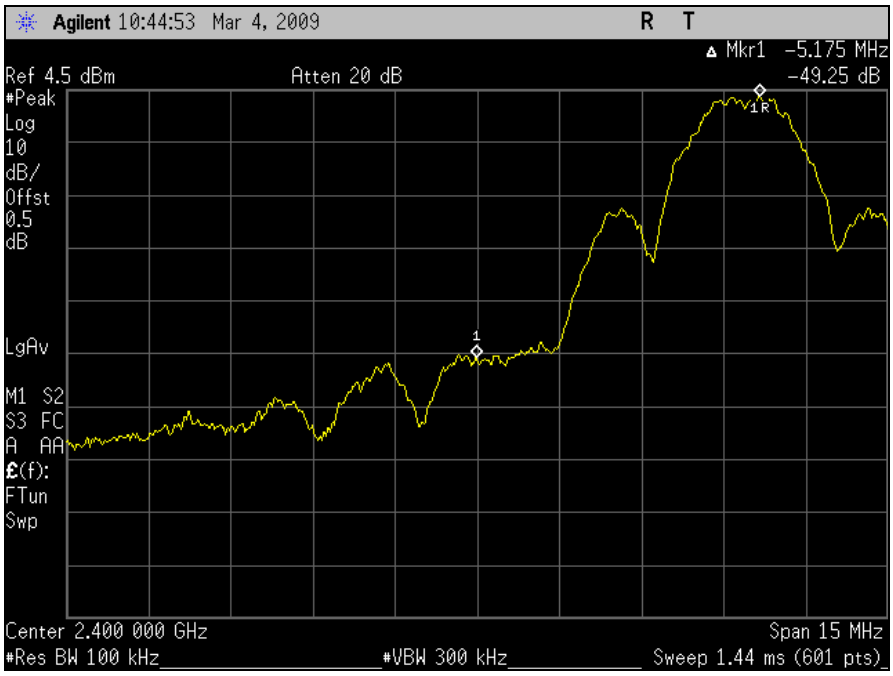



**Plot 45. Spurious Conducted Emissions, High Channel, 1 GHz – 18 GHz**

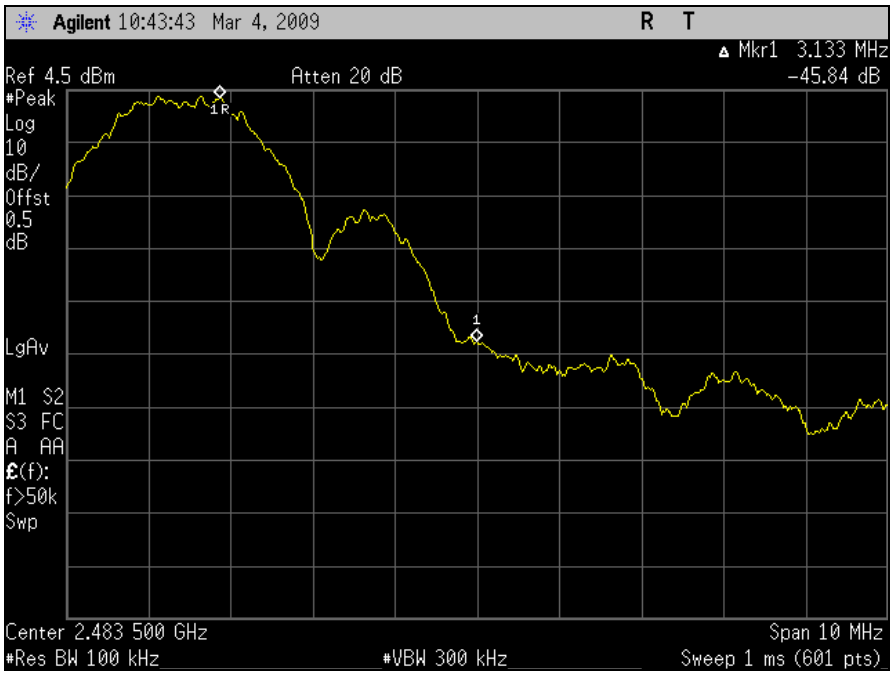



**Plot 46. Spurious Conducted Emissions, High Channel, 18 GHz – 26 GHz**

## Conducted Band Edge




**Plot 47. Lower Conducted Band Edge**




**Plot 48. Upper Conducted Band Edge**

## Electromagnetic Compatibility Criteria for Intentional Radiators

### § 15.247(e) Peak Power Spectral Density

**Test Requirements:** **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

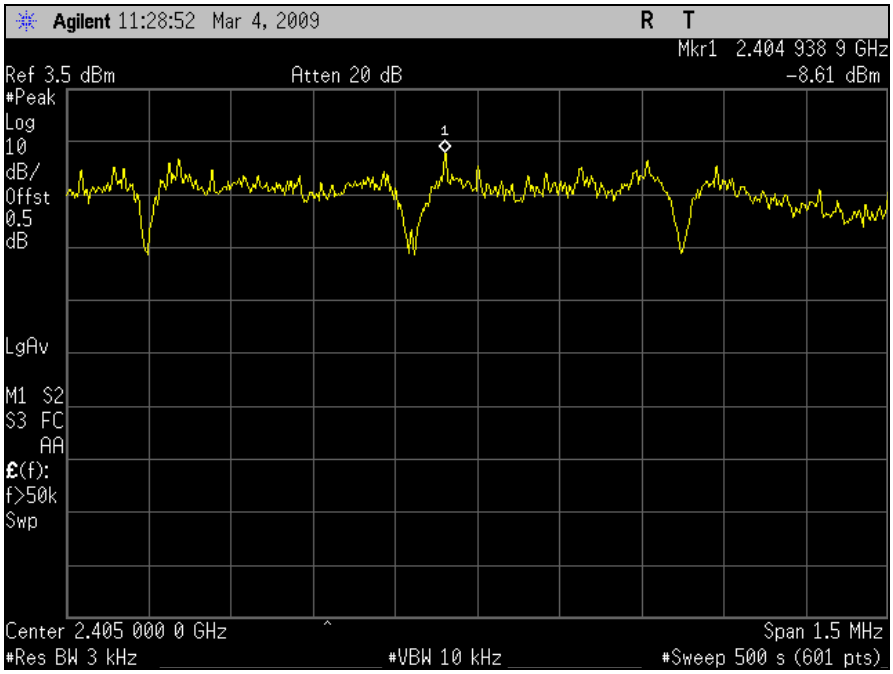
**Test Procedure:** The transmitter was connected directly to a Spectrum Analyzer through a directional couple. The power was monitored at the coupler port with a Peak Power Meter. The power level was set to the maximum level. The RBW was set to 3 kHz and VBW was set to 10 kHz and a SPAN of 1.0 MHz with a 333.3 second sweep to the Spectrum Analyzer. Measurements were carried out at the low, mid and high channels..

**Test Results:** The EUT was compliant with the peak power spectral density limits of **§ 15.247 (e)**. The peak power spectral density was determined from plots on the following page(s).

| Carrier Channel | Frequency (MHz) | Measured PPSD (dBm) | Limit (dBm) | Margin (dB) |
|---|---|---|---|---|
| Low | 2402 | -8.61 | 8 | 16.61 |
| Mid | 2443 | -8.83 | 8 | 16.83 |
| High | 2478 | -8.67 | 8 | 16.67 |

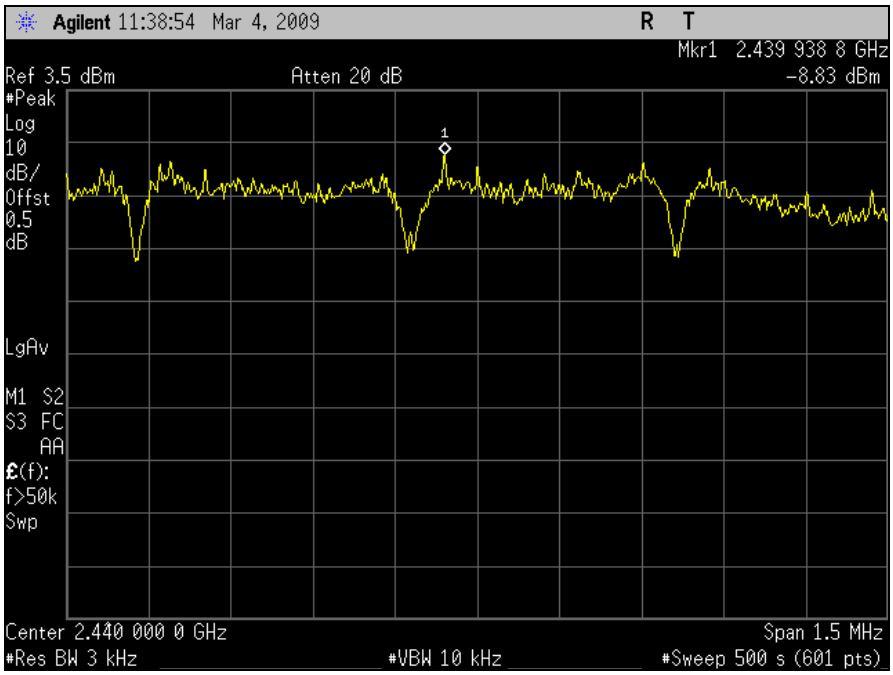
**Test Engineer:** Anderson Soungpanya

**Test Date:** 03/04/09

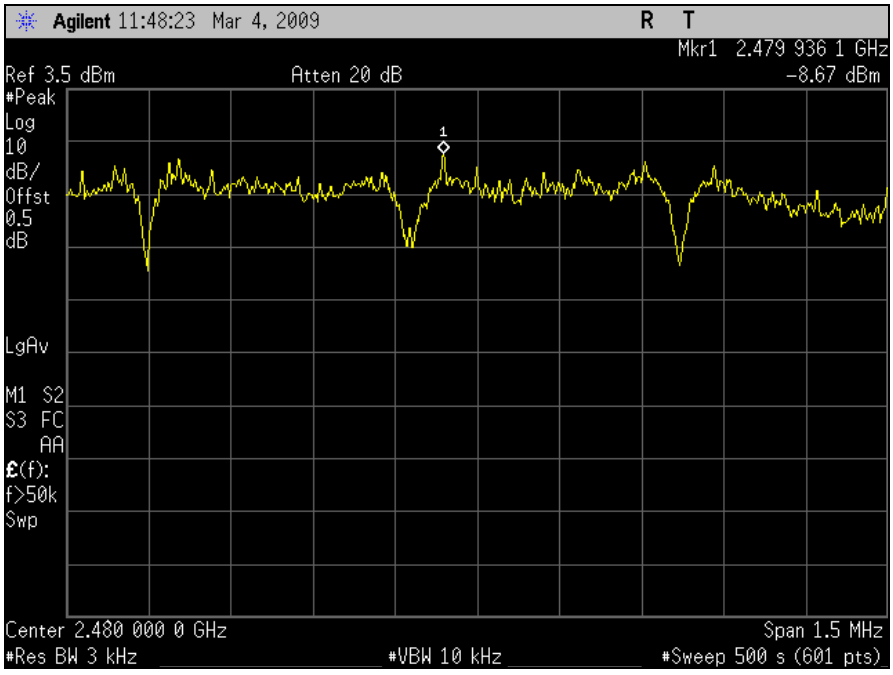



**Plot 49. Peak Power Spectral Density, Low Channel**




**Plot 50. Peak Power Spectral Density, Mid Channel**




**Plot 51. Peak Power Spectral Density, High Channel**

# IV. Test Equipment

## Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ANSI/NCSL Z540-1-1994 and ANSI/ISO/IEC 17025:2000.

| MET Asset # | Equipment | Manufacturer | Model | Last Cal Date | Cal Due Date |
|---|---|---|---|---|---|
| 1S2508 | AC LISN | SOLAR ELECTRONICS | TYPE 9252-50-R-24-BNC | 4/22/08 | 4/22/09 |
| 1S2438 | TRANSIENT LIMITER | AGILENT | 11947A | SEE NOTE | |
| 1S2460 | SPECTRUM ANALYZER | AGILENT | E4407B | 3/24/08 | 3/24/09 |
| 1S2198 | HORN ANTENNA | EMCO | 3115 | 9/10/09 | 9/10/10 |
| 1S2421 | EMI TEST RECEIVER | ROHDE & SCHWARZ | ESIB7 | 11/6/08 | 11/6/09 |
| 1S2506 | SPECTRUM ANALYZER | ROHDE & SCHWARZ | FSP | 4/30/2008 | 4/30/2009 |
| 1S2457 | HORN ANTENNA | COM POWER | AHA 118 | 4/8/2008 | 4/8/2009 |
| 1S2518 | HYGROMETER/THERMOMETER | FISCHER SCIENTIFIC | 11-661-7D | 1/21/08 | 1/21/10 |
| 1S2121 | PREAMP | HEWLETT PACKARD | 8449B | 10/26/08 | 10/26/09 |
| 1S2501 | EMI TEST RECEIVER | ROHDE & SCHWARZ | ESU 40 | 4/8/08 | 4/8/09 |
| 1S2482 | 5M CHAMBER | PANASHEILD | 641431 | 11/18/08 | 11/18/09 |
| 1S2583 | SPECTRUM ANALYZER | AGILENT | E4447A | 1/12/09 | 1/12/10 |
| 1S2485 | BILOG ANTENNA | TESEQ | CBL-6112D | 1/26/09 | 1/26/10 |
| 1S2481 | 10M CHAMBER | ETS-LINDGREN | DKE 8X8 DBL | 12/26/2008 | 12/26/2009 |
| N/A | HIGH PASS FILTER | MICRO-TRONICS | HPM13146 | SEE NOTE | |

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

# V. Certification & User's Manual Information

# Certification & User's Manual Information

## A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

**§ 2.801 Radio-frequency device defined.**

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

(a) The various types of radio communication transmitting devices described throughout this chapter.

*(b) The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*

(c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.

(d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

**§ 2.803 Marketing of radio frequency devices prior to equipment authorization.**

(a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:

(1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or

(2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.

(d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

(e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:

*(i) Compliance testing;*

(ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or

(v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.

(e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.

(f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

## Certification & User's Manual Information

**The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:**

**§ 2.901 Basis and Purpose**

(a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.[1] *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer*, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.

(b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

**§ 2.907 Certification.**

(a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.

(b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

[1] In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

## Certification & User's Manual Information

### § 2.948 Description of measurement facilities.

(a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.

(1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.

*(i) If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*

(ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.

(2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

# Certification & User's Manual Information

## Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

**§ 15.19 Labeling requirements.**

*(a) In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

i. Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

ii. A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

iii. All other devices shall bear the following statement in a conspicuous location on the device:

*This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

(4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

(5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

**§ 15.21 Information to user.**

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

## Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

**§ 15.105 Information to the user.**

(a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.

– Increase the separation between the equipment and receiver.

– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

– Consult the dealer or an experienced radio/TV technician for help.

## ICES-003 Procedural & Labeling Requirements

From the Industry Canada Electromagnetic Compatibility Advisory Bulletin entitled, "Implementation and Interpretation of the Interference-Causing Equipment Standard for Digital Apparatus, ICES-003" (EMCAB-3, Issue 2, July 1995):

> "At present, CISPR 22: 2002 and ICES technical requirements are essentially equivalent. Therefore, if you have CISPR 22: 2002 approval by meeting CISPR Publication 22, the only additional requirements are: to attach a note to the report of the test results for compliance, indicating that these results are deemed satisfactory evidence of compliance with ICES-003 of the Canadian Interference-Causing Equipment Regulations; to maintain these records on file for the requisite five year period; and to provide the device with a notice of compliance in accordance with ICES-003."

**Procedural Requirements:**

According to Industry Canada's Interference Causing Equipment Standard for Digital Apparatus ICES-003 Issue 4, February 2004:

Section 6.1: A record of the measurements and results, showing the date that the measurements were completed, shall be retained by the manufacturer or importer for a period of at least five years from the date shown in the record and made available for examination on the request of the Minister.

Section 6.2: A written notice indicating compliance must accompany each unit of digital apparatus to the end user. The notice shall be in the form of a label that is affixed to the apparatus. Where because of insufficient space or other constraints it is not feasible to affix a label to the apparatus, the notice may be in the form of a statement in the user manual.

**Labeling Requirements:**

The suggested text for the notice, in English and in French, is provided below, from the Annex of ICES-003:

> This Class [2] digital apparatus complies with Canadian ICES-003.
>
> Cet appareil numérique de la classe [1] est conforme à la norme NMB-003 du Canada.

[2] Insert either A or B but not both as appropriate for the equipment requirements.

# End of Report