Test of Zebra Enterprise Solutions Corp.
WhereLAN III Location Sensor

To: FCC 47 CFR Part 15.247 & IC 210

Test Report Serial No.: GBCC01-U1 Rev A

# TEST REPORT

From

**Test of:** Zebra Enterprise Solutions Corp. WhereLAN III Location Sensor

**To:** FCC 47 CFR Part 15.247 & IC RSS-210

**Test Report Serial No.:** GBCC01-U1 Rev A

This report supersedes: None

| | |
|---|---|
| **Applicant:** | Zebra Enterprise Solutions Corp.<br>2940 N. First Street<br>San Jose, CA 95134<br>USA |
| **Product Function:** | Wireless Location Sensor |
| **Copy No:** pdf | **Issue Date:** 6th December 2010 |

**This Test Report is Issued Under the Authority of;**


**MiCOM Labs, Inc.**
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TESTING CERTIFICATE #2381.01

**MiCOM Labs is an ISO 17025 Accredited Testing Laboratory**

# TABLE OF CONTENTS

# 1 ACCREDITATION, LISTINGS & RECOGNITION

## 1.1 TESTING ACCREDITATION

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard EN ISO/IEC 17025. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-01.pdf

## 1.2 RECOGNITION

MiCOM Labs, Inc has widely recognized Electrical testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA** countries. Our test reports are widely accepted for global type approvals.

| Country | Recognition Body | Status | Phase | Identification No. |
|---|---|---|---|---|
| USA | Federal Communications Commission (FCC) | TCB | - | Listing #: 102167 |
| Canada | Industry Canada (IC) | FCB | APEC MRA 2 | Listing #: 4143A |
| Japan | VCCI | - | - | No. 2959 |
| | MIC | RCB | APEC MRA 2 | US0159 |
| Europe | European Union | NB | N/A | |
| Australia | Australian Communications and Media Authority (ACMA) | CAB | APEC MRA 1 | |
| Hong Kong | Office of the Telecommunication Authority (OFTA) | CAB | APEC MRA 1 | |
| Korea | Ministry of Information and Communication Radio Research Laboratory (RRL) | CAB | APEC MRA 1 | |
| Singapore | Infocomm Development Authority (IDA) | CAB | APEC MRA 1 | |
| Taiwan | National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI) | CAB | APEC MRA 1 | |
| Vietnam | Ministry of Communication (MIC) | CAB | APEC MRA 1 | |

**APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement.
Is a recognition agreement under which test lab is accredited to regulatory standards of the APEC member countries.
Phase I - recognition for product testing
Phase II – recognition for both product testing and certification
N/A – Not Applicable

## 1.3 PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard EN ISO/IEC Guide 65. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-02.pdf


The American Association for Laboratory Accreditation

World Class Accreditation

*Accredited Product Certification Body*

A2LA has accredited

**MICOM LABS**

*Pleasanton, CA*

for technical competence as a

Product Certification Body

This product certification body is accredited in accordance with the recognized International Standard ISO/IEC Guide 65:1996 *General requirements for bodies operating product certification systems*. This accreditation demonstrates technical competence for a defined scope and the operation of a quality management system for a Telecommunications Certification Body (TCB) meeting FCC (U.S.), and IC (Canada) requirements.

Presented this 24th day of June 2010.

President & CEO
For the Accreditation Council
Certificate Number 2381.02
Valid to November 30, 2011

*For the product certification schemes to which this accreditation applies, please refer to the organization's Product Certification Scope of Accreditation.*

**United States of America – Telecommunication Certification Body**

TCB Identifier – US0159

**Industry Canada – Certification Body**

CAB Identifier – US0159

# 2 DOCUMENT HISTORY

| Document History | | |
|---|---|---|
| **Revision** | **Date** | **Comments** |
| Draft | | |
| Rev A | 6th December 2010 | Initial Release |
| | | |
| | | |

# 3 TEST RESULT CERTIFICATE

| | | | |
|---|---|---|---|
| Applicant: | Zebra Enterprise Solutions Corp.<br>2940 N. First Street<br>San Jose<br>CA , 95134, USA | Tested By: | MiCOM Labs, Inc.<br>440 Boulder Court<br>Suite 200<br>Pleasanton<br>California, 94566, USA |
| Product: | WhereLAN III Location Sensor | Telephone: | +1 925 462 0304 |
| Model No.: | LOS-5000 | Fax: | +1 925 462 0306 |
| S/No's: | M12120901M12 | | |
| Date(s) Tested: | 25th Oct to 2nd November 2010 | Website: | www.micomlabs.com |

| STANDARD(S) | TEST RESULTS |
|---|---|
| FCC 47 CFR Part 15.247 & IC 210 | EQUIPMENT COMPLIES |

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

**Notes:**

1. This document reports conditions under which testing was conducted and the results of testing performed.
2. Details of test methods used have been recorded and kept on file by the laboratory.
3. Test results apply only to the item(s) tested.

**Approved & Released for MiCOM Labs, Inc. by:**

ACCREDITED
TESTING CERTIFICATE #2381.01

Graeme Grieve
Quality Manager MiCOM Labs, Inc.

Gordon Hurst
President & CEO MiCOM Labs, Inc.

# 4 REFERENCES AND MEASUREMENT UNCERTAINTY

## 4.1 Normative References

| Ref. | Publication | Year | Title |
|---|---|---|---|
| **i.** | 47 CFR Part 15, SubPart 15.247 | 2007 | For Digitally Modulated Intentional Radiators |
| **ii.** | Industry Canada RSS-210 | Issue 7 June 2007 | Low Power License-Exempt Radiocommunication Devices (All Frequency Bands) |
| **iii.** | Industry Canada RSS-Gen | Issue 2 June 2007 | General Requirements and Information for the Certification of Radiocommunication Equipment. |
| **iv.** | ANSI C63.4 | 2009 | American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz |
| **v.** | CISPR 22/ EN 55022 | 2008 2006+A1:2007 | Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment |
| **vi.** | M 3003 | Edition 1 Dec. 1997 | Expression of Uncertainty and Confidence in Measurements |
| **vii.** | LAB34 | Edition 1 Aug 2002 | The expression of uncertainty in EMC Testing |
| **viii.** | ETSI TR 100 028 | 2001 | Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics |
| **ix.** | A2LA | 9th June 2010 | Reference to A2LA Accreditation Status – A2LA Advertising Policy |

## 4.2 Test and Uncertainty Procedures

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.

# 5 TEST SUMMARY

**List of Measurements:**

The following table represents the list of measurements required under the **FCC CFR47 Part 15.247** and **Industry Canada RSS-210** and **Industry Canada RSS-Gen.**

| Section(s) | Test Items | Description | Condition | Result | Test Report Section |
|---|---|---|---|---|---|
| **15.247(a)(2)**<br>**A8.2(1)**<br>**4.4** | 6 dB and 99 % Bandwidths | ≥500 kHz | Conducted | Complies | 7.1 |
| **15.247(b)(3)**<br>**15.31(e)**<br>**A8.4(4)** | Peak Output Power<br>Voltage Variation | Shall not exceed 1W<br>Variation of supply voltage 85 % -115 % | Conducted | Complies | 7.2 |
| **15.247(e)**<br>**A8.2** | Peak Power Spectral Density | Shall not be greater than +8 dBm in any 3 kHz band | Conducted | Complies | 7.3 |
| **15.247(i)**<br>**5.5** | Maximum Permissible Exposure | Exposure to radio frequency energy levels | Conducted | Complies | 7.4 |
| **15.247(d)**<br>**15.205 /**<br>**15.209**<br>**A8.5**<br>**2.2**<br>**4.7** | Spurious Emissions<br>(30MHz - 26 GHz b/g and 30 MHz – 40 GHz a) | The radiated emission in any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density | Conducted | Complies | 7.5 |

## List of Measurements (continued)

The following table represents the list of measurements required under the **FCC CFR47 Part 15.247, Industry Canada RSS-210,** and **Industry Canada RSS-Gen.**

| Section(s) | Test Items | Description | Condition | Result | Test Report Section |
|---|---|---|---|---|---|
| **15.247(d)**<br>**15.205 /**<br>**15.209**<br>**A8.5**<br>**2.2**<br>**2.6**<br>**4.7** | Radiated Emissions<br>Transmitter Radiated Spurious Emissions<br>Radiated Band Edge | Restricted Bands<br>Emissions above 1 GHz<br>Band-edge results<br>Peak Emissions | Radiated | Complies<br>Complies<br>Complies | 7.6 |
| Industry Canada only<br>**RSS-Gen §4.10, §6** | Receiver Spurious Emissions | Emissions above 1 GHz | Conducted | Complies | *7.7* |
| **15.205 /**<br>**15.209**<br>**2.2** | Radiated Spurious Emissions | Emissions <1 GHz (30M-1 GHz) | Radiated | Complies | *7.8* |
| **15.207**<br>**7.2.2** | AC Wireline Conducted Emissions 150 kHz–30 MHz | Conducted Emissions | Conducted | Complies | *7.9* |

***Note 1:*** *Test results reported in this document relate only to the items tested*
***Note 2:*** *The required tests demonstrated compliance as per client declaration of test configuration, monitoring methodology and associated pass/fail criteria*
***Note 3:*** *Section 3.7 Equipment Modifications highlights the equipment modifications that were required to bring the product into compliance with the above test matrix*

# 6 PRODUCT DETAILS AND TEST CONFIGURATIONS

## 6.1 Test Program Scope

The scope of the test program was to test the Zebra Enterprise Solutions Corp. WhereLAN III Location Sensor Wireless Location System for compliance against FCC 47 CFR Part 15, SubPart 15.247 & IC RSS-210.

**APPLICANT:** Zebra Enterprise Solutions Corp.

**PRODUCT:** WhereLAN III LOCATION SENSOR

## 6.2 EUT Details

| Detail | Description |
|---|---|
| Purpose: | Test of the Zebra Enterprise Solutions Corp. WhereLAN III Location Sensor Wireless Location System for compliance against FCC 47 CFR Part 15, SubPart 15.247 & IC RSS- 210 |
| Applicant: | Zebra Enterprise Solutions Corp. |
| Manufacturer: | Zebra Enterprise Solutions Corp. |
| Test Laboratory: | MiCOM Labs, Inc.<br>440 Boulder Court, Suite 200<br>Pleasanton, California 94566 USA |
| Test report reference number: | GBCC01 |
| Date EUT received: | 25th October 2010 |
| Dates of test (from - to): | 25th October to 2nd November 2010 |
| No of Units Tested: | 1 |
| Product Name: | WhereLAN III Location Sensor |
| Manufacturers Trade Name: | WhereLAN III Location Sensor |
| Model No.: | LOS-5000 |
| Equipment Primary Function: | Wireless Location System |
| Equipment Secondary Function(s): | None |
| Type of Technology: | Wireless (802.11b/g and ISO24730) |
| Installation type: | Fixed |
| Construction/Location for Use: | Indoor/Outdoor |
| Software/Firmware Release: | Rev B |
| Hardware Release: | Rev 01 |
| Test Software Release: | Windows XP HyperTerminal and FEPdebugger.exe dated 1/13/2009 |
| Transmit/Receive Operation: | Full Duplex |
| Output Power Type | Stepped fixed for ISO |
| AutomaticTransmit Power Control Available: | N/A |
| Remote Frequency Control Available: | N/A |
| Operating Frequency: | 2441.75 MHz |
| Rated Input Voltage and Current DC: | Nominal: 48 Max: 36 Min: 57<br>Current: 0.35 (A) |
| Operating Temperature Range ºC: | Min: -40 Max: +60°C |
| ITU Emission Designator(s): | 802.11b/g<br>ISO24730 DSSS BPSK |
| Long Term Frequency Stability: | 20 ppm |
| Equipment Dimensions: | 10.25 in X 12.25 in X 1.50 in |
| Weight: | 7 lbs |

## 6.3 External A.C/D.C Power Adaptor

| Type | Manufacturer | Manufacturers P/N | Input | Output |
|---|---|---|---|---|
| AC/DC P/S | MEPOS | SIDA25A-S11 | 100-240V (47-63Hz) 0.55A | 48Vdc 0.52A |
| AC/DC P/S | MEPOS | STDA16A-S11 | 100-240V (47-63Hz) 0.4A | 48Vdc 0.31A |
| POE | ITE | PW182RB4800F01 | 100-240V (50-60Hz) 0.6A | 48Vdc 0.35A |

## 6.4 Operational Power Range

| Declared O/P Power Range | Mode 1 | |
|---|---|---|
| | Max | Min |
| EUT | 10 | 0 |

## 6.5 Types of Modulation Supported

| Modulation / Mode | BW 1 |
|---|---|
| ISO24730 DSSS BPSK | 60 MHz |
| 802.11b/g | 22 MHz |

## 6.6 Antenna Details

The following is a description of the EUT antennas.

| Antenna Type: | Manufacturer | Model | Gain (dBi) | Frequency Range (MHz) |
|---|---|---|---|---|
| ISO24730, Helical | ZES | AK-210-10 | 3 | 2412-2472 |
| ISO24730, Helical | ZES | AK-110-10 | 3 | 2412-1472 |
| 802.11, Dipole | Cisco | AIR-ANT4941 | 2 | 2402-2495 |
| 802.11, Dipole | Cisco | AIR-ANT2506 | 5.2 | 2400-2484 |
| 802.11 Yagi | Cisco | AIR-ANT1949 | 13.5 | 2400-2484 |

## 6.7 Cabling and I/O Ports

The following is a description of the cable and input, output ports available on the EUT.

| Type of I/O Ports | Description | Screened (Y/N) | Qty |
|---|---|---|---|
| RJ-45 | Eithernet | N | 1 |
| RJ-22 | Timing Ports | N | 3 |
| DB-9 Male | Serial Port | N | 1 |
| MCX female | RF output ports for ISO24730 | Y | 2 |
| SMB male | RF output port for WIFI | y | 1 |

## 6.8 EUT Configurations

| Band (GHz) | Mode | Freq Band (MHz) | Freq Range (MHz) | Low ch | Mid ch | High ch | # Ch | Ch Spacing (MHz) | ChBW (MHz) |
|---|---|---|---|---|---|---|---|---|---|
| 2.4 | ISO24730 DSSS | 2400 - 2483.5 | 2412 - 2462 | -- | 2441.75 | -- | 1 | -- | 67 |

## 6.9 Equipment Details

The following is a description of EUT and supporting equipment used during the test program.

| Type (EUT/Support) | Equipment Description | Manufacturer | Model No. | Part No (s). |
|---|---|---|---|---|
| EUT | Location Sensor | Zebra Enterprise Solutions Corp. | LOS-5000 | LOS-5000-01AA |
| Support | Remote Telemetry Module | Zebra Enterprise Solutions Corp. | TFF-2225 | TFF-2225-00AA |
| Support | Laptop PC | Dell | PP18L | 72MUF A02 |
| Support | Laptop PC | Dell | PPL | 9172P |

## 6.10 Test Configurations

| Operational Mode(s) | Data Rate Tested | Duty Cycle |
|---|---|---|
| ISO24730 DSSS | 59.7 kbps | 100 |

## 6.11 Equipment Modifications

The following modifications were required to bring the equipment into compliance:

- No modifications required.

## 6.12 Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:

- No deviations required.

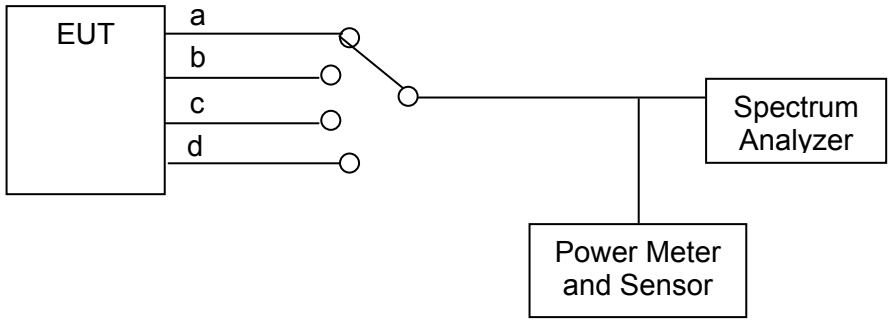
# 7 TEST RESULTS

## 7.1 6 dB and 99% Bandwidth

**Test Procedure**
The test methodology and conditions utilized for each measurement is referenced in the following test results matrix. 6 dB and 99% bandwidth were measured per the Test Configuration identified below.

Testing was restricted to a single port.

**Test Configuration**




Test configuration for 6 dB & 99% Bandwidth

**Specification**

**Limits**

**§15.247 (a)(2) & RSS-210 §A8.2(1)**
The minimum 6 dB bandwidth shall be at least 500 kHz.

**§ IC RSS-Gen 4.4.1 Occupied Bandwidth** When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured.

**§ IC RSS-Gen 4.4.2 6 dB Bandwidth** Where indicated, the 6 dB bandwidth is measured at the points when the spectral density of the signal is 6 dB down from the in –band spectral density of the modulated signal, with the transmitter modulated by a representative signal.

**Traceability**

| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask' | 0158, 0252, 0313, 0314, 0116, 0117, 0287, 0363 |

### 7.1.1 6 dB and 99% Bandwidth Results: DSSS

| | | | | | |
|---|---|---|---|---|---|
| **Test Conditions:** | 15.247 (a)(2) | | **Rel. Humidity (%):** | 35 to 42 | |
| **Variant:** | DSSS | | **Ambient Temp. (ºC):** | 19 to 22 | |
| **TPC:** | HIGH | | **Pressure (mBars):** | 998 to 1003 | |
| **Modulation:** | ON | | **Duty Cycle (%):** | 100 | |
| **Beam Forming Gain (Y):** | N/A | dB | **Antenna Gain:** | 3 | dBi |
| **Applied Voltage:** | 48.00 | Vdc | | | |
| **Notes 1:** | | | | | |
| **Notes 2:** | | | | | |

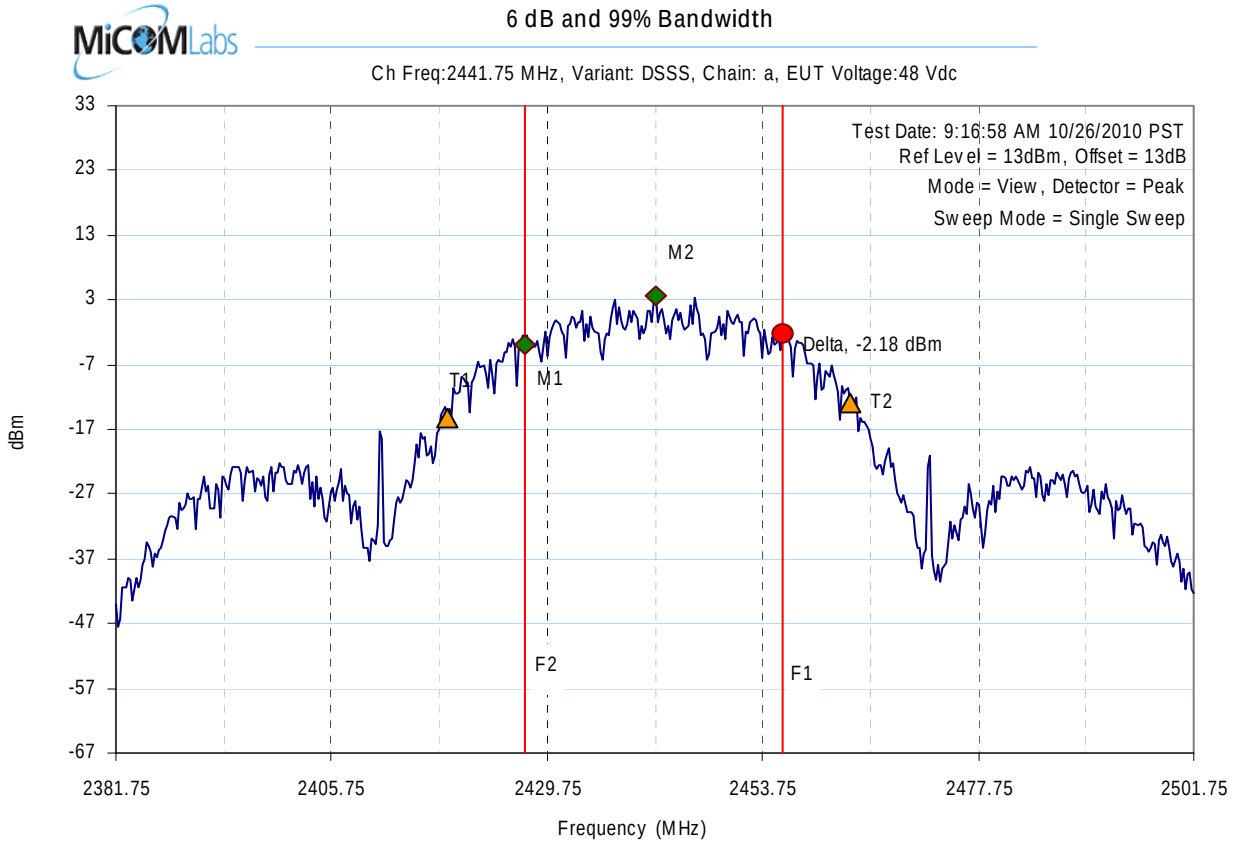
***6 dB Bandwidth***

| Test Frequency | 6 dB Bandwidth MHz | | | | Minimum 6dB Bandwidth Limit | | Margin |
|---|---|---|---|---|---|---|---|
| **MHz** | **a** | **b** | **c** | **d** | **kHz** | **MHz** | **MHz** |
| 2441.750 | 28.858000 | -- | -- | -- | 500 | 0.5 | -28.358000 |
| -- | -- | -- | -- | -- | | | |
| -- | -- | -- | -- | -- | | | |

***99% Bandwidth***

| Test Frequency | 99 % Bandwidth MHz | | | | | | |
|---|---|---|---|---|---|---|---|
| **MHz** | **a** | **b** | **c** | **d** | | | |
| 2441.750 | 45.210000 | -- | -- | -- | | | |
| -- | -- | -- | -- | -- | | | |
| -- | -- | -- | -- | -- | | | |

| | |
|---|---|
| **Measurement uncertainty:** | ±2.81 dB |



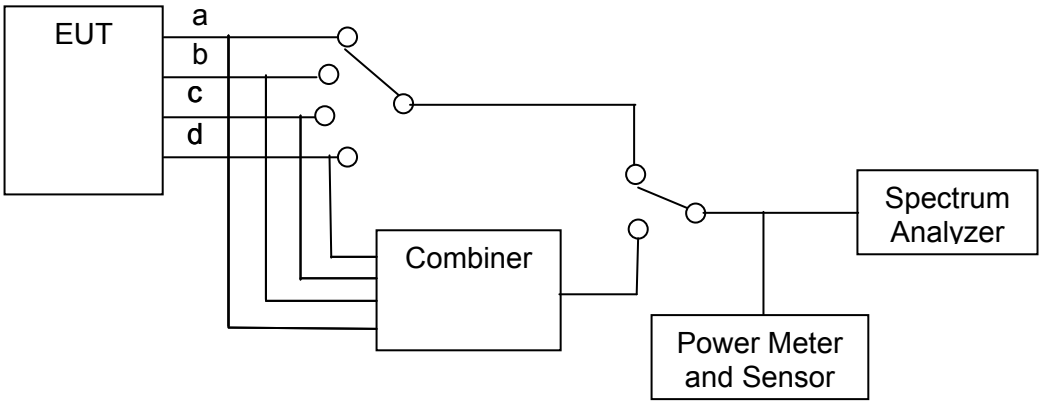

| Analyser Setup | Marker : Frequency : Amplitude | Test Results |
|---|---|---|
| RBW = 100.00KHz | M1 : 2427.200902MHz : -3.894dBm | Center frequency = 2441.75MHz |
| VBW = 300.00KHz | M2 : 2441.870240MHz : 3.539dBm | 6dB BW(Delta-M1) = 28.857715MHz |
| Sweep time(s) = 20 | Delta : 2456.058617MHz : -2.182dBm | 99% OBW(T2-T1) = 45.210421MHz |
| RF Atten (dB) = 10 | T1 : 2418.543587MHz : -15.346dBm | |
| Span = 120.00MHz | T2 : 2463.513527MHz : -12.859dBm | |

## 7.2 Peak Output Power

**Test Procedure**
The test methodology and conditions utilized for each measurement is referenced in the test results matrix. The average output power was measured per the test configuration identified below.

Per the standard measurements were taken at ambient conditions, nominal voltage.

**Test Configuration**




Measurement set-up for Peak Output Power

Total Power = A + G + Y + 10 log (1/x) dBm

A = Total Power [10 $Log_{10}$ ($10^{a/10}$ + $10^{b/10}$ +$10^{c/10}$ + $10^{d/10}$)], G = Antenna Gain,
Y = Beam Forming Gain, x = Duty Cycle

## Specification

### Limits

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

**§15.247 (b) (3)** For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands: 1.0 watt.

**15.247 (b) (4)** The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

15.247 (c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted 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.

(ii) 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 conducted output power.

**§15.31 (e)** For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

**§ RSS-210 A8.4(4)** For systems employing digital modulation techniques operating in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands the maximum peak conducted power shall not exceed 1 watt.

### Traceability

| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-01 'Measuring RF Output Power' | 0158, 0252, 0313, 0314, 0223, 0116, 0117, 0287, 0363 |

### 7.2.1 Measurement Results: DSSS

| | | | | | |
|---|---|---|---|---|---|
| **Test Conditions:** | 15.247 (b) | | **Rel. Humidity (%):** | 35 to 42 | |
| **Variant:** | DSSS | | **Ambient Temp. (ºC):** | 19 to 22 | |
| **TPC:** | HIGH | | **Pressure (mBars):** | 998 to 1003 | |
| **Modulation:** | ON | | **Duty Cycle (%):** | 100 | |
| **Beam Forming** | N/A | dB | **Antenna Gain:** | 3 | dBi |
| **Applied Voltage:** | 48.00 | Vdc | | | |
| **Notes 1:** | | | | | |
| **Notes 2:** | | | | | |

| Test Frequenc | Measured Peak Power RF Port (dBm) | | | | Total Power (dBm) | | Limit | Margin |
|---|---|---|---|---|---|---|---|---|
| **MHz** | **a** | **b** | **c** | **d** | **Combined** | **Calculated** | **dBm** | **dB** |
| 2442 | 18.52 | -- | -- | -- | 18.52 | -- | 30.00 | -11.48 |
| 0 | -- | -- | -- | -- | -- | -- | 30.00 | |
| 0 | -- | -- | -- | -- | -- | -- | 30.00 | |

| | |
|---|---|
| **Measurement uncertainty:** | ±1.33 dB |

## 7.3 Peak Power Spectral Density

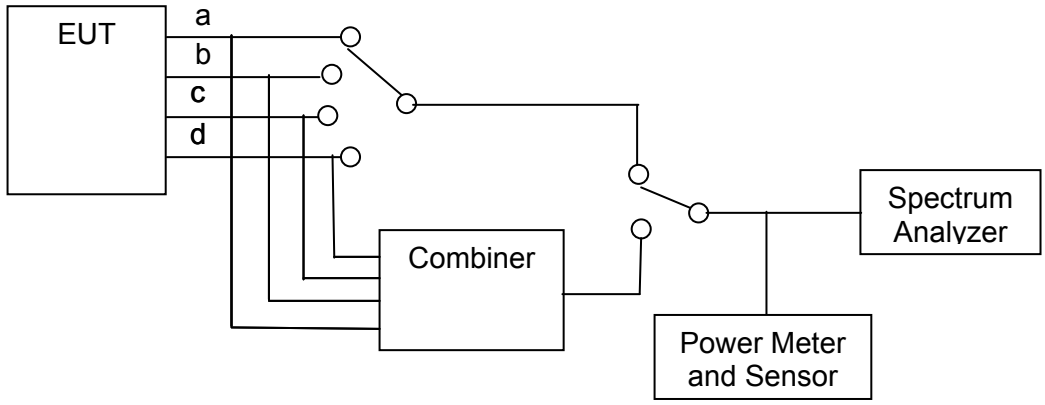
**Test Procedure**

The test methodology and conditions utilized for each measurement is referenced in the following test results matrix. RF output power, transmit power control and power density were measured per the Test Configuration identified below.

Testing was performed on the highest and lowest power settings of the equipment.

Per the standard measurements were taken at ambient and extreme temperature conditions at nominal and extreme voltage levels.

**Test Configuration**




Measurement set-up for Peak Power Spectral Density

**Specification**

**Peak Power Spectral Density Limits**

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

**RSS-210** §**A8.2(2)** The transmitter power spectral density (into the antenna) shall not be greater than +8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0 second duration.

**Traceability**

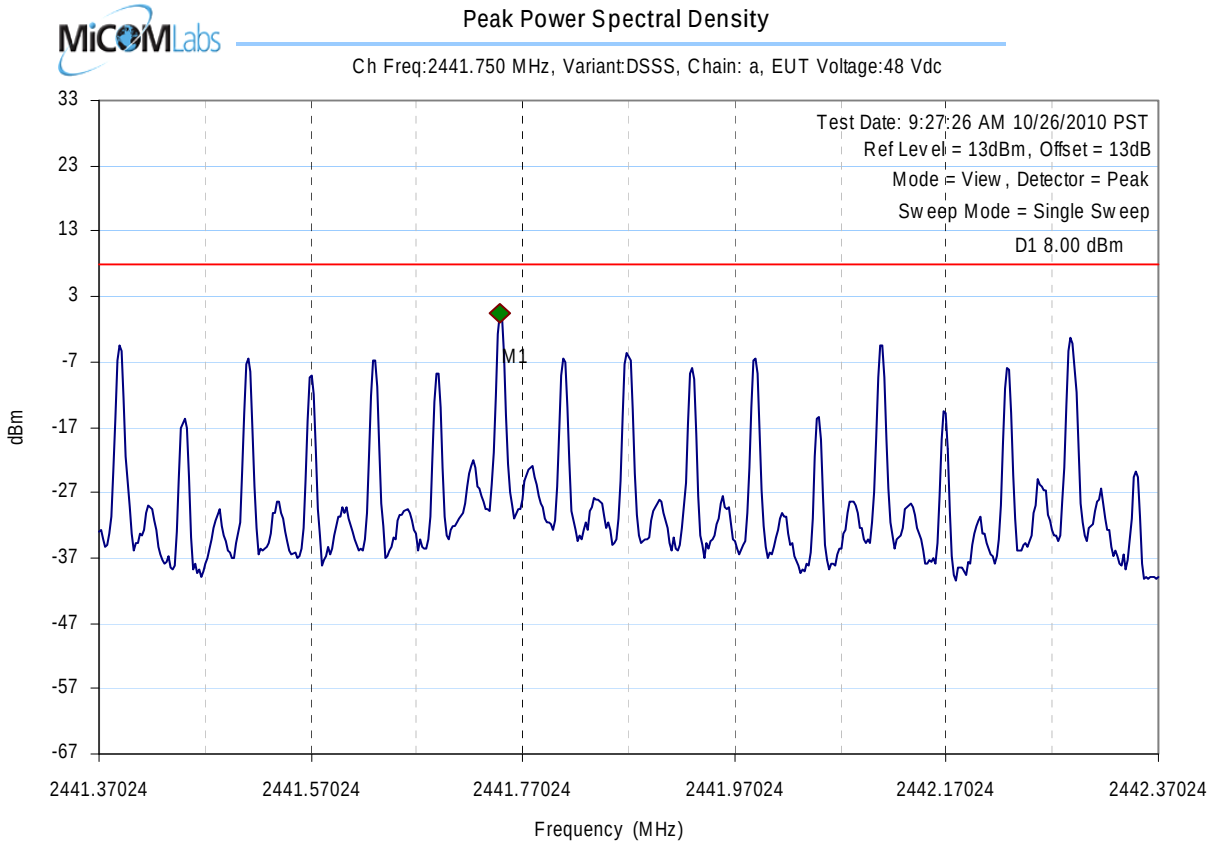
| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-01 'Measuring RF Output Power' | 0158, 0252, 0313, 0314, 0223, 0116, 0117, 0287, 0363 |

### 7.3.1 Measurement results for DSSS

| | | | | | |
|---|---|---|---|---|---|
| **Test Conditions:** | 15.247 (e) | | **Rel. Humidity (%):** | 35 to 42 | |
| **Variant:** | DSSS | | **Ambient Temp. (ºC):** | 19 to 22 | |
| **TPC:** | HIGH | | **Pressure (mBars):** | 998 to 1003 | |
| **Modulation:** | ON | | **Duty Cycle (%):** | 100 | |
| **Beam Forming** | N/A | dB | **Antenna Gain:** | 3 | dBi |
| **Applied Voltage:** | 48.00 | Vdc | | | |
| **Notes 1:** | | | | | |
| **Notes 2:** | | | | | |

| Test Frequency | Measured Power Density RF Port (dBm) | | | | Total Peak Power Spectral Density (dBm) | | Limit | Margin |
|---|---|---|---|---|---|---|---|---|
| **MHz** | **a** | **b** | **c** | **d** | **Combined** | **Calculated** | **dBm** | **dB** |
| 2441.750 | 0.47 | -- | -- | -- | 0.47 | -- | 8.00 | -7.53 |
| 0.000 | -- | -- | -- | -- | -- | -- | 8.00 | |
| 0.000 | -- | -- | -- | -- | -- | -- | 8.00 | |

| **Measurement uncertainty:** | ± 1.33 dB |
|---|---|




| Analyser Setup | Marker : Frequency : Amplitude | Test Results |
|---|---|---|
| RBW = 3.00KHz | M1 : 2441.748998MHz : .472dBm | Center frequency = 2441.75MHz |
| VBW = 10.00KHz | | |
| Sweep time(s) = 350 | | |
| RF Atten (dB) = 20 | | |
| Span = 1.00MHz | | |

## 7.4 Maximum Permissible Exposure

**FCC, Part 15 Subpart C §15.407(f)**
**Industry Canada RSS-Gen §5.5**

**Calculations for Maximum Permissible Exposure Levels**

Power Density = Pd (mW/cm2) = EIRP/(4πd2)
EIRP = P * G
P = Peak output power (mW)
G = Antenna numeric gain (numeric)
d = Separation distance (cm)
Numeric Gain = 10 ^ (G (dBi)/10)

The peak power in the table below is calculated by assuming a worst case scenario where all of the EUT transmitters are operating simultaneously in the same band. The Peak Power in mW is the highest transmitter power measured and summed across all transmitters.

Because the EUT belongs to the General Population/Uncontrolled Exposure the limit of power density is 1.0 mW/cm2

| Freq. Band (MHz) | Antenna Gain (dBi) | Numeric Gain (numeric) | Peak Output Power (dBm) | Peak Output Power (mW) | Calculated Safe Distance @ 1mW/cm$^2$ Limit(cm) | Minimum Separation Distance (cm) |
|---|---|---|---|---|---|---|
| 2400 – 2500 | 3.0 | 2.0 | 18.52 | 71.12 | 3.4 | 20.00 |

*Note: for mobile or fixed location transmitters the minimum separation distance is 20cm, even if calculations indicate the MPE distance to be less.

**Specification**

**Maximum Permissible Exposure Limits**

§15.247(i) 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 levels in excess of the Commission's guidelines.

FCC §1.1310 Limit = 1mW / cm2 from 1.310 Table 1

**RSS-Gen §5.5** Before equipment certification is granted, the application requirements of RSS-102 shall be met.

**Laboratory Measurement Uncertainty for Power Measurements**

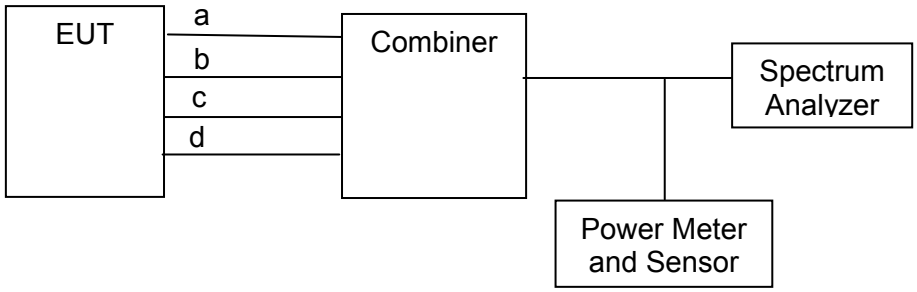
| | |
|---|---|
| Measurement uncertainty | ±1.33 dB |

## 7.5 Conducted Spurious

**Test Procedure**
Conducted emissions were measured at a limit of 20 dB below the highest in-band spectral density measured with a spectrum analyzer connected to the antenna terminal. Emissions at the band edge were measured and recorded. Measurements were made while EUT was operating in transmit mode of operation at the appropriate center frequency.

Measurements were made using a combiner with the transmitter tuned to the channel closest to the band-edge being measured. All emissions were maximized during measurement. Limits which were derived from the peak emission.

**Test Measurement Set up**




Conducted Spurious Emission measurement test configuration

## Specification

### Limits Band-Edge

| Lower Limit Band-edge | Upper Limit Band-edge | Limit below highest level of desired power |
|---|---|---|
| 2,400 MHz | 2,483.5 MHz | ≥ 20 dB |
| 5725 MHz | 5850 MHz | |

**§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 radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

**§15.247(d)**
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section §15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(a)).

**RSS-210 §A8.5** If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required. In addition, radiated emissions which fall in the restricted bands of Table 1 must also comply with the radiated emission limits specified in Tables 2 and 3.

**RSS-Gen §4.7**
The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate of carrier frequency), or from 30 MHz , whichever is the lowest frequency, to the 5$^{th}$ harmonic of the highest frequency generated without exceeding 40 GHz.

### Traceability

| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-05 'Measurement of Spurious Emissions' | 0158, 0252, 0313, 0314, 0223, 0116, 0117, 0287, 0363. |

### 7.5.1 Measurement Results for DSSS

| | | | | | |
|---|---|---|---|---|---|
| **Test Conditions:** | 15.247 (a)(2) | | **Rel. Humidity (%):** | 35 to 42 | |
| **Variant:** | DSSS | | **Ambient Temp. (ºC):** | 19 to 22 | |
| **TPC:** | HIGH | | **Pressure (mBars):** | 998 to 1003 | |
| **Modulation:** | ON | | **Duty Cycle (%):** | 100 | |
| **Beam Forming** | N/A | dB | **Antenna Gain:** | N/A | dBi |
| **Applied Voltage:** | 48.00 | Vdc | | | |
| **Notes 1:** | | | | | |
| **Notes 2:** | | | | | |

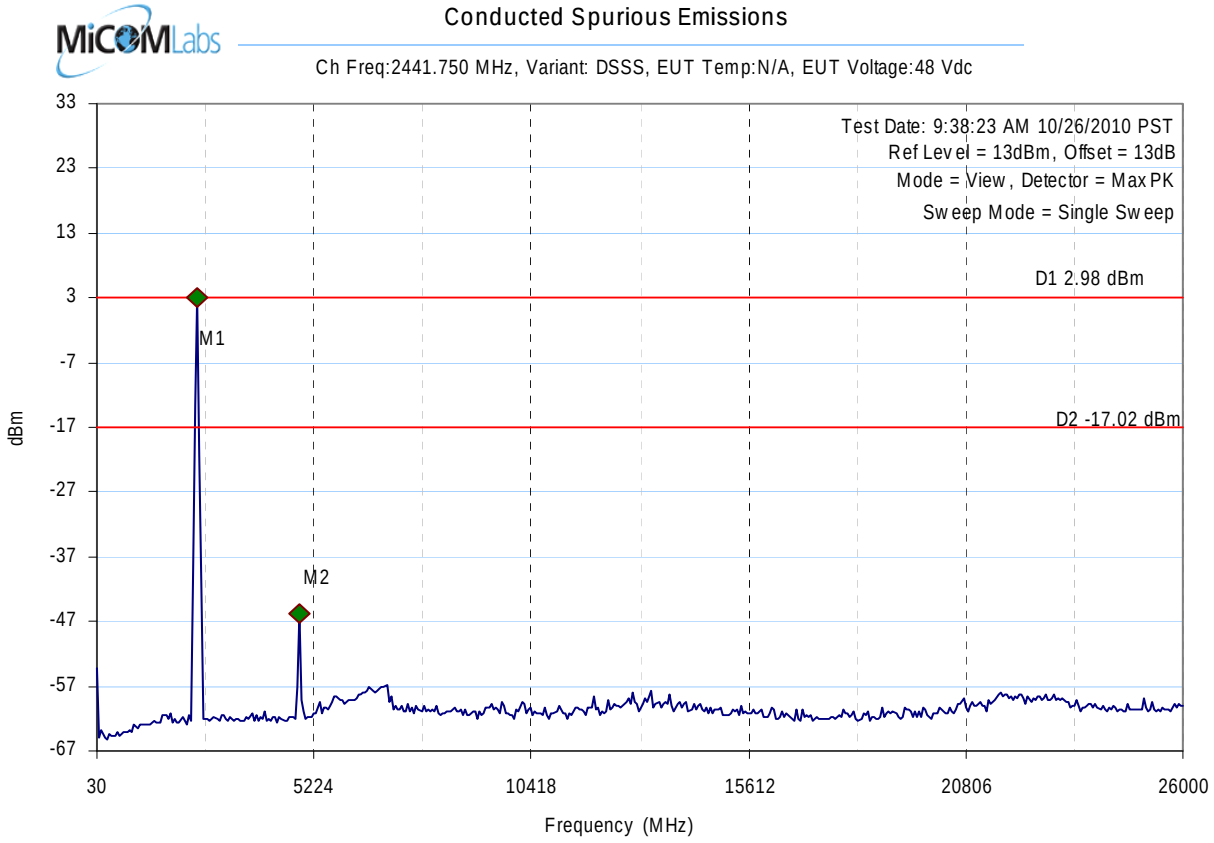
***Conducted Spurious Measurment***

| Test Frequency | Start Frequency | Stop Frequency | Maximum Observed Emission | Limit (20 dB below peak of fundamental) |
|---|---|---|---|---|
| **MHz** | **MHz** | **MHz** | **dBm** | **dBm** |
| 2441.750 | 30.00 | 26000.00 | -45.75 | -17.02 |
| | | | | |
| | | | | |

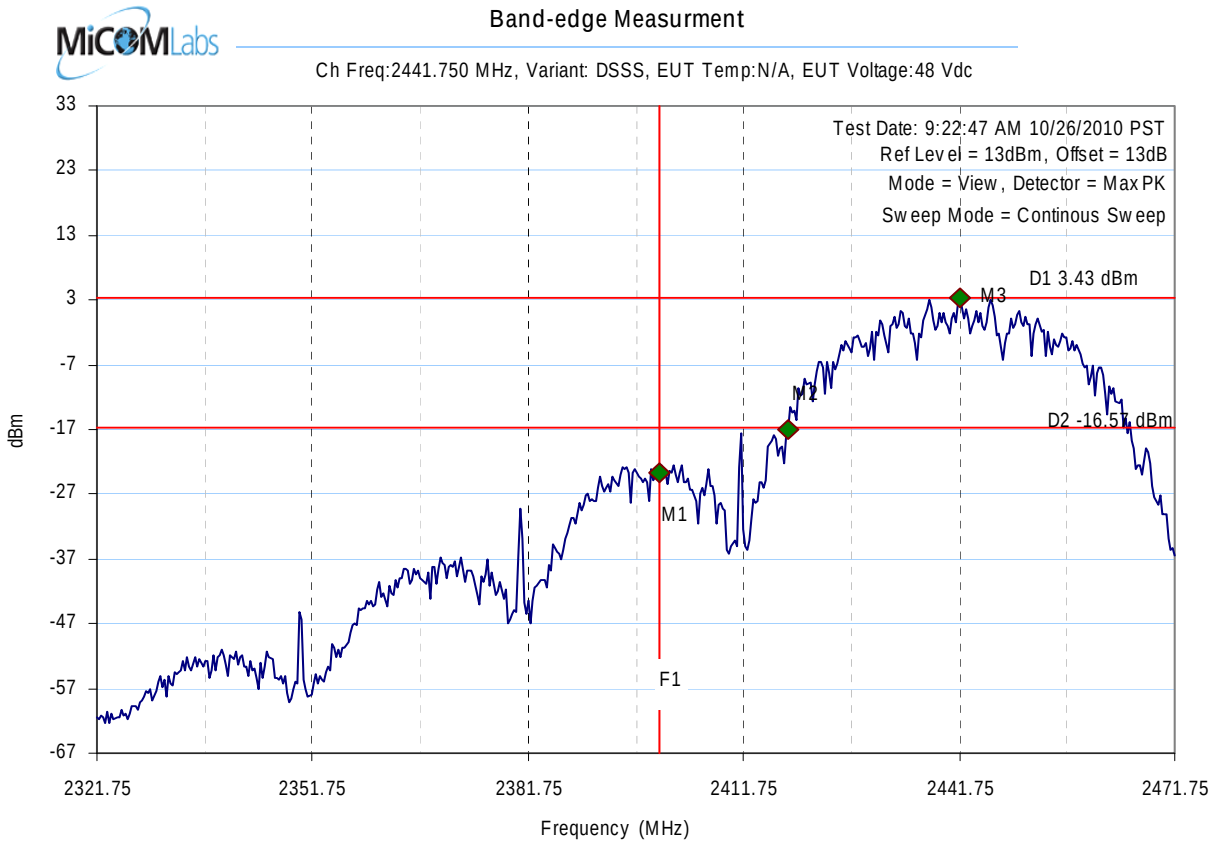
***Band-edge Measurment***

| Test Frequency | Band-edge Frequency | Emission Amplitude @ Band-edge | Limit (20 dB below peak of fundamental) | Margin |
|---|---|---|---|---|
| **MHz** | **MHz** | **dBm** | **dBm** | **dB** |
| 2441.750 | 2400.00 | -23.70 | -16.57 | -7.13 |
| 2441.750 | 2483.50 | -25.28 | -16.93 | -8.36 |

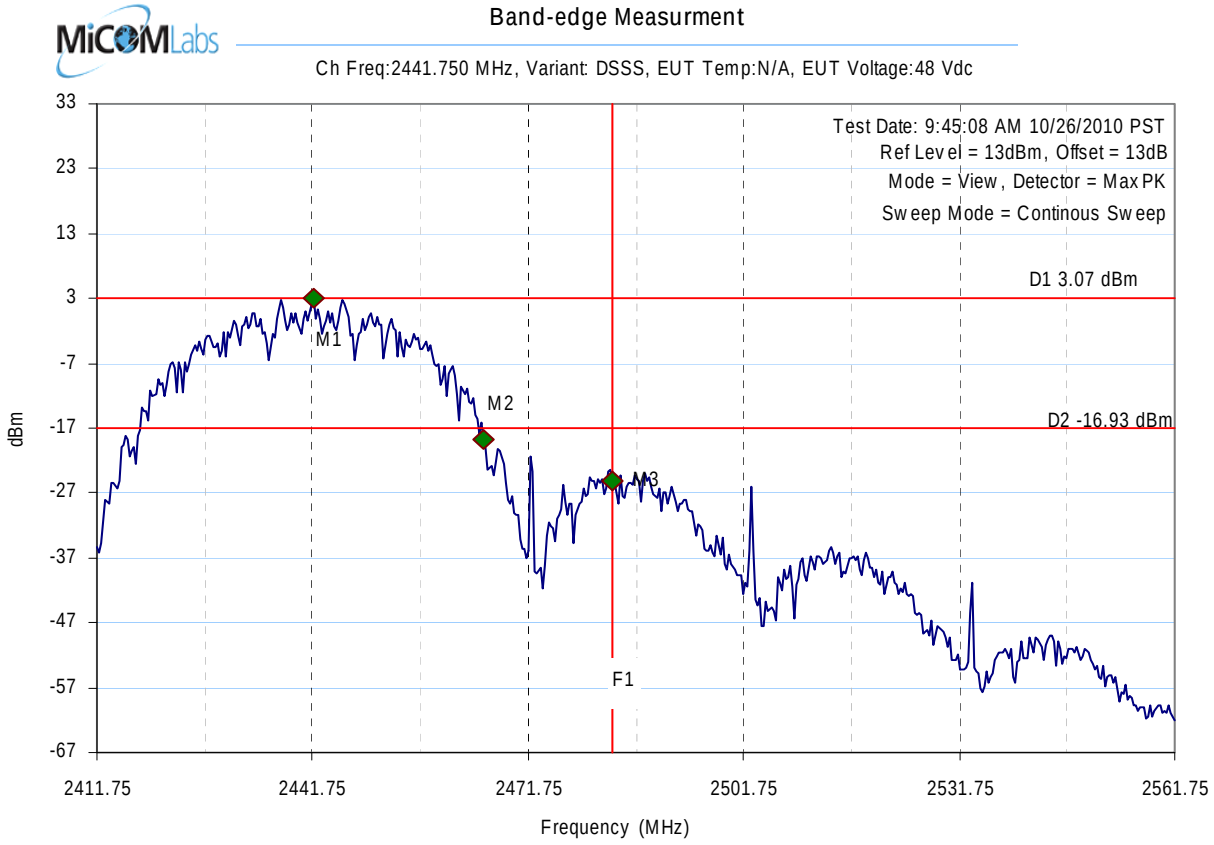
| | |
|---|---|
| **Measurement uncertainty:** | ±2.81 dB |




| Analyser Setup | Marker : Frequency : Amplitude | Test Results |
|---|---|---|
| RBW = 100.00KHz | M1 : 2424.028056MHz : 2.978dBm | Center frequency = 2441.75MHz |
| VBW = 300.00KHz | M2 : 4870.100200MHz : -45.749dBm | |
| Sweep time(s) = 60 | | |
| RF Atten (dB) = 10 | | |
| Span = 25.97GHz | | |




| Analyser Setup | Marker : Frequency : Amplitude | Test Results |
|---|---|---|
| RBW = 100.00KHz | M1 : 2400.000000MHz : -23.699dBm | Center frequency = 2441.75MHz |
| VBW = 300.00KHz | M2 : 2417.942385MHz : -17.061dBm | |
| Sweep time(s) = 20 | M3 : 2441.990481MHz : 3.427dBm | |
| RF Atten (dB) = 10 | | |
| Span = 150.00MHz | | |




| Analyser Setup | Marker : Frequency : Amplitude | Test Results |
|---|---|---|
| RBW = 100.00KHz | M1 : 2441.810120MHz : 3.073dBm | Center frequency = 2441.75MHz |
| VBW = 300.00KHz | M2 : 2465.557615MHz : -18.836dBm | |
| Sweep time(s) = 20 | M3 : 2483.500000MHz : -25.283dBm | |
| RF Atten (dB) = 10 | | |
| Span = 150.00MHz | | |

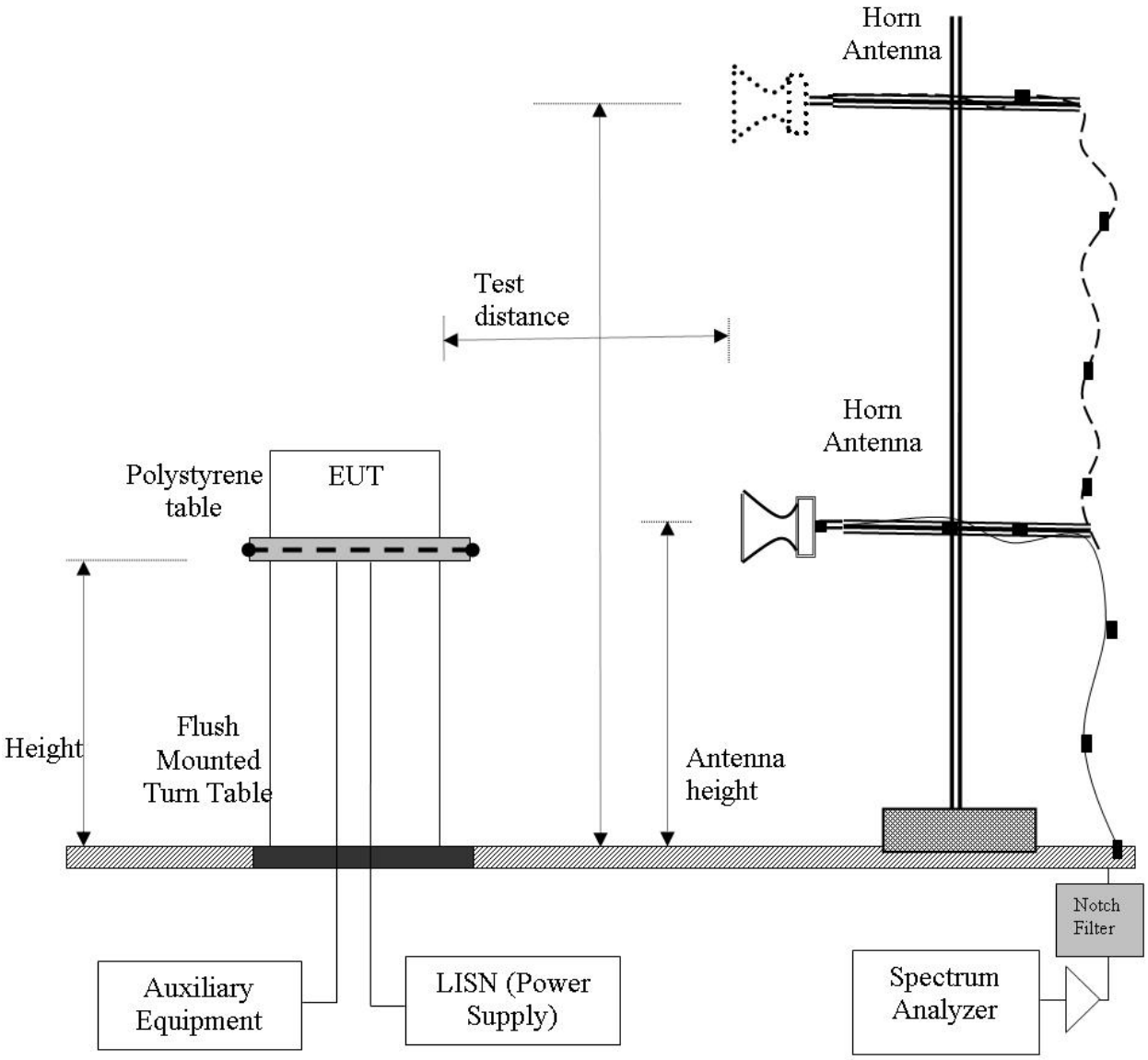
## 7.6 Radiated Spurious Emissions

### Test Procedure

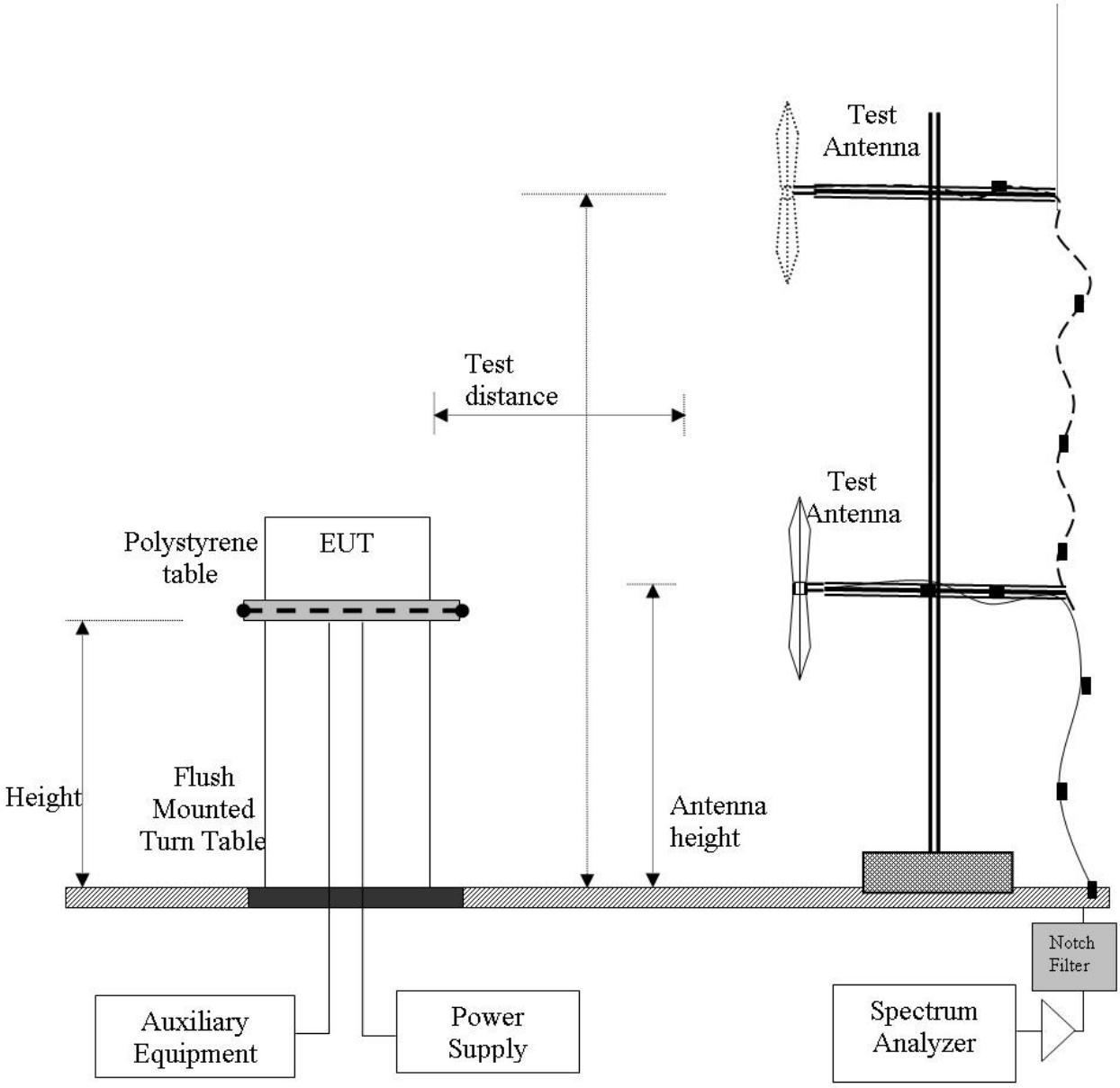
Testing was performed in a 3-meter anechoic chamber. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. Preliminary emissions were recorded with in Spectrum Analyzer mode, using a maximum peak detector while in peak hold mode.

Emissions nearest the limits were chosen for maximization and formal measurement using a CISPR Compliant receiver. Emissions above 1000 MHz are measured utilizing a CISPR compliant average detector with a tuned receiver, using a bandwidth of 1 MHz. Emissions from 30 MHz – 1000 MHz are measured utilizing a CISPR compliant quasi-peak detector with a tuned receiver, using a bandwidth of 120 kHz. Only the highest emissions relative to the limit are listed.

**Radiated Emission Measurement Setup – Above 1 GHz**



**Radiated Emission Measurement Setup – Below 1 GHz**



**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.

**FS = R + AF + CORR – FO**

FS = Field Strength
R = Measured Spectrum analyzer Input Amplitude
AF = Antenna Factor

**CORR = Correction Factor = CL – AG + NFL**

CL = Cable Loss
AG = Amplifier Gain
FO = Distance Falloff Factor
NFL = Notch Filter Loss or Waveguide Loss

Field Strength Calculation Example:

Given receiver input reading of 51.5 dBμV; Antenna Factor of 8.5 dB; Cable Loss of 1.3 dB; Falloff Factor of 0 dB, an Amplifier Gain of 26 dB and Notch Filter Loss of 1 dB. The Field Strength of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3 dBμV/m

Conversion between dBμV/m (or dBμV) and μV/m (or μV) are done as:

Level (dBμV/m) = 20 * Log (level (μV/m))

40 dBμV/m = 100 μV/m
48 dBμV/m = 250 μV/m

**Specification Limits**

**FCC §15.247(d) and RSS-210 §A8.5** 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 radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

**FCC §15.247(d)**
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section §15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(a)).

**IC RSS-210 §A8.5** If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Tables 2 and 3 is not required. In addition, radiated emissions which fall in the restricted bands of Table 1 must also comply with the radiated emission limits specified in Tables 2 and 3.

**IC RSS-Gen §4.7**
The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate of carrier frequency), or from 30 MHz , whichever is the lowest frequency, to the 5$^{th}$ harmonic of the highest frequency generated without exceeding 40 GHz.

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

**FCC §15.205 (a)** Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

**FCC §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 the following table.

**Table 1: FCC 15.209 and RSS-Gen §6 Spurious Emissions Limits**

| Frequency (MHz) | Field Strength (µV/m) | Field Strength (dBµV/m) | Measurement Distance (meters) |
|---|---|---|---|
| 30-88 | 100 | 40.0 | 3 |
| 88-216 | 150 | 43.5 | 3 |
| 216-960 | 200 | 46.0 | 3 |
| Above 960 | 500 | 54.0 | 3 |

**Laboratory Measurement Uncertainty for Radiated Emissions**

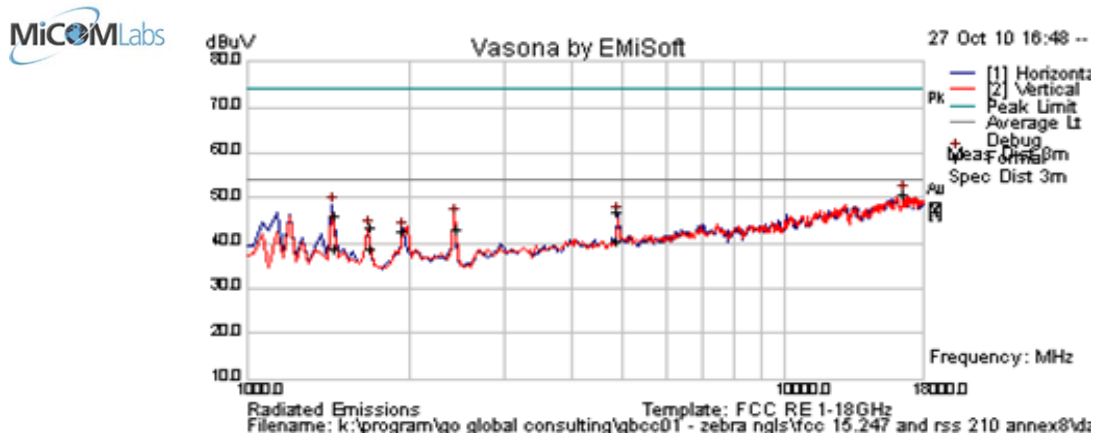
| | |
|---|---|
| **Measurement Uncertainty** | +5.6/ -4.5 dB |

**Traceability:**

| Method | Test Equipment Used |
|---|---|
| Work instruction WI-03 | 0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312 |

### 7.6.1 Measurement Results DSSS mode: Transmitter Radiated Spurious Emissions

| | | | |
|---|---|---|---|
| **Test Freq.** | 2412 MHz | **Engineer** | SB |
| **Variant** | DSSS 2441.75 | **Temp (ºC)** | 22 |
| **Freq. Range** | 1000 MHz - 18000 MHz | **Rel. Hum.(%)** | 34 |
| **Power Setting** | 18 dBm max power | **Press. (mBars)** | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | **Duty Cycle (%)** | 100 |
| **Test Notes 1** | 25 w PSU | | |
| **Test Notes 2** | | | |




**Formally measured emission peaks**

| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1465.056 | 51.2 | 2.4 | -14.6 | 38.9 | Peak | V | 147 | 360 | 74.0 | -35.1 | Pass | |
| 4883.464 | 51.8 | 4.5 | -9.3 | 47.0 | Peak | V | 98 | 170 | 74.0 | -27.0 | Pass | |
| 1709.200 | 54.6 | 2.5 | -13.4 | 43.7 | Peak | V | 98 | 245 | 74 | -30.3 | Pass | |
| 1465.056 | 58.4 | 2.4 | -14.6 | 46.1 | Average | V | 98 | 360 | 54 | -7.9 | Pass | |
| 4883.464 | 45.2 | 4.5 | -9.3 | 40.4 | Average | V | 98 | 170 | 54 | -13.6 | Pass | |
| 1709.200 | 49.7 | 2.5 | -13.4 | 38.8 | Average | V | 98 | 245 | 54 | -15.2 | Pass | |
| 16534.980 | 41.7 | 8.8 | 0.4 | 50.9 | Peak [Scan] | V | 200 | 0 | 54 | -3.1 | Pass | NRB |
| 1953.443 | 51.6 | 2.7 | -11.6 | 42.8 | Peak [Scan] | V | 98 | 0 | 54 | -11.2 | Pass | NRB |
| 2452.372 | 0.0 | 0.0 | -13.4 | 42.9 | Peak [Scan] | V | 98 | 0 | 54 | -11.1 | Pass | NRB |

| | |
|---|---|
| Legend: | TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission |
| | RB = Restricted Band (15.209 Limits); NRB = Non Restricted Band, Limit is 20dB below fundamental peak |

### 7.6.2 DSSS Radiated Band Edge Emissions

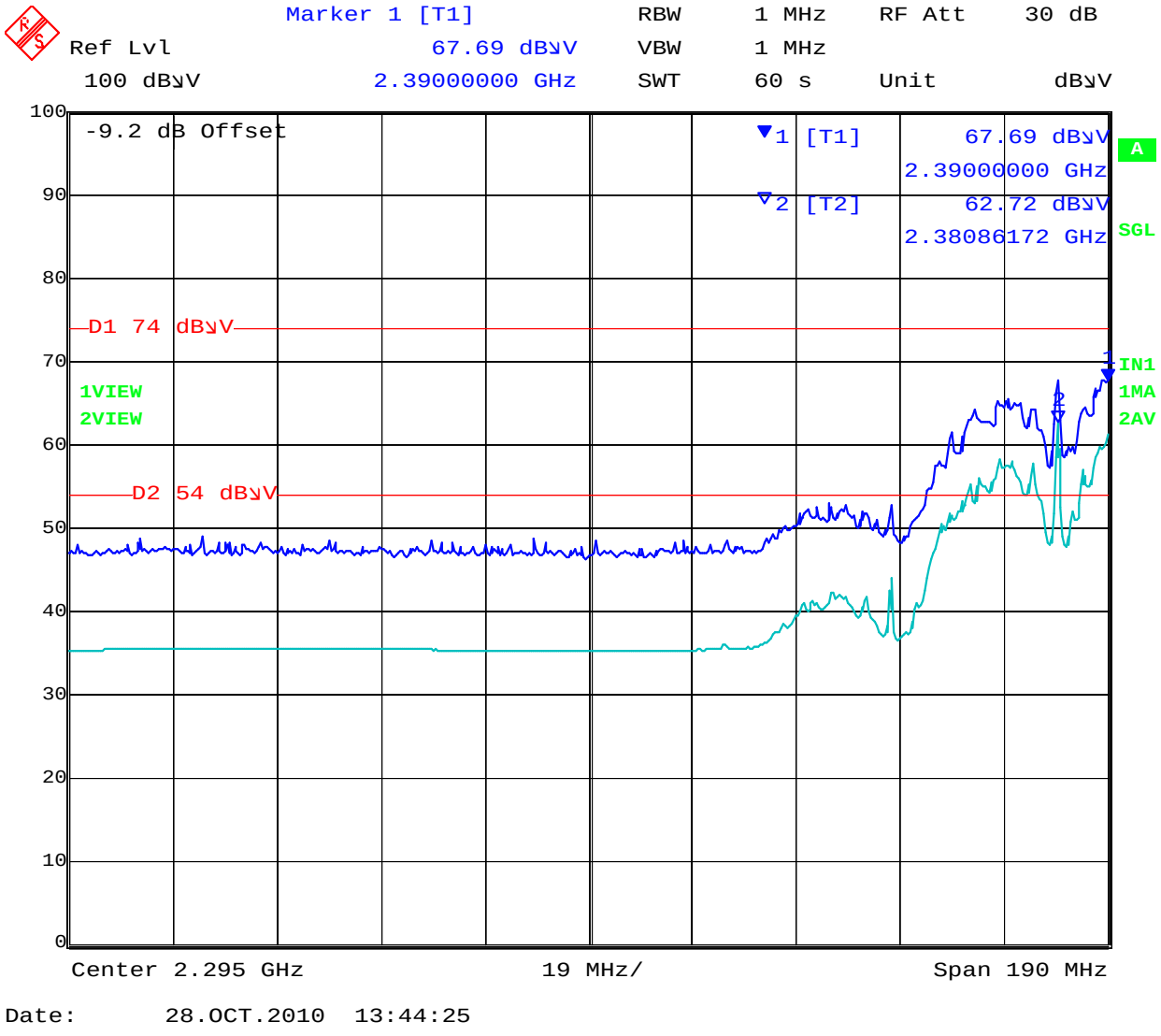
Duty cycle correction factor was applied to spurious emissions in the restricted bands closest to the fundamental transmission.

EUT Operational Duty Cycle: 2.55%
Correction Factor = 20 * LOG (2.55 / 100)
Correction Factor = -31.87 dB
Corrected Value = Measured Value (dB) - 31.87 (dB)

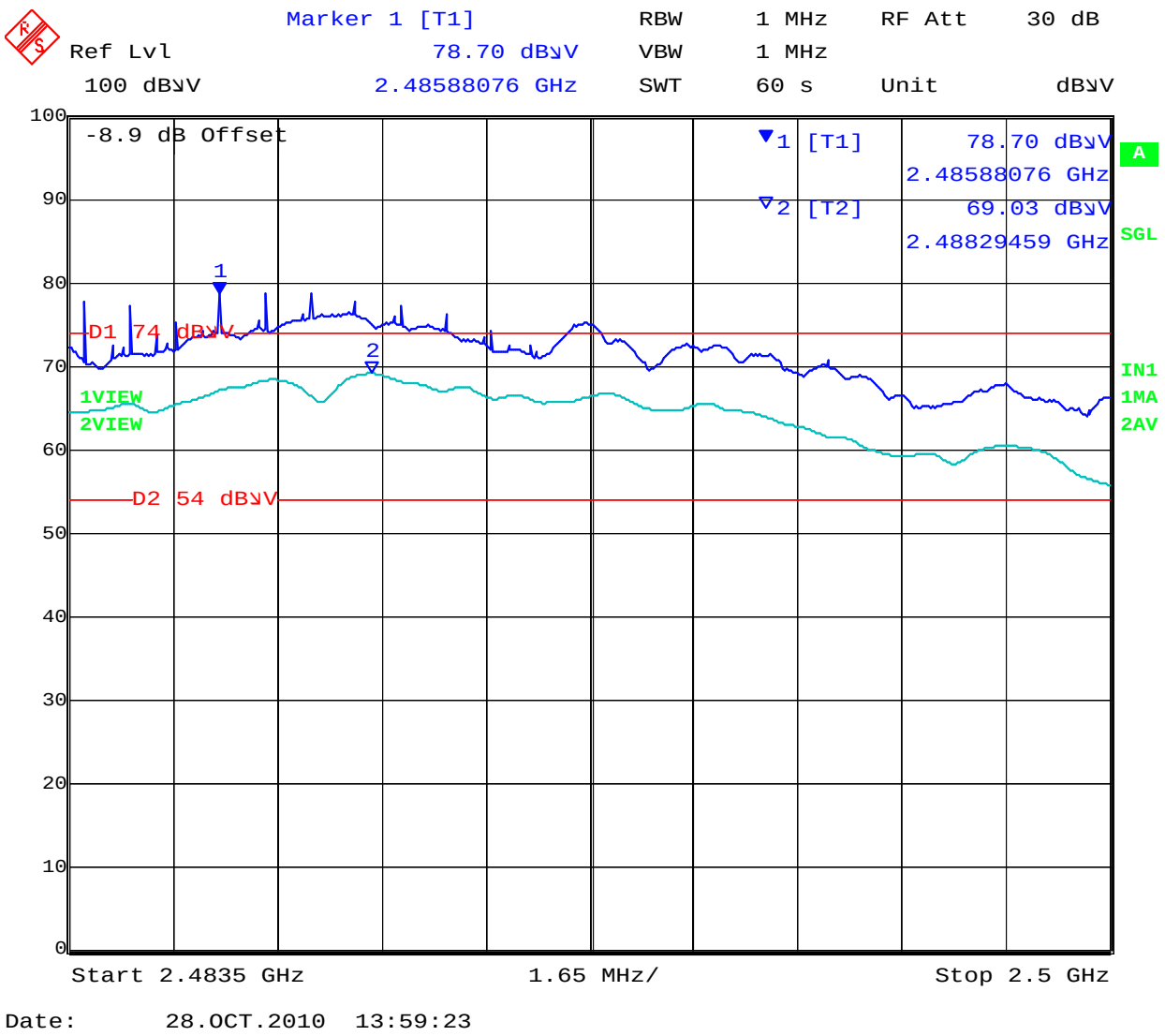
| Frequency (MHz) | Measured Value (dBuV/m) | Measurement Type | Corrected Value | Margin (dB) | Pass / Fail |
|---|---|---|---|---|---|
| 2390.000 | 67.69 | Peak | 35.82 | -38.18 | Pass |
| 2380.861 | 62.72 | Average | 30.85 | -23.15 | Pass |
| 2485.880 | 78.70 | Peak | 46.83 | -27.17 | Pass |
| 2488.294 | 69.03 | Average | 37.16 | -16.84 | Pass |

### 7.6.3 Measurement Results AK-210-10 & AK-110-10: Band Edge

**Band Edge 2390-2400 MHz DSSS 2441.75mhz h=100cm azt=180**

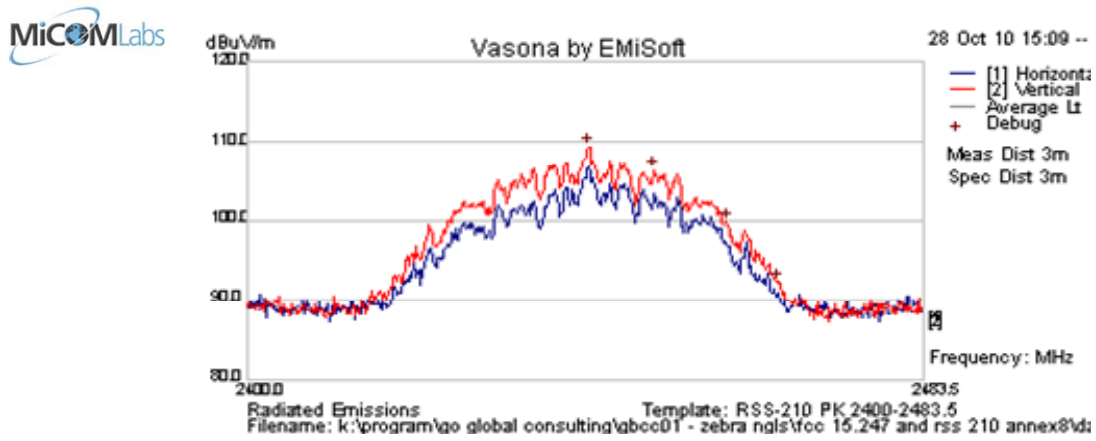


**BE 2483.5-2500 MHz DSSS 2441.75mhz h=100cm azt=180**



### 7.6.4 Measurement Results AK-210-10 & AK-110-10: Peak Emissions

| | | | |
|---|---|---|---|
| **Test Freq.** | 2441.75 MHz | **Engineer** | SB |
| **Variant** | DSSS | **Temp (°C)** | 22 |
| **Freq. Range** | 2400 - 2483.5 MHz | **Rel. Hum.(%)** | 34 |
| **Power Setting** | Max Power 18 dBm | **Press. (mBars)** | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | **Duty Cycle (%)** | 100 |
| **Test Notes 1** | | | |
| **Test Notes 2** | | | |




**Formally measured emission peaks**

| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV/m | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV/m | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2441.834 | 64.2 | 13.0 | 32.3 | 109.4 | Peak [Scan] | V | | | | | | Pk |

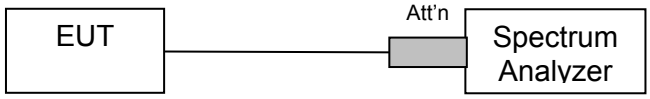
| | |
|---|---|
| Legend: | TX = Transmitter Emissions; DIG = Digital Emissions; FUND = Fundamental; WB = Wideband Emission |
| | PK = Peak emissions of Fundamental |

## 7.7 Receiver Conducted Spurious Emissions

**Industry Canada RSS-Gen §4.10, §6**

**Test Procedure**
Conducted emissions were measured with a spectrum analyzer connected to the antenna terminal. Measurements were made while EUT was operating in receive mode.

**Test Measurement Set up**




Receiver Conducted spurious emission measurement test configuration

**Specification**

**Receiver Radiated Spurious Emissions**

**Industry Canada RSS-Gen §4.10,**
The search for spurious emissions shall be from the lowest frequency internally generated or used in the receiver (e.g. local oscillator, intermediate or carrier frequency), or 30 MHz, whichever is the higher, to at least 3 times the highest tunable or local oscillator frequency, whichever is the higher, without exceeding 40 GHz.

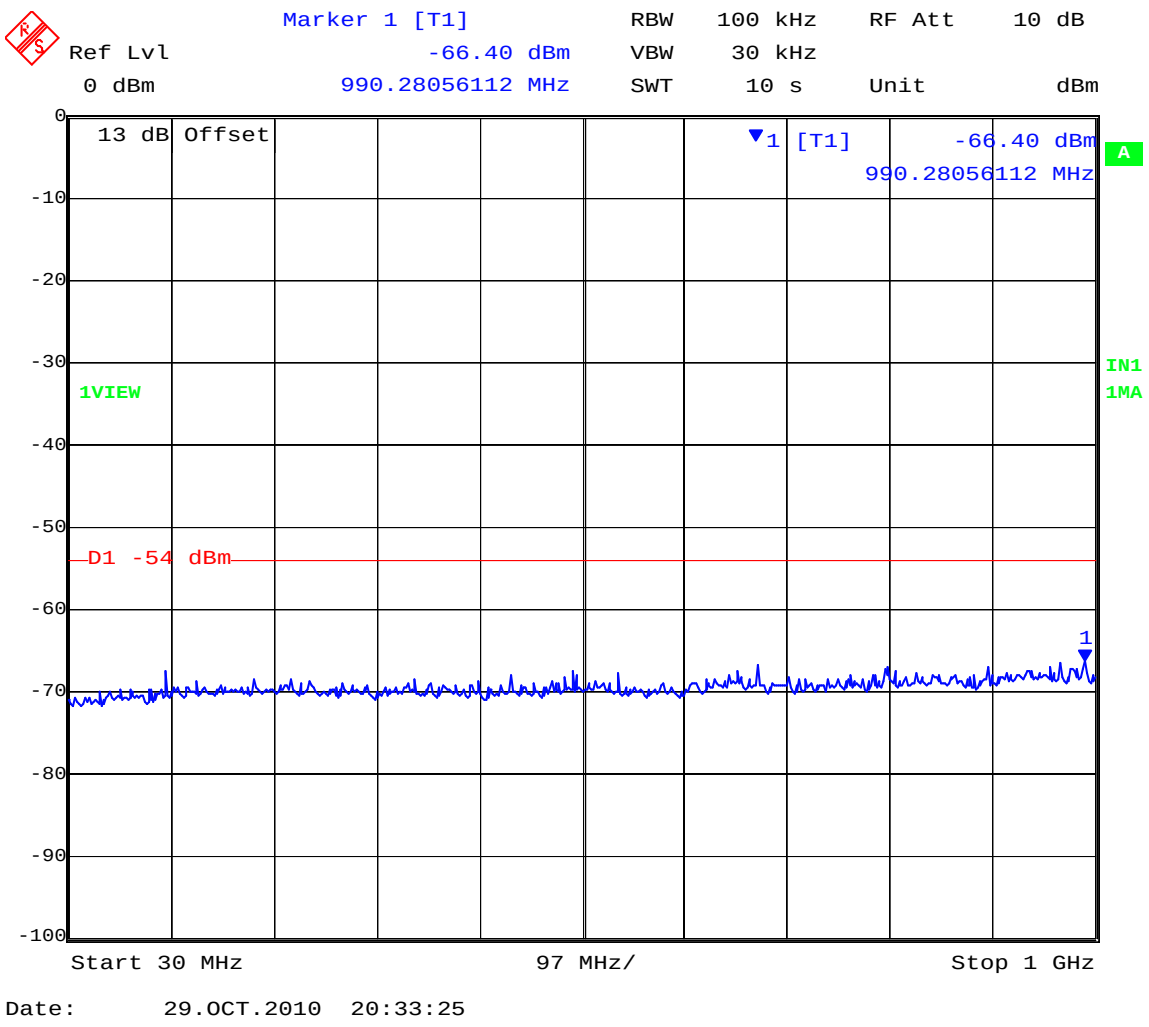
For emissions below 1 GHz, measurements shall be performed using a CISPR quasi-peak detector and the related measurement bandwidth. As an alternative to CISPR quasi-peak measurement, compliance with the emission limit can be demonstrated using measuring equipment employing a peak detector with the same measurement bandwidth as that for CISPR quasi-peak measurements. Above 1 GHz, measurements shall be performed using an average detector and a resolution bandwidth of 300 kHz to 1 MHz.

**RSS-Gen §6 (b)**
If a conducted measurement is made, no spurious output signals appearing at the antenna terminals shall exceed 2 nanowatts per any 4 kHz spurious frequency in the band 30-1000 MHz, or 5 nanowatts above 1 GHz.

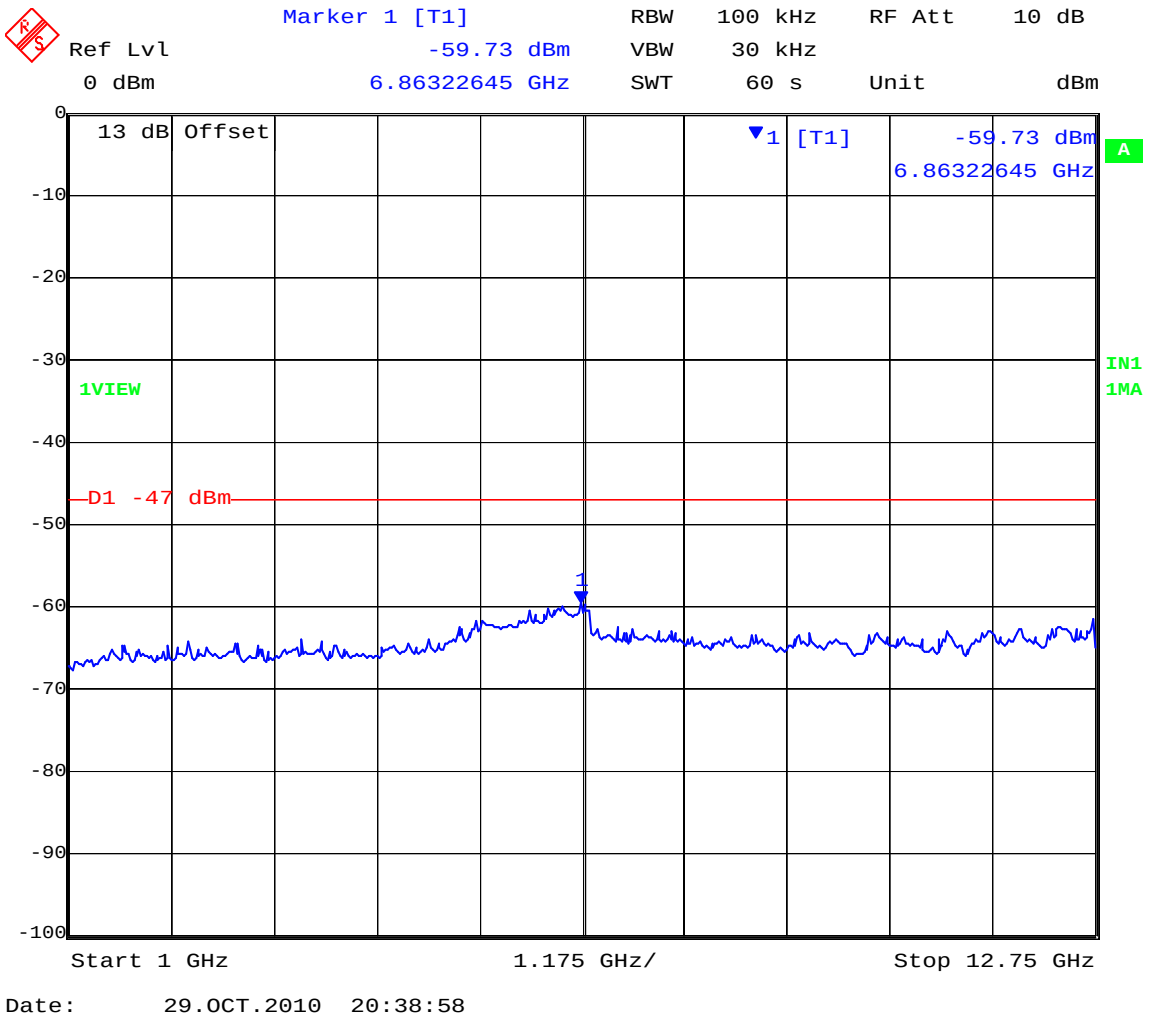
**Traceability**

| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-05 'Measurement of Spurious Emissions' | 0287, 0158, 0252, 0223, 0116, 0117, 0287, 0363. |

## Receiver Conducted Emissions 30 MHz to 1GHz



## Receiver Conducted Emissions 1 GHz to 12.75 GHz



## 7.8 Radiated Spurious Emissions – Digital Apparatus

### Standard Reference

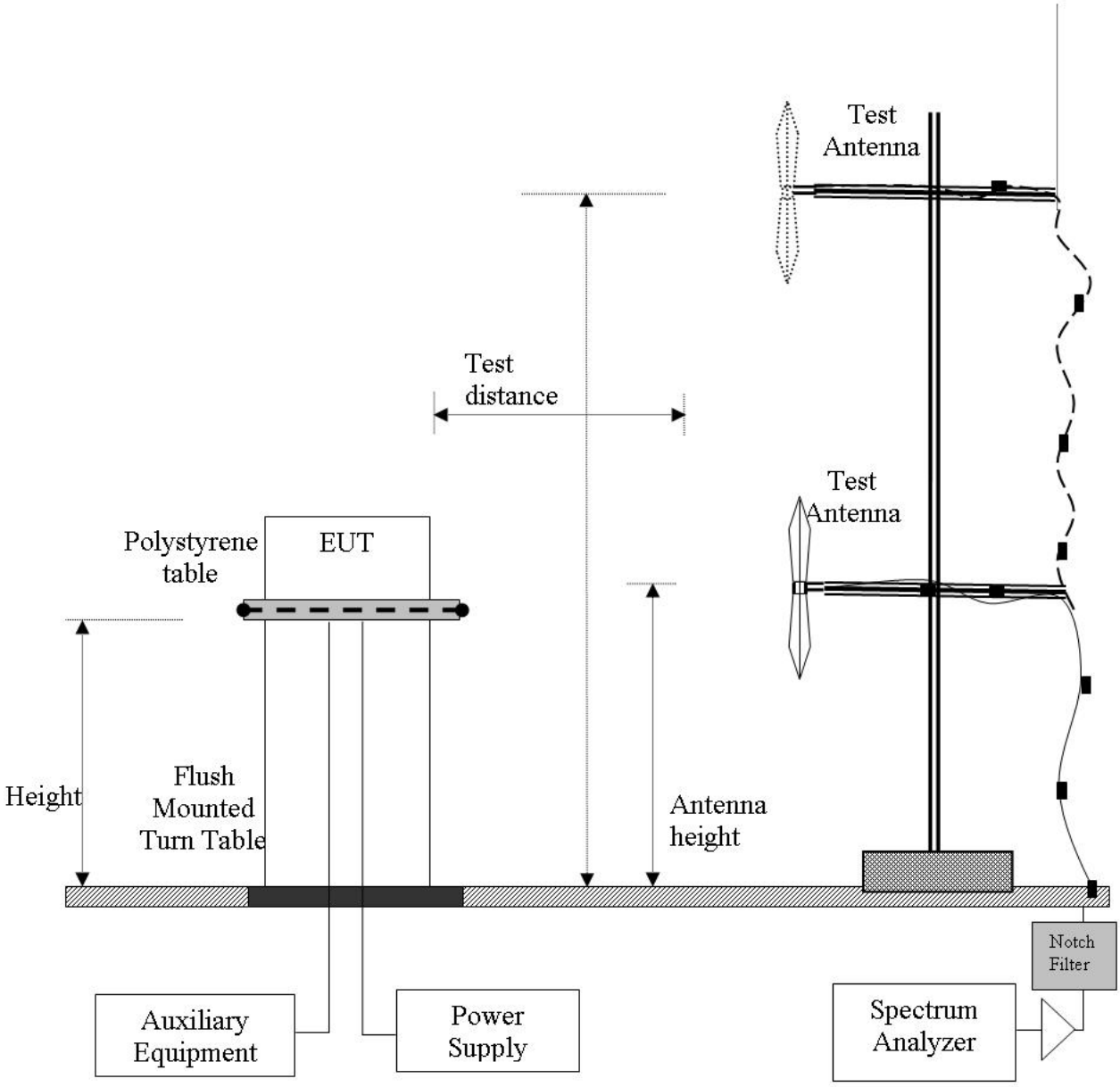
FCC, Part 15 Subpart B §15.109
Industry Canada ICES-003 §5

### Test Procedure

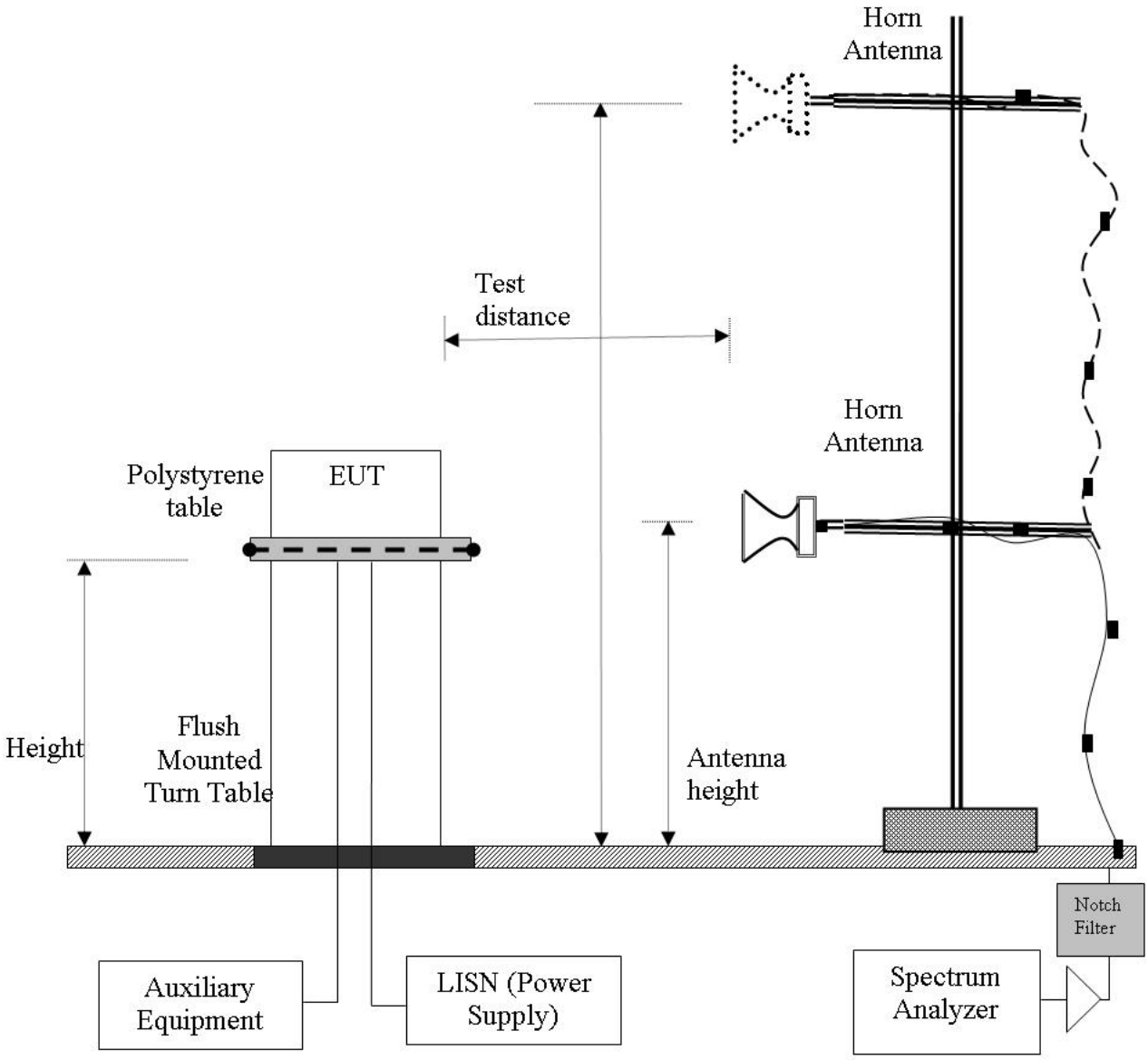
Testing was performed in a 3-meter semi-anechoic chamber. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. Preliminary emissions were recorded with in Spectrum Analyzer mode, using a maximum peak detector while in peak hold mode.

Emissions nearest the limits were chosen for maximization and formal measurement using a CISPR Compliant receiver. Emissions from 30 MHz – 1000 MHz are measured utilizing a CISPR compliant quasi-peak detector with a tuned receiver, using a bandwidth of 120 kHz. Emissions above 1000 MHz are measured utilizing a CISPR compliant average detector with a tuned receiver, using a bandwidth of 1 MHz. Only the highest emissions relative to the limit are listed.

**Test Measurement Set up**




Measurement set up for Radiated Emission Test < 1 GHz




Measurement set up for Radiated Emission Test > 1 GHz

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.

**FS = R + AF + CORR – FO**

FS = Field Strength
R = Measured Spectrum analyzer Input Amplitude
AF = Antenna Factor

**CORR = Correction Factor = CL – AG + NFL**

CL = Cable Loss
AG = Amplifier Gain
FO = Distance Falloff Factor
NFL = Notch Filter Loss or Waveguide Loss

Field Strength Calculation Example:

Given receiver input reading of 51.5 dBμV; Antenna Factor of 8.5 dB; Cable Loss of 1.3 dB; Falloff Factor of 0 dB, an Amplifier Gain of 26 dB and Notch Filter Loss of 1 dB. The Field Strength of the measured emission is:

FS = 51.5 + 8.5 + 1.3 - 26.0 +1 = 36.3 dBμV/m

Conversion between dBμV/m (or dBμV) and μV/m (or μV) are done as:

Level (dBμV/m) = 20 * Log (level (μV/m))

40 dBμV/m = 100 μV/m
48 dBμV/m = 250 μV/m

**Specification**

**Radiated Spurious Emissions – Digital Apparatus**

**FCC, Part 15 Subpart B §15.109**
A representative type or model of each digital apparatus shall be tested in accordance with the measurement methods described in FCC Part 15; Subpart A - General and FCC Subpart B – Unintentional Radiators.

**Industry Canada ICES-003**
A representative type or model of each digital apparatus shall be tested in accordance with the measurement method described in the publication referred to in Section 7.1 [Canadian Standards Association Standard CAN/CSA-CEI/IEC CISPR 22:02, "Limits and Methods of Measurement of Radio Disturbance Characteristics of Information Technology Equipment."].

**FCC, Part 15 Subpart B §15.109 Spurious Emissions Limits**

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 following values.

| Frequency (MHz) | Field Strength (µV/m) | Field Strength (dBµV/m) | Measurement Distance (meters) |
|---|---|---|---|
| 30-88 | 100 | 40.0 | 3 |
| 88-216 | 150 | 43.5 | 3 |
| 216-960 | 200 | 46.0 | 3 |
| Above 960 | 500 | 54.0 | 3 |

Field Strength of radiated emissions for a Class A digital device are as follows.

| Frequency (MHz) | Field Strength (µV/m) | Field Strength (dBµV/m) | Measurement Distance (meters) |
|---|---|---|---|
| 30-88 | 100 | 49.5 | 3 |
| 88-216 | 150 | 54.0 | 3 |
| 216-960 | 200 | 57.0 | 3 |
| Above 960 | 500 | 60.0 | 3 |

**ICES-003 §5 Spurious Emissions Limits**

**Class A Digital Device:** The field intensity of radio noise emissions that are radiated from a Class A digital apparatus shall not exceed the limits specified in Table 5 of the publication referred to in Section 7.1, within the indicated frequency range.

| Frequency range MHz | Quasi-peak limits dB(µV/m) @ 10m | Quasi-peak limits dB(µV/m) @ 3m |
|---|---|---|
| 30 to 230 | 40 | 50.5 |
| 230 to 1 000 | 47 | 57.5 |
| Note 1 | The lower limit shall apply at the transition frequency. | |
| Note 2 | Additional provisions may be required for cases where interference occurs | |

**Class B Digital Device:** The field intensity of radio noise emissions that are radiated from a Class B digital apparatus shall not exceed the limits specified in Table 6 of the publication referred to in Section 7.1, within the indicated frequency range.

| Frequency range MHz | Quasi-peak limits dB(µV/m) @ 10m | Quasi-peak limits dB(µV/m) @ 3m |
|---|---|---|
| 30 to 230 | 30 | 40.5 |
| 230 to 1 000 | 37 | 47.5 |
| Note 1 | The lower limit shall apply at the transition frequency. | |
| Note 2 | Additional provisions may be required for cases where interference occurs | |

Laboratory Measurement Uncertainty for Spectrum Measurement

| Measurement Uncertainty | +5.6/ -4.5 dB |
|---|---|

Traceability

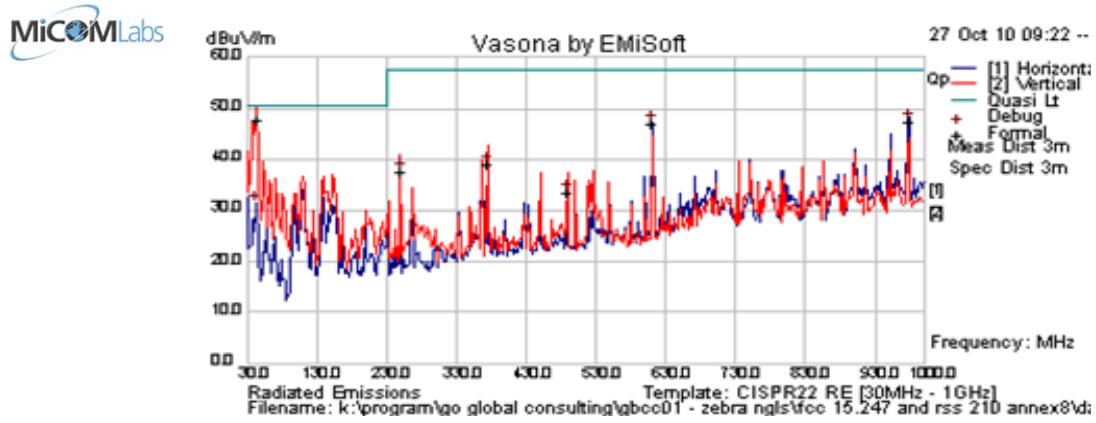
| Method | Test Equipment Used |
|---|---|
| Work instruction WI-03 | 0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312 |

### 7.8.1 Measurement Results for Radiated Spurious Emissions – Digital Apparatus

Please note: Radio emissions were investigated during digital emissions testing. No radio emissions were witnessed in the range 30 - 1000 MHz during testing.

POE Configuration

| | | | |
|---|---|---|---|
| **Test Freq.** | 2441.75 MHz | **Engineer** | SB |
| **Variant** | Digital Emissions | **Temp (ºC)** | 22 |
| **Freq. Range** | 30 MHz - 1000 MHz | **Rel. Hum.(%)** | 34 |
| **Power Setting** | 18 dBm Max | **Press. (mBars)** | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | | |
| **Test Notes 1** | POE Adapter no ferrite(s) | | |
| **Test Notes 2** | S/N# PW182RB4800F01 | | |



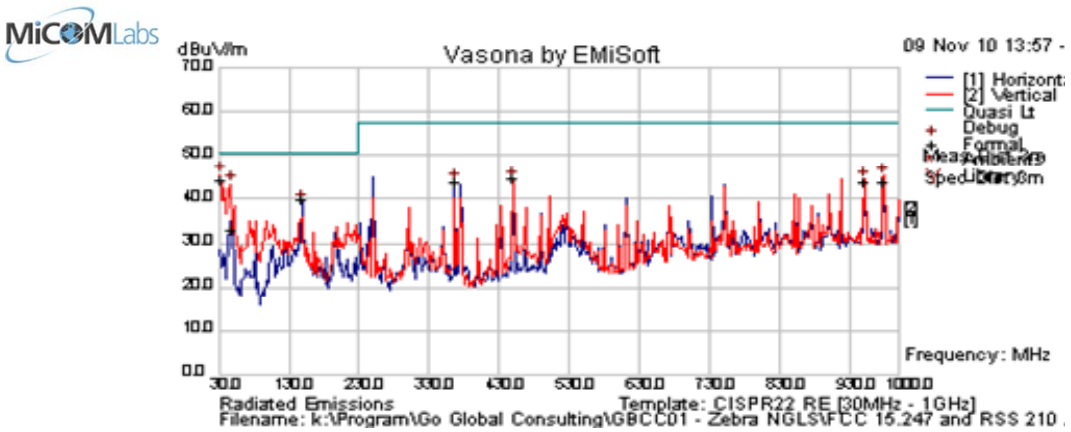

**Formally measured emission peaks**

| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV/m | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV/m | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 43.797 | 63.9 | 3.6 | -19.6 | 48.0 | Quasi Max | V | 119 | 30 | 50.5 | -2.6 | Pass | DIG |
| 611.219 | 51.9 | 6.4 | -11.1 | 47.2 | Peak [Scan] | H | 98 | 343 | 57.5 | -10.3 | Pass | DIG |
| 249.924 | 51.3 | 5.0 | -18.8 | 37.5 | Peak [Scan] | V | 98 | 343 | 57.5 | -20.0 | Pass | DIG |
| 374.069 | 48.5 | 5.6 | -15.2 | 38.9 | Peak [Scan] | V | 98 | 343 | 57.5 | -18.6 | Pass | DIG |
| 978.757 | 46.2 | 7.6 | -6.3 | 47.5 | Peak [Scan] | H | 98 | 343 | 57.5 | -10.0 | Pass | DIG |
| 489.181 | 39.9 | 6.0 | -12.5 | 33.4 | Peak [Scan] | V | 98 | 343 | 57.5 | -24.2 | Pass | DIG |

| | |
|---|---|
| Legend: | DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency |
| | NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band |

PSU-STDA16A-S11

| | | | |
|---|---|---|---|
| **Test Freq.** | 2441.75 MHz | **Engineer** | SB |
| **Variant** | Digital Emissions | **Temp (ºC)** | 22 |
| **Freq. Range** | 30 MHz - 1000 MHz | **Rel. Hum.(%)** | 34 |
| **Power Setting** | 18 dBm Max | **Press. (mBars)** | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | | |
| **Test Notes 1** | AC to DC PSU MEPOS Switching PSU STDA16A-S11 (15 W) | | |
| **Test Notes 2** | | | |



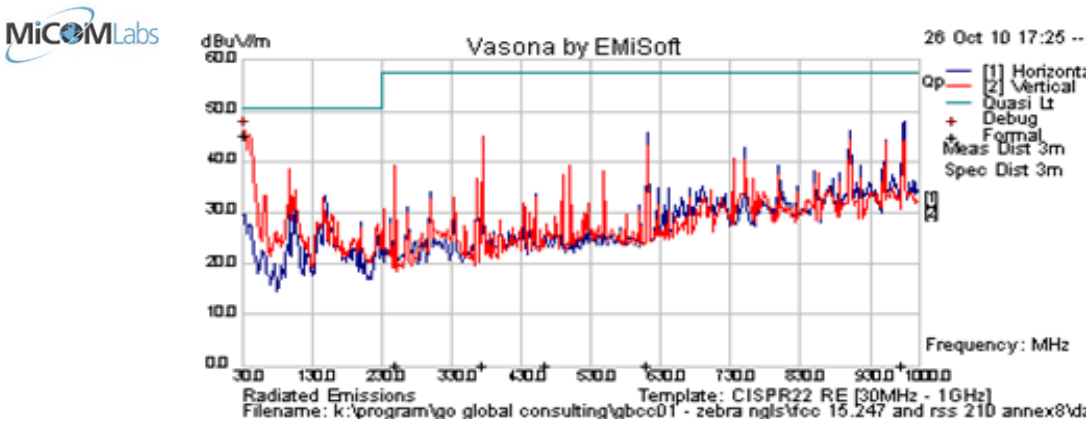

## Formally measured emission peaks

| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV/m | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV/m | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32.619 | 52.2 | 3.4 | -11.1 | 44.5 | Quasi Peak | V | 98 | 360 | 50.5 | -6.0 | Pass | DIG |
| 450.000 | 52.7 | 5.8 | -13.8 | 44.7 | Quasi Max | V | 112 | 0 | 57.5 | -12.8 | Pass | DIG |
| 950.015 | 42.9 | 7.5 | -6.6 | 43.9 | Quasi Max | V | 99 | 286 | 57.5 | -13.6 | Pass | DIG |
| 366.260 | 53.4 | 5.5 | -15.2 | 43.7 | Quasi Max | H | 98 | 117 | 57.5 | -13.8 | Pass | DIG |
| 150.005 | 53.8 | 4.5 | -18.3 | 40.0 | Quasi Max | H | 173 | 136 | 50.5 | -10.5 | Pass | DIG |
| 976.694 | 42.6 | 7.6 | -6.4 | 43.9 | Quasi Max | V | 98 | 107 | 57.5 | -13.6 | Pass | DIG |
| 48.108 | 50.9 | 3.7 | -21.7 | 32.9 | Quasi Max | V | 145 | 117 | 50.5 | -17.6 | Pass | DIG |

| | |
|---|---|
| Legend: | DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency |
| | NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band |

PSU SIDA25A-S11

| | | | |
|---|---|---|---|
| **Test Freq.** | 2441.75 MHz | **Engineer** | SB |
| **Variant** | Digital Emissions | **Temp (ºC)** | 22 |
| **Freq. Range** | 30 MHz - 1000 MHz | **Rel. Hum.(%)** | 33 |
| **Power Setting** | 18 dBm Max | **Press. (mBars)** | 1000 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | | |
| **Test Notes 1** | AC to DC Power Supply SIDA25A-S11 (25 W) | | |
| **Test Notes 2** | | | |




## Formally measured emission peaks

| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV/m | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV/m | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33.679 | 53.8 | 3.5 | -12.1 | 45.2 | Quasi Max | V | 98 | 170 | 50.5 | -5.3 | Pass | DIG |
| 250.005 | 52.5 | 5.0 | -18.8 | 38.7 | Peak [Scan] | V | 98 | -- | 57.5 | -18.8 | Pass | DIG |
| 374.989 | 54.2 | 5.6 | -15.1 | 44.7 | Peak [Scan] | V | 98 | -- | 57.5 | -12.8 | Pass | DIG |
| 610.428 | 50.0 | 6.4 | -11.2 | 45.3 | Peak [Scan] | H | 98 | -- | 57.5 | -12.2 | Pass | DIG |
| 976.693 | 46.7 | 7.6 | -6.4 | 47.9 | Peak [Scan] | H | 98 | -- | 57.5 | -9.6 | Pass | DIG |
| 500.391 | 45.5 | 5.9 | -12.9 | 38.4 | Peak [Scan] | V | 98 | -- | 57.5 | -19.1 | Pass | DIG |

| | |
|---|---|
| Legend: | DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency |
| | NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band |

Note: Emissions above 1 GHz did not change based on power supply used, Radio transmit frequency, or modulation type.

## 7.9 Conducted Disturbance at Mains Terminal (150 kHz – 30 MHz)

### Standard Reference

FCC, Part 15 Subpart C §15.107
Industry Canada ICES-003 §5.3

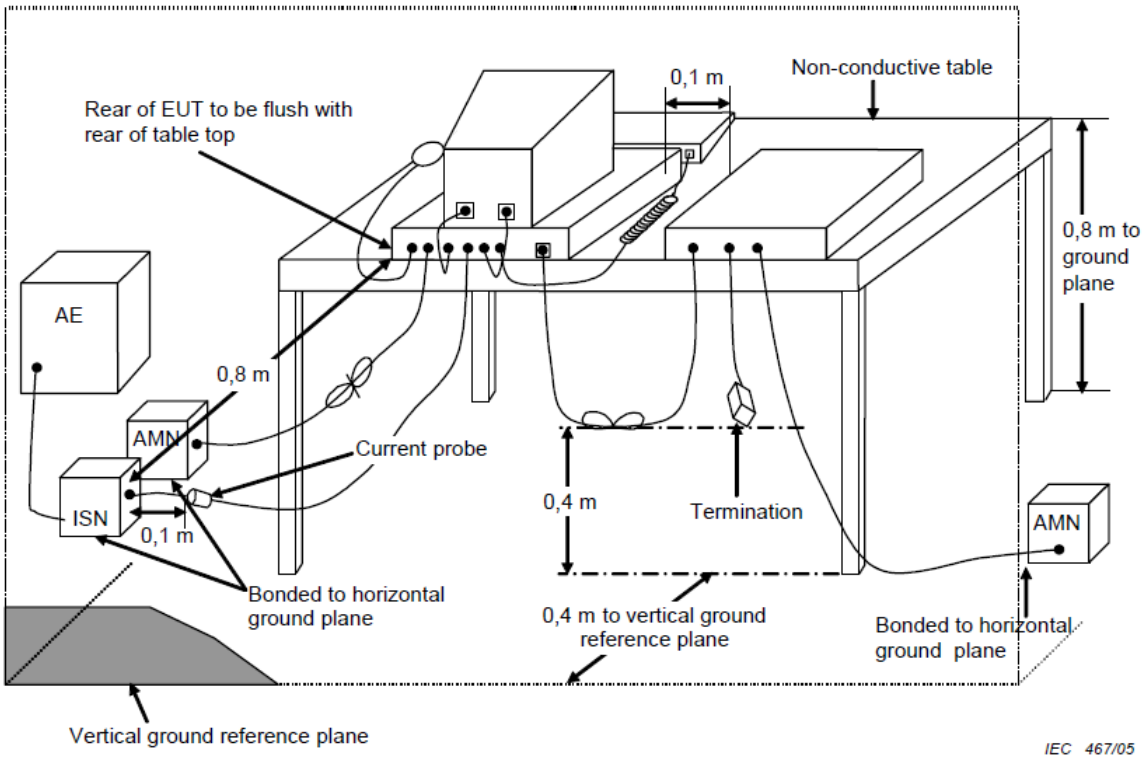
### Test Procedure

The EUT is configured in accordance with ANSI C63.4. The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9 kHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.

If the reading of the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded with the exception of any brief isolated high reading which shall be ignored.

## Test Measurement Set up




Measurement set up for Conducted Disturbance at Mains Terminals

**Specification**

**Conducted Disturbance at Mains Terminal – Digital Apparatus**

**FCC, Part 15 Subpart B §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 the following table, 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 band edges.

(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 the following table, as measured using a 50 μH/50 ohms 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.

**Industry Canada ICES-003**
The voltage of radio noise emissions that are conducted along the power supply lines of a Class A digital apparatus shall not exceed the limits specified in Table 1 of the publication referred to in Section 7.1 [Canadian Standards Association Standard CAN/CSA-CEI/IEC CISPR 22:02, "Limits and Methods of Measurement of Radio Disturbance Characteristics of Information Technology Equipment."], within the indicated frequency range.

The voltage of radio noise emissions that are conducted along the power supply lines of a Class B digital apparatus shall not exceed the limits specified in Table 2 of the publication referred to in Section 7.1 [Canadian Standards Association Standard CAN/CSA-CEI/IEC CISPR 22:02, "Limits and Methods of Measurement of Radio Disturbance Characteristics of Information Technology Equipment."], within the indicated frequency range.

**FCC, Part 15 Subpart B §15.107 & Industry Canada ICES-003 Limits**

Limits for conducted disturbance at the mains ports of class B ITE

| Frequency of emission (MHz) | Quasi-peak dBuV | Average dBuV |
|---|---|---|
| 0.15–0.5 | 66 to 56* | 56 to 46* |
| 0.5–5 | 56 | 46 |
| 5–30 | 60 | 50 |
| Note 1 | * Decreases with the logarithm of the frequency | |
| Note 2 | * The lower limit applies at the boundary between frequency ranges | |

Limits for conducted disturbance at the mains ports of class A ITE

| Frequency of emission (MHz) | Quasi-peak dBuV | Average dBuV |
|---|---|---|
| 0.15–0.5 | 79 | 66 |
| 0.5–30 | 73 | 60 |
| Note 1 | * The lower limit shall apply at the transition frequency. | |

Laboratory Measurement Uncertainty for Conducted Emissions

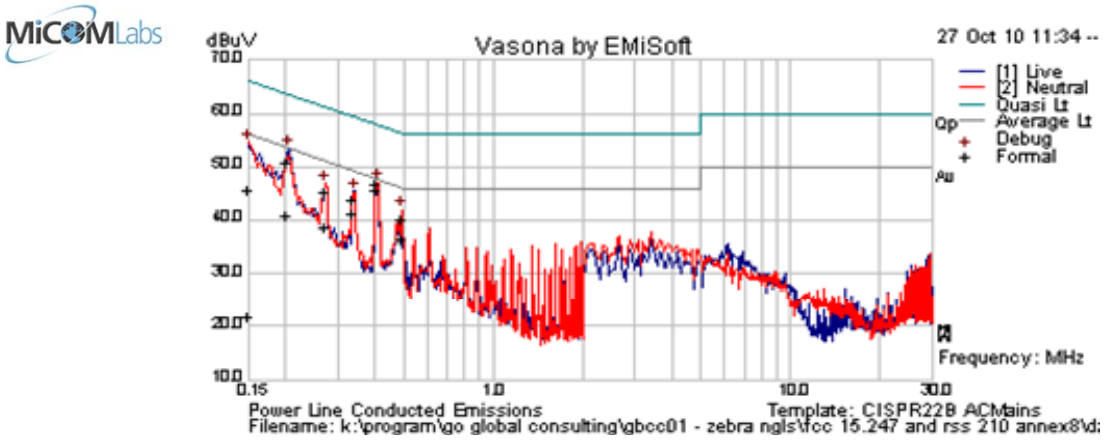
| Measurement uncertainty | ±2.64 dB |
|---|---|

Traceability

| Method | Test Equipment Used |
|---|---|
| Work instruction WI-EMC-01 | 0158, 0184, 0193, 0190, 0293, 0307 |

### 7.9.1 Conducted Disturbance at Mains Terminal (150 kHz – 30 MHz)

| | | | |
|---|---|---|---|
| **Test Freq.** | N/A | **Engineer** | SB |
| **Variant** | AC Mains | **Temp (ºC)** | 22 |
| **Freq. Range** | 0.150 MHz - 30 MHz | **Rel. Hum.(%)** | 34 |
| **Power Setting** | Max Output | **Press. (mBars)** | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | | |
| **Test Notes 1** | MEPOS 25 W AC to DC Adapter | | |
| **Test Notes 2** | AC to DC Power Supply SIDA25A-S11 (25 mW) | | |

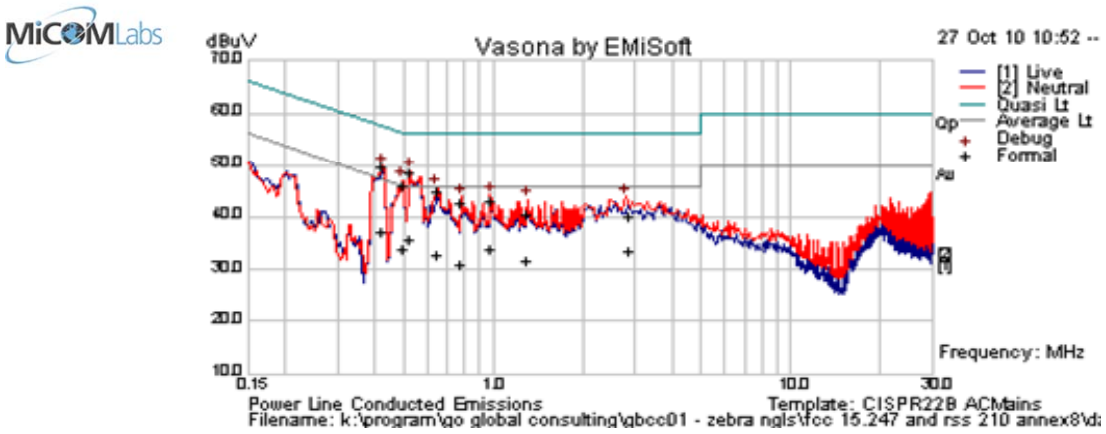



## Formally measured emission peaks

| Frequency MHz | Raw dBuV | Cable Loss | Factors dB | Level dBuV | Measurement Type | Line | Limit dBuV | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.338 | 33.7 | 9.9 | 0.1 | 43.7 | Quasi Peak | Live | 59.25 | -15.6 | Pass | |
| 0.203 | 40.9 | 9.9 | 0.1 | 50.9 | Quasi Peak | Live | 63.47 | -12.6 | Pass | |
| 0.492 | 30.0 | 9.9 | 0.1 | 40.0 | Quasi Peak | Neutral | 56.14 | -16.1 | Pass | |
| 0.406 | 36.8 | 9.9 | 0.1 | 46.7 | Quasi Peak | Neutral | 57.74 | -11.0 | Pass | |
| 0.150 | 35.9 | 9.9 | 0.1 | 45.8 | Quasi Peak | Neutral | 65.99 | -20.2 | Pass | |
| 0.271 | 35.2 | 9.9 | 0.1 | 45.1 | Quasi Peak | Neutral | 61.08 | -16.0 | Pass | |
| 0.338 | 31.3 | 9.9 | 0.1 | 41.3 | Average | Live | 49.25 | -8.0 | Pass | |
| 0.203 | 30.8 | 9.9 | 0.1 | 40.8 | Average | Live | 53.47 | -12.7 | Pass | |
| 0.492 | 26.4 | 9.9 | 0.1 | 36.4 | Average | Neutral | 46.14 | -9.7 | Pass | |
| 0.406 | 35.8 | 9.9 | 0.1 | 45.8 | Average | Neutral | 47.74 | -2.0 | Pass | |
| 0.150 | 11.7 | 9.9 | 0.1 | 21.7 | Average | Neutral | 55.99 | -34.3 | Pass | |
| 0.271 | 28.5 | 9.9 | 0.1 | 38.5 | Average | Neutral | 51.08 | -12.6 | Pass | |

| | |
|---|---|
| Legend: | DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency |
| | NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band |

| | | | |
|---|---|---|---|
| **Test Freq.** | N/A | | SB |
| **Variant** | AC Main | | 22 |
| **Freq. Range** | 0.150 MHz - 30 MHz | | 34 |
| **Power Setting** | Max Output | | 1005 |
| **Antenna** | AK-210-10 "Bull Horn" Omni all weather | | |
| **Test Notes 1** | MEPOS 15 W AC to DC Adapter | | |
| **Test Notes 2** | DC Cable Ferrite 0431167281 1 loop 2 turns 7 inchs tip of power adapter plug input | | |




## Formally measured emission peaks

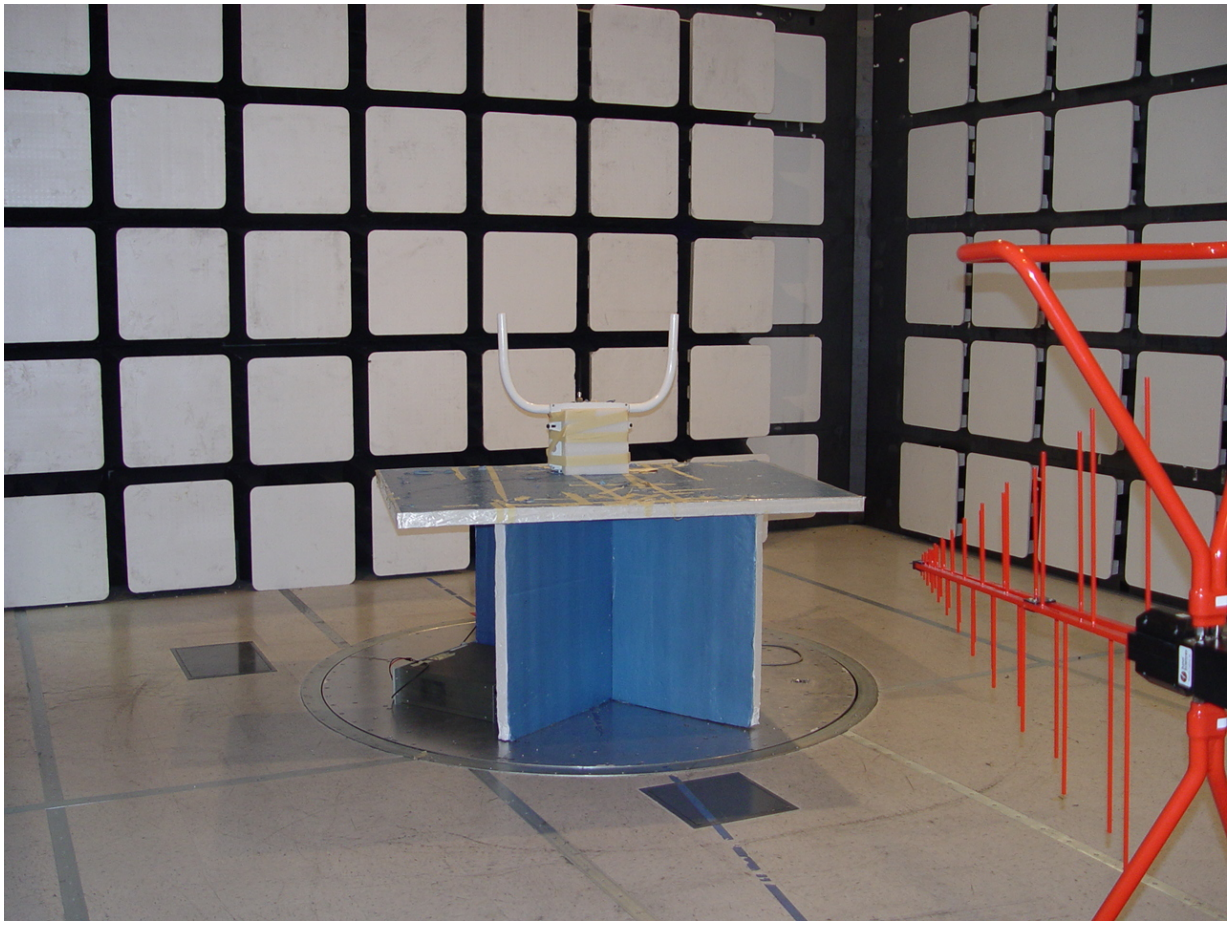
| Frequency MHz | Raw dBuV | Cable Loss | Factors dB | Level dBuV | Measurement Type | Line | Limit dBuV | Margin dB | Pass /Fail | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.522 | 38.6 | 9.9 | 0.1 | 48.6 | Quasi Peak | Neutral | 56.0 | -7.4 | Pass | |
| 0.427 | 39.9 | 9.9 | 0.1 | 49.8 | Quasi Peak | Neutral | 57.3 | -7.5 | Pass | |
| 0.497 | 36.0 | 9.9 | 0.1 | 46.0 | Quasi Peak | Neutral | 56.1 | -10.1 | Pass | |
| 0.653 | 34.9 | 10.0 | 0.1 | 45.0 | Quasi Peak | Neutral | 56.0 | -11.1 | Pass | |
| 0.979 | 33.2 | 9.9 | 0.1 | 43.2 | Quasi Peak | Neutral | 56.0 | -12.8 | Pass | |
| 0.784 | 32.6 | 10.0 | 0.1 | 42.6 | Quasi Peak | Neutral | 56.0 | -13.4 | Pass | |
| 2.867 | 29.8 | 10.1 | 0.1 | 40.1 | Quasi Peak | Neutral | 56.0 | -16.0 | Pass | |
| 1.308 | 30.4 | 10.0 | 0.1 | 40.4 | Quasi Peak | Neutral | 56.0 | -15.6 | Pass | |
| 0.522 | 25.8 | 9.9 | 0.1 | 35.8 | Average | Neutral | 46.0 | -10.2 | Pass | |
| 0.427 | 27.2 | 9.9 | 0.1 | 37.2 | Average | Neutral | 47.3 | -10.1 | Pass | |
| 0.497 | 23.8 | 9.9 | 0.1 | 33.8 | Average | Neutral | 46.1 | -12.3 | Pass | |
| 0.653 | 22.9 | 10.0 | 0.1 | 32.9 | Average | Neutral | 46.0 | -13.1 | Pass | |
| 0.979 | 23.7 | 9.9 | 0.1 | 33.8 | Average | Neutral | 46.0 | -12.3 | Pass | |
| 0.784 | 20.8 | 10.0 | 0.1 | 30.9 | Average | Neutral | 46.0 | -15.1 | Pass | |
| 2.867 | 23.2 | 10.1 | 0.1 | 33.4 | Average | Neutral | 46.0 | -12.6 | Pass | |
| 1.308 | 21.8 | 10.0 | 0.1 | 31.8 | Average | Neutral | 46.0 | -14.2 | Pass | |

| | |
|---|---|
| Legend: | DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency |
| | NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band |

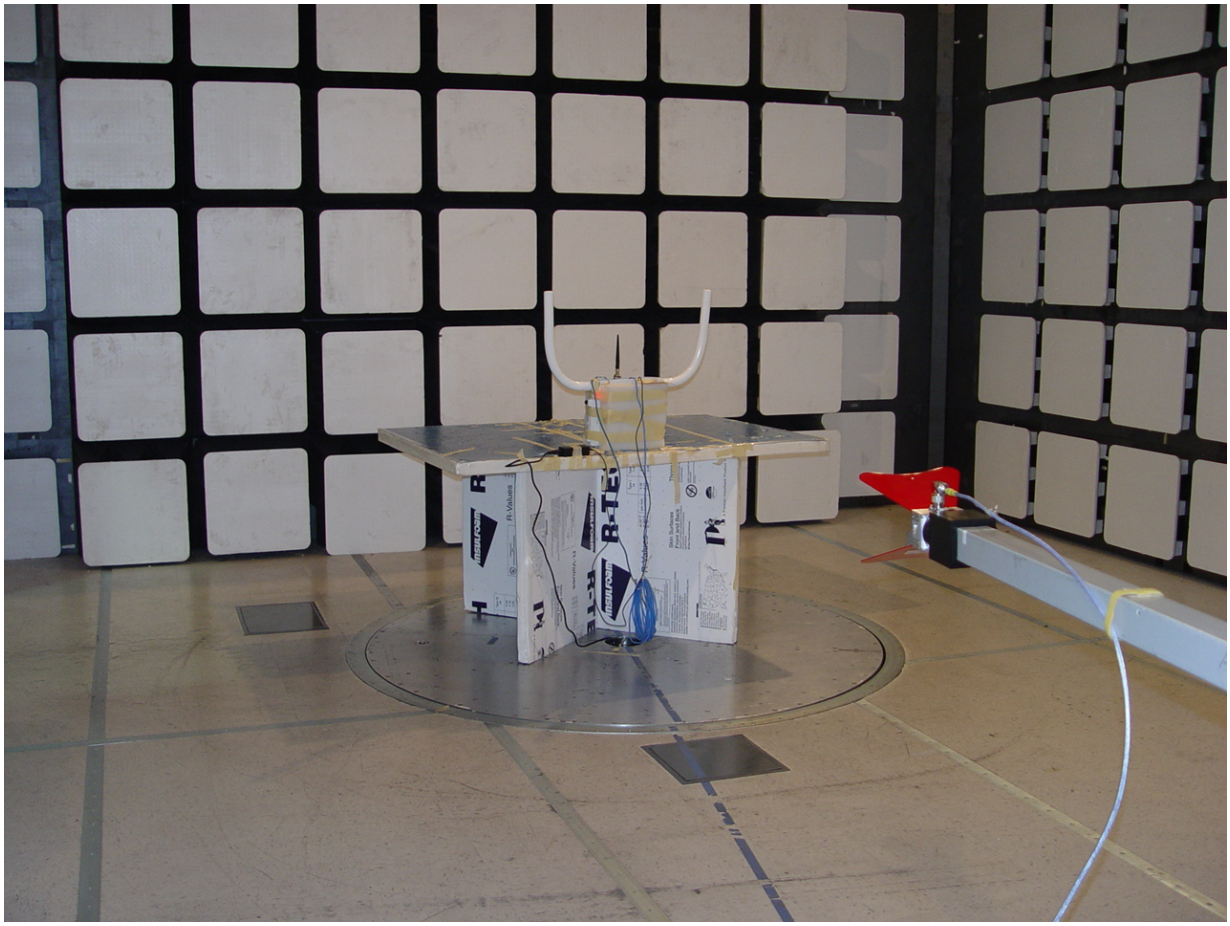
# 8 PHOTOGRAPHS

## 8.1 Conducted RF Measurement Set Up

## 8.2 Radiated Spurious Emissions Below 1 GHz



## 8.3 Radiated Spurious Emissions Above 1 GHz



# 9 TEST EQUPIMENT DETAILS

| Asset # | Instrument | Manufacturer | Model # | Serial # |
|---|---|---|---|---|
| 0072 | Signal Generator | Hewlett Packard | HP 83640A | 2927A00105 |
| 0075 | Environmental Chamber | Thermatron | SE-300-2-2 | 27946 |
| 0338 | Antenna (30M-3GHz) | Sunol Sciences | JB3 | A052907 |
| 0083 | Coupler | Hewlett Packard | HP 87301D | 3116A00389 |
| 0287 | EMI Receiver | Rhode & Schwartz | ESIB 40 | 100201 |
| 0335 | Horn Antenna | The Electro-Mechanics Company | 3117 | 00066580 |
| 0116 | Power Sensor | Hewlett Packard | 8485A | 3318A19694 |
| 0117 | Power Sensor | Hewlett Packard | 8487D | 3318A00371 |
| 0134 | Amplifier | ComPower | PA-122 | 181910 |
| 0158 | Barometer /Thermometer | Control Co. | 4196 | E2844 |
| 0193 | EMI Receiver | Rhode & Schwartz | ESI 7 | 838496/007 |
| 0223 | Power Meter | Hewlett Packard | HP EPM-442A | US37480256 |
| 0252 | K-Cable | Megaphase | Sucoflex 104 | Unknown |
| 0253 | K-Cable | Megaphase | Sucoflex 104 | Unknown |
| 0256 | K-Cable | Megaphase | Sucoflex 104 | Unknown |
| 0251 | K-Cable | Megaphase | Sucoflex 104 | Unknown |
| 0305 | 20M-2GHz Amplifier | ML | ML001 | 001 |
| 0310 | 2m SMA Cable | Micro-Coax | UFA210A-0-0787-3G03G0 | 209089-001 |
| 0312 | 3m SMA Cable | Micro-Coax | UFA210A-1-1181-3G0300 | 209092-001 |
| 0313 | Coupler | Hewlett Packard | 86205A | 3140A01285 |
| 0314 | 30 dB N-Type Attenuator | ARRA | N944-30 | 1623 |
| Dipole | 20MHz-1GHz Dipole Antennas | EMCO | 3121C | 9009-505 |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