

Test of iControl, iCHIME 802.15.4

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

Test Report Serial No.: ICON09-A2 Rev A





Test of iControl, iCHIME 802.15.4
to
To FCC 47 CFR Part 15.247 & IC RSS-210

Test Report Serial No.: ICON09-A2 Rev A

This report supersedes: None

Applicant: iControl, Incorporated
3235 Kifer, Suite 260
Santa Clara
California, 95051 USA

Product Function: 802.15.4 Radio Frequency
Identification (RFID)

Copy No: pdf **Issue Date:** 8th December 2009

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
440 Boulder Court, Suite 200
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www.micomlabs.com



CERTIFICATE #2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory



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ACCREDITATION, LISTINGS and RECOGNITION

ACCREDITATION

MiCOM Labs, Inc. an accredited laboratory complies with the international standard BS 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>



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LISTINGS

MiCOM Labs test facilities are listed by the following organizations;

North America

United States of America

Federal Communications Commission (FCC): 102167

Canada

Industry Canada: 4143A

Japan Registration

VCCI Membership Number: 2959

- Radiation 3 meter site; Registration No. R-2881
- Line Conducted, Registration Nos. C-3181 & T-1470
- Emissions; Registration Nos. C-3180 & T-1469

RECOGNITION

APEC MRA (Asia-Pacific Economic Community Mutual Recognition Agreement)

Conformity Assessment Body (CAB) – MiCOM Labs

Test data generated by MiCOM Labs is accepted in the following countries under the APEC MRA.

| Country | Recognition Body | Phase | CAB Identification No. |
|-----------|---|--------|------------------------|
| Australia | Australian Communications and Media Authority (ACMA) | I | US0159 |
| Hong Kong | Office of the Telecommunication Authority (OFTA) | I | |
| Korea | Ministry of Information and Communication Radio Research Laboratory (RRL) | I | |
| Singapore | Infocomm Development Authority (IDA) | I | |
| Taiwan | Directorate General of Telecommunications (DGT) Bureau of Standards, Metrology and Inspection (BSMI) | I I | |

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DOCUMENT HISTORY

| Document History | | |
|------------------|-------------------------------|-----------------|
| Revision | Date | Comments |
| Draft | | |
| A | 8 th December 2009 | Initial Release |
| | | |
| | | |
| | | |

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1. TEST RESULT CERTIFICATE

| | | | |
|---------------|---|------------|--|
| Manufacturer: | iControl, Incorporated 3235 Kifer, Suite 260 Santa Clara California, 95051 USA | Tested By: | MiCOM Labs, Inc. 440 Boulder Court Suite 200 Pleasanton California, 94566, USA |
| EUT: | Radio Frequency Identification (RFID) | Telephone: | +1 925 462 0304 |
| Model: | iCHIME | Fax: | +1 925 462 0306 |
| S/N: | N/A | | |
| Test Date(s): | 21st September to 19th November 2009 | Website: | www.micomlabs.com |

| STANDARD(S) | TEST RESULTS |
|-------------------------------------|--------------------|
| FCC 47 CFR Part 15.247 & IC RSS-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.

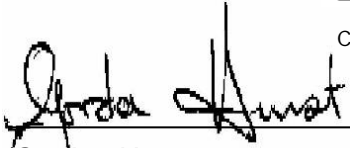
Notes:

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:



Graeme Grieve
Quality Manager MiCOM Labs,



Gordon Hurst
President & CEO MiCOM Labs, Inc.



CERTIFICATE #2381.01

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2. REFERENCES AND MEASUREMENT UNCERTAINTY

2.1. Normative References

| Ref. | Publication | Year | Title |
|--------|-------------------------|---------------------------------------|--|
| (i) | FCC 47 CFR Part 15.247 | 2007 | Code of Federal Regulations |
| (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 | 2003 | 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 | 1997 1998 | 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 | 14 th September 2005 | Reference to A2LA Accreditation Status – A2LA Advertising Policy |

2.2. 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.



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3. PRODUCT DETAILS AND TEST CONFIGURATIONS

3.1. Technical Details

| Details | Description |
|--|--|
| Purpose: | Test of the iControl, iCHIME 802.15.4 to FCC Part 15.247 and Industry Canada RSS-210 regulations. |
| Manufacturer: | As Applicant |
| Applicant: | iControl, Incorporated 3235 Kifer, Suite 260 Santa Clara California, 95051 USA |
| Laboratory performing the tests: | MiCOM Labs, Inc. 440 Boulder Court, Suite 200 Pleasanton, California 94566 USA |
| Test report reference number: | ICON09-A2 Rev A |
| Date EUT received: | 21 st September 2009 |
| Standard(s) applied: | FCC 47 CFR Part 15.247 & IC RSS-210 |
| Dates of test (from - to): | 21st September to 19th November 2009 |
| No of Units Tested: | 3 units total were tested. - iChime Rev 2.0 used for conducted testing. Conducted testing, RF connector (UFL) provided on iCHIME. - iChime Rev 2.0 with integrated F antenna connected was used for radiated testing. - iChime Rev 2.0 with RF connector (UFL) provided on iChime used for external antenna testing |
| Type of Equipment: | 802.15.4 Wireless Device |
| Model: | iCHIME |
| Location for use: | Indoor/Outdoor |
| Declared Frequency Range(s): | 2400 - 2483.5 MHz |
| Type of Modulation: | Per 802.15.4 |
| Declared Nominal Average Output Power: | +15.0 dBm |
| EUT Modes of Operation: | 802.15.4 |
| Transmit/Receive Operation: | Time Division Duplex |
| Rated Input Voltage: | Nominal: 3.7 Vdc Minimum: 3.3 Vdc Maximum: 4.1 Vdc |
| Operating Temperature Range: | -40 to +80°C |
| ITU Emission Designator: | 802.15.4 – 2M6G7DFN |
| Frequency Stability: | ±20 ppm max |
| Equipment Dimensions: | 1.375" W x 2.75" L x 0.375" D |
| Weight: | 1 oz |
| Primary function of equipment: | Radio Frequency Identification (RFID) tag designed for tracking shipping containers in a worldwide supply chain |

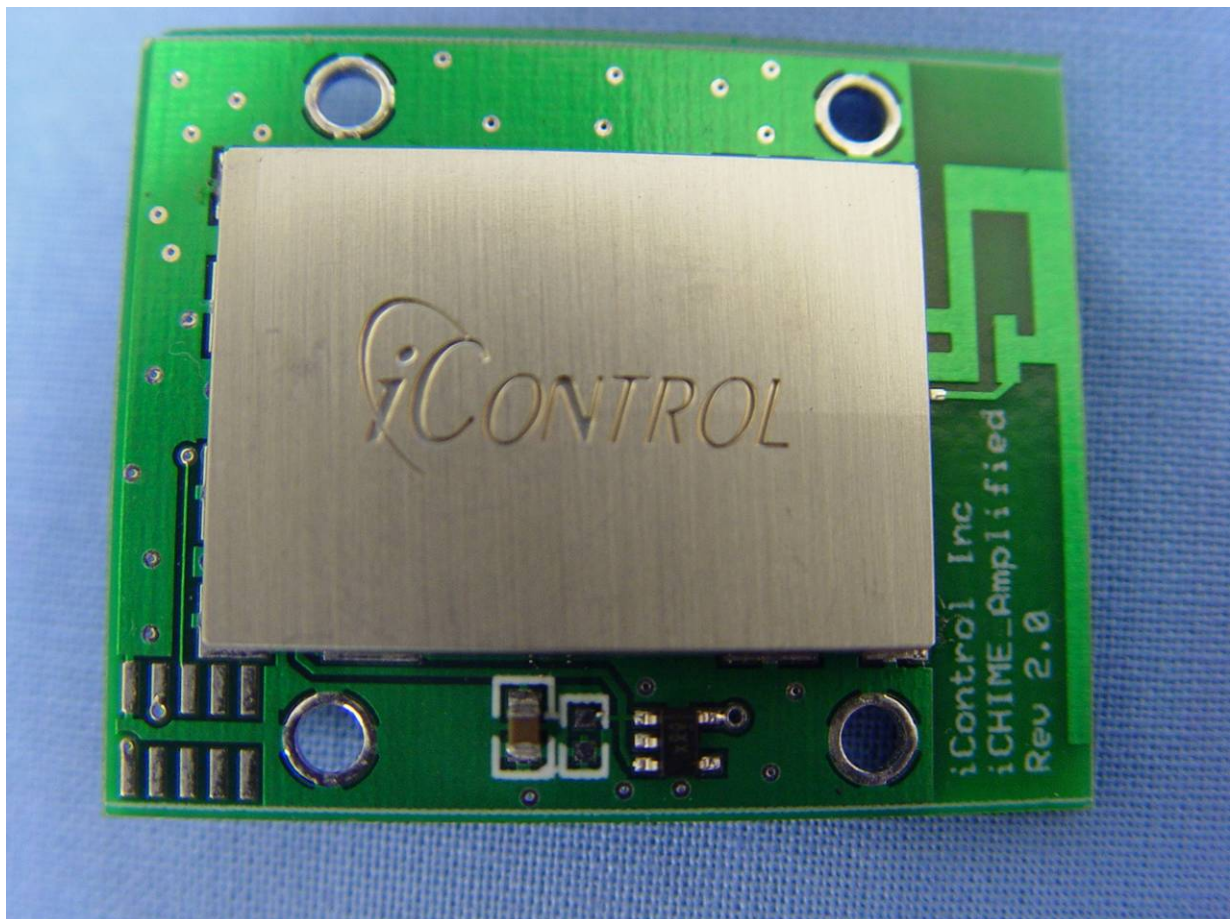
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3.2. Scope of Test Program

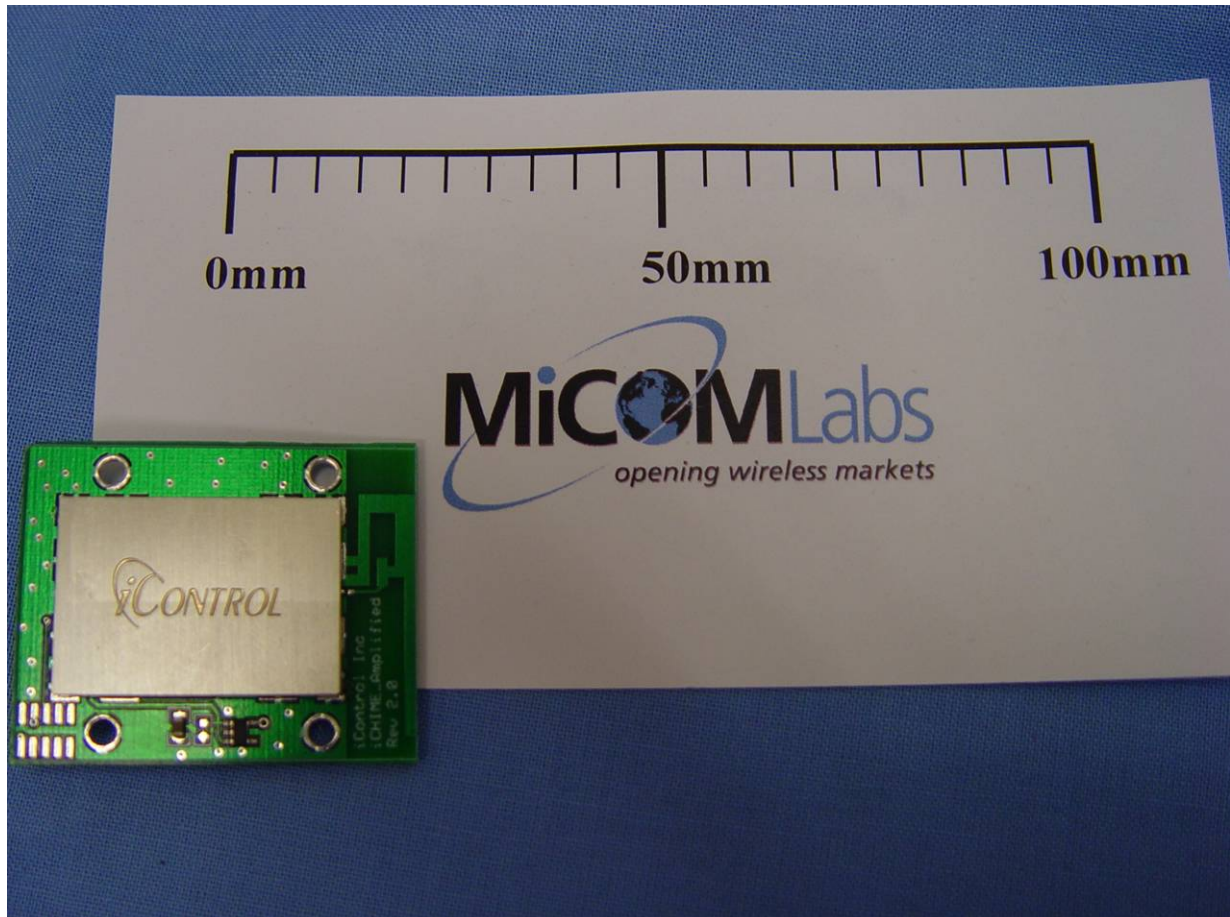
The scope of the test program was to test the iControl 802.15.4 iCHIME in the frequency range 2400 - 2483.5 MHz, FCC 47 CFR Part 15.247 and Industry Canada RSS-210 specifications. This equipment is intended for periodic reporting of tracking and lock status.

The unit operates via a 3.7 Vdc Lithium battery.

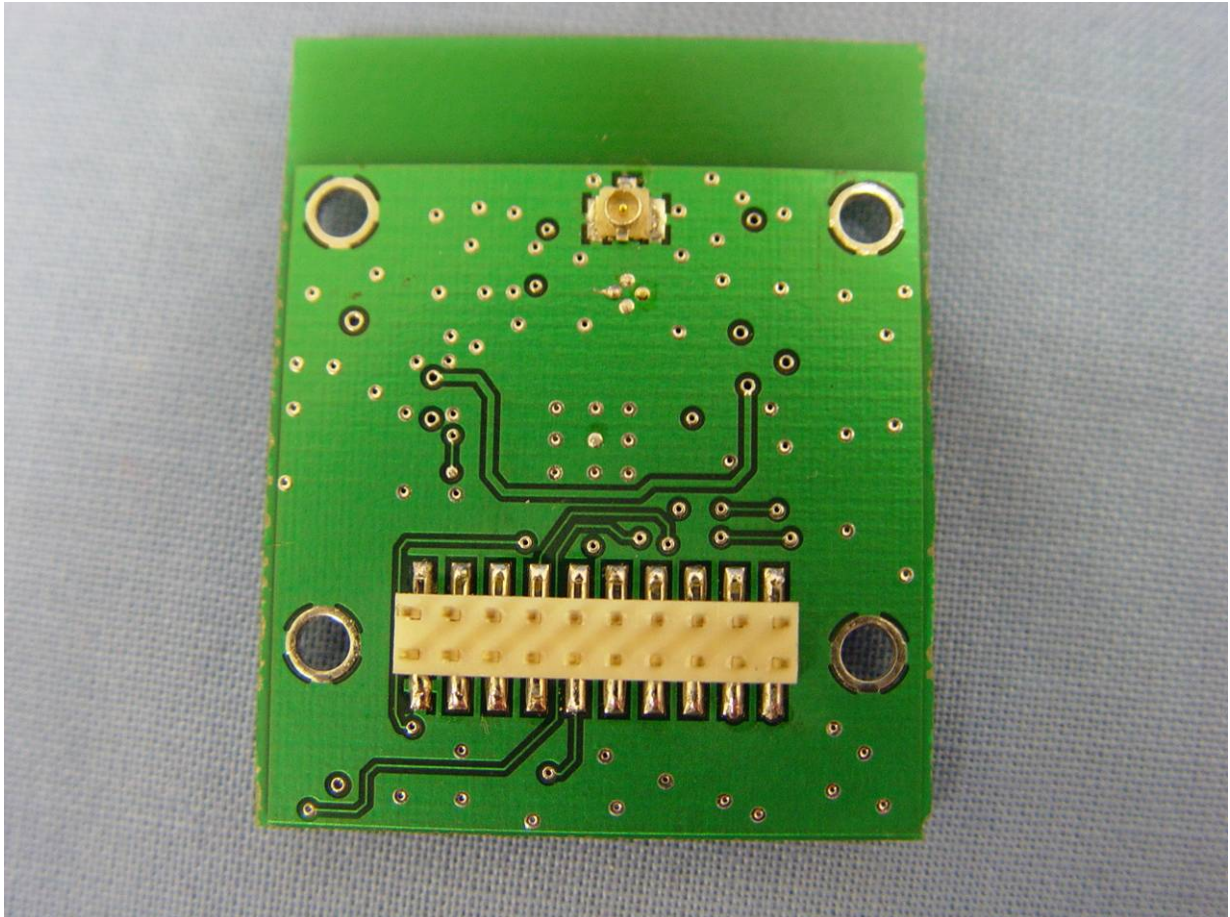
iControl iCHIME - Front



iControl iCHIME - Dimensions



iControl iCHIME - Rear





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3.3. Equipment Model(s) and Serial Number(s)

| Type (EUT/Support) | Equipment Description (Including Brand Name) | Mfr | Model No. | Serial No. |
|--------------------|--|------------------------|------------------|-------------|
| EUT | 2.4 GHz ZigBee 802,15.4 | iControl, Incorporated | iCHIME | N/A |
| Support | 2.4 GHz Wireless Control PCB | iControl, Incorporated | iDAC Motherboard | -- |
| Support | ac Adapter 115Vac 60Hz 9Vdc 1.3A | Unifive | US100913 | 302-004675 |
| Support | DC Power Supply | Hewlett Packard | 6274B | 2713A-09023 |
| Support | Laptop | IBM | N/A | N/A |

3.4. Antenna Details

1. 2400-2483.5 MHz

- Integral Inverted F Antenna (IFA) – Texas Instruments, Max Gain: 3.3 dBi
- External Antennas: The following list of external antennas was supplied by iControl and these are available for use with the iCHIME. The EUT was tested with antenna models HG2408U, HG2414P, and HG2414SP-120, representing the highest gain of each type of antenna (Omni, Flat Panel, and Sector Panel).

| Manufacturer | Product Name | Model Number | Gain | Horizontal Beam Width | Configuration |
|--------------|-----------------|---------------|------|-----------------------|----------------|
| Hyperlink | | HG2408U | 8 | 360 (Omni) | single |
| Hyperlink | | HGV-2409U | 8 | 360 (Omni) | single |
| Hyperlink | | HG2403MGURB | 3 | 360 (Omni) | single |
| Antenova | Titanis 2.4 GHz | 2010B48440-01 | 2.2 | 360 (Omni) | single |
| Hyperlink | | HG2414P | 14 | 30 (Flat Panel) | single |
| Hyperlink | | HG2414SP-120 | 14 | 120 (Sector Panel) | single or dual |
| Superpass | | SPDG14T2 | 11 | 120 (Sector Panel) | single |

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3.5. Cabling and I/O Ports

Number and type of I/O ports

1. 12 inch N Male to SMA Mail shielded coax cable used for external antenna testing

3.6. Test Configurations

Matrix of Channel test configurations.

| Channel Operational Mode (802.15.4) | Frequencies (MHz) |
|---|----------------------|
| 11 | 2405 |
| 19 | 2445 |
| 26 | 2480 |

3.7. Equipment Modifications.

The following modifications were required to bring the equipment into compliance with the requirements for Radiated Emissions:

1. Channel 26 (2480 MHz) removed from allowable channels when using Integral Antenna.
2. Channel 26 (2480 MHz) removed from allowable channels when using Antenna HG2414P.
3. Channel 26 (2480 MHz) removed from allowable channels when using Antenna HG2414SP-120
4. Power output reduced per tables below.

| Antenna | Integral | | | | |
|---------|----------|----------------|--------------------------|---------------------------|-------------------------|
| | Channel | Freq. (MHz) | Compliant Power (dBm) | Compliant Pwr. Setting | Nominal Pwr. Setting |
| Low | CH 11 | 2405 | 9.86 | 82 | 95 |
| Middle | CH 19 | 2445 | 13.65 | 90 | 95 |
| High | CH 25 | 2475 | -1.77 | 70 | 95 |



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| Antenna | HG2408U | | | | |
|---------|---------|-------------|-----------------------|------------------------|----------------------|
| | Channel | Freq. (MHz) | Compliant Power (dBm) | Compliant Pwr. Setting | Nominal Pwr. Setting |
| Low | CH 11 | 2405 | -1.77 | 70 | 95 |
| Middle | CH 19 | 2445 | 13.65 | 90 | 95 |
| High | CH 26 | 2480 | -29.2 | 65 | 95 |

| Antenna | HG2414P | | | | |
|---------|---------|-------------|-----------------------|------------------------|----------------------|
| | Channel | Freq. (MHz) | Compliant Power (dBm) | Compliant Pwr. Setting | Nominal Pwr. Setting |
| Low | CH 11 | 2405 | -8.61 | 67 | 95 |
| Middle | CH 19 | 2445 | 13.65 | 90 | 95 |
| High | CH 25 | 2475 | -24.04 | 66 | 95 |

| Antenna | HG2414SP-120 | | | | |
|---------|--------------|-------------|-----------------------|------------------------|----------------------|
| | Channel | Freq. (MHz) | Compliant Power (dBm) | Compliant Pwr. Setting | Nominal Pwr. Setting |
| Low | CH 11 | 2405 | -8.61 | 67 | 95 |
| Middle | CH 19 | 2445 | 13.65 | 90 | 95 |
| High | CH 25 | 2475 | -24.04 | 66 | 95 |

3.8. Deviations from the Test Standard

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

1. NONE

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4. 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) A8.2(1) 4.4 | 6 dB and 99 % Bandwidths | ≥500 kHz | Conducted | Complies | 5.1.1 |
| 15.247(b)(3) 15.31(e) A8.4(4) | Peak Output Power Voltage Variation | Shall not exceed 1W Variation of supply voltage 85 % -115 % | Conducted | Complies | 5.1.2 |
| 15.247(e) A8.2 | Peak Power Spectral Density | Shall not be greater than +8 dBm in any 3 kHz band | Conducted | Complies | 5.1.3 |
| 15.247(i) 5.5 | Maximum Permissible Exposure | Exposure to radio frequency energy levels | Conducted | Complies | 5.1.4 |
| 15.247(d) 15.205 / 15.209 A8.5 2.2 4.7 | Spurious Emissions (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 | 5.1.5 |

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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) 15.205 / 15.209 A8.5 2.2 2.6 4.7 | Radiated Emissions | Restricted Bands | Radiated | Complies | 5.1.6 |
| | Transmitter Radiated Spurious Emissions | Emissions above 1 GHz | | Complies | 5.1.6.1 |
| | Radiated Band Edge | Band-edge results | | Complies | 5.1.6.2. |
| | Receiver Radiated Spurious Emissions | Peak Emissions Emissions above 1 GHz | | N/A | 5.1.6.3 |
| Industry Canada only RSS-Gen §4.8, §6 | | | | | |
| 15.205 / 15.209 2.2 | Radiated Spurious Emissions | Emissions <1 GHz (30M-1 GHz) | Radiated | Complies | 5.1.6.4 |
| 15.207 7.2.2 | AC Wireline Conducted Emissions 150 kHz–30 MHz | Conducted Emissions | Conducted | Not Applicable | 5.1.7 |

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 modifications that were required to bring the product into compliance with the above test matrix

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5. TEST RESULTS

5.1. Device Characteristics

5.1.1. 6 dB and 99 % Bandwidth

FCC, Part 15 Subpart C §15.247(a)(2)

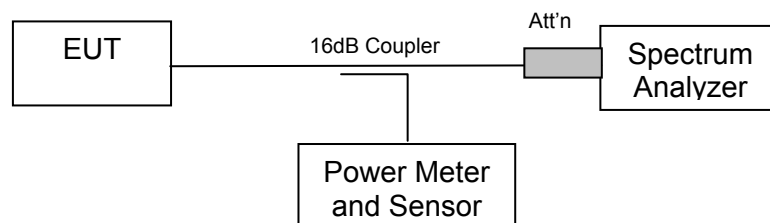
Industry Canada RSS-210 §A8.2

Industry Canada RSS-Gen §4.4

Test Procedure

The bandwidth at 6 dB and 99 % is measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

Test Measurement Set up



Measurement set up for 6 dB and 99 % bandwidth test

Measurement Results for 6 dB & 99% Bandwidth

Ambient conditions.

Temperature: 17 to 23 °C

Relative humidity: 31 to 57 %

Pressure: 999 to 1012 mbar

Radio Parameters

Duty Cycle: 100%

Output: Modulated Carrier

Power: Maximum



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Measurement Results for 6 dB and 99% Operational Bandwidth(s)

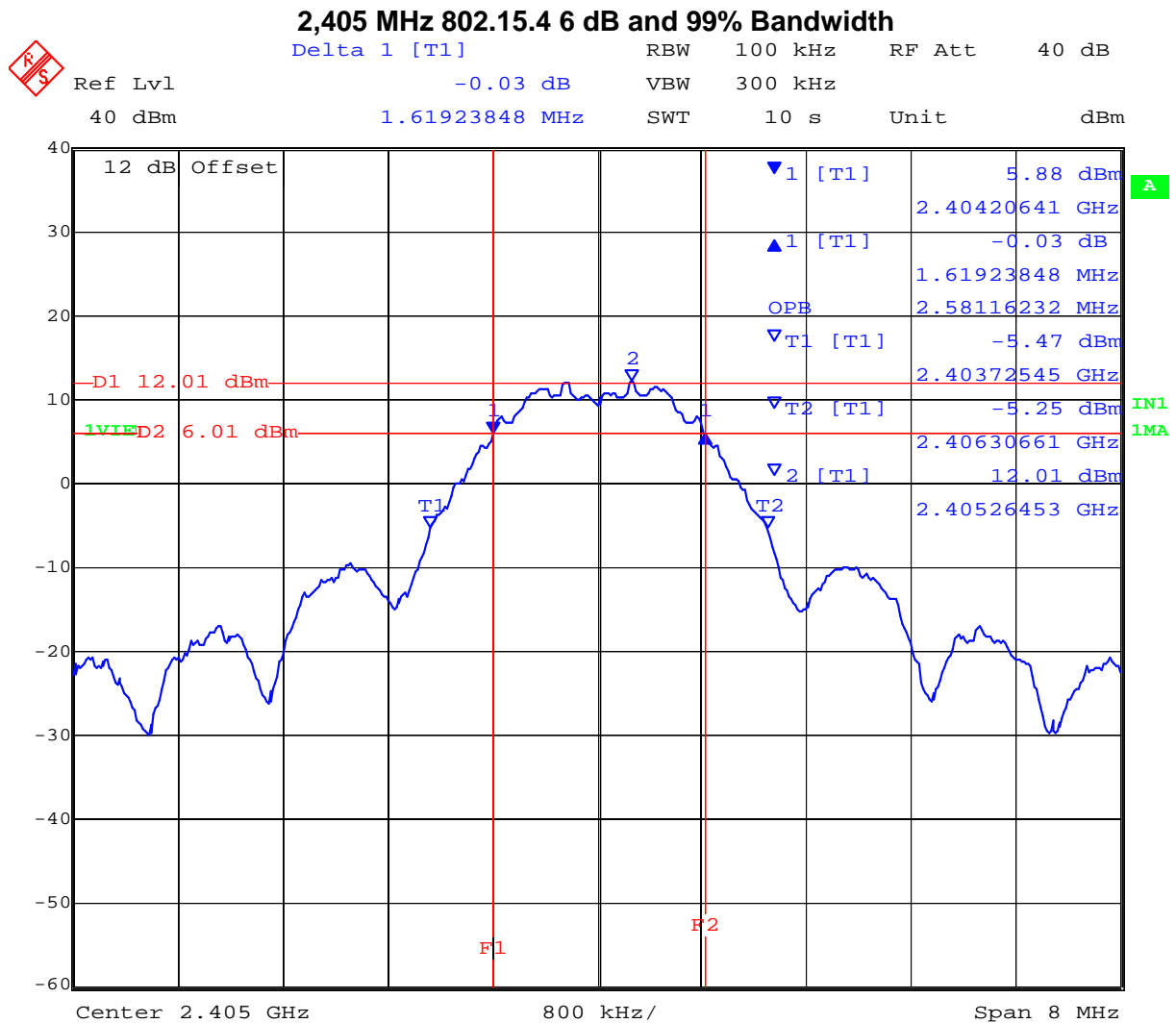
Ambient conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

TABLE OF RESULTS

| Center Frequency (MHz) | 6 dB Bandwidth (MHz) | 99% Bandwidth (MHz) |
|-----------------------------------|---------------------------------|--------------------------------|
| 2,405 | 1.619 | 2.581 |
| 2,445 | 1.619 | 2.549 |
| 2,480 | 1.603 | 2.565 |

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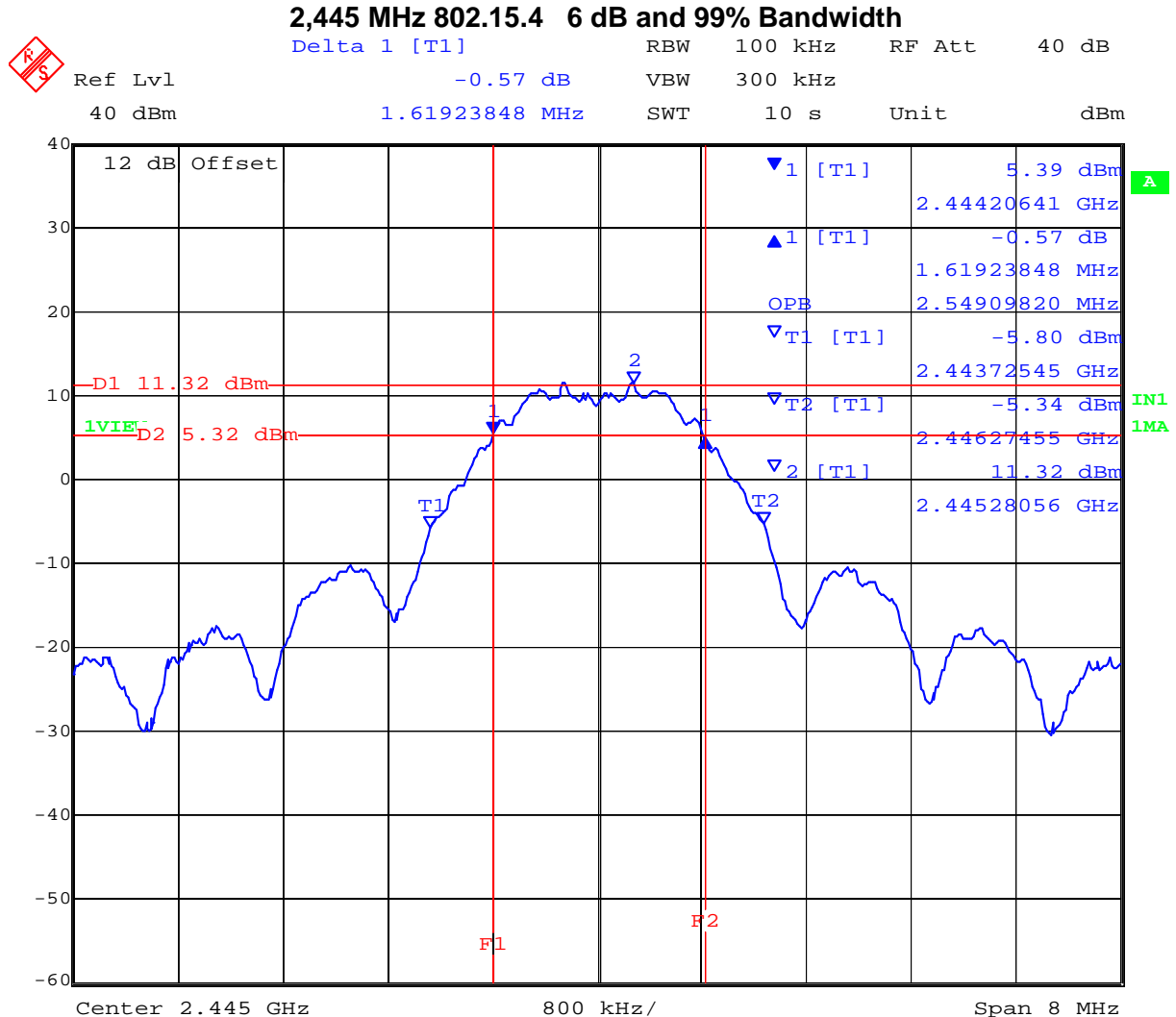


Date: 23.SEP.2009 08:51:26

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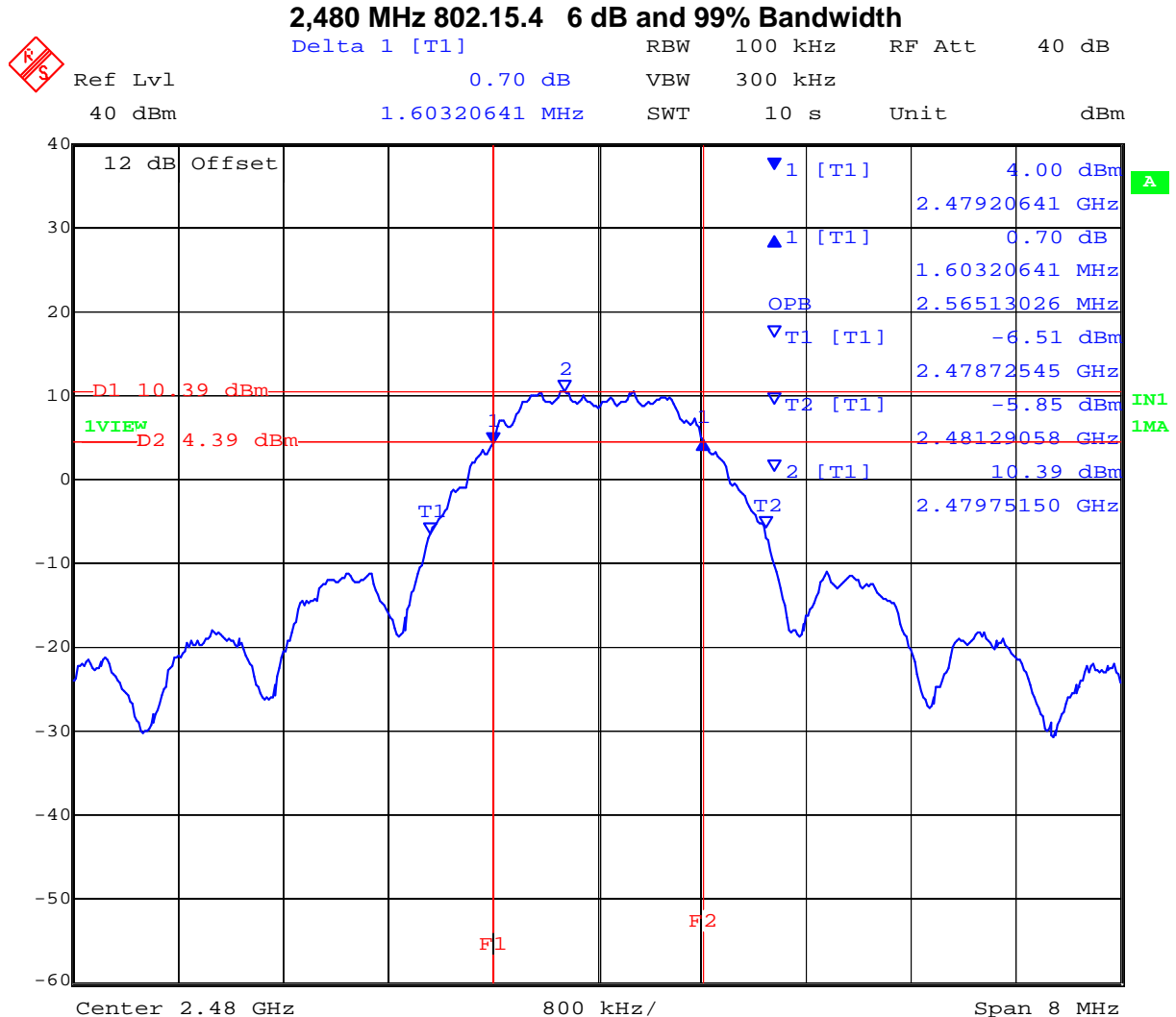


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Date: 23.SEP.2009 09:01:23

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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.

Laboratory Measurement Uncertainty for Spectrum Measurement

| | |
|-------------------------|----------|
| Measurement uncertainty | ±2.81 dB |
|-------------------------|----------|

Traceability

| Method | Test Equipment Used |
|---|--|
| Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask' | 0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117 |

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5.1.2. Peak Output Power

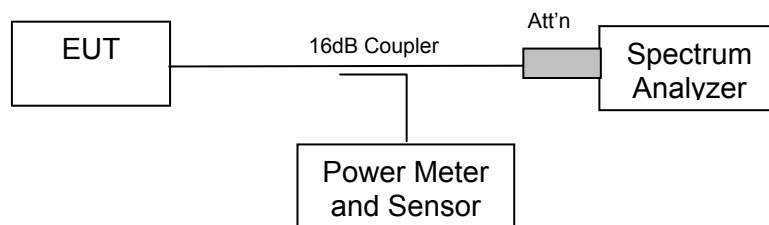
FCC, Part 15 Subpart C §15.247(b)(3), §15.31(e)

Industry Canada RSS-210 §A8.4(4)

Test Procedure

The transmitter terminal of EUT was connected to the input of the spectrum analyzer set to measure peak power. The resolution filter bandwidth was set to 6 dB, peak detector selected and the analyzer built-in power function was used to measure peak power over the 99 % bandwidth.

Test Measurement Set up



Measurement set up for Transmitter Peak Output Power

Ambient conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

Maximum Antenna Gain: 14.0 dBi



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TABLE OF RESULTS
Maximum Conducted Power

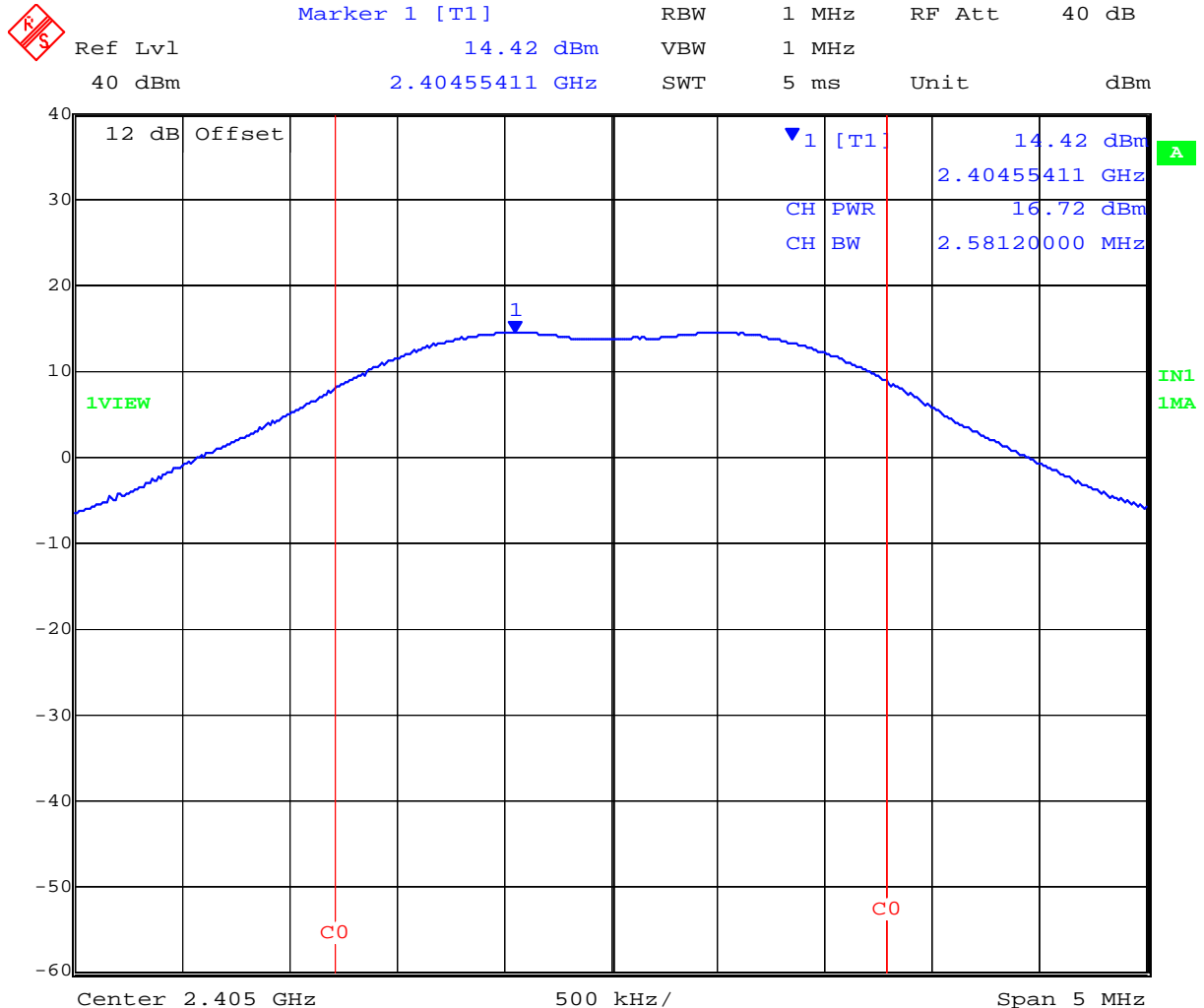
| Center Frequency (MHz) | 99% Measurement Bandwidth (MHz) | Average Power (dBm) | Peak Power (dBm) | Peak Power EIRP 14 dBi Integral Antenna (dBm) |
|------------------------|---------------------------------|---------------------|------------------|---|
| 2,405 | 2.581 | +14.38 | +16.72 | +30.72 |
| 2,445 | 2.549 | +14.19 | +16.37 | +30.37 |
| 2,480 | 2.565 | +13.95 | +15.95 | +29.95 |

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2,405 MHz 802.15.4 Peak Power (dBm)



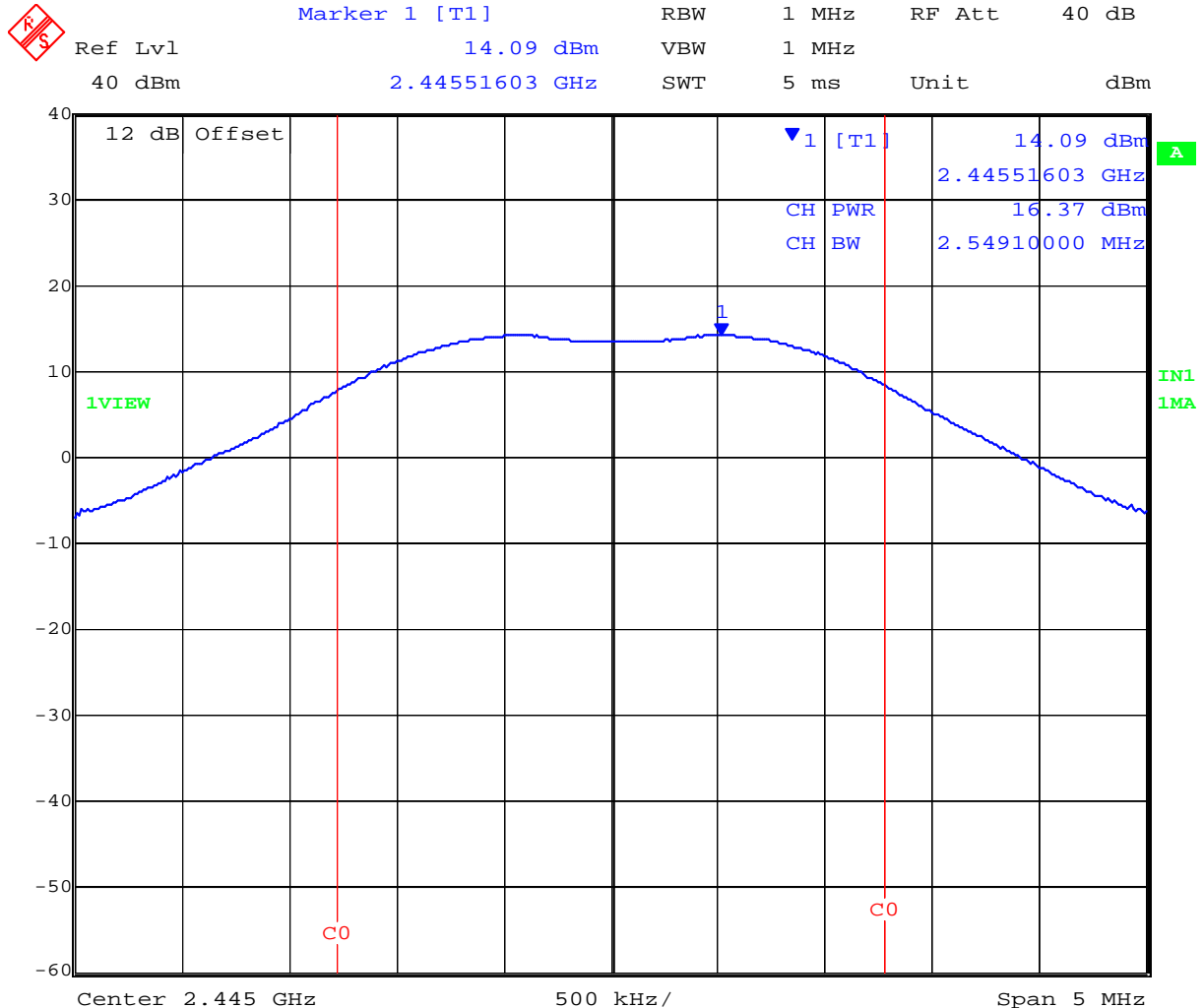
Date: 23.SEP.2009 10:54:03

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2,445 MHz 802.15.4 Peak Power (dBm)



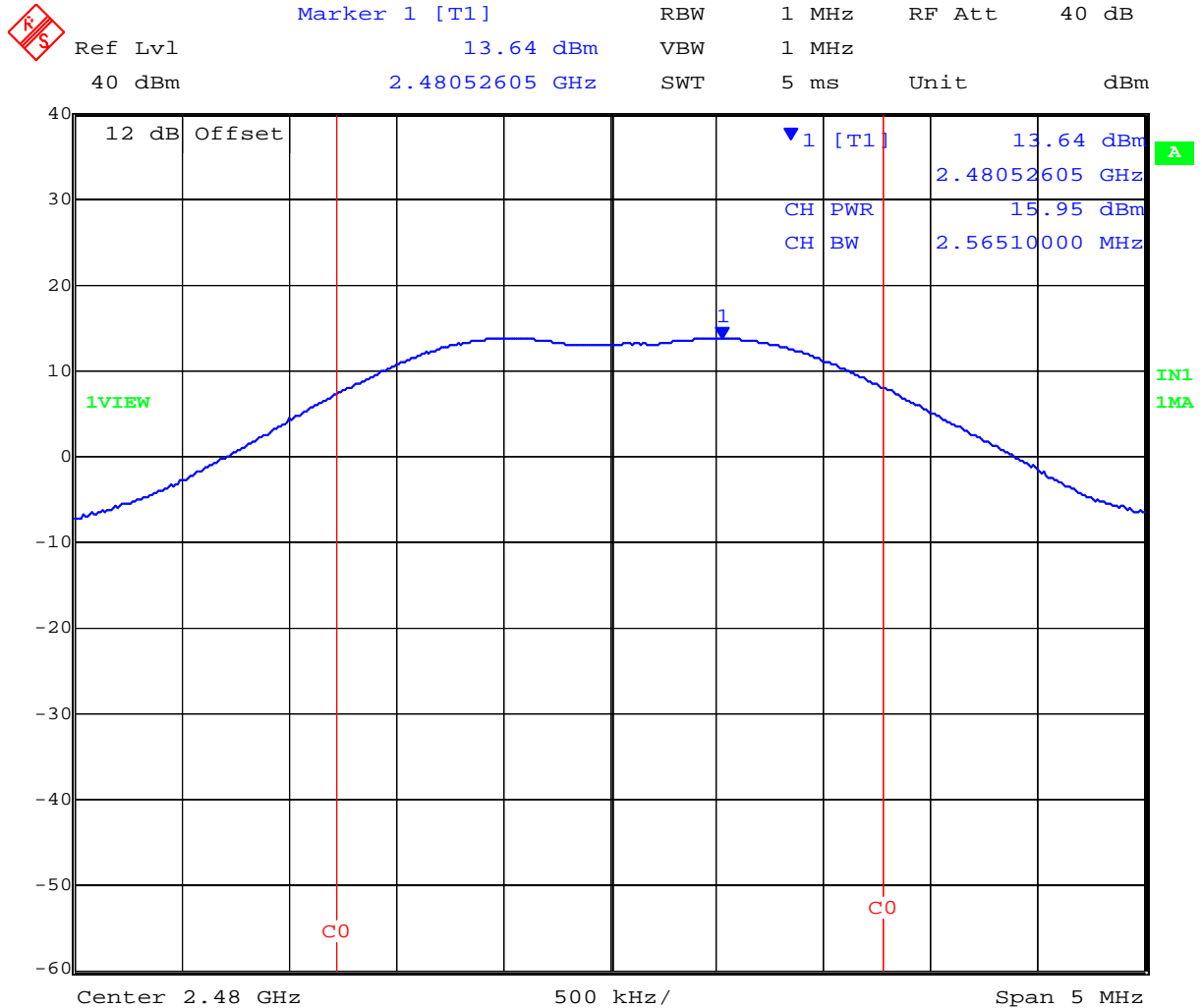
Date: 23.SEP.2009 10:52:51

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2,480 MHz 802.15.4 Peak Power (dBm)



Date: 23.SEP.2009 10:51:34

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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.



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Laboratory Measurement Uncertainty for Power Measurements

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

Traceability

| Method | Test Equipment Used |
|---|--|
| Measurements were made per work instruction WI-01 'Measuring RF Output Power' | 0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117 |

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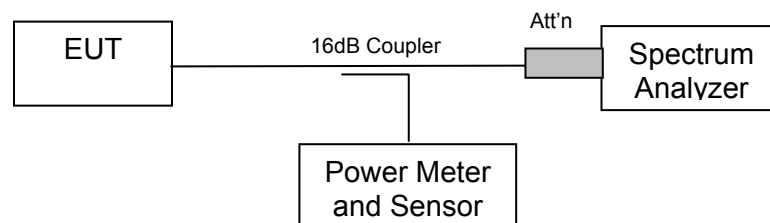
5.1.3. Peak Power Spectral Density

FCC, Part 15 Subpart C §15.247(e)
Industry Canada RSS-210 §A8.2

Test Procedure

The transmitter output was connected to a spectrum analyzer and the maximum level in a 3 kHz bandwidth was measured. A peak value was found over the full emission bandwidth and the frequency span reduced to obtain enhanced resolution. Sweep time \geq span / 3 kHz with video averaging turned off. The Peak Power Spectral Density is the highest level found across the emission in a 3 kHz resolution bandwidth.

Test Measurement Set up



Measurement set up for Peak Power Spectral Density

Measurement Results for Peak Power Spectral Density

Ambient conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

Radio Parameters

Duty Cycle: 100%

Output: Modulated Carrier



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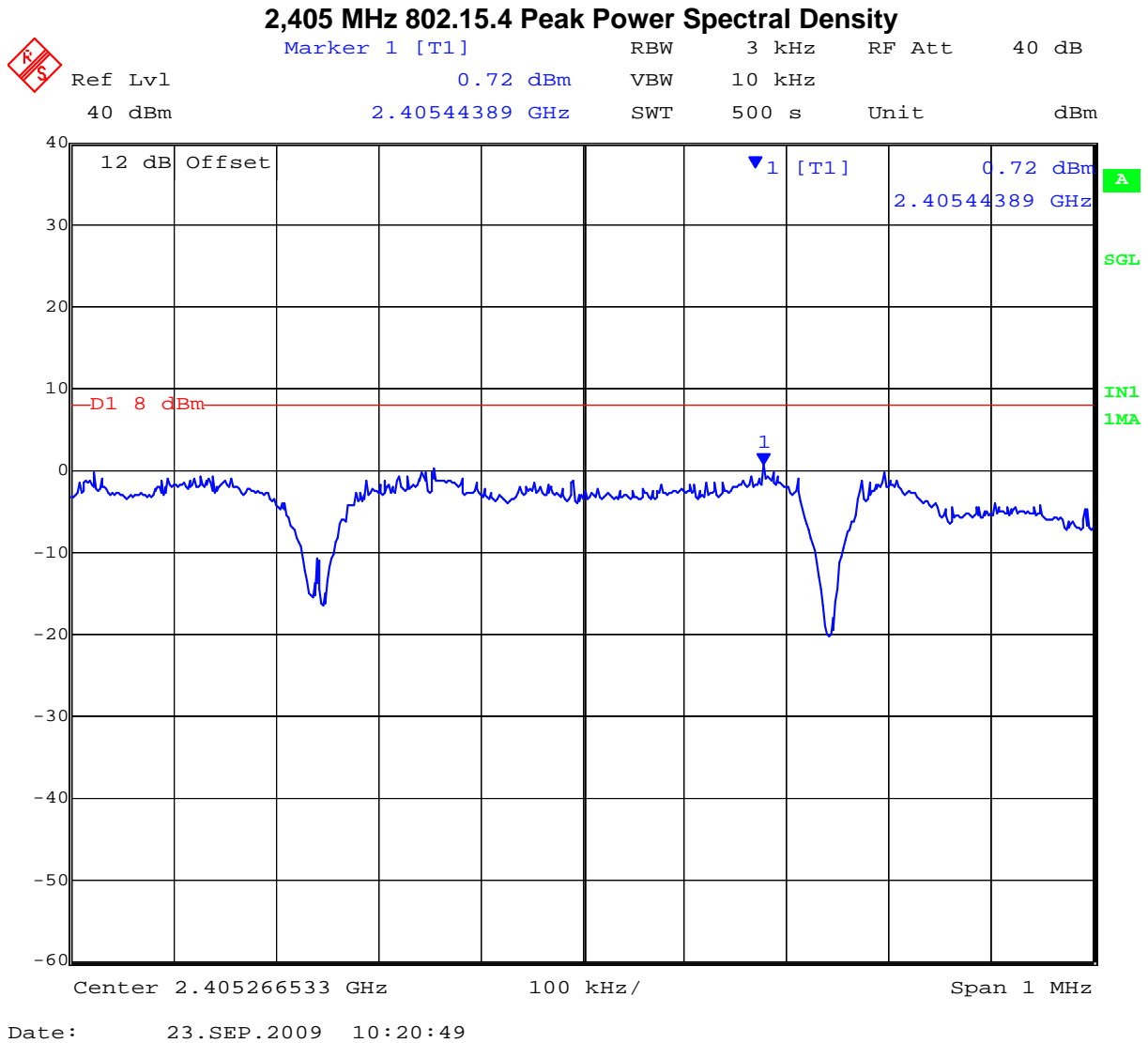
TABLE OF RESULTS

| Center Frequency (MHz) | Peak Frequency (MHz) | PPSD (dBm) | Limit (dBm) | Margin (dBm) |
|---------------------------|-------------------------|---------------|----------------|-----------------|
| 2,405 | 2405.44389 | +0.72 | +8.00 | -7.28 |
| 2,445 | 2445.44188 | +0.20 | +8.00 | -7.80 |
| 2,480 | 2480.44188 | -0.75 | +8.00 | -8.75 |

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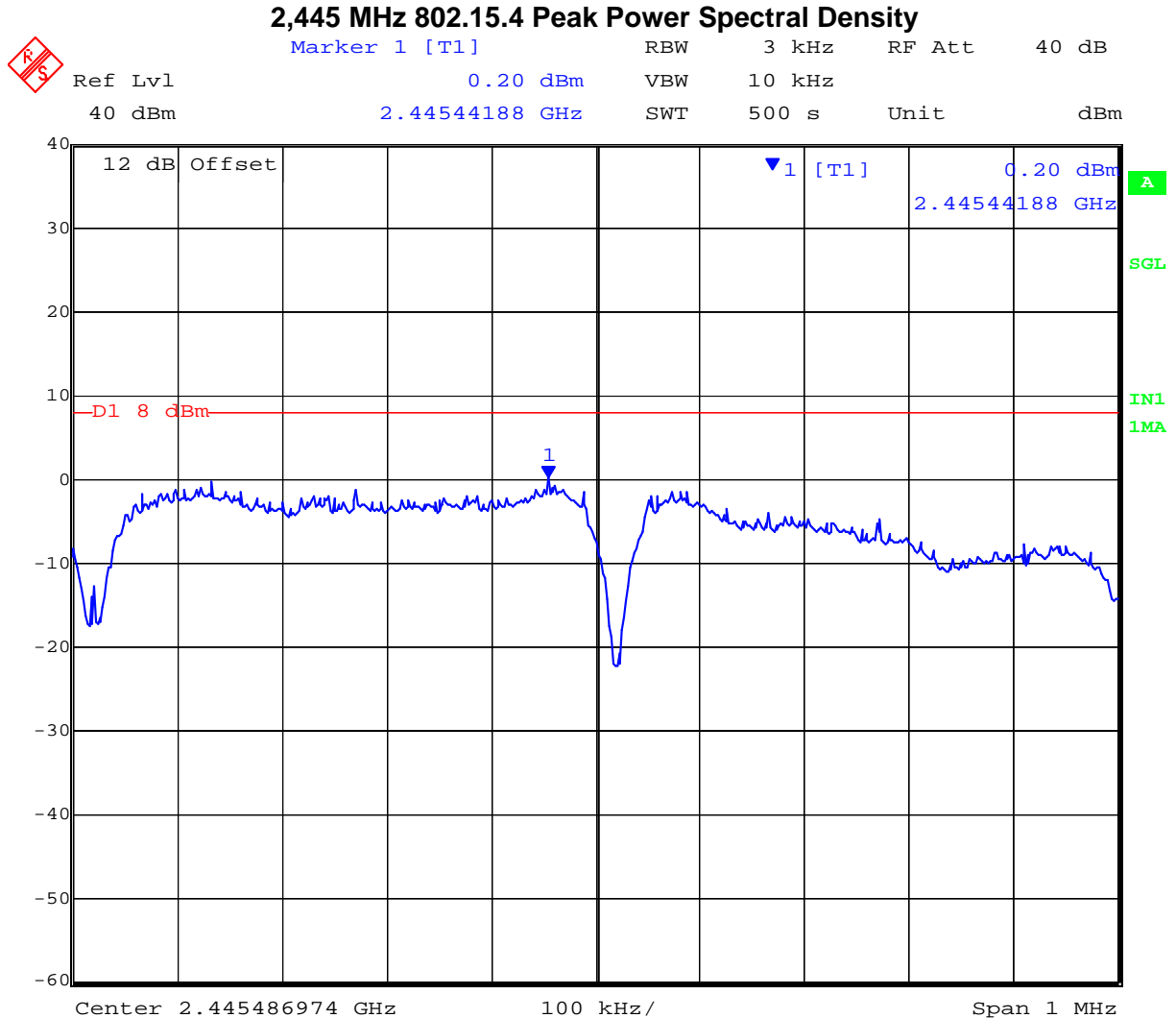
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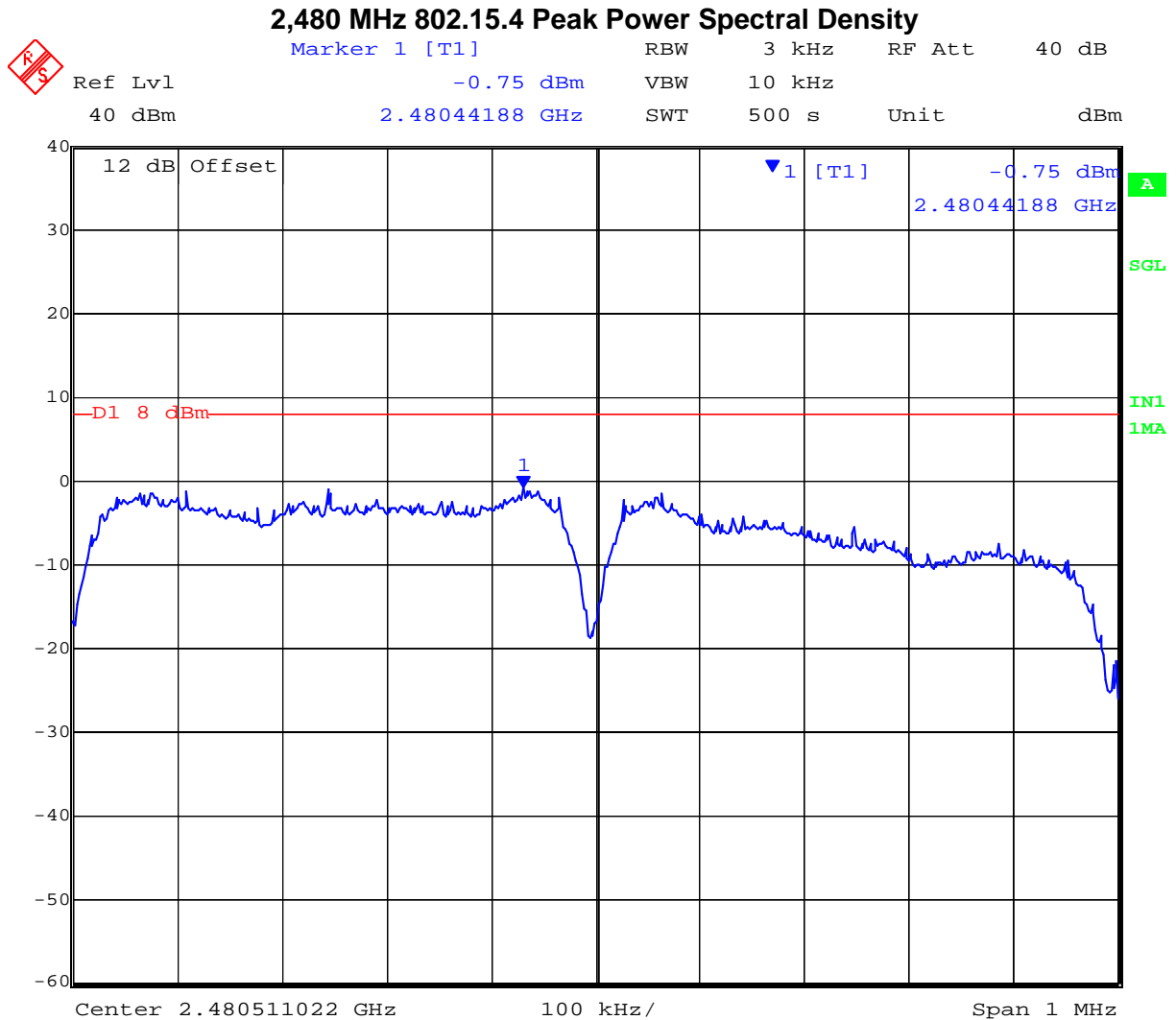


Date: 23.SEP.2009 10:31:16

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Date: 23.SEP.2009 10:47:33

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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.

Laboratory Measurement Uncertainty for Spectral Density

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

Traceability

| Method | Test Equipment Used |
|---|--|
| Measurements were made per work instruction WI-01 'Measuring RF Output Power' | 0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117 |

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5.1.4. Maximum Permissible Exposure

FCC, Part 15 Subpart C §15.247(i)
Industry Canada RSS-Gen §5.5

Calculations for Maximum Permissible Exposure Levels

Power Density = P_d (mW/cm²) = $EIRP / (4\pi d^2)$

$EIRP = P * G$

P = Peak output power (mW)

G = Antenna numeric gain (numeric)

d = Separation distance (cm)

Numeric Gain = $10^{(G \text{ (dBi)}/10)}$

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

| Freq. Band (GHz) | 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) |
|------------------|--------------------|------------------------|-------------------------|------------------------|--|----------------------------------|
| 2.4 | 14.0 | 25.12 | +16.72 | 46.99 | 9.7 | 20.0 |

***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 applicable requirements of RSS-102 shall be met.

Laboratory Measurement Uncertainty for Power Measurements

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

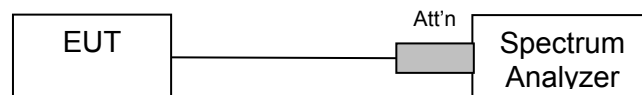
5.1.5. Conducted Spurious Emissions

FCC, Part 15 Subpart C §15.247(d); 15.205; 15.209
Industry Canada RSS-210 §A8.5, §2.2
Industry Canada RSS-Gen 4.7

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.

Test Measurement Set up



Band-edge measurement test configuration

Measurement Results of Conducted Spurious Emissions

Ambient conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

Radio Parameters

Duty Cycle: 100%

Output: Modulated Carrier



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Conducted Band-Edge Results

Measurements were performed 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 band-edge measurements provided below are drawn on each plot.

TABLE OF RESULTS

| Center Frequency (MHz) | Band edge Frequency (MHz) | Limit (20 dB below peak of fundamental) | Amplitude @ Band edge (dBm) | Margin (dB) |
|------------------------|---------------------------|---|-----------------------------|-------------|
| 2,405 | 2,400.0 | -8.69 | -29.22 | -20.53 |
| 2,480 | 2,483.5 | -9.70 | -29.65 | -19.95 |

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Conducted Spurious Emissions at the 2,400 MHz Band Edge



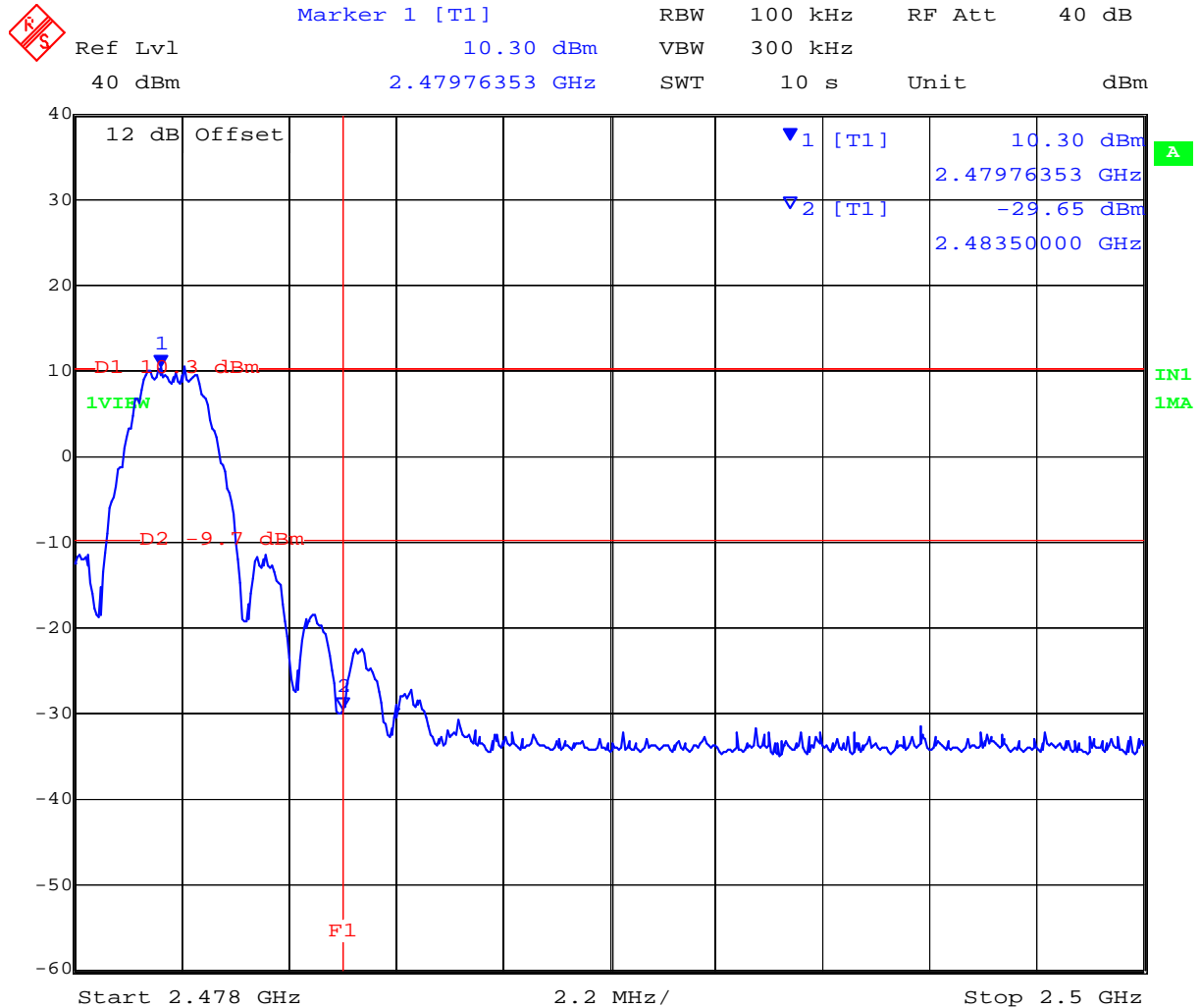
Date: 23.SEP.2009 11:00:20

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Conducted Spurious Emissions at the 2,483.5 MHz Band Edge



Date: 23.SEP.2009 11:03:59

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Spurious Emissions (30 - 26,000 MHz)

TABLE OF RESULTS

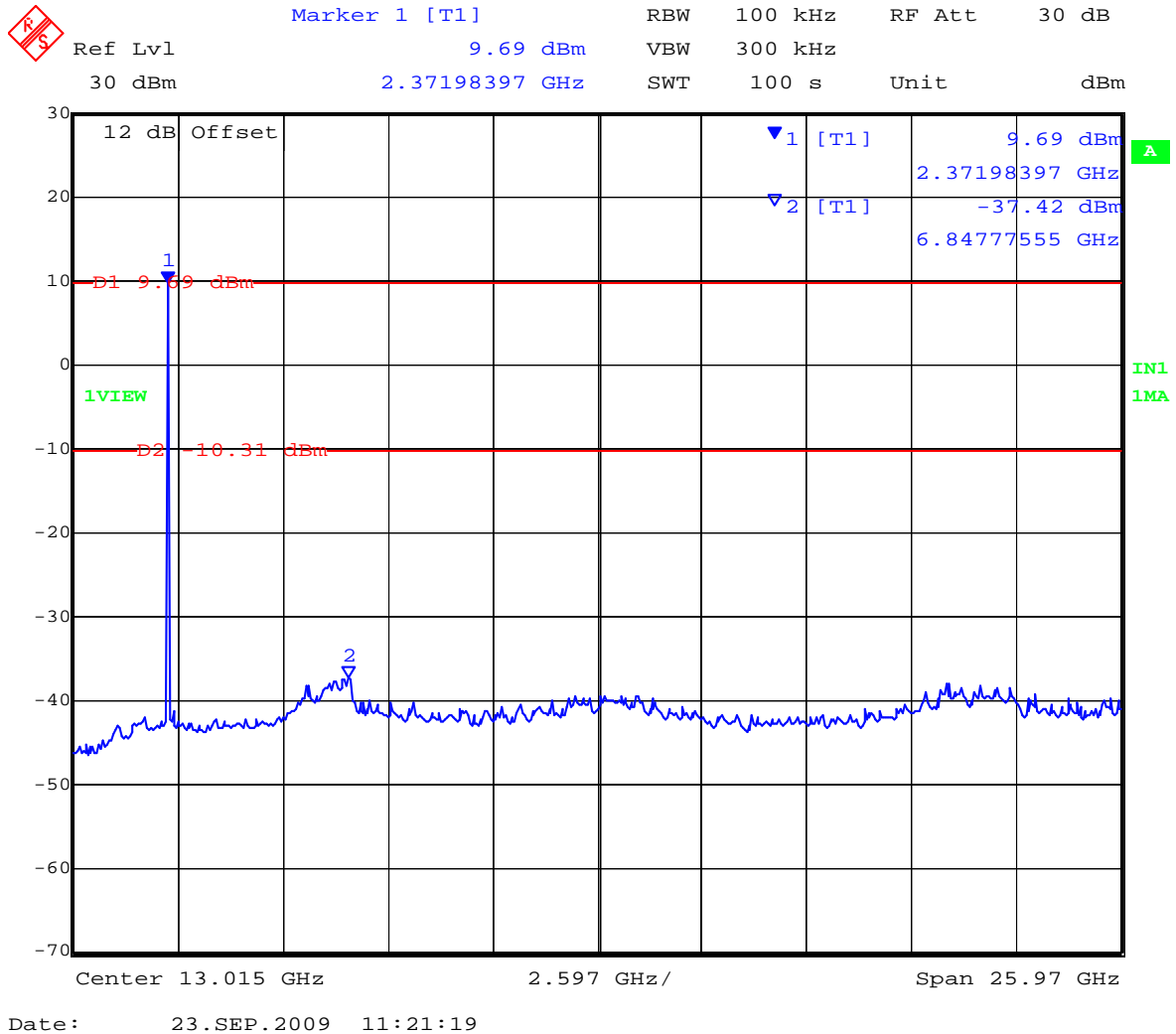
| Channel Centre Frequency (MHz) | Start Frequency (MHz) | Stop Frequency (MHz) | Maximum Emission Observed (dBm) | Limit (dBm) | Margin (dB) |
|---|-----------------------------|----------------------------|--|----------------|----------------|
| 2,405 | 30 | 26,000 | -37.42 | -10.31 | -27.11 |
| 2,445 | | | -37.32 | -9.08 | -28.24 |
| 2,480 | | | -15.45 | -10.34 | -5.11 |

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2,405 MHz Conducted Spurious Emissions 30 to 26,000 MHz

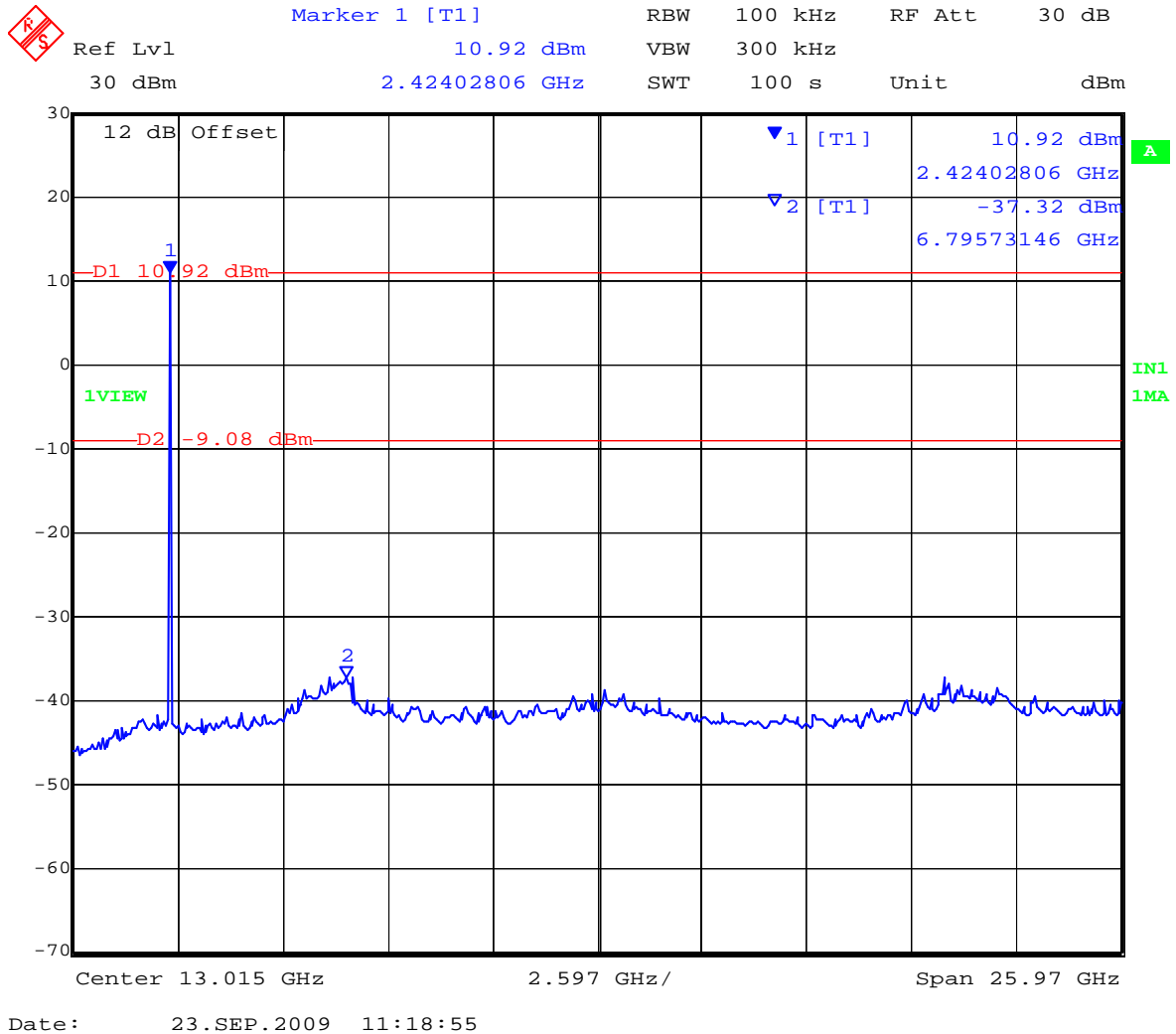


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2,445 MHz Conducted Spurious Emissions 30 to 26,000 MHz

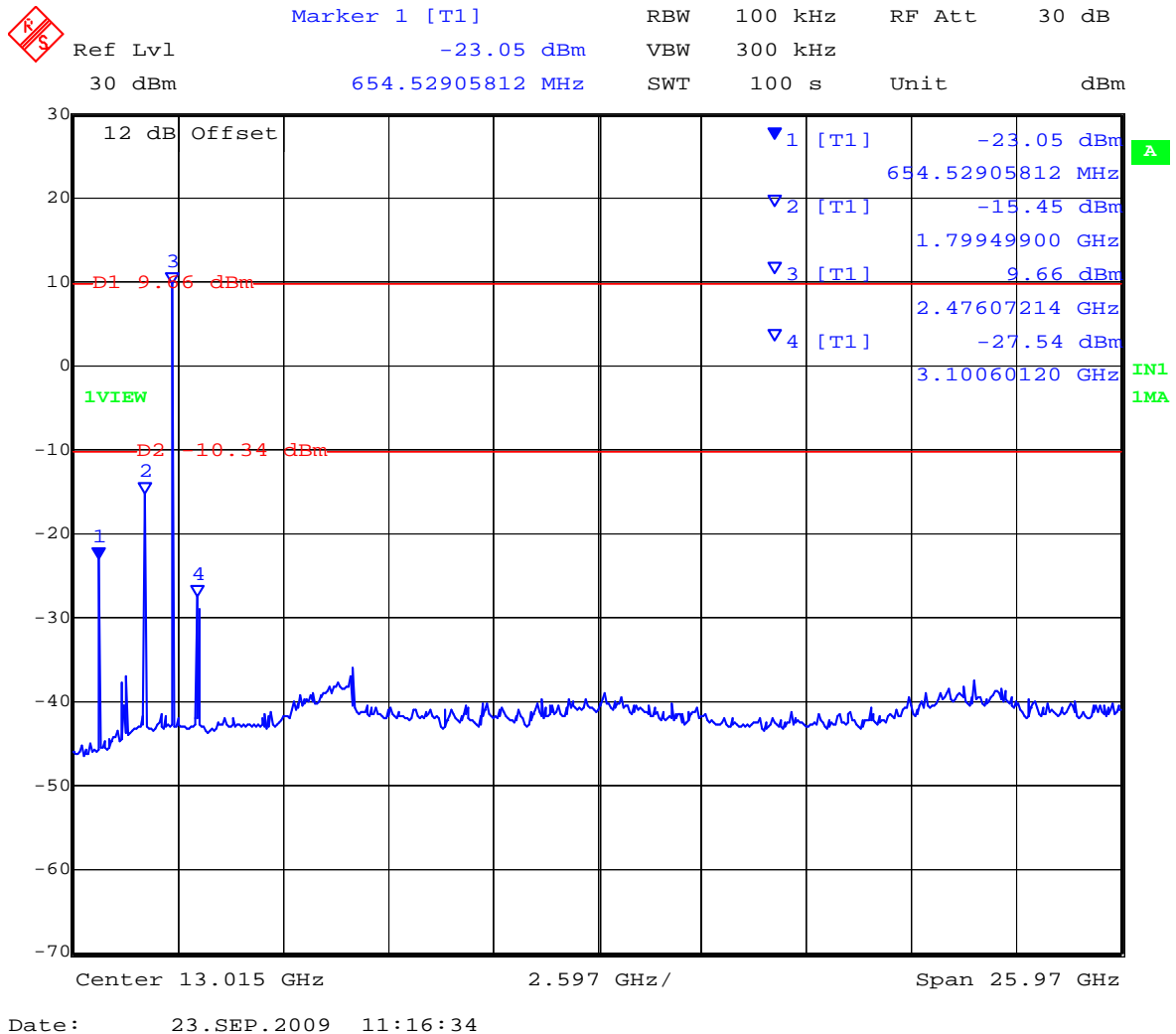


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2,480 MHz Conducted Spurious Emissions 30 to 26,000 MHz



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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 |

§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.

§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 5th harmonic of the highest frequency generated without exceeding 40 GHz.

Laboratory Measurement Uncertainty for Conducted Spurious Emissions

| | |
|-------------------------|---------------|
| Measurement uncertainty | ± 2.37 dB |
|-------------------------|---------------|

Traceability

| Method | Test Equipment Used |
|---|---|
| Measurements were made per work instruction WI-05 'Measurement of Spurious Emissions' | 0088, 0158, 0193, 0252, 0313, 0314, 0070, 0116, 0117. |

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5.1.6. Radiated Emissions

5.1.6.1. Transmitter Radiated Spurious Emissions (above 1 GHz)

FCC, Part 15 Subpart C §15.247(d) 15.205; 15.209

Industry Canada RSS-210 §A8.5, §2.2, §2.6

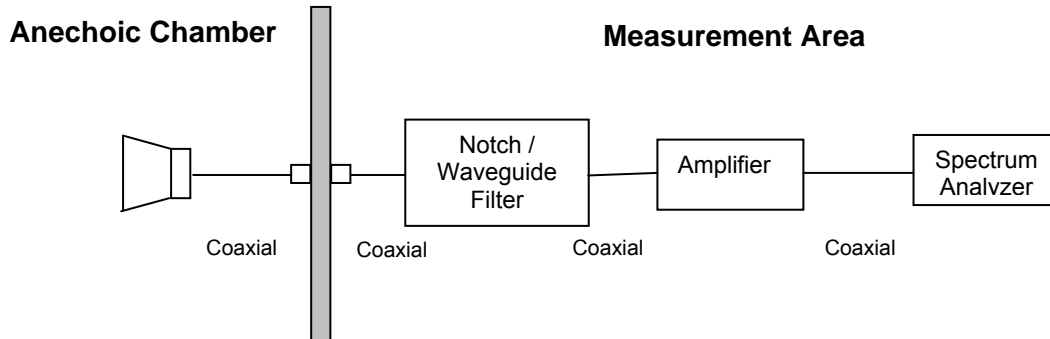
Industry Canada RSS-Gen §4.7

Test Procedure

Radiated emissions above 1 GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarities. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. Depending on the frequency band spanned a notch filter and waveguide filter was used to remove the fundamental frequency. The highest emissions relative to the limit are listed for each frequency spanned.

All measurements on any frequency or frequencies over 1 MHz are based on the use of measurement instrumentation employing an average detector function. All measurements above 1 GHz were performed using a minimum resolution bandwidth of 1 MHz.

Test Measurement Set up



Measurement set up for Radiated Emission Test

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.

$$FS = R + AF + CORR - FO$$

where: 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



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For example:

Given receiver input reading of 51.5 dB μ V; 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:

$$FS = 51.5 + 8.5 + 1.3 - 26.0 + 1 = 36.3 \text{ dB}\mu\text{V/m}$$

Conversion between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as:

$$\text{Level (dB}\mu\text{V/m)} = 20 * \text{Log (level (\mu V/m))}$$

$$40 \text{ dB}\mu\text{V/m} = 100 \mu\text{V/m}$$

$$48 \text{ dB}\mu\text{V/m} = 250 \mu\text{V/m}$$

Ambient conditions.

Temperature: 17 to 23°C

Relative humidity: 31 to 57 %

Pressure: 999 to 1012 mbar

Radio Parameters

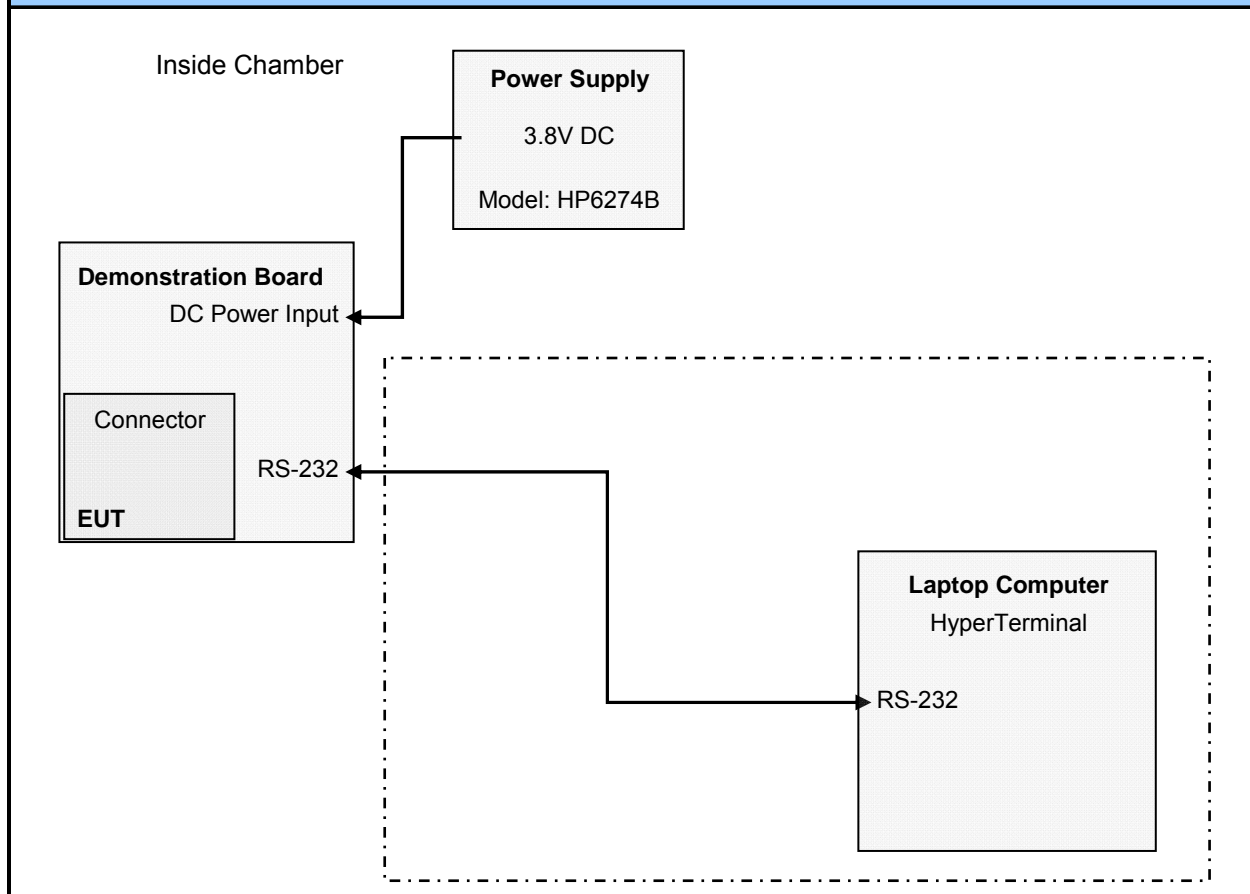
Duty Cycle: 100%

Output: Modulated Carrier

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Radiated Spurious Emissions above 1 GHz

EUT Setup Diagram



Test Setup Description

Both Vertical and Horizontal EUT positions were investigated during preliminary testing. EUT was setup in the worst case position (Verticle) for final tests.

EUT was connected to demonstration board to provide DC power and control. HP 6274B DC Power Supply was connected during test, and placed on the ground plane next to EUT.

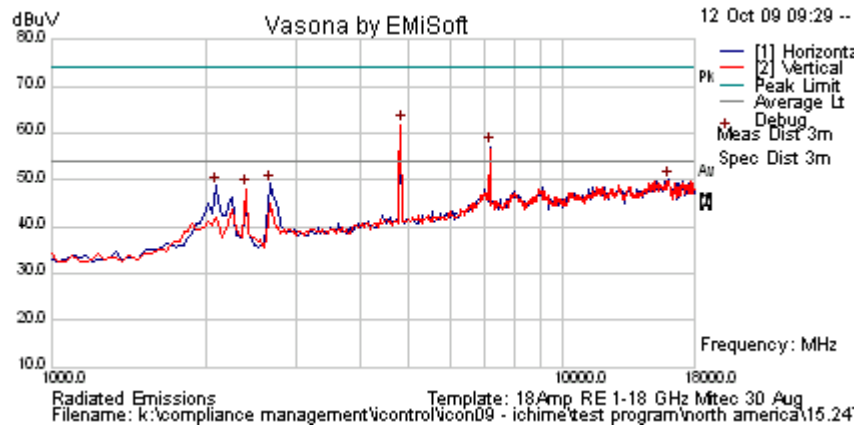
Hyperterminal was used for setup and control of the EUT (i.e.changing the transmit and receive frequencies, changing output power, change Tx/Rx modes) The computer was connected via RS-232 control. The RS-232 cable and computer was removed from chamber before prescans or final measurements were performed.



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Integral Antenna Test Data

| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2405 MHz (CH11) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 82 in test utility (9.86 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| Test Notes 2 | Powered reduced on Channel 11 to meet band edge requirements | | |



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 |
|---------------|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 4808.959 | 56.9 | 4.5 | -8.7 | 52.6 | Average | V | 121 | 199 | 54 | -1.4 | Pass | RB |
| 4808.959 | 64.0 | 4.5 | -8.7 | 59.7 | Peak | V | 121 | 199 | 74 | -14.3 | Pass | RB |
| 7216.492 | 51.6 | 5.4 | -2.4 | 54.7 | Peak | V | 98 | 223 | 74 | -19.4 | Pass | RB |
| 7216.492 | 40.6 | 5.4 | -2.4 | 43.7 | Average | V | 98 | 223 | 54 | -10.3 | Pass | RB |
| 2380.100 | -- | -- | -- | 62.8 | Peak | H | 100 | 246 | 74 | -11.2 | Pass | BE |
| 2260.922 | -- | -- | -- | 52.7 | Average | H | 100 | 246 | 54 | -1.3 | Pass | BE |

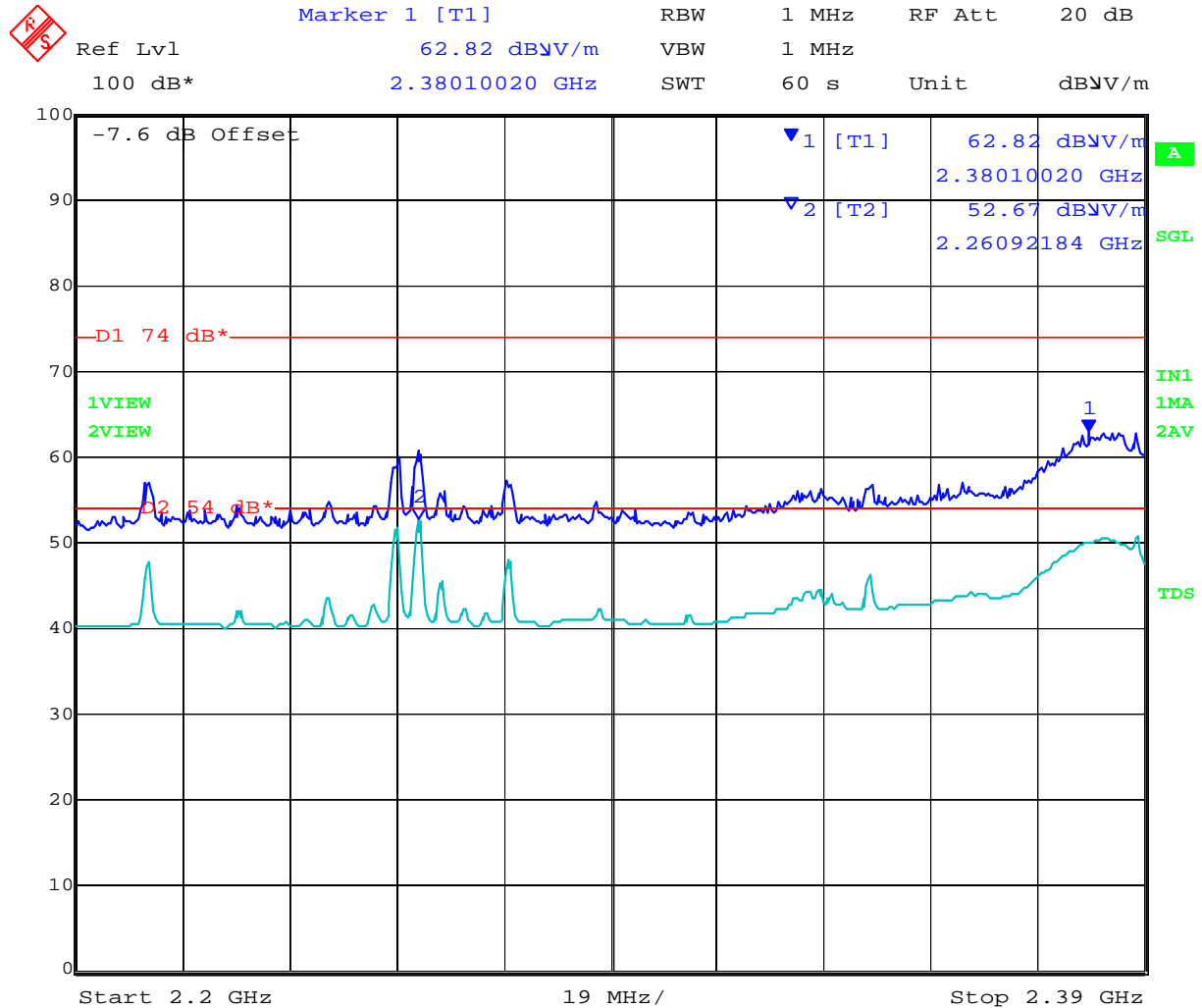
Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq.
 BE = Emission in Restricted Band Nearest Transmission Band Edge;

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Band-Edge 2405 MHz



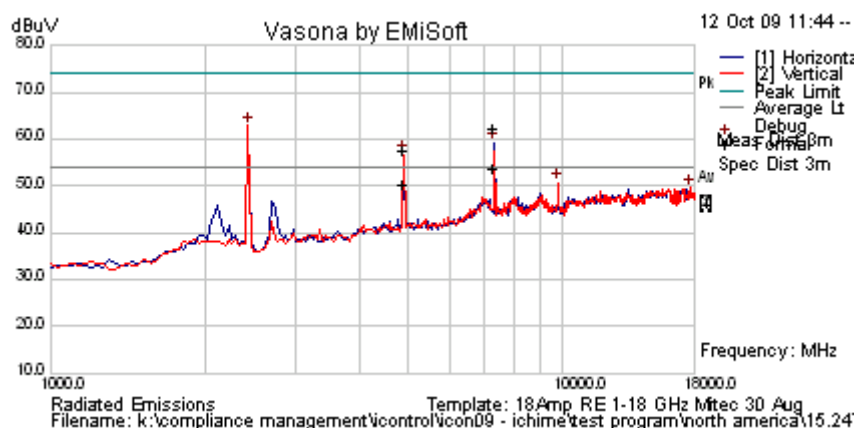
Date: 14.OCT.2009 13:17:04

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| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2445 MHz (CH19) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 90 in test utility (13.67 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| Test Notes 2 | | | |



Formally measured emission peaks

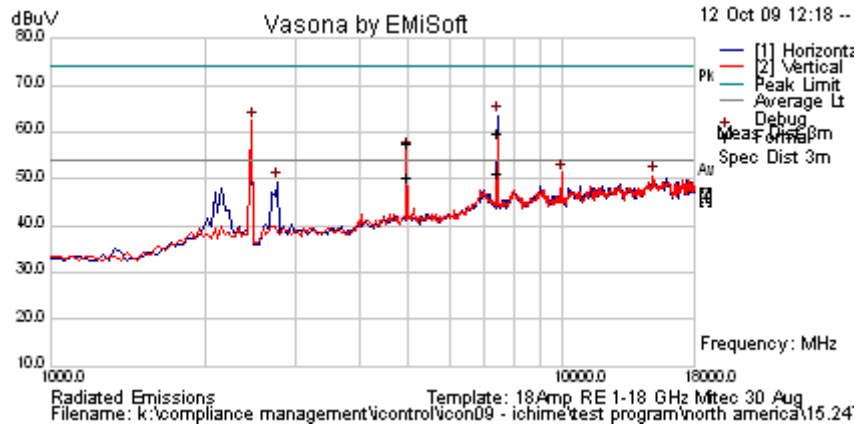
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|---|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 4890.976 | 61.85 | 4.53 | -8.73 | 57.65 | Peak | V | 98 | 186 | 74 | -16.35 | Pass | |
| 4890.976 | 54.51 | 4.53 | -8.73 | 50.3 | Average | V | 98 | 186 | 54 | -3.7 | Pass | |
| 7336.441 | 59.6 | 5.5 | -3.0 | 62.1 | Peak | V | 113 | 242 | 74 | -11.9 | Pass | |
| 7336.441 | 51.3 | 5.5 | -3.0 | 53.8 | Average | V | 114 | 242 | 54 | -0.3 | Pass | |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq. | | | | | | | | | | | | |
| BE = Emission in Restricted Band Nearest Transmission Band Edge; | | | | | | | | | | | | |

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| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2475 MHz (CH25) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 70 in test utility (-1.77 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| Test Notes 2 | Power reduced on Channel 25 to meet Band Edge requirements | | |



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 |
|---------------|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 4958.964 | 54.58 | 4.58 | -8.74 | 50.43 | Average Max | V | 104 | 204 | 54 | -3.57 | Pass | RB |
| 4958.964 | 61.58 | 4.58 | -8.74 | 57.43 | Peak Max | V | 104 | 204 | 74 | -16.57 | Pass | RB |
| 7441.445 | 49.3 | 5.5 | -3.6 | 51.2 | Average Max | V | 130 | 228 | 54 | -2.8 | Pass | RB |
| 7441.445 | 57.7 | 5.5 | -3.6 | 59.6 | Peak Max | V | 130 | 228 | 74 | -14.4 | Pass | RB |
| 9918.006 | 46.87 | 6.43 | -2 | 51.3 | Peak | V | 100 | 0 | 74 | -22.7 | Pass | NRB |
| 2491.535 | -- | -- | -- | 61.6 | Peak | V | 100 | 311 | 74 | -12.4 | Pass | BE |
| 2491.502 | -- | -- | -- | 49.6 | Average | V | 100 | 311 | 54 | -4.4 | Pass | BE |

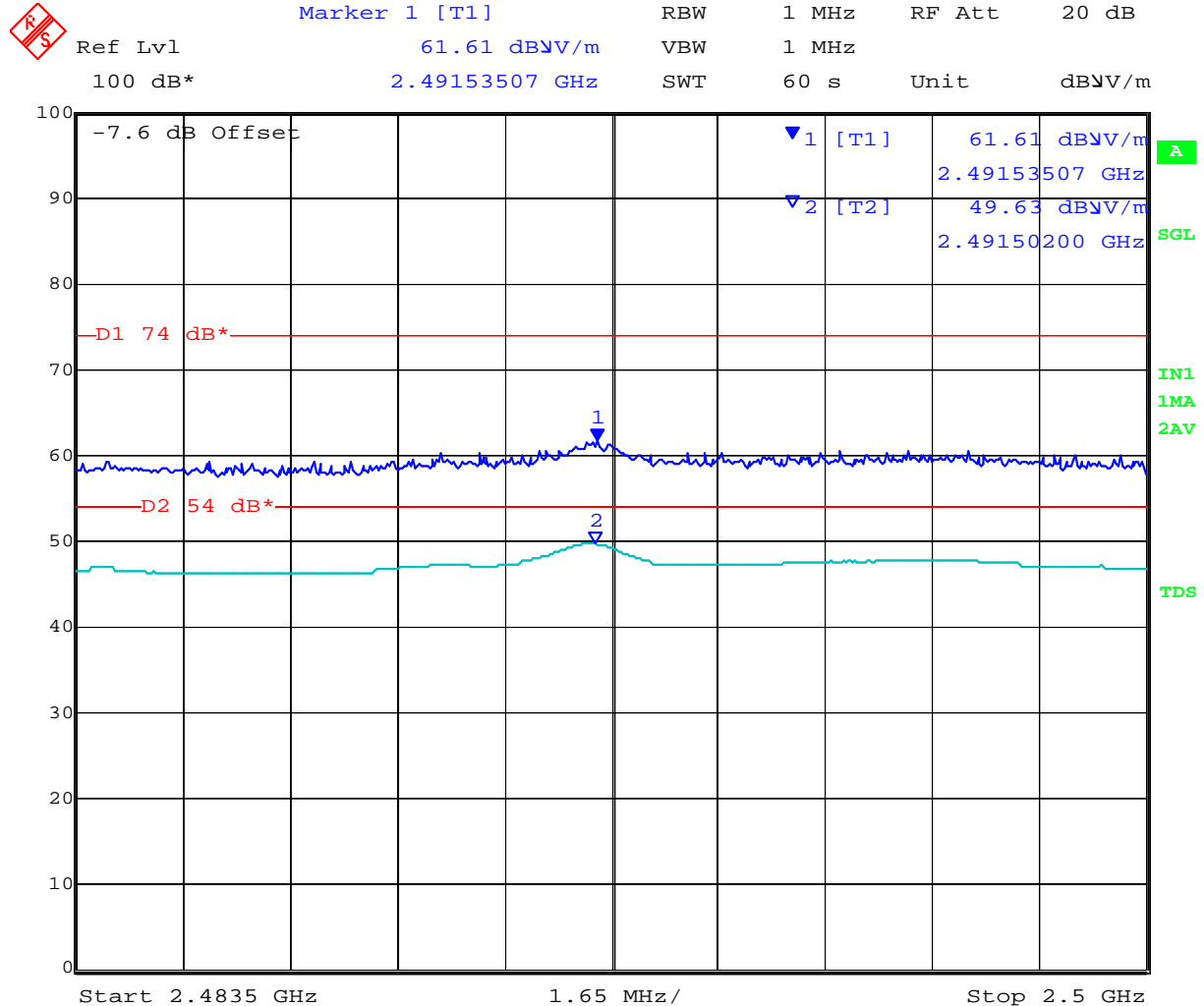
Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq.
 BE = Emission in Restricted Band Nearest Transmission Band Edge;

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Band-Edge 2475 MHz

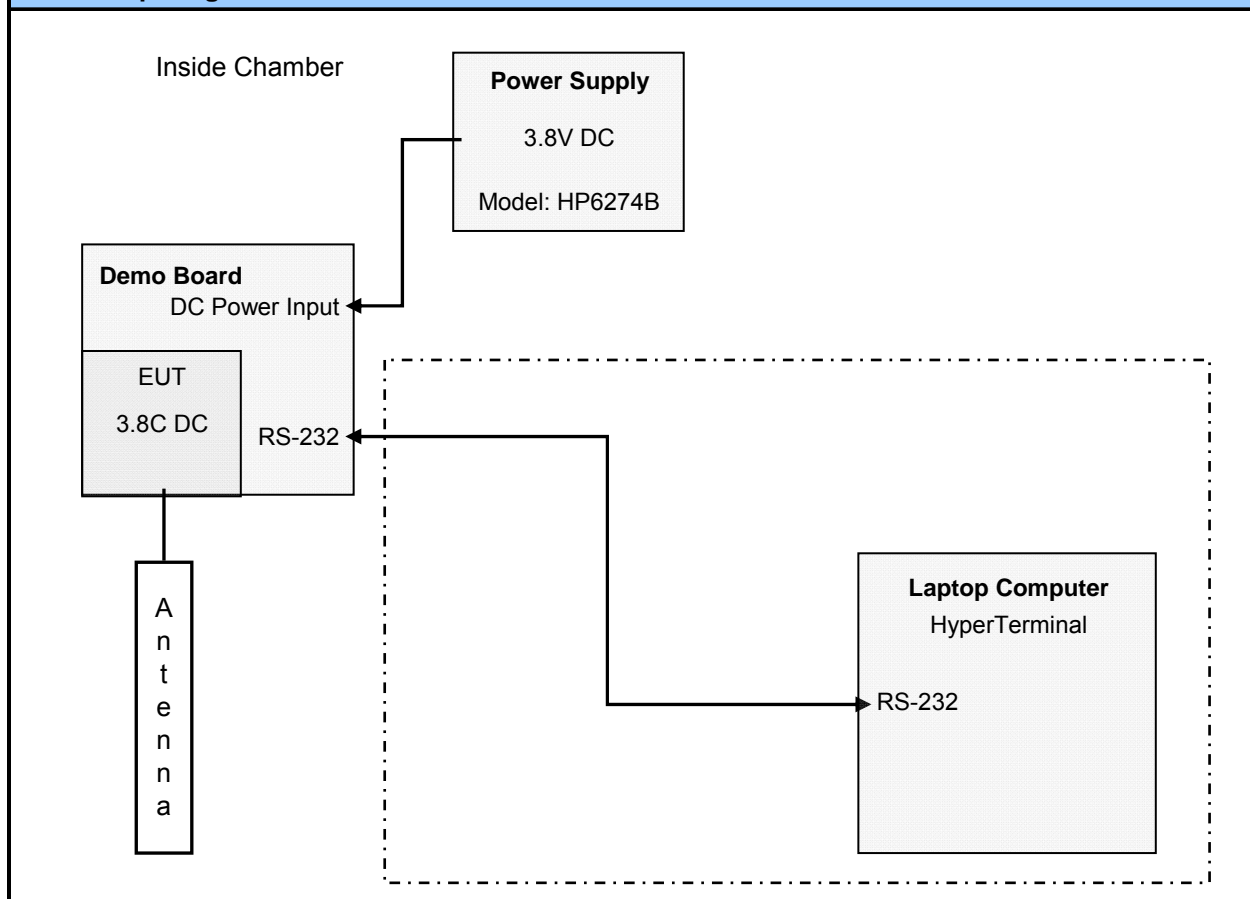


Date: 15.OCT.2009 15:11:41

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External Antenna Test Data

EUT Setup Diagram



Test Setup Description

Both Vertical and Horizontal EUT positions were investigated during preliminary testing. EUT was setup in the worst case position (Vertical) for final tests.

EUT was connected to demonstration board to provide DC power and control. HP 6274B DC Power Supply was connected during test, and placed on the ground plane next to EUT.

Antenna was connected to EUT via supplied cable.

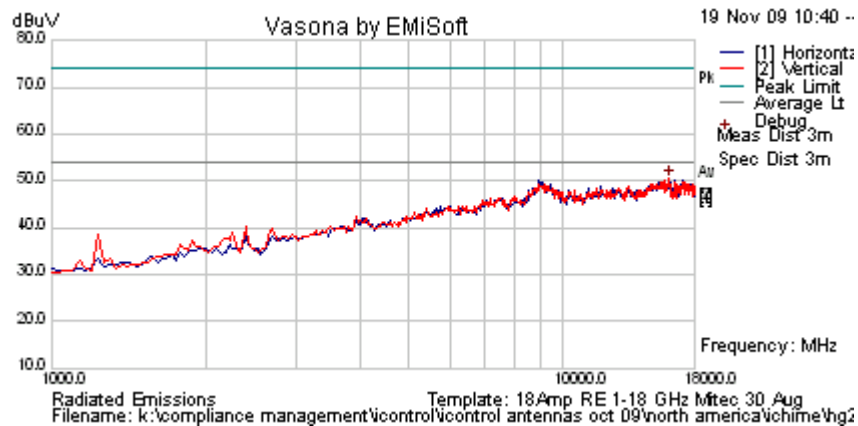
Hyperterminal was used for setup and control of the EUT (i.e. changing the transmit and receive frequencies, changing output power, change Tx/Rx modes) The computer was connected via RS-232 control. The RS-232 cable and computer was removed from chamber before prescans or final measurements were performed.



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External Antenna HG2408U

| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2405 MHz (CH11) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 70 in test utility (-1.77 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2408U | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



Formally measured emission peaks

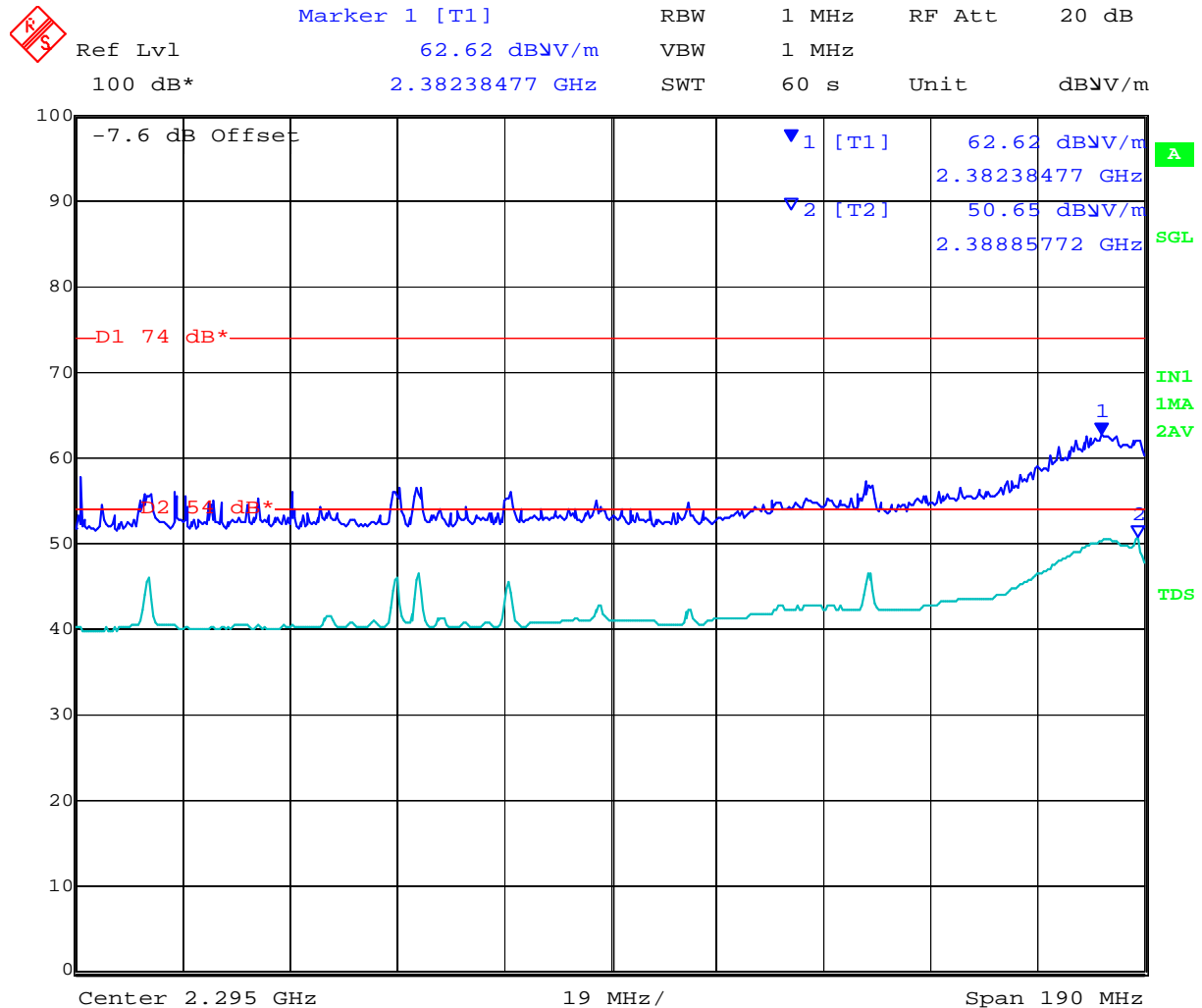
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|--|----------|------------|-------|------------|------------------|------|--------|---------|------------|-----------|------------|----------|
| 2382.385 | -- | -- | -- | 62.6 | Peak | Vert | 109 | 179 | 74 | -11.4 | Pass | BE |
| 2388.858 | -- | -- | -- | 50.7 | Average | Vert | 109 | 179 | 54 | -3.4 | Pass | BE |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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Band-Edge 2405 MHz



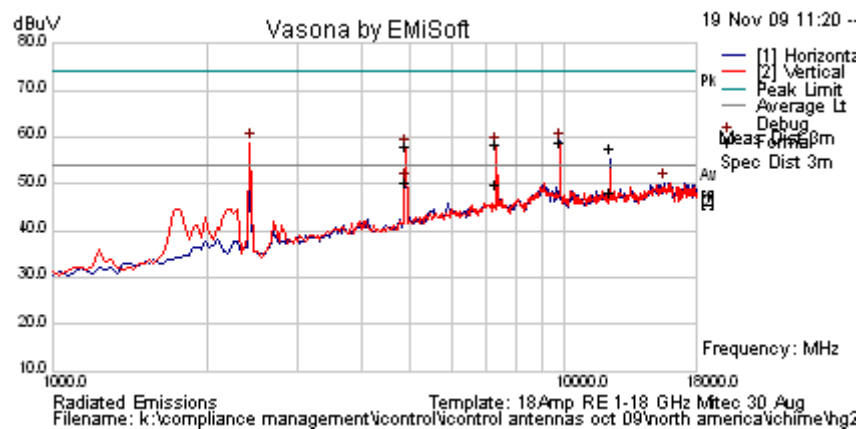
Date: 19.NOV.2009 10:21:25

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2445 MHz (CH19) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 90 in test utility (13.65 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2408U | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



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 |
|---------------|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 4890.962 | 54.25 | 4.53 | -8.6 | 50.18 | Average Max | H | 98 | 164 | 54 | -3.82 | Pass | RB |
| 4890.962 | 62.26 | 4.53 | -8.6 | 58.19 | Peak Max | H | 98 | 164 | 74 | -15.81 | Pass | RB |
| 7336.483 | 47.1 | 5.5 | -2.5 | 50.1 | Average Max | V | 100 | 158 | 54 | -4.0 | Pass | RB |
| 7336.483 | 55.6 | 5.5 | -2.5 | 58.6 | Peak Max | V | 100 | 158 | 74 | -15.4 | Pass | RB |
| 9781.924 | 52.8 | 6.4 | -0.2 | 59.0 | Peak (scan) | H | -- | -- | -- | -- | Pass | NRB |
| 12227.495 | 52.2 | 7.0 | -1.6 | 57.7 | Peak Max | H | 98 | 206 | 74 | -16.3 | Pass | RB |
| 12227.495 | 42.6 | 7.0 | -1.6 | 48.1 | Average Max | H | 98 | 206 | 54 | -5.9 | Pass | RB |

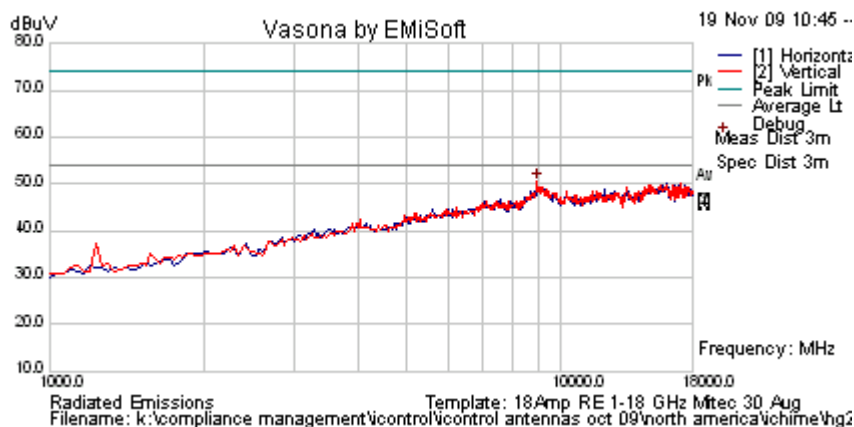
Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results
 BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq.

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2480 MHz (CH26) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 65 in test utility (-29.2 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2408U | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



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 |
|---------------|----------|------------|-------|------------|------------------|------|--------|---------|------------|-----------|------------|----------|
| 2483.665 | -- | -- | -- | 62.61 | Peak | Vert | 108 | 179 | 74 | -11.39 | Pass | BE |
| 2483.930 | -- | -- | -- | 52.14 | Average | Vert | 108 | 179 | 54 | -1.86 | Pass | BE |

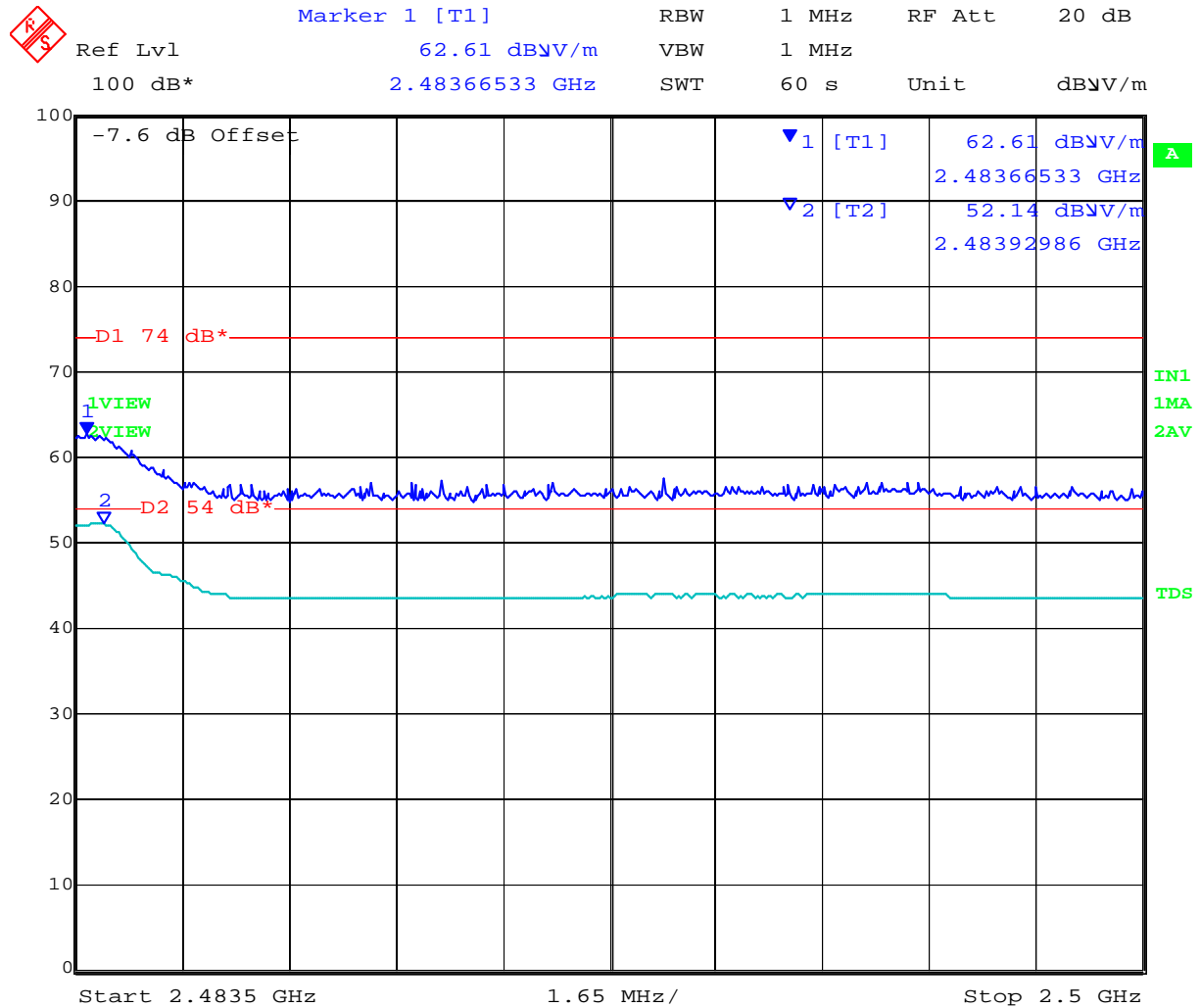
Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results
 BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq.

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Band-Edge 2480 MHz



Date: 19.NOV.2009 10:27:50

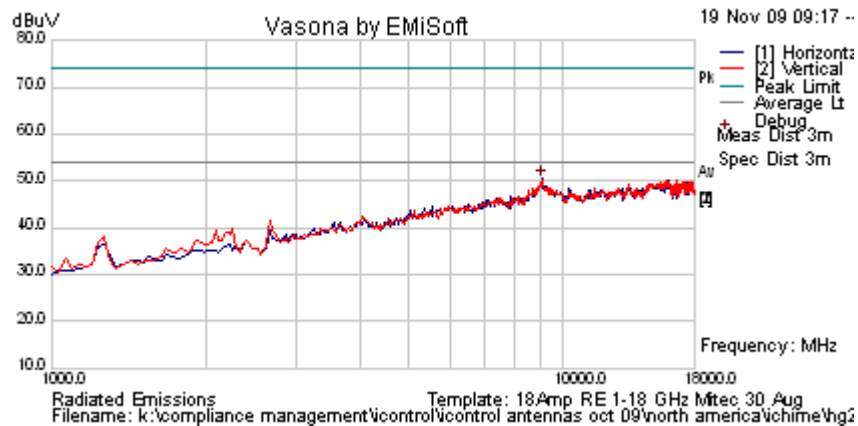
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External Antenna HG2414P

| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2405 MHz (CH11) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 18.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 33 |
| Power Setting | 67 in test utility (-8.61 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414P | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



Formally measured emission peaks

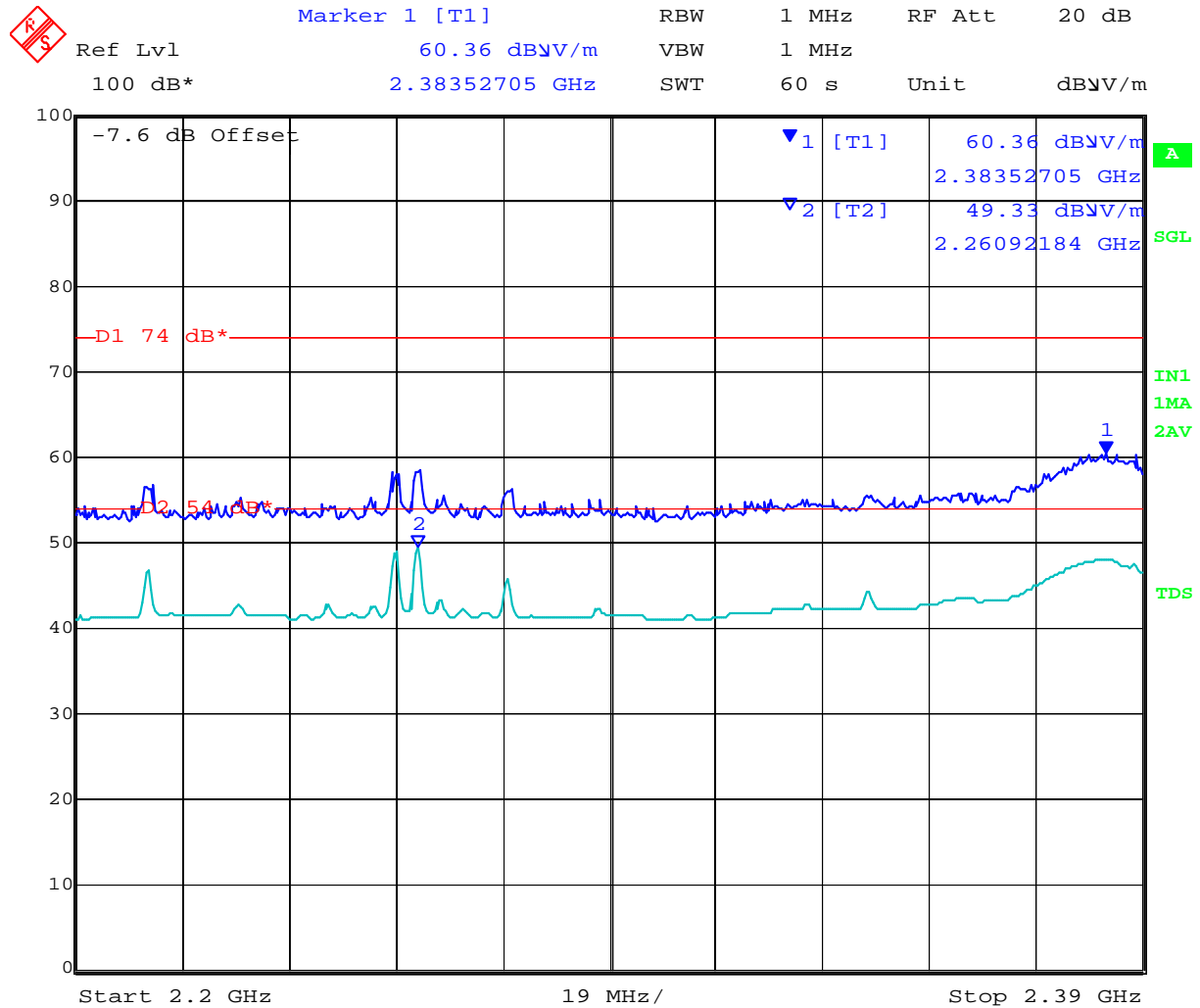
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|--|----------|------------|-------|------------|------------------|------|--------|---------|------------|-----------|------------|----------|
| 2383.527 | -- | -- | -- | 60.4 | Peak | Vert | 100 | 193 | 74 | -13.6 | Pass | BE |
| 2260.922 | -- | -- | -- | 49.3 | Average | Vert | 100 | 193 | 54 | -4.7 | Pass | BE |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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Band-Edge 2405 MHz



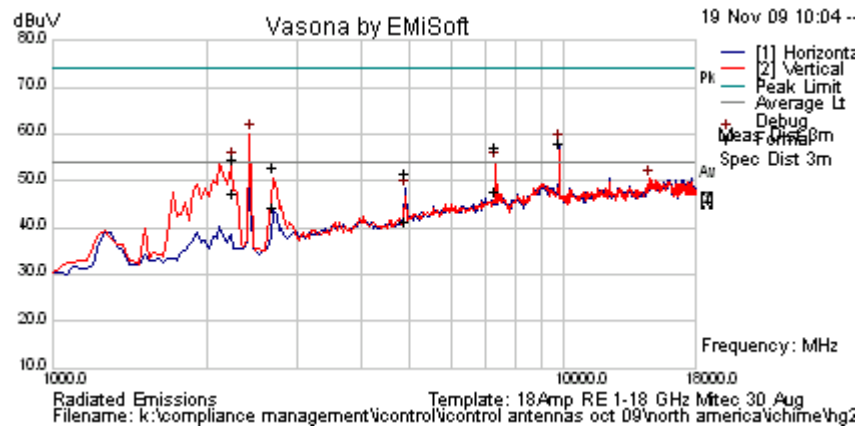
Date: 19.NOV.2009 08:52:23

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 18.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 33 |
| Power Setting | 90 in test utility (13.65 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414P | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



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 |
|---------------|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 2253.331 | 57.63 | 2.88 | -13 | 47.54 | Average Max | V | 98 | 187 | 54 | -6.46 | Pass | RB |
| 2253.331 | 64.52 | 2.88 | -13 | 54.43 | Peak Max | V | 98 | 187 | 74 | -19.57 | Pass | RB |
| 2701.477 | 53.3 | 3.2 | -12.3 | 44.1 | Average Max | V | 98 | 199 | 54 | -9.9 | Pass | RB |
| 2701.477 | 62.3 | 3.2 | -12.3 | 53.1 | Peak Max | V | 98 | 199 | 74 | -20.9 | Pass | RB |
| 4891.099 | 55.6 | 4.5 | -8.6 | 51.5 | Peak Max | H | 101 | 152 | 74 | -22.5 | Pass | RB |
| 4891.099 | 45.5 | 4.5 | -8.6 | 41.4 | Average Max | H | 101 | 152 | 54 | -12.6 | Pass | RB |
| 7336.495 | 44.9 | 5.5 | -2.5 | 47.9 | Average Max | V | 98 | 185 | 54 | -6.2 | Pass | RB |
| 7336.495 | 54.3 | 5.5 | -2.5 | 57.3 | Peak Max | V | 98 | 185 | 74 | -16.7 | Pass | RB |
| 9777.966 | 51.7 | 6.4 | -0.2 | 57.9 | Peak [Scan] | H | 100 | 0 | 74 | -16.1 | Pass | NRB |

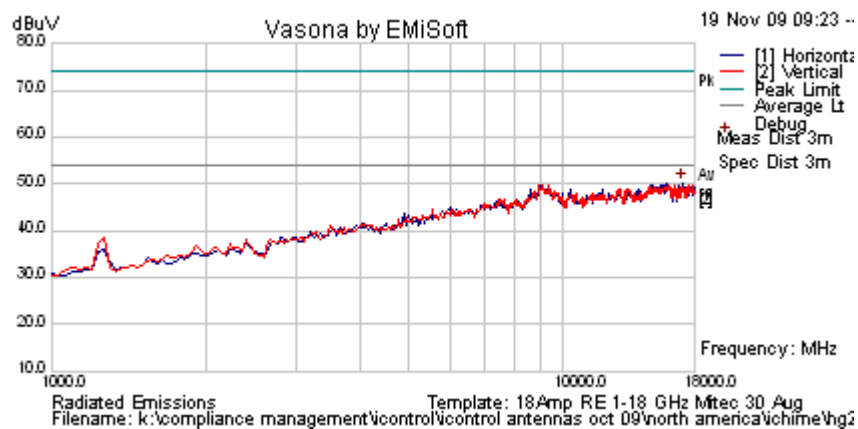
Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results
 BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq.

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2475 MHz (CH25) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 18.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 33 |
| Power Setting | 66 in test utility (-24.04 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414P | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna vertical on table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



Formally measured emission peaks

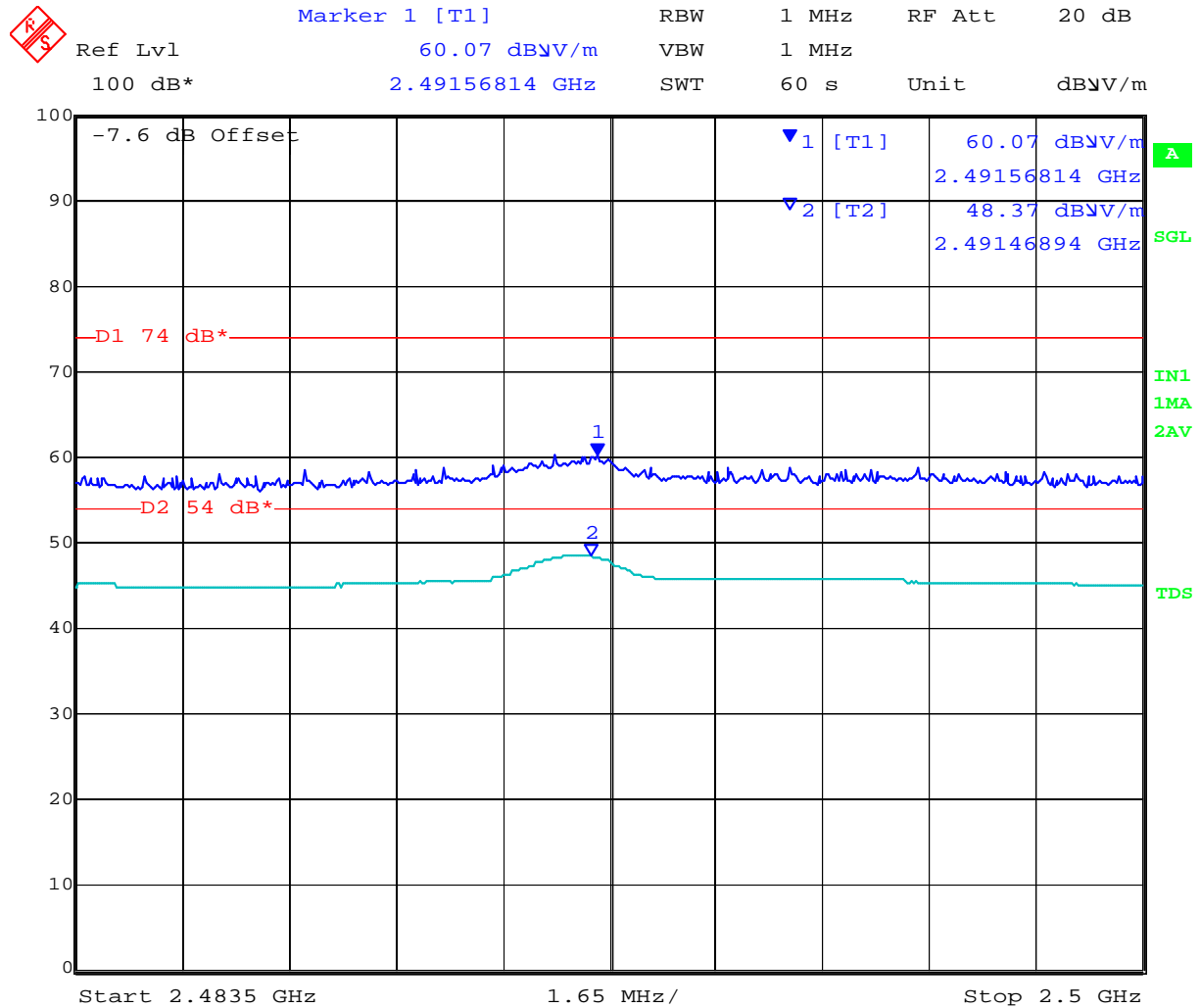
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|--|----------|------------|-------|------------|------------------|------|--------|---------|------------|-----------|------------|----------|
| 2491.568 | -- | -- | -- | 60.07 | Peak | Vert | 108 | 184 | 74 | -13.93 | Pass | BE |
| 2491.469 | -- | -- | -- | 48.37 | Average | Vert | 108 | 184 | 54 | -5.63 | Pass | BE |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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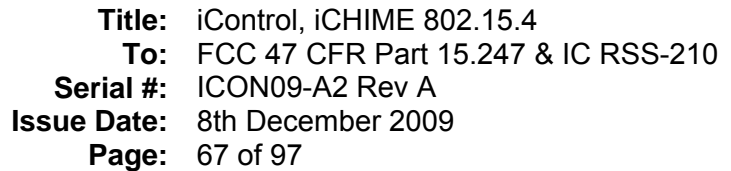
Title: iControl, iCHIME 802.15.4
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Band-Edge 2475 MHz



Date: 19.NOV.2009 09:03:38

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2405 MHz (CH11) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 67 in test utility (-8.61 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414SP-120 | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna Horizontal on Table | | |
| Test Notes 2 | Duty Cycle = 100% | | |

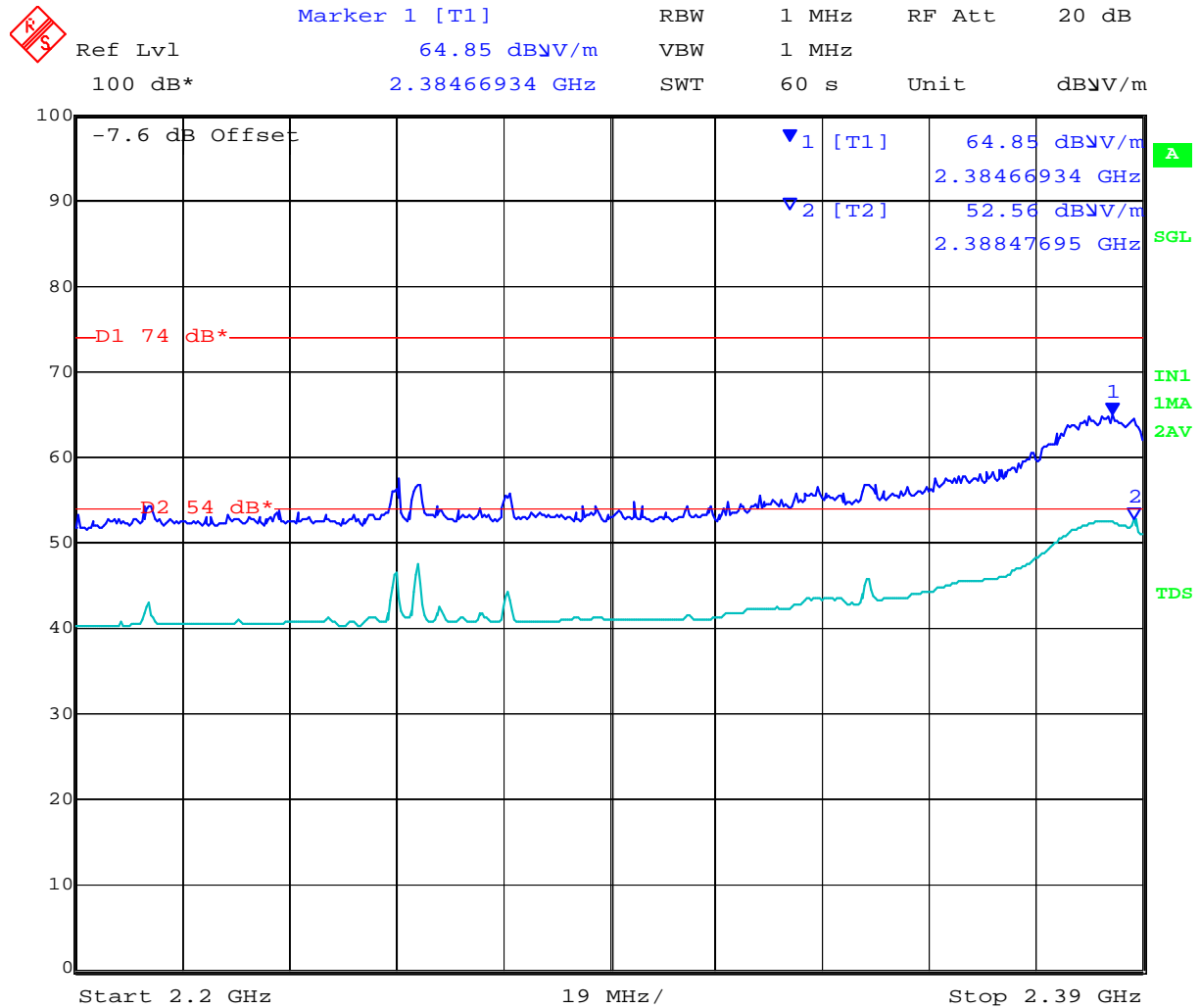


MiCOM Labs, 440 Boulder Court, Suite 200, Pleasanton, CA 94566 USA, Phone: 925.462.0304, Fax: 925.462.0306, www.micomlabs.com



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Band-Edge 2405 MHz



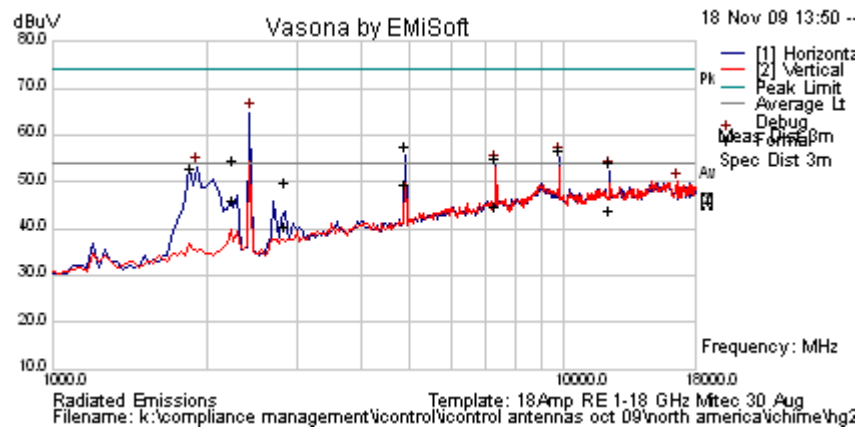
Date: 18.NOV.2009 11:45:59

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2445 MHz (CH19) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 90 in test utility (13.65 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414SP-120 | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna Horizontal on Table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



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 |
|---------------|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 1868.858 | 64.64 | 2.66 | -14.4 | 52.95 | Peak [Scan] | H | 100 | 0 | 54 | -1.05 | Pass | NRB |
| 2252.550 | 56.1 | 2.88 | -13 | 46 | Average Max | H | 114 | 199 | 54 | -8 | Pass | RB |
| 2252.550 | 64.7 | 2.9 | -13.0 | 54.6 | Peak Max | H | 114 | 199 | 74 | -19.5 | Pass | RB |
| 2845.361 | 59.0 | 3.3 | -12.2 | 50.1 | Peak Max | H | 110 | 197 | 74 | -23.9 | Pass | RB |
| 2845.361 | 49.3 | 3.3 | -12.2 | 40.4 | Average Max | H | 110 | 197 | 54 | -13.6 | Pass | RB |
| 4890.952 | 61.7 | 4.5 | -8.6 | 57.6 | Peak Max | H | 114 | 163 | 74 | -16.4 | Pass | RB |
| 4890.952 | 53.5 | 4.5 | -8.6 | 49.5 | Average Max | H | 114 | 163 | 54 | -4.6 | Pass | RB |
| 7333.457 | 41.6 | 5.5 | -2.5 | 44.6 | Average Max | H | 98 | 162 | 54 | -9.4 | Pass | RB |
| 7333.457 | 52.1 | 5.5 | -2.5 | 55.1 | Peak Max | H | 98 | 162 | 74 | -18.9 | Pass | RB |
| 9781.964 | 50.4 | 6.4 | -0.2 | 56.6 | Peak [Scan] | V | 100 | 0 | 54 | 2.6 | Fail | NRB |
| 12227.457 | 48.8 | 7.0 | -1.6 | 54.3 | Peak Max | H | 98 | 173 | 74 | -19.7 | Pass | RB |
| 12227.457 | 38.2 | 7.0 | -1.6 | 43.7 | Average Max | H | 98 | 173 | 54 | -10.3 | Pass | RB |

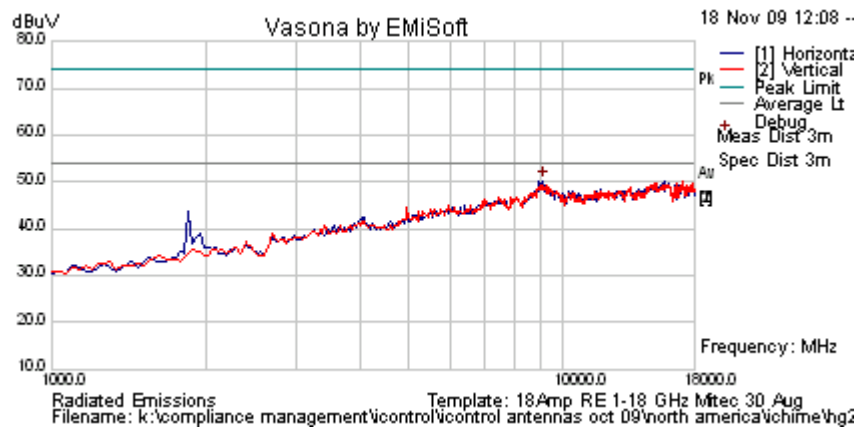
Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results
 BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq.

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| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2475 MHz (CH25) | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 20.5 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 66 in test utility (-25.1 dBm) | Press. (mBars) | 1007 |
| Antenna | HG2414SP-120 | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna Horizontal on Table | | |
| Test Notes 2 | Duty Cycle = 100% | | |



Formally measured emission peaks

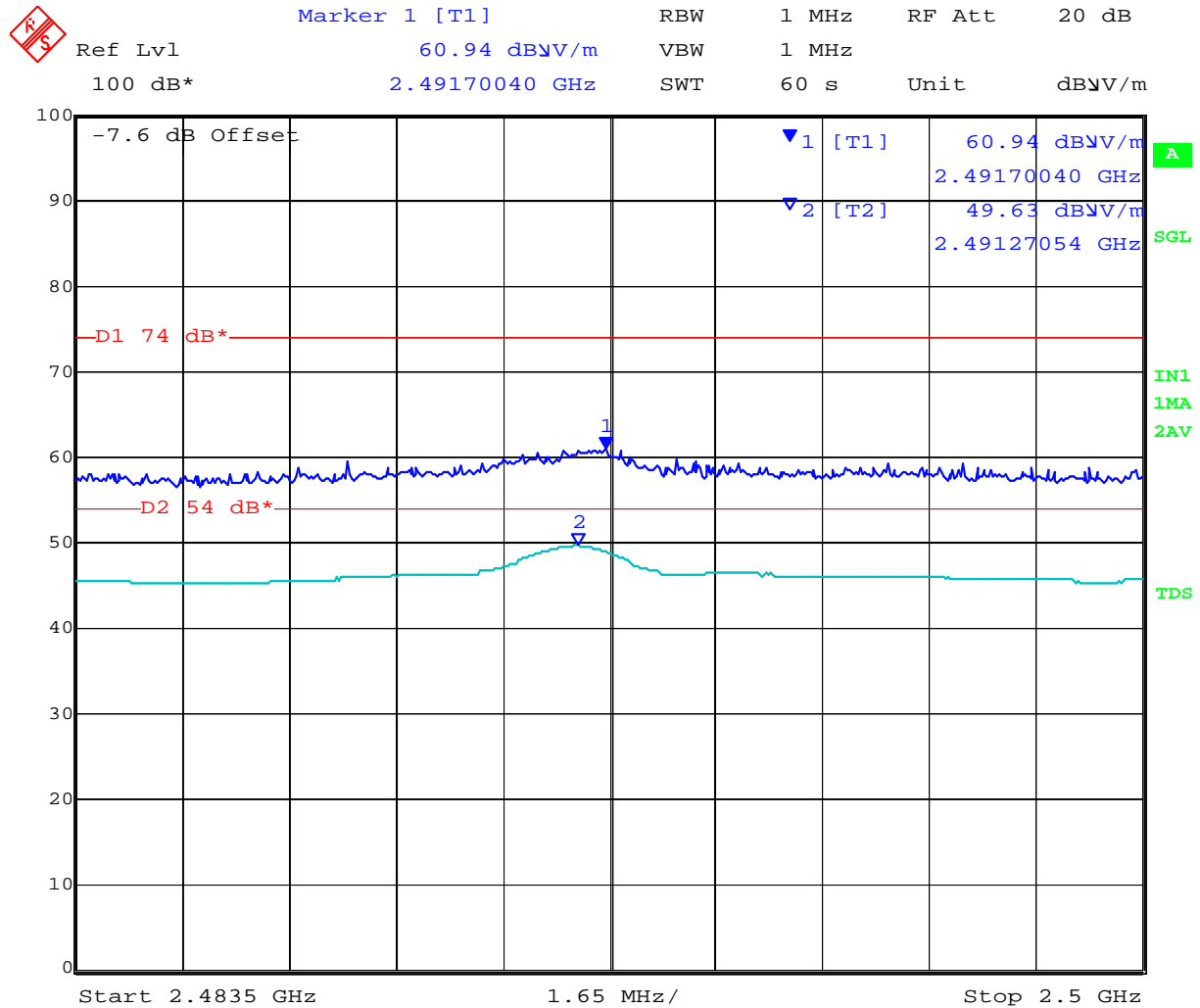
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV | Margin dB | Pass /Fail | Comments |
|--|----------|------------|-------|------------|------------------|-----|--------|---------|------------|-----------|------------|----------|
| 2491.700 | -- | -- | -- | 60.94 | Peak | Hor | 101 | 192 | 74 | -13.06 | Pass | BE |
| 2491.271 | -- | -- | -- | 49.63 | Average | Hor | 101 | 192 | 54 | -4.37 | Pass | BE |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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Band-Edge 2475 MHz



Date: 18.NOV.2009 11:59:40

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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 or carrier frequency), or from 30 MHz, whichever is the lowest frequency, to the 5th 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.



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§15.209 (a) Limit Matrix

| Frequency(MHz) | Field Strength (μ V/m) | Field Strength (dB μ V/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 |
|---|--|
| Measurements were made per work instruction WI-03 'Measurement of Radiated Emissions' | 0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312 |

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5.1.6.2. Receiver Radiated Spurious Emissions

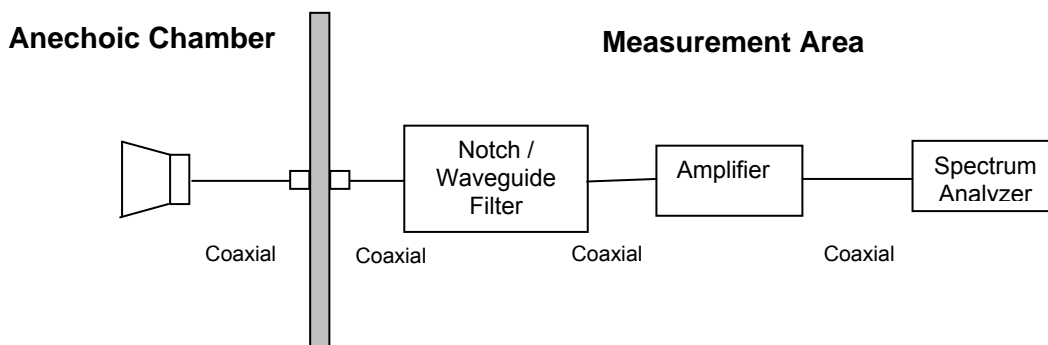
Industry Canada RSS-Gen §4.8, §6

Test Procedure

Radiated emissions above 1 GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarities. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. Depending on the frequency band spanned a notch filter and waveguide filter was used to remove the fundamental frequency. The highest emissions relative to the limit are listed for each frequency spanned.

All measurements on any frequency or frequencies over 1 MHz are based on the use of measurement instrumentation employing an average detector function. All measurements above 1 GHz were performed using a minimum resolution bandwidth of 1 MHz.

Test Measurement Set up



Measurement set up for Radiated Emission Test

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.

$$FS = R + AF + CORR - FO$$

where: 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



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For example:

Given receiver input reading of 51.5 dB μ V; 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:

$$FS = 51.5 + 8.5 + 1.3 - 26.0 + 1 = 36.3 \text{ dB}\mu\text{V/m}$$

Conversion between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as:

$$\text{Level (dB}\mu\text{V/m)} = 20 * \text{Log (level (\mu V/m))}$$

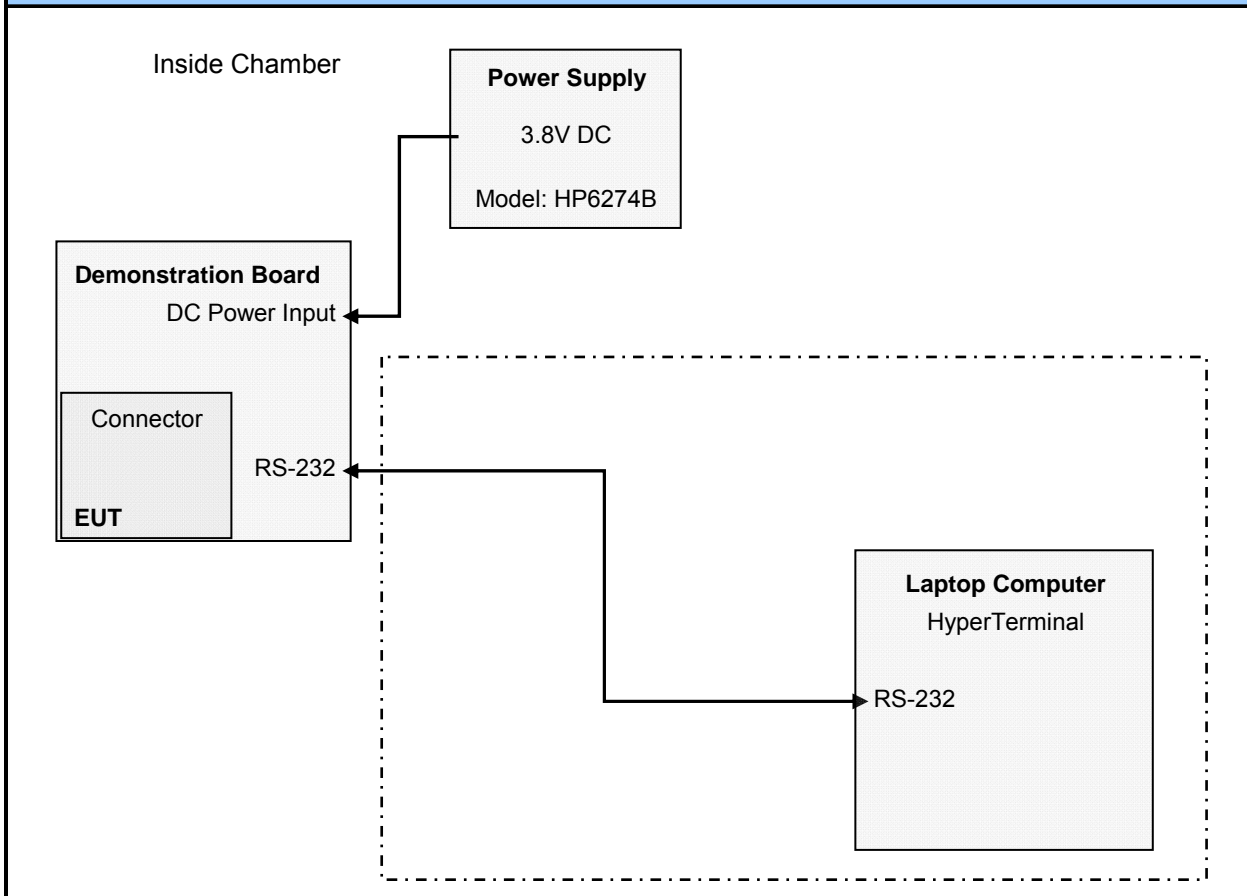
$$40 \text{ dB}\mu\text{V/m} = 100 \mu\text{V/m}$$

$$48 \text{ dB}\mu\text{V/m} = 250 \mu\text{V/m}$$

This test is not applicable for FCC certification

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EUT Setup Diagram



Test Setup Description

Both Vertical and Horizontal EUT positions were investigated during preliminary testing. EUT was setup in the worst case position (Verticle) for final tests.

EUT was connected to demonstration board to provide DC power and control. HP 6274B DC Power Supply was connected during test, and placed on the ground plane next to EUT.

Hyperterminal was used for setup and control of the EUT (i.e.changing the transmit and receive frequencies, changing output power, change Tx/Rx modes) The computer was connected via RS-232 control. The RS-232 cable and computer was removed from chamber before prescans or final measurements were performed.

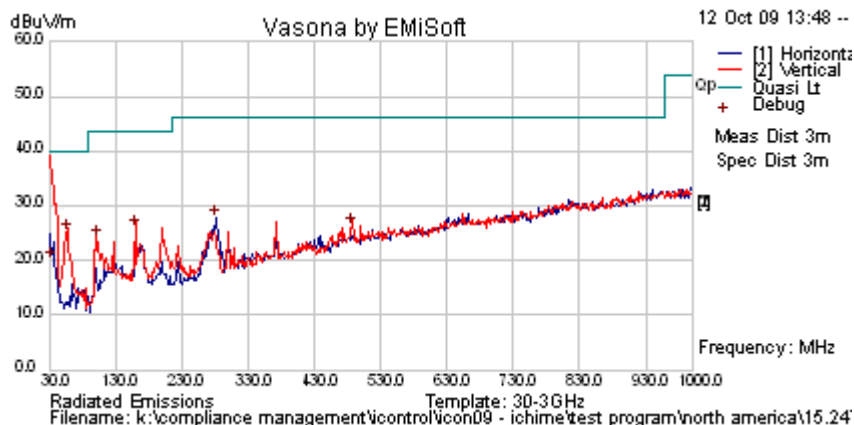


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Integral Antenna

Receiver Radiated Spurious Emissions below 1 GHz

| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Receive in Test Utility | Temp (°C) | 23 |
| Freq. Range | 30 MHz - 1000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | Not Applicable in Receive Mode | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT in Vertical position on Table | | |
| 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 |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| 32.995 | 28.5 | 3.4 | -12.1 | 19.9 | Quasi Peak | V | 98 | 213 | 40 | -20.1 | Pass | DIG |
| 56.294 | 45.2 | 3.8 | -23.8 | 25.1 | Peak | V | 98 | 213 | 40 | -14.9 | Pass | DIG |
| 102.859 | 39.7 | 4.2 | -20.1 | 23.8 | Peak | V | 98 | 213 | 43.5 | -19.7 | Pass | DIG |
| 159.960 | 39.9 | 4.5 | -18.5 | 26.0 | Peak | V | 98 | 213 | 43.5 | -17.5 | Pass | DIG |
| 280.620 | 39.7 | 5.1 | -17.1 | 27.7 | Peak | V | 98 | 213 | 46 | -18.3 | Pass | DIG |
| 485.912 | 32.9 | 5.9 | -12.5 | 26.3 | Peak | V | 98 | 213 | 46 | -19.7 | Pass | DIG |
| Legend: DIG = Digital Emissions; RX = Receiver Emission | | | | | | | | | | | | |

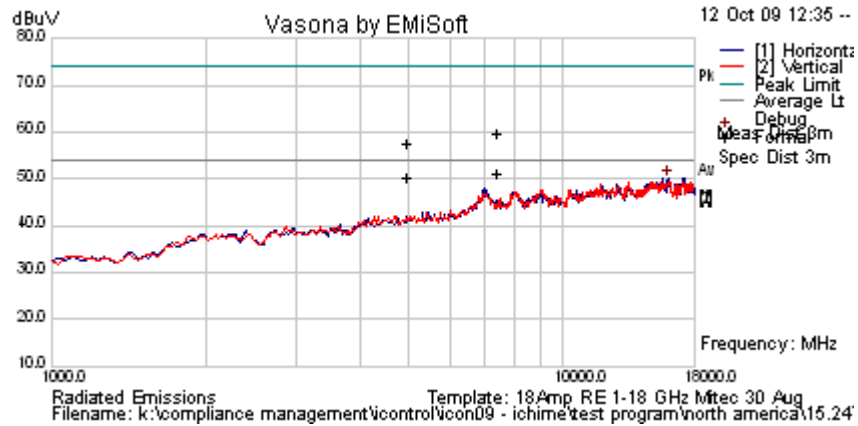
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Receiver Radiated Spurious Emissions above 1 GHz

| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2445 MHz (CH19) | Engineer | CSB |
| Variant | Receive in Test Utility | Temp (°C) | 23 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | Not Applicable in Receive Mode | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT in Vertical position on Table | | |
| 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 |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| No Receiver Emissions within 6dB of limit. | | | | | | | | | | | | |
| Legend: DIG = Digital Emissions; RX = Receiver Emission | | | | | | | | | | | | |

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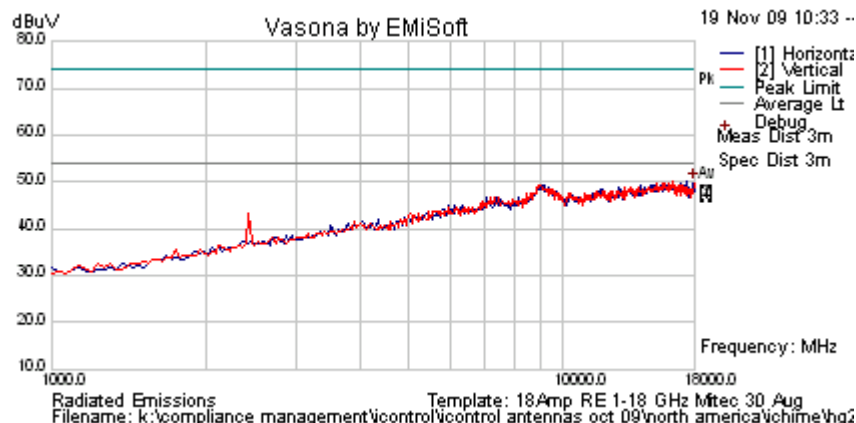


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External Antenna HG2408U

Receiver Radiated Spurious Emissions above 1 GHz

| | | | |
|---------------|---|----------------|------|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Receive in Test Utility | Temp (°C) | 20 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | Not Applicable in Receive Mode | Press. (mBars) | 1007 |
| Antenna | HG2408U | | |
| Test Notes 1 | EUT vertical on table. Antenna Vertical on table. | | |
| 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 |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| No Receiver Emissions within 6dB of limit. | | | | | | | | | | | | |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results | | | | | | | | | | | | |
| BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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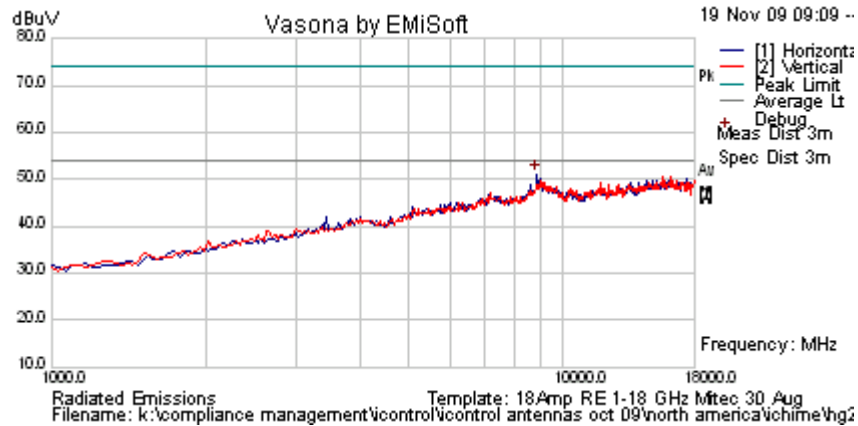


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External Antenna HG2414P

Receiver Radiated Spurious Emissions above 1 GHz

| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Receive in Test Utility | Temp (°C) | 18 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 33 |
| Power Setting | Not Applicable in Receive Mode | Press. (mBars) | 1007 |
| Antenna | HG2414P | | |
| Test Notes 1 | EUT Vertical on Table. Antenna Vertical on Table | | |
| 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 |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| No Receiver Emissions within 6dB of limit. | | | | | | | | | | | | |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band - Limit is 20dB below carrier - See conducted results | | | | | | | | | | | | |
| BE = Emission in Restricted Band Nearest Transmission Band Edge; FUND = Fundamental Freq. | | | | | | | | | | | | |

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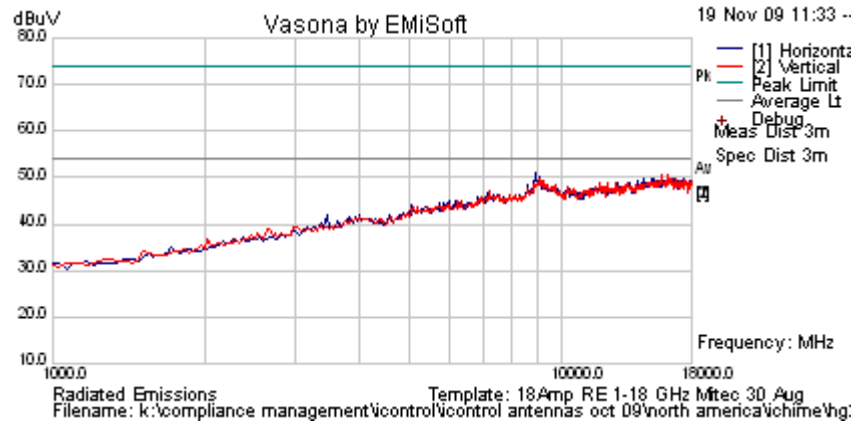


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External Antenna HG2414SP-120

Receiver Radiated Spurious Emissions above 1 GHz

| | | | |
|----------------------|--|-----------------------|------|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Receive in Test Utility | Temp (°C) | 20 |
| Freq. Range | 1000 MHz - 18000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | Not Applicable in Receive Mode | Press. (mBars) | 1006 |
| Antenna | HG2414SP-120 | | |
| Test Notes 1 | EUT board sitting vertically on table; Antenna horizontal on table | | |
| 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 |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| No Receiver Emissions within 6dB of limit. | | | | | | | | | | | | |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq. | | | | | | | | | | | | |
| BE = Emission in Restricted Band Nearest Transmission Band Edge; | | | | | | | | | | | | |

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Specification

Receiver Radiated Spurious Emissions

Industry Canada RSS-Gen §4.8,

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.

RSS-Gen §6

The following receiver spurious emission limits shall be complied with;

(a) If a radiated measurement is made, all spurious emissions shall comply with the limits of Table 1.

| Frequency (MHz) | Field Strength ($\mu\text{V/m}$) | Field Strength (dB $\mu\text{V/m}$) | 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 |
|---|--|
| Measurements were made per work instruction WI-03 'Measurement of Radiated Emissions' | 0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312 |

5.1.6.3. Radiated Spurious Emissions (30M-1 GHz)

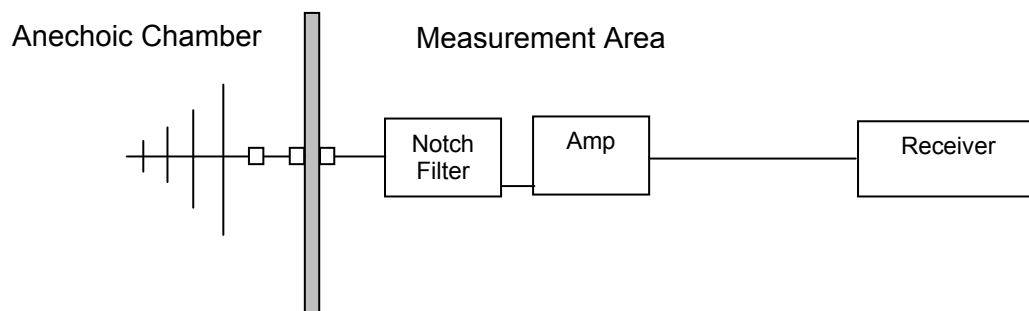
FCC, Part 15 Subpart C §15.205/ §15.209
Industry Canada RSS-210 §2.2

Test Procedure

Testing 30M-1 GHz was performed in a 3-meter anechoic chamber using a CISPR compliant receiver. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. To further maximize emissions the receive antenna was varied between 1 and 4 meters. The emissions are recorded with receiver in peak hold mode. Emissions closest to the limits are measured in the quasi-peak mode with the tuned receiver using a bandwidth of 120 kHz. Only the highest emissions relative to the limit are listed. The anechoic chamber test set-up is identified in Section 6 Test Set-Up Photographs.

The EUT had two methods of powering on ac/dc converter and Power over Ethernet (POE). Both modes were tested for emissions below 1GHz.

Test Measurement Set up



Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. In this test facility, the Antenna Factor, Cable Loss, and Amplifier Gains are loaded into the Rohde & Schwarz Receiver and the corrected field strength can be read directly on the receiver.

$$\text{FS} = \text{R} + \text{AF} + \text{CORR}$$

where:

FS = Field Strength
R = Measured Receiver Input Amplitude
AF = Antenna Factor
CORR = Correction Factor = CL – AG + NFL
CL = Cable Loss
AG = Amplifier Gain



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For example:

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

$$FS = 51.5 + 8.5 + 1.3 - 26.0 + 1 = 36.3\text{dB}\mu\text{V/m}$$

Conversion between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as:

$$\text{Level (dB}\mu\text{V/m)} = 20 * \text{Log (level (}\mu\text{V/m))}$$

$$40 \text{ dB}\mu\text{V/m} = 100\mu\text{V/m}$$

$$48 \text{ dB}\mu\text{V/m} = 250\mu\text{V/m}$$

Measurement Results for Spurious Emissions (30 MHz – 1 GHz)

Ambient conditions.

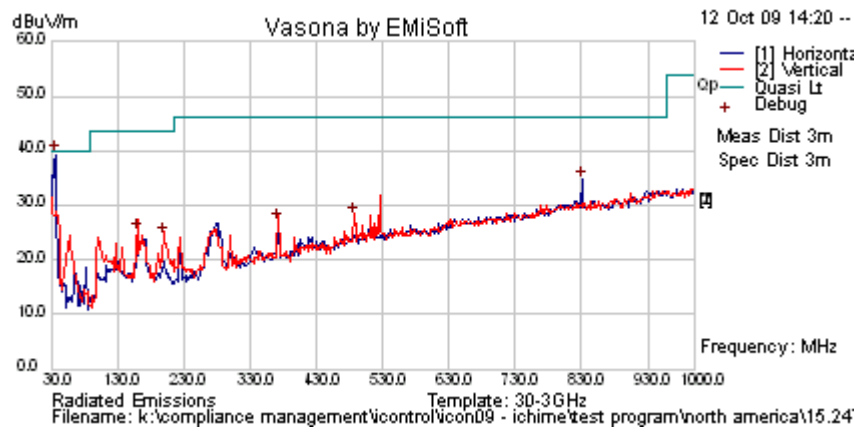
Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

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| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2405 MHz | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 30 MHz - 1000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 82 in test utility (11.54 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| Test Notes 2 | | | |



Formally measured emission peaks

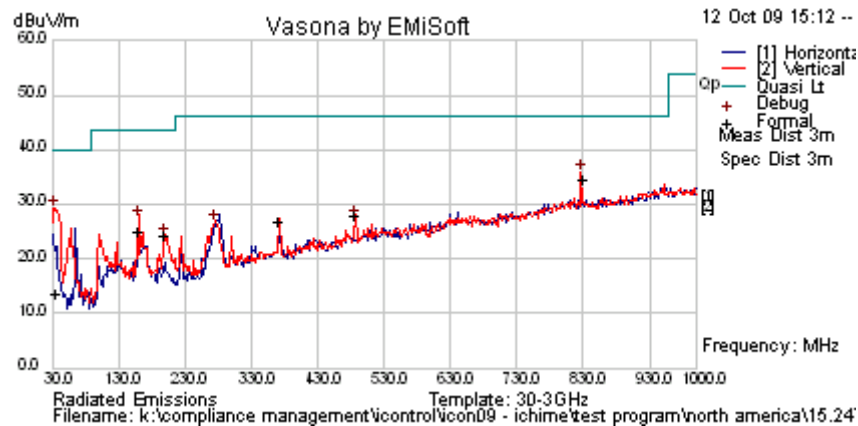
| Frequency MHz | Raw dBuV | Cable Loss | AF dB | Level dBuV/m | Measurement Type | Pol | Hgt cm | Azt Deg | Limit dBuV/m | Margin dB | Pass/Fail | Comments |
|---|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|-----------|----------|
| 36.241 | 24.6 | 3.5 | -14.6 | 13.5 | Quasi Peak | H | 119 | 53 | 40 | -26.5 | Pass | WB |
| 160.006 | 39.1 | 4.5 | -18.5 | 25.2 | Peak [Scan] | V | 98 | 0 | 43.5 | -18.3 | Pass | DIG |
| 200.235 | 37.3 | 4.8 | -17.6 | 24.4 | Peak [Scan] | V | 98 | 360 | 43.5 | -19.1 | Pass | TX |
| 372.263 | 36.5 | 5.6 | -15.1 | 26.9 | Peak [Scan] | V | 98 | 360 | 46 | -19.1 | Pass | DIG |
| 486.812 | 34.5 | 5.9 | -12.5 | 27.9 | Peak [Scan] | V | 98 | 360 | 46 | -18.1 | Pass | DIG |
| 832.000 | 35.3 | 7.2 | -7.9 | 34.6 | Peak [Scan] | H | 98 | 360 | 46 | -11.4 | Pass | DIG |
| Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq.; WB = Wideband BE = Emission in Restricted Band Nearest Transmission Band Edge; TX = Transmitter; DIG = Digital Emission | | | | | | | | | | | | |

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| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2445 MHz | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 30 MHz - 1000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 90 in test utility (13.34 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| 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 |
|---------------|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|------------|----------|
| 33.047 | 37.93 | 3.44 | -12.1 | 29.27 | Peak [Scan] | V | 98 | 360 | 40 | -10.73 | Pass | WB |
| 160.001 | 41.17 | 4.54 | -18.5 | 27.23 | Peak [Scan] | V | 98 | 360 | 43.5 | -16.27 | Pass | DIG |
| 200.458 | 36.7 | 4.8 | -17.7 | 23.8 | Peak [Scan] | V | 98 | 360 | 43.5 | -19.7 | Pass | TX |
| 273.716 | 38.9 | 5.1 | -17.3 | 26.7 | Peak [Scan] | V | 98 | 360 | 46 | -19.3 | Pass | DIG |
| 486.789 | 33.8 | 6.0 | -12.5 | 27.2 | Peak [Scan] | V | 98 | 360 | 46 | -18.8 | Pass | DIG |
| 827.036 | 36.5 | 7.2 | -7.9 | 35.7 | Peak [Scan] | V | 98 | 360 | 46 | -10.3 | Pass | DIG |

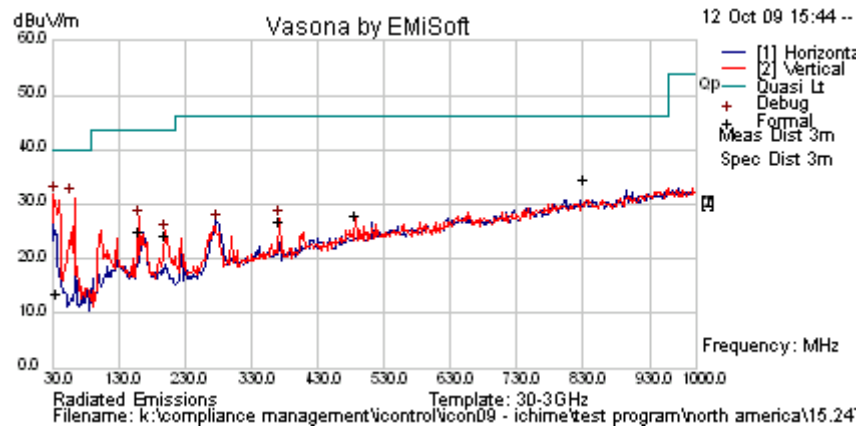
Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq.; WB = Wideband
 BE = Emission in Restricted Band Nearest Transmission Band Edge; TX = Transmitter; DIG = Digital Emission

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| | | | |
|----------------------|--|-----------------------|-----|
| Test Freq. | 2480 MHz | Engineer | CSB |
| Variant | Tx in Test Utility | Temp (°C) | 23 |
| Freq. Range | 30 MHz - 1000 MHz | Rel. Hum.(%) | 32 |
| Power Setting | 86 in test utility (12.02 dBm) | Press. (mBars) | 999 |
| Antenna | Integral Trace Antenna included on PCB active during testing | | |
| Test Notes 1 | EUT board sitting vertically on table | | |
| 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 |
|---------------|----------|------------|-------|--------------|------------------|-----|--------|---------|--------------|-----------|-----------|----------|
| 32.493 | 39.73 | 3.43 | -11.7 | 31.49 | Peak [Scan] | V | 98 | 360 | 40 | -8.51 | Pass | WB |
| 58.327 | 51.24 | 3.8 | -23.8 | 31.23 | Peak [Scan] | V | 98 | 360 | 40 | -8.77 | Pass | DIG |
| 160.001 | 41.1 | 4.5 | -18.5 | 27.2 | Peak [Scan] | V | 98 | 360 | 43.5 | -16.4 | Pass | DIG |
| 200.465 | 37.8 | 4.8 | -17.7 | 24.9 | Peak [Scan] | V | 98 | 360 | 43.5 | -18.6 | Pass | TX |
| 276.486 | 38.82 | 5.09 | -17.2 | 26.67 | Peak [Scan] | H | 98 | 360 | 46 | -19.33 | Pass | DIG |
| 372.271 | 36.8 | 5.6 | -15.1 | 27.3 | Peak [Scan] | V | 98 | 360 | 46 | -18.7 | Pass | DIG |

Legend: RB = Restricted Band; NRB = Non-Restricted Band; FUND = Fundamental Freq.; WB = Wideband
 BE = Emission in Restricted Band Nearest Transmission Band Edge; TX = Transmitter; DIG = Digital Emission

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Specification

Limits

§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.

§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.

§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.

§15.209 (a) and RSS-Gen §2.2 Limit Matrix

| Frequency(MHz) | Field Strength ($\mu\text{V/m}$) | Field Strength (dB $\mu\text{V/m}$) | 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 |
|---|--|
| Measurements were made per work instruction WI-03 'Measurement of Radiated Emissions' | 0088, 0158, 0134, 0304, 0311, 0315, 0310, 0312 |



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5.1.7. AC Wireline Conducted Emissions (150 kHz – 30 MHz)

FCC, Part 15 Subpart C §15.207
Industry Canada RSS-Gen §7.2.2

Test is not applicable as the device is battery operated

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Specification

Limit

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, 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 30 MHz shall not exceed the limits in the following table, as measured using a 50 $\mu\Omega$ line impedance stabilization network (LISN), see §15.207 (a) matrix below. 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.

RSS-Gen §7.2.2

The radio frequency voltage that is conducted back into the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in the table below. The tighter limit applies at the frequency range boundaries.

§15.207 (a) and **RSS-Gen §7.2.2** Limit Matrix

The lower limit applies at the boundary between frequency ranges

| Frequency of Emission (MHz) | Conducted Limit (dB μ V) | |
|-----------------------------|------------------------------|-----------|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

* Decreases with the logarithm of the frequency

Laboratory Measurement Uncertainty for Conducted Emissions

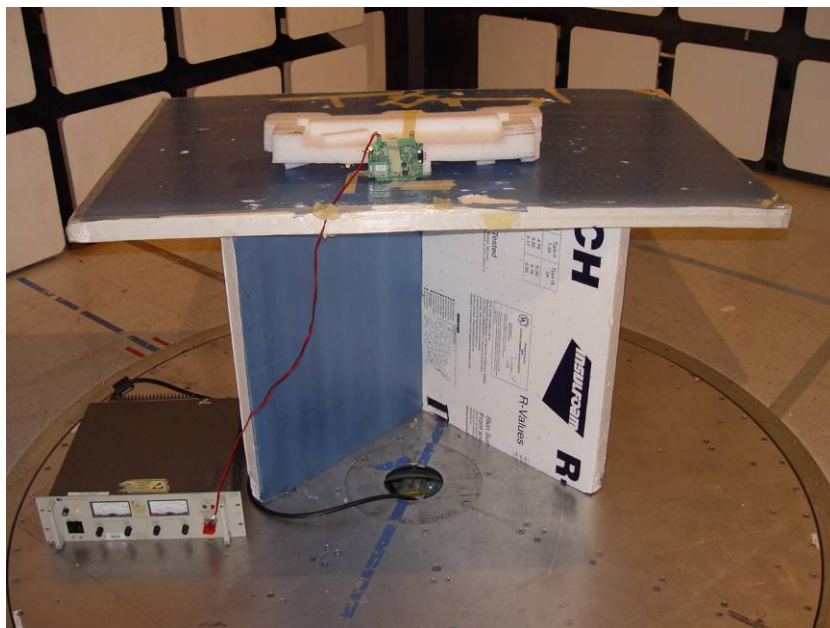
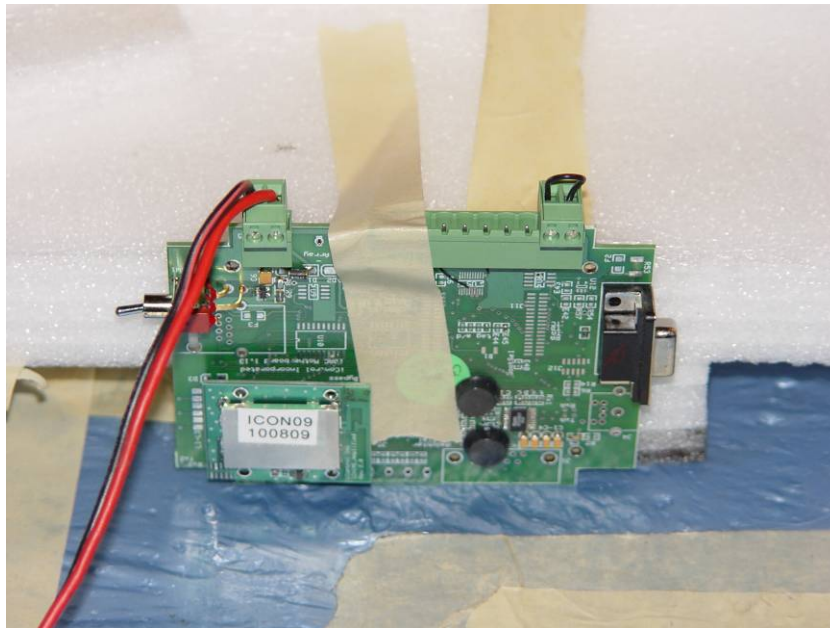
| | |
|-------------------------|---------------|
| Measurement uncertainty | ± 2.64 dB |
|-------------------------|---------------|

Traceability

| Method | Test Equipment Used |
|--|------------------------------------|
| Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions' | 0158, 0184, 0193, 0190, 0293, 0307 |

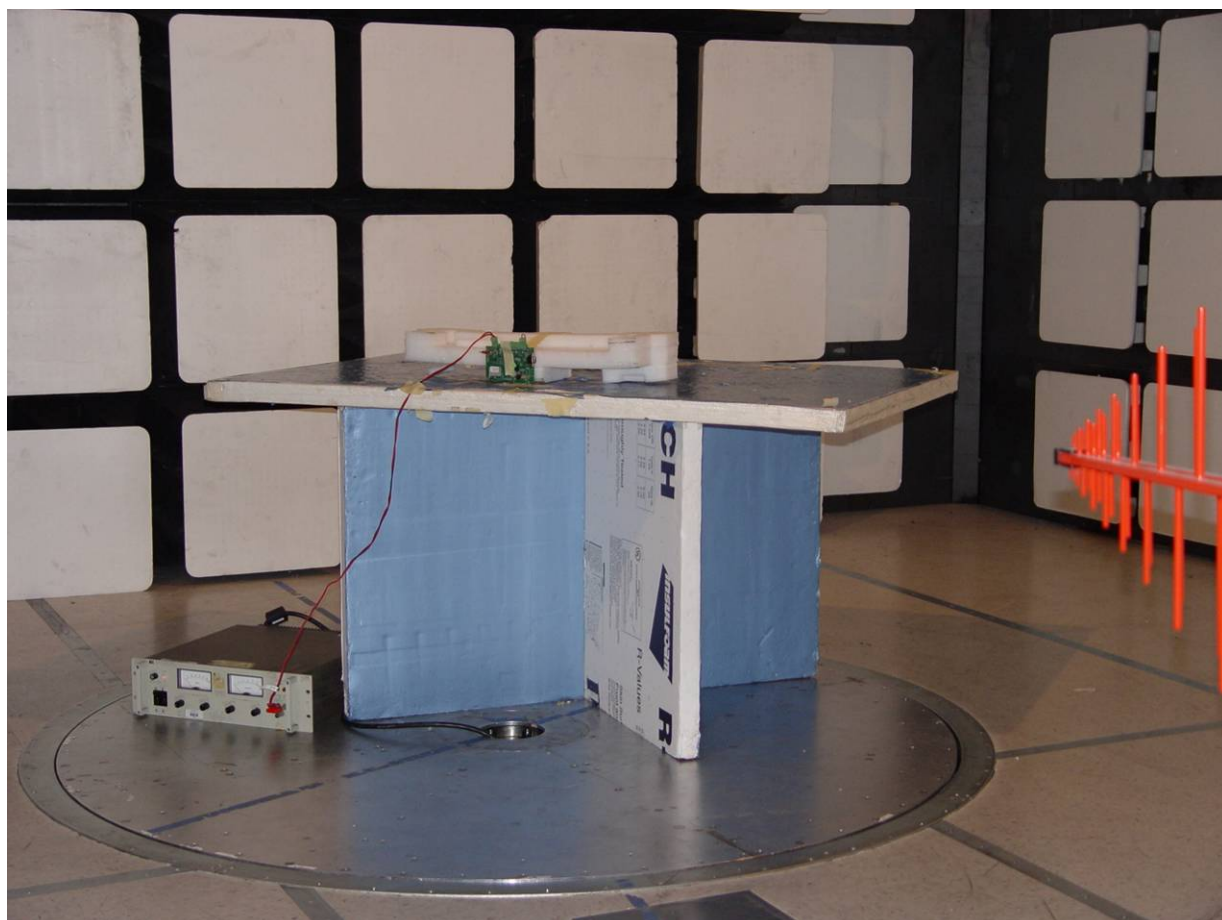
6. PHOTOGRAPHS

6.1. Radiated Spurious Emissions – Test Configuration



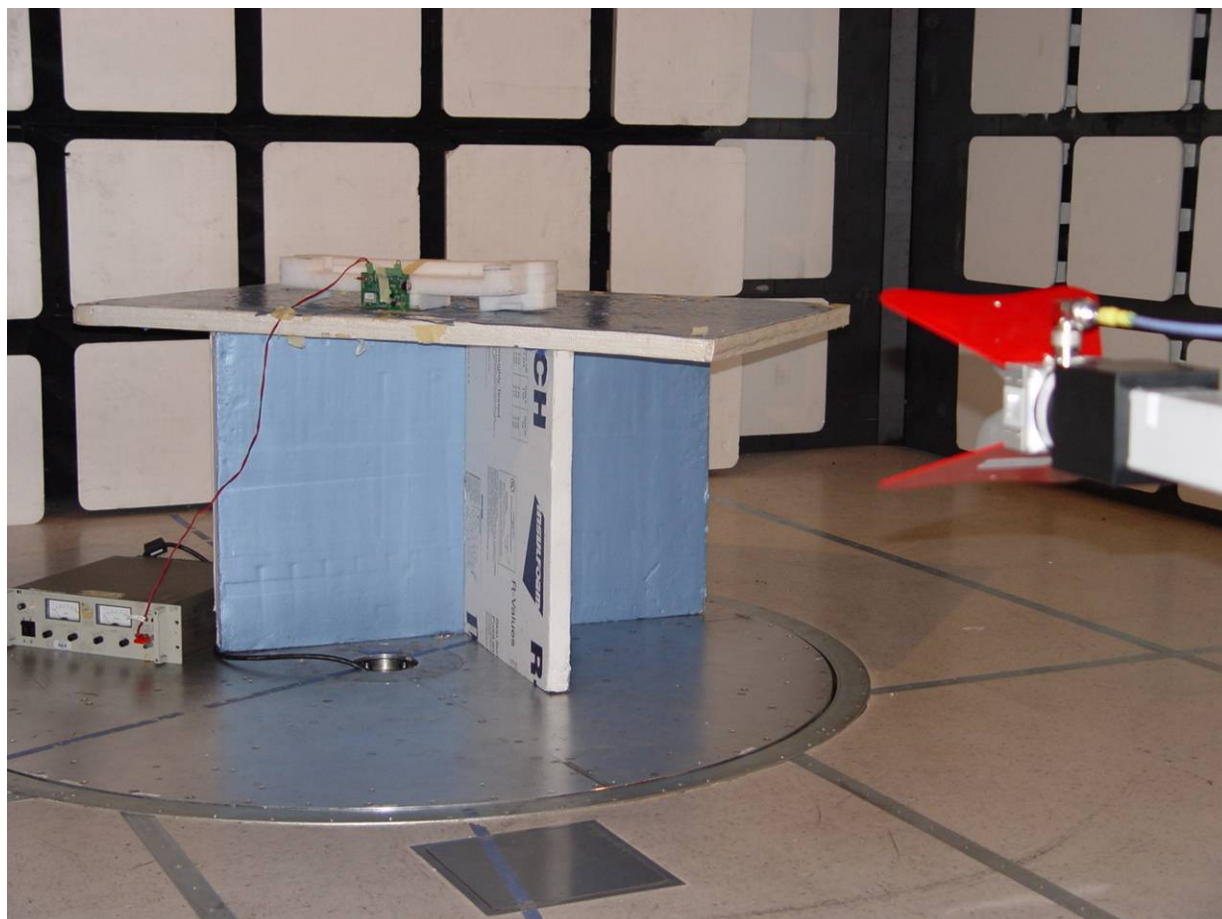
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6.2. Radiated Spurious Emissions - below 1 GHz



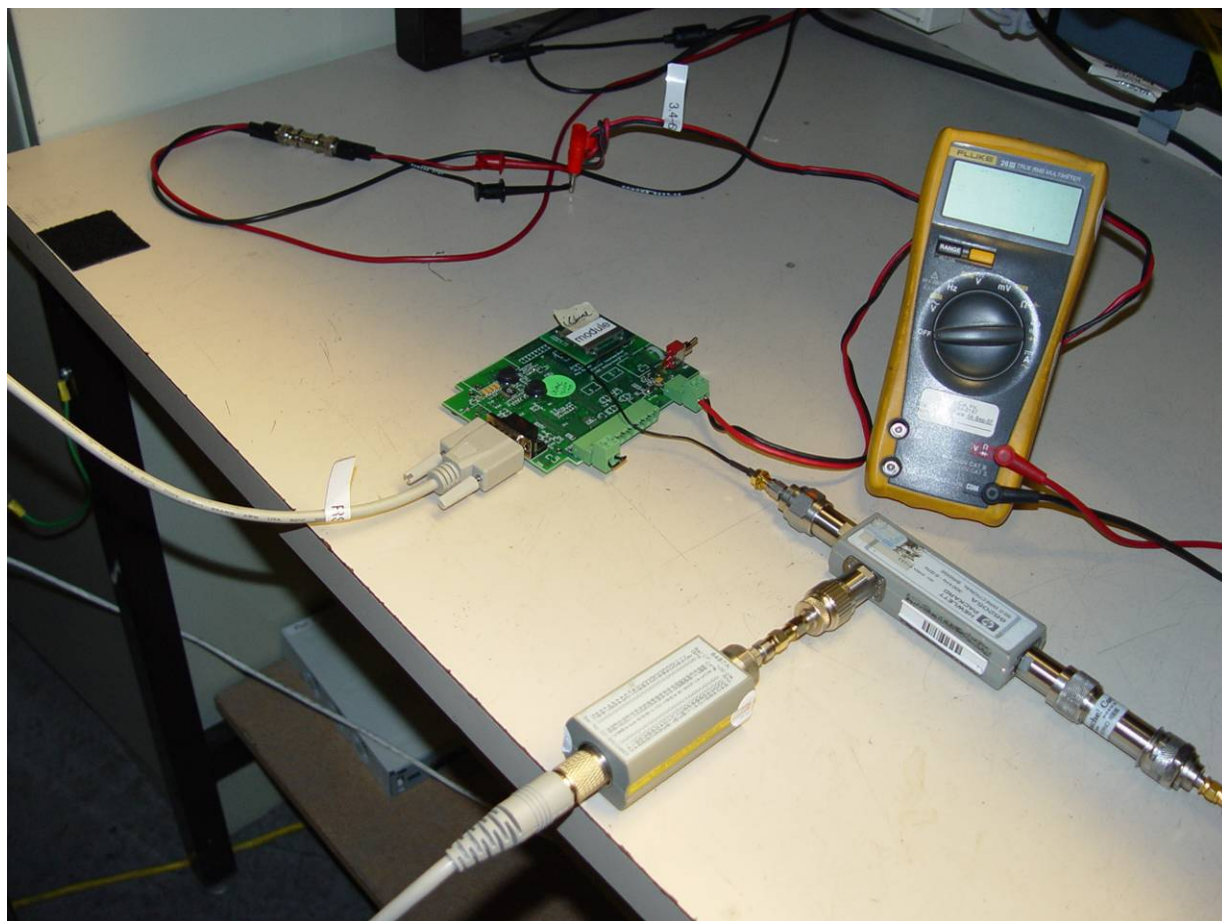
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6.3. Radiated Spurious Emissions - above 1 GHz



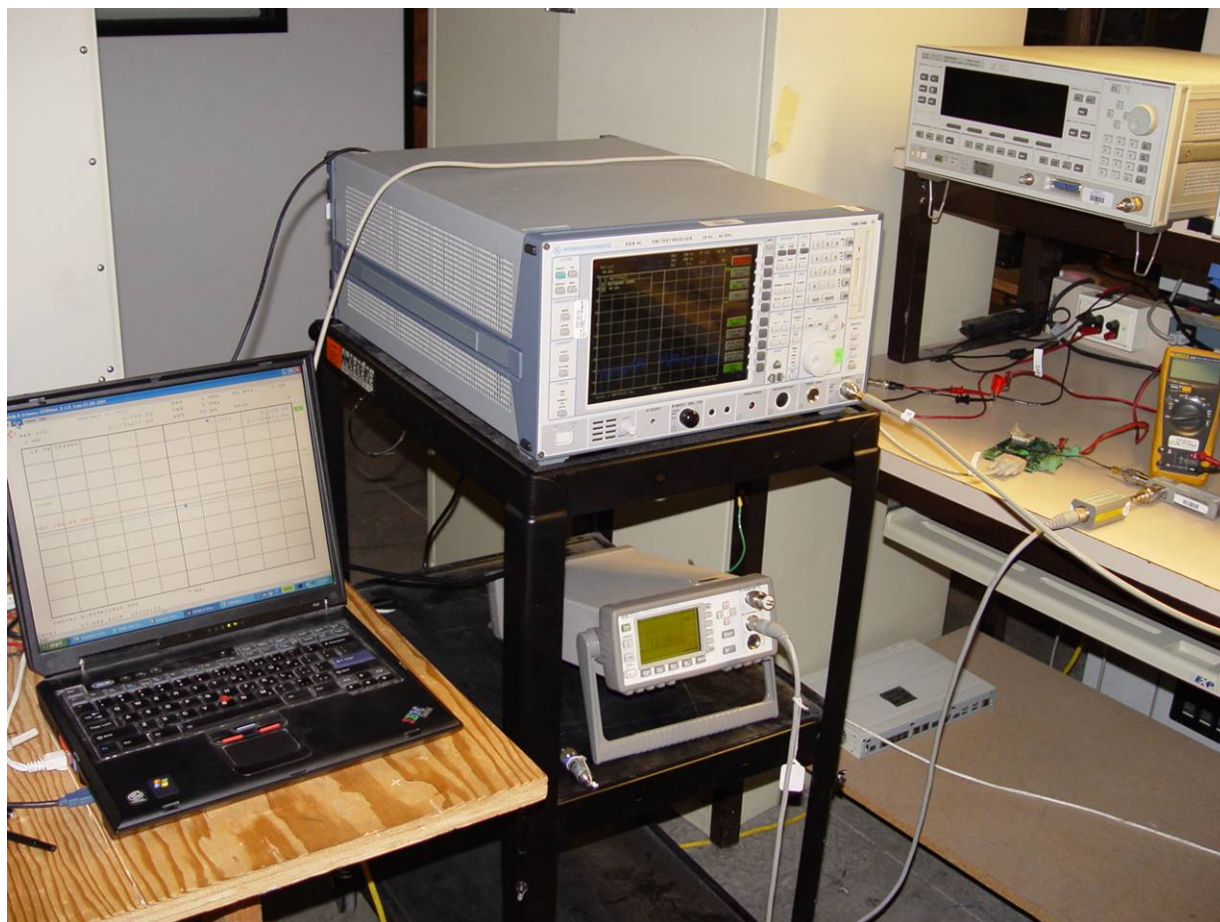
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6.4. Conducted Measurement Test Set-Up



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6.5. Conducted Measurement Test Equipment



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7. TEST EQUIPMENT DETAILS

| Asset # | Instrument | Manufacturer | Part # | Serial # |
|---------|---------------------------|------------------|-----------------------|-------------|
| 0088 | Spectrum Analyzer | Hewlett Packard | 8564E | 3410A00141 |
| 0134 | Amplifier | Com Power | PA 122 | 181910 |
| 0158 | Barometer /Thermometer | Control Co. | 4196 | E2846 |
| 0193 | EMI Receiver | Rhode & Schwartz | ESI 7 | 838496/007 |
| 0252 | SMA Cable | Megaphase | Sucoflex 104 | None |
| 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 | 30dB N-Type Attenuator | ARRA | N9444-30 | 1623 |
| 0070 | Power Meter | Hewlett Packard | 437B | 3125U11552 |
| 0116 | Power Sensor | Hewlett Packard | 8485A | 3318A19694 |
| 0117 | Power Sensor | Hewlett Packard | 8487D | 3318A00371 |
| 0184 | Pulse Limiter | Rhode & Schwartz | ESH3Z2 | 357.8810.52 |
| 0190 | LISN | Rhode & Schwartz | ESH3Z5 | 836679/006 |
| 0293 | BNC Cable | Megaphase | 1689 1GVT4 | 15F50B001 |
| 0301 | 5.6 GHz Notch Filter | Micro-Tronics | RBC50704 | 001 |
| 0302 | 5.25 GHz Notch Filter | Micro-Tronics | BRC50703 | 002 |
| 0303 | 5.8 GHz Notch Filter | Micro-Tronics | BRC50705 | 003 |
| 0304 | 2.4GHzHz Notch Filter | Micro-Tronics | -- | 001 |
| 0307 | BNC Cable | Megaphase | 1689 1GVT4 | 15F50B002 |
| 0335 | 1-18GHz Horn Antenna | ETS- Lindgren | 3117 | 00066580 |
| 0337 | Amplifier | MiCOM Labs | -- | -- |
| 0338 | Antenna | Sunol Sciences | JB-3 | A052907 |

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