LS Research, LLC

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ENGINEERING TEST REPORT # 307192 TX TCB Rev. 1

Compliance Testing of:
22dB Radio Module
Model #: EM-0033A and EM-0033B

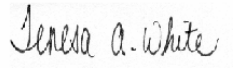
Test Date(s):
April, May, June, 2007

Prepared For:
Trilliant Networks
Attn.: Mr. Bob Fischette
950 Rue Cowie
Granby Quebec J2J 1P2
Canada

In accordance with:
Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Digital Modulation Transmitters (DTS) Operating in the
Frequency Band 2400 MHz – 2483.5 MHz

This Test Report is issued under the Authority of:
Brian E. Petted, VP of Engineering

Signature:  Date: September 27, 2007

Test Report Prepared by:	**Tested by:**
Teresa A. White, Quality Manager	Kenneth L. Boston, PE
Signature: 	Signature: 
Date: September 27, 2007	Date: September 27, 2007

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LSC Revision Control

Date	Revision #	Revised By
9-06-06	2.0	AS/TAW

EXHIBIT 1. INTRODUCTION

1.1 SCOPE

References:	FCC Part 15, Subpart C, Section 15.247
Title:	Telecommunication – Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	To gain FCC Certification Authorization for Digital Modulation Transmitters operating in the Frequency Band of 2400 MHz – 2483.5 MHz
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Environmental Classification:	• Commercial, Industrial or Business • Residential

1.2 NORMATIVE REFERENCES

Publication	Year	Title
47 CFR, Parts 0-15 (FCC)	2005	Code of Federal Regulations - Telecommunications
ANSI C63.4	2004	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
CISPR 16-1-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.
CISPR 16-2-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 201: Conducted disturbance measurement.
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding Spread Spectrum Devices.
FCC Procedures	2005, 03-23	Measurement of Digital Transmission Systems operating under Section 15.247.

1.3 LS Research, LLC TEST FACILITY

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025, 2005 "General Requirements for the Competence of Calibration and Testing Laboratories".

LS Research, LLC's scope of accreditation includes all test methods listed herein, unless otherwise noted. A copy of the accreditation may be accessed on our web site: www.lsr.com. Accreditation status can be verified at A2LA's web site: www.a2la2.net.

1.4 LOCATION OF TESTING

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Compact Chamber
- Semi-Anechoic Chamber
- Open Area Test Site (OATS)

1.5 TEST EQUIPMENT UTILIZED

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated in accordance with A2LA standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 CLIENT INFORMATION

Manufacturer Name:	**Trilliant Networks**
Address:	**950 Rue Cowie** **Granby Quebec J2J 1P2** **Canada**
Contact Person:	**Bob Fischette**

2.2 EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information has been supplied by the applicant.

Product Name:	22dB Radio Module
Model Number:	EM-0033A & EM-0033B
Serial Number:	n/a

2.3 ASSOCIATED ANTENNA DESCRIPTION

Two antenna options - an on board trace antenna and an external dipole (whip) antenna.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

Frequency Range (in MHz)	2400-2483 MHz
RF Power in Watts	0.158 Watts
Conducted Output Power (in dBm)	22.0 dBm
Field Strength (and at what distance)	119.8 dBuV/m at 2440 MHz, 3 meters
Occupied Bandwidth (99% BW)	1590 kHz (6dB); 2633 kHz (99%)
Type of Modulation	DTS with duty cycle
Emission Designator	2M67G1D
EIRP (in mW)	158 mW
Transmitter Spurious (worst case)	53.4 dBuV/m (average) at 2389.5 MHz
Frequency Tolerance %, Hz, ppm	500 Hz
Microprocessor Model # (if applicable)	n/a
Antenna Information	
Detachable/non-detachable	PCB Trace, Nearson Whip
Type	
Gain (in dBi)	PCB trace, F antenna 3.8 dBi
	Nearson Whip, 2.0 dBi
EUT will be operated under FCC Rule Part(s)	47 CFR 15.247
Modular Filing	x Yes ☐ No

RF Technical Information:

Type of Evaluation (check one)		SAR Evaluation: Device Used in the Vicinity of the Human Head
		SAR Evaluation: Body-worn Device
	X	RF Evaluation

If RF Evaluation checked above, test engineer to complete the following:

- Evaluated against exposure limits: ☒ General Public Use ☐ Controlled Use
- Duty Cycle used in evaluation: 100 %
- Standard used for evaluation: OET 65
- Measurement Distance: 3 m
- RF Value: 0.006 ☐ V/m ☐ A/m ☒ W/m^2
  ☐ Measured ☐ Computed ☒ Calculated

2.5 PRODUCT DESCRIPTION

The 22dB Radio Module is an 802.15.4 radio module to be used in electric meter applications to transfer data. The frequency of operation is the 2.4 GHz ISM band. Standard 802.15.4 modulation is used (O-QPSK with 16 orthogonal sequences and a chip rate of 2 MCps). All data is generated on board. 16 channels are offered at 5 MHz increments between 2405 and 2480 MHz. Power is supplied externally at a nominal 3.3 V. Two antenna options will be tested - an on board trace antenna and an external dipole (whip) antenna.

The modules for test will be programmed to operate in a continuous mode on a specific frequency. Operation will begin once dc power is applied to the marked connector on the edge of the module.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	20-22 C
Humidity:	35-60 %
Pressure:	98.0 kPa

3.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Paragraph	Test Requirements	Compliance (yes/no)
15.207	Power Line Conducted Emissions Measurements	Yes
15.247(a)(2)	6 dB Bandwidth of a Digital Modulation System	Yes
15.247(b) & 1.1310	Maximum Output Power	Yes
15.247(i), 1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
15.247(c)	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(d)	Transmitted Power Spectral Density of a Digital Modulation System	Yes
15.247(c), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices and the associated Radio Receiver has also been tested and found to comply with Part 15, Subpart B – Radio Receivers. The Receiver Test Report is available upon request.		

3.3 MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

☒ **None** ☐ **Yes (explain below)**

3.4 DEVIATIONS & EXCLUSIONS FROM TEST SPECIFICATIONS

☒ **None** ☐ **Yes (explain below)**

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.247, and Industry Canada RSS-210 (2005), Section Annex 8 (section 8.2) for a Digital Spread Spectrum (DTS) Transmitter.

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

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15 and ANSI C63.4-2003. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in O-QPSK modulated mode for final testing. using power as provided by an HP bench supply. The unit has the capability to operate on 16 channels, controllable via a laptop PC.

The applicable limits apply at a 3 meter distance. Measurements above 5 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels: low (2405MHz), middle (2440MHz) and high (2475/2480 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using a PC.

5.2 Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. From 18 GHz to 25 GHz, the EUT was measured at a 1.0 meter separation, using a standard gain Horn Antenna and pre-amplifier.

The EUT was rotated along three orthogonal axis during the investigations to find the highest emission levels.

5.3 Test Equipment Utilized

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

Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 for a DTS transmitter [Canada RSS-210 (2005), Annex 8 (section 8.2). The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.4 Test Equipment List

Test Equipment	Manufacturer	Model No.	Serial No.
EMI Receiver	HP	8546A	3617A00320
EMI Receiver Pre-Select.	HP	85460A	3448A00296
Spectrum Analyzer	Agilent	E4446A	US45300564
Log Periodic Antenna	EMCO	93146	9701-4855
Horn Antenna	EMCO	3115	6907
Bicon Antenna	EMCO	93110B	9702-2918
Pre-Amp	Adv. Microwave	WLA612	1145A04094
Horn Antenna – Std. Gain	EMCO	3160-09	9809-1120

5.5 CALCULATION OF RADIATED EMISSIONS LIMITS

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

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands.

Frequency (MHz)	3 m Limit μV/m	3 m Limit (dBμV/m)	1 m Limit (dBμV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion from field strength μV/m to dBμV/m:

$dB\mu V/m = 20 \log_{10} (100)$

= 40 dBμV/m (from 30-88 MHz)

For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.

960 MHz to 10,000 MHz

500μV/m or 54.0 dB/μV/m at 3 meters

54.0 + 9.5 = 63.5 dB/μV/m at 1 meter

5.6 RADIATED EMISSIONS TEST DATA CHART

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

Manufacturer:	Trilliant Networks						
Date(s) of Test:	April 6, 23, 27; June 27, 28 and August 17, 2007						
Test Engineer(s):	Ken Boston						
Voltage:	3.3 VDC						
Operation Mode:	Normal, continuous transmit, modulated						
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %						
EUT Power:		Single Phase ___VAC		3 Phase ___VAC			
		Battery	X	Other:3.3 vdc			
EUT Placement:	X	80cm non-conductive table		10cm Spacers			
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS			
Measurements:		Pre-Compliance		Preliminary	X	Final	
Detectors Used:	X	Peak (with 1 MHz VBW)		Quasi-Peak	X	Average	

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

Frequency (MHz)	Ant./EUT Polarity	Host Mode (Channel)	Height (meters)	Azimuth (0° - 360°)	Measured Peak EFI (dBμV/m)	Corrected EFI (-20.0dB)	15.205 Limit (dBμV/m)	Margin (dB)
2388.5	V/V	2405	1.19	262	71.4	51.4	54.0	2.6
2389.6	V/V	2405	1.19	262	73.4	53.4	54.0	0.6
2484.0	V/V	2475	1.12	323	72.7	52.7	54.0	1.3
2486.0	V/V	2475	1.12	323	73.3	53.3	54.0	0.7
2490.5	V/V	2475	1.12	323	70.4	50.4	54.0	3.6
4809	V/V	2405	1.09	250	69.0	49.0	54.0	5.0
4879	V/V	2440	1.18	308	65.0	45.0	54.0	9.0
4987	V/V	2475	1.18	46	72.3	52.3	54.0	1.7

Note:
A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz.

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

Frequency (MHz)	**Ant./EUT Polarity**	**Antenna Used**	**Height (meters)**	**Azimuth (0-360)**	**Measured EFI (dBuV/m)**
2405.5	V/V	F Ant.	1.22	250	119.0
2440..5	V/V	F Ant.	1.15	266	119.8
2474.5	V/V	F Ant.	1.13	323	117.4
2479.5	V/V	F Ant.	1.13	320	96.6

RADIATED EMISSIONS TEST DATA CHART *(continued)*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 2405:

Frequency (MHz)	Ant./EUT Polarity	Host Mode	Height (meters)	Azimuth (0° - 360°)	Measured Peak EFI (dBμV/m)	Corrected EFI (-20.0 dB)	15.247 Limit (dBμV/m)	Margin (dB)
7216.6	V/V	Whip	1.20	43	75.6	55.6	99.0*	43.4
9622.0	H/Side	F Ant.	1.05	40	82.3	62.3	99.0*	36.7
12022.7	H/Side	F Ant.	1.00	46	76.9	56.9	63.5	6.6
14427.0	H/Side	F Ant.	1.02	225	78.6	58.6	99.0	40.4
19236.5	H/Side	F Ant.	1.00	300	70.4	50.4	63.5	13.1

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 2440:

Frequency (MHz)	Ant./EUT Polarity	Host Mode	Height (meters)	Azimuth (0° - 360°)	Measured Peak EFI (dBμV/m)	Corrected EFI (-20.0 dB)	15.247 Limit (dBμV/m)	Margin (dB)
7318.5	V/V	Whip	1.07	25	77.2	57.2	63.5	6.3
9762.0	H/Side	F Ant.	1.04	323	84.6	64.6	98.8*	34.2
12197.5	H/Side	F Ant.	1.03	33	70.6	50.6	63.5	12.9
14637.0	H/Side	F Ant.	1.00	225	75.5	55.5	98.8*	43.3
19516.0	H/Side	F Ant.	1.00	345	67.0	47.0	63.5	16.5

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 2475:

Frequency (MHz)	Ant./EUT Polarity	Host Mode	Height (meters)	Azimuth (0° - 360°)	Measured Peak EFI (dBμV/m)	Corrected EFI (-20.0 dB)	15.247 Limit (dBμV/m)	Margin (dB)
7423.0	V/V	Whip	1.07	245	73.3	53.3	63.5	10.2
9898.0	H/Side	F Ant.	1.00	50	83.0	63.0	97.4*	34.4
12372.5	V/V	F Ant.	1.07	330	68.2	48.2	63.5	15.3
14847.5	H/Side	F Ant.	1.00	245	71.1	51.1	97.4*	46.3
17328.5	H/Side	F Ant.	1.04	285	70.1	50.1	97.4*	47.3
19796.6	V/V	F Ant.	1.10	0	67.3	47.3	63.5	16.2

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 2480:

Frequency (MHz)	Ant./EUT Polarity	Host Mode	Height (meters)	Azimuth (0° - 360°)	Measured Peak EFI (dBμV/m)	Corrected EFI (-20.0 dB)	15.247 Limit (dBμV/m)	Margin (dB)
					Note 3			

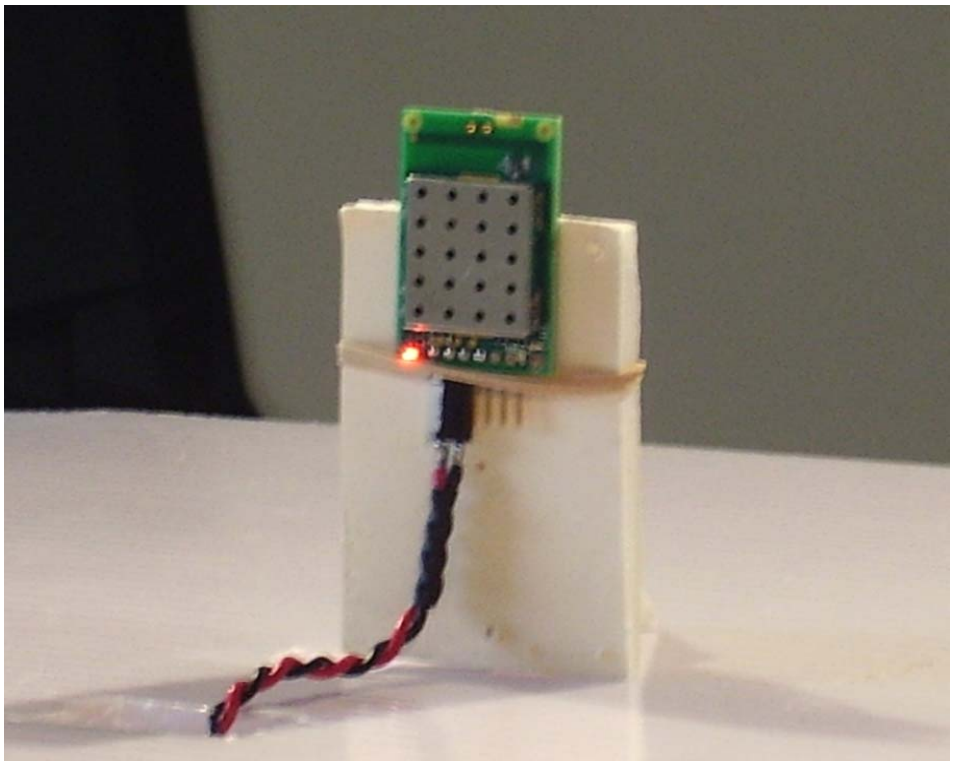
Notes:

1) A Peak as well as an Average Detector was used in measurements above 1 GHz.
2) Measurements above 5 GHz were made at 1 meters of separation from the EUT
3) Measurement at receiver system noise floor.
4) For measurements of the fundamental power, because of spectral bandwidth, the receiver was set to RBW=VBW=3 MHz.
5) A relaxation of the limit is invoked based on the average duty factor of the transmitter on-air-time. Justification appears in Appendix D. The peak emissions were reduced by 20 dB as a correction factor, and compared with the average limit.

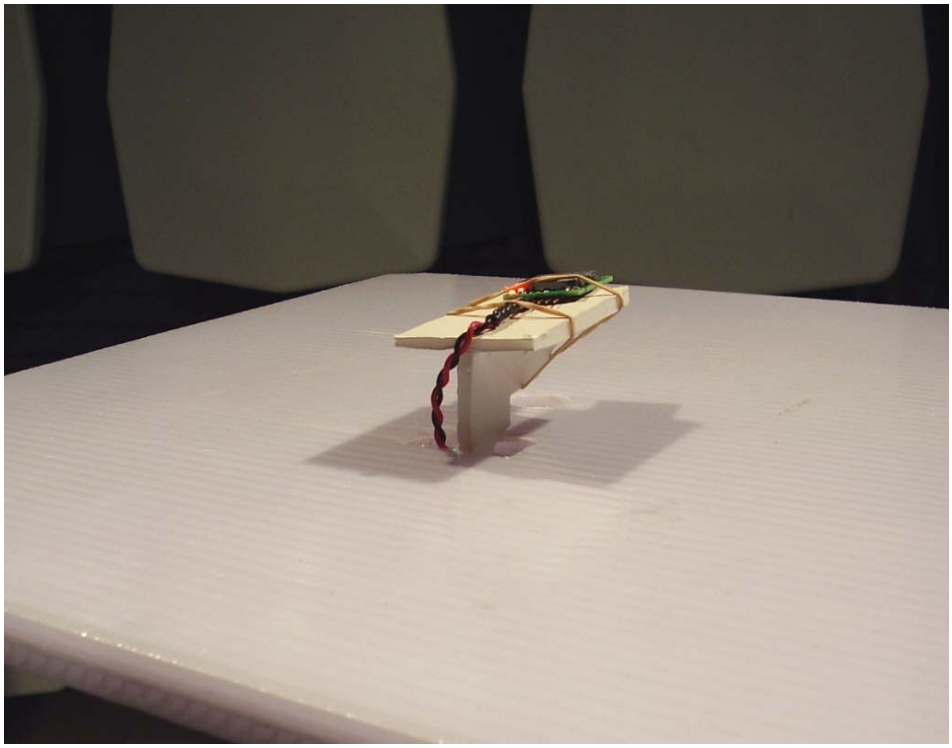
* Limit outside of the 15.247 restricted band (-20dBc).

5.7 Test Setup Photo(s) – Radiated Emissions Test

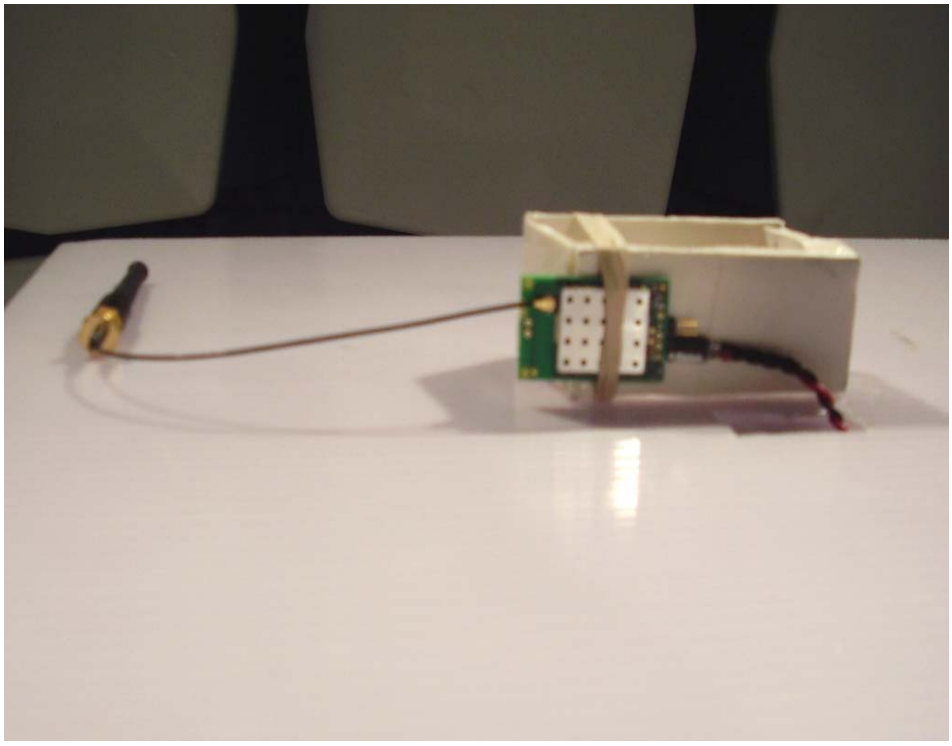
Vertical Orientation



Horizontal Orientation



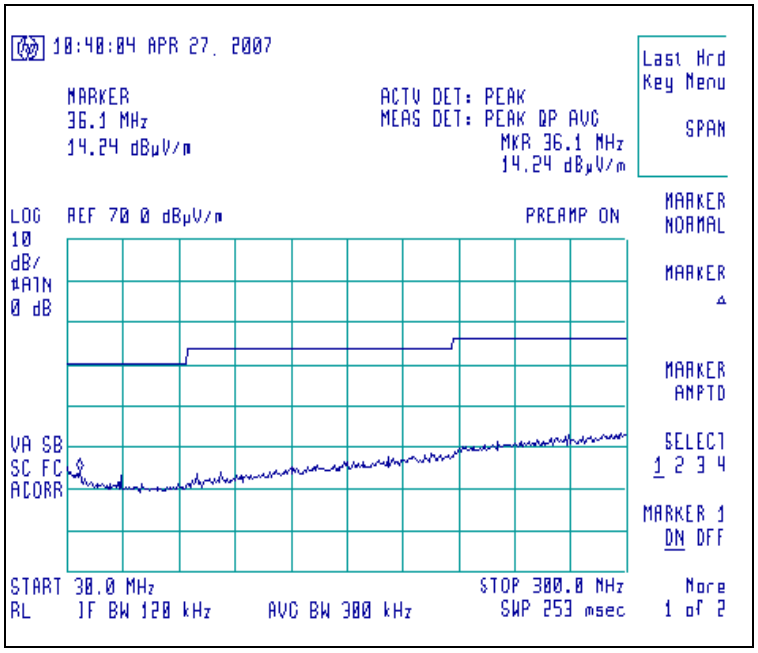
Side Orientation



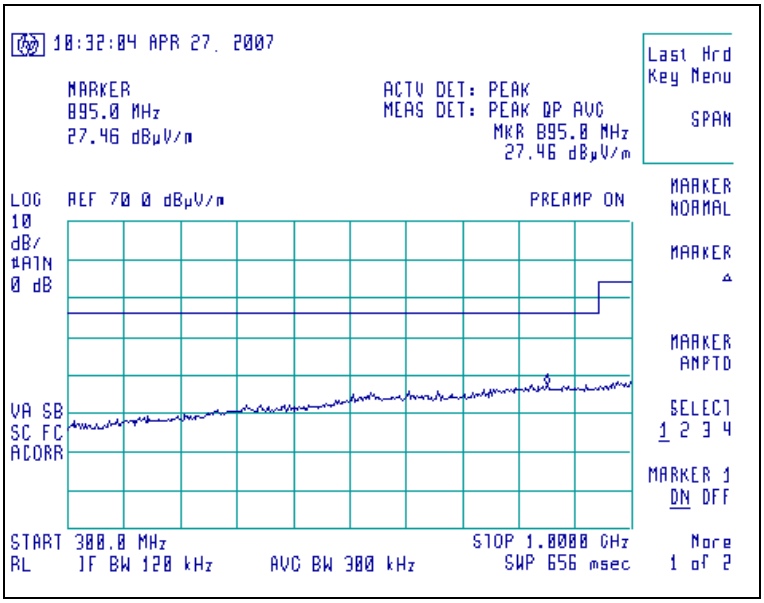
5.8 Screen Captures - Radiated Emissions Testing

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a Peak detector function is utilized when measuring frequencies above 1 GHz. In addition, some signals were re-measured using an average detector.

Channel 2440, Antenna Vertically Polarized, 30-300 MHz, at 3m

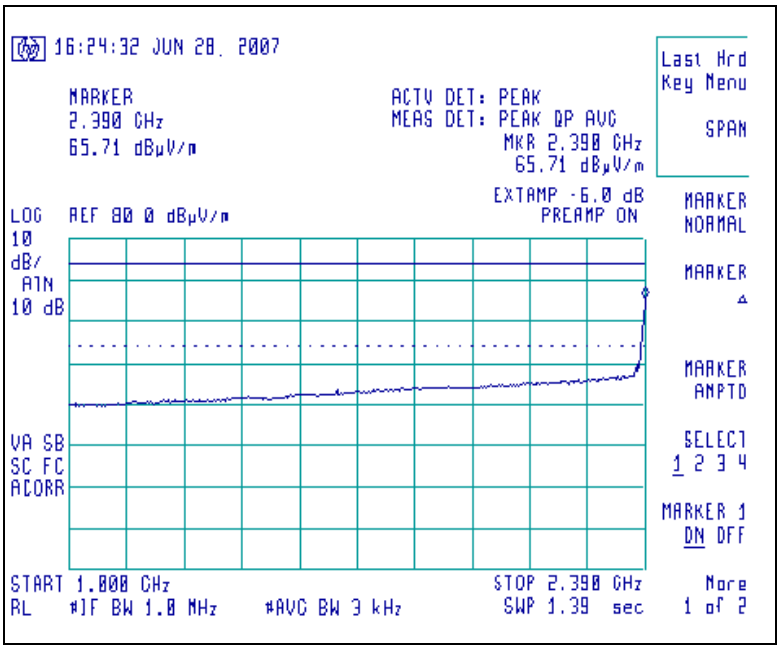


Channel 2440, Antenna Vertically Polarized, 300-1000 MHz, at 3m

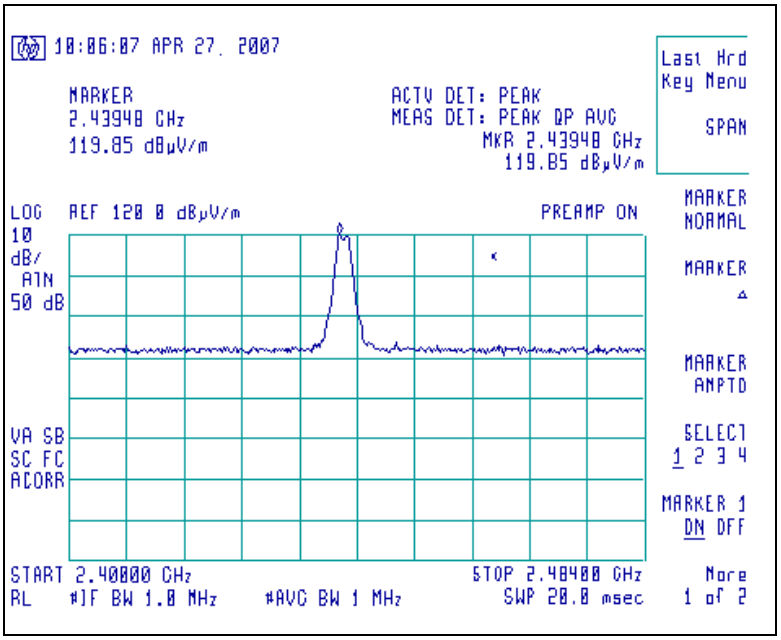


Screen Captures - Radiated Emissions Testing ***(continued)***

Channel 2405, Antenna Vertically Polarized, 1000-2390 MHz, at 3m

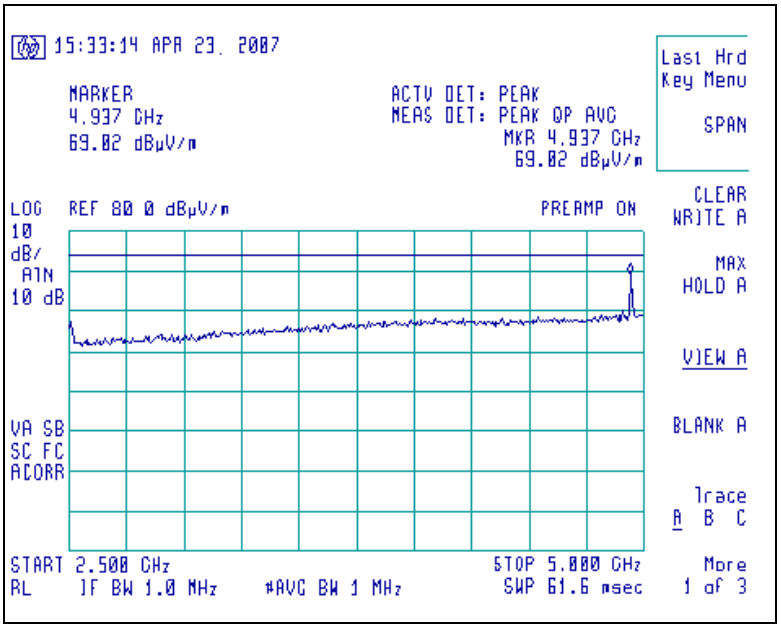


Channel 2440, Antenna Vertically Polarized, 2400-2484.0 MHz, at 3m

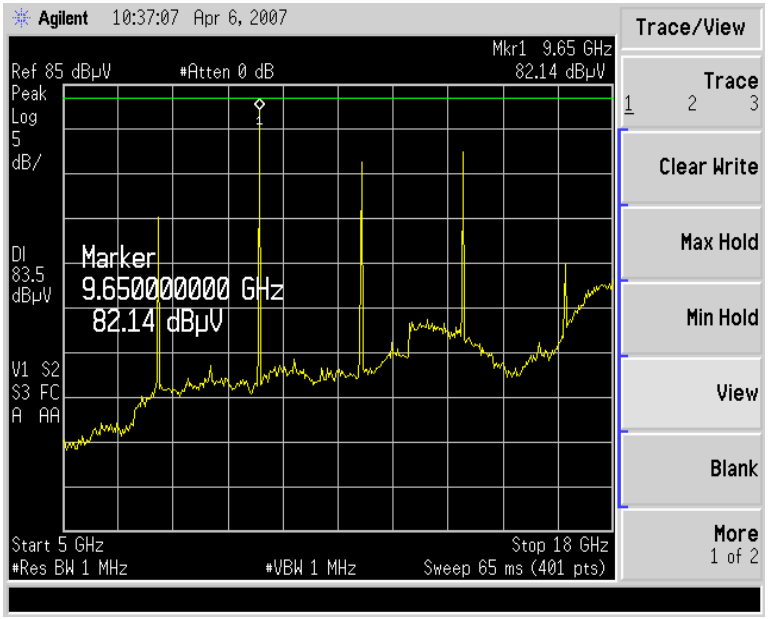


Screen Captures - Radiated Emissions Testing *(continued)*

Channel 2475, Antenna Vertically Polarized, 2500.0-5000 MHz, at 3m



Channel 2405, Antenna Horizontal Polarized, 5000-18000 MHz, at 1m,side,F ant



Screen Captures - Radiated Emissions Testing ***(continued)***

Channel 2440, Antenna Vertically Polarized, 18000-25000 MHz,

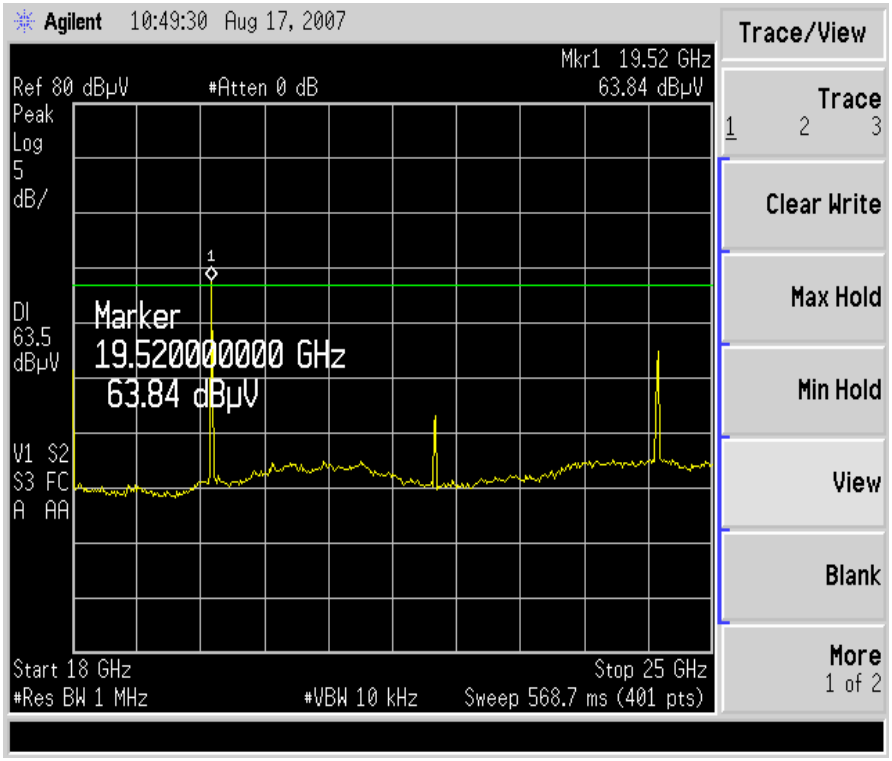


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE: 15.207

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15 (Industry Canada RSS-210, Issue 6). The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120V was provided to the Conducted Emissions Site via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to a 10 dB Attenuator-Limiter, and then to the HP 8546A EMI Receiver. The EMCO LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

6.2 Test Procedure

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

Test Equipment Utilized

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

6.3 Test Equipment List

Test Equipment	Manufacturer	Model No.	Serial No.
EMI Receiver	HP	8546A	3617A00320
Spectrum Analyzer	Agilent	E4446A	US45300564
LISN	EMCO	3816/2NM	9701-1057
Transient Limiter	HP	119474A	3107A01708

Test Results

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

6.4 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)		Measuring Bandwidth
	Quasi-Peak	Average	
0.150 -0.50 *	66-56	56-46	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the logarithm of the frequency in this range.			

6.5 CONDUCTED EMISSIONS TEST DATA CHART

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 Class B

Manufacturer:	Trilliant Networks					
Date(s) of Test:	September 24, 2007					
Test Engineer:	Ken Boston					
Model #:	EM-0033A & EM-0033B					
Serial #:	n/a					
Voltage:	115 VAC source to HP6284A, supplying 3.3 VDC to the EUT					
Operation Mode:	Normal, continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
Test Location:	X	Conducted Emissions Ground Planes				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

		QUASI-PEAK			AVERAGE		
Frequency (MHz)	Line	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµ V)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµ V)	Average Margin (dB)
0.158	L1	51.3	65.5	14.2	19.2	55.5	36.3
0.744	L1	39.0	56.0	17.0	8.7	46.0	37.3
0.155	L2	51.5	65.7	14.2	19.0	55.7	36.7
0.744	L2	38.5	56.0	17.5	8.5	46.0	37.5

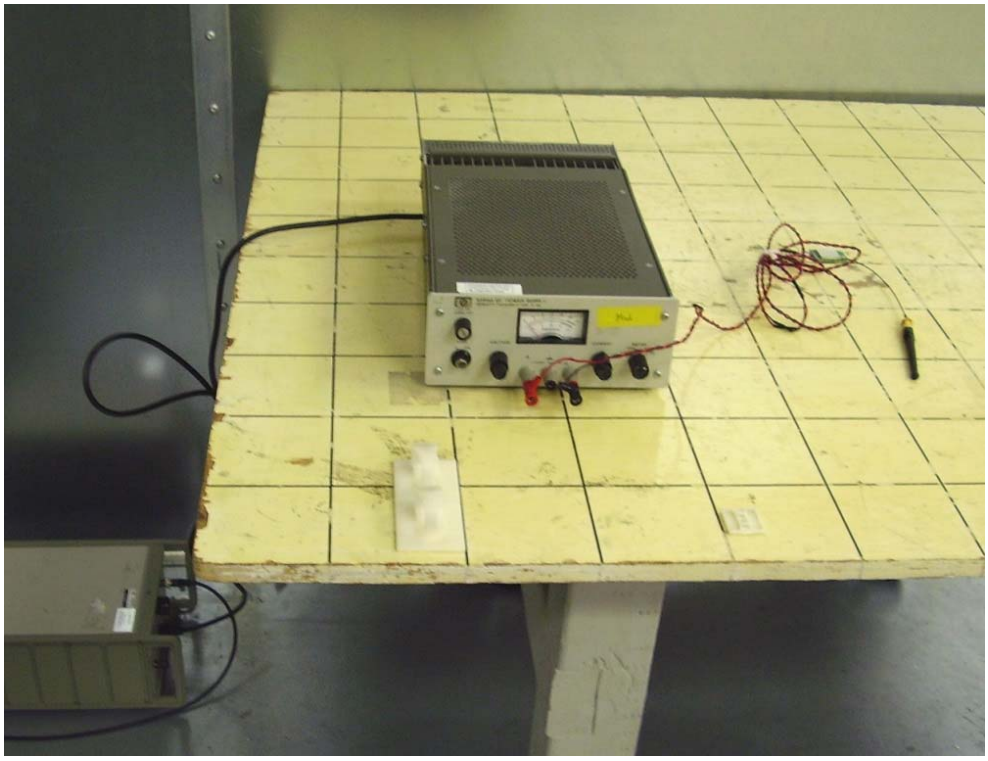
Notes:

1) The emissions listed are characteristic of the power supply used, and did not change due to the presence of the EUT.

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

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

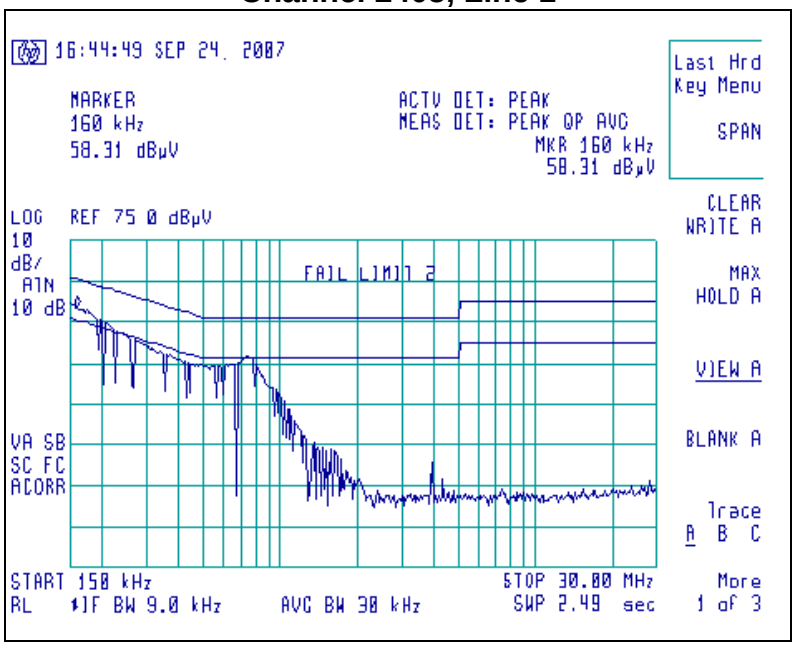
6.6 Test Setup Photo(s)-Conducted Emissions Test



6.7 Screen Captures – Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.207.

Channel 2405, Line 1



Channel 2405, Line 2

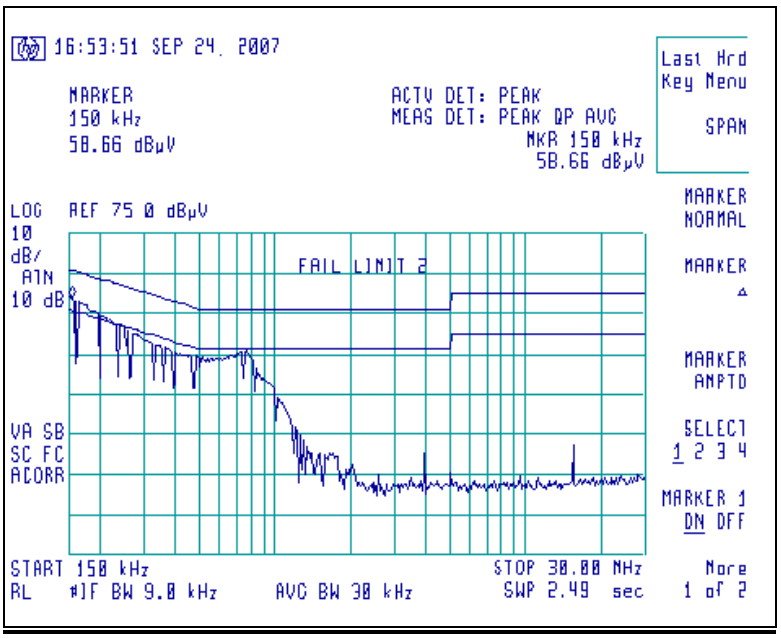


EXHIBIT 7. OCCUPIED BANDWIDTH: 15.247(a)(2)

7.1 Limits

For a Digital Modulation System, the 6 dB bandwidth shall be at least 500 kHz.

7.2 Method of Measurements

Refer to ANSI C63.4 and FCC Procedures (March 23, 2005) for Digital Transmission Systems operating under 15.247.

The transmitter output was connected to the Spectrum Analyzer. The bandwidth of the fundamental frequency was measured with the Spectrum Analyzer using 100 kHz RBW and VBW=100 kHz.

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

From this data, the closest measurement when compared to the specified limit, is 1590 kHz, which is above the minimum of 500 kHz.

Test Data

Channel	Center Frequency (MHz)	Measured -6 dBc Occ. BW (kHz)	Minimum -6 dBc Limit (kHz)	Measured -20 dBc Occ.Bw (kHz)
2405	2405	1590	500	2663
2440	2440	1610	500	2670
2475	2475	1600	500	2670
2480	2480	1600	500	2633

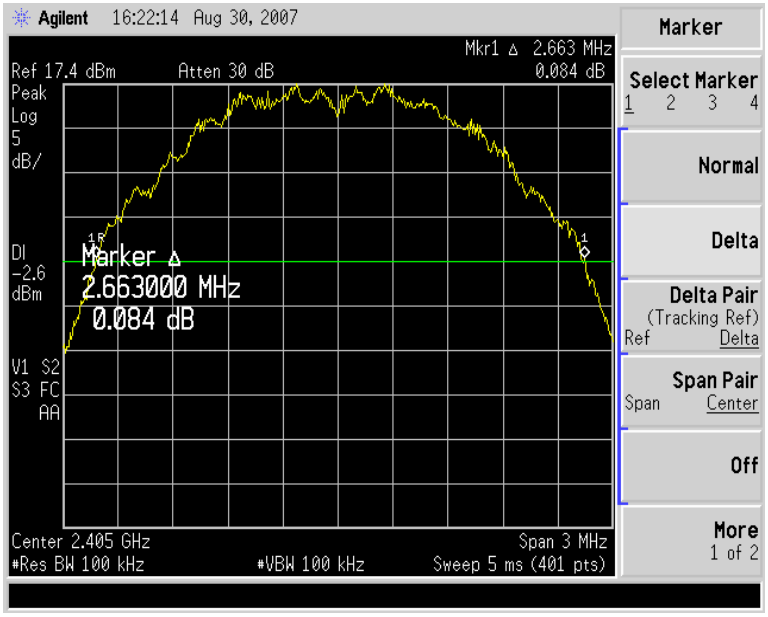
7.3 Test Equipment List

Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4407B	US39160256
Spectrum Analyzer	Agilent	E4446A	US45300564

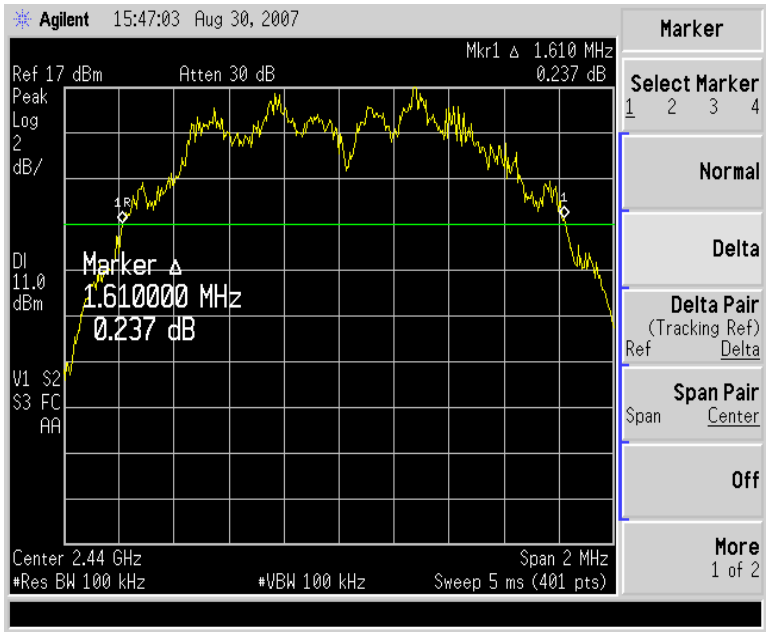
7.4 Screen Captures - OCCUPIED BANDWIDTH

Channel 2405 -6 dBc Occupied Bandwidth

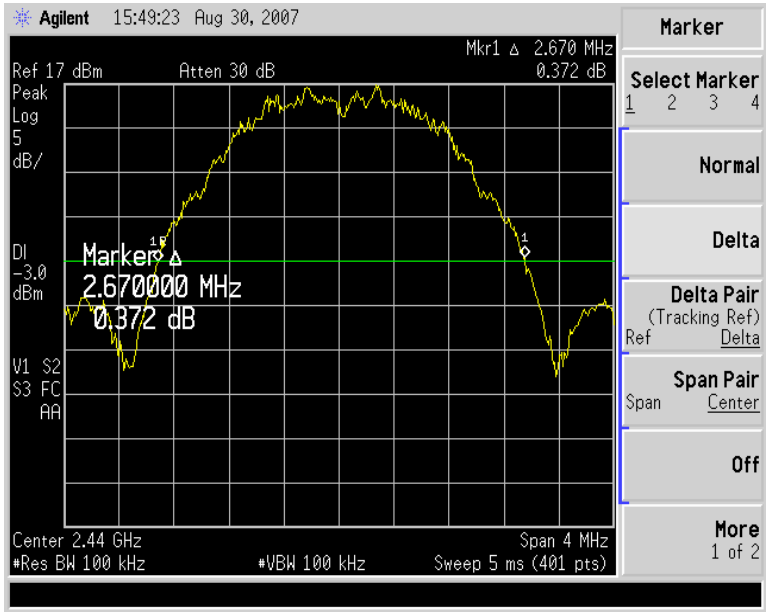
Channel 2405 -20 dBc Occupied Bandwidth



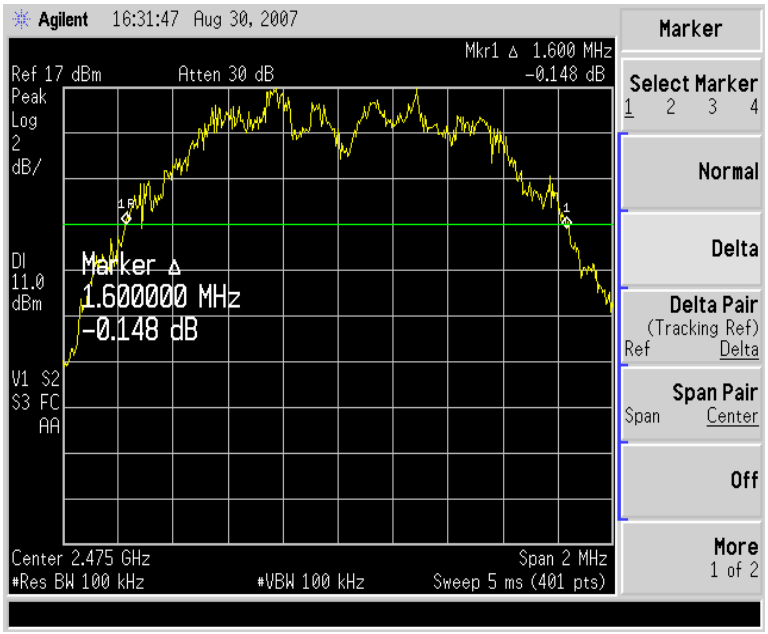
Channel 2440 -6 dBc Occupied Bandwidth



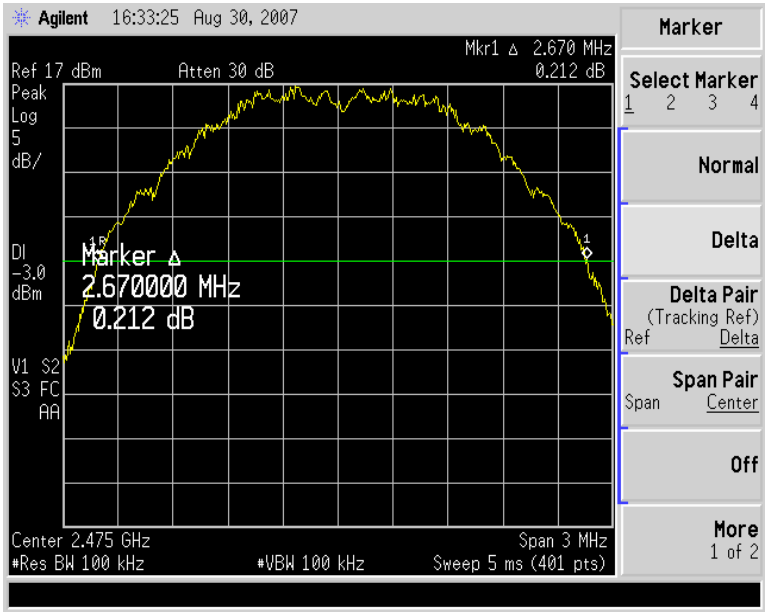
Channel 2440 -20 dBc Occupied Bandwidth



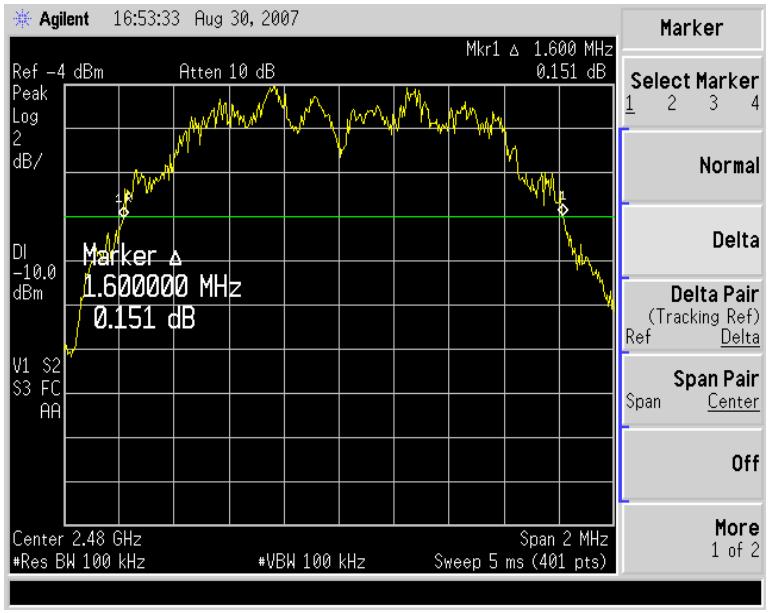
Channel 2475 -6 dBc Occupied Bandwidth



Channel 2475 -20 dBc Occupied Bandwidth



Channel 2480 -6 dBc Occupied Bandwidth



Channel 2480 -20 dBc Occupied Bandwidth

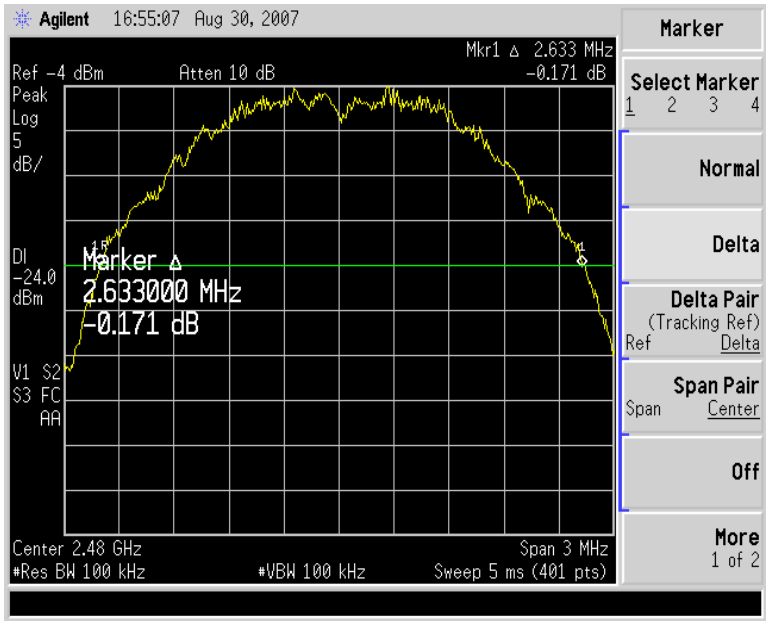


EXHIBIT 8. BAND-EDGE MEASUREMENTS

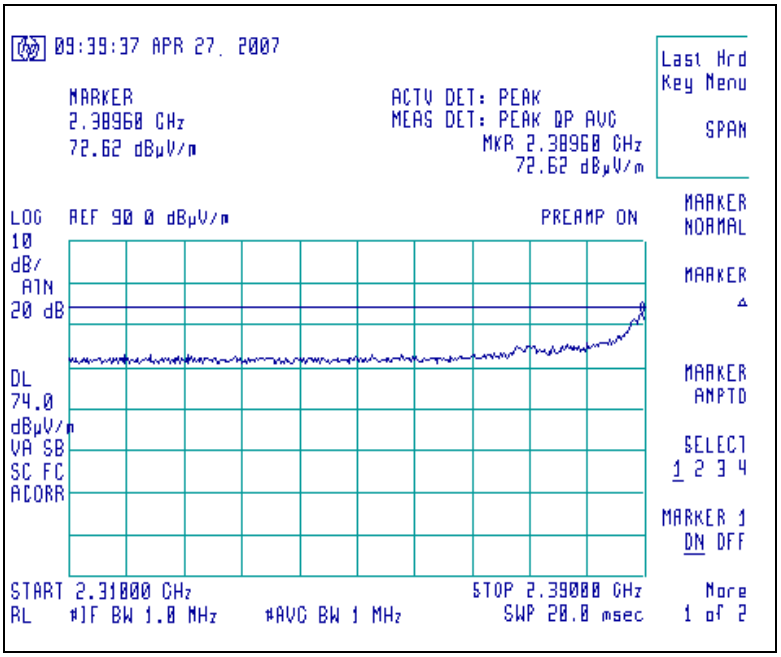
8.1 Method of Measurements

FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. The following screen captures demonstrate compliance of the intentional radiator at the 2400-2483.5 MHz Band-Edges. The EUT was operated in continuous transmit mode with continuous modulation, with internally generated data as the modulating source. The EUT was operated at the lowest channel for the investigation of the lower Band-Edge, and at the highest channel for the investigation of the higher Band-Edge.

The Lower Band-Edge limit, in this case, would be -20 dBc with respect to the fundamental level, and 54 dBuV/m in the band 2310-2390 MHz, at 3 meters..

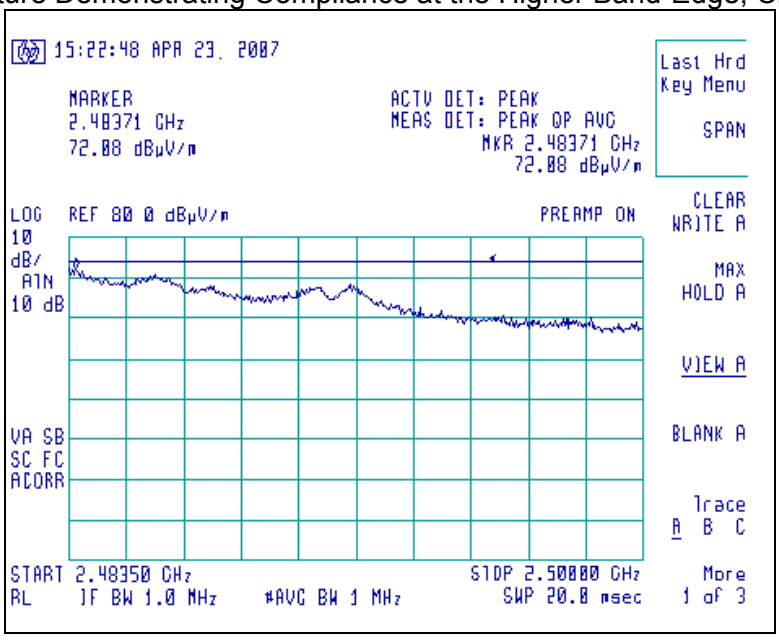
The Upper Band-Edge limit, in this case, would be + 54 dBµV/m at 3m.

Screen Capture Demonstrating Compliance at the Lower Band-Edge, Channel 2405

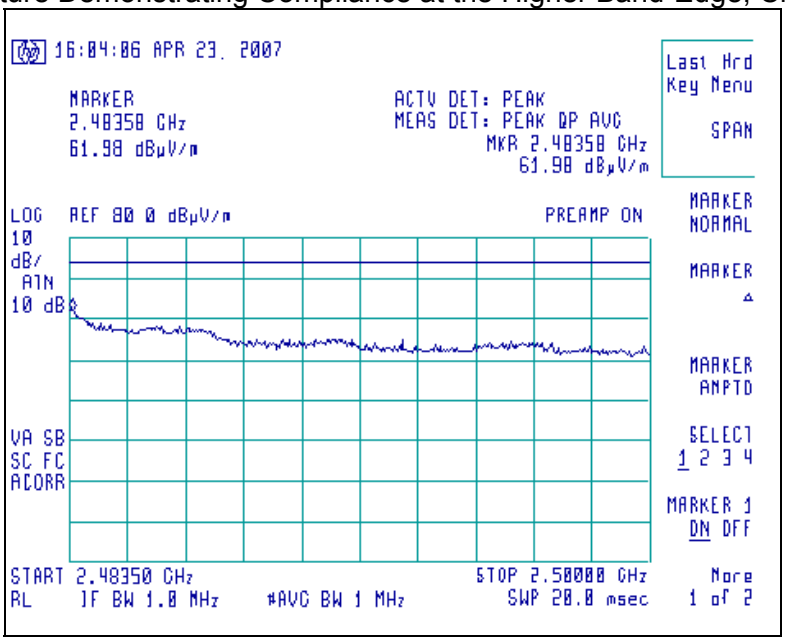


Note: Plots indicate peak radiated level, compared to the peak limit of 74 dBuV/m. Consult table on page 14 of this report for values corrected for the 20 dB duty cycle.

Screen Capture Demonstrating Compliance at the Higher Band-Edge, Channel 2475



Screen Capture Demonstrating Compliance at the Higher Band-Edge, Channel 2480



Note: Plots indicate peak radiated level, compared to the peak limit of 74 dBuV/m. Consult table on page 14 of this report for values corrected for the 20 dB duty cycle.

EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

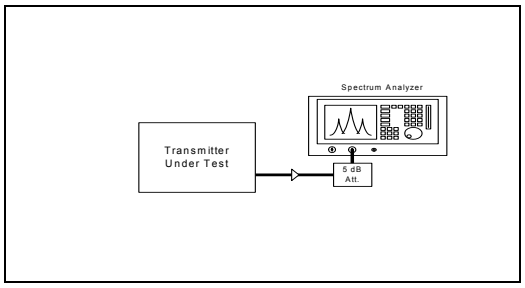
9.1 Method of Measurements

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, there by allowing direct measurements without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with resolution and video bandwidths set to 3 MHz, and a span of 9 MHz, with measurements from a peak detector presented in the chart below.

9.2 Test Data

Transmitter Channel	Freq. (MHz)	Peak Power at Antenna Terminal (dBm)	Calculated |E| @3m (dBuV/m) [1]	Conducted Power Limit (dBm)
Lowest	2405	20.87	119.9	30.0
Middle	2445	20.71	119.7	30.0
	2475	20.99	120.0	30.0
Highest	2480	-0.165	98.9	30.0

[1] EIRP Calculation:
EIRP = (Peak power at antenna terminal in dBm) + (EUT Antenna gain in dBi; 3.8 dBi) + (95.23 dB correction to convert power to field strength at 3 meters)



Rated RF power output (in watts): 0.158

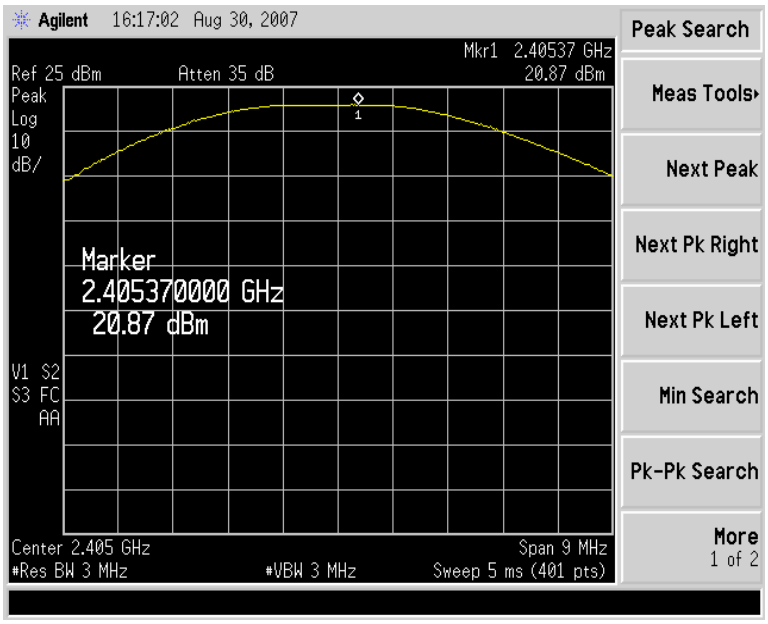
Measured RF Power Output (in Watts): 0.125
Declared RF Power Output (in Watts): 0.158

9.3 Test Equipment List

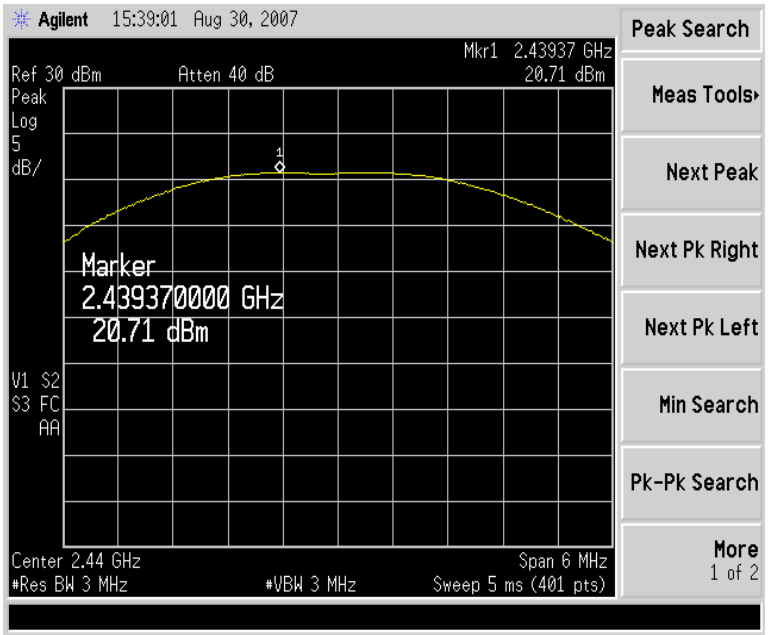
Test Equipment	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Agilent	E44446A	US45300564	To 44 GHz

9.4 Screen Captures – Power Output (Conducted)

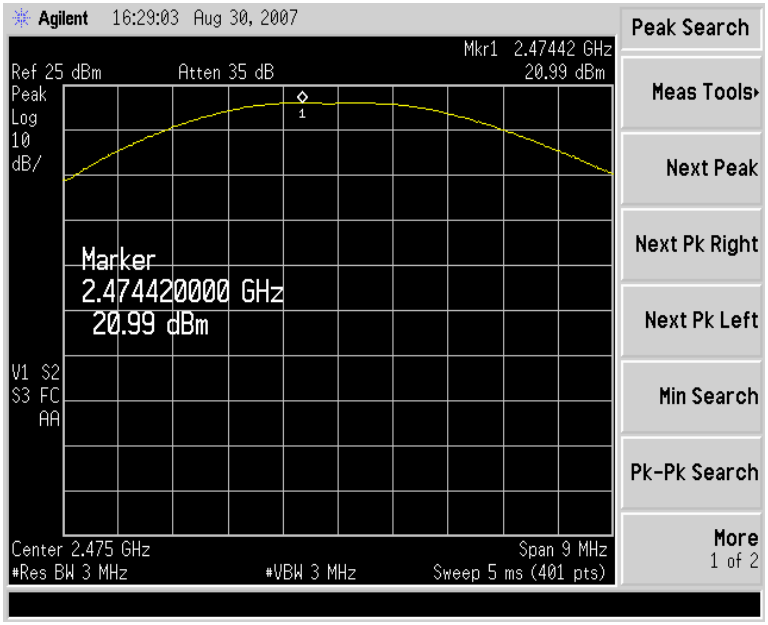
Channel 2405



Channel 2440



Channel 2475



Channel 2480

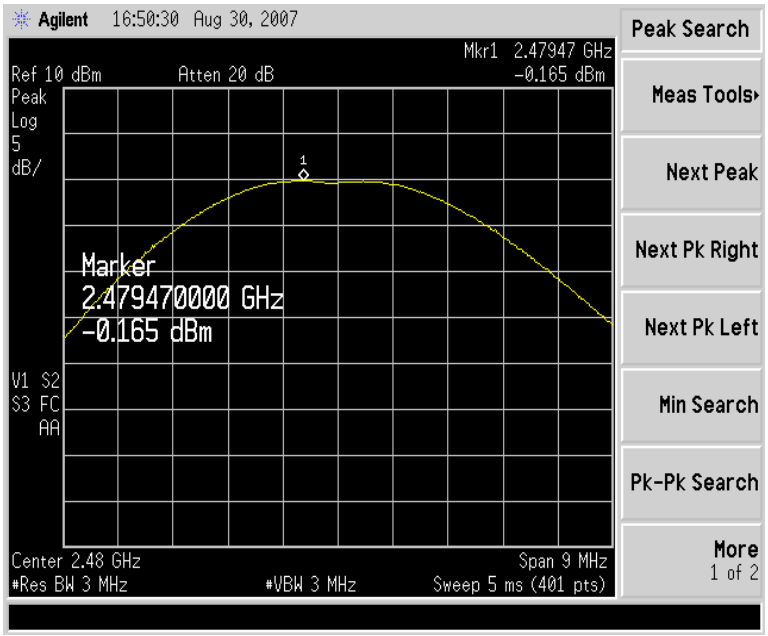


EXHIBIT 10. POWER SPECTRAL DENSITY: 15.247(e)

10.1 Limits

For digitally modulate 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.

In accordance with FCC Part 15.247(e), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in previous sections. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep, and a power density measurement was performed. The highest density in a 3 kHz B.W. was found to be no greater than 6.9 dBm, which is under the allowable limit by 1.1 dB.

10.2 Test Equipment List

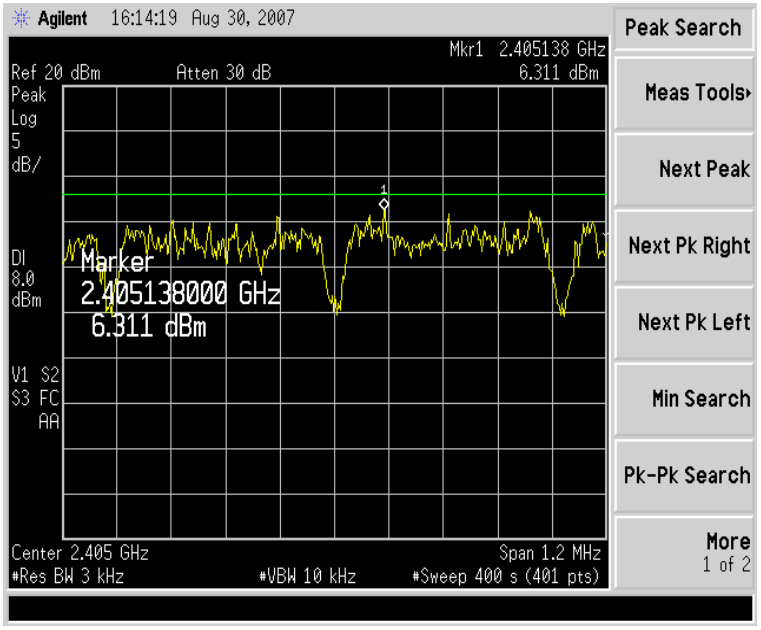
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4446A	US45300564

10.3 Test Data

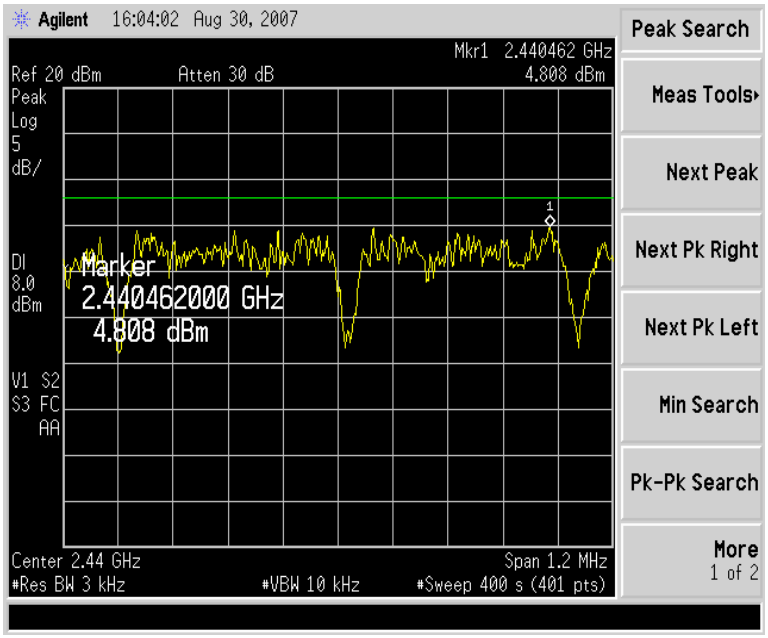
Transmitter Channel	Frequency (MHz)	RF Power Level In 3 kHz BW (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Comments Pass/Fail
Lowest	2405	6.3	8.0	1.7	Pass
Middle	2445	4.8	8.0	3.2	Pass
	2475	6.9	8.0	1.1	Pass
Highest	2480	-14.4	8.0	22.4	Pass

10.4 Screen Captures – Power Spectral Density

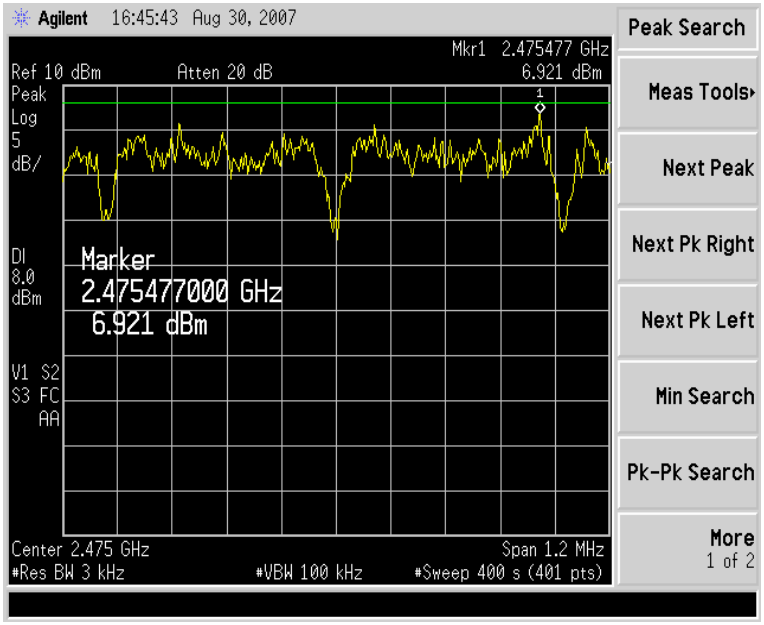
Channel 2405



Channel 2440



Channel 2475



Channel 2480

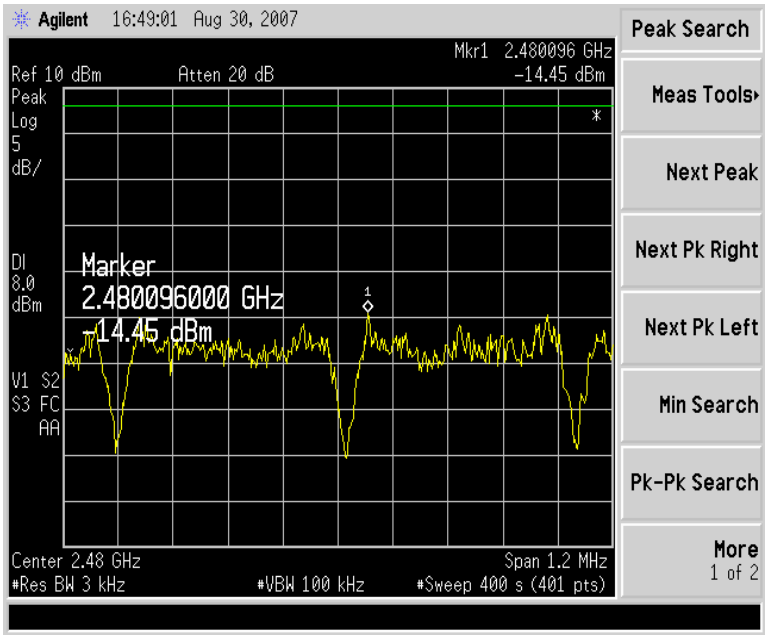


EXHIBIT 11. SPURIOUS RADIATED EMISSIONS: 15.247(d)

11.1 Limits

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 lease 20 db below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

In addition, radiated emissions, which fall in the restricted band, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(e)

Remarks:

- Applies to harmonics/spurious emissions that fall in the restricted bands listed in Section 15.205. The maximum permitted average field strength is listed in Section 15.209.
- The emission limits as specified above are based on measurement instrument employing an average detector. The provisions in Section 15.35 for limiting peak emissions apply.

FCC 47 CFR 15.205(a) – Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 – 0.110	162.0125 – 167.17	2310 – 2390	9.3 – 9.5
0.49 – 0.51	167.72 – 173.2	2483.5 – 2500	10.6 – 12.7
2.1735 – 2.1905	240 – 285	2655 – 2900	13.25 – 13.4
8.362 – 8.366	322 – 335.4	3260 – 3267	14.47 – 14.5
13.36 – 13.41	399.9 – 410	3332 – 3339	14.35 – 16.2
25.5 – 25.67	608 – 614	3345.8 – 3358	17.7 – 21.4
37.5 – 38.25	960 – 1240	3600 – 4400	22.01 – 23.12
73 – 75.4	1300 – 1427	4500 – 5250	23.6 – 24.0
108 – 121.94	1435 – 1626.5	5350 – 5460	31.2 – 31.8
123 – 138	1660 – 1710	7250 – 7750	36.43 – 36.5
149.9 – 150.05	1718.8 – 1722.2	8025 – 8500	Above 38.6
156.7 – 156.9	2200 – 2300	9000 – 9200	

FCC 47 CFR 15.209(a) Field Strength Limits within Restricted Frequency Bands

Frequency (MHz)	Field Strength Limits (microvolts/m)	Distance (Meters)
0.009 – 0.490	2,400 / F (kHz)	300
0.490 – 1.705	24,000 / F (kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

Calculation of Radiated Emission Measurements

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

FCC Part 15.247(d) requires a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. A Hewlett Packard model E4446A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

No significant emissions could be noted within -50 dBc of the fundamental level for this product.

	Channel 2405	Channel 2440	Channel 2475
Fundamental	+ 17.6 (dBm)	+ 16.2 (dBm)	+ 16.25 (dBm)
2nd Harmonic	Note (1)	Note (1)	Note (1)
3rd Harmonic	Note (1)	Note (1)	Note (1)
4th Harmonic	- 46.8 (dBm)	- -45.4 (dBm)	- 44.8 (dBm)
5th Harmonic	Note (1)	Note (1)	Note (1)
6th Harmonic	Note (1)	Note (1)	Note (1)
7th Harmonic	Note (1)	Note (1)	Note (1)
8th Harmonic	Note (1)	Note (1)	Note (1)
9th Harmonic	Note (1)	Note (1)	Note (1)
10th Harmonic	Note (1)	Note (1)	Note (1)

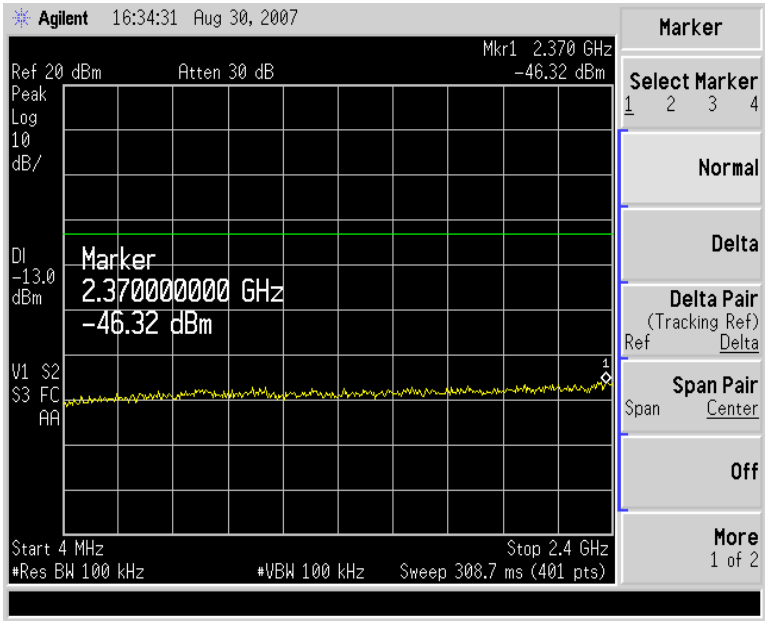
Notes:
(1) Measurement at system noise floor.
(2) Fundamental of channel 2480 was below -5.0 dBm, and all harmonics were at the system noise floor.

11.2 Test Equipment List

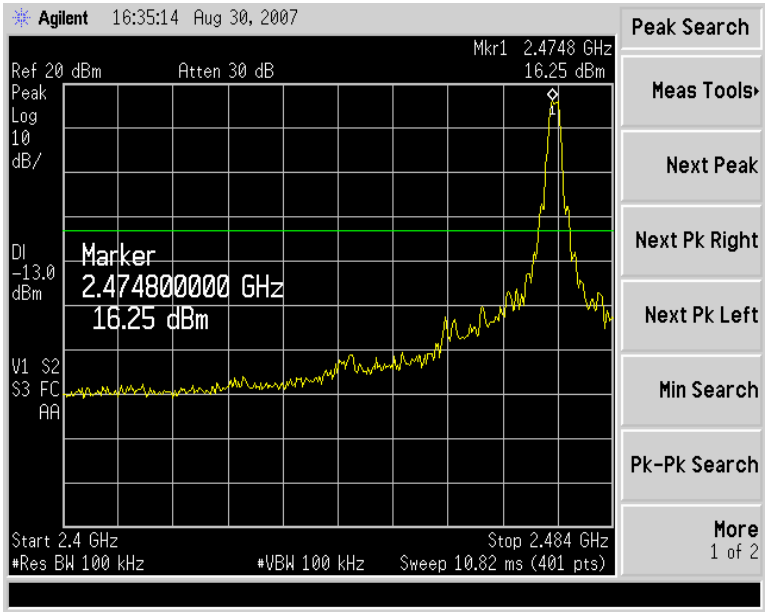
Test Equipment	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Agilent	E4446A	US45300564	To 44 GHz

11.3 Screen Captures – Spurious Radiated Emissions

Channel 2475, shown from 4 MHz up to 2400 MHz



Channel 2475, shown from 2400 MHz up to 2484 MHz



Channel 2475, shown from 2500 MHz up to 25000 MHz

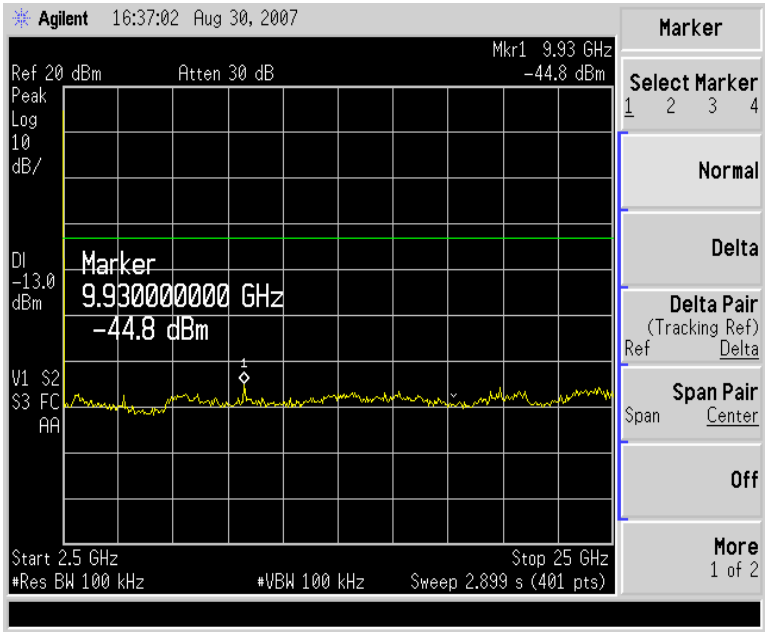


EXHIBIT 12. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

The stability of the device was examined as a function of the input voltage available to the EUT.

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

	DC/AC Voltage Source		
	2.8 VDC	3.3 VDC	3.8 VDC
Channel 2405	2405.0343	2405.0342	2405.0338
Channel 2475	2475.2900	2475.02905	2475.02906

The RF Power Output of the EUT was also monitored in a separate test, also using a Spectrum Analyzer with RBW=VBW=3 MHz setting while the voltage was varied.

	DC/AC Voltage Source		
	2.8 VDC	3.3 VDC	3.8 VDC
Channel 2405	19.3 dBm	20.7 dBm	21.7 dBm
Channel 2475	19.5 dBm	20.8 dBm	21.8 dBm

EXHIBIT 13. MPE CALCULATION

The following MPE calculations are based on a 1.8 centimeter inverted-F printed circuit board trace antenna, with a measured ERP of 119.8 dBµV/m, at 3 meters over a reflective ground plane, and conducted RF power of +20.71 dBm as presented to the antenna. The calculated gain of this antenna, based on the ERP measurements is 3.8 dB (119.8 – 95.23 - 20.71 = 3.86 rounded down to 3.8).

Prediction of MPE limit at a given distance

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

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

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

Maximum peak output power at antenna input terminal:	21.00	(dBm)
Maximum peak output power at antenna input terminal:	125.893	(mW)
Antenna gain(typical):	3.8	(dBi)
Maximum antenna gain:	2.399	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2400	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Power density at prediction frequency:	0.060080	(mW/cm^2)
Maximum allowable antenna gain:	16.0	(dBi)
Margin of Compliance at 20 cm =	12.2	dB

APPENDIX A

Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	12/6/07	12/6/08
AA960031	HP	119474A	3107A01708	Transient Limiter	Note 1	Note 1
AA960077	EMCO	93110B	9702-2918	Biconical Antenna	9/19/07	9/19/08
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	9/19/07	9/19/08
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	12/04/06	12/04/07
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	1/11/07	1/11/08
EE960004	EMCO	2090	9607-1164	Device Controller	N/A	N/A
EE960013	HP	8546A	3617A00320	Receiver RF Section	9/20/07	9/20/08
EE960014	HP	85460A	3448A00296	Receiver Pre-Selector	9/20/07	9/20/08
EE960073	Agilent	E4446A	US45300564	Spectrum Analyzer	8/17/07	8/17/08
N/A	LSC	Cable	0011	3 Meter ½" Armored Cable	Note 1	Note 1
N/A	LSC	Cable	0050	10 Meter RG 214 Cable	Note 1	Note 1
N/A	Pasternack	Attenuator	N/A	10 dB Attenuator	Note 1	Note 1

Note 1 - Equipment calibrated within a traceable system.

Uncertainty Statement

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

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

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

Appendix B

Justifications of Average Duty Factor Calculations

The following calculations support the request for relaxation factor as applied to the radiated EFI measurements, based on the duty factor of the transmitter.

Relaxation Factor
Average Factor = 20 * Log_{10} (EUT On-time over 100 ms time window)
With a 6 millisecond packet length, the relaxation factor allowance is calculated as:

Average Factor = 20 * Log_{10} (6.0 ms) = -24.4 dB

A relaxation factor of 20.0 dB (the highest allowed cap) would be allowable for this product.

Trilliant Networks 22dB Radio Module
Relaxation Factor

May 16, 2007

The Trilliant Networks 22dB Radio Module does not transmit for more than 10ms over a 100ms time period. The reason allows timeouts between packets for acknowledgements to individual messages that exceeds the 100ms timeframe. The radio module receives its information by a host module and is limited by both communication speed and timeouts allowed for responses from the mesh network. Shown below are two examples of communication, packet retry and subsequent packets.

A typical example where a packet is retried over the network:

A) Message is transmitted by the radio, with the total transmission requiring 6ms over the air time.
B) We allow up to 125ms for an acknowledgement before message retries.
C) In the retry scenario, the message would be resent 125ms after the first message.

An example of subsequent different messages would be:

A) Message packet 1 is transmitted by the radio, with the total transmission requiring 6ms over the air time.
B) An acknowledgement is received quickly, within 35ms.
C) The radio sends the host module that the ACK occurred, and a second packet is sent from the host module to the radio. Due to different communication speeds and protocol, the second message is sent to the radio within 75ms.
D) In the subsequent message scenario, the second packet of 6ms duration is sent 110ms in an absolute best-case scenario after the first message is completed.

In both cases, the transmission time is max. 6 milliseconds within a 110 or 125 millisecond time window.

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