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ENGINEERING TEST REPORT # 307131 TX
LSR JOB # R-351

Compliance Testing of:
Crestron Freestar Front-End RF Module
Model #: CWD1014 and CWD1015

Test Date(s):
December 8th – 17th, 2007

Prepared For:
Crestron
Attn: Paul Connell
6 Volvo Drive
Rockleigh, NJ 07647

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: January 17, 2008

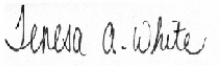
Test Report Reviewed by:	**Tested by:**
Teresa A. White, Quality Manager	Ryan M. Urness, EMC Lab Manager
Signature: 	Signature: 
Date: January 17, 2008	Date: 01/17/08

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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 Split Modular 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:	Crestron
Address:	6 Volvo Drive Rockleigh, NJ 07647
Contact Person:	Paul Connell

2.2 EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information has been supplied by the applicant.

Product Name:	Crestron Freestar Front-End RF Module
Model Number:	CWD1014 & CWD1015
Serial Number:	Engineering Samples

2.3 ASSOCIATED ANTENNA DESCRIPTION

Two antenna configurations were used during testing. These antenna configurations included:

a.) ACE Technology ACE-2400NF dipole antenna. Non-standard reverse SMA connector, 0-90° adjustable (0°=12cm, 90°=10cm), manufacturer declared gain of 2dBi ±0.5.

b.) Crestron cabled PCB Ceramic chip antenna. U.FL connector type. Cable measures 5cm.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

Frequency Range (in MHz)	2400 – 2483.5 MHz
RF Power in Watts	.0887 W
Conducted Output Power (in dBm)	19.48 dBm
Field Strength (and at what distance)	117.8 dBµV/m @ 3m
Occupied Bandwidth (99% BW)	2.47 MHz
Type of Modulation	MSK
Emission Designator	F1D2M4
EIRP (in mW)	180 mW
Transmitter Spurious (worst case)	60.48 dBµV/m @ 9.62 GHz
Frequency Tolerance %, Hz, ppm	< 100ppm
Microprocessor Model # (if applicable)	MC9S08GT60CFDE
Antenna Information	
Detachable/non-detachable	Detachable
Type	Dipole & Ceramic Chip
Gain (in dBi)	2.0 dBi +/- 0.5
EUT will be operated under FCC Rule Part(s)	15.247
Modular Filing	☒ 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: CFR 47 Part 15 § 247
- Measurement Distance: 3m
- RF Value: 0.776247 ☒ V/m ☐ A/m ☐ W/m^2
  ☐ Measured ☐ Computed ☒ Calculated

2.5 PRODUCT DESCRIPTION

The Crestron CWD1014 & CWD1015 RF Module shall be classified as a split modular device as defined in CFR 47 Part 15 § 212 (2). The front end module consists of the Freescale MC13192FC transceiver working in conjunction with a power amplifier. The radio control element is based on the Freescale MC9S08GT60CFDE processor. The I/O associated with the radio front-end is realized by PCB castellations and are all captive between the radio front end and radio control element assemblies.

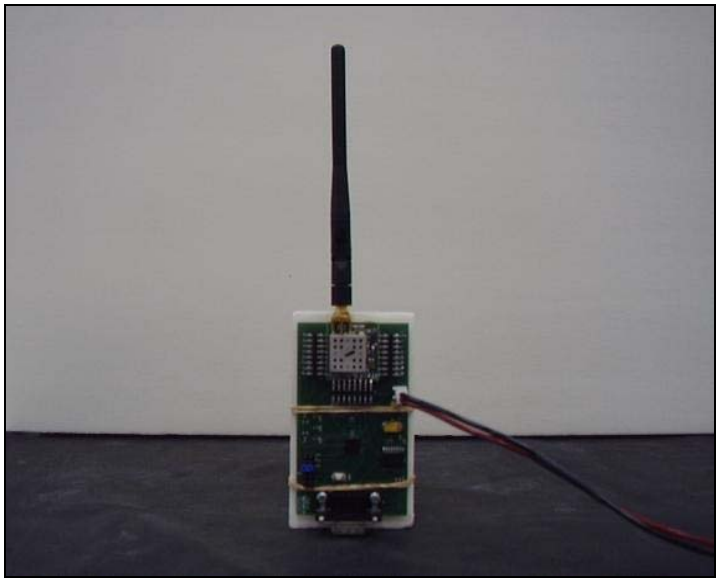
For the purpose of testing, two evaluation platform fixtures were used during testing. The radio control element was placed in a Crestron supplied evaluation platform fixture, part number CEN-HPRFGW, for radiated fundamental, harmonics and conducted measurements. The radio control element was placed in a LS Research evaluation platform fixture for radiated spurious measurements.

Two alternative antenna configurations were tested. These antenna configurations included:

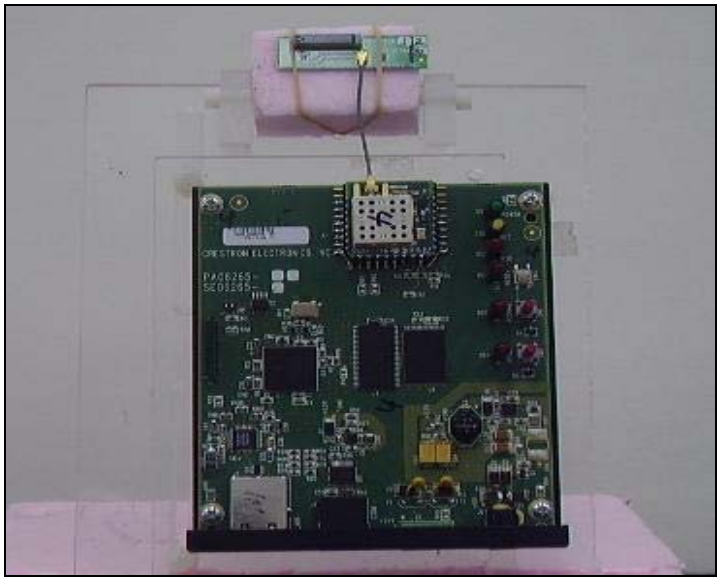
1.) ACE Technology ACE-2400NF dipole antenna. Non-standard reverse SMA connector, 0-90° adjustable (0°=12cm, 90°=10cm), manufacturer declared gain of 2dBi ±0.5.

2.) Crestron cabled PCB Ceramic chip antenna. U.FL connector type. Cable measures 5cm.

PHOTO (Optional)



LSR Evaluation Platform Fixture with ACE-2400NF Dipole Antenna Configuration



Customer Supplied Evaluation Platform Fixture (CEN-HPRFGW) with PCB Ceramic Chip Antenna Configuration

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	72°
Humidity:	40%
Pressure:	102 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)**

The module was operated in reduced power setting on several channels:

Channel	Power Setting (Dipole)	Power Setting (Ceramic Chip)
11 (2405MHz)	06	10
12 (2410MHz)	16	16
18 (2440MHz)	16	16
23 (2465MHz)	16	16
24 (2470MHz)	10	10
25 (2475MHz)	06	06
26 (2480MHz)	02	02

The maximum power setting possible for the module is 21, however the manufacturer will set the maximum at 16 by means of firmware. The end user will not have access to power control and thus will limit the maximum power setting at 16. Power settings as listed above will be set by the manufacturer in the final product.

Note: Power level 16 will hence be called full power in the remainder of this report.

3.4 DEVIATIONS & EXCLUSIONS FROM TEST SPECIFICATIONS

☐ **None** ☒ **Yes (explain below)**

1.) A 4.7 dB relaxation factor is used when comparing emissions to the limits due to the transmission nature of the module. Justification and request for relaxation is included in the report in Appendix D.

2.) Although the fundamental and the band edge measurements were made on 7 channels, the harmonics measurements were made on the lowest, medium and highest channel at full power (instead of reduced power on the lowest and highest channel). Based on sound engineering principles, it would be valid to conclude that if the harmonics on the lowest and highest channels operating at full power are below the limit, the harmonics of the remaining channels operating at reduced power levels will also.

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 modulating continuous transmit mode, using 3.0Vdc power as provided by an 120VAC voltage regulator and customer provided Evaluation Platform Fixture (CEN-HPRFGW), or laboratory grade DC power supply and LSR Evaluation Platform Fixture. The unit has the capability to operate on 15 channels, controllable via laptop PC (CEN-HPRFGW) or jumpers (LSR Fixture).

The applicable limits apply at a 3 meter distance. Measurements above 5 GHz were performed at a 1 meter separation distance. Measurements above 18 GHz were performed at a 0.30 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 (2480MHz) to comply with FCC Part 15.35.

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 0.3 meter separation, using a standard gain Horn Antenna and pre-amplifier.

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

When testing the EUT configuration using the ACE-2400NF dipole antenna, both 0° and 90° antenna adjustments.

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

For measurements made at 0.3 meter, a 20 dB correction has been invoked.

960 MHz to 10,000 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 20 = 74 dB/μV/m at 0.3 meters

5.6 RADIATED EMISSIONS DATA CHART

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

Manufacturer:	Crestron						
Date(s) of Test:	December 8th – 17th, 2007						
Test Engineer(s):	Ryan Urness						
Voltage:	3.3Vdc						
Operation Mode:	Modulated Continuous Output						
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %						
EUT Power:		Single Phase ___VAC		3 Phase ___VAC			
		Battery	X	Other: 3.3Vdc			
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	X	Quasi-Peak	X	Average	

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 11:

Frequency (MHz)	EUT/Ant. Polarity	Antenna Type	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2405	H/H	Dipole St.	1.15	243°	117.8	125.2	7.4
2405	H/V	Dipole 90°	1.75	0°	112.8	125.2	12.4
2405	V/H	Cer. Chip	1.93	265°	115.4	125.2	9.8
4810	H/H	Dipole St.	1.00	290°	48.5	63.5	15.0
4810	H/V	Dipole 90°	1.00	54°	47.6	63.5	15.9
4810	S/H	Cer. Chip	1.00	46°	49.3	63.5	14.2
7215	H/V	Dipole St.	1.22	346°	51.2	105.2	54.0
7215	H/V	Dipole 90°	1.22	347°	52.4	105.2	52.8
7215	S/V	Cer. Chip	1.00	353°	57.5	105.2	47.7
9620	H/V	Dipole St.	1.00	30°	50.4	105.2	54.8
9620	H/V	Dipole 90°	1.00	35°	47.0	105.2	58.2
9620	S/H	Cer. Chip	1.00	12°	60.5	105.2	44.7
12025	H/H	Dipole St.	1.08	316°	52.6	63.5	10.9
12025	H/H	Dipole 90°	1.05	307°	50.3	63.5	13.2
12025	V/H	Cer. Chip	1.00	7°	53.8	63.5	9.7
14430	H/V	Dipole St.	1.00	347°	50.5	105.2	54.7
14430	H/V	Dipole 90°	1.00	345°	48.9	105.2	56.3
14430	S/V	Cer. Chip	1.00	38°	54.6	105.2	50.6

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 18:

Frequency (MHz)	EUT/Ant. Polarity	Antenna Type	Height (meters)	Azimuth (0° - 360°)	Measured EFl (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2440	H/H	Dipole St.	1.10	247°	116.9	125.2	8.3
2440	H/V	Dipole 90°	1.16	175°	115.2	125.2	10.0
2440	S/V	Cer. Chip	1.10	194°	115.8	125.2	9.4
4880	S/H	Dipole St.	1.00	115°	53.4	63.5	10.1
4880	S/H	Dipole 90°	1.00	117°	51.3	63.5	12.2
7320	S/H	Dipole St.	1.00	138°	55.5	63.5	8.0
7320	S/H	Dipole 90°	1.00	45°	57.3	63.5	6.2
7320	S/V	Cer. Chip	1.00	6°	57.0	63.5	6.5
9760	S/H	Dipole St.	1.00	130°	52.7	105.2	52.5
9760	S/H	Dipole 90°	1.00	123°	52.1	105.2	53.1
9760	S/H	Cer. Chip	1.00	15°	59.8	105.2	45.4
12200	S/H	Dipole St.	1.00	104°	52.3	63.5	11.2
12200	S/H	Dipole 90°	1.00	116°	50.3	63.5	13.2
12200	S/V	Cer. Chip	1.00	0°	56.6	63.5	6.9
14640	S/H	Dipole St.	1.00	156°	44.5	105.2	60.7
14640	S/V	Cer. Chip	1.00	310°	49.6	105.2	55.6

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 26:

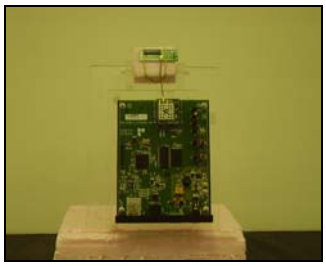
Frequency (MHz)	EUT/Ant. Polarity	Antenna Type	Height (meters)	Azimuth (0° - 360°)	Measured EFl (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2480	H/H	Dipole St.	1.10	106°	114.8	125.2	10.4
2480	H/V	Dipole 90°	1.15	177°	113.6	125.2	11.6
2480	V/H	Cer. Chip	1.08	202°	116.1	125.2	9.1
4960	S/H	Dipole St.	1.00	117°	48.6	63.5	14.9
4960	S/H	Dipole 90°	1.00	112°	48.1	63.5	15.4
4960	S/V	Cer. Chip	1.00	18°	45.3	63.5	18.2
7440	S/H	Dipole St.	1.00	52°	56.1	63.5	7.4
7440	S/H	Dipole 90°	1.00	39°	56.9	63.5	6.6
7440	S/V	Cer. Chip	1.00	40°	53.2	63.5	10.3
9920	S/H	Dipole St.	1.00	114°	51.0	105.2	54.2
9920	S/H	Dipole 90°	1.00	113°	50.5	105.2	54.7
9920	S/V	Cer. Chip	1.00	25°	56.8	105.2	48.4
12400	S/V	Dipole St.	1.00	89°	53.5	63.5	10.0
12400	S/V	Dipole 90°	1.00	92°	52.2	63.5	11.3
12400	S/V	Cer. Chip	1.00	347°	49.0	63.5	14.5

Notes:

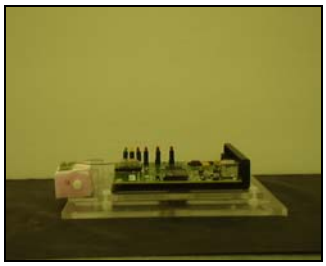
1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2) Measurements above 5 GHz were made at 1 meters of separation from the EUT, and at 0.3 m separation for frequencies between 18 – 25 GHz.
3) Measurement at receiver system noise floor.
4) For measurements of the fundamental power, because of spectral bandwidth, the receiver was set to RBW=VBW=1 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 measurements have been recalculated and reduced by 4.7 dB as justified by the averaging factor.

5.7 Test Setup Photo(s) – Radiated Emissions Test

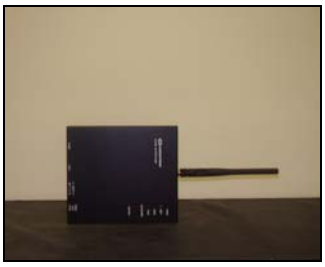
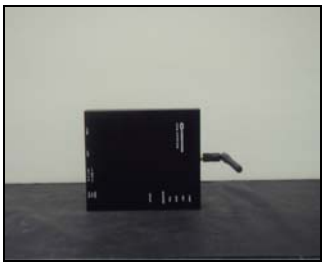
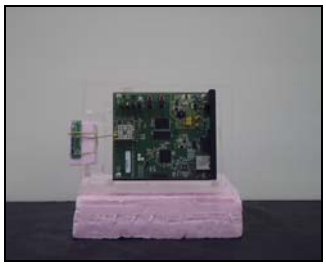
Vertical Orientation

Dipole Antenna (Straight)	Dipole Antenna (90°)	Ceramic Chip Antenna
		

Horizontal Orientation

Dipole Antenna (Straight)	Dipole Antenna (90°)	Ceramic Chip Antenna
		

Side Orientation

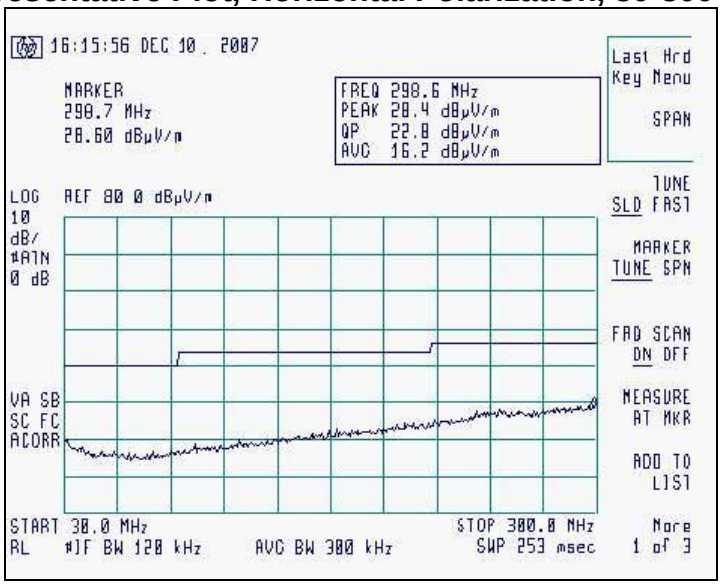
Dipole Antenna (Straight)	Dipole Antenna (90°)	Ceramic Chip Antenna
		

5.8 Screen Captures - Radiated Emissions Testing

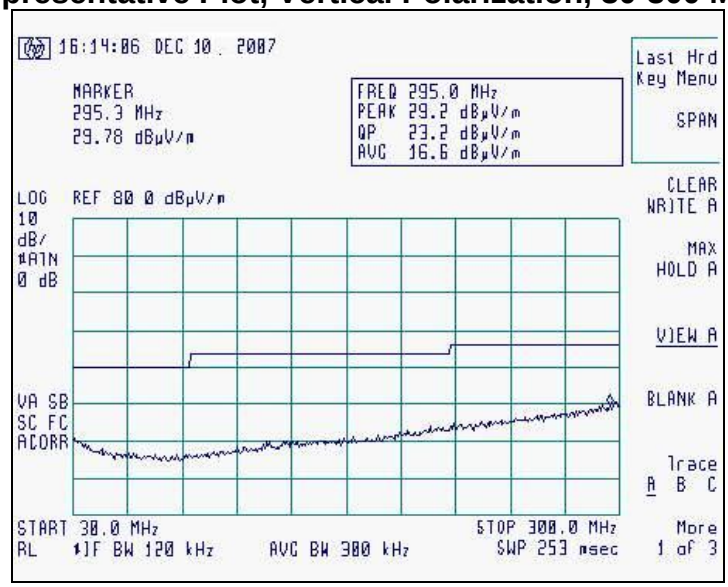
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and an Average detector function is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 11, 18, or 26, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Representative Plot, Horizontal Polarization, 30-300 MHz

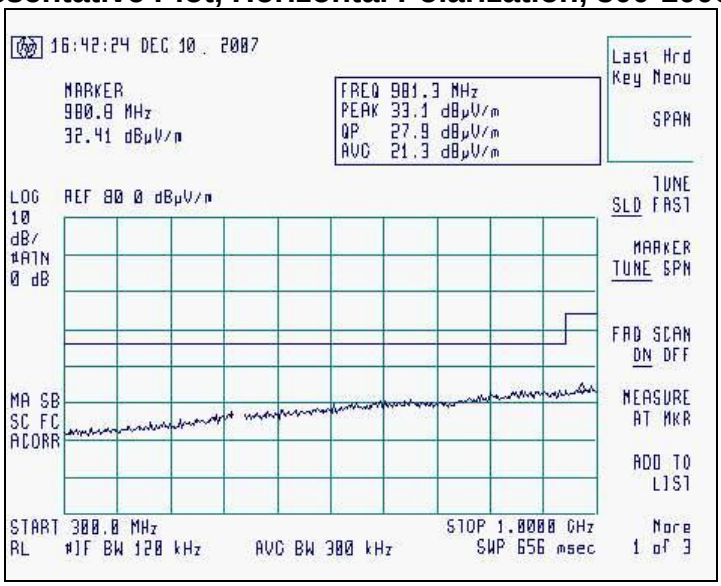


Representative Plot, Vertical Polarization, 30-300 MHz

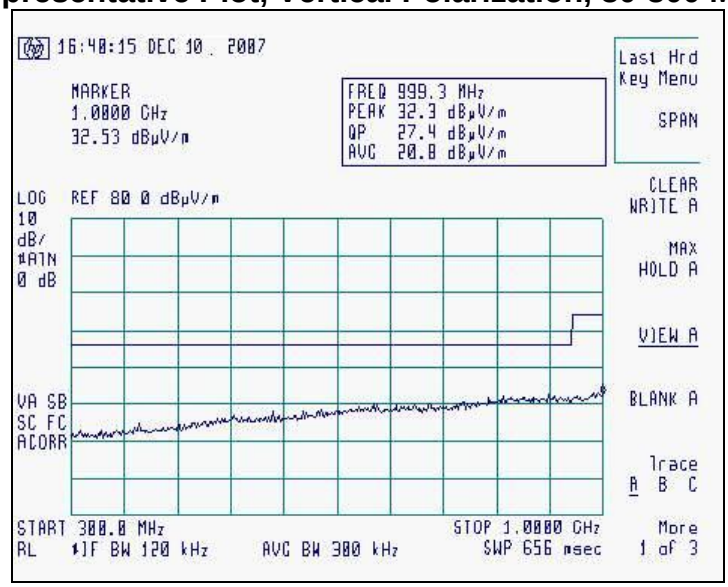


Screen Captures - Radiated Emissions Testing (continued)

Representative Plot, Horizontal Polarization, 300-1000 MHz

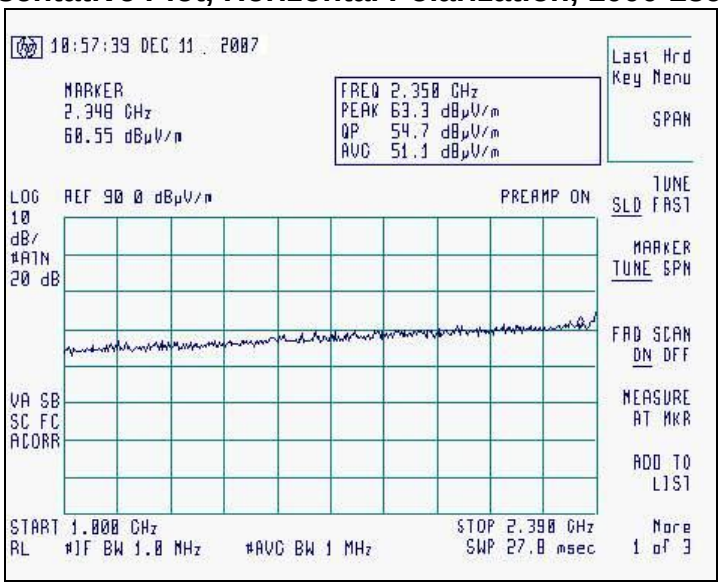


Representative Plot, Vertical Polarization, 30-300 MHz

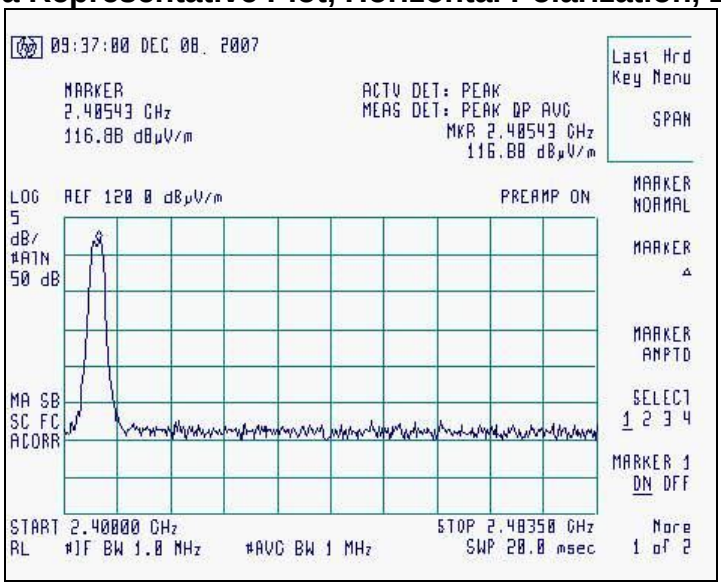


Screen Captures - Radiated Emissions Testing (continued)

Representative Plot, Horizontal Polarization, 1000-2390 MHz

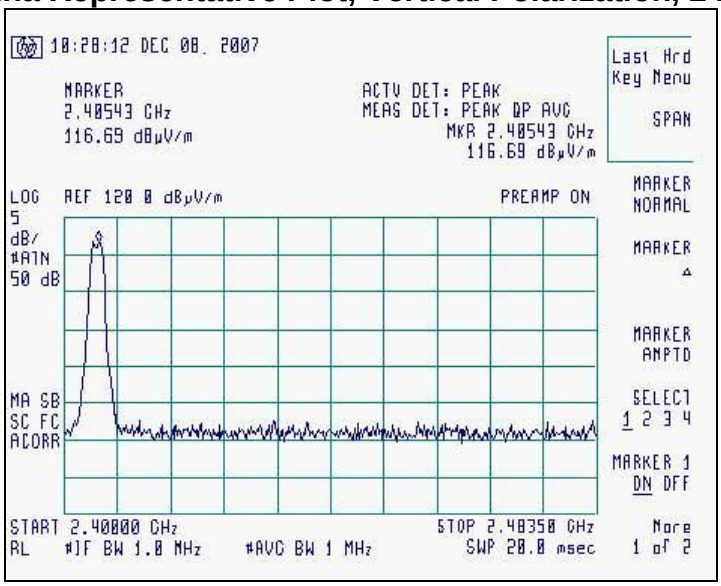


Dipole Antenna Representative Plot, Horizontal Polarization, 2400-2483 MHz

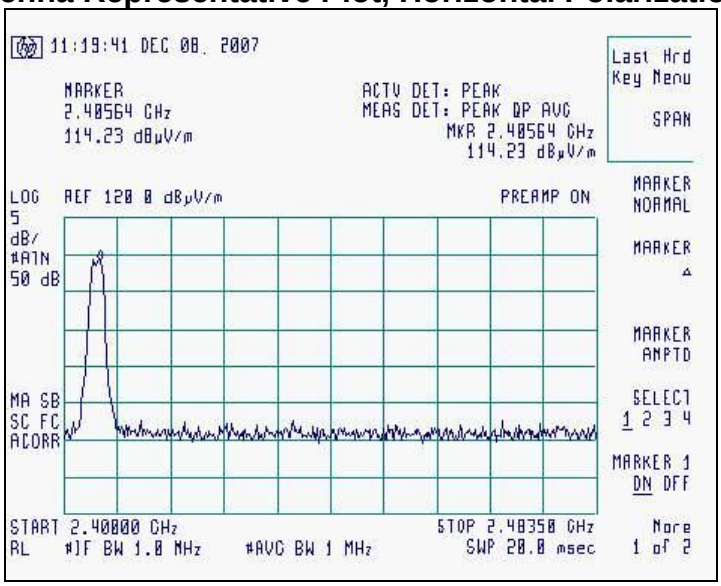


Screen Captures - Radiated Emissions Testing (continued)

Dipole Antenna Representative Plot, Vertical Polarization, 2400-2483 MHz

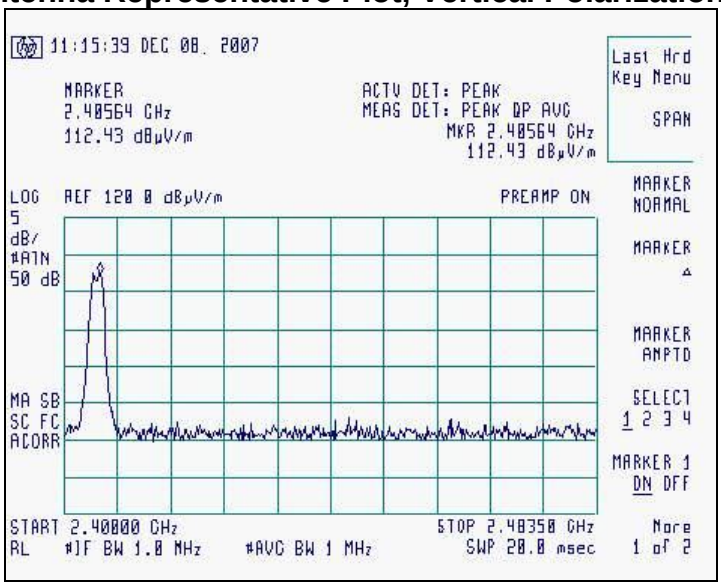


Ceramic Chip Antenna Representative Plot, Horizontal Polarization, 2400-2483 MHz

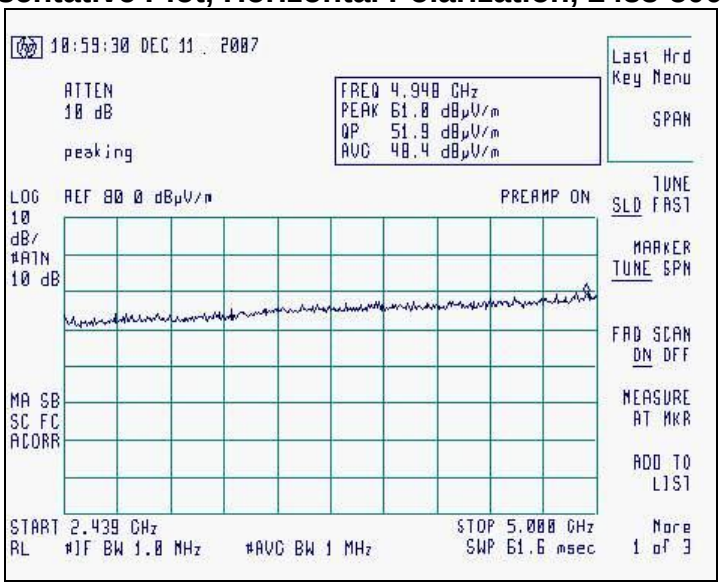


Screen Captures - Radiated Emissions Testing (continued)

Ceramic Chip Antenna Representative Plot, Vertical Polarization, 2400-2483 MHz

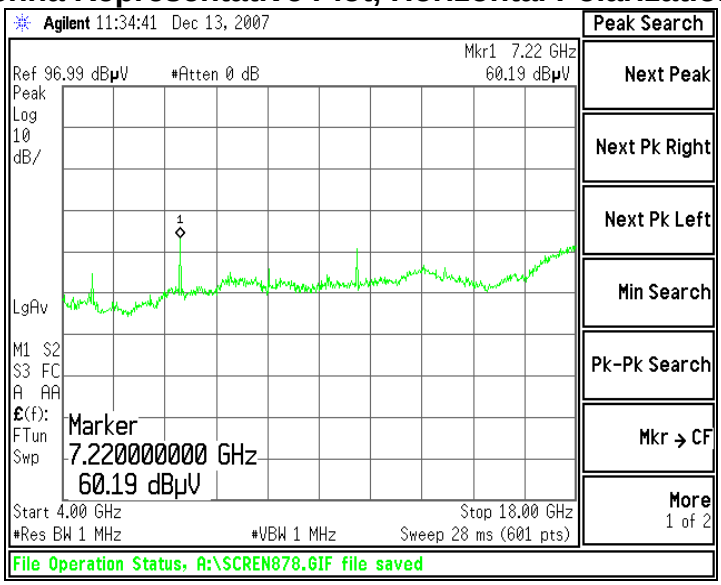


Representative Plot, Horizontal Polarization, 2483-5000 MHz

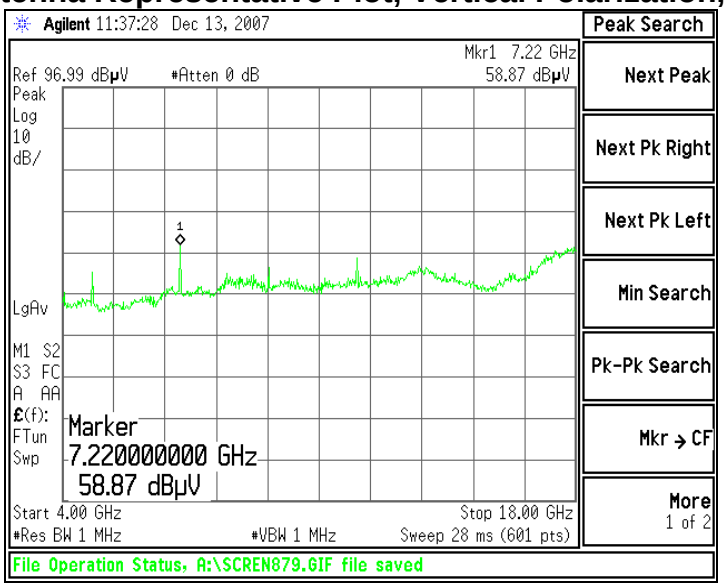


Screen Captures - Radiated Emissions Testing (continued)

Ceramic Chip Antenna Representative Plot, Horizontal Polarization, 4000-18000 MHz

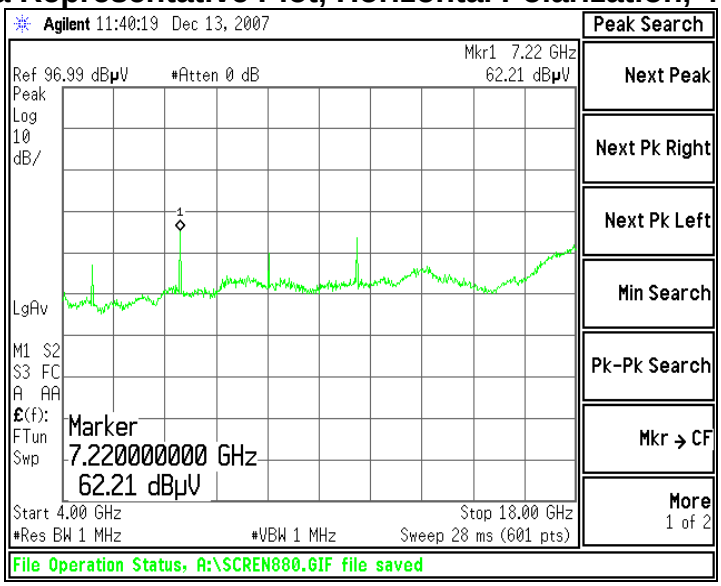


Ceramic Chip Antenna Representative Plot, Vertical Polarization, 4000-18000 MHz

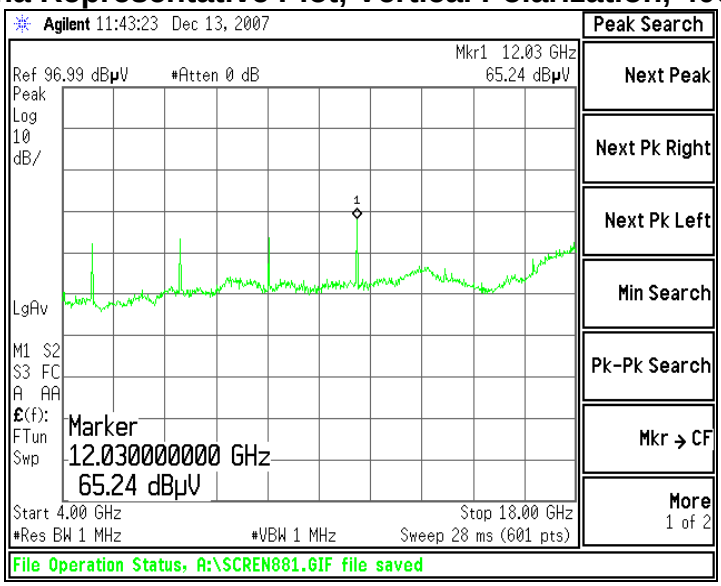


Screen Captures - Radiated Emissions Testing (continued)

Dipole Antenna Representative Plot, Horizontal Polarization, 4000-18000 MHz

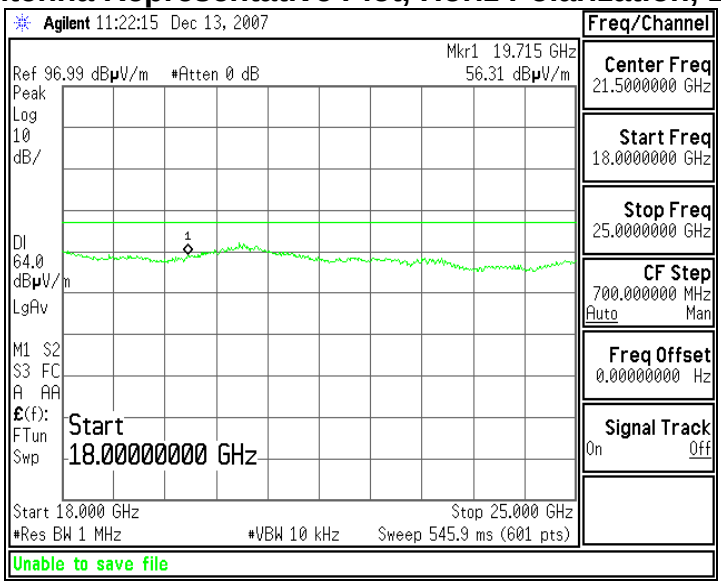


Dipole Antenna Representative Plot, Vertical Polarization, 4000-18000 MHz

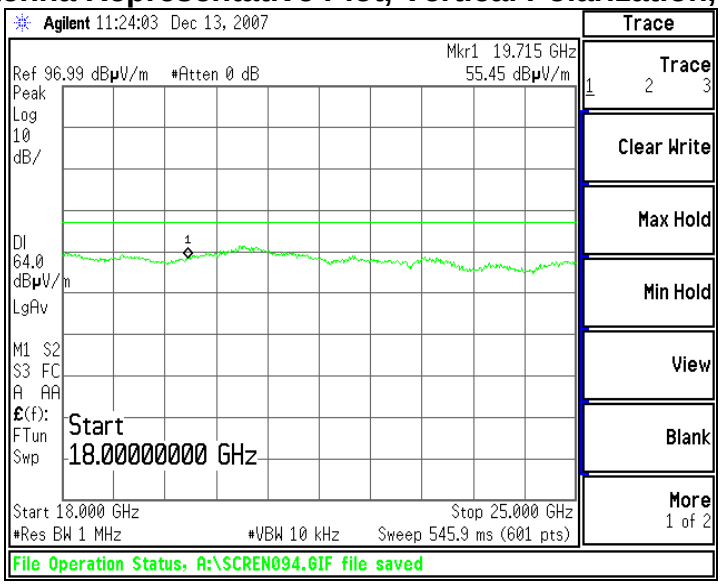


Screen Captures - Radiated Emissions Testing (continued)

Ceramic Chip Antenna Representative Plot, Horiz Polarization, 18000-25000 MHz

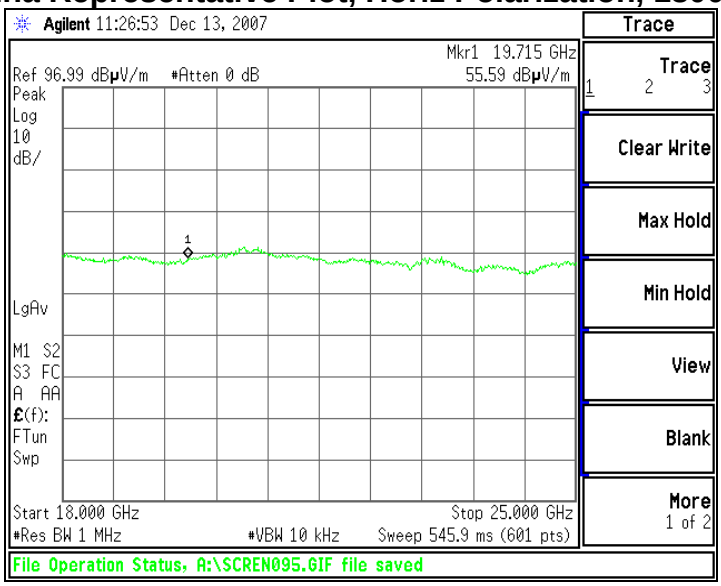


Ceramic Chip Antenna Representative Plot, Vertical Polarization, 18000-25000 MHz



Screen Captures - Radiated Emissions Testing (continued)

Dipole Antenna Representative Plot, Horiz Polarization, 18000-25000 MHz



Dipole Antenna Representative Plot, Vertical Polarization, 18000-25000 MHz

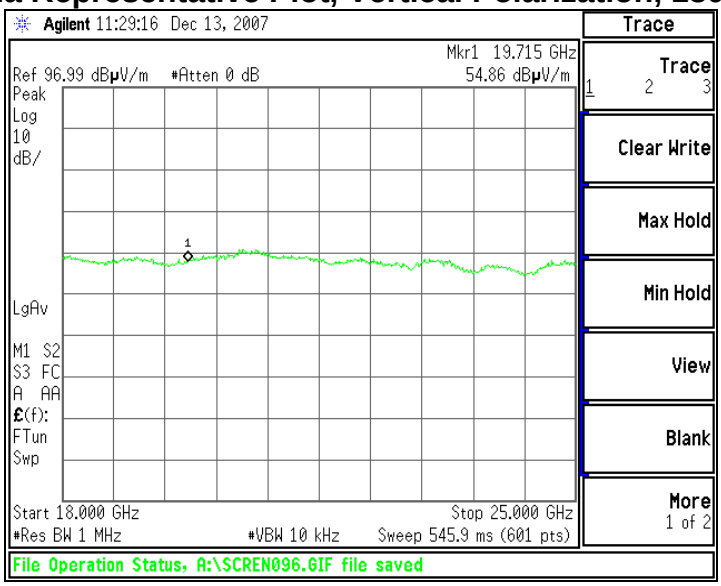


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE: 15.207

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 in the conducted emission setup 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 TEST DATA CHART CONDUCTED EMISSION

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 Class B

Manufacturer:	Crestron					
Date(s) of Test:	January 17th, 2008					
Test Engineer:	Ryan Urness					
Model #:	CWD1014 and CWD1015					
Serial #:	Engineering Sample					
Voltage:	3.0 VDC					
Operation Mode:	Normal, continuous transmit, modulated or C.W. mode					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
Test Location:	X	Conducted Emissions Test Area				Chamber
EUT Placed On:		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)
0.152	L2	49.4	65.9	16.5	21.8	55.9	34.1
0.153	L1	49.4	65.8	16.4	16.7	55.8	39.1
214.0	L1	45.8	63.1	17.3	18.1	53.1	35.0
236.1	L2	44.6	62.2	17.6	16.7	52.2	35.5
4.0	L1	36.3	56.0	19.7	35.1	46.0	10.9
4.0	L2	36.3	56.0	19.7	35.1	46.0	10.9

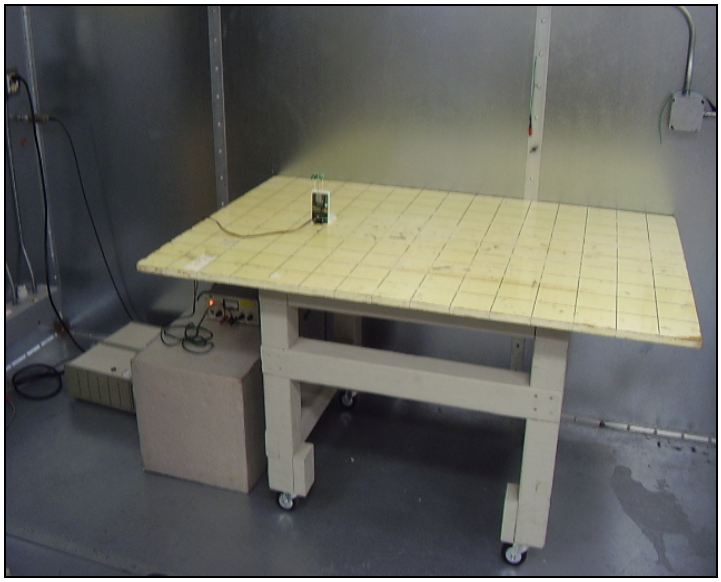
Notes:

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

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

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

6.6 Test Setup Photo(s) – Conducted Emissions Test

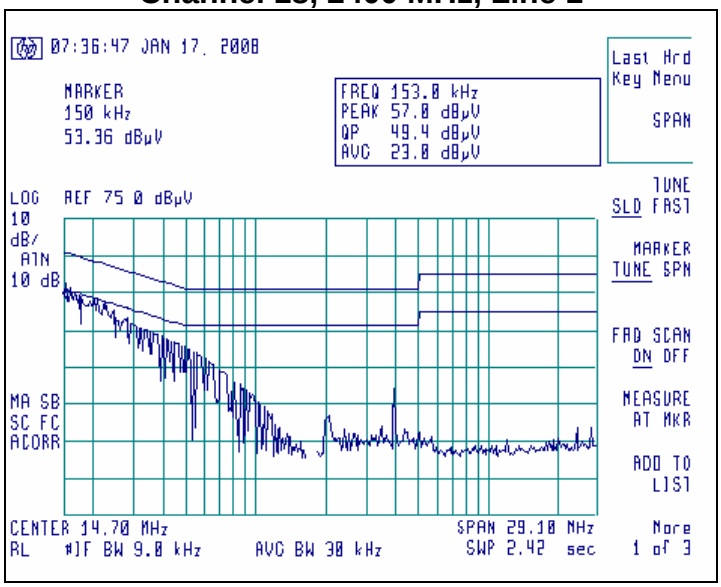


6.7 Screen Captures – Conducted Emissions Test

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.

The signature scans shown here are from channel 18, chosen as being a good representative of channels.

Channel 18, 2400 MHz, Line 1



Channel 18, 2400 MHz, Line 2

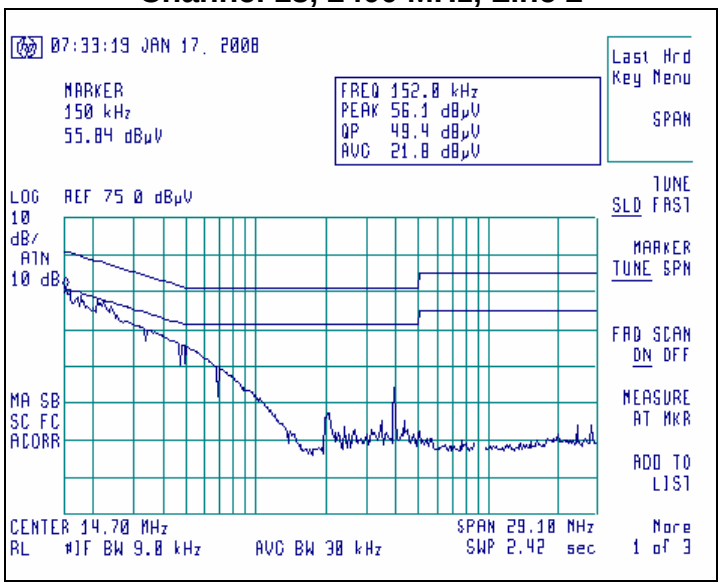


EXHIBIT 7. OCCUPIED BANDWIDTH: 15.247(a)(2)

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. The loss from the cable was 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 of the reverse SMA connection when compared to the specified limit is 1556 kHz, which is above the minimum of 500 kHz. The closest measurement of the U.FL connection when compared to the specified limit is 1577 kHz, which is above the minimum of 500 kHz.

Test Data

Reverse SMA Connection

Channel	Center Frequency (MHz)	Power Setting	Measured -6 dBc Occ. BW (kHz)	Minimum -6 dBc Limit (kHz)	Measured -20 dBc Occ.Bw (kHz)
11	2405	6	1617	500	2428
12	2410	16	1582	500	2454
18	2440	16	1584	500	2462
23	2465	16	1583	500	2476
24	2470	10	1556	500	2464
25	2475	6	1596	500	2453
26	2480	2	1598	500	2459

Test Data (continued)

U.FL Connection

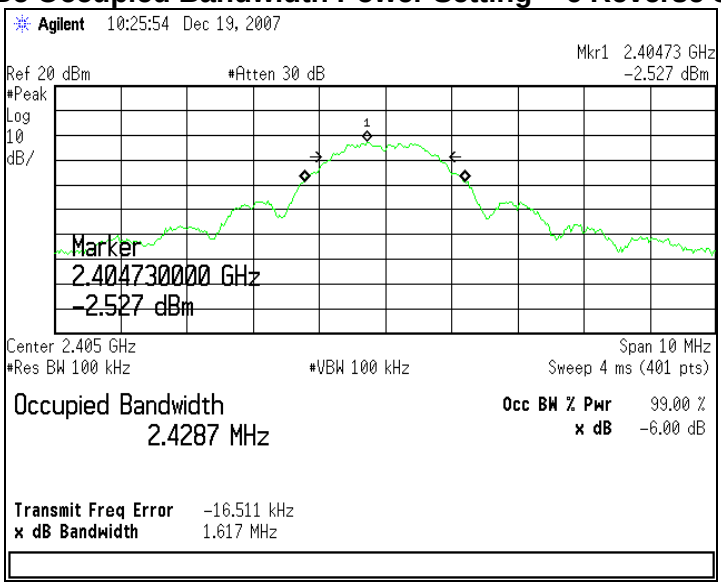
Channel	Center Frequency (MHz)	Power Setting	Measured -6 dBc Occ. BW (kHz)	Minimum -6 dBc Limit (kHz)	Measured -20 dBc Occ.Bw (kHz)
11	2405	10	1606	500	2451
12	2410	16	1584	500	2438
18	2440	16	1609	500	2458
23	2465	16	1585	500	2470
24	2470	10	1607	500	2470
25	2475	6	1577	500	2462
26	2480	2	1627	500	2448

7.3 Test Equipment List

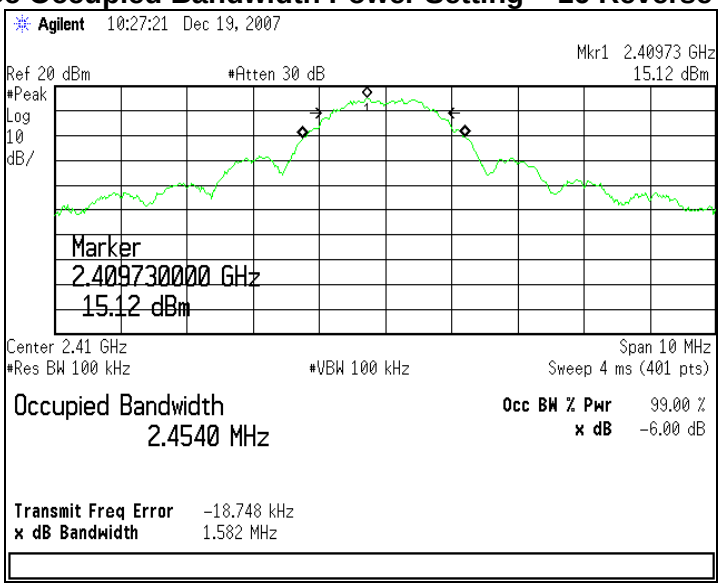
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4407B	US39160256
Spectrum Analyzer	Agilent	E4446A	US45300564

7.4 Screen Captures - OCCUPIED BANDWIDTH

Channel 11 -6 dBc Occupied Bandwidth Power Setting = 6 Reverse SMA Connection

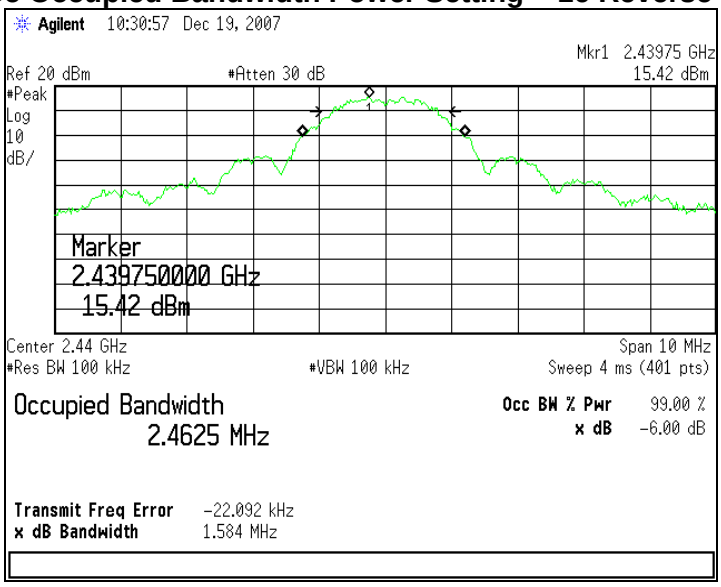


Channel 12 -6 dBc Occupied Bandwidth Power Setting = 16 Reverse SMA Connection

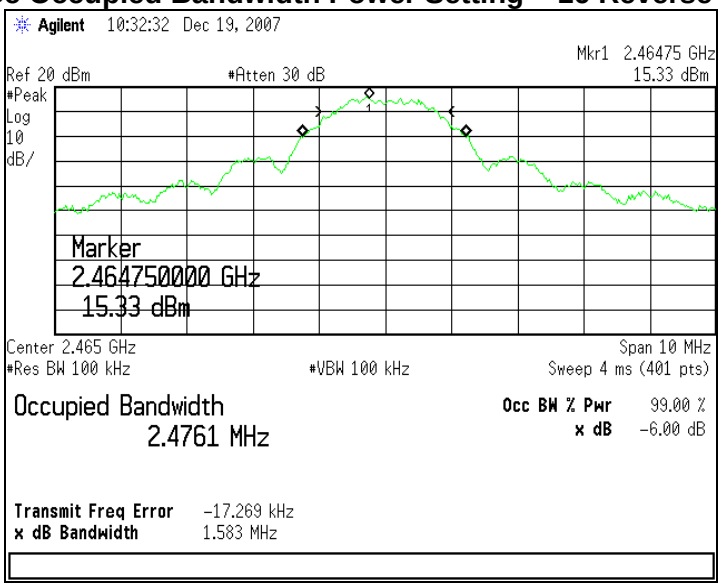


Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 18 -6 dBc Occupied Bandwidth Power Setting = 16 Reverse SMA Connection

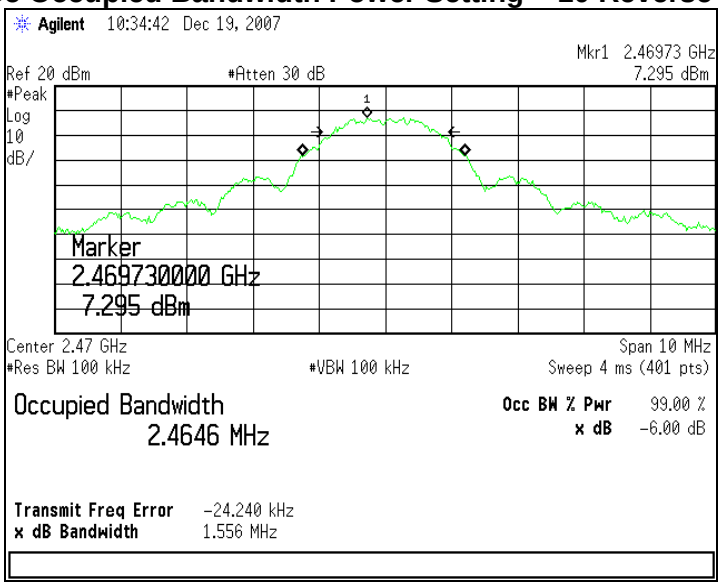


Channel 23 -6 dBc Occupied Bandwidth Power Setting = 16 Reverse SMA Connection

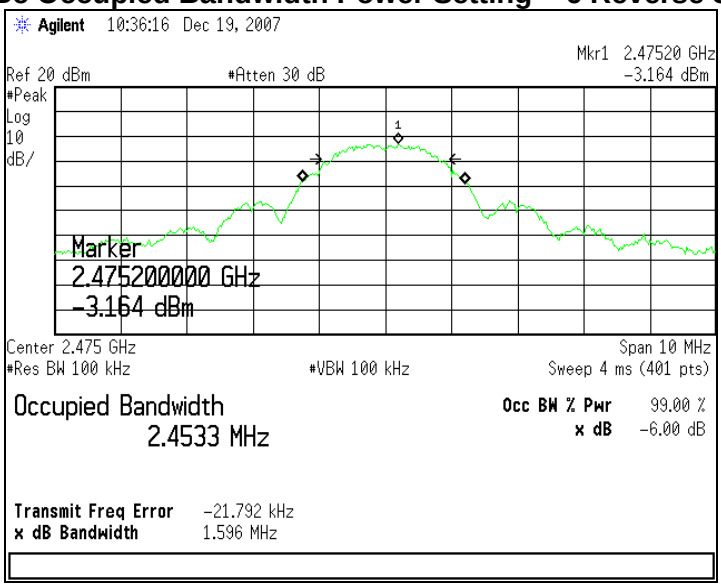


Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 24 -6 dBc Occupied Bandwidth Power Setting = 10 Reverse SMA Connection

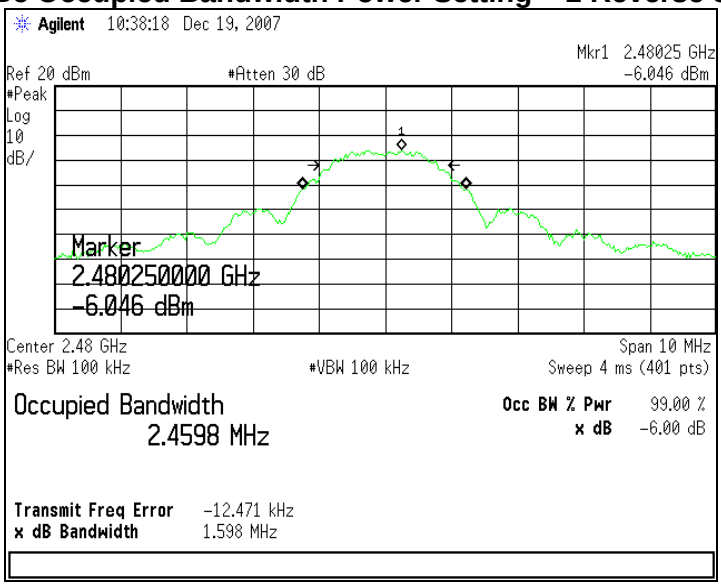


Channel 25 -6 dBc Occupied Bandwidth Power Setting = 6 Reverse SMA Connection

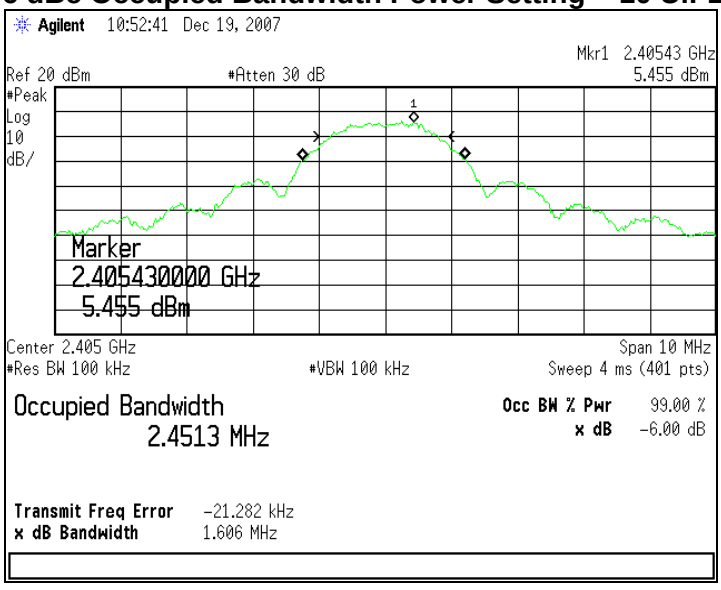


Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 26 -6 dBc Occupied Bandwidth Power Setting = 2 Reverse SMA Connection

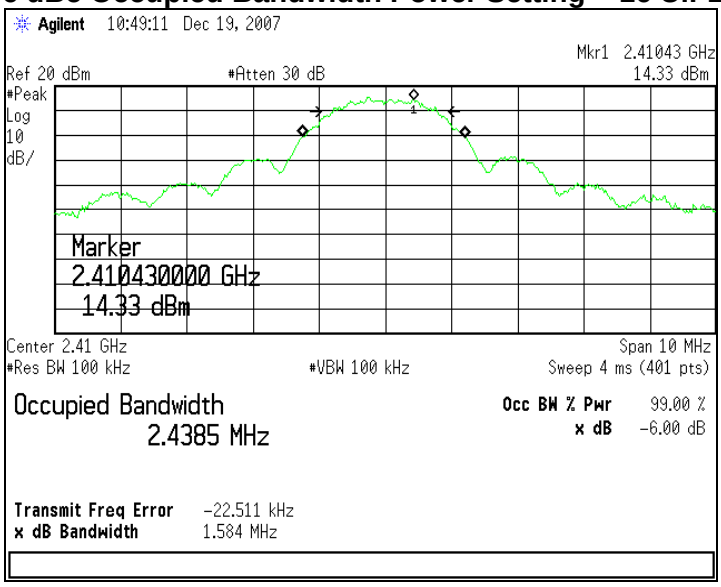


Channel 11 -6 dBc Occupied Bandwidth Power Setting = 10 U.FL Connection

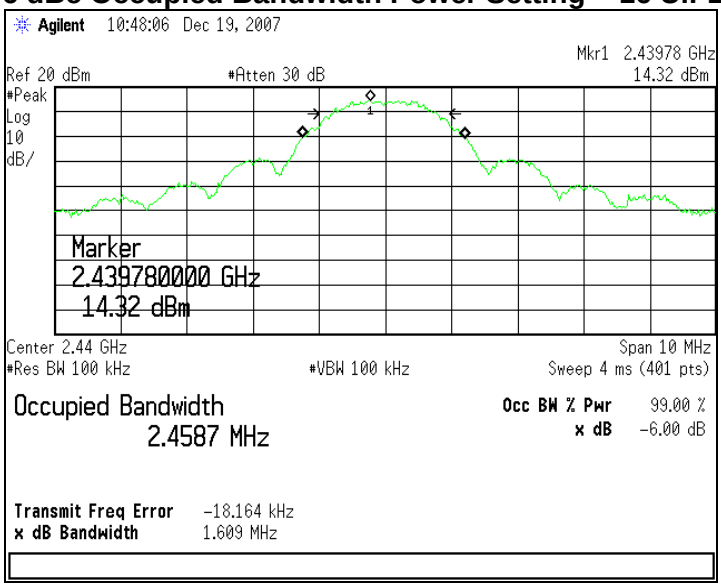


Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 12 -6 dBc Occupied Bandwidth Power Setting = 16 U.FL Connection

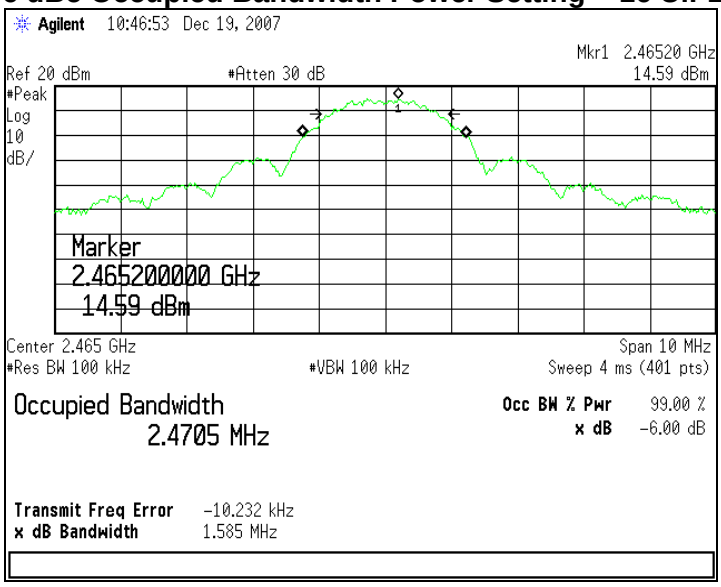


Channel 18 -6 dBc Occupied Bandwidth Power Setting = 16 U.FL Connection

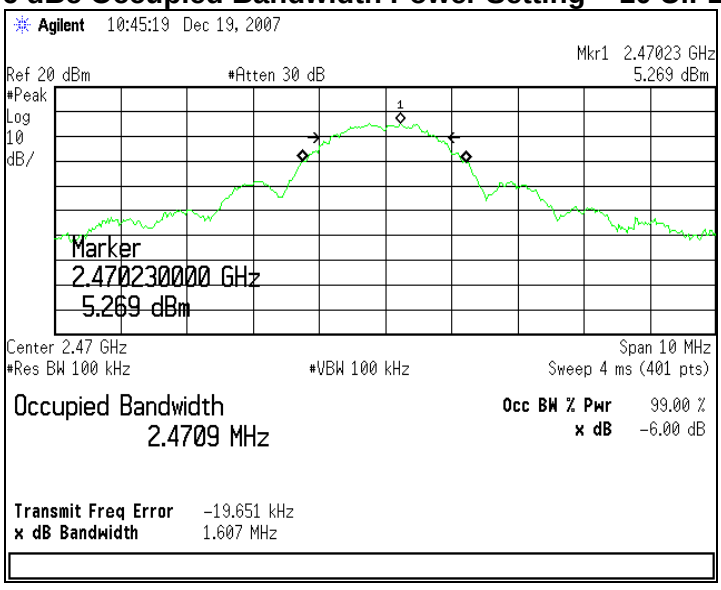


Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 23 -6 dBc Occupied Bandwidth Power Setting = 16 U.FL Connection

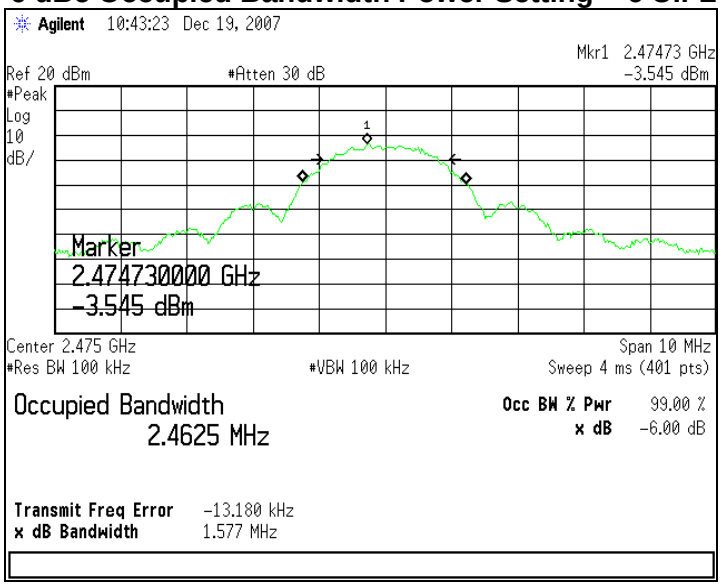


Channel 24 -6 dBc Occupied Bandwidth Power Setting = 10 U.FL Connection



Screen Captures - OCCUPIED BANDWIDTH (continued)

Channel 25 -6 dBc Occupied Bandwidth Power Setting = 6 U.FL Connection



Channel 26 -6 dBc Occupied Bandwidth Power Setting = 2 U.FL Connection

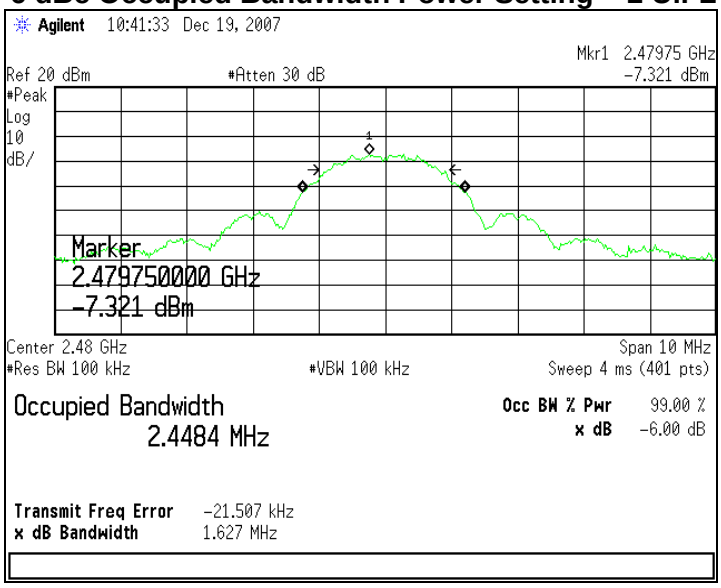


EXHIBIT 8. BAND-EDGE MEASUREMENTS

8.1 Method of Measurements

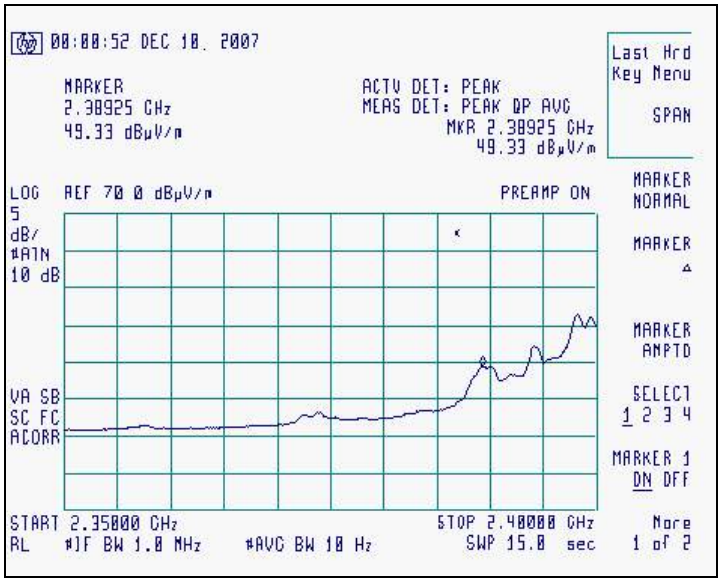
FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. The following screen captures demonstrate compliance of the intentional radiator at the 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 below 2390MHz was +54 dBµV/m at 3m, and -20dBc between 2390MHz - 2400MHz with respect to the fundamental level. The upper band-edge limit above 2483.5MHz was +54 dBµV/m at 3m.

A 4.7 dB relaxation factor is used when comparing emissions to the limits due to the transmission nature of the module. Justification and request for relaxation is included in the report in Appendix D.

Band-Edge Screen Captures:

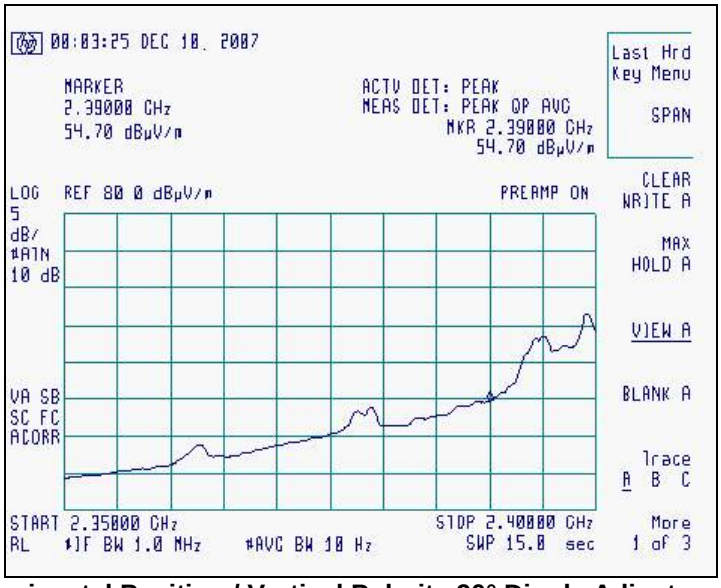
Channel 11 Radiated Output Power Setting = 6 Dipole antenna



Horizontal Position / Horizontal Polarity Straight Dipole Adjustment

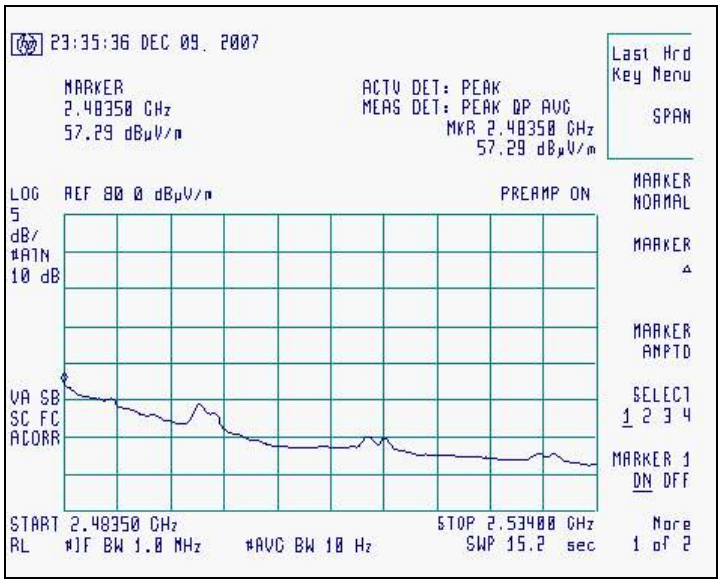
Band-Edge Screen Captures (continued):

Channel 12 Radiated Output Power Setting = 16 Dipole antenna



Horizontal Position / Vertical Polarity 90° Dipole Adjustment

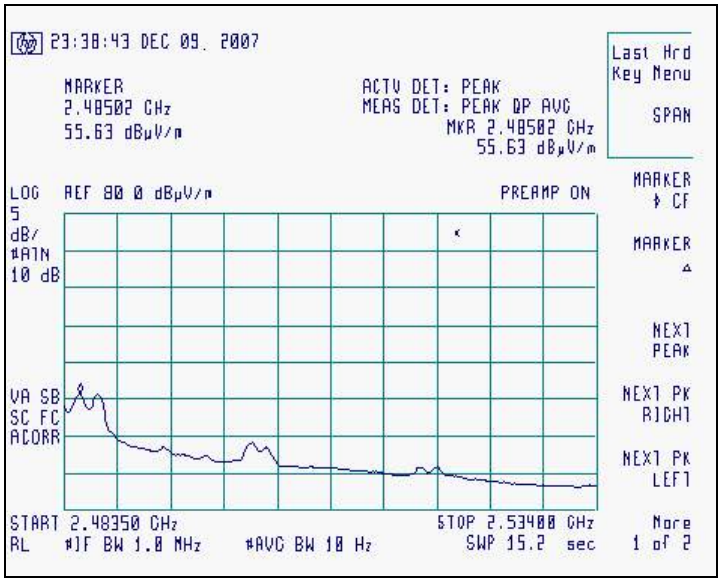
Channel 23 Radiated Output Power Setting = 16 Dipole antenna



Horizontal Position / Vertical Polarity 90° Dipole Adjustment

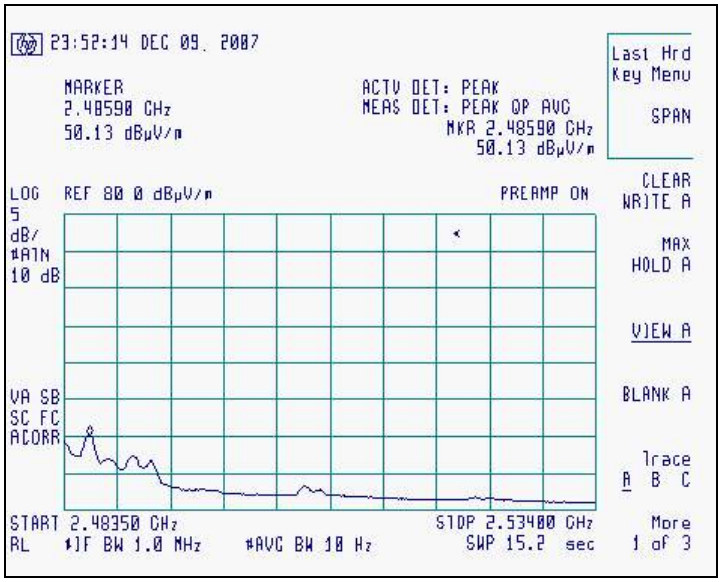
Band-Edge Screen Captures (continued):

Channel 24 Radiated Output Power Setting = 10 Dipole antenna



Horizontal Position / Horizontal Polarity Straight Dipole Adjustment

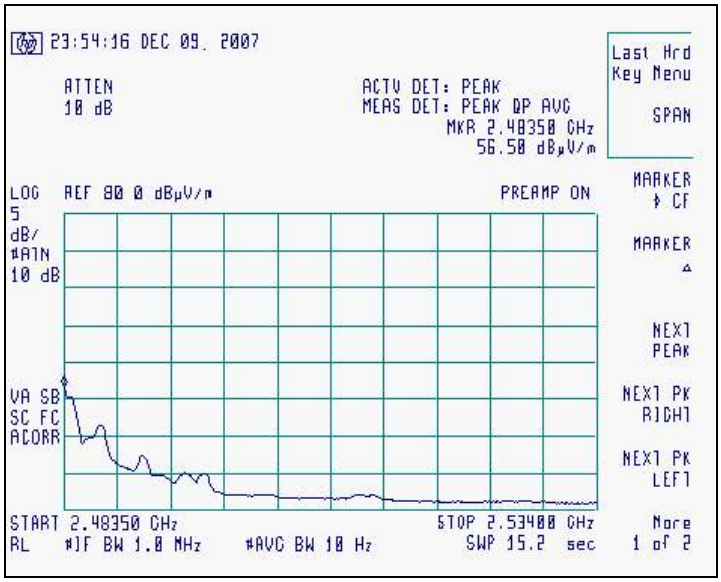
Channel 25 Radiated Output Power Setting = 6 Dipole antenna



Horizontal Position / Horizontal Polarity Straight Dipole Adjustment

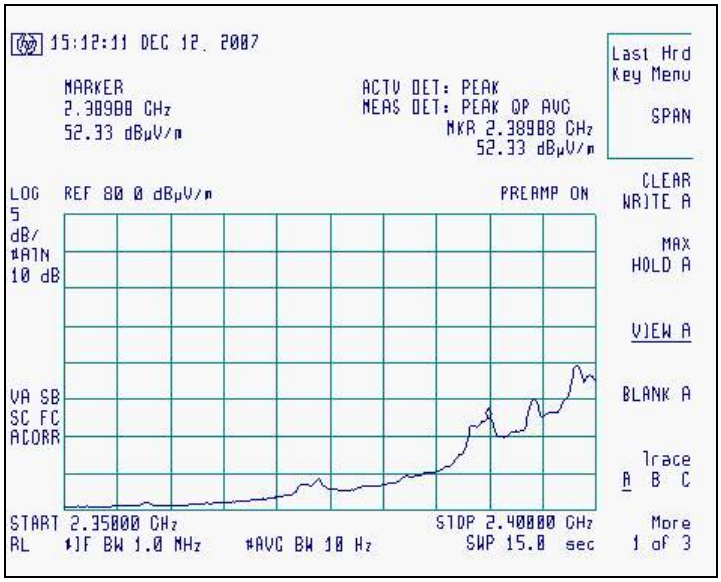
Band-Edge Screen Captures (continued):

Channel 26 Radiated Output Power Setting = 2 Dipole antenna



Horizontal Position / Horizontal Polarity Straight Dipole Adjustment

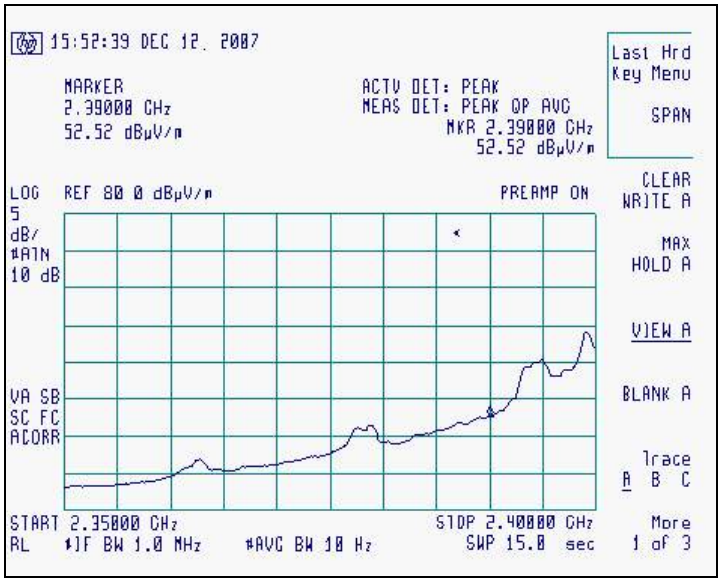
Channel 11 Radiated Output Power Setting = 10 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

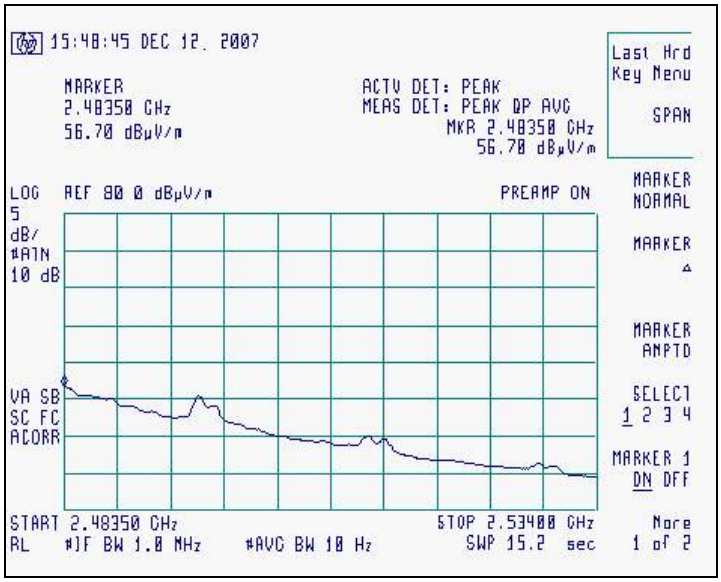
Band-Edge Screen Captures (continued):

Channel 12 Radiated Output Power Setting = 16 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

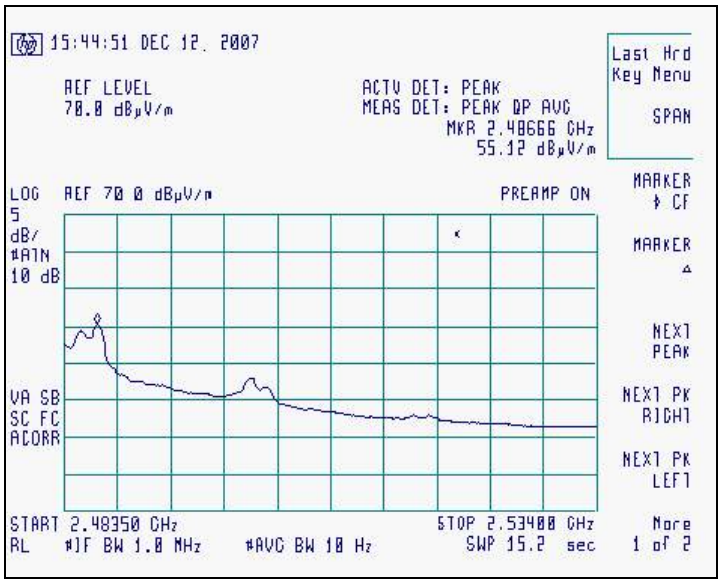
Channel 23 Radiated Output Power Setting = 16 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

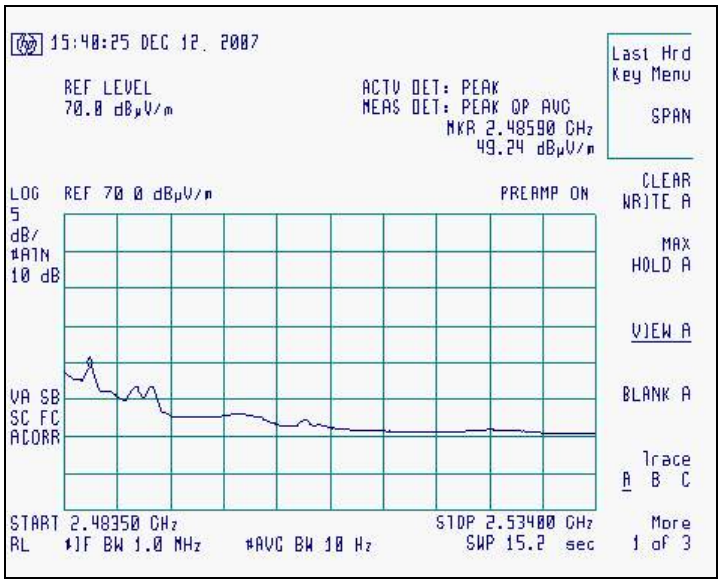
Band-Edge Screen Captures (continued):

Channel 24 Radiated Output Power Setting = 10 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

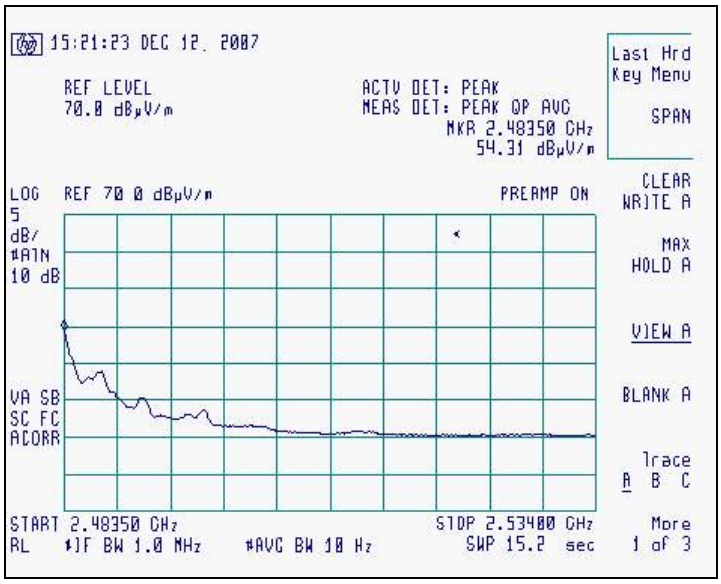
Channel 25 Radiated Output Power Setting = 6 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

Band-Edge Screen Captures (continued):

Channel 26 Radiated Output Power Setting = 2 Ceramic Chip antenna



Vertical Position / Horizontal Polarity

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 for the spectrum analyzer. The loss from the cable was added on the analyzer, 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 5 MHz, with measurements from a peak detector presented in the chart below.

9.2 Test Data

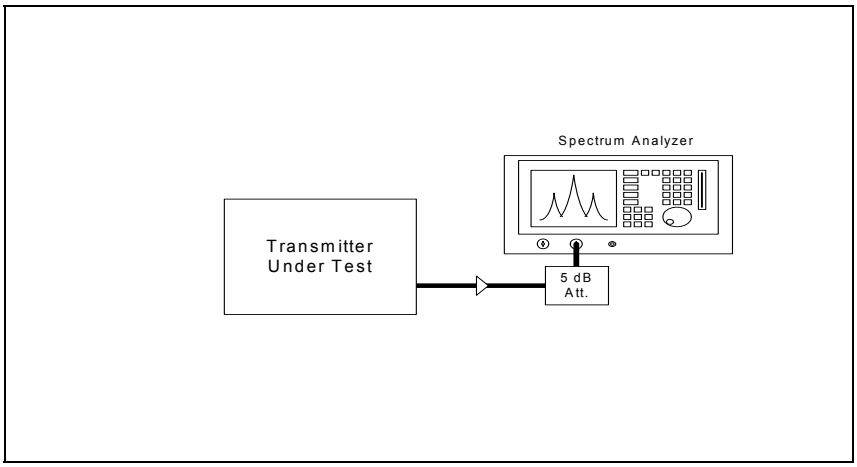
Reverse SMA Connection

Channel	Power Setting	Center Freq (MHz)	Limit (dBm)	Measured Power (dBm)	Margin (dB)
11	6	2405	30 dBm	1.967	28.033
12	16	2410	30 dBm	19.46	10.54
18	16	2440	30 dBm	19.41	10.59
23	16	2465	30 dBm	19.21	10.79
24	10	2470	30 dBm	11.18	18.82
25	6	2475	30 dBm	1.836	28.164
26	2	2480	30 dBm	-1.706	31.706

U.FL Connection

Channel	Power Setting	Center Freq (MHz)	Limit (dBm)	Measured Power (dBm)	Margin (dB)
11	10	2405	30 dBm	9.848	20.152
12	16	2410	30 dBm	18.91	11.09
18	16	2440	30 dBm	18.80	11.20
23	16	2465	30 dBm	18.50	11.50
24	10	2470	30 dBm	9.549	20.451
25	6	2475	30 dBm	0.803	29.197
26	2	2480	30 dBm	-2.681	32.681

Test Data (continued)



Declared RF Power Output (in mW):	**100.00**
Measured Radiated RF Power Output Dipole Antenna (in mW):	**180.76**
Measured Radiated RF Power Output Ceramic Chip (in mW):	**122.21**
Measured Conducted Power Output Reverse SMA Connector (in mW):	**88.31**
Measured Conducted Power Output U.FL Connector (in mW):	**77.80**

Referenced Equations:

Output (dBm) = 10Log (P_{mW})

Output (dBµV/m) = 20Log ($\sqrt{30P_W}/d$) + 120

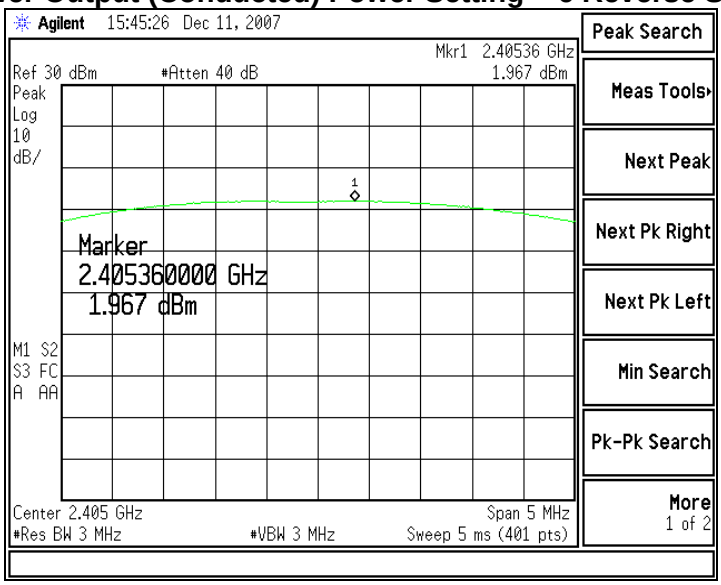
P_{mW} = Power (in mW)
P_W = Power (in W)
d = Distance (in Meters)

9.3 Test Equipment List

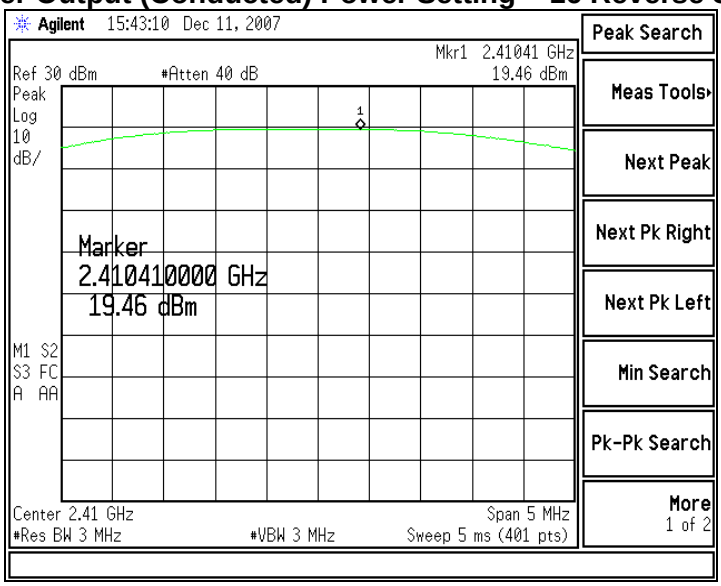
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4446A	US45300564

9.4 Screen Captures – Conducted Power Output

Channel 11 Power Output (Conducted) Power Setting = 6 Reverse SMA Connection

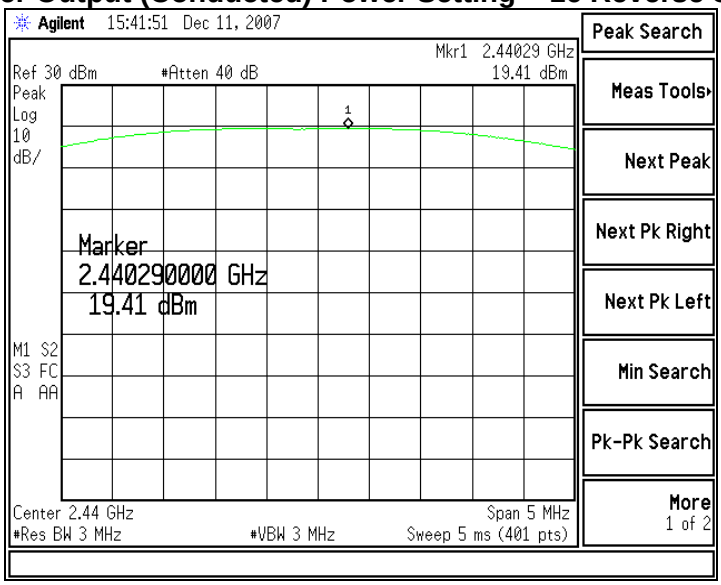


Channel 12 Power Output (Conducted) Power Setting = 16 Reverse SMA Connection

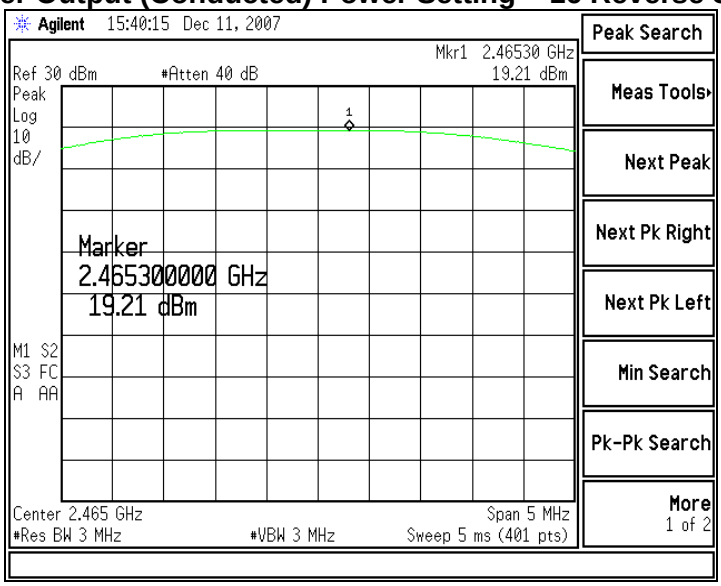


Screen Captures – Conducted Power Output (continued)

Channel 18 Power Output (Conducted) Power Setting = 16 Reverse SMA Connection

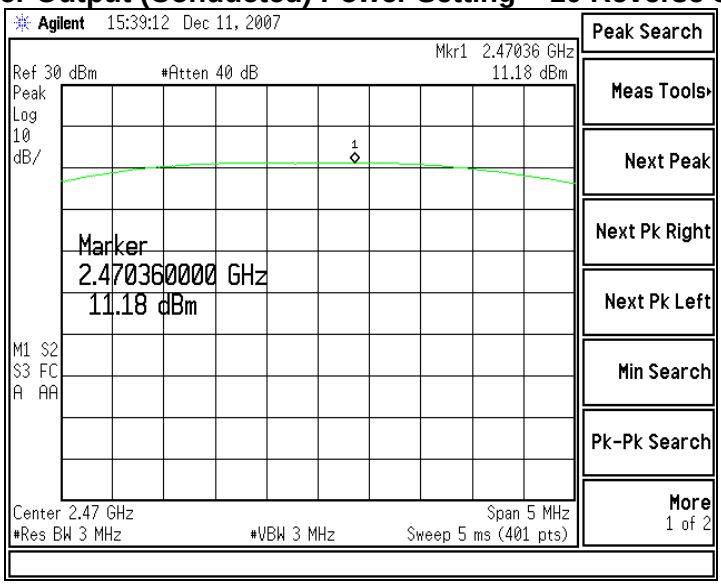


Channel 23 Power Output (Conducted) Power Setting = 16 Reverse SMA Connection

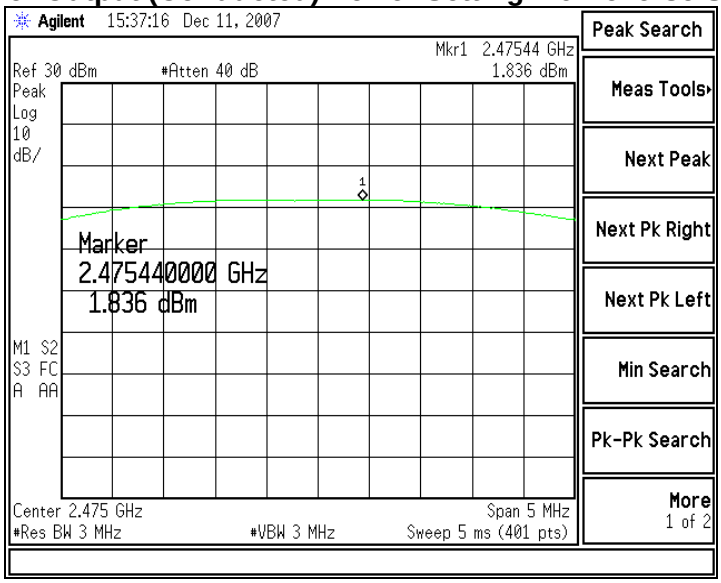


Screen Captures – Conducted Power Output (continued)

Channel 24 Power Output (Conducted) Power Setting = 10 Reverse SMA Connection

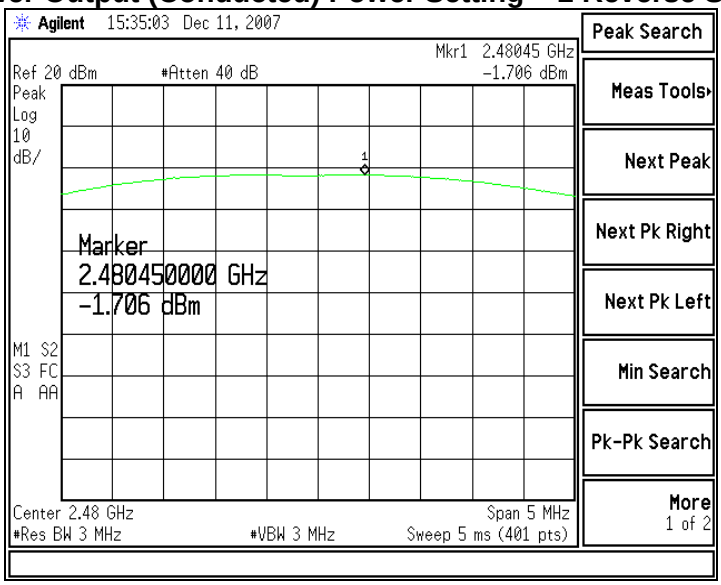


Channel 25 Power Output (Conducted) Power Setting = 6 Reverse SMA Connection

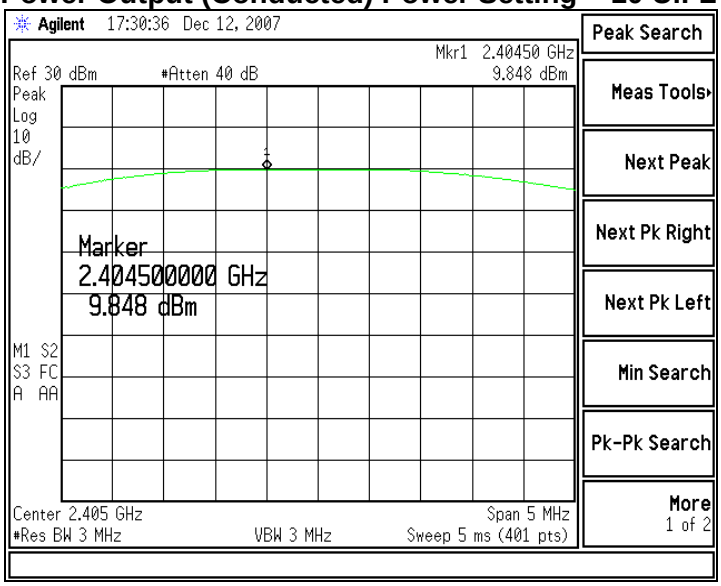


Screen Captures – Conducted Power Output (continued)

Channel 26 Power Output (Conducted) Power Setting = 2 Reverse SMA Connection

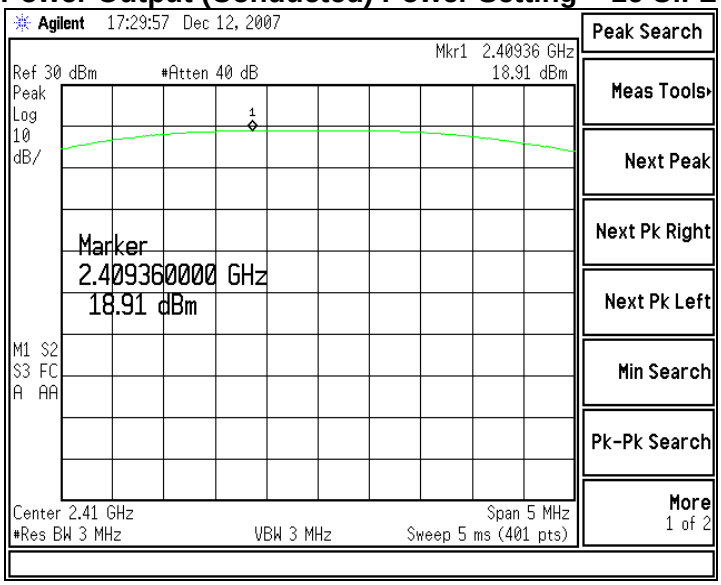


Channel 11 Power Output (Conducted) Power Setting = 10 U.FL Connection

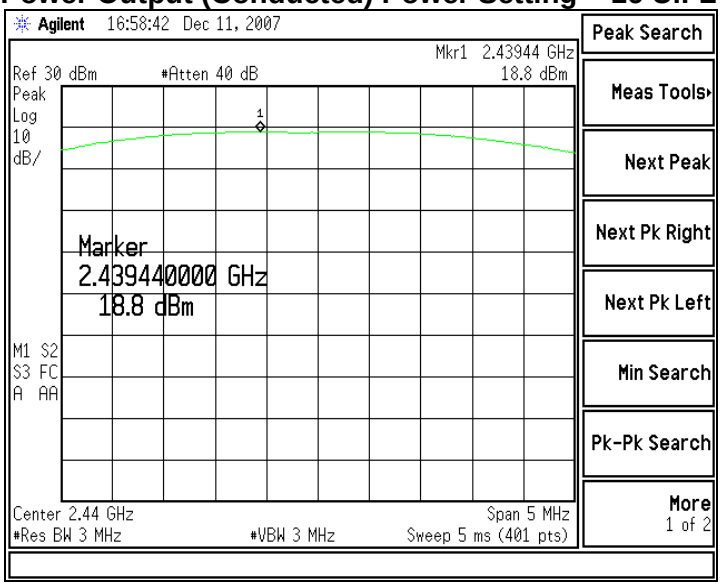


Screen Captures – Conducted Power Output (continued)

Channel 12 Power Output (Conducted) Power Setting = 16 U.FL Connection

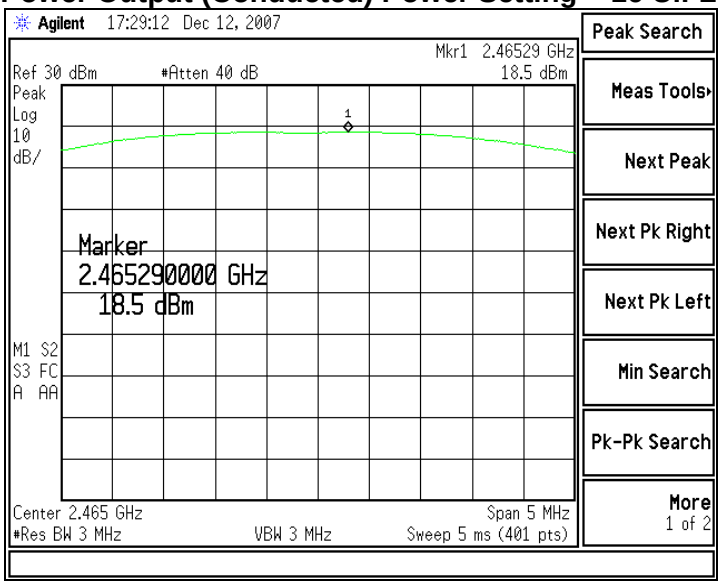


Channel 18 Power Output (Conducted) Power Setting = 16 U.FL Connection

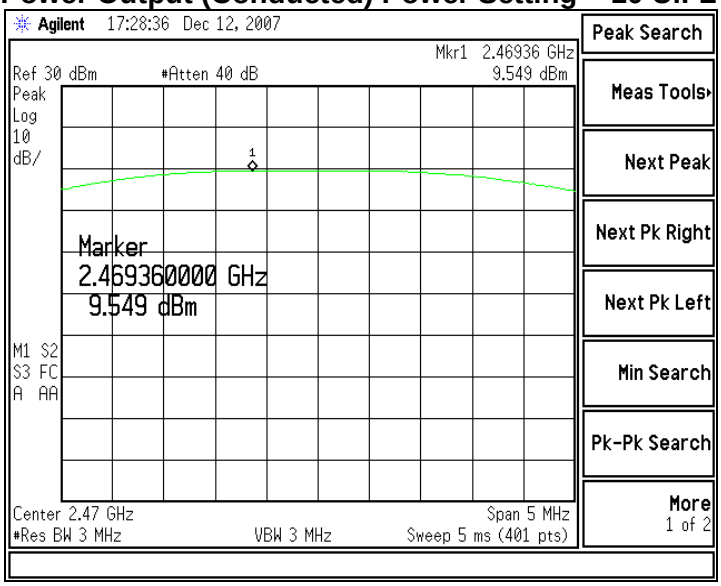


Screen Captures – Conducted Power Output (continued)

Channel 23 Power Output (Conducted) Power Setting = 16 U.FL Connection

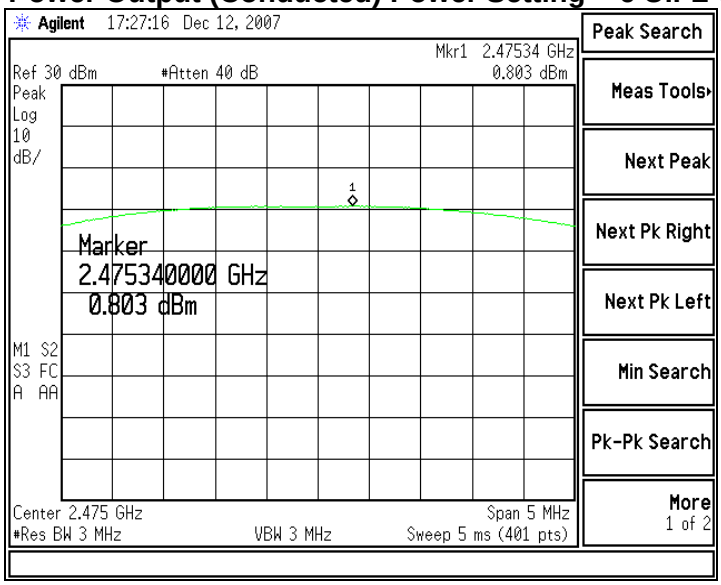


Channel 24 Power Output (Conducted) Power Setting = 10 U.FL Connection



Screen Captures – Conducted Power Output (continued)

Channel 25 Power Output (Conducted) Power Setting = 6 U.FL Connection



Channel 26 Power Output (Conducted) Power Setting = 2 U.FL Connection

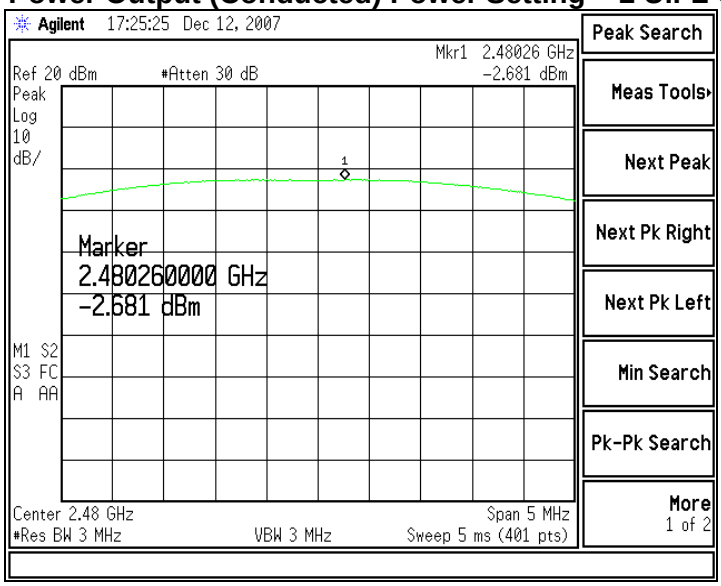


EXHIBIT 10. POWER SPECTRAL DENSITY: 15.247(e)

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 using the utility built into the HP Analyzer. The resultant density was then corrected to a 3 kHz bandwidth. The highest density for the reverse SMA connector was found to be no greater than 3.871 dBm, which is under the allowable limit by 4.129 dB. The highest density for the U.FL connection was found to be no greater than 4.263 dBm, which is under the allowable limit by 3.737 dB.

10.2 Test Equipment List

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

10.3 Test Data

Dipole Antenna

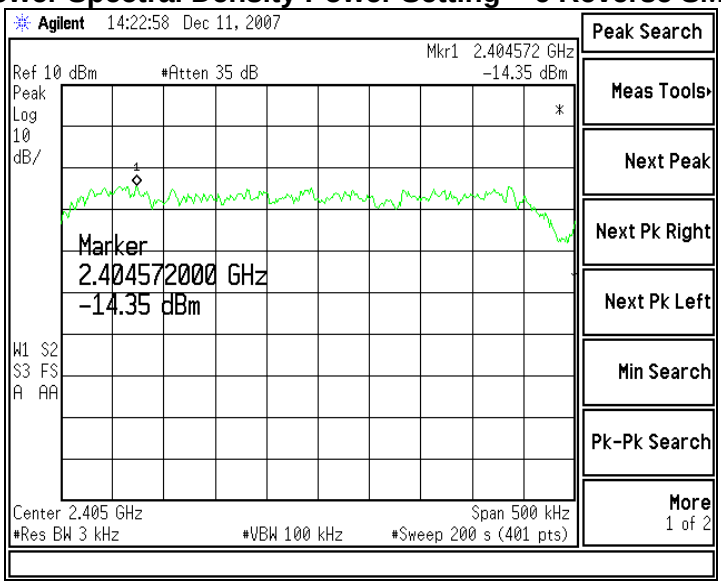
Transmitter Channel	Frequency (MHz)	Power Setting	RF Power Level In 3 kHz BW (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Pass/Fail
11	2405	6	-14.35	8.0	22.35	Pass
12	2410	16	3.871	8.0	4.129	Pass
18	2440	16	3.773	8.0	4.227	Pass
23	2465	16	3.678	8.0	4.322	Pass
24	2470	10	-4.567	8.0	12.567	Pass
25	2475	6	-13.99	8.0	21.99	Pass
26	2480	2	-17.78	8.0	25.78	Pass

Ceramic Chip Antenna

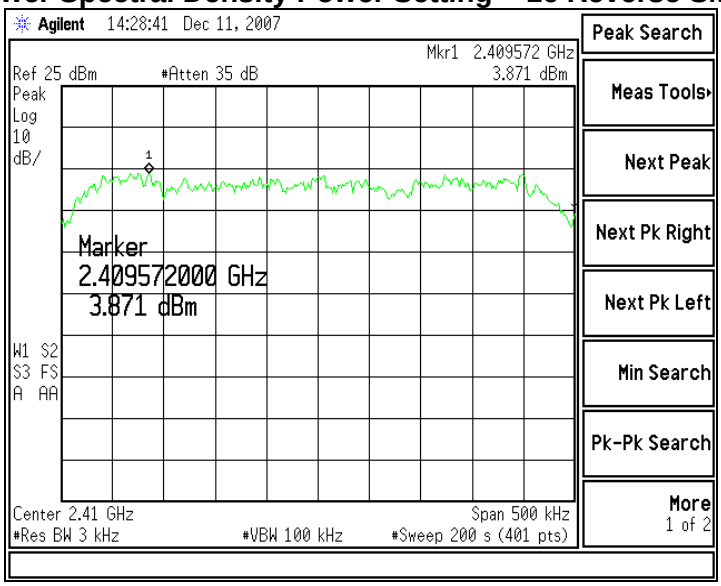
Transmitter Channel	Frequency (MHz)	Power Setting	RF Power Level In 3 kHz BW (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Pass/Fail
11	2405	10	-5.3	8.0	13.30	Pass
12	2410	16	4.027	8.0	3.973	Pass
18	2440	16	4.263	8.0	3.737	Pass
23	2465	16	3.744	8.0	4.256	Pass
24	2470	10	-5.281	8.0	13.281	Pass
25	2475	6	-14.87	8.0	22.87	Pass
26	2480	2	-18.11	8.0	26.11	Pass

10.4 Screen Captures – Power Spectral Density

Channel 11 Power Spectral Density Power Setting = 6 Reverse SMA Connection

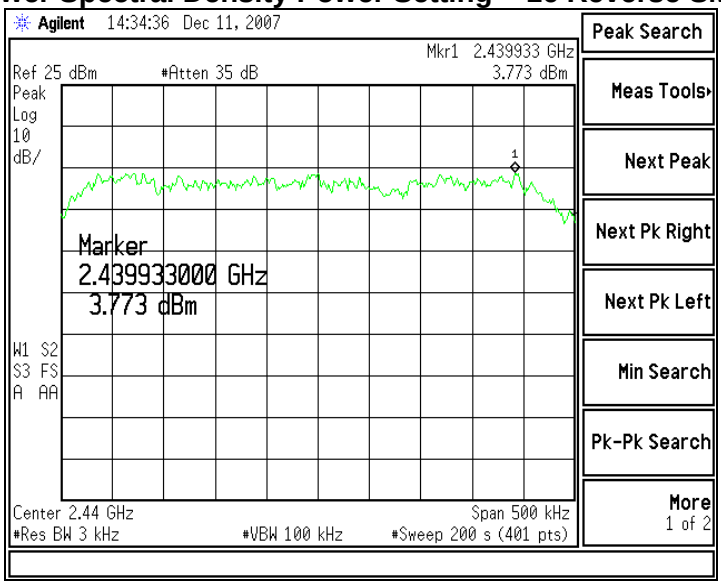


Channel 12 Power Spectral Density Power Setting = 16 Reverse SMA Connection

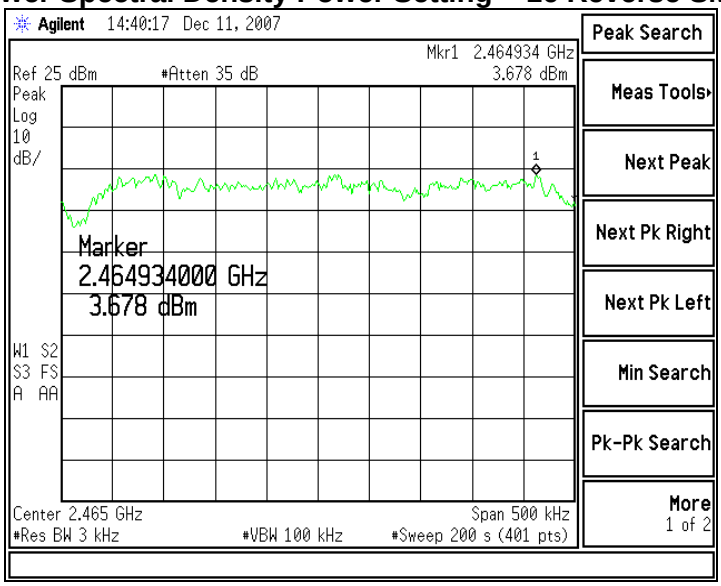


Screen Captures – Power Spectral Density (continued)

Channel 18 Power Spectral Density Power Setting = 16 Reverse SMA Connection

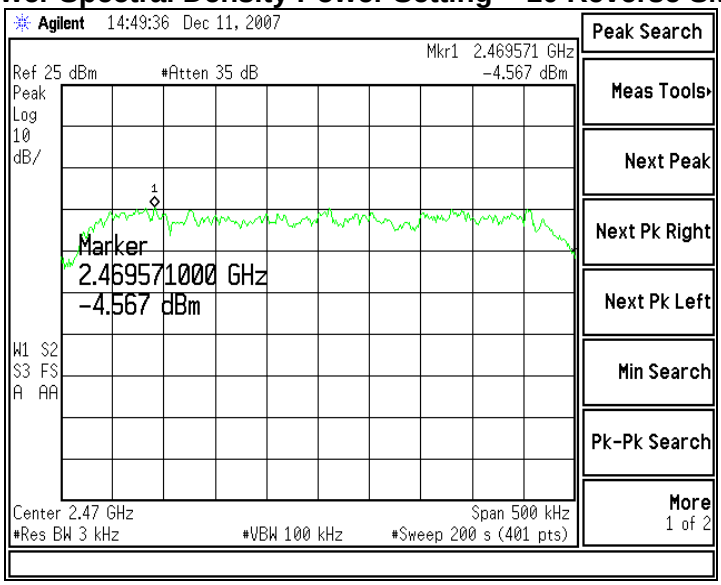


Channel 23 Power Spectral Density Power Setting = 16 Reverse SMA Connection

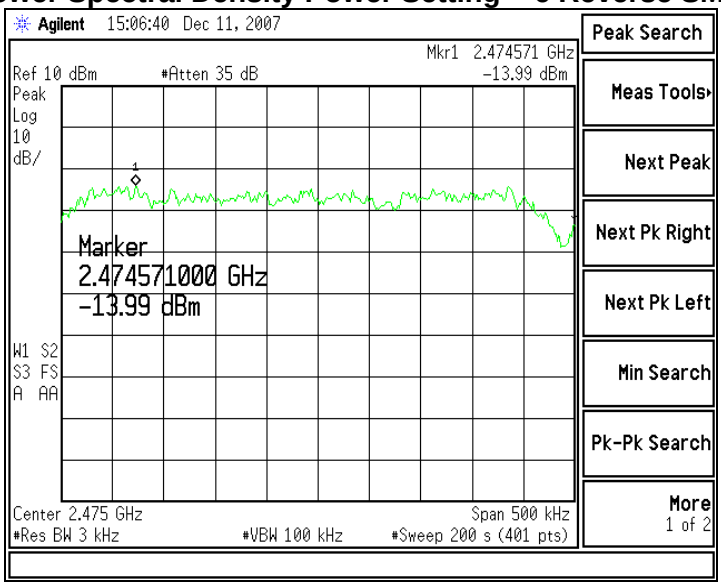


Screen Captures – Power Spectral Density (continued)

Channel 24 Power Spectral Density Power Setting = 10 Reverse SMA Connection

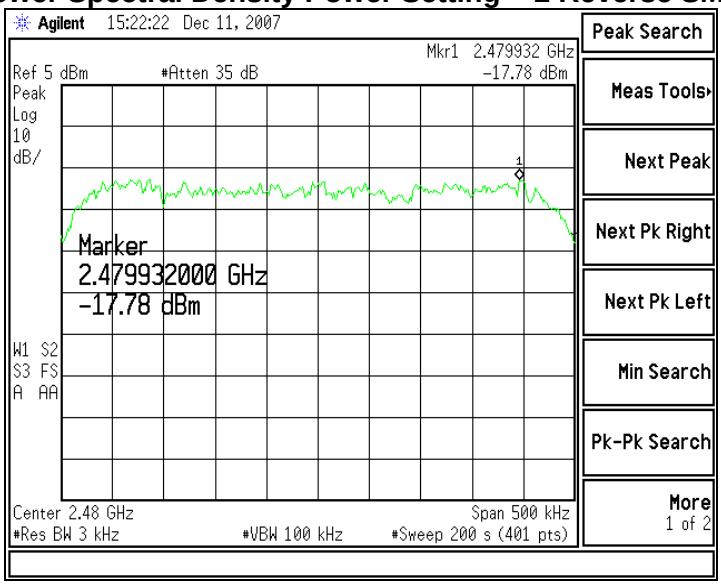


Channel 25 Power Spectral Density Power Setting = 6 Reverse SMA Connection

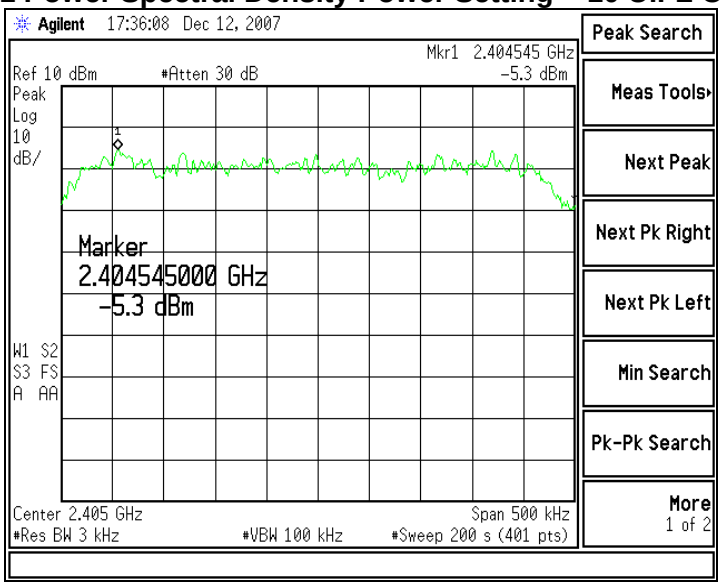


Screen Captures – Power Spectral Density (continued)

Channel 26 Power Spectral Density Power Setting = 2 Reverse SMA Connection

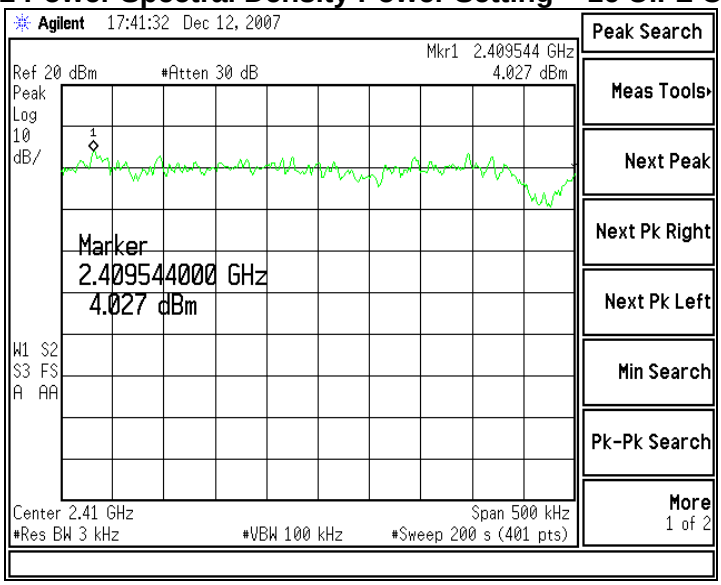


Channel 11 Power Spectral Density Power Setting = 10 U.FL Connection

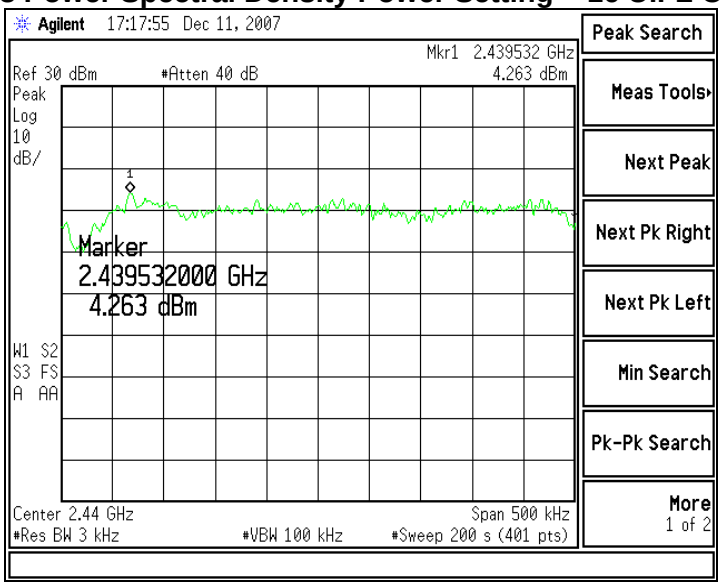


Screen Captures – Power Spectral Density (continued)

Channel 12 Power Spectral Density Power Setting = 16 U.FL Connection

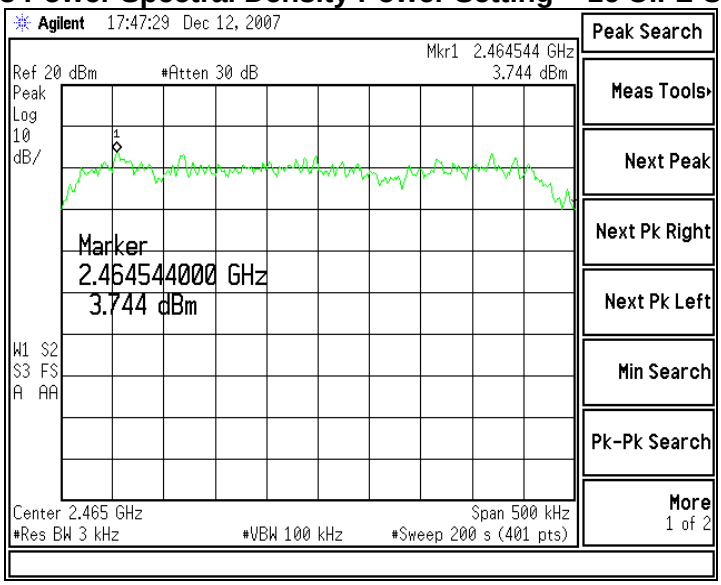


Channel 18 Power Spectral Density Power Setting = 16 U.FL Connection

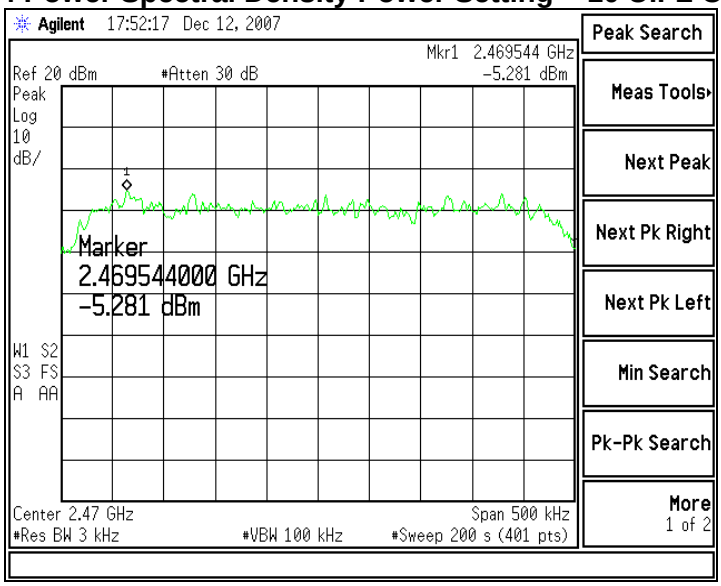


Screen Captures – Power Spectral Density (continued)

Channel 23 Power Spectral Density Power Setting = 16 U.FL Connection

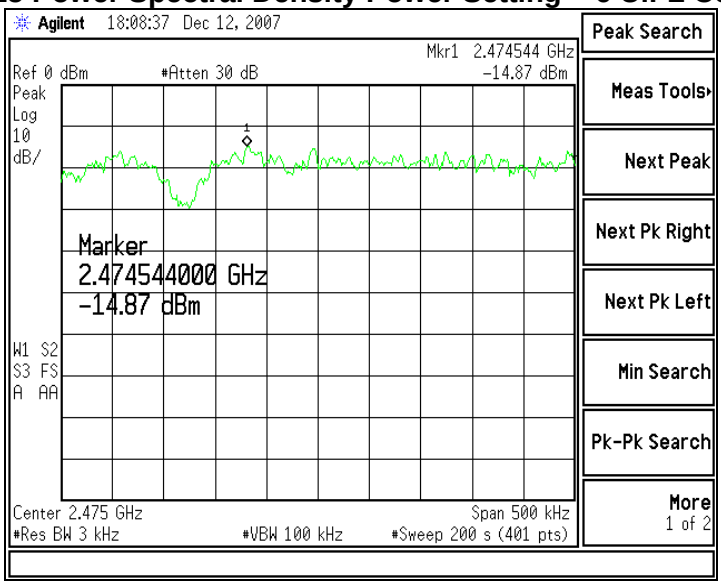


Channel 24 Power Spectral Density Power Setting = 10 U.FL Connection



Screen Captures – Power Spectral Density (continued)

Channel 25 Power Spectral Density Power Setting = 6 U.FL Connection



Channel 26 Power Spectral Density Power Setting = 2 U.FL Connection

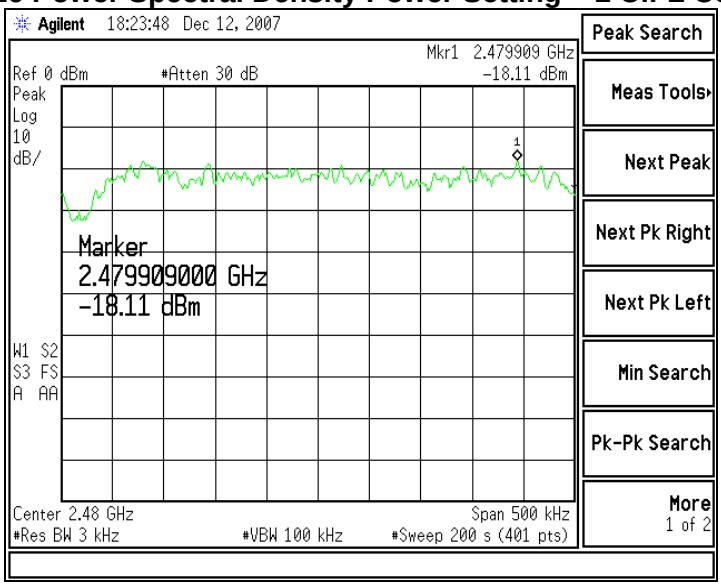


EXHIBIT 11. SPURIOUS EMISSIONS: 15.247(d)

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 an RF conducted measurement.

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 E4407B spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

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

	Dipole Channel 11(dBm)	Dipole Channel 18(dBm)	Dipole Channel 23(dBm)	Ceramic Chip Channel 11(dBm)	Ceramic Chip Channel 18(dBm)	Ceramic Chip Channel 23(dBm)
Fund.	17.21	17.48	16.81	16.15	15.24	16.18
2nd f	Note (1)	Note (1)	Note (1)	-55.25	-60.74	-71.39
3rd f	-45.15	-45.55	-47.05	-50.73	-50.54	-52.11
4th f	-47.25	-45.33	-44.77	-52.80	-55.92	-64.60
5th f	-60.30	-58.56	-58.80	Note (1)	Note (1)	Note (1)
6th f	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)
7th f	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)
8th f	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)
9th f	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)
10th f	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)	Note (1)

Notes:
(1) Measurement at 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

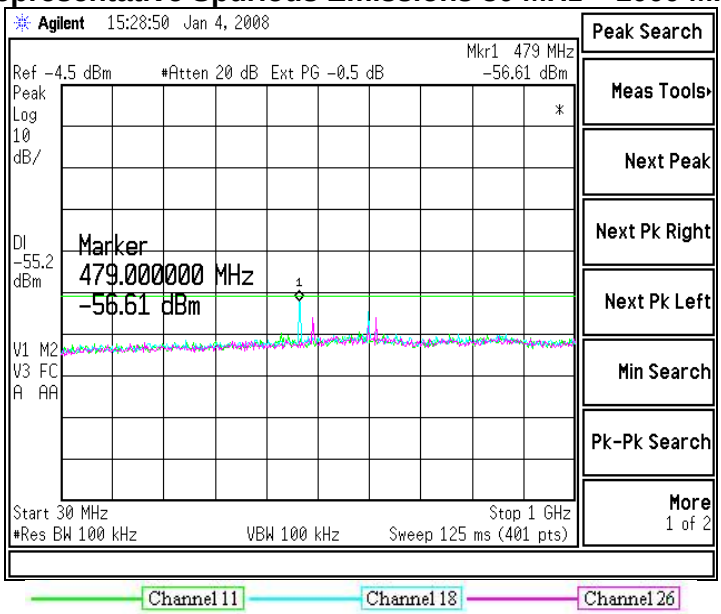
11.3 Test Data

Fundamental Frequency: *2400 – 2480 MHz*
Modulation: *MSK*
Frequency Test Range: *30MHz – 25000 MHz*

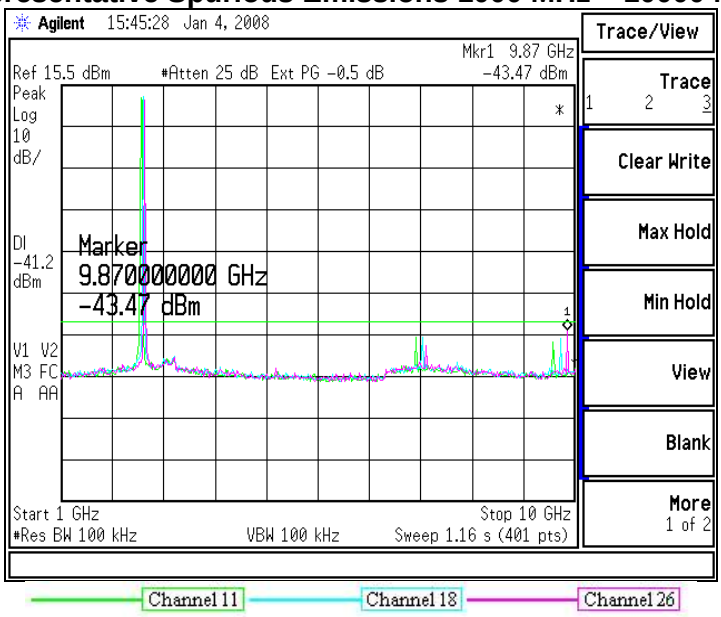
Frequency (MHz)	Channel	RF Level (dBm)	Limit 15.209 (dBm)	Limit 15.247 (dBm)	Margin (dB)	Pass/ Fail
445	11	-63.93	-	-8.19	55.74	Pass
481	18	-56.55	-	-8.19	48.36	Pass
505	23	-60.25	-	-8.19	52.06	Pass
610	11	-59.03	-49.23	-	9.8	Pass
610	18	-59.03	-49.23	-	9.8	Pass
624	23	-60.89	-	-8.19	52.70	Pass

11.4 Screen Captures – Spurious Conducted Emissions

Representative Spurious Emissions 30 MHz – 1000 MHz



Representative Spurious Emissions 1000 MHz – 10000 MHz



Screen Captures – Spurious Conducted Emissions

Representative Spurious Emissions 10000 MHz – 25000 MHz

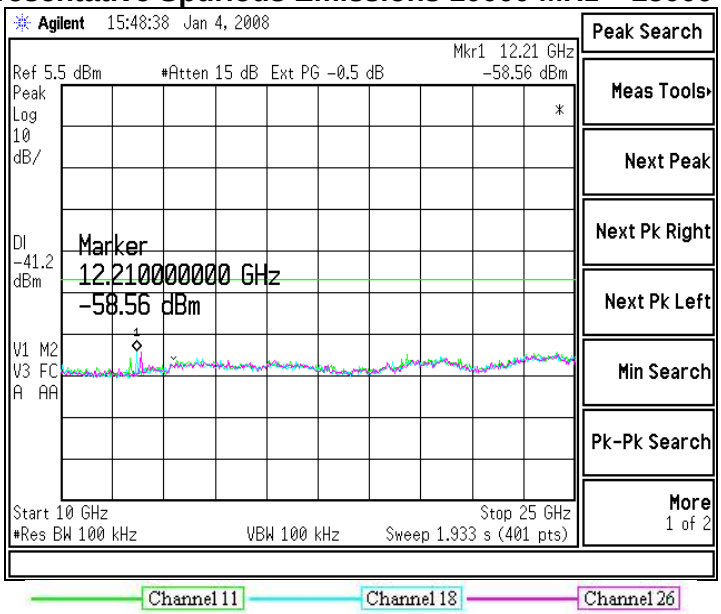


EXHIBIT 12. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

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. The transmitter portion of the EUT was placed in CW modulated continuous transmit mode. Power was supplied by an external bench-type variable power supply, and the frequency of operation was monitored using the spectrum analyzer.

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=10 kHz settings while the voltage was varied.

	DC Voltage Source		
	2.55 VDC	3.0 VDC	3.45 VDC
Channel 11	2405.0205 (MHz)	2405.02 (MHz)	2405.02 (MHz)
Channel 18	2440.02 (MHz)	2440.0205 (MHz)	2440.0205 (MHz)
Channel 23	2465.0213 (MHz)	2465.0211 (MHz)	2465.0206 (MHz)

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 Voltage Source		
	2.55 VDC	3.0 VDC	3.45 VDC
Channel 11	13.81 (dBm)	19.47 (dBm)	21.75 (dBm)
Channel 18	13.79 (dBm)	18.99 (dBm)	21.51 (dBm)
Channel 23	13.74 (dBm)	18.73 (dBm)	21.37 (dBm)

The power was then cycled On/Off to observe system response. No unusual response was observed, the emission characteristics were within expected parameters, and the system returned to the same state of operation as before the power cycle.

EXHIBIT 13. MPE CALCULATIONS

The following MPE calculations are based on the ACE-2400NF dipole and ceramic chip antennas, with a measured ERP of 117.8 dBµV/m and 116.1 dBµV/m respectively at 3 meters, and conducted RF power of +19.46 dBm and +18.91 dBm respectively as presented to the antenna. The declared typical gains of these antennas, based on the information in Appendix B of this document, are 2.0dBi (dipole) and 1.2dBi (chip).

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

EUT (Dipole Antenna Configuration):

Maximum peak output power at antenna input terminal:	19.46	(dBm)
Maximum peak output power at antenna input terminal:	88.308	(mW)
Antenna gain(typical):	2	(dBi)
Maximum antenna gain:	1.585	(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:	0.027844	(mW/cm^2)
Maximum allowable antenna gain:	17.6	(dBi)
Margin of Compliance at 20 cm =	15.6	dB

EUT (Chip Antenna Configuration):

Maximum peak output power at antenna input terminal:	18.91	(dBm)
Maximum peak output power at antenna input terminal:	77.804	(mW)
Antenna gain(typical):	1.2	(dBi)
Maximum antenna gain:	1.318	(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:	0.020405	(mW/cm^2)
Maximum allowable antenna gain:	18.1	(dBi)
Margin of Compliance at 20 cm =	16.9	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	12/04/07	12/04/08
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.

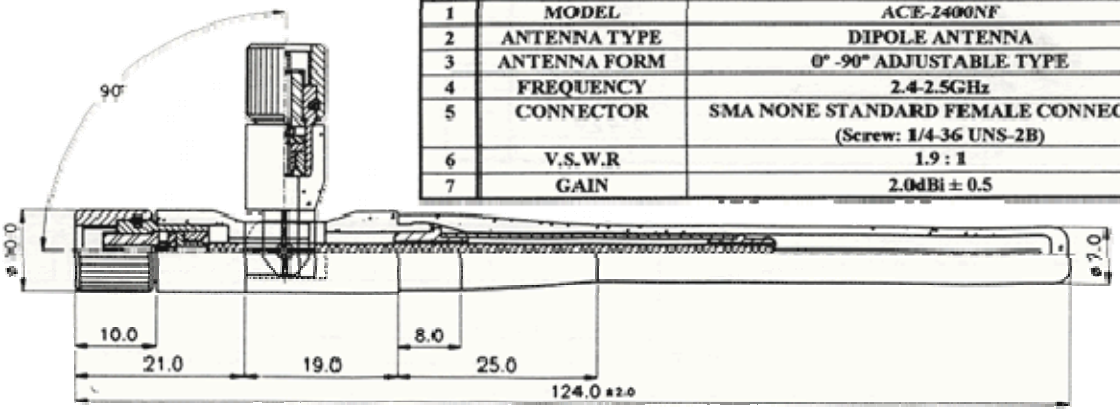
Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

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

Antenna Specification(s)

No	ITEM	SPECIFICATION
1	MODEL	ACE-2400NF
2	ANTENNA TYPE	DIPOLE ANTENNA
3	ANTENNA FORM	0° -90° ADJUSTABLE TYPE
4	FREQUENCY	2.4-2.5GHz
5	CONNECTOR	SMA NONE STANDARD FEMALE CONNECTOR (Screw: 1/4-36 UNS-2B)
6	V.S.W.R	1.9 : 1
7	GAIN	2.0dBi ± 0.5



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antenova

General data

Product Name	Mica 2.4 GHz
Article No.	3030A5645-01
Frequency	2.4-2.5 GHz
Polarization	Linear
Operating temperature	-40 to + 85 degC
Impedance	50 Ohm
Weight	0.4 gram
Antenna type	SMD

Electrical characteristics

	Characteristics			Conditions*
	Min	Typ	Max	
Peak Gain	0.8 dBi	1.2 dBi	1.9 dBi	Frequency 2.4-2.5 GHz, Measured in 3D chamber (near field)
Efficiency	70%	75%	79%	
VSWR	1.0:1	1.5:1	1.9:1	Frequency 2.4-2.5 GHz, Measured in Network Analyzer

*Note all data provided in this table are based on the gigaNOVA™ reference board

Appendix C

Firmware and Setup Instructions

When the device was utilized in the LSR Evaluation Platform Fixture, setup was performed through the use of jumper combinations located at PCB designation “J2”. This allowed the device to be configured in transmit or receive mode, and provided the test laboratory with the capability to select one of three available channels (11, 18, 26), and either enable/disable modulation.

When the device was utilized in the Customer Supplied Evaluation Platform Fixture (CEN-HPRFGW), setup was performed through a hyper terminal serial communication link. This allowed the device to be configured in transmit or receive mode, and provided the test laboratory the capability to select any of the fifteen available channels, set the output power level, and to transmit in two modulation modes: pseudo-random data, and a “1010” data stream.

Appendix D

Justifications of Average Duty Factor Calculations

The relaxation factor due to duty cycle is being requested because in the proprietary protocol, with the large packet size available when transmitted at the fastest rate possible, results in the transmitter being on for 58.30ms in any 100ms window. All remaining applications have a shorter transmit time. The timing is a function of the protocol that can be run on the module and has a fixed setting.

Average (Relaxation) Factor

Average Factor = 20* Log_{10} (Worst Case EUT On-time over 100 ms time window)

The transmit packet occupies 58 ms of time, within any 100 ms window. Therefore, the relaxation factor allowance is calculated as:

Average Factor = 20* Log_{10} (58 / 100 ms) = -4.73

A relaxation factor of -4.7 dB would be allowable for this product.