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ENGINEERING TEST REPORT # 306546 TX

Compliance Testing of:
Wireless Room Temperature Sensor

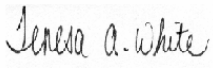
Test Date(s):
December 8th, 11th and 12th 2006

Prepared For:
Bill Heidrich
Siemens building Technologies
1000 Deerfield Parkway
Buffalo Grove,
IL 60089

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 19, 2007

Test Report Prepared by:	**Tested by:**
Teresa A. White, Document Coordinator	Khairul Aidi Zainal, EMC Engineer
Signature: 	Signature: 
Date: January 19, 2007	Date: January 19, 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:	**Siemens**
Address:	**1000 Deerfield Parkway, Buffalo Grove, IL, 60089**
Contact Person:	**Bill Heidrich**

2.2 EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information has been supplied by the applicant.

Product Name:	Wireless Room Temperature Sensor
Model Number:	WRTS
Serial Number:	06450481 (Conducted Measurements) 06450363 (Radiated Measurements)

2.3 ASSOCIATED ANTENNA DESCRIPTION

The only available antenna for this unit is the printed circuit board inverted F antenna.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

Frequency Range (in MHz)	2405 MHz – 2480 MHz
RF Power in Watts	0.0013 Watts
Field Strength (and at what distance)	95.4 dBuV/m at 3 meters (2475 MHz)
Occupied Bandwidth (99% BW)	3200 kHz
Type of Modulation	DSSS
Emission Designator	F1D3M18
Transmitter Spurious (worst case)	56.1 dBµV/m at 1m (4950 MHz)
Frequency Tolerance %, Hz, ppm	Better than 100 PPM
Microprocessor Model # (if applicable)	Atmel ATMEGA 128L
EUT will be operated under FCC Rule Part(s)	47 CFR part 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
	√	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: 47 CFR 15.247, RSS 210
- Measurement Distance: 3 m
- RF Value: 0.058 ☒ V/m ☐ A/m ☐ W/m^2
  ☒ Measured ☐ Computed ☐ Calculated

2.5 PRODUCT DESCRIPTION

The product is a thermostat module that communicates with a central control via a 2.4 GHz link using Ember Mesh protocol. The radio hardware is an Ember EM2420 with no external PA. Output power is nominally 0dBm into a printed circuit board inverted F antenna. Frequency of operation is from 2405 MHz to 2480 MHz in 5 MHz steps, with the highest channel (2480 MHz) operating at reduced power. The power setting for the reduced power channel at the control menu was set at -5dBm.
Data source is internal digital modulation from the EM2420. Powering the unit is an internal 3.6 lithium primary cell. A serial connection is needed to enter test modes. This connection is then removed for testing. During initial setup a field service personnel will use the serial connection to set up the system. However, this connection will be removed thus making any modifications to the unit impossible for end users.

PHOTO

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	70º Fahrenheit
Humidity:	40%
Pressure:	740 mmHg

3.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Paragraph	Test Requirements	Compliance (yes/no)
15.207	Power Line Conducted Emissions Measurements	N/A
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)**

Reduced power at channel 1a (2480 MHz) to -5dBm (P 05 at the control menu) to comply with band edge requirements.

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 modulated continuous transmit mode for final testing with power as provided by a 3.6 V Lithium primary cell. The unit has the capability to operate on 15 channels, controllable via a control menu available using a hyper-terminal window.

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 four (4) standard channels: 0b (2405MHz), 12 (2440MHz), 19 (2475MHz) and 1a (2480MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using a control menu available using a hyper-terminal window.

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 battery voltage was checked frequently, and the batteries were replaced as necessary.

The EUT was rotated along three orthogonal axes 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

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:	Siemens					
Date(s) of Test:	December 8th, 11th and 12th 2006					
Test Engineer(s):	Khairul Aidi Zainal					
Voltage:	3.6 VDC					
Operation Mode:	Modulated continuous transmit.					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
EUT Power:		Single Phase ___VAC		3 Phase ___VAC		
	√	Battery		Other:		
EUT Placement:	√	80cm non-conductive table		10cm Spacers		
EUT Test Location:	√	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS		
Measurements:		Pre-Compliance		Preliminary	√	Final
Detectors Used:		Peak	√	Quasi-Peak	√	Average

RADIATED EMISSIONS DATA CHART *(continued)*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 0b:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2405.0	V/V	1.22	206	90.2	125.2	35.0
4810.0	V/V	1.03	190	53.3	63.5	10.2
7215.0	H/S	1.00	40	45.6	70.3	30.7
9620.0	H/S	1.00	252	39.6	70.3	30.7
12025.0				Note 3		
14430.0				Note 3		
16835.0				Note 3		
19240.0				Note 3		
21645.0				Note 3		
24050.0				Note 3		

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 12:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2440.0	V/V	1.16	227	92.9	125.2	32.3
4880.0	V/V	1.00	178	53.9	63.5	9.6
7320.0	H/S	1.00	41	44.0	63.5	19.5
9760.0	H/S	1.00	250	38.7	73.0	34.3
12200.0				Note 3		
14640.0				Note 3		
17080.0				Note 3		
19520.0				Note 3		
21960.0				Note 3		
24400.0				Note 3		

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 19:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2475.0	V/V	1.13	228	95.3	125.2	29.9
4950.0	V/V	1.08	188	56.1	63.5	7.4
7425.0	H/S	1.00	43	44.2	63.5	19.3
9900.0	H/S	1.00	249	39.9	75.4	35.5
12375.0				Note 3		
14850.0				Note 3		
17325.0				Note 3		
19800.0				Note 3		
22275.0				Note 3		
24750.0				Note 3		

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 1a:

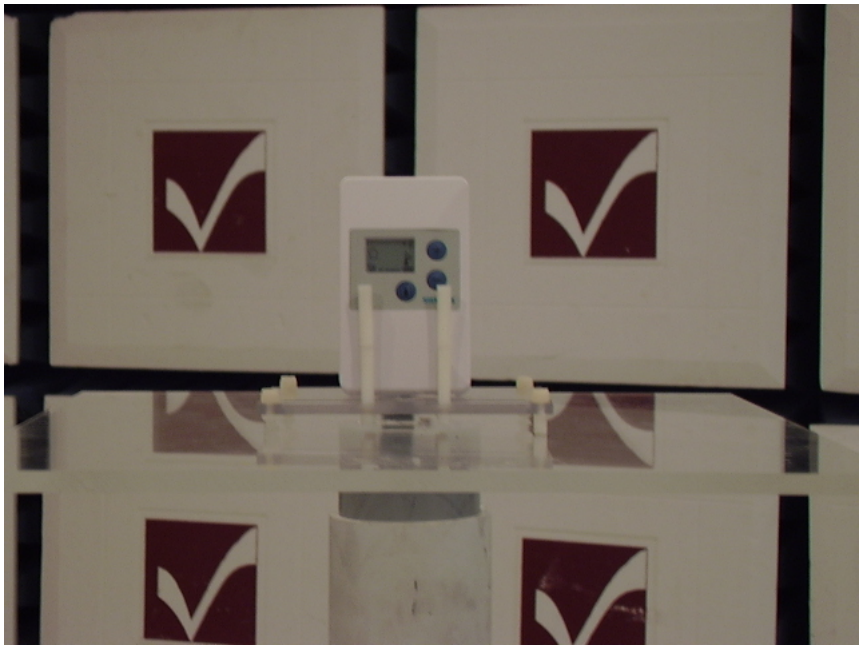
Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2480.0 **Note 5**	V/V	1.20	161	95.0	134.4	39.4
4960.0	V/V	1.04	127	53.2	63.5	10.3
7440.0	H/S	1.00	36	38.7	63.5	24.8
9920.0				Note 3		
12400.0				Note 3		
14880.0				Note 3		
17360.0				Note 3		
19840.0				Note 3		
22320.0				Note 3		
24800.0				Note 3		

Notes:

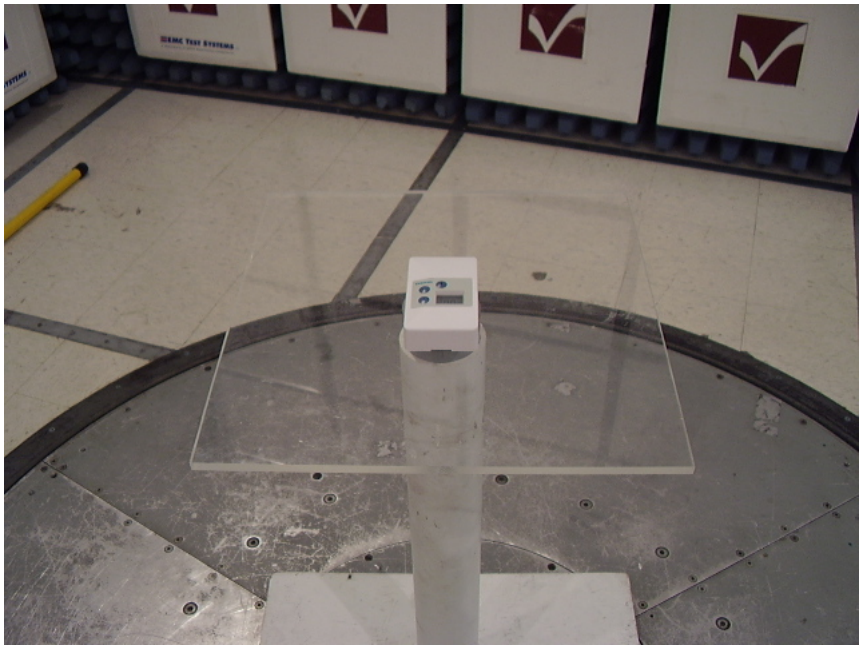
1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above 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=3 MHz.
5) Measurement of the fundamental for this channel was made at a separation distance of 1m.

5.7 Test Setup Photo(s) – Radiated Emissions Test

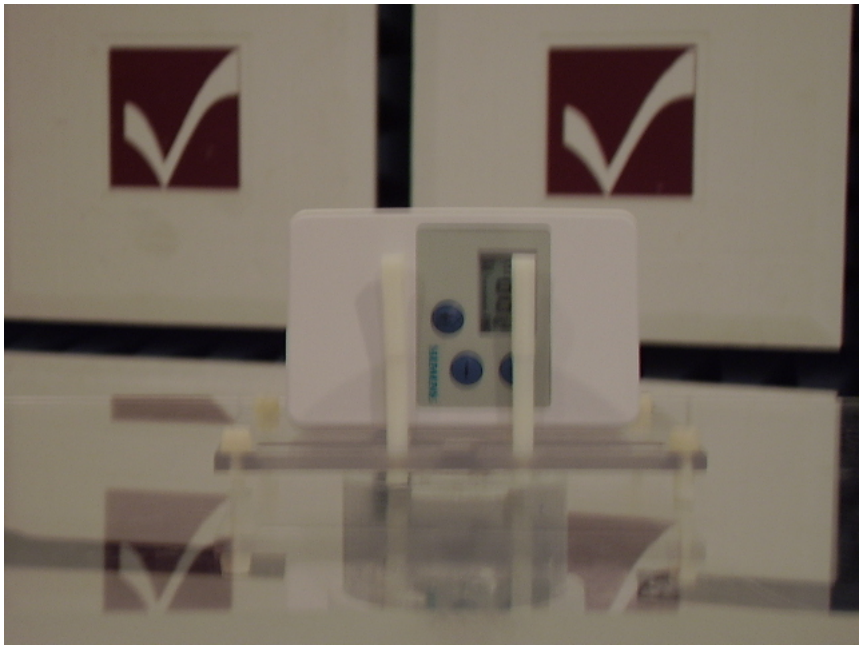
Vertical Orientation



Horizontal Orientation



Side Orientation

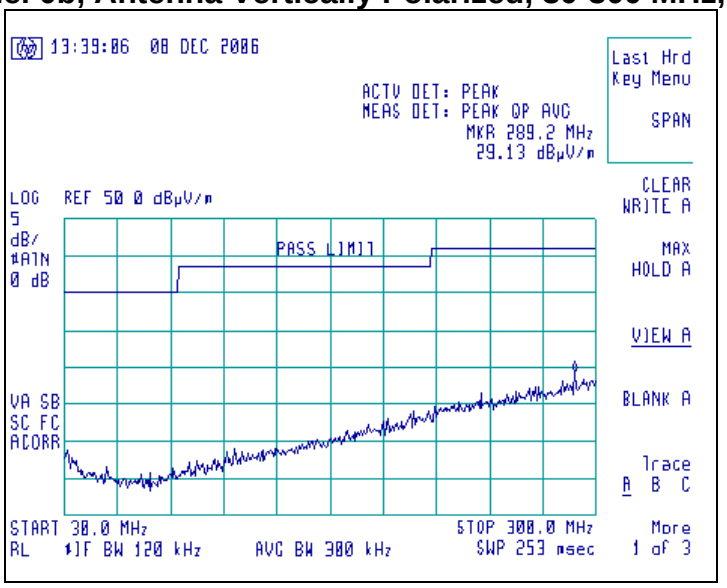


5.8 Screen Captures - Radiated Emissions Testing

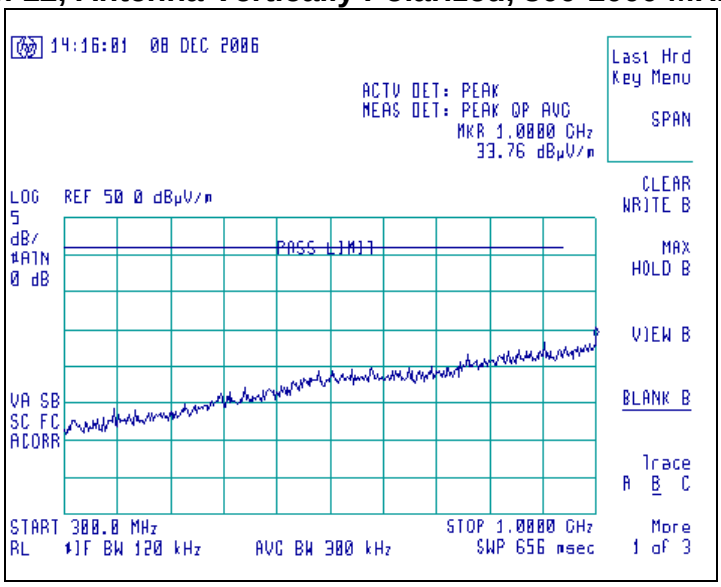
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and an Average detector function is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 0b, 12, 19 or 1a, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Channel 0b, Antenna Vertically Polarized, 30-300 MHz, at 3m

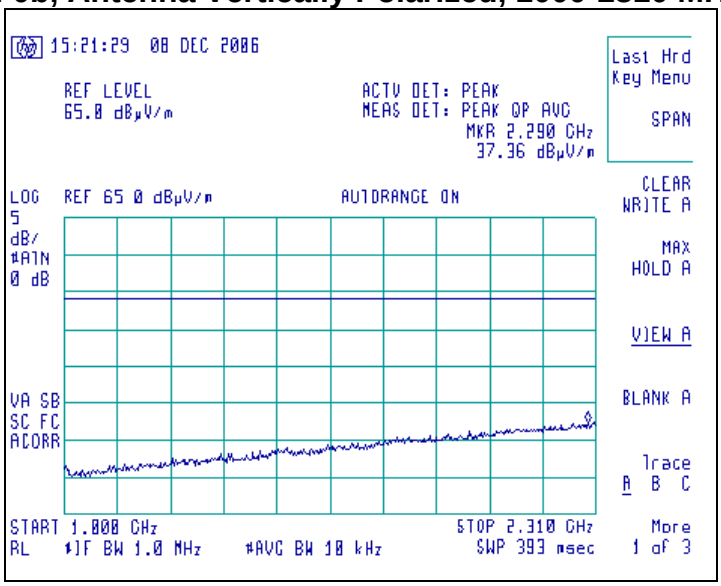


Channel 12, Antenna Vertically Polarized, 300-1000 MHz, at 3m

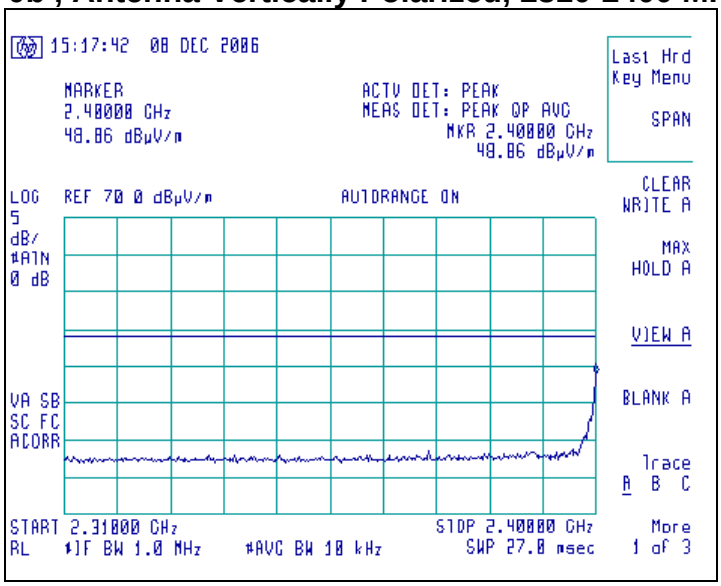


Screen Captures - Radiated Emissions Testing ***(continued)***

Channel 0b, Antenna Vertically Polarized, 1000-2310 MHz, at 3m

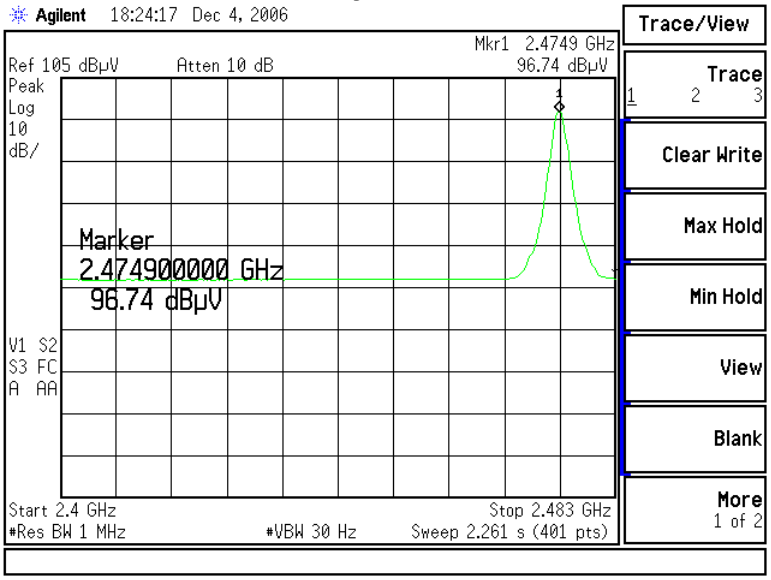


Channel 0b , Antenna Vertically Polarized, 2310-2400 MHz, at 3m

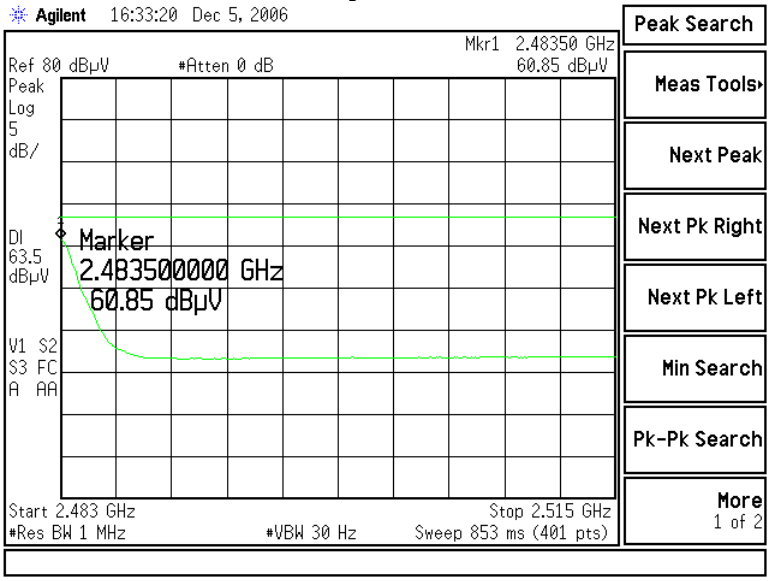


Screen Captures - Radiated Emissions Testing *(continued)*

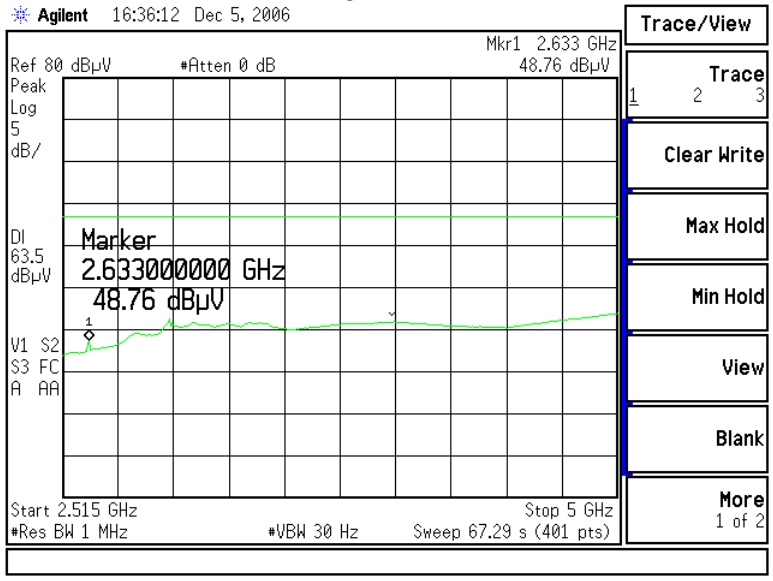
Channel 19, Antenna Vertically Polarized, 2400-2483 MHz, at 1m



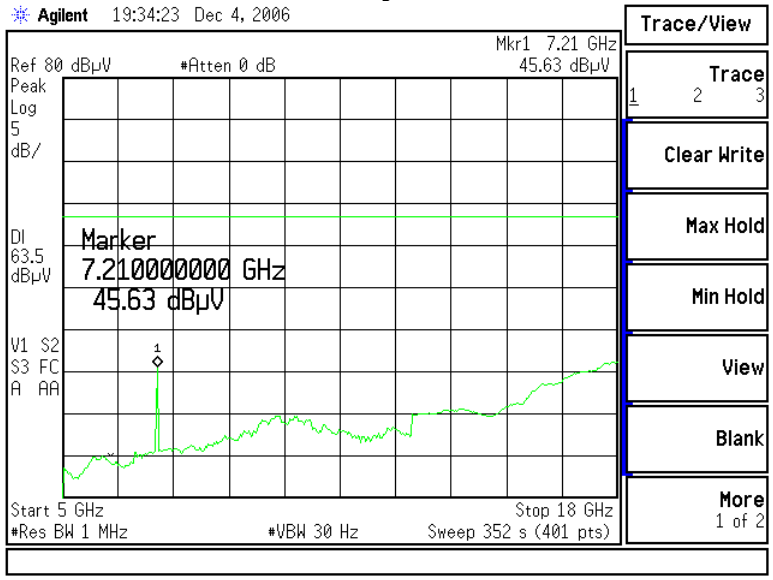
Channel 1a, Antenna Vertically Polarized, 2483 -2515 MHz, at 1m



Channel 1a, Antenna Vertically Polarized, 2515 - 5000 MHz, at 1m



Channel 0b, Antenna Horizontally Polarized, 5000-18000 MHz, 1 m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 19, Antenna Horizontally Polarized, 18000-25000 MHz, at 30cm

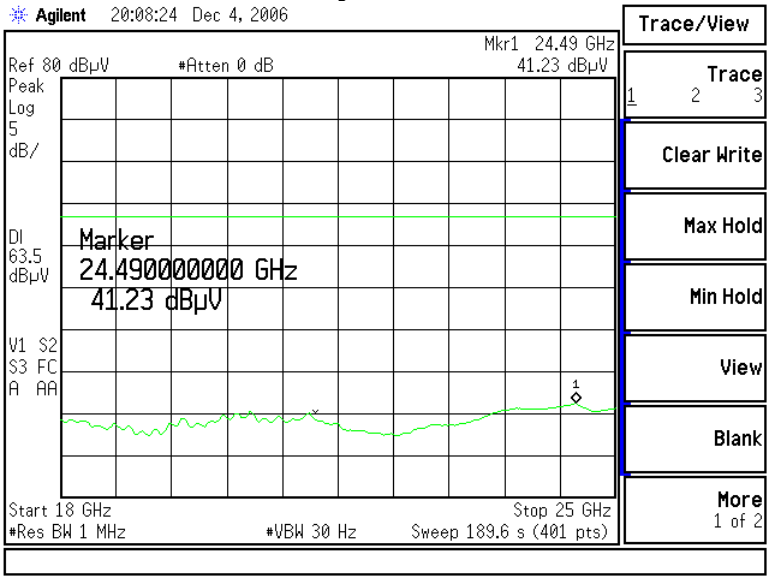


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE: 15.207

The EUT runs only on Batteries (3.6 V Lithium primary cell) thus this test was not applicable.

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=300 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 modulated 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 1.58 MHz, which is above the minimum of 500 kHz.

-

Test Data

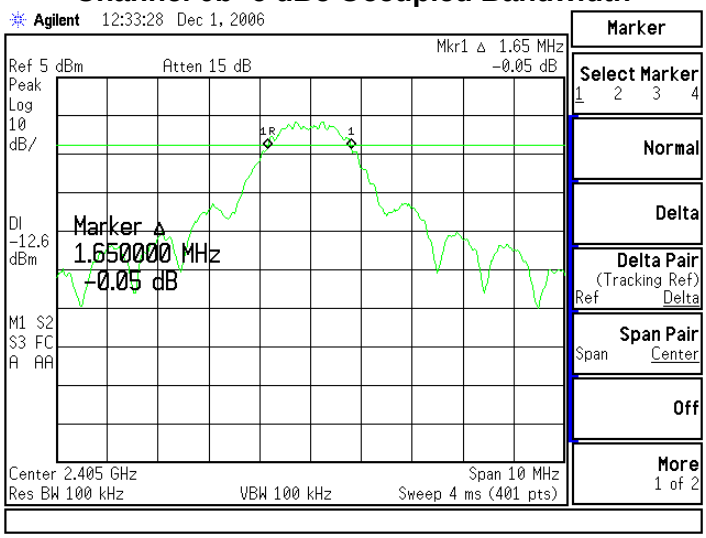
Channel	Center Frequency (MHz)	Measured -6 dBc Occ. BW (kHz)	Minimum -6 dBc Limit (kHz)	Measured -20 dBc Occ.Bw (kHz)
0b	2405	1.65	500	2.75
12	2440	1.65	500	2.93
19	2475	1.63	500	3.18
1a	2480	1.58	500	2.85

7.3 Test Equipment List

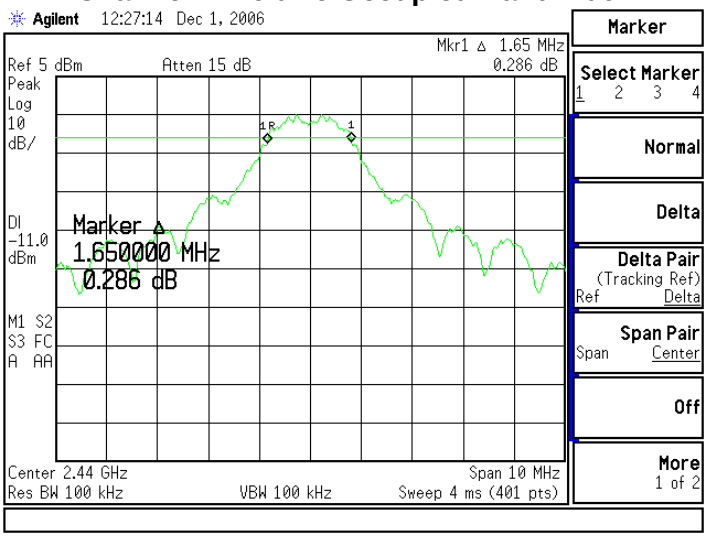
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4407B	US39160256
Spectrum Analyzer	Agilent	E4446A	US45300564

7.4 Screen Captures - OCCUPIED BANDWIDTH

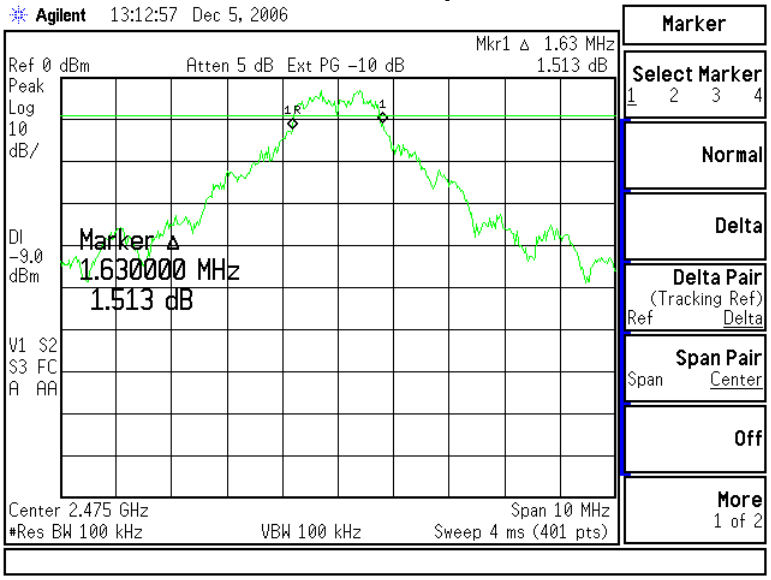
Channel 0b -6 dBc Occupied Bandwidth



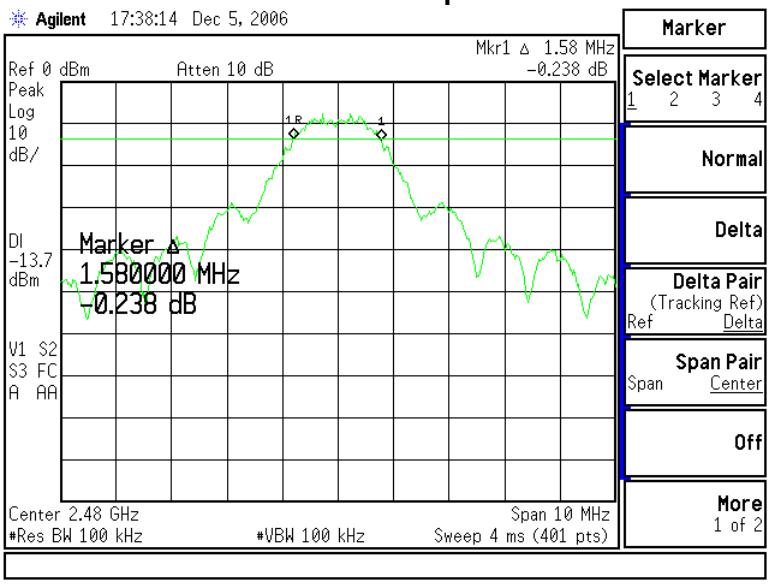
Channel 12 -6 dBc Occupied Bandwidth



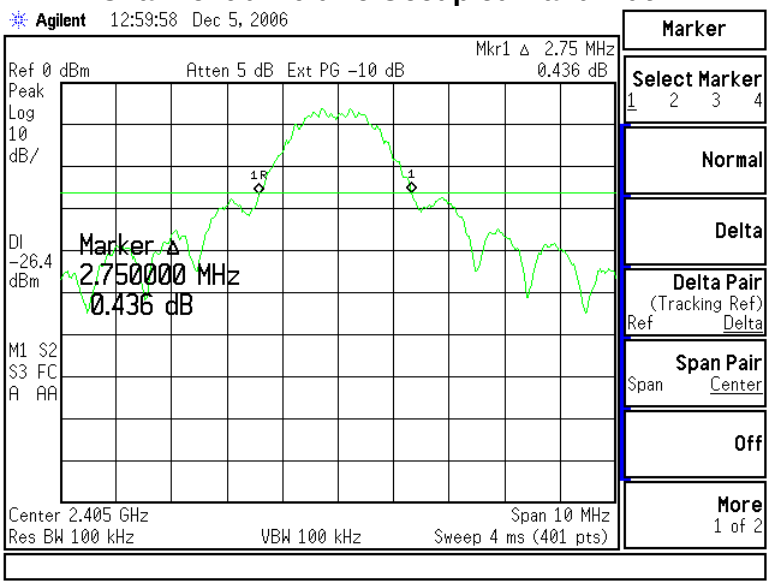
Channel 19 -6 dBc Occupied Bandwidth



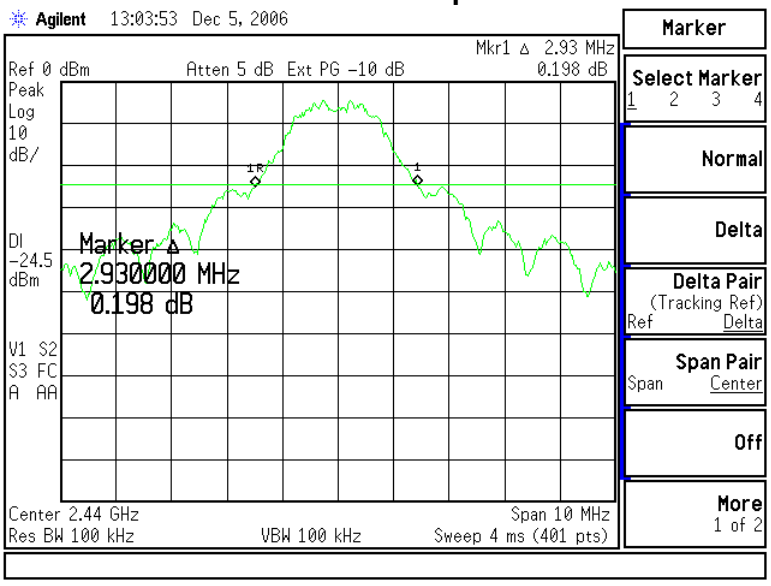
Channel 1a -6 dBc Occupied Bandwidth



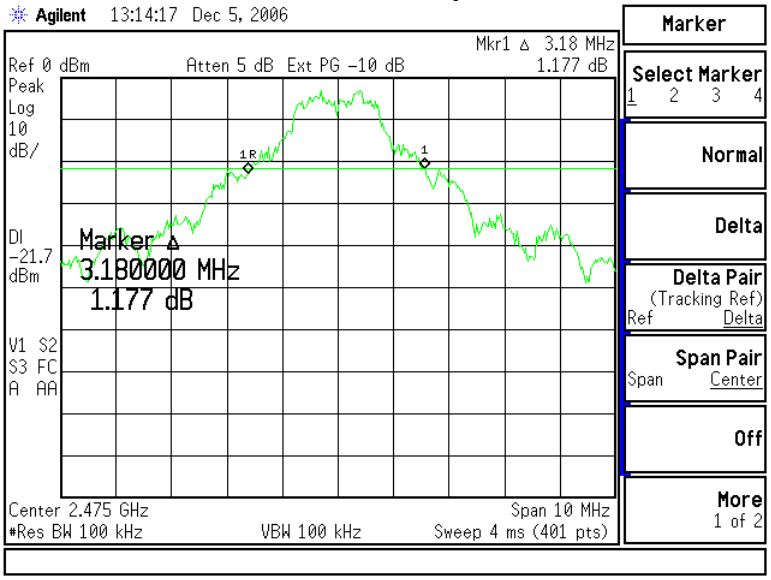
Channel 0b -20 dBc Occupied Bandwidth



Channel 12 -20 dBc Occupied Bandwidth



Channel 19 -20 dBc Occupied Bandwidth



Channel 1a -20 dBc Occupied Bandwidth

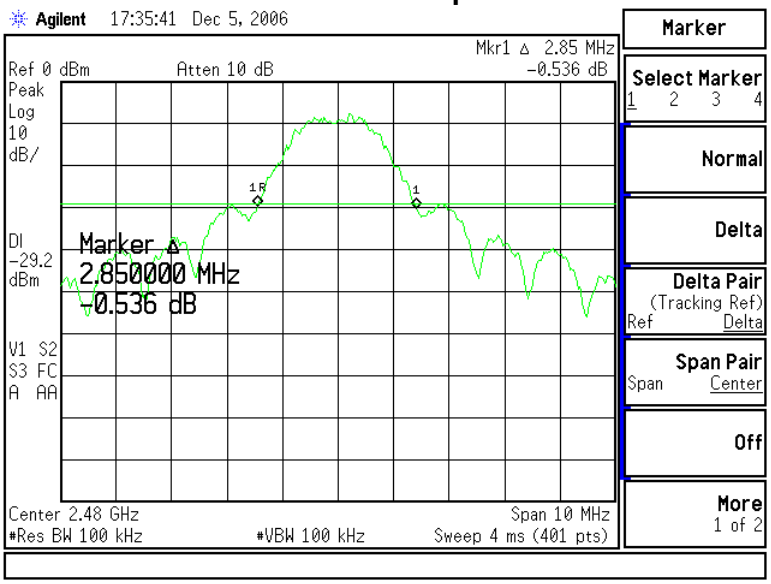


EXHIBIT 8. BAND-EDGE MEASUREMENTS

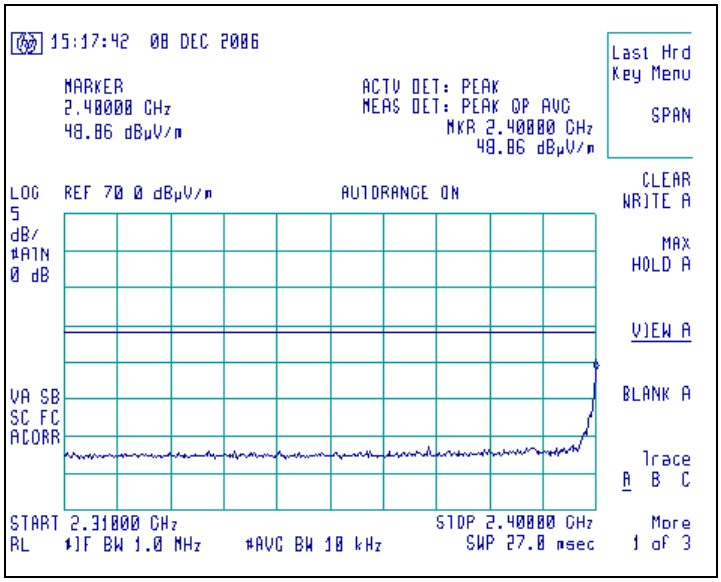
8.1 Method of Measurements

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 + 70.3 dBµV/m at 3 meters

The Upper Band-Edge limit, in this case, would be + 63.5 dBµV/m at 1 meter

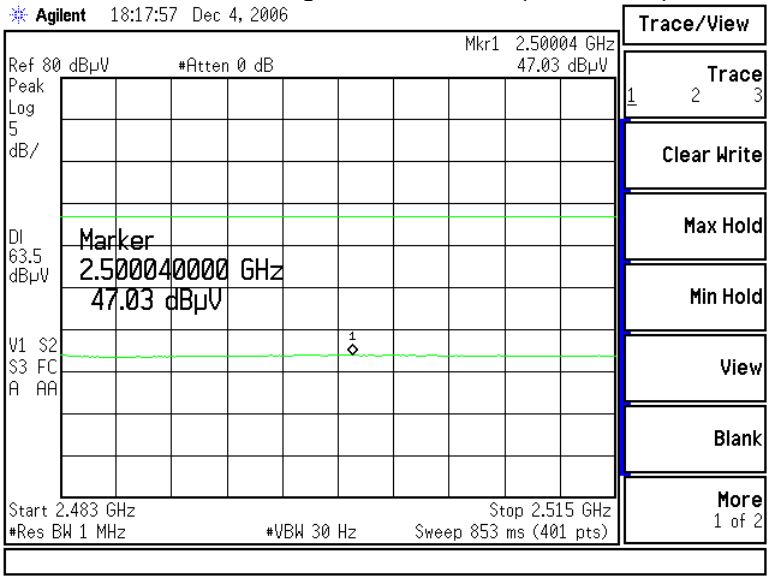
Screen Capture Demonstrating Compliance at the Lower Band-Edge



EUT transmitting on channel 0b (2405 MHz).

Screen Capture Demonstrating Compliance at the Higher Band-Edge

EUT transmitting on channel 19 (2475 MHz)



EUT transmitting on channel 1a (2480 MHz)

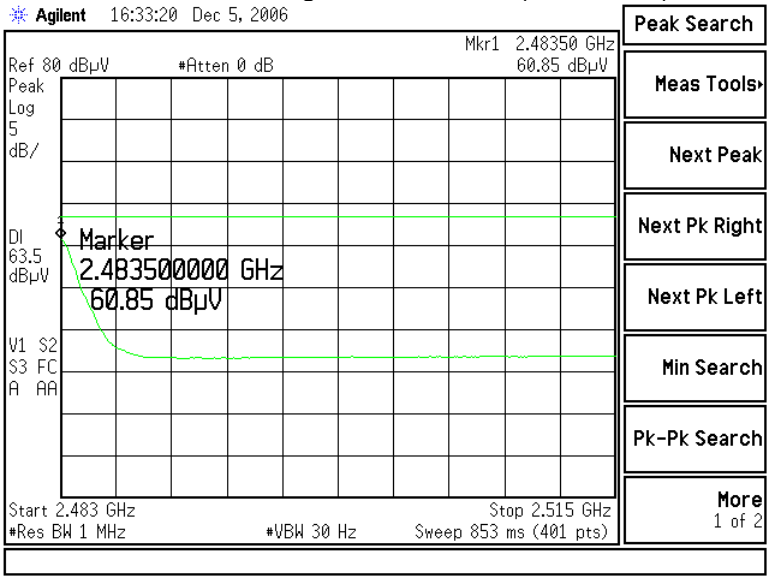


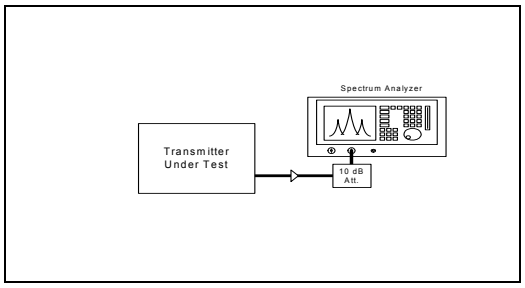
EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

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 internal data as a modulation source. The spectrum analyzer was used with resolution and video bandwidths set to 3 MHz and 5 MHz (Channel 19), and a span of 20 MHz, with measurements from a peak detector presented in the chart below.

9.2 Test Data

CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
0b	2405	+30 dBm	-2.3	32.3
12	2440	+30 dBm	-0.7	30.7
19	2475	+30 dBm	1.3	28.7
1a	2480	+30 dBm	-4.1	34.1



Radiated RF power output (in watts): 0.0010 Watts

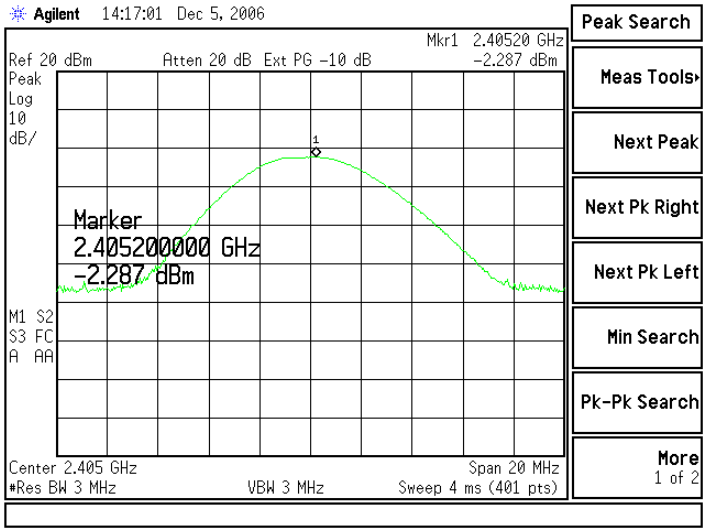
Measured RF Power Output (in Watts): 0.0013 Watts
Declared RF Power Output (in Watts): 0.0010 Watts

9.3 Test Equipment List

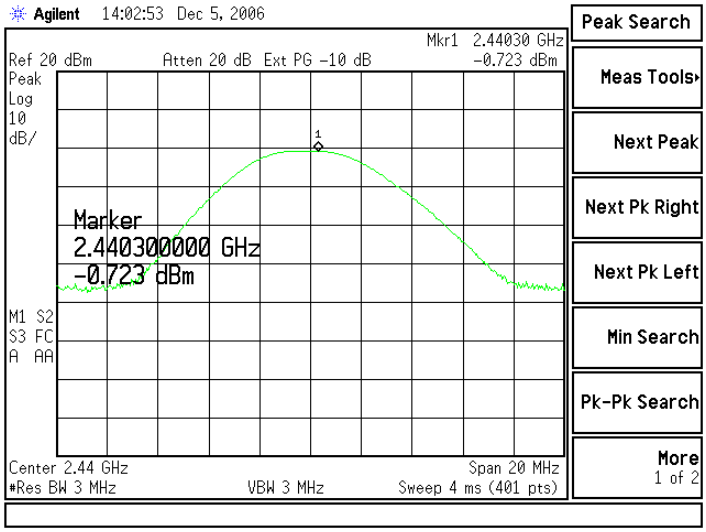
Test Equipment	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Agilent	E4446A	US45300564	3Hz to 44 GHz

9.4 Screen Captures – Power Output (Conducted)

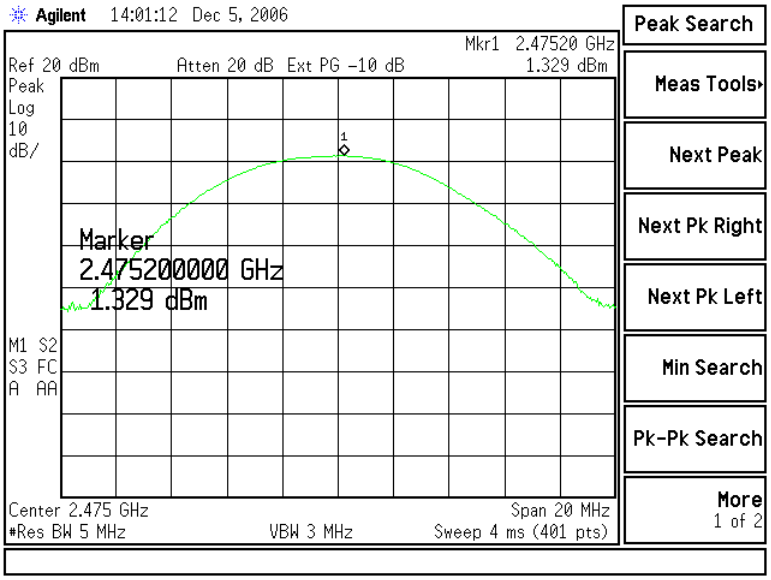
Channel 0b



Channel 12



Channel 19



Channel 1a

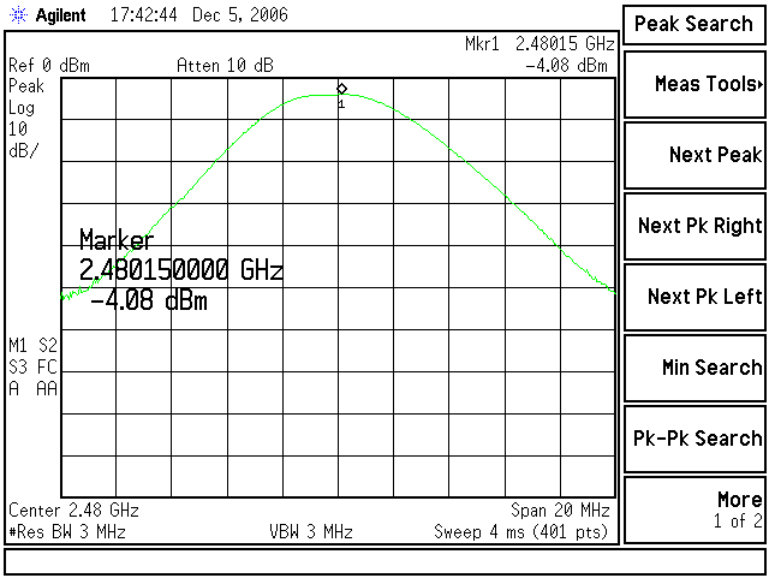


EXHIBIT 10. POWER SPECTRAL DENSITY: 15.247(e)

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 was found to be no greater than -12.3 dBm, which is under the allowable limit by 20.3 dB.

10.2 Test Equipment List

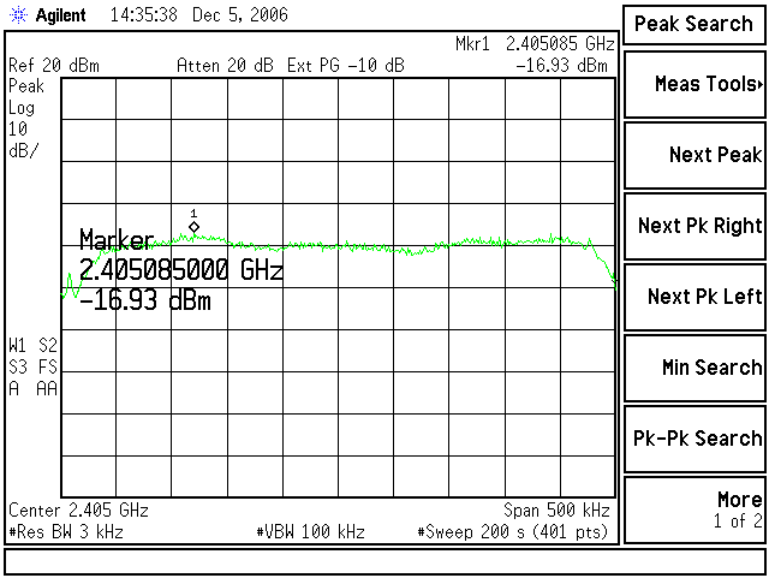
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4446A	US45300564

10.3 Test Data

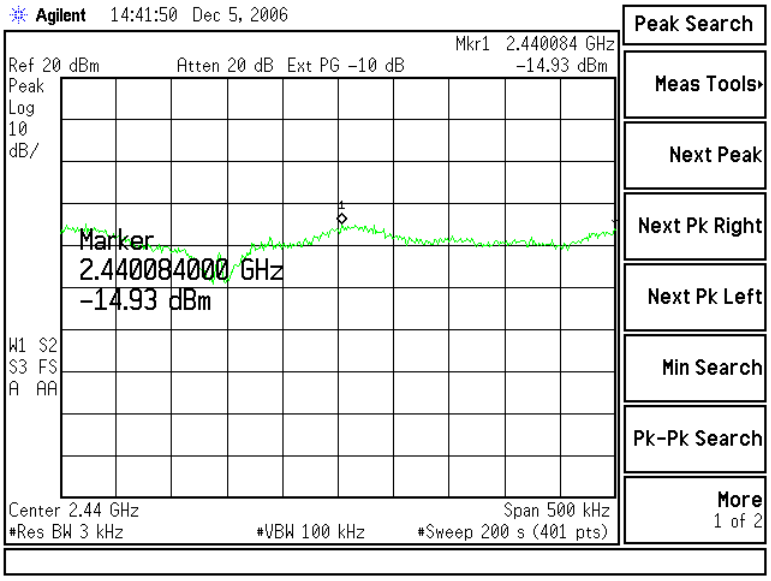
Transmitter Channel	Frequency (MHz)	RF Power Level In 3 kHz BW (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Comments Pass/Fail
0b	2405	-16.9	8.0	24.9	Pass
12	2445	-14.9	8.0	22.9	Pass
19	2475	-12.3	8.0	20.3	Pass
1a	2480	-18.4	8.0	26.4	Pass

10.4 Screen Captures – Power Spectral Density

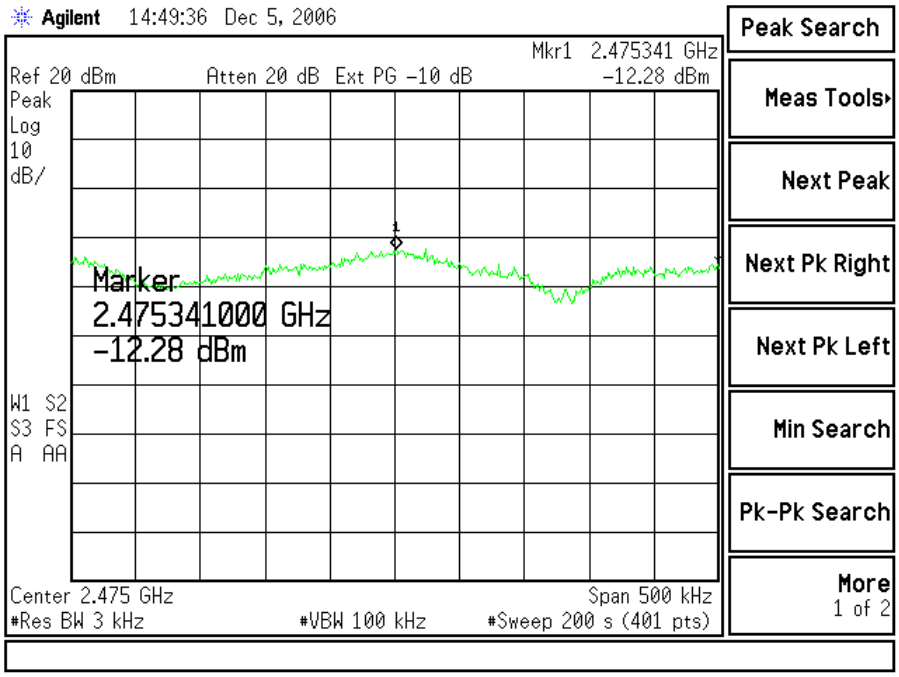
Channel 0a



Channel 12



Channel 19



Channel 1a

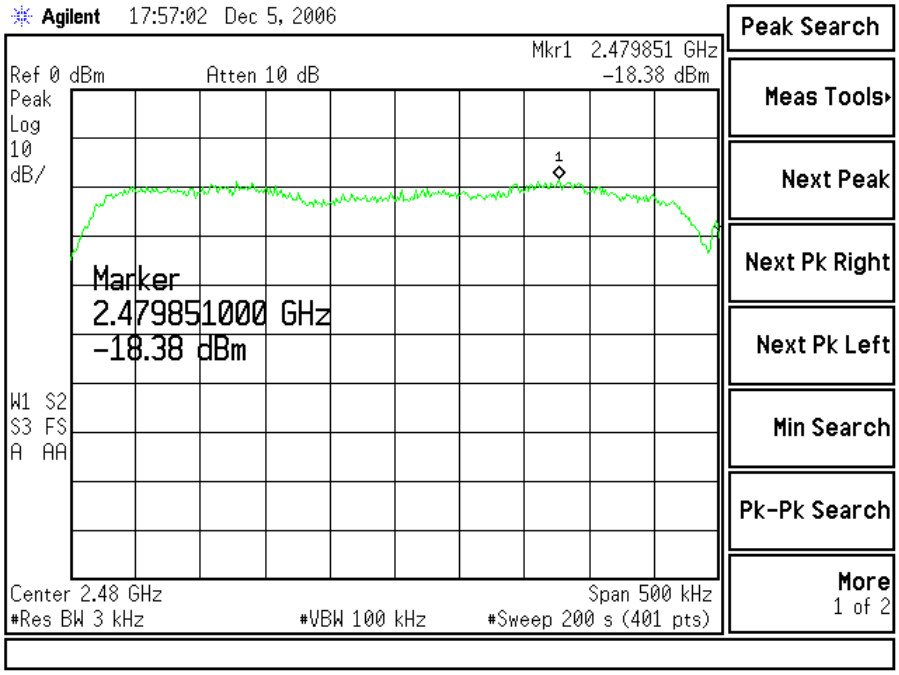


EXHIBIT 11. SPURIOUS RADIATED EMISSIONS: 15.247(d)

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 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.

11.2 Test Equipment List

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

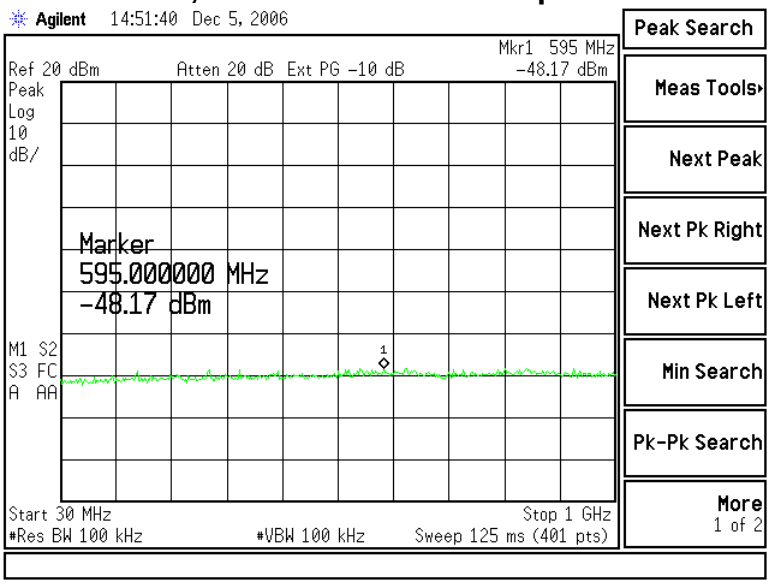
11.3 Test Data

	Channel 0b	Channel 12	Channel 19	Channel 1a
Fundamental	-6.15 (dBm)	-4.45 (dBm)	-2.61 (dBm)	-8.22 (dBm)
2nd Harmonic	-35.6 (dBm)	-34.2 (dBm)	-30.6 (dBm)	-48.2 (dBm)
3rd Harmonic	-44.2 (dBm)	-43.8 (dBm)	-40.6 (dBm)	-61.0 (dBm)
4th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
5th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
6th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
7th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
8th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
9th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)
10th Harmonic	Note (1)	Note (1)	Note (1)	Note (1)

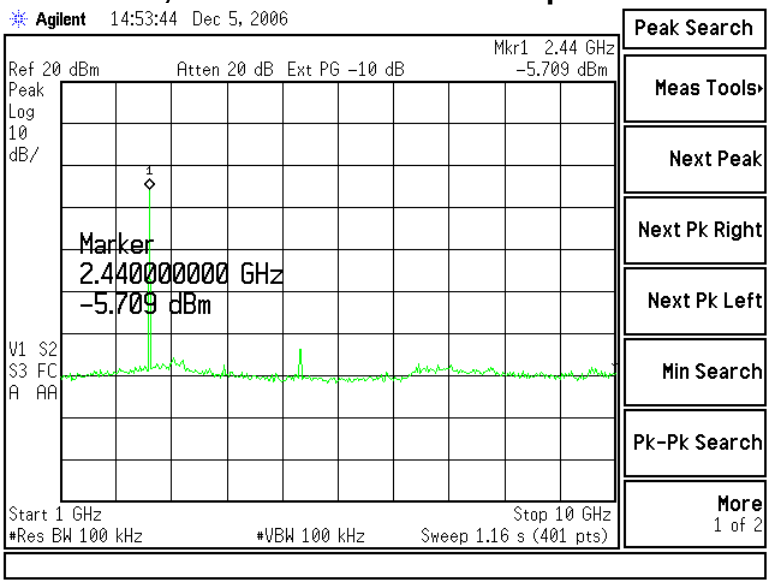
Notes:
(1) Measurement at system noise floor.

11.4 Screen Captures – Spurious Radiated Emissions

Channel 12, shown from 30 MHz up to 1000 MHz



Channel 12, shown from 1000 MHz up to 10000 MHz



Channel 12, shown from 10000 MHz up to 25000 MHz

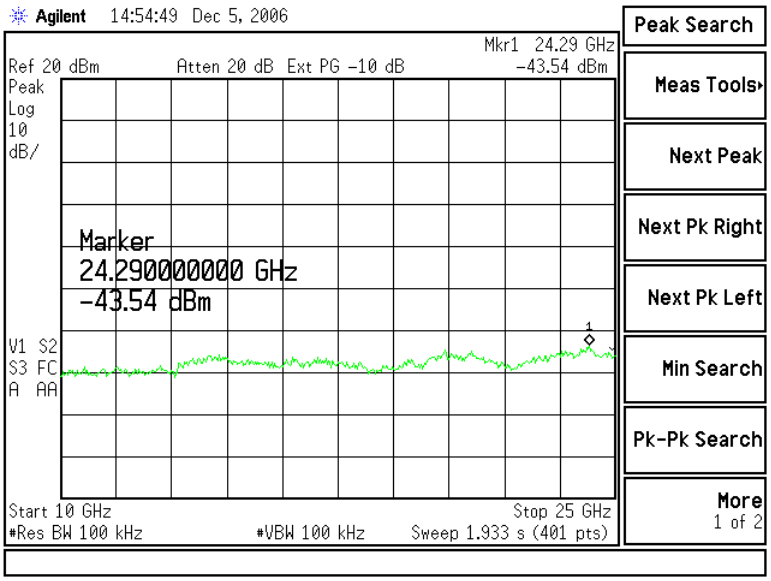


EXHIBIT 12. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

The EUT operates on a 3.6 V Lithium primary cell. Since some parts on the EUT has a maximum voltage rating of 3.6 V, EUT power and frequency stability was only tested with the EUT operating at 15% lower voltage and not operating at voltage exceeding 3.6 VDC.

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 kHz settings while the voltage was varied.

	DC Voltage Source		
	3.1 VDC	3.6 VDC	4.14 VDC
Channel 0b	2404.980000(MHz)	2404.980000(MHz)	N/A
Channel 12	2439.980000(MHz)	2439.980000(MHz)	N/A
Channel 19	2474.980000(MHz)	2474.980000(MHz)	N/A
Channel 1a	2479.980000(MHz)	2479.980000(MHz)	N/A

The RF Power Output of the EUT was also monitored in a separate test, also using a Spectrum Analyzer with RBW=VBW=3 MHz and 5 MHz (channel 19) setting while the voltage was varied.

	DC Voltage Source		
	3.1 VDC	3.1 VDC	3.1 VDC
Channel 0b	-2.3 (dBm)	-2.3 (dBm)	N/A
Channel 12	-0.8 (dBm)	-0.7 (dBm)	N/A
Channel 19	1.3 (dBm)	1.3 (dBm)	N/A
Channel 1a	-3.9 (dBm)	-4.1 (dBm)	N/A

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

No anomalies were noted in the measured transmit power during the voltage variation tests.

EXHIBIT 13. CHANNEL PLAN AND SEPARATION

Optional for DTS

EXHIBIT 14. MPE CALCULATIONS

The following MPE calculations are based on a inverted-F printed circuit board trace antenna, with a measured ERP of 95.3 dBµV/m, at 3 meters, and conducted RF power of 1.3 dBm as presented to the antenna. The calculated gain of this antenna, based on the ERP measurements is -1.2 dB.

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:	1.30	(dBm)
Maximum peak output power at antenna input terminal:	1.349	(mW)
Antenna gain(typical):	-1.2	(dBi)
Maximum antenna gain:	0.759	(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:	0.000204	(mW/cm^2)
Maximum allowable antenna gain:	35.7	(dBi)
Margin of Compliance at 20 cm =	36.9	dB

APPENDIX A

Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	9/27/05	9/27/06
AA960031	HP	119474A	3107A01708	Transient Limiter	Note 1	Note 1
AA960077	EMCO	93110B	9702-2918	Biconical Antenna	7/26/06	7/26/07
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	7/20/06	7/20/07
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	12/07/05	12/07/06
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	12/29/05	12/29/06
EE960004	EMCO	2090	9607-1164	Device Controller	N/A	N/A
EE960013	HP	8546A	3617A00320	Receiver RF Section	9/29/05	9/29/06
EE960014	HP	85460A	3448A00296	Receiver Pre-Selector	9/29/05	9/29/06
EE960073	Agilent	E4446A	US45300564	Spectrum Analyzer	2/01/06	2/01/07
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

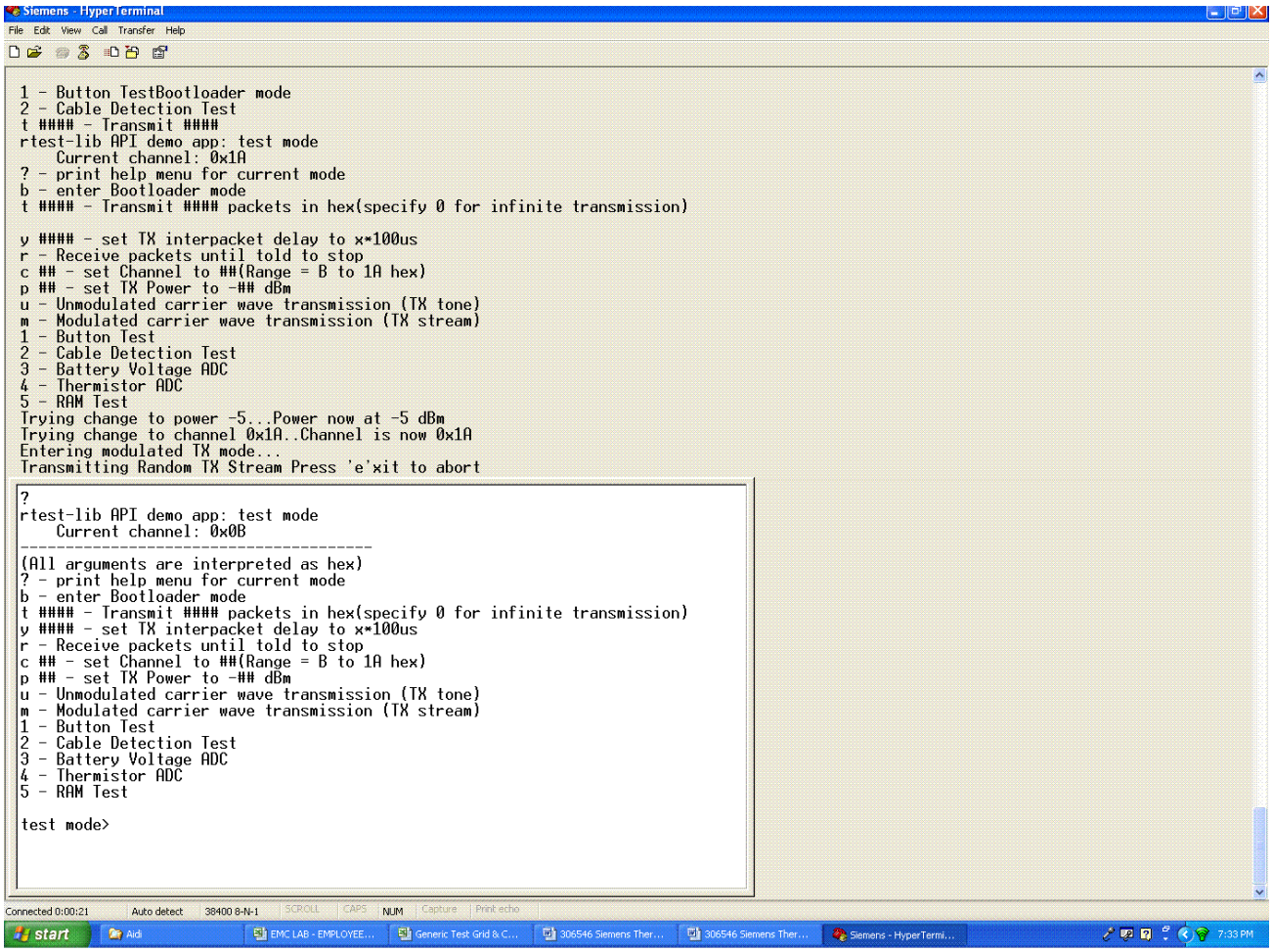
Appendix B

Antenna Specification(s)

Not Available.

Appendix C

Firmware and Setup Instructions



Channels are controlled by typing at the prompt :

C 12 (for channel operating at 2440 MHz)

For modulated signal, type ‘m’ at the prompt and for un-modulated signal type ‘u’.

To set EUT in receive mode, type ‘r’ at the prompt.