L.S. Compliance, Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012
262-375-4400 Fax: 262-375-4248

COMPLIANCE TESTING OF:

OC-Battery Sensor

Prepared For:

Eaton Corporation
Attention: Mr. Richard Harwell
170 Industry Drive
Pittsburg, PA 15275
United States of America

Test Report Number:

305495-Tx-v0

Test Dates:

December 1ST through 6TH, 2005

All results of this report relate only to the items that were tested. This report is not to be reproduced, except in full, without written approval of L. S. Compliance, Inc.

Table of Contents

1. L. S. Compliance In Review

L.S. Compliance - Accreditations and Listing's

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025 : 1999
with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-212 – Issue 1
File Number: IC 3088-A

On file, 3 and 10 Meter OATS based on RSS-212 – Issue 1
File Number: IC 3088

U. S. Conformity Assessment Body (CAB) Validation

Validated by the European Commission as a U. S. Competent Body operating under the U. S. /EU, Mutual Recognition Agreement (MRA) operating under the European Union Electromagnetic Compatibility –Council Directive 89/336/EEC, Article 10.2.
Date of Validation: January 16, 2001

Validated by the European Commission as a U.S. Notified Body operating under the U.S./EU, Mutual Recognition Agreement (MRA) operating under the European Union Telecommunication Equipment – Council Directive 99/5/EC, Annex V.

Date of Validation: November 20, 2002
Notified Body Identification Number: 1243

2. A2LA Certificate of Accreditation

THE AMERICAN
ASSOCIATION
FOR LABORATORY
ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

L.S. COMPLIANCE, INC.
Cedarburg, WI

for technical competence in the field of

Electrical Testing

The accreditation covers the specific tests and types of tests listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratories" and any additional program requirements in the identified field of testing.

Presented this 29th day of April 2005.

President
For the Accreditation Council
Certificate Number 1255.01
Valid to January 31, 2007

For tests or types of tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

3. A2LA Scope of Accreditation

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999

L.S. COMPLIANCE, INC.
W66 N220 Commerce Court
Cedarburg, WI 53012
James Blaha Phone: 262 375 4400

ELECTRICAL (EMC)

Valid to: January 31, 2007 Certificate Number: 1255.01

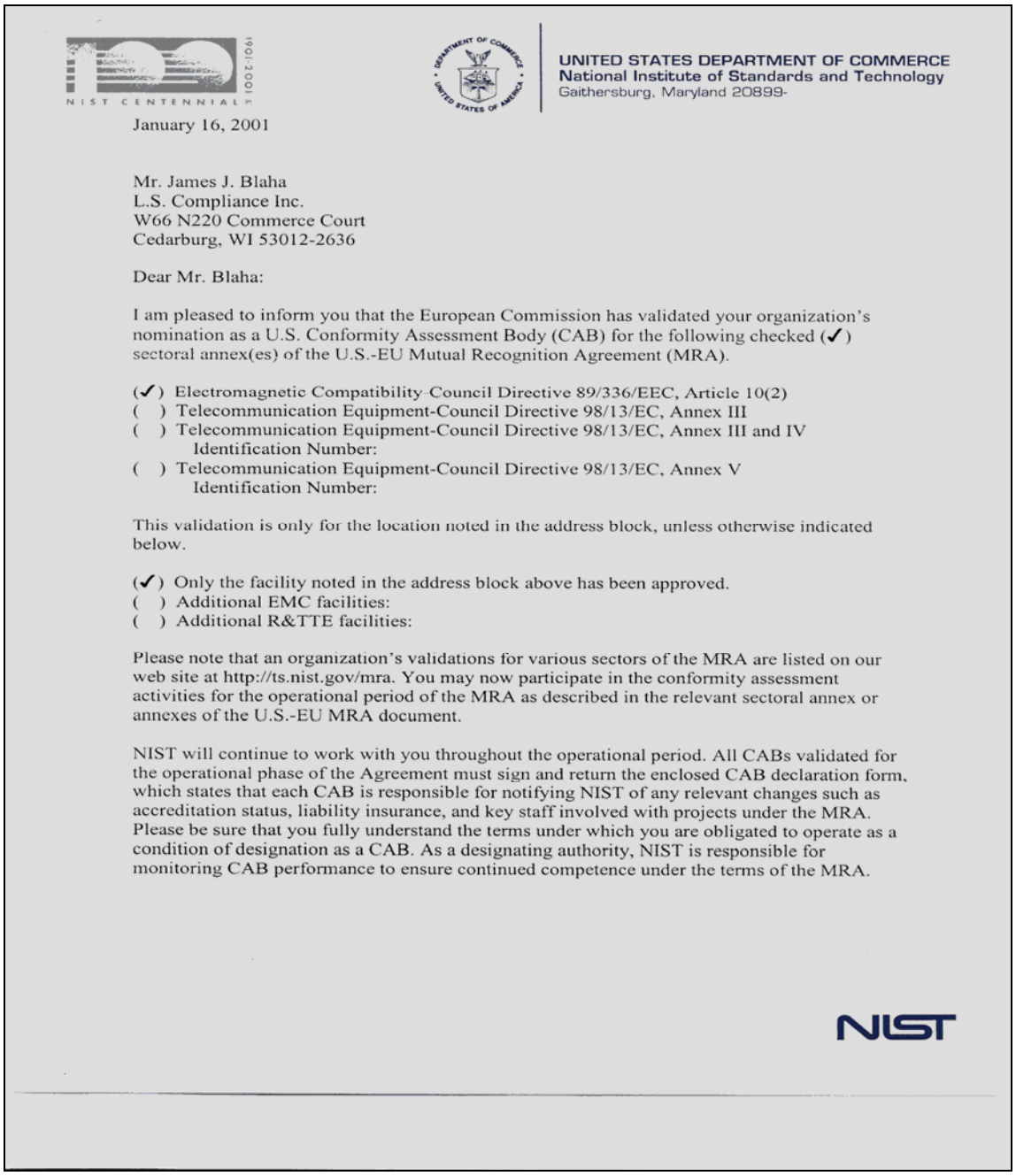
In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests:

Test	Test Method(s)
Emissions	
Conducted Continuous/Discontinuous	Code of Federal Regulations (CFR) 47, FCC Method Parts 15, 18 using ANSI C63.4; EN: 55011, 55022, CISPR: 11, 12, 14-1 (excluding clicks), 22;
Radiated	Code of Federal Regulations (CFR) 47, FCC Method Parts 15, 18 using ANSI C63.4 (3 meter chamber only); EN: 55011, 55022, CISPR: 11, 12, 14-1, 22;
Current Harmonics	IEC 61000-3-2; EN 61000-3-2
Voltage Fluctuations & Flicker	IEC 61000-3-3; EN 61000-3-3
Generic and Specific	EN 61000-6-3, EN 61000-6-4
Immunity	
Generic and Specific	EN 61000-6-1 EN 61000-6-2 CISPR: 14-2, 24
Conducted Immunity	
Fast Transients/Burst	IEC 61000-4-4; EN 61000-4-4
Surge	IEC: 61000-4-5; ENV 50142; EN 61000-4-5
RF Fields	IEC: 61000-4-6; ENV 50141; EN 61000-4-6

5301 Buckeystown Pike, Suite 350 • Frederick, MD 21704-8373 • Phone: 301-644 3248 • Fax: 301-662 2974

Test	Test Method(s)
Voltage Dips/Interruptions	IEC 61000-4-11; EN 61000-4-11
Radiated Immunity	
RF Fields	IEC: 61000-4-3; EN: 61000-4-3
RF Fields (50 Hz)	IEC 61000-4-8; EN 61000-4-8
RF Fields (Pulse Mode)	ENV 50204
Electrostatic Discharge (ESD)	IEC: 61000-4-2; EN 60801-2; EN: 61000-4-2

4. Validation Letter – U.S. Competent Body for EMC Directive 89/336/EEC



UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

January 16, 2001

Mr. James J. Blaha
L.S. Compliance Inc.
W66 N220 Commerce Court
Cedarburg, WI 53012-2636

Dear Mr. Blaha:

I am pleased to inform you that the European Commission has validated your organization's nomination as a U.S. Conformity Assessment Body (CAB) for the following checked (✓) sectoral annex(es) of the U.S.-EU Mutual Recognition Agreement (MRA).

(✓) Electromagnetic Compatibility-Council Directive 89/336/EEC, Article 10(2)
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex III and IV
Identification Number:
( ) Telecommunication Equipment-Council Directive 98/13/EC, Annex V
Identification Number:

This validation is only for the location noted in the address block, unless otherwise indicated below.

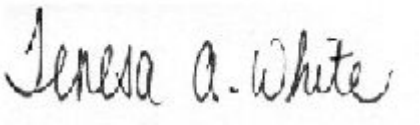
(✓) Only the facility noted in the address block above has been approved.
( ) Additional EMC facilities:
( ) Additional R&TTE facilities:

Please note that an organization's validations for various sectors of the MRA are listed on our web site at http://ts.nist.gov/mra. You may now participate in the conformity assessment activities for the operational period of the MRA as described in the relevant sectoral annex or annexes of the U.S.-EU MRA document.

NIST will continue to work with you throughout the operational period. All CABs validated for the operational phase of the Agreement must sign and return the enclosed CAB declaration form, which states that each CAB is responsible for notifying NIST of any relevant changes such as accreditation status, liability insurance, and key staff involved with projects under the MRA. Please be sure that you fully understand the terms under which you are obligated to operate as a condition of designation as a CAB. As a designating authority, NIST is responsible for monitoring CAB performance to ensure continued competence under the terms of the MRA.

NIST

5. Signature Page



Prepared By: December 12, 2005

Teresa A. White, Document Coordinator Date

Tested By: December 12, 2005

Abtin Spantman, EMC Engineer Date

Approved By: December 12, 2005

Brian E. Petted, VP of Engineering Date

6. Product and General Information

Manufacturer:	Eaton Corporation					
Date(s) of Test:	December 1ST through 6TH, 2005					
Test Engineer(s):		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	OC-Battery Sensor					
Serial #:	Pre-production Samples					
Voltage:	3.0 VDC					
Operation Mode:	Normal operation and continuous transmit					

7. Introduction

Between December 1ST and 6TH, 2005, a series of Conducted and Radiated RF Emission tests were performed on two pre-production samples of the Eaton Corporation's Model Number: *"OC-Battery Sensor",* here forth collectively referred to as the "*Equipment Under Test*" or "*EUT*". These tests were performed using the procedures outlined in ANSI C63.4-2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.247 (Industry Canada RSS-210) for a low power transmitter. These tests were performed by Abtin Spantman, EMC Engineer at L.S. Compliance, Incorporated.

All Radiated and Conducted RF Emission tests were performed upon the EUT to measure the emissions in the frequency bands described in Title 47 CFR, FCC Part 15, including 15.35, 15.205, 15.247 and Industry Canada RSS-210 to determine whether these emissions are below the limits expressed within the standards. These tests were performed in accordance with the procedures described in the 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 (ANSI C63.4-2003). Another document used as a reference for the EMI Receiver specification was the Comite International Special Des Perturbations Radioelelectriques (CISPR) Number 16-1, 2003.

All tests were performed at L.S. Compliance, Inc., in Cedarburg, Wisconsin, unless otherwise noted.

8. Product Description

The Eaton “Open-Close Sensor” is a part of a Home monitoring system.
Specifically, this is a battery operated sensor which provides a message burst when a magnetic reed switch or a water sensor is perturbed. The unit can be installed as either a window or door sensor (using a magnetic reed switch) or as a water level sensor (using a resistive sensor which is perturbed by moisture). This unit operates from a self contained and non-rechargeable battery, type CR-123 Lithium, at 3.0 VDC nominal voltage. While, the unit is intended to be placed on a vertical surface, such as a door frame or window, horizontal mountings may also be possible.

The Eaton “Open-Close Sensor” (OC-battery sensor as referred to in this report) is a transceiver operating in the 2400-2483.5 MHz ISM band, qualifying under 47CFR15.247 as a DTS type device. The device only operates on batteries, with no contingencies for connection to AC mains. The device uses a ceramic ‘Chip Antenna’ permanently installed on the PC-board, with no contingencies for any other types of antennae. **The transmitter portion of this transceiver is being tested and the results presented here in this report.**

The Eaton “Open-Close Sensor”

9. Test Requirements

The above mentioned tests were performed in order to determine the compliance of the Eaton Corporation's Model Number "***OC-Battery Sensor***" with limits contained in various provisions of Title 47 CFR, FCC Part 15, including:

15.31	15.247a	15.247d
15.205	15.247b	15.247e
15.207	15.247c	

10. Summary of Test Report

DECLARATION OF CONFORMITY

The Eaton Corporation's Model Number "***OC-Battery Sensor***" transmitter was found to **MEET** the requirements as described within the specification of Title 47 CFR FCC, Part 15.247, and Industry Canada RSS-210, Section 6.2.2(o) for a Digital Spread Spectrum (DTS) Transmitter.

11. Radiated Emissions Test

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 continuous transmit modulated mode for this portion of the testing, using 3.0 VDC power as provided by one standard '123' type Lithium battery. The unit has the capability to operate on 15 channels. During the testing, the channel and mode selection was accomplished by reprogramming the EUT using the PCB programming/test pads on the circuit board, along with a lap-top computer and a terminal program.

The applicable limits apply at a 3 meter distance. Measurements above 5 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels: low (Ch:0, 2405 MHz), middle (Ch 7, 2440 MHz) and high (Ch E, 2475 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed by reprogramming the EUT.

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 axis during the investigations to find the highest emission levels.

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, Clause 6.2.2(o)]. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

CALCULATION OF RADIATED EMISSIONS LIMITS

The maximum peak output power of an intentional radiator in the 2400-2483.5 MHz band, as specified in 47 CFR 15.247 (b)(3), is 1 Watt. The harmonic and spurious RF emissions, as measured in any 100kHz 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 Class B limits for an unintentional radiator. 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	-
960-25,000	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

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:	Eaton Corporation							
Date(s) of Test:	December 1ST through 6TH, 2005							
Test Engineer(s):		Tom Smith	√	Abtin Spantman		Ken Boston		
Model #:	OC-Battery Sensor							
Serial #:	Pre-production Samples							
Voltage:	3.0 VDC							
Operation Mode:	Normal operation and continuous transmit							
EUT Power:		Single Phase ___VAC				3 Phase ___VAC		
	√	Battery: 3.0 VDC				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	

Environmental Conditions in the Lab:
Temperature: 20 – 25°C
Relative Humidity: 30 – 60 %

Test Equipment Used:
EMI Measurement Instrument: HP8546A and Agilent E4407B
Log Periodic Antenna: EMCO #93146
Horn Antenna: EMCO #3115
Biconical Antenna: EMCO 93110
Pre-Amp: Advanced Microwave WHA6224
Standard Gain Horn: EMCO 3160-09

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

Frequency (MHz)	Antenna Polarity	Channel	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.205 Limit (dBμV/m)	Margin (dB)
Notes (1)							

Notes:

1) There were no significant spurious emissions observed to be within 20 dB of the limits.

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

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2405	H	1.05	25	101.4 (Note 4)	125.2	23.8
4810	V	1.00	225	52.7 (Note 5)	54.0	1.3
7215	H	1.10	120	65.6	90.9	25.3
9620	H	1.00	220	55.6	90.9	35.3
12025	H	1.00	80	50.7	63.5	12.8
14430	H	1.00	90	40.8	63.5	22.7
16835	H	1.00	0	42.4	90.9	48.5
19240	V	1.00	90	52.9	74.0	21.1
21645	V	1.00	75	47.5	101.4	53.9
24050	V	1.00	80	42.3	101.4	59.1

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 7:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2440	H	1.05	25	98.0 (Note 4)	125.2	27.2
4880	V	1.00	200	50.9 (Note 5)	54.0	3.1
7320	H	1.10	120	63.1	63.5	0.4
9760	H	1.00	125	49.0	78.0	29.0
12200	V	1.00	355	48.5	63.5	15.0
14640	H	1.00	340	41.0	78.0	37.0
17080	H	1.00	0	42.6	78.0	35.4
19520	V	1.00	90	50.5	74.0	23.5
21960	V	1.00	75	41.8	87.5	45.7
24400	V	1.00	80	42.0	87.5	45.5

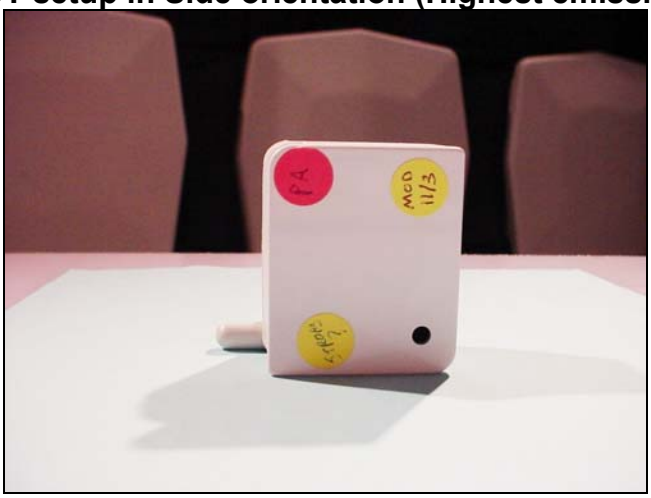
The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel E:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2475	H	1.05	30	98.4 (Note 4)	125.2	26.8
4950	V	1.00	0	50.8 (Note 5)	54.0	3.2
7425	H	1.10	120	62.1	63.5	1.4
9900	H	1.00	125	51.9	78.4	26.5
12375	H	1.00	350	47.3	63.5	16.2
14850	H	1.00	355	39.7	78.4	38.7
17325	H	1.00	0	42.1	78.4	36.3
19800	V	1.00	90	51.5	74.0	22.5
22275	V	1.00	80	43.9	74.0	30.1
24750	V	1.00	80	42.4	87.9	45.5

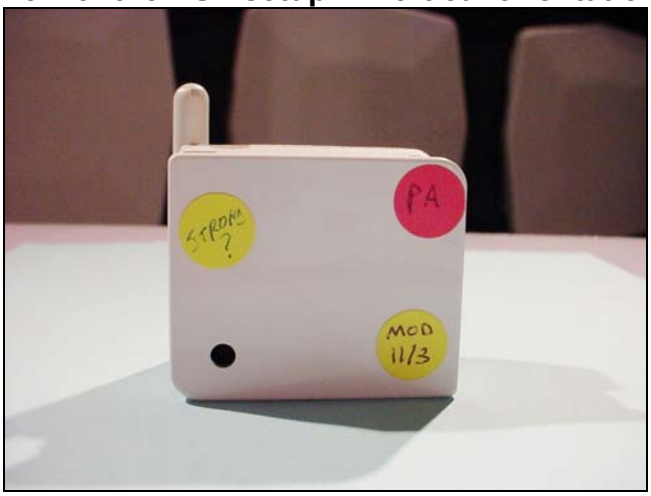
Notes:

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=3 MHz.
5) A relaxation of the limit is invoked based on the average duty factor of the transmitter on-air-time. Justification appears in appendix D. The measurements have been recalculated and reduced by 4 dB as justified by the averaging factor.

View of the EUT setup in Side orientation (Highest emissions measured)



View of the EUT setup in vertical orientation



View of the EUT setup in Horizontal orientation

View of the EUT setup on the test pedestal

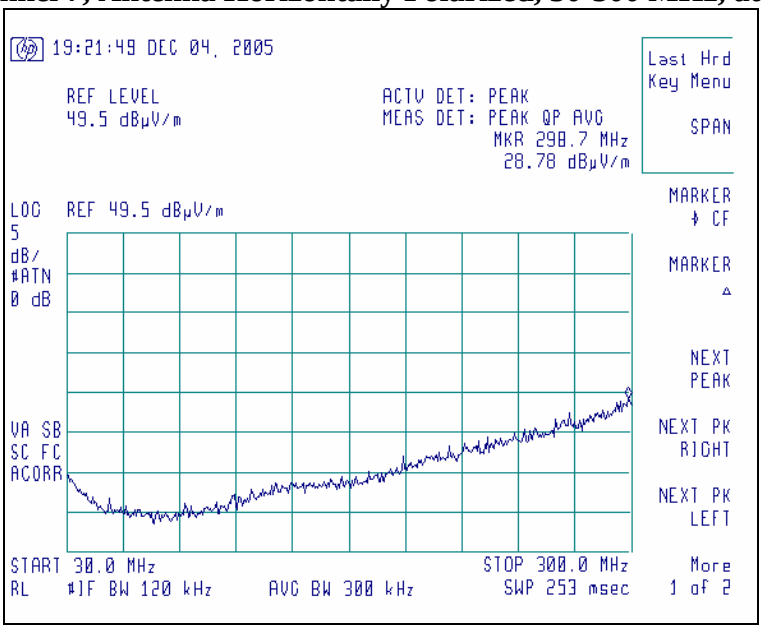
Graphs made during Radiated Emission Testing

Screen Captures of Radiated RF Emissions:

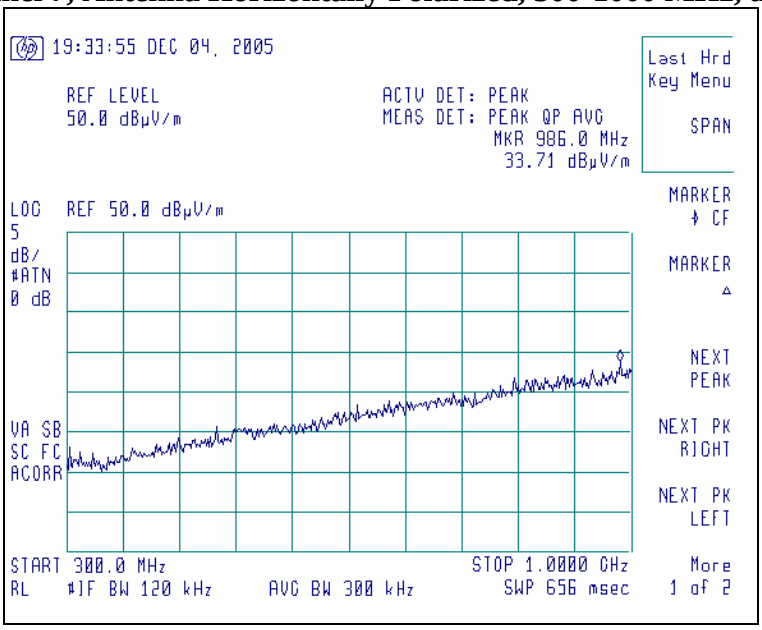
Please note these screen captures represent Peak Emissions. For radiated emission measurements, we utilize a Quasi-Peak detector function when measuring frequencies below 1 GHz, and an Average detector function when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 0, 7, or E, with the sense and EUT antennas both in vertical polarity for worst case presentations.

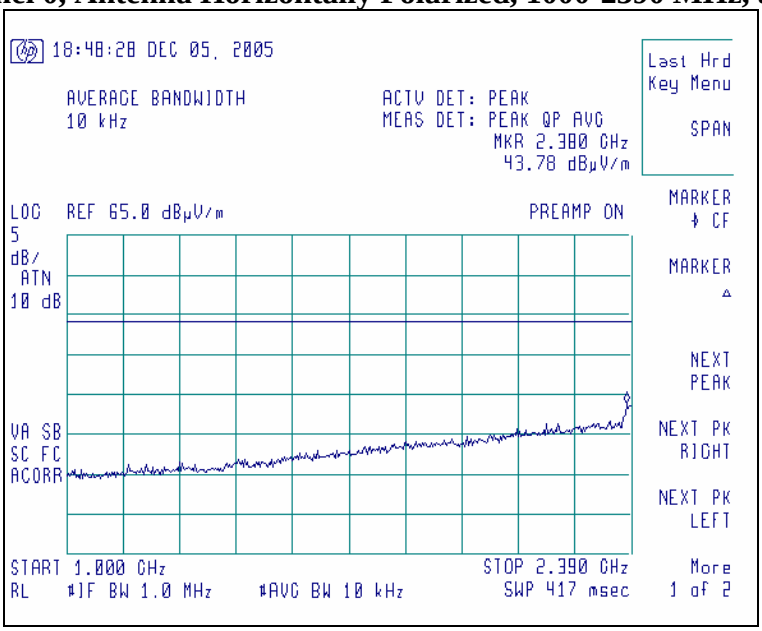
Channel 7, Antenna Horizontally Polarized, 30-300 MHz, at 3m.



Channel 7, Antenna Horizontally Polarized, 300-1000 MHz, at 3m.

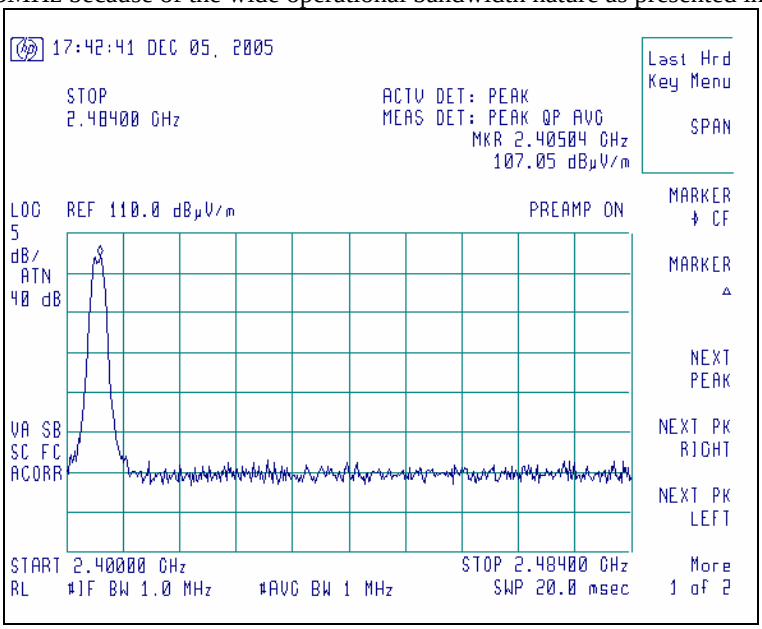


Channel 0, Antenna Horizontally Polarized, 1000-2390 MHz, at 3m.

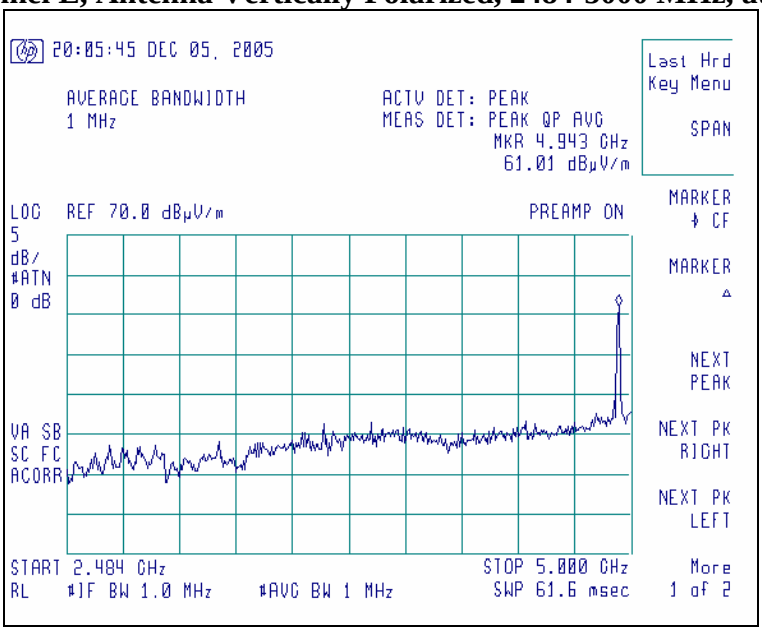


Channel 0, Antenna Horizontally Polarized, 2400-2484 MHz, at 3m.

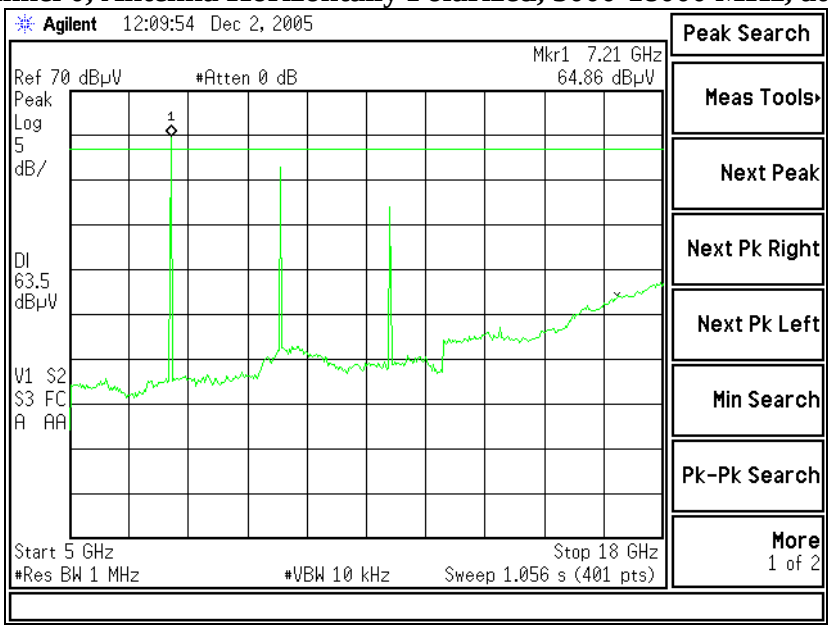
Signature scan shown here is with RBW=VBW=1MHz, but measurements of the fundamental power was made with RBW=VBW=3MHz because of the wide operational bandwidth nature as presented in the data chart.



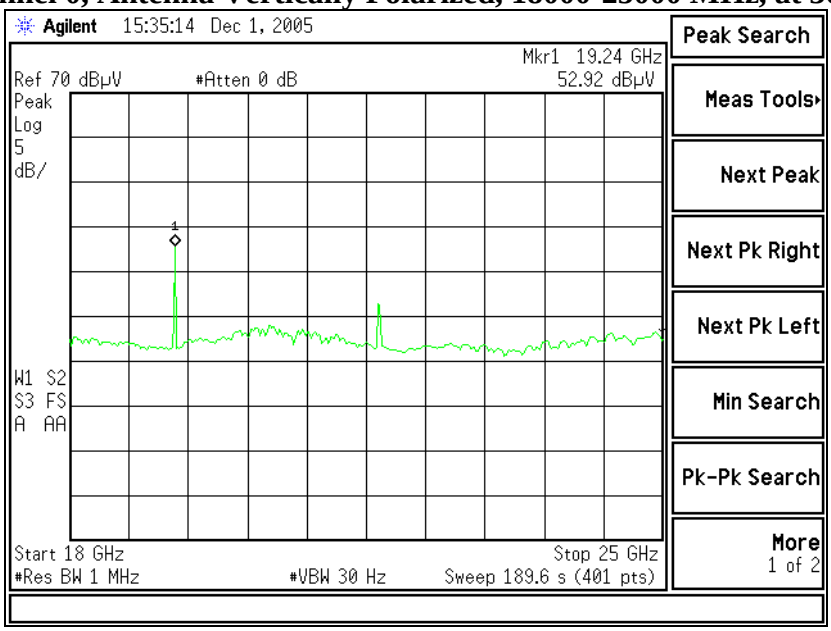
Channel E, Antenna Vertically Polarized, 2484-5000 MHz, at 3m.



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



Channel 0, Antenna Vertically Polarized, 18000-25000 MHz, at 30cm.

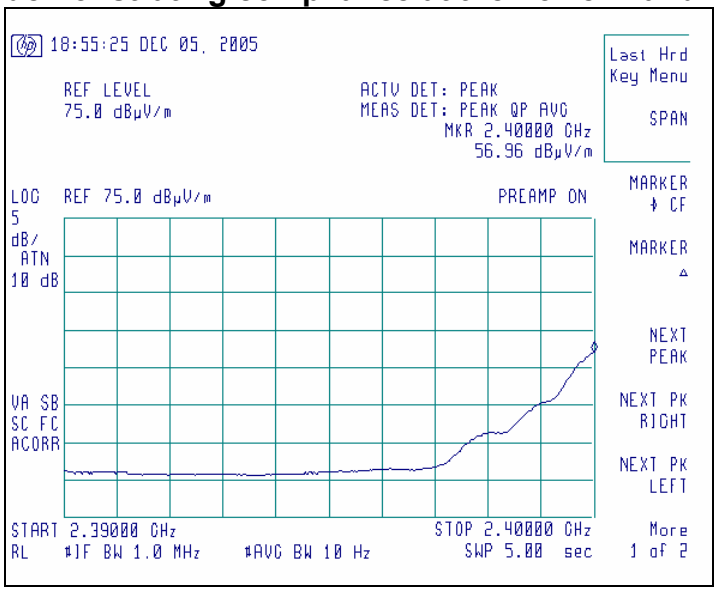


12. Band-Edge Measurements

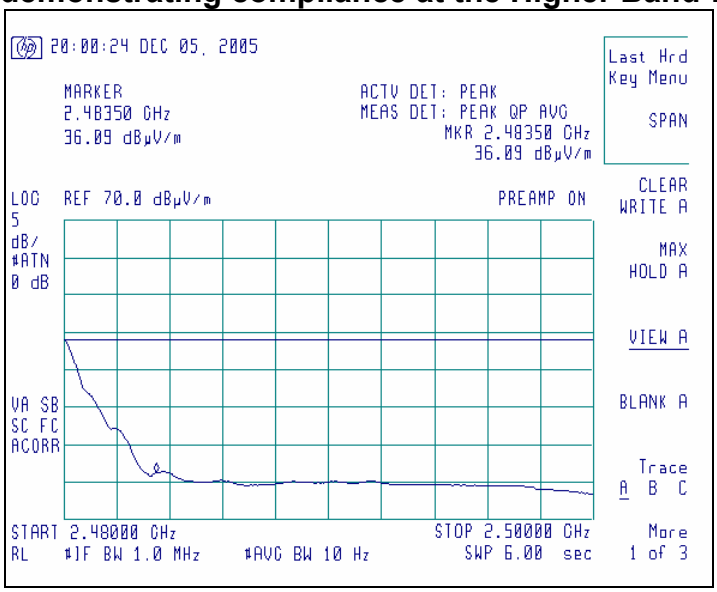
FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the band-edges where the intentional radiator operates. The following screen captures demonstrate compliance of the intentional radiator at the 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 = -20dBc with respect to the fundamental level.
The Upper Band-Edge limit, in this case, would be = +54 dBµV/m at 3m.

Screen Capture demonstrating compliance at the Lower Band-Edge, Channel 0



Screen Capture demonstrating compliance at the Higher Band-Edge, Channel E



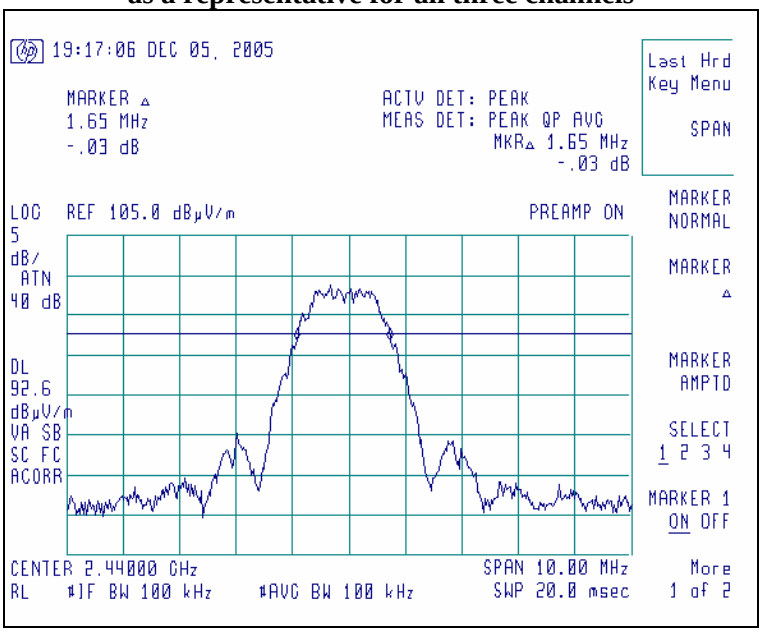
13. Occupied Bandwidth

The 20 dB 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 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 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.

Channel	Center Frequency (MHz)	Measured 6 dB BW (kHz)	Minimum Limit (kHz)
0	2405	1650	500
7	2440	1650	500
E	2475	1650	500

Plots of Occupied Bandwidth

Channel 07 Occupied Bandwidth,
as a representative for all three channels



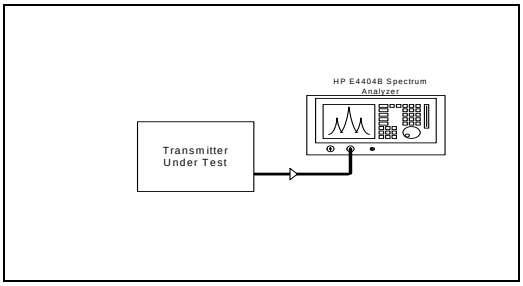
14. Conducted RF Emissions Test on AC Power Line

This product operates on one standard 'CR-123' type battery only, and does not get connected to the AC Mains. Conducted AC-Mains RF Emissions Tests were not performed on this device.

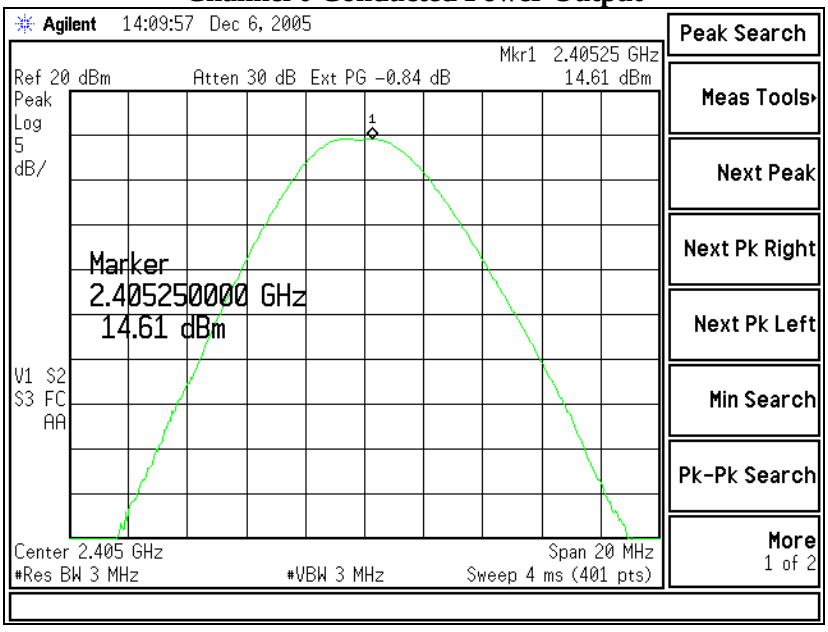
15. Power Output 15.247(b)

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 as gain offset settings, there by allowing direct readings of the measurements made 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 20 MHz, with measurements from a peak detector presented in the chart below.

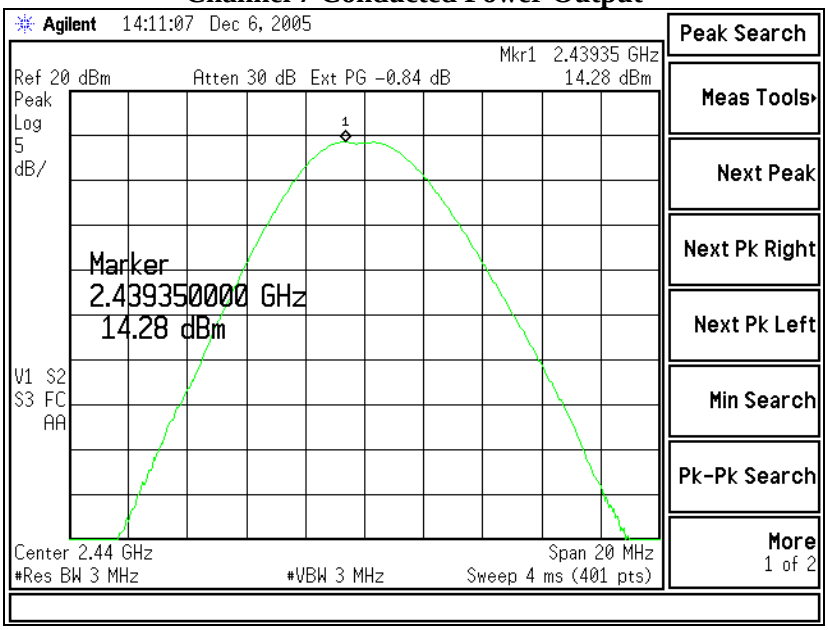
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
0	2405	+ 30 dBm	+ 14.6	15.4
7	2440	+ 30 dBm	+ 14.3	15.7
E	2475	+ 30 dBm	+ 14.0	16.0



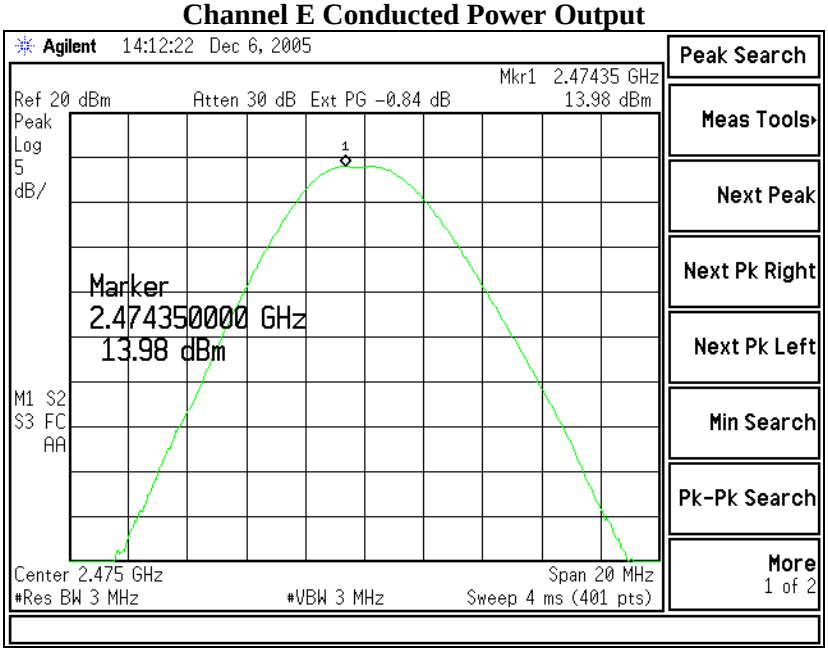
Channel 0 Conducted Power Output



Channel 7 Conducted Power Output



Channel E Conducted Power Output



16. Spurious Emissions 15.247(d)

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. The loss from the cable was 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.

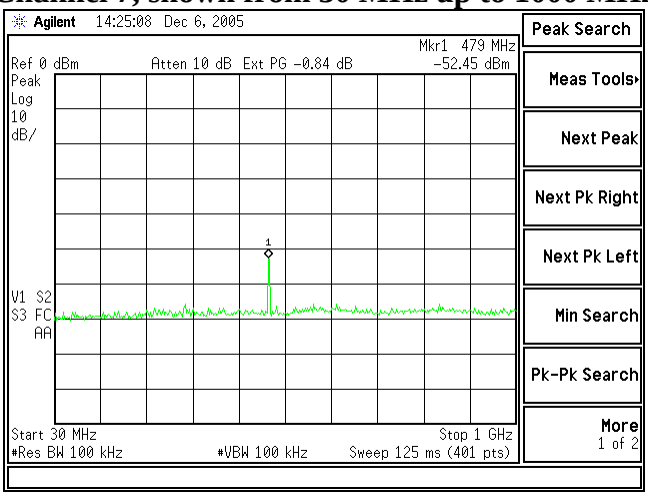
No significant emissions could be noted within -50 dBc of the fundamental level for this product.

	Channel 0	Channel 7	Channel E
Fundamental	+ 10.9 (dBm)	+ 10.5 (dBm)	+ 10.4 (dBm)
2nd Harmonic	- 56.0 (dBm)	- 74.7 (dBm)	- 58.9 (dBm)
3rd Harmonic	- 53.5 (dBm)	- 78.6 (dBm)	- 63.8 (dBm)
4th Harmonic	- 78.8 (dBm)	- 77.8 (dBm)	- 80.4 (dBm)
5th Harmonic	- 71.8 (dBm)	- 72.1 (dBm)	- 71.5 (dBm)
6th Harmonic	Note (1)	Note (1)	Note (1)
7th Harmonic	Note (1)	Note (1)	Note (1)
8th Harmonic	Note (1)	Note (1)	Note (1)
9th Harmonic	Note (1)	Note (1)	Note (1)
10th Harmonic	Note (1)	Note (1)	Note (1)

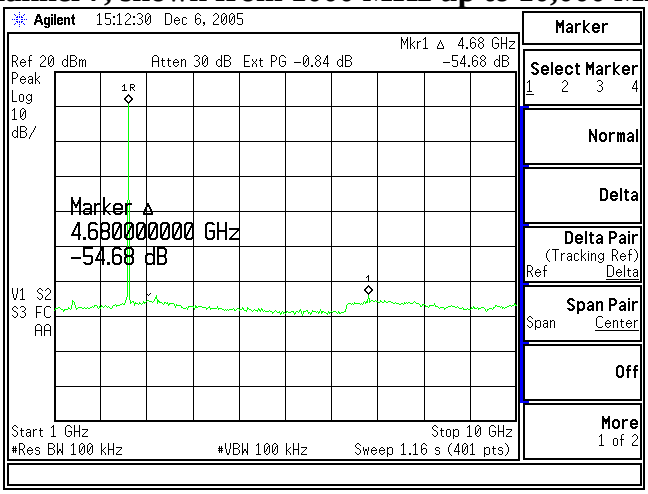
Notes:
(1) Measurement at system noise floor.

Representative plots for the middle channel are presented here, for the conducted RF spurious measurements.

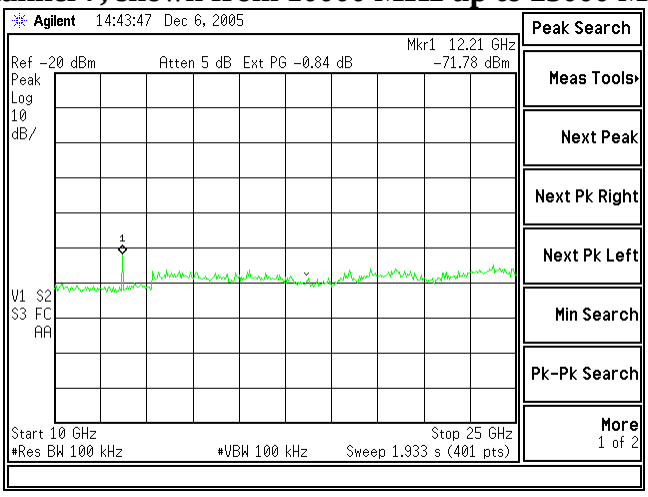
Channel 7, shown from 30 MHz up to 1000 MHz



Channel 7, shown from 1000 MHz up to 10,000 MHz



Channel 7, shown from 10000 MHz up to 25000 MHz

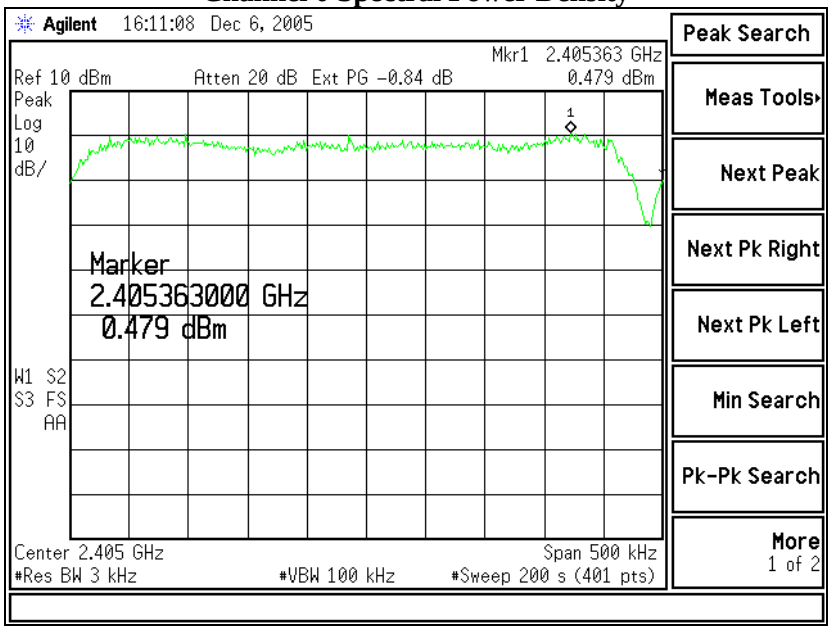


17. Spectral Density

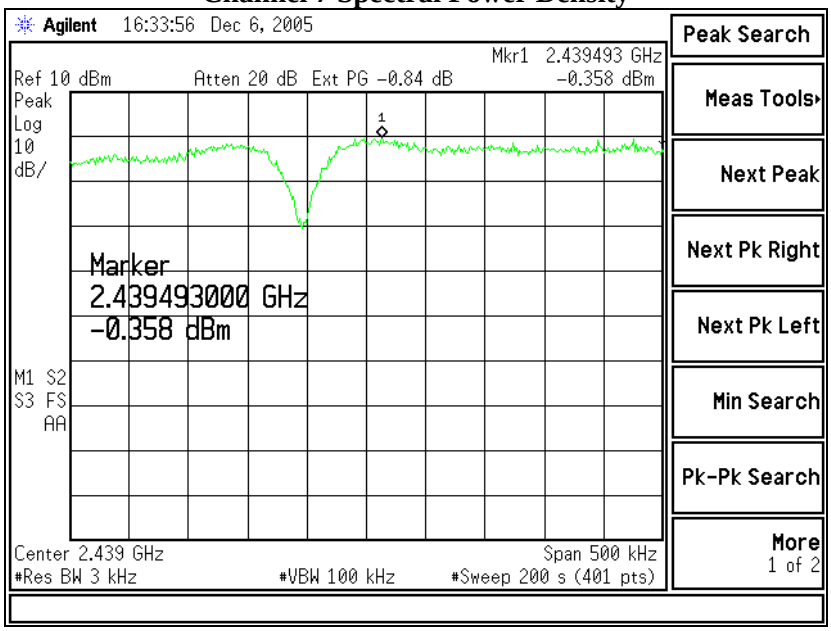
In accordance with FCC Part 15.247(e), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in previous sections. The peak output frequency for each representative frequency was 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 +0.5 dBm, which is under the allowable limit by 7.5 dB.

Channel	Center Frequency (MHz)	Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)
0	2405	+ 0.5	+8 dBm	7.5
7	2440	- 0.3	+8 dBm	8.3
E	2475	- 0.1	+8 dBm	8.1

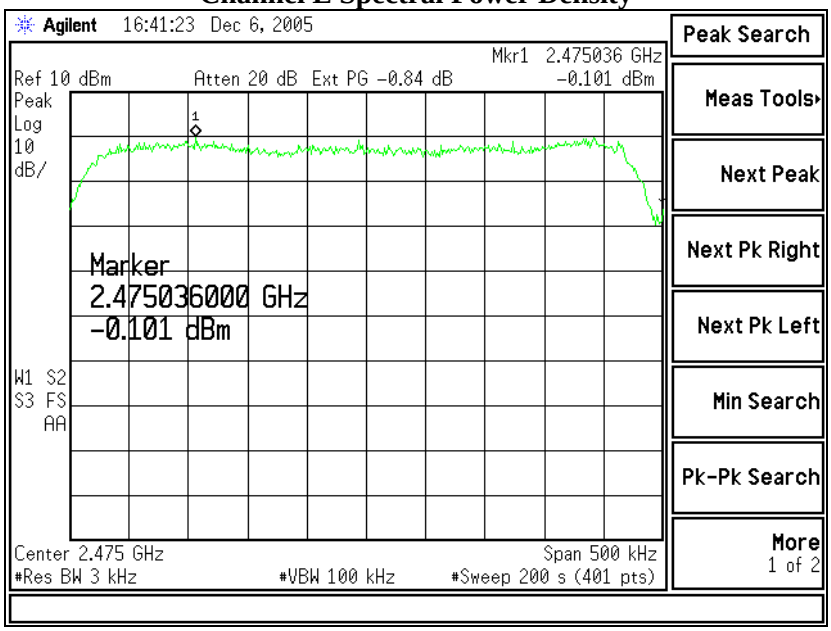
Channel 0 Spectral Power Density



Channel 7 Spectral Power Density



Channel E Spectral Power Density



18. Frequency and Power Stability over Voltage and Temperature Variations

The stability of the device was examined as a function of the input voltage available to the EUT.
In this case, the EUT uses a single type "CR-123" Lithium battery, with a nominal voltage of 3.0 VDC.
The working range of this battery is 3.4 VDC to 2.5 VDC (50% life), but the defined operation range of the EUT is limited to 2.80 VDC on the low end.

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=1kHz settings while the voltage was varied.

	DC Voltage Source		
	2.80 V	3.00 V	3.45 V
Channel 0	2.4049265 (MHz)	2.4049260 (MHz)	2.4049260 (MHz)
Channel 7	2.4399255 (MHz)	2.4399255 (MHz)	2.4399255 (MHz)
Channel E	2.4749240 (MHz)	2.4749240 (MHz)	2.4749240 (MHz)

The RF power output of the EUT was also monitored in a separate test, also using a spectrum analyzer with RBW=VBW=3MHz setting while the voltage was varied.

	DC Voltage Source		
	2.80 V	3.00 V	3.45 V
Channel 0	+11.4 (dBm)	+14.6 (dBm)	+18.0 (dBm)
Channel 7	+10.8 (dBm)	+14.2 (dBm)	+17.7 (dBm)
Channel E	+10.5 (dBm)	+14.0 (dBm)	+17.5 (dBm)

The power was then cycled On/Off to observe system response. No unusual response was observed during power loss, the emission characteristics were well behaved, and the system returned to the proper power-up state (standby state, not transmitting).

19. MPE Calculations

The MPE calculations are based on the
Johnson Technology Brand antenna, part number: 2450AT18A100
Ceramic Chip Antenna

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:	14.60	(dBm)
Maximum peak output power at antenna input terminal:	28.840	(mW)
Antenna gain(typical):	0.5	(dBi)
Maximum antenna gain:	1.122	(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:	0.006438	(mW/cm^2)
Maximum allowable antenna gain:	22.4	(dBi)
Margin of Compliance at 20 cm =	21.9	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	9/27/05	9/27/06
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	9/27/05	9/27/06
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	12/06/04	12/06/05
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	12/07/04	12/07/05
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
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

The EUT uses a “Ceramic Chip” antenna, and does not have any other facilities for external or commercial antenna connections.

"High Frequency Ceramic Solutions"

2.45 GHz Antenna — **P/N 2450AT18A100**
Detail Specification: 09/03/03 — Page 1 of 3

General Specifications

Part Number	2450AT18A100
Frequency Range	2400 - 2500 Mhz
Peak Gain	0.5 dBi typ. (XZ-V)
Average Gain	-0.5 dBi typ. (XZ-V)
Return Loss	9.5 dB min.

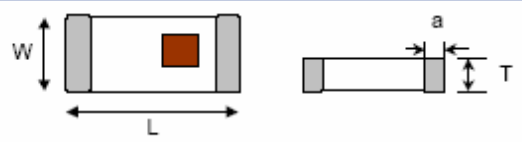
Input Power	500mW max.
Impedance	50 Ω
Operating Temperature	-40 to +85°C
Reel Quanity	3,000

No.	Function
1	Feeding Point
2	NC

Terminal Configuration

Mechanical Dimensions

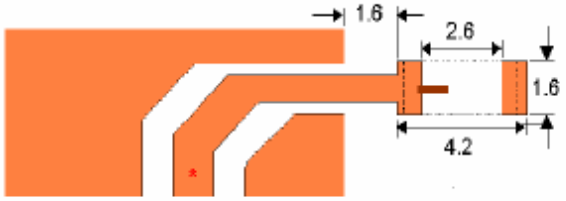
	In	mm
L	0.126 ± 0.008	3.20 ± 0.20
W	0.063 ± 0.008	1.60 ± 0.20
T	0.051 +.004/-.008	1.30 +0.1/-0.2
a	0.020 ± 0.012	0.50 ± 0.30



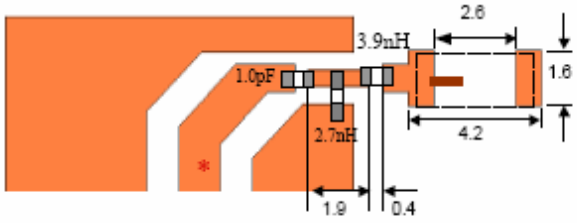
Mounting Considerations

Mount these devices with brown mark facing up. Units: mm
Line width should be designed to provide 50Ω impedance matching characteristics.

a) Without Matching Circuits



b) With Matching Circuits



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Appendix C

Firmware and Setup Instructions

The EUT was presented for testing with special firmware that accepted programming.
The modes were changed by reprogramming the EUT at each step. A laptop computer was used to reprogram the EUT using programming/test-pads already on the PCB, and a terminal program, set to communicate at 38400-8-N-1-N, along with a custom bed-of-nails programming fixture.

Appendix D

Transmitter Duty Factor Calculations

A request for relaxation of the limits has been made, for this product, based on the duty cycle of the transmitter in normal operation. The requested relaxation is for 4 dB, to be invoked when comparing measurements to the limits for radiated RF harmonic emissions, and if needed, to the band-edge limits.

The following is a description of the transmit duty cycle as presented by the manufacturer.
Worst-Case Duty factor for the transmitter "On-Time" is 62.6%, yielding a relaxation allowance of 4 dB.

IEEE 802.15.4 2.4 GHz PHY

Data Rate	250000	bits / sec	
	31250	bytes / sec	
Symbols/byte	2	sym / bytes	
Symbol Timing	62500	sym / sec	
	0.000016	sec / sym	
Byte Timing	0.000032	sec / byte	
PHY PSDU	6	bytes	4 Pramble, SPD, Length
Max Length	127	bytes	
Total Packet Length	133	bytes	
Maximum Time TX PKT	0.004256	sec	

Long Frame Scenario:

1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) Wait for LIFS
4) Repeat

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	40	sym	
ACK Frame	11	bytes	
Backoff Period	20	sym	
Maximum Backoff	7		Random between 0 and 7
Backoff Required	2		
Backoff Time	60	sym	

Transmit Time	
TX Time (Packet)	0.004256
TX Time (ACK)	0.000352
Total TX Time (sec)	0.004608

Off Time	
Backoff Time	0.00192
tack(minimum)	0.000192
LIFS	0.00064
Total Off Time	0.002752

Duty Cycle (On /total) 62.61% — Represents MAC only performance

MAC Constants		
maxBE	5	
aMaxFrameResponseTime	1220	symbols
aMaxFrameRetries	3	
aUnitBackoffPeriod	20	symbols
macAckWaitDuration	54	symbols
macBattLifeExtPeriods	6	Backoff periods
macMaxCSMABackoffs	4	
macMinBE	3	
aMinLIFSPeriod	40	symbols
aMinSIFSPeriod	12	symbols
aMinCAPLength	440	symbols
NB	0	
CW	2	
BE	3	

Short InterFrame Spacing (Slotted w/ ACK)			
Short Frame	18	bytes	
Data Frame Payload	18	bytes	
ACK Frame	5	bytes	
tack	12	sym	
SIFS	12	sym	
ACK Frame	11	bytes	
Backoff Period	20	sym	
Maximum Backoff	7		Random between 0 and 7
Backoff Required	2		
Backoff Time	60	sym	

Transmit Time	
TX Time (Packet)	0.000768
TX Time (ACK)	0.000352
Total TX Time (sec)	0.00112

Off Time	
Backoff Time	0.00192
tack(minimum)	0.000192
SIFS	0.000192
Total Off Time	0.002304

Duty Cycle (On /total) 32.71%

Network Based Calculation

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	625	sym	Single hop data indicates 10 ms interpacket spacing
ACK Frame	11	bytes	
Backoff Period	20	sym	
Maximum Backoff	7		Random between 0 and 7
Backoff Required	2		
Backoff Time	60	sym	

Transmit Time	
TX Time (Packet)	0.004256
TX Time (ACK)	0.000352
Total TX Time (sec)	0.004608

Off Time	
Backoff Time	0.00192
tack(minimum)	0.000192
LIFS	0.01
Total Off Time	0.012112

Duty Cycle (On /total) 27.56% Calculated Network Performance

Alternative calculation

Max radio throughput	250000	bps	
Measured throughput single hop	66816	bps	Max test network results 44544 (packet payload)

Duty Cycle 26.73% Measured Network Performance

Use for FCC Calculations	27%