L.S. Compliance, Inc.

W66 N220 Commerce Court
Cedarburg, WI 53012
262-375-4400   Fax: 262-375-4248

COMPLIANCE TESTING OF:

WRS-BTxx Wireless Sensor

Prepared For:

Johnson Controls, Incorporated
Attention: Mr. Tom Arnold
507 East Michigan Street
Milwaukee, WI 53201

Test Report Number:

304311-Tx-v1

Test Dates:

January 19TH to 25TH, 2005

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

Listing of 3 and 10 meter OATS based on Title 47CFR – Part 2.948
FCC Registration Number: 90757

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

(A2LA Cert. No. 1255.01) 04/29/05 Page 1 of 2

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

NIST CENTENNIAL 1901-2001

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.

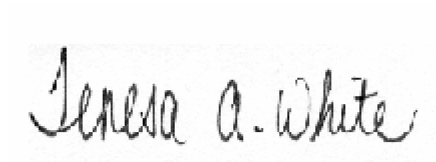
(✓) Only the facility noted in the address block above has been approved.
( ) Additional EMC facilities:
( ) Additional R&TTE facilities:

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.

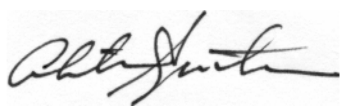
NIST

5. Signature Page



Prepared By: June 7, 2005

Teresa A. White, Document Coordinator Date



Tested By: June 7, 2005

Abtin Spantman, EMC Engineer Date

Approved By: June 7, 2005

Kenneth L. Boston, EMC Lab Manager Date
PE #31926 Licensed Professional Engineer
Registered in the State of Wisconsin, United States

6. Product and General Information

Manufacturer:	Johnson Controls, Inc.
Date(s) of Test:	January 19TH to 25TH, 2005
Test Engineer(s):	Tom Smith / √ Abtin Spantman / Ken Boston
Model #:	WRS-BTxx
Serial #:	Engineering Unit
Voltage:	3.0 VDC
Operation Mode:	Normal operation and continuous transmit

7. Introduction

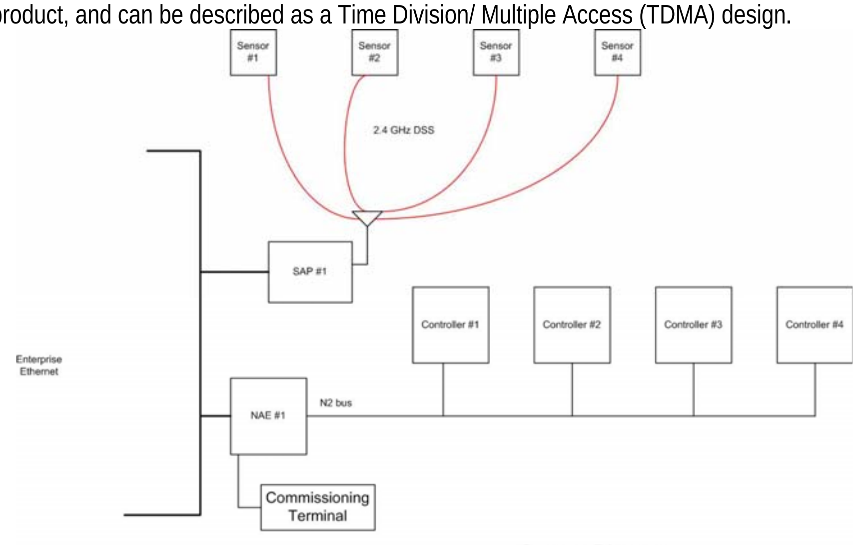
Between January 19TH and 25TH, 2005, a series of Conducted and Radiated RF Emission tests were performed on one sample of the Johnson Controls' Model Number WRS-BTR0000-0, here forth referred to as the "*Equipment Under Test*" or "*EUT*". These tests were performed using the procedures outlined in ANSI 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.

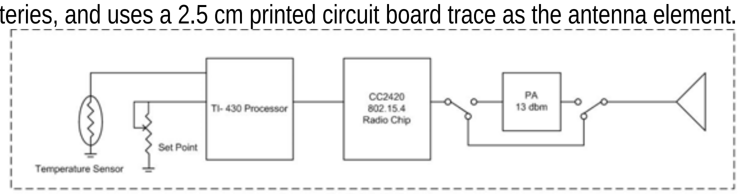
8. Product Description

The JCI Wireless Remote Sensor System (WRS) is a remote temperature sensor coupled with a receiver communicating over a DSSS RF link operating in the 2.4 GHz. ISM band. The RF link is designed around a Chipcon CC2420SK radio chip, which complies with the 802.15.4 specification. While this radio chip is used on products using the Zigbee network protocol, the JCI radio does not use Zigbee. The physical design of the radios and the custom protocol they will use has been designed specifically for the product, and can be described as a Time Division/ Multiple Access (TDMA) design.

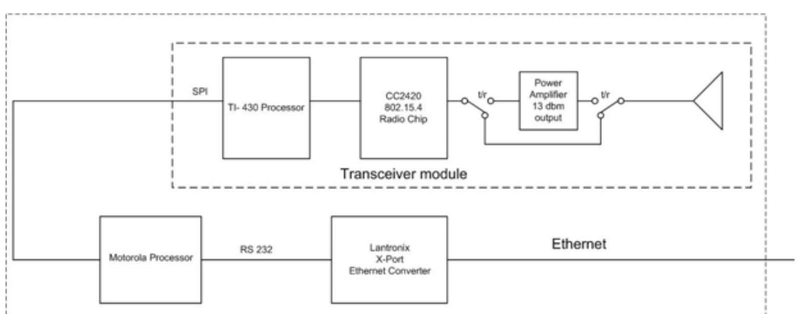


System Diagram

The Wireless Remote Sensor System (WRS) contains an RF transceiver. The RF characteristics of the transmitter portion of the transceiver were tested and covered in this report.
The following diagram shows the general design of both the sensor and the (Sensor Access Point – SAP). The transmitter is designed to operate between 2400 MHz and 2483.5 MHz, with a nominal RF output power of 13.0 dBm, peak frequency deviation of ±250 kHz and a final chipping rate of 2 Mcps. The Wireless Remote Sensor System (WRS) operates on 3.0 VDC as provided by two "AA" batteries, and uses a 2.5 cm printed circuit board trace as the antenna element.



Sensor/Set Point Module



Sensor Access Point

Multiple System operation –
In many buildings, there will be multiple sensor systems operating. They are not synchronized to each other but the transmissions are randomly dithered in time a small amount so that sustained collisions are unlikely. This is the main reason for the long slot times compared to the approximately 2 ms transmit time.

Three versions of the sensor module that are variations in the set point configuration are in the initial product release. All RF functions are identical.

9. Test Requirements

The above mentioned tests were performed in order to determine the compliance of the Johnson Controls' Model Number WRS-BTR0000-0 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 Johnson Controls' Model Number WRS-BTR0000-0 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 two standard 'AA' type batteries connected in series. The unit has the capability to operate on 15 channels. During the testing, the channel and mode selection was accomplished by the press of a button, that was programmed to switch between the desired test modes.

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 (2405 MHz), middle (2445 MHz) and high (2475 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using the button with the programmed test modes.

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:

$$dB\mu V/m = 20 \log_{10} (100)$$
$$= 40\ dB\mu V/m \text{ (from 30-88 MHz)}$$

<u>For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.</u>

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

<u>For measurements made at 0.3 meter, a 20 dB correction has been invoked.</u>

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:	Johnson Controls, Inc.					
Date(s) of Test:	January 19TH to 25TH, 2005					
Test Engineer(s):		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	WRS-BTxx					
Serial #:	Engineering Unit					
Voltage:	3.0 VDC					
Operation Mode:	Normal operation and continuous transmit					
EUT Power:		Single Phase ___VAC		3 Phase ___VAC		
	√	Battery: 3.0 VDC (2x'AA')		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 ERP (dBμV/m)	15.205 Limit (dBμV/m)	Margin (dB)
2261	H	00	1.18	30	44.5	54.0	9.5

Notes:

1) *There were no other 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 01:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2405	H	1.60	155	110.7 (Note 4)	125.2	14.5
4810	H	1.60	150	43.8	54.0	10.2
7215	H	1.00	130	37.1	90.7	53.6
9620	H	1.00	85	43.6	90.7	47.1
12025	H	1.25	125	40.1	63.5	23.4
14430	H	1.00	0	42.8 (Note 3)	63.5	20.7
16835	H	1.00	0	46.2 (Note 3)	90.7	44.5
19240	H	1.00	0	51.0 (Note 3)	74.0	23.0
21645	H	1.00	0	50.0 (Note 3)	110.7	60.7
24050	H	1.00	0	53.0 (Note 3)	110.7	57.7

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 09:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2445	H	1.60	155	110.6 (Note 4)	125.2	14.6
4890	H	1.60	150	48.2	54.0	5.8
7335	H	1.00	265	37.8	63.5	25.7
9780	H	1.05	35	45.1	90.6	45.5
12225	H	1.20	100	38.2	63.5	25.3
14670	H	1.25	45	42.1	90.6	48.5
17115	H	1.00	0	46.4 (Note 3)	90.6	44.2
19560	H	1.00	0	51.0 (Note 3)	74.0	23.0
22005	H	1.00	0	50.0 (Note 3)	110.6	60.6
24450	H	1.00	0	53.0 (Note 3)	110.6	57.6

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 15:

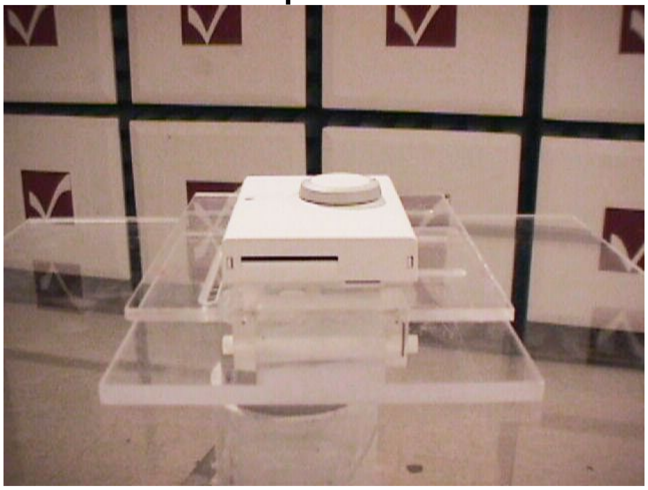
Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2475	H	1.30	155	109.9 (Note 4)	125.2	15.3
4950	H	1.25	160	48.8	54.0	5.2
7425	H	1.05	20	38.6	63.5	24.9
9900	H	1.00	40	46.6	89.9	43.3
12375	H	1.00	290	38.2	63.5	25.3
14850	H	1.00	0	41.5 (Note 3)	89.9	48.4
17325	H	1.00	0	44.8 (Note 3)	89.9	45.1
19800	H	1.00	0	51.0 (Note 3)	74.0	23.0
22275	H	1.00	0	50.0 (Note 3)	74.0	24.0
24750	H	1.00	0	53.0 (Note 3)	109.9	56.9

Notes:

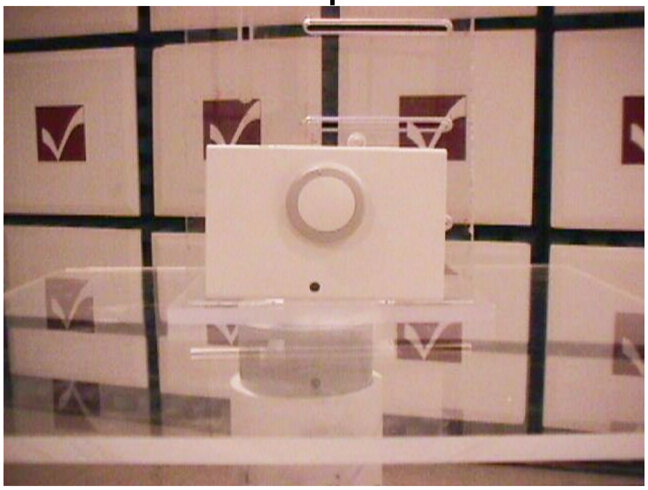
1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above 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.

View of the EUT setup in vertical orientation

View of the EUT setup in Horizontal orientation



View of the EUT setup in Side orientation



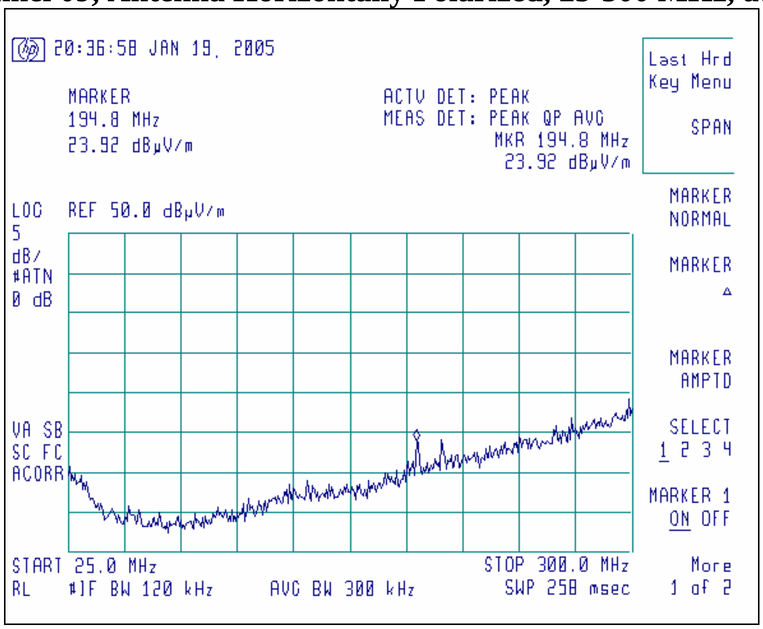
Graphs made during Radiated Emission Testing

Screen Captures of Radiated RF Emissions:

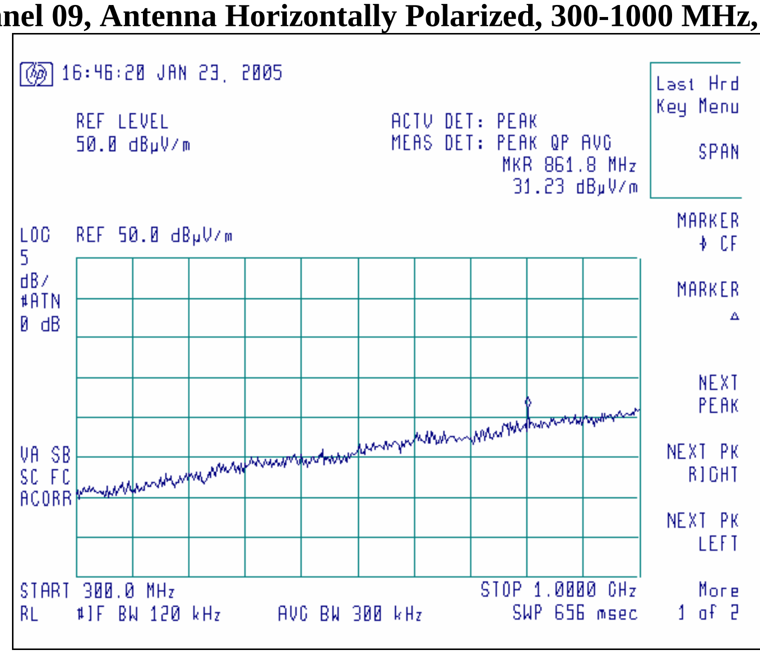
Please note these screen captures represent Peak Emissions. For radiated emission measurements, we utilize a Quasi-Peak detector function when measuring frequencies below 1 GHz, and an Average detector function when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 01, 09, or 15, with the sense and EUT antennas both in vertical polarity for worst case presentations.

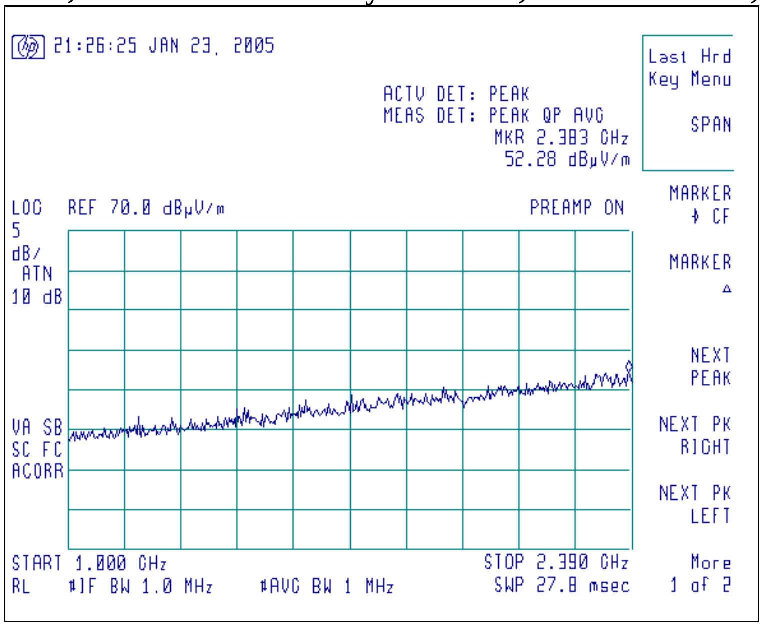
Channel 09, Antenna Horizontally Polarized, 25-300 MHz, at 3m.



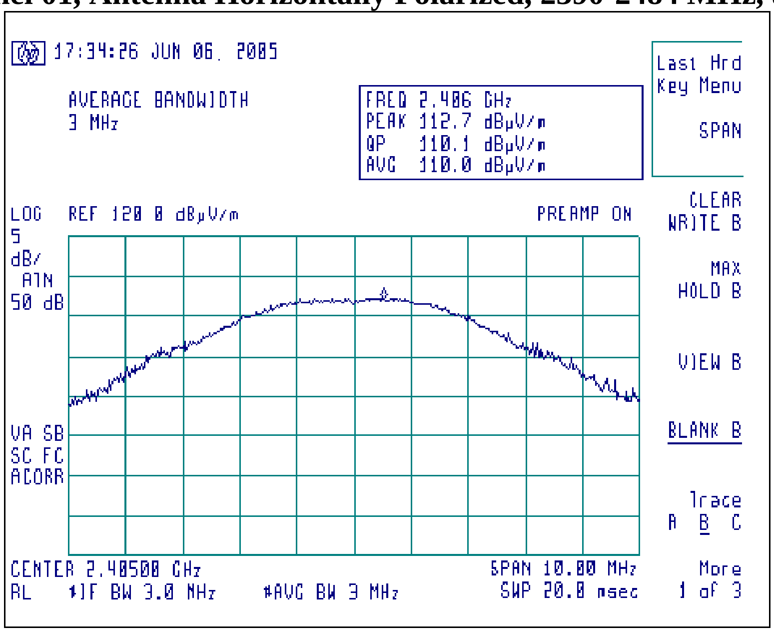
Channel 09, Antenna Horizontally Polarized, 300-1000 MHz, at 3m.



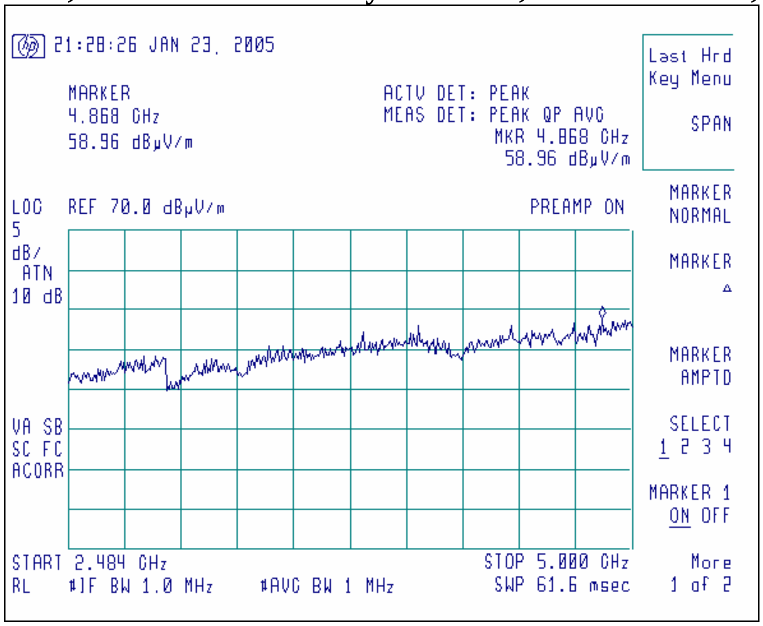
Channel 09, Antenna Horizontally Polarized, 1000-2390 MHz, at 3m.



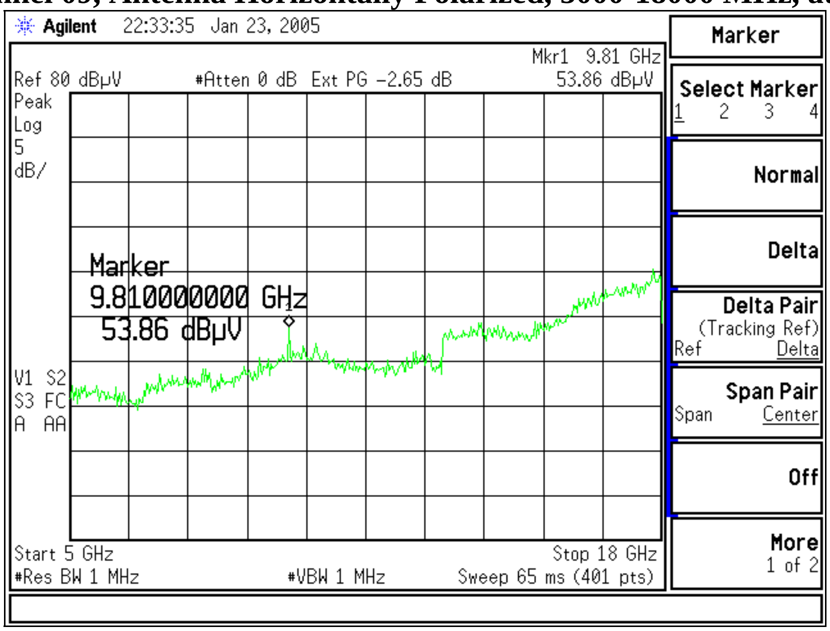
Channel 01, Antenna Horizontally Polarized, 2390-2484 MHz, at 3m.



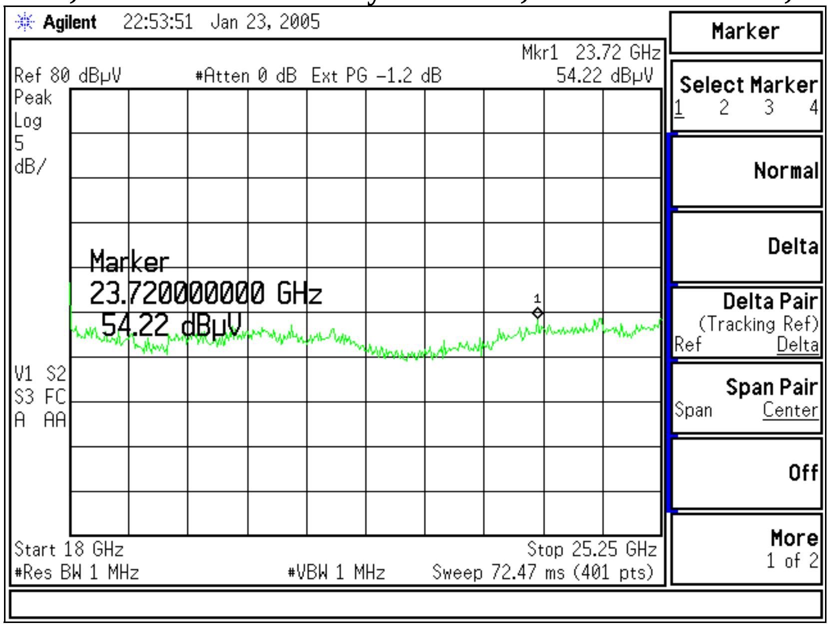
Channel 09, Antenna Horizontally Polarized, 2484-5000 MHz, at 3m.



Channel 09, Antenna Horizontally Polarized, 5000-18000 MHz, at 1m.



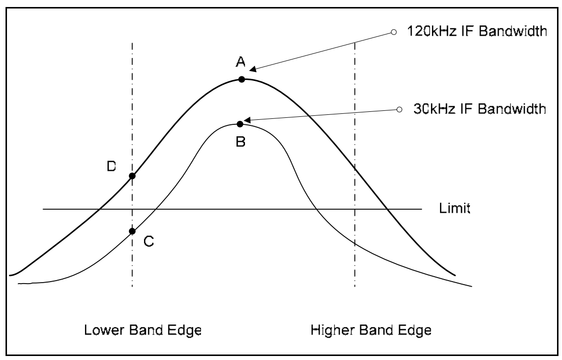
Channel 09, Antenna Horizontally Polarized, 18000-25000 MHz, at 30cm.



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 bandwidth of the modulated signal is measured using a marker delta method, to ensure that the modulated signal does not exceed the emission limits outside of the operational band. The EUT was placed in continuous transmit mode with internal typical data as the source of modulation. The emissions were then measured at the operational band edges to ensure compliance. The following diagram and formula illustrates how the band edge measurements were taken.



Measurement A is taken using a 3 MHz IF Bandwidth at the Center Frequency.
Measurement B is taken using a 30kHz IF Bandwidth at the Center Frequency.
Measurement C is taken using a 30kHz IF Bandwidth at the lower Band Edge Frequency

To Calculate the Value for lower Band Edge Frequency at Point D:

$$A - B = \Delta$$

$$\Delta + C = D$$

The Lower Band-Edge limit, in this case, would be D = -20dBc.
The Upper Band-Edge limit, in this case, would be D = 54 dB.

The measurements and calculations are as follows:

At the Lower Band-edge:

$A - B = \Delta$; $104.2 dB\mu V/m - 94.4 dB\mu V/m = 9.8 dB$

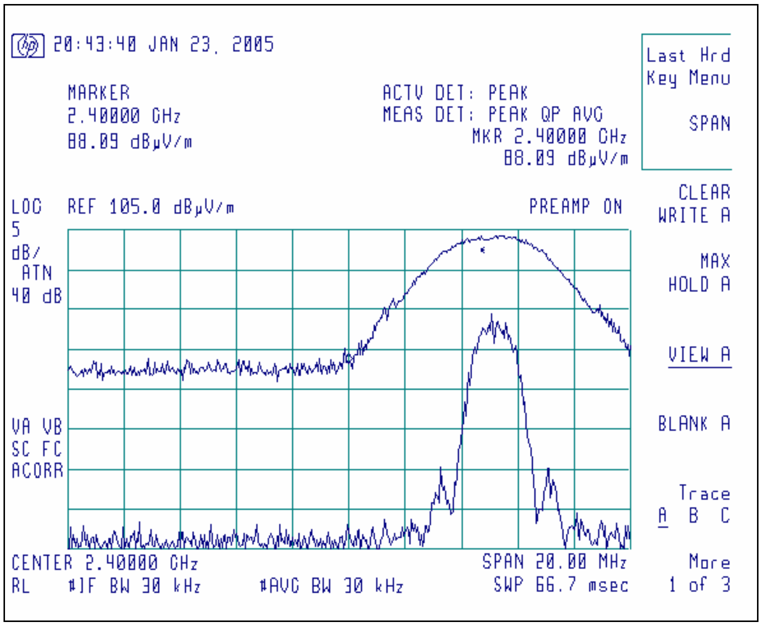
$\Delta + C = D$; $9.8 dB + 67.5 dB\mu V/m = 77.3 dB\mu V/m$ Showing compliance at Lower Band-Edge

At the Upper Band-edge:

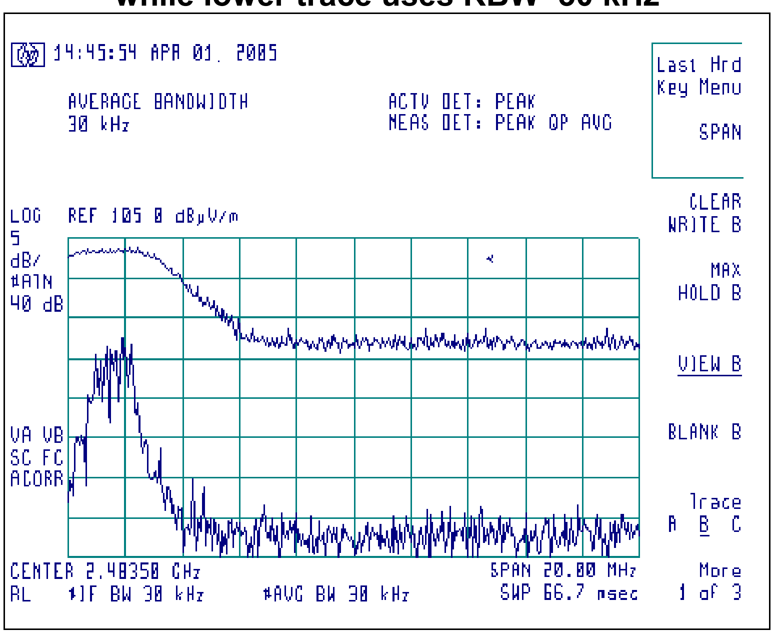
$A - B = \Delta$; $102.5 dB\mu V/m - 93.5 dB\mu V/m = 9.0 dB$

$\Delta + C = D$; $9.0 dB + 42.6 dB\mu V/m = 51.6 dB\mu V/m$ Showing compliance at Lower Band-Edge

Screen Capture demonstrating compliance at the Lower Band-Edge
Top trace shows spectral signature using RBW=3 MHz,
while lower trace uses RBW=30 kHz



Screen Capture demonstrating compliance at the Higher Band-Edge
Top trace shows spectral signature using RBW=3 MHz,
while lower trace uses RBW=30 kHz



13. Occupied Bandwidth

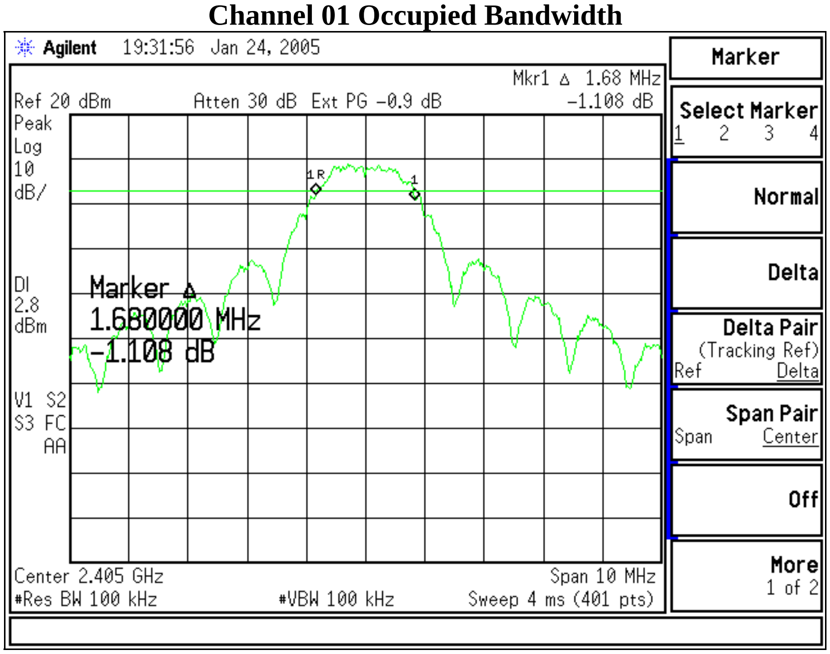
The 20 dB bandwidth requirement found in FCC Part 15.247(a)(2) requires a minimum -6dBc occupied bandwidth of 500 kHz. For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to the HP E4407B spectrum analyzer. 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.

From this data, the bandwidth of Channel 15, which is the closest data to the specification limit, is 1630 kHz, which is above the minimum of 500 kHz.

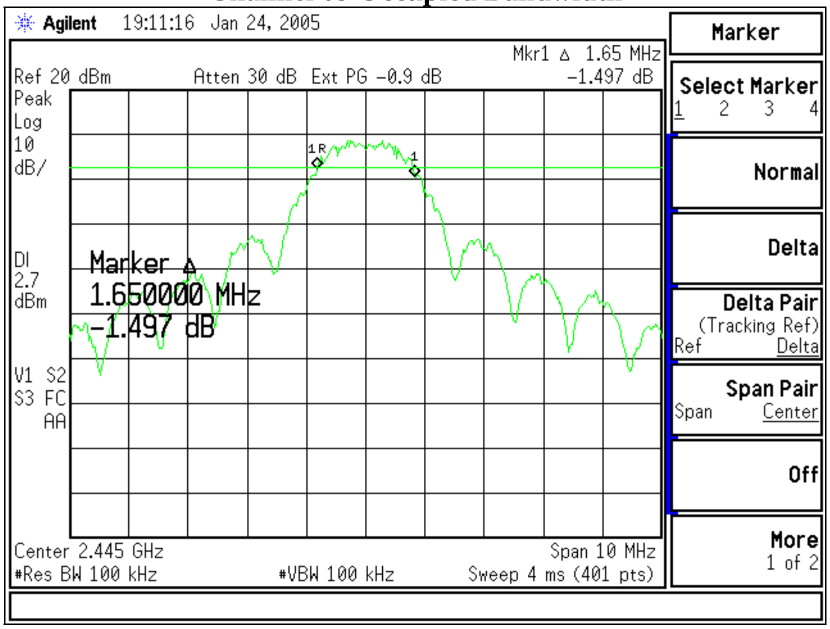
Channel	Center Frequency (MHz)	Measured 6 dB BW (kHz)	Minimum Limit (kHz)
01	2405	1680	500
09	2445	1650	500
15	2475	1630	500

Plots of Occupied Bandwidth

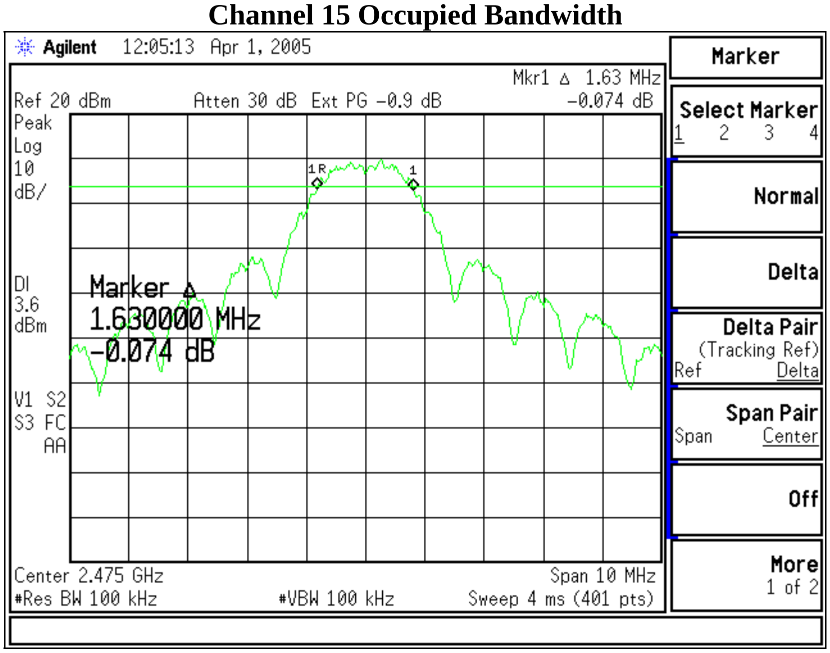
Channel 01 Occupied Bandwidth



Channel 09 Occupied Bandwidth



Channel 15 Occupied Bandwidth



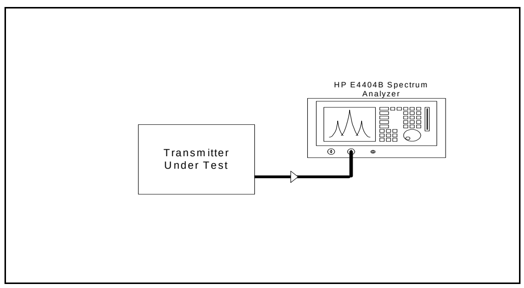
14. Conducted RF Emissions Test on AC Power Line

This product operates on two standard ‘AA’ type batteries only, and does not get connected to the AC Mains. Conducted AC-Mains RF Emissions Tests were not performed on this device.

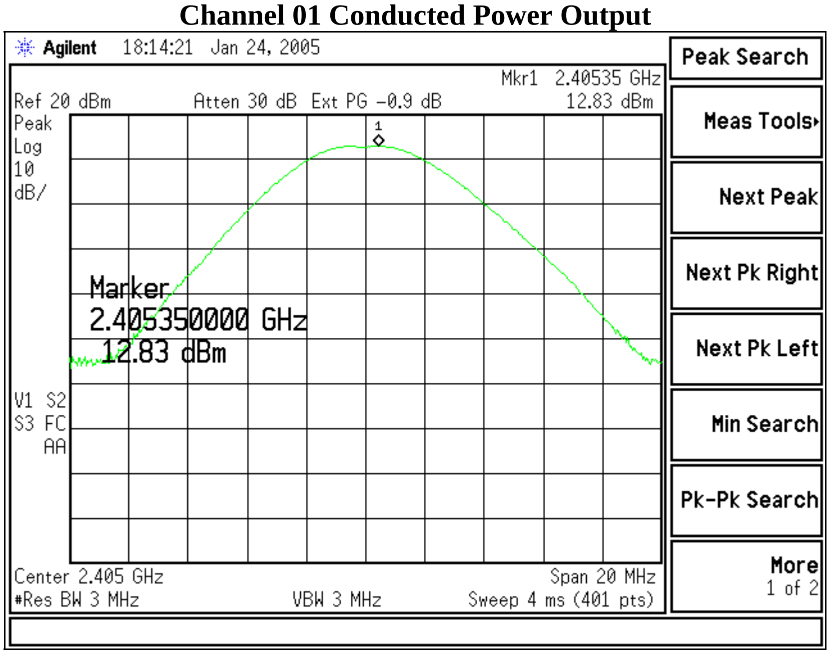
15. Power Output 15.247(b)

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. RF Power Output was also monitored while varying the DC voltage as sourced by a DC bench type power supply. No discernable variation in output power was seen while setting the DC voltage to 2.55 VDC (-15%) or to 3.45 VDC (+15%).

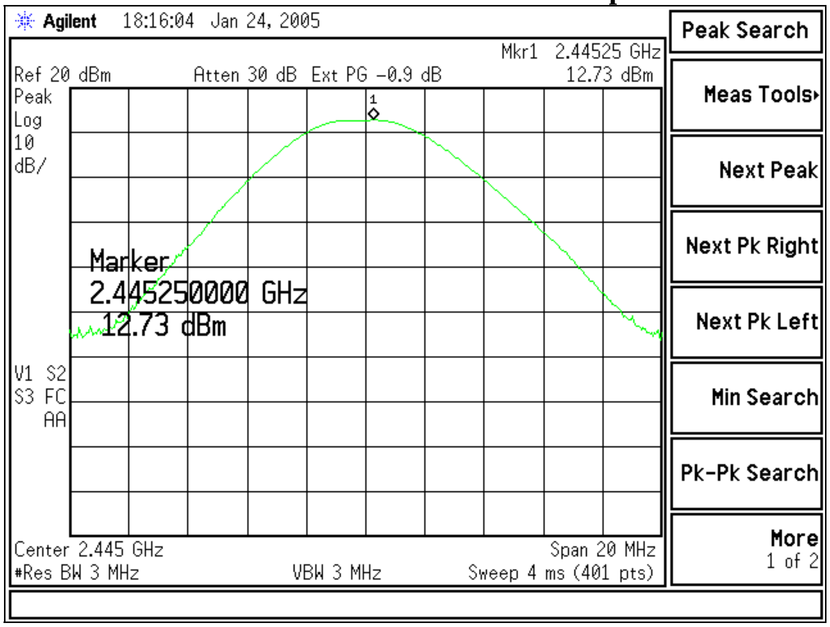
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
01	2405	30 dBm	12.8	17.2
09	2445	30 dBm	12.7	17.3
15	2475	30 dBm	13.2	16.8



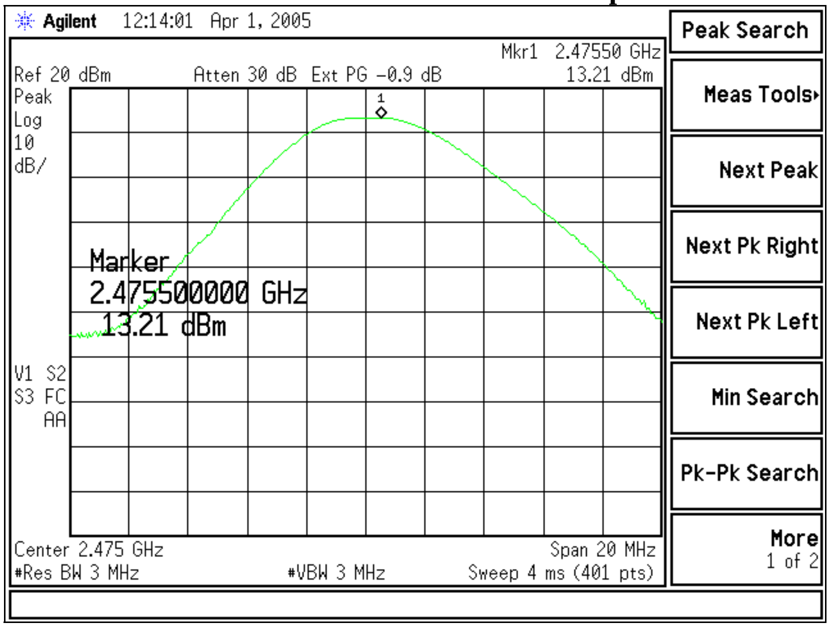
Channel 01 Conducted Power Output



Channel 09 Conducted Power Output



Channel 15 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.

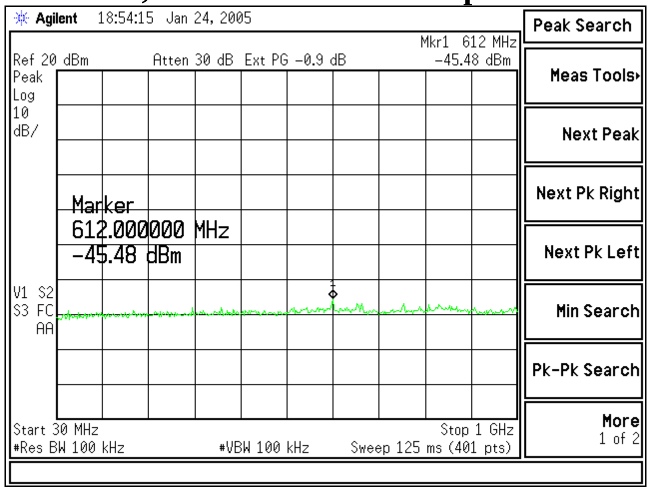
No significant emissions could be noted within -40 dBc of the fundamental level for this product.

	Channel 01	Channel 09	Channel 15
650-675MHz	- 42.8 (dBm)	- 45.5 (dBm)	- 39.0 (dBm)
Fundamental	+ 10.2 (dBm)	+ 10.8 (dBm)	+ 10.4 (dBm)
2nd Harmonic	- 45.9 (dBm)	- 49.1 (dBm)	- 50.0 (dBm)
3rd Harmonic	- 47.3 (dBm)	- 47.4 (dBm)	- 48.3 (dBm)
4th Harmonic	Note (1)	Note (1)	Note (1)
5th Harmonic	Note (1)	Note (1)	Note (1)
6th Harmonic	Note (1)	Note (1)	Note (1)
7th Harmonic	Note (1)	Note (1)	Note (1)
8th Harmonic	Note (1)	Note (1)	Note (1)
9th Harmonic	Note (1)	Note (1)	Note (1)
10th Harmonic	Note (1)	Note (1)	Note (1)

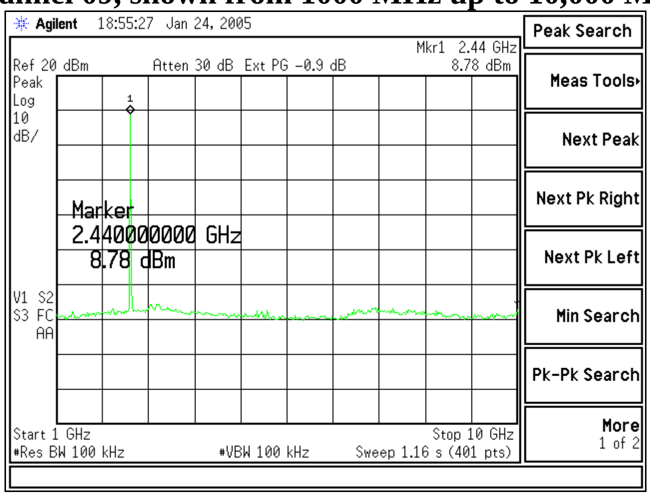
Notes:
(1) Measurement at system noise floor.

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

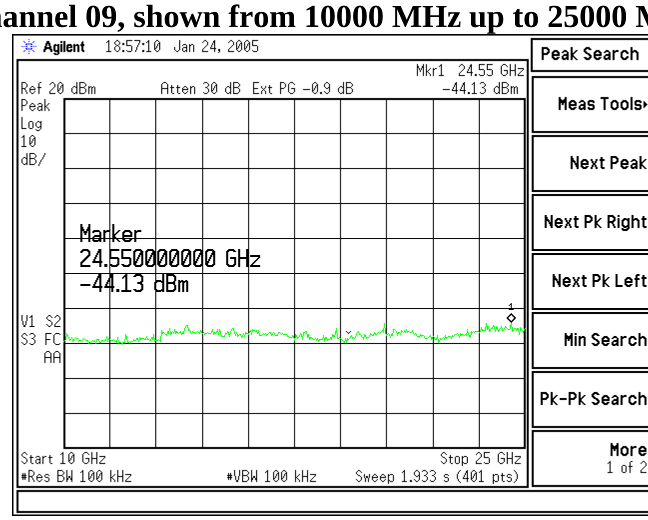
Channel 09, shown from 30 MHz up to 1000 MHz



Channel 09, shown from 1000 MHz up to 10,000 MHz



Channel 09, shown from 10000 MHz up to 25000 MHz

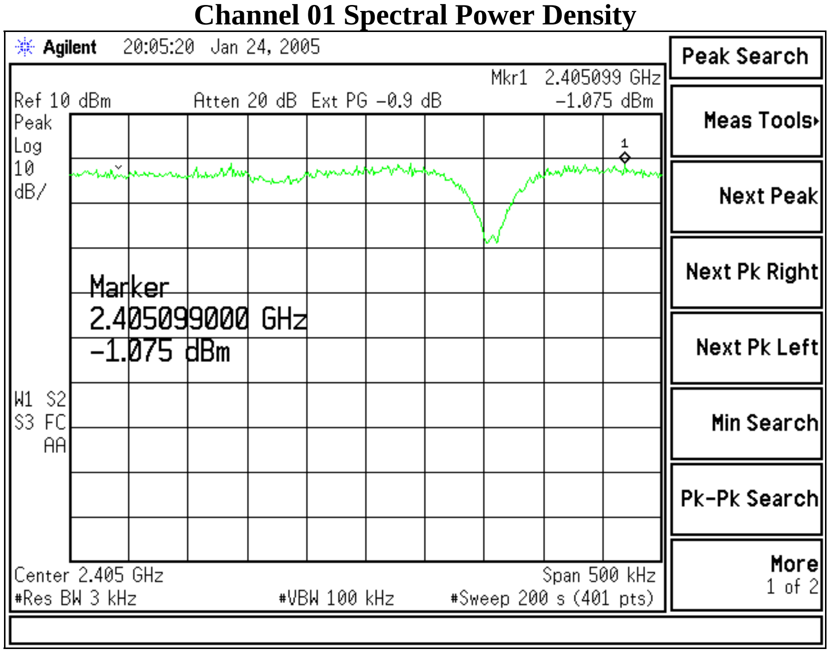


17. Spectral Density

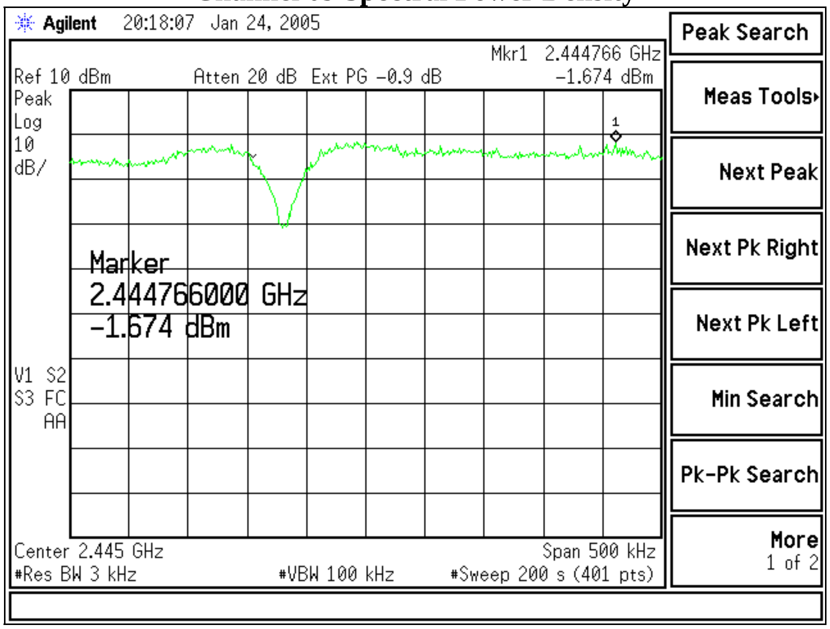
In accordance with FCC Part 15.247(e), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in previous sections. The peak output frequency for each representative frequency was 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 –1.07 dBm, which is under the allowable limit by 9 dB.

Channel	Center Frequency (MHz)	Measured Power (dBm)	Limit (dBm)	Margin (dB)
01	2405	-1.07	+8 dBm	9.07
09	2445	-1.67	+8 dBm	9.67
15	2475	-1.58	+8 dBm	9.58

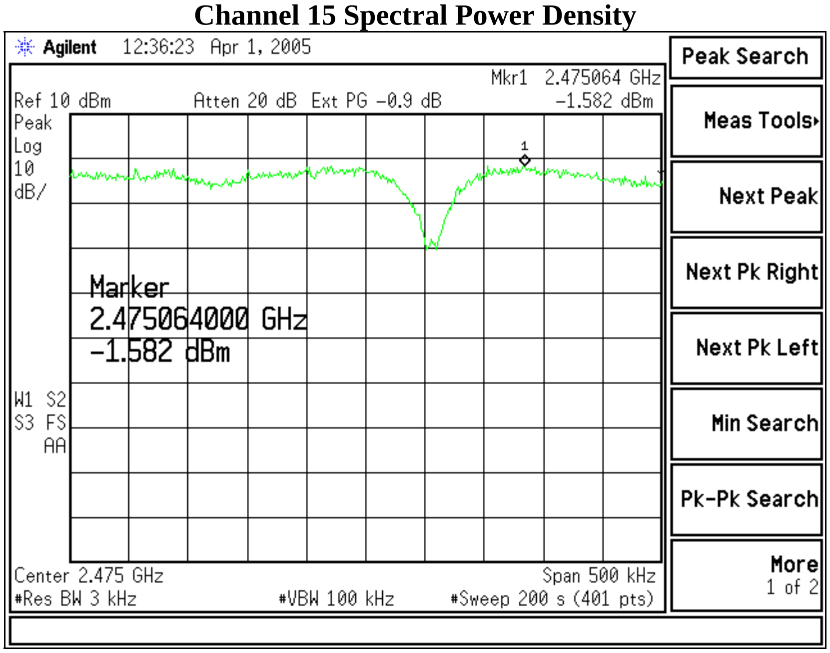
Channel 01 Spectral Power Density



Channel 09 Spectral Power Density



Channel 15 Spectral Power Density



18. Frequency and Power Stability over Voltage and Temperature Variations

For measurements of the frequency and voltage stability, the transmitter was placed inside a temperature controlled environmental chamber (Thermotron S-8C). A Spectrum Analyzer was used to measure the frequency at the appropriate frequency markers. For this test, the EUT was place inside a temperature chamber, with the transmitter portion of the EUT 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. The power supply and spectrum analyzer were located outside the temperature chamber. The frequency was measured with a receiver resolution bandwidth of 10 Hz, and video bandwidth of 10 Hz.

		DC Voltage Source		
		2.55	3.00	3.45
Temperature °C	+55	2404.97900	2404.97930	2404.97930
	+40	2404.98030	2404.98030	2404.97980
	+30			
	+25	2404.98610	2404.98585	2404.98560
	+20	2404.98750	2404.98765	2404.98735
	+10			
	0	2404.99135	2404.99135	2404.99140
	-10			
	-20	2404.97320	2404.97355	2404.97345

Max Freq	2404.99140	MHz
Min Freq	2404.97320	MHz
Total Freq Excur	0.01820	MHz
Limit	0.24050	MHz
	Pass	

		Center Freq	2445.00	MHz
		DC Voltage Source		
		2.55	3.00	3.45
Temperature °C	+55	2444.97900	2444.97900	2444.97900
	+40	2444.92950	2444.97935	2444.97940
	+30			
	+25	2444.98565	2444.98560	2444.98540
	+20	2444.98725	2444.98745	2444.98735
	+10			
	0	2444.99125	2444.99130	2444.99130
	-10			
	-20	2444.97300	2444.97330	2444.97300

Max Freq	2444.99130	MHz
Min Freq	2444.92950	MHz
Total Freq Excur	0.06180	MHz
Limit	0.24450	MHz
	Pass	

		Center Freq	2475.00	MHz
		DC Voltage Source		
		2.55	3.00	3.45
Temperature °C	+55	2474.97850	2474.97850	2474.97850
	+40	2474.97930	2474.97930	2474.97930
	+30			
	+25	2474.98510	2474.98490	2474.98495
	+20	2474.98745	2474.98750	2474.98735
	+10			
	0	2474.99120	2474.99120	2474.99125
	-10			
	-20	2474.97160	2474.97260	2474.97285

Max Freq	2474.99125	MHz
Min Freq	2474.97160	MHz
Total Freq Excur	0.01965	MHz
Limit	0.24750	MHz
	Pass	

	DC Voltage Source		
	2.55 V	3.00 V	3.45 V
Channel 01	+9.4 (dBm)	+10.1 (dBm)	+10.6 (dBm)
Channel 09	+9.2 (dBm)	+10.0 (dBm)	+10.3 (dBm)
Channel 15	+9.0 (dBm)	+10.2 (dBm)	+10.3 (dBm)

The power was then cycled On/Off to observe system response. No unusual response was observed, the emission characteristics were well behaved, and the system returned to the proper power-up state. At the extreme temperature settings, a wide frequency sweep was also investigated, with minimum and maximum input voltages, to ensure that no unexpected anomalies have occurred. No anomalies were noted, in the measured transmit power, varying less than 1 dB, during the voltage variation tests.

19. MPE Calculations

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:	13.20	(dBm)
Maximum peak output power at antenna input terminal:	20.893	(mW)
Antenna gain(typical):	2.1	(dBi)
Maximum antenna gain:	1.622	(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:	0.006741	(mW/cm^2)
Maximum allowable antenna gain:	23.8	(dBi)
Margin of Compliance at 20 cm =	21.7	dB

Appendix A

Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	9/15/04	9/15/05
AA960031	HP	119474A	3107A01708	Transient Limiter	Note 1	Note 1
AA960077	EMCO	93110B	9702-2918	Biconical Antenna	9/16/04	9/16/05
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	9/16/04	9/16/05
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	12/06/04	12/06/05
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	12/06/04	12/06/05
EE960004	EMCO	2090	9607-1164	Device Controller	N/A	N/A
EE960013	HP	8546A	3617A00320	Receiver RF Section	9/16/04	9/16/05
EE960014	HP	85460A	3448A00296	Receiver Pre-Selector	9/16/04	9/16/05
N/A	LSC	Cable	0011	3 Meter ½" Armored Cable	Note 1	Note 1
N/A	LSC	Cable	0038	1 Meter RG 214 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 2.5 cm printed circuit board trace antenna, and does not have any other facilities for external or commercial antenna connections.

Appendix C

Firmware and Setup Instructions

The EUT was presented for testing with firmware test modes.
The modes were changed by repeatedly pressing the ‘set’ button on the EUT, until the desired mode of operation was reached from the list of available modes.