L.S. Compliance, Inc.

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

COMPLIANCE TESTING OF:

MS-BTCVT-0

Prepared For:

Johnson Controls, Incorporated
Controls Group
Attention: Mr. Michael Schantzen
507 East Michigan Street
Milwaukee, WI 53202

Test Report Number:

304405-TX

Test Dates:

November 29TH through December 2ND, 2004

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. Testing and calibration laboratories that comply with this International Standard also operate in accordance with ISO 9001 or ISO 9002 (1994).

Presented this 26th day of March 2003.

President
For the Accreditation Council
Certificate Number 1255.01
Valid to January 31, 2005

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, 2005 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, 50081-1, 50081-2; CISPR: 11, 12, 14-1, 22; CNS 13438
Radiated	Code of Federal Regulations (CFR) 47, FCC Method Parts 15, 18 using ANSI C63.4; EN: 55011, 55022, 50081-1, 50081-2; CISPR: 11, 12, 14-1, 22; CNS 13438
Current Harmonics	IEC 61000-3-2; EN 61000-3-2
Voltage Fluctuations & Flicker	IEC 61000-3-3; EN 61000-3-3
Immunity	EN: 50082-1, 50082-2 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
Voltage Dips/Interruptions	IEC 61000-4-11; EN 61000-4-11

Roxanne M. Robinson

(A2LA Cert. No. 1255-01) 05/13/03 Page 1 of 2

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

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: February 18, 2005

Teresa A. White, Document Coordinator Date

Tested By: February 18, 2005

Abtin Spantman, EMC Engineer Date

Approved By: February 18, 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:	November 29th through December 2nd , 2004
Test Engineer(s):	Tom Smith; √ Abtin Spantman; Ken Boston
Model #:	MS-BTCVT-0
Serial #:	Pre-production address 3AC8
Voltage:	15 VDC at 250 mA provided by host or wall-type transformer
Operation Mode:	Normal, continuous transmit, and 'Hopping' mode

7. Introduction

Between November 29th and December 2nd, 2004, a series of Conducted and Radiated RF Emission tests were performed on one pre-production sample of the Johnson Controls' model MS-BTCVT-0 Converter with Bluetooth® Wireless Technology, here forth referred to as the "*Equipment Under Test*" or "*EUT*". The pre-production samples do not have a serial number assigned to them, but can be identified through the Bluetooth® assigned address for each individual unit. The sample with Bluetooth® address ending with 3AC8 was initially configured to use the integral trace antenna, for radiated tests, then reconfigured with a 50 Ω SMA jack for conducted RF emission testing.

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, Inc. and was witnessed by Mike Schantzen of Johnson Controls, 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, 15.209, 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

Description:

The Converter with Bluetooth® wireless technology (BTCVT) is a communications converter that provides a temporary connection between AIM software and a field device to commission, synchronize, and balance Metasys® system extended architecture hardware controllers. The BTCVT provides communication from the Field Controller (FC) bus or the Sensor and Actuator (SA) bus to a Bluetooth wireless technology enabled device, such as a laptop computer. The BTCVT converts Master Slave Token Passing (MSTP) protocol to 2.4 GHz Bluetooth wireless communication and from wireless communication back to MSTP. A strap, provided with the BTCVT, allows you to hang the BTCVT next to the controller while the wireless connection allows you to be up to 10 m (33 ft) away while you commission the controller with a laptop computer. The BTCVT is compatible with the following MSTP devices:

- Field Equipment Controller (FEC)
- Variable Air Volume Modular Assembly (VMA)
- Input/Output Module (IOM)
- Network Sensors

The BTCVT uses Bluetooth wireless technology, but is not compatible with other Bluetooth wireless devices. The BTCVT can only be used with the wireless card supplied with the BTCVT or a wireless processor as provided by Johnson Controls.

Parts Included

- one BTCVT
- one 3Com® Bluetooth PC card and vendor-supplied software
- one 5-ft coiled retractable cable
- one set of Installation Instructions
- one hanging strap with internal magnet

Special Tools Needed

The BTCVT provides a wireless link to the controller. To access the BTCVT, you need the following:

- laptop Computer running Microsoft® Windows® 2000 Professional operating system or later with the wireless card installed.
- AIM software

Power Supply, Network, and Communication Connections

See Figure 1 for the location of the communications terminal on the BTCVT.

SA/FC Port

The SA/FC Port on the BTCVT is a 6-pin RS-485 port designed to connect the BTCVT to an accessible SA or FC port on an MSTP device using the cable assembly provided. The SA/FC is a straight through, 1-to-1connection (not a cross-over). The maximum allowable cable length is 100 ft. Do not plug the SA/FC Port into a standard phone jack.

Table 2: SA/FC Port Pin Designations

Pin Number (Both Ends of Cable)	Signal Name
1	(FC or SA) +
2	(FC or SA) -
3	15 VDC Common
4	15 VDC Hot
5	No Connection
6	No Connection

Establishing a Connection between the BTCVT and AIM Software

The connection between the BTCVT and AIM software is handled by the AIM software once you have set up the correct COM Port setting in the AIM software. Refer to the AIM Software Help for details.

Status Indication LEDs

The Converter has 4 LEDs to indicate power and communication status. Figure 4 shows the LEDs and Table 3 describes their function.

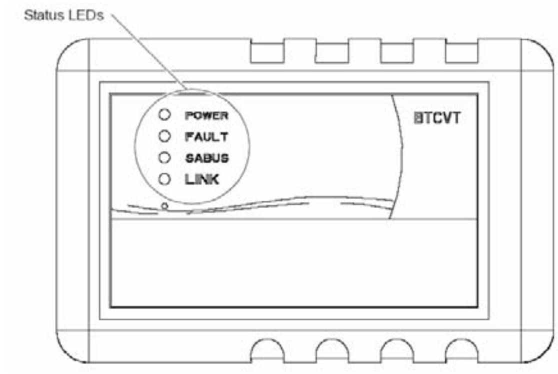


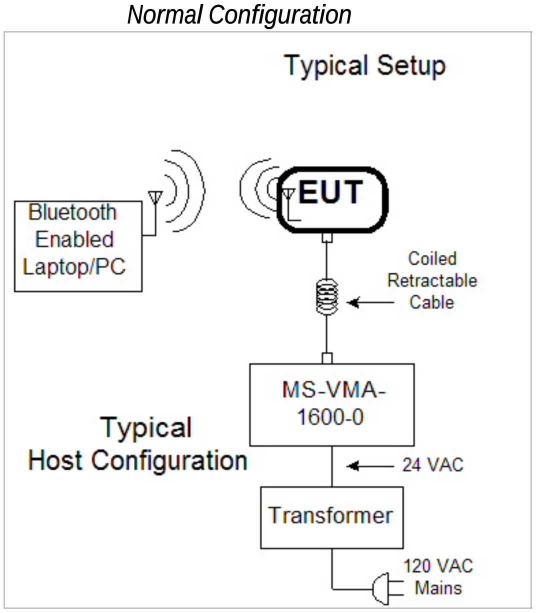
Table 3: Converter LED Designations and Descriptions

Color	LED Name	Normal	Descriptions/Other Conditions
Green	**Power**	On Steady	On Steady = Power is Supplied by Primary Voltage Off = No Power
Red	**Fault**	Off	Off Steady = No Faults On Steady = Device Fault
Green	**SA/FC Bus**	Flicker	Flicker = Data Transmission Off Steady = No Data Transmission
Blue	**Link**	On	On Steady = Bluetooth communication link established Off Steady = Bluetooth communication link not established

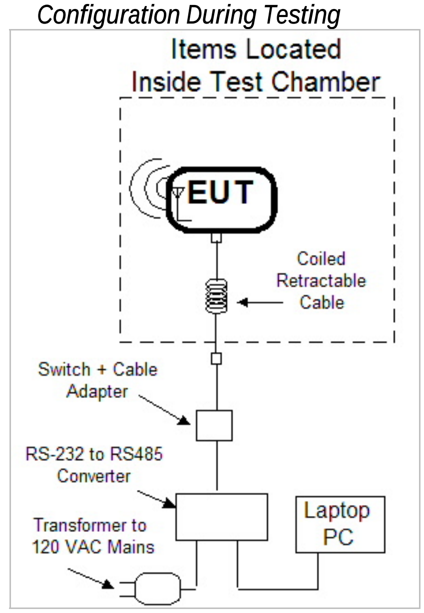
Configuration During Testing

The EUT was configured as shown below, and supported by host devices that are typical for an installation.

Normal Configuration



Configuration During Testing



9. Test Requirements

The above mentioned tests were performed in order to determine the compliance of the Johnson Controls' model MS-BTCVT-0 Converter with Bluetooth® Wireless Technology with limits contained in various provisions of Title 47 CFR, FCC Part 15, including:

15.19	15.207	15.247b	15.247g
15.31	15.205	15.247c	15.209
15.33	15.247a	15.247d	

10. Summary of Test Report

DECLARATION OF CONFORMITY

The Johnson Controls' model MS-BTCVT-0 Converter with Bluetooth® Wireless Technology 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(0) for a Frequency Hopping Spread Spectrum Transmitter.

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.

The enclosed test results pertain to the sample(s) of the test item listed, and only for the tests performed on the data sheets. Any subsequent modification or changes to the test items could invalidate the data contained herein, and could therefore invalidate the findings of this report.

11. Conducted Emissions Test, Occupied Bandwidth

The 20 dB bandwidth requirement found in FCC Part 15.247(a)(1)(i) states a maximum general allowed occupied bandwidth of 500 kHz for devices operating in the 902-928 MHz band, and a maximum of 1 MHz for devices operating in the 5725-5850 MHz band. For devices operating in the 2400 MHz band, there are no stated maximum occupied bandwidth limits.

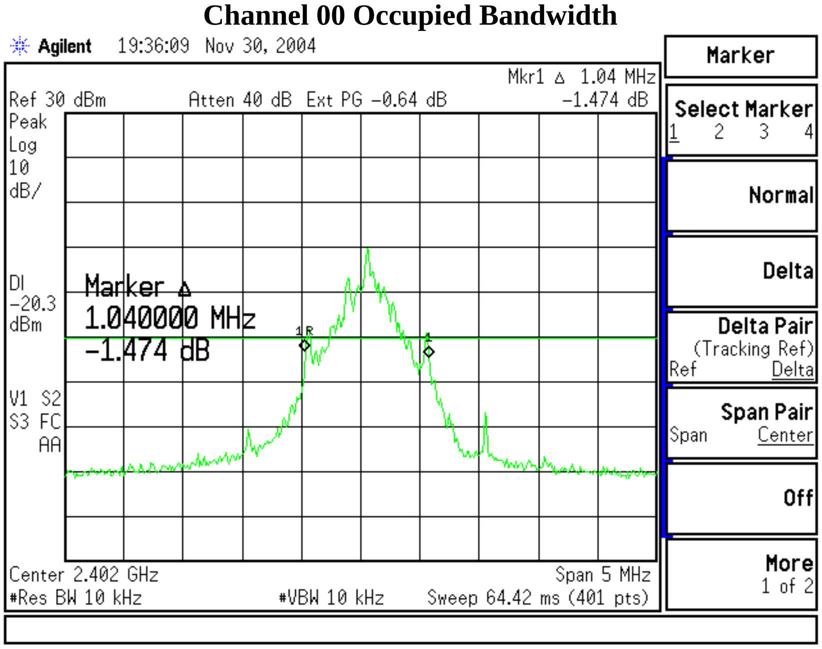
For this portion of the tests, the printed circuit board trace antenna was electrically disconnected and replaced with a 50Ω RF connector. A direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to the HP E4407B spectrum analyzer. The loss from 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 10 kHz for this portion of the tests. The EUT was configured to run in a continuous transmit mode, while being supplied with typical binary data patterns 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 occupied bandwidth is typically at 1040 kHz.

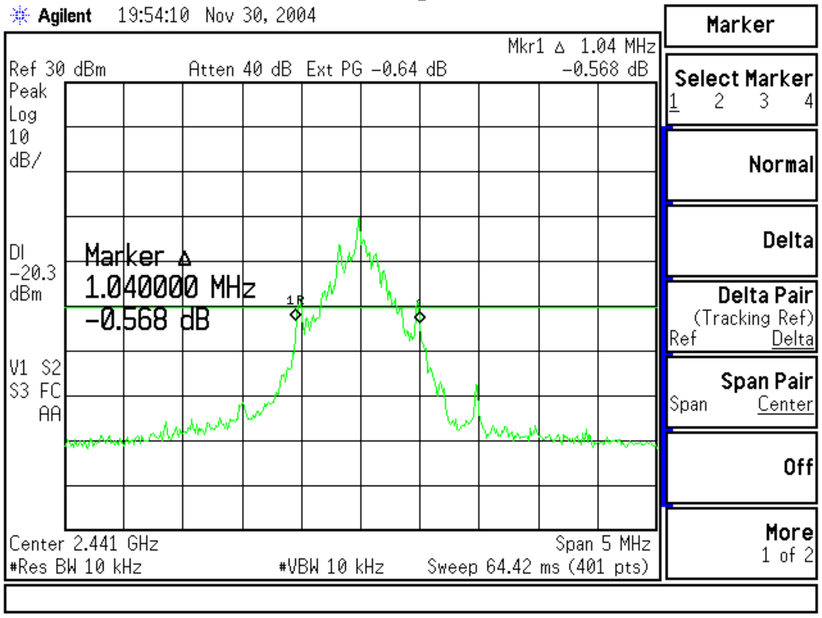
Channel	Center Frequency (MHz)	Measured -20 dB BW (MHz)
00	2402	1.04
39	2441	1.04
78	2480	1.04

Plots of Occupied Bandwidth

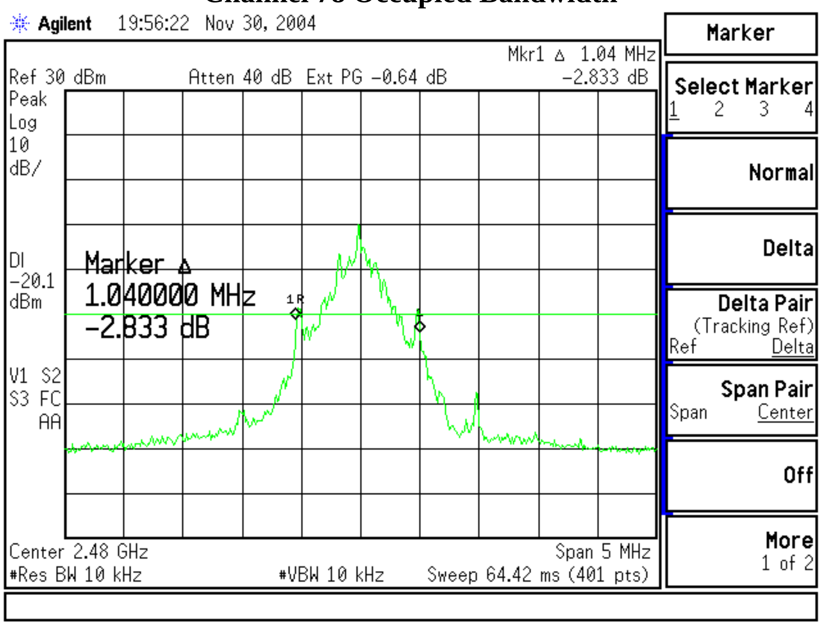
Channel 00 Occupied Bandwidth



Channel 39 Occupied Bandwidth



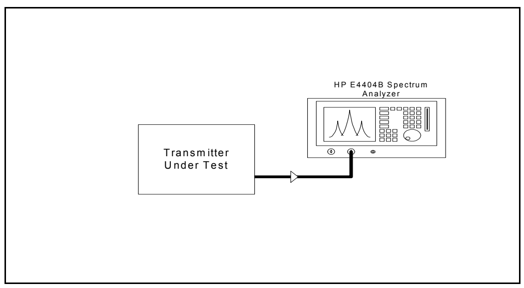
Channel 78 Occupied Bandwidth



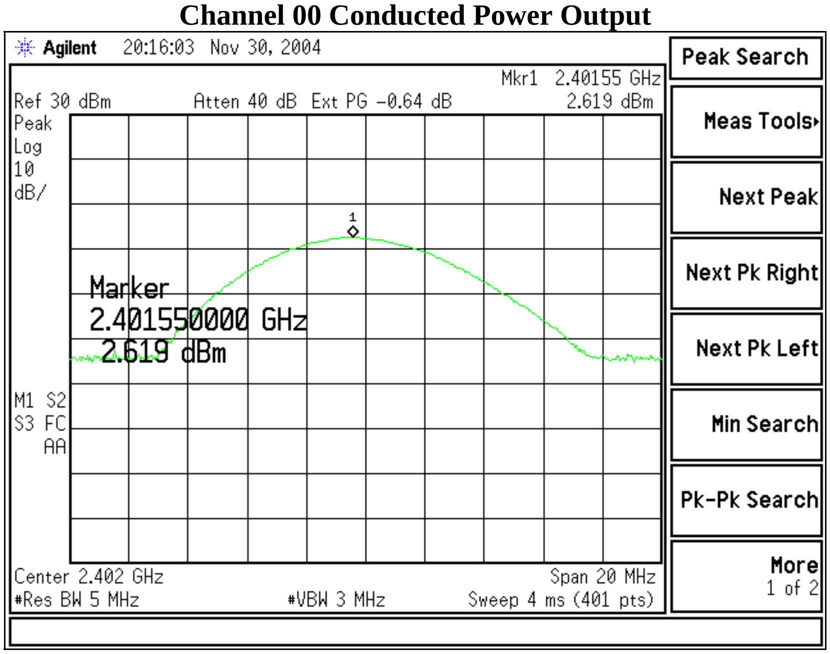
12. Conducted Emissions Test, Power Output 15.247(b)

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable to 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. The unit was configured to run in a continuous transmit mode, while being supplied with typical binary data patterns as a modulation source. The spectrum analyzer was used with resolution bandwidth set to 5 MHz, video bandwidth set to 1 MHz, and a span of 20 MHz, with measurements from a peak detector presented in the chart below.

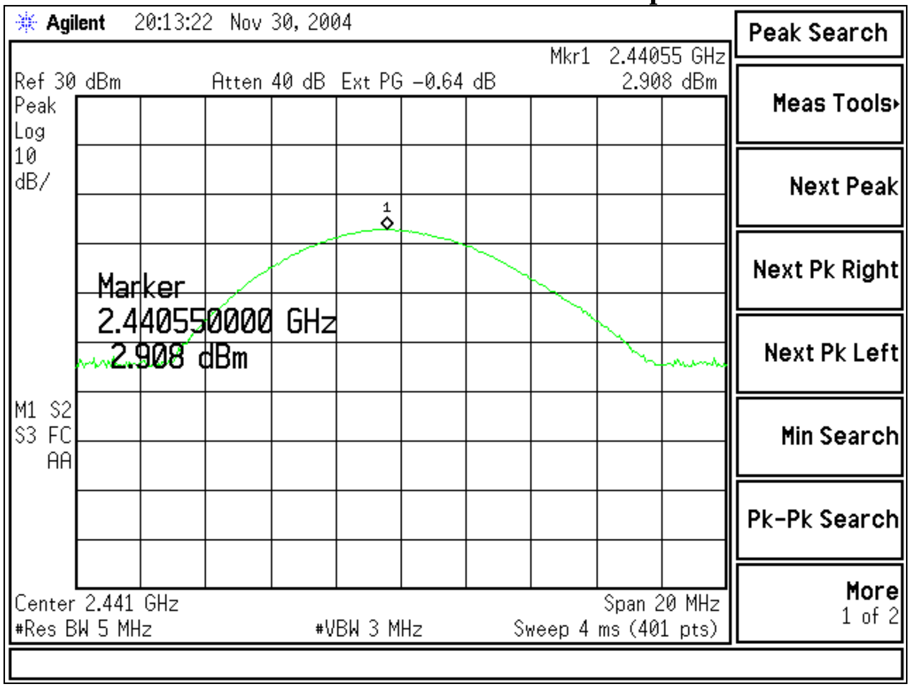
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
00	2402	20.9 dBm	2.6	18.3
39	2441	20.9 dBm	2.9	18.0
78	2480	20.9 dBm	2.5	18.4



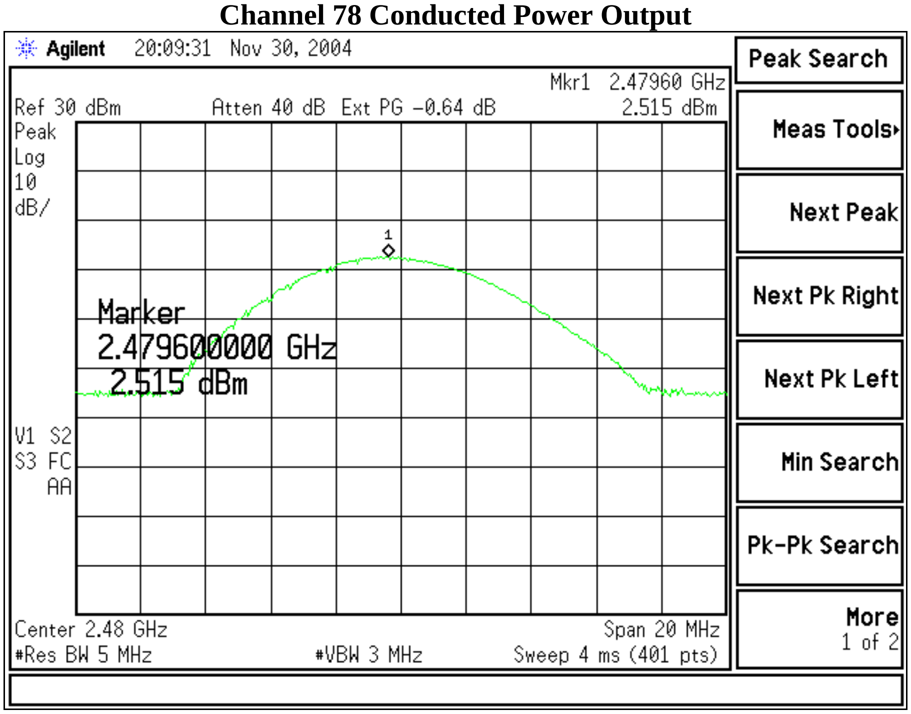
Channel 00 Conducted Power Output



Channel 39 Conducted Power Output



Channel 78 Conducted Power Output



13. 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 modulated continuous transmit mode. Power was supplied by an external bench-type variable power supply, and the frequency of operation was monitored using the spectrum analyzer, with the antenna placed inside the chamber. The power supply and spectrum analyzer were located outside the temperature chamber. The frequency was measured with a receiver resolution and video bandwidth of 100 Hz, and span of 200 kHz.

Model	BTCVT
Serial	3AC8
Channel	0

Center Freq	2402	MHz

Min Voltage 13.00

Nom Voltage 14.00

Max Voltage 15.00

Temperature °C	DC Voltage Source 11.05	14.00	17.25
+50	2401.9603	2401.9603	2401.9603
+40	2401.9690	2401.9690	2401.9690
+30	2401.9810	2401.9810	2401.9810
+25	2401.9850	2401.9850	2401.9850
+20	2401.9945	2401.9945	2401.9945
+10	2402.0070	2402.0070	2402.0070
0	2402.0175	2402.0175	2402.0175
-10	2402.0255	2402.0255	2402.0255
-20	2402.0315	2402.0315	2402.0315

Max Freq	2402.0315	MHz
Min Freq	2401.9603	MHz
Total Freq Excursion	0.0712	MHz
Limit	0.2402	MHz
	Pass	

Model	BTCVT
Serial	3AC8
Channel	39

Center Freq	2441	MHz

Temperature °C	DC Voltage Source 11.05	14.00	17.25
+50	2440.9595	2440.9595	2440.9595
+40	2440.9695	2440.9695	2440.9695
+30	2440.9810	2440.9810	2440.9810
+25	2440.9860	2440.9860	2440.9860
+20	2440.9945	2440.9945	2440.9945
+10	2441.0065	2441.0065	2441.0065
0	2441.0175	2441.0175	2441.0175
-10	2441.0265	2441.0265	2441.0265
-20	2441.0315	2441.0315	2441.0315

Max Freq	2441.0315	MHz
Min Freq	2440.9595	MHz
Total Freq Excursion	0.0720	MHz
Limit	0.2441	MHz
	Pass	

Model	BTCVT
Serial	3AC8
Channel	78

Center Freq	2480	MHz

Temperature °C	DC Voltage Source 11.05	14.00	17.25
+50	2479.9590	2479.9590	2479.9590
+40	2479.9680	2479.9680	2479.9680
+30	2479.9810	2479.9810	2479.9810
+25	2479.9860	2479.9860	2479.9860
+20	2479.9940	2479.9940	2479.9940
+10	2480.0065	2480.0065	2480.0065
0	2480.0180	2480.0180	2480.0180
-10	2480.0265	2480.0265	2480.0265
-20	2480.0315	2480.0315	2480.0315

Max Freq	2480.0315	MHz
Min Freq	2479.9590	MHz
Total Freq Excursion	0.0725	MHz
Limit	0.2480	MHz
	Pass	

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 standby state after power up, as required by the manufacturer.

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, in order to meet 15.31(e). Frequency stability and temperature stability were also performed, in order to show compliance with other regulatory limits.

14. Conducted Emissions Test, 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 to 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 binary data patterns 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 -30 dBc of the fundamental level for this product.

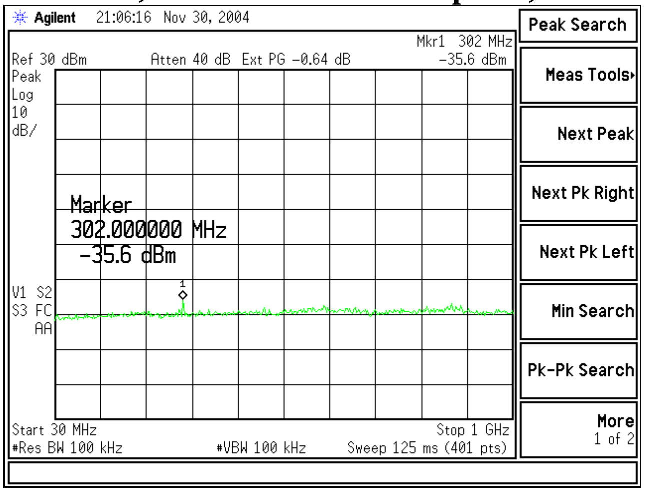
	Channel 00	Channel 39	Channel 78
Fundamental	+ 1.1 (dBm)	+ 1.6 (dBm)	+ 1.4 (dBm)
2nd Harmonic	- 34.8 (dBm)	- 34.0 (dBm)	- 35.2 (dBm)
3rd Harmonic	- 39.4 (dBm)	- 38.2 (dBm)	- 38.9 (dBm)
4th Harmonic	Note (1)	Note (1)	Note (1)
5th Harmonic	Note (1)	Note (1)	Note (1)
6th Harmonic	Note (1)	Note (1)	Note (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:

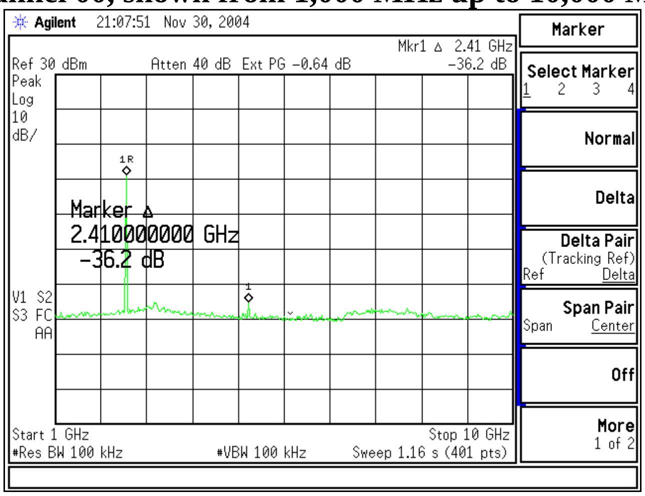
10 Measurement at system noise floor.

Plots of Conducted Spurious and Fundamental Levels

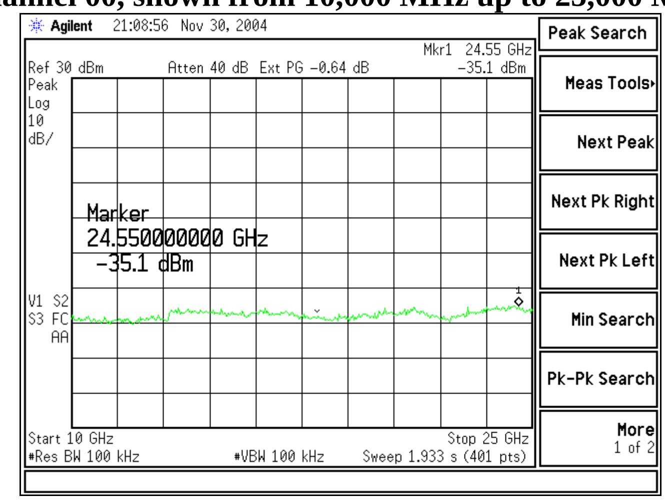
Channel 00, shown from 30MHz up to 1,000 MHz



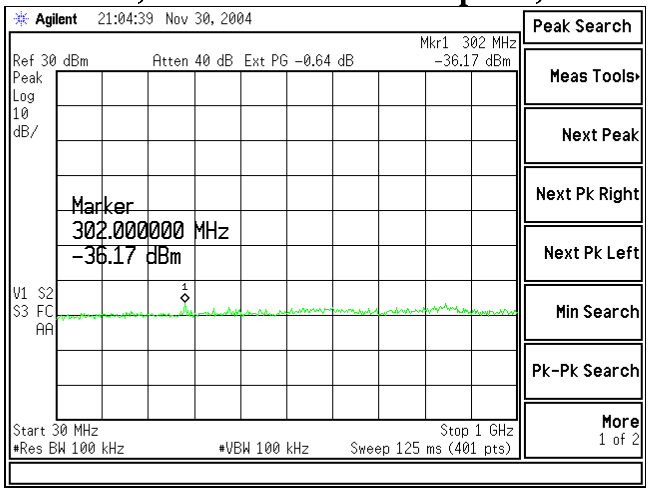
Channel 00, shown from 1,000 MHz up to 10,000 MHz



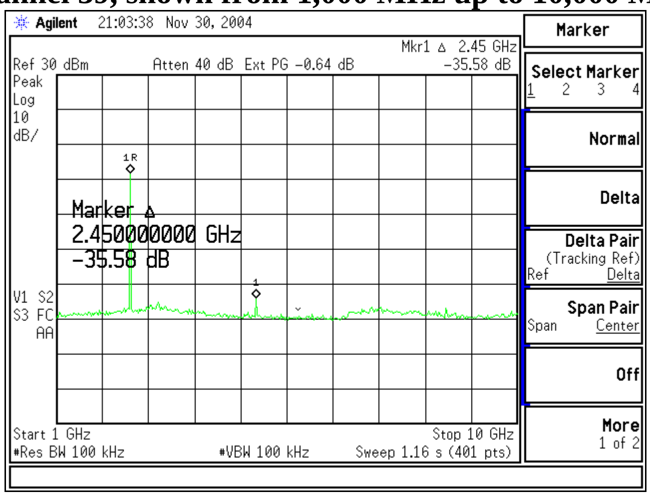
Channel 00, shown from 10,000 MHz up to 25,000 MHz



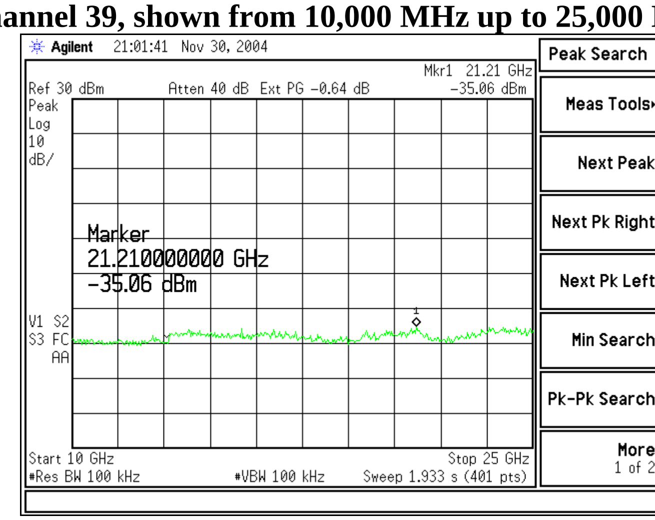
Channel 39, shown from 30 MHz up to 1,000 MHz



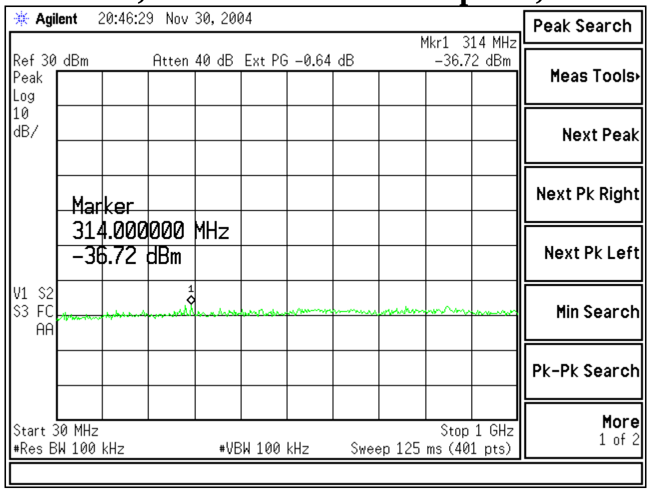
Channel 39, shown from 1,000 MHz up to 10,000 MHz



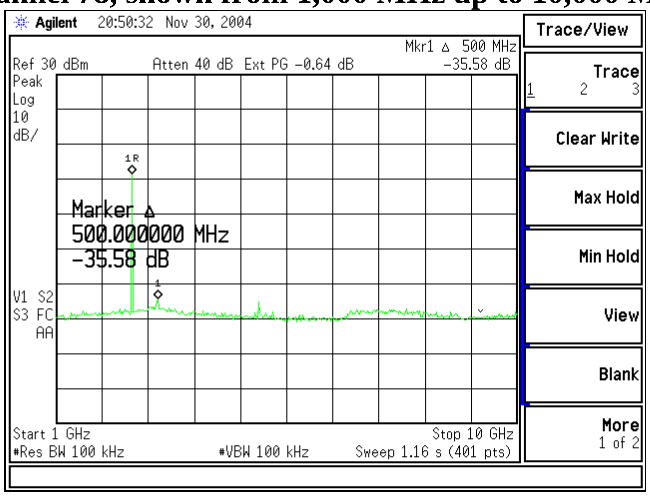
Channel 39, shown from 10,000 MHz up to 25,000 MHz



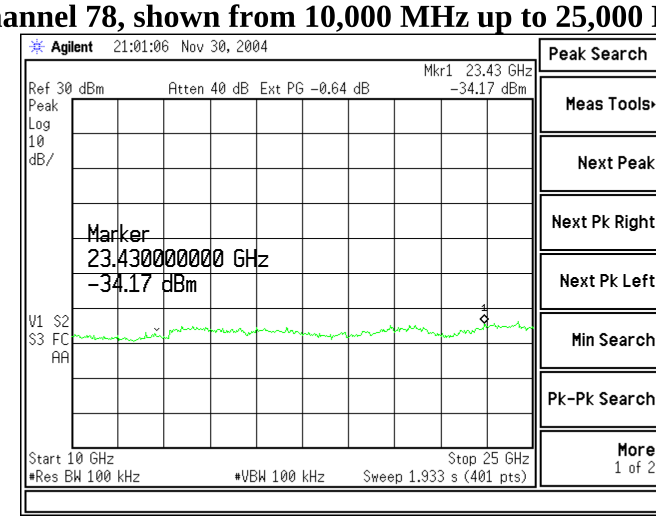
Channel 78, shown from 30 MHz up to 1,000 MHz



Channel 78, shown from 1,000 MHz up to 10,000 MHz



Channel 78, shown from 10,000 MHz up to 25,000 MHz



15. Conducted Emissions Test, Minimum Channel Separation

Part 15.247(a)(1) requires a minimum channel separation of 25 kHz or the equivalent of the 20 dB occupied bandwidth of the fundamental transmission, whichever is greater. Alternatively[Note 1], for systems operating in the 2400 MHz band, the hopping channel carrier frequencies may be separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, which ever is greater. An HP E4407B spectrum analyzer was used with a resolution bandwidth of 30 kHz to measure the channel separation of the EUT.

The channel-separations measured for this device is 1MHz. The maximum occupied bandwidth of the device, as reported in the previous section is 1050 kHz. The minimum channel separation for the EUT exceeds both the 25 kHz criteria and the two-thirds of 20 dB occupied bandwidth criteria, and hence meets the requirements. The following plots describe this spacing, and also establish the number of hop channels, total of 79.

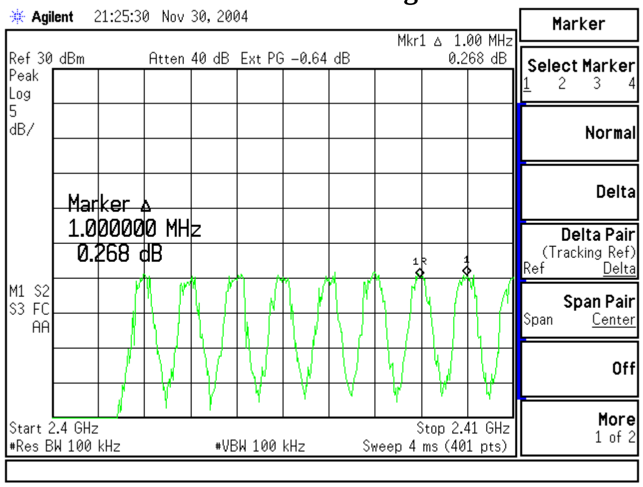
Frequency Span (MHz)	Number of Channels	Minimum Separation (MHz)
2400-2410	9	1.0
2410-2420	10	1.0
2420-2430	10	1.0
2430-2440	10	1.0
2440-2450	10	1.0
2450-2460	10	1.0
2460-2470	10	1.0
2470-2480	10	1.0
2480-2490	0	-

Notes:

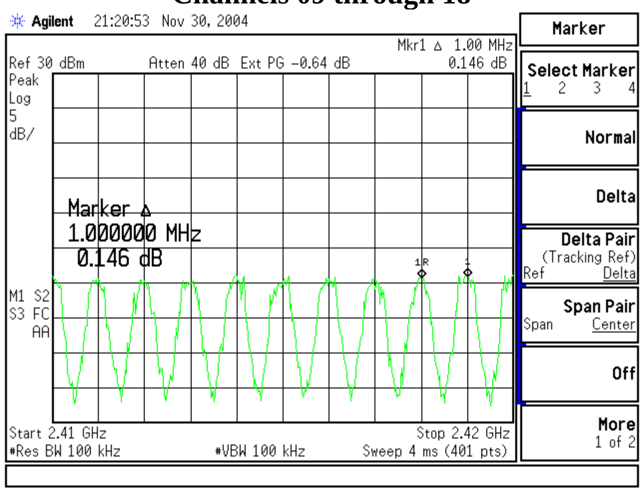
1)Allowance valid for systems operating with an output power no greater than 125 mW, conducted at the antenna port.

Plots of Channel Separations

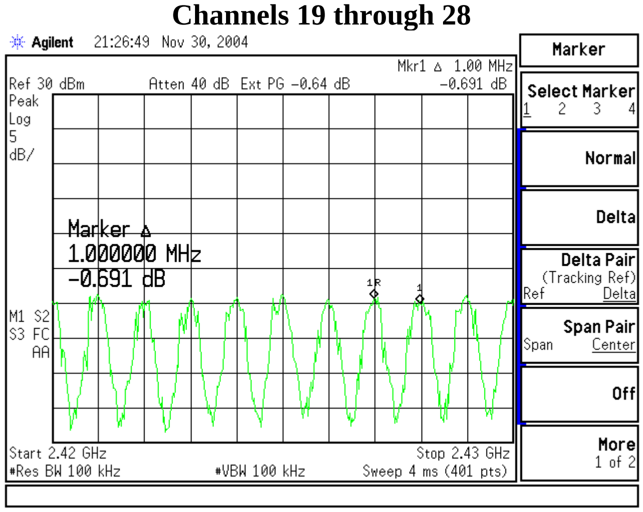
Channels 00 through 08



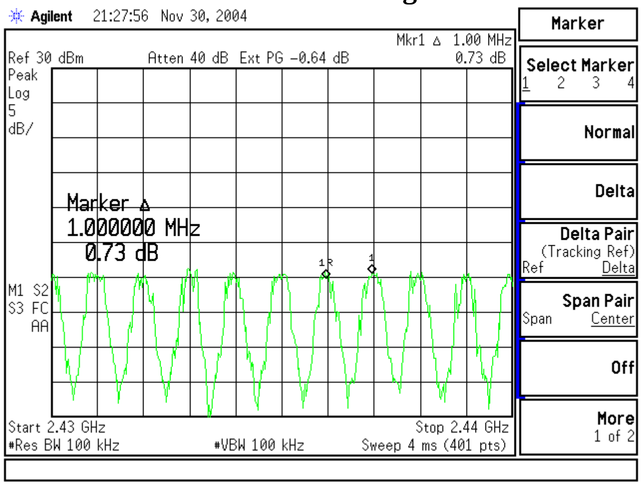
Channels 09 through 18



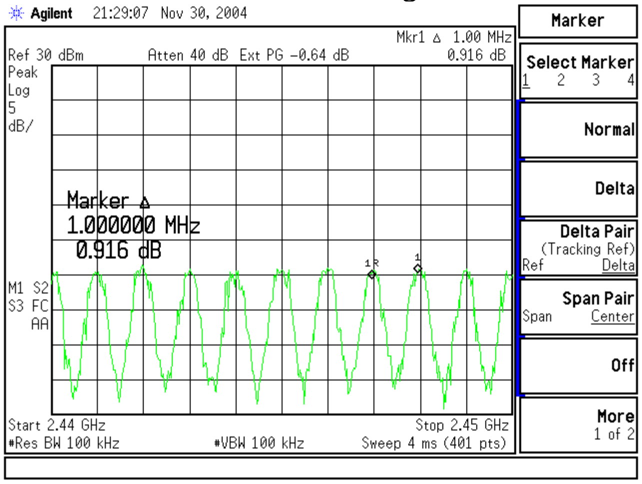
Channels 19 through 28



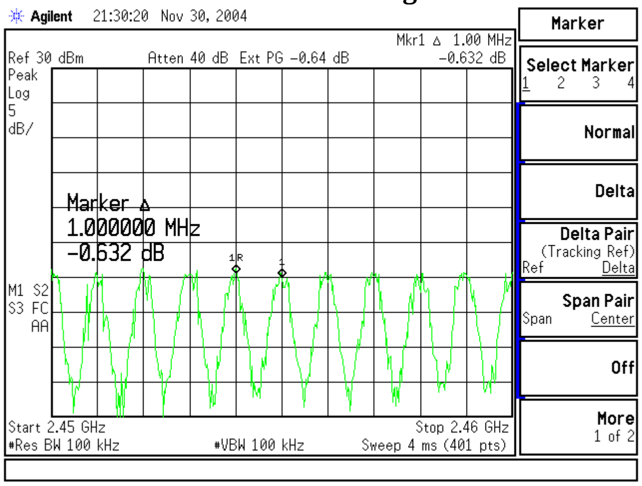
Channels 29 through 38



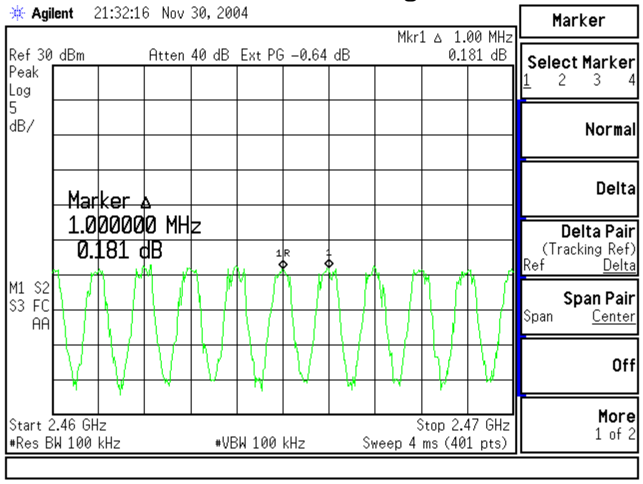
Channels 39 through 48



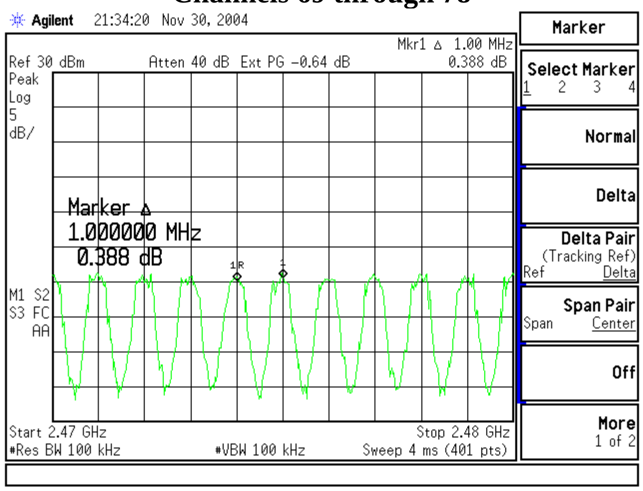
Channels 49 through 58



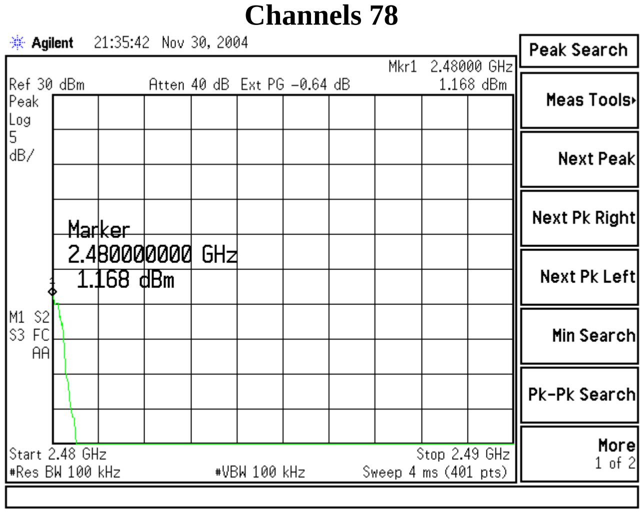
Channels 59 through 68



Channels 69 through 78



Channels 78



16. <u>Conducted Emissions Test, Channel Occupancy</u>

Part 15.247(a)(1)(iii) requires the use of a minimum of 15 channels, and a channel occupancy, of no more than 0.4 seconds in a any 0.4 seconds multiplied by the number of hopping channels employed. The channel occupancy for this EUT was measured using an HP E4407B spectrum analyzer, set to zero-span at the frequency of interest. With the analyzer in peak-hold mode, the transmission lengths can be measured by adjusting the sweep rate of the analyzer. A suitable sweep rate was used to measure the channel occupancy at the low, mid and high channels.

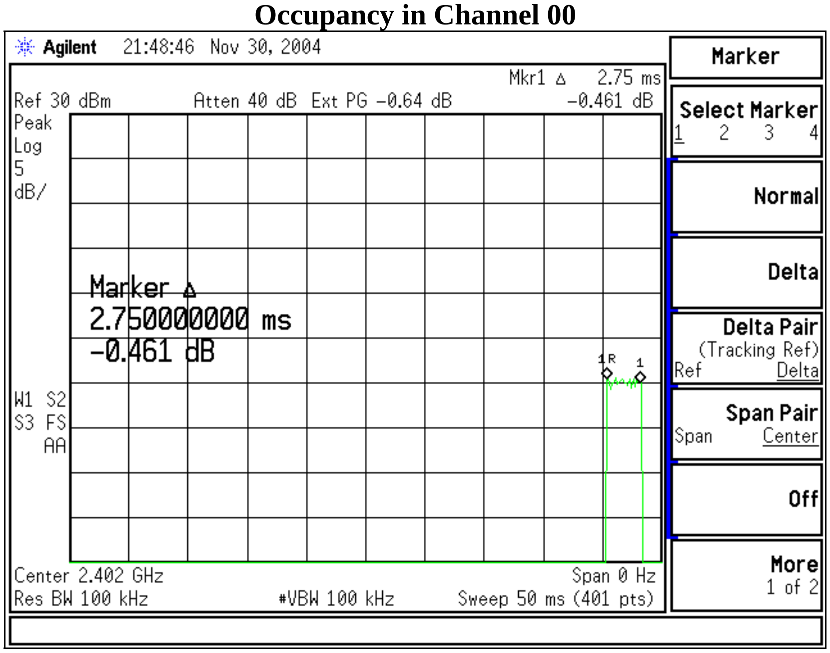
Window of assessment: 0.4 seconds x 79 channels = 31.6 seconds.

The longest time any transmission will occur on a single channel is 2.88 ms. Mathematically, a 2.75ms occupancy produces the highest channel occupation, and hence presented here. With a total of 79 channels used, each occupying a 2.88 ms slot, it will take 0.228 seconds for the sequence to repeat. In a 31.6 second window, each channel would have 138.6 transmission cycles. The maximum occupancy in a 31.6 second window is calculated by multiplying the 138.6 transmission cycles by 2.88 ms transmission duration per cycle, to arrive at 399.2 ms total occupancy.

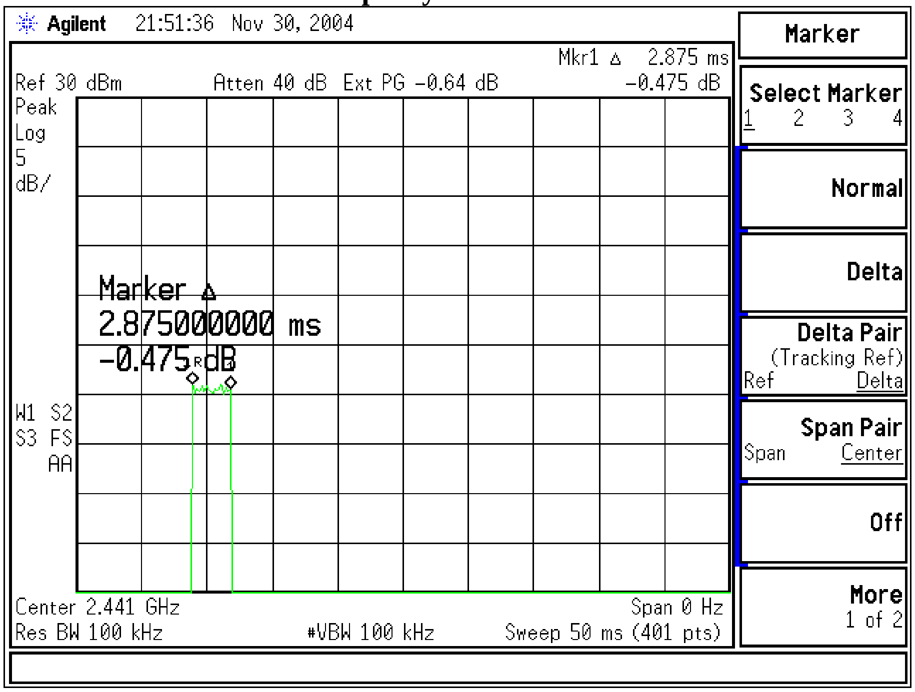
Channel	Frequency (MHz)	Occupancy Per transmission (ms)	Occupancy in window [(0.4 ms) x (# ch)] (ms)
00	2402	2.75	400
40	2442	2.88	399
78	2480	2.88	399

Plots of Channel Occupancy

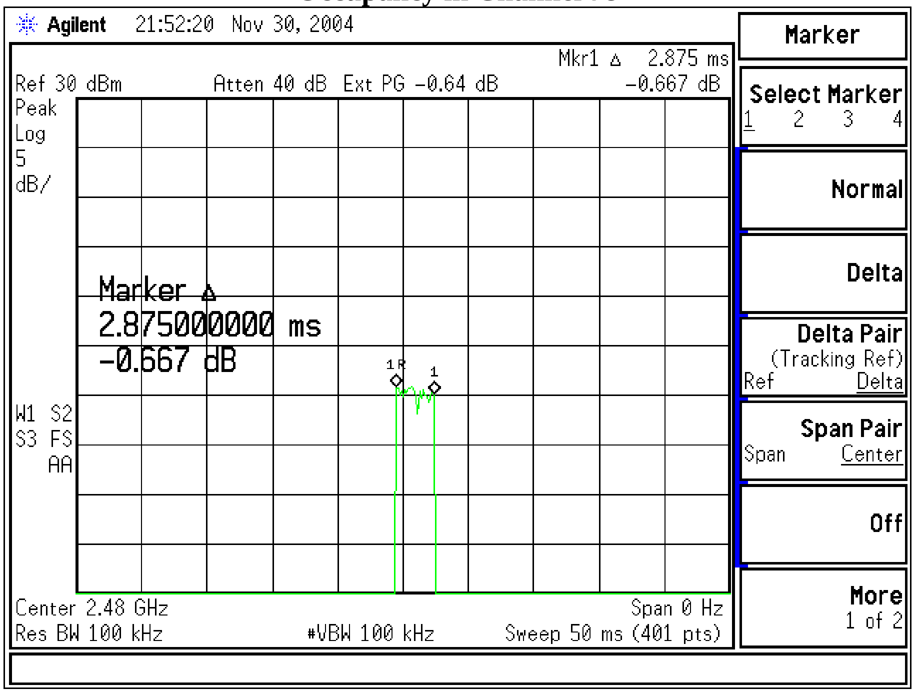
Occupancy in Channel 00



Occupancy in Channel 39



Occupancy in Channel 78



The information on this page is provided by the manufacturer.

17. Equal Channel Usage

79 Channels are available, under the Bluetooth standard, and are used from a pseudo-random hop sequence. See Section 18 below for more information. There are multiple substates used in the Bluetooth™ protocol, such as the ‘Page Scan’ substate, ‘Inquiry’ substate, ‘Master’ substate, ‘Slave’ substate, and ‘Connection’ states. Each state has pre-defined hop patterns to ensure equal channel usage, among the 79 available channels defined by the Bluetooth™ standard.

18. Pseudorandom Hopping Pattern

The Bluetooth™ standard has the Pseudorandom Sequence selection process as described here. The hop selection kernels for the 79 hop system are shown in the figure below. The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master transmission. The inputs A to D determine the ordering within the segment, the inputs E and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the hop frequencies. This list should be created such that first all even hop frequencies are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz, whereas a 16-hop segment spans the entire 23-MHz. The selection procedure consists of an addition, an XOR operation, a permutation operation, an addition, and finally a register selection. In the remainder of this chapter, the notation A*i* is used for bit i of the BD_ADDR.

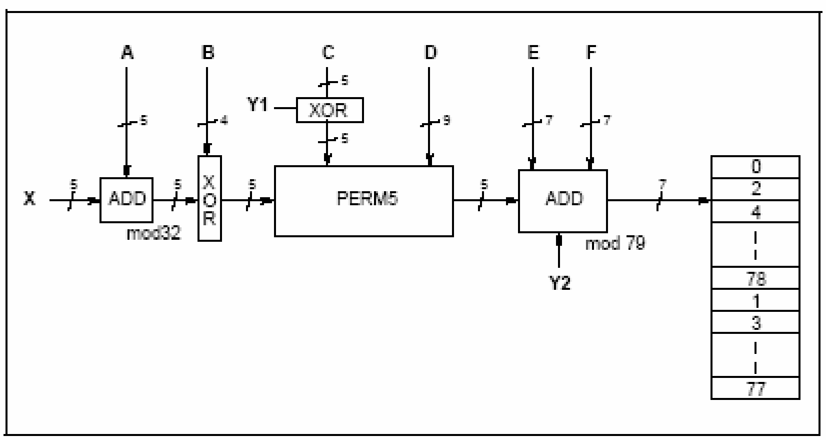


Figure 11.3: Block diagram of hop selection kernel for the 79-hop system.

In case of pseudorandom bit sequence, the same sequence of bits is used for each transmission (i.e. the packet is repeated, see above). A PRBS-9 Sequence2 is used. The properties of this sequence are as follows. The sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage (see Figure 2.4), and the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones.

- Number of shift register stages: 9
- Length of pseudo-random sequence: $2^9 - 1$ 511 bits
- Longest sequence of zeros: 8 (non-inverted signal)

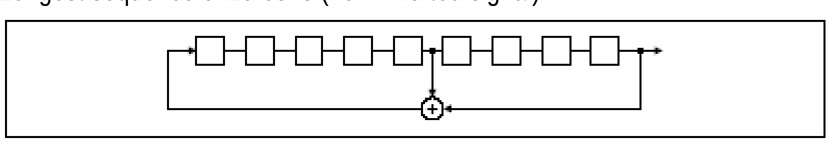


Figure 2.4: Linear Feedback Shift Register for Generation of the PRBS sequence

19. 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 mode, using power as provided by the external wall-type transformer setup. The unit has the capability to operate on 79 channels, controllable via a laptop PC with a cable harness, mimicking the host controller, during these testes.

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 (2402 MHz), middle (2441 MHz) and high (2480 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using a Laptop PC.

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 24 GHz, the EUT was measured at a 0.3 meter separation, using a standard gain Horn Antenna and pre-amplifier.

The EUT was rotated along three orthogonal 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 18000 GHz, an HP E4407 Spectrum Analyzer and an EMCO Horn Antenna were used. From 18 GHz to 24 GHz, the HP E4407 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 FHSS transmitter [Canada RSS-210, Clause 6.2.2(0)]. 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 902-928 MHz band, as specified in 47 CFR 15.247(b)(1), is 1 Watt for systems employing at least 75 hopping channels. Alternatively, as described in 15.247(a)(1), wideband systems utilizing occupied bandwidths greater than 500 kHz may only operate with a maximum output power of 125 mW.

The system under test, as covered in this report utilizes bandwidths greater than 500 kHz, and hence is limited to a maximum power output of 125 Mw, or 116.19 dB μV/m when measured at 3 meters.

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 15.205I.

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	-
960-24,000	500	54.0	63.5

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

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

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

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(FHSS)
Frequency Range Inspected: 30 MHz to 25000 MHz

Manufacturer:	Johnson Controls, Inc.					
Date(s) of Test:	November 29th through December 2nd, 2004					
Test Engineer(s):		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	MS-BTCVT-0					
Serial #:	Pre-production address 3AC8					
Voltage:	15 VDC at 250 mA provided by host or wall-type transformer					
Operation Mode:	Normal, continuous transmit, and 'Hopping' mode					
EUT Power:		Single Phase ___VAC		3 Phase 480VAC		
		Battery	√	Other: 15VDCWall Transformer		
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	Host Mode	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.205 Limit (dBμV/m)	Margin (dB)
137.6	V	Link	1.00	130	42.4	43.0	0.6
609.5	V	Link	1.00	120	27.5	46.0	18.5
981.9	V	Link	1.00	120	27.4	54.0	26.6

Notes:

1) *A Quasi-Peak Detector was used in measurements below 1 GHz, and an Average Detector was used in measurements above 1 GHz. The Peak detector was also use to ensure that the emission levels do not exceed 20 dB beyond the Average limits.*
2) *No significant spurious emissions observed. All spurious emissions were better than 20 dB below the limits..*

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 00:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2402	V	1.10	225	92.1	116.2	24.1
4808	H	1.00	230	48.7	54.0	5.3
7206	V	1.10	75	51.6	81.6	30.0
9608	V	1.00	185	44.6	81.6	37.0
12010	V	1.00	180	38.7	63.5	24.8
14412	V	1.00	0	42.3	81.6	39.3
16814	V	1.00	0	46.2	81.6	35.4
19216	V	1.00	200	42.0	74.0	32.0
21618	V	1.00	0	39.2	92.1	52.9
24020	V	1.00	0	42.0	92.1	50.1

The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 39:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2441	V	1.05	225	93.6	116.2	22.6
4882	H	1.20	110	48.6	54.0	5.4
7323	V	1.15	55	50.2	63.5	13.3
9764	V	1.00	190	45.6	83.1	37.5
12205	V	1.00	195	45.5	63.5	18.0
14646	V	1.00	0	42.1	83.1	41.0
17087	V	1.00	0	47.1	83.1	36.0
19528	V	1.00	210	44.4	74.0	29.6
21969	V	1.00	0	39.8	93.6	53.8
24410	V	1.00	0	43.2	93.6	50.4

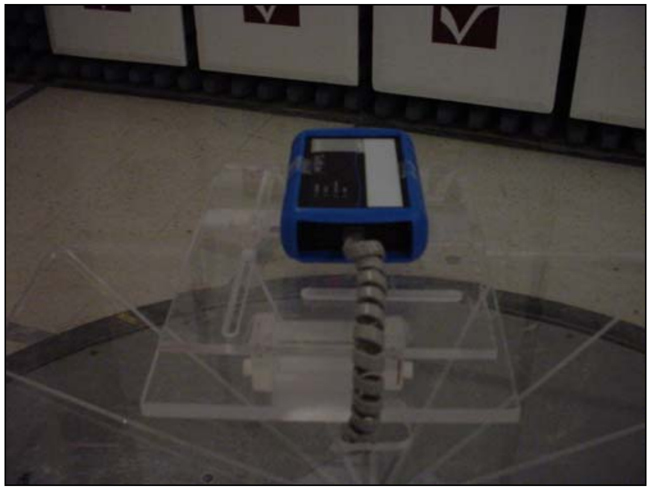
The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 78:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2480	V	1.05	265	91.6	116.2	24.6
4960	H	1.00	150	48.6	54.0	5.4
7440	V	1.10	80	50.6	63.5	12.9
9920	V	1.00	185	46.8	81.1	34.3
12400	V	1.00	185	39.1	63.5	24.4
14880	V	1.00	0	42.6	81.1	38.5
17360	V	1.00	0	46.3	81.1	34.8
19840	V	1.00	195	45.2	74.0	28.8
22320	V	1.00	0	38.7	74.0	35.3
24800	V	1.00	0	43.1	91.6	48.5

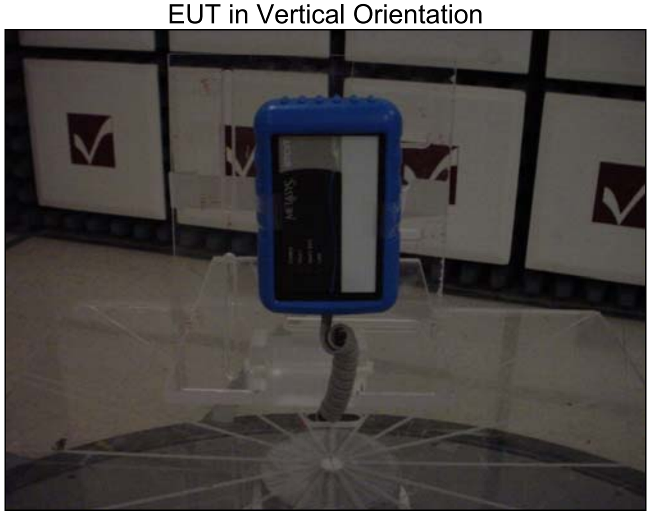
Notes: A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits. Measurements above 5 GHz were made at 1 meters of separation from the EUT, and at 0.3 m separation at 18 – 26 GHz.

Views of the EUT setup on the test pedestal.

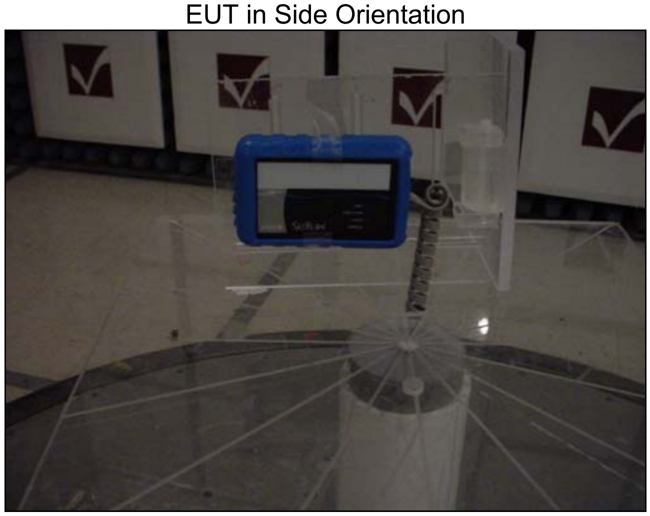
EUT in Horizontal Orientation



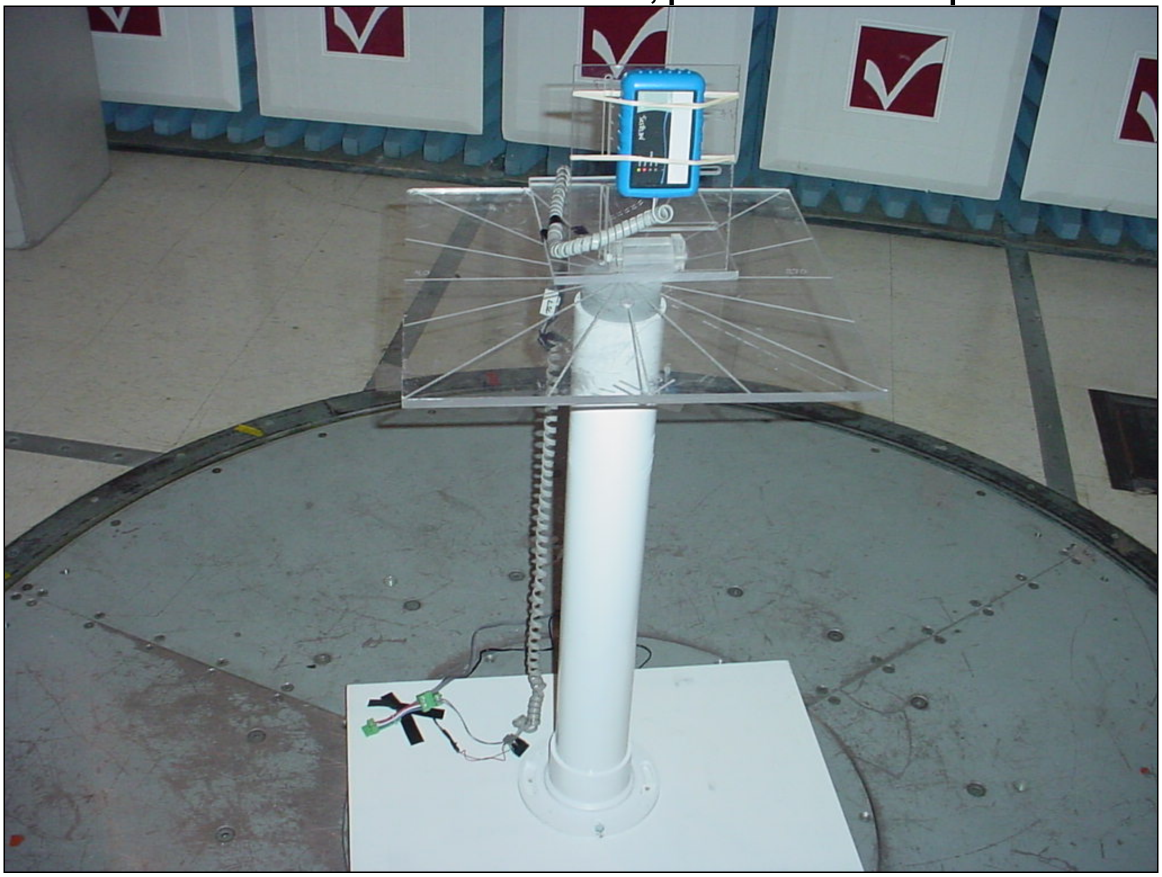
EUT in Vertical Orientation



EUT in Side Orientation



View of the EUT in vertical orientation, placed on the test pedestal.



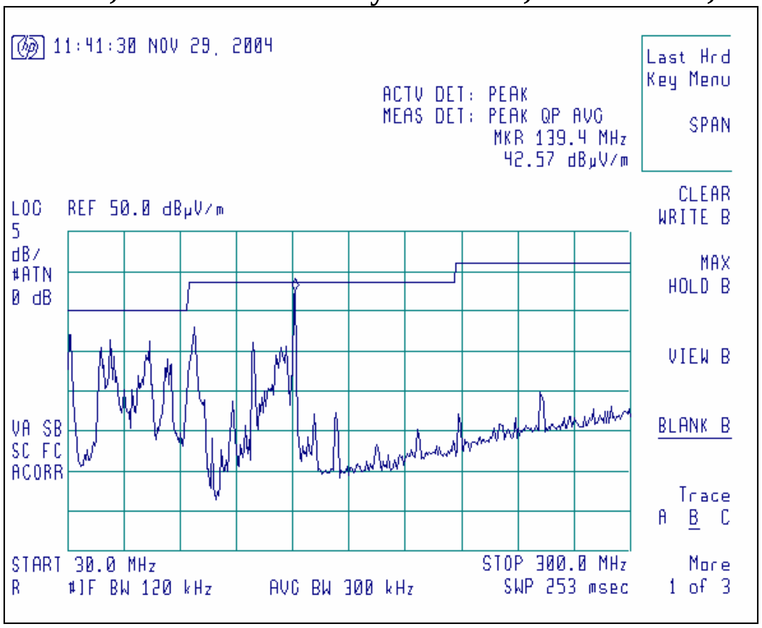
Graphs made during Radiated Emission Testing

Screen Captures of Radiated RF Emissions:

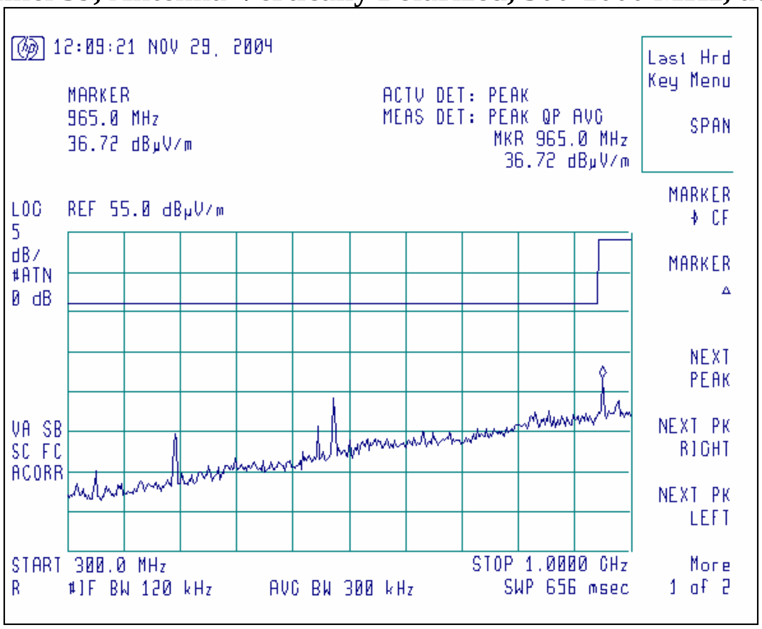
Please note these screen captures represent Peak Emissions. For radiated emission measurements, we utilize a Quasi-Peak detector function when measuring frequencies below 1 GHz, and an Average detector function when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 00, 40, or 78, with the sense and EUT antennas both in vertical polarity for worst case presentations.

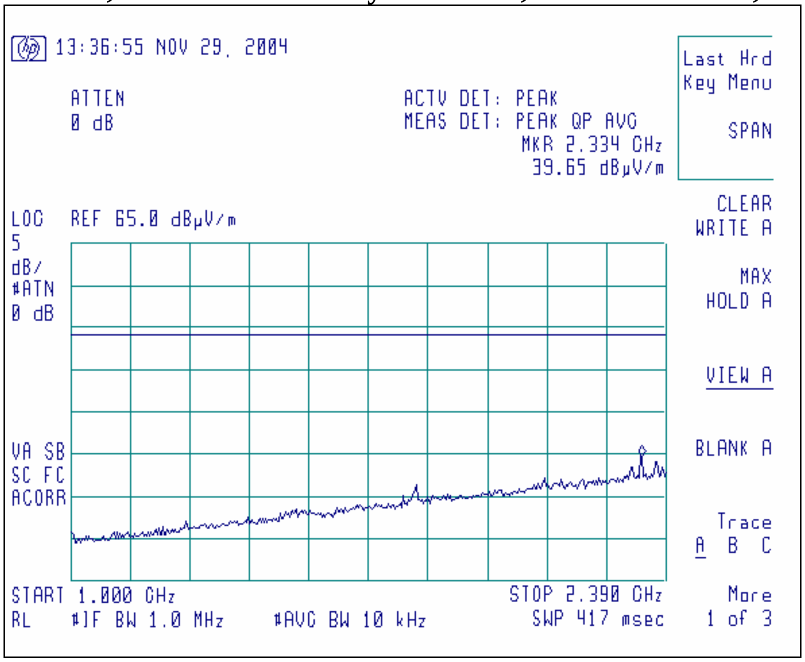
Channel 39, Antenna Vertically Polarized, 30-300 MHz, at 3m.



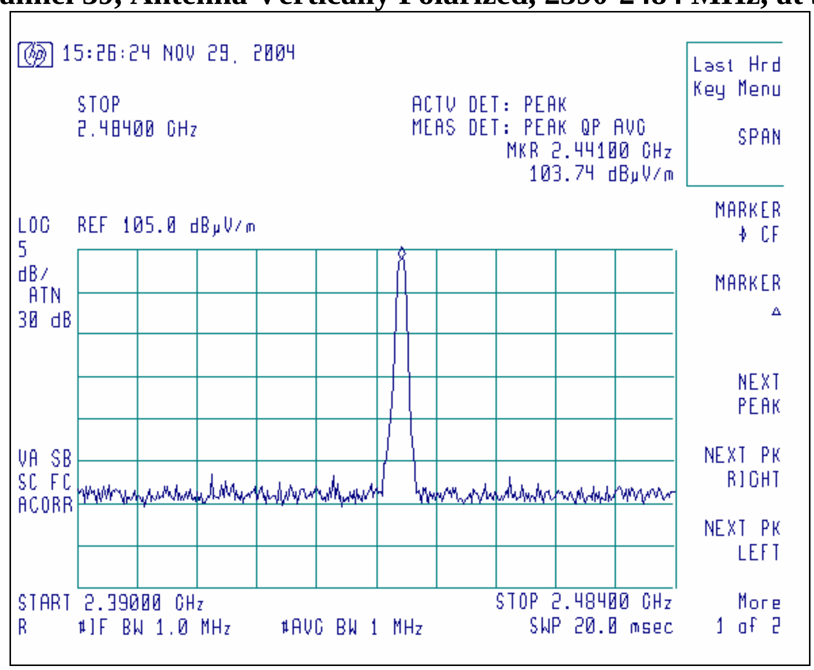
Channel 39, Antenna Vertically Polarized, 300-1000 MHz, at 3m.



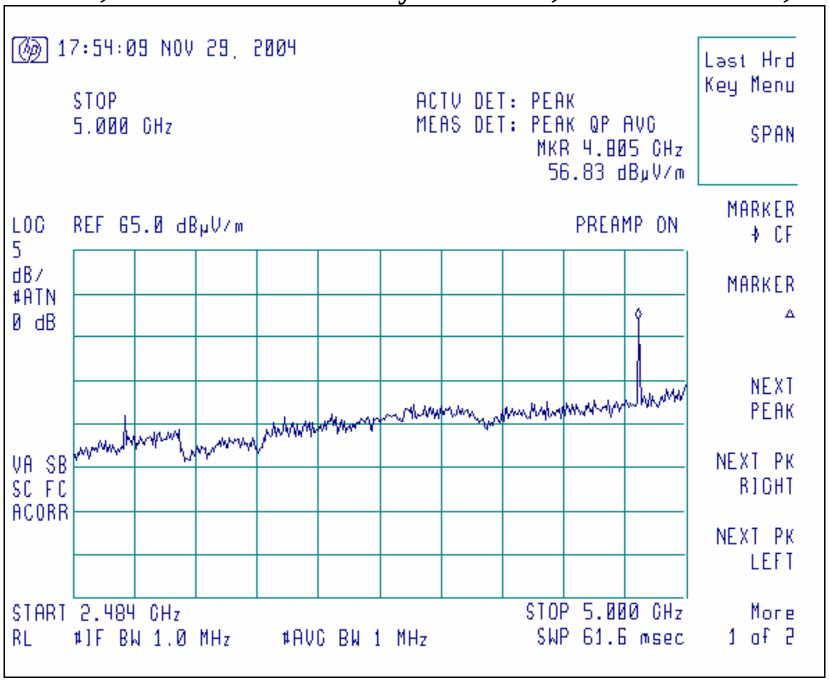
Channel 39, Antenna Vertically Polarized, 1000-2390 MHz, at 3m.



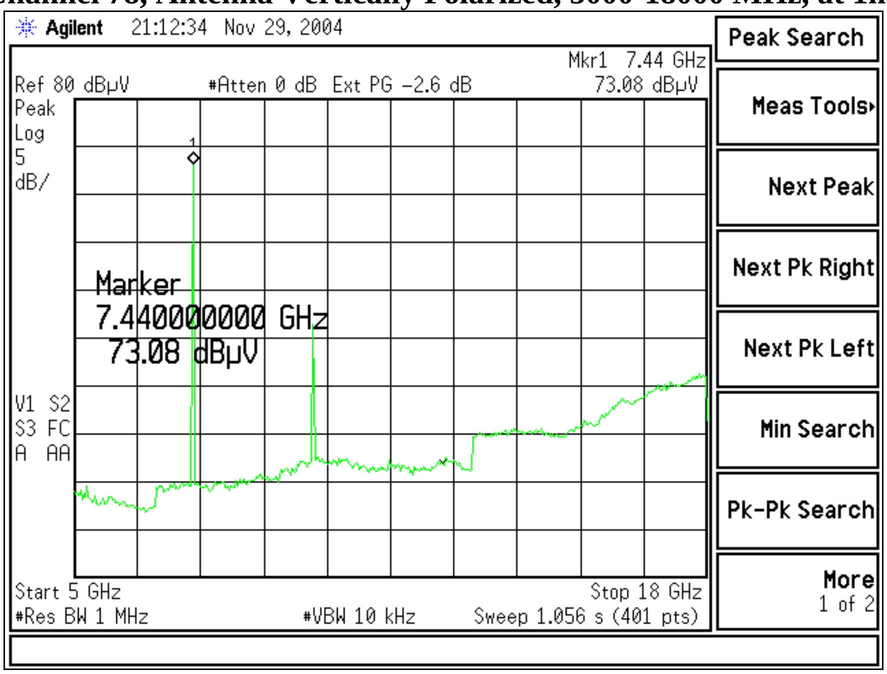
Channel 39, Antenna Vertically Polarized, 2390-2484 MHz, at 3m.



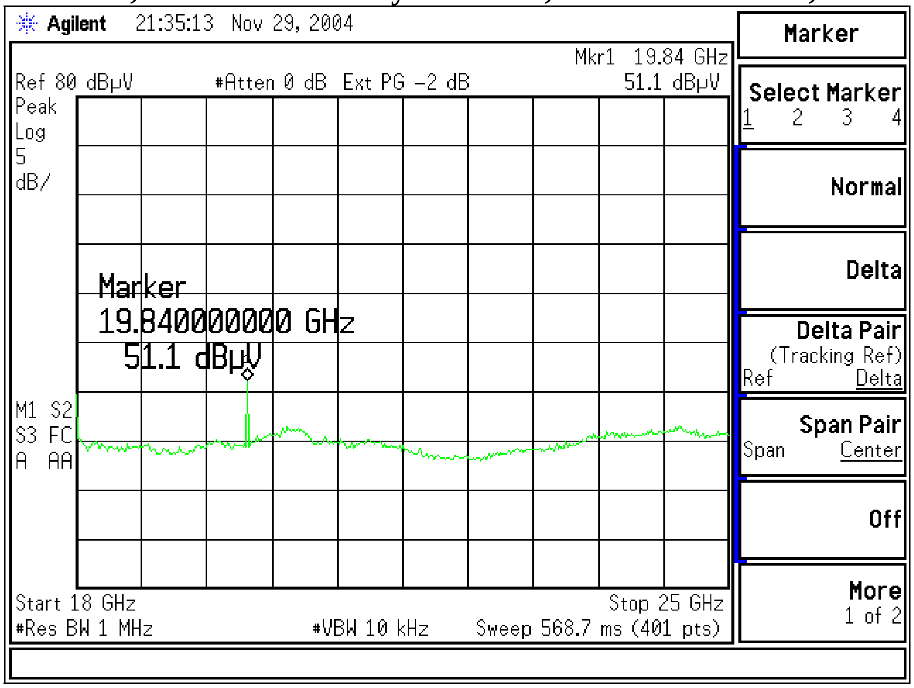
Channel 00, Antenna Horizontally Polarized, 2484-5000 MHz, at 3m.



Channel 78, Antenna Vertically Polarized, 5000-18000 MHz, at 1m.



Channel 78, Antenna Vertically Polarized, 18000-25000 MHz, at 30cm.

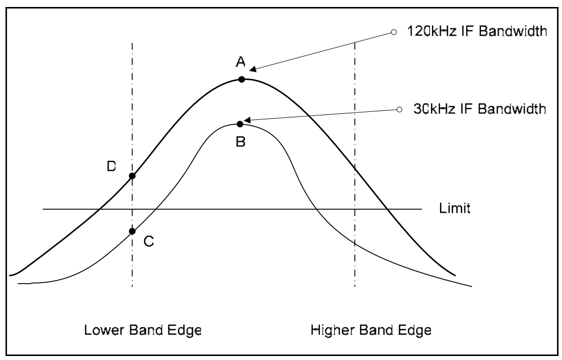


20. Band-Edge Measurements

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 measurements demonstrate compliance of the intentional radiator at the 2400-2483.5 MHz band-edges.

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 1 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 Band Edge limit, in this case, would be D = 54.0 dBµV/m.
The measurements and calculations are as follows:

At the Lower Band-edge:

$A - B = \Delta$; $102.5 dB\mu V/m - 100.9\, dB\mu V/m = 1.6\, dB$

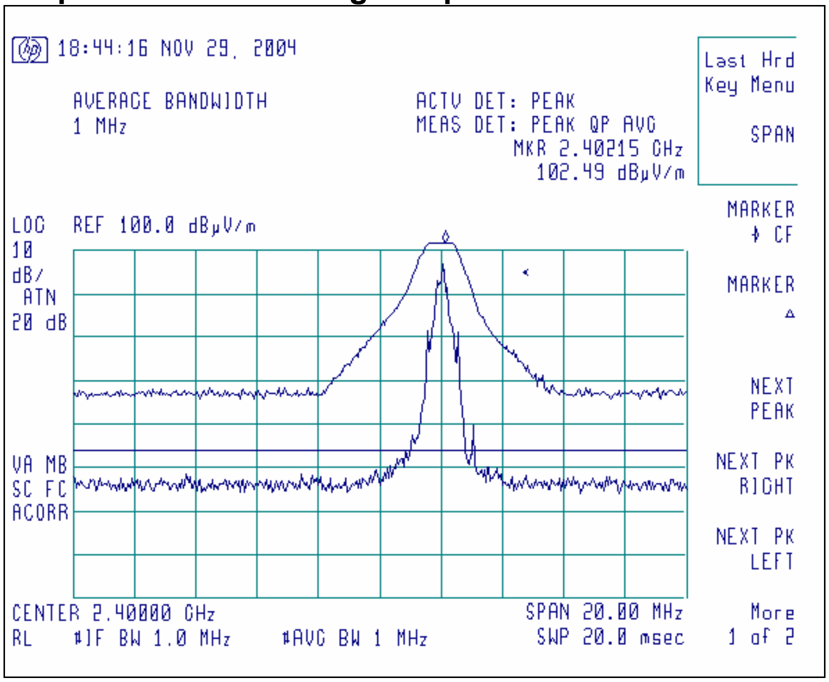
$\Delta + C = D$; $1.6\, dB + 49.9\, dB\mu V/m = 51.5\, dB$ Showing compliance at Lower Band-Edge

At the Upper Band-edge:

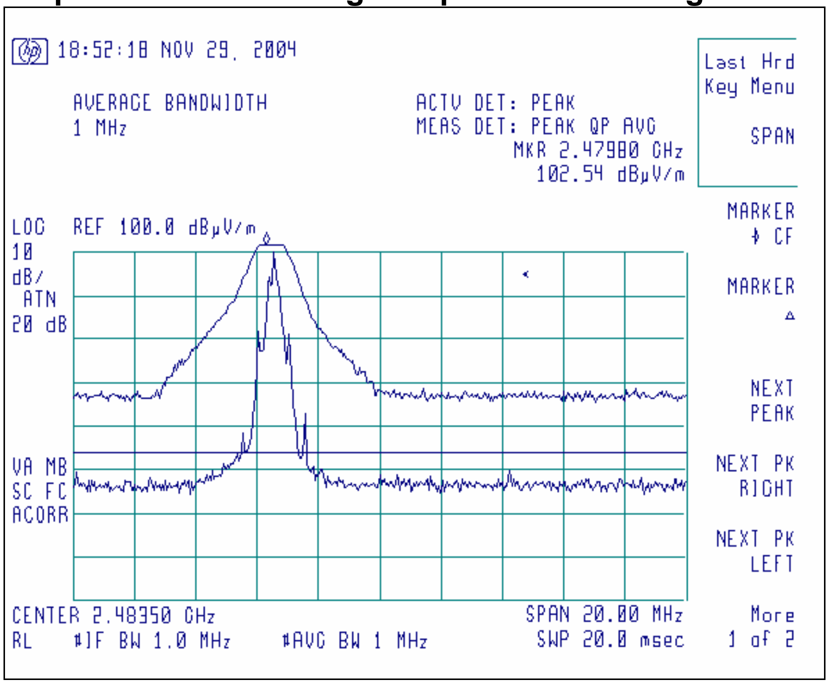
$A - B = \Delta$; $102.5\, dB\mu V/m - 100.1 dB\mu V/m = 2.4\, dB$

$\Delta + C = D$; $2.4\, dB + 47.9\, dB\mu V/m = 50.3\, dB$ Showing compliance at Upper Band-Edge

Screen Capture demonstrating compliance at the Lower Band-Edge



Screen Capture demonstrating compliance at the Higher Band-Edge



21. Conducted RF Emissions Test, on AC Power Line

Test Setup

The Conducted Emissions test was performed at L.S. Compliance, Inc. in Cedarburg, Wisconsin. The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15 (Industry Canada RSS-210). The EUT was placed on a non-conductive pedestal, with a height of 80 cm above the reference ground plane. During the radio testing, the EUT was powered by a wall-type transformer, through the special cable, and hence was tested for conducted RF emissions onto the AC mains. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120 VAC, 60 Hz was provided inside the Shielded Room via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to a 10 dB Attenuator-Limiter, and then to the HP 8546A EMI Receiver. The EMCO LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either phase.

Test Procedure

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

Test Equipment Utilized

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

Test Results

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

Calculation of Conducted Emissions Limits

The following table describes the Class B limits for an unintentional radiator. These limits are obtained from Title 47 CFR, Part 15.107 (a) for Conducted Emissions.

Frequency (MHz)	Quasi-Peak Limit (dBμV)	Average Limit (dBμV)
0.15 – 0.5	66 – 56 *	56 – 46
0.5 – 5.0	56	46
5.0 – 30.0	60	50

10Decreases with the logarithm of the frequency.

Sample calculation for the limits in the 0.15 to 0.5 MHz:

$$\text{Limit} = -19.12 \, (\text{Log}_{10} \, (F[\text{MHz}] / 0.15 \, [\text{MHz}])) + 66.0 \text{ dB}\mu\text{V}$$

For a frequency of 200 kHz for example:

$$\text{Quasi-Peak Limit } (F = 200\text{kHz}) = -19.12 \, (\text{Log}_{10} \, (0.2[\text{MHz}] / 0.15 \, [\text{MHz}])) + 66.0 \text{ dB}\mu\text{V}$$

Quasi-Peak Limit (F = 200kHz) = 63.6 dBμV

$$\text{Average Limit } (F=200\text{kHz}) = -19.12 \, (\text{Log}_{10}(0.2[\text{MHz}]/0.15[\text{MHz}])) + 56.0 \text{ dB}\mu\text{V}$$

Average Limit (F = 200 kHz) = 53.6 dBμV

Measurement of Electromagnetic Conducted Emission

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 (a)

Manufacturer:	Johnson Controls, Inc.					
Date(s) of Test:	November 29th through December 2nd , 2004					
Test Engineer:		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	MS-BTCVT-0					
Serial #:	Pre-production address 3AC8					
Voltage:	15 VDC at 250 mA provided by wall-type transformer					
Operation Mode:	Normal, continuous transmit, and 'Hopping' mode					
Test Location:	√	Shielded Room				Chamber
EUT Placed On:	√	40cm from Vertical Ground Plane				10cm Spacers
	√	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	√	Final
Detectors Used:		Peak	√	Quasi-Peak	√	Average

Environmental Conditions in the Lab:
Temperature: 20 – 25° C
Atmospheric Pressure: 86 kPa – 106 kPa
Relative Humidity: 30 – 60%

Test Equipment Utilized:
EMI Receiver: HP 8546A
LISN: EMCO 3816/2NM
Transient Limiter: HP 119474A

		QUASI-PEAK			AVERAGE		
Frequency (MHz)	Line	Q-Peak Reading (dBµV/m)	Q-Peak Limit (dBµ V/m)	Quasi-Peak Margin (dB)	Average Reading (dBµV/m)	Average Limit (dBµ V/m)	Average Margin (dB)
0.153	L1	50.3	65.8	15.5	19.0	55.8	36.8
0.155	L2	53.2	65.7	12.5	21.5	55.7	34.2
0.160	L2	51.6	65.5	13.9	19.9	55.5	35.6

Notes:

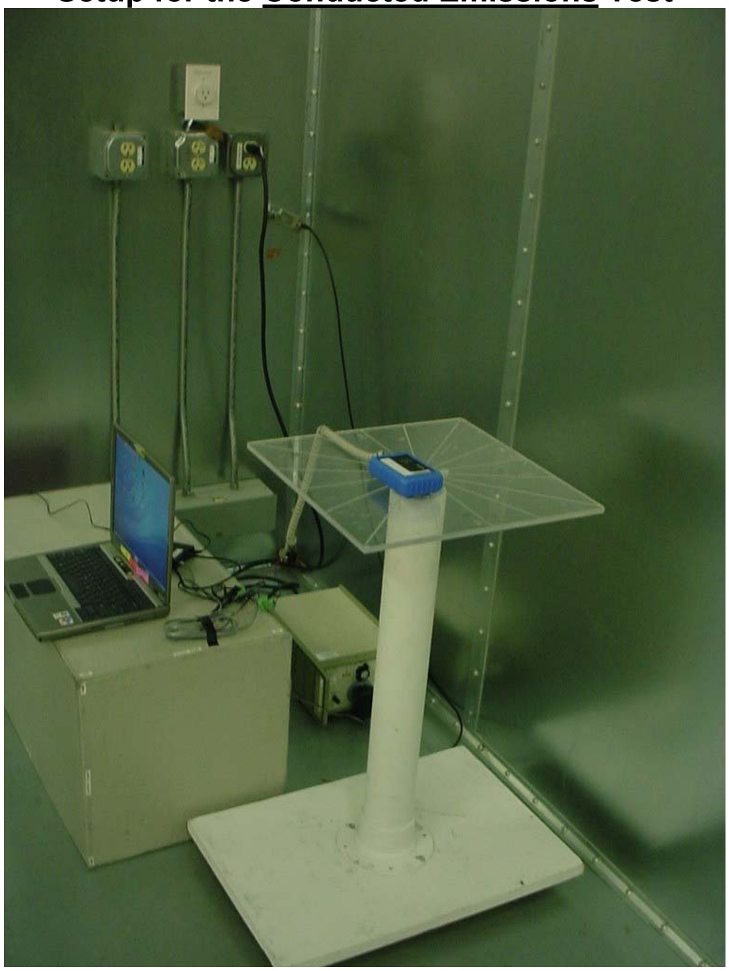
1) The emissions listed are characteristic of the host system, and were not affected by the EUT.

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

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

Photo(s) Taken During Conducted Emission Testing

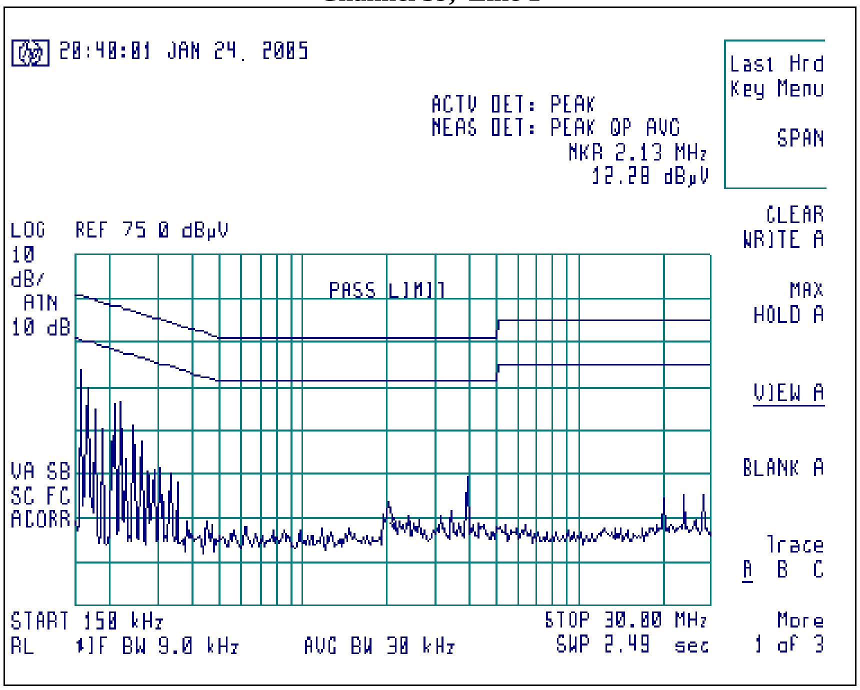
Setup for the Conducted Emissions Test



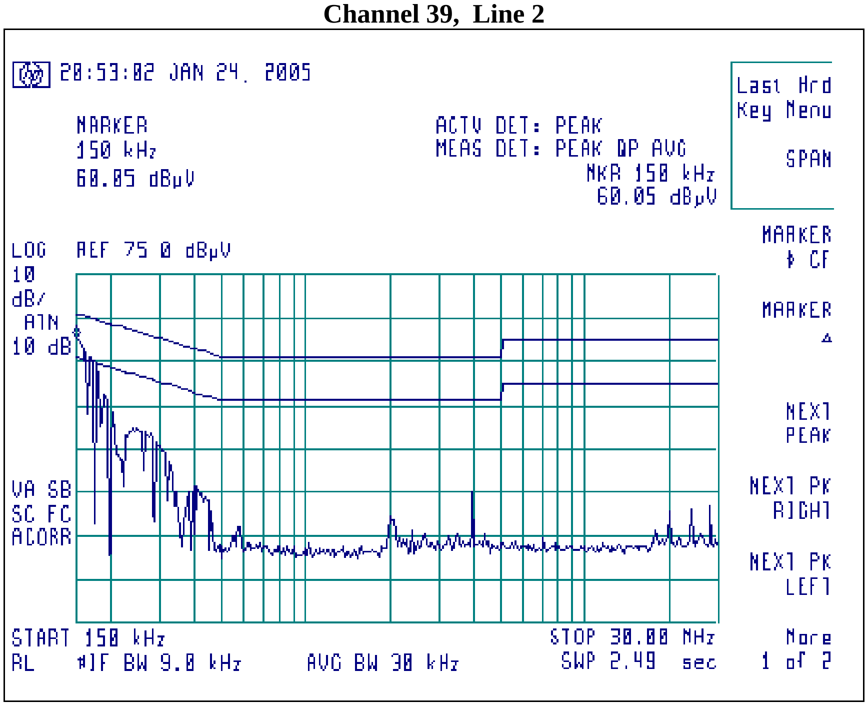
Screen Captures of Conducted AC Mains Emissions:

Please note these screen captures represent Peak Emissions. For conducted emission measurements, we utilize both a Quasi-Peak detector function as well as the Average detector function for measurements. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.209.
The signature scans shown here are from channel 39, chosen as being a good representative of channels.

Channel 39, Line 1



Channel 39, Line 2



22. Receiver Synchronization

Bluetooth operates in the unlicensed ISM band at 2.4GHz. In the US a band of 83.5MHz is available. In this band the bluetooth technology defined 79 RF channels spaced 1MHz(2402-2480). The actual RF channel is chosen from a pseudo-random hopping sequence through the 79 channels. A channel is occupied for a defined amount of time slots, with a normal slot length of 625uS. The max dwell time on the channel is defined by the packet type and is 625uS for DH1 packet,1.875ms for DH3 and 3.125ms for DH5. The normal hop rate is 1600hop/s for DH1, 1600/3 hop for DH3 and 1600/5 hop for DH5. All frequencies are equally used. The max nominal average time occupancy is 0.4s within a period of 0.4*79 channels.

23. Receiver Input Bandwidth

Bluetooth has hopping channels separated by 1MHz. The receiver input bandwidth is also 1MHz. The receiver will synchronize with the transmitted signal if the shift is within +/-70KHz.

Simultaneous occupancy of one channel by multiple systems is possible under the Bluetooth standard. Bluetooth 1.2 contains accommodations for adaptive frequency hopping whereby channels that are identified to contain known and persistent interferers are removed from the list of pseudo randomly hopped channels.

24. MPE Calculations

Base Station Transceiver
MPE Calculation

The antenna used is a printed circuit board trace, configured as a ¼ wave dipole.
Although the gain of the antenna is not published, it is reasonable to expect a gain of approximately 2.2 dBi, for the purpose of 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:	2.90	(dBm)
Maximum peak output power at antenna input terminal:	1.950	(mW)
Antenna gain(typical):	2.2	(dBi)
Maximum antenna gain:	1.660	(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:	0.000644	(mW/cm^2)
Maximum allowable antenna gain:	34.1	(dBi)
Margin of Compliance at 20 cm =	31.9	dB

Appendix A

Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	9/15/04	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	12/07/04	12/07/05
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 antenna used is a printed circuit board trace, configured as a ¼ wave dipole.
Although the gain of the antenna is not published, it is reasonable to expect a gain of approximately 2.2 dBi, for the purpose of MPE calculations.

Appendix C

Firmware and Setup Instructions

Proprietary test software was provided by Johnson Controls, Incorporated for the specific purpose of testing. This test software was used in conjunction with a Laptop PC to control the EUT, by connection to communication lines between the controller and the EUT.