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

COMPLIANCE TESTING OF:

Sensor Access Point RF Module WRS-RTN0000-0

Prepared For:

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

Test Report Number:

304308-Tx-v2

Test Dates:

January 26TH through April 9TH, 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. 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

4. Signature Page

Prepared By: July 19, 2005

Teresa A. White, Document Coordinator Date

Tested By: July 19, 2005

Abtin Spantman, EMC Engineer Date

Approved By: July 19, 2005

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

5. **Product and General Information**

Manufacturer:	Johnson Controls, Inc.					
Date(s) of Test:	January 26TH through April 9TH, 2005					
Test Engineer(s):		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	Sensor Access Point RF Module WRS-RTN0000-0					
Serial #:	RF Module S/N: ES3 ; Motherboard S/N: A00					
Voltage:	3.0 VDC					
Operation Mode:	Normal operation and continuous modulated transmit					

6. **Introduction**

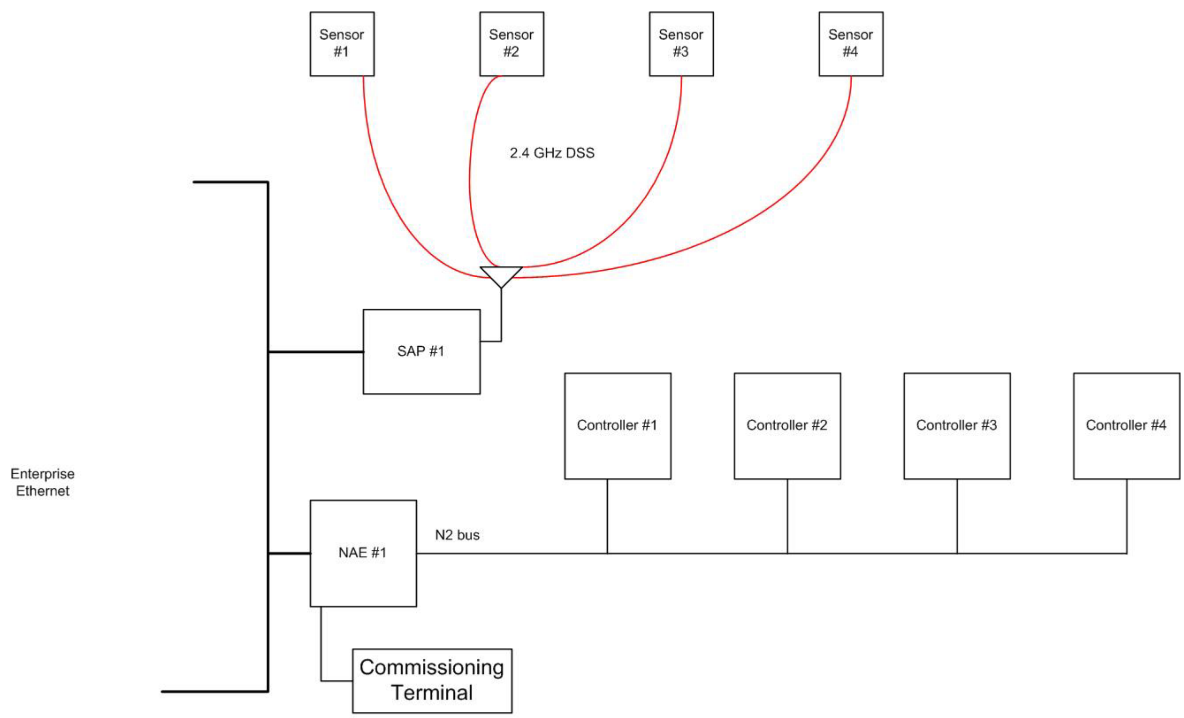
Between January 19TH and April 9TH, 2005, a series of Conducted and Radiated RF Emission tests were performed on one sample of the Johnson Controls' Sensor Access Point RF Module, model number WRS-RTN0000-0, serial number ES3, here forth referred to as the "*Equipment Under Test*" or "*EUT*". These tests 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.

7. 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. The WRS system is designed as a many-to-one system so that up to 100 sensors can be received by any one data receiver (Sensor Access Point – SAP). The sensor data is transmitted over the RF link to the SAP, which then places the data on the enterprise Ethernet where it is picked up by the NAE. This device will then pass the data out to the appropriate controller. The entire control system is shown below

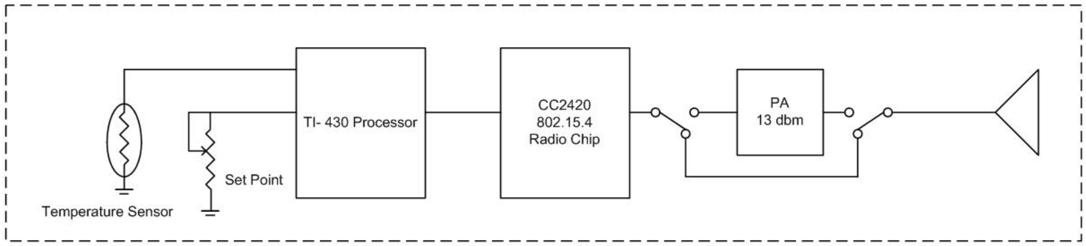


System Diagram

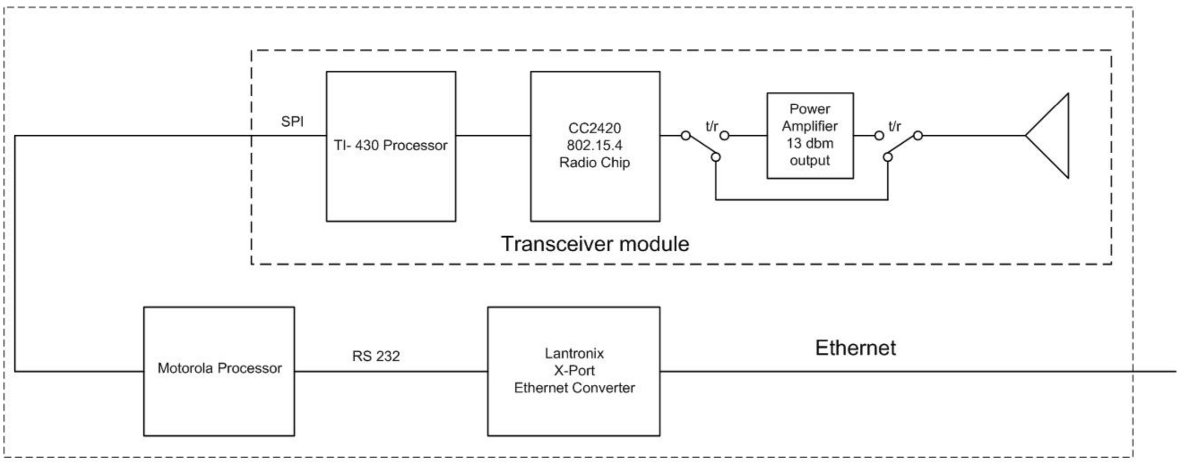
Both the sensor radio and the receiver radio module within the SAP are RF transceivers. The following diagram shows the general design of both the sensor and the SAP.

The RF characteristics of the transmitter portion of the transceiver module within the Service Access Point (SAP) 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.



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.

RF Transceiver Module –
The RF module will also be used in other versions of the system that require one-to-one communications, such as buildings without an Ethernet and needing a limited number of control loops. In this case the RF Transceiver will be used in a similar design to the Many-to-one described here, but as a one-to-one link with variations in the motherboard for the particular controller interface required. The transmit interval would remain about 60 seconds.

The module is also designed for possible use inside a controller as an imbedded data receiver. In this case, the received data would go directly from the module to the controller processor.

The Wireless module within the Sensor Access Point operates on 3.0 VDC as provided by the host (SAP), and uses a 2.5 cm printed circuit board trace as the antenna element. The transceiver was tested as a module, using a 1.5 meter extension wire harness connected to the host SAP, providing power, data and control signal connections. The host SAP was placed outside the test area.

8. Test Requirements

The above mentioned tests were performed in order to determine the compliance of the Johnson Controls' Model Number WRS-RTN0000-0 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	

9. Summary of Test Report

DECLARATION OF CONFORMITY

The Johnson Controls' Model Number WRS-RTN0000-0 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.

10. 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. Power, data and control signals were provided for the EUT by the host SAP through a 1.5 meter extension wire harness. The host SAP was then controlled by a Laptop PC, using proprietary test software from Johnson Controls. The EUT was placed and operated in continuous transmit modulated mode for this portion of the testing, using 3.0 VDC power as provided by the host SAP. The unit has the capability to operate on 15 channels. During the testing, the channel and mode selection was accomplished by a special serial link interface board, provided solely for the test sequence, along with a terminal program on a lap-top PC 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 (Ch 11: 2405 MHz), middle (Ch 19: 2445 MHz) and high (Ch 25: 2475 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using a lap-top PC with the special test serial link.

Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. From 18 GHz to 25 GHz, the EUT was measured at a 0.3 meter separation, using a standard gain Horn Antenna and pre-amplifier.

The EUT was rotated along three orthogonal 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 25 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	-
960-24,000	500	54.0	63.5

Sample conversion from field strength μV/m to dBμV/m:
dBμV/m = 20 log $_{10}$ (100)
= 40 dBμV/m (from 30-88 MHz)

For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.

960 MHz to 10,000 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 9.5 = 63.5 dB/μV/m at 1 meter

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

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

Radiated Emissions Data Chart

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

<table>
<tr><td>Manufacturer:</td><td colspan="6">Johnson Controls, Inc.</td></tr>
<tr><td>Date(s) of Test:</td><td colspan="6">January 19TH to 25TH, 2005</td></tr>
<tr><td>Test Engineer(s):</td><td></td><td>Tom Smith</td><td>√</td><td>Abtin Spantman</td><td></td><td>Ken Boston</td></tr>
<tr><td>Model #:</td><td colspan="6">Sensor Access Point RF Module WRS-RTN0000-0</td></tr>
<tr><td>Serial #:</td><td colspan="6">RF Module S/N: ES3 ; Motherboard S/N: A00</td></tr>
<tr><td>Voltage:</td><td colspan="6">3.0 VDC</td></tr>
<tr><td>Operation Mode:</td><td colspan="6">Normal operation and continuous transmit</td></tr>
<tr><td rowspan="2">EUT Power:</td><td></td><td colspan="2">Single Phase ___VAC</td><td></td><td colspan="2">3 Phase ___VAC</td></tr>
<tr><td></td><td colspan="2">Battery:</td><td>√</td><td colspan="2">Other: Host 3.0 VDC, 100 mA</td></tr>
<tr><td>EUT Placement:</td><td>√</td><td colspan="2">80cm non-conductive table</td><td></td><td colspan="2">10cm Spacers</td></tr>
<tr><td>EUT Test Location:</td><td>√</td><td colspan="2">3 Meter Semi-Anechoic FCC Listed Chamber</td><td></td><td colspan="2">3/10m OATS</td></tr>
<tr><td>Measurements:</td><td></td><td>Pre-Compliance</td><td></td><td>Preliminary</td><td>√</td><td>Final</td></tr>
<tr><td>Detectors Used:</td><td>√</td><td>Peak</td><td>√</td><td>Quasi-Peak</td><td>√</td><td>Average</td></tr>
</table>

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)	15.247 Limit (dBμV/m)	Margin (dB)
147.8	V	11	1.00	0	28.2	94.7	66.5
156.2	V	11	1.00	0	27.6	94.7	67.1
653.0	V	11	2.00	195	35.9	94.7	58.8
655.0	H	11	1.35	0	35.8	94.7	58.9
676.0	V	25	1.80	190	46.7	93.6	46.9
680.0	V	25	1.80	190	42.0	93.6	51.6
728.0	H	11	2.10	0	44.9	94.7	49.8
732.0	H	11	2.10	0	41.7	94.7	53.0
748.0	V	25	1.00	150	39.6	93.6	54.0
752.0	V	25	1.00	150	43.1	93.6	50.5
2549	V	11	1.00	345	50.4	94.7	44.3
2632	V	25	1.00	0	49.5	93.6	44.1

Notes:
1) *There were no other significant spurious emissions observed to within 20 dB below the limits.*
2) *Emission falls within a restricted band of operation , as defined in 47CFR 15.205, and is subject to Part 15.205 limits.*

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

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2405	H	1.00	280	114.7 (Note 4)	125.2	10.5
4810	H	1.00	110	47.2	54.0 (Note 5)	6.8
7215	V	1.10	40	46.4	104.2	57.8
9620	V	1.00	275	48.5	104.2	55.7
12025	H	1.05	180	58.2	63.5 (Note 5)	5.3
14430	H	1.00	90	42.2 (Note 3)	63.5 (Note 5)	21.3
16835	H	1.10	115	46.9	104.2	57.3
19240				(Note 3)	114.7	
21645				(Note 3)	114.7	
24050				(Note 3)	114.7	

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

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2445	H	1.00	135	114.1 (Note 4)	125.2	11.1
4890	V	1.55	340	47.0	54.0 (Note 5)	7.0
7335	H	1.00	165	49.5	63.5 (Note 5)	14.0
9780	V	1.00	60	45.8	103.6	57.8
12225	H	1.05	165	55.1	63.5 (Note 5)	8.4
14670	H	1.00	180	41.8 (Note 3)	103.6	61.8
17115	H	1.00	0	46.7 (Note 3)	103.6	56.9
19560				(Note 3)	74.0 (Note 5)	
22005				(Note 3)	114.1	
24450				(Note 3)	114.1	

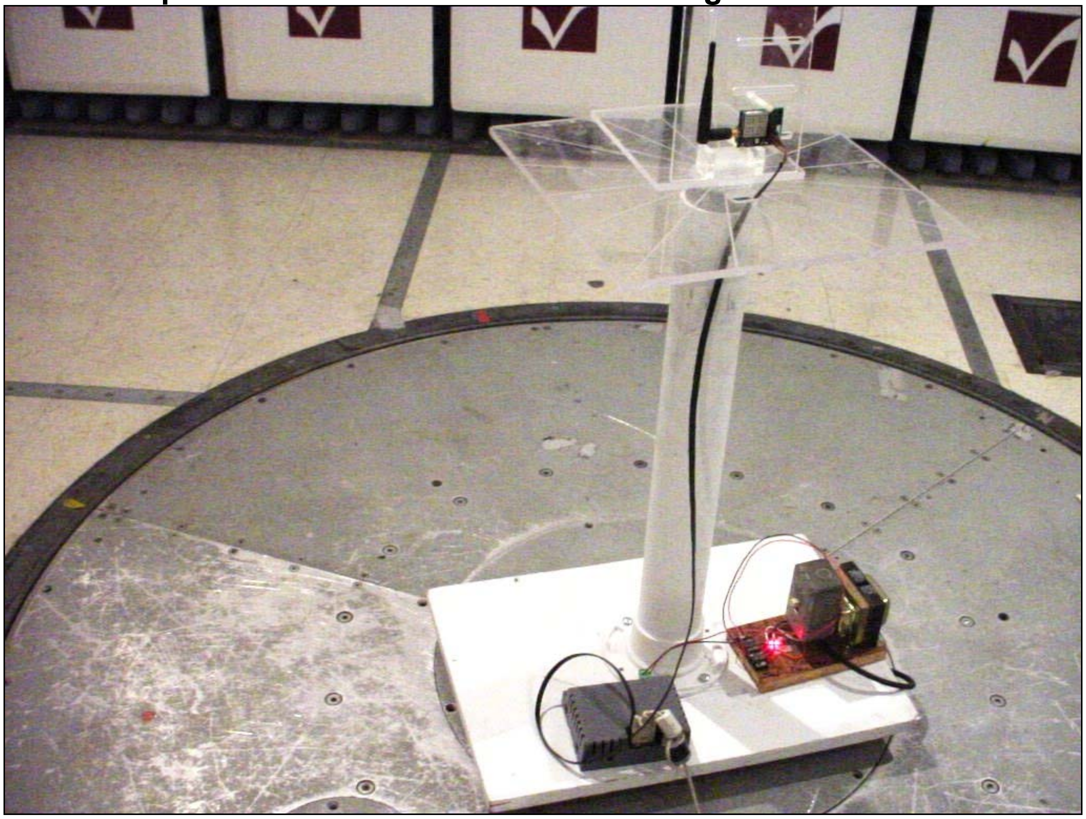
The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on Channel 25:

Frequency (MHz)	Antenna Polarity	Height (meters)	Azimuth (0° - 360°)	Measured ERP (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
2475	H	1.25	280	113.6 (Note 4)	125.2	11.6
4950	V	1.05	345	46.9	54.0 (Note 5)	7.1
7425	H	1.00	190	47.5	63.5 (Note 5)	16.0
9900	V	1.15	45	43.0	103.1	60.1
12375	H	1.00	195	47.7	63.5 (Note 5)	15.8
14850	V	1.00	0	44.3 (Note 3)	103.1	58.8
17325	H	1.00	0	47.1 (Note 3)	103.1	56.0
19800				(Note 3)	74.0 (Note 5)	
22275				(Note 3)	74.0 (Note 5)	
24750				(Note 3)	113.6	

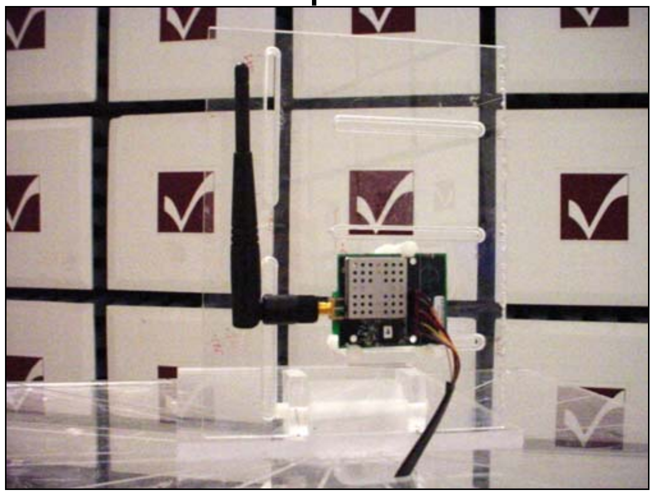
Notes:

1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. Only the results from the Average detector are published in the table above. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2) Measurements above 5 GHz were made at 1 meters of separation from the EUT, and at 0.3 m separation for frequencies between 18 – 25 GHz.
3) Measurement at receiver system noise floor.
4) For measurements of the fundamental power, because of spectral bandwidth, the receiver was set to RBW=VBW=3 MHz.
5) Emission falls within a restricted band of operation, as defined in 47CFR, 15.205; and is subject to Part 15.205 limits.

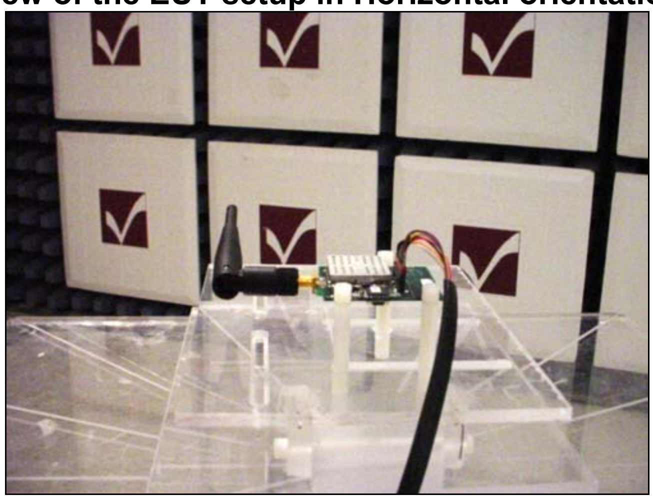
General setup of the EUT on the test stand during radiated emissions tests.



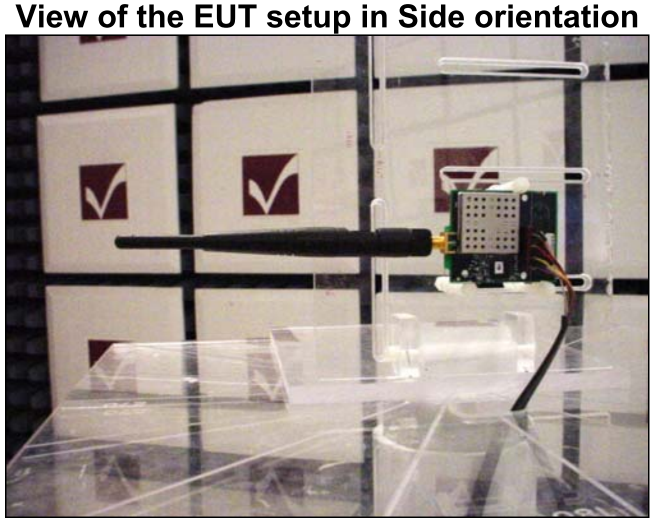
View of the EUT setup in vertical orientation



View of the EUT setup in Horizontal orientation



View of the EUT setup in Side orientation



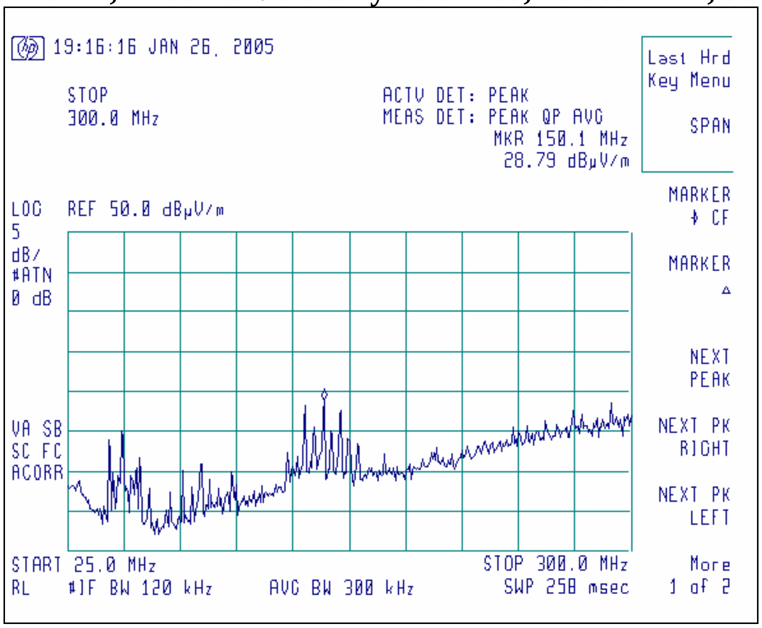
Graphs made during Radiated Emission Testing

Screen Captures of Radiated RF Emissions:

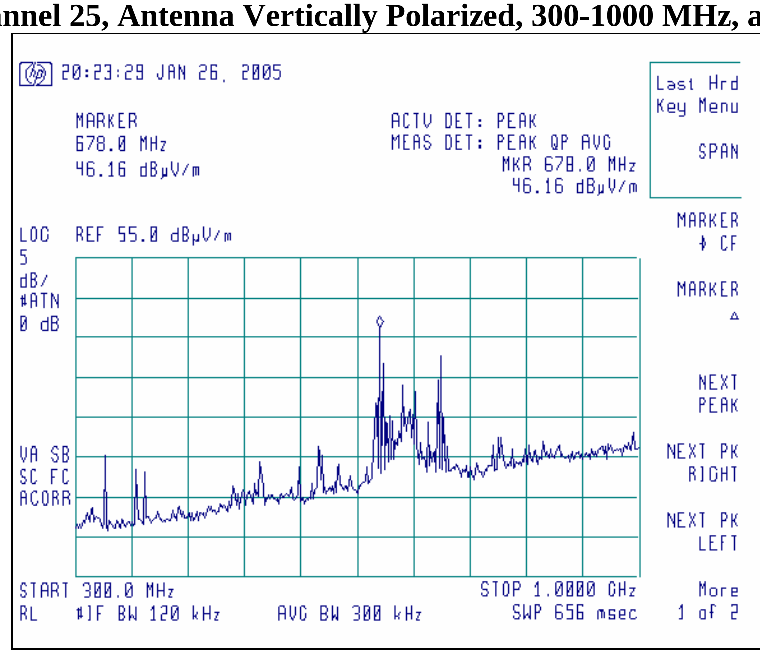
Please note these screen captures represent Peak Emissions. For radiated emission measurements, we utilize a Quasi-Peak detector function when measuring frequencies below 1 GHz, and an Average detector function when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 11, 19, or 25, with the sense and EUT antennas both in vertical polarity for worst case presentations.

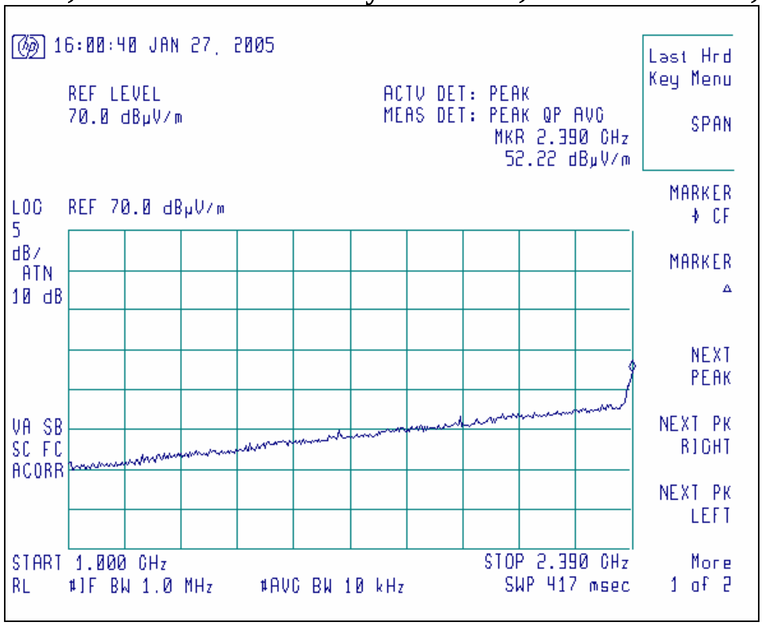
Channel 11, Antenna Vertically Polarized, 25-300 MHz, at 3m.



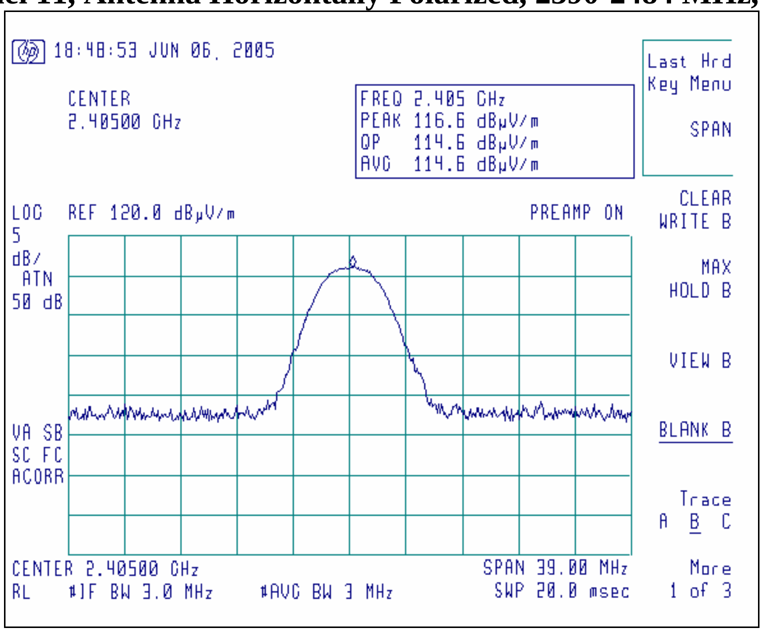
Channel 25, Antenna Vertically Polarized, 300-1000 MHz, at 3m.



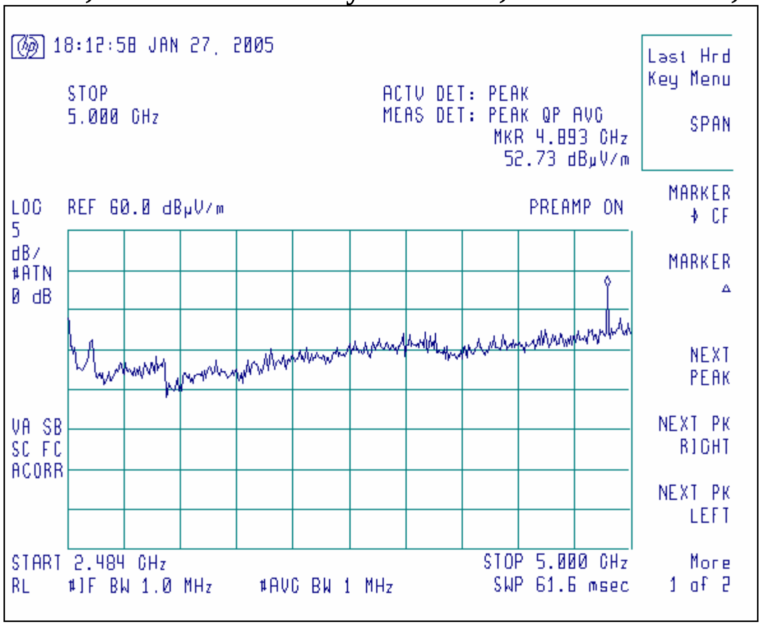
Channel 11, Antenna Horizontally Polarized, 1000-2390 MHz, at 3m.



Channel 11, Antenna Horizontally Polarized, 2390-2484 MHz, at 3m.



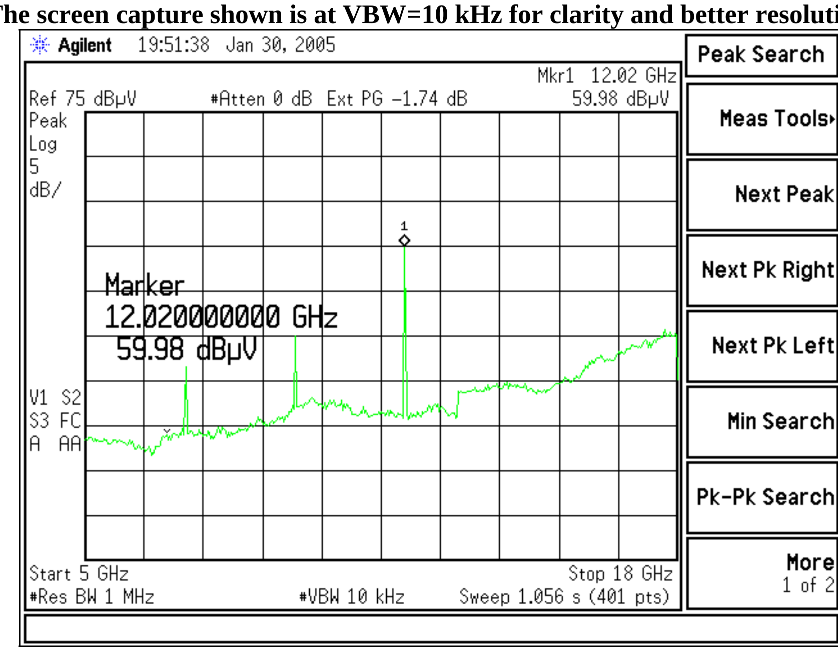
Channel 19, Antenna Vertically Polarized, 2484-5000 MHz, at 3m.



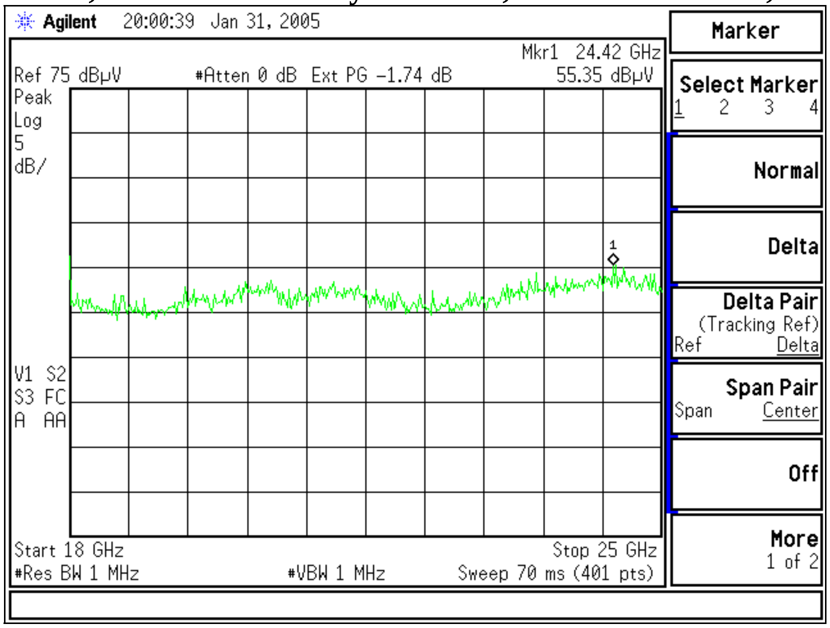
Channel 11, Antenna Horizontally Polarized, 5000-18000 MHz, at 1m.

Measurements were made at RBW=VBW=1MHz,

The screen capture shown is at VBW=10 kHz for clarity and better resolution.



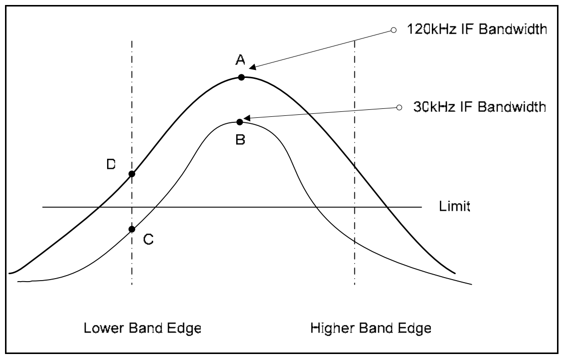
Channel 19, Antenna Vertically Polarized, 18000-25000 MHz, at 30cm.



11. 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:

$A - B = \Delta$; $115.9 dB\mu V/m - 107.6 dB\mu V/m = 8.3 dB$

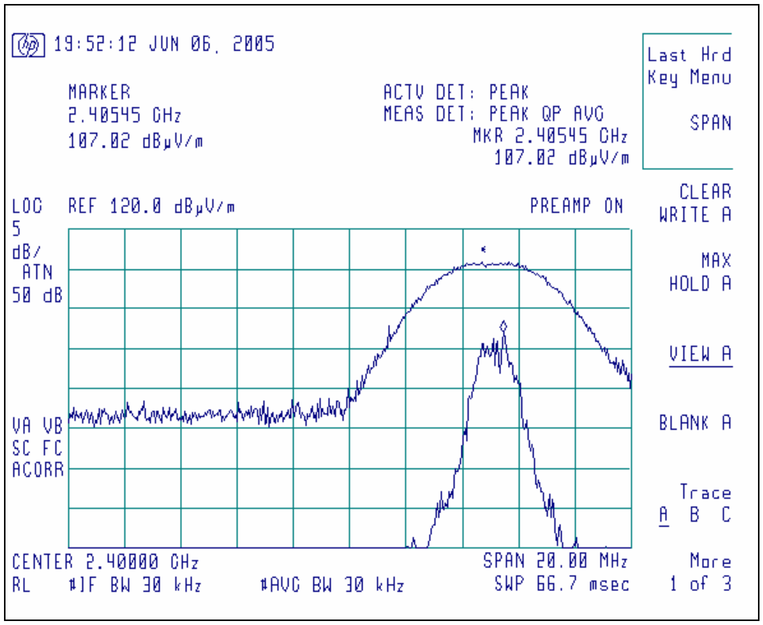
$\Delta + C = D$; $8.3 dB + 76.5 dB\mu V/m = 84.8 dB\mu V/m$ Showing compliance at Lower Band-Edge

At the Upper Band-edge:

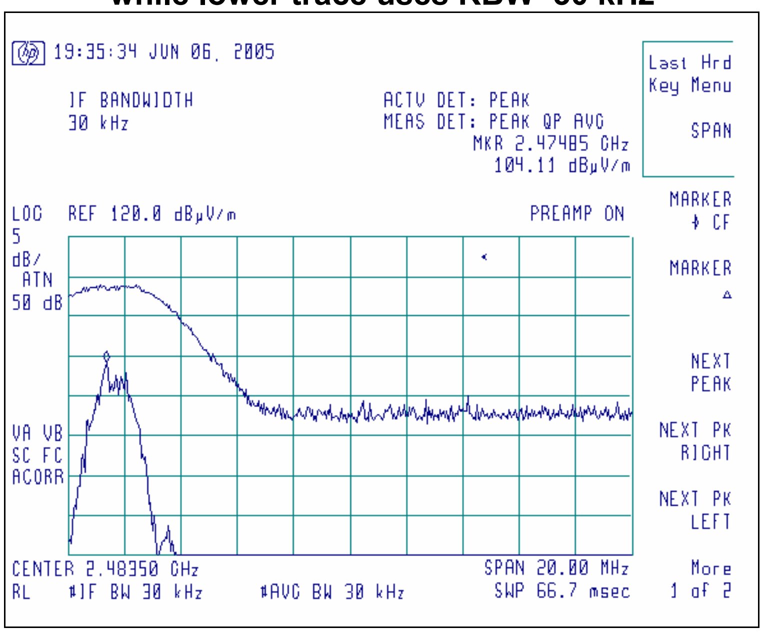
$A - B = \Delta$; $113.8 dB\mu V/m - 104.1 dB\mu V/m = 9.7 dB$

$\Delta + C = D$; $9.7 dB + 40.6 dB\mu V/m = 50.3 dB\mu V/m$ Showing compliance at Upper 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



12. Occupied Bandwidth

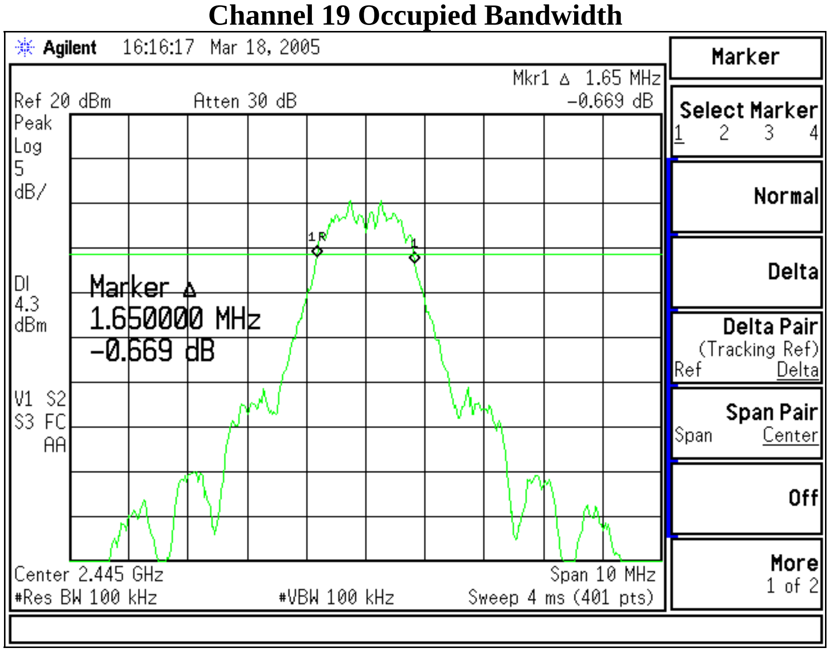
The 20 dB bandwidth requirement found in FCC Part 15.247(a)(2) requires a minimum -6dBc occupied bandwidth of 500 kHz. For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to the HP E4407B spectrum analyzer. 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 19, which is the closest data to the specification limit, is 1650 kHz, which is above the minimum of 500 kHz.

Channel	Center Frequency (MHz)	Measured 6 dB BW (kHz)	Minimum Limit (kHz)
11	2405	1700	500
19	2445	1650	500
25	2475	1680	500

Plots of Occupied Bandwidth

Channel 19 Occupied Bandwidth



13. 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 wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The power supply of 120VAC, 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 typical data for modulation during this portion of the testing. A generic step-down transformer was used to provide 24 VAC to the SAP host, as would typically be the case in a typical installation. The 'Line' side of the step-down transformer was connected to the sampling port of the LISN. The SAP host in turn provided power to the RF module through the 1.5 meter test cable harness. 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 15.207 (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

* Decreases with the logarithm of the frequency.

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

Limit = -19.12 ($\log_{10}$ (F[MHz] / 0.15 [MHz])) + 66.0 dBμV

For a frequency of 200 kHz for example:

Quasi-Peak Limit (F = 200kHz) = -19.12 ($\log_{10}$ (0.2[MHz] / 0.15 [MHz])) + 66.0 dBμV

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

Average Limit (F=200kHz) = -19.12 ($\log_{10}$(0.2[MHz]/0.15[MHz])) + 56.0 dBμV

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), Class B

Manufacturer:	Johnson Controls, Inc.					
Date(s) of Test:	January 19TH to 25TH, 2005					
Test Engineer:		Tom Smith	√	Abtin Spantman		Ken Boston
Model #:	Sensor Access Point RF Module WRS-RTN0000-0					
Serial #:	RF Module S/N: ES3 ; Motherboard S/N: A00					
Voltage:	3.0 VDC					
Operation Mode:	Normal operation and continuous modulated transmit					
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)
0.164	L1	44.5	65.3	20.8	15.7	55.3	39.6
0.214	L1	43.4	63.0	19.6	13.7	53.0	39.3
0.311	L1	41.8	59.9	18.1	12.5	49.9	37.4
1.130	L1	36.7	56.0	19.3	32.4	46.0	13.6
1.250	L1	40.8	56.0	15.2	37.4	46.0	8.6
0.169	L2	45.6	65.0	19.4	20.7	55.0	34.3
0.269	L2	44.3	61.2	16.9	14.5	51.2	36.7
0.307	L2	43.8	60.1	16.3	14.4	50.1	35.7
0.347	L2	43.0	59.0	16.0	14.1	49.0	34.9
1.250	L2	33.4	56.0	22.6	30.6	46.0	15.4
1.129	L2	30.6	56.0	25.4	26.4	46.0	19.6
1.640	L2	31.0	56.0	25.0	27.8	46.0	18.2

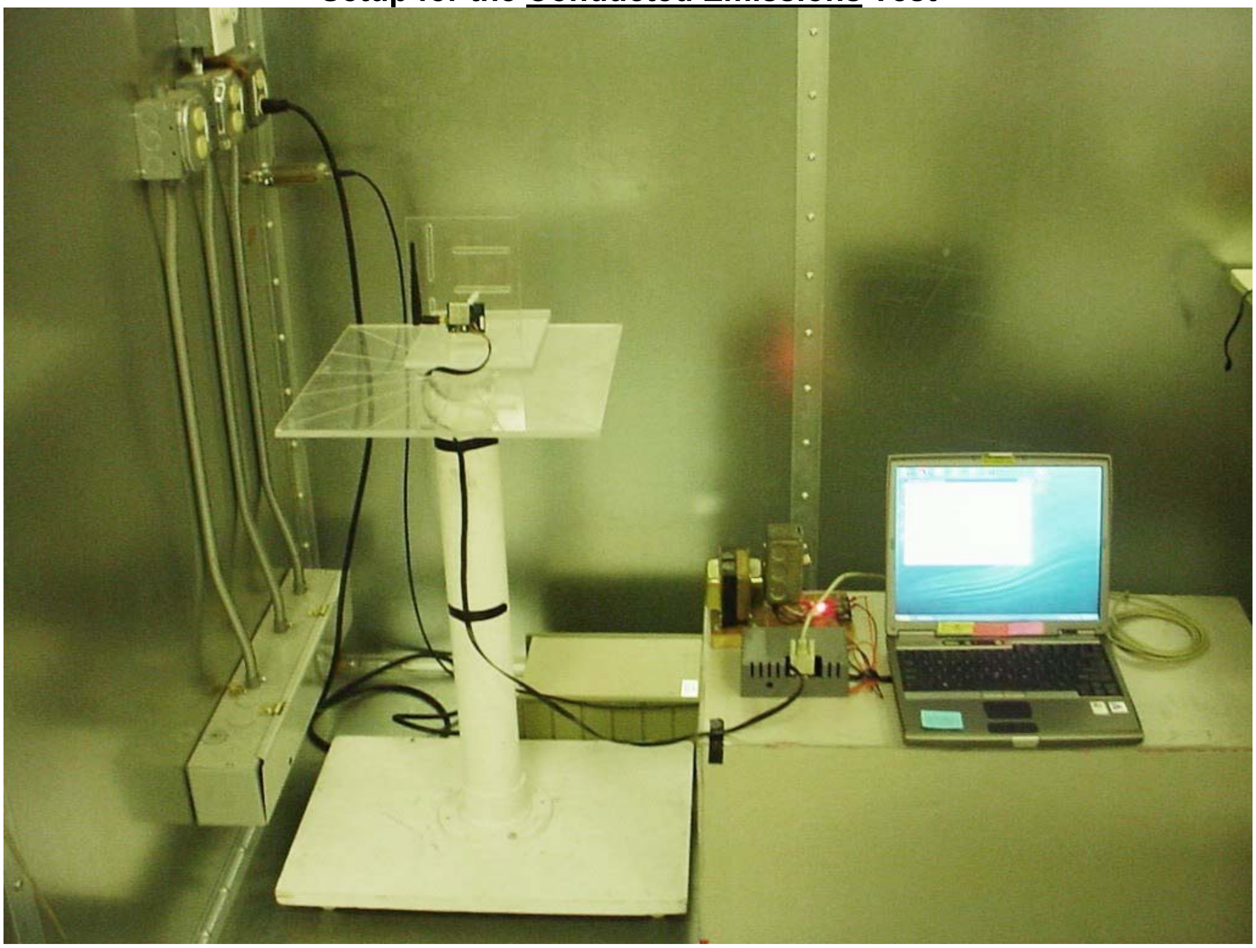
Notes:

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

2) 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

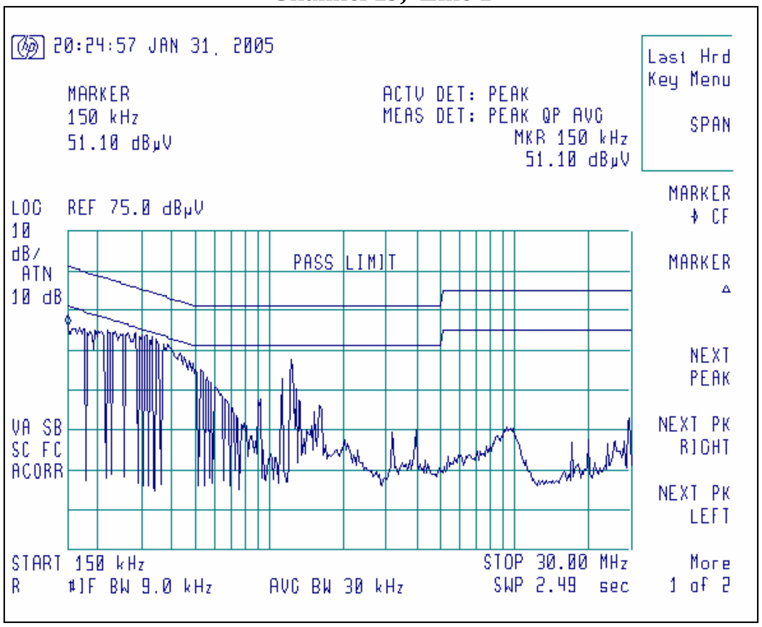
Setup for the Conducted Emissions Test



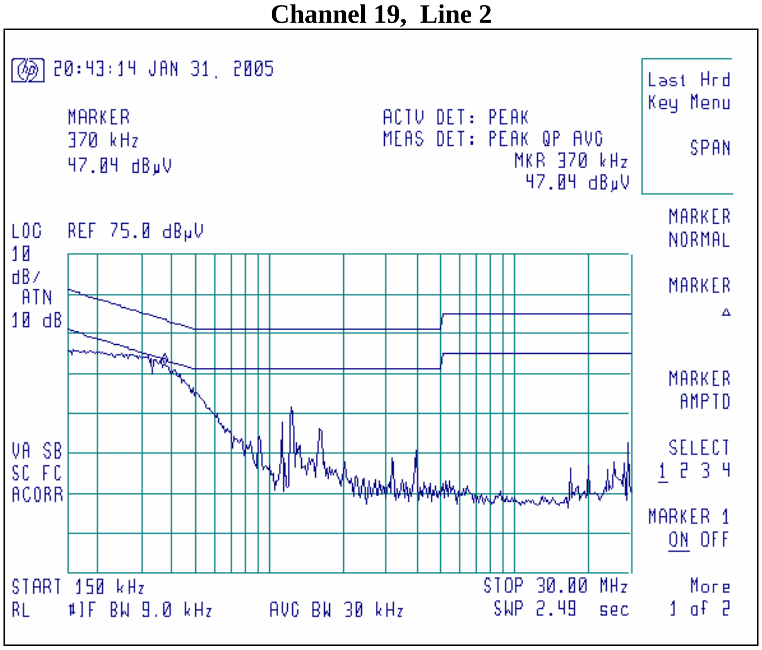
Screen Captures of Conducted AC Mains Emissions:

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 40, chosen as being a good representative of channels.

Channel 19, Line 1



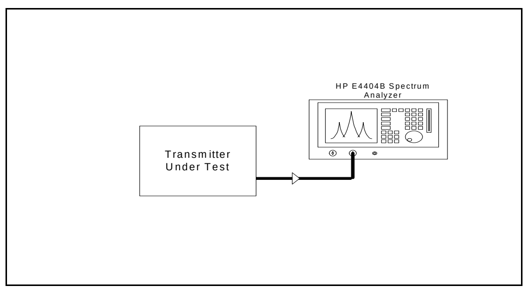
Channel 19, Line 2



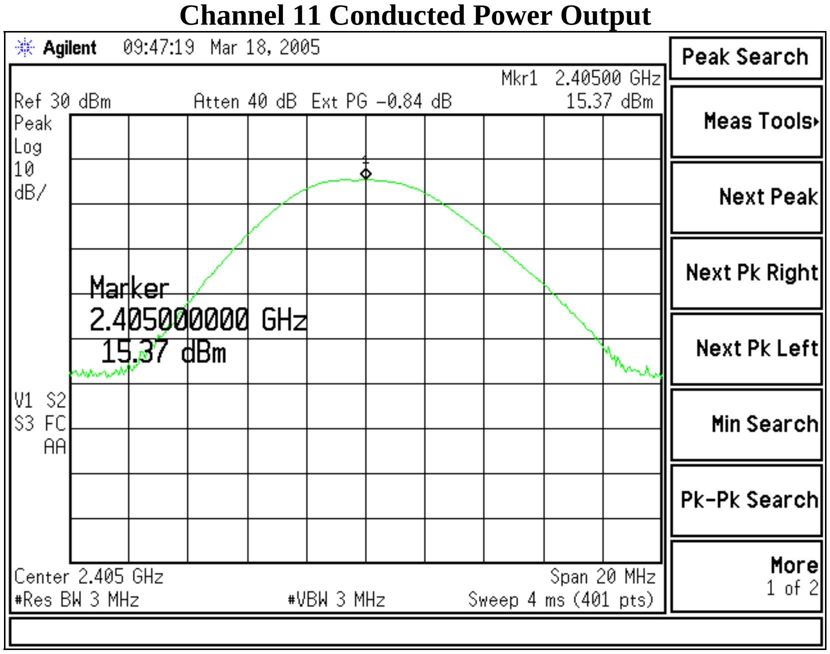
14. Power Output 15.247(b)

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 considerable variation in output power was seen while setting the DC voltage to 2.55 VDC (-15%) or to 3.45 VDC (+15%).

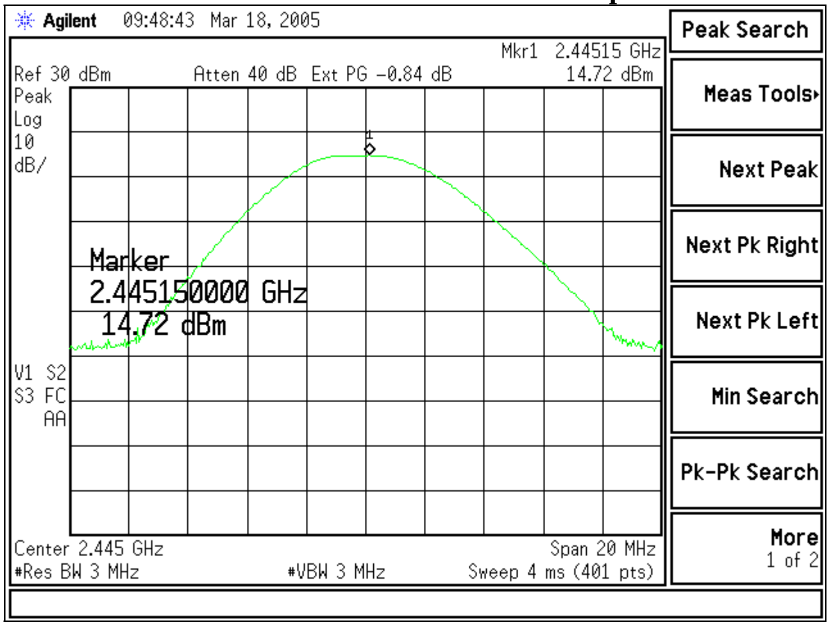
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
11	2405	30 dBm	15.4	14.6
19	2445	30 dBm	14.7	15.3
25	2475	30 dBm	13.6	16.4



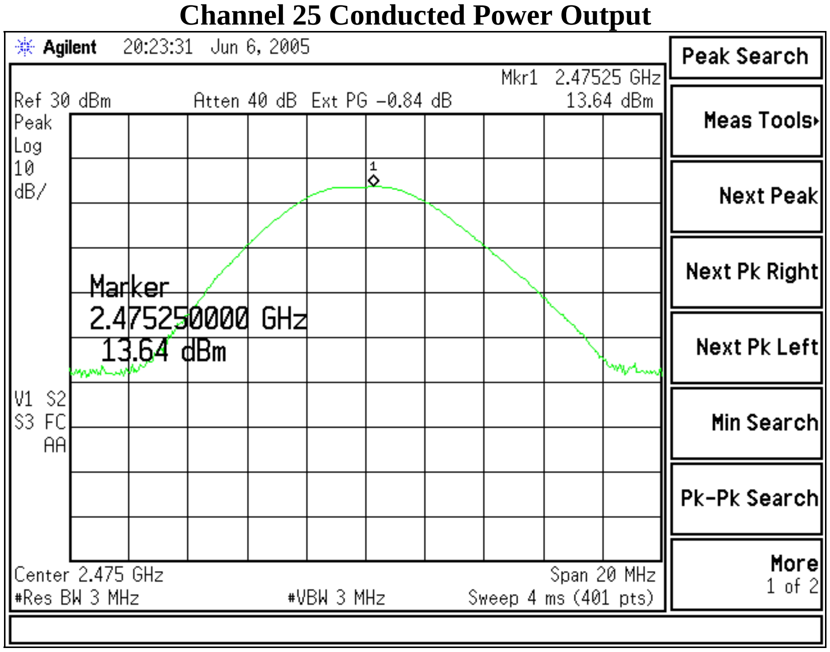
Channel 11 Conducted Power Output



Channel 19 Conducted Power Output



Channel 25 Conducted Power Output



15. Spurious Emissions 15.247(d)

FCC Part 15.247(d) requires a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable. The loss from the cable was added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. A Hewlett Packard model E4407B spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

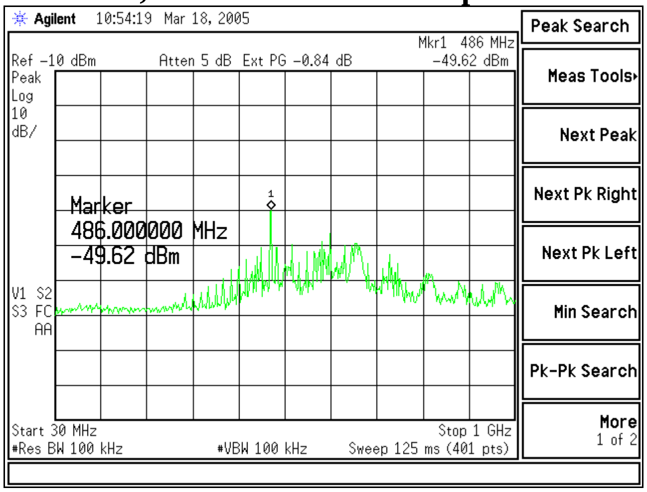
No significant emissions could be noted within -50 dBc of the fundamental level for this product.

	Channel 11	Channel 19	Channel 25
445-525MHz	- 56.1 (dBm)	- 49.6 (dBm)	- 55.7 (dBm)
570-600MHz	- 53.7 (dBm)	- 54.2 (dBm)	- 50.1 (dBm)
610-680MHz	- 51.6 (dBm)	- 56.5 (dBm)	- 48.8 (dBm)
Fundamental	+ 11.0 (dBm)	+ 10.1 (dBm)	+ 8.7 (dBm)
2nd Harmonic	- 77.0 (dBm)	- 76.3 (dBm)	- 69.4 (dBm)
3rd Harmonic	- 62.1 (dBm)	- 69.3 (dBm)	- 67.4 (dBm)
4th Harmonic	- 72.0 (dBm)	- 77.8 (dBm)	- 76.6 (dBm)
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)

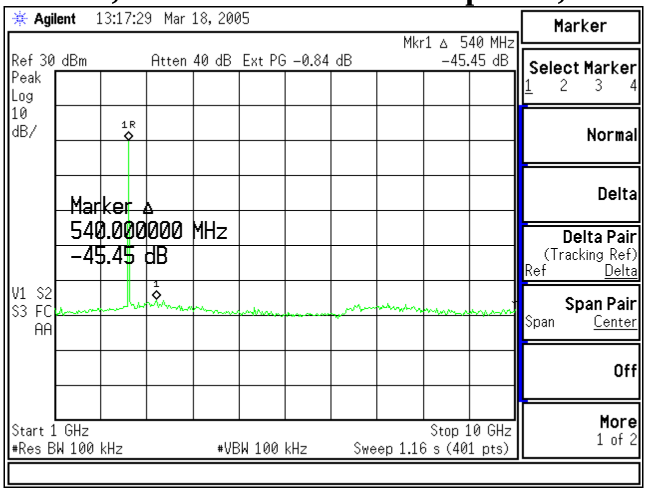
Notes:
(1) Measurement at system noise floor.

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

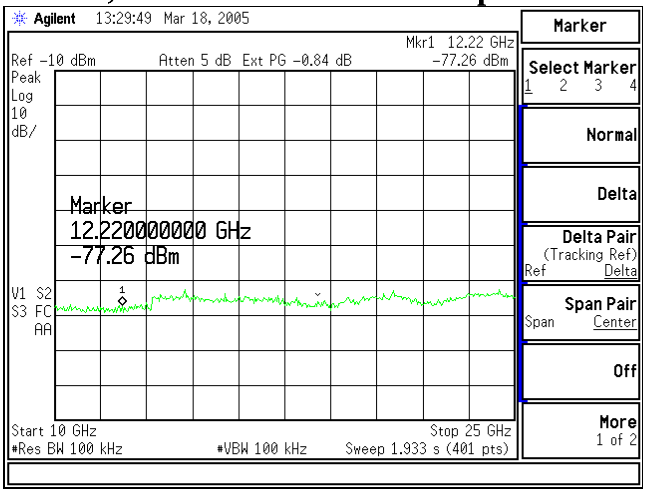
Channel 19, shown from 30 MHz up to 1000 MHz



Channel 19, shown from 1000 MHz up to 10,000 MHz



Channel 19, shown from 10000 MHz up to 25000 MHz

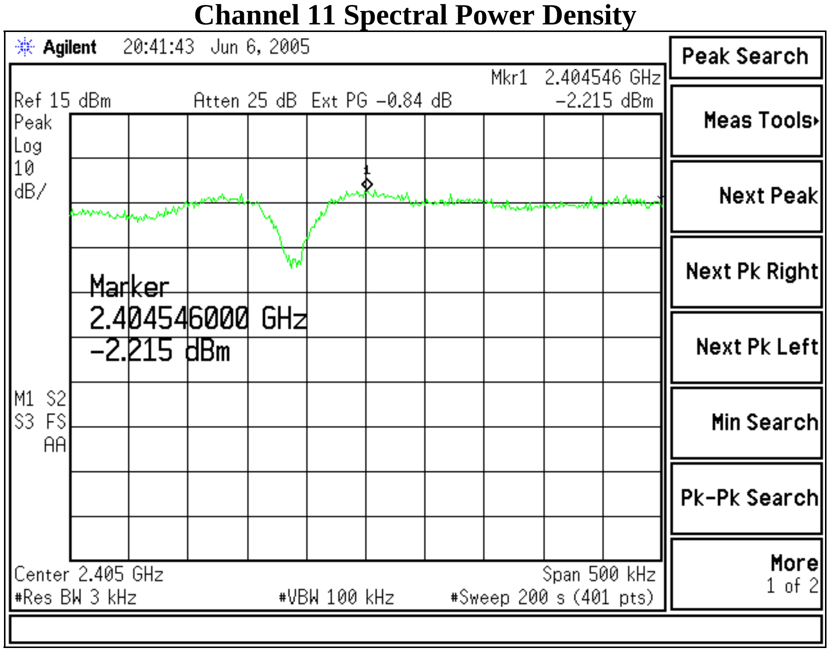


16. Spectral Density

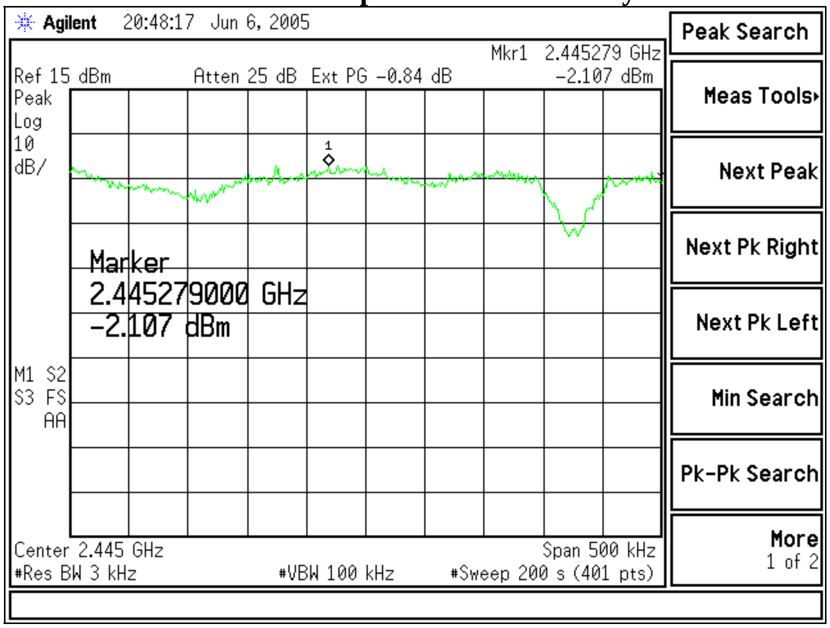
In accordance with FCC Part 15.247(e), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings performed as described in previous sections. The peak output frequency for each representative frequency was 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 –2.0 dBm, which is under the allowable limit by 10 dB.

Channel	Center Frequency (MHz)	Measured Power (dBm)	Limit (dBm)	Margin (dB)
11	2405	-2.2	+8 dBm	10.2
19	2445	-2.1	+8 dBm	10.1
25	2475	-2.0	+8 dBm	10.0

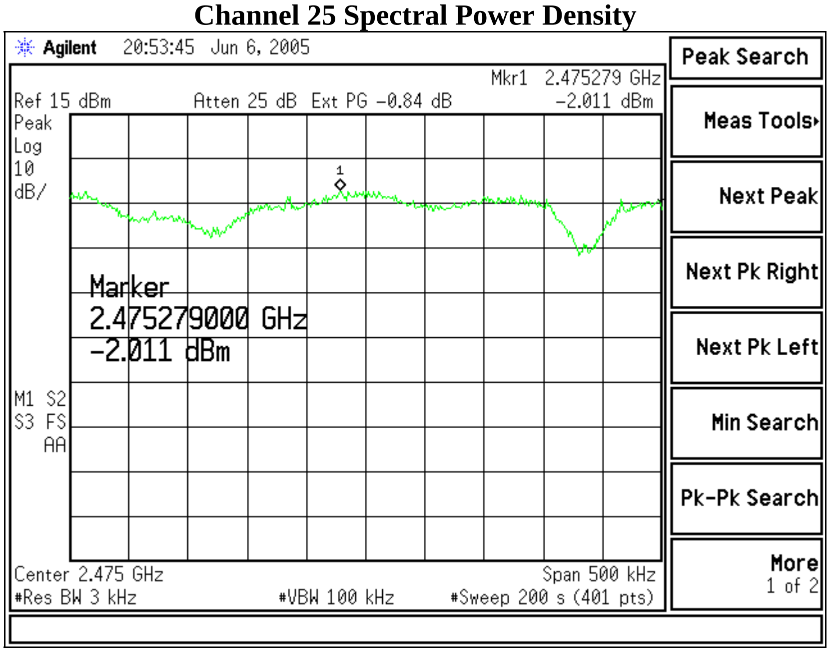
Channel 11 Spectral Power Density



Channel 19 Spectral Power Density



Channel 25 Spectral Power Density



17. 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 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 100 Hz, and video bandwidth of 100 Hz. The RF module derives regulated power from the host only. The host derives power from a step-down transformer connected to the mains. The mains would be the most likely source of power variation, with variations being transformed down to 24VAC. The 24VAC source was therefore chosen as the voltage to be tested at ±15%.

Center Freq 2405.00 MHz

Temperature °C	DC Voltage Source 20.40	24.00	27.60
+55	2404.986855	2404.987155	2404.987200
+40	2404.988155	2404.988155	2404.987680
+30			
+25	2404.993955	2404.993705	2404.993500
+20	2404.995355	2404.995505	2404.995205
+10			
0	2404.999205	2404.999205	2404.999255
-10			
-20	2404.981060	2404.981405	2404.981310

Max Freq	2404.99926	MHz
Min Freq	2404.98106	MHz
Total Freq Excur	0.01819	MHz
Limit	0.24050	MHz
	Pass	

Center Freq 2445.00 MHz

Temperature °C	DC Voltage Source 20.40	24.00	27.60
+55	2444.986348	2444.986360	2444.986410
+40	2444.936854	2444.986705	2444.986755
+30			
+25	2444.993010	2444.992955	2444.992720
+20	2444.994605	2444.994799	2444.994703
+10			
0	2444.998605	2444.998700	2444.998660
-10			
-20	2444.980351	2444.980655	2444.980348

Max Freq	2444.99870	MHz
Min Freq	2444.93685	MHz
Total Freq Excur	0.06185	MHz
Limit	0.24450	MHz
	Pass	

Center Freq 2475.00 MHz

Temperature °C	DC Voltage Source 20.40	24.00	27.60
+55	2474.986800	2474.986800	2474.986800
+40	2474.987600	2474.987640	2474.987600
+30			
+25	2474.993480	2474.993200	2474.993250
+20	2474.995750	2474.995800	2474.995650
+10			
0	2474.999500	2474.999500	2474.999552
-10			
-20	2474.979980	2474.980900	2474.981149

Max Freq	2474.99955	MHz
Min Freq	2474.97998	MHz
Total Freq Excur	0.01957	MHz
Limit	0.24750	MHz
	Pass	

	AC Voltage Source 20.4 VAC	24.0 VAC	27.6 VAC
Channel 11	+15.0 (dBm)	+15.4 (dBm)	+15.8 (dBm)
Channel 19	+14.7 (dBm)	+14.7 (dBm)	+15.3 (dBm)
Channel 25	+13.2 (dBm)	+13.6 (dBm)	+13.8 (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 (no transmissions). 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.

18. MPE Calculations

The MPE calculations are based on a
Nearson Half-wave Dipole Antenna
Model: S181AH-2450S

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:	15.40	(dBm)
Maximum peak output power at antenna input terminal:	34.674	(mW)
Antenna gain(typical):	2	(dBi)
Maximum antenna gain:	1.585	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2400	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)
Power density at prediction frequency:	0.010933	(mW/cm^2)
Maximum allowable antenna gain:	21.6	(dBi)
Margin of Compliance at 20 cm =	19.6	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.

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 <u>*Nearson Half-Wave Dipole, Model: S181AH-2450S*</u>

PURCHASING SECTION

DESCRIPTION	REVISION LEVEL CONTROL
Antenna, Half Wave Dipole, Omni-Directional, 2.4GHz, 90 Deg Swivel, SMA Reverse Polarity	

CHG/REL DOC		REV	DATE
PRTM 6181		-	10/28/04
RTM 6181	(03/10/05)	-	10/28/04

ENG DOC:	K. Halbrooks
SQ APPROVAL:	R. Gibeson
REVIEWED BY:	O. Mageland
ENG APPROVAL:	S. Jamieson

APPROVED SUPPLIER(S):
(1) Nearson P/N S181AH-2450S

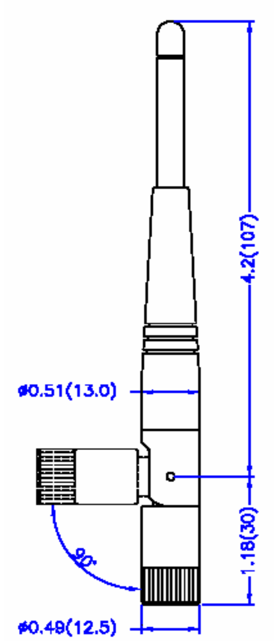
SUPPLIER PACKAGING: Bulk Packaging

COMPONENT / MATERIAL IDENTIFICATION: The supplier name and P/N, JCI P/N, and date code must be identified on the component/material or on/in the packaging.

AGENCY REQUIREMENT(S): No Specific Agency Requirements

COMPONENT / MATERIAL SECTION

Electrical Properties
Frequency Range: 2.4 ~ 2.5GHz
Impedance: 50Ω Nom.
VSWR: < 2.0 : 1
Gain: 2 dBi
Radiation: Omni
Polarization: Vertical
Wave: Half Wave Dipole



<u>Mechanical Properties</u>
Connector: SMA Reverse Plug (male)
Material: Whip: Polyurethane (Black)
Swivel Mechanism: Polycarbonate (Black)
Connector: Brass with black chrome plating
Operating Temperature Range: -20°C to +65°C
Storage Temperature Range: -30°C to +75°C

Shelf Life @ JCI: 1 Yr. max.

Appendix C

Firmware and Setup Instructions

The EUT was presented for testing with firmware test modes available through an RS-232 type serial link. The EUT was connected to a typical host, such as the Johnson Controls' "Access Point", and the host was then connected to a PC or laptop for control and changing test modes. The following is the programming sequence and instructions that were used.

Connect to host (Access Point Mother Board) with an RS-232 serial port.
Use a terminal access program (Hyperterm or Teraterm) with communication parameters set to 115200-8-N-1-None.
Power host and EUT, then hit any key to see the Terminal Command menu shown below:

Terminal Commands:
0 = Off
1 = All SPI
2 = Sensor SPI
3 = Sensor formatted
4 = Xport msgs
5 = Xport config
6 = SAP config
7 = Add test sensor
8 = Del test sensor
9 = Del all test sensors
T = RF test mode

Choose T for RF test mode:

mod/unmod (m/u): u ch# (11-26): 11

Choose modulated/unmodulated and the channel of interest.
The EUT should respond as soon as these parameters are entered.

Note:
These configurations are not available to the end user, and are provided here for the purpose of testing only.