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ENGINEERING TEST REPORT # 306159-TX-v1

Compliance Testing of:
Sensicast OEM-1000

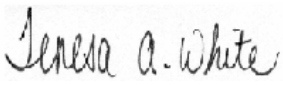
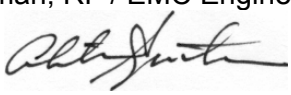
Test Date(s):
February 27TH, through May 31ST, 2006

Prepared For:
Sensicast Systems Incorporated
220-3 Reservoir Street
Needham, MA 02494
U.S.A.

In accordance with:
Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247 FHSS TX
Frequency Hopping Spread Spectrum Operating in the
Frequency Band 902 MHz – 928 MHz

This Test Report is issued under the Authority of:
Brian E. Petted, VP of Engineering

Signature:  Date: August 4, 2006

Test Report Prepared by:	**Tested by:**
Teresa A. White, Document Coordinator	Abtin Spantman, RF / EMC Engineer
Signature: 	Signature: 
Date: August 4, 2006	Date: August 4, 2006

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LSR Revision Control

Date	Revision #	Revised By
8-04-06	01	TAW

EXHIBIT 1. INTRODUCTION

1.1 SCOPE

References:	FCC Part 15, Subpart C, Section 15.247
Title:	Telecommunication – Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	To gain FCC Certification Authorization for Digital Modulation Transmitters operating in the Frequency Band of 902 MHz – 928 MHz
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Environmental Classification:	• Commercial, Industrial or Business • Residential

1.2 NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-15	2005	Code of Federal Regulations - Telecommunications
ANSI C63.4	2004	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
CISPR 16-1-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.
CISPR 16-2-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 201: Conducted disturbance measurement.
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding Spread Spectrum Devices.
FCC Procedures	2005, 03-23	Measurement of Digital Transmission Systems operating under Section 15.247.

1.3 LS Research, LLC TEST FACILITY

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025, 2005 "General Requirements for the Competence of Calibration and Testing Laboratories".

LS Research, LLC's scope of accreditation includes all test methods listed herein, unless otherwise noted. A copy of the accreditation may be accessed on our web site: www.lsr.com. Accreditation status can be verified at A2LA's web site: www.a2la2.net.

1.4 LOCATION OF TESTING

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Compact Chamber
- Semi-Anechoic Chamber
- Open Area Test Site (OATS)

1.5 TEST EQUIPMENT UTILIZED

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated in accordance with A2LA standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 CLIENT INFORMATION

Manufacturer Name:	**Sensicast Systems Incorporated**
Address:	**220-3 Reservoir Street** **Needham, MA 02494** **U.S.A.**
Contact Person:	**Mr. Jay Werb**

2.2 EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information has been supplied by the applicant.

Product Name:	Sensicast OEM-1000 transceiver module
Model Number:	OEM-1000
Serial Number:	05511017

2.3 ASSOCIATED ANTENNA DESCRIPTION

The antenna used, as qualified in this report, is a commercially available patch antenna soldered to the module.

The antenna is a “Antenna Factor” brand, model number “Ant-916-SP”, with a peak gain of 2.5dBi. The specification sheet for this antenna may be found in the Appendix. Declarations of gain are from the manufacturer, “Antenna Factor”, as an email response, on record at LS Research.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

Frequency Range (in MHz)	902-928 MHz
RF Power in Watts	0.78 Watts
Operating Voltage	3.20 VDC
Field Strength (and at what distance)	128.4 dBµV/m at 3m, 913.85 MHz
Occupied Bandwidth (99% BW)	250 kHz
Type of Modulation	FHSS-FSK
Emission Designator	F1D-250K
Transmitter Spurious (worst case)	72.1dBµV/m at 3m, 1805 MHz
Frequency Tolerance %, Hz, ppm	Tol. < 100 ppm
Microprocessor Model # (if applicable)	TI M430F149
EUT will be operated under Regulation Part(s)	47 CFR 15.247, and 15.109 IC: RSS-Gen and RSS-210
Modular Filing	☒ Yes ☐ No

RF Technical Information:

Type of Evaluation (check one)		SAR Evaluation: Device Used in the Vicinity of the Human Head
		SAR Evaluation: Body-worn Device
	X	RF Evaluation

If RF Evaluation checked above, test engineer to complete the following:

- Evaluated against exposure limits: ☒ General Public Use ☐ Controlled Use
- Duty Cycle used in evaluation: 100 %
- Standard used for evaluation: OET Bulletin 65, IC Safety Code 6
- Measurement Distance: 3m
- RF Value: 2.63 ☒ V/m ☐ A/m ☐ W/m^2
  ☒ Measured ☐ Computed ☐ Calculated

2.5 PRODUCT DESCRIPTION

The OEM1000 is a component of the Sensicast H900 Wireless Sensor Network Platform. The module includes a board mounted antenna, radio transceiver (Chipcon CC1000), microcontroller, and an optional temperature and humidity sensor. The frequency band used is the 915MHz ISM band with a peak transmit output power of 1 Watt, and a nominal output power of 0.8 Watts. 50 hopping channels are used. The data is FHSS-FSK modulated.

The OEM-1000 utilizes a patch type antenna that is directly soldered onto the module. The module is only qualified with the patch antenna as defined in this report. The OEM1000 is powered by 3.2 VDC at 1.1 A, and was tested with a wall-type power transformer as covered in this report

The transmitter portion of this transceiver module was tested as covered in this report.

The Sensicast OEM-1000 Transceiver Module.

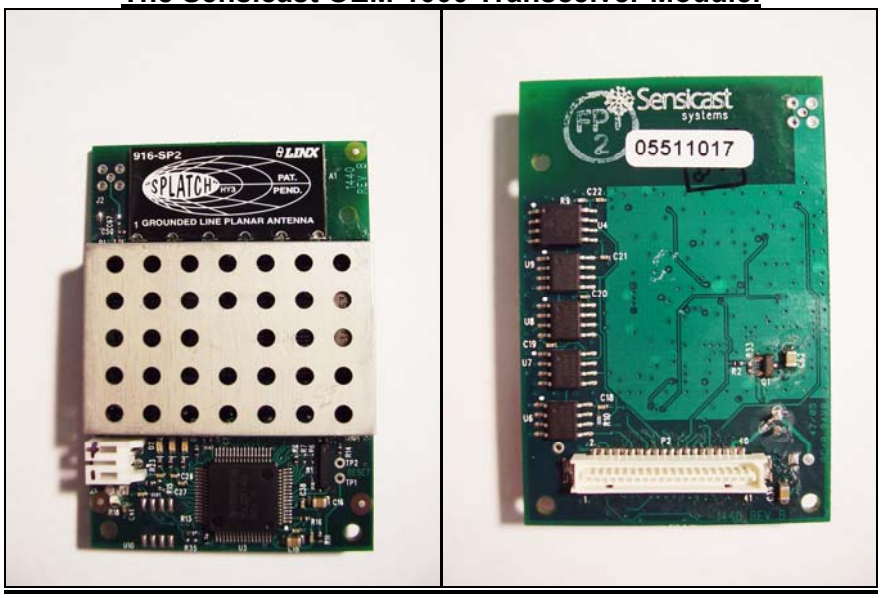


EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	24 °C
Humidity:	28%
Pressure:	98.2 kPa

3.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Paragraph	Test Requirements	Compliance (yes/no)
15.207	Power Line Conducted Emissions Measurements	Yes
15.247(a)(1)	Bandwidth of an FHSS System	Yes
15.247(b) & 1.1310	Maximum Output Power	Yes
15.247(i), 1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
15.247(d)	RF Spurious Emissions	Yes
15.247(a),(g)	Equal pseudorandom usage of channels across band	Yes
15.247(b), 15.247(c), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
The transmitter circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart C, and the associated Radio Receiver and digital circuitry has also been tested and found to comply with Part 15, Subpart B – Unintentional radiators and radio receivers. The Receiver Test Report is available upon request.		

3.3 MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

☐ **None** ☒ **Yes (explain below)**

The EUT must have RF section shield cover soldered at all contact points available over solder mask, for compliance with the harmonic radiated emission levels.

3.4 DEVIATIONS & EXCLUSIONS FROM TEST SPECIFICATIONS

☒ **None** ☐ **Yes (explain below)**

3.5 TEST SPECIFICATIONS AND RELATED DOCUMENTS

Document	Date	Title
FCC CFR Title 47	2004	Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15-Radio Frequency Device
ANSI C63.4	2003	Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
IC RSS-210 Issue 6	2005	Low Power License-Exempt Radio Communication Devices (All Frequency Bands)
IC RSS-212 Issue 1		Test Methods for Radio Equipment
RSS-GEN	2005	General Requirements and Information for the Certification of Radio Communication Equipment

The test procedures used are in accordance with ANSI document C63.4-2003, "Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The specific procedures are described herein. Radiated testing was performed at an antenna to EUT distance of 3 meters. The antenna was raised and lowered from 1 to 4 meters.

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to **MEET** the requirements as described within the specification of FCC Title 47, CFR Part 15.247, and Industry Canada RSS-210 (2006), Section Annex 8 (section 8.1) for a Frequency Hopping Spread Spectrum (FHSS)Transmitter.

If some emissions are seen to be within 3 dB of their respective limits:
As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15 and ANSI C63.4-2003. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in continuous transmit mode, modulated with typical data encoded by the module, using power as provided by an external wall-transformer DC power supply. The unit has the capability to operate on 50 channels, controllable via a laptop PC through a custom programming fixture.

The applicable limits apply at a 3 meter distance. Measurements above 1 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 (902.49 MHz), middle (913.85 MHz) and high (925.77 MHz) to comply with FCC Part 15.35.

5.2 Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 10000 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 10 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.

The EUT was rotated along three orthogonal axis during the investigations to find the highest emission levels.

5.3 Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an N.I.S.T. traceable site. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an 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 10 GHz, an HP E4407B Spectrum Analyzer and an EMCO Horn Antenna were used

5.4 Test Equipment List

Test Equipment	Manufacturer	Model No.	Serial No.
EMI Receiver	HP	8546A	3617A00320
EMI Receiver Pre-Select.	HP	85460A	3448A00296
Spectrum Analyzer	Agilent	E4402B	US39160256
Spectrum Analyzer	Agilent	E4446A	US45300564
Log Periodic Antenna	EMCO	93146	9701-4855
Horn Antenna	EMCO	3115	6907
Bicon Antenna	EMCO	93110B	9702-2918
Pre-Amp (5 -18 GHz)	Adv. Microwave	WLA612	0123101
Pre-Amp (18-25 GHz)	Adv. Microwave	WLA622-4	0123001
Horn Antenna – Std. Gain	EMCO	3160-09	9809-1120

5.5 Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 for an FHSS transmitter [Canada RSS-210 (2005), Annex 8 (section 8.1). The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.6 CALCULATION OF RADIATED EMISSIONS LIMITS

The maximum peak output power of an intentional radiator in the 902-928 MHz band, as specified in Title 47 CFR 15.247 (b)(1), is 1 Watt. The harmonic and spurious RF emissions, as measured in any 100 kHz bandwidth, as specified in 15.247 (d), shall be at least 20 dB below the measured power of the desired signal, and must also meet the requirements described in 15.205(c).

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands.

Frequency (MHz)	3 m Limit (μV/m)	3 m Limit (dBμV/m)	1 m Limit (dBμV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion from field strength μV/m to dBμV/m:
$dB\mu V/m = 20 \log_{10} (100)$
= 40 dBμV/m (from 30-88 MHz)

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

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

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

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

5.7 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 10000 MHz

Manufacturer:	Sensicast Systems, Incorporated						
Date(s) of Test:	February 27TH through May 31ST, 2006						
Test Engineer(s):	Abtin Spantman						
Voltage:	3.2 VDC, 1100 mA						
Operation Mode:	Continuous transmit with modulation						
Environmental Conditions in the Lab:	Temperature: 24° C Relative Humidity: 28 %						
EUT Power:		Single Phase ___VAC			3 Phase ___VAC		
		Battery		√	Other: Wall transformer- 3.2 VDC		
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

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

Frequency (MHz)	Ant./EUT Polarity	Channel	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	Spurious Limit (dBμV/m)	Margin (dB)
873.0	H / S	Low	1.00	195	47.0	105.4	58.4
890.8	H / S	Low	1.00	195	40.1	105.4	65.3
901.5	H / S	Mid	1.00	190	46.0	108.4	62.4
943.4	H / S	Mid	1.00	190	58.4	108.4	50.0
948.2	H / S	Mid	1.00	190	48.2	108.4	60.2
972.8	H / S	Mid	1.00	190	50.0	108.4	58.4
928.3	H / S	High	1.00	200	69.7	107.6	37.9
933.1	H / S	High	1.00	200	53.7	107.6	53.9
955.3	H / S	High	1.00	200	55.5	107.6	52.1

Notes: The Spurious limit is a combination of the 15.247 and 15.205 limits.

RADIATED EMISSIONS DATA CHART *(continued)*

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

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
902.49	H / S	1	195	125.4	131.2	5.8
1805	V / V	1.2	265	72.1	105.4	33.3
2707	H / S	1	95	48.6	63.5	14.9
3610	H / S	1	0	45.5	63.5	18.0
4512	H / S	1	0	45.7	63.5	17.8
5415	H / H	1.25	90	41.0	63.5	22.5
6317	V / S	1.15	90	41.2	114.9	73.7
7220	V / H	1.2	180	38.9	114.9	76.0
8122	H / V	1	175	38.0	63.5	25.5
9025	H / V	1	170	42.9	63.5	20.6

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

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
913.85	H / S	1	190	128.4	131.2	2.8
1828	V / V	1.2	200	68.0	108.4	40.4
2742	H / S	1.15	15	53.5	63.5	10.0
3655	H / S	1	0	45.7	63.5	17.8
4569	H / S	1	0	46.1	63.5	17.4
5483	H / H	1	90	46.8	117.9	71.1
6397	V / S	1	175	45.2	117.9	72.7
7311	V / H	1.2	80	44.0	63.5	19.5
8225	H / V	1.05	160	43.0	63.5	20.5
9139	H / V	1.05	200	43.0	63.5	20.5

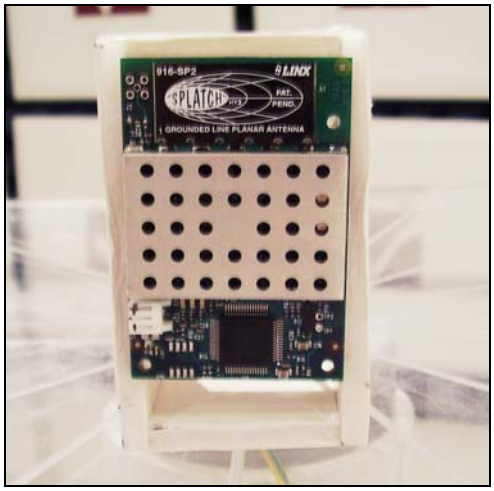
The following table depicts the level of significant radiated RF fundamental and harmonic emissions seen on the High Channel:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (0° - 360°)	Measured EFI (dBμV/m)	15.247 Limit (dBμV/m)	Margin (dB)
925.77	H / S	1	200	127.6	131.2	3.6
1852	V / V	1	85	65.3	107.6	42.3
2777	H / S	1.2	180	56.4	63.5	7.1
3703	H / S	1	90	48.3	63.5	15.2
4629	H / S	1	280	49.1	63.5	14.4
5555	H / H	1	350	45.1	117.1	72.0
6480	V / S	1.1	100	45.2	117.1	71.9
7406	V / H	1.35	350	40.2	63.5	23.3
8332	H / V	1.05	210	40.4	63.5	23.1
9258	H / V	1.05	180	47.7	117.1	69.4

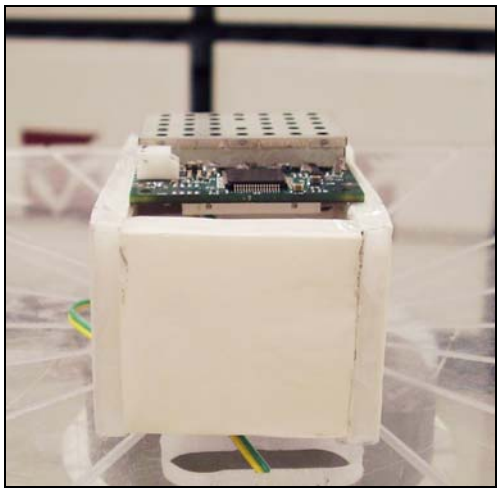
1) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2) Measurements above 1 GHz were made at 1 meters of separation from the EUT.
3) Measurement at receiver system noise floor.

5.8 Test Setup Photo(s) – Radiated Emissions Test

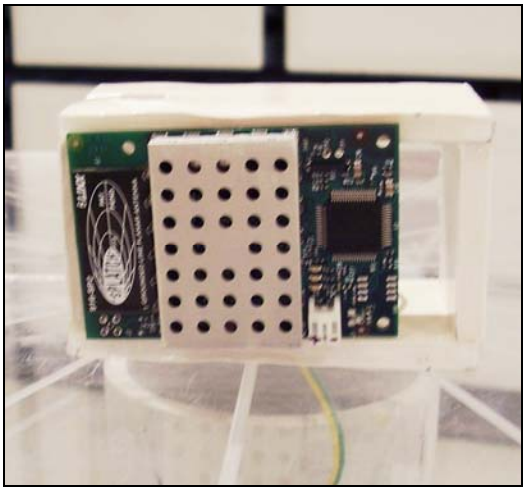
EUT in Vertical Orientation



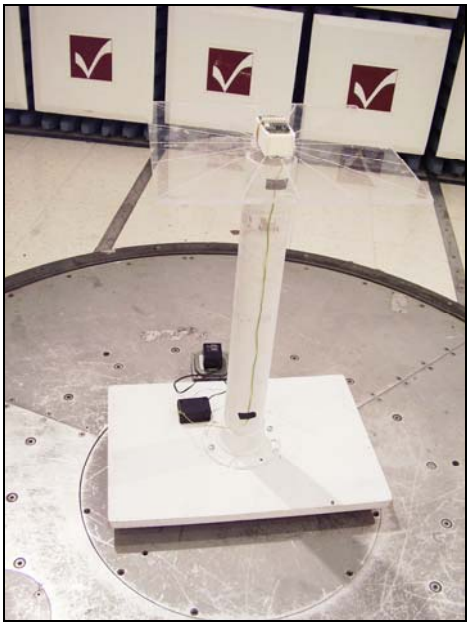
EUT in Horizontal Orientation



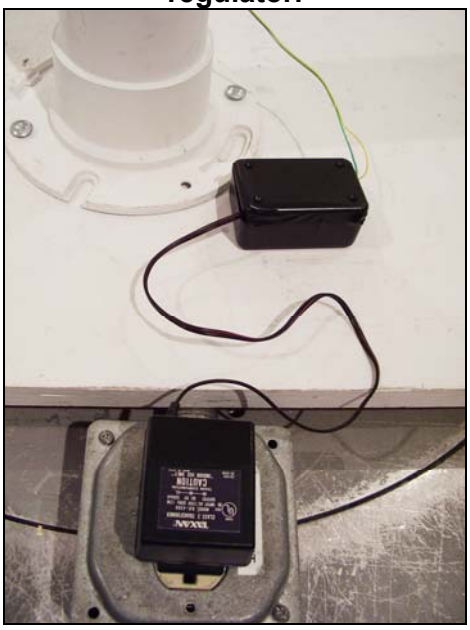
EUT in Side Orientation



Front view of the EUT on the Test Pedestal



Rear view of the EUT, showing the wall-type transformer and the AC-to-DC linear regulator.

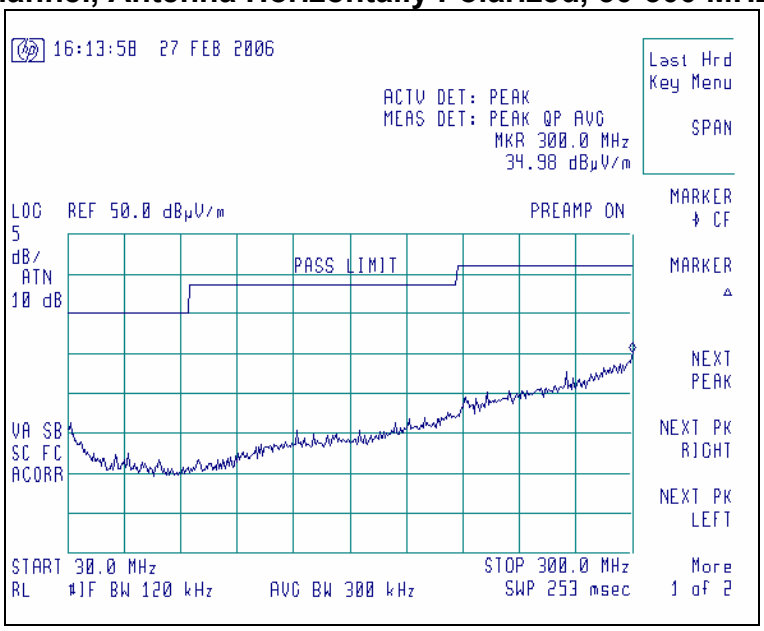


5.9 Screen Captures - Radiated Emissions Testing

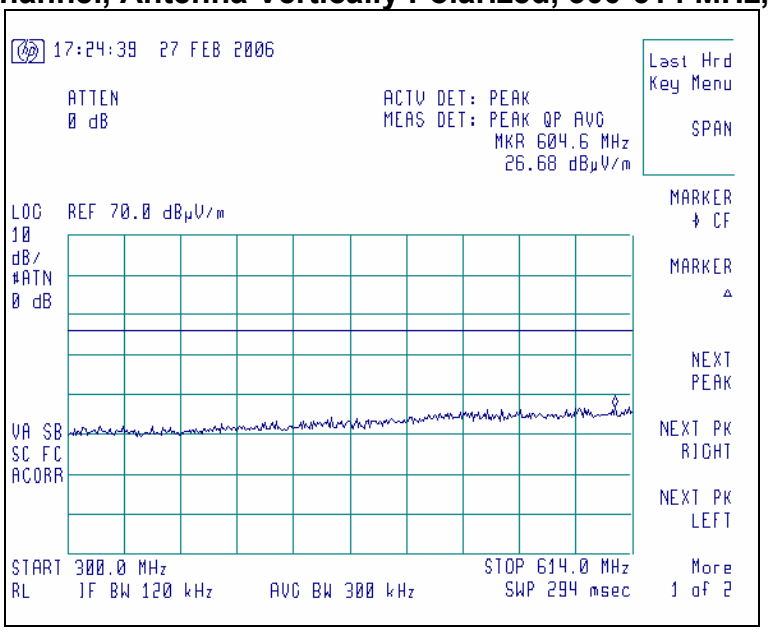
These screen captures represent Peak emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and an Average detector function is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on low, mid and high channels, with the sense antenna both in vertical and horizontal polarity.

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

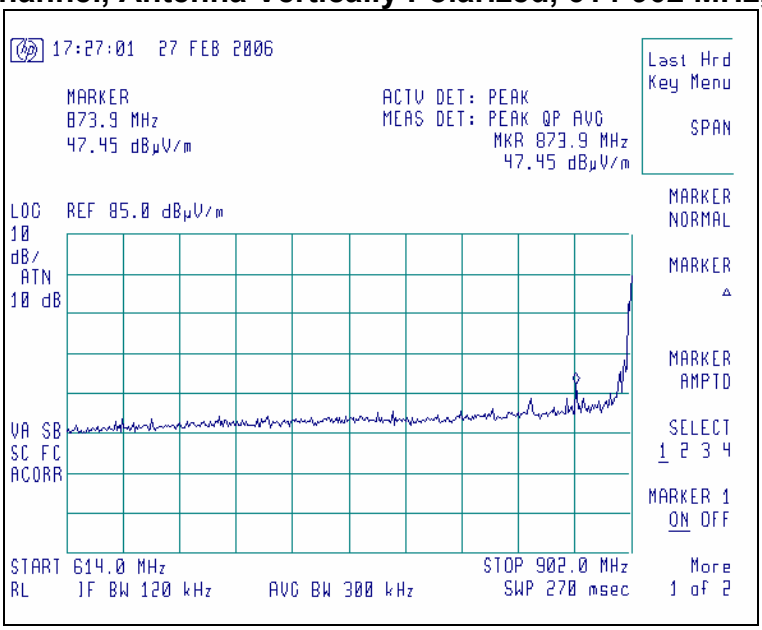


Low Channel, Antenna Vertically Polarized, 300-614 MHz, at 3m



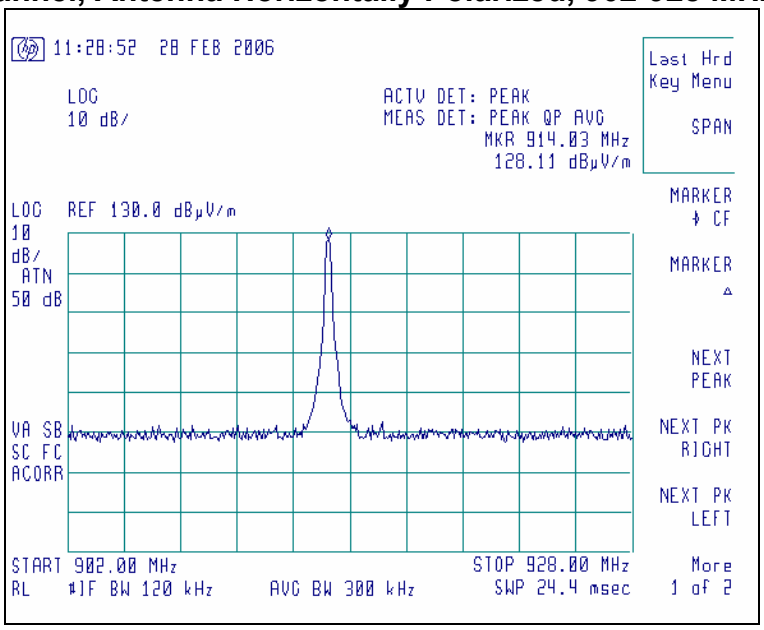
Screen Captures - Radiated Emissions Testing ***(continued)***

Low Channel, Antenna Vertically Polarized, 614-902 MHz, at 3m

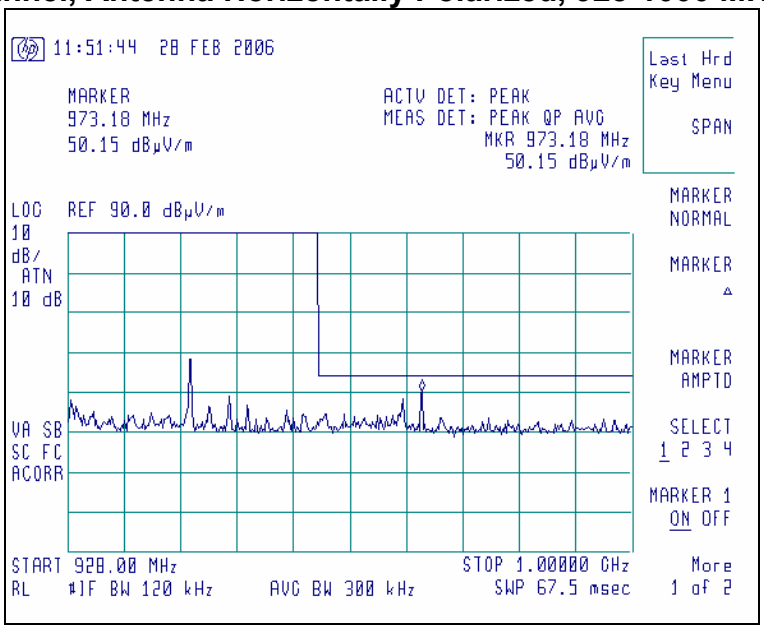


Screen Captures - Radiated Emissions Testing ***(continued)***

Mid Channel, Antenna Horizontally Polarized, 902-928 MHz, at 3m

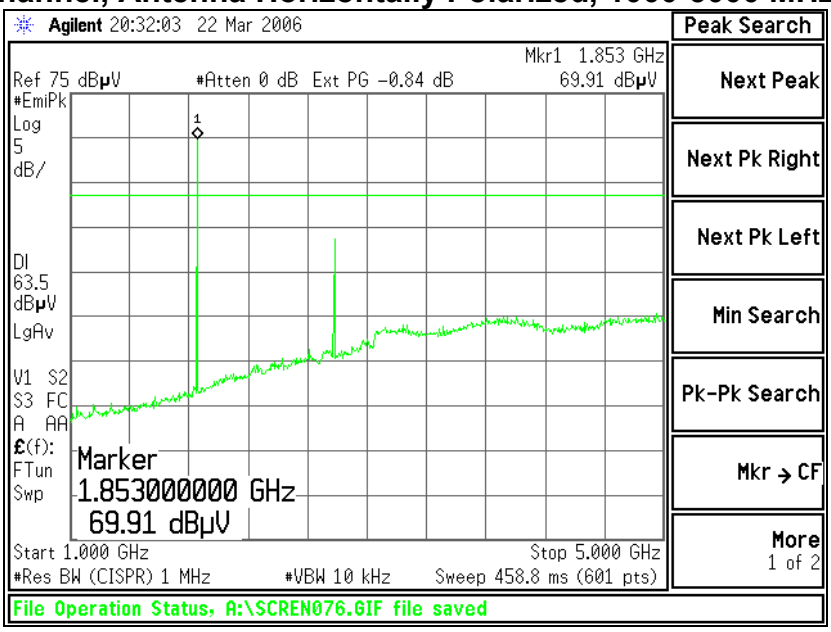


Mid Channel, Antenna Horizontally Polarized, 928-1000 MHz, at 1m



Screen Captures - Radiated Emissions Testing *(continued)*

High Channel, Antenna Horizontally Polarized, 1000-5000 MHz, at 1m



High Channel, Antenna Horizontally Polarized, 5000-10000 MHz, at 1m

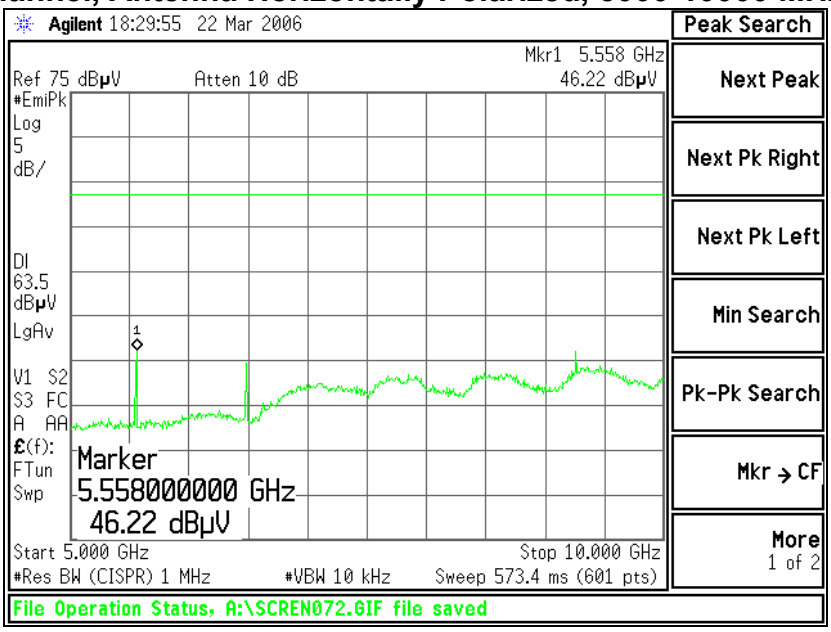


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE: 15.207

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15 (Industry Canada RSS-GEN (section 7.2.2). 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 AC power supply of 120V was provided via an appropriate broadband EMI Filter, and then to the LISN line input. 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 L1 (line) or L2 (neutral).

6.2 Test Procedure

The EUT was investigated in continuous modulated transmit mode 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 30 MHz.

6.3 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 used as measurements.

6.4 Test Equipment List

Test Equipment	Manufacturer	Model No.	Serial No.
EMI Receiver	HP	8546A	3617A00320
Spectrum Analyzer	Agilent	E4446A	US45300564
LISN	EMCO	3816/2NM	9701-1057
Transient Limiter	HP	119474A	3107A01708

6.5 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.

6.6 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)		Measuring Bandwidth
	Quasi-Peak	Average	
0.150 -0.50 *	66-56	56-46	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the logarithm of the frequency in this range.			

6.7 TEST DATA CHART CONDUCTED EMISSION

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 Class B

Manufacturer:	Sensicast Systems, Incorporated					
Date(s) of Test:	February 27TH through May 31ST, 2006					
Test Engineer:	Abtin Spantman					
Model #:	OEM-1000					
Serial #:	05511017					
Voltage:	3.2 VDC, 1100 mA from wall transformer and linear regulator.					
Operation Mode:	Continuous transmit mode with modulation					
Environmental Conditions in the Lab:	Temperature: 24° C Relative Humidity: 28 %					
Test Location:		Conducted RF Emissions Area				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

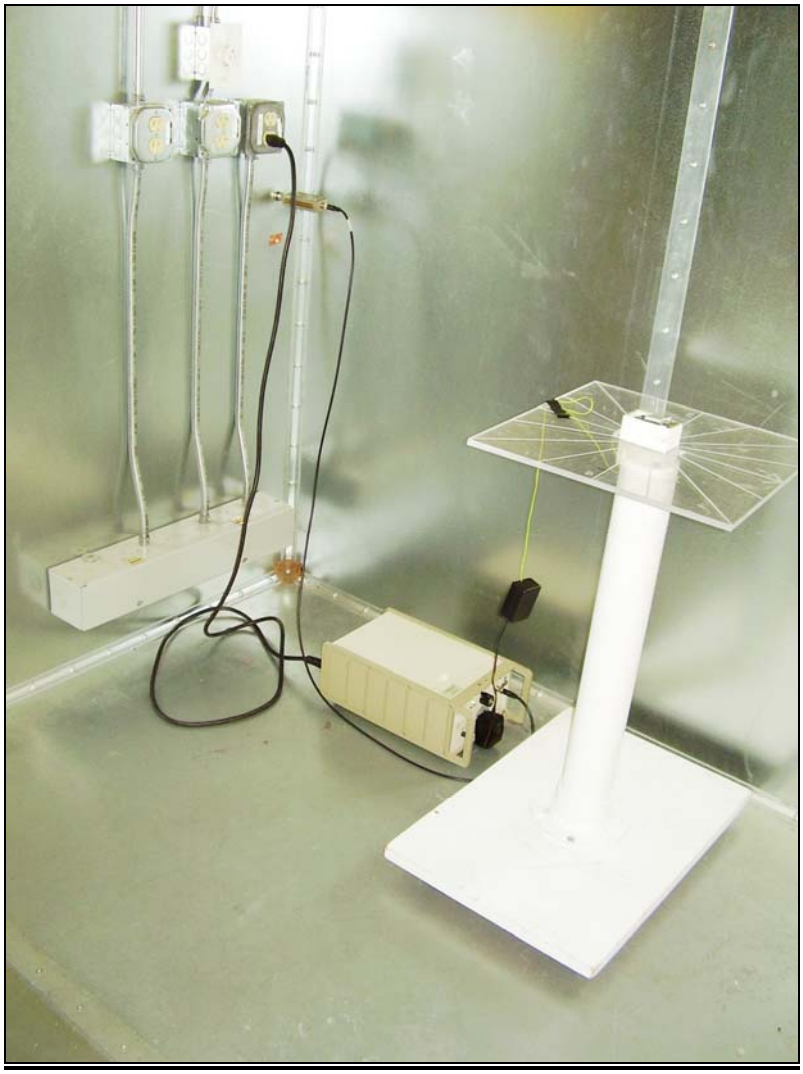
		QUASI-PEAK			AVERAGE		
Frequency (MHz)	Line	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)
0.996	L1	25.1	56.0	30.9	15.5	46.0	30.5
2.639	L1	28.1	56.0	27.9	27.3	46.0	18.7
11.97	L1	36.9	60.0	23.1	35.4	50.0	14.6
23.95	L1	42.1	60.0	17.9	35.9	50.0	14.1
29.93	L1	44.5	60.0	15.5	40.7	50.0	9.3
0.996	L2	25.2	56.0	30.8	15.5	46.0	30.5
2.633	L2	27.4	56.0	28.6	26.6	46.0	19.4
11.97	L2	37.3	60.0	22.7	35.9	50.0	14.1
23.95	L2	42.1	60.0	17.9	36.1	50.0	13.9
29.93	L2	44.4	60.0	15.6	40.8	50.0	9.2

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.

6.8 Test Setup Photo(s) – Conducted Emissions Test

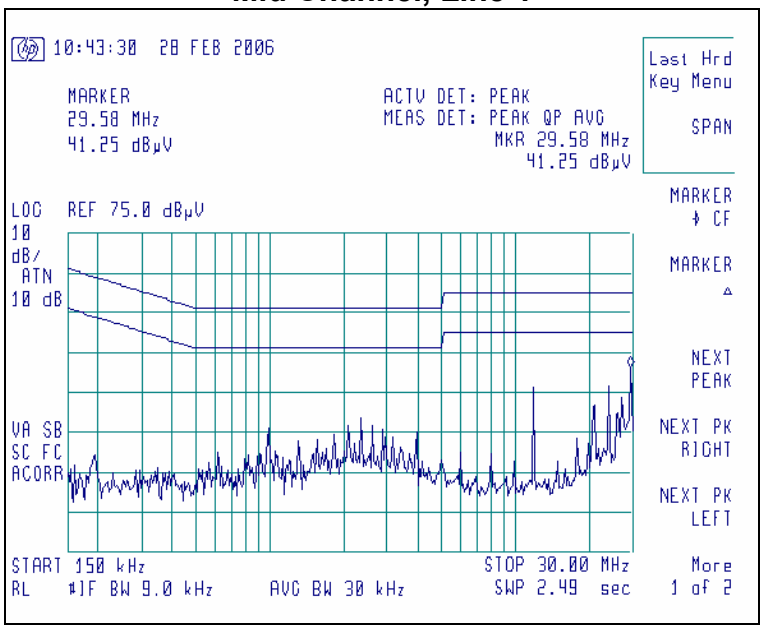


6.9 Screen Captures – Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.207.

The signature scans shown here are from the middle channel, chosen as being a good representative of all channels.

Mid Channel, Line 1



Mid Channel, Line 2

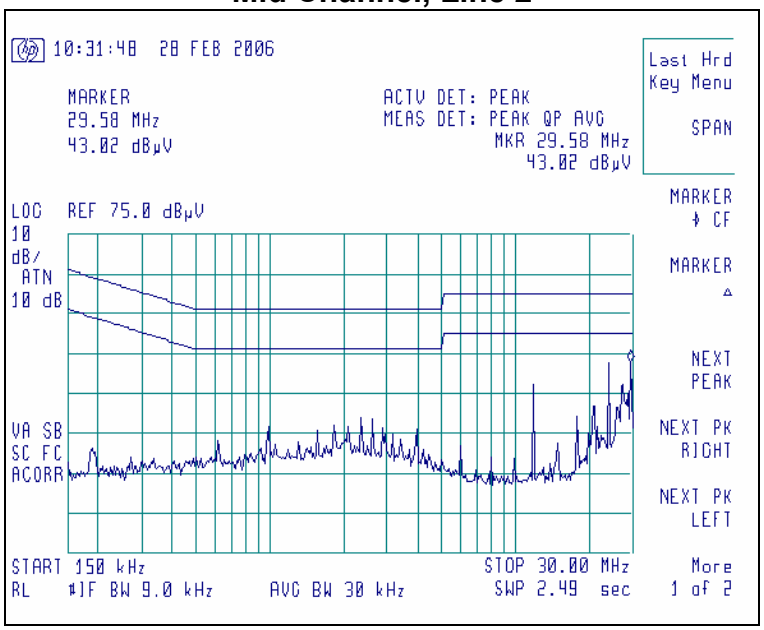


EXHIBIT 7. OCCUPIED BANDWIDTH: 15.247(a)(1)

7.1 Limits

For a Frequency Hopping Spread Spectrum, the -20 dBc bandwidth shall be at most 500 kHz.

7.2 Method of Measurements

Refer to ANSI C63.4 and FCC Procedures (March 23, 2005) for FHSS Systems operating under 15.247.

The bandwidth requirement found in FCC Part 15.247(a)(1)(i) requires a maximum -20dBc 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 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 30 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 closest measurement when compared to the specified limit, is 250 kHz, which is below the maximum of 500 kHz.

7.3 Test Data

Channel	Center Frequency (MHz)	Measured -20 dBc Occ. BW (kHz)	Maximum -20 dBc Occ. BW Limit (kHz)
Low	902.5	235	500
Mid	913.9	250	500
High	925.8	218	500

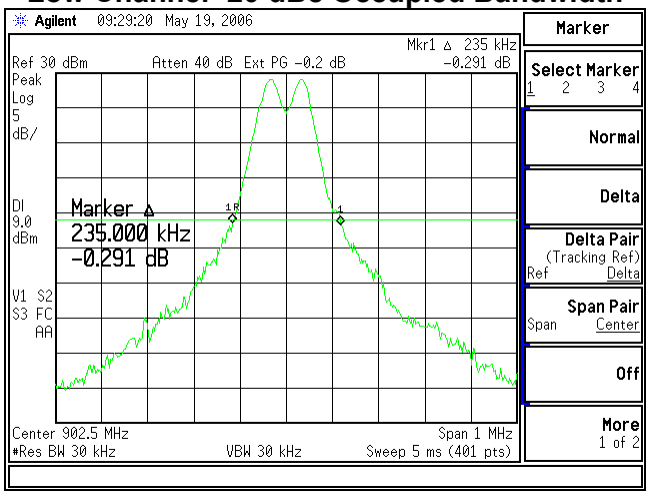
Note: The occupied bandwidth measurements reported in the table are with a receiver bandwidth of 30 kHz. This device exhibits an operational or occupied bandwidth of less than 250 kHz when measured with narrower receiver bandwidths, and hence more representative of the operation of the device.

7.4 Test Equipment List

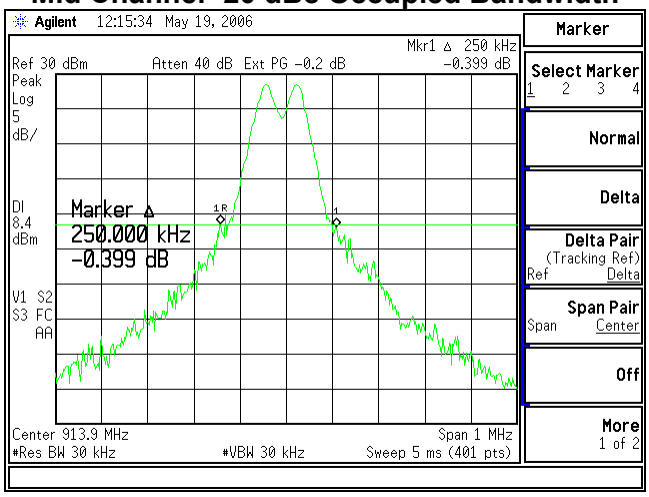
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4407B	US39160256

7.5 Screen Captures of the Occupied Bandwidth

Low Channel -20 dBc Occupied Bandwidth



Mid Channel -20 dBc Occupied Bandwidth



High Channel -20 dBc Occupied Bandwidth

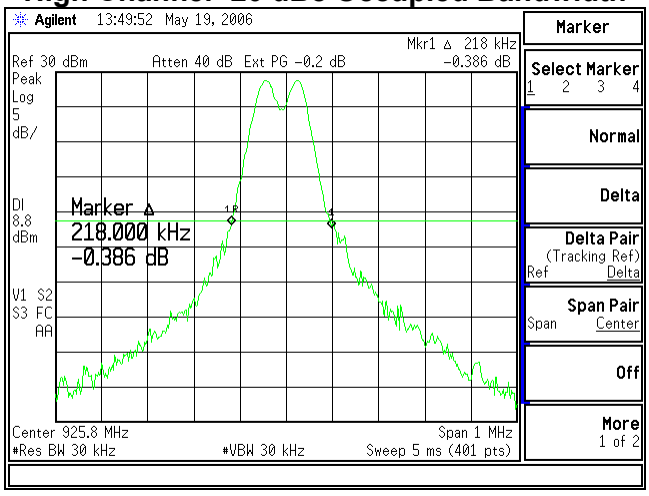


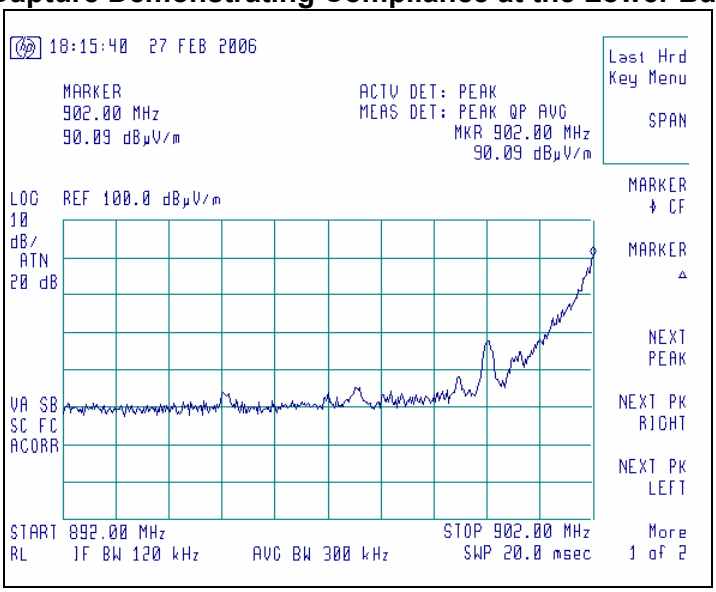
EXHIBIT 8. BAND-EDGE MEASUREMENTS

8.1 Method of Measurements

FCC 15.247(d) requires 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 902-928 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 Upper and Lower Band-Edge limit, in this case, would be -20 dBc with respect to the fundamental level.

Screen Capture Demonstrating Compliance at the Lower Band-Edge



Screen Capture Demonstrating Compliance at the Higher Band-Edge

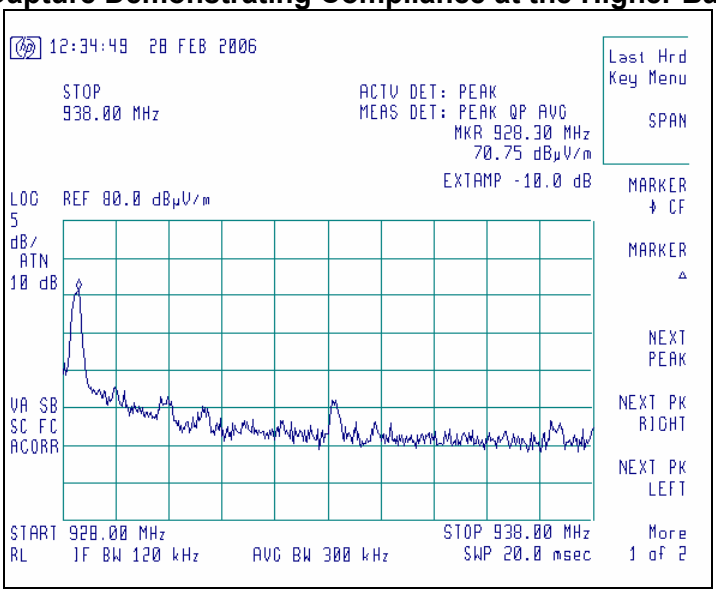


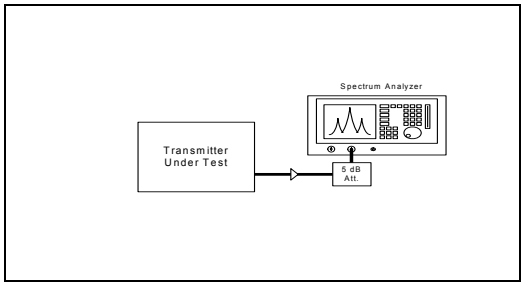
EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

9.1 Method of Measurements

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable to 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 to be 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 300 kHz, and a span of 1 MHz, with measurements from a peak detector presented in the chart below.

9.2 Test Data

CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
Low	902.5	+ 30.0	+ 28.9	1.1
Mid	913.9	+ 30.0	+ 28.5	1.5
High	925.8	+ 30.0	+ 28.9	1.1



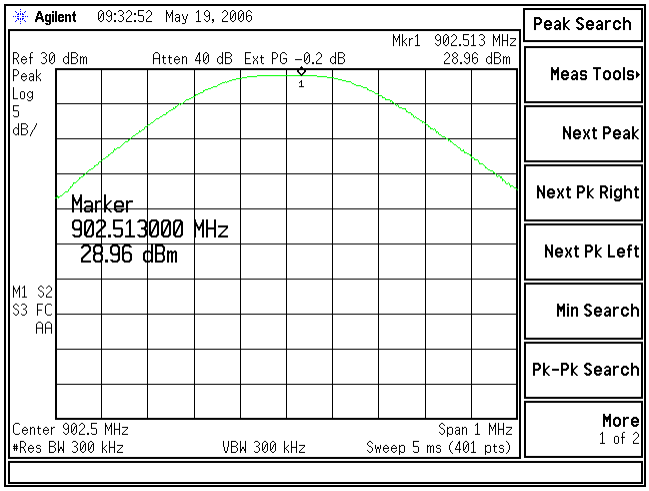
Measured Radiated RF power output (in watts): 2.08 Watts
Measured Conducted RF Power Output (in Watts): 0.78 Watts
Manufacturer-Declared RF Power Output (in Watts): 0.50 Watts

9.3 Test Equipment List

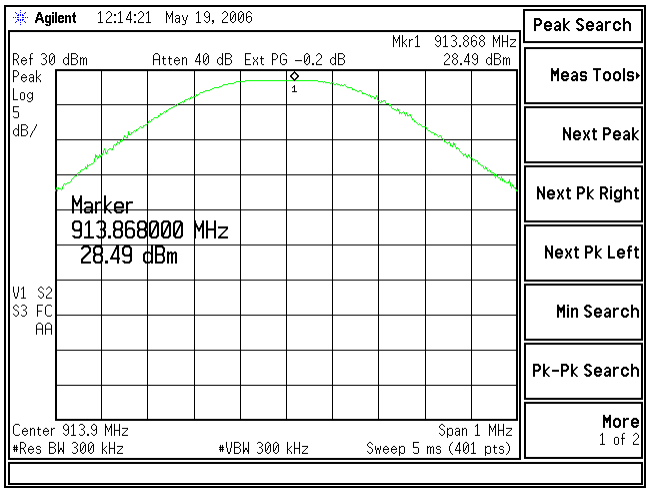
Test Equipment	Manufacturer	Model No.	Serial No.
Spectrum Analyzer	Agilent	E4407B	US39160256

9.4 Screen Captures – Power Output (Conducted)

Low Channel



Mid Channel



High Channel

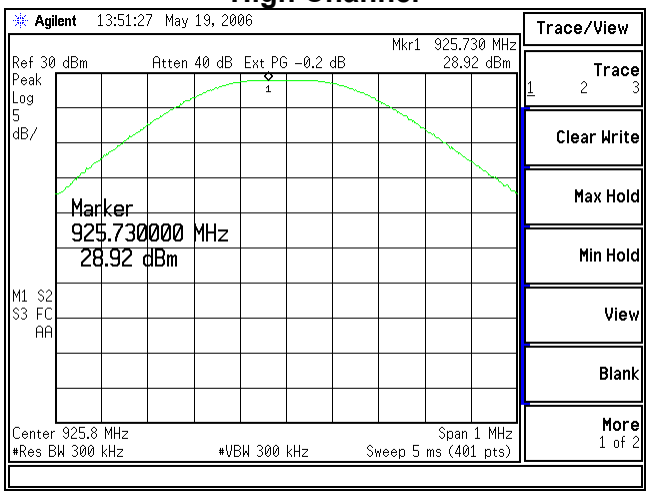


EXHIBIT 10. CHANNEL OCCUPANCY

10.1 Test Setup & Procedure

Part 15.247(a)(1)(i) requires a channel occupancy, for this device, of no more than 400 milliseconds in a 10 second period if utilizing between 25 and 50 channels, or in a 20 second period if utilizing 50 or more channels. 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.

The Sensicast system is designed to switch channels every 400ms, or 2.5 times per second.

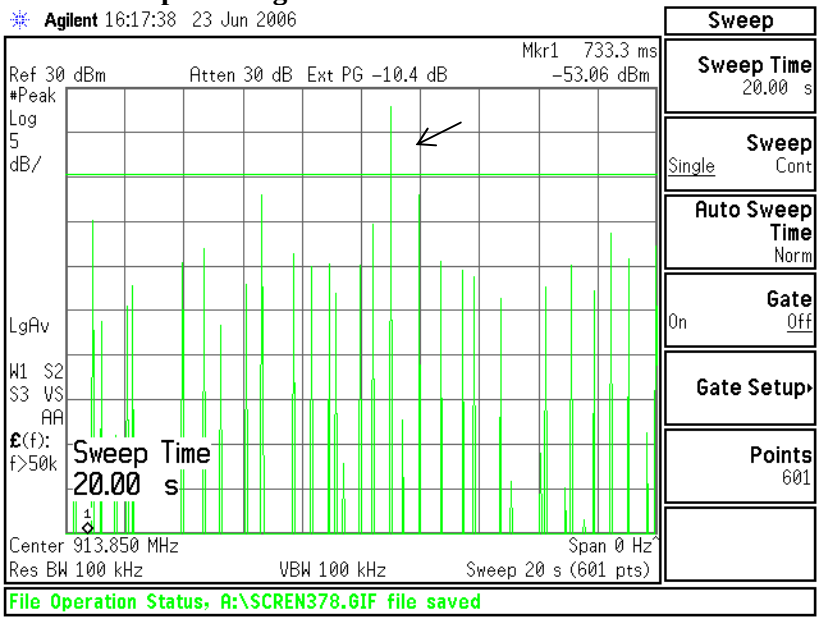
The longest transmission time physically measured on the EUT sample was 14.67 ms.
As the screen capture demonstrates, the transmission is limited to once per 20 seconds, even if it does carry a payload larger than 14.67ms.

10.2 Test Data

Channel	Frequency (MHz)	Occupancy Per transmission (ms)	Occupancy in 400 ms window (ms)
Low	902.5	14.33	14.33
Mid	913.9	14.00	14.00
High	925.8	14.67	14.67

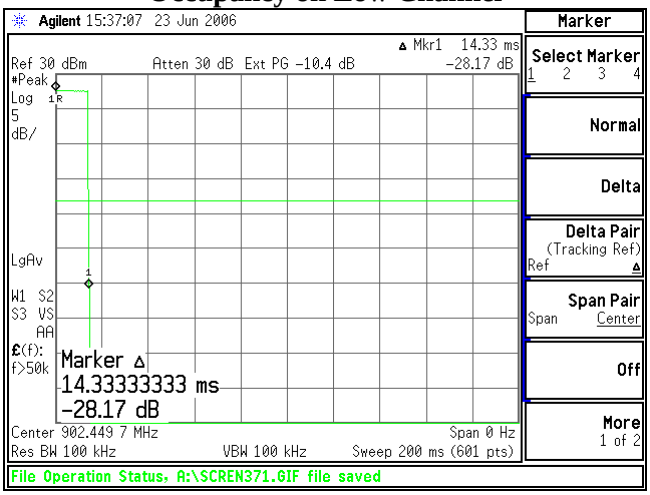
10.3 Plots of Channel Occupancy

20 second sweep showing one transmission event on the Mid Channel.

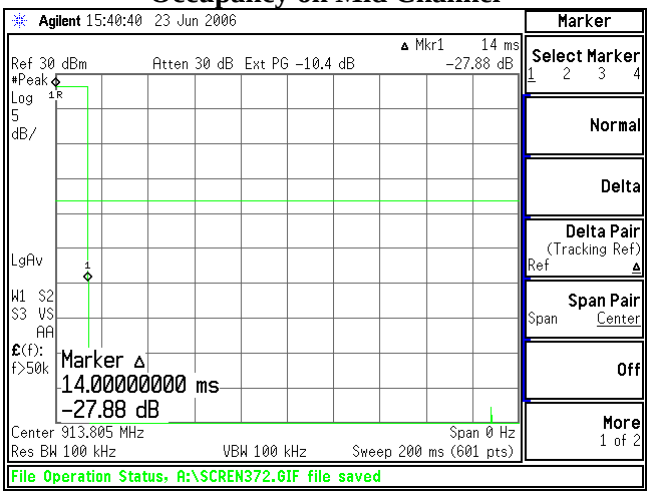


Plots of Channel Occupancy continued:

Occupancy on Low Channel



Occupancy on Mid Channel



Occupancy on High Channel

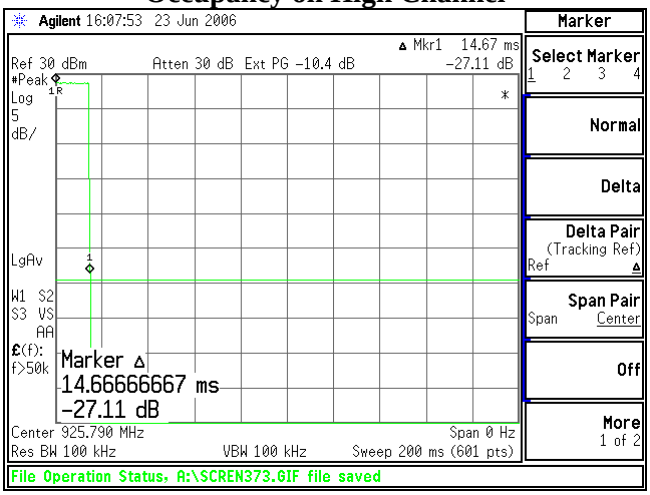


EXHIBIT 11. SPURIOUS EMISSIONS: 15.247(d)

11.1 Limits

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 was added on the analyzer as gain offset settings, there by allowing direct readings of the measurements made without the need for any further corrections. A Hewlett Packard model E4407B spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

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

11.2 Test Equipment List

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

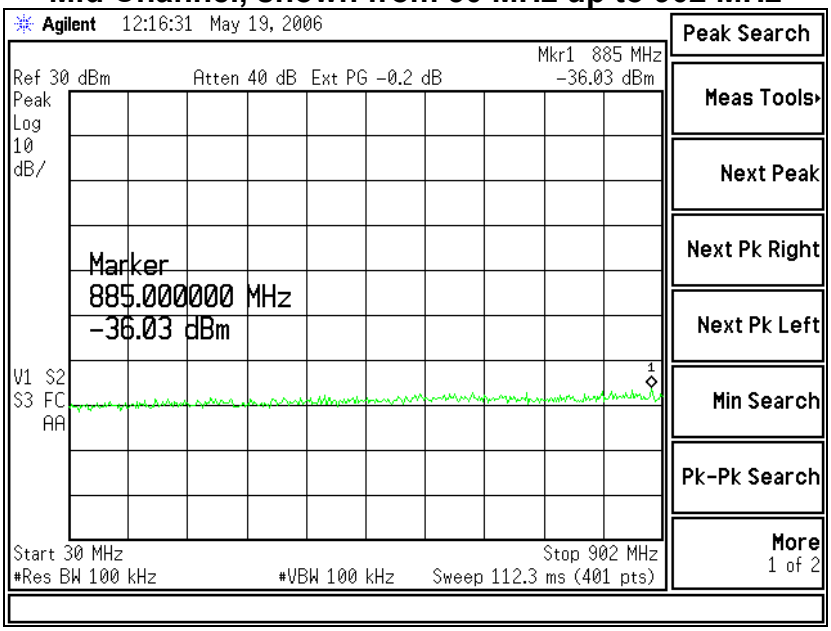
11.3 Test Data

	Low Channel	Mid Channel	High Channel
899-923 MHz (Note 1)	-28.1 (dBm)	-27.3 (dBm)	-29.4 (dBm)
992-936 MHz (Note 1)	-27.4 (dBm)	-27.5 (dBm)	-29.7 (dBm)
992-936 MHz (Note 1)	-34.4 (dBm)	-39.7 (dBm)	-39.6 (dBm)
Fundamental	+ 28.7 (dBm)	+ 28.7 (dBm)	+ 28.8 (dBm)
2nd Harmonic	- 20.8 (dBm)	- 25.2 (dBm)	- 32.8 (dBm)
3rd Harmonic	- 54.0 (dBm)	- 51.9 (dBm)	- 56.9 (dBm)
4th Harmonic	- 77.3 (dBm)	- 86.1 (dBm)	- 84.5 (dBm)
5th Harmonic	- 78.7 (dBm)	- 86.0 (dBm)	- 80.9 (dBm)
6th Harmonic	- 72.4 (dBm)	- 81.7 (dBm)	- 74.1 (dBm)
7th Harmonic	- 65.7 (dBm)	- 90.2 (dBm)	- 86.1 (dBm)
8th Harmonic	- 73.0 (dBm)	- 85.2 (dBm)	- 81.1 (dBm)
9th Harmonic	- 74.1 (dBm)	- 88.2 (dBm)	- 78.5 (dBm)
10th Harmonic	- 77.2 (dBm)	- 82.3 (dBm)	- 79.6 (dBm)

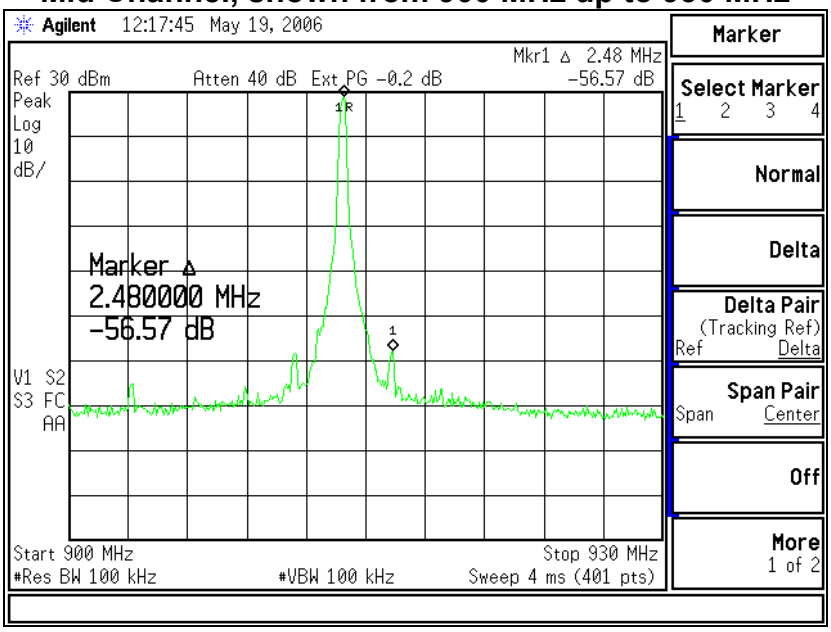
Notes:
1) Reference oscillator spurs.

11.4 Screen Captures – Spurious Emissions

Mid Channel, shown from 30 MHz up to 902 MHz

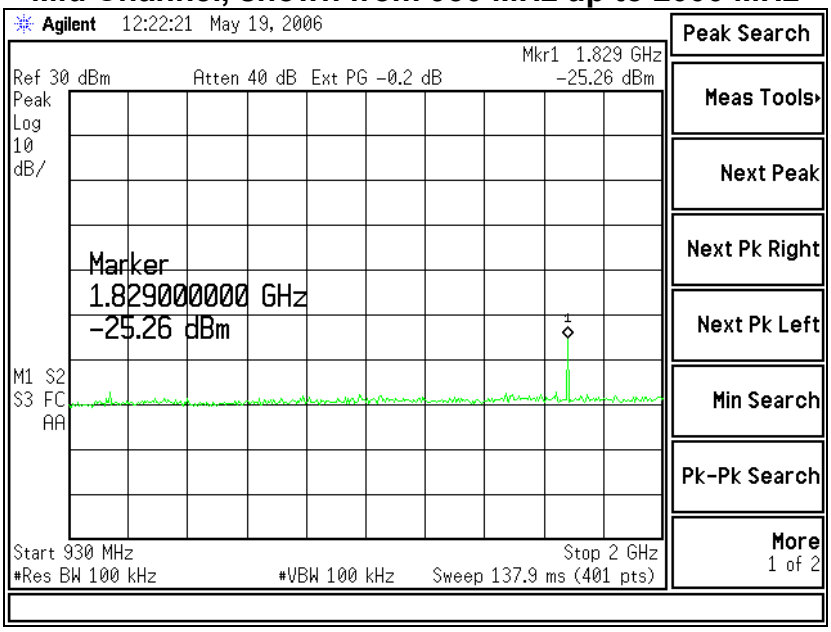


Mid Channel, shown from 900 MHz up to 930 MHz



Screen Captures continued – Spurious Emissions

Mid Channel, shown from 930 MHz up to 2000 MHz



Mid Channel, shown from 2000 MHz up to 10000 MHz

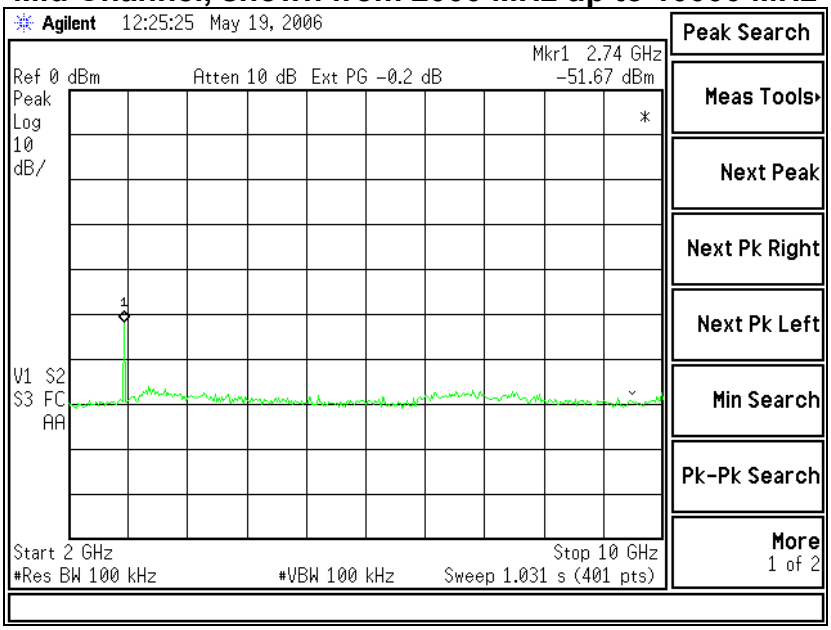


EXHIBIT 12. STABILITY OVER VOLTAGE VARIATIONS

The stability of the device was examined as a function of the input voltage available to the EUT. A Spectrum Analyzer was used to measure the frequency at the appropriate frequency markers. For this test, the transmitter portion of the EUT placed in continuous transmit mode. Power was supplied by an external bench-type variable power supply, and the operation was monitored using the spectrum analyzer.

The RF Power Output of the EUT was monitored using a spectrum analyzer with RBW=VBW=1 MHz setting while the voltage was varied.

	DC Voltage Source		
	2.72 VDC	3.20 VDC	3.68 VDC
Low Channel	+ 27.1 (dBm)	+ 28.2 (dBm)	+ 29.1 (dBm)
Mid Channel	+ 27.5 (dBm)	+ 28.5 (dBm)	+ 29.4 (dBm)
High Channel	+ 27.4 (dBm)	+ 28.6 (dBm)	+29.6 (dBm)

The power was then cycled On/Off to observe system response. No unusual response was observed, and the system returned to the standby state of operation.

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

EXHIBIT 13. CHANNEL PLAN AND SEPARATION

An HP E4407B spectrum analyzer was used with a resolution bandwidth of 30 kHz to measure the channel separation of the EUT.

The minimum and maximum channel-separations measured for this device are 398 kHz and 525 kHz respectively. The maximum occupied bandwidth of the device, as reported in the previous section is 250 kHz. The following plots describe this spacing, and also establish the channel separation and plan.

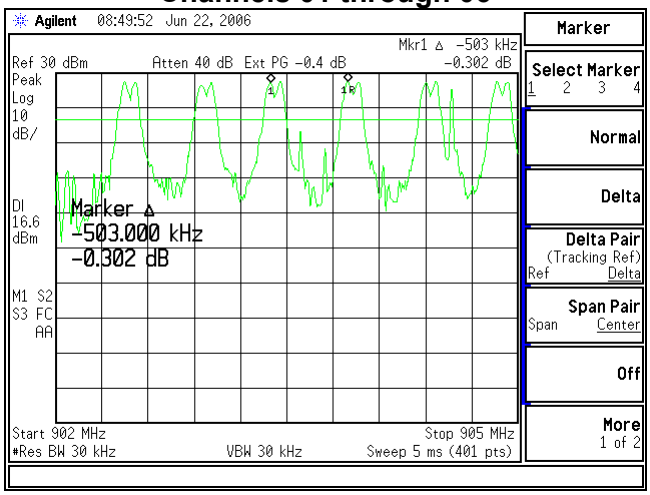
13.1 Test Data

Frequency Span	Number of Channels	Minimum Separation (kHz)
902-905 MHz	6	503
905-908 MHz	6	398
908-911 MHz	6	525
911-914 MHz	7	443
914-917 MHz	6	413
917-920 MHz	6	443
920-923 MHz	7	524
923-926 MHz	6	450
926-928 MHz	0	-

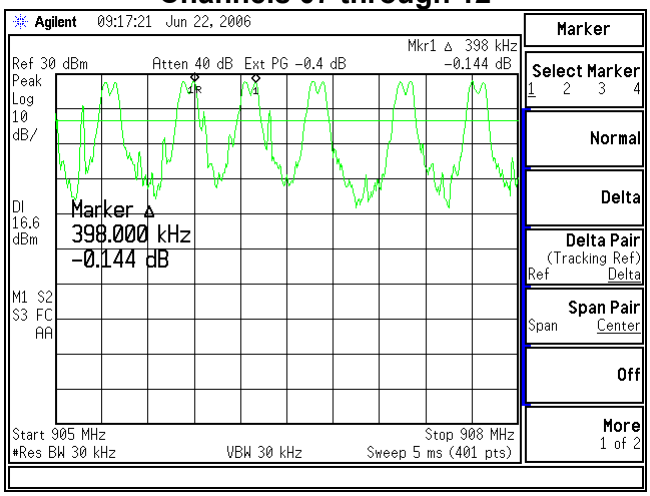
The system MEETS the minimum requirement of utilizing 50 channels, as well as maintaining a minimum channel separation of 398 kHz, which is greater than the -20 dBc OCCBW of 250 kHz.

13.2 Screen Captures – Channel Separation

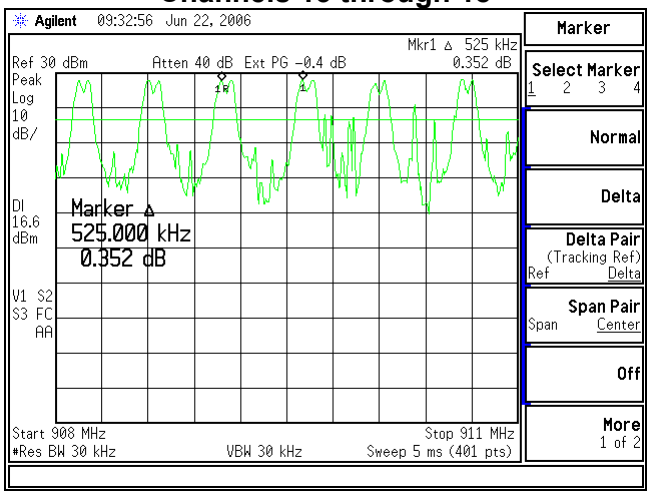
Channels 01 through 06



Channels 07 through 12

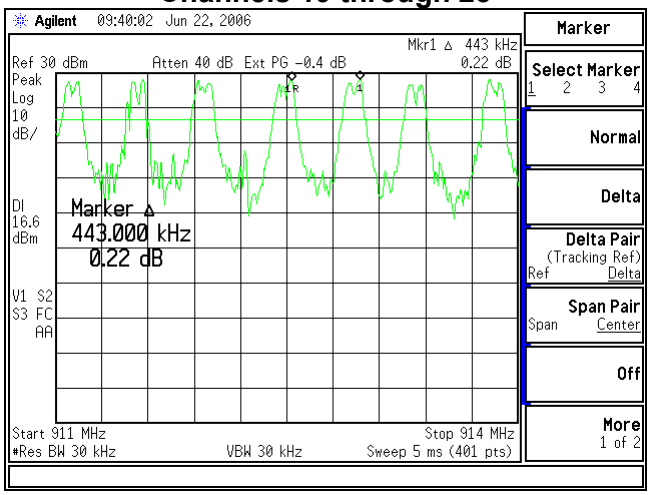


Channels 13 through 18

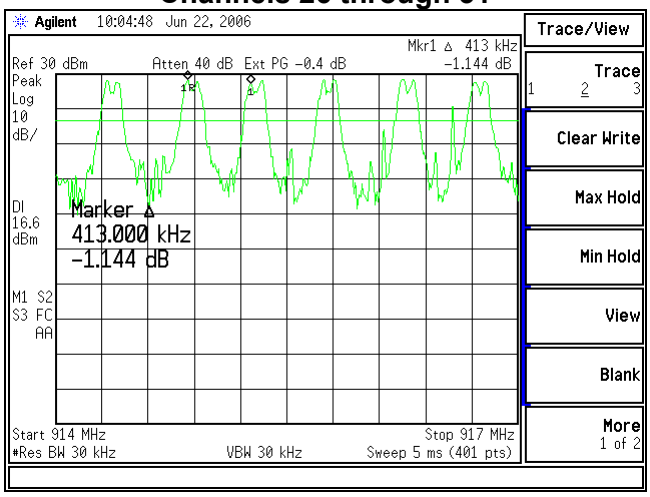


Screen Captures – Channel Separation *(continued)*

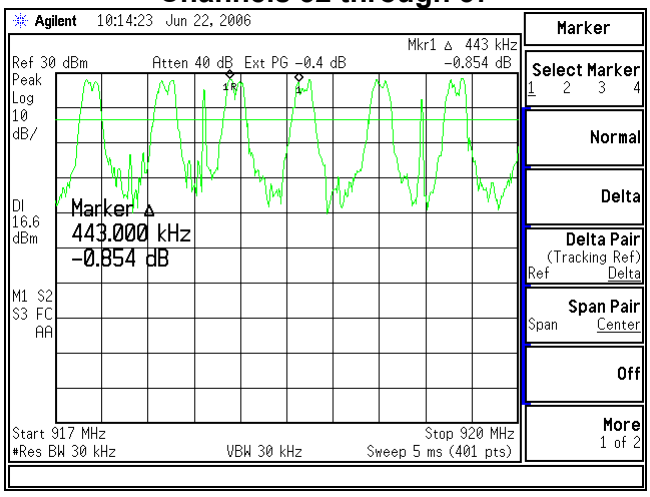
Channels 19 through 25



Channels 26 through 31

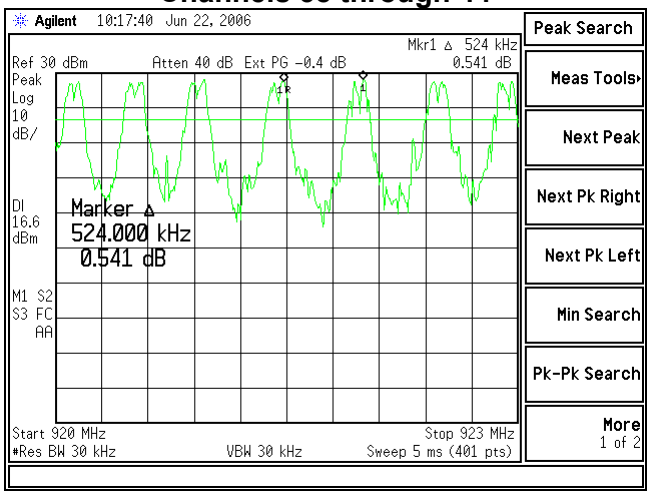


Channels 32 through 37

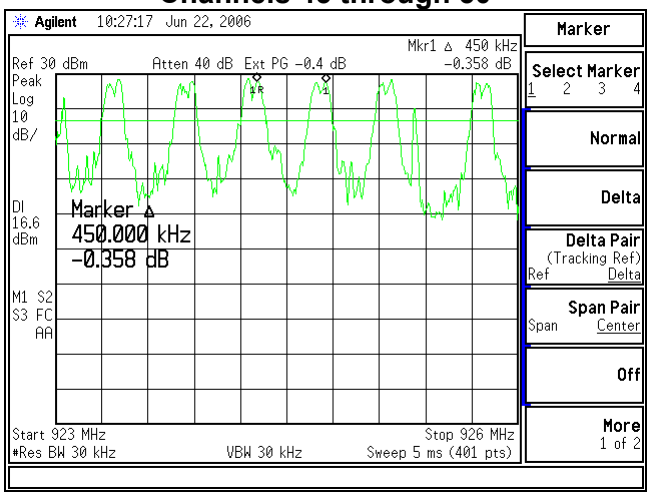


Screen Captures – Channel Separation *(continued)*

Channels 38 through 44



Channels 45 through 50



Frequency space above channel 50

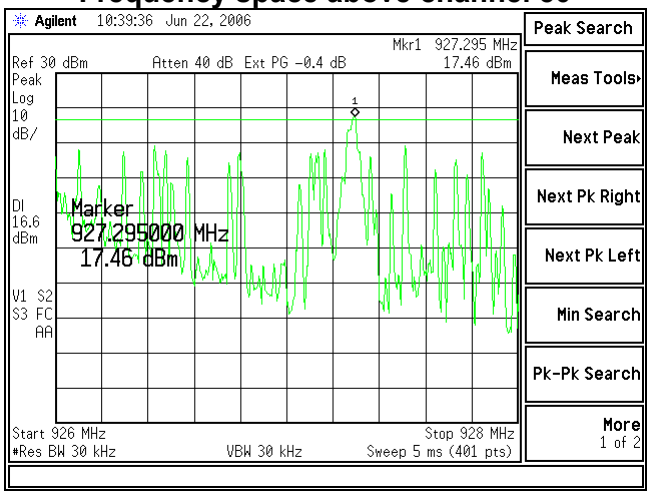


EXHIBIT 14. EQUAL CHANNEL USAGE

Currently, the system operates at 38.4 kilobaud. However, the radio is capable of operating at up to 76.8 kilobaud, and in the future this rate may be enabled with a software upgrade. Frequency hopping is handled in OSI level 2. When the network or application needs to send a packet, it initiates the request without regard to the position in the hop pattern, thus resulting in a system that does not favor one frequency over another over time. The one exception to this is that layers above OSI level 2 may wait for the next hop during the backoff-and-retry procedure. If a message is sent by the system to a node but no acknowledgment is received, the system waits for the next hop and resends the message. (Because the system simply waits for the next hop, whatever it happens to be, this procedure does not bias the system toward the use of a particular channel.)

Star nodes operate on a low duty cycle to conserve battery power, transmitting heartbeats to their parent Mesh nodes an average of once per minute. Most of the time, Star nodes are “asleep.” When they awaken, if they have messages to transmit, the Star nodes initiate communication, transmitting messages to their parent Mesh nodes to be propagated toward the host.

Mesh nodes do not normally propagate heartbeats or transmit “node present” messages when a heartbeat is heard. Instead, in order to limit bandwidth consumption, Mesh nodes propagate messages toward the host when a Star node's heartbeat is not heard.

EXHIBIT 15. PSEUDORANDOM HOPPING PATTERN

Sensicast's system utilizes frequency hopping among 50 possible channels (0-49). The system switches channels every 400 ms, or 2.5 times per second. The system hops according to a pseudorandom sequence. Supported sequences include:

Sequence A
20,42,8,33,1,37,15,49,14,34,16,31,7,36,21,48,9,41,23,5,22,39,13,38,18,
43,3,44,25,2,28,47,0,29,10,27,12,30,4,26,11,35,17,32,6,46,24,40,19,45

Sequence B
45,19,40,24,46,6,32,17,35,11,26,4,30,12,27,10,29,0,47,28,2,25,44,3,43,
18,38,13,39,22,5,23,41,9,48,21,36,7,31,16,34,14,49,15,37,1,33,8,42,20

Sequence C
9,30,14,1,24,40,18,34,15,5,45,28,46,4,25,35,0,39,10,20,38,13,31,12,48,
33,21,36,3,47,16,2,19,43,7,49,6,29,17,32,22,41,23,37,27,44,11,42,8,26

Sequence D
26,8,42,11,44,27,37,23,41,22,32,17,29,6,49,7,43,19,2,16,47,3,39,21,33,
48,12,31,13,38,20,10,39,0,35,25,4,46,28,45,5,15,34,18,40,24,1,14,30,9

Sequence E
45,30,0,29,14,46,28,6,35,4,43,11,49,9,38,12,34,13,36,18,3,21,42,27,10,
40,25,5,24,8,26,7,32,47,15,41,20,39,2,22,37,19,44,23,1,17,33,48,31,16

Sequence F
16,31,48,33,17,1,23,44,19,37,22,2,39,20,41,15,47,32,7,26,8,24,5,25,40,
10,27,42,21,3,18,36,13,34,12,38,9,49,11,43,4,35,6,28,46,14,29,0,30,45

Through the host software, the user can select which pseudorandom sequence is used. Currently, the entire network utilizes the same hop schedule.

EXHIBIT 16. MPE CALCULATIONS

Antenna Manufacturer: Antenna Factor
Model Number: ANT-916-SP
Declared Antenna Gain: 2.5 dBi

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:	28.90	(dBm)
Maximum peak output power at antenna input terminal:	776.247	(mW)
Antenna gain(typical):	2.5	(dBi)
Maximum antenna gain:	1.778	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	915	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	0.62	(mW/cm^2)

Power density at prediction frequency:	0.274619	(mW/cm^2)
Maximum allowable antenna gain:	6.0	(dBi)
Margin of Compliance at 20 cm =	3.5	dB

APPENDIX A

Test Equipment List

Asset #	Manufacturer	Model #	Serial #	Description	Date	Due
AA960008	EMCO	3816/2NM	9701-1057	Line Impedance Stabilization Network	9/27/05	9/27/06
AA960031	HP	119474A	3107A01708	Transient Limiter	Note 1	Note 1
AA960077	EMCO	93110B	9702-2918	Biconical Antenna	7/26/06	7/26/07
AA960078	EMCO	93146	9701-4855	Log-Periodic Antenna	7/20/06	7/20/07
AA960081	EMCO	3115	6907	Double Ridge Horn Antenna	12/07/05	12/07/06
CC00221C	Agilent	E4407B	US39160256	Spectrum Analyzer	12/29/05	12/29/06
EE960004	EMCO	2090	9607-1164	Device Controller	N/A	N/A
EE960013	HP	8546A	3617A00320	Receiver RF Section	9/29/05	9/29/06
EE960014	HP	85460A	3448A00296	Receiver Pre-Selector	9/29/05	9/29/06
EE960073	Agilent	E4446A	US45300564	Spectrum Analyzer	2/01/06	2/01/07
N/A	LSC	Cable	0011	3 Meter ½" Armored Cable	Note 1	Note 1
N/A	LSC	Cable	0050	10 Meter RG 214 Cable	Note 1	Note 1
N/A	Pasternack	Attenuator	N/A	10 dB Attenuator	Note 1	Note 1

Note 1 - Equipment calibrated within a traceable system.

Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k=2.

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 – Meter chamber, Biconical Antenna	4.24 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.8 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	1.128 Volts/Meter
Conducted Immunity	3 Volts level	1.0 V

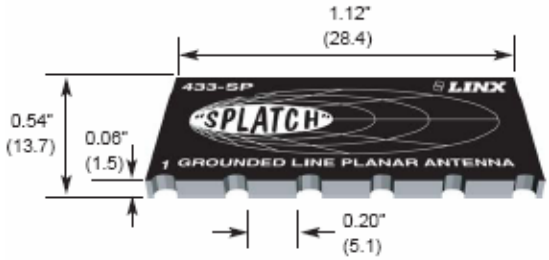
Appendix B

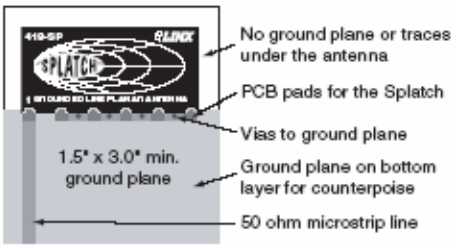
Antenna Specification(s)

ANTENNA FACTOR

ANT-916-SP DATA SHEET

Product Dimensions





Description

The Splatch uses a grounded-line technique to achieve outstanding performance from a tiny surface-mount element. This unique antenna is designed for hand or reflow mounting directly to a product's circuit board. Its low cost makes it ideal for volume applications. Unlike many compact antennas, the Splatch exhibits good proximity performance, making it an appropriate choice for hand-held applications such as remote controls, pagers, and alert devices. Typical performance is below that of many external antennas, but the Splatch is an excellent choice when cosmetic or mechanical issues dictate the use of an internal antenna.

Features

- Ultra-compact package
- Very low cost
- Ideal for concealed/internal mounting
- Suitable for hand or reflow assembly
- Perfect for compact portable devices
- Resistant to proximity effect
- Direct PCB attachment*
  * 1.5" x 3.0" minimum ground plane

Electrical Specifications

- Center Freq. 916MHz
- Bandwidth 30MHz
- Wavelength 1/4-wave
- VSWR <1.9 typ. at center
- Impedance 50 ohms
- Gain TBD
- Connection Surface-mount

Note: Electrical specifications and plots measured on a 1.50" x 3.29" ground plane

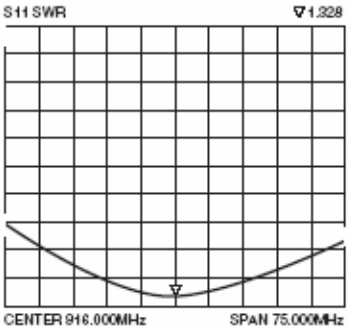
Ordering Information

- ANT-916-SP (supplied in tubes of 20 pcs.)

Plots

Azimuth

Elevation



Typical VSWR

Antenna Factor 575 S.E. Ashley Place Grants Pass, OR 97526-3237 www.antennafactor.com
541-956-0931 (phone) 541-471-6251 (fax)

Rev 07-28-05