EMISSIONS TEST REPORT FOR A LOW POWER TRANSMITTER

I. GENERAL INFORMATION

Requirement:	FCC, Industry Canada
Test Requirements:	FCC: Part 2, Part 15 IC: RSS-Gen, RSS-210,
Applicant:	Silver Spring Networks 575 Broadway Street Redwood City, CA 94063
FCC ID:	**OWS-IMU520**
IC:	**5975A-IMU520**
Model No.:	221-020001 rev 01

II. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

The Silver Spring Networks (SSN) IMU520 is a battery-operated radio module for gas meter communications use. The board incorporates a 900 MHz FHSS radio.

III. TEST DATES AND TEST LOCATION

Antenna port conducted were performed at Silver Spring Networks on 23 March 2011.

Radiated emissions tests above 1 GHz were performed 12 October and 7 November 2011 at BACL in Sunnyvale, CA

T.N. Cokenias 27 December 2011
EMC Consultant/Agent for Silver Spring Networks

15.203 Antenna connector requirement

The EUT uses a custom permanently attached integral antenna,

Antenna description	Mfr.	Model No.	Gain
Built-in sheet metal	SSN	n/a	1dBi at 915 MHz

TEST PROCEDURES

All tests were performed in accordance with the applicable procedures called out in the following documents, unless otherwise noted:

FCC 47CFR15

RSS-Gen, Issue 3: General Requirements and Information for the Certification of Radio Apparatus (December 2010)
RSS-210 Issue 8: Low power license exempt radio frequency devices (December 2010)
RSS-212: Test Facilities and Test Methods for Radio Equipment

ANSI C63.4 – 2003, 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.

Tests were performed at three frequencies:

Channel 0 (LOW) – 902.3 MHz
Channel 43 (MID) -915.2 MHz
Channel 82 (HIGH) – 926.9 MHz

Test Equipment

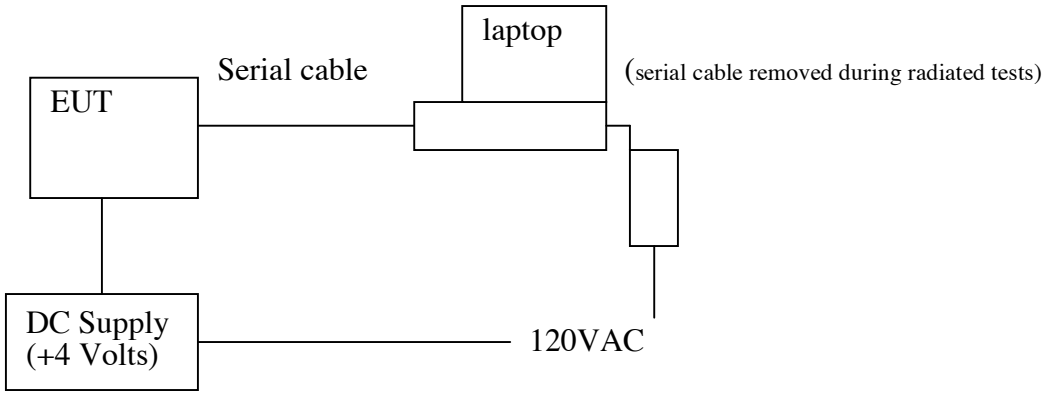
Silver Spring Networks:

Equipment	Mfr	Model	Serial No.	Cal Due
Spectrum analyzer	Agilent	E44053	MY45113391	10/19/11
Spectrum analyzer	Agilent	EXA	MY48030147	10/19/11

BACL

DESC.	Model	Freq. Range	Mfr	Serial No.	Last Cal	Cal Due
Antenna, Biconi-Log	JB3	30 - 3000MHz	Sunol Sciences	A020106-2	2011-08-10	2012-08-10
Amplifier	ZVA-183-S	1-18 GHz	Mini-Circuits	570400946	2011-05-09	2012-05-09
Amplifier, Pre	8447D	0.1-1300 MHz	HP	2944A06639	2011-06-09	2012-06-09
Antenna, Horn	3115	1-18 GHz	EMCO	9511-4627	2011-10-03	2012-10-03
Analyzer, Spectrum	E4440A	3Hz - 26.5GHz	Agilent	MY44303352	2011-05-10	2012-05-10

Test Set-up Diagram



Support Equipment

Equipment	Mfr	Model	Asset No.
DC Power Supply	Agilent	E3610A	2844
Laptop PC	Dell	PP01L	TW-0791UH1280-OC9-6558
AC/DC adapter	CUI Inc.	DSA-60W-20	2607HB

FREQUENCY HOPPING SPREAD SPECTRUM RADIO EMISSIONS

TEST RESULTS
Radiated Test Set-up, 30 MHz-9.3 GHz
FCC: 15.109, 15.205, 15.209
IC: RSS-Gen, Sec. 6.1, 7.7.2

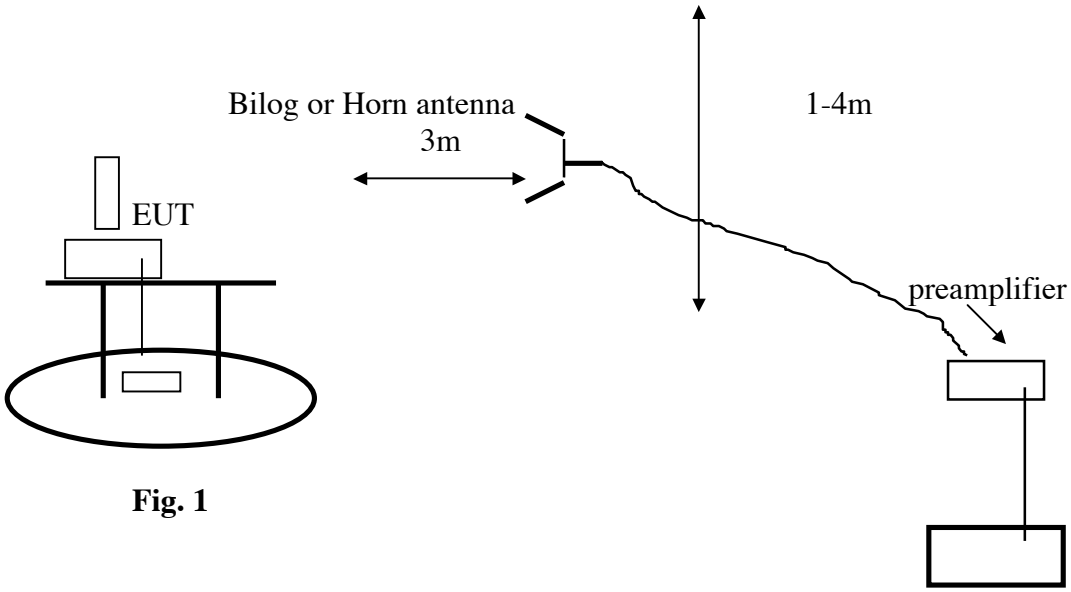


Fig. 1

Test Procedures

Radiated emissions generated by the transmitter portion of the EUT were measured.

1. The EUT was placed on a wooden table resting on a turntable on the test site. The search antenna was placed 3m from the EUT. The EUT antenna was mounted in the with the EUT TX antenna pointed directly to the search antenna.

2. The turntable was slowly rotated to locate the direction of maximum emission at each emission falling in the restricted bands of 15.205.

3. Emissions were investigated to the 10^{th} harmonic of the fundamental.

4. Once maximum direction was determined, the search antenna was raised and lowered in both vertical and horizontal polarizations. The maximum readings so obtained are recorded in the data listed below.

Test Results: Worst-case results are presented. Refer to data sheets below. Restricted band emissions meet 54 dBuV/m. Other undesired emissions from the transmitter meet the -20 dBc requirement in 15.247(d).

15.205 Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505 (1)	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 -	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.52525	2655 - 2900	22.01 - 23.12
8.41425 - 8.41475	156.7 - 156.9	3260 - 3267	23.6 - 24.0
12.29 - 12.293	162.0125 - 167.17	3332 - 3339	31.2 - 31.8
12.52075 - 12.52025	167.72 - 173.2	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	240 - 285	3600 - 4400	
13.36 - 13.41	322 - 335.4		

15.209 General Field Strength Limits

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F (kHz)	300
0.490 - 1.705	24000/F (kHz)	30
1.705 - 30.0	30	30
30 - 88	100 **	3
88 - 216	150 **	3
216 - 960	200 **	3
Above 960	500	3

Transmitter Radiated Emissions Above 1 GHz

Company: Silver Spring Network
Project number: T1109233
Frequency range: 902.3-926.9 MHz
measurement: Spurious Emission above 1GHz
Date: 10-12-2011
Tester: Quinn Jiang

American: Mac: 0013500200059E99

Middle Channel: 915.2 Mhz

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	Part 15C		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
2745	47.3	313	188	H	28.574	3.97	27.57	52.274	74	-21.726	Peak
2745	43.79	348	181	V	28.574	3.97	27.57	48.764	74	-25.236	Peak
2745	43.35	313	188	H	28.574	3.97	27.57	48.324	54	-5.676	Avg
2745	37.86	348	181	V	28.574	3.97	27.57	42.834	54	-11.166	Avg
3660	47.57	127	160	H	30.862	4.6	26.93	56.102	74	-17.898	Peak
3660	47.56	45	161	V	30.862	4.6	26.93	56.092	74	-17.908	Peak
3660	44.18	127	160	H	30.862	4.6	26.93	52.712	54	-1.288	Avg
3660	45.11	45	161	V	30.862	4.6	26.93	53.642	54	-0.358	Avg

from prescan (peak): 1825 MHz: approx 50 dbuV
4570 MHz: approx 40.8 dbuV

High Channel: 926.9 MHz

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	Part 15C		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
3707	41.17	319	178	H	31.481	4.79	27.19	50.251	74	-23.749	Peak
3707	41.51	47	52	V	31.427	4.79	27.19	50.537	74	-23.463	Peak
3707	31.41	319	178	H	31.481	4.79	27.19	40.491	54	-13.509	Avg
3707	32.55	47	52	V	31.427	4.79	27.19	41.577	54	-12.423	Avg

11/7/2011 w/o serial cable

LC 902.3 MHz

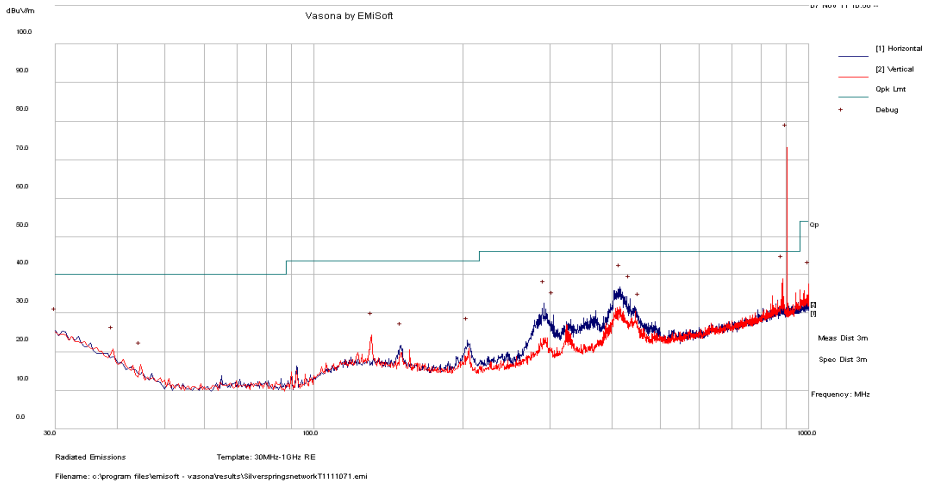
Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	Part 15C		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
2707	46.45	200	100	H	28.574	3.97	27.57	51.424	74	-22.576	Peak
2707	45.31	164	108	V	28.395	3.97	27.57	50.105	74	-23.895	Peak
2707	43.02	200	100	H	28.574	3.97	27.57	47.994	54	-6.006	Avg
2707	40.99	164	108	V	28.395	3.97	27.57	45.785	54	-8.215	Avg

TX Radiated Emissions Below 1 GHZ

Worst case: Low channel

30MHz-1GHz Scan

LC 902.3 MHz



Vasona Data : List of Debug Frequencies

No	Frequency MH	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement	Pol	Limit dBuV/m	Margin dB
1	902.515	61.7	13.47	-1.88	73.28	Peak [Scan]	V	46	27.28
2	883.6	28.09	13.35	-2.52	38.92	Peak [Scan]	V	46	-7.08
3	415.09	33.28	12.05	-8.62	36.71	Peak [Scan]	H	46	-9.29
4	434.975	29.9	12.08	-8.22	33.76	Peak [Scan]	H	46	-12.24
5	291.415	32.25	11.56	-11.31	32.5	Peak [Scan]	H	46	-13.5
6	30	18.5	10.02	-3.04	25.48	Peak [Scan]	H	40	-14.52
7	304.025	29.05	11.63	-11.08	29.6	Peak [Scan]	H	46	-16.4
8	998.545	24.97	13.83	-1.28	37.52	Peak [Scan]	V	54	-16.48
9	453.405	25.26	12.09	-8.13	29.22	Peak [Scan]	H	46	-16.78
10	130.88	24.61	10.74	-11.04	24.31	Peak [Scan]	V	43.5	-19.19
11	39.215	20.94	10.09	-10.37	20.66	Peak [Scan]	V	40	-19.34
12	204.115	24.77	11.13	-12.98	22.92	Peak [Scan]	H	43.5	-20.58
13	149.795	22.9	10.86	-12.16	21.6	Peak [Scan]	H	43.5	-21.9
14	44.55	20.56	10.13	-14.07	16.62	Peak [Scan]	V	40	-23.38

Receiver Radiated Emissions

All emissions 30 MHz - 9.3 GHz more than 20 dB below limits

20 dB Bandwidth and 99% Occupied Bandwidth

FCC: 15.247(a) 1(i)
IC: RSS-210 A8.1, RSS-Gen 4.6.1

LIMIT

500 kHz maximum

99% Bandwidth

RSS-210, RSS-Gen

LIMIT

None, for reporting purposes only

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The analyzer OCC BW function was activated to measure and display both the -20 dB and the 99% Occupied Bandwidth.

RESULTS

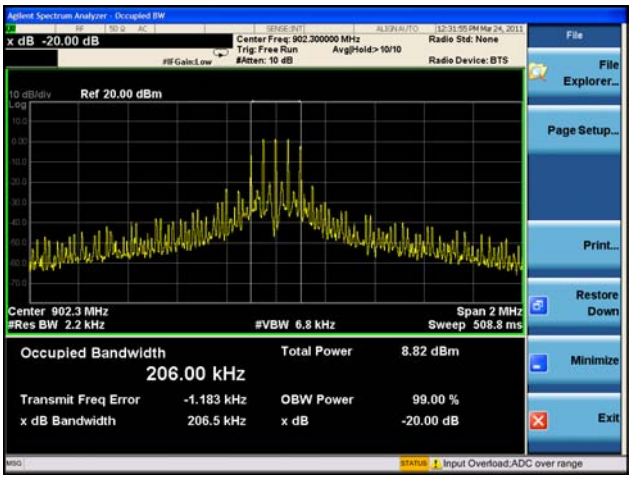
No non-compliance noted:

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	902.3	206.5
Middle	915.2	206.3
High	926.9	205.9

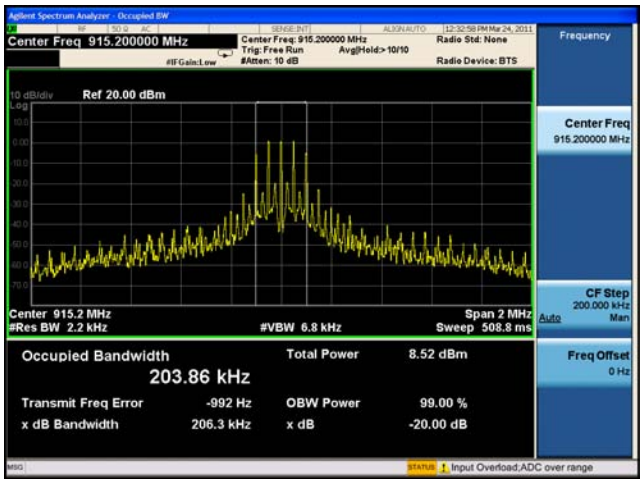
Channel	Frequency (MHz)	99% Occ BW (kHz)
Low	902.3	206
Middle	915.2	203.86
High	926.9	203.71

Emission Designator: 206KF1D

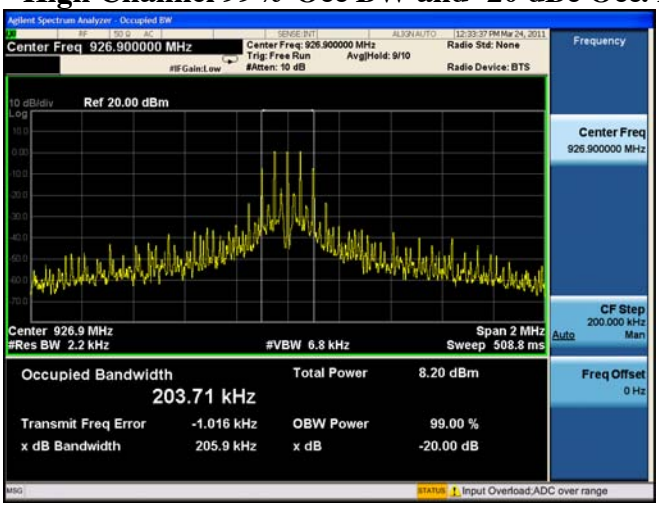
Low Channel 99% and -20 dBc Occ. BW



Mid Channel 99% Occ BW and -20 dBc Occ. BW



High Channel 99% Occ BW and -20 dBc Occ. BW



Emission designator: 206KF1D

HOPPING FREQUENCY SEPARATION

FCC: 15.247(a) 1
IC: RSS-210 A8.1 (a)

LIMIT

§15.247 (a) (1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping channel, whichever is greater.

TEST PROCEDURE

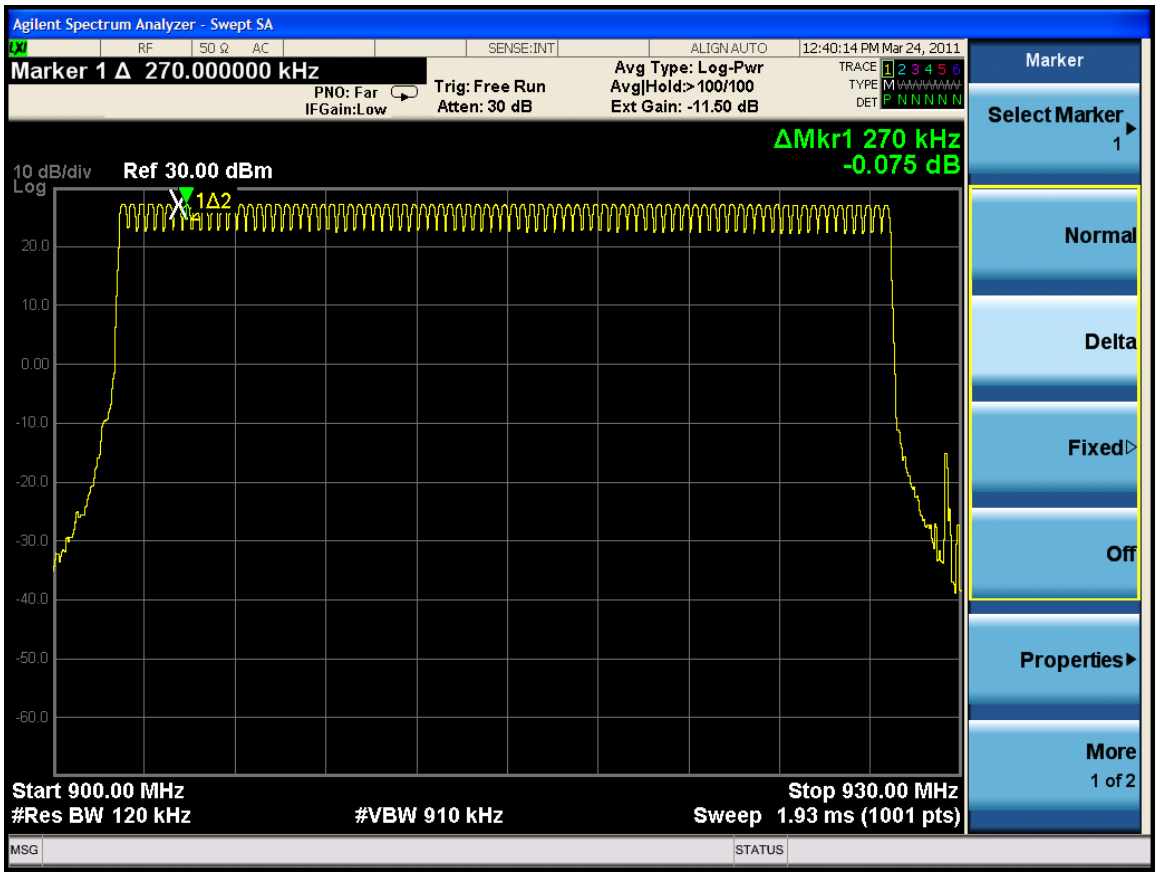
The transmitter output is connected to a spectrum analyzer. The RBW is set to 120 kHz and the VBW is set to 910 kHz. The sweep time is coupled.

RESULTS

No non-compliance noted:

The separation is 270 kHz.

HOPPING FREQUENCY SEPARATION



NUMBER OF HOPPING CHANNELS

FCC: 15.247 (a) 1(i)
IC: RSS 210 A8.1 (b)

LIMIT

§15.247 (a) (1) (i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to 30 kHz. The analyzer is set to Max Hold.

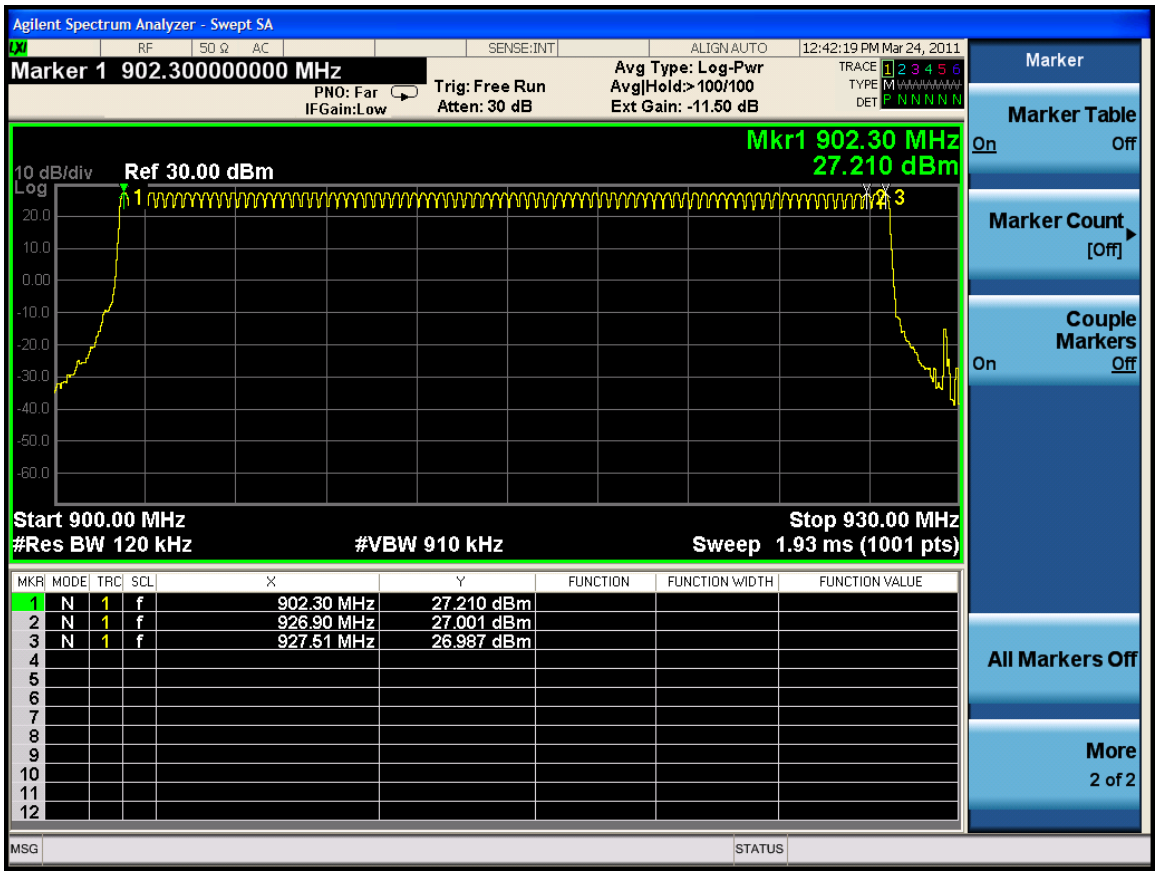
RESULTS

No non-compliance noted:

87 channels total, channels 0-82 are US channels (902.3 – 926.9 MHz). Channels 43 – 86 are frequencies authorized for use in Australia.

83 total US channels.

NUMBER OF HOPPING CHANNELS



AVERAGE TIME OF OCCUPANCY

FCC: 15.247(a) 1(i)
IC: RSS 210 A8.1(c)

LIMIT

§15.247 (a) (1) (i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 20 second scan, to enable resolution of each occurrence.

RESULTS

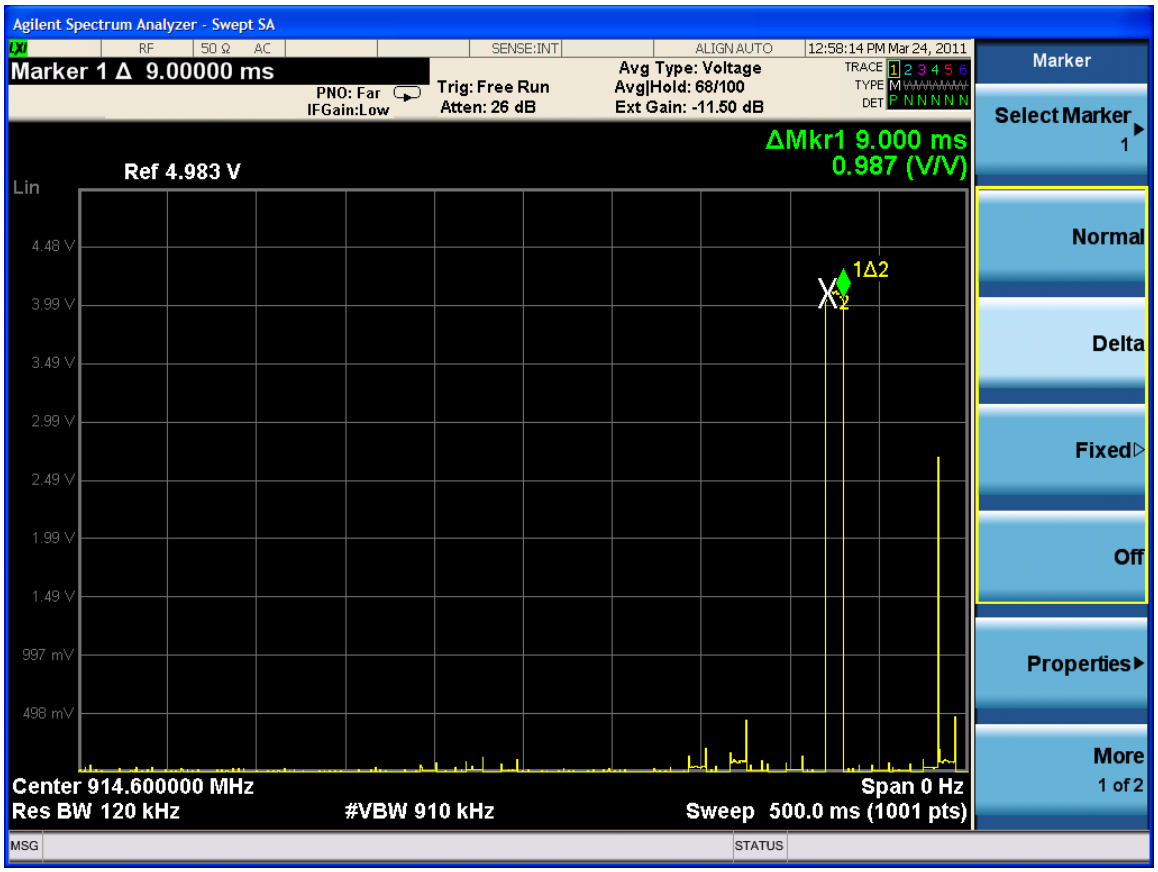
No non-compliance noted:

There are 2 pulse2 within the 20-second period. The on time for each pulse is 19 msec.

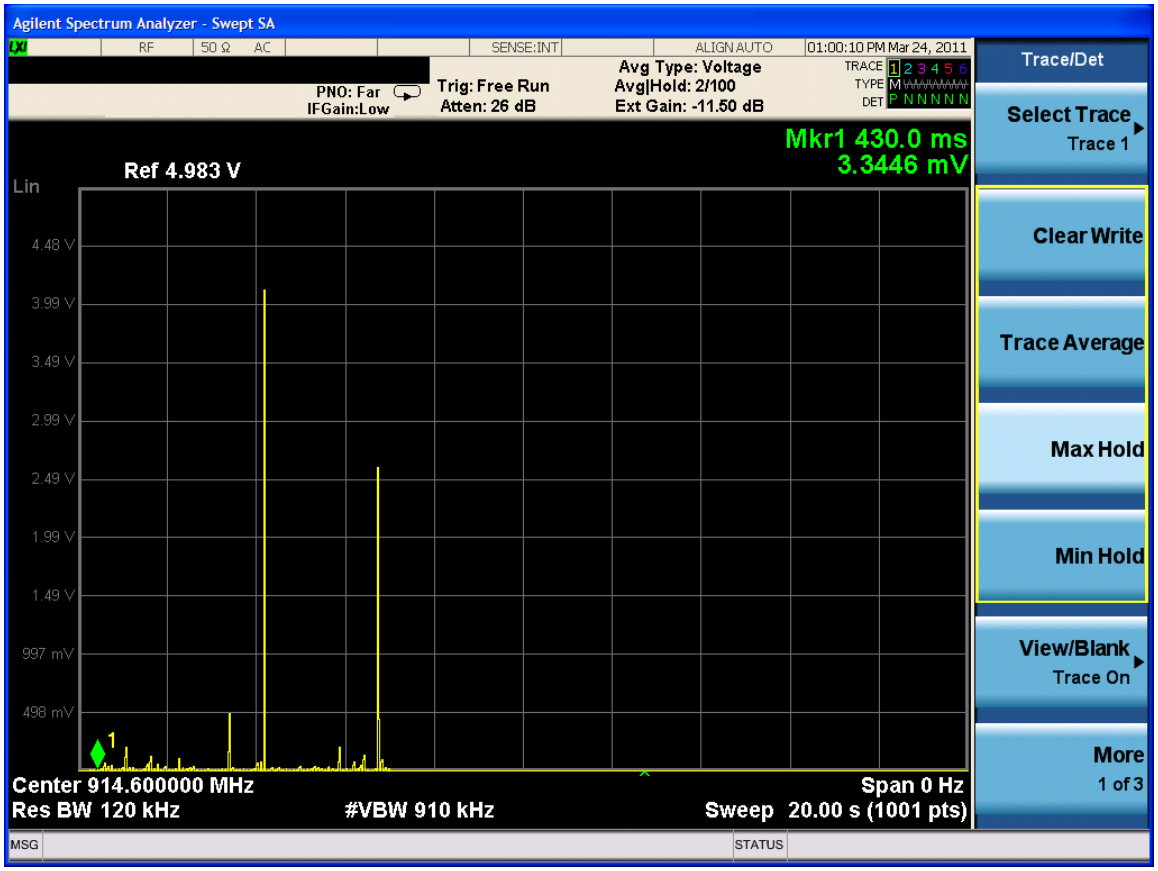
Therefore, the average time of occupancy in the specified 20-second period is 38 msec.

Limit: 400 msec

PULSE WIDTH


Agilent Spectrum Analyzer - Swept SA
RF
50 Ω AC
SENSE:INT
ALIGN AUTO
12:58:14 PM Mar 24, 2011
Marker 1 Δ 9.00000 ms
PNO: Far
IFGain:Low
Trig: Free Run
Atten: 26 dB
Avg Type: Voltage
Avg|Hold: 68/100
Ext Gain: -11.50 dB
TRACE 1 2 3 4 5 6
TYPE M
DET P N N N N N
ΔMkr1 9.000 ms
0.987 (V/V)
Ref 4.983 V
Lin
4.48 V
3.99 V
3.49 V
2.99 V
2.49 V
1.99 V
1.49 V
997 mV
498 mV
1Δ2
Center 914.600000 MHz
Res BW 120 kHz
#VBW 910 kHz
Span 0 Hz
Sweep 500.0 ms (1001 pts)
MSG
STATUS
Marker
Select Marker 1
Normal
Delta
Fixed
Off
Properties
More 1 of 2

NUMBER OF PULSES IN 20 SECOND OBSERVATION PERIOD



PEAK OUTPUT POWER

FCC: 15.247(b) 2
RSS-210 A8.4 (1)

The maximum antenna gain is 1 dBi, the number of hopping channels is over 50, therefore the power limit is 30 dBm.

TEST PROCEDURE

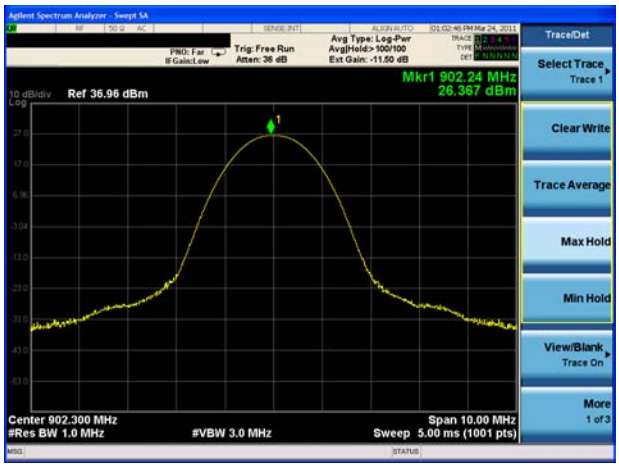
The transmitter output is connected to a spectrum analyzer and the analyzer bandwidth is set to a value greater than the 20 dB bandwidth of the EUT.

RESULTS

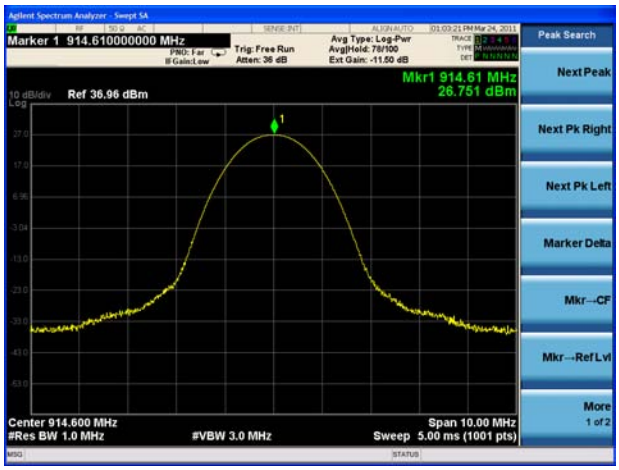
No non-compliance noted:

Channel	Frequency	P out, dBm	Pout, watts
Low	902.3	26.37	0.434
Mid	915.2	26.75	0.473
High	926.9	26.65	0.462

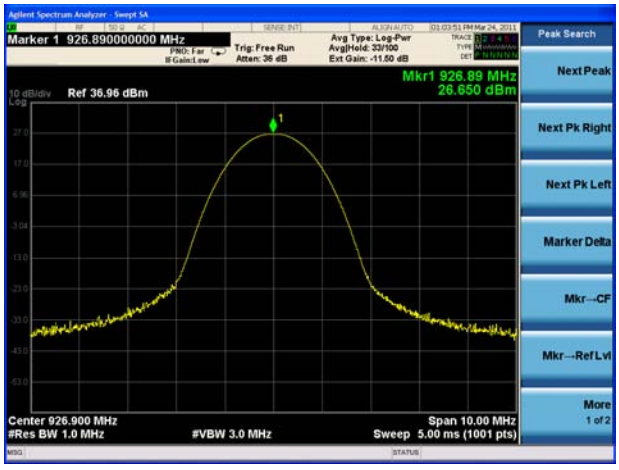
OUTPUT POWER LOW CHANNEL



OUTPUT POWER MID CHANNEL



OUTPUT POWER HIGH CHANNEL



MAXIMUM PERMISSIBLE EXPOSURE

FCC: 1.1310
IC: RSS-102

LIMITS

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*($900/f^2$)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*($180/f^2$)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density
NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

CALCULATIONS

Given

$E = \sqrt{(30 * P * G) / d}$

and

$S = E \wedge 2 / 3770$

where

E = Field Strength in Volts/meter
P = Power in Watts
G = Numeric antenna gain
d = Distance in meters
S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$d = \sqrt{((30 * P * G) / (3770 * S))}$

Changing to units of Power to mW and Distance to cm, using:

P (mW) = P (W) / 1000 and
d (cm) =100 * d (m)

yields

$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$
$d = 0.282 * \sqrt{(P * G / S)}$

where

d = distance in cm
P = Power in mW
G = Numeric antenna gain
S = Power Density in mW/cm^2

Substituting the logarithmic form of power and gain using:

P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (dBi) / 10)

yields

$d = 0.282 * 10 \wedge ((P + G) / 20) / \sqrt{S}$ Equation (1)

where

d = MPE distance in cm
P = Power in dBm
G = Antenna Gain in dBi
S = Power Density Limit in mW/cm^2

Equation (1) and the measured peak power is used to calculate the MPE distance.

LIMITS

From §1.1310 Table 1 (B), S = 0.6 mW/cm^2

RESULTS

No non-compliance noted:

Power Density Limit (mW/cm^2)	Output Power (dBm)	Antenna Gain (dBi)	S, mW/cm2 at 20cm
0.6	26.75	1.00	0.12

MPE Distance: 8.89 cm

NOTE: For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC: 15.247 (c)
IC: RSS 210 A8.5

TEST PROCEDURE

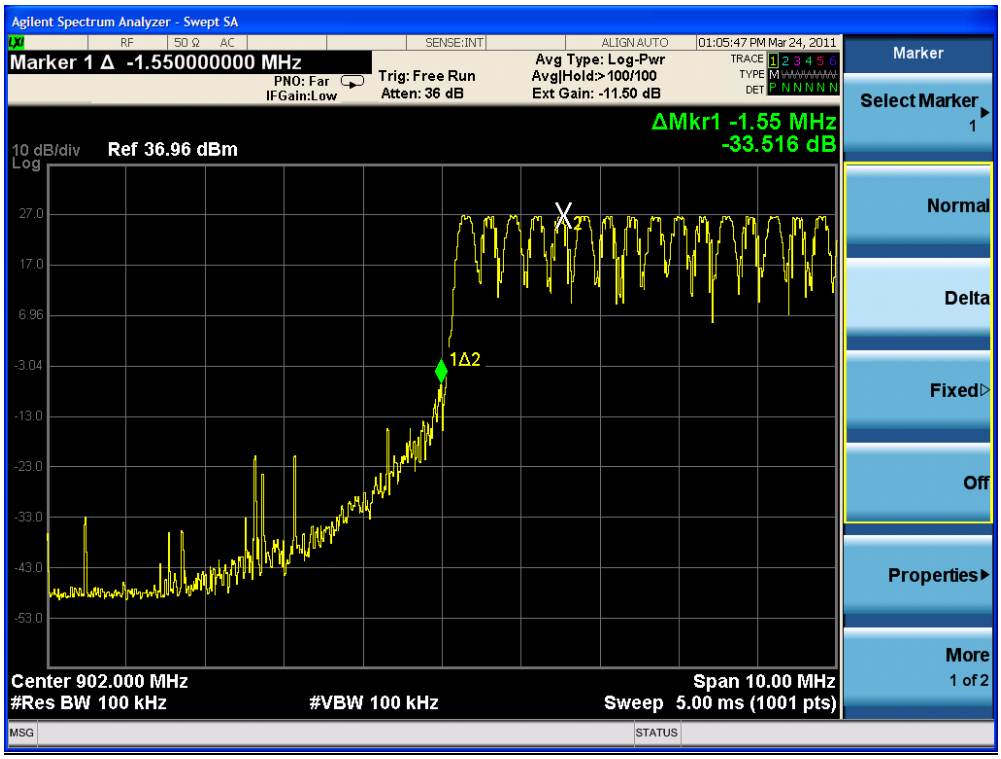
The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 100 kHz.

The spectrum from 30 MHz to 10 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

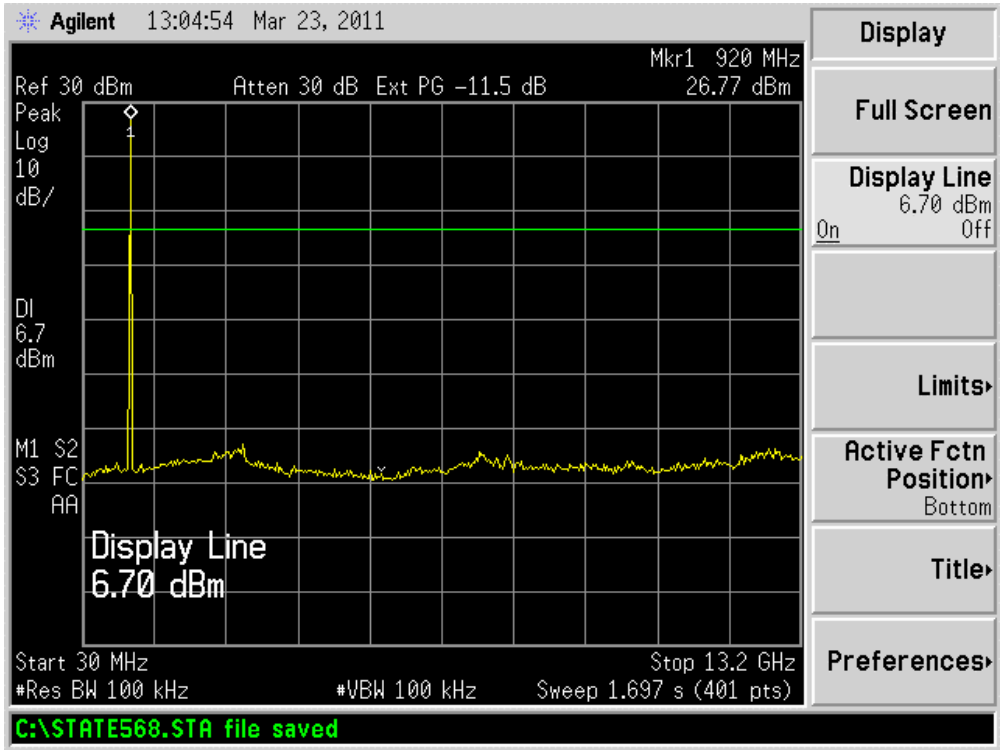
RESULTS

No non-compliance noted:

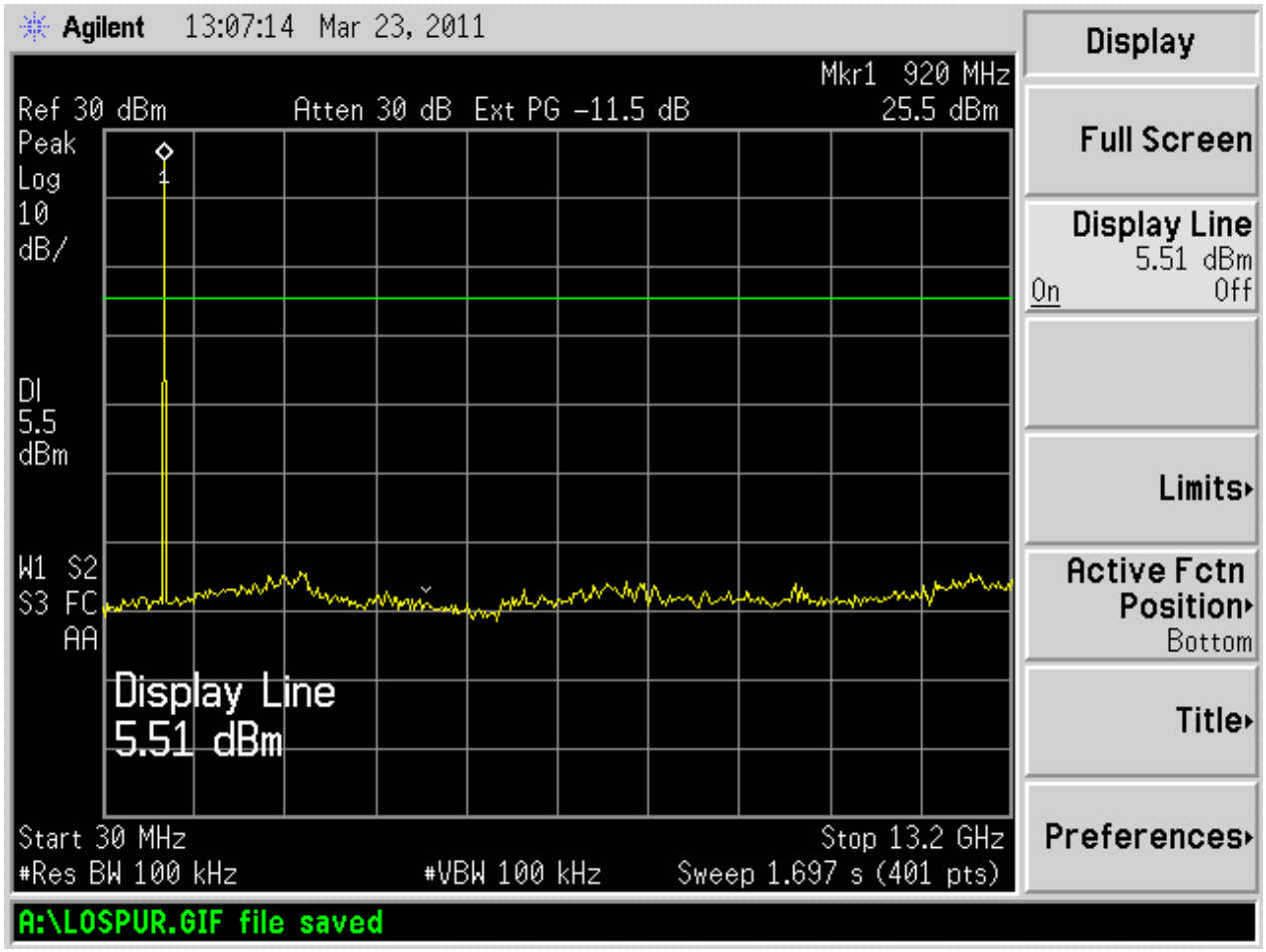
SPURIOUS EMISSIONS, LOW CHANNEL, HOPPING



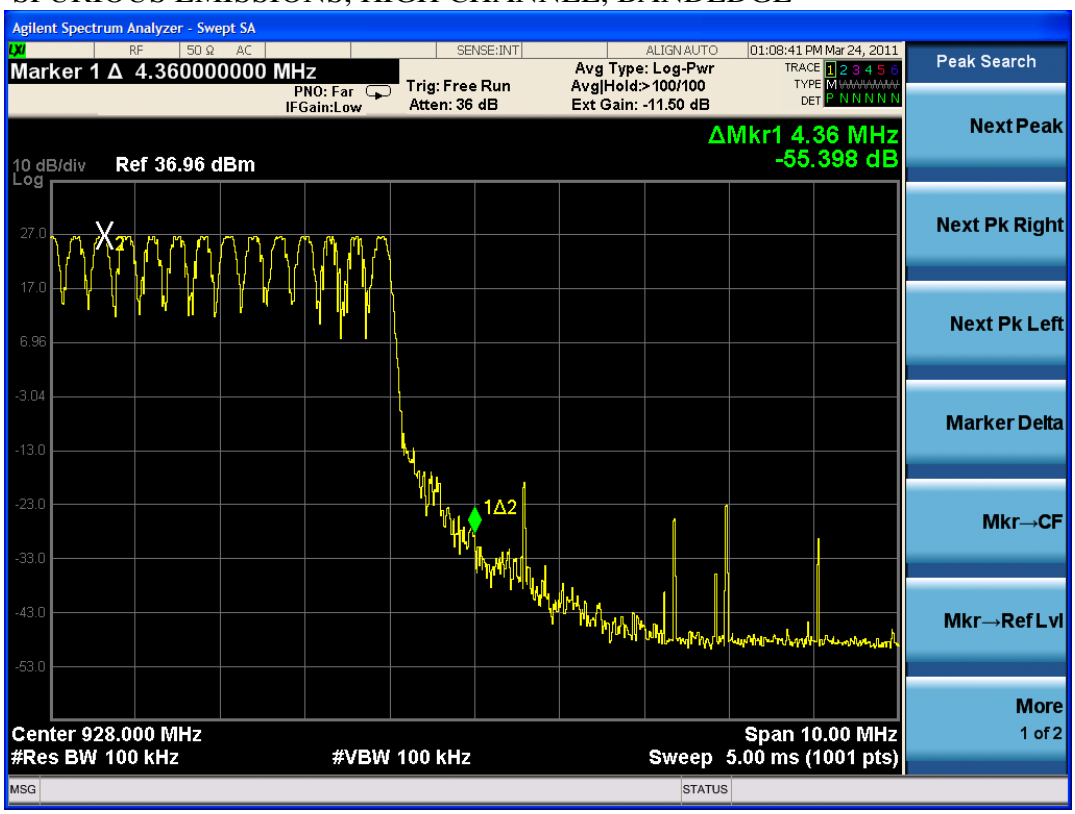
SPURIOUS EMISSIONS, LOW CHANNEL



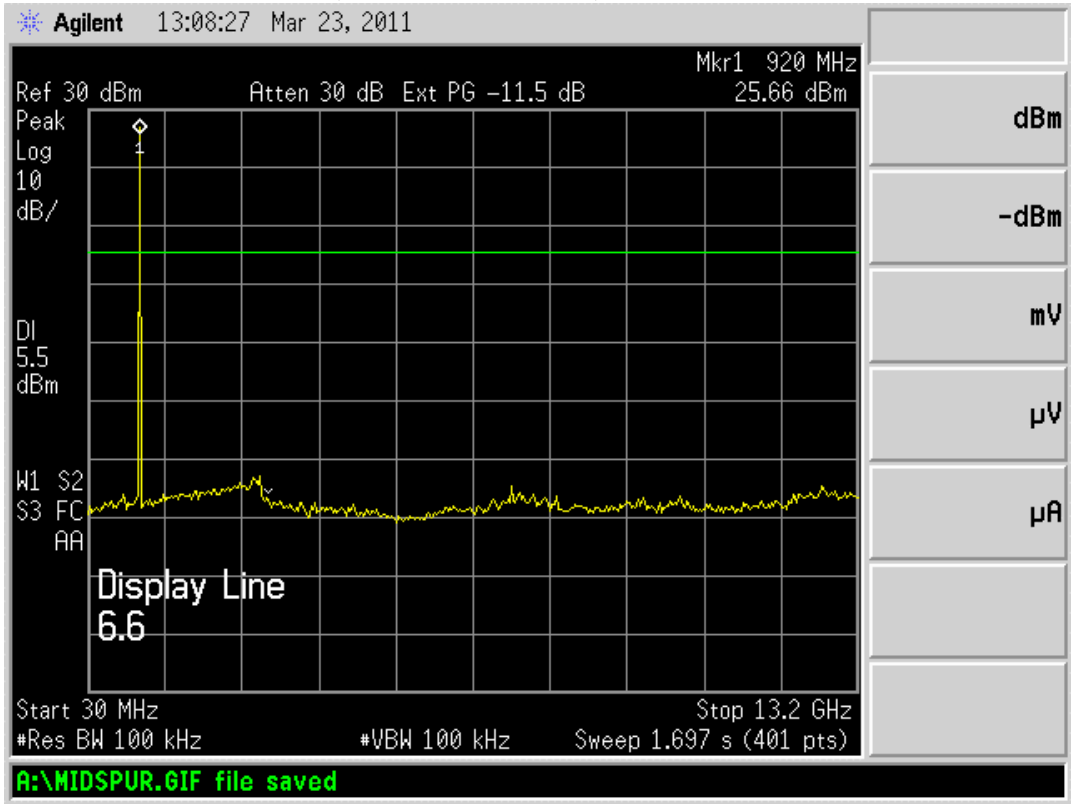
SPURIOUS EMISSIONS, MID CHANNEL



SPURIOUS EMISSIONS, HIGH CHANNEL, BANDEDGE



SPURIOUS EMISSIONS, HIGH CHANNEL, HOPPING



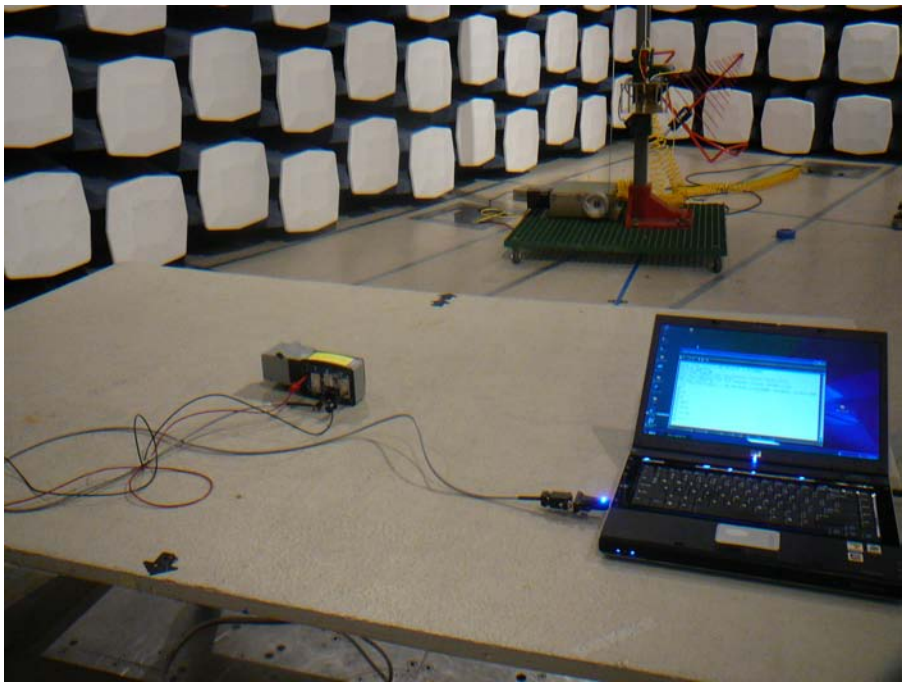
4.4 POWERLINE CONDUCTED EMISSIONS

LIMIT

FCC: 15.207
IC: RSS-Gen Sec. 7.2.4

TEST NOT REQUIRED. EUT is battery powered only.

SETUP PHOTOS



NOTE: Laptop and serial cable were removed after EUT parameters were set and the EUT was transmitting continuously at the desired channel and power.

END OF REPORT

Report Revision History

Revision No.	Revision Description	Pages Revised	Revised by	Date
-	Initial release		T. Cokenias	12/27/2011