

## **EMISSIONS TEST REPORT FOR A LOW POWER TRANSMITTER**

### **I. GENERAL INFORMATION**

Requirement: FCC, Industry Canada  
Test Requirements: FCC Part 15, RSS-Gen, RSS-210

Applicant: SONOS, INC.  
223 E. De La Guerra  
Santa Barbara, CA 93101

FCC ID: SBVRM002  
IC: 5373A-RM002  
Model No.: WMP-N06

### **II. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)**

The Sonos WMP-N06 is a 2.4 GHz 3x3 MIMO radio module operating in accordance with provisions in IEEE 802.11n.

Testing was performed for the purpose of qualifying two new antenna sets for use with this module, the "Avalon" antenna set and the "Wembley" antenna set. For these antenna sets, only two transmit modes are supported:

802.11g, 24 Mbps, CDD  
802.11 HT20 3x3 MIMO, MCS9

### **III. TEST DATES AND TEST LOCATION**

Testing was performed 7,8, 12 and 17 October. Tests were performed at:

Compliance Certification Services  
47173 Benicia Street  
Fremont, CA 94538



T.N. Cokenias  
EMC Consultant/Agent for Sonos Inc.

6 December 2009

### 15.203 Antenna description

The Avalon and Wembley antenna sets consists of 3 monopole antennas mounted on pcbs, one for each transmitter chain, with integral antenna cables of differing lengths. Maximum antenna gains for each monopole/cable combination are listed below

#### Avalon Antenna Set

Antenna description	Gain, dBi
Chain 1 antenna	1.0
Chain 2 antenna	2.26
Chain 3 antenna	0.79

#### Wembley Antenna Set

Antenna description	Gain, dBi
Chain 1 antenna	0.46
Chain 2 antenna	1.99
Chain 3 antenna	0.79

### TEST PROCEDURES

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

FCC 47CFR15

RSS-210 Issue 7: Low power license exempt radio frequency devices (July 2007)

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.

FCC KDB 558074: DTS Measurement, published on Apr 16 2007

Tests were performed at three frequencies:

LOW: Channel 1 2412 MHz

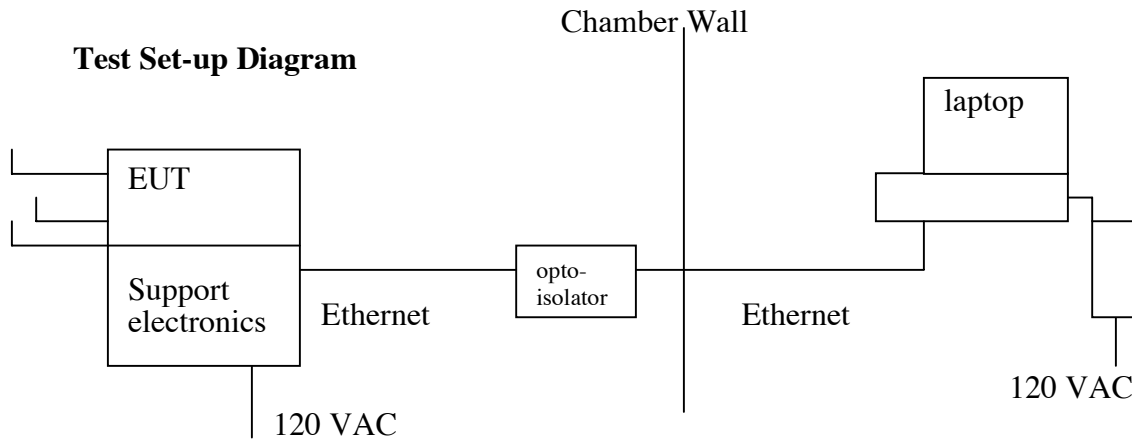
MID: Channel 6 2437 MHz

HIGH: Channel 11 2462 MHz

**Test Equipment**

Compliance Certification Services:

TEST EQUIPMENT LIST				
Description	Manufacturer	Model	Asset Number	Cal Due
Spectrum Analyzer, 44 GHz	Agilent / HP	E4446A	C01069	01/05/10
Antenna, Bilog, 2 GHz	Sunol Sciences	JB1	C01011	01/14/10
Preamplifier, 1300 MHz	Agilent / HP	8447D	C00885	12/16/09
Antenna, Horn, 18 GHz	EMCO	3115	C00945	01/29/10
Preamplifier, 26.5 GHz	Agilent / HP	8449B	C01052	02/04/10



**Support Equipment**

Equipment	Mfr	Model
DC Power Supply	Apple	A1021
Laptop	Apple	PP01L
Support electronics for power and I/O	Sonos	TBD

## TEST RESULTS

### Radiated Test Set-up, 30 MHz-25 GHz

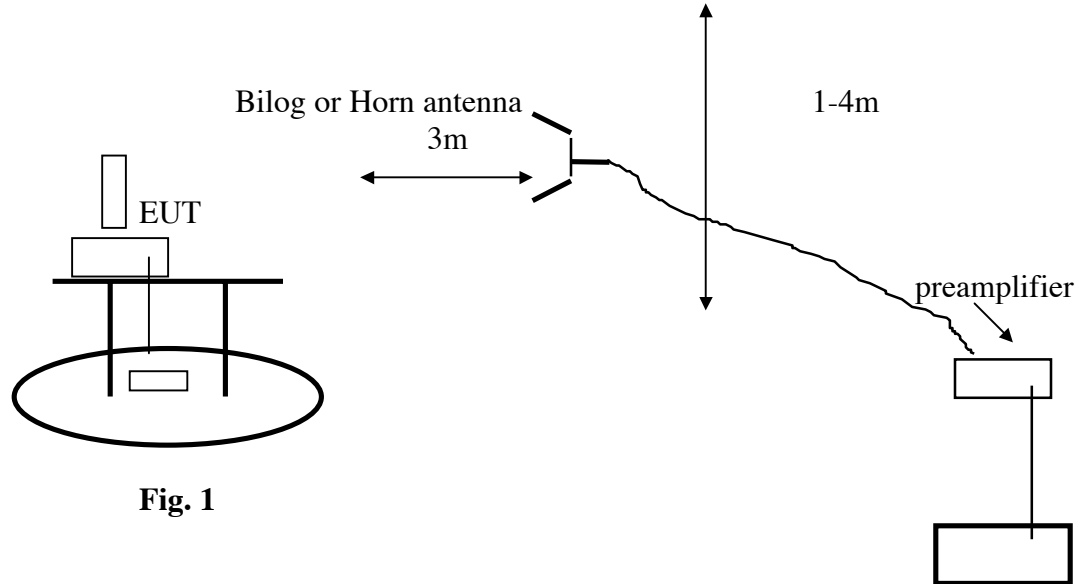


Fig. 1

### Test Procedures

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

1. The EUT was placed on a non-conductive 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<sup>th</sup> 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**

<b>MHz</b>	<b>MHz</b>	<b>MHz</b>	<b>GHz</b>
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
12.51975 - 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**

<b>Frequency (MHz)</b>	<b>Field Strength (microvolts/meter)</b>	<b>Measurement Distance (meters)</b>
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

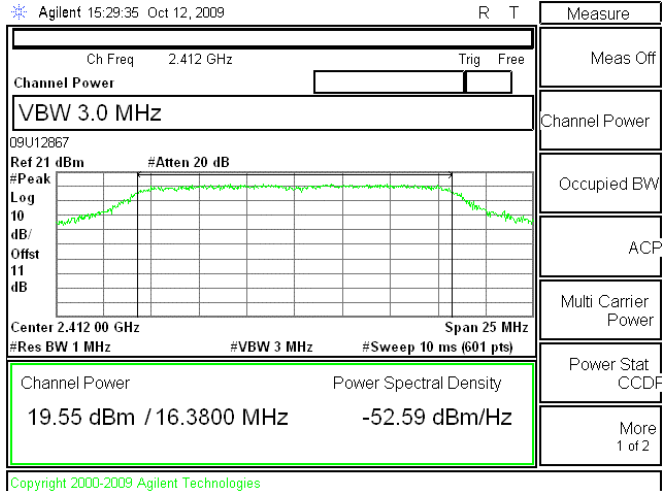
**Peak RF Output Power Measurements**

Peak Power and Average Power Test Results Summary  
 (average power readings for reference only)

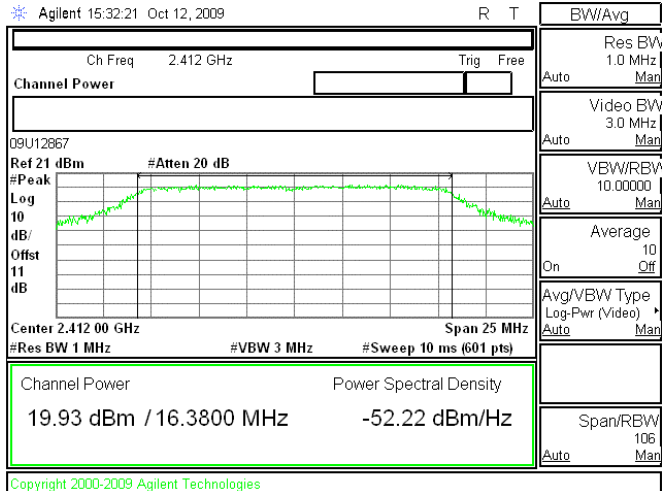
FCC ID: SBVRM002  
 C2PC Power Settings

Channel	Mode	Pset dBm	P meter ChB dBm	P meter ChA dBm	P meter ChC dBm	Pout Tot dBm
Ave Power						
1	802.11g	15	14.1	13.9	13.3	18.6
6	802.11g	19	18.31	17.7	18	22.8
11	802.11g	15	14.34	13.9	14	18.9
1	HT20	15	14.27	13.8	13.3	18.6
6	HT20	19	18.38	17.8	18	22.8
11	HT20	15	14.3	13.8	13.9	18.8
Peak Power						
1	802.11g	15	19.9	19.5	19.3	24.3
6	802.11g	19	24.33	23.86	23.82	28.78
11	802.11g	15	19.97	19.9	19.6	24.6
1	HT20	15	19.99	19.79	19.52	24.5
6	HT20	19	24.47	23.88	23.98	28.89
11	HT20	15	20.21	19.99	20.02	24.8

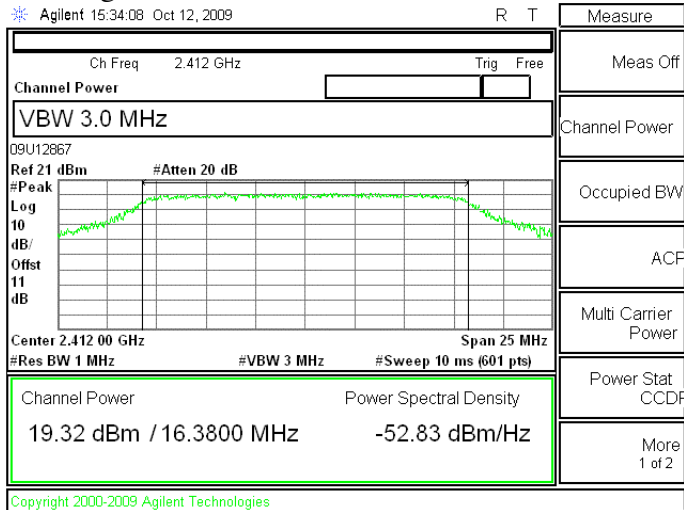
Peak Output Power Plots  
 802.11 g LOW Channel Chain A



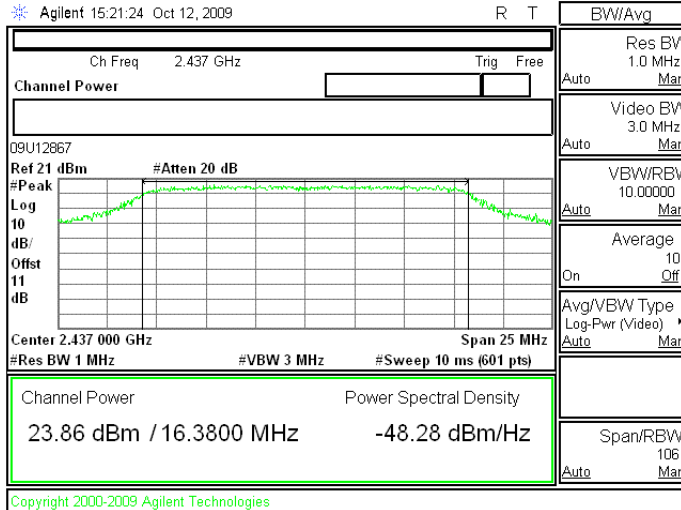
802.11 g LOW Channel Chain B



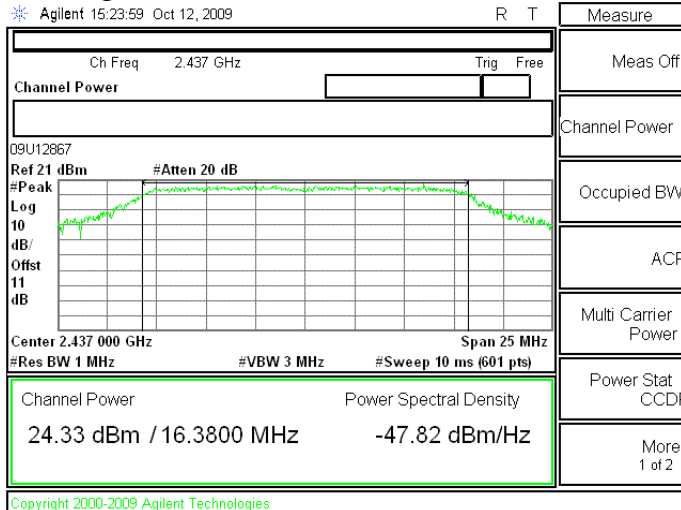
802.11 g LOW Channel Chain C



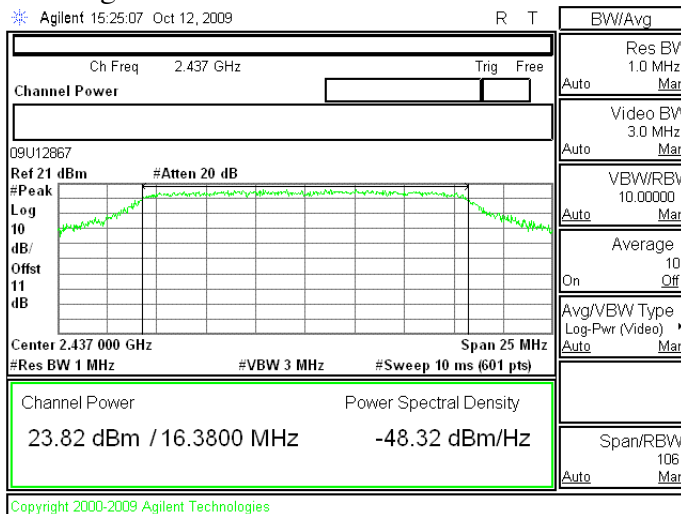
Peak Output Power Plots  
 802.11 g MID Channel Chain A



802.11 g MID Channel Chain B

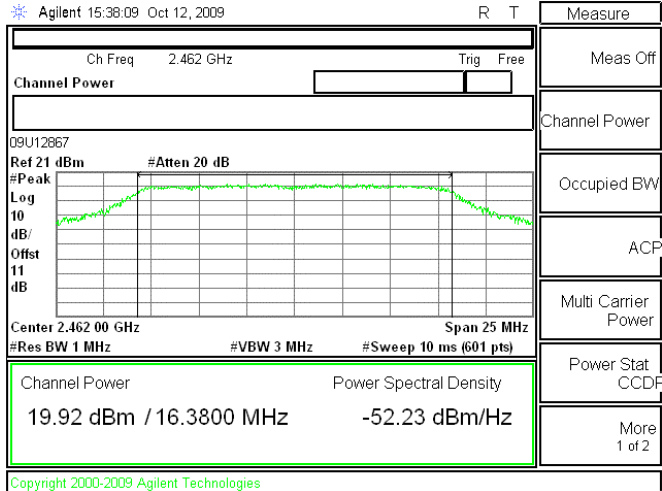


802.11 g MID Channel Chain C

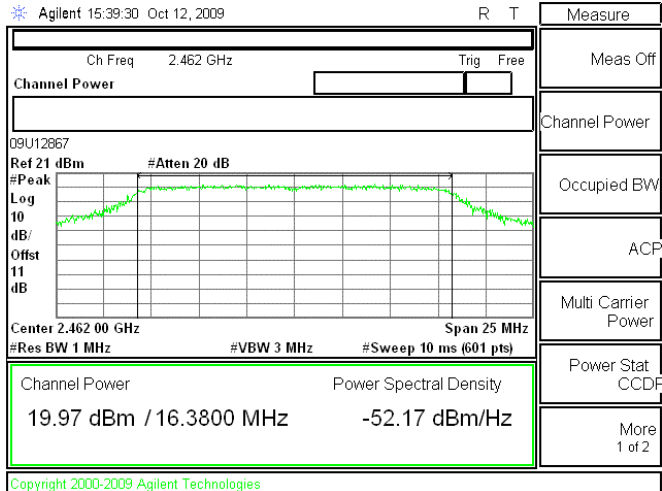




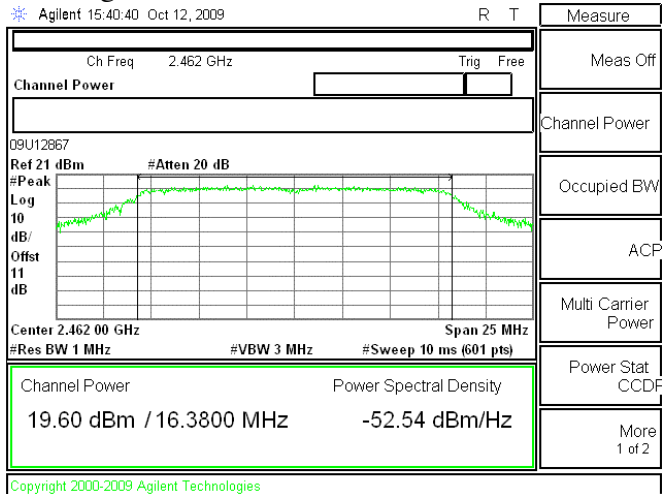
Peak Output Power Plots  
 802.11 g HIGH Channel Chain A



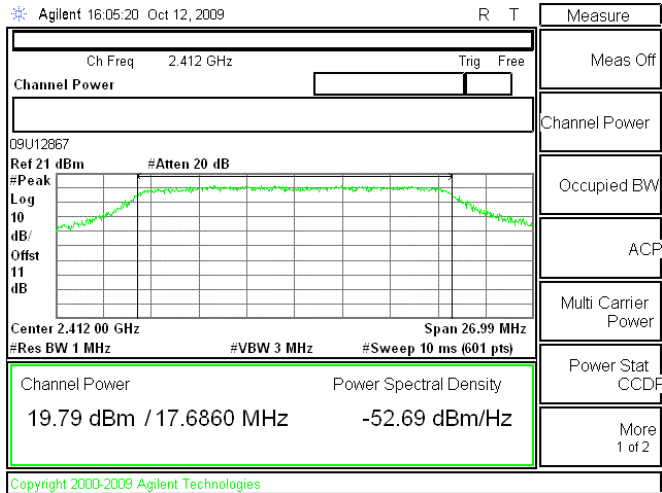
802.11 g HIGH Channel Chain B



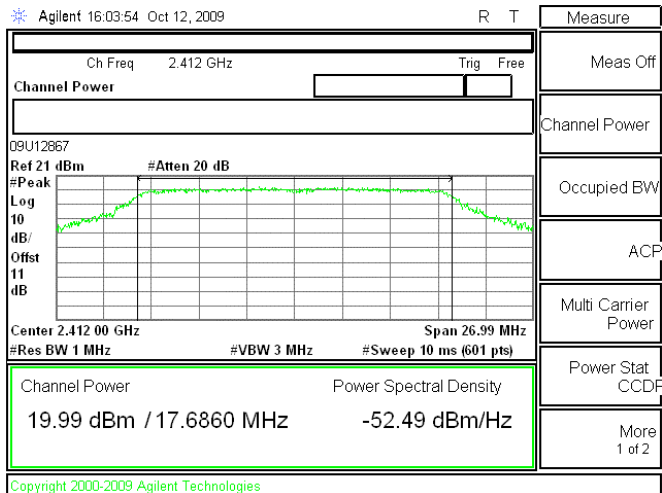
802.11 g HIGH Channel Chain C



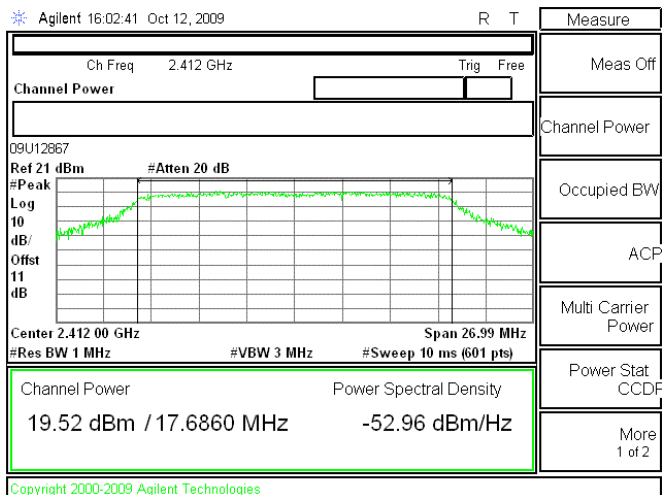
Peak Output Power Plots  
 802.11 HT20 LOW Channel Chain A



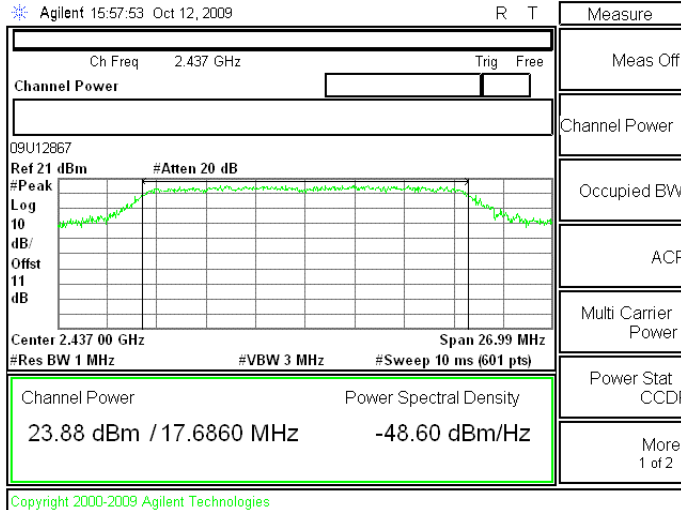
802.11 HT20 LOW Channel Chain B



802.11 HT20 LOW Channel Chain C

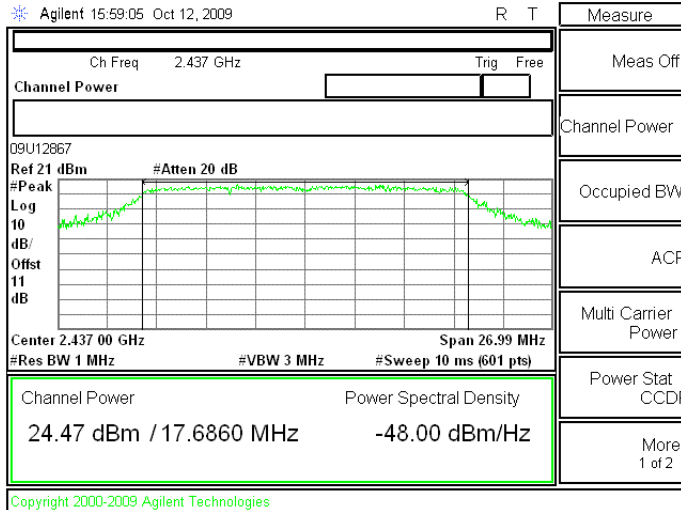


Peak Output Power Plots  
 802.11 HT20 MID Channel Chain A



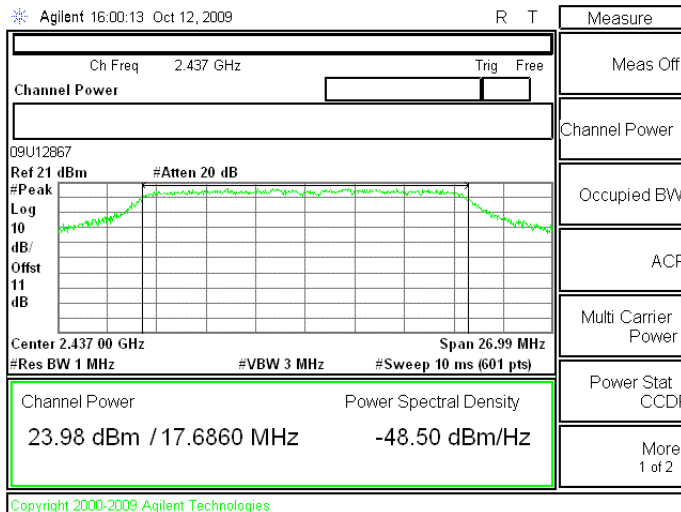
Measure
Meas Off
Channel Power
Occupied BW
ACP
Multi Carrier Power
Power Stat
CCDF
More 1 of 2

802.11 HT20 MID Channel Chain B



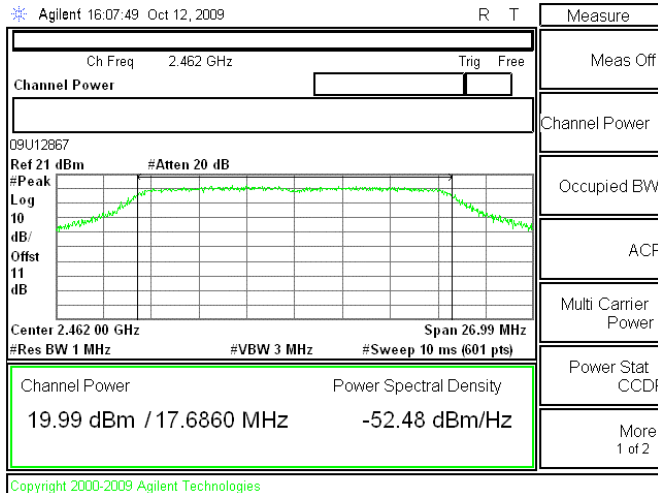
Measure
Meas Off
Channel Power
Occupied BW
ACP
Multi Carrier Power
Power Stat
CCDF
More 1 of 2

802.11 HT20 MID Channel Chain C

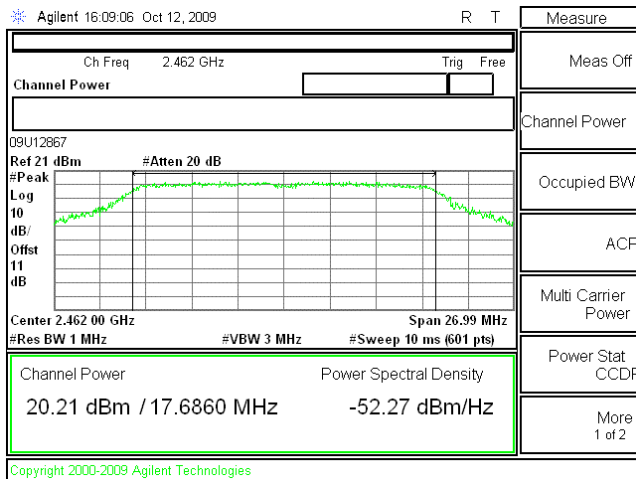


Measure
Meas Off
Channel Power
Occupied BW
ACP
Multi Carrier Power
Power Stat
CCDF
More 1 of 2

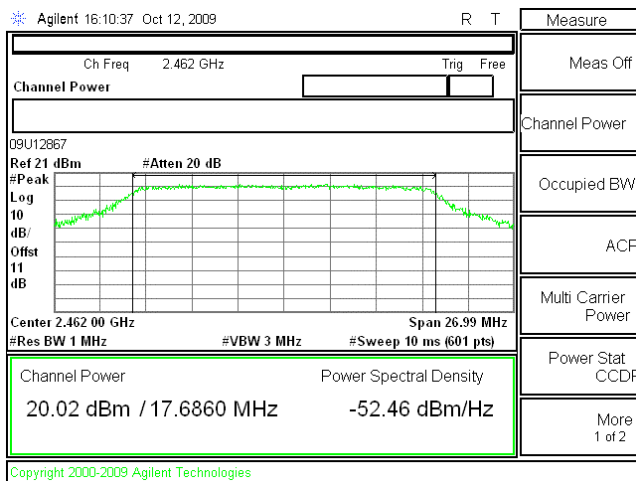
Peak Output Power Plots  
 802.11 HT20 HGH Channel Chain A



802.11 HT20 HGH Channel Chain B



802.11 HT20 HGH Channel Chain C

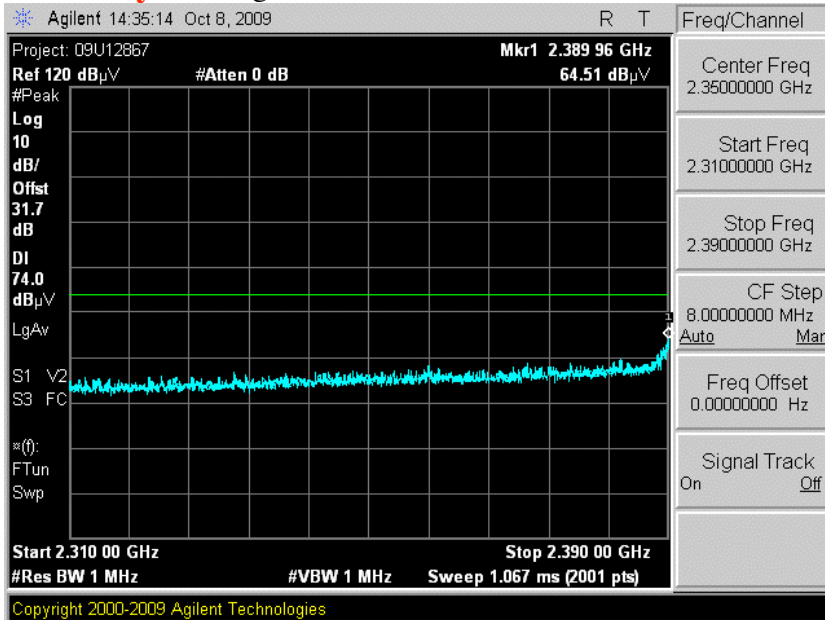


## Radiated Emissions

### Band Edge Emissions

Maximum band edge readings were found with search antenna in the vertical polarity, which is the same polarity as the EUT antennas.

### Wembley 802.11g LOW Channel, Vertical Peak

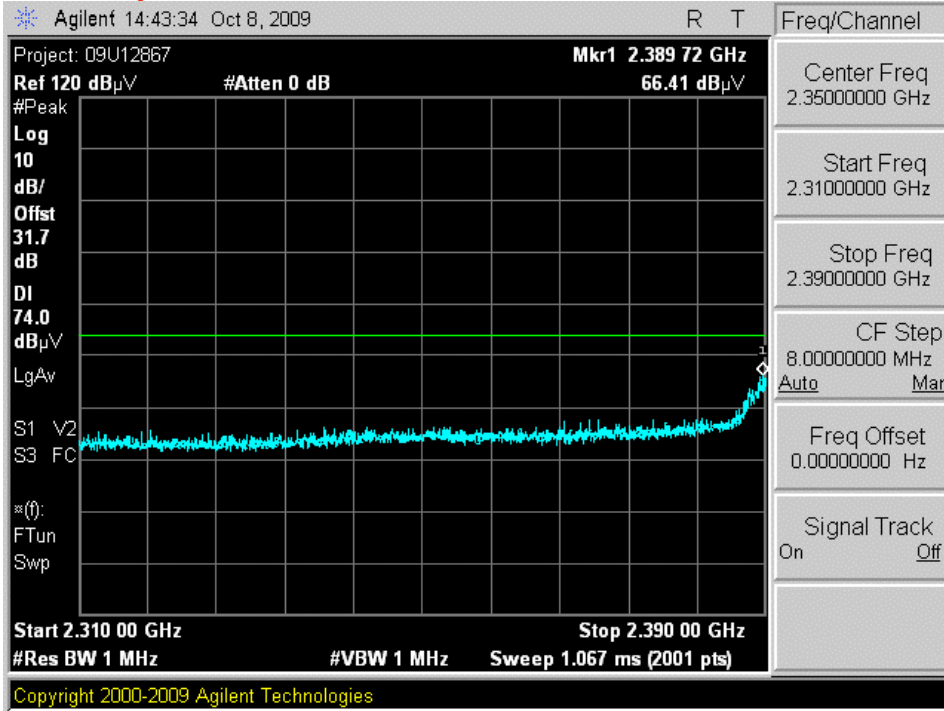


### Wembley 802.11g LOW Channel, Vertical Average

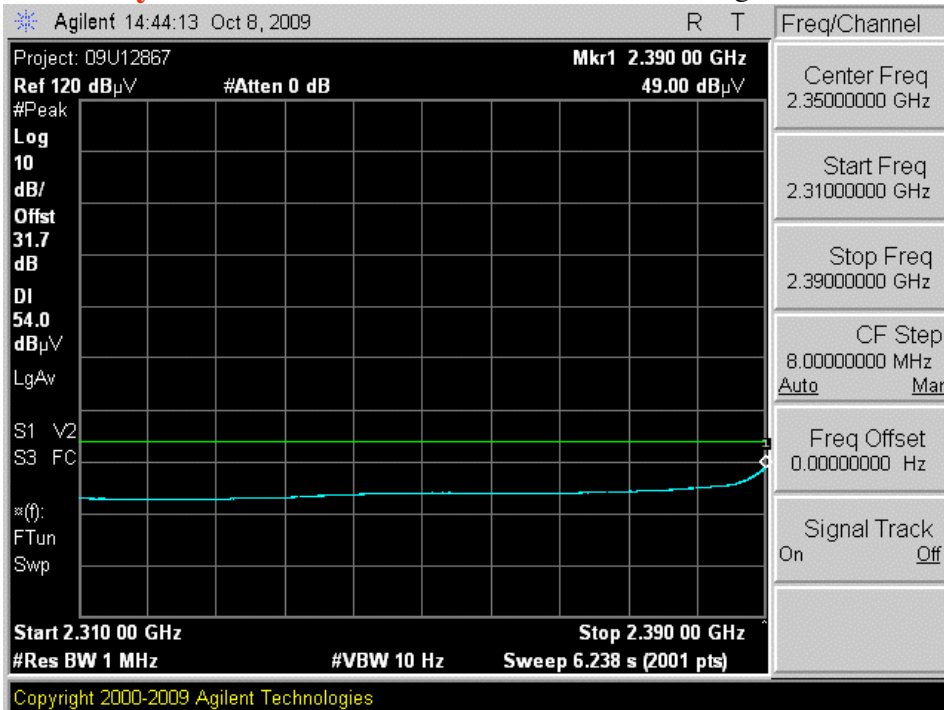


Band Edge Emissions

**Wembley** 802.11 HT20 LOW Channel, Vertical Peak

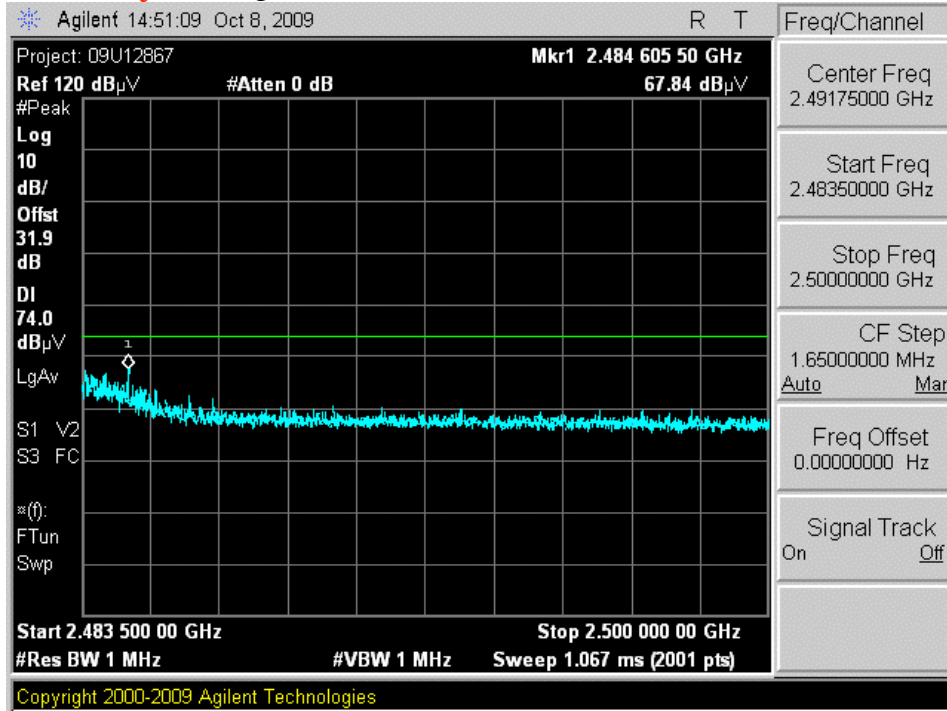


**Wembley** 802.11 HT20 LOW Channel, Vertical Average

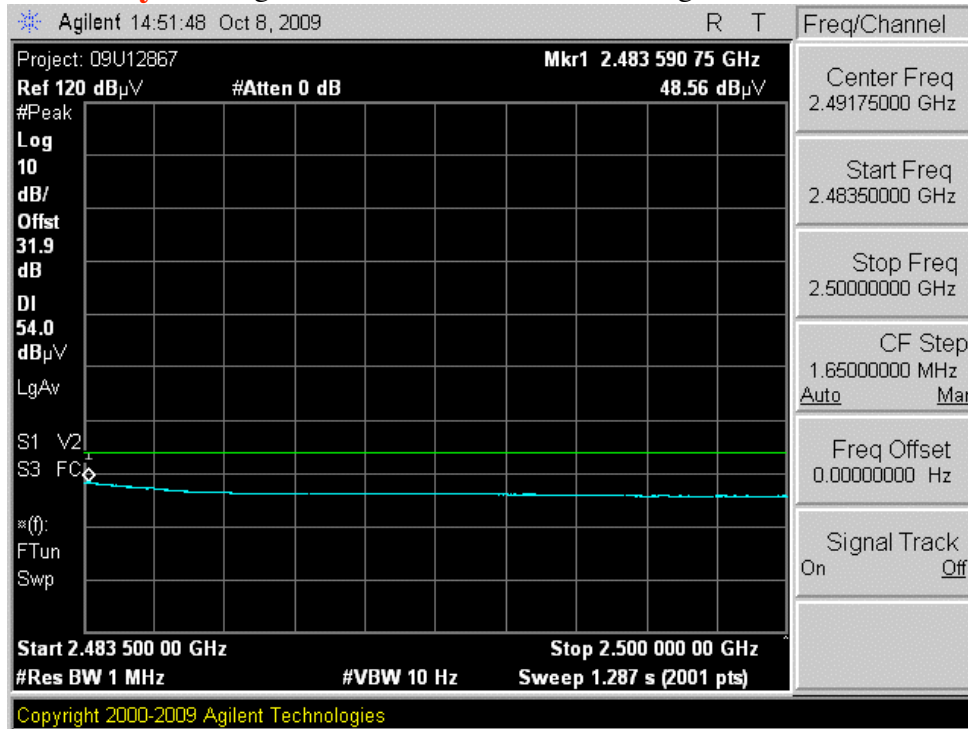


Band Edge Emissions

**Wembley** 802.11g HIGH Channel, Vertical Peak

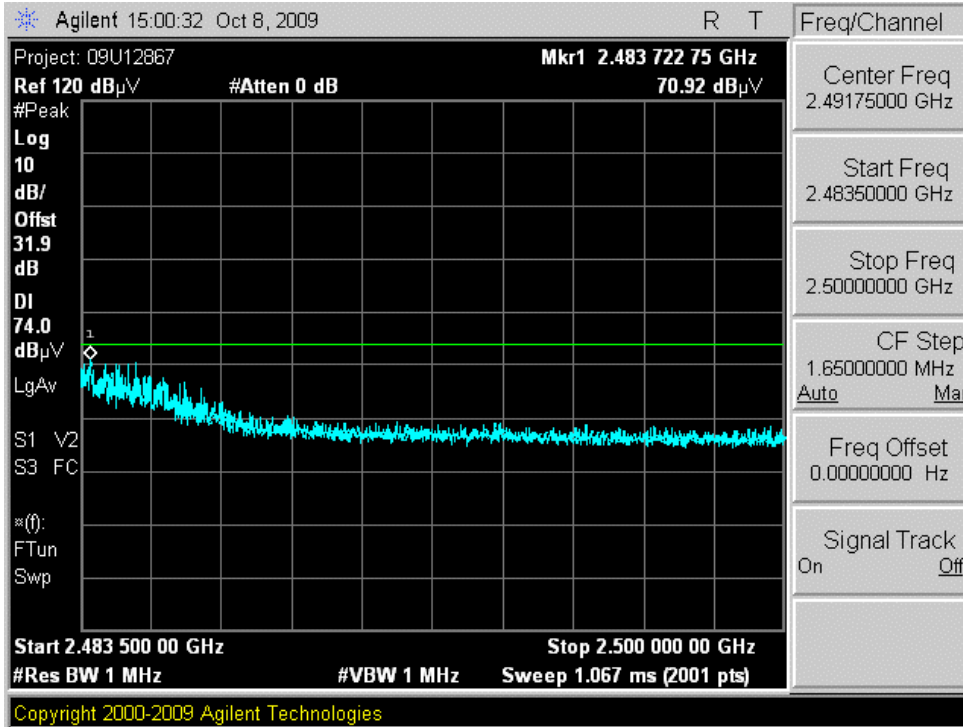


**Wembley** 802.11g HIGH Channel, Vertical Average

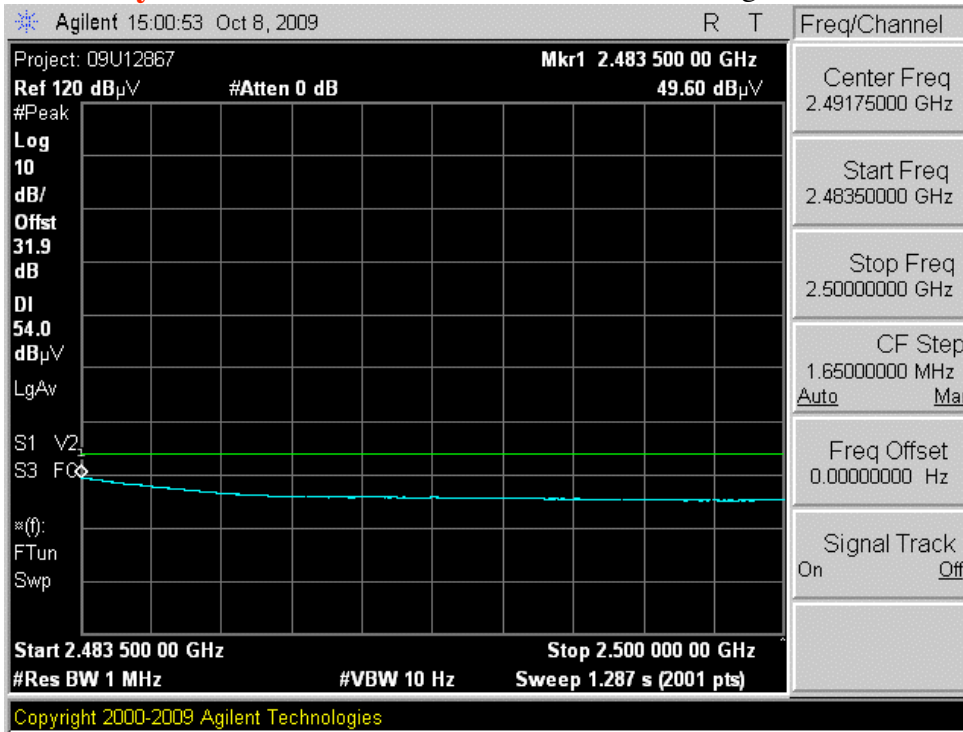


Band Edge Emissions

**Wembley** 802.11 HT20 HIGH Channel, Vertical Peak

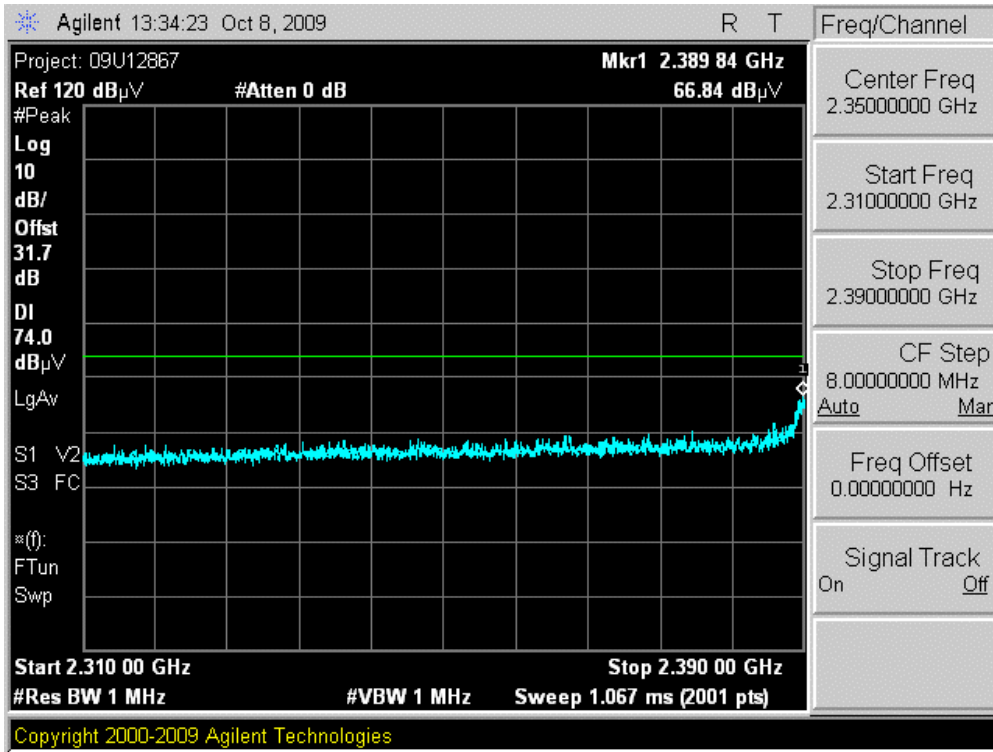


**Wembley** 802.11 HT20 HIGH Channel, Vertical Average

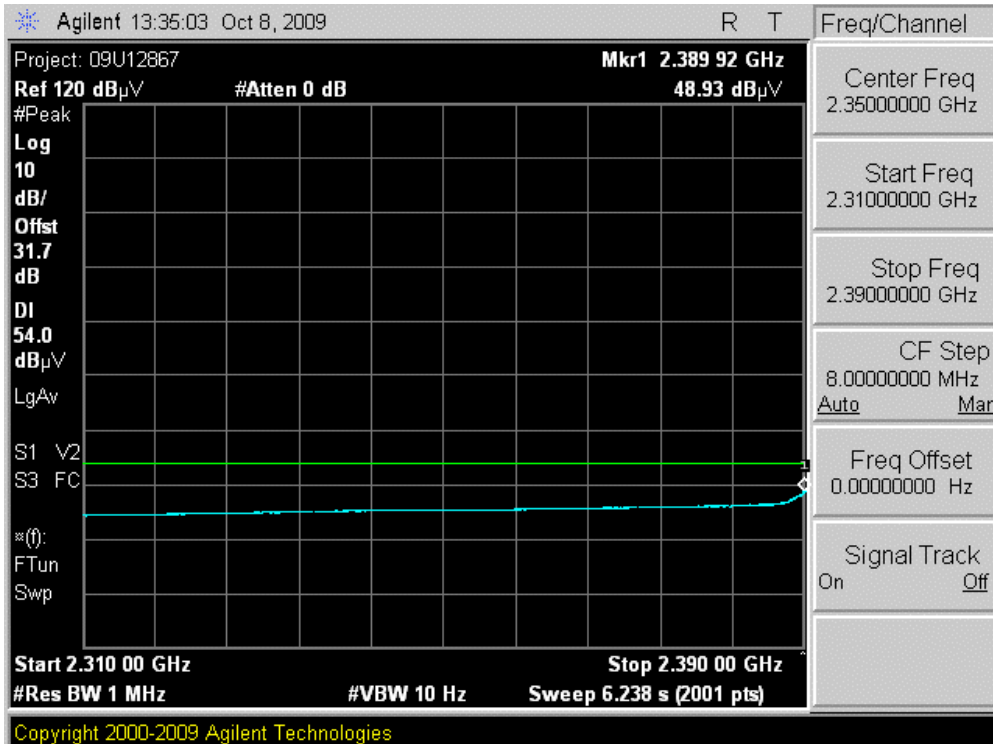




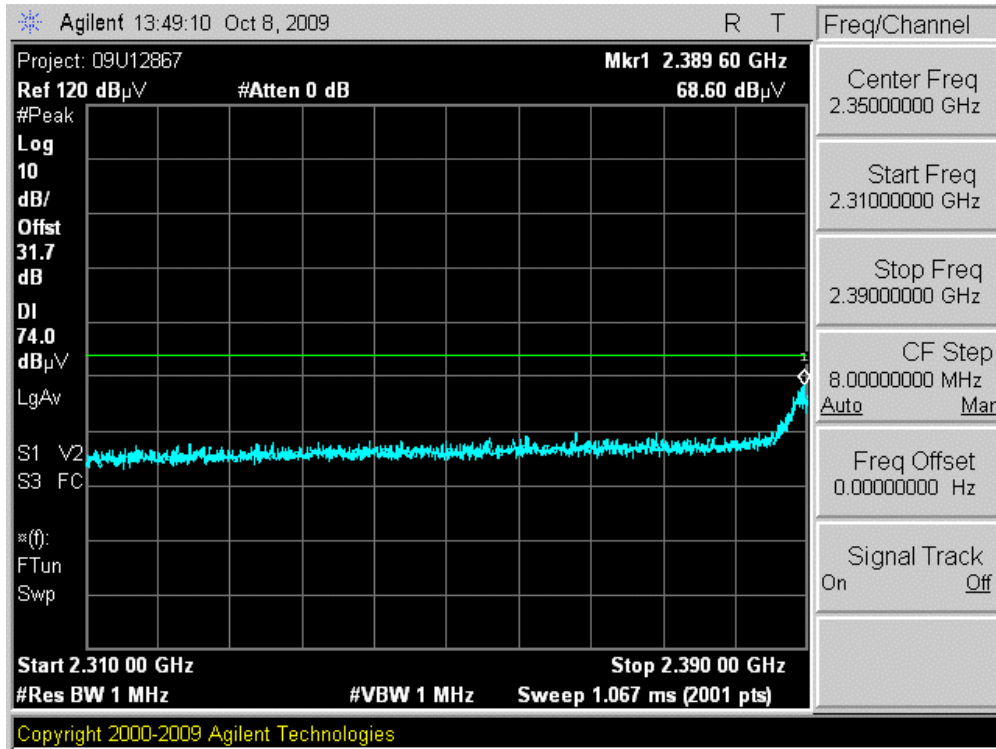
**Avalon** 802.11g LOW Channel, Vertical Peak



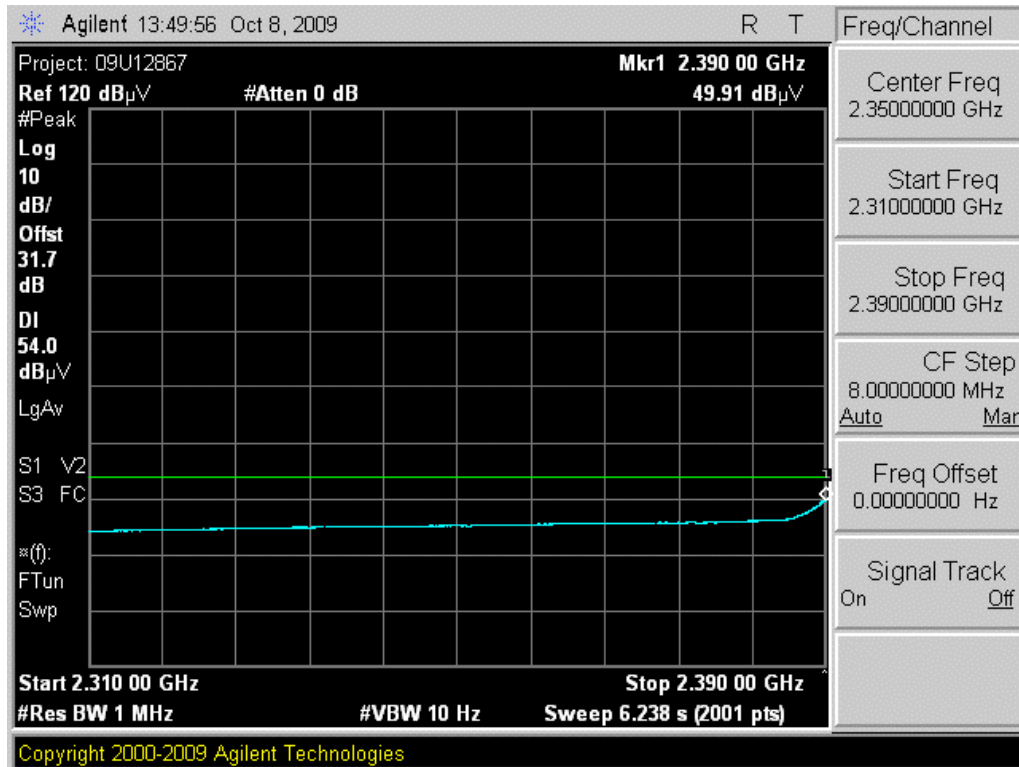
**Avalon** 802.11g LOW Channel, Vertical Average



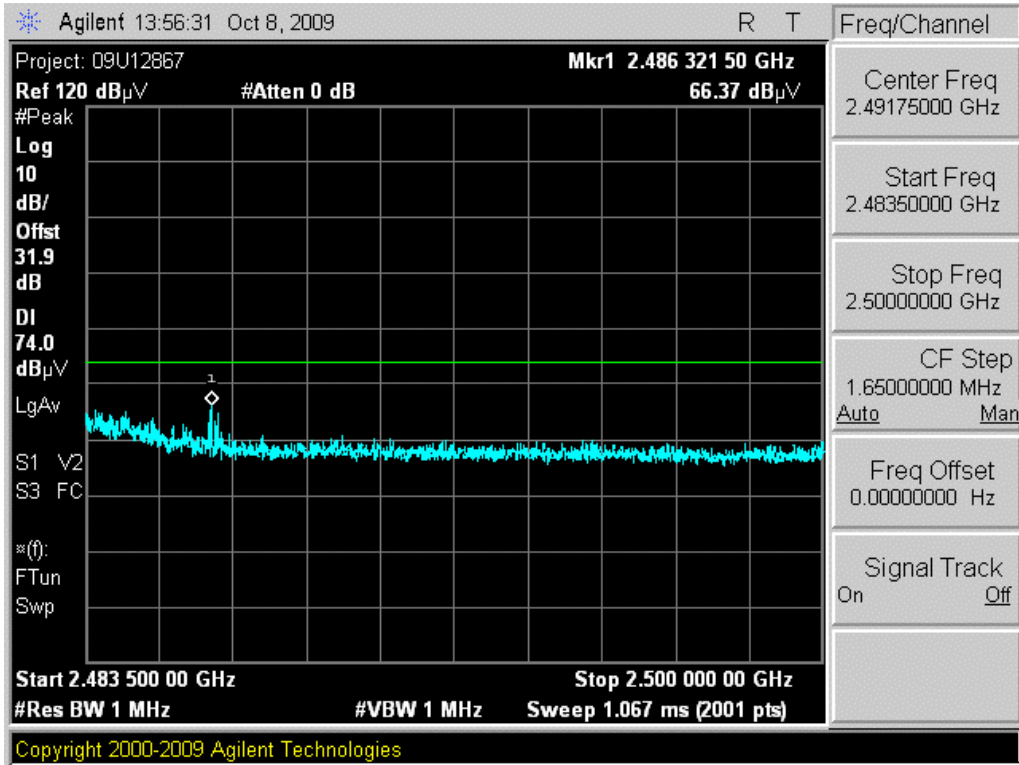
### Avalon 802.11HT20 LOW Channel Vertical Peak



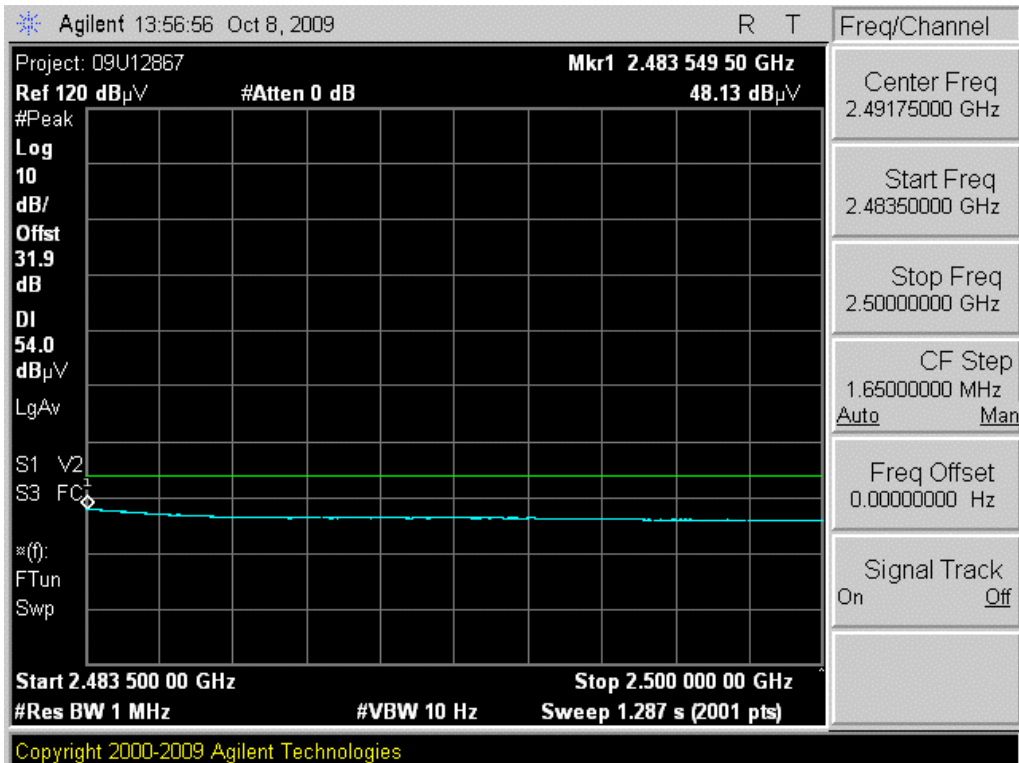
### Avalon 802.11HT20 LOW Channel Vertical Average



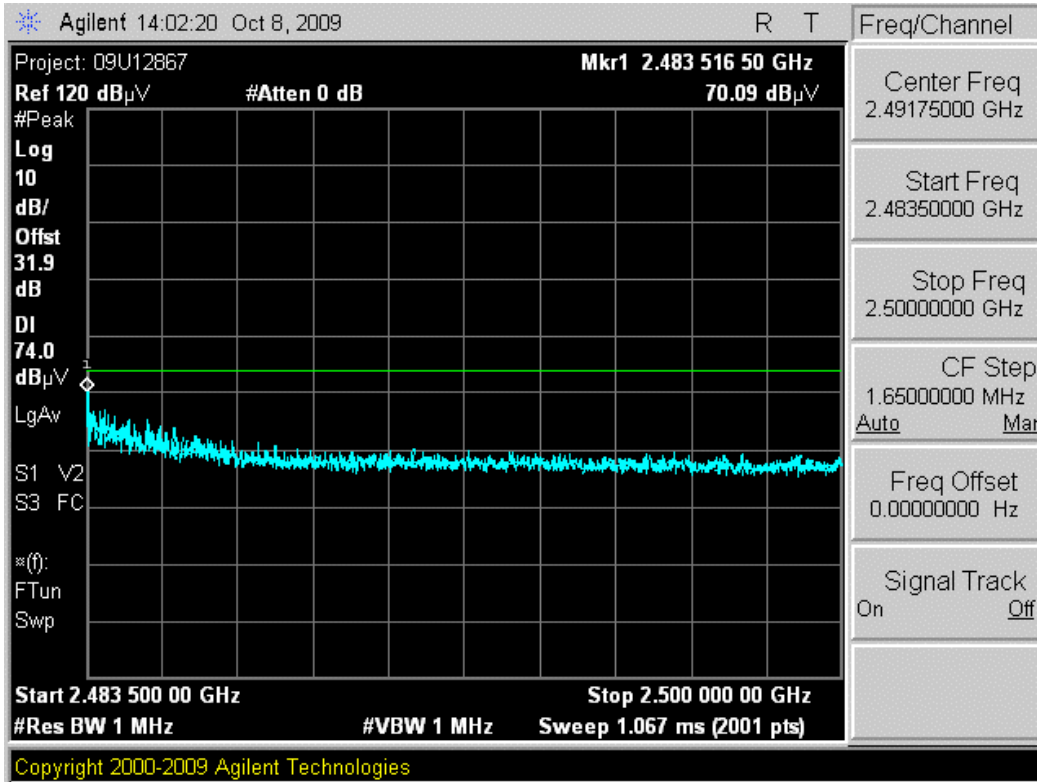
**Avalon 802.11g HIGH Channel Vertical Peak**



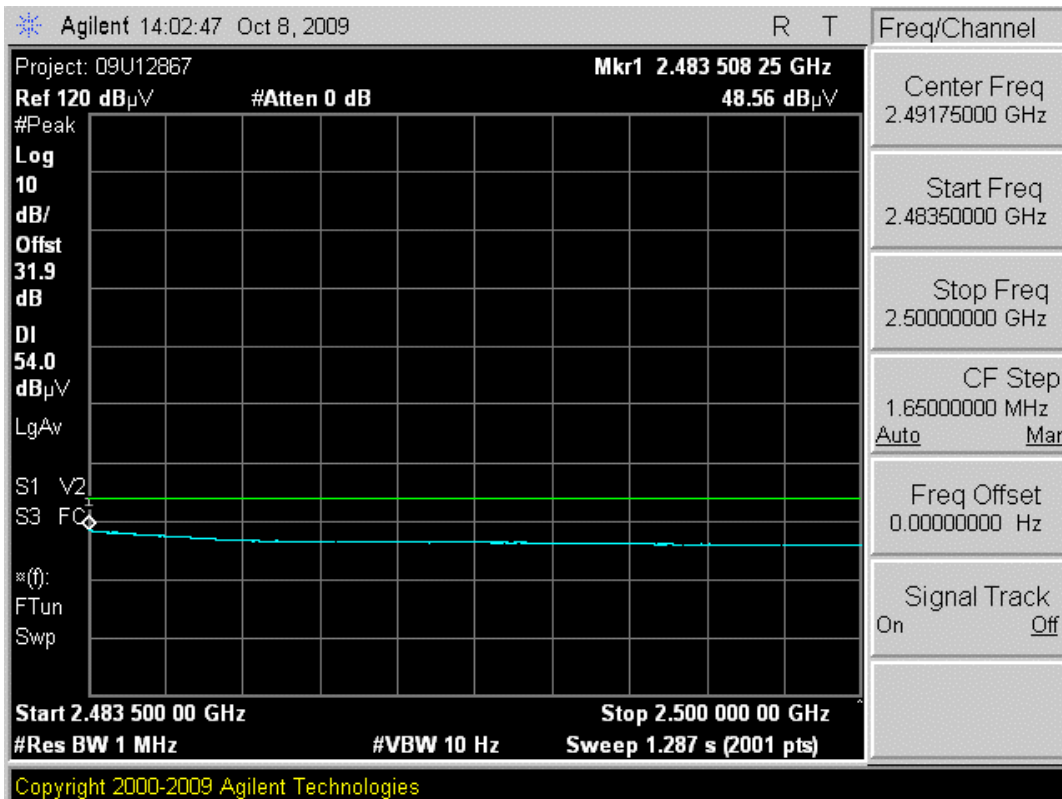
**Avalon 802.11g HIGH Channel Vertical Average**



**Avalon 802.11HT20 HIGH Channel Vertical Peak**



**Avalon 802.11 HT20 HIGH Channel Vertical Average**



## Radiated Emissions

### Wembley 802.11g and HT20 modes

High Frequency Measurement Compliance Certification Services, Fremont 5m Chamber																
Test Engr:		Tom Chen														
Date:		10/17/08														
Project #:																
Company:		Sonos														
EUT Description:		802.11g/HT20 radio module														
EUT M/N:		RM002 module with Wembley antennas														
Test Target:																
Mode Oper:		Continuous TX														
f	Measurement Frequency	Amp	Preamp Gain	Average Field Strength Limit												
Dist	Distance to Antenna	D Corr	Distance Correct to 3 meters	Peak Field Strength Limit												
Read	Analyzer Reading	Avg	Average Field Strength @ 3 m	Margin vs. Average Limit												
AF	Antenna Factor	Peak	Calculated Peak Field Strength	Margin vs. Peak Limit												
CL	Cable Loss	HPF	High Pass Filter													
f GHz	Dist (m)	Read dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Filtr dB	Corr. dBuV/m	Limit dBuV/m	Margin dB	Ant. Pol. V/H	Det. P/A/QP	Ant.High cm	Table Angle Degree	Notes	
<b>2412 MHz Low CH</b>																
4.824	3.0	39.0	33.1	5.9	-36.5	0.0	0.0	41.5	74.0	-32.5	V	P	197.4	261.6	Power set 15 dBm, g mode	
4.824	3.0	26.5	33.1	5.9	-36.5	0.0	0.0	29.1	54.0	-24.9	V	A	197.4	261.6	Power set 15 dBm, g mode	
7.236	3.0	37.6	35.4	7.3	-36.2	0.0	0.0	44.1	74.0	-29.9	V	P	197.4	261.6	Power set 15 dBm, g mode	
7.236	3.0	25.4	35.4	7.3	-36.2	0.0	0.0	31.9	54.0	-22.1	V	A	197.4	261.6	Power set 15 dBm, g mode	
<b>2437 MHz Mid CH</b>																
4.874	3.0	39.4	33.1	5.8	-36.5	0.0	0.0	41.8	74.0	-32.2	V	P	174.0	277.9	Power set 19 dBm, g mode	
4.874	3.0	26.5	33.1	5.8	-36.5	0.0	0.0	29.0	54.0	-25.0	V	A	174.0	277.9	Power set 19 dBm, g mode	
7.311	3.0	38.8	35.3	7.3	-36.2	0.0	0.0	45.2	74.0	-28.8	V	P	174.0	277.9	Power set 19 dBm, g mode	
7.311	3.0	26.2	35.3	7.3	-36.2	0.0	0.0	32.6	54.0	-21.4	V	A	174.0	277.9	Power set 19 dBm, g mode	
<b>2462 MHz High CH</b>																
4.924	3.0	39.0	33.1	5.9	-36.5	0.0	0.0	41.5	74.0	-32.5	V	P	155.1	322.8	Power set 15 dBm, g mode	
4.924	3.0	26.5	33.1	5.9	-36.5	0.0	0.0	29.0	54.0	-25.0	V	A	155.1	322.8	Power set 15 dBm, g mode	
7.386	3.0	38.8	35.4	7.3	-36.2	0.0	0.0	45.3	74.0	-28.7	V	P	155.1	322.8	Power set 15 dBm, g mode	
7.386	3.0	25.7	35.4	7.3	-36.2	0.0	0.0	32.2	54.0	-21.8	V	A	155.1	322.8	Power set 15 dBm, g mode	
<b>2412 MHz Low CH</b>																
4.824	3.0	39.2	33.0	5.8	-36.5	0.0	0.0	41.5	74.0	-32.5	V	P	191.9	124.4	Power set 15 dBm, HT20	
4.824	3.0	26.6	33.0	5.8	-36.5	0.0	0.0	28.9	54.0	-25.1	V	A	191.9	124.4	Power set 15 dBm, HT20	
7.236	3.0	37.1	35.2	7.2	-36.2	0.0	0.0	43.3	74.0	-30.7	V	P	191.9	124.4	Power set 15 dBm, HT20	
7.236	3.0	25.2	35.2	7.2	-36.2	0.0	0.0	31.4	54.0	-22.6	V	A	191.9	124.4	Power set 15 dBm, HT20	
<b>2437 MHz Mid CH</b>																
4.874	3.0	39.0	33.1	5.8	-36.5	0.0	0.0	41.5	74.0	-32.5	V	P	140.3	262.0	Power set 19 dBm, HT20	
4.874	3.0	26.0	33.1	5.8	-36.5	0.0	0.0	28.4	54.0	-25.6	V	A	140.3	262.0	Power set 19 dBm, HT20	
7.311	3.0	39.6	35.3	7.3	-36.2	0.0	0.0	45.9	74.0	-28.1	V	P	140.3	262.0	Power set 19 dBm, HT20	
7.311	3.0	26.6	35.3	7.3	-36.2	0.0	0.0	32.9	54.0	-21.1	V	A	140.3	262.0	Power set 19 dBm, HT20	
<b>2462 MHz High CH</b>																
4.924	3.0	38.3	33.1	5.9	-36.5	0.0	0.0	40.8	74.0	-33.2	V	P	102.1	311.6	Power set 15 dBm, HT20	
4.924	3.0	26.3	33.1	5.9	-36.5	0.0	0.0	28.9	54.0	-25.1	V	A	102.1	311.6	Power set 15 dBm, HT20	
7.386	3.0	37.6	35.4	7.3	-36.2	0.0	0.0	44.1	74.0	-29.9	V	P	102.1	311.6	Power set 15 dBm, HT20	
7.386	3.0	25.3	35.4	7.3	-36.2	0.0	0.0	31.8	54.0	-22.2	V	A	102.1	311.6	Power set 15 dBm, HT20	

Rev. 4.1.2.7

Note: No other emissions were detected above the system noise floor.

## Radiated Emissions

### Avalon 802.11g mode

High Frequency Measurement Compliance Certification Services, Fremont 5m Chamber															
Test Engr:		Tom Chen													
Date:		10/08/09													
Project #:		09U12867													
Company:		Sonos Inc.													
EUT Description:		802.11g/HT20 module													
EUT M/N:		RM002 module with Avalon Antennas													
Test Target:															
Mode Oper:		Continuous transmission - 802.11g													
f	Measurement Frequency	Amp	Preamp Gain		Average Field Strength Limit										
Dist	Distance to Antenna	D Corr	Distance Correct to 3 meters		Peak Field Strength Limit										
Read	Analyzer Reading	Avg	Average Field Strength @ 3 m		Margin vs. Average Limit										
AF	Antenna Factor	Peak	Calculated Peak Field Strength		Margin vs. Peak Limit										
CL	Cable Loss	HPF	High Pass Filter												
f GHz	Dist (m)	Read dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Filtr dB	Corr. dBuV/m	Limit dBuV/m	Margin dB	Ant. Pol. V/H	Det. P/A/QP	Ant.High cm	Table Angle Degree	Notes
2412 MHz Low CH															
4.824	3.0	38.6	33.0	5.8	-36.5	0.0	0.0	41.0	74.0	-33.0	V	P	123.9	6.5	Power set 15 dBm, g mode
4.824	3.0	26.6	33.0	5.8	-36.5	0.0	0.0	29.0	54.0	-25.0	V	A	123.9	6.5	Power set 15 dBm, g mode
2412 MHz Low CH															
7.236	3.0	37.4	35.2	7.2	-36.2	0.0	0.0	43.6	74.0	-30.4	V	P	123.9	6.5	Power set 15 dBm, g mode
7.236	3.0	25.3	35.2	7.2	-36.2	0.0	0.0	31.5	54.0	-22.5	V	A	123.9	6.5	Power set 15 dBm, g mode
2412 MHz Low CH															
9.648	3.0	36.8	37.4	8.5	-37.0	0.0	0.0	45.8	74.0	-28.2	V	P	123.9	6.5	Power set 15 dBm, g mode
9.648	3.0	24.8	37.4	8.5	-37.0	0.0	0.0	33.8	54.0	-20.2	V	A	123.9	6.5	Power set 15 dBm, g mode
2412 MHz Low CH															
4.824	3.0	39.1	33.0	5.8	-36.5	0.0	0.0	41.4	74.0	-32.6	H	P	169.4	340.0	Power set 15 dBm, g mode
4.824	3.0	26.6	33.0	5.8	-36.5	0.0	0.0	28.9	54.0	-25.1	H	A	169.4	340.0	Power set 15 dBm, g mode
2412 MHz Low CH															
7.236	3.0	38.0	35.2	7.2	-36.2	0.0	0.0	44.2	74.0	-29.8	H	P	169.4	340.0	Power set 15 dBm, g mode
7.236	3.0	25.2	35.2	7.2	-36.2	0.0	0.0	31.4	54.0	-22.6	H	A	169.4	340.0	Power set 15 dBm, g mode
2412 MHz Low CH															
9.648	3.0	37.0	37.4	8.5	-37.0	0.0	0.0	46.0	74.0	-28.0	H	P	169.4	340.0	Power set 15 dBm, g mode
9.648	3.0	24.7	37.4	8.5	-37.0	0.0	0.0	33.7	54.0	-20.3	H	A	169.4	340.0	Power set 15 dBm, g mode
2437 MHz Mid CH															
4.874	3.0	38.9	33.1	5.8	-36.5	0.0	0.0	41.4	74.0	-32.6	H	P	177.1	234.0	Power set 19 dBm, g mode
4.874	3.0	26.2	33.1	5.8	-36.5	0.0	0.0	28.6	54.0	-25.4	H	A	177.1	234.0	Power set 19 dBm, g mode
2437 MHz Mid CH															
7.311	3.0	39.0	35.3	7.3	-36.2	0.0	0.0	45.4	74.0	-28.6	H	P	177.1	234.0	Power set 19 dBm, g mode
7.311	3.0	26.3	35.3	7.3	-36.2	0.0	0.0	32.6	54.0	-21.4	H	A	177.1	234.0	Power set 19 dBm, g mode
2437 MHz Mid CH															
9.748	3.0	37.5	37.4	8.6	-37.0	0.0	0.0	46.5	74.0	-27.5	H	P	177.1	234.0	Power set 19 dBm, g mode
9.748	3.0	25.0	37.4	8.6	-37.0	0.0	0.0	34.0	54.0	-20.0	H	A	177.1	234.0	Power set 19 dBm, g mode
2437 MHz Mid CH															
4.874	3.0	38.8	33.1	5.8	-36.5	0.0	0.0	41.2	74.0	-32.8	V	P	174.9	116.0	Power set 19 dBm, g mode
4.874	3.0	26.5	33.1	5.8	-36.5	0.0	0.0	29.0	54.0	-25.0	V	A	174.9	116.0	Power set 19 dBm, g mode
2437 MHz Mid CH															
7.311	3.0	41.7	35.3	7.3	-36.2	0.0	0.0	48.0	74.0	-26.0	V	P	174.9	116.0	Power set 19 dBm, g mode
7.311	3.0	27.6	35.3	7.3	-36.2	0.0	0.0	33.9	54.0	-20.1	V	A	174.9	116.0	Power set 19 dBm, g mode
2437 MHz Mid CH															
9.748	3.0	38.3	37.4	8.6	-37.0	0.0	0.0	47.4	74.0	-26.6	V	P	174.9	116.0	Power set 19 dBm, g mode
9.748	3.0	25.9	37.4	8.6	-37.0	0.0	0.0	34.9	54.0	-19.1	V	A	174.9	116.0	Power set 19 dBm, g mode
2462 MHz High CH															
4.924	3.0	40.0	33.1	5.9	-36.5	0.0	0.0	42.6	74.0	-31.4	V	P	176.2	19.5	Power set 15 dBm, g mode
4.924	3.0	26.3	33.1	5.9	-36.5	0.0	0.0	28.9	54.0	-25.1	V	A	176.2	19.5	Power set 15 dBm, g mode
2462 MHz High CH															
7.386	3.0	40.8	35.4	7.3	-36.2	0.0	0.0	47.3	74.0	-26.7	V	P	176.2	19.5	Power set 15 dBm, g mode
7.386	3.0	26.5	35.4	7.3	-36.2	0.0	0.0	33.0	54.0	-21.0	V	A	176.2	19.5	Power set 15 dBm, g mode
2462 MHz High CH															
9.848	3.0	36.7	37.5	8.7	-37.0	0.0	0.0	45.8	74.0	-28.2	V	P	176.2	19.5	Power set 15 dBm, g mode
9.848	3.0	24.7	37.5	8.7	-37.0	0.0	0.0	33.8	54.0	-20.2	V	A	176.2	19.5	Power set 15 dBm, g mode
2462 MHz High CH															
4.924	3.0	38.8	33.1	5.9	-36.5	0.0	0.0	41.4	74.0	-32.6	H	P	135.9	267.2	Power set 15 dBm, g mode
4.924	3.0	26.3	33.1	5.9	-36.5	0.0	0.0	28.9	54.0	-25.1	H	A	135.9	267.2	Power set 15 dBm, g mode
2462 MHz High CH															
7.386	3.0	37.7	35.4	7.3	-36.2	0.0	0.0	44.2	74.0	-29.8	H	P	135.9	267.2	Power set 15 dBm, g mode
7.386	3.0	25.2	35.4	7.3	-36.2	0.0	0.0	31.7	54.0	-22.3	H	A	135.9	267.2	Power set 15 dBm, g mode
2462 MHz High CH															
9.848	3.0	37.5	37.5	8.7	-37.0	0.0	0.0	46.5	74.0	-27.5	H	P	135.9	267.2	Power set 15 dBm, g mode
9.848	3.0	24.7	37.5	8.7	-37.0	0.0	0.0	33.8	54.0	-20.2	H	A	135.9	267.2	Power set 15 dBm, g mode

Rev. 4.1.2.7

Note: No other emissions were detected above the system noise floor.

## Radiated Emissions

### Avalon HT20 mode

High Frequency Measurement															
Compliance Certification Services, Fremont 5m Chamber															
Test Engr:		Tom Chen													
Date:		10/07/08													
Project #:															
Company:		Sonos													
EUT Description:		802.11g/HT20 radio module													
EUT M/N:		RM002 with Avalon antennas													
Test Target:															
Mode Oper:		Continuous transmission - HT20 mode													
f	Measurement Frequency	Amp	Preamp Gain		Average Field Strength Limit										
Dist	Distance to Antenna	D Corr	Distance Correct to 3 meters		Peak Field Strength Limit										
Read	Analyzer Reading	Avg	Average Field Strength @ 3 m		Margin vs. Average Limit										
AF	Antenna Factor	Peak	Calculated Peak Field Strength		Margin vs. Peak Limit										
CL	Cable Loss	HPF	High Pass Filter												
f GHz	Dist (m)	Read dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Filtr dB	Corr. dBuV/m	Limit dBuV/m	Margin dB	Ant. Pol. V/H	Det. P/A/QP	Ant.High cm	Table Angle Degree	Notes
2412 MHz Low CH															
4.824	3.0	39.1	33.0	5.8	-36.5	0.0	0.0	41.5	74.0	-32.5	H	P	182.5	61.7	Power set 15 dBm, HT20
4.824	3.0	26.4	33.0	5.8	-36.5	0.0	0.0	28.8	54.0	-25.2	H	A	182.5	61.7	Power set 15 dBm, HT20
2412 MHz Low CH															
7.236	3.0	37.9	35.2	7.2	-36.2	0.0	0.0	44.1	74.0	-29.9	H	P	182.5	61.7	Power set 15 dBm, HT20
7.236	3.0	25.2	35.2	7.2	-36.2	0.0	0.0	31.4	54.0	-22.6	H	A	182.5	61.7	Power set 15 dBm, HT20
2412 MHz Low CH															
9.648	3.0	37.0	37.4	8.5	-37.0	0.0	0.0	46.0	74.0	-28.0	H	P	182.5	61.7	Power set 15 dBm, HT20
9.648	3.0	24.5	37.4	8.5	-37.0	0.0	0.0	33.5	54.0	-20.5	H	A	182.5	61.7	Power set 15 dBm, HT20
2412 MHz Low CH															
4.824	3.0	39.1	33.0	5.8	-36.5	0.0	0.0	41.5	74.0	-32.5	V	P	119.3	182.4	Power set 15 dBm, HT20
4.824	3.0	26.4	33.0	5.8	-36.5	0.0	0.0	28.8	54.0	-25.2	V	A	119.3	182.4	Power set 15 dBm, HT20
2412 MHz Low CH															
7.236	3.0	37.9	35.2	7.2	-36.2	0.0	0.0	44.1	74.0	-29.9	V	P	119.3	182.4	Power set 15 dBm, HT20
7.236	3.0	25.2	35.2	7.2	-36.2	0.0	0.0	31.4	54.0	-22.6	V	A	119.3	182.4	Power set 15 dBm, HT20
2412 MHz Low CH															
9.648	3.0	37.2	37.4	8.5	-37.0	0.0	0.0	46.2	74.0	-27.8	V	P	119.3	182.4	Power set 15 dBm, HT20
9.648	3.0	24.7	37.4	8.5	-37.0	0.0	0.0	33.7	54.0	-20.3	V	A	119.3	182.4	Power set 15 dBm, HT20
2437 MHz Mid CH															
4.874	3.0	39.3	33.1	5.8	-36.5	0.0	0.0	41.8	74.0	-32.2	V	P	171.7	151.4	Power set 19 dBm, HT20
4.874	3.0	26.2	33.1	5.8	-36.5	0.0	0.0	28.6	54.0	-25.4	V	A	171.7	151.4	Power set 19 dBm, HT20
2437 MHz Mid CH															
7.311	3.0	38.9	35.3	7.3	-36.2	0.0	0.0	45.3	74.0	-28.7	V	P	171.7	151.4	Power set 19 dBm, HT20
7.311	3.0	26.0	35.3	7.3	-36.2	0.0	0.0	32.4	54.0	-21.6	V	A	171.7	151.4	Power set 19 dBm, HT20
2437 MHz Mid CH															
9.748	3.0	37.6	37.4	8.6	-37.0	0.0	0.0	46.6	74.0	-27.4	V	P	171.7	151.4	Power set 19 dBm, HT20
9.748	3.0	25.1	37.4	8.6	-37.0	0.0	0.0	34.1	54.0	-19.9	V	A	171.7	151.4	Power set 19 dBm, HT20
2437 MHz Mid CH															
4.874	3.0	38.2	33.1	5.8	-36.5	0.0	0.0	40.7	74.0	-33.3	H	P	199.6	9.8	Power set 19 dBm, HT20
4.874	3.0	25.9	33.1	5.8	-36.5	0.0	0.0	28.3	54.0	-25.7	H	A	199.6	9.8	Power set 19 dBm, HT20
2437 MHz Mid CH															
7.311	3.0	37.9	35.3	7.3	-36.2	0.0	0.0	44.2	74.0	-29.8	H	P	199.6	9.8	Power set 19 dBm, HT20
7.311	3.0	25.5	35.3	7.3	-36.2	0.0	0.0	31.9	54.0	-22.1	H	A	199.6	9.8	Power set 19 dBm, HT20
2437 MHz Mid CH															
9.748	3.0	37.0	37.4	8.6	-37.0	0.0	0.0	46.0	74.0	-28.0	H	P	199.6	9.8	Power set 19 dBm, HT20
9.748	3.0	24.4	37.4	8.6	-37.0	0.0	0.0	33.5	54.0	-20.5	H	A	199.6	9.8	Power set 19 dBm, HT20
2462 MHz High CH															
4.924	3.0	38.6	33.1	5.9	-36.5	0.0	0.0	41.1	74.0	-32.9	H	P	152.6	0.0	Power set 15 dBm, HT20
4.924	3.0	26.3	33.1	5.9	-36.5	0.0	0.0	28.9	54.0	-25.1	H	A	152.6	0.0	Power set 15 dBm, HT20
2462 MHz High CH															
7.386	3.0	37.5	35.4	7.3	-36.2	0.0	0.0	44.0	74.0	-30.0	H	P	152.6	0.0	Power set 15 dBm, HT20
7.386	3.0	25.2	35.4	7.3	-36.2	0.0	0.0	31.7	54.0	-22.3	H	A	152.6	0.0	Power set 15 dBm, HT20
2462 MHz High CH															
9.848	3.0	36.6	37.5	8.7	-37.0	0.0	0.0	45.7	74.0	-28.3	H	P	152.6	0.0	Power set 15 dBm, HT20
9.848	3.0	24.6	37.5	8.7	-37.0	0.0	0.0	33.7	54.0	-20.3	H	A	152.6	0.0	Power set 15 dBm, HT20
2462 MHz High CH															
4.924	3.0	38.5	33.1	5.9	-36.5	0.0	0.0	41.1	74.0	-32.9	V	P	134.5	328.1	Power set 15 dBm, HT20
4.924	3.0	26.3	33.1	5.9	-36.5	0.0	0.0	28.9	54.0	-25.1	V	A	134.5	328.1	Power set 15 dBm, HT20
2462 MHz High CH															
7.386	3.0	38.2	35.4	7.3	-36.2	0.0	0.0	44.7	74.0	-29.3	V	P	134.5	328.1	Power set 15 dBm, HT20
7.386	3.0	25.2	35.4	7.3	-36.2	0.0	0.0	31.7	54.0	-22.3	V	A	134.5	328.1	Power set 15 dBm, HT20
2462 MHz High CH															
9.848	3.0	37.6	37.5	8.7	-37.0	0.0	0.0	46.7	74.0	-27.3	V	P	134.5	328.1	Power set 15 dBm, HT20
9.848	3.0	24.6	37.5	8.7	-37.0	0.0	0.0	33.7	54.0	-20.3	V	A	134.5	328.1	Power set 15 dBm, HT20
										0.0					
										0.0					
										0.0					
										0.0					

Rev. 4.1.2.7

Note: No other emissions were detected above the system noise floor.

**MAXIMUM PERMISSIBLE EXPOSURE**

**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 <sup>2</sup> )	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 <sup>2</sup> )	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 <sup>2</sup> )	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 <sup>2</sup> )	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

$$S = E^2 / 3770$$

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:

$$P \text{ (mW)} = P \text{ (W)} / 1000 \text{ and}$$

$$d \text{ (cm)} = 100 * d \text{ (m)}$$

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<sup>2</sup>

Substituting the logarithmic form of power and gain using:

$$P \text{ (mW)} = 10^{(P \text{ (dBm)} / 10)} \text{ and}$$

$$G \text{ (numeric)} = 10^{(G \text{ (dBi)} / 10)}$$

yields

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

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm<sup>2</sup>

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

**LIMITS**

From §1.1310 Table 1 (B), S = 1.0 mW/cm<sup>2</sup>

**RESULTS**

No non-compliance noted:

**WEMBLEY ANTENNA MPE CALCULATIONS**

**Legacy 802.11g Mode**

<b>Power Density Limit (mW/cm<sup>2</sup>)</b>	<b>Output Power (dBm)</b>	<b>Antenna Gain (dBi)</b>	<b>S, mW/cm<sup>2</sup> at 20cm</b>	<b>MPE Distance (cm)</b>
1.0	28.80	5.88	0.62	15.86

**HT20 MIMO Mode**

<b>Power Density Limit (mW/cm<sup>2</sup>)</b>	<b>Output Power (dBm)</b>	<b>Antenna Gain (dBi)</b>	<b>S, mW/cm<sup>2</sup> at 20cm</b>	<b>MPE Distance (cm)</b>
1.0	28.89	1.99	0.24	9.87

Antenna gains: 0.46 dBi, 1.99 dBi, and 0.79 dBi

**Maximum Antenna gain, legacy mode =  $10\log(10^{0.46/10} + 10^{1.99/10} + 10^{0.79/10}) = 5.88$  dBi**

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.

**AVALON ANTENNA MPE CALCULATIONS**

**Legacy 802.11g Mode**

<b>Power Density Limit (mW/cm<sup>2</sup>)</b>	<b>Output Power (dBm)</b>	<b>Antenna Gain (dBi)</b>	<b>S, mW/cm<sup>2</sup> at 20cm</b>	<b>MPE Distance (cm)</b>
1.0	28.80	6.2	0.63	15.86

**HT20 MIMO Mode**

<b>Power Density Limit (mW/cm<sup>2</sup>)</b>	<b>Output Power (dBm)</b>	<b>Antenna Gain (dBi)</b>	<b>S, mW/cm<sup>2</sup> at 20cm</b>	<b>MPE Distance (cm)</b>
1.0	28.89	1.50	0.24	9.27

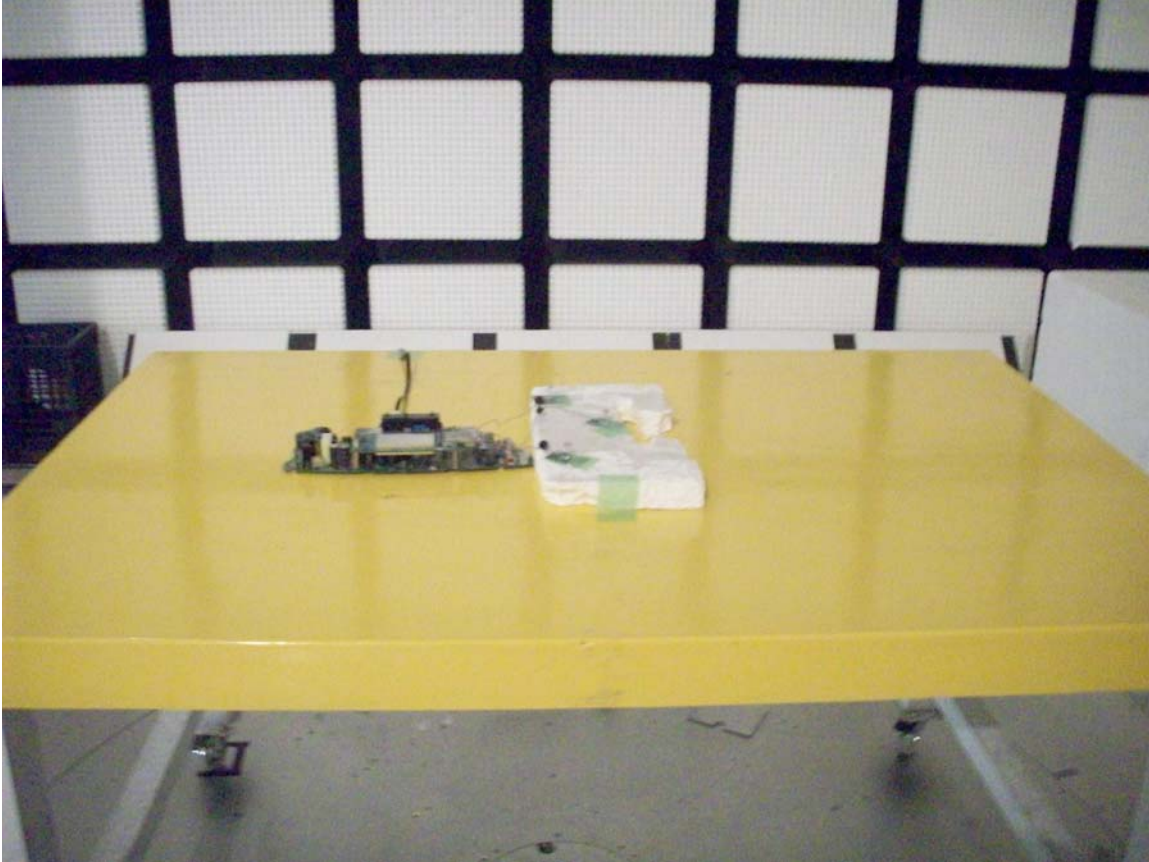
Antenna gains: 1.0 dBi, 2.26 dBi, and 0.79 dBi

**Maximum Antenna gain, legacy mode =  $10\log(10^{1.0/10} + 10^{2.26/10} + 10^{0.79/10}) = 6.2$  dBi**

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.

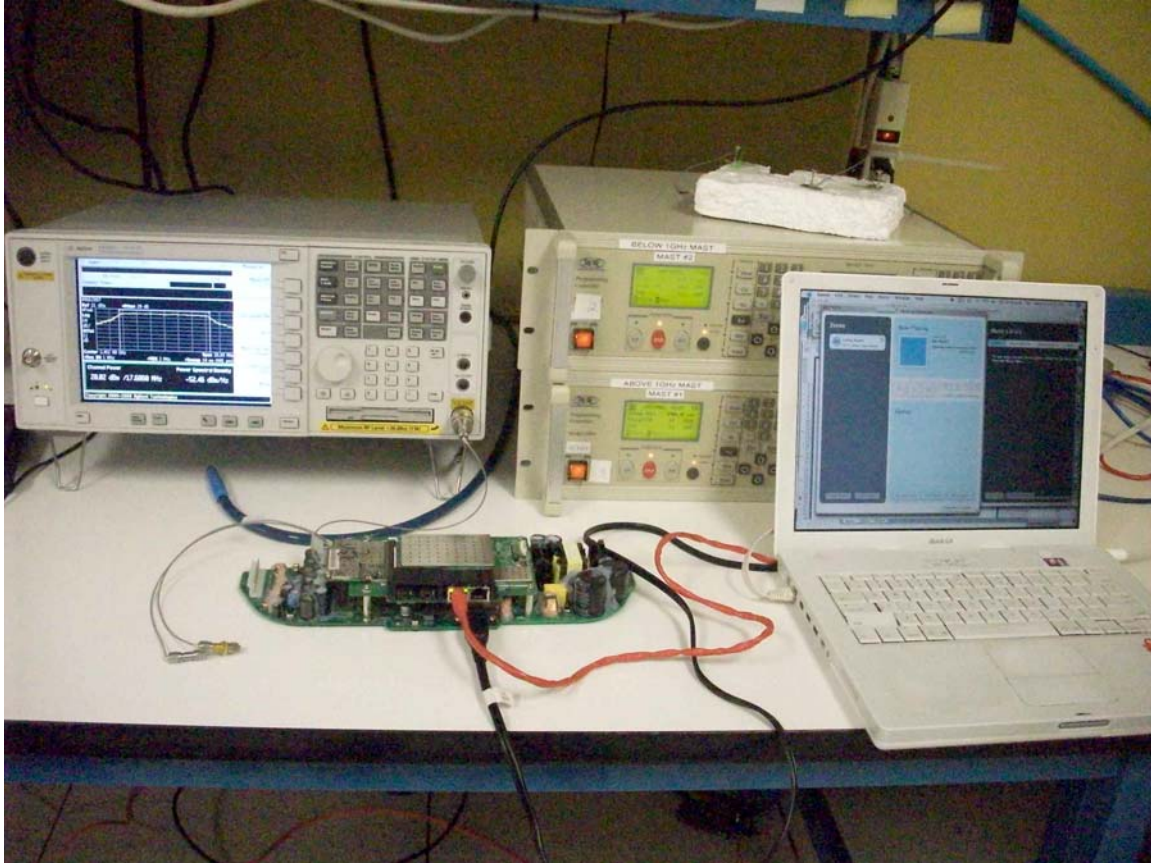
## SETUP PHOTOS

### Radiated Emissions Test Setup



## SETUP PHOTOS

### Peak Output Power Measurement Test Setup



**END OF REPORT**

#### Report Revision History

Revision No.	Revision Description	Pages Revised	Revised by	Date
-	Original Issue		T. Cokenias	12/06/09