



**FCC CFR47 PART 15 SUBPART E  
CLASS II PERMISSIVE CHANGE  
TEST REPORT**

**FOR**

**Broadcom 802.11ag/Draft 802.11n Wireless LAN PCI-E**

**MODEL NUMBER: BCM94321CM**

**FCC ID: QDS-BRCM1024**

**REPORT NUMBER: 06U10375-2**

**ISSUE DATE: JULY 06, 2006**

*Prepared for*  
**BOARDCOM CORP.  
190 MATHILDA PLACE  
SUNNYVALE, CA 94086, USA**

*Prepared by*  
**COMPLIANCE CERTIFICATION SERVICES  
561F MONTEREY ROAD  
MORGAN HILL, CA 95037, USA  
TEL: (408) 463-0885  
FAX: (408) 463-0888**

**NVLAP<sup>®</sup>**  
**LAB CODE:200065-0**

Revision History

Rev.	Issue Date	Revisions	Revised By
--	07/06/06	Initial Issue	Thu

## TABLE OF CONTENTS

<b>1. ATTESTATION OF TEST RESULTS.....</b>	<b>4</b>
<b>2. TEST METHODOLOGY .....</b>	<b>5</b>
<b>3. FACILITIES AND ACCREDITATION .....</b>	<b>5</b>
<b>4. CALIBRATION AND UNCERTAINTY.....</b>	<b>5</b>
4.1. MEASURING INSTRUMENT CALIBRATION.....	5
4.2. MEASUREMENT UNCERTAINTY.....	5
<b>5. EQUIPMENT UNDER TEST.....</b>	<b>6</b>
5.1. DESCRIPTION OF EUT .....	6
5.2. MAXIMUM OUTPUT POWER .....	6
5.3. DESCRIPTION OF AVAILABLE ANTENNAS .....	6
5.4. SOFTWARE AND FIRMWARE .....	6
5.5. WORST-CASE CONFIGURATION AND MODE.....	6
5.6. DESCRIPTION OF TEST SETUP .....	7
<b>6. TEST AND MEASUREMENT EQUIPMENT .....</b>	<b>9</b>
<b>7. LIMITS AND RESULTS .....</b>	<b>10</b>
7.1. AVERAGE POWER.....	10
7.2. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND .....	12
7.3. RADIATED EMISSIONS.....	12
7.3.1. TRANSMITTER RADIATED SPURIOUS EMISSIONS .....	12
7.3.2. TRANSMITTER ABOVE 1 GHZ FOR 5150 TO 5350 MHz BAND .....	15
7.3.3. WORST-CASE RADIATED EMISSIONS BELOW 1 GHz.....	24
7.4. POWERLINE CONDUCTED EMISSIONS .....	28
<b>8. SETUP PHOTOS .....</b>	<b>32</b>

## 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** Broadcom Corp.  
190 Mathilda Place  
Sunnyvale, CA 94086, USA

**EUT DESCRIPTION:** Broadcom 802.11ag/Draft 802.11n Wireless LAN PCI-E

**MODEL:** BCM94321MC

**SERIAL NUMBER:** APPLE LAPTOP #AOU257940, CARD #376

**DATE TESTED:** JUNE 17 TO 21, 2006

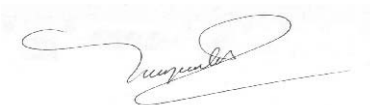
APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
FCC PART 15 SUBPART E	NO NON-COMPLIANCE NOTED

Compliance Certification Services, Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Compliance Certification Services and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Compliance Certification Services will constitute fraud and shall nullify the document. No part of this report may be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any government agency.

Approved & Released For CCS By:

Tested By:



---

THU CHAN  
EMC SUPERVISOR  
COMPLIANCE CERTIFICATION SERVICES

---

VIEN TRAN  
EMC ENGINEER  
COMPLIANCE CERTIFICATION SERVICES

## 2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2003, FCC CFR 47 Part 2 and FCC CFR 47 Part 15.

## 3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 561F Monterey Road, Morgan Hill, California, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

## 4. CALIBRATION AND UNCERTAINTY

### 4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

### 4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Radiated Emission, 30 to 200 MHz	+/- 3.3 dB
Radiated Emission, 200 to 1000 MHz	+4.5 / -2.9 dB
Radiated Emission, 1000 to 2000 MHz	+4.5 / -2.9 dB
Power Line Conducted Emission	+/- 2.9 dB

Uncertainty figures are valid to a confidence level of 95%.

## **5. EQUIPMENT UNDER TEST**

### **5.1. DESCRIPTION OF EUT**

The EUT is an 802.11n MIMO transceiver chip and installed inside Apple laptop, operating in 2400-2483.5 MHz band & 5150-5850 MHz band.

The EUT name and Applicant name were changed after testing commenced. All data in this report is applicable to the EUT name and Applicant name documented in Section 1 above.

### **5.2. MAXIMUM OUTPUT POWER**

Please refer to CCS project 06U10233-2C report.

### **5.3. DESCRIPTION OF AVAILABLE ANTENNAS**

The antenna manufacturer is Tyco  
The antenna model is 056-1579  
The Peak Gain is:

2440 MHz -1.6 dBi  
5130 MHz -4.12 dBi  
5360 MHz +4.06 dBi  
5590 MHz +7.44 dBi  
5825 MHz +2.02 dBi

### **5.4. SOFTWARE AND FIRMWARE**

The EUT driver software installed in the host support equipment during testing was BCM94321, version. 4.80.9.2.

The test utility software used during testing was wl\_tools.

### **5.5. WORST-CASE CONFIGURATION AND MODE**

Please refer to CCS project 06U10233-2C report.

All the RF conducted emissions were performed under the previous CCS project 06U10233-2C report. This report only confirmed on the output power & performed on all radiated emissions, e.g. spurious emissions, harmonic, bandedge, and LC tests for the worst case of portable configuration.

## 5.6. DESCRIPTION OF TEST SETUP

### SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Apple	A1150	AOU257940	DoC
AC Adapter	Apple	A1152	N/A	N/A
Mouse	Delta Electronic	ADP-90UBC	N/A	N/A

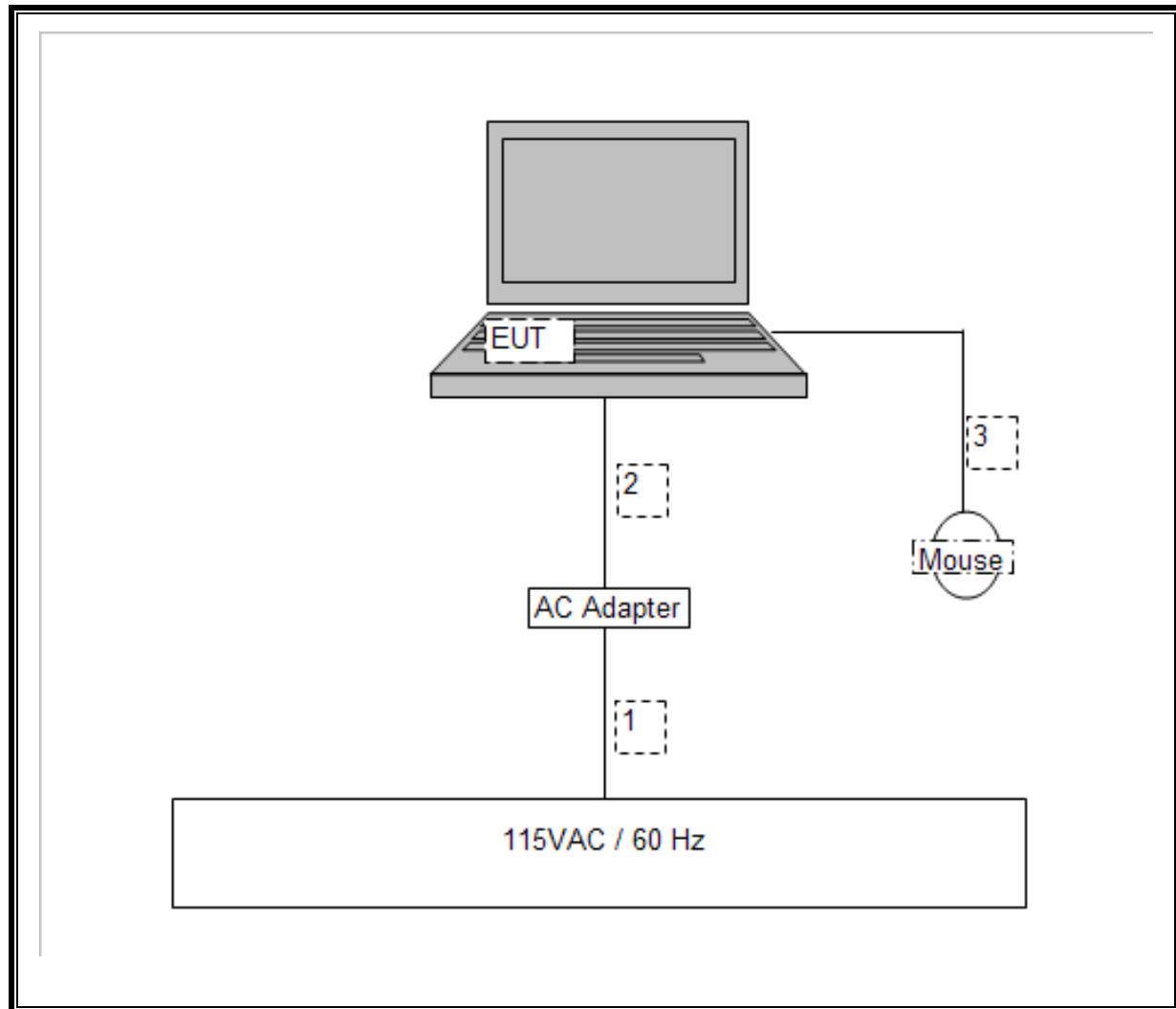
### I/O CABLES

I/O CABLE LIST						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length	Remarks
1	AC	1	US115	Shielded	1.2m	No
2	DC	1	DC	Unshielded	.8m	No
3	USB	1	USB	Unshielded	.5m	Yes

### TEST SETUP

The EUT is installed in a host laptop computer Test software exercised the radio card.

**SETUP DIAGRAM FOR TESTS**





## 6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	Cal Due
EMI Receiver, 9 kHz ~ 2.9 GHz	Agilent / HP	8542E	3942A00286	2/4/2007
RF Filter Section	Agilent / HP	85420E	3705A00256	2/4/2007
Antenna, Bilog 30 MHz ~ 2 Ghz	Sunol Sciences	JB1	A121003	9/3/2006
LISN, 10 kHz ~ 30 MHz	FCC	LISN-50/250-25-2	2023	8/30/2006
LISN, 10 kHz ~ 30 MHz	Solar	8012-50-R-24-BNC	8379443	8/30/2006
EMI Test Receiver	R & S	ESHS 20	827129/006	11/3/2006
Antenna, Horn 1 ~ 18 GHz	EMCO	3115	2238	4/22/2007
Preamplifier, 1 ~ 26.5 GHz	Agilent / HP	8449B	3008A00561	10/3/2007
Spectrum Analyzer 3 Hz ~ 44 GHz	Agilent / HP	E4446A	MY43360112	4/28/2007
7.6 Highpass Filter	Micro-Tronics	HPM13195	1	CNR

## **7. LIMITS AND RESULTS**

### **7.1. AVERAGE POWER**

#### **AVERAGE POWER LIMIT**

None; for reporting purposes only.

#### **TEST PROCEDURE**

The transmitter output is connected to a power meter.

#### **RESULTS**

No non-compliance noted:

The cable assembly insertion loss of 10.7 dB (including 10 dB pad and 0.7 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

Conducted average power:

**802.11a (6 Mbs)**

Channel	Frequency (MHz)	Main (dBm)	AUX (dBm)
Low	5180	7.0	7.0
Middle	5260	14.0	14.0
High	5300	14.0	14.0
High	5320	14.5	14.5

**802.11n HT20 (6.5 Mbs)**

Channel	Frequency (MHz)	Main (dBm)	AUX (dBm)
Low	5180	10.20	10.25
Middle	5260	16.20	16.25
High	5320	13.21	13.13

**802.11n HT40 (13.5 Mbs)**

Channel	Frequency (MHz)	Main (dBm)	AUX (dBm)
Low	5190	12.30	12.35
Middle	5260	15.85	15.83
High	5310	12.33	12.18

## 7.2. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND

Please refer to CCS project 06U10233-2C reports.

## 7.3. RADIATED EMISSIONS

### 7.3.1. TRANSMITTER RADIATED SPURIOUS EMISSIONS

#### LIMITS

§15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
<sup>1</sup> 0.495 - 0.505	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 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2655 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	( <sup>2</sup> )
13.36 - 13.41			

<sup>1</sup> Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

<sup>2</sup> Above 38.6

§15.205 (b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
30 - 88	100 **	3
88 - 216	150 **	3
216 - 960	200 **	3
Above 960	500	3

\*\* Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

§15.209 (b) In the emission table above, the tighter limit applies at the band edges.

## **TEST PROCEDURE**

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.4. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

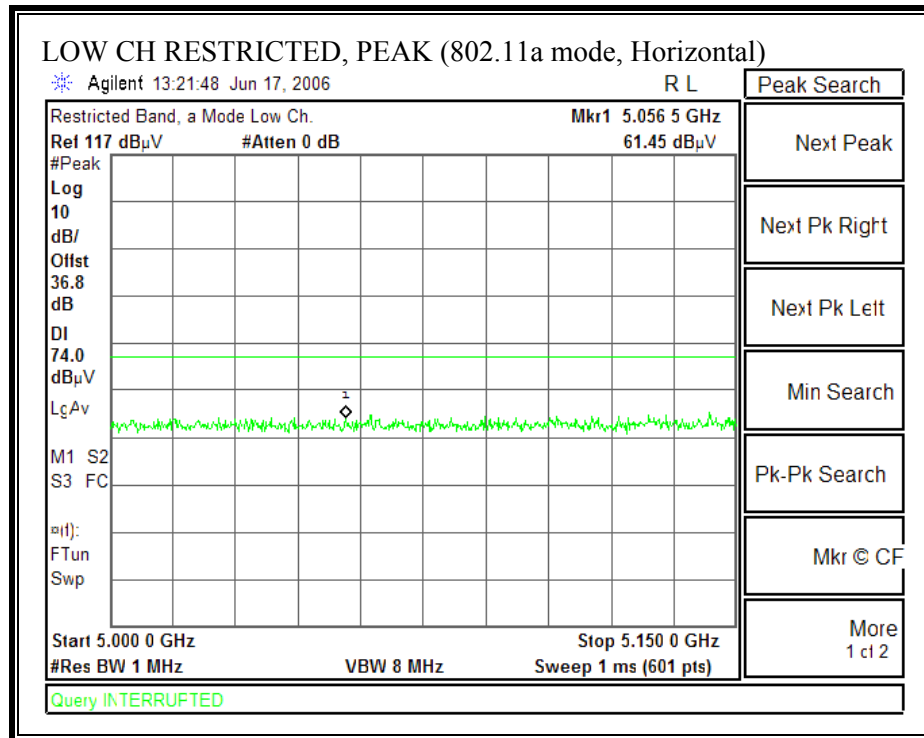
The spectrum from 30 MHz to 40 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each band.

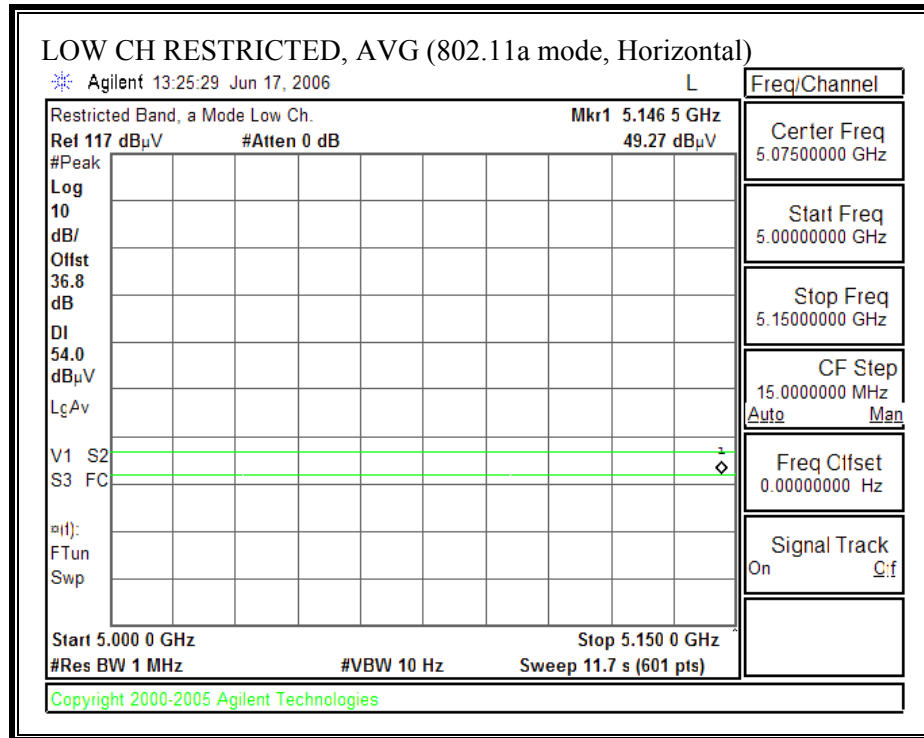
The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

### 7.3.2. TRANSMITTER ABOVE 1 GHz FOR 5150 TO 5350 MHz BAND

#### MIMO 20 MHz BANDWIDTH – 5.2 GHz BAND – WORST CASE

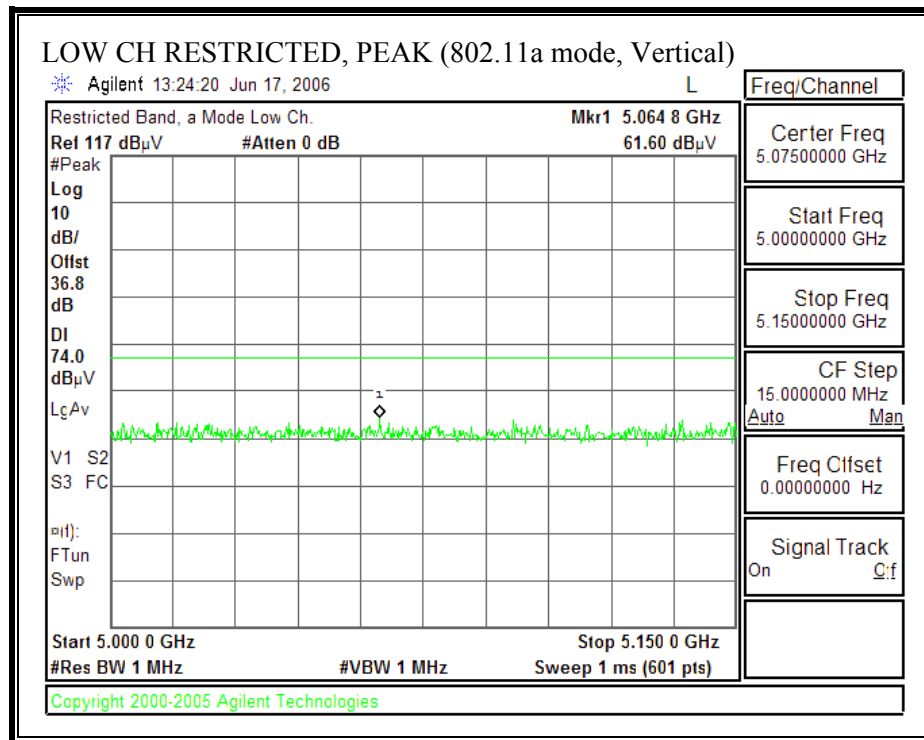
#### RESTRICTED BANDEDGE (802.11a MODE, LOW CHANNEL, HORIZONTAL)

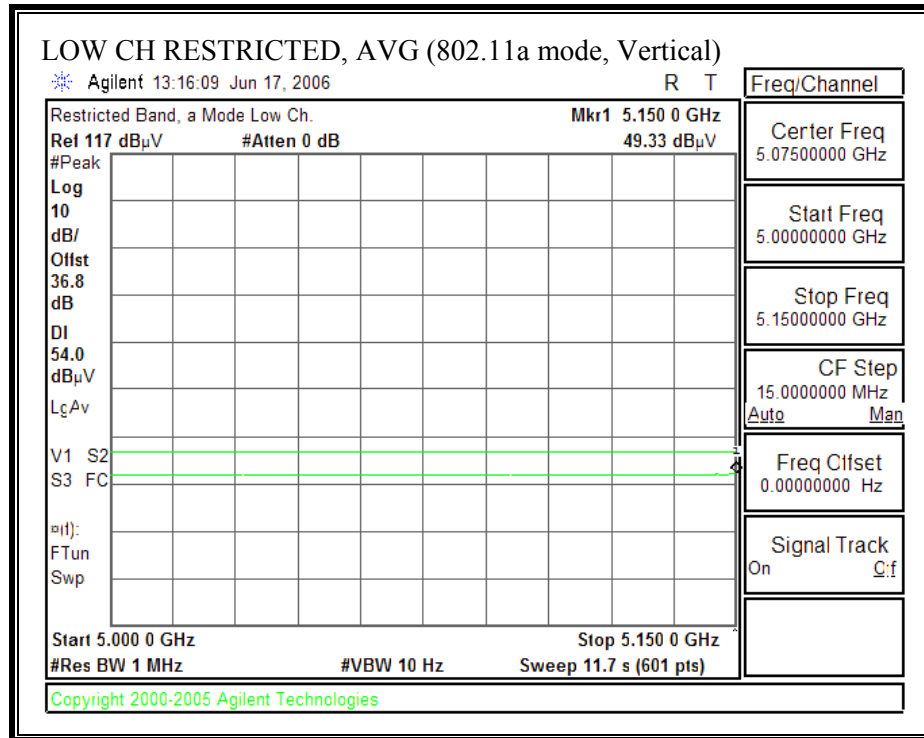




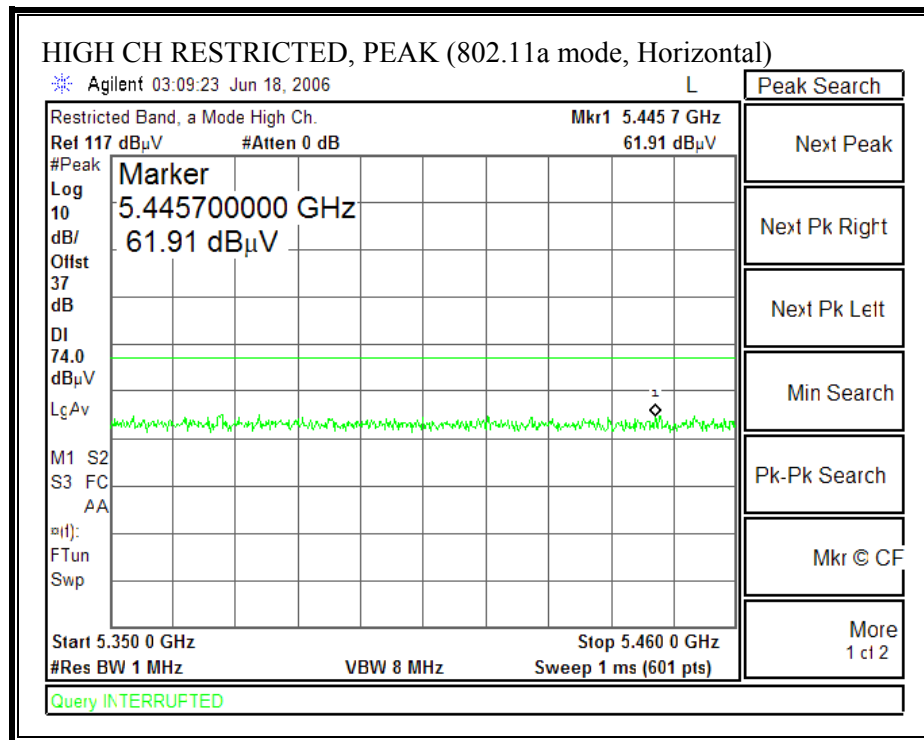


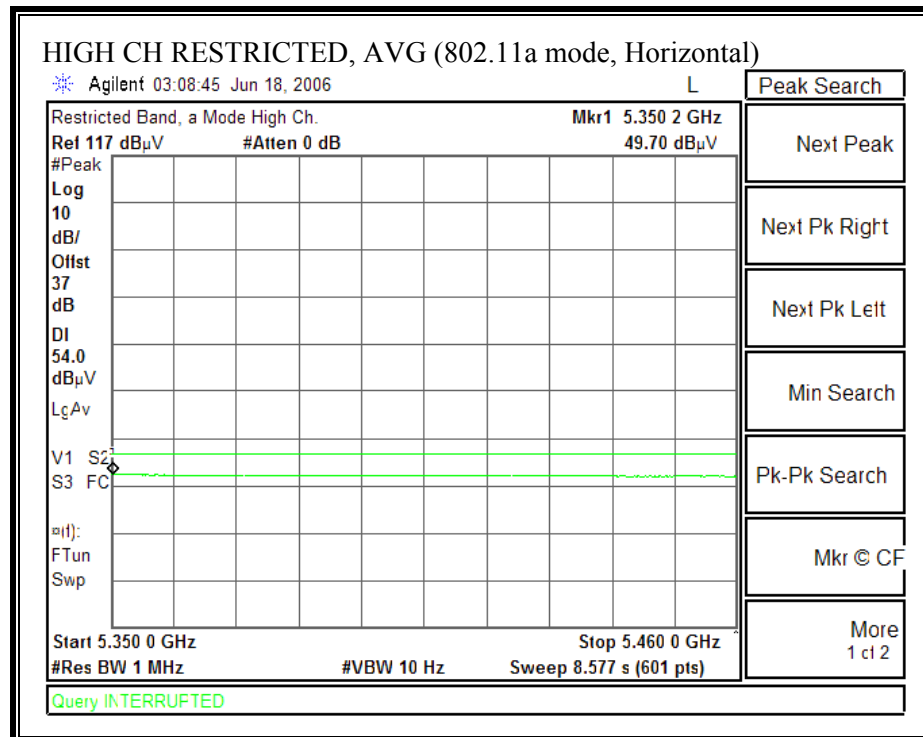
**RESTRICTED BANDEDGE (802.11a MODE, LOW CHANNEL, VERTICAL)**



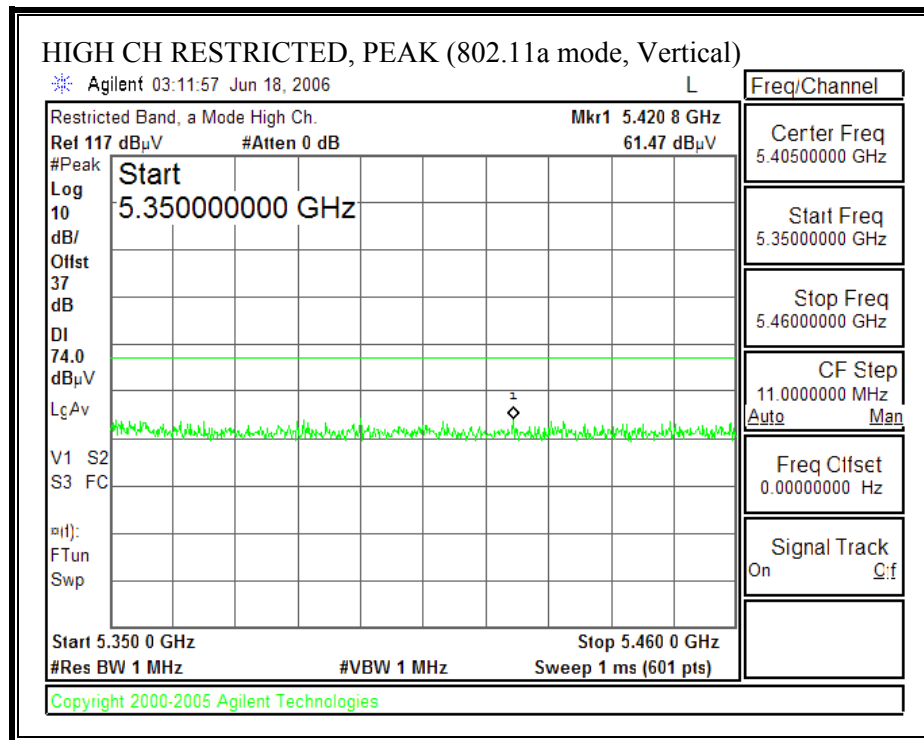


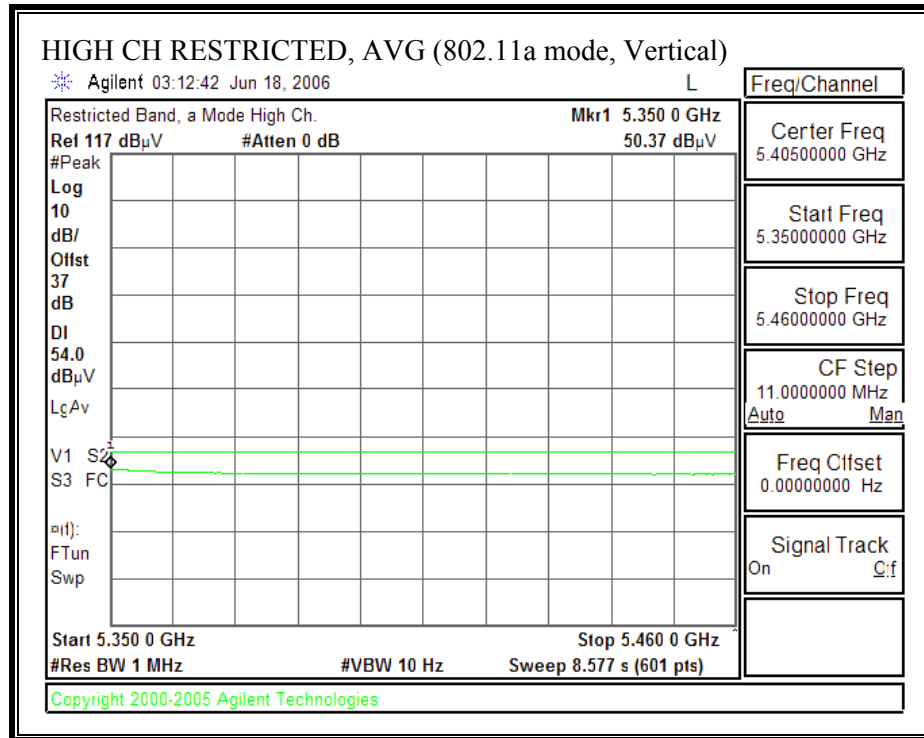
**RESTRICTED BANDEDGE (802.11a MODE, HIGH CHANNEL, HORIZONTAL)**





**RESTRICTED BANDEDGE (802.11a MODE, HIGH CHANNEL, VERTICAL)**





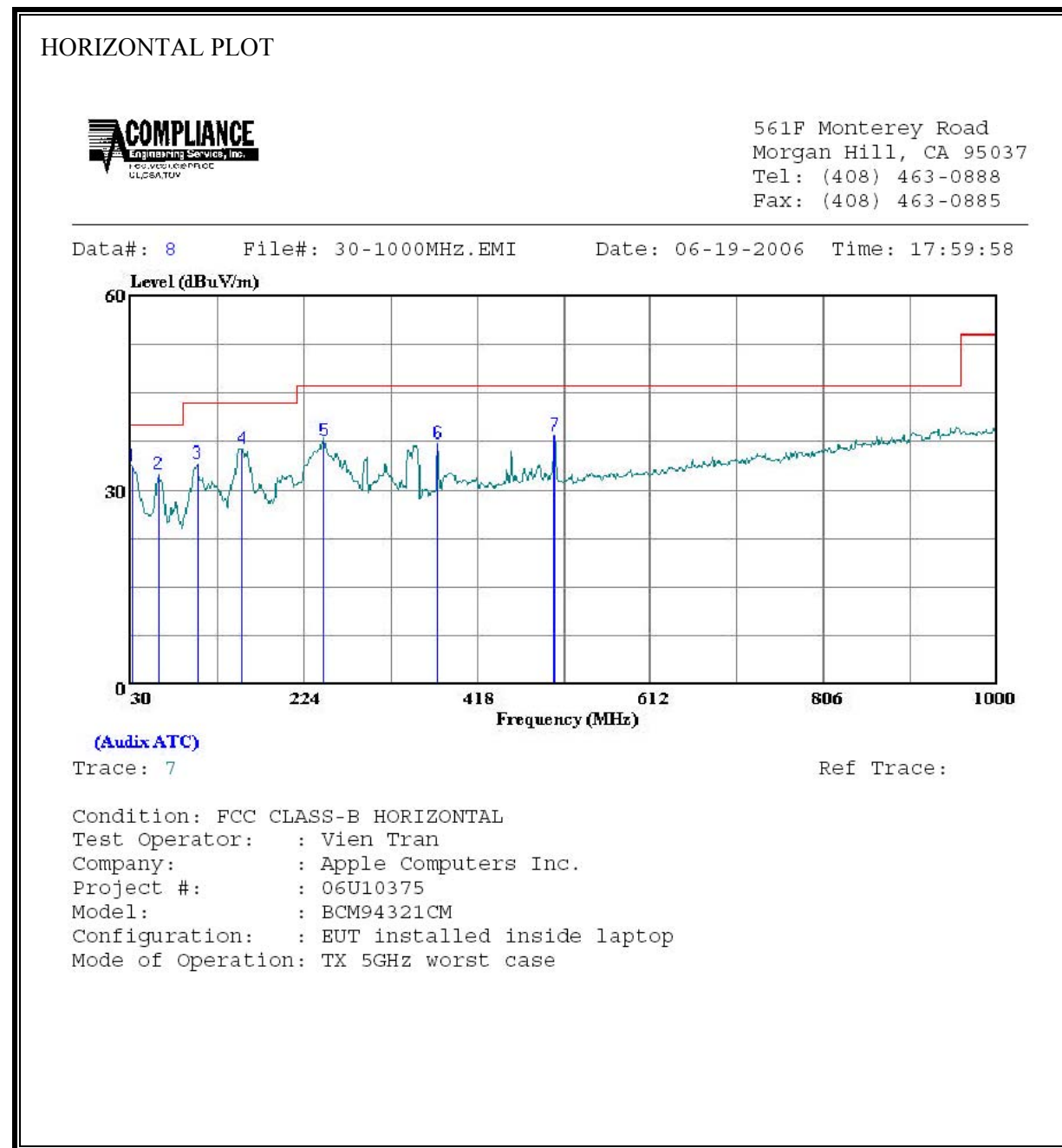
**HARMONICS AND SPURIOUS EMISSIONS (802.11a MIMO 20MHz MODE)**

High Frequency Measurement																
Compliance Certification Services, Morgan Hill Open Field Site																
Company: Apple Computer Inc.																
Project #: 06U10375																
Date: 06/20/06																
Test Engineer: Vien Tran																
Configuration: 802.11abgn Wireless LAN Card (Card #376)																
Mode: MIMO 20MHz Tx BW 11a Mode_5.2 GHz Band																
Average Power Meter: Low = 16 dBm, Mid = 16 dBm, High = 16 dBm																
Test Equipment:																
Horn 1-18GHz		Pre-amplifier 1-26GHz		Pre-amplifier 26-40GHz		Horn > 18GHz		Limit								
T60; S/N: 2238 @3m		T145 Agilent 3008A0056						FCC 15.205								
Hi Frequency Cables																
2 foot cable		3 foot cable		12 foot cable		HPF		Reject Filter		Peak Measurements RBW=VBW=1MHz Average Measurements RBW=1MHz; VBW=10Hz						
		Vien 187215002		Vien 197209005		HPF_7.6GHz										
f GHz	Dist (m)	Read Pk dBuV	Read Avg. dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Filt dB	Peak dBuV/m	Avg dBuV/m	Pk Lim dBuV/m	Avg Lim dBuV/m	Pk Mar dB	Avg Mar dB	Notes (V/H)	
LOW CH, 5180 MHz																
15.540	3.0	44.8	32.8	38.0	5.8	-32.3	0.0	0.7	57.0	45.0	74	54	-17.0	-9.0	V	
15.540	3.0	44.2	32.5	38.0	5.8	-32.3	0.0	0.7	56.4	44.7	74	54	-17.6	-9.3	H	
MID CH, 5260 MHz																
15.780	3.0	43.7	32.7	37.9	5.8	-32.2	0.0	0.7	55.9	44.9	74	54	-18.1	-9.1	V	
15.780	3.0	42.7	32.1	37.9	5.8	-32.2	0.0	0.7	54.9	44.3	74	54	-19.1	-9.7	H	
HI CH, 5320 MHz																
10.640	3.0	58.0	44.3	37.3	4.8	-34.2	0.0	0.8	66.6	53.0	74	54	-7.4	-1.0	V	
15.960	3.0	43.2	32.2	37.8	5.9	-32.2	0.0	0.7	55.4	44.4	74	54	-18.6	-9.6	V	
10.640	3.0	53.5	39.4	37.3	4.8	-34.2	0.0	0.8	62.1	48.0	74	54	-11.9	-6.0	H	
15.960	3.0	42.9	31.6	37.8	5.9	-32.2	0.0	0.7	55.1	43.8	74	54	-18.9	-10.2	H	
No other emissions were detected above system noise floor.																
f	Measurement Frequency			Amp	Preamp Gain			Avg Lim	Average Field Strength Limit							
Dist	Distance to Antenna			D Corr	Distance Correct to 3 meters			Pk Lim	Peak Field Strength Limit							
Read	Analyzer Reading			Avg	Average Field Strength @ 3 m			Avg Mar	Margin vs. Average Limit							
AF	Antenna Factor			Peak	Calculated Peak Field Strength			Pk Mar	Margin vs. Peak Limit							
CL	Cable Loss			HPF	High Pass Filter											

### 7.3.3. WORST-CASE RADIATED EMISSIONS BELOW 1 GHz

#### 5 GHz BAND - WORST CASE

#### SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, HORIZONTAL)





HORIZONTAL DATA

	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV/m	dBuV/m	dB	
1	30.970	13.22	20.45	33.67	40.00	-6.33	Peak
2	61.040	23.67	8.78	32.45	40.00	-7.55	Peak
3	104.690	21.62	12.38	34.00	43.50	-9.50	Peak
4	154.160	22.38	13.99	36.37	43.50	-7.13	Peak
5	246.310	23.75	13.75	37.49	46.00	-8.51	Peak
6	373.380	19.77	17.46	37.23	46.00	-8.77	Peak
7	504.330	18.15	20.26	38.41	46.00	-7.59	Peak

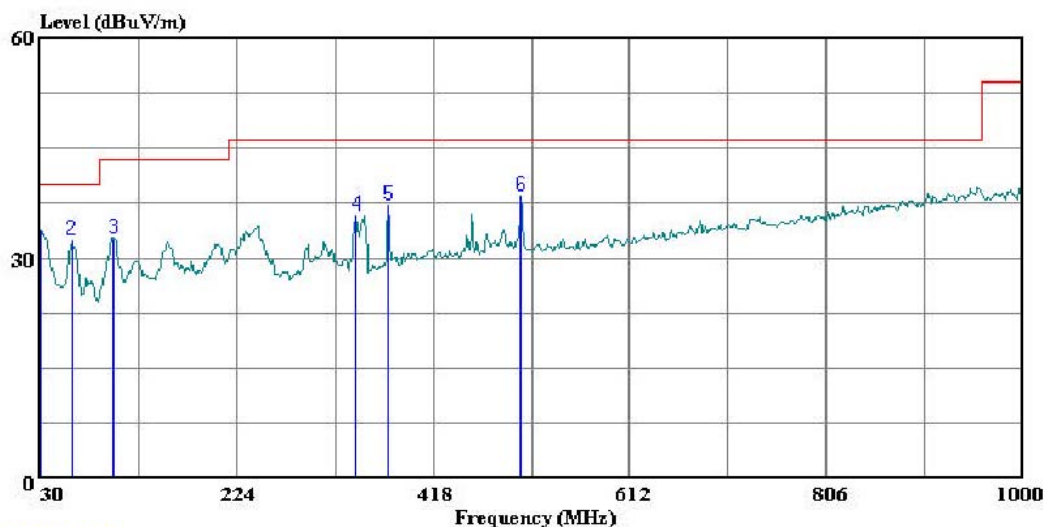
**SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION, VERTICAL)**

VERTICAL PLOT



561F Monterey Road  
Morgan Hill, CA 95037  
Tel: (408) 463-0888  
Fax: (408) 463-0885

Data#: 6 File#: 30-1000MHz.EMI Date: 06-19-2006 Time: 17:44:53



(Auxiliary ATC)

Trace: 5

Ref Trace:

Condition: FCC CLASS-B VERTICAL  
Test Operator: : Vien Tran  
Company: : Apple Computers Inc.  
Project #: : 06U10375  
Model: : BCM94321CM  
Configuration: : EUT installed inside laptop  
Mode of Operation: TX 5GHz worst case

VERTICAL DATA

	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV/m	dBuV/m	dB	
1	30.000	13.30	20.45	33.75	40.00	-6.25	Peak
2	61.040	23.67	8.78	32.45	40.00	-7.55	Peak
3	102.750	20.71	12.00	32.70	43.50	-10.80	Peak
4	342.340	18.99	16.68	35.67	46.00	-10.33	Peak
5	373.380	19.77	17.46	37.23	46.00	-8.77	Peak
6	504.330	18.15	20.26	38.41	46.00	-7.59	Peak

## 7.4. POWERLINE CONDUCTED EMISSIONS

### LIMIT

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50  $\mu$ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal.

The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 <sup>*</sup>	56 to 46 <sup>*</sup>
0.5-5	56	46
5-30	60	50

<sup>\*</sup> Decreases with the logarithm of the frequency.

### TEST PROCEDURE

The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.4.

The resolution bandwidth is set to 9 kHz for both peak detection and quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

Line conducted data is recorded for both NEUTRAL and HOT lines.

### RESULTS

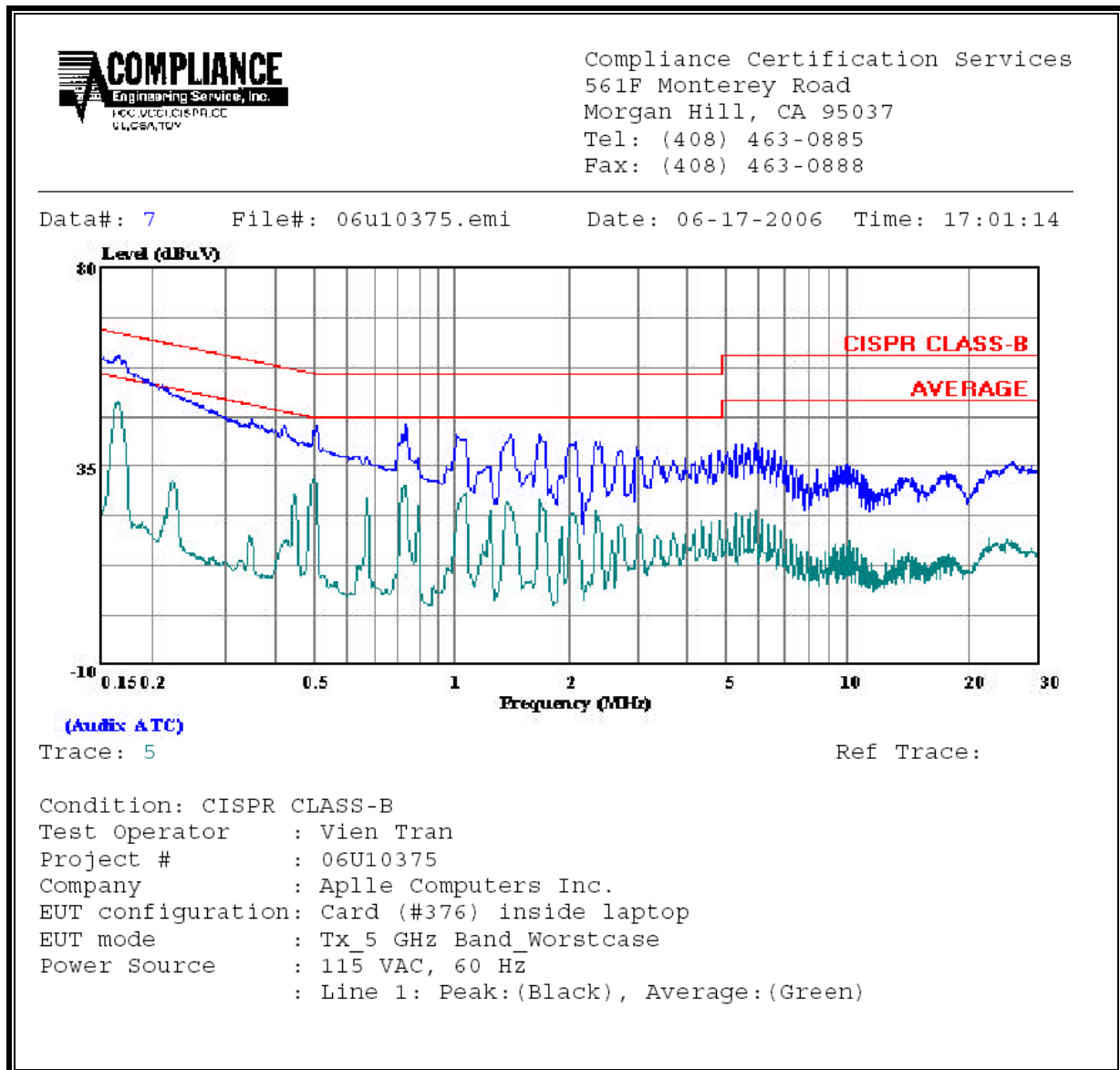
No non-compliance noted:

## 5 GHz BAND – WORST CASE

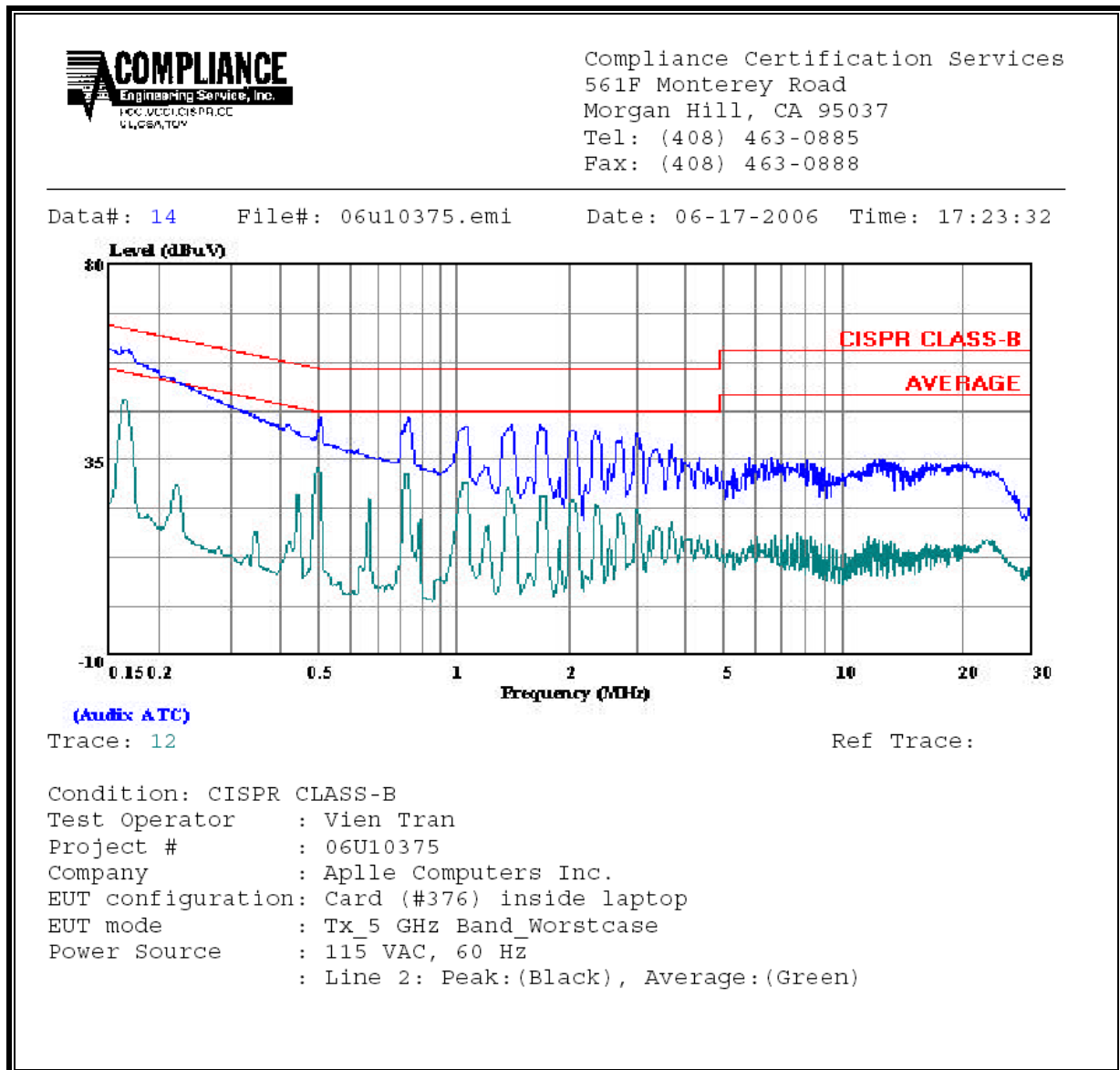
### 6 WORST EMISSIONS

5 GHz BAND									
CONDUCTED EMISSIONS DATA (115VAC 60Hz)									
Freq.	Reading			Closs	Limit	FCC B	Margin		Remark
(MHz)	PK (dBuV)	QP (dBuV)	AV (dBuV)	(dB)	QP	AV	QP (dB)	AV (dB)	L1 / L2
0.16	59.89	--	49.42	0.00	65.26	55.26	-5.37	-5.84	L1
0.51	44.24	--	33.32	0.00	56.00	46.00	-11.76	-12.68	L1
0.84	44.54	--	30.31	0.00	56.00	46.00	-11.46	-15.69	L1
0.16	59.98	--	48.81	0.00	65.26	55.26	-5.28	-6.45	L2
0.51	45.10	--	33.10	0.00	56.00	46.00	-10.90	-12.90	L2
0.84	44.62	--	31.69	0.00	56.00	46.00	-11.38	-14.31	L2
6 Worst Data									

## LINE 1 RESULTS

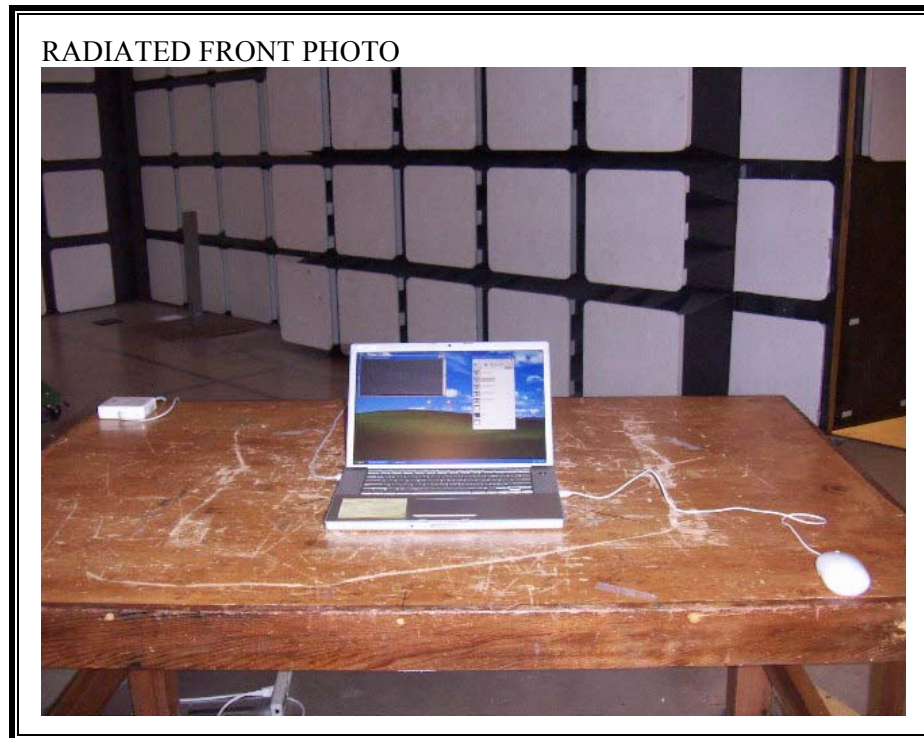


## LINE 2 RESULTS



## 8. SETUP PHOTOS

### RADIATED RF MEASUREMENT SETUP

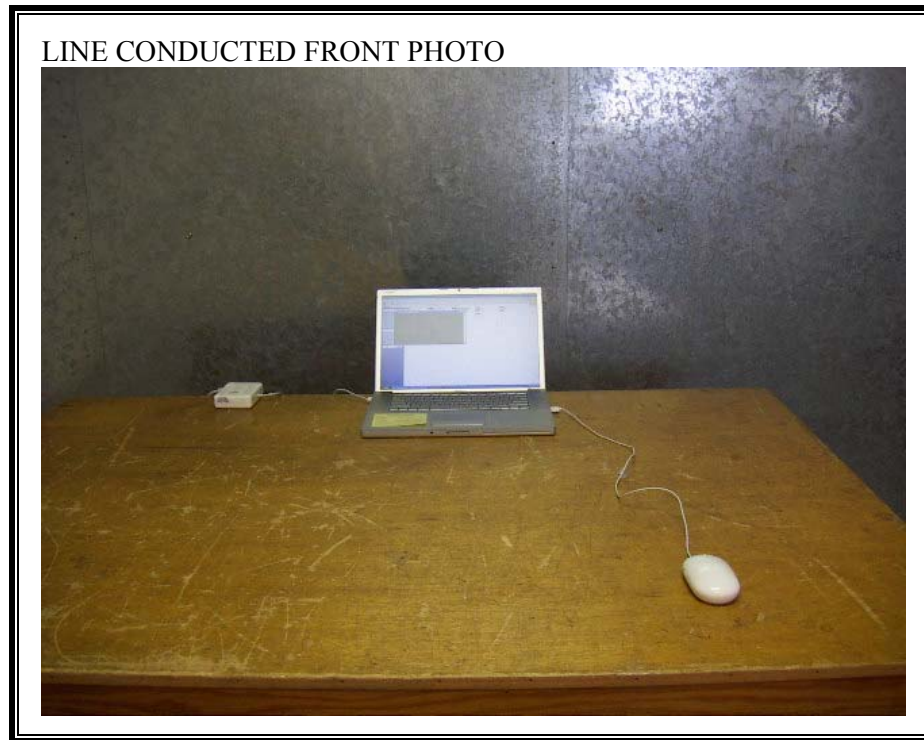




RADIATED BACK PHOTO



**POWERLINE CONDUCTED EMISSIONS MEASUREMENT SETUP**



LINE CONDUCTED BACK PHOTO



**END OF REPORT**