TEST REPORT

for the

Bluetooth Keyboard

Model # A1016

Apple Computer, Inc.

July1, 2003

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EMC NVLAP Technical Manager: _____ Date: July 1, 2003
Robert Steinfeld
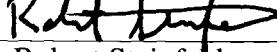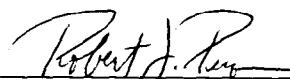
EMC Test Engineer: _____ Date: 7/1/03
Robert Pera

Test Report Summary

Specification from CFR 15 Subpart C	Test Description	Result	Comment
CFR 15.203	Antenna Requirement	Pass	Section 1.6
CFR 15.209(a)	Radiated Emissions 30 MHz to 25 GHz	Pass	Section 2
CFR 15.247(a)(1)	Channel Separation Greater of 25 kHz or 20 dB BW of hopping channel	Pass	Section 3
CFR 15.247(a)(1)(ii)	Number of Hopping Channels Used Requirement: 75 minimum (equally spaced)	Pass	Section 4
CFR 15.247(a)(1)(ii)	20 dB Bandwidth for Frequency Hopping Spread Spectrum Requirement: 1 MHz maximum	Pass	Section 5
CFR 15.247(a)(1)(ii)	Dwell Time on each channel Requirement: 0.4 seconds maximum (within a 30 second period)	Pass	Section 6
CFR 15.247(b)(1)	Maximum Peak Output Power Requirement: Less then 1 Watt	Pass	Section 7
CFR 15.247(b)(4)	RF Exposure	Pass	Section 8
CFR 15.247(c)	-20 dBc Spurious Emissions	Pass	Section 9
CFR 15.247(f)	Power Spectral Density - Hopping Disabled Requirement: Less then +8 dBm in any 3 kHz bandwidth	Pass	Section 10

TABLE OF CONTENTS

1   General Information

1.1   Introduction and Purpose of test report

This report contains the test results for the Apple Bluetooth keyboard and is intended to demonstrate that the module complies with the FCC Part 15 rules for Frequency Hopping Spread Spectrum transmitters.   This report includes data for two different antennas.

1.2   Product General and Technical Descriptions

Information on the Apple Bluetooth keyboard is provided in the table below.

Apple Bluetooth keyboard information	
Model Number	A1016
FCC ID	BCGA1016
Class	Spread Spectrum Transceiver
Method	Frequency Hopping Spread Spectrum
Maximum RF Power Output	0 dBm
Frequency Range	2402 MHz - 2480 MHz
Number of Channels	79 equally spaced
Antenna Type/Antenna Gain	PCB / 1.08 dBi

1.5 **Product Label**

below is the label that appears on the back of the keyboard.

$C\mathcal{E}$ 0984   (!)

Complies with the Canadian ICES-003 Class B specifications. Rated 6V DC FCC ID: BCGA1016 IC: 579C-A1016
EMC No.: 1937 TM and © 2003 Apple Computer, Inc. All rights reserved. アップルコンピュータ株式会社

*below is the label that appears inside the battery well*

This device complies with part 15 of the FCC Rules. Operation is subject to the following
two conditions: 1) This device may not cause harmful interference and 2) this device must
accept interference received, including interference which may cause harmful interference.

1.6   Antenna Information

1.6.1   CFR 47 Section 15.203(a) Antenna Requirement

Per CFR 47 Section 15.203(a), an intentional radiator shall be designed to insure that no antenna other than that furnished by the responsible party shall be used with the device.

1.6.2   Antenna Photograph

The Apple Bluetooth Keyboard uses a printed antenna on the PCB. Below is a picture.
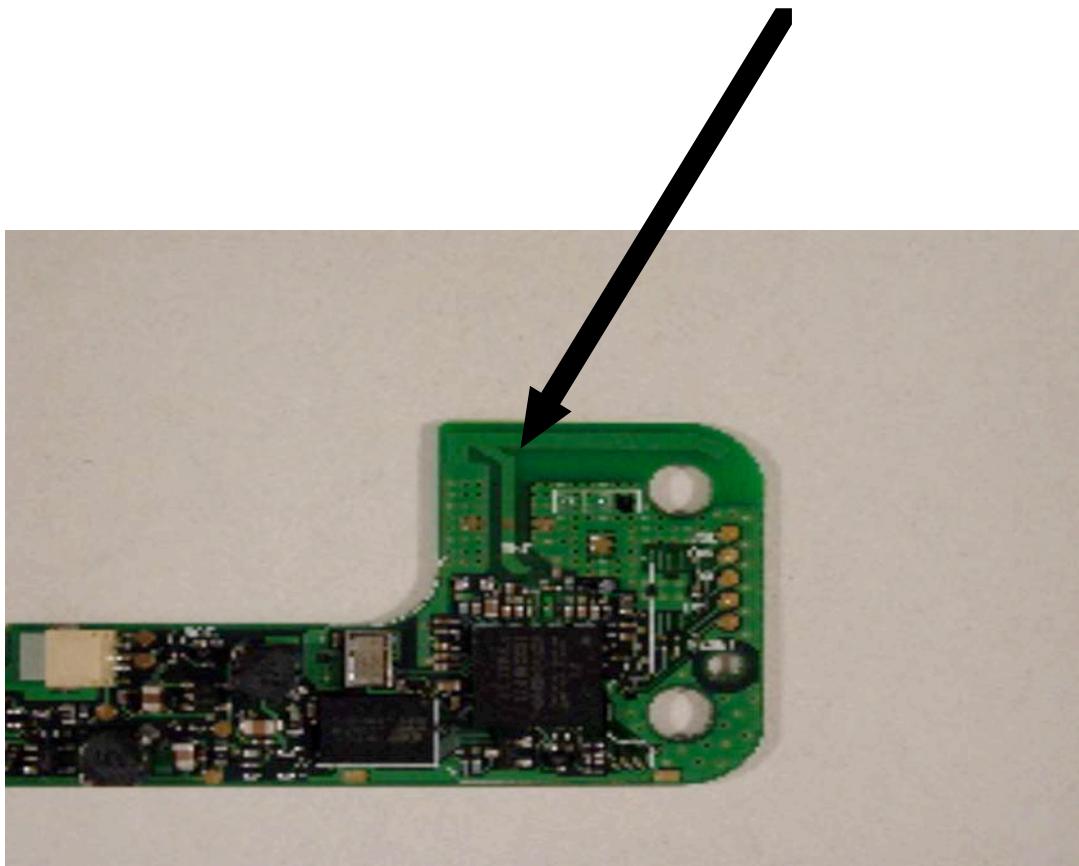
1.6.3   Antenna Electrical Information

Radiation Pattern

**Azimuth Radiation Pattern; Q6; Complete Unit w/ Batteries
(V and H Pol Summed)**

Top View

BT Module and Antenna

dBi
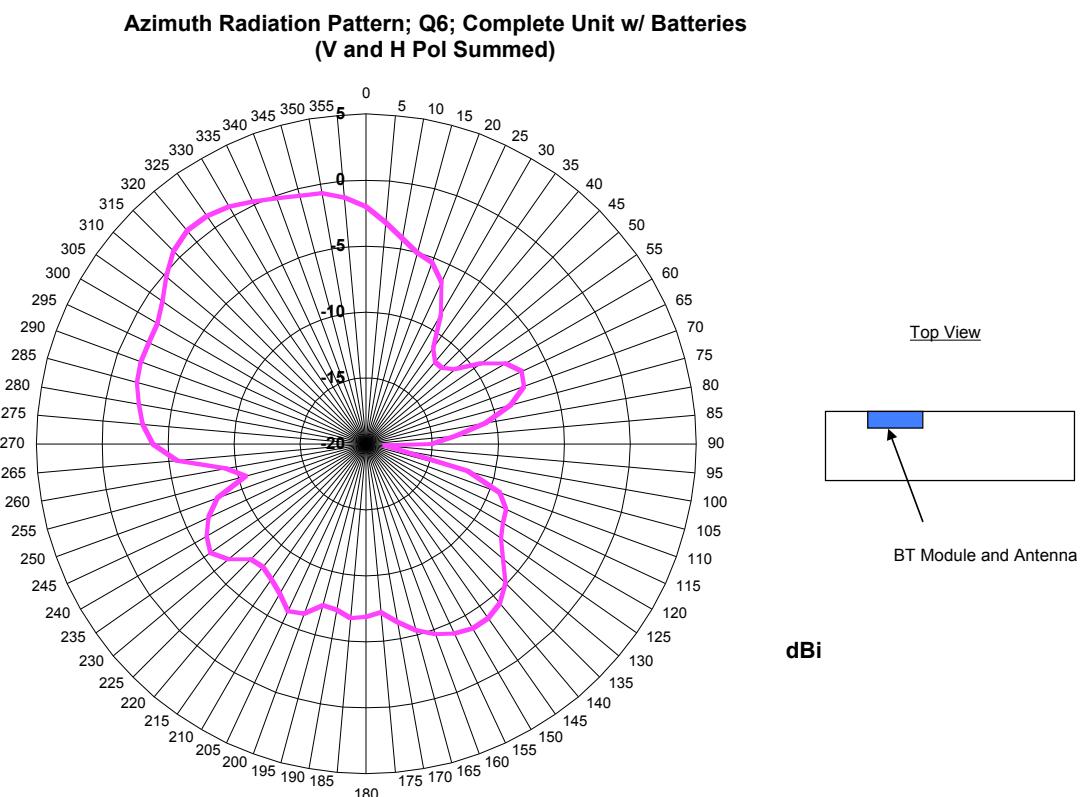
Tabular Data of Antenna Radiation Patterns

| Degree	Gain (dBi)		Degree	Gain (dBi)
0	-2.00		180	-6.90
5	-3.13		185	-6.75
10	-4.23		190	-7.23
15	-5.00		195	-7.32
20	-5.40		200	-6.30
25	-6.46		205	-6.03
30	-8.71		210	-6.92
35	-11.14		215	-7.49
40	-11.89		220	-7.83
45	-11.82		225	-7.66
50	-11.23		230	-6.36
55	-9.37		235	-5.62
60	-7.82		240	-6.05
65	-7.03		245	-6.83
70	-7.28		250	-8.04
75	-8.65		255	-10.55
80	-10.80		260	-9.21
85	-13.15		265	-5.63
90	-15.08		270	-3.85
95	-18.61		275	-2.99
100	-17.65		280	-2.51
105	-12.07		285	-2.05
110	-9.23		290	-1.83
115	-8.28		295	-1.85
120	-8.01		300	-1.74
125	-7.49		305	-1.16
130	-6.44		310	-0.22
135	-5.11		315	0.65
140	-4.22		320	1.08
145	-3.86		325	1.08
150	-3.86		330	0.78
155	-4.16		335	0.27
160	-4.63		340	-0.20
165	-5.37		345	-0.55
170	-6.32		350	-0.70
175	-7.20		355	-1.29

2   CFR 15.209(a) Radiated Emissions
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2.1   CFR 15.209(a) Radiated Emissions less than 1 GHz

       Pre-scans below 1 GHz were performed with the transmitter frequency set to the low, mid and high channels.   In each case, the emissions below 1 GHz were found to be similar.   Thus radiated emissions data in this report below 1 GHz is provided for channel 1 only.

2.1.1   CFR 15.209(a) Radiated Emissions less than 1 GHz Test Setup

       Radiated Emission measurements at or below 1 GHz were performed at the Apple Computer Test Site ALTS #1, located at 123 East Evelyn Ave., Mountain View, California.   The EUT was placed on a nonmetallic table, 80 cm above the metallic ground-plane.   The EUT and peripherals were powered from a filtered ac mains supply.

Radiated Test Setup - Top View
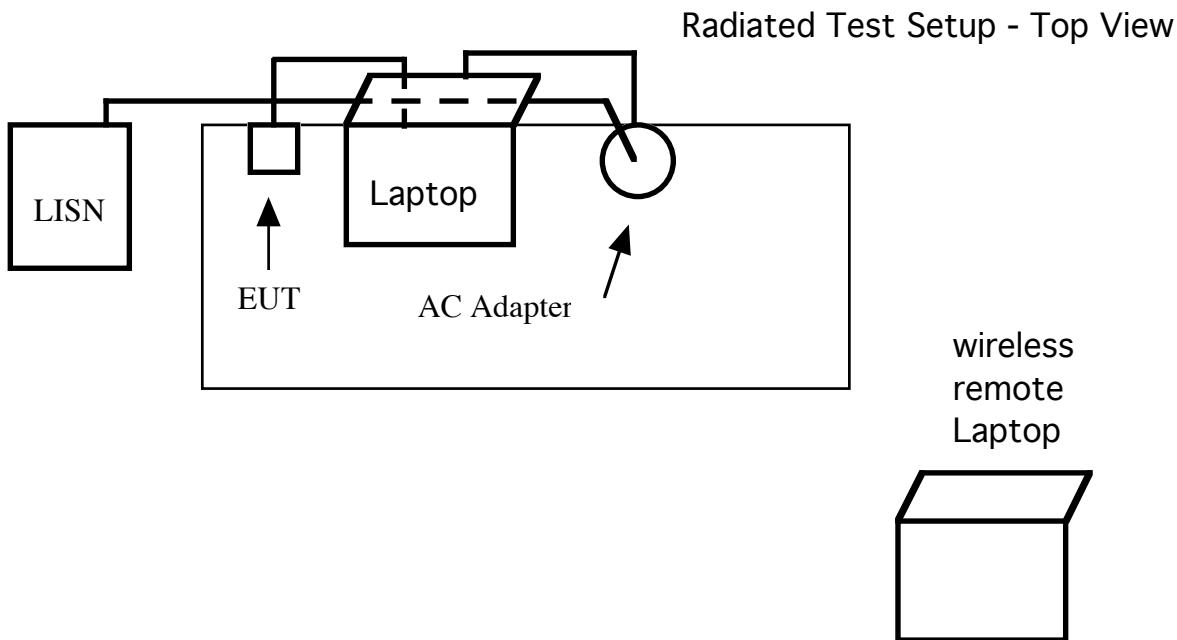
2.1.2 CFR 15.209(a) Radiated Emissions less than 1 GHz Test Procedure

The frequency spectrum from 30 MHz to ≤ 1 GHz was scanned and the emission levels maximized at each frequency recorded. The antenna was varied in height between 1.0 and 4.0 meters and the system was rotated 360 degrees while scanning for maximum emission amplitudes. This procedure was performed for both horizontal and vertical polarization of the receiving antenna. During maximization the position of the cables was varied and the scanning repeated until the worst case emission was found. The data recorded in this report are the maximum emission levels measured.

Radiated Emission measurements at or below 1 GHz were performed at an EUT to antenna distance of 3 meters.

2.1.3 CFR 15.209(a) Radiated Emissions less than 1 GHz Test Equipment

The following test equipment was used when performing radiated emissions tests below 1 GHz.

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	Hewlett Packard	8566	E4663/E	7/02	7/03
EMI Receiver	R&S	ESI 26	100025	8/02	8/03
Amplifier	HP	8449B	3008A00713	3/03	3/04
Coaxial Cable	Huber & Suhner	SF106	0.29	4/03	4/04
Antenna	Horn Antenna	3115	9205-3852	9/00	9/03

Notes: HP is an abbreviation for Hewlett Packard.
                     R&S is an abbreviation for Rhode & Schwarz.
N/A is an abbreviation for Not Applicable
The above equipment is traceable to NVLAP calibration standards.

3.1.3.1 CFR 15.209(a) Radiated Emissions less than 1 GHz Instrument Settings:

Instrument Settings				
Frequency Range	Reference Level	Attenuation	Resolution BW	Video BW
30 MHz - 1 GHz	90 dBuV	10	100 kHz	100 kHz

### 2.1.4 CFR 15.209(a) Radiated Emissions less than 1 GHz EUT Operation Conditions

The Bluetooth keyboard was activated using special test software which sets the transmitter to continuously transmit at a single frequency.   The transmitter was set to the lowest, mid and highest channels. In each case the scans were performed.

• low (channel 1) - 2.402 GHz
• mid (channel 40) - 2.441 GHz
• high (channel 79) - 2.480 GHz

Data below 1 GHz looked similar regardless of whether the transmitter was set to the low, mid or highest channel. In this report, data is provided for the lowest channel only.

2.1.5   CFR 15.209(a) Radiated Emissions less than 1 GHz - Vertical Data

The data below was collected with a transmitter frequency of 2.402 GHz which is the lowest channel.

Frequency	Level	Limit	Delta	Raw Data	Antenna	Cable	Amp	All Factor
MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB	dB
209.97	19.9	26.0	−6.1	56.03	11.21	2.51	49.79	36.08
795.68	26.9	33.0	−6.1	48.21	21.69	5.64	48.61	21.29
918.27	27.2	33.0	−5.8	47.00	22.54	6.24	48.55	19.77
939.68	27.7	33.0	−5.3	47.46	22.29	6.32	48.39	19.78
953.30	27.9	33.0	−5.1	46.60	23.10	6.45	48.29	18.74
964.97	27.4	33.0	−5.6	45.65	23.50	6.50	48.21	18.20
984.43	28.7	33.0	−4.3	46.06	23.89	6.61	47.81	17.31
1000.00	29.7	33.0	−3.3	46.09	24.40	6.67	47.46	16.38

2.1.6   CFR 15.209(a) Radiated Emissions less than 1 GHz - Horizontal Data

The data below was collected with a transmitter frequency of 2.402 GHz.
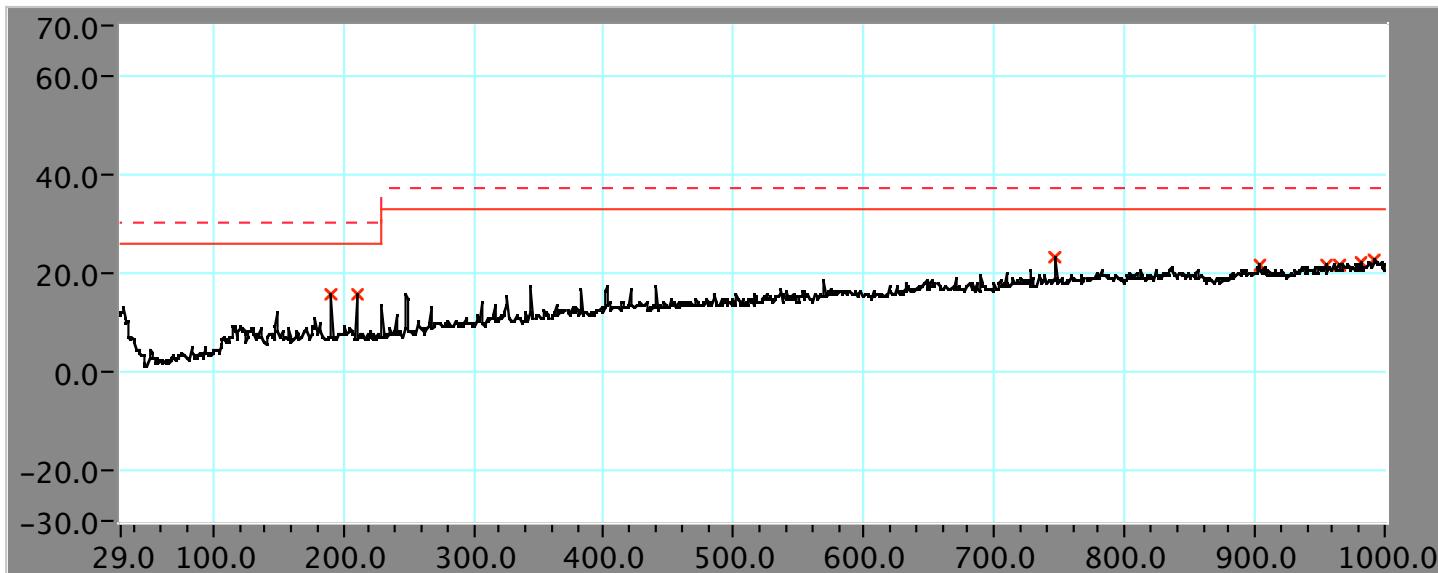
Frequency	Level	Limit	Delta	Raw Data	Cable	Amp	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB	dB	dB
191.16	15.7	26.0	−10.3	54.20	2.72	52.74	38.50
210.58	15.9	26.0	−10.1	55.21	2.86	52.88	39.31
747.54	23.0	33.0	−10.0	49.53	5.52	52.61	26.53
903.87	21.7	33.0	−11.3	46.76	6.15	52.79	25.06
954.36	21.6	33.0	−11.4	45.16	6.41	52.53	23.56
965.04	21.4	33.0	−11.6	44.81	6.46	52.47	23.41
981.55	22.2	33.0	−10.8	44.71	6.49	52.23	22.51
992.23	22.5	33.0	−10.5	44.34	6.57	51.97	21.84

All levels are with a peak detector.

2.2   CFR 15.209(a) Radiated Emissions greater than 1 GHz

2.2.1   CFR 15.209(a) Radiated Emissions greater than 1 GHz Test Setup

Radiated Emission measurements above 1 GHz were performed at the Apple Computer 3 meter semi-anechoic chamber located at 20650 Valley Green Drive. The EUT was placed on a nonmetallic table, 80 cm above the metallic ground-plane. The EUT and peripherals were powered from a filtered main supply.

Radiated Emission measurements above 1 GHz were performed at an EUT to antenna distance of 1 meter.

2.2.2   CFR 15.209(a) Radiated Emissions greater than 1 GHz Test Procedure

The frequency spectrum from 1 GHz to 25 GHz was scanned and the emission levels maximized at each frequency. The antenna was varied in height and the system was rotated 360 degrees while scanning for maximum emission amplitudes. This procedure was performed for both horizontal and vertical polarization of the receiving antenna.

Scans above 1 GHz were performed with the transmitter frequency set to the low, mid and high channels and Radiated Emissions data is provided in this report for each case.

• low (channel 1) - 2.402 GHz
• mid (channel 40) - 2.441 GHz
• high (channel 79) - 2.480 GHz

2.2.3   CFR 15.209(a) Radiated Emissions greater than 1 GHz Test Equipment

The following test equipment was used when performing radiated emissions tests above 1 GHz.

Description	Model	Serial Number	Last Calibration	Next Calibration
Spectrum Analyzer	R&S ESIB 26	100025	8/03	8/04
Receiver	R&S ESIB 26	100025	8/03	8/04
Spectrum Analyzer	HP 8566	E4662_E4663	5/02	5/03
Antenna	Horn Antenna 3115	9205-3852	9/00	9/03
Cable	Huber & Schuner SF106	0.29	4/03	4/04

2.2.3.1 CFR 15.209(a) Radiated Emissions greater than 1 GHz Instrument Settings

Instrument Settings				
Frequency Range	Reference Level	Attenuation	Resolution BW	Video BW
1 GHz - 7 GHz	110 dBuV	20	1 MHz	1 MHz
7 GHz - 13 GHz	120 dBuV	30	1 MHz	1 MHz
13 GHz - 18 GHz	100 dBuV	10	1 MHz	1 MHz
18 GHz - 25 GHz	100 dBuV	0	1 MHz	1 MHz

2.2.4   CFR 15.209(a) Radiated Emissions greater than 1 GHz EUT Operating Conditions

The Bluetooth keyboard keyboard was set to continuously transmit on low, mid, and high channels using special test software.

2.2.5   CFR 15.209(a) Radiated Emissions - Vertical, channel 1 (2.402 GHz)
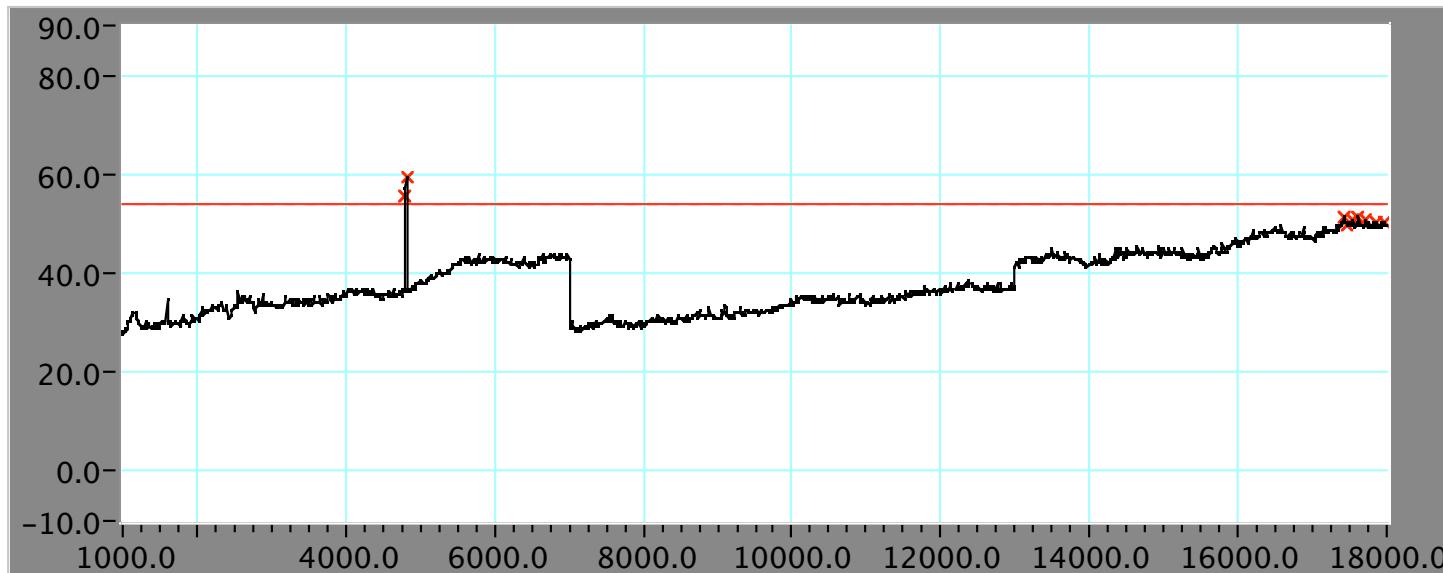

Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
17478.96	49.9	54.0	−4.1	42.10	−7.83
17849.70	50.2	54.0	−3.8	42.40	−7.82
17959.92	50.2	54.0	−3.8	42.44	−7.78
17539.08	51.0	54.0	−3.0	43.04	−7.91
17709.42	51.0	54.0	−3.0	43.16	−7.86
17418.84	51.2	54.0	−2.8	43.61	−7.55
17619.24	51.4	54.0	−2.6	43.50	−7.88
4803.68	55.8 Av	54.0	1.8	69.57	13.74
4811.62	59.5	54.0	5.5	73.13	13.65

All levels are with a peak detector unless otherwise indicated.

***NOTE:

The frequency line at 4.803GHz appears to produce a failure. However, in applying the duty cycle compensation factor, a -32.4dB reduction is realized. (See page 42)

### 2.2.6 CFR 15.209(a) Radiated Emissions - Horizontal, channel 1 (2.402 GHz)
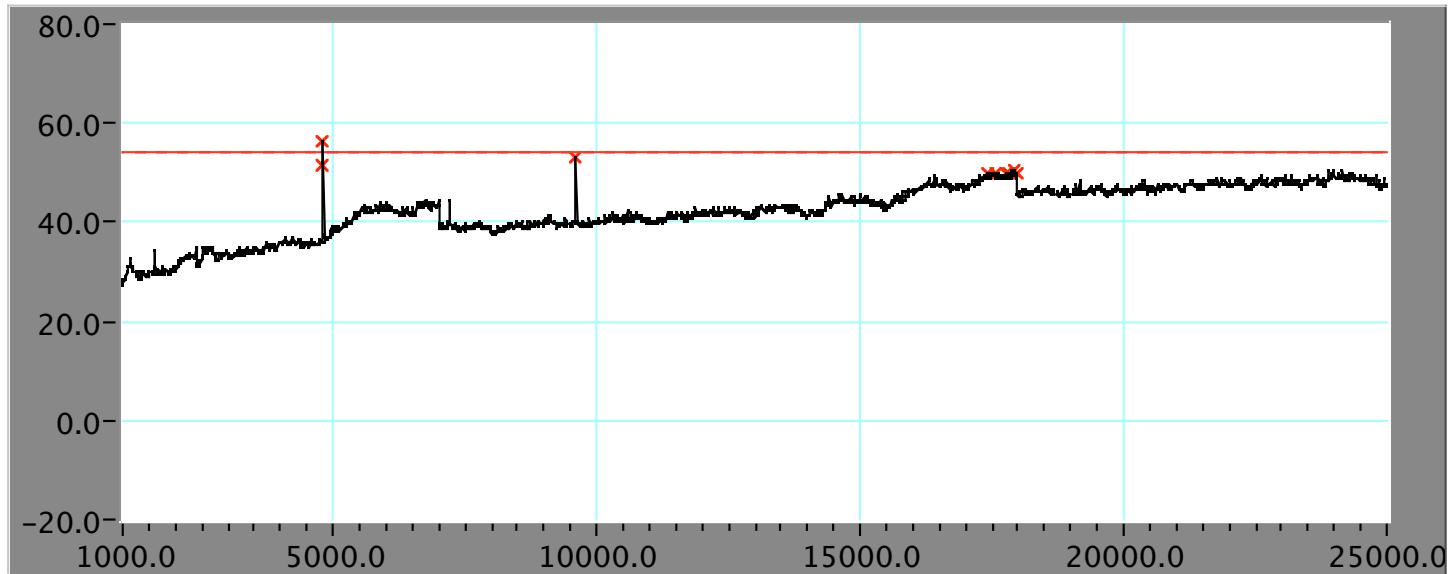
Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
17759.52	49.7	54.0	−4.3	42.01	−7.65
17839.68	49.8	54.0	−4.2	42.15	−7.69
17408.82	49.9	54.0	−4.1	42.74	−7.15
17989.98	50.1	54.0	−3.9	42.32	−7.76
17589.18	50.2	54.0	−3.8	42.59	−7.56
17919.84	50.3	54.0	−3.7	42.58	−7.73
4803.68	51.3 Av	54.0	−2.7	65.04	13.74
9609.22	52.9	54.0	−1.1	57.89	4.99
4811.62	56.2	54.0	2.2	69.89	13.65

All levels are with a peak detector unless otherwise indicated.

2.2.7 CFR 15.209(a) Radiated Emissions - Vertical channel 40 (2.441 GHz)
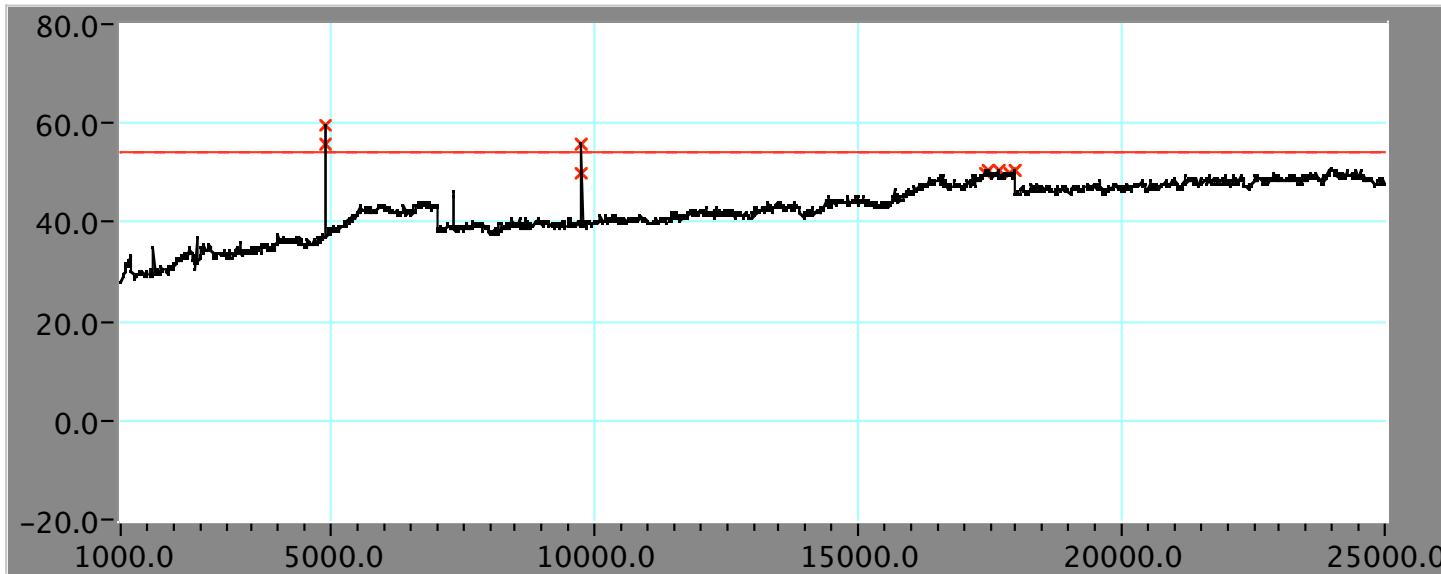


Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
4881.63	55.8 Av	54.0	1.8	68.93	13.12
4883.77	59.5	54.0	5.5	72.59	13.12
9764.62	49.8 Av	54.0	−4.2	54.43	4.60
9765.53	56.0	54.0	2.0	60.56	4.60
17408.82	49.7	54.0	−4.3	42.22	−7.51
17478.96	50.4	54.0	−3.6	42.55	−7.83
17669.34	50.3	54.0	−3.7	42.44	−7.87
17859.72	49.9	54.0	−4.1	42.13	−7.81
17959.92	50.2	54.0	−3.8	42.41	−7.78

All levels are with a peak detector unless otherwise indicated.

***NOTE:

The frequency line at 4.803GHz appears to produce a failure. However, in applying the duty cycle compensation factor, a -31.1dB reduction is realized. (See page 42)

2.2.8 CFR 15.209(a) Radiated Emissions - Horizontal channel 40 (2.441 GHz)
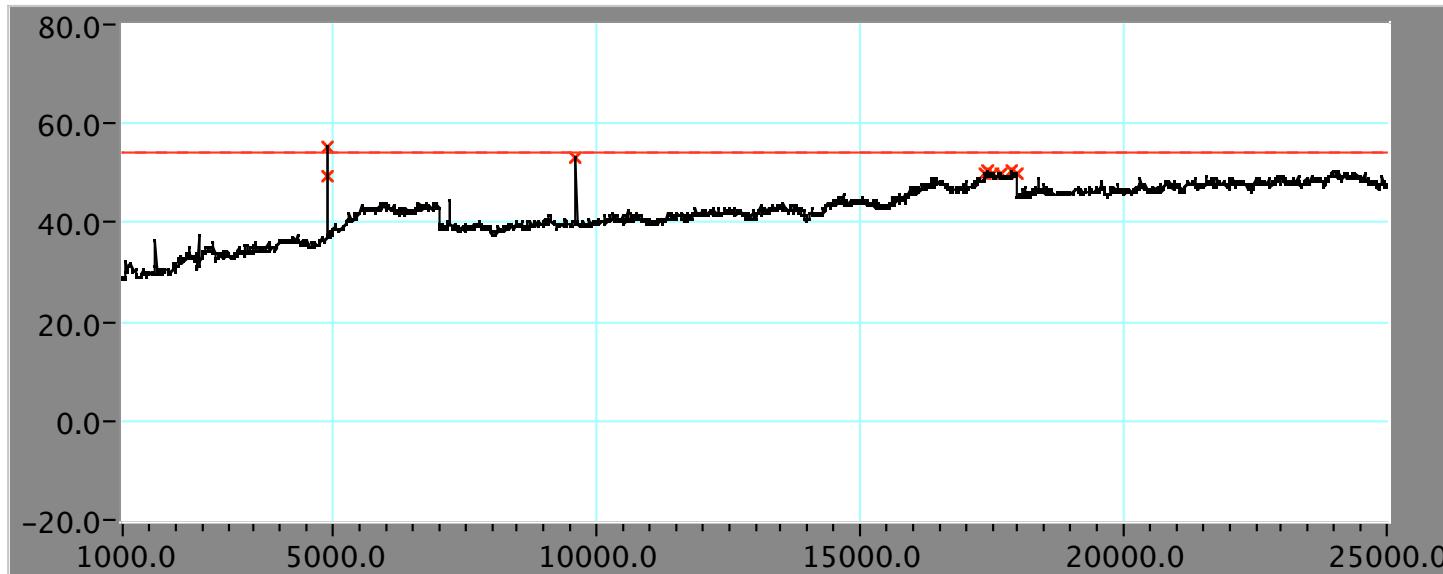
Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
4882.27	49.4 Av	54.0	−4.6	62.51	13.12
4883.77	55.2	54.0	1.2	68.35	13.12
9609.22	52.9	54.0	−1.1	57.89	4.99
17378.76	49.8	54.0	−4.2	42.82	−7.02
17438.88	50.3	54.0	−3.7	43.01	−7.27
17519.04	50.1	54.0	−3.9	42.52	−7.53
17679.36	49.8	54.0	−4.2	42.19	−7.61
17889.78	50.5	54.0	−3.5	42.81	−7.71
18000.00	49.9	54.0	−4.1	42.08	−7.77

All levels are with a peak detector unless otherwise indicated.

**2.2.9   CFR 15.209(a) Radiated Emissions - Vertical Channel 79 (2.480 GHz)**
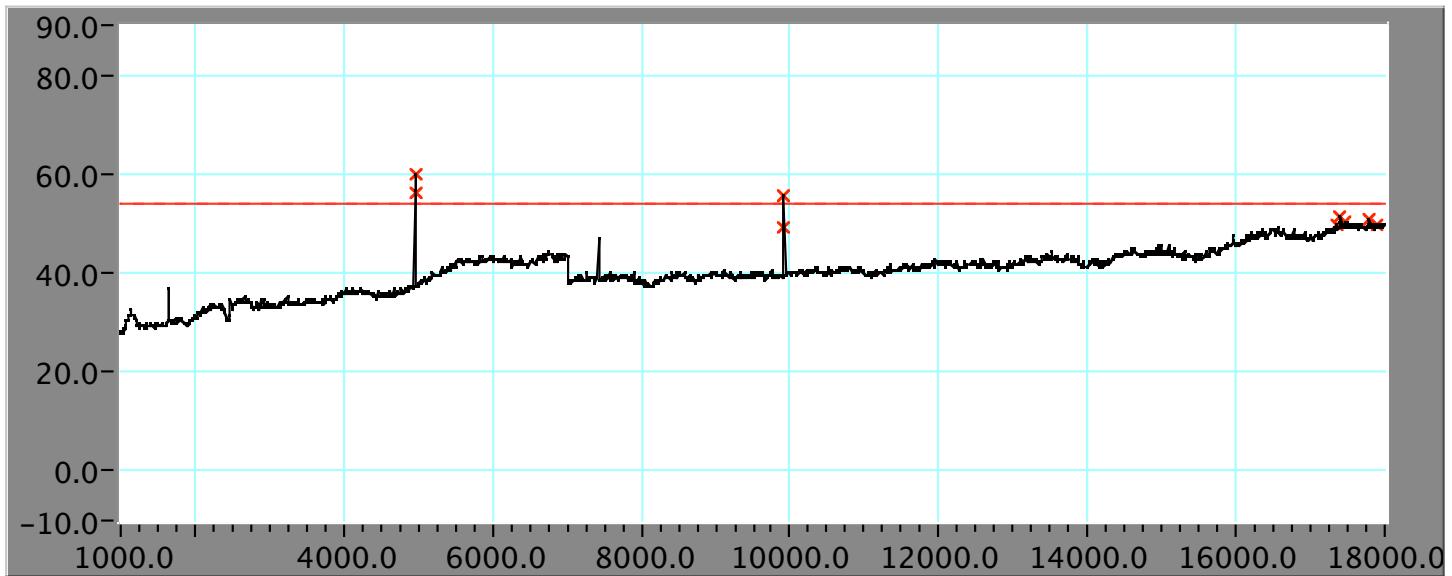
Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
4960.02	56.2 Av	54.0	2.2	68.77	12.59
4967.94	59.9	54.0	5.9	72.40	12.50
9920.46	49.2 Av	54.0	−4.8	53.38	4.20
9921.84	55.7	54.0	1.7	59.88	4.20
17348.70	49.9	54.0	−4.1	42.62	−7.24
17408.82	51.1	54.0	−2.9	43.61	−7.51
17468.94	50.2	54.0	−3.8	42.42	−7.78
17799.60	50.8	54.0	−3.2	43.01	−7.83
17899.80	49.8	54.0	−4.2	42.01	−7.80

All levels are with a peak detector unless otherwise indicated.

***NOTE:

The frequency line at 4.803GHz appears to produce a failure. However, in applying the duty cycle compensation factor, a -31.1dB reduction is realized. (See page 42)

2.2.10 CFR 15.209(a) Radiated Emissions - Horizontal Channel 79 (2.480 GHz)
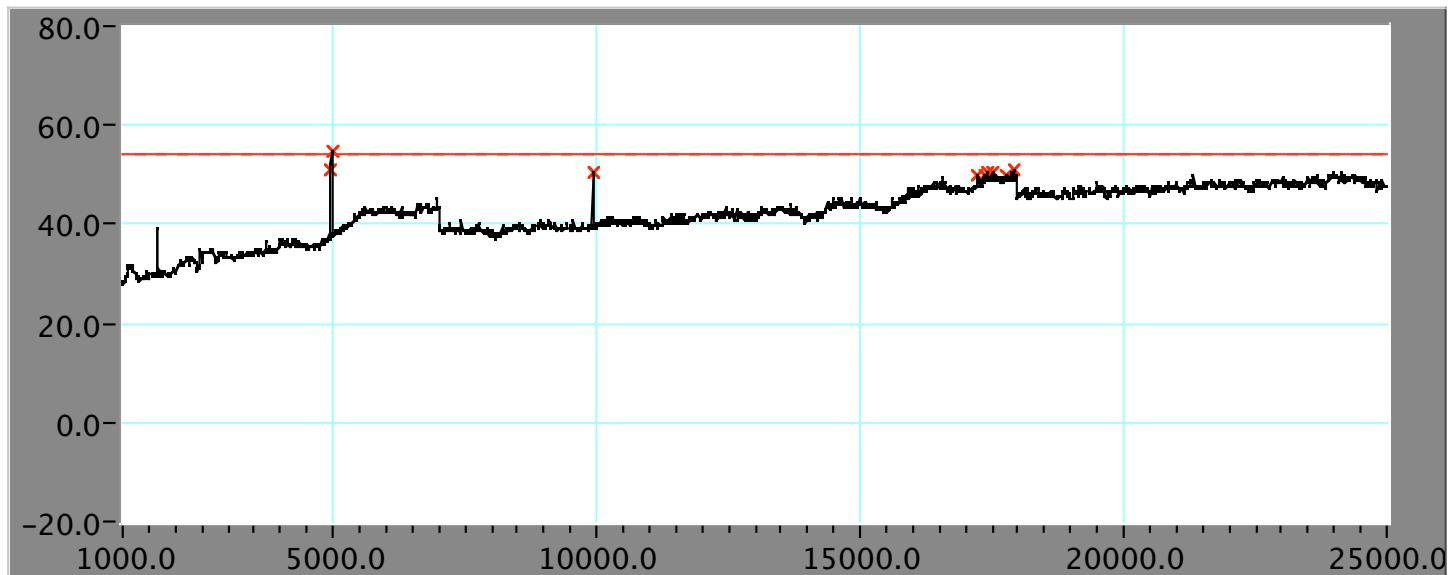
Frequency	Level	Limit	Delta	Raw Data	All Factors
MHz	dBuV/m	dBuV/m	dB	dBuV	dB
17238.48	49.7	54.0	−4.3	43.30	−6.45
17348.70	49.8	54.0	−4.2	42.94	−6.90
17799.60	49.9	54.0	−4.1	42.20	−7.67
17418.84	50.4	54.0	−3.6	43.18	−7.19
17499.00	50.6	54.0	−3.4	43.06	−7.52
9921.84	50.6	54.0	−3.4	54.78	4.20
17919.84	50.7	54.0	−3.3	42.97	−7.73
4960.22	50.8 Av	54.0	−3.2	63.41	12.59
4967.94	54.6	54.0	0.6	67.07	12.50

All levels are with a peak detector unless otherwise indicated.

2.3 **CFR 15.247(c) Band Edge Tests**

The emissions at the band edges must be -20 dB below the highest emission of the operating band within a 100 kHz bandwidth.

2.3.1 **CFR 15.247(c) Band Edge Test Description**

Band Edge measurements were performed at the Apple Computer EMC lab located in Mountain View. The EUT was placed on a nonmetallic table. The EUT and peripherals were powered from a filtered main supply. Using special test software, the Apple Bluetooth keyboard was placed into continous modulated transmit on the high and low channels. Peak and average scans were obtained at the band edges.

2.3.2 **CFR 15.247(c) Band Edge Test Equipment**

The following test equipment was used when performing band edge measurements.

Description	Model	Serial Number	Last Calibration	Next Calibration
Spectrum Analyzer	R&S ESIB 26	100025	8/03	8/04
Receiver	R&S ESIB 26	100025	8/03	8/04
Spectrum Analyzer	HP 8566	E4662_E4663	5/02	5/03
Antenna	Horn Antenna 3115	9205-3852	9/00	9/03
Cable	Huber & Schuner SF106	0.29	4/03	4/04

**2.3.3** **CFR 15.247(c) Band Edge - Hopping Enabled Instrument Settings**

Peak Measurements

Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
10 dBm	40 dB	1000 kHz	1000 kHz	200 Seconds	12 MHz

Average Measurements

Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
10 dBm	40 dB	1000 kHz	0.01 kHz	200 Seconds	12 MHz

2.3.4 Low Band Edge Results

Peak Measurement, Vertical Polarity
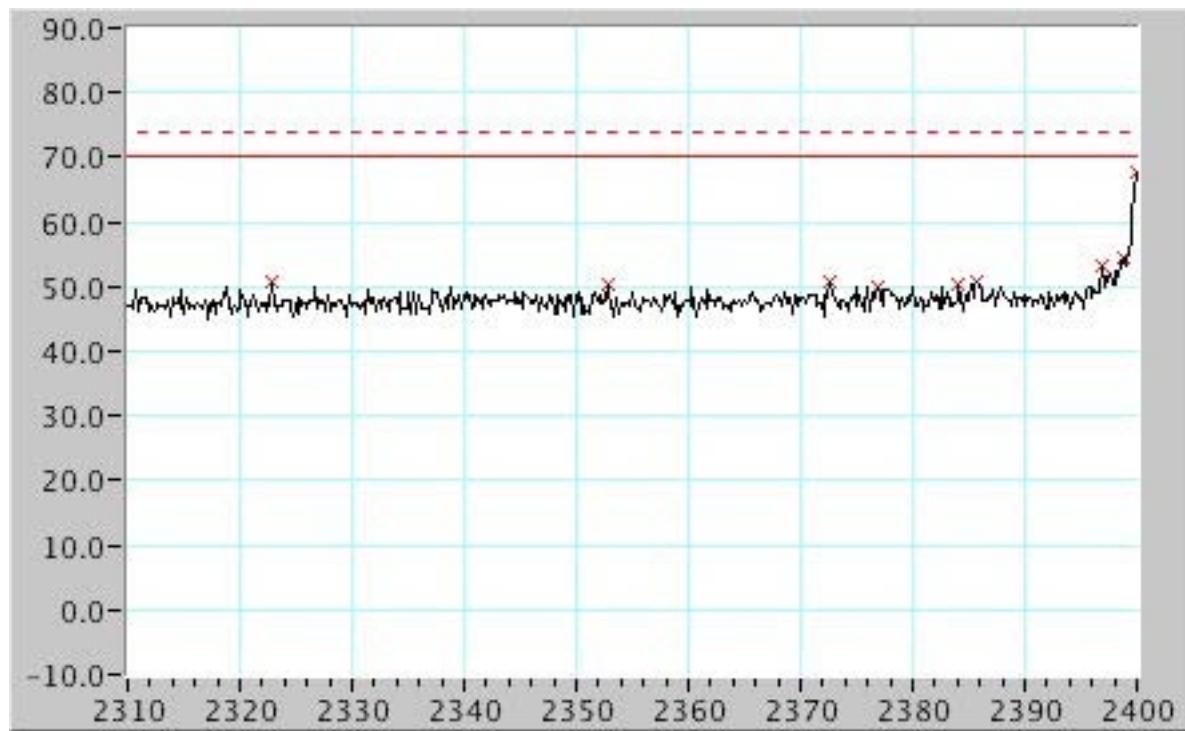
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2322.8	50.6	70.0	-19.4
2352.7	50.3	70.0	-19.7
2372.6	50.9	70.0	-19.1
2376.9	50.1	70.0	-19.9
2384.1	50.3	70.0	-19.7
2385.8	50.7	70.0	-19.3
2396.9	53.2	70.0	-16.8
2398.7	54.6	70.0	-15.4
2400.0	67.7	70.0	-2.3

Average Measurement, Vertical Polarity
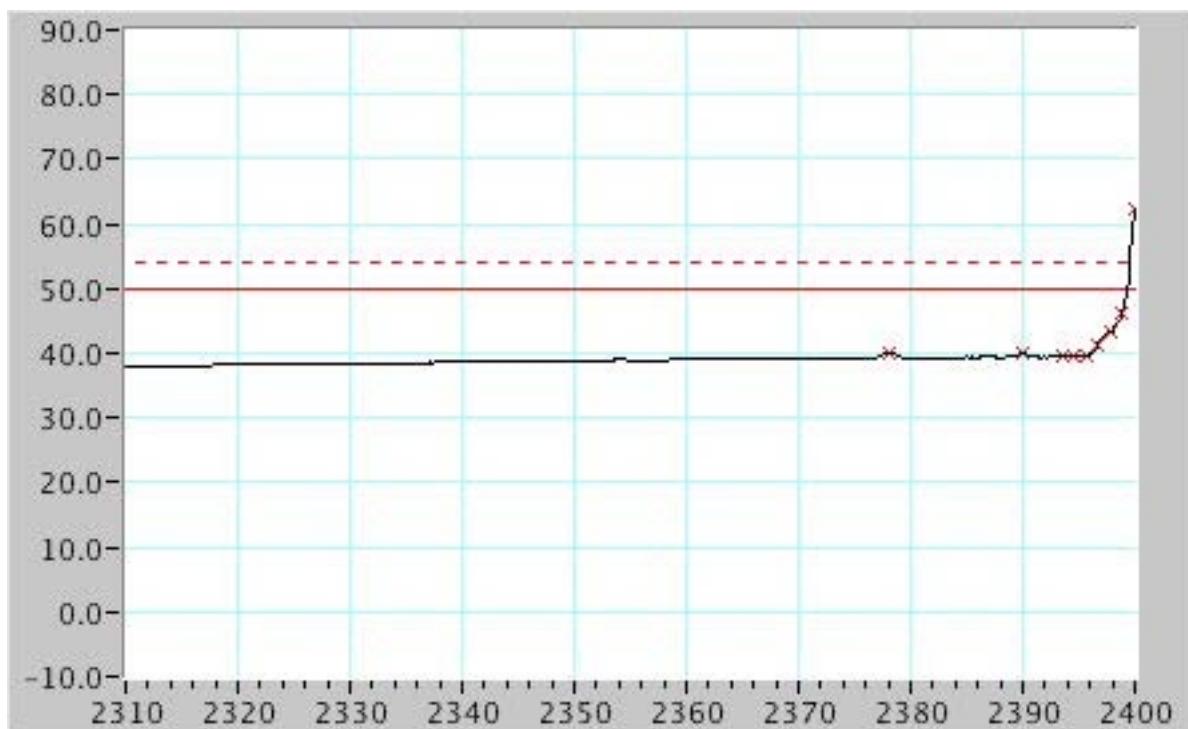
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2378.2	40.1	50.0	-9.9
2390.1	39.9	50.0	-10.1
2393.5	39.5	50.0	-10.5
2394.6	39.5	50.0	-10.5
2395.7	39.7	50.0	-10.3
2396.8	41.3	50.0	-8.7
2397.8	43.3	50.0	-6.7
2398.9	46.2	50.0	-3.8
2400.0	62.3	50.0	12.3

Peak Measurement, Horizontal Polarity
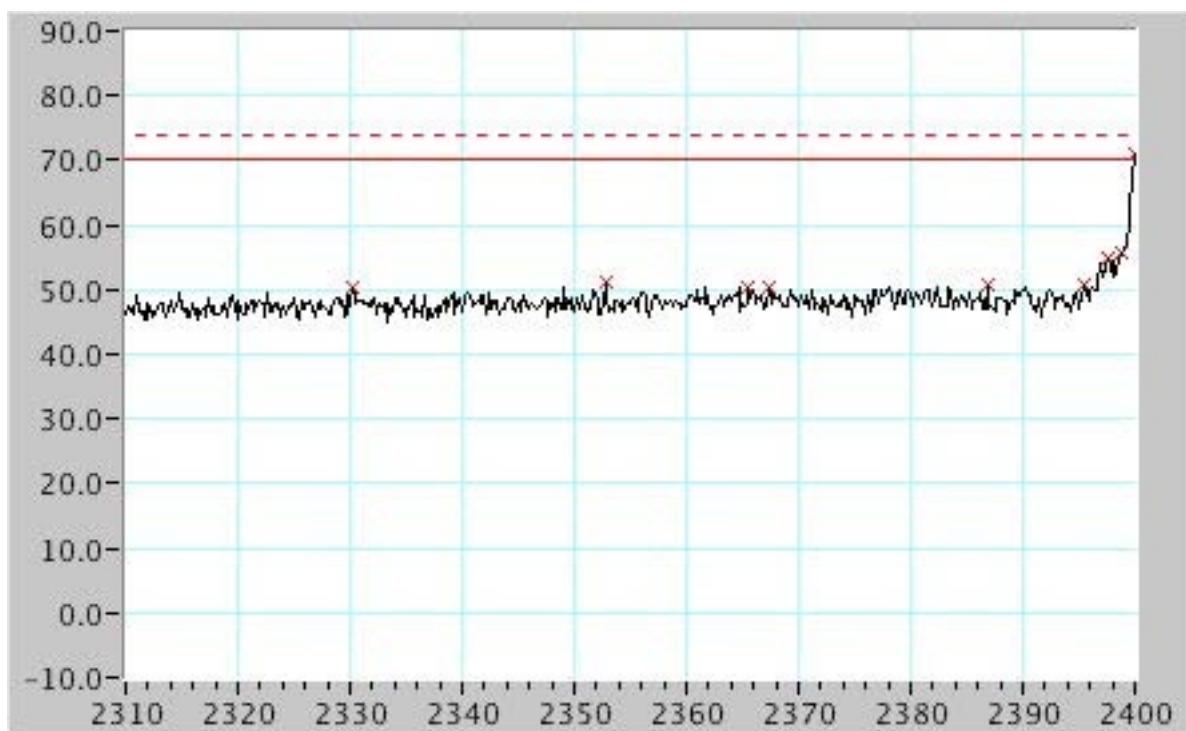
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2330.2	50.5	70.0	-19.5
2352.7	51.1	70.0	-18.9
2365.6	50.3	70.0	-19.7
2367.4	50.5	70.0	-19.5
2386.8	50.9	70.0	-19.1
2395.5	50.7	70.0	-19.3
2397.7	55.0	70.0	-15.0
2398.9	55.6	70.0	-14.4
2400.0	71.1	70.0	1.1

Average Measurement, Horizontal Polarity
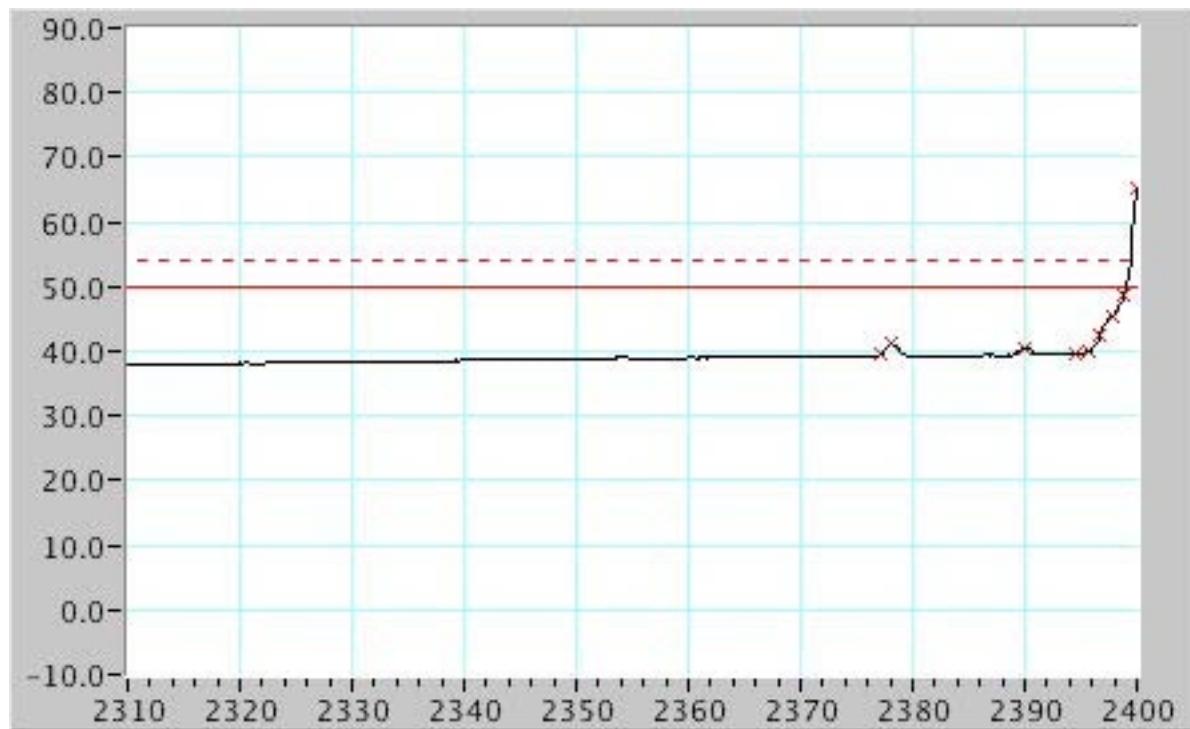
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2377.1	39.5	50.0	-10.5
2378.2	41.1	50.0	-8.9
2390.1	40.4	50.0	-9.6
2394.6	39.6	50.0	-10.4
2395.7	39.9	50.0	-10.1
2396.8	42.7	50.0	-7.3
2397.8	45.4	50.0	-4.6
2398.9	48.8	50.0	-1.2
2400.0	65.1	50.0	15.1

2.3.4 High Band Edge Results

Peak Measurement, Vertical Polarity
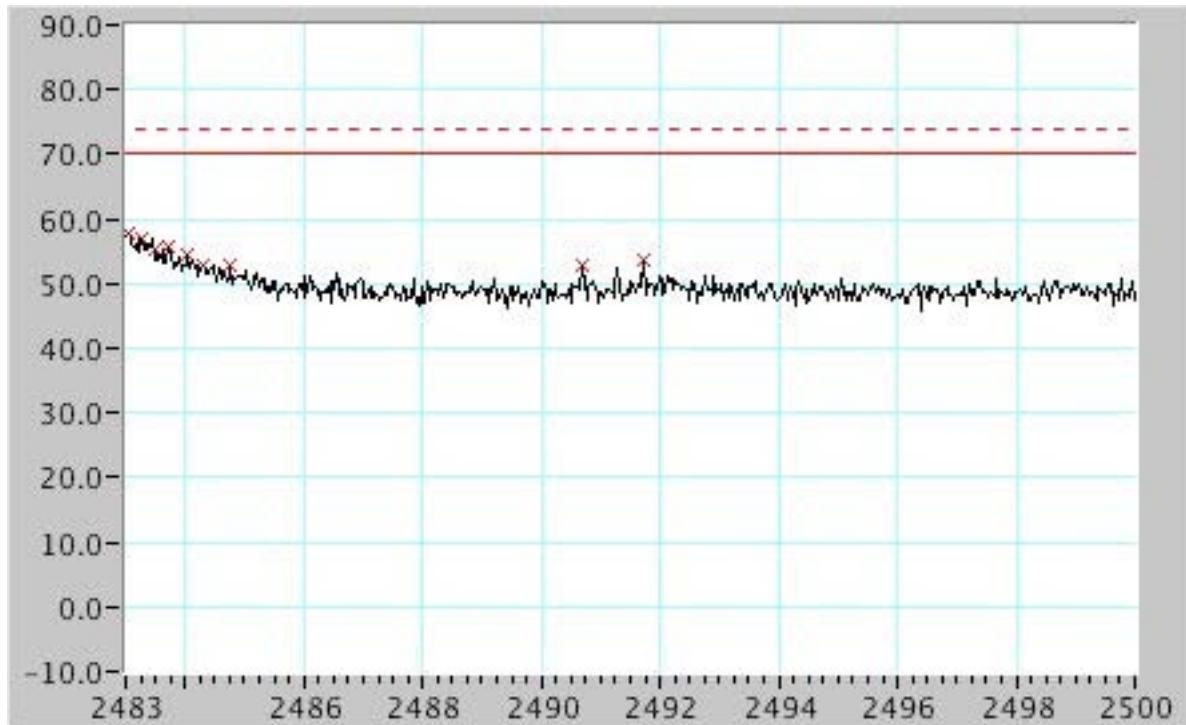
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2483.0	57.7	70.0	-12.3
2483.3	57.0	70.0	-13.0
2483.5	55.5	70.0	-14.5
2483.7	55.8	70.0	-14.2
2484.1	54.6	70.0	-15.4
2484.3	53.0	70.0	-17.0
2484.8	53.0	70.0	-17.0
2490.7	52.6	70.0	-17.4
2491.7	53.6	70.0	-16.4

Average Measurement, Vertical Polarity
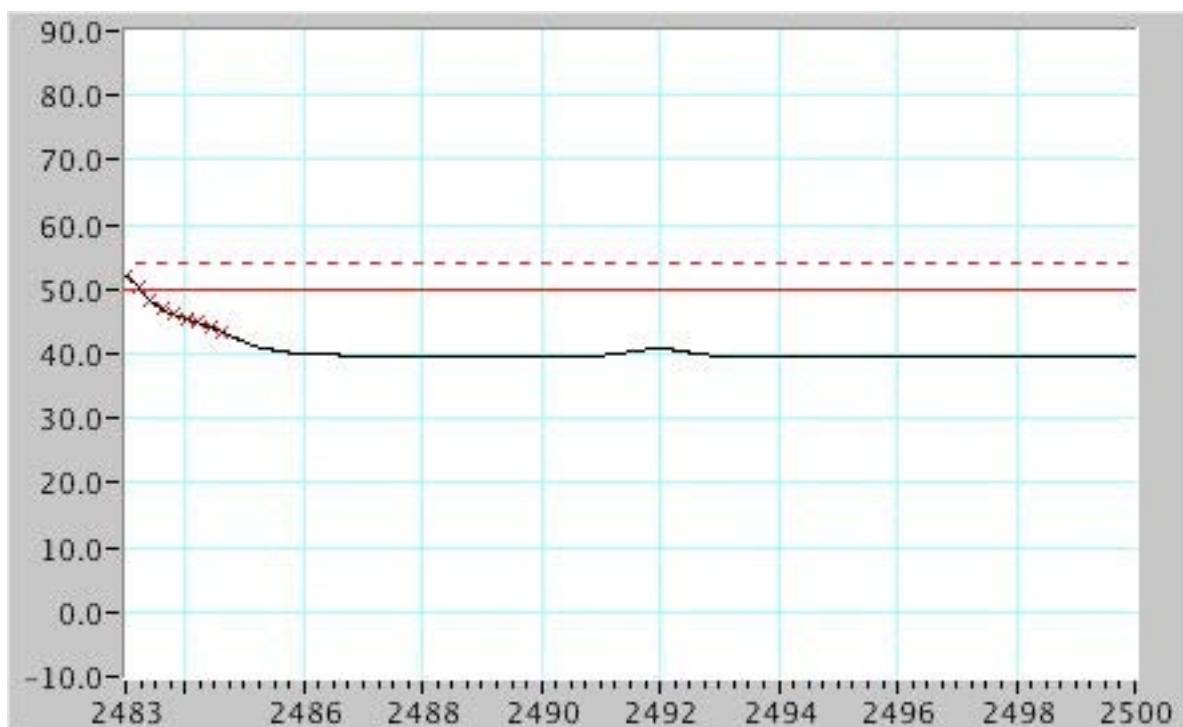
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2483.0	51.9	50.0	1.9
2483.2	50.2	50.0	0.2
2483.4	48.2	50.0	-1.8
2483.6	46.9	50.0	-3.1
2483.8	46.0	50.0	-4.0
2484.0	45.4	50.0	-4.6
2484.2	44.8	50.0	-5.2
2484.4	44.1	50.0	-5.9
2484.6	43.3	50.0	-6.7

Peak Measurement, Horizontal Polarity
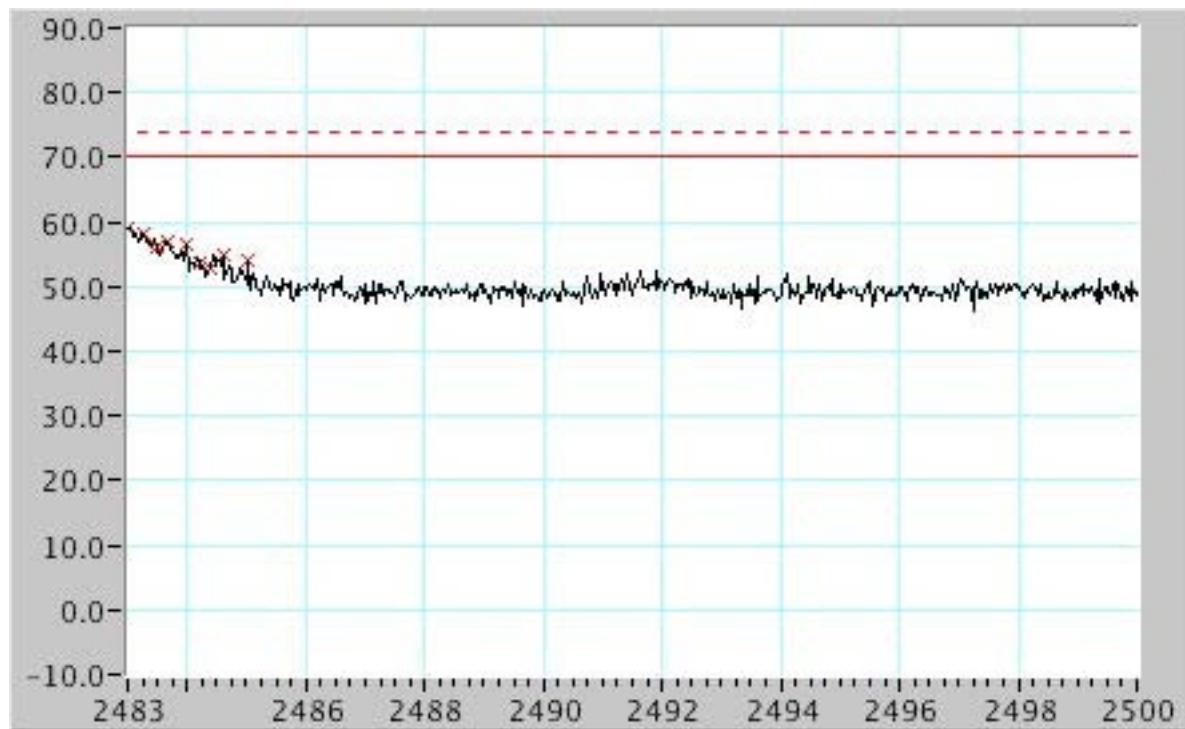
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2483.0	59.2	70.0	-10.8
2483.3	58.3	70.0	-11.7
2483.5	56.0	70.0	-14.0
2483.7	57.0	70.0	-13.0
2484.0	56.7	70.0	-13.3
2484.2	53.6	70.0	-16.4
2484.4	52.9	70.0	-17.1
2484.6	55.1	70.0	-14.9
2485.0	53.9	70.0	-16.1

Average Measurement, Horizontal Polarity
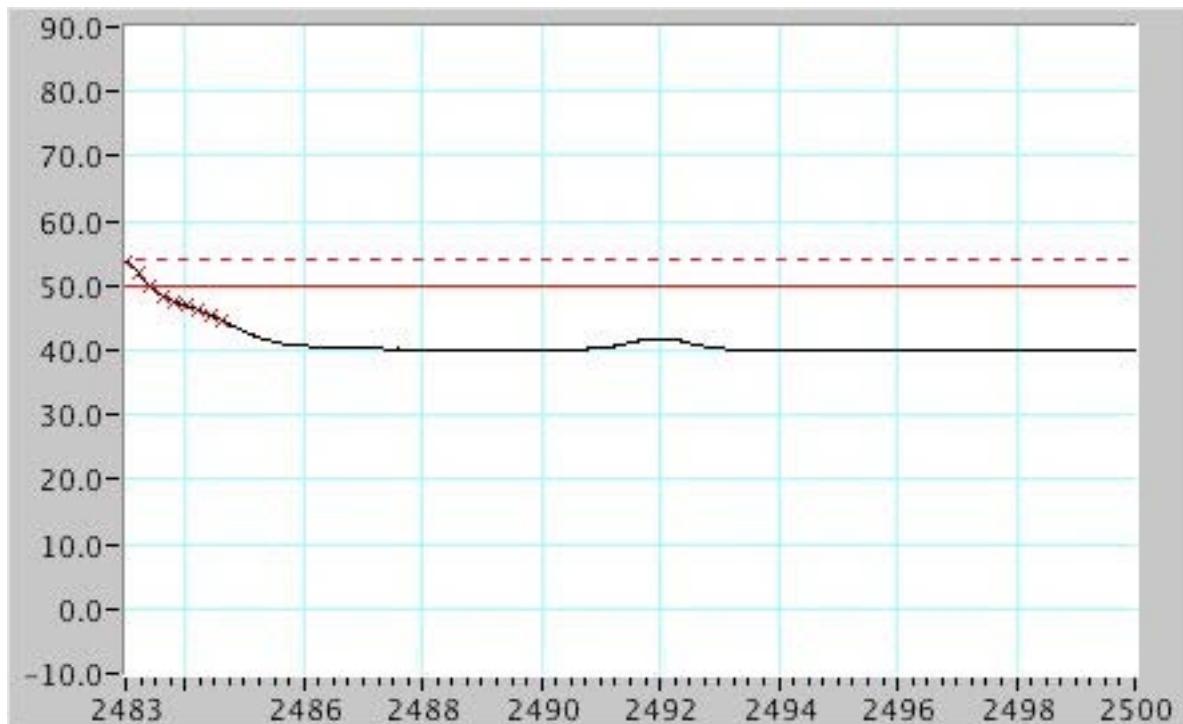
Frequency	Level	Limit	Delta
MHz	dBuV/m	dBuV/m	dB
2483.0	53.6	50.0	3.6
2483.2	51.9	50.0	1.9
2483.4	49.9	50.0	-0.1
2483.6	48.4	50.0	-1.6
2483.8	47.5	50.0	-2.5
2484.0	46.8	50.0	-3.2
2484.2	46.2	50.0	-3.8
2484.4	45.4	50.0	-4.6
2484.6	44.6	50.0	-5.4

3   CFR 15.247(a)(1) Channel Separation

3.1   CFR 15.247(a)(1) Channel Separation Test Setup Block Diagram

The channel separation for frequency hopping systems shall be a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.   The 20 dB bandwidth of the Apple Bluetooth keyboard 891 kHz (See section 6 in this test report).   The Setup for measuring the channel separation is depicted in the figure below.

Channel Separation Test Setup
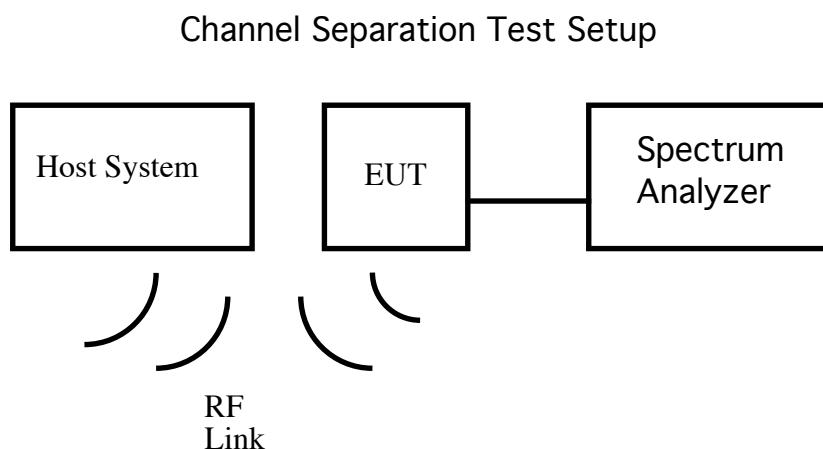
3.2   CFR 15.247(a)(1) Channel Separation Test Procedures

The transmitter output is connected to the spectrum analyzer RF input. The bandwidth of the spectrum analyzer was set to 30 kHz.

3.3   CFR 15.247(a)(1) Channel Separation Test Equipment

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	August, 2002	August, 2003

4.3.1   CFR 15.247(a)(1) Channel Separation Instrument Settings

Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
20 dBm	30 dB	30 kHz	30 kHz	200 Seconds	10 MHz

3.4   CFR 15.247(a)(1) Channel Separation EUT Operating Conditions

Using special test software, the Apple Bluetooth keyboard was placed in continous hopping mode across all 79 hopping channels.

### 3.5   CFR 15.247(a)(1) Channel Separation - Lower Channels
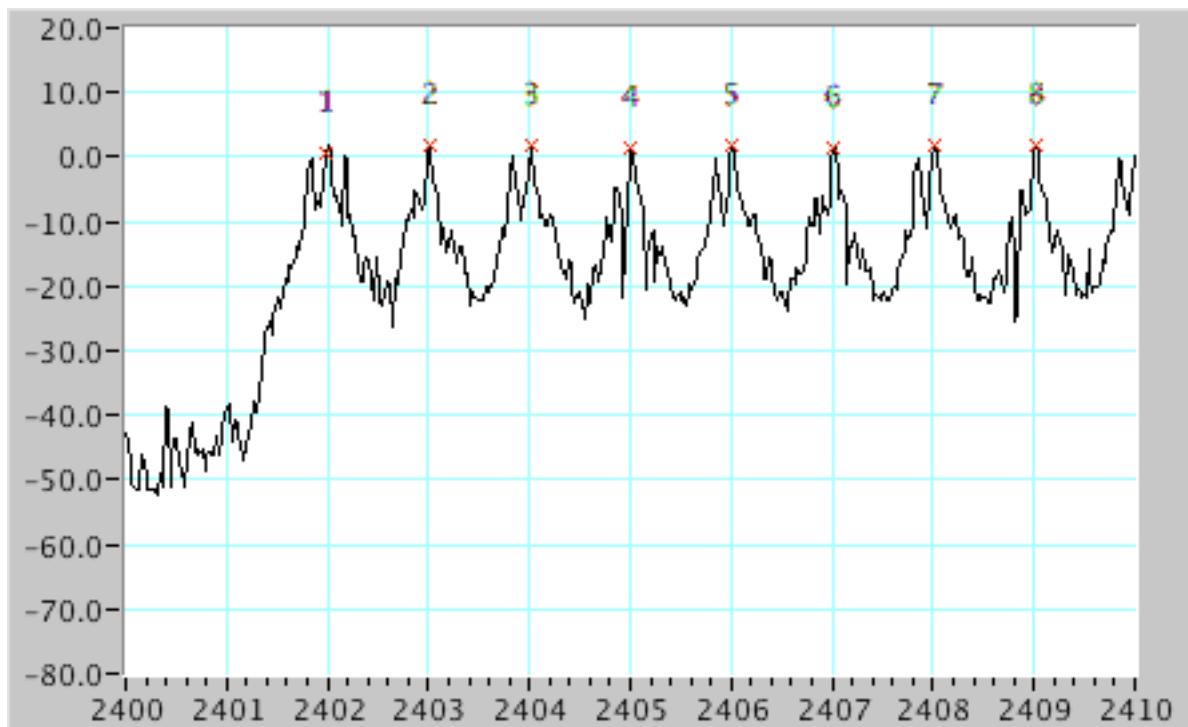
Marker	Frequency (GHz)
1	2402.0
2	2403.0
3	2404.0
4	2405.0
5	2406.0
6	2407.0
7	2408.0
8	2409.0

*Channel Spacing greater than 25kHz and 20dB bandwidth in all instances*

3.6   CFR 15.247(a)(1) Mid Channels Channel Separation
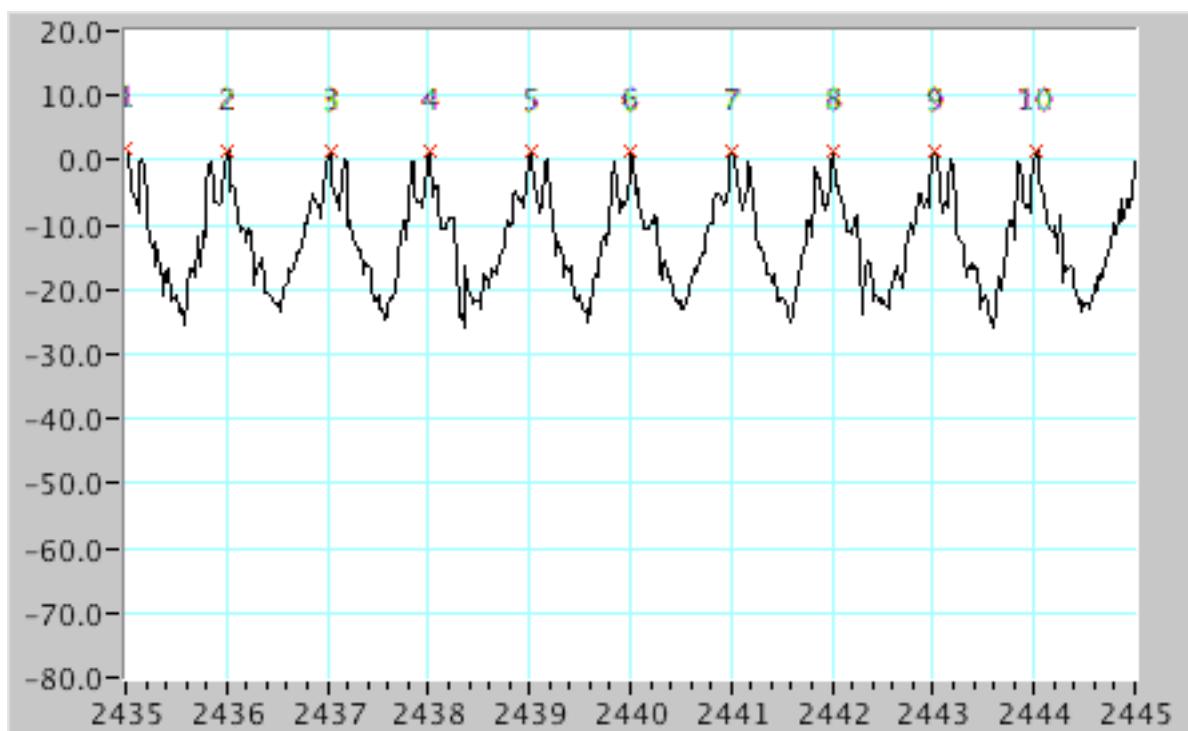
Marker	Frequency (GHz)
1	2435.0
2	2436.0
3	2437.0
4	2438.0
5	2439.0
6	2441.0
7	2441.0
8	2442.0
9	2443.0
10	2444.0

Channel Spacing greater than 25kHz and 20dB bandwidth in all instances

3.7   CFR 15.247(a)(1) High Channels Channel Separation
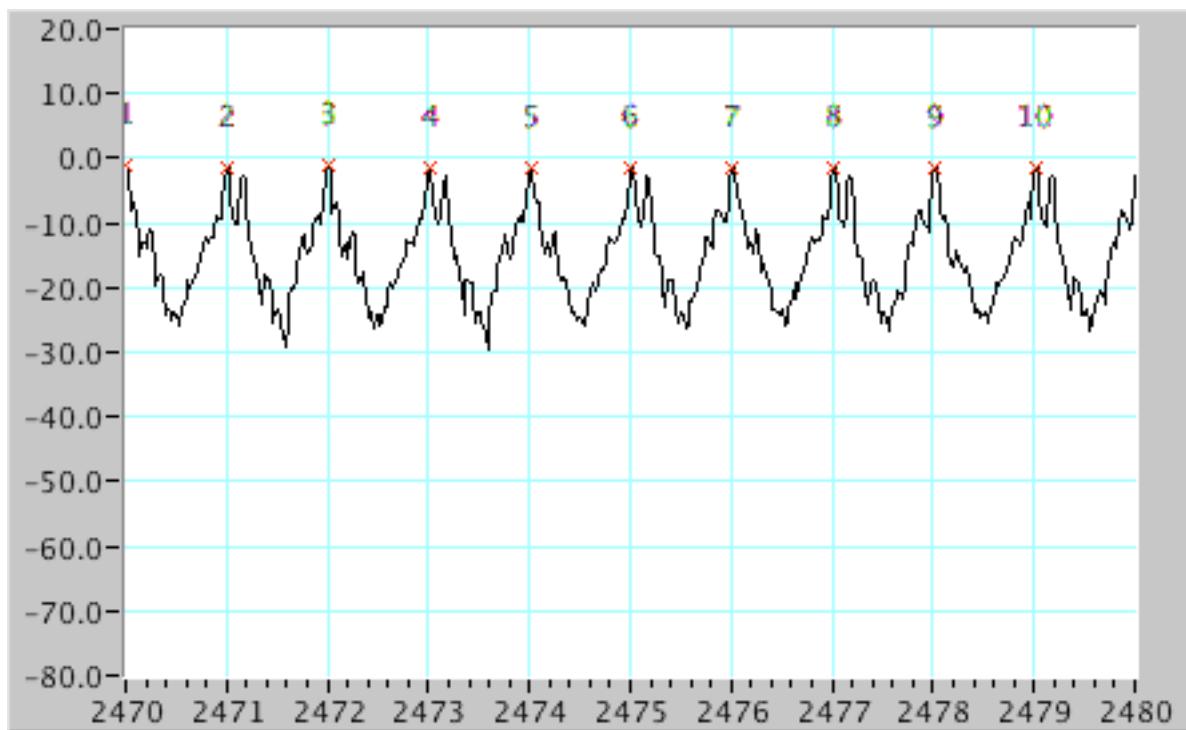
Marker	Frequency (GHz)
1	2470.0
2	2471.0
3	2472.0
4	2473.0
5	2474.0
6	2475.0
7	2476.0
8	2477.0
9	2478.0
10	2479.0

Channel Spacing greater than 25kHz and 20dB bandwidth in all instances

Result: The channel separation for the low, mid and high channels is greater then the minimum as defined by the 20 dB bandwidth.

Conclusion: PASS

4   CFR 15.247(a)(1) Number of Hopping Frequencies

4.1   CFR 15.247(a)(1) Number of Hopping Frequencies Setup Block Diagram

The minimum number of Hopping frequencies is 75.   The Setup for measuring the number of hoping frequencies is depicted in the figure below.

Channel Count Test Setup
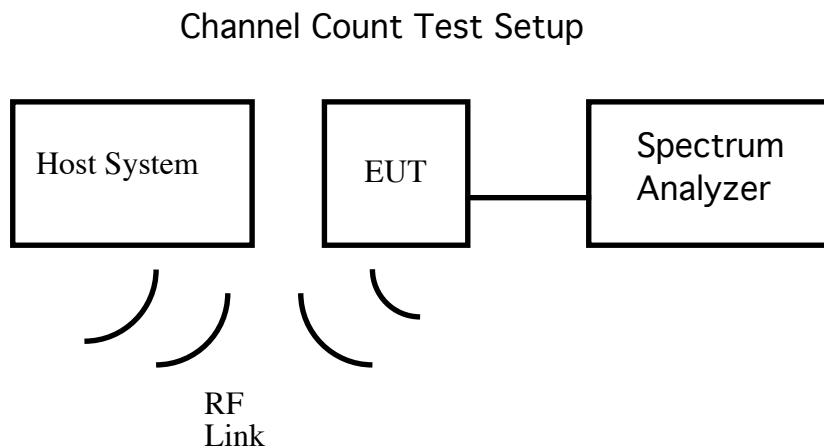
4.2   CFR 15.247(a)(1) Number of Hopping Frequencies Test Procedures

The transmitter output is connected to the spectrum analyzer RF input. An RF link was established using special software which enabled a chat mode.   All channels were enabled.   Using the spectrum analyzer settings shown below, record the RF emissions over the frequency range of 2400 MHz to 2485.3 MHz.

4.3   CFR 15.247(a)(1) Number of Hopping Frequencies Test Procedures Test Equipment

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	May, 2003	May, 2004

4.3.1   CFR 15.247(a)(1) Number of Hopping Frequencies Test Procedures Instrument Settings

| Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
20 dBm	30 dB	100 kHz	100 kHz	100 Seconds	20 MHz*

*The frequency range of 2460 to 2483.5 MHz was measured using a 23.5 MHz span.

4.4   CFR 15.247(a)(1) Number of Hopping Frequencies EUT Operating Conditions

Using special test software, the Apple Bluetooth keyboard was placed in continous hopping mode.

4.5   CFR 15.247(a)(1) Number of Hopping Frequencies Test Results

     Measurements were performed over 4 band of approximately 20 MHz each.   The graphical data of the 4 bands was combined and is displayed below. A total of 79 equally spaced channels were detected. The graph below shows the results of the measurement of the number of hopping frequencies on the Apple Bluetooth keyboard.
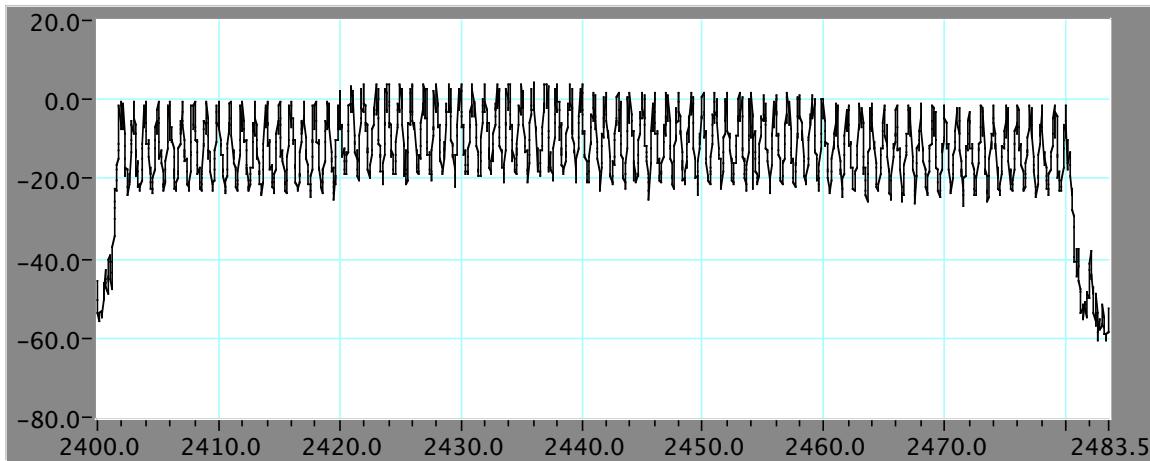
Result: The number of hopping channels is greater then 75.
Conclusion: PASS

5   CFR 15.247(a)(1)(ii) 20 dB Bandwidth

The Maximum 20 dB bandwidth of the hopping channel is 1 MHz.

5.1   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Test Setup

20 dB Bandwidth measurements were performed at the Apple Computer EMC lab located at 20650 Valley Green Drive. The EUT was placed on a nonmetallic table. The EUT and peripherals were powered from a filtere main supply.

5.2   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Test Procedure

20 dB Bandwidth Measurements were performed with the transmitter frequency set to the low, mid and high channels using special OS X test software called RFTestApp.   The -20 dBc Spurious Emissions data is provided in this report for each case.

• low channel - 2.402 GHz
• mid channel - 2.441 GHz
• high channel - 2.480 GHz

5.3   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Test Equipment

The following test equipment was used when performing 20 dB Bandwidth tests.

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	August, 2002	August, 2003

5.3.1   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Instrument Settings

| Instrument Settings					
Frequency Range	Resolution BW	Video BW	Reference Level	Attenuation	Sweep Time
2.4 GHz - 2.483 GHz	30 kHz	300 kHz	0 dBm	10 dB	50 mSeconds

5.4   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Test Results

The Apple Bluetooth keyboard complies with the 20 dB Bandwidth requirements.   The results are listed in the table below.

Channel	20 dB Bandwidth
1	960 kHz
40	860 kHz
79	950 kHz

5.5   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Channel 1
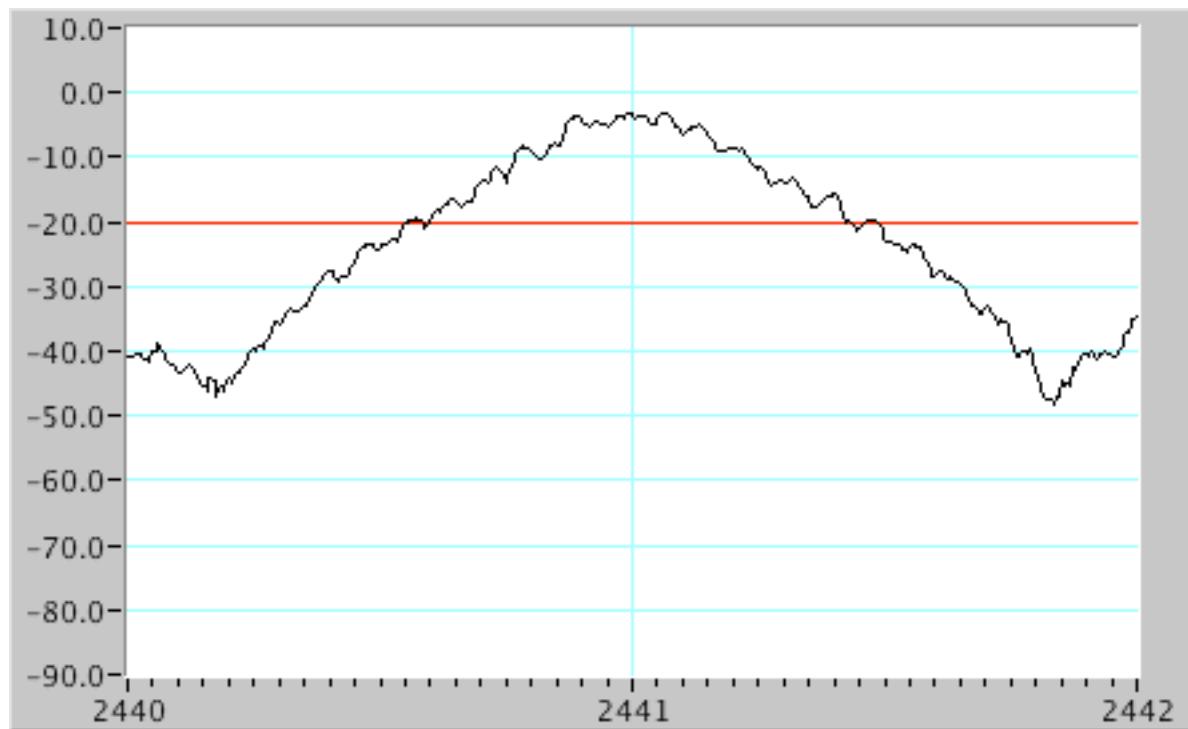
-20dBc Point	-20dBc Point	20 dB Bandwidth
2401.53 MHz	2402.49 MHz	960 kHz

5.6   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Channel 40

-20 dBc Point	-20 dBc Point	20 dB Bandwidth
2441.56 MHz	2441.42 MHz	860 kHz

5.7   CFR 15.247(a)(1)(ii) 20 dB Bandwidth Channel 79
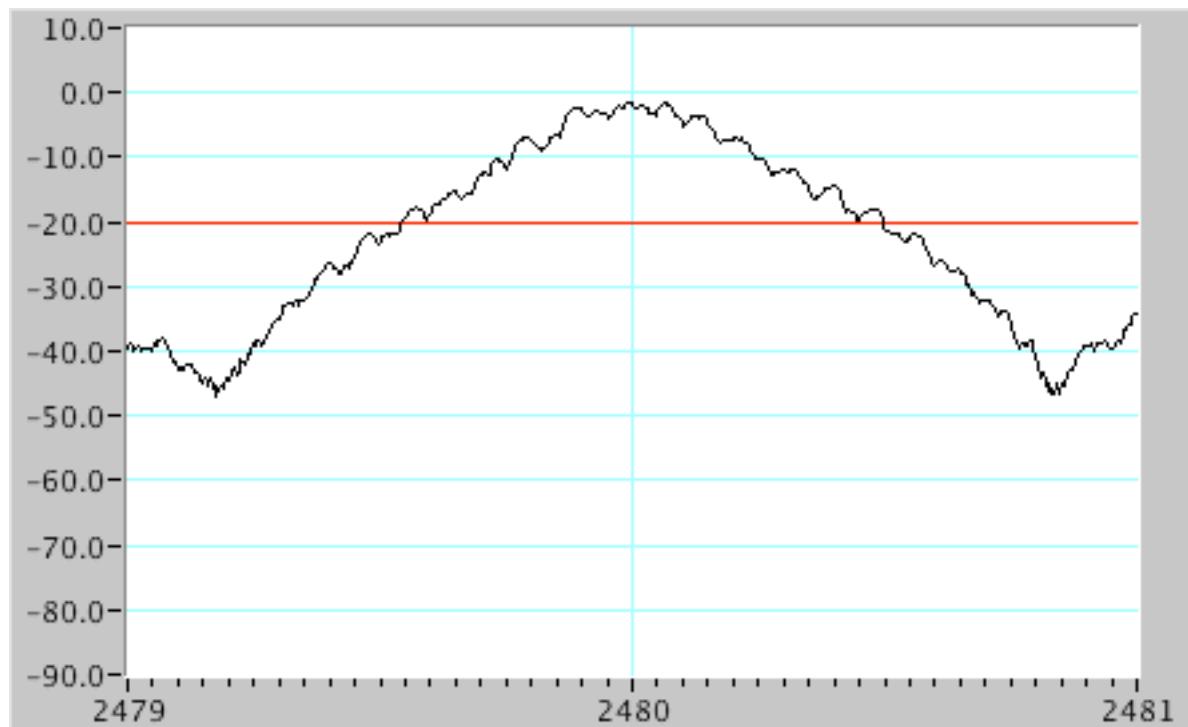
-20 dBc Point	-20 dBc Point	20 dB Bandwidth
2479.54 MHz	2480.49 MHz	950 kHz

Result: The 20 dB channel bandwidth is less then 1 MHz
Conclusion: PASS

6   CFR 15.247(a)(1)(ii) Dwell Time

6.1   CFR 15.247(a)(1)(ii) Dwell Time Setup Block Diagram

The maximum dwell time within any 30 second period is 0.4 Seconds.   The Setup for measuring the dwel is depicted in the figure below.

Dwell Test Setup

RF LINK
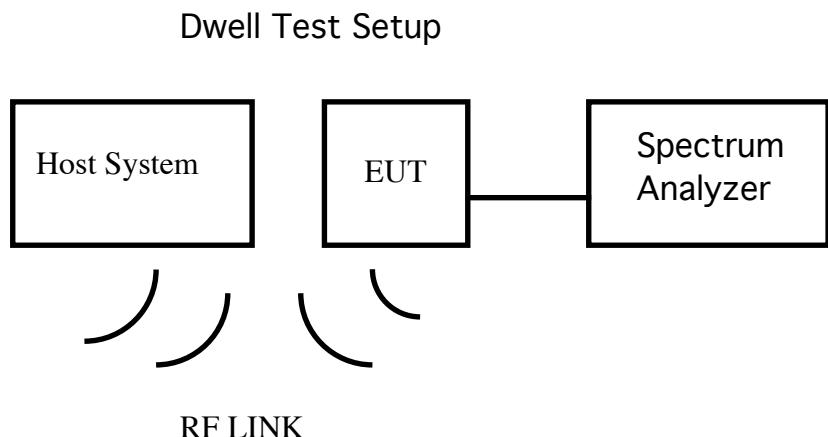
6.2   CFR 15.247(a)(1)(ii) Dwell Time Test Procedures

The transmitter output is connected to the spectrum analyzer RF input. The bandwidth of the spectrum analyzer was set to 100 kHz. The 6 dB bandwidth of the transmitter is defined as the portion of the signal which i higher than the peak signal minus 6 dB.

6.3   CFR 15.247(a)(1)(ii) Dwell Time Test Equipment

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	May, 2002	May, 2003

6.3.1   CFR 15.247(a)(1)(ii) Dwell Time Instrument Settings

Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
10 dBm	30 dB	100 kHz	100 kHz	5 mSeconds	0 Hz

6.4   CFR 15.247(a)(1)(ii) Dwell Time EUT Operating Conditions

Using special test software, the Apple Bluetooth keyboard was placed in hopping mode and the low, mid, high channels were monitored.

6.5   CFR 15.247(a)(1)(ii) Dwell Time Test Results

The single channel dwell time for each of the channels is well under the 0.4 Second limit.   An explanation of how the results were arrived at is provided below.

The dwell time over a 30 second period can be calculated by measuring the pulse duration of a single hop and multiplying that measurement by the hopping rate and the 30 second period and then dividing by the number of channels.   The Apple Bluetooth keyboard hops over 79 channels.   The maximum hopping rate is 1600 hops/second. A sample calculation is provided:

(Single Hop Dwell*Hopping Rate)/(Total number of Channels) * Period = Total Dwell Time

(0.00012*1600) / 79 * 30 = 0.073 Seconds

The dwell time results are summarized in the table below.

Channel	Single Hop Dwell	Hopping Rate	Total number of Channels	Period	Total Single Channel 30 Second Dwell Time	Maximum Dwell time Limit
2402	120 μSeconds	1600 hops/Sec	79	30 Seconds	0.073 Seconds	0.4 Seconds
2441	140 μSeconds	1600 hops/Sec	79	30 Seconds	0.085 Seconds	0.4 Seconds
2480	140 μSeconds	1600 hops/Sec	79	30 Seconds	0.085 Seconds	0.4 Seconds

Below are the measured pulse duration of a single hop for 3 channels.   Measurements were performed at the low, mid and highest channel.

DUTY CYCLE COMPENSATION FACTOR
(as described in "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems", DA 00-705, Released March 30, 2000)

Compensation Factor = 20*log(dwell time in 100 ms interval / 100ms)

looking at pg.44-46, the single hop dwell is found in a 5ms span. If we multiply this value by twenty, we will have the dwell time in a 100ms span.

Channel (MHz)	5ms interval dwell	100ms interval dwell	Compensation Factor
2402	120 μSeconds	2.4 ms	20*log(2.4/100)= **-32.4dB**
2441	140 μSeconds	2.8 ms	20*log(2.8/100)= **-31.1dB**
2480	140 μSeconds	2.8 ms	20*log(2.8/100)= **-31.1dB**

6.6   CFR 15.247(a)(1)(ii) Channel 1 Single Hop Dwell Time
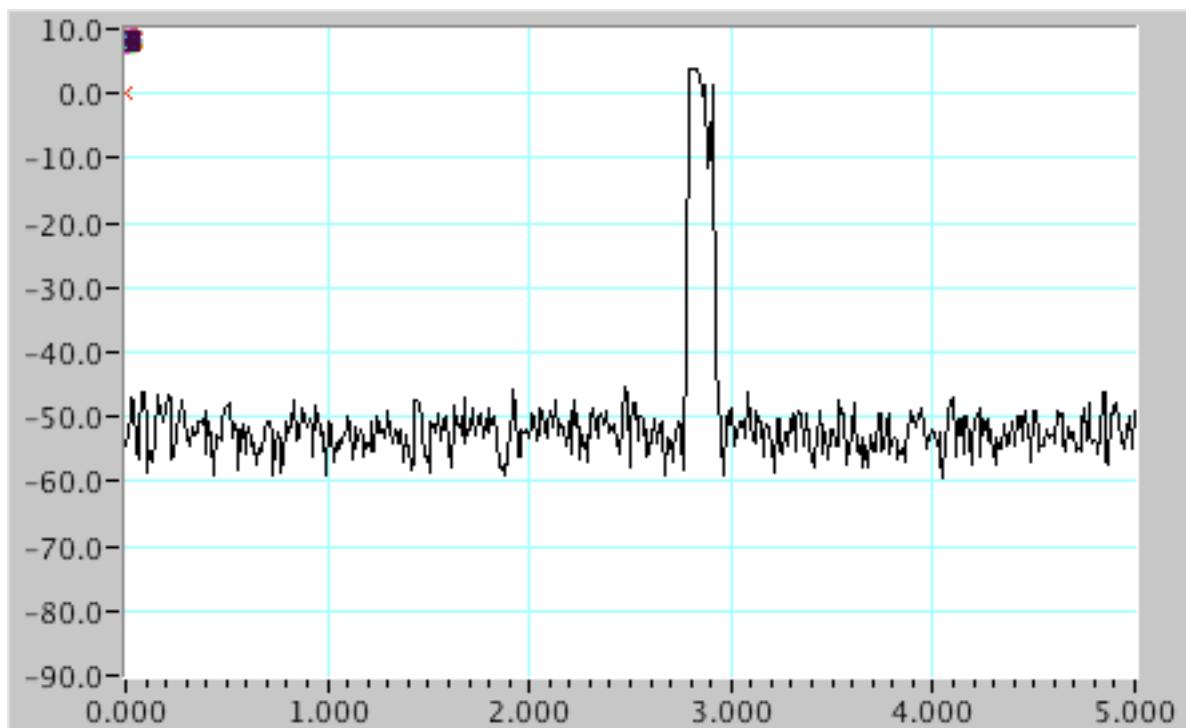
Frequency	Marker 1	Marker 2	Single Hop Dwell
2402 MHz	1.774ms	1.894ms	120 μSeconds

6.7   CFR 15.247(a)(1)(ii) channel 40 Single Hop Dwell Time
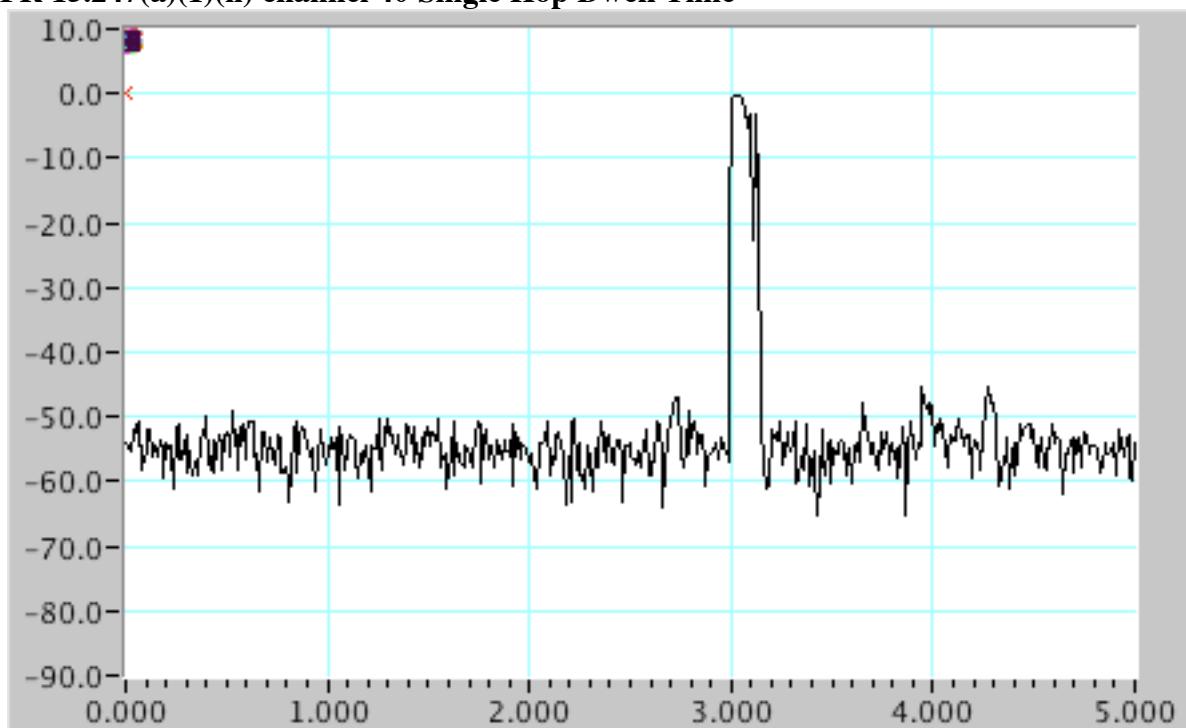
Frequency	Marker 1	Marker 2	Single Hop Dwell
2441 MHz	2.996ms	3.136ms	140μSeconds

6.8   CFR 15.247(a)(1)(ii) Channel 79 Single Hop Dwell Time
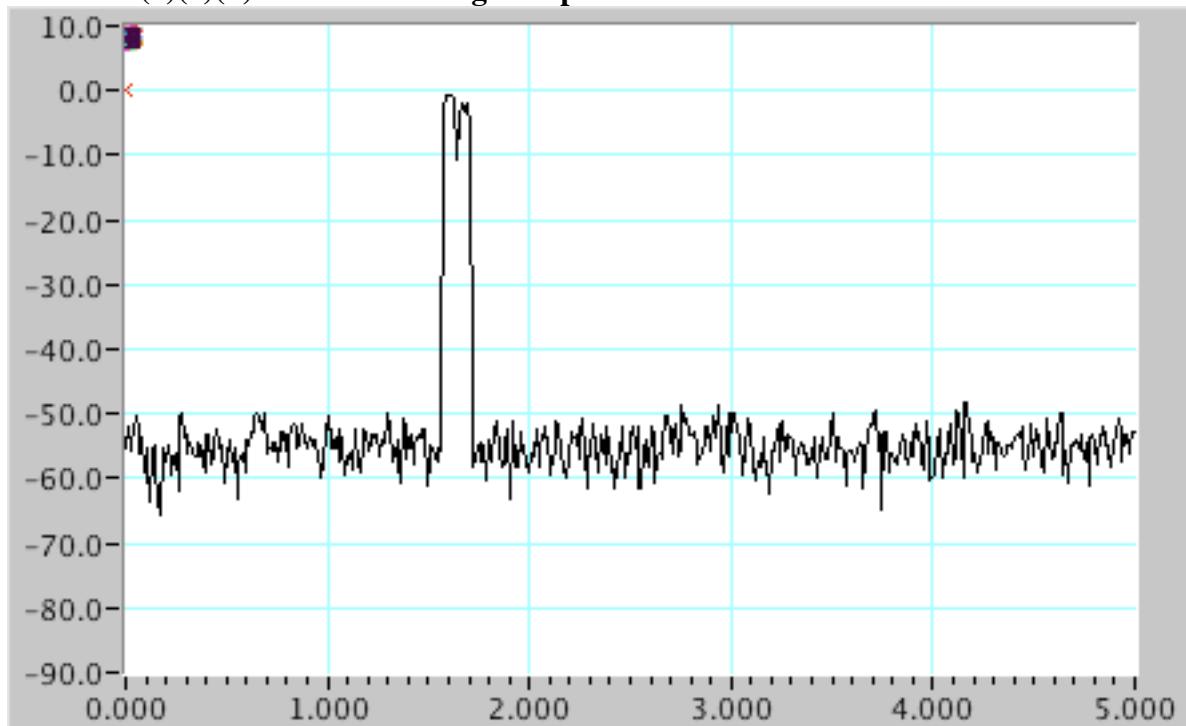
Frequency	Marker 1	Marker 2	Single Hop Dwell
2480 MHz	1.573 mSeconds	1.713 mSeconds	140 μSeconds

Result: The maximum dwell time is less then 0.4 Seconds.
Conclusion: PASS

7   CFR 15.247(b)(1)Maximum Power Output

7.1   CFR 15.247(b)(1)Maximum Power Output Test Setup

The maximum power output was found using the substitution method. First, the TX ouput from the mouse was connected to a power meter and this output power was noted. Next, a carrier wave from the signal generator using the same cables and set to the mouse carrier frequency was varied in power until it matched the recorded power from the last step. This carrier power from the signal generator represents the conducted output power from the mouse.
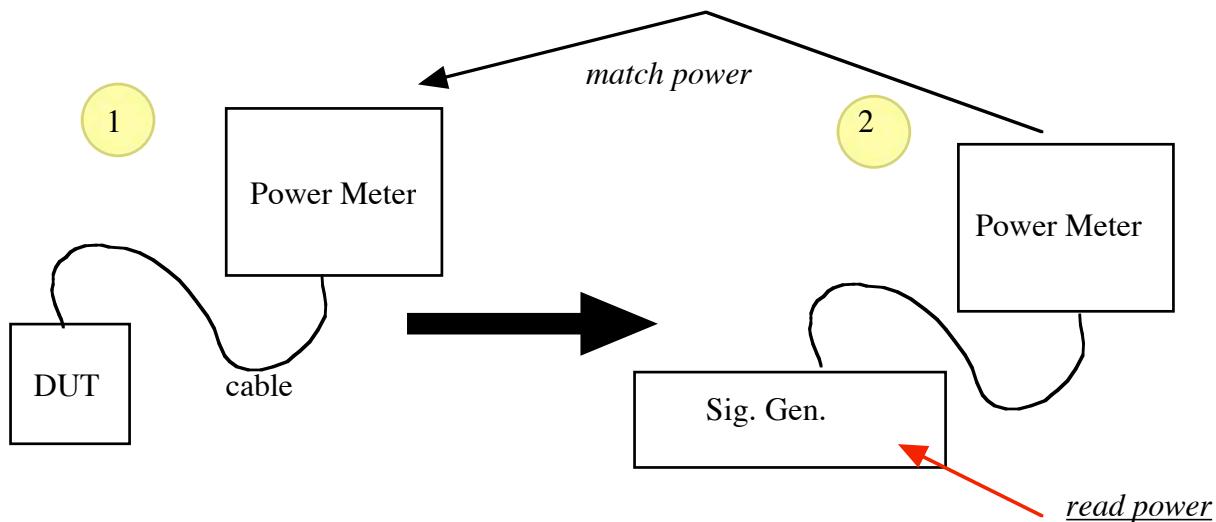
7.2   CFR 15.247(b)(1)Maximum Power Output Test Procedures

The transmitter output is connected to the power meter RF input. The power is measured with the transmitter set to 3 channels, low, mid and high.

7.3   CFR 15.247(b)(1)Maximum Power Output Test Equipment

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Sig Gen	R&S	13054-4523	13054-4523	May, 2003	May, 2004
Power Meter	HP	4358	1995 100	May, 2002	May, 2004

7.4   CFR 15.247(b)(1)Maximum Power Output EUT Operating Conditions

The transmitter was set to transmit continuously at the low, mid and high channels.

7.5   CFR 15.247(b)(1)Maximum Power Output - Channels 1, 39 and 79

Channel	Frequency	Maximum Output Power (1 Mbps)
1	2402 MHz	2.2 dBm
39	2441 MHz	2.0 dBm
79	2480 MHz	1.7 dBm

Results: The maximum power levels are below the 30 dBm Limit
Conclusion: PASS

8   CFR 15.247(b)(4) RF Exposure

SAR tests were performed on the Apple Bluetooth keyboard using the ceramic antenna and again using the PCB dipole antenna.   The reports are listed below. These reports demonstrate that the Apple Bluetooth keyboard's RF exposure levels are well under the limit of 1.6 mW/g.

Description	Antenna Description	SAR Report Number
Apple Bluetooth Keyboard	PCB antenna	03U2032-2

9   CFR 15.247(c) -20 dBc Spurious Conducted Emissions

9.1   CFR 15.247(c) -20 dBc Spurious Conducted Emissions Test Setup

Spurious Emissions measurements were performed at the Apple Computer EMC lab located at 20650 Valley Green Drive. The EUT was placed on a nonmetallic table. The EUT and peripherals were powered from a filtere main supply.

9.2   CFR 15.247(c) -20 dBc Spurious Conducted Emissions Test Procedure

The frequency spectrum from 1 GHz to 25 GHz was scanned

Scans were performed with the transmitter frequency set to the low, mid and high channels.   The -20 dBc Spurious Emissions data is provided in this report for each case.

• low channel - 2.402 GHz
• mid channel - 2.441 GHz
• high channel - 2.480 GHz

9.3   CFR 15.247(c) -20 dBc Spurious Conducted Emissions Test Equipment

The following test equipment was used when performing spurious emissions tests above 1 GHz.

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	May, 2003	May, 2004

9.3.1   CFR 15.247(c) -20 dBc Spurious Conducted Emissions Instrument Settings

| Instrument Settings					
Frequency Range	Resolution BW	Video BW	Reference Level	Attenuation	Sweep Time
1 GHz - 2.4 GHz	100 kHz	100 kHz	20 dBm	30 dB	350 mSeconds
2.4 GHz - 2.835 GHz	100 kHz	100 kHz	20 dBm	30 dB	100 mSeconds
2.8 GHz - 25 GHz	100 kHz	100 kHz	20 dBm	30 dB	800 mSeconds

9.4   CFR 15.247(c) -20 dBc Spurious Conducted Emissions EUT Operating Conditions

The Bluetooth Keyboard was placed in modlated continous transmit on the following channels. Spurius spectral content was observed for each case.

Channel 1   2402 MHz
channel 40   2441 MHz
Channel 79   2480 MHz

9.5   CFR 15.247(c) -20 dBc Spurious Conducted Emissions -Channel 1 (2.402 GHz)
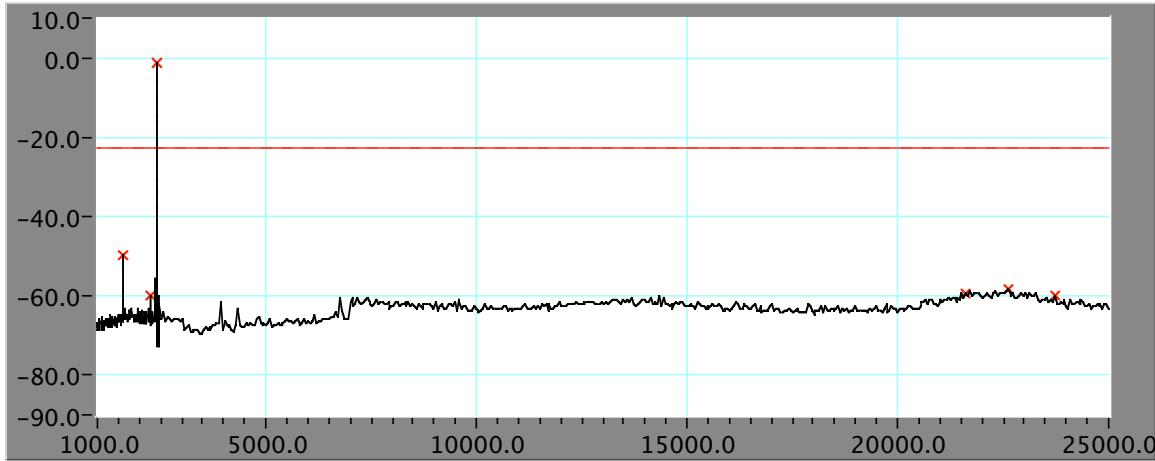
Frequency	Level	Limit	Delta
MHz	dBm	dBm	dB
1603.21	−49.9	−22.9	−27.0
2259.72	−59.7	−22.9	−36.8
2401.84	−1.4	−22.9	21.5
21615.76	−59.3	−22.9	−36.4
22608.47	−58.1	−22.9	−35.2
23736.55	−60.0	−22.9	−37.1

All levels are with a peak detector unless otherwise indicated.

9.6 CFR 15.247(c) -20 dBc Spurious Conducted Emissions - Channel 40 (2.441 GHz)

Frequency	Level	Limit	Delta
MHz	dBm	dBm	dB
1628.46	−49.5	−22.9	−26.6
2441.00	0.9	−22.9	23.8
2444.51	−44.8	−22.9	−21.9
21931.62	−59.2	−22.9	−36.3
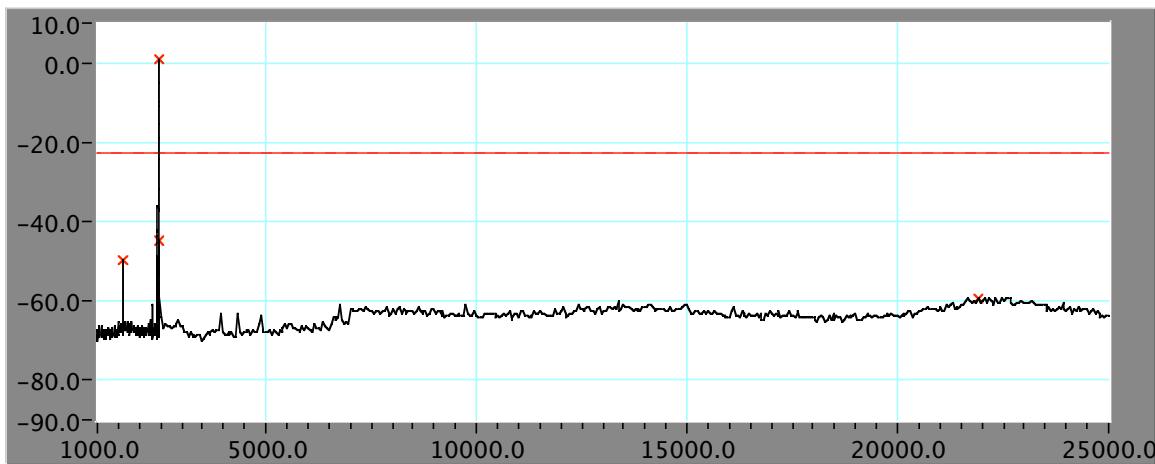
All levels are with a peak detector unless otherwise indicated.

9.7   CFR 15.247(c) -20 dBc Spurious Conducted Emissions Channel 79 (2.480 GHz)
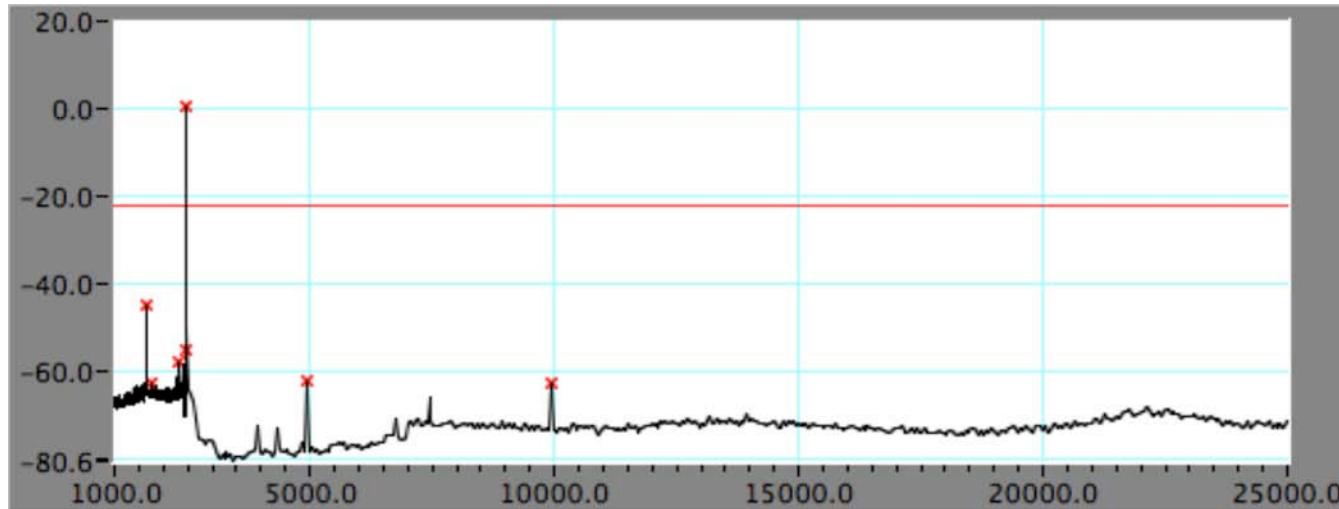
Frequency	Level	Limit	Delta
MHz	dBm	dBm	dB
1653.71	−45.1	−22.3	−22.8
1760.32	−62.6	−22.3	−40.3
2338.28	−58.0	−22.3	−35.7
2456.06	−55.2	−22.3	−32.9
2480.15	0.4	−22.3	22.7
4920.16	−62.3	−22.3	−40.0
9928.84	−63.0	−22.3	−40.7

All levels are with a peak detector unless otherwise indicated.

Result: Spurious emissions for low, mid and high channels are below 20 dBc.
Conclusion: Pass

10   CFR 15.247(f) Power Spectral Density - Hopping Disabled

The peak power spectral density conducted from the intentional radiator to the antenna shall not be greater then 8 dBm in any 3 kHz bandwidth.

10.1   CFR 15.247(f) Power Spectral Density - Hopping Disabled Test Setup

Peak Power Spectral Density measurements were performed at the Apple Computer EMC lab located at 20650 Valley Green Drive. The EUT was placed on a nonmetallic table. The EUT and peripherals were powered from a filtered main supply. Using special test software, the Apple Bluetooth keyboard was set to transmit in single channel mode for each of the low, mid and high channels.

10.2   CFR 15.247(f) Power Spectral Density - Hopping Disabled Test Procedure

The frequency spectrum at each of the low, mid and high channels was scanned.

**10.3   CFR 15.247(f) Power Spectral Density - Hopping Disabled Test Equipment**

The following test equipment was used when performing power spectral density measurements.

Description	Manufacturer	Model No.	Identification No.	Last Cal	Next Cal
Spectrum Analyzer	R&S	ESIB 40	100105	May, 2003	May, 2004

10.3.1   CFR 15.247(f) Power Spectral Density - Hopping Disabled Instrument Settings

| Instrument Settings					
Reference Level	Attenuation	Resolution BW	Video BW	Sweep Rate	Span
10 dBm	40 dB	3 kHz	3 kHz	560 mSeconds	2 MHz

10.4   CFR 15.247(f) Power Spectral Density - Hopping Disabled - Low Channel
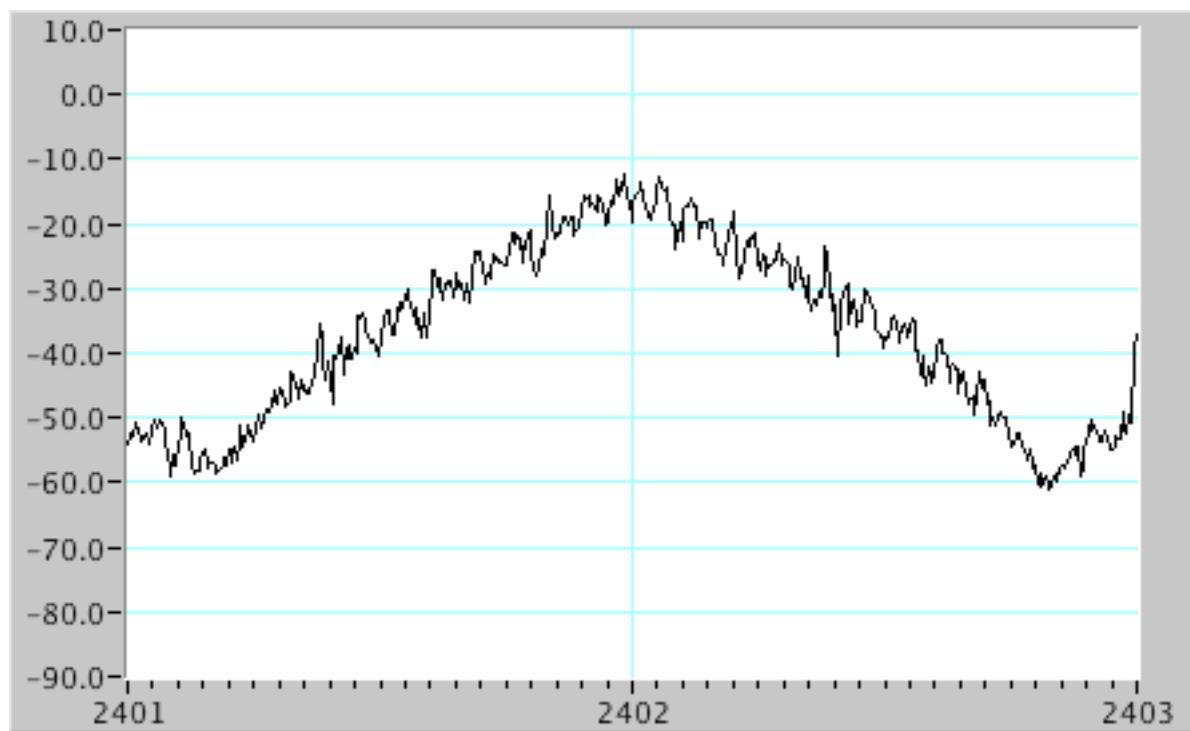
10.5   **CFR 15.247(f) Power Spectral Density - Hopping Disabled - Mid Channel**
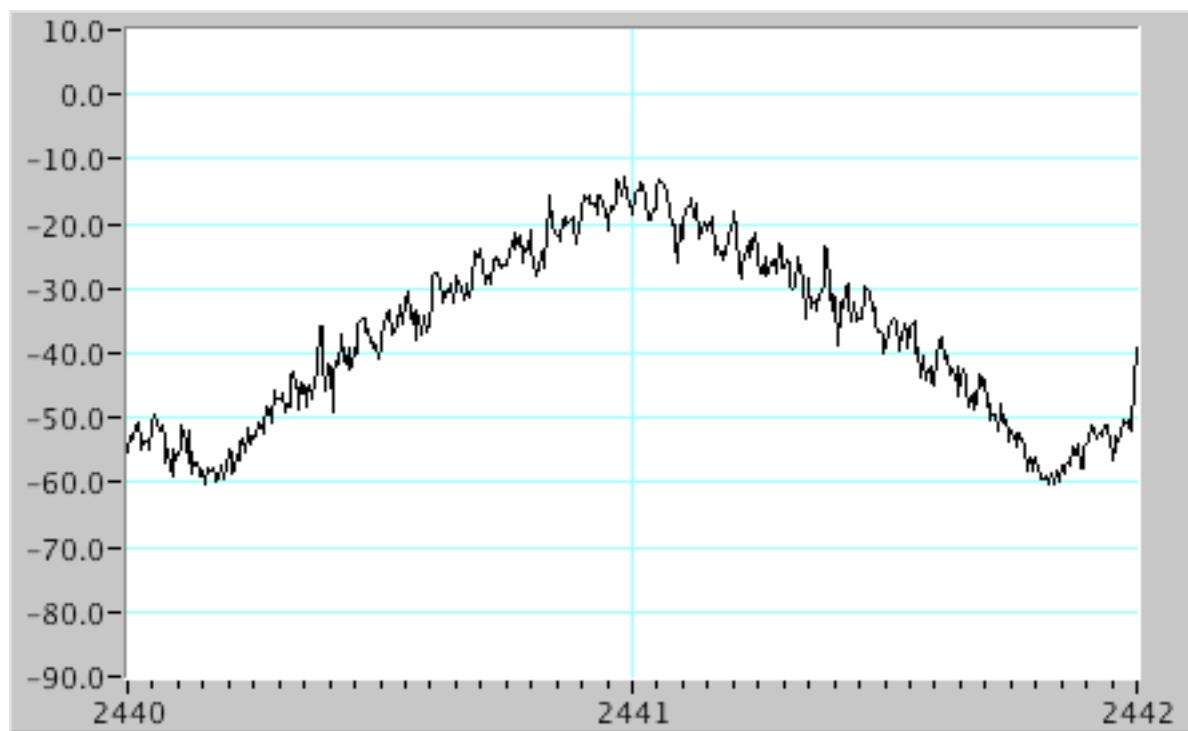
10.6   **CFR 15.247(f) Power Spectral Density - Hopping Disabled - High Channel**
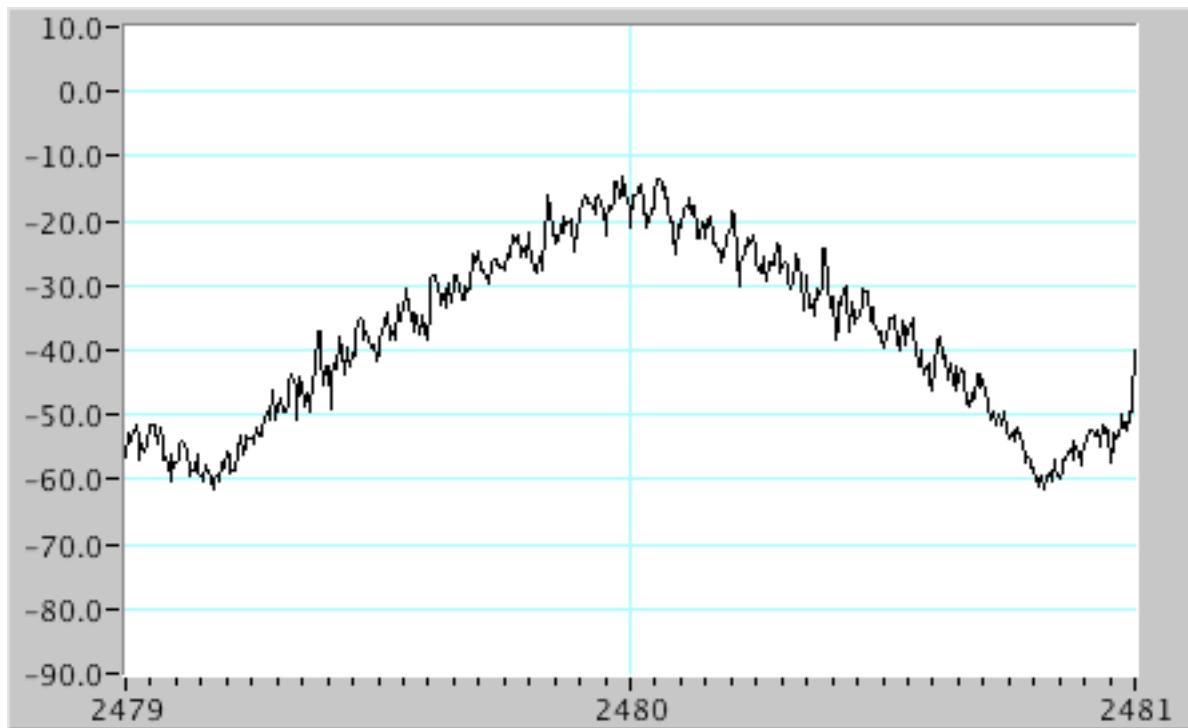
Result: The peak power spectral density for low, medium and high channels is less than 8 dBm.
Conclusion: Pass