110 Nortech Parkway
San Jose, California, 95134

FCC Part 15.247 Certification Application

Industrie Canada RSS210 Certification

EMI Test Report
and
Technical Documentation
on
Airespace Virtual Access Point.
Model: 1200

FCC ID: QTZVAP1200

Prepared by:
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General Information

Unit(s) Under Test: Virtual Access Point (VAP)
Model: 1200
Product Description: IEEE 802.11A / B Access point

FCC ID: QTZVAP1200

Tested For: Airespace
110 Nortech Parkway
San Jose, Ca. 95134

Tested At: Elliott Laboratories
684 West Maude Ave
Sunnyvale, CA 94086

Tested By: Chris Byleckie, Sr. Test Engineer, Elliott Laboratories
Juan Martinez, Sr. Test Engineer, Elliott Laboratories
David Waitt, (Independent Consultant)

Test Specifications: FCC CFR 47, Part 15.247, 2.4 GHz DSSS

Test Date: December 2002

Requested Certification: Part 15.247 Certification

Company Background
Started in 2001, Airspace (formerly Black Storm Networks) is a small privately funded start up company based in San Jose, California. Airespace is currently developing state of the art IEEE802.11 products.

Detailed Product Information

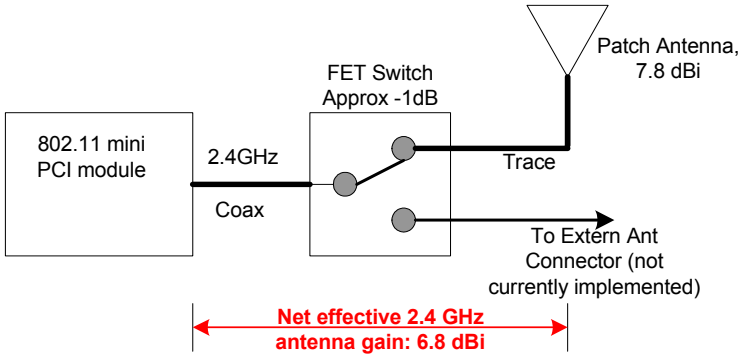
The Airespace radio is an IEEE 802.11 A / B Virtual Access point (VAP) intended to be professionally installed and configured in corporate and industrial environments.

The device utilizes a mini PCI module manufactured by an outside vendor. At the time of this certification the module had not received FCC approval as a module. For this reason that Black Storm is pursuing its own certification.

The VAP utilizes integral antennas on the 802.11 A / B bands. The VAP includes two integral 5 GHz patch antennas pointing 180^{o} from each other to create a somewhat omni directional 5GHz pattern (The 5 GHz antenna system is addressed in the UNII Part 15 Subpart E report). The VAP essentially includes only a single 2.4GHz patch antenna. There are actually two 2.4 GHz antennas. The VAP switches rapidly between them and when a signal is detected, the VAP uses the antenna offering the best connection. At any one time, there is only one antenna connected to the module.

The effective gain of the 2.4 GHz antenna path (the antenna switch and the antenna itself) is 6.8dBi. The diagrams below outline the RF path from the output of the mini PCI module within the VAP to the integral antennas within the VAP .See the antenna patterns included with this application (Note that only the Part 15.247 2.4 GHz portion is covered by this particular report)

There is a provision for attaching external antennas to the VAP (which, when implemented will disable the integral antenna by means of the switch) however at this time, since external antennas are not included in this certification application, the ability to utilize an external antenna, and even switch the antenna selection switch to the other position will be disabled in the configuration software. The hardware was put in place to support the future use of external antennas once such use is authorized either by permissive change of new grant.



Test Results Summary

This report presents the results of the tests that verify compliance with FCC Part 15.247. This includes all of the 2.4 GHz band and part of the 5GHz band used by the device. Compliance of the remaining (UNII) portion of the 5 GHz band is detailed in a separate report. Because there are commonalities in the testing of the product for the two rule parts, some of the information is duplicated in both reports in an attempt to make both reports complete.

A brief results summary of all the in this report is below.

Part 15 Paragraph	RSS-210 Paragraph	Test	Results
15.247(b)	6.2.2(o)(a) 3	Maximum Power Output at Antenna Terminal 14 dBm Setting 17 dBm Setting	 12.97 dBm Max 15.29 dBm Max
15.247(a)(2)	6.2.2(o)(e1)	6dB Bandwidth	12.6 MHz Min
15.247(d)	6.2.2(o)(d1)	Power Spectral Density	-10.11dBm/3kHz Max
15.247(c)	6.2.2(o)(a) 4	Out of Band Spurious Emissions	-45.33 dBc Max
15.205	6.3(c)	Radiated Emissions in Restricted bands	.87 dB in spec min @2483.5MHz

Test Facilities

Many of the certification tests were performed at:

Elliott Labs
684 West Maude Ave
Sunnyvale, CA 94086

The tests performed at Elliott include:

- All radiated emissions tests required in FCC Part 15.205 for 2.4 and 5GHz.
- Out of band emissions (Conducted) (for 2.4 GHz)

General:

Final radiated test measurements were taken in Dec 2002 at the Elliott Laboratories Open Area Test Site #4.

The test site contains separate areas for radiated and conducted emissions testing. Pursuant to section 2.948 of the Rules, construction, calibration, and equipment data has been filed with the Commission.

The FCC recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement with the exception of predictable local TV, radio, and mobile communications traffic. The test site contains separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent FCC requirements.

OATS:

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated emissions are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 Guidelines.

Antenna, Antenna Mast and Turntable

The Horn antennas that are use to measure radiated emissions above 1000MHz are amounted on a non-conductive antenna mast equipped with a motor drive to vary the antenna height.

ANSI C63.4 specifies that the test height above the ground plane shall be 80cm unless the equipment is intended to be floor mounted. During the radiated emissions tests the equipment is positioned on a motorized turntable in conformance with the ANSI requirement.

Equipment Lists

Instrument Calibration

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

All remaining “Conducted RF” tests were performed at by David Waitt in an Engineering lab utilizing calibrated Agilent test equipment. – See Additional test equipment list

The following test equipment was used to perform the testing

Elliott Test Equipment

Item	Desc.	Manufacturer	Model	S/N (Elliott #)	Cal due date
1.	Spectrum Analyzer	Agilent	8564E	Elliott 1393	21 Feb 03
2.	3.5 GHz HPF	HP	NA	84300-80038	1 Mar 03
3.	Pre Amp	Miteq	ASF 44	805817	7 Jan 03
4.	Antenna	EMCO	3116	9711-5359	2 Mar 03
5.	Peak Power Meter	Rhode & Schwartz	NRYS	835360/070	6 Sept 03
6.	Power Head	Rhode & Swartz		836019/016	6 Sep 03

Additional Test Equipment

Item	Desc.	Manufacturer	Model	S/N	Cal due date
1.	Peak Power meter	Agilent	4416A	GB40320299	7 July 03
2.	Power Head	Agilent	E9327A	US40440899	16 Oct 03
3.	Spectrum Analyzer	Agilent	E4404B	US40521093	3 Sep 03

Test Methods

The tests are performed at a low, middle and high channel of the applicable band. The typical frequencies used for the Part15.247 2.4 GHz tests are listed below. Unless otherwise noted, all testing was performed on these channels / frequencies

ISM 802.11 B	
2400 – 2483.5 MHz	
Channel	Freq(MHz)
Low	2412
Mid	2437
High	2462

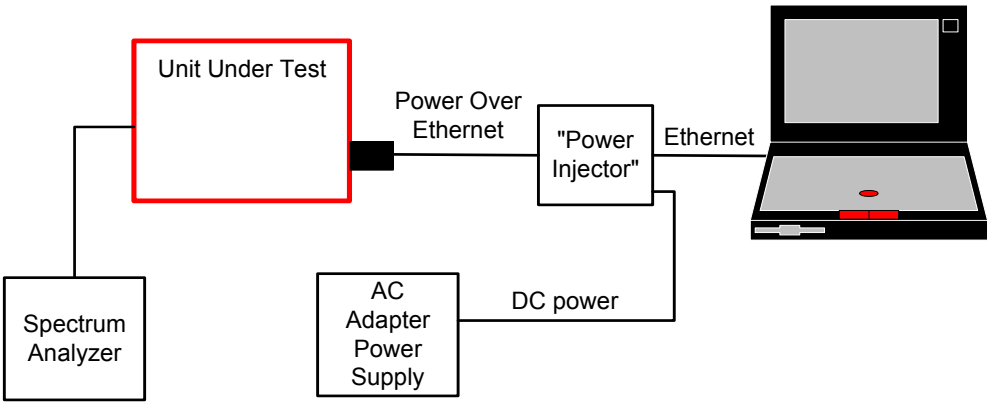
In order to comply with the “radiated emissions in restricted bands” requirements the transmit power had to be lowered on some of the channels at the edges of the operating band. The maximum power setting that allowed compliance with the radiated emissions requirements will be programmed into the configuration firmware of the access point ensuring that maximum possible power setting will be correct for each channel. Given that the access point will normally be operated at these power settings, these same settrings were also used during the “bench top” conducted RF tests (Spectral density, bandwidth etc).

The transmit power setting for the 2.4 GHZ ISM band 802.11 B channels used in the testing is shown in the table below. The power setting was +14 dBm on channels 1 and 11 to improve restricted band emissions at the band edges. All channels (in the 2.4 GHz band) other than 1 and 11 will be configured for +17 dBm power out.

Pout settings Vs. Channel	802.11a/b Channel	Frequency (MHz)	Tx Pout Set Point (dBm)
2.4 GHz ISM	1	2412.00	+14.00
	6	2437.00	+17.00
	11	2462.00	+14.00

The tests listed below are performed using the basic “conducted” test setup shown below unless otherwise noted. In most cases, the EUT was running special diagnostic software to allow it to transmit random data on a particular channel indefinitely.

Part 15	Test
15.247(a)(1)	6dB Bandwidth
15.247(c)	Out of Band Conducted Emissions
15.247(a)(1)(i)	Power Spectral Density
15.247(b)	Transmit Power



Basic Conducted RF Bench Test Setup

Unless otherwise noted, the support equipment for the bench tests is listed below.

Support Equipment				
Description	**Model number**	**FCC ID or SN**	**Manufacturer**	**Power Cable**
Laptop	Armada E 500	P31000T4X20DC12N2	Compaq	Laptop PS
Test Software	Atheros Radio Test		Atheros	
48VDC AC adapter	Generic		Generic	Standard Twin lead DC wire

NOTE: The “Power Injector” is simply a connector attached to wires “broken out” of the Ethernet cable. It is not really a piece of equipment.

Test Results

Detailed test procedures and test results are contained in the following sections. In cases where the test setup differs from the Conducted RF test setup shown earlier, the test setup is also presented.

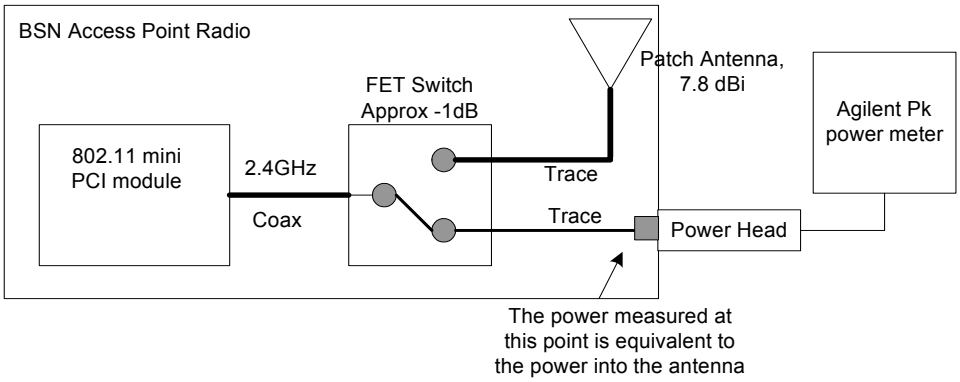
Test Conditions			
Temperature	24 C	**Humidity:**	52%
ATM pressure	1017 mBar	**Grounding:**	None
Tested By	David Waitt	**Date of Test:**	Dec 02 / Jan 03
Test Reference	Refer to individual test results		
Tested Range	Test Dependent		
Test Voltage	48 VDC to the VAP		
Modifications	No modifications were made to the unit during the tests		

802.11 B Maximum RF Power Output at Antenna Terminals

Specifications:
FCC Specification: Paragraph: 15.247(b)

Procedure:
The test was configured as shown in the conducted RF test setup. The unit was tuned to the test channels and configured to transmit random data packets.

Because the unit will be operated at different power levels depending on the channel being used, the RF power out was measured at the appropriate power setting for the given test channel (see table above). The setting used for each channel is indicated in the results table below.



RF Transmit Power Result:
The following power levels were measured on low, mid and high channels of the ISM bands.

Pout settings Vs. Channel	802.11a/b Channel	Frequency (MHz)	Tx Pout Set Point (dBm)	Specification (dBm)	Measured Pout (Pk, dBm)	Measured Pout (Pk , Watts)
2.4 GHz ISM	1	2412.00	+14.00	30	**12.00**	.01584
	6	2437.00	+17.00	30	**15.29**	.03380
	11	2462.00	+14.00	30	**12.97**	.01981

Given the power measured above , the EIRP of the VAP, for each channel tested, is listed below.

Pout settings Vs. Channel	802.11a/b Channel	Specification (dBm EIRP)	Measured Pout (Pk, dBm)	Antenna Gain MAX dBi	Max Measured EIRP (dBm)
2.4 GHz ISM	1	36	12.00	6.8	**18.80**
	6	36	15.29	6.8	**22.09**
	11	36	12.97	6.8	**19.77**

ISM 6 dB bandwidth

Specifications
FCC Specification: Paragraph 15.247(a)(2)

Procedure:

The Airespace VAP access point operates on the standard IEEE 802.11 A / B channels. The 6dB bandwidth was measured on the low middle and high channel of the 2.4 GHz ISM band using the conducted RF test setup. The spectrum analyzer was configured for MAX HOLD and the trace allowed to stabilize. A peak search was performed and the then Delta-Marker used to locate the point –6dB below the peak.

Once this was complete, the point was used as a reference and another delta measurement was performed to the and an attempt made to make the two markers "level". The delta frequency between the two markers was measured as the 6 dB BW of the signal. The bandwidth test was performed at the power settings that will be used in the final system.

Results:

Band	802.11a/b Channel	Frequency (MHz)	Measured BW (MHz)
2.4 GHz ISM 6 dB BW	1	2412.00	**12.00**
	6	2437.00	**12.60**
	11	2462.00	**12.08**

6dB Bandwidth plots are contained in the report appendix

ISM Power Spectral Density

FCC Specification: Paragraph: 15.247(4)(d)

Procedure

The test setup was configured as shown in the conducted test setup. The UUT was configured to continuously transmit random data packets.

Procedure(2.4 GHz):

Initially the bandwidth of the entire channel was examined. Using MAX HOLD, the trace was allowed to stabilize. Once the trace was stable, a peak search was performed and the frequency with the maximum power was determined.

The measurement span was then narrowed to 300kHz and centered on the "MAX power" frequency, the RBW set to 3 kHz with a 100 second sweep. The analyzer was then set to MAX HOLD and a display line placed at +8dBm.

The power spectral density was measured at the low, middle and high test channels with the appropriate power setting for the given test channel.

Results:

Band	802.11a/b Channel	Frequency (MHz)	Specification dBm /	Measured PSD (dBm)
2.4 GHz ISM PSD	1	2412.00	8dBm/3kHz	**-15.24**
	6	2437.00	8dBm/3kHz	**-10.11**
	11	2462.00	8dBm/3kHz	**-12.80**

The power spectral density plots are contained in the appendix of the report

ISM Out of Band Emissions

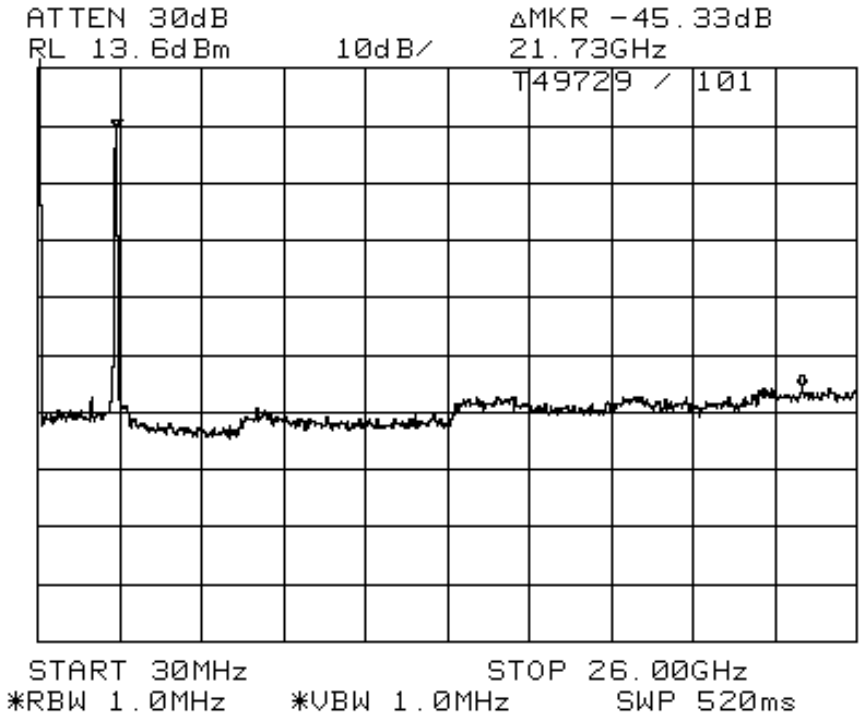
Specifications:
FCC Part 15 Paragraph 15.247(c)

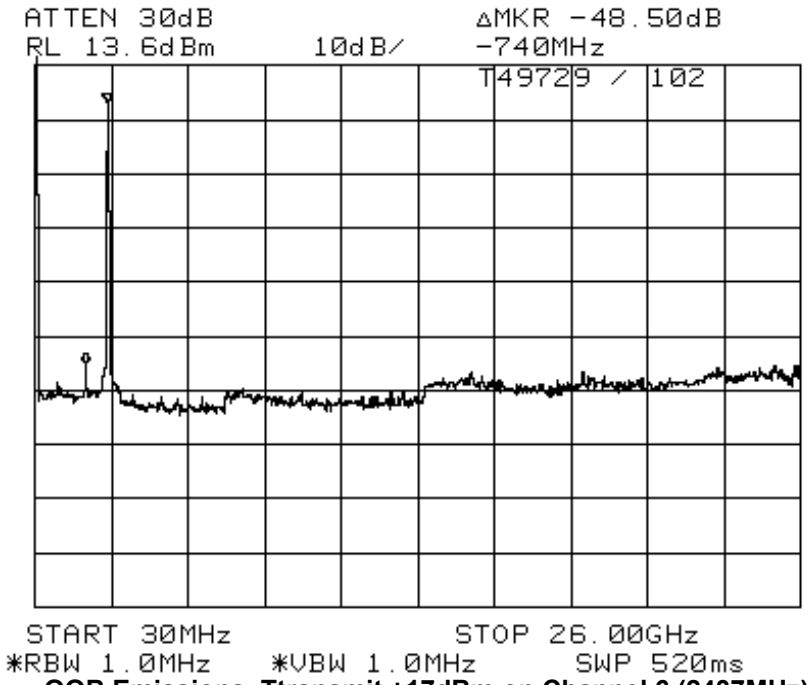
Procedure:
The test was configured as shown in the bench conducted RF test setup. The UUT was configured to transmit random data packets. The band from 1 GHz to 25GHz was examined for spurious emissions. This test was conducted the low middle and high channels. The UUT was configured to transmit +14 dBm for channels 1 and 11 and + 17 dBm for channel 6.

Results:
The entire band of interest was examined at one time to clearly demonstrate compliance. There were no spurious emissions above the limit (-20dBc)

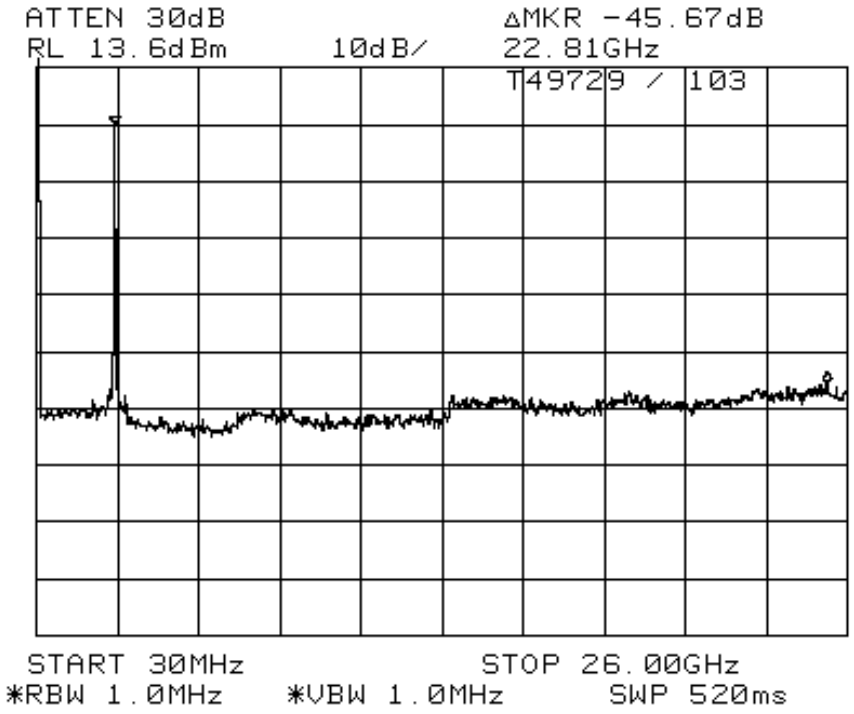
Out of Band Emissions Plots

UUT Set to transmit +14 dBm on Channel 1





OOB Emissions, Ttransmit +17dBm on Channel 6 (2437MHz)



OOB Emissions, transmit +17 on Channel 11 (2462MHz)

ISM Radiated Emissions in Restricted bands

Specifications:

FCC Part 15 Paragraph 15.247(c)

Procedure:

This test was conducted on a 3-meter open-air test site at Elliott Laboratories The unit was placed on a rotating wooden table 80cm above the ground plane. A 1 - 18 GHz Horn antenna was secured to a mast 3 meters away. The unit was tested at each of the Low, Mid and High channels. The UUT was running in the diagnostic mode and set to transmit CW at maximum power on each of the channels. The test equipment was configured as shown below.

The harmonics of the fundamental that fell within restricted bands (up to the tenth) were measured (See table 1 below). A high pass filter prior to the pre-amplifier was required to prevent the large signal level of the fundamental frequency from overloading the front end of the spectrum analyzer and creating harmonics within the analyzer.

The EUT was rotated 360 degrees and the height of the antenna adjusted from 1 to 4 meters above the ground plane to determine the maximum level of the emission. The level of the harmonic emission was measured in two modes, “Peak” and “Average” .

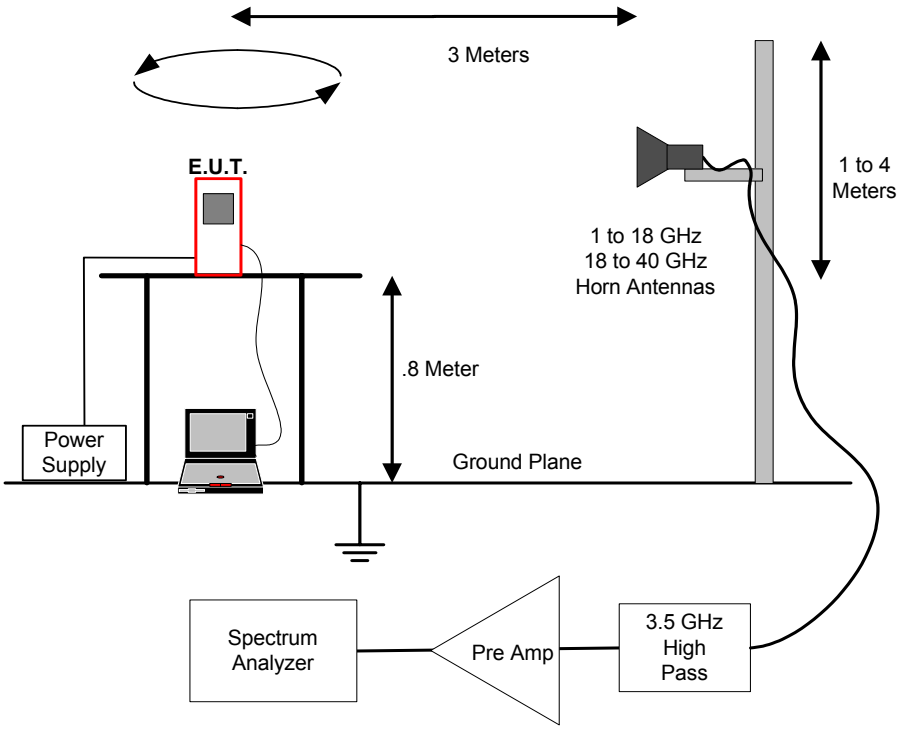
The spectrum analyzer reading was entered into a spreadsheet where correction factors (antenna factor, cable loss, pre-amplifier gain, HPF loss...) were then applied by Elliott Lab’s Software to obtain a final corrected measurement.

This procedure was repeated for the low, mid and high channels within the 2400-2485.5MHz band. The table below indicates the harmonics that fall within restricted bands.

FUND	Harmonic (MHz)								
	2	3	4	5	6	7	8	9	10
2412	**4824**	**7236**	9648	**12060**	**14472**	16884	**19296**	21708	24120
2437	**4874**	**7311**	9748	**12185**	14622	17059	**19496**	21933	24370
2462	**4924**	**7386**	9848	**12310**	14772	17234	**19696**	**22158**	24620

15.205 Harmonic test tables

*NOTE: **RED** indicates a harmonic that falls within a restricted band and is subject to 15.205. The harmonics in **black** are NOT in restricted bands and are subject to 15.209*



Radiated Emissions in Restricted Bands Test Setup

Support Equipment				
Description	**Model number**	**FCC ID or SN**	**Manufacturer**	**Power Cable**
Laptop	Armada E 500	P31000T4X20DC12N2	Compaq	Laptop PS
Test Software	Atheros Radio Test		Atheros	
48VDC AC adapter	Generic		Generic	Standard Twin lead DC wire

Test Conditions			
Temperature	19 C	**Humidity:**	39%
ATM pressure	1020 mBar	**Grounding:**	None
Tested By	J Martinez / C Byleckie Elliott Labs	**Date of Test:**	Dec 2002
Test Reference	FCC Part 15.205 IC Paragraph RSS210, 6.2.3 (c)		
Setup Method	ANSI C63.4		
Tested Range	1 GHz to 24 GHz		
Test Voltage	120 VAC / 60 Hz		
Modifications	No modifications were made to the unit		

Results:

Low Channel: 2412 MHz

Run #1a: Radiated Spurious Emissions, 30-24120 MHz.
Low Channel @ 2412 MHz
Power level set to 14

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	**Margin**	Pk/QP/Avg	degrees	meters
4823.487	45.1	V	74.0	**-28.9**	Pk	0	1.0
4823.862	32.3	V	54.0	**-21.7**	Avg	0	1.0
12059.66	54.7	V	74.0	**-19.3**	Pk	0	1.0
12059.42	41.8	V	54.0	**-12.2**	Avg	0	1.0
4824.607	45.5	H	74.0	**-28.5**	Pk	0	1.0
4823.415	32.3	H	54.0	**-21.7**	Avg	0	1.0
12060.03	54.7	H	74.0	**-19.3**	Pk	0	1.0
12059.80	41.8	H	54.0	**-12.2**	Avg	0	1.0

Mid Channel: 2437 MHz

Run #1b: Radiated Spurious Emissions, 30-24420 MHz. Center Channel @ 2437 MHz
Power level set to 17

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters
4873.912	47.3	H	74.0	**-26.7**	Pk	262	1.2
4873.929	38.7	H	54.0	**-15.3**	Avg	262	1.2
7311.574	52.5	H	74.0	**-21.5**	Pk	0	1.0
7310.806	40.7	H	54.0	**-13.3**	Avg	0	1.0
12185.31	55.1	H	74.0	**-18.9**	Pk	0	1.0
12185.42	41.9	H	54.0	**-12.1**	Avg	0	1.0
4874.181	48.3	V	74.0	**-25.7**	Pk	0	1.0
4873.972	40.3	V	54.0	**-13.7**	Avg	0	1.0
7312.503	56.0	V	74.0	**-18.0**	Pk	111	1.0
7312.033	45.8	V	54.0	**-8.2**	Avg	111	1.0
12184.90	54.8	V	74.0	**-19.2**	Pk	0	1.0
12184.77	41.9	V	54.0	**-12.1**	Avg	0	1.0

High Channel: 2462 MHz

Run #1c: Radiated Spurious Emissions, 30-24620 MHz.
High Channel @ 2462 MHz
Power level set at 14

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBmV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4924.086	48.2	V	74.0	**-25.8**	Pk	200	1.4	
4924.017	39.1	V	54.0	**-14.9**	Avg	200	1.4	
7385.328	53.9	V	74.0	**-20.1**	Pk	0	1.0	
7385.286	40.6	V	54.0	**-13.4**	Avg	0	1.0	
12309.57	54.8	V	74.0	**-19.2**	Pk	0	1.0	
12309.33	41.7	V	54.0	**-12.3**	Avg	0	1.0	
5629.35	44.8	V	92.1	**-47.3**	Pk	315	1.6	BW=100kHz
6334.01	46.9	V	92.1	**-45.2**	Pk	315	1.6	BW=100kHz
3341.00	53.2	V	92.1	**-38.9**	Pk	270	1.0	BW=100kHz
4924.383	45.8	H	74.0	**-28.2**	Pk	0	1.0	
4923.955	33.3	H	54.0	**-20.7**	Avg	0	1.0	
7386.216	53.0	H	74.0	**-21.0**	Pk	0	1.0	
7386.043	39.9	H	54.0	**-14.1**	Avg	0	1.0	
12310.10	54.4	H	74.0	**-19.6**	Pk	0	0.0	
12309.94	41.6	H	54.0	**-12.4**	Avg	0	0.0	

NOTES: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental. No emission detected above 15GHz.

Restricted Band Peak Measurements: Resolution and Video BW: 1 MHz
Restricted Band Average Measurements: Resolution Bw: 1MHz and Video Bw: 10 Hz.
All other measurements, RBW = 1MHz and VBW = 3MHz, video averaging on (100 samples).

Raw lab test data along with troubleshooting notes is contained in the appendix.

Radiated Emissions in the Restricted bands near the operating band

Since this is an 802.11 A / B product, there are three instances where there is an adjacent restricted band next to the operating band.

- The restricted that ends at 5.15 GHz where the UNII band begins. (UNII Report)
- The restricted band that begins where the UNII band ends at 5.35 GHz (UNII Report)
- The restricted band that begins at 2.4835 GHz where the ISM band ends

Procedure

There are three steps to performing this test. The first involves making a radiated measurement of the fundamental signal with the UUT on the operating channel closest to the edge of the band. This measurement is made using the peak and average RBW and VBW of 1MHz/1MHz and 1MHz/10Hz. This measured radiated level is then used as a “fundamental reference” level

Then, a second measurement is made using narrower bandwidths (100 kHz) to determine a –dBc (delta dB) level between the fundamental level (measured in a 100 kHz BW) and the highest level within the restricted band near the operating band.

A third and final measurement is made to determine the apparent drop in fundamental carrier power when the RBW is narrowed from 1MHz (in the reference measurement) to 100kHz (for the delta dB measurement). This is referred to below as the “BW Delta”. This correction factor is only allowed in the highest emission in the restricted band is less than 2 “standard bandwidths” from the edge of the restricted band.

This measurement is made because it is the intent of the restricted band emission test to reference the measurement made in the restricted band to a radiated measurement made in a 1 MHz BW

The level of the emission in the restricted band is then calculated using the formulas below

Restricted band level (AVG) = AVG reference level - delta dB - BW Delta dB
Restricted band level (Peak) = Peak reference level - delta dB - BW Delta dB

2.400 ISM Band Edge (Restricted band @ 2.390GHz)

Pol	Pwr	Fundemental		Delta	RBW	Radiated Level at Band Edge		Specification		Delta	
	Stg	Ref Msmt		Msmt	Delta						
		Peak	Avg		msmt	Peak	Avg	Peak	Avg	Peak	Avg
	dBm	dbuv/m	dbuv/m	dBc	dB	dBuv/m	dBuv/m	dBuv/m	dBuv/m	dBuv/m	dBuv/m
Vert	14	111.3	107.6	53.55	4.522	53.228	49.528	74	54	20.8	4.47
Horz	14	99.9	96.2	53.55	4.522	41.828	38.128	74	54	32.2	15.9

2.4835 ISM Band Edge (Restricted band @ 2.4835 GHz)

Chan	Pwr	Fundemental		Delta	RBW	Radiated Level at Band Edge		Specification		Delta	
	Stg	Ref Msmt		Msmt	Delta						
		Peak	Avg		msmt	Peak	Avg	Peak	Avg	Peak	Avg
	dBm	dbuv/m	dbuv/m	dBc	dB	dBuv/m	dBuv/m	dBuv/m	dBuv/m	dBuv/m	dBuv/m
Vert	14	112.1	108.8	48.34	7.328	56.432	53.132	74	54	17.6	0.87
Horz	14	101.6	98.4	48.34	7.328	45.932	42.732	74	54	31.3	11.3

Radiated emissions at band edge sample calculation:

Emission Level = Fund Ref Msmt – Delta msmt – RBW Delta Msmt

Example: 112.1dBuV/m – 48.34dB – 7.328dB = 53.132dBuv/m

Plots showing the delta measurement and the BW delta measurement for both, the 2.39 and the 2.4836 GHz Restricted are contained in the appendix of this report

Radiated Emissions Sample Calculations

Receiver readings are compared directly to the specification limit. The receiver internally corrects for cable loss, preamp gain and antenna factor. The calculations are in reverse from the signal flow, meaning that cable loss is actually added to the reading and amplification is subtracted. Antenna factor is a measure of the conversion of the voltage at the coaxial connector to the field strength at the antenna elements. A distance factor, for the electric field is calculated using the following formula

$$F_d = 20 \text{ Log}_{10} (D_m/D_s)$$

Where:
F_d = Distance Factor
D_m = Measurement distance in meters
D_s = specification distance in meters

Measurement distance is the distance at which the measurements were taken and the specification distance is the distance at which the specification limit is based.

The margin of a given emissions peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

Where :
R_r = Relative reading in dBuV/m
F_d = Distance Factor
R_c = Corrected reading in dBuV/m
L_s = specification Limit in dBuV/m
M = Margin in dB relative to the spec.

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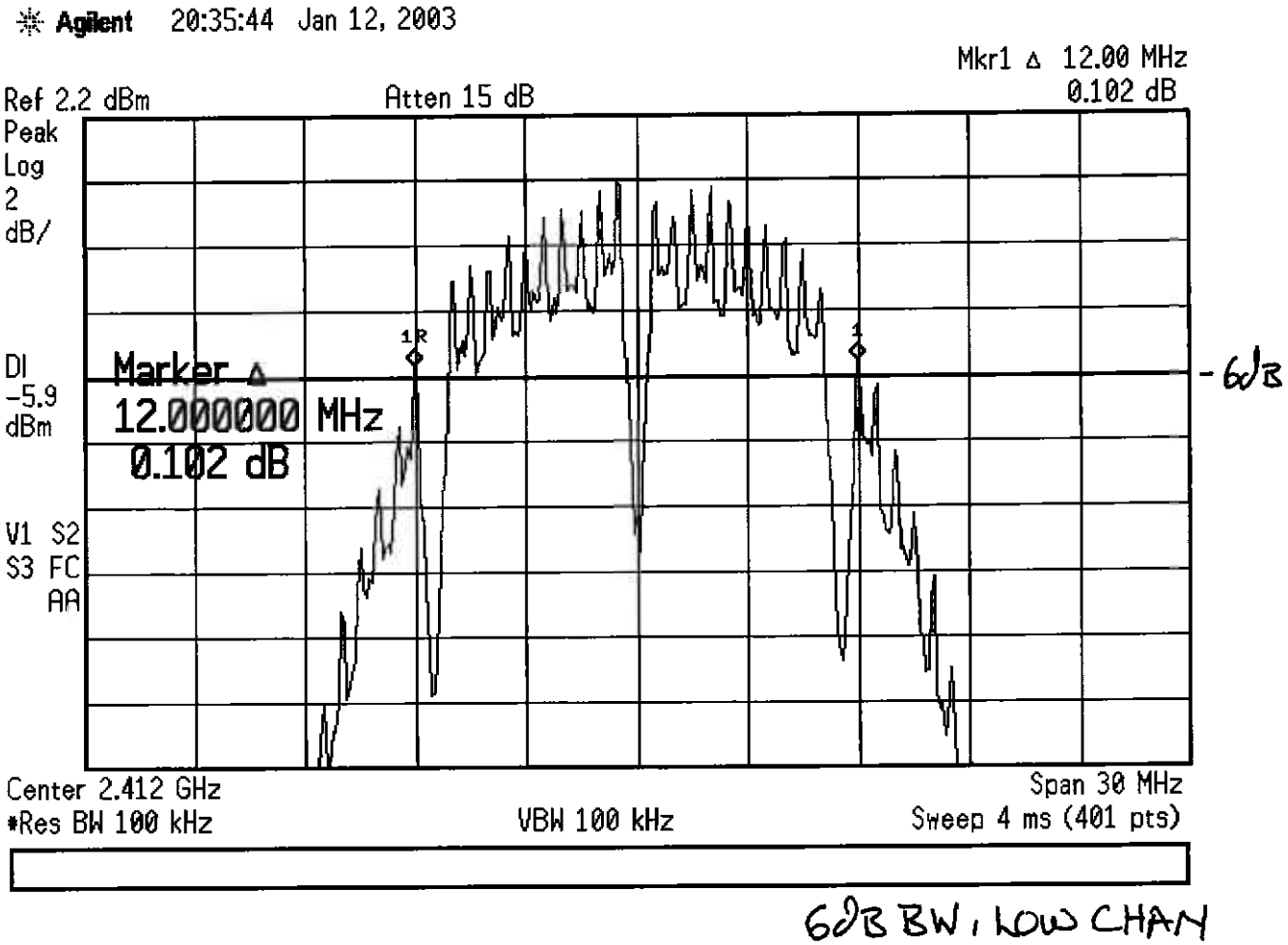
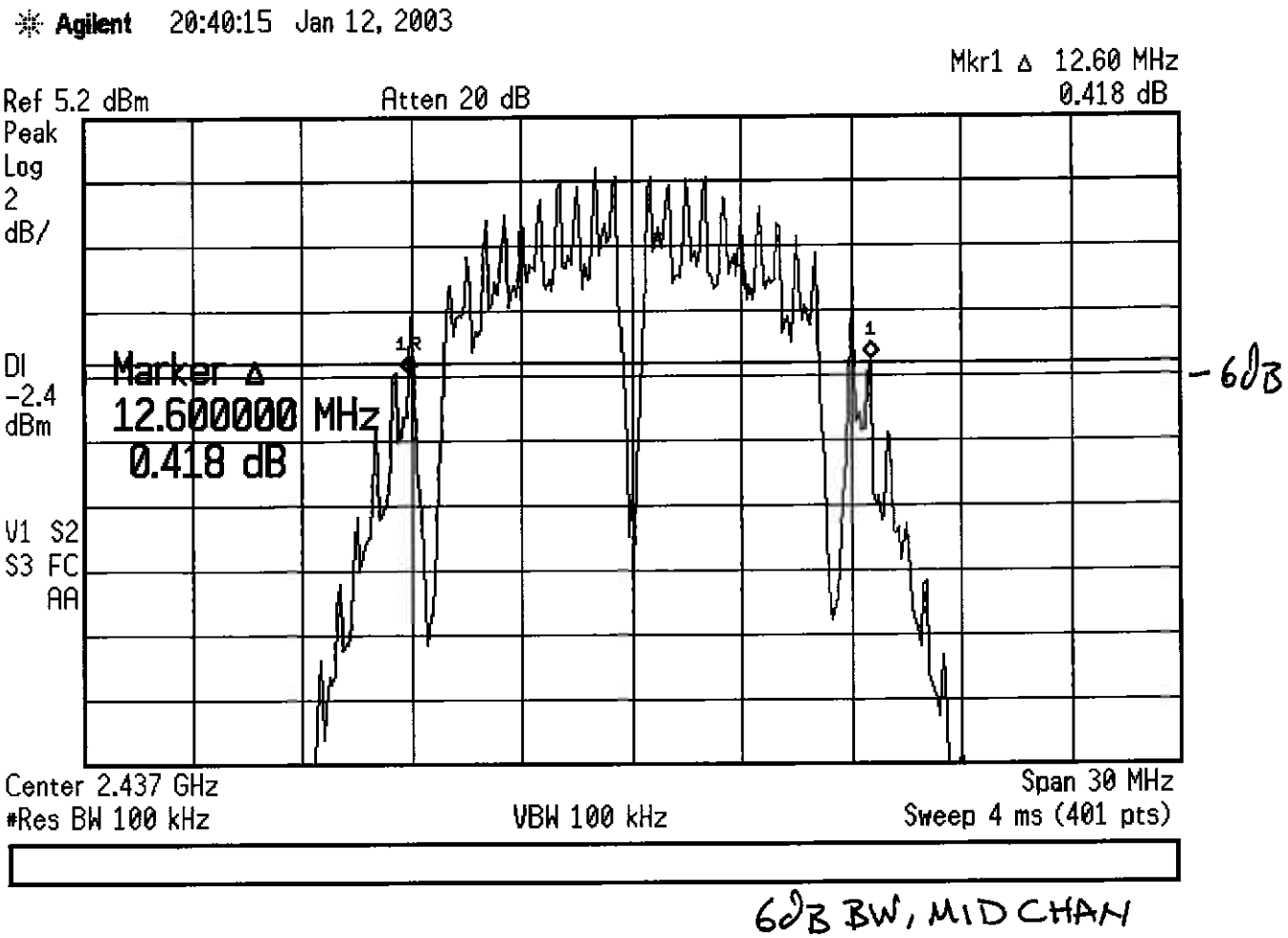
San Jose, California, 95134

Airespace Certification Application

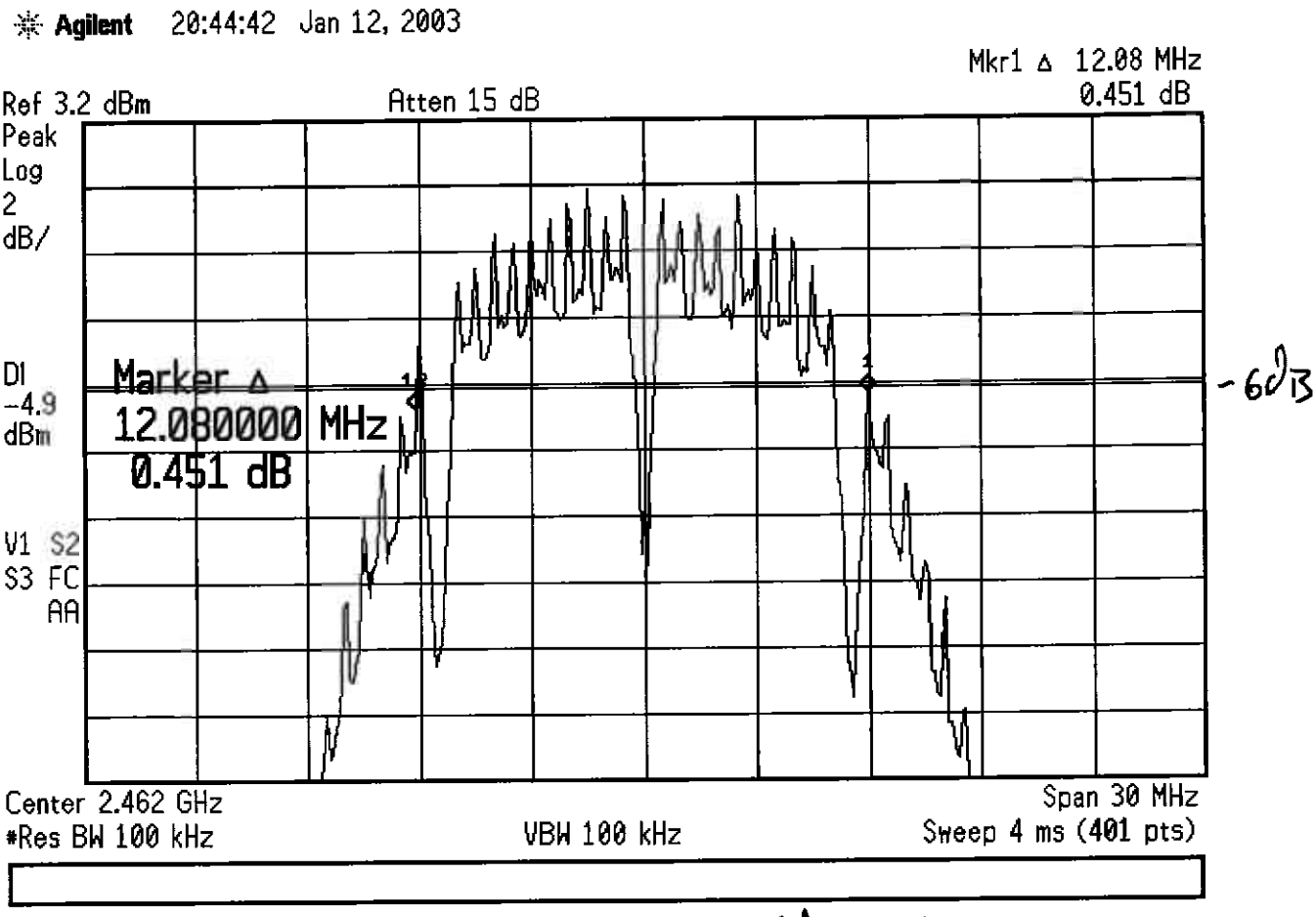
Appendix



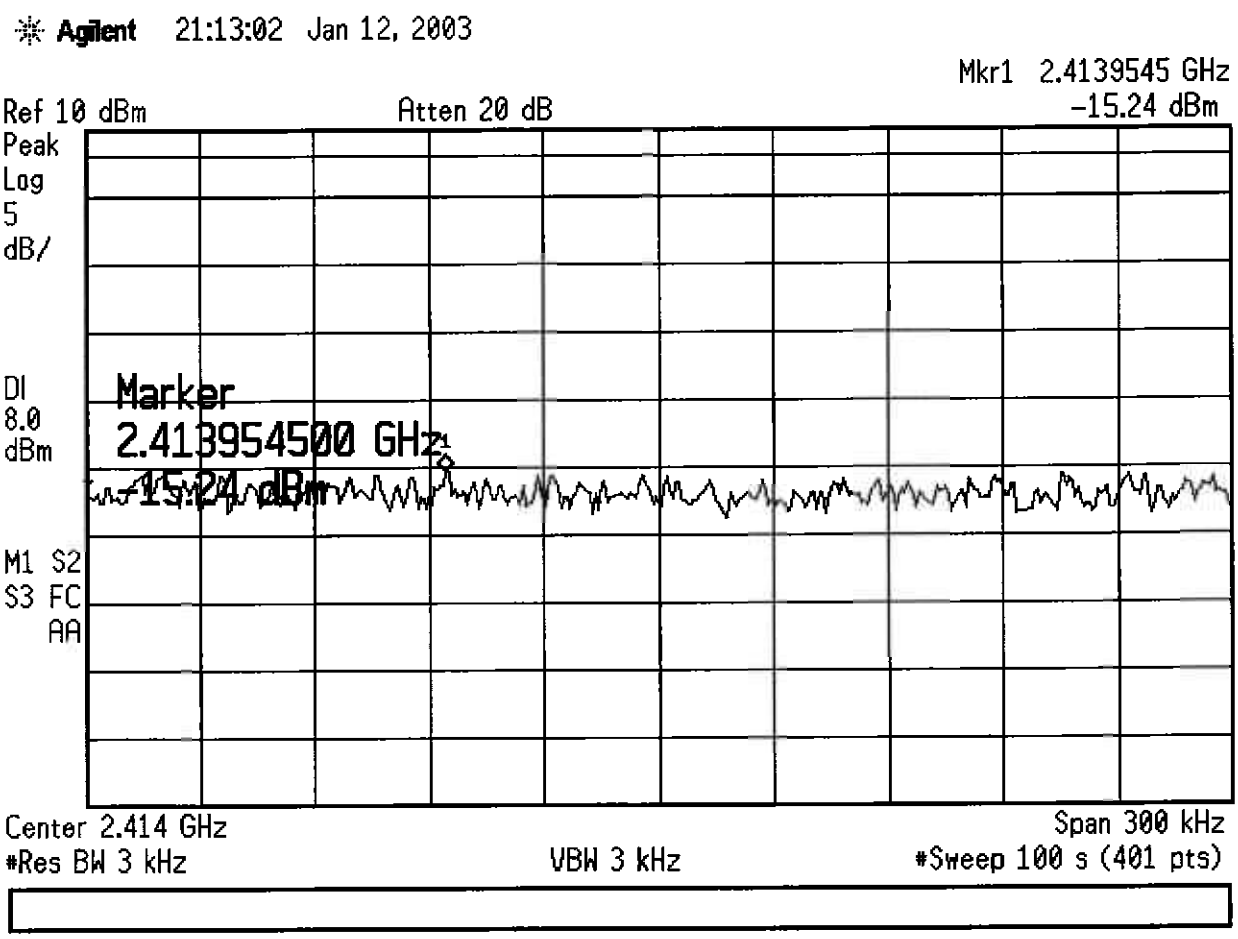
6dB BW, LOW CHAN



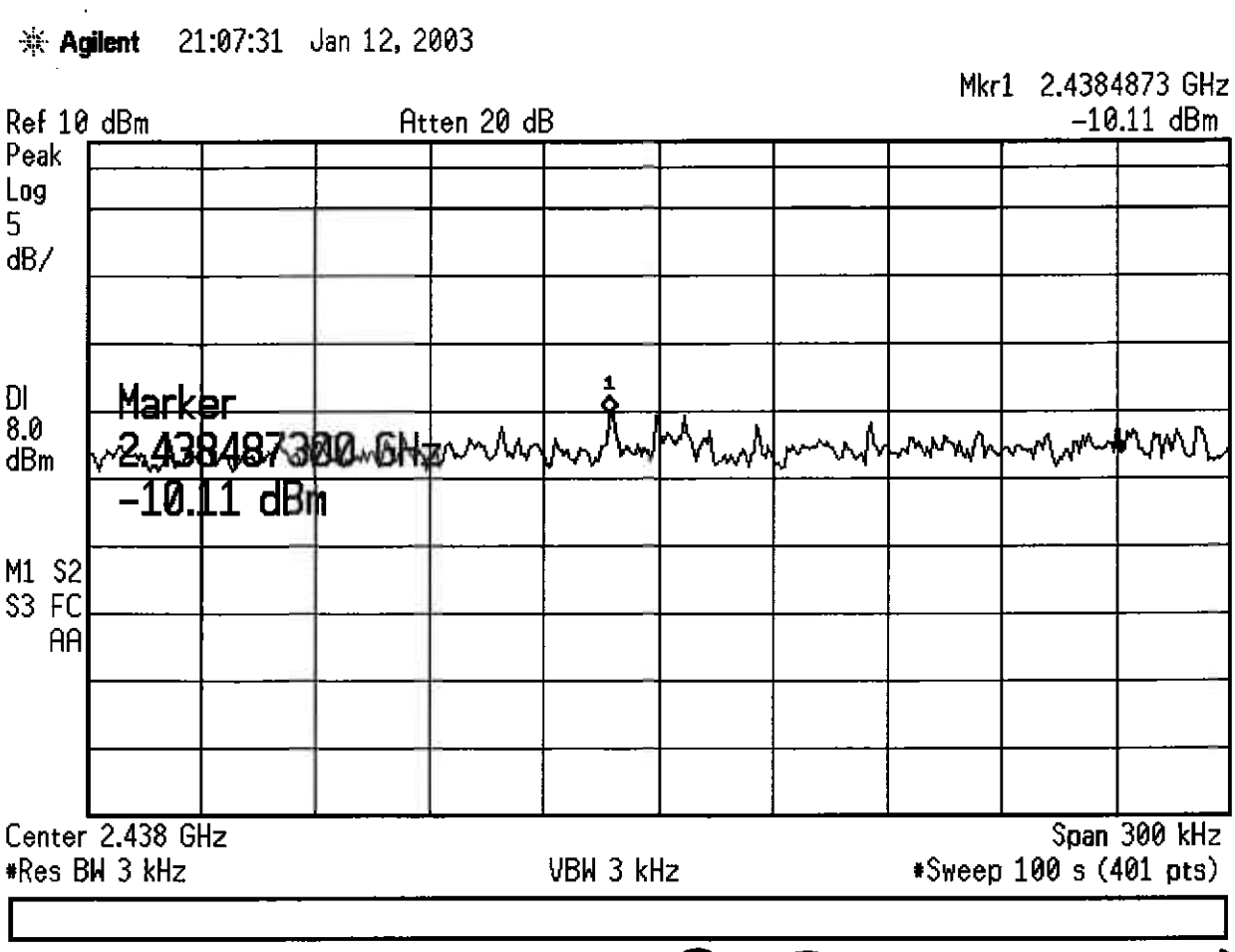
6dB BW, MID CHAN



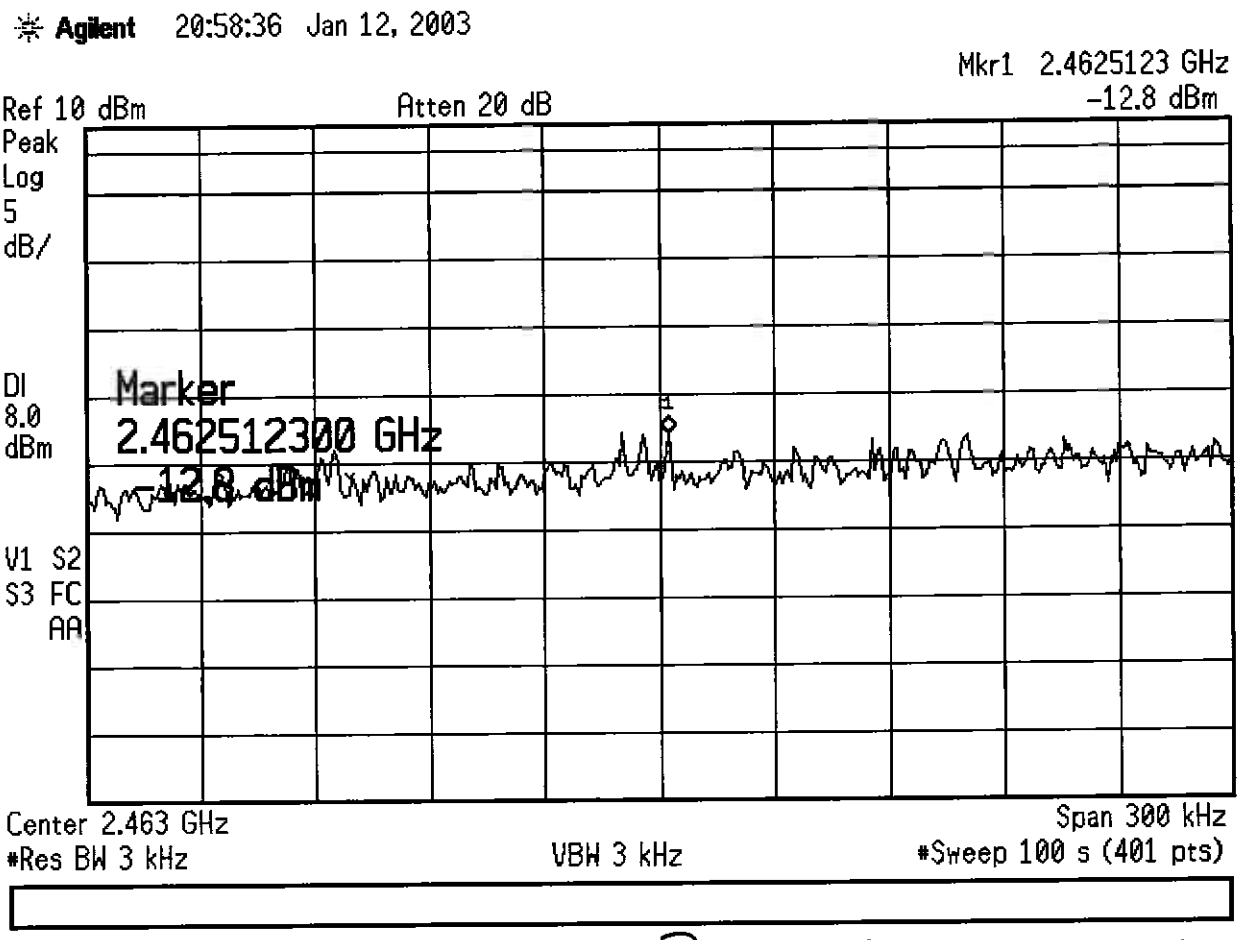
6dB BW, HIGH CHAN



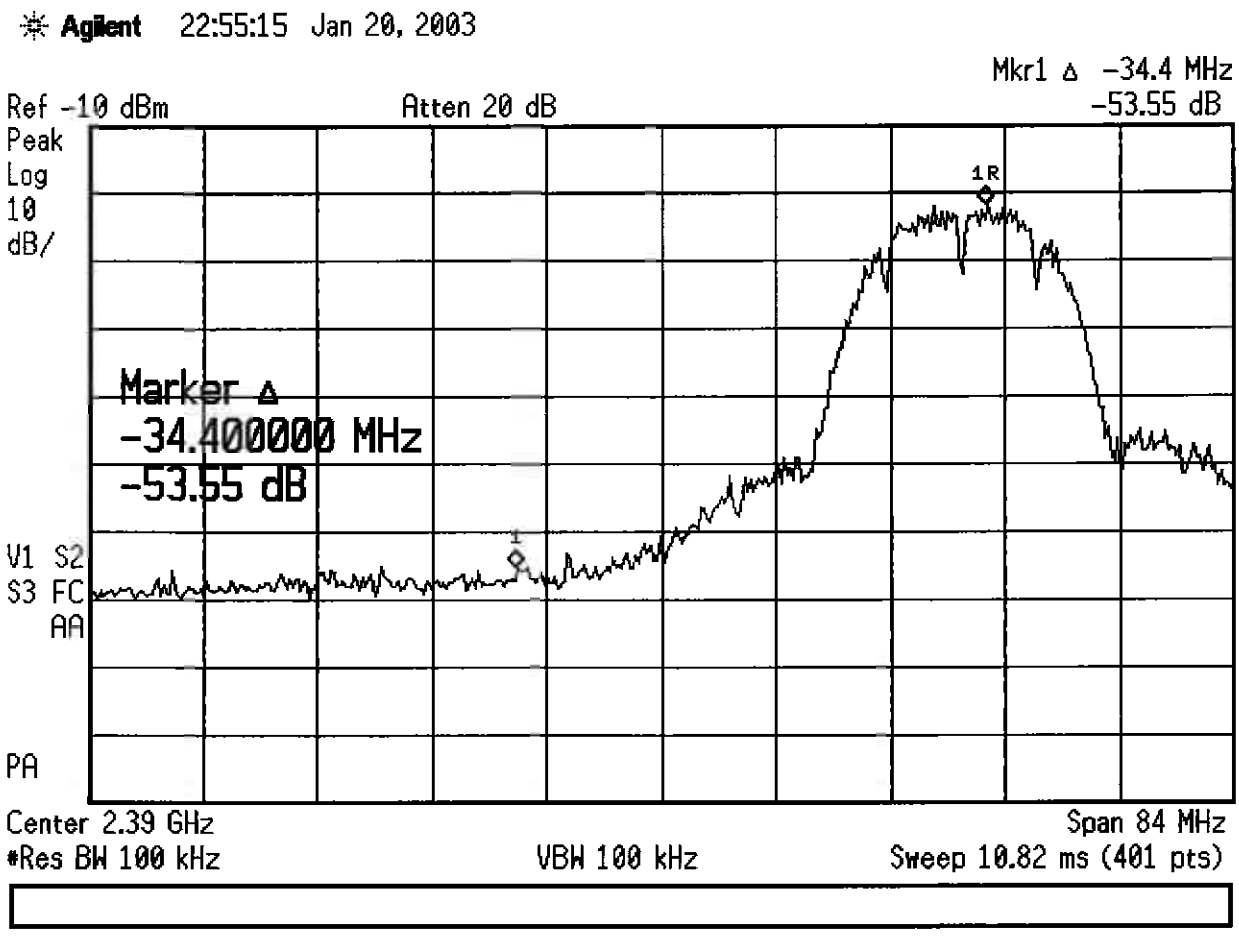
POWER SPECTRAL DENSITY
LOW CHAN



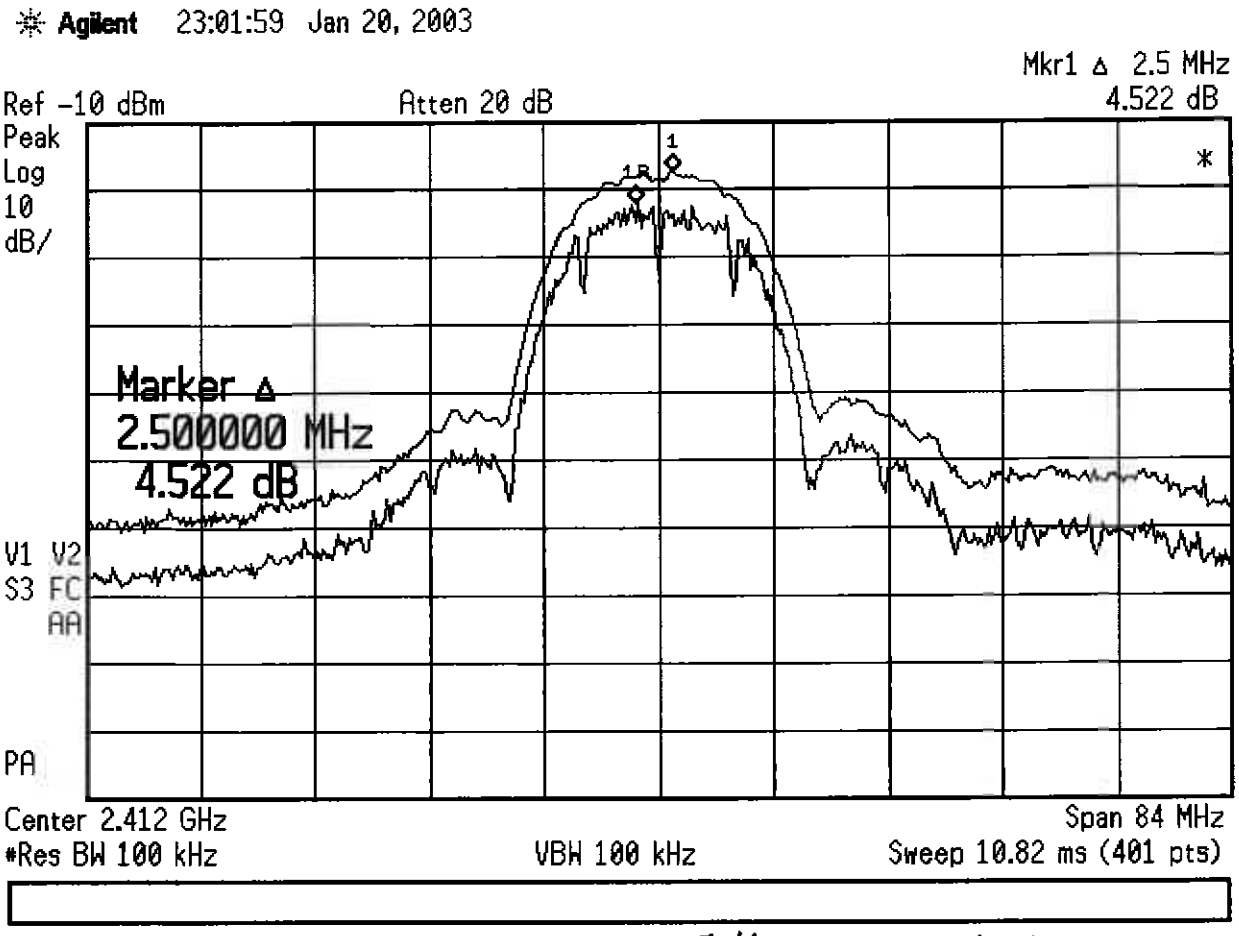
POWER SPECTRAL DENSITY
MID CHAN



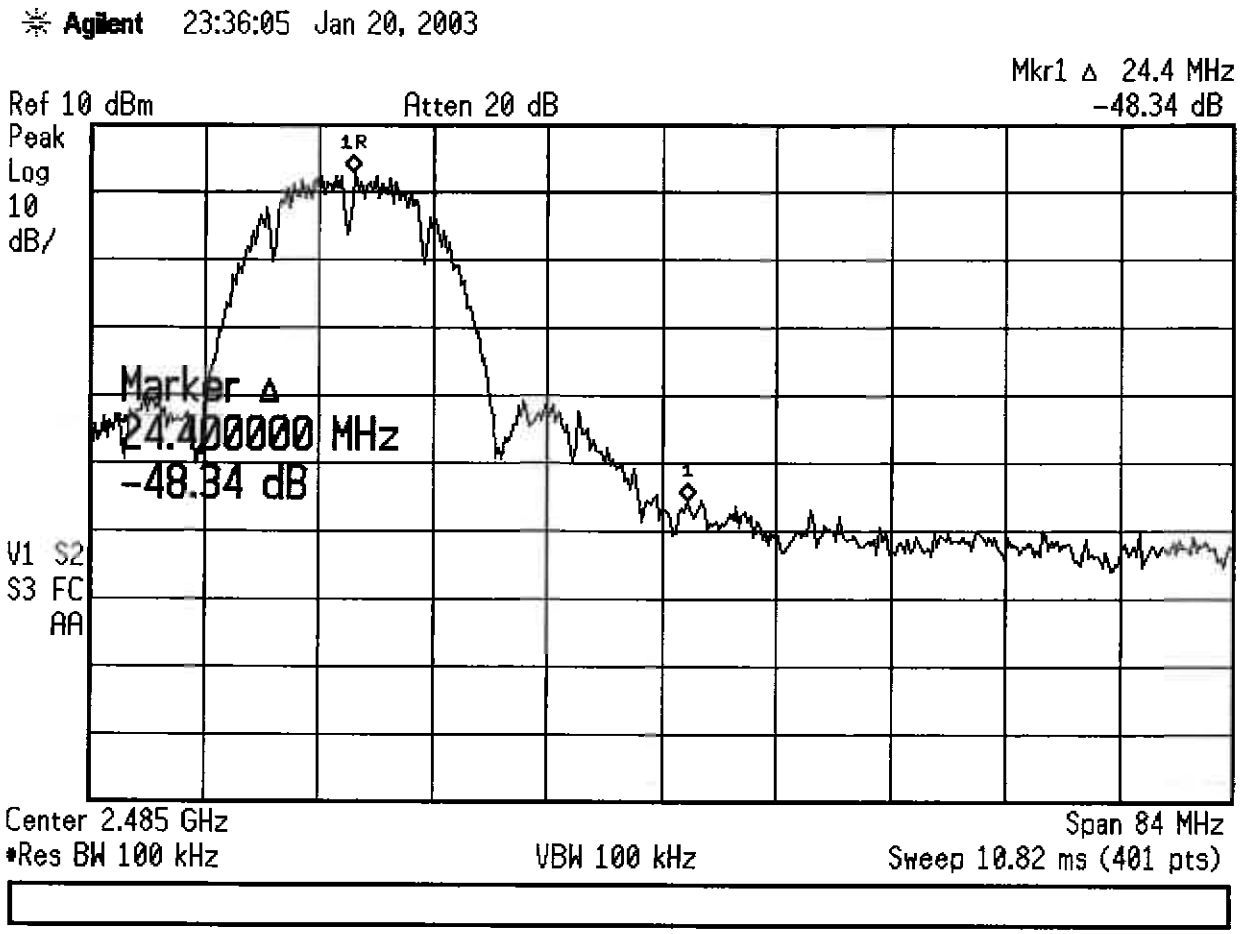
POWER SPECTRAL DENSITY
HIGH CHAN



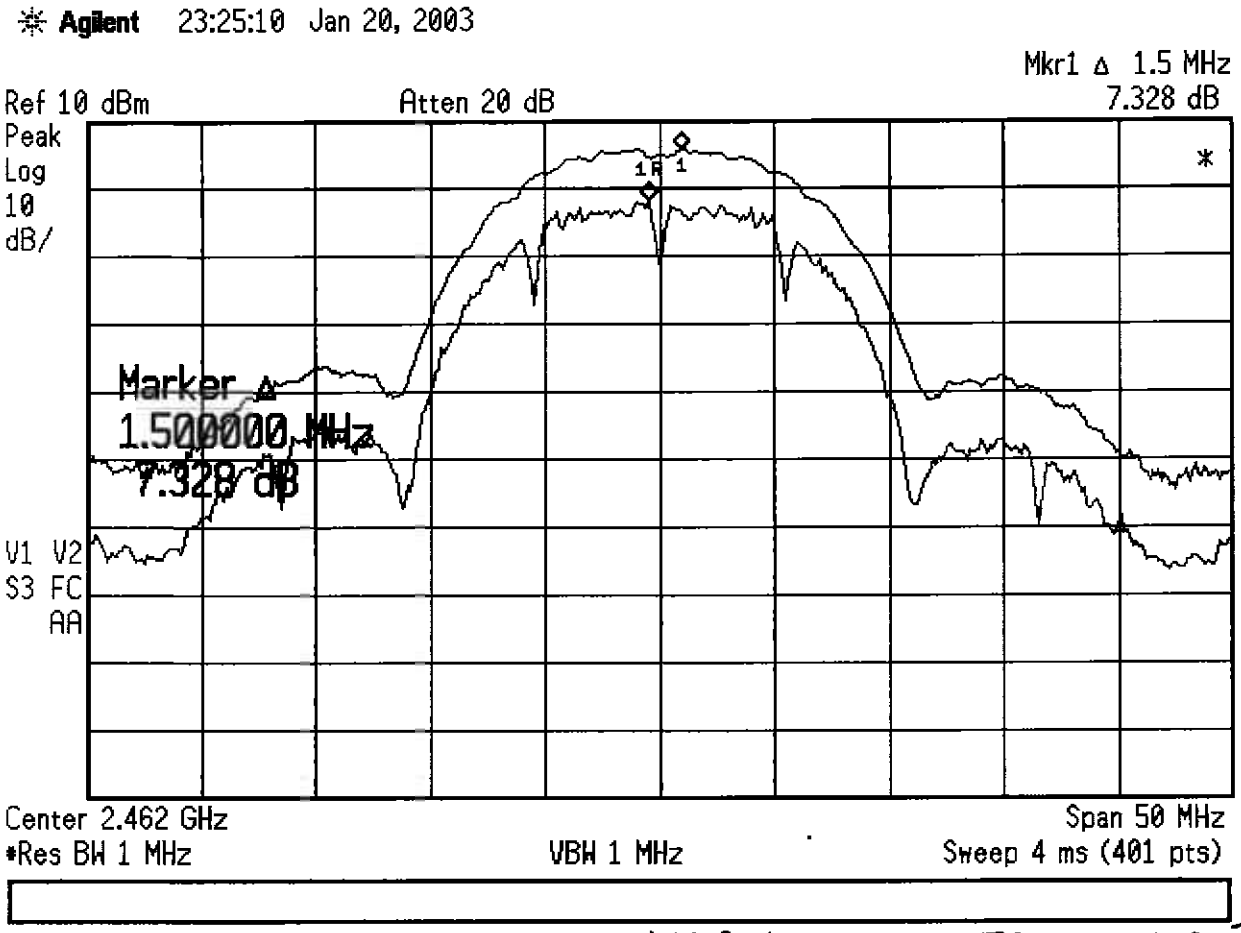
2.4 GHZ, LOW EDGE MSMT
100K/100K Δ MSMT FOR R-BAND
@ 2390



2.4GHZ, CH 1, 2412 MHZ
BW CORRECTION, 1MHZ→100KHZ



2.4 GHZ, HIGH EDGE, (2483.5)
100K/100K Δ MSMT



2.4 GHZ, HIGH BAND EDGE
1 MHZ → 100 KHZ BW CORRECTION

Elliott

EMC Test Data

Client:	Blackstorm Networks	Job Number:	J49705
Model:	Blackstorm LRAD	T-Log Number:	T49728
		Proj Eng:	Enter on cover sheet
Contact:	Pete Liu		
Spec:	FCC Part 15 B and E, RSS-210	Class:	N/A

Radiated Emissions

Test Specifics

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 1/3/2003
Test Engineer: Chris byleckie
Test Location: SVOATS #4

Config. Used:
Config Change:
EUT Voltage: 120V/60Hz

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing. All remote support equipment was located approximately 30 meters from the EUT with all I/O connections running on top of the groundplane or routed in overhead in the GR-1089 test configuration.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

Ambient Conditions:

Temperature: 16°C
Rel. Humidity: 50%

Summary of Results

Run #	Test Performed	Limit	Result	Margin
	RE, 30 - 25000 MHz - Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	
	6dB Bandwidth	15.247(a)		
	Output Power	15.247(b)		
	Power Spectral Density (PSD)	15.247(d)		
	Processing Gain	15.247(e)		Manufacturer to provide data.

Modifications Made During Testing:

Modifications are detailed under each run description.

Deviations From The Standard

No deviations were made from the requirements of the standard.

Run #1a: Radiated Spurious Emissions, 30-24120 MHz. Low Channel @ 2412 MHz

Power level set to 14

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4823.487	45.1	V	74.0	-28.9	Pk	0	1.0	
4823.862	32.3	V	54.0	-21.7	Avg	0	1.0	
12059.66	54.7	V	74.0	-19.3	Pk	0	1.0	
12059.42	41.8	V	54.0	-12.2	Avg	0	1.0	
4824.607	45.5	H	74.0	-28.5	Pk	0	1.0	
4823.415	32.3	H	54.0	-21.7	Avg	0	1.0	
12060.03	54.7	H	74.0	-19.3	Pk	0	1.0	
12059.80	41.8	H	54.0	-12.2	Avg	0	1.0	

Note 1:	For emissions in restricted bands, the limit of 15.209 was used.
Note 2:	No emission detected above 15GHz

Fundamental signal measurements (to calculate the band edge field strengths): (2.412 GHz)

Power set at 14

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2413.024	99.9	H	-	-	Pk	187	1.5	
2412.788	96.2	H	-	-	Avg	187	1.5	
2413.011	111.3	V	-	-	Pk	218	1.2	
2412.803	107.6	V	-	-	Avg	218	1.2	

Band Edge Field Strength Calculations

The levels for the 2.390GHz bandedge include the 3.7dB correction factor obtained from the fundamental level measured at RBW=1MHz and RBW=100kHz

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2390.0	50.4	h	74.0	-23.6	Pk	-	-	
2390.0	42.4	h	54.0	-11.6	Avg	-	-	
2390.0	61.8	v	74.0	-12.2	Pk	-	-	
2390.0	53.8	v	54.0	-0.2	Avg	-	-	

Run #1b: Radiated Spurious Emissions, 30-24420 MHz. Center Channel @ 2437 MHz

Power level set to 17

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4873.912	47.3	H	74.0	-26.7	Pk	262	1.2	
4873.929	38.7	H	54.0	-15.3	Avg	262	1.2	
7311.574	52.5	H	74.0	-21.5	Pk	0	1.0	
7310.806	40.7	H	54.0	-13.3	Avg	0	1.0	
12185.31	55.1	H	74.0	-18.9	Pk	0	1.0	

12185.42	41.9	H	54.0	-12.1	Avg	0	1.0	
4874.181	48.3	V	74.0	-25.7	Pk	0	1.0	
4873.972	40.3	V	54.0	-13.7	Avg	0	1.0	
7312.503	56.0	V	74.0	-18.0	Pk	111	1.0	
7312.033	45.8	V	54.0	-8.2	Avg	111	1.0	
12184.90	54.8	V	74.0	-19.2	Pk	0	1.0	
12184.77	41.9	V	54.0	-12.1	Avg	0	1.0	

Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	No emission detected above 15GHz

Run #1c: Radiated Spurious Emissions, 30-24620 MHz. High Channel @ 2462 MHz

Power level set at 14

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4924.086	48.2	V	74.0	-25.8	Pk	200	1.4	
4924.017	39.1	V	54.0	-14.9	Avg	200	1.4	
7385.328	53.9	V	74.0	-20.1	Pk	0	1.0	
7385.286	40.6	V	54.0	-13.4	Avg	0	1.0	
12309.57	54.8	V	74.0	-19.2	Pk	0	1.0	
12309.33	41.7	V	54.0	-12.3	Avg	0	1.0	
5629.35	44.8	V	92.1	-47.3	Pk	315	1.6	BW=100kHz
6334.01	46.9	V	92.1	-45.2	Pk	315	1.6	BW=100kHz
3341.00	53.2	V	92.1	-38.9	Pk	270	1.0	BW=100kHz
4924.383	45.8	H	74.0	-28.2	Pk	0	1.0	
4923.955	33.3	H	54.0	-20.7	Avg	0	1.0	
7386.216	53.0	H	74.0	-21.0	Pk	0	1.0	
7386.043	39.9	H	54.0	-14.1	Avg	0	1.0	
12310.10	54.4	H	74.0	-19.6	Pk	0	0.0	
12309.94	41.6	H	54.0	-12.4	Avg	0	0.0	

Note 1:	For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.
Note 2:	No emission detected above 15GHz

Fundamental signal measurements (to calculate the band edge field strengths): (2.462 GHz)

Power set to 14

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2460.917	112.1	V	-	-	Pk	205	1.2	
2461.172	108.8	V	-	-	Avg	205	1.2	
2463.034	101.6	H	-	-	Pk	186	1.5	
2462.873	98.4	H	-	-	Avg	186	1.5	

Band Edge Field Strength Calculations

The levels for the 2.4835GHz bandedge include the 3.7dB correction factor obtained from the fundamental level measured at RBW=1MHz and RBW=100kHz

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2483.5		v	74.0	-74.0	Pk	-	-	
2483.5	53.8	v	54.0	-0.2	Avg	-	-	

Note 1: Changing the data rate from 1 Mbit/s to 11 Mbit/s does not affect the delta between the inband and restricted band

Atheros Reference card

Fundamental signal measurements (to calculate the band edge field strengths): (2.412 GHz)

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2410.971	116.7	V	-	-	Pk	81	1.2	
2411.132	113.0	V	-	-	Avg	0	0.0	
2412.949	101.9	H	-	-	Pk	163	1.3	
2412.913	99.2	H	-	-	Avg	0	0.0	

Band Edge Field Strength Calculations

Frequency	Level	Pol	15.209 / 15.407		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
2385.3		v	74.0	-74.0	Pk	-	-	
2385.3		v	54.0	-54.0	Avg	-	-	