FCC Part 15 Subpart C

Frequency Hopping
Spread Spectrum Transmitter

Certification Test Report
(Modular Approval)

Manufacturer: Cirronet, Inc.

Model: WIT2411

FCC ID: HSW-2411M

Rules Section: 15.247(Modular Approval)

Test Begin Date: September 10, 2001

Test End Date: September 25, 2001

Report Issue Date: October 9, 2001

Test Result: PASS

Prepared by: R. Sam Wismer Engineering Manager

Table of Contents

1.0 GENERAL

1.1 Introduction

The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description

1.2.1 General

The Equipment Under Test (EUT), is the Model WIT2411 manufactured by Cirronet Inc. Located at the following address:

Cirronet Inc.
5375 Oakbrook Parkway
Norcross, GA 30093
USA

Detailed Photographs of the EUT are filed separately as appendix A.

1.2.2 Intended Use

The WIT2411 is a wide band frequency hopping spread spectrum transmitter module designed to be integrated into fixed location devices.

1.2.3 Technical Specifications

Table 1.2.3-1: Specifications

Frequency Band	2400-2483.5 MHz
Number of Channels	43
Channel Bandwidth	1.625 MHz
Channel Spacing	1.8432 MHz
Maximum User Rate	1.8432 Mbps
Output power	17 to 18dBm nominal
Operating Voltage	3.3 v
Rx Sensitivity	-87 to –90 dBm (BER 10^{-5})

1.2.4 Antennas

Table 1.2.4-1 below gives the antennas that will be employed with the WIT2411. Photographs are submitted separately as appendix B with this filing.

Table 1.2.4-1: Antennas

Mfg.	Mfg. Model No.	Antenna Type	Gain (dBi)	Connector Type	System EIRP (dBm)
Mobile Mark	0D9-2400-RN	Omni	9	N-Female	26
Mobile Mark	SCR9-2400-RN	Corner Reflector	9	N-Female	26
Ace Communication	ACE-2400NF	Omni	2	SMA-M	19
Cirronet	A-7030-0192	Patch	6	MMCX	23

2.0 LOCATION OF TEST FACILTY

All testing except for radiated spurious emissions was performed at:

ACS, Inc.
3630 Burnette Park Dr.
Suwanee, GA 30024

Radiated spurious emissions was performed in a 3 meter semi-anechoic chamber at an ACS facility located at:

ACS, Inc.(Formerly CTL)
137 Airport Road
Liberty, SC 29657

2.1 DESCRIPTION OF TEST FACILITY

All tests were conducted at an ACS facility specifically prepared for this testing. The 3 meter semi-anechoic chamber meets the Normailzed Site Attenuation (NSA) characteristics of ANSI C63.4:1992, Industry Canada RSS 212, CISPR 16 and EN 55022:1998. This site has been fully described, submitted to, and accepted by, the FCC and Industry Canada

A nonconductive remotely controlled turntable approximately 0.91m x 1.2m x 0.8m was used to measure radiated emissions from all sides of the EUT. The turntable has a center opening that allows cabling to be routed directly down to the conducting ground plane.

2.2 Radiated Emissions Testing Facility Drawing

All dimensions are in meters(m)

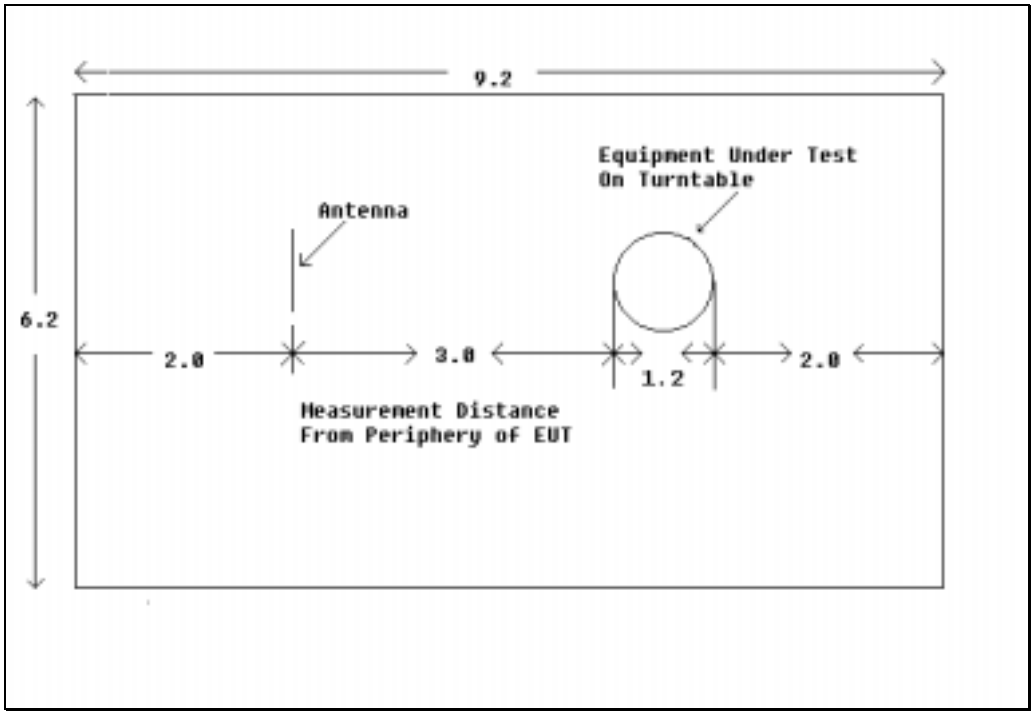


Figure 2.2-1: Semi-Anechoic Chamber Emission Test Set-up

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

1 - ANSI C63.4-1992: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz

2 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2000)

3 - FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturers specifications.

Table 4-1: Test Equipment

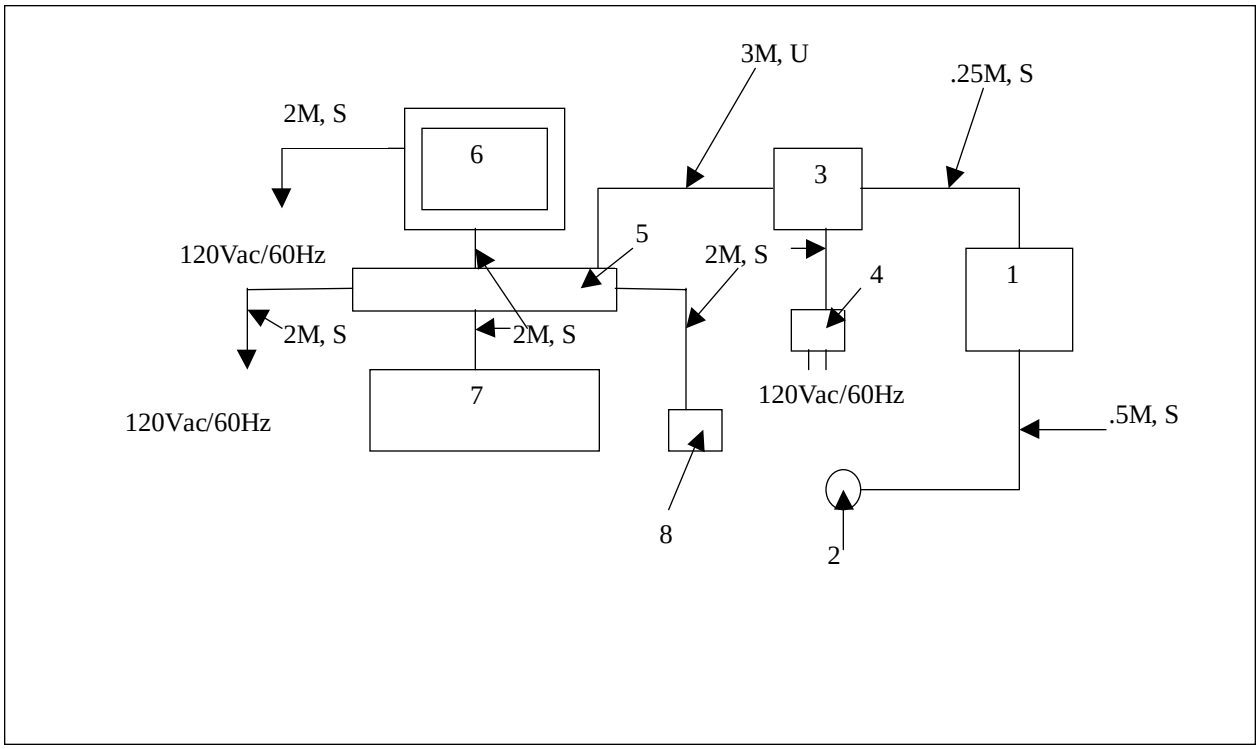
MFG Name	Item Name	Model #:	Serial #	Recal Date:
Hewlett Packard	Amp, .01-26.5 GHz	83006A	3104A00543	11/30/01
Microwave Circuits	High-Pass Filter	H3G020G2	0001 DC9853	1/27/01
	RF Cables (High Freq. Short)	None	Copper	11/17/01
	RF Cables (High Freq. Double)	7015/6986	MFR-57500	11/17/01
Chase	Bi-Log Antenna			10/20/01

5.0 SUPPORT EQUIPMENT

Table 5-3: Support Equipment

Manufacturer	Equipment Type	Model Number	Serial Number	FCC ID
AT&T GIS	Computer	7000	17-26152639	None
TVM Professional	Monitor	MD-14 I +S	None	11BMD-1452
Unknown	Mouse	M-SAS51	LZA83800046	JNZ211167
Volgen	AC/DC Converter	SPU10R-1	None	None

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM



M = Meters **S = Shielded** **U = Unshielded**

Figure 6-1: EUT Test Setup

7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement - FCC Section 15.203

To ensure compliance with 15.203, we propose attaching a reverse-sex SMA connector to the 2dBi Stub, and a reverse N to the 9dBi omni and the 9dBi corner reflector. The 6dBi patch employs the specialty MMCX connector and so is exempt.

We have arranged for the manufacturer of the stub antenna to provide reverse-sex SMA connector for this antenna. OEM customers wanting to use this antenna in their product will first need to obtain a special part number from Cirronet to give to the antenna manufacturer. The manufacturer, upon receipt of this number, will know to attach the reverse-sex SMA connector to the end of the antenna before shipping.

The customer then purchases an adapter cable from Cirronet that will connect the
MMCX port on our module to the reverse-sex connector on the antenna. No other type of commercially available antenna will attach to this reverse-sex SMA.

This same process will also be used with the 9dBi omni antenna and the corner reflector but using reverse N connectors rather than reverse SMA. Given the nonstandard nature of the interconnect between module and antenna and the difficulty involved in circumventing that connection, we believe that this procedure meets the requirements called out in 15.203.

The special Cirronet part numbers for the three antennas equipped with reverse sex connectors are listed below.

Mobile Mark 9dBi Corner Reflector	SCR9-2400-RN
ACE 2dBi Stubby	ACE-2400NF
Mobile Mark 9dBi Omni	OD9-2400-RN

7.2 Power Line Conducted Emissions - FCC Section 15.207

The EUT is powered by a proprietary power bus from the host device supplying 3.3Vdc, and has no connection to the AC Mains. Conducted emissions are not required.

7.3 Radiated Emissions - FCC Section 15.209

Radiated emissions tests were performed over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120KHz for measurements above 30MHz. Class A limits were applied and a range correction factor of 10.46dB was applied to correct for the range adjustment from 10m to 3m.

The EUT was caused to go into a "Receive Only" mode of operation for this test. Results of the test are given in Figure 7.3-1 and Table 7.3-1 below:

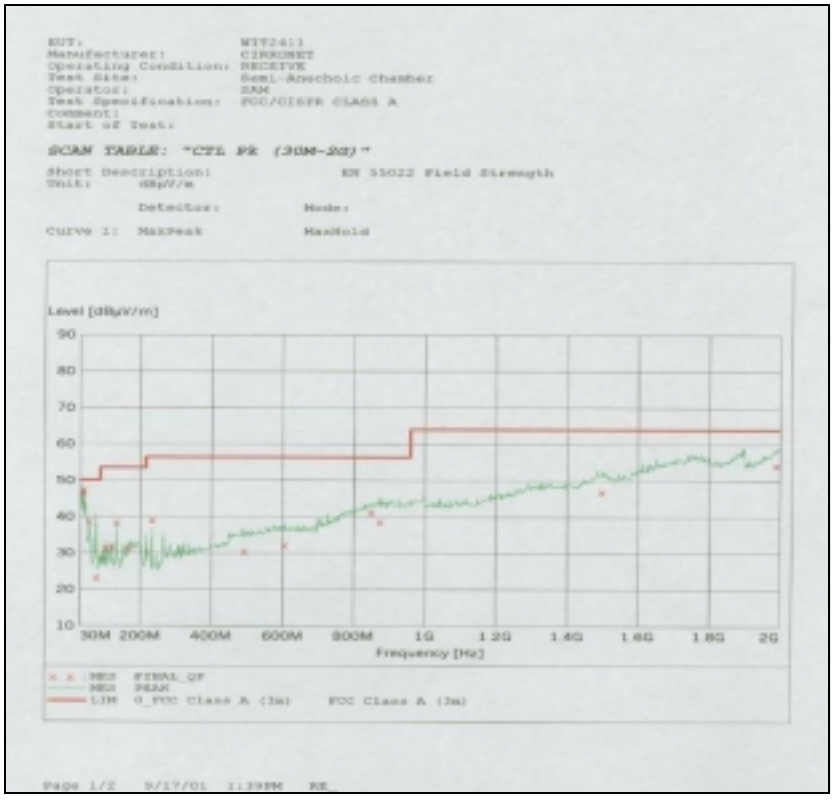


Figure 7.3-1: Radiated Emissions Graph

Table 7.3-1: Radiated Emissions Tabulated Data

MEASUREMENT RESULT: "FINAL_QP"

9/17/01 1:10PM

Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Polarisation
36.880000	46.70	17.6	50.0	3.2	103.0	90.00	VERTICAL
40.560000	47.30	15.7	50.0	2.6	101.0	304.00	VERTICAL
56.480000	38.90	8.7	50.0	11.0	107.0	226.00	VERTICAL
76.720000	23.30	9.2	50.0	26.6	100.0	215.00	VERTICAL
101.440000	31.40	12.1	53.5	22.0	175.0	283.00	HORIZONTAL
120.000000	31.90	13.7	53.5	21.5	100.0	299.00	VERTICAL
133.360000	38.60	14.6	53.5	14.8	206.0	296.00	HORIZONTAL
168.000000	31.60	13.5	53.5	21.8	225.0	79.00	HORIZONTAL
233.360000	39.20	14.5	56.4	17.1	125.0	259.00	HORIZONTAL
492.320000	30.60	23.6	56.4	25.7	275.0	335.00	VERTICAL
606.640000	32.40	25.6	56.4	23.9	100.0	200.00	VERTICAL
849.360000	41.30	30.2	56.4	15.0	356.0	263.00	HORIZONTAL
873.680000	38.80	30.1	56.4	17.5	275.0	348.00	HORIZONTAL
1498.720000	47.10	38.8	64.0	16.8	101.0	79.00	HORIZONTAL
1989.440000	54.30	47.5	64.0	9.6	225.0	325.00	VERTICAL

7.4 Peak Output Power Requirement - FCC Section 15.247(b)

The peak output power of frequency hopping systems employing less than 75 hopping channels, shall be .125 Watts (21dBm) or less.

The peak output power of the EUT was made at the antenna connector using an HP436A power meter and an HP8482H power sensor. The EUT was caused to generate a constant carrier on high, mid and low channels of the device. Table 7.4-1 below shows the results of this test.

Table 7.4-1: Peak Output Power

Low Channel 2412MHz (dBm)	Middle Channel 2442MHz (dBm)	High Channel 11 2462MHz (dBm)
16.5	16.44	16.21

7.5 Channel Usage – FCC Section 15.247(a)(1)(iii)

Frequency hopping systems in the 2400–2483.5 MHz band may utilize hopping channels whose 20 dB Bandwidth is greater than 1 MHz provided the systems use at least 15 non-overlapping channels. The total span of hopping channels shall be at least 75 MHz. The average time on any one channel shall not be greater than .4 seconds within the time period to hop through the channels.

7.5.1 20dB Bandwidth

For the 20dB bandwidth test, the EUT was caused to generate a continuous carrier on the high, middle and low channels. Tabulated data is shown below in table 7.5.1-1 and a plot of the worst case is shown in figure 3 below. The plot is of the low channel(2402 MHz).

Table 7.5.1-1: 20dB Bandwidth

Low Channel 2402MHz (MHz)	Middle Channel 2440MHz (MHz)	High Channel 2480MHz (MHz)
1.650	1.642	1.625

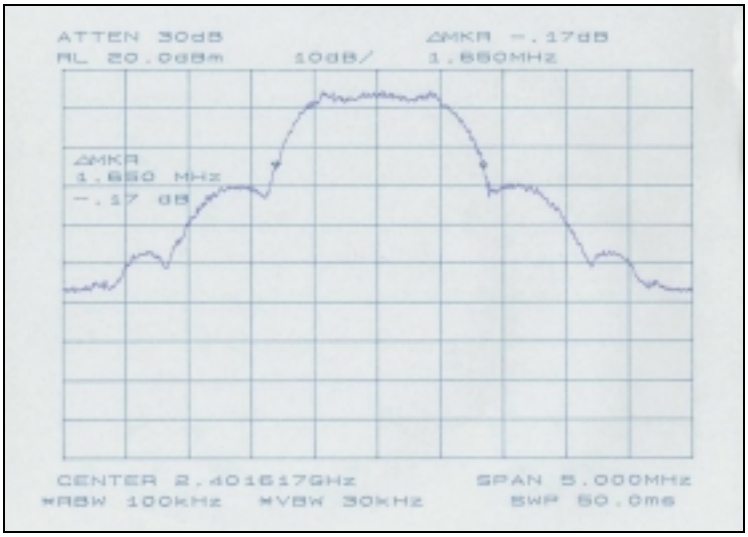


Figure 7.5.1-1: Worst Case 20dB Bandwidth

7.5.2 Hopping Channels

The EUT employs 43 non-overlapping channels as shown in Figure 7.5.2-1 below. The total span of the hopping channels is 75MHz.

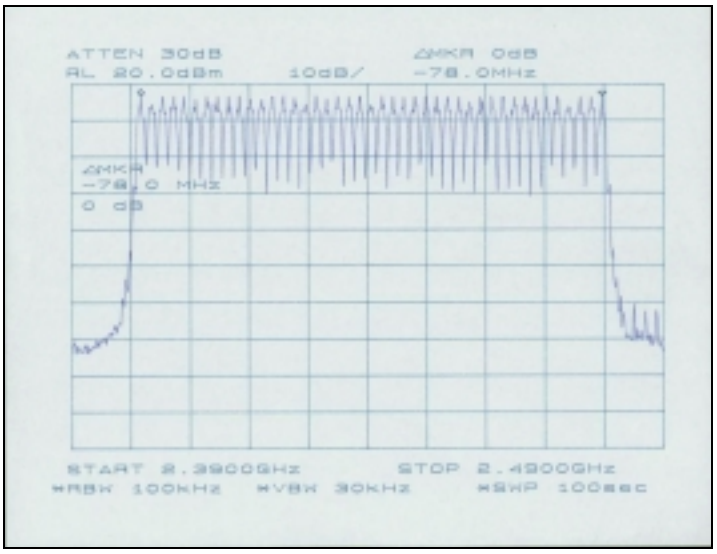


Figure 7.5.2-1: Hopping Channels

7.5.3 Adjacent Channel Spacing

Figure 7.5.3-1 below shows the adjacent channels are non-overlapping at their 20dB points:

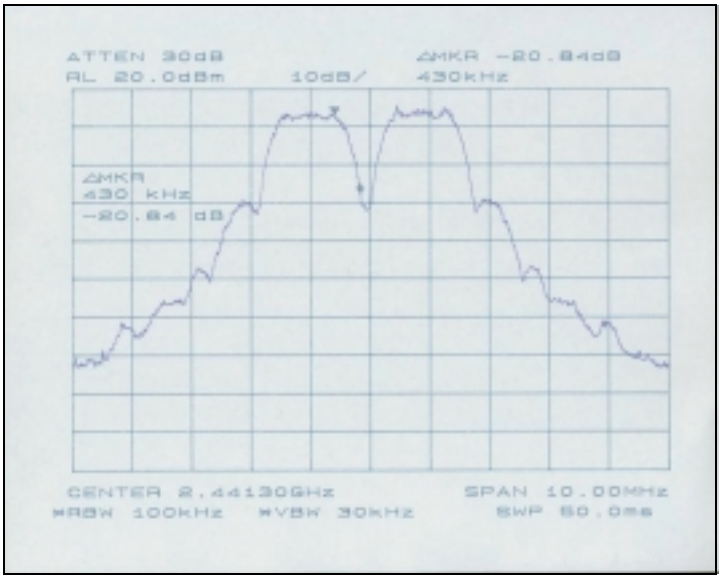


Figure 7.5.3-1: Adjacent Channel Spacing

7.5.4 Channel Dwell Time

In the worst case operation, the EUT will operate for 30mS out of any 100mS duration. The transmitter is designed to transmit for 17mS and to receive for 13mS, then according to the pseudo random hopping pattern, the EUT will then change to a new channel and repeat the transmission. The EUT will never transmit more than once on any channel in any 100mS period.

7.6 Spurious Emissions - FCC Section 15.247(c)

7.6.1 RF Conducted Spurious Emissions

The EUT was investigated for conducted spurious emissions from 30MHz to 25GHz, 10 times the highest fundamental frequency. For each measurement, the spectrum analyzer's VBW was set to 100kHz and the RBW was set to 1MHz.

The RF conducted spurious emissions found in the band of 30MHz to 25GHz are reported in Table 7.6.1-1 below. Each emission was compared to the fundamental reference level, also reported in the table below, to determine if they were at least 20dB below the reference level. Plots of the emissions were taken and filed separately as Appendix C.

Table 7.6.1-1: Conducted Spurious Emissions

Channel	Fundamental Frequency (MHz)	Fundamental Reference Level (From Section 7.4) (dBm)	Frequency of Spurious Emissions (GHz)	Level (dBm)	Δ(dB)
Low	2402	16.50	2.3621	-42.01	-58.51
			4.7951	-33.09	49.59
			7.0530	-37.0	53.5
			11.570	-42.0	58.5
Mid	2440	16.44	1.2470	-40.23	-56.67
			4.8625	-31.09	-47.53
			7.1195	-42.5	-58.94
			9.3765	-41.5	-57.94
High	2480	16.21	2.2322	-40.74	-56.95
			4.9890	-41.5	-57.71
			12.4109	-39.42	-55.63

7.6.2 Radiated Spurious Emissions(Restricted Bands) - FCC Section 15.205

7.6.2.1 Test Procedure

Radiated emissions tests were made over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency on each antenna given in section 1.2.3.

The receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. The spectrum analyzer's resolution bandwidth was set to 1MHz and the video bandwidth set to 10Hz for average measurements.

The EUT was caused to generate a constant carrier on the high, mid and low channels of operation.

7.6.2.2 Duty Cycle Correction Factor

In the worst case operation, the EUT will operate for 30mS out of any 100mS duration. The transmitter is designed to transmit for 17mS and to receive for 13mS, then according to the pseudo random hopping pattern, the EUT will then change to a new channel and repeat the transmission. The EUT will never transmit more than once on any channel in any 100mS period.

Therefore the duty cycle of the EUT is 17% giving a correction factor of 15.4dB. The correction factor is figured using the formula 20*log(.17). The measurements reported in tables 7-1 through 7-4 have been reduced by 15.4dB to account for the duty cycle as described above.

7.6.2.3 Correction Factors and Sample Calculations

AF = Antenna Factor
CA = Cable Attenuation
AG = Amplifier Gain
RC = Range Correction
DC = Duty Cycle

If used, range Correction is determined using the formula 20Log(D1/D2), where D1 is the specified distance used and D2 is actual distance used to make measurements = [20Log(3/1)] = 9.54 dB

Duty Cycle correction is determined using the formula 20log(Duty Cycle).

Therefore:
CF_T = Total Correction Factor = AF+CA-AG-DC

Note that it was not necessary to apply a range correction during this procedure since spurious emissions were detectable at the specified distance of 3 meters.

Sample Calculations
Corrected Level(dBm) = RL+ CF_T
Conversion from dBm to uV/m = Antilog(dBm + 107)/20)

7.6.2.4 Test Results

Detectable points are reported below in tables Table 7.6.2.4-1 through Table 7.6.2.4-4. Plots of each significant signal were taken and were filed separately as appendix D.

Table 7.6.2.4-1: Ace Communications 2dBi Omni

Channel	Frequency (MHz)	Antenna Polarity	Detector (P/A)	Level (dBm)	Correction Factors (dB)	Corrected Level (dBm)	Corrected Level (uV/m)	Margin (uV)	Final Result (Pass/Fail)
Low: 2402MHz	4804	V	A	-72.41	17.23	-70.58	66.19	433.81	PASS
	7203	V	A	-74.60	24.08	-65.92	113.25	386.75	PASS
	9605	V	A	-83.36	25.80	-72.96	50.37	449.63	PASS
	12001	H	A	-85.21	29.47	-71.14	62.12	437.88	PASS
Mid: 2440MHz	4881	V	A	-67.41	17.41	-65.40	120.25	379.75	PASS
	7322	V	A	-82.21	23.96	-73.65	46.53	453.47	PASS
	9762	V	A	-83.66	25.62	-73.44	47.62	452.38	PASS
High: 2480MHz	4957	V	A	-71.65	17.60	-69.45	75.39	424.61	PASS
	7438	V	A	-78.58	23.85	-70.13	69.75	430.25	PASS
	9916	H	A	-84.78	25.43	-74.75	40.98	459.02	PASS

Table 7.6.2.4-2: Cirronet 6dBi Patch

Channel	Frequency (MHz)	Antenna Polarity	Detector (P/A)	Level (dBm)	Correction Factors (dB)	Corrected Level (dBm)	Corrected Level (uV/m)	Margin (uV)	Final Result (Pass/Fail)
Low: 2402MHz	4802	V	A	-71.35	17.22	-69.53	74.74	425.26	PASS
	7204	v	A	-74.65	24.08	-65.97	112.59	387.41	PASS
	9605	h	A	-84.22	25.80	-73.82	45.62	454.38	PASS
Mid: 2440MHz	4881	v	A	-72.16	17.41	-70.15	69.60	430.40	PASS
	7319	v	A	-83.36	23.97	-74.79	40.77	459.23	PASS
	9764	h	A	-84.27	25.61	-74.06	44.38	455.62	PASS
High: 2480MHz	4958	v	A	-81.27	17.60	-79.07	24.91	475.09	PASS
	7436	v	A	-83.08	23.85	-74.63	41.56	458.44	PASS
	9917	v	A	-82.29	25.43	-72.26	54.57	445.43	PASS
	12400	h	A	-84.32	31.12	-68.60	83.16	416.84	PASS

Table 7.6.2.4-3: Mobile Mark 9dBi Omni

Channel	Frequency (MHz)	Antenna Polarity	Detector (P/A)	Level (dBm)	Correction Factors (dB)	Corrected Level (dBm)	Corrected Level (uV/m)	Margin (uV)	Final Result (Pass/Fail)
Low: 2402MHz	4802	v	a	-68.50	17.22	-66.68	103.76	396.24	PASS
	7206	h	a	-79.5	24.08	-70.82	64.40	435.60	PASS
	9608	v	a	-82.54	25.80	-72.14	55.34	444.66	PASS
	12009	h	a	-85.29	29.51	-71.18	61.78	438.22	PASS
Mid: 2440MHz	4881	v	a	-72.36	17.41	-70.35	68.01	431.99	PASS
	7319	v	a	-80.28	23.97	-71.71	58.13	441.87	PASS
	7319	h	a	-82.52	23.97	-73.95	44.91	455.09	PASS
	9768	h	a	-84.14	25.61	-73.93	45.02	454.98	PASS
High: 2480MHz	4957	v	a	-68.93	17.60	-66.73	103.11	396.89	PASS
	7480	v	a	-81.76	23.81	-73.35	48.14	451.86	PASS

Table 7.6.2.4-1: Mobile Mark 9dBi Corner Reflector

Channel	Frequency (MHz)	Antenna Polarity	Detector (P/A)	Level (dBm)	Correction Factors (dB)	Corrected Level (dBm)	Corrected Level (uV/m)	Margin (uV)	Final Result (Pass/Fail)
Low: 2402MHz	4803	v	a	-70.03	17.22	-68.21	87.03	412.97	PASS
	7203	v	a	-80.69	24.08	-72.01	56.18	443.82	PASS
	9605	h	a	-74.55	25.80	-64.15	138.90	361.10	PASS
	12006	h	a	-84.14	29.49	-70.05	70.43	429.57	PASS
	14406	h	a	-82.42	32.43	-65.39	120.37	379.63	PASS
Mid: 2440MHz	4879	v	a	-65.86	17.41	-63.85	143.67	356.33	PASS

	7321	h	a	-76.42	23.97	-67.85	90.63	409.37	**PASS**
	9768	v	a	-84.14	25.61	-73.93	45.02	454.98	**PASS**
High: 2480MHz	**4958**	v	a	-67.26	17.60	-65.06	125.00	375.00	**PASS**
	7436	h	a	-81.71	23.85	-73.26	48.66	451.34	**PASS**
	9918	v	a	-84.78	25.43	-74.75	40.97	459.03	**PASS**

8.0 RF EXPOSURE SECTION 15.247(b)(4)

The EUT is a module designed for integration into fixed location devices only. In accordance with FCC rules, the antennas of these devices will be located at a distance greater than 20cm for the user or the general population. Due to the intended use of this device, it was determined SAR evaluation is not required.

9.0 CONCLUSION

In the opinion of ACS, Inc. the WIT2411 frequency hopping spread spectrum module, manufactured by Cirronet, Inc., meets the requirements of FCC Part 15 subpart C.