Metricom, Inc.
980 University Avenue
Los Gatos, CA, 93030
(Tel)408-399-8200
(Fax) 408-354-1024

Part 15 Certification Application for FCC ID 21100

EMI Test Report and Technical Documentation on Alps, Inc. Wireless Modem for use on the Metricom MCDN Network

Prepared by:

Metricom, Inc
980 University Ave.
Los Gatos, CA 95032

Test date(s): June 1999

1.0 Verification of Compliance

Description:	Ricochet GS Wireless Modem
Model Number:	21100
Serial Number(s):	Pre-Production Models
Applicant:	Metricom Inc.
Type of Test:	FCC part 15.247 Application for Part 15 Certification under GNW 21100
Date(s) of test:	June 1999
Tested By	David Waitt (Metricom, Los Gatos) Electronic Compliance Laboratories. (EC Labs)

The above equipment was tested by Metricom Inc. and EC Labs and found to be in compliance with the requirements set forth in Part 15 of the FCC Rules and Regulations.

David Waitt
Engineer
Metricom, Inc.

2.0 General Information

Applicant:	Metricom, Inc 980 University Ave Los Gatos, CA 95032
Contact Person	David Waitt
Equipment Under Test:	Ricochet GS Wireless Modem
Model Number:	21100
Serial Number(s):	Pre-Production models
Manufacturer:	Alps, Inc.
Type of Test:	FCC Part 15.247 Certification, FCC ID GNW-21020

Reason for testing: Alps has developed, for Metricom, Inc. a new version of the Ricochet Wireless modem. It is similar in general functionality to the current Ricochet Wireless modem (FCC GNW 21062). The Ricochet Wireless modem operates on Metricom's MCDN wireless network. The modem will be sold or rented to subscribers of Metricom's Ricochet service. The Ricochet service allows subscribers to send / receive email, connect to the Internet, ect. without the necessity of a telephone line.

The Ricochet GS modem (Model 21100) is a frequency hopping spread spectrum radio-modem that operates within the 902-928 MHz band. The modem transmits and receives digital packet data. The transmit power of the modem is 1 Watt. The modems are capable of communicating with MCDN radios that make up the MCDN network or other modems. A technical overview of the MCDN network is contained in the Appendix.

The new GS Ricochet modem is similar to the current Ricochet modem. The most notable differences are:

Modulation: The new modem employs a number of possible modulations. However, in normal operation, pi/4 DPSK modulation will be used currently. This allows for faster data transfer between the modem and the MCDN network radios

3.0 Results Summary

Summary: Since this is a new certification request, a complete set of tests demonstrating compliance with FCC Part 15.247 was conducted. Compliance with the following Part 15 regulations was verified:

Paragraph	Test	Results
15.247(b)	Maximum Power Output at Antenna Terminals	+ 29.23dBm Max
15.247(a)(1)(i)	Minimum Number of Hopping Channels	50 Demonstrated 50 (Actual)
15.247(a)(1)	Channel Frequency Separation	160 kHz (by design)
15.247(a)(1)	Average Channel Occupancy Time	194 ms / 20 Sec Avg.
15.247(c)	Out of Band Conducted Emissions Out of Band Conducted Emissions (1 – 10 GHz)	- 20.2 dB @ band edge -72dBm @ 1.8 GHz
15.247(c)	Out of Band Radiated Emissions	9.6 dB in spec, min
15.205	Radiated Emissions in Restricted bands	1.7 dB in spec, min
15.109	Class B Unintentional Radiated Emissions	9.6 dB in spec, min

4.0 Test Facilities

The following tests:

15.247(c) Out of Band Radiated Emissions
15.205 Radiated Emissions in Restricted bands
15.207 AC Line Conducted Emissions

were conducted at:

Electronic Compliance Laboratories (**)
1249 Birchwood Drive
Sunnyvale, CA. 94089

The remaining tests described in this report were performed at:

Metricom, Inc.
980 University Ave
Los Gatos, CA. 95030

(**)
A description of the sites located at EC Labs is on file at:

Federal Communications Commission
PO 429
Columbia, MD. 21045

All of the sites at EC Labs are constructed and calibrated to meet ANSI C63.4-1994 requirements.

5.0 Test Equipment & General Test Methods

Equipment:
The following test equipment was used to perform the testing

Item	Desc.	Manufacturer	Model	S/N
1.	EMI Receiver	HP	8546A	3325A00137
2.	Pre Amp	HP	8449B	3008A00527
3.	LISN	EM	ANS-25/2	2532
4.	Plotter	HP	7470A	2644V00365
5.	20 dB Pad	HP	NA	Not Req'd
6.	Spectrum Analyzer	HP	8563A	137A01183
7.	2.0 - 4.0 GHz HPF	Laboratory Grade		NA
8.	4.0 - 10 GHz HPF	Laboratory Grade		NA
9.	Diagnostic Software	Metricom	DALEC	---------
10.	Spectrum Analyzer	HP	8563E	3450A2982

HP = Hewlett Packard EM = ElectroMetrics
** = Response Plots on file at EC Labs

Methods:

Many of the tests are performed at the low, middle and the high portion of the 902 - 928 MHz band. These tests are typically performed on the following channels / frequencies:

Channel	Frequency (MHz)
0	902.08
75	914.08
161	927.84

These are referred to as the "Standard Test Channels". For a complete table of Channel Vs. Frequency, see Appendix B.

Many of the tests required that the UUT be operated in modes that are not possible with the normal operating software. In these cases, the UUT was operating on special Diagnostic Software. There are also cases where the UUT has to operate normally, however some special instructions must be sent to the UUT. This is referred to operating the UUT in Diagnostic Mode.

The tests below are performed using the basic test setup shown in Fig 1. The only difference between several of the tests is the mode that the UUT is being operated in or the software that the UUT is operating from.

Paragraph	Test
15.247(a)(1)(i)	Minimum Number of Hopping Channels
15.247(a)(1)	Channel Frequency Separation
15.247(c)	Out of Band Conducted Emissions

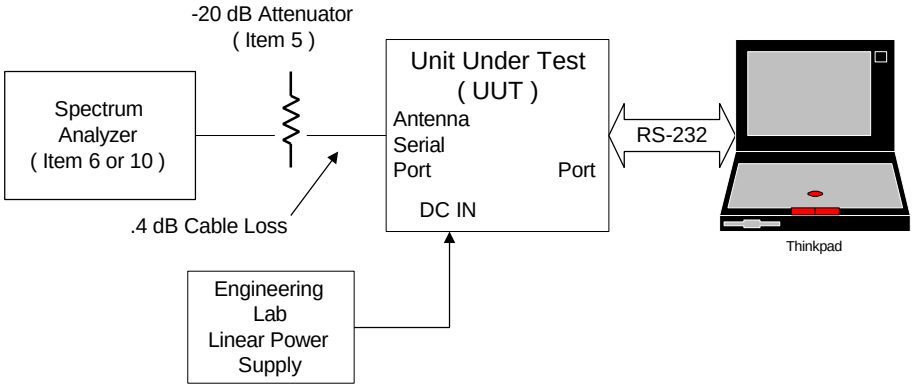

Figure 1. Basic Test Setup

6.0 Test Results

Maximum Power Output at Antenna Terminals Paragraph: 15.247(b)

Specification:

The maximum peak output power shall not exceed 1 watt. If the gain of the antenna that is connected to the system is greater than 6 dBi, then the RF power at the antenna terminal must be reduced such that the Effective Isotropic Radiated Power (EIRP) is +36 dBm or less.

Procedure:

The UUT was configured to run on the Diagnostic Software (Item 9) and the hopping function was disabled. The test was configured as spown in Fig 1. The power was then read directly from the spectrum analyzer

Result:

The following power levels were measured on the standard test channels:

Freq. (MHz)	Level (dBm)	Level (Watts)
902.08	28.77	.753
914.08	28.91	.788
927.84	29.23	.837

Minimum Number of Hopping Channels Paragraph: 15.247(a)(1)(i)

Specification:

The unit must utilize a minimum of 50 hopping channels within the 902 - 928 MHz band.

Procedure:

The UUT was placed in diagnostic mode. The basic test setup shown in Figure 1 was used. The analyzer was set to sweep over a small portion of the 902 - 928 MHz band, (i.e.: 902 - 912 MHz), and wide resolution bandwidth was chosen to allow a fast sweep. The analyzer is set to MAX HOLD.

The UUT was commanded to transmit for 1 sec on each of the “up-link” channels that it would use in normal operation. With the analyzer on MAX HOLD, each of these channels was recorded.

Results:

The number of channels were demonstrated in the following bands.

Band (MHz)	Number of channels demonstrated in band
902 – 912	21
912 - 928	29
Total 902 - 928	50

Plots showing the results of the test are contained in appendix A,

Average Channel Occupancy Time

FCC Specification: **Paragraph 15.247(a)(1)(I) and (ii)**

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Industrie Canada Specification: **Paragraph 6.2.2.(o)(a)(1)**

The average time occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Procedure:

The test was configured as shown below. The units were configured to perform a “Z Modem” file transfer of a 10 MB file. The number of times each channel was used during the transfer was obtained from the modem using a special diagnostic command. The average number of hits per channel was calculated with Excel.

The spectrum analyzer was used to measure the duration of transmissions. This is the time required to transmit one packet. With this information and the average number of hits per channel and the total time required for the file transfer to take place, the total time on channel can be calculated.

The file was transferred in the following directions.

```
Modem to Ethernet Radio                 900 MHz
Modem to MCDN Network Radio             900 MHz
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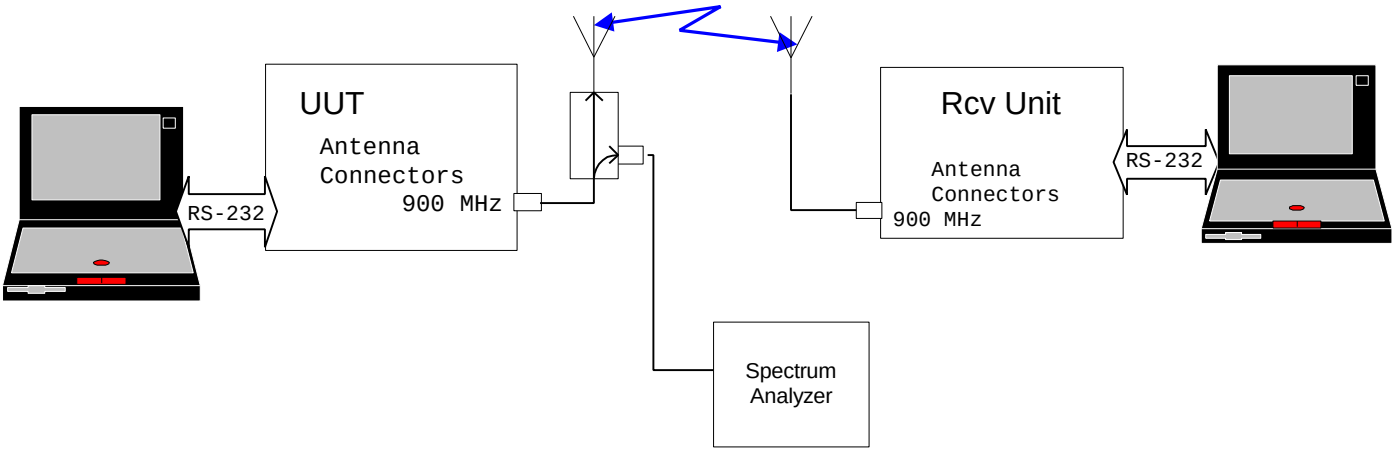


Time on Channel Test Setup

Results:

The following data was gathered:

```
Total time required to transfer the file in seconds
Average number of hits per channel
Time of each transmission in seconds
```

The test results were calculated using the following formula

$$\frac{\left(\text{Avg Transmissions per channel} \times \text{Time per transmission}\right)}{\left(\frac{\text{Total file transfer time}}{\text{Spec Window (Sec)}}\right)} = \frac{\text{Total time on channel}}{\text{Qty of "Spec Windows"}} = \text{Time on Channel per "spec" Sec.}$$

The results are presented in the table below. Plots showing the time of a given transmission are presented in the appendix.

From...	To ...	Avg hits/ channel/file Xsfer	Total File Xsfer Time(s)	Time/ xmission (ms)	Avg Time/ Channel "window" (ms)	Spec
Modem	Ethernet Radio	185	914.66	0.0467	0.189	.4s/20s
Modem	Network Radio	191	918.67	0.0467	0.194	.4s/20s

Channel Frequency Separation **Paragraph 15.247(a)(1)**

Specification:

Frequency hopping systems shall have a hopping channel separation of a minimum of 25 kHz *or* the 20 dB bandwidth of the hopping channel, whichever is greater. In the case of the Ricochet wireless network, the 20 dB bandwidth specification applies.

Procedure:

The channels that the Ricochet network operates on are evenly spaced within the 902.08 to 927.84 MHz band, and there are 50 transmit channels. Most of these channels are spaced at 320 kHz, however some of the channels are spaced at 160 kHz, therefore the 20 dB bandwidth must be less than 160 kHz.

Test Channel	Modulation	20 dB BW kHz
LOW	2FSK	134.0
LOW	4FSK	157.0
LOW	pi/4 DPSK	158.8
MID	2FSK	134.0
MID	4FSK	159.0
MID	pi/4 DPSK	160.0
HIGH	2FSK	134.0
HIGH	4FSK	159.0
HIGH	pi/4 DPSK	158.8

The test was configured as shown in Figure 1 and performed on the standard test channels. The UUT was running the diagnostic software and set to transmit random data at the highest possible data rate on one of the standard test channels. The spectrum analyzer was set to a resolution bandwidth as close as possible to 1/10 the 20 dB bandwidth (based on design knowledge) of the transmitted signal. This resulted in a resolution bandwidth setting of 10 kHz. The video bandwidth was also set to 10 kHz. The bandwidth of each of the modulations that will be used was measured. The results are contained in the table. The plots are contained in appendix A.

Radiated Emissions in Restricted Bands **Paragraph 15.205**

Specification:

Any emission falling within one of the restricted bands specified in 15.205 shall be below the limits specified in 15.209.

Procedure:

This test was conducted on a 3 meter open air test site at EC Labs. The unit was placed on a rotatable wooden table 1 meter 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 standard test channels. The UUT was running diagnostic software and set to transmit CW at maximum power on Channel 0. The test equipment was configured as shown in figure 2. The harmonics of the fundamental that fell in 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.

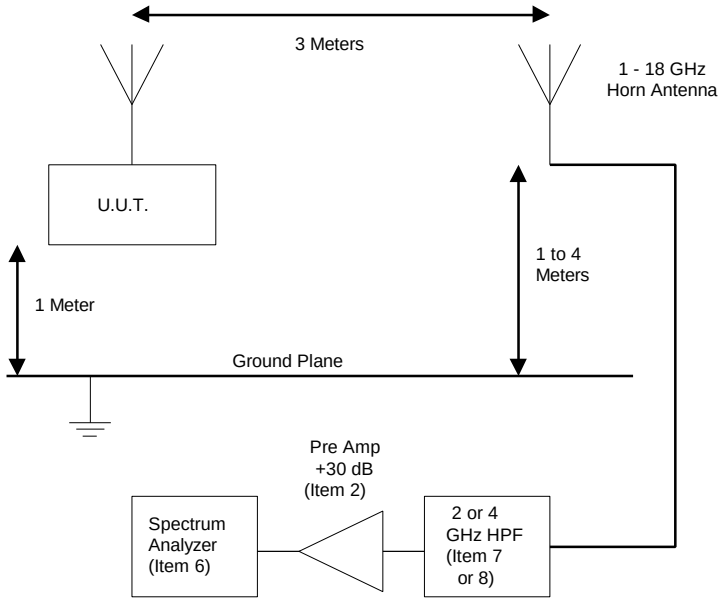
The UUT was rotated 360 degrees and the height of the antenna adjusted from 1 to 4 meters above the ground plane to determine the maximum level of the emission. The level of the harmonic emission is measured in two modes, "Peak" and "Average" . The spectrum analyzer reading was entered into a spread sheet where correction factors (antenna factor, cable loss, pre-amplifier gain, HPF loss...) were then applied by EC Lab's Software to obtain a final corrected measurement..

Once all the harmonics that fall in a restricted band (up to the 10th harmonic) have been examined for channel 0, the test is repeated for the remaining two standard test channels.

CHAN	HARMONICS							
(MHz)	3	4	5	6	7	8	9	10
902.24	2706.24	3608.32	4510.40	5412.48	X	X	8118.72	9020.80
914.08	2742.24	3656.32	4570.40	x	x	7312.64	8226.72	9140.80
927.84	2783.52	3711.36	4639.20	x	x	7422.72	8350.56	x

Table 1: 15.205 Harmonic test table

NOTE: X means that this harmonic does NOT fall within a restricted band, it is therefore subject to the limits of 15.209, NOT 15.205



Radiated Emissions in Restricted Bands Test Setup

Results:

There were some harmonic emissions detected during the test. In many cases the resolution bandwidth and the video bandwidth were reduced well below what is required of the specifications in an attempt to find the actual level of the emission. In the case of the "PEAK" measurement the RBW and VBW were always set to 1 MHz. The "AVG" test was conducted with the RBW and VBW set to 10 kHz maximum. There were some cases where an emission was not visible using these 10k/10k bandwidth settings and the bandwidths were set to 1 kHz In an effort to determine if an emission was present. In some cases, even with these lower bandwidths, there was no emission detected. in the N.F. (Noise Floor) column of the data sheet.

The worst case emission was 1.6 dB below the limit. This was at the 10^{th} harmonic of 914.08 MHz. The data sheet showing the emission levels that were measured is contained in appendix A.

Out of Band Emissions **Paragraph 15.247(c)**

OVERVIEW

Two tests were performed to demonstrate compliance with the 15.247(c) specification. The first test was performed as a conducted test using the Basic Test Setup shown in Figure 1. Only the "edges" of the 902 to 928 MHz band are examined since these are expected to be the worst case frequencies. (The two points where the in-band UUT signal is most likely to "spill" out of the 902 to 928 MHz band)

The second test is performed as a conducted test that examines the band from 1 GHz to 10 GHz. In this etst the unit is in diagnostic mode and configured to transmit CW in the middle of the band. In the case of a Ricochet

compatible device, the limits set forth in 15.209 are not relevant to the test (for spurs produced from modulation products of the spreading sequence, the information sequence and the carrier frequency, NOT falling in a restricted band) since the transmit power of the modem is about 1 Watt, the -20 dB rule will be the governing limit.

Spec:

In any 100 kHz band outside the 902 - 928 MHz the total amount of RF power produced by the modulation products of the spreading sequence, the information sequence and the carrier frequency, shall be less than 20 dB below the total power in any 100 kHz band within the 902 - 928 MHz band or shall not exceed the general levels specified in 15.209(a) whichever results in the lesser attenuation.

Test 1 Procedure (Conducted, Band Edge):

The spectrum analyzer was set to a 10 kHz RBW and a VBW of 10 kHz (The same settings used to measure the Occupied Bandwidth). The UUT was running the Diagnostic Software and is set to on channel 161 (927.84 MHz). The sweep was set to 927 - 928 MHz. A peak search was done with the marker and then a delta measurement was made to insure that the signal level was at least -20 dBC at 928.0 MHz for each of the modulations that may be used.

The test was then repeated with the sweep set to 902 - 903 MHz and the UUT set to transmit on the lowest channel (902.08 MHz).

Test 1 Result (Conducted, Band Edge):

The results are shown in the table to the right. The plots are contained in Appendix A.

900 MHz Band Edge	Modulation	-dBc @ Band Edge
LOW	2FSK	43.0
LOW	4FSK	39.5
LOW	pi/4 DPSK	21.8
HIGH	2FSK	41.1
HIGH	4FSK	40.2
HIGH	pi/4 DPSK	20.2

Test 2 Procedure (Conducted, Out of Band Emissions)

The 1 to 10 GHz band was examined in small segments to ensure that all out of band spure were at least 20 dB below the carrier.

Test 2 Results (Conducted, Out of Band Emissions)

The plots of the out of band emissions are contained in the appendix. The worst case emission was at approximately –72 dBm @ 1.8 GHz.

Class B Unintentional Radiated Emissions Paragraph 15.109

Specification:

The field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

FREQ (MHz)	Field Strength (uV/M)
30->88	100
88->216	150
216->960	200
Above 960	500

Procedure

This was performed on the 3 meter open air test site located at EC Labs with the UUT running normal operating software. The band from 30 MHz to 10 GHz was examined using a BiConical, Log Periodic and a Horn antenna. The UUT was put on the OATS turntable, and powered up in normal operating mode. The entire 30 MHz to 1 GHz band was examined in small segments. There was, of course, a lot of background “noise” present (T.V., broadcast radio, ...) so the turn-table was rotated and the spectrum analyzer closely watched for any signals that appear to coincide with the table movement. In some cases the unit under test was powered off to see if the emission disappeared (it was from the unit under test) or if it remains (it is from another source). The test setup is shown below.

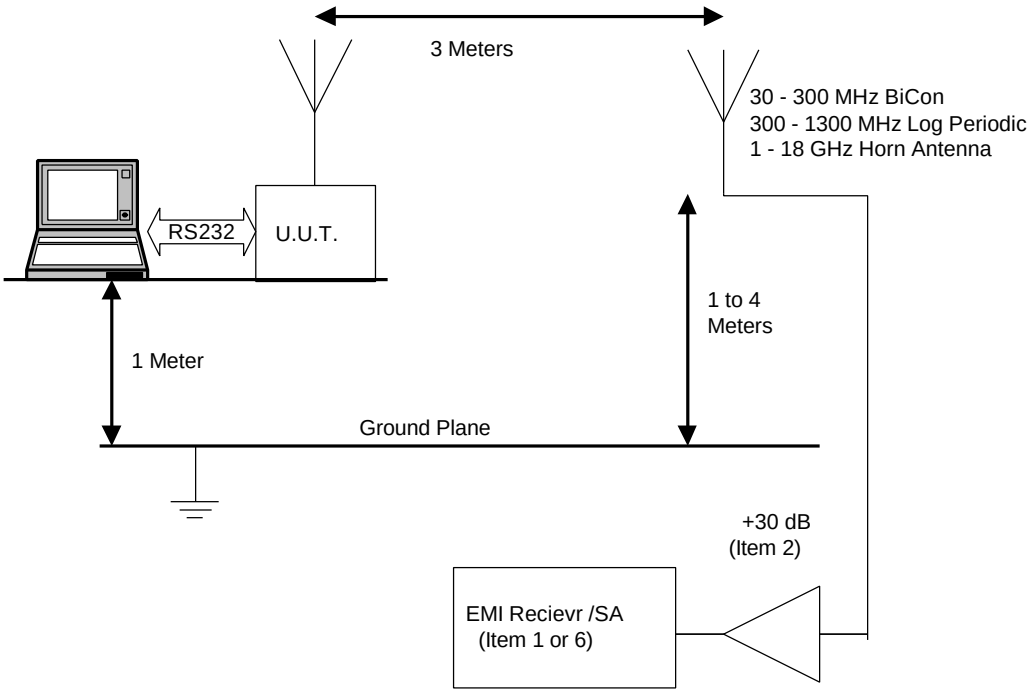


Figure 3: 15.247(c) Out of Band Emissions Radiated Test Setup

Test 2 Results (Radiated):

The level of the highest emission that was detected was 30.4 dBuV/m at 32.0 MHz using a Quasi-Peak detector. This level is 9.6 dB below the 40.0 dBuV/m specification. The data sheet showing the levels of the detected emissions is contained in appendix A.