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Part 15 Certification Application for FCC ID: GNW 22131

EMI Test Report and Technical Documentation on "GT" Wireless Modem for use on the Metricom MCDN Network

Prepared by:

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

Test date(s): April / May 2000

Schematics, block diagrams and algorithm descriptions subject to enclosed confidentiality statement

1.0 Verification of Compliance

Description:	Ricochet GT Wireless Modem
Model Number:	22131
Serial Number(s):	Pre-Production Models
Applicant:	Metricom Inc.
Type of Test:	FCC part 15.247 Application for Part 15 Certification under GNW 22131
Date(s) of test:	April / May 2000
Tested By	David Waitt (Metricom, Los Gatos, CA) Chris Byleckie (Elliott Labs, Sunnyvale,CA)

The above equipment was tested by Metricom Inc. and Elliott 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 GT Wireless Modem
Model Number:	22131
Serial Number(s):	Pre-Production models
Manufacturer:	Metricom, Inc
Type of Test:	FCC Part 15.247 Certification, FCC ID GNW-22131
Reason for testing:	Metricom Inc. has developed a new version of the Ricochet Wireless modem for use with the new high speed Ricochet wireless micro-cellular data network (MCDN). It is similar in general functionality to the current Ricochet Wireless modem (FCC ID: GNW 21100). 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, etc. without the necessity of a telephone line. The Ricochet GT modem (Model 22131) 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 just below 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 GT Ricochet modem is capable for four different modulations. "GEN1" - To communicate with the older, first generation network (It is 2FSK w/ special info in the header of the packet) "2FSK" - 2 "position" frequency shift keying "4FSK" - 4 "position" frequency shift keying "pi/4 DPSK - 4 "position" phase shift keying These are referred to as MOD 0, 1, 2 and 3 respectively. The modulations are chosen automatically by the modem depending on the robustness of the communications link between itself and the Network Radio (GNW 24000)

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	+ 29.90 dBm 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	43.5 ms / 20 Sec Avg.
15.247(c)	Out of Band Conducted Emissions	- 27.8 dB @ band edge
	Out of Band Conducted Emissions (1 – 10 GHz)	–69 dBc @ 931.84MHz .
15.205 (a)	Radiated Emissions in Restricted bands	.3 dB in spec, min
15.109	Class B Unintentional Radiated Emissions	5 dB in spec, min

4.0 Test Facilities

The following tests:

15.109 Class B, Radiated Emissions
15.205 Radiated Emissions in Restricted bands
15.207 AC Line Conducted Emissions

were conducted at:

Elliott Labs (**)
684 West Maude Ave
Sunnyvale, CA. 94086

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 Elliott is on file at:

Federal Communications Commission
PO 429
Columbia, MD. 21045

All of the sites at Elliott 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 at Metricom. Equipment used at Elliott Labs in contained in the file "Elliott_equip_list.pdf"

Item	Desc.	Manufacturer	Model	S/N
1.	Spectrum Analyzer	HP	8563E	3450A2982
2.	Pre Amp	HP	8449B	3008A00527
3.	Plotter	HP	7470A	2644V00365
4.	20 dB Pad	HP	NA	Not Req'd
5.	Power Meter	HP		
6.	Diagnostic Software	Metricom	MFGMODE	---------

HP = Hewlett Packard
** = Response Plots on file at Elliott 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)
1	902.16
75	914.24
161	927.84

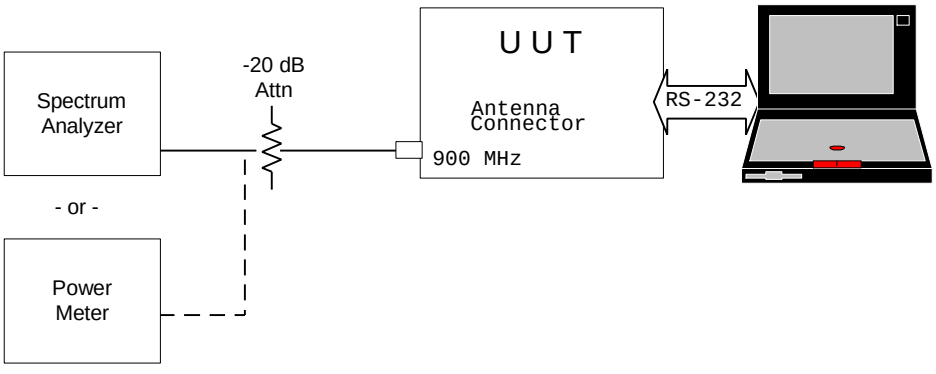
These are referred to as the "Standard Test Channels". For a complete table of Channel Vs. Frequency, see Appendix B.

Many of the tests required that the UUT be operated in modes that are not possible with the normal operating software, for example, the hopping function disabled. In these cases, some special instructions must be sent to the UUT. This is referred to operating the UUT in Diagnostic Mode. It is not possible for a typical Ricochet customer to operate the modem in Diagnostic Mode

The tests below are performed using the basic test setup shown in Fig 1.

Paragraph	Test
15.247(a)(1)(i)	Minimum Number of Hopping Channels
15.247(a)(1)	20 dB Bandwidth
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 in Diagnostic Mode with the hopping function was disabled. The test was configured as shown in Fig 1. The power was then read directly from the Power meter and adjusted for the 20 dB pad.

Note, the modem is calibrated during the manufacturing process to transmit as close to 1 Watt as possible on modulations 0, 1, and 2, it is calibrated to transmit ½ watt on modulation 3. The antenna gain of the antenna that will be used with the modem is specified at 0 dBi.

Results:

The following power levels were measured on the standard test channels for modulations 0, 1, and 2:

Freq. (MHz)	Level (dBm)	Level (Watts)
902.16	29.90	.977
914.24	29.90	.977
927.84	29.90	.977

The following power levels were measured on the standard test channels for modulation 3

Freq. (MHz)	Level (dBm)	Level (Watts)
902.16	27.00	.500
914.24	27.10	.512
927.84	27.00	.500

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

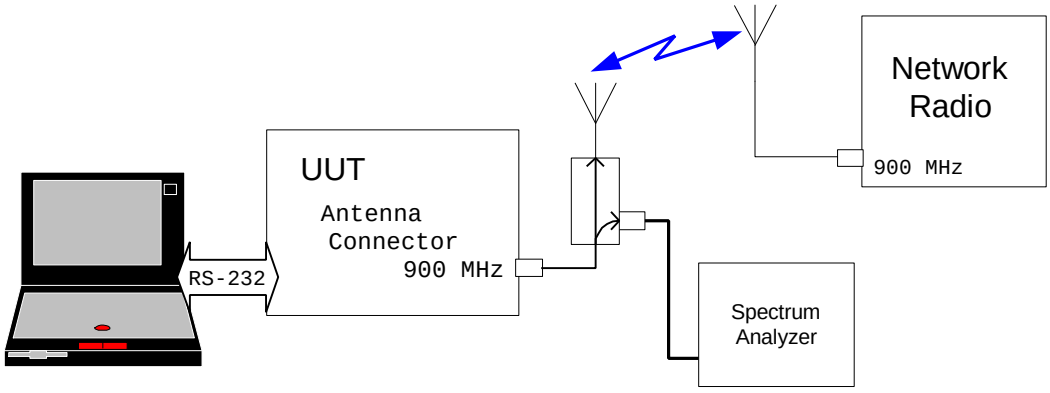
Specification:

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 below was used. The analyzer was set to sweep over a small portion of the 902 - 928 MHz band, (i.e.: 902 - 910 MHz), and wide resolution bandwidth was chosen to allow a fast sweep. The analyzer was set to MAX HOLD.

The UUT was commanded to transmit many large data packets to the network radio With the analyzer on MAX HOLD, each of these channels used for trannsmission was recorded.



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

(Cont)

Results:

The number of channels were demonstrated in the following bands.

Band (MHz)	Number of channels demonstrated in band
902 – 910	17
910 - 920	21
920 – 928	12
Total 902 - 928	50

Plots showing the results of the test are contained in the included file: "number_of_channels.pdf"

Average Channel Occupancy Time, Paragraph 15.247(a)(1)(I) and (ii)

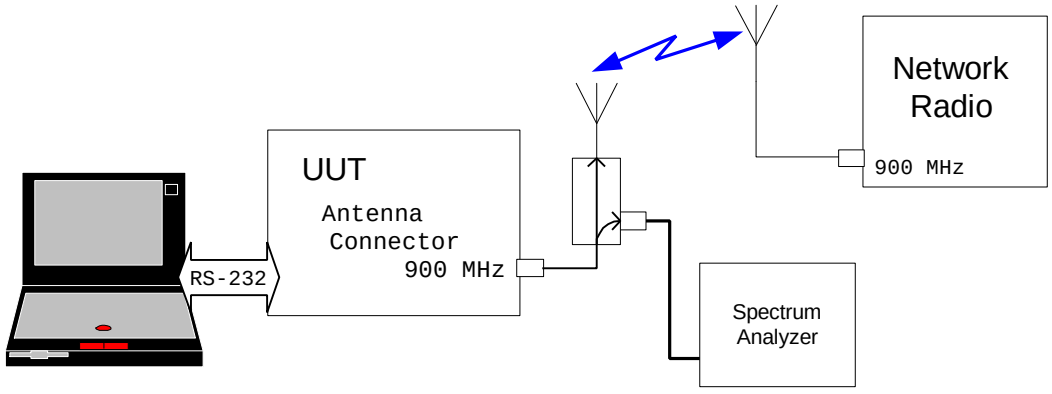
Specification:

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.

Procedure:

The test was configured as shown below. The units were configured to transfer of a total of 16.8 MB to the receive network radio. The number of times each channel was used during the transfer was obtained from the modem using a special diagnostic command. The response from the modem was read into Excel and the average number of hits per channel was calculated.

Each packet that was transmitted was 1120 bytes long and transmitted at a fixed data rate of 200 Kbps. This information allows the time to transmit each packet to be calculated. With the "time per hit", the average number of "hits per channel" and the total time required for the data transfer to take place, the total time on channel can be calculated.



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.

From...	To ...	Avg hits/ channel/file Xsfer	Total File Xsfer Time(s)	Time/ xmission (ms)	Avg Time/ Channel "window" (ms)	Spec (ms/20S)
Modem	Network Radio	150	3088.12	44.8	43.500	400

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. The channels that the GT modem operates on are evenly spaced within the 902.24 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.

Procedure:

The test was configured as shown in Figure 1 and performed on the standard test channels. The UUT was running in the diagnostic mode 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 of 3 kHz. The video BW was equal to the resolution BW. The analyzer was set to MAX HOLD and the "marker-delta" method was used to determine the bandwidth

Results:

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 the included file "20db_bw.pdf"

Test Channel	Modulation	20 dB BW kHz
LOW	2FSK	122.5
LOW	4FSK	145.3
LOW	pi/4 DPSK	160.0
MID	2FSK	122.5
MID	4FSK	145.7
MID	pi/4 DPSK	154.2
HIGH	2FSK	123.3
HIGH	4FSK	134.0
HIGH	pi/4 DPSK	160.0

Radiated Emissions in Restricted Bands Paragraph 15.205

Specification:

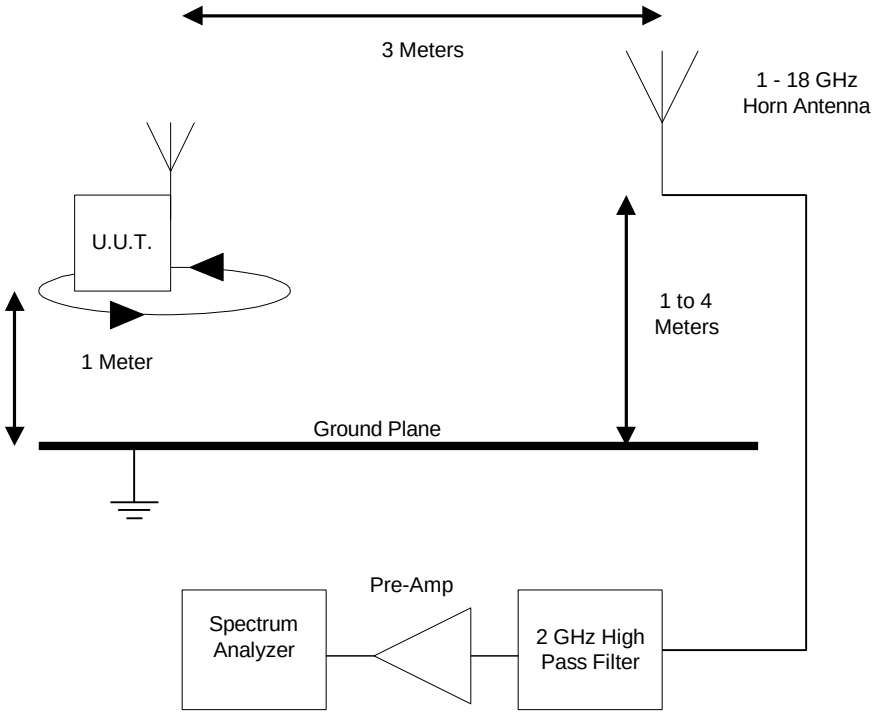
Any emission falling within one of the restricted bands specified in 15.205 shall be below the limits specified in 15.209.

Procedure:

This test was conducted on a 3 meter open air test site at Elliott Labs in Sunnyvale,CA. 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 in diagnostic mode and set to transmit CW at maximum power on Channel 0. The test equipment was configured as shown below. 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 receive antenna adjusted from 1 to 4 meters above the ground plane to maximize the 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 Elliott's Software to obtain a final corrected measurement..

After all the harmonics that fell in restricted bands (up to the 10th harmonic) had been examined for channel 0, the test was repeated for the remaining two standard test channels.



Radiated Emissions in Restricted Bands Test Setup

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

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 .3 dB below the limit. This was at the 5th harmonic of 927.83 MHz. The data sheet showing the emission levels that were measured is included as file "rbands_and_classB.pdf".

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

NOTE:

Two tests were performed to demonstrate compliance with the 15.247(c) specification.

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.

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.

Test 1 Procedure (Conducted, Band Edge):

The test was performed as a conducted test using the Basic Test Setup shown in Figure 1. The unit was in diagnostic mode and configured to transmit continuously using modulation 1. Only the "edges" of the 902 to 928 MHz band are examined since these are expected to be the worst case frequencies.

The UUT was in diagnostic mode and set to transmit on the highest channel. The sweep was set to 928 MHz +/- 500kHz. 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. This was repeated for modulation 1,2, and 3.

The entire test was then repeated with the spectrum analyzer sweep set to 902 MHz +/- 500 kHz and the UUT configured to transmit on the lowest channel with each of the modulations.

900 MHz Band Edge	Modulation	-dBc @ Band Edge
LOW	2FSK	35.0
LOW	4FSK	38.2
LOW	pi/4 DPSK	27.8
HIGH	2FSK	31.7
HIGH	4FSK	39.7
HIGH	pi/4 DPSK	31.2

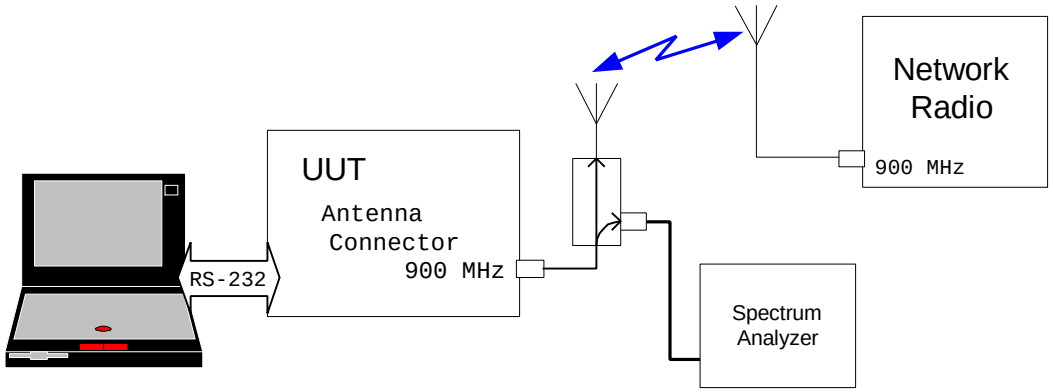
Test 1 Result (Conducted, bandedges)

The results are shown in the table to the right. The plots are contained in the file "upper_lower_bandedge.pdf"

Test 2 Procedure (Conducted, Out of Band Emissions)

The test was configured as shown. The UUT was in diagnostic mode and transmitting large packets to the receiver.

The 1 to 10 GHz band was then examined in small segments to ensure that all out of band spurs were at least 20 dB below the carrier. (Adjusted for the coupler loss)



Test 2 Results (Conducted, Out of Band Emissions)

The plots of the out of band emissions are included as file "out_of_band_conducted_emissions.pdf". The worst case emission was at approximately –69 dBc (–39 dBm) @ 931.84MHz .

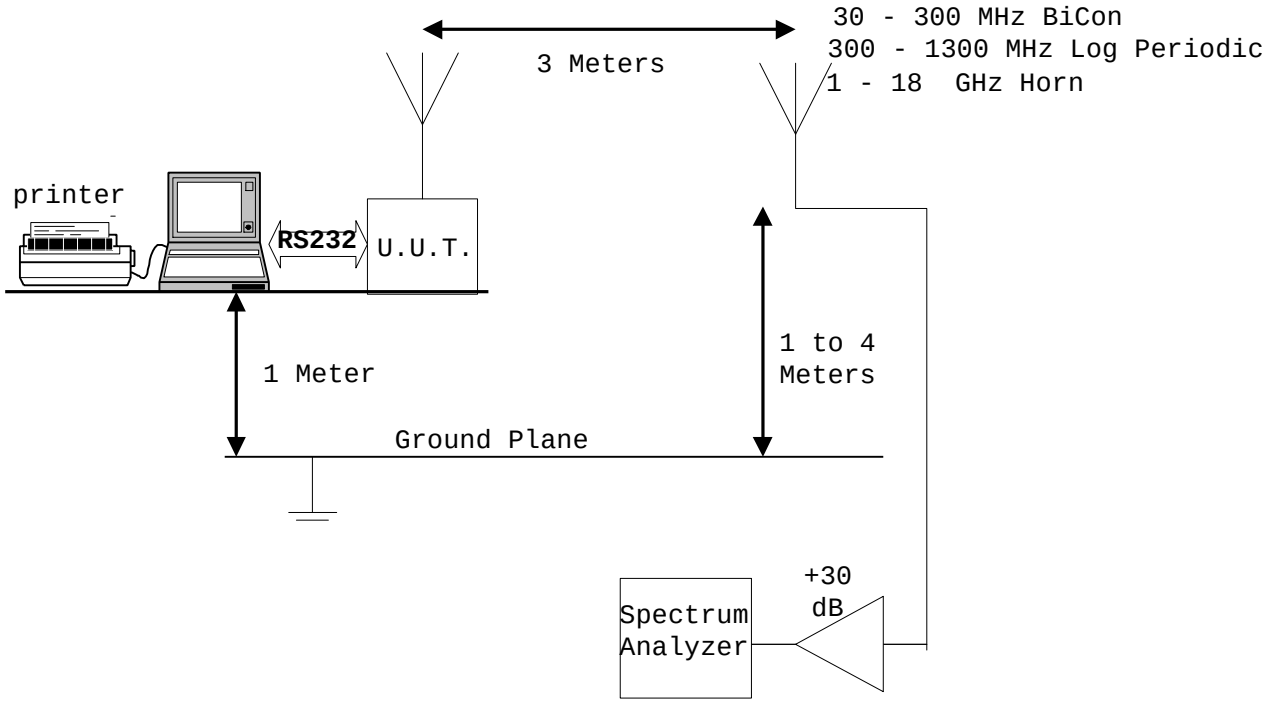
Class B Unintentional Radiated Emissions Paragraph 15.109

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 Elliott Labs with the UUT running in the normal operating mode. The band from 30 MHz to 1 GHz was examined using a BiConical, Log Periodic and a Horn antenna. 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.



15.247(c) Out of Band Emissions Radiated Test Setup

Test 2 Results (Radiated):

The level of the highest emission that was detected was 41 dBuV/m at 400 MHz. This is 5 dB below the 46 dBuV/m specification. The data sheet showing the levels of the detected emissions is included as file "rbands_and_classB.pdf".