SIERRA WIRELESS
HEART OF THE WIRELESS MACHINE™

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Part 15 Certification Application for FCC ID: O6UACRD400

EMI Test Report

On

AirCard 400 Wireless Modem

Prepared by:

Sierra Wireless, Inc
13575 Commerce Parkway, Suite 150
Richmond, B.C. V6V 2L1, Canada

Test date(s): August / September 2000

1.0 Verification of Compliance

Description:	PC Card Type Wireless Modem
Model Number:	AirCard 400
Serial Number(s):	Pre-Production Models
Applicant:	Sierra Wireless, Inc.
Type of Test:	FCC part 15.247 Application for Part 15 Certification under O6UACRD400
Date(s) of test:	August / September 2000
Tested By	Ying Wang (Sierra Wireless Inc., Richmond, BC, Canada) Paul Slavens (Acme Testing Inc., Acme, WA) Dan Staton (Acme Testing Inc., Acme, WA)

The above equipment was tested by Sierra Wireless Inc. and Acme Testing Inc. and found to be in compliance with the requirements set forth in Part 15 of the FCC Rules and Regulations.

Ying Wang
RF Engineer
Sierra Wireless, Inc.

2.0 General Information

Applicant: Sierra Wireless, Inc
13575 Commerce Parkway, Suite 150
Richmond, BC V6V 2L21
Canada

Contact Person Ying Wang

Equipment Under Test: PC Card Type Wireless Modem

Model Number: AirCard 400

Serial Number(s): Pre-Production models

Manufacturer: Sierra Wireless, Inc

Type of Test: FCC Part 15.247 Certification, FCC ID O6UACRD400

Reason for testing: Sierra Wireless Inc. has developed AirCard 400 modem for use with the new high speed Ricochet wireless micro-cellular data network (MCDN). The modem will be sold or rented to subscribers of the Ricochet service. The Ricochet service allows subscribers to send / receive email, connect to the Internet, etc. without the necessity of a telephone line.

The AirCard 400 modem 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 included file "`add_tech_info.pdf`".

The AirCard 400 modem is capable of transmitting in two different modulations.

"2FSK" - 2 "position" frequency shift keying
"4FSK" - 4 "position" frequency shift keying

These are referred to as MOD 1 and 2 respectively. The modulations are chosen automatically by the modem depending on the robustness of the communications link between itself and the Network Radio.

3.0 Results Summary

Summary: 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	+ 30.00 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	51.9 ms / 20 Sec Avg.
15.247(c)	Out of Band Conducted Emissions Out of Band Conducted Emissions (20MHz–10 GHz)	-43.83 dBc @ band edge -47.01 dBc @ 902MHz
15.205 (a)	Radiated Emissions in Restricted bands	2.4 dB in spec, min
15.109	Class B Unintentional Radiated Emissions	3.0 dB in spec, min
15.207	AC Line Conducted Emissions	8.9 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:

Acme Testing Inc. (**)
2002 Valley Highway
P.O.Box 3 Acme, WA 98220

The remaining tests described in this report were performed at:

Sierra Wireless, Inc.
13575 Commerce Parkway, Suite 150
Richmond, BC. V6V 2L1
Canada

(**)
A description of the sites located at Acme Testing Inc. is on file at:

Federal Communications Commission
P.O.Box 429
Columbia, MD 21045

All of the sites at Acme Testing Inc. 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 Sierra Wireless. Equipment used at Acme Testing is contained on Page 11 of the document "Acme_test_data.pdf"

Item	Description	Manufacturer	Model	S/N	Calibration Date
1	Spectrum Analyzer	HP	8593E	3536A00151	Jan 24, 2000
2	Power Meter	HP	E4418B	US39251117	Feb 24, 2000
3	20 dB Attenuator	Pasternack	PE7005	N/A	N/A
4	Diagnostic Software	Sierra Wireless	MFGMODE	N/A	N/A

HP = Hewlett Packard

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)
Low	902.16
Mid	914.16
High	924.08

These are referred to as the "Standard Test Channels".

Many of the tests required that the EUT 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 EUT. This is referred to operating the EUT in Diagnostic Mode. It is not possible for a typical AirCard 400 user 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(b)	Maximum Power Output at Antenna Terminals
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

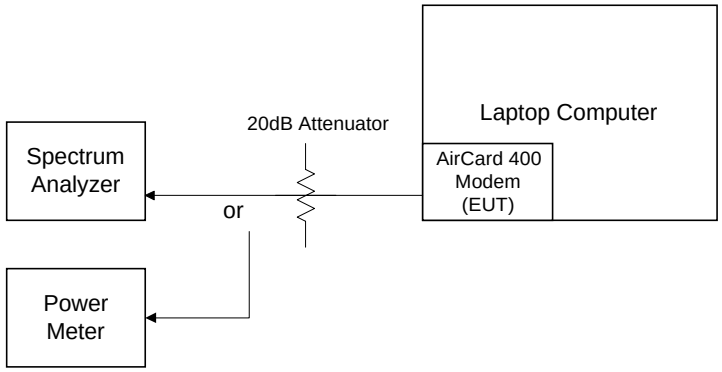

Figure 1. Basic Test Setup

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 EUT was configured to run in Diagnostic Mode with the hopping function 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. Two different antennas, monopole or sleeve dipole, will be used with the modem. The gain of the monopole antenna is specified at 0 dBi and the gain of the sleeve dipole is specified at 1.5 dBi.

Results:

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

Freq. (MHz)	Level (dBm)	Level (Watts)
902.16	29.7	.933
914.16	29.7	.933
924.08	29.7	.933

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 basic test setup shown in Fig 1 was used. The spectrum analyzer was set to sweep over a small portion of the 902-928 MHz band, (i.e. 902-911MHz). The analyzer was set to MAX HOLD. The EUT was placed in diagnostic mode and configured to sequentially step through all transmitting channels transmitting CW for 1 second on each channel. There were many peaks (channels) recorded. This data was plotted and the number of channels could then be read off the plot. This was repeated for another portion of the band until the fact that there were at least 50 channels had been demonstrated.

Results:

The number of channels were demonstrated in the following bands.

Band (MHz)	Number of channels demonstrated in band
902 – 911	20
911 – 921	20
921 – 928	10
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 10 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 1000 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.

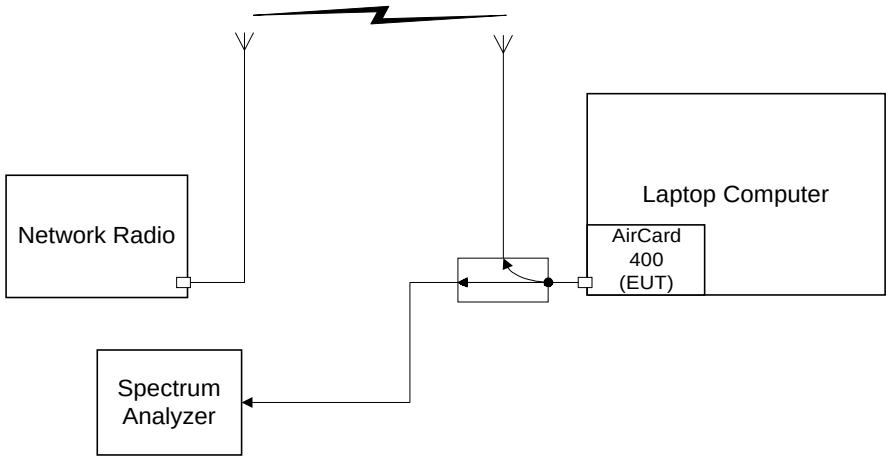

Figure 2 Time on Channel Test Setup

Results:

The following data was gathered:

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Total time required to transfer the file in seconds
Average number of hits per channel
Time of each transmission in seconds
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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	199.4	3074	40	51.9	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. Most of the channels that the AirCard 400 modem transmits on are evenly spaced at 480 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 EUT 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 10 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.

Test Channel	Modulation	20 dB BW kHz
LOW	2FSK	130.0
LOW	4FSK	156.0
MID	2FSK	130.0
MID	4FSK	156.0
HIGH	2FSK	130.0
HIGH	4FSK	152.0

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"

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 Acme Testing Inc. in Acme, WA. The unit was placed on a wooden turntable 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 EUT was running in diagnostic mode and set to transmit CW at maximum power on Channel 1. 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.

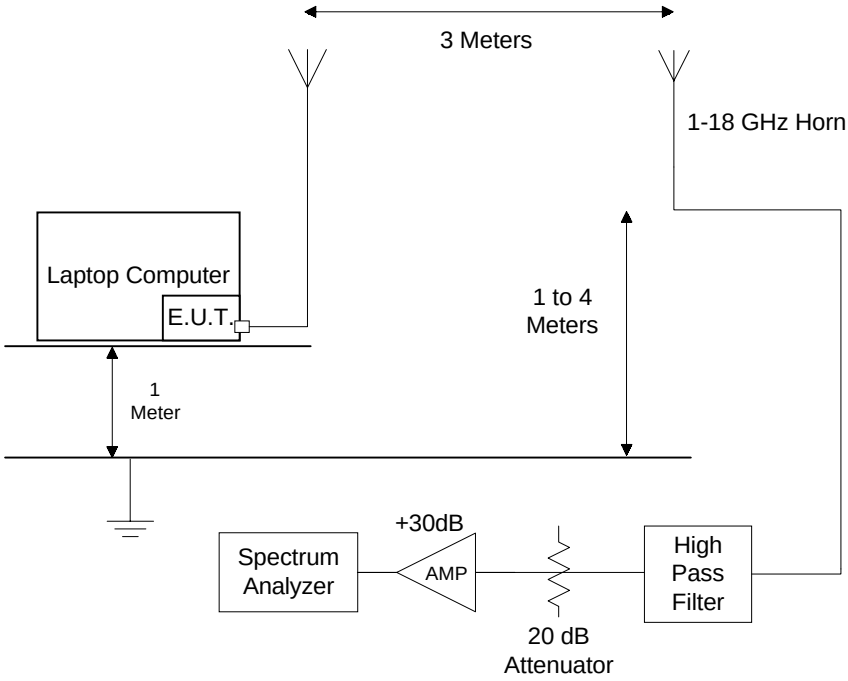

Figure 3 Test Setup for Radiated Emissions in Restricted Bands

The EUT 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 Acme Testing'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 Low channel, the test was repeated for the remaining two standard test channels.

Standard Channel	AirCard 400 Modem Standard Channel Harmonics (MHz)								
	2	3	4	5	6	7	8	9	10
902.16MHz	1804.32	2706.48	3608.64	4510.8	5412.96	6315.12	7217.28	8119.44	9021.6
914.16MHz	1828.32	2742.48	3656.64	4570.8	5484.96	6399.12	7313.28	8227.44	9141.6
924.08MHz	1848.16	2772.24	3696.32	4620.4	5544.48	6468.56	7392.64	8316.72	9240.8

Table 1 AirCard 400 Modem Standard Channel Harmonics

NOTE: The shaded areas are NOT in restricted bands; they are not therefore subject to the limits of 15.209.

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.

The worst case emission was 2.4 dB below the limit. This was at the 3rd harmonic of 924.08 MHz. The data sheet showing the emission levels that were measured is included in file "Acme_test_data.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. Except if the frequency of the emission falls in a restricted band, then it must meet the limits specified in §15.209 and the –20dBc limit does not apply.

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 EUT 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 and 2.

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

900 MHz Band Edge	Modulation	-dBc @ Band Edge
LOW	2FSK	44.2
LOW	4FSK	46.5
HIGH	2FSK	46.0
HIGH	4FSK	43.8

Test 1 Result (Conducted, Band Edge)

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

Test 2 Procedure (Conducted, Out of Band Emissions)

The test was configured as shown below. The EUT was directly connected to the spectrum analyzer. Since the network radio was very close to the EUT, a very small leakage signal from the EUT was strong enough to maintain the communication. The EUT was set in diagnostic mode and transmitting large packets to the network radio.

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.

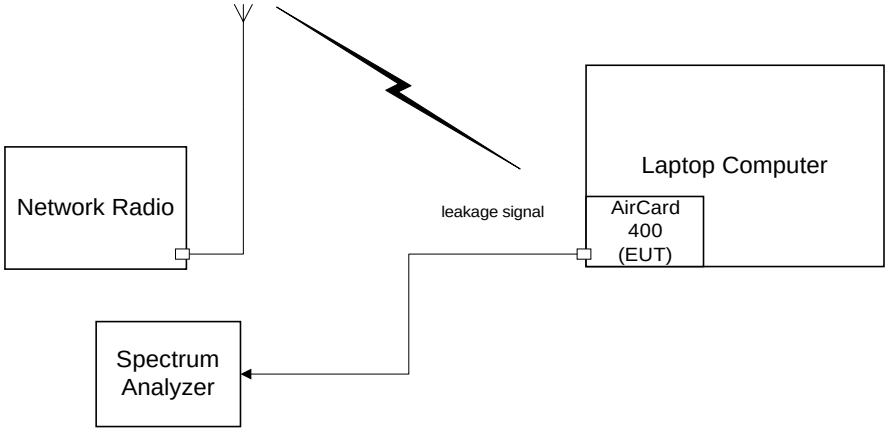

Figure 4: Test Setup for Out of Band Conducted Emissions

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 –47dBc (–17 dBm) @ 902MHz .

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 (µV/M)
30->88	100
88->216	150
216->960	200
Above 960	500

Procedure

This was performed as a radiated test on the 3 meter open air test site located at Acme Testing Inc with the EUT running in the normal operating mode. The band from 30 MHz to 1 GHz was examined using a BiConical and a Log Periodic antenna. During this test a printer was connected to the laptop parallel port and an IR adapter was connected to the laptop serial port. 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 EUT) or if it remains (it is from another source). The test setup is shown below.

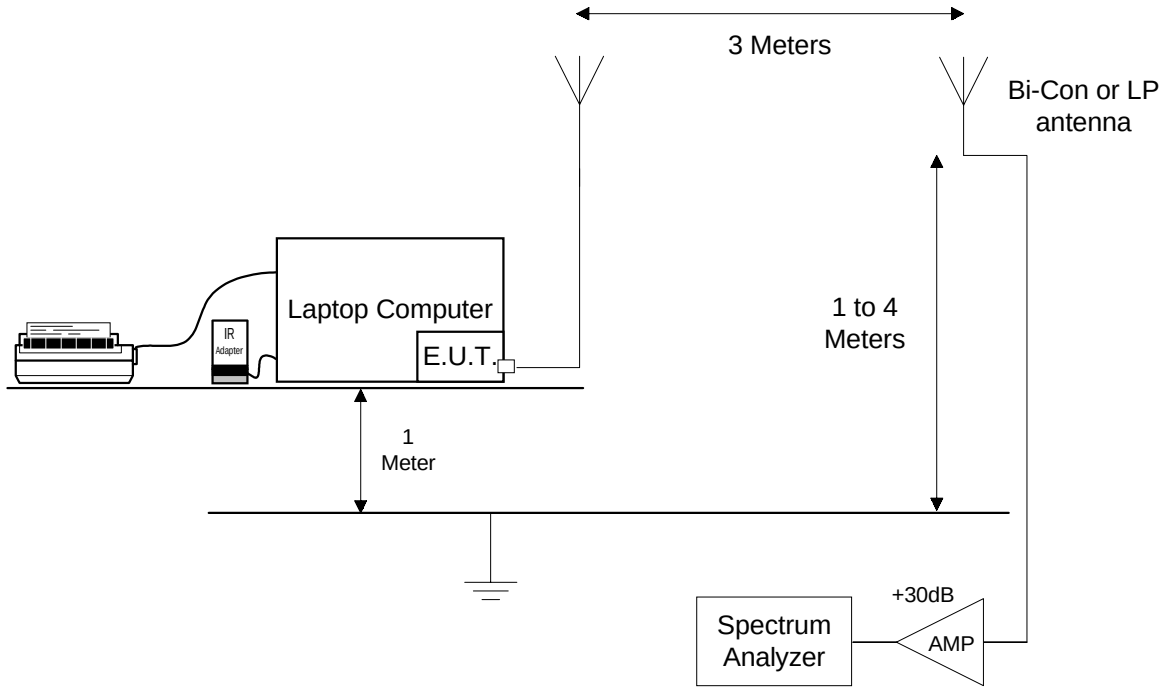

Figure 5 Test Setup for Class B Digital Emissions

Test 2 Results (Radiated):

The level of the highest emission that was detected was 43 dBµV/m at 240.508 MHz. This is 3 dB below the 46 dBµV/m specification. The data sheet showing the levels of the detected emissions is included in file "Acme_test_data.pdf".

AC Line Conducted Emissions Paragraph 15.207

Specification:

The radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 450 KHz to 30 MHz shall not exceed 250 µVs. Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminals.

Description:

This test was performed at Acme Testing Inc with the EUT placed on a non-conductive table running in normal operating mode. The AC adapter was plugged into a 50Ohm, 50µH Line Impedance Stabilization Network (LISN). RF emissions on both, the LINE and the NEUTRAL AC lines were measured using the receiver connected to the LISN port. The data sheet showing the levels of the detected emissions is included in file "Acme_test_data.pdf".