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Part 15 Certification Application for FCC ID: NBZ NRM R900

Test Report and Technical Documentation for "Merlin for Ricochet" Modem

Prepared by:

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Test date(s): August / September 2000

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

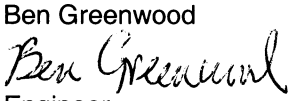
Table of Contents

1.0 Verification of Compliance

Description:	"Merlin for Ricochet" PCMCIA card modem.
Model Number:	NRM R900
Serial Number(s):	Pre-Production Model D7
Applicant:	Novatel Wireless Technologies, Ltd.
Type of Test:	FCC part 15.247 Application for Part 15 Certification under NBZ NRM R900
Date(s) of test:	August / September 2000
Tested By:	Chris Byleckie (Elliott Labs, Sunnyvale,CA), David Waitt (Metricom, Los Gatos, CA) Ben Greenwood (Novatel, Calgary, Canada)

This equipment was tested by Elliott Laboratories and Novatel Wireless Technologies and found to be in compliance with the requirements set forth in the Federal Communications Commission Part 15 Rules and Regulations.

Ben Greenwood



Engineer
Novatel Wireless Technologies, Ltd.

2.0 General Information

Applicant: Novatel Wireless Technologies, Ltd.
Suite 200, 6715-8th Street NE
Calgary, Alberta
Canada T2E 7H7

Contact Person Ben Greenwood

Equipment Under Test: "Merlin for Ricochet" wireless modem

Model Number: NRM R900

Serial Number(s): Pre-Production model D7

Manufacturer: Solectron Corporation

Type of Test: FCC Part 15.247 Certification, FCC ID: NBZ NRZ R900

Reason for testing: Novatel Wireless Technologies, Ltd. Has developed a PCMCIA modem for use on Metricom's high speed Ricochet wireless micro-cellular data network (MCDN). It is similar in general functionality to Metricom's 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 and connect to the Internet without the necessity of a telephone line.

The "Merlin for Ricochet" modem (Model NRZ R900) 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 maximum 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 within this submission.

The "Merlin for Ricochet" modem is capable of transmitting with two different modulations types:

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

These are referred to as gears 1 and 2, respectively. The modulation type is selected automatically by the modem depending on the quality of the communications link between itself and the Network Radio (GNW 24000)

3.0 Results 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	Spec	Pass/Fail
15.247(b)	Maximum Power Output at Antenna Terminals	+29.87 dBm	+30dBm max	Pass
15.247(a)(1)(i)	Minimum Number of Hopping Channels	50	50	Pass
15.247(a)(1)	Channel Frequency Separation	156.3 kHz	160 kHz max	Pass
15.247(a)(1)	Average Channel Occupancy Time	286ms per 20s	400 ms per 20s	Pass
15.247(c)	Out of Band Conducted Emissions @ bandedge Out of Band Conducted Emissions (1 – 10 GHz)	>20 dB margin >40 dB margin	20 dBc minimum 20 dBc minimum	Pass Pass
15.205 (a)	Radiated Emissions in Restricted bands	2 dB margin	54 dBuV/m max	Pass
15.109	Class B Unintentional Radiated Emissions	7 dB margin	Varies with Freq	Pass
15.207	AC Line Conducted Emissions	24.7 dB margin	48 dBuV	Pass

Please Note: All results presented are the worst case measurements.

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[1]
684 West Maude Ave
Sunnyvale, CA. 94086

The remaining tests described in this report were performed at:

Novatel Wireless Technologies
Suite 200, 6715-8th Street NE
Calgary, Canada T2E 7H7

[1] A description of the sites located at Elliott Laboratories is on file at: FCC, PO Box 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_radiated.pdf"

Item	Description	Manufacturer	Model Number	Serial Number	Calibration Due
1	Power Meter	Hewlett Packard	E4418B	GB40204768	July 26th, 20001
2	Spectrum Analyzer	Hewlett Packard	FSEM	DE35494	Jan 24th, 20001
3	Laptop	Toshiba	320CJ Protege	68016230	N/A
4	Poletop Modem	Metricom	108023-000	LG-840120F9	N/A
5	Directional Coupler	Narda	3020A	33874	N/A
6	20 dB attenuators (3)	Weinschel	4J-20-12	N/A	N/A

Methods:

The bulk of 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
80	914.88
161	927.84

These are referred to as the "Standard Test Channels". For a complete table of Channels vs. Frequency please refer to "theory_of_operations.pdf".

Some tests require that the UUT be operated in modes that are not possible under normal operating conditions (for example disabling frequency hopping). In these cases special instructions must be sent to the UUT from Diagnostic Mode. It is not possible for a 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)	20 dB Bandwidth
15.247(c)	Out of Band Conducted Emissions
15.247 (b)	Maximum Power Output at Antenna Terminals

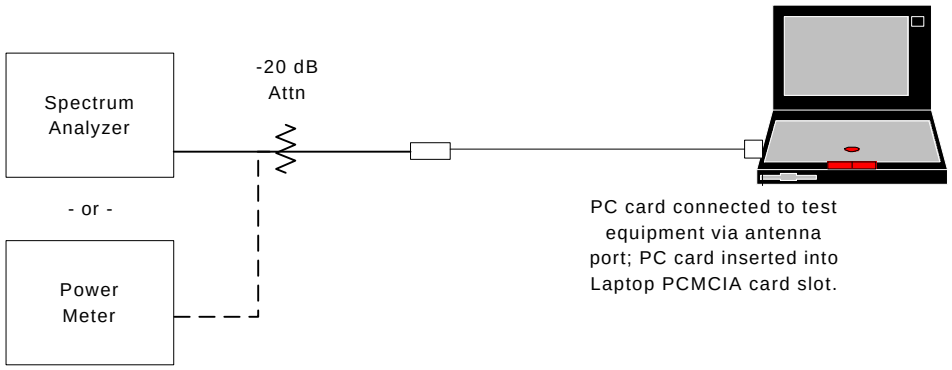


Figure 1. Basic Test Setup

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 modem was configured to run in Diagnostic Mode with the hopping function disabled. The test was configured as per Figure 1. The output power level was then read directly from the power meter and adjusted for the 20 dB pad and cable loss.

Please note: the modem is calibrated during the manufacturing process to transmit as close to 1 Watt as possible on modulations 1 and 2. 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 1 and 2:

Freq. (MHz)	Level (dBm)	Level (Watts)
902.16	29.87	0.9705
914.24	29.67	0.9268
927.84	29.57	0.9057

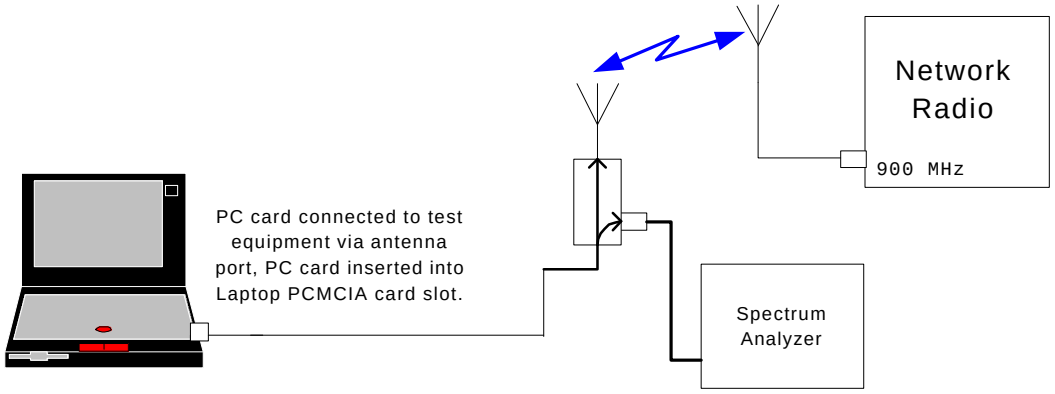
Minimum Number of Hopping Channels:
Paragraph: 15.247(a)(1)(i)

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 fast sweep over a small portion of the 902-928 MHz band, (i.e.: 902-912 MHz). 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 channel used for transmission was recorded.

Results:

The number of channels was demonstrated in the following bands.

Band (MHz)	Number of channels demonstrated in band
902 – 912	21
910 - 920	17
920 – 928	12
Total 902 - 928	50

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

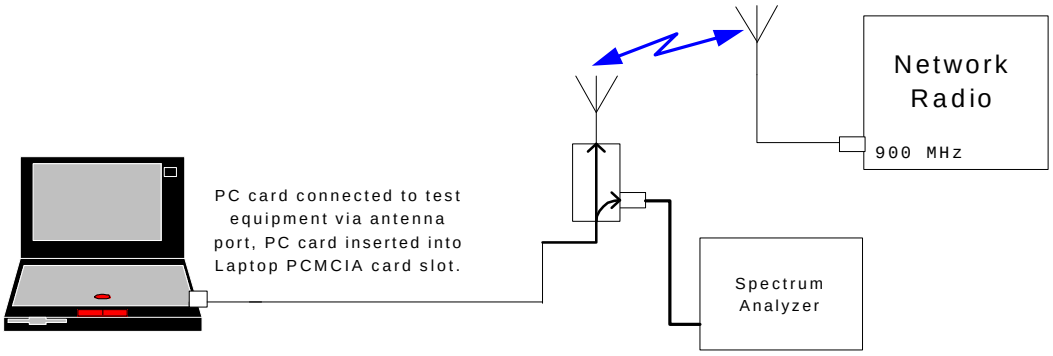
Average Channel Occupancy Time:
Paragraph: 15.247(a)(1)(I) and (ii)

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.

Procedure:

The test was setup as shown below. The units were configured to transfer of a total of 5000 packets to a 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 imported into Excel and the average number of hits per channel was calculated.



Each packet that was transmitted was 1100 bytes long (or 8800 bits) and transmitted at a fixed data rate of 100 kilobits per second. 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.

Results:

The following data was gathered:

```
Total time required to transfer the file in seconds (Duration of Test)
Average number of transmissions per channel
Time of each transmission in seconds
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Results are presented in the table below.

Bits per Packet	Data Rate (kbps)	Time per packet (ms)	Average transmissions per channel	Total Time Transmitting per channel (seconds)	Duration of Test (seconds)	20 Second Windows During Test	Time on Channel per 20 seconds (ms)	Spec. (ms / 20 S)
8800	100	88	100	8.8	615	30.75	286	400

Where:

Time per Packet = Bits Per Packet / Data Rate
Total Time Transmitting per Channel = Average Transmissions per Channel * Time per Packet
20 S Windows During Test = Duration of Test / 20 Seconds

And the result is calculated by:

Time on Channel per 20 Sec = Total Time Transmitting per Channel / Number of 20 Sec Windows During Test

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. The 20 dB bandwidth specification applies to the "Merlin for Ricochet" modem. The channels that the modem operates on are evenly spaced within the 902.24 to 927.84 MHz band, and there are 50 valid transmit channels. Most of these channels are spaced at 320 kHz, however, some channels are spaced at 160 kHz. Therefore the 20 dB bandwidth must be less than 160 kHz.

Procedure:

The test setup used was per Figure 1. The UUT was running in the diagnostic mode and set to transmit random data in both modulation modes on each of the standard test channels. The spectrum analyzer resolution and video bandwidths were 10 kHz and the trace was set to MAX HOLD. The "marker-delta" method was used to determine the bandwidth.

Results:

Results are shown in the table below. The plots are contained in the included file "20db_bw.pdf"

Test Channel	Modulation Type	20 dB Bandwidth (kHz)
Low	2 FSK	129.3
Low	4 FSK	156.3
Mid	2 FSK	129.3
Mid	4 FSK	156.3
High	2 FSK	130.3
High	4 FSK	153.3

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.
The table below shows which harmonics fall under this requirement:

CHAN	HARMONICS							
(MHz)	3	4	5	6	7	8	9	10
902.16	***2706.48***	***3608.64***	***4510.80***	***5412.96***	X	X	***8119.44***	***9021.60***
914.88	***2744.64***	***3659.52***	***4574.40***	x	x	***7319.04***	***8233.92***	***9148.80***
927.84	***2783.52***	***3711.36***	***4639.20***	x	x	***7422.72***	***8350.56***	x

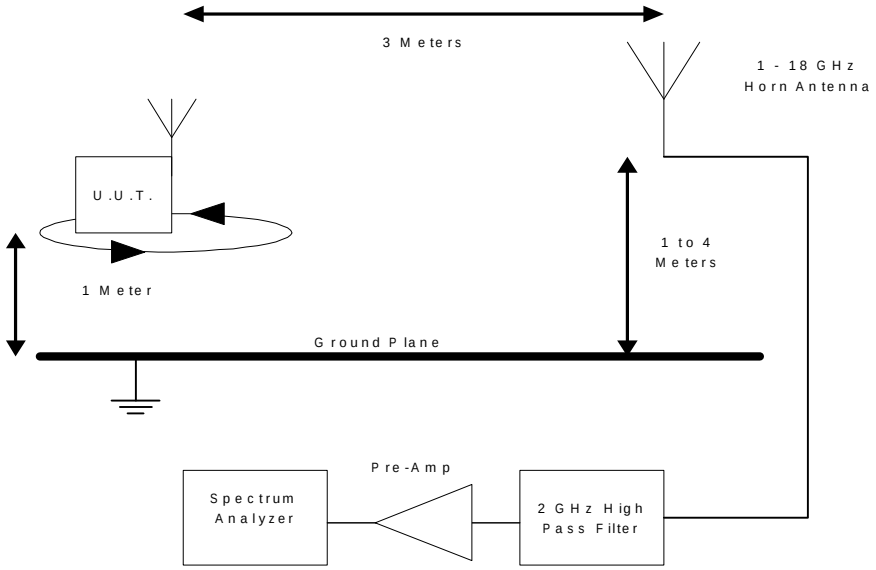
NOTE: X means that the harmonic does NOT fall within a restricted band and is therefore subject to the limits of 15.209.

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 in diagnostic mode and set to transmit CW. The conducted output power was measured using a power meter and adjusted for 1Watt output power on Channel 80. 1 Watt is the absolute maximum allowable output power and the modem was so aligned to obtain worst case results.

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 above). 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 internally generating 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 corrected for antenna factor, cable loss, pre-amplifier gain, etc. by Elliott Labs' software and a final corrected measurement was obtained. Measurements were obtained with the receive antenna in both horizontal and vertical polarity. After all the harmonics that fell in restricted bands (up to the 10th harmonic) had been examined for channel 80 the test was repeated for the remaining two standard test channels.



Results:

The worst case emission met specification with 2 dB margin. This was at the 6th harmonic of 914.85 MHz. The data sheet showing the emission levels that were measured is included as file "rbands&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 band the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power based on an RF conducted or radiated measurement.

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. The marker was placed at the center frequency and a delta measurement was then made to the peak power within the desired band. A resolution bandwidth of 100 kHz was used. This was repeated for both modulation modes.

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 modulation mode.

Test 1 Result (Conducted, bandedges)

The results are summarized in the table below. The plots are contained in the file "bandedge.pdf".

900 MHz Band Edge	Modulation Type	Attenuation Below Carrier (dBc)
LOW	2FSK	47.3
LOW	4FSK	47.5
HIGH	2FSK	42.9
HIGH	4FSK	43.4

Test 2 Procedure (Conducted, Out of Band Emissions)

The same basic test setup was used (Figure 1). The spectrum analyzer was used to determine the channel with the highest power within the band which was channel 80. A reference measurement of this power level was taken using a 100 kHz resolution bandwidth.

The UUT was then entered into diagnostic mode and set to transmit CW on this channel as the 30 MHz 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.

Test 2 Results (Conducted, Out of Band Emissions)

The plots of the out of band emissions are included as file "out_of_band_conducted.pdf". No emissions with a power higher than 60 dBc were observed.

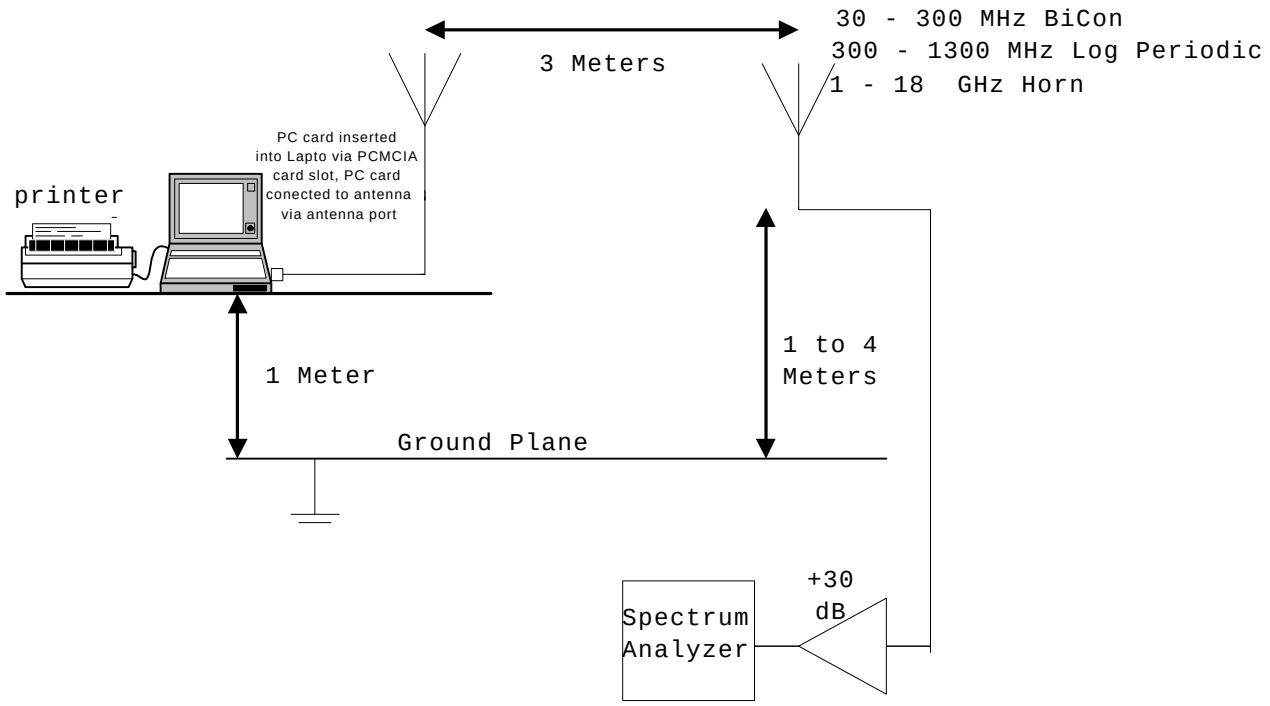
Class B Unintentional Radiated Emissions:
Paragraph 15.109

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. A lot of ambient noise was 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.

Test 2 Results (Radiated):

The level of the highest emission that was detected was within specification with a 7 dB margin at 99.965 MHz. The data sheet showing the levels of the detected emissions is included as file "rbands&classB.pdf".

7.0 Additional Documentation List

FILENAME	DESCRIPTION
Confidentiality.pdf	Confidentiality request.
MPE_calc.pdf	MPE Calculations
R900rep.pdf	This document.
Number_of_channels.pdf	Test results to demonstrate number of channels.
20dB_BW.pdf	20 dB bandwidth plots.
Rbands&ClassB.pdf	Test results from restricted bands and Class B testing from Elliott Labs.
Out_of_band_conducted.pdf	30 MHz to 10 GHz out of band conducted plots.
Bandedge.pdf	Plots of out of band conducted emissions at the band edges.
Conducted_Setup_Photos.pdf	Photographs of the test setup for conducted testing at Novatel.
Radiated_Photos.pdf	Photographs of the test setup for testing at Elliott labs.
Product_Photos.pdf	Photographs of the "Merlin for Ricochet" product.
Theory_of_Operation.pdf	Theory of operation, hopping algorithms, etc.
Schematics.pdf	Schematic diagrams.
Block_Diagrams.pdf	Block diagrams.
Ant_Conn.pdf	Antenna connector datasheet and gain measurements.
Label.pdf	FCC label and placement diagram.
User_Warning.pdf	User document with FCC warning statement.