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Electromagnetic Emissions Test Report In Accordance With FCC Part 90 on the Falcon Packet Radio Model: FPR-U20-110 & FPR-U20-120

GRANTEE:	Wireless-Networks 2322 El Camino Real San Mateo, CA 94403
TEST SITE:	Elliott Laboratories, Inc. 684 W. Maude Ave Sunnyvale, CA 94086
REPORT DATE:	September 26, 2000
FINAL TEST DATE:	September 20 and September 22, 2000

AUTHORIZED SIGNATORY: _____

Juan Martinez
EMC Engineer

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FCC CERTIFICATION INFORMATION

The following information is in accordance with FCC Rules, 47CFR Part2, Subpart J, Section 2.1033(C).

2.1033(c)(1) Applicant: Wireless-Networks, Inc.
2322 El Camino Real
San Mateo, CA 94403

2.1033(c)(2) FCC ID: **O8J-FPR-U20**

Technical Description

The EUT is a wireless modem, which is designed to transmit and receive financial transaction-oriented data. It operates in the 450-480 MHz frequency range with maximum power output of 2 watts. The EUT uses a 12.5 kHz channel bandwidth. The Unit will be sold with a 3.2-dBi antenna (M/N: RT-V/U) and a 22 ft. cable (M/N: RG-58 A/U).

2.1033(c)(3) Instructions/Installation Manual

The instruction Manual is included as a draft. The original User's Manual will be submitted as soon as it's available. The Theory of Operation is also included in. Please refer to Exhibit 7: User Manual, Theory of Operation, and Tune-up procedure.

2.1033(c)(4) Type of emissions

11K25F1D (4 level FSK) (12.5 kHz channel)

2.1033(c)(5) Frequency Range

Transmitter: 450 - 470 MHz

2.1033(c)(6) Range of Operation Power

2-Watt maximum power output

2.1033(c)(7) Maximum Power Rating

Section 90.205: limited 2 Watts E.I.R.P. peak power at 2 km

2.1033(c)(8) Applied voltage and currents into the final transistor elements

Voltage: +7.2 VDC, Current 350 mA

2.1033(c)(9) Tune-up Procedure

Refer to Exhibit 7: User Manual, Theory of Operation, and Tune-up Procedure.

2.1033(c)(10) Schematic Diagram of the Transmitter

Refer to Exhibit 6. The schematic diagram is located on page 55 of the Technical Manual.

2.1033(c)(10) Means for Frequency Stabilization

RF Module synthesizer reference is Y801, a 14.40 MHz TCVCXO (P/N 6187009527) with a specified tolerance of +/- 1.5 PPM, -30 to +60 deg. C

2.1033(c)(10) Means for Attenuating Higher Audio Frequencies

The output low pass filter on the DataRadio RF module output is located under the final amplifier shield and is comprised of L561, L563, C561, C562, and C564

2.1033(c)(10) Means for Limiting Modulation

N/A. EUT uses digital modulation.

2.1033(c)(10) Means for Limiting Power

N/A

2.1033(c)(11) Photographs or Drawing of the Equipment Identification Plate or Label

Refer to Exhibit 4

2.1033(c)(12) Photographs of equipment

Refer to Exhibit 5

2.1033(c)(13) Equipment Employing Digital Modulation

4 level FSK modulation

2.1033(c)(14) Data taken for Section 2.1046 to 2.1057

Refer to Exhibit 2

SCOPE

FCC Part 90 testing was performed for the equipment mentioned in this report. The equipment was tested using Sections 2.1046 to 2.1057. TIA-603 was used as a test procedure guideline to perform the required test. Other EIA/TIA procedure guidelines pertaining to the equipment under test were also used.

The intentional radiator above was tested in a simulated typical installation to demonstrate compliance with the relevant FCC performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

OBJECTIVE

The primary objective of the manufacturer is compliance with FCC part 90. Certification of these devices is required as a prerequisite to marketing as defined in Section 2.1033.

Certification is a procedure where the manufacturer or a contracted laboratory makes measurements and submits the test data and technical information to FCC. FCC issues a grant of equipment authorization and a certification number upon successful completion of their review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units subsequently manufactured.

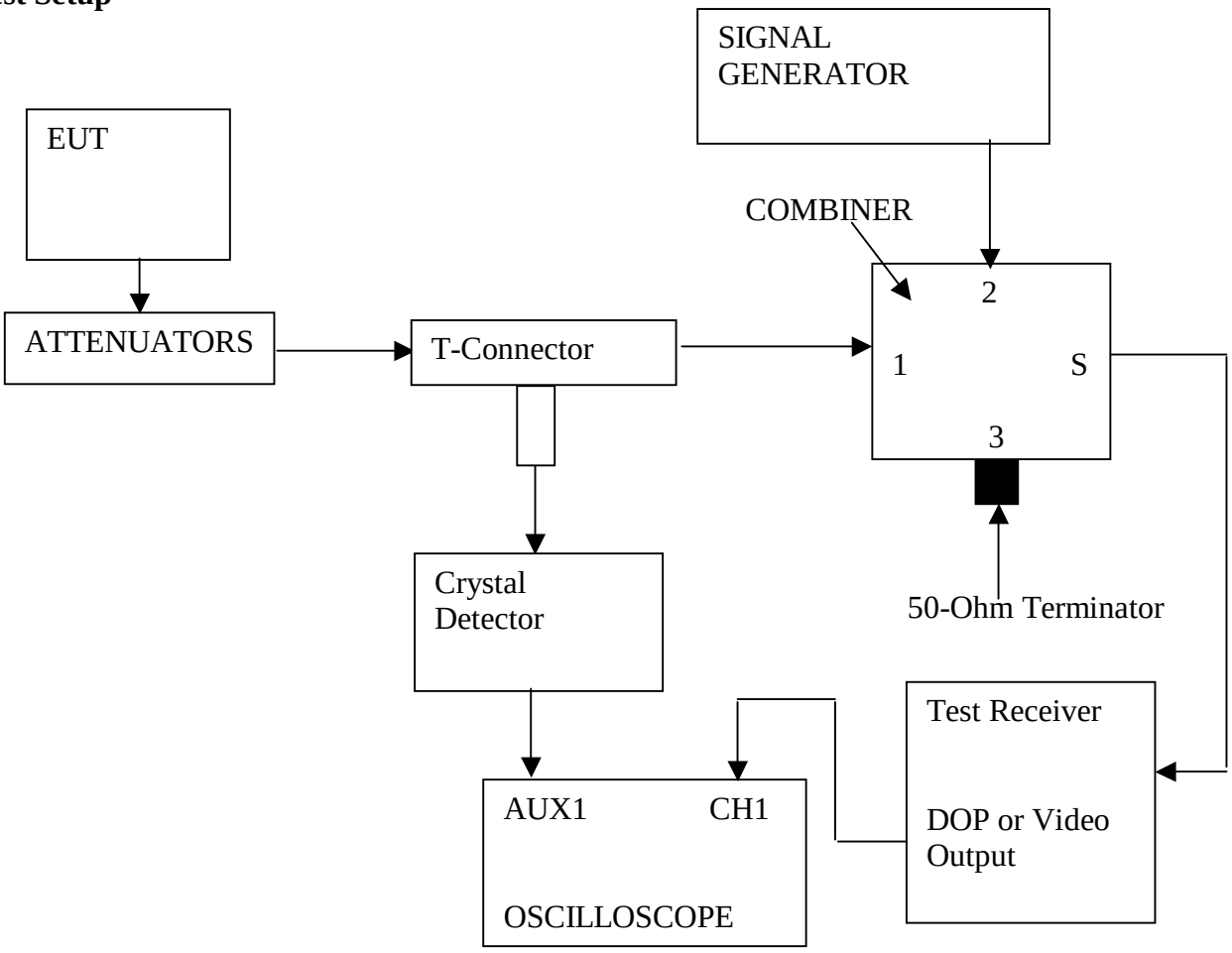
Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product that may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

EMISSION TEST RESULTS

The following emissions tests were performed on the Wireless-Networks, Model: FPR-U20-110 & FPR-U20-120. The actual test results are contained in an exhibit of this report.

Section 90.214: Transient Frequency Behavior

Test Setup



Test Procedure:
The TIA/EIA 603 procedure was used. Please refer to Setup Photo# 3 under Exhibit 3.

1) Connected the Test Receiver DOP or Video Output to Channel 1 of the oscilloscope. The output of the RF detector was connected to Auxiliary channel 1, which served as a trigger input. The output of the combiner was connected to the Test Receiver.

2) Set the EUT to maximum power and connected as illustrated above. Set the signal generator to the assigned transmitter frequency and modulate it with a 1 kHz tone at 12.5 kHz deviation and set its output to –100 dBm. Turn on the EUT.

3) The Combiner output side was connected to the Test Receiver, which was used to measure the Power. Used enough external attenuation so that the output at the combiner

was set to -10 dBm, which is 40 dB below the maximum input of the Test Receiver. Turn off the EUT.

4) Set the signal generator to –30 dBm, which is 20 dB below step 3, this level was maintained for the remainder of the test.

5) Set the horizontal sweep rate on the storage oscilloscope to 10 milliseconds per division and adjusted the display to continuously view the 1 kHz tone from the DOP or Video Output. Adjusted the vertical amplitude control to display the 1 kHz at +/- 4 divisions vertically centered on the display.

6) Set the oscilloscope to trigger at the AUX channel 1 input port.

7) Removed enough external attenuation so that the input to the RF detector and combiner is increased by 30 dB.

8) Turn on the transmitter and plotted the result for **Ton**, **T1**, and **T2**.

9) Set the oscilloscope to trigger in decreasing magnitude from the RF detector.

10) Turn off the transmitter and plotted the result for **T3**.

Please, refer to data included under **Exhibit 2**: Test Measurement Data.

Section 2.1046: RF Power Output

The EUT tested complied with the limits detailed in Section 90.205(E).

Note: A 22-foot long (Min) section of RG-58 A/U Type cable with a measured loss of 2.7 dB was used to connect the EUT to the spectrum analyzer, but the loss was not included in the measurement. But the EUT was set to 2-Watts max power.

The EUT antenna was removable, so conducted measurements was performed. The EUT was connected to the spectrum analyzer. Attenuators were used to protect the input of the analyzer. The EUT was set to transmit continuous packets of data and the Fundamental Frequency set to the middle of the EUT frequency range. Used a Resolution and Video bandwidth of 10 kHz.

Please refer to Setup Photo# 2 under Exhibit 3.
Please, refer to data included under **Exhibit 2**: Test Measurement Data.

SECTION 2.1047: MODULATION CHARACTERISTICS

Not Applicable. EUT uses digital modulation technique. The EUT was set to transmit 4-level FSK modulation.

SECTION 2.1049: OCCUPIED BANDWIDTH

Note: A 22-foot long (Min) section of RG-58 A/U Type cable with a measured loss of 2.7 dB was used to connect the EUT to the spectrum analyzer, but the loss was not included in the measurement. But the EUT was set to 2-Watts max power.

The EUT was connected directly to the spectrum analyzer and used an attenuator to protect the input of the analyzer. The EUT antenna was removable, so conducted measurements was performed. The EUT was set to transmit continuous packets of data and the Fundamental Frequency set to the middle of the EUT frequency range.

Since EUT is designed with a 12.5 kHz channel Section 90.210 (d)(1)(2)(3) was used to show compliance for the emission mask.

Any emission must be attenuated below the power (P) as follow:

90.210 (d)(1): 5.625 kHz: 0 dB

90.210(d)(2): 5.625 kHz: 20 dB
12.5 kHz: 70 dB

90.210(d)(3): more than 12.5 kHz: -20 dBm

The following Resolution and Video bandwidth was used per Section 90.210(d)(4) to show compliance for the above requirement: 100 Hz.

Please refer to Setup Photo# 2 under Exhibit 3.

Refer to data included under **Exhibit 2**: Test Measurement Data.

The EUT was designed with a 12.5 kHz channel bandwidth. The EUT was set to transmit 4-level FSK modulation. The Occupied Bandwidth was measured using the spectrum analyzer built-in 99% bandwidth option.

Per Section 90.209: the authorized bandwidth for 421-512 MHz is 11.25 kHz.

The measured value, **8.3 kHz**, was within the authorized bandwidth stated in Section 90.209 for a 12.5 kHz channel bandwidth.

Please refer to Setup Photo# 2 under Exhibit 3.
Refer to data included under **Exhibit 2**: Test Measurement Data.

SECTION 2.1051: SPURIOUS EMISSION AT ANTENNA TERMINAL.

Note: A 22-foot long (Min) section of RG-58 A/U Type cable with a measured loss of 2.7 dB was used to connect the EUT to the spectrum analyzer, but the loss was not included in the measurement. But the EUT was set to 2-Watts max power.

The EUT was connected directly to the spectrum analyzer and used an attenuator to protect the input of the analyzer. The EUT antenna was removable, so conducted measurements was performed. The EUT was set to transmit continuous packets of data and the Fundamental Frequency set to the middle of the EUT frequency range.

The Out-of-Band emissions was tested to Section 90.210(d)(3) using the Resolution and Video Bandwidth instrumentation settings per Section 90.210(m) 10 kHz below 1 GHz and 1 MHz above 1 GHz. The Out-of-Band was check from 1 MHz to the 10^{th} harmonic of the fundamental.

Please refer to Setup Photo# 2 under Exhibit 3.
Refer to data included under **Exhibit 2**: Test Measurement Data.

SECTION 2.1053: FIELD STRENGTH OF SPURIOUS RADIATION.

The following measurements were extracted from the data recorded during the radiated electric field emissions scan and represent the highest amplitude peaks relative to the specification limit. The actual test data is contained in the appendices of this report. The field reading includes the correction factors that were applied on the Test equipment by software means. For measurements above 1 GHz a Resolution and Video bandwidth of 1MHz was used for Peak measurements. For Average measurements a Resolution Bandwidth of 1 MHz and a Video Bandwidth of 10 Hz, linear mode, was used.

Maximized Radiated Unwanted Emissions

Frequency	Level	Pol	FCC 90.210(d)(3)		Detector	Azimuth	Height	Comments
MHz	dBµV/m	V/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
923.975	43.0	H	77.4	-34.4	Pk	151	1.0	

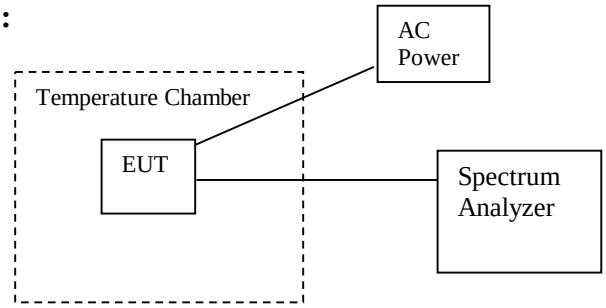
The 22-ft cables was left connected to the EUT antenna port and a 50-ohm load was place at the end of the cable. The EUT was set to transmit continuously at maximum power. The frequency was set to the middle of the EUT frequency range.

Please refer to Setup Photo# 1 under Exhibit 3.
Please, refer to data included under **Exhibit 2**: Test Measurement Data.

SECTION 2.1055: FREQUENCY STABILITY

The EUT tested complies with Section 90.213.

Test Setup:



Limit:
412 – 512 MHz: 2.5 ppm (12.5 kHz channel)

The frequency of the transmitter varied by less than 17 Hz over the temperature range of –30 to +50 degrees Celsius.

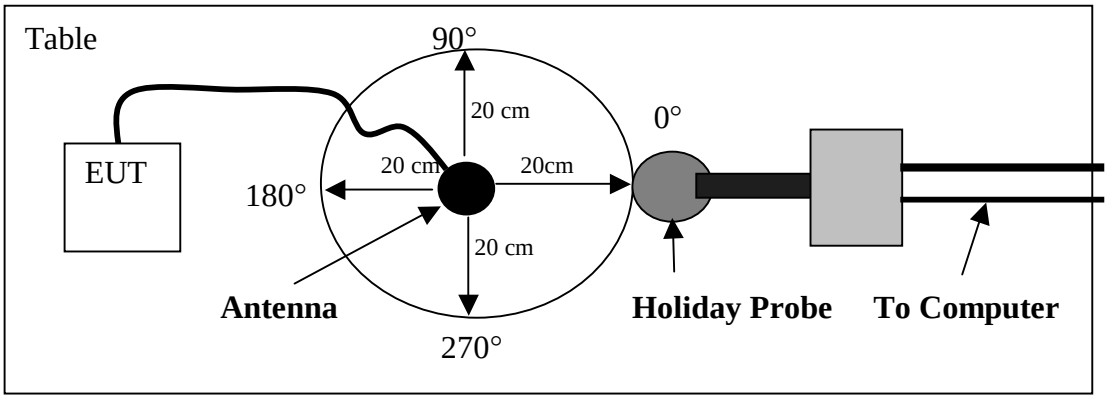
For voltage stability, the EUT's nominal voltage was varied 85% and 115%.

The following test method was used:
The EUT was placed inside a temperature chamber. All support and test equipment was place outside and next to the chamber. Set the Spectrum Analyzer Res and Video Bw till 6 digits are shown in the marker function section. The spectrum analyzer built-in frequency counter was used to measure the maximum deviation of the Fundamental Frequency at each temperature. For Voltage stability used a variac transformer to set the appropriate test voltages.

Please, refer to data included under **Exhibit 2**: Test Measurement Data

Section 2.1091: Radiofrequency radiation exposure evaluation: Mobile devices.

Test Setup:



The EUT will be sold with a 17" base-loaded whip antenna, Model RT-V/U, with a gain of 3.2 dBi and a 22 foot long (Min) section of RG-58 A/U Type cable with a measured loss of 2.7 dB.

MPE Evaluation was performed using the **OET 65-supplement C** test procedure, for mobile devices.

The EUT was set to transmit at maximum power of 2 watts. The EUT was set to transmit continuous packets of data and the Fundamental Frequency set to the middle of the EUT's frequency range. The EUT and antenna were placed on top of a table, located in an Anechoic Chamber. The measuring probe was place 20-cm away from the EUT's antenna. The probe was moved around the antenna, while keeping the 20-cm separation. At the same time the probe was increased and lowered in height to measure the maximum points of the 17" antenna. The top of the antenna was also measured, 20-cm away. Both unmodulated and modulated modes were tested. The probe was connected to a computer, which displayed the measured levels in mW/cm^2.

Normally the EUT will not be transmitting continuously data due to amplifier heat built-up. So the RF exposure from the antenna will be greatly reduced due to the short burst of data being transmitted.

Please refer to Setup Photo# 4 under Exhibit 3.
Please, refer to data included under **Exhibit 2**: Test Measurement Data

TEST SITE

GENERAL INFORMATION

Final test measurements were taken on September 21, 2000 at the Elliott Laboratories Open Area Test Site #1 located at 684 West Maude Avenue, Sunnyvale, California. Pursuant to section 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing are performed in conformance with Section 2 of FCC Rules. Measurements are made with the EUT connected to a spectrum analyzer through an attenuator to prevent overloading the analyzer.

RADIATED EMISSIONS CONSIDERATIONS

Radiated measurements are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR 16-1 defined elliptical area.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1 is used for emissions measurements. The receivers are capable of measuring over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the particular detector used during measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. If average measurements above 1000MHz are performed, the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz is used.

INSTRUMENT CONTROL COMPUTER

A Rohde and Schwarz EZM Spectrum Monitor/Controller are utilized to convert the receiver measurements to the field strength at the antenna, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate.

The EZM provides a visual display of the signal being measured. In addition, the EZM Spectrum Monitor runs the automated data collection programs that control both receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically. .

POWER METER

A power meter and thermister mount may be used for output power measurements from transmitters as they provide a broadband indication of the power output.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or EUT and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transmitters and transient events.

ANTENNAS

A biconical antenna is used to cover the range from 30 MHz to 300 MHz and a log periodic antenna is utilized from 300 MHz to 1000 MHz. Narrowband tuned dipole antennas are used over the 30 to 1000 MHz range for precision measurements of field strength. Above 1000 MHz, a horn antenna is used. The antenna calibration factors are included in site factors programmed into the test receivers

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor drive to vary the antenna height.

The requirements of ANSI C63.4 were used for configuration of the equipment turntable. It specifies that the test height above ground for table-mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An appendix of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The FCC requires that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.4, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements are performed with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.

RADIATED EMISSIONS

Radiated emissions measurements are performed in two phases. A preliminary scan of emissions is conducted in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed from the lowest frequency generated in the device up to the frequency required by the regulation specified on page 1. One or more of these is with the antenna polarized vertically while the one or more of these are with the antenna polarized horizontally. During the preliminary scans, the EUT is rotated through 360°, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit.

A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth that results in the highest emission is then maintained while varying the antenna height from one to four meters. The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain. Emissions that have values close to the specification limit may also be measured with a tuned dipole antenna to determine compliance.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for radiated emissions are based on the power of the transmitter at the operating frequency. Data is measured in the logarithmic form of decibels relative to one milliwatt, or dB milliwatts (dBm). The field strength of the emissions from the EUT is measured on a test site with a receiver.

RADIATED EMISSIONS SPECIFICATION LIMITS, SECTION 90.210(d)(3)

Operating Power Range	2 watts
Outside of the assigned frequency block	$50+10\log_{10}$ (mean output power in watts) dB below the measured amplitude at the operating power.

CALCULATIONS – EFFECTIVE ISOTROPICALLY RADIATED POWER

$$E(V/m) = \frac{\sqrt{30 * P * G}}{d}$$

P= Power in Watts
G= Gain of antenna in numeric gain (Assume 1 dB for E.I.R.P)
d= distance in meters

$$E(V/m) = \frac{\sqrt{30 * 2 \text{ watts} * 1 \text{ dB}}}{3 \text{ meters}} = 2.582 \text{ V/m}$$

20 * log (2.582 V/m * 1,000,000) = 128.24 **dBuV/m** @ 3 meters

50 + 10 log (P)

50 + 10 log (2 watt) = **53 dB** attenuation.

128.24 dBuV/m – 53 dB = 75.2 dBuV/m @ 3 meter.

All Spurious and Harmonic emission must not exceed **75.2 dBuV/m** @ 3 meters.

EQUIPMENT UNDER TEST (EUT) DETAILS

The Wireless-Networks model FPR-U20-110 & FPR-U20-120 is a 450-470 MHz wireless modem to be used in industrial environments for financial transaction-oriented data. The sample was received on September 20, 2000 and tested through September 22, 2000. The EUT consisted of the following component(s):

Manufacturer/Model/Description	Serial Number
Wireless-Networks/FPR-U20-110/Wireless Modem	N/A
Ying Hao Metal Industrial/RT-V/U/Whip antenna	N/A
N/A / RG-58 A/U/22-ft coaxial cable	N/A

ENCLOSURE

The EUT enclosure is primarily constructed of plastic with metal shield inside.

SUPPORT EQUIPMENT

The following equipment was used as remote support equipment for emissions testing:

Manufacturer/Model/Description	**Serial Number**	**FCC ID Number**

EXTERNAL I/O CABLING

The I/O cabling configuration during emissions testing was as follows:

Cable Description	Length (m)	From Unit/Port	To Unit/Port
coaxial cable	7.3	Antenna Output	External Antenna

TEST SOFTWARE

During testing the EUT was set to transmit continuous data packets at maximum power. Internal software was used to configure the EUT properly for the required tests.

TEST MODES

During emissions testing the transmitter was set to the normal operating mode using 4-level FSK modulation.

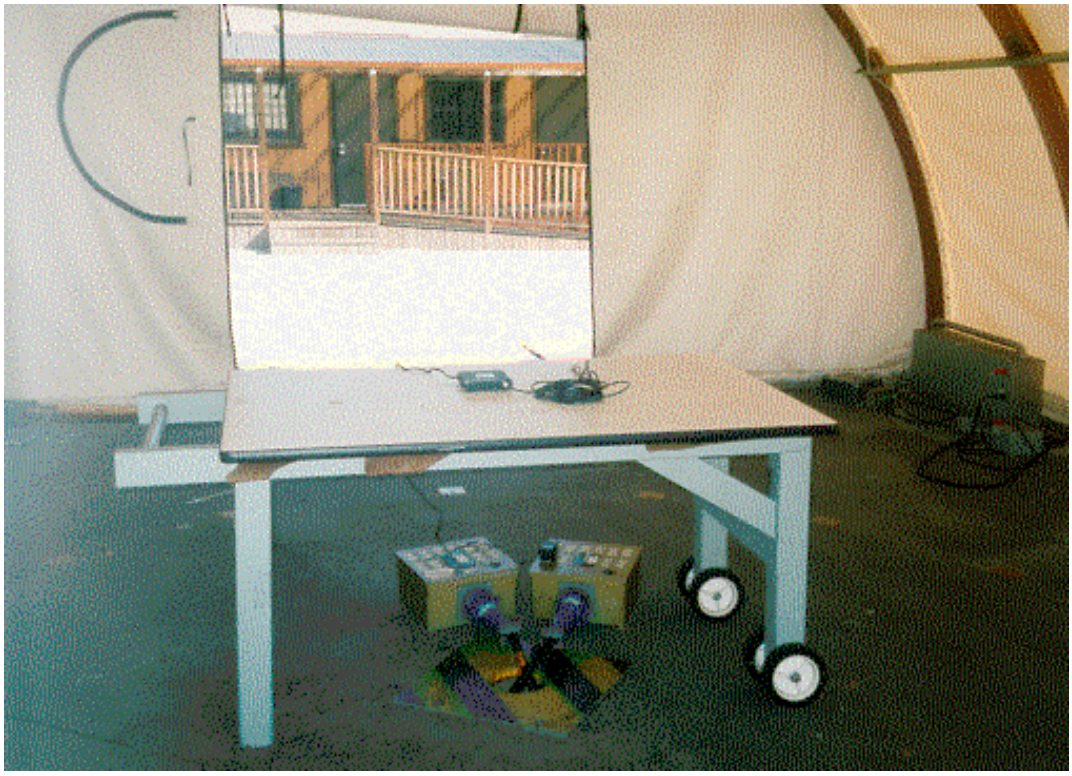
EXHIBIT 1: Test Equipment Calibration Data

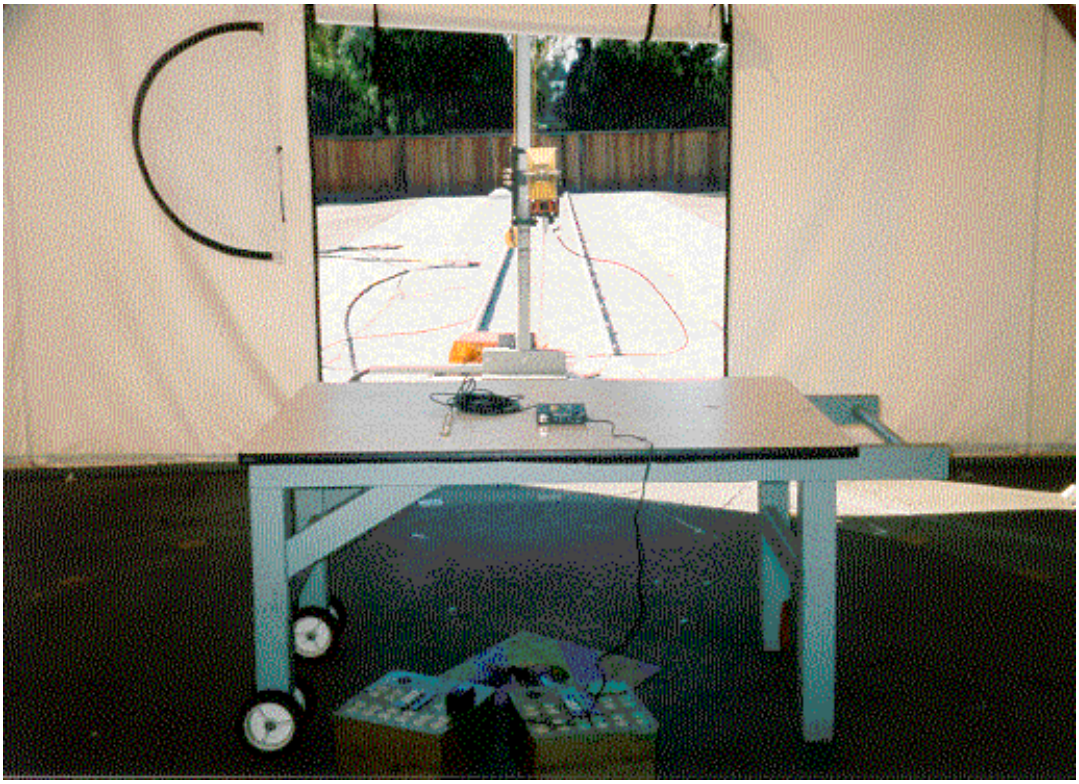
EXHIBIT 2: Test Measurement Data

The following data includes conducted and radiated emission measurements of the Wireless-Networks model FPR-U20-110 & FPR-U20-120.

16 Pages

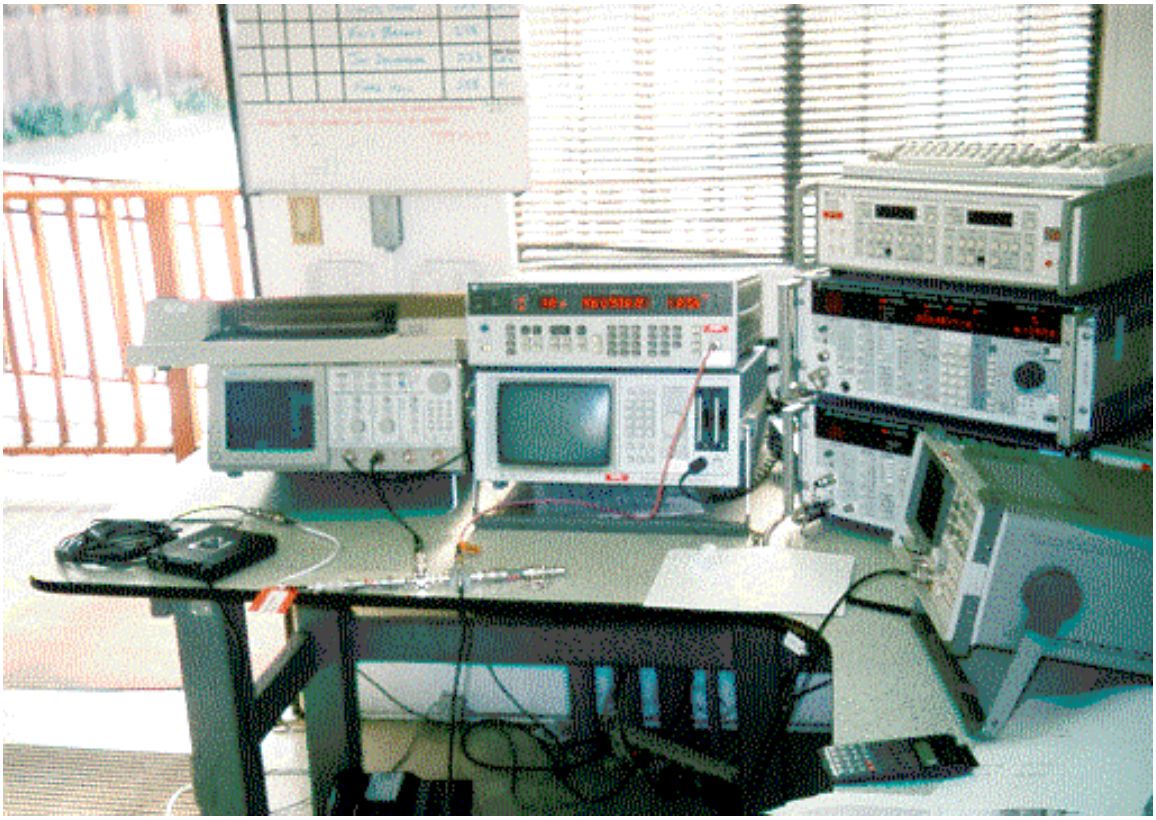
EXHIBIT 3: Photographs of Test Configuration





Setup Photo# 1

Setup Photo# 2



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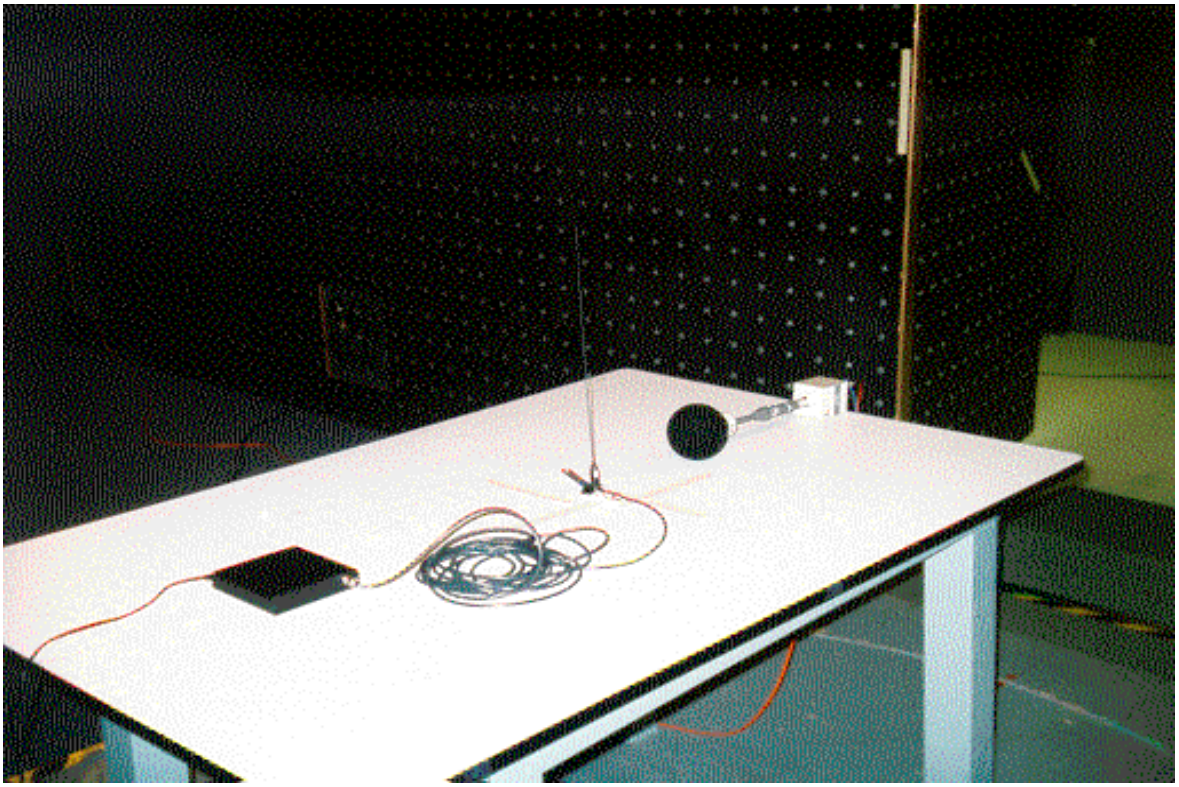

Setup Photo# 4

EXHIBIT 4: FCC ID Label and Location

1 page

EXHIBIT 5: Internal and External Photos

EXHIBIT 6: Schematics, Block Diagram, and Parts list

EXHIBIT 7: User Manual, Theory of Operation, and Tune-Up procedure