Chapter 11 Test Report

Overview

This section includes the test report and data showing compliance with all applicable technical standards.

Contents

11.1 Test Methodology

This section describes the test methodology used to validate the performance of the AT&T Wireless Services PWAN Remote Unit against the applicable requirements of FCC Part 2, 15, and Part 24.

11.1.1 Introduction

The purpose of this chapter is to present the test methodology used to verify FCC regulatory compliance of the PWAN Remote Unit.

Throughout this document, all depictions of test configurations utilize a common set of interfaces. These interfaces are described in detail in Chapter 7, "Operational Description" of this document. The name and purpose of each interface is summarized in Table 11.1 below:

Table 11.1 PWAN Interface Definitions

Interface ID	Description
T Interface	Terminal interface to Remote Units
A Interface	Air interface between Remote Units and Base Station radio equipment
P Interface	Interface between Base Station radio equipment and Base Station control
Csw Interface	Interface that provides public switched telephone network (PSTN) connectivity for call processing

11.1.2 Equipment Classification

The AT&T PWAN Remote Unit is designed to be mounted to a building, therefore it is classified as a "fixed station" as defined in Subpart 24.5 of the FCC Rules and Regulations. Consequently, the output power limitations associated with base stations described under FCC Subpart 24.232(a) were applied to this unit. However, it should be noted that the Effective Isotropic Radiated Power (EIRP) of the PWAN Remote Unit will not exceed 2 watts EIRP average power.

11.1.3 Remote Unit RF Frequency Stability vs. Temperature Test Methodology

11.1.3.1 Applicable FCC Rules Parts

FCC Subpart 2.995 - Measured over the temperature range of -30 to +50 C. Frequency measurements shall be made at the extremes and at intervals of not greater than 10 degrees C throughout the range. Only the frequency determining portions of the transmitter need be subjected to this test.

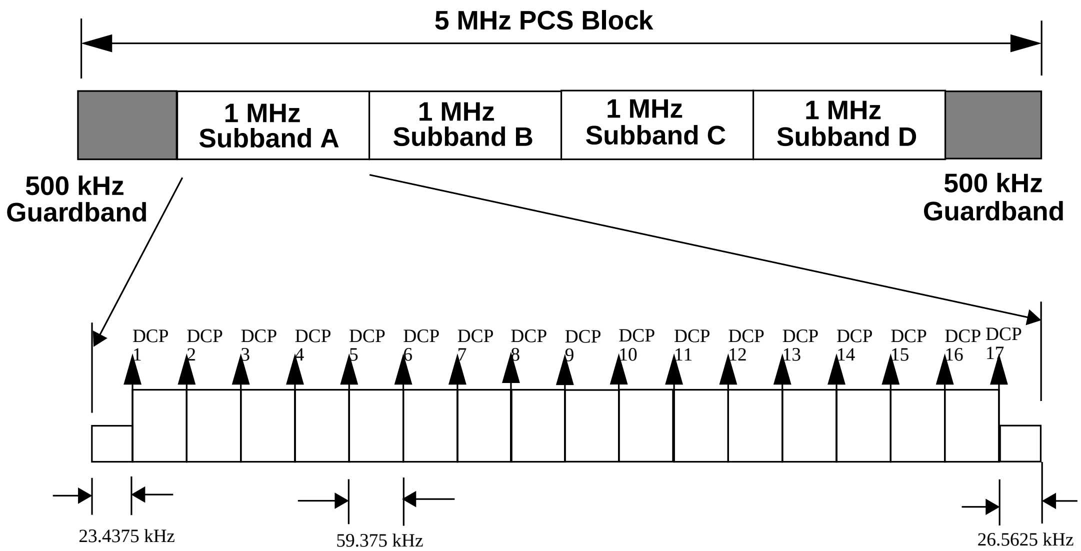
FCC Subpart 24.236 - The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

11.1.3.2 Overview

The PWAN Remote unit obtains its frequency stability from the serving Base Station by synchronizing its internal TCXO to the serving Base Station frequency reference pilots. If a remote unit is unable to locate the reference pilots from the serving Base Station, it will not transmit. Consequently, the frequency accuracy of the Remote Unit can be verified only while it is receiving a transmission from a Base Station.

Once a Remote Unit has synchronized to the serving base, it is capable of transmitting Delay Compensation Pilots (DCPs) upon request. DCPs consist of 17 tones with static modulation (fixed amplitude and phase) spaced at 59.375 kHz intervals beginning 23.4375 kHz from the lower edge of the 1 MHz transmit subband (refer to Figure 11.1). Any frequency error present in the Remote Unit reference oscillator and synchronization circuits will create a corresponding frequency error in each transmitted DCP tone.

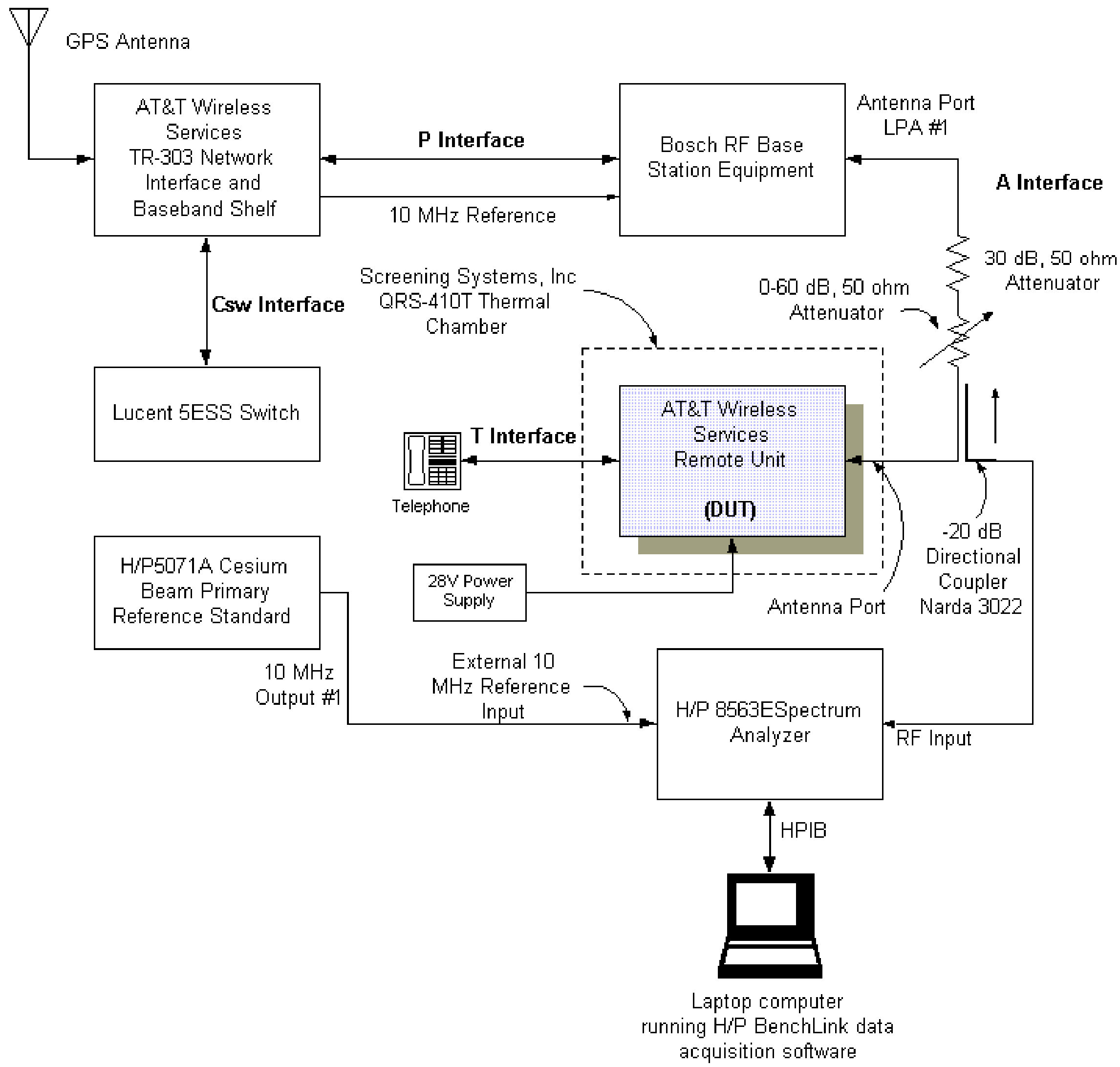
Figure 11.1 Remote Unit Delay Compensation Pilot Frequency Relationships



11.1.3.3 Test Methodology

The Remote Unit under test was placed into a Screening Systems, Inc. model QRS-410T thermal chamber. The standard Remote Unit antenna was replaced with a plate containing an RF connector. This change allowed a direct cabled connection between the Base Station and the Remote Unit while maintaining the integrity and thermal characteristics of the housing (refer to Figure 11.2).

Figure 11.2 Remote Unit Frequency Stability vs. Temperature Test Configuration



A Base Station in an adjacent room supplied the downlink signal necessary to permit synchronization of the Remote Unit. The Base Station reference oscillator was phase locked to GPS for the duration of the Remote Unit frequency stability tests. The frequency counter in a Hewlett-Packard 8563A Spectrum Analyzer was used to monitor the frequency of DCP tone #1 from the Remote Unit under test. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the spectrum analyzer's frequency counter. The spectrum analyzer's frequency counter resolution was set to 1 Hz.

The frequency accuracy of DCP tone #1 was tracked over the temperature range of -30 to +50 Celsius. During this test the thermal chamber "stair-stepped" from -40 to +60 degrees Celsius in temperature increments of 10 degrees Celsius. A sensing thermocouple placed inside the electronics compartment of the Remote Unit assured that the DUT was kept to within ±5 degrees Celsius of each pre-determined thermal step. The chamber held each thermal step for 15 minutes. The total run time was three hours per test.

The frequency error was calculated for each temperature step using the formula in Equation 11.1:

(Eq 11.1)

$$\mathrm{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1 \times 10^{6}\right) = \left(\left(\frac{f(\mathrm{measured}) - f(\mathrm{ideal})}{f(\mathrm{ideal})}\right) \cdot 1 \times 10^{6}\right)$$

11.1.4 Remote Unit Frequency Stability vs. Input Voltage Test Methodology

11.1.4.1 Applicable FCC Rule Parts

FCC Subpart 2.995 - Measured over the temperature range of -30 to +50 C. Frequency measurements shall be made at the extremes and at intervals of not greater than 10 degrees C throughout the range. Only the frequency determining portions of the transmitter need be subjected to this test.

FCC Subpart 24.236 - The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

11.1.4.2 Overview

The PWAN Remote unit obtains its frequency stability from the serving Base Station by synchronizing its internal TCXO to the serving Base Station frequency reference pilots. If a remote unit is unable to locate the reference pilots from the serving Base Station, it will not transmit.

Consequently, the frequency accuracy of the Remote Unit can be verified only while it is receiving a transmission from a Base Station.

Once a Remote Unit has synchronized to the serving base, it is capable of transmitting Delay Compensation Pilots (DCPs) upon request. DCPs consist of 17 tones with static modulation (fixed amplitude and phase) spaced at 59.375 kHz intervals beginning 23.4375 kHz from the lower edge of the 1 MHz transmit subband (refer to Figure 11.1). Any frequency error present in the Remote Unit reference oscillator and synchronization circuits will create a corresponding frequency error in each transmitted DCP tone.

Under normal operation, the Remote Unit is powered by an Uninterruptible Power Supply (UPS), that produces an output voltage of 28 volts, regulated to within ± 5%, regardless of the primary supply voltage or the internal battery voltage (down to the minimum battery cutoff voltage of 10.5 VDC). Although the power cable used for this test is not representative of an actual Remote Unit cable in terms of its length, the voltage range over which the Remote Unit was tested simulates a worst-case supply voltage over multiple lengths of cable, including the maximum length allowable in an actual equipment installation.

11.1.4.3 Test Methodology

The Remote Unit under test received a direct RF feed for frequency synchronization from the Base Station as shown in Figure 11.3. The Base Station reference oscillator was phase locked to GPS for the duration of the Remote Unit frequency stability tests. The frequency counter in a Hewlett-Packard 8563A Spectrum Analyzer was used to monitor the frequency of DCP tone #1 from the Remote Unit under test. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the spectrum analyzer's frequency counter. The spectrum analyzer's frequency counter resolution was set to 1 Hz.

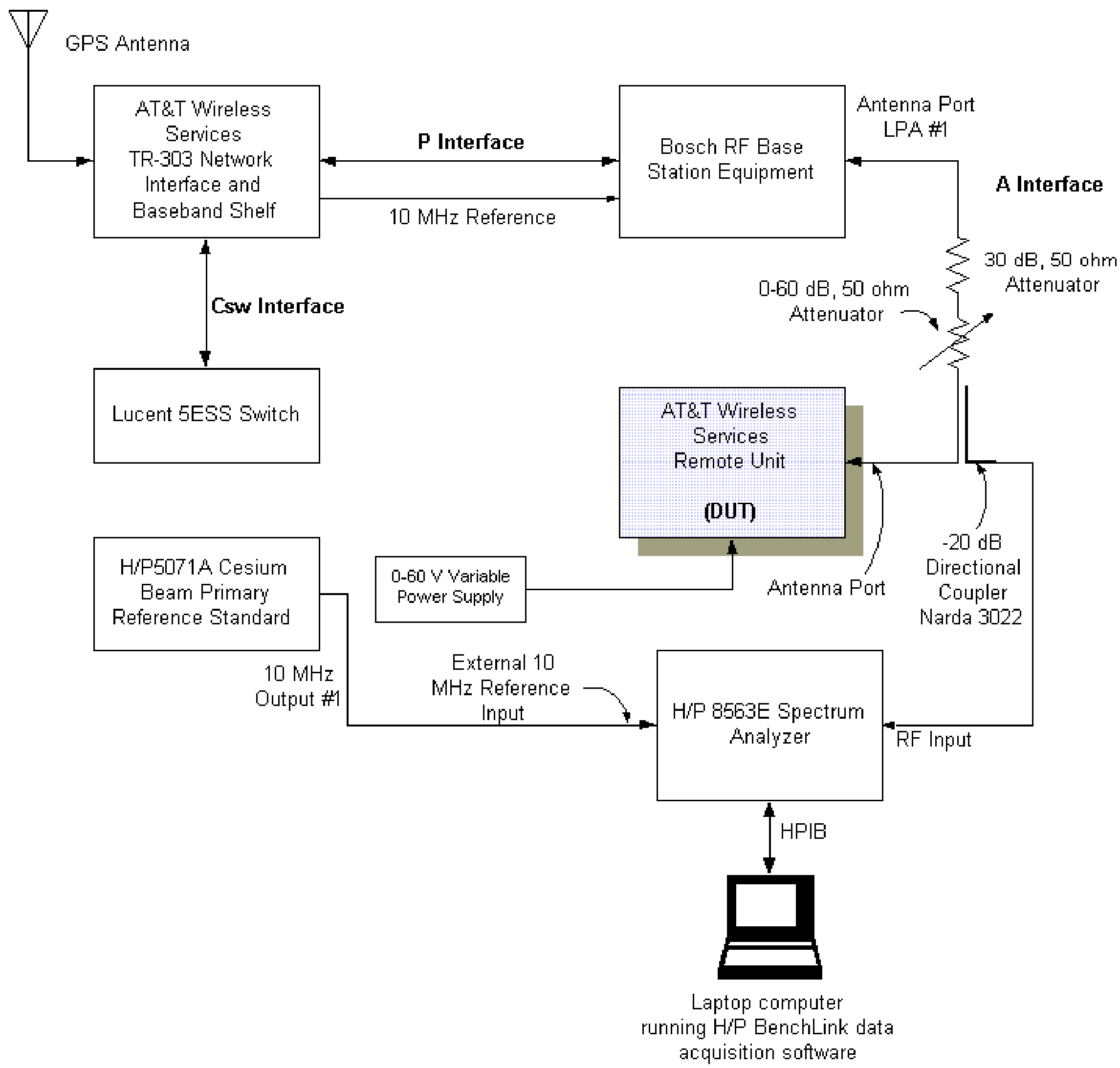
The frequency accuracy of DCP tone #1 was tracked while varying the Remote Unit supply voltage in 0.5 volt steps from a minimum of -23.5 volts to a maximum of -32.5 volts (±15% of the nominal -28-volt input voltage).

The frequency error was calculated for each temperature step using the formula in Equation 11.2:

(Eq 11.2)

$$\text{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1\times10^6\right) = \left(\left(\frac{f(\text{measured}) - f(\text{ideal})}{f(\text{ideal})}\right) \cdot 1\times10^6\right)$$

Figure 11.3 Remote Unit Frequency Stability vs. Input Voltage Test Configuration



11.1.5 Remote Unit Occupied Bandwidth Test Methodology

11.1.5.1 Applicable FCC Rule Parts

FCC Subpart 2.989 - Occupied bandwidth is defined as 99% of the total mean power, measured according to Subpart 2.989 (i), which requires full loading of the baseband, modulated such that the occupied bandwidth is consistent with that expected during normal operation.

11.1.5.2 Overview

PWAN Remote Unit transmitter occupied bandwidth measurements do not differ substantially from any other system. The occupied bandwidth of a PWAN Remote Unit is maximized when all 17 of its Delay Compensation Pilots (DCPs) are active. However, this is an infrequent occurrence, taking place for only 1.5 ms during Solicited Common Access Channel (SCAC) bursts. SCAC bursts occur only when the Remote Unit is responding to an access command from the Base Station (such as during a Base Station-Remote Unit call setup), and as a result the transmission of DCP tones comprise a very small percentage of the transmit activity from a Remote Unit. Under normal operating conditions, the Remote Unit's occupied bandwidth is maximized during a High-Speed Data session when two FDMA slots are simultaneously active in a single TDMA slot. However, the worst-case occupied bandwidth will not exceed that of the Remote Unit operating with DCPs only, so they were used as the stimulus during the execution of this test.

11.1.5.3 Test Methodology

A software switch in the Remote Unit was set to generate constant Delay Compensation Pilots. The resulting transmitter output was sampled through a -20 dB directional coupler and viewed with a Hewlett-Packard 89441A Vector Signal Analyzer using the Hewlett-Packard 89451A Digital Radio Personality option, set up to measure 99% Occupied Bandwidth (refer to Figure 11.4). The configuration parameters of the 89451A are listed in Table 11.2.

Figure 11.4 Remote Unit Occupied Bandwidth and Modulation Characterization Test Configuration

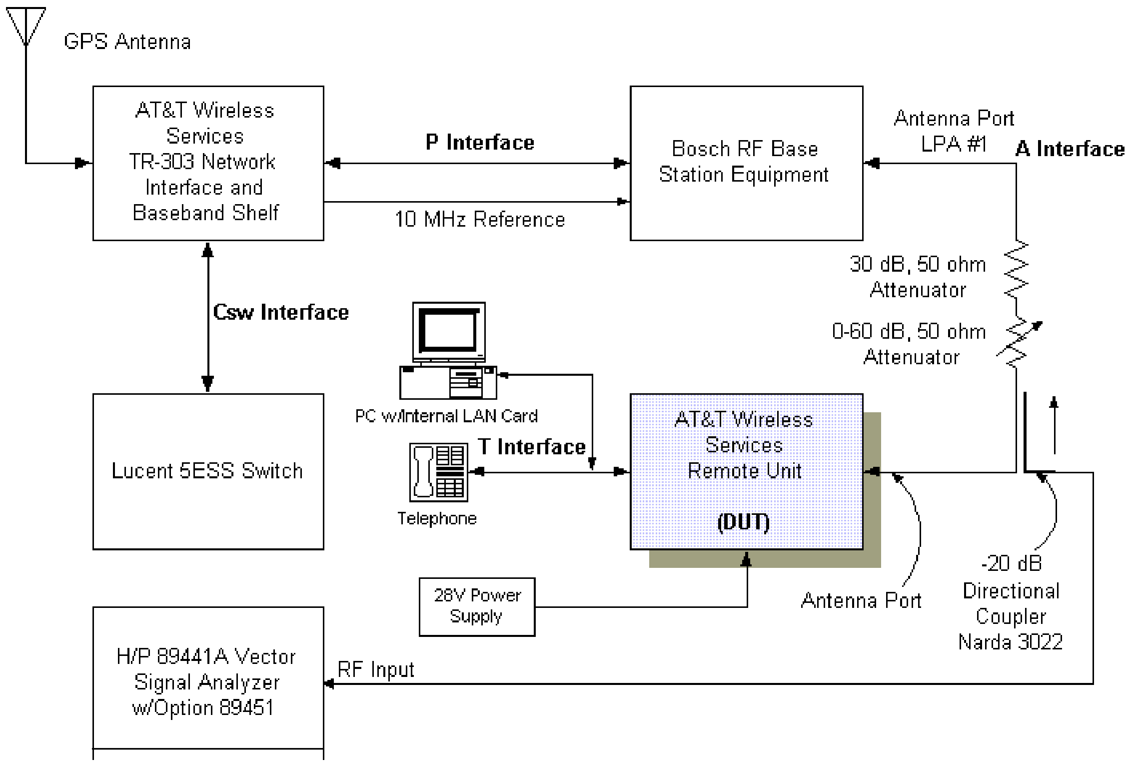


Table 11.2 Hewlett-Packard 89441A Occupied Bandwidth Test Parameters

Parameter	Value
Center Frequency	1869.0 MHz
Span	1 MHz
Main Time Length	400 µs
Gate Time Length	320 µs
Gate Delay	50 µs
Trigger Type	IF Channel 1
Input Level	+10 dBm
External Attenuation	21.1 dB
Trigger Delay	Selected to center 320 µs transmission bursts in time gate (typically -43 µs)
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential

11.1.6 Modulation Characterization Test Methodology

11.1.6.1 Applicable FCC Rules

FCC Subpart 2.987 - Requires a curve or equivalent data which shows that the equipment will meet the requirements of the rules under which the equipment is to be licensed. Provide data showing that the modulation being employed does not cause the spectral purity to exceed the requirements of 2.985 and 24.238.

11.1.6.2 Overview

The modulation characteristics of the PWAN Remote Unit transmitter differ substantially from any other system. The OFDM time-domain waveform transmitted by the Remote Unit is a composite of several discrete logical “channels”. In this test, each logical “channel” was characterized individually in both the time and frequency domain. The channels characterized by this measurement include:

- Single Voice traffic channel
- High-Speed Data traffic channel
- Network Access channel
- Delay Compensation channel

These logical channels are described in detail in Chapter 2 of this document.

A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize each of the discrete channels listed above. For each channel, the 89441A was used to obtain the following information:

- 99% occupied bandwidth in kHz
- Integrated power across the measured occupied bandwidth in dBm
- Power vs. frequency (in dBm) at a 12 kHz resolution bandwidth
- Time-domain average RF burst power
- Complimentary Cumulative Distribution Function (CCDF) of the peak to average ratio made up of *x* samples of the time-domain RF bursts

The specific operating parameters of the Hewlett-Packard 89441A Vector Signal Analyzer are summarized in Table 11.3

Table 11.3 Hewlett-Packard 89441A Modulation Characterization Test Parameters

Parameter	Value
Center Frequency	1869.0 MHz
Span	1 MHz
Main Time Length	400 us
Gate Time Length	320 us
Gate Delay	50 µs
Trigger Type	IF Channel 1
Input Level	+10 dBm
External Attenuation	21.1 dB
Peak/Average Metric	99.0%
Trigger Delay	Selected to center 320 µs transmission bursts in time gate (typically -43 µs)
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1601
Resolution BW	12 kHz

11.1.6.3 Test Methodology

Single Voice Channel

A single telephone call was established between the Remote Unit under test and the Base Station using the test configuration shown in Figure 11.4. The Hewlett-Packard 89441A Vector signal analyzer was configured according to the parameters shown in Table 11.3. The random nature of the data produced by the LD-CELP compression algorithm is sufficient to assure results representative of a normally operating system.

High-Speed Data Channel

An HSD session was established between the Remote Unit under test and the Base Station using the test configuration shown in Figure 11.4. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.3. During this test, a text file was transferred from the Remote Unit to an FTP server on the AWS network. The random nature of the data contained in this file is sufficient to assure results representative of a normally operating system.

Network Access Channel

Characterization of the network access channel took place utilizing the test configuration shown in Figure 11.4. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

In normal operation, transmission of unsolicited network access bursts is kept to a minimum to reduce contention on the shared common access channel. In this test, in order to obtain statistically meaningful measurement of the peak power and the peak/average ratio, greater transmission persistence from the DUT was required. This was accomplished by disabling the uplink receiver in the Base Station. Without any network access acknowledgments from the Base Station, the DUT was capable of transmitting multiple Network Access bursts, which were measured and analyzed.

Delay Compensation Channel

The Remote Unit Delay Compensation Pilots (DCPs) were characterized using the test configuration shown in Figure 11.4. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

In normal operation, an Remote Unit will only transmit DCPs for 1.5 ms during a solicited network access attempt. However, the Remote Unit is capable of supporting a test function by which it will transmit DCPs in four of the eight TDMA slots continuously. This test mode was utilized for the characterization of the Delay Compensation channel.

11.1.7 RF Output Power Test Methodology

11.1.7.1 Applicable FCC Rules

FCC Subpart 24.232 - Base stations are limited to 1640 watts EIRP peak power, and in no case shall the output power of a base station exceed 100 watts. Peak transmitter power may be measured over any interval of continuous transmission using instrumentation calibrated in terms of RMS equivalent voltage. The measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc., so as to obtain a true peak measurement for the emission in question over the full bandwidth of the channel.

11.1.7.2 Overview

Peak RF Output Power from the Remote Unit is maximized during High Speed Data (HSD) operation. Consequently, maximum RF output power was characterized while the Remote Unit was operating in this mode.

A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize the Remote Unit’s composite RF output signal according to the following criteria:

- Time-domain average burst power
- Time-domain peak envelope burst power at the 99.0% level
- Time-domain peak/average ratio at the 99.0% level

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Table 11.4 Hewlett-Packard 89441A RF Power Test Parameters

Parameter	Value
Center Frequency	1869.0 MHz
Span	1 MHz
Main Time Length	400 µs
Gate Time Length	320 µs
Gate Delay	50 µs
Input Level	+10 dBm
External Attenuation	21.1 dB

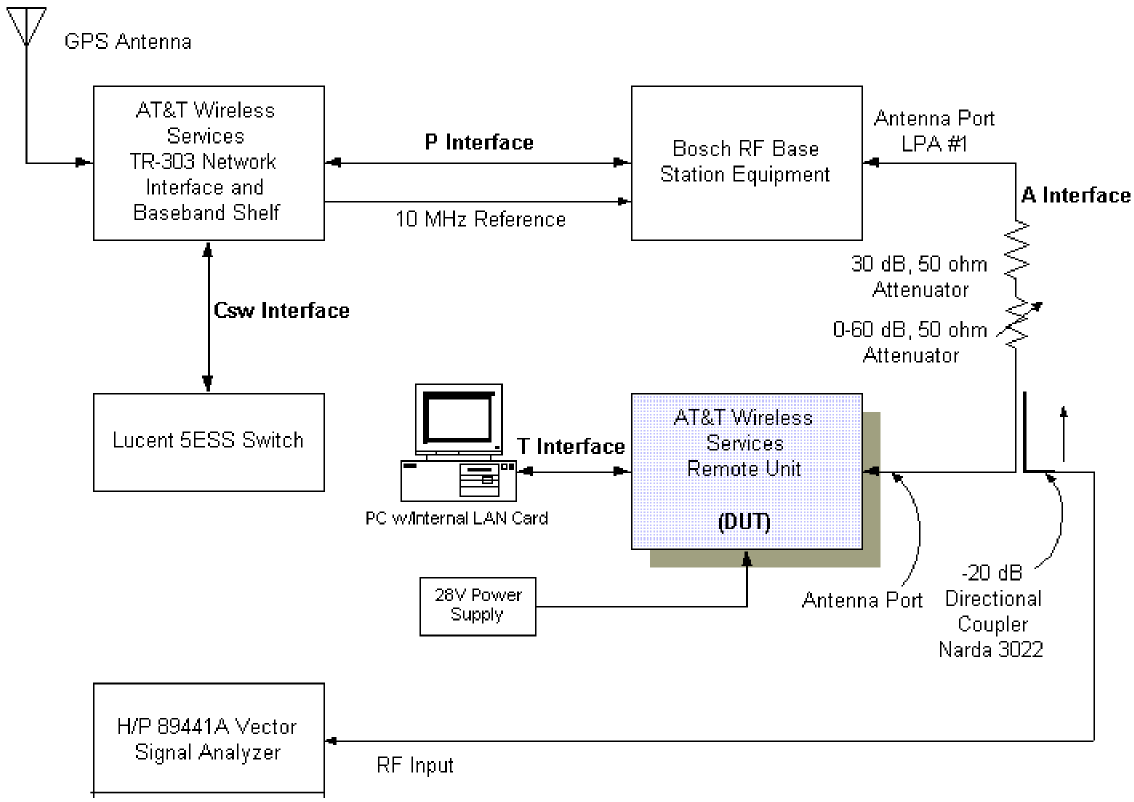
Table 11.4 Hewlett-Packard 89441A RF Power Test Parameters

Parameter	Value
Peak/Average Metric	99.0%
Trigger Type	IF Channel 1
Trigger Delay	Selected to center 320 µs transmission bursts in time gate (typically -43 µs)
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1601
FFT Resolution BW	12 kHz

11.1.7.3 Test Methodology

For this test, an HSD session was established between the Remote Unit under test and the Base Station using the test configuration shown in Figure 11.5. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.4. During this test, a text file was transferred from the Remote Unit to an FTP server on the AWS network. The random nature of the data contained in this file is sufficient to assure results representative of a normally operating system. A -20 dB directional coupler provided the required RF sample for measurement

Figure 11.5   Remote Unit Output Power Test Configuration



11.1.8 Spurious Emissions at the Antenna Terminal Test Methodology

11.1.8.1 Applicable FCC Rules

FCC Subpart 2.985 - Requires that the RF Output be measured at the antenna power terminals into a dummy load after the transmitter has been adjusted in accordance with the manufacturers tune up procedure. Requires documentation of measurement configuration. Transmitter spectral output shall not have any components that exceed the spectral mask applicable to the rule part under which the equipment shall be operated.

FCC Subpart 24.238 - On any frequency outside a licensee’s block, the power of any emission shall be attenuated below the transmitter power (P) by at least 43+10Log(P) dB. Compliance is based on measurement within a 1 MHz resolution bandwidth. However, in the 1 MHz bands immediately adjacent to the frequency block a resolution bandwidth of at least 1 percent of the emission bandwidth may be employed. The emission bandwidth is defined as the width of the signal between two points, one above and one below the carrier frequency, outside of which all emissions are attenuated by at least 25 dB below the transmitter power.

11.1.8.2 Overview

The RF spectral purity of the Remote Unit transmitter does not differ substantially from a conventional TDMA transmitter, other than the characteristics of any intermodulation products that are produced. Intermodulation products are only generated during the TDMA slots occupied by the Remote Unit, consequently, accurate emissions measurements must be synchronized to the transmitted bursts. This implies the use of a receiver capable of performing an FFT triggered on the presence of RF burst energy. This requirement is met by the Hewlett-Packard 89441A Vector Signal Analyzer, which was used to characterize the emissions from the Remote Unit transmitter while operating at full peak output power. The specific operating parameters of the Hewlett-Packard 89441A Vector Signal Analyzer are summarized in Table 11.5. The emission mask utilized through the course of this test is shown in Figure 11.6.

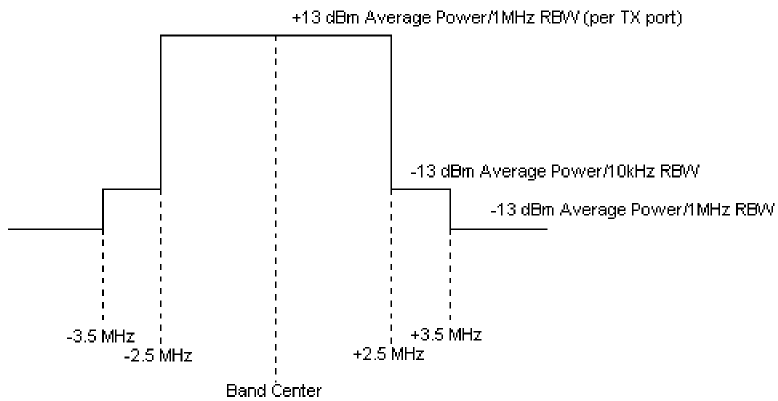
Table 11.5 Hewlett-Packard 89441A Spectral Purity Test Configuration Parameters

Parameter	Value
Center Frequency	Varies with measurement
Span	4 MHz and 7 MHz
Main Time Length	400 µs @ 4MHz Span, 229 µs @ 7 MHz Span
Gate Time Length	320 µs @ 4 MHz Span, 229 µs @ 7 MHz Span
Gate Delay	50 µs @ 4 MHz Span, 0 µs @ 7 MHz Span
Input Level	+20 dBm
External Attenuation	11.2 dB

Table 11.5 Hewlett-Packard 89441A Spectral Purity Test Configuration Parameters (continued)

Trigger Type	IF Channel 1; Free Run for measurements with fundamental outside of span
Trigger Delay	-43 µs @ 4 MHz span, +50 µs @ 7 MHz span
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1601
Resolution BW	12 kHz @ 4 MHz Span, 17 kHz @ 7 MHz Span

Figure 11.6 RU Conducted Power Spectral Mask



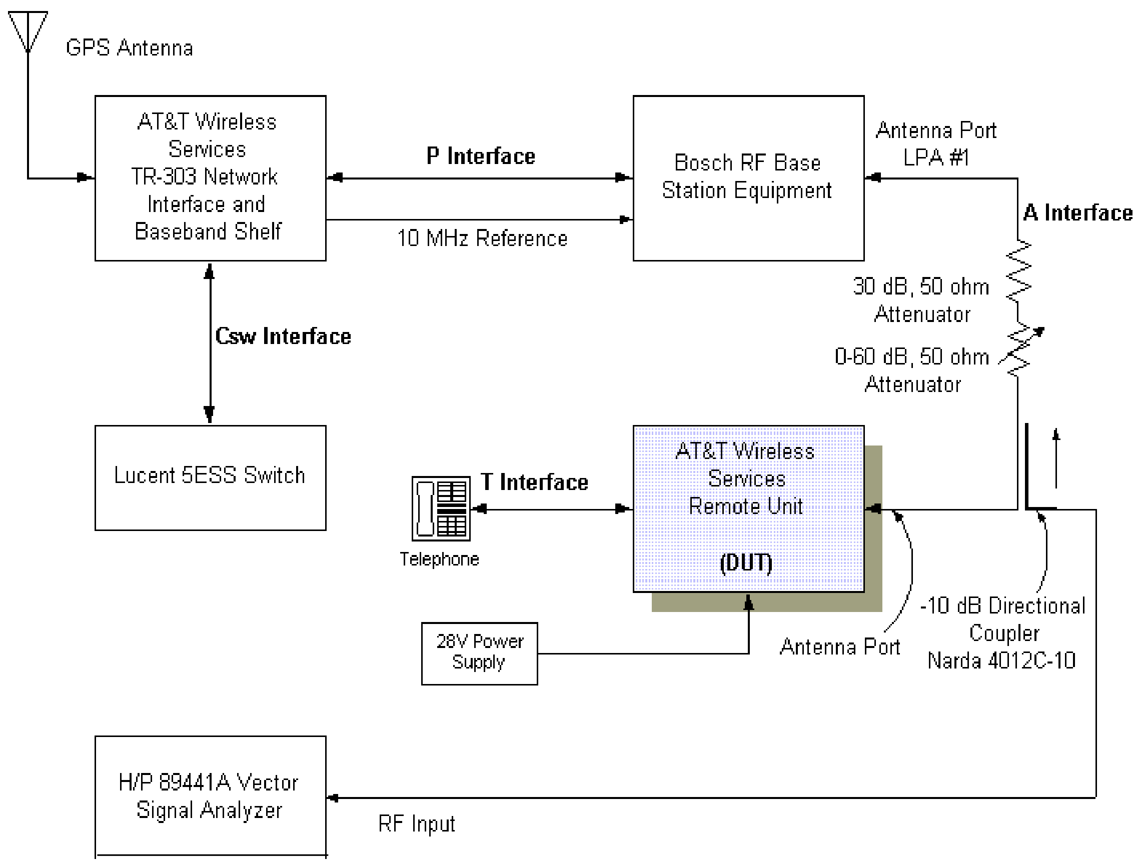
11.1.8.3 Test Methodology

RF Output Power and Out-Of-Band (OOB) emissions from the Remote Unit are maximized when transmitting Delay Compensation Pilots at an “elevated” power level. For this test, the DCP average power level was increased to the point where the DCP peak power was equal to the peak power of an HSD session. Under normal operation, Delay Compensation Pilots are transmitted for 1.5 ms during Solicited Common Access Channel (SCAC) attempts, such as during airlink setup when the Base Station is terminating a call to a Remote Unit. As a result, DCP transmissions are typically infrequent, however, the nature of the tones that make up the DCP suite lend themselves to the evaluation of spurious output from the Remote Unit, as any intermodulation products produced by the Remote Unit are maximized. For this test, a software switch in the Remote Unit was set to transmit continuous DCP tones during four of the eight TDMA slots, and the transmitter attenuators were set to obtain a peak power with DCP stimulus equivalent to an HSD session (≈+22 dBm). This power level simulates a worst-case condition for the generation of IM products.

Spectral purity measurements were made with the Remote Unit operating in the lowest and highest subbands allocated in the “D” PCS block. Any Out-Of-Band (OOB) intermodulation and spurious signals will be contributed by RUs operating in the exterior subbands. OOB spectral contributions from Remote Units operating within the two interior subbands will be negligible.

A Hewlett-Packard 89441A Vector Signal Analyzer was used to evaluate the spectral purity of the Remote Unit. The test configuration is shown in Figure 11.7. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.3.

Figure 11.7 Spectral Purity Test Configuration



The Vector Signal Analyzer was configured to trigger on the presence of RF burst energy during all measurements over spans that included the Remote Unit fundamental. Measurements over spans that did not include the Remote Unit fundamental were made with the Vector Signal Analyzer trigger disabled (free-running).

The 89441A VSA is optimized to provide highly accurate measurements in the frequency-domain with narrow resolution bandwidths. Conversely, the instrument does not perform well with the wide (1 MHz) resolution bandwidths required by §2.985 and §24.238. However, the 89441A is capable of making integrated power measurements across any desired bandwidth, the results of which are identical to using a 1 MHz resolution bandwidth in a conventional spectrum analyzer. All spectral purity measurements made with the 89441A utilized a 12 kHz resolution bandwidth for 4 MHz spans and a 17 kHz resolution bandwidth for 7 MHz spans. Band power markers (set to 1 MHz BW) were used to measure the total integrated power in 1 MHz segments at frequencies of concern across the range of 1853 to 1882 MHz. Emissions at all applicable frequencies above and below this range have been documented in Section 11.3.4.3, "Radiated to Conducted Spurious Emissions."

11.1.9 RF Human Exposure

11.1.9.1 Applicable FCC Rules

FCC Subpart 24.51 - Applications for Type Approval of transmitters operating within the PCS region must determine that the equipment complies with IEEE C95.1-1991, "IEEE Standards for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" as measured using methods specified in IEEE C95.3 - 1991, "Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave."

11.1.9.2 Overview

Bioelectromagnetics Consulting (BEMC), Schmid & Partner Engineering AG (SPEAG), and SARTest Ltd. were each provided with a physical model of the RU antenna, which consisted of a 4 patch antenna array fed from a stripline network connected to two coaxial cable input power connectors. The patch antenna array and stripline network was backed by a ground plane designed to be bolted to a mounting framework and covered by a HB plastic radome. The gain of the antenna as provided by the manufacturer was measured to be 15.03 dBi when each coaxial input connector is fed with in phase equal power. For this analysis the total input power at a frequency of 1.92 GHz was split equally between coaxial feed connectors.

11.1.9.2.1 Test Methodology

The Remote Unit RF Human Exposure verification was accomplished by completing both an FDTD model analysis and SAR testing. The FDTD analysis technique was used to calculate the near and far fields and induced SAR patterns in exposed tissues from the antenna. The FDTD technique is currently the most popular theoretical method of choice for analyzing the safety and compliance of wireless technology devices with human RF exposure MPLs. In addition to the FDTD analysis, SAR testing was setup at two independent laboratories. Both homogeneous and non-homogeneous SAR testing was completed on head and upper torsal models.

11.1.10 Radiated Emissions

11.1.10.1 Applicable FCC Rules

FCC Subpart 15.209 - The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the field strength levels specified in table 15.209 (a). Emission limits shown in the table below 1000 MHz are based on measurements employing a CISPR quasi-peak detector. Emission limits above 1000 MHz are based on measurements employing an average detector.

11.1.10.2 Overview

The radiated emissions from the Remote Unit must not exceed the levels as stated within the FCC Part 15, Class B requirements. The testing provides the necessary assurance that the RU when installed in a typical field environment will not interfere with other electronic devices. To make the appropriate measurements the RU must be setup in a typical installation configuration and made operational. Utilizing an EMI receiver and quasi-peak detector radiated measurements shall meet the FCC limits as specified in subpart 15.207.

11.1.10.3 Test Methodology

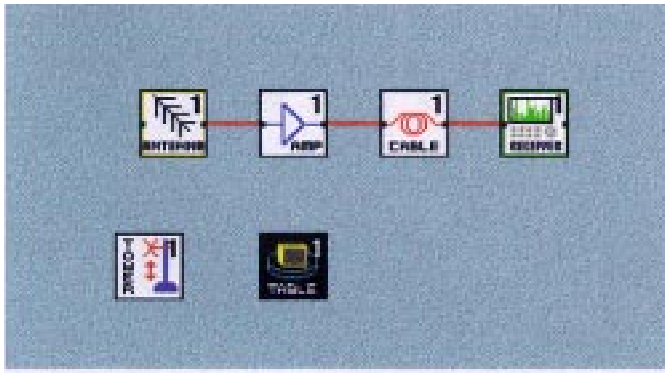
Radiated emissions measurements shall be made over the frequency range specified by the regulatory agency. In this case, per FCC Part 15, subpart 15.207. Measurements shall be made at the EUT azimuth and antenna height such that the maximum radiated emissions level will be detected. This was accomplished using both an automated 360 degree turntable and 1 to 4 meter height antenna positioners. Sixteen azimuth cuts at 22.5 degrees and 1 to 4 meter antenna scans in both polarizations were utilized. The Remote Unit was setup in a typical field configuration, as shown in Figure 12.1, consisting of the RU being attached to the mounting bracket and the bracket be mounted to a vertical piece of typical house siding which was placed on the center of a wooden table located in the center of the turntable. Proper interconnecting cable was utilized from the RU to the system power supply via the network interface device (NID). Various cable lengths were utilized to determine worse case configuration and a Base Station antenna was placed in the chamber for RU wireless communication. All radiated emissions testing was completed in three configurations; 1) with only one continuous voice channel, 2) with both voice channels continuously utilized, and 3) with both voice channels and the high speed data (HSD) be continuously utilized. Testing was completed from 30 MHz to 26 GHz. When testing close to or over the fundamental frequency range, a notch filter tuned to the RU and Base Station fundamental frequencies was utilized to prevent receiver overload and/or damage.

The RU test configuration and test setup photos can be found in Chapter 12, “Test Setup Photos”.

11.1.10.4 Radiated Emissions Equipment Configuration 30-1000 MHz

Completing FCC Part 15 radiated emissions for the RU required the test equipment as shown in Table 11.18. The test equipment was setup, monitored, and operated as shown in Figure 12.1 and Figure 11.8, consisting of an HP 8546A EMI Receiver, measured cable, pre-amplifier, and EMI antenna. The measurement equipment includes a turntable, antenna mast, and dual position controller to properly scan and step the antenna and EUT, respectively. Testing was completed with the measurement equipment located within a shielded control room chamber.

Figure 11.8 Equipment Set Graph



11.1.10.4.1Equipment Settings

The following is list detailing the individual pieces of equipment and their settings used to complete the 30 -1000 MHz radiated emissions measurement, including antenna scan heights and turntable azimuth settings.

Setting Details

Config. band: 30MHz - 1000 MHz

Antenna 1: Horizontal and Vertical Polarizations

Cable 1: 53-foot RG-214

Tower 1: 1 to 4 meter scan

Turntable 1: 22.5 degree steps during scans

Amplifier 1: PREAMP OFF

Receiver I (Standard)

EMI BW (RBW): Default FCC

Average BW (VBW): Default FCC

Attenuation: Auto

Reference level: Auto

Sweep time: Auto

Input: Input #2 (20 MHz - 2.9 GHz)

Receiver I (Maximization)

EMI BW (RBW): Default FCC

Average BW (VBW): Default FCC
Attenuation: Auto
Reference level: Auto
Sweep time: Auto
Span: Auto
Single signal per segment: No
Amplitude resolution: 10 dB/div
Detector: Sample
Input: Input #2 (20 MHz - 2.9 GHz)
Maximization traces
  Max. step-mode dwell: 1 sec / 1 sweeps
  Video average: None
  Remove impulses: No
Demodulation: Off

11.1.10.5 Measure Parameters

Measurements for radiated emissions were completed during the first pass with a peak detector, with the following settings:

Peak

- Auto settings: Yes
- Span 240 kHz, RBW 120 khz, VBW 1000 kHz
- Max dwell time: *5* seconds
- Max number of sweeps: *5* seconds

Measurements for radiated emissions were completed on all peak detected signals that exceeded the limit line margin with a quasi-peak detector at the following settings:

QP

- Auto settings: Yes
- Span 90 kHz, RBW 120 kHz, VBW 1000 kHz
- Max dwell time: *5* seconds
- Max number of sweeps: *5* seconds

The tune and listening settings were set to the following span, resolution, and video bandwiths:

Tune/Listen setting

- Narrow span 100 kHz, RBW 30 kHz, VBW 10 kHz

11.1.10.6Antenna Factors

The Chase, model CBL6111 EMI measurement antenna was used for radiated emissions measurements from 30 - 1000 MHz. The antenna correction factors are shown in Table 11.6.

Table 11.6 Antenna Factors

Frequency (MHz)	Amplitude (db/m)
30	18.4
35	16.4
40	13.7
45	11.1
50	8.6
60	6.4
70	6.8
80	7.4
90	8.5
100	9.5
120	11.8
125	12
140	11.6
150	11.1
160	10.5
175	9.4
180	9.2
200	9
250	12.1
300	13

Table 11.6 Antenna Factors (continued)

Frequency (MHz)	Amplitude (db/m)
400	15.4
500	17.5
600	19.3
700	20.6
800	21.2
900	22.1
1000	24.1

11.1.10.7Cable Factors

The measurement system setup, as shown in Figure 11.8 is interconnected with 53 feet of RG214 coaxial cable. The cable insertion loss was measured and documented for receiver data correction. Table 11.7 outlines the measurement system's cable correction factors.

Table 11.7 Cable Corrections

Frequency (MHz)	Amplitude (dB)
30	-0.74
40	-0.85
50	-0.95
60	-1.05
70	-1.16
80	-1.23
90	-1.31
100	-1.39
120	-1.52
140	-1.7
160	-1.81
180	-1.93
200	-2.05
220	-2.14
240	-2.3
260	-2.4
280	-2.48
300	-2.58

Table 11.7 Cable Corrections (continued)

Frequency (MHz)	Amplitude (dB)
320	-2.65
340	-2.76
360	-2.88
380	-2.96
400	-3.04
420	-3.13
440	-3.19
460	-3.27
480	-3.34
500	-3.4253
520	-3.5
540	-3.59
560	-3.66
580	-3.72
600	-3.79
620	-3.87
640	-3.97
660	-4.03
680	-4.1
700	-4.16
720	-4.25
740	-4.33
760	-4.41
780	-4.47
800	-4.5
820	-4.55
840	-4.67
860	-4.75

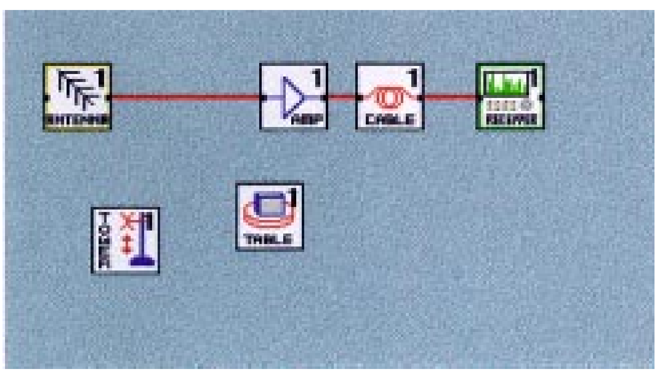
Table 11.7 Cable Corrections (continued)

Frequency (MHz)	Amplitude (dB)
880	-4.85
900	-4.85
920	-4.89
940	-4.94
960	-5
980	-5.1
1000	-5.1881

11.1.10.8 Radiated Emissions Equipment Configuration 1000-3500 MHz

Completing FCC Part 15 radiated emissions for the RU required the test equipment as shown in Table 11.18. The test equipment was setup, monitored, and operated as shown in Figure 12.1 and Figure 11.9, consisting of an HP 8546A EMI Receiver, measured cable, pre-amplifier, and EMI antenna. The measurement equipment includes a turntable, antenna mast, and dual position controller to properly scan and step the antenna and EUT, respectively. Testing was completed with the measurement equipment located within a shielded control room chamber.

Figure 11.9 Equipment Set



Equipment Settings

The following is list detailing the individual pieces of equipment and their settings used to complete the 1000 -3500 MHz radiated emissions measurement, including antenna scan heights and turntable azimuth settings

Config. band: 1000 MHz - 6000 MHz Antenna 1:
Cable 1: 53-foot RG-214

Tower 1: 1 to 4 meter scan

Turntable 1: 22.5 degree steps during scans

Amplifier 1: Preamp ON;

Receiver 1 (Standard)

- EMI BW (RBW): 1000 kHz
- Average BW (VBW): 1000 kHz
- Attenuation: Auto
- Reference level: Auto
- Sweep time: Auto
- Input: Input #2 (1 GHz - 3.5 GHz)

Receiver 1 (Maximization)

- EMI BW (RBW): 1000 kHz
- Average BW (VBW): 1000 kHz
- Attenuation: Auto
- Reference level: Auto
- Sweep time: Auto
- Span: Auto
- Single signal per segment: No
- Amplitude resolution: 10 dB/div
- Detector: Sample
- Input: Input #2 (1 GHz - 6.5 GHz*)*
- Maximization traces
  - Max. step-mode dwell: 1 sec / 1 sweeps
  - Video average: None
  - Remove impulses: No
- Demodulation: Off

11.1.10.8.1Measure Parameters

Measurements for radiated emissions were completed during the first pass with a peak detector, with the following settings:

Peak

- Auto settings: Yes
- Span 240 Hz, RBW 1000 kHz, VBW 1000 kHz
- Max dwell time: *5* seconds
- Max number of sweeps: *5* seconds

Measurements for radiated emissions were completed on all peak detected signals that exceeded the limit line margin with an average detector at the following settings:

Average

- Auto settings: Yes
- Span 90 kHz, RBW 1000 kHz, VBW 1000 kHz
- Max dwell time: *5* seconds
- Max number of sweeps: *5* seconds
- Auto selection of avg. VBW: Yes

The tune and listening settings were set to the following span, resolution, and video bandwisths:

Tune/Listen setting

- Narrow span 100 kHz, RBW 30 kHz, VBW 10 kHz

11.1.10.8.2 Antenna Factors

The EMCO, model 3115 EMI measurement horn antenna was used for radiated emissions measurements from 1000 - 3500 MHz. The antenna correction factors are shown in Table 11.8.

Table 11.8 Antenna Factors

Frequency (MHz)	Amplitude (dB/m)
1000	24.8
1500	24.9
2000	27.1
2500	28.7
3000	30.9
3500	33
4000	32.2
4500	32.2
5000	33.7
5500	34.7
6000	35.2
6500	35.1
7000	36
7500	37
8000	37.4
8500	38.6
9000	38.8
9500	38.6
10000	38.2
10500	38.4
11000	38.8
11500	39.2
12000	39.2
12500	39.5
13000	40.5
13500	41
14000	41.8
14500	40.8

Table 11.8 Antenna Factors

Frequency (MHz)	Amplitude (dB/m)
15000	39
15500	37.9
16000	38.2
16500	40.6
17000	43.9
17500	45.6
18000	46.7

11.1.10.9Cable Factors

The measurement system setup, as shown in Figure 12.1 and Figure 11.9 is interconnected with 53 feet of RG-214 coaxial cable. The cable insertion loss was measured and documented for receiver data correction. Table 11.9 outlines the measurement system's cable correction factors.

Table 11.9 Cable Corrections

Frequency (MHz)	Amplitude (dB)
1000	-4.5
1100	-4.8
1200	-5
1300	-5.2
1400	-5.5
1500	-5.7
1600	-6
1700	-6.2
1800	-6.4
1900	-6.6
2000	-6.8
2100	-7.2
2200	-7.4
2300	-7.8
2400	-7.8
2500	-7.8
2600	-8.2
2700	-8.4

Table 11.9 Cable Corrections (continued)

Frequency (MHz)	Amplitude (dB)
2800	-9
2900	-9
3000	-9.2
3100	-9.7
3200	-9.7
3300	-10.5
3400	-10.5
3500	-10.6

11.2 RF Characterization Test Results

This section describes the test results obtained during the validation of the AT&T Wireless Services Remote Unit against the applicable requirements of FCC Part 2 and Part 24.

11.2.1 Test Equipment List

Test cases within this section were completed utilizing the equipment in the following table. Calibration of equipment, where required, was completed by Hewlett Packard and tracks to NIST.

Table 11.10 Test Equipment

Instrument Name	Manufacturer	Model Number	Serial Number	Calibration Last Date	Calibration Due Date
Thermal Chamber	Screening Systems Inc.	QRS-410T	9511-110	N/A	N/A
Directional Coupler	Narda	3022	76836	N/A	N/A
Directional Coupler	Narda	4012C-10	11626	N/A	N/A
Signal Generator	Hewlett-Packard	8657B	2935U00456	5/11/98	5/11/99
Power Meter	Hewlett-Packard	EPM-442A	GB37170555	5/14/98	5/14/99
Power Sensor	Hewlett-Packard	8482A	3318A26922	5/27/98	5/27/99
Cesium Beam Clock	Hewlett-Packard	5071A	3249A00701	N/A	N/A
Vector Signal Analyzer	Hewlett-Packard	89441A	3416A01258	5/13/98	5/13/99
Frequency Counter	Hewlett-Packard	53132A	3736A06180	08/21/98	08/21/99
Spectrum Analyzer	Hewlett-Packard	8563E	5317A03669	5/1/97	5/1/99
Network Analyzer	Hewlett-Packard	8753E	US377390776	5/15/98	5/15/99

11.2.2 Equipment Under Test List

Test cases within this section were executed using the equipment under test listed in Table 11.11.

Table 11.11 EUT Equipment Under Test List

Board Type	Serial No.	Revision Level
RF Board	185206980922	B
Digital Board	175259981022	6
Network Interface Board	135236981020	1

11.2.3 Remote Unit RF Frequency Stability vs. Temperature Test Results

11.2.3.1 Applicable FCC Rules Parts

FCC Subpart 2.995 - Measured over the temperature range of -30 to +50 C. Frequency measurements shall be made at the extremes and at intervals of not greater than 10 degrees C throughout the range. Only the frequency determining portions of the transmitter need be subjected to this test.

FCC Subpart 24.236 - The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

11.2.3.2 Test Configuration

The Remote Unit under test was placed into a Screening Systems, Inc., model QRS-410T thermal chamber (refer to Figure 11.2).

The frequency accuracy of DCP tone #1 was tracked over the temperature range of -30 to +50 Celsius. During this test the thermal chamber “stair-stepped” from -40 to +60 degrees Celsius in temperature increments of 10 degrees Celsius. A sensing thermocouple placed inside the electronics compartment of the Remote Unit assured that the device under test was kept to within ±5 degrees Celsius of each pre-determined thermal step. The chamber held each thermal step for 15 minutes.

The Remote Unit transmit frequency error was calculated for each temperature step using the formula in Equation 11.3:

(Eq 11.3)

$$\text{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1\times10^{6}\right) = \left(\left(\frac{f(\text{measured}) - f(\text{ideal})}{f(\text{ideal})}\right) \cdot 1\times10^{6}\right)$$

The ideal frequency for DCP tone #1 is exactly 23.4375 kHz above the bottom edge of the selected 1 MHz subband. For example, if the Remote Unit is operating in the first 1 MHz subband within the “D” PCS block, the bottom edge of the subband is 1865.5 MHz. Consequently, the ideal tone frequency for DCP tone #1 is

1865.5234375 MHz. However, the duty cycle and cyclical prefix of the transmitted RF burst will cause this DCP tone to appear to have a constant frequency offset of about -0.630 PPM when measured with a swept-frequency spectrum analyzer. During this test, the change in this measurement offset (expressed in PPM) is representative of the Remote Unit's frequency stability over the -40 to +60 Deg. Celsius temperature range.

11.2.4 Results Summary

The measured frequency stability vs. temperature is depicted in Figure 11.10. The results of these tests are summarized in Table 11.12 below:

Figure 11.10 Remote Unit Frequency Stability vs. Temperature, DCP Tone #1

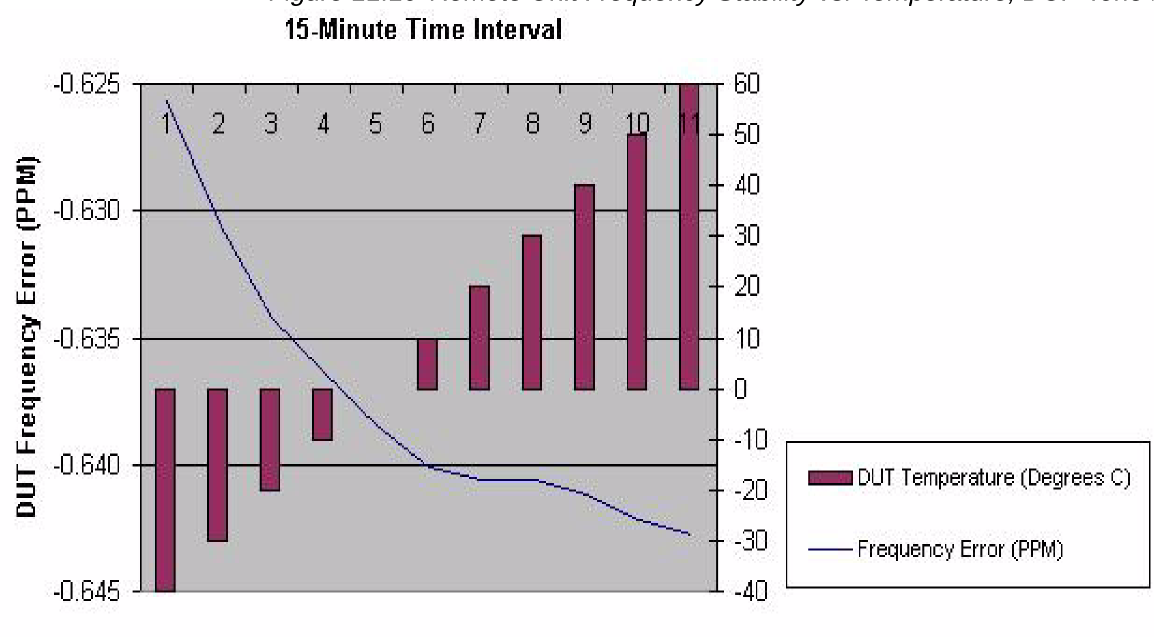


Table 11.12 Remote Unit Transmit Frequency Stability vs. Temperature

Parameter	Measured Value
Transmit frequency stability at 1867 MHz between -40 Deg. Celsius and +60 Deg. Celsius	Frequency change of ≤ 0.02 PPM

11.2.5 Remote Unit Frequency Stability vs. Input Voltage Test Results

11.2.5.1 Applicable FCC Rule Parts

FCC Subpart 2.995 - Measured over the temperature range of -30 to +50 C. Frequency measurements shall be made at the extremes and at intervals of not greater than 10 degrees C throughout the range. Only the frequency determining portions of the transmitter need be subjected to this test.

FCC Subpart 24.236 - The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorized frequency block.

11.2.5.2 Test Configuration

The Remote Unit under test was connected to a variable DC power supply (refer to Figure 11.3). The frequency accuracy of DCP tone #1 was tracked while varying the Remote Unit supply voltage in 0.5 volt steps from a minimum of -23.5 volts to a maximum of -32.5 volts (±15% of the nominal 28 volt input voltage).

The frequency error was calculated for each temperature step using the formula in Equation 11.4:

(Eq 11.4)

$$\mathrm{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1 \times 10^{6}\right) = \left(\left(\frac{f(\mathrm{measured}) - f(\mathrm{ideal})}{f(\mathrm{ideal})}\right) \cdot 1 \times 10^{6}\right)$$

The ideal frequency for DCP tone #1 is exactly 23.4375 kHz above the bottom edge of the selected 1 MHz subband. For example, if the Remote Unit is operating in the first 1 MHz subband within the “D” PCS block, the bottom edge of the subband is 1865.5 MHz. Consequently, the ideal tone frequency for DCP tone #1 is 1865.5234375 MHz. However, the duty cycle and cyclical prefix of the transmitted RF burst will cause this DCP tone to appear to have a constant frequency offset of about -0.630 PPM when measured with a swept-frequency spectrum analyzer. During this test, the change in this measurement offset (expressed in PPM) is representative of the Remote

Unit's frequency stability over the -23.5 to -32.5 VDC input voltage range.

11.2.5.3 Results Summary

The measured frequency stability vs. input voltage for the Remote Unit under test is depicted in Figure 11.11. The results of these tests are summarized in Table 11.13 below:

Figure 11.11 Remote Unit Frequency Stability vs. Input Voltage

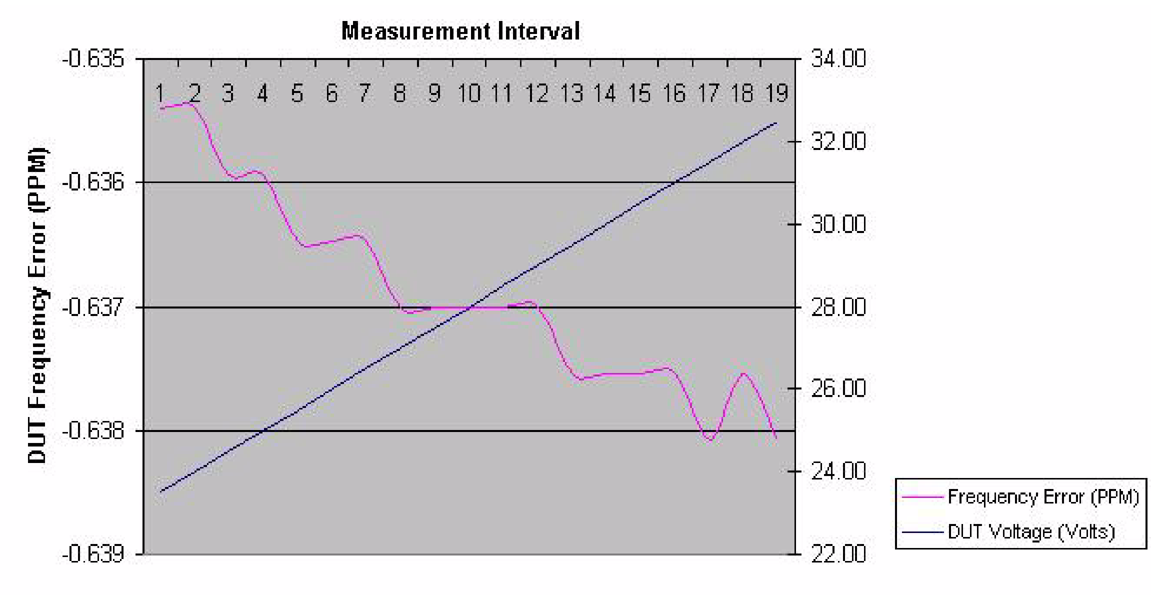


Table 11.13 Transmit Frequency Stability vs. Input Voltage

Parameter	Measured Value
Transmit frequency stability at 1869 MHz between -23.5 VDC and -32.5 VDC input voltage	Total frequency change of ≤ 0.003 PPM

11.2.6 Remote Unit Occupied Bandwidth Test Results

11.2.6.1 Applicable FCC Rule Parts

FCC Subpart 2.989 - Occupied bandwidth is defined as 99% of the total mean power, measured according to Subpart 2.989 (i), which requires full loading of the baseband, modulated such that the occupied bandwidth is consistent with that expected during normal operation.

11.2.6.2 Test Configuration

A software switch in the Remote Unit was set to generate constant Delay Compensation Pilots. The resulting transmitter output was sampled through a -20 dB directional coupler and viewed with a Hewlett-Packard 89441A Vector Signal Analyzer using the Hewlett-Packard 89451A Digital Radio Personality option, set up to measure 99% Occupied Bandwidth. The test configuration is depicted in Figure 11.4. The configuration parameters of the 89451A are listed in Table 11.2.

11.2.6.3 Results Summary

The 99% Occupied Bandwidth for the Remote Unit is depicted in Figure 11.12. The test results are summarized in Table 11.14

Figure 11.12 Remote Unit 99% Occupied Bandwidth During Delay Compensation Pilot Operation

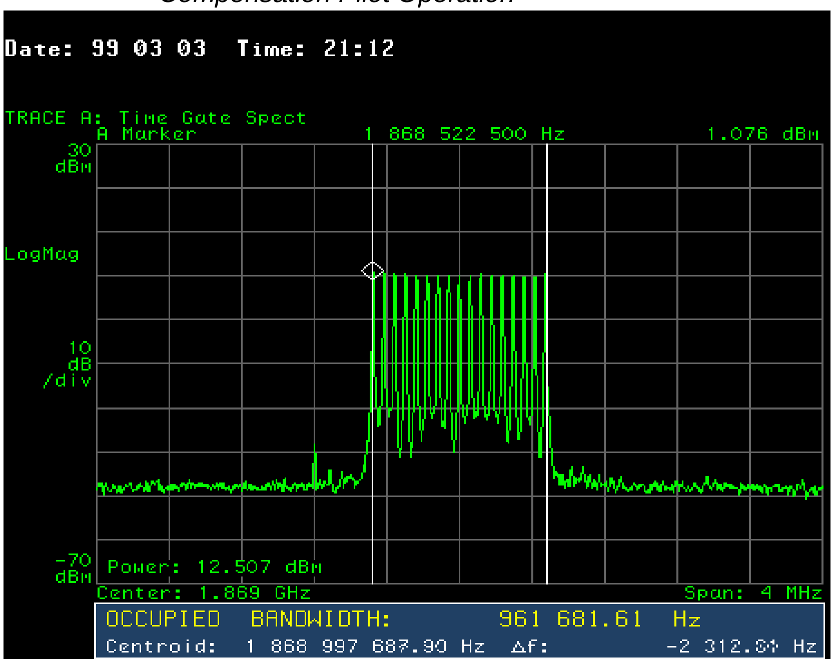


Table 11.14 Occupied Bandwidth Test Result Summary

Parameter	Measured Value
99% Occupied Bandwidth During Delay Compensation Pilot Operation	$\leq$ 962 kHz

11.2.7 Modulation Characterization Test Results

11.2.7.1 Applicable FCC Rules

FCC Subpart 2.987 - Requires a curve or equivalent data which shows that the equipment will meet the requirements of the rules under which the equipment is to be licensed. Provide data showing that the modulation being employed does not cause the spectral purity to exceed the requirements of 2.985 and 24.238.

11.2.7.2 Test Configuration

A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize each of the following discrete logical channels:

- Single Voice traffic channel
- High-Speed Data traffic channel
- Network Access channel
- Delay Compensation pilot channel

For each logical channel, the 89441A Vector Signal Analyzer was used to obtain the following information:

- 99% occupied bandwidth in kHz
- Integrated power across the measured occupied bandwidth in dBm
- Power vs. frequency (in dBm) in a 12 kHz resolution bandwidth
- Time-domain average RF burst power
- Complimentary Cumulative Distribution Function (CCDF) of the peak to average ratio made up of *x* samples of the time-domain RF bursts

11.2.7.3 Results Summary

Single Voice Channel

A single telephone call was established between the Remote Unit under test and the Base using the test configuration shown in Figure 11.4. The Hewlett-Packard 89441A Vector signal analyzer was configured according to the parameters shown in Table 11.3. The measured characteristics of a single voice channel are depicted in Figure 11.13 and Figure 11.14. The results of these tests are summarized in Table 11.15 below:

Figure 11.13 Voice Channel Power vs. Frequency, 99.0% Occupied BW, and Time-Domain Average Burst Power

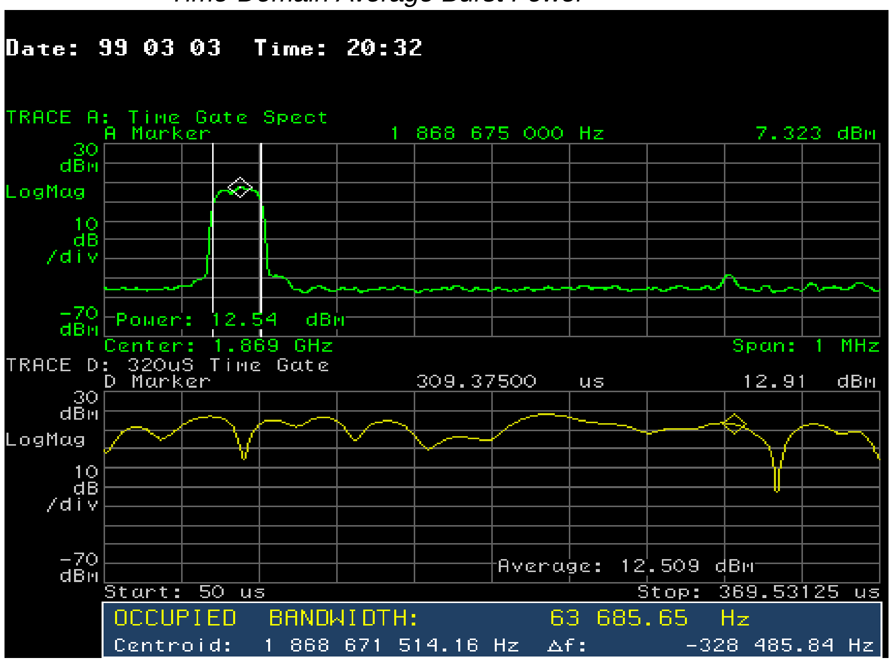
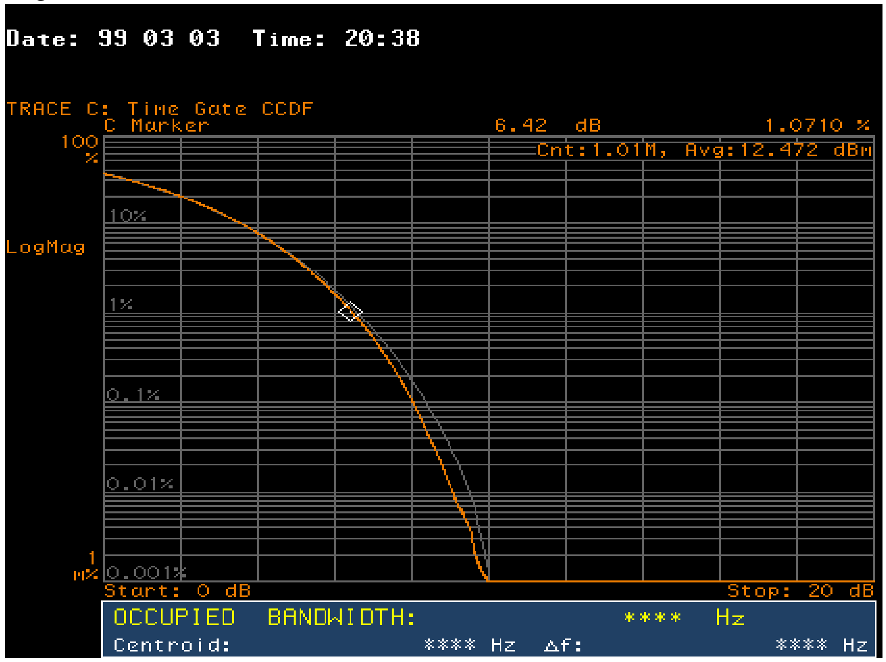


Figure 11.14 Voice Channel CCDF



High-Speed Data Channel

A High-Speed Data session was established between the Remote Unit under test and the Base using the test configuration shown in Figure 11.4. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.3. During this test, a text file was transferred from the Remote Unit to an FTP server on the AWS network. The random nature of the data contained in this file is sufficient to assure results representative of a normally operating system.

Results Summary

The measured characteristics of the High-Speed Data channel are depicted in Figure 11.15 and Figure 11.16. The results of these tests are summarized in Table 11.15 below:

Figure 11.15 High-Speed Data Channel Power vs. Frequency, 99% Occupied BW, and Time-Domain Average Burst Power

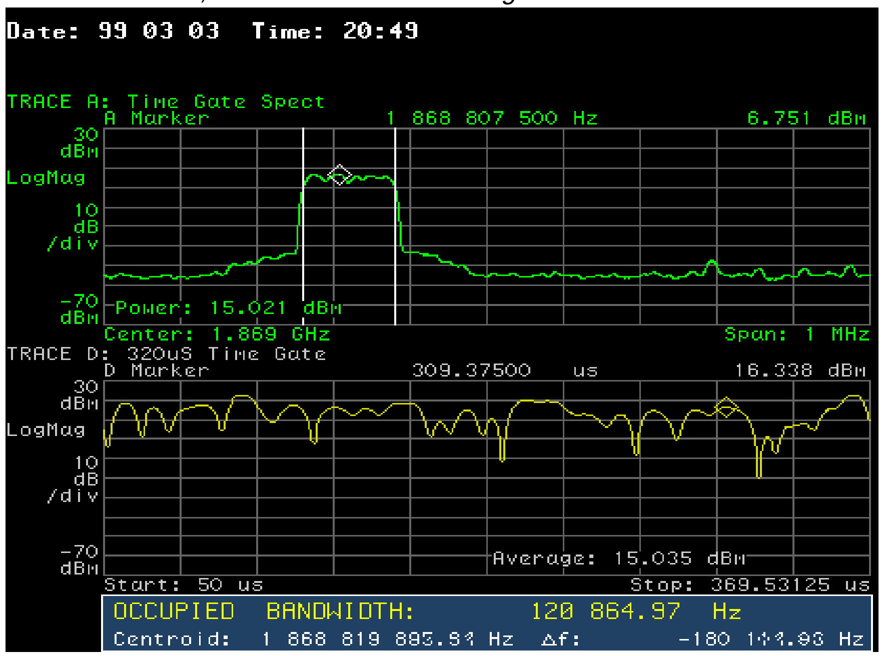
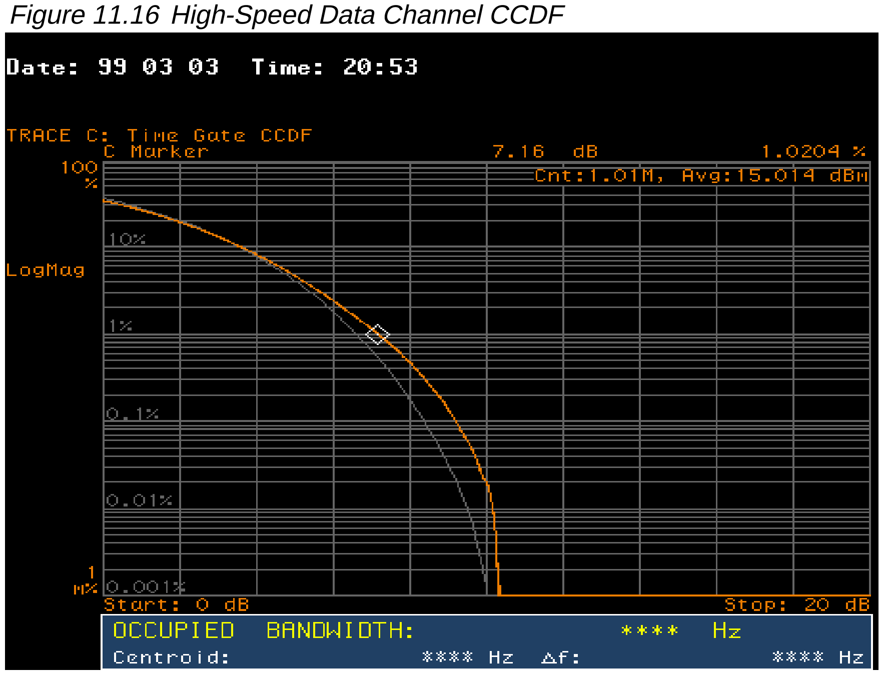


Figure 11.16 High-Speed Data Channel CCDF



Network Access Channel

Characterization of the network access channel took place utilizing the test configuration shown in Figure 11.4. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

Results Summary

The measured characteristics of the Network Access channel are depicted in Figure 11.17 and Figure 11.18. The results of these tests are summarized in Table 11.15 below:

Figure 11.17 Network Access Channel Power vs. Frequency, 99% Occupied Bandwidth, and Time-Domain Average Power

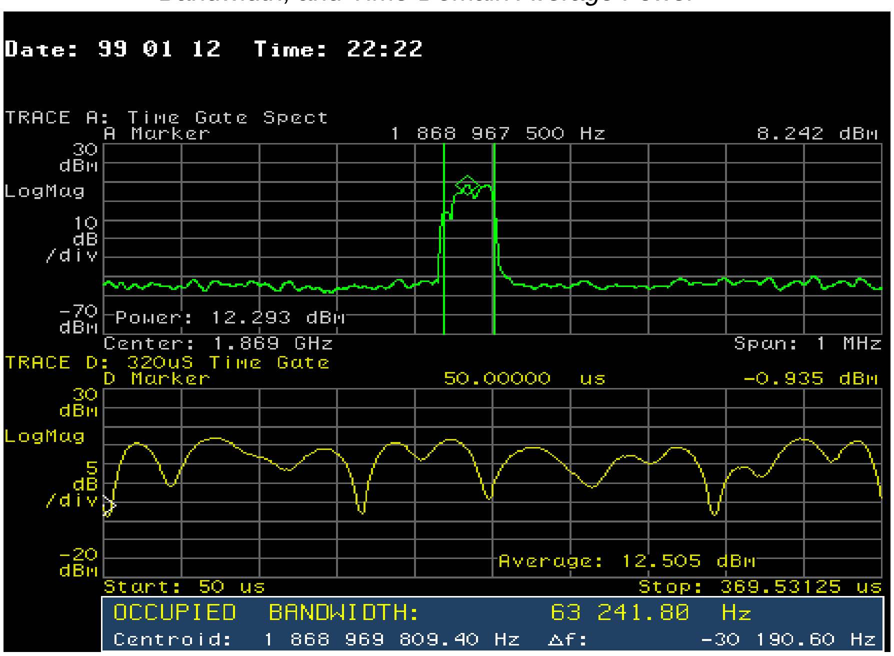
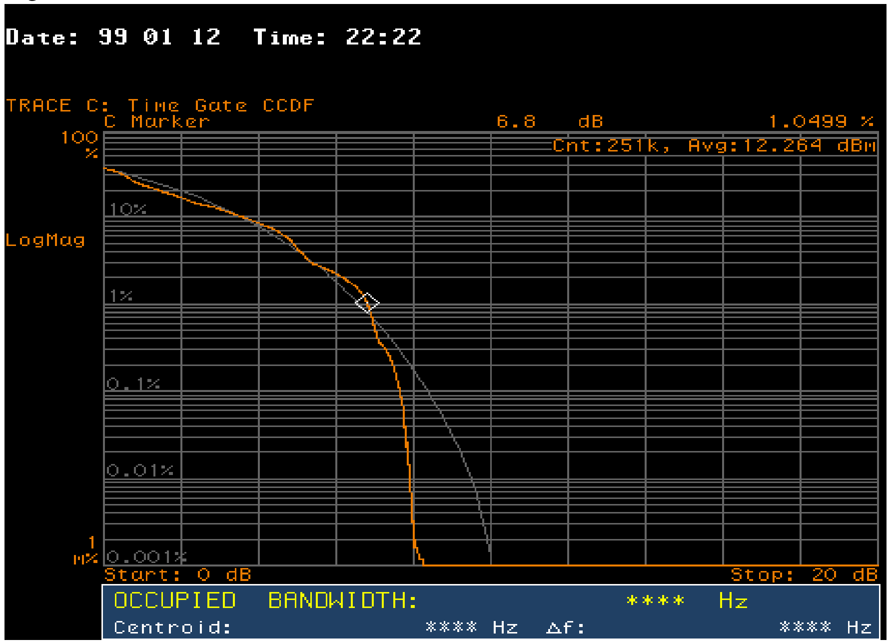


Figure 11.18 Network Access Channel CCDF



Delay Compensation Channel

The Remote Unit Delay Compensation Pilots (DCPs) were characterized using the test configuration shown in Figure 11.4. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

Results Summary

The measured characteristics of the Delay Compensation channel are depicted in Figure 11.19 and Figure 11.20. The results of these tests are summarized in Table 11.15 below:

Figure 11.19 Delay Compensation Channel Power vs. Frequency, 99% Occupied BW, and Time-Domain Average Power

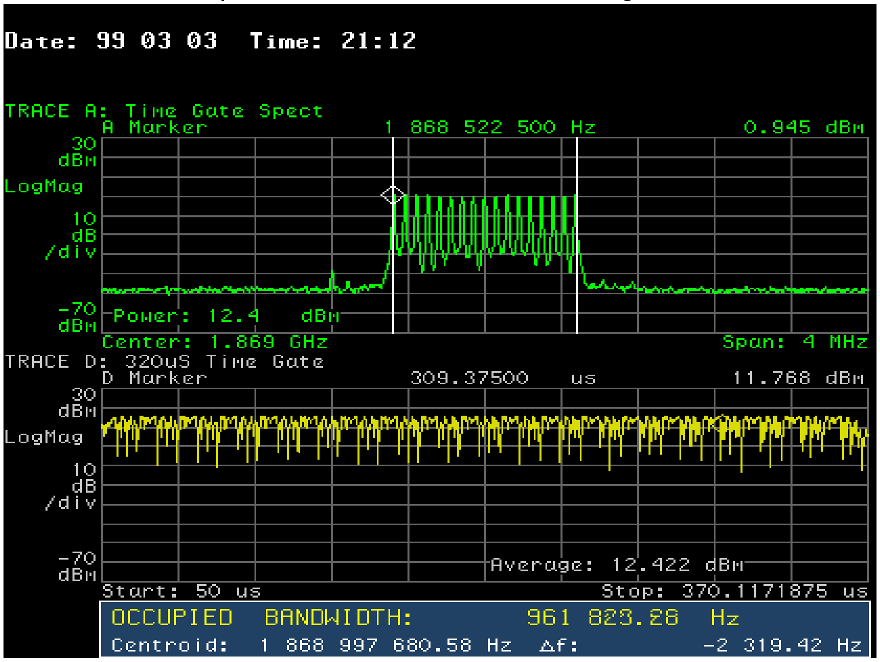


Figure 11.20 Delay Compensation Channel CCDF

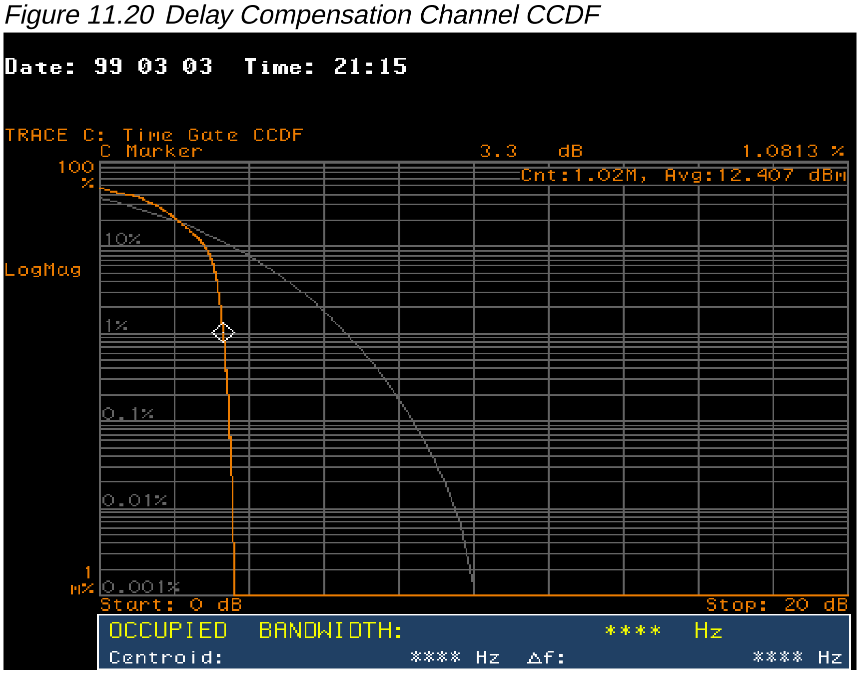


Table 11.15 Channel Characterization Test Results

Parameter	Measured Value
Voice Channel 99% Occupied Bandwidth	≤ 64 kHz
Voice Channel Average Power	+12.5 dBm
Voice Channel Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	6.4 dB
High-Speed Data Channel 99% Occupied Bandwidth	≤ 122 kHz
High-Speed Data Channel Average Power	+15.0 dBm
High-Speed Data Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	7.2 dB
Network Access Channel 99% Occupied Bandwidth	≤ 63 kHz
Network Access Channel Average Power	+12.5 dBm
Network Access Channel Peak/Average Ratio at ≤ 99.0% after $2.5x10^5$ samples	6.8 dB
Delay Compensation Channel 99% Occupied Bandwidth	≤ 962 kHz
Delay Compensation Channel Average Power	+12.4 dBm
Delay Compensation Channel Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	3.3 dB

11.2.8 RF Output Power Test Results

11.2.8.1 Applicable FCC Rules

FCC Subpart 24.232 - Base stations are limited to 1640 watts EIRP peak power, and in no case shall the output power of a base station exceed 100 watts. Peak transmitter power may be measured over any interval of continuous transmission using instrumentation calibrated in terms of RMS equivalent voltage. The measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc., so as to obtain a true peak measurement for the emission in question over the full bandwidth of the channel.

11.2.8.2 Test Configuration

Average and peak RF Output Power from the Remote Unit is maximized during High Speed Data (HSD) operation,. Consequently, maximum RF output power was characterized while the Remote Unit was operating in this mode.

A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize the Remote Unit's composite RF output signal according to the following criteria:

- Time-domain average burst power
- Time-domain peak envelope burst power at the 99.0% level
- Time-domain peak/average ratio at the 99.0% level

For this test, an HSD session was established between the Remote Unit under test and the Base using the test configuration shown in Figure 11.5. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.4. During this test, a text file was transferred from the Remote Unit to an FTP server on the AWS network. The random nature of the data contained in this file is sufficient to assure results representative of a normally operating system. A -20 dB directional coupler provided the required RF sample for measurement.

Results Summary

The RF output power of the Remote Unit while supporting an HSD session is depicted in Figure 11.21, Figure 11.22 and Figure 11.23. The results of these tests are summarized in Table 11.16 below:

Figure 11.21 Time-Domain Power Envelope, Average Power

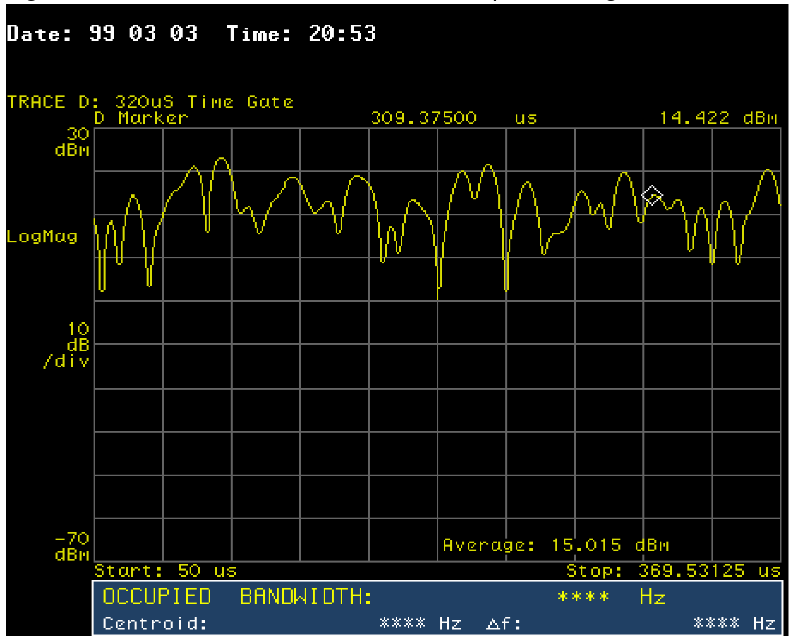


Figure 11.22 Time-Domain Power Envelope, Peak Power at ≤ 99.0% Occurrence

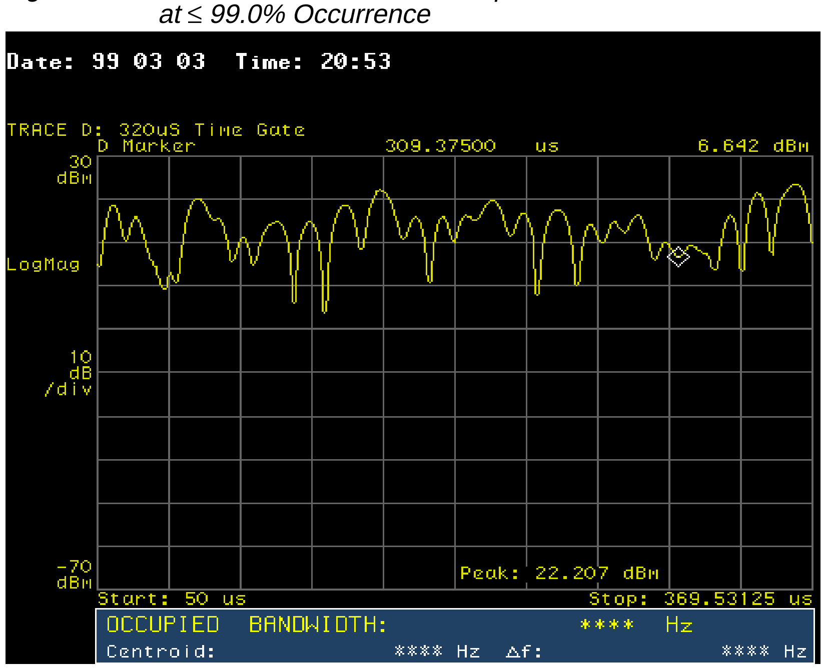


Figure 11.23 Time-Domain Power Envelope, Peak/Average Ratio at ≤ 99.0% Occurrence

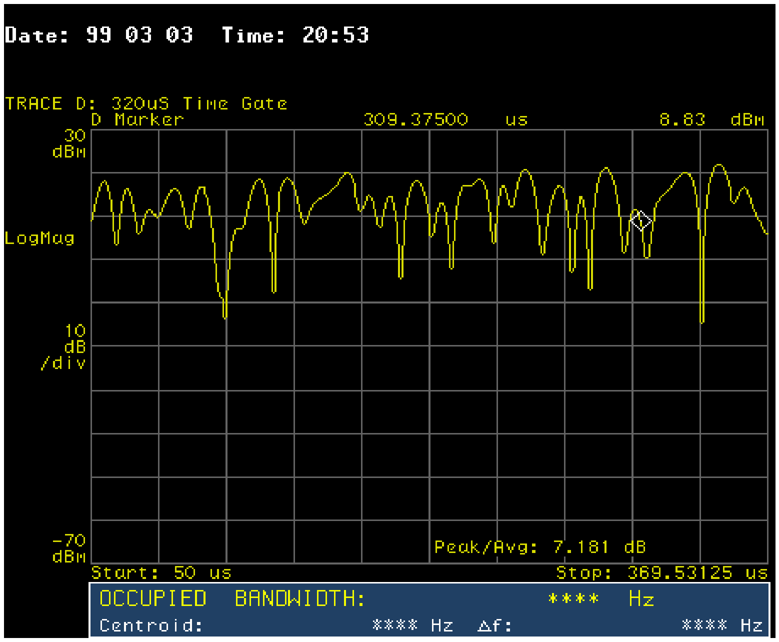


Table 11.16 RF Output Power Characteristics

Parameter	Measured Value	FCC Part 24 Limit
Time-Domain Average Power	+15.0 dBm	N/A
Time-Domain Peak Power at ≤ 99.0% Occurrence	+22.2 dBm	+45.1 dBm/TX port
Time-Domain Peak/Average Ratio at ≤ 99.0% Occurrence	7.2 dB	N/A

11.2.9 Spurious Emissions at the Antenna Terminal

11.2.9.1 Applicable FCC Rules

FCC Subpart 2.985 - Requires that the RF Output be measured at the antenna power terminals into a dummy load after the transmitter has been adjusted in accordance with the manufacturers tune up procedure. Requires documentation of measurement configuration. Transmitter spectral output shall not have any components that exceed the spectral mask applicable to the rule part under which the equipment shall be operated.

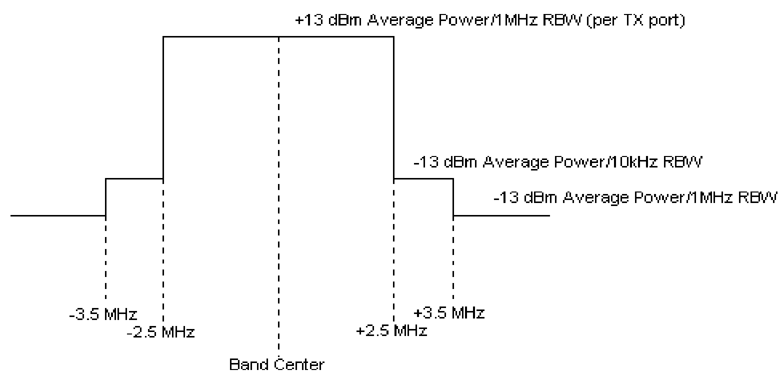
FCC Subpart 24.238 - On any frequency outside a licensee's block, the power of any emission shall be attenuated below the transmitter power

(P) by at least 43+10Log(P) dB. Compliance is based on measurement within a 1 MHz resolution bandwidth. However, in the 1 MHz bands immediately adjacent to the frequency block a resolution bandwidth of at least 1 percent of the emission bandwidth may be employed. The emission bandwidth is defined as the width of the signal between two points, one above and one below the carrier frequency, outside of which all emissions are attenuated by at least 25 dB below the transmitter power.

11.2.9.2 Test Configuration

The Remote Unit under test was configured to transmit continuous Delay Compensation Pilots, with the transmit chain variable attenuators adjusted to provide a peak output power equal to that of an HSD session. This test was executed with the Remote Unit operating in the lowest-frequency subband and again in the highest subband within the PCS “D” block. A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize the Remote Unit’s spectral purity with DCP stimulus in each subband. A -10 dB directional coupler provided the required RF sample for measurement. The specific operating parameters of the Hewlett-Packard 89441A Vector Signal Analyzer are summarized in Table 11.5. The test configuration is depicted in Figure 11.7. The emission mask utilized through the course of this test is shown in Figure 11.24.

Figure 11.24 RU Conducted Power Spectral Mask



11.2.9.3 Results Summary

The measured spectral purity of the Remote Unit across the 1853 to 1882 MHz range while transmitting Delay Compensation Pilots at a peak output power equivalent to that of an HSD session is depicted in

Figure 11.25 through Figure 11.34. The results of these tests are summarized in Table 11.17 below. Emissions at all applicable frequencies above and below the 1853-1882 MHz range have been documented in Section 11.3.4.3, “Radiated to Conducted Spurious Emissions.”

Figure 11.25 1-MHz Band-Power Between 1865.5 and 1866.5 MHz

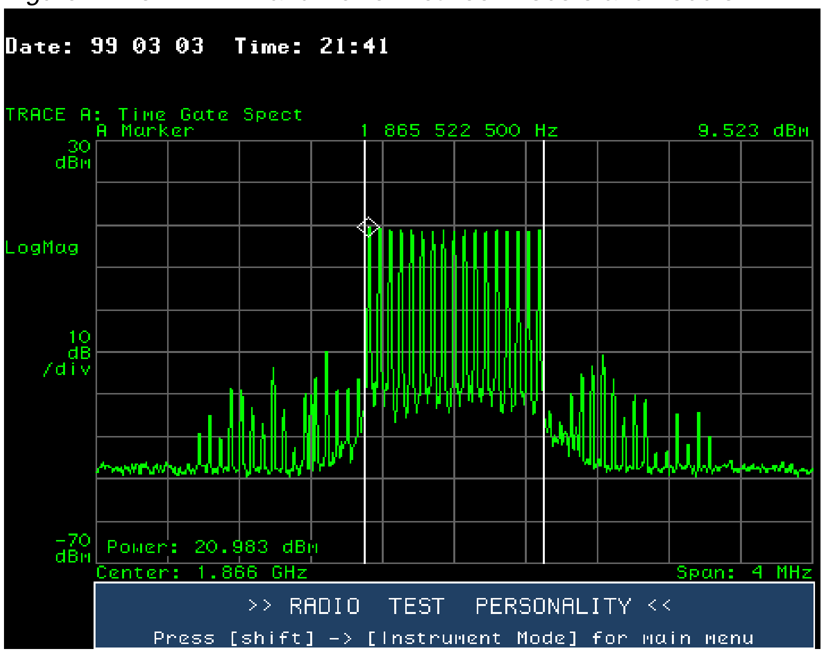


Figure 11.26 1-MHz Band Power Between 1866.5 and 1867.5 MHz

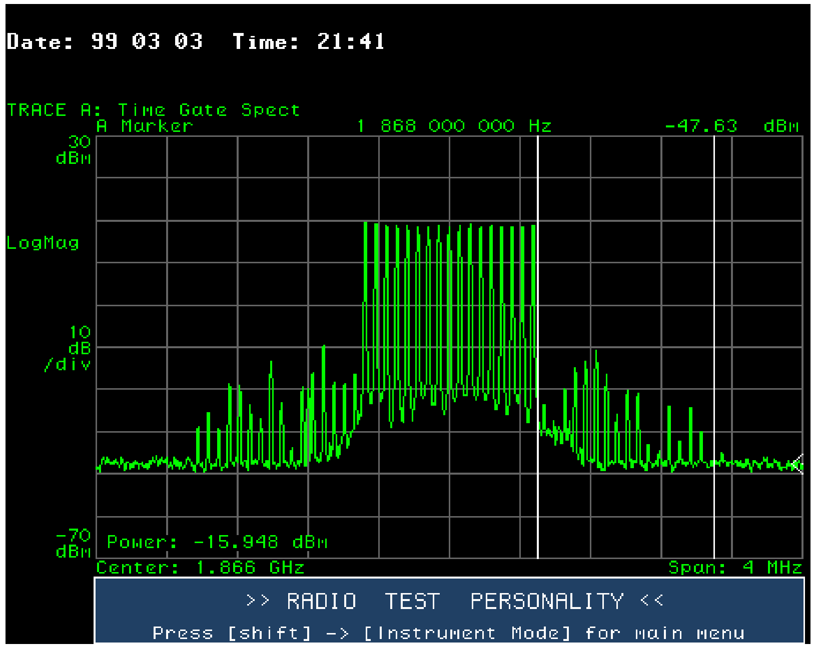


Figure 11.27 1 MHz Channel Power Between 1867.5 and 1868.5 MHz

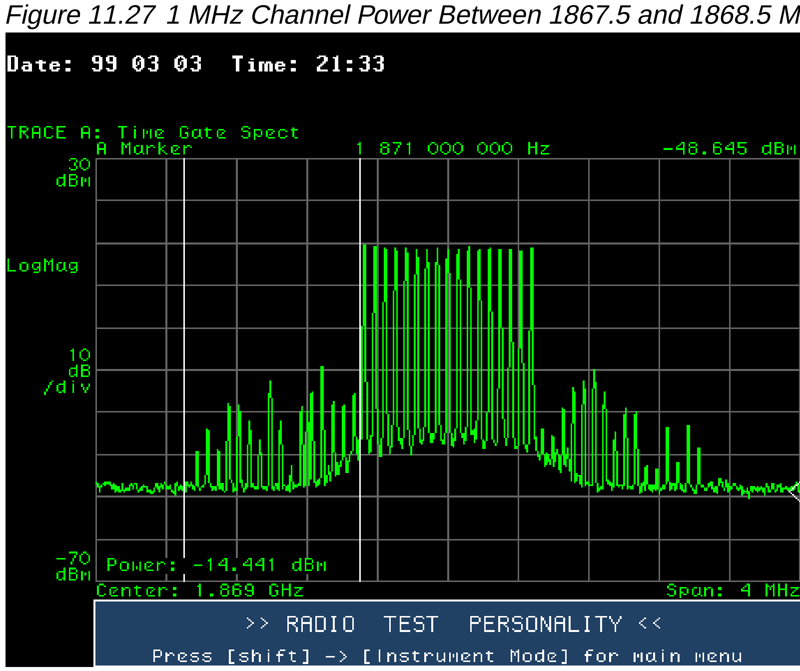


Figure 11.28 1 MHz Channel Power Between 1868.5 and 1869.5 MHz

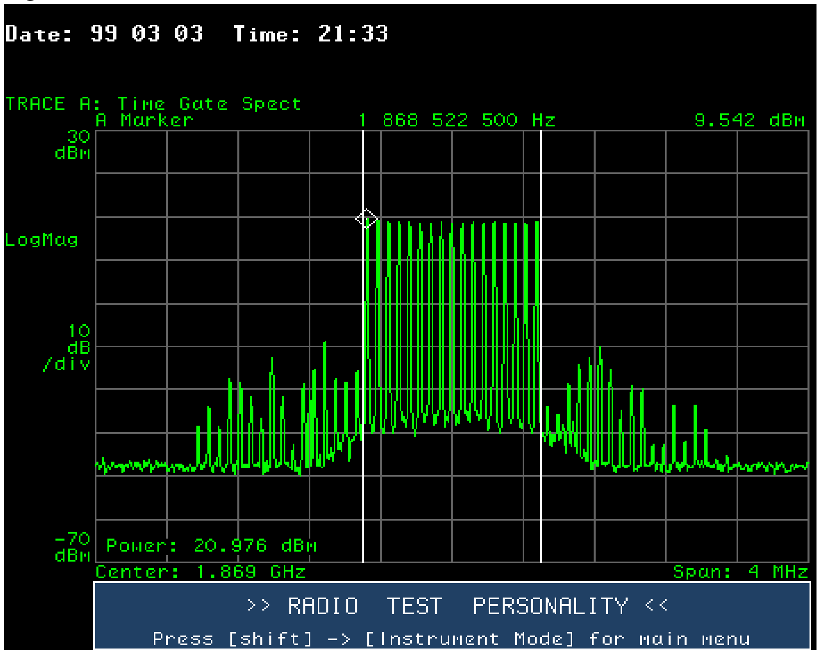


Figure 11.29 Maximum Lower Guard Band Spurious Power, Measured in a 12 kHz Resolution BW

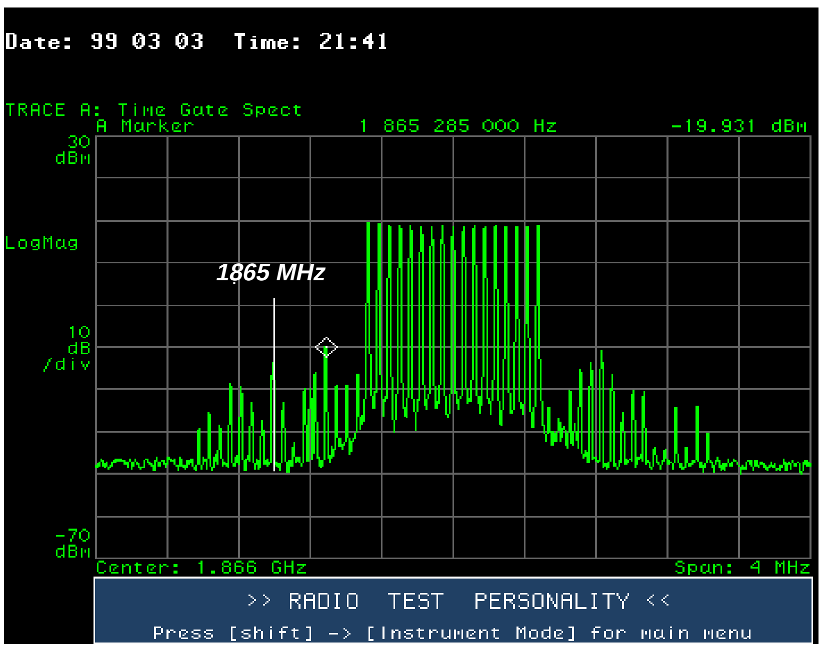


Figure 11.30 Maximum Upper Guard Band Spurious Power Measured in a 12 kHz Resolution BW

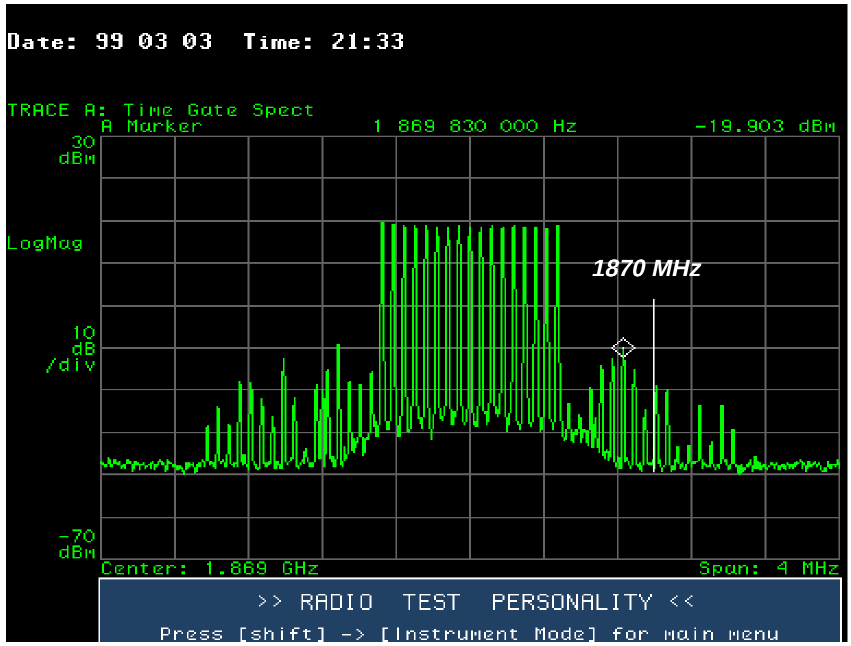


Figure 11.31 Spectral Purity from 1859.5 MHz to 1866.5 MHz, with Spurious Power Between 1863 and 1864 MHz Measured in a 1 MHz Bandwidth

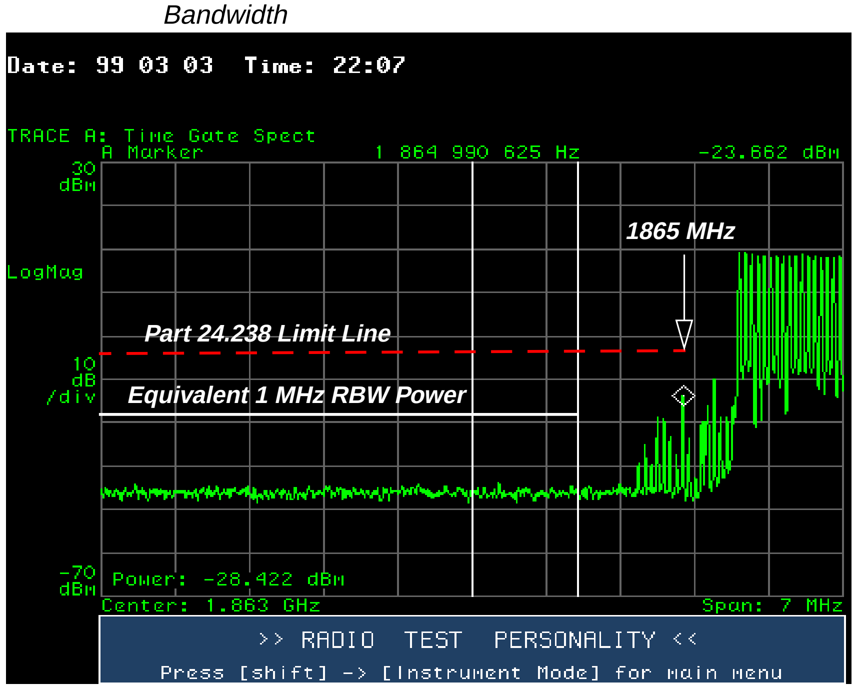


Figure 11.32 Spectral Purity from 1853 to 1860 MHz, with Spurious Power Measured in a 1 MHz Band-Power Marker Centered on 1859 MHz

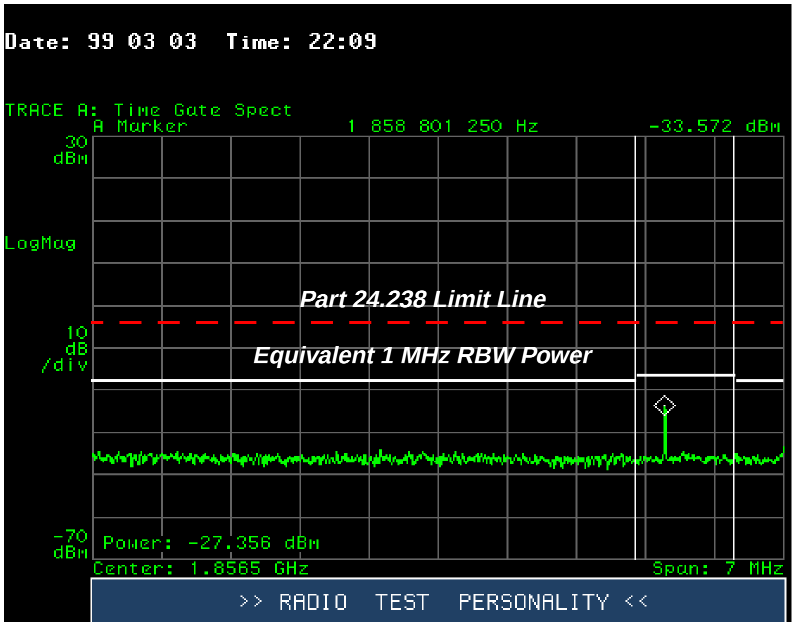


Figure 11.33 Spectral Purity from 1868.5 MHz to 1875.5 MHz with 1 MHz Band-Power Reference Between 1871 and 1872 MHz

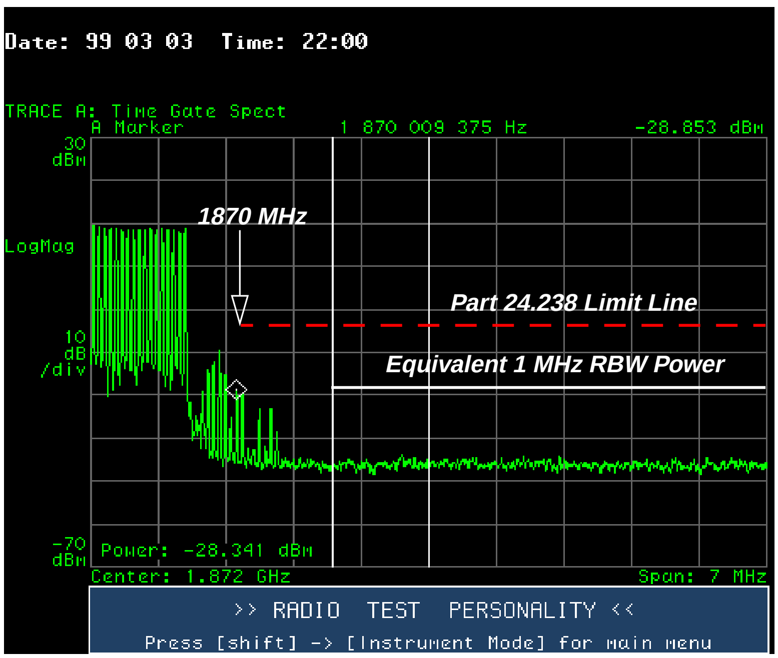


Figure 11.34 Spectral Purity from 1875 MHz to 1882 MHz with 1 MHz Band-Power Reference Centered at 1878 MHz

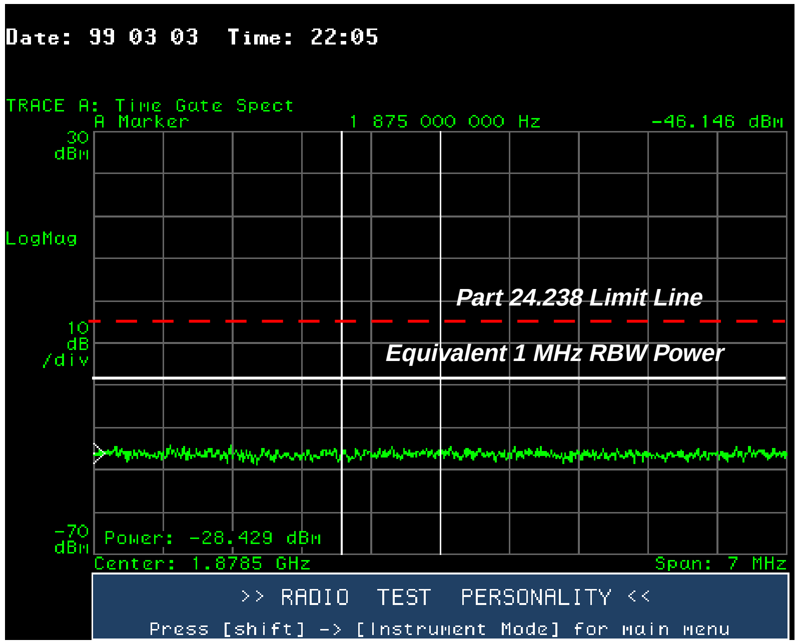


Table 11.17 Remote Unit In-Band and Out-Of-Band Power Summary

Parameter	Measured Value	FCC Part 24 Limit
Total power centered @ 1866 MHz	+21.0 dBm in a 1 MHz BW	+45.1 dBm/1 MHz RBW
Total power centered @ 1867 MHz	-15.9 dBm in a 1 MHz BW	+45.1 dBm/1 MHz RBW
Total power centered @ 1868 MHz	-14.4 dBm in a 1 MHz BW	+45.1 dBm/1 MHz RBW
Total power centered @ 1869 MHz	+21.0 dBm in a 1 MHz BW	+45.1 dBm/1 MHz RBW
Max. guard band spurious power between 1865 and 1865.5 MHz	-19.9 dBm in a 12 kHz RBW	+45.1 dBm/1 MHz RBW

Table 11.17 Remote Unit In-Band and Out-Of-Band Power Summary

Parameter	Measured Value	FCC Part 24 Limit
Max. guard band spurious power between 1869.5 and 1870 MHz	-19.9 dBm in a 12 kHz RBW	+45.1 dBm/1 MHz RBW
Maximum spurious power between 1864 and 1865 MHz	-23.7 dBm in a 12 kHz RBW	-13 dBm/10 kHz RBW
Maximum spurious power between 1870 and 1871 MHz	-28.9 dBm in a 12 kHz RBW	-13 dBm/10 kHz RBW
Maximum spurious power between 1853 and 1860 MHz	-33.6 dBm in a 1 MHz BW	-13 dBm/1 MHz RBW
Maximum spurious power between 1859.5 and 1864 MHz	-27.4 dBm in a 1 MHz BW	-13 dBm/1 MHz RBW
Maximum spurious power between 1871 and 1875.5 MHz	-28.3 dBm in a 1 MHz BW (analyzer noise floor)	-13 dBm/1 MHz RBW
Maximum spurious power between 1875 and 1882 MHz	-28.4 dBm in a 1 MHz BW (analyzer noise floor)	-13 dBm/1 MHz RBW

11.3 Electromagnetic Compatibility Test Results

This section describes the test results obtained during the validation of the AT&T Wireless Services Remote Unit (RU) against the applicable requirements of FCC Parts 15 and 24 (Spurious Emissions 5 MHz outside fundamental).

11.3.1 Introduction

The purpose of this chapter is to present the test results used to verify FCC regulatory compliance of the PWAN Remote Unit. The data presented in this chapter are the test results obtained from completing FCC Part 15, radiated and conducted emissions. Additional data representing FCC Part 24 spurious emissions 5 MHz outside the fundamental frequency is also presented. Testing was completed within the FCC regulatory guidelines, including the utilization of ANSI C63.4-1992 standard entitled “American National Standard for Methods of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz. Per these standards, all Part 15 emission testing was performed within the FCC accredited 3-meter Anechoic Chamber shown to meet FCC requirements as outlined within subpart 2.948 as referenced in FCC memo 31040/SIT 1300F2.

During testing, the Remote Unit was setup and configured as close to actual field installation as possible. The RU was mounted to a test fixture designed and built to simulate the exterior siding of a typical residence, including the position, mounting, and orientation. The RU was then mounted to the test fixture and cabled, powered, and operated in a field installation configuration. The supporting test fixture consisted of an FCC and UL Listed power supply that provides 24 volt DC power and system status to the RU and a standard network interface device (NID) that meets FCC and UL requirements which connects the RU to a communication device, i.e. telephones. The system was then tested in a wireless configuration, communicating with a Base Station, in the following configurations:

- Single voice call
- Dual voice call
- High-speed data (HSD) and dual voice call

After testing these various configurations, it was found that worst case emissions were generated while the RU was being operated in the HSD and dual voice call configuration.

11.3.2 Equipment Lists

Test cases within this section were completed utilizing the test equipment outlined in Table 11.18. Equipment calibration is completed on a bi-yearly schedule by the Hewlett Packard Company and is monitored by both HP and AT&T Wireless. All calibration material is stored in both hard copy and electronic form, tracking to NIST standards.

Table 11.18 Emissions Test Equipment

Instrument Name	Manufacturer	Model Number	Serial Number	Calibration Last Date	Calibration Due Date
Semi-anechoic Chamber	Rantec Test Systems	3-meter semi anechoic	N/A	Shield Test NSA 3/6/98	3/6/00
Antenna 1	EMCO	3115	5515	7/2/98	7/2/99
Cable 1	Belden	RG-214/U, 3 cables (6,14,33)	1-6-1, 1-14-1, 1-33-1	3/6/98	3/6/99
Analyzer	Hewlett Packard	8546A	3520A00260	3/6/98	3/6/99
Preselector	Hewlett Packard	8546A internal	3330A0010	3/6/98	3/6/99
QPeak Adapter	Hewlett Packard	internal to RF section	internal	3/6/98	3/6/99
Pre-Amplifier	Hewlett Packard	8546A internal	internal	3/6/98	3/6/99
Tower 1	EMCO	1050	1123	11/19/98	11/19/99
Turntable 1	EMCO	1060	1049	11/19/98	11/19/99
Amplifier 1	HP	8546A	Internal	3/6/98	3/6/99
Turnable Notch Filter	K & L	3TNF-1000/2000-0/0	0007	11/5/98	11/5/99
Cable 2	Belden	RG-214	2-2-2	12/2/98	12/2/99
Antenna	Chase	CBL6111A	1704	4/28/98	4/28/99
Positioner Controller	EMCO	2090	9601-1101	N/A	N/A
EMI Measurement System	Hewlett Packard	84125C	4536439012	5/15/98	5/15/99

11.3.3 Equipment Under Test List

Test cases within this section were executed using the equipment under test listed in Table 11.19.

Table 11.19 EUT Equipment Under Test List

Board Type	Serial No.	Revision Level
RF Board	185519981219	B
Digital Board	175263981022	6
Network Interface Board	135234981020	1

11.3.4 Test Results

11.3.4.1 Radiated Emissions

Radiated emissions measurements shall be made over the frequency range specified by the regulatory agency, in this case the FCC Part 15, subpart 15.207. Measurements shall be made at the EUT azimuth and antenna height such that the maximum radiated emissions level will be detected. This was accomplished using both an automated 360 degree turntable and 1 to 4 meter height antenna positioners. Sixteen azimuth cuts at 22.5 degrees and 1 to 4 meter antenna scans in both polarizations were utilized. The Remote Unit was setup in a typical field configuration, as shown in Figure 12.1, consisting of the RU being attached to the mounting bracket and the bracket being mounted to a vertical piece of typical house siding which was placed on the center of a wooden table located in the center of the turntable. Proper interconnecting cable was utilized from the RU to the system power supply via the network interface device (NID). Various cable lengths were utilized to determine worse case configuration and a Base antenna was placed in the chamber for RU wireless communication. All radiated emissions testing was completed in three configurations; 1) with only one continuous voice channel, 2) with both voice channels continuously utilized, and 3) with both voice channels and the high speed data (HSD) be continuously utilized. Testing was completed from 30 MHz to 26 GHz, accomplishing the FCC requirement of testing to the 10th harmonic of the fundamental frequency being used by the transmitter. When testing close to or over the fundamental frequency range, a notch filter tuned to the RU and Base fundamental frequencies was utilized to prevent receiver overload and/or damage.

The test fixture utilized to mount the RU during testing was designed and built to create an actual installation scenario, as shown in figures Figure 12.2, Figure 12.3, and Figure 12.4. The power and telco test fixtures were mounted and located outside the anechoic chamber, as shown in figure Figure 12.5. The power supply and NID have already completed the appropriate FCC testing and have an FCC Identification Number.

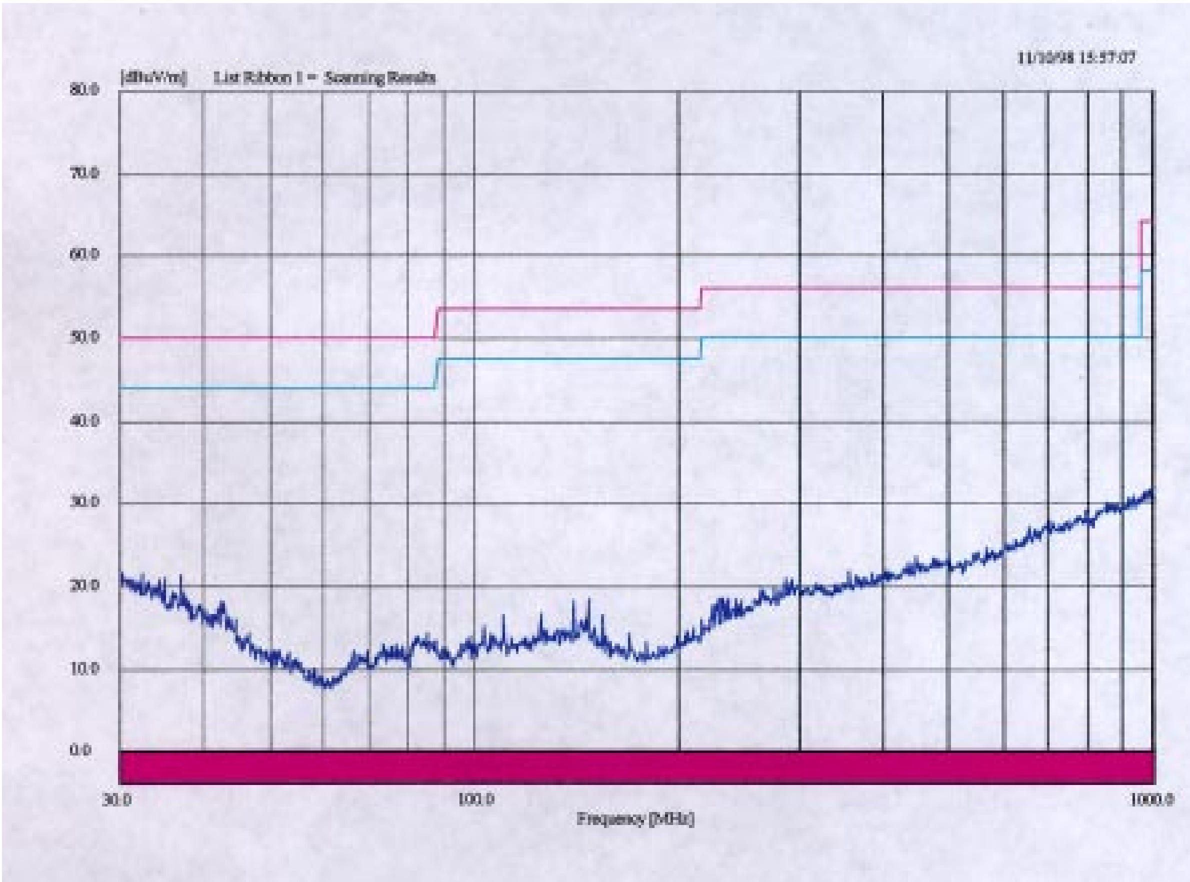
Testing was completed and the radiated emissions detected from the Remote Unit was found to be within the FCC radiated emissions requirements as set forth in Table 11.20.

Table 11.20 FCC Radiated Emissions Limits

Frequency (MHz)	Field Strength (MicroVolts/meter)	Measurement Distance (Meters)
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

A measurement of the 3-meter shielded chamber was conducted previous to FCC measurements to establish the chamber ambients. A plot of the chamber's ambient measurement is shown in Figure 11.35.

Figure 11.35 3-meter Chamber Ambient



11.3.4.1.1 Applicable FCC Rules

FCC Subpart 15.209 - The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the field strength levels specified in table 15.209 (a). Emission limits shown in the table below 1000 MHz are based on measurements employing a CISPR quasi-peak detector. Emission limits above 1000 MHz are based on measurements employing an average detector.

11.3.4.1.2 Test Configuration

Radiated emissions scans were performed in the AT&T 3-m semi-anechoic chamber. The Remote Unit was placed on a non-conductive table 80 cm above the ground plane with a receive antenna placed a distance of 3 m from the device under test. The test setup consisted of a

1-meter shielded cable grounded at the enclosure via a pressure clamp, routed through a patch panel for connection to the NID and Universal Power Supply (UPS). Two simultaneous voice calls together with high-speed data operating over an RF Link via the field installed NID and UPS exercised the unit in a worse case scenario. The Remote Unit (RU) under test was comprised of the following components: 1) RU digital version 2.6. 2) RU RF version 2.27 (transmitter attenuation was manually set to 10 dB as a typical case condition), and 3) RU HSD version 0.8. Three shield cans on the top side of the RF board in conjunction with BeCu gasketing material separates the RF and digital sections, two additional cans over the transmit and receive local oscillators are being used on the bottom side of the board with the antenna cables routed around them. A 40 mil conductive gasket was used where the Ball antenna assembly mounted to the RU chassis.

11.3.4.1.3 Test Results

One Voice Call Configuration

RU digital 2.6, RU RF 2.27, and RU HSD board 30 MHz - 1000 MHz radiated emissions scan. The RU was exercised with one voice call continuously throughout the duration of the test. Please refer to Figure 11.36.

Figure 11.36 30 - 1000 MHz: One Voice Call

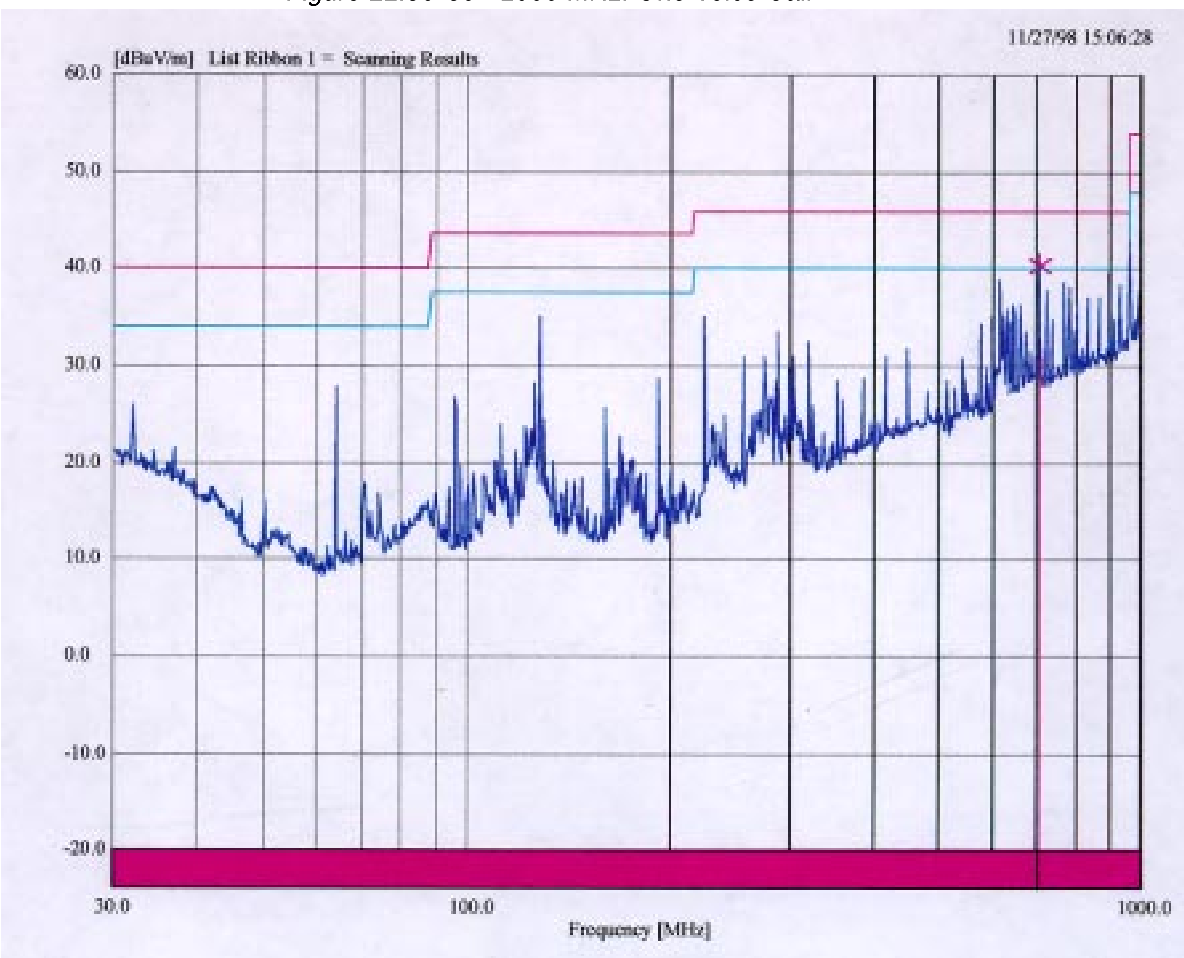
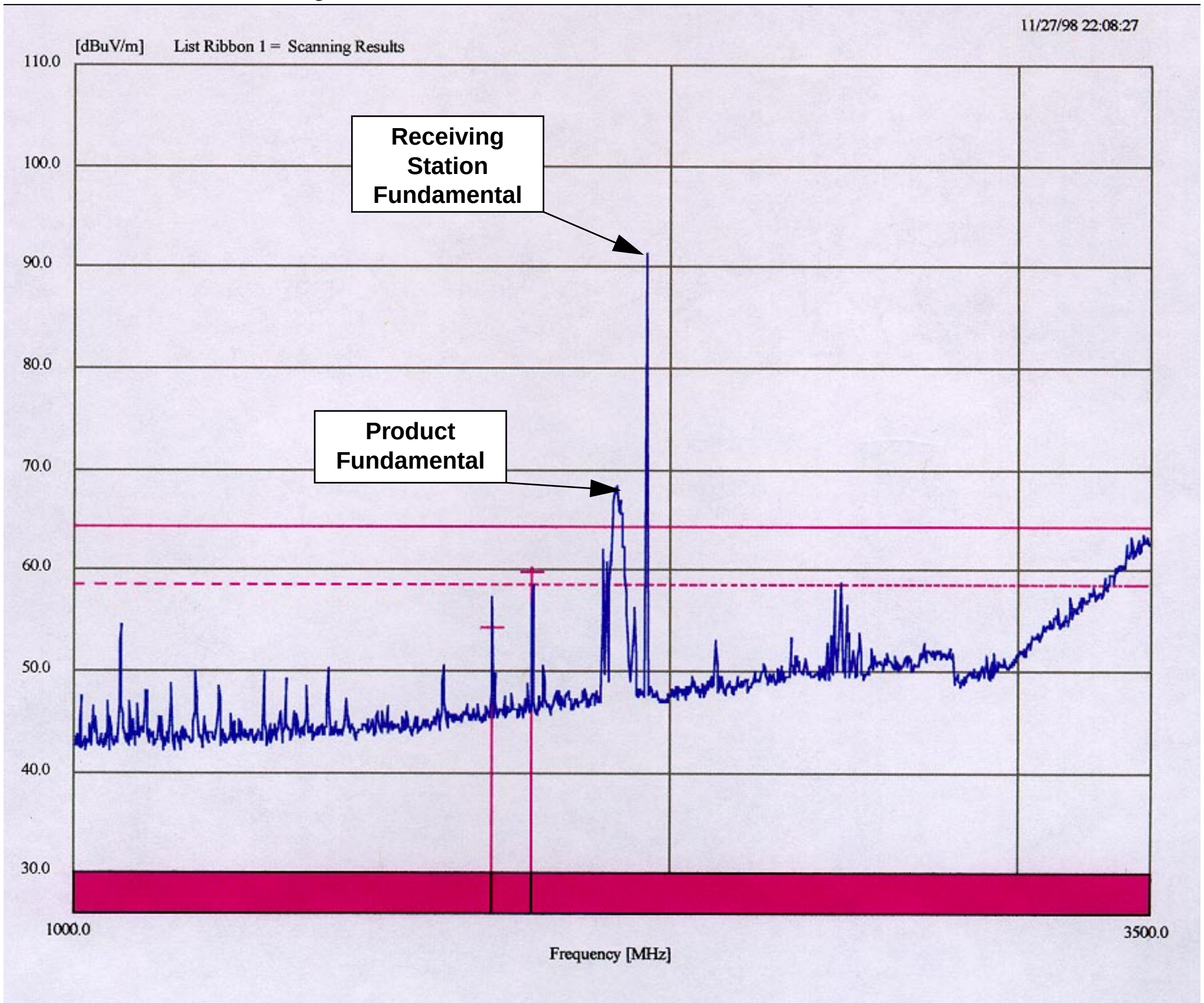


Figure 11.37 is the RU digital 2.6, RU RF 2.27, and RU HSD board 1000 MHz - 3500 MHz radiated emissions scan. The RU was exercised with one voice call continuously throughout the duration of the test.

Figure 11.37 1000 - 3500 MHz: One Voice Call



Two Voice Calls Configuration

Figure 11.38 is the RU digital 2.6, RU RF 2.27, and RU HSD board 30 MHz - 1000 MHz radiated emissions scan. The RU was exercised with two voice calls continuously throughout the duration of the test.

Figure 11.38 30 - 1000 MHz: Two Voice Calls

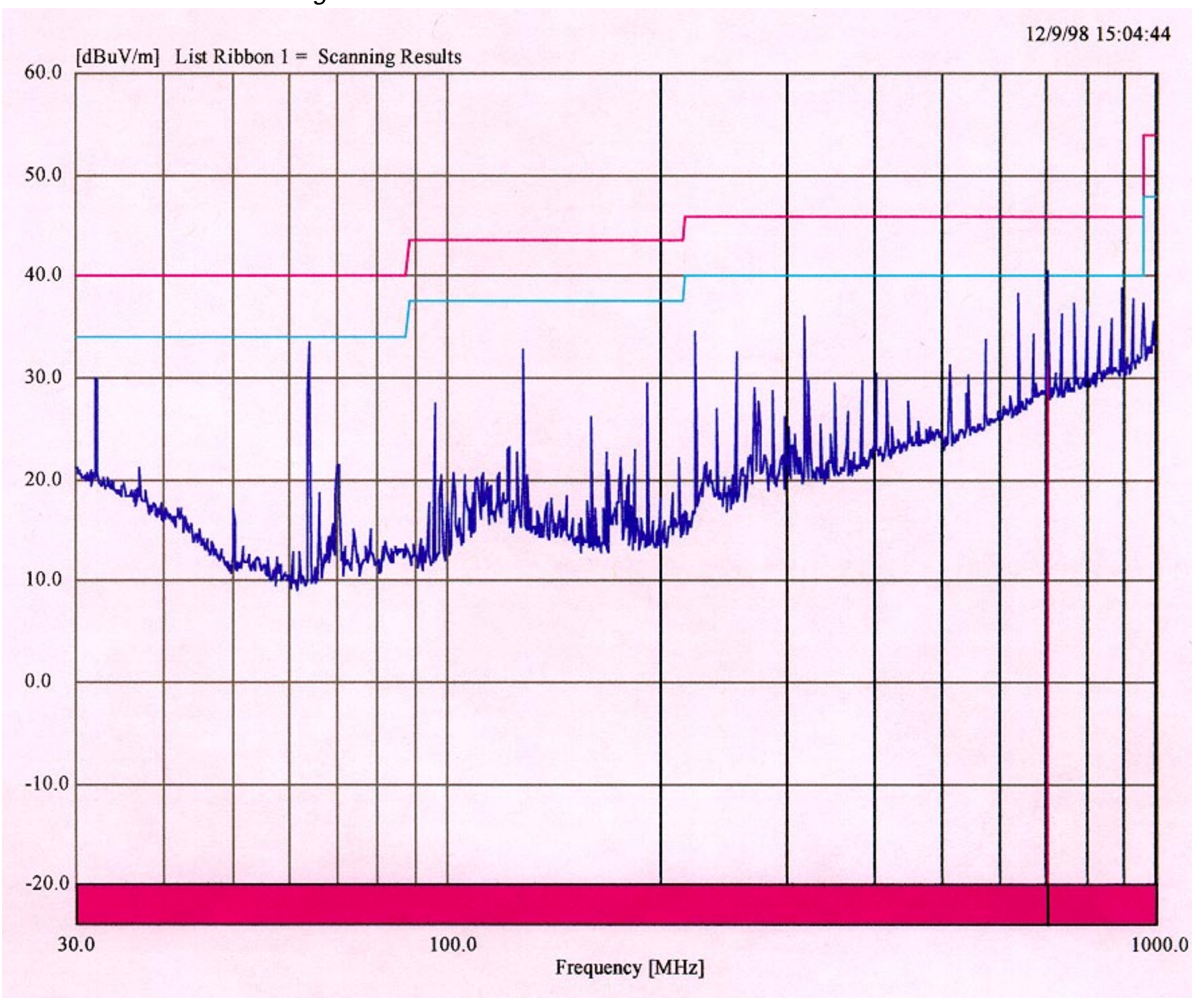
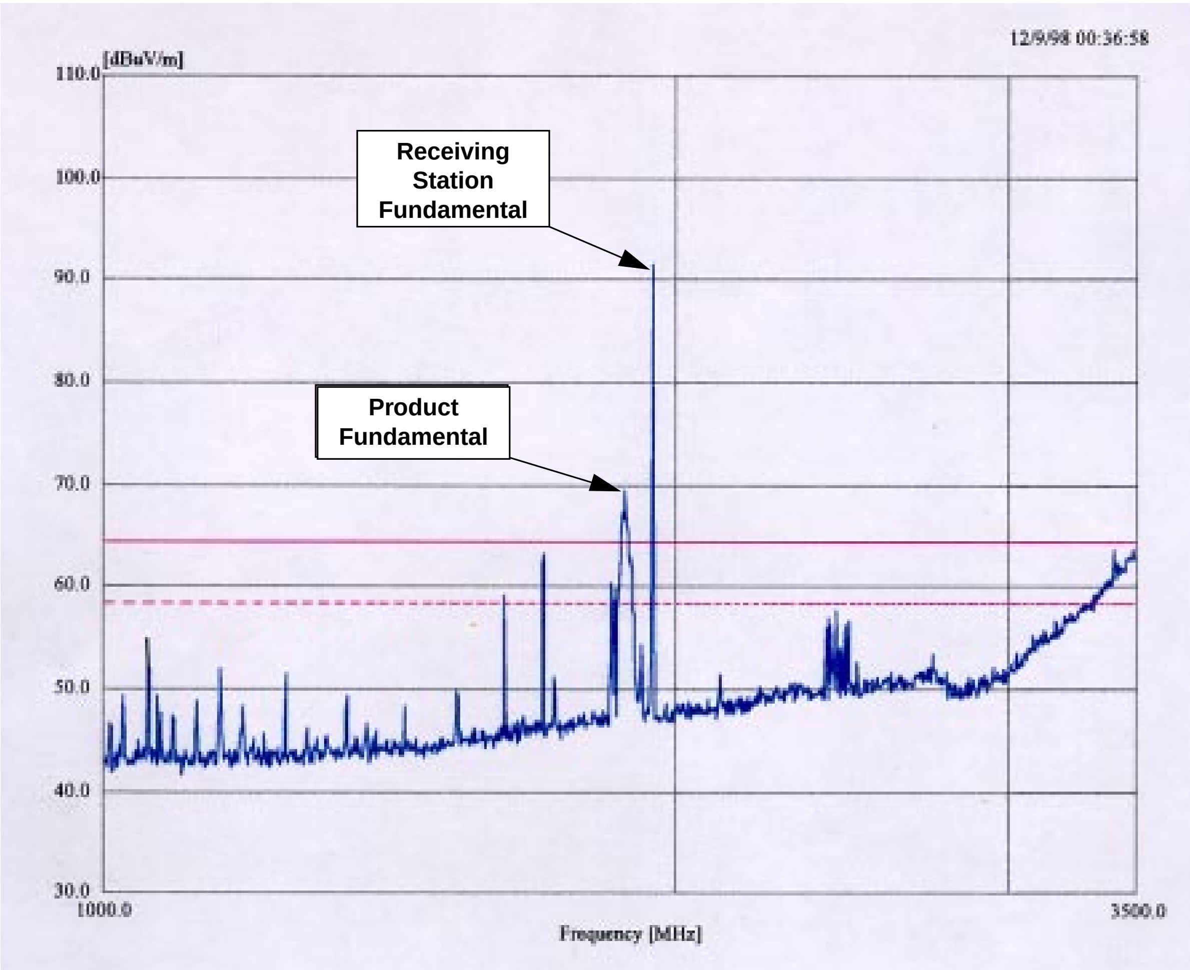


Figure 11.39 is the RU digital 2.6, RU RF 2.27, and RU HSD board 1000 MHz - 3500 MHz radiated emissions scan. The RU was exercised with two voice calls continuously throughout the duration of the test.

Figure 11.39 1000 - 3500 MHz: Two Voice Calls



Two Voice Calls and HSD Configuration

Figure 11.40 is the RU digital 2.6, RU RF 2.27, and RU HSD board 30 MHz - 1000 MHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.40 30 - 1000 MHz: Two Voice Calls and HSD

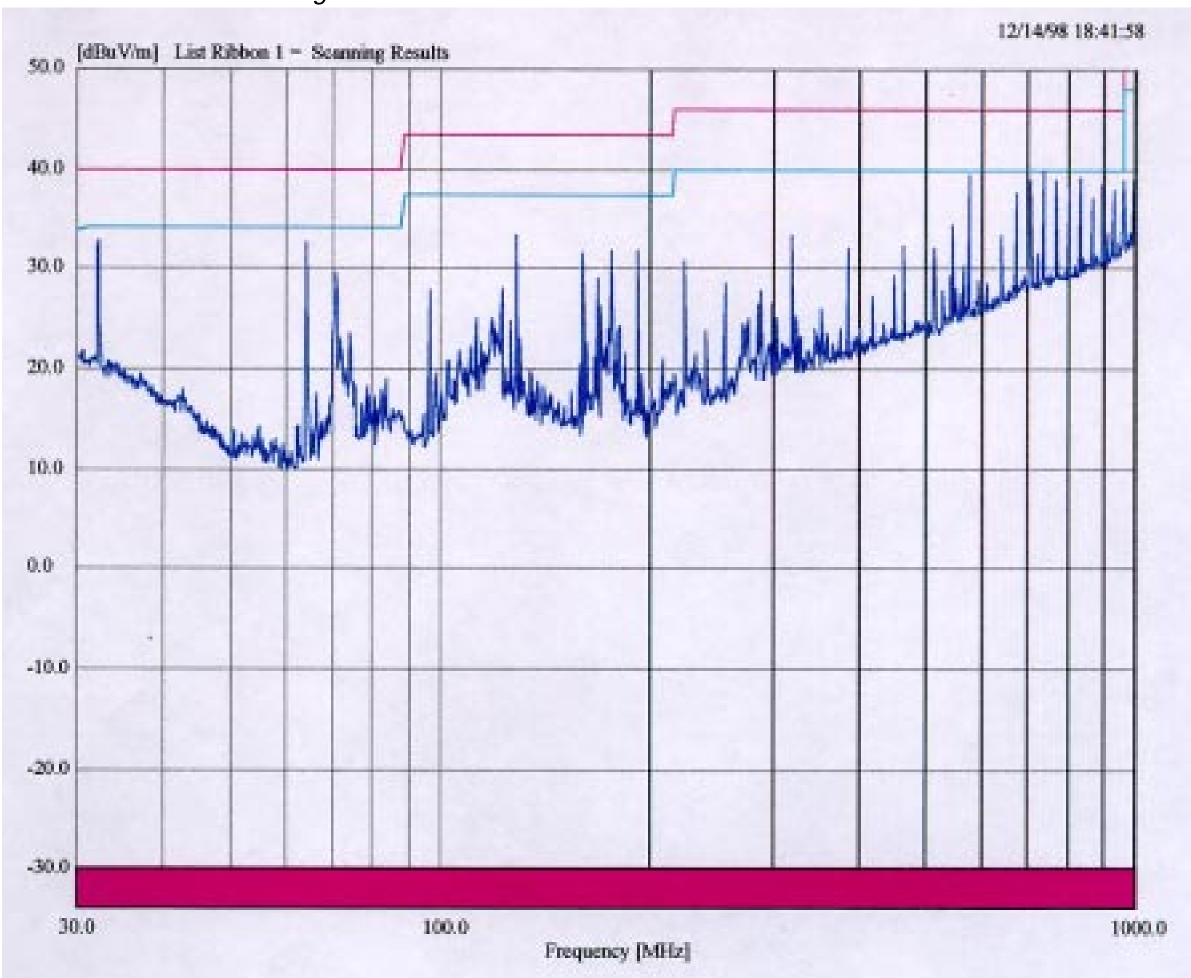


Figure 11.41 is the RU digital 2.6, RU RF 2.27, and RU HSD board 1000 MHz - 3500 MHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.41 1000 - 3500 MHz: Two Voice Calls and HSD

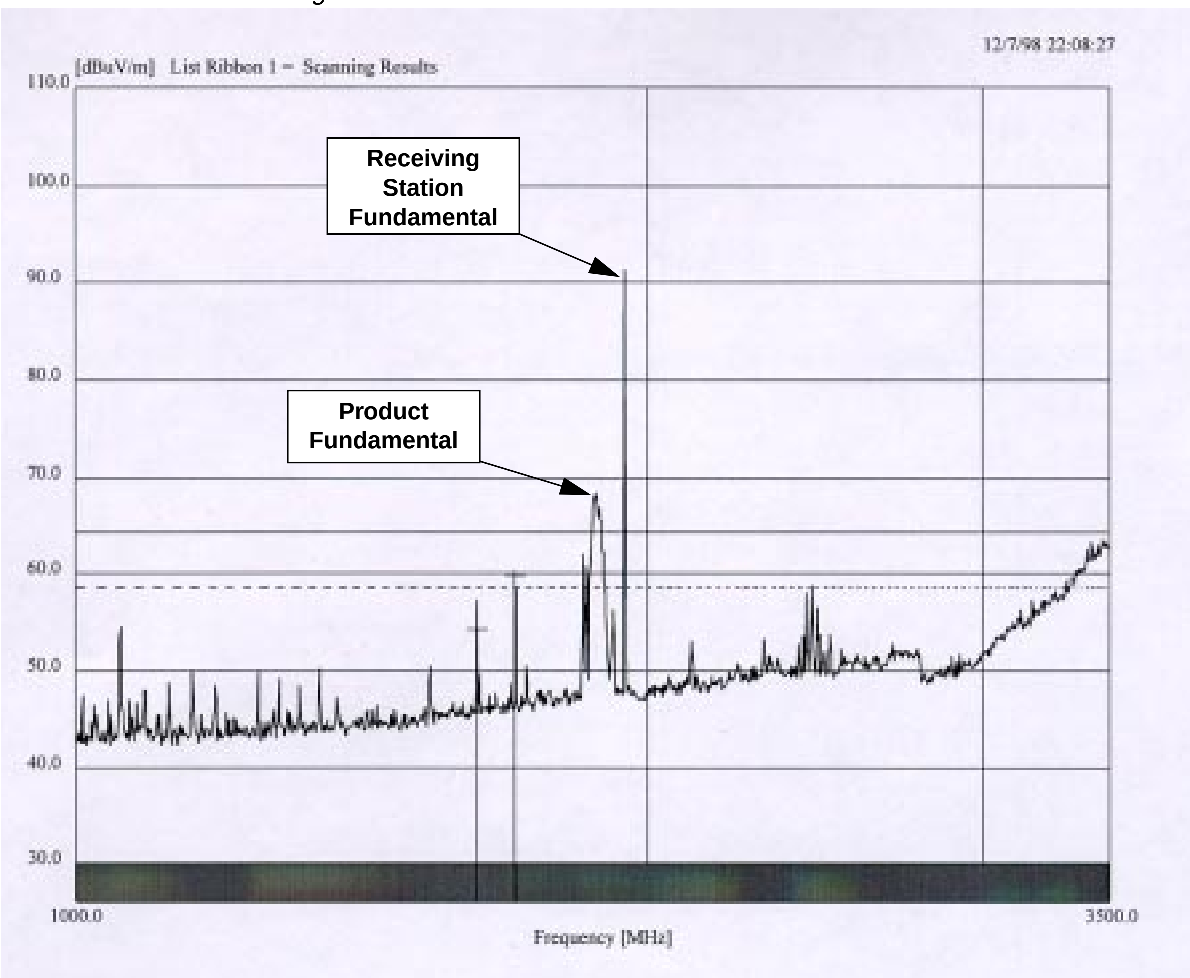


Figure 11.42 is the RU digital 2.6, RU RF 2.27, and RU HSD board 3.5 - I8 GHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.42 3.5 - 18 GHz Horizontal: Two Voice Calls and HSD

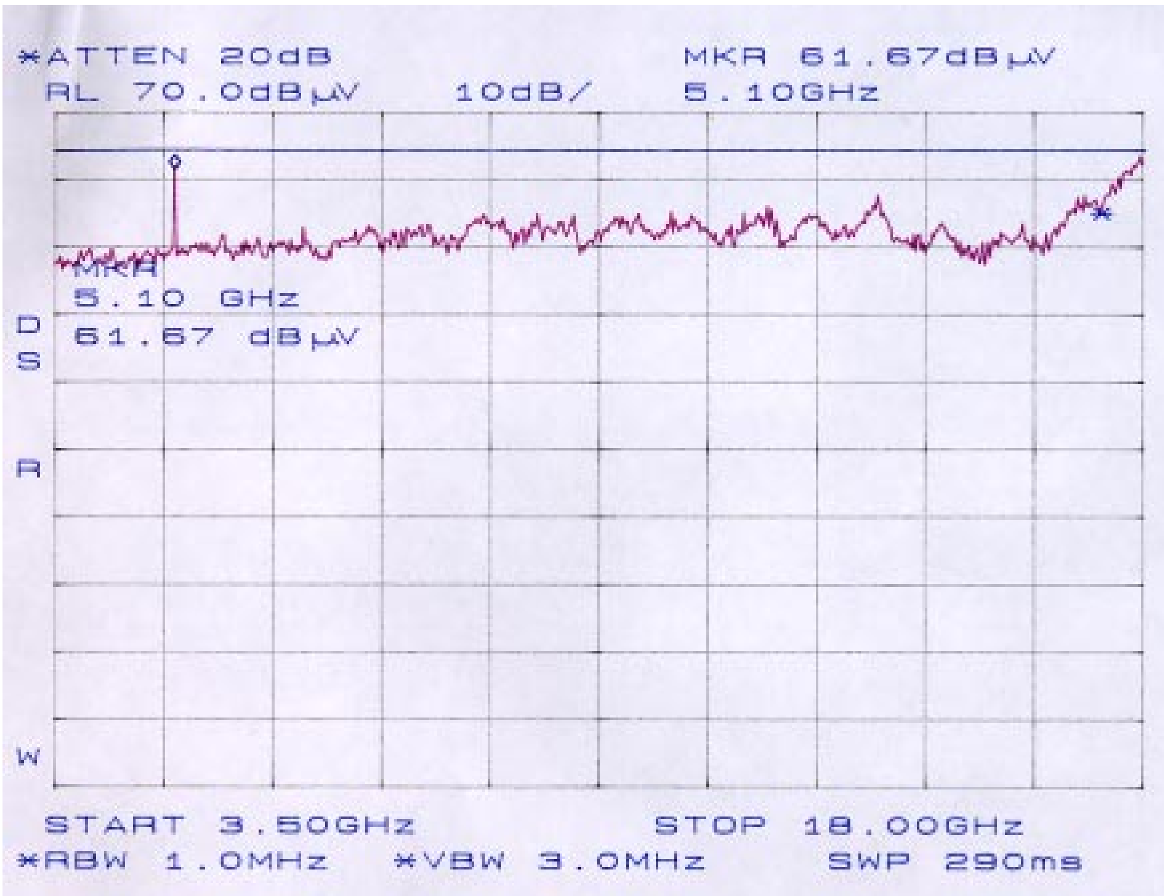


Figure 11.43 is the RU digital 2.6, RU RF 2.27, and RU HSD board narrow band emissions scan. Maximized emissions scan on the signal marked in Figure 11.42. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.43 Narrow Span of Marked Signal in Figure 11.42

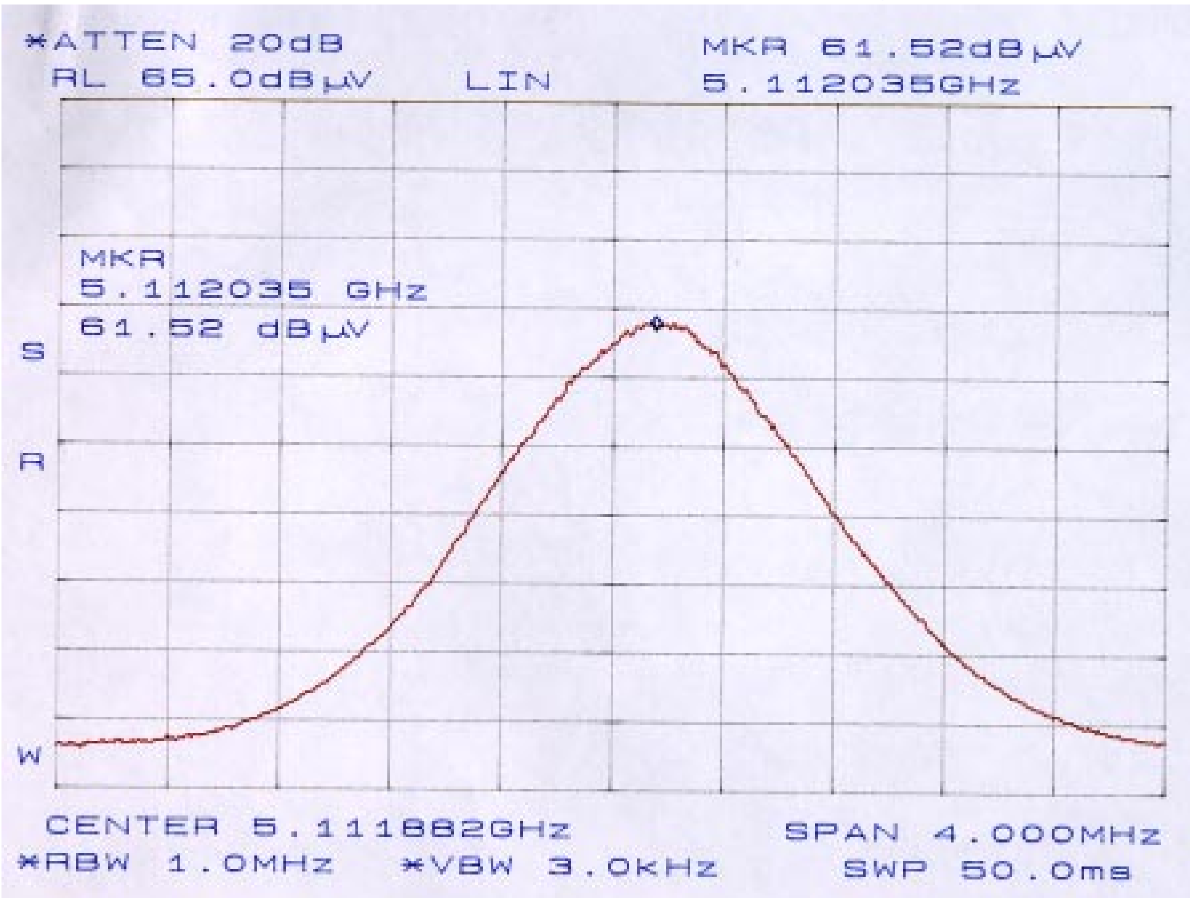


Figure 11.44 is the RU digital 2.6, RU RF 2.27, and RU HSD board 3.5 - 18 GHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.44 3.5- 18 GHz Vertical: Two Voice Calls and HSD

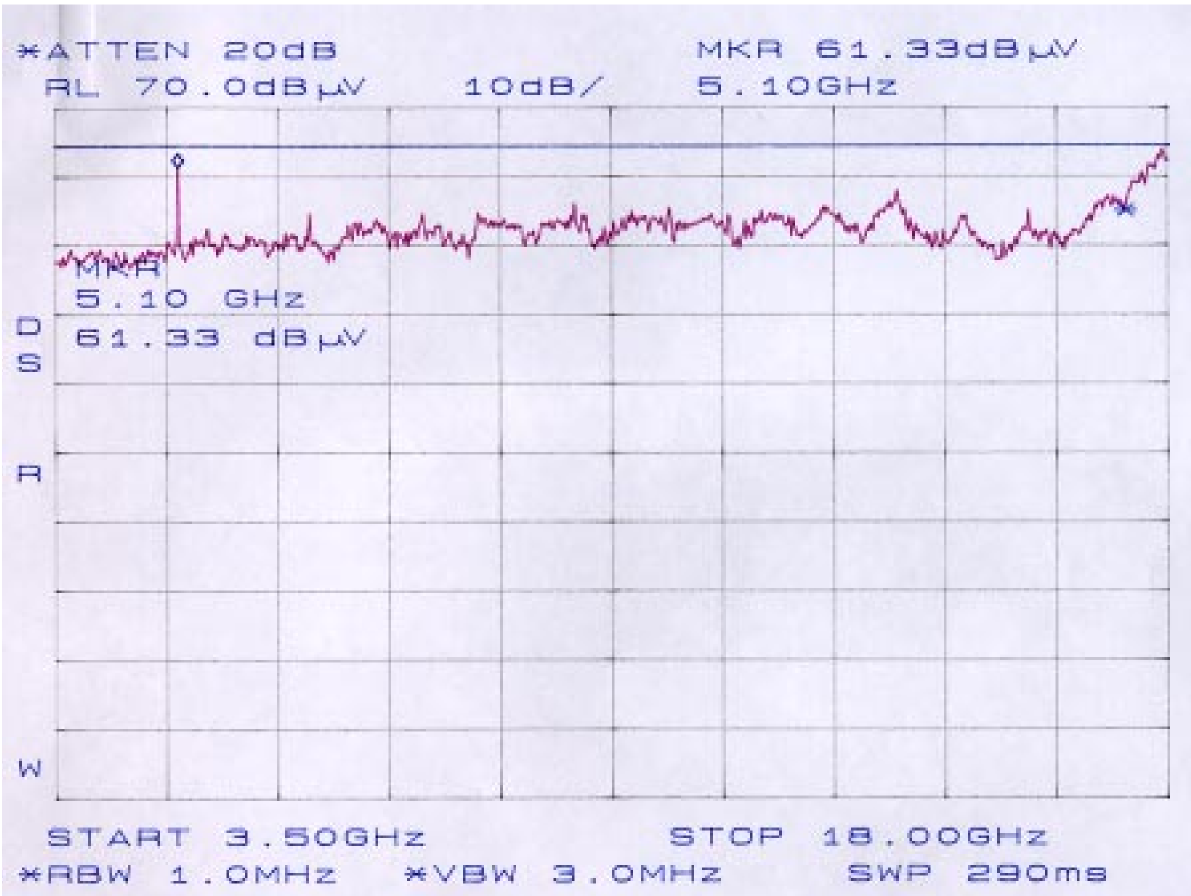


Figure 11.45 is the RU digital 2.6, RU RF 2.27, and RU HSD board 3.5 - 18 GHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.45 Narrow Span of Marked Signal in Figure 11.44

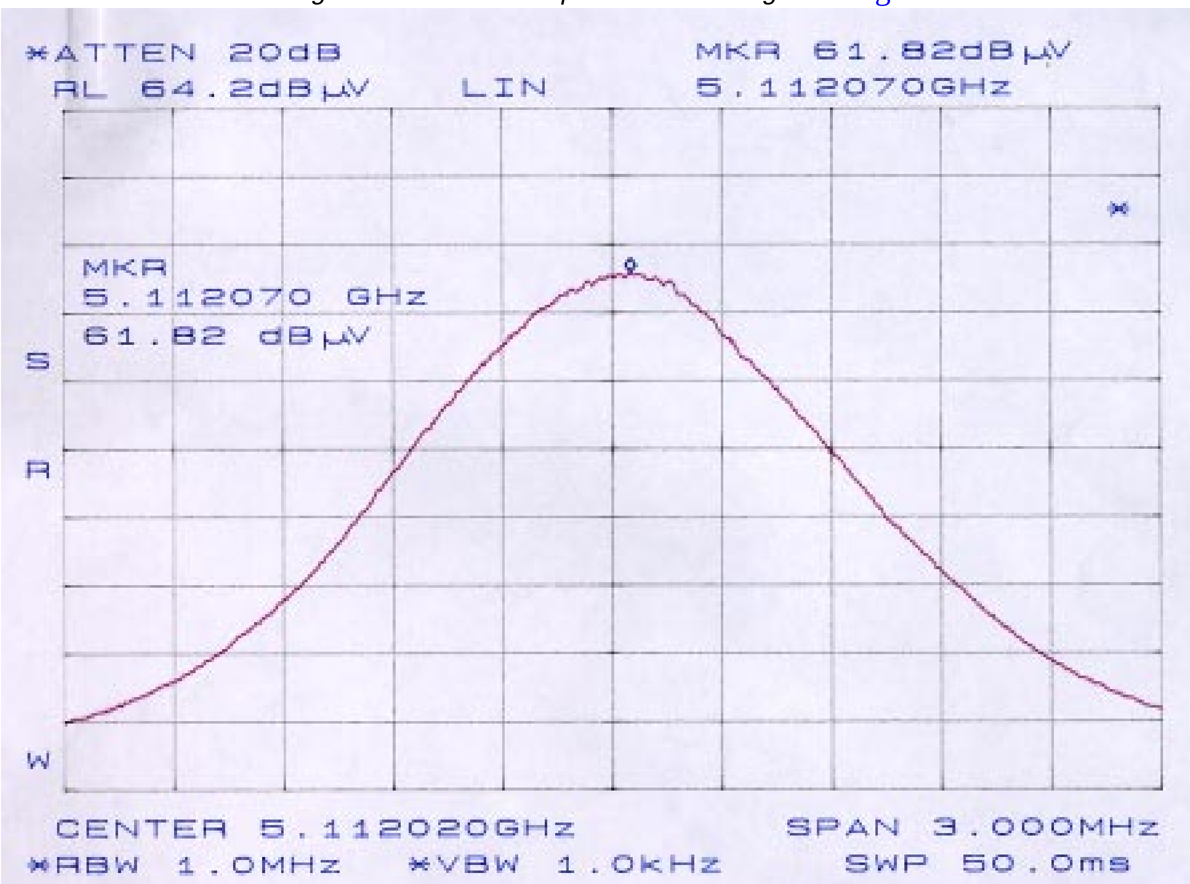


Figure 11.46 is the RU digital 2.6. RU RF 2.27, and RU HSD board 18 - 26.5 GHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.46 18 - 26.5 GHz Horizontal: Two Voice Calls and HSD

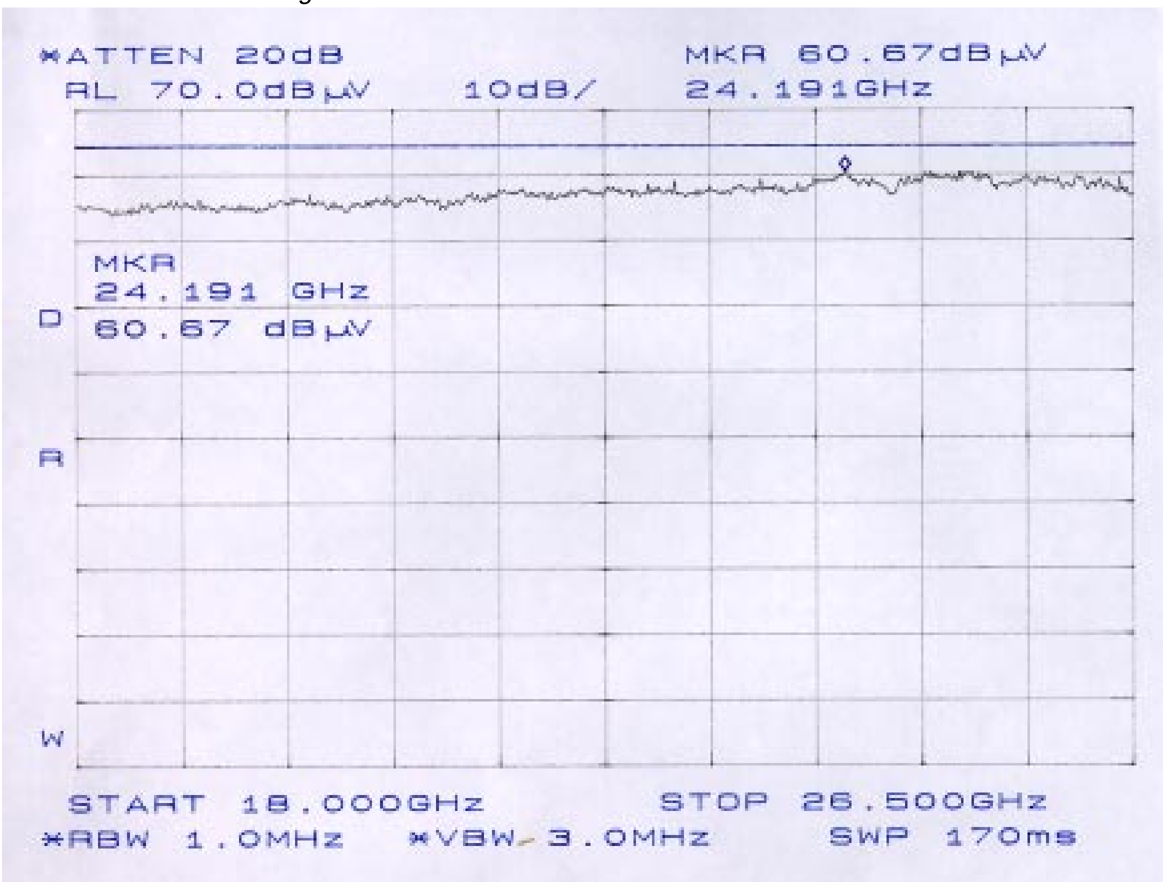


Figure 11.47 is the RU digital 2.6. RU RF 2.27, and RU HSD board 18 - 26.5 GHz radiated emissions scan. The RU was exercised with two voice calls and high-speed data continuously throughout the duration of the test.

Figure 11.47 18 - 26.5 GHz Vertical: Two Voice Calls and HSD

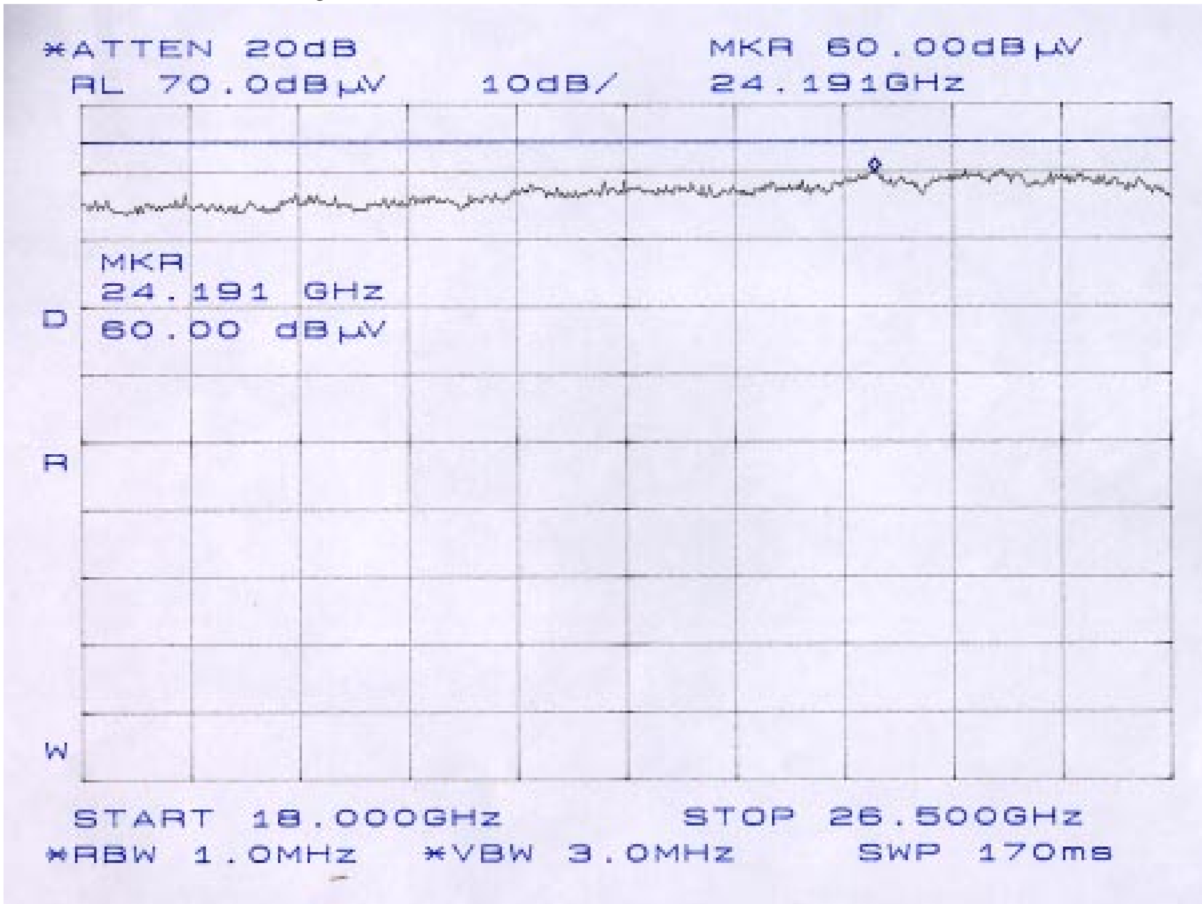
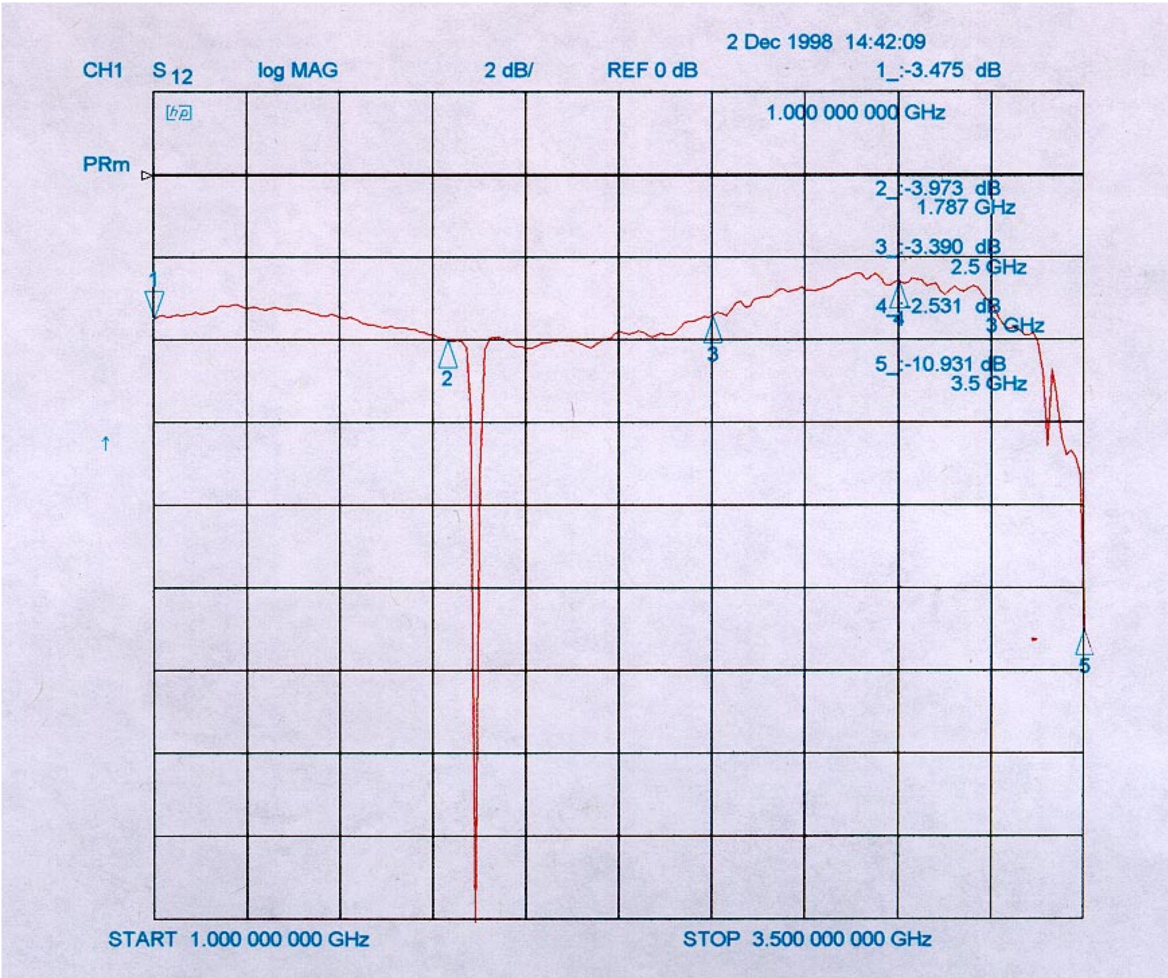


Figure 11.48 shows the K&L notch filter characteristics as used within the 1 to 3.5 GHz radiated emissions testing. Provided for notching the fundamental frequency, thus protecting the EMI 8546A receiver.

Figure 11.48 Notch Filter Characterization From 1 - 2 GHz



11.3.4.2 Conducted Emissions

The purpose of this test is to measure the product emissions on the input power lines to insure that the product will not interfere with other electronic devices. However, the RU has no direct connection to an AC power source. Therefore, conducted testing was completed on the RU power supply while properly loaded with an RU.

The Remote Unit interconnecting cable consists of two 18-gauge twisted pairs, with one pair providing -24 volts DC for RU operation and the other pair providing status of the power supply. In addition, there are two 24-gauge twisted pairs, providing telco connection to the telephones via the network interface device and residential wiring. All four twisted pairs are contained together in a shielded PVC jacketed cable.

The battery backed-up power supply is connected to the AC power utility, via an eight foot 18-gauge non-polarized plug. Testing was conducted on the power supply by the manufacturer, contains an FCC identification number and is used by this product (RU) as an off the shelf power supply. The test setups and data were supplied by the manufacturer and verified at the AT&T Wireless EMC laboratory located in Redmond, Washington.

Radio-frequency line voltage noise being conducted back to the AC utility must not exceed the FCC requirements shown in Table 11.21.

Table 11.21 FCC Conducted Emission Limits

Frequency (MHz)	Maximum Radio - Frequency Live Voltage	
	(μV)	(dBμV)
0.45 - 1.705	250	47.9
1.705 - 30	250	47.9

11.3.4.2.1 Applicable FCC Rules

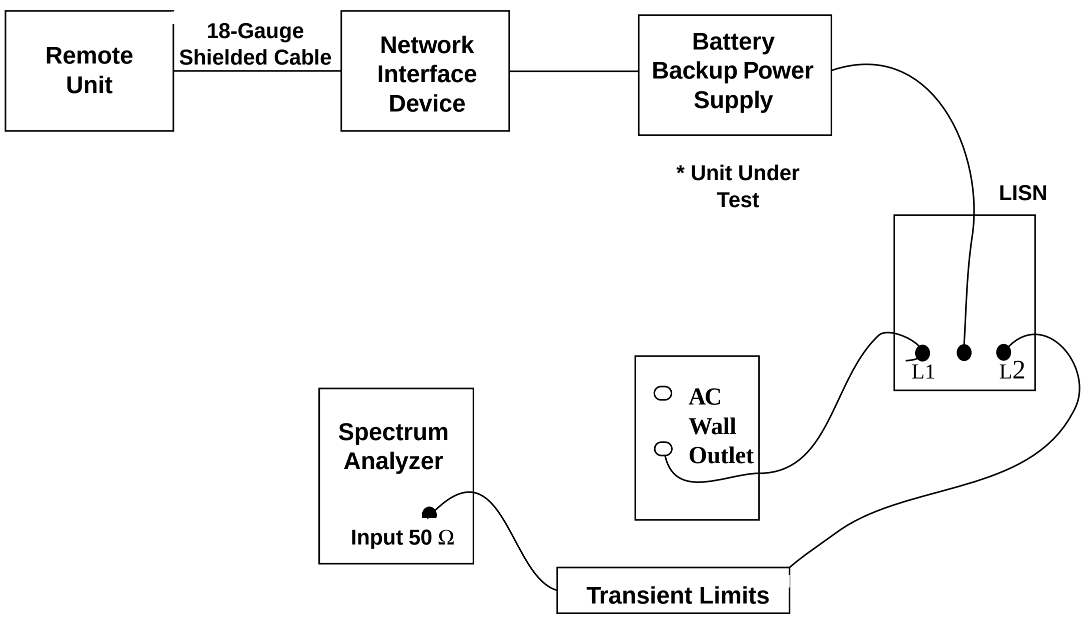
FCC Subpart 15.207 - Device that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

11.3.4.2.2 Test Configuration

The power supply and RU should be setup as shown in Figure 11.49. The power supply’s AC power cord is plugged into the LISN. The extra cord is wrapped in a figure-8 fashion around the 2 posts located on the top of the LISN. The LISN’s AC power cord is plugged into the AC outlet at the wall. The spectrum analyzer is plugged in the AC wall outlet and options 021 and103 are chosen on the back of the spectrum analyzer. One end of the Transient Limiter is plugged into the Input 50

Ohms on the spectrum analyzer, and the other end is plugged into either L1 or L2 on the LISN.

Figure 11.49 Conducted Emission Setup

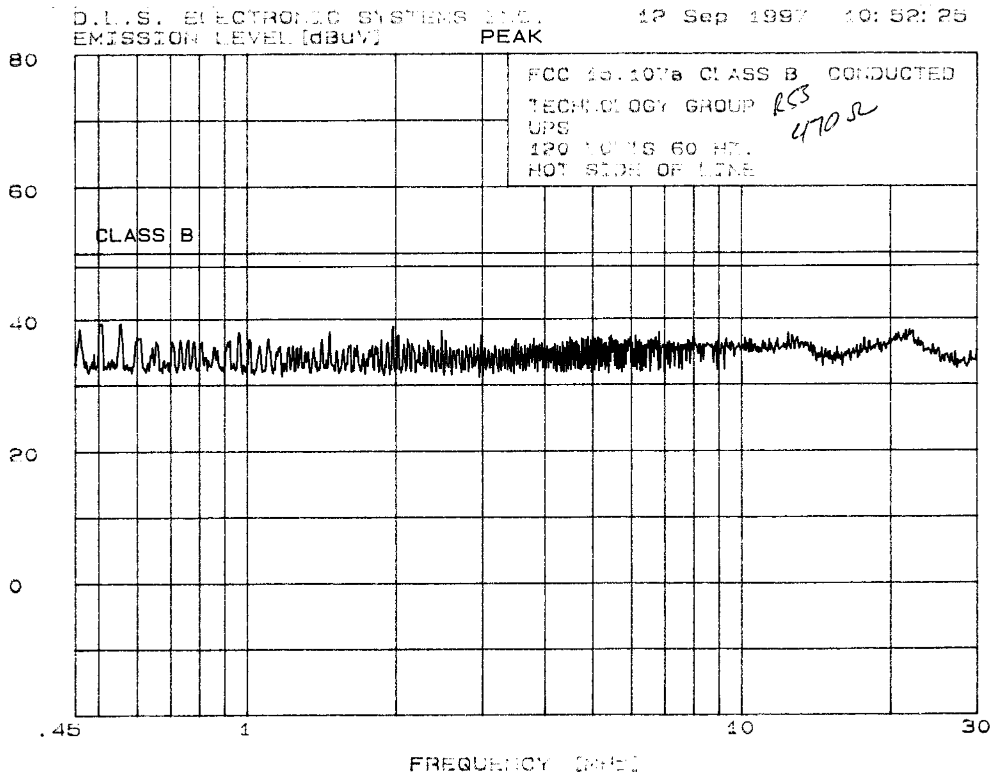


The spectrum analyzer uses the peak detector, a resolution bandwidth of 9.0 kHz, and a video bandwidth of 30 kHz. The limit line was set to 47.9 dBuV, with a reference level of 80 dbuV, and a sweep time of 10 seconds. Testing was completed with a 120 volt, 60 Hz on both the "Hot Side" and "Neutral Side".

11.3.4.2.3 Test Results

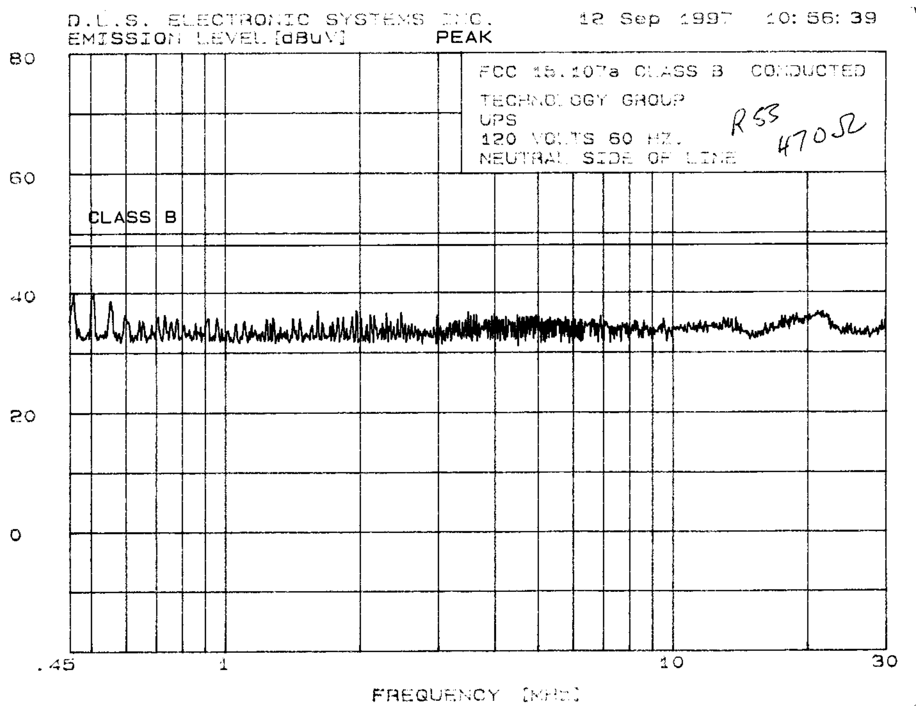
The RU was powered by the power supply and test equipment setup as shown in Figure 11.49. Conducted emission testing was than performed on the "Hot Side of Line" with the results being documented in Figure 11.50. As the data shown indicates, the highest conducted emissions was 10 dB below the FCC limit.

Figure 11.50 120 Volt; 60 Hz - Hot Side



Conducted emissions testing was then performed on the “Neutral Side of Line” with the results being documented in Figure 11.51. As the data shown indicates, the highest conducted emissions was 10 dB below the FCC limit.

Figure 11.51 120 Volt; 60 Hz - Neutral Side



Since the RU only has DC power supplied to function properly and does not connect to the AC utility, the RU was not tested to the AC conducted emission requirement. However, the power supply which is plugged into the AC utility was tested and shown to pass while loaded properly with the RU. As indicated by the data shown in this section the power supply in which the RU is connected meets the FCC requirement for conducted emissions while under load.

11.3.4.3 Radiated to Conducted Spurious Emissions

The conducted spurious emissions at the antenna terminal was tested at +/- 5 MHz from the fundamental frequency within Chapter 4 of the report, specifically Section 4.3.6. The testing within Chapter 4 was conducted with a HP Signal Vector Analyzer, specifically suited for close in measurements to the fundamental frequency. To further evaluate the RU for spurious emissions outside the +/- 5 MHz fundamental investigation using the test setup outlined in Section 12.1, Figure 12.1 and Figure 11.24 was used. This allowed the flexibility to scan for RU harmonics from 1000 to 3500 MHz.

11.3.4.3.1 Applicable FCC rules

FCC Subpart 2.985 -This requires that the RF output be measured at the antenna power terminals into a dummy load after the transmitter has been adjusted in accordance with the manufacturers tune up procedure. Requires documentation of measurement configuration. Transmitter spectral output shall not have any components that exceed the spectral mask applicable to the rule part under which the equipment shall be operated.

FCC Subpart 24.238 - On any frequency outside a licensee’s block, the power of any emission shall be attenuated below the transmitter power (P) by at least 43+10Log(P) dB. Compliance is based on measurement within a 1 MHz resolution bandwidth. However, in the 1 MHz bands immediately adjacent to the frequency block a resolution bandwidth of at least 1 percent of the emission bandwidth may be employed. The emission bandwidth is defined as the width of the signal between two points, one above and one below the carrier frequency, outside of which all emissions are attenuated by at least 25 dB below the transmitter power.

11.3.4.3.2 Test Configuration

Radiated emissions scans were performed in the AT&T 3-m semi-anechoic chamber. The Remote Unit was placed on a non-conductive table 80 cm above the ground plane with a receive antenna placed a distance of 3 m from the device under test. The test setup consisted of a 1 meter shielded cable grounded at the enclosure via a pressure clamp, routed through a patch panel for connection to the Network Interface Device (NID) and Universal Power Supply (UPS). Two simultaneous voice calls together with high-speed data operating over an RE Link via the field installed NID and UPS exercised the unit in a worse case scenario. The Remote Unit (RU) under test was comprised of the following components:

- RU digital version 2.6.
- RU RF version 2.27 (transmitter attenuation was manually set to 10 dB as a worse case condition), and
- RU HSD version 0.8.

Three shield cans on the top side of the RF board in conjunction with BeCu gasketing material separates the RE and digital sections, two additional cans over the transmit and receive local oscillators are being used on the bottom side of the board with the antenna cables routed around them. A 40 mil conductive gasket was used where the ball antenna assembly mounted to the RU chassis

11.3.4.3.3 Test Results

The data presented here is in addition to the results presented in Section 11.1.8. After completion of the radiated emission scans, Figure 11.36 through Figure 11.47, the highest 6 signals closest to the fundamental frequency were evaluated to the spurious emission spectrum as shown in Figure 11.24. These frequencies were converted from dBμV to dBm and compares to the FCC Part 24 spurious emissions limit. Testing was completed with a resolution and video bandwidth of 1000 MHz. Table 11.22 provides the data and comparison to both the dBuV and dBm FCC limits. It should be noted that the frequencies contained within the following table have been evaluated and found to be non-spurious occurrences.

Table 11.22 Part 24 Spurious Emission Limits

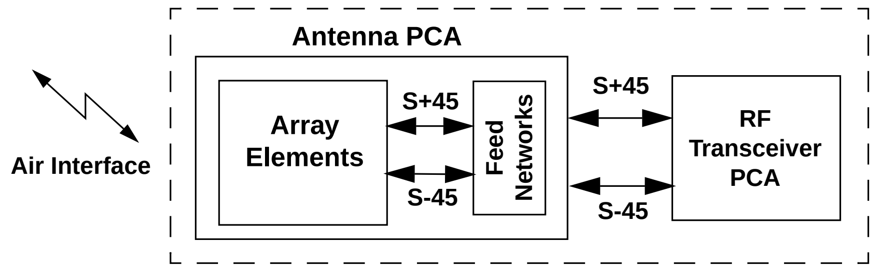
Frequency (GHz)	Part 15 Avg Level (dBμV)	Avg dBm	dB Below -13 dBm Limit Line
1.626	54.35	-52.65	39.7
1.704	59.87	-47.13	34.1
2.408	53.21	-53.79	40.8
2.417	54.63	-52.37	39.4
5.112035	61.52	-45.48	32.5
24.191	60.67	-46.33	33.3

11.4 RU Antenna Specifications

11.4.1 Overview

The RU antenna is composed of a planar array of dual slant polarized radiating elements fed with integral feed networks. This antenna will form a single fixed broadside beam with sufficient gain, sidelobe level, beamwidth and cross-polarization isolation to provide adequate coverage to its serving Base Station in the specified bands of the 1.85 to 1.99 GHz personal communication system (PCS) spectrum. The antenna assembly will provide two outputs (slant+45º and slant-45º) to the two radio frequency (RF) receivers that reside in the same housing. In transmit, the antenna will be driven in such a manner as to radiate vertical polarization. Figure 11.52 is a functional block diagram showing antenna interfaces.

Figure 11.52 RU Antenna Interfaces



11.4.2 Antenna Specification

The RU antenna consists of an array of dual slant polarized (slant+45º and slant-45º) radiating elements and their integrated corporate feed networks. The radiating elements and corporate feed networks may be etched on microwave laminate(s) and bonded together to form a microstrip/stripline multilayered board. This will be referred to as the antenna printed circuit assembly (PCA). The cost versus performance of the laminate material is an important consideration. Designs utilizing materials such as FR-4 would be preferred.

The size of this antenna PCA is planned to be no greater than 13" x 13". The depth of the enclosure housing the antenna assembly and associated RF, digital, and power supply electronics is 3.75". The antenna assembly can occupy up to 1 inch of this depth. Refer to the mechanical drawing for proposed final dimensions.

The interface between the RF transceiver PCA and antenna PCA will be made through two RF connectors located on the antenna. In transmit, these two antenna ports will be driven via an in-phase splitter located on the RF transceiver PCA. The amplitude and phase of the antenna's feed networks will be properly balanced so that vertical polarization is achieved in transmit. The antenna input impedance at the connectors is nominally 50 ohms.

The antenna assembly should provide additional shielding effectiveness for the RF transceiver PCA.

The RU antenna will be installed with appropriate mounting hardware such that it points directly to its Base Station antenna within +/- 10 degrees.

Table 11.23 gives performance specifications for the RU antenna.

Table 11.23 RU Antenna Performance Specifications

Specification	Required Value
Frequency Range	1850 - 1990 MHz
Gain	14 dBi (min.)
Azimuth Half-Power Beamwidth	30^o
Azimuth Sidelobe Level	-13 dB (max)
Azimuth Beam-Squint	$+/-3^o$
Front-to-Back Ratio	>25 dB
Polarization	Transmit: Vertical Receive: Slant+45^o & Slant-45^o
Cross-Polarization Isolation	Transmit: -20 dB (Horizontal) Receive: -20 dB
VSWR	1.5:1(max.), 50 ohms
IM Distortion (with two 10 W tones applied at input connector)	-150 dBc
RF Connectors	SMA
Typical Connecting Cable Loss	0.3 dB
Ambient temperature range	-40^o C to $+50^o$ C outside air temperature
Operating temperature range	-40^o C to $+70^o$ C inside RU with solar loading

11.4.3 Operational Temperature Ranges

Operational temperature range:
Outdoor air temperature: -40°C to +70°C (-40°F to +158°F)
Relative humidity: 5% to 95%

11.4.4 RU Antenna Pattern

The manufacturer completed an antenna pattern measurement as shown in Figure 11.53, showing an antenna gain of 15 dBi. This antenna and pattern was verified to meet the minimum AT&T antenna specifications and was measured to have a 14 dBi gain as shown in Figure 11.54 at the AT&T Redmond, Washington EMC/Antenna Laboratory. The insertion loss of the cables used to connect the antenna to the RF 2.27 board is shown in Figure 11.55.

Figure 11.53 Manufacturer's Antenna Pattern

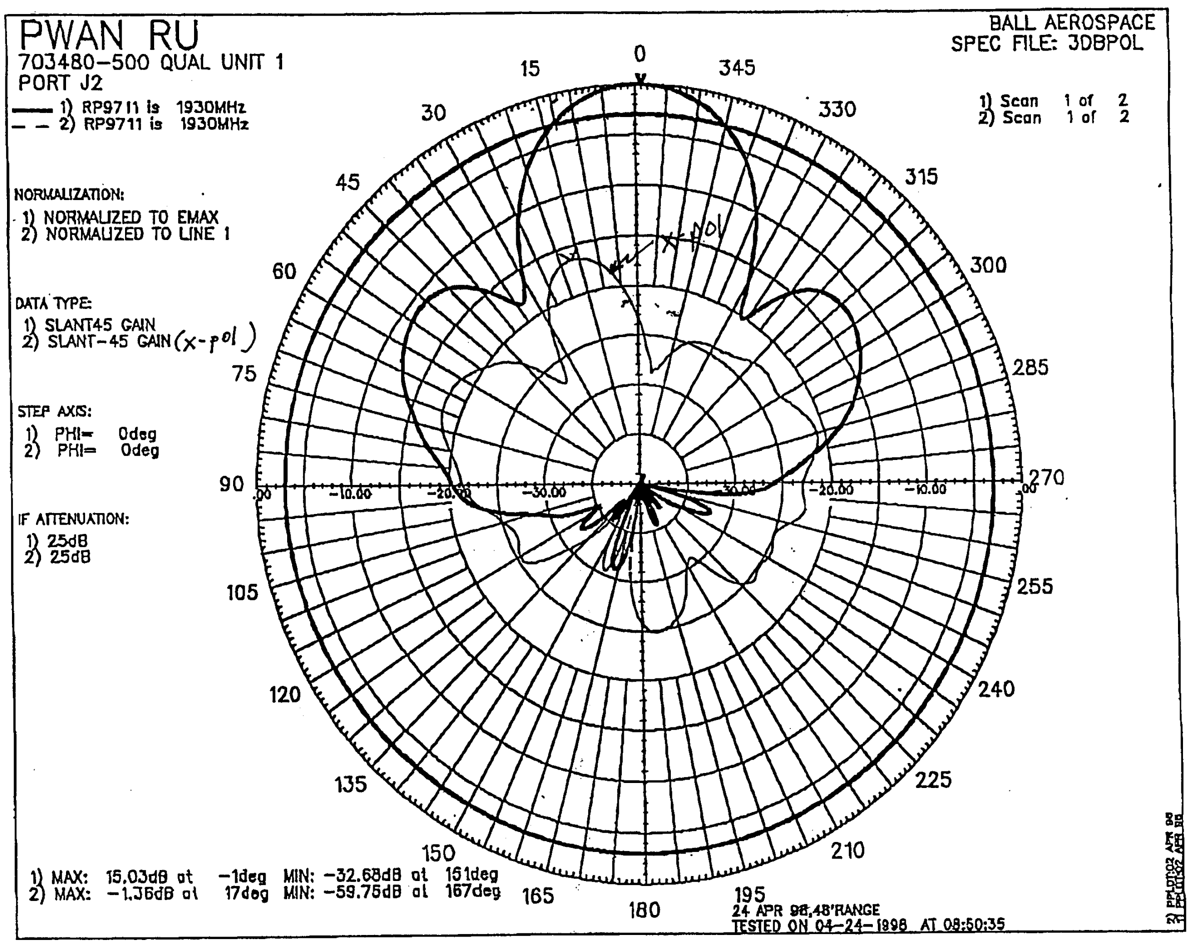
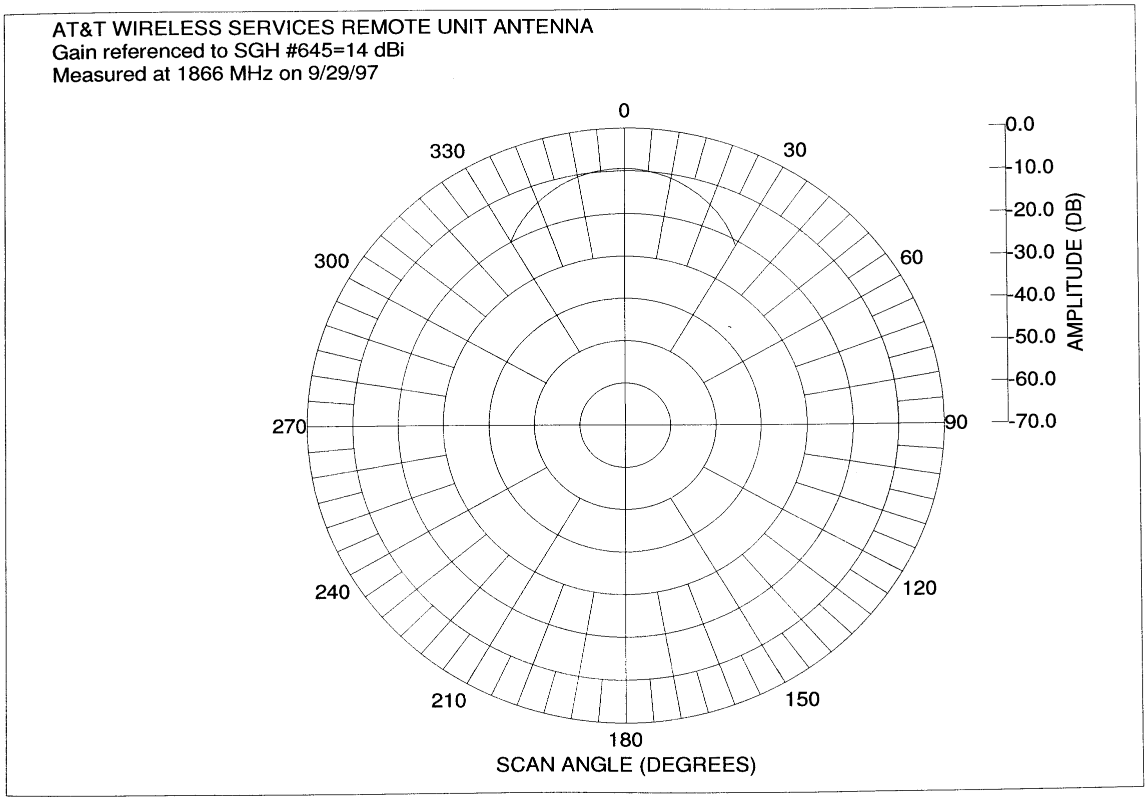


Figure 11.54 AT&T RU Antenna Pattern



Scientific-Atlanta, Inc.

Figure 11.55 Antenna Connecting Cable Loss vs. Frequency