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 11-2
11.2 RF Characterization Test Results 11-31
11.3 Electromagnetic Compatibility Test Results. 11-65

11.1 Test Methodology

This section describes the test methodology used to validate the performance of the AT&T Wireless Services PWAN Base Station 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 Base Station.

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 Base Station Frequency Stability vs. Temperature

11.1.2.1 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.

11.1.2.2 Overview

The PWAN Base Station obtains its frequency stability from GPS-disciplined 10 MHz ovenized oscillators located on the station's primary and redundant Synchronization Cards. Either Synchronization Card is capable of functioning in one of the following three operational modes:

Oscillator operating in GPS Locked Mode: During normal operation, the frequency of the 10 MHz oscillator is disciplined by GPS to an accuracy of approximately 0.005 PPM.

Oscillator operating in GPS Holdover Mode: In the event that GPS signals are lost (due to an antenna or GPS receiver failure), the 10 MHz oscillator will utilize the most current correction data obtained from the on-board GPS receiver to maintain an accuracy of approximately 0.02 PPM over a 24 hour period.

Oscillator operating in GPS Free-Run mode: In the event that GPS is completely unobtainable, the 10 MHz oscillator will free-run with an accuracy of approximately. 0.2 PPM.

The 10 MHz disciplined oscillators on the primary and redundant Synchronization Cards serve as the main frequency-determining element in the Base Station. Any frequency error present in the 10 MHz output of the Synchronization Cards will create a corresponding frequency error in each transmitted OFDM tone at the Base Station operating frequency.

The Base Station also contains its own low stability (approx. 5 PPM) 10 MHz reference oscillator. This internal oscillator is phase-locked to the active Synchronization Card for the purpose of minimizing the effects of reference oscillator phase noise. The Base Station software is designed to disable RF output power in the event that both of the Synchronization Cards fail (or are not present). As a result, the Base Station will not transmit while using the internal oscillator as its 10 MHz reference.

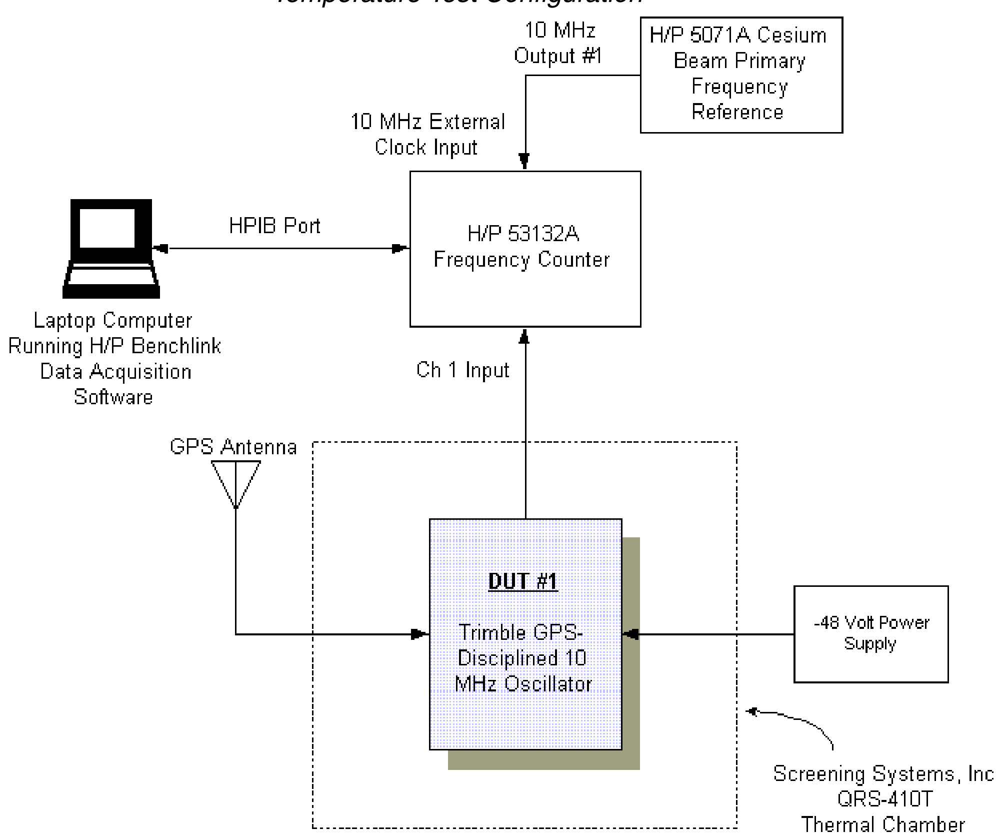
11.1.2.3 Test Methodology

The Synchronization Card under test was placed into a Screening Systems, Inc. model QRS-410T thermal chamber (refer to Figure 11.1). A Hewlett/Packard 53132 frequency counter was used to monitor the output frequency of the DUT. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the 53132A frequency counter. The frequency counter resolution was set to 0.001 Hz.

The frequency accuracy of the 10 MHz oscillator 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. The thermal chamber’s sensing thermocouple was attached to the Synchronization Card about 10 cm from the ovenized oscillator to assure 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 stability of the DUT was measured over temperature in each of the three operating modes.

Figure 11.1 Base Station Synchronization Card Frequency Stability vs. Temperature Test Configuration



11.1.3 Base Station Frequency Stability vs. Input Voltage

11.1.3.1 Applicable FCC Rules Parts

FCC Subpart 2.995 - The frequency stability shall be measured with variation of primary supply voltage as follows: 1) Vary primary voltage from 85 to 115 percent of the nominal value for other than hand carried equipment. 3) The supply voltage shall be measured at the input to the cable provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

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 Base Station obtains its frequency stability from GPS-disciplined 10 MHz ovenized oscillators located on the station's primary and redundant Synchronization Cards. Either Synchronization Card is capable of functioning in one of the following three operational modes:

Oscillator operating in GPS Locked Mode: During normal operation, the frequency of the 10 MHz oscillator is disciplined by GPS to an accuracy of approximately 0.005 PPM.

Oscillator operating in GPS Holdover Mode: In the event that GPS signals are lost (due to an antenna or GPS receiver failure), the 10 MHz oscillator will utilize the most current correction data obtained from the on-board GPS receiver to maintain an accuracy of approximately 0.02 PPM over a 24 hour period.

Oscillator operating in GPS Free-Run mode: In the event that GPS is completely unobtainable, the 10 MHz oscillator will free-run with an accuracy of approximately. 0.2 PPM.

The 10 MHz disciplined oscillators on the primary and redundant Synchronization Cards serve as the main frequency-determining element in the Base Station. Any frequency error present in the 10 MHz output of the Synchronization Cards will create a corresponding frequency error in each transmitted OFDM tone at the Base Station operating frequency.

The Base Station also contains its own low stability (approx. 5 PPM) 10 MHz reference oscillator. This internal oscillator is phase-locked to the active Synchronization Card for the purpose of minimizing the effects of reference oscillator phase noise. The Base Station software is designed to disable RF output power in the event that both of the Synchronization Cards fail (or are not present). As a result, the Base Station will not transmit while using the internal oscillator as its 10 MHz reference.

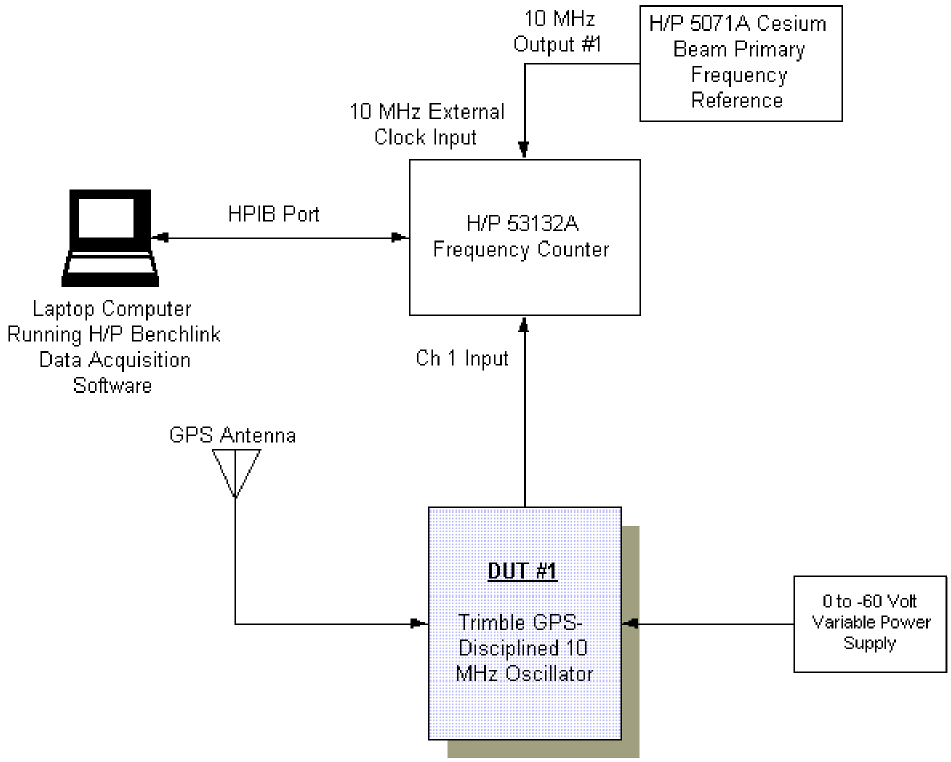
11.1.3.3 Test Methodology

The Synchronization Card under test was connected to a variable DC power supply (refer to Figure 11.2). A Hewlett/Packard 53132 frequency counter was used to monitor the output frequency of the DUT. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the 53132A frequency counter. The frequency counter resolution was set to 0.001 Hz.

The frequency accuracy of the 10 MHz oscillator was tracked over the voltage range of -40.8 to -55.2 VDC (±15%) in 1.0 volt increments.

The output frequency stability of the DUT was measured over voltage in each of the three operating modes.

Figure 11.2 Base Station Synchronization Card Frequency Stability vs. Input Voltage Test Configuration



11.1.4 Base Station Occupied Bandwidth

11.1.4.1 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.

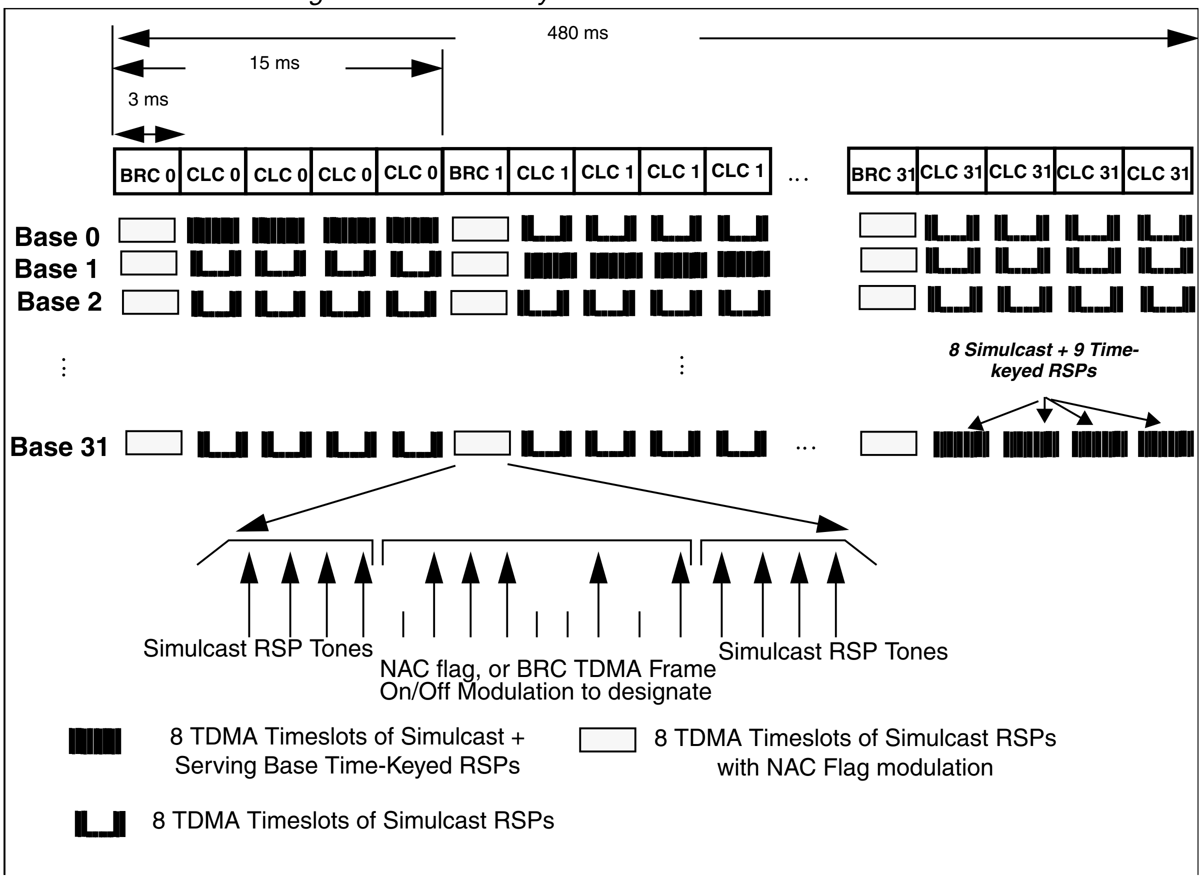
11.1.4.2 Overview

PWAN Base Station occupied bandwidth measurements do not differ substantially from any other system. The occupied bandwidth of a PWAN Base Station is maximized while transmitting eight simulcast Remote Synchronization Pilots (RSP's) without any voice or high-speed data traffic.

11.1.4.3 Test Methodology

The Base Station was allowed to operate in the idle mode (no call processing or data transfer).During normal operation, the number of RSP tones transmitted by the base varies according to the time slot associated with each transmission burst (refer to Figure 11.3).

Figure 11.3 Time Keyed RSP Structure

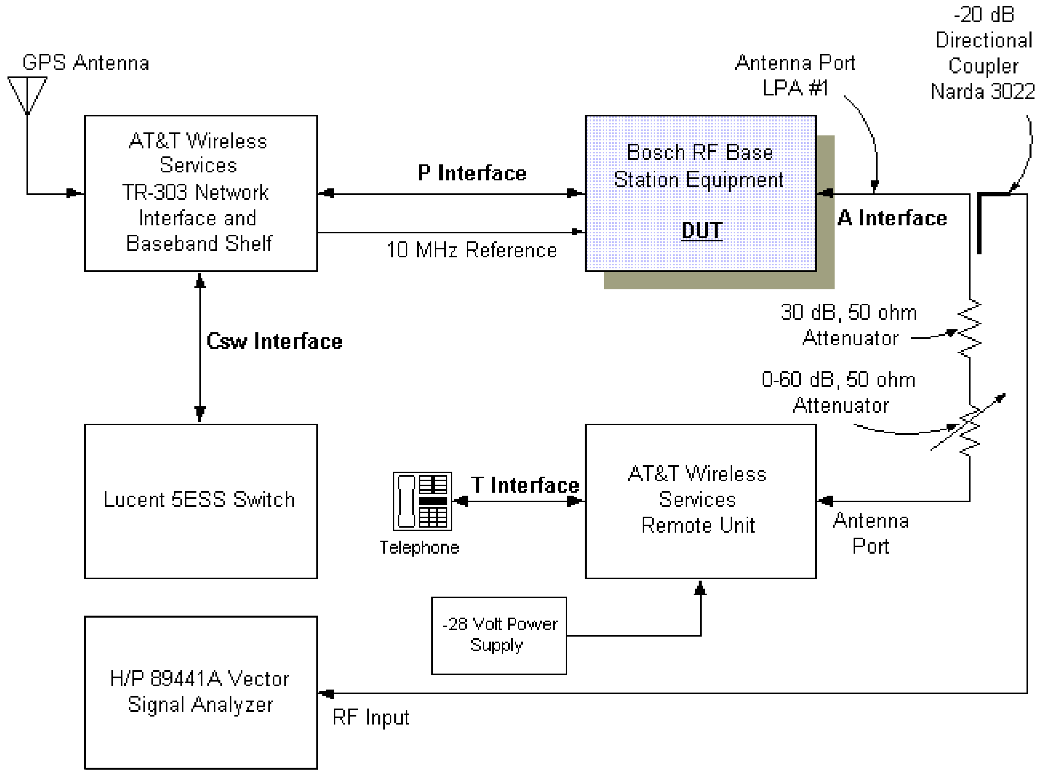


As Figure 11.3 indicates, each base will transmit eight RSPs continuously and five time-keyed RSPs every 15 ms. Every 480 ms, each base will transmit all 17 RSPs and a Broadcast Channel message. Because the Base Station's RSP activity is temporal (resulting in varying RF power per burst according to the number of active RSP tones in each TDMA slot), characterization of these pilots is difficult. Therefore, the Hewlett-Packard 89441A Vector Signal Analyzer and 89451A Digital Radio Personality option was configured to capture a 375 ms time record at the Base Station operating frequency (refer to Table 11.2 for configuration parameters). RF bursts contained in this time record were analyzed individually to obtain an occupied bandwidth measurement.

Table 11.2 Hewlett-Packard Type 89451A Radio Personality Configuration Parameters (Time Capture Mode)

Parameter	Value
Center Frequency	1949.0 MHz
Span	2 MHz
Main Time Length	400 µs
Gate Time Length	320 µs
Gate Delay	50 µs
Input Level	+25 dBm
Input Mode	Time Capture
External Attenuation	21.1 dB
Frequency-Domain Averaging	Off
FFT Window Type	Flat Top
FFT Frequency Points	1501
FFT Resolution BW	12 kHz

Figure 11.4 Base Station Occupied Bandwidth Test Configuration



11.1.5 Modulation Characterization

11.1.5.1 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.

11.1.5.2 Overview

The modulation characteristics of the PWAN Base Station transmitter differ substantially from any other system. The OFDM time-domain waveform transmitted by the Base Station 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:

- Multiple Voice Traffic channel

- High-Speed Data Traffic channel
- High Speed Data Control channel
- Broadcast channel
- Time-Keyed Remote Synchronization channel
- Simulcast Remote Synchronization channel

These logical channels are described in detail in Chapter 7 “Operational Description” 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 10^6 samples of the time-domain RF bursts (this measurement was not possible for Remote Synchronization channel measurements).

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 (Real-Time Measurement Mode)

Parameter	Value
Center Frequency	1949.0 MHz
Span	2 MHz
Main Time Length	400 us
Gate Time Length	320 us
Gate Delay	50 µs
Trigger Type	IF Channel 1
Input Level	+25 dBm
External Attenuation	21.1 dB

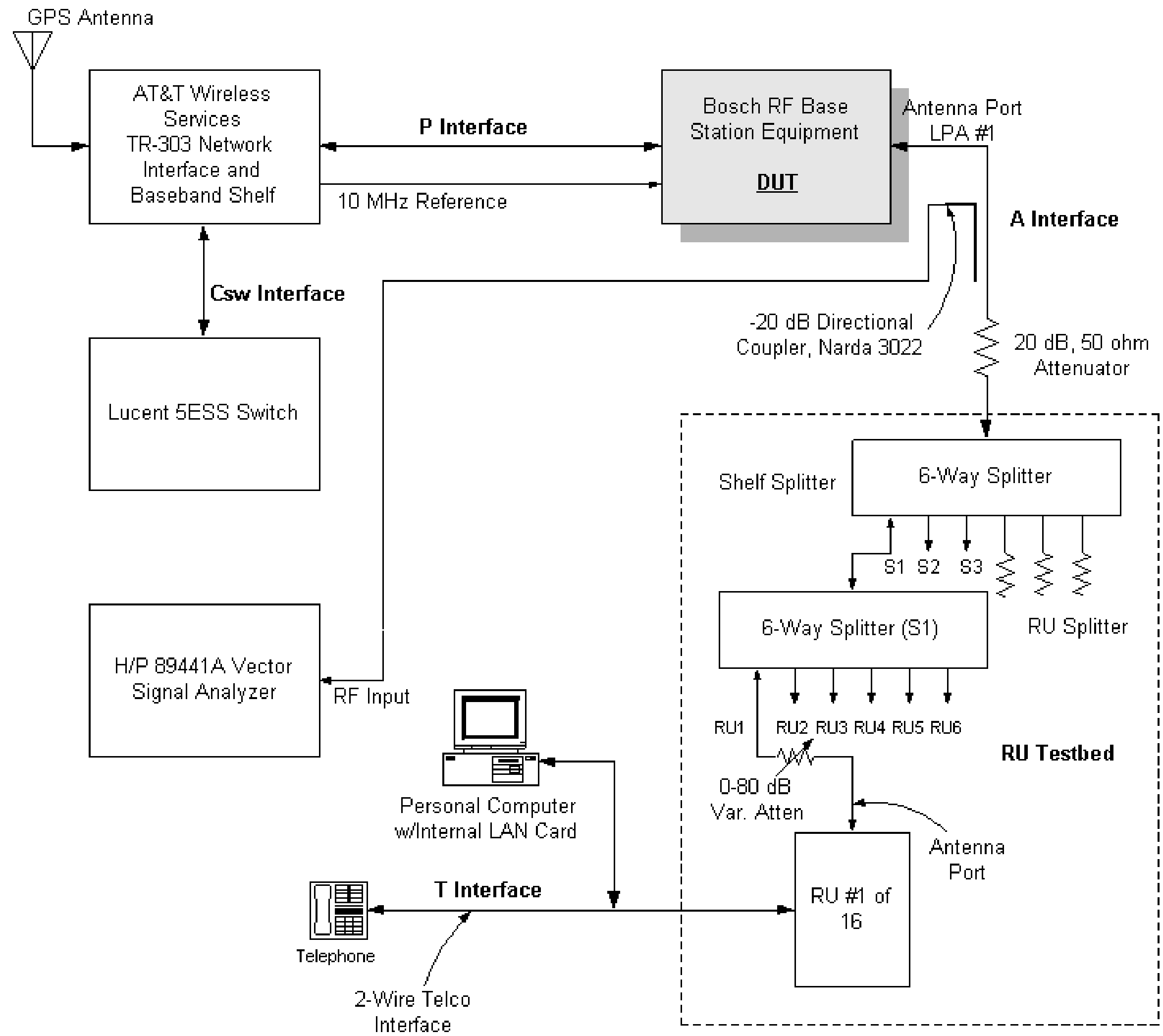
Table 11.3 Hewlett-Packard 89441A Modulation Characterization Test Parameters (Real-Time Measurement Mode)

Peak/Average Metric	99.0%
Trigger Delay	Selected to center 320 µs transmission bursts in time gate (typically -55 µs)
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1501
Resolution BW	12 kHz

Table 11.4 Hewlett-Packard 89441A Modulation Characterization Test Parameters (Time Capture Mode)

Parameter	Value
Center Frequency	1949.0 MHz
Span	2 MHz
Main Time Length	400 µs
Gate Time Length	320 µs
Gate Delay	50 µs
Input Level	+25 dBm
Input Mode	Time Capture
External Attenuation	21.1 dB
Frequency-Domain Averaging	Off
FFT Window Type	Flat Top
FFT Freq Points	1501
FFT Resolution BW	12 kHz

Figure 11.5 Modulation Characterization Test Configuration



11.1.5.3 Test Methodology

11.1.5.3.1 Voice Channel

A total of 15 telephone calls within a single TDMA slot were established between a pool of Remote Units and the Base Station under test using the configuration shown in Figure 11.5. A Hewlett-Packard 89441A Vector signal analyzer was configured according to the parameters shown in Table 11.3. The random nature of the airlink data produced by the LD-CELP compression algorithm is sufficient to assure results representative of a normally operating system.

11.1.5.3.2 High-Speed Data Channel

A High Speed Data (HSD) session was established between a single Remote Unit and the Base Station under test using the configuration shown in Figure 11.5. A Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.3.

During this test, a text file was copied from an AWS network file server (using File Transfer Protocol) through the Base to a personal computer connected to a Remote Unit. The random nature of the data contained in this file was sufficient to assure results representative of a normally operating system.

11.1.5.3.3 High Speed Data Control Channel

Characterization of the High Speed Data (HSD) Control channel took place utilizing the test configuration shown in Figure 11.5. A Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

During normal operation, the HSD Control channel is used to transmit a single pilot tone and two DSMA status flags during two TDMA slots in each TDMA frame (25% duty cycle). The HSD Control channel for the Base Under Test was characterized during a period of HSD Traffic Channel inactivity.

11.1.5.3.4 Broadcast Channel

The Broadcast Channel was characterized using the test configuration shown in Figure 11.5. A Hewlett-Packard 89441A Vector Signal Analyzer was configured according to the parameters shown in Table 11.1.

11.1.5.3.5 Time-Keyed Remote Synchronization Channel

During normal operation, the number of Remote Synchronization Pilot (RSP) tones transmitted by the base varies according to the time slot associated with each transmission burst. For example, of the 17 RSP tones available, eight are transmitted continuously and nine are time-keyed (refer to Figure 11.3). Every 480 ms, each base will transmit all 17 RSPs and a Broadcast Channel message.

Because the Base Station's RSP activity is temporal (resulting in varying RF power per burst according to the number of active RSP tones in each TDMA slot), characterization of these pilots is difficult. Therefore, the Hewlett-Packard 89441A Vector Signal Analyzer and 89451A Digital Radio Personality option was configured to capture a 375 ms time record at the Base Station operating frequency. Because bursts were analyzed manually, insufficient data points were available to produce a meaningful CCDF. Consequently, this parameter was excluded from the Time-Keyed Remote Synchronization channel characterization measurements.

11.1.5.3.6 Simulcast Remote Synchronization Channel

During normal operation, the number of Remote Synchronization Pilot (RSP) tones transmitted by the base varies according to the time slot associated with each transmission burst (refer to Figure 11.3).

Because the Base Station's RSP activity is temporal (resulting in varying RF power per burst according to the number of active RSP tones in each TDMA slot), characterization of these pilots is difficult. Therefore, the Hewlett-Packard 89441A Vector Signal Analyzer and 89451A Digital Radio Personality option was configured to capture a 375 ms time record at the Base Station operating frequency. Because each burst was analyzed manually, insufficient data points were available to produce a meaningful CCDF. Consequently, this parameter was excluded from the Simulcast Remote Synchronization channel characterization measurements.

11.1.6 RF Output Power

11.1.6.1 Applicable FCC Rules

FCC Subpart 2.985-Power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in §2.983 (d)(5). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

FCC Subpart 24.232 - In no case may the peak output power of a base station transmitter 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.

11.1.6.2 Overview

Peak RF Output Power from the Base Station is maximized while supporting 15 simultaneously active FDMA slots. A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize the Base Stations'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

The specific operating parameters of the Hewlett-Packard 89441A Vector Signal Analyzer are summarized in Table 11.5

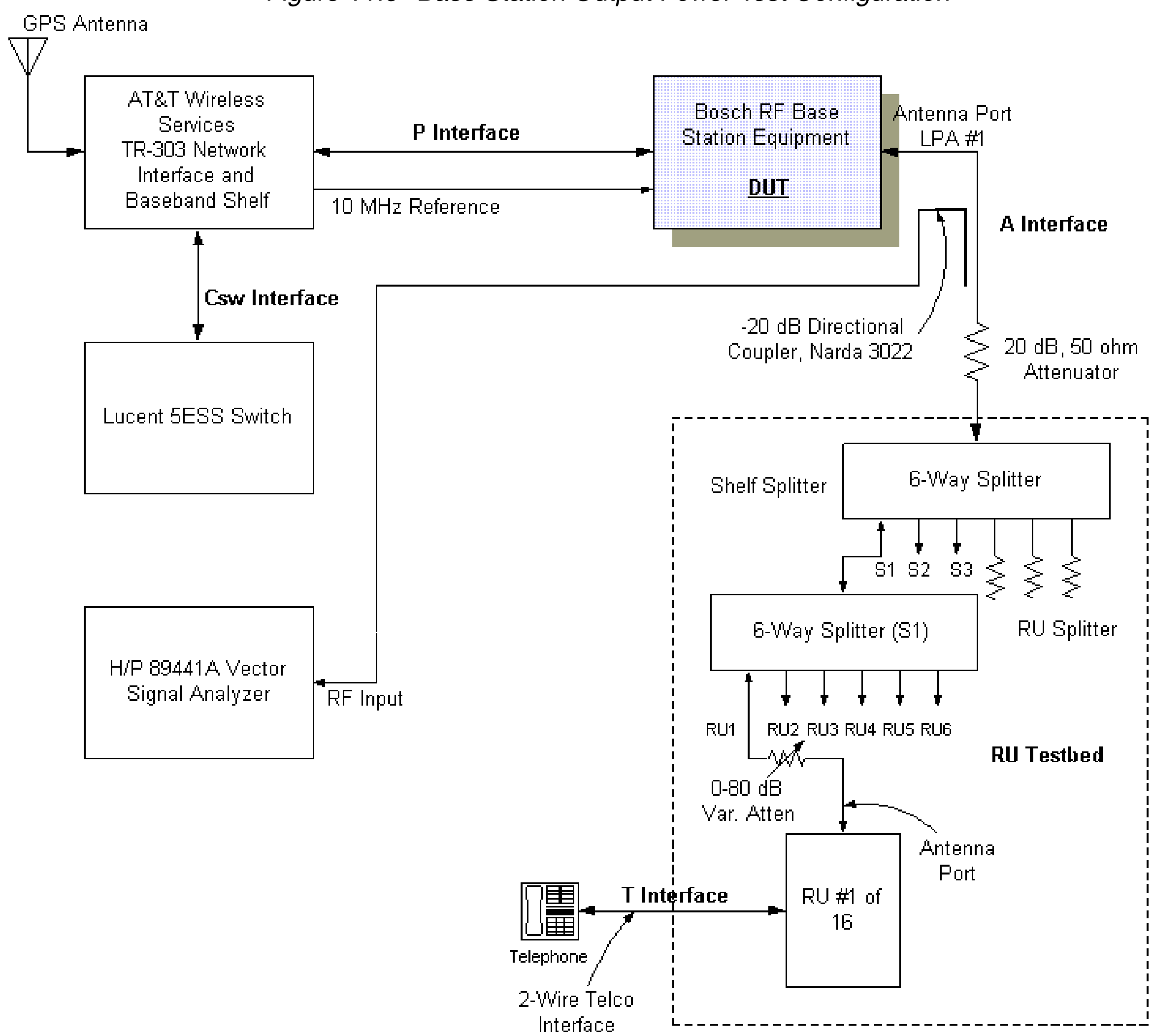
Table 11.5 Hewlett-Packard 89441A RF Power Test Parameters

Parameter	Value
Center Frequency	1949.0 MHz
Span	2 MHz
Main Time Length	400 µs
Gate Time Length	320 µs
Gate Delay	50 µs
Input Level	+25 dBm
External Attenuation	21.1 dB
Peak/Average Metric	99.0%
Trigger Type	IF Channel 1
Trigger Delay	Selected to center 320 µs transmission bursts in time gate (typically -55 µs)
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1501
FFT Resolution BW	12 kHz

11.1.6.3 Test Methodology

Peak RF output power from the Base Station is maximized while supporting 15 simultaneously active FDMA slots. For this test, a total of 15 voice calls were established between multiple Remote Units and the Base Station under test using the equipment configuration shown in Figure 11.6. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.5. The random nature of the data generated by the LD-CELP compression algorithm was sufficient to assure results representative of a normally operating system.

Figure 11.6 Base Station Output Power Test Configuration



11.1.7 Spurious Emissions at the Antenna Terminal

11.1.7.1 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.

11.1.7.2 Overview

The RF spectral purity of the PWAN Base Station transmitter does not differ substantially from a conventional TDMA transmitter, other than the characteristics of any intermodulation products that are produced. RF Output Power and Out-Of-Band (OOB) emissions from the PWAN Base Station are maximized while transmitting 15 simultaneous FDMA slots within a TDMA slot.

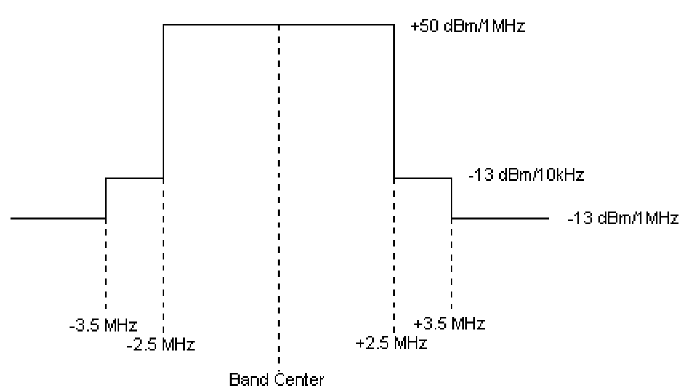
Spectral purity measurements were made with the Base Station operating in the lowest and highest subbands allocated in the "D" PCS block. Any Out-Of-Band (OOB) intermodulation and spurious signals will be contributed by Base Stations operating in the exterior subbands.

OOB spectral contributions from Base Stations operating within the two interior subbands will be negligible.

Table 11.6 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, 0 µs @ 7 MHz Span
Gate Delay	50 µs @ 4 MHz Span, 0 µs @ 7 MHz Span
Input Level	+25 dBm
External Attenuation	21.1 dB
Trigger Type	IF Channel 1, Free Run for measurements with fundamental outside of span
Trigger Delay	-56 µs @ 4 MHz Span, 0 µS @ 7 MHz Span
Trigger Holdoff	2300 µs
Frequency-Domain Averaging	20 Samples, RMS Exponential
FFT Window Type	Flat Top
FFT Freq. Points	1501
Resolution BW	12 kHz @ 4 MHz Span, 17 kHz @ 7 MHz Span

Figure 11.7 Base Station Conducted Power Spectral Mask



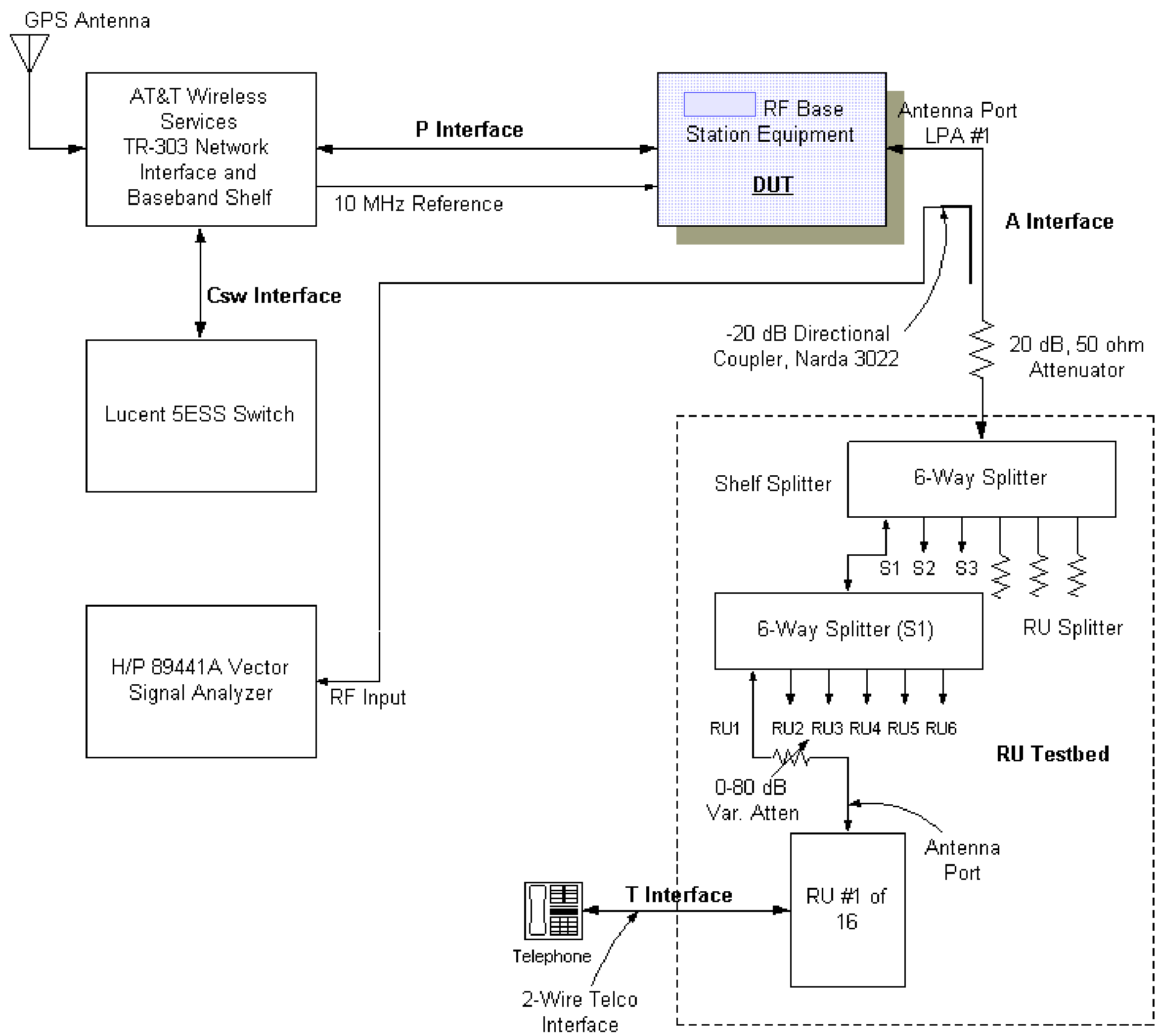
11.1.7.3 Test Methodology

PWAN Base Station emissions measurements near the operating frequency must be synchronized to the transmitted bursts in order to be accurate. This implies the use of a receiver capable of performing an FFT which has been triggered by the presence of RF burst energy at a selected power level. This requirement is met by the Hewlett-Packard 89441A Vector Signal Analyzer, which was used to characterize the emissions from the Base Station transmitter while operating at full peak output power. For this test, a total of 15 voice calls were placed from a pool of Remote Units connected to the Base Station under test. The attenuators in the Base Station transmitter chain were set to produce a nominal average output power of 2.5 watts (+34 dBm) during the TDMA slot containing 15 simultaneous voice calls. The 89441A VSA was configured to trigger on the high level RF burst power present during this TDMA slot. When making measurements over spans that did not include the Base Station fundamental, the VSA trigger was disabled (trigger free-running). The specific operating parameters of the 89441A VSA are summarized in Table 11.6. The emission mask utilized through the course of this test is shown in Figure 11.7

The 89441A Vector Signal Analyzer design 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 corresponding 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 1933 to 1962 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”.

Due to the amount of attenuation required to prevent overloading the VSA, noise contributed by the analyzer’s front-end diminished the resolution of low-level spurious products removed by greater than about 2 MHz from the carrier center frequency. To improve the effective noise floor of the instrument during such measurements, mathematical subtraction of front-end noise in the frequency domain was employed. For example, a 50-ohm termination was connected to the VSA's front-end RF input connector, and the instrument's intrinsic frequency-domain noise was averaged using the VSA parameters listed in Table 11.6. The resulting noise trace was saved into one of the instrument's data registers. The Base Station under test was then reconnected to the RF input through a -20 dB directional coupler as shown in Figure 11.8. By invoking a simple mathematical function, the VSA subtracted the instrument's front-end noise trace from the frequency-domain spectra of the DUT. This methodology results in approximately 20 dB of improvement in the instrument's noise floor.

Figure 11.8 Base Station Spectral Purity Test Configuration



11.1.8 Radiated Emissions

11.1.8.1 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.

11.1.8.2 Overview

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

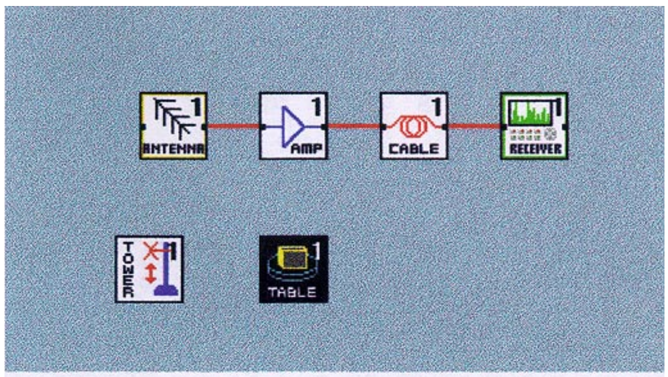
11.1.8.3 Test Methodology

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 PWAN Base Station was setup in a typical field configuration, as shown in Figure 12.3, consisting of the PWAN Base Station being placed inside two EMC cabinets with the digital shelves in one cabinet and the RF components in the other. The cabinets, PWAN Base Station were each grounded to an NEC-approved grounding method. A typical battery backup power supply was present, as well as sectored antennas atop a tower (Tower Top Amplifiers are ahead of the antenna). Various cable lengths were utilized to determine worse case configuration. All radiated emissions testing was completed in a worst case scenario; 1) 15 voice calls within same time slot (maximum time slot capacity). Testing was completed from 30 MHz to 18.0 GHz.

The PWAN Base Station test configuration and test setup photos can be found in Section 12.3, “EUT Test Configuration Photos.”

11.1.8.4 Radiated Emissions Equipment Configuration 30-1000 MHz

Figure 11.9 Test Equipment Configuration



11.1.8.5 Equipment Settings for 30 - 1000 MHz Band

The following list details the individual pieces of equipment and their settings used to complete the 30 -1000 MHz radiated emission measurements, including antenna scan heights and turntable azimuth settings.

Antenna 1: Horizontal and Vertical Polarizations

Gore Cable 1: 40-foot

Tower 1: 1 to 4 meter scan

Turntable 1: 22.5 degree steps during scans

Amplifier 1: PREAMP ON

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

11.1.8.6 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 6 dB 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

11.1.8.7 Antenna 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 11.7.

Table 11.7 Antenna Factors

Frequency (MHz)	Amplitude (db/m)
30	19.3
40	13.7
50	7.9
60	5.4
70	6.6
80	8.4
90	9.6
100	9.5
120	12.7
140	12.2
150	11.8
150	10.7
180	9.1
200	9.4
250	12.2
300	13

Table 11.7 Antenna Factors (continued)

Frequency (MHz)	Amplitude (db/m)
400	15.9
500	17.4
600	18.9
700	20.5
800	21.5
900	22.6
1000	24

11.1.8.8 Cable Factors

The measurement system setup, as shown in Figure 11.9 is interconnected with 40feet of Gore coaxial cable. The cable insertion loss was measured and documented for receiver data correction. Table 11.8 outlines the measurement system's cable correction factors

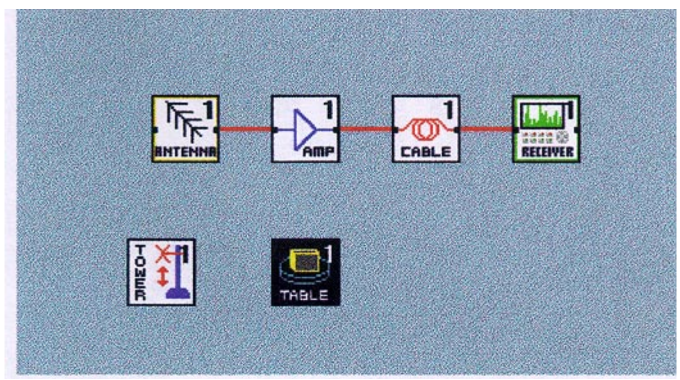
Table 11.8 Cable Correction Factors

Frequency (MHz)	Amplitude (dB)
0.03	-0.090
300.00	-2.080
600.00	-2.650
1000.00	-3.220
1250.00	-3.560
1500.00	-3.820
1750.00	-4.130
2000.00	-4.420
2250.00	-4.580
2500.00	-4.840
2750.00	-5.060
3000.00	-5.310
3250.00	-5.560
3500.00	-5.900
3750.00	-6.320

Frequency (MHz)	Amplitude (dB)
4000.00	-7.770
4100.00	-8.690
4250.00	-7.260
4500.00	-7.700
5000.00	-7.700
5500.00	-8.030
6000.00	-8.200

Radiated Emissions Equipment Configuration 1000-3500 MHz

Figure 11.10 Test Equipment Configuration



Equipment Settings

The following list details 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: Gore Cable 1:40 feet

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

11.1.8.8.1 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 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 6dB 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

11.1.8.9 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 11.9

Table 11.9 Antenna Correction Factors — 1000 - 6000 MHz

Frequency (MHz)	Amplitude (dB/m)
1000	25.5
1500	26.9
2000	28.9
2500	30.6
3000	31.8
3500	32.8
4000	34.5
4500	33.9
5000	35.1
5500	36.1
6000	36.8

11.1.8.10Cable Factors

The measurement system setup, as shown in Table 11.10 is interconnected with 40 feet of Gore coaxial cable. The cable insertion loss was measured and documented for receiver data correction. Table 11.10 outlines the measurement system's cable correction factors

Table 11.10 Cable Correction Factors

Frequency (MHz)	Amplitude (dB)
0.03	-0.090
300.00	-2.080
600.00	-2.650
1000.00	-3.220
1250.00	-3.560
1500.00	-3.820
1750.00	-4.130
2000.00	-4.420
2250.00	-4.580
2500.00	-4.840
2750.00	-5.060
3000.00	-5.310
3250.00	-5.560
3500.00	-5.900
3750.00	-6.320
4000.00	-7.770
4100.00	-8.690
4250.00	-7.260
4500.00	-7.700
5000.00	-7.700
5500.00	-8.030
6000.00	-8.200

11.2 RF Characterization Test Results

This section describes the test results obtained during the validation of the AT&T Wireless Services PWAN Base Station 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 11.11 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	11526	N/A	N/A
Signal Generator	Hewlett-Packard	8665A	SDG005780	11/9/99	11/9/02
Power Meter	Hewlett-Packard	EPM-442A	GB37170550	2/4/00	2/4/01
Power Sensor	Hewlett-Packard	8482A	3318A26922	06/07/00	06/07/01
Cesium Beam Clock	Hewlett-Packard	5071A	3249A00701	N/A	N/A
Vector Signal Analyzer	Hewlett-Packard	89441A	3415A02243	8/31/00	8/31/01
Frequency Counter	Hewlett-Packard	53132A	3736A06180	2/7/00	2/7/01
Spectrum Analyzer	Hewlett-Packard	8563E	5317A03669	12/5/00	12/5/01
Network Analyzer	Hewlett-Packard	8753D	3410A05861	5/15/01	5/15/02

11.2.2 Base Station RF Frequency Stability vs. Temperature

11.2.2.1 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.

11.2.2.2 Test Configuration

The Synchronization Card under test was placed into a Screening Systems, Inc. model QRS-410T thermal chamber (refer to Figure 11.1). A Hewlett/Packard 53132 frequency counter was used to monitor the output frequency of the DUT. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the 53132A frequency counter. The frequency counter resolution was set to 0.001 Hz.

The frequency accuracy of the 10 MHz oscillator 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. The thermal chamber’s sensing thermocouple was attached to the Synchronization Card about 10 cm from the ovenized oscillator to assure 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 stability of the DUT was measured over temperature in each of the three operating modes.

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

(Eq 11.1)

$$\text{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1\times10^{6}\right) = \left(\left(\frac{f(\text{measured}) - 1\times10^{7}}{1\times10^{7}}\right) \cdot 1\times10^{6}\right)$$

11.2.2.3 Results Summary

The measured frequency stability vs. temperature is depicted in Figure 11.11, Figure 11.12, and Figure 11.13. The results of these tests are summarized in Table 11.12 below:

Figure 11.11 Base Station Synchronization Card Frequency Stability vs. Temperature, GPS Locked Mode

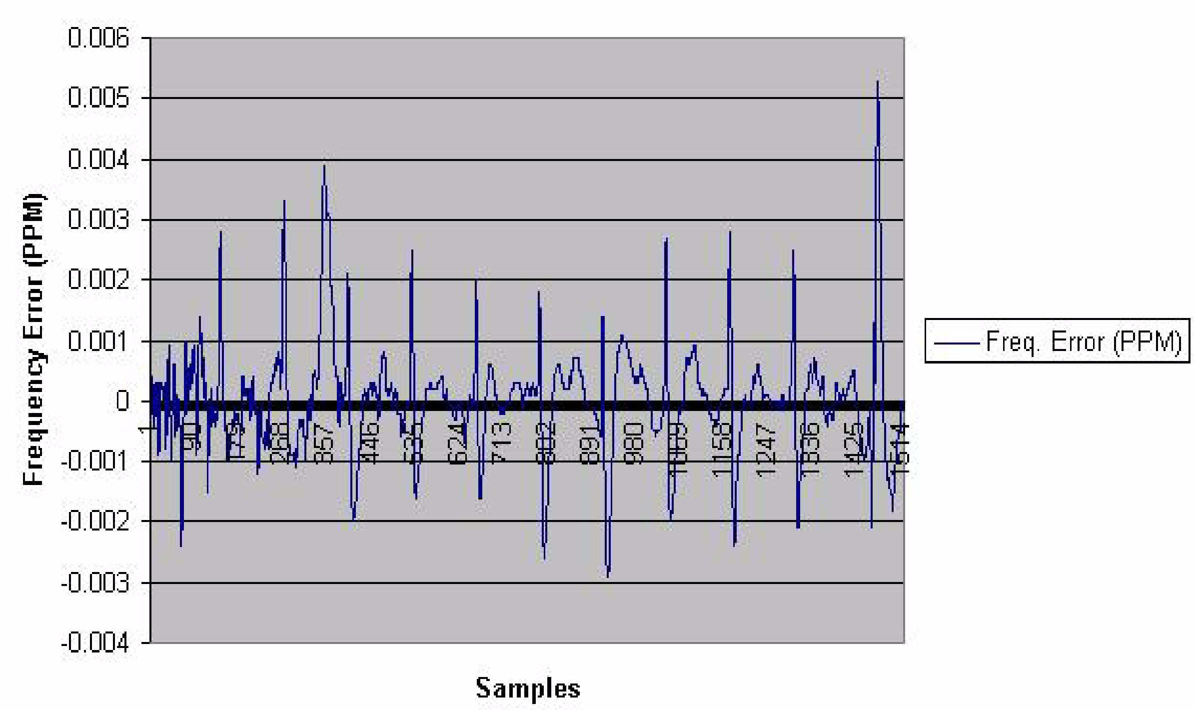


Figure 11.12 Base Station Synchronization Card Frequency Stability vs. Temperature, GPS Holdover Mode

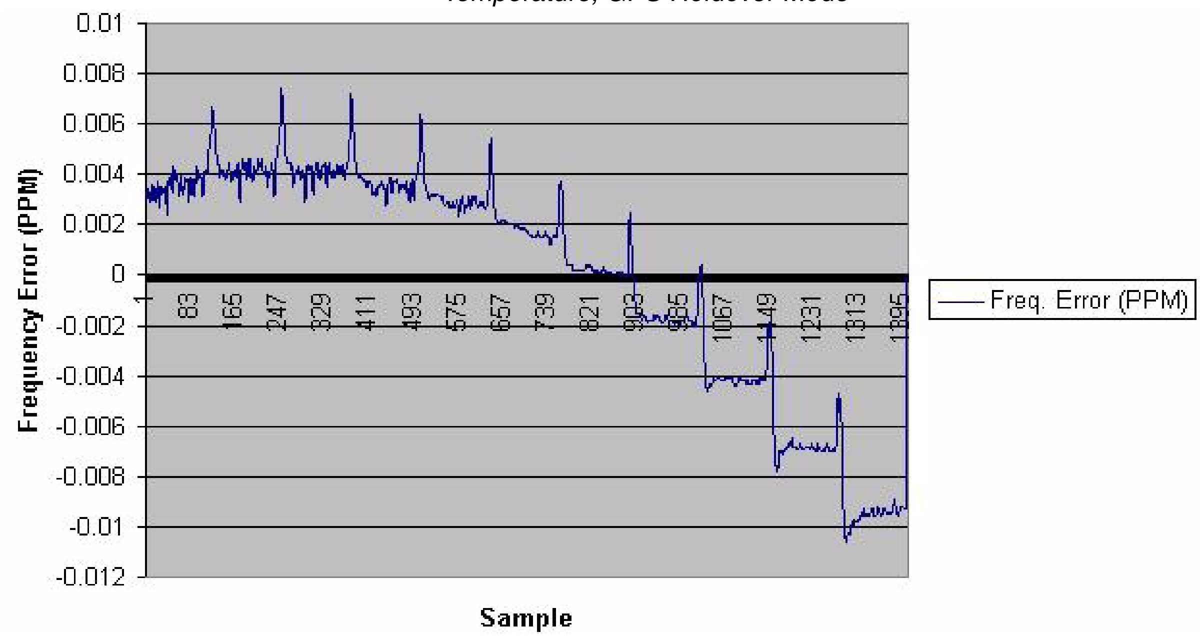


Figure 11.13 Base Station Synchronization Card Frequency Stability vs. Temperature, GPS Free-Run Mode

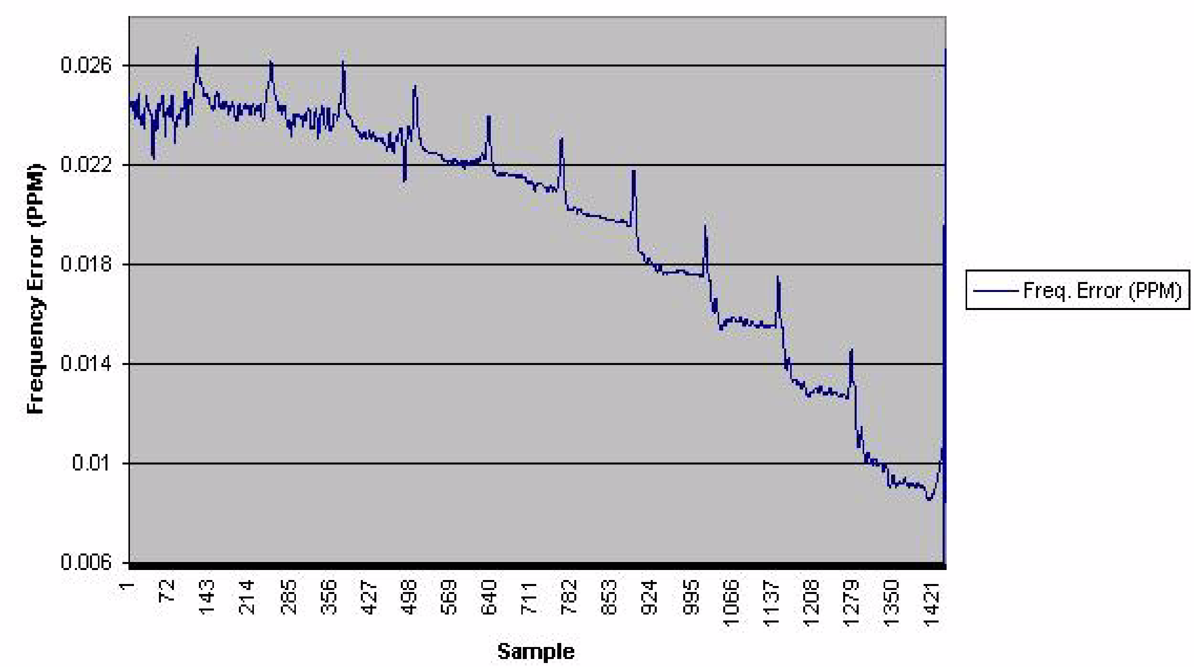


Table 11.12 Base Station Synchronization Card Frequency Stability vs. Temperature Summary

Parameter	Measured Value
Frequency stability at 10.0 MHz Synchronization Card between -40 Deg. Celsius and +60 Deg. Celsius in GPS Locked Mode	Frequency change of ≤ 0.009 PPM @ 10 MHz
Frequency stability at 10.0 MHz Synchronization Card between -40 Deg. Celsius and +60 Deg. Celsius in GPS Holdover Mode	Frequency change of ≤ 0.02PPM @ 10 MHz
Frequency stability at 10.0 MHz Synchronization Card between -40 Deg. Celsius and +60 Deg. Celsius in GPS Free-Run Mode	Frequency change of ≤ 0.02 PPM @ 10 MHz

11.2.3 Base Station Frequency Stability vs. Input Voltage

11.2.3.1 Applicable FCC Rule Parts

FCC Subpart 2.995 - The frequency stability shall be measured with variation of primary supply voltage as follows: 1) Vary primary voltage from 85 to 115 percent of the nominal value for other than hand carried equipment. 3) The supply voltage shall be measured at the input to the cable provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

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 Synchronization Card under test was connected to a variable DC power supply (refer to Figure 11.2). A Hewlett/Packard 53132 frequency counter was used to monitor the output frequency of the DUT. A Hewlett-Packard 5071A cesium beam primary standard was utilized as a precision frequency reference for the 53132A frequency counter. The frequency counter resolution was set to 0.001 Hz.

The frequency accuracy of the 10 MHz oscillator was tracked over the voltage range of -40.8 to -55.2 VDC (±15%) in 1.0 volt increments.

The output frequency stability of the DUT was measured over voltage in each of the three operating modes.

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

(Eq 11.2)

$$\mathrm{FrequencyError(PPM)} = \left(\left(\frac{\Delta f}{f}\right) \cdot 1\times10^{6}\right) = \left(\left(\frac{f(\mathrm{measured}) - 1\times10^{7}}{1\times10^{7}}\right) \cdot 1\times10^{6}\right)$$

11.2.3.3 Results Summary

The measured frequency stability vs. input voltage for the Base Station under test is depicted in Figure 11.14, Figure 11.15, Figure 11.16. The results of these tests are summarized in Table 11.13 below:

Figure 11.14 Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Locked Mode,

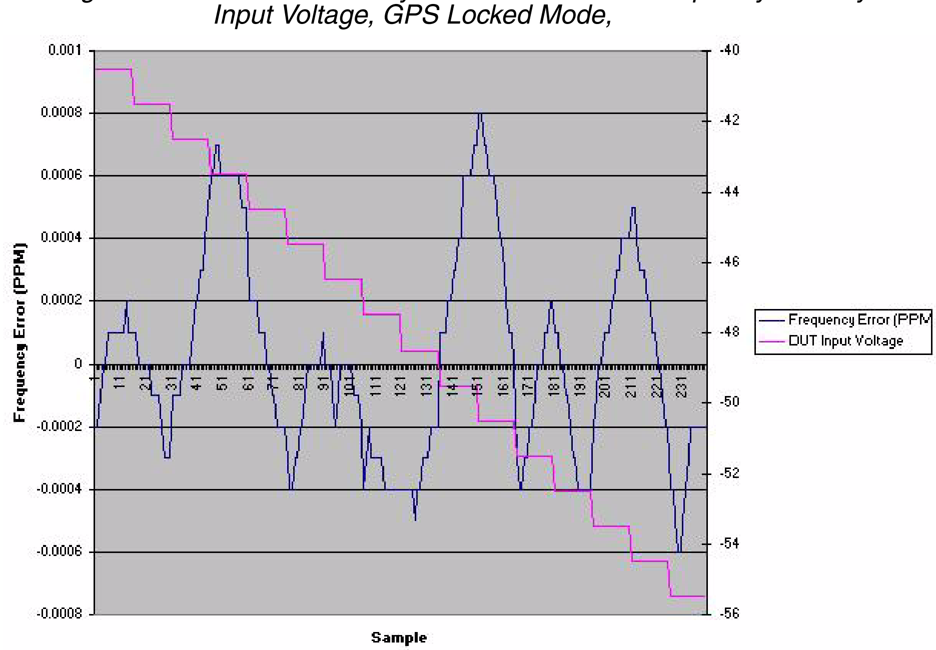


Figure 11.15 Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Holdover Mode

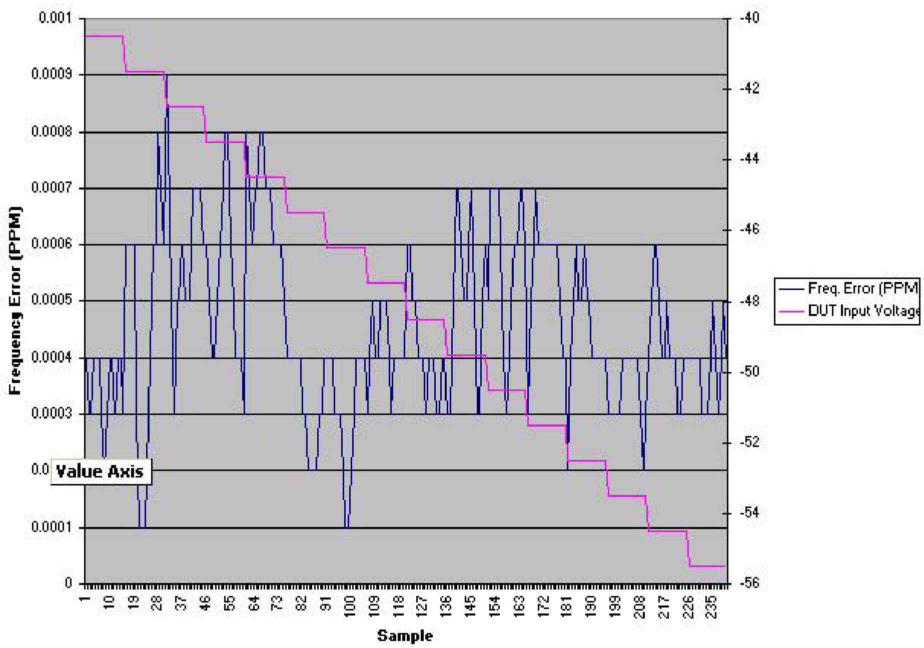


Figure 11.16 Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Free-Run Mode

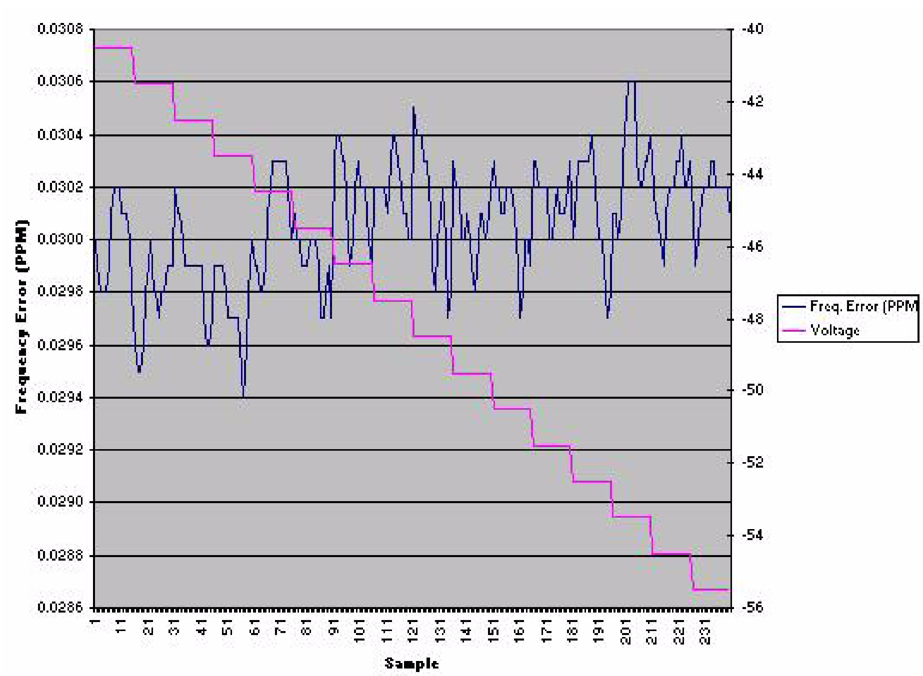


Table 11.13 Base Station Synchronization Card Frequency Stability vs. Input Voltage Summary

Parameter	Measured Value
Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Locked Mode	Total frequency change of ≤ 0.0015 PPM
Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Holdover Mode	Total frequency change of ≤ 0.001 PPM
Base Station Synchronization Card Frequency Stability vs. Input Voltage, GPS Free-Run Mode	Total frequency change of ≤ 0.0015 PPM

11.2.4 Base Station Occupied Bandwidth

11.2.4.1 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.

11.2.4.2 Test Configuration

The occupied bandwidth of a PWAN Base Station is maximized while transmitting eight simulcast Remote Synchronization Pilots (RSPs) without any voice or high-speed data traffic. The Base Station was allowed to operate in the idle mode (no call processing or data transfer).

The transmitter was sampled through a -20 dB directional coupler and viewed with a Hewlett-Packard 89441A Vector Signal Analyzer and 89451A Digital Radio Personality option, set up to measure 99% Occupied Bandwidth (refer to Figure 11.4). A 375 ms time record was captured to obtain the measurement data included in this report. The configuration parameters of the 89451A are listed in Table 11.2.

11.2.4.3 Test Summary

The 99% Occupied Bandwidth for the Base Station is depicted in Figure 11.7. The test results are summarized in Table 11.15

Figure 11.17 Base Station 99% Occupied Bandwidth While Transmitting Simulcast Remote Synchronization Pilots

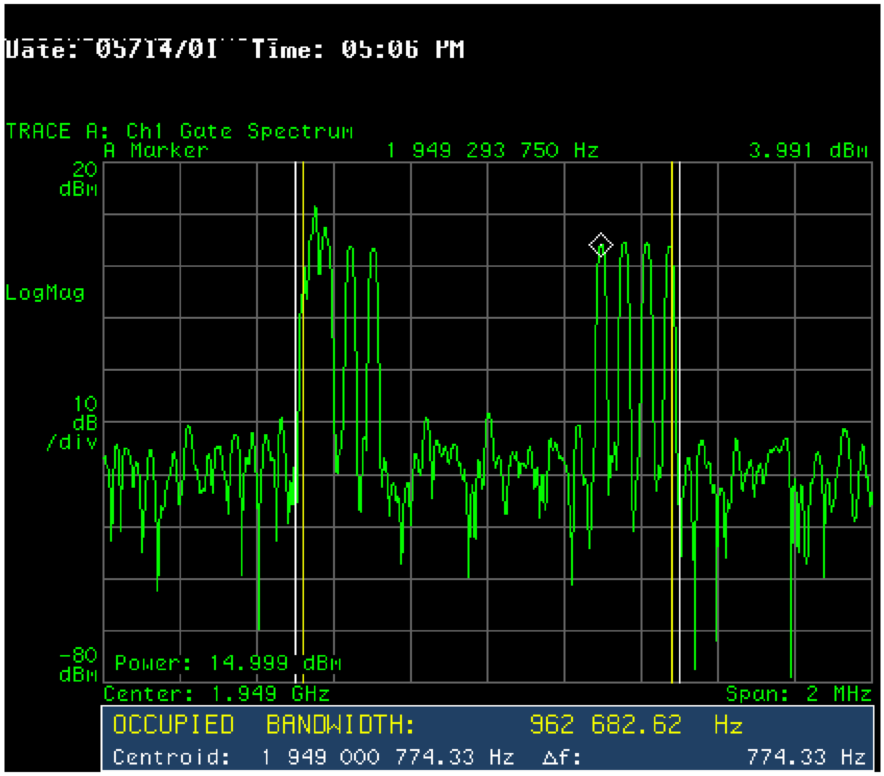


Table 11.14 Occupied Bandwidth Test Result Summary

Parameter	Measured Value
99% Occupied Bandwidth While Transmitting Remote Synchronization Pilots	≤963 kHz

11.2.5 Modulation Characterization

11.2.5.1 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.

11.2.5.2 Test Configuration

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

- Multiple Call Voice Traffic channel
- High-Speed Data Traffic channel
- High Speed Data Control channel
- NAC channel
- Time-Keyed Remote Synchronization channel
- Simulcast Remote Synchronization 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 (this measurement was not possible for Remote Synchronization channel measurements)

11.2.5.3 Results Summary

11.2.5.3.1 Multiple Call Voice Traffic Channel

A total of 15 telephone calls were established between a pool of Remote Units and the Base Station under test using the test configuration shown in Figure 11.5. The Hewlett-Packard 89441A Vector signal analyzer was configured according to the parameters shown in Table 11.3. The measured characteristics of a fully occupied voice TDMA slot are depicted in Figure 11.18 and Figure 11.19. The results of these tests are summarized in Table 11.16 below:

Figure 11.18 Voice Channel Power vs. Frequency, 99.0% Occupied BW, and Time-Domain Average Burst Power

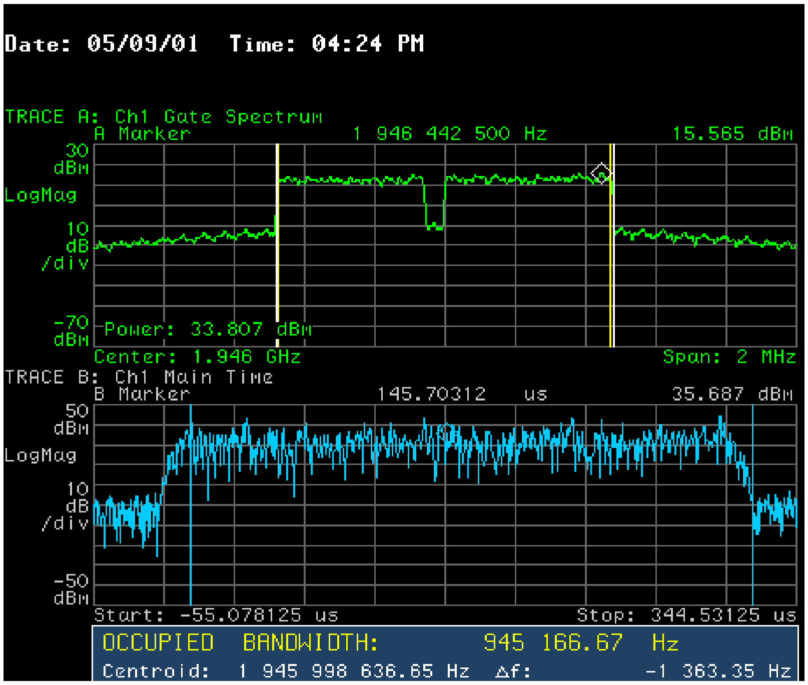
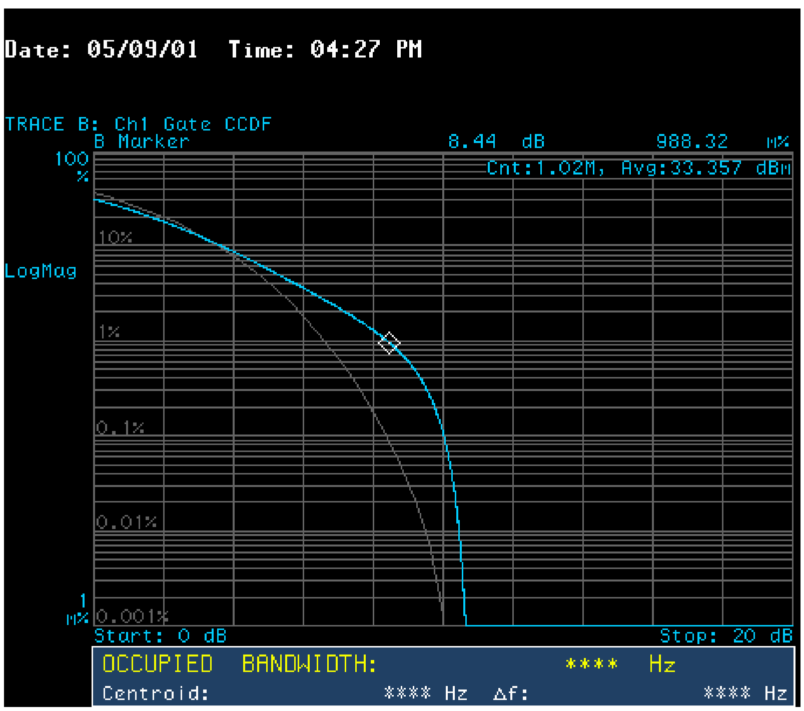


Figure 11.19 Voice Channel CCDF



11.2.5.3.2 High-Speed Data Channel

A single High-Speed Data session was established between the Base Station 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 11.3. During this test, a 20 MB text file was transferred from the Base Station 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.

11.2.5.3.3 Results Summary

The measured characteristics of the High-Speed Data channel are depicted in Figure 11.20 and Figure 11.21. The results of these tests are summarized in Table 11.16 below:

Figure 11.20 High-Speed Data Channel Power vs. Frequency, 99.0% Occupied BW, and Time-Domain Average Burst Power

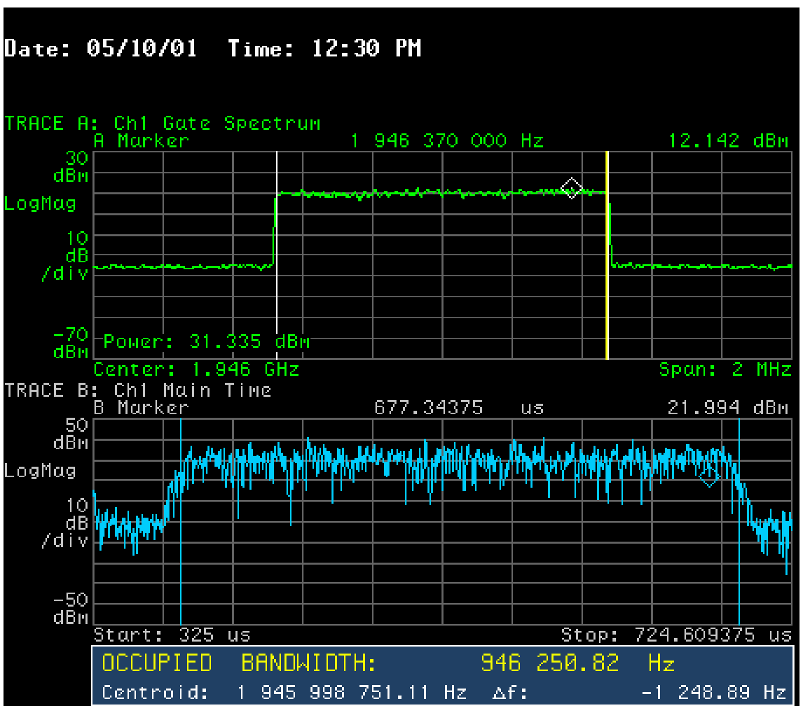
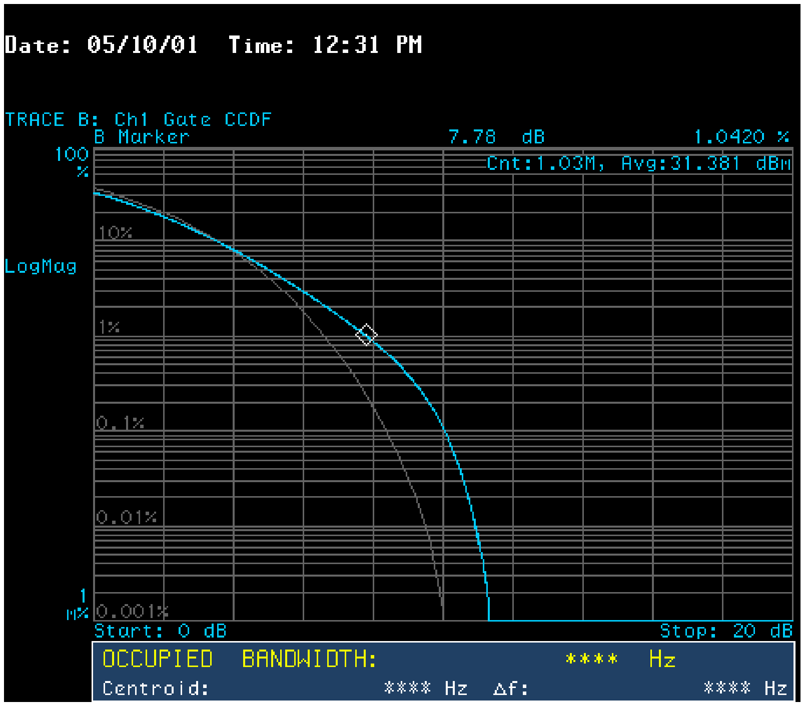


Figure 11.21 High-Speed Data Channel CCDF



11.2.5.3.4 High Speed Data Control Channel

Characterization of the High-Speed Data Control channel took place utilizing the test configuration shown in Figure 11.5. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

11.2.5.3.5 Results Summary

The measured characteristics of the High-Speed Data Control channel are depicted in Figure 11.22 and Figure 11.23. The results of these tests are summarized in Table 11.16 below:

Figure 11.22 High Speed Data Control Channel Power vs. Frequency, 99.0% Occupied Bandwidth, and Time-Domain Average Power

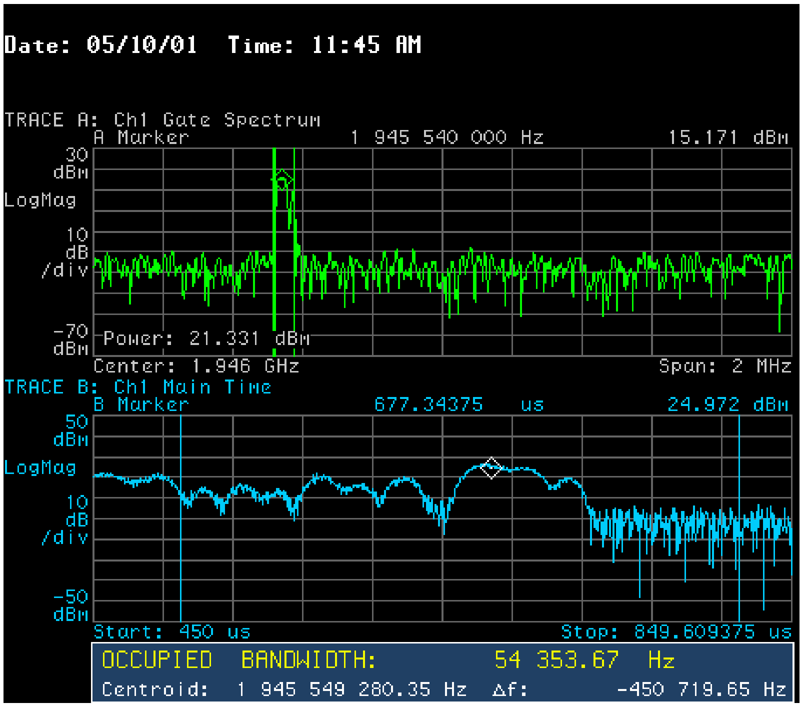
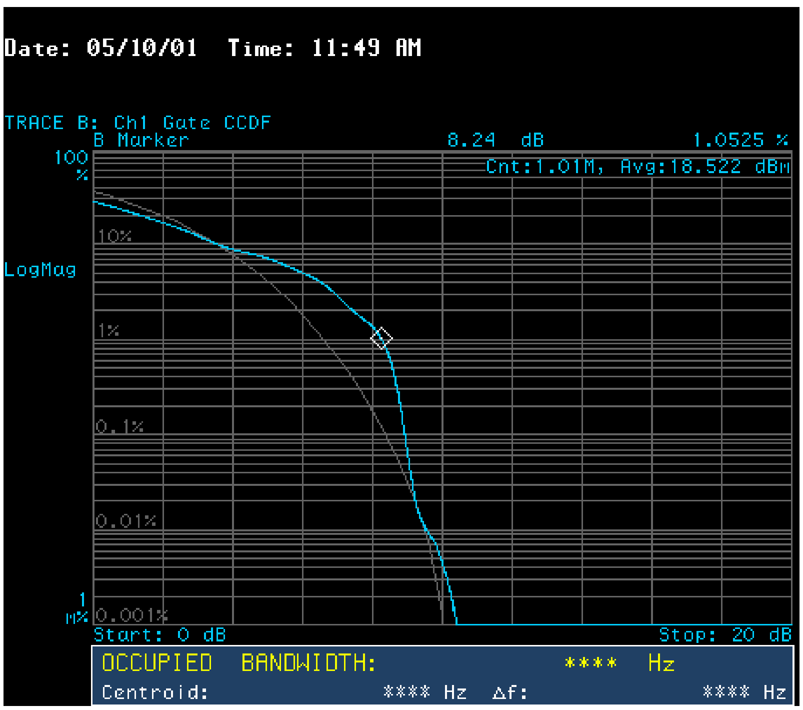


Figure 11.23 High Speed Data Control Channel CCDF



11.2.5.3.6 Broadcast Channel

The Base Station Broadcast channel was characterized using the test configuration shown in Figure 11.5. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.3.

11.2.5.3.7 Results Summary

The measured characteristics of the NAC channel are depicted in Figure 11.24 and Figure 11.25. The results of these tests are summarized in Table 11.16 below:

Figure 11.24 NAC Channel Power vs. Frequency, 99.0% Occupied BW, and Time-Domain Average Power

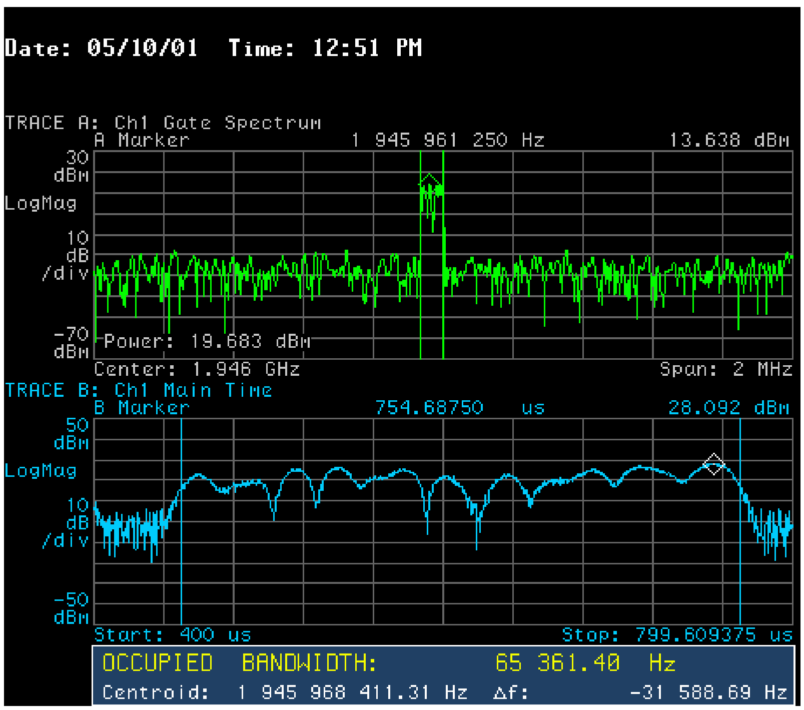
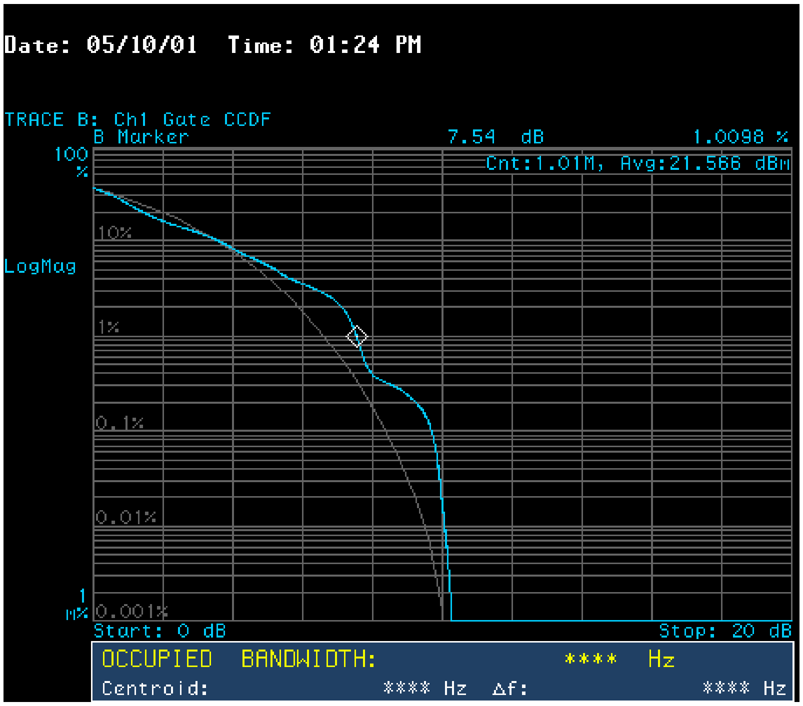


Figure 11.25 NAC Channel CCDF



11.2.5.3.8 Time-Keyed Remote Synchronization Channel

Time-Keyed Remote Synchronization Pilots (RSPs) were characterized using the test configuration shown in Figure 11.5. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.4.

11.2.5.3.9 Results Summary

The measured characteristics of the Time-Keyed Remote Synchronization channel are depicted in Figure 11.26 and Figure 11.27. The results of these tests are summarized in Table 11.16 below:

Figure 11.26 Time-Keyed Remote Synchronization Pilots Power vs. Frequency, 99.0% Occupied Bandwidth, and Time-Domain Average Burst Power

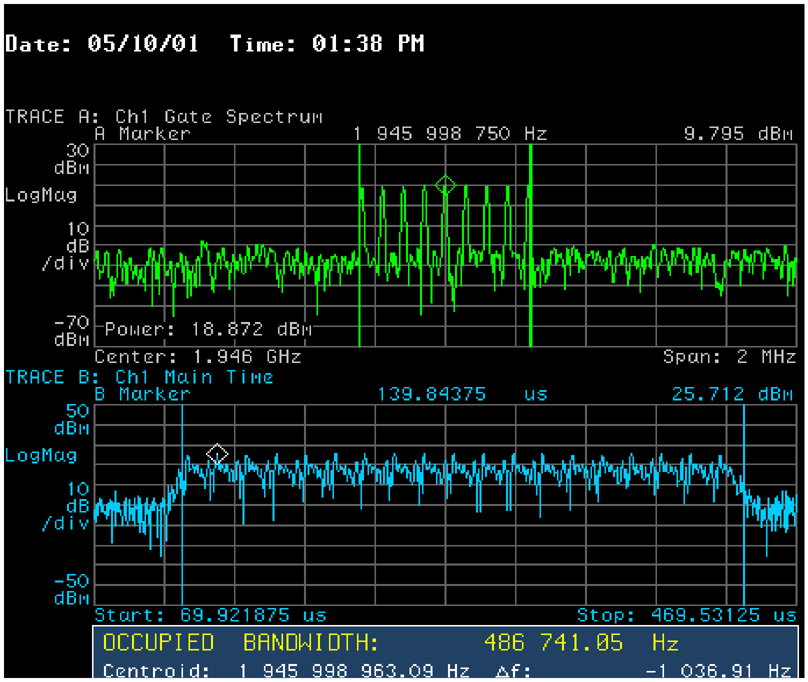
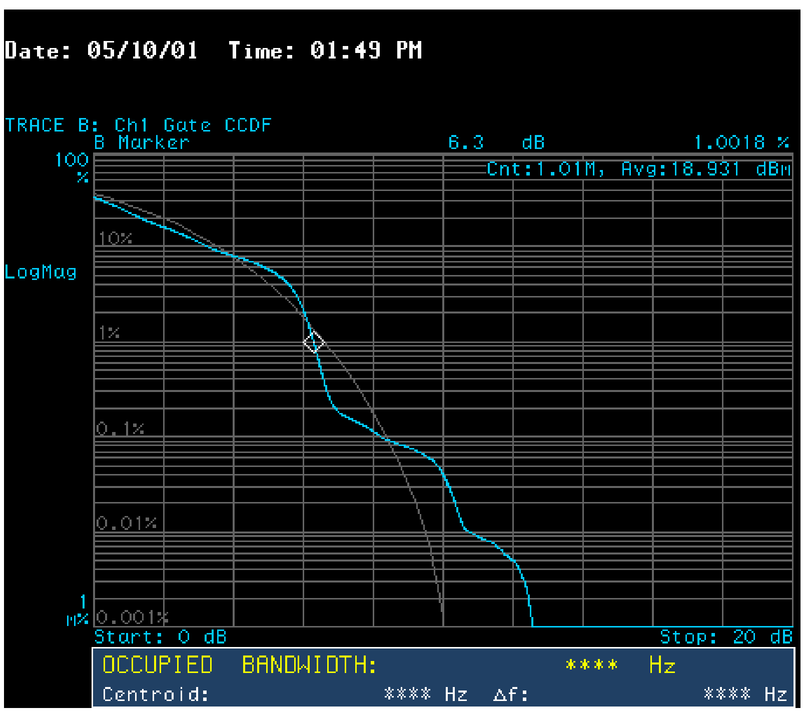


Figure 11.27 Time-Keyed Remote Synchronization Pilots CCDF



11.2.5.3.10 Simulcast Remote Synchronization Channel

Simulcast Remote Synchronization Pilots (RSPs) were characterized using the test configuration shown in Figure 11.5. The Hewlett-Packard Vector Signal Analyzer was configured according to the parameters shown in Table 11.4.

11.2.5.3.11 Results Summary

The measured characteristics of the Remote Synchronization channel are depicted in Figure 11.28. The results of these tests are summarized in Table 11.16 below:

Figure 11.28 Simulcast Remote Synchronization Pilots Power vs. Frequency, 99.0% Occupied Bandwidth, and Time-Domain Average Burst Power

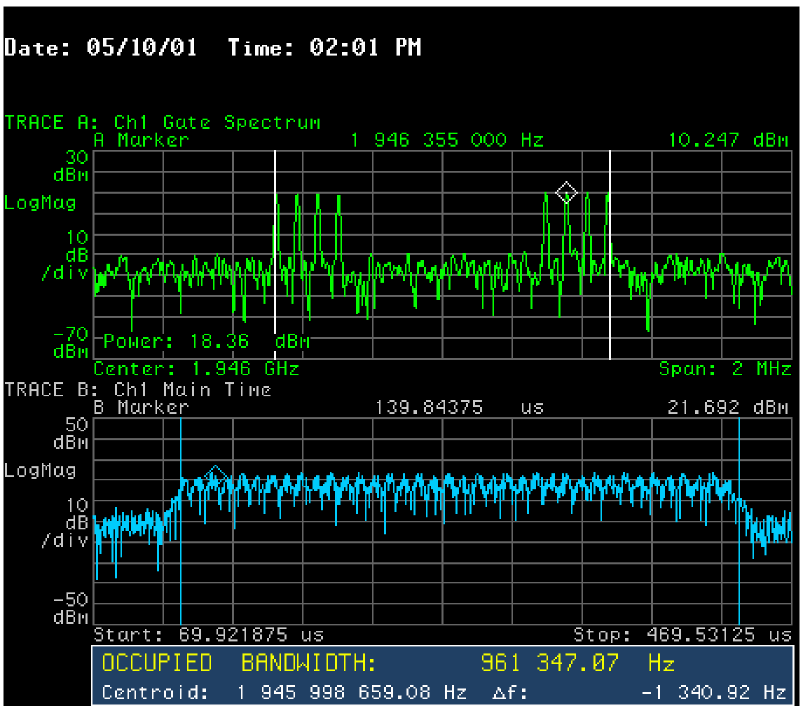


Figure 11.29 Simulcast Remote Synchronization Pilots CCDF

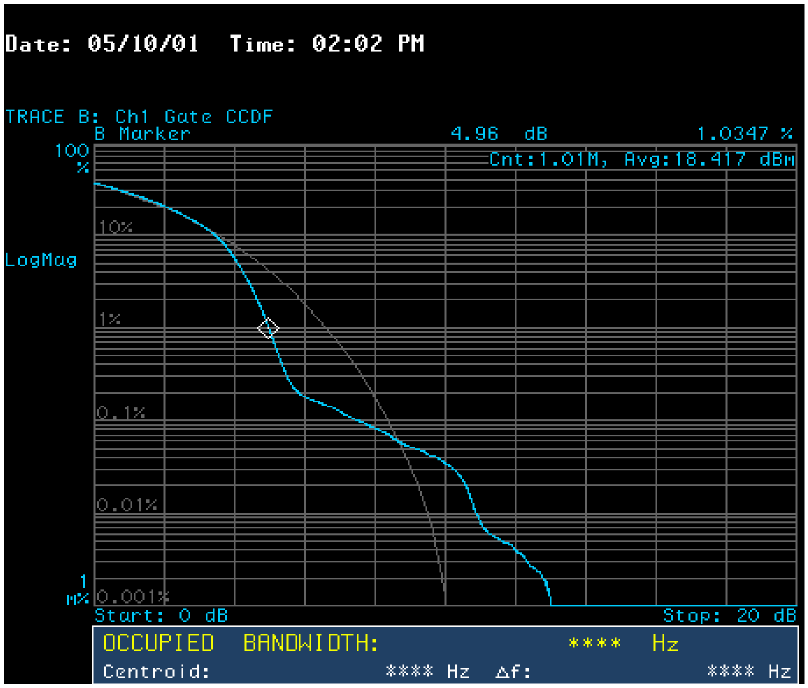


Table 11.15 Logical Channel Characterization Test Results Summary

Parameter	Measured Value
Multiple Voice Channel 99% Occupied Bandwidth	≤ 946 kHz
Multiple Voice Channel Average Power	33.8 dBm
Voice Channel Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	8.4 dB
High-Speed Data Channel 99% Occupied Bandwidth	≤ 947 kHz
High-Speed Data Channel Average Power	+31.3 dBm
High-Speed Data Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	7.8 dB
High-Speed Data Control Channel 99% Occupied Bandwidth	≤ 66 kHz
High-Speed Data Control Channel Average Power	+19.7 dBm
High-Speed Data Control Channel Peak/Average Ratio at ≤ 99.0% after $1x10^6$ samples	8.2 dB
NAC Channel 99% Occupied Bandwidth	≤ 66 kHz
NAC Channel Average Power	19.7 dBm
NAC Channel Peak/Average Ratio at ≤ 99.0% occurrence after $1x10^6$ samples	7.5 dB
Time-Keyed Remote Synchronization Channel 99% Occupied Bandwidth	≤ 487 kHz
Time-Keyed Remote Synchronization Channel Average Power	18.9 dBm
Remote Synchronization Channel 99% Occupied Bandwidth	≤ 963 kHz
Remote Synchronization Channel Average Power	15 dBm
Time-keyed Remote synchronization Channel Peak/ Average Ration at ≤ 99.0% occurrence after $1x10^6$ samples	6.3 dB
Simulcast Remote Synchronization Channel 99% Occupied Bandwidth	≤ 962 kHz
Simulcast Remote Synchronization Channel Average Power	+18.9 dBm
Simulcast Remote Synchronization Channel Peak/ Average Ratting at ≤ 99.0% occurrence after $1x10^6$ samples	5.0 dB

11.2.6 RF Output Power

11.2.6.1 Applicable FCC Rules

FCC Subpart 2.985-Power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in §2.983 (d)(5). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

FCC Subpart 24.232 - In no case may the peak output power of a base station transmitter 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.

11.2.6.2 Test Configuration

Peak RF Output Power from the Base Station is maximized while supporting 15 simultaneously active FDMA slots.

A Hewlett-Packard 89441A Vector Signal Analyzer was used to characterize the Base Station'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, a total of 15 voice calls were established between multiple Remote Units and the Base Station under test using the equipment configuration shown in Figure 11.18.

The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.17. The random nature of the data generated by the LD-CELP compression algorithm was sufficient to assure results representative of a normally operating system. A -20 dB directional coupler provided the required RF sample for measurement.

11.2.6.2.1 Results Summary

The measured RF output power of the Base Station while supporting 15 simultaneous voice calls in a single TDMA slot is depicted in Figure 11.31 and Figure 11.32. The results of these tests are summarized in Table 11.16 below:

Figure 11.30 Time-Domain Power Envelope, Average Power

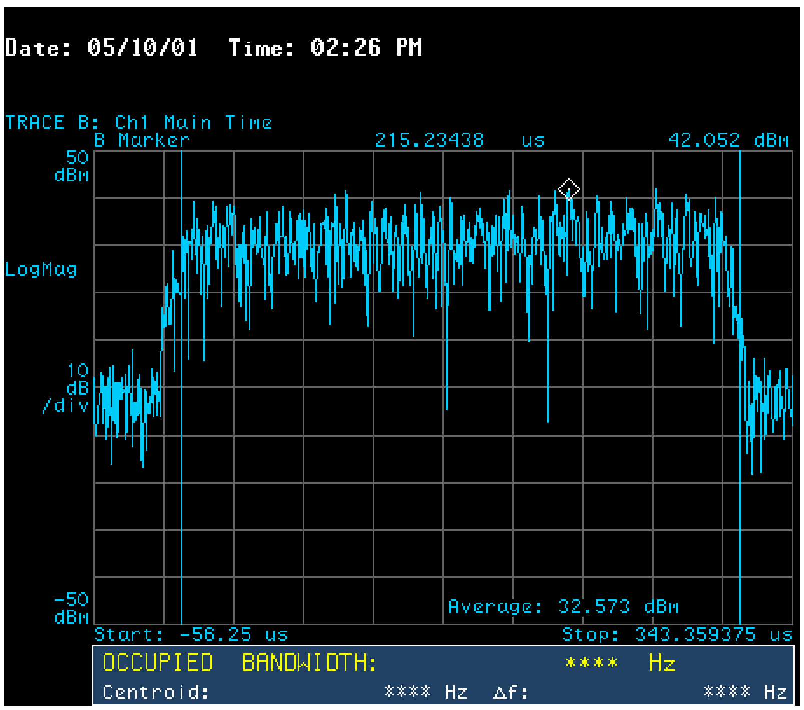


Figure 11.31 Time-Domain Power Envelope, Peak Power at <_99.0% Occurrence

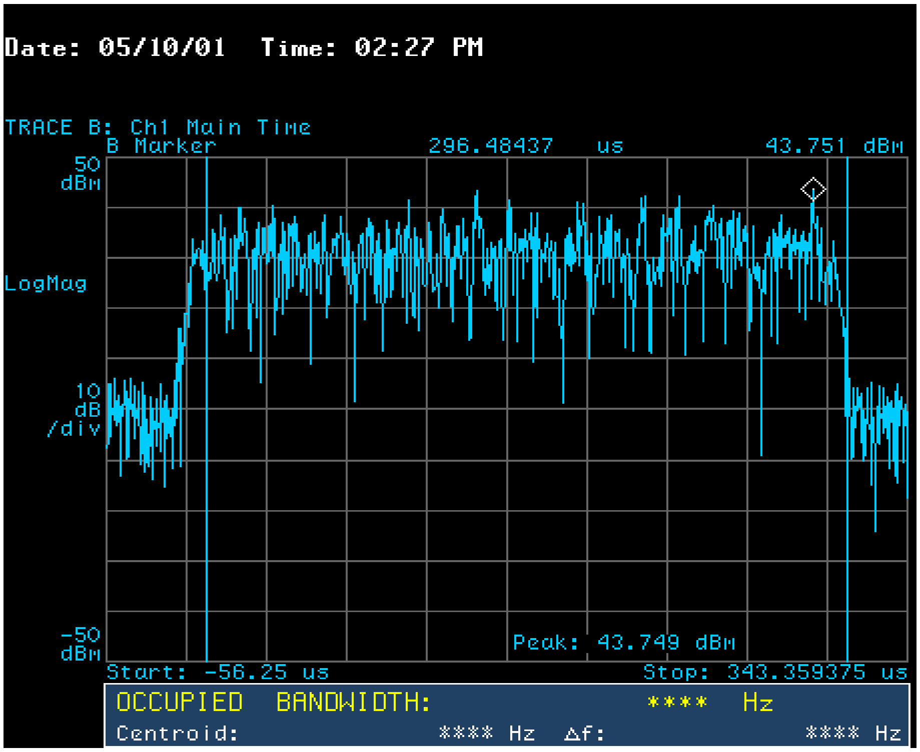


Figure 11.32 Time-Domain Power Envelope, Peak/Average Ratio at <_99.0% Occurrence

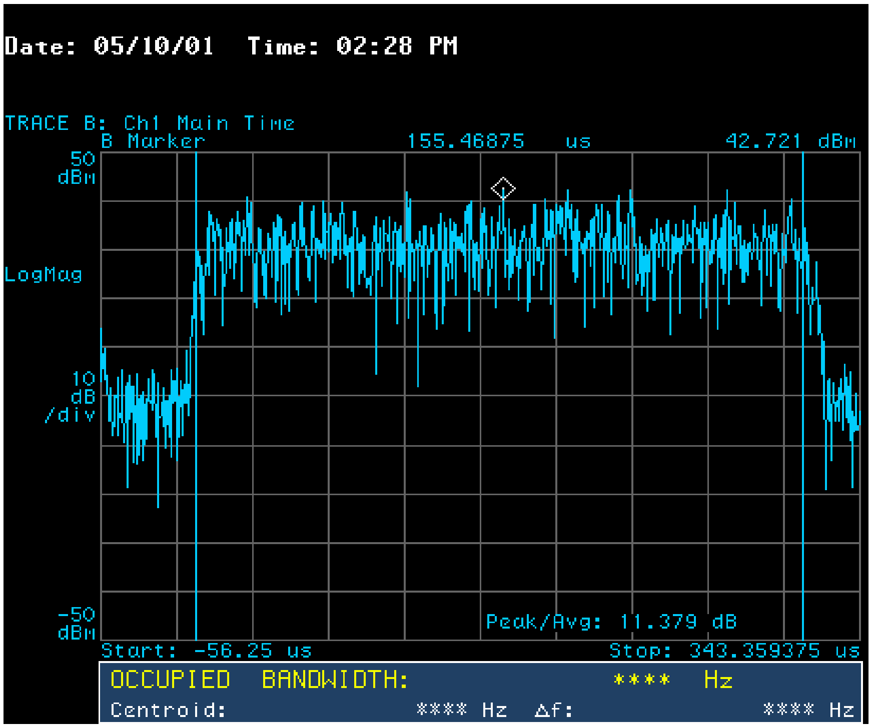


Table 11.16 RF Output Power Characteristics

Parameter	Measured Value	FCC Part 24 Limit
Time-Domain Average Power	+32.57 dBm/1 MHz	N/A
Time-Domain Peak Power at ≤ 99.0% Occurrence	+43.7 dBm/1 MHz RBW	+50.0 dBm/1 MHz RBW
Time-Domain Peak/Average Ratio at ≤ 99.0% Occurrence	11.4 dB	N/A

11.2.7 Spurious Emissions at the Antenna Terminal

11.2.7.1 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.

11.2.7.2 Test Configuration

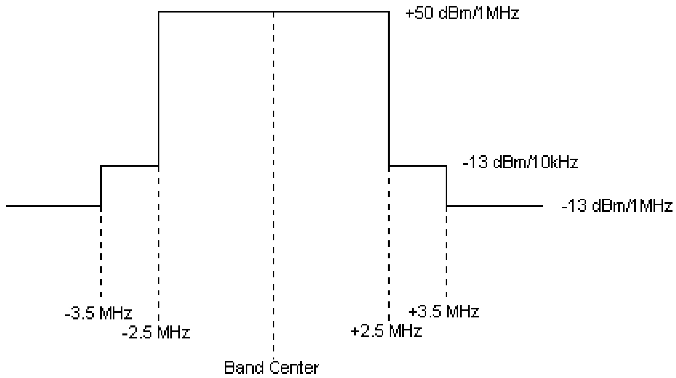
RF Output Power and Out-Of-Band (OOB) emissions from the Base Station are maximized while transmitting 15 simultaneous FDMA slots within a TDMA slot. For this test, 15 Remote Units were used to set up 15 voice calls within a single TDMA slot from the base. The Base Station under test was configured to produce a nominal average output power of 2.5 watts (+34 dBm) during the TDMA slot containing 15 simultaneous voice calls.

Spectral purity measurements were made with the Base Station 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 Base Stations operating in the exterior subbands. OOB spectral contributions from Base Stations 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 Base Station. The test configuration is shown in Figure 11.33. The Hewlett-Packard 89441A Vector Signal Analyzer was configured according the parameters shown in Table 11.24 .

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 1933 to 1962 MHz. Emissions at all applicable frequencies above and below this range have been documented in "Radiated to Conducted Spurious Emissions".

Figure 11.33 Base Station Conducted Power Spectral Mask



11.2.7.3 Results Summary

The measured spectral purity of the Base Station while transmitting 15 simultaneous voice calls in a single TDMA slot is depicted in Figure 11.33, through Figure 11.45. The results of these tests are summarized in Table 11.17 below:

Figure 11.34 1MHz Band-Power Between 1945.5 and 1946.5MHz

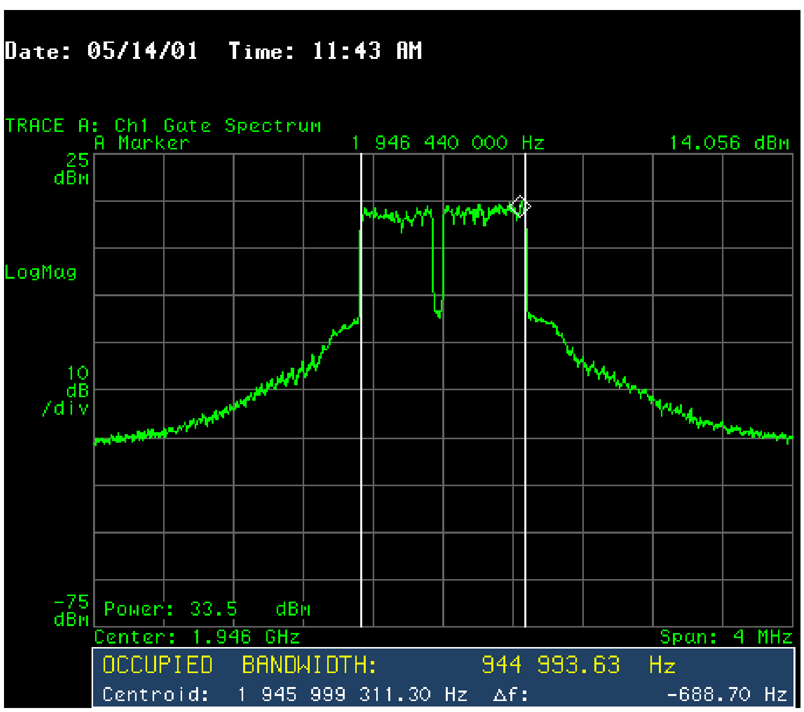


Figure 11.35 Maximum Lower Guard Band Spurious Power, Measured in a 1MHz Resolution BW. Marker indicates edge of Subband

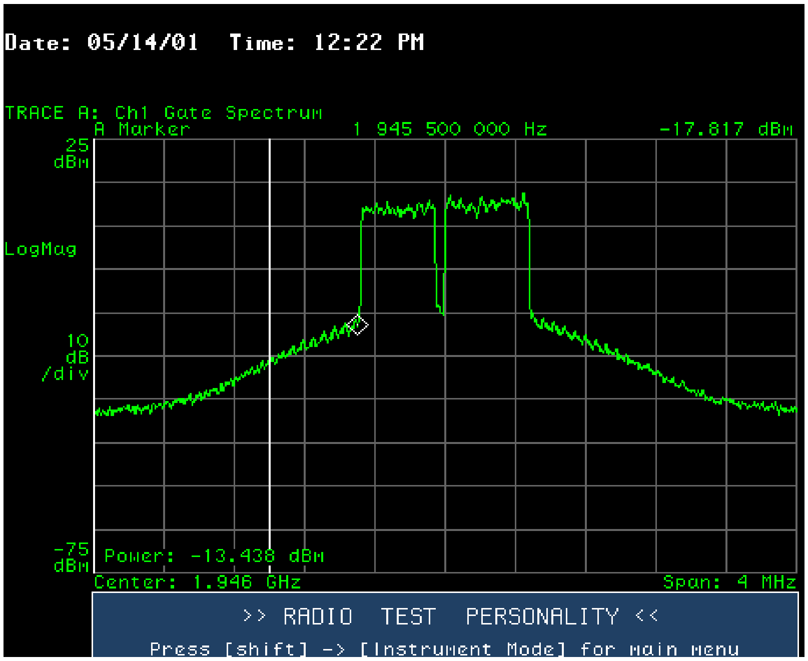


Figure 11.36 Spectral Purity from 1937MHz to 1944MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1938.8MHz denoting spurious emissions

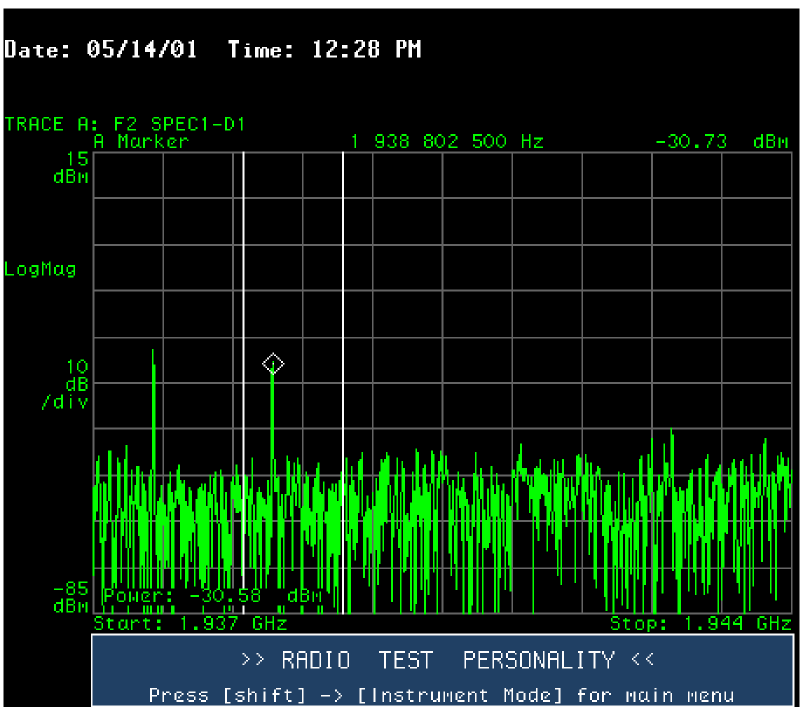


Figure 11.37 Spectral Purity from 1937MHz to 1944MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1937.6MHz denoting spurious emissions

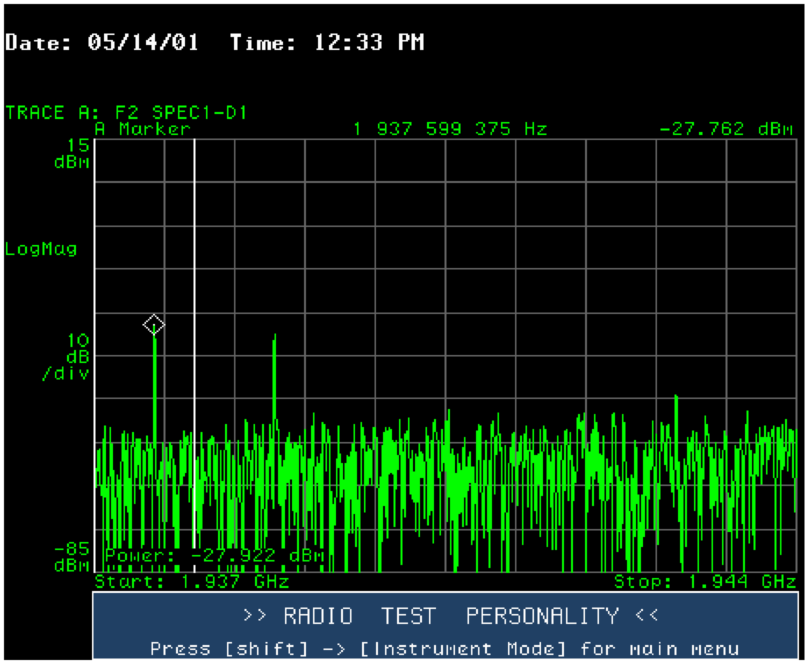


Figure 11.38 Spectral Purity from 1931MHz to 1938MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1937.6MHz denoting spurious emissions

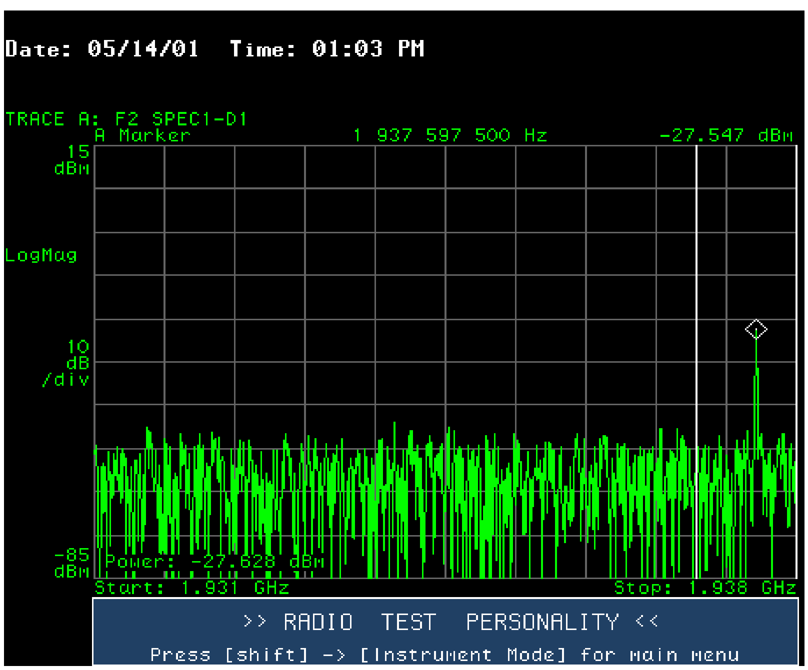


Figure 11.39 Spectral Purity from 1925MHz to 1932MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1930MHz denoting spurious emissions

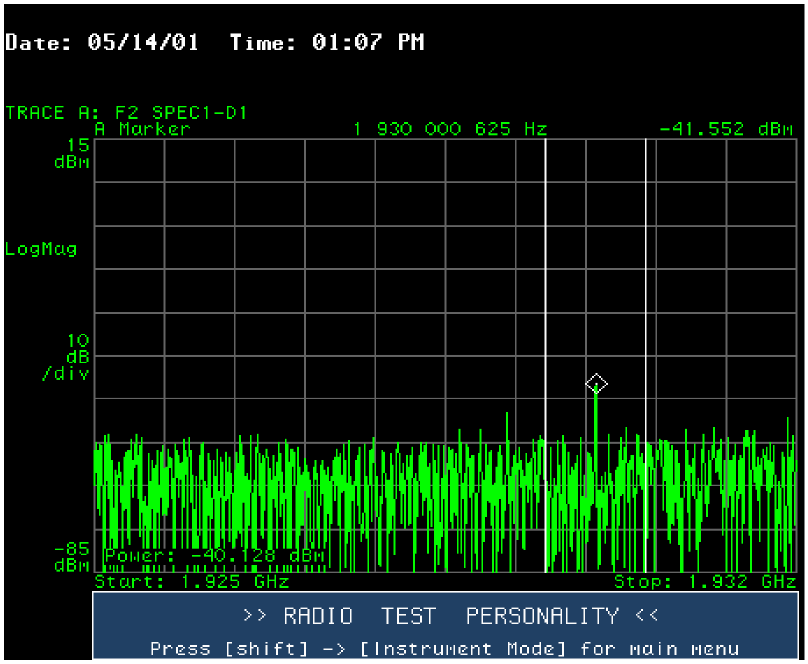


Figure 11.40 1MHz Band-Power Between 1948.5 and 1949.5MHz

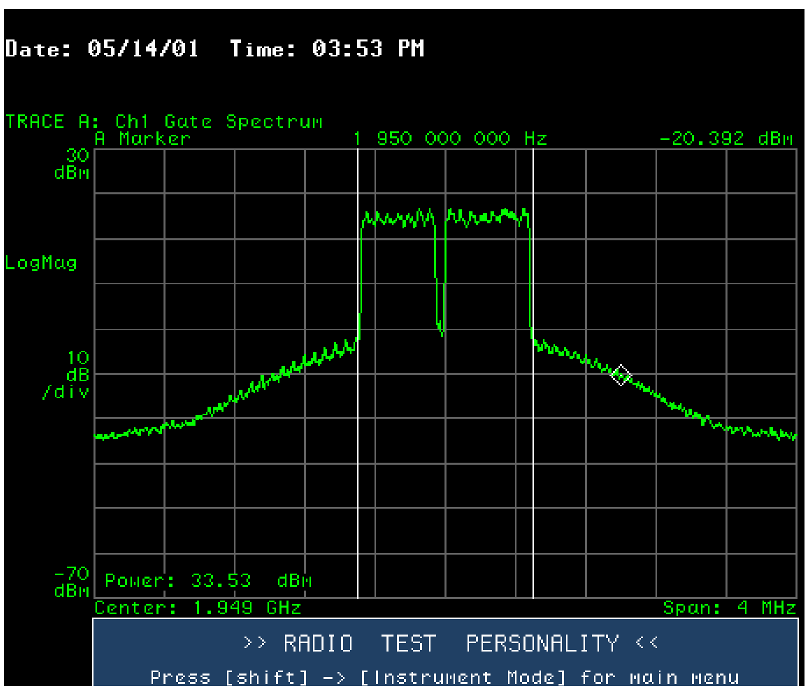


Figure 11.41 Spectral Purity from 1941MHz to 1948MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1941.8MHz denoting spurious emissions

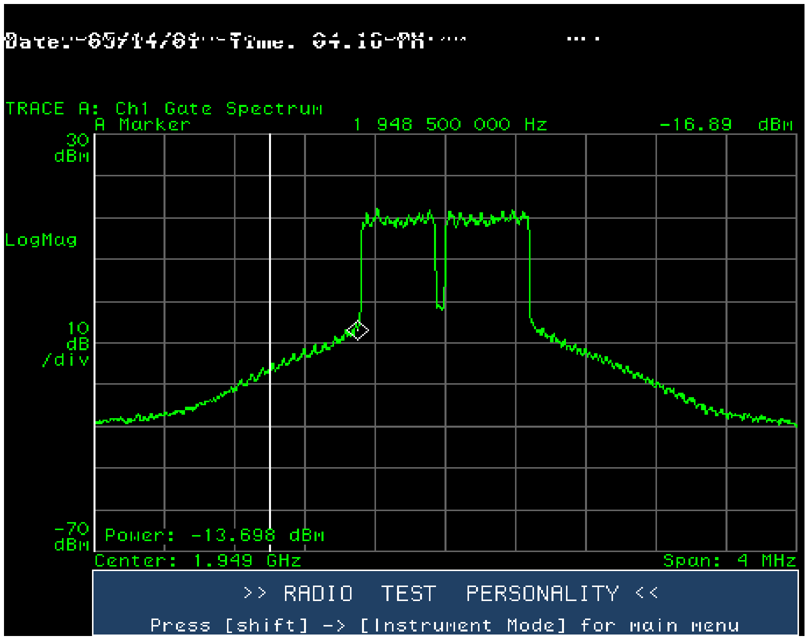


Figure 11.42 Spectral Purity from 1941MHz to 1948MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1941.8MHz denoting spurious emissions

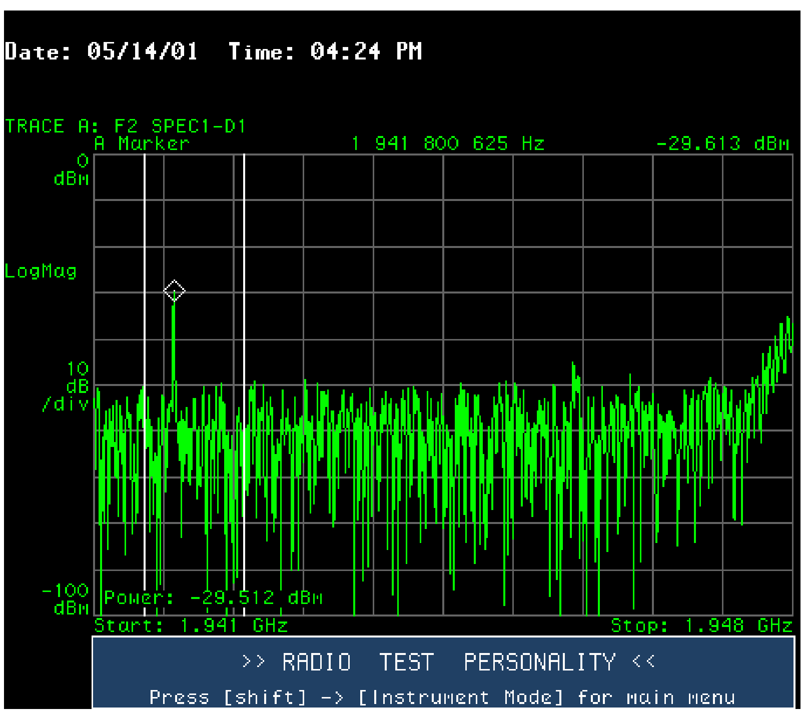


Figure 11.43 Spectral Purity from 1952MHz to 1959MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1949.5MHz denoting edge of subband

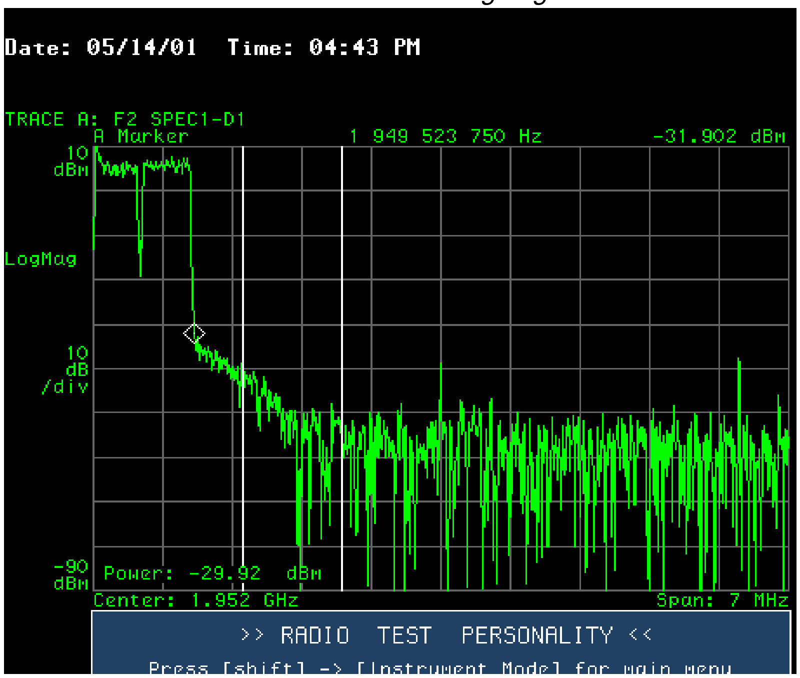


Figure 11.44 Spectral Purity from 1952MHz to 1959MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1952MHz denoting spurious emissions

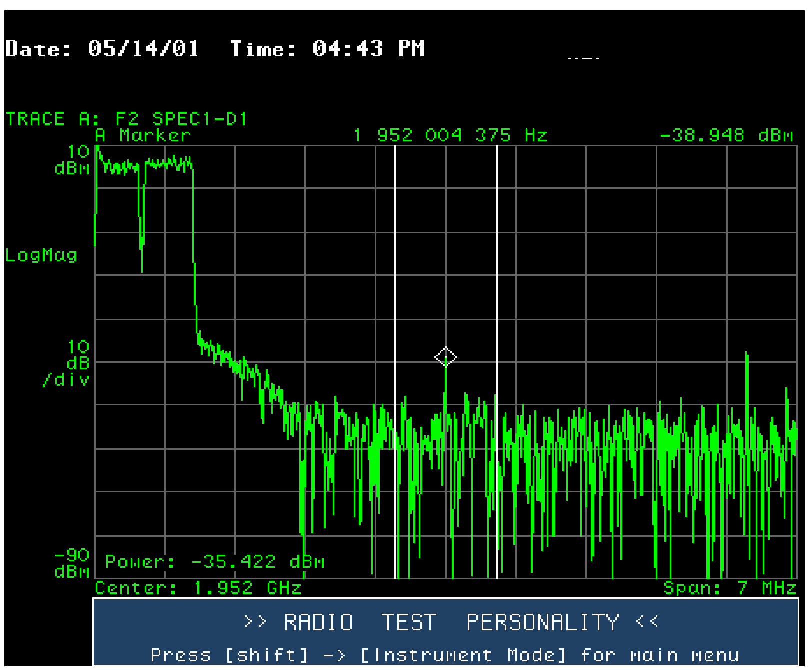


Figure 11.45 Spectral Purity from 1952MHz to 1959MHz, with Spurious Power measured in a 1MHz Band-Power, Marker Centered on 1955MHz denoting spurious emissions

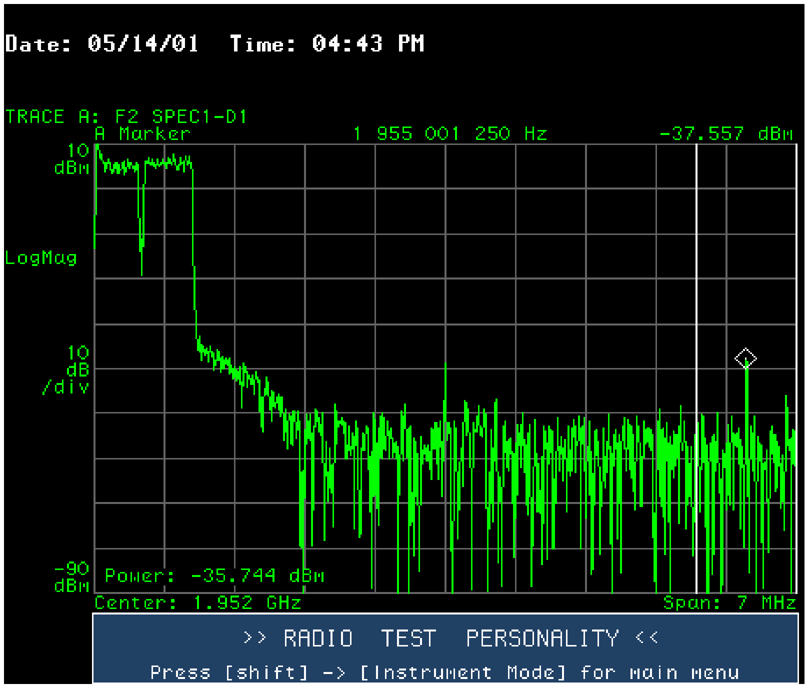


Figure 11.46 Spectral Purity from 1955MHz to 1962MHz, with Spurious Power measured in a 1MHz Band-Power

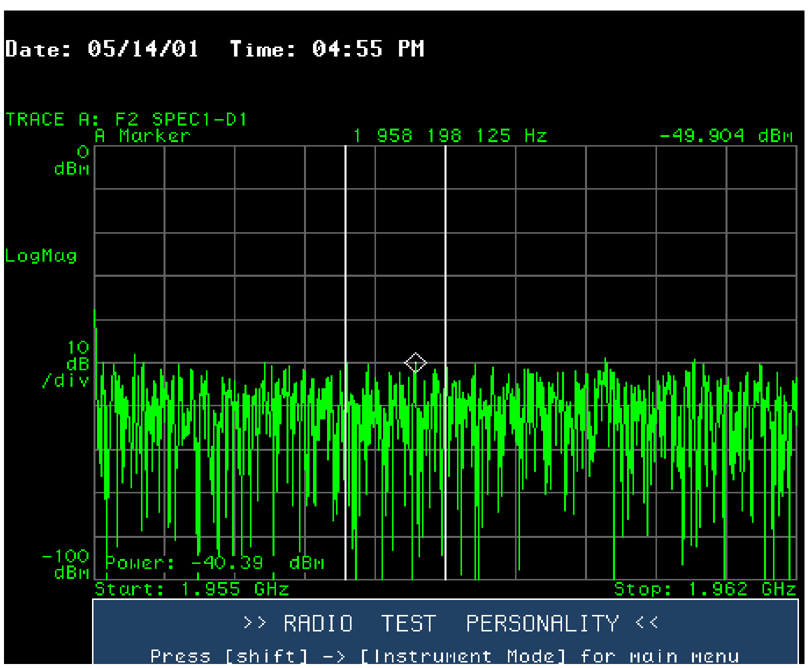


Figure 11.47 Spectral Purity from 1955MHz to 1962MHz, with Spurious Power measured in a 1MHz Band-Power

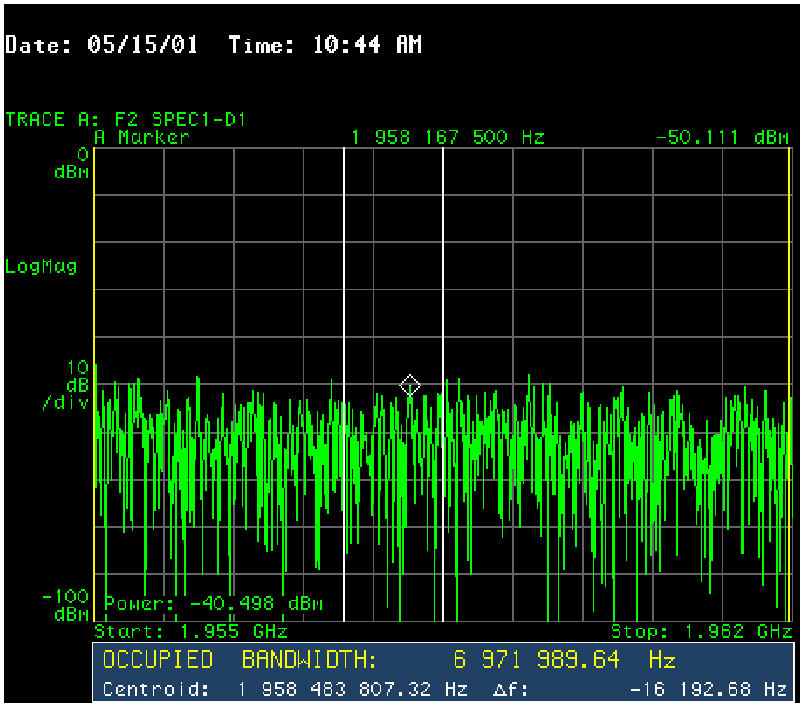


Table 11.17 Base Station In-Band and Out-Of-Band Power Summary

Parameter	Measured Value	FCC Part 24 Limit
Total power centered @ 1946 MHz	+33.5 dBm in a 1 MHz BW (+41.0 peak)	+50.0 dBm/ 1MHz RBW
Max Spurious Power between 1944 and 1945 MHz	-13.4 dBm in a 1 MHz BW	+7 dBm/ 1 MHz RBW
Max Spurious Power between 1937 and 1944 MHz	-30.6 dBm in a 1 MHz BW	-13 dBm/ 1 MHz RBW
Max Spurious Power between 1931 and 1938 MHz	-27.6 dBm in a 1 MHz BW	-13 dBm/ 1 MHz RBW
Max Spurious Power between 1925 and 1932 MHz	-40.1 dBm in a 1 MHz RBW @ 1945.5 MHz	-13 dBm/ 1 MHz RBW
Total Power Centered @1949 MHz	+33.5 dBm in a 1 MHz RBW	+50.0 dBm/1 MHz RBW
Maximum spurious power between 1950 and 1951 MHz	-29.9 dBm in a 1 MHz RBW	+7 dBm/ 1 MHz RBW
Maximum spurious power between 1948.5 and 1955.5 MHz	-35.4 dBm in a 1 MHz RBW	-13 dBm/ 1 MHz RBW
Maximum spurious power between 1955 and 1962 MHz	-40.4 dBm in a 1 MHz RBW	-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 PWAN Base Station against the applicable requirements of FCC Parts 15 and 24 (Spurious Emissions 20 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 Base Station. 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 PWAN Base Station was setup and configured as close to actual field installation as possible. The EUT was configured in multiple modes of operation. The following modes were tested per FCC Regulatory Standards:

- Completely loaded sector, (ie. maximum number of TSP and NIF cards)
- 15 voice calls within same time slot (maximum time slot capacity-worst case scenario)
- Various power and NIF cable interface lengths

11.3.2 Equipment List

Test cases within this section were completed utilizing the test equipment outlined in Table 11.19. 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	8/6/00	8/6/01
Antenna 1	EMCO	3115	5514-9807	3/11/00	3/11/01
Cable 1	Gore	53 ft.	00195373, 00195374, 00195375	10/23/00	10/23/01
Analyzer	Hewlett-Packard	8546A	3520A00260	06/06/00	06/06/01
Preselector	Hewlett-Packard	8546A internal	3330A0010	06/06/00	06/06/01
QPeak Adapter	Hewlett-Packard	internal to RF section	internal	06/06/00	06/06/01
Pre-Amplifier	Hewlett-Packard	8546A internal	internal	06/06/00	06/06/01
Tower 1	EMCO	1050	1123	N/A	N/A
Turntable 1	EMCO	1060	1049	N/A	N/A
Antenna	Chase	CBL6111 A	1704	08/10/00	08/10/01
Positioner Controller	EMCO	2090	9601-1101	N/A	N/A
EMI Measurement System	Hewlett-Packard	84125C	4536439012	11/20/00	11/20/01

11.3.3 List of Equipment Under Test

Test cases within this section were executed using the equipment under test listed in the following tables.

Table 11.19 Network Components

Card Name	Serial Number	Revision
Sync-P	19999011 04	D
Sync-R	19990152	D
TSI-P	205826	D
TSI-R	205789	D
NIF-1	0998032100	J
NIF-2	0998005253	G
NIF-3	0998005105	G
NIF-4	099803229	J
DNIF-5	0998032281	J
DNIF-6	0998000435	A
DNIF-7	0998000425	A
NMP	106315	C
ICP-P	75652	B
ICP-R	75854	D

Table 11.20 Baseband Components

Card Name	Serial Number	Revision
(Top Left) BBC	15286	D
NSP	115939	G
TSP-1	0998004948	H
TSP-2	0998038747	L
TSP-3	0998038826	L
TSP-4	0998038736	L
TSP-5	0998038708	L
TSP-6	0998038438	L
TSP-7	0998038699	L
MODEM	86299	L
BBC	15313	D
NSP	117115	G
TSP-1	0998004934	H

Table 11.20 Baseband Components

Card Name	Serial Number	Revision
TSP-2	0998038711	L
TSP-3	0998038889	L
TSP-4	0998038414	L
TSP-5	0998038474	L
TSP-6	0998038362	L
TSP-7	0998038765	L
MODEM	8622	L
BBC	15388	D
NSP	117017	G
TSP-1	0998004885	H
TSP-2	0998038733	L
TSP-3	0998038787	L
TSP-4	0998038781	L
TSP-5	0998038428	L
TSP-6	0998038366	L
TSP-7	0998038390	L
MODEM	86339	L

Table 11.21 Transceiver Components

Card Name	Serial Number	Revision
FE Unit 1	241012	A
FE Unit 2	240911	A
FE Unit 3	240912	A
FE Unit 4	240913	A
FE Unit 5	240910	A
FE Unit 6	240914	A
FE Unit 7	240984	A
FE Unit 8	240917	A
DSI 0	427793	A
DSI 1	427828	A
DSI 2	427836	A
DSI 3	427802	A

11.3.4 Test Results

11.3.4.1 Radiated Emissions

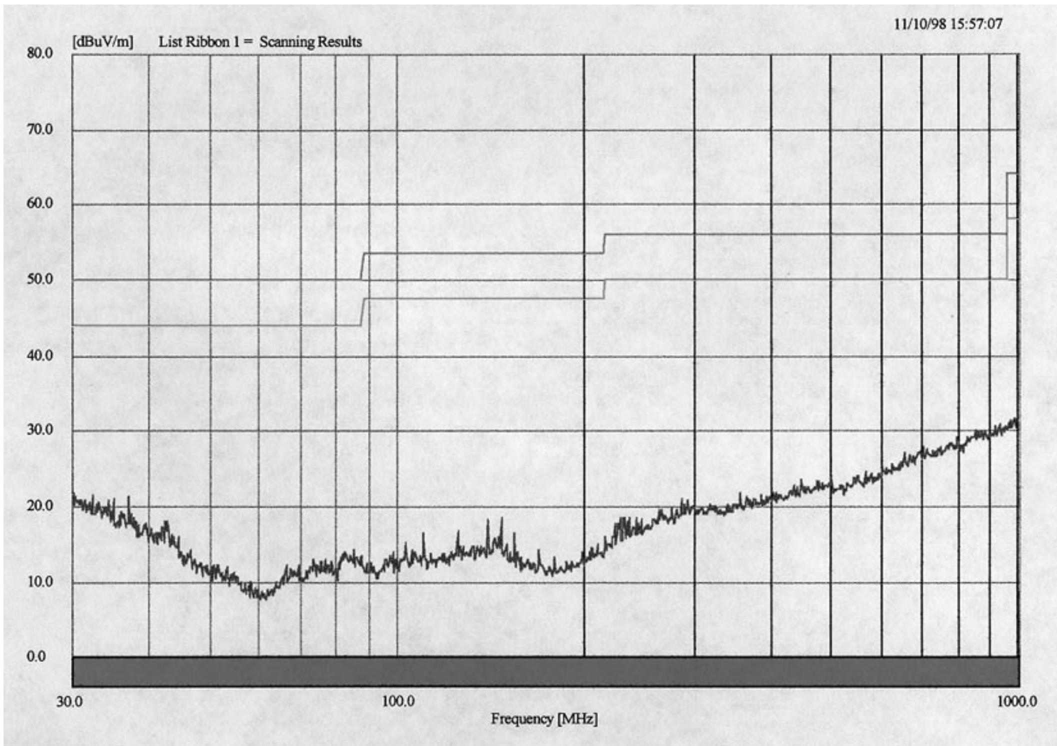
An FCC approved three-meter room was utilized to complete the necessary Part 15, Class A testing. Class A three-meter limits are outlined in Table 11.22. These limits were extrapolated to establish the radiated emission limits for Class A devices.

Table 11.22 FCC Radiated Emission Limits for Class A Devices at Three Meters

Frequency (MHz)	Field Strength dB(MicroVolts/ meter)	Measurement Distance (Meters)
30 - 88	50	3
88 - 215	53.5	3
215 - 960	56.5	3
Above 960	60	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 11.48.

Figure 11.48 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

The radiated emissions testing was performed within an FCC certified 3 Meter semi-anechoic chamber located at 9461 Willows Rd., Redmond, WA within an AT&T Wireless Services facility. Figure 11.49 through Figure 11.54 correspond to the emissions profile of the PWAN Base Station, measured from 30MHz – 18.0 GHz within the following configuration setup: the PWAN Base Station was located within an EMC shield cabinet, with all interface cabling (power, T1's, GPS, RF, etc) entering and exiting through the bottom of the digital cabinet as seen in the typical field configuration. Both cabinets making up the PWAN Base Station (digital and RF) were grounded via a 2 inch wide braid at the outer corners. To accomplish the worst case digital configuration of 15 voice calls located within the same TDMA slot, the upper digital Baseband shelf, sector A, was fully loaded with six TSP cards in order to fully populate the PWAN Base Station

11.3.4.2 Test Results - Configuration 15 Voice Calls on single TDMA Slot - Worst Case Scenario

The top horizontal line shown in Figure 11.49 depicts the FCC Class A limit line extrapolated to a 3 Meter test distance. The lower horizontal line indicates the 6 dB margin used during all radiated emission testing. The ten peak signals that exceed the 6 dB margin, as shown in Figure 11.49, were further investigated using a quasi-peak detector. The quasi-peak amplitudes are identified in Table 11.24 and shown in Figure 11.49, denoted by a sideways “X” symbol. As shown on the data plot, the amplitudes of the ten signals investigated with a quasi-peak detector, dropped below the 6 dB margin.

Figure 11.49 30-1000MHz, 15 calls on Single TDMA slot

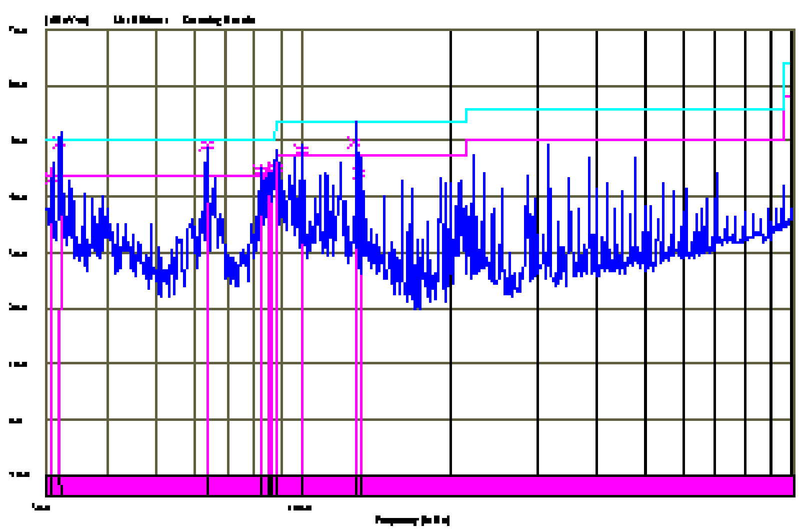


Table 11.23 30MHz-1000MHz emissions scan, 15 calls on single TDMA slot

Freq. MHz	Peak dBuV/m	Peak Limit dBuV/m	DelLim-Pk dB	QP dBuV/m	QP Lmt dBuV/m	Del Lim dBuV/m	OP-Hgt cm	Angle deq	Pol
30.883548	45.48	44.00	1.48	43.40	44.00	-0.60	143	1	Vert
31.991325	49.93	44.00	5.93	49.75	44.00	5.75	147	43	Vert
63.990152	49.54	44.00	5.54	49.19	44.00	5.19	196	45	Vert
81.909269	46.40	44.00	2.40	44.64	44.00	0.64	170	179	Vert
85.215326	46.22	44.00	2.22	42.33	44.00	-1.67	98	357	Vert
86.389870	45.03	44.00	1.03	44.43	44.00	0.43	147	359	Vert
88.415865	49.21	47.50	1.71	45.36	47.50	-2.14	115	136	Vert
99.986458	47.89	47.50	.039	48.46	47.50	.096	153	357	Vert
127.988309	50.26	47.50	2.76	49.89	47.50	2.39	212	135	Vert
131.061947	45.27	47.50	-2.23	44.34	47.50	-3.15	113	90	Vert

Table 11.23 lists all frequencies that lie above the FCC Class A 6dB margin and is in the following column order: Frequency (in MHz), Peak (the peak amplitude in dBuV/m), Peak Lmt (the peak limit line as compared to the 6dB margin in dBuV/m), DelLim-Pk (delta between the peak reading and the 6-dB margin in dB), QP (quasi-peak reading in dBuV/m), QP Lmt (quasi-peak limit line in dBuV/m), DelLim-QP (delta between the quasi-peak reading and the quasi-peak limit line in dB), Hgt (height of the antenna in cm), Angle (angle of the turntable in degrees), and the Pol (polarity of the antenna at the time of the measurement). As shown in Table 11.23, both frequencies fell below the FCC Class A limit line.

Figure 11.50 1000MHz-35000MHz emissions scan, 15 calls on single TDMA slot

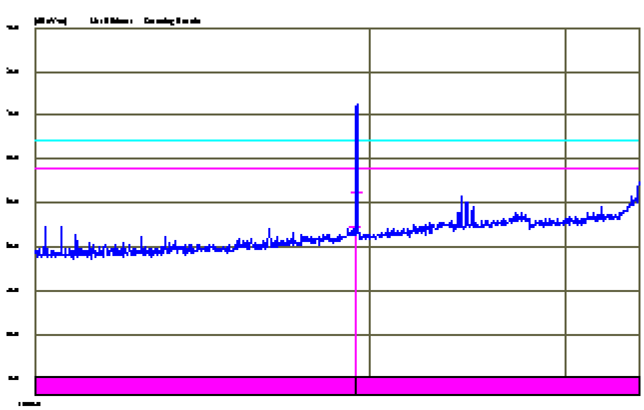


Table 11.24 1000MHz-35000MHz emissions scan, 15 calls on single TDMA slot

Freq. MHz	Peak dBuV/m	Peak Limit dBuV/m	DelLim-Pk dB	QP dBuV/m	QP Lmt dBuV/m	Del Lim dBuV/m	OP-Hgt cm	Angle deq	Pol
1945.818360	67.42	53.5	13.92	44.52	59.5	-14.98	270	104	Horz
1948.582317	72.32	53.5	18.82	52.41	59.5	-7.09	45	100	Horz

The group of signals shown in Figure 11.50 corresponds to the PWAN Base authorized transmit frequencies. The time variant noise within the Base were within the noise floor of the receiver during average detector measurements.

Table 11.24 lists all frequencies that lie above the FCC Class A 6dB margin and is in the following column order: Frequency (in MHz), Peak (the peak amplitude in dBuV/m), Peak Lmt (the peak limit line as compared to the 6dB margin in dBuV/m), DelLim-Pk (delta between the peak reading and the 6-dB margin in dB), QP (quasi-peak reading in dBuV/m), QP Lmt (quasi-peak limit line in dBuV/m), DelLim-QP (delta between the quasi-peak reading and the quasi-peak limit line in dB), Hgt (height of the antenna in cm), Angle (angle of the turntable in degrees), and the Pol (polarity of the antenna at the time of the measurement). As shown in Table 11.24, both frequencies fell below the FCC Class A limit line.

Figure 11.51 3.5GHz-18.0GHz @1m Antenna height emissions scan, Vertical polarization, 15 calls same TDMA

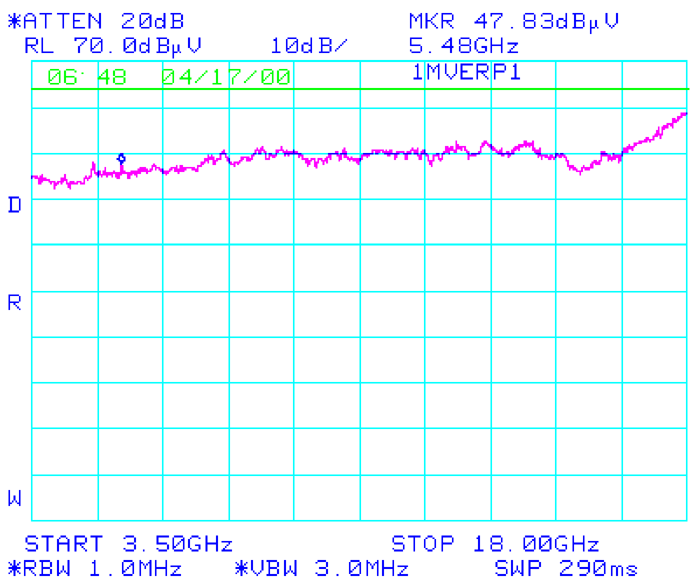


Figure 11.51 is the PWAN Base Station radiated emissions scan (3.5GHz – 18GHz) in the vertical polarization at a 1 meter antenna height. The PWAN Base Station was loaded with 15 calls on the same TDMA slot continuously throughout the duration of the test.

Figure 11.52 3.5 GHz-18.0 GHz @1m Antenna height emissions scan, Horizontal polarization, 15 calls same TDMA

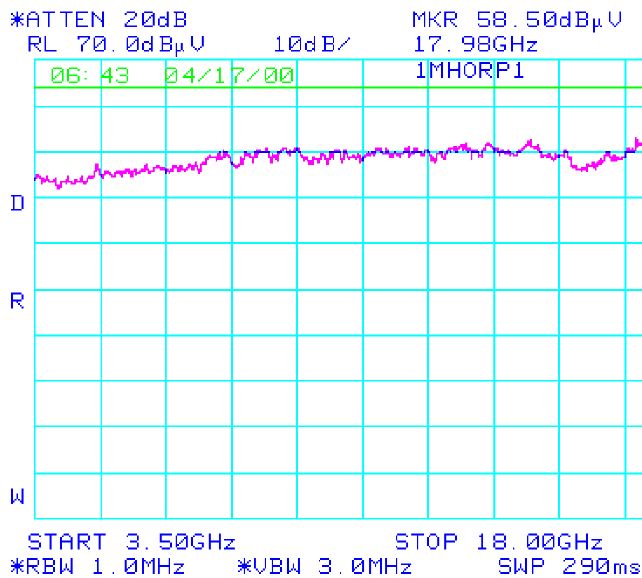


Figure 11.52 is the PWAN Base Station radiated emissions scan (3.5 GHz – 18.0 GHz) in the horizontal polarization at a 1 meter antenna height. The PWAN Base Station was loaded with 15 calls on the same TDMA slot continuously throughout the duration of the test.

Figure 11.53 3.5 GHz- 18.0 GHz @1.5m antenna height emissions scan, Vertical Polarization, 15 calls, same TDMA Slot

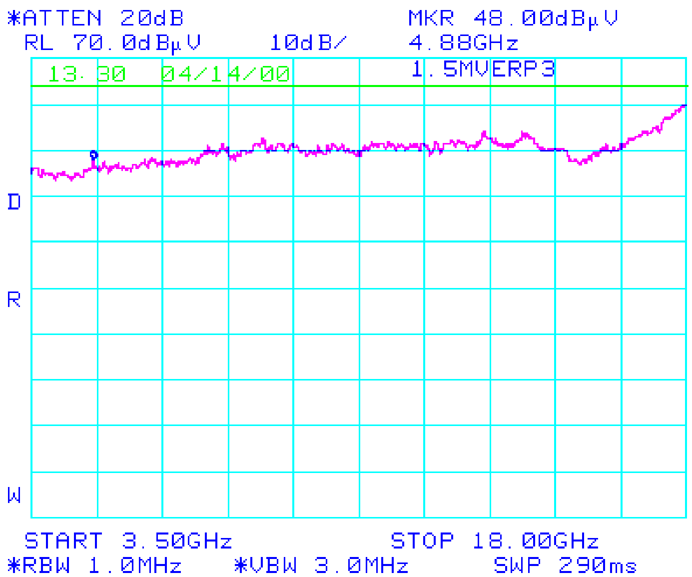


Figure 11.53 identifies the PWAN Base Station radiated emissions data (3.5 GHz - 18.0 GHz) in the vertical polarization at a 1.5-m measurement height. The PWAN Base Station was loaded with 15 calls on the same TDMA slot continuously throughout the duration of the test.

Figure 11.54 3.5 GHz-18.0 GHz @ 1.5m Antenna height emissions scan, Horizontal polarization, 15 calls same TDMA

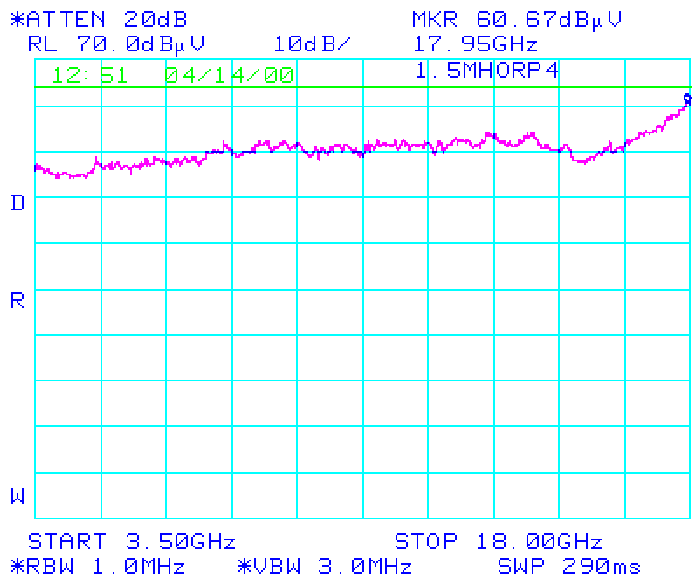


Figure 11.54 identifies the PWAN Base Station radiated emissions data (3.5 GHz - 18.0 GHz) in the horizontal polarization at a 1.5 meter antenna measurement height. The PWAN Base Station was loaded with 15 calls on the same TDMA slot continuously throughout the duration of the test.

11.3.4.3 Radiated to Conducted Spurious Emissions

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

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 11.46 through Figure 11.54 indicate no spurious emissions other than the authorized PCS PWAN Base Station transmit frequencies.