Test Notebook: Common cdmaOne BTS Measurements

The following sections offer guidelines for tests to verify BTS RF performance and solve problems.

1.0 Transmitter Frequency Error

Standard: IS-97 4.1.2

What is being measured?

This measurement determines the difference between the actual transmitted carrier frequency of a base station sector and the designated frequency.

Why do I need to test this?

If a transmitted signal is slightly "off-center" from a designated frequency, the faulty signal may interfere with neighboring transmissions.

What are the consequences?

Frequency errors degrade the overall quality of service and may pollute neighboring systems' operations.

How is frequency error measured?

The test set evaluates the CDMA signal, determines the characteristic frequency of the signal and compares it with the desired frequency to determine the error. In the standards, this test is one of the group of "waveform quality" measurements that should be performed with the BTS transmitting only a pilot signal. Since that would require taking the base station off-line and disrupting service, test sets have been designed to make the measurements during normal operating conditions in the presence of multiple active signals and Walsh codes.

Note: When the tester uses the BTS reference frequency as its standard, it can only verify the error of the transmitted frequency versus that reference, not any error in the reference itself.

What is the specified limit?

IS-97 specifies a frequency error of less than +5 x 10^{-8} (0.05 ppm) of the frequency assignment. This translates to approximately +45 Hz for cellular and +90 Hz for PCS frequencies.

2.0 Pilot Time Tolerance (Tau)

Standard: IS-97 4.3.1.1

What is being measured?

The difference between the transmitted start of the PN sequence of the pilot Walsh code and a system-based external trigger event is measured to determine the Pilot Time Tolerance (see Figure 4).

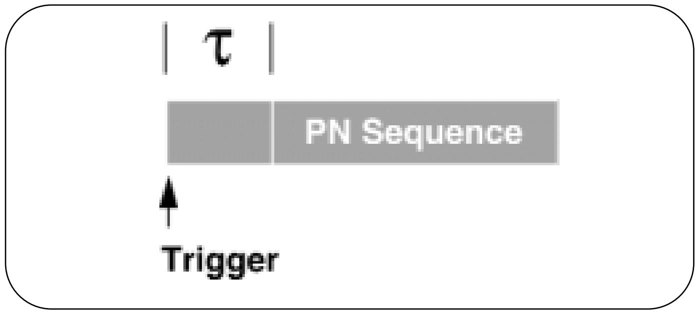

Figure 4. *Pilot time tolerance.*

Why do I need to test this?

All base stations must be synchronized within a few microseconds for station ID mechanisms to work reliably. cdmaOne networks use a Global Positioning System (GPS) to maintain system time. This fundamental measurement ensures that the pilot signal for any given sector of a base station is "tracking" with the network's system time.

What are the consequences?

Deviation from network timing could result in dropped calls and missed handoffs, since the faulty base station timing would not match the timing on the remainder of the system's base stations.

How is pilot time tolerance measured?

Transmitter output from the base station is demodulated in order to determine the start of the pilot PN sequence. The test set uses the "even second clock" signal (available on all base stations) as the external trigger reference for zero offset. Taking into account the programmed PN offset, the test set then calculates the difference between the time of the trigger and the time of the pilot PN sequence and reports that difference as a single time tolerance value expressed in microseconds. This measurement is another of the waveform quality standards that suggest a pilot-only transmission from a base station. In practice, most testers are able to make the measurement of pilot time-alignment error on a live mixed signal with paging, sync and traffic Walsh codes active, avoiding any disruption of service.

What is the specified limit?

IS-97 specifies that the pilot time-alignment error **must be** less than 10 microseconds. Both specifications also state that the value **should be** less than 3 microseconds.

3.0 Waveform Quality (rho)

Standard: IS-97 4.3.2

What is being measured?

Waveform quality, often referred to as rho (ρ), is perhaps the most common measurement for CDMA systems. Rho is a correlation that represents how closely the transmitted signal matches the ideal power distribution for a CDMA signal (see Figure 5). Think of the tested signal power distribution as the numerator of a fraction and the ideal distribution as the denominator – a waveform quality constant of 1.0 would represent a perfectly correlated CDMA signal.

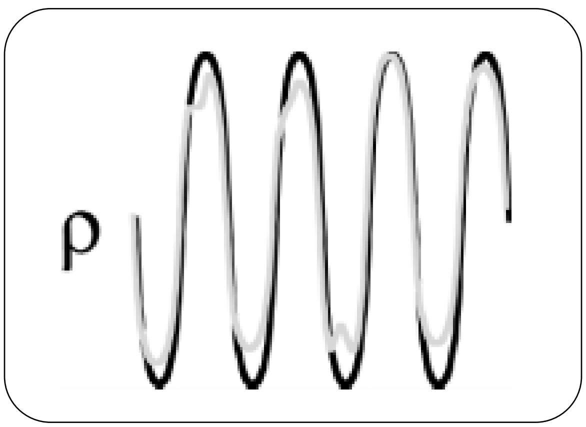

***Figure 5**. Waveform quality measurement (the darker trace represents the ideal signal).*

Why do I need to test this?

This measure is a good tool for judging the modulation quality of the transmitted CDMA signal and offers a quick and easy "snapshot" of the overall performance of the system.

What are the consequences?

Deviations in code power distribution degrade system performance for the user and lower efficiency for the operator.

How is waveform quality measured?

The test set demodulates the transmitter output from the base station and compares the distribution of power received to the ideal power distribution at specified "decision points" in the CDMA transmission. IS-97 specifies that this measurement is to be made on a pilot-only forward link signal. Furthermore, the test is to be made over a sample period of at least 1280 chips (see Figure 6). In practice, a pilot-only transmission from a base station implies that the base station has been removed from service. Most testers now offer an "estimated rho" capability that allows the factor to be derived in the presence of multiple Walsh codes – the approximate rho value can be calculated without taking down a sector of the base station.

What is the specified limit?

IS-97 specifies that the waveform quality constant be greater than 0.912.

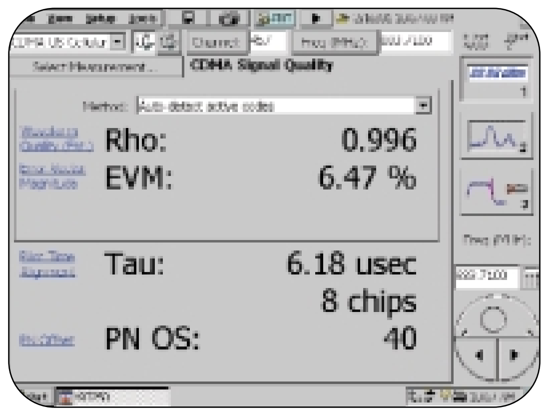

***Figure 6.** Waveform quality result example.*

4.0 Total Power, or Channel Power

Standard: IS-97 4.4.1

What is being measured?

This measurement verifies the total output power from the base station or appropriate sector of the base station (see Figure 7).

Why do I need to test this?

Power is the fundamental measurement of BTS range and performance.

What are the consequences?

Overall power levels must be contained within limits to prevent interference among neighboring stations while maximizing coverage.

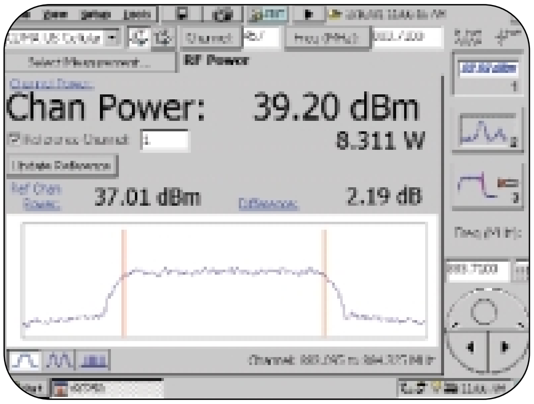

Figure 7. *Display of total output power.*

How can total power be measured?

The unique composition of a CDMA signal makes the measurement of power more demanding than with other communications systems. The spread-spectrum signal has the appearance of a "noise-like" signal spread over 1.23 MHz bandwidth, but it can contain much higher peak-to-average power ratios than a noise signal, making it very difficult to derive the true RMS values with some types of test equipment.

Total power can be measured directly with a dedicated thermal power head meter. Spectrum analyzers have been used to make this measurement by summing the power measurements across the 1.23 MHz wide CDMA bandwidth. However, most spectrum analyzers assume that inputs are CW signals, so power measurements of CDMA signals can be 9 dB or more in error, depending upon which Walsh codes are active. Most CDMA BTS testers now use well-defined DSP sampling techniques to measure power with appropriate RMS computations. IS-97 specifies a base station signal configuration of pilot, paging, sync and six traffic channels active for this measurement (see Table 2).

What is the specified limit?

IS-97 specifies that the total power shall remain within +2 dB and –4 dB of the specified base station (or sector) power.

Table 2. Nominal Testing Model (from IS-97)

Code Type	Number of Channels	Power (dB)	Comments
Pilot	1	–7.0	Code channel 0
Sync	1	–13.3	Code channel 32, always 1/8 rate
Paging	1	–7.3	Code channel 1, full rate only
Traffic	6	–10.3	Variable code channel assignments; full rate only

5.0 Pilot Power

Standard: IS-97 4.4.3

What is being measured?

The ratio of power in the pilot channel to the total channel power transmitted (see Figure 8).

Why do I need to test this?

Pilot power is a measure of the BTS range to mobile devices.

What are the consequences?

A pilot power level that deviates substantially from desired values, can affect the coverage characteristics of the network.

How is pilot power measured?

The test equipment demodulates the transmitted signal to analyze power levels in the code domain. The power contained in Walsh code 0 is then reported in dBm and watts.

What is the specified limit?

IS-97 specifies that the pilot power shall remain within ±0.5 dB of the BTS sector configuration value.

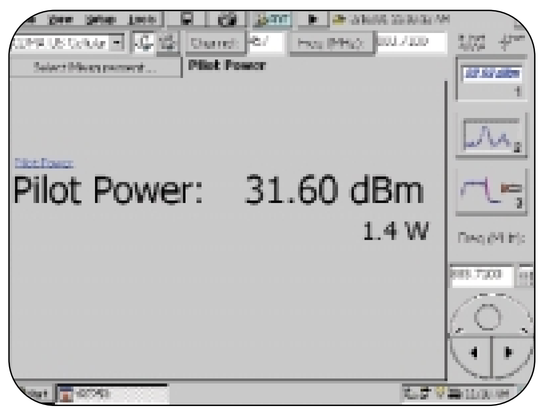

Figure 8. *Automatic measurement of power contained in the pilot.*

6.0 Code Domain Power

Standard: IS-97 4.4.4

What is being measured?

In a CDMA system, individual user transmissions are isolated by their codes. The test equipment measures the ratio of power in each of the forward link Walsh codes, to the total transmitted channel power. Figure 9 shows a graph of the Code Domain.

Why do I need to test this?

A base station's ability to accurately control the power in individual Walsh codes is a prerequisite to properly handle multiple user links with varying RF losses and to ensure interference-free transmissions.

What are the consequences?

Loss of quality and channel capacity due to inadequate or unbalanced power.

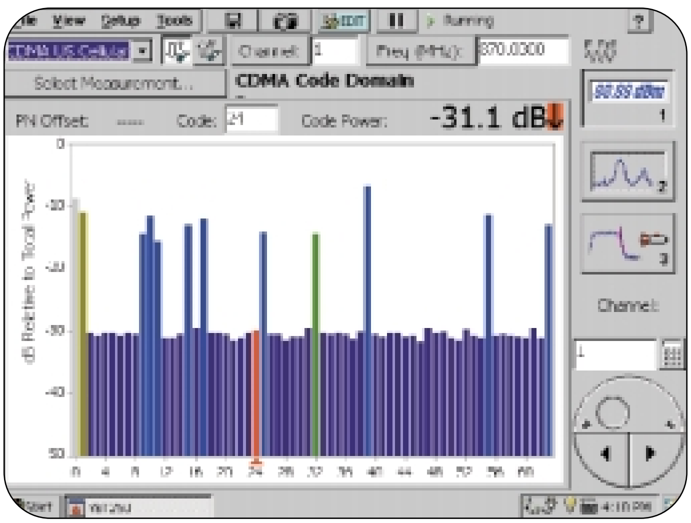

Figure 9. *Code Domain Power graph, with the noise level of an inactive code highlighted.*

How is code domain power measured?

The test equipment demodulates the transmitted signal to analyze power levels in each of the 64 forward link Walsh codes. The power in each of the codes is expressed in dB relative to the total transmitter power in the channel. Code domain power is verified with the base station sector producing a combination of Pilot, Sync, Paging and six traffic channels (see Table 2 in Section 4.0). The level of the inactive Walsh codes (those forward codes without an overhead or traffic signal), can be compared against the standard, as well.

What is the specified limit?

IS-97 specifies that the code domain power in each inactive Walsh code shall be 27 dB or more below the total output power.

References

Standard referenced in this document:

- ***TIA/EIA/IS-97****, Recommended Minimum Performance Standards for Base Stations Supporting Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*