Introduction: The Challenges of cdmaOne BTS Testing

A communications network is only as good as the quality of its user access – customer satisfaction and operating efficiency begin and end with the link between the system and its subscribers. In wireless telecommunication systems, the Base Transceiver Station (BTS) provides the user access with its RF air interfaces to mobile devices. Since these interfaces are also the elements of the system that are most susceptible to faults and outside interference, they present a formidable challenge to those who install and maintain them.

Leading edge troubleshooting tools and techniques are essential to the maintenance of systems at peak performance. These modern testers provide clear insight into the complex transmitter systems by capturing and displaying information in formats that are easy to interpret. Testers must also be compact, dependable and rugged to withstand the rigors of field use. Most of all, portable troubleshooting tools must get the job done quickly and efficiently – zeroing in on problems and minimizing service disruptions and time spent off-line.

The stakes are high. Network systems must perform reliably in the face of fierce competition – success or failure will be the direct result of customer satisfaction. Sophisticated new technology must coexist in a complicated landscape of previous generations and new mobile systems – most of which must be supported for many years to come. Exponential growth in other wireless and RF devices is introducing new sources of noise and interference that threaten to degrade performance.

This application note addresses the most common measurement challenges faced by RF technicians and engineers who maintain cdmaOne base station equipment. It explains the fundamental concepts of key transmitter signals, examines typical faults and their consequences and offers guidelines for tests to verify performance and troubleshoot problems in the field. Reference information is also provided on the differences between cdmaOne and previous analog and 2G digital standards and the evolution to new 3G systems.

We'll begin with a brief overview of analog and digital multiplexing methods and a review of key CDMA signal parameters. We will then examine the various types of testing tools used to characterize those parameters. In this document there is a Test Notebook that provides summaries and guidelines for making key transmitter measurements at an operating cdmaOne base station. For a brief history of wireless telephony please see Appendix (page 11).

CDMA Basics

What are CDMA and cdmaOne?

Code Division Multiple Access (CDMA), as defined in Interim Standard 95 (IS-95), describes a digital air interface standard for mobile equipment that enhanced the capacity of older analog methods with greatly improved transmission quality. "cdmaOne" is the brand name[1] for the complete wireless telephone system that incorporates the IS-95 interface. CDMA systems were serving over 65 million subscribers worldwide by June, 2000.[2]

CDMA has proven itself as a successful wireless access technology in 2nd generation networks. Furthermore, the evolving third generation systems will rely on CDMA techniques for radio access. However, the structure of the physical layer of a cdmaOne network is significantly different than its GSM or IS-136 counterparts.

Characteristics of cdmaOne Signals

The digital technologies in the cdmaOne BTS introduce a significant number of new measurement parameters for the operation and maintenance of a network. In analog systems, we measure parameters such as signal-to-noise ratio and harmonic levels, in order to quantify how well a base station is performing on a network. In cdmaOne systems, these familiar analog parameters are often mixed with or replaced by new quality metrics such as Pilot Time Tolerance (Tau) and Waveform Quality.

Standards: Within the United States, the Telecommunications Industry Association (TIA) has written Interim Standard IS-95 for CDMA mobile/base station compatibility and IS-97 for CDMA BTS transmitter and receiver minimum standards. Standards maintained by the Association of Radio Industries and Business/Telecommunication Technology Committee (ARIB/TTC) in Japan and Telecommunications Technology Association (TTA) in South Korea describe similar tests for BTS performance.

Walsh Codes: "Walsh code" is the term used for the digital modulation code that separates the individual conversations and control signals on the RF carrier being transmitted from a cdmaOne base station. This code uniquely identifies each of the forward traffic channels (user conversations). There are 64 possible Walsh codes; each code is 64 bits long. In cdmaOne, the only way to address individual user channels in a transmission is to demodulate the RF signal and detect their individual Walsh codes.

[1] cdmaOne is a registered trademark of the CDMA Development Group (CDG)

[2] CDMA Development Group (CDG), Subscriber Growth History, http://www.cdg.org/world/cdma_world_subscriber.asp

Many of the measurements we will discuss in this application note depend upon looking at a CDMA signal in the “Code Domain,” data in individual code channels obtained from a demodulated signal. Code domain power, for instance, is a graph of the power levels in each of the 64 Walsh codes. In Figure 1, the power is graphed on the vertical axis and the 64 Walsh codes (Channels 0 to 63) are displayed on the horizontal axis. In this example, power levels in codes 0, 1, 8, 32, 59, 60, 61, 62, and 63 indicate that they are carrying traffic or system data of some sort.

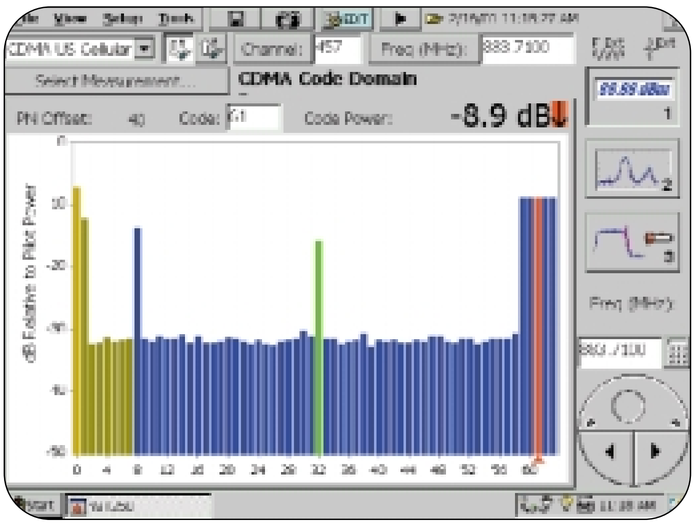

Figure 1. *Code Domain Power display.*

Pilot, Paging, Sync and Traffic Channels are forward link channels – logical channels sent from a base station to a mobile phone at any given moment. Pilot, paging and sync channels are “overhead,” or system channels that are used to establish system timing and station identity with mobiles and to manage the transmissions between them. Traffic channels carry individual user conversations or data.

The ***Pilot*** signal serves almost the same purpose as a lighthouse; it continuously repeats a simple spread signal at high power levels so that mobile phones can easily find the base station. The Pilot signal is usually the strongest of the 64 Walsh channels, and is always on Walsh code 0. ***Paging*** channels can be found on one or more of Walsh codes 1 to 7. These channels are used to notify mobile transceivers of incoming calls from the network and to handle their responses in order to assign them to traffic channels. The synchronization, or ***Sync***, channel is always found on Walsh code 32. This channel carries a single repeating message with timing and system configuration information from the cdmaOne network. Finally, a ***Traffic*** channel is a forward link channel that is used to carry a conversation or data transmission to a mobile user.

The ***Reverse CDMA Channel*** carries traffic and signaling in the mobile-to-station direction. An individual reverse channel is only active at the BTS during calls or access signaling from a mobile.

Chip: The term “chip” is used in CDMA to avoid confusion with the term “bit.” A bit describes a single digital element of a digitized user conversation or data transmission. Since data is “spread” before being transmitted via RF, the term “chip” represents the smallest digital element **after spreading**. For example, one version of cdmaOne equates 128 chips to one bit.

Short Code and PN Offset: Each base station sector in a cdmaOne network may transmit on the same frequency, using the same group of 64 Walsh codes for pilot, paging, sync and forward traffic channels. Therefore, another layer of coding is required so that a mobile phone can differentiate one sector from another.

The PN offset plays a key role in this code layer. The abbreviation “PN” stands for pseudo-random noise – a long bit sequence that appears to be random when viewed over a given period of time, but in fact is repetitive. In cdmaOne transmissions, the entire PN sequence is defined to form a **short code** that is 32,768 chips in length and repeats once every 0.027 seconds. The short code is exclusive OR’d with the data and transmitted in each of the forward channels (pilot, paging, sync, and traffic). Within the 32,768 chip sequence, 512 points have been chosen to provide PN offsets. Each base station transceiver uses a different point in the sequence to create a ***unique* PN offset** to the short code in its forward link data. As a result, a mobile phone can identify each base station sector by the PN offset in the received signal.