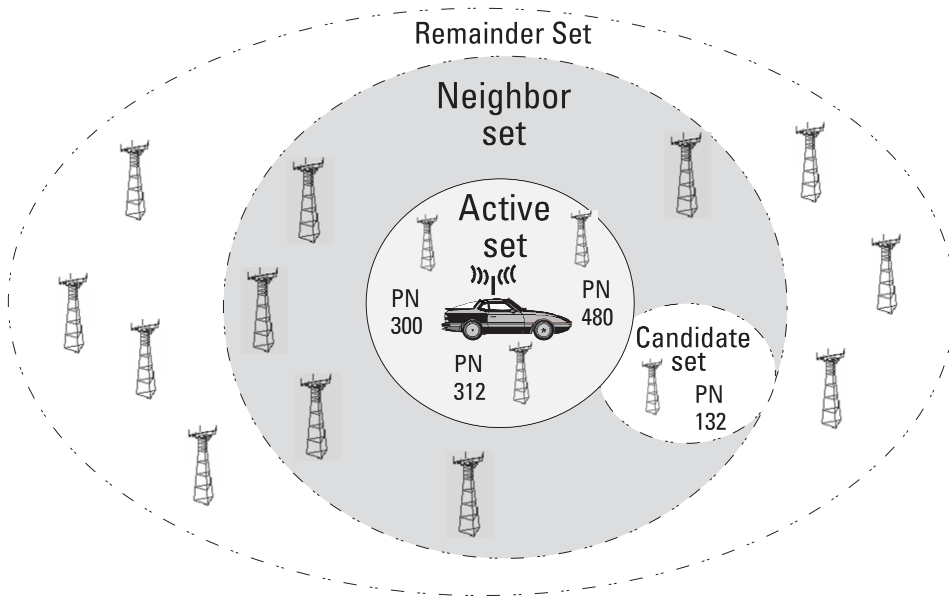
Optimizing Your CDMA Wireless Network Today and Tomorrow

Using Drive-Test Solutions

Application Note-1345



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Section 1: Introduction

The growth and expansion of cellular and PCS networks continues at a rapid pace throughout the world. To retain existing customers and attract new customers, wireless service providers must maintain the highest quality of service throughout their networks. Drive-testing remains an essential part of the network life cycle, as an effective means for continually optimizing network performance to maintain customer satisfaction and reduce subscriber churn.

This application note provides an overview of how drive-test tools can help optimize your CDMA-based cellular and PCS networks. These tools allow you to turn-up networks faster, reduce optimization time and improve network quality of service. Drive-test tools include both those required for collecting data as it relates to a user's location and those that are used to post-process the collected data for final analysis.

Drive-test solutions are used for collecting measurement data over a CDMA air interface. The optimum solution combines network-independent RF measurements using a digital receiver with traditional phone-based measurements. A typical collection system includes a digital RF receiver, phone, PC, GPS receiver and antennas.

Who should read this application note?

This application note is for engineers and technicians in RF engineering or network performance departments who are responsible for drive-testing and optimizing CDMA networks. Companies that include such positions include wireless service providers (or operators), network equipment manufacturers of base station infrastructure and/or mobile handsets, and engineering consultants.

Refer to the end of this document for more references on drive-testing applications and product-specific information from Agilent Technologies.

Section 2: Network optimization overview

Optimization process

This section discusses what drive-testing is and why it is important. There are a number of applications for drive-testing in the life cycle of a wireless network, as shown in Figure 1. (This discussion assumes that band clearing has already been performed.)

Prior to installation of the base stations, it is first necessary to perform site evaluation measurements to determine an appropriate location for the base stations. This generally consists of transmitting a CW (continuous wave or unmodulated) signal from a candidate site and measuring it with a receiver such as the one found in a drive-test system. Next, initial optimization and verification is performed to take a first-pass look at the RF coverage when the modulated CDMA carrier is turned on.

The next step is the acceptance-testing phase, after which the network is handed over from the network equipment manufacturer to the wireless service provider and a sign-off process is completed. The acceptance criteria rely on data collected from drive-testing the network. Once the wireless service provider starts commercial service, ongoing optimization and troubleshooting are continually performed during the life of the network as new cell sites are added for increased capacity or additional geographic coverage. Changes in the propagation paths continually occur, including the addition of new buildings, growth of trees, changing foliage conditions, and equipment deterioration. Moreover, as more subscribers are added and channel traffic increases, CDMA networks need to be re-optimized to account for increased levels of interference caused by the added traffic. (See explanation of Io in Section 3.) In addition, cell breathing caused by varying wireless traffic usage throughout the day requires ongoing network optimization to ensure adequate channel capacity. Drive-testing is an excellent way to assist the service provider by measuring RF coverage and interference that affects overall network capacity.

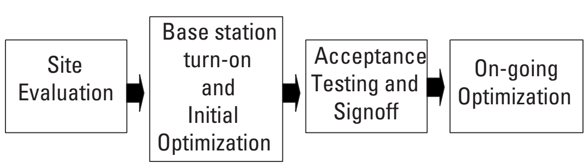

Figure 1. Network life cycle, showing where drive testing is needed

Optimization is an important step in the life cycle of a wireless network. An overview of the optimization process is illustrated in Figure 2. Drive-testing is the first step in the process, with the goal of collecting measurement data as it relates to a user's location. Once the data has been collected over the desired RF coverage area, the data is output to a post-processing software tool. Engineers can use the post-processing and collection tools to identify the causes of potential RF coverage or interference problems and analyze how these problems can be solved. Once the problems, causes, and solutions are identified, steps are performed to solve the problem.

Figure 2 illustrates that optimization is an ongoing process. The goal is to improve quality of service, retain existing subscribers, and attract new oneswhile continually expanding the network.

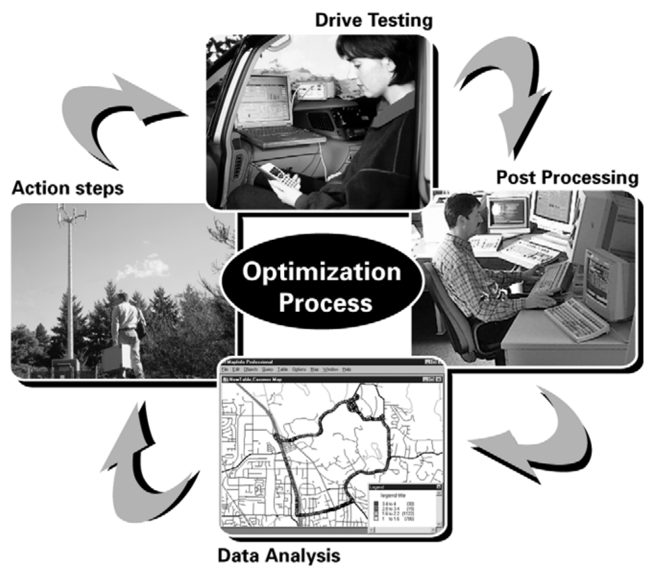

Figure 2. Optimization process begins with drive testing, moves to post-processing, then requires data analysis, and finally action needs to be taken to correct the problems. Drive-testing is performed again to verify that the actions were effective.

Drive-test overview

This section describes the basic concepts of drive-testing. Both network equipment manufacturers and wireless service providers perform drive-testing. Wireless service providers need to optimize their networks, as new cell sites are added, new buildings constructed or other conditions change. Drive-testing allows them to perform this optimization on an ongoing basis. Traditionally, CDMA drive-testing is performed using a phone connected to a portable computer. Cellular and PCS subscribers view the performance of their service on the basis of the network coverage or the call quality. The drive-test tool uses a phone to re-create the problems that a subscriber is experiencing. For example, if a subscriber's call is dropped while operating in a moving vehicle in a particular location, the drive-test should be able to duplicate this problem.

Other examples of subscriber complaints include blocked calls (access failures), poor voice quality, and lack of significant coverage. The drive-test system makes these measurements, stores the data in the computer database, and stamps the data as a function of time and location. Frame erasure rate (FER) is a phone measurement that provides an indication of link quality.

Several types of drive-test systems are available—phone-based, receiver-based and combination phone- and receiver-based. Figure 3 shows a combination phone- and receiver-based drive-test system.

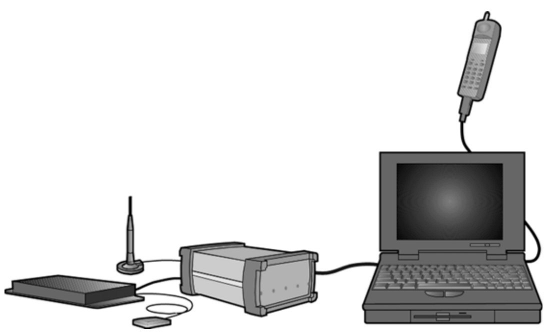

Figure 3. Typical combination phone- and receiver-based drive test collection tool. A GPS receiver and antenna, and a laptop PC, are also required.

The drive-test system is placed in a vehicle and driven throughout the wireless service provider's network coverage area. Refer to Figure 4.

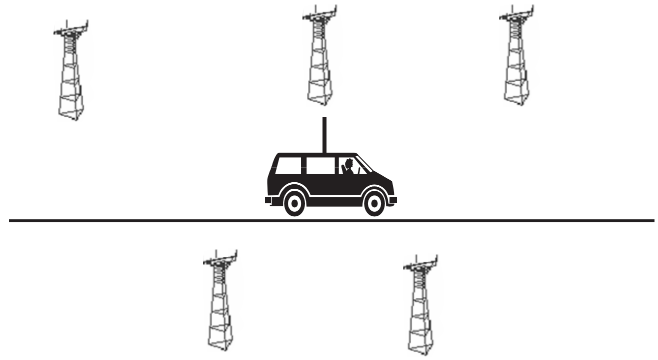

Figure 4. Typical drive-test van in a CDMA wireless network.

Possible causes of network problems

There are a number of causes for blocked calls (failed originations), dropped calls, and poor FER. (A more detailed explanation is provided later in this document). These causes can include the following: poor RF coverage, pilot pollution, missing neighbors, search window setting problems, and timing errors. (Note: this document focuses on causes related to RF parameters rather than those associated with cell site capacity, backhaul capacity, or call processing software issues.)

Lack of RF coverage is often the cause of dropped calls and blocked calls. This may occur due to a localized coverage hole (such as a low spot in the road), or it could be due to poor coverage at the extreme edge of the coverage area. Pilot pollution is the presence of too many CDMA pilot signals. The additional pilots act like interference to the subscriber's call. The missing neighbor condition occurs when the phone receives a high-level pilot signal and it does not appear in the phone's neighbor list. Again, it acts as an interfering signal and can cause dropped calls and high FER. Likewise, dropped calls can occur when the search window is not set properly. In this case, the phone cannot find pilots that are in its neighbor list. Finally, base station timing errors can lead to dropped calls, since CDMA systems depend on having synchronous timing between base stations. These topics are discussed later in this document.

Section 3: CDMA concepts—understanding drive-test measurements

CDMA background

A background tutorial on CDMA concepts will facilitate a better understanding of future measurement descriptions. If you are already familiar with the concepts of CDMA, please skip to page 7 for the phone-based measurement section or page 9 for the receiver-based measurement section. Cellular and PCS networks employing the CDMA air-interface are based on the IS-95 and J-Std008 standards, respectively. Rather than dividing the voice calls into frequency channels, as was done in analog FM networks, CDMA (code division multiple access) is a spread-spectrum format that utilizes orthogonally coded signals occupying the same 1.25-MHz spectral bandwidth. Refer to Figure 5.

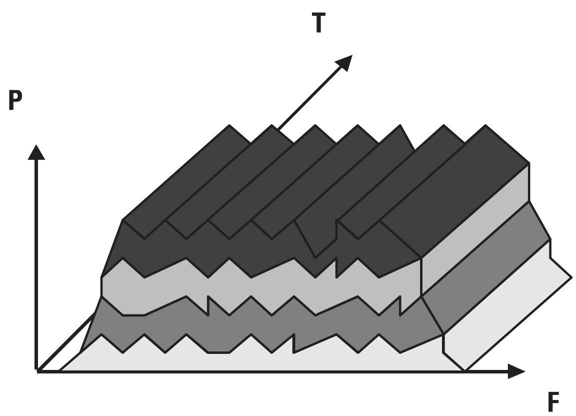

Figure 5. CDMA spectrum occupies 1.25-MHz bandwidth and consists of multiple code-domain channels, rather than individual narrowband frequency channels that were used in analog FM systems.

Each channel in a CDMA signal is spread by one of 64 orthogonal codes called Walsh codes, as shown in Figure 6. The Walsh codes spread the signal over a bandwidth range of approximately 1.25 MHz. Most of the Walsh codes are used for voice traffic channels. The other codes are dedicated to pilot, paging and sync channels. The paging channels (Walsh codes 1 through 7) are used by the base station to alert the phone. In most networks, only Walsh code 1 is used for paging, making codes 2 through 7 available for traffic use. The sync channel (Walsh code 32) is used to provide timing to the phone. Refer to figure 6.

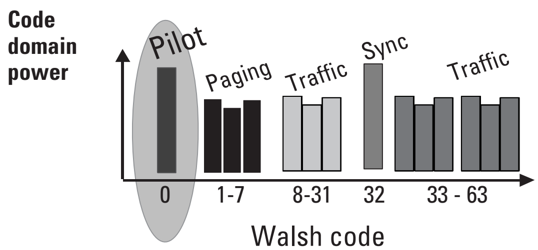

Figure 6. Walsh codes comprising CDMA signal

To understand how the pilot signal works, it is necessary to understand short codes. The last step in generating the CDMA signal in the base station is modulation of the data by a pseudo-random sequence called a short code. The short code is identical for all base stations, with one exception. Each base station has a different phase-delayed version of the same short code. This is usually represented as a time shift measured in chips. (A chip is approximately 0.8 microseconds). This time offset in the short code is what uniquely identifies each base station. The time offset essentially acts as a color code.

The pilot channel (Walsh code 0) is an unmodified version of the short code just described. Therefore, it is identical for every base station, with the exception of the timing of its short code generator. It is this pilot channel timing offset that is used by a mobile phone to identify a particular base station, distinguish it from the others, and thereby communicate with the proper base station.

The pilot channel timing offset is expressed as a "PN offset" referenced to absolute time. The short code sequence repeats every 2 seconds, which is the period of the GPS even-second clock. Therefore, PN 0 aligns with the beginning of the short code period, exactly on the GPS even-second clock. PN 1 is advanced in timing by 64 chips. PN 2 is 128 chips higher than PN 0, and so on. "PN" stands for "pseudo noise," a term that has its origins in spread spectrum theory. There are up to 512 unique PN offsets available to network operators, although only a subset is typically used. The set of PNs is further confined to integer multiples of a PN value known as the PN increment. Common PN increments used by wireless service providers are 3, 4 or 6. A PN increment of 3 means that PN 0, PN 3, PN 6, PN 9, for example, may be assigned to base stations or base station sectors in the network. Each CDMA operator selects a value of PN increment based primarily on its base station density. A PN increment of 3 provides more PN offsets than a PN increment of 6, since the total number is computed by dividing 512 by the PN increment. PN values may be reused in the same network, provided the base stations are located at a significant distance from one another and their antennas are pointed away from each other.

It is the pilot channel that is measured by the digital receiver-based drive-test system. To identify a base station, the receiver measures the timing offset of the short code comprising the pilot channel. The receiver obtains its precise timing from the pulse-per-second reference signal available on standard GPS receivers. Numerous examples of base station pilot displays will be shown later when the drive-test measurements are described. Phones can also measure pilot signals. However, they depend on the network to tell them which pilots to measure. (A description of neighbor lists will be given later.)

Measuring pilot signals

Drive-test systems exploit the fact that the pilot channel (Walsh code 0) transmits continuously and provides a means of identifying each base station. Scanning the pilots allows engineers to quickly examine the RF coverage in the wireless network. Figure 7 is a display of the levels of the strongest pilots measured by a network-independent digital receiver. Note the PN offsets at the bottom of each of the bar graphs, identifying the base station or base station sector that transmitted each pilot. The numbers shown at the top of the bars represent the Ec/Io of each pilot signal. This is a measure of the relative amplitude of each base station received by the drive-test system, as described in the next section.

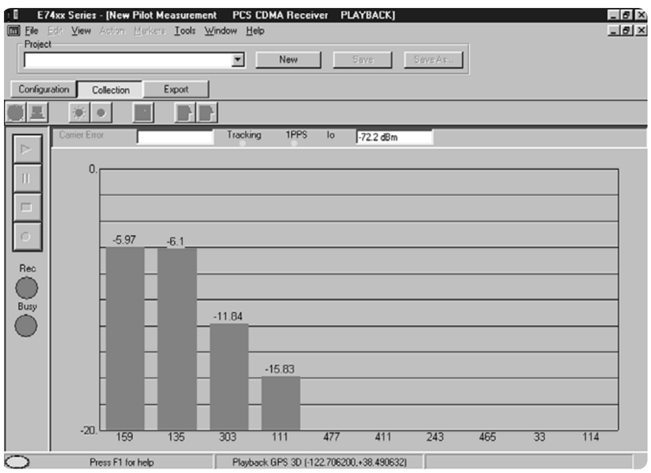

Figure 7. Receiver-based drive test measurement display of the four highest-level pilots.

Figure 8 is a depiction of the four closest base stations that correspond to the four pilot signals shown in Figure 7. The diagram is simplified for illustration purposes and does not include the sectorization normally present at each base station. Note also that it is not always the closest base station that produces the highest received pilot signal strength. Different propagation conditions often exist that allow distant signals to be received at higher levels, presenting difficult-to-solve problems. It will be shown later that the receiver-based drive-test tool helps diagnose these problems.

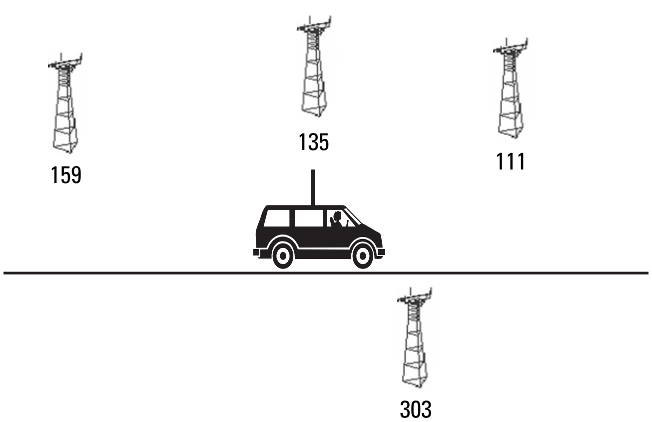

Figure 8. Wireless network consisting of multiple base stations.

Ec and Io definitions

Depending on whether a phone or a receiver is used to perform pilot scanning, the pilot displays are usually measured in units of Ec, Io, or Ec/Io. Ec is the signal strength measurement of the pilot expressed in dBm units. For example, the pilot signal may have an Ec value of -50 dBm, -80 dBm, or -100 dBm, depending on where the drive-test equipment is located with respect to the base station transmitting that pilot signal. Figure 9 illustrates that each base station Ec is just a small portion of the total power in the 1.25 MHz bandwidth channel.

Io is a measure of the total power (dBm) within the 1.25 MHz bandwidth channel. It includes the power of all 64 Walsh codes from each base station and any noise or interference that may reside in the 1.25 MHz channel. Practically speaking, Ec/Io is the power in an individual base station pilot divided by the total power in the 1.25 MHz channel, expressed in dB. It provides a useful ratio to compare the power levels of the base stations with respect to one another. (The more technical definition of Ec/Io is the ratio of energy per chip to the interference power spectral density. It is equivalent to thinking of these terms—Ec and Io—as the ratio of powers.)

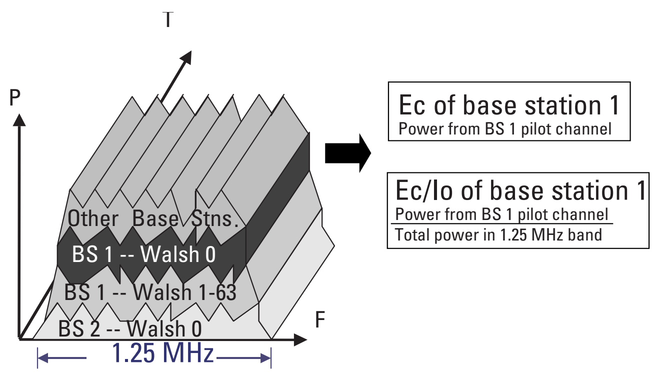

Figure 9. CDMA composite signal consisting of all the Walsh codes of each base station.

Pilot signals can be displayed by drive-test solutions in several ways, depending on whether a network-independent receiver or a test mobile phone performs the measurements. The pilot display shown in Figure 7 originated from a receiver. The receiver measures all the pilots, completely independent of any network instructions. In contrast, a phone-based drive-test measurement display will look somewhat different.

To better understand the contributions that the phone and receiver each provide, the next two sections of this document are split between phone-based and receiver-based drive-test measurements. The remainder of the document describes the benefits of combining the phone and receiver into an integrated drive-test solution.

Section 4: Phone-based drive-test measurements

CDMA phone concepts

Phone-based tools are the minimum set of equipment required for drive-testing. Basic measurements of dropped calls and blocked calls (also called access failures) are needed to understand the network performance from the subscriber's perspective. The phone can also measure FER to obtain an indication of call quality, and it can decode layer 3 messages to assist in network troubleshooting. Figure 10 shows a phone-based drive system that includes a GPS receiver for accurate location-based measurements.

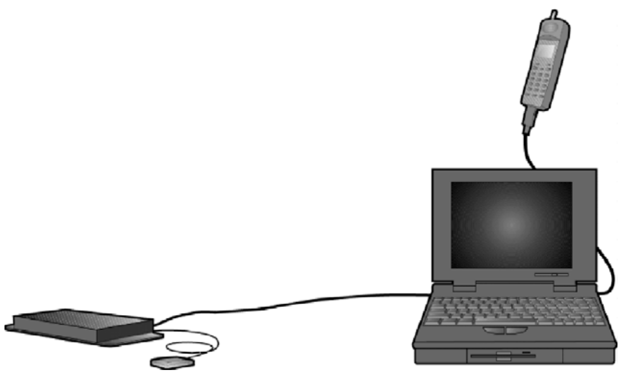

Figure 10. The phone-based drive-test tool with laptop PC, and GPS receiver with antenna.

Since a test mobile phone is dependent on the network, it displays the pilots that it is instructed to measure. To better understand how a phone measures base station pilot signals, refer to Figure 11. A phone categorizes base station pilots into three major sets: active, candidate and neighbor. All other pilots are part of a fourth group called the remainder set. As described later, the receiver-based drive-test tool measures all pilots, including those in the remainder set, which are often the source of interference.

As Figure 11 illustrates, the phone is constantly in communication with many base stations. Active pilots represent those base stations that are currently involved in transmitting and receiving a "live" call. Candidate pilots indicate those base stations that are transitioning into or out of the active set, depending on whether their power levels rise above or fall below a network-defined threshold (Tadd or Tdrop). The neighbor pilot set includes a list of base stations that are potential choices for the active set. The wireless service provider's network planning staff programs the network to download the neighbor list to the mobile phone. It usually represents the nearby base stations that are servicing the mobile phone. Consequently, the neighbor list is constantly changing as the mobile moves through the network coverage area. Each base station sector has a unique neighbor list. When a call is in the hand-off process from one cell to another (or one sector to another on the same cell), the phone's neighbor list is comprised of the neighbors associated with each sector involved in the hand-off.

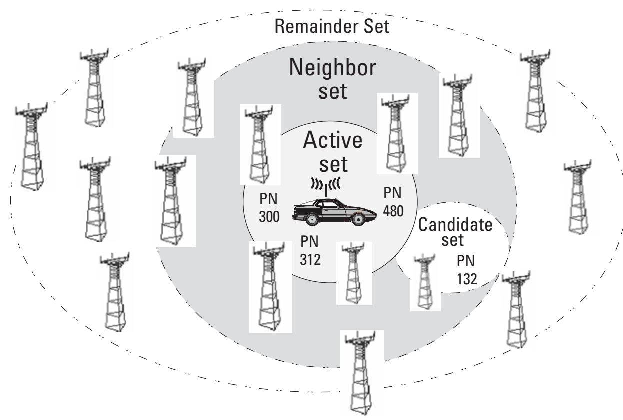

Figure 11. Active, candidate, and neighbor pilot set lists are constantly being updated.

To represent the three pilot sets, the phone-based drive system displays the pilot categories in color—red for active, yellow for candidate and blue for neighbor. Since this document does not use color, the categories are indicated with titles above each pilot set in Figure 12. The number inside each of the active pilots indicates which phone rake receiver finger (or correlator) is currently demodulating the active phone call. Most CDMA phones have three rake fingers for use in soft handoff or for holding calls in low signal environments by using different multipath signals.

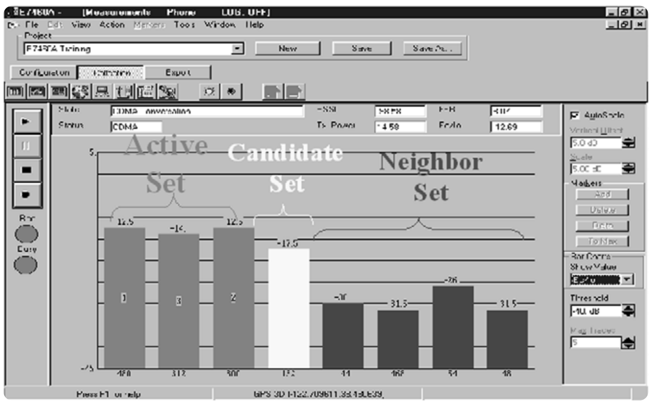

Figure 12. Phone-based drive-test measurement shows active, candidate, and neighbor pilots.

Phone-based tools are necessary for assessing the performance of the wireless network with call statistics such as blocked and dropped calls as a function of the user's location. Figure 13 shows an example summary of these statistics.

1 Call Control Phone	
	1 Call Control ...
Channel	50
Access Time	0 s
Redial In	0 s
Dropped Calls	0
Blocked Calls	1
Attempted Calls	1
Remaining Calls	0
Drop Rate	0.
Block Rate	1.

Figure 13: Phone-based drive-test system measures statistics like dropped and blocked calls.

While phone-based tools tell the engineer 'what' the symptom of the problem is, they often do not tell 'why' the problem occurred. For example, why did a dropped call occur at a specific location? To better understand the cause of air-interface network problems, a receiver-based drive-test tool was developed by Agilent Technologies.

Since the network controls phone-based tools, they lack the independence to make measurements in an unconstrained manner. The phone's timing is initially derived from the network using the base station sync channel (Walsh code 32). Any timing errors in the base station will cause subsequent errors in the phone. In addition, the network tells the phone which base station pilots to scan, based on the neighbor list that is sent to the phone over-the-air from the base station. Base stations that are not included in the neighbor list may never be measured by the phone, although they can cause major interference, resulting in dropped calls.

In contrast, receiver-based drive-test tools are completely independent of the network. Thus, they have the capability to measure all pilots (up to 512) independent of any neighbor lists. In addition, they can perform absolute timing measurements, which are the cause of many network problems.

Section 5: Receiver-based drive-test measurements

Overview

This section reviews the concepts, measurements and benefits of CDMA receiver-based drive-test systems. Section 4 described how a phone-based drive-test solution is required to tell "what" network symptoms exist, including dropped calls, access failures (blocked calls), or high FER. This section will illustrate that a receiver-based drive-test tool is necessary to tell "why" the problems are occurring.

Phone-only-based drive-test systems often have the same network problems they are trying to resolve. What is needed is a network-independent drive-test solution. The receiver-based drive tool was specifically designed to overcome this problem. Since the receiver uses GPS to synchronize its timing, it does not need to be tied to the network. Furthermore, it scans all 512 pilots, rather than being limited to the neighbor list as a phone is.

In contrast to a mobile subscriber phone or a phone-based drive-test tool, the receiver does not use the sync channel of the base station for its timing. Rather, it uses GPS (global positioning system) satellites to obtain the one pulse-per-second required to accurately measure all the pilots that are detected at the RF input. GPS is also used to tag the location (longitude and latitude) to each measurement made by the receiver.

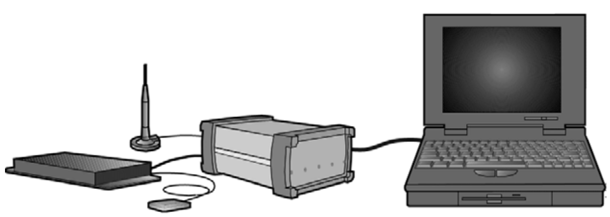

Figure 14. In a receiver-based drive-test system, the GPS receiver provides one pulse-per-second timing and location information.

CDMA pilot scanning overview

Figure 15 shows a possible display of a measurement window from a receiver-based system. The bar chart is a Top N display of the strongest pilots measured by the receiver and placed in descending order of power level. The value of N can be set between 1 and 20. The PN offset values of the pilots are shown at the bottom of each bar. The y-axis choices are either Ec or Ec/Io.

There are many choices available for the value that is displayed on top of each bar. The choices include delay, Ec, Ec/Io, aggregate Ec, aggregate Ec/Io, delay spread and aggregate-peak. In this example, the value displayed is Ec/Io.

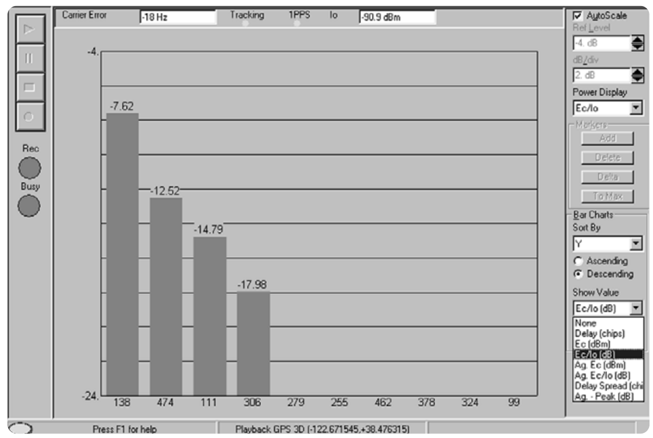

Figure 15. Receiver Top N pilot measurement window.

It is important to remember that the receiver derives its timing from the GPS one pulse-per-second signal. The receiver's timing is aligned with the even-second clock of GPS, which is the same timing signal that CDMA base stations use. To correctly measure the pilots, the receiver requires knowledge of the PN increment for the particular network. The PN increment is the spacing of the pilot signals within a given service provider's network. A PN increment of 3 means that PN0, PN3, PN6, PN9, can be used by a provider. The user must enter this PN increment value into the receiver-based drive tool software.

Pilot pollution measurements

Another form of interference in CDMA networks is pilot pollution. It is defined as the presence of more than three pilots having significant power. The rake receiver of the phone has three fingers that are used either to demodulate up to three different pilots in a soft hand-off situation, or to demodulate up to three multipath components of the same pilot, while maintaining a call in low signal-level conditions. (A combination of the soft hand-off and multipath conditions can also occur.) If more than three significant pilots are presented to the rake receiver at one time, it cannot make use of them. In fact, the presence of a high-level fourth or fifth pilot results in excessive active set churn, higher levels of Io, and consequently worse Ec/Io. The result of all of these conditions is often higher FER or a potential increased dropped-call rate.

Figures 16 and 17 show examples of both a good network (with only three significant pilots) and a bad network (having seven or eight high-level pilots). This pilot pollution condition is easily measured by the receiver-based drive-test system, since it can measure all the pilots independently of network neighbor lists. Phone-based tools are capable of measuring multiple pilots, but there is no guarantee that all pilots will be detected, due to neighbor list limitations. Pilot pollution and missing neighbor conditions are often closely related. Having an integrated receiver and phone in combination with automatic software alarms ensures the best detection of these problems in the minimum amount of time. This keeps operating costs to a minimum, compared to phone-only drive-test solutions that often require multiple drives and higher labor costs.

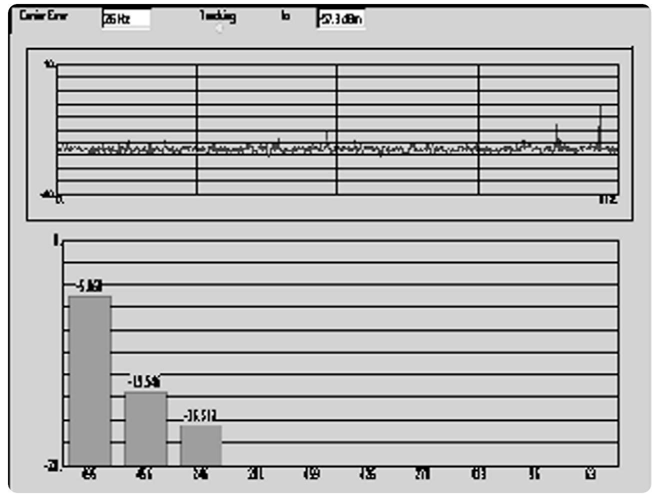

Figure 16. Properly optimized network. Receiver display indicates that pilot pollution is not present. Both the All Pilots and Top N displays are shown.

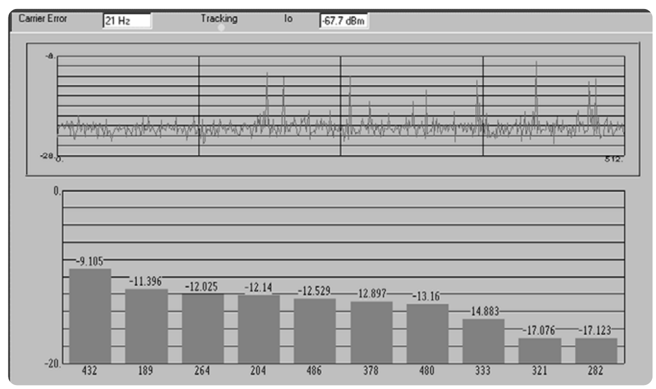

Figure 17. Poorly optimized network. Receiver display indicates that pilot pollution is present, since more than three significant pilots are present.

Pilot measurements: absolute timing delay

Since CDMA-based systems are synchronous with GPS timing, any base station timing errors can result in dropped calls. Figure 18 shows the receiver Top N pilot display with the bar chart values showing delay in chip units. One chip equals approximately 0.8 microseconds. To measure the base station timing error, the drive-test vehicle must be located near the base station or at a known distance from the base station. Otherwise, the system cannot distinguish between base station timing error and propagation delay. The timing delay measurement can also serve a secondary purpose. Since propagation delay is approximately equal to six chips per mile, the measured delay can provide a quick way to estimate the distance from the drive-test vehicle to the base station being measured. For example, if the delay is 62 chips, the base station is estimated at ten miles away, assuming a direct line-of-sight propagation.

Often, a pilot with this excessive delay will not be in the phone's neighbor list or may appear outside the search window of the phone. So the receiver not only finds the missing neighbor pilot, but it also provides the timing delay information that can quickly resolve the source of the problem.

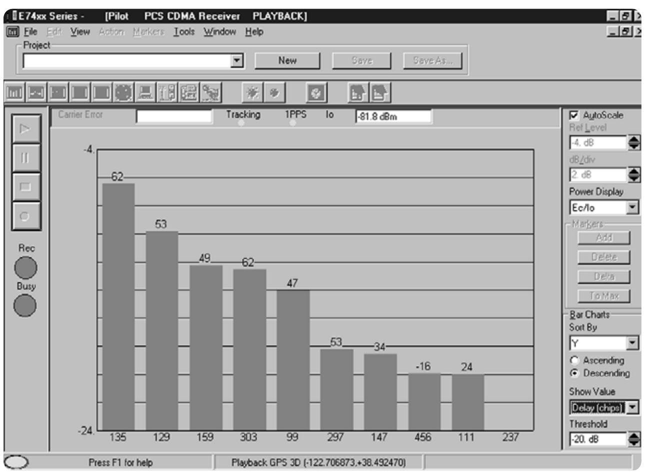

Figure 18. Absolute timing delay measurement using receiver-based system.

Pilot measurements: characterizing multipath

In addition to measuring absolute timing delays, the receiver-based system can characterize the multipath content of the pilot signal. Multipath includes the multiple components of the same transmitted signal, containing numerous propagation paths due to reflections from hills, buildings, and other types of structures. In addition to evaluating the absolute delay of a pilot signal, it is necessary to understand the multipath characteristics of the signal to correctly optimize the search window settings of a subscriber phone. The phone search window is an interval of time over which the phone searches for pilot signals. If the search window is set too wide, the phone needlessly wastes time trying to correlate power at large delays. If it is set too narrow, any system timing delays could result in the signal being missed.

To characterize multipath for properly setting search windows, receiver-based solutions often include the following measurements: delay spread, aggregate Ec (and Ec/Io), and aggregate - peak Ec (or Ec/Io). Using the Top N display shown in Figure 19, the desired measurement values can be displayed. The propagation of a base station pilot results in a signal composed of multiple peaks and valleys.

The peaks correspond to multipath components that can be utilized by the phone's rake receiver fingers, more so in weak coverage areas. Therefore, it is important to set the phone's search window wide enough to capitalize on these useful multipath components. Earlier it was shown that absolute delay is measured at the highest peak of this signal waveform. Delay spread is a measurement of the duration over which the significant energy in the entire signal is dispersed, including all the significant multipath components. The delay spread values in chips are shown above each pilot's bar graph.

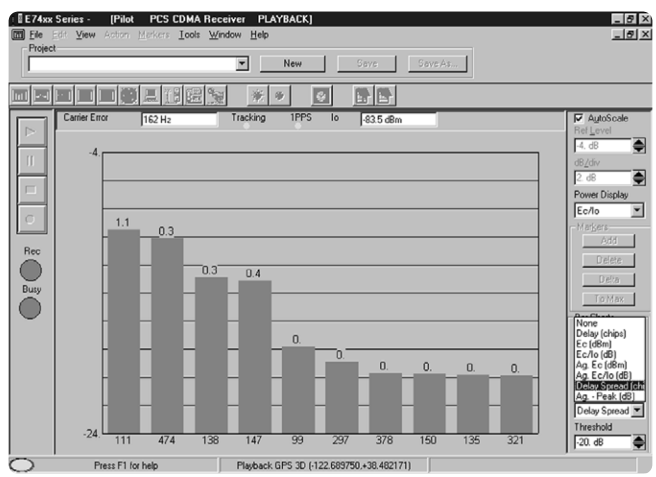

Figure 19. Delay spread measurement, using the receiver-based system, helps to characterize multipath.

CW, channel power, and spectrum measurements

Receiver-based drive tools are useful for network-independent pilot scanning, interference analysis and timing error analysis. The remainder of this section describes measurements that can be performed using the receiver-based drive-test system. The functions include CW, channel power and spectrum measurements.

CW measurements

During the early life cycle of a wireless network, it is necessary to evaluate prospective cell site locations to see if construction of the cell site will provide adequate coverage. To perform this evaluation, a signal generator with a power amplifier is used to transmit CW (continuous wave) signals from the potential cell site. Often the signal generator and antenna are positioned to the approximate elevation of the proposed antennas using a forklift or crane. Then a receiver, with antenna and accompanying collection software, is driven around in a van along the roads in the proposed cell site coverage area. This receiver is usually a dedicated instrument only capable of measuring CW signals. The collected data is exported to a mapping software package and the CW coverage results are evaluated.

Using a receiver-based drive-test system, both CW and CDMA drive-test measurements can be performed (simultaneously, if desired) using the same hardware. A single compact receiver reduces costs when compared to other systems that require separate receivers for CW and CDMA measurements. Using a narrow, 30-kHz analog filter and numerous choices of DSP filtering, the receiver-based system records CW power as a function of the user's location. CW power is the power at the peak of the transmitted signal. (This is equivalent to placing a marker on a spectrum analyzer trace.) CW power is different than channel power, which is the integrated power in a defined channel bandwidth.

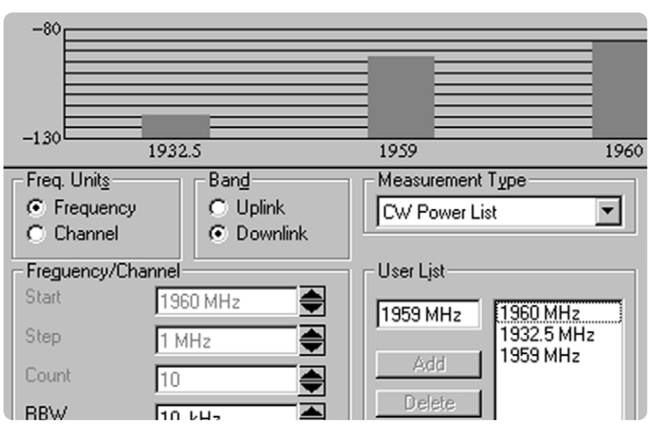

Figure 20. CW power measurements using the receiver-based solution are useful for the site evaluation stage of the wireless network life cycle. Channel power measurements are also available.

Channel power measurements

Receiver-based systems can also be used to measure channel power. Channel power is the integrated power within a defined bandwidth. For example, if the channel bandwidth is defined to be 1.25 MHz, the channel power function will measure the power of the entire CDMA channel. Or, if measurements of analog cellular systems are desired, the channel power can be set to 30 kHz. The channel power in a 1.25-MHz bandwidth is equivalent to the Io value displayed in the pilot virtual front-panel display.

Spectrum analyzer display for troubleshooting

Receiver-based solutions often include built-in spectrum analyzer capability to help optimization engineers troubleshoot problems in the frequency domain. DSP-based receivers are capable of making a core set of spectrum analyzer measurements in addition to the CDMA and CW measurements just mentioned.

Figure 21 is a spectrum display of the entire 1900 MHz PCS downlink band covering the 1930 to 1990 MHz range of the receiver. The uplink band of 1850 to 1910 MHz can also be viewed. Likewise, other receivers can scan the 869 to 894 MHz downlink band and/or the 824 to 849 MHz uplink band. High dynamic range and low noise figure are two key receiver parameters needed for spectrum measurements.

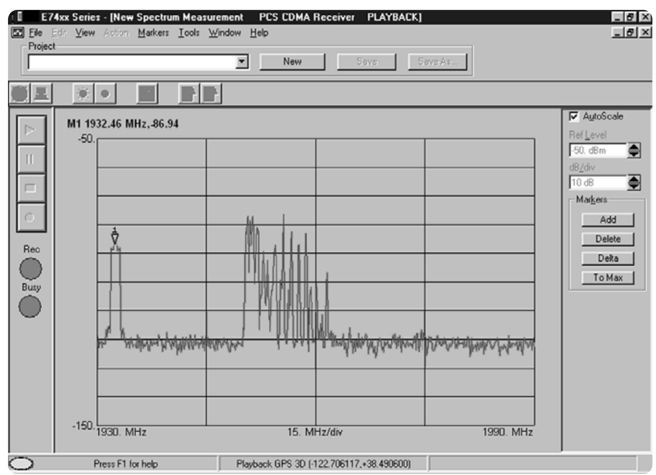

Figure 21. The receiver–based drive-test system with built-in spectrum analyzer capability. A CDMA carrier (with marker) and several GSM signals are shown.

Receiver-based measurement summary

In summary, the multiple functions built into the receiver-based solutions benefit the drive-test engineer by providing a compact and lightweight design that can be used throughout the network life cycle. This includes site evaluation using CW measurements, to network turn-up and buildout using the network-independent pilot scanning capabilities, to over-the-air troubleshooting using the spectrum analyzer capability.

Integrated phone and receiver

It is important to understand that having both a phone and a receiver integrated into the same system assures the highest level of network optimization. Figure 22 illustrates how the integrated drive-test system can help to determine the source of network air-interface problems. The phone can tell "what" the symptom of the problem is, and the receiver can tell "why"the problem occurred.

For example, the phone-based software can measure the drop call or FER percentage. High FER can cause subscribers to experience dropped calls or poor voice quality, but the phone does not reveal why this condition is happening. The phone can measure the active and neighbor pilots, as shown here, but this is not sufficient to locate the source of the problem. On the other hand, the receiver can measure all the pilots, and indicates that PN 129 is a pilot that is not in the phone’s neighbor list. Therefore, this missing neighbor can cause excessive interference to the phone, with high drop rates and high FER. In this case, the missing neighbor is the dominant pilot, so the problem is even worse. Optimization engineers using only phone-based tools could spend hours and perhaps days trying to resolve this problem.

Using a drive-test solution that includes an integrated receiver and phone can help engineers to significantly reduce the time and resources spent resolving wireless network problems. With the addition of automatic alarms in the drive-test collection solution, the task of immediately identifying problems is further simplified. Finally, post-processing the collected drive-test data allows the engineer to quickly spot the problems as a function of the user’s location on street-level maps.

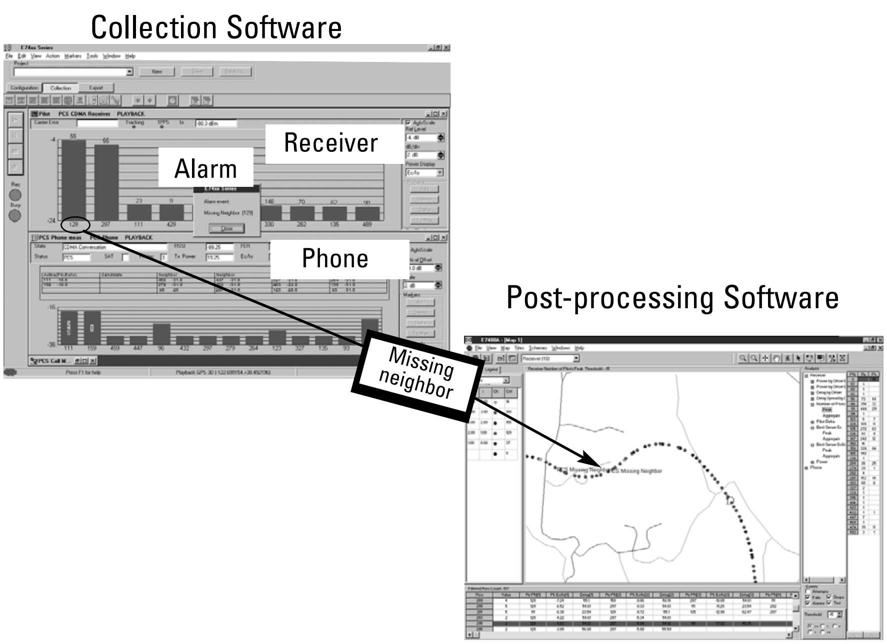

Figure 22. Integrated drive-test solution with RF receiver and phone quickly identifies "missing neighbor" condition. Alarms and post-processing software simplify the identification of wireless network problems.

Section 6: Conclusion

We have demonstrated how CDMA drive-test systems can help wireless service providers and network equipment manufacturers quickly optimize their CDMA networks. Based on an integrated receiver and phone approach, the solutions benefit the optimization engineer by telling "what" the problem is and “why” it happened. This reduces the resources required and minimizes the time needed to optimize networks, resulting in financial savings to the wireless company.

We offer application notes that span many of today's RF network issues:

- *Optimizing your GSM Network Today and Tomorrow. Using Drive-testing to Troubleshoot Coverage, Interference, Handover Margin, and Neighbor Lists. Application Note-1344* (literature number 5980-0218E)
- *Optimizing your TDMA Network Today and Tomorrow. Using Drive-testing to Identify Interference in IS-136 TDMA Wireless Networks Application Note-1342* (literature number 5980-0219E)

For specific examples of how the Agilent Technologies drive-test solutions are used to solve optimization problems:

- *CDMA Drive-Test Product Note* (literature number 5968-5554E)
- *Spectrum and Power Measurements Using the Agilent CDMA, TDMA and GSM Drive-Test System Product Note* (literature number 5968-8598E)

For additional Agilent Technologies CDMA drive-test information:

- *CDMA Drive-Test System Technical Specifications* (literature number 5968-5555E)
- *CDMA Drive-Test System Configuration Guide* (literature number 5968-5553E)
- *CDMA Post-Processing Product Overview* (literature number 5968-1549E)

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