cdma2000 1x EV-DO Wireless Networks: Challenges in Maintenance and Testing

Introduction

Around the globe, cell phone users have come to depend on high-quality cellular voice services to conduct business and stay in contact. As voice networks mature, network operators are eager to continue their rapid growth by providing high-speed data services as well.

While data services are currently available in most second-generation (2G) CDMA networks, these networks are optimized for voice traffic and low to moderate data rates. In order to achieve higher data rates, network operators are evaluating or deploying cdma 2000 1x EV-DO.

This application note discusses the forward link (base station- to-mobile) measurements necessary to ensure high Quality of Service (QoS) in cdma2000 1x EV-DO base stations. Measurement examples will utilize the Tektronix NetTek® analyzer. This portable field tool provides all of the essential forward link signal quality, power, and modulation tests, including co-channel and out-of-channel RF interference testing.

This document is a companion to the Technology Overview titled “cdma2000 1x EV-DO Wireless Networks: Technology Overview” (Tektronix publication number 2FW-18494-0), which provides additional details about the protocol and characteristics of the cdma2000 1x EV-DO RF forward-link signal. Following the convention established in the companion piece, the abbreviated term “EVDO” will be used throughout this application note in place of the full cdma2000 1x EV-DO nomenclature.

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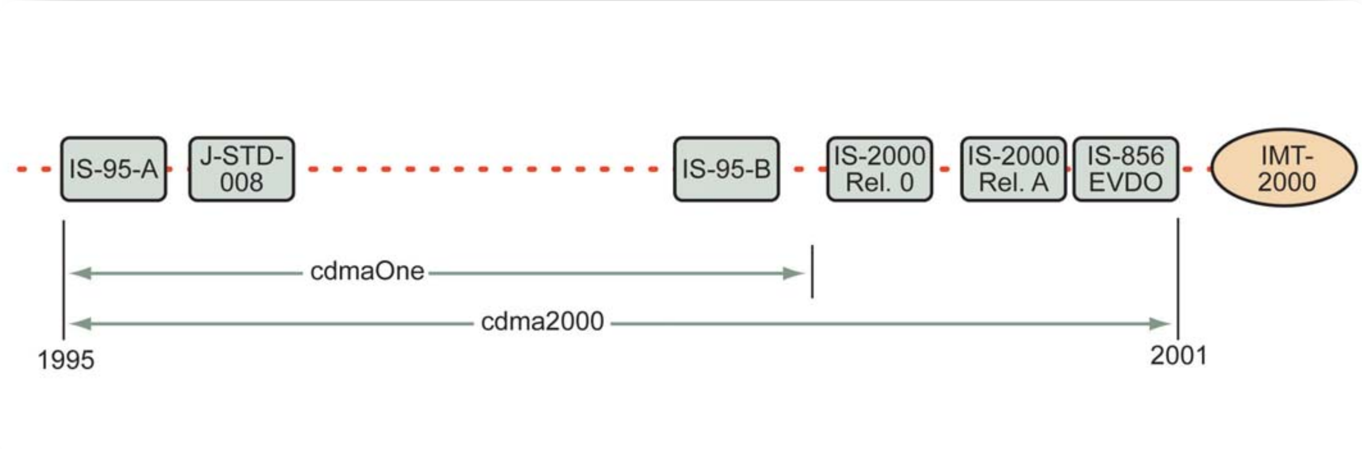


▶ **Figure 1.** *The Evolution of CDMA Technology*

Moving from 2G CDMA to EVDO

Code division multiple access (CDMA) is a second-generation (2G) spread-spectrum technology that came to market as an alternative to GSM-based frequency-hopping architectures. The IS-95 standard, which defined CDMA technology, achieved widespread success. Basic CDMA systems deliver approximately 10X the voice capacity of first-generation (1G) analog systems.

CDMA architecture was designed to include several stepping stones toward eventual third-generation (3G) global wireless communication systems. Most networks have advanced their early CDMA infrastructures to meet the cdma2000 standards. EVDO is the next step in the evolution toward a robust 3G technology.

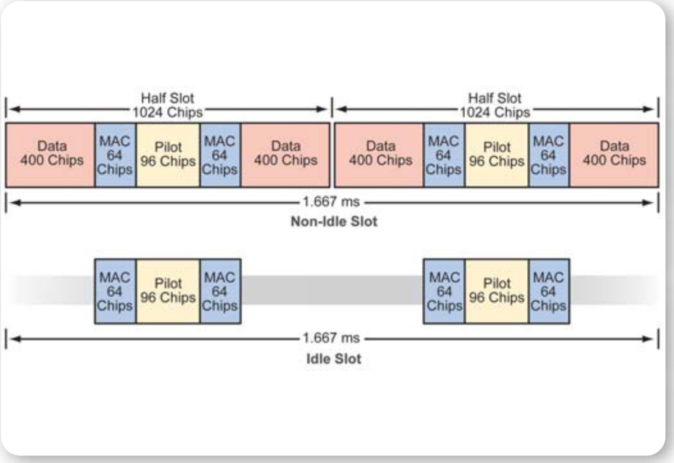
Important QoS considerations when deploying EVDO

When wireless voice services were first introduced, users naturally made comparisons to their traditional wire-line connections. Similarly, comparison of EVDO to existing high-speed data services such as DSL or broadband cable will be unavoidable.

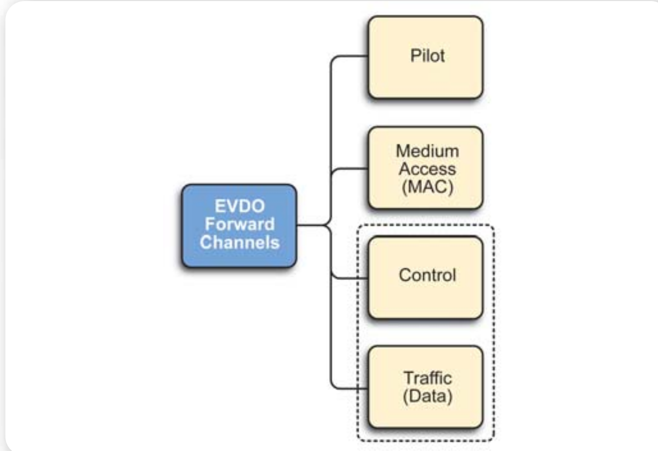
EVDO is capable of delivering performance on a par with these services; however, doing so in a wireless environment will be a challenge. The highest EVDO data rates are most easily achieved where the signal to noise ratio is the highest, close to the base station. As users move away from the base station and encounter lower signal levels (worse signal to noise ratio), EVDO uses additional error correction and more robust modulation formats to ensure a stable but slower connection.

Stable connections are certainly important, however, data users who have come to expect good performance may become dissatisfied if data rates decrease significantly. These customers will terminate the call long before it drops, making traditional metrics such as dropped call rates, inadequate for measuring Quality of Service (QoS).

To ensure high data rates as far from the base station as possible, network operators will need to ensure high quality transmission by testing and maintaining base station components on a regular basis.



▶ **Figure 2.** *The EVDO Non-Idle (Active) and Idle Slots*



▶ **Figure 3.** *The EVDO Forward Link Channel Structure*

Overview of EVDO

This section will briefly review the technology and concepts of EVDO from the perspective of the forward-link air access interface.

EVDO spectrum utilization

EVDO uses existing 1.25 MHz CDMA channels to apportion usable bandwidth for packetized data. EVDO also uses the same chip rate (1.2288 Mchips/s) and transmit filters found in cdma2000 and earlier systems, so spectrum utilization is identical to prior versions of CDMA.

Time Division Multiplexing

EVDO forward-link transmissions utilize Time Division Multiplexing (TDM) to deliver traffic data transmissions at full power to one and only one user at a time. This ensures that a given user will receive the maximum data rate possible given their current reception conditions. Not all EVDO channels utilize TDM, though, so further discussion of the EVDO channel structure is necessary.

EVDO forward-link channel format and structure

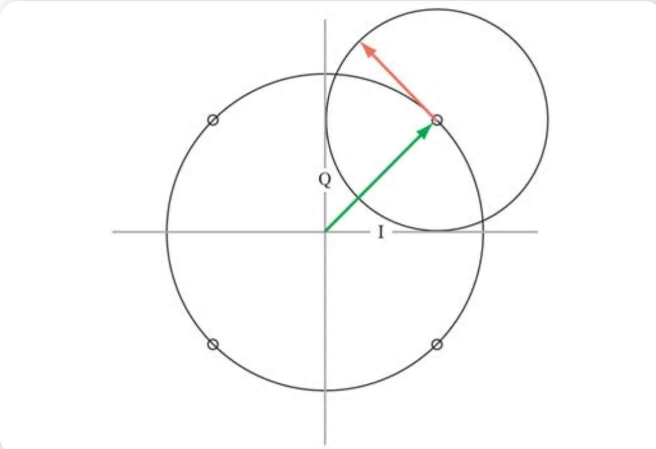
EVDO data is transmitted in Slots that are 2048 chips in length. As illustrated by Figure 2, each slot is further divided into Half-slots that are 1024 chips in length. Each half slot contains 800 data chips, 128 Media Access Control (MAC) chips, and 96 Pilot chips.

Slots transmitted with user data are called Non-Idle Slots and slots transmitted without data are called Idle Slots. During idle transmissions, base station power is reduced by a minimum of 7 dB. This helps reduce interference to users in adjacent sectors.

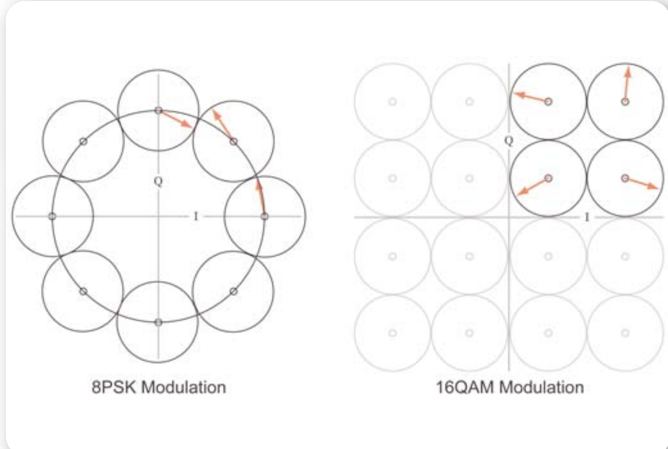
As shown in Figure 3, an EVDO transmission contains four types of channels.

Within each half-slot, the Pilot and MAC channels are always transmitted at the same location and with the same length. The Control and Traffic channels, however, share the data portion of each slot. A preamble, if present, is placed at the beginning of the first half-slot and varies in length. The primary function of each channel is as follows:

- **Pilot:** used by all Access Terminals (AT: the new EVDO term for a mobile device) to identify the unique sector and to obtain system timing.
- **MAC:** transmits unique data rate control information to each ATs simultaneously by utilizing a unique Walsh code for each AT
- **Control:** Control channels are data transmissions which are addressed to all users, as indicated by a unique preamble pattern. They are structured the same as Traffic (data) packets and, when present, are transmitted at the start of the first half-slot. All ATs monitor the Control channel information.
- **Traffic (Data):** the packetized data payload. Data is sent to only one AT at a time, with the preamble section indicating the intended recipient of the packet.



▶ **Figure 4.** *The IQ Diagram for QPSK Modulation*



▶ **Figure 5.** *The IQ Diagram for 8PSK and 16QAM Modulation*

Flexible data rates change to fit the circumstances

Transmission rates are determined by a handshake mechanism between the AT and the Access Node (AN: the EVDO term for a base station). The rate selection depends on observed and predicted transmission conditions. This subject is discussed in more detail in the companion Technical Overview.

In an optimal situation (when the AT is near the base station and/or the signal-to-noise ratio is high), a data rate up to 2.4 Mb/s is achievable with 16QAM modulation. When the AT is distant from the base station or when other factors degrade the signal, the system switches to simple QPSK modulation and the data rate can be as low as 38.4 kb/s.

EVDO RF modulation methods

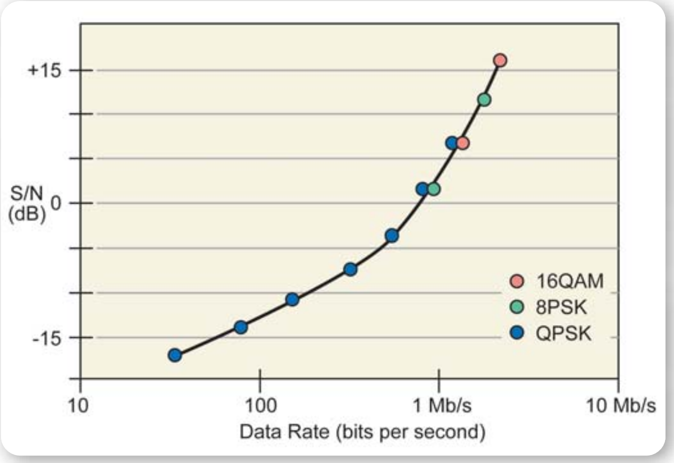
cdma2000 versions prior to EVDO use a modulation method called QPSK (Quadrature Phase Shift Keying) to encode the data stream information onto the RF signal. This is a phase modulation method that transmits one symbol (two bits) per phase shift.

Figure 4 shows a QPSK I-Q diagram, which is a useful way to represent phase and amplitude modulation. Phase shifts are measured around the central circle, while amplitude is measured as the distance from the origin. QPSK modulation is represented by four different phase states on the constellation diagram. The sized and shape of the phase states are influenced by the amount of inter-symbol interference and other factors. Each state (or symbol) represents two bits of data (00, 01, 10, or 11).

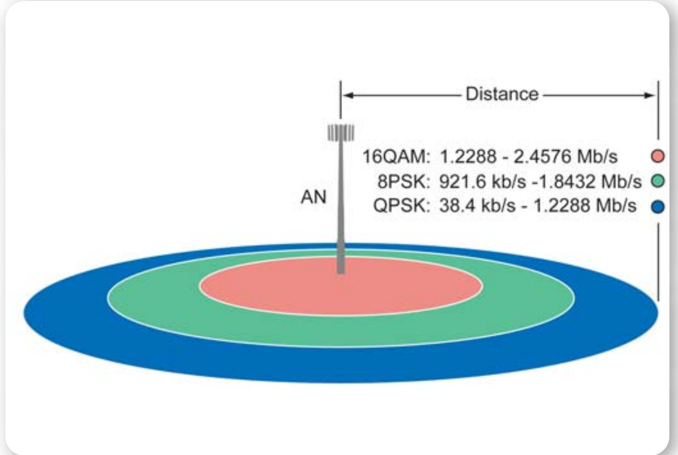
In order to increase data rates, EVDO utilizes two additional modulation formats: 8PSK (8-ary Phase Shift Keying) and 16QAM (16-ary Quadrature Amplitude Modulation). IQ diagrams of these modulation formats are shown in Figure 5.

When compared to QPSK, an 8PSK constellation contains twice the number of symbols (eight versus four), with each symbol representing more data (three bits versus two bits). 16QAM has four times the number of symbols (sixteen versus four) and each symbol represents twice the amount of data (four bits versus two bits).

While the new modulation methods increase data rates, they also increase susceptibility to errors. Comparing Figure 4 to the IQ diagrams in Figure 5 clearly shows a reduction in the maximum permissible error vector (the red arrows) before there is confusion between symbols (inter-symbol interference). The negative impact of decoding errors is also increased since each lost symbol represents more lost data.



▶ **Figure 6.** *Signal to Noise in Relation to the Data Rate*



▶ **Figure 7.** *Signal Quality Declines as Distance Increases*

The problem statement

The network operations manager's challenge is to deliver consistently high Quality of Service (QoS) as cost-effectively as possible. For voice networks, QoS parameters such as dropped calls, blocked calls, and lack of signal are important metrics. While these metrics are also important for EVDO networks, the greater concern is customer dissatisfaction due to disappointingly slow data rates.

From a network maintenance perspective, EVDO forward link measurements address four areas critical to ensuring maximum data rates and, ultimately, satisfied users.

Maximizing the EVDO data rate-signal quality

EVDO monitors dynamic RF environmental conditions and the handset's responses to them. The higher the received signal quality, the higher the data rate can be. Conversely, users experience ever-slower data rates as signal quality declines. Figure 6 illustrates the relationship of data rate to signal quality in terms of Signal to Noise Ratio (S/N).

High signal quality (high S/N) is naturally experienced close to the base station where the signal level is high. As the AT moves further from the base station, interference, noise, and other factors reduce the signal quality (lower S/N).

Maximizing the cell radius over which reliable high-rate data transmissions are delivered requires that network operators start with the highest signal quality possible. A rigorous schedule of measurements to evaluate power levels, waveform/modulation quality, and code domain behavior is the only sure way to ensure that subscribers receive the full benefit of EVDO.

Reducing interference

At the lowest data rates, EVDO signals are no more susceptible to interference than prior cdma2000 versions and, in some ways, even more robust. This is because EVDO sends data multiple times at slower data rates, allowing the AT multiple opportunities to receive and decode the information. As soon as the AT is able to receive the data, retransmission is terminated.

EVDO also uses variable coding rates to send multiple bits for each bit of data. The code rate can be as high as 1:5, sending 5 bits of information for each actual bit of data (See the companion Technical Overview for additional information on repeat rates and coding rates.).

At higher data rates, data is not repeated and code rates are significantly increased (from 1:5 to 2:3). Adding modulation formats (8PSK and 16QAM) that are more susceptible to interference highlights the importance of finding and controlling interference sources in an EVDO system.

Fluctuating RF power levels

EVDO has the compelling benefit of retrofitting into existing CDMA network equipment. It uses existing RF amplifiers and related transmission hardware. However, this capability is not without its risks.

Existing CDMA base stations were designed to deliver a steady long-term power level. EVDO is different: Idle Slots cause frequent large power changes in the transmission. This may be a challenge for the RF amplifier in particular, which must shift from idle to active, and back, very quickly. It is essential to understand and test the power behavior of Idle Slots and their active counterparts, as well as that of the Pilot and Medium Access Channel.

Because each base station in a CDMA system transmits on the same frequency, power must be set accurately. Setting power too high will create interference for ATs in adjacent cells, reducing capacity. Setting power too low will create dead spots and result in handoff problems.

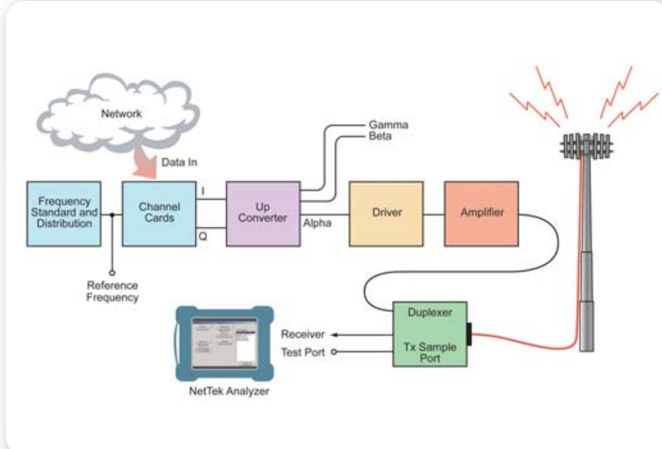
The solution - transmitter testing

Selecting the right test tool

In-the-field measurements of base station transmitted RF signals can provide the basic information needed to evaluate the RF components related to QoS and data throughput. Traditionally these tests have been performed either by complex compliance testers, which can be difficult to use, or very simple testers such as cell phones. The latter can detect the existence of problems, but are not so useful for correcting the problems.

The Tektronix NetTek YBT250 BTS Field Tool, a transmitter and interference tester, is optimized to provide the right set of tests for field maintenance technicians and RF engineers to maintain and troubleshoot EVDO base station transmitters. A series of basic Pass/Fail tests summarizes base station performance and pinpoints problems. The in-depth tests available in the NetTek analyzer are a great help in solving the more challenging problems.

In the following sections, we will look in detail at the measurement methods and the results of these measurements for optimizing EVDO base stations.



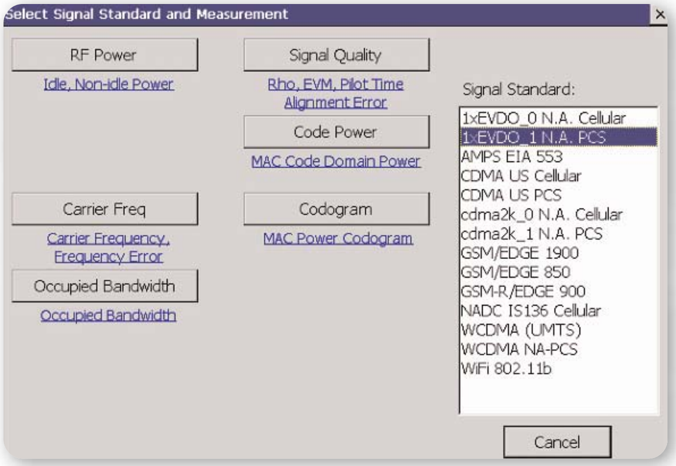
▶ **Figure 8.** *Direct Connect Measurements*

Accessing the signal

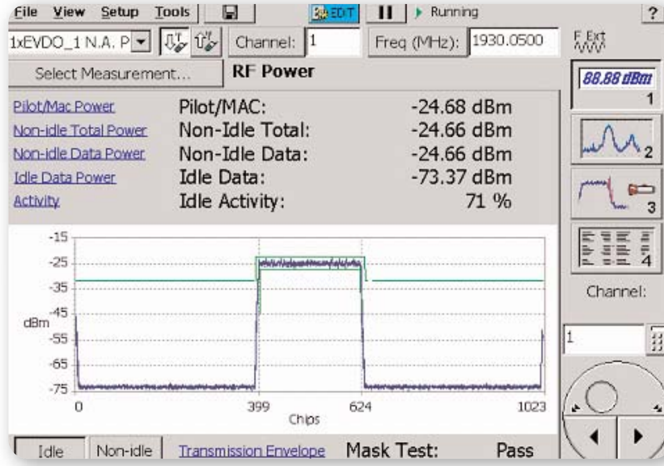
The Tektronix NetTek analyzer can be used to make measurements and perform evaluations in either a direct connect configuration or an over-the-air configuration using a directional receive antenna. Direct physical connection to a base station transmitter RF output or coupled port provides the most accurate measurements.

Important BTS transmitter tests

This section is an overview of key base station maintenance tests for QoS programs, routine maintenance, diagnostics, and repair. A regular testing regime with an appropriate integrated test set can ensure a level of base station performance that meets customer expectations. Measurements can be made by connecting the analyzer directly to the RF output of the transmitter (using attenuators where appropriate), a coupled test port, or to the receive antennae, as shown in Figure 8. Coupled port connection has the added benefit of allowing in-service testing.



▶ **Figure 9.** *The EVDO Measurements Selection Window*



▶ **Figure 10.** *The EVDO Idle Slot RF Power Measurement Screen*

After connecting to the base station, the NetTek analyzer EVDO measurements are available from the menu shown in Figure 9.

This section will describe each common EVDO direct connected measurement in turn, describing what is being measured, why the test is needed, pass/fail guidelines if appropriate, and common sources of problems, if any.

RF power measurements

The NetTek analyzer configured with the YBT250 Transmission Analyzer measures the RF Power of an EVDO signal within the selected forward channel. A base station using EVDO signals may transmit at idle and non-idle power levels depending on the use of the individual slots for carrying data at that time. The YBT250 distinguishes between idle and non-idle slots and performs power measurements on each type of slot. Power measurements shown on the Idle or Non-idle screens are averages taken over multiple slots.

The RF power mask test-Idle Slot

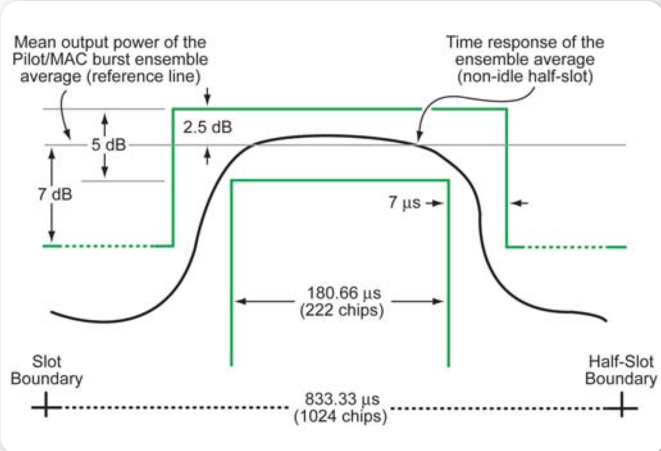
What is measured? During the transmission of an Idle Slot, the transmitted power in the Data portion of the slot must be reduced by a minimum of 7 dB below the level during the Pilot and MAC channels. During the transmission of the Pilot/MAC channels, the power should ramp up at the specified time, stay up during transmission, and ramp down.

The Idle Slot Mask test collects power versus time waveforms from slots with idle data intervals. It averages up to 100 of these power waveforms to an ensemble average wave form, which is then compared to the mask. Figure 10 shows a typical measurement result screen.

As illustrated in Figure 2, a complete active slot is made up of two Pilot/MAC channel bursts of 224 chips and four data bursts of 400 chips, all subdivided into two symmetrical half-slots. In other words, The Pilot/MAC Channels are transmitted in bursts of 224 chips every half slot. The test measures the time response of the mean output power for Idle Slots (Pilot/MAC bursts). Variations should be within ±2.5 dB of the mean output power of the ensemble average shown in Figure 10.

Why test? In each Idle Slot, power must be ramped quickly to ensure accurate the transmission of the Pilot/MAC information. In addition, power should ramp down quickly to help eliminate interference to ATs in adjacent sectors and cells.

EVDO is an add-in to existing CDMA2000 equipment. The RF amplifiers in CDMA base stations were not originally designed to switch on and off as quickly as EVDO requires. Equipment vendors are certain to have considered the impact of rapidly switching power on and off for Pilot/MAC Channel transmission, however, the technology is new and monitoring the amplifier performance and health is advised.



▶ **Figure 11.** *The RF Power Mask Limits*

What are the guidelines? Figure 11 shows the RF power mask as specified by the EVDO standard. The data section of each idle half-slot should be at least 7 dB lower than the average power during the Pilot/MAC transmission. During transmission of the Pilot/MAC data, the power should be within ±2.5 dB of the average.

If the waveform strays outside the green mask lines, the section(s) of the mask containing the failure turn from green to red. There are mask sections for each data interval and each Pilot/MAC interval.

What are the potential sources of faults? Slow or fast rise times could be due to faulty amplifiers or damage to antennae, cables, or connectors. Violations of limits may be due to amplifier instability or interference. In some instances, repeated data patterns could result in mask violations. This is most likely to occur in the MAC channel when few users are on the system. As a result, the standard recommends 14 MAC channels configured to provide a good random characteristic to the MAC interval.

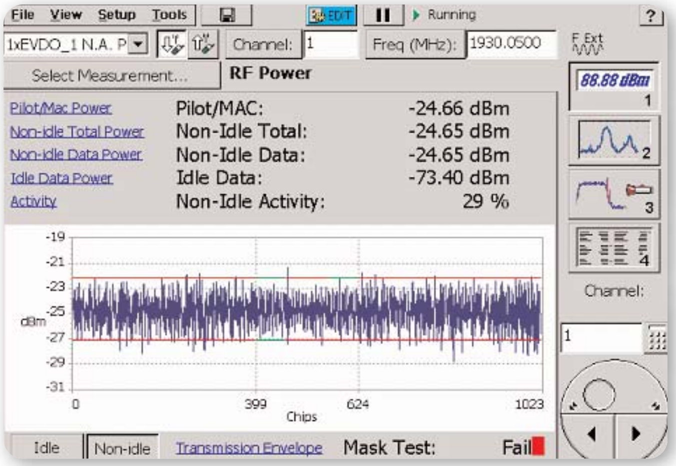
Pilot/MAC Channel Power

What is measured? EVDO Pilot channel and MAC channel RF power are both measured. The Pilot and MAC intervals carry system control information. The channels are transmitted by the base station at full power in every time slot. The readout gives the average power in dBm of the Pilot/Mac portion of the slots collected.

Why test? The Pilot/MAC power level is critical to the proper operation of the AN. Pilot power is used by ATs to make initial power settings and to determine handoff criteria. The pilot power level effectively determines the ANs footprint. If the power is too high, it will extend the cell's geographical coverage, causing unbalanced cell loading and premature handoffs from other cells. High pilot power also causes interference with adjacent cells and a reduction in the effective rate of EVDO data services. Conversely, if Pilot/MAC power is too low, poor coverage can result, leading to dropped connections and reduce data rates at cell boundaries.

What are the guidelines? The absolute power level setting will vary, however, the Pilot/MAC channel should be at least 7 dB above the Data channel.

What are the potential sources of faults? Problems in the Pilot/MAC channel power level may be the result of RF amplifier drift or faulty cables and connectors within the base station. Power should be reset to the specified level and the base station retested.



▶ **Figure 12.** *The EVDO Non-Idle Slot RF Power Measurement Screen*

Non-Idle Data Power

What is measured? Non-Idle Slots are those that carry user data content. The base station transmits the data at full power during the appropriate intervals. The Non-Idle Data Power measurement is an average (expressed in dBm) of the power delivered during the data portion of the time slot.

Why test? As shown in Figure 12, the base station devotes its full power to data transmission during non-idle (active) timeslots. Therefore, the Non-Idle Data Power should be similar in level to the Non-Idle Total Power and Pilot/MAC power.

If Non-Idle Data Power is low, then the mobile does not receive the power the base station assumes is being sent and error rates will increase. If Non-Idle Data Power is too high, it could cause amplifier distortion and result in increased error rates. In either case, data rates and capacity will be reduced.

What are the guidelines? The absolute power level setting will vary, however, the Non-Idle Data power levels should correlate closely with the Pilot/MAC power levels.

What are the potential sources of faults? Differences in power levels between the Data and Pilot/MAC power levels are likely due to systems settings.

Non-Idle Power Mask

What is measured? In non-idle slots, the base station transmits the data at full power. The Non-Idle Total Power is an average reading of RF power, expressed in dBm, during the active timeslots. The test displays the time response of the mean output power for non-idle slots from 100 half-slot power waveforms averaged together.

Why test? As explained previously, the base station devotes its full power to the data transmission during non-idle times-lots. Therefore the Non-Idle Data Power should be similar in level to the Non-Idle Total and Pilot/MAC power. It is necessary to know the Data, Pilot/MAC, and Total figures for comparison purposes.

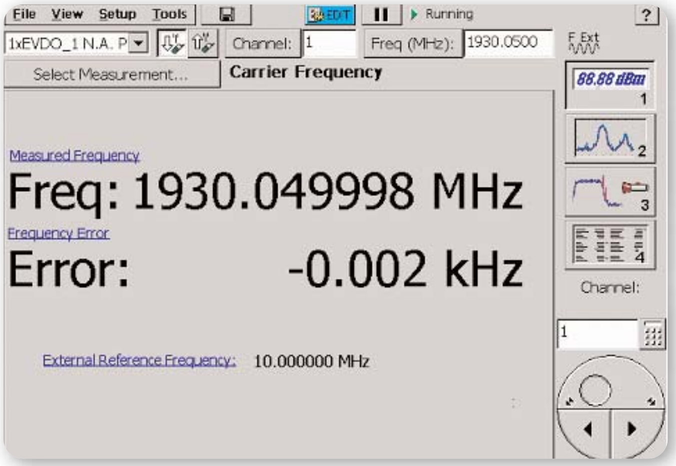
What are the guidelines? Within an ensemble of non-idle half-slots, the time response of the ensemble average must be within the ±2.5 dB of the average. The image in Figure 12 illustrates actual results from a Non-Idle Total Power measurement. Note that this particular measurement failed-the signal penetrated the green mask lines that define the limits.

What are the potential sources of faults? Total power level problems consistently across the slot are likely due to an incorrect base station setting, faulty amplifier, or a bad cable or connector. Mask violations may also be caused by a faulty power amplifier that is clipping the signal. Mask violations at the beginning or end of the slot are likely due to a power amplifier that is struggling to switch on and off between idle and non-idle slots. Adjusting the power level and observing the amplifier behavior may prove helpful in finding a faulty amplifier.

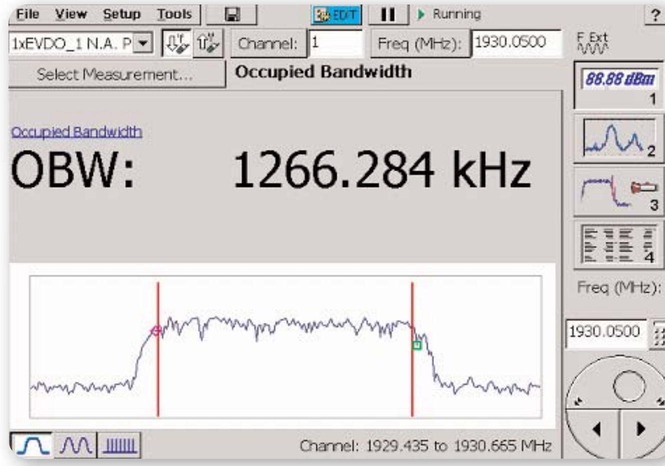
Idle/Non-Idle activity

What is being measured? This test determines the percentage of idle slots currently being transmitted. Non-Idle Slots also can be tabulated. The NetTek analyzer will attempt to collect many slots before giving a result. If it is unable to do so within 1000 half-slots, it will display the average waveform for as many half-slots as it could collect, and display an alert.

Why test? Idle Activity and its complement, Non-Idle Activity, equate to system loading or utilization. Idle Activity can be used to monitor capacity during peak hours to indicate overloading or under-loading of the cell. Overloading may require the need for an additional base station. Under-loading during a period of high traffic may point to problems with the base station that reduce capacity, requiring further investigation.



▶ **Figure 13.** *The Carrier Frequency Measurements Screen*



▶ **Figure 14.** *The Occupied Bandwidth Measurements Screen*

Carrier Frequency and bandwidth measurements

Carrier Frequency and Frequency Error

What is measured? The Carrier Frequency test is self-explanatory. It measures the actual frequency for the selected channel and compares it against a tolerance defined in the EVDO specification. The test applies to every band class that the sector supports.

Frequency Error is the difference in frequency between the measured frequency of the selected channel and the frequency assigned to the channel in the Channel Table file. Frequency error is expressed in frequency and parts per million (ppm).

Why test? Like any other radio environment, EVDO transmitters must adhere to their carrier frequency assignment or risk interference with adjacent channels. An effect of poor frequency accuracy is difficulty or inability of ATs to handoff into or out of the AN sector.

What are the guidelines? For all operating temperatures specified by the manufacturer, the average frequency difference should be ±5 x 10-8 of the frequency assignment (an allowable tolerance of ±0.05 ppm). In practice this amounts to a range from 40 Hz to 110 Hz, depending on the RF band used.

What are the potential sources of faults? Frequency errors may be due to problems in the local oscillator within the base station or a faulty base station GPS frequency reference.

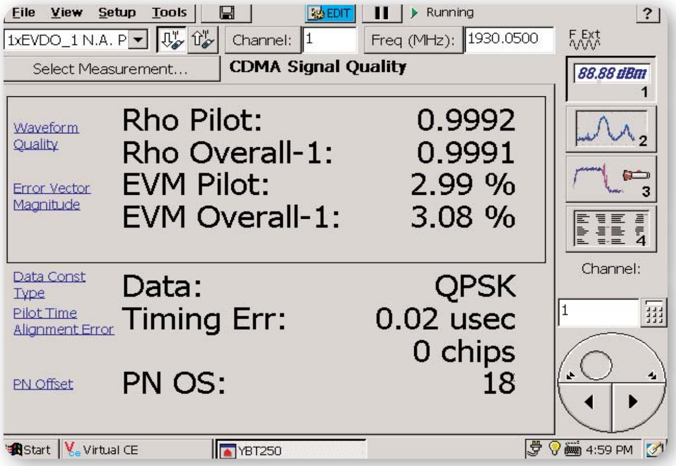
Occupied Bandwidth

What is measured? The Occupied Bandwidth (OBW) is the frequency range that encompasses 99% of the power transmitted within a single channel.

Why test? Excessive OBW creates interference with adjacent RF channels, in turn reducing the system capacity and data rates in adjacent channels.

What are the guidelines? The occupied bandwidth is specified not to exceed 1.48 MHz.

What are the potential sources of faults? OBW problems may arise from intermodulation due to faulty mixers or "unintended" mixers such as those caused by corrosion in the antenna cable fittings.



▶ **Figure 15.** *The Signal Quality Screen*

Signal quality measurements

Rho Pilot and Rho Overall-1

What is measured? Rho is a measurement of the signal's general waveform quality. As a figure of merit, the Rho Pilot measurement is a correlation of the power in the actual signal to that of an ideal signal. The highest possible Rho value is 1.0, indicating that the power found in the ideal and actual signals match perfectly. Values of Rho significantly less than 1.0 indicate signal impairment or interference.

There are two Rho measurements derived for an EVDO signal. Rho Pilot examines only the Pilot intervals of the waveform. Rho Overall-1 is computed on all chips of one Non-Idle (active data) Slot waveform, including the pilot, MAC, and data intervals. Rho Overall-1 is computed only when Non-Idle Slots are detected in the input signal.

Why test? Low signal quality has an effect similar to noise. Low Rho values can reduce coverage, cause registration problems, and can drop data sessions unexpectedly. More importantly, low signal quality will reduce data rates and system capacity.

What are the guidelines? Rho Pilot and Rho Overall 1 must be greater than 0.972 (excess uncorrelated power < 0.13 dB).

What are the potential sources of faults? Low Rho values imply distortion due to compression, switching, IQ modulation or other RF issues.

EVM Pilot and EVM Overall-1

What is measured? Error Vector Magnitude (EVM) is a measure of distortion in the RF signal path. EVM measurements represent the phase and amplitude instability of the signal.

EVM Pilot is computed only on chips in the Pilot intervals of the waveform, over 10 slots. EVM Overall-1 is computed on all chips of non-idle (active data) slot waveform, including pilot, MAC, and data intervals. EVM Overall 1 is only computed when non-idle slots are detected in the input signal.

Why do I need to test? Poor EVM results indicate base station and/or air interface issues that elevate error rates, degrading data throughput and capacity.

What are the guidelines? EVM is not specified in the EVDO standard. Still, its proven usefulness in monitoring other wireless formats has led many EVDO operators to adopt EVM guidelines of their own. Lower EVM numbers are always better.

What are the potential sources of faults? Power amplifier issues such as power settings, compression, clipping, and power supply faults can affect EVM. Unstable frequency references and RF path issues ranging from loose connectors to failing cables can also degrade EVM.

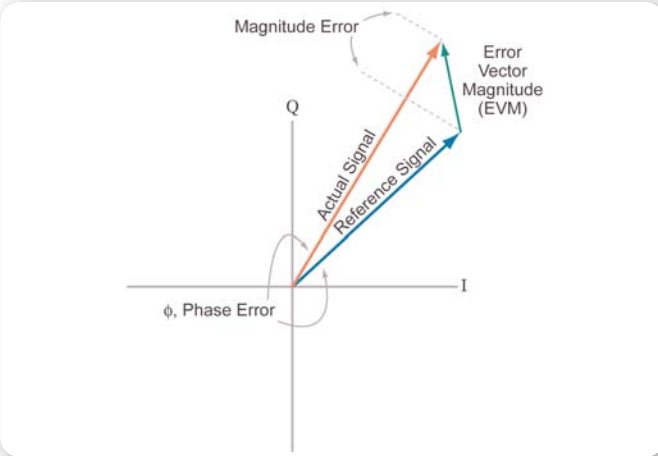
Pilot Time Alignment Error

What is measured? The Pilot Time Alignment Error (see Figure 15) measures the difference between an ideal signal, with PN timing exactly aligned to a particular PN Offset, and the received signal, as observed at the input port of the measurement tool. The difference is the residual timing error of the received signal from the nearest legal PN Offset. The error can be expressed in both microseconds and equivalent number of chips.

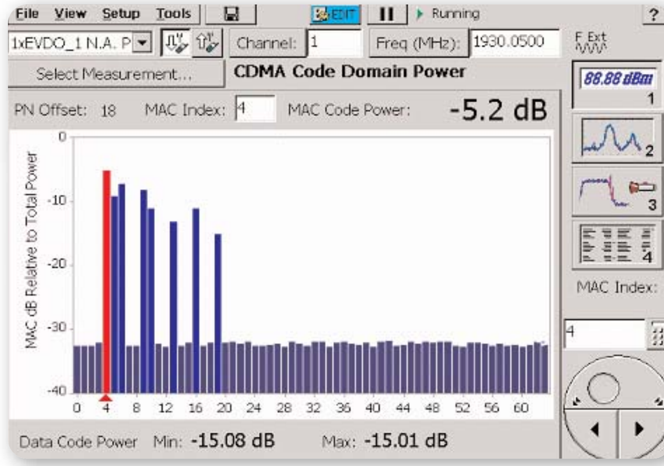
Why test? Timing accuracy relative to the legal PN offset impacts handoffs; possibly causing “Island Cells” that can not accept handoffs into or out of the cell.

What are the guidelines? According to the EVDO specification, Pilot Time Alignment “should be” less than 3 µsec and “shall be” less than 10 µsec.

What are the potential sources of faults? Pilot timing errors may be due to improper base station settings such as pilot time delays or a faulty GPS timing reference.



▶ **Figure 16.** *The phase transfer function of a 4th order PLL in Response to Phase Fluctuations in both the Reference and the VCO.*



▶ **Figure 17.** *The MAC Code Domain Power Screen*

EVM - Error Vector Magnitude

EVM is a measurement which evaluates the signal quality.

EVM is computed from the vector difference between the actual received signal and a calculated, ideal reference signal (Figure 16).

EVM is simply a visualization of the digital modulation process. The horizontal axis represents the real (I) component of the transmitted signal, while the vertical axis maps the imaginary (Q) component. Using this depiction, the magnitude and phase of every symbol state on the modulation constellation can be shown.

Code domain measurements

MAC Code Domain Power

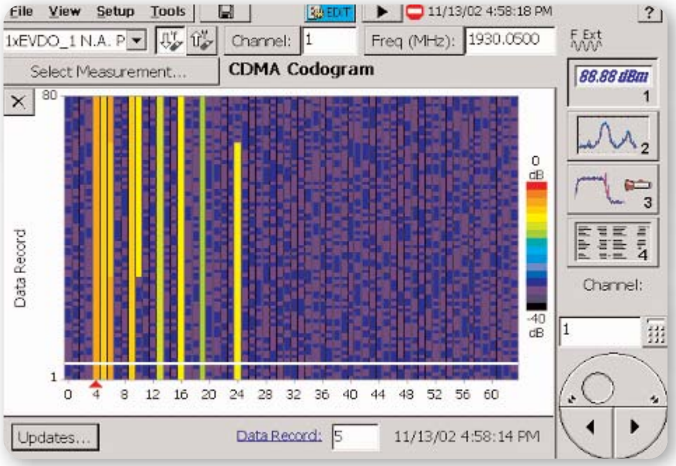
What is measured? The Code Domain Power measurement (Figure 17) displays the power in each of the 60 MAC code channels relative to the total power of the signal. The display shows the MAC index number in the horizontal axis and the power of each code channel with the height of the corresponding bar. All measurements are in dB relative to the total average power.

For non-idle slots, the minimum and maximum value for data codes is also shown. Although data is sent to a single AT, EVDO still uses multiple Walsh codes to send it. The receiving AT will decode all the codes in the Data Channel to obtain the data. The level of each Data code should be -15.05 dB ±0.5 dB below average Pilot/MAC power level (relative to total average power). If the minimum and maximum code power values are within the range, all codes are guaranteed to be within the legal range.

Why test? The MAC Code Domain Power test ensures that the noise floor of the inactive channels is within the specified guideline of -31.5 dB below the MAC Code Power. This screen also provides an indication of system loading through observation of the code channels.

All data codes (Non-Idle Slots) should be transmitted at a constant power level, so the Data Code Power minimum and maximum provide an indication of the flatness.

What are the potential sources of faults? A high noise floor may indicate problems with a modulator or power amplifier. In this instance, EVM and Rho should also be examined.



▶ **Figure 18.** *The MAC Channel Codogram*

Codogram

What is being measured? The Codogram is a different perspective on the Code Domain Power measurement. It displays the relative power levels in all of the MAC Code channels, and adds the dimension of time to the display. In the codogram, the power level is expressed by color (red is the highest level) and the time is on the vertical axis. Figure 18 depicts the same signal activity, but the Codogram makes it clear that MAC code 4 is consistently operating at a higher power level than all of the other codes.

Why test? The Codogram reveals changes in code levels over time, making it easier to spot and record intermittent faults and interference. It also indicates trends in cell loading over a period of time.

What are the guidelines? The Code Domain Power guidelines apply. The Code Domain Power in each inactive channel must be 31.5 dB or more below the total MAC power.

What are the potential sources of faults? The same faults found on the Code Domain Power screen can also be found with the Codogram. Of course the Codogram makes it much easier to spot trends and changes over time.

Conclusion

cdma2000 1x EV-DO is an important evolutionary step toward full implementation of 3G cellular communications infrastructure. Successful deployment and operation of EVDO networks will be critical to the success of wireless service providers. Old tools and traditional metrics, once adequate for a robust voice system, are not sufficient to guarantee high data rates in a complex EVDO signal that varies data rates according to signal quality. Regular testing and maintenance programs help service providers maximize capacity, high data rates, and revenues for premium EVDO data services.

The Tektronix NetTek analyzer is purpose-built for base station technicians and field RF engineers. It brings performance, usability and value to network operations managers. The Tektronix NetTek analyzer provides the essential testing capability for maintenance personnel to increase their productivity and effectiveness, while maintaining high QoS and customer satisfaction. This application note has reviewed the important measurements to be made on EVDO base stations. We have provided testing guidelines, extracted from the appropriate standards and specifications. Lastly, we have identified potential sources of problems that need to be investigated and repaired or adjusted if necessary.

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